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TABLES

ATTACHMENTS

Chapter 1

INTRODUCTION

1-1. Purpose. There is a continuing need within the USEUCOM weather community to rapidly acquaint newly arrived forecasters with the weather of this region. This pamphlet was written to fulfill part of that need. Many aspects of European weather are different from those of the Pacific, or continental United States. This pamphlet is designed to provide basic orientation to the geography, climatology, weather and some aspects of forecasting in Europe. In addition it should prove a valuable reference during your tour in the European theater.

1-2. Plan of the Pamphlet:

a. Climatic Controls.
b. Climatology and General Circulation.
c. Significant Weather.
d. General Forecasting Techniques.
e. Communications, Weather Units, and Products.

1-3. How To Use This Pamphlet:

a. First, glance through the entire pamphlet to observe the content and organization.

b. Next read the introductory sections of the chapters and individual sections. By this time you should have a good idea of the contents of the pamphlet.

c. Finally if you are interested in the weather of a particular country or region, read the sections dealing with those locations. Figure 2-1 will orient you.

d. The national boundaries, as well as the ''new'' names for the most recently created countries, quoted in this publication are current as of 1 April 1992.

Chapter 2

CLIMATIC CONTROLS

2-1. Introduction. The more obvious climatic differences between Europe and the United States include a higher frequency of low ceilings and visibilities north of the Alps, lower seasonal temperature extremes, less severe weather, and differences in the movement of synoptic systems. This chapter will discuss the factors affecting the weather of Europe. Figure 2-1 shows the present theater political boundaries and the geographic regions. In general, there are considered to be six climatic controls. They are described briefly here and in more detail in later sections:

a. **Latitude** - the factor determining both the annual range of solar elevation and day length. These two factors determine the location's incoming solar radiation (insolation).

b. **Elevation** - the height above sea level, and orientation to both insolation and moisture flux.

c. **Topography** - smoothness/roughness and shape of the terrain, as well as the soil type.

d. **Distribution of Land and Water** - proximity to water influences both temperature and humidity, depending on the air mass transport.

e. **Ocean Currents** - can cause deviations of temperature regime at a given latitude.

f. **Pressure Center Locations and Paths** - a prime determinant of a region's frequency of good or poor weather, also associated with the climatological wind direction and speed.

NOTE: Climatic elements, the directly measurable numbers that give information about an area's climatology include temperature, precipitation, humidity, pressure, and surface winds.

SECTION A - EFFECTS OF LATITUDE

2-2. Introduction. Latitude is the primary climatic control of both diurnal and annual temperature range for a given location. In general, average annual temperature decreases with increasing latitude. Figure 2-2 shows day length as a function of latitude and month.

2-3. Comparison of North American and European Latitudes:

a. The continental United States extend from 28°N to 49° N and occupy 60° of longitude. Conversely, the European continent extends from about 40°N to 70°N and occupies 55° of longitude. Figure 2-3 shows a European map (shaded) superimposed on a map of North America, for size and latitude comparison. Many European cities are located considerably farther north than stateside cities with comparable climates. Note that Paris lies on the same latitude as Vancouver, Frankfurt the same as Winnipeg, and Madrid the same as Philadelphia.

b. Though these European cities are farther north than many in North America, they enjoy a milder climate as defined by both mean temperature and mean temperature range. This is caused by several interrelated factors,

among them: the effects of warm ocean currents, the lack of a north-south terrain barrier and, Europe's location relative to semi-permanent synoptic features and storm tracks.

2-4. Northern Europe. Northern portions remain in darkness from late October through much of February, while in the summer there is continuous daylight from mid-April through August.

2-5. Central Europe. Winter is characterized by long nights and short days, with the reverse true in summer.

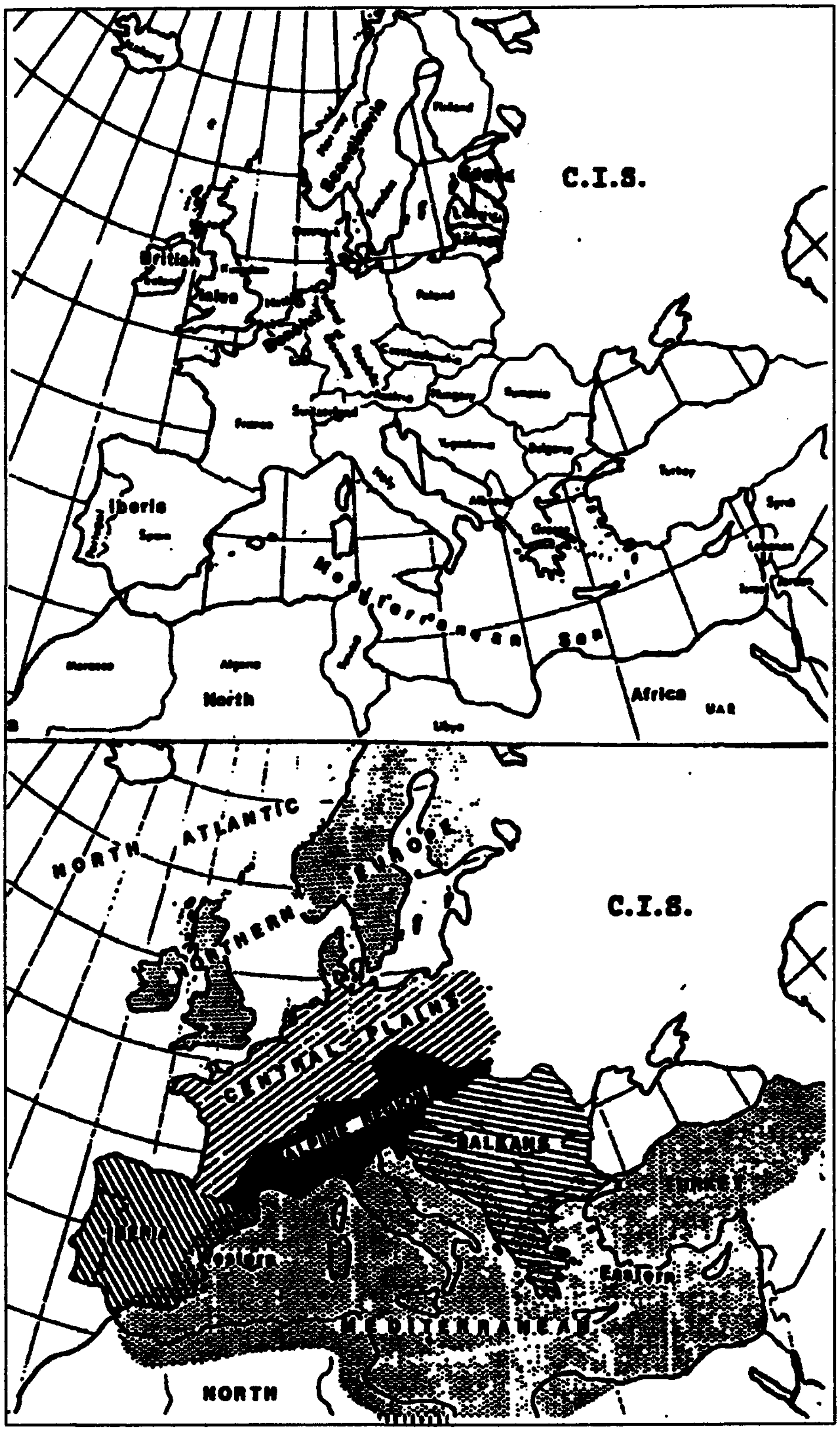


Figure 2-1. The European Theater: Countries (top) and Geographic Regions (bottom).

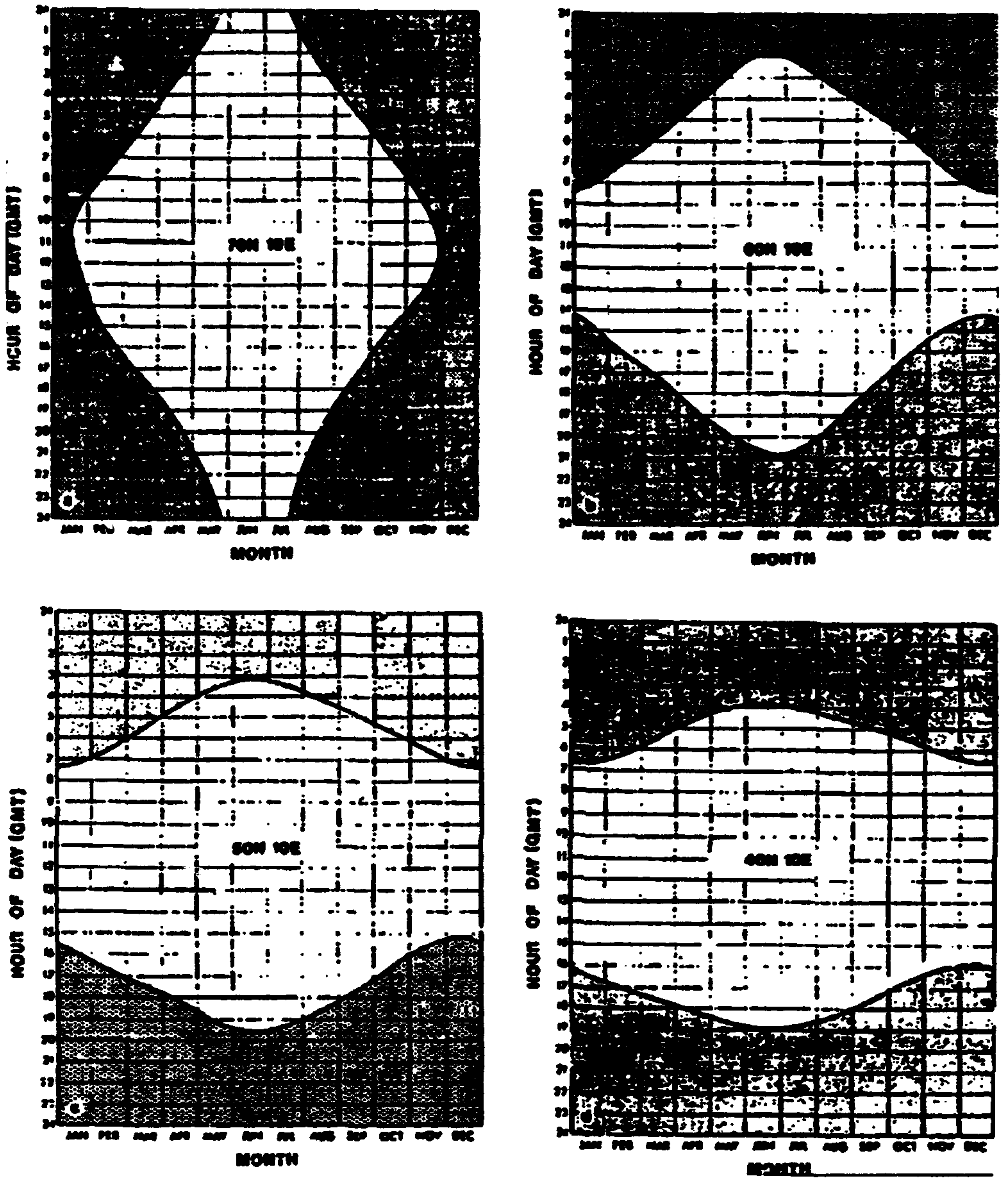


Figure 2-2. Sunrise-Sunset Curves for Latitudes 40° N to 70° N at 10° E. (Shaded Area Represents Night Hours.)

2-6. Southern Europe. Locations closer to the Equator experience less latitudinal climatic control.

2-7. The Commonwealth of Independent States (CIS). This confederation of states extends from 45° N to 80° N and many of the climatic elements, temperature in particular, have large ranges. During winter, the combination of short day length, low solar angle, and continentality contribute to make northern portions some of the coldest on Earth.

Figure 2-3. Latitudinal and Areal Comparison of North America and the European Theater.

SECTION B - EFFECTS OF ELEVATION AND TOPOGRAPHY

2-9. Introduction. In this section we will deal with the combined climatic effects caused by the various regions' elevations and topography. The primary difference between the topography of Europe and North America is the lack of a north-south oriented mountain range in Europe. Except in Scandinavia and Italy the major European ranges are oriented east-west (see figure 2-4).

2-10. Terrain Features:

a. The most significant mountain ranges in Europe are the Alps (Italy, Switzerland, Austria, Germany and France); the Pyrenees (France and Spain); the Kjølen Mountains (Scandinavia); the Apennines (Italy); the Carpathians (Czechoslovakia, CIS, Romania); the Taurus and Pontic Ranges (Turkey); the Caucasus (CIS); and the Atlas (Morocco, Algeria). Numerous smaller ranges exert more localized effects.

b. Lowlands occur mostly in coastal areas as well as in northern France, the Benelux, northern Germany, and much of the UK.

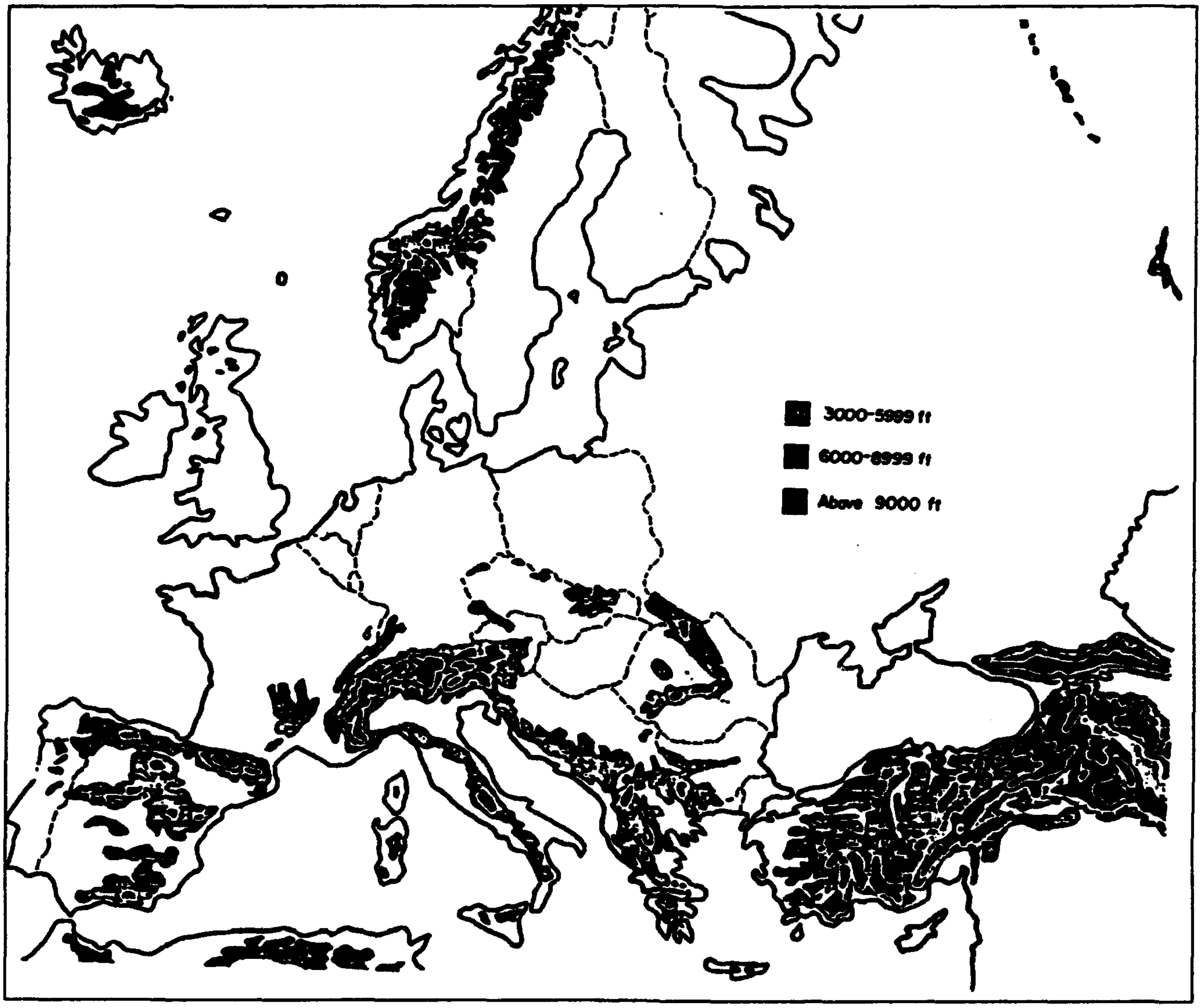


Figure 2-4. Major Terrain Features.

2-11. Effects of Topography:

a. The lack of a north-south mountain barrier allows warm Atlantic air masses to move unimpeded deep into the European continent. Conversely, there is little to block the westward transport of frigid Siberian air into northern Europe, during some winter flow regimes.

b. The mountains in Scandinavia do block the eastward movement of the Atlantic maritime Atlantic air masses, and likewise form a barrier to the westward movement of extremely cold Siberian air during winter.

c. The east-west oriented mountain ranges in southern Europe, of which the Alps are the most prominent, separate the warm southern region from the cooler northern region. In addition, they block the northward progress of storms that frequent the Mediterranean during winter. The following are more detailed descriptions of the terrain of the individual European regions and countries.

2-12. Scandinavian Peninsula:

a. The Kjølen range, covers most of Norway and much of Sweden. There is a pronounced contrast in the weather conditions on the western and eastern slopes. The mountains block or slow the movement of warm maritime air to the east. Enhanced precipitation occurs on the western slopes (Norway) and both average cloud cover and precipitation are lessened to the east (Sweden). The Kjølen also block the westward flow of cold air in winter. Winters in northern Sweden are much colder than in Norway.

b. Most of the Swedish terrain along the eastern edge of the Kjølen consists of low rolling hills. Though elevations are not great, the hills do provide sufficient lift to the southwesterly maritime air to generate higher precipitation amounts than in areas farther north.

c. Most of the southern Sweden is comprised of lowlands with elevations less than 300 ft (91 m), with several large lakes. The lakes provide a moisture source as well as a moderating influence on the local climate.

d. There are three distinct lowland areas in Norway: the extreme northeast; the central west coast; and the southeast tip. The northeastern area, above the arctic circle, experiences bitter cold winters. The central west coast has comparatively mild winters due to the proximity of the Atlantic Drift, and the blocking of Siberian outbreaks by the Kjølen. The southeastern lowlands get a combination of maritime influence from the North Atlantic, as well as an occasional continental (Siberian) influence.

e. The fjords have little influence on the general climate of Scandinavia, but can exert a marked influence on local weather.

2-13. Finland. The most significant topographic features influencing the climate of Finland are the previously described Kjølen mountains of Norway and Sweden. The mountains usually deflect most storms north or south of Finland. The storms that do get across the mountains are considerably weakened upon arrival. Finlandic terrain, mostly plains and low rolling hills, exerts little influence on climatology. The many lakes, streams and marshes moderate local-scale climate.

2-14. British Isles:

a. The terrain here, though less extreme than in many other European countries, does exert some affect on climate. Major features are the Northwest Highlands, Southern Uplands, and the Grampians (all in Scotland); the Pennine Chain (northern England); and the Cambrian Mountains (Wales). Both Ireland and Northern Ireland are dotted with small orographic features, generally less than 3000 ft (914 m) in elevation. While the terrain barriers are not great, they do stop a significant amount of cloud and precipitation on their windward sides.

b. Large plains such as the Eastern Plain in England, and the Central Plain in Ireland constitute a large percentage of the total area. Elevations are generally less than 600 ft (183 m).

c. Terrain variations over the approximately 5500 nearby small islands affect the local climates of those islands.

2-15. Denmark. Most of the land surface of Denmark is less than 300 ft (91 m) high, The topography has little influence on the moist Atlantic air transported across the peninsula.

2-16. Benelux. Topography of the Benelux countries (Belgium, the Netherlands, and Luxembourg) has a minor influence on the climate of the region. The Netherlands and northern half of Belgium are relatively flat, with elevations from below sea level to less than 650 ft (198 m). Southern Belgium, Luxembourg, and southwestern Netherlands consist of rolling hills and low mountains that affect the region's climate. Highest elevations in the Ardennes are 1900 ft (519 m) in Luxembourg and 2300 ft (701 m) in Belgium.

2-17. France:

a. The terrain of France consists of three homogeneous zones: the western lowlands, the interior highlands, and the Mediterranean coast.

(1) The western lowlands include the western coast as well as the plains of north-central France.

(2) The interior highlands, with elevations greater than 1000 ft (294 m) include the Cevennes, the Central Plateau (Massif Central), the Cote d'Or, the northern slopes of the Pyrenees, and the western slopes of the Alps. The Garonne-Carcassone Gap lies between the Pyrenees and the Massif Central, and the Rhone-Saone Gap lies between the Massif Central and the Alps. The latter acts as a channel for the often-fierce *mistral* winds.

(3) The Mediterranean Coast (also known as the Cote d'Azur) is a narrow low plain, bordering the Gulf of Lions.

b. Major French rivers include the Loire and its tributaries, flowing westward into the Bay of Biscay; the Seine, flowing into the English Channel; and the Rhone, which flows into the Gulf of Lions.

2-18. Germany:

a. The Alps exert large influence on several aspects of Germany's climate. This range of high mountains along Germany's southern border acts as an effective (though not insurmountable) barrier to southerly air flow from the Mediterranean. Along the northern slopes, moist air from the Atlantic is forced to rise. This results in mostly cloudy conditions, rain showers, thunderstorms, and in the winter, significant snowfall.

b. There are several ranges of low, rolling mountains, interspersed with broad river valleys in central Germany. This terrain, although only a few hundred meters high, generates clouds and precipitation in upslope flow. Some of the more prominent of these ranges are the Harz, Taunus, Eifel, Erzgebirge, Hunsrück, Schwarzwald, Jura, and Westerwald. The North German Plain is relatively flat with elevations generally less than 340 ft (103 m).

c. Major rivers in Germany include the Rhein, Main, Weser, Mosel, and Elbe. Fog often shrouds the adjacent valleys during the winter months.

2-19. Poland. Most of the country consists of low rolling plains with elevations generally less than 700 ft (213 m). Elevations in the Carpathian and Sudeten Mountains to the south are mostly less than 4000 ft (1217 m) with isolated peaks to 5000 ft (1521 m). While the plains influence climate little, the southern mountains deflect impinging storm systems. The mountains' interruption of north-south airflow is an important influence on the climate of southern Poland.

2-20. Czechoslovakia. Surrounded by the Carpathians (northeast), Erzgebirge (northwest), and Bohemian Forest (southwest), the mountains exert strongest influence in winter when moist air stagnates in the interior basin. Fog and stratus are slow to clear because the mountains block passage of cold Siberian air masses.

2-21. Austria and Switzerland:

a. The Alps make up about three-fourths of the land mass of these two countries and are the strongest regional climatic control. Alpine valleys are interspersed with the lofty mountains making for quite a variety of weather.

b. The non-Alpine portions of these two countries occur only in northwestern Switzerland, and northern and eastern Austria. The Swiss lowlands are generally temperate and humid while those of Austria have a more continental climate.

c. The Alps block the general flow and deform the weather boundaries that move that far inland. The barrier effect of the Alps can also generate heavy snowfall in southeastern Austria when moisture rich Mediterranean systems move in from the southeast.

2-22. Hungary. Hungary lies in a basin formed by the Carapthians to the north and east, Transylvanian Alps and Apuseni Mountains, southeast, the Alps to the west, and Dinaric Alps to the southwest. Since many of these ranges are higher than 6000 ft (1829 m), much of the moisture carried from practically any direction is blocked. Surrounding mountains also help deflect movement of shallow Siberian air in winter.

2-23. Yugoslavia. (Borders are fluid at present. We will describe the country as a single entity.) About 80 percent of Yugoslavia consists of rugged highlands. Paralleling the Adriatic coast, the highest range is the Dinaric Alps. Northeast of the mountains are plains and rolling hills with elevations generally less than 1300 ft (396 m). The mountains block the advection of the moist Mediterranean air. In winter, other ranges to the north and east, keep most of the cold Siberian air beyond Yugoslavia's northern border.

2-24. Romania and Bulgaria:

a. In Romania the Carpathians join the Transylvanian Alps to form a great crescent from the nor border, clockwise to the western border with Yugoslavia. Between this arc and the smaller Apuseni Mountains lies the elevated plateau and hill country of the upland Transylvanian Basin. The Great Hungarian Plain lies northwest of the crescent. To the southeast, the Walachian Plains slope down through the Danube Valley to the Black Sea.

b. In Bulgaria, the Balkan Mountains stretch from the Black Sea westward to just inside the Yugoslav border. The Rhodope Mountain chain extends from near Sofia (Sofyia) southeastward along the southern Bulgarian border.

c. As with Yugoslavia, mountains protect most of the region, (except Donau Valley) from the Siberian outbreaks. Blocked by the mountains farther west, little Mediterranean moisture travels this far inland.

2-25. Iberia:

a. The primary topographic feature of the Iberian Peninsula is the Pyrenees Mountain chain. Some peaks are over 11000 ft (3343 m) in elevation. Lesser ranges include the Cordillera Cantabrica along the north coast, the Cordillera Penibetica and Sierra Nevada along southeast coast, and Sierra de Guadarrama in the central highlands, near Madrid.

b. Lowlands and plains are near Spanish coasts, near river valleys, and over much of western Portugal.

c. Though maritime air often flows toward the Spanish mainland, the windward slopes of the mountains receive most of the precipitation, causing the interior to be quite dry. The northern mountains also affect temperature, since they block migration of colder air masses moving westward from Eurasia.

2-26. Italy:

a. The Apennines extend over the entire length of the Italian Peninsula. They and the Alps to the north, are the major topographic features. In winter, the Alps protect Italy from cold air outbreaks and storms from the north (and in all but southerly mid-level flow, create a rain shadow on the south side.) Likewise, the Apennines protect the west coast from colder air to the northeast, making the Tyrrhenian coast warmer than the Adriatic coast at the same latitude.

b. The Alps contribute to lee-side cyclogenesis in the Ligurian Sea, while the Apennines have the same effect in the Adriatic. With northeasterly flow, cyclogenesis will often occur to the west of the Italian Peninsula (the "Genoa Low" that occurs when cold air enters the Mediterranean via the Rhone Valley).

c. The climate variations of the Po River valley (between the Alps and the Apennines), is the most extreme in the country. Po winters are cold cloudy and (persistently) foggy, while spring and summer are warm with frequent rain showers. Significant thunderstorms can occur in the Po Valley when cold mid-level Alpine air overflows the warm, moist, near-surface air, suddenly destabilizing the atmosphere.

2-27. Greece:

a. Greece occupies the southernmost portion of the Balkan Peninsula and hundreds of islands of varying sizes. Most of the terrain is hilly or mountainous, with the mountains extending into the sea as peninsulas or chains of islands. Much of the terrain is over 3000 ft (914 m) with some peaks taller than 6000 ft (1825 m). The lowlands are confined to the coastal plains and confined interior plains. The combined area of all the plains makes up less than 5% of the country.

b. The rugged mountains and plateaus of north and northeast Greece act as a barrier to the cold air from central Eurasia.

c. Greece's major ranges include the Pindus Mountains, paralleling the Adriatic; the Taiyetos Oros and the Parnon Range on the large island of Peloponnesos; and the Rhodope Mountains in the north. There are no major river systems in Greece that affect other than local climate. The valleys surrounding these small rivers can channel and accelerate local winds. In winter, cold air arrives via the Dardanelles Strait, causing, at times, significant snowfall in the Peloponnesos.

2-28. Turkey:

a. The topography of Turkey varies from the lowlands of the narrow coastal plain to tall mountains, several in taller than 11500 ft (3500 m). The country is interspersed with lakes and is cut in the north by the Dardanelles Strait between the Black Sea and Mediterranean Sea.

b. Major mountain ranges are the Taurus in the south, the Pontic Range in the north, and the Aegean mountains along the west coast. The Taurus and Aegean Mountains limit the incursion of Mediterranean air to the southern and western coasts. The Caucasus and Pontic chains block cold outbreaks from the CIS.

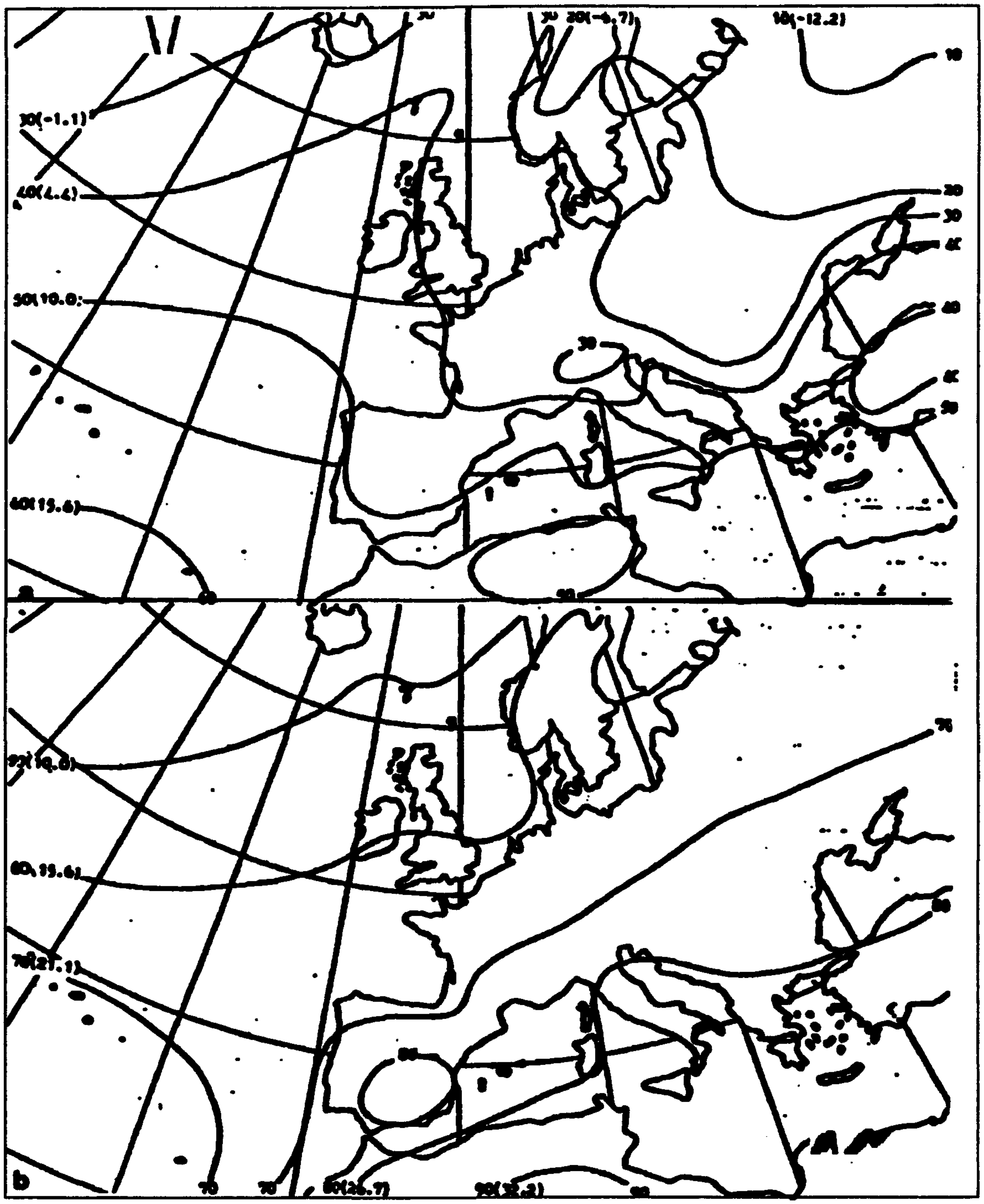
c. Much of the area between the coastal ranges is made up of a high flat-lands known as the Anatolian Plateau. The central plateau is a region of large diurnal temperature variation due to its elevation.

2-29. North Africa. The topography of Morocco, Algeria, Tunisia, and Libya varies from low coastal plain, to low-lying desert, to mountains over 12000 ft (3658 m). The major terrain feature is the Atlas Chain where elevations average between 5000 and 10000 ft (1524-3048 m).

2-30. CIS. The "European" portion, which we will concentrate on, consists of the land west of the Urals to the Caspian Sea. It consists of low rolling steppe, forested plain, extensive marshes and tundra. As alluded to several times before the main topographic forcing is the enormous size of the landmass. It is responsible for the continentality of the air masses originating here.

SECTION C - EFFECTS OF OCEAN CURRENTS

2-31. Introduction. In this section we will deal with both European land/water distribution, as well as the warming provided by the North Atlantic Drift. The moderate climate experienced by most European countries is due, in large part, to the warm ocean currents flowing into the area. Figure 2-5 shows the mean surface air temperatures, while figure 2-6 shows sea surface temperatures. The North Atlantic Drift may be thought of as an extension of the Gulf Stream. Once it reaches Europe, it is divided by the continental configuration into several smaller currents, which further circulate the warm water. The current flow in the smaller seas (Mediterranean, Adriatic, Baltic and Black) is mostly driven by regional climatological wind systems. Figure 2-7 shows the major ocean currents near the European continent.



2-5. **Mean Sea Level Air Temperatures in Degrees F (C) During: January (top); July (bottom).**

2-32. **Scandinavian Peninsula.** The mean ocean temperature off the west coast of Scandinavia is about 9° F (5 C) warmer than average for this latitude. This feature is most significant along western coasts during winter (though it is felt even in Northern Norway where ports usually remain open year-round). The warmth diminishes rapidly away from the coast because of the Kjølen mountains.

2-33. Finland. To the west and south, the Gulf of Bothnia, Baltic Sea and Gulf of Finland all add moisture to the atmosphere, and to some extent moderate the climate. The influence is less during winter, however, when the portions of the Gulf of Bothnia, as well as the Barents Sea to the North, freeze.

2-34. British Isles. The islands in the direct path of the North Atlantic Drift, feel the greatest influence. Temperatures along the western coasts are seldom below freezing in winter, nor above 70° F (21 C) in summer. These numbers gain significance when one considers the southernmost of the Isles is farther north than the northernmost of the continental United States.

2-35 . Denmark. The warm waters of the North Atlantic Drift are responsible for the moderate, damp winters and cool summers over the peninsula. The cooler waters entering the Skagerrat and Kattegat, from the Baltic make average winter temperatures slightly cooler over the eastern part of the peninsula.

2-36. Benelux. Oceanic proximity gives mild winters and cool summers with extensive cloudiness and precipitation.

2-37. France. In the west, wintertime temperatures are about 20° F (11 C) warmer than normal for this latitude. Winters are mild, cloudy and damp, and summers are cool. Along the Mediterranean coast, flow is usually from land to sea. That, coupled with the predominant subsidence, and lack of land/sea temperature contrast decreases the cloudiness of Atlantic air masses..

2-38. Germany. The North Sea and the Baltic are the primary oceanic influences. The predominant wind flow is westerly year-round and the air's high moisture content produces extensive cloudiness and precipitation. Winters are warmer than expected from the latitude and summers are cool. The lack of significant terrain allows oceanic effects to penetrate far inland.

2-39. Poland. Though far from the Atlantic, the lack of intervening terrain features allows the (lessened) effect to be felt even here. The Baltic Sea influences Poland's climate but little. Effects are most pronounced along the northern coast, decreasing rapidly inland because of the predominant (westerly) flow pattern. The climate is more continental in southeastern Poland.

2-40. Czechoslovakia. Though landlocked, Czechoslovakia still feels some influence from the waters to the north and south. During winter, westerly flow from the Atlantic, generates cloudiness and precipitation, concentrated on the windward slopes of the mountains. In summer, the precipitation is more often convective, especially in the southern part of the country.

2-41. Austria and Switzerland. The mountains of these two landlocked countries provide the first topographic barrier to the maritime air from the North Atlantic. This causes extensive cloudiness and significant precipitation amounts on the windward portions of the Alps.

2-42. Hungary. Landlocked and surrounded on all sides by mountains, the maritime influence causes, at times, persistent winter fog and stratus.

2-43. Yugoslavia. The influence of the Adriatic Sea is felt only along the coastal lowlands. The mountains, only a short distance inland, stop the maritime influence from proceeding further inland.

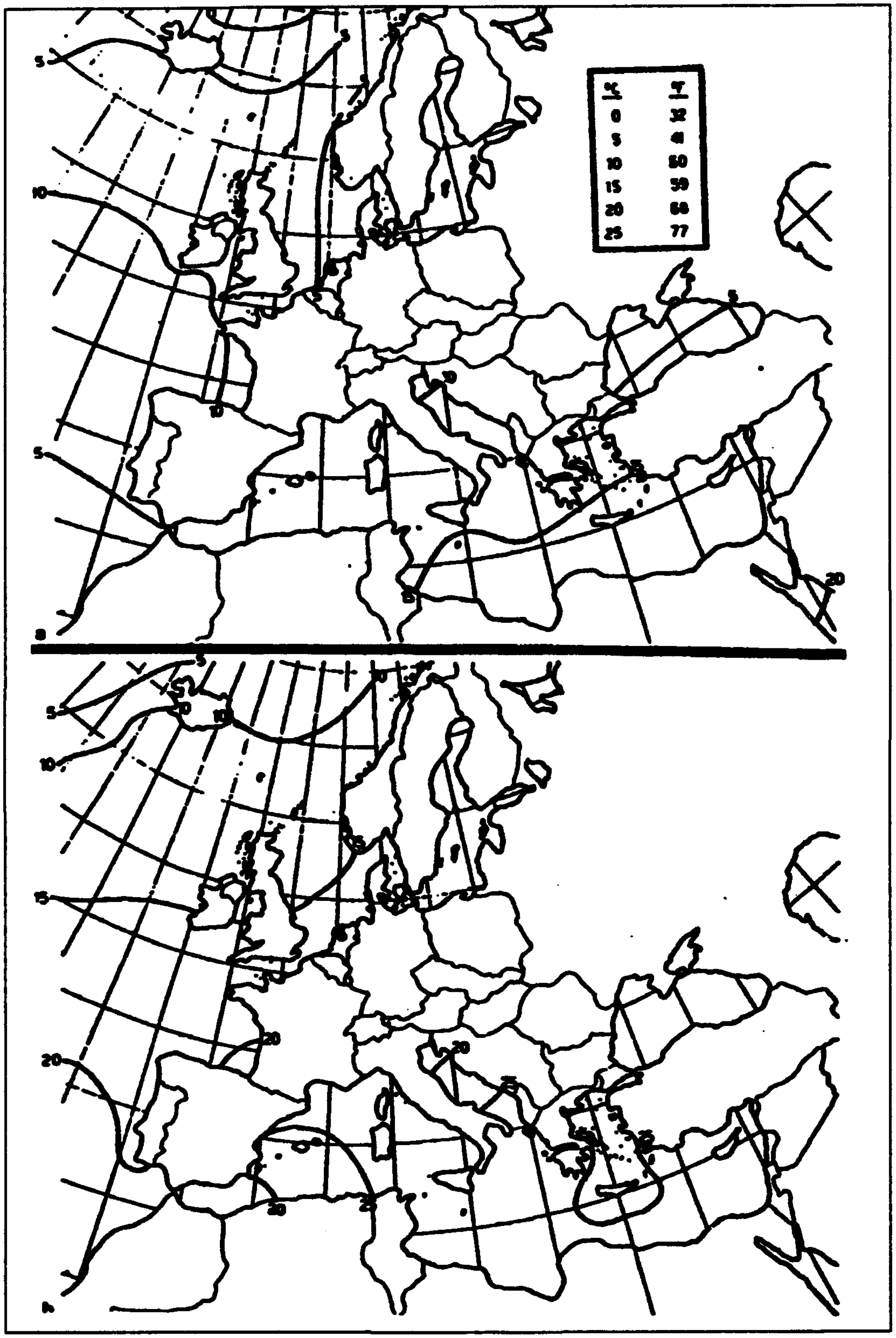


Figure 2-6. Mean Sea Surface Temperatures in Degrees C During: February (Top); and August (Bottom).

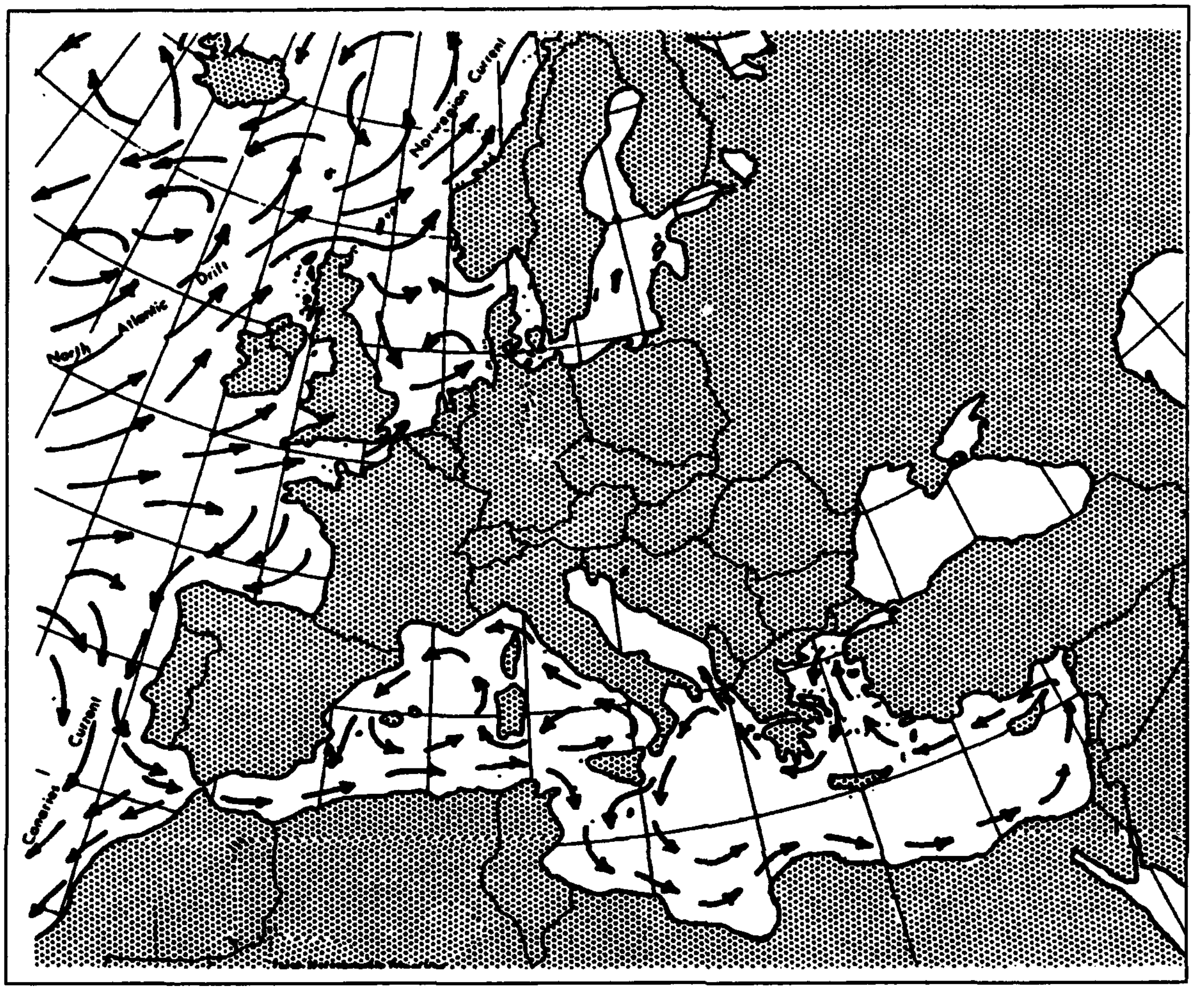


Figure 2-7. Ocean Currents Affecting Europe.

2-44. Romania and Bulgaria. Though close to the Black Sea to the east, and the Mediterranean to the south, these two countries have, for the most part, a continental climate. The predominate wind regime lessens the effect of the Black Sea (except within 40 km of the coast), while the Balkans shut of the flow from the Mediterranean.

2-45. Iberia:

a. In Spain, oceanic influence is mostly limited to the narrow coastal areas where seasonal and diurnal variations are small compared to those inland.

b. Portugal, with a broader coastal lowland area, has cool summers and warm winters. Relative humidities are high here and clouds and precipitation are enhanced on windward slopes.

2-46. Italy. The Mediterranean may be regarded as being divided in two by the Italian Peninsula, with the Aegean and Adriatic Seas forming the northern extent of the eastern basin. Note in figure 2-7 that both the Adriatic and Tyrrhenian gyres (as well as the Balearic to the west) are cyclonic. This is a function of local wind systems as well as land-water orientation.

a. Moisture supplied by the Mediterranean, Adriatic, and Ligurian Seas generate significant cloudiness and precipitation amounts along the windward slopes of the Italian Alps, and Apennines.

b. The Po Valley has frequent dense fog and low cloud when the fetch is off the Adriatic.

c. The southern portion of the peninsula has a temperate climate, much influenced by the warm waters of the Mediterranean.

2-47. Turkey. Although bordered on three sides by water, maritime influence on Turkey is limited. The steep rise of the mountains a short distance inland creates enough adiabatic lift that most of the moisture is deposited on the windward slopes of the coast before passing far inland.

2-48. North Africa. The effects of the Mediterranean Sea and Atlantic Ocean have varying effects on this region's climate, limited by both the arrangement of terrain as well as the climatological fetch of the winds aloft.

a. In Morocco, the major maritime influence occurs in the fall when moist air masses cause overcast skies and precipitation. Most of this moist air is deposited on the windward slopes of the Atlas, and Rif Ranges. Along the Atlantic Coast, winds tend to parallel the coast, limiting the maritime influence to a narrow coastal band.

b. Over the remainder of the region the Mediterranean Sea exerts a significant influence. In fall and winter, the maritime air is able to move inland, moderating the seasonal cooling. In spring and summer, the moist air causes clouds and precipitation on the windward slopes of the hills and mountains.

2-49. Commonwealth of Independent States:

a. As stated previously, the lack of significant north-south terrain features in Europe, allows the influence (though lessened) of the North Atlantic Drift to be felt all the way to the Urals. During summer, sufficient moisture is available for frequent rain shower and thunderstorm activity. The Black and Caspian Seas exert a lesser influence because prevailing winds are offshore and these seas experience significant annual temperature variations.

b. To the north, The Murman Coast Current influences the climate of both the Kola Peninsula and western Arctic Islands. Though it could hardly be described as "warm," it does keep sea lanes open for most of the year (at least to the west of the port of Murmansk- a major factor in the logistic resupply of Russian forces by the Allies during the Second World War).

CHAPTER 2 REVIEW QUESTIONS

1. What are climate controls?

2. What is the major effect of latitude?

3. Which part of the European theater is most affected by latitude controls: the north, the central or the south? Why?

4. Why is the climate of Frankfurt milder than that of Winnipeg Manitoba, even they are on the same latitude?

5. What is the major difference in topography between North America and the European continent?

6. What is the most important topographic feature in the European theater. Why?

7. What is the most obvious effect of warm ocean currents on northern Europe?

Chapter 3

CLIMATOLOGY

3-1. Introduction. As stated earlier, Europe as a whole, experiences a mild climate considering its latitudinal location. Extremes in weather variability are confined to northeastern portions of Scandinavia, the central part of the Commonwealth of Independent States (CIS), and desert North Africa. (We mention North Africa because it is in the EUCOM Area of Operations, not because of climate similarities to Europe.) The primary reasons for the mildness of European weather are the proximity to the North Atlantic Drift and the absence of a blocking north-south oriented terrain feature. The Ural Chain does block the Commonwealth States to their east. This region is snow covered for much of the winter and extremely cold air masses predominate. The orientation of average isotherms in winter here is north-south. (An historical aside: This winter north-south isotherm orientation was apparently ignored by German war-planners during the Second World War. In 1941 the German offensive against the Soviet Union bogged down due to the winter weather. In 1942, the Germans tried again, attacking about 300 km further south. But this attack failed too, since the German Army was "crossing the same isotherms" they had the previous year.)

a. A continental climate is one "*characterized by the interior of a land mass of continental size. It is marked by large annual, daily and day-to-day ranges of temperature, low relative humidity, and (generally) by a moderate or small and irregular rainfall" (Huschke, 1959). Continentality is usually measured by the diurnal, or annual difference between high and low temperature, a function of the air's moisture content.

b. Conversely, a maritime climate is one in which the air mass characteristics *"are developed over an extensive water surface. There are small diurnal and annual ranges of temperature." (Huschke, 1959).

c. The most abrupt change in climate occurs across the Alps in southern Europe, where the Mediterranean air is separated from that to the north.

d. The seasons referred to in this section are as follows:

(1) Winter: December, January, February
(2) Spring: March, April, May
(3) Summer: June, July, August
(4) Fall: September, October, November

e. The reader is cautioned on the use and interpretation of charts in this section and in the rest of the pamphlet. These are mean charts, and show only mean values. To use climatological values realistically, one must know both the mean as well as the distribution about the mean. A further caveat: the data used in preparation of these charts comes from several sources. Observational criteria as well as period of record are not necessarily consistent.

SECTION A - GENERAL CLIMATOLOGY

3-2. Mean Annual Precipitation. Figure 3-1 depicts the mean annual distribution of precipitation over the European theater (and also reflects topographic influence on precipitation). Keep in mind the predominant upper-air flow over the region is westerly. Note the precipitation maximum along the east coast of the Adriatic, as well as the 80 inch maximum at the eastern end of the Black Sea. The upslope effect caused by

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*Huschke, R.E., 1959: The Glossary of Meteorology. Amer. Meteor. Soc., 638 pp.

the northern slopes of the Pontic Mountains in Turkey is also apparent. The continentality of the central part of the CIS is shown by the eastward decrease in precipitation amounts. The Kjølen mountains of Scandinavia generate 40+ inches of precipitation on their windward side, and a rain shadow alee.

3-3. Mean Number of Days With Snow. Figure 3-2 reflects the several climatic controls responsible for snowfall in the region. The most obvious, as above, are the climatological upper-level winds, together with the arrangement of terrain barriers. Latitudinal effects are perhaps the second most important. In the absence of terrain forcing, snow isopleths are oriented generally east-west (especially in the more continental climate regions). The zonal orientation of snow-day isopleths is somewhat reduced in western portions of Europe, because the warmth of the air masses originating over the North Atlantic Drift is too high to generate a significant number of snow-days.

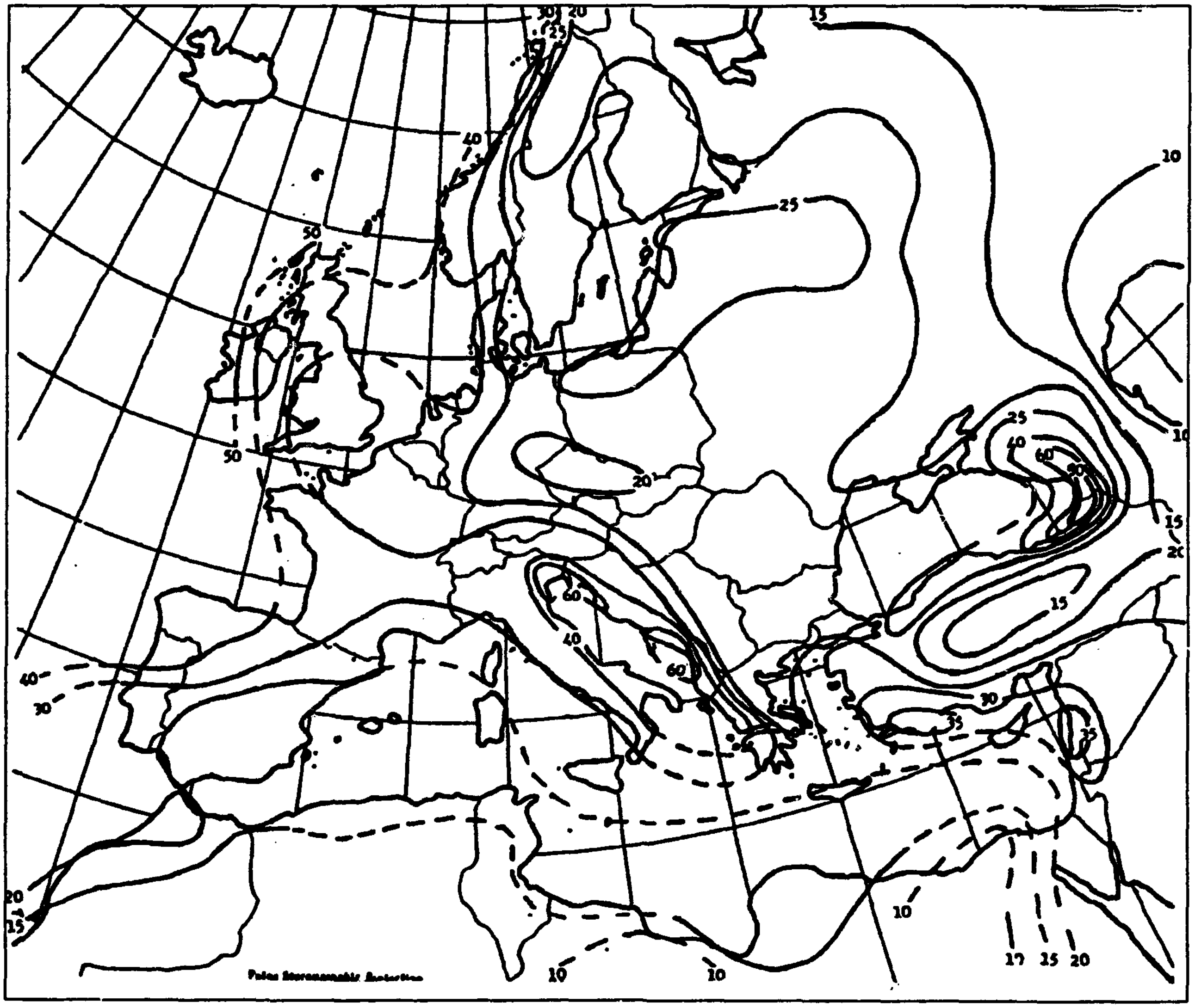


Figure 3-1. Mean Annual Precipitation Over the European Theater.

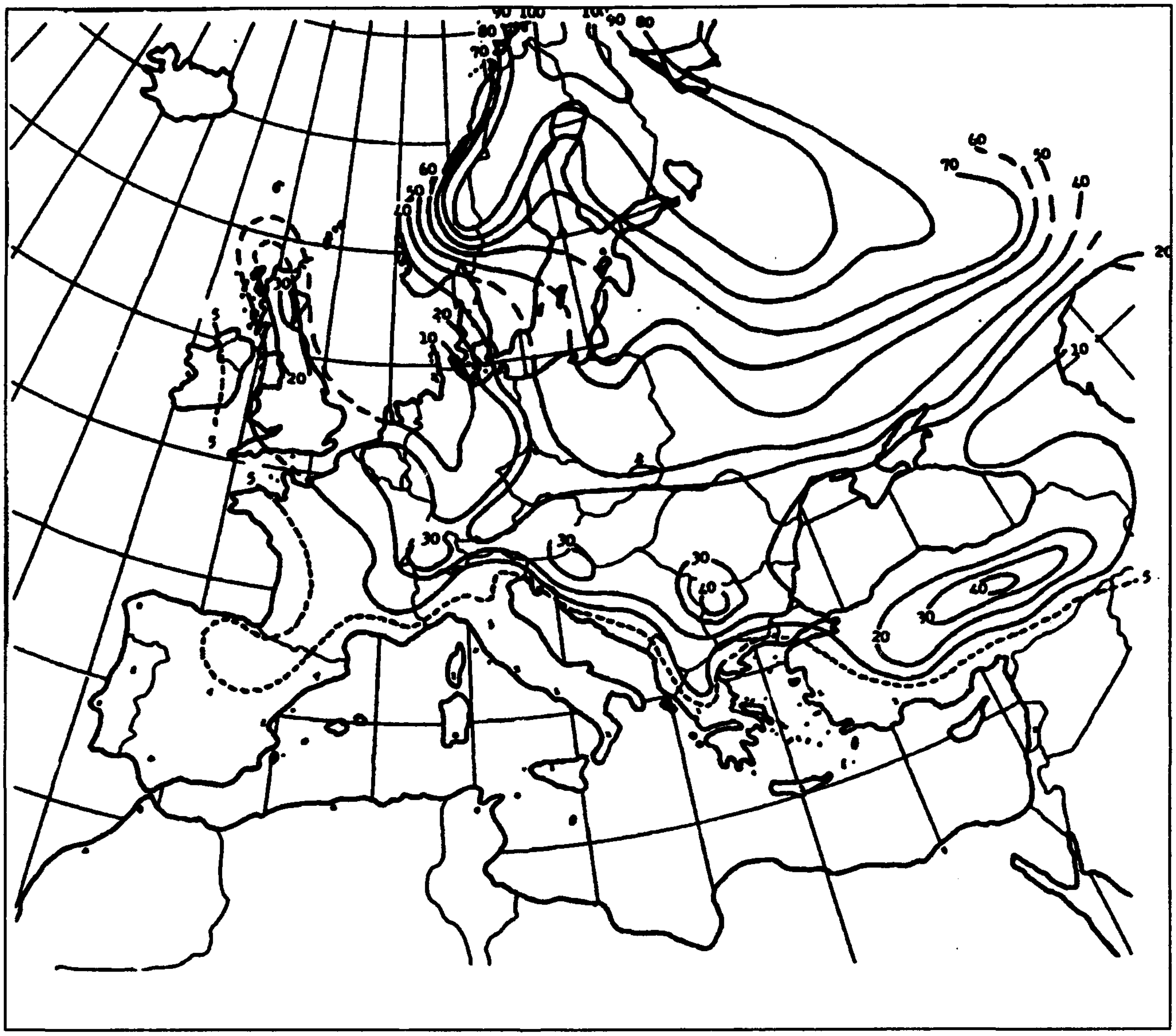


Figure 3-2. Mean Annual Number of Days With Snow Over the European Theater.

3-4. Mean January Maximum and Minimum Temperatures:

a. Mean maximum temperatures reflect the continental or maritime influence over the region (figure 3-3). Note the northward bulge of isotherms over the Atlantic and North Sea, reflecting the influence of the North Atlantic Drift. Conversely, the equatorward bulge of isotherms over eastern Europe and the CIS, shows the continentality of this region. The coolness of higher elevations can be seen over Spain, the Alps, and Turkey. Note the weak gradient of isotherms over the Mediterranean.

b. The mean minimum temperature distribution (figure 3-4) has a similar orientation to that of the maximum temperature, that is, north-south over western Europe, and east-west over the central and eastern CIS, where the maritime influence is lessened. Regions with higher terrain also show a similar isotherm orientation to that of the maximum temperature distribution.

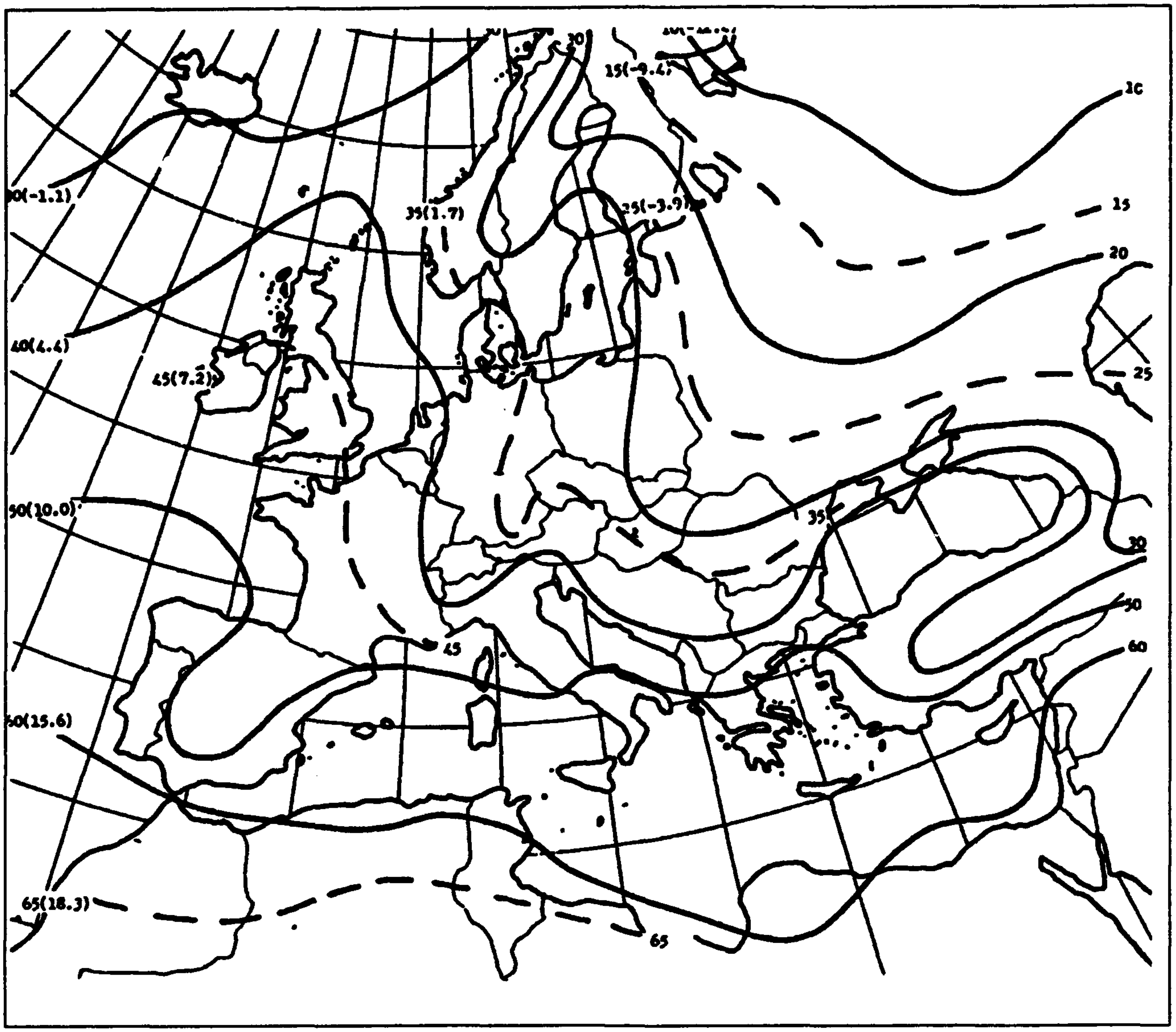


Figure 3-3. Mean January Maximum Temperature in °F (C).

3-5. Mean July Maximum and Minimum Temperatures. The average isotherms are more zonally-oriented during summer when land-water temperature difference is reduced, and incoming solar radiation (insolation) generates more surface heating.

a. Of particular note in figure 3-5 is the warm bulge over southern Sweden, and the high temperatures of central Spain and eastern Turkey.

b. The mean minimum summer temperatures (figure 3-6) show a maritime influence over central and western Europe, but show larger diurnal fluctuations over the highlands of Spain, Turkey and North Africa.

3-6. Mean January and July Wind Roses. Figures 3-7 and 3-8 show the winter and summer distributions of surface wind at specific locations.

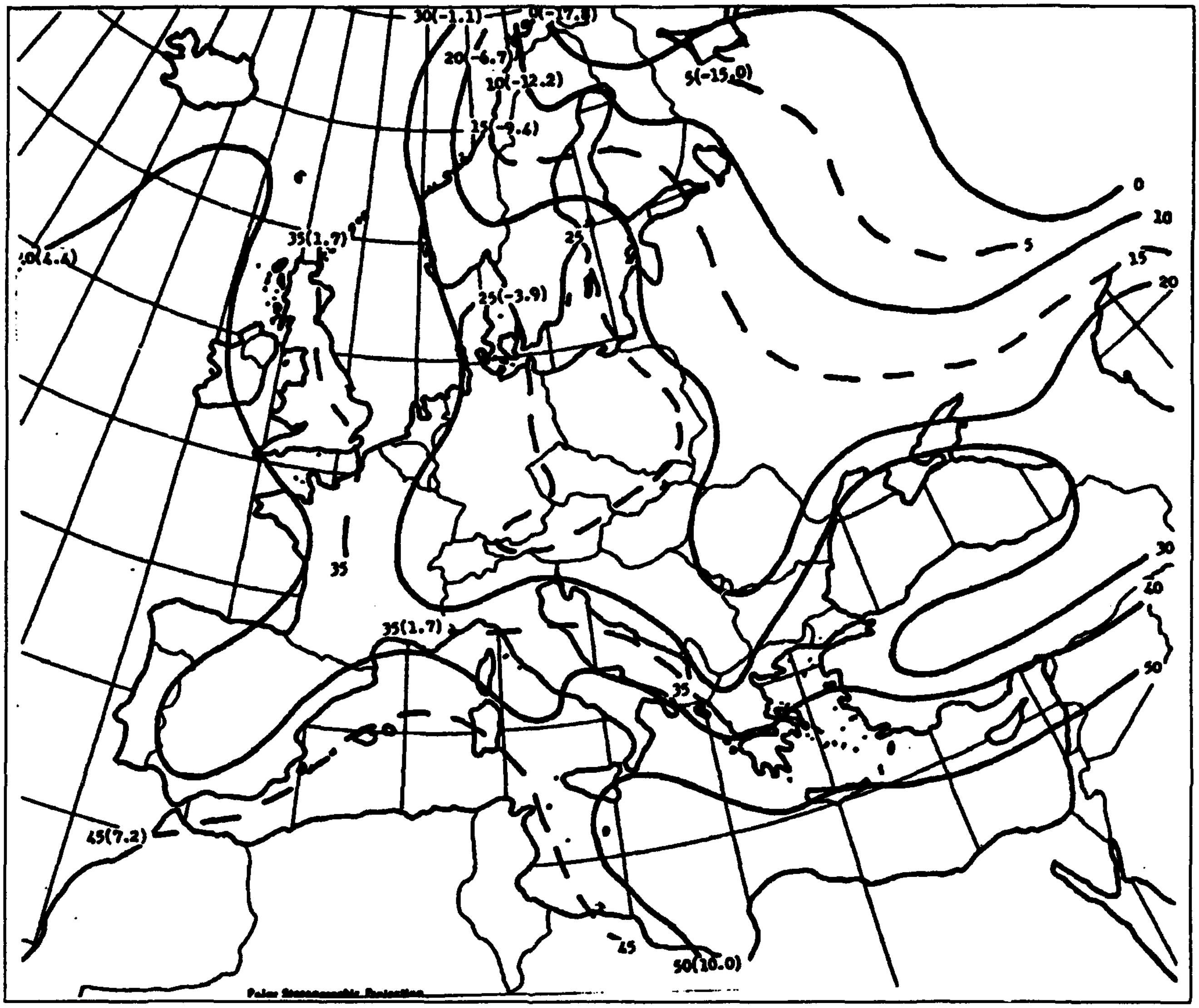


Figure 3-4. Mean January Minimum Temperature in °F (C).

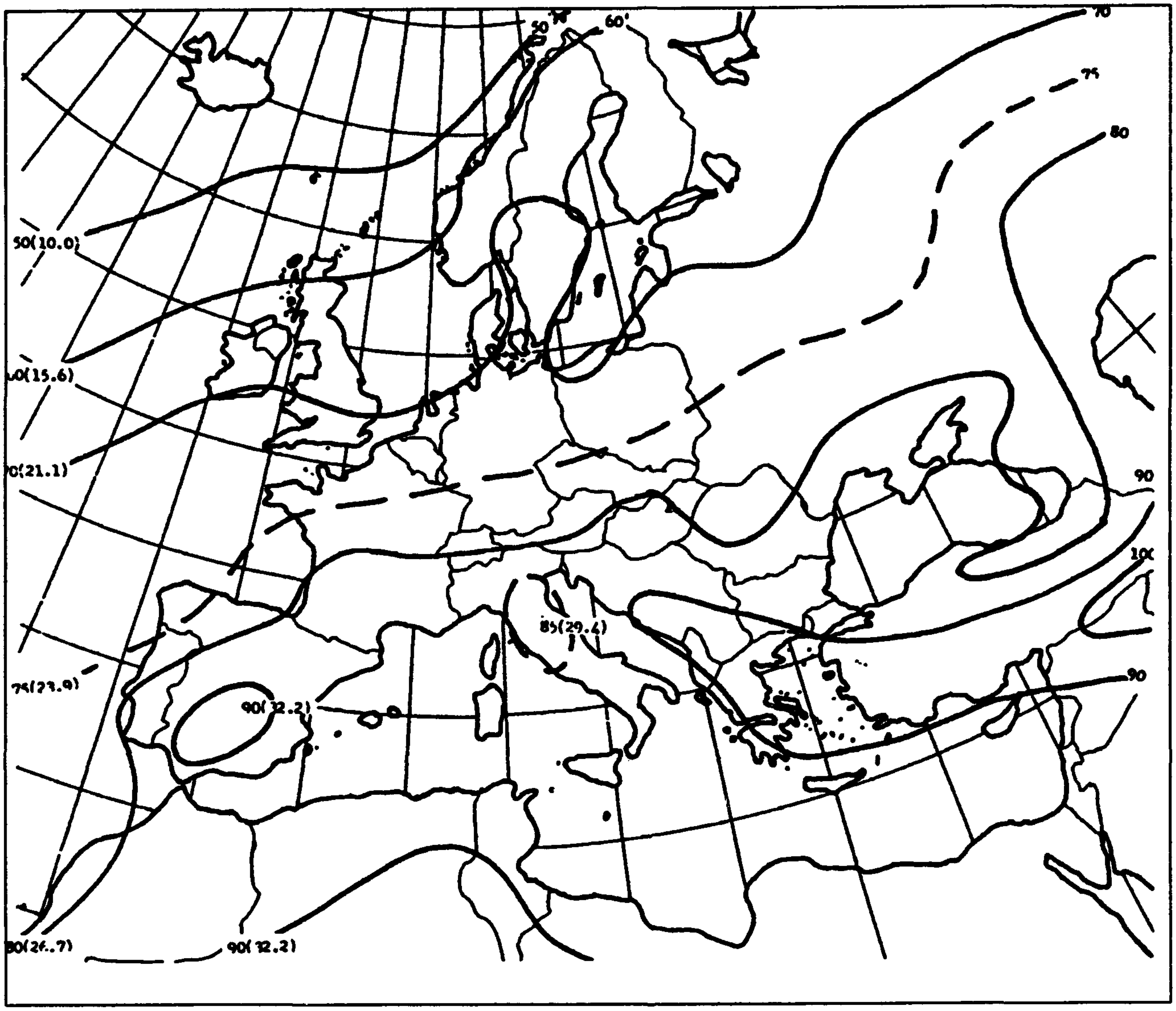


Figure 3-5. Mean July Maximum Temperature in °F (C).

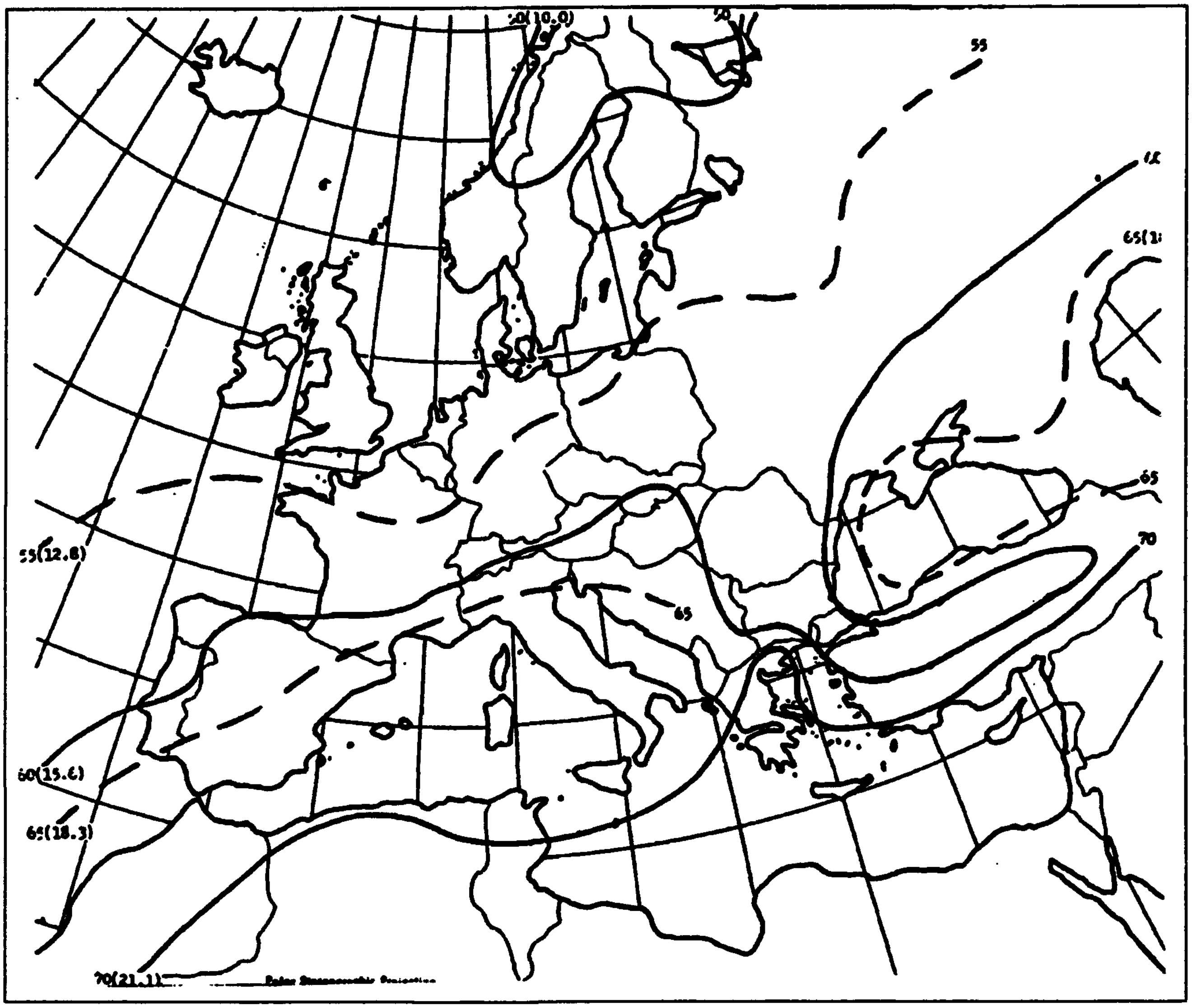


Figure 3-6. Mean July Minimum Temperature in °F (C).

Figure 3-7. Mean January Wind Roses for Selected Locations. Circles are at increments of 10% of observations. Number beneath the wind rose is % calm.

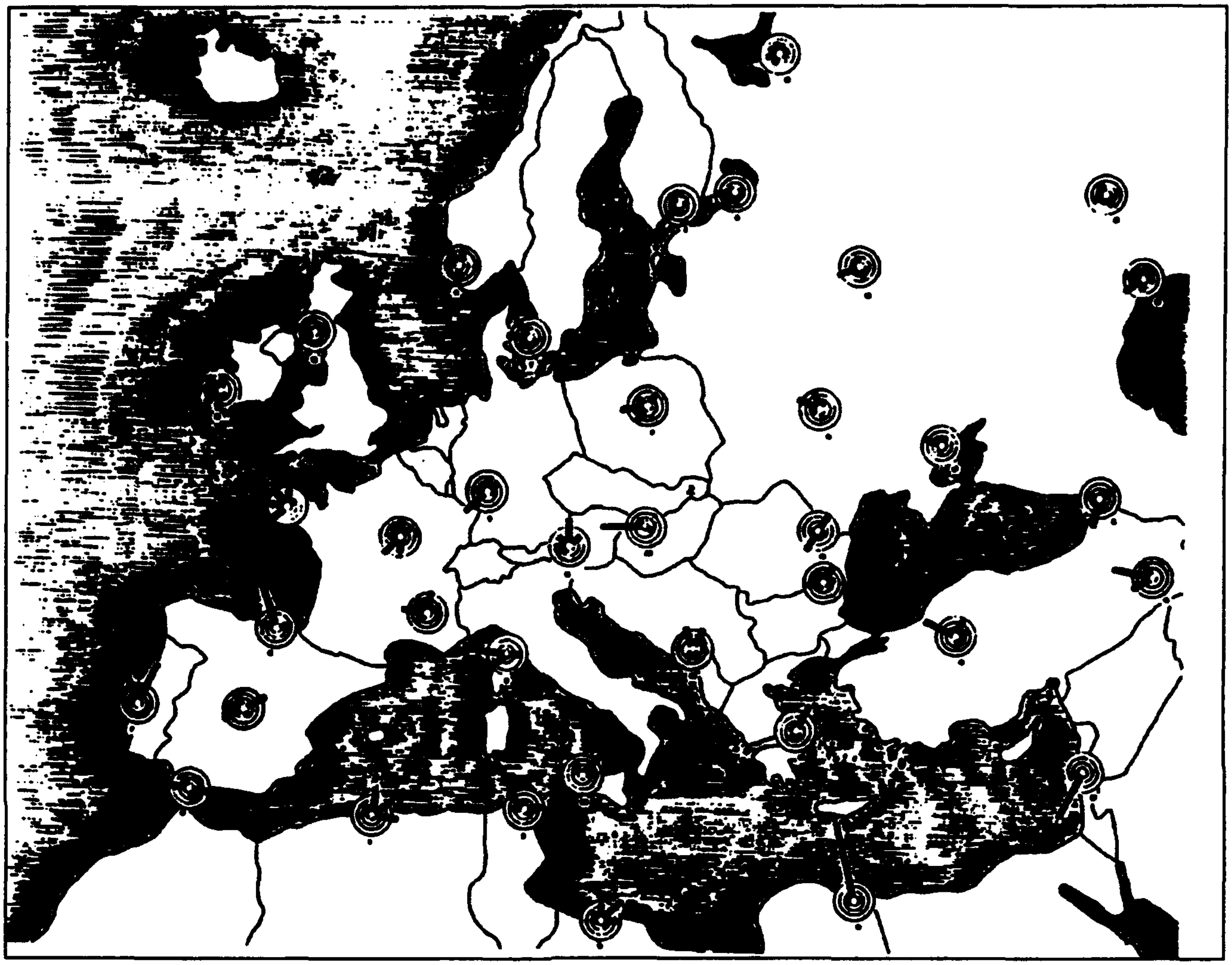


Figure 3-8. Mean July Wind Roses for Selected Locations. Circles are at increments of 10% of observations. Number beneath the wind rose is % calm.

SECTION B - REGIONAL CLIMATOLOGY AND GENERAL CIRCULATION

3-7. Introduction. The European theater has some climatological features in common, but has several regional differences. Regions with similar weather characteristics include the following:

a. Northern Europe.
b. Central Plains.
c. Alpine Region.
d. Balkans.
e. Western Mediterranean and Iberia.
f. Eastern Mediterranean and Turkey.
g. Commonwealth of Independent States (CIS).
h. North Africa.

Figure 3-9 shows mean surface pressure patterns and circulations for the four seasons (also refer to figure 2-1). Figure 3-10 shows the mean winter, and summer positions of the semi-permanent synoptic pressure centers that affect the European climate. The most distinguishing feature common to figures 3-9 and 3-10 is the Icelandic Low and its associated pressure trough.
NOTE: This does not mean there is always a low in this locale. There are, however, enough low pressure systems occurring here that the composite (especially in winter) picture is one of a low. Comparison of figure 3-10 (top) and (bottom) show that in winter, the Icelandic Low and Siberian High strengthen, while the Azores High weakens. Conversely, in summer, with the full day irradiation of the Polar Cap, the north-south temperature gradient weakens, as does the Icelandic Low. During summer, the Azores High strengthens, the Siberian High "goes away," and the low over Pakistan strengthens. Figure 3-11 is the locator chart to be used with climatological tables 3-1 through 3-8.

3-8. Northern Europe. The winter location of the Icelandic Low is associated with the predominant west-southwesterly flow over northern Europe. The Icelandic low weakens during spring and especially summer, with a corresponding decrease in winds over northern Europe. See table 3-1 for representative climatology.

3-9. Central Plains. The climate here is predominantly maritime, with occasional winter outbreaks of continental air from the central Asia. Winter is cloudy and frequently stormy with relatively mild temperatures. During winter, the cold Siberian High gains enough strength at times to spread over Germany. Most winter precipitation is caused by the migrating storms that cross over, or just north of the region. Genoa lows, tracking eastward advect enough mid-level cold air across the Alps, over the comparatively warm low level air in the plains. The resulting destabilization can generate persistent stratiform rain events. If the winter storm track is oriented over Scandinavia, lack of insolation allows the Central Plains to radiationally cool. If enough cooling takes place, the first storms that do pass over can generate freezing precipitation. Spring is cloudy with frequent showers over the entire area. Summer weather is somewhat less cloudy, and cool. Precipitation occurs in all seasons but amounts are highest during summer. Then, moisture content of the warmer air is greater, and insolation is a maximum. The summer intensification of the Azores High creates a block to most transient storms over the region (see table 3-2).

3-10. Alpine Region (Table 3-3). Climatic variations can show considerable variation over short distances, with variations occurring in the vertical more than in the horizontal. Because of mean flow and topographic lift, summer is the season of greatest rainfall on the north side. To the east and south, autumn precipitation

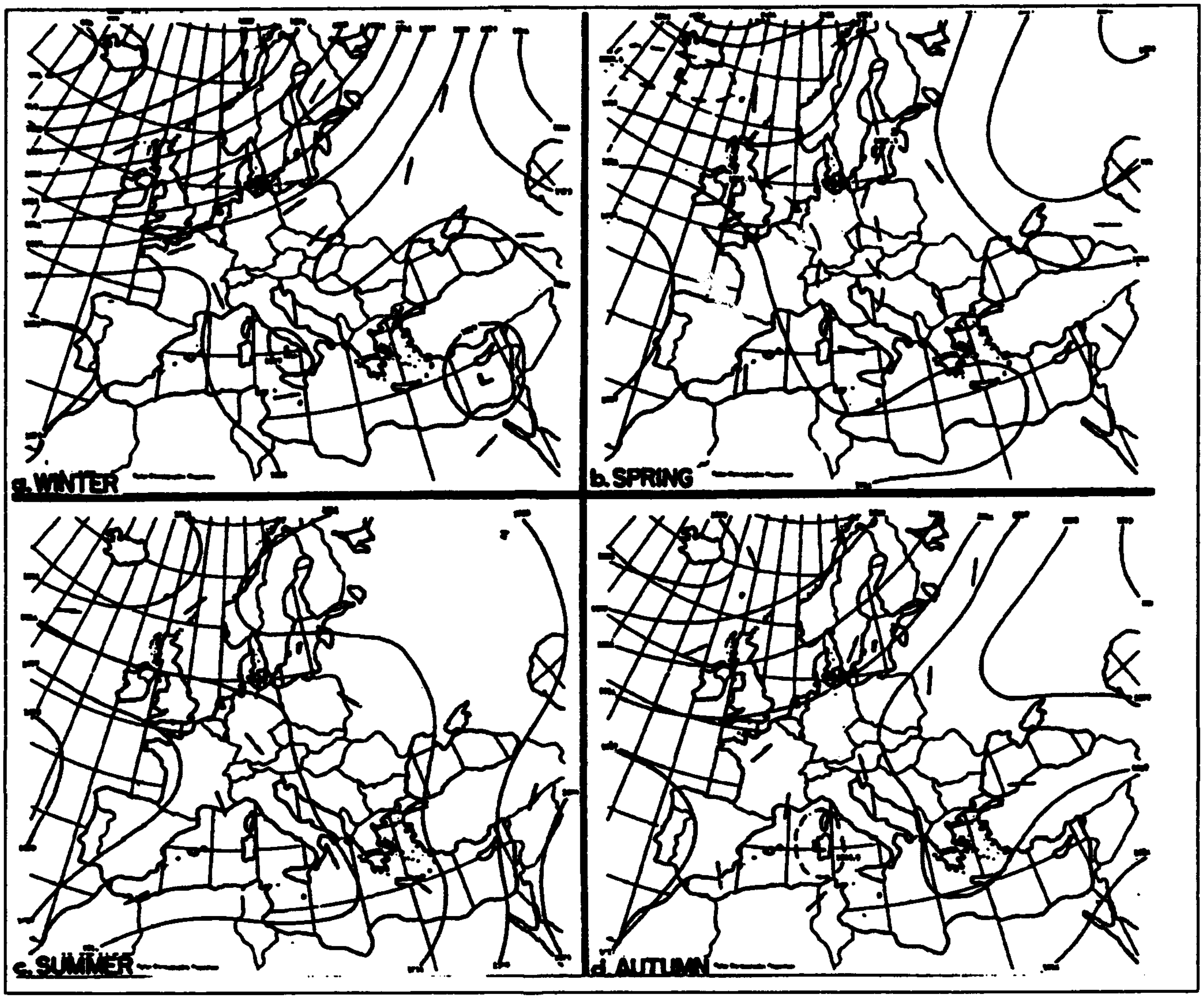


Figure 3-9. Mean Sea Level Pressure, Circulation and Flow, by Season.

is greater. The frequent variation of pressure system location and intensity show as a lack of isopleths over the Alpine region, in figures 3-9 and 3-10. Overall circulation is best developed in the winter and early spring. During summer the predominant flow is weakly northwesterly, so local effects dominate the climatological picture. During autumn, a general intensification of the winter pressure centers begins, with the four fields identifiable by mid-November. Autumnal flow begins to show a trend toward west-southwesterly.

3-11. The Balkans (Table 3-4). Many climate controls interact to provide the weather peculiar to the Balkan Peninsula. Along coastal areas, a Mediterranean climate exists, with warm to hot summers and cool, rainy winters. The mountains inland provide the climatic divide between the maritime coast and the continental interior. Inland, winters are cold and dry, and summers hot and showery. During winter and early spring, precipitation falls as rain along the coast, and routinely as snow inland. Coastal areas have their greatest rainfall amounts in winter, while interior regions show a summer maximum. In winter, the Balkans lie in an area of relatively low pressure between the Azores and Siberian Highs. This low pressure regime

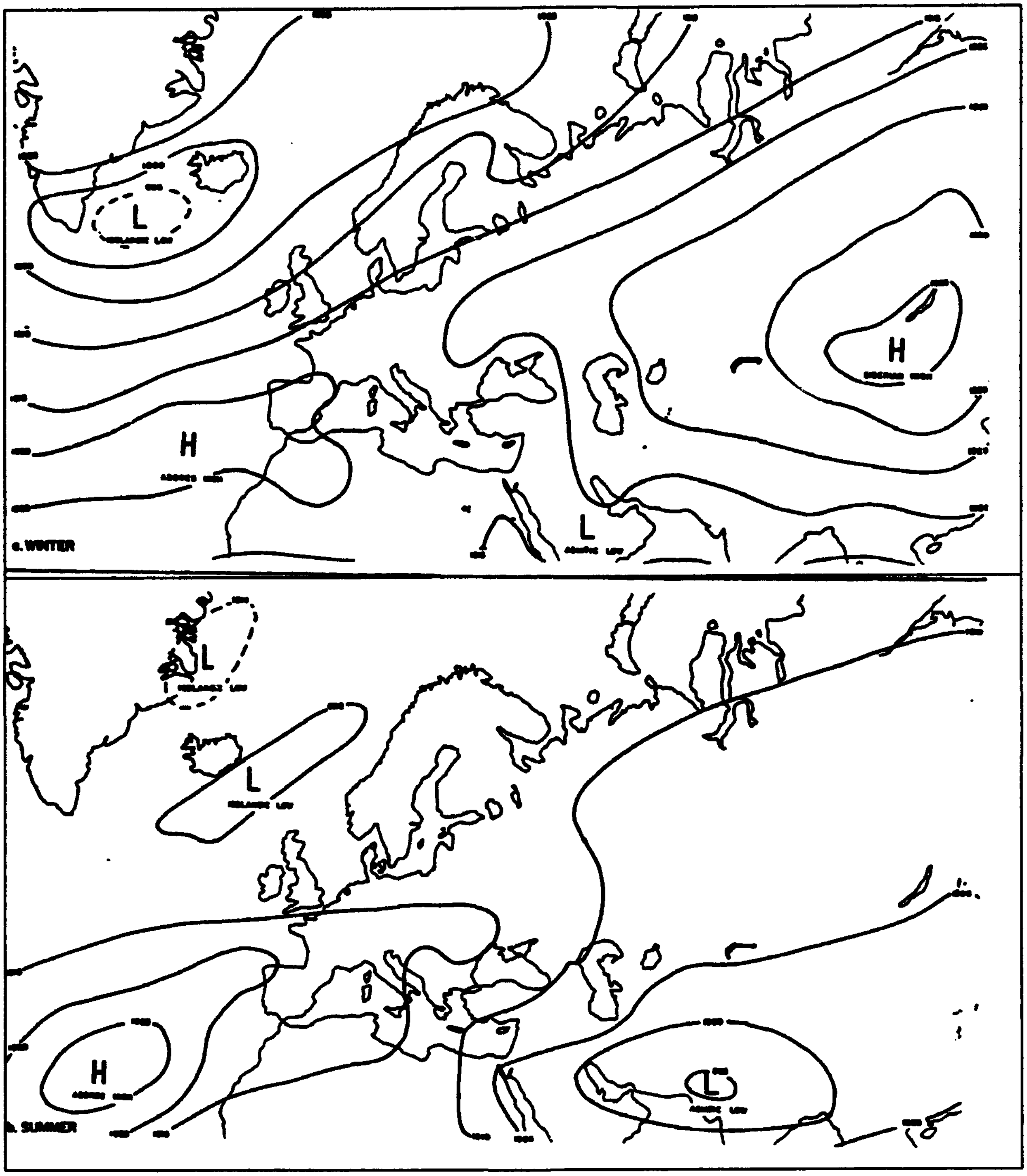


Figure 3-10. Mean Positions of the Major Semi-Permanent Synoptic Features: Winter (Top); Summer (Bottom).

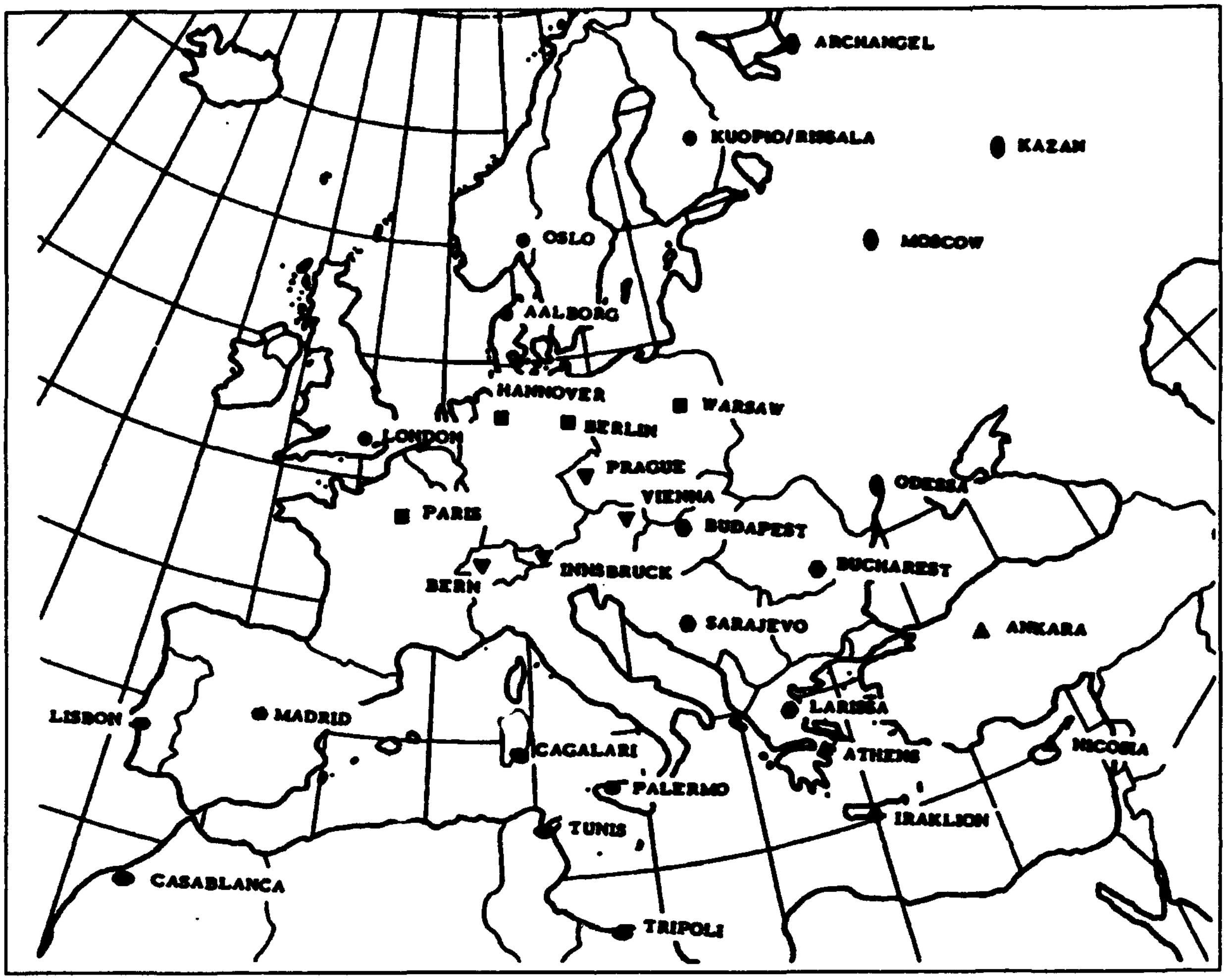


Figure 3-11. Locator Chart for Tables 3-1 Through 3-8.

is responsible for much of the adverse weather. Though daily circulation cannot be described exactly, winter winds are mostly from the southeast. During summer with the weakening of both the Icelandic Low and the Siberian High, Balkan circulation is more influenced by the heat low over Pakistan. The resulting northerly flow coincides with a decrease in the number of migratory lows and weather is generally good.

3-12. The Western Mediterranean (Table 3-5):

a. The winter climate of the Iberian Peninsula consists of mild, wet weather in the lowlands; cold, damp, windy weather in higher elevations; and heavy snow in the northern mountains. The primary winter climatic controls are the proximity of the ocean, and flow pattern. In addition, the high terrain a short distance inland restricts the flow of both maritime air from the west, and the frigid air to the east. During summer, the primary controls are the Azores High, and the increased insolation over the central highlands. In coastal lowlands, summers are hot and humid, while at higher central locations, days are hot and sunny, and nights are quite cool. Rainfall in the northern and central highlands is somewhat greater during fall, winter, spring, because of the migratory systems crossing the area. During summer, when the area is dominated by the Azores High, precipitation amounts are at a minimum in all locations.

b. Italy experiences significant climatic differences because of its size (10° of latitude), terrain orientation, and proximity to water on three sides. The Alps generally cut Italy off from the climatic controls

Table 3-1
Climatological Statistics for Selected Stations in the Northern European Region

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean Number of Days with ≤ 3/10 Cloud Cover													
London[d]	5	4	5	3	3	4	3	3	3	4	4	4	45
Aalborg[a,d]	6	5	7	8	8	8	7	5	7	6	5	5	76
Oslo [d]	9	7	8	5	7	7	7	6	5	7	7	6	81
Kuopio/Rissala[e]	4	6	9	7	6	4	4	4	4	3	3	3	56
Mean Number of Days with ≥ 8/10 Cloud Cover													
London[d]	21	17	17	18	19	15	20	14	16	18	20	22	217
Aalborg[b,d]	20	19	19	15	16	19	16	18	15	21	21	22	216
Oslo [c,d]	20	18	18	17	19	15	15	15	17	20	21	21	216
Kuopio/Rissala[e]	24	19	19	17	18	18	17	20	21	25	25	26	254
Mean Monthly Precipitation (Inches)													
London	1.8	1.5	1.7	1.5	1.7	2.1	2.2	2.2	1.9	2.7	2.2	2.3	23.8
Aalborg	1.7	1.3	1.5	1.6	1.7	1.8	2.4	3.2	2.1	2.6	2.1	2.2	24.2
Oslo	1.6	1.5	1.5	1.6	1.7	2.1	3.0	3.5	2.4	2.6	2.0	1.9	25.4
Kuopio/Rissala	1.8	1.5	1.4	1.3	1.6	2.2	2.7	2.9	2.4	2.0	1.9	1.8	23.4
Mean Number of Days with Precipitation ≥ 0.004 Inches													
London	16	13	14	13	12	12	12	13	12	17	16	17	167
Aalborg	15	12	15	13	13	11	14	17	15	12	16	18	176
Oslo	13	11	12	10	11	11	13	16	11	13	13	15	149
Kuopio/Rissala	17	14	13	10	11	13	16	17	15	15	15	16	170
Mean Number of Days with Snow													
London	3	3	3	1	*	0	0	0	0	0	1	2	13
Aalborg	6	5	4	2	*	0	0	0	0	*	1	4	22
Oslo	13	11	11	5	1	0	0	0	*	2	6	12	61
Kuopio/Rissala	16	14	12	6	2	*	0	0	*	4	12	14	81
Mean Number of Days with Thunderstorms													
London	*	*	1	1	2	2	3	3	1	1	*	*	14
Aalborg	*	*	*	*	1	1	3	3	1	*	*	*	9
Oslo	0	0	0	0	1	3	6	4	1	*	*	*	15
Kuopio/Rissala	0	*	0	*	1	4	5	3	*	*	0	0	13
Mean Number of Days with Fog													
London	4	4	3	2	1	*	*	1	2	4	6	6	33
Aalborg	4	4	4	2	1	1	1	2	2	3	4	3	32
Oslo	6	5	4	2	*	*	*	1	2	5	7	8	40
Kuopio/Rissala	1	1	1	1	1	0	0	1	1	2	2	1	12
Mean Daily Maximum and Minimum Temperatures													
London	45	46	50	54	63	68	71	70	65	58	49	46	57
	36	36	37	40	46	51	55	54	50	44	39	37	44
Aalborg	34	33	40	50	59	66	69	67	62	54	45	39	51
	27	25	30	35	43	50	54	53	49	44	37	32	40
Oslo	30	32	40	50	62	69	73	69	60	49	37	31	51
	20	20	25	34	43	51	56	53	45	37	29	24	36
Kuopio/Rissala	23	20	28	42	55	65	71	66	54	42	32	25	44
	12	6	13	28	38	49	56	52	43	34	25	15	31

[a] <2/8 cloud cover
[b] ≥6/8 cloud cover
[c] ≥7/10 cloud cover
[d] 1300 LST
[e] 1400 LST
* < 0.5 day

Table 3-2
Climatological Statistics for Selected Stations in the Central Plains Region

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean Number of Days with ≤ 3/10 Cloud Cover													
Paris [c]	5	5	8	8	7	5	7	6	6	7	3	3	70
Hannover [c]	4	3	6	5	6	4	3	4	4	7	2	4	52
Berlin [c]	5	4	7	6	5	5	4	4	7	6	3	4	60
Warsaw [a,c]	5	5	8	6	4	5	5	4	6	7	3	3	59
Mean Number of Days with ≥ 8/10 Cloud Cover													
Paris [c]	22	17	16	11	13	14	12	12	13	13	17	20	180
Hannover [c]	22	19	18	16	16	14	17	15	17	17	22	22	215
Berlin [c]	20	18	16	14	14	13	14	14	12	16	21	22	194
Warsaw [b,c]	25	20	18	19	19	18	18	19	17	20	24	26	242
Mean Monthly Precipitation (Inches)													
Paris	1.3	1.5	1.8	1.9	2.1	2.1	2.3	1.9	1.9	2.4	2.0	2.3	23.9
Hannover	2.0	1.5	1.8	1.8	2.1	2.5	3.1	3.0	2.0	2.0	1.7	1.9	25.4
Berlin	1.7	1.4	1.1	1.6	2.0	2.5	2.6	2.5	1.8	1.4	1.8	1.6	22.0
Warsaw	1.3	0.9	1.0	1.4	2.1	2.3	3.3	2.8	1.7	1.4	1.5	1.3	21.0
Mean Number of Days with Precipitation ≥ 0.004 Inches													
Paris	17	14	13	14	14	12	12	12	12	14	15	17	166
Hannover	17	14	15	15	14	14	16	16	14	14	14	16	179
Berlin	16	13	10	12	12	12	13	14	11	12	14	14	153
Warsaw	14	12	13	13	14	13	14	14	11	13	14	15	160
Mean Number of Days with Snow													
Paris	4	3	2	*	0	0	0	0	0	*	1	2	12
Hannover	2	2	1	*	*	0	0	0	0	*	1	1	7
Berlin	5	4	1	*	0	0	0	0	0	*	*	2	13
Warsaw	11	10	8	2	*	0	0	0	0	1	5	9	46
Mean Number of Days with Thunderstorms													
Paris	*	0	1	1	3	4	5	4	2	1	*	0	20
Hannover	*	*	1	1	4	4	5	4	2	*	*	*	21
Berlin	1	2	1	2	4	5	6	4	3	3	3	3	36
Warsaw	1	*	*	1	5	7	7	6	2	*	*	0	29
Mean Number of Days with Fog													
Paris	12	9	6	3	3	1	1	2	6	6	11	11	71
Hannover	3	2	2	1	1	*	1	1	1	3	4	3	22
Berlin	19	18	17	10	7	6	7	10	12	16	18	20	160
Warsaw	12	11	8	5	2	2	2	4	6	13	13	14	93
Mean Daily Maximum and Minimum Temperatures													
Paris	42	46	52	59	67	73	76	75	70	60	49	44	60
	33	33	36	40	47	52	55	55	51	44	38	35	43
Hannover	37	40	46	54	65	70	72	71	66	55	45	40	55
	29	30	33	38	46	51	55	54	49	43	36	32	41
Berlin	35	36	46	57	66	72	74	73	68	56	45	37	56
	27	27	33	41	49	55	58	58	52	44	37	31	43
Warsaw	30	32	41	54	67	72	75	73	65	54	40	32	53
	21	23	28	38	48	53	56	55	48	41	32	25	39

[a] <2/8 cloud cover
[b] ≥6/8 cloud cover
[c] 1300 LST
* <0.5 day

Table 3-3
Climatological Statistics for Selected Stations in the Alpine Region

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean Number of Days with ≤ 3/10 Cloud Cover													
Bern [a,d]	5	4	8	7	5	8	8	9	10	6	3	3	76
Innsbruck [d]	7	8	9	4	5	8	6	8	9	9	9	8	90
Vienna [d]	4	3	5	5	5	5	4	6	7	7	4	3	57
Prague [b,e]	5	5	7	6	4	4	4	4	8	8	3	4	60
Mean Number of Days with ≥ 8/10 Cloud Cover													
Bern [d]	24	21	18	17	19	16	16	15	15	21	22	25	229
Innsbruck [d]	21	16	19	22	22	17	17	16	17	18	17	19	220
Vienna [d]	23	22	21	19	20	19	19	17	17	19	22	26	243
Prague [c,e]	22	19	19	18	18	16	18	16	14	18	23	24	224
Mean Monthly Precipitation (Inches)													
Bern	1.9	2.0	2.6	3.0	3.7	4.4	4.4	4.3	3.5	3.5	2.7	2.5	38.5
Innsbruck	2.1	1.3	1.7	2.5	2.9	4.0	4.4	4.7	3.0	2.4	2.2	2.3	33.5
Vienna	1.5	1.3	1.8	2.1	2.8	2.7	3.1	2.7	2.0	1.9	1.8	1.8	25.4
Prague	0.9	0.8	1.1	1.5	2.4	2.8	2.6	2.7	1.6	1.2	1.2	0.9	19.2
Mean Number of Days with Precipitation ≥ 0.004 Inches													
Bern	14	11	15	17	17	16	15	14	13	14	13	15	174
Innsbruck	8	8	11	12	14	16	17	16	12	10	8	9	139
Vienna	13	11	13	13	14	14	15	13	11	13	14	15	158
Prague	12	12	13	12	11	14	14	12	11	11	13	13	150
Mean Number of Days with Snow													
Bern	7	5	6	4	*	0	0	0	0	1	4	6	33
Innsbruck	7	6	7	2	1	0	0	*	*	1	3	7	33
Vienna	7	5	4	1	0	0	0	0	*	*	3	6	26
Prague	7	7	6	2	*	0	0	0	0	1	2	6	32
Mean Number of Days with Thunderstorms													
Bern	0	*	*	1	4	4	4	4	2	*	*	*	20
Innsbruck	0	0	0	*	1	4	7	5	2	*	0	0	20
Vienna	*	*	*	2	5	6	7	5	2	*	*	*	26
Prague	0	*	*	2	7	8	7	7	2	0	0	*	33
Mean Number of Days with Fog													
Bern	12	7	3	1	1	*	*	*	3	8	10	9	54
Innsbruck	8	4	2	*	1	*	1	1	4	8	6	5	40
Vienna	15	15	14	8	6	4	4	5	7	17	18	17	130
Prague	6	6	6	1	1	*	*	1	3	8	7	9	49
Mean Daily Maximum and Minimum Temperatures													
Bern	36	40	48	55	65	69	73	72	66	55	43	37	55
	26	26	32	38	46	51	54	54	49	41	33	28	40
Innsbruck	34	41	51	59	70	74	77	75	68	58	44	37	57
	21	24	32	38	46	51	53	53	48	40	30	25	38
Prague	34	38	47	57	67	74	77	75	68	56	46	36	56
	26	28	33	41	49	56	60	58	53	44	37	29	43

[a] <2/10 cloud cover
[b] ≥2/8 cloud cover
[c] ≥6/8 cloud cover
[d] 1400 LST
[e] 1300 LST
* < 0.5 day

Table 3-4
Climatological Statistics for Selected Stations in the Balkan Region

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean Number of Days with ≤ 3/10 Cloud Cover													
Budapest [a,e]	6	4	7	5	4	2	6	8	8	8	5	4	66
Sarajevo [a,e]	6	6	8	5	4	4	10	14	13	10	4	4	87
Larissa [b,e]	7	5	5	5	6	8	16	18	13	9	5	6	103
Bucharest [c,e]	8	6	8	9	8	8	14	18	15	11	8	6	119
Mean Number of Days with ≥ 8/10 Cloud Cover													
Budapest [d,e]	21	20	18	16	19	16	12	11	10	17	23	24	206
Sarajevo [d,e]	22	18	18	18	18	15	11	9	10	16	22	24	202
Larissa [e]	10	10	8	5	3	1	*	1	2	6	11	11	69
Bucharest [e]	15	13	14	10	10	7	5	3	6	11	14	17	125
Mean Monthly Precipitation (Inches)													
Budapest	1.5	1.5	1.7	2.0	2.7	2.6	2.0	1.9	1.8	2.1	2.4	2.0	24.3
Sarajevo	2.3	2.1	2.9	2.7	3.2	3.7	2.5	2.5	3.0	3.8	3.2	2.8	34.7
Larissa	1.9	1.7	1.5	1.5	2.1	1.3	0.9	0.7	1.0	2.6	2.8	2.4	20.4
Bucharest	1.3	1.1	1.7	1.7	2.5	3.5	2.7	2.0	1.6	1.7	1.9	1.6	23.3
Mean Number of Days with Precipitation ≥ 0.004 Inches													
Budapest	13	11	12	12	13	11	10	7	9	11	13	15	139
Sarajevo	12	11	12	13	15	15	11	11	11	13	14	13	151
Larissa	10	9	9	9	10	8	5	4	5	9	10	11	98
Bucharest	9	8	10	10	13	13	10	7	8	8	10	9	113
Mean Number of Days with Snow													
Budapest	7	5	3	1	*	0	0	0	0	*	2	6	24
Sarajevo	10	7	7	3	*	0	0	0	*	1	2	9	38
Larissa	2	1	1	0	0	0	0	0	0	0	*	1	11
Bucharest	6	4	3	1	*	0	0	0	*	*	2	4	21
Mean Number of Days with Thunderstorms													
Budapest	0	0	0	1	4	5	3	3	1	*	0	*	18
Sarajevo	*	0	*	*	1	2	4	2	1	1	*	*	11
Larissa	*	*	*	*	1	1	1	1	1	1	*	*	6
Bucharest	*	*	1	1	6	9	7	4	2	*	*	*	31
Mean Number of Days with Fog													
Budapest	10	8	3	1	*	*	0	*	1	3	8	11	44
Sarajevo	11	8	3	1	1	1	2	3	8	10	6	10	64
Larissa	5	3	3	2	1	*	*	*	1	2	2	4	23
Bucharest	9	6	4	1	*	*	*	*	1	3	6	11	42
Mean Daily Maximum and Minimum Temperatures													
Budapest	35	40	51	62	72	78	82	81	74	61	47	38	60
	26	28	36	44	52	57	67	59	53	45	37	31	44
Sarajevo	34	40	49	58	66	72	77	77	70	60	46	39	57
	22	26	33	41	48	53	60	55	50	44	35	29	41
Larissa	50	54	62	71	80	87	93	93	85	73	60	53	72
	33	35	40	47	55	63	67	66	61	53	44	37	50
Bucharest	20	25	32	41	51	58	61	60	52	44	34	29	42

[a] < 2/8 cloud cover
[b] ≤ 2/10 cloud cover
[c] ≤ 0 to 1/10 cloud cover
[d] > 6/8 cloud cover
[e] 1300 LST
* < 0.5 day

Table 3-5
Climatological Statistics for Selected Stations in the Western Mediterranean and Iberia

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean Number of Days with ≤ 3/10 Cloud Cover													
Lisbon[a,f]	10	8	11	8	5	11	18	19	18	10	7	7	128
Madrid[a,g]	8	8	8	8	9	10	20	19	12	9	8	10	130
Cagliari[b,h]	4	4	3	4	6	12	21	16	6	6	6	4	92
Palermo[b,h]	3	2	3	5	7	na	20	16	8	5	3	2	na
Mean Number of Days with ≥ 8/10 Cloud Cover													
Lisbon[c,f]	17	16	12	16	19	11	8	6	8	15	17	19	168
Madrid[c,g]	17	14	16	12	14	11	3	4	8	13	14	15	142
Cagalari[d,h]	16	15	18	15	14	8	3	8	11	13	15	17	153
Palermo[d,h]	21	19	21	16	13	na	3	5	12	15	19	21	na
Mean Monthly Precipitation (Inches)													
Lisbon	3.4	2.7	2.4	2.2	1.3	0.6	0.2	0.1	1.4	2.4	3.5	3.4	24.6
Madrid	1.1	1.7	1.7	1.7	1.5	1.2	0.4	0.3	1.2	1.9	2.2	1.6	16.5
Cagalari	1.9	1.4	2.0	1.6	1.1	0.7	0.1	0.1	1.2	2.4	3.0	2.2	17.7
Palermo	3.4	2.7	2.7	1.9	1.1	0.6	0.2	0.4	1.8	3.2	3.3	3.7	21.1
Mean Number of Days with Precipitation ≥ 0.004 Inches													
Lisbon	14	12	14	10	9	11	2	1	6	9	12	14	108
Madrid	9	9	11	9	9	6	3	2	6	8	10	9	91
Cagalari	9	9	11	10	7	5	1	1	4	8	11	12	88
Palermo	15	13	12	11	7	4	2	2	6	12	13	16	113
Mean Number of Days with Snow													
Lisbon	*	*	0	0	0	0	0	0	0	0	0	*	*
Madrid	1	1	1	*	0	0	0	0	0	0	*	1	4
Cagalari	0	0	0	0	0	0	0	0	0	0	0	0	0
Palermo	*	*	*	0	0	0	0	0	0	0	0	*	1
Mean Number of Days with Thunderstorms													
Lisbon	*	1	1	1	1	1	*	*	1	1	1	1	9
Madrid	0	0	*	1	3	2	1	1	2	*	*	*	10
Cagalari	1	1	1	1	1	1	1	1	2	3	2	0	16
Palermo	1	2	1	1	1	*	*	1	1	3	2	1	15
Mean Number of Days with Fog													
Lisbon	5	3	2	1	*	*	*	*	1	2	4	5	24
Madrid	5	1	*	*	*	*	0	0	*	1	*	4	13
Cagalari	2	2	1	1	1	1	8	1	1	1	2	2	23
Palermo	*	0	*	*	0	0	0	*	0	0	*	*	1
Mean Daily Maximum and Minimum Temperatures													
Lisbon	56	58	61	64	69	75	79	80	76	69	62	57	67
	46	47	49	52	56	60	63	64	62	57	52	47	55
Madrid	47	51	57	64	71	80	87	86	77	66	54	48	66
	33	35	40	44	50	57	62	62	56	48	40	35	47
Cagliari	57	58	61	66	72	80	86	86	80	72	65	58	70
	44	45	47	51	55	61	67	68	65	58	52	45	55
Palermo	60	61	65	69	75	82	88	89	85	77	70	62	73
	42	42	44	48	53	59	64	65	62	57	50	44	53

[a] < 2/8 cloud cover
[b] ≥ 2/10 cloud cover
[c] ≥ 6/8 cloud cover
[d] > 7/10 cloud cover
[e] ≥ 0.04 inch
[f] 1100 LST
[g] 1200 LST
[h] 1900 LST
* < 0.5 day
na not available

of the central plains to the north. During winter, the intense Siberian High often extends to over the Balkans, with the weakened Azores ridge to the west of the Mediterranean. Between the two, over the warm waters of the Mediterranean a weak trough of low pressure occurs. This, together with the foehn cyclone effect (much like the lee-side cyclones of the midwestern US), can cause strong winter storms in the Mediterranean. Conversely the summer pattern over the western Mediterranean is stable, the strengthened Azores ridge keeping migratory systems out of the area.

3-13. Turkey and the Eastern Mediterranean (Table 3-6):

a. The Turkish climate, especially in winter, is characterized by rapid and extreme changes in the weather, due to the differing characteristics of the land, and the seas surrounding the country. Temperatures can rise to more than 110°F (43 C) in the summer and fall to -45° F (-43 C) in the winter over the interior, characteristic of a continental climate. Turkey experiences most precipitation during winter and spring. Amounts are greatest in coastal regions, diminishing rapidly inland.

b. A Mediterranean climate exists over most of the remainder of the region. Winters are mild with moderate precipitation, and summers are warm/ hot with very little rainfall.

c. In winter, most of the wintertime precipitation is generated by weak cyclones formed over the warm waters of the Mediterranean or Black Seas. In summer, the Azores ridge lies over the Mediterranean, closing the area to frontal passages.

3-14. The CIS (Table 3-7). The primary climate controls that govern the weather of the CIS are latitude, the enormous size of the land-mass, and the proximity of water sources, to the west and north.

a. The climate of the region is mostly continental. There is a gradual decrease from south to north in the amount of solar heating, temperature and evaporation; but a gradual increase in cloudiness, relative humidity and snow-cover. Average temperatures show greater variation from west to east than from south to north, showing the maritime influence to be greater than the latitudinal, on the climate of the region.

b. Winters are cold, humid, and cloudy. Winter temperatures of 20° F (-7 C) have been recorded everywhere but along the Black Sea coast, while readings of -60° F (-51 C) occur in the northern interior. Precipitation is at a minimum during winter, usually as snow, (but can attain considerable depth in many locations). The transition from winter to summer is abrupt, if late. The melting of the extensive snow cover consumes a great deal of the heat that would otherwise be available to gradually warm the atmosphere in spring. Once the snow is gone, however, the land surface and the lower atmosphere warm rapidly.

c. The westerly flow regime, and lack of significant intervening European terrain allows the western Commonwealth States to have a relatively mild winter for their latitude (though they are certainly more continental than the countries of western Europe). The climate of the southern CIS is comparable to that of the north-central US, while the north and eastern portions are, in winter, some of the coldest on earth. Variation in climate is significantly greater in the eastern 2/3 of the Commonwealth.

d. Summers are generally warm, less humid, and less cloudy, with the exception of the northern coasts and islands which remain cold, and cloudier than in winter. Summer high temperatures of 80° F (27 C) have been recorded in all locations but the extreme north. Summer precipitation is less frequent than in winter, but because it is usually convective, amounts are greater than in winter.

3-15. North Africa (Table 3-8):

a. The coastal lowlands and seaward slopes of the region have a Mediterranean climate. In the interior, a desert climate prevails, characterized by marked dryness, extremely high day-time temperatures, and cool/ cold nights. The climate in the mountainous regions may resemble either of the above depending on exposure.

Table 3-6
Climatological Statistics for Selected Stations in the Eastern Mediterranean and Turkey

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean Number of Days with ≤ 3/10 Cloud Cover													
Athens [a,c]	4	4	6	7	8	13	24	24	17	9	4	4	121
Iraklion [c]	3	3	6	9	11	20	27	26	18	8	4	4	139
Nicosia [d]	6	9	9	11	12	20	28	27	23	14	8	8	176
Ankara [a,e]	3	2	4	4	5	9	17	19	16	10	6	3	98
Mean Number of Days with ≥ 8/10 Cloud Cover													
Athens	10	9	7	5	4	1	*	*	1	5	8	10	59
Iraklion	11	10	8	4	3	*	*	*	1	3	8	9	57
Nicosia [b]	17	11	14	12	12	2	0	1	2	8	12	15	105
Ankara	15	13	11	8	6	2	1	*	2	5	9	17	89
Mean Monthly Precipitation (Inches)													
Athens	2.2	1.6	1.4	0.8	0.8	0.6	0.2	0.4	0.6	1.7	2.8	2.8	15.8
Iraklion	3.4	2.8	1.8	1.1	0.9	0.1	**	0.3	0.7	1.5	3.9	3.6	20.1
Nicosia	3.2	2.4	1.3	0.8	1.1	0.3	0.0	0.0	0.3	0.8	1.7	3.0	14.9
Ankara	1.3	1.2	1.3	1.2	1.9	1.0	0.5	0.4	0.6	0.9	1.2	1.9	13.4
Mean Number of Days with Precipitation ≥ 0.004 Inches													
Athens	14	12	10	9	9	6	2	2	4	9	12	14	103
Iraklion	18	15	12	8	6	2	*	1	2	7	10	16	97
Nicosia	9	8	7	4	3	1	*	*	1	3	7	10	53
Ankara	12	12	10	10	11	8	3	2	4	7	8	13	100
Mean Number of Days with Snow													
Athens	1	1	1	0	0	0	0	0	0	0	*	1	4
Iraklion	1	1	*	*	0	0	0	0	0	0	0	1	3
Nicosia	0	0	0	0	0	0	0	0	0	0	0	0	0
Ankara	8	7	4	1	0	0	0	0	0	*	1	4	25
Mean Number of Days with Thunderstorms													
Athens	1	1	1	1	2	2	1	1	2	2	2	1	17
Iraklion	1	1	*	*	0	0	0	0	0	0	0	1	3
Nicosia	0	0	0	0	0	0	0	0	0	0	0	0	0
Ankara	0	0	0	2	7	6	2	2	1	2	1	0	23
Mean Number of Days with Fog													
Athens	1	1	1	1	1	0	0	0	*	1	1	4	11
Iraklion	0	0	*	*	*	0	0	0	0	0	0	*	1
Nicosia	*	*	*	*	*	*	0	*	*	0	*	*	2
Ankara	7	4	4	3	1	1	*	*	1	2	5	6	34
Mean Daily Maximum and Minimum Temperatures													
Athens	55	55	60	67	70	85	90	90	83	74	64	57	71
	42	43	46	52	60	67	72	72	66	60	52	46	57
Iraklion	60	60	64	70	76	82	85	85	82	71	71	64	73
	48	48	50	54	60	67	72	71	68	62	56	51	59
Nicosia	58	59	65	74	83	91	97	97	91	83	73	62	78
	41	41	51	63	72	80	86	87	78	69	56	43	63
Ankara	38	41	51	63	72	80	86	87	78	69	56	43	63
	24	26	31	40	49	55	59	60	52	44	36	29	42

[a] < 2/10 cloud cover
[b] ≥ 7/10 cloud cover
[c] ≥ 1300 LST
[d] 1400 LST
[e] All hours
* < 0.5 day
** < 0.05 inch

Table 3-7
Climatological Statistics for Selected Stations in the CIS

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean Number of Days with ≤ 3/10 Cloud Cover													
Archangel[a,b]	2	2	3	3	1	3	1	1	1	1	1	1	20
Moscow[a,b]	5	5	8	9	9	8	9	8	7	6	3	3	80
Odessa[a,b]	2	1	3	6	5	4	10	12	10	6	2	2	63
Kazan[a,b]	3	4	4	5	5	4	4	4	3	2	1	2	41
Mean Number of Days with ≥ 8/10 Cloud Cover													
Archangel[b]	20	16	14	14	14	12	14	16	18	20	21	20	199
Moscow[b]	19	16	16	11	8	7	7	9	12	17	22	22	166
Odessa[b]	18	15	15	11	7	5	2	2	4	8	16	19	122
Kazan[b]	18	14	13	10	8	8	8	8	12	17	22	20	158
Mean Monthly Precipitation (Inches)													
Archangel	0.9	0.8	0.9	0.8	1.4	2.0	2.3	2.5	2.2	1.8	1.3	1.1	18.0
Moscow	1.6	1.4	1.4	1.4	1.9	2.5	3.1	2.8	2.4	2.5	1.8	1.7	24.5
Odessa	1.0	1.0	1.1	0.9	1.1	1.2	1.6	1.2	1.0	1.3	0.9	1.1	13.4
Kazan	0.9	0.9	0.8	1.0	1.2	2.4	2.3	1.9	1.7	1.6	1.3	1.0	17.0
Mean Number of Days with Precipitation ≥ 0.004 Inches													
Archangel	16	14	13	13	13	12	15	16	15	16	17	16	176
Moscow	16	15	14	12	12	12	15	14	14	15	17	8	174
Odessa	7	4	5	6	6	7	6	5	4	5	5	6	66
Kazan	19	13	12	8	10	12	12	13	13	13	16	18	146
Mean Number of Days with Snow													
Archangel	8	9	8	4	3	1	0	0	1	6	10	10	60
Moscow	18	15	13	6	1	0	0	0	1	5	14	18	91
Odessa	6	6	4	1	0	0	0	0	0	0	2	5	24
Kazan	14	12	10	4	0	0	0	0	0	2	12	15	69
Mean Number of Days with Thunderstorms													
Archangel	0	0	0	0	2	2	5	3	*	0	0	0	12
Moscow	*	0	*	1	4	7	7	5	2	*	*	*	26
Odessa	*	*	*	1	5	7	7	4	2	1	*	1	29
Kazan	*	*	*	*	2	8	9	6	2	0	*	*	27
Mean Number of Days with Fog													
Archangel	2	4	4	3	2	1	1	2	1	3	2	2	27
Moscow	8	8	7	6	4	4	3	6	4	5	8	7	70
Odessa	11	13	14	6	2	2	2	1	3	9	12	12	87
Kazan	7	6	5	3	1	1	2	1	1	4	7	6	44
Mean Daily Maximum and Minimum Temperatures													
Archangel	9	11	22	36	47	57	64	59	49	36	23	12	35
	1	0	8	23	35	44	51	48	40	30	16	4	25
Moscow	15	19	29	44	60	67	71	67	56	44	29	19	43
	6	8	16	30	42	50	54	51	42	33	22	12	31
Odessa	29	33	39	52	67	74	79	79	68	58	42	33	54
	22	26	32	41	54	62	66	63	56	48	34	27	45
Kazan	9	14	25	43	63	70	75	71	57	43	25	13	42
	0	4	13	30	46	53	58	54	44	33	18	5	30

[a] < 2/10 cloud cover

[b] $\underline{\Sigma}$ 1300 LST

* < 0.5 day

Table 3-8
Climatological Statistics for Selected Stations in North Africa

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean Number of Days with ≤ 3/10 Cloud Cover													
Casablanca[a,c]	9	6	14	11	13	18	16	20	14	5	5	12	143
Tunis[d]	6	6	5	7	11	14	26	24	13	7	5	5	127
Tripoli[e]	12	12	14	14	18	22	19	19	22	14	11	11	108
Hún[d]	14	13	18	16	19	24	30	29	23	16	14	13	226
Mean Number of Days with ≥ 8/10 Cloud Cover													
Casablanca[b,c]	12	12	10	7	10	8	5	4	6	17	16	13	119
Tunis[b,d]	16	13	16	14	11	7	1	2	7	14	16	17	134
Tripoli[e]	9	7	7	6	6	3	*	*	2	5	6	8	59
Hún[b,d]	8	6	5	7	5	2	*	*	1	5	9	8	58
Mean Monthly Precipitation (Inches)													
Casablanca	2.0	1.9	1.9	1.5	0.8	0.2	**	**	0.2	1.6	2.6	2.9	15.6
Tunis	2.5	2.0	1.6	1.4	0.7	0.4	0.1	0.3	1.3	2.0	1.9	2.4	16.5
Tripoli	1.6	1.3	0.7	0.3	0.1	**	**	**	0.3	1.2	3.0	3.6	12.1
Hún	0.2	0.2	0.1	0.1	0.2	**	0.0	**	0.1	0.2	0.1	0.2	1.4
Mean Number of Days with Precipitation ≥ 0.004 Inches													
Casablanca	8	8	8	8	5	2	*	*	2	7	8	10	66
Tunis	13	12	11	9	6	5	2	3	7	9	11	14	102
Tripoli	7	6	5	3	1	*	*	*	1	5	8	10	46
Hún	1	1	1	1	2	*	0	*	1	2	2	1	12
Mean Number of Days with Snow													
Casablanca	0	0	*	0	0	0	0	0	0	0	0	0	*
Tunis	na	na	na	na	na	na	na	na	na	na	na	na	na
Tripoli	*	*	0	0	0	0	0	0	0	0	0	0	*
Hún	na	na	na	na	na	na	na	na	na	na	na	na	na
Mean Number of Days with Thunderstorms													
Casablanca	1	1	2	2	1	1	0	1	1	1	1	2	14
Tunis	1	1	2	2	3	3	1	3	5	6	3	1	31
Tripoli	*	*	*	*	*	1	0	*	1	1	1	1	7
Hún	0	*	0	*	1	0	0	*	1	1	*	*	4
Mean Number of Days with Fog													
Casablanca	5	4	4	3	5	3	5	7	5	5	3	4	53
Tunis	2	4	3	1	2	1	1	2	1	2	2	2	23
Tripoli	0	0	1	1	1	0	0	1	0	0	1	1	6
Hún	2	1	1	2	*	1	0	*	*	1	1	1	10
Mean Daily Maximum and Minimum Temperatures													
Casablanca	63	64	67	69	72	76	79	81	79	76	69	65	72
	45	46	49	52	56	61	65	66	63	58	52	47	55
Tunis	58	61	65	70	76	84	90	91	87	77	60	60	74
	44	44	47	51	56	64	68	69	66	59	51	44	55
Tripoli	60	62	66	71	75	81	85	86	85	80	72	64	73
	47	49	53	57	62	68	72	73	71	67	59	51	60
Hún	67	71	78	86	92	100	101	101	97	88	79	69	86
	37	40	44	51	59	65	66	66	64	57	49	51	53

[a] < 2/8 cloud cover
[b] ≥ 6/8 cloud cover
[c] 1400 LST
[d] 1300 LST
[e] 1200 to 1400 LST
* < 0.5 day
** < 0.005 inch
na not available

b. The principle pressure systems affecting the region are the Azores High, and the extensive heat lows over southwestern Asia, and interior Africa. The weakening/strengthening and migration of these systems are tied to the seasonal changes in the region's circulation.

c. In winter, an extension of the Azores ridge extends across North Africa with a small high pressure center frequently over eastern Libya. A trough of relatively low pressure forms between this ridge and the Siberian ridge over the Mediterranean. Most of the winter storms affecting the region have their origin in this trough.

d. By summer the Azores ridge migrates north replacing the winter Mediterranean trough. Fronts from the Atlantic rarely affect the region in summer. The Siberian High weakens, the low over southwest Asia strengthens, and the thermal low over Africa moves northward. The resulting interaction of the summer pressure systems is associated with nearly constant northerly flow from Europe across the Mediterranean.

SECTION C - EUROPEAN FLYING WEATHER

3-16. Comparison. The saying goes that the worst average stateside weather is better than the best average European weather. While not strictly true, the air bases and Army airfields north of the Alps do have worse ceilings and visibilities than most stateside military bases. See table 3-9 for station identifiers. NOTE: Some of these bases no longer exist. They were included for comparison. Table 3-10 shows the winter ceiling/visibility summary, and table 3-11 shows the summary of ceilings and visibilities for summer.

Table 3-9. Station Identifiers

EGVG	RAF Woodbridge	KOFF	Offutt NE
EGVJ	RAF Bentwaters	KLIZ	Loring ME
EGVT	RAF Wethersfield	KGUS	Grissom IN
EGUA	RAF Upper Heyford	KSSC	Shaw SC
EGWZ	RAF Alconbury	KBIX	Keesler MS
EGUL	RAF Lakenheath	KBKF	Buckley CO
EGUN	RAF Mildenhall	KSAW	Sawyer MI
EDAS	Sembach GM	KGRF	Ft Lewis WA
EDAB	Bitburg GM	KFRI	Ft Riley KS
EDAT	Stuttgart GM	KHOP	Ft Campbell KY
EDAD	Spangdahlem GM	KCOS	Colorado Spr CO
EDAH	Hahn GM	KLUF	Luke AZ
EDAA	Rhein Main GM	KTCM	McChord WA
EDAW	Wiesbaden GM	LTAG	Incirlik TU
EDAR	Ramstein GM	LETO	Torrejon SP
EDOV	Bad Tölz	LEZG	Zaragoza SP
EDID	Hanau GM	LGWA	Athens GR
EDIE	Heidelberg GM	LIPA	Aviano IT
EDIC	Grafenwöhr GM	EDIN	Kitzigen GM
EDOT	Finthen GM	EDEW	Nürnberg GM
EDOP	Schwäbisch Hall GM	EDAM	Zweibrücken GM

Table 3-10.
Ceiling/Visibility Restrictions - Europe vs. United States During January

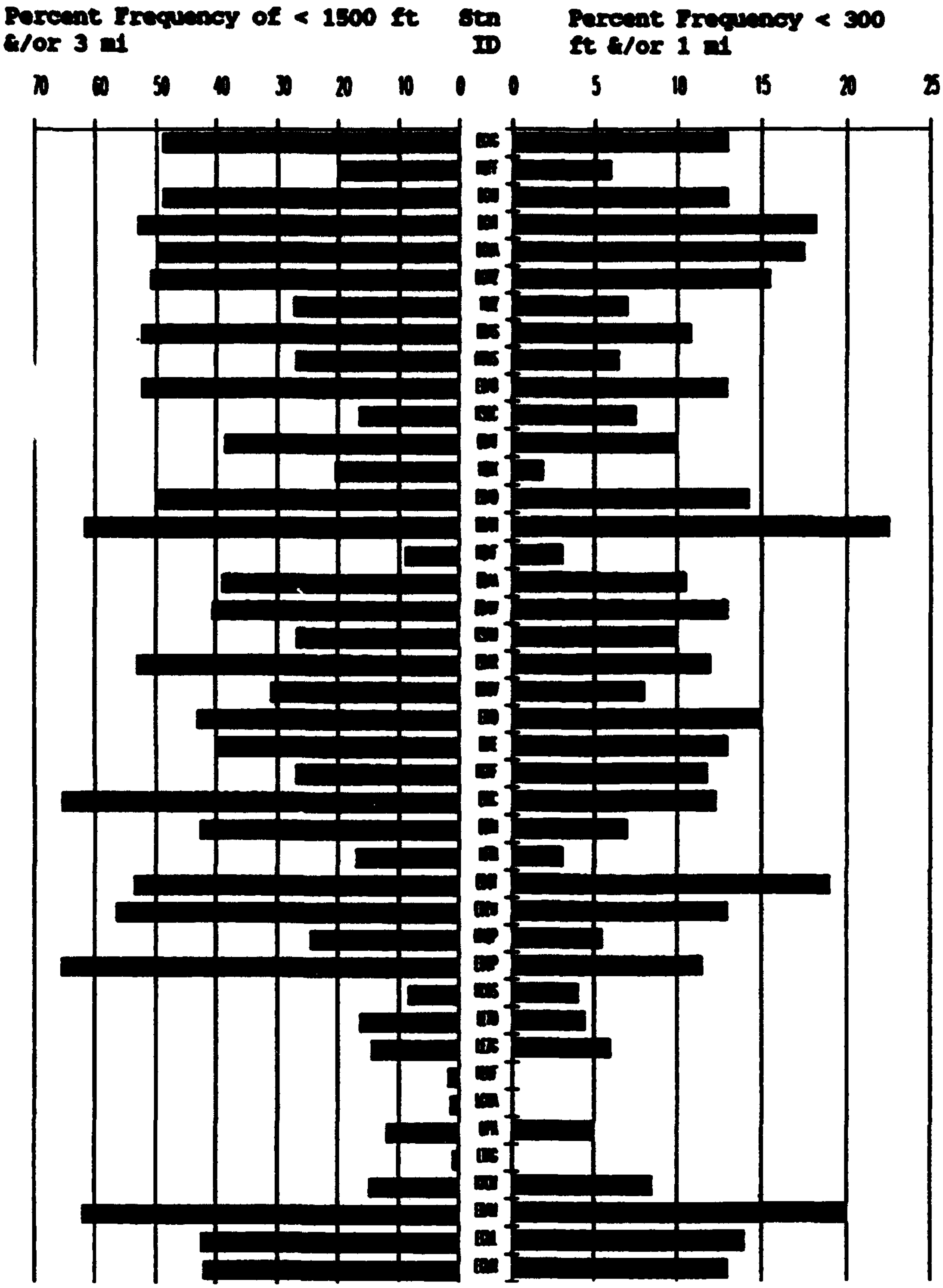
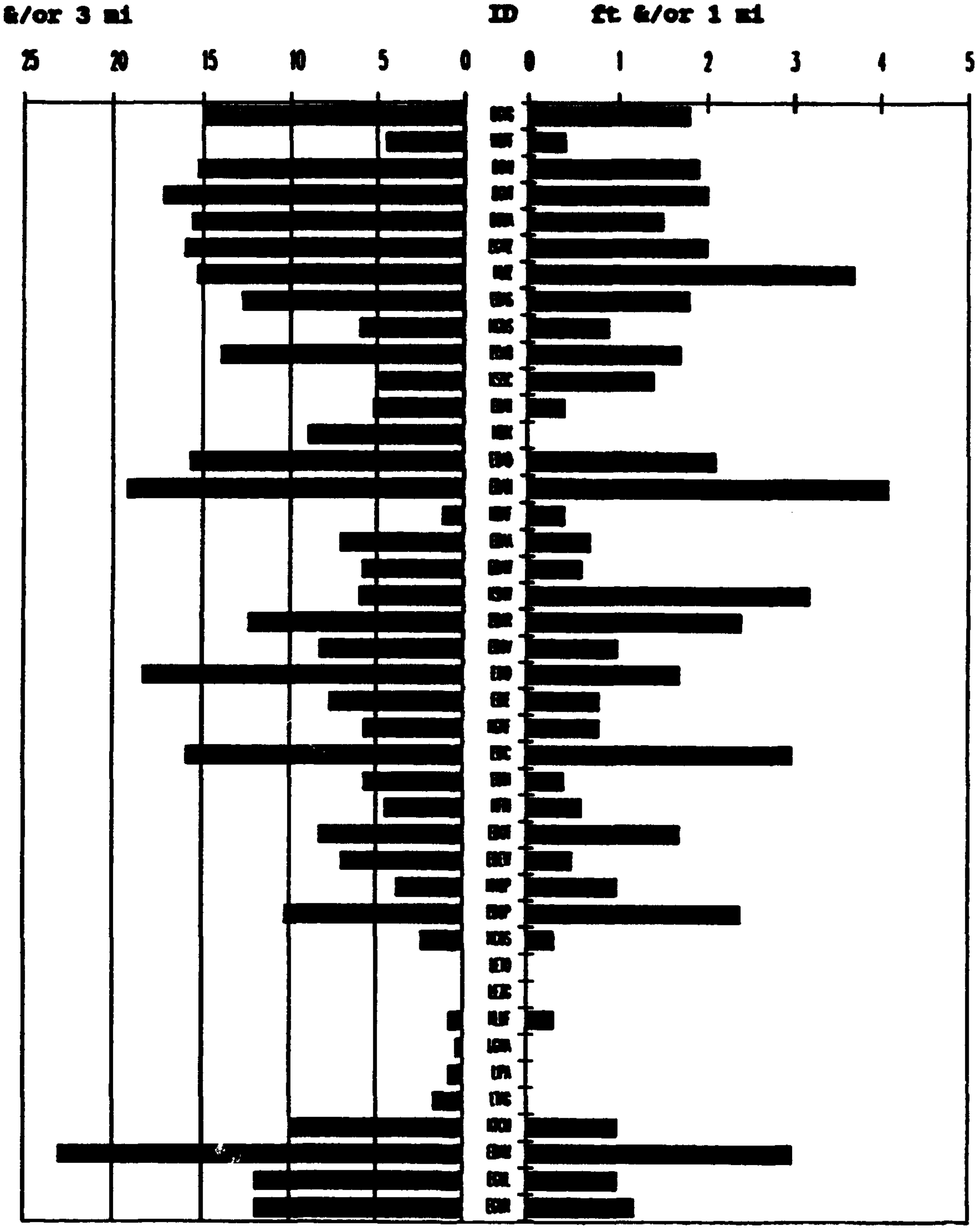


Table 3-11.

Ceiling/Visibility Restrictions - Europe vs. United States During July



SECTION D - PRESSURE SYSTEMS

3-17. Introduction. This section will discuss seasonal movement of pressure systems, areas of cyclogenesis, and anticyclogenesis, and finally, the relationship of the storm tracks to topography and bodies of water. The atmospheric motion of pressure systems is influenced by differential heating, the earth's ability to exchange heat with the atmosphere, and topography. Refer to figures 2-4, and 3-12 through 3-15.

3-18. Thermodynamic/Terrain Effects:

a. Terrain features cause distortion in airflow in the horizontal and vertical. The location of different landmasses and bodies of water affect both genesis and movement of pressure systems. The configuration of differential heating is more important than the actual temperature differences. Anticyclogenesis is favored over locally cooler areas, while cyclogenesis occurs more often over warmer areas.

(1) In winter, a body of relatively warm water surrounded by cooler landmasses contributes to enhanced cyclogenesis over the water, and anticyclogenesis over the land. In addition, large elevated plateaus are favored locations for anticyclogenesis.

(2) During summer, the reverse is true. Land masses warm more rapidly than water, contributing to "thermal low" cyclogenesis. An example is the enhanced cyclogenesis over North Africa in the Spring.

b. High Terrain forms blocks around which cyclones must steer. In addition to influencing the movement of cyclones, terrain can contribute to cyclogenesis due to lee-side effects.

3-19. Upper Air Circulation:

a. Comparison of climatological upper-air, and cyclone track charts shows the cyclone tracks lie to the left of the maximum climatological wind band (and anticyclone tracks to the right). But one cannot say the cyclones cause the high winds. Nor can one say that the shear generated by the winds cause cyclogenesis and cyclone track location. They appear together.

b. Areas of genesis and maximum occurrence are generally farthest south in February, and farthest north in August. This parallels the seasonal march of the climatological maximum wind band.

c. Most cyclones move in the general direction of the upper air flow, but slightly to the right of the contour pattern.

3-20. Cyclogenesis and Cyclone Paths (Figures 3-12 and 3-13):

a. Winter:

(1) The winter season is characterized by greater frequency of cyclogenesis than any other, particularly, west of the Italian Peninsula. Then, land-water temperature differences are greatest, and the component of wind normal to the European Alps contributes a lee-side effect to the cyclogenesis in the northern Mediterranean.

(2) Most of the cyclones that affect the European Theater move zonally along (near) one of three preferred paths. The primary paths are north, or south of the European continent, with a lower-frequency third track, across the North and Baltic Seas. Few storms enter the southern track from the vicinity of the UK. The majority actually form in the Mediterranean. These southern track storms usually travel east-southeastward to a center of maximum frequency over Greece. There, flow splits with the primary track heading toward northern India, and the secondary track toward the Black Sea.

b. Spring:

(1) With warming of the land masses, frequency of cyclogenesis over land increases during spring.

(2) Spring in Europe is characterized by the appearance of a secondary storm track from the northern Adriatic through eastern Europe, and the strengthening of the storm track from the mid-Atlantic to

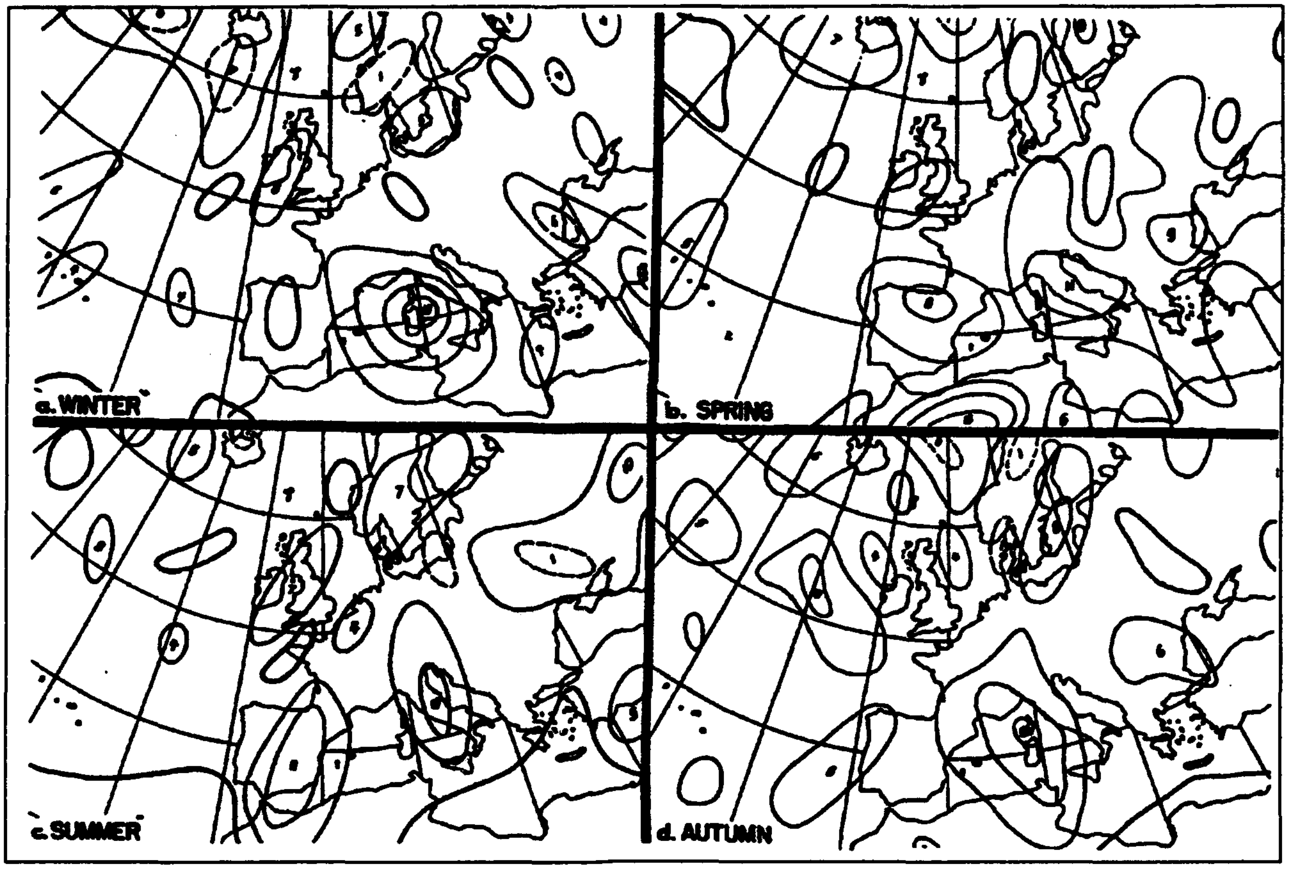


Figure 3-12. Mean Areas of Cyclogenesis by Season During: (a) Winter; (b) Spring; (c) Summer; (d) Autumn. Heavy line encloses areas of no occurrence.

over the British Isles. The latter is possibly associated with the increased blocking activity in the eastern Atlantic in spring. By late spring, landmasses have warmed sufficiently that in some locations, the land/sea temperature gradient reverses. The winter cyclone centers of action in the Denmark Strait, Adriatic Sea, Black Sea, and Aral Sea either disappear or are displaced landward. At the same time, new centers of maximum cyclone frequency occur inland over central Europe and southern Scandinavia.

c. Summer:

(1) The summer is characterized by cyclogenesis frequency maxima over the hot land-masses, particularly, Spain, Italy, and the central CIS.

(2) Many new and typically summer features appear early in the season. They include a well-defined, zonal trajectory of cyclones in the eastern Atlantic (*Berry et al. 1954), a minor storm track off the west coast of the UK, and the disappearance of the tracks in southern Europe. In late summer, the hemispheric west wind belt is farther north than in any other month. The principal storm track is likewise farthest north, typically around 60° N over the Atlantic and Eurasia, with a secondary track at 70 to 80°N.

d. Autumn. The cyclogenetic centers of action begin their "march back to the sea." In early autumn, the principal storm tracks are still far to the north. The Icelandic region leads the hemisphere in the number

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Berry, F.A., G.V. Owens, and H.P. Wilson, 1954: Arctic Track Charts, *Proceedings of the Toronto Meteorological Conference, September 9-15, 1953* Amer Meteor. Soc., pp 91-102.

of lows per 5° quadrangle. Another seasonal feature is the marked increase in cyclone activity west of Norway, and north of Europe. Cyclone activity resumes, but weakly, over the Mediterranean. In mid-autumn, with the seasonal decrease of insolation, the land cools more rapidly than the water. Enhanced cyclogenesis occurs over the Black Sea, and the Gulf of Genoa. The main band of mid and upper-tropospheric westerlies begins to migrate southward. The increased wind speeds and intensifying north-south temperature gradients are accompanied by a greater frequency of cyclonic activity in the western Mediterranean. In late autumn, the primary storm track in the Atlantic shifts from the east, to the west side of Iceland, and a center of maximum cyclone frequency appears in the Denmark Strait.

3-21. Anticyclogenesis and Anticyclone Paths (Figures 3-14 and 3-15):

a. Winter. During winter over-land anticyclogenesis is the rule. Land/water temperature differences are then greatest. Migratory winter anticyclones are primarily of two types: those which originate in mid-latitudes and move eastward, and those which originate at high latitudes and move southward. The highs that break off the Azores ridge and enter western Europe, contribute to a primary track at about 50° N. The existence of this track is reinforced by anticyclogenesis in France, the Balkans, Russia, and Scandinavia. A few of the Azores offshoots make it to Spain and Algeria, where frequent anticyclogenesis shows as another primary track. This double anticyclone regime is associated with a double jet stream aloft, (polar and subtropical), characteristic of the winter season. In the south Atlantic, the primary anticyclone tracks are

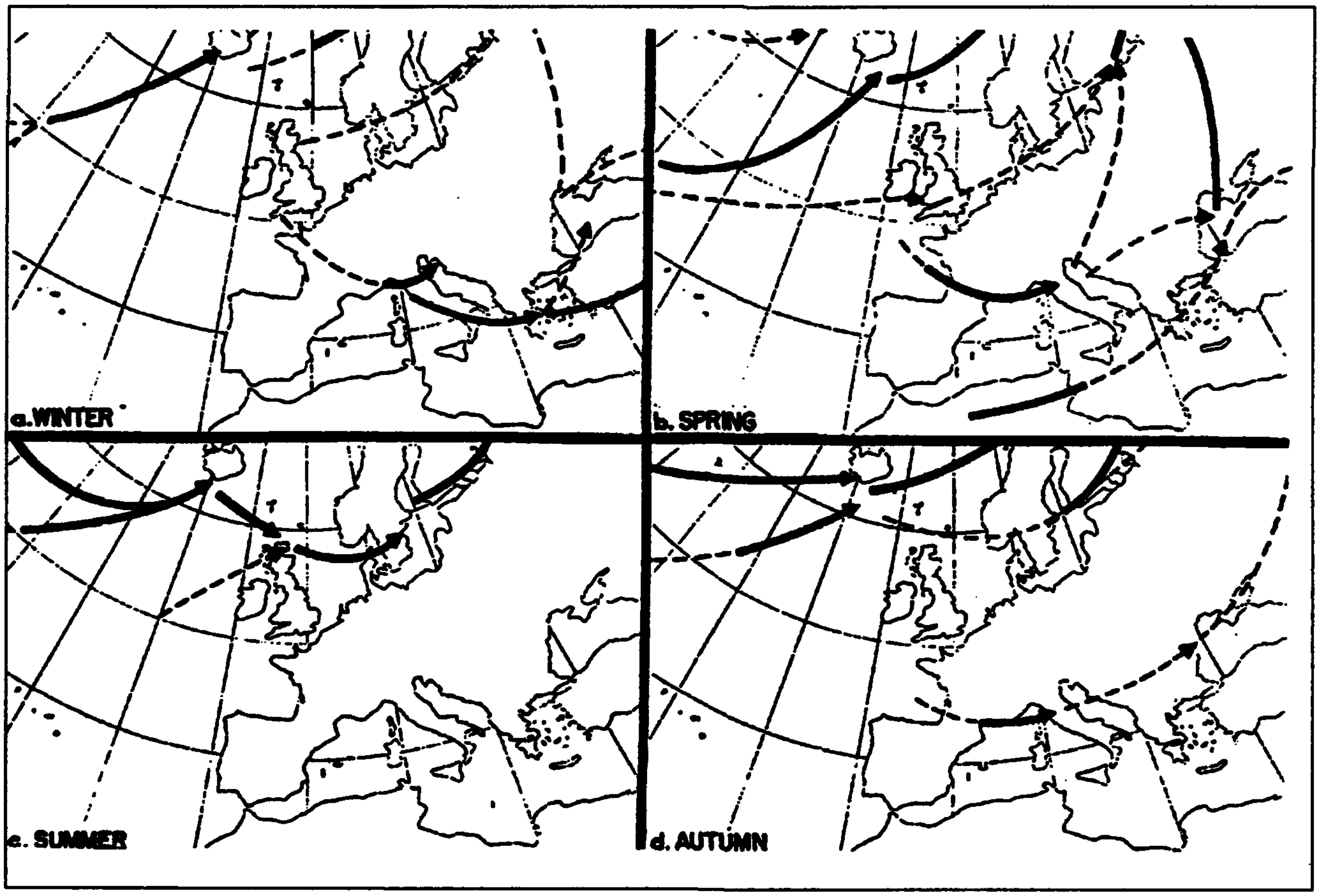


Figure 3-13. Mean Paths of Cyclones During: (a) Winter; (b) Spring; (c) Summer; (d) Autumn. Primary track (solid); secondary track (dashed).

farther south than during any other season.

b. Spring. During this season, increasing insolation starts to affect anticyclogenetic location. Centers of activity shift to over the cooler Baltic, Black, and the Caspian Seas. The primary track in North Africa is displaced northward to over the Mediterranean. The poleward shift of cyclone tracks becomes more extensive during May. Weakening of the low latitude westerlies accompanies the disappearance of the southern cyclone track in the Mediterranean. Farther north, the tracks through the Baltic and the Urals, become more significant.

c. Summer. Anticyclone tracks occur in a mostly zonal pattern across the Atlantic, between 40 and 55° N. The cooler water of the Mediterranean is associated with enhanced anticyclogenesis there. Similar effects are also seen over the other seas in the region. In Europe, the anticyclonic path at about 50° N becomes more coherent during mid-summer. This track is further enhanced by polar intrusions from the Norwegian or Greenland seas. Overall, the principal tracks of anticyclones, like cyclones are farther north during this season than during any other.

d. Autumn. A well defined anticyclone track still occurs across the Atlantic between 40 and 50° N. The summer primary northern European track is now secondary, and a sharp fall in anticyclonic frequency is noted over the seas. As autumn progresses, the anticyclone tracks start to migrate south everywhere in the Northern Hemisphere except over the North Atlantic. At the same time, new centers of anticyclonic activity appear over the cooling landmasses (like Algeria). By late autumn the spring/summer anticyclone track over the Mediterranean has shifted to North Africa.

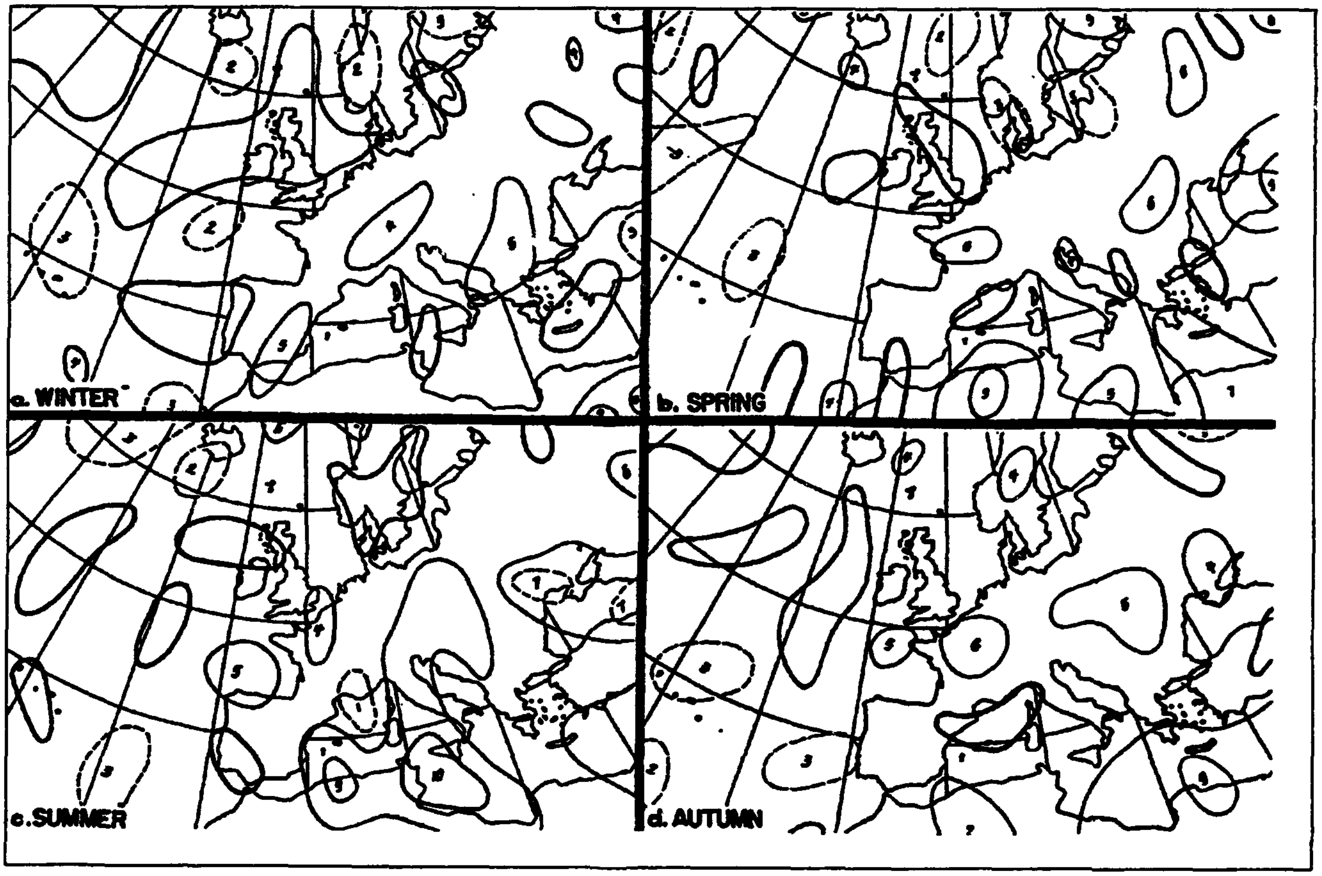


Figure 3-14. Mean Areas of Anticyclogenesis During (a) Winter; (b) Spring; (c) Summer; (d) Autumn.

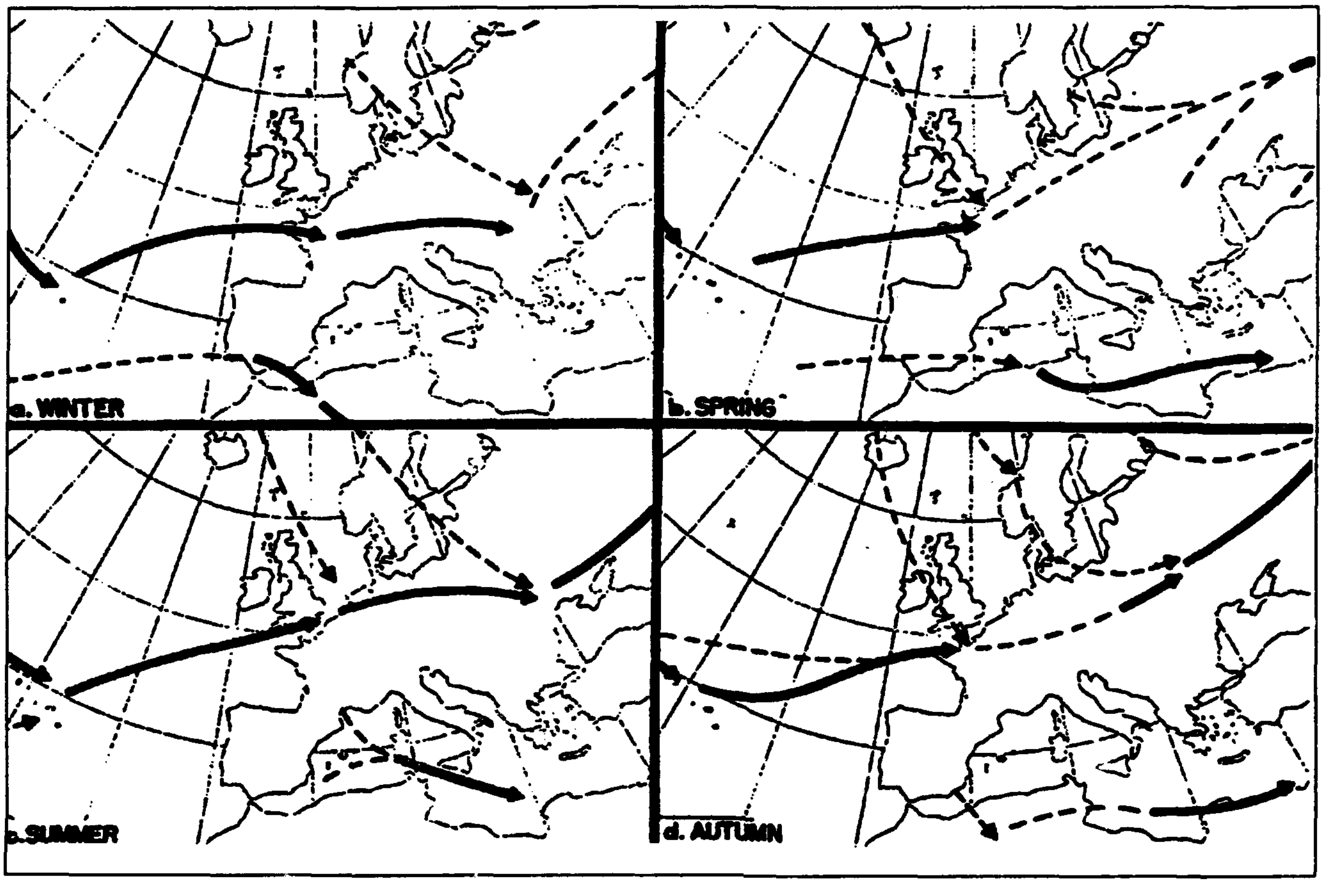


Figure 3-15. Mean Paths of Anticyclones During: (a) Winter; (b) Spring; (c) Summer; (d) Autumn. Primary track (solid); secondary track (dashed).

SECTION E - AIR MASSES

3-22. Introduction. Air masses are described by their moisture distribution: maritime (m), or continental (c). They are further classified by the thermal properties of their source region: arctic (A), polar (P), or tropical (T). (You may see them described still further as being colder (k), or warmer (w) than the surface over which they flow. General seasonal air mass sources are shown in figures 3-16 and 3-17.

3-23. Winter (Figure 3-16):

a. Maritime Polar Air (mP).

(1) During winter, the air over Europe north of 45° N usually comes from the eastern Atlantic. Source region and trajectory determine initial air mass stability. Air masses originating in the Greenland-Spitzbergen area reach northwestern Europe as cool unstable air masses. The instability is caused by both the original low tempera- ture (coming from the north), and by the low-level heat and moisture absorbed during the over-water fetch. On the other hand, continental polar (cP) air that departs North America, has more time to be modified by the warmer water it traverses. It arrives over northwestern Europe as a warm neutral, or slightly stable air mass. Usually, European mP invasions are characterized by warm temperatures, high relative humidities, and high frequencies of cloudiness.

(2) As the mP air mass moves over the winter European continent, it is cooled from below, becoming more stable. On occasion, in the rear of deep cyclones, the air may travel far enough south that it becomes unstable because of surface heating. This, however, is the exception rather than the rule. When mP air stagnates over land under the influence of an anticyclonic circulation, continuous radiational cooling from below produces a stable moist air mass, commonly with widespread low cloudiness and fog.

b. Maritime Tropical Air (mT). The winter source of mT air is restricted to the tropical portions of the central Atlantic. Due to the long over-water trajectory, they arrive over Europe with warm temperatures (55° F or 12 C) and very high, near-surface relative humidities. An over-land fetch cools the mT air from below, making it more stable than the mP air from the North Atlantic. Fog and drizzle are common.

c. Continental Polar Air (cP). The vast winter source region of cP air is the snow-covered regions of eastern Europe and the CIS north of 45° N. These air masses are characterized by unusually low surface temperatures, low humidities and stable lapse rates. CP air masses absorb heat and moisture from the existing underlying surface or air mass, often producing stratocumulus clouds.

d. Continental Tropical Air (cT). These warm dry air masses originate over North Africa. They usually move only as far north as the Mediterranean region, advected northward in advance of migratory cyclones. Passage over the Mediterranean cools the cT air mass and adds moisture, so the air is warm and moist upon reaching Italy and the Aegean Sea.

3-24. Summer (Figure 3-17):

a. Maritime Polar Air (mP). During summer mP outbreaks produce mild weather over northwest Europe, north of 45° N. Slow passage over land in the weak wind regime allows the air masses to be heated from below, decreasing stability, and cumuliform clouds are common. When flow is toward the sea, the air mass is cooled and moistened from below, causing widespread cloudiness and fog over the water. This regime is common over the North Sea in early summer.

b. Maritime Tropical Air (mT). These air masses are common in summer when the extension of the Azores ridge lies over Europe. In summer, mT air masses are cooler than the land over which they flow. This makes for occasionally steep daytime lapse rates in the lower levels, especially inland. With the pronounced stability in the eastern portion of the ridge, however, convection is discouraged.

c. Continental Polar Air (cP). During summer, these air masses are confined to the northern latitudes, and are generally characterized by low temperatures and humidities.

d. Continental Tropical Air (cT). In summer, the continental region south of about 45° N is source region for these air masses. All cT air masses are very warm and convectively unstable. Cumulus clouds and thunderstorms occur when enough moisture is mixed into the cT air.

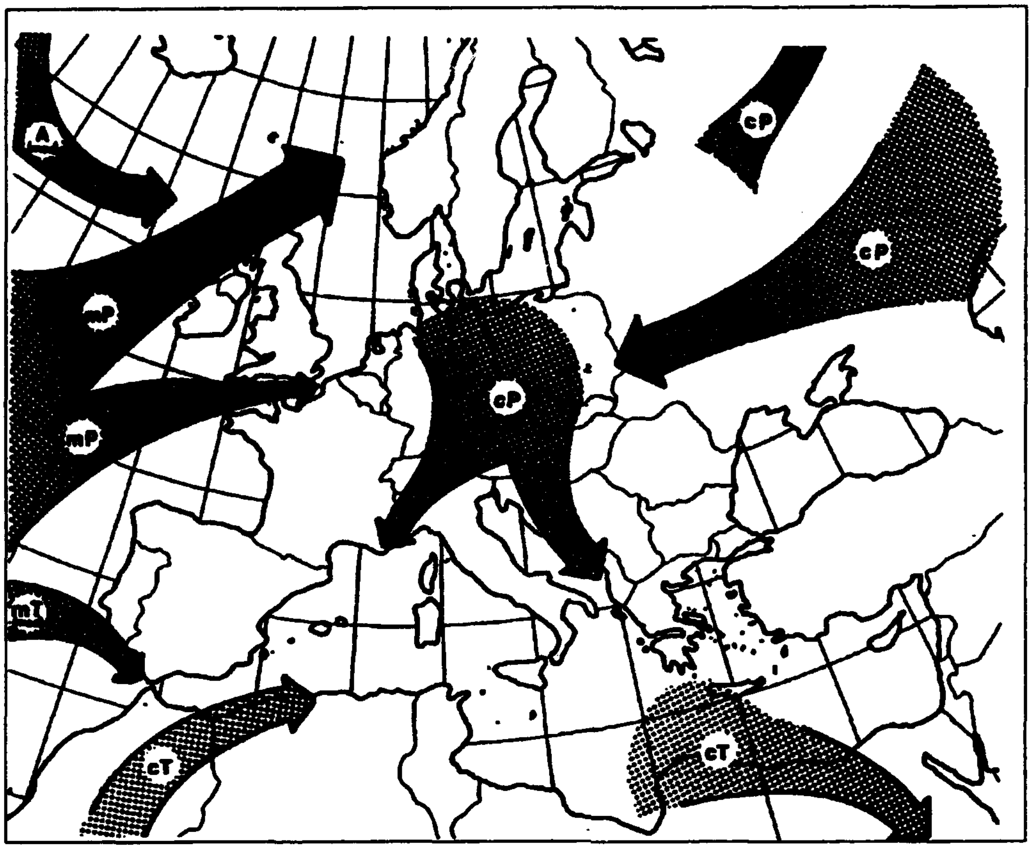


Figure 3-16. Winter Air Mass Source Regions, Type and Movement.

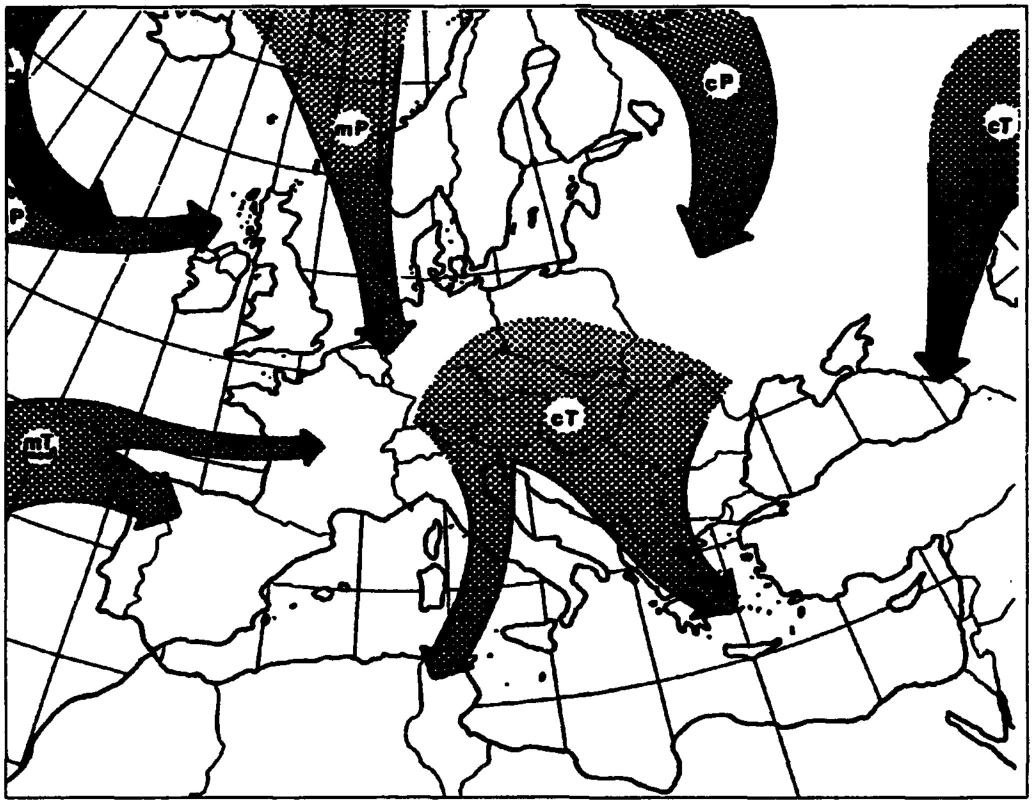


Figure 3-17. Summer Air Mass Source Regions, Type and Movement.

SECTION F - UPPER WINDS

3-25. Introduction. Europe lies in the band of the mid-latitude westerlies. The mean flow at most locations is westerly. Migratory systems imbedded in the upper air wind band, however, cause frequent and large deviations deviations from the mean direction. In all seasons there is over Europe, a reduction in the gradient of wind speed seen over the eastern Atlantic. Likewise, there is a weak mean trough (strongest in autumn and spring) positioned over southern Europe and the western Mediterranean (see figures 3-18 through 3-21).

3-26. Jet Streams. Two jets frequent the European theater: the subtropical jet (STJ), and the polar front jet (PFJ) (see figure 3-21).

a. The STJ appears on mean charts near the 200 mb level. In January, over North Africa, highest mean wind speeds (110-120 kt) occur at about 25° N. During summer the STJ is occasionally visible over the Mediterranean but has weakened considerably.

b. The PFJ occurs farther north than the STJ and is usually strongest near the 300 mb level. The general flow is northwesterly over western Europe, turning to west-southwesterly over eastern Europe. Winter-time PFJ wind speeds above 150 kt are infrequent in this theater, while in summer average speeds decrease to less than 80 kt.

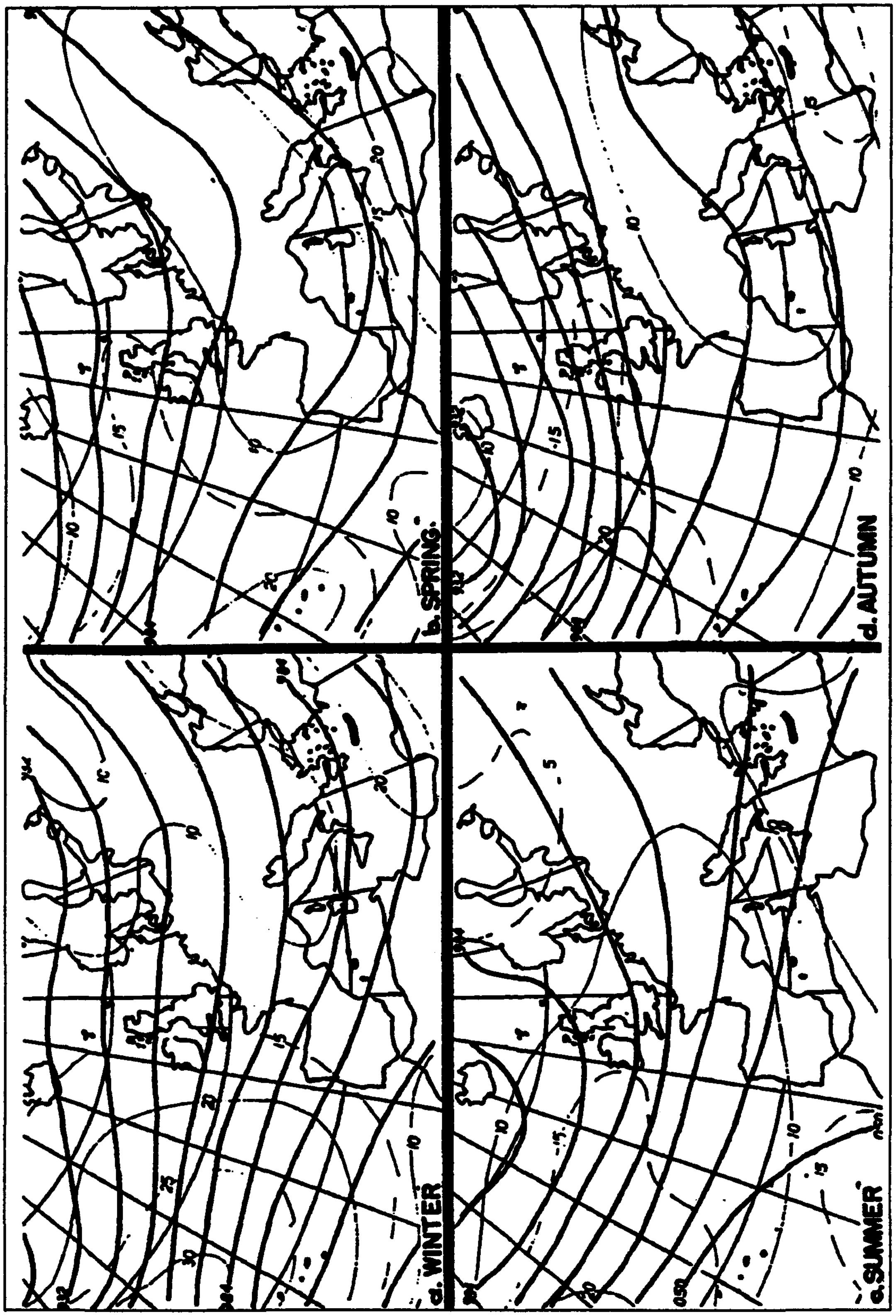


Figure 3-18. Mean 700 mb Flow by Season; (a) Winter; (b) Spring; (c) Summer; (d) Autumn. Heavy lines are contours. Light lines are isotachs.

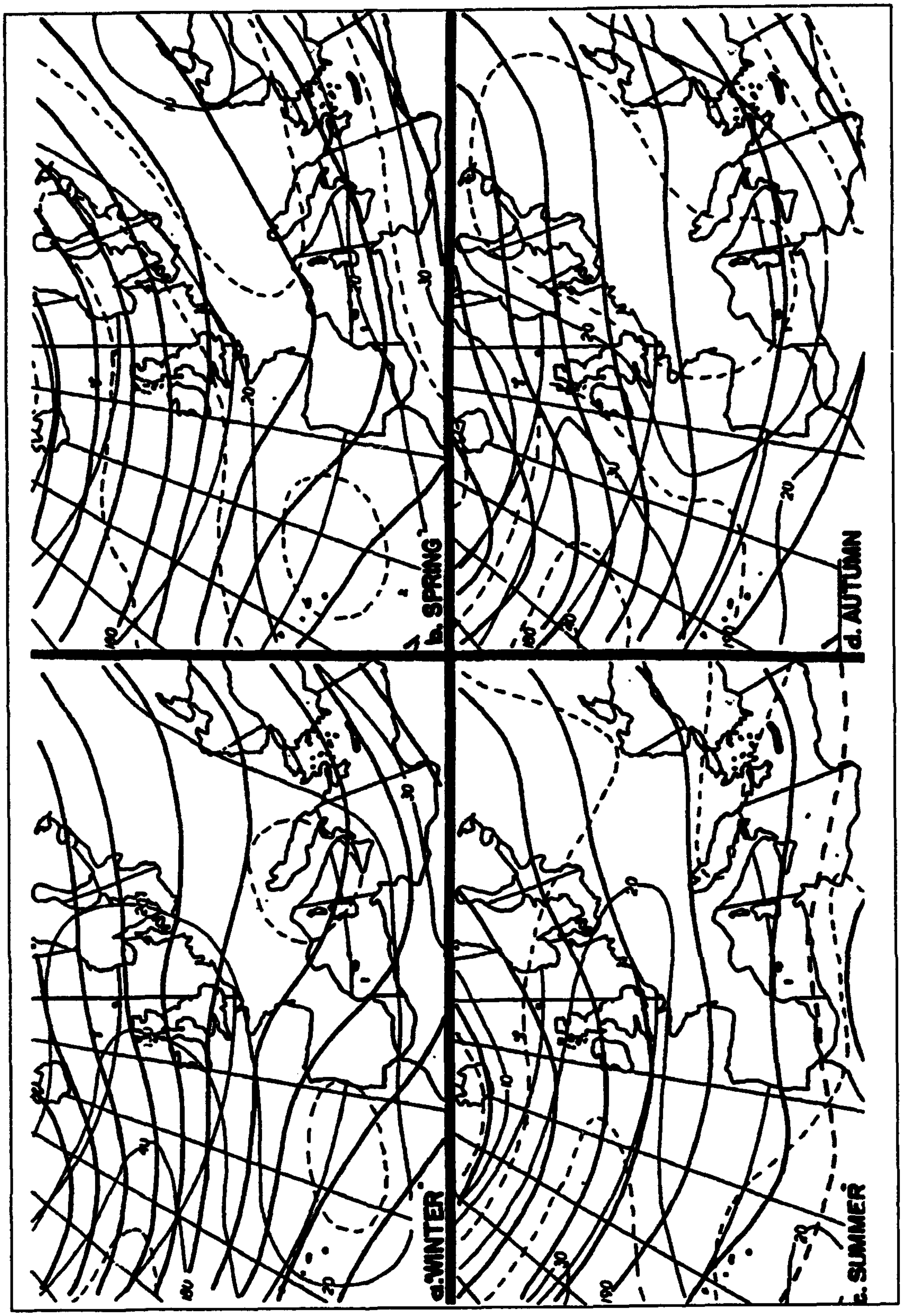


Figure 3-19. Mean 500 mb Flow by Season; (a) Winter; (b) Spring; (c) Summer; (d) Autumn. Heavy lines are contours. Light lines are isotachs.

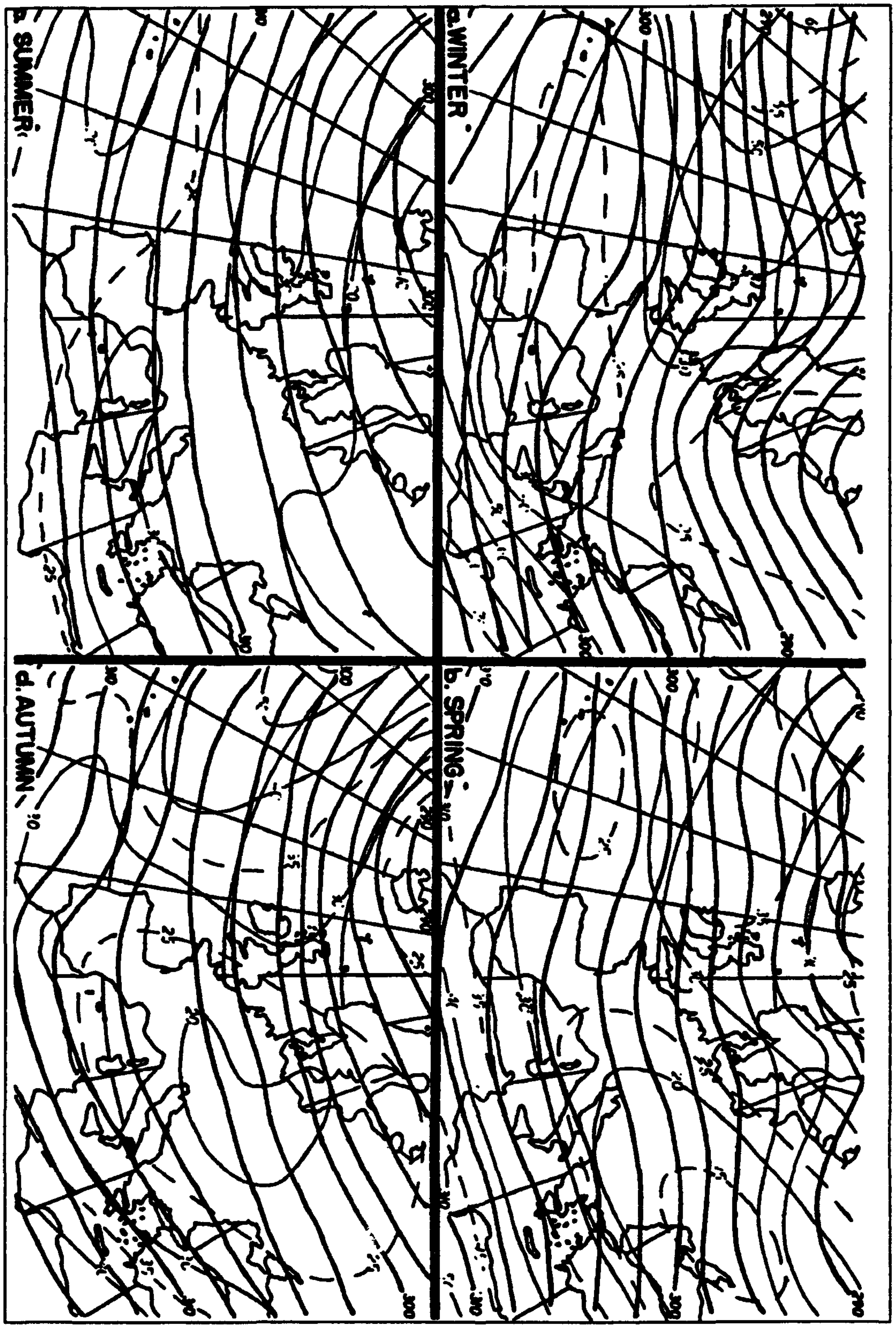


Figure 3-20. Mean 300 mb flow by Season; (a) Winter; (b) Spring; (c) Summer; (d) Autumn. Heavy lines are contours. Light lines are isotachs.

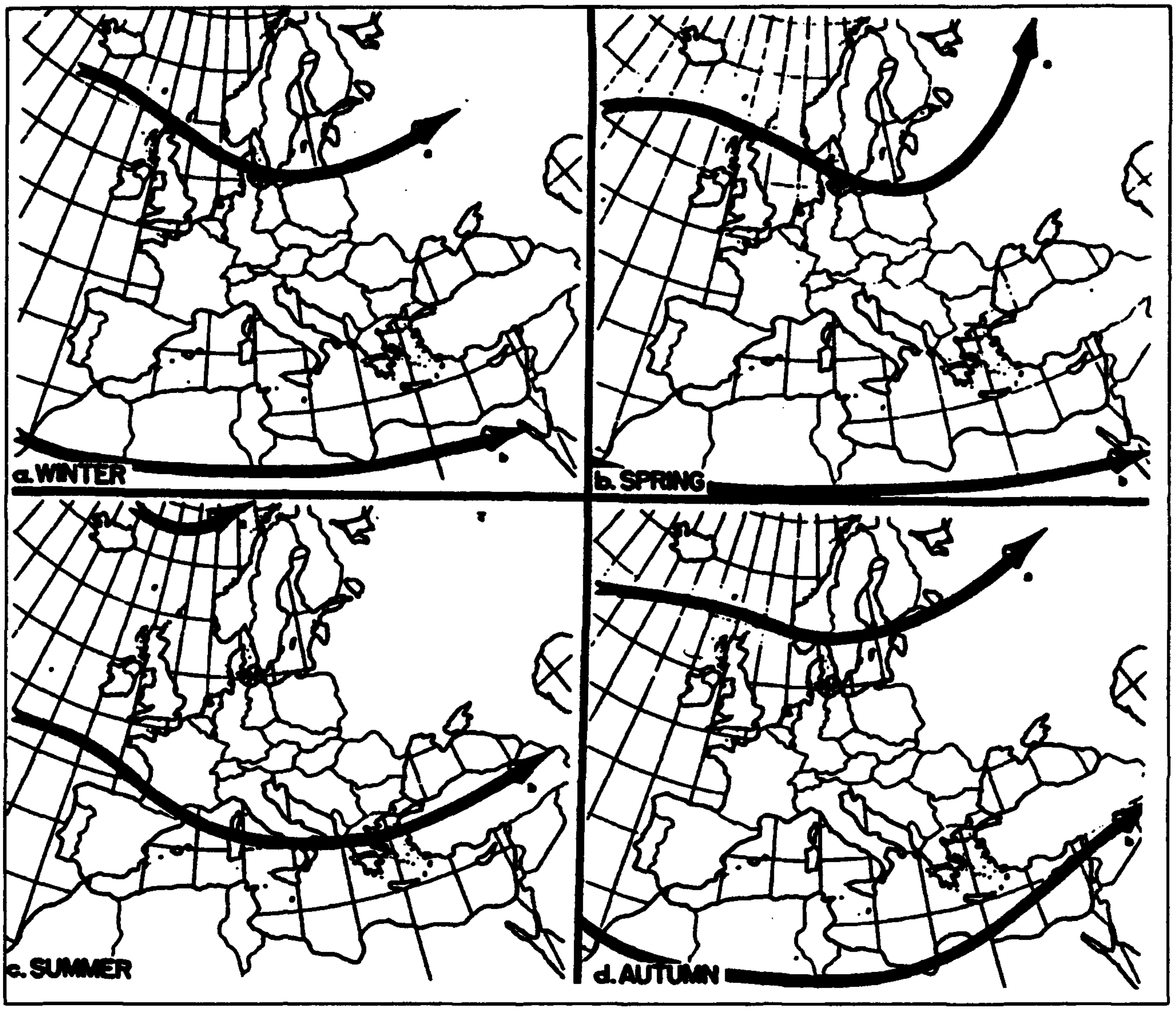


Figure 3-21. Mean Positions of the Polar Front Jet and the Subtropical Jet During: (a) Winter, (b) Spring; (c) Summer; (d) Autumn.

CHAPTER 3 REVIEW QUESTIONS

1. What is the primary reason for the mildness of the European climate?

2. Why can the mean alone not be used to describe a region's climate.

3. Why do coastal locations have less snow on average than inland areas?

4. Why do northern European regions have anomalously warm temperatures?

5. Name the four major synoptic features that affect the European theater.

6. What can be said of the average weather north of the Alps, in comparison to stateside weather.

7. What factors contribute to the motion of atmospheric pressure systems?

8. Name a climatic factor that contributes to genesis of pressure systems.

9. What are the three storm paths over the European theater?

10 What are the primary locations for cyclogenesis during summer?

11. What are the winter source regions of mP air.

12. What is the primary region influenced by cT air in winter?

13. What type air mass enters the Mediterranean during a bora event?

14. What is the predominant wind direction of upper air flow over the European theater?

Chapter 4

SIGNIFICANT WEATHER

4-1. Introduction. This chapter deals with the significant weather affecting the European Theater. We should define our use of the term significant. If you are arriving here from stateside, you may associate it with severe weather. Though there is considerably less severe weather, on average, here than in the states, there is generally more weather that will hinder your customer's operations. We define significant in that context. This chapter is laid out with a short climatology of the event, followed by some forecasting hints.

SECTION A - FOG AND STRATUS

4-2. Introduction. From autumn through early spring, fog is a serious hazard to surface as well as air travel over most of northern and central Europe. Thus, it is the primary forecast problem of the European forecaster.

a. Fog over the interior regions is usually either the radiation or the radiation-advection type, forming under the domination of a cold anticyclone. Upslope fog, advection fog, pre-frontal fog, and sea fog account for most of the remainder of fog events. Often, during the European winter, low sun angles and short daylight periods do not provide enough solar energy to dissipate the fog.

b. Fog frequency and season of occurrence vary widely by location. Figure 4-1 shows the mean number of fog days, by month, at selected European and Mediterranean locations.

4-3. Types of Fog. There are basically three types: advection, mixing, and radiation. They may occur singly or together. For instance, you have radiation fog and warm moist advection is occurring over your station. The radiation fog problem will be compounded by the advection. The following are more detailed descriptions of the basic types as well as combination fogs.

a. Advection Fog. Moist air saturates when radiationally cooled from below, or when mixed with the cold air already in place. Advection fog is more common than radiation fog in coastal regions. Clear skies and snow cover are less common there, so conditions are not favorable for strong radiational cooling. In Europe, advection fog frequency is greatest in late winter and early spring, when land/water temperature differences are greatest.

b. Freezing Fog. Actually just advection fog when the surface temperature is less than 3 C. Usually happens when warm moist air advects over a near or sub-freezing surface.

c. Frontal Fog.

(1) Prefrontal Fog. Occurs over the widespread areas of warm fronts, caused by the evaporation, of precipitation into colder air. Fog forms when the cold air reaches saturation.

(2) Postfrontal Fog. After frontal passage, standing water from previous rainfall evaporates, then condenses into the cold air behind the front.

d. Ice Fog. Usually man-made fog, it occurs when moisture, trapped beneath a low-level inversion condenses on aerosols. By definition, ice fog only occurs when temperatures are less than -20° F.

e. Radiation Fog. It forms when the temperature of stagnant air in contact with the ground, is cooled to its dew point by nocturnal radiation.

NOTE: In mountainous terrain, night-time radiational cooling in the valleys is greater because of the apparent earlier sunset and later sunrise caused by the mountains. The formation of freezing fog is similar, but after condensation, droplets freeze onto objects whose temperatures are below freezing. See figure 4-2 for a typical synoptic situation bringing fog to central Europe.

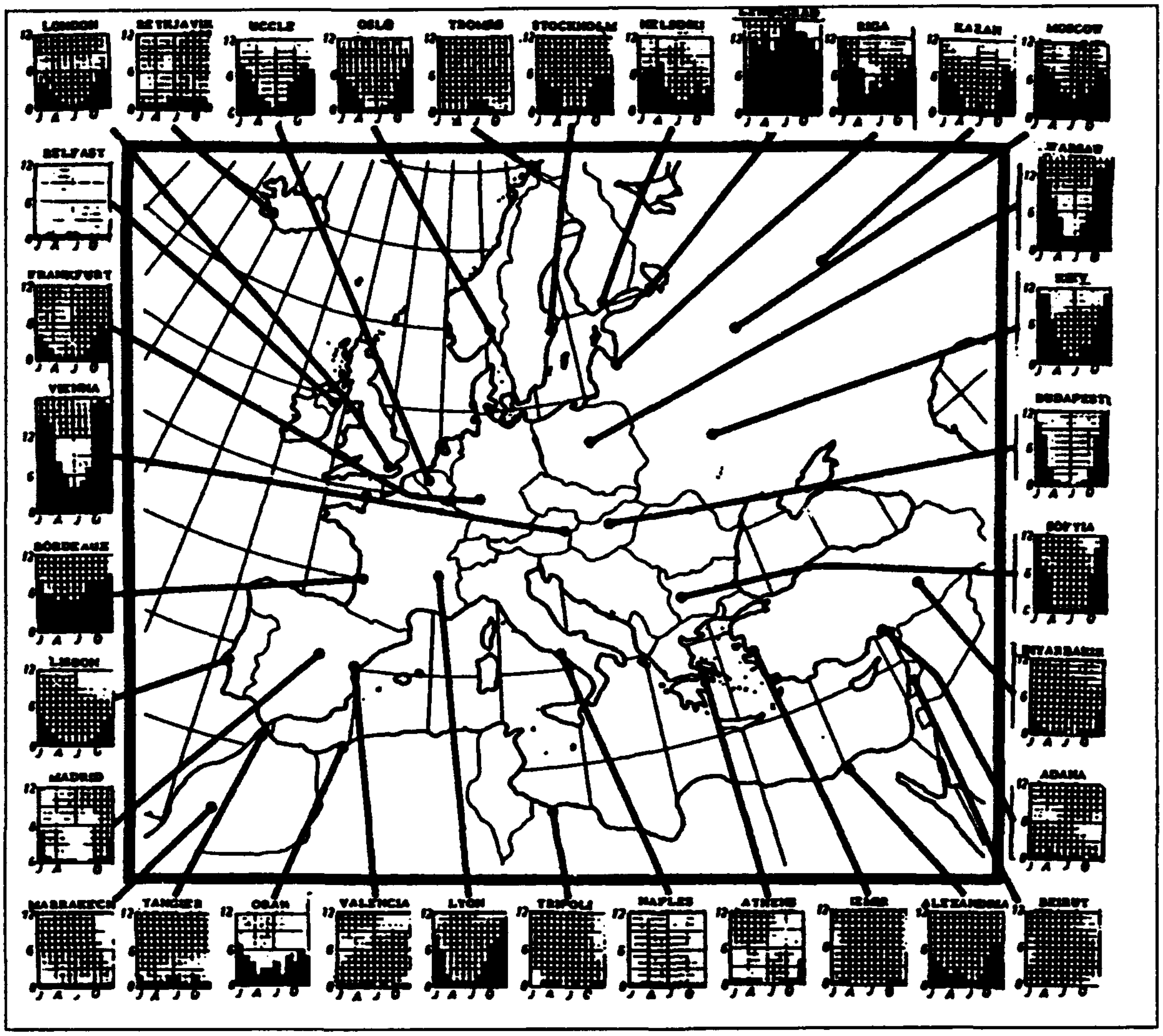


Figure 4-1. Average Number of Fog Days per Month at Selected Locations.

f. Sea Fogs. A form of advection fog, it forms when warm moist air is cooled to saturation during passage over cold water. There are some unique mechanisms attendant to its formation. The dew point should be equal to or warmer than the sea temperature to encourage widespread formation. Normally as the air travels over the water, the dew point stays the same or decreases slowly, while the temperature drops more rapidly. Saturation is rapidly achieved. If both the temperature and dew point are still warmer than the sea, a low level inversion develops. This provides additional stability necessary to create and sustain sea fog. Sea fog may advect back onto coastal areas, but on losing moisture support, breaks up a few miles inland. (For instance, RAF Bentwaters can get sea fog on a day when Mildenhall will not.)

g. Steam Fog. When very cold air blows over a water source, the underlying water evaporates into it, and condenses. With a low-level inversion in place, visibility can be decrease to less than 300 m.

h. Upslope Fog. Air, forced up a slope, cools adiabatically, and condenses if saturation is reached.

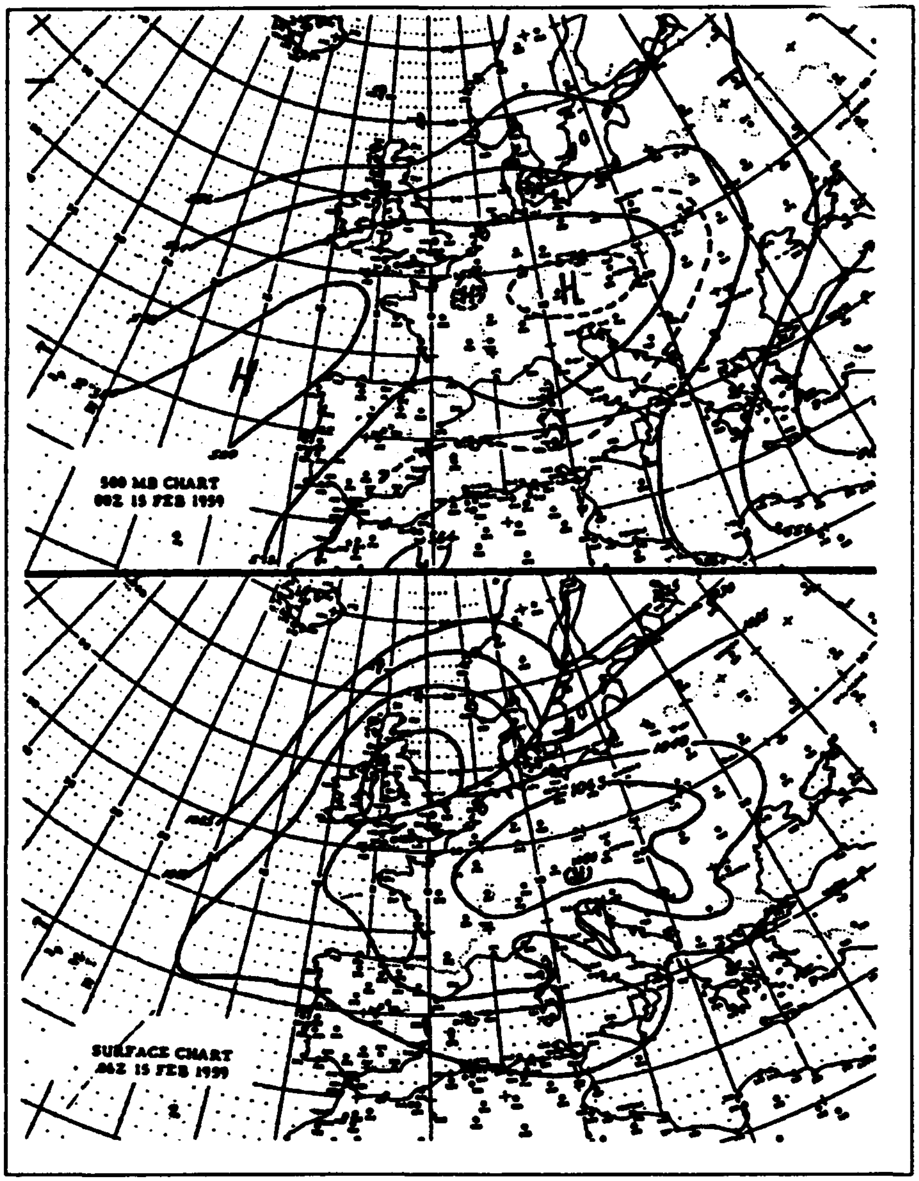


Figure 4-2. Typical Synoptic Situation Accompanying the Occurrence of Widespread Fog Over Central Europe.

4-4. Ingredients. There are three key factors necessary for the formation of radiation fog:

a. Clear to Scattered Skies. At night, this permits the radiational cooling needed. (It could also occur if you have a thin cirrus deck.) Cooling occurs faster near the surface, setting up an inversion. If clouds are present, some of the radiation is reflected back down, keeping temperatures above the dew point. Fog does not form or formation is limited. But without clouds, cooling can continue until the air near the surface is cooled to the point of saturation.

b. High Humidity. The most persistent fog is associated with inversions in both temperature as well as hydrolapse (dew-point curve). With only a temperature inversion, you may see haze, with patchy fog formation near water sources.

(1) An ideal fog situation occurs when there are rain or showers during the day, followed by clearing at night. The lower layers of the atmosphere are both cooled and approach saturation as precipitation

evaporates into them. When the sun goes down you lose sensible heat. It will take only a small temperature drop to saturate the lower layers. In post-frontal situations, you must determine if the drier air will get to your station fast enough to stop fog formation. to stop fog formation.

(2) For evaluation of moisture between surface and 850 mb, use the twice daily RAOB reports. They report "second standard level" data at the end of the TTBB section. The sequence is 52525 92hhh ttdd dddff. The height of the second standard level varies with field elevation, but will be the same for each report for that station. The FJUE trajectory bulletins also report second standard level data. These products provide additional tools to observe low level inversions.

c. **Light Winds.** From the surface to 2000 ft, ideally less than 10 kt. Light winds create enough turbulent mixing to increase the thickness of the cold layer of surface air and permit the fog to spread through a deeper layer. Winds greater than 10 kt can lift fog, turning it into a stratus deck.

d. **Other Factors.** Unlike the above three, these do not have universal applicability. They include upslope/downslope, proximity to water, soil type, time of year, air pollution sources, shape of flow (cyclonic or anticyclonic curvature). The importance of each of these is best determined locally.

4-5. Stratus. Clouds which are associated with a stable atmosphere in which vertical currents are very light. Bases and tops usually occur at the level where relative humidity exceeds 65%. Straight or slightly cyclonically curved contours help maintain stratus clouds. Stratus can range from tens of feet to several thousand feet in thickness.

a. **Dissipation of Stratus.** The Navy Aerographer's Mate Manual suggests forecasting 360 ft of stratus dissipation per hour of heating. For example an 1800 ft thick deck would take about 5 hours to burn off.

b. **Alternate Method.** The above rule of thumb is ineffective during the European winter months. Then, low sun angle and short day length don't provide enough heat to burn off the stratus. What follows is a modified calculation, better suited to the theater.

(1) Computation: Using a representative sounding, determine average mixing ratio between the surface and base of inversion. If no sounding is available, use the cloud base as determined by observation. Extrapolate the top of stratus using head-up display (HUD) or using nearby observations (or PIREPS).

(2) Project the average mixing ratio upward through the sounding.

(3) The intersection of the average mixing ratio with the temperature curve gives the base and top of the stratus layer. Note also the dew point depression will be between 0 and 3°C between the base and the top of the deck.

(4) Follow a dry adiabat from the base of the stratus deck (or the first intersection from the previous step) to the surface. This is the temperature at which the deck will start to dissipate.

(5) Follow a dry adiabat from the top of the stratus layer down to the surface. This is the temperature at which the deck will totally dissipate.

(6) Using either a diurnal temperature curve, or the Skew-T, forecast the possibility of reaching either or both of the two temperatures. Once the base temperature is reached, for each hour of heating, you lose 360 feet of stratus. If forecast temperatures are not forecast to exceed the top temperature, the stratus will stay. Another caveat; be careful of other cloud cover and/or low-level cold air advection, which will retard the burn off process just described.

4-6. Rules and Hints for Fog and Cloud Forecasting:

a. If you expect precipitation, then clearing, and the ridge axis is upstream, consider forecasting fog. This of course is dependent on time of day, season, strength of the ridge, etc. Local thumb rules are beneficial here. Consult your TFRN.

b. An increase at the 850 mb level of 3-5° C and a slight cooling at the surface, sets up the inversion layer. Watch the TAF worksheet values the strength of the upstream ridge axis.

c. In central Europe, forecast the fog to last all day if it has not broken by the following times:

(1) September: 09Z
(2) October: 10Z
(3) December: 12Z
(4) January: 11Z
(5) February: 10Z

Note burn-off times are the same as the number of the number of the month, except January and February.

d. 850 mb winds greater than 15 kt are a good no fog predictor.

e. If you had fog yesterday (and synoptic picture hasn't changed much,), forecast it today. (Verified 70% at EDOC).

f. A change from anticyclonic to cyclonic flow overhead is the first indicator of the end of a fog regime.

g. During September, watch for southerly or southeasterly flow when the 850 mb temperature is at or greater than 15° C, and 850 mb winds are less than 15 kt.

h. If the 850 mb temperature is higher than your previous day's maximum temperature, there is a good chance that if fog occurs, it will stay until the flow regime changes.

i. Baur types WA and HM, similar to figure 4-2, are famous for fog.

j. Use 2WW Tech Note 79-008 (Fog Index). The lower the index, the higher chance of fog. (< 31: Forecast it; 31-55: Think seriously; > 55: doubtful.) Try substituting the maximum inversion temperature, maximum surface temperatures and dew-points.

k. Dew point depression for cloud layers:

0-2° C:	Overcast with possible precipitation
2-4° C:	Scattered to Broken Clouds
>4 ° C:	Clear to Scattered

l. Relative Humidity Values and Cloud Cover:

%	Cloud Cover in eighths
< 65%	0
70%	1-2
75%	3
80%	4-5
85%	6-7
90	8

4-7. UK Radiation Fog Case Study:

a. What follows is a typical chart sequence that led to dense persistent fog. Figure 4-3 shows the 12Z surface analysis from 11 October 1986. A ridge is pushing into the southern UK. No fog formed. Why not?

b. The earlier 11/00Z 850 mb analysis (figure 4-4) gives some clues. A cold front had moved through the area earlier that evening. Though the air behind the front was colder, it was too dry for fog formation.

c. Figure 4-5 shows the 11/00Z sounding from Hemsby, which provides another clue. There is a small temperature inversion just off the ground, but there was no supporting dew-point inversion. The moist layer was too shallow to support fog formation.

d. As stated earlier, a cold pocket can inhibit the formation of very dense fog. Note on the 12/00Z 850 mb analysis (figure 4-6), the packing of warmer isotherms to the south.

e. Figure 4-7 shows the 12/00Z Hemsby sounding. This time, there is a stronger temperature inversion and a slight dew-point inversion. This is enough to restrict visibility somewhat but not enough to keep it down. The temperature required to break the inversion was 12° C. Most locations had 14+° C by noon.

f. Figure 4-8 shows the surface analysis of the 12th at 12Z. Note the ridge centered over central Europe. East Anglia is under southerly flow. Some areas had patchy morning fog, but most locations broke out by noon.

g. Figure 4-9 shows the 13/00Z 850 mb analysis. During the night strong warm air advection (WAA) took place at the lower levels. This was no longer just a radiation fog only event.

h. Figure 4-10 shows the Crawley 13/00Z sounding. The low-level WAA has made both the temperature as well as the dew-point inversions much stronger today. Note that by tracing the inversion temperature down a dry adiabat to the surface, you get 16° C. Tracing the top of the dew-point inversion to the surface, moist adiabatically, yields 14° C. Some stations started breaking out at 14° C. Remember, you start to break out when you exceed the dew point temperature at the top of the inversion. The fog is gone by the time you break the temperature inversion.

i. Figure 4-11 shows the 13/12Z surface analysis. Most stations were still down, some as low as 500 m. Reference: 2 WW/TN-79/008

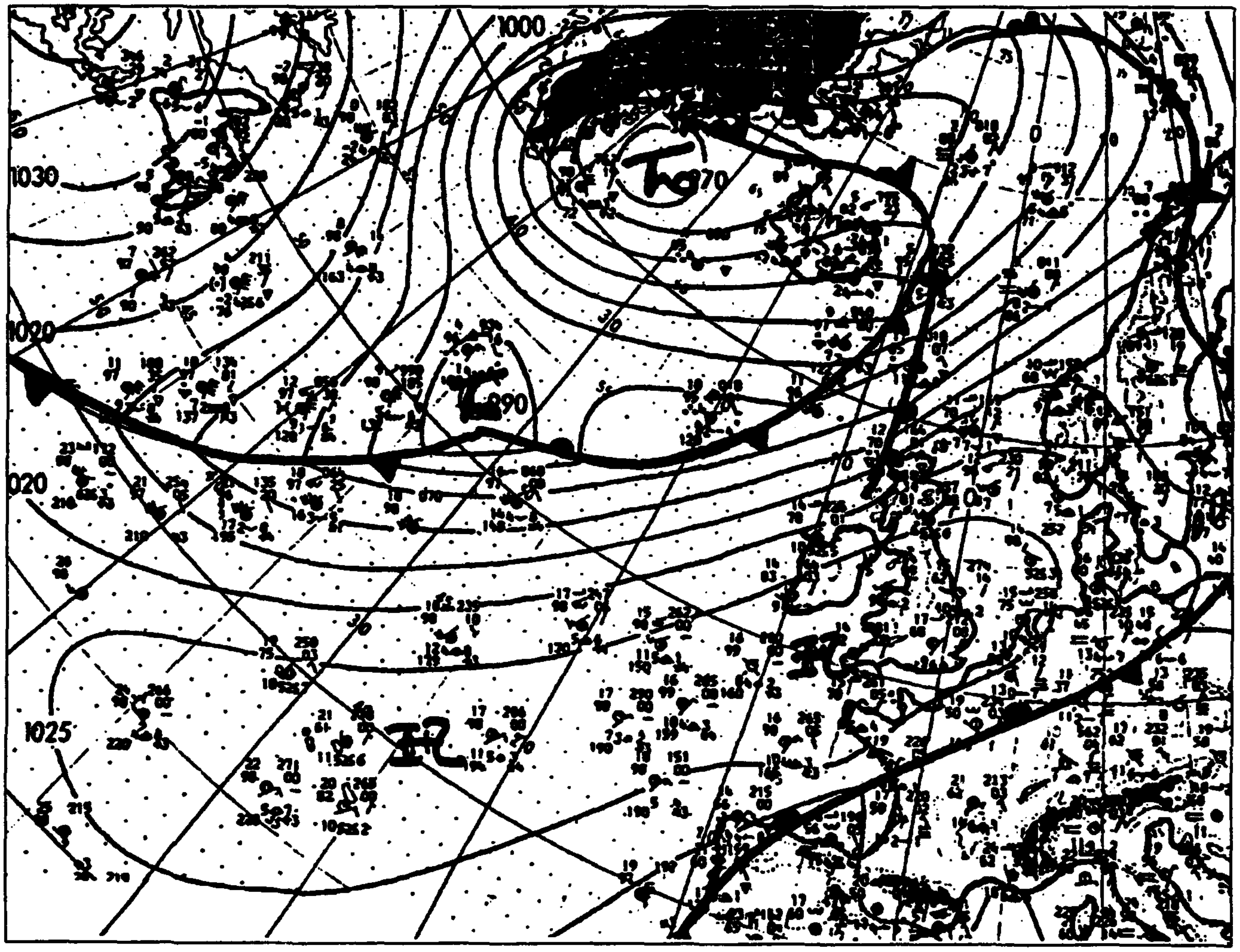


Figure 4-3. 1200Z 11 October 1986 Surface Analysis.

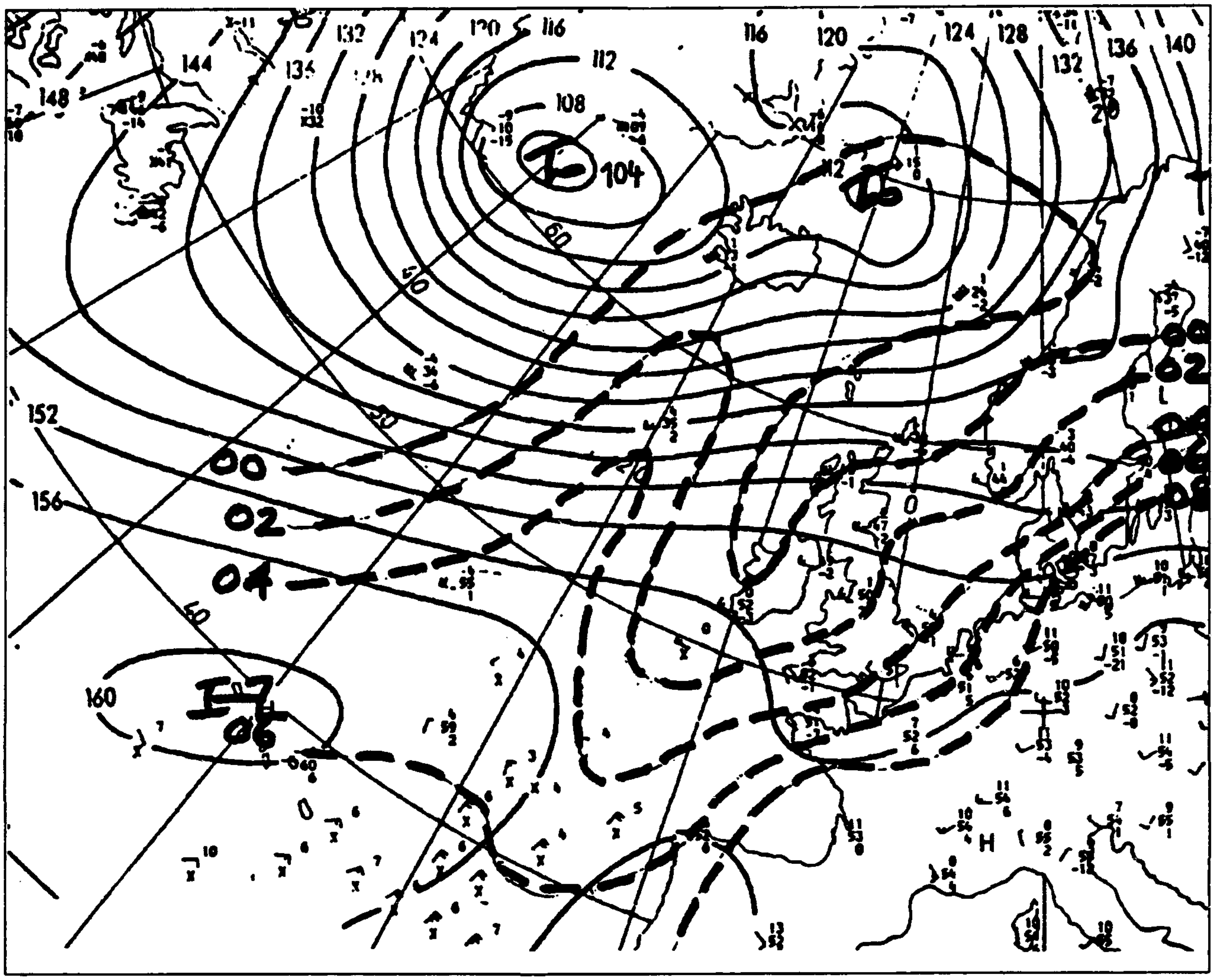
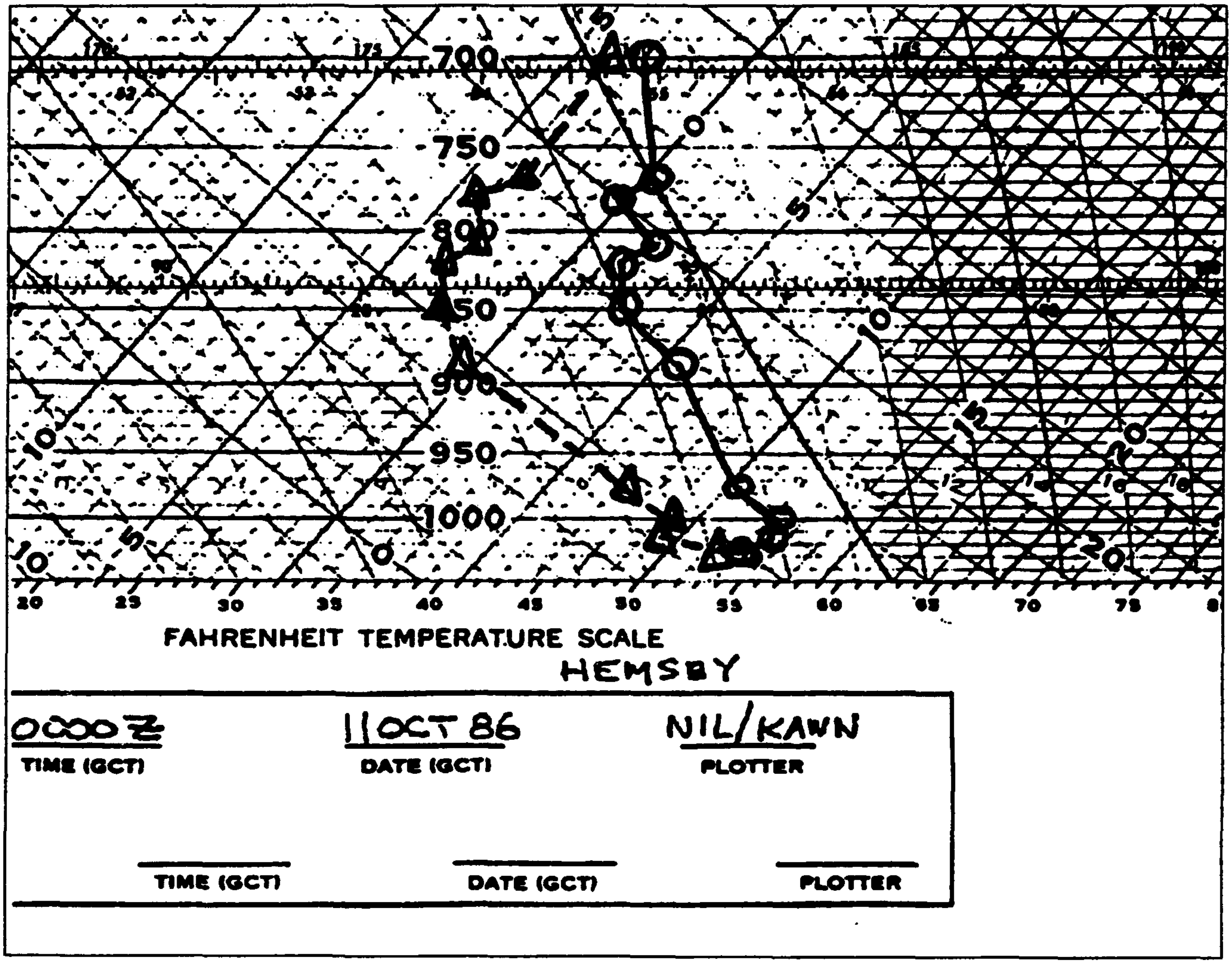


Figure 4-4. 0000Z 11 October 1986 850 mb Analysis.



HEMSBY

0000Z	11 OCT 86	NIL/KAWN
TIME (GCT)	DATE (GCT)	PLOTTER
TIME (GCT)	DATE (GCT)	PLOTTER

Figure 4-5. 0000Z 11 October 1986 Hemsby Sounding

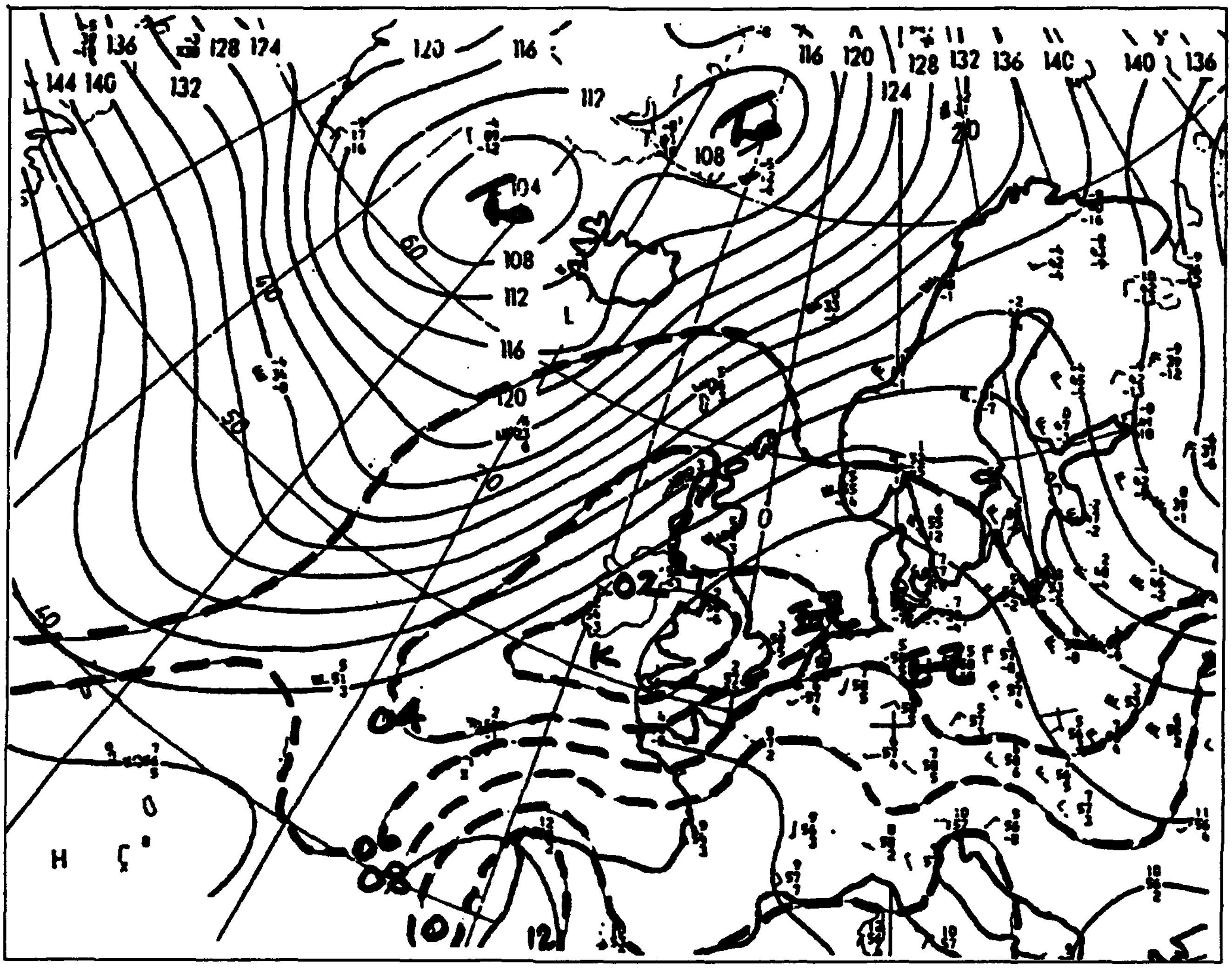
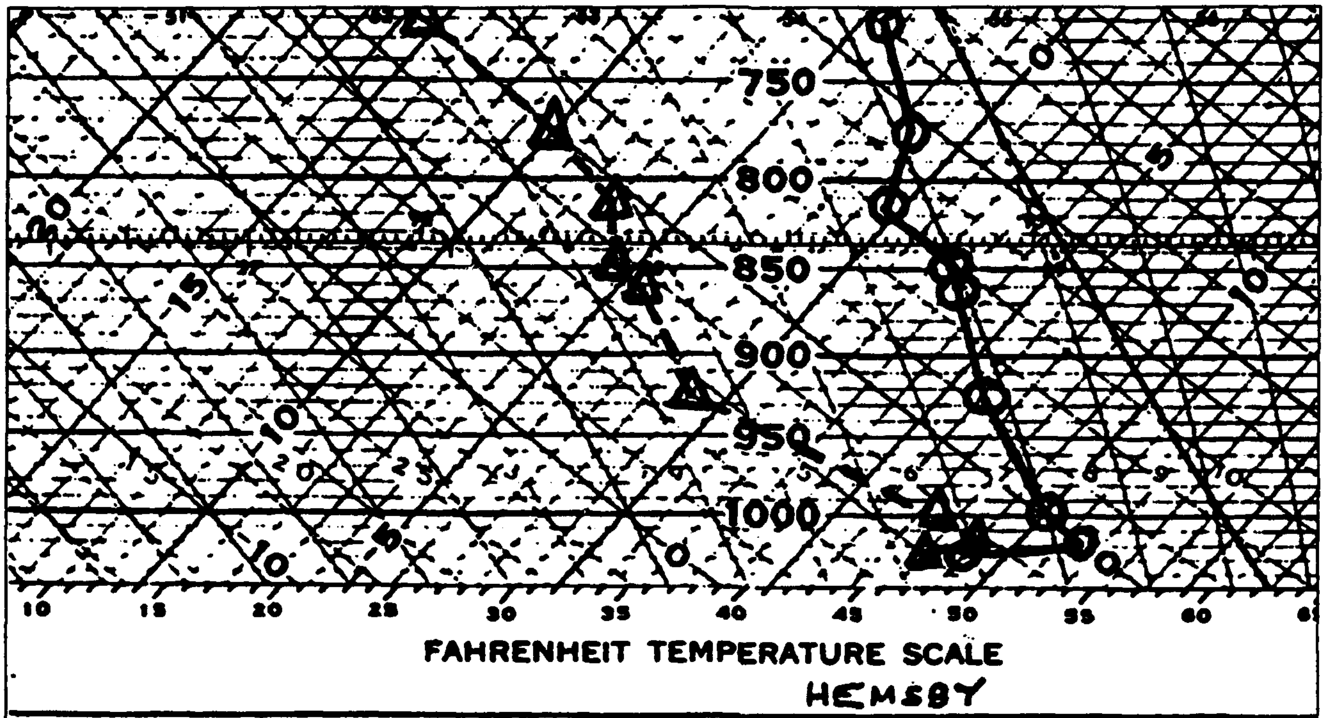


Figure 4-6. 0000Z 12 October 1986 850 mb Analysis.



0000Z	12OCT86	KQXX
TIME (GCT)	DATE (GCT)	PLOTTER

PLOTTER	TIME (GCT)	DATE (GCT)	PLOTTER

Figure 4-7. 0000Z 12 October 1986 Hemsby Sounding.

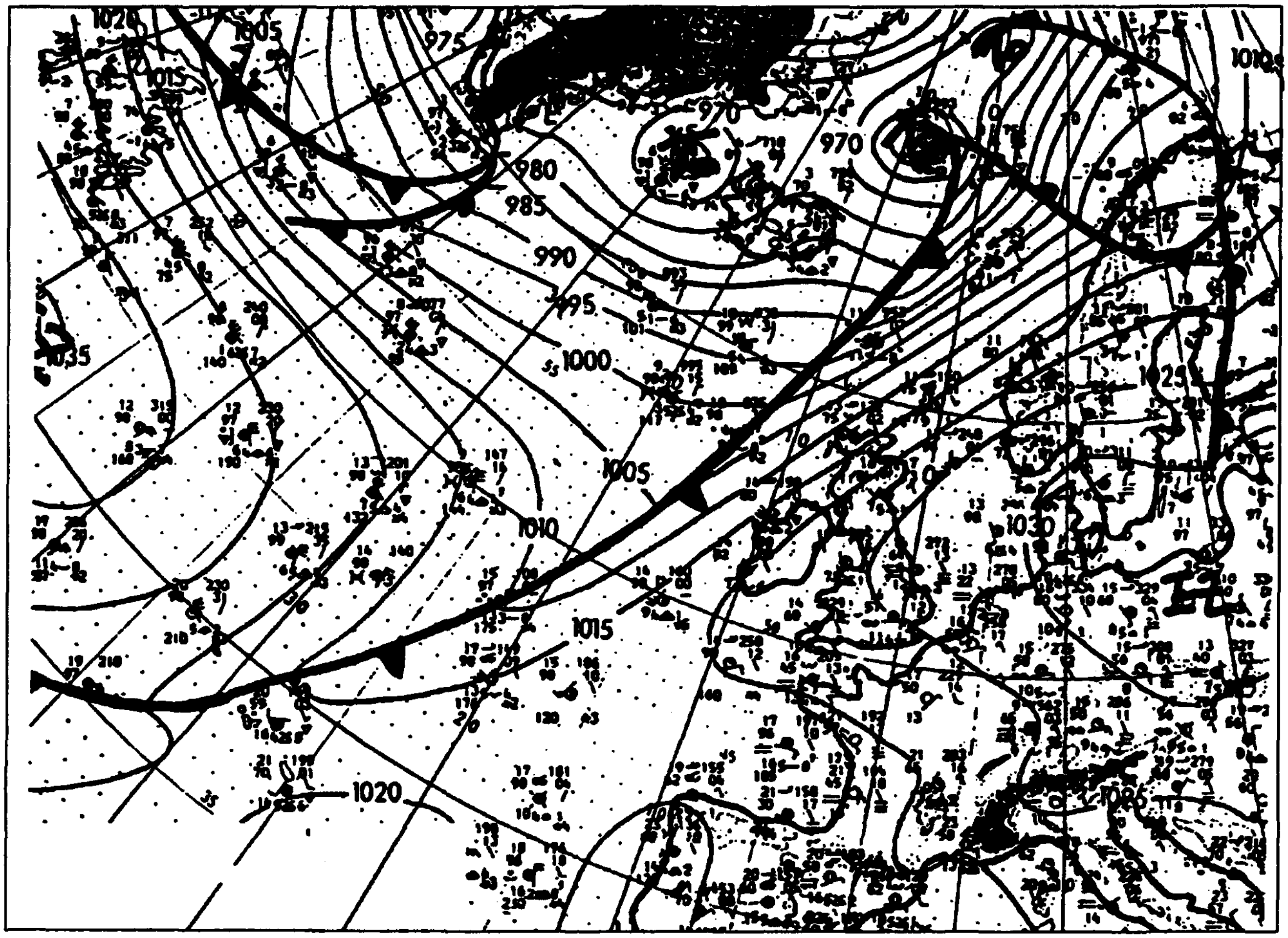


Figure 4-8. 1200Z 12 October 1986 Surface Analysis.

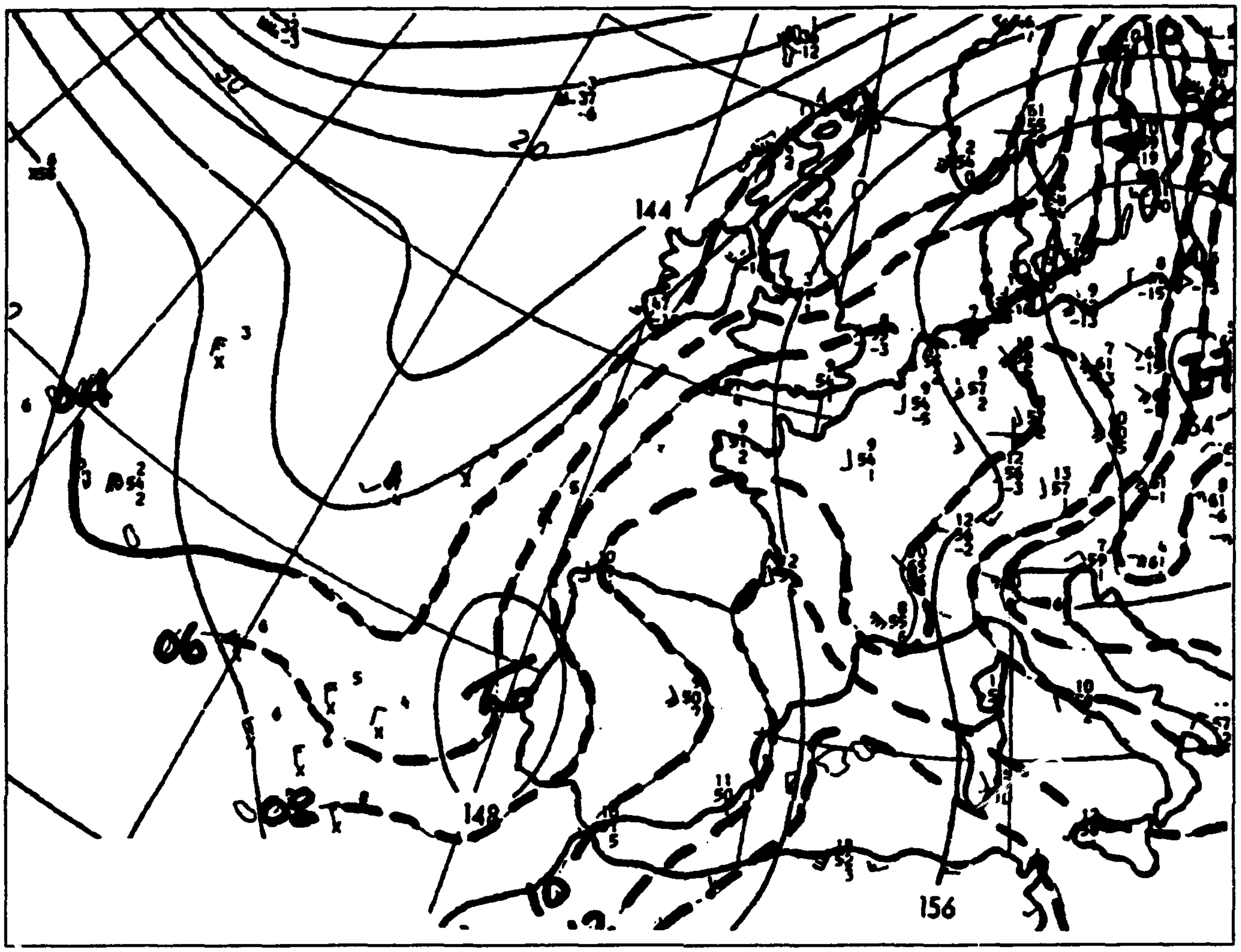
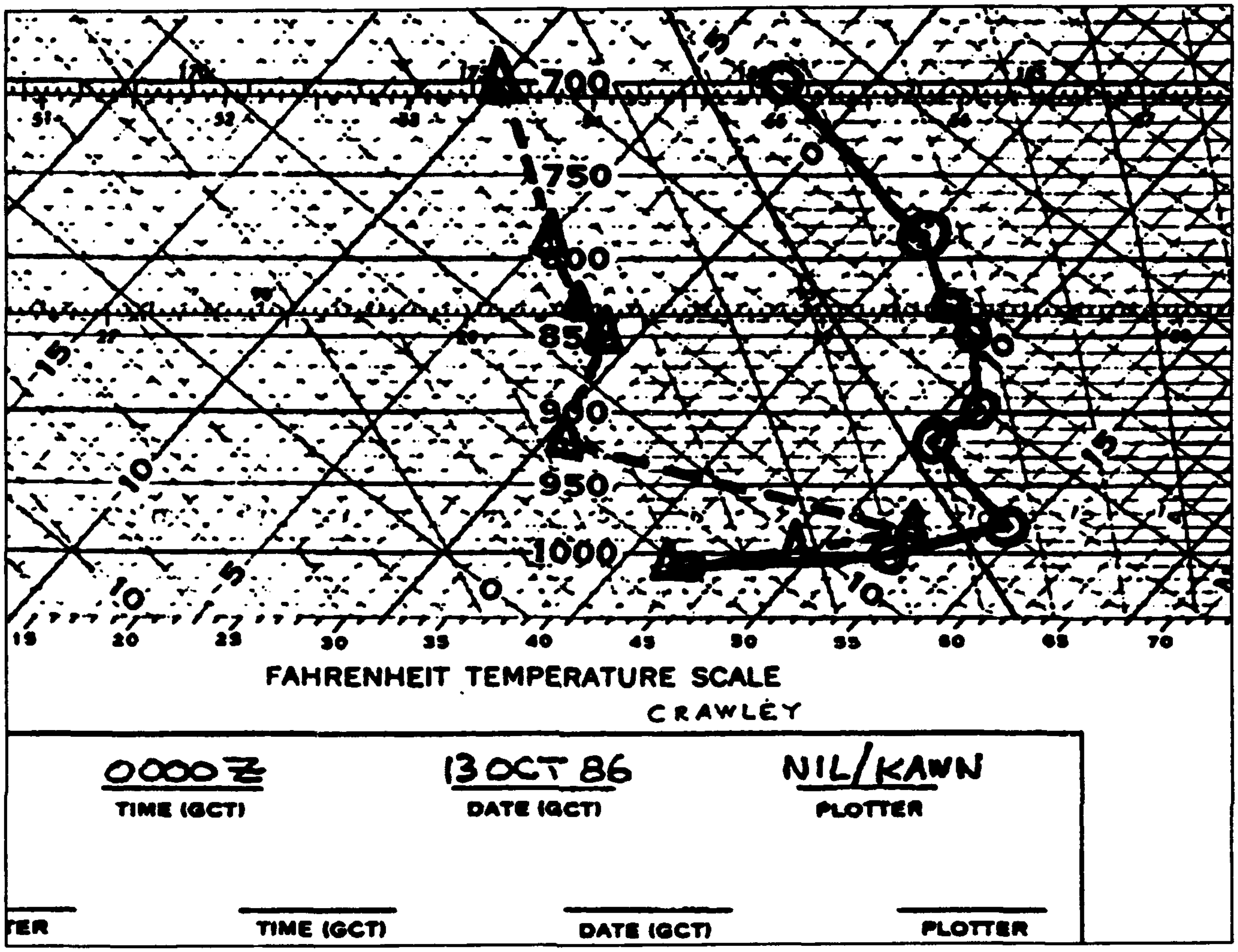


Figure 4-9. 0000Z 13 October 1986 850 mb Analysis.



0000Z
TIME (GCT)

13 OCT 86
DATE (GCT)

NIL/KAWN
PLOTTER

TER

TIME (GCT)

DATE (GCT)

PLOTTER

Figure 4-10. 0000Z 13 October 1986 Crawley Sounding.

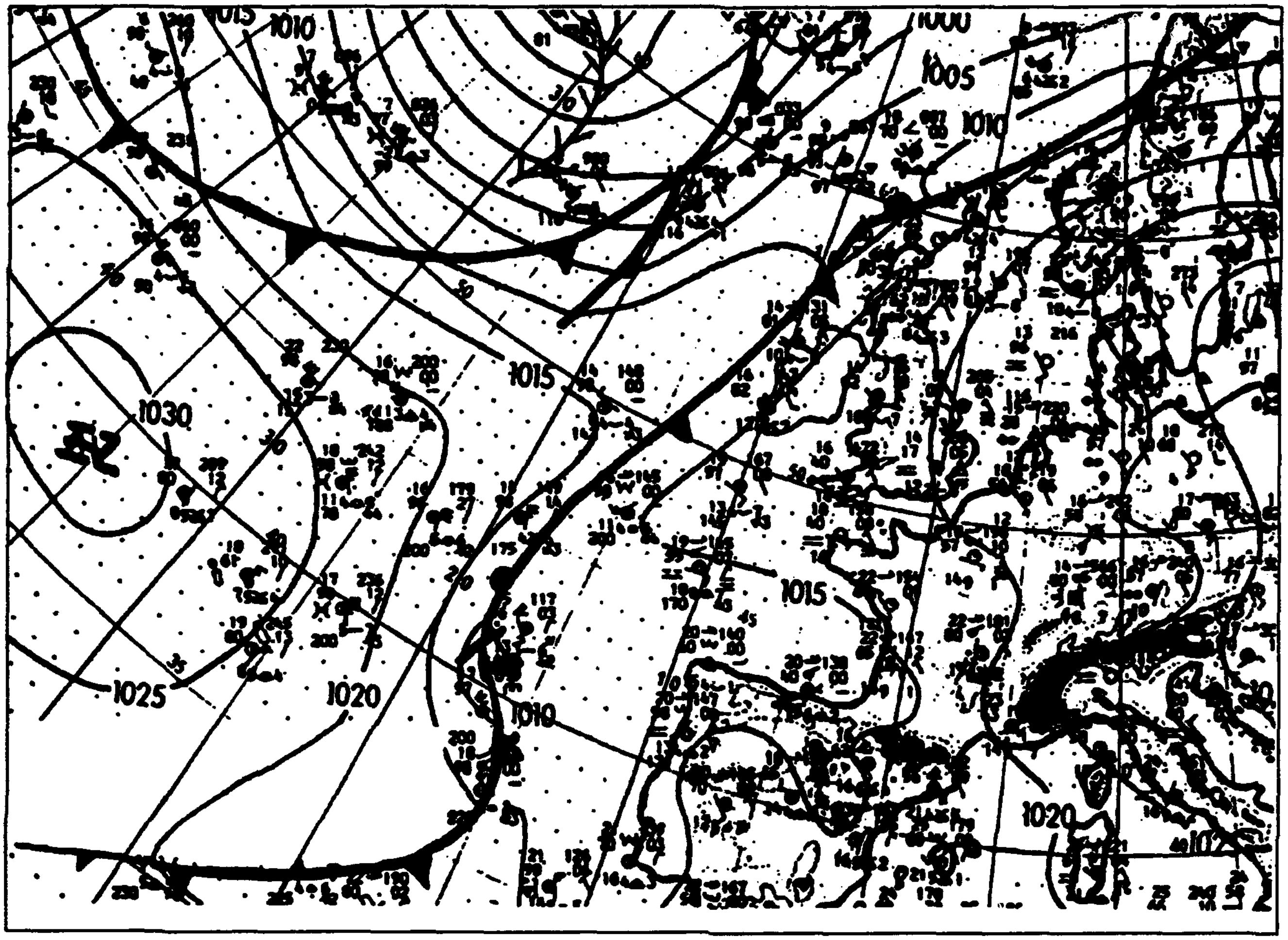


Figure 4-11. 1200Z 13 October 1986 Surface Analysis.

SECTION B - THUNDERSTORMS

4-9. Introduction. Thunderstorms, a continual problem to both airmen and forecasters, occur over the entire European theater. Conditions causing thunderstorms in Europe and the Mediterranean are the same as those causing thunderstorms in the United States. Figure 4-12 shows the frequency of thunderstorm days by month at selected locations.

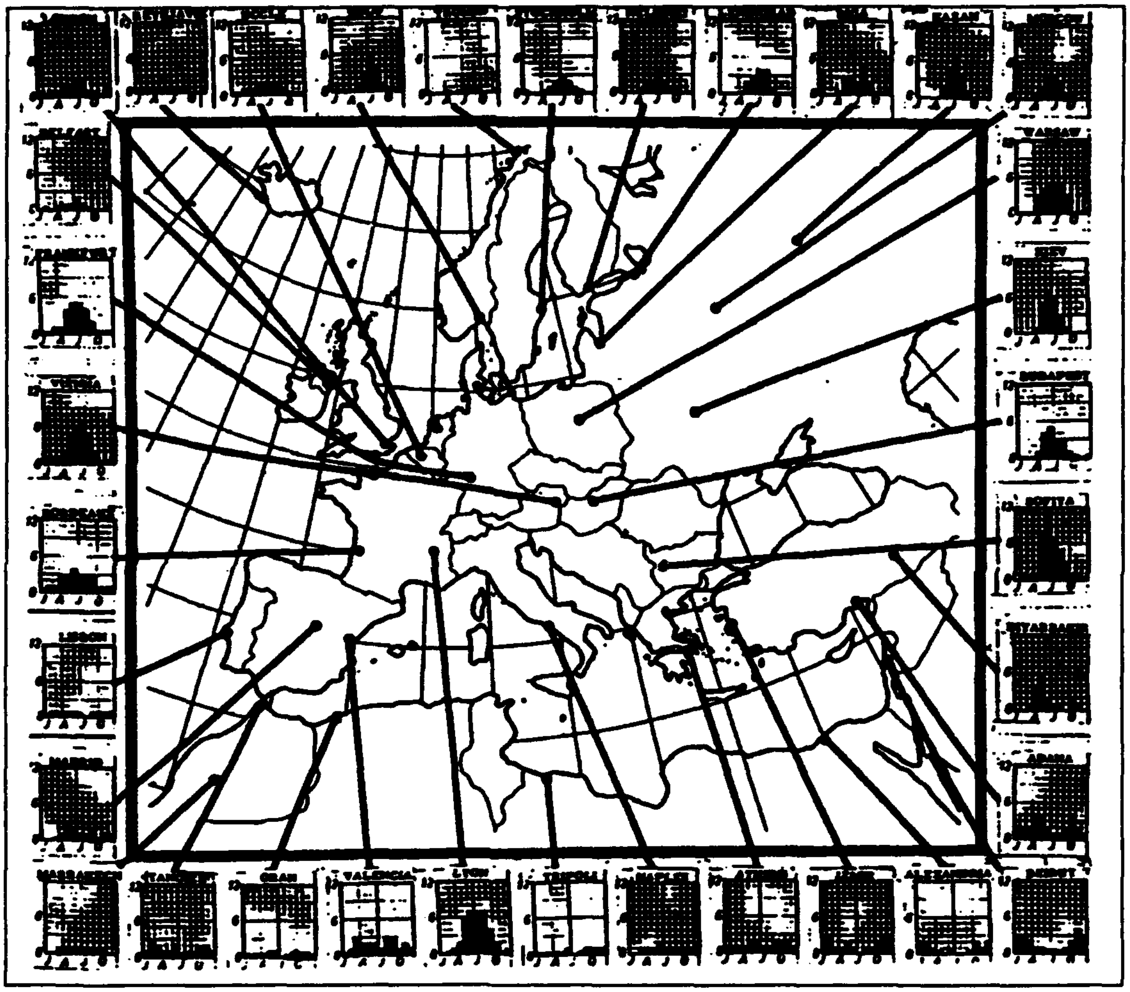


Figure 4-12. Average Number of Thunderstorm Days per Month at Selected Locations.

a. Figure 4-12 shows that, for most European locations north of 40° N, spring and especially summer are the thunderstorm seasons. The lack of thunderstorm activity here during the colder months of the year is caused primarily by the lack of insolation. The central part of the CIS, eastern Europe, and eastern Turkey see most convective activity in the spring. This is, caused by increased heating of the land mass, in conjunction with the fronts that still frequent the region (see figure 4-13). Locations in North Africa appear to have a relatively ''flat'' annual distribution of thunderstorm activity. Less definitive statements can be made about thunderstorms in the eastern Mediterranean. (Figure 4-14 shows a typical synoptic situation that brought thunderstorms to the Mediterranean.) Eastern Turkey has two maxima, one in spring and another in fall. In the southeastern Mediterranean, the thunderstorm season occurs from fall through spring, when

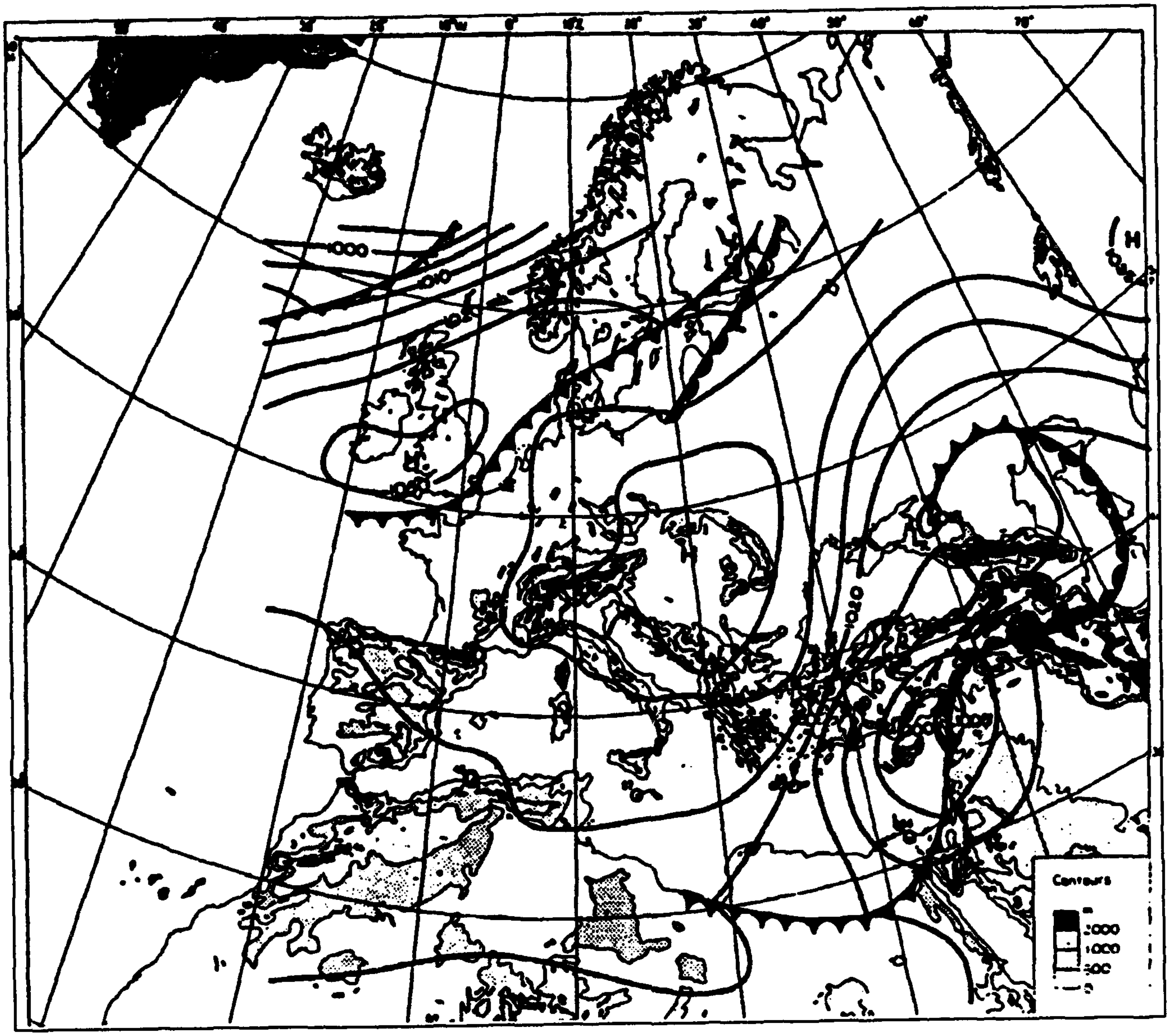


Figure 4-13. Typical Synoptic Situation Associated With Thunderstorms in Turkey.

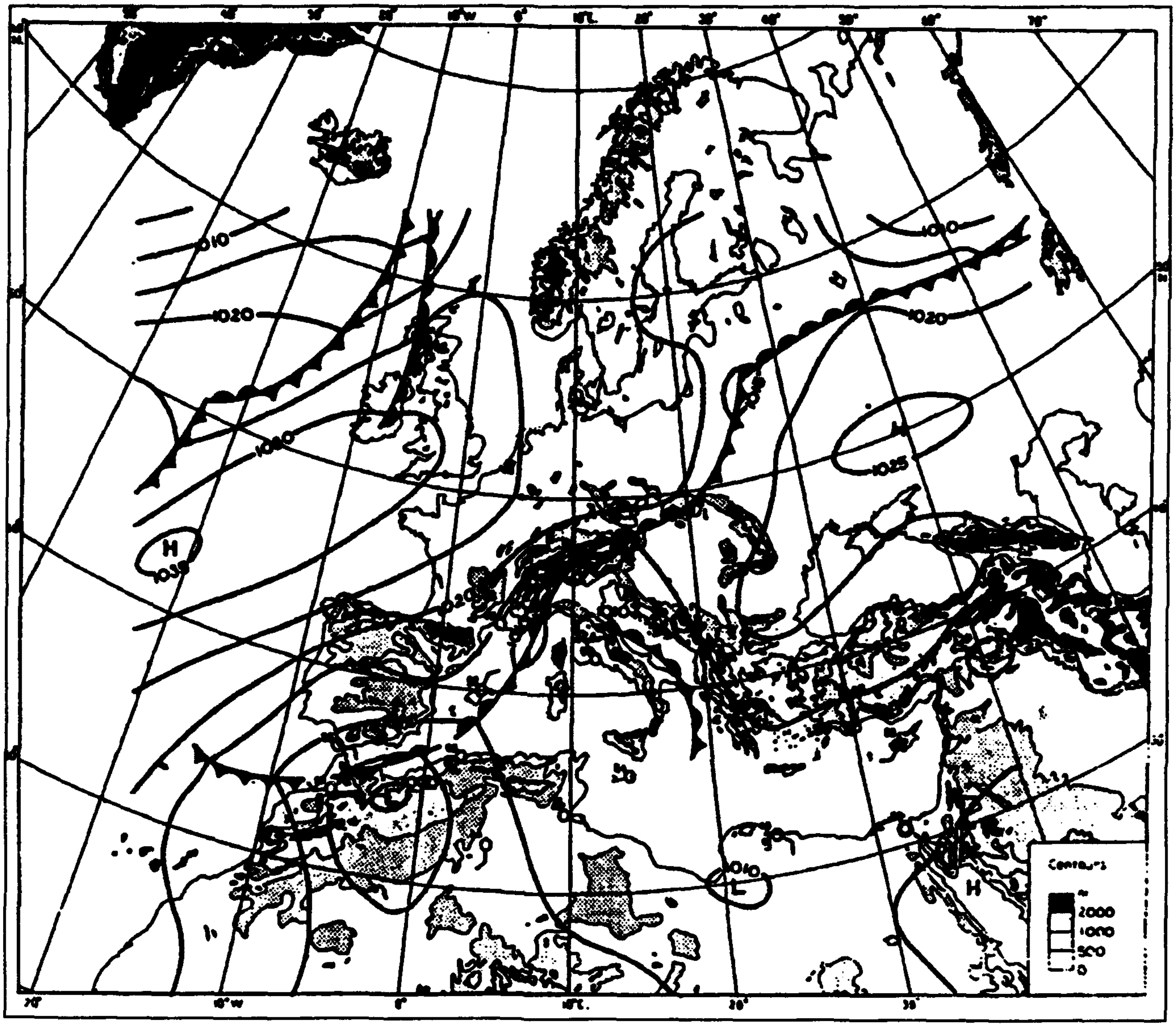


Figure 4-14. Typical Synoptic Situation Associated With Thunderstorms in the Mediterranean.

invasions of polar or arctic pass over the warm waters of the Mediterranean.

b. There are, however, scale differences. The typical midwestern thunderstorm is over 30,000 feet tall. In the UK, thunder can come from a 12,000 footer and hail falls frequently falls from rainshowers. We will present some back-to-basics on thunderstorms, and show the necessary ingredients.

4-10. The Basics. Regardless of location, a thunderstorm requires three ingredients. Without any one of them, it won't start. The required ingredients are moisture, instability, and lift. Once a thunderstorm cell has developed, the cell is free to run its course, even with the removal of all three ingredients. The difference is that no new cells will form.

a. Moisture. In Europe, it's everywhere. Ever-present inversions trap it in the lower levels even when the weather is fair aloft. So the first requirement for thunderstorms is virtually always present, waiting for the catalysts - instability and lift.

b. Instability. We will review the three most successful stability indices in Europe. Some work well regionally, but only one was designed specifically for use in Europe. Table 4-1 summarizes them.

(1) Third place goes to the Total Totals index. Used widely in both states and Europe, it is available to forecasters via trajectory bulletins. Since it fails to consider low-level moisture, it tends to under-forecast convection here. Calculation is as follows:

$$TT = T850 + Td850 - 2(T500)$$

(2) Second place: The familiar Showalter Index. (Take the 850 temperature, go dry adiabatically to saturation, then moist adiabatically 500 mb. Compare that 500 mb temperature to the 500 mb sounding temperature.) Though it does not show anomalies below 850 mb either, it enjoys a higher success rate. (Note that the threshold TS value here in Europe is +2, not 0 like stateside.)

(3) The KO index wins the gold hands down. The reasons KO works better than the other two is that it considers data below 5000 ft, and it includes moisture at all levels. (Unlike the previous two, changing lower or upper-level dew points will shift the index.) It is also conservative, removing moisture by adiabatic processes. The KO's drawback is its apparent complexity. Your first try will probably take you 10 minutes, you will get faster with experience.

The KO equation is:

$$KO = \frac{(\Theta_e 500 + \Theta_e 700)}{2} - \frac{(\Theta_e 850 + \Theta_e 1000)}{2}$$

(a) Θ_e = the equivalent potential temperature at a given level. To find Θ_e, first find the LCL of a level. Continue up the moist adiabat until all moisture is removed from the parcel. This occurs at the level where the moist and dry adiabats become parallel. From there, take the parcel back down to 1000 mb dry adiabatically. The temperature at this point is Θ_e.

(b) An easier solution is the following. Instead of coming down the dry adiabat to 1000 mb, continue up the dry adiabat to the top edge of the chart. There, you may read Θ_e directly.

(c) Do this for each of the four pressure levels in the equation and plug into the equation. The result is the KO index.

(d) A sounding, of course, will give you the stability solution for a particular location. But, what about the KO indices for the entire theater? Deutsches Wetterdienst (DWD) transmits a chart daily at around 14Z (HF frequency 134.2 on your 9315TRT dial). Analysis of the KO chart should keep you from experiencing unexpected thunderstorms.

TABLE 4-1. SUMMARY OF STABILITY INDICES

INDEX	ADVANTAGES	DISADVANTAGES	CRITICAL VALUE
TT	Readily Available	Under-forecasts Convection	>42 = TRW PSBL >48 = TRW VCNTY >50 = TRW in TAF
SSI	Popular, easy to compute two levels	Considers only	<2 = TRW
KO	Accurate, conservative, multi-layered	Complicated	>6 = NO TRW 2-6 = TRW PSBL <2 = SVR TRW PSBL

c. **Lift.** Moisture and instability will have a direct effect on the severity of the storm but lift is only necessary to start it. After enough lift is supplied, the storm makes its own. Not surprisingly, lift here is the same as elsewhere in the world. Possible sources include topographic, frontal, thermal, and dynamic (low level convergence). We described synoptic scale topographic features in the first two chapters. This pamphlet cannot address the topographic features affecting each base. Use your Upslope/Lee charts, TFRN, and the following section that describes thermal lift, the lift associated with air mass thunderstorms.

(1) Many forecasters think when the surface temperature reaches the convective condensation temperature (CT), thunderstorms will develop (assuming there is enough moisture and instability). This is not true, and will cause major over-forecasting of convective events. Reaching the CT will cause convection to occur. Convection is the formation of clouds due to adiabatic process. If the heat is taken away, which usually occurs when clouds form, the clouds will dissipate. The dissipation then allows heating to increase, and so on. This is the classic cumulus development cycle seen on most any day.

(2) What, then, is required to produce a thunderstorm? The answer is **auto-convection**. It occurs when a parcel continues to rise under its own power, after the external heating is taken away. To produce auto-convection, the temperature must increase to that of the level of free convection, or LFC. If this occurs, a thunderstorm is in the making.

4-11. Severity. Once you find that today you have all the necessary ingredients to put thunderstorms in the TAF, you must then decide potential for severity.

a. If you're stationed in the Mediterranean, AWS Tech Report 200 works adequately. Anywhere else in the theater, it will be terribly pessimistic. There is, however, a technique that works very well in the predominantly maritime air masses north of the Alps. Developed by the GMGO (German military meteorological organization), and verified by 2 WW/DNC, it is based on the vertical extent of convective clouds and the height of the freezing level. (This technique has also been incorporated into the HUD. By using the guide, forecasting the severity of a thunderstorm is relatively simple, reasonably accurate, consistent (see table 4-2).

b. Begin with a sounding. RAREPs and PIREPs are additional sources. Find the cloud top temperature and the extent of cloud above the freezing level. Move across the table to derive the most probable condition that will occur.

NOTE: The result is not the worst case. Be sure to use the less severe of the two entry conditions if there is a discrepancy.

TABLE 4-2. GMGO THUNDERSTORM SEVERITY CHART

CLOUD TOP TEMP (C)	EXTENT ABV FREEZ LVL (THOUSANDS)	EVENT	PRECIP (MM)	VSBY RAIN (KM)	VSBY SNOW (KM)	HAIL (CM)	PK GUST (KT)
-10 -15	5 7	RW-	<1	8	3-6		<20
-15 -20	7 9	RW	1-2	6-8	1-3		20 25
-20 -25	9 12	RW+	2 3	4 6	.5 1		25 30
-25 -35	12 17	TRW-	3 5	3 40	.5		30 35
-35 -45	17 20	TRW	5 10	2 3		<1	35 45
45 -55	22 27	TRW+	1 30	1 2		1-4	45 60
-55 -70	27 35	TRW++	30 100	<1		4 10	60 100

4-12. Probability of Lightning Conditions (POLC). This subject is unique to Europe and therefore warrants our discussion. Many aircrews believe the best way to avoid a lightning strike is to avoid thunderstorms. That is true up to a point. A better way, however, is to avoid **all** lightning and electrostatic discharge environments.

a. There has been much confusion in the past on the exact definition of POLC. Customer education is your best defense against this sort of thing. A POLC of 90%, does not mean there is a 90% chance of a lightning strike. It simply means that 90% of the factors known to produce a discharge will simultaneously exist along the route of flight.

b. POLC is routinely briefed to USAFE and "transit" aircrews. (7 WS weather activities have no requirement to brief it to Army aircrews.) Also, "non-flyers" shouldn't need this type of advisory. It only applies to flight operations.

c. Likewise, a POLC advisory and a lightning-within-5-miles advisory are two different things (with two different customers).

4-13. Procedure:

a. Figure 4-15 is the decision schematic for POLC calculations. There are several blocks of, "If yes, then..." and "If no, then..." format which the forecaster uses.

b. The reason for the complexity of this chart was that a lower threshold used to be briefed to USAFE pilots. The POLC briefing threshold, as well as the weather advisory threshold is now 80%. The portion of the chart inside the double line include all the criteria that will lead you to forecast a POLC ≥ 80%. If the flow chart takes you outside the thick lines you automatically have less than 80% POLC without proceeding any further. As the chart shows, there are four requirements that must occur simultaneously. Anything less, and you'll be below the threshold. CBs or TCUs must be present. The flight must be in clouds other than CI. Precipitation must be occurring at flight level, and the temperature must be within the ± 10°C envelope. Reference: 2WW FM 88-003.

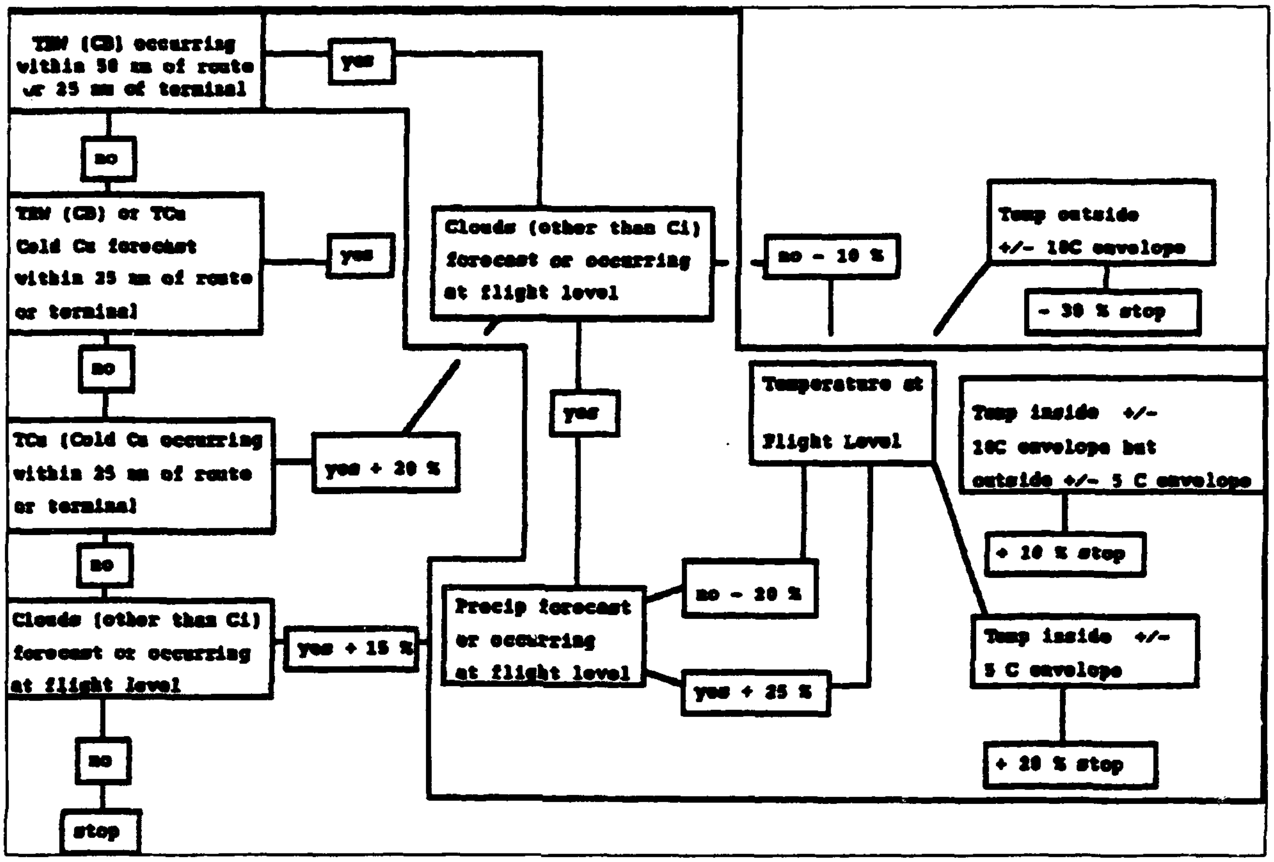


Figure 4-15. POLC Decision Tree.

SECTION C - TORNADOES AND WATERSPOUTS

4-14. Introduction. Tornadoes do occur in Europe but with much lower frequency than in the Central Plains of the United States. We mention them here to acquaint the reader with the major areas of occurrence. Caution: The lack of reported tornadoes does not necessarily mean none have ever occurred. In general, the typical European tornado bears a strong resemblance to the ropy structure of a waterspout. In fact, the warm waters of the North Atlantic and the Mediterranean are usually the spawning grounds for these phenomena, as shown in *figure 4-16.

4-15. Areas of Tornado Occurrence:

a. Tornadoes occur in the British Isles, although they are not common. Unlike the central US, there are more reports of winter tornadoes in the British Isles. This is probably caused by the advection of cold air over the relatively warm water surrounding the isles in winter. The resulting a seasonal decrease in stability is coincident with the annual peak in both thunderstorm and tornadic activity.

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*Peterson, R.E. 1981: Tornadic Activity in Europe in the Last Half-Century. Atmospheric Science Group, Texas Tech Univ, Lubbock Texas.

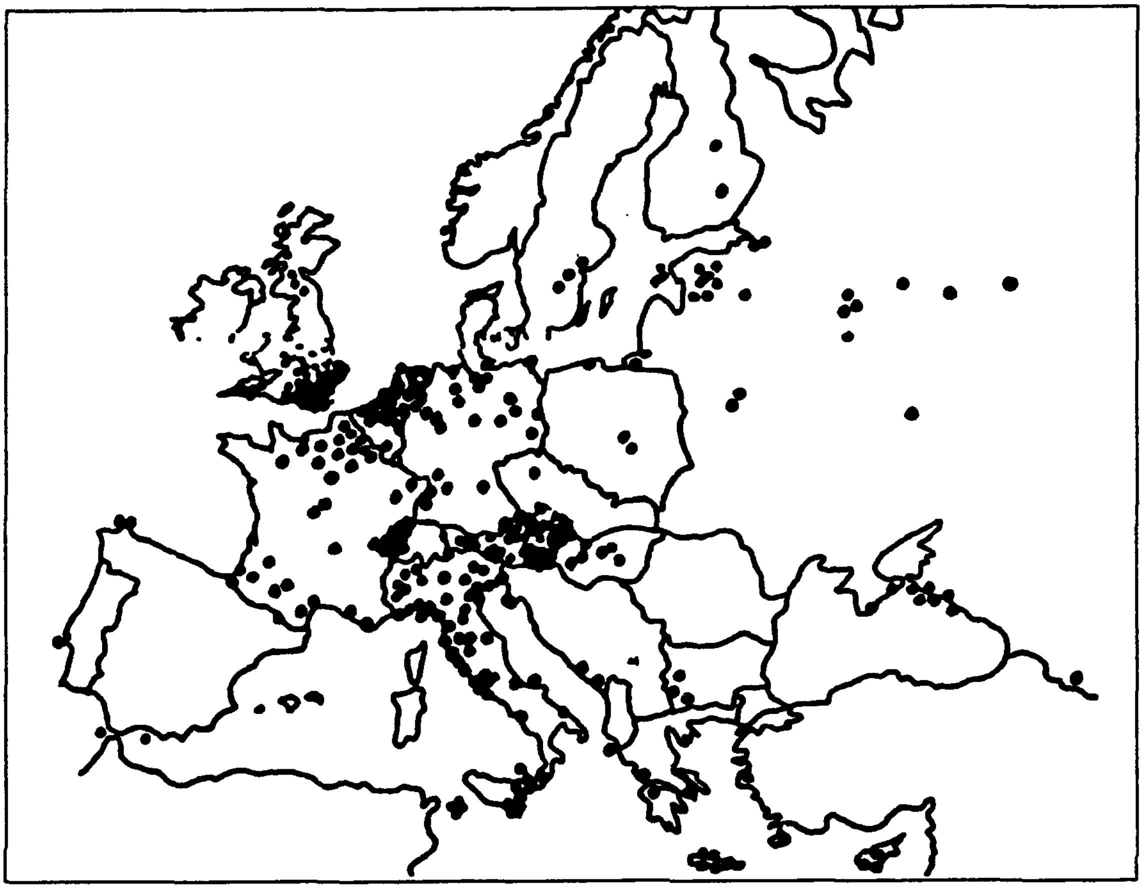

*Figure 4-16. Locations of Tornadoes Reported Since World War I. (after Peterson, 1981)

b. In Germany, the northern plains and the Bavarian highlands appear to be favorable areas for tornado occurrence. The most favorable synoptic situation for tornado formation here is a surface depression to the west of Ireland, with a cold front extending into Spain. The strong southerly 850-mb flow over the Bay of Biscay becomes southwesterly over northern France. There is a steep thermal gradient between central France-central Germany and the Channel and North Sea coast. The low-level jet extends into the tornado forming area. A 2 WW study found that in Europe, most tornadoes occur in the late afternoon or evening during the summer months.

c. The most common tornado formation areas in France are the north-central lowlands and plains. Synoptic conditions necessary for tornado formation here are similar to those of tornadoes in Germany.

d. Since more than 90% of the Mediterranean region is covered by water, most tornadic activity here occurs as waterspouts. As in the British Isles, the maximum threat occurs during the autumn (especially) and winter months. Waterspouts are thought to be less dangerous than tornadoes, but the associated winds are still strong enough to pose a danger to aircraft and shipping. Waterspouts are common in both the Strait of Gibraltar and Alboran Channel. They also occur with the onset of the *vendevale*, a strong easterly or northeasterly wind that occurs from the northeastern Mediterranean Sea to the Gibraltar-Alboran Channel.

e. In the CIS, the enormous land mass and relative lack of inhabitants make it difficult to estimate the

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*Peterson, R.E. 1981: Tornadic Activity in Europe in the Last Half-Century. Atmospheric Science Group, Texas Tech Univ, Lubbock Texas.

number of tornadoes that do occur. Certainly the ingredients: moisture, heating, lift are available. Although reports are not frequent, several tornadoes are sighted each year.

f. So, should the forecaster worry about tornadoes? The answer is, **yes and no**. First, while you must remain alert to the possibility of tornadoes, you will not spend a major portion of your tour tracking them. Second, the forecast state of the art (and lack of European NEXRAD) simply does not allow us to forecast the time and location of the next tornado. The best we can hope is to be able to recognize conditions favorable to the formation of tornadoes and warn when one is sighted.

SECTION D - WINDS

4-16. Introduction. The occurrence of extreme wind conditions over Europe affects flying, paradrop, amphibious, and river operations, and even communications equipment. We will not discuss general wind conditions in this section; only those winds of unusual character or of a severe nature. See figure 4-17 for an area summary of major winds discussed in this section.

4-17. North Atlantic. North Sea gales are the primary wind of consequence over this region. A gale is defined as having wind speeds of Beaufort force 8 to 12 (34 to 71 kt). Well developed cyclonic activity dominates this region during winter, and as cyclones approach the British Isles, gales occasionally occur with open wave frontal systems. Cyclones, occasionally forced to move south by a well developed high over Scandinavia, produce strong gales through the English Channel, the North Sea, and surrounding coastal areas. These strong winds often continue over Denmark and southern Sweden. Gale-associated winds can blow from any direction but are usually stronger from the northwest. Occasionally, winds in this region exceed hurricane force (64 kt), but this is usually confined to open water areas. Gales continue, to a lesser degree, into the spring, becoming rare during summer.

4-18. Northern Europe:

a. Gale force winds affect the coastal and exposed highland areas of Scandinavia, with maximum frequency along the northern and western coasts. They are associated with the approach and passage of an intense cyclone from the North Atlantic. When these winds blow over the relatively narrow and unsheltered Jutland Peninsula and Swedish lowlands, they may cause damage a considerable distance inland.

b. In Norway a *bora*-type wind known as the *elvegust* or *sno* occurs in the mouths of Norwegian fjords. It is associated with cold air drainage from the surrounding highlands toward the warmer sea. Principally a winter phenomenon, it occurs during a clear, cold high over the interior. The approach of a cyclone from the North Atlantic initiates the rush of cold air toward the coast. Katabatic winds also occur along the open coast but being less confined, they are generally not as violent.

4-19. Central Plains. Cyclone passage through the English Channel or over the North Sea causes strong southerly or southwesterly winds over much of the lowland area of this region. Wind speeds often exceed 40 kt and considerable channeling of wind can occur in the river valleys.

4-20. Alpine Region:

a. The foehn is particularly strong and extremely gusty in certain valleys known as "foehn channels." The most famous channels are: the Rhone River Valley from the bend of the Martigny to the Lake of Geneva, the Aare, Reuss, and Linth River Valleys, the Rhine River Valley as far north as Lake Constance in Switzerland, and Wipptal from Brenner Pass as far north as Innsbruck in the Tyrol (Austria). In the Alpine Region there are two types of foehn: the southerly foehn on the north slopes, and the northerly foehn on the south slopes. They are especially common during spring and summer.

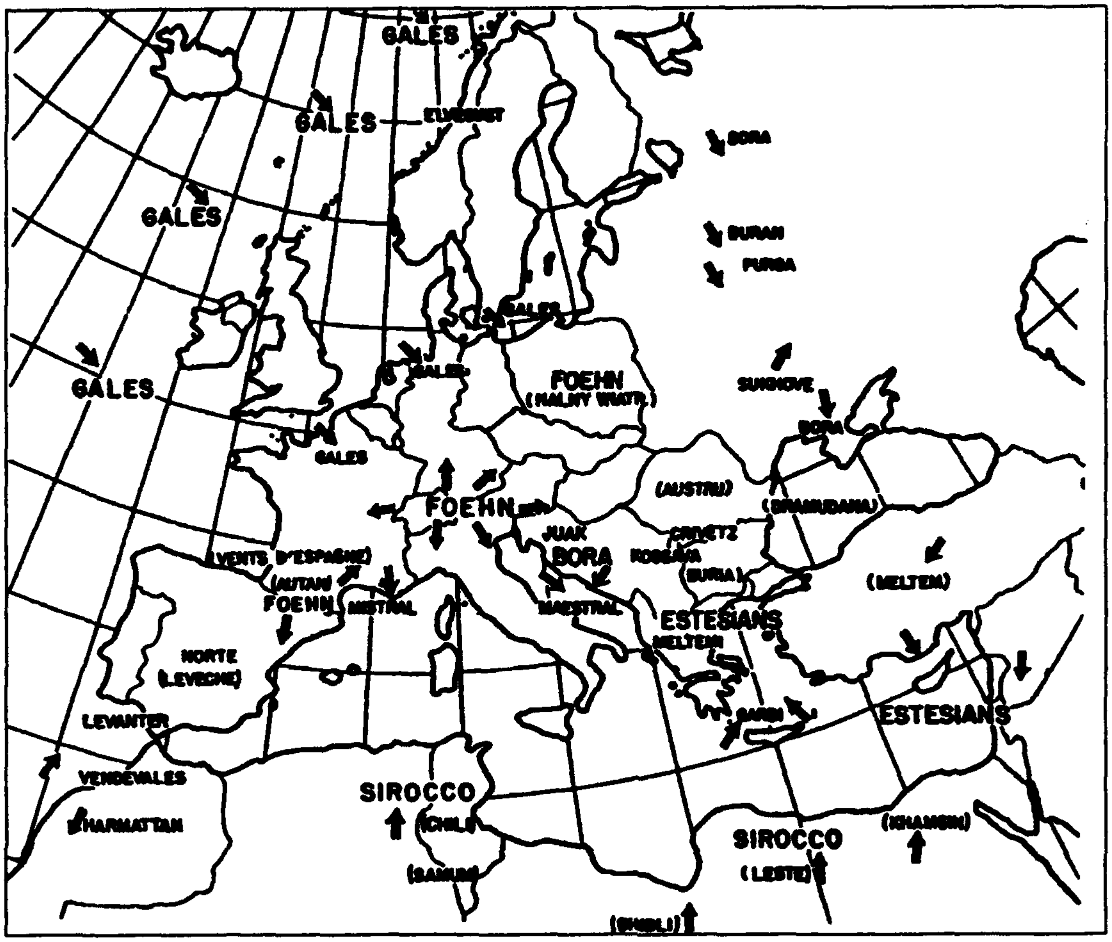

Figure 4-17. Major Wind Systems and Local Names ( ) for Winds in the European Theater.

b. Foehns are particularly frequent between Geneva, Switzerland and Salzburg, Austria (occurring 30 to 50 times per year). Figure 4-18 shows a typical synoptic situation for a southerly foehn. These prefrontal warm sector foehns are a signal of the approach of a cold front north of the Alps.

c. The northerly foehn is experienced in the valleys on the Italian side of the Alps. It occurs when air from the north descends into the valleys flowing into the Po River Valley. The northerly foehn is more frequent than the southerly foehn. North foehns are known in Italy as *tramontana* winds, meaning "winds coming from the other side of the Alps." The adiabatic warming coincident with the *tramontana*, is much less dramatic than the southerly foehn. This is because the *tramontana* starts from a relatively cold area. The adiabatic warming of the air while descending the southern slopes of the Alps is barely sufficient to compensate for the temperature difference between the source region and the destination.

d. The major difference between Alpine foehns and chinooks of the Rocky Mountains is that foehns can occur in two directions. Chinooks occur with much greater frequency from the Pacific toward the east.

e. The frequency of foehns depends upon the number of lows passing through, as well as their relative strengths. Foehns can also occur with the subsidence beneath anticyclones. Anticyclonic foehns do not display a rainy/cloudy side or a warm/dry lee side since there is no transport of air masses from one side of the mountains to the other. Because a climatological ridge occurs over the Alps in winter, anticyclonic foehns are very frequent. With the small winter lapse rate, the thermal effect is pronounced, particularly in the southern foothills of the Alps.

f. A fall wind known locally in Czechoslovakia as a *polake*, occurs when very cold air drains down mountain slopes into the valleys. It is most frequent in spring. The mountainous areas also experience strong canyon winds which are funneled through the narrow mountain passes.

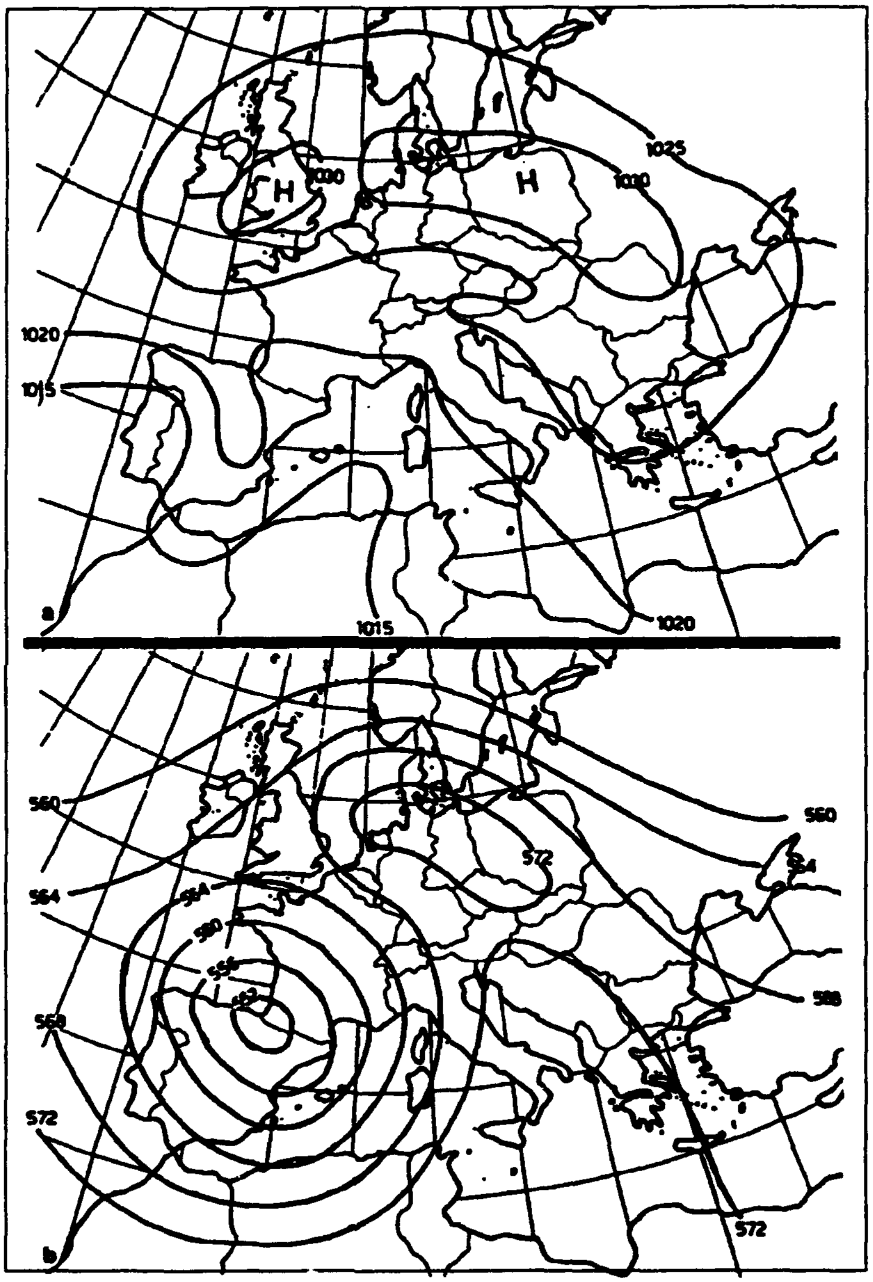

***Figure 4-18. A Typical Synoptic Situation Causing a Southerly Foehn. (0700Z 3 October 1941. (a) surface analysis; (b) 500 mb analysis. (after Godske et.al.,1957)**

Godske, C.L., T. Bergeron, J. Bjerknes, and R.C. Bundegard. 1957: *Dynamic Meteorology and Weather Forecasting*. Amer. Meteor. Soc. 800 pp.

4-21. Balkans. Foehn winds are relatively frequent along the slopes of the Carpathian, Balkan, and Rhodope Mountains, and the Dinaric Alps. Another intense wind affecting this region is the *crivetz* of southern Romania. It is a strong, gusty, severely cold wind originating in the Ukraine. It occurs frequently in the spring and autumn, and regularly during winter. Another wind of the same origin is the *nemere*, a blizzard which occurs in the Carpathians and the Transylvanian Basin. Still another wind affecting this region is the *kossava*, a southerly wind that affects both Yugoslavia and the southern part of the Romanian plains. This cold, dry, gusty wind is violent in the mountainous areas of Yugoslavia.

4-22. Mediterranean and North Africa. Since much of the terminology and many of the wind systems affect large areas of the Mediterranean, the entire region will be discussed as one. Winds will be discussed by type and area. Major wind types of the Mediterranean coasts are the *etesian*, *sirocco*, foehn, and *bora*.

a. ***Etesian*:**

(1) The *etesian* winds of the eastern Mediterranean are the great and uniform, northerly, summer drifts toward the convergence center of the climatological low pressure over Iran, Afghanistan, and northwestern India. They are also known as *meltemi* (Greece), *meltem* (Turkey), and *maestral* (Italy).

(2) The *etesian* dominate the wind flow over the Adriatic, Ionian, Aegean, and Levant Seas, Greece, and, to a certain extent in parts of the Middle East. Their influence is felt as far east as the Caspian Sea and Turkestan. They constitute the most constant and steady drift known on the European continent. The wind starts around mid-May and lasts until mid-September. Breaks, particularly in July, are not unusual, especially in the northern areas. The winds reach their greatest strength in the early afternoon and often cease during the night. Figure 4-19 is a typical synoptic situation for the *etesian*.

(3) Over the Adriatic and Ionian Seas, on Crete, and off the mouth of the Nile River, the *etesians* are northwest winds; over the Aegean Sea and Greece, north winds; over Turkey, northeast winds. The Libyan coast is completely dominated by north winds. The onshore flow over the eastern and southern Mediterranean moderate coastal surface temperatures significantly.

b. ***Sirocco*:**

1) The name *sirocco* is derived either from the Arabic *shorq*, meaning "east," or from a Greek verb meaning "to dry up." Both derivations show the desert origin and the dryness of these southerly or southeasterly winds. They originate in the deserts and semi-deserts of North Africa, Israel, and Syria which, in most cases, lie under the warm sectors of east-bound Mediterranean disturbances. Thus, genuine *siroccos* are extremely hot in summer and of moderate temperature in winter. This is a function of the seasonal change of desert surface temperature. Relative humidities, at the point of origin can be as low as 8%. *Siroccos* usually last a day or two, and their depth averages 6000 to 7000 ft(1829 to 2134 m).

(2) *Siroccos* are often modified by the surfaces over which they move. The *sirocco* becomes very humid before it reaches Malta, southern Italy, and the coasts of the Adriatic, Aegean, and Black Seas. Its occurrence is particularly frequent in the eastern Adriatic, where it occurs as a southeast wind on the eastern side of the winter Pelagosa Low. The Adriatic *sirocco* reaches much farther north than other members of the *sirocco* group, particularly during transitional seasons. *Sirocco* frequency decreases considerably north of Lussin, Yugoslavia.

(3) *Siroccos* are often associated with dust storms. Dust may be carried to above 13,000 ft in the unstable air over the hot desert soil. African dust is frequently deposited as "blood rains" over Malta, southern Italy, and western Yugoslavia. The mountains of central Yugoslavia experience "red snow" almost annually. In extreme cases, African dust has been deposited in the Alps, in England, in Denmark, and even in eastern Russia (Perm), 2500 mi (4023 km) from its source region. Along a warm front, from one to two million tons of African desert dust may be transported to the north and northeast, increasing the turbidity over half of Europe. Figure 4-20 is typical of synoptic situation associated with a *sirocco*.

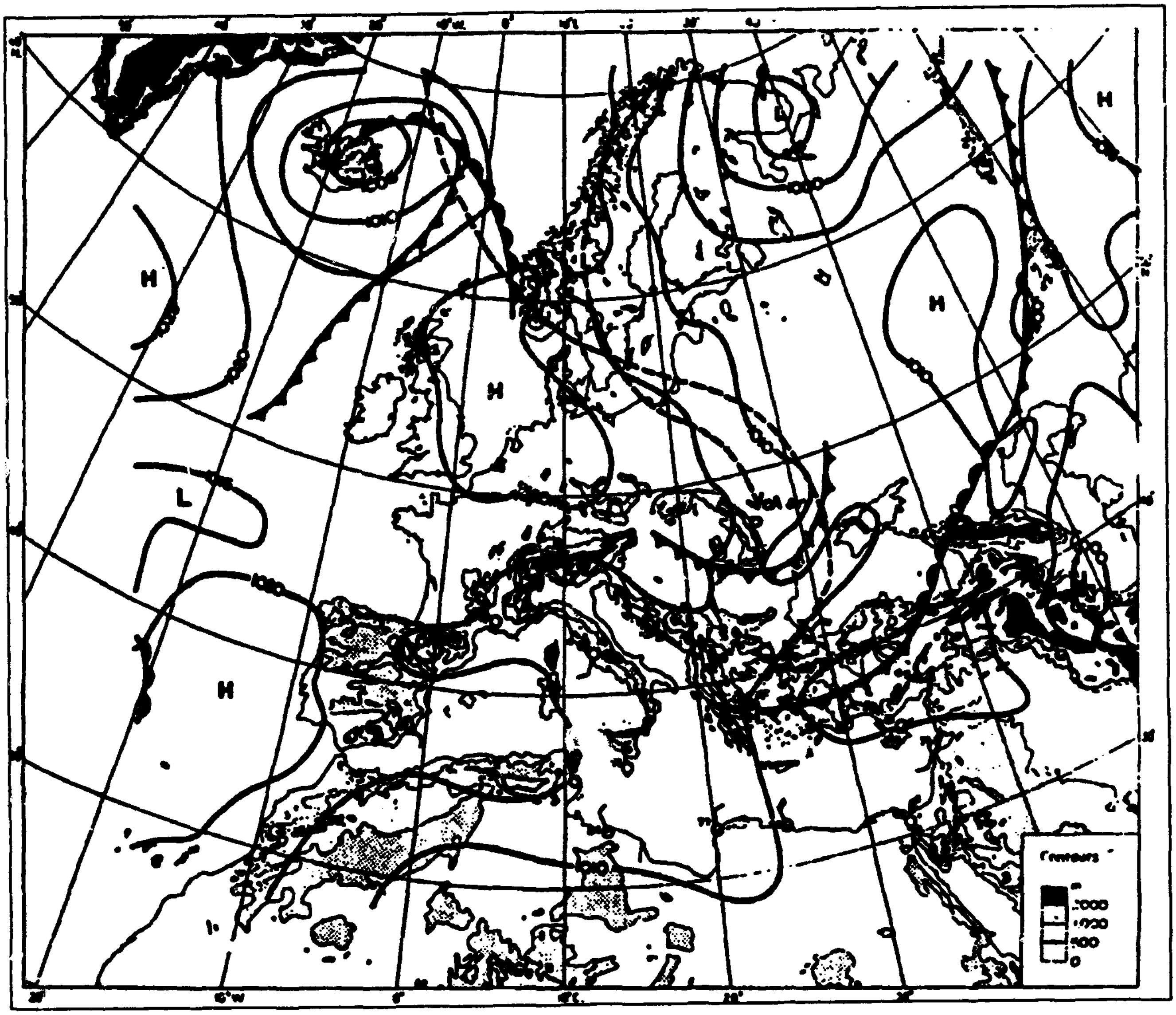

Figure 4-19. Typical Synoptic Situation Associated With an *Etesian* Wind.

(4) The frequency and seasonal distribution of *siroccos* seem to be a function of the number of eastbound Mediterranean disturbances. The western Mediterranean experiences about 50 *siroccos* per year, with the number decreasing eastward. Spring is the primary season of *siroccos* and of "blood rains" in Europe. It is reasonable to assume that this maximum is related to the seasonal shifting of storm tracks. In winter, when lows travel in all latitudes of the Mediterranean area, many warm sectors reach as far north as the European shores of the Mediterranean. More *siroccos* penetrate farther north than in winter. In summer the number of lows is small, and the storm tracks are restricted to the northernmost parts of the Mediterranean, so *siroccos* are uncommon. With spring, the temperature contrasts between warm sector and the maritime polar air behind the cold fronts are more pronounced than in autumn. Moreover, the number of lows in the Mediterranean is much greater in spring than in autumn. For these two reasons, spring *siroccos* are more common and conspicuous.

(5) Other names are used for the *sirocco* depending on the location of occurrence: *leste, samum, leveche, khamsins, garbi, sahat, chili,* and *ghibli.*

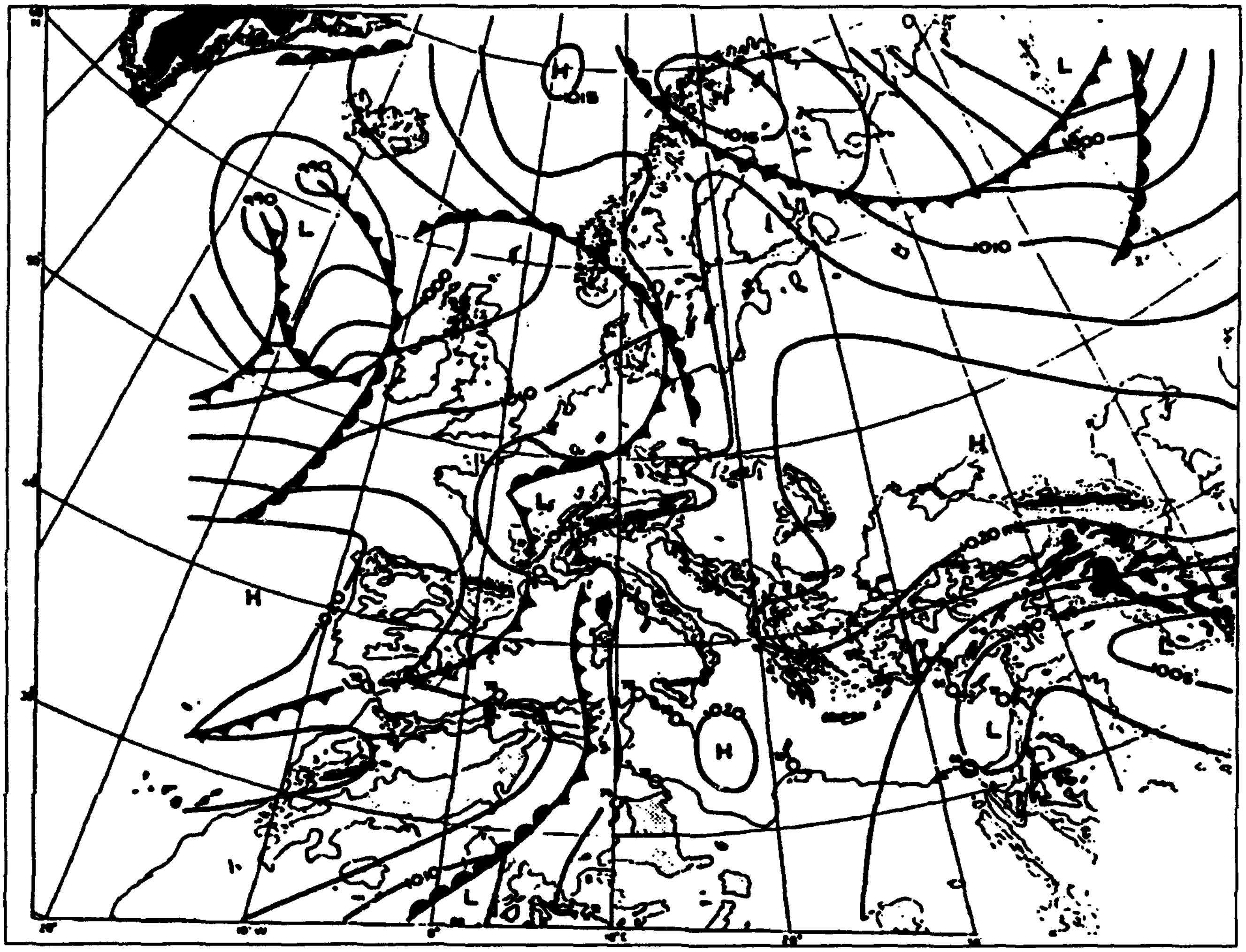

Figure 4-20. Typical Synoptic Situation Associated With a *Sirocco*.

c. ***Bora*:**

(1) The cold downslope winds of the eastern coast of the Adriatic Sea, known as *bora* winds (derived from the Greek boreas, "north wind"). By definition, *boras* are drainage winds from cold continental source regions toward warm seashores or lowlands. Though adiabatic warming does occur during the descent, the air still feels quite cold upon arrival at the bottom, because it was so cold when it started. They occur along the entire coast of the Adriatic from the Istrian Peninsula to the Albanian shores. They are particularly violent around Trieste (see figure 4-21).

(2) *Bora* winds are much weaker where mountains are lower than 2300 ft (701 m), or where lowlands are located more than 2 to 3 mi (3 to 5 km) inland. Examples include the Istrian coast between Capodistria and Pola, and coastal plain of central Dalmatia south of Zara. *Bora* winds are most frequent in winter, when temperature as well as barometric gradients between Serbian highlands and Adriatic are greatest.

(3) The temperature contrast between land and sea reaches it diurnal maximum around sunrise and its minimum in the early afternoon. Likewise, *bora* winds are most frequent between 0700 and 0800 LST and least frequent around 1400 LST. In winter the interior of the Balkan Peninsula, with its snow-covered mountains, strong outgoing radiation, and frequent cold waves from Russia, is much colder than the Adriatic coast. The average lapse rate in the coastal mountains can exceed 1 C per 100 m and more. *Bora* durations of 3 to 4 days are very common, but may last for weeks. The characteristics of the anticyclonic *bora* are

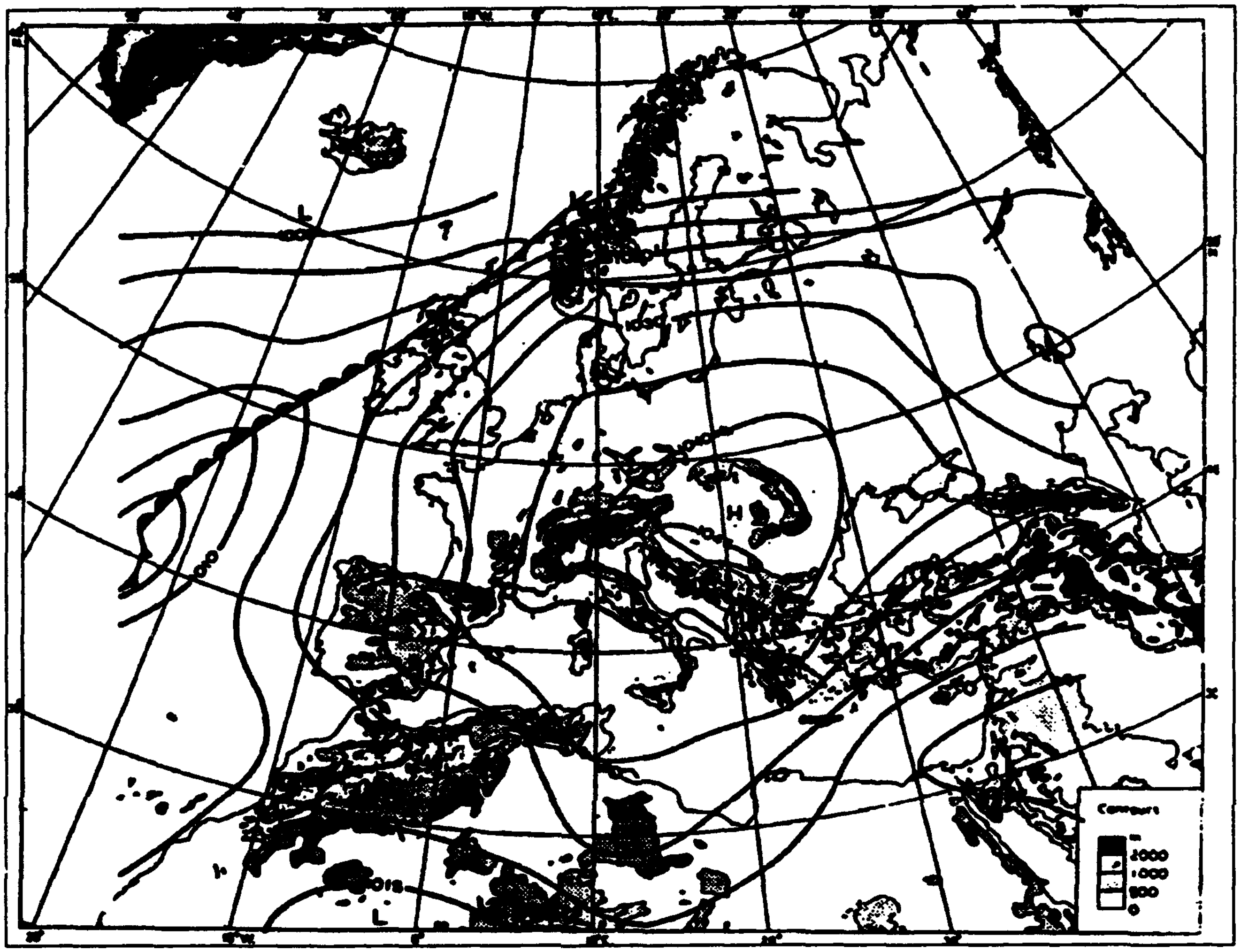

Figure 4-21. Typical Synoptic Situation Associated With a *Bora* in the Adriatic Sea.

winds from the northeast quadrant, dryness of air (relative humidity sometimes as low as 15 percent), low temperatures (but only occasionally lower than 32 F (0 C), fair skies with a wall of cumulus clouds over mountain ridges (similar to the foehn wall over the Alps), and extreme gustiness, especially in passes and gaps. The average velocity of a well developed *bora* is approximately 70 kt. With gusts, velocities of 115 kt and more have been recorded. As the Adriatic is a common storm-track area, another type of *bora* is quite common, particularly during the colder half of the year. When a center of low pressure is passing the central Adriatic, the northern regions experience the *bora* while the southern area simultaneously records a *sirocco*. In such cases (cyclonic or ''black'' *bora*), the ceiling over the *bora* area is cirrostratus and altostratus clouds, which are indications of the approaching warm front. Rain or snow falling in the convergence area, explains the designation as black *bora*.

(4) *Bora* winds occur also in summer. With decreased coastal/interior temperature gradients, they are much weaker and less frequent.

d. ***Mistral***:

(1) During winter and spring, the high, snow-covered central plateau and the mountains, particularly the Cevennes, are much colder than the Mediterranean coast. Northerly or northwesterly winds (the *mistral*) blow toward the sea. The interior/southern coast temperature gradient is so great that the adiabatic warming of the downslope winds does not prevent the *mistral* from reaching the sea as a cold fall wind.

Mistral winds also occur on the coasts from Ebro River Valley in Spain (known as *cierco*). Their frequency is greatest in the Provence and Languedoc regions of France, while the Rhone River Valley south of Donzere, experience the most violent *mistral* winds. During the colder half of the year, temperature as well as barometric gradients cause mostly northerly and northwesterly winds. They become particularly strong when a low passes over the Gulf of Lion or when continental polar or continental arctic air enters northern France. Usually, the *mistral* is not felt far offshore from the Rhone Delta, but sometimes severe *mistral* gales are experienced even in the waters between the Balearic Islands and Corsica.

(2) These winds are very frequent in summer when the coastal plains and especially the Crau (the so-called French Sahara) warm up quickly and increase the temperature gradient between there and the interior highlands. There are cases on record of 24 consecutive days with *mistral*. Main characteristics of these winds are their low temperatures (in winter, often well below freezing), the dryness of the air (long-lasting summer *mistrals* cause serious soil aridity), fair skies, and extreme gustiness. Average speed of the *mistral* winds is about 45 kt, and gusts of 80 kt are common. The depth can reach 6500 ft (1981 m).

(3) Locally, the *mistral* of southern France is also known as *mangeofango*, *aurassos*, and *cisampo*.

e. **Other Winds:**

(1) In the Strait of Gibraltar easterly winds are particularly frequent in March and from July to October. Known as *levanter*, they occur with a high pressure area (Azores extension) over western Europe, and a low over the Atlantic or Morocco. The banner cloud of the Rock of Gibraltar, often stretching a mile downwind, and the complex of eddies around the Rock (Carmen Vortices) are famous.

(2) The rain-bearing east winds on the southeast coast of Spain and at Gibraltar are known as *solanos*. They blow toward an approaching low.

(3) *Vendevales* are southwest winds, accompanied by rain, gales, and poor visibility off the east coast of Spain with a maximum frequency from September to March.

4-23. CIS. A *bora* type wind occurs over northern tundra areas. The *buran* is the name for blizzards that occur over the flat plains in north central portions of the region. The *purga* is a severe snowstorm of greater intensity than the *buran*. A late summer wind known as *sukhovei* is a hot, dry easterly or southeasterly wind of the southern regions of the CIS.

4-24. Case Study - Strong Winds. We present two studies of strong winds in the UK. Winds in the first case occur from an unusual direction The second is an example of wind speed as a function of stability.

4-25. A Southerly Wind Event. This situation was atypical due to strong winds from the south. The normally reliable Fine Mesh model missed in intensity and location, but the ''analyzable'' factors contributing to the development of this situation were (in hindsight) quite clear.

a. The most typical synoptic precursor of strong wind situation occurs when a system moves from over the Atlantic into **pre-existing trough** or **low already** in the eastern Atlantic. The western system is usually accompanied by a west-southwesterly jet, with wind speed sometimes 120 kt. *Figure 4-22 (after Lorenc, et. al., 1988) shows the operational global assimilation analyses of 0000Z 14 October 1987.

(1) The surface low (to affect UK) is centered at 42°N, 40°W. The associated trough extends from Scotland to the Azores, and there is a strong 850 mb temperature gradient north of the low in the central Atlantic. When low pressure centers get close to each other the resulting flow initially intensifies both.

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*After Lorenc, A.C., R.S. Bell, T. Davies, and G.J. Shutts , 1988: Numerical Forecast Studies of the October 1987 Storm Over Southern England. *Meteorological Magazine,* Her Majesty's Stationary Office, Bracknell, Berkshire UK.

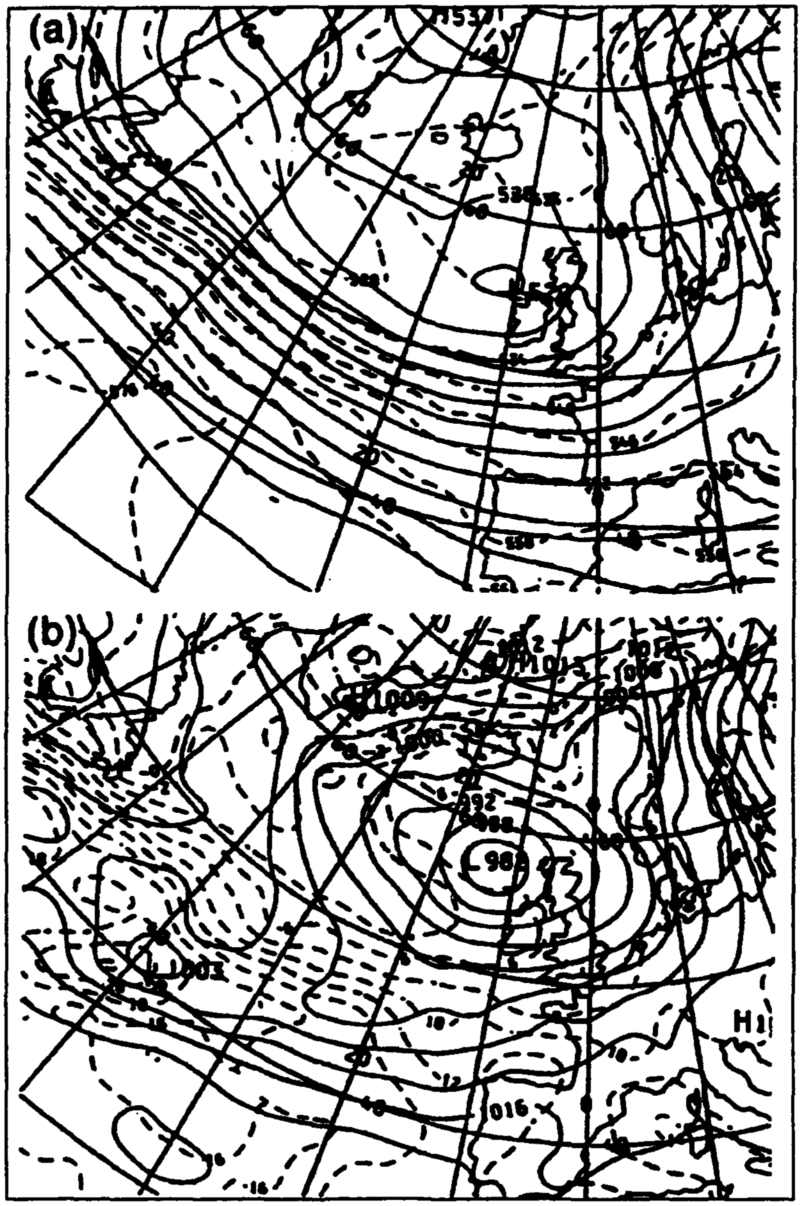

***Figure 4-22. 0000Z 14 October 1987 Operational Global Analyses. (a) 500 mb heights (solid) and thickness (dashed) in gpm; (b) sea level pressure (solid-mb) and wet bulb potential temperature (dashed-C).**

(2) The western low center is now over the Azores. Note the back side. The strong 850 thermal gradient is perpendicular to the contours, and stage is set for massive cold air infusion into the low. Already deepened due to induced cyclogenesis, the low then deepened further due to cold air advection (CAA).

(3) Strong surface winds are only a symptom of a maturing cyclone. You must also look at upper air features which may enhance intensification (upper troughs and thermal advection). Figure 4-22a (after Lorenc, 1988) shows the 500 mb height/thickness contours mostly in phase.

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*After Lorenc, A.C., R.S. Bell, T. Davies, and G.J. Shutts., 1988: Numerical Forecast Studies of the October 1987 Storm Over Southern England. *Meteorological Magazine,* Her Majesty's Stationary Office, UK, Bracknell, Berkshire UK.

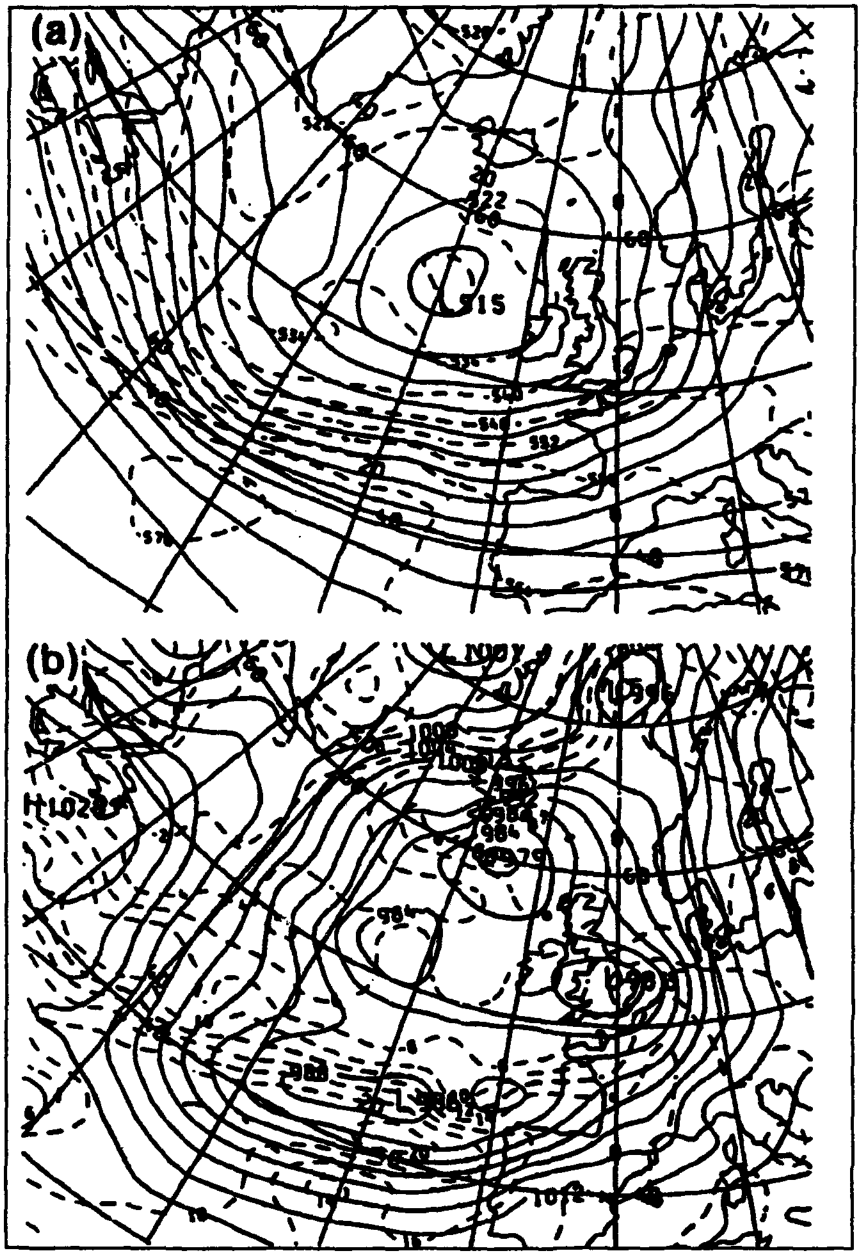

***Figure 4-23. 0000Z 15 October 1987 Operational Global Analysis. (a) 500 mb heights (solid) and thickness (dashed) in gpm; (b) sea level pressure (solid) and wet bulb potential temperature (dashed).**

(4) *Figure 4-23a (after Lorenc, et. al., 1988), the 15/00Z 500 mb height/thickness chart, shows the trough becoming much more definitive. Now at 35°W, it is only 500 miles behind surface feature. The gap is closing fast. There is still CAA into the rear, indicated by lowering thickness values.

(5) *Figure 4-23b (after Lorenc, et.al., 1988), the 15/00Z sea level pressure/WBPT analysis shows **two separate and coherent low centers.**

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*After Lorenc, A.C., R.S. Bell, T. Davies, and G.J. Shutts , 1988: Numerical Forecast Studies of the October 1987 Storm Over Southern England. *Meteorological Magazine,* Her Majesty's Stationary Office, Bracknell, Berkshire UK.

(6) *Figure 4-24 (after Woodroffe, 1988), the 15/12Z surface analysis, shows the trough pivoting from a WSW/ENE to SW/NE orientation. The wind max was ahead of the trough, but there was continued cold air advection into the rear. The system remained stationary but changed shape. What did the change of alignment mean? The system was now pivoting to the left, and the new trajectory was steering it over central England, affecting all of our UK bases.

(7) Preliminary analysis shows only one low. The finalized analysis shows two, with the second one just south of the Brittany Peninsula.

(8) *Figure 4-25 (after Woodroffe, 1988) shows the finalized (9a) and preliminary (9b) 16 Oct 00Z

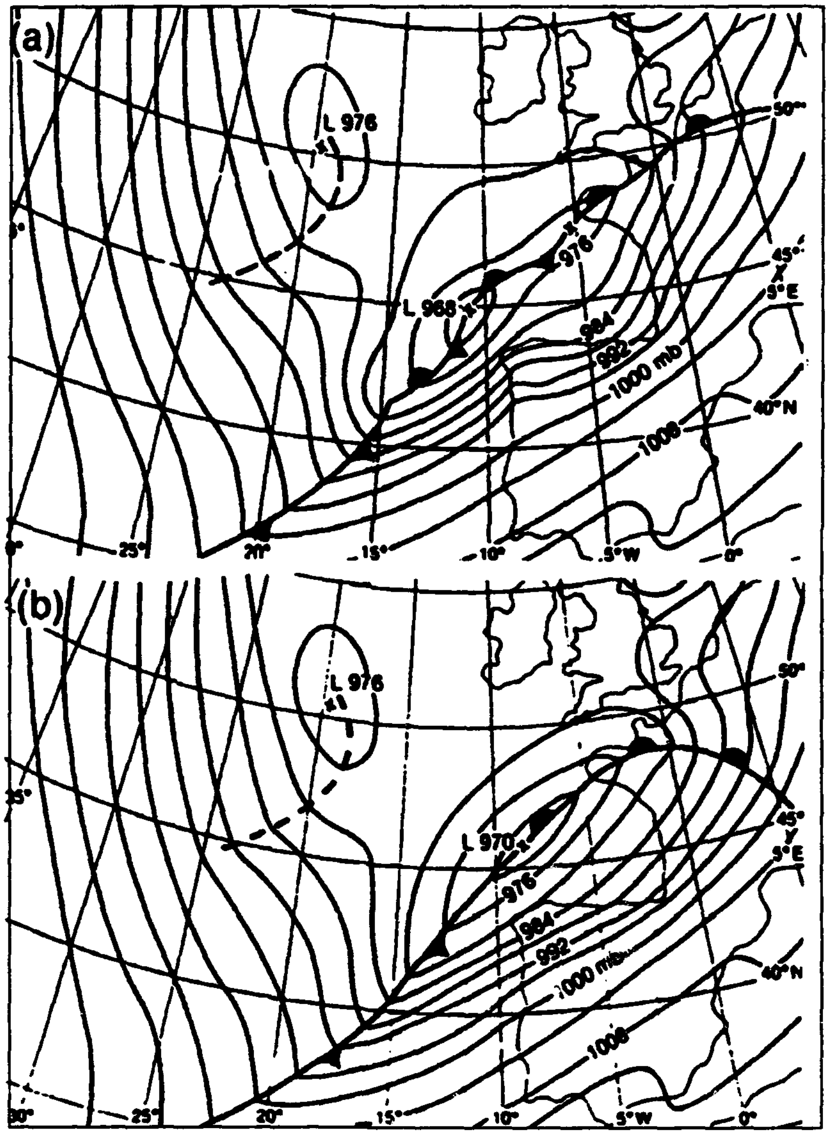

***Figure 4-24. Operational Surface Analyses for 1200Z 15 October 1987. (a) finalized; (b) preliminary.**

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*After Woodroffe, A., 1988: Summary of the Weather Pattern Developments of the Storm of 15/16 October 1987. *Meteorological Magazine,* Her Majesty's Stationary Office, Bracknell, Berkshire UK.

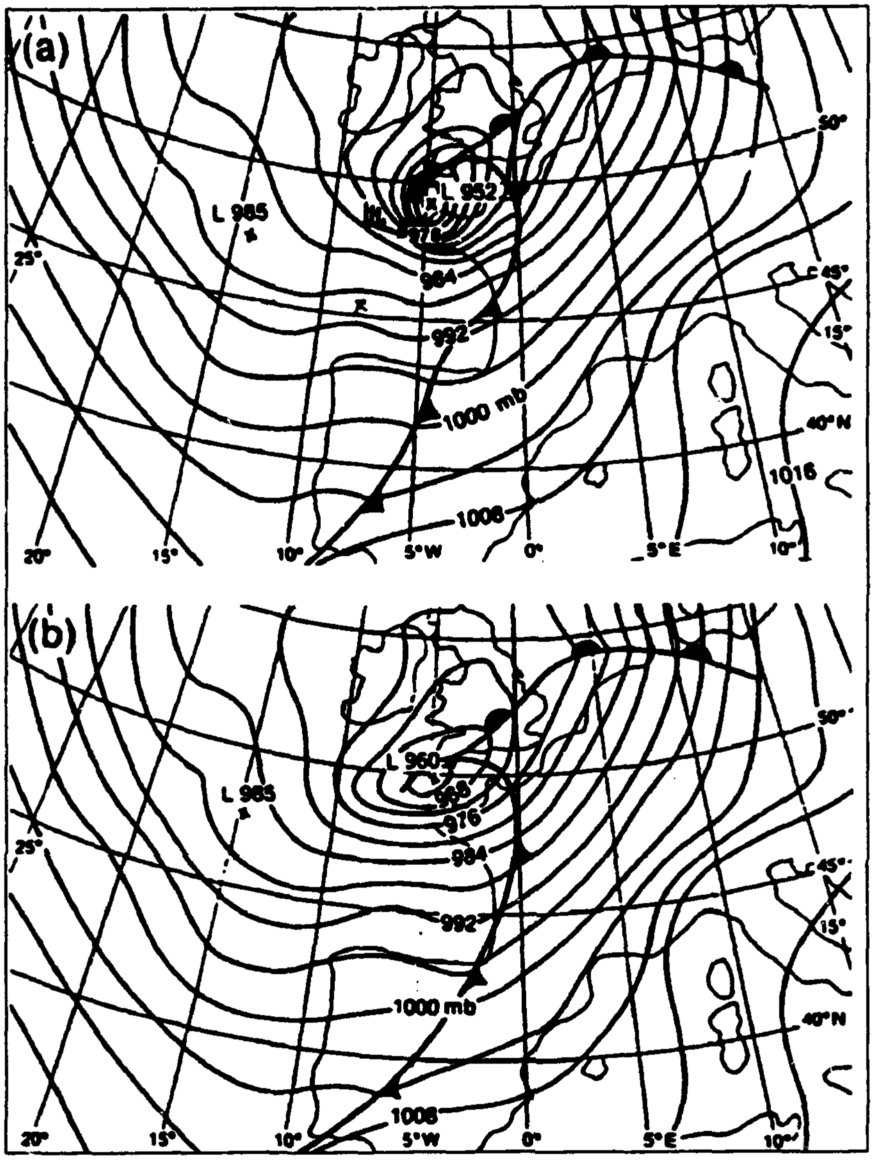

***Figure 4-25. Operational Surface Analyses for 0000Z 16 October 1987. (a) finalized; (b) preliminary.**

surface analyses as the system reached maximum intensity. More confusion: the low in the finalized analysis was 8mb deeper than in the preliminary analysis. Due to data sparse trajectory over water, the model continually underestimated intensity.

(9) **Figure 4-26 (after Advisory Services Branch, 1988) shows the thermograph traces from Bracknell. There was an initial sharp rise in temperature, indicative of a strong pre-frontal thermal ridge. This is often a precursor to a strong wind situation (in association with other favorable factors). This was

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*After Woodroffe, A., 1988: Summary of the Weather Pattern Developments of the Storm of 15/16 October 1987. *Meteorological Magazine,* Her Majesty's Stationary Office, Bracknell, Berkshire UK.

**After Advisory Services Branch, 1988: A Detailed Description of Wind and Weather During the Passage of the Storm of 15/16 October 1987. *Meteorological Magazine,* Her Majesty's Stationary Office, Bracknell, Berkshire UK.

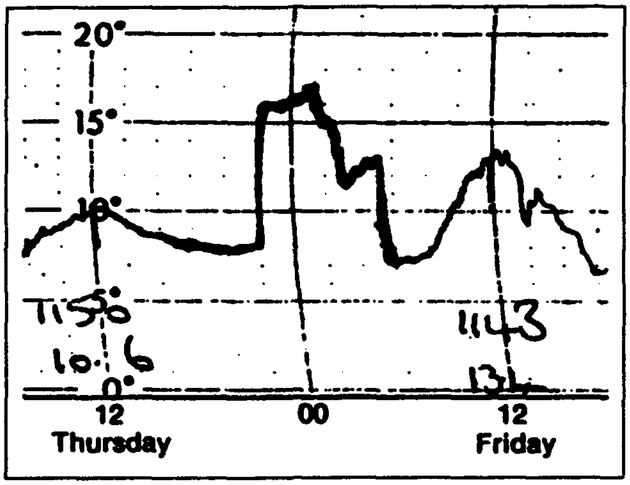

***Figure 4-26. Thermograph Trace From Bracknell.**

followed by a sharp drop in temperature just before 03Z, with a secondary 10° C drop. The latter was coincident with the passage of the trough (strong CAA). Trough passage was also reflected in the wind shift from S to SW

(10) *Figure 4-27 (after Advisory Services Branch, 1988) shows Bracknell's barograph trace. The pressure falls were unexceptional, averaging 8 mb per 3 hours. The pressure rises, however, were exceptional; 20 mb per 3 hours (Bracknell: 23). Gradient winds were 90 kt with both with pressure falls and with rises. Surface gusts were 60 kt ahead and behind despite the disparity between the speed of pressure falls and rises.

(11) Figure 4-28 (after Advisory Services Branch, 1988) shows the surface wind plots for the southern UK. The 06Z gusts were to 50-60 kt, but direction had shifted to the SW. Maximum gusts recorded were in the 90 kt range, and by 9Z gusts were down to 30-40 kt.

(12) In summary, the strong winds recorded with this event were a result of several factors occurring

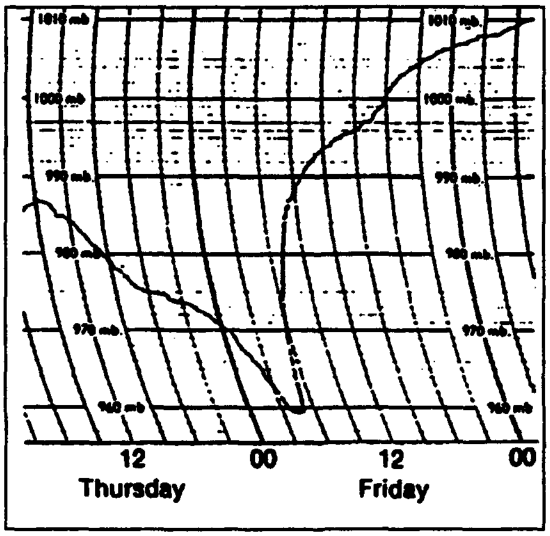

***Figure 4-27. Barograph Trace From Bracknell.**

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*After Advisory Services Branch, 1988: A Detailed Description of Wind and Weather During the Passage of the Storm of 15/16 October 1987. *Meteorological Magazine*, Her Majesty's Stationary Office, Bracknell, Berkshire UK.

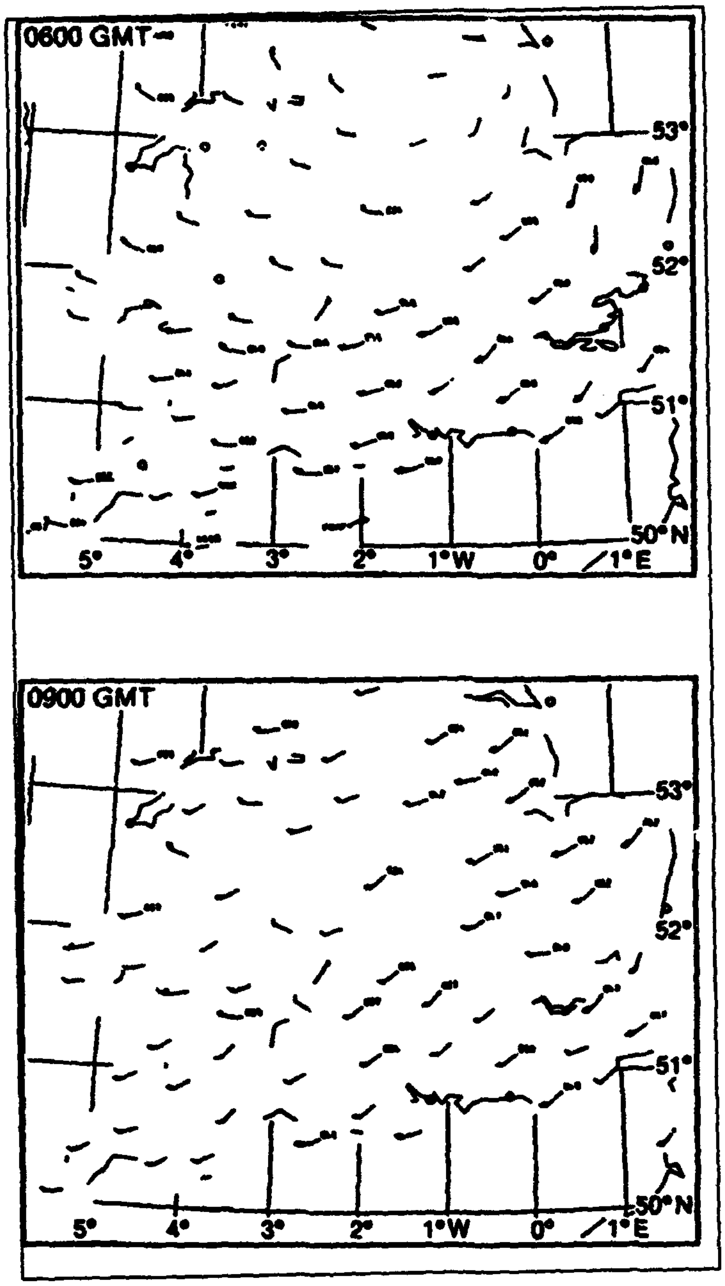

***Figure 4-28. Wind Speeds and Gusts Over the Southern UK on 16 October 1987. (a) 0600Z; (b) 0900Z.**

simultaneously. An upper trough caught up to a surface feature. Interaction between two lows contributed cyclogenetic forcing. Strong CAA at all levels into the rear of the trough deepened it. A strong jet was in the area. Finally, a strong thermal ridge formed ahead of the front and progressively increased in amplitude.

(13) For lessons learned, "the computer" usually models well but data sparse regions or late

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*After Advisory Services Branch, 1988: A Detailed Description of Wind and Weather During the Passage of the Storm of 15/16 October 1987. *Meteorological Magazine,* Her Majesty's Stationary Office, Bracknell, Berkshire UK.

observations can cause it to fail. The GSM, Fine Mesh and the Coarse Mesh never agreed on what was happening - A clue to when we must use all the available tools (hand analysis, initialization, METSAT, and basic met principles) to learn what is happening.

4-28. Downward Mixing as a Function of Stability. The "classic" European synoptic scale wind storm is an outgrowth of the effects of the Icelandic Low. The greatest threat occurs from late fall through late spring. The UK usually takes the brunt of the force, but areas north of the Alps are also vulnerable. The following is a case study from the storm of Thanksgiving 1984. During this period, virtually all locations from Scotland to Munich experienced winds greater than 50 knots. Many reported 80+ knots. We'll look at the 850 mb charts from 20-24 November.

a. Notice that initially (figure 4-29), the Icelandic Low was west of its usual position and quite weak. Winds over Europe were also weak.

b. By 21 Nov (figure 4-30), the storm started to move eastward, and began to undergo explosive development. Though winds at 5000 ft, over the UK were 40 knots, they were still light at the surface.

c. On the 22nd (figure 4-31), the storm center was near 55°N, 30°W with a central contour height below 960 gpm. While this was not unusual, the 50 knot surface winds then being felt by the UK and the coast of France were. Eastern France and all of Germany still just had light winds.

(1) The strong surface wind zones are outlined in dashed line. Coincidentally, that line is also the +5° C isotherm. There is nothing magical about the +5° C isotherm. What IS important is the strong warm air advection taking place within the lower levels of the atmosphere.

(2) The instability in this unusually warm lower layer allows the free mixing of air from the wind speed maximum down to the surface. The thermal ridge at 850 mb is simply the reflection of this phenomena.

d. By the 23rd (figure 4-32), northern Europe was experiencing the full fury of the system. The 850 mb winds over UK were stronger than those over the continent but the UK surface winds had dropped considerably. Note the location of the thermal ridge on the 23 Nov panel.

e. The 24 November 850 mb chart is shown in figure 4-33.

f. In summary, the contour gradient around the Icelandic Low usually strengthens during fall and winter. This in itself does not indicate the onset of destructive surface winds. As shown in this study, only a portion of the intensity of winds aloft will be felt at the surface. The strength of the surface winds is largely determined by the lapse rate in the lower 5-10 thousand feet of the atmosphere. We have divided the various lapse rates into six distinct classifications (table 4-3).

(1) The wind that will reach the surface is a percentage of the wind aloft, that percentage dependent upon the lapse class between the surface and the level above it. Each lapse rate class has different tendencies to allow downward mixing of the winds.

TABLE 4-3. WIND AS A FUNCTION OF STABLITY

CLASS	DEFINITION	% FELT AT SFC
1	Super adiabatic	90
2	Conditionally unstable	85
3	Conditionally stable	75
4	Stable	70
5	Isothermal	65
6	Inversion	60

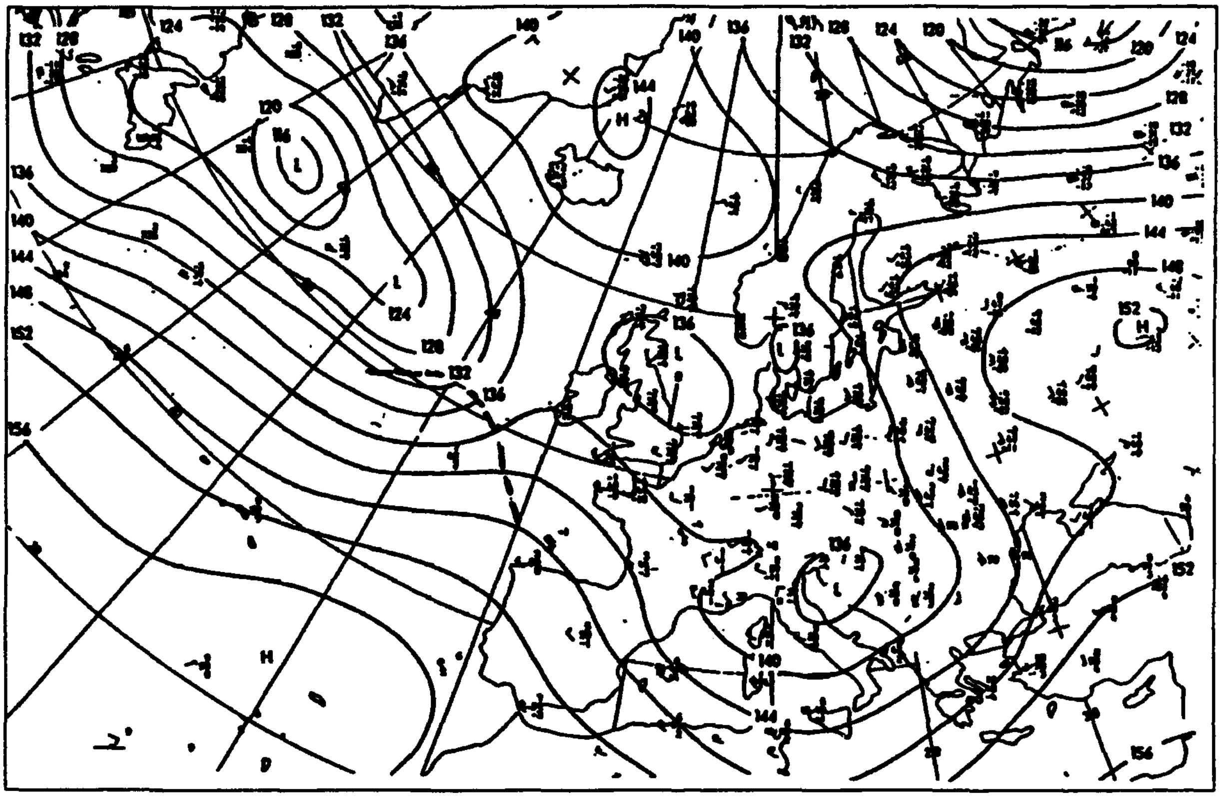

Figure 4-29. 0000Z 20 October 1984 850 mb Chart.

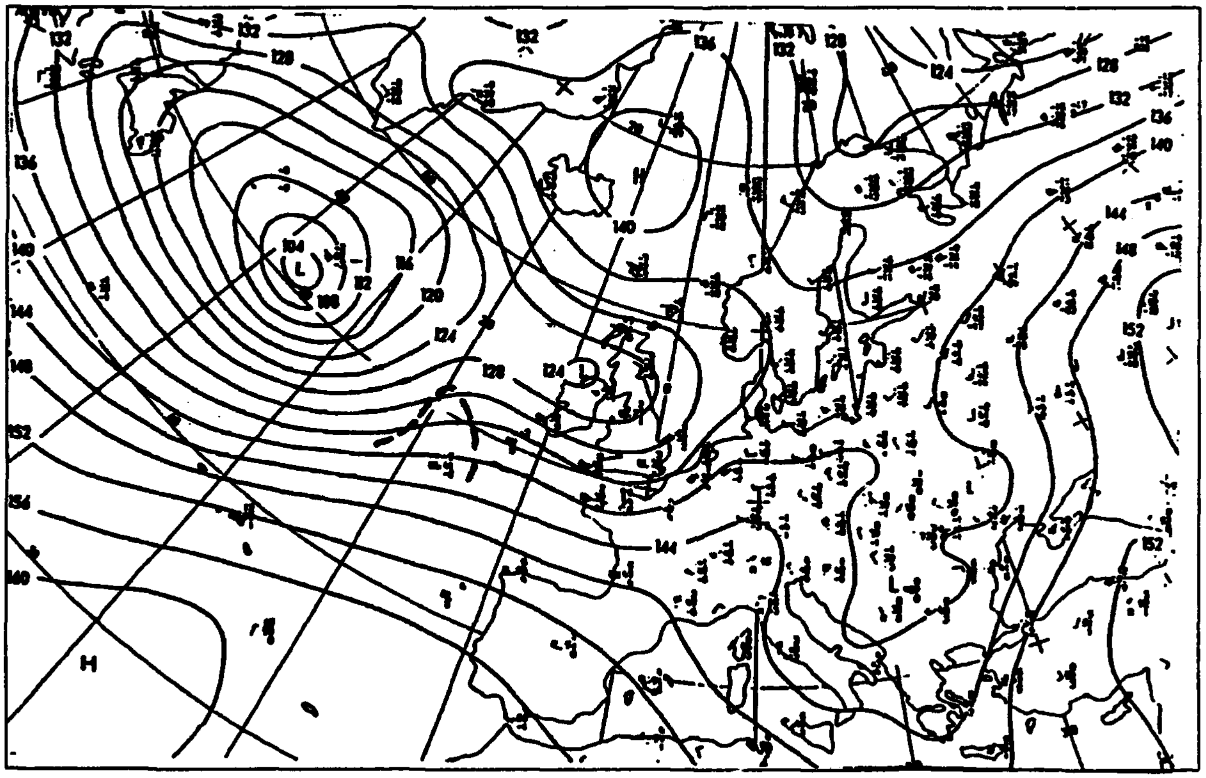

Figure 4-30. 0000Z 21 October 1984 850 mb Chart.

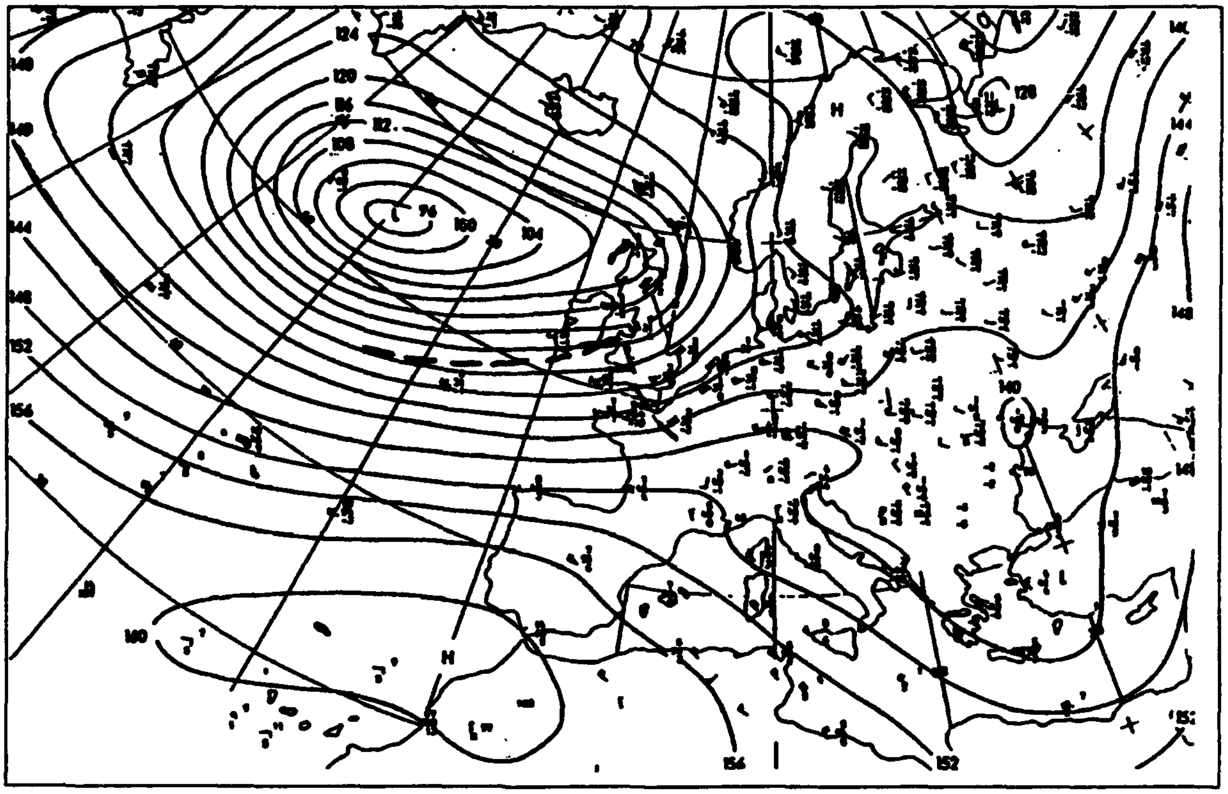

Figure 4-31. 0000Z 22 October 1984 850 mb Chart.

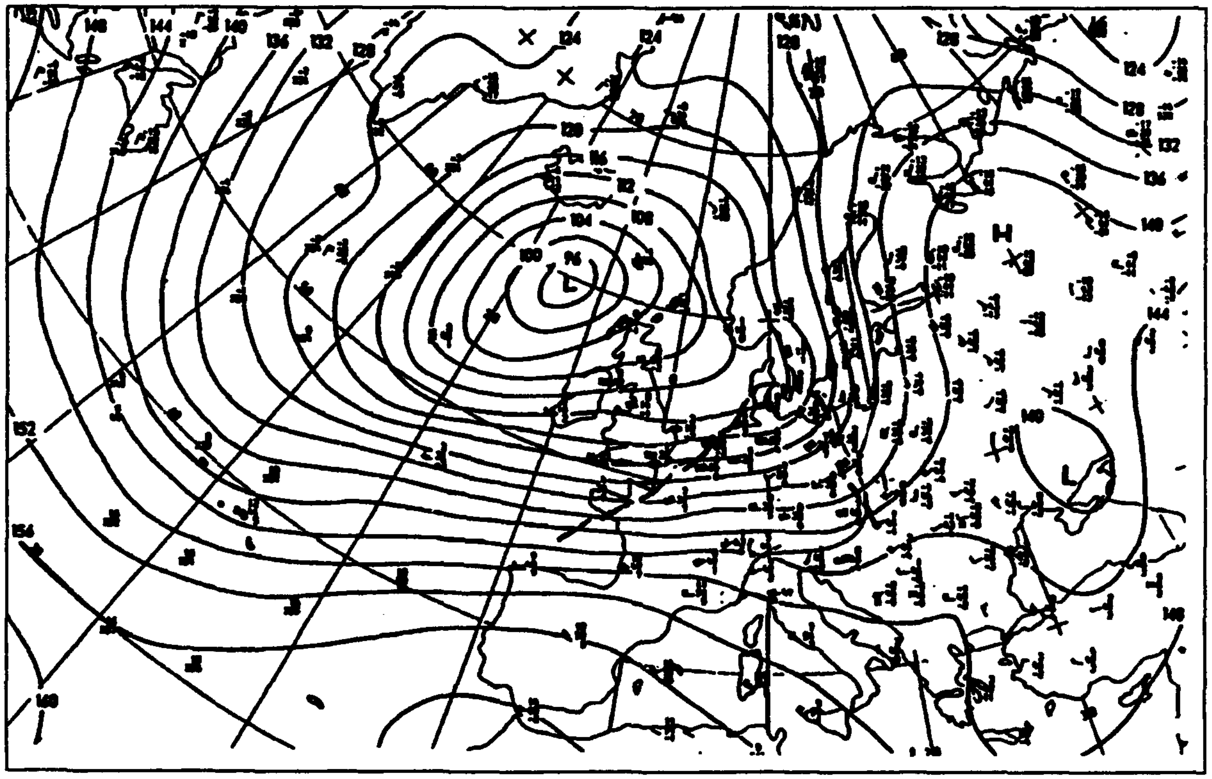

Figure 4-32. 0000Z 23 October 1984 850 mb Chart.

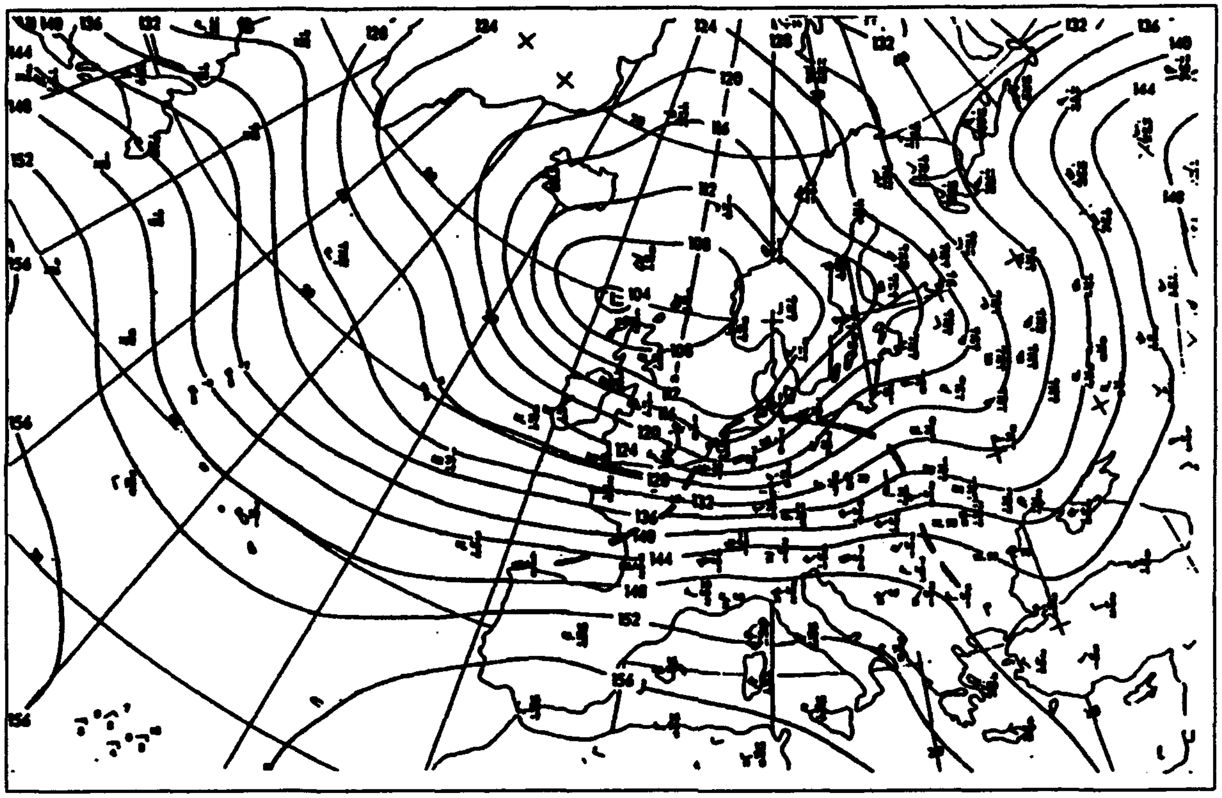

Figure 4-33. 0000Z 24 October 1984 850 mb Chart.

SECTION E - TURBULENCE

4-29. Introduction. Low level mechanical turbulence has a large impact on the operation of aircraft, as well as the conduct of paradrop, and surface military operations. We limit the following discussion to turbulence occurring below 10,000 ft (3048 m), caused by mechanical or thermal processes, or mountain (lee) waves. We will not discuss clear air turbulence associated with the jet stream.

4-30. Low Level Turbulence:

a. Low level mechanical turbulence is caused by strong low level winds blowing over/around obstructive terrain features under certain conditions of stability. Since much of Europe is mountainous or at least hilly, this type of turbulence affects a large percentage of our area of interest. Refer back to figure 2-4 for the areas in theater, considered to have terrain rough enough to cause turbulence. Turbulence can also occur over smooth terrain, but generally, higher wind speeds and greater instability are necessary. In Europe, the turbulence season runs from October through March, coincident with the higher frequency of strong surface winds.

b. Areas of Europe that have both a high incidence of turbulence as well as a large amount of military air traffic include the Rhine and Mosel River Valleys, the Eifel and Hunsruck Mountains, and the Rhone River Valley.

(1) The rugged nature of the terrain adjacent to the Rhine and Mosel Valleys enhances both the frequency of occurrence and intensity of turbulence here. The channeling of the wind in the valleys is also a factor.

(2) The channeling of low level winds in the Alps causes frequent and often dangerous turbulent conditions in southern France. The Rhone Valley, famous for its *mistral* winds, is an example area.

4-31. Inversions and Aircraft, Thermal Turbulence:

a. Figure 4-34 shows a representative sounding in a desert climate or in any other area on a hot dry day. The solid line is the early morning dry-bulb temperature sounding. Notice the low level radiation inversion which can easily range up to 40° F in the desert. Consider the following points. The radiation inversion is very shallow and with large insolation (remember, the atmosphere is very dry) it will quickly heated out of existence. This will result in a very rapid rise in temperature during the morning, followed by only slight temperature changes later. The maximum surface temperature could be up to 5° F (2.8 C) greater than that indicated by the dry adiabatic lapse rate. When the inversion breaks, any previously trapped low level moisture is released, and cumulus will form at the lifting condensation level. While the inversion exists, the low level winds are calm or nearly so, and in this example, the wind at the top of the inversion is 35 kt.

b. There will be two effects on flying operations. First, an aircraft changes air speed +35 kt (depending on direction of flight relative to the wind). Disaster beckons if the plane is near minimum flying speed

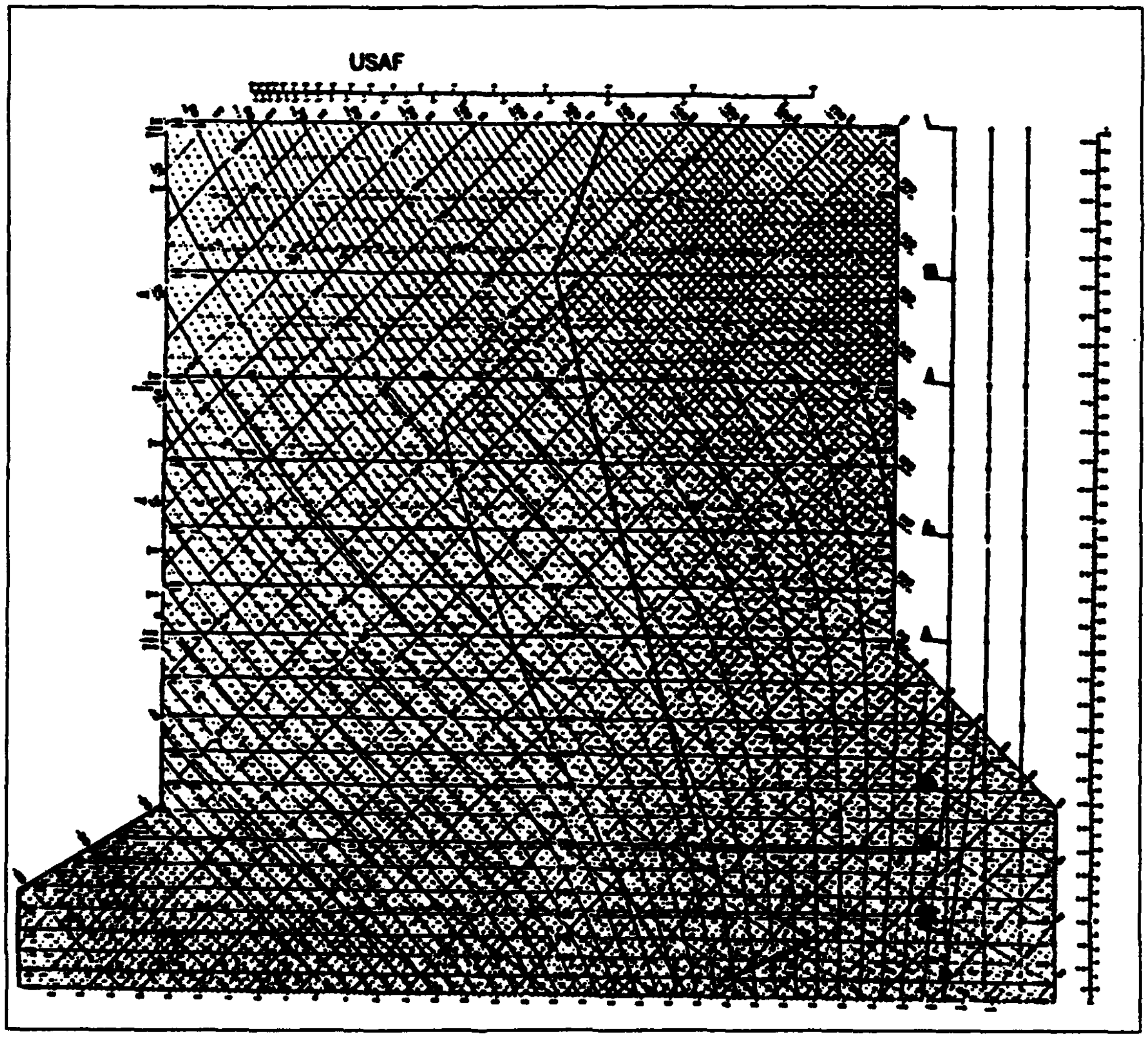

Figure 4-34. Representative Sounding in a Dry Climate.

during landing or take-off. Later, as the inversion burns away, there is no longer a barrier to the stronger winds aloft. With the adiabatic lapse rate, air moving at 35 kt mixes downward, resulting in gusty surface winds.

c. Finally, if there is a second inversion above the unstable layer, expect turbulence in that inversion. The air that has been freely "zooming up the adiabat" grinds to a halt in the stable layer. This will produce significant thermal turbulence as the aircraft climbs through the upper inversion.

4-32. Mountain Wave Turbulence. Lee wave turbulence occurs with strong upper level winds over higher terrain, and a capping inversion near the peaks. This turbulence occurs over the higher terrain features of central Europe and the Alpine region with certain synoptic conditions.

a. Over the Swiss and Austrian Alps, turbulence occurs when a deep low pressure system over central France produces a strong southerly or southwesterly flow over the mountains. A strong southerly jet stream overhead, and 50 kt winds at the 850 mb level can generate severe turbulence here.

b. Over the French Alps and the Cevennes Mountains, turbulence occurs with a strong short wave trough at 5 to 8° E and a high pressure ridge which moves rapidly into central France. The deep trough in northern Italy, together with the ridge in France produce a strong pressure gradient over the Cevennes Mountains and Rhone Valley.

c. Low pressure over the Ligurian Sea with strong easterly flow over the French Alps produces a mountain wave along the mountain ridge east of the Rhone Valley.

d. On the French side of the Pyrennees, turbulence occurs with a deep trough off the west coast of Spain, and a strong southwesterly jet stream over central Spain and southwestern France. The surface chart will show a deep depression in the Bay of Biscay with strong southerly or southwesterly gradient winds ahead of a cold front. An occluded front occurs east of the low pressure center. The strong southerly flow over the Pyrennees causes the lee wave.

e. Strong northerly flow causes mountain wave activity over Spain in the lee of the Pyrenees.

f. A deep trough over the western Mediterranean can cause lee wave turbulence over the Adriatic and over the eastern portions of Greece. If the systems shift more eastward, areas of Turkey can be affected by the phenomenon. Locations to the lee of the Caucasus also experience mountain waves.

g. Mountain wave turbulence is relatively frequent during winter in the lee of the Kjølen Range in Scandinavia in a strong westerly flow regime.

h. Turbulence occurs over the mountainous regions of the Balkan countries during passage of low pressure systems to the north of Romania or along the Romania-Bulgaria border.

4-33. Tools. Having the "big photo" synoptically is you best defense against mountain wave turbulence. Things to look for include:

a. Strong mid-, or upper-level flow, perpendicular to the mountains.

NOTE: If the flow impinges the terrain at less than a 90° angle, the perpendicular component will determine the severity.

b. A capping inversion at or slightly above the level of the mountain peaks. This inversion acts as the top of a drum to reflect the turbulence back downward, creating the familiar "roll clouds" associated with mountain wave turbulence.

c. Speaking of roll clouds, be sure to use satellite imagery to look for signatures of mountain wave turbulence. The clouds will be arrayed in lines nearly parallel to, and in the lee of the range. These clouds form in the "top of the roll" due to adiabatic cooling. The gaps in the clouds are the "bottoms of the rolls" where the cloud particles have evaporated due to adiabatic warming during descent.

(1) Beware, however. If the air is extremely dry in the lee of the range, there may not be sufficient

moisture to show up as clouds. In this case the synoptic charts may be a better tool than the satellite receiver.

(2) With some experience, you can estimate the winds at the peaks by how far apart each roll cloud is from the adjacent one. The faster the winds, the farther apart the clouds are.

4-34. Turbulence Decision Tree. The following decision tree originated in the CONUS, but it works as well here as it does in the states.

TABLE 4-4. TURBULENCE DECISION TREE

These thresholds were developed for the following aircraft: 727, C-9, C-130, F-4, F-5, F-14, F-15, F-16, F-106; which have similar turbulence sensitivities. Very light aircraft and rotary wing aircraft may experience slightly more turbulence while extremely heavy aircraft (B-52, C-5) may experience slightly less. Synoptic situation, local terrain, PIREPs and aircraft type should all be considered before the final forecast is made.

		$30 \le$ Gusts ≤ 39	Light: Sfc to 2000 to 3000 ft
	Flat Smooth Terrain	$40 \le$ Gusts ≤ 49	Light-Moderate: Sfc to 3000 ft
		Gusts ≥ 50	Moderate: Sfc to 3000-5000 ft
SURFACE WINDS			
		$20 \le$ Gusts ≤ 24	Light: Sfc to 3000 ft above Ridge Height
	Rough Terrain	$25 \le$ Gusts ≤ 34	Light-Moderate Sfc to 3000-5000 ft above Ridge Height
		$35 \le$ Gusts ≤ 49	Moderate: Sfc to 5000 ft above Ridge Height
		Gusts ≥ 50	Severe: Sfc to 5000 ft above Ridge Height

ean Wind Speed	**Vertical Vector Wind Shear (kt/1000 ft)**					
	5-7	8-10	11-20	21-30	31-50	>50
40-60 kt	N	L	L-M	M	M-S	S
61-120 kt	L	L-M	M	M-S	S	S-X
>120 kt	L	L-M	M	M-S	S	X

=None; L=Light; M=Moderate; S=Severe; X=Extreme

SECTION F - FREEZING RAIN, AND RAIN VS. SNOW

4-35. Introduction. As stated earlier, forecasters use the term **severe** to describe not only **violent** weather, but also weather that has significant mission impact. Consider the impact of freezing precipitation.

- Severe aircraft structural icing.
- Severe aircraft engine inlet icing.
- Unusable roadways, taxiways, and runways.

The classic freezing precipitation synoptic situation is as follows: Sub-zero temperatures have settled in over the continent as an extension of the Siberian High. These temperatures have remained below zero for the last several days, and a warm type occlusion is approaching from the west. As the front overruns the cold pool, a double freezing level situation occurs and produces freezing precipitation. We include no climatology with this section but show three methods for forecasting precipitation type. The GSM method is a broad-brush approach for synoptic scale areas.

a. GSM Method. Use the following panels of the GSM:

(1) The moisture panel
(2) The high-level (850 - 500 mb) thickness panel
(3) The low-level (1000 - 850 mb) thickness panel
    (a) Make a composite of the three charts.
        1. From the moisture panel, highlight both 2° and 5° dew point depression (Tdd) isopleths.
        2. From the high-level thickness panel, highlight the 4080 contour.
        3. From the low-level thickness panel, highlight the 1290 contour.

(b) From the composite chart, the freezing precipitation will be between the 1280 contour to the south, and 4020 contour to the north. If this area lies inside the 2° Tdd line, expect steady precip; within the 5° degree line, precip will be intermittent.

b. 31 WS Method. In 1985, forecasters from 31 WS met to tackle the problem of forecasting freezing precipitation. The outcome of their gathering was a checklist of requirements that ALL occurrences of freezing precip must have. Table 4-5 is the checklist.

TABLE 4-5. FREEZING PRECIPITATION CHECKLIST

	YES	NO
SFC temp ≤ 0 for at least 12 hrs	___	___
850 mb temp ≥ -4°	___	___
Warmest temp aloft\ is ≥ 0	___	___
1000 - 850 mb thickness 1280 - 1320	___	___
1000 - 500 mb thickness 5350 - 5450	___	___

If all are yes, forecast freezing precipitation
If any answer is **no**, freezing precipitation will not occur.

c. 2WW/TN-86/002 Method. While the tech note doesn't specifically address freezing precipitation, values around 50% are a danger signal to the forecaster that precip type may either be mixed or freezing.

(1) Building the Unit Worksheet. If precipitation is forecast, use this worksheet to determine the type to forecast. Figure 4-35 is a completed worksheet showing the format. To build one, you must determine the 50% predictors unique to your station (i.e., once you compute them, they never change). We

provide three ways to determine these values.

(a) Look them up by block number in 2WW/TN-86/002, Appendix A. (Not all stations are listed.)

(b) Find the predictors from the graphs in 2WW/TN-86/002, Appendix B. On the appropriate graph, locate the station elevation (in meters) along the horizontal axis and draw a vertical line up to the graph line. From this point, draw a horizontal line to the predictor axis to get the 50% value. Figure 2 in 2WW/TN-86/002 shows an example for a station with an elevation of 420 m.

(c) If you forecast for several areas you might wish to use the slope/intercept formula and the values listed in 2WW/TN-86/002, table 1. The formula for the 50% predictor value is:

50% value = (Slope * Stn Elev (m)) + Intercept

Substitute the appropriate values and use the station elevation in meters. The resulting predictor goes on the worksheet. In 2WW/TN-86/002, figure 3, the 50% predictor column was calculated using Furstenfeldbruk's elevation of 1703 ft (=524 m).

(2) Using the worksheet. Take the following steps:

(a) Step 1. Fill in the observed (forecast) values for the seven snow predictors.

(b) Step 2. Subtract the station's predetermined 50% values from the observed (forecast) values to obtain the deviations. Watch your signs!

(c) Step 3. For each predictor's deviation, determine the probability additive from the table provided with the worksheet. If the deviation is not within the specified range of values, the additive is zero.

(d) Sum the probability additives and the constant to determine the probability of occurrence.

TABLE 4-6. SLOPE INTERCEPT VALUES FOR 50% PREDICTORS

Predictor	Slope	Intercept	Error	Standard Correlation to Sta Elev
Surface Dry Bulb Temp	0.00126	-0.16	±0.5 C	0.485
Potential Temp 50 mb Above Sfc	0.0109	+1.7	±1.7 C	0.987
850 mb Temp (C)	0.0067	-6.1	±0.4 C	0.969
WBZ Height AGL (m)	0.087	123.	±40.0 m	0.463
1000/850 mb Thickns (m)	0.0285	1292.	± 2.0 gpm	0.959
1000/700 mb Thickns (m)	0.0652	2792.	± 5.0 gpm	0.955
1000/500 mb Thickns (m)	0.144	5263	±15.0 gpm	0.915

(e) Probabilities of greater than 50% imply that precipitation will likely fall as snow. But since most weather activities issue yes/no forecasts rather than probabilities, they will prefer to set thresholds. Verification of this technique in central Germany indicate that thresholds in excess of 54% probability verify as snow 91%.

d. Other "Thumb-Rules."

(1) Look at both elevation and siting of your base. Obviously the higher you are the more snow you can expect. Temperatures are generally lower on northern slopes due to sun angle.

RAIN/SNOW WORKSHEET

LOCATION Furstenfeldbruk VALID 9 Dec 91

FCSTR LD VERIFICATION Rain (ld)

Predictor	OBS/FCST Value	50% Value	Deviation	Additive
Surface Dry Bulb Temp	3	.5	2.5	+8.2
Potential Temp 50 mb Above Sfc	7	7.4	-.4	+4.4
850 mb Temp (C)	-5.5	-2.6	-2.9	0
WBZ Height (m)	415	169	246	0
1000/850 mb Thickns (m)	1300	1307	-7	12.7
1000/700 mb Thickns (m)	2820	2826	6	6.3
1000/500 mb Thickns (m)	5250	5338	-88	4
CONSTANT				+ 4.9

Probability of Snow = 40.5 %

Additives based on predictor deviations.

Predictor	Deviation (Obsvd/Fcst value - 50% value)	Additive
Surface Dry Bulb Temp (0°C)	<0.0 C	+8.7
	0.0 to <3.0 C	+8.2
Potential Temp 50 mb Above Sfc	<-2.0 C	+10.4
	-1.9 to <+1.0 C	+4.4
850 mb Temp (C)	≥+5.0 C	-7.4
WBZ Height AGL (m)	< 0 m	+43.1
	0 to < 200 m	+18.4
	200 m to < 400 m	+0
	400 m to < 700 m	-3.6
1000/850 mb Thickns (m)	< -20 gpm	+12.5
	-20 to < -10 gpm	+15.3
	-10 to < 0 gpm	+12.7
	0 to < +10 gpm	+0
	+10 to < +20 gpm	-3.3
1000/700 mb Thickns (m)	< -20 gpm	+15.9
	-20 to < +20 gpm	+6.3
1000/500 mb Thickns (m)	< -50 gpm	+4.0

Figure 4-35. Completed Rain - Snow Worksheet.

(2) If unstable cold air is entering Germany and the UK after a warm spell, snow will fall if T850 ≤ -6 C or 1000/500 Thickness ≤ 5260.

(3) If warmer air is entering Germany and the UK after a cold spell, snow can fall if T850 ≤ -2 C or 1000/500 Thickness ≤ 5380. (This does not work with Gulf of Genoa Lows.)

4-36. Icing. Depending on the forecast manual you read, there are several methods of forecasting aircraft icing. All, in one method or another take in temperature and dew point depression data and wind up with a forecast for the occurrence as well as type and intensity of icing. The two we will deal with here are the "-8D" method (suggested in the Navy Aerographer's Mate 1 and C manual, and use in the "Skew-T Pro" program); and the procedure used by the European Forecast Unit (EFU). The latter is a form of the AWS method you are used to, modified slightly for the weather conditions north of the Alps.

a. The - 8D method. This method is based on the premise that sub-freezing air may be saturated with respect to water, but be supersaturated with respect to ice. The procedure is as follows:

(1) Find the dew point depression at each reported sounding level.

(2) Multiply that Tdd by -8 and plot the result on the same Skew-T.

(3) Icing will occur between those levels where the "-8D" curve crosses the temperature curve, and the environmental temperature curve is on the left.

(4) The manual suggests that the amount can be inferred from the area between the curves.

b. EFU Method. (See table 4-7.) The following notes apply:

(1) Use upslope/lee effects charts for orographic effects.

(2) Winds must cross isotherms at greater than 40° angles, with a greater than 5 C thermal gradient for "strong advection."

(3) Determine weak vs. active fronts by the extent of the cloud shield, frontal speed, thermal gradient (see (2) above) and thermal advection.

(4) Watch for icing type/intensity changes caused by changes in temperature, relative humidity, or advection.

(5) Stratiform clouds should be thicker than 1500 ft. Thickness greater than can generate significant icing. This thumb rule does not apply if freezing precipitation is occurring.

(6) When either cold or warm advection is occurring, use the bottom portion of the decision tree.

(7) For slow-moving, less-active regions of the cold front, downgrade the icing intensity by one category.

TABLE 4-7. EFU ICING DECISION TREE

	clds/temp	spread/rh	amount/type
Wk Warm Front (3); Wk Orographic; Wk/ Filling Low; Stnry or Occluded Front	stratiform -2 to -17 C	>2 / <90%	Trace/None
		≤2 / ≥90%	Light Rime
	cumuliform -2 to -8 C	>2 / <90%	Trace/None
		≤2 / ≥90%	Light Clear
	cumuliform -9 to -17 C	>3 / <90%	Trace/None
		≤3 / ≥90%	Light Mixed
	<-17 C		Trace/None

	clds/temp	spread/rh	amount/type
Cold Front (7); Str Orographic; Str Active Warm Front (3); or Deep Low	stratiform -2 to -17 C	>2 / <90%	Trace/None
		≤2 / ≥90%	Mdt Rime
	cumuliform -2 to -8 C	>2 / <90%	Trace/None
		≤2 / ≥90%	Mdt Clear
	cumuliform -9 to -17 C	>3 / <90%	Trace/None
		≤3 / ≥90%	Mdt Mixed
	<-17 C		Trace/None
Frzg Fog; Frzg Dzl	Mdt Clear	(Sfc to Frzg Level)	
Frzg Rain	Svr Clear	(Sfc to Frzg Level)	

SECTION G - BLACK ICE

4-37. Introduction. This section deals with the meteorological conditions favorable for formation of black ice. These hints are based upon personal observations of the author (Lt Col D. L. Best), in the Kaiserslautern area. (**They have not been verified for other locations.** Use them as guidance at your location and modify them as required.)

a. Definition. The *Glossary of Meteorology* (Huschke et. al., 1959) defines black ice as "*thin new ice composed of fresh or salt water which appears dark in color because of its transparency." Soil type, state of the ground, vegetation, extent of buildings, type of road or sidewalk surface (stones, concrete, tar), etc., with weather conditions, largely influence black ice formation. Such environmental information is not readily available in a weather station where forecasters are primarily concerned with flying operations.

b. Ingredients. Frequent precipitation, negligible evaporation and near freezing temperatures provide the meteorological environment to form black ice. The "season" over most of southern and central Germany runs from late September through early June. Northern Germany, the Netherlands and the UK most likely see black ice from late October through early May.

c. Caveat. Forecasting black ice must, therefore, be restricted to general terms like "black ice formation possible" or "patchy black ice on roads" or "widespread black ice," etc. There are, however, some general features that can help forecasters to determine whether black ice will form.

4-38. Black Ice Forecasting Techniques. The greatest threat of black ice formation occurs with a clear or scattered sky following a rain (roads are still moist or wet), weak winds, and air temperatures below 35°F (2°C) (but clear skies, calm winds with 40°F (5C) suffice!). In any case, recent weather history needs to be included. The following paragraphs contain several sets of conditions for consideration in making weather forecasts.

4-39. Scenario I. Consider the following conditions:

a. Total cloud cover is 6/8 - 8/8, ceiling <5,000 ft.

b. Winds speed >5 kt.

c. Temperature of 35°-36°F (2 to 3 C) in the evening, dropping to 33°F (0 to -1 C).

d. Temperatures have been consistently warmer than 35°F (2 C) for at least 2 weeks.

(1) If conditions a through d are fulfilled, black ice will most likely not form.

(2) If conditions a through c are simultaneously met, and there have been below-freezing temperatures during the past 24 hours, black ice will form along forested areas and open terrain depressions since weak wind will not reach such areas.

(3) If conditions a through c are simultaneously fulfilled, and the ground is still partly snow-covered, black ice will form close to snow-covered areas.

(4) If conditions a through c are simultaneously met, following a severe cold spell (i.e., ground has been frozen for a week or more), black ice will slowly form beginning shortly before the astronomical sunset because of fading daylight. Black ice will most likely form in the forested areas first, and spread over open terrain during the night.

(5) If conditions a, c and d are met, and the wind speed is less than 2 kt, black ice may form over open terrain, but is generally very spotty (i.e., still rather unlikely).

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*Huschke et. al., 1959: *The Glossary of Meteorology*. Amer. Meteor. Soc., 638 pp.

4-40. Scenario II. Consider the following:

a. Total cloud cover is 6/8 - 8/8, ceiling <5,000 ft.

b. Wind speed is 2-5 kt.

c. Temperature hovers at 33°-34°F (around 1 C).

d. If these conditions are simultaneously met, it is generally possible for black ice to form. Furthermore, it is:

(1) Very spotty if temperatures have been warmer than 34°F (approximately 1°C) for at least 2 weeks.

(2) Likely along forested areas by midnight if temperatures were below freezing the night before.

(3) Imminent after sunset if the ground is still frozen or snow-covered (superficially melted) due to a previous cold spell.

(4) If the conditions a and b are met, but temperatures are 32°-33°F (just above 0°C) during the day, black ice will form beginning near sunset. It is a slow process, but by midnight black ice will be widespread.

4-42. Scenario III. Consider the following:

a. Total cloud cover is 4/8-5/8, ceiling <5,000 ft.

b. Wind speed is >5 kt.

c. Temperature is >35°F (approximately 2 C) during the day, becoming 33°F (0 to -1 C) at night.

d. Temperatures were below freezing the night before.

(1) If conditions a through d are met, black ice very likely will form in terrain depressions (no wind) or in forested areas shortly after sunset. It will form during the night in all areas not exposed to the wind.

(2) If conditions a through d are fulfilled, and the ground is only superficially melted due to a cold spell before, or a snow cover is still present, black ice formation is imminent 2 hours before *sunset*, most likely beginning near snowfields or in forested terrain.

(3) If conditions a through d are met, and the night frost was the first of the season, black ice can only form in "frost holes," i.e., locations which are notorious for shallow cold air stagnation. (There are no hints for that; these are locations that must be known).

(4) If conditions a, c and d are met, and the wind speed is less than 5 kt, black ice will form by sunset and will have covered large areas before midnight (if winds are <2 kt, most likely within 4 hours after sunset).

4-42. Scenario IV. Consider the following:

a. Total cloud cover is less than 4/8.

b. Wind speed is >5 kt in the afternoon, becoming <2 kt in the evening.

c. Temperatures drop to <40°F (5 C) by sunset.

d. Temperatures never have been below freezing.

(1) If conditions a through d are fulfilled, black ice can form over open terrain approximately 2 hours after sunrise. It will most likely occur after midnight. Forested areas escape black ice formation until temperature drops to 33°F (just above 0 C).

(2) If conditions a through c are met, and below-freezing temperatures occurred the night before, black ice will form immediately after sunset. It can form up to 2 hours before sunset in forested terrain.

(3) If conditions a through c are fulfilled, and the ground is only superficially frozen due to a previous cold spell, or snow is still on the ground, black ice will start forming 2 hours before sunset.

4-43. Scenario V. Consider the following:

a. Ceiling >10,000 ft or no ceiling.

b. Wind speed becomes <2 kt after sunset.

c. Temperatures are <30°F (-1 C).

d. Roads have been salted.

e. If conditions a through d are fulfilled, black ice will most likely form 1-2 hours after sunset or after the traffic has died down.

4-44. Surface Materials. Roads with heavy traffic will dry much faster than roads with little traff Therefore, the black ice threat on heavy traffic roads is generally much smaller than that on light traf roads. Radiative transfer with the surrounding environment, chiefly the atmosphere, causes tarred (asphalt roads to freeze much faster than concrete roads. If black ice has formed or is beginning to form on concrete runways, it very likely has already formed on tarred roads or sidewalks.

4-45. Reference. 2WW FM 89-001.

CHAPTER 4 REVIEW QUESTIONS

1. In the European theater what is the major winter forecast problem?

2. Which are the predominant types of fog here?

3. Of the three ingredients for thunderstorm formation, which is nearly always present here?

4. What is the turbulence season in Europe?

5. Name a region where gales are common.

6. What is a common location for foehn winds?

7. What is a common location for *estesian* winds?

8. What are the characteristics of a *sirocco*? Common location?

9. What is a common location for *bora* winds?

10. What is a common location for *mistral* winds?

11. Name the European locations where tornadoes are most common.

12. What is the danger to aircraft passing through a well-defined radiation inversion?

Chapter 5

ANALYSIS TECHNIQUES

5-1. Introduction. The basic forecasting rules you used during previous assignments will work equally well in Europe. However, there are important differences. This chapter will discuss some of the similarities, differences, and peculiarities of forecasting the weather in Europe. Undoubtedly, there are many more analysis and forecasting techniques that you will discover during your tour. The forecaster memos (FM) and tech notes (TN) published earlier by 2 WW should be used to supplement this chapter. We encourage numbered air forces (NAF), squadrons and detachments to add supplemental sections as they feel appropriate.

SECTION A - FRONTAL ANALYSIS CONCEPTS FOR WESTERN EUROPE

5-2. Introduction. This section identifies and discusses some peculiarities of frontal analysis in western Europe.

5-3. Analysis Comparison. AFGWC applies a consistent philosophy to all its products regardless if they are for the midwest or for the Mediterranean. Problems occur if we fail to acknowledge the limitations and applications of this philosophy. GWC's philosophy is based on the polar front model, the basic premise of which is that fronts are discontinues between air masses. They are conserved, continuous (ideally), stack vertically, and are supported dynamically by such things as thickness packing, temperature discontinuity, upper tropospheric jet streams, and pressure troughs.

a. European Characteristics. Here in Europe, fronts do not have the unique characteristics you may be used to seeing stateside.

(1) Long trajectories over the Atlantic and associated open-water areas cause air masses to lose the characteristics of their source regions.

(2) It is difficult to differentiate between displacing, and displaced air masses.

(3) Only truly southerly or easterly flow brings Europe air masses that are describable by conventional methods.

(4) When air masses lose their definition, fronts are harder to identify.

b. Problems. One problem arises in that you were taught to track fronts as surface features. Due to the lack of insolation, central Europe, in winter, is covered by a pool of cold air. The pool is persistent, deep (up to 2000 ft) and dense.

(1) Often, approaching "cold" fronts will ride over the cold pool instead of displacing it. Such a system will be analyzed as a surface feature while the front may be identifiable only above 1500 ft AGL. If the front is strong enough, it will displace the cold pool or at least erode it over a course of a few days.

(2) Standard indicators like surface temperature, surface troughs, pressure tendencies, and 1000/500 mb thickness are muted by the surface cold pool. The front is however identifiable at the 850 mb level.

(3) The weather patterns commonly associated with cold fronts may be likewise absent.

(a) Surface winds, blocked by the inversion are not as gusty as expected or may be absent altogether.

(b) With the approach of the front, you may experience overrunning weather conditions, as the moist air rides over the cold air at the surface.

(4) An unusual associated phenomenon you will no doubt observe is that, with a "cold" FROPA, temperatures will rise. This occurs when the cold air at the surface is replaced by cool air behind the front.

(5) Another is that the surface front often lags behind the front aloft. Surface indicators resemble a warm frontal occlusion, while above 850 mb, the front is still cold. A cross-section shows the front aloft clearly but it is less obvious at the surface.

c. **Air Mass Discontinuities.** European forecasters are more concerned with the sensible weather associated with fronts than with the air mass discontinuities. They do consider air mass discontinuities but are not as "preoccupied with them as AFGWC."

d. **Multiple Warm Fronts.** The first example we will describe is the double warm front. These two boundaries obviously do not separate three different air masses. They do however show clouds, precipitation and thermal patterns.

(1) The trailing warm front is probably the one you would analyze. It depicts the surface position of the warm front as well as the back edge of the weather. Behind it temperatures are warm throughout the troposphere.

(2) The leading warm front indicates the leading edge of the cloud mass. The air ahead of the leading front will be cold from the surface to the troposphere.

(3) The thermal pattern in the air mass between the two fronts will generally be cool/cold at the surface and warm at some level aloft.

e. **Multiple Cold Fronts.** Whenever possible, cold fronts are placed where there is a surface discontinuity (wind shift, dry/moist boundary, a line of precipitation). The fronts may be placed by radar observations, satellite photos, or precipitation observations. Since fronts are not drawn necessarily to depict air mass discontinuities, you will sometimes see them drawn through the middle of a high (to mark the boundary between dry and moist air). They may also be drawn where an American forecaster would just show a post-frontal trough.

f. **European Weather Service Analysis Differences.** Figures 5-1 and 5-2 are surface charts from the same analysis period (1200Z 12 December 1989). Figure 5-1a is from DWD, 5-1b from United Kingdom Met Office (UKMO), and 5-2 was analyzed using "AWS" techniques. True, frontal analysis is a subjective process. We call your attention, however, to the "liberal" use of fronts by European forecast services.

(1) DWD and GMGO, draw fronts using the 850 mb temperature and dew point discontinuity and 1000/500 mb thickness packing. If this is not possible they will draw the front at a discontinuity (as described earlier).

(2) UKMO also uses thickness patterns and discontinuity but usually likes to draw fronts at precipitation boundaries. Satellite obser-vations play a big part. Likewise, UKMO places a large emphasis on continuity. Pressure centers have letters assigned them, making it easy to track features. You may see frontal boundaries carried after the associated sensible weather has dissipated. (These boundaries can, however, be identified using an 850 mb wet bulb potential temperature analysis.) They may look innocuous on satellite, and be unidentifiable on upper air charts, they can trigger when they merge with another front or move into unstable areas.

g. **Summary.** In short, the European analysis and forecast products may look strange and unsupportable at first glance, but it is foolish to reject them outright. They are frequently tracking a boundary that could blossom into a significant weather event at a later time. Analysis philosophies will be further described in chapter 6.

5-4. Mediterrean Analysis:

a. The Mediterranean and North African regions lie on the southern flank of the westerlies and are strongly influenced by them. Particularly during the winter, the weather is essentially determined by the large-scale fluctuations of the primary westerly flow pattern, and the method of frontal analysis practiced in temperate latitudes can be applied successfully.

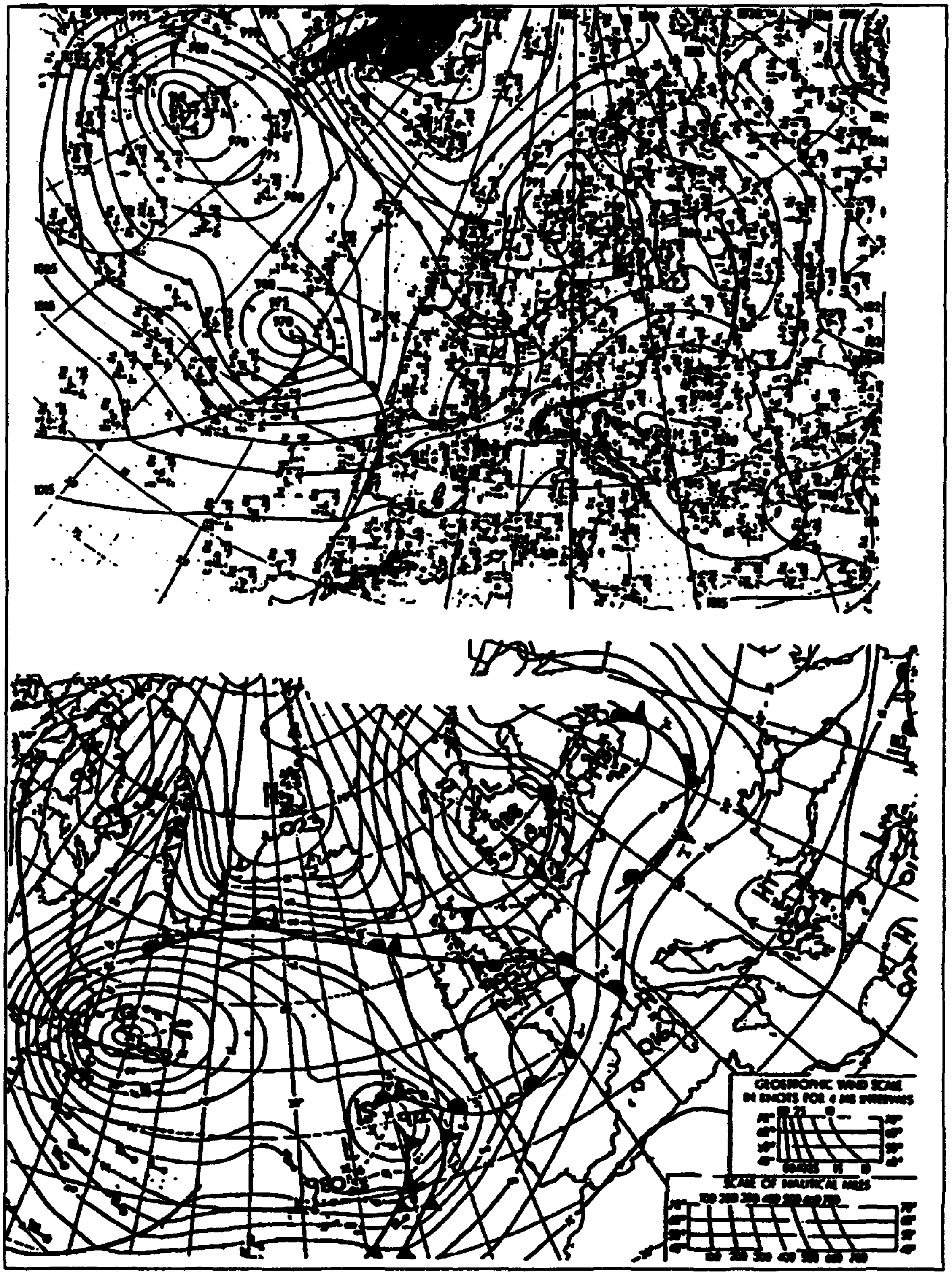


Figure 5-1. 1200Z 12 December 1989 Surface Analysis. (a) DWD analysis; (b) UKMO analysis.

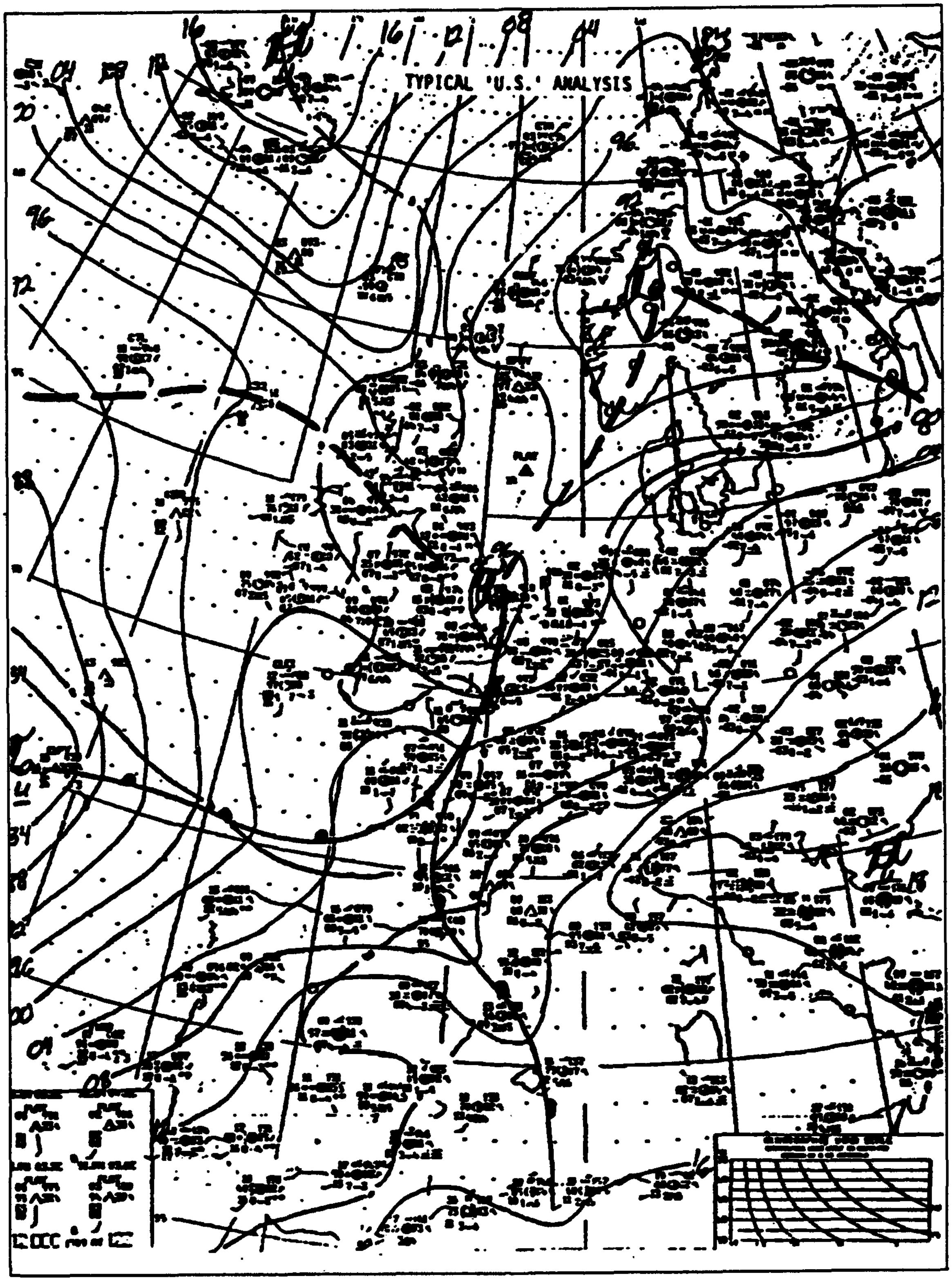


Figure 5-2. 1200Z 12 December 1989 Surface Analysis, "AWS" Techniques.

b. At other times, especially during the spring, the weather of the Mediterranean and North Africa is determined by a succession of minor troughs and ridges in the high troposphere, in conjunction with the thermal contrast between the cold sea and the rapidly warming land masses. Topographic effects also come into play. Non-adiabatic processes take on greater significance.

c. As in western Europe, it is more useful in Mediterranean to view ''fronts'' as circulative systems where the frontal layer is discernible by discontinuity of temperature gradient and wind shear, not by temperature and wind, themselves.

SECTION B - EFFECTS OF ANTICYCLONIC BLOCKING

5-5. Introduction. Across the North Atlantic and most of Europe, 500 mb flow is strongly zonal. Not infrequently, however, a cellular pattern replaces the zonal. This occurs when a quasi-stationary high in the eastern North Atlantic (between 5° W to 15° E) splits the westerlies into a two-jet stream regime. One branch flows northward (75-80° N), and the other southward (about 35° N), around the blocking high. There is a general lull in blocking activity from July to October (minimum in July-August-September). Blocking events occur most often in the spring (maximum in April) (see figure 5-3).

5-6. Effects of Blocking Highs on Storm Tracks:

a. The blocking action of the warm high and the resultant splitting of the jet, realign the routes of traveling disturbances. The general effect is to reduce the number of active centers moving eastward in the vicinity of 50-55°N, concentrating them to the north or south of central Europe. Thus, a primary storm track lies well to the north over Iceland, Spitzbergen, and North Cape; with a southern track following the southern jet into the Mediterranean. Two other disturbance tracks are associated with the converging branches of the jet in the lee of the blocking high. One of these marks the path of perturbations moving south and southwest from northwestern CIS The other follows the southerly jet as it bends northeastward over the southern CIS from the Black Sea area.

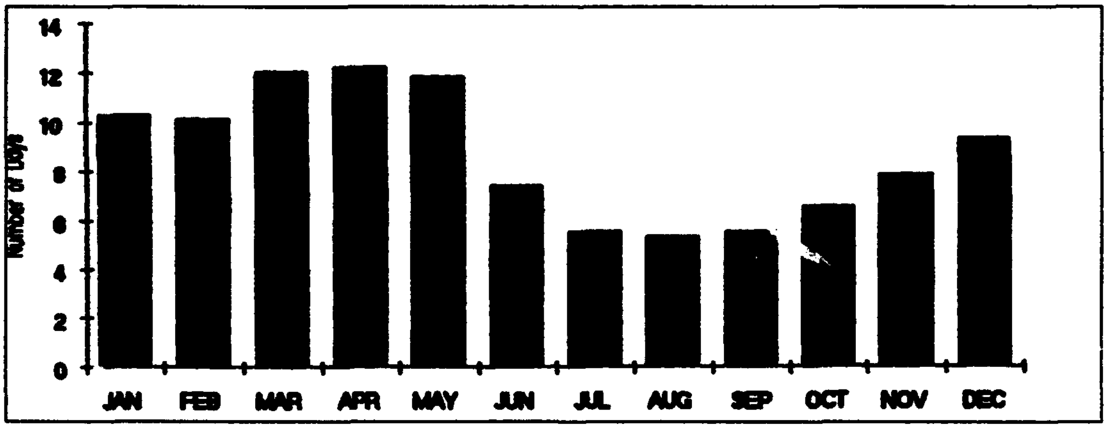


Figure 5-3. Number of Blocking Events by Month Over the European Theater.

b. The effects of blocking action occur often enough that they appear to affect the general pattern of disturbance routes over Europe. Considering the annual number of disturbances with central pressures less than 1000 mb (figure 5-4), note that two areas of concentration are (1) across Scotland and Scandinavia and (2) along the axis of the Mediterranean Sea--two favored jet positions during a block. Blocking is not the only mechanism involved. Recall from chapter 3 that heat is transferred to the atmosphere from the warm waters of both Mediterranean and North Sea during winter. This heating also contributes to cyclogenesis.

5-7. Effects of Blocking on the Weather:

a. Important effects of blocking action upon weather and climate are to be expected. It has been shown that during a period of winter blocking action, a tongue of positive temperature anomalies coincides with the western and northern margins of the blocking high where a strengthened southwesterly flow prevails (figure 5-5a). Most of Norway, Sweden, Finland, northwestern European CIS and the whole North Atlantic between Greenland and Scandinavia on such occasions may be warmer than normal. Negative temperature anomalies, by contrast, are concentrated to the east of the blocking high, where cold continental polar surface air, moves southward into a well developed pressure trough which is very conspicuous at 500 mb.

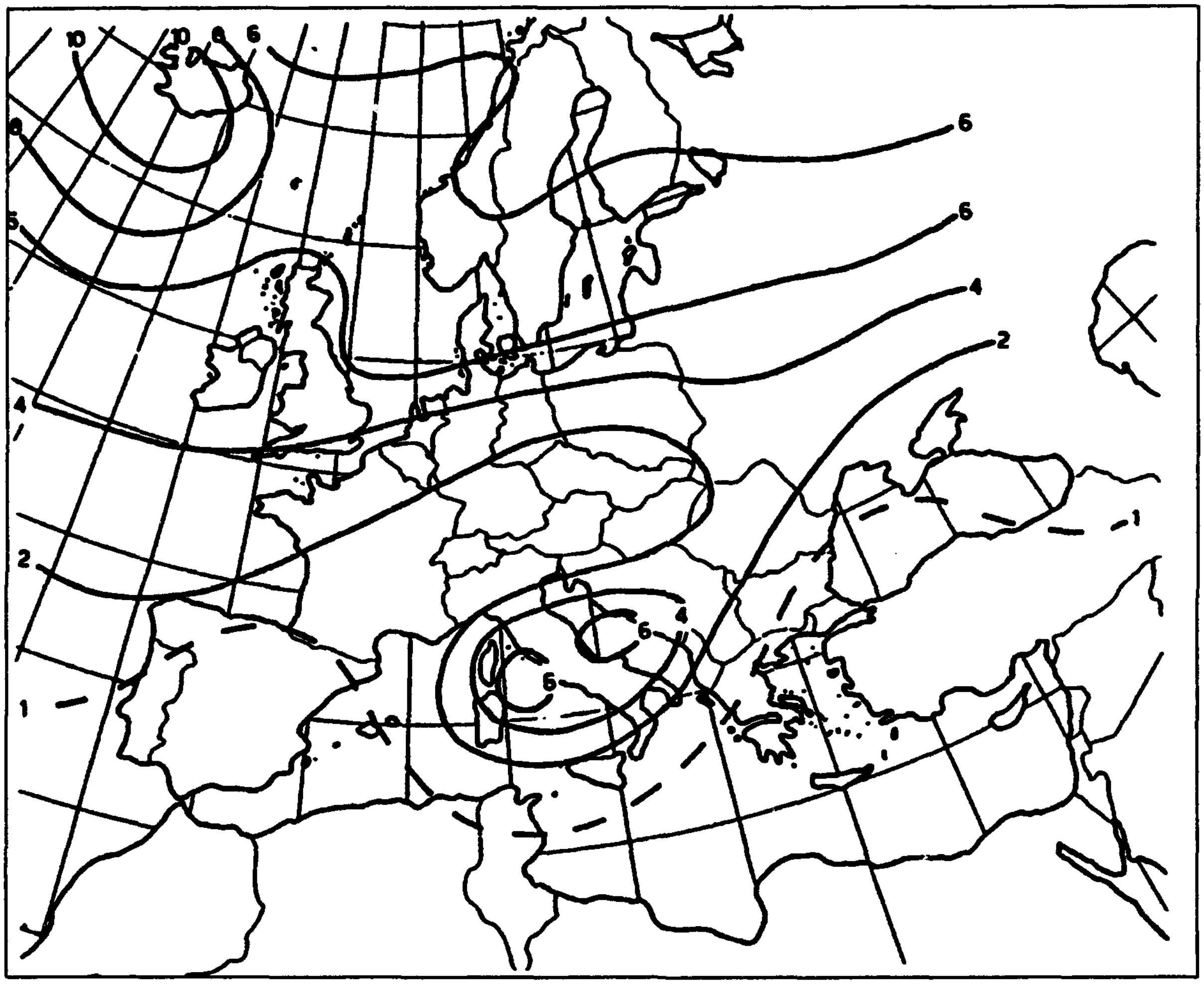


Figure 5-4. Mean Annual Frequency of Cyclones With Central Pressure Less Than 1000 mb.

b. Summer blocking appears to produce effects upon temperature distribution in Europe similar to those of winter (though lessened of course). While extreme western and northern Europe show weak positive anomalies during blocking episodes, much of central and eastern Europe, together with the western Mediterranean, is characterized by negative temperature anomalies (figure 5-5b). The same mid-troposphere trough of low pressure, lying east of the blocking warm high, tends to channel cool air from the north, over much of the continent.

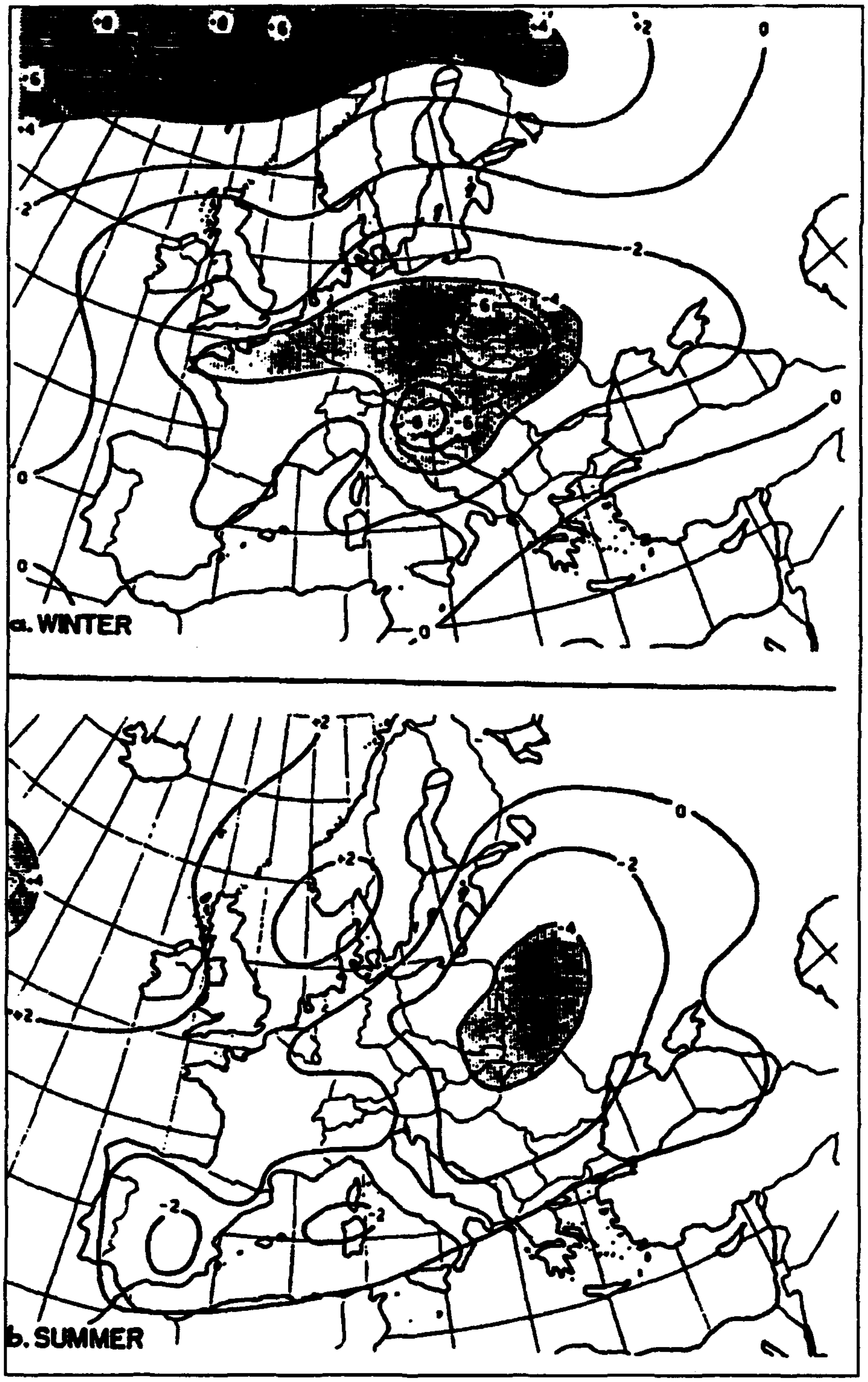


Figure 5-5. Mean Sea-Level Temperature Anomalies (C) During Anticyclonic Blocking Episodes in the Eastern Atlantic and Western Europe. (a) winter; (b) summer.

SECTION C - SOME SYNOPTIC SITUATIONS

5-8. Warm Frontogenesis Ahead of an Easterly or Southeasterly Moving Atlantic Cold Front:

a. A development which is often overlooked in synoptic analysis over the eastern Atlantic and western Europe is the frontogenesis of a warm front ahead of an easterly or southeasterly moving Atlantic cold front. We emphasize here the term frontogenesis applies to the frequently observed regeneration of an existing but weak front. This regeneration is usually accompanied by marked cyclogenesis and an increase in circulation.

b. The mechanism associated with this type of development is relatively simple and straight-forward. The synoptic situation is that of a well- developed cyclone over the eastern North Atlantic or western Europe with an old occluded polar front. A strong trough or ''secondary'' cold front surges eastward, warm air is advected northward in the increasing southwesterly flow ahead of the cold front. Warm frontogenesis and further occlusion of the polar front soon occurs. The first signs of this development are a wide area of increasing pressure falls, then, most important, the appearance of extensive middle and high cloud with rain well ahead of the cold front. In many cases the occlusion process is well underway over the ocean before enough data are available to confirm development. This points out the importance of using satellite imagery to help in frontal analysis. Study of many cases of this type of development indicates the existence of a weak frontal structure, long before the apparent frontogenesis. See figures 5-6a through d.

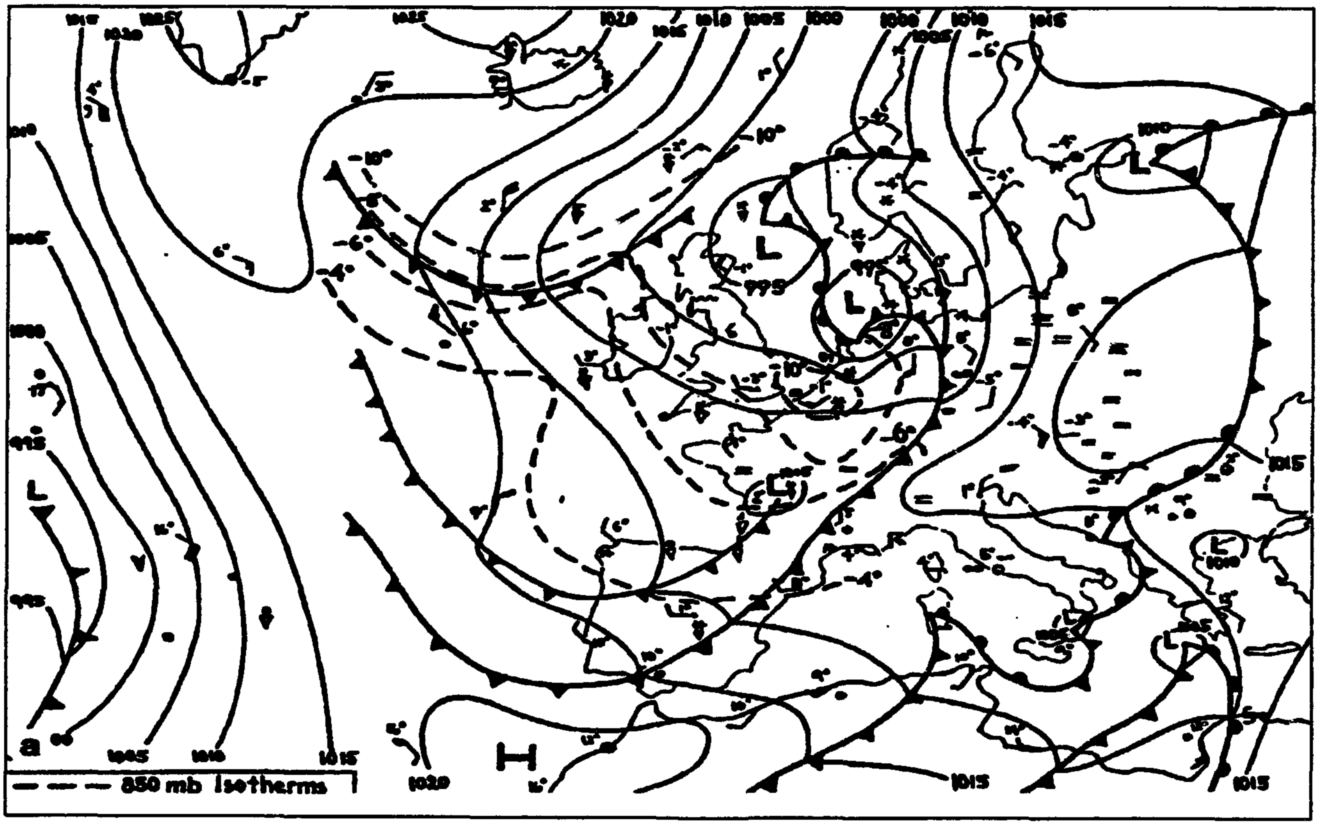


Figure 5-6A. Example of Warm Frontogenesis Ahead of an Eastward or Southeastward-Moving Atlantic Front. 850 mb Chart for 1800Z, 22 January 1958.

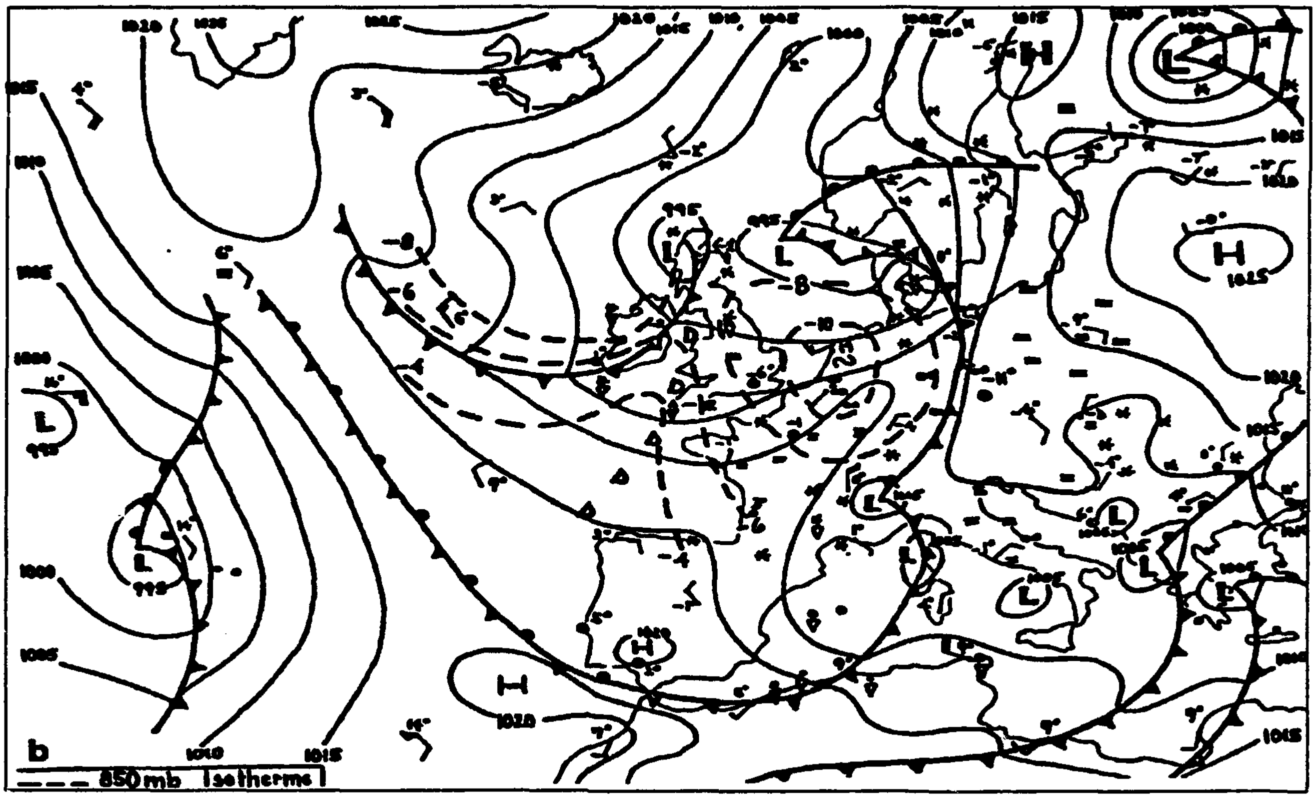


Figure 5-6B. Example of Warm *Frontogenesis* Ahead of an Eastward or Southeastward-Moving Atlantic Front. 850 mb Chart for 0600Z, 23 January 1958.

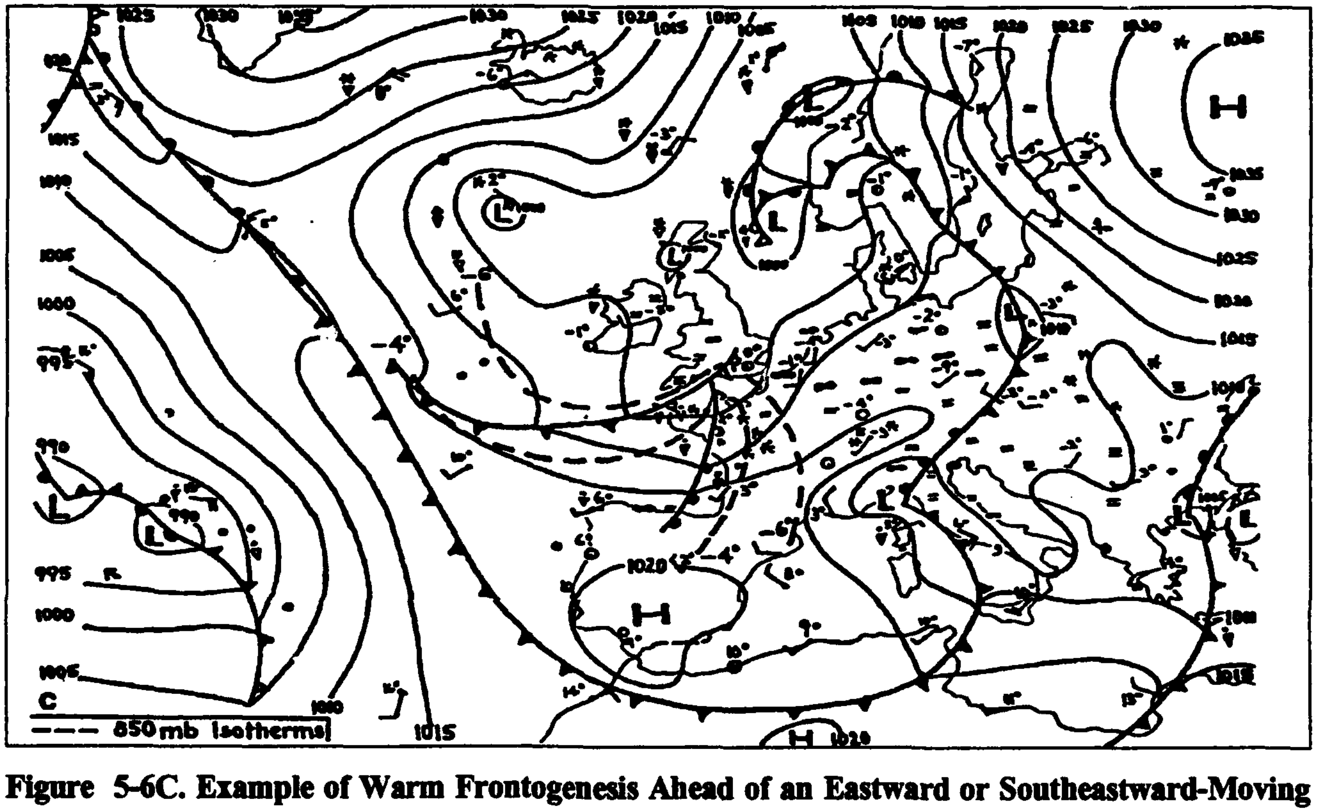


Figure 5-6C. Example of Warm Frontogenesis Ahead of an Eastward or Southeastward-Moving Atlantic Front. 850 mb Chart for 1800Z, 23 January 1958.

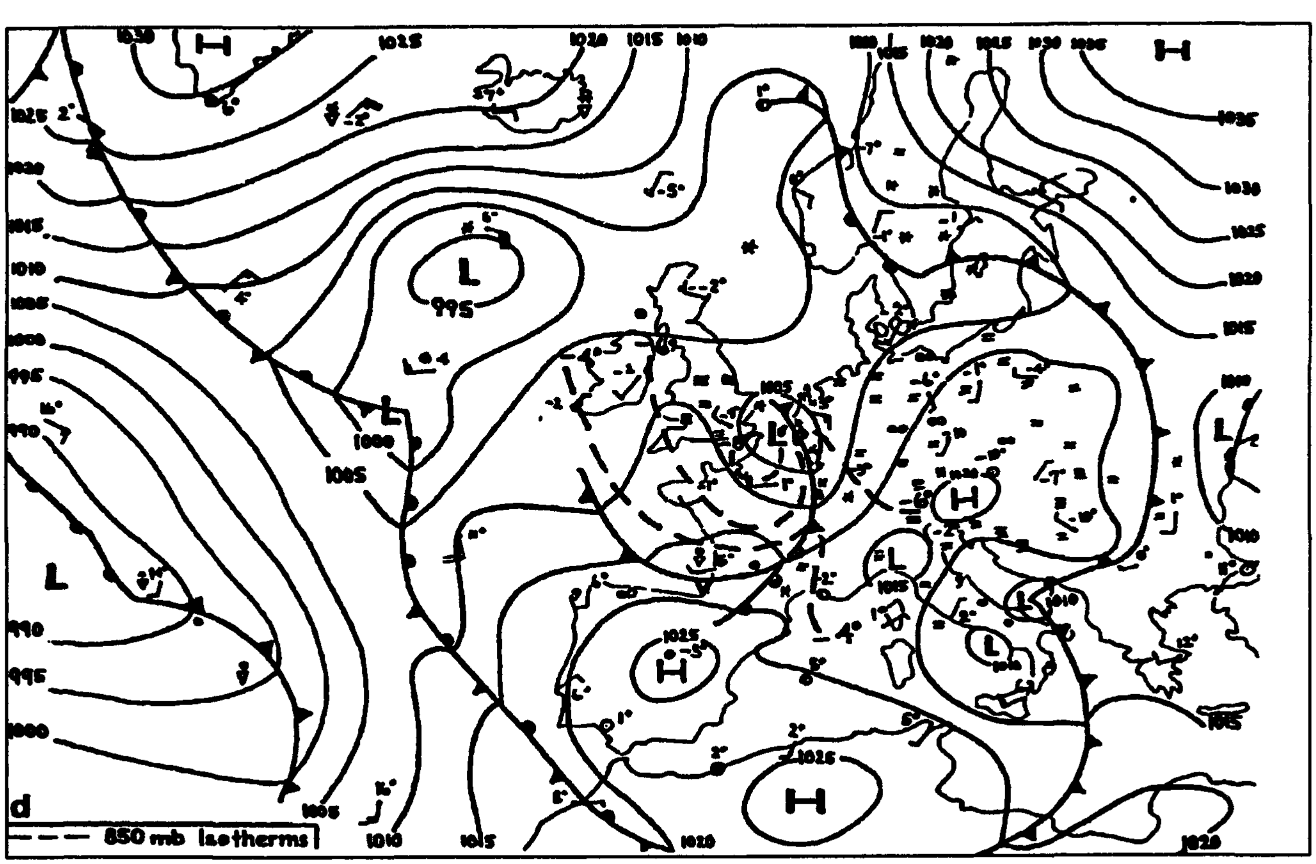


Figure 5-6D. Example of Warm Frontogenesis Ahead of an Eastward or Southeastward-Moving Atlantic Front. 850 mb Chart for 0600Z, 24 January 1958.

5-9. Frontogenesis Along the West Coast of France:

a. The normal land-sea temperature difference makes the west cost of France a favored area for frontogenesis. This is aided by diurnal heating, plus frictional effects over land. Again, we find that what appears as frontogenesis, in most cases, is merely a re-strengthening of an existing weak front, or an unsuspected secondary cold front. Development occurs in all seasons but is most frequent between May and October. It often results in surprise thunderstorm events. From an apparently listless fair weather situation, significant weather develops within 12 hours and moves across Europe during the following 48 hours.

b. The development follows this general pattern: A cold front develops along the coast, while strong day-time heating inland develops a thermal low. As the cold front advances, additional warm air is advected from the south and warm frontogenesis takes place. The area affected and severity of the event depend upon the speed of formation, motion, and the time of day cool air enters the land areas (see figures 5-7a and b).

5-10. Summertime Cyclogenesis and Frontogenesis Over Spain and Western France. This is an often misanalyzed, situation which affects weather over France and Germany. It is a subtle but definite cyclogenetic-frontogenetic process which begins in Spain and intensifies over France as it moves northeastward. The usual sequence of events is as follows: There is a weak or weakening ridge over France and Germany. Closer analysis will reveal an old quasi-stationary, inactive frontal structure across Spain and southern France. Cool maritime air lies to the west, and warm/hot air over Spain and southern France. A thermal low first develops over Spain, then France. As the wave cyclone develops, more warm air enters from the south, and thermal discontinuity/induced instability initiates the cold front. The perturbation then

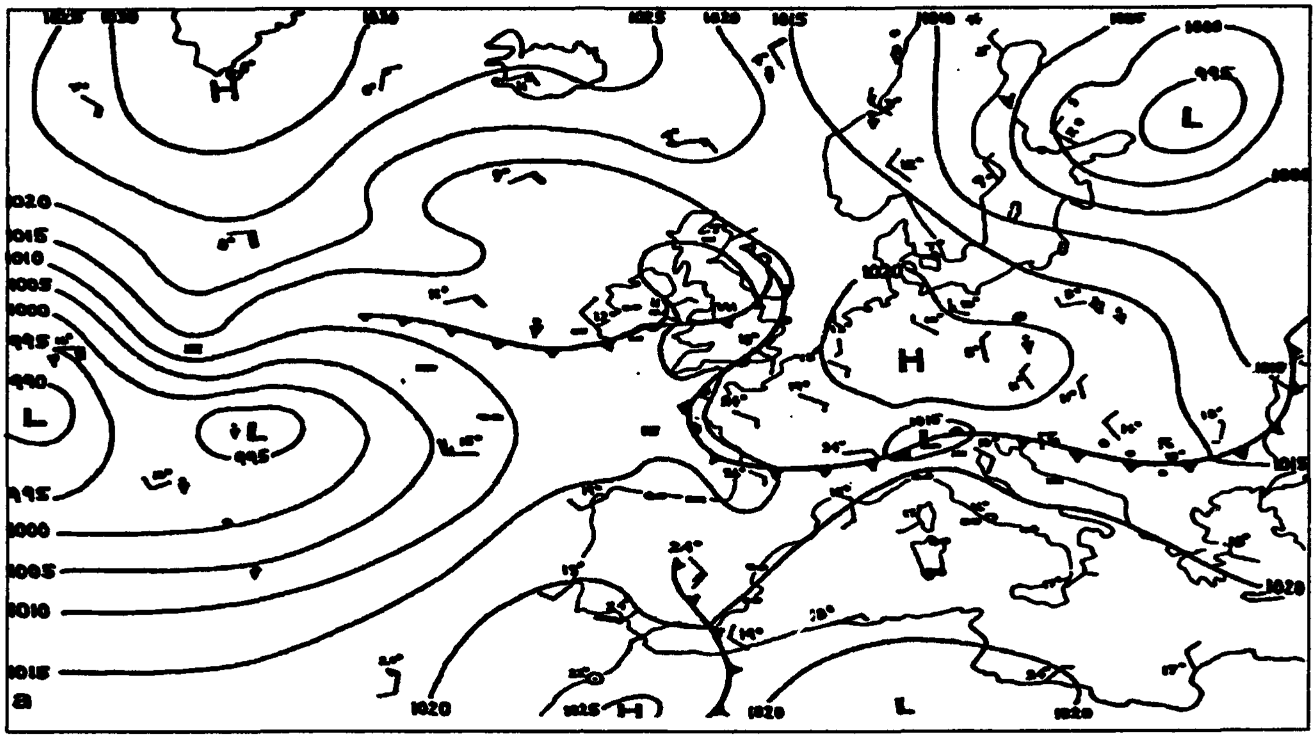


Figure 5-7A. Example of Frontogenesis Along the West Coast of France–Surface Chart for 1800Z 4 May 1956.

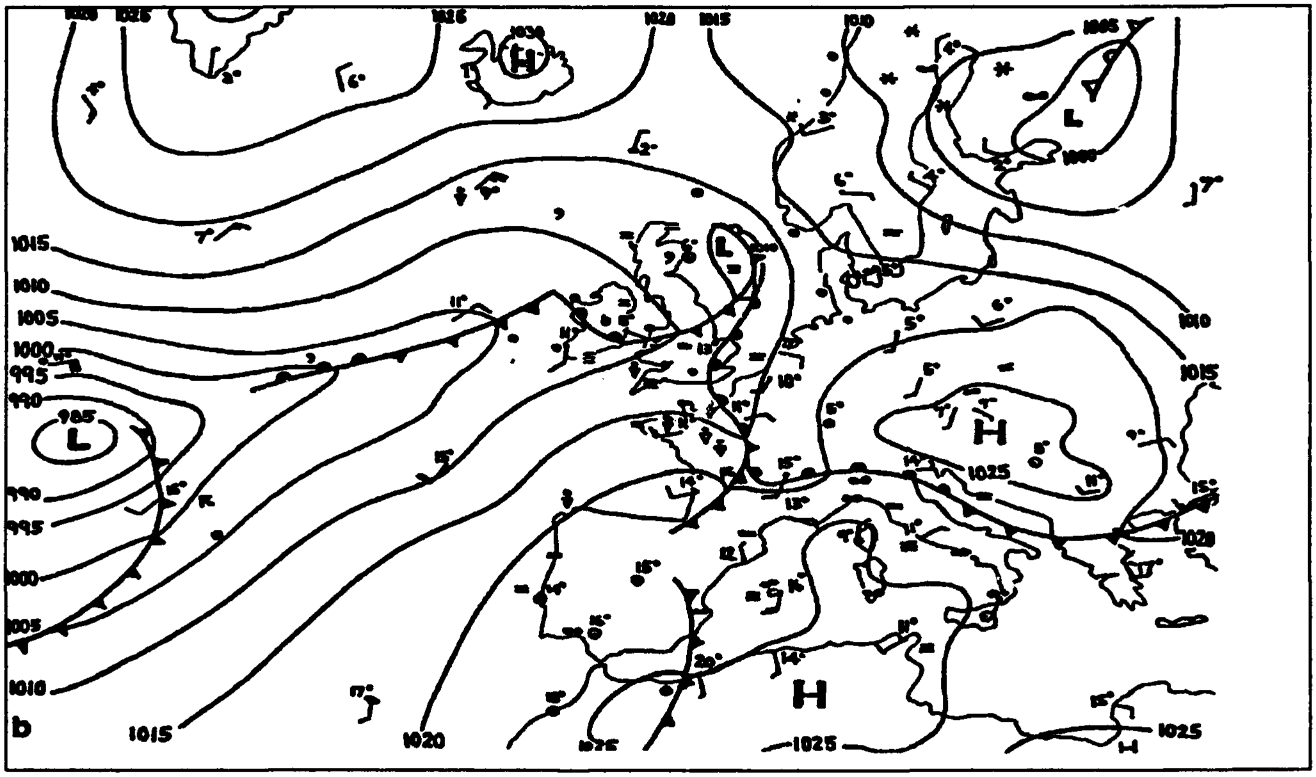


Figure 5-7B. Example of Frontogenesis Along the West Coast of France–Surface Chart for 0600Z 5 May 1958.

begins to move toward the northeast. In some instances a strong polar front in the Atlantic will overtake the cyclone. This may result in an intense front with severe thunderstorms. A study of the synoptic situations during the summer of 1958 reveals that during a 3-month period, this situation occurred ten times. The first thunderstorm activity in northwestern Spain may continue in the mean southwesterly flow for up to 48 hours. Figures 5-8a through d show an example of this situation. The 850-mb isotherm pattern is included to support the analysis and demonstrate the extreme usefulness of this chart in synoptic analysis over western Europe.

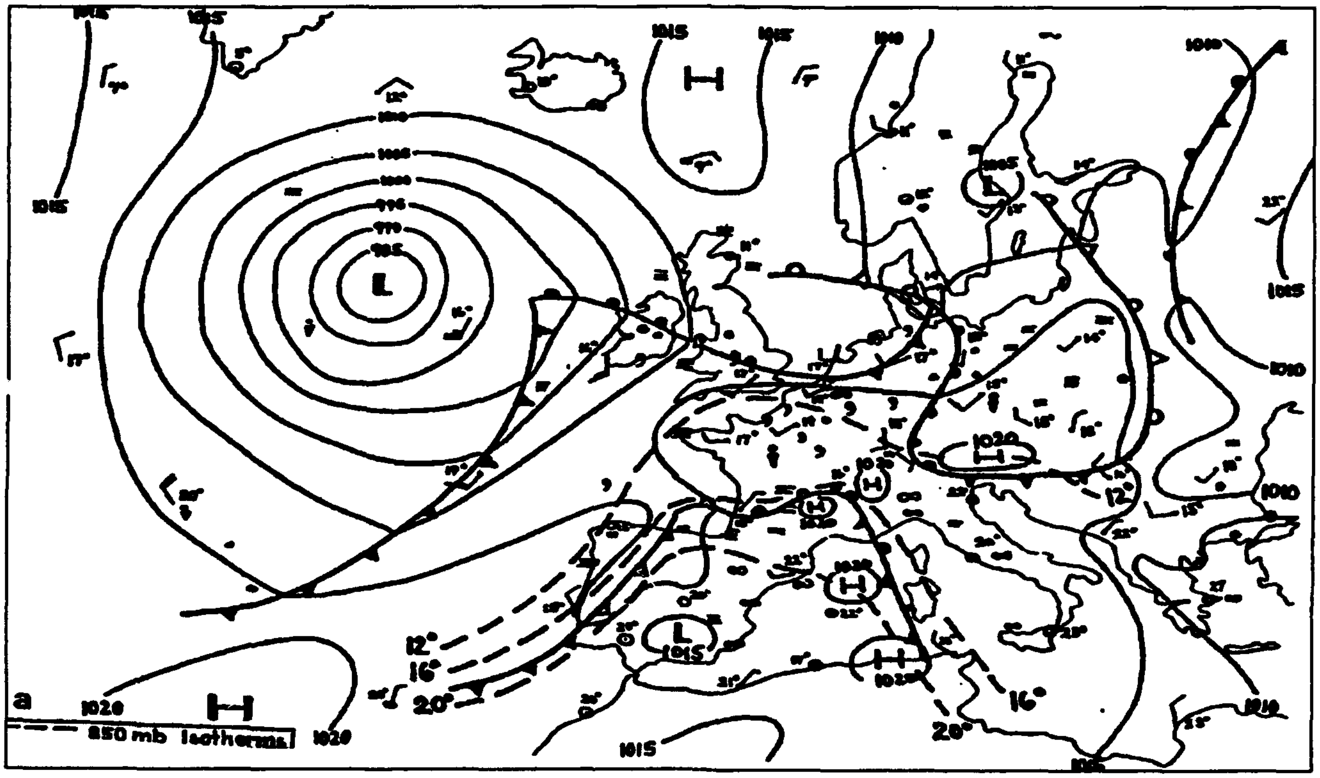


Figure 5-8A. Example of Summer Cyclogenesis and Frontogenesis Over Spain and Western France- - 850 mb chart for 0600Z, 9 August 1968.

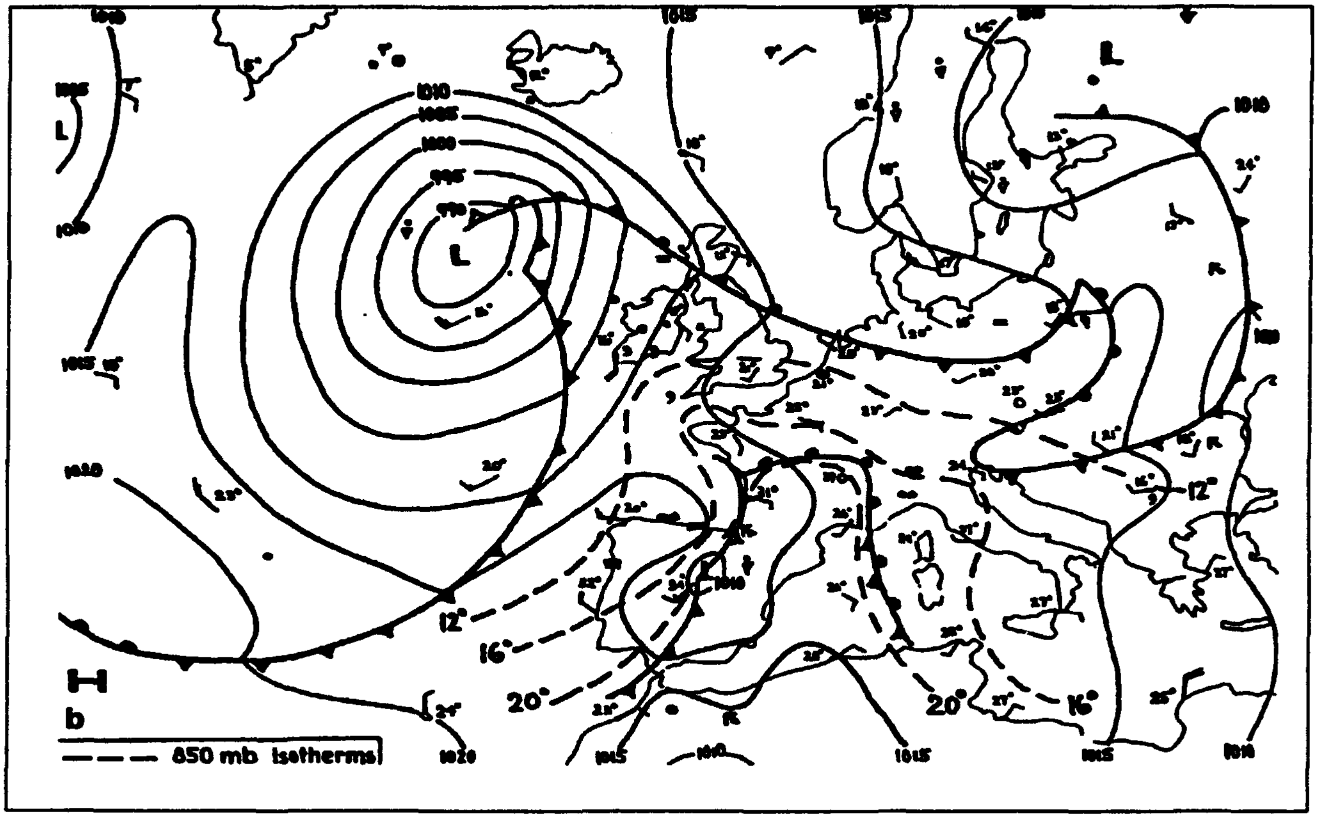


Figure 5-8B. Example of Summer Cyclogenesis and Frontogenesis Over Spain and Western France--850 mb chart for 1800Z, 9 August 1968.

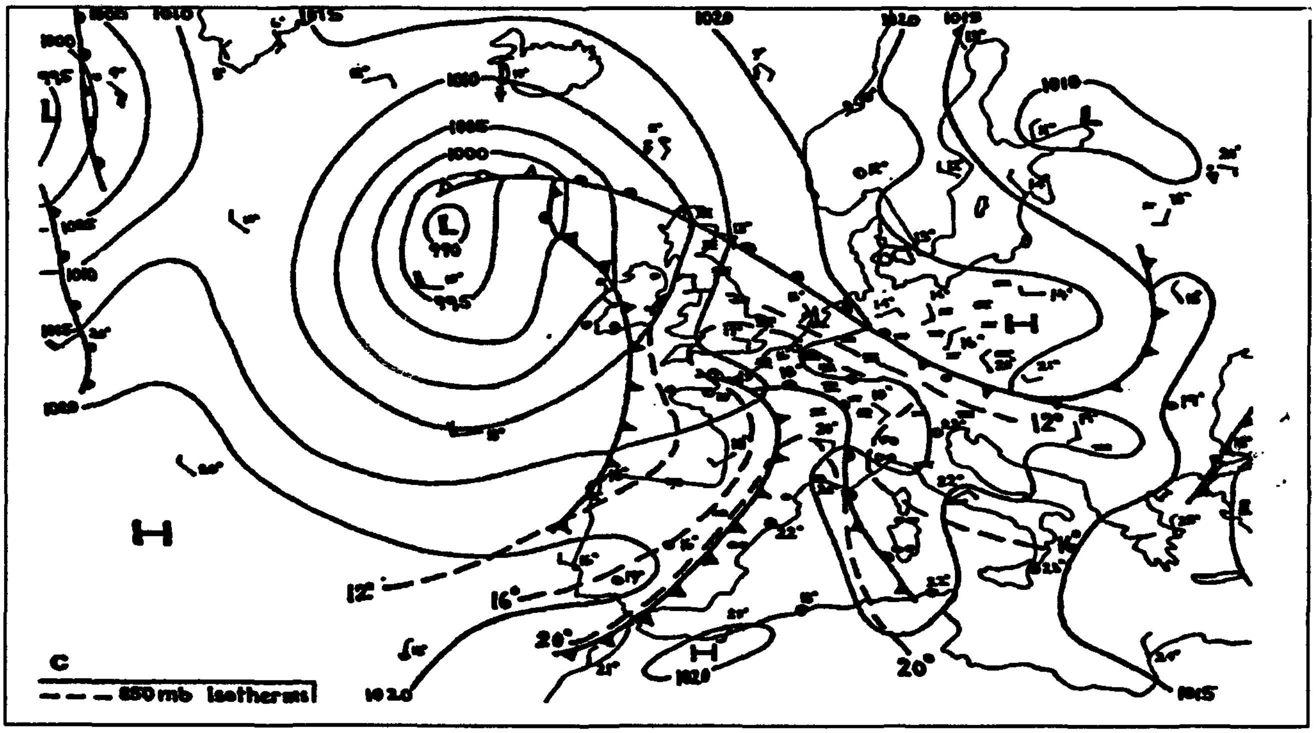


Figure 5-8C. Example of Summer Cyclogenesis and Frontogenesis Over Spain and Western France--850 mb chart for 0600Z, 10 August 1968.

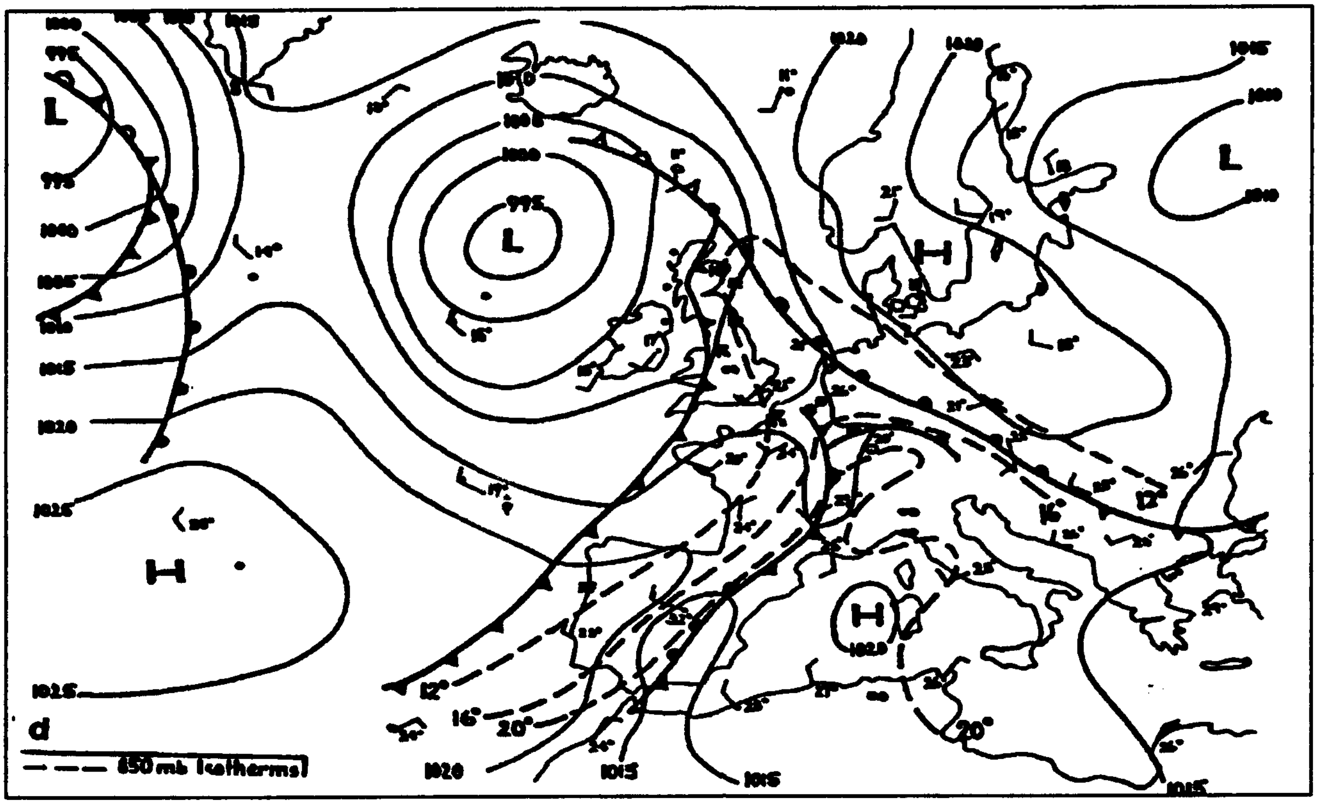


Figure 5-8D. Example of Summer Cyclogenesis and Frontogenesis Over Spain and Western France- - 850 mb Chart for 1800Z, 10 August 1968.

5-11. The Arctic Front:

a. There is a marked tendency among forecasters to neglect, forget or minimize the arctic front. Its source region is the arctic fields of ice and snow over the Commonwealth of Independent States (CIS). The front forms between this cold air (cA) and the warmer (cP) air, or much warmer air (mP) from the Atlantic. Frontogenesis in the region from Iceland to Siberia is particularly active when the Icelandic Low is farther east than normal.

b. The importance of the Arctic Front in determining weather over western Europe is well demonstrated by a survey of the winter-time synoptic events. For example, during the 5-month period from 1 December 1957 through 30 April 1958, the arctic front was evident over western Europe on 50% of the days.

c. The two parameters used to identify arctic air are the 850 mb temperature field, correlated with the surface synoptic pattern; and the 1000/850 mb thickness field.

(1) Temperature:

(a) After the arctic air has crossed the North Sea or moved down to an equivalent latitude in the North Atlantic Ocean, the leading edge of the arctic air will have a temperature at 850 mb of about -6 C. The really cold arctic air temperatures of -10 to -15 C affect the continental areas to the northeast. Remember, the primary polar front in the colder seasons follows the +6 to +8 C isotherm. Use caution however. At times the Arctic front does not reach to the 850 mb level.

(b) Significant low-level heating occurs during the movement over warm water. In this case, surface temperature cannot be used to identify the leading edge of the arctic air. However, this strong heating from below acts as a strong cyclogenetic and frontogenetic mechanism. In some cases, the synoptic pattern is such that the arctic air continues to stream southward for a long period. Cyclogenetic processes will result in a series of wave cyclones occurring over several days. An example of this occurred 18 through 25 of January 1958 (see figures 5-6a through d).

(2) Thickness:

(a) Shallow fronts or multiple fronts are often difficult to identify with the 1000/500 mb thickness lines. Since arctic air masses are shallow, it is usually necessary to rely on the 1000/850 mb thickness chart to locate the position of fronts.

d. Weather Associated With the Arctic Front:

(1) In the winter and early spring the presence of arctic air is usually necessary for snowfall over the lowland areas of France, England, and Germany. Identification and continuity of the arctic front are essential for the accurate forecasting of the associated weather.

(2) The Rhone Valley acts as a channel for cold air from the north and warm air from the south. When southerly flow exists over southern France, a tongue of warm, moist air may rapidly move up the Rhone Valley into northeastern France causing widespread, poor weather conditions. You can avoid surprise, however, by careful analysis of data from all of the mountain stations and the 850-mb chart.

5-12. A Cut-off Low off the West Coast of Spain:

a. One of the more common features on a CONUS weather map is a cut-off low off the coast of California. A similar feature is common off the coast of Spain (figure 5-9). What kind of weather does it cause, and how does one forecast its movement?

b. The cut-off low generally appears innocuous, with one or perhaps two closed isobars surrounding it. It's location is south of the high speed band of the westerlies. It shows only small changes in intensity with height. Cloud cover is greatest, and precipitation most intense at the center, decreasing more-or-less uniformly toward the outer edges. When the low deepens, the weather spreads in all directions and, conversely, when the low fills, the cloud pattern contracts.

c. When the system does start to move, it moves slowly at first, and may make several "false starts." After the landfall of the outer edge of the system, the low continues to accelerate and associated weather tends toward banding, not unlike the bands of a tropical storm. With further acceleration, a band moving northeastward through the southeast quadrant acts like a strong warm front, with moderate rain, and frequent convective activity. After passage of the band, there is a rapid decrease of cloud cover and the rain stops. Bands moving eastward across the southern portion of the system can act as secondary troughs.

d. Forecasting the movement of a cut-off low before it begins to move is extremely difficult, but not impossible. You can find some early signs of movement. Recall we said that the cut-off low lies outside the westerlies. Thus, the natural tendency is for the low not to move until something moves it. The low may remain nearly stationary for a day, or up to a month (There is no preferred period of stagnation). Often the cut-off low will make several false starts, retrograde, deepen, or fill apparently at random. Though the low's movement is frustrating to forecast, it will have a profound influence on your weather when it does move. Computer prognoses almost invariably move the cut-off low too soon. Be critical of these prognoses, but don't reject them without examining the clues. An upper trough passing to the north may trigger movement of the system. An influx of cold air almost certainly will. Watch coastal station pressure or height falls (even slight ones). Increasing winds, increasing cloudiness, or precipitation may be signs that the low is either moving or deepening. Watch the satellite!

e. These cut-off lows may remain innocuous, or they may become the major storm of the summer half of the year. The important point to remember is, don't stereotype the cut-off low. Study each as an independent system.

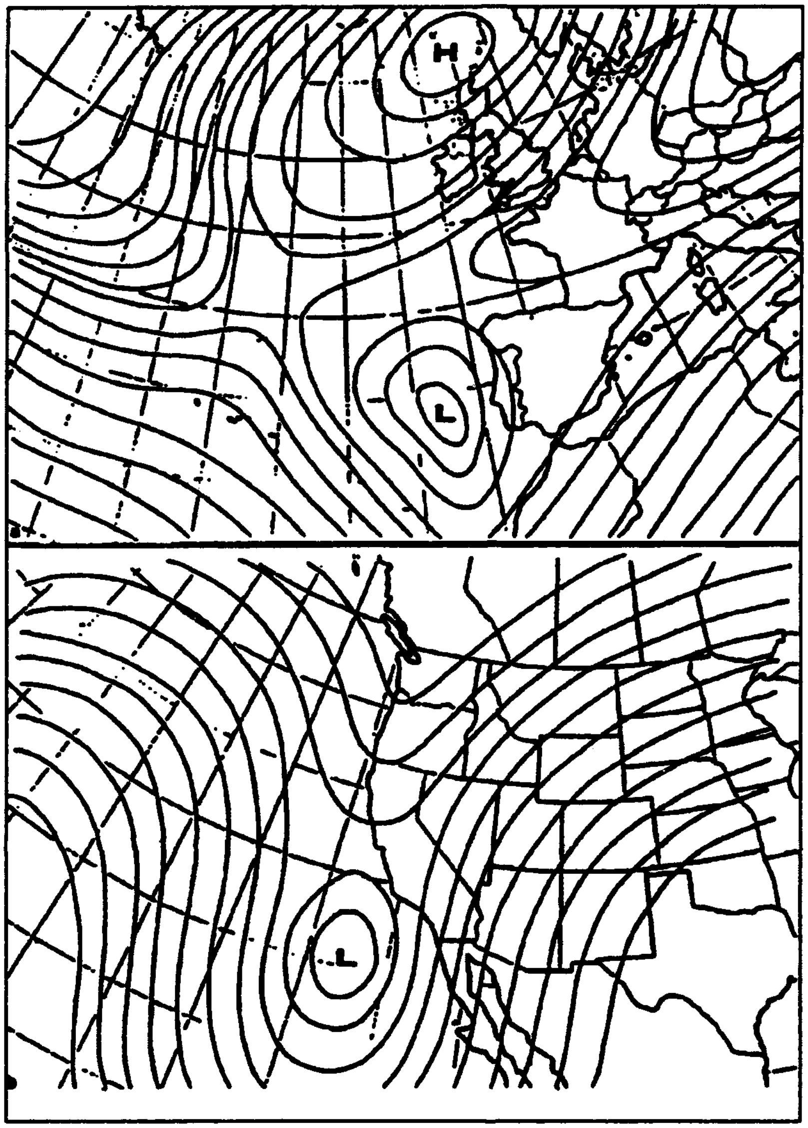


Figure 5-9. Examples of Cut-Off Lows off the West Coasts of: (a) Spain; (b) California.

f. If you were stationed in Germany, observed the 500 mb winds shown in figure 5-10, and no surface fronts other than the one in southeastern Germany, how would you assess the situation? Northwesterly flow with a few showers and coastal stratus until the ridge gets closer? Look again. The winds at London, Land's End, and Birmingham are stronger than the other winds in the vicinity. What does this mean? Let's apply to Riehl's (1962) jet stream model. Ignoring streamline curvature and the contribution of thermal advection to vertical motion, parcels of air exiting the left-front (looking downstream) quadrant of the jet streak will experience a loss of cyclonic shear. As far as the vorticity of the parcel, this is the same as losing cyclonic curvature. The upper level flow in this quadrant is divergent. Upper-level divergence, by Dine's compensation, implies low-level convergence, and thus, upward vertical motion. The opposite arguments apply for the case of parcels exiting the right front quadrant of the jet streak. In this quadrant, downward vertical motion is implied beneath the upper-level convergence zone. Observe the flow in the vicinity of the English Channel, north of the axis of maximum wind. Look closely at the surface data there. Do winds, pressure tendencies, etc., show anything that might indicate frontogenesis? This may be the only precursor of thunderstorms, gusty winds, etc.

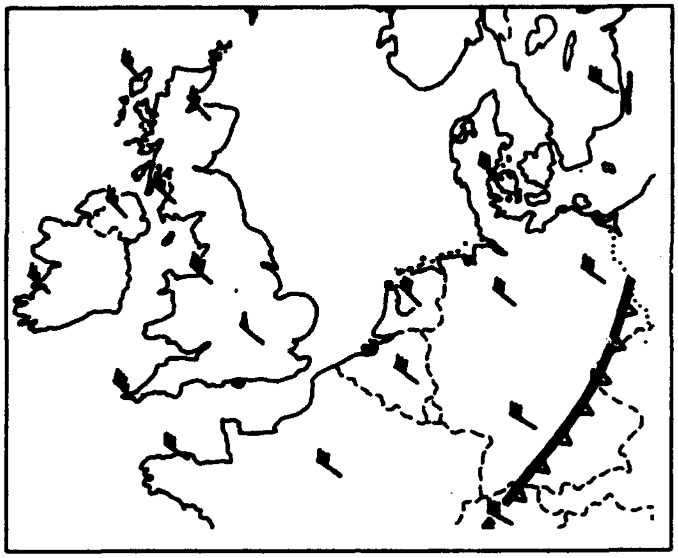


Figure 5-10. Example of Wind Speed Convergence.

g. Earlier, we suggested paying close attention to key coastal stations. Some upstream and at least one "back door" station should be included in your meteorological watch program. Keep in mind wind, weather, pressure, temperature, and dew point changes. Find out why changes occurred. Why did the wind shift? Did the amount of middle cloud suddenly increase?

5-13. Mountains and Clouds:

a. Even though the mountains of Europe do little to block migratory systems travelling zonally, they do influence weather in many of the same ways that mountains in the United States influence North American weather. The mountains block the flow of low-level air. As a result the windward sides experience orographic cloudiness, precipitation, and fog while the lee side is warmer, drier, and sometimes windier. Consider the case of a deep low near Corsica. Normally with a low in this location, rain and stratus would be expected over northern Italy, and if the circulation system were extensive enough, there would be warm, dry air over Munich. There are, however, several cautionary signs to look for. Remember that the mountains only block the flow to the level of the tops of the mountains. Thus, middle and high clouds will pass over the mountains (modified by the aerodynamics around the peaks). With convergence or confluence at middle cloud level, rain will fall from the middle clouds but evaporate in the dry air. Given enough time - several days, at least, the air below the middle clouds will become saturated from the rain, and clouds will form at lower and lower levels.

b. Naturally, with winds over the mountains, you should consider mountain waves and associated hazards - downslope gusty winds, orographic turbulence, faulty or misleading pressure altitudes, and so on. Keep an eye on the satellite. One additional warning. Closely examine the terrain upstream from your station. Is there a mountain pass or gap through which the clouds can flow? Can the moist air come around the end of the mountain chain and in the back door? Beware of the end run!

5-14. Slow Moving Low Over the North Sea. See figure 5-11. This situation produces a series of troughs, approximately 4-6 hours apart. The troughs move zonally at 15-25 kt across central Europe. They produce scattered rain showers and trigger thunderstorms mostly north of 50° N. When the low center moves between northern Denmark and southern Norway, cool air is advected from the North Sea into the northern

Benelux and Germany. It usually reaches central Germany within 24 hours. This cool moist advection, with upslope effects, create ceilings 1700-2400 ft MSL with tops between 6000 and 8000 ft MSL. The freezing level lowers to 5000-6000 ft MSL. These systems may produce precipitation for 24-48 hours depending on the strength of advection and moisture content. As the low moves farther eastward, the advection stops and the cold pocket (seen on the 850 mb chart) starts to dissipate in the westerly flow. During the winter months this situation brings cold, moist air and moderate snow, sometimes 1-3 inches in 24 hours.

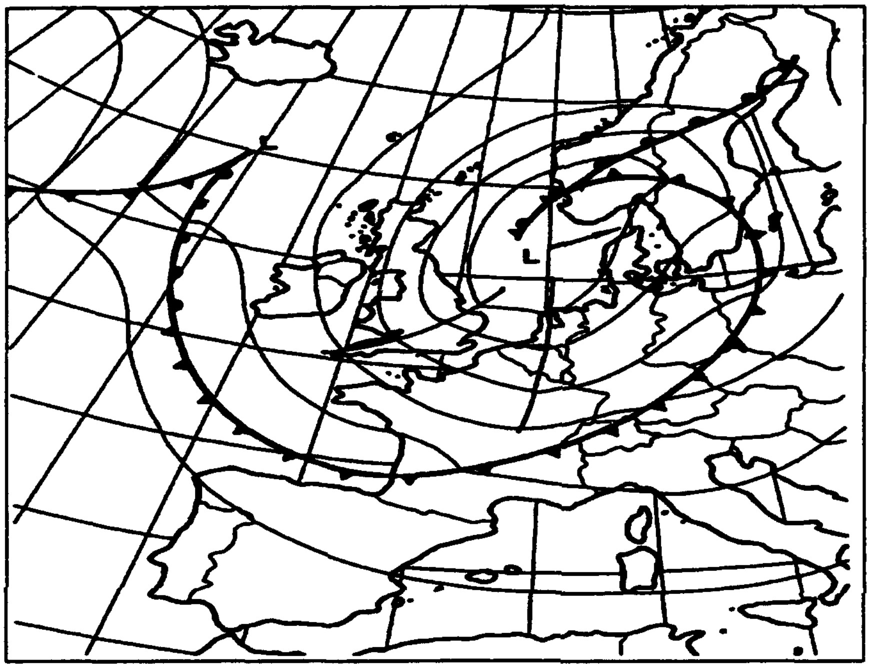


Figure 5-11. Example of a Slow-Moving Low Over the North Sea.

5-15. Deep Low in Ligurian Sea. When a closed low in the Ligurian Sea (figure 5-12) stagnates up to 300 mb, it may remain stationary for several days. The climatological storm track lies across northern Italy via Gulf of Venice to northern Yugoslavia and Austria. Some storms have come into southern Germany as far north as 49°N. During movement, moisture is constantly transported northward on the eastern side of the low, creating warm fronts or troughs. These troughs move northwestward, and with time, can extend a continuous rain pattern from southern Germany as far north as 50°N. The ridge over northern Europe adds to easterly flow over central Germany. The trough and rain pattern move at 5-15 kt. Usually 1 to 2 days pass before lower (2-3000 ft) clouds reach central Germany. When the low center is near 49 °N, thunderstorms may occur (usually without strong winds). Over south Germany, lows usually recurve, fill and move northeastward. When these situations occur during winter, they are accompanied by heavy snowfall.

5-16. Stationary Siberian High. An intense stationary Siberian High is most common during winter. The high builds over eastern Europe, becomes stationary over Finland or lowlands of Sweden and brings cold, dry, arctic air into central Germany (figure 5-13). During the first days, it is common to see low stratus ceilings and snow during the day, and fog at night through early mornings. Often a cold front will form between arctic and polar air, identifiable by snow patterns and low ceilings. It is common for the weather pattern to move southwestward. After arctic air has displaced the air mass originally in place in the central plains, very cold temperatures and clear to scattered skies follow.

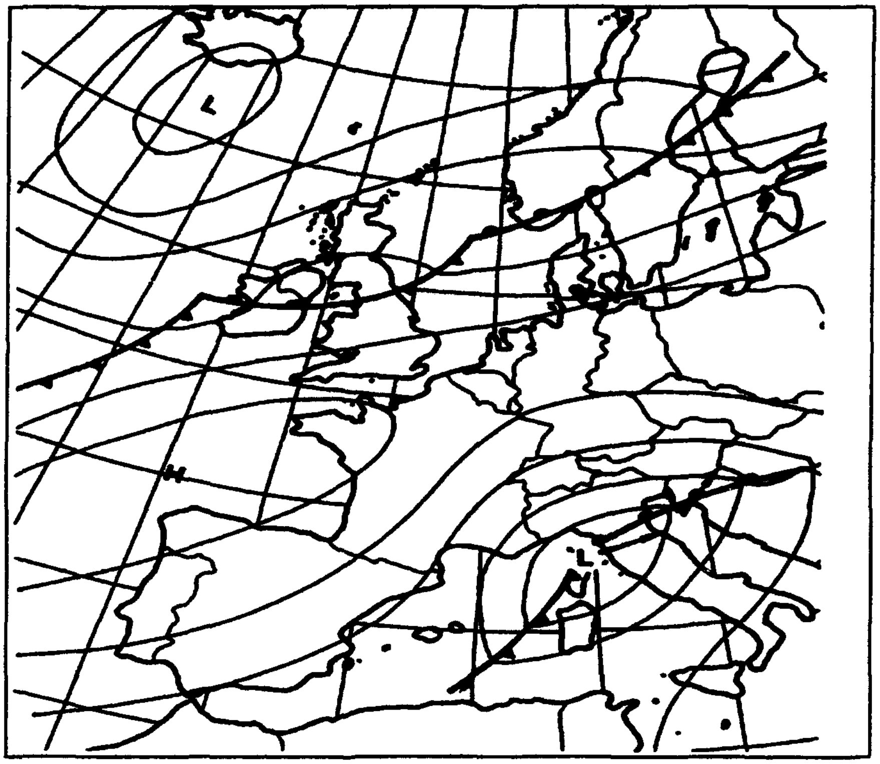


Figure 5-12. Example of a Deep Low in the Ligurian Sea.

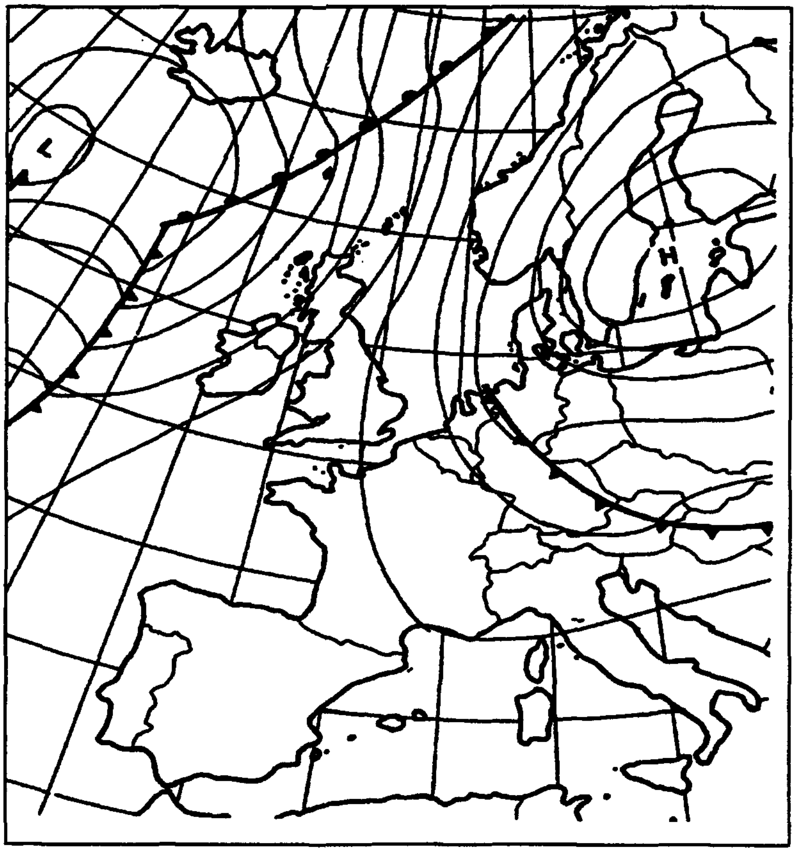


Figure 5-13. Example of a Stationary Siberian High.

CHAPTER 5 REVIEW QUESTIONS

1. With flow at lower levels blocked by the Alps and convergence at middle levels, what weather should one expect over a period of several days?

2. What are some of the influences that cause analysis difficulties in the Mediterranean?

3. How should you consider fronts in the Mediterranean?

4. What accounts for the west coast of France being an area of frontogenesis?

5. What parameter is best used to identify the arctic front?

6. What 850-mb temperatures are used to identify multiple fronts?

7. Why should surface temperatures not be used to identify the leading edge of arctic air?

8. What is the particular value of the 850-mb chart in frontal analysis?

9. When is the period of most frequent anticyclonic blocking?

10. What are the general effects of anticyclonic blocking on precipitation and temperature for most of central Europe?

Chapter 6

CENTRALIZED SUPPORT AND FORECAST TOOLS

6-1. Introduction. The purpose of this chapter is to introduce you to the communication assets, theater production weather activities, the products they issue, and descriptions of the weather products themselves. Missions in the theater are changing rapidly. This chapter is current as of 1 April 1992.

SECTION A - COMMUNICATIONS

6-2. Introduction. This section describes some of the communications assets in the European theater, the data available over them, and some problems you may encounter .

6-3. EURMEDS and EURDIGS. Available at most weather activities (as dets and OLs are now called), they mimic COMEDS and AFDIGS circuits stateside. But instead of the signal coming to you via Carswell, this arrives via Croughton UK. You will be briefed at your activity how the circuit is routed to your unit.

6-4. Satellite Data:

a. There are two ways of receiving METSAT data in Europe:

(1) Satellite Imagery Display System (SIDS). This consists of a phone line network connected to two DMSP direct receiving "Mark IV" vans (located in Croughton UK and Bann GM). Data consists of mixture of METEOSAT IR, water vapor, and visual imagery; NOAA IR and visual imagery; and DMSP IR and visual imagery. Users have computer based SIDS receivers that store, enhance and loop the data.

(2) Direct AND Downlink Reception. Some units have purchased satellite loopers. These receive METEOSAT data direct from the satellite via a weather station antenna. Some users also have the capability to receive NOAA data on these systems. You cannot get DMSP data as it is encrypted.

b. The Satellites:

(1) METEOSAT: EUMETSAT, headquartered in Darmstadt, is the European organization responsible for European Space Agency (ESA) meteorological satellites. We have no control over the METEOSAT products sent, nor the format. METEOSAT is located in a geostationary orbit at an altitude of 22,235 nautical miles (nm), above 0° longitude and latitude. METEOSAT transmits imagery as low resolution analog (WEFAX) data. IR and water vapor resolution is 5 km, and visual is 1.25 km. The satellite measures water vapor imagery between the 500 and 250 Mb levels (with the peak of the moisture column at 350 Mb). One image of a METEOSAT signal is 3.5 minutes long.

(2) NOAA: Polar orbiting satellites, with flight altitudes of about 450 nm.

(a) NOAA imagery is received live in the Automatic Picture Transmission format (APT). It consists of one IR channel and one visual channel, transmitted simultaneously. The signals usually last between 8 and 12 minutes.

(b) The DMSP vans also get higher resolution NOAA imagery and send it out over the SIDS network. There are five different transmission channels. Channel 1 and 2 are visual, and 3 through 5 are IR. Depending on time of day, and year, channels 2, 3 and 4 are sent to the field. The higher resolution signal varies in length, averaging about 14 minutes. Data resolution varies from 1.1 km in the center of the picture to 4.4 km at the edge.

(3) DMSP: These are also polar orbiting satellites with flight altitudes of about 450 nm altitude, but operated by DOD. DMSP data can only be received through the SIDS circuit, because the signal from the satellite to the van is encrypted. There are only two channels of data: IR, and visual. The DMSP visual

sensors have the added capability of being able to use lunar light to process nighttime moonlight visual imagery. (These are useful in showing areas of low level stratus and fog that normally do not show up on thermal imagery.) DMSP satellites send two different resolutions of data simultaneously.

(a) FINE DATA: The resolution of fine DMSP data is 0.5 km. Normally visual fine data is sent during the day and thermal fine at night. A different type of sensor is used than the NOAA satellite so the resolution is constant across the entire image.

(b) SMOOTH DATA: Smooth data resolution is 1.5 km. Normally IR smooth data is sent during the day and Visual smooth at night.

(c) The METSAT Coordinator (MSC): The MSC's primary job is to ensure that quality satellite products are sent from the DMSP vans in theater. He or she coordinates the SIDS product transmission schedule, to best meet customer requirements. The transmission schedule comes out weekly. Customer requirements that cannot be met via the SIDS line (i.e., that require equipment modification or purchases), should be solved at the base level. The MSC is available to help units decide which weather satellite receiver system will best meet their needs, both in the base weather station, and during tactical deployments. The MSC also sends out periodic newsletters to weather activities, describing satellite status and new METSAT techniques or procedures. (You can contact the MSC through 86 WS.)

6-5. High Frequency Facsimile (HF Fax). There are two USAF units that routinely transmit HF Fax: The High Frequency Regional Broadcast (HFRB) in Croughton and the European Forecast Unit (EFU) at Traben Trarbach.

a. HFRB provides 24-hour-a-day teletype and facsimile data for "worldwide" deployments. The radio transmitter at RAF Croughton receives a direct circuit feed from the ADWS for teletype, and from the EFU at Traben Trarbach for facsimile.

b. These products are transmitted by ionospheric bounce antennas. Both teletype and facsimile broadcasts can be encrypted (but so far, have not).

(1) Teletype are transmitted in the lower side band (LSB)* at 75 baud (100 WPM).

(2) Fax portion broadcasts "EURDIGS" maps in upper side band (USB)*, at 120 scans per minute.

NOTE: * LSB requires tuning down about 2 khz; USB, up about 2 khz.

(3) The primary HF receivers used by weather activities are the Alden 9315TR, and 9315TRT. These machines can intercept both HF Fax and HF teletype (RTTY). Future addition of a KG-84 encrypter will allow 9315TR(T)s to receive encrypted broadcasts from American sources. Your facility will have a list of the stations you routinely intercept. The 9315TR(T) routinely uses either a whip, or a dipole antenna. The whip is fast to put up, and omni-directional, but has limited range. The dipole has greater range, but is more cumbersome to set up, must be pointed in the right direction, and must be "cut" to the right length for the frequency you are intercepting.

6-6. Local Weather Dissemination System (LWDS). Used in place of the "telewriter," to keep the local customer aware of the latest weather observations, forecasts, advisories, and warnings. Hardware consists of one or more Z-248s (or Z-184s), modems, monitors and printers (optional). It uses the existing telewriter circuitry for data transmission.

6-7. Microcomputers on the AWN. An interim step between EURMEDS and AWDS, MICROS on the AWN are providing a new dimension to BWS capabilities. (AWS must approve a unit's request before they hook up to the system.) The system does data processing, limited tearing and filing, and automatic plotting of Skew-T data. Required hardware includes a Z-248 (or IBM computer with at least 20 mb, and capable of multitasking), monitor, printer, a step-down converter, and a Codex modem. AWNCOM send/receive software allows your computer to talk to the ADWS computer at Croughton. Omniview software allows the computer to used for other tasks (putting out TAFS, sending Obs, issuing weather advisories, etc.), while data is being received and stored. Applications software is used to sort, store, and receive weather data on hard disk or floppy disk.

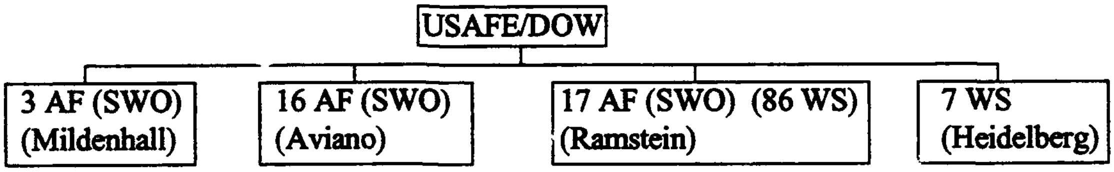
6-8. STRIFAX. Weather stations in the UK have access to a dedicated, analog, land-line, facsimile circuit. Source office is Strike Command Meteorological Office at RAF High Wycombe (see 2 WW/FM-90/004).

6-9. MOLFAX. This is a teletype circuit from the United Kingdom Meteorological Office (UKMO) to USAFE weather units in the UK.

6-10. Automated Weather Distribution System (AWDS). (The following is a cursory description. Future ETWO updates will contain more detailed information.) AWDS is a network of computers designed to automatically process and distribute weather data. US weather units in Europe will receive approximately 30 AWDS systems, beginning in December 1992. Planned for US Army and Air Force weather support worldwide, AWDS will be our primary tool for constructing weather forecasts. AWDS will replace European Digital Graphics System (EURDIGS), European Meteorological Distribution System (EURMEDS), and Local Weather Distribution System (LWDS). The system gets graphics data from Air Force Global Weather Central, and receives/transmits alphanumeric data in US weather network. Hardware includes terminals for flight operations, air traffic control, forecasting, observing, and obtaining notices to airmen (NOTAM). The system was designed to eliminate manual plotting and analyzing to allow weather personnel more time for primary jobs of forecasting and observing. An automated alerting system notifies users of adverse weather conditions observed in the local flying area.

SECTION B - THEATER WEATHER ACTIVITIES

6-11. Support Structure. HQ USAFE/DOW is, since the reorganization, now a MAJCOM, and intermediate layer between XOW and the weather squadrons and numbered air forces (NAF). USAFE/DOW is charged with establishing policy and ensuring the standardization of weather services in theater. They no longer have as much tasking authority over the squadrons and NAFs as they did when they were 2 WW. Support structure and headquarters locations are as follows:



a. 3 AF oversees operations for the weather activities in the UK.

b. 16 AF oversees weather activities in Spain (for the time being), Italy, and Turkey.

c. 86 WS is a unit with both centralized weather facilities (European Forecast Unit or EFU at Traben Trarbach, and the Weather Support Unit or WSU, at Ramstein), as well as Boerfink and EUCOM at Stuttgart-Vaihingen. The Det 1 Commander also acts as 17 AF SWO.

d. 7 WS provides weather support to the US Army - Europe (USAREUR) units throughout Germany.

e. The following paragraphs describe weather activities that provide centralized support in the theater.

6-12. The European Forecast Unit (EFU). The EFU (Det 1, 86 WS) is located in the German Military

Geophysical Office (or GMGO, the military counterpart to the German Civil Meteorological Service (DWD)), bunker at Traben-Trarbach.

a. Benefits of Collocation. The benefits of collocation include survivability, interoperability, and increased technical capability. The increased technical capability comes from three areas. They include access to indigenous weather products, automation through the GMGO's Geophysical Forecast Computers (GEOVOR), and automation through the interactive graphics system or IGS ("German AWDS"). This section will deal with EFU, their forecast products, the indigenous German products they send, and some hints for their use (see also 2WW/TN-89/005).

(1) The tasks handled by GEOVOR include processing weather data, running the GMGO BKF and mesoscale forecast models, and storing gridded data from the DWD and ECMWF forecast models (ECMWF: European Center for Medium Range Weather Forecasting in Reading UK).

(2) The IGS consists of computer display terminals linked to GEOVOR. Like AWDS it can store data and enable the team on duty to call up weather data and overlay it onto a chart. They can also superimpose METSAT images for instant initialization. Though EFU must metwatch all of Europe, the automation systems allow them to perform this task with no more duty personnel than in an average BWS.

b. EFU Support Priorities:

(1) Emergency War Order (EWO) activities.
(2) Contingency actions as tasked in OPLANS/OPORDS.
(3) Severe weather support.
(4) Exercise support (REFORGER, etc.).
(5) Mission planning forecasts.
(6) Operational planning forecast support (includes area forecasts).
(7) News media support (AFN, etc.).
(8) Additional forecast support.
(9) Technical and administrative support.

c. Requesting Support From the EFU. To request support for any of the services listed above, you must make a request (such as AWSR 105-18) through 86 WS/CC. See section C for descriptions of the charts and bulletins EFU transmits. The following are contact procedures:

(1) Phone (military: 450-7375 or DBP: 06541-18456)
(2) AWN (call sign EDKG)
(3) Telefax (06541-18457)

6-13. Weather Support Unit (WSU). Located in HQ USAFE Operations Support Center (OSC), the WSU is also dual-hatted as USAFE/DOCW under the USAFE Directorate of Command and Control. Its mission is to provide routine and specialized weather support, to accomplish wartime, contingency, and humanitarian missions worldwide. Though the WSU's primary customers are HQ USAFE and HQ Allied Air Forces in Central Europe (HQ AAFCE), support is provided to various customers worldwide (many of whom are unknown at any specific time). Most of the WSU support is to non-routine, specialized missions. Due to the fluid nature of most of these missions, the WSU personnel work closely with the customer in planning weather support. The WSU's survivability in wartime also ensures continuity of vital forecasting services. At least one forecaster is on duty 24 hours a day, 7 days a week.

a. Communications. The WSU has access to the following communications resources:

(1) AUTOSEVOCOM
(2) WWMCCS
(3) MAXI (24 hour AUTODIN system)
(4) 24 hour Communications Center

(5) HF Secure Radio (SATCOM)
(6) Worldwide Command Post Access
(7) Secure/Non-Secure Fax

b. Duties. The WSU acts as a central coordination point providing a wide variety of operational weather support. Support assistance requests (SAR) are processed through the 86 Weather Squadron.

(1) Twenty-four hour METWATCH service for major USAFE and Air Mobility Command (AMC) terminals.

(2) Air refueling forecasts. They produce centralized AR forecasts for all European tracks (from 10W-30E).

(3) Mission planning forecasts (MPF) and mission control forecasts (MCF) for various training and contingency operations including:

(a) Joint Airborne/Air Transportation Training (JA/ATT).

(b) Operational readiness inspections (ORI).

(c) North Atlantic Treaty Organization (NATO), USAFE, AMC, and Air Combat Command (ACC) exercises within the EUCOM area of responsibility.

(d) CORONET support for tactical fighter deployments to and from theatre.

(e) Nuclear Accident/Incident Response Action (NAIRA) support.

(4) Deployed Weather Force Support

(5) Advisory Support for special locations.

(6) SIGMET validation for indigenous high-level SIGMETS (weather advisories for such phenomenon as icing and turbulence). Issued by civilian aviation agencies, SIGMETS often have limited applicability to heavier military aircraft. Upon request, the WSU reviews SIGMETS for levels above 10,000 ft MSL and validates them for USAF aircraft.

(7) USAFE Metro. The WSU provides pilot-to-metro service (PMSV) to aircrews through phone patch with Croughton, Ascension, Incirlik, Lajes, and Andrews airways.

(8) Report computer flight plan errors (CFP busts) to Air Force Global Weather Central.

(9) VIP and presidential trip forecast service.

c. Contacting the WSU. The WSU can be reached by one of the following methods:

(1) ETS: 480-8250 (civilian 6371-47-8250) To call secure: call 480-8250 for instructions.

(2) AUTODIN (RUFTRWA) OPS SUPPORT CENTER RAMSTEIN AB GM//DOCW//. NOTE: Be sure the above address is on all correspondence sent to the 86 WS. Information is processed much quicker by using the DOCW address)

(3) Teletype: EDAX

(4) Mailing Address: B-Flight, 86 Weather Squadron, Unit 8495, APO AE 09094

SECTION C - WEATHER PRODUCTS AVAILABLE IN THEATER

6-14. Introduction. This section deals with the charts and teletype products available to theater forecasters. We begin with those from AFGWC, and later discuss some of the available indigenous products.

6-15. AFGWC. Here in Europe, we're fortunate to have many excellent indigenous forecast products (described more detail in later sections) to choose from. So why the interest in AFGWC products?

- Having used them before, you're already familiar with them
- In wartime, they may be all you'll get.

We'll discuss computer models that build AFGWC products, analysis philosophy, and charts themselves.

6-16. Numerical Weather Prediction (NWP). Computers use NWP to predict the future state of the atmosphere. This requires three-dimensional, large-scale weather observations; a mathematical model of the atmosphere; and a method of solving these equations by integrating over time - to yield the future state of the atmospheric variables.

a. The first step is to interpolate the available observations to a regular spaced grid, define the initial state, check for gross errors in input data, and perform an analysis.

b. To solve the predictive equations, we need fast, large capacity computers. Since the equations are "partial differentials," there's no known way to solve them exactly. The models approximate a solution using what are called numerical methods. The closer the approximation, the more iterations you have to do, and that uses computer time. Since we must issue our forecast before the fact, we have to use some assumptions and simplifications.

c. One approximation is the finite difference approach (FDA). With this method, an atmospheric wave is approximated by picking the wave height at specified points, and then connecting the dots with straight lines. The area between the two curves is the error. You replace the wave with a sort of stick figure. Computer models, beginning with a rough guess of the initial weather at widely spaced, discrete points, can only forecast a rougher guess future. Because of the grid spacing, small waves can get lost in the analysis, or move slower than in "real life."

d. A better approach is to approximate the wave by a series of trigonometric functions, (sine or cosine waves). By summing an infinite number of waves, we could exactly fit any wave form. As with the FDA method, time and computer constraints say we can only use a few waves to approximate the real wave to some acceptable error level. The result is not a perfect fit, but much closer than the FDA. This "spectral" approach is used by the Global Spectral Model, which in turn drives all the AFGWC upper-air progs. The GSM can see smaller waves than the FDA, and doesn't slow the short waves down so much.

6-17. NWP Output Usage. Since all models have errors, some worse than others, blind reliance on progs can cause your forecast to suffer. Before using a model, you must two things:

a. Initialize. Use the forecast analysis panel with a satellite image of the same time, to see how well the two match. If the analysis is wrong, the forecast will be too.

b. Verify. Take an earlier run of the prog and see how well the forecast panel matches the current analysis. If the last run of the prog did well, and the analysis is comparable, you can be confident that the system is being handled well. But, proceed with caution! Remember, the computer's view of the world is limited. Computer models may throw out data showing cyclogenesis, where a human analyst would not.

6-18. AFGWC Analysis and Prognostic Models:

a. High Resolution Analysis. The HIRAS is AFGWC's primary analysis model, analyzing weather data pole-to-pole with a resolution of 175 X 250 nm. This analysis is then saved in a 2.5 X 2.5° resolution data base. HIRAS is a spectral model, and it analyzes winds, geopotential heights, specific humidity, and temperatures first at the 100 mb level. Weather variables at other heights are then derived from the height and wind field, and checked with data above and below that level for consistency. HIRAS benefits include:

(1) Good 500 mb vorticity pattern and short wave definition.

(2) Good 250 mb height analysis.

(3) Superior 850 mb height analysis - especially if GOES/ METEOSAT low level winds were available. But the HIRAS scheme has some drawbacks, too:

(4) Since there is only one gross error check at the beginning, bad data can creep into the analysis.

(5) Derived temperatures lack resolution in developing systems.

(6) Jet Maxima are overestimated by 5-10 kt. Upstream/down-stream winds are underestimated by 5-10 kt.

b. The Global Spectral Model (GSM). GSM has been running operationally since September 1985, and forecast parameters are the same as HIRAS, (but the moisture is "turned off"). GSM is an aviation forecast model, so levels are clustered near 250 mb. NMC verification on the GSM indicated the model was good at maintaining long wave amplitudes. But as with the HIRAS, there are also some drawbacks.

(1) GSM's temperature forecasts in the troposphere are generally too warm. Since the GSM forecast heights are derived from temperature, they are generally too "high" in the troposphere.

(2) The GSM moisture forecasts are generally too dry and lack resolution. Precipitation forecasting suffers accordingly.

(3) With most levels clustered high in the stratosphere, surface features have lower resolution. Here in Europe this can cause problems as much of the weather is attributable to smaller-than-synoptic-scale forcing.

6-19. AFGWC Philosophy. A single coherent philosophy is necessary to standardize products and services at AFGWC. They have adopted a modified "Norwegian polar front" theory. This states that polar fronts are semi-permanent, semi-continuous transitions between tropical and polar air defined at the surface and vertically consistent to at least 500 mb. Arctic fronts are shallow transition zones not associated with major cyclones.

a. AFGWC doesn't depict fronts unless/until they are well supported by both surface indicators and upper-air fields. Otherwise, they draw the area as a trough.

b. Once a front is analyzed, it is carried on succeeding charts as long as possible.

c. Satellite imagery is used to position fronts but not necessarily to analyze them.

d. As a result of this philosophy, you'll often see large differences between GWC and indigenous weather products. Where GWC may draw a trough approaching the UK, and a cold front in central Europe, the Germans might show two fronts. Neither interpretation is "wrong." They only reflect the differences of analysis philosophy.

6-20. AFGWC Facsimile Products. We will now describe some of the GWC charts used in this theater. Check your latest schedule for transmission times (see also AFGWCP 105-1).

a. AUEU. European data plots with automated analysis. (Looks like the AUEU EDZX described later but the GWC chart shows more area.)

b. FEEU. A four panel 500 mb D-value prog (i.e.. shows forecast difference from the standard 500 mb height) based on the GSM. Panels are valid at the +4, +5, +6, and +7 day from data time. Generally good at both long and short wave speeds, and amplitudes. Has occasional difficulty however, in blocking situations.

c. FHNH(i). A 24 (i=2), and 36-hour (i=3) nephanalysis showing ceilings, visibilities, precipitation and visibility restrictions, using standard AWS symbology.

d. FSNH(i). A hemispheric 24 (i=2), and 36-hour (i=3) synoptic scale surface prog, showing pressure centers, fronts, troughs, isobars, and ceilings and visibilities below 1000 ft and 1 mi. Prog reasoning is available in the PDEU KGWC bulletin

e. FUEU (ii). The "ii" is the pressure level i.e., ii=50 at the 500 mb level. This is an 18 hour guidance prog centered on Europe, showing D-value contours, pressure centers, temperatures at 850, 700, and 300 mb; and vorticity at 500 mb.

f. FUNH(i). A 24 (i=2), and 36-hour (i=3) northern hemispheric upper level horizontal weather depiction (HWD) prognosis of clouds above 10000 ft and winds at 300 mb.

g. FUNT (ii). The "ii" is the pressure level as described above. A 30-hour forecast over the North Atlantic, showing winds, temperature, D-values, and height centers. Check AFGWCP 105-1 for chart boundaries.

h. FXEU Package. Based on the GSM, it consists of an analysis, 12, 24, 36, 48 hour progs, with four panels each.

(1) 500 mb heights (solid) and vorticity (dashed). This product has good resolution of amplitudes and speeds of both long and short waves, all year. An occasional problem occurs during the first few days of a blocking regime over Europe. The GSM may try to break down the block too quickly.

(2) Heights at 850 mb (solid) and 1000/850 mb thickness (dashed). The 850 mb height field shows a pattern similar to that at the surface. Generally works well all year. This thickness value is subject to diurnal effects, and is of little use in elevated terrain. It is, however, useful in describing the location of polar, and especially arctic fronts. Also used in the UK for snow/rain forecasting.

(3) 700 mb omega (solid) and 850/500 mb thickness (dashed) fields. The Omega field shows synoptic scale 700 mb vertical velocity and is used for forecasting the development, of weather systems, as well as precipitation areas, types, and intensities. Omega is the change of pressure with time. Rising air results in a decrease in pressure, Omega is negative ("+" = down, "-" = up). The omega fields are more reliable in winter when systems are stronger. The thickness field is used to find polar fronts in winter. It is also useful in tracking maritime Polar (mP) fronts that have lifted, passing over colder air at the surface. Forecasters new to Germany often remark that cold frontal passages are often accompanied by a 1-2 C rise in temperature. This occurs when a mP front pushing across Germany encounters the cold pool at the surface. During the lift of the mP air mass, mixing between the two air masses initially warms the one at the surface. The warming continues until the air mass overhead is homogeneous. Then, temperatures fall, sometimes accompanied by freezing rain or snow (see chapter 4 for details).

(4) 700 mb heights (solid) and 700 mb dew point depression (wide dashes: 70%; narrow dashes: 90%). Tdd shows atmospheric moisture present, and is used for cloud and precipitation forecasting. The values shown are usually too dry, and resolution is low, so use a satellite picture or BKFG for more accurate atmospheric moisture data.

6-21. AFGWC Teletype Products:

a. Trajectory Bulletin. (See also 2WW TN 89-002.) The trajectory bulletin identifies a parcel's 3-D point of origin and the forecast conditions upon arrival. It provides forecasts at 6, 12, 18, 24, 30, 36, and 48 hours from the current synoptic time. Remember, each bulletin contains seven separate starting points for each level. Do not "connect the dots" for a level. Only the starting points are included. The exact path must be interpolated from other data.

(1) The following is a sample:

```
FJUE53 KGWC 160000Z
GG  TT DP LA LON PPP TT DP N LA LON PPP TT DP  N LA LON PPP TT DP    N SI EDAR
850MB                 700MB                    500MB
                                                               16/0000Z  JAN 91
6  M6  M7  49  M11 853  M8M12  3  49  M10  701  M1  M17  3  49  M12  498 M30  M40  2  11
12 M2  M5  48  M13 852  M5M12  1  48  M13  695  M12M23   0  48  M15  490 M30  M39  2  9
18 M1  M1  49  M16 848  M4M10  1  47  M14  687  M12M24   0  47  M17  483 M29  M43  0  8
```

etc., where:

GG = Forecast time from synoptic observation time, in hours

TT = Temperature in C (precede by M if negative)

DP = Dew point in C (preceded by M if negative)

N = Cloud amounts in eighths
LA = Latitude in degrees.
LON= Longitude in degrees (preceded by M if east of 0°).
PPP= Originating pressure level SI = Showalter Stability Index

(2) The following list shows the bulletin headers with stations included on each:

FJUE50	EDEX EDIC EDIN EDOP EDID EDOT	FJUE51	EGUA EGUN EGVJ EGVA
FJUE52	EDRM EDDN EDDM	FJUE53	EDDS EDAB EDAH EDAR EDOB
FJUE54	LETO LPLA LEZA	FJUE55	LIYW
FJUE56	LGAT	FJUE57	LTAG LTBL
FJUE58	EDBB	FJUE59	EHSB

b. The WXEU is a teletype product whose purpose is to back up the AFGWC charts usually available. It is sent only when USAFE/DOW requests it. It comes via the AWN or by AUTODIN message, and covers the area from 15° W to 45° E from 10° N to 80° N. Below are the products included:

(1) Surface Progs, valid at the 48, 72, and 120 hour point. The charts show fronts, troughs, and pressure centers.

(2) Horizontal Weather Depiction (HWD) progs, valid at the 48 and 72 hour point. The charts show areas where ceiling and visibility are less than 1000/1 mi, precip types and areas.

(3) 700, 500 and 300 mb progs valid at 48 and 72 hours, show wind, temperatures and D-values.

(4) 500 mb prog valid at 120 hours, show D-values and centers.

6-22. Indigenous Weather Products. This section describes the indigenous forecast products available to the theater forecaster. Indigenous products were designed to work specifically in Europe, where local effects often play a larger part in influencing the weather. For that reason, they (especially the indigenous mesoscale models) often work better than the synoptic-scale GSM. Keep in mind, however, that during time of conflict, these products may not be available to you. We deal first with the German products that enter the system via the EFU. We then spend some time on the UKMO products available over the MOLFAX network. Refer to the schedules in your station for chart and bulletin availability times. This list cannot cover the available products completely. Other 2 WW publications that do are listed at the end of the chapter.

6-23. EFU Facsimile Products. Three header suffixes identify the weather service that provided the chart/data: EDKG (EFU), EDZX (GMGO), and EDZW (DWD). Check your latest schedule for file times

a. **ASXX(ii) EDZX (Central Tactical Analysis).** The "ii" is the data base time: 00, 06, 12, or 18Z. EFU produces the CTA four times daily. Covering central Europe and the UK, it provides an analysis of weather, winds, and clouds (to include the height of bases in 100s of ft MSL). See figure 6-1.

b. **AUEU(ii) EDZX (European Upper Air Charts).** The "ii" in the title refers to the chart level. AUEU85 is an 850 mb chart. There are two sets of four charts daily based on the 00Z and 12Z data bases Each includes analysis of temperature, dew point, wind, height, and contours. Analysis intervals are 2.5 C for temperature. and 60 gpm for heights (see figure 6-2).

c. **AXEU EDKG (Weekend Weather Continuity Chart).** EFU re-transmits the four analysis panels from the 12Z 850 mb and 500 mb charts for Saturday and Sunday at 02Z Monday morning. This is done to provide weekend continuity for limited-duty stations. If Monday is a holiday, they send the Sunday and Monday analyses, Tuesday morning at 02Z.

d. **BKFG1 EDKG.** ("BKFG# EDKG" is the title of the output forecasts from the GMGO Moist Baroclinic Model). Shows surface pressure, 850 mb temperature, 1000/ 500mb thickness, and 700 mb

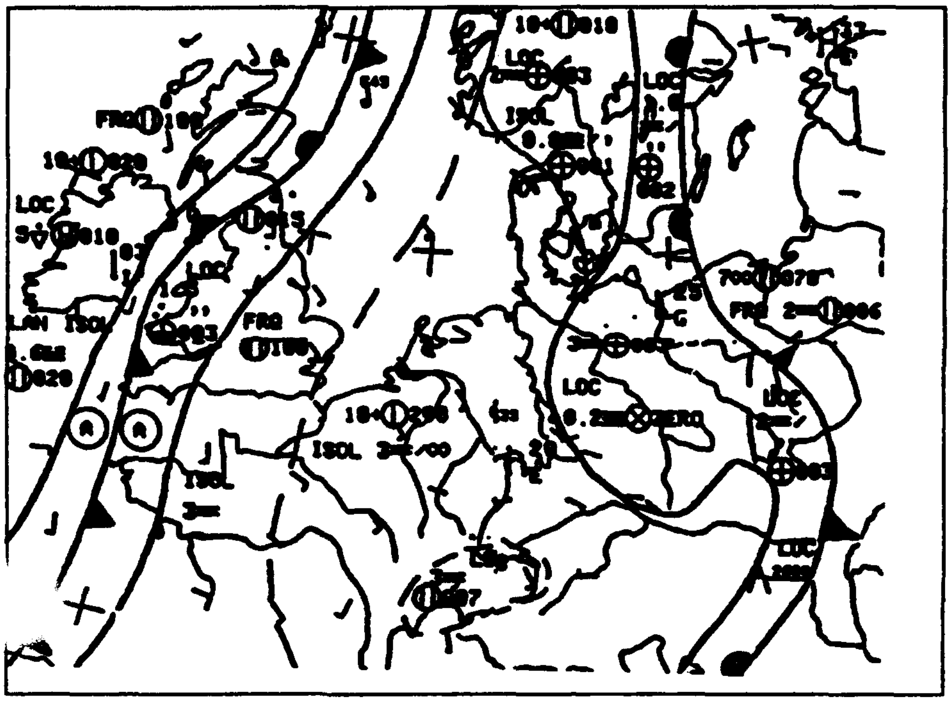


Figure 6-1. ASXX EDZX Chart.

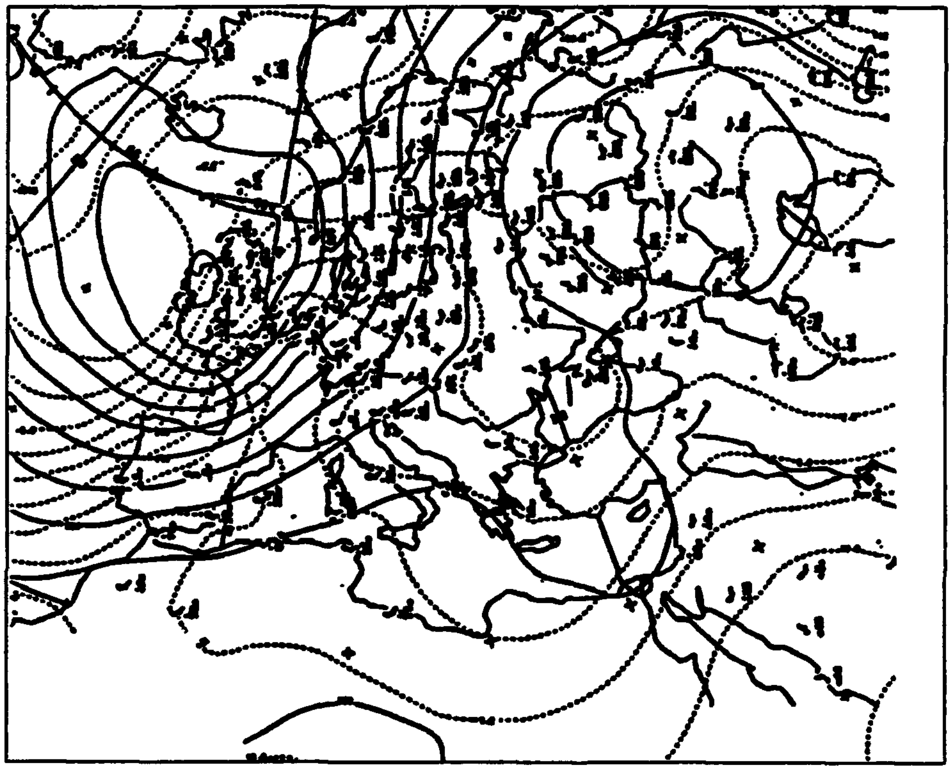


Figure 6-2. AUEU EDZX Chart.

heights and temperatures. Includes an analysis, 12, 24, 36 hour panels (see figure 6-3).

e. **BKFG2 EDKG.** Shows 500 mb heights and vorticity, 850/500 mb thickness and 700 mb moisture. Includes analysis, 12, 24, 36 hour panels.

f. BKFG3 EDKG. Shows surface pressure, 850 mb temperature, 1000/500 mb thickness.

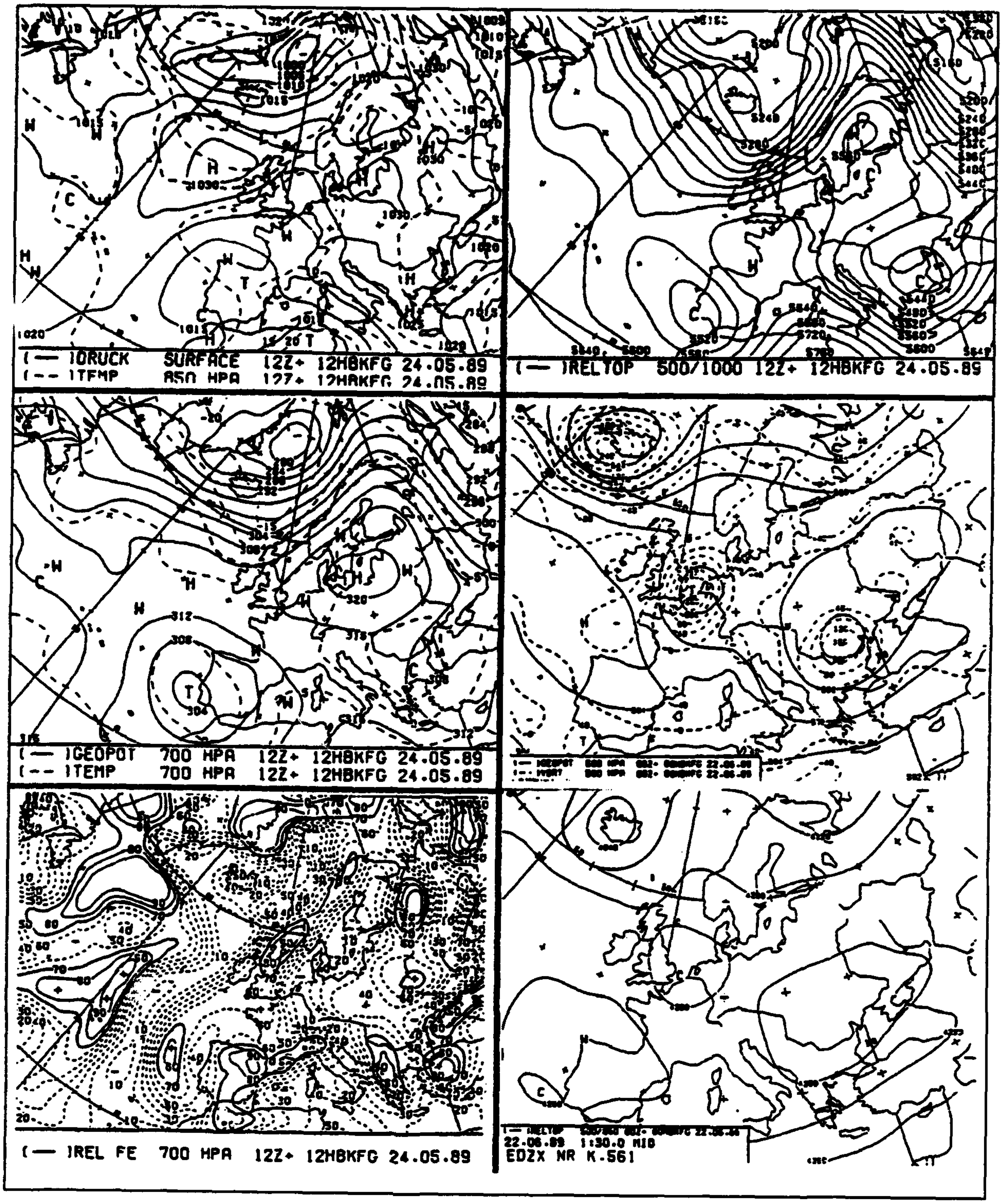


Figure 6-3. Output from the BKFG. (a) surface pressure (solid) and 850 mb temperature (dashed in C); (b), 1000/ 500mb thickness (gpm); (c) 700 mb heights (solid, in gpm) and temperatures (dashed in C); (d) 500 mb heights (solid in gpm) and vorticity (dashed); (e) 700 mb relative humidity (+/- refer to maximum/minimum respectively); (f) 850/500 mb thickness (m).

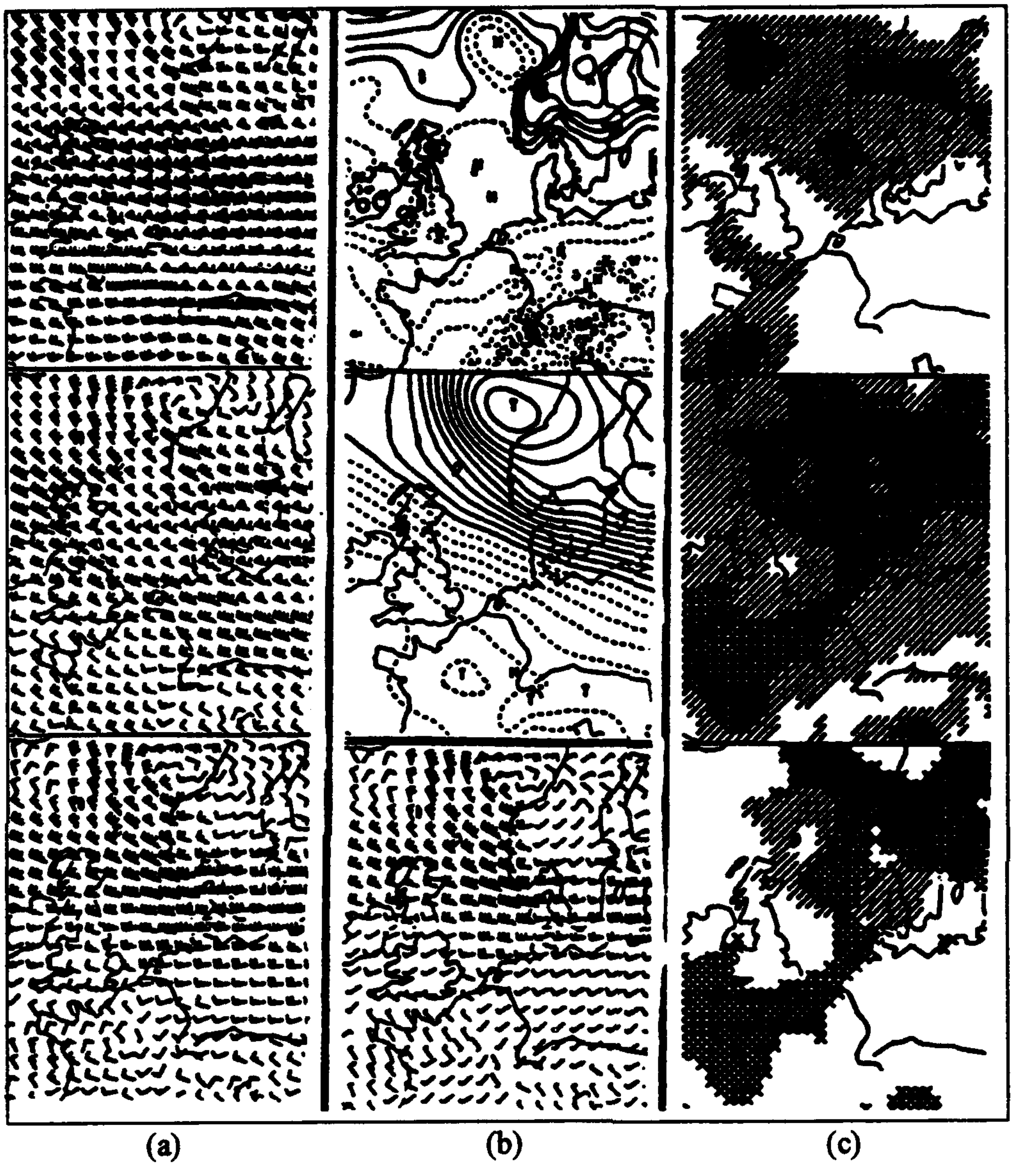


Figure 6-4. Analysis Panel Output–BLM. (a) wind prog (kt-see text for levels); (b) surface temp, pressure, wind; (c) med and low clouds, ceiling (" "=CLR, "/"=SCT, "X"= BKN/OVC).

g. **BKFG4 EDKG.** 500 mb vorticity, 850/500 mb thickness, and 700 mb moisture. Includes 48 and 72 hour panels.

h. **BLM1 EDKG.** (BLM# EDKG refers to the forecast output from the German Mesoscale Boundary Layer Model. See figure 6-4.) BLM1 is the wind prognosis, showing upper-level winds at 1500 ft AGL, 5000 ft AGL and at the height of the freezing level: Analysis, 12, 24, and 36 hour panels.

i. **BLM2 EDKG.** The surface prognosis shows surface pressure, temperature and wind. Includes an analysis, 12, 24, and 36 hour panels.

j. **BLM3 EDKG.** Shows the cloud and ceiling prognosis at T=0 (analysis), 12, 24, and 36 hour points.

k. **BLM4 EDKG (Figure 6-5).** Shows precipitation type, with the size of the symbols showing quantity. Includes 9, 18, 27 and 36 hour panels. (Time cycles are different so the forecasts can be verified with the intermediate European synoptic observation hours.)

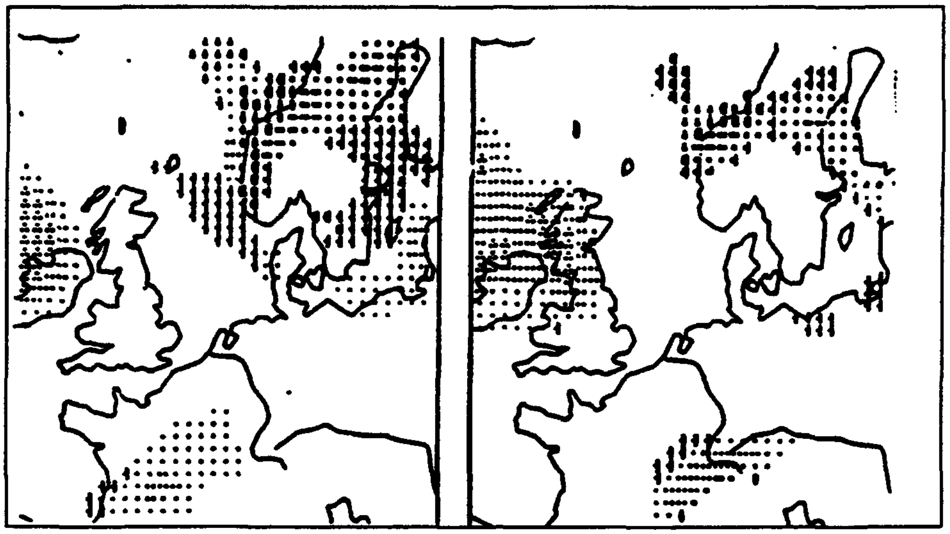


Figure 6-5. Nine and 18-Hour-Point Forecasts From the BLM. Shows precipitation type and

l. **BLM5 EDKG (not shown).** A four-panel analysis of relative humidity, temperature, heights and winds at the 920 mb level. (920 mb is taken as the gradient level in Europe.)

m. **The FAEU EDKG (Low-Level Turbulence and Icing Advisory, Figure 6-6).** Forecast icing and turbulence over Europe at and below 10,000 MSL (levels given in 100s of feet), during the next 12 hours.

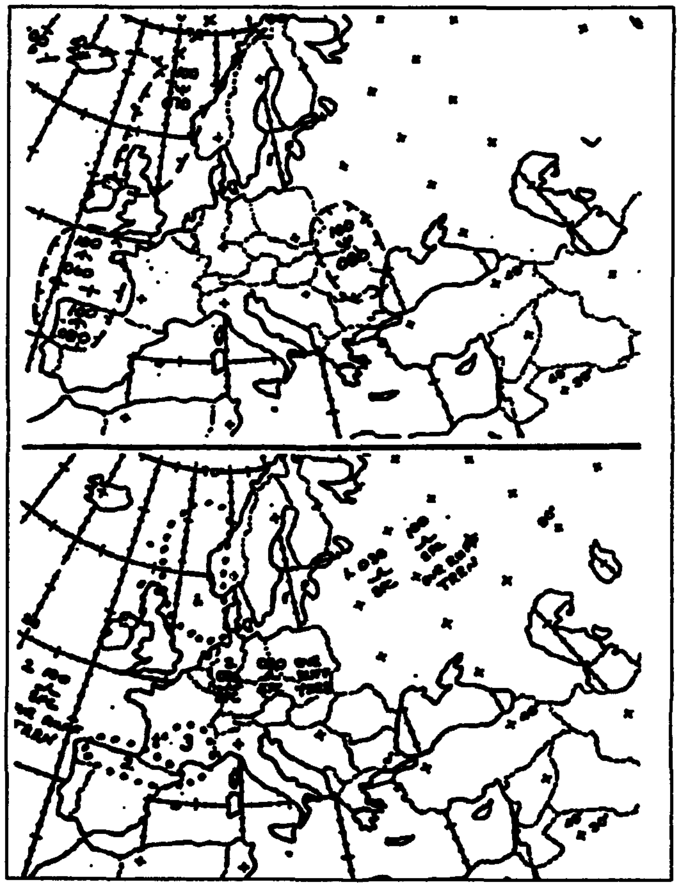


Figure 6-6. FAEU EDZX Chart.

Amendments are transmitted via EURMEDS only, under the same MANOP heading.

n. The FEEU EDZW (DWD 48/72 Hour Surface Prog). This is a two panel chart showing fronts and pressure centers, isobars (at 5 mb intervals) and scalloping to indicate higher than 70% relative humidity. EFU transmits this product as a sub-original, so picture quality varies.

o. The FSEU EDZW (DWD 24 hour Surface Prog). A two panel chart. Top shows +24 hour surface features, centers and 700 mb RH. Bottom panel shows 24 hour precipitation accumulation (see figure 6-7).

p. FSEU EDZX (NATO Central Tactical Forecast or CTF). It consists of two time-phased (+12-18 hour and +18-24 hour) surface progs. It shows sensible weather, visibility, clouds (bases and tops in 100s of ft MSL), and freezing level for central Europe (Good source for IR/TDA input.) See figure 6-8.

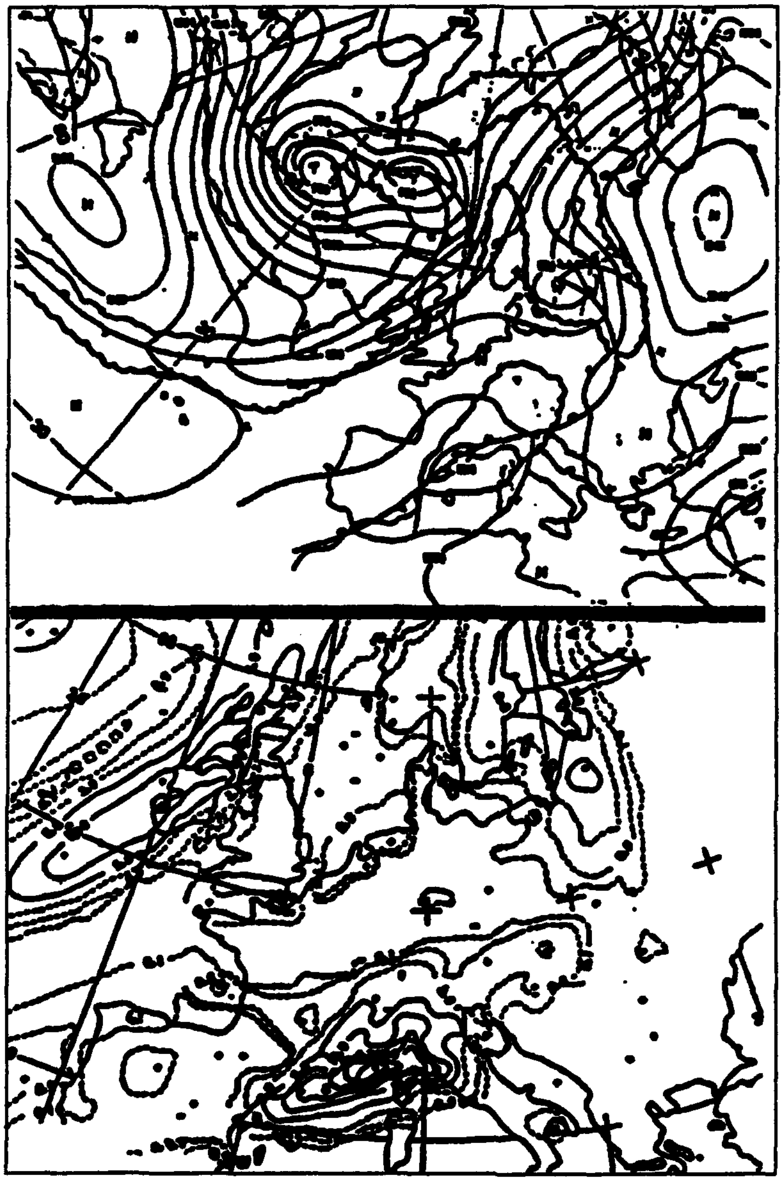


Figure 6-7. DWD 24 Hour Surface Prog.

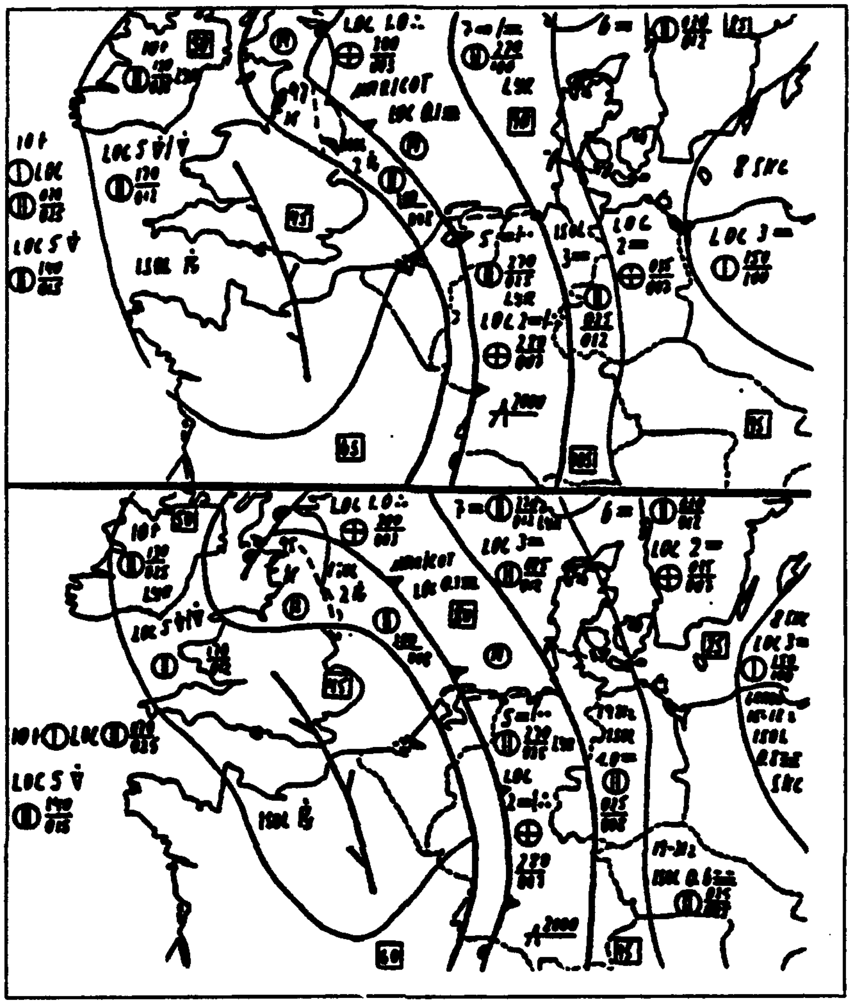


Figure 6-8. NATO Central Tactical Forecast (CTF).

q. **HXEU EDKG (E-O Central Europe Planning Forecast).** Shows sensible weather, synoptic systems, visibility, and clouds for 24, 48, 72 hours. These charts represent consensus prog on which other EFU-developed products are based. It can be used for all mission planning, except during NATO exercises or contingencies, when the NATO Unified Weather Forecast (UWF EDZX) must be used. Available Monday thru Friday, except holidays, this is first choice for IR/TDA input (figure 6-9 is an example).

r. **STDL EDZX (Snow Depth Surface Plot-not shown).** Surface plot of 06Z snow depths, in cm, over western Europe. From the GMGO BLM.

s. **SIEM(ii) EDZX (Intermediate Hour Synoptic Chart-not shown).** "ii" in the unanalyzed computer-plotted chart of surface synoptic observations over western Europe.

t. **SMEU(ii) EDZX (Primary Hour Synoptic Chart-not shown).** "ii" in the header refers to the observation hour: 00, 06, 12, or 18Z. A computer-plotted chart of surface synoptic observations over western Europe. Two charts are transmitted - one analyzed, the other unanalyzed.

u. **UWF(i) EDZX (not shown).** In the same format as the CTF, this is a five-panel forecast valid at the 24, 36, 48, and 72-hour point. This chart took the place of the earlier central planning forecast or CPF. An example of the 24 hour panel appears in figure 6-10.

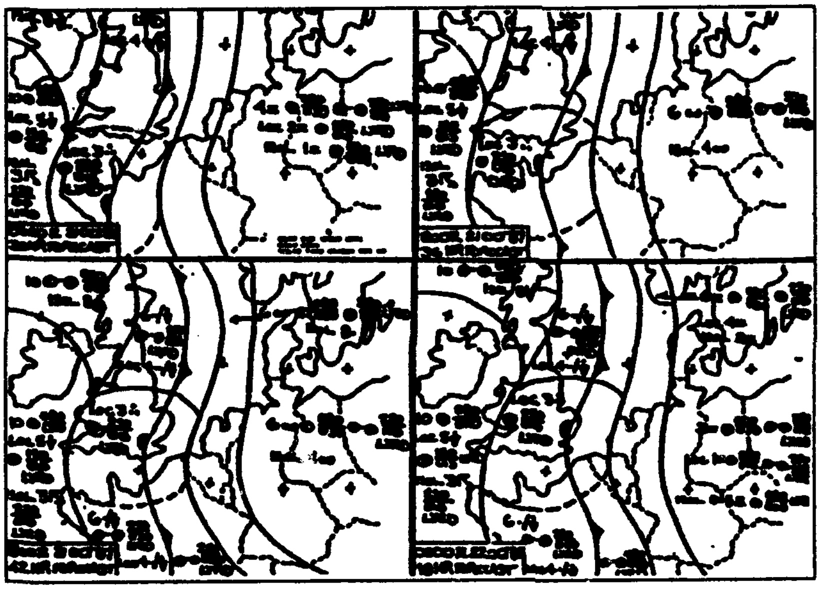


Figure 6-9. HXEU EDKG Chart.

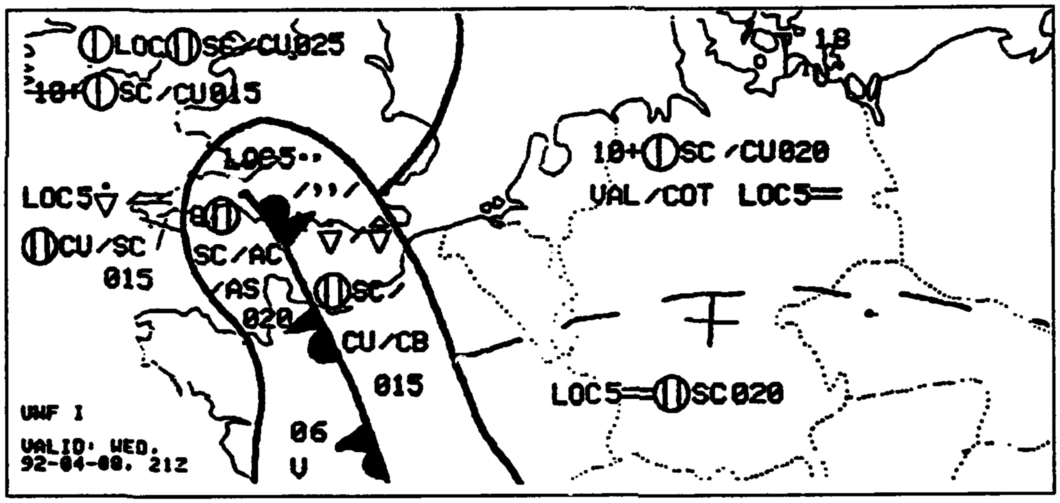


Figure 6-10. UWF EDZX 24 hr Panel.

6-24. EFU Teletype Products:

a. AAEU40 EDKG: EURDIGS status bulletin. Check it before requesting re-runs.

b. FAEU EDKG: Amends or corrects the FAEU chart. Also a chart backup during EURDIGS outages.

c. FAGE EDKG: Aviation Low-Level Advisory for icing, turbulence and thunderstorms for units without EURDIGS.

d. FEDL44 EDKG: Ground Commanders' bulletin. Designed to provide forecast guidance to Army commanders without direct weather support.

e. FOXX20/25 EDKG: Discussion of European weather expected for the next 72 hours, with forecast reasoning. FOXX20 is based on 12Z progs, and FOXX25 on the 00Z.

f. FOXX26 EDKG: Zulu alert forecast for Bitburg AB.

g FOXX35 EDKG: Space shuttle support bulletin forecast for Moron AB. Only issued during a space shuttle mission.

h. FPDL41 EDKG: General area forecast for central Europe and the UK, provided to AFN.

i. NOEU EDKG: EURDIGS status message. Issued as needed throughout the entire day, unlike the AAEU40 which is issued only once per day.

j. WWEU EDKG: Amends and corrects the WWEU chart. Backup during EURDIGS outages.

6-25. EFU Backup to AFGWC. In the event AFGWC suffers a prolonged transmission outage, EFU/GMGO have developed the following products as backup. Except where otherwise noted, 86 WS/CC must task EFU to perform the backup. All charts are sent on MOMMS code 014.

a. FAEU2 EDKG (Significant Weather Prognosis). EFU will transmit a second FAEU chart for icing and turbulence above 10000 ft MSL, over Europe. Thunderstorms, depicted on the WWEU EDKG won't be shown. The chart is valid at the +12 to +24 hour point after issue.

b. FOEU41/42 EDKG. Area Forecast for USAFE Special Operations. This is a 12 or 18 hour forecast, sent automatically when GWC goes down. The chart shows forecast cloud coverage and bases; significant weather; isolines of ALSTG; and surface temperatures. An 850 mb as well as a 1000 mb chart will be transmitted to show low-level winds.

c. FXEU81 EDZX. Basic Defensive Wind Bulletin. (Backs up FUEU 42 KGWC) EFU will transmit a GMGO product, the FXEU81 EDZX, that provides upper air winds from 2 km to 30 km (in 2 km increments) for central and eastern Europe. The forecast, valid at the +1 to +7 hour point, is transmitted four times per day via EURMEDS), and is also available via EURDIGS.

d. FUEU43/44 EDKG. High Level Wind and Contrail Forecast. GMGO produces backup bulletin for the wind forecast, while EFU produces the contrail forecast (bases and tops).

6-26. EFU Back-up During Prolonged UKMO Fax Outage. Many EFU products replicate the UKMO charts rather closely. The following list shows the EFU chart that correlates with the UKMO chart.

UKMO	EFU
Global Model	BKFG
Regional Model	BLM
ASXX Surface Analysis	ASXX EDZX (CTA)
FASTEST 24 Hr Surface Prog	FSEU EDZW (DWD 24 Hr Surface Prog) HXEU EDKG (24 Hr Panel)
48-72 hr Surface Prog	FEEU EDZW (DWD 48-72 Hr Surface Prog or HXEU EDKG (48 &72 hr Panels)
3-Hourly European Plots	SIEM and SMEU 3-hourly Surface Plots)

6-27. United Kingdom Meteorological Office (UKMO) Products. We describe MOLFAX products available, and focus on how to get the most out of them.

NOTE: Many of the techniques described are applicable to AFGWC as well as the German indigenous products. Refer to your latest schedule for product availability times. (See also 2 WW/FM-89/005 (MOLFAX), and 2 WW/FM 90-004 (STRIFAX products)).

6-28. The UKMO Model. We highlight the latest changes to the UKMO models:

a. Based on a 20-layer primitive equation (PE) model.

b. Incorporate Sigma levels to divide the vertical field into 20 different levels.. The thickness of each layer varies, with the greatest resolution in the lowest 5 layers.

c. Four major processes:

(1) Large Scale Precipitation. Air at model gridpoints becomes supersaturated due to convergence/ radiational cooling.

(2) Convection. Based on parcel theory modified by entrainment. The Fine Mesh model only represents convective precipitation when a minimum depth of cloud exists. Small-scale convection can occasionally be missed.

(3) Radiation. The model incorporates diurnal and seasonal effects. As daily insolation in Northern Europe varies from 8 hours in winter to 16 hours in summer. The seasonal variation is pertinent to the successful forecasting of sensible weather elements, including type and character of precipitation, and fog formation and dispersal. (Fog which routinely disperses during high summer will linger all day or longer during the winter.) Radiation is also interactive with temperature, humidity, and cloud amount (inferred from the existence of upper level humidity).

(4) Boundary Layer. Greatest resolution is in the lowest four layers. Parameters considered include vertical transfer of heat, moisture, and momentum by turbulent mixing.

d. The model includes the following reports, if available within ± 3 hours of the run:

(1) Winds derived from satellite cloud tracks

(2) Temperature soundings derived from satellite

(3) Rawinsonde reports

(4) PIREPs

(5) Land and ship reports

(6) Drifting buoy reports

(7) The data is first converted into variables which the model can use. These include potential temperature, wind components, relative humidity and model surface pressure.

6-29. Production Scheme. There are two fully-operational versions of the UKMO model from which products are routinely transmitted: the global version and the regional version.

a. Global Version. (Replaced the "Coarse Mesh". Recent resolution improvements have upgraded it to fine mesh resolution (1.25° longitude by .833° latitude). It is called the Global Version.) This is designed to support the UKMO's worldwide forecasting support tasks including national defense, shipping interests, civil aviation, and general guidance for medium-range forecasting. The data base times are 00Z and 12Z, with the results available 5 hours later. The main forecast output we see is the 4-panel GMF.

b. Limited Area or "Regional" Version (Replaced the "Fine Mesh"). This output is geared towards supporting short range public forecasting requirements within the UK, and marine interests in the North Sea and Mediterranean. While the data base times are the same as for the Global Version, the results are available at 03Z and 15Z. The forecast product output is the 14-panel LMF, based on a grid of 0.4425° longitude by 0.4425° latitude, normalized along 60°N. The finer resolution enables more precise forecasting of frontal positions, precipitation and wind.

6-30. Model Strengths and Weaknesses. The global and regional models described above are so "new" that generalizations about performance cannot be made as yet. We hope the recently adopted changes will improve the model performance over earlier versions. The following describes strengths and weaknesses of older models. (For that reason, we refer to older models as "Coarse Mesh" and "Fine Mesh.")

a. Strengths:

(1) Sigma Levels. Some of the advantages of this innovation were described earlier. The benefits are seen when the Fine Mesh forecasts precipitation amounts and areas to decrease as a front moves from upslope terrain to downslope. In addition, resolution in the upper troposphere should cover steering

variations better.

(2) Data Insertion. The early coarse and fine mesh models had problems in data sparse areas. To correct this, the UKMO forecasters began inserting climatological data in silent areas to give the model something to work with. This worked reasonably well and minimized gross distortions. An example distortion was the isothermal "bull's-eye" pattern that used to appear on the Fine Mesh over Greenland, caused by high terrain, supercooling, and lack of reporting stations. Ultimately, this practice has enhanced model consistency.

b. Weaknesses:

(1) Fails to fill deep maritime lows fast enough once they move over land.

(2) Blocking highs are occasionally broken down too fast.

(3) Cutoff lows are, at times, forecast poorly. Usually the evolution into the cut-off stage is not successfully predicted, and the models tend to fill lows and move them out too rapidly.

6-31. GMF Output. A completely automated product, output consists of an analysis, 12, 24, and 36 hour prognoses. Four constant pressure surfaces are evaluated, as follows:

a. 850 mb Panel. See figure 6-11.

(1) Heights. Every 60 gpm with base height of 1500 m.

(2) Wet Bulb Potential Temperature (WBPT) Isotherms. Dashed lines, every 2°C, with a base of 0°. Since WBPT is generally not extensively used outside of Europe, we will discuss it at greater length here. WBPT does the following:

(a) Combines temperature and **vapor content** into a single figure. The resultant figure more conservative for adiabatic changes (If you look at a Skew-T, you see that the moist adiabatic lapse rate results in a slower change trend than the dry lapse rate).

(b) WBPT's conservative nature permits the tracking of an air mass even in the absence of clouds on visible, or conventional IR imagery (though the corresponding moisture is visible on water vapor imagery). The absence of sensible weather in the area of such a thermal gradient at times, contributes to the "unexpected" intensification of newly-arrived depressions entering the area.

(c) WBPT isotherms are used just like conventional isotherms in the placement of fronts. Warm fronts occur behind the maximum packing, cold fronts just ahead, and occlusions in the thermal ridge.

(d) Additional Data Application.

1. Continuity. Determine changes in the location, intensity and alignment of supporting troughs/ridges.

2. Fog/Stratus Forecasting. Warm air advection can help initiate fog/stratus, or perpetuate it when it already exists (particularly during winter, with its associated shorter days and lower sun angles.) Cold air advection tends to discourage such formation, particularly in the absence of surface moisture. Most fog/stratus forecasting techniques employ the 850 mb temperature.

3. Air-mass Thunderstorm Alert. When the +16°C WBPT isotherm moves into your area, start looking for other triggers to thunderstorm development.

4. Rain vs. Snow. The graph below provides a rough idea of the relationship between WBPT and snow probability. 850 mb WBPT means the same thing on both the Coarse Mesh and the Fine Mesh. Remember, this is a starting point; if favorable, look for other confirmation.

WBPT (C)	5	4	3	2	1	0	-1
SNOW PROBABILITY	26%	39%	57%	78%	90%	96%	100%

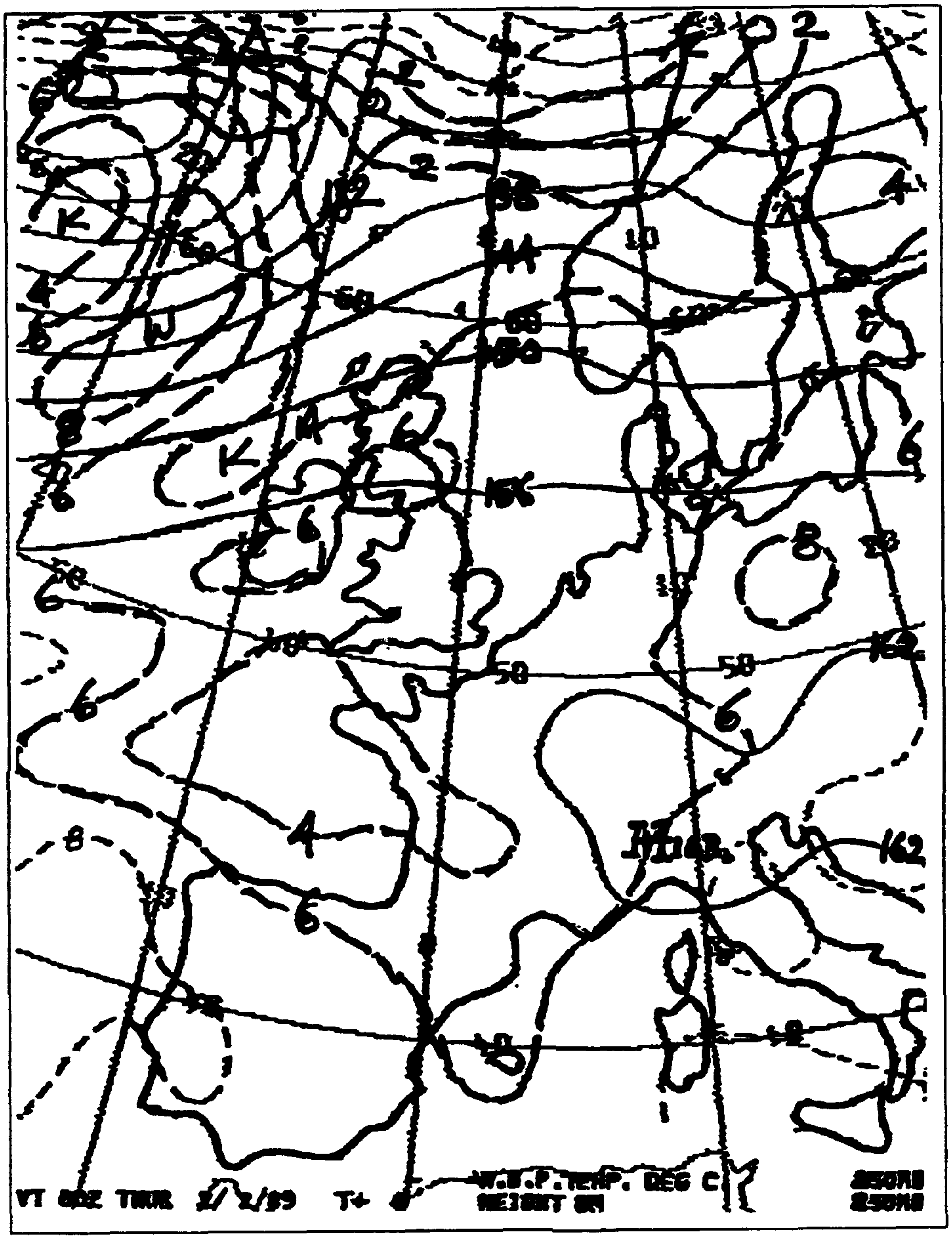


Figure 6-11. Example GMF 850 mb Panel.

b. 700 mb Panel (Figure 6-12):

(1) Heights. Every 60 gpm with a base height of 3,000 m. Labelled in decameters.

(2) Moisture. Represented by dashed isopleths known as isohumes. Baseline is zero, with 19% intervals.

(3) Data Application.

(a) First Guess Synoptic Picture. In general, look for overcast skies and precipitation inside the 95% isohume; broken/overcast clouds with showers from 76% to 94%. We can also incorporate general terrain influences into this relationship as shown below (cloud amount refers to lowest cloud; actual ceiling

Figure 6-12. GMF 700 mb Panel.

category is too dependent on season and system variation to classify):

	UPSLOPE	DOWNSLOPE
>95%	OVC -STEADY PRECIP	OVC/BKN-STEADY/INTER PRECIP
76-94%	BKN/OVC-INTER PRECIP	BKN-PRECIP/NONE
57-75%	BKN-INTER PRECIP/NONE	BKN/SCT-NONE

None means precipitation is unlikely at your station. You may see isolated showers or virga on your radar.

(b) Frontal Placement. You can place fronts in the moist zones. Ideally, warm fronts go behind the maximum moisture band, and cold fronts just ahead. The triple point of occlusions normally coincides with a moisture maxima within the moist band. Normally, the 76% isohume will show the elongated frontal pattern, but in summer, with weaker fronts, you may have to use the 57% isohume. This varies, based on frontal alignment with jet stream, so 850 mb thermal packing is still the better tool to find the front.

(c) The precipitation probability can be related to the shape of the flow. Mid-level moisture in anticyclonic flow tends to be discourage large-scale precipitation occurrence, unlike cyclonic flow.

c. 500 mb Panel (Figure 6-13):

(1) Heights. Every 60 gpm with a baseline of 5,400 m. Labelled in decameters.

(2) Thickness. The 1000-500 mb thickness field is shown in dashed isopleths, at 60 meter intervals. Baseline is also 5,400 m.

(3) Data Application.

(a) Frontal Placement/Vertical Consistency. Cold fronts are normally found just downstream of the tightest thickness gradient. Warm fronts are generally analyzed just upstream the thickness gradient, on the warm side. Occlusions normally go in the thickness ridge. You can also use this panel to track upper level troughs.

(b) Thermal Advection. Decreasing thickness values indicate cold air advection, and thickness isopleths tend to parallel vorticity isopleths. Densely packed, decreasing thickness isopleths usually coincide with strong PVA.

(c) Stability. Dense, lowering thickness values upstream are a precursor to system **intensification**. Initialize against stability. If the Total Totals index is in the high 40's, and showers are heading toward you with strong lowering thickness values, think thunder! If you already have gusts to 40 kt at your station and gradient winds increase from 60 kt overhead to 75 kt upstream, think 50 kt for your station. This was one of the key factors in the 16 October 87 windstorm in East Anglia. Lowering thickness means cold air advection; it gives low pressure systems the upper level destabilization they need for intensification.

d. 300 mb Panel (Figure 6-14):

(1) Heights. Every 60 gpm with baseline at 9,000 m. Contours labeled in decameters.

(2) Wind Bands. Isotachs depicted as dashed lines in 20 knot

(3) Data Application:

(a) Relation of Jet Streams Alignment to Upper Air Troughs. When a jet maximum is behind a trough, the trough will stall and deepen. When the jet max is ahead of a trough, the trough moves out, and movement becomes more predictable. A ''challenging'' situation occurs when more than one jet max occurs in the same trough (indicating more than one embedded disturbance). The trough may then change its alignment or shape, rather than move out. You must analyze surface charts carefully and do a detailed isothermal analysis of upper air charts (2 C interval may be necessary) to isolate the secondary features. You will often find secondary troughs associated with black cloud cirrus patches.

(b) On which side of the front will the weather occur? This concerns the relationship between the frontal position and the jet position. Failure to analyze this accurately can **bust** a forecast. When a frontal system is perpendicular to a jet, the front moves normally, pushing the sensible weather ahead of it. However, when the front aligns parallel to a jet, the front does not move, until the jet changes orientation. Consequently, the poorest weather backs up behind the front. The massive cirrus shield ahead of the front may impact A/R missions, but the surface weather is behind, not under the cirrus shield. It will not show up as readily on IR imagery because of lessened radiative temperature contrast with other features upstream.

(c) Location of the Triple Point. There is some diversity of opinion this. The conventional wisdom states the triple point can usually be found on the warm side of the jet, just ahead of a strong speed maxima, where the contours are change from cyclonic to anticyclonic curvature. On METSAT, this will be at the trailing edge of the deformation cirrus, with the cloud head downstream. Using this method, you will

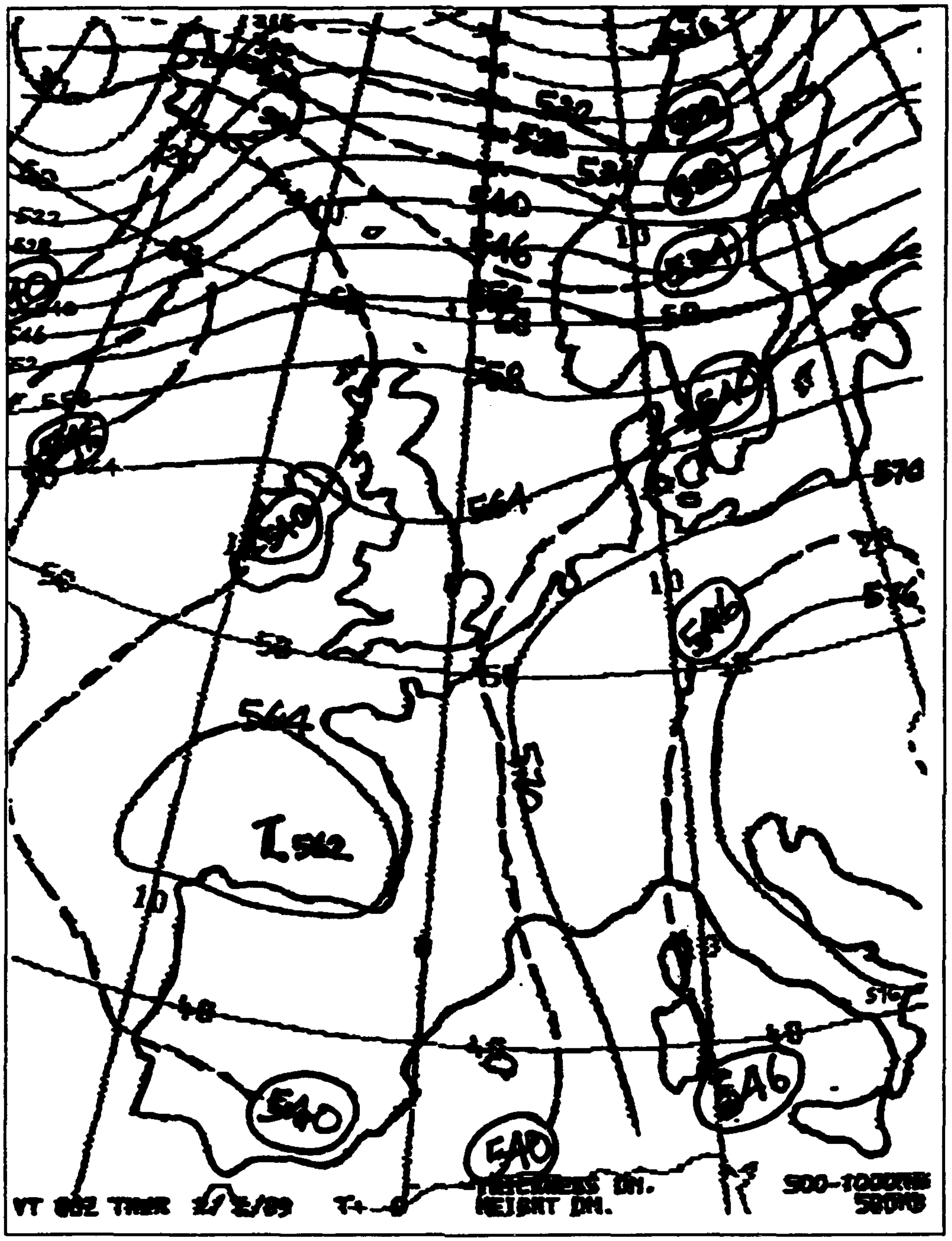


Figure 6-13. A GMF 500 mb Panel.

at least be in the ball park.

(d) During the winter, strong winds may frequently be found as low as 400 mb. You may also see the subtropical jet superimposed on the polar jet. This will markedly increase the vertical shear and may generate significant turbulence.

6-32. Limited Area (Regional) Model Output. This product consists of an analysis, and 6, 12, 18, 24, 30 and 36-hr prognoses. We will discuss the data analyzed, and give some applications.

a. T=0 Upper Panel. Percentage snow probability at mean sea level, in dashed lines for 20, 50, and 80%; and mean sea-level pressure (MSLP) in solid lines, at 4 mb intervals, from a *1000* mb baseline. See figure 6-15a .

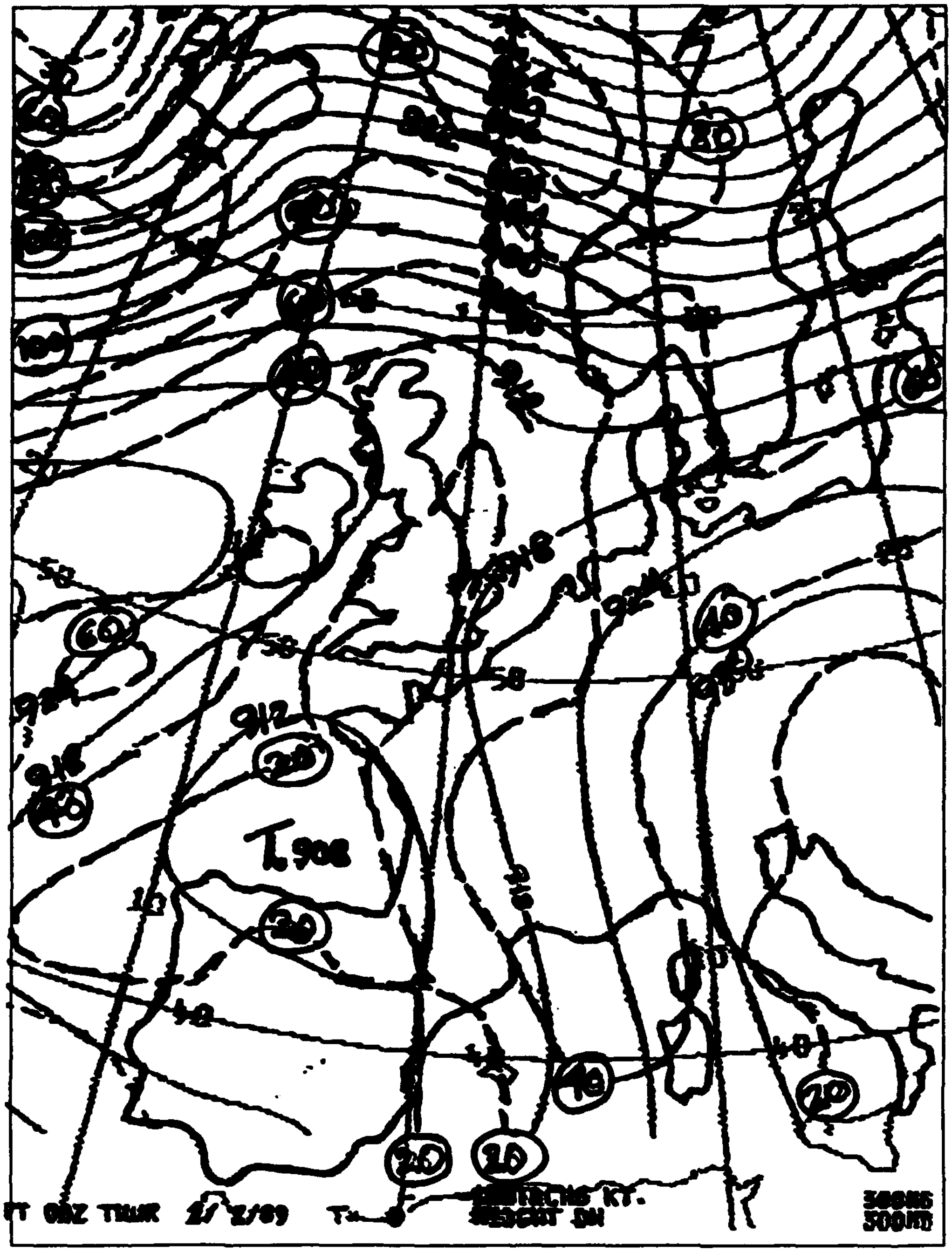


Figure 6-14. GMF 300 mb Panel.

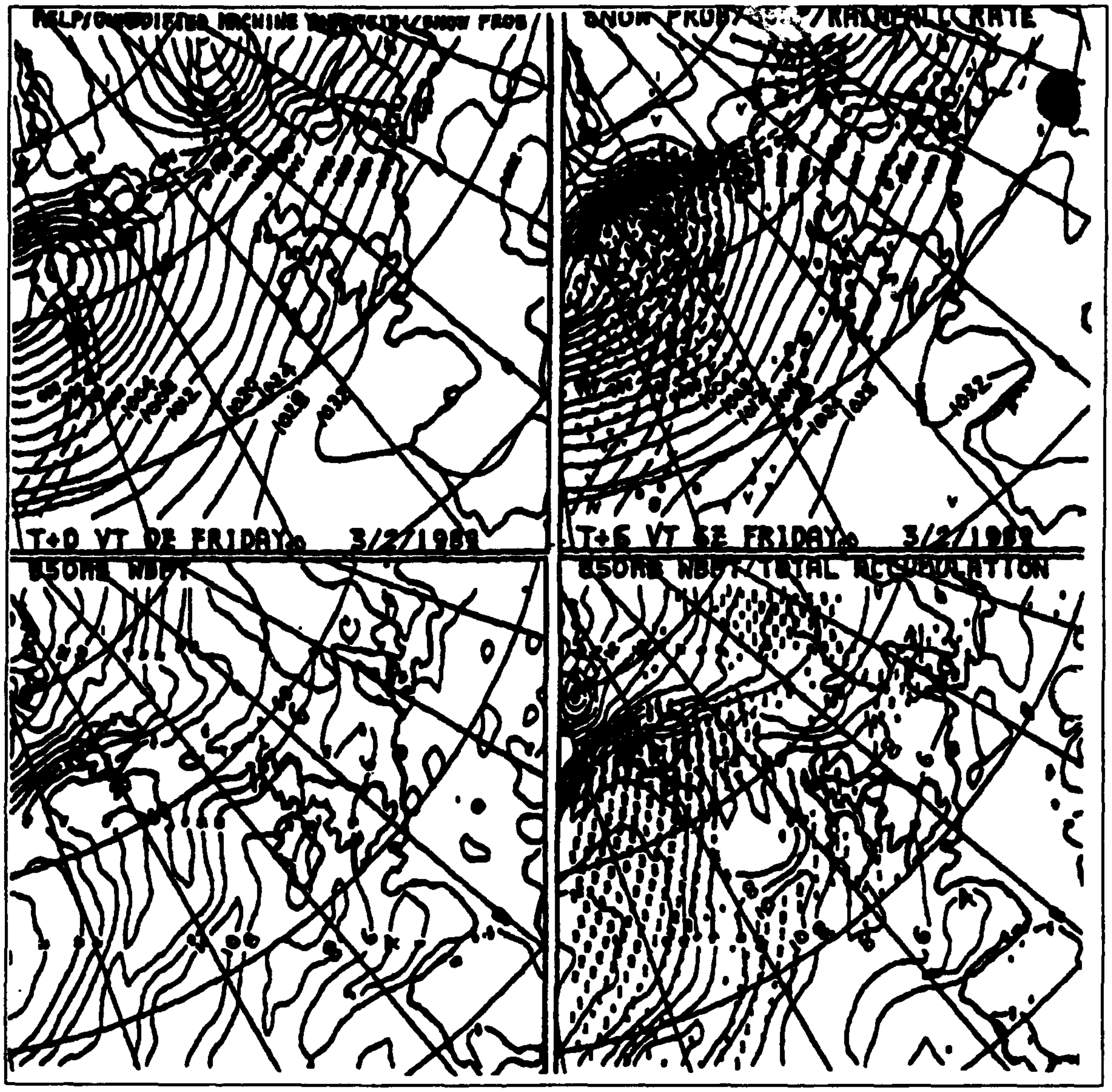
b. T=0 Lower Panel. WBPT (C) in 2 C intervals.

c. Forecasts. Six-panel pages (see figure 6-15b), showing the following parameters at each forecast time:

(1) Percent of snow probabilities at mean sea level. Dashed lines at 20, 50 and 80% probability. Informal ground rules follow:

(a) 0-20%. Precip will be mainly liquid, unless warm air is overrunning a subfreezing surface. Mountain tops will get snow.

(b) 20-50%. Precip will be predominantly liquid during daylight hours, but mixed, during night



(a) (b)

Figure 6-15. LMF Output. (a) T=0 panel, showing snow probability and MSLP; (b) T+6 forecast panel showing snow probability, rainfall rate, MSLP, 850 mb WBPT and total accumulation.

hours. Showers from the North Sea will be predominantly RASN, even during the day. Mountains and hills will get snow.

(c) 50-80%. Precip will be predominantly snow. During daylight hours, it can be mixed, in relatively flat terrain, if the wind is southwesterly. If the flow is from the North Sea, break out the shovels.

(d) >80% Break out the shovels.

(2) Total (liquid equivalent) precipitation rate in mm/hr. The legend for precipitation type and amount is at the top right of the page. An approximate conversion: millimeters * .04= inches.

(3) MSLP in 4 mb increments, with a 1000 mb baseline.

(a) Primary Use. To forecast altimeter settings during the forecast period. Compare your present altimeter settings with those derived from the analysis and the 6-hr panel. If the pressure is falling faster than predicted by this panel, consider applying a correction to forecast the minimum altimeter setting more correctly. This will also help you forecast other developments. For example, if pressure is falling faster, the system might be intensifying more than expected. This would slow movement and affect forecast timing.

(b) Secondary Use. To help forecast winds, particularly advisory and warning criteria. Measure the difference in pressure between one panel and the next (6-hour interval). Then divide by two to get a forecast APP (3-hourly pressure change). If you have developed a relationship between pressure change and gradient wind (obtained from soundings) you will have a representative wind forecast for the period.

(4) 850 mb WBPT in solid lines at 2 C increments. The principle here is the same as with the Coarse Mesh. Since gridding for the Fine Mesh is smaller, expect to see some minor differences. The Fine Mesh WBPT field is more likely to reveal warm and/or cold pockets. If there are radical differences between the Coarse Mesh and the Fine Mesh, use the upper-air analyses to resolve the difference. Rain vs. snow determination from WBPT is performed as with the coarse mesh model.

(5) Rainfall amount (mm) during the 6-hour period ending at the valid time of the chart, given in alphanumerics. The legend is at the bottom. If the 06Z panel depicts a group of 5's over the eastern UK, it means 5 mm (.2 in) of precip is expected to fall during the period 00Z-06Z. If it fell as snow, would mean an accumulation of 2.0 inches during the 6-hour period (according to the FMH-1B, 10 inches of snow melts down to 1 inch of liquid). This is advisory or warning criteria for many stations.

6-33. Surface Plots. There are two types; an hourly surface plot depicting only the UK, and a 3-hourly surface plot (00Z PE 3 hours) showing all of Europe. Synoptic code is used. The difference between the two charts is that on the 3-hourly surface plot, indicated cloud height is (100 ft X) the square root of the actual cloud height. This enables the UKMO to get more surface plots on the chart. (Example: A 2,500 ft ceiling over Manston is represented by the number 25 on the hourly surface plot. On the 3-hourly plot, this will be encoded as 5.).

6-34. Surface Analysis/Prognosis. As distinguished from the surface plots, the surface analysis/prognosis arrives, pre-analyzed. The disadvantage is there are no individual plots on these charts so you cannot check them. These are plotted first by computer, after which human analysts correct for "excessive smoothing."

a. ASXX EGRR (Analysis). Sent four times daily (see figure 6-16).

b. FSXX EGRR (Prognosis). With the same transmission frequency as the analysis, it arrives about 30 minutes after the analysis. Figure 6-17 is an example.

c. Parameters. Both analyze for the same parameters, as discussed below:

(1) Fronts. An unusual feature is the frequency of "double fronts" one cold front trailing less than 100 miles behind another, with similar directional orientation). This happens when fronts become parallel to the upper level flow. The weather builds back behind the leading front, sometimes as much as 100 mi, so you have a transition air mass in between the two fronts. UKMO's analysis philosophy, in this case, is to place one front at the leading edge of the cloud mass, and a second front at the trailing edge.

(2) Pressure Centers. **X** indicates the center. The **H** or **L** is frequently placed off-center, so do **not** confuse the **H** or **L** with the actual center.

(3) Isobars are drawn at 4 mb intervals, labeled every 8.

(4) System Classification. The UKMO assigns a letter to each significant front and pressure center on the analysis, and uses the same letter on the prognosis, as well as on the discussion bulletin. Fronts and pressure centers retain this classification during their synoptic lifetime, or until they move off the chart. This procedure is quite helpful for continuity.

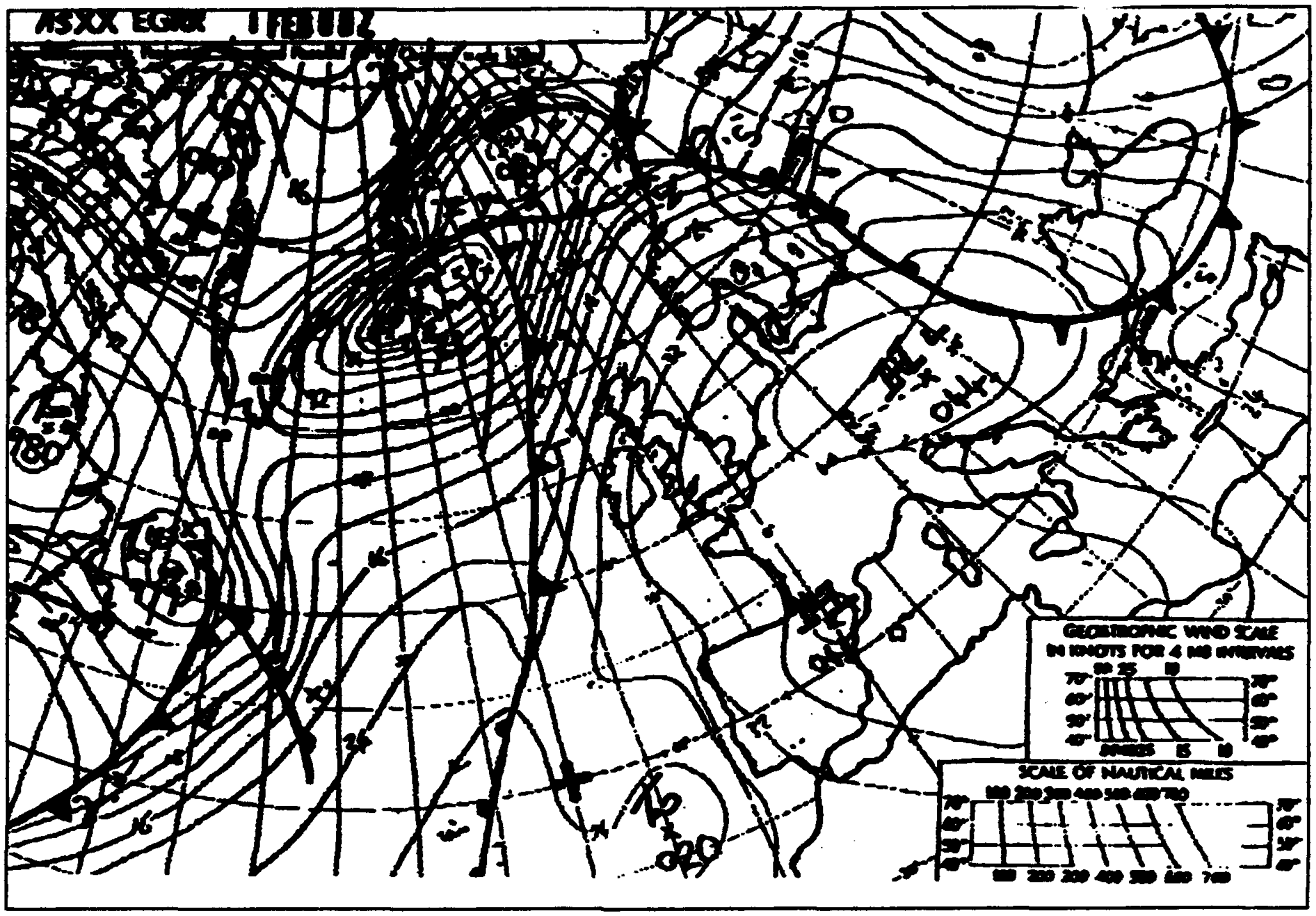


Figure 6-16. ASXX Surface Analysis.

d. ASXX Data Application:

(1) Continuity. Extract frontal positions from previous ASXX analyses (Do not use another system's analysis or you will contaminate your data base.) and plot them on the chart. Then, try to extrapolate future positions, accounting for expected changes of intensity or alignment. Use all available tools to determine such changes. Finally, compare your extrapolated positions to those on the corresponding FSXX prognosis.

(2) Initialization. Identify upper air support for the surface systems and determine the stacking. Then compare to each level as follows:

(a) 300 mb Analysis. Front/jet alignment shows both where the worst weather will occur relative to the front, and also the character of the weather. With a front parallel to the jet (active front), the significant weather will occur with and behind the front, and be frequently stratiform. If the front is perpendicular to the jet (inactive front), most weather will occur at and ahead of the front, and will be mostly convective - especially with day-time heating.

(b) 500 mb Analysis. By initializing against the Coarse Mesh (thickness) and the GSM (vorticity and thickness), you can see intensity changes that will affect the movement of systems. Decreasing thickness values indicate not only cold air advection, but also correlate with positive vorticity advection. When destabilization occurs, systems tend to slow down since the energy goes into development rather than movement. Surface weather intensifies.

(c) 700 mb Analysis. Identify and track available moisture from the Coarse Mesh (or Trajectory

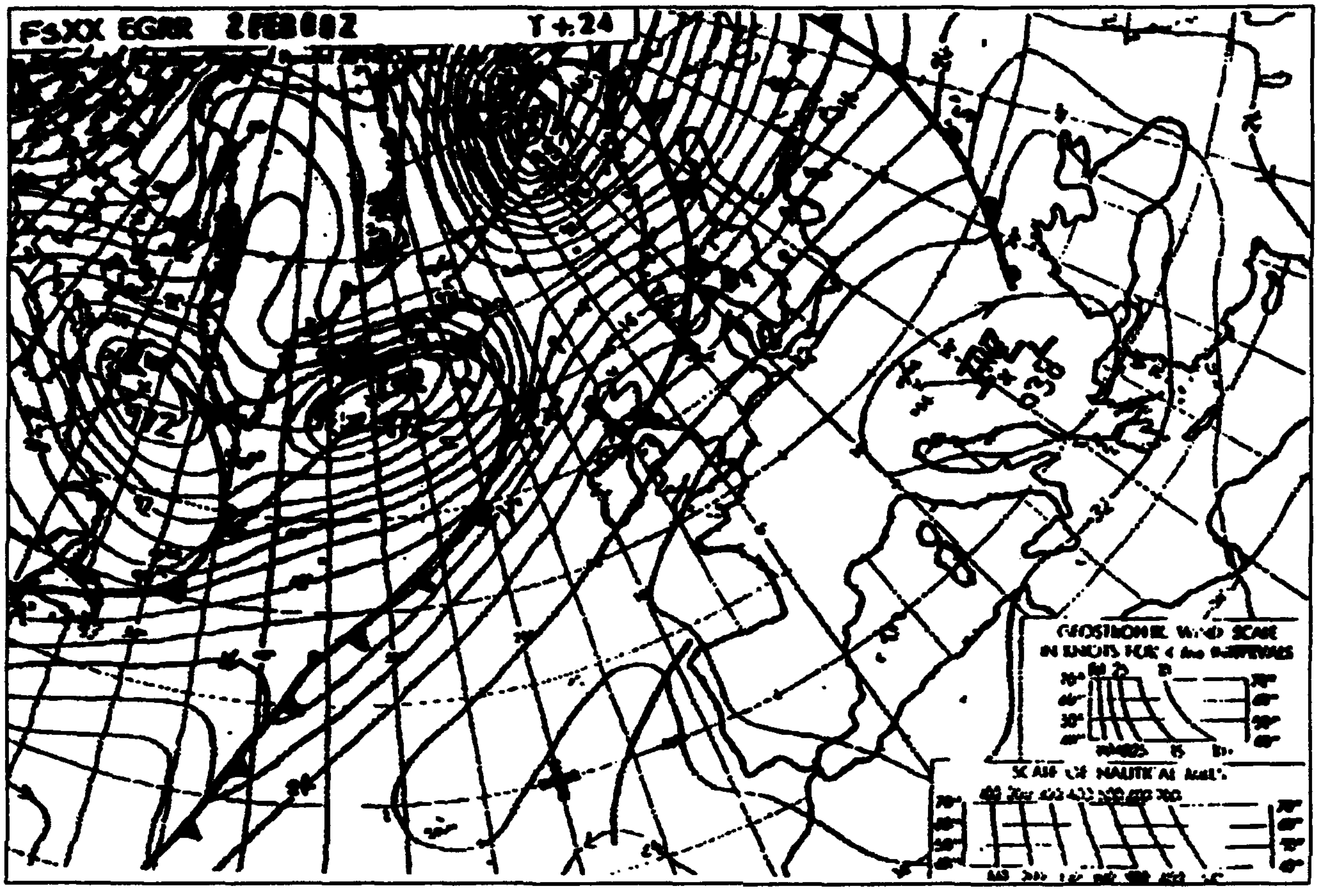


Figure 6-17. FSXX Surface Analysis.

Bulletin). Moisture availability at 700 mb is highly correlated with large scale precipitation. You may see only mid and high-level overrunning moisture ahead of an active warm front. The low cloud and precipitation may be behind the front.

(d) 850 mb Analysis. Ensure that the front is supported by isothermal packing at this level (conventional or WBPT isotherms).

(e) Surface Plot. The analysis should compare well to the surface plot for the same time.

(f) RADAR. Use all radar tools available, including both your local station radar and the JASMIN system. If the front is active, the JASMIN should show most of the precip associated with it.

(g) METSAT. IR imagery shows relative cloud types, and enhancement enables you to spot the highest tops. If you have a looping capability, make sure the cloud motion supports the frontal extrapolation. Sometimes, you can spot wave development on METSAT the analysis missed.

(h) Use as a Wind Forecasting Aid.

1. The surface wind direction will normally be 30° **backed** from the indicated isobaric direction. A 30° difference may exceed a crosswind advisory threshold.

2. You can deduce wind speed from the Geostrophic Wind Scale in the lower right hand corner. **UKMO Thumb-rule: Assuming** no topographic contamination, use 80% of V_g for max gust, and 50% for average sustained wind speed.

e. FSXX Data Application:

(1) Continuity. Compare your extrapolated analysis to this product. If it differs, you may not have accounted for intensity changes. The UKMO uses the analysis position of the feature and the forecast position, then draws an arrow to illustrate movement. Since the arrows differ in length, you can tell at a glance where the strongest upper-level winds are.

(2) Initialization. Here we go again, but you must initialize against upper air prognoses from the same period to see if the models agree. Plot the FSXX frontal position on the 24-hr 500 mb Coarse Mesh. If the front is too far ahead of the thickness packing, either the Coarse Mesh is too slow, or, the surface model is too fast (or maybe both are wrong!). Your own analysis can resolve the difference. The rules for initialization of the ASXX also apply here.

(3) Wind Forecasting Aid. See the section above on the ASXX analysis data application. The FSXX is used to determine future winds.

6-35. AUXX/FUXX Series. Consist of an analysis and a 24-hr prognosis of the 500 mb heights and 1000-500 mb thickness. Data base times are 00Z and 12Z. Uses/advantages are as follows:

a. This product looks farther out into the North Atlantic than the Coarse Mesh.

b. If presented with a medium range forecasting problem, start with climatology, and modify based on developments shown by this product.

6-36. 200/300 mb Heights. A 24-hr prognosis only. Same data base time as the thickness charts, these show the long wave pattern well.

6-37. Upper Air Soundings:

a. UM/UWXX Series. The UKMO transmits fully-plotted soundings with winds, twice daily, based on 23Z and 11Z data base times (see figure 6-18).

NOTE: As of 1 July 1991, the World Meteorological Organization (WMO) instituted a change in the reporting of upper air data. Among other things that change stipulated the inclusion of the 925 mb level in the TTAA section of upper air soundings. As of this writing, some European countries have complied with the change. The addition had serious consequences for units using "Skew-T Pro" to analyze upper air soundings. "Skew-T Pro" was designed to analyze upper air data from AWNCOM in a particular order, and the new format interrupted that order. Unless you manually remove this level from the TTAA group, or use a filter program to reorganize the data, "Skew=T Pro" will not work.

b. UWEW Series. The UKMO also sends winds aloft data based on 06Z and 18Z data. Lag time is 2½ hours. Strengths include:

(1) Pre-plotted soundings save labor during surges. Your main task is to analyze.

(2) The intermediate pibals give 6-hr continuity, providing greater advance notice of significant wind developments. A sudden increase in gradient-level wind speed is often a precursor to threshold winds.

(3) There are weaknesses however:

(a) Transmitted on reduced-size format, these charts can be difficult to read. You may inadvertently miss a significant feature.

(b) Observer/forecaster plotting skills can atrophy, adversely affecting operations in a "single-station" situation.

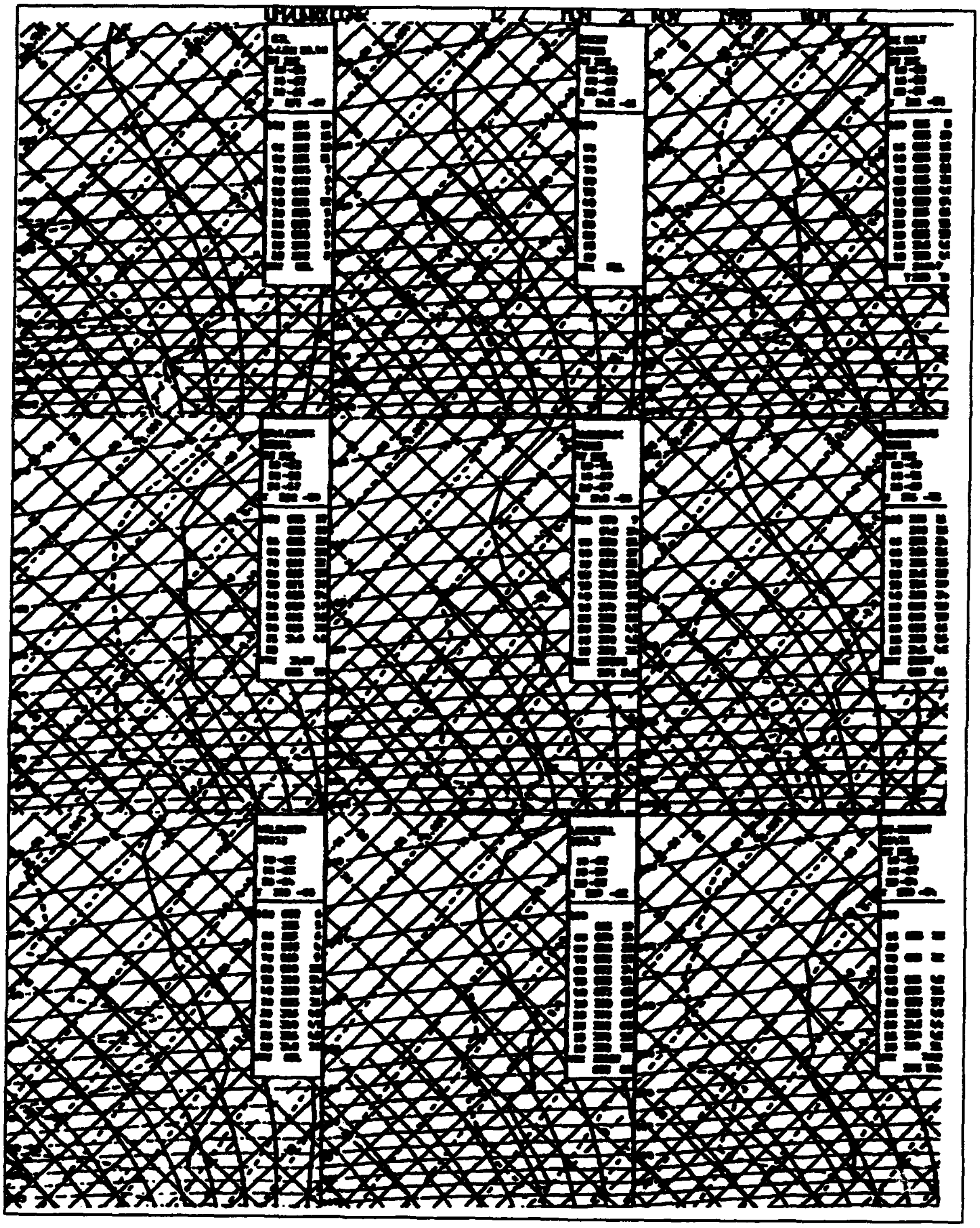


Figure 6-18. UM/UWXX Soundings.

6-38. Medium Range Surface Progs (Figure 6-19). These are two separate charts: a 48/72 hr prog, and a 96/120 hr prog. They show fronts, pressure centers, and 1000/500 mb thickness isopleths. The superposition of thickness and surface features shows at a glance, the relationship of warm/cold advection areas and frontal positions. This makes it easier to discriminate between rain and snow, as well as to forecast system intensity changes.

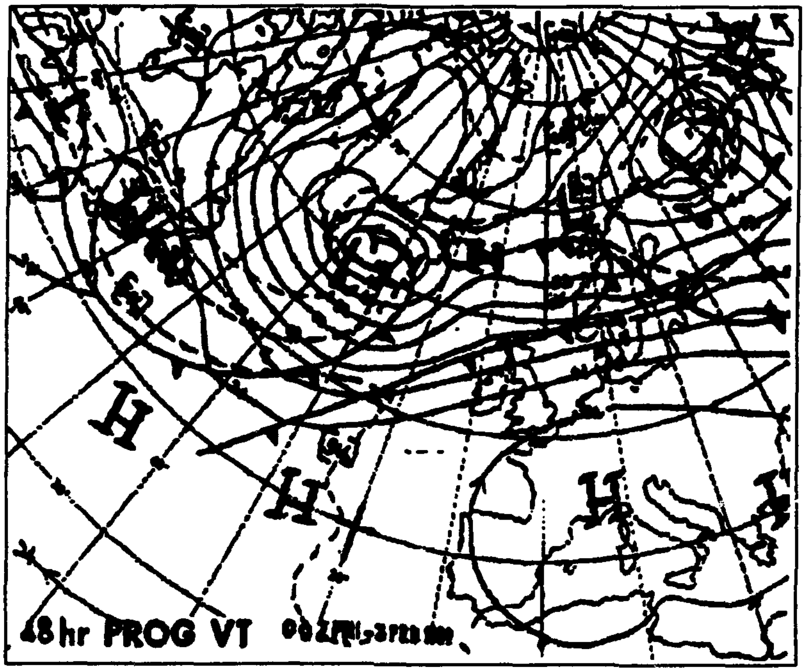


Figure 6-19. FS/FUXX Medium Range Surface Prog.

6-39. Teletype Bulletins. We discuss only the most *frequently used products.*

a. ASXX21/41 EGRR. The encoded backup to the ASXX Surface Analysis. Available 4 times daily, with pressure centers, fronts and isobars encoded. We suggest the ASXX41 is more user-friendly than the ASXX21. See 2WW/FM-81/001 for complete decoding instructions.

b. FSXX21/41 EGRR. The encoded backup to the FSXX 24 Hour Surface Prog. All other information is the same as for the ASXX bulletin.

c. AXXX1 EGRR. A synoptic discussion bulletin available four times daily, describing expected events in lay terms. It tells three things: what is happening, primary model initialization results, and what will happen. Review this as part of your shift change briefing.

d. AXXX2 EGRR. A more technically worded synoptic discussion. It discusses both primary model performance, and also the results from "in-house" models. (those whose output is not transmitted to the field). For example, the global assimilation model or MOS temperature guidance is sometimes discussed.) The discussion helps resolve disagreements between models, and between models and analysis continuity. An absolute "must read" for effective shift change briefings.

e. FEUK1 EGRR. A 5-day outlook, it describes each day is separately. While there is some technical verbiage, it is primarily an outlook in non-technical terms.

f. FXUK70/71 EGRR. Colloquially known as the "Doomsday Bulletin," these show the Effective Downwind Forecast for various parts of the UK. The UK is divided into 15 geographical areas; the FXUK70 covers Areas UK1 through UK9, while FXUK71 does the remainder. These are the same lay-out as the AFGWC FUEU21/22 KGWC. Shown below is a sample with decoded information:

UK4 A005010 BXXX007 C055010 D065010 E070015 F075015 G075020

- UK4 is UK Area 4

- Each letter refers to a specific bomb yield threshold, less than or equal to the following: A=2 kiloton, B=5 kiloton, C=30 kiloton, D=100 kiloton, E=300 kiloton, F=1.0 megaton, and G=3.0 megaton.

- The first three numbers of each group indicate the direction **toward which** the fallout is **going**. XXX means variable. In the example above, the 5 kiloton group shows 7 km/hr dispersal, equal in all directions.
- The last three numbers are wind speed in km/hr.

SECTION D - CLIMATOLOGY TOOLS

6-40. Introduction. Numerous climatic tools are available to you here in the European theater. We will discuss the tools themselves, AWS products available, DOD products, and finally indigenous products. You've probably seen most of the AWS products before, so we will spend more time on the indigenous climatology tools.

6-41. Use of Climatology Data. Most forecasters use climatology extensively in developing the TAF. For instance, using WSCC tables, or diurnal curves to forecast fog dispersal. By using AWS Climatic Briefs, you can determine if an event can happen by seeing if it has happened before. To help you differentiate between good climatology and bad climatology, we explain some tests of reliability.

a. Database Size. A longer period of record means more "singular (rare) events will be incorporated. A longer period also evens out the average if long periods of abnormally dry or wet weather have occurred.

b. Database Consistency. Continuous operation is optimum. For example, a RUSSWO from a low-level gunnery range is not much good since they take range observations only when the range is open. If the weather goes below certain thresholds, they close. The available observations are optimistically contaminated.

c. Database Currency. In locations where industrial activity has in-creased since the last climatology data update, reliability of climatology tools can be compromised. Pollutants generated may cause current visibilities in some areas to be, on average, lower than those listed.

6-42. The Standard Summary Package (SSP). The basis of a unit's climatology collection. It consists of a surface observation climatic summary (SOCS), wind stratified conditional climatology (WSCC) tables, hourly temperature and dew point change summary, and a station climatic summary. A station must have at least 5 years of recorded observations to qualify for a SSP.

a. Surface Observation Climatic Summary (SOCS). The SOCS is replacing the Revised Uniform Summary of Surface Weather Observations (RUSSWO) and Limited Surface Observation Climatic Summary (LISOCS) as the prime component of the SSP. It contains eight parts:

(1) Part A, Atmospheric Phenomena Summaries by selected wind sectors (TS, FG, SN, etc.).

(2) Part B, Precipitation, Snowfall, and Snow Depth (and average first and last day of snow).

(3) Part C, Surface Wind (speed and direction by 3-hour block, and month).

(4) Part D, Ceiling Visibility, and Sky Cover (by 3-hour block, and month).

(5) Part E, Temperature and Relative Humidity (mean and extremes for each month. Also includes dry, and wet bulb temperatures, and dew point temperatures).

(6) Part F, Pressure (including sea level pressure, station pressure and altimeter setting.

(7) Part G, Crosswind Summaries (% frequency of 2 thresholds).

(8) Part H, Degree Day Summaries. (based on 65°F).

b. Wind Stratified Conditional Climatology (WSCC). The probability that a change in TAF category will occur given different wind sectors. See also 5WW/TN-78/1. The following are some hints:

(1) Overuse leads to excessively optimistic forecasts.

(2) Be sure to modify subjectively as needed, that is, if the winds are 270 at 12 and will shift to 120 at 5 in 2 hours, use the latter wind to find succeeding hours forecasts.

(3) Note the number of observations when evaluating a category in a particular wind sector. If one sector doesn't result in firm categorical guidance, try using the "all" sector, which is based on many more observations and may be a more reliable guide.

(4) Don't throw up your hands if a front is approaching. Remember the table is based on all observations. Consider the second most frequent category at a given hour. It might be more representative of the weather conditions in the frontal zone.

c. Hourly Temperature/Dew Point Curves. Diurnal temperature curves showing T/TD changes as a function of cloud cover, wind direction and speed. 5WW/TN-72/1 gives details. Following are some hints:

(1) A curve will not be plotted unless there were four or more occurrences. In cases where your forecast direction is not represented by a curve, use the "X" or mean curve to determine temperature progression.

(2) You must forecast sky condition and wind changes correctly. Changes in sky condition/wind speed may necessitate changing to a different chart. Be alert for such changes.

(3) Always use to evaluate forward in time. Evaluating backward may give you unrepresentative results.

(4) Diurnal curves work poorly during strong advection or dynamic temperature changes.

(5) Ensure the direction from which you are advecting is thermally representative of the air mass. (Example: FROPA is expected an hour from now. Winds are now southwesterly, but will shift to northwesterly. It might be better to use westerly, or northwesterly from the start.)

d. Station Climatic Summaries:

(1) AWS Climatic Briefs. Gives means and extremes for many types of phenomena, as well as ceiling/visibility percentages at the four TAF thresholds.

(2) AWS Climatic Briefs for Limited Duty Stations. Same format as the AWS *Climatic Brief* but for those bases with less than 24-hour a day observing. Missing data may be replaced by data from nearby stations.

e. Operational Climatic Data Summaries (OCDS). These have a different format still but contain the same information. These summaries are primarily developed for non-AWS locations. Data may be missing (or doubtable) at some locations. While ETAC makes every effort to substitute a climatologically similar station (based on location, elevation and proximity to similar terrain), the substitute won't be exactly the same. In addition, ETAC uses data from many different sources, each with different standards of QC and evaluation. This lowers the reliability.

6-43. Other AWS Climatic Tools. Some units may have these on hand but generally you'll have to contact ETAC to get them.

a. Situation Climatic Briefs. These are produced by ETAC and are organized by country. They are an excellent source of narrative information, but since only one or two points are listed, and statistical information sketchy, are a poor source of statistical information. Use them accordingly.

b. Worldwide Airfield Climatic Data Summaries (WWACDS). WWACDS were developed by ETAC in the early 1960s, and represented their first attempt to provide standardized information on a lot of locations. These are now considered obsolete, because primitive climatology-spreading techniques were used to develop climatology information for some data-sparse locations.

c. N-Summaries. These were produced by ETAC until the early 1970s. Frequently, they were derived from synoptic data, and are best used for winds, cloud heights/amounts and visibility. They were also a source of mission-oriented information, relating the number of days favorable for specific military operations like visual high-level bombing hemical operations, based on combinations of different weather parameters.

d Upper Air Summaries. These were produced by ETAC until the early 70s. They consist of the Uniform Summary of Winds Aloft Observations and the Uniform Summary of Rawinsondes. In most cases, small sample sizes reduce reliability.

e. Climatology Handbooks. These were first written by 2 WW in response to a need for planning weather information for data-sparse, data-denied areas immediately behind the "Iron Curtain." Later, with superior climatology resources, ETAC took over authorship and finalized them, upgrading two to tech note status.

(1) They show percentage frequencies of low-level weather conditions critical to ground, helicopter and close air support operations.

(2) Reliability is impaired by the sparsity of forward area observation sites and the wide variety of terrain in the area (i.e., fog in one valley and clear in the next).

(3) The 2WW Climatological Guides are the 2WW 105- series of pamphlets, but are no longer printed. Check your library for a full listing. Most are for central Europe, but one--2WWP 105-13, covers all of Europe. These guides consist of maps displaying analyzed climatological fields and data tables for various stations within the area. These data tables were updated whenever updated SSP products were received on them. As stated before, reliability is marginal to satisfactory, depending on data availability.

6-44. Other DOD-Produced Climatic Tools:

a. US Navy Marine Climatic Atlas. The prime source for sea surface temperatures. Information is worldwide for each month of the year.

b. Selected Heights, Temperatures and Dew Points for the Northern Hemisphere. Good data for the mandatory reporting levels.

c. Summary of Meteorological Observations, Surface. Produced by ETAC for Navy stations (using Navy observations), but otherwise identical to the RUSSWO in format and content.

d. National Intelligence Survey. Produced by the Central Intelligence Agency on most countries many years ago. It's the leading (often the only) source of climatology data for "silent areas" such as Mongolia, Albania, etc. While information is fairly detailed, database quality is variable.

6-45. Indigenous Sources of Climatology:

a. The Bulletin Mensuel and the Résumé Climatologique. The Belgian Weather Service authors two publications - The Bulletin Mensuel and the Résumé Climatologique. Both are surface statistics, but the Bulletin Mensuel is more detailed. Data is available 2-6 months after occurrence.

b. The European Meteorological Bulletin. The Deutscher Wetterdienst publishes the European Meteorological Bulletin (Europaischet Wetterbericht) daily. It provides a complete upper-air package and surface chart for that day. The bulletin also contains synoptic observations from German stations, and coded upper air reports. If you're trying to do a case study, and don't have the charts, call us for a copy of this publication. We have copies back to 1978.

c. The Berliner Wetterkarte. The free University of Berlin produces the Berliner Wetterkarte daily. It contains temperature and precip totals, two satellite images, some numerical output, and a short description of the day's weather.

d. The Trappenberg Study. (See also 2WW/TN-83-001.) This was a study done by Dr. R. Trappenberg in the 1960s, updated in 1983. It shows low-level routes or areas that may have VFR conditions when the general weather is IFR. It is especially useful for helicopter flying operations. Routes or areas are related to the reference station's ceiling height (like if station X has a ceiling of at least #, then route Z will have flyable ceilings (400 ft)). The study assumes homogeneous conditions i.e.. no fronts or troughs in the area. Limitations of the study include the fact that it was performed over a limited area, was

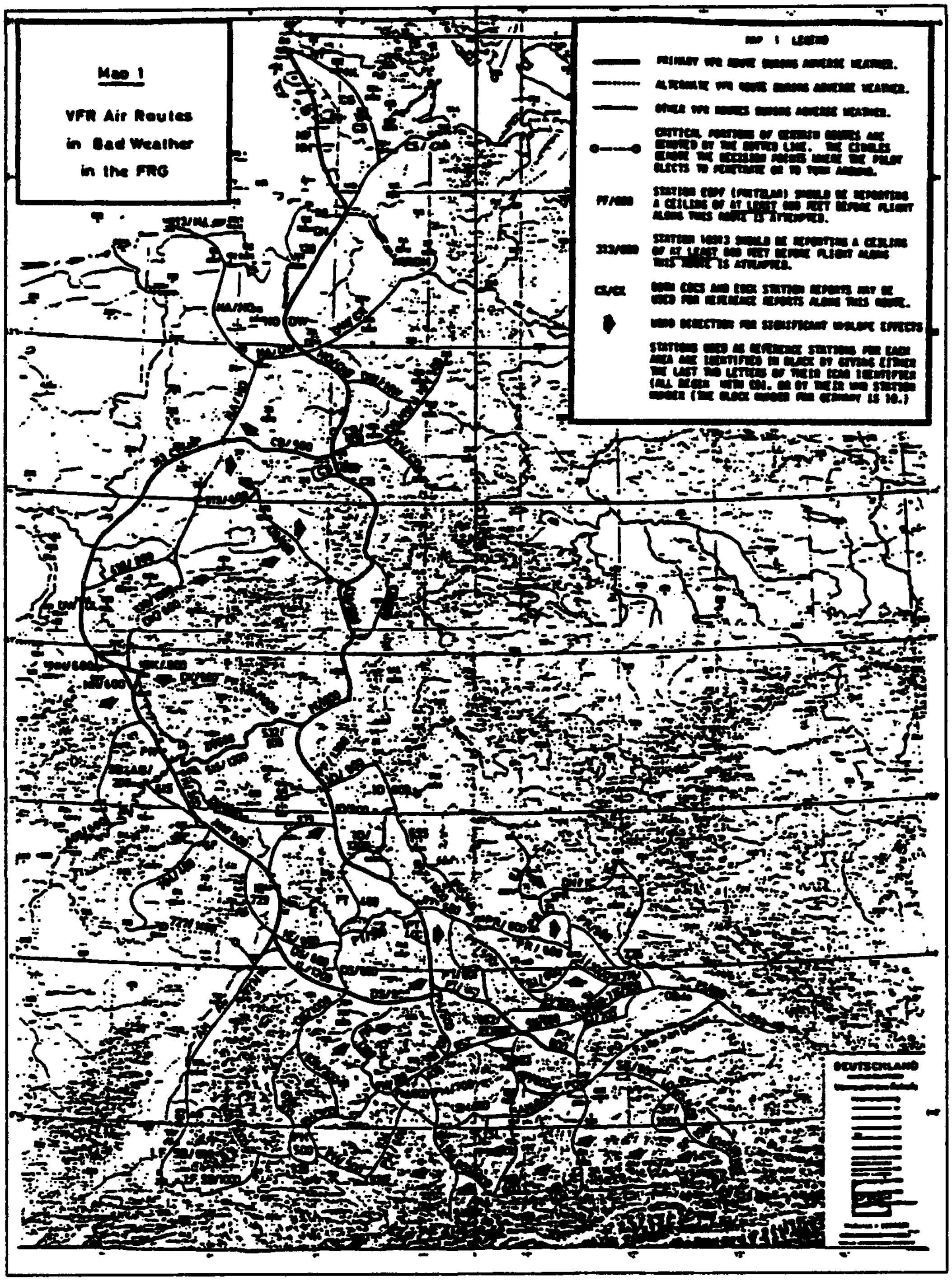


Figure 6-20. The Trappenberg Study.

never verified, and that some of the original stations used in the study have closed. Still, it contains useful general information on Germany, and should be studied by each forecaster new to the theater. Figure 6-20 is an example. (See also 2 WW/TN-83/001.)

e. **Upslope/Lee Effects Charts (not shown).** These visual aids are absolutely essential for the forecasting cloud formation and dissipation due to topographic effects. They show the degree (light, moderate, heavy) of upslope or lee effect based on wind direction. The drawback of these charts are that they are presented on a 1:5,000,000 scale and do not show all the detail necessary for local effects forecasting. For that, we suggest you try to get 1:250,000 plastic relief maps - sometimes available in bookstores on the local economy, of the area surrounding your base, as well as the routes your aircrews routinely fly. (See also 5 WW/FM86/006.)

f. The GMGO Nighttime Illumination Tables (Figure 6-21). This booklet, published one per year (usually in November/December for the upcoming year), gives data for use by customers who routinely use night vision goggles (NVG). AWS/FM-85-008, the translation of a GMGO document, gives instructions for the use of the manual. Night illumination depends on elevations of the sun and moon as well as phase of

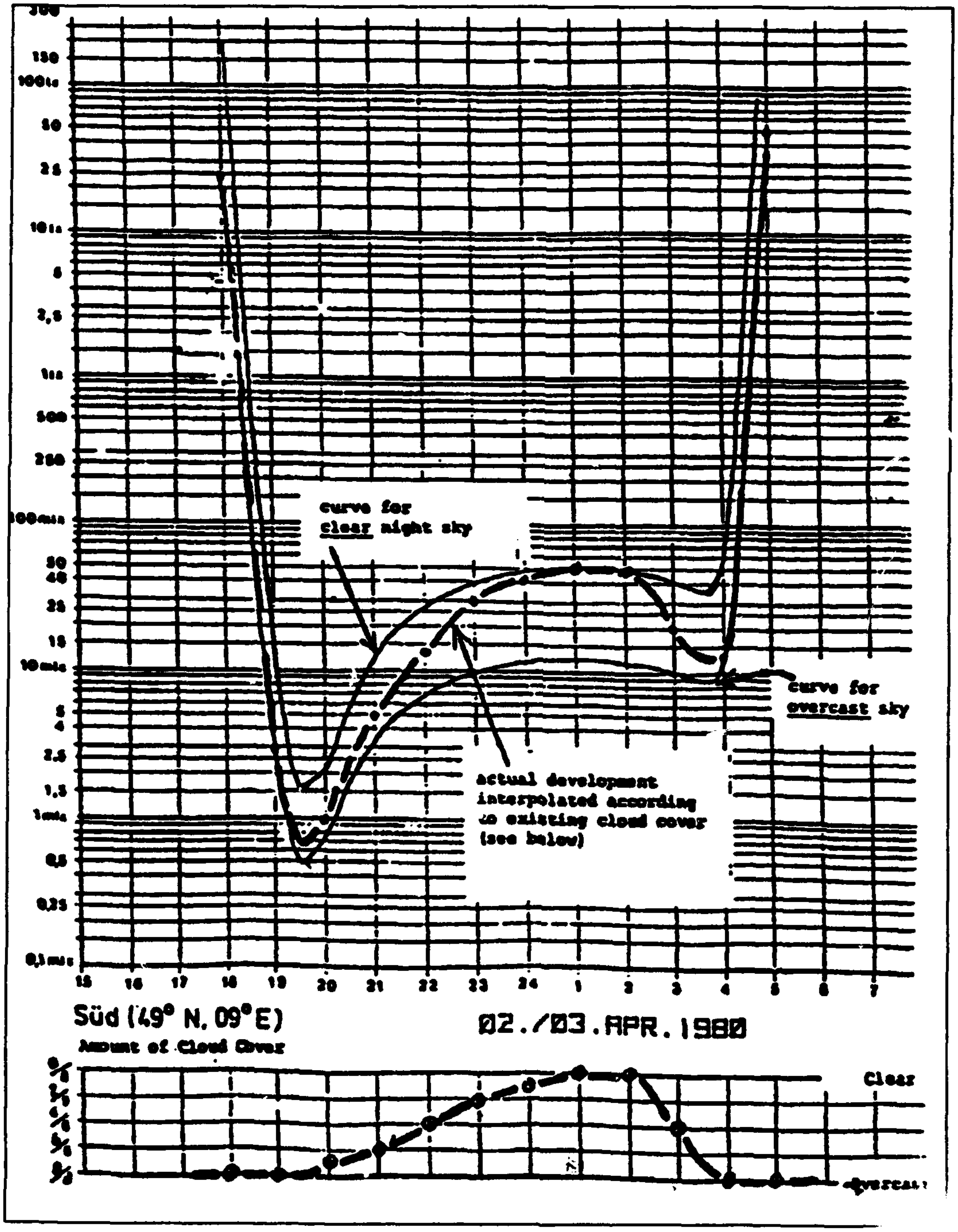


Figure 6-21. Night Illumination Table, With Applied Correction for Cloud Cover During the Period.

the moon, clouds, precip, state of the ground, and artificial light. The tables show the nighttime illumination at Bremen and Stuttgart, for both clear and overcast cloud cover, for the individual nights of the year. Again, be sure to account for the cloud cover, your relative location, and availability of artificial light.

g. **The Turkish Meteorological Bulletin.** The Turkish Weather Service has compiled detailed surface climatology information on many Turkish stations into a bound volume known as the Turkish Meteorological Bulletin. It doesn't contain ceiling or visibility data. We have an English language edition at USAFE/DOW.

h. **Catalog of Large-Scale European Weather Types.** Also known as the "Baur Catalog," the booklet gives specimen weather charts for a specified flow pattern (like southwesterly). They are further subdivided into cyclonic and anticyclonic regimes. A brief description follows about what characteristic weather to expect. Available at most weather activities, it is good for introduction to general European weather regimes.

i. **European Map Catalogs.** These are based on Baur map typing, updated by 2WW in the late 1980s. They comprise 10 volumes. The first nine give an overview of typical summer and winter weather associated with a particular flow regime over a period of days. This provides forecasters with a more dynamic view of the atmosphere than the static views shown in the Baur catalog. The last volume is the "how to" manual for the first nine. They are available at most weather activities..

6-46. References:

a. 2WW/FM-86/002 (describes indigenous European products).
b. 2WW/FM-81/001 (for decoding UKMO bulletins).
c. AWS/TR-79/006 (for WBPT determination).
d. AWSP 105-52, Vol 3 (for list of TTY products).
e. *Meteorological Magazine* (UKMO), August 1985, pp 221-226.
f. AFGWCP 105-1, Vol 3 (derived for downwind message decoding).
g. 2 WW/TN-89/003 (BKFG description).
h. 2 WW/TN-89/005 (EFU Backup to AFGWC).
i. 2 WW/FM-89/005 (MOLFAX products).
j. 2 WW/FM 90-004 (STRIFAX products).
k. 2 WW/TN-90/001 (BLM description).

CHAPTER 6 REVIEW QUESTIONS

1. State the differences between METEOSAT and DMSP. (Satellites, orbits, data handling, capabilities from a weather standpoint.

2. Name the two centralized weather activities in the European theater.

3. Why is the primary reason for interest in weather products from AFGWC?.

4. What are the two key steps in getting the most out of computer generated forecast products?.

5. What are some of the good points of the Global Spectral Model (GSM)?

6. What are some of the bad points of the GSM?

7. What are some of the backup data sources in the event communications with AFGWC are interrupted.

8. (UK) What are some of the benefits of using wet bulb potential temperature?

9. (GM) What was the purpose of the Trappenberg study?

10. What are some of the uses of Upslope/Lee charts?

11. Who are some of the primary users of the night illumination tables?

Chapter 7

CONCLUSION

7-1. Summary. In this publication we have tried to give you the best information available on various aspects of European theater weather. We have drawn from all sources we feel contain valuable information. Much of this information would not be readily available to the forecaster in another form. After you answer the chapter review questions, refer to attachment 1 for the correct answers. We list some additional reading that you may find useful in attachment 2. Attachment 3 is an atlas and reference map compiled with country names current as of 1 April 1992. For those who want to challenge their expertise, there is a "final examination" and map exercise at attachment 4. Refer to attachment 5 for supplemental information helpful to the European forecaster.

7-2. The Challenge. Professional competence is the most important qualification for any officer on NCO. A conscientious study of this pamphlet will help you acquire a firm foundation of European forecasting competence.

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Commander in Chief

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OFFICIAL

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131 WF, Barnes MPT, Westfield MA 01085-1385.	1
140 WF, Willow Grove NAS PA 19090-5101	1
146 WF, GTR Pittsburgh ANG Annex PA 15231-0459	1
154 WF, Camp Robinson, N Little Rock AR 72118-2200	1

156 WF, 5225 Morris Field Dr, Charlotte NC 28208-5797	1
164 WF, Rickenbacker ANGB OH 43217-5007	1
181 WF, Hensley Field, Dallas TX 75211-9503	1
195 WF, 4146 Navalair Rd, Channel Islands ANGB CA 93042-4001	1
200 WF, 5680 Beulah Rd, Sandston VA 23150-6109	1
202 WF, Otis ANGB MA 02542-5001	1
203 WF Ft Indiantown Gap, Annville PA 17003-5002	1
204 WF, McGuire AFB NJ 08641-6004	1
207 WF, RR2, Box 124, Shelbyville IN 46176-9414	1
208 WF, 206 Airport Dr, Paul MN 55107-4098	1
209 WF, Camp Mabry, Austin TX 78763-5218	7
210 WF, Ontario ANGS CA 91761-7627	1
220 OSS/DOW, March AFB 92518-5000	3
325 OSS/OSW, Stop 22, Tyndall AFB FL 32403-5048	1
347 OSS/OSW, Moody AFB GA 31699-5000	1
355 TS/OSW, Davis Monthan AFB AZ 85707-6801	1
363 FW/DOM, Shaw AFB SC 29152-5070	1
363 FW/DOMS, Shaw AFB SC 29152-5070	1
OL-A 363 FW/DOMS, McEntire ANGB, RFD 1, Eastover SC 29044-9690	1
366 OSS/OSW, Mountain Home AFB ID 86348-5000	1
3380 SPTG/OSFWX, Keesler AFB MS 39534-5000	1
3395 TTS/TTMV, Keesler AFB MS 39534-5000	1
3395 TCHTS/TTMV, Keesler AFB MS 39534-5000	1
AFGWC/DOO, Offutt AFB NE 68113-4039	5
AFSOC/WE, Hurlburt Fld FL 32544-5000	1
Det 1, 5 WS Ft Campbell KY 42223-5000	1
Det 3, 5 WS, Ft Bragg NC 28307	3
Det 4, 5 WS, Ft Drum NY 13602-5042	1
Det 6, 5 WS, Ft Lewis WA 98433-5000	1
Det 7, 5 WS, Ft Ord CA 93941-5620	1
Det 8, 5 WS, Ft Riley KS 66442-5317	1
Det 10, 5 WS, Ft Benning GA 31905-6034	1
Det 12 5 WS, Ft Devens MA 01433-5310	1
Det 14, 5 WS, Ft Hood TX 76544-5076	1
Det 21, 5 WS, Hunter AAF GA 31409-5193	1
Det 31, 5 WS, Ft Polk LA 71459-6250	1
Det 58, 5 WS, Ft Carson CO 80913-5000	1
DITC, Cameron Station, Alexandria VA 22314-5000	1
FCWE/SWO, Bldg 168, Ft McPherson GA 30330-5000	3
HQ AFMC/DOW, Wright Patterson AFB OH 45433	1
HQ ATC/DOW, Randolph AFB TX 78150-5000	1
HQ AWS/RMI, Scott AFB IL 62225-5008	1
HQ First US Army AFKA-OP-IW, Ft Meade MD 20755-7000	1
HQ 5 WS/DO, Ft McPherson GA 30330-5000	1
HQ AMC/XOW, Scott AFB IL 62225-5000	20
HQ PACAF/DOWX, Hickam AFB HI 96853-5000	1
HQ AAC/DOWR, Langley AFB VA 23655-5524	1
HQ USAF/XOW, Washington DC 20330-5045	1
OIC NAVOCEANCOMDET, Box 72, FPO AE 09499	1
TRADOC SWO (ATCD-1W), Fort Monroe VA 23651-5000	1
Cmdr USASOC, Attn: ADIN-ST, Ft Bragg NC 28307-5203	1
USACAC SWO (ATZL-CAW-E), Ft Leavenworth KS 66027-5000	1
USAICS SWO (ATS1-CDW), Ft Huachuca AZ 86513-6000	1
USAFETAC/LDE, Scott AFB IL 62225-5438	7
USAFETAC/IM, Buchanan St Bldg 859 Scott AFB IL 62225-5438	1
JSOC/WX, PO BOX 70239, Ft Bragg NC 28307-5000	2
US Naval Oceanography Command Center, PSC 819, Box 31, FPO AE 09645-3200	1
HQ USEUCOM/ECJ3-WE, UNIT 30400 BOX 1000, APO AE 09128-4209	1

ANSWERS FOR CHAPTER REVIEW EXERCISES

CHAPTER 2

1. Climatic controls are the various factors which affect the weather and climate of a region.
2. Latitude controls the amount of possible insolation received at a location.
3. The northern portion of Europe is most affected by the latitudinal control since the greatest extremes occur over this region. Insolation is weak in winter and strong in summer.
4. Several factors cause a milder climate at Frankfurt: warm ocean currents, the lack of a north-south terrain barrier, the location with regard to the semipermanent synoptic features, and the location with respect to the pressure system paths.
5. Generally, there are no north-south terrain barriers in Europe and no east-west terrain barriers in North America.
6. The Alps are the most important topographical feature in Europe. They separate the cool air masses to the north from the warm air to the south.
7. Warm ocean currents provide a great source of heat which warms the bordering land areas.

CHAPTER 3

1. The mildness of the European climate arises from oceanic exposure to the north, west, and south.
2. Mean values without any measure of spread such as standard deviation or extremes can be misleading.
3. The warming caused by the North Atlantic Drift causes a decrease in the number of days with snow at coastal locations.
4. The warm waters of the North Atlantic Drift cause this anomaly.
5. The four major semi-permanent synoptic features affecting the climate of the European theater are the Azores High, the Icelandic Low, the Siberian High, and the Asiatic Low.
6. The air bases and airfields have more adverse ceiling and visibility conditions more frequently than air bases and airfields in the US.
7. Motions of pressure systems depend upon topography and the ability of the earth's surface to exchange heat with the atmosphere.
8. Differential heating contributes to vorticity production which in turn aids genesis.
9. The three preferred winter storm paths are along the northern and southern borders of Europe and across the North and Baltic Seas.
10. Cyclogenesis areas are generally over the warmer land in summer.
11. The mP air mass of winter comes from the eastern Atlantic.
12. The cT air masses influence only the Mediterranean during winter.
13. A modified cP air mass is present when the *bora* occurs in the Mediterranean.
14. West is the predominant upper level wind direction over Europe.

CHAPTER 4

1. The major winter forecast problem is fog.
2. The major fog type is radiation or radiation advection.
3. Moisture is nearly always present for thunderstorm formation.
4. Turbulence is most frequent during October through March.
5. Gales are most significant over the North Sea.
6. Foehns occur to the north and south of the Alps, the north of the Pyrenees, and to some extent along the other major mountain systems.
7. *Etesian* winds are generally an eastern Mediterranean phenomena.

8. *Siroccos* are generally hot, dry winds from Africa.
9. The *bora* is noted as an Adriatic Sea phenomena.
10. The *mistral* is the channel wind of the Rhone Valley.
11. United Kingdom, Germany, and France have relatively frequent occurrences (for Europe) or tornadoes.
12. There is generally a wind speed shear at the level of the inversion which will cause sudden changes in air speed.

CHAPTER 5

1. The air below the middle level will become increasingly moist from rain, and clouds will form at lower and lower levels.
2. The influence of orography and the effects of land-sea thermal contrasts cause analysis in the Mediterranean to be difficult.
3. Consider fronts in the Mediterranean as circulative systems where the frontal layer is separated by discontinuities of temperature gradient and wind shear--not of temperature and wind.
4. The permanent land-sea temperature difference makes the west coast of France an area of frontogenesis.
5. The best parameter to identify the arctic front is the 850-mb temperature field, particularly the -6 C isotherm.
6. The 850-mb +17, +7, and -6 C isotherms are used to identify multiple fronts.
7. Considerable low level heating occurs during the southward movement of the arctic air. As a result, surface temperatures are not good indicators of the leading edge of the arctic air.
8. The 850-mb level is high enough to be above most of the topographic and diurnal effects and low enough that the thermal pattern is still organized.
9. Anticyclonic blocking occurs most frequently from December through May, with the April, the maximum.
10. Both temperatures and precipitation amounts are below normal during periods of anticyclonic blocking.

CHAPTER 6

1. METEOSAT is in a geostationary orbit, DMSP in a polar orbit. METEOSAT is not encrypted, DMSP is METEOSAT is "loopable," DMSP is not.
2. EFU and EWOC.
3. Because in war-time, they may be the only products available here.
4. Initialization and Verification, so you know the model is handling the systems correctly.
5. Good 500 mb long and short wave definition and speed, good vorticity, good 850 mb height resolution if satellite derived wind are available.
6. Only one error check at the beginning of the analysis, poor resolution near the surface, poor moisture resolution at 700 mb level.
7. If you still have teletype communications, you can use the products listed in paragraph 6-13b. Communications may still be up with EFU so you can still get the German charts. You can tune in indigenous forecast units via the 9315TR.
8. This parameter combines the temperature and moisture characteristics of a parcel into one term. Conservation of WBPT allows you to track an airmass, place fronts, forecast fog/stratus, look for thunderstorm potential, and differentiate between rain and snow.
9. To determine flight corridors that might be VFR when most of the rest of the region was IFR.
10. Forecasting cloud formation and dissipation, fog, convection.
11. NVG users.

SUGGESTED READINGS

We made reference to other USAFE unique technical publications in each of the previous chapters. In addition, we recommend the following meteorology-related texts.

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ATLAS AND REFERENCE MAP

A

Aalborg: city in N Denmark (5730N, 00955E).

Aare River: in Switzerland; flows into the Rhine.

Adana: city in S Turkey (3659N 03518E).

Adriatic Sea: arm of Mediterranean between Italy and Yugoslavia-Albania.

Aegean Mountains: range in W Turkey bordering Aegean Sea.

Aegean Sea: arm of the Mediterranean between Greece and Turkey.

Afghanistan: country in W Asia; capital is Kabul.

Albania: country bordering Adriatic Sea; capital is Tirane.

Alboran Channel: body of water between Morocco and Spain.

Alexandretta, Gulf of: see Iskenderon.

Algeria: country in N Africa; capital is Algiers.

Algiers: capital city of Algeria (3643N, 00315E).

Almeria: city of SE Spain (3650N, 00228W).

Alps: mountain system of S central Europe; about 660 mi long from France to Yugoslavia. Highest point is 15,781 ft (4813m).

Anatolian Plateau: the high plateau region of the western peninsula portion of Asian Turkey.

Andalusian Mountains: range in S Spain.

Ankara: capital city of Turkey (3957N, 03253E).

Anti-Taurus Mountains: range in E Asian Turkey northeast of Taurus Mountains.

Apennines Mountains: range in central Italy- (the "spine"). Highest point is 9585 ft (2922m).

Aral Sea: inland sea in Kazakhstan.

Archangel: city in NW Russia (6435N, 04030 E).

Ardennes Mountains: range in S Belgium and Luxembourg. Highest point is less than 1600 ft (488 m).

Armenian Highlands: highlands area of E Turkey near the border of the CIS.

Armenian Knot: complex of mountains near junction of Turkey, Iran, and CIS.

Asia Minor: peninsula forming western extremity of Asia between the Black Sea and Mediterranean Sea.

Athens: capital city of Greece (380N, 02340E).

Atlas Mountains: range 1500 mi long in NW and N Africa. Highest peaks are over 13,000 ft (3962 m).

Austria: country in central Europe; capital city is Vienna (Wien).

Avignon: city in SE France (4357N, 00449E).

Azores: island group near 38N, 26W (belongs to Portugal).

B

Belearic Islands: island group in W Mediterranean about 3930N, 00300E. (Spain owns).

Balkan Mountains: range from Yugoslavian border to Black Sea. Highest point is about 7800 ft (2377 m).

Balkan Peninsula: in SE Europe between Adriatic and Ionian Seas on the west and Aegean and Black Seas on the east.

Baltic Sea: arm of the Atlantic Ocean between the Scandinavian Peninsula and the CIS.

Barents Sea: part of Arctic Ocean between Spitzbergen and Novaya Zemlya.

Bavaria: region in S Germany.

Bavarian Alps: portion of Alps located in Bavaria

Beirut: capital city of Lebanon (3349N, 03529E).

Belgium: country in W Europe on North Sea.

Benelux: a tripartite union formed by Belgium, Netherlands, and Luxembourg.

Berlin: city in eastern Germany.

Bern: capital city of Switzerland. (4657N, 00727E).

Birmingham: city in England (5229N, 00156W).

Biscay, Bay of: inlet on Atlantic Ocean on W coast of France.

Black Sea: sea between Europe and Asia north of Turkey.

Bosporus: strait between Asian and European Turkey connecting Sea of Marmara and Black Sea.

Bothnia, Gulf of: N arm of Baltic Sea between Sweden and Finland.

Brest: city in NW France on Brest Peninsula (4824N, 00430W).

British Isles: island group comprising Great Britain, Ireland, and 5000+ adjacent islands.

Bucharest: capital city of Rumania (4429N, 02608E).

Budapest: capital city of Hungary (4730N, 01920E).

Bulgaria: country SE Europe. Borders on Black Sea; capital is Sofia (Sofiya).

C

Canaries Current: a cool ocean current flowing by the Canary Islands, along the coast of Africa.

Cape de Gata: projection of land in SE Spain.

Cape Nao: peninsula in E Spain.

Capodistria (Koper): city on Gulf of Trieste (4532N, 01343E).

Carpathian Mountains: range in central Europe between Czechoslovakia and Poland highest point is near 5000 ft (1524 m).

Casablanca: city in W Morocco (3339N, 00735W).
Caspian Sea: inland salt lake between Europe and Asia
Caucasus Mountains: range about 700 mi long between Black and Caspian Seas; highest point is 18, 481 ft (5633 m).
Cevennes Mountains: range in S France; highest point is 5753 ft (1753 m)
Cilician Plain: lowland area of S Turkey bordering on Gulf of Iskenderon.
Cordillera Contabrica: range along coast of N Spain; highest point is 8787 ft (2679 m).
Corsica: island in W Mediterranean (France owns).
Cote d' Or: range of hills in E France.
Crau: plains region in SE France.
Crete: island E Mediterranean south of Greece (Greece).
Crimea: peninsula in S CIS extending into Black Sea.
Cyrenaica: region in NE Libya.
Cyprus: island E Mediterranean Sea.
Czechoslovakia: country in central Europe; capital is Prague (Praha).

D

Dalmatia: region of Yugoslavia along Adriatic coast.
Danube River: in central Europe from S Germany to Black Sea; 1725 mi long.
Dardanelles: strait between European and Asian Turkey. See Bosporus.
Denmark: country on Jutland Peninsula and adjacent islands; capital: Copenhagen.
Denmark Strait: channel between SE Greenland and Iceland.
Dinaric Alps: range of Alps in W Yugoslavia.
Donzere: city in S France (4426N, 00443E).

E

Ebro River: in NE Spain, flows to Mediterranean Sea.
Eifel Mountains: region of Germany NW of Moselle River.
Elbe River: in Czechoslovakia and Germany; flows into the North Sea.
England: political subdivision of United Kingdom
Erzgebirge: range of mountains in Germany and Czechoslovakia.
Essen: city in Germany (5126N, 00700E).
Etna: volcano in NE Sicily; 10,741 ft (3274 m) high.

F

Finland: country in N Europe bordering Gulf of Bothnia and CIS; capital is Helsinki.
Finland, Gulf of: arm of Baltic Sea south of Finland.
France: country in W Europe; capital is Paris.
Frankfurt: city in central Germany, on Main River (5060N, 00840E).
Franz Josef Land: island group in Arctic Ocean near 80N, 50E (Russia).
"French Sahara:" see Crau.

G

Garonne-Carcassonne Gap: pass separating the Pyrenees from the Massif Central of France.
Geneva, Lake of: in SW Switzerland and E France.
Genoa, Gulf of: arm of Ligurian Sea north of Corsica.
Germany: country in central Europe. .
Grampians: mountain system in N Scotland; highest point is 4406 ft (1343 m).
Great Britain: island in British Isles, part of the United Kingdom of Great Britain and Northern Ireland.
Greece: country in S Europe on Balkan Peninsula; capital is Athens.
Gulf Stream: warm ocean current of N Atlantic Ocean.

H

Hannover: city in NW Germany (5223N, 00944E).
Harz Mountains: range in central Germany; highest point is 3747 ft (1143 m).
Heidelberg: city in SW Germany (4924N, 00839E).
Hun: city in Libya (2980N, 01557E).
Hungary: country in central Europe; capital is Budapest.
Hunsrück Mountains: chain in W Germany.

I

Iberian Plateau: highland region of N Spain
Iberia: peninsula occupied by Spain and Portugal.
Iceland: island country in N Atlantic; capital is Reykjavik.
India: country in S Asia; capital is New Delhi.
Innsbruck: city in W Austria (4716N, 01123E).
Ionian Sea: body of water between SE Italy and W Greece.
Iraklion: c [illegible] on Crete (3560N, 02500E).
Iran: country in SW Asia; capital is Tehran.
Iraq: country in SW Asia; capital is Baghdad.
Ireland: one of the British Isles; occupied by the Republic of Ireland and Northern Ireland.
Iskenderon, Gulf of: arm of Mediterranean Sea northeast of Cyprus.
Israel: country along E coast of Mediterranean; capital is Jerusalem.
Istria: peninsula in SW Europe at head of Adriatic Sea.
Italy: country in S Europe; capital is Rome.

J

Jordan Depression: Jordan River and Dead Sea area of Jordan and Israel.

Julian Alps: section of E Alps in NW Yugoslavia north of Istria.

Jura Mountains: range in France and Switzerland; highest point is 5624 ft (1714 m).

Jutland: peninsula in N Europe occupied by parts of Denmark and W Germany.

K

Kara Sea: arm of Arctic Ocean N of Ural Mountains.

Kattegat: arm of North Sea between Sweden and Jutland.

Kazan: city in E European CIS (5547N, 04911E).

Kjølen Mountains: range along Norway-Sweden boundary; highest point is 6963 ft (2121 m).

Kola-Karelia Mountains: range in NW CIS.

Kola Peninsula: projection of land on NE end of Scandinavian Peninsula.

Kuopio/Rissala: city in Finland (6310N, 02748E).

Kyparissia, Gulf of: arm of Ionian Sea off W Peloponnesos.

L

Lake Constance (Konstanz): on border of Switzerland with Germany and Austria.

Land's End: cape in extreme SW England.

Languedoc: region of S central France.

Larissa: city in Greece (3938N, 02225E)

Lebanon: country on E coast of Mediterranean; capital is Beirut.

Levant Sea: eastern end of Mediterranean bounded by Greece to the United Arab Republic (UAR).

Libya: country in N Africa; capital is Tripoli.

Ligurian Sea: section of Mediterranean between Corsica and Genoa.

Linth River: in central Switzerland.

Lion (Lyons), Gulf of: inlet of Mediterranean on coast of S France.

Lisbon: capital city of Portugal (3846N, 00956W).

Loire River: in France flowing into Bay of Biscay.

London: capital city of the UK (5129N, 00027W).

Lussin (Losini): island south of Istrian Peninsula (Yugoslavia).

Luxembourg: country in W Europe between Belgium and Germany; capital: Luxembourg City.

M

Madrid: capital of Spain (4028N, 00334W).

Mahon: city in Balearic Islands of Spain (3952N, 00416E).

Main River: in Germany; flows into the Rhine River.

Majorca: (Mallorca) largest of the Balearic Islands.

Malta: island in Mediterranean S of Italy

Maritsa River: in S Europe from S Bulgaria to Aegean Sea.

Martigny: area of SW central Switzerland near Rhone River.

Massif Central: a plateau region in central France.

Mediterranean Sea: body of water between Europe and Africa.

Mons: city in Belgium (5027N, 00357E).

Mont Blanc: highest peak in Alps; elevation 15,781 ft (4810 m).

Montpellier: city in S France (4335N, 0035E).

Morocco: country in NW Africa; capital is Rabat.

Moscow: city in the CIS, capital of Russia (5545N, 03734E).

Mosel River: (Moselle) in W Europe from E France to Rhine in Germany.

Mount Ida: in NW Asia Minor; 5810 ft (1771 m).

Munich: (München) city in SW Germany (4808N, 01133E).

Murman Coast Current: warm current flowing along NW coast of CIS.

N

Netherlands, The: country in NW Europe bordering on North Sea; capital is Amsterdam with the seat of government at The Hague.

Nicosia: city on island of Cyprus (3519N, 03317E).

Nile River: in UAR and Sudan; flows north into Mediterranean Sea.

Nimes: city in S France (4352N, 00425E).

North Africa: As used in this pamphlet, region comprising African countries bordering Mediterranean Sea

North Atlantic: As used in this pamphlet, the section of the Atlantic Ocean north of about 35N .

North Atlantic Drift: ocean current that is an extension of the Gulf Stream.

North Cape: cape in N Norway; northernmost point in Europe (7110N)

Northern Ireland: a political subdivision of the United Kingdom of Great Britain and Northern Ireland; located on the island of Ireland.

North Sea: arm of the Atlantic Ocean between European continent and Great Britain.

Northwest Highlands: mountain range in W Scotland; highest point is over 3000 ft (914 m).

Northwood: city in UK (5233N, 00036E).

Norway: country on Scandinavian Peninsula; capital is Oslo.

Norwegian Current: warm current which flows northward along the coast of Norway.

Novaya Zemyla: (Nova Zemyla) two islands in Arctic Ocean NE of CIS.

O

Odessa: city in CIS on Black Sea (4629N, 03038E).

Oslo: capital of Norway (6012N, 01105E).

P

Palermo: city in Sicily (3811N, 01305E).

Paris: capital city of France (4900N, 00230E).

Parnon Mountains: range in SE Pelaponnesos, Greece; highest point is 6000 ft (1829 m).

Pelagosa Islands: group in central Adriatic near 4224N, 01615E.

Peloponnesos: peninsula forming southern part of mainland Greece.

Pennine Chain: mountains in N England: highest point is 2930 ft (893 m).

Pindus Mountains: range in N Greece; highest point is over 7500 ft (2286 m).

Plovdiv: (Pola or Pula) city in S Bulgaria (4250N, 02444E).

Plymouth: city in the UKi (5021N, 00407W).

Pola: city in NW Yugoslavia (4452N, 01351E).

Poland: country in E Europe on Baltic Sea; capital is Warsaw.

Pontic Mountains: range along the Black Sea coast of Turkey.

Po River: in N Italy; flows into Adriatic Sea.

Portugal: country in W Europe on Iberian Peninsula; capital is Lisbon(Lisboa)

Prague: (Praha) capital city of Czechoslovakia (5030N, 01425E).

Provence: region of SE France bordering on Mediterranean Sea.

Pyrenees Mountains: range along Spain-France border; highest point is 11,169 ft (3353 m).

R

Reuss River: in central Switzerland; flows into Aare River.

Rhine (Rhein) River: in W Europe flowing from SE Switzerland to North Sea; 820 mi long.

Rhineland: region of Germany west of Rhine River.

Rhodope Mountains: range in S Bulgaria, N Greece; highest point is 9595 ft (2926 m).

Rhone-Saone Gap: pass which separates the Massif Central from the Alps.

Rhone River: in Switzerland and France flowing from Alps to Mediterranean; 500 mi long.

Riviera: region of SE France and NW Italy.

Romania (Rumania): country in E Europe on Black Sea; capital is Bucharest.

Rosyth: city in the UK (5612N, 00327W).

Russia: a political subdivision of the CIS.

S

Sahara Desert: region of deserts and oases in N Africa.

Salzburg: city in Austria (4748N, 01300E).

Sarajevo: city in central Yugoslavia (4350N, 01821E).

Sardinia: island in W Mediterranean Sea (Italy).

Scandinavia: area of Europe comprised of Norway, Sweden, and Denmark.

Scandinavian Peninsula: peninsula occupied by Norway and Sweden.

Schwarzwald: Black Forest area of SW Germany.

Scotland: political subdivision of the UK. It occupies the northern portion of Great Britain.

Sea of Azov: sea in S Russia north of and connected to the Black Sea.

Seine River: in N France flowing into the English Channel.

Serbia: region in Yugoslavia.

Siberia: region in northern CIS.

Sicily: island off toe of Italian boot (Italy owns).

Sidra, Gulf of: inlet of Mediterranean on coast of Libya.

Sierra de Guadarrama: mountain range in central Spain; highest point is 7890 ft (2405 m).

Sierra Nevada: mountain range in S Spain; highest point is 11,420 ft (3481m)

Sinai: peninsula W Asia between Mediterranean and Red Sea.

Siret-Prut Hills: region in E Rumania.

Skagerak: arm of North Sea between Norway and Denmark.

Sofia (Sofiya): capital of Bulgaria (4249N, 02323E).

Southern Uplands: hilly area in N England; highest point is over 1800 ft (549 m).

Spain: country in SW Europe on Iberian Peninsula; capital is Madrid.

Spitzbergen: island group in Arctic Ocean about

7800N, 01700E (Norway).

Stockholm: capital city of Sweden (5920N, 01850E).

Strait of Gibraltar: passage between Spain and Africa connecting Atlantic Ocean with Mediterranean Sea.

Stuttgart: city in SW Germany (4846N, 00911E).

Sudeten Mountains: range in N Czechoslovakia, S Poland; highest point is 5266 ft (1605m).

Sweden: country in N Europe on Scandinavian Peninsula; capital is Stockholm.

Switzerland: country in central Europe; capital is Bern.

Syria: country in W Asia along E coast of Mediterranean Sea; capital is Damascus.

T

Tai'yetos Oros: mountain range on Peloponnesos.

Taunus Mountains: range in central Germany.

Taurus Mountains: range in S Turkey running parallel to Mediterranean coast; highest point is above 11,000 ft (3353 m).

Tirol (Tyrol): region in E Alps, chiefly in Austria.

Toulon: city in SE France (4342N, 00556E).

Transylvanian Alps: mountain range in Rumania, and extension of the Carpathian Mountains.

Trieste: city at head of Adriatic Sea; (4539N, 01345E).

Trieste Gap: pass between the Alps and the Dinaric Alps.

Tripoli: capital city in NW Libya (3245N, 01315E).

Tripolitania: region of NW Libya bordering on the Mediterranean.

Tromso: city in N Norway (6935N, 01900E).

Tunis: capital city of Tunisia (3700N, 01030E).

Tunisia: country in N Africa bordering on Mediterranean Sea;

Turkestan: region of central Asia N of Afghanistan.

Tyrrhenian Sea: part of Mediterranean Sea southwest of Italy, north of Sicily, and east of Sardinia.

U

United Kingdom: made up of Great Britain and Northern Ireland; capital is London.

Ural Mountains: range in CIS from Kara Sea to Aral Sea; highest point is under 6000 ft (1829 m).

Ural River: in CIS; flowing into Caspian Sea.

V

Venice, Gulf of: northern Adriatic Sea between Po River delta and Istrian Peninsula.

Vermion Oros: mountain range in N Greece.

Vienna: (Wien) capital city of Austria (4815N, 01622E).

W

Walcheren: island in the Netherlands (5132N, 00335E).

Warsaw: (Warszawa) capital city of Poland (95211N, 02058E).

Western Europe: as used in this pamphlet, the area west of approximately 15E.

Western Lowlands: hill and plain region of W France.

Westerwald: mountain and forest region of Germany.

White Sea: *gulf of Barents* Sea S *of* Kola Peninsula.

Wiesbaden: city in Germany (5030N, 00820E).

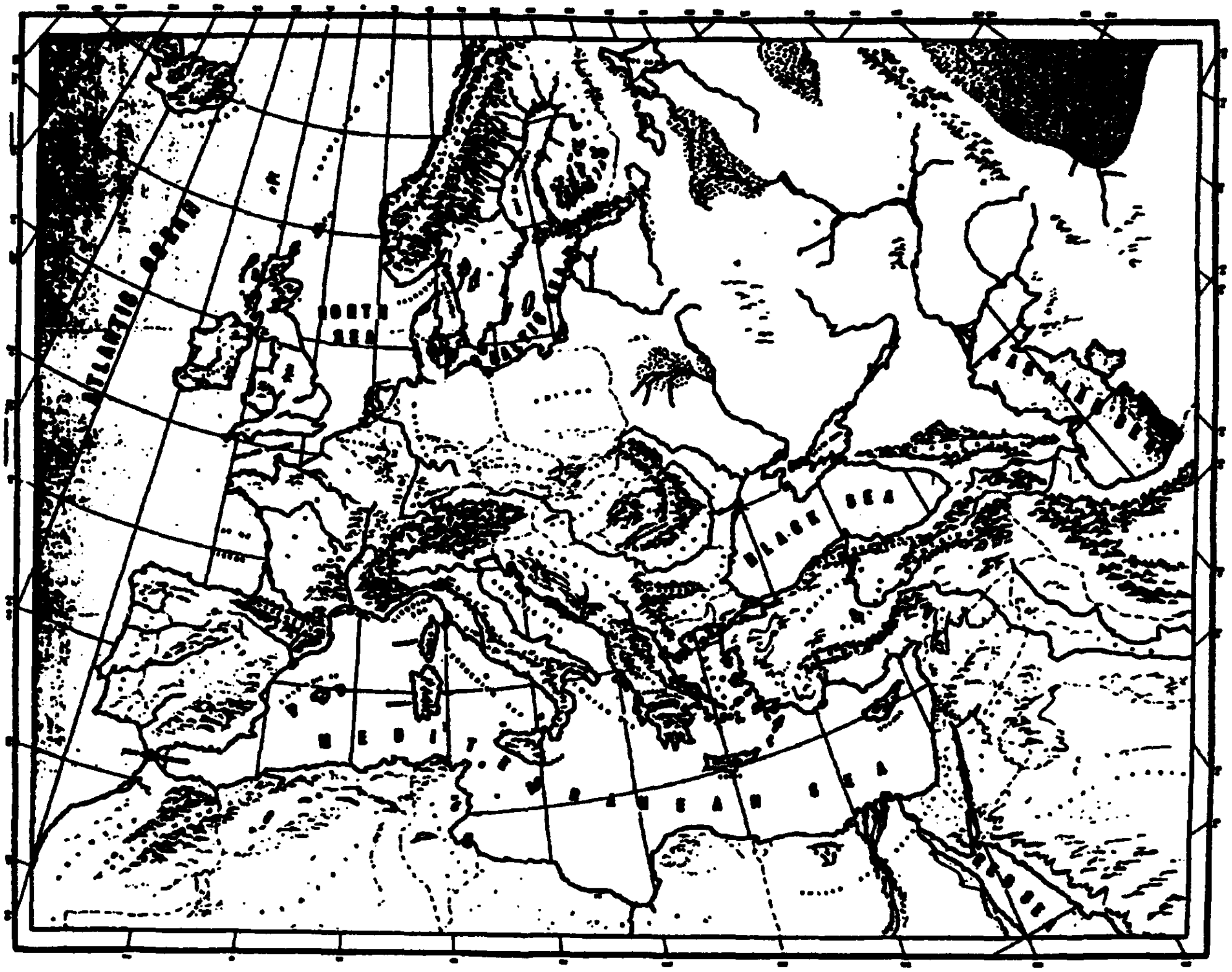
Wipptal: river in W Austria.

Y

Yugoslavia: country in SE Europe bordering on Adriatic Sea; capital is Belgrade.

Z

Zara: (Zadar) city in W Yugoslavia (4442N, 01514E).


ATLANTIC OCEAN
NORTH SEA
BLACK SEA
CASPIAN SEA
MEDITERRANEAN SEA
RED SEA

FINAL EXAMINATION/MAP EXERCISE

This examination is in two parts, multiple choice and a map exercise.

PART A - MULTIPLE CHOICE

INSTRUCTIONS: Select one answer that best fits the question except where it states there is more that one answer.

1. Temperature, precipitation, humidity, pressure, and surface winds are
   a. climatic controls.
   b. climatic phenomena.
   c. climatic elements.
   d. meteorological controls.

2. The various climatic controls are
   a. terrain features, distribution of land and water, pressure center paths, and air mass transport.
   b. latitude, elevation, ocean currents, and upper-level winds.
   c. latitude, terrain features, distribution of land and water, and upper-level winds.
   d. Both a and b.

3. The primary climatic control of both diurnal and annual temperature range is
   a. distribution of land and water.
   b. terrain features.
   c. latitude.
   d. upper-level winds.

4. In Europe, effects of latitude on the local weather and climate of a region become more pronounced the farther
   a. North one goes.
   b. South one goes.
   c. East one goes.
   d. West one goes.

5. Which of the following statements best describe the comparison between Europe and North America?
   a. Europe is nearly the same size as North America.
   b. Most of Europe is north of 60N.
   c. Most of Europe is north of the United States.
   d. All of the above.

6. The most important topographic features in the European Theater are the
   a. land and sea distribution.
   b. various mountain ranges.
   c. great rolling plains.
   d. extensive lowlands.

7. The lack of major north-south terrain barriers in eastern Europe
   a. enables the westward spread of cold continental air.
   b. does not affect the USAFE area of operations.
   c. enables the Siberian High to dominate the winter weather in western Europe.
   d. enables severe snow storms of eastern Europe to move westward.

8. In the British Isles
    a. There are no important terrain features.
    b. Major terrain features are the Southern Highlands, Northwest Uplands, the Grampians of England, the Pennine Chain in Wales, and the Cambrian Mountains of Scotland.
    c. The island group is composed of about 5500 islands.
    d. Plains constitute a small percentage of the total area.

9. Which is probably the most important topographical feature in Germany?
    a. Eifel Mountains
    b. Alps
    c. Taunus Mountains
    d. Harz Mountains

10. What effect do the Pyrenees Mountains have on the climate of the Iberian Peninsula?
    a. Little effect.
    b. Causes the interior to be drier.
    c. Protects the region from cold air masses from the Eurasian continent.
    d. b and c.

11. Which of the following statements best describes the topography of Greece?
    a. Hilly and mountainous.
    b. Large lowland plain.
    c. Composed of many islands.
    d. a and c above.

12. The _____ provides a great source of heat to the European continent.
    a. English Channel Current
    b. North Atlantic Drift
    c. Humbolt Current
    d. Norwegian Current

13. Which of the following countries receive the greatest maritime influence?
    a. United Kingdom and Ireland.
    b. France.
    c. Norway.
    d. Spain.

14. What is the cause for the northward bulge of the mean January isotherms over the North Atlantic?
    a. Lack of data.
    b. The Norwegian Current.
    c. The North Atlantic Drift.
    d. The Canaries Current.

15. When does the Icelandic low reach its maximum development?
    a. During mid-winter.
    b. During early summer.
    c. During mid-summer.
    d. During late autumn.

16. The climate of northern Sweden and Finland can be characterized by
    a. very cold, cloudy winters and mild somewhat less cloudy summers.
    b. cold, less cloudy winters and relatively cool, cloudy summers.
    c. relatively mild, cloudy winters and warm, sunny summers.
    d. moderate, cloudy winters and moderate, cloudy summers.

17. Which season usually brings extensive rain showers over the Central Plains?
    a. Winter.
    b. Summer.
    c. Spring.
    d. All seasons.

18. In the Balkans precipitation
    a. is generally highest in winter.
    b. is generally highest in summer.
    c. amounts and distribution vary throughout the area.
    d. is fairly evenly distributed.

19. The uniform climate of Italy can be described as
    a. warm and dry throughout the year.
    b. mild, rainy winters and hot, dry summers.
    c. mild, dry winters and hot summers with severe thunderstorm activity.
    d. Italy does not have a uniform climate.

20. In Europe ceiling and visibility conditions of 300/1 or less
    a. present no serious problems during summer.
    b. are considerably greater than in the United States.
    c. do not occur in summer.
    d. a and b.

21. In winter, cyclones generally move
    a. along the northern and southern borders of the European continent.
    b. from north to south.
    c. from southwest to northeast.
    d. from the Atlantic through central Europe.

22. In all months, except July and August, the principal axis of cyclogenesis is at
    a. 30°N.
    b. 40°N.
    c. 50°N.
    d. 60°N.

23. In Europe, cyclogenesis occurs most frequently during
    a. Winter.
    b. Summer.
    c. Spring.
    d. Autumn.

24. In Europe, air mass sources are usually found in
    a. France.
    b. The Mediterranean.
    c. Northern Europe.
    d. There is no real source.

25. In winter the mP air that frequently invades Europe north of 45N comes from the
    a. North Pole.
    b. Arctic.
    c. Central Asia.
    d. Eastern Atlantic.

26. In winter the properties of mP air
    a. depend on its trajectory over the water.
    b. are seasonably cool and unstable.
    c. are relatively warm and humid.
    d. are low temperature, high relative humidity, and high frequency of cloudiness.

27. In the European winter, when mP air stagnates over the land and is under the influence of anticyclonic circulation
    a. Continual radiational cooling produces widespread fog and stratus.
    b. The fog and stratus always break no later than maximum heating time.
    c. Fog and stratus infrequently occur.
    d. mP air seldom stagnates over Europe.

28. A vast winter source region of cP air
    a. originates in central Europe.
    b. is located over the snow-covered regions of eastern Europe and Asia.
    c. is in the Alps.
    d. is in the eastern Atlantic.

29. In winter cT air masses
    a. produce the greatest amount of good flying weather in Europe.
    b. produce the least amount of good flying weather in Europe.
    c. influence only the Mediterranean Region.
    d. are restricted to the Iberian Peninsula.

30. During summer, mP invasions into northwestern Europe
    a. produce relatively cold weather.
    b. produce mild weather.
    c. originate southwest of Iberia.
    d. originate in the eastern Atlantic.

31. In summer modified mT air masses
    a. have higher temperatures and greater instability along the west coast of Europe.
    b. produce lower temperatures inland because of radiation effects.
    c. have higher temperatures and greater instability inland than along the west coast of Europe.
    d. are similar to mT air masses that affect eastern North America.

32. In Europe, summer cP air masses are usually separated from cT air masses
    a. at the Baltic Sea.
    b. at the Mediterranean Sea.
    c. at the Alps.
    d. There is no distinct line of separation.

33. In summer the humidity of a cT air mass will
    a. vary considerably from one region to another.
    b. usually be relatively high because of the many water sources.
    c. usually be relatively low.
    d. be too low to provide sufficient moisture for cumulus activity.

34. During winter, in connection with the *bora*, modified cP air enters the eastern Mediterranean as a _____ air mass.
    a. warm, dry
    b. cold, dry
    c. warm, moist
    d. cold, moist

35. At its origin the *sirocco* is best described as a _____ wind.
    a. cold, moist
    b. warm, moist
    c. cold, dry
    d. warm, dry

36. In summer the Mediterranean Region generally has a
    a. relatively large land-sea temperature contrast.
    b. comparatively small land-sea temperature contrast.

37. In summer the Mediterranean Region generally experiences
    a. many cyclones.
    b. few cyclones.

38. During the warm portion of the year the Mediterranean is a region of
    a. widespread fog and stratus.
    b. widespread cumulus and/or stratocumulus.
    c. variable cloudiness, but generally partly cloudy skies.
    d. clear skies or thin cirrus cloudiness.

39. In winter the Mediterranean Region can best be described as
    a. an area affected by zonal flow.
    b. an area of local effects.
    c. a transition zone or region that is invaded by air from adjacent sources.
    d. an area dominated by the *mistral*.

40. The *mistral* generally occurs in a _________ air mass
    a. warm, dry
    b. cold, dry
    c. warm, moist
    d. cold, moist

41. Europe lies in the band of mid-latitude westerlies, therefore the mean upper-level winds
   a. are not affected by transitory upper air systems.
   b. are nearly true westerly but transitory upper air systems continually move with this band of winds causing infrequent large deviations from the mean.
   c. are nearly true westerly but transitory upper air systems continually move with this band of winds causing frequent large deviations from the mean.
   d. are nearly true westerly and are not affected by transitory upper air systems.

42. There is a weak mean upper air trough over southern Europe and western Mediterranean. This trough is most prevalent during
   a. Winter.
   b. Spring and autumn.
   c. Summer.
   d. Winter and summer.

43. The predominant upper level wind direction over Europe is most nearly
   a. Northwest.
   b. Southwest.
   c. West.
   d. South.

44. The maximum variation of upper level wind direction occurs over northern Europe in
   a. Winter.
   b. Spring and autumn.
   c. Summer.
   d. Winter and summer.

45. In the Central Plains there is a large percentage of relatively light winds below
   a. 2500 ft.
   b. 5000 ft.
   c. 10,000 ft.
   d. 15,000 ft.

46. On the average, upper winds over the Central Plains have greatest speeds at
   a. 30,000 ft.
   b. 35,000 ft.
   c. 40,000 ft.
   d. between 30,000 and 40,000 ft.

47. Winds of the Alpine summits are not entirely representative of wind conditions in the free atmosphere. Much of the air is forced to rise in passing over the mountains and in doing so is subjected to
   a. accelerations.
   b. decelerations.
   c. great variations in direction.
   d. All the above.

48. Winds aloft over the Iberian Peninsula are in the prevailing westerlies during all seasons; wind speeds are generally
   a. stronger than at more northerly latitudes.
   b. about the same as more northerly latitudes.
   c. considerably stronger than at more northerly latitudes.
   d. not so great as at more northerly latitudes.

49. Winds aloft over the Balkans are in general
   a. usually westerly throughout the year.
   b. mainly westerly in winter but easterly in summer.
   c. mainly westerly in winter but northerly in summer.
   d. westerly in winter and summer but southerly in spring and autumn.

50. Winds aloft over the CIS can best be described as
   a. westerly becoming southerly with altitude.
   b. westerly with little change of direction with altitude.
   c. easterly with little change of direction with altitude.
   d. easterly becoming westerly with altitude.

51. The subtropical jet stream in the vicinity of the Mediterranean is usually found at or near the ________ level.
   a. 150mb
   b. 200mb
   c. 250mb
   d. 300mb

52. In the Polar Front Jet Stream wind speeds over ________kt are infrequent.
   a. 200 kt
   b. 150 kt
   c. 100 kt
   d. 75 kt

53. In the autumn and winter months the primary terminal forecast problem in Europe is
   a. precipitation.
   b. liquid versus freezing or frozen precipitation.
   c. strong winds.
   d. fog.

54. In Scandinavia during winter, one type of fog occurs
   a. on the windward side of the peninsula at the lower elevations.
   b. on the windward side of the peninsula at the higher elevations.
   c. on the lee side of the peninsula at the lower elevations.
   d. on the lee side of the peninsula at the higher elevations.

55. In Scandinavia frontal fog is mainly characteristic of
   a. interior regions and is not as persistent as radiation fog.
   b. coastal regions and is more persistent than radiation fog.
   c. interior regions and is more persistent than radiation fog
   d. coastal regions and is not as persistent radiation fog.

56. Along the coast of Norway, sea fog is of greatest frequency during
   a. January.
   b. April.
   c. July.
   d. October.

57. In the British Isles cooling of moist, maritime air during periods of weak flow or stagnation causes fog primarily
   a. during summer at coastal locations.
   b. during winter at interior locations.
   c. during summer at interior locations.
   d. during winter at coastal locations.

58. Most of the winter fog in Germany is
   a. advection fog.
   b. frontal fog.
   c. radiation fog.
   d. upslope fog.

59. In the Alpine valleys of Bavaria radiational cooling at night is
   a. greater because of the apparent earlier sunset and later sunrise produced by the high mountains.
   b. less because of the constant cloudiness.
   c. greater because of the light winds.
   d. less because of the strong winds.

60. In winter, the coastal areas of Germany have fog that is primarily of the _______ type.
   a. advection
   b. frontal
   c. radiation
   d. upslope

61. In winter, fog occurs in the Eifel Mountain areas of central Germany
   a. Infrequently.
   b. As a result of advection from the Atlantic.
   c. Due to radiation in the lower valleys.
   d. As a result of radiation, forming first in the valleys

62. Which of the following statements about the occurrences of fog or low visibility in Germany is <u>false.</u>
   a. The frequency of morning fog increases from north to south because of the increasing complexity of the terrain.
   b. During spring the average frequency of occurrence of poor visibilities is low.
   c. During summer, fog occurs infrequently.
   d. During summer, when fog occurs, the most favorable time of occurrence is generally just after midnight.

63. Late October and November in Germany is usually
   a. one of the least foggy times of the year.
   b. when the densest fog occur.
   c. one of the foggiest times of the year.
   d. Both b and c.

64. Although fog is relatively infrequent over Iberia, the area of Spain that experiences the greatest frequency of fog is the
   a. interior.
   b. Northern coast.
   c. East coast.
   d. South coast.

65. The Po River Valley is located in
   a. France and experiences little fog.
   b. France and experiences the most fog in that country.
   c. Spain and experiences little fog.
   d. Italy and experiences the most fog in that country.

66. Thunderstorms in the USAFE area of interest
   a. are limited to the moist coastal regions.
   b. are confined to the Mediterranean Region.
   c. occur over the entire area.
   d. occur only over the mountainous areas.

67. When is the period of most frequent occurrence of thunderstorms in the British Isles?
   a. April through mid-July.
   b. May through mid-September.
   c. July through October.
   d. May through August.

68. The occurrence of hail larger than ¼ inch with thunderstorms over the British Isles
   a. is quite common in all types of convective activity.
   b. occurs only in the northern regions of the British Isles.
   c. rare.
   d. does not occur.

69. Where do thunderstorms occur most frequently in Germany?
   a. Bavarian Alps.
   b. Baltic Sea coast.
   c. Northern Plains.
   d. North Sea coast.

70. Thunderstorms in the Mediterranean Region are most frequent
   a. in the Strait of Gibraltar area.
   b. over northern Italy and the Balkans.
   c. over eastern Spain.
   d. along the north coast of Africa.

71. Thunderstorm frequencies in Spain are comparable to those
   a. of the southeastern United States.
   b. of the plains of France and Germany.
   c. of the arid southwestern United States.
   d. of the Rocky Mountains of the United States.

72. Which of the following best describes thunderstorm activity in Greece?
   a. Infrequent
   b. Evenly distributed over Greece
   c. Evenly distributed throughout the year
   d. Frequent

73. Which of the following areas have both a high incidence of turbulence plus a high volume of military air traffic?
   a. Rhine River Valley
   b. Rhone River Valley
   c. Eifel-Hünsruck Mountains
   d. All of the above

74. What period during the year has the greatest frequency of low-level turbulence?
   a. March through October due to the higher frequency of strong surface winds.
   b. April through September due to the greater instability of the air masses.
   c. October through March due to the higher frequency of strong winds.
   d. October through March due to the greater instability of the air masses.

75. In which of the following countries do foehns not occur?
   a. Germany
   b. Switzerland
   c. Poland
   d. None of the above

76. Foehn winds in the Alps occur
   a. predominantly as south foehn on the northern slopes.
   b. more frequently as north foehn on the southern slopes.
   c. commonly in spring and autumn.
   d. all of the above

77. Where is the most famous region for the occurrence of the *bora*?
   a. Austria
   b. Norway
   c. Yugoslavia
   d. Greece

78. What is the name given to the channel wind of the Rhone River Valley?
   a. *Mistral*
   b. Foehn
   c. *Sirocco*
   d. *Etesian*

79. How should one consider fronts in the Mediterranean?
   a. As discontinuities of temperature and wind
   b. As discontinuities of dewpoint temperature
   c. As they are considered in more northerly latitudes
   d. As discontinuities of temperature gradient and wind shear

80. Which 850 mb temperatures should be used to identify multiple fronts?
    a. +20 C, +10 C, and 0 C
    b. -17 C, - 7 C, and +6 C
    c. +17 C, + 7 C, and -6 C
    d. +17 F +7 F, and -6 F

81. What causes the west coast of France to be a favored frontogenetical area?
    a. Configuration of the land
    b. The land-sea temperature difference
    c. The coastal terrain
    d. The air mass stability in the region

82. Why is the arctic front important in European forecasting?
    a. It occurs frequently in winter.
    b. It is not important.
    c. It causes severely cold weather.

83. Where do cyclones with pressure less that 1000 mb occur most frequently?
    a. Off the west coast of France
    b. Across Scotland and Scandinavia
    c. Along the axis of the Mediterranean Sea
    d. b and c

84. What month has the greatest mean number of days of blocking highs?
    a. March
    b. January
    c. June
    d. April

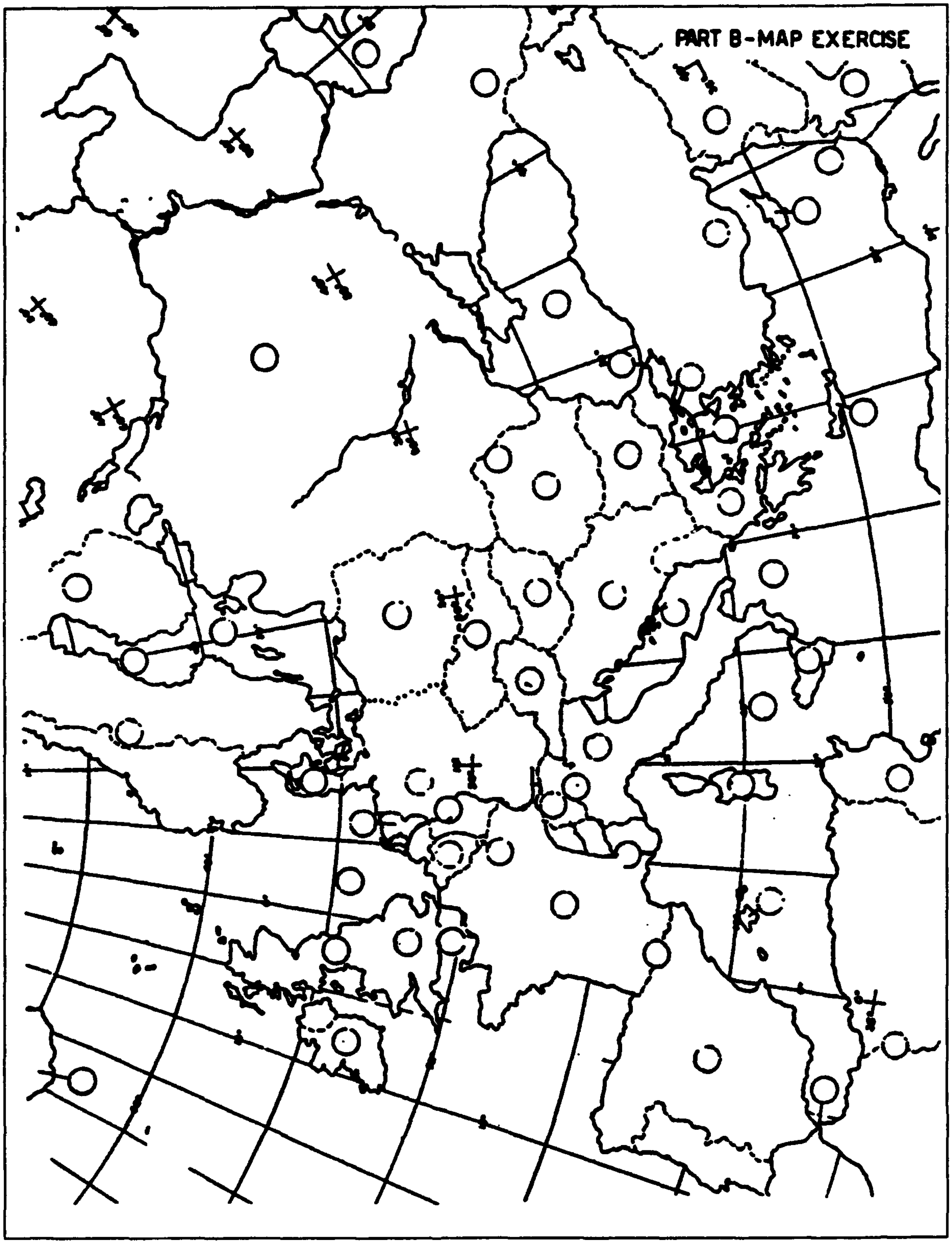
85. Which <u>one</u> of thc following statements is <u>true</u> about temperature anomalies associated with anticyclonic blocking?
    a. In winter, northern Europe is warmer than normal.
    b. In summer, central and eastern Europe are warmer than normal.
    c. In winter, areas along Lat 50N are cooler than normal.
    d. In summer, western and northern Europe are slightly cooler than normal.

86. Which one of the following synoptic situations is responsible for the heaviest snowfalls in southern Germany?
    a. Slow-moving low over the North Sea
    b. Deep low in the Ligurian Sea
    c. A wave on the polar front in the Bay of Biscay
    d. Stationary Siberian High

PART B - MAP EXERCISE

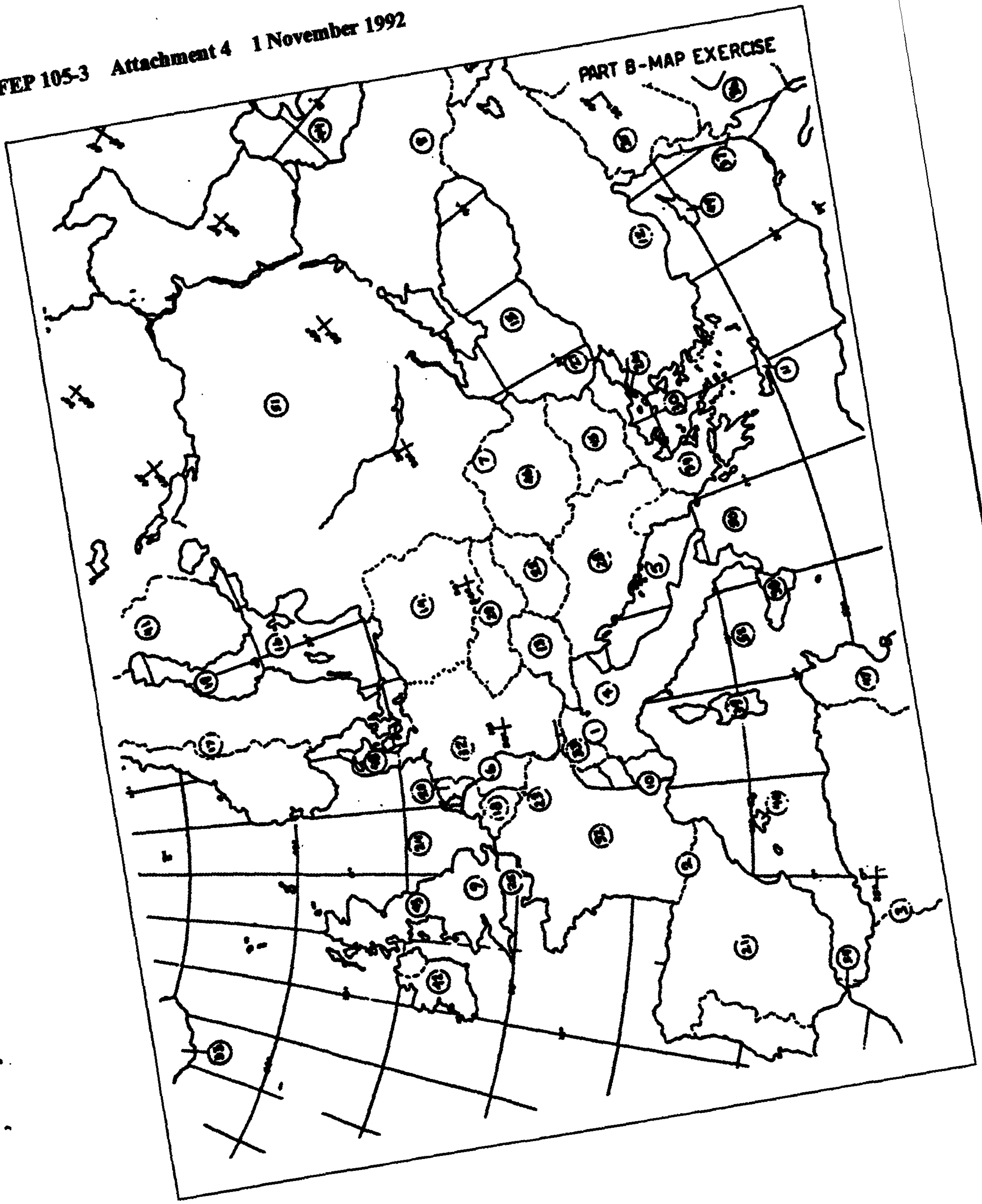
INSTRUCTIONS: Place the number identifying the geographic feature in the following list in the appropriate shaded circle on the accompanying map.

1. Alps
2. Pyrenees Mountains
3. Atlas Mountains
4. Po River Valley
5. Adriatic Sea
6. Rhine River
7. Carpathian Mountains
8. Caucasus Mountains
9. England
10. Rhone River
11. Crete
12. Taurus Mountains
13. Austria
14. Poland
15. Black Sea
16. Baltic Sea
17. Scandinavian Peninsula
18. Belgium
19. Gulf of Bothnia
20. The Netherlands
21. Iberian Peninsula
22. Hungary
23. Luxembourg
24. North Sea
25. English Channel
26. Dardanelles
27. Bosporus
28. Yugoslavia
29. Czechoslovakia
30. Aegean Sea
31. France
32. Federal Republic of Germany
33. Switzerland
34. Greece
35. Syria
36. Jordan
37. Israel
38. Sicily
39. Sardinia
40. Majorca
41. Finland
42. Ireland
43. Great Britain
44. Caspian Sea
45. Bulgaria
46. Romania
47. Tunisa
48. Denmark
49. Cyprus
50. Ionian Sea
51. CIS
52. Tyrrhenian Sea
53. Iceland
54. Strait of Gibraltar


PART B-MAP EXERCISE

ANSWER SHEET TO ETWO EXAMINATION - PART A

1. c
2. d
3. c
4. a
5. c
6. b
7. a
8. c
9. b
10. d
11. d
12. b
13. a
14. c
15. a
16. a
17. c
18. c
19. d
20. d
21. a
22. b
23. a
24. d
25. d
26. a
27. a
28. b
29. c
30. b
31. c
32. d
33. a
34. b
35. d
36. b
37. b
38. d
39. c
40. b
41. c
42. b
43. c
44. a
45. c
46. d
47. d
48. d
49. a
50. b
51. b
52. b
53. d
54. b
55. a
56. c
57. b
58. c
59. a
60. a
61. d
62. d
63. c
64. b
65. d
66. c
67. b
68. c
69. a
70. b
71. c
72. a
73. d
74. c
75. d
76. b
77. c
78. a
79. d
80. c
81. b
82. a
83. d
84. d
85. c
86. b



PART 8-MAP EXERCISE

SUPPLEMENTAL INFORMATION

A5-1. NATO Color Codes:

a.

COLOR CODE	ABBREVIATION	CEILING (>/=)	SURFACE VSBY (>/=)
Blue	BLU	2500 ft	8000 m
White	WHT	1500 ft	5000 m
Green	GRN	700 ft	3700 m
Yellow	YLO	300 ft	1600 m
Amber	AMB	200 ft	800 m
Red	RED	<200 ft	<800 m
Black	BLK	Airfield not Useable for reasons other than CIG/ VSBY minima.	

b. Color is determined solely by cloud base AGL and surface visibility. Other factors ie. cross winds are not considered.

c. Color code in force is the one indicating the worse of either cloud base or visibility. Examples:

EDAR 0600 27005 3700 10BR 2ST006 4SC020 8AS060 02/00 2964INS/CIGM020 VIS SW 1800 GRN
EGWZ 0600 300015/25 9999 2CU030 5SC035 08/01 3002INS/CIGM035 BLU FIRST

A5-2. Quick Reference Guide to Synoptic Code. To highlight only those portions of a synoptic report that are essential to the operation of a weather activity. The sample synoptic observation is given below (from RAF Marham,UK) Each group is numbered to correspond with its expanded description below.

1	2	3	4	5	6	7	8	9	10	11	12
03482	11586	22705	10141	20074	40292	58004	69921	70310	82101	333	82825
aabbb	ccdee	fgghh	ijkkk	lmmnn	opppq	rsttt	uvvvw	xyyzz	abcde	fff	ghijk

a. Block 1. 03482 is the station block number. The first two numbers represents the country (UK) and the last three represent the station.

b. Block 2. 11586: the first two numbers are not important. The third digit is the lowest cloud height (AGL). The last two digits show visibility and break down as follows:

50 or less: The actual visibility in hundreds of meters ("40"=4000m)
51-55: Not Used
56 TO 89: Subtract 50 to get the visibility in thousands of meters
("86"= (86-50)=36X1000=36000m or 36 km. 90= "vsby less than 50 m"

* You may consider this to be prevailing visibility. This code makes no allowance for sector visibility. The prevailing visibility may actually be the worst sector visibility

c. Block 3. 22705: The first digit is total cloud cover in eighths. Second and third digits are wind direction (true) to nearest 10° from which the wind is blowing. Last 2 digits are wind speed to the nearest kt. *Gusts are not reported on synoptic reports (Here 270° at 5 kt.)

d. Block 4. 10141: "1" is the identifier for temperature data (celsius). The second digit represents the sign (0=+ and 1=-) referenced to 0 C. The last 3 are the temperature to the nearest tenth.

e. Block 5. 20074: "2" is the indicator for dew point data. breakdown is the same as for temperature.

f. Block 6. 40292: ''4'' is the indicator for sea level pressure data. The last 4 digits show pressure to the nearest tenth of a milibar (''0292''=1029.2 mb)

g. Block 7. 57004: ''5'' is the indicator for pressure change group. The second digit shows whether the pressure is greater than 3 hours ago (0-3); the same (4); or less than 3 hours ago (5-8). ''M'': missing. The last three digits show the APP tendency in tenths of a milibar. In this example''7004" shows that the pressure fell .4 mb in the last 3 hours.

h. Block 8. 69921: ''6'' is the total precipitation amount group in tenths of a mm. It appears on 6-hourly reports only. The next 3 digits show the amount as follows: 990=trace; 991 to 999=from .1 mm to .9 mm; 001 to 989= 1 to 989 mm. ''000'' is not used. The last digit is the time period over which the precip was measured, ending at the current hour. ''1''=6 hrs; ''2''=12 hrs; ''3''=18 hrs; ''4''=24 hrs.

i. Block 9. 70310: ''7'' is the code for sensible weather. The next two digits are for present weather (96 =TRW with hail) . The last two are for past weather. (9= TRW). ''M''= missing.

j. Block 10. 82101 ''8'' is the primary cloud cover group. The second digit is total cloud cover. The third through fifth digits are the low, mid, and high cloud types, respectively. ''2101'' shows 2/8 cloud cover, with cumulus, no mid cloud and cirrus.

k. Block 11. 333: Means that additive data will follow.

l. Block 12. 82825: These are secondary ''8'' groups that give cloud types and heights as well as amounts. The second digit is cloud amount in eighths. The third digit is type of cloud. The fourth digit is the height. (Encoding is the same as for visibility except substitute feet for meters. ''2825'' means 2/8 of low cloud 8 at 2500 ft.

A5-3. Meteorological Conditions and Chemical Weapon Use:

a. Highly Favorable Weather for Chemical Weapon Employment:

(1) Inversion
(2) Temperature greater than or equal to 40°F
(3) No precipitation
(4) Winds 3-9 kt

b. Moderately Favorable Weather for Chemical Weapon Use:

(1) Inversion or neutral atmosphere
(2) Temperature greater than or equal to 0°F
(3) No precipitation
(4) Winds less than 3; greater than 9 kt

c. Unfavorable Weather for Chemical Weapon Employment:

(1) Unstable atmosphere
(2) Very low temperature
(3) No precipitation
(4) High winds, near-calm winds, or variable direction winds

A5-4. KAC Coding. On occasion, weather activities must relay weather data via unprotected teletype or facsimile circuits. One method protecting this information is by using a code provided by the National Security Agency. This is the AKAC code. It is CONFIDENTIAL CRYPTO material and adequate safeguards must be used to protect it against compromise.

a. The appropriate AKAC series is issued to designated units in booklets valid for one month at a time. One sheet of the booklet is used per day. There are 4 code sets per sheet, and each set is valid during a specific 6-hour time block.

b. Familiarity with the code sheet and use of common terminology will prevent confusion and mistakes.

The following are definitions:

(1) SET INDICATOR: The two letters that preceed the encrypted text or two randomly selected letters used to encrypt the text. Any two letters except "Z" can be used.

(2) SET INDICATOR COLUMN: The bold vertical column of letters (A thru Y) under the heading " SET INDICATOR COLUMN."

(3) SET LETTER: The letter immediately to the right of the second letter of the SET INDICATOR.

(4) SET LINE: The line of letters immediately to the right of the SET LETTER in the SET INDICATOR COLUMN.

(5) CIPHER LETTERS: The bold grouped letters in the SET LINE.

(6) PLAINTEXT LETTERS/NUMBERS: The small groupings of letters and numbers arranged above the CIPHER LETTERS and repeated on the page.

c. The act of encrypting a report can be reduced to two objectives.The first is to determine the SET LINE, and the next is to encrypt the text.

(1) Objective 1: Determine SET LINE.

(a) SET INDICATOR: Randomly select two letters (not "Z")

Example: MC

(b) Go down the SET INDICATOR COLUMN to the letter M.

(c) SET LETTER: Move right to the letter C. The letter to the right of C is the SET LETTER. If C is the last letter in the row, use the first in that same row. Example: The SET LETTER is "O."

(d) SET LINE: Return to the SET INDICATOR Column and descend to the letter "O." This line is the SET LINE.

(2) Objective 2: Encrypt

(a) Use the cipher letters to encrypt the location.

(b) Locate the letter or number to be encrypted in the PLAINTEXT LETTERS/NUMBERS above the SET LINE.

(1) Letters: For each letter of the text substitute the CIPHER LETTER that appears immediately below it on the identified SET LINE. This is restricted to a one-for-one substitution.

(2) Numbers: For each number of the text, substitute a CIPHER LETTER that appears below it on the identified SET LINE. Numbers will be encrypted one at a time, in the same order as they appear in plain text.use a different CIPHER LETTER from the same group for repeated numbers.

d. Decoding. This is the procedure of using the identified SET INDICATOR to determine the SET LINE, and then converting the CIPHER LETTER back to PLAINTEXT LETTERS/NUMBERS.

e. Authentication. This procedure is performed to ensure that the people you are communicating with are "friendlies." To authenticate, choose two random letters (except "Z") Find the first letter in the SET INDICATOR COLUMN. Move right to the "second letter". The authentication letter expected will be the first letter beneath the "second letter" you just found. If another unit requests authentication, they will say, for instance,"ISET AE." Find "A" in the SET INDICATOR COLUMN. Move right to "E." The letter under "E" is your authentication reply.

f. KAC Summary.

(1) To encrypt you go from PLAINTEXT to CIPHER TEXT.

(2) To decrypt you go from CIPHER TEXT to PLAINTEXT.

(3) Encoded locations may be either UTM coordinates or LAT/LON. Each is coded differently.

A5-6. Conversions:

a. Pressure:

1 mb=.029532 inches of Mercury
1 inch of Mercury= 33.86389 mb
1 psi=2.03612 inches of Mercury=.068 bar

b. Distance:

1 foot= .3048 m = 30.48 cm
1 inch= 2.54 cm
1mm= .04 in
1m =39.37 in $1m^2 = 10.76\ ft^2$
1 km = .621 sm = .54 nm
1 degree Latitude= 111.137 km =59.969 nm (Longitudinal distance varies with distance from the equator.

c. Liquid Volume:

1 US qt = .946 l
1 l = 1.057 US qt
1 US gal =3.79 l

d. Speed:

1 m/s= 3.6 km/hr = 1.9425 kt = 3.28 ft/s
1 kt= .515 m/s

e. Temperature:

K = C + 273.16.
1°F =9/5 X C +32 (Take the C Temp. Double it. Subtract 10 %. Add 32= F Temp)
1°C = F-32) X 5/9 (Take the F Temp. Subtract 32. Halve it. Add 10 %= C Temp)

A5-7. "Earth" Standards:

(1) $G= 9.806\ m/s^2$

(2) Thickness - Standard Atmosphere

layer	thickness (Z_s)
1000/500:	5463 gpm
1000/700:	2901 gpm
1000/850:	1346 gpm
850/500:	4117
850/700:	1555 gpm

(3) Heights of constant pressure surfaces in a standard atmosphere

mb	Height (gpm) ((Z_s))
1000	111
850	1457
700	3012
500	5574
300	9164
200	11784

D values are computed as follows
$D= Z- Z_s$ Where Z is the height of the constant pressure surface, and Z_s is the standard height.

A5-8. Wind Chill:

1-4	30	25	20	15	10	5	0	-5	-10	-20	-20	-25	-30	-35	-40	-45	-50	-60
5-9	20	15	10	5	0	-10	-15	-20	-25	-35	-40	-45	-50	-60	-65	-70	-75	-80
10-13	15	10	0	-5	-10	-20	-25	-30	-40	-45	-50	-60	-65	-70	-80	-85	-90	-100
14-17	10	5	0	-10	-20	-25	-30	-40	-45	-55	-60	-65	-75	-80	-90	-95	-105	-110
18-22	10	0	-5	-15	-20	-30	-35	-45	-50	-60	-65	-75	-80	-90	-95	-105	-110	-120
23-26	5	0	-10	-20	-25	-35	-40	-50	-55	-65	-70	-80	-85	-95	-100	-110	-120	-125
>26	5	-5	-10	-20	-30	-35	-40	-50	-60	-65	-75	-80	-90	-100	-105	-115	-120	-130

Higher Speeds Add Little Effect	Little Danger (Green)	Increasing Danger (Yellow)	Great Danger (Red)