UNCLASSIFIED

AD NUMBER

AD911125

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to U.S. Gov't. agencies only; Test and Evaluation; 01 JUN 1973. Other requests shall be referred to US Army War College, Carlisle Barracks, PA 17013.

AUTHORITY

US Army War College ltr dtd 7 Feb 1974

THIS PAGE IS UNCLASSIFIED

MONOGRAPH

13 FEBRUARY 1973

Research paper,

IMPACT OF WEATHER ON MILITARY OPERATIONS: PAST, PRESENT, FUTURE

BY

LIEUTENANT COLONEL GARY D. ATKINSON

USAF

US ARMY WAR COLLEGE, CARLISLE BARRACKS, PENNSYLVANIA

USAWC RESEARCH PAPER

IMPACT OF WEATHER ON MILITARY OPERATIONS: PAST, PRESENT, FUTURE

A MONOGRAPH

by

Lieutenant Colonel Gary D. Atkinson
United States Air Force

US Army War College
Carlisle Barracks, Pennsylvania
13 February 1973

ABSTRACT

AUTHOR: Gary D. Atkinson, LTC, USAF
FORMAT: A Monograph
DATE: 13 February 1973 PAGES: 37 CLASSIFICATION: Unclassified
TITLE: Impact of Weather on Military Operations: Past, Present, Future

Weather has been a significant, and sometimes decisive, factor in military operations throughout history. This paper reviews some of the more striking examples where weather played a major role in the outcome of military battles or campaigns and discusses its probable impact on future military operations. The more detailed examples are limited to the period of World War II and after; however, a few classic cases from earlier history also are discussed. History shows that as weapon systems become more complex and costly, accurate weather information (climatological data, observati[illegible] and forecasts) becomes increasingly important for their effective and efficient employment. Most modern commanders have recognized intuitively the importance of weather information; however, only recently have studies been made to quantify the value of military weather service. The results of these studies, some of which are summarized herein, dramatically illustrate that the current and potential benefits to military operations from a viable and responsive weather service far exceed the costs of such service.

TABLE OF CONTENTS

CHAPTER I

WORLD WAR I AND EARLIER

The first recorded human battle occurred about 50,000 B.C. between two cave men named Og and Ug. During the battle, a rain storm developed causing the handle of Og's club to become slippery. As a result, he lost his grip and his club went sailing off into space during one mighty swing. Ug, however, had anticipated the possibility of adverse weather and had roughened his club handle with an abrasive stone before the battle. Seizing the advantage from his defenseless opponent, Ug promptly dispatched Og to the happy hunting ground in the sky.

While this story is fictitious, the fact remains that military operations throughout history often have been significantly affected by the weather. Like Og, many military commanders have learned a painful lesson by ignoring the possible effects of weather on their operations.

This monograph reviews specific examples of the impact of weather on military operations in the past and discusses its probable impact on future military operations. The term weather, in this context, is restricted to those parameters with which the average layman normally associates the term (e.g., clouds, precipitation, fog, wind, etc.) including the affects of these parameters at the earth's surface (i.e., trafficability, ocean wave height, etc.). Specialized areas of the physical environment which affect present and future military operations in space or under the sea will not be covered. The more detailed examples of weather's impact on military operations are limited to the period of World War II and after; however, a few classic cases from earlier history are discussed briefly in this chapter.

One of the most comprehensive historical surveys of weather and war was published in 1907 by Lord Bentley.[1] In this work, he documents hundreds of military campaigns and battles throughout the recorded history of Europe where weather played a major and often a decisive role in determining the outcome. Readers wishing to pursue the subject of weather and war before the 20th century are referred to this excellent article.

Weather has been a major factor in naval operations throughout history. For example, the Japanese word "Kamikaze" which came to have a special meaning to American sailors operating in the Pacific during the closing campaigns of World War II is derived from a naval battle which occurred nearly 700 years earlier. In 1281, two mongolian fleets led by Kublai Khan were threatening to invade Japan. The defeat of the weaker Japanese forces they opposed seemed certain when a vicious typhoon wrecked the majority of the mongolian ships and forced the remainder to retreat. Thus, a divine (kami) wind (kaze) saved Japan from a Mongol invasion.[2]

Weather is often credited with being a decisive factor in the defeat of the Spanish Armada by the British Navy in 1588.[3,4,5]

A closer examination of the facts, however, disputes this legend. The Armada had been soundly beaten by British warships in good weather before it encountered the storms off the coasts of Scotland and Ireland which led to the destruction of a few more ships. Nevertheless, both countries involved found it advantageous to perpetuate the "winds of god" myth, the British to incalcate the belief that God was on the Protestant side and the Spanish because it was easier to accept defeat at the hands of God than at the hands of men.[6] This case is one of many throughout history where military leaders or statesmen have used weather as a convenient whipping boy, rightly or wrongly, to explain the failure of a military operation to a disgruntled superior or indignant populace.

A campaign that was severely affected by a major storm occurred during the Crimean War. As the Allied forces were preparing for their winter encampment, a major storm hit the Crimea area on 14 November 1854. The strong winds razed the Allied camps to the ground and wrecked a fleet of British supply ships in Balaclava harbor. The entire supply system collapsed as horses starved to death for lack of hay and the few remaining supplies had to be carried by hand. The lack of adequate provisions and shelter caused immense suffering during the Crimean winter; and by February 1855, more than 22,000 British troops had become casualties.[7]

Because of this catastrophe, the French astronomer Le Verrier was commissioned to investigate the storm and determine if it could have been predicted. He collected all available European weather data for days preceding the storm, plotted simultaneous observations on maps, and analyzed the pressure fields. These maps showed the storm (low pressure center) moved from England through Europe to the Black Sea in a few day period. This discovery and Le Verrier's recommendations thereafter eventually led to the development of the first weather forecasting service.[8]

One final maritime disaster before 1900 caused by weather is worthy of mention. In 1889, the Germans were attempting some empire building in Samoa with the backing of three German men-of-war. The United States responded by sending three warships to Samoa. A state of near war existed when on 16 March 1889 a hurricane struck Apia harbor and wrecked all six warships.[9] This hurricane may have prevented a war between the two countries. In speaking of it, Robert Louis Stevenson said:

> Thus in what seemed the very article of war, and within a single day, the sword arm of each of the two angry powers was broken, their formidable ships reduced to junk, the disciplined hundreds to a horde of castaways. The hurricane of March 16 made, thus, a marking epoch in world history; directly and at once it brought about the congress and treaty of Berlin; indirectly, . . . it founded the modern navy of the United States.[10]

The above are some of the more striking examples of how military naval operations have been subject to the whims of mother nature with disasterous results. The history of land warfare also provides many illustrations where weather had a significant or even decisive effect on campaigns or battles. An example frequently referenced is Napoleon's Russian Campaign of 1812. Napoleon and the Grand Army of around 600,000 strong crossed the Niemen River into Russia on 24 June 1812. When the remnants of the army recrossed the Niemen in December 1812 after their disastrous retreat from Moscow, only about 100,000 troops remained.[11] The Russian climate was a significant factor in the immense losses of men and material. Early in the campaign, the army suffered much in the continental summer from heat and scarcity of water.[12] When it reached Vilna, major rains occurred turning the roads into rivers of mud causing the first of many breakdowns in supplies which plagued the army during the entire campaign.[13] The major weather effects, however, occurred after Napoleon began his retreat from Moscow on 19 Octol On 6 November, a snowstorm followed by a severe cold wave hit the army which was ill prepared for the Russian winter. "From that night onward the Grand Army steadily and rapidly disintegrated and . . . became little better than a formless mob, stumbling forward without hope and without shape."[14] A famous painting by Vereshtshagin captured the reality of the Russian winter and its dire consequences for Napoleon's Army.[15]

A few years later, weather again played a significant role in Napoleon's final defeat at Waterloo. Shortly before the battle, a heavy thunderstorm turned the future battlefield of Waterloo into a veritable marshland, practically impassable to men and horses. This forced Napoleon's army to take the main highway which soon became congested, slowing the march and upsetting executi of Napoleon's plans. Conversely, the British troops suffered less from the storm since they were already in position when it began. Later Victor Hugo would write, "If it had not rained the night of January 18, 1815, the future of Europe would have been changed. A few drops more or less proved to be the undoing of Napoleon."[16]

In World War I, weather effects on military operations became even more significant for two major reasons: the development and employment of new weapon systems and the frequent occurrence of adverse weather in Europe which affected these systems. Weather was of critical importance to the effectiveness of practically all aircraft operations: reconnaissance, strategic and tactical bombing, counterair operations, and visual observation and direction of artillery fire. Likewise, gas warfare was critically dependent on surface wind direction and speed and low-level stability (influenced by radiation, cloud cover, temperature advection, etc.). While artillery was not a new weapon system, World War I saw the first use of upper air soundings to greatly increase its accuracy through use of ballistic wind and density factors.[17]

In addition to their effects on these new or improved weapon systems, weather elements affected ground operations as they have throughout history. The most important element was rainfall and its affect on mobility. In fact, after the stalemate of 1914, no really active winter campaigns were undertaken in the western war zone due to poor trafficability and resulting difficulty for rapid movement of troops, ammunition, and supplies. The season of aggressive military operations generally was limited to the period between April and November.[18]

The final German offensive during the spring of 1918 was obviously chosen to coincide with a period of fine dry weather which lasted over a week. In addition, light easterly winds and stable atmospheric conditions favored the use of gas by the Germans. The Germans also used dense morning fogs to achieve tactical surprise. Despite these favorable meteorological advantages, they failed to break through allied lines. Then, heavy rains set in, greatly handicapping movement of German troops and supplies and bogging down their offensive. While the Germans attempted other offensives during the spring and summer of 1918, the momentum gradually shifted to the allied side allowing the war to be concluded on 4 November 1918.[19]

Weather was definitely on the allied side on the Austro-Italian front in the summer of 1918. A few days after Austrian forces crossed the Piave River, it flooded due to heavy rains which fell for a week in the mountains of northern Italy. Practically all bridges were swept away and resupply of the Austrian troops became impossible. Thousands of troops were drowned or shot in the water as they attempted to recross the now raging river. The total Austrian loss was 200,000 killed and 20,000 taken prisoner.[20]

The examples in this chapter dramatically illustrate the major impact weather has had on military sea and land operations up through

World War I. The next chapter focuses on weather effects during World War II and Korea.

CHAPTER I

FOOTNOTES

1. Richard Bentley, "Weather in War Time," Quarterly Journal of the Royal Meteorological Society, April 1907, pp. 88-138.

2. Han C. Adamson and George F. Kasco, Halsey's Typhoons, pp. 5-6.

3. Robert L. Lash, "Why Not Use the Weather?" Military Review, July 1952, p. 16.

4. Robert J. Martin, "Meteorology in Peace and War," The Military Engineer, September-October 1940, p. 343.

5. John H. Manley, "Aerospace Systems and Weather," Air University Review, November-December 1972, p. 43.

6. Garrett Mattingly, The Armada, pp. 390-1.

7. Peter Gibbs, Crimean Blunder, pp. 255-7.

8. Irving P. Krick, War and Weather, p. 4.

9. Adamson and Kosco, pp. 12-13.

10. The Military Engineer, p. 345.

11. "Napoleonic Wars" Encyclopedia Britannica (1968), Vol. 16, pp. 24-25.

12. V. Conrad, "War Climatology," Bulletin American Meteorological Society, May 1942, p. 217.

13. Leonard Cooper, Many Roads to Moscow, p. 80.

14. Ibid., p. 151.

15. Bulletin American Meteorological Society, p. 218.

16. "Weather and War," New York Times, 14 January 1940, p. II-7.

17. "The Signal Corp Meteorological Service, A. E. F.," Monthly Weather Review, December 1919, pp. 870-1.

18. Robert DeC. Ward, "Weather Controls over the Fighting during the Spring of 1918," The Scientific Monthly, July 1918, p. 24.

19. Ibid., pp. 24-27.

20. Robert DeC. Ward, "Weather Controls over the Fighting during the Summer of 1918," The Scientific Monthly, October 1918, pp. 293-294.

CHAPTER II

WORLD WAR II AND KOREA

During World War II, military forces had to contend with an extreme variety of weather from the heat, humidity, torrential rains, and typhoons of the tropical Pacific; to the snow and bitter cold of Russia; to the cloudy, foggy, and rainy weather of Europe and the Aleutians. Mud, and resulting poor trafficability, was encountered at various seasons in practically all theaters of operations. Weather could seldom be classified as neutral. Regardless of what the weather was, clear skies with unlimited visibility to zero-zero in fog, it almost always favored one side more than the other in any campaign or battle. Many military decisionmakers recognized its importance and did everything possible to take advantage of it or minimize its adverse effects. Others chose to ignore it as an important factor and lived to regret their oversight. Following are a few of the most significant cases in World War II and Korea where commanders used weather information intelligently or otherwise.

During the initial campaigns of the war, German commanders made excellent use of weather in planning their operations. Dry weather and relatively clear skies were essential for optimum employment of their blitzkrieg tactics employing armored Panzer divisions with Luftwaffe close air support. They used climatology and long range forecasts (calling for below normal rainfall) to select September 1939 for their invasion of Poland. The forecast and campaign were completely successful.[1] Hitler then turned his attention to the invasion of France which he wanted to occur in mid-October 1939. The German Army chiefs, however, considered 12 November as the earliest possible date for the invasion. A storm system caused this initial date to be postponed until 17 November.[2] Thereafter, D-Day was postponed 16 more times between November 1939 and May 1940 because Hitler's meteorologists could not assure him of a prolonged period of good weather considered necessary to accomplish his objectives rapidly. When the invasion did occur in May 1940, dry soil conditions and good flying weather again favored Germany's blitzkrieg operations.[3]

After these initial successes where weather was used brilliantly in planning, inadequate consideration of weather was a significant factor in Germany's failure during its Russian campaign of 1941-42. The reasons this happened are varied and complex, e.g., Hitler planned to complete the campaign before winter set in, he underestimated Russian resistance, he overestimated ability of his forces to contend with the mud and later bitter cold and snow of western Russia, and political considerations dominated all other factors. In any case, the weather was against the German attackers and for the Russian defenders throughout most of the campaign.

Heavy fall rains and resulting mud frequently bogged down German armored units and supply convoys. Likewise, frequent poor flying weather greatly hampered German air operations. When winter came with its snow and bitter cold, the German Army was woefully unprepared. Winter clothing had not been supplied, and the soldiers suffered more casualties from the cold than from enemy action. Antifreeze was not on hand at the beginning of winter and breakdowns of all types of equipment due to the extreme cold were common. Conversely, Russian troops were adequately clothed and well prepared for and accustomed to winter operations. They often used adverse weather such as blizzards or dense fog to achieve complete tactical surprise.[4] In summary, weather played a major, if not decisive role, in Hitler's failure in Russia which proved to be the turning point of the war.

During the North African campaigns, weather came to the rescue of Rommel's forces on several occasions. After his defeat at El Alamein, Rommel withdrew his remaining forces westward along the coast of North Africa. Montgomery attempted to outflank this retreat by moving his forces through the desert parallel to the coast; however, heavy rains on 6-7 November 1942 turned the desert routes into a morass of mud. This delayed the British forces and allowed the Germans traveling by hard-surface coastal roads sufficient time to escape to Tunisia.[5] A few weeks later, Allied forces moving toward Tunisia from the west after their successful invasion of North Africa were also stopped by mud. As a result, the attack on Tunis and destruction of the remaining German forces had to be delayed until the spring of 1943.[6]

Weather also played important roles in the campaigns in Sicily and Italy during 1943. An unreasonable storm almost upset plans for the invasion of Sicily; however, the storm and wave heights moderated sufficiently as forecast to allow the invasion on 10 July 1943. Conditions were far from optimum, however, and the loss of life and equipment which occurred during the invasion itself was due primarily to weather (i.e., rough seas) and not enemy action. Conversely, the decision to invade under marginal weather conditions may have saved more lives because of the relaxed vigilance of the Axis forces attributable to the storm.[7] Later that year, fall rains and mud combined with rugged terrain and a stubborn enemy greatly hampered the allied offensive in southern Italy. After the initial success of the Anzio landing in January 1944, frequent grounding of the allied air forces by poor weather contributed to the prolongation of that campaign.[8]

Probably no major military campaign in history was as critically dependent on the weather as operation OVERLORD, the Allied invasion of Normandy in June 1944. Each service had unique weather requirements it considered necessary for successful operations. Additionally, certain tidal and moonlight illumination conditions had to be met. The critical environmental conditions were eventually condensed to the following.

1. D-Day should be one day before to two days after a new or full moon.

2. D-Day and following three days should have wind speeds of less than 12 mph onshore and 24 mph offshore.

3. Cloud cover should be less than 3/10 below 8,000 feet with cloud bases not lower than 3,000 feet.

4. Visibility should be three miles or greater.

The odds of a given day having the necessary simultaneous conditions were uncomfortably low: 24 to 1 against in May, 13 to 1 against in June, and 33 to 1 against in July. Nevertheless, on 8 May 1944, Eisenhower set D-Day for 5 June 1944 with 6 and 7 June as alternates. The next favorable period would not occur until 19 June. In early June, the weather situation looked grim. The favorable weather which had occurred in May broke down and a series of storms brought unsettled weather and high winds. Early Sunday morning, 4 June 1944, Eisenhower ordered a 24-hour postponement until 6 June based on the weather forecast. That night, allied meteorologists predicted a 24-hour period of improved, but still far from optimum, weather to occur on 6 June. Based on that forecast, Eisenhower made one of the most momentous decisions in military history as he decided to proceed with the invasion.[9] Even though the wind speed and wave heights were higher and cloud bases lower than desired,[10] the invasion was successful. Like Sicily, the Germans were caught completely off guard because their meteorologists had not predicted the break in the weather.[11] Thousands of allied soldiers undoubtedly were saved as a result.

The final European campaign where weather played a major role was the Battle of the Bulge in December 1944. Germany desperately needed to launch a counteroffensive but required a period of poor flying weather to neutralize the air superiority of the Allies.[12] German meteorologists successfully forecast such a period and the German Panzer forces attacked on 16 December. A solid week of extremely foggy weather allowed the Germans to make significant gains including the surrounding of two airborne divisions near Bastogne. In addition to the Germans, American forces at Bastogne had to contend with snow, bitter cold temperatures, and lack of adequate supplies. The weather finally cleared on 23 December allowing Allied air power on this and following days to airdrop supplies to the Bastogne defenders and stop the German counteroffensive. Coincidently (or maybe not), 23 December was also the day that the prayer for good weather that General Patton ordered his chaplain to prepare was published and distributed to his troops.[13]

Weather also impacted significantly on military operations in the Pacific Theater. Because of the nature of the Pacific war, however, weather's main impact was on naval (including amphibious) and air operations rather than sustained ground operations.

The Japanese were acutely aware of weather's importance and often used weather disturbances to screen movements of their naval forces. For example, a major reason the Japanese naval force which struck Pearl Harbor went-undetected was that it departed its home port under cover of thick fog and followed a series of storm systems across the North Pacific.[14] Likewise, the Japanese used a storm system successfully to conceal their naval forces who attacked Dutch Harbor and seized Attu and Kiska in the Aleutian Islands in June 1942.[15] Later in the war in July 1943, persistent cloudiness and fog around Kiska allowed a Japanese task force to secretly evacuate all their forces on that island. This daring evacuation remained completely unknown to the Allies until they invaded Kiska in mid-August 1943 and failed to find a single Japanese soldier.[15]

The Japanese use of weather in tactical planning failed them during the Battle of Midway in June 1942. The same storm system which shielded the Japanese forces attacking the Aleutians had also shielded the task force due to attack Midway. However, the clouds on the southern side of this system disputed a few hundred miles west of Midway exposing the Japanese naval forces to attack by US land and carrier based aircraft.[16] The resulting Japanese defeat is considered by many to be the turning point of the Pacific war.

Another decisive naval battle where weather failed the Japanese and aided the Allies was the Battle of the Bismarck Sea in March 1943. A 22-ship Japanese convoy enroute to reinforce their troops at New Guinea used a major storm system to conceal its movement. Before it reached its objective, however, an enlisted AAF meteorologist correctly forecast the disipation of the storm clouds. The result was the detection and destruction of the entire Japanese convoy by Allied planes and a battlefield commission for the young meteorologist.[18]

Later in the war, two typhoons deal severe blows to US naval forces operating under Admiral Halsey's command in the North Pacific. The first and most destructive case occurred on

18 December 1944 when naval vessels supporting the Philippine invasion were caught near the center of a typhoon of extreme violence 300 miles east of Luzon. Three destroyers capsized and sunk with practically all hands, nearly 800 sailors. Some 2[illegible] other ships suffered various degrees of damage and 146 carrier planes were destroyed.[19] Near the end of the war in June 1945, the fleet operating against southern Japan and Okinawa encountered another typhoon. In this incidence, 33 ships were damaged, 92 planes were destroyed or seriously damaged, and six lives were lost.[20] Because inaccurate information on typhoon location and intensity contributed to these disasters, Halsey strongly advocated establishment of aircraft weather reconnaissance squadrons dedicated to typhoon tracking. His suggestion was implemented just before the war ended and such squadrons have been in continuous operation since then.[21]

Weather was a major factor in the effectiveness of all types of aircraft operations during World War II. The primary weather effect was clouds and/or restrictions to visibility which prevented aircrews from seeing and destroying their targets. Other factors hampering air operations were low ceilings/visibilities or high winds preventing landings or take offs, thunderstorms and associated turbulence, aircraft icing, winds aloft for bombing and navigational accuracy, contrails affecting aircraft detection, etc. Weather was always a critical factor in the European Theater of Operations due to the large-scale strategic bombing operation there and the high frequency of poor or marginal weather for visual bombing. In fact, once full offensive capabilities were established, weather was the principal controlling factor in operations. It governed the number of days on which operations could be conducted, area to be attacked, size of the force, timing of the attack, and method of bombing. Even though various blind bombing techniques were available, they were much less accurate and effective than visual bombing.[22]

Because of the critical importance of accurate weather information, an elaborate weather support system was developed. Each European Air Force had its own weather central.[23] Planning of bombing operations based on weather forecasts was much more successful than if missions had been dis ed haphazardly without regard to weather.[24] Applied climatology was also used effectively. Using weather observations for German cities obtained before the war, optimum times of day and altitudes were determined for each target. In addition, processing of thousands of simultaneous observations was used to determine the best alternate targets when weather at the primary target was unfavorable. When planning flexibility permitted use of multi-targeting based on weather forecasts and climatology, the probabilities of visual bombing were about twice as great as the single target probabilities.[25]

Applied military climatology was also used very effectively in strategic bombing operations against Japan. A classic example of this was in planning incendiary bombing raids. The problem was to determine which days would be favorable for incendiary raids on Tokyo and other Japanese cities. No fire [illegible]rds from Tokyo were available, so meteorologists selected Raleigh, North Carolina as a location which had a climate clos[illegible] [illegible]alogous to Tokyo. They analyzed Raleigh's fire records for a 4-year period and correlated the frequency of various types of fires with weather parameters. From this analysis, they isolated the following conditions as being favorable for fire weather: (1) relative humidity less than 40% in afternoons, (2) no measurable rainfall on day of fire and previous three days, and (3) surface wind speeds greater than 13 miles per hour. Applying these conditions to historical Tokyo weather records, they determined the monthly climatology of good fire weather days. They also examined the synoptic weather situations over the Far East on good fire weather days and developed a simple but effective analog system to forecast occurrence of these days.[26]

Aided by such use of weather information in their planning, incendiary bombing raids were conducted against Japan with devastating results. In one raid, some 15.8 square miles of the heart of Tokyo were burned out in the most destructive air attack in history prior to the use of the atomic bomb. Altogether, nearly 169 square miles of some 66 Japanese cities were destroyed by incendiary raids. Never in the history of aerial warfare was such destruction achieved at such moderate cost.[27]

During the Korean War, weather was once again a significant factor in the conduct of military operations. Space limitations prohibit a detailed description of these weather effects; however, the US Army sponsored a comprehensive study of weather in the Korean conflict which can be consulted for detailed accounts of weather effects.[28] The following is a brief synopsis of impressions gained from reading this study.

In general, weather effects in Korea were similar to those of World War II. This is not surprising since, for the most part, the Korean War was fought with World War II equipment subject to the same limitations of weather and climate. Korea is far from an ideal place to fight a war as anyone involved in this conflict will testify. It experiences a wide range of climatic conditions from the oppressive heat and humidity and heavy rains of summer to the snow and extreme cold of winter. These climatic extremes had their usual impact in greatly reducing personnel and equipment effectiveness. The lessons of Napoleon's and Hitler's campaigns in Russia had to be relear d; during the first winter season, cold weather injuries were far in excess of what they should have been due to inadequate clothing, supplies, and training. Surface mobility was a major problem throughout much of the year due to heavy rains, snowfall, frequent freezing and thawing cycles, and flash floods combined with the rugged terrain. Korea lies near several major mid-latitude storm tracks and air operations were frequently hampered or canceled completely due to poor flying weather. Persistent fog in mountain valleys often prevented close air support operations. Because of this and the air superiority of the United Nation forces, the Communists often launched their attacks under the cover of bad weather. Weather affected military operations on both sides; however, one gains the distinct impression that it hampered United Nation's forces more than the Communist forces. This is because on many occasions it negated the advantages which the United Nation's forces should have enjoyed due to their overwhelming air superiority and their superior armored and mechanized forces.

In this chapter, we saw how the winds of war and the winds of weather were closely entwined during World War II and Korea. In the final chapter, we examine weather's impact on military operations in the current Southeast Asian conflict and attempt to project weather's importance for future military operations.

CHAPTER II

FOOTNOTES

1. W. O. Senter, "The Importance of Weather in Modern Warfare," in United States at War, p. 99.

2. Army Electronic Proving Ground, Weather Information for Army Tactical Operations (German Supporting Study), p. 162.

3. Ibid., pp. 94-95.

4. Fred W. Decker, et. al., Weather Effects on Army Operations: Weather in World War II, Vol. I, pp. I-1 to I-14.

5. Ibid., pp. II-1 to II-4.

6. Ibid., pp. III-1 to III-9.

7. Ibid., pp. IV-1 to IV-5.

8. Ibid., pp. VI-1 to VI-6.

9. Philip M. Flammer, "Weather and the Normandy Invasion," Military Review, June 1961, pp. 20-28.

10. Headquarters, Army Air Forces, An Analysis of the Weather Factor in this War for June 1944, pp. 5-6.

11. Military Review, p. 28.

12. Weather Information for Army Tactical Operations, pp. 211-212.

13. Decker, Vol. I, pp. IX-1 to IX-22.

14. Fred W. Decker, et. al., Weather Effects on Army Operations: Weather in World War II, Vol. II, p. Log-2.

15. US War Department, War and the Weather, pp. 7-8.

16. Decker, Vol. I., p. XI-4.

17. US War Department, p. 8.

18. Edward O. Jess, letter to author, 15 November 1972.

19. Adamson and Kosco, pp. 149-150.

20. Ibid., p. 190.

21. Ibid., p. 145.

22. Military Analysis Division, Weather Factors in Combat Bombardment Operations in the European Theater, p. 1.

23. Ibid., p. 3.

24. Ibid., p. 1.

25. Ibid., p. 13.

26. H. E. Landsberg, G. S. Benton, and H. Bond, Weather Conditions in Relation to Incending Bombing of the Tokyo Area, pp. 1-15.

27. H. H. Arnold, "War in the Pacific," in American Defense Policy in Perspective, ed. by Raymond G. O'Conner, p. 268.

28. Fred W. Decker, et. al., Weather Effects on Army Operations: Weather in the Korean Conflict. (two volumes).

CHAPTER III

SOUTHEAST ASIA AND BEYOND

A comprehensive survey of weather effects during the current Southeast Asian conflict has not yet been published. Without doubt, however, such a survey will show that weather and climate have been significant factors throughout the entire war. Practically every location in Southeast Asia experiences extreme seasonal variations in sensible weather (i.e., cloudiness, thunderstorms, precipitation amounts, visibility, etc.) which impact significantly on military planning and operations. For example, due to a unique combination of the general circulation, moisture sources, and terrain, North Vietnam experiences much worse flying weather (especially during the cool season) than other regions at similar latitudes. This has been a major limiting factor in tactical bombing operations over North Vietnam which require good weather for highly accurate bombing and for avoiding surface-to-air missiles in heavily defended areas. The prevailing low cloud cover over North Vietnam in December 1972 undoubtedly influenced the decision for the first large-scale use of B-52s (and their radar bombing techniques) in the Hanoi-Haiphong area.[1]

In many ways, the ground war in South Vietnam has been a seasonal conflict due primarily to the large seasonal change in trafficability and supply traffic over the Ho Chi Minh Trail in Laos. The lowest level of supply movement occurs during the rainy season from May through September and highest level in the dry season from November through March. The interdiction campaign against North Vietnam's logistics operation is geared to this changing pattern with destruction of vehicular traffic on the trail receiving priority in the dry season and attacks on supply concentrations receiving priority in the wet season. This interdiction campaign is heavily dependent on weather information. In addition to daily weather forecasts required for air operations, a knowledge of the amount and distribution of rainfall over the trail network to determine expected trafficability conditions is vitally important. The Air Force Weather Service uses a variety of techniques (including meteorological radar and satellite data, rainfall data from Laos stations, and a computer model of monsoon rainfall) to determine daily rainfall patterns over the trail area. In recent years, data from the IGLOO WHITE electronic, anti-infiltration system has also proved to be extremely useful in determing rainfall intensity, spatial extent, movement, and duration.[2] This interdiction campaign has been extremely successful, e.g., from the period 1 November 1970 to 1 November 1971 only about 9,500 tons of supplies got through of the 68,500 tons than entered the trail (approximately 14%).[3]

The Allied invasion of Cambodia in May 1970 to uncover and seize or destroy Communist supply caches was extremely well timed to take advantage of the seasonal rainfall/trafficability patterns. Occurring near the end of the dry season, it denied the Communists sufficient time to replenish the seized supplies before the southwest monsoon rains set in. Also, the good trafficability in early

May greatly facilitated movement of armored and mechanized units during the invasion and the truck traffic to transport the captured supplies back to South Vietnam. Incidently, the southwest monsoon started two weeks later than normal in 1970, as forecast by Air Force meteorologists, giving allied forces precious additional time under optimum operating conditions.

In late March and early April 1972, weather was an ally of the North Vietnamese forces who invaded the northern portion of South Vietnam. Trafficability conditions were excellent since the central Vietnamese coastal lowlands receive little rainfall during the spring months. This facilitated rapid movement of the North Vietnamese tanks, trucks, and artillery. In addition, allied air attacks against the invading forces during the first week after the invasion were greatly hampered by persistent low clouds and poor visibility in fog and drizzle.[4] Most of the Communist territorial gains were made during this first week of poor weather. Thereafter, improved flying weather facilitated stopping of the Communist momentum and regaining of lost territory through allied air, ground, and sea action.

Many other examples of how weather affected military operations in Southeast Asia can be cited, e.g., effects of tropical heat and high humidity on personnel/equipment effectiveness and deterioration of supplies; typhoons affecting naval operations in Gulf of Tonkin and B-52 operations from Guam, poor weather hampering aerial resupply and close air support operations during seize of Khe San, etc. It is obvious, however, from the few examples given here that even with today's modern military forces, weather is still a significant factor which must be carefully considered in planning and executing military operations.

What about the future? Will weather effects and weather service be more or less important to military operations than in the past? In the author's opinion, they will become more important. The remainder of this paper is devoted to supporting this position.

In the past, the "all weather" syndrone caused weapon system designers to advocate maximum allowable adverse-weather specifications to allow continuous operation under almost all weather conditions.[5] The result was extremely costly equipment due to the expensive and complex avionics required for the so called "all weather" capability. The classic example of this, of course, is the F-111. As a result of enormous cost overruns in many of these weapon systems, only a fraction of the initially envisaged force levels could be acquired. As a result of these experiences, attitudes of weather system designers are changing. It is now being realized that even if it might be possible to design truly "all-weather" systems, it is often not cost effective to do so.[6]

The design specifications for the new A-X fighter reflect this new outlook. This aircraft will be optimized to perform close air support, be relatively inexpensive, and be easy to maintain in an austere environment. Lower attack speeds combined with redundant control systems, self sealing fuel tanks, and heavy armor plating for survivability will allow improved close-in support under low ceilings and poor visibility conditions.[7]

The new generation of air-to-ground weapons now coming into the inventory such as the guided or "smart" bombs which use electro-optical or laser guidance systems are limited to use under visual conditions.[8] Likewise, the Maverick missile (with its television homing guidance) and the new generation of aircraft guns (e.g., the 30 mm. GAU-8) will depend on being able to see the target to destroy it.[9]

It is obvious that weather effects and weather service will be critically important for effective employment of these new systems. Applied climatology will be necessary to determine the appropriate weapons mix (aircraft and ordnance) for specific areas and seasons. Once deployed, accurate weather forecasts will be vital to effective mission planning. These facts were emphasized by Admiral Moorer when he stated:

> While weather has always been a factor in the prosecution of wars, that as military technology has advanced and become more complex, military operations have become more sensitive to the environment. . . . one of the most difficult decisions facing the operational commander today . . . is the selection of the optimum weapon's system to be used . . . such a decision cannot be made without competent weather advice.[10]

The astronomical cost of many of the current and future weapons systems make it imperative that these systems be protected from catastrophic weather events which could damage or destroy them. The cost of this protection itself may be substantial. For example, the recent evacuation of 150 B-52s from Guam due to a threatening typhoon undoubtedly cost hundred of thousands of dollars. Nevertheless, the risk of not evacuating them, in this case, was completely unacceptable. In the past, when tornadoes have hit military airfields and destroyed aircraft it was regarded as an unfortunate "Act of God." In the future, a tornado destroying a fleet of B-1s could be a national disaster.

Another example of protecting expensive systems is the C-5 fleet. The structural problems of the C-5 are now well known. To extend the operational life of the C-5s, they will be operated, during peacetime, at much less than initially programmed rates with reduced payloads.[11] It also will be vital to keep the C-5 out of areas of convective turbulence (i.e., associated with thunderstorms) or areas of potential severe clear air turbulence. As a result, tailored weather service support which recognizes their operating limitations has been established for C-5 operations. Just these few examples illustrate that the cost of an effective and vigilant military weather service is a small price to pay for the protection of costly systems against catastrophic weather events.

Until recently, little had been done to quantify the value of weather support to military activities. The opinions, both pro and con, of its value were generally based on subjective judgement. Recognizing this problem, Hq USAF recently sponsored two large-scale study efforts to attempt to put weather effects and service on a more objective/quanitative-basis. The first of these studies was an Air Weather Service Mission Analysis on the Gathering and Use of Weather Information conducted during 1970 and 1971. In this study, the environmental impacts on the following four representative missions were analyzed: tactical nonnuclear bombing, deployment/employment of strike contingency forces, operations affected by the space environment, and strategic missile strikes.[12] The study successfully assessed in quantitative terms the value of weather support to the effectiveness of these military operations. For example, in the STRICOM analysis the maximum weather support contribution was found to be in paradrop and close air support operations. For such operations in a selected area and season in South Vietnam, the probability of mission success with no forecast was 28%; with current forecast accuracy, 50%; and with perfect forecasts, 74%. In all cases, the probability of mission success varied directly with forecast accuracy and value of good forecasts increased directly with frequency of bad weather.[13]

This initial study was followed in 1971-72 by a study to evaluate the impact of weather and weather support on Air Force and Army missions through 1985. It determined types and quality of weather support required, examined alternative means of providing that support, and provided a plan to meet these requirements. An Air Force and Army-wide survey was made of expected requirements for future weather support in peacetime, nonnuclear, and nuclear conflict and reduced to the following set of meteorological requirements.[14]

OPERATIONAL REQUIREMENTS FOR WEATHER DATA

Cloud forecasts for targets

Terminal forecasts, including severe weather warnings, for aircraft recovery

Solar and atmospheric effects on communications and surveillance (real-time data and forecasts)

Air refueling forecasts

Area, enroute, and battlefield severe and sensible weather forecasts for all aircraft and Army ground operations

Global winds forecast (surface to 100,000 feet) for ICBM targeting, aircraft operations, and aircraft ordnance delivery

Forecasts of atmospheric density for ICBM targeting and of pressure altitude for aircraft ordnance delivery

Space density measurements and forecasts for satellite control and positioning

Climatology of global winds and clouds for operational planning

Contrail forecasts for air defense and high altitude bombing and reconnaissance operations

Diffusion forecasts for toxic fuel handling, including missile launch operations

Comfort/Stress forecasts of weather extremes for Army and Air Force ground operations

Climatology for use in weapon system studies

In addition to these large-scale contract study efforts, the Air Force Weather Service also has prepared a number of economic analyses showing the value of weather support to military decisionmakers.[15] Results from some of these studies are briefly summarized below.

Air Force flying training activities require warnings of severe weather (i.e., thunderstorms with hail and/or strong surface winds) to recall or divert airborne aircraft. At one base alone, tailored weather warning support contributed over $1 million per year in terms of increased base productivity. The study also showed annual savings of $2 million for increased aircraft availability and $150,000 in repair costs resulting from reduction aircraft damage.

In June 1972, Hurricane Agnes passed near Eglin and Tyndall Air Force Bases in Florida. The National Hurricane Center forecast the storm to come ashore with 100-knot maximum winds. Air Force meteorologists, however, saw the storm was weakening rapidly offshore and advised their respective base commanders accordingly. Based on this advice, the decision was made not to evacuate Eglin and to reduce the amount of storm preparation made at Tyndall. The Air Force forecasts verified accurately and the total savings (for both bases combined) amounted to approximately $1 million.

The Defense Fuel Supply Center procures diesel fuels for DOD. The chemical composition of the fuel allows its use at any temperature at or above various design temperatures; however, the cost of the fuel increases as the design temperature decreases. Due to a lack of definitive temperature data, the operating requirements for diesel fuel in many locations were well below the minimum actually required. A comprehensive study by the USAF Environmental Technical Applications Center provided realistic design temperatures for each geographic area of interest. By applying these data to their fuel purchases, DOD may eventually realize a savings of $2.3 million annually.

These and similar economic analyses showed annual cost savings of $320 million directly attributable to weather support. In classified Special Strategic Programs alone, the annual value of weather support was estimated to be $240 million. This figure by itself is much greater than the total annual cost of operating the Air Force Weather Service. Since these economic analyses have only begun recently and are still limited by available manpower and data to perform them, the potential worth of weather support is undoubtedly much greater than these figures indicate. Annual savings of $1 to 2 billion may eventually be documented.

In summary, we see that weather has always been an important factor in military operations. As military operations and equipment have become more complex and costly, the importance of weather effects and weather service has also increased dramatically. As with Ug in 50,000 B.C., military decisionmakers of the future will depend more and more on enlightened weather advice to increase the effectiveness and/or decrease the costs of their operations.

Gary D. Atkinson

GARY D. ATKINSON
LTC USAF

CHAPTER III

FOOTNOTES

1. "More Bombs Than Ever," Time, 1 Janurary 1973, p. 10.

2. James F. Shunk, "The Capability of IGLOO WHITE for Weather Detection," Aerospace Sciences Review, August 1972, pp. 20-25.

3. Robert C. Seamans Jr., "Air Force Appropriations Request FY-73," Supplement to the Air Force Policy Letter for Commanders, April 1, 1972, p. 3.

4. "Vietnamization: A Policy Under the Gun," Time, 17 April 1972, p. 36.

5. John H. Manley, "Aerospace Systems and Weather," Air University Review, November-December 1972, p. 50.

6. Ibid., p. 44.

7. Supplement to the Air Force Policy Letter for Commanders, pp. 23-24.

8. Air University Review, p. 49.

9. Supplement to the Air Force Policy Letter for Commanders, p. 19.

10. Thomas H. Moorer, "Importance of Weather to the Modern Seafarer," Bulletin American Meteorological Society, December 1966, p. 978.

11. Supplement to the Air Force Policy Letter for Commanders. p. 16.

12. Frank T. Boyle, "Gathering and Use of Weather Information, Executive Summary, pp. 1-2.

13. Ibid., p. 7-8.

14. Air Force System Command, Mission Analysis of Air Force Weather Mission 1985, Executive Summary, pp. 1-6.

15. William H. Best Jr., "Environmental Service: What is it Worth?," pp. 1-20. Cited with special permission of B/Gen Best.

SELECTED BIBLIOGRAPHY

1. Adamson, H. C., and Kosco, G. F. Halsey's Typhoons. New York: Crown, 1967. (MH D767 A3).

2. Air Force Systems Command, Electronic Systems Division. Mission Analysis of Air Force Weather Mission 1985, Executive Summary (Book 1) (U). L. G. Hanscom Field, Mass.: Draft, July 1972. SECRET NOFORN.

3. Hq, Army Air Forces. An Analysis of the Weather Factor in this War, June 1944. Washington: 1944.

4. Army Electronic Proving Ground. Weather Information for Army Tactical Operations (German Supporting Study). Fort Huachuca, Ariz.: AEPG-SIG Report No. 950-14, Supplement No. 1, 15 December 1955.

5. Bentley, Richard, "Weather in War Time." Quarterly Journal of the Royal Meteorological Society, Vol. 33, April 1907, pp. 88-138.

6. Best, William H. Jr. Environmental Service: What is it Worth? Briefing given to Air Staff, Hq USAF, 16 November 1972. (Cited with special permission of B/Gen Best).

7. Boyle, Frank J. Gathering and Use of Weather Information, Executive Summary (U), Air Force Systems Command, Space and Missile Systems Organization, SAMSO TR 70-239, Los Angeles: 9 March 1971.

8. Conrad, V. "War Climatology." Bulletin American Meteorological Society, Vol. 23, May 1972, pp. 217-219.

9. Cooper, Leonard. Many Roads to Moscow. New York: Coward-McCann, 1968. (MH DK51.7).

10. Decker, Fred W., et. al. Weather Effect on Army Operations: Weather in World War II (2 Volumes). Corvallis, Oregon: Oregon State College, Department of Physics, 1956. (MH OSC DP WEAO WW II).

    (A comprehensive survey of how weather affected military operations throughout World War II.)

11. Decker, Fred W., et. al. Weather Effect on Army Operations: Weather in the Korean Conflict (2 Volumes). Corvallis, Oregon: Oregon State College, Department of Physics, 1956. (MH OSC DP WEAO Korea).

12. Encyclopedia Britannica. Chicago: William Benton, 1968. Vol. 16, pp. 24-25: "Napoleonic Wars: The Russian Campaign, 1812."

13. Flammer, Philip M. "Weather and the Normandy Invasion." Military Review, Vol. 41, June 1961, pp. 20-28.

14. Fuller, Grace H. Weather in Relation to War, A List of References. Washington: Library of Congress, 7 January 1943.

(A comprehensive bibliography on weather influence on military operations up to early in World War II.)

15. Gibbs, Peter. Crimean Blunder. New York: Holt, Rinehart, and Winston, 1960. (MH DK214 G5).

16. Jacobs, Woodrow C. "Wartime Developments in Applied Climatology." Monographs, American Meteorological Society, Vol. 1, August 1947, 52 pp.

(An excellent report on how climatology was applied to military decisionmaking during World War II.)

17. Jess, Edward O. (Retired Colonel, USAF). Letter to author, 15 November 1972.

18. Krick, Irving P. War and Weather. Washington: Hq, Air Material Command, May 1946. (TL 558 UGK7).

19. Landsberg, H. E.; Benton, G. S.; and Bond, H. Weather Conditions in Relation to Incendiary Bombing of the Tokyo Area. Washington: Hq. 20th Air Force, Operations Analysis Division, 20 April 1945.

20. Lash, Robert L. "Why Not Use the Weather?" Military Review, Vol. 32, July 1952, pp. 16-23.

21. Manley, John H. "Aerospace Systems and Weather." Air University Review, Vol. 24, November-December 1972, pp. 42-52.

22. Martin, Robert J. "Meteorology in Peace and War." The Military Engineer, Vol. 32, September-October 1940, pp. 343-346.

23. Mattingly, Garrett. The Armada. Boston: Houghton Mifflin, 1959. (MH DA360 M3).

24. Military Analysis Division. Weather Factors in Combat Bombardment Operations in the European Theater. Washington: Part of the United States Strategic Bombing Survey, January 1947. (MH D785 U6).

25. Military Intelligence Service, US War Department. War and the Weather. Washington: 9 July 1942.

26. Moorer, Thomas H. "Importance of Weather to the Modern Sea Farer." Bulletin American Meteorological Society, Vol. 47, December 1966, pp. 976-979.

27. "More Bombs Than Ever." Time, Vol. 101, 1 January 1973, pp. 10 +.

28. O'Conner, Raymond G., ed. American Defense Policy in Perspective From Colonial Times to the Present. New York: John Wiley, 1965, pp. 266-269: "War in the Pacific," by H. H. Arnold. (UA23 033).

29. Seamans, Robert C. Jr. "Air Force Appropriations Request FY-73." Supplement to the Air Force Policy Letter for Commanders, April 1972, pp. 2-28.

30. Senter, W. O. "The Importance of Weather in Modern Warfare." In: United States at War: December 7, 1942-December 7, 1943 Washington: Army and Navy Journal, 1944.

31. Shunk, James F. "The Capability of IGLOO WHITE For Weather Detection." Aerospace Sciences Review (Published by Hq Air Weather Service). August 1972, pp. 20-25.

32. "The Signal Corps Meteorological Service, A. E. F." Monthly Weather Review, Vol. 47, December 1919, pp. 870-871.

33. US Engineer School Library. Weather and War, A Selected List of Articles. Fort Belvoir, Va., March 1947. (MH ENGSL WW Bibl).

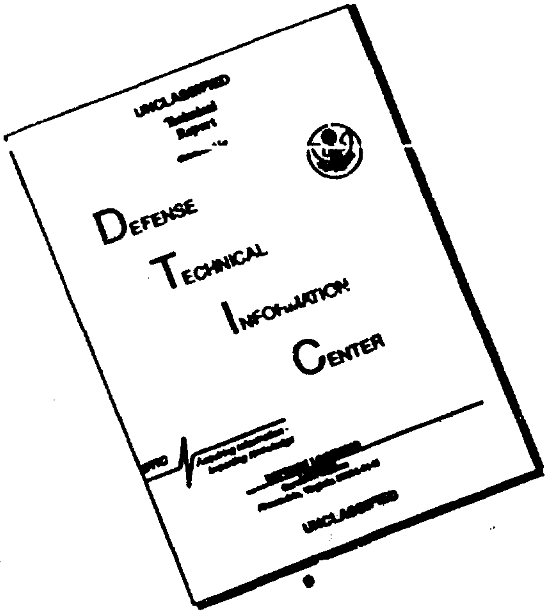
34. "Vietnamization: A Policy Under the Gun." Time, Vol. 99, 17 April 1972, pp. 30 +.

35. Ward, Robert DeC. "Weather Controls Over the Fighting During the Spring of 1918." The Scientific Monthly, Vol. 7, July 1918, pp. 24-33.

36. Ward, Robert DeC. "Weather Controls Over the Fighting During the Summer of 1918." The Scientific Monthly, Vol. 7, October 1918, pp. 289-298.

37. "Weather and War," New York Times, 14 January 1940, p. II-7.

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.