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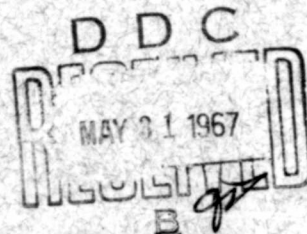
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RESEARCH STUDY REPORT RER-34

ANALOGS OF YUMA CLIMATE IN SOUTH AMERICA
YUMA ANALOGS No. 9

THOMAS G. TURNBULL
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YUMA ANALOGS No. 9

⑦ THOMAS G. TURNBULL,

REGIONAL ENVIRONMENTS RESEARCH BRANCH

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ABSTRACT

NO AREA OF CLOSE ANALOGY TO YUMA CLIMATE IS FOUND IN SOUTH AMERICA. HOWEVER, WHEN SINGLE ELEMENTS OF CLIMATE ARE CONSIDERED, SUCH AS MEAN TEMPERATURE FOR THE COLDEST MONTH OR MEAN ANNUAL PRECIPITATION, SOME AREAS ARE CLOSELY ANALOGOUS. WHEN AREAS OF SEMIANALOGY ARE ADDED, CERTAIN CLIMATIC ELEMENTS ARE FOUND TO BE COMPARABLE TO YUMA OVER MUCH OF THE CONTINENT.

WARMEST MONTH TEMPERATURE ANALOGY OCCURS IN NORTHERN ARGENTINA, WESTERN PARAGUAY, AND EASTERN BOLIVIA. COLDEST MONTH TEMPERATURE ANALOGY IS FOUND ON THE NORTHERN COAST OF CHILE, THE ANDEAN FOOTHILLS OF WESTERN PERU, AND THE HIGHLANDS OF ECUADOR, COLOMBIA, AND VENEZUELA. ON THE EASTERN SIDE OF THE ANDES MORE AREAS OF ANALOGY ARE FOUND IN BOLIVIA, URUGUAY, SOUTHERN BRAZIL, AND THE LOWLANDS OF NORTHERN ARGENTINA. MEAN DAILY MAXIMUM TEMPERATURE ANALOGY IS CONFINED TO A SMALL AREA OF NORTHERN ARGENTINA. MUCH OF NORTHERN ARGENTINA, SOUTHERN BRAZIL, URUGUAY, AND VARIOUS AREAS OF THE ANDES ARE ANALOGOUS FOR MEAN DAILY MINIMUM TEMPERATURES DURING THE COLDEST MONTH. ANALOGOUS MEAN DAILY TEMPERATURE RANGES ARE FOUND THROUGHOUT MOST OF ARGENTINA, URUGUAY, AND PARAGUAY, AND AT VARIOUS ELEVATIONS IN THE ANDES AND UPLAND REGIONS OF THE NORTHERN COUNTRIES IN THE STUDY AREA. A SMALL AREA OF ABSOLUTE MAXIMUM TEMPERATURE ANALOGY EXISTS IN NORTHERN ARGENTINA. A NARROW STRIP OF PRECIPITATION ANALOGY IS FOUND IN PERU AND EXTENDS SOUTHWARD TO CENTRAL CHILE BETWEEN THE DRIER COASTAL LOWLANDS AND THE WETTER UPLANDS, AS WELL AS IN NORTHWESTERN ARGENTINA. WARMEST MONTH CLOUDINESS ANALOGY IS FOUND IN THE WESTERN FOOTHILLS OF THE ANDES BETWEEN 22° AND 37° SOUTH LATITUDE. ANALOGOUS AREAS OF WINDSPEED ARE FOUND OVER MOST OF THE STUDY AREA. THERE ARE NO REGIONS OF MEAN DEW-POINT ANALOGY FOR THE WARMEST MONTH OR MEAN RELATIVE HUMIDITY FOR THE DRIEST MONTH IN SOUTH AMERICA.

ANALOGS OF YUMA CLIMATE IN SOUTH AMERICA

1. INTRODUCTION

THIS REPORT IS THE NINTH IN A SERIES OF STUDIES COMPARING THE CLIMATE OF YUMA TEST STATION, ARIZONA, WITH THAT OF OTHER DESERTS OF THE WORLD.* PREVIOUS STUDIES HAVE COMPARED THE CLIMATE OF YUMA WITH THAT OF DESERT REGIONS IN ASIA, AFRICA, AND NORTH AMERICA. SINCE YUMA TEST STATION HAS ALREADY BEEN THE SUBJECT OF AN ENVIRONMENTAL STUDY(1) WHICH SUMMARIZES BOTH THE LONG-TERM RECORDS OF THE YUMA WEATHER BUREAU STATION AND SHORTER RECORDS FROM STATIONS WITHIN YUMA TEST STATION PROPER, THE PRESENT REPORT CONSISTS OF A COMPARISON BETWEEN THE YUMA DATA AND RECORDS FROM STATIONS IN SOUTH AMERICA.

THERE HAS BEEN NO ATTEMPT TO PREPARE A REGIONAL CLIMATOLOGY OF SOUTH AMERICA. THE APPROACH HAS BEEN TO SELECT CERTAIN CLIMATIC ELEMENTS THAT ARE CONSIDERED MOST SIGNIFICANT, AND FOR EACH TO MAP THE AREAS HAVING CONDITIONS THAT MIGHT BE REGARDED AS CLOSELY ANALOGOUS TO THOSE AT YUMA. THE INFORMATION ON THESE MAPS ALSO HAS BEEN CONSOLIDATED INTO A SINGLE COMPOSITE MAP SHOWING AREAS WHERE THERE IS A COINCIDENCE OF ANALOGOUS AREAS FOR MORE THAN ONE CLIMATIC ELEMENT. THIS REPORT CONSISTS ESSENTIALLY OF A SERIES OF MAPS, AN EXPLANATORY TEXT, AND TABLES SHOWING CLIMATIC VALUES FOR ALL MONTHS AT SELECTED STATIONS.

2. RESEARCH TECHNIQUES

SINCE THE PRIMARY PURPOSE OF THE STUDY WAS COMPARISON AND ANALOGY, IT WAS NECESSARY TO MODIFY ACCEPTED CLIMATOLOGICAL RESEARCH TECHNIQUES AND TO DEVELOP NEW ONES. THE TECHNIQUES, LIMITATIONS OF THE STUDY, AND DEFINITIONS ADOPTED ARE DISCUSSED BELOW.

A. METHODS

THE PROCEDURE CONSISTED OF THE CHOICE, PLOTTING, AND ANALYSIS OF SIGNIFICANT CLIMATIC ELEMENTS FOR COMPARISON. CLIMATIC ELEMENTS WERE CHOSEN WITH THE OBJECT OF DERIVING MEANINGFUL COMPARISON WITH OBSERVATIONS

*THE SCOPE OF THE ANALOG SERIES ORIGINALLY CONSISTED OF YUMA ANALOGS NOS. 1 THROUGH 8, COVERING THE EIGHT DESERT REGIONS OF THE NORTHERN HEMISPHERE. THESE WERE PREPARED FOR THE CORPS OF ENGINEERS IN RESPONSE TO THEIR REQUEST FOR A CLIMATIC EVALUATION OF YUMA AS A DESERT TESTING SITE. YUMA ANALOGS NOS. 9 THROUGH 11 EXTEND THE COVERAGE OF THE SERIES TO INCLUDE THE SOUTHERN HEMISPHERE DESERTS. THESE STUDIES, UNDERTAKEN BY QMREC, COMPLETE THE ANALYSIS OF THE WORLD'S DESERT REGIONS.

CONTAINED IN THE YUMA CLIMATOLOGICAL RECORDS(7). AVAILABILITY OF DATA FOR SOUTH AMERICA AND THE COMPARABILITY OF THESE DATA WITH RECORDS FROM YUMA WERE CONSIDERED.

TEMPERATURE, HUMIDITY, PRECIPITATION, CLOUD COVER, AND WINDSPEED WERE SINGLED OUT AS IMPORTANT ELEMENTS. IT WAS ASSUMED THAT TEST PERSONNEL ARE MOST INTERESTED IN STRESS PERIODS AND IN OBSERVED EXTREMES OF CLIMATIC ELEMENTS; THEREFORE, THE WARMEST AND COLDEST MONTHS OF THE YEAR AT EACH STATION, RATHER THAN SPECIFIC CALENDAR MONTHS, WERE STUDIED.

DATA FOR ALL STATIONS IN THE STUDY AREA, FROM ALL AVAILABLE SOURCES, WERE PLOTTED ON SEPARATE BASE MAPS FOR EACH ELEMENT. AT EACH STATION THE VALUE OF THE ELEMENT, THE PERIOD OF RECORD, AND THE MONTH OF OBSERVATION WERE ENTERED. FROM THE DATA SHOWN, THE MOST REPRESENTATIVE VALUES, CONSISTENT WITH SURROUNDING VALUES AND WITH THOSE TO BE EXPECTED FROM THEORETICAL CONSIDERATIONS, WERE SELECTED.

CLASSES WERE THEN ESTABLISHED DEFINING THE RANGE OF VALUES CONSIDERED TO BE CLOSELY ANALOGOUS TO THE YUMA CLIMATE. IN DEALING WITH TEMPERATURES, A RANGE EXTENDING 5°F ABOVE AND BELOW THE YUMA TEMPERATURE IS CONSIDERED TO BE CLOSELY ANALOGOUS. EXTENSIONS OF 5°F BEYOND BOTH ENDS OF THIS RANGE ARE DESIGNATED AS SEMIANALOGOUS, HOTTER OR COOLER. VALUES OF MEAN ANNUAL PRECIPITATION BETWEEN 2 AND 6 INCHES ARE CONSIDERED ANALOGOUS; VALUES LESS THAN 2 INCHES AND BETWEEN 6 AND 9 INCHES ARE DESIGNATED SEMIANALOGOUS. MEAN WINDSPEEDS OF 4 TO 7 MILES PER HOUR ARE CONSIDERED ANALOGOUS, AND THE SEMIANALOGOUS CLASSES INCLUDE VALUES OF LESS THAN 4, AND FROM 8 TO 12 MILES PER HOUR. SYMBOLS WERE ADOPTED TO REPRESENT THESE CLASSES AND THE APPROPRIATE SYMBOL FOR EACH STATION WAS ENTERED ON THE MAPS.

ANALOGOUS REGIONS WERE THEN DELIMITED, BASED ON THE DISTRIBUTION OF CLASS SYMBOLS AND UPON EXTRAPOLATION IN AREAS WHERE STATIONS ARE LACKING. FROM THE INDIVIDUAL MAPS OF ANALOGOUS AREAS, A COMPOSITE MAP WAS PREPARED, INDICATING REGIONS OF SUMMER AND WINTER TEMPERATURE ANALOGY AND ANNUAL PRECIPITATION ANALOGY.

B. LIMITATIONS

THE PROCEDURE, AS OUTLINED, HAS CERTAIN DEFINITE LIMITATIONS IN DRAWING ANALOGIES. FOREMOST AMONG THESE IS THE LACK OF QUANTITATIVE DATA FOR LARGE PARTS OF THE STUDY AREA. OTHER LIMITATIONS ARE:

(1) SIGNIFICANT DATA FOR SOME TYPES ARE NOT AVAILABLE FOR MUCH OF SOUTH AMERICA. GUST VELOCITY, VISIBILITY, CLOUD TYPE, AND DUST COUNT ARE AMONG THE FACTORS OMITTED FOR THIS REASON.

(2) NO TREATMENT OF DURATION OR FREQUENCY OF TEMPERATURES AND PRECIPITATION HAS BEEN ATTEMPTED BECAUSE THE ORIGINAL DATA REQUIRED FOR SUCH TREATMENT ARE NOT READILY AVAILABLE.

(3) STATIONS ARE NOT ALWAYS REPRESENTATIVE OF LARGE SURROUNDING AREAS BECAUSE OF LOCAL TERRAIN DIFFERENCES.

C. DEFINITIONS

THE ELEMENTS COMPARED AND MAPPED IN THIS STUDY ARE DEFINED BELOW. THE TERM "MEAN" IN THE DEFINITIONS EMBRACES THE PERIOD OF RECORD AT THE STATION. ALL TEMPERATURES ARE EXPRESSED IN DEGREES FAHRENHEIT.

MEAN MONTHLY TEMPERATURE - AVERAGE OF THE MEAN TEMPERATURES FOR EACH DAY WITHIN A GIVEN MONTH, AVERAGED OVER A PERIOD OF YEARS.

MEAN DAILY MAXIMUM TEMPERATURE - AVERAGE OF THE MAXIMUM TEMPERATURES OF EACH DAY WITHIN A GIVEN MONTH, AVERAGED OVER A PERIOD OF YEARS.

ABSOLUTE MAXIMUM TEMPERATURE - THE HIGHEST TEMPERATURE EVER OBSERVED AT THE STATION.

MEAN DAILY MINIMUM TEMPERATURE - AVERAGE OF THE MINIMUM TEMPERATURES OF EACH DAY WITHIN A GIVEN MONTH, AVERAGED OVER A PERIOD OF YEARS.

MEAN DAILY TEMPERATURE RANGE - THE DIFFERENCE BETWEEN THE MEAN DAILY MAXIMUM TEMPERATURE AND THE MEAN DAILY MINIMUM TEMPERATURE FOR A GIVEN MONTH.

MEAN ANNUAL PRECIPITATION - AVERAGE OF THE PRECIPITATION TOTALS OF EACH YEAR WITHIN THE PERIOD OF RECORD.

MEAN CLOUD COVER - THE ARITHMETIC MEAN OF ALL OBSERVATIONS OF CLOUD COVER IN TENTHS OF SKY COVERAGE FOR A GIVEN MONTH, AVERAGED OVER A PERIOD OF YEARS.

MEAN WINDSPEED - THE ARITHMETIC MEAN OF HOURLY WINDSPEEDS IN MILES PER HOUR FOR EACH DAY OF A GIVEN TIME PERIOD, USUALLY A MONTH, AVERAGED OVER A PERIOD OF YEARS.

PREVAILING WIND DIRECTION - THE MOST FREQUENTLY OCCURRING WIND DIRECTION DURING A GIVEN TIME PERIOD, SUCH AS A MONTH, FOR SEVERAL YEARS OF RECORD.

MEAN RELATIVE HUMIDITY - AVERAGE OF THE HOURLY RELATIVE HUMIDITY VALUES FOR EACH DAY OF THE MONTH, AVERAGED OVER A PERIOD OF YEARS.

3. GEOGRAPHIC SETTING

THE REGION TREATED IN THIS STUDY COMPRISES THE CONTINENT OF SOUTH AMERICA, AND INCLUDES THE FALKLAND ISLANDS.

A. TOPOGRAPHY

THE STUDY AREA CONTAINS A GREAT DIVERSITY OF LANDFORMS. THE ANDES MOUNTAINS PARALLEL THE ENTIRE WESTERN COAST OF THE STUDY AREA, FROM TIERRA DEL FUEGO IN THE SOUTH TO THE CARIBBEAN COASTS OF VENEZUELA AND COLOMBIA IN THE NORTH, A DISTANCE OF OVER 4,000 MILES. THEIR WIDEST PART EXCEEDS 400 MILES IN BOLIVIA. THEIR PEAKS, MANY OF WHICH ARE HIGHER THAN MT. MCKINLEY (HIGHEST IN NORTH AMERICA), INCLUDE AGONCAGUA (22,835 FT.), THE HIGHEST IN THE AMERICAS. TO THE EAST OF THE ANDEAN CORDILLERA IS THE AMAZON BASIN, A REGION ABOUT THE SIZE OF THE UNITED STATES, CONTAINING THE WORLD'S LARGEST TROPICAL RAIN FOREST. TO THE SOUTH OF THE AMAZON BASIN ARE THE GRASSLANDS OF ARGENTINA, PARAGUAY, AND URUGUAY. THE UPLANDS, OR PLATEAUS, OF CENTRAL AND EASTERN BRAZIL COMPRISE THE ONLY OTHER GREAT NATURAL REGION OF THE STUDY AREA.

IMPORTANT RIVERS WHICH FLOW THROUGH THE STUDY AREA INCLUDE THE AMAZON, PARANA, URUGUAY, MADEIRA, NEGRO, AND SAO FRANCISCO, ALL OF WHICH ORIGINATE IN UPLAND AREAS AND FLOW THROUGH REGIONS WHERE PRECIPITATION IS PLentiful.

THE STUDY AREA INCLUDES ONE MAJOR DESERT, THE ATACAMA DESERT OF NORTHERN CHILE. THIS DESERT, AVERAGING 2,000 FEET IN ELEVATION, IS A SERIES OF DRY SALT BASINS BOUNDED ON THE WEST BY THE PACIFIC COASTAL RANGE, ABOUT 2,500 FEET IN ELEVATION, AND ON THE EAST BY THE CORDILLERA DE DONEYKO, A FLANKING RANGE OF THE ANDES SEPARATING THE DESERT FROM THE HIGHLANDS. THE ATACAMA EXTENDS FROM 18° TO 28° SOUTH LATITUDE. THERE IS LITTLE VEGETATION, AND ONLY A FEW STREAMS FLOW THROUGH IT TO THE PACIFIC OCEAN.

NORTH OF THE ATACAMA DESERT IS A DRY COASTAL AREA EXTENDING TO THE BORDER OF ECUADOR. THIS DRY COASTAL AREA IS EXTREMELY NARROW AS THE MOUNTAINS OF THE ANDEAN CHAIN REACH ALMOST TO THE OCEAN. SMALLER AREAS OF DESERT ENVIRONMENT ARE ALSO FOUND IN SOUTHERN ARGENTINA.

B. CLIMATE

THE CLIMATE OF THE ATACAMA DESERT AND THE DRY COASTAL AREAS OF PERU DIFFERS GREATLY FROM THAT OF YUMA. MEAN SUMMER TEMPERATURES ARE IN THE SEVENTIES IN COMPARISON TO THE NINETIES OF YUMA. MEAN WINTER TEMPERATURES ARE IN THE HIGH FIFTIES AND SIXTIES, CLOSELY ANALOGOUS TO THOSE AT YUMA. PRECIPITATION IS GENERALLY LESS THAN ONE INCH ANNUALLY THROUGHOUT THIS REGION.

IN THE DESERT REGIONS OF SOUTHERN ARGENTINA RAINFALL IS COMPARABLE TO THAT OF YUMA, BUT SUMMER TEMPERATURES ARE EVEN LOWER THAN THOSE IN THE ATACAMA DESERT. WINTER TEMPERATURES ARE MUCH COLDER THAN THOSE AT YUMA, AVERAGING IN THE THIRTIES.

ELSEWHERE IN THE STUDY AREA SUMMER TEMPERATURES ANALOGOUS TO YUMA ARE FOUND IN NORTHERN ARGENTINA, PARAGUAY, AND BOLIVIA. ANALOGOUS WINTER TEMPERATURES ARE FOUND IN THE LOWLANDS OF NORTHERN ARGENTINA, SOUTHERN BRAZIL, URUGUAY, BOLIVIA, THE WESTERN FOOTHILLS OF THE ANDES IN PERU, AND THE HIGHLANDS OF ECUADOR, COLOMBIA, AND VENEZUELA.

THROUGHOUT MOST OF SOUTH AMERICA PRECIPITATION FAR EXCEEDS THAT AT YUMA. THE HIGHER ELEVATIONS OF THE ANDES, THE GREAT EXPANSE OF THE AMAZON BASIN, THE UPLANDS OF EASTERN AND CENTRAL BRAZIL, AND THE SOUTHERNMOST AREAS OF CHILE ALL RECEIVE MORE RAIN THAN YUMA.

THERE IS ONLY A SMALL AREA ON THE WESTERN COAST OF CHILE WHICH HAS A CLOUD COVER ANALOGOUS TO THAT AT YUMA DURING THE WARMEST MONTH. THIS REGION IS JUST SOUTH OF THE ATACAMA DESERT.

ANALOGOUS AREAS OF MEAN WINDSPEED DURING THE ENTIRE YEAR CAN BE FOUND OVER MOST OF THE STUDY AREA. IN THE HIGHER ELEVATIONS OF THE ANDEAN CORDILLERA AND THE EXTREME SOUTHERN REGIONS OF CHILE AND ARGENTINA WINDSPEEDS GREATLY EXCEED THOSE AT YUMA.

MOST OF SOUTH AMERICA IS ANALOGOUS TO YUMA IN AT LEAST ONE CLIMATIC ELEMENT. HOWEVER, THERE IS ONLY ONE SMALL REGION IN THE STUDY AREA WHICH HAS SEVERAL CLIMATIC ELEMENTS WHICH ARE ANALOGOUS TO YUMA -- A NARROW STRIP WITHIN THE CENTRAL ANDES OF WESTERN PERU AND NORTHERN CHILE.

4. ANALYSIS OF INDIVIDUAL MAPS

TO DIFFERENTIATE AREAS OF ANALOGY AND SEMIANALOGY EFFECTIVELY, MAPS OF THE FOLLOWING CLIMATIC ELEMENTS HAVE BEEN PLOTTED AND ANALYZED: MEAN TEMPERATURE FOR THE WARMEST AND COLDEST MONTHS, MEAN DAILY MAXIMUM TEMPERATURE FOR THE WARMEST MONTH, ABSOLUTE MAXIMUM TEMPERATURE, MEAN DAILY MINIMUM TEMPERATURE FOR THE COLDEST MONTH, MEAN RELATIVE HUMIDITY FOR THE DRIEST MONTH, MEAN ANNUAL PRECIPITATION, PREVAILING WIND DIRECTION, MEAN WIND VELOCITY FOR THE DRIEST MONTH, AND MEAN CLOUDINESS DURING THE WARMEST MONTH. A COMPOSITE MAP WAS MADE OF SUMMER AND WINTER TEMPERATURES AND PRECIPITATION.

A. MEAN TEMPERATURE, WARMEST MONTH (FIG. 2)

ANALOGOUS CLASSES FOR MEAN TEMPERATURE WARMEST MONTH ARE FROM 86°F THROUGH 96°F. THERE ARE 2 SMALL REGIONS IN THE STUDY AREA WHICH ARE ANALOGOUS. THE LARGER OF THESE IS LOCATED IN THE NORTHERN PART OF ARGENTINA AND EXTENDS THROUGH WESTERN PARAGUAY INTO EASTERN BOLIVIA. THE REMAINING AREA CENTERS AROUND ONE STATION IN CENTRAL VENEZUELA.

THE ANALOGOUS AREAS FOR MEAN TEMPERATURE OF THE WARMEST MONTH EXPERIENCE TEMPERATURES SLIGHTLY COOLER THAN THOSE AT YUMA. BOTH HAVE A MEAN

TEMPERATURE OF 86°F WHEREAS YUMA HAS A MEAN TEMPERATURE OF 91°F FOR THE WARMEST MONTH.

B. MEAN DAILY MAXIMUM TEMPERATURE, WARMEST MONTH (FIG. 3)

TEMPERATURES FROM 101°F THROUGH 111°F ARE CONSIDERED CLOSELY ANALOGOUS FOR THE MEAN DAILY MAXIMUM TEMPERATURE FOR THE WARMEST MONTH. THE AREA OF ANALOGY OF MEAN MAXIMUM TEMPERATURE IS SMALLER THAN THAT FOR MEAN TEMPERATURE FOR THE WARMEST MONTH. THE ANALOGOUS AREA CENTERS AROUND THE STATION OF RIVADAVIA IN NORTHERN ARGENTINA. ITS MEAN DAILY MAXIMUM TEMPERATURE IS 6°F HIGHER THAN THE NEAREST STATION FOR WHICH DATA ARE AVAILABLE. THE MEAN MAXIMUM TEMPERATURE OF 103°F AT RIVADAVIA COMPARES FAVORABLY WITH THE 106°F AT YUMA.

C. ABSOLUTE MAXIMUM TEMPERATURE (FIG. 4)

THE ABSOLUTE MAXIMUM TEMPERATURE AT YUMA IN A PERIOD OF 84 YEARS IS 123°F . THUS, THE VALUES FOR ANALOGOUS TEMPERATURES OCCUR BETWEEN 118°F AND 128°F . WITHIN THE STUDY AREA ANALOGOUS ABSOLUTE MAXIMUM TEMPERATURES ARE FOUND AT 3 STATIONS WITHIN A SMALL AREA. THE AREA IS LOCATED IN NORTHERN ARGENTINA WITH RIVADAVIA REPORTING 120°F ., THE HIGHEST ABSOLUTE MAXIMUM TEMPERATURE. THE OTHER 2 ANALOGOUS STATIONS ARE TUCMAN AND SELVA, ARGENTINA.

D. MEAN DAILY TEMPERATURE RANGE, WARMEST MONTH (FIG. 5)

AT YUMA THE WARMEST MONTH IS JULY WITH A MEAN RANGE OF 29.4°F , ON WHICH THE ANALOGOUS CLASS OF 24°F TO 34°F IS BASED.

ANALOGOUS AREAS ARE FOUND THROUGHOUT THE STUDY AREA. THE MAJOR AREA INCLUDES NEARLY ALL OF ARGENTINA, WESTERN URUGUAY, EASTERN PARAGUAY, AND THE HIGHLANDS OF EASTERN BRAZIL. SMALL AREAS OF ANALOGY OCCUR AT DIFFERENT ELEVATIONS WITHIN THE ANDES MOUNTAINS AND THE HIGHEST ELEVATIONS OF VENEZUELA AND THE GUIANAS. THE EFFECT OF THE OCEANS UPON THE COASTAL STATIONS IS NOTICEABLE. THE MEAN DAILY RANGE IS ONLY HALF THAT FOUND IN MOST OF INLAND SOUTH AMERICA.

E. MEAN TEMPERATURE, COLDEST MONTH (FIG. 6)

THE RANGE OF ANALOGY FOR MEAN TEMPERATURE FOR THE COLDEST MONTH IS 50°F TO 60°F . ANALOGOUS AREAS FOR MEAN TEMPERATURE OF THE COLDEST MONTH ARE FOUND ACROSS MOST OF NORTHERN ARGENTINA, URUGUAY, SOUTHERN PARAGUAY, AND IN THE EXTREME SOUTHERN PART OF BRAZIL. ANALOGOUS AREAS ALSO ARE FOUND ALONG MUCH OF THE SOUTHEASTERN COAST OF BRAZIL, THE COAST OF CENTRAL AND NORTHERN CHILE, AND IN THE MOUNTAINS OF PERU, BOLIVIA, ECUADOR, AND COLOMBIA.

REGIONS WHICH ARE TOO COLD FOR ANALOGY ARE FOUND IN THE HIGHLANDS OF CHILE AND PERU AS WELL AS IN THE SOUTHERN PART OF ARGENTINA AND CHILE.

F. MEAN DAILY MINIMUM TEMPERATURE, COLDEST MONTH (FIG. 7)

ANALOGOUS MEAN DAILY MINIMUM TEMPERATURES FOR THE COLDEST MONTH OCCUR BETWEEN 37°F AND 47°F. THE LARGEST ANALOGOUS REGION OF MEAN DAILY MINIMUM TEMPERATURE IS FOUND ALONG THE COAST OF CENTRAL ARGENTINA, NORTHERN ARGENTINA, URUGUAY, AND PORTIONS OF SOUTHERN BRAZIL. ON THE WEST SIDE OF THE STUDY AREA ANALOGOUS REGIONS EXTEND FROM THE LOWLANDS OF SOUTHERN CHILE INTO THE LOWER ELEVATIONS OF THE ANDES IN NORTHERN CHILE, BOLIVIA, AND PERU, AND THE HIGHEST REGIONS OF ECUADOR. THE ANALOGOUS AREA OF SOUTHERN BRAZIL IS INTERRUPTED BY A BAND OF LOWLANDS WHICH IS SLIGHTLY WARMER THAN YUMA.

G. MEAN ANNUAL PRECIPITATION (FIG. 8)

THE RANGE OF MEAN ANNUAL PRECIPITATION CONSIDERED CLOSELY ANALOGOUS TO THAT AT YUMA (3.4 INCHES PER YEAR) IS 2 TO 6 INCHES. AREAS OF PRECIPITATION ANALOGY IN THE STUDY EXIST IN THE HIGHER ELEVATIONS OF THE ANDES MOUNTAINS IN NORTHERN CHILE AND PERU. SMALLER AREAS OF ANALOGY EXIST IN SCATTERED REGIONS OF SOUTHERN ARGENTINA.

A LARGE AREA TOO DRY FOR CLOSE ANALOGY (SEMIANALOGOUS) IS FOUND IN THE ATACAMA DESERT OF NORTHERN CHILE AND ALONG THE COAST OF PERU NORTHWARD TO THE BORDER OF ECUADOR. MOST OF THESE AREAS RECEIVE LESS THAN ONE INCH OF PRECIPITATION EACH YEAR, AND MANY AREAS AVERAGE LESS THAN ONE-HALF INCH PER YEAR.

H. MEAN RELATIVE HUMIDITY, DRIEST MONTH (FIG. 9)

ALTHOUGH AN ANALOGOUS RANGE FOR MEAN RELATIVE HUMIDITY DURING THE DRIEST MONTH WAS SET UP (19% TO 29%), NO AREA WAS FOUND WHICH WAS ANALOGOUS. HOWEVER, TWO AREAS OF SLIGHTLY HIGHER SEMIANALOGY ARE FOUND. THE LARGER AREA OF SEMIANALOGY IS LOCATED IN NORTHEASTERN CHILE AND NORTHWESTERN ARGENTINA, AN AREA OF INTERIOR DRAINAGE THAT CONTAINS SEVERAL SALT LAKES AND SMALL BASINS. THE SMALL AREA CENTERS AROUND CONCEPCION, CHILE.

I. MEAN CLOUDINESS, WARMEST MONTH (FIG. 10)

DATA ON CLOUDINESS ARE ALMOST ENTIRELY LACKING OVER THE NORTHERN PART OF THE STUDY AREA. HOWEVER, ENOUGH DATA ARE AVAILABLE IN THE SOUTHERN PART TO MAP THE CLOSELY ANALOGOUS AREA. THE ANALOGOUS REGIME IS CONSIDERED TO BE FROM 1.1 TO 2.0 TENTHS.

AN AREA OF ANALOGY FOR MEAN CLOUDINESS EXISTS IN THE HIGHLANDS OF CENTRAL AND NORTHERN CHILE AND THE EXTREME WESTERN PART OF ARGENTINA. THIS ANALOGOUS AREA REACHES THE COAST ONLY IN ONE LOCALITY -- AROUND THE STATIONS OF CONSTITUCION AND CHANCO AT 36° SOUTH LATITUDE.

J. MEAN WINDSPEED, DRIEST MONTH (FIG. 11)

AT YUMA, MEAN WINDSPEED DURING THE DRIEST MONTH IS 6.1 MPH; WINDS OF 4 TO 7 MPH ARE CONSIDERED CLOSELY ANALOGOUS. AREAS WHERE MEAN WINDSPEEDS ARE ANALOGOUS TO THOSE AT YUMA ARE LOCATED ALONG THE NORTHERN COAST OF THE STUDY AREA, AS WELL AS ALONG THE COASTS OF BRAZIL AND SOUTHERN ARGENTINA. INLAND, ANALOGOUS AREAS ARE FOUND IN PORTIONS OF THE BRAZILIAN HIGHLANDS, PARAGUAY, ARGENTINA, AND BOLIVIA.

THE LARGEST AREA WITH MEAN WINDSPEED LOWER THAN THAT AT YUMA IS LOCATED IN THE BRAZILIAN HIGHLANDS. REGIONS WITH MEAN WINDSPEED HIGHER THAN THAT OF YUMA ARE FOUND ON THE SOUTHERN COASTS OF CHILE AND ARGENTINA, AND THE COAST OF URUGUAY.

5. COMPOSITE OF ANALOGOUS AREAS (FIG. 12)

ANALOGOUS AREAS OF MEAN TEMPERATURE FOR THE WARMEST AND COLDEST MONTHS AND MEAN ANNUAL PRECIPITATION IN THE STUDY AREA ARE PRESENTED IN FIGURE 12. THESE ELEMENTS ARE REGARDED AS BEING MOST IMPORTANT IN DETERMINING THE TOTAL ENVIRONMENTAL ANALOGY.

ON A BASE MAP OF THE STUDY AREA AN OUTLINE WAS DRAWN OF THE ANALOGOUS AREAS FOR MEAN TEMPERATURE FOR THE WARMEST AND COLDEST MONTHS. TO EACH WAS GIVEN A DISTINCT PATTERN OF SHADING. SINCE THERE WAS NO OVERLAPPING, NO NEW PATTERN WAS EVOLVED. HOWEVER, WHEN THE OUTLINE OF ANALOGOUS PRECIPITATION IS ADDED TO THE BASE MAP, A NARROW AREA OF OVERLAPPING OCCURS WITHIN THE LOWER ELEVATIONS OF THE ANDES ON THE WESTERN COAST OF PERU AND THE COAST OF CHILE BETWEEN 29° AND 31° SOUTH LATITUDE.

NOWHERE IN THE STUDY AREA DO REGIONS OF MEAN TEMPERATURE FOR THE WARMEST MONTH OVERLAP WITH THE ANALOGOUS AREA OF MEAN ANNUAL PRECIPITATION. THE ANALOGOUS AREA OF MEAN TEMPERATURE FOR THE COLDEST MONTH GREATLY EXCEEDS THAT SHOWN FOR THE MEAN TEMPERATURE FOR THE WARMEST MONTH.

6. TABLES OF MONTHLY VALUES

IN ORDER TO SHOW THE MONTHLY VARIATION IN THE CLIMATIC ELEMENTS CONSIDERED IN THIS REPORT, A SERIES OF TABLES IS INCLUDED SHOWING MEAN VALUES OF THESE ELEMENTS FOR ALL MONTHS OF THE YEAR AT 25 SELECTED STATIONS (INCLUDING YUMA) REPRESENTING VARIOUS PARTS OF THE STUDY AREA. STATIONS ARE LISTED, TOGETHER WITH GEOGRAPHICAL COORDINATES, ELEVATIONS, AND PERIODS OF RECORD, IN THE FIRST TABLE OF THIS SERIES. THESE REPRESENT SUCH DIVERSE AREAS AS THE AMAZON BASIN (MANAOS), THE HIGHER ELEVATIONS OF THE ANDES (CUZCO), THE DESERT OF NORTHERN CHILE (IQUIQUE), AND THE GRASSLANDS OF ARGENTINA (TUCUMAN). IN EACH TABLE THE MEAN VALUES FOR YUMA ARE ALSO SHOWN FOR COMPARISON. THE ELEMENTS SHOWN ON THESE TABLES ARE THE SAME AS THOSE PRESENTED IN THE MAP SERIES, WITH THE ADDITION OF ABSOLUTE MINIMUM TEMPERATURE AND THE DELETION OF MEAN DEWPOINT.

A REVIEW OF THESE TABLES REVEALS CHARACTERISTICS OF CLIMATIC ANALOGS THAT ARE NOT EVIDENT FROM THE MAPS. FOR EXAMPLE, THE PRECIPITATION VALUES ON THE MAPS ARE ANNUAL MEANS WHILE THE TABLE GIVES SOME INFORMATION ABOUT THE DISTRIBUTION OF THE PRECIPITATION THROUGHOUT THE YEAR. THE TABLES ALSO BRING OUT CERTAIN FEATURES OF THE MONTHLY MEAN TEMPERATURES. IT IS NOTED THAT YUMA AND RIO DE JANEIRO HAVE ANALOGOUS MEAN TEMPERATURES FOR THE YEAR, ALTHOUGH THE MONTHLY VARIATION AT YUMA GREATLY EXCEEDS THAT EXPERIENCED AT RIO DE JANEIRO.

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TABLE 1: STATIONS USED IN TABLES OF MONTHLY VALUES

STATION	ELEVATION IN FEET	LATITUDE	LONGITUDE	PERIOD OF RECORD (YRS)		
				TEMP.	PREC.	OTHER
AMBATO ECUADOR	8,596	1° 10' S	78° 42' W	5	5	3
ANDAGOYA COLOMBIA	250	5° 04' N	76° 55' W	8	15	--
BELEM BRAZIL	33	1° 27' S	48° 27' W	12	15	10
BUENOS AIRES ARGENTINA	25	34° 35' S	58° 27' W	68	53	45
CARACAS VENEZUELA	3,420	10° 30' N	66° 53' W	22	46	16
COL. SARMIENTO ARGENTINA	886	45° 36' S	69° 05' W	20	20	12
CUYABA BRAZIL	541	15° 35' S	56° 06' W	15	29	10
CUZCO PERU	10,581	13° 33' S	71° 55' W	4	12	3-5
DADANAWA BR. GUIANA	625	2° 30' N	59° 30' W	9	9	--
GEORGETOWN BR. GUIANA	6	6° 50' N	58° 12' W	41	37	12
IQUIQUE CHILE	30	20° 12' S	70° 11' W	13	40	8
LIMA PERU	518	12° 02' S	77° 02' W	10	18	5
MANAOS BRAZIL	147	3° 10' S	60° 00' W	10	27	10
MERIDA VENEZUELA	5,384	8° 36' N	71° 05' W	9	19	9
MORRO DO CHAPEU BRAZIL	997	11° 31' S	41° 14' W	6	13	6
NATAL BRAZIL	52	5° 46' S	35° 12' W	18	13	5-9
PORTO VELHO BRAZIL	407	8° 46' S	63° 55' W	14	14	--
POSADAS ARGENTINA	138	27° 24' S	55° 55' W	11	20	11
PUCALLPA PERU	495	8° 23' S	74° 32' W	7	7	--
RIO DE JANEIRO BRAZIL	149	22° 54' S	43° 10' W	38	84	29
SANTIAGO CHILE	1,705	33° 27' S	70° 42' W	14	58	14
SUCRE BOLIVIA	9,344	19° 03' S	65° 17' W	5	52	3
TUCUMAN ARGENTINA	1,465	26° 50' S	65° 10' W	40	40	12
USHUAIA ARGENTINA	26	54° 50' S	68° 20' W	20	20	4
YUMA UNITED STATES	206	32° 40' N	114° 36' W	80	84	44

TABLE 11: MEAN MONTHLY TEMPERATURE (°F)

<u>STATIONS</u>	<u>JAN</u>	<u>FEB</u>	<u>MAR</u>	<u>APR</u>	<u>MAY</u>	<u>JUN</u>	<u>JUL</u>	<u>AUG</u>	<u>SEP</u>	<u>OCT</u>	<u>NOV</u>	<u>DEC</u>	<u>YR</u>
AMBATO	58	58	58	58	57	56	54	54	56	58	58	58	57
ANDAGOYA	82	82	82	82	82	82	81	81	81	82	81	81	82
BELEM	79	79	79	80	80	80	80	80	80	80	80	80	80
BUENOS AIRES	74	73	69	61	55	50	49	51	55	60	66	71	61
CARACAS	64	65	66	68	69	69	68	68	68	68	67	65	67
COL. SARMIENTO	65	64	59	52	45	38	37	42	46	53	58	62	52
CUYABA	80	79	79	78	75	72	72	75	78	81	81	80	78
CUZCO	54	54	54	52	52	50	48	51	53	54	55	54	53
DADANAWA	82	82	83	83	82	81	81	82	84	85	85	82	83
GEORGETOWN	79	79	80	80	80	80	80	81	81	81	81	80	80
IQUIQUE	69	69	67	65	62	61	59	60	61	63	66	68	64
LIMA	73	74	74	70	66	63	61	61	61	63	66	69	67
MANAOS	79	80	79	79	80	80	80	81	82	82	81	80	80
MERIDA	65	66	66	68	68	68	68	68	68	67	66	65	67
MORRO DO CHAPEU	69	69	69	68	65	63	62	62	65	68	68	68	66
NATAL	82	81	81	79	79	77	75	76	78	80	81	81	79
PORTO VELHO	81	81	81	81	81	80	80	82	83	82	82	81	81
POSADAS	80	79	77	70	64	60	61	61	67	70	74	78	70
PUCALLPA	80	80	80	79	79	78	76	79	80	80	80	80	79
RIO DE JANEIRO	78	79	77	75	72	69	68	69	70	72	74	76	73
SANTIAGO	69	68	65	59	53	48	48	50	54	58	63	67	59
SUCRE	55	55	56	55	52	50	50	53	56	56	58	57	54
TUCUMAN	77	75	72	66	60	54	54	57	64	69	73	75	66
USHUAIA	50	49	47	41	37	33	34	35	39	43	44	49	42
YUMA	55	59	64	70	77	85	91	90	85	73	62	55	72

TABLE III: MEAN DAILY MAXIMUM TEMPERATURE (°F)

<u>STATIONS</u>	<u>JAN</u>	<u>FEB</u>	<u>MAR</u>	<u>APR</u>	<u>MAY</u>	<u>JUN</u>	<u>JUL</u>	<u>AUG</u>	<u>SEP</u>	<u>OCT</u>	<u>NOV</u>	<u>DEC</u>	<u>YR</u>
AMBATO	70	69	70	70	68	67	65	66	67	70	72	70	69
ANDAGOYA	90	89	90	90	89	89	89	89	89	90	88	88	89
BELEM	86	86	86	87	88	88	88	88	89	89	89	88	88
BUENOS AIRES	84	84	78	71	64	58	57	59	63	69	75	82	70
CARACAS	75	77	78	80	80	78	77	78	79	79	77	75	78
COL. SARMIENTO	78	77	70	62	54	46	45	51	57	66	70	74	62
CUYABA	91	91	91	91	88	88	90	93	92	92	91	90	91
CUZCO	64	63	64	66	65	64	63	66	66	67	68	65	65
DADANAWA	93	92	93	92	90	89	90	92	94	97	96	93	93
GEORGETOWN	84	83	84	85	85	85	85	86	87	87	87	84	85
IQUIQUE	77	77	75	72	69	66	65	66	67	70	73	75	71
LIMA	80	82	81	77	72	67	65	65	66	68	72	76	72
MANAOS	88	88	88	87	88	88	89	91	92	92	91	90	89
MERIDA	73	74	74	75	76	76	77	77	77	75	74	73	75
MORRO DO CHAPEU	77	79	81	78	74	72	71	72	76	80	80	81	77
NATAL	86	85	86	86	85	83	82	82	84	85	85	86	85
PORTO VELHO	85	85	85	86	86	86	88	90	91	88	87	85	87
POSADAS	93	92	90	83	76	70	71	74	78	82	87	91	82
PUCALLPA	89	88	88	87	88	88	87	91	91	90	88	89	89
RIO DE JANEIRO	84	85	83	80	77	75	75	76	75	77	79	82	79
SANTIAGO	85	84	80	74	65	58	59	62	66	72	78	83	72
SUCRE	63	61	64	63	63	61	61	65	67	65	68	66	64
TUCUMAN	90	88	83	77	70	66	67	71	79	82	86	87	79
USHUAIA	59	59	56	51	42	41	41	44	46	55	55	57	51
YUMA	67	72	78	86	93	102	106	104	100	88	76	68	87

TABLE IV: MEAN DAILY MINIMUM TEMPERATURE (°F)

STATIONS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YR
AMBATO	49	48	48	49	49	47	46	45	46	47	47	48	47
ANDAGOYA	74	74	74	75	74	74	74	74	73	74	74	74	74
BELEM	72	72	73	73	73	72	71	71	71	71	71	72	72
BUENOS AIRES	64	63	60	54	47	42	42	43	47	51	56	60	52
CARACAS	56	56	57	60	62	62	61	61	61	61	60	58	60
COL. SARMIENTO	52	51	47	42	36	31	29	33	36	41	46	49	41
CUYABA	73	73	72	70	66	63	61	63	67	71	72	72	69
CUZCO	44	44	43	41	39	36	33	37	40	42	42	43	40
DADANAWA	72	71	72	73	73	72	72	72	73	73	73	72	72
GEORGETOWN	74	74	75	76	75	75	75	75	76	76	75	75	75
IQUIQUE	62	62	60	57	56	55	54	54	55	57	58	60	57
LIMA	67	67	66	63	60	58	57	57	56	58	59	63	61
MANAOS	75	75	75	75	75	75	74	75	75	76	76	75	75
MERIDA	57	58	58	60	61	60	59	59	59	60	59	57	59
MORRO DO CHAPEU	59	60	60	59	56	54	53	53	54	57	58	59	57
NATAL	76	76	75	73	72	71	69	69	72	75	76	77	73
PORTO VELHO	76	76	76	76	75	73	72	74	76	76	76	76	75
POSADAS	68	67	65	60	54	50	50	52	55	57	61	66	59
PUCALLPA	72	72	72	71	69	68	66	67	69	71	71	72	70
RIO DE JANEIRO	73	73	72	69	66	64	63	63	65	66	68	71	68
SANTIAGO	53	52	49	45	41	37	37	39	42	45	48	51	45
SUCRE	48	48	47	45	40	38	37	40	44	46	48	49	44
TUCUMAN	67	67	64	58	52	45	44	45	52	58	62	65	57
USHUAIA	41	42	39	36	28	30	28	28	31	35	36	39	35
YUMA	42	46	50	54	60	68	71	77	70	58	48	44	58

TABLE V: ABSOLUTE MAXIMUM TEMPERATURE (°F)

<u>STATIONS</u>	<u>JAN</u>	<u>FEB</u>	<u>MAR</u>	<u>APR</u>	<u>MAY</u>	<u>JUN</u>	<u>JUL</u>	<u>AUG</u>	<u>SEP</u>	<u>OCT</u>	<u>NOV</u>	<u>DEC</u>	<u>YR</u>
AMRATO	81	82	79	79	76	74	75	77	75	78	81	78	82
ANDAGOYA	96	95	98	97	96	100	100	98	100	99	95	96	100
BELEM	91	91	91	91	91	92	91	91	91	93	94	92	94
BUENOS AIRES	99	103	93	85	79	75	76	76	86	87	95	100	103
CARACAS	83	88	91	88	89	85	84	86	85	86	84	83	91
COL. SARMIENTO	99	96	93	83	71	64	68	67	76	86	92	99	99
CUYABA	--	--	--	--	--	--	--	--	--	--	--	--	--
CUZCO	75	79	76	74	76	76	76	75	80	79	80	80	80
DADANAWA	98	101	99	98	96	97	95	100	100	103	100	102	103
GEORGETOWN	88	89	89	89	90	88	90	90	91	92	91	89	92
IQUIQUE	90	92	89	85	80	86	82	78	80	85	89	91	92
LIMA	87	88	90	86	88	85	76	74	77	77	85	86	90
MANAOS	99	97	97	94	95	95	94	96	99	99	99	102	102
MERIDA	79	82	81	84	83	82	85	83	83	83	80	78	85
MORRO DO CHAPEU	84	86	90	88	82	86	80	80	86	89	89	91	91
NATAL	89	90	90	89	91	89	87	87	89	89	89	88	91
PORTO VELHO	96	96	96	96	96	96	96	100	100	104	98	97	104
POSADAS	--	--	--	--	--	--	--	--	--	--	--	--	--
PUCALLPA	--	--	--	--	--	--	--	--	--	--	--	--	--
RIO DE JANEIRO	102	98	97	94	95	90	91	93	100	102	100	102	102
SANTIAGO	96	98	94	88	87	80	81	85	88	92	97	99	99
SUCRE	80	75	82	78	72	72	74	78	77	77	79	78	82
TUCUMAN	118	111	100	95	90	97	99	98	106	108	110	106	118
USHUAIA	81	79	72	65	59	57	54	59	61	70	73	80	81
YUMA	84	92	100	107	120	119	120	119	123	108	96	83	123

TABLE VI: ABSOLUTE MINIMUM TEMPERATURE (°F)

STATIONS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YR
AMBATO	37	36	32	40	39	33	32	34	35	34	33	33	32
ANDAGOYA	68	71	70	70	72	70	70	70	70	69	68	66	66
BELEM	69	68	69	69	68	69	64	68	65	68	67	67	64
BUENOS AIRES	47	46	44	35	33	30	28	32	30	37	40	46	28
CARACAS	47	46	45	51	52	53	52	53	53	54	51	47	45
COL. SARMIENTO	34	34	27	18	11	8	-27	3	14	19	29	32	-27
CUYABA	--	--	--	--	--	--	--	--	--	--	--	--	--
CUZCO	35	36	38	32	32	28	28	28	32	31	33	36	28
DADANAWA	66	68	68	68	70	69	68	70	70	70	70	69	66
GEORGETOWN	68	69	69	71	70	69	70	71	69	70	69	70	68
IQUIQUE	52	53	48	47	46	45	43	42	44	46	48	50	42
LIMA	57	60	59	57	51	50	52	49	52	54	53	54	49
MANAOS	70	70	69	69	70	66	69	70	71	71	70	69	66
MERIDA	52	52	53	54	56	55	54	54	54	55	53	52	52
MORRO DO CHAPEU	52	54	54	51	47	47	44	49	47	49	52	53	44
NATAL	68	68	66	61	65	64	63	63	64	68	65	68	56
PORTO VELHO	70	70	70	71	57	56	57	58	62	70	64	68	56
POSADAS	--	--	--	--	--	--	--	--	--	--	--	--	--
PUCALLPA	--	--	--	--	--	--	--	--	--	--	--	--	--
RIO DE JANEIRO	60	63	64	60	56	52	52	53	50	57	59	56	50
SANTIAGO	43	43	38	33	27	26	24	26	31	32	37	36	24
SUCRE	40	41	38	37	29	27	25	30	29	33	40	41	25
TUCUMAN	52	50	46	36	31	26	26	27	31	36	44	44	26
USHUAIA	28	28	27	21	-4	-1	-3	9	18	24	26	27	-4
YUMA	22	25	31	38	39	50	61	58	50	38	29	22	22

TABLE VII: MEAN MONTHLY PRECIPITATION (IN INCHES)

<u>STATIONS</u>	<u>JAN</u>	<u>FEB</u>	<u>MAR</u>	<u>APR</u>	<u>MAY</u>	<u>JUN</u>	<u>JUL</u>	<u>AUG</u>	<u>SEP</u>	<u>OCT</u>	<u>NOV</u>	<u>DEC</u>	<u>YR</u>
AMBATO	1.8	1.7	2.2	2.6	2.1	0.7	0.9	0.7	1.0	1.5	1.4	1.3	17.9
ANDAGOYA	24.9	21.4	19.5	26.1	25.5	25.8	23.3	25.3	24.6	22.7	22.4	19.5	281.0
BELEM	9.2	13.6	17.3	16.7	11.7	9.1	3.1	3.0	1.8	3.3	1.1	4.2	94.1
BUENOS AIRES	3.0	2.4	4.5	3.1	3.0	2.6	2.2	2.4	3.0	3.5	3.0	3.9	36.6
CARACAS	0.9	0.4	0.6	1.3	3.1	4.0	4.3	4.3	4.2	4.3	3.7	1.8	32.8
COL. SARMIENTO	0.2	0.4	0.4	0.5	0.8	0.5	0.8	0.4	0.5	0.2	0.2	0.2	5.1
CUYABA	10.0	9.6	8.1	4.0	2.2	0.5	0.3	1.1	1.8	5.2	6.0	8.1	56.9
CUZCO	6.5	5.4	4.4	2.0	0.6	0.2	0.2	0.4	1.0	2.7	2.9	5.5	31.8
DADANAWA	1.3	2.2	2.2	5.6	7.7	13.8	10.2	8.0	2.6	1.6	1.1	2.0	58.3
GEORGETOWN	7.3	5.9	6.1	6.7	11.1	12.1	9.6	6.4	2.8	2.3	5.8	11.3	87.3
LIQUIQUE	*	*	*	*	*	*	0.0	*	*	*	*	0.0	0.0
LIMA	0.0	*	*	*	0.1	0.2	0.4	0.4	0.4	0.2	0.1	*	1.8
MANAOS	9.8	9.2	9.8	8.6	7.0	3.8	2.3	1.4	2.0	4.1	6.1	7.8	71.9
MERIDA	2.4	1.5	3.3	7.0	10.1	7.4	4.9	5.8	6.9	10.3	8.5	3.4	71.5
MORRO DO CHAPEU	3.9	4.3	4.0	3.5	1.8	2.0	1.9	1.5	1.0	2.1	3.9	4.0	33.9
NATAL	3.1	4.9	5.7	9.0	7.1	10.5	7.7	3.6	3.4	1.0	0.6	1.2	57.8
PORTO VELHO	14.6	13.5	15.0	8.9	5.0	1.4	0.6	2.1	3.6	8.9	11.2	13.9	98.8
POBADAS	4.5	5.6	5.3	6.1	4.9	5.0	4.5	3.2	3.6	5.8	5.3	5.0	58.8
PUCALLPA	4.2	5.1	7.3	7.4	4.1	2.3	2.1	1.8	2.6	5.5	7.5	7.2	58.2
RIO DE JANEIRO	4.9	4.8	5.1	4.2	3.1	2.1	1.6	1.7	2.6	3.1	4.1	5.4	42.6
SANTIAGO	0.1	0.1	0.2	0.5	2.5	3.3	3.0	2.2	1.2	0.6	0.3	0.2	14.1
SUCRE	7.3	4.9	3.7	1.6	0.2	0.1	0.2	0.3	1.0	1.6	2.6	4.3	27.8
TUCUMAN	7.1	6.7	5.9	2.7	1.1	0.6	0.4	0.5	0.7	2.3	3.7	6.6	38.3
USHUAIA	1.7	2.1	1.7	1.9	1.5	1.6	1.2	0.9	1.2	1.5	1.9	1.8	19.0
YUMA	0.4	0.4	0.3	0.1	*	*	0.2	0.6	0.4	0.3	0.2	0.5	3.4

*LESS THAN 0.05 INCH

TABLE VIII: MEAN CLOUDINESS (IN TENTHS OF SKY COVERED)

<u>STATIONS</u>	<u>JAN</u>	<u>FEB</u>	<u>MAR</u>	<u>APR</u>	<u>MAY</u>	<u>JUN</u>	<u>JUL</u>	<u>AUG</u>	<u>SEP</u>	<u>OCT</u>	<u>NOV</u>	<u>DEC</u>	<u>YR</u>
AMBATO	7.6	7.5	7.9	7.9	7.9	7.5	8.1	7.9	7.7	7.4	7.1	7.4	7.7
ANDAGOYA	---	---	---	---	---	---	---	---	---	---	---	---	---
BELEM	6.5	7.4	7.4	7.1	6.1	5.1	4.4	4.0	3.8	3.9	4.2	5.3	6.8
BUENOS AIRES	4.0	4.2	4.0	4.0	5.1	5.8	5.0	4.8	4.7	5.3	4.5	4.1	4.6
CARACAS	5.2	4.9	5.8	7.2	7.9	8.4	7.9	7.5	7.1	6.9	7.1	6.1	6.8
COL. SARMIENTO	6.2	6.0	6.4	6.2	6.2	6.2	6.1	5.8	6.2	6.1	6.8	6.4	6.2
CUYABA	7.3	7.1	7.1	5.6	4.4	4.3	3.6	3.5	4.8	6.0	6.6	7.6	5.7
CUZCO	6.4	6.4	6.2	5.2	4.4	3.8	3.4	3.4	4.7	5.3	5.4	6.8	5.1
DADANAWA	---	---	---	---	---	---	---	---	---	---	---	---	---
GEORGETOWN	6.2	5.8	6.0	6.2	6.3	6.4	6.0	5.7	5.3	5.6	5.8	6.3	6.0
LIQUIQUE	4.8	3.6	3.6	4.0	5.7	7.9	8.5	8.5	8.2	7.0	5.7	4.3	6.0
LIMA	5.9	5.6	4.8	4.7	6.2	8.2	8.9	9.1	8.6	7.9	6.5	6.0	6.9
MANAOS	6.6	6.9	6.8	6.9	6.6	6.3	5.5	6.0	6.1	6.3	6.4	6.7	6.4
MERIDA	---	---	---	---	---	---	---	---	---	---	---	---	---
MORRO DO CHAPEU	5.6	6.2	5.8	5.8	6.0	5.8	5.9	6.0	5.4	5.7	5.9	6.2	5.9
NATAL	5.1	5.4	5.1	5.8	5.8	6.1	5.1	4.7	4.2	4.1	4.4	5.0	5.1
PORTO VELHO	---	---	---	---	---	---	---	---	---	---	---	---	---
POSADAS	5.2	5.2	4.9	5.2	5.1	5.8	5.4	5.3	5.5	5.1	4.4	5.1	5.2
PUCALLPA	---	---	---	---	---	---	---	---	---	---	---	---	---
RIO DE JANEIRO	6.6	5.9	6.0	5.9	5.6	5.3	5.0	5.6	7.0	6.9	6.9	6.8	6.1
SANTIAGO	1.7	2.2	2.2	3.7	6.3	6.8	5.8	6.2	5.7	5.0	3.6	2.4	4.3
SUCRE	8.5	8.6	7.2	5.5	4.4	4.1	4.0	3.3	5.2	7.2	7.7	8.0	6.1
TUCUMAN	5.9	5.9	6.0	5.9	5.0	4.4	4.0	3.2	4.0	5.3	5.4	5.5	5.0
USHUAIA	6.9	6.6	6.3	5.9	6.4	5.8	5.9	5.6	5.9	6.5	6.6	7.1	6.3
YUMA	2.3	2.4	2.1	1.5	1.1	0.6	1.6	1.8	1.1	1.2	1.6	2.4	1.6

TABLE IX: MEAN WINDSPEED (MPH)

<u>STATIONS</u>	<u>JAN</u>	<u>FEB</u>	<u>MAR</u>	<u>APR</u>	<u>MAY</u>	<u>JUN</u>	<u>JUL</u>	<u>AUG</u>	<u>SEP</u>	<u>OCT</u>	<u>NOV</u>	<u>DEC</u>	<u>YR</u>
AMBATO	2.7	2.2	2.5	2.2	2.2	2.2	2.9	2.9	2.7	2.7	2.7	2.9	2.6
ANDAGOYA	---	---	---	---	---	---	---	---	---	---	---	---	---
BELEM	---	---	---	---	---	---	---	---	---	---	---	---	---
BUENOS AIRES	10.0	10.5	8.9	9.9	8.3	8.8	9.8	10.0	10.9	10.1	10.2	10.1	9.8
CARACAS	6.9	8.0	8.8	7.9	7.8	8.5	7.8	6.5	6.2	6.2	6.3	6.7	7.3
COL. SARMIENTO	---	---	---	---	---	---	---	---	---	---	---	---	---
CUYABA	4.7	3.6	3.3	2.9	2.9	2.9	2.9	3.3	2.9	3.6	3.3	3.6	3.3
CUZCO	---	---	---	---	---	---	---	---	---	---	---	---	---
DADANAWA	---	---	---	---	---	---	---	---	---	---	---	---	---
GEORGETOWN	8.2	8.5	8.9	8.6	7.3	6.2	5.5	5.6	6.5	6.6	6.5	7.2	7.1
IQUIQUE	1.2	1.2	1.2	1.2	1.2	1.4	1.4	1.4	1.5	1.4	1.4	1.2	1.4
LIMA	4.5	4.5	3.6	3.1	2.9	3.4	3.6	4.3	5.7	5.4	5.1	5.4	4.3
MANAOS	3.8	4.3	3.8	3.8	3.4	4.0	3.8	4.3	4.5	4.3	4.3	3.8	4.0
MERIDA	---	---	---	---	---	---	---	---	---	---	---	---	---
MORRO DO CHAPEU	4.7	4.4	4.0	4.4	5.5	6.8	6.8	6.8	6.0	3.3	3.6	4.7	5.1
NATAL	13.2	10.6	10.1	10.1	10.6	12.1	11.6	14.2	15.9	15.9	14.8	14.8	12.6
PORTO VELHO	---	---	---	---	---	---	---	---	---	---	---	---	---
POSADAS	---	---	---	---	---	---	---	---	---	---	---	---	---
PUCALLPA	---	---	---	---	---	---	---	---	---	---	---	---	---
RIO DE JANEIRO	7.2	7.4	7.4	6.5	6.0	5.6	5.8	6.5	7.6	8.5	8.9	8.9	7.2
SANTIAGO	1.4	1.2	1.0	0.8	0.7	0.6	0.6	0.7	0.9	1.1	1.2	1.4	0.9
SUCRE	5.1	5.4	5.8	5.3	5.2	4.7	4.9	5.5	6.7	6.9	6.5	6.0	5.7
TUCUMAN	2.7	2.2	2.1	1.4	1.4	1.4	1.6	1.8	2.4	2.4	2.2	2.4	2.0
USHUAIA	8.6	8.5	7.3	6.6	7.2	6.3	8.4	7.0	9.9	9.7	9.3	7.9	8.1
YUMA	6.0	6.0	7.0	7.0	6.0	6.0	6.0	6.0	5.0	5.0	5.0	5.0	5.8

TABLE X: MEAN DEWPOINT TEMPERATURE (°F)*

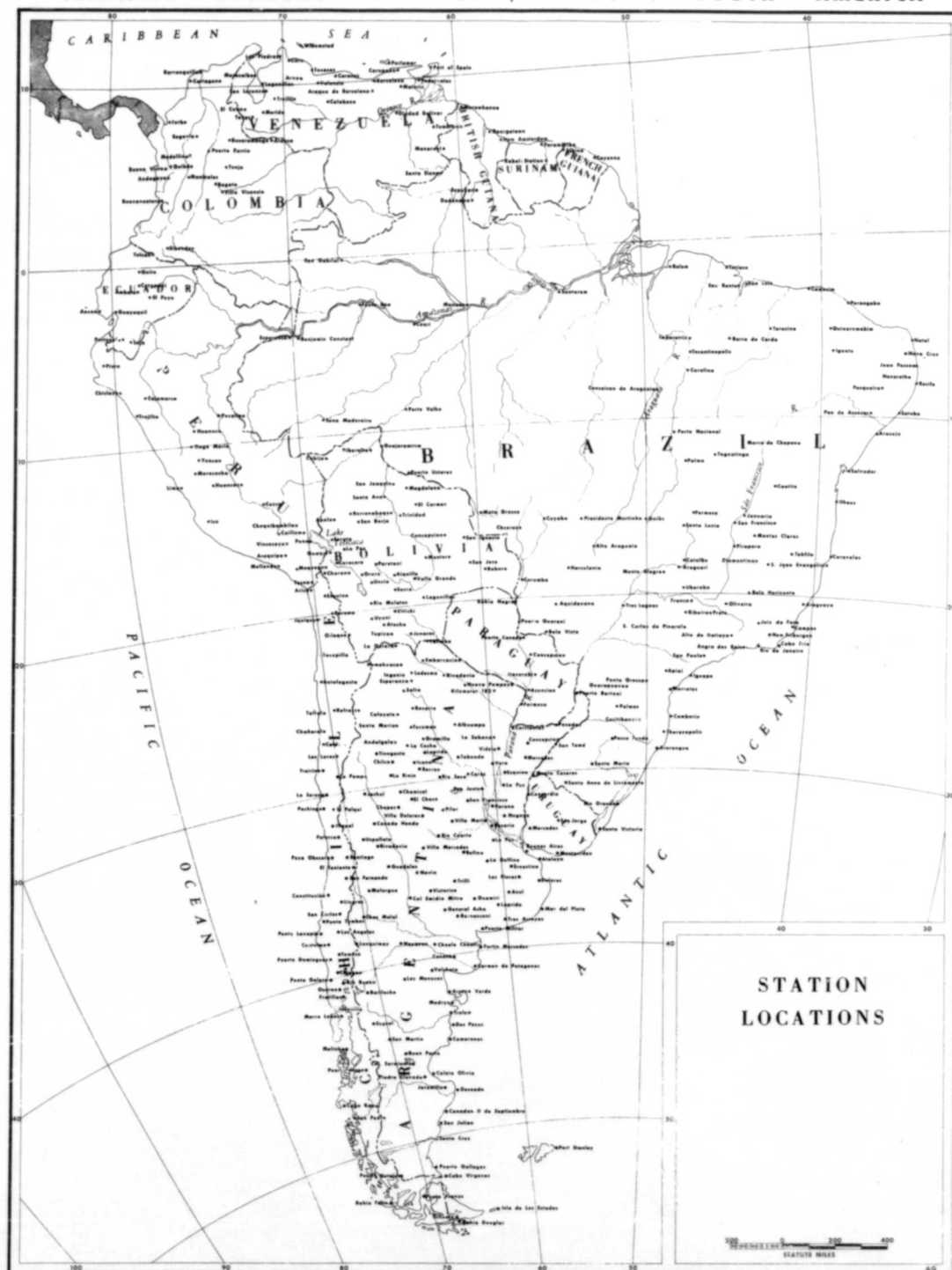
STATIONS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YR
AMBATO	50	50	50	50	49	49	46	46	48	50	49	50	49
ANDAGOYA	--	--	--	--	--	--	--	--	--	--	--	--	--
BELEM	77	77	77	77	77	75	76	76	75	75	75	77	76
BUENOS AIRES	63	64	61	55	50	46	45	44	48	52	57	61	54
CARACAS	57	58	58	60	62	62	62	62	62	62	61	59	60
COL. SARMIENTO	45	45	43	39	34	30	29	31	33	37	39	42	37
CUYABA	73	72	72	71	67	63	59	60	63	69	72	72	68
CUZCO	46	47	46	45	42	36	33	42	43	44	47	47	43
DADANAWA	--	--	--	--	--	--	--	--	--	--	--	--	--
GEORGETOWN	72	72	72	72	74	74	74	75	74	74	74	74	73
IQUIQUE	63	62	61	59	56	55	52	53	55	57	60	61	58
LIMA	66	66	67	64	59	59	57	56	56	57	61	62	61
MANAOS	72	74	73	73	74	73	72	72	73	73	73	73	73
MERIDA	57	58	59	61	62	62	61	61	61	61	60	59	60
MORRO DO CHAPEU	62	62	62	62	60	59	58	56	57	59	61	60	59
NATAL	74	73	73	72	72	71	69	69	70	72	72	72	71
PORTO VELHO	--	--	--	--	--	--	--	--	--	--	--	--	--
POSADAS	70	70	68	63	58	55	53	53	58	60	63	56	60
PUCALLPA	--	--	--	--	--	--	--	--	--	--	--	--	--
RIO DE JANEIRO	71	72	70	68	65	62	61	61	63	65	67	69	66
SANTIAGO	52	53	52	49	45	42	41	42	45	47	47	49	47
SUCRE	46	45	46	44	35	31	32	36	41	42	44	45	41
TUCUMAN	66	65	64	59	53	45	44	43	50	57	60	61	59
USHUAIA	41	39	38	33	31	28	30	31	33	37	38	43	35
YUMA	32	33	35	37	42	47	59	64	57	47	36	34	44

*FIGURES FOR ALL STATIONS EXCEPT YUMA ARE APPROXIMATE, BASED UPON RELATIONS BETWEEN MEAN MONTHLY TEMPERATURES AND RELATIVE HUMIDITIES.

9. LIST OF MAPS

- FIGURE 1: STATION LOCATION
- FIGURE 2: MEAN TEMPERATURE, WARMEST MONTH
- FIGURE 3: MEAN DAILY MAXIMUM TEMPERATURE, WARMEST MONTH
- FIGURE 4: ABSOLUTE MAXIMUM TEMPERATURE
- FIGURE 5: MEAN DAILY TEMPERATURE RANGE, WARMEST MONTH
- FIGURE 6: MEAN TEMPERATURE, COLDEST MONTH
- FIGURE 7: MEAN DAILY MINIMUM TEMPERATURE, COLDEST MONTH
- FIGURE 8: MEAN ANNUAL PRECIPITATION
- FIGURE 9: MEAN RELATIVE HUMIDITY, DRIEST MONTH
- FIGURE 10: MEAN CLOUDINESS, WARMEST MONTH
- FIGURE 11: MEAN WINDSPEED, DRIEST MONTH
- FIGURE 12: COMPOSITE OF ANALOGOUS AREAS

CLIMATIC ANALOGS OF YUMA, ARIZONA — SOUTH AMERICA



CLIMATIC ANALOGS OF YUMA, ARIZONA — SOUTH AMERICA

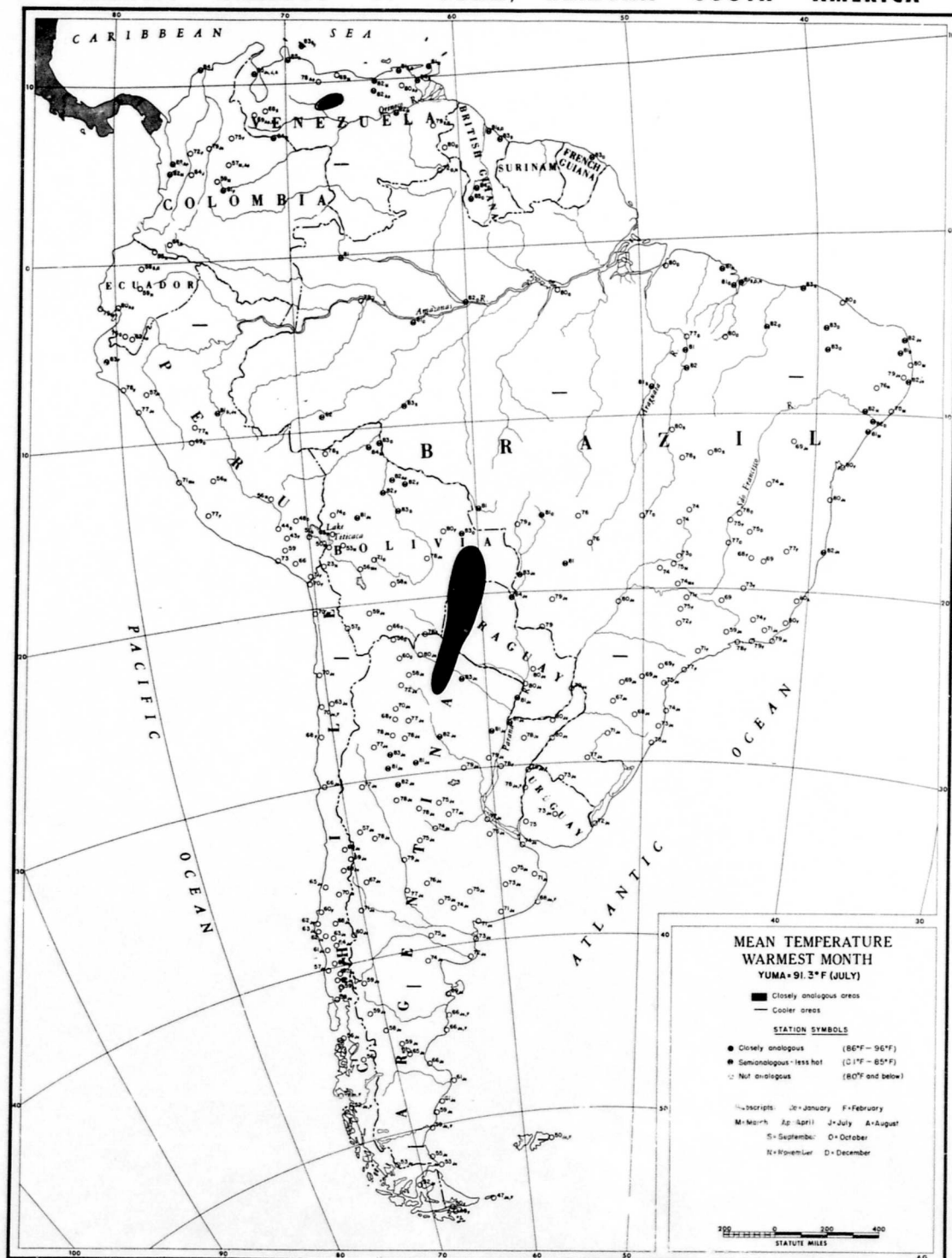


Figure - 2

CLIMATIC ANALOGS OF YUMA, ARIZONA — SOUTH AMERICA



Figure - 3

CLIMATIC ANALOGS OF YUMA, ARIZONA — SOUTH AMERICA

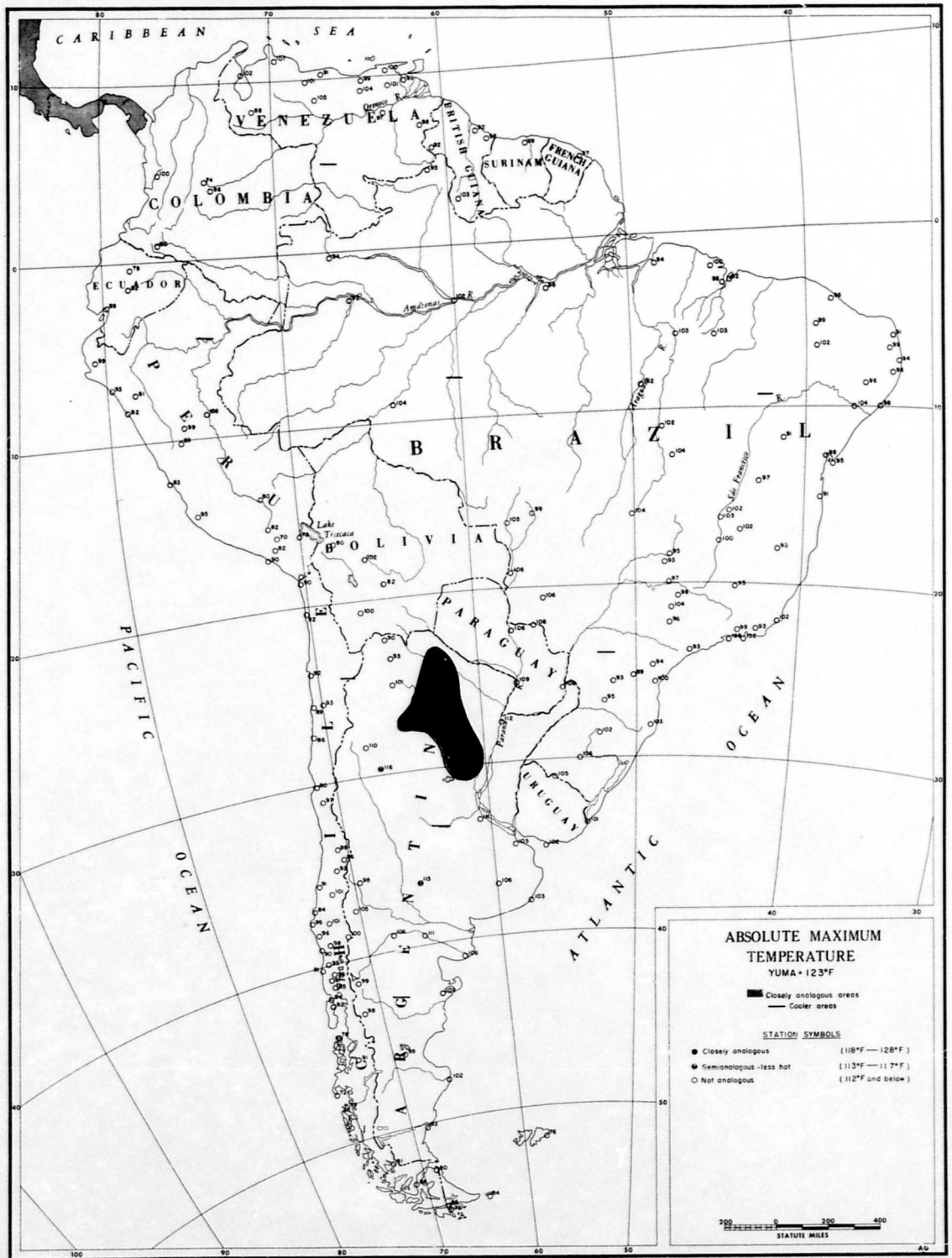


Figure - 4

CLIMATIC ANALOGS OF YUMA, ARIZONA — SOUTH AMERICA

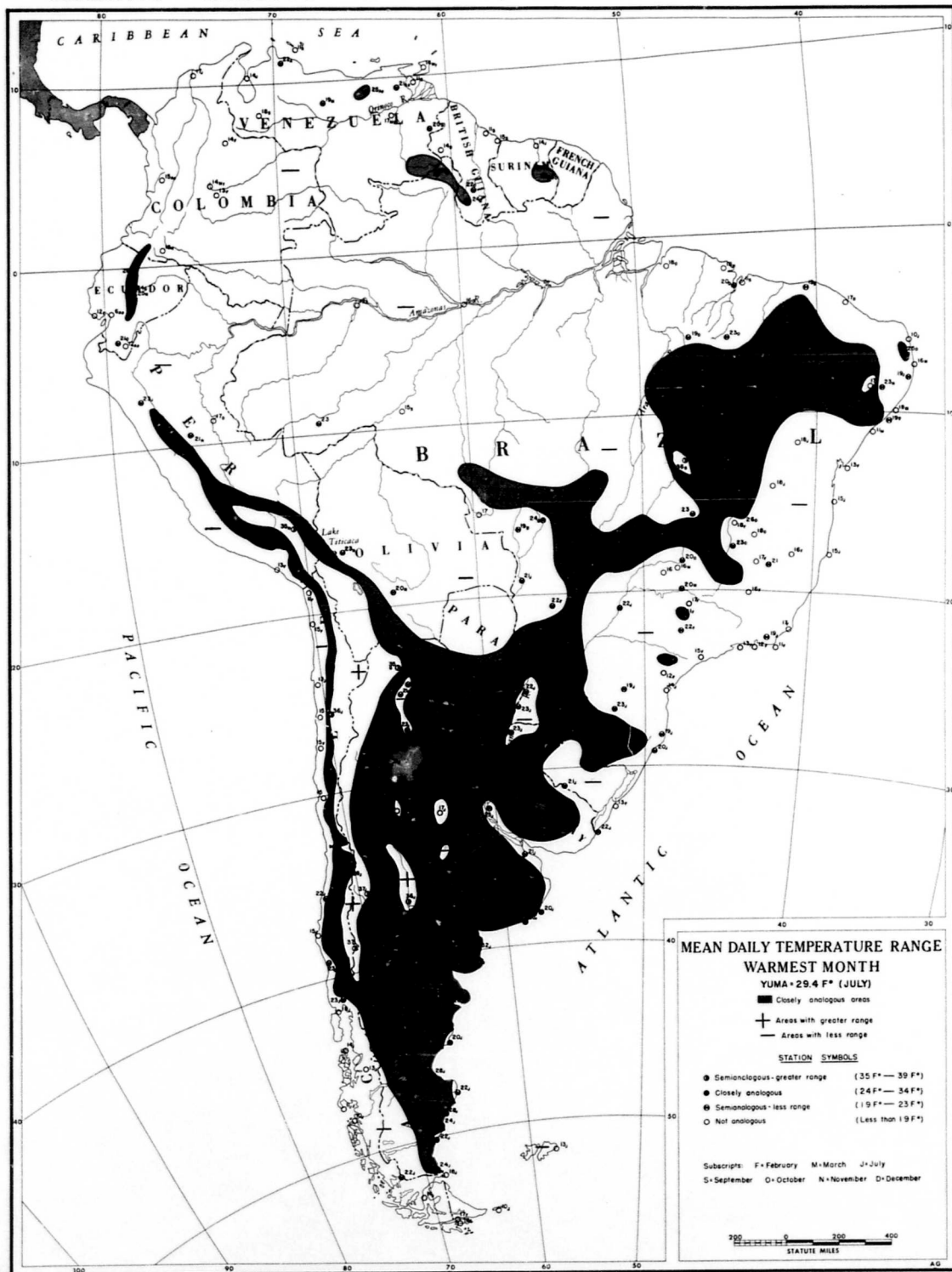


Figure - 5

CLIMATIC ANALOGS OF YUMA, ARIZONA — SOUTH AMERICA

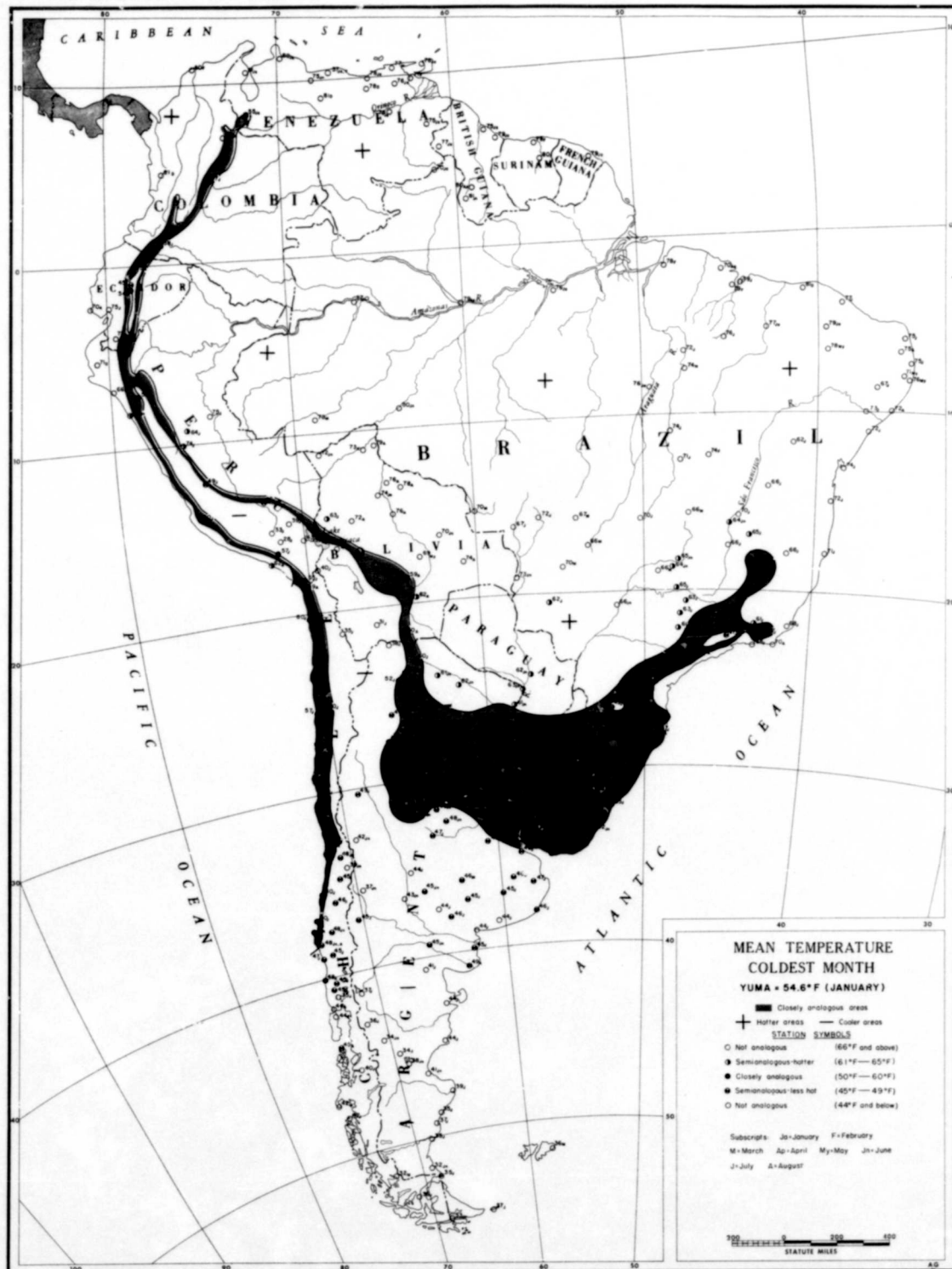


Figure - 6

CLIMATIC ANALOGS OF YUMA, ARIZONA — SOUTH AMERICA



Figure - 7

CLIMATIC ANALOGS OF YUMA, ARIZONA — SOUTH AMERICA



Figure - 8

CLIMATIC ANALOGS OF YUMA, ARIZONA — SOUTH AMERICA

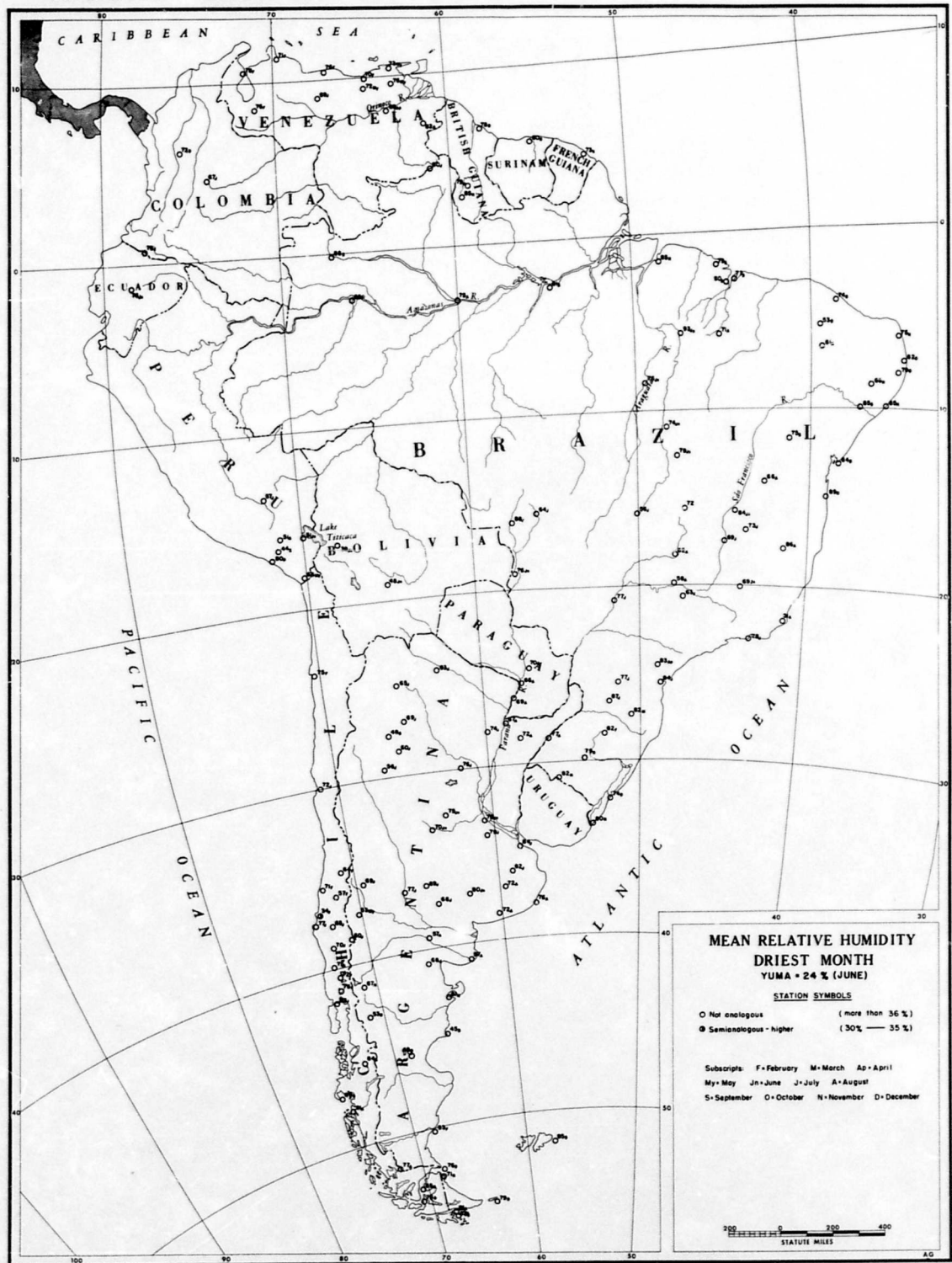


Figure - 9

CLIMATIC ANALOGS OF YUMA, ARIZONA — SOUTH AMERICA

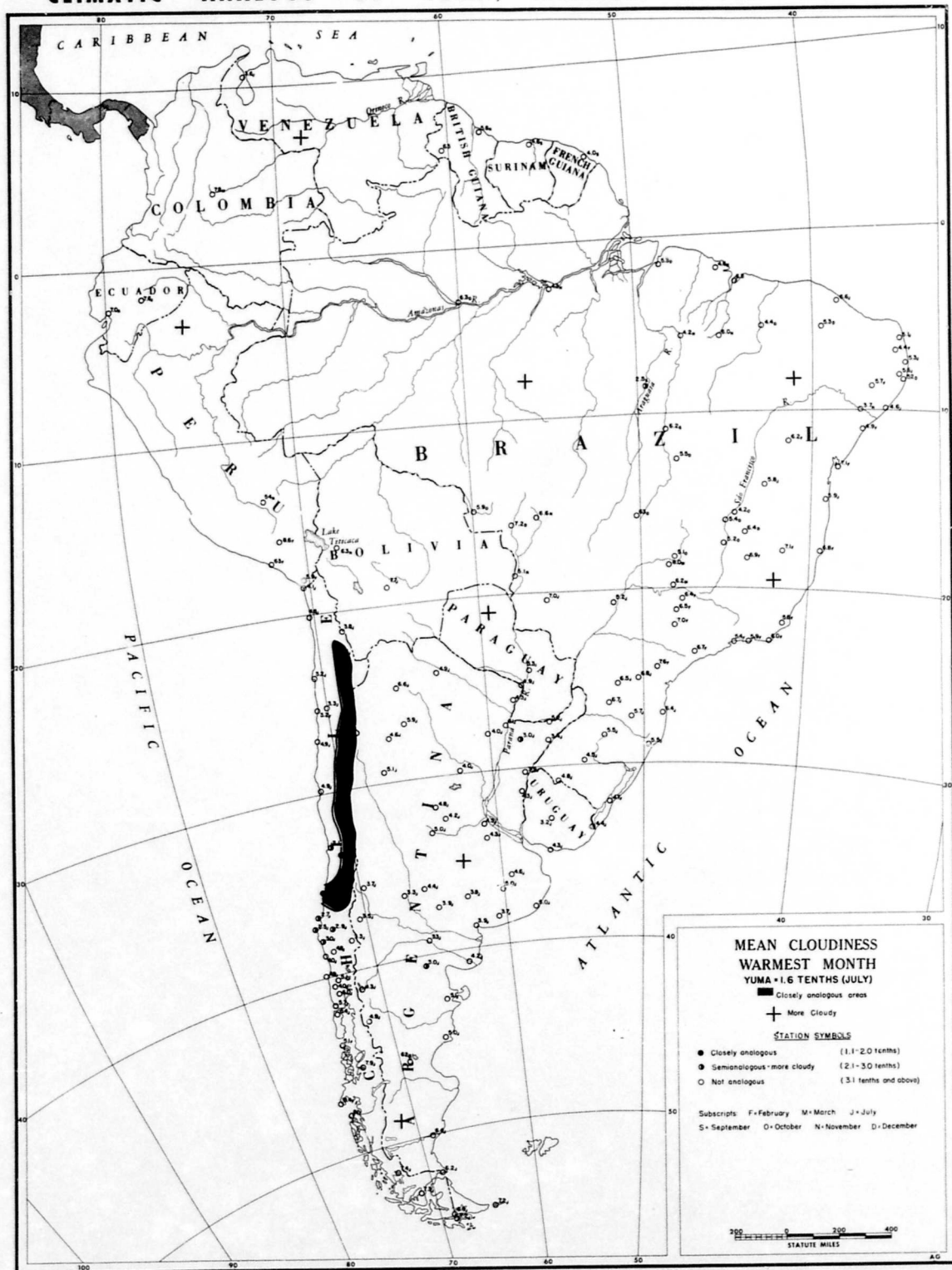


Figure - 10

CLIMATIC ANALOGS OF YUMA, ARIZONA — SOUTH AMERICA

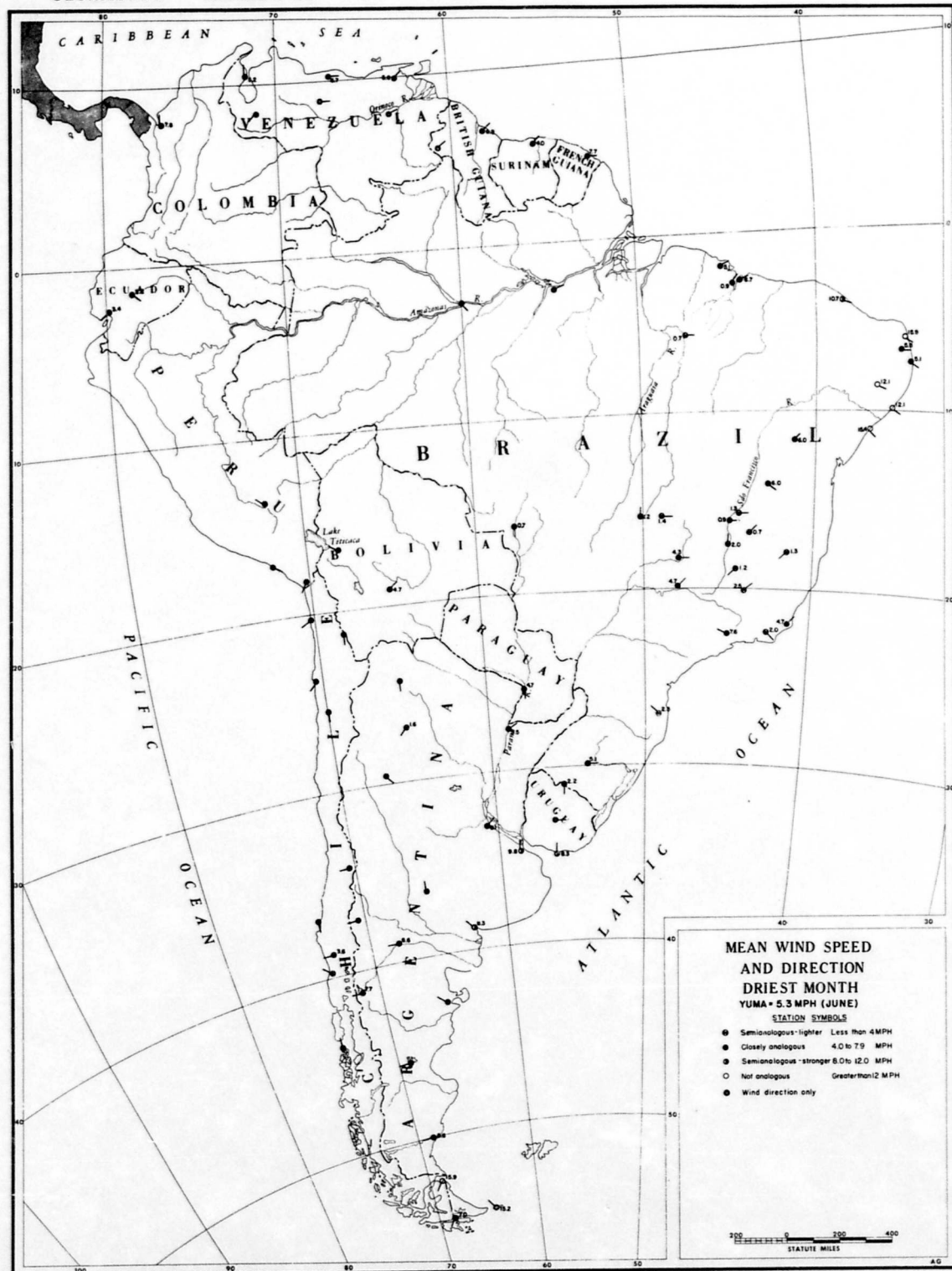


Figure - 11

Figure - 12