

AD-A132 121

TERMINAL FORECAST REFERENCE NOTEBOOK FOR AVIANO AB
ITALY(U) WEATHER SQUADRON (31ST) APO NEW YORK 09293
DETACHMENT 7 B D SILLIMAN 15 NOV 81

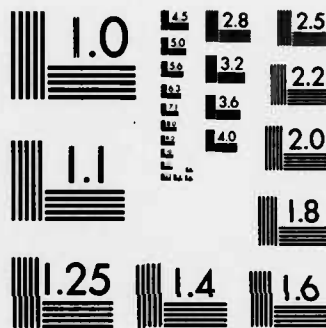
1/2

UNCLASSIFIED

F/G 4/2

NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

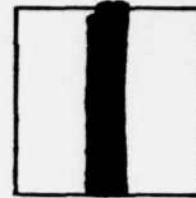
PHOTOGRAPH THIS SHEET

ADA132121

DTIC ACCESSION NUMBER



LEVEL



INVENTORY

Terminal Forecast Reference Notebook for
Aviano AB, Italy

DOCUMENT IDENTIFICATION

Final

96P

15 Nov. 81

DISTRIBUTION STATEMENT A

Approved for public release;
Distribution Unlimited

DISTRIBUTION STATEMENT

ACCESSION FOR

NTIS GRA&I

DTIC TAB

UNANNOUNCED

JUSTIFICATION



BY

DISTRIBUTION /

AVAILABILITY CODES

DIST

AVAIL AND/OR SPECIAL

A

DISTRIBUTION STAMP

DTIC
ELECTE
SEP 6 1983
D

DATE ACCESSIONED



83 08 31 058

DATE RECEIVED IN DTIC

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-DDA-2

ADA 132121



TERMINAL FORECAST REFERENCE NOTEBOOK

FOR

AVIANO AB, ITALY



APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED

PUBLISHED BY
DETACHMENT 7
31ST WEATHER SQUADRON
2D WEATHER WING (MAC)
UNITED STATES AIR FORCE
15 November 1981

Review and Approval Statement

This report approved for public release. There is no objection to unlimited distribution of this report to the public at large, or by the Defense Technical Information Center (DTIC) to the National Technical Information Service (NTIS).

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

UNCLAS

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Terminal Forecast Reference Notebook for Aviano AB, Italy		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Detachment 7, 31st Weather Squadron APO New York 09293		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Headquarters, 2d Weather Wing Aerospace Sciences Division (2WW/DN) APO New York 09012		12. REPORT DATE 15 Nov 81
		13. NUMBER OF PAGES 90
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for Public Release; Distribution Unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		

DD FORM 1473

1 JAN 73

EDITION OF 1 NOV 65 IS OBSOLETE

UNCLAS

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

BLANK PAGE

TABLE OF CONTENTS

	PAGE
Table of Contents.....	ii
Introduction.....	1
SECTION I - LOCATION AND TOPOGRAPHY	
1. General.....	2
2. Large Scale Features.....	2
a. Mountainous Areas.....	2
b. Valley Areas.....	4
c. Ocean, Lake, and River Areas.....	6
d. Industrial Areas.....	6
3. Small Scale Features.....	6
a. Mountainous Areas.....	7
b. Plains Areas.....	7
c. Obstructions.....	7
SECTION II - CLIMATIC AIDS	
1. General Climatology.....	9
2. Relationship of Climatic Elements on Flying Operations.....	9
a. Synoptic Patterns.....	9
b. Effect of Climatic Elements on Flying Operations.....	14
(1) Thunderstorms and Tornadoes.....	14
(2) Fog.....	15
(3) Rain.....	16
(4) Freezing Precipitation.....	16
(5) Snow.....	16
(6) Stratus.....	16

(7) Fronts	16
(8) Winds	17
(9) Operationally Critical Elements & Threshold Values..Attachment 1	
SECTION III - APPROVED LOCAL FORECAST STUDIES AND RULES OF THUMB	
1. Critical Forecast Elements	18
2. Visibility Study	18
3. Thunderstorm Study	18
4. Rules of Thumb	18
SECTION IV - WEATHER CONTROLS	
1. Seasonal Climatic Controls	19
2. Principal Weather Types That Affect Aviano AB, Italy (Capt Serhij Pilipowskyj)	22
APPENDICES	
1. A Dynamic Technique For Forecasting Thunderstorms at Aviano AB, Italy (1Lt Mel Castillo)	41
2. Summary of Thunderstorm Study Verification Data 1962-1979	82
3. Summary of Rules of Thumb Verification Data 1972-1979	83
4. Cyclogenesis at Aviano AB, Italy	84
5. Visibility Forecast Study (MSGt Arnold Saunders)	86
FIGURES	
1. Topographic Map of the Area Surrounding Aviano AB, Italy 50NM Concentric Circles (5,000,000:1 Scale)	3
2. Topographic Map of the Area Surrounding Aviano AB, Italy 25NM Concentric Circles (2,000,000:1 Scale)	5
3. Surface Observing Equipment Plan at Aviano AB, Italy (Not to Scale)	8
4. Climatological Statistics	10
5. Climatological Statistics	11
6. Climatological Statistics	12
7. Climatological Statistics	13

8. Upper Air Flow Pattern, Type IA.....	25
9. Upper Air Flow Pattern, Type IB.....	28
10. Upper Air Flow Pattern, Type II.....	30
11. Upper Air Flow Pattern, Type III-A.....	32
12. Upper Air Flow Pattern, Type III-B.....	35
13. Upper Air Flow Pattern, Type III-C.....	37
14. Upper Air Flow Pattern, Type IV.....	39
15. Mean Frequency of Thunderstorms, 1956 - 1959.....	44
16. Thunderstorm Nomogram.....	78
17. Thunderstorm Worksheet.....	79
18. Revised Thunderstorm Worksheet.....	80
19. Visibility Forecast Study Worksheet	87

INTRODUCTION

There are many factors which influence the timeliness and accuracy with which a terminal forecast is made. Important among these factors are a forecaster's meteorological knowledge, concise analysis and integration of meteorological parameters, and the knowledge of factors which tend to modify or retard weather systems. This Terminal Forecast Reference Notebook (TFRN) is the first step in supplying the forecaster this necessary knowledge.

The TFRN has been divided into four sections. First is Location and Topography which will discuss the large scale and small scale features which influence the weather. Because of its close proximity to mountains these small scale features play a vital part in forecasting at Aviano. The second section Climatic Aids gives the general climatology and also the relationship of the climate to flying operations. Thirdly, are Approved Local Forecast Studies and Rules of Thumb. Aviano's thunderstorm study is a proven forecasting tool and with the newly approved visibility study give the forecaster a good start towards forecasting the two most critical elements at Aviano. Last are Weather Controls, principally Seasonal Climatic Controls and Principal Weather Types Affecting Aviano. This section contains a thorough description and analysis of the various types of weather that affect Aviano.

Aviano is located in northeastern Italy LAT 46DEG 02MIN N, LONG 12DEG 36MIN E. The station elevation is 413FT. Aviano also issues limited forecasts to support flying operations for the Maniago Range which is located 16.7NM northeast of Aviano. Elevation of the range is 725FT. For forecasting purposes the weather at Maniago will be approximately the same as at Aviano.

Italian weather data is available through normal communications networks. Sites at international airports, large cities, and mountain top stations, transmit excellent observations. Italian RAOB's and upper wind reports are also excellent forecast tools. Mountain top stations, sea ports, and mountain valley stations are extremely valuable in determining cloud coverage, upper temperatures and winds on an hourly basis. Most changes in the weather can first be noted from these reports. AERO and synoptic reports from these stations have additional groups which will provide more information. Because Aviano is currently the only U. S. Air Base in Italy, the Italian weather network is a vital part in forecasting the weather.

Hopefully the forecaster who reads this notebook will be better able to understand and then forecast weather changes and conditions for Aviano.

TSgt Bruce D. Silliman is the writer and editor of this Terminal Forecast Reference Notebook. Credit must also be given to Capt Edwin W. Jenkins, 31WSq/DON for his technical and organizational assistance in compiling this notebook and to TSgt John A. Cuomo, NCOIC, Det Admin for his typing and editing skills.

SECTION I

LOCATION AND TOPOGRAPHY

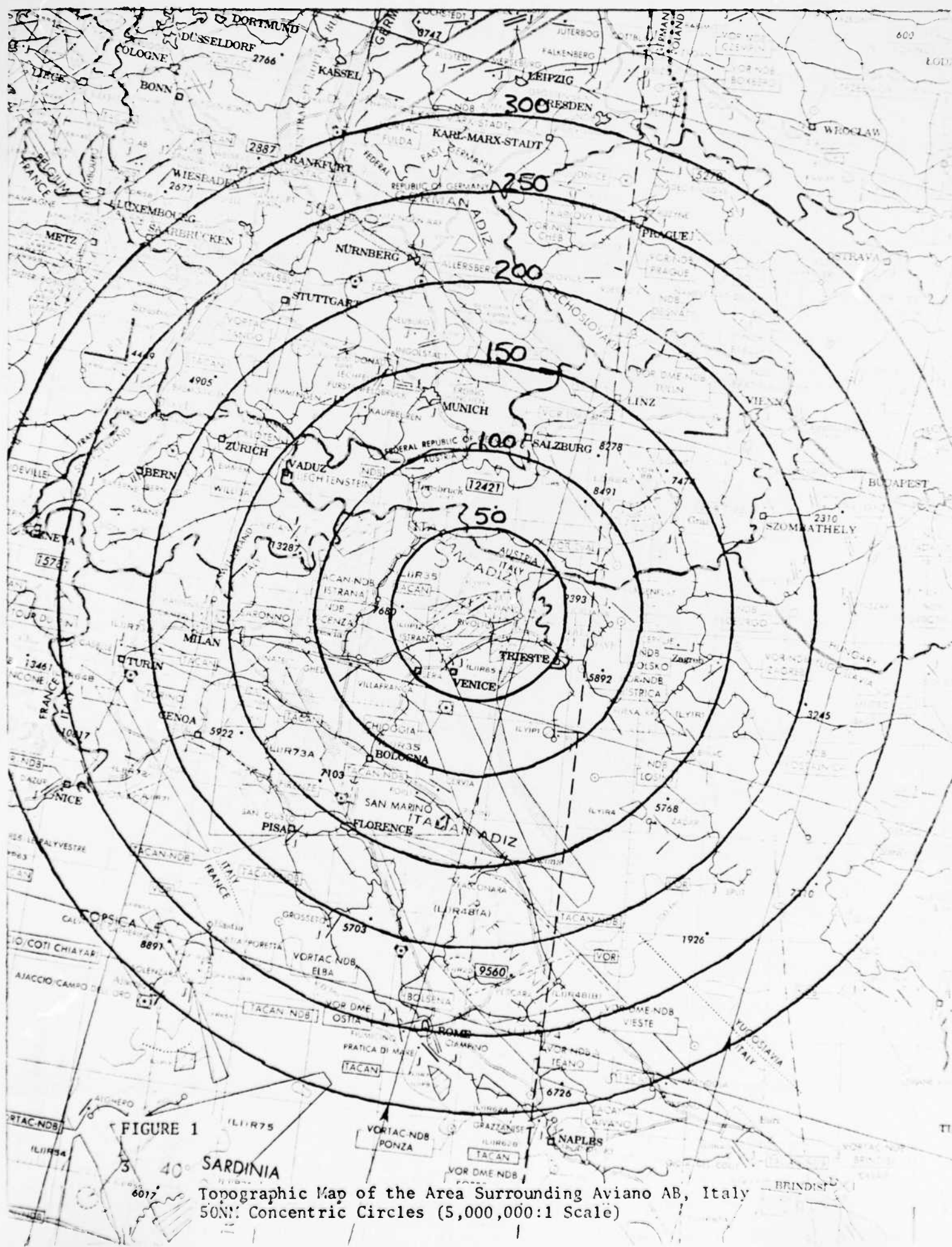
1. General.

The location of a station with respect to mountainous areas, valleys, oceans and other water sources must always be considered in terminal forecasting. These geographic and topographic features, both large scale and small scale, must be carefully studied to determine what effect they have on general air mass movements as they approach and pass the station. Certain geographic features are conducive to fog thunderstorm formation because of their proximity to moisture sources and physical triggering mechanisms. Certain large scale mountain barriers deflect wind currents, modify and retard frontal systems, prevent or accentuate cold air outbreaks and cause stagnant air masses to prevail in the valley areas. It is therefore evident that a forecaster must have a concise knowledge of the macro and micro features of the area near a station to accurately provide terminal forecasts and explain the unique behavior of any weather system.

2. Large Scale Features.

a. Mountainous Areas. The principal and nearest mountain range is the Alpine Arc which originates at the southern end of the Italian-French border, circles north for 150 miles and then generally, due east to the Austrian-Yugoslavia border (See Figure 1). This formidable mountain range is 100 miles wide with highest peaks averaging between 12,000 to 16,000 (east and west ranges respectively). The next in importance is the Apennine Range which originates near Genoa and extends southward across Italy. The Balkan Mountain Range begins 60 miles east of Aviano and extends south through Yugoslavia along the western Adriatic. A very important feature of the intersection of the Alpine Arc and the Balkans is the Trieste Gap which is of special meteorological significance.

The Alpine Mountains exercise a profound control over the climatic and weather of Aviano. These mountains often deflect air currents, block the passage of air masses, retard and reorient fronts, cause lee side lows to form over the valley areas, and trigger strong wind currents due to funneling. The degree of control is generally inversely proportional to the strength of the air flow. If the upper flow is westerly through north-westerly most frontal systems will move over the mountains at roughly half their original speed if the original frontal speed was 25 knots or more. Therefore, a 500MB wind normal to the front of 50 knots or more would suffice in order to expect a frontal passage over Aviano in one form or another. More frequently, however, the upper air flow would be insufficiently strong enough to provide the necessary impetus. Especially



significant with strong upper air flow from the west through northwest is the formation of jet streams with strong winds, frequently in excess of 100 knots, thereby causing "mountain wave" clear air turbulence and triggering numerous thunderstorms over the mountain peaks.

A strong ridge to the west or strong low pressure to the southeast will cause northerly or northeasterly flow depending on the orientation of the pressure system. A front moving south from Northern Germany will cause a fog producing lee side low to form in the valleys. If the upper air flow is strong enough the front will pass Aviano aloft resulting in a cold air outbreak. This is called the "Tramontana Current: and will clear the fog caused earlier. Northeasterly upper air flow (especially 60 miles east) manifests itself in a peculiar form through the Trieste Gap. The air mass trajectories in this case originate in Russia and are fed by the Siberian high. As the air masses approach streamline convergence results as they pass through the Trieste Gap. The air masses then descend from a relatively high plateau to the adjacent valley and coastal areas. With the streamline convergence (funneling) through the gap and insufficient adiabatic heating the air mass enters in the form of a strong northeasterly cold current and spreads over the Adriatic area. It can prevail for several days depending upon the persistency of the pressure pattern. This wind, called the "Bora", seldom results in gusts in excess of thirty-five knots at Aviano, but velocities up to 85 knots are reported in some areas near Trieste.

Southwesterly flow over the Apennine Mountains is also important. During November and December frequent depressions move into the Mediterranean, intensify over the Gulf of Genoa and penetrate the Po Valley through the intersections of the Alpine Arc and the Apennines. These storms are not effectively retarded by the mountains and move across Northern Italy causing poor weather conditions. These storms will be retarded by the Apennines if they follow a southeasterly trajectory across the Mediterranean. The weather at Aviano is then better because the storm will pass across Central Italy. Mountain waves are also quite common with strong southwesterly flow over the Apennines.

b. Valley Areas. Multiple valley systems crisscross the mountainous area and it is impossible to describe them. The important valley area is between and enclosed by the Alps, the Apennines, the Balkans, and the Adriatic. The Po Valley is a wide flat area extending from the Western Alps, to the Adriatic. It is about 100 miles wide along the N-W axis. The plains of Friuli, where Aviano is located, is also a flat valley area extending south from the Dolomite Alps for 40 miles to the Northern Adriatic Sea. (See Figures 1 and 2).

Generally the valley areas are the location of poor weather during the winter. During periods of westerly through northerly flow, cold stagnant air may persist for days with low level stratus and fog predominating. The fog will clear rapidly with a cold air outbreak from the "Tramontana or Bora" currents. The cold mountain breeze at night will clear the fog in the higher valley areas as is common in the Aviano area. A "fog front" is thus formed and the degree of clearing is a function of the period

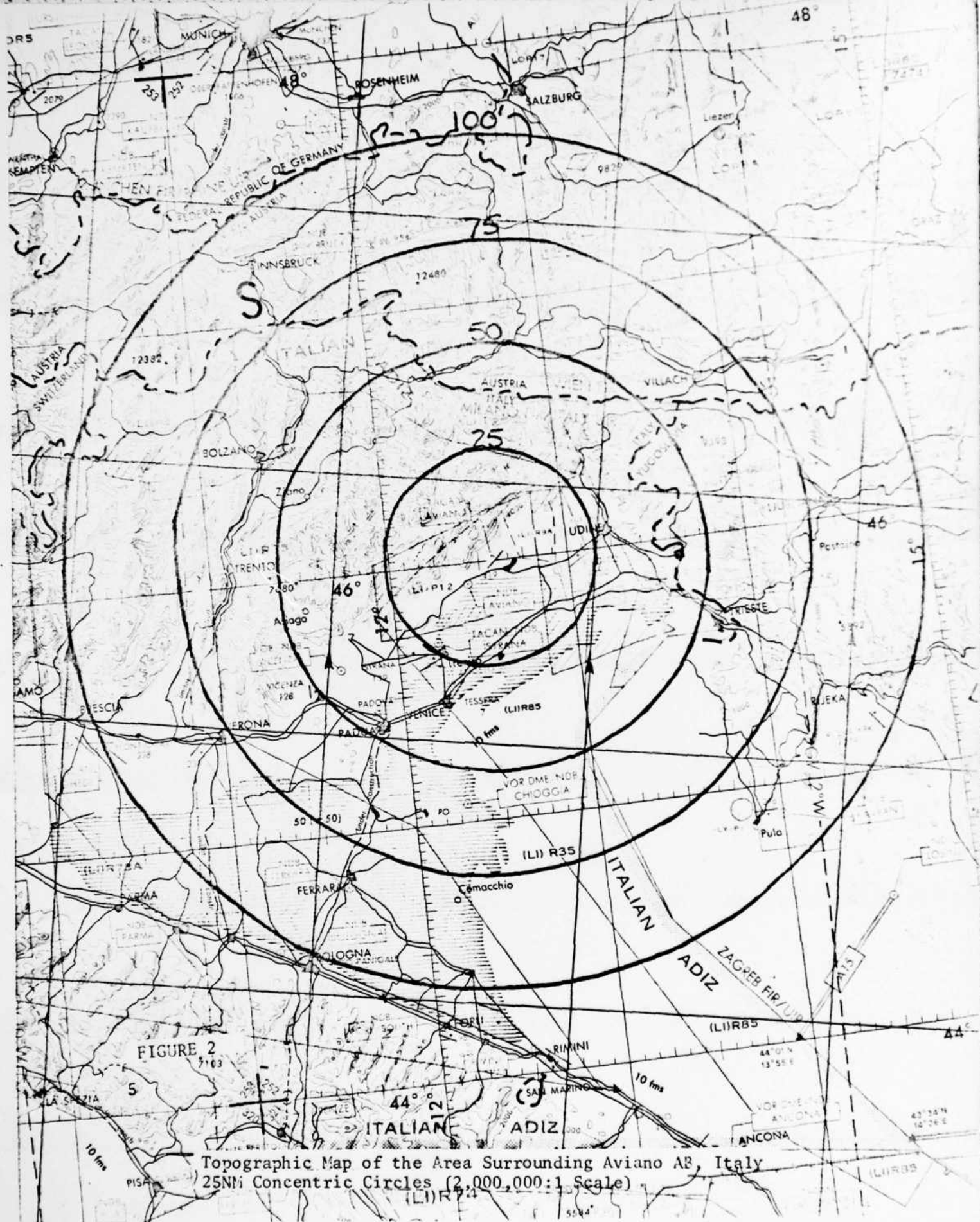


FIGURE 2
Topographic Map of the Area Surrounding Aviano AB, Italy
25NM Concentric Circles (2,000,000:1 Scale)

during which the cold current persists. It is important to note that clearing will occur only when the cold air arrives at a given point colder than the air mass which it replaces.

c. Ocean, Lake, and River Areas. The Mediterranean and Adriatic seas are the principal large bodies of water. The Mediterranean is the largest, bordered by the Iberian Peninsula, North Africa, France, and Italy. The Adriatic Sea penetrates deep into Eastern Europe and is bordered by Yugoslavia and Italy. The main river system is the Po River which flows into the Adriatic south of Chioggia. There are three minor river systems flowing north to south across the plains of Friuli. They are the Piave, Livenza, and Tagliamento rivers. There are numerous lakes in Northern Italy at the base of the Alps, Lake Garda, Lake Maggiore, Lake Lugano, and Lake Como are a few of the larger lakes. These areas are the principal moisture sources. The Mediterranean and Adriatic are principal moisture sources when air mass trajectories follow a path from them to Aviano. This occurs with southwesterly and southeasterly flows from the Mediterranean and Adriatic respectively. The Gulf of Genoa is a center of cyclogenesis and warm frontogenesis will frequently occur along the Eastern Italian coast (Western Adriatic). These two phenomena result in poor weather conditions for Aviano area from over the Adriatic causes air mass parcels to converge along the Dolomites and thunderstorms will occur because of orographic lifting. The river and lake areas are also numerous moisture sources for fog and thunderstorms.

d. Industrial Areas. There are three heavy industrial regions in Northern Italy which have a profound effect on the weather at Aviano. They are the Milano-Torino industrial complex in the western Po Valley; the Bologna center in the south-central Po Valley; and the Mestre-Venezia area only forty miles southwest of Aviano. Light industry is spotted throughout the entire valley. These areas are centers of large amounts of pollution during the entire year. The industrial centers provide great amounts of condensation nuclei for the entire area. Condensation nuclei is therefore present in large amounts at Aviano when the wind flows from these areas. Widespread fog in the vicinity of these areas are enhanced by the presence of the nuclei when a stagnant air mass exists. Sufficient hygroscopic nuclei will always be present to support condensation at Aviano since so many sources exist. It is interesting to note, however, that a minimum amount of nuclei are present during prolonged periods of the "tramontana or bora currents."

3. Small Scale Features.

It is important to consider the relative orientation and proximity of the surface features at Aviano to determine the micro-scale effects of the weather at Aviano. It is difficult to arbitrarily choose an area which is significant on a micro-scale basis, however, a 40 mile radius from Aviano was chosen for the purpose of discussion.

a. Mountainous Areas. A range of mountains oriented southwest to northeast with an average height of 5000 feet is located only three miles from the field. It extends from 20 miles southwest to 25 miles northeast of the field. The main ridge, with average peaks of 7000 feet forms the perpendicular bisector of the southwest-northeast ridge and extends for 25 miles northwest. The Alps extend southwesterly to Verona and southeasterly to Trieste on either side. The Alpine Arc extends 100 miles north to Innsbruck from Aviano. The southwest-northeast ridge effectively shields Aviano from any strong surface winds. The general wind direction is either northeasterly or southwesterly. During the summer, strong valley and sea breezes converge on the ridge and numerous air mass thunderstorms occur. Thunderstorms often form in the Bolzano area and are moved over the field when strong northwesterly flow is present. During the winter the mountain breeze tends to push the advection fog away from the field and is especially significant at night.

b. Plains Area. The slope from 40 miles southwest to the field shows a 16% rise and a 9% rise northwest of the field. The slope along the northwest-southeast axis consists of a 25% drop in elevation to the southeast. Storm cells which form or move from the southwest area of Aviano frequently move along the mountain ridge across Aviano. Since these storms are moving up a rise the result is quite often low ceilings. Fog and haze which forms along the Adriatic coast or in the Po Valley also receives an upslope flow with the valley breeze.

c. Obstructions. There are no small scale effects caused by obstructions near the meteorological sensors. Figure 3 shows the location of the airfield sensors at Aviano AB.

SECTION II

CLIMATIC AIDS

1. General Climatology.

The mountains and the Mediterranean and Adriatic Seas are important factors influencing Aviano's weather. The mountain barrier north of the base deflects air currents with a funneling effect which sometimes results in a strong easterly wind known locally as a "Bora". While these winds rarely exceed 30 knots at Aviano, winds in excess of 85 knots have occurred in the Trieste Gap area. The mountains also greatly aid the development of summertime thunderstorm activity. The Mediterranean and Adriatic Seas provide most of the moisture for precipitation at Aviano.

The Po Valley of Northern Italy has generally poor flying weather during the winter due to fog and stratus. Fog and stratus drifting north-eastward from the Po Valley accounts for nearly all of the below minimum conditions at Aviano. Ceilings below 200 feet and visibilities of less than 0.5 miles average about 1% per year. The local mountain and valley winds determine how long the low ceilings and visibilities will last. Shortly after sunset a cool mountain drainage wind sets in from the north-east clearing the fog in the higher valley areas like Aviano, however, shortly after sunrise a reverse valley wind from the southeast to southwest can move the fog and stratus back. In many cases this fog bank is only a few miles from Aviano and its return can be very rapid.

Fronts approaching from the west and north are usually retarded by the Alps, and most of the weather associated with these fronts during the summer is left on the north and west slopes of the mountains. Fronts from the southwest produce most of the frontal precipitation at Aviano.

The Mediterranean Sea provides the moisture for storm systems that develop during the winter in the Gulf of Genoa. These systems, which account for the majority of the winter precipitation, move across Northern Italy and usually bring one to three days of cloudy and rainy weather.

The summer months give credence to the "Sunny Italy" phrase, with scattered clouds and occasional afternoon thunderstorms the order of the day. However, industrial smoke and haze still restrict the visibilities in the Po Valley during the morning and late afternoon. Figures 4-7 show yearly climatological statistics.

2. Relationship of Climate to Flying Operations.

a. Synoptic Patterns. Meaningful synoptic patterns occur mainly in the winter months when storm tracks are far enough south to reach Italy, and frontal systems have enough push to carry them across the Alps. The primary pattern is for a low pressure area to develop or move to the west side of Italy and intensify (this developing low is called the Genoa low). The low will then move along one of two routes; east across north or central Italy and into the Balkans or south down across the toe of Italy and into the eastern Mediterranean. Which track it will take depends on the

CLIMATOLOGICAL STATISTICS

<u>Winds.</u>	Mean Speed	Extreme Maximum	Prevailing Directions
January	2.9KTS	56 KTS	NNE-21.3%, NE-15.3%, CALM-27.8%
February	3.7	37	NNE-19.0 , NE-17.8 , CALM-21.2
March	3.8	36	NNE-17.7 , NE-15.3 , CALM-16.4
April	3.9	38	NNE-14.9 , NE-13.9 , CALM-16.4
May	3.6	45	NNE-13.8 , NE-13.1 , CALM-16.6
June	3.3	45	NNE-13.1 , NE-12.9 , CALM-18.5
July	3.5	48	NNE-13.5 , NE-11.6 , CALM-17.2
August	3.3	43	NNE-14.6 , NE-11.1 , CALM-18.8
September	3.1	58	NNE-19.3 , NE-12.4 , CALM-20.2
October	3.0	34	NNE-26.1 , NE-12.4 , CALM-21.9
November	3.3	36	NNE-22.2 , NE-16.4 , CALM-22.3
December	3.2	31	NNE-25.2 , NE-16.0 , CALM-22.6

Visibility. $\geq 0.7\text{NM}$ $\geq 1.0\text{NM}$ $\geq 2.0\text{NM}$ $\geq 3.0\text{NM}$

January	94.8%	93.7%	88.7%	85.2%
February	97.0	96.1	91.2	86.7
March	99.1	98.8	96.9	93.4
April	99.8	99.7	98.0	95.3
May	99.8	99.8	98.7	97.7
June	99.8	99.8	99.3	98.2
July	100.0	100.0	99.9	99.2
August	100.0	99.9	99.8	99.1
September	99.8	99.5	96.6	93.7
October	98.9	98.2	93.4	89.3
November	97.7	96.7	91.3	88.0
December	96.0	95.4	91.9	90.1

Ceiling. $\geq 200\text{FT}$ $\geq 300\text{FT}$ $\geq 1000\text{FT}$ $\geq 1500\text{FT}$ $\geq 3000\text{FT}$

January	97.3%	96.7%	93.5%	90.6%	79.7%
February	97.6	97.2	93.7	89.6	74.2
March	99.4	99.1	96.9	94.7	86.6
April	99.8	99.7	98.0	96.0	89.8
May	100.0	99.8	99.0	98.5	94.5
June	100.0	100.0	99.5	99.1	96.7
July	100.0	100.0	100.0	99.9	99.1
August	100.0	100.0	99.9	99.8	97.7
September	99.9	99.9	98.8	98.1	93.6
October	99.5	99.4	98.3	97.6	92.6
November	99.1	98.4	96.0	94.0	84.1
December	98.8	98.2	95.5	93.8	85.3

FIGURE 4

Ceiling versus visibility (NATO Conditions).

	RED ≤ 200/.5	AMBER ≥ 200/.5	YELLOW ≥ 300/1.0	GREEN ≥ 700/2.0	WHITE ≥ 1500/2.7	BLUE ≥ 2500/4.3
January	4.6%	95.4%	93.6%	88.3%	83.3%	74.4%
February	2.8	97.2	96.0	90.8	83.9	72.3
March	0.8	99.2	98.7	96.4	90.2	81.5
April	0.3	99.7	99.4	97.2	93.1	86.4
May	0.2	99.8	99.6	98.4	97.3	93.2
June	0.1	99.9	99.8	99.1	97.8	94.0
July	0.0	100.0	100.0	99.9	99.1	95.4
August	0.1	99.9	99.9	99.7	99.0	94.5
September	0.1	99.9	99.4	96.4	93.0	87.3
October	0.8	99.2	98.2	93.3	89.0	83.8
November	1.8	98.2	96.5	91.1	86.5	78.0
December	3.5	96.5	95.3	91.7	88.8	81.3

Present Weather.

Thunderstorms (#days of occurrence)

January	1.0	July	12.0
February	1.0	August	9.8
March	1.4	September	5.6
April	5.0	October	2.9
May	10.8	November	1.7
June	13.3	December	1.0

Precipitation (other than snow)

	Mean Monthly	Extreme Max Min	24-Hr Max	#days
January	3.04	13.04/T	4.24	10.6
February	3.67	11.69/T	3.35	10.2
March	4.28	14.48/.06	4.68	12.9
April	6.21	11.52/1.78	4.23	15.9
May	5.02	10.15/.81	3.97	17.7
June	6.39	12.62/1.77	3.57	18.4
July	4.15	7.23/1.74	1.45	15.1
August	4.59	11.15/.59	2.44	14.6
September	4.56	9.73/.56	3.59	11.7
October	4.78	13.99/.01	4.61	10.2
November	7.41	14.83/2.25	6.81	12.9
December	4.48	15.82/.10	3.39	10.2

FIGURE 5

Present Weather con't.

Snowfall

	Mean Monthly	Extreme Max	24-Hr Max
Janaury	0.9	5.9	3.0
February	1.1	6.7	5.6
March	0.7	6.9	5.0
April	Trace	Trace	Trace
May-October	None	None	None
November	Trace	0.7	0.7
December	0.5	4.8	4.0

Fog (LST)	Hours of max occurrence	Hours of min occurrence
January	21-23	03-05
February	03-05	12-14
March	06-08	15-17
April	06-08	15-17
May	03-05	15-17
June	06-08	12-14
July	03-05	09-11
August	06-08	18-20
September	06-08	15-17
October	03-05	15-17
November	00-02	15-17
December	21-23	12-14

Haze (LST)	Hours of max occurrence	Hours of min occurrence
January	15-17	03-05
February	15-17	03-05
March	18-20	03-05
April	18-20	03-05
May	09-11	03-05
June	09-11	00-02
July	06-08	00-02
August	09-11	15-17
September	18-20	03-05
October	18-20	06-08
November	15-17	00-02
December	15-17	03-05

FIGURE 6

Temperature.

	Extreme Maximum	Mean Maximum	Mean	Mean Minimum	Extreme Minimum
January	61	44.3	37.1	29.4	08
February	69	47.6	39.8	31.5	13
March	74	53.5	45.5	37.0	11
April	77	61.3	53.4	45.0	26
May	86	70.4	62.1	53.3	34
June	91	76.1	67.9	59.2	44
July	99	81.2	72.3	62.9	39
August	95	80.2	71.4	62.2	46
September	93	73.9	65.4	56.5	37
October	83	64.7	56.1	46.9	28
November	72	53.8	47.0	39.7	15
December	65	45.9	38.7	31.1	10

FIGURE 7

strength of the high pressure area over the Balkans. During November and December, and March and April the normal track will be across northern Italy. During January and February the high pressure area which dominates eastern Europe and the Balkans forces the low centers to the more southern track.

During the summer months a weak high pressure area prevails over all of the Mediterranean, giving central and southern Italy a period of hot, dry and nearly cloudless days. The northern Italian Alps are still affected by lows and fronts passing to the north across Germany which trigger outbreaks of thunderstorms and rain showers. Otherwise, the weaker synoptic pattern is the same as to the south.

b. Effect of Climatic Elements on Flying Operations.

(1) Thunderstorms and tornadoes. Thunderstorms occur frequently at Aviano but they are almost always not damaging. Surface winds associated with thunderstorms are usually not a problem. Visibility is seldom reduced below three miles and ceiling seldom lowers below 3000 feet. Lines form in the Milano-Parma area during the late afternoon. The lines usually move eastward during the evenings and dissipate during the early morning hours in the vicinity of Padova. These storms usually form ahead of a N-S cold front across eastern France and with a thermal low over the Po Valley (late June, July, and August). They will not move to Aviano unless the surface front is strong and continues to move towards Aviano. These fronts usually wave and remain north of the Alps for several days during summer and will only move east of Aviano when the associated 500MB trough along the west coast of Europe is reinforced by cold air (-20 to -25°C summer) from the Northern Atlantic. The lines may be aided in formation by cold air aloft (10,000 to 15,000 feet) from the snow capped French and Swiss Alps and a southwesterly flow ahead of the front in the Gulf of Genoa.

Thunderstorms can occur with all flow patterns except strong northerly anti-cyclonic flow. Most severe activity is in the late afternoon and early evening with maximum surface heating, 500MB trough passage, and Dew Points of 60°F or more. Thunderstorms will occur with almost every frontal passage or when a surface low is in northern Italy. Once thunderstorms have begun to occur with a system, they will continue to reform day after day until the passage of the 500MB trough, or until warm air advection aloft builds a ridge over Italy thus repositioning the major trough to the west over the Atlantic. Most thunderstorms do not pass directly over the airfield, but often will move along the mountain ridge line due to the prevailing upper level wind flow (SW). Generally the thunderstorms will last 20 to 30 minutes. However, they will continue to reform at all hours as long as triggering mechanisms are present.

Surface hail occurs most often during the late Spring months, but will usually be less than ¼" in size. The largest hail occurs with severe summer storms.

Surface winds associated with thunderstorms are rarely of weather warning criteria. Wind speed will range from 20-25 knots or less with the CCL above 5000 feet and from 25-35 knots when the CCL is below 5000 feet and the SSI is 0 to -2. Wind direction is difficult to forecast due to the close proximity of the mountains, but generally will be from the northwest.

Severe weather (tornadoes, winds greater than 35 knots, and hail GE 3/4") is rarely seen at the airfield, but will occur with the CCL below 5000 feet and the SSI -3 to -6. Tornadoes in Northern Italy are most common in the lakes region during late summer, however, as late as September of 1977 a tornado was detected on the FPS-77 and visually sighted 10NM northeast of Aviano.

(2) Fog. Most occurrences are from November or December through February. Fog is almost always pre-frontal and advection. Fog can move across Aviano at any hour of the day with usually one to two cases per month during winter of zero-zero conditions. Aviano fog is always preceded by heavy fog formations in the Po Valley.

Fog is usually preceded by heavy haze build up in a stagnant air mass with a persistent inversion at about 5000 feet. Zero-zero conditions usually will not last more than nine hours and about one half of all cases will improve in four to five hours. Although these zero-zero fogs usually will not persist, but will improve with diurnal heating or wind shifts, they will continue to reform with cooling and up-slope winds until frontal passage from the west or northwest, or strong low formation in the Gulf of Genoa.

Winds associated with fog almost always are situations less than five knots, directions almost always northerly during the night and southerly during the day. Winds will shift about mid-afternoon in the winter, and about two hours after sunrise during the spring and summer. This southerly shift of winds during the winter accounts for most late afternoon fogs at Aviano. Improvement will almost always follow the northerly shift in the evening. Winds usually follow this diurnal pattern except during frontal passages or with strong lows in the Gulf of Genoa. If lower pressure is to the south of Aviano, forecast no fog.

Some cases of heavy fog with down slope winds will occur, but these fogs will only occur when the air mass is extremely moist, and when the winds shift rapidly to southerly just off the surface. These southerly winds will continue to feed low level moisture, while the northerly surface winds provide insufficient downslope to dissipate the fog.

Ice fog almost never occurs. Cold (below freezing) moist air masses are rare at Aviano. Cold air masses have their source regions in Central Europe and must move southerly to Aviano. As a result, continental air masses arrive dry.

(3) Rain. Most prolonged rains will begin with a major low in the Gulf of Biscay. These systems once formed in Biscay will cause lows to form in the Gulf of Genoa, and are almost always followed by heavy rains at Aviano, usually one to two days in winter, three to four days in summer. As a rule most low formations in the Gulf of Genoa will cause precipitation at Aviano. Only during January and February (months with minimum rainfall) will the majority of these systems miss Aviano. Increasing precipitation reports will spread across the western Po Valley as far north as Venice. Then the low will begin to move southeastward along the Italian peninsula and take the associated weather with it.

(4) Freezing Precipitation. Freezing precipitation is a rare occurrence at Aviano. Most systems are over-running systems which will cause rapid warming in the mid levels and with the rain increasing the temperature below.

(5) Snow. Snow is infrequent at Aviano and almost always light. At Aviano as with most other places in Western Europe and West Central Europe, air masses with sufficient moisture for snow are generally too warm as they have their source regions over water. Snow at Aviano is almost always preceded by a strong cold outbreak from Siberia. Most of these Arctic outbreaks will arrive clear and cold and will not cause snow at Aviano. However, they usually will produce snow south along the Adriatic and in the western Po Valley. Cold outbreaks that produce snow are usually preceded by an extremely cold, retrograding 500MB closed low over Poland which drops southwest or west. Surface flow will be easterly at Aviano changing to southerly aloft flow from the Adriatic. The 700MB temperature will be -10°C or less, usually -12 to -14°C , with a surface temperature of 30 to 36°F . Heavy snow is usually observed over Bavaria, Austria, Yugoslavia, the western Po Valley, and in the mountain stations of Italy one to two days before snow at Aviano. Moisture source must be from the Adriatic for lasting accumulations of snow. With moisture source from the southwest, precipitation will usually begin as snow and will change rapidly to rain.

(6) Stratus. Low diurnal stratus (500 to 1000 feet) most always forms at Aviano during early morning in late February, March, and early April, but will usually lift or dissipate by 1200 hours in February, 0900 to 1000 hours in March and April. It forms when surface conditions are too unstable for fog due to a slight instability near the surface (caused by an east thru southwest wind of four to five knots). Conditions are the same as for advection fog except that surface winds are stronger.

(7) Fronts. Fronts pass Aviano from all directions, some surface, some aloft. Most fronts approaching from the west or southwest will pass as surface fronts. Arctic or cold Polar fronts passing to the north or east usually pass aloft, most of the time dry, and surface around the Venice-Padova line and then continue southward as surface fronts. They sometimes return as surface warm fronts when

the cold outbreak is weak and the upper trough reorientates itself to the west. Fronts approaching from the west or southwest are usually old and have lost many of their identifying characteristics, but they can usually be positioned quite accurately by RAOB inversions and cloud and precipitation patterns.

Weak fronts blocked along the northern slope of the Alps by the Azores ridge over the western Mediterranean may be blocked for days during both winter and summer. In summer, with extremely cold outbreaks from northern regions, these fronts sometimes reform and begin to move southward passing Aviano from the north or northeast (usually during early morning hours). Severe thunderstorms are trapped by this front as it passes Aviano and the thunderstorms produce strong gusts, surface hail, and sometimes one to two inches of rain in very short periods. Reformation of these fronts and their southerly movement can sometimes be forecast by careful analysis of 500MB thermal patterns over Poland and Central Europe. If you sometimes think this front is there but cannot quite find it, check the Italian coded analysis. The Italian analysis frequently positions weather systems over the Mediterranean regions much better than we do. This same front during winter will cause persistent haze and fog at Aviano. These conditions will not significantly improve until the front passes from the north and the colder dry air mass follows. Persistent haze and fog conditions will usually lower visibility to two to three miles at Aviano (occasionally to zero-zero with weak lows and stable waves forming over south Germany which shift the winds to southerly at Aviano). This southerly wind will advect the lower conditions (which are always present at all hours) in the Po Valley to Aviano. Similar haze and fog buildups are quite common ahead of slow moving N - S fronts which are blocked by the French Alps. These fronts frequently cause low formations over the Gulf of Genoa with following precipitation and northeast flow at Aviano which improve conditions. The rest of the Po, however, will remain foggy.

(8) Winds. Surface winds at Aviano do not impose problems upon operations. All winds during the summer greater than 10-14 knots are thunderstorm winds and of short duration. Their directions are almost always from the northwest. Infrequently during winter however, strong, deep, well developed lows move out of the Gulf of Genoa to the northern Adriatic. A strong high will usually be present over West and Central Europe. This situation can produce surface winds at Aviano to 30 or 40 knots (most of the time 15-25 knots). Wind direction will be from the northeast. About one of these storms occurs here during the winter. Most often it will occur during late December or January.

OPERATIONALLY CRITICAL ELEMENTS
AND THRESHOLD VALUES

<u>ELEMENT</u>	<u>THRESHOLD VALUE</u>
1. Tornadoic Activity	Within 5NM radius of Runway Complex
2. Surface Wind	A. Steady or gusts of greater than 34 knots, but less than 50 knots B. Steady or gusts of equal to or greater than 50 knots
3. Hail	Half inch or greater in diameter
4. Freezing Precipitation	Trace or greater
5. Heavy Rain	Two inches or more within twelve hours
6. Snow Accumulation	Two inches or more within twelve hours
7. Probability of Lightning Condition (POLC)	Enroute forecast of fifty percent or greater

SECTION III

APPROVED LOCAL FORECAST STUDIES AND RULES OF THUMB

1. Critical Forecast Elements. Thunderstorms are the most critical forecast element at Aviano. The objective TS forecast study (Appendix 1) is an occurrence tool which consistently verifies well, but does not forecast the actual time of occurrence. At Aviano there is no "cut and dried" afternoon or nocturnal times favorable for thunderstorm occurrence. Visibility is the other critical element.

2. Visibility Study. As the pollution sources surrounding Aviano expand, the visibility problem also expands. An objective visibility study has been implemented that is based upon the 11Z low level wind flow, the 11Z temperature/dew point spread, and a forecast height of the mixing layer. This data is entered on a nomogram to yield a forecast for visibility above or below 3 nautical miles. See Appendix 2A.

3. Thunderstorm Study. The thunderstorm study is a semi-objective technique which uses a synoptic and parametric approach. The parameters used are Showalter Stability Index (SSI) from the Udine (16044) 0000Z RAOB, the LIPA max forecast temperature, and the LIPA 0300Z temperature/dew point depression. This data is entered on a nomogram to yield an initial yes or no forecast. This forecast is then modified, if needed, using synoptic considerations.

Since the development of this study it has shown a consistently good verification rate. The overall Heidke Skill Score (HSS) is .506 with a % correct of 73%. (see Appendix 2 for complete totals). Appendix 1 contains the entire thunderstorm study for those interested in studying the development and initial evaluation of the study.

4. Rules of Thumb. Currently there are three active Rules of Thumb being used. All three are used in the forecast of thunderstorms. One uses surface frontal passage as the triggering action and the other two use the passage of the 500mb trough as the trigger. The Rules of Thumb are:

ROT A: If there will be a frontal passage from any direction other than N thru E, then forecast thunderstorms with its passage. (Valid, May thru Sep).

ROT B: If there will be an upper air trough passage (500mb), then forecast thunderstorms associated with its passage. (Valid, Apr thru Sep).

ROT C: If there are thunderstorms occurring, then forecast them to end after the passage of the upper air trough (500mb). (Valid, Apr thru Sep).

Complete verification of these Rules of Thumb can be found in Appendix 3.

SECTION IV

WEATHER CONTROLS

1. Seasonal Climatic Controls.

a. In January there is strong frontal activity over Italy. Frontal systems approaching from the west or northwest frequently undergo cyclogenesis over the Gulf of Genoa. These lows then move into the northern Adriatic region, producing one to three days of cloudiness and precipitation at Aviano. The strongest systems are often followed by an expansion of the Siberian High building toward Italy, advecting cold, dry air into northern Italy and producing prolonged periods of clear, cold weather. As the high begins to weaken, industrial pollution will help create the Po Valley fog. This fog may be advected into the Aviano area by southwesterly low level winds. January is drier than the previous two months, and is more frequently affected by the Po Valley fog, often going to zero-zero.

b. February has a southerly shift in the path of Gulf of Genoa lows as they move away from their point of cyclogenesis. They show a preference for a southeasterly track along the west side of the Apennine mountains, and produce no significant weather at Aviano. One or two will track to the east across the northern Adriatic and cause most of the precipitation during the month. High pressure dominates the weather of northern Italy for the majority of the month. When the Azores high stagnates to the east of its normal position, the fog in the Po Valley will advect into the local Aviano area. Poor flying conditions will be the rule. High pressure expanding to the southwest from Russia will bring easterly low level flow of cold dry air to cause prolonged periods of cold clear weather.

c. March is the month of change from winter to spring weather. An average of three low pressure systems will form or move over the western Mediterranean during the month. They will tend to follow a northerly track across the Gulf of Genoa to the upper Adriatic and produce most of the precipitation at Aviano. The incidence of Po Valley fog decreases and flying conditions improve significantly during the month.

d. April is a transition month and migratory lows are more common than in previous months, making April the cloudiest month of the first half of the year. Ceilings are generally above 3000'. April marks the beginning of the thunderstorm season, with the frequency of activity increasing through June and the thunderstorm severity increasing through July.

e. The month of May is the beginning of the summer season and Aviano's thunderstorm season is in full swing. Frequent frontal passages continue during May and convective activity can be expected with these fronts. Fronts become progressively weaker as the Icelandic Low moves northward and weakens, and the Azores High builds toward southern Europe and the Mediterranean. Weak frontal systems will be blocked/delayed north of the Alps. Weak lows will continue forming over the Gulf

of Genoa and are the major cause of severe weather at Aviano. Field conditions improve drastically with the only limitations to flying occurring during thunderstorm activity.

f. During June weak pressure gradients throughout northern Italy, coupled with the trailing ends of cold fronts will continue to cause pressure troughs and even weak closed low centers to move into the Po Valley and northern Adriatic Sea. In June these situations produce thunderstorms and/or rainshowers instead of prolonged rain, as is true earlier in the year. Strong frontal systems occasionally move through the area, causing moderate to severe thunderstorm activity. June is the peak of the thunderstorm season.

g. No major storm tracks will affect the local area, and a very weak pressure gradient will dominate at the surface during July. Upper air troughs which cross central Europe will extend into northern Italy and, coupled with the orographic effects of the Alps, will cause thunderstorms and/or rainshowers in the vicinity of Aviano. Isolated cases of moderate to severe thunderstorms are to be expected, and the gusty winds and hail associated have the potential to do considerable damage to aircraft and ground installations.

h. August continues under the summer pattern of good flying conditions interrupted by frequent thunderstorms. The percentage of ceilings/visibilities below 3000'/3NM increases slightly and the frequency of thunderstorm activity decreases slightly, although we remain in the midst of our thunderstorm season.

i. During September a weak pressure gradient prevails throughout northern Italy. No definite storm tracks exist during the month but weak migratory low pressure cells move through the upper Mediterranean and Adriatic Seas. This month marks the beginning of the Po Valley fog season with an increase in conditions below 3000' and/or 3NM. Conditions still rarely decrease below training minimums. September is the last month with significant thunderstorm activity. This thunderstorm activity is generally associated with migratory low pressure systems.

j. Frontal systems moving across Europe penetrate further south during October than during the summer months. Secondary low pressure cells may form as the cool air behind these fronts moves across the warm water of the Mediterranean. These lows migrate eastward to the upper Adriatic and normally cause one to three day periods of overcast skies with rain. The thunderstorms which occur are frontal type and usually are embedded in layers of cloud, making them difficult to detect without radar. The Po Valley fog continues to build, and field conditions lower only slightly from September.

k. Frontal systems pass through northern Italy more frequently than during October. Often cyclogenesis occurs on these frontal systems as they cross the Gulf of Genoa. Widespread precipitation throughout northern Italy results, making November the rainiest month

of the year, percentagewise (hourly obs) and with regards to total rainfall. The Po Valley fog becomes a common occurrence and will cause frequent problems for VFR low level flights in the valley. Field conditions at Aviano continue to decrease with the percentage of time below training minimums occurring twice as often as during October.

1. Frequency of frontal activity at Aviano continues to increase during December with frontal passages showing a preference for evening hours. Strong areas of low pressure develop over the Gulf of Genoa in the pressure of an upper air trough. These lows will often become attached to strong fronts moving across Italy from the northwest or west, move to the upper Adriatic region and produce most of the precipitation and strongest surface winds at Aviano. Prolonged periods of clear and cold will follow as high pressure builds over the Alps. Stagnant highs will account for the long periods of Po Valley fog, which will build in the valley and may advect in with southerly winds to cause short periods of near zero-zero conditions.

2. Principal Weather Types That Affect Aviano AB, Italy. (Capt Serhij Pilipowskyj).

a. Introduction. The large scale weather patterns discussed in this paper are those that exist at the surface and at 500mb over the following area: 10°W to 30°E and 35°N to 55°N . The most important single condition considered in this study is the flow at 500mb over the Aviano area; the primary factor that determines the local weather. The study does not cover in detail such specific weather phenomena as air-mass thunderstorms or radiation fog which are described elsewhere, but it gives a more general picture of the weather conditions that can be expected at Aviano AB for a certain flow aloft.

In terms of time, the scope of this paper is limited to about a 24 hour factor. Thus, it is not a tool for long-range forecasts of weather patterns but rather an index as to what the weather at Aviano should be, based upon an upper-air flow forecast. In this respect it is similar to the "Catalogue of Large Scale Weather Types" issued by Technical Services, 2nd Weather Wing, AWS.

Some of the worst weather at Aviano is caused by cyclogenesis in the Gulf of Genoa or in the Adriatic and no study of the effects of this cyclogenesis on Aviano AB has yet been published. Therefore, a few comments on this event are included in Appendix 4.

b. Method. In compiling this study, the following daily information was utilized for a period from 1 Apr 61 to 30 Mar 63:

- (1) 500 mb wind flow over Udine, Italy (25nm east of Aviano).
- (2) 500 mb flow pattern over Europe.
- (3) Surface weather pattern over Europe.
- (4) Typical and significant weather observations for Aviano AB, (LIPA).

Thus, a total of some 730 cases were studied and categorized. The upper-air flow patterns were divided into the following categories and sub-categories:

I Northerly

- A. NW to NE, Anticyclonic
- B. NE to NW, Cyclonic

II Westerly

III Southwesterly

- A. SW Anticyclonic
- B. SW Slightly cyclonic
- C. SW Strongly cyclonic

IV Southeasterly and Easterly

Each of the categories or sub-categories is now presented with illustrated examples.

c. TYPE I-A. Northwest to Northeast, Anticyclonic. The maps for Type I-A illustrate one of the situations giving northerly, anticyclonic flow over the Aviano area. In most cases this situation is due to a closed high over northwest Europe or to an extension of the Azores high into the northeast Atlantic.

The resultant surface high over central Europe will give Aviano light easterly or southerly winds at low levels. This results in fair visibilities but with a subsidence inversion that gives a haze layer at about 6000 feet. In the winter time this situation is favorable to heavy radiation fog formation and in late summer the haze layer can descend to the surface, sharply reducing daytime visibilities (see Example 1). Some cumulus clouds will usually obscure the mountain tops during daylight hours but, otherwise, there will be little significant cloudiness. If this situation persists for a prolonged period in the summer, isolated thunderstorms may form over the Alps and move over the base improving the surface visibility by breaking the inversion (see Example 2).

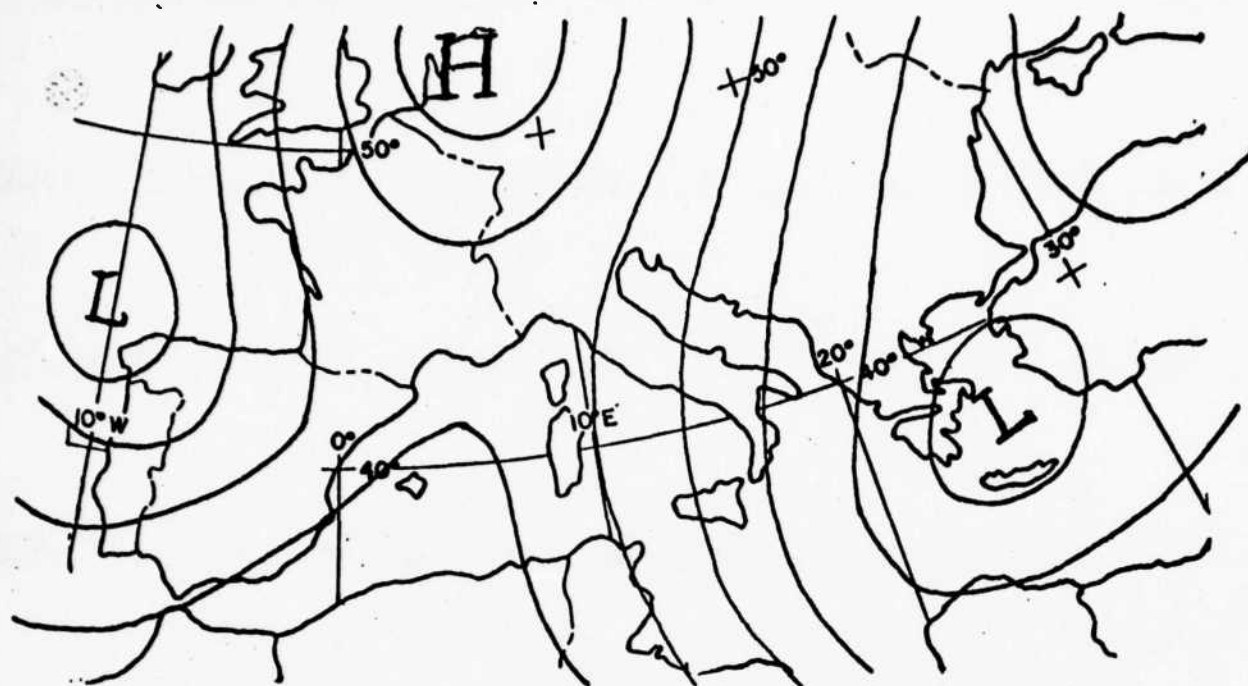
Type I-A flow occurs on an average of six days per month, with a maximum of seven days per month from June to August and a minimum of four days per month from September to November. This northerly, anticyclonic flow usually establishes itself from a northerly, cyclonic flow I-B (see Example 3). In other cases a ridge builds over western Europe after a trough passage over northern Italy, so that case I-A follows almost immediately III-B or III-C (see Examples 4,5). Once established, the I-A flow can persist from three to six days depending on the hemispheric wave pattern. In breaking down, it will usually change to westerly flow (Type II), followed by southwesterly (III-A). In the spring or winter it is possible for the flow to change back to Type I-B allowing a cold-core low to slip south from Scandinavia into eastern Europe (see Example 5).

EXAMPLES

- 1) 24-29 September 1961
 Originated from Type IV
 100 @ 8 → 50 @ 5H → 50 @ 2H → 30 @ 1H/GF
 Changed to Type II with heavy fog.

- 2) 21-24 June 1962
 Originated from Type III-A
 80 $\textcircled{D}$ 15 $\rightarrow$ 90 $\textcircled{D}$ 15 $\rightarrow$ CLR 8
 Changed to Type II, resulting in three days of thunderstorms.
- 3) 12-15 October 1961
 Originated from Type I-B
 / $\textcircled{D}$ 12 $\rightarrow$ 50 $\textcircled{D}$ 5H $\rightarrow$ 20 $\textcircled{D}$ 5H $\rightarrow$ 50 $\textcircled{D}$ 5H
 Changed to Type II with 10 $\textcircled{D}$ 1F followed by thunderstorms.
- 4) 8-15 December 1961
 Originated from Type III-B
 100 $\textcircled{D}$ 15 $\rightarrow$ 80 $\textcircled{D}$ 12 $\rightarrow$ 30 $\textcircled{D}$ 5H
 Changed to Type I-B with 30 $\textcircled{D}$ 10 $\rightarrow$ 100 $\textcircled{D}$ 12
- 5) 15-21 December 1962
 Originated from Type III-C
 60 $\textcircled{D}$ 6H $\rightarrow$ / $\textcircled{D}$ 12 $\rightarrow$ / $\textcircled{D}$ 8 $\rightarrow$ / $\textcircled{D}$ 4H
 Changed to Type I-B

500 MB PATTERN



TYPE I-A

NORTHWEST TO NORTHEAST, ANTICYCLONIC

3. SURFACE PATTERN



FIGURE 8

d. TYPE I-B. Northwest to Northeast, Cyclonic. This flow is most common in the winter and spring when a cold-air pool and the associated upper-air low slip down from Scandinavia into eastern Europe. The surface lows stay well east of Aviano and, thus, this area avoids almost all significant weather associated with these systems. The cold fronts which slip over the Alps from the northeast tend to form ceilings at about 4,000 feet, increase the visibility and drop the temperature to record lows in the winter. The air is cold and dry with a downslope motion in the Aviano area. No fog and little precipitation are expected with these systems but strong northerly winds above 7000 ft create mountainwave turbulence above 5000 ft. In spring the cold air aloft may provide enough instability to cause thunderstorm formation over the Alps and cause shower activity over the Base (see Example I). Some violent winds gusting from the east can accompany these thunderstorms.

The I-B flow is most common from January to June with an average of eight days per month and it is least common from August to October with an average of four days per month. This flow usually establishes itself after the trough passages as shown in Type III-B and persists for periods of three to nine days. The length of persistence is usually dependent on the intensity of the cold-air pocket aloft over eastern Europe. During summer and autumn, the I-B flow will change to Type I-A. In the spring however, a strong upper-air low can move into the southern Adriatic creating a Type IV flow.

Westerly flow usually develops out of the breakdown of a weak ridge over western Europe (I-A or III-A) which is replaced by a low over the North Sea. The summertime westerlies will persist for three to six days changing back into a ridge (I-A or III-A) with little associated weather except for air-mass thunderstorms.

These examples will illustrate the summer situation. Reduced visibilities are associated with ridges and good visibilities with troughs. After several days of this flow, thunderstorms will usually develop.

- 1) 23-25 July 1962
Originated from Type I-A
CLR 8 --> 100 @ 7 --> CLR 15
Changed to Type III-A, then III-B with thunderstorms.
- 2) 23-29 August 1962
Originated from Type I-A
90 @ / @ 15 --> 80 @ / @ 8 --> 90 @ 4H --> 40 @ 2H
CLR 8 --> 80 @ 5H --> 60 @ 5TRW
Changed to Type I-A with isolated thunderstorms.

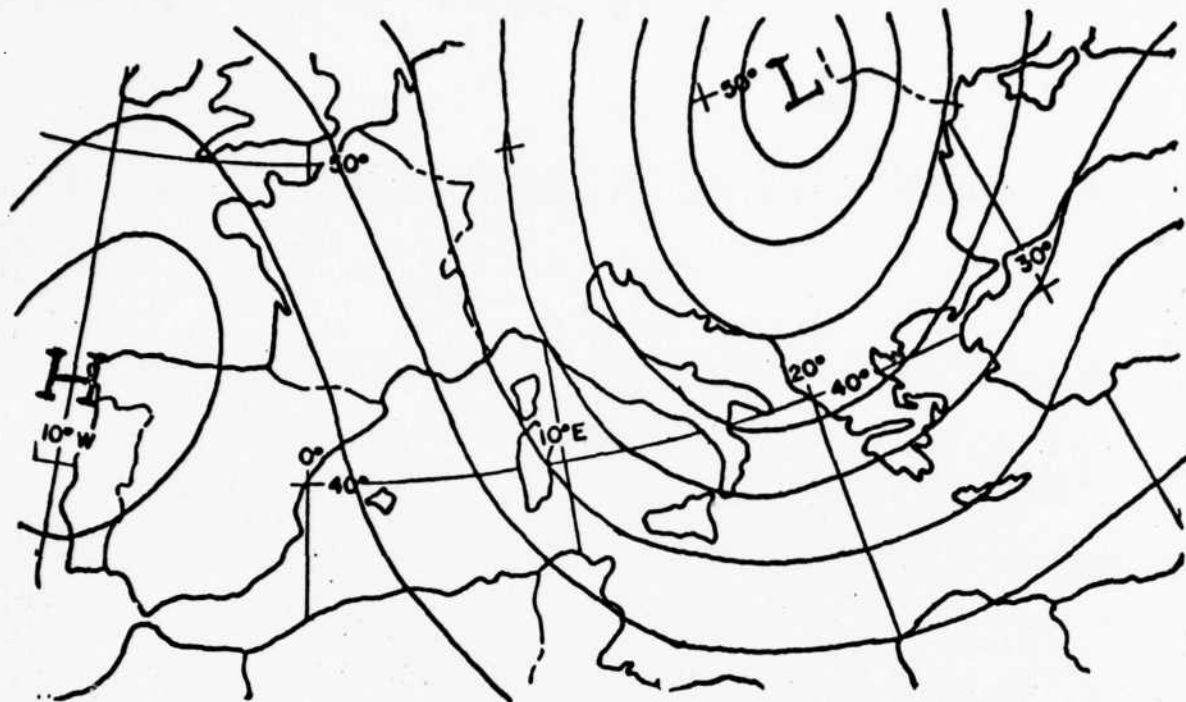
During winter and early spring, the westerly flow is generally a short transition period from a dissipating ridge to a period of southwesterlies (Type I-A to III-B). It will persist for periods of two to four days. As this westerly flow changes into Type III-B, it is very likely that one of the many fronts moving in from the west can trigger cyclogenesis in the Gulf of Genoa or in the Adriatic giving Aviano some of its worst weather. (See Appendix 4 for Cyclogenesis). The following are examples of the winter situation:

- 1) 4-11 June 1962
 Originated from Type III-B
 50 ⊕ 7RW --> 50 ⊕ 15 --> 50 ⊕ 15 --> 50 ⊕ 10RW
 --> 40 ⊕ 10 --> 40 ⊕ 10RW --> 60 ⊕ 10RW
 Changed to Type I-A

- 2) 1-3 September 1961
 Originated from Type III-B
 CLR 10 --> / ⊕ 10 --> / ⊕ 8
 Changed to Type I-A

- 3) 17-21 November 1961
 Originated from Type I-A
 / ⊕ 15 --> 30 ⊕ 8 --> 100 ⊕ 15 --> 80 ⊕ 8 --> CLR8

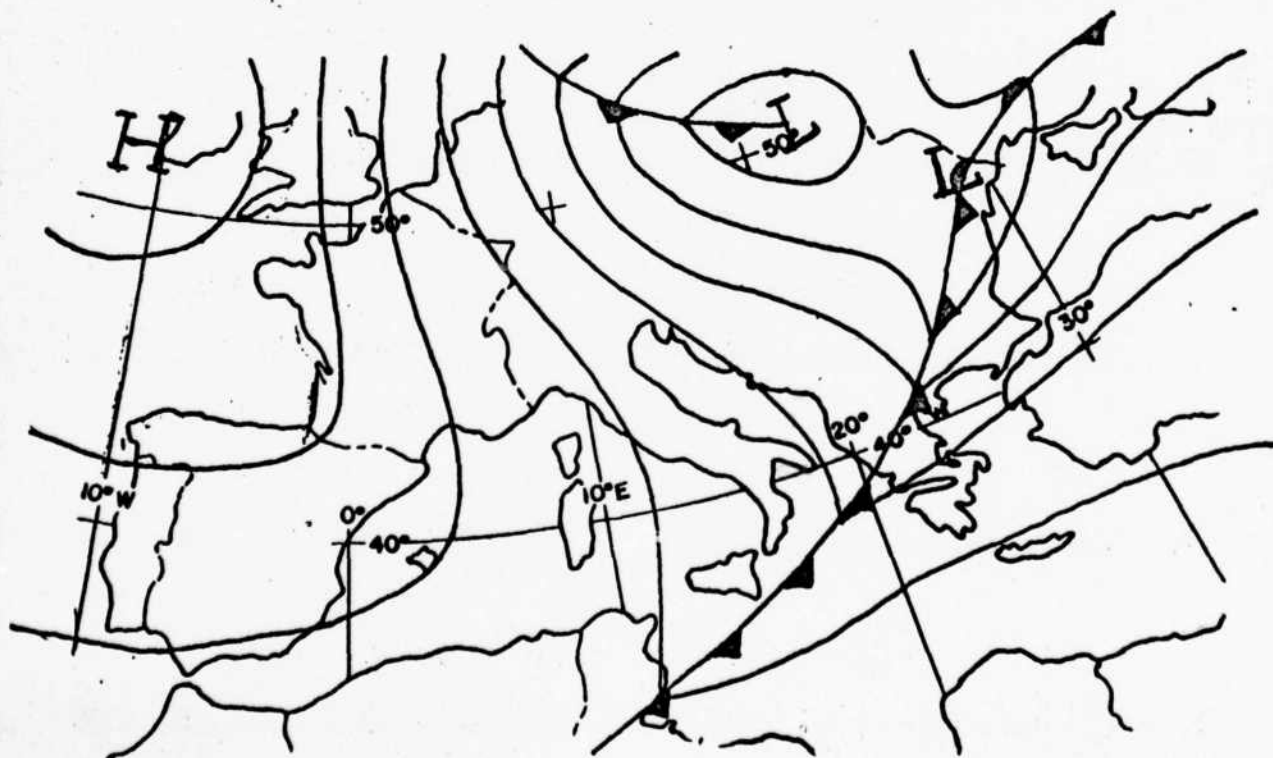
500 MB PATTERN



TYPE I-B

NORTHWEST TO NORTHEAST, CYCLONIC

SURFACE PATTERN

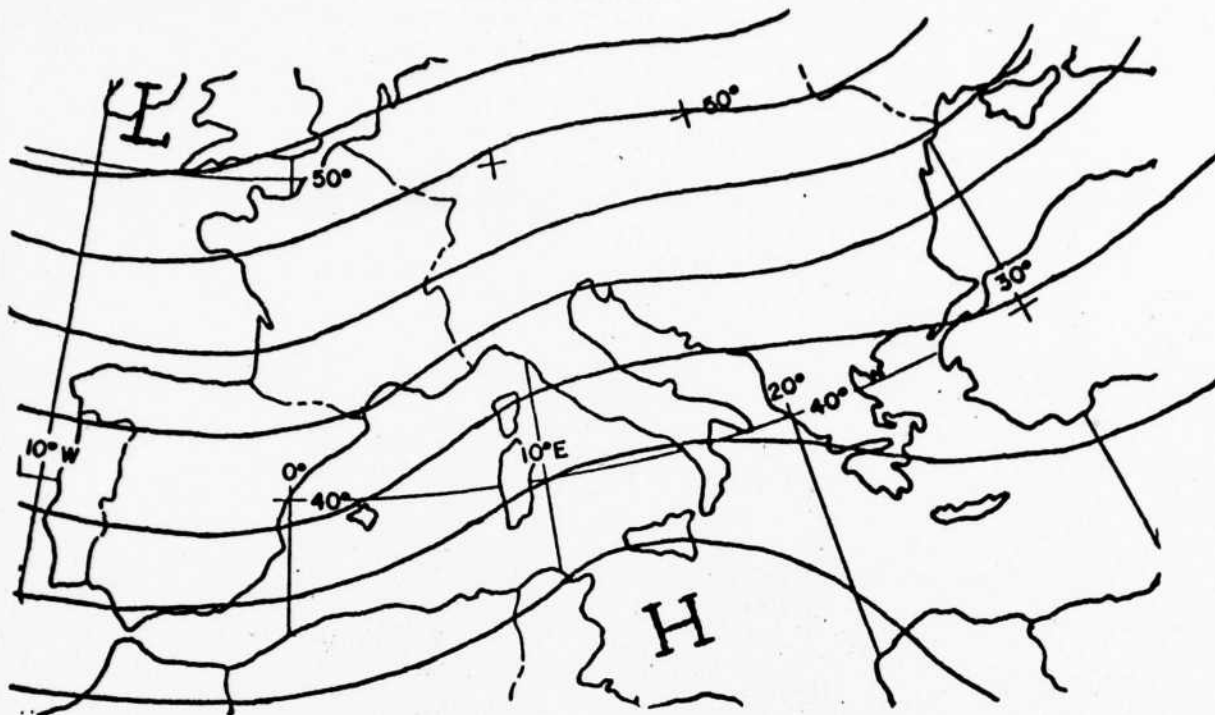


e. TYPE II. Westerly, Cyclonic or Anticyclonic. A westerly flow has been defined for the purpose of this study as a wind from 250° to 300° , being slightly cyclonic or anticyclonic, but always associated with a high-index flow. As shown on the map, this means generally westerly flow with short, low amplitude waves. The westerlies have an average occurrence of five days per month with a minimum of three days per month occurring from April to June. The two maxima, one in July and August and another in December and January, have seven days per month each.

These two maxima are important for the following reasons: during the summer maximum the westerly jet stream is well north of Aviano with the flow over this area being more anticyclonic (similar to Type III-A) and with little associated weather. During the winter maximum, however, the jet stream drops south into the Aviano area or even further south into the Mediterranean. The flow in this case is more cyclonic. This allows frontal systems from the Atlantic to reach the Alps and to effect the Aviano area with extensive periods of poor weather.

- 1) 23-26 December 1961
Originated from Type I-A
 $40 \oplus 6RS \rightarrow 80 \oplus 10 \rightarrow / \oplus 10 \rightarrow 15 \oplus 1RS$
Changed to Type III-B with 5 days of fog and rain.
- 2) 7-8 March 1963
Originated from Type I-A
 $/ \oplus 4H \rightarrow 40 \oplus 1F \rightarrow 20 \oplus 1F$
Changed to Type III-B and $30 \oplus 1RF$
- 3) 17-18 January 1963
Originated from Type I-B
 $70 \oplus / \oplus 7 \rightarrow 70 \oplus 7SW-$
Changed to Type III-B and $10 \oplus 1S$
- 4) 2-4 December 1961
Originated from Type I-A
 $10 \oplus 1F \rightarrow 30 \oplus 3RF \rightarrow 30 \oplus 5GF$
Changed to Type III-B, Cyclogenesis in Gulf of Genoa
With $20 \oplus 2RF$, TRW and 2.7" rain in one day

500 MB PATTERN



TYPE II

WESTERLY

SURFACE PATTERN

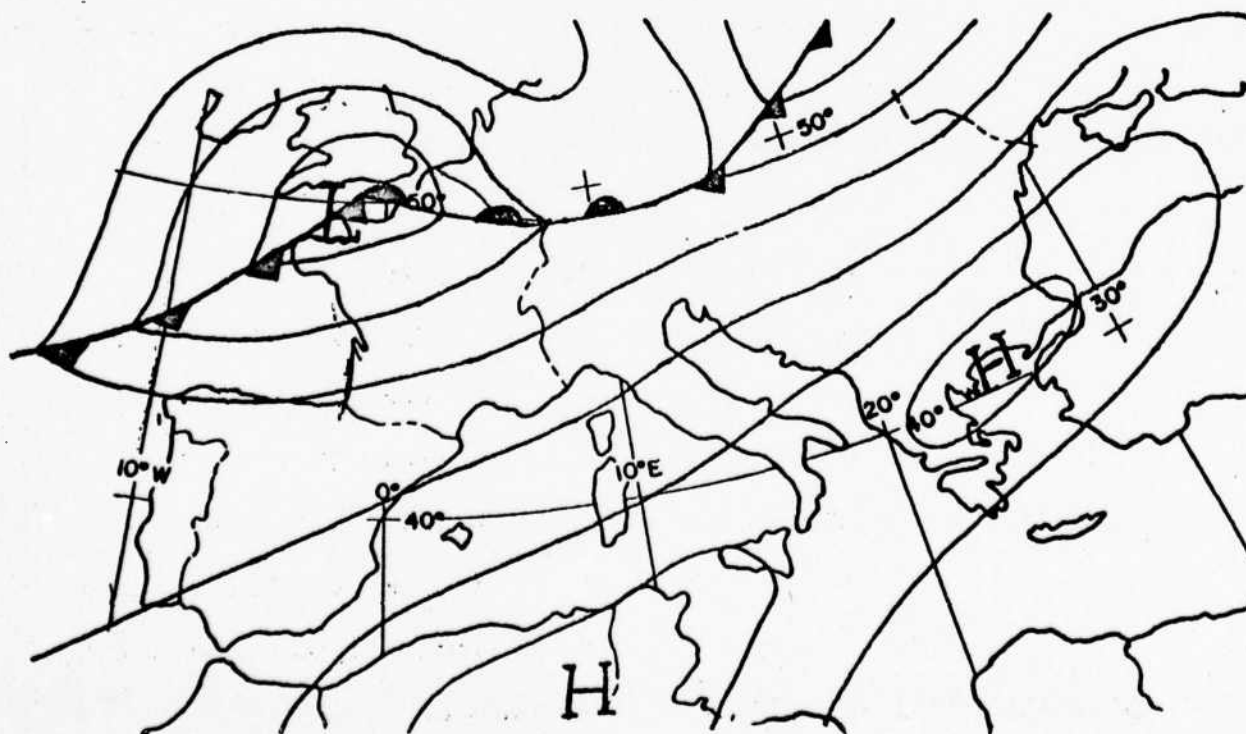


FIGURE 10

f. TYPE III-A. Southwest, Anticyclonic. This is the southwest flow with the least inclement weather. It affects Aviano by reducing the visibility and brings occasional rain. As shown on the map, this flow is usually caused by a strong upper-air ridge over the Balkans or eastern Europe with weak troughing over western Europe. This flow occurs most frequently from March to June with five days per month. The minimum is from November to January with one day per month.

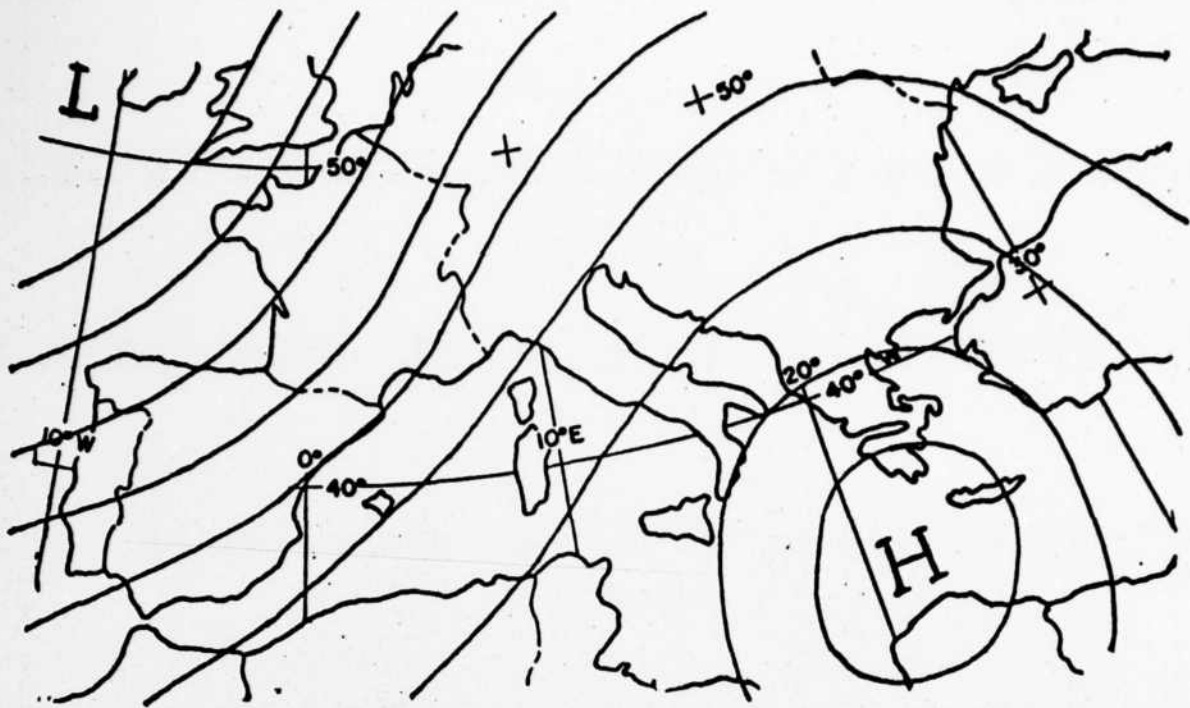
The Aviano weather generally associated with this flow is variable with high ceilings and reduced visibilities. In summer it is usually associated with the warmest weather and is frequently followed by westerly flow and thunderstorms. Similar to Type I-A, the anticyclonic southwest flow is very conducive to the formation of an inversion at about 5000 ft with heavy haze below. This, along with some cumulus, tends to obscure the mountains of northeastern Italy during daylight hours. In some winter situations, it has been observed that, if the flow is beginning to change to Type II, heavy fog will affect the Aviano area.

Type III-A usually originates from Type I-A or Type II flow and persists for periods of two to three days. In fall and winter it will usually change to Type II or II-B with the associated inclement weather.

EXAMPLES

- 1) 9-10 March 1962
Originated from Type I-A
120 $\oplus$ 12 --> 20 $\oplus$ 3RH
Changed to Type III-B with 04 $\oplus$ 1/2 RF
- 2) 21-22 March 1962
Originated from Type II
CLR8 --> 120 $\oplus$ / $\oplus$ 8
Changed to Type III-B with 60 $\oplus$ 5H
- 3) 25-28 July 1962
Originated from Type II
100 $\oplus$ 7 --> CLR 15 --> CLR 5H --> 50 $\oplus$ / $\oplus$ 6H
Changed to Type III-B with 40 $\oplus$ 3 TRW-A
- 4) 17-19 January 1962
Originated from Type I-A
CLR 15 --> / $\oplus$ 10 --> 60 $\oplus$ 10 --> 25 $\oplus$ 5H
Changed to Type II and 18 hours of WOXOF
- 5) 15-16 August 1962
Originated from Type I-A
60 $\oplus$ / $\oplus$ 10 --> 60 $\oplus$ / $\oplus$ 15
Changed to Type III-B with thunderstorms

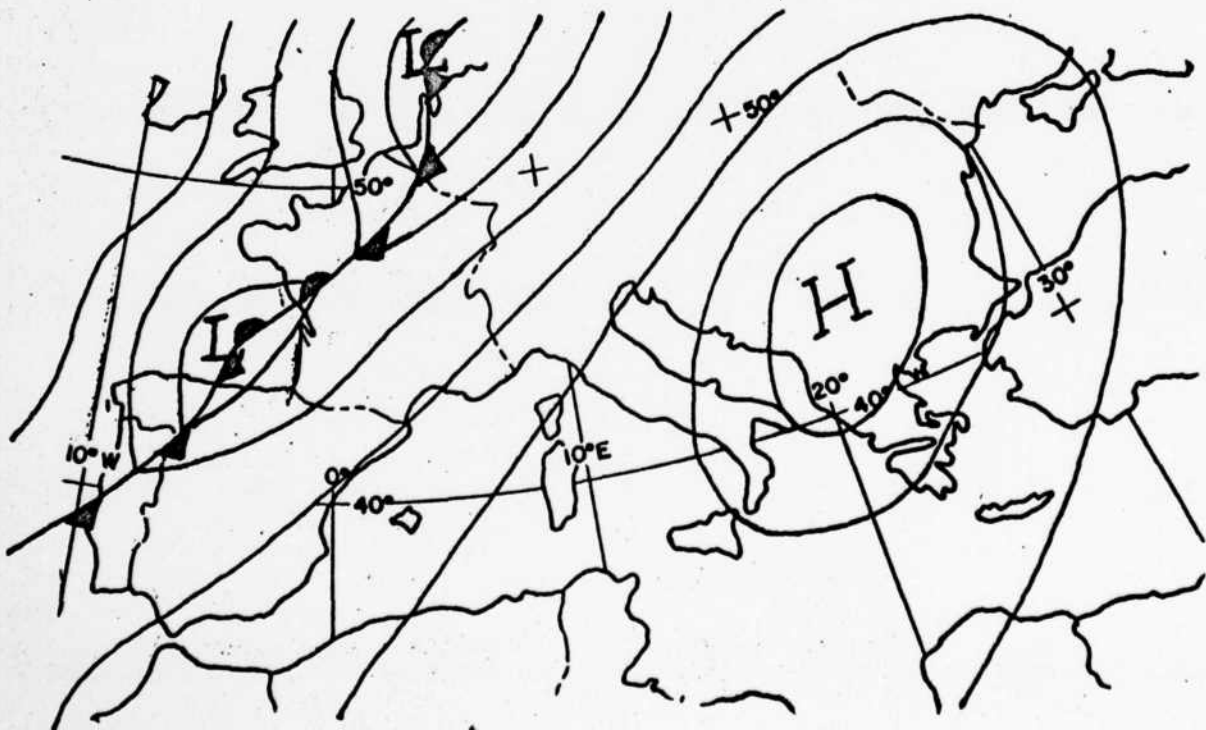
500 MB PATTERN



TYPE III-A

SOUTHWEST, ANTICYCLONIC

SURFACE PATTERN



g. TYPE III-B. Southwest, Cyclonic. This is the type of flow most frequently observed in the Aviano area. It is generally associated with the presence of a strong, upper-air low over England or the North Sea with a trough extending to the southwest. Frontal systems are thus brought into central and southern Europe from the Atlantic. Troughing is strongest during the winter months and the Atlantic frontal systems are brought into northern Italy with the associated inclement weather. In summer the systems are weaker, stay further to the North, move rapidly northeastward and have little effect on the Aviano area except for occasional thunderstorm activity (Example 1).

The flow preceding Type III-B is usually westerly (II) or southwesterly anticyclonic (III-A). Once established, it persists for short periods in summer and for very long periods in winter; up to 12 days at a time in November or December. In summer this type flow will revert back to III-A or I-A. A deeper summertime system will produce I-B flow; all three situations producing generally fair weather (Example 2).

A weak or moderate wintertime passage of III-B flow will generally result in a Type I-B situation with rapidly improving visibilities and strong, cold, northeasterly winds at Aviano Air Base (Example 3). In many cases, however, especially from October to December, III-B flow is observed to slow down and intensify, forming a III-C pattern. This results in the poorest flying weather at Aviano. Heavy, continuous precipitation, poor visibilities, imbedded thunderstorms and above normal temperature are characteristic of III-B flow over all of northern Italy (Example 4).

Type III-B flow is also associated with cyclogenesis in the Gulf of Genoa or in the northern Adriatic. If the upper-air trough is fast moving, the newly formed surface storm will be pushed southeastward by the northerly winds aloft giving the worst weather to central and southern Italy. Should the trough be slow moving, or change into Type III-C, the surface low will be pushed northeastward over the Alps depositing great quantities of heavy rain in the Aviano area and be accompanied by numerous thunderstorms.

EXAMPLES

- 1) 29-30 July 1962
 Originated from Type III-A
 50 $\oplus$ / $\oplus$ 10 --> 40 $\oplus$ 3TRWA --> 50 $\oplus$ 8 RW
 Changed to Type I-A with isolated showers
- 2) 1-3 June 1962
 Originated from Type III-A
 40 $\oplus$ 8 --> 20 $\oplus$ 70 $\oplus$ 7 TRW --> 30 $\oplus$ 8RW occasional TRW
 Changed to Type I-B 60 $\oplus$ 7RW --> 50 $\oplus$ 15

3) 12-13 January 1963

Originated from Type II

40 ⊕ 5S --→ 10 ⊕ 1S --→ 60 ⊕ 10 --→ / ⊕ 10

Changed to Type I-B with cold clear weather.

Total snow fall was 2.5 in and record low temperature was set.

4) 5-16 November 1962

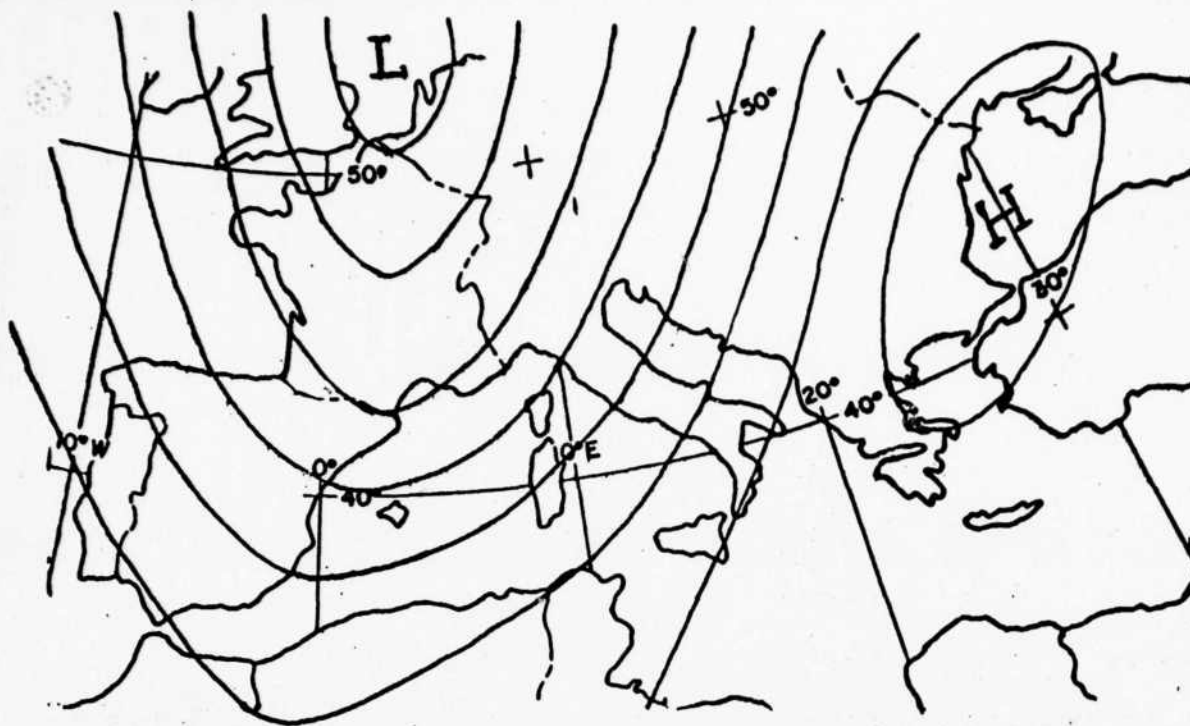
Originated from Type III-A

/ ⊕ 10 --→ 30 ⊕ 3R --→ 15 ⊕ 2R --→ etc.

Visibility varied between WOXOF nad 15RW for several days, thunderstorms and fog were observed; about 10 in of rain fell in 10 days.

Changed to Type II.

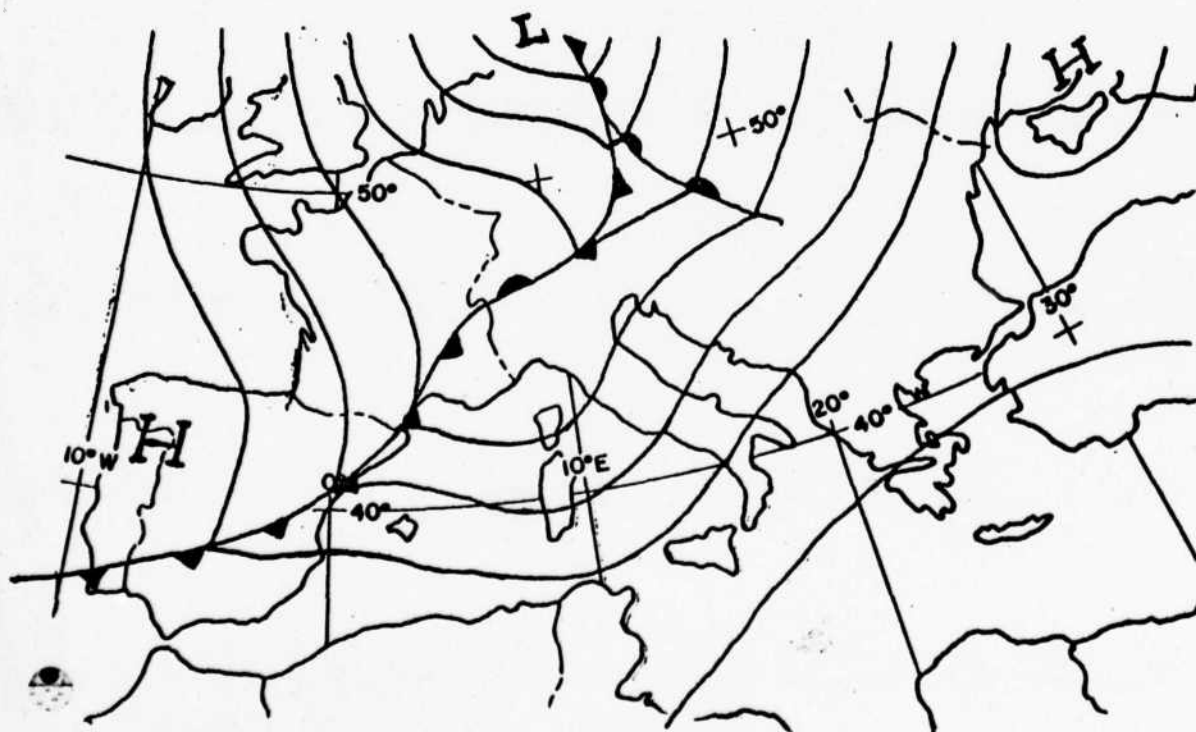
500 MB PATTERN



TYPE III-B

SOUTHWEST, CYCLONIC

SURFACE PATTERN



h. TYPE III-C. Southwesterly, Strongly Cyclonic. This is the definition applied to the strong cyclonic flow shown in the accompanying illustration. It is very closely related to case III-B but the low centers are closer to Aviano and the flow over this area is more southerly. This situation will in most cases trigger cyclogenesis in the Gulf of Genoa or the northern Adriatic. The surface lows will move northeastward, passing to the north or over Aviano. This movement is usually preceded by periods of poor visibility and is accompanied by prolonged periods of low ceilings, heavy rains and thunderstorm activity which can persist for several days. If the upper-air low is stationary, repeated cyclogenesis can take place at 24 hour intervals.

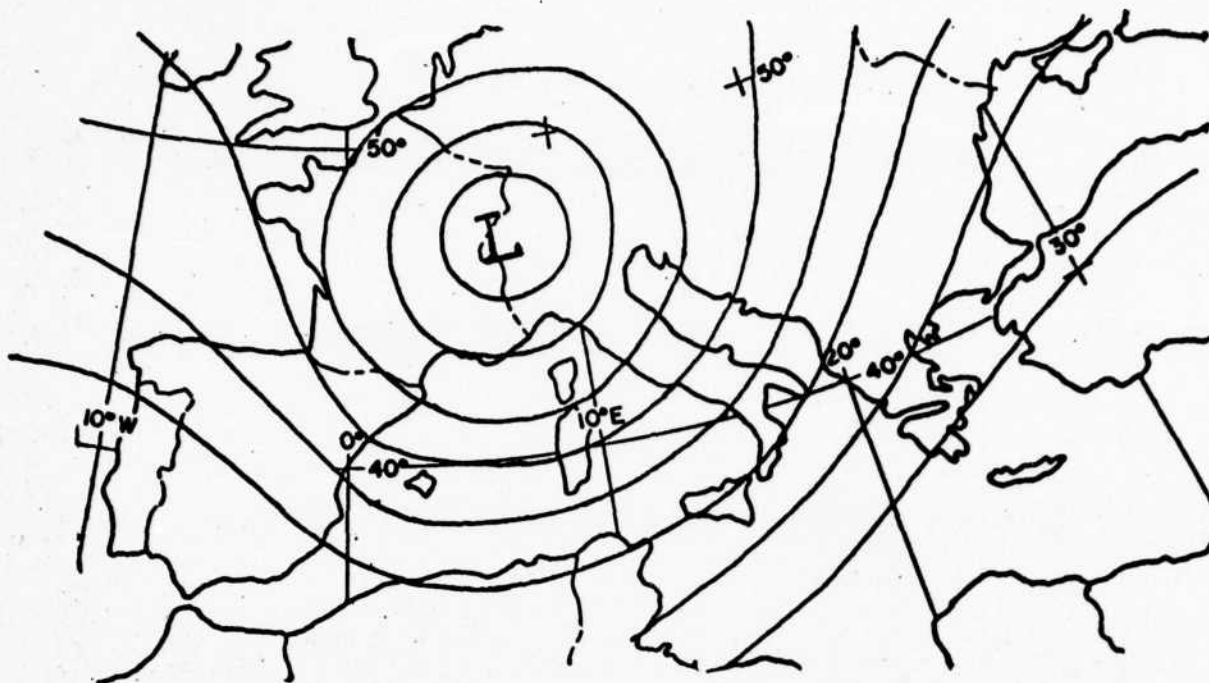
Type III-C flow is in almost all cases an intensification of the III-B pattern and occurs on the average of two days per month from November to May, with a maximum of three days per month in December (Example 1). Occurrences from June to September are seldomly observed. The III-C pattern generally persists for a period of two days, thereupon reverting to a III-B situation (Example 2, 3). As the low fills or moves into eastern Europe, it leaves a trough and continued inclement weather over northern Italy. The conditions of III-B and III-C can alternate to provide up to 12 days of continuous warm, but damp and rainy, weather with occasional fog and thunderstorms (Example 4).

In some cases, notably in the spring, the low will move south giving Aviano rapid clearing and Type IV flow.

EXAMPLES

- 1) 13-14 December 1962
 Originated from Type III-B
 20 ⊕ 2RF --> 10 ⊕ 2RF --> 60 ⊕ 1GF --> 80 ⊕ 8
 Changed to Type I-A
- 2) 17-18 October 1962
 Originated from Type III-B
 10 ⊕ 1RF --> thunderstorms with 1.2 in of rain
 Changed to Type III-B
- 3) 6-7 October 1961
 Originated from Type III-B
 08 ⊕ 1TRW with s.8 in of rain
 Changed to Type III-B with 25 ⊕ 6RW
- 4) 10-16 May 1962
 Originated from Type III-B
 40 ⊕ 10RW --> 03 ⊕ 1RF --> Cyclogenesis Gulf of Genoa
 --> 6 hours of WOXOF with Type III-B flow
 --> 40 ⊕ 10TRW --- 30 ⊕ 10TRWA --> Cyclogenesis in Gulf of Genoa
 Changed to Type I-B.

500 MB PATTERN



TYPE III-C

SOUTHWEST, STRONGLY CYCLONIC

SURFACE PATTERN

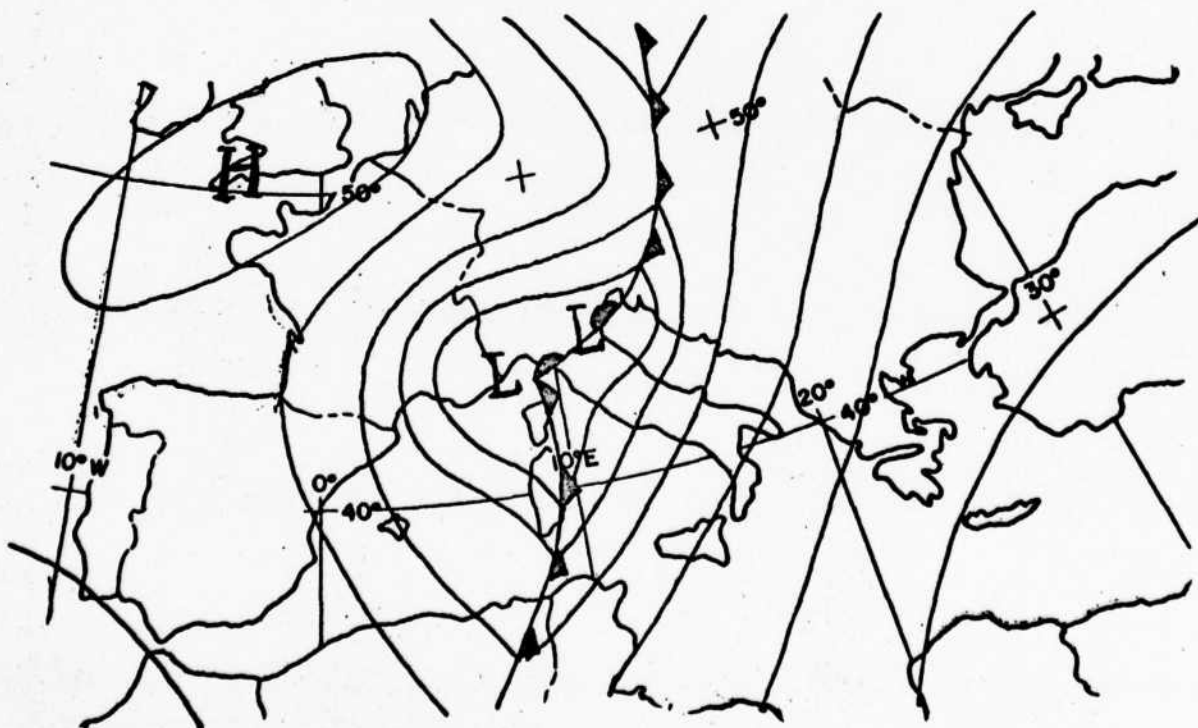


FIGURE 13

i. TYPE IV. East to Southeast, Cyclonic or Anticyclonic. As shown on the map, the easterly or southeasterly flow over Aviano is generally associated with the presence of a strong, closed, upper-air low over the western Mediterranean or over Italy south of 44° North. This type of flow frequently develops from a strong pattern such as Type I-B or III-C but with a large cold-air pocket aloft and very slow, eastward movement. Frontal systems from the Atlantic are forced into a southerly patch along the African coast with a possibility of cyclogenesis in the Tyrrenean Sea.

In the Aviano area this flow sets up a strong, easterly wind at low levels bringing generally cool temperatures, excellent visibilities and occasional light shower activity from clouds at the 5000 ft level. Showers are heavier and ceilings lower if the cyclogenesis takes place far enough north to affect Aviano.

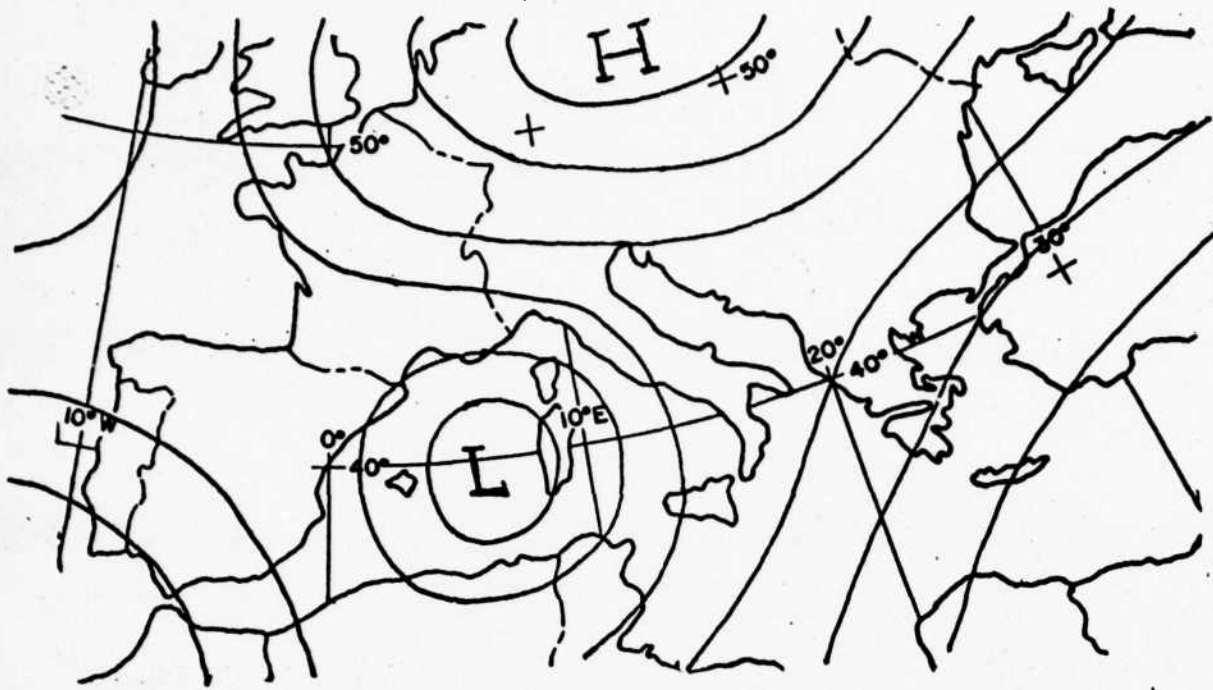
The Type IV flow persists for periods of two to four days usually changing into flow I-A as the low fills and moves eastward (Examples 1,2). In some cases, notably in late winter and early spring, the low may tend to move back north causing overrunning of cold air by warm, moist air with resulting snow or freezing rain over northern Italy (Example 3).

Flow Type IV occurs on an average of two days per month with a maximum of four days per month from September to February. The minimum is from May to August when Type IV is seldom observed. Over a two year period, few cases of southeasterly flow were observed to be associated with significant weather and then usually as they were changing into a southwesterly flow (Examples 3, 4). Thus, fair weather is most typical for Type IV flow (Examples 1,2, 5).

EXAMPLES

- 1) 22-25 January 1963
Originated from Type I-B
CLR 15 --> CLR 8
Changed to Type I-A
- 2) 18-23 September 1961
CLR 10 --> CLR 8 --> CLR 6 H
Originated from Type III-A
Changed to Type I-A
- 3) 10-12 February 1963
Originated from Type III-B
80 ⊕ 7 --> 20 ⊕ 5R --> 12 ⊕ 3RFS --> 40 ⊕ 8
Changed back to Type III-B
- 4) 3-5 October 1961
Originated from Type III-B
90 ⊕ 8 --> 120 ⊕ 8 --> 120 ⊕ 8
Changed to Type III-B and the day following, to III-C
08 ⊕ 1 TRW and 4.7 in of rain in 2 days.
- 5) 3-8 December 1962
Originated from Type I-B
80 ⊕ 15 --> 100 ⊕ 15 --> CLR 15 --> / ⊕ 15
Changed to Type III-A

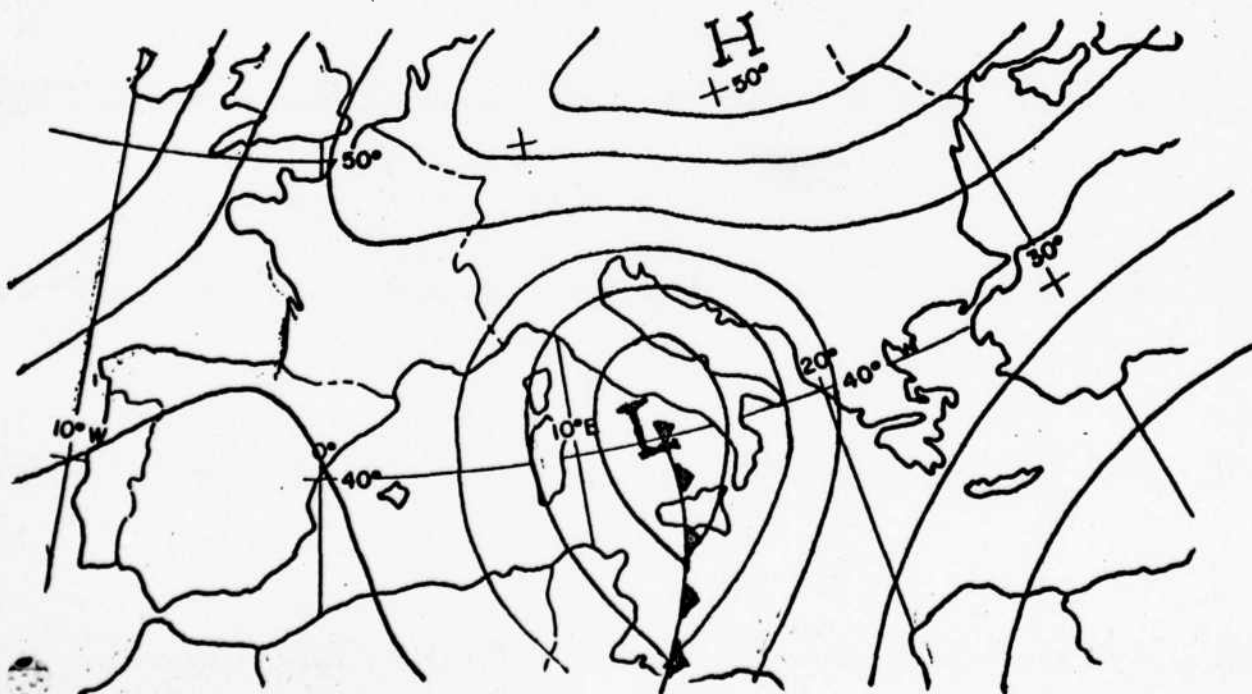
500 MB PATTERN



TYPE IV

EAST TO SOUTHEAST, CYCLONIC OR ANTICYCLONIC

SURFACE PATTERN



j. Statistical Summary of Principal Weather Types (Pilipowskyj).

Period utilized for this study: 1 April 1961 to 31 March 1963.

Total number of days studied and classified: 730.

Significant weather was observed on 225 days (30.8% of total).

Distribution of days with significant weather by types of flow:

TYPE	% OF ALL CASES	% OF CASES WITH WEATHER	% OF ALL WEATHER CASES
I-A	20.5	14.0	9.6
I-B	20.0	5.4	3.5
II	14.5	46.2	21.7
III-A	10.1	16.2	5.3
III-B	24.0	57.0	44.7
III-C	4.6	88.2	13.3
IV	6.3	8.6	1.9

From the above table we see that three types of flow were associated with most of the weather: II, III-B, and III-C. While they constituted only 43.1% of the days, they accounted for 80.7% of the days with significant weather.

If only cases III-B and III-C are considered, it is seen that they occurred 28.6% of the time, but account for 59.0% of the days with weather

NOTE: A day with significant weather, for the purpose of this study, is defined as a day when conditions went below a 2000 foot ceiling or below 5 nm visibility for at least one hour, or precipitation in excess of 0.1 inch or a thunderstorm occurred.

APPENDIX 1

A DYNAMIC TECHNIQUE FOR FORECASTING THUNDERSTORMS AT AVIANO AIR BASE ITALY

By 1st Lt Mel Castillo

Outline

Page

PART I	Abstract
PART II	Introduction
PART III	Analysis

- A. Statement of Forecast Problem and Possible Solutions
 - 1. Weather Event
 - 2. Operational Weather and Time Limits Established
 - 3. Precise Statement of the Problem
 - 4. Possible Predictors
 - 5. Pertinent Data Collected and Analyzed
 - B. Analysis of Static Predictors
 - 1. The Showalter Stability Index
 - a. Discussion
 - b. Results
 - c. Conclusions
 - 2. The 0300Z Aviano Temperature-Dew Point Depression
 - a. Discussion
 - b. Results
 - c. Conclusions
 - 3. The Maximum Convective Temperature at Aviano
 - a. Discussion
 - b. Results
 - c. Conclusions
 - 4. Conclusion of Analysis of Static Predictors
 - C. Analysis of the Synoptic Pattern
 - 1. Thunderstorm Forecasting and the Synoptic Pattern
 - a. Frontal Thunderstorms
 - b. Air Mass Thunderstorms
 - 2. Conclusions Synoptic Pattern
 - D. The Dynamic Thunderstorm Technique for Aviano
 - 1. Discussion
 - 2. Results
 - a. Aviano Summer Thunderstorm Forecast Checklist
 - b. Aviano Short Range Thunderstorm Checklist
- PART IV Forecasting Sky Conditions, Winds,
and Hail for Thunderstorm Activity
at Aviano
- A. Sky
 - B. Wind and Peak Wind Gust
 - 1. Checklist for Forecasting Winds and Peak Wind Gusts
 - C. Hail
 - D. Table Five (Mean Value of Thunderstorm Weather 1956-1959)
 - 1. Thunderstorm NE Quadrant
 - 2. Thunderstorm SE Quadrant

3.	Thnuderstorm SW Quadrant
4.	Thunderstorm NW Quadrant
5.	Thunderstorm Moving Overhead
PART V	Conclusion
PART VI	Bibliography
PART VII	Synoptic Weather Patterns
PART VIII	Analysis of the 1961 Results
A.	Discussion
B.	Results
C.	Conclusion

PART I - Abstract

This study is a concise analysis of the occurrence and behavior of thunderstorms at Aviano Air Base, Italy. Various aspects of thunderstorm weather have also been studied in an effort to forecast this phenomenon more accurately.

This study was made at Aviano during 1959 and 1960. The aim of the technique developed is to provide a useful tool to the Aviano forecaster and to serve as an aid for orientating newly assigned forecasters to Aviano.

PART II - Introduction

Aviano Air Base, located four miles from the Italian Alps, experiences a large number of summer thunderstorms. Thunderstorm frequency varies from a maximum of 16 days in June to a minimum of 4 days in September. (See Section II of TFRN for statistics, 1959-1976). The wide diversity of the air mass sources and the varied topography, coupled with many different triggering mechanisms, provide optimum conditons for rapid building of cumulonimbi. The mediterranean, the Adriatic, and the Bay of Biscay are the main sources of moist unstable air masses. Frequently the moist low level flow, coupled with dry upper air flow over the Alps, creates an ideal thunderstorm producing condition. Horizontal mass convergence in upper air troughs, air mass trajectories over the mountain, and fronta-passages are the most common triggering mechanisms. The fluctuation or the building of a jet stream over Aviano also results in thunderstorm activity.

Forecasting sky condition, peak wind gusts, hail, and precipitation with the occurrence or non-occurrence of thunderstorms has been considerably difficult in the past.

It will be evident that the forecaster must be extremely cognizant of the synoptic pattern in order to accurately forecast thunderstorms at Aviano. Moreover, he must correctly identify air masses and establish their forecast movement. The ability to recognize and forecast stability parameter, triggering mechanisms, and other factors conducive to the development of cumulonimbi is also of prime importance.

This study was prepared in three parts. The first part of the study represents an analysis of three parameters and their correlation with thunderstorms. The second part deals with the synoptic patterns.

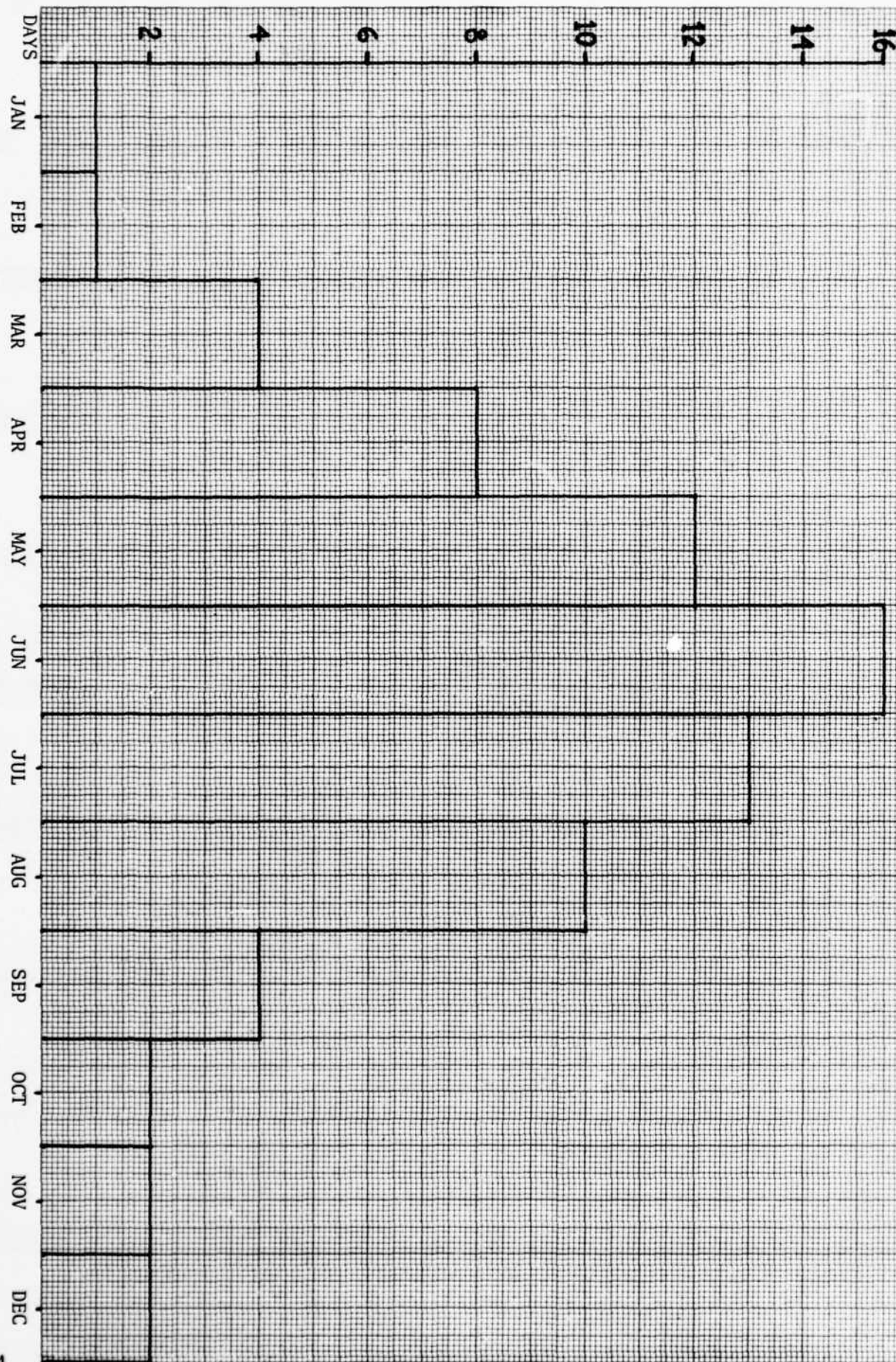
The third part considers the characteristic weather associated with thunderstorm activity. The examples reflect typical synoptic patterns which have resulted in varied thunderstorm activity.

This study was made utilizing WBAN data available from 1956 through 1960. There are no RAOB's at Aviano; however, RAOB's from nearby UDINE for 1958-1960 were used.

PART III - Analysis

- A. Statement of Forecast Problem and Possible Solutions
 - 1. Weather Event: Summer Thunderstorms at Aviano
 - 2. Operational Weather and Time Limits Established: The weather limit was the occurrence or non-occurrence of thunderstorms within a 25 nautical mile radius of Aviano. The time period was from 0600Z to 2400Z. The forecast study is valid from the first May to the end of September.
 - 3. Precise Statement of the Problem:
 - a. Based on data available at the Aviano weather station at 0300Z to forecast the occurrence or non-occurrence of thunderstorms within 25NM of Aviano from 0600Z to 2400Z.
 - b. Based on the data available at the Aviano weather station at 1200Z to provide a check for the forecast made in 3a.
 - 4. Possible Predictors;
 - a. For 0300Z forecast
 - (1) 0000Z Udines stability (Showalter)
 - (2) 0300Z temperature-dew-point depression (Aviano)
 - (3) Maximum forecast temperature
 - (4) 0000Z 500mb, 700mb, and 850mb advection
 - b. For 1200Z forecast
 - (1) 0000Z-1200Z Udine stability change
 - (2) 0000Z-1200Z 500mb, 700mb, and 850mb wind change
 - (3) Radar reports, pilot reports, and synoptic observations
 - 5. Pertinent Data Collected and Analyzed:
 - a. The preliminary analysis revealed that summer thunderstorm activity is predominately of the air mass type. Figure 15 shows the mean frequency of thunderstorm days for the year 1956-1959. During the months May through August, the mean frequency was at least ten thunderstorm days with a maximum of 16 during June.
 - b. Subsequently, considerable analysis of RAOB's, WBAN's, and other records revealed that stability, amount of moisture, convective temperature, and the synoptic pattern were integral factors to consider when determining the probability of thunderstorm activity.
- B. Analysis of Static Predictors
 - 1. The Showalter Stability Index (SSI)
 - a. Discussion: The 0000Z SSI for cases under study were determined from the Udine RAOB's. The SSI actually increased even during thunderstorm formation in 63% of the cases. Rapid cooling at night caused the SSI

FIGURE 15
 MEAN FREQUENCY OF THUNDERSTORMS
 AT AVIANO AIR BASE, ITALY 1956 - 1959



to decrease substantially from the value at noon. Generally, a decrease of the SSI from 0000Z to 1200Z proved significant. If the SSI rose slightly from 0000Z to 1200Z, the change did not prove significant in the forecast.

b. Results:

Table I

0000Z Showalter Stability Index (Udine) May-June 1959-1960*

SSI	TSTM DAY**	NON-TSTM DAY
<3	37 (88%)	34 (53%)
≥ 3 < 5	4 (9.5%)	10 (15.8%)
≥ 5	1 (2.5%)	19 (31.2%)

The Showalter Stability Index (Udine) July-August

SSI	TSTM DAY	NON-TSTM DAY
<3	29 (76.3%)	27 (41.5%)
≥ 3 < 5	6 (15.8%)	18 (27.7%)
≥ 5	3 (7.9%)	20 (30.8%)

Table I shows that the frequency of thunderstorms increased as the SSI decreased. It also shows that the instability required for thunderstorms was less in July and August than May and June. (Note that 23.7% of the thunderstorm cases had stabilities of greater than 3 in July and August compared with 12% in May and June).

Table II

Table II presents a break-down of thunderstorm and non-thunderstorm cases into four stability groups. May-June 0000Z Showalter Stability Index (Udine) 1958-1960.

SSI	TSTM DAY	NON TSTM DAY
<1	16 (24%)	12 (12.6%)
≥ 1 < 3	44 (66.7%)	39 (41%)
≥ 3 < 5	5 (7.8%)	11 (11.6%)
≥ 5	1 (1.5%)	33 (34.8%)

July-August 0000Z Showalter Stability Index (Udine)

SSI	TSTM DAY	NON-TSTM DAY
<1	20 (35.7%)	11 (11%)
≥ 1 < 3	24 (42.9%)	36 (36%)
≥ 3 < 5	8 (14.3%)	22 (22%)
≥ 5	4 (7.1%)	31 (31%)

* Data 20-30 August 1960 not included.

** As defined in Glossary of Meteorology P. 582.

- c. Conclusions:
- (1) Thunderstorm activity will be infrequent when the 0000Z Udine SSI is 5 or greater.
 - (2) Thunderstorms will occur only under special conditions when the 0000Z SSI is greater than 3 but less than 5.
 - (3) 85.2% of the thunderstorm activity occurs when the SSI is 3 or less-
 - (4) The 0000Z SSI is less indicative of TSTM activity in July and August than in May and June.
2. The 0300Z Aviano Temperature-Dew Point Depression
- a. Discussion: The 0300Z Aviano surface temperature-dew point depression was chosen as an index of moisture. The RAOB from nearby Udine (30 miles away) is not representative at low levels because Aviano lies at the foot of the Alps and is therefore subjected to a greater mountain influence. Therefore, a surface parameter was chosen as an index of moisture since the low level Udine moisture RAOB may differ significantly.

b. Results:

Table III

May-June 1959-1960

$T-T_d$ (F)	<u>TSTM DAY</u>	<u>NON-TSTM DAY</u>
0-5	29 (58%)	32 (54.3%)
5-10	13 (26%)	19 (32.2%)
10	8 (16%)	8 (13.5%)

July-August 1959-1960

$T-T_d$ (F)	<u>TSTM DAY</u>	<u>NON-TSTM DAY</u>
0-5	31 (72%)	36 (55.4%)
5-10	10 (23.3%)	19 (29.2%)
10	2 (4.7%)	10 (15.4%)

- c. Conclusions:
- (1) Over 60% of all cases were within the 0-5 temperature-dew point spread.
 - (2) 72% of the thunderstorm cases were within the temperature spread range of 0-5 in July and August, whereas only 58% in May and June.
 - (3) Thunderstorms occurred in some cases when $T-T_d$ was 5-10 degrees and above 10 degrees but only under special conditions, such as the subsequent passage of a front, with a strong jet, or southeasterly upper air flow.
3. The Maximum Convective Temperature at Aviano
- a. Discussion: The amount of surface heating was considered significant in forecasting the degree of cumulus activity. Surface heating was generally more important during cases of isolated to scattered activity and 24 hours after frontal passages.

b. Results:

Table IV

May-June 1959-1960

MAX TEMP F	TSTM DAY	NON-TSTM DAY
60-70	13 (26%)	25 (35.2%)
70-80	25 (50%)	39 (55%)
80-90	12 (24%)	7 (9.8%)

July-August 1959-1960

MAX TEMP F	TSTM DAY	NON-TSTM DAY
60-70	4 (8%)	1 (1.8%)
70-80	25 (50%)	30 (54.5%)
80-90	21 (42%)	24 (43.7%)

c. Conclusions: Generally the higher the temperature the greater the probability of thunderstorm activity. The greater number of thunderstorm and non-thunderstorm cases occurred in the 70-80 temperature range.

4. Conclusions of Analysis of Static Predictors: The analysis of the three parameters revealed that the 0000Z Udine Showalter Stability Index was very indicative of thunderstorm formation. The temperature-dew point depression (0300Z) and the maximum forecast temperature were also indicative but to a lesser degree. Since the Showalter Stability Index was found to be the dominating parameter, a nomogram was plotted to determine the occurrence or non-occurrence of thunderstorms under varying values of temperature and temperature-dew point depression with given ranges of the 0000Z Udine SSI. The nomogram functions as follows: The 0300Z Aviano T-T_d (degree F) and the maximum forecast temperature are entered on the nomogram. The curve to use is determined by the stability range in which the 0000Z Udine SSI falls. If the point falls above the curve being used, thunderstorm activity is probable.

C. Analysis of the Synoptic Pattern

1. Thunderstorm Forecasting and the Synoptic Pattern: The key to successful thunderstorm forecasting at Aviano in the past has been accurate evaluation of the synoptic pattern. Air mass and frontal systems often undergo rapid changes and substantial modification as they proceed over the rugged Alps, Gulf of Genoa, and the Adriatic. The rapid changes make it very difficult to apply long range static parameters to a forecast technique. The forecaster must be able to accurately evaluate and forecast changes in the synoptic pattern in order to be successful at thunderstorm forecasting. The following categories were analyzed:
 - a. Frontal Thunderstorm: The study revealed that in greater than 95% of the direct frontal passages at Aviano, thunderstorm activity occurred. The degree

and persistence of activity depended upon the direction of movement of the front.

- (1) Associated with FROPA from the southwest - A frontal passage from the southwest to northeast usually triggers numerous thunderstorm activity, strong surface winds, hail, low ceilings, and low visibilities for several hours.
- (2) Associated with FROPA from the west - A front moving from west to east over the Alps, gives little or no indication of activity until the front is nearly at Aviano. The winds and weather from this type of frontal thunderstorm are usually very severe and difficult to forecast because mountain frontal analysis is very complicated.
- (3) Associated with FROPA from the northwest or north - A front moving from the northwest to the southeast or north to south causes high level thunderstorms to form over the mountains. These are generally moderate because considerable dissipation occurs as the thunderstorm cells move over MT Cavallo (Elev 7200') and the field.

b. Air Mass Thunderstorms

- (1) Associated with general 500mb flow
 - (a) Northwesterly flow - Northwesterly flow over the Alps during the summer usually advects dry continental (modified polar) air. Isolated thunderstorms form over the mountains with substantial heating and low level moisture. The thunderstorms are observed to form during the middle afternoon and move over Aviano several hours later. Several mountain stations, such Dobbiacco and Mt. Grappa, are useful in detecting these thunderstorms for a short range forecast. This type forms frequently soon after the passage of a frontal or upper air system.
 - (b) Southwesterly flow - A higher percentage of thunderstorms occur with southwesterly upper air flow since the air masses proceeding from the Gulf of Genoa over the Po Valley are generally moist and unstable. Numerous thunderstorm cells form southwest of the station and move along the ridge of the mountains with regularity. Ceilings and visibilities deteriorate very rapidly as the cells move over the station. Thunderstorm cells frequently form northeast of the field and move against the apparent wind pattern over the field. Radar observations are quite useful in tracking and short range forecasting of these thunderstorms.
 - (c) Northeasterly flow - Very few thunderstorms except those noted above were observed with

northeast flow especially if the flow was from a ridge. Northeast flow occasionally occurs with a weak upper air trough and will result in scattered activity.

- (d) Southeasterly flow - Southeasterly flow is infrequent at Aviano. However, the thunderstorm cases associated with southeasterly flow were high. The study revealed that thunderstorms occurred even with high stability (SSI 3-5) and seemingly dry air mass. The reason for this phenomenon is apparent when one considers that the mountain ridge 4 miles from Aviano is oriented NE - SW. Air mass parcels proceeding from the Gulf of Venice to Aviano (southeasterly flow) experience abrupt lifting as they rise from sea level to Aviano (elev 432') and then to Mt. Cavallo (elev 7200'), thus triggering considerable activity.

(2) Associated with upper air trough

- (a) The flow from an upper trough west of Aviano is southwesterly. However, this pattern should be treated separately since special phenomena are observed with it. A fairly deep upper air trough is usually associated with a front approaching from the southwest. Weather from the system commences with the passage of the zero vorticity line and very rapidly improves with the passage of the main trough lines. It is observed quite frequently that the trough line passes Aviano moving easterly and then retrogresses, triggering numerous thunderstorms for another 24 hours. Therefore, the forecaster must be alert to detect possible retrogressions since the thunderstorms from this condition usually form very rapidly; are numerous and are very severe.

2. Conclusions Synoptic Pattern:

a. General Results

- (1) Thunderstorm activity will generally occur with a frontal passage at Aviano.
- (2) Air mass thunderstorms will occur with 500mb flow from any direction but are most common with southwesterly flow.
- (3) The few days immediately after the passage of a system advecting moisture are optimum for thunderstorm activity with 500mb flow from any direction (such as soon after a frontal passage or transitory low cell).
- (4) The thunderstorm cases with southeasterly flow are high even though parameters indicate that formation is improbable.

b. Typical examples of the synoptic pattern and thunderstorm activity for 1960 have been reproduced in PART VII.

D. The Dynamic Thunderstorm Technique for Aviano

1. Discussion: The analysis of the static predictors and the synoptic pattern yielded several interesting results. First, the nomogram is the graphical result of the relative correlation of stability, surface moisture, and surface temperature with thunderstorm occurrence. The analysis of the synoptic pattern presents a qualitative correlation and the results are quite useful when used in conjunction with an objective technique. Subsequently, with the results of both aspects in mind, a checklist was designed to serve as the forecast technique.

2. Results:

a. Aviano Summer Thunderstorm Forecast Checklist

- (1) To be applied between 0300Z and 0600Z. Forecast valid 0600Z to 2400Z.

- (a) Forecast maximum temperature _____ F
- (b) 0000Z Showalter Stability Index _____
- (c) 0300Z temperature-dew point depression _____
- (d) 500mb direction of flow is _____
- (e) Is front approaching? _____
- (f) Is jet stream forming over Aviano? _____

(2) Procedure:

- (a) Enter data from a. (1) (a) (b) (c) in thunderstorm nomogram.
 - 1 If case falls above curve being used, proceed to part (2b)
 - 2 If case falls below curve, proceed to part (2c).
- (b) Case falls above curve
 - 1 If 0000Z SSI is greater than or equal to 5, forecast "no" and stop except when a deep trough, strong front, or a strong jet is approaching, forecast "yes" and stop.
 - 2 If strong ridge and surface high pressure system causing considerable drying is forecast to persist or intensify forecast "no".
 - 3 Forecast "yes" for all other cases falling above curve on nomogram.
- (c) Forecast "no" for all cases falling below curve on nomogram, except when a deep trough, a strong front, or a strong jet is approaching, or when there is strong southeasterly flow, forecast "yes".

b. Aviano Short-Range Thunderstorm Checklist

- (1) To be applied for 1200Z forecast valid 1200Z to 2400Z.

- (a) Will forecast temperature verify within 5 degrees F? _____
- (b) Has the Showalter Stability Index decreased? _____
- (c) Has the SFC Temp-Dp depression decreased? _____
- (d) Has the synoptic pattern remained the same? _____
- (e) Do present weather and RAREP's verify convective activity? _____

(2) Procedure:

- (a) If answer to all 5 is "yes", continue original forecast.
- (b) If answer to any question is "no", reevaluate

the case using the checklist 2.a.

PART IV - Forecasting Sky Conditions, Winds and Hail for Thunderstorm Activity at Aviano.

- A. Sky Condition: The cloud bases and tops depend upon the quadrant in which the thunderstorm cell forms and upon its subsequent movement. The study showed that thunderstorms which formed overhead, to the southwest and the northeast were low level and had low ceilings and visibilities. Thunderstorms which formed to the northwest or the north of Aviano (on the mountain ridge), were high-level and ceilings and visibilities did not deteriorate considerably. Table V shows mean ceilings, visibilities, and other characteristics during the period 1956 to 1959.
- B. Winds and Peak Wind Gusts: Several methods of forecasting winds and peak wind gusts during thunderstorms were tested by Aviano forecasters. These methods were somewhat unsatisfactory. The previous studies forecast wind magnitudes and direction entirely different from those observed. It seems probable that these techniques can be modified to compensate for the deviation. However, the deviations are so erratic that it appears to be a difficult task.

A study of winds and peak wind gusts for the past five years revealed some interesting facts. The winds and gusts were plotted on hodographs according to the quadrant in which the thunderstorm formed. The hodographs showed that about 95% or more of the winds recorded at Aviano were from the quadrant in which the thunderstorm formed, regardless of the upper wind pattern. Therefore, it seems logical to conclude that the wind direction forecast should be from the quadrant in which the thunderstorm will form. Only general rules can be applied. It is significant to note that when thunderstorms move across the field the wind direction changes accordingly. A wind direction forecast of variable seems most feasible unless the forecaster is sure that the thunderstorm will remain in a certain quadrant. The following table shows the percentage of gusts within certain ranges:

GUSTS	10-20 Knots	20-30 Knots	30-40 Knots	40 Knots
May-June	67.4% (31)	21.7% (10)	10.9% (5)	NONE
July-August	31.6% (12)	36.8% (14)	18.4% (7)	13.2% (5)

Therefore, peak wind gusts are more prevalent during July and August.

Gusts as a function of stability:

GUSTS	2 (SSI)	1 (SSI)
10-20	80% (16)	20% (4)
20-30	37% (16)	63% (8)
30-40	00 (00)	100% (15)

All of the wind gusts in the 30-40 knot range occurred with stabilities of +1 or less. Stability, therefore, is quite

indicative of the peak wind gust; other techniques seem to forecast accurately if applied when the stability index is +1 or less.

1. Checklist For Forecasting Winds and Peak Wind Gusts

a. For thunderstorms forming in the NE quadrant forecast wind:

- (1) 360-090 degrees at 10 knots
- (2) Gusts to 20 if SSI is +3 or more
- (3) Gusts to 30 if SSI is +1 to +3
- (4) Use Technique in Severe Weather Warning Manual (AWSM 105-37) if SSI is +1 or less

b. Thunderstorms forming SW quadrant forecast winds:

- (1) 180-270 degrees at 10 knots
- (2) Remainder same as part 1.a(2,3,4)

c. Forecast vrbl/10 gusts to 20 knots for thunderstorm forming NW or SE quadrant unless SSI is +1 or less, then use part 1.a.(3)

C. Hail: There are very few cases of surface hail at Aviano. However, surface hail occurs during the early spring and late summer over the mountains and in the central Po Valley. There were about cases of hail reported at Aviano in the period from 1956 to 1959. Generally the hail occurred when the Showalter Stability Index was negative. There were not enough hail cases to arrive at definite conclusions. Methods described by AWSM 105-37 were tested by Aviano forecasters and proved unsatisfactory. It seems logical to forecast surface hail at Aviano only under very special conditions, such as with negative stability.

D. Table V: Mean Values of Thunderstorm Weather 1956 to 1959

1. Thunderstorm NE Quadrant

- a. Weather 40 sctd 60 bkn high bkn, vsby 7 TRW-
- b. SFC winds 360-090 at 10-15 gusts 20-3- knots
- c. 500mb wind 240-290 degrees
- d. If SSI is less than zero (0), weather 5 ovc, vsby $\frac{1}{2}$ TRW-
- e. 37% of total form NE

2. Thunderstorm SE Quadrant

- a. Weather 60 bkn, vsby 10 TRW-
- b. Winds vrbl at 10 knots gusts 30
- c. 500mb wind 180-270 degrees
- d. 0.2% of total form SE

3. Thunderstorm SW Quadrant

- a. Weather 15 bkn 40 ovc, vsby 3 TRW
- b. SFC wind 180-270 degrees at 20 knots gusts 20-40
- c. 500mb wind 180-270 degrees
- d. If SSI is +1 or less weather will be: 5 ovc vsby 0.2TRW+
- e. 15% of total form SW

4. Thunderstorm NW Quadrant

- a. Weather 40 sct 80 bkn high ovc, vsby 10
- b. SFC winds vrbl at 10 knots gust 20
- c. 500mb wind all quadrants
- d. If SSI is less than zero (0), weather will be: 10 ovc vsby 1 TRW
- e. 47.8% of total formed NW

5. Thunderstorm Moving Overhead
 - a. Weather 10 bkn 30 ovc, vsby 1 TRW
 - b. SFC winds vrb1 15-20 knots gusts 20-40
 - c. 500mb wind 090-180 degrees
 - d. Weather WOXO TRW+ if the SSI is low

PART V - Conclusion: The study revealed many interesting facts about the occurrence of thunderstorms and their behavior at Aviano. Many conclusions can be made about the parameters affecting this phenomenon and have been reflected in the construction of the nomogram showing graphical correlation. The results from the synoptic analysis are also significant. The forecast checklists developed in the study were used during the 1961 season and verification of the forecast maintained. Some modification of the nomogram will be essential as additional data are made available. Also more accurate study of hail and winds will be possible.

The analysis on sky condition, winds, and hail for thunderstorm activity will be particularly useful in orientating new forecasters.

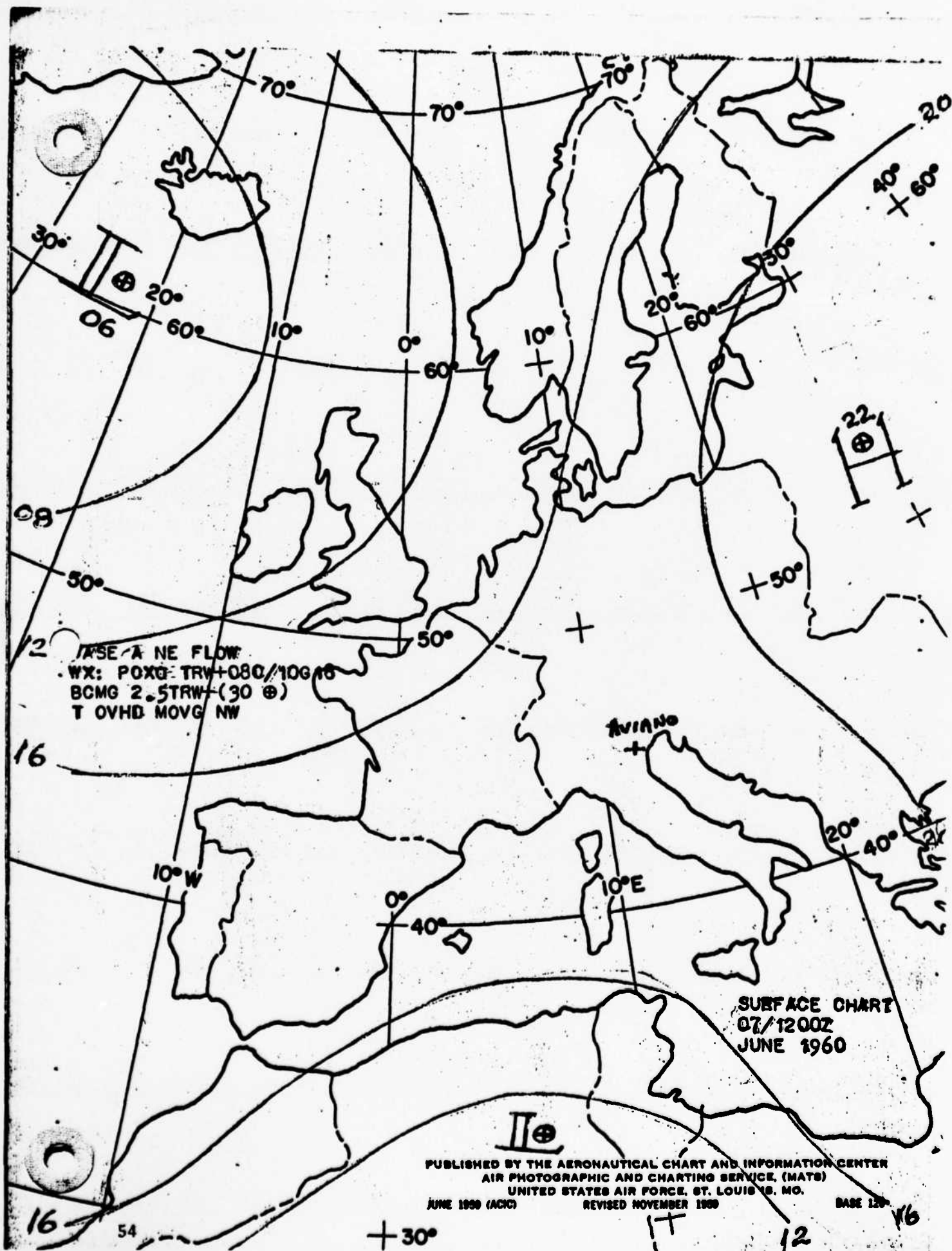
PART VI - Bibliography

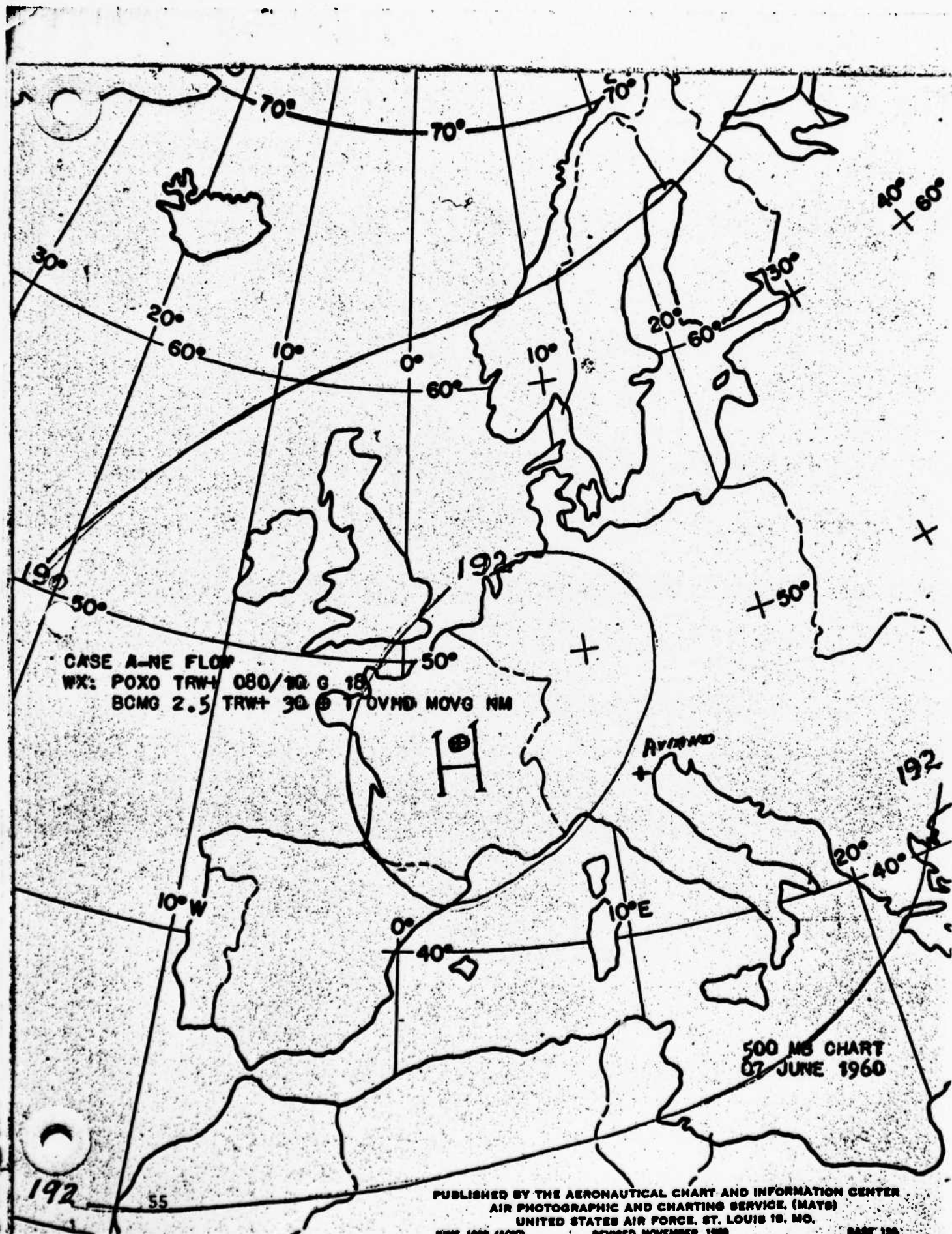
- A. Byers, Horace R., The Thunderstorm, The U.S. Dept of Commerce, June 1949, pp.17-119.
- B. Willett, Hurd C., Descriptive Meteorology, Academic Press Inc., 1944, pp. 266-277.
- C. Saucier, Walter J., Principles of Meteorological Analysis, University of Chicago Press, 1955, pp. 83,89,291-295.

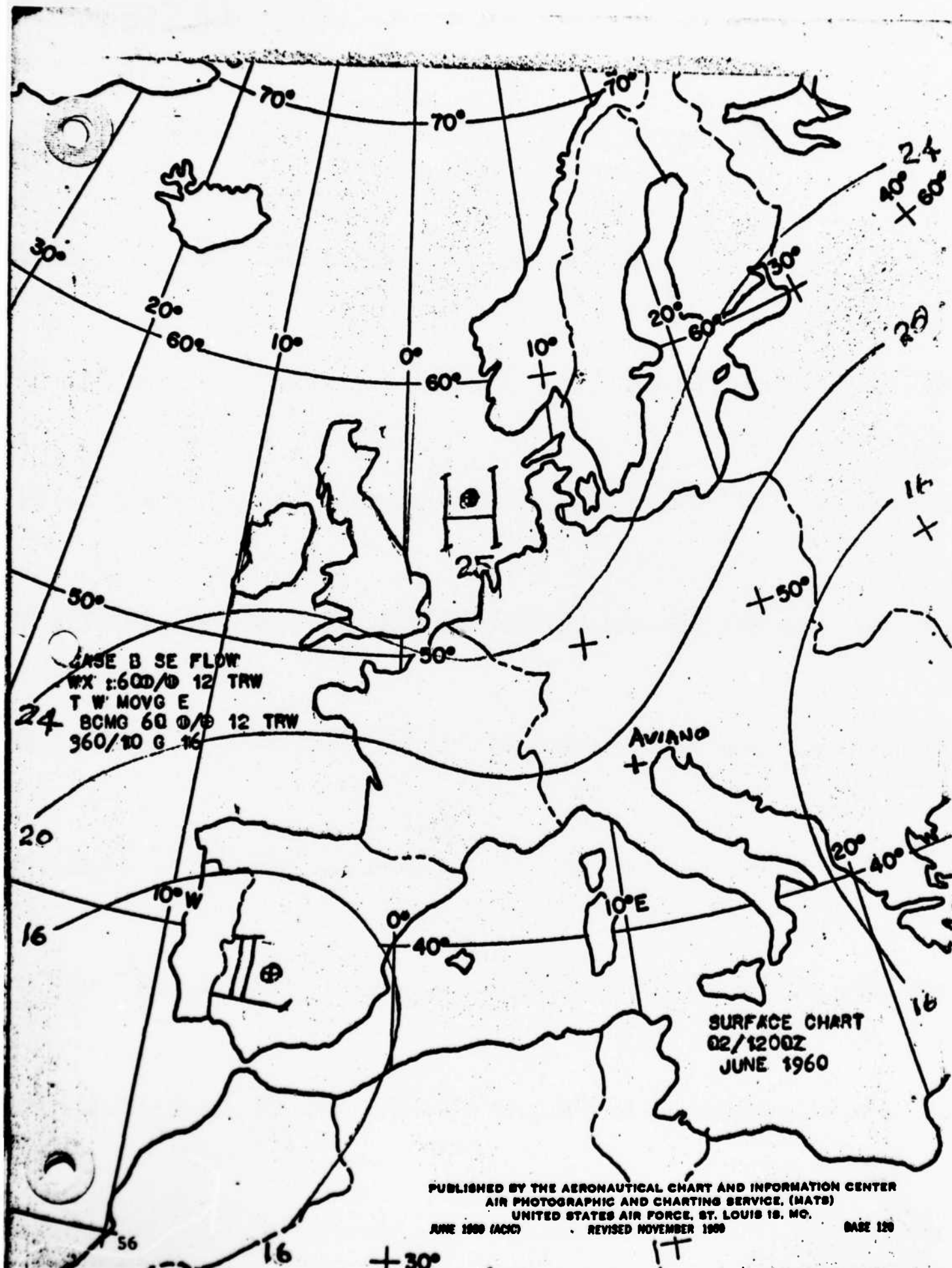
PART VII - Synoptic Weather Patterns: The cases shown are typical examples of the synoptic pattern and weather observed with each type of thunderstorm case studied. A study of these cases will be especially useful for the new forecaster as an introduction and orientation guide. A description of the case is typewritten on each sheet.

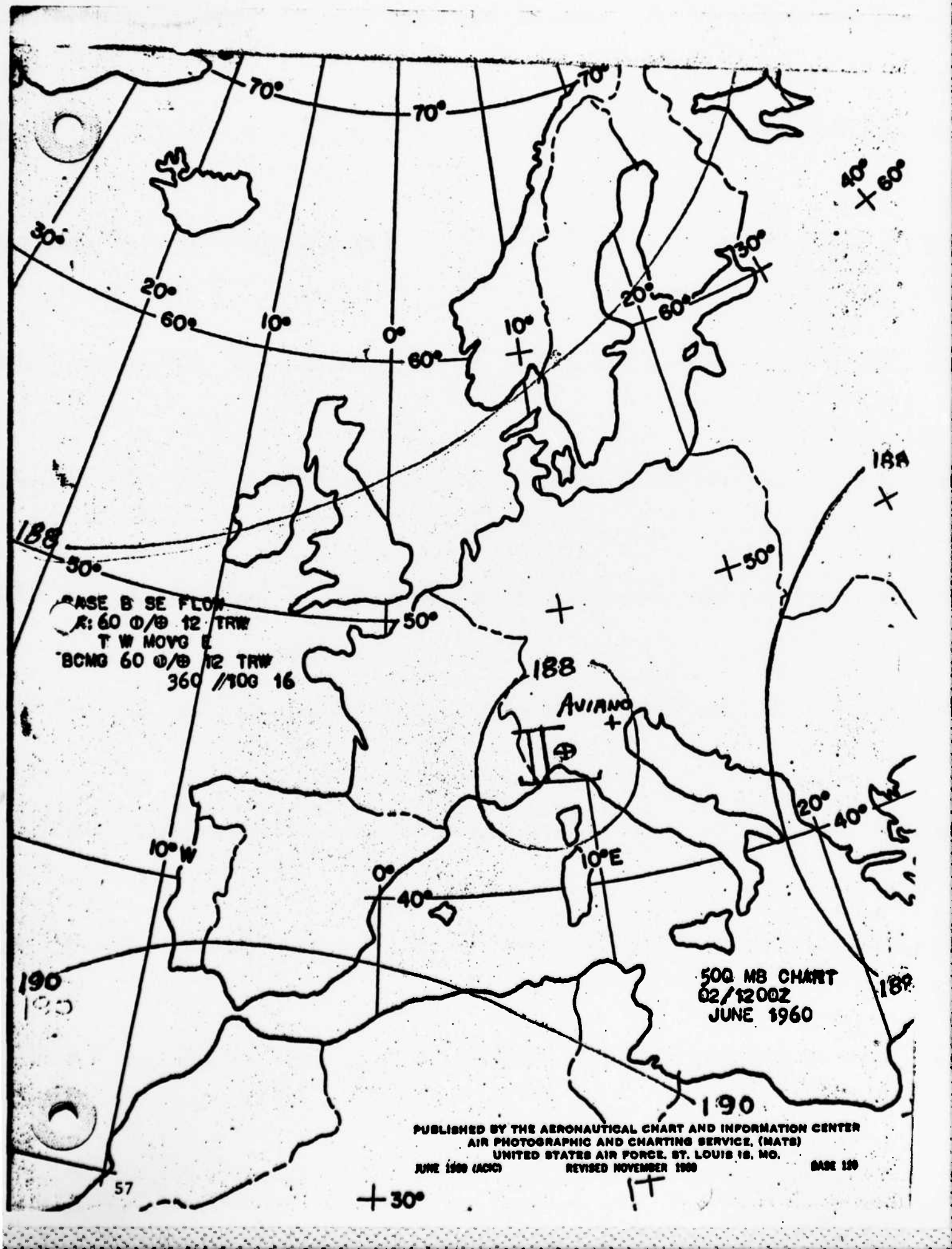
- A. Synoptic Weather Patterns and their associated weather at Aviano AB, Italy. Eleven (11) cases during June-Sep 1960.

1. Case A	NE FLOW	07 June 1960
2. Case B	SE FLOW	02 June 1960
3. Case C	NW FLOW	05 July 1960
4. Case C ¹	NW FLOW	09 June 1960
5. Case D	SW FLOW	02 July 1960
6. Case D ²	SW FLOW	26 June 1960
7. Case E	Fropa NW	19 Aug 1960
8. Case F	Fropa WSW with trough	20 Sep 1960
9. Case F ¹	Retrogression of Trough	21 Sep 1960
10. Case G	Fropa SW	12 Aug 1960
11. Case H	Fropa W	30 Aug 1960



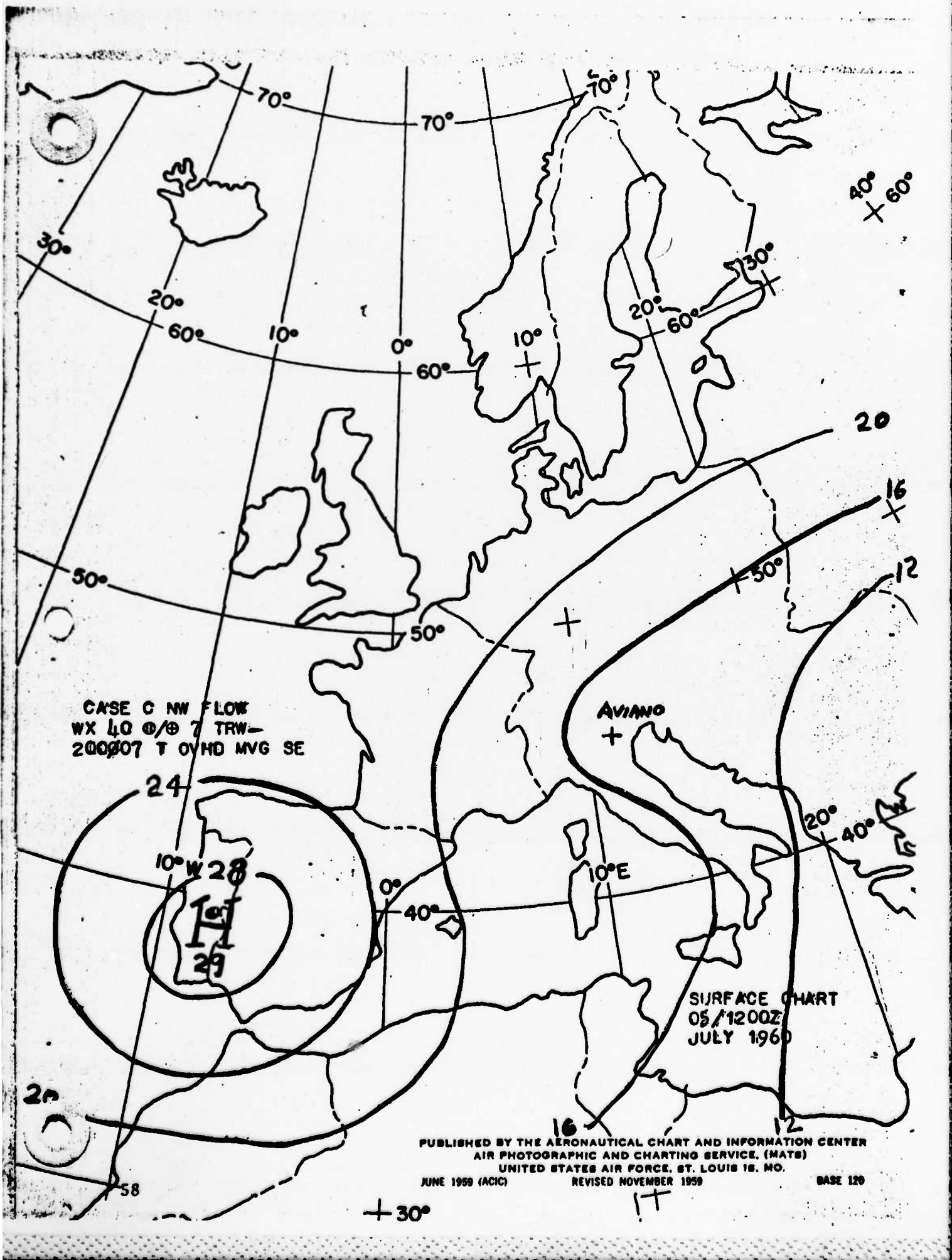


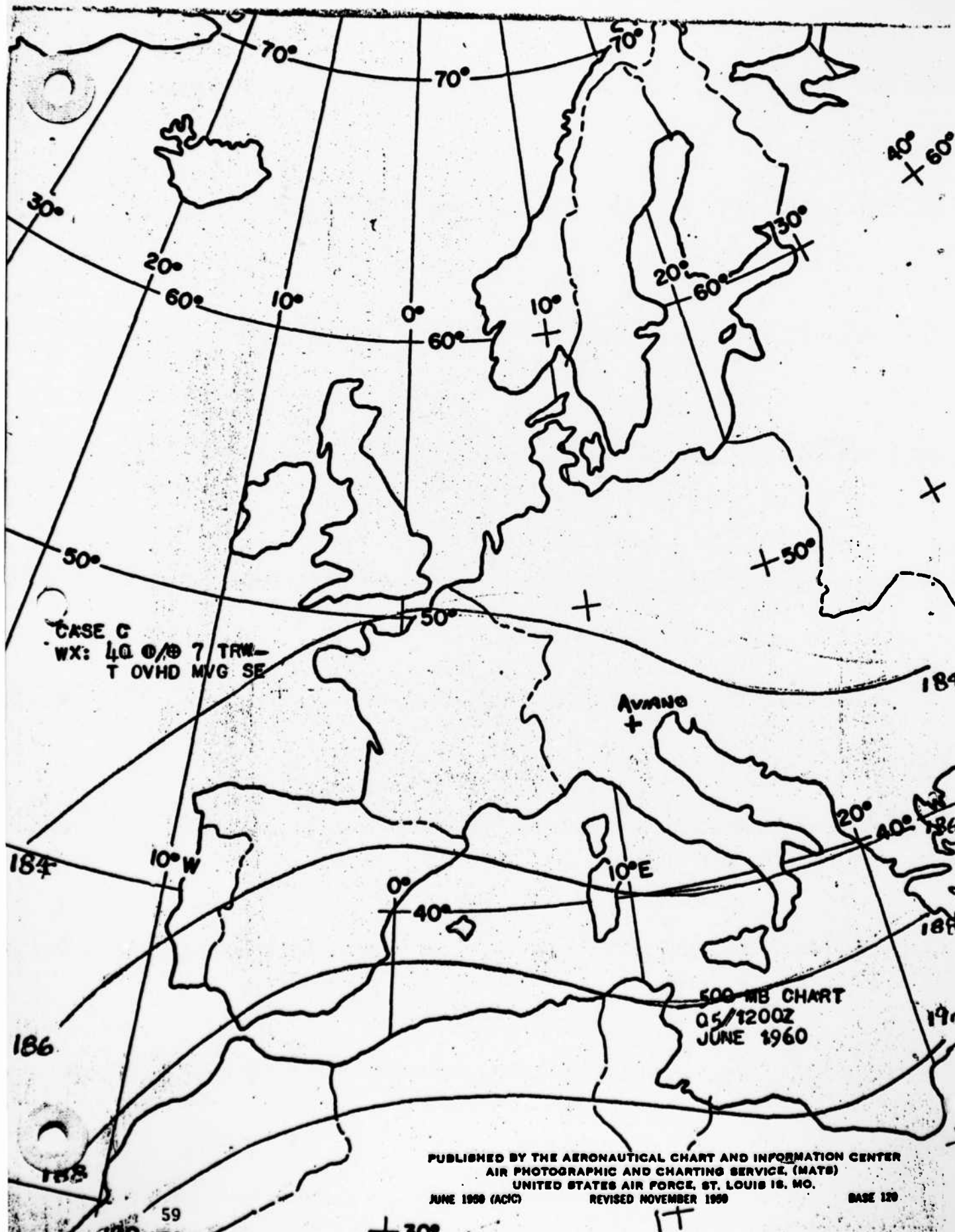




PUBLISHED BY THE AERONAUTICAL CHART AND INFORMATION CENTER
AIR PHOTOGRAPHIC AND CHARTING SERVICE, (NATS)
UNITED STATES AIR FORCE, ST. LOUIS 18, MO.
JUNE 1960 (ACIC) REVISED NOVEMBER 1960

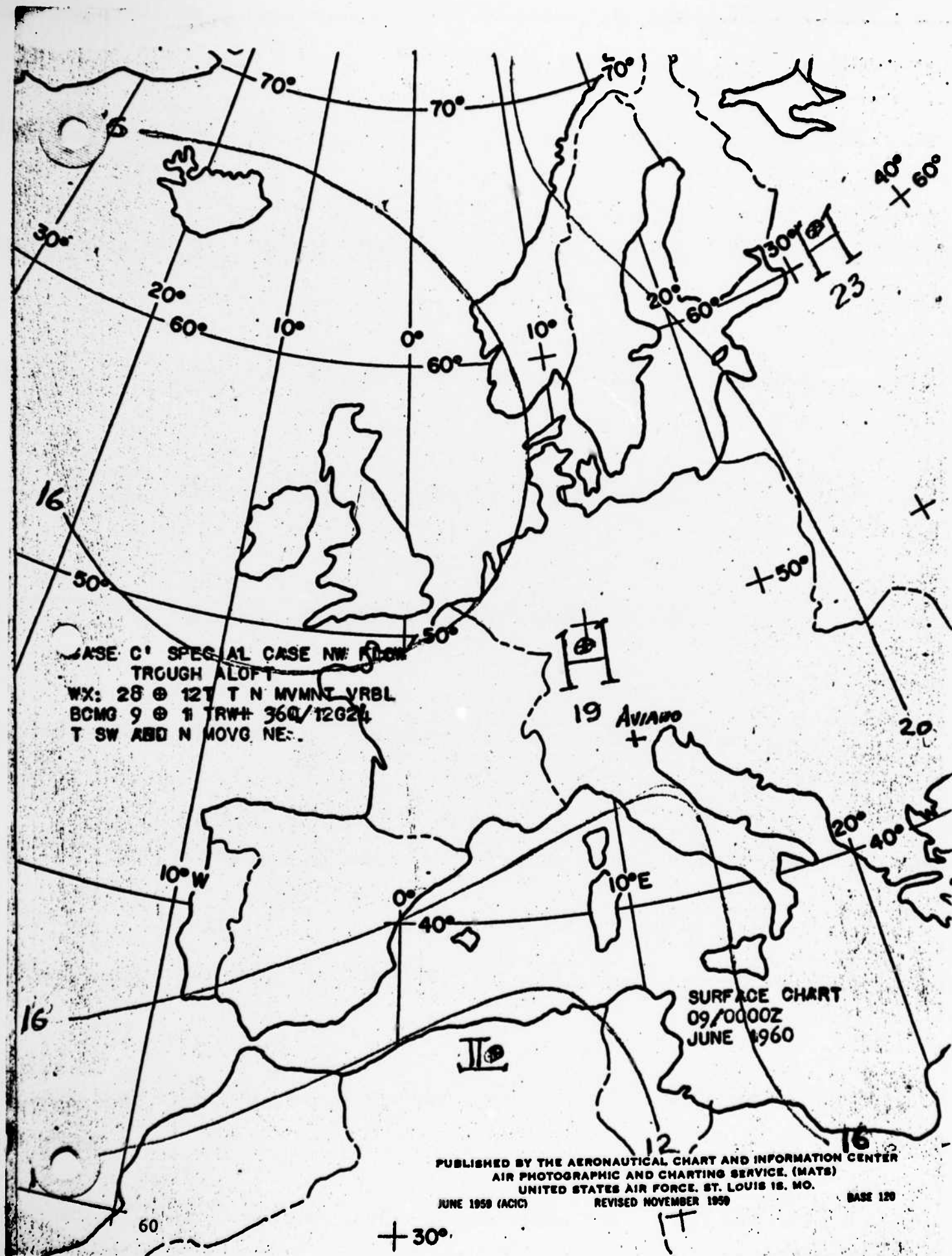
BASE 120

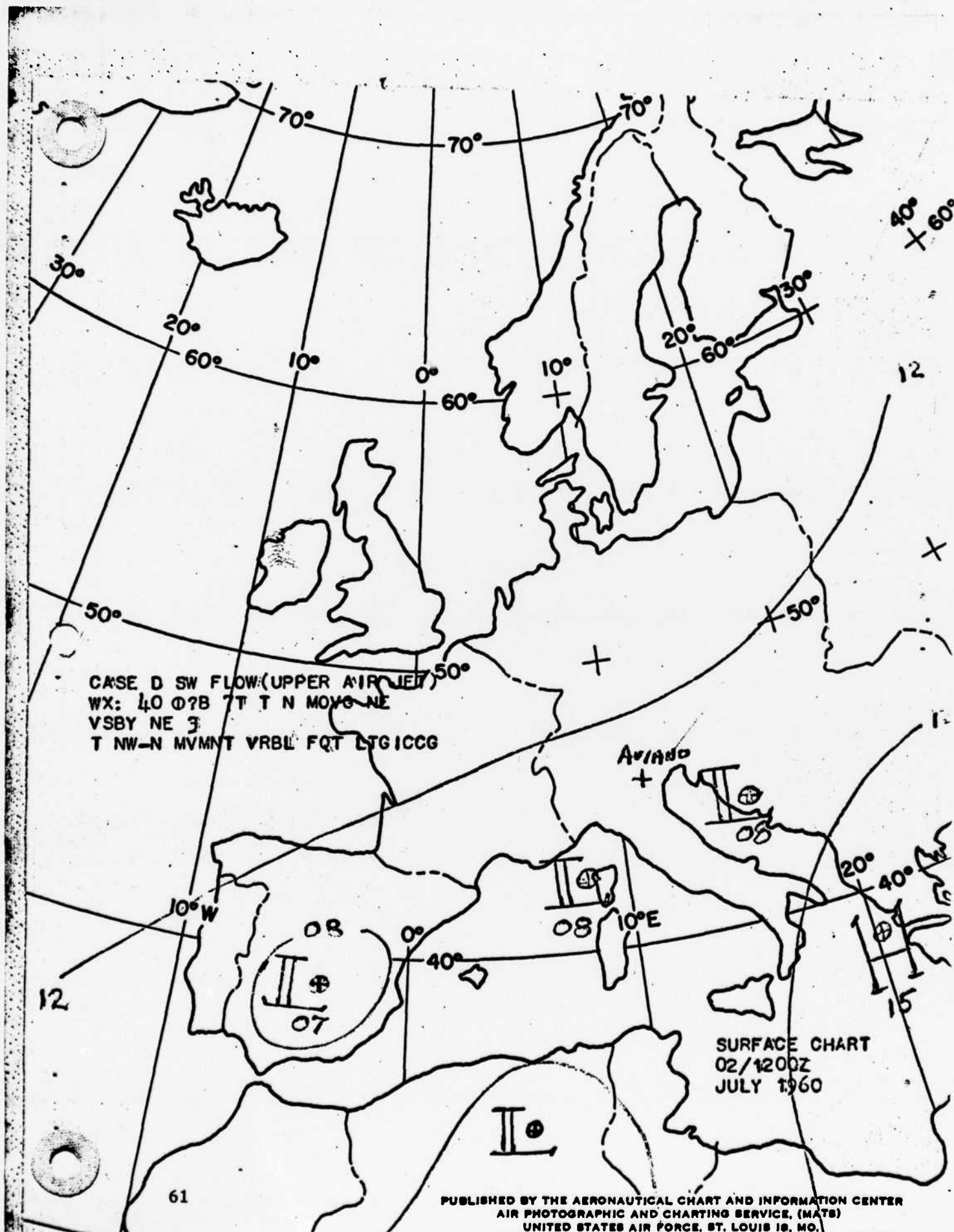




PUBLISHED BY THE AERONAUTICAL CHART AND INFORMATION CENTER
 AIR PHOTOGRAPHIC AND CHARTING SERVICE, (MATS)
 UNITED STATES AIR FORCE, ST. LOUIS 18, MO.
 JUNE 1960 (ACIC) REVISED NOVEMBER 1960

BASE 120

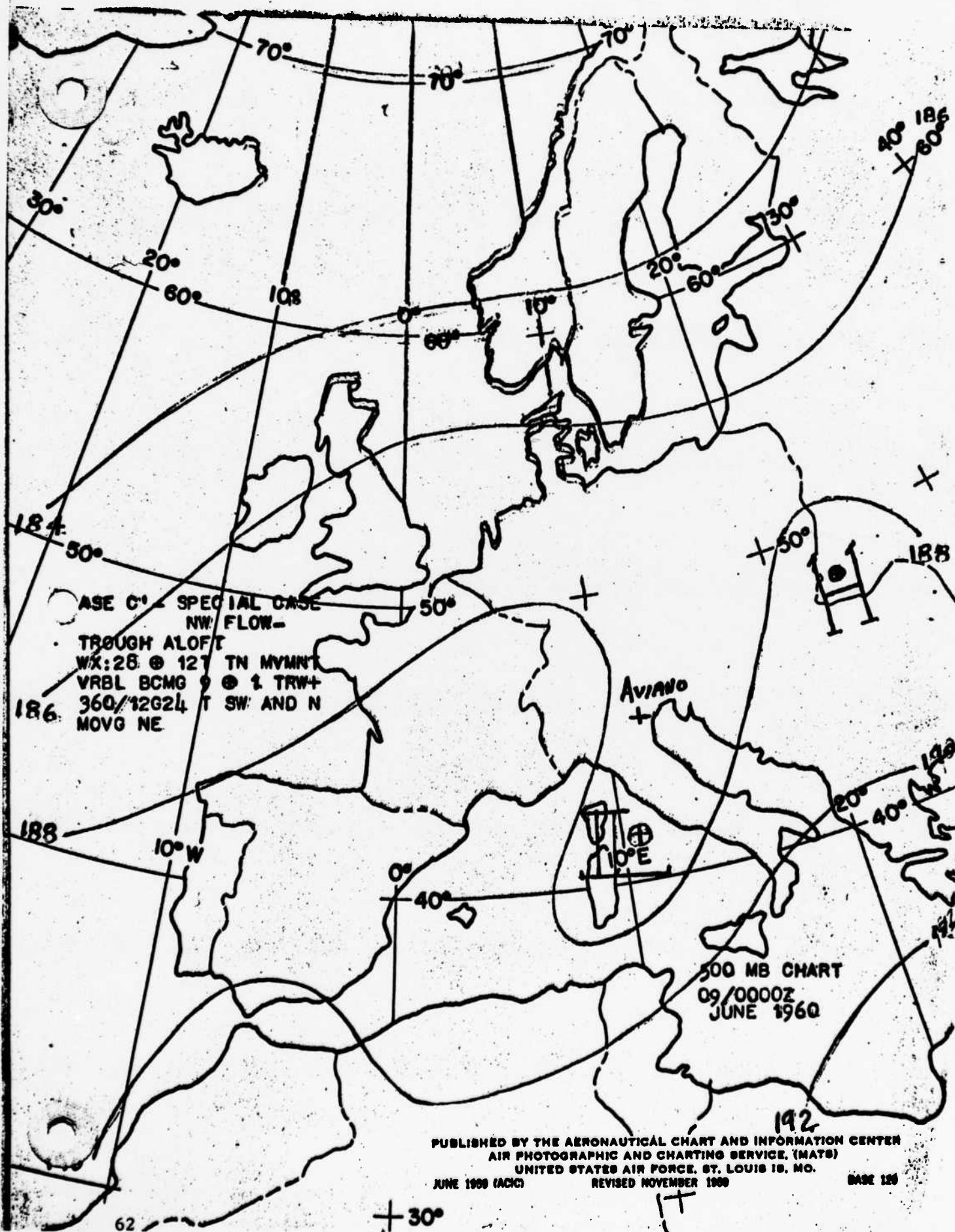




CASE D SW FLOW (UPPER AIR JET)
WX: 40 0?B 7T T N MOVG NE
VSBY NE 3
T NW-N MVMNT VRBL FQT LTGICCG

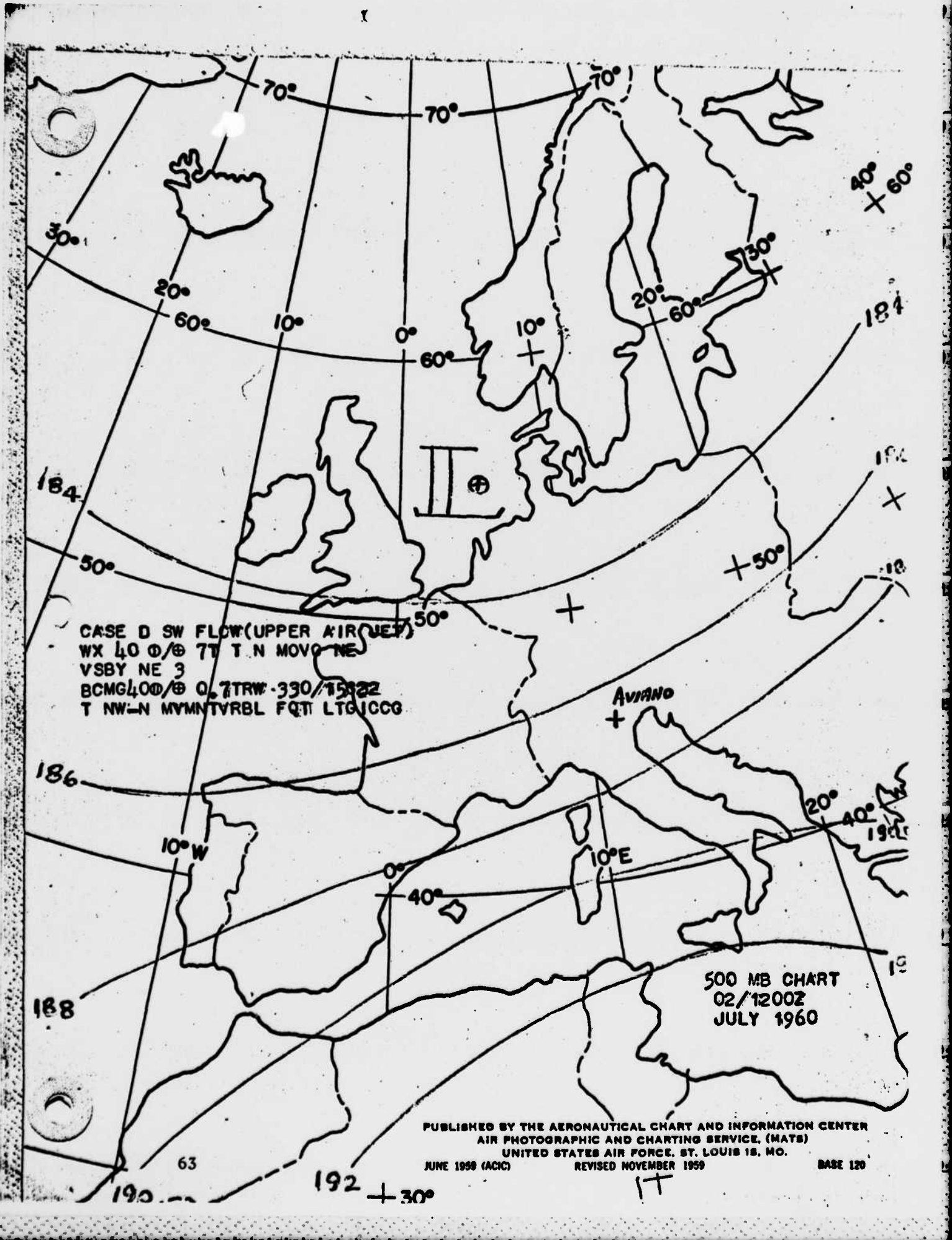
Aviatio
+

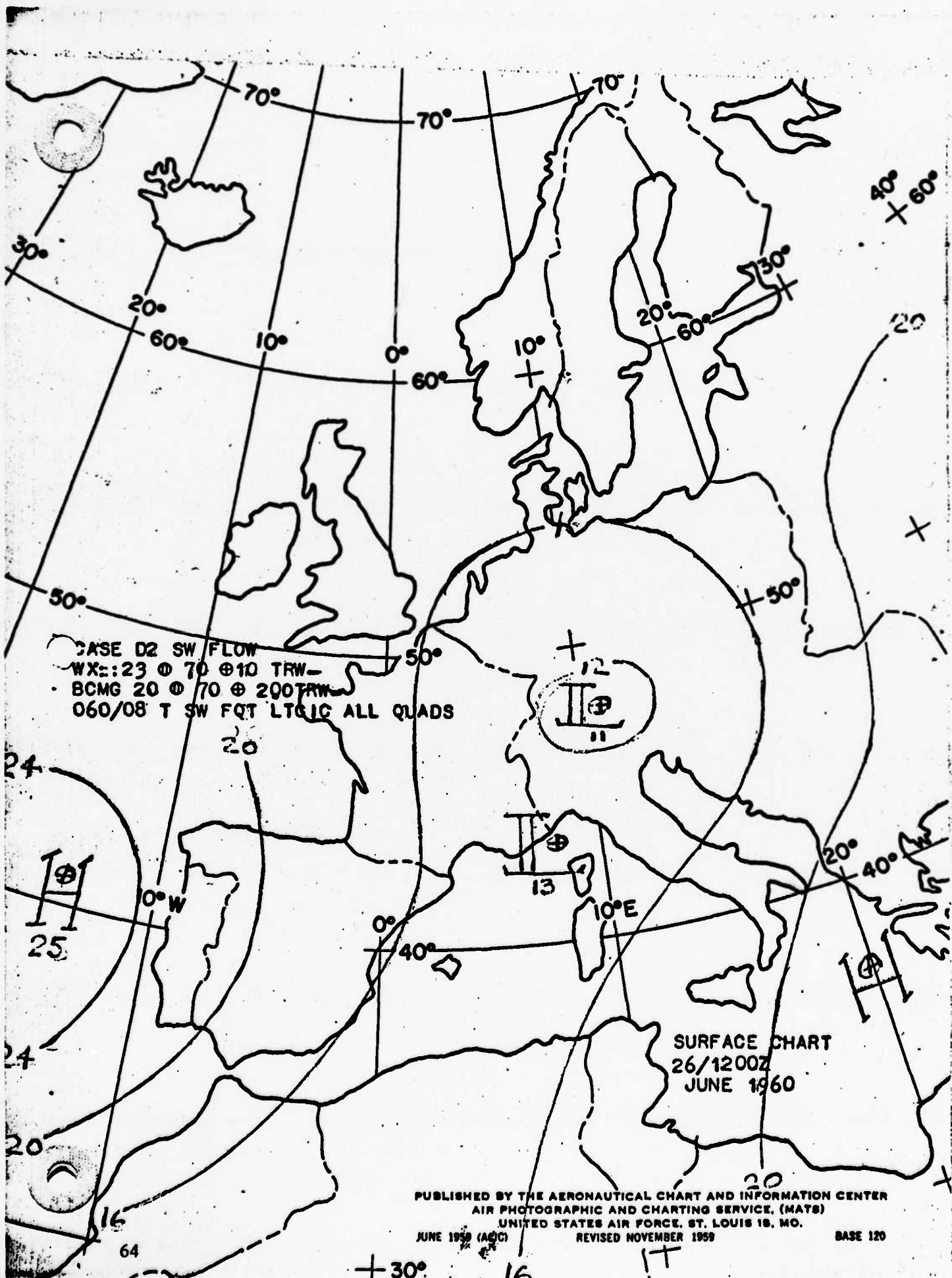
SURFACE CHART
02/1200Z
JULY 1960



**PUBLISHED BY THE AERONAUTICAL CHART AND INFORMATION CENTER
AIR PHOTOGRAPHIC AND CHARTING SERVICE. (MATS)
UNITED STATES AIR FORCE, ST. LOUIS 19, MO.
JUNE 1966 (ACI) REVISED NOVEMBER 1966**

PAGE 120





CASE D2 SW FLOW

WX: 23 @ 70 @ 10 TRW-

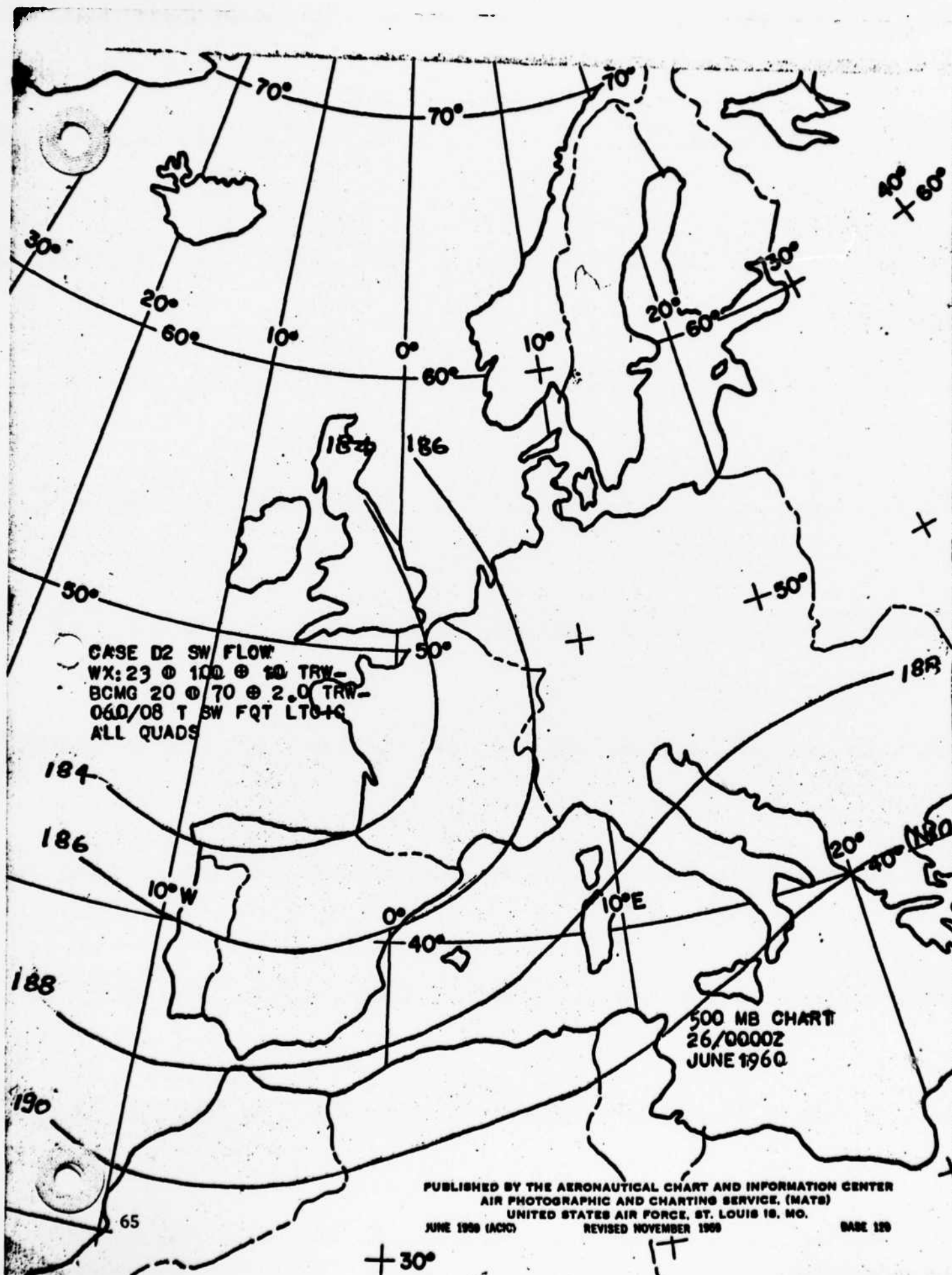
BCMG 20 @ 70 @ 200 TRW

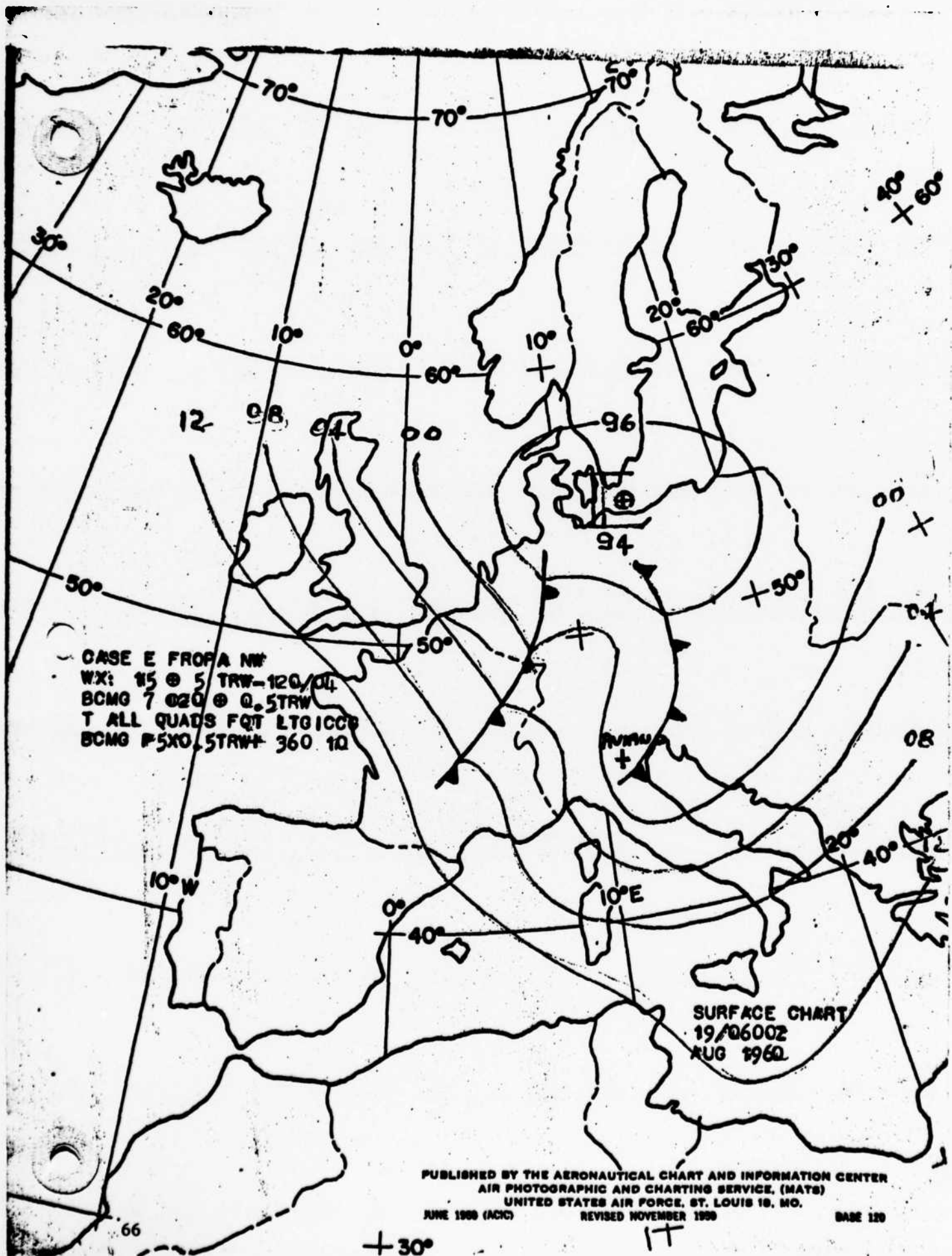
060/08 T SW FQT LTG IC ALL QUADS

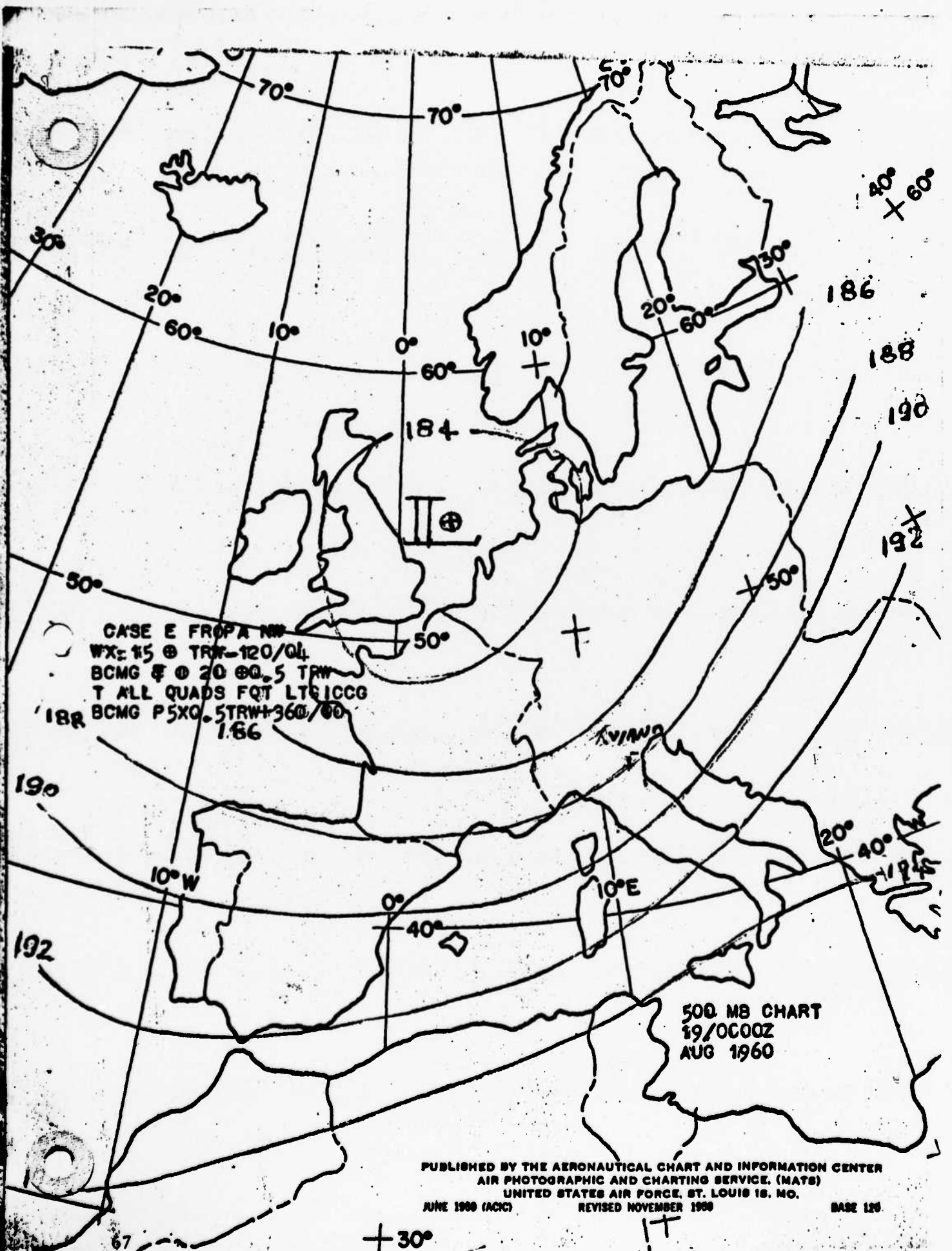
SURFACE CHART
26/1200Z
JUNE 1960

PUBLISHED BY THE AERONAUTICAL CHART AND INFORMATION CENTER
AIR PHOTOGRAPHIC AND CHARTING SERVICE, (MATS)
UNITED STATES AIR FORCE, ST. LOUIS 18, MO.
JUNE 1959 (AGC) REVISED NOVEMBER 1959

BASE 120





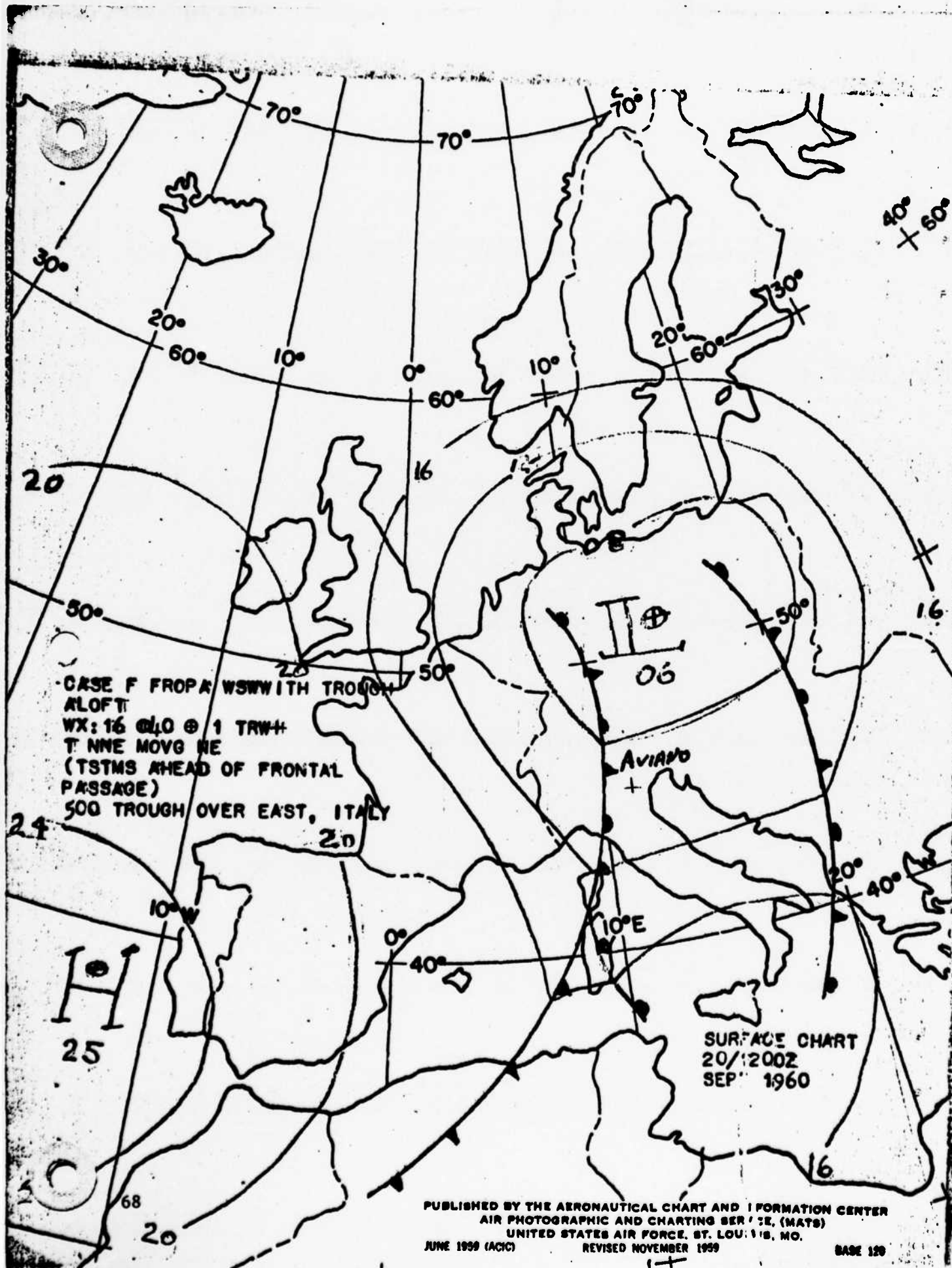


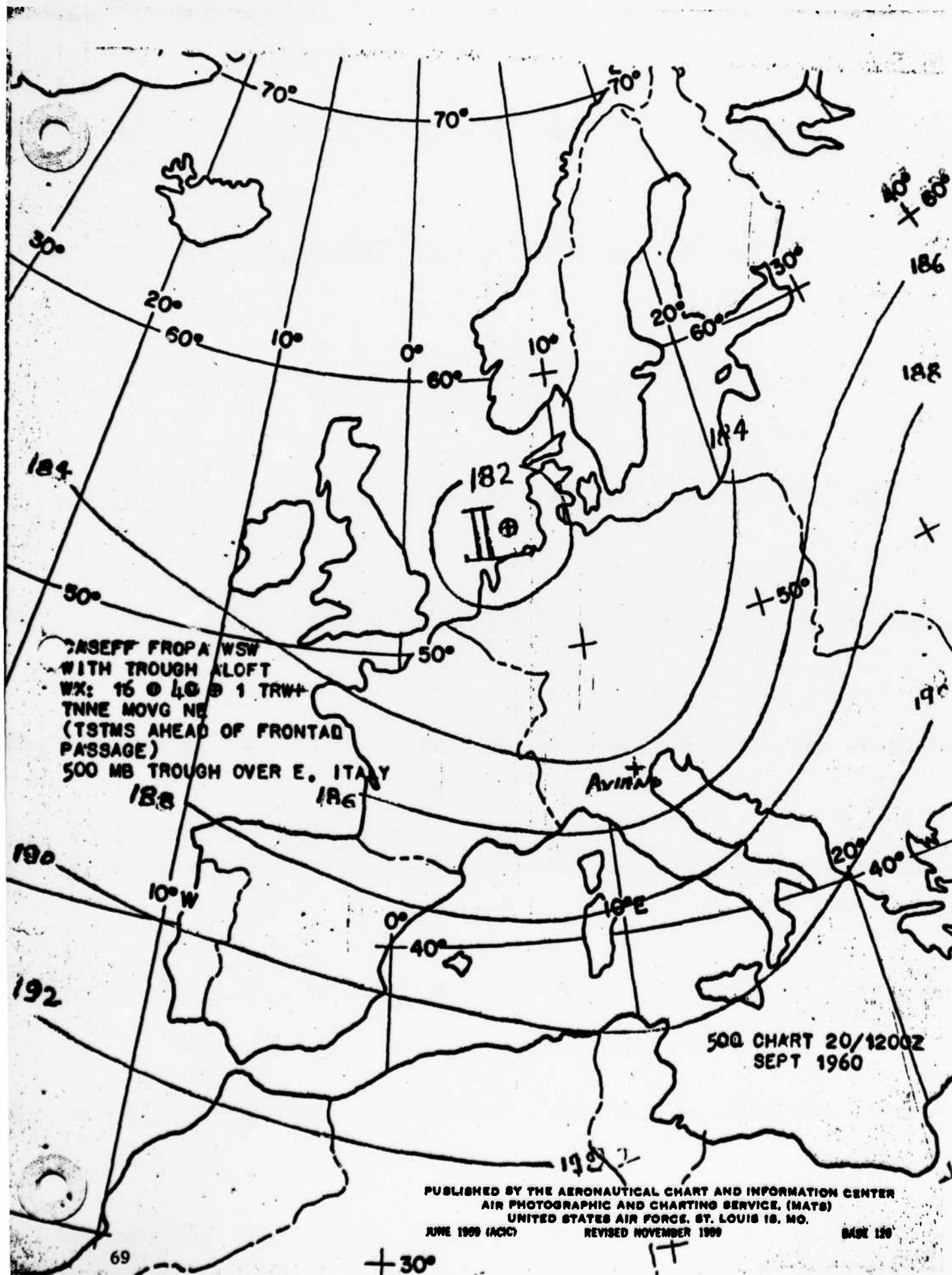
CASE E FROMA NW
WX: 15 @ TRW-120/04
BCMG 8 @ 20 @ 0.5 TRW
T ALL QUADS FQT LTRICCG
BCMG P5XQ-5TRW-360/00
18R 186

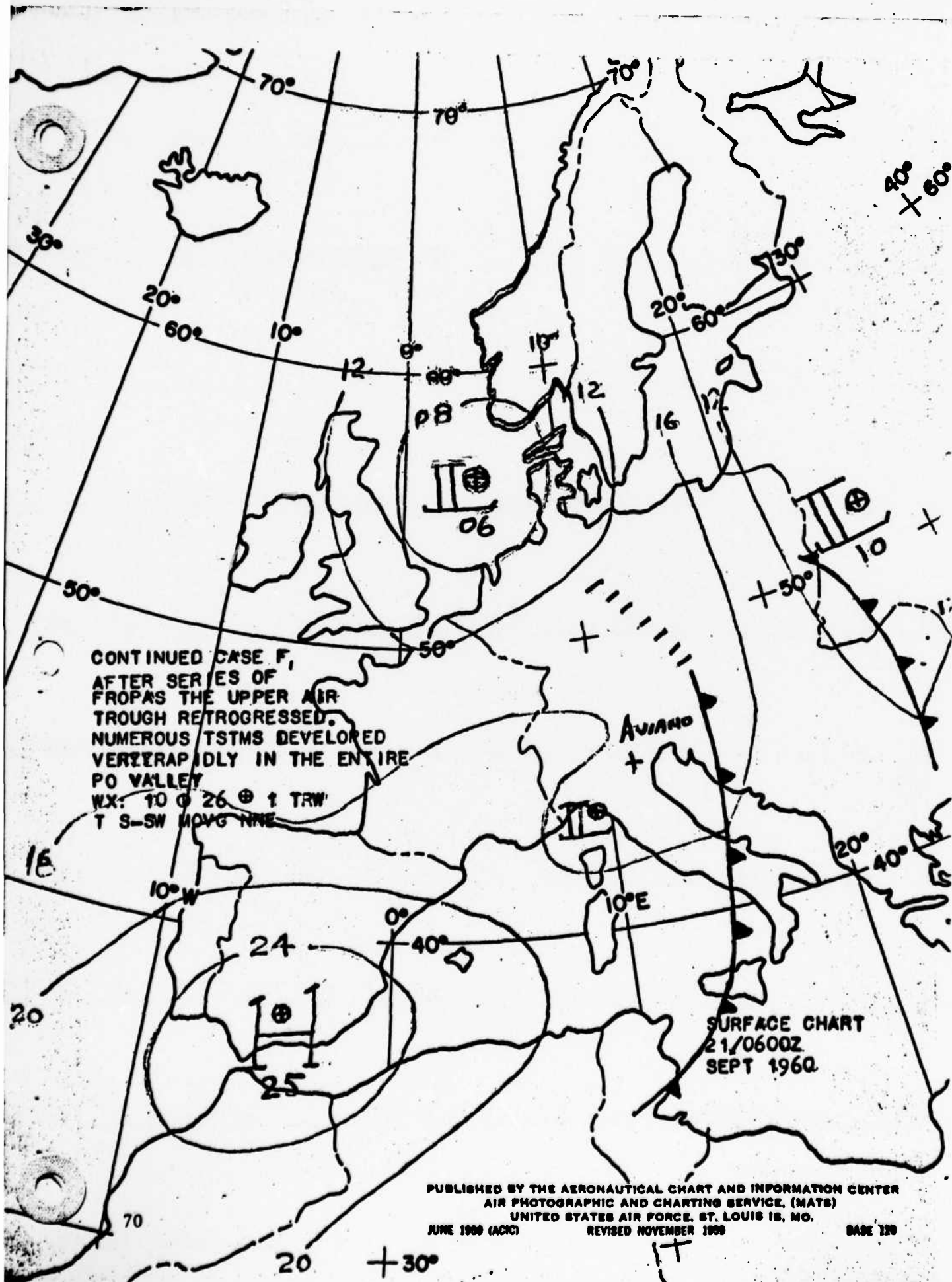
500 MB CHART
19/0000Z
AUG 1960

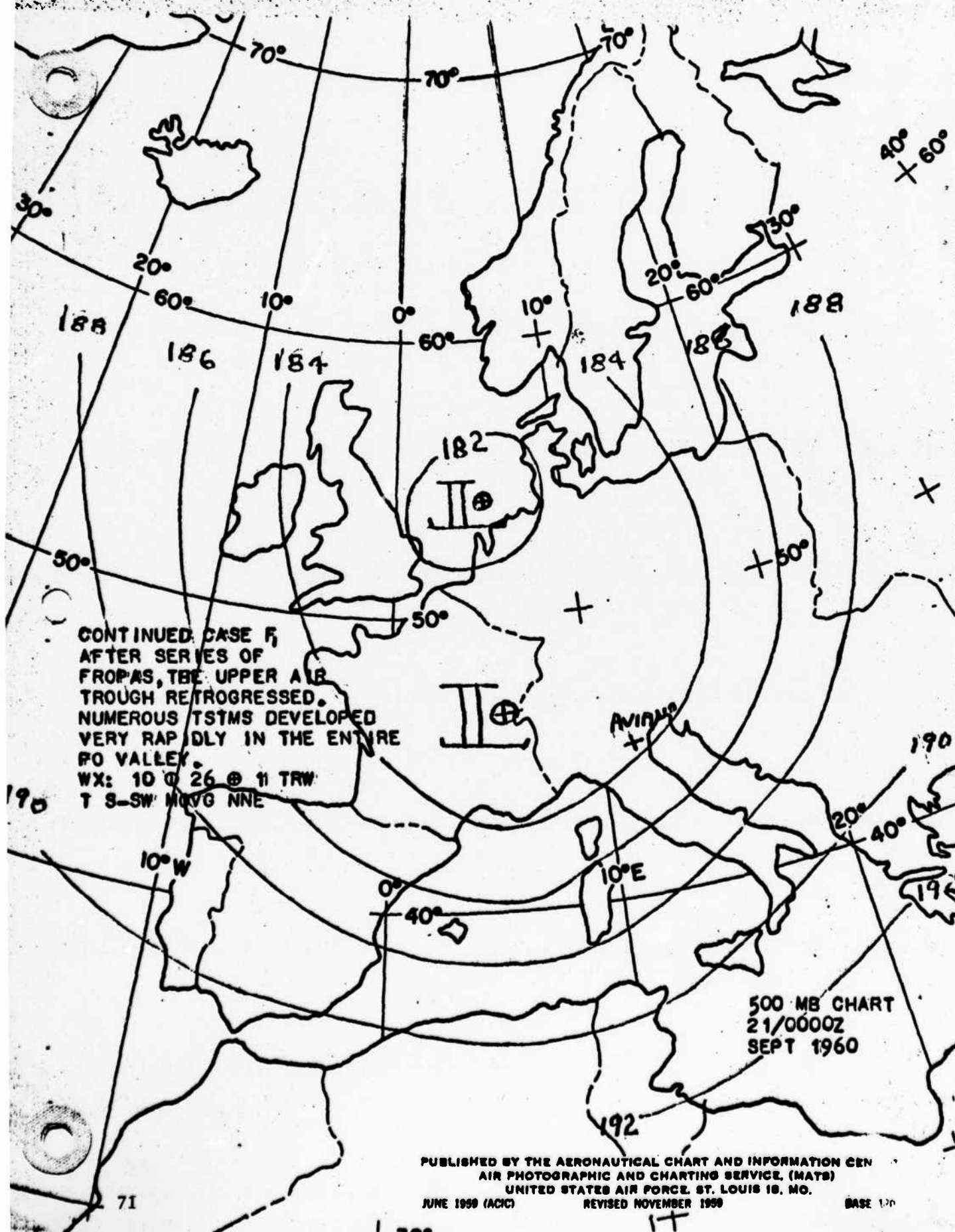
PUBLISHED BY THE AERONAUTICAL CHART AND INFORMATION CENTER
AIR PHOTOGRAPHIC AND CHARTING SERVICE, (NATS)
UNITED STATES AIR FORCE, ST. LOUIS 18, MO.
JUNE 1960 (ACIC) REVISED NOVEMBER 1960

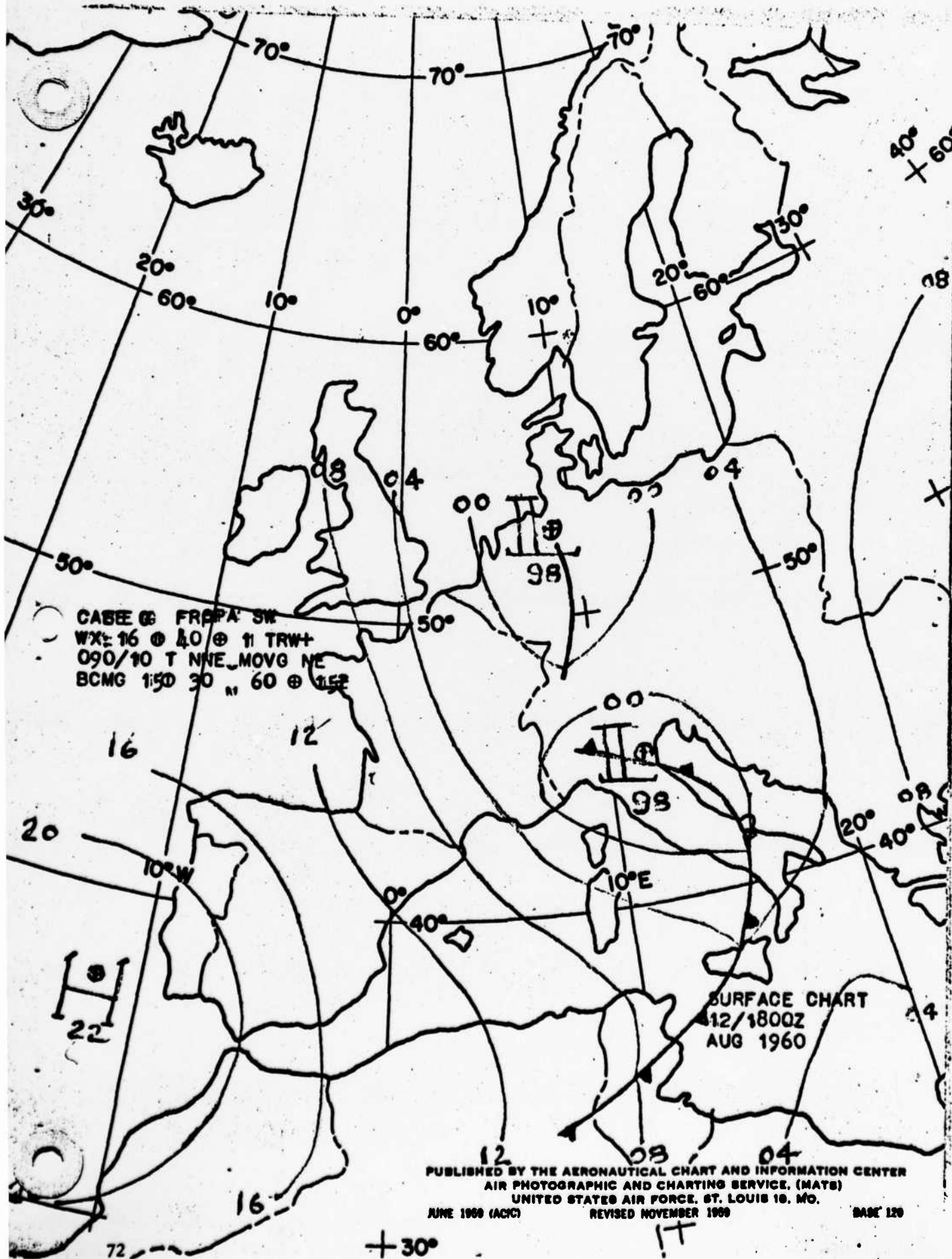
BASE 120

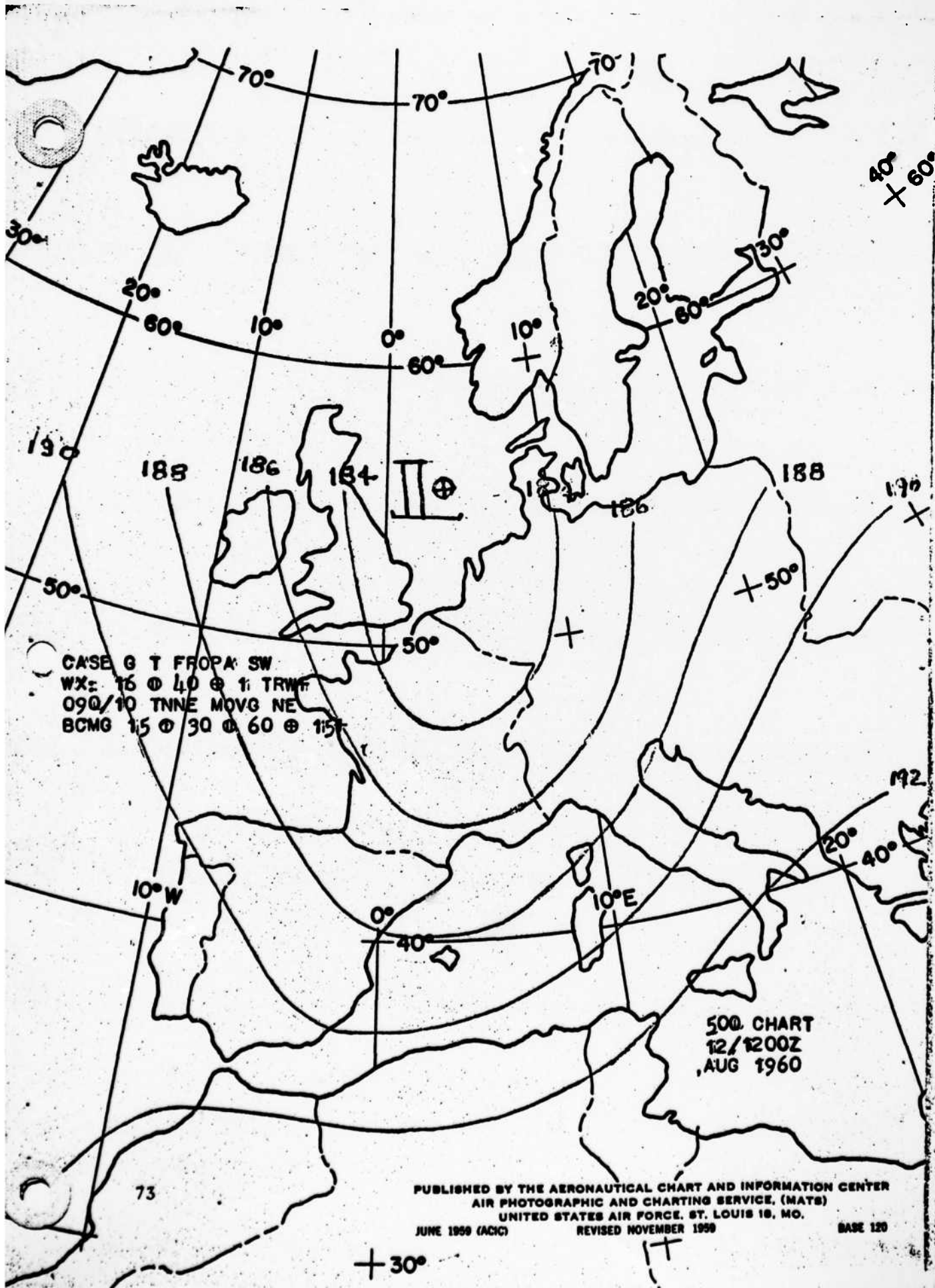












CASE G T FROM SW
WX: 15 @ 40 @ 1 TRWF
090/10 TNNE MOVG NE
BCMG 15 @ 30 @ 60 @ 15

500. CHART
12/1200Z
AUG 1960

PUBLISHED BY THE AERONAUTICAL CHART AND INFORMATION CENTER
AIR PHOTOGRAPHIC AND CHARTING SERVICE, (MATS)
UNITED STATES AIR FORCE, ST. LOUIS 18, MO.
JUNE 1959 (ACIC) REVISED NOVEMBER 1959

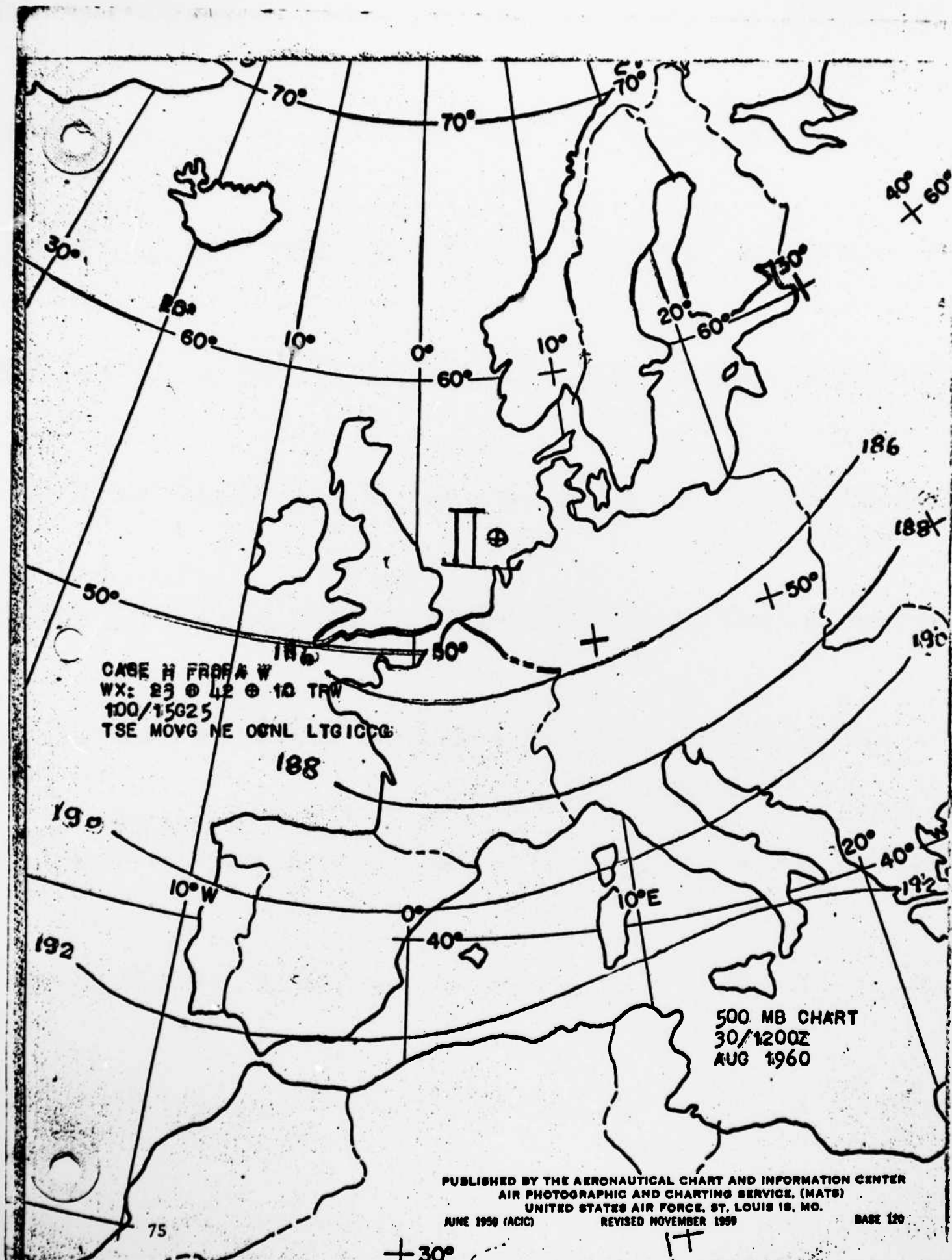
BASE 120

CASE H FROM W:
 WX:23 @ 42 @ 10 TRV
 100/15 G25
 T SE MOVG NE OCNL LTG ICGG

SURFACE CHART
 30/1880Z
 AUG 1960

PUBLISHED BY THE AERONAUTICAL CHART AND INFORMATION CENTER
 AIR PHOTOGRAPHIC AND CHARTING SERVICE, (MATS)
 UNITED STATES AIR FORCE, ST. LOUIS 18, MO.
 JUNE 1959 (ACIC) REVISED NOVEMBER 1959

BASE 120



PART VIII - Analysis of the 1961 Results

- A. Discussion: A verification of the study was made during the thunderstorm season of 1961. The forecasts during the early summer were made using only the thunderstorm nomogram. However, the thunderstorm checklist was incorporated in July and was used during the remainder of the season. It is quite probable, then, to assume that 1961 was not a representative year during which a representative evaluation of the study was possible because the more sophisticated technique (the checklist) was not used during the entire period. However, definite conclusions can be drawn on the basis of the 1961 data.

It is interesting to note that the thunderstorm activity during May, June, and July was about 20% below the 1956-1959 mean frequency. The number of thunderstorms during August however, were 16 compared to the 1956-1959 mean of 10. Consequently, these deviations could have prevented a representative evaluation since we do not know what effect the unusually good weather during May, June, and July had on the nomogram.

- B. Results: The following tables give the results of the 1961 thunderstorm season:

May 1961

FCST YES	VERIF YES	VERIF NO	FCST NO	VERIF NO	VERIF YES
10	4 (40%)	6 (60%)	21	14 (66.7%)	7 (33.3%)
$\%VT = \frac{4 + 14}{31} \times 100 = 58\%$					

$$\%VT = \frac{(\# \text{ YES VERIF} + \# \text{ NO VERIF})}{\# \text{ FCSTS}} \times 100$$

June 1961

FCST YES	VERIF YES	VERIF NO	FCST NO	VERIF NO	VERIF YES
11	10 (91%)	1 (9%)	18	14 (77.8%)	4 (22.2%)
$\%VT = \frac{10 + 14}{29} \times 100 = 83\%$					

July 1961

FCST YES	VERIF YES	VERIF NO	FCST NO	VERIF NO	VERIF YES
13	8 (61.5%)	5 (38.5%)	13	12 (92.8%)	1 (7.7%)
$\%VT = \frac{8 + 12}{26} \times 100 = 77\%$					

August 1961

FCST YES	VERIF YES	VERIF NO	FCST NO	VERIF NO	VERIF YES
18	16 (88.9%)	2 (11.1%)	11	11 (100%)	0 (0%)
$\%VT = \frac{16 + 11}{29} \times 100 = 93.2\%$					

Cumulative Results

		OBSERVED				
		YES	NO	TOTAL		
FORECAST	YES	38	14	52	SKILL SCORE	.54
	NO	12	51	63	PERCENT CORRECT	77.4%
TOTAL		50	65	115		

Comparison of Verification

	% VERIF YES FCST YES	% FCST YES VERIF NO	% VERIF NO FCST NO	% VERIF YES FCST NO
MAY	40%	60%	66.7%	33.3%
JUNE	91%	9%	77.8%	22.2%
JULY	61.5%	38.5%	92.3%	7.7%
AUGUST	88.9%	11%	100%	0%
TOTAL	73%	27%	81%	19%

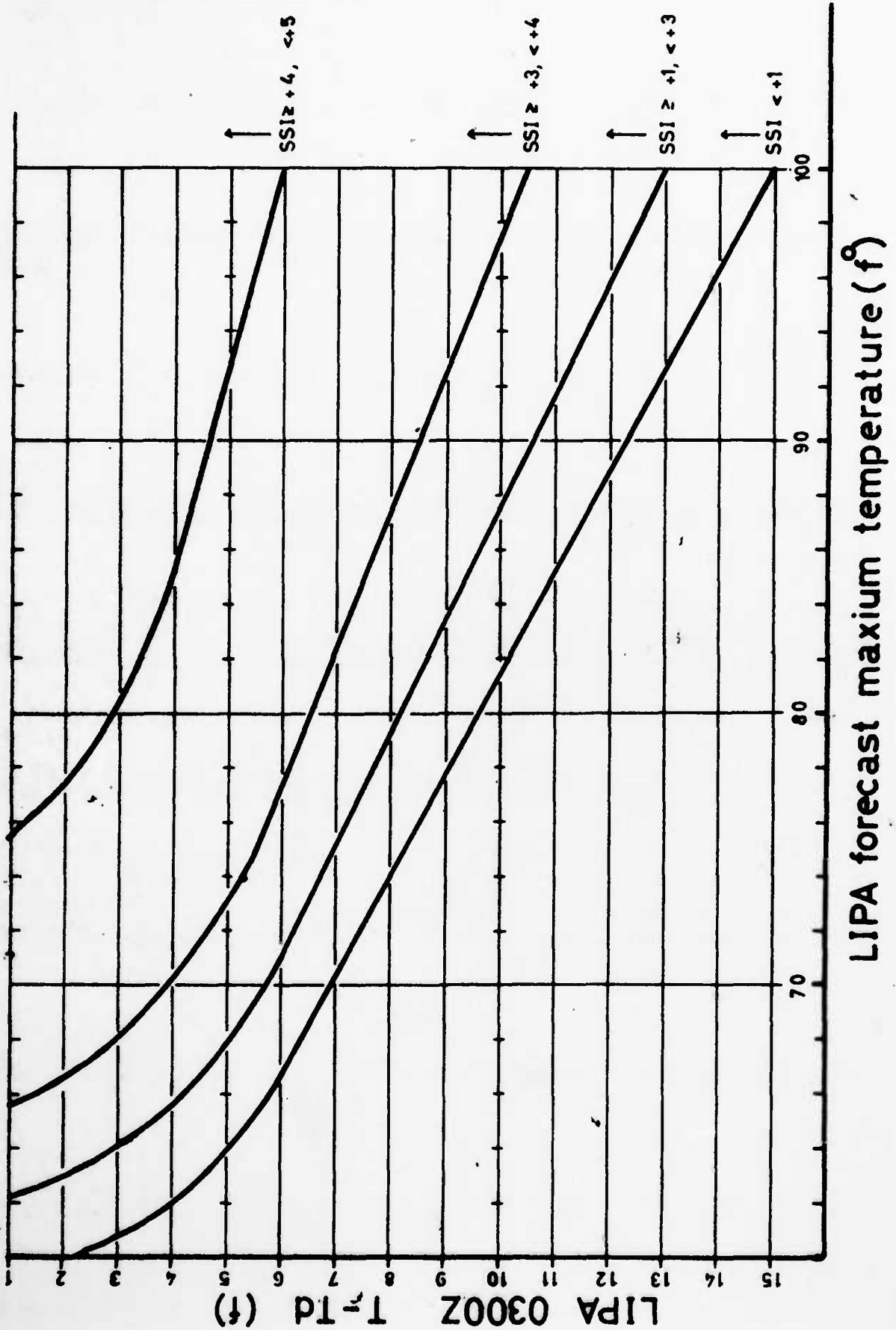
- C. Conclusion: The poorest verification occurred during May when only 40% of the "yes" forecasts verified and 66.7% of the "no" forecasts verified. The "yes" forecasts verified the best during June and August while the "no" forecasts verified the best during July and August. It is also important to note that the overall percentage verification increased every month and by August it reached an average high of 94.5%

It is difficult to explain why the verification was poor during the month of May. It is possible that the nomogram is not valid for May. Also better verification could have been obtained if the technique outlined in the checklist had been followed instead of relying solely on the nomogram. Another factor which is important in May is the fact that there occur many days when thunderstorms are forecast but only CB activity prevail. The case is usually a marginal one on the nomogram. May is the month of transition from Spring to Summer. Therefore, surface heating is sometime marginal for Air Mass Thunderstorms. Also it was noted that the maximum temperature forecast was missed in the cases where thunderstorm activity was forecast but did not occur.

It was encouraging to note that the "yes" forecasts verified very well during June, July, and August. Very important was the high verification of "no" forecasts during July and August. Concluding, the 1961 verification of the forecast technique did not conclusively evaluate the study but did provide important data for later modification of the study. Since the final checklist was not used during all of the season, the results are not entirely representative. The results of 1962 should provide a good basis to evaluate the study.

0000Z LIPD SHOWALTER INDEX

THUNDERSTORM NOMOGRAM for AVIANO AB



FROM: Det 7, 31WSq/CC
APO 09293

DATE: _____

SUBJECT: Thunderstorm Study and ROT Data Collection

TO: Files

1. Data Collection: Data Base Time: 00-03Z 12-15Z

a. Maximum Temperature (°F).....	_____ (fcst)	_____ (Actual)
b. Showalter Stability Index.....	_____	_____
c. 0300Z LIPA (T-Td): _____		
d. 500mb flow direction.....	_____	_____
e. Is a 500mb trough approaching?.....	_____	_____
f. Is a front approaching?.....	_____	_____
If YES, Forecast frontal passage time.....	_____	_____
g. Is a jet stream approaching LIPA?.....	_____	_____
h. Lifted Index.....	_____	_____
i. Total Totals.....	_____	_____
j. Convective Condensation Level (CCL).....	_____	_____
k. Wet Bulb Zero Height.....	_____	_____
l. Maximum Wind Sfc-5000ft (direction/speed)..	_____	_____
m. Maximum Wind 10000-18000ft(dir/spd).....	_____	_____

2. Long Range (morning) Procedures:

- a. Enter data from 1a, 1b, and 1c in thunderstorm nomogram.
- (1) If case falls above curve being used, proceed to part 2b.
- (2) If case falls below curve being used, proceed to part 2c.
- b. Case falls above curve:
- (1) If 0000Z SSI is greater than or equal to plus 5, forecast NO and stop, unless a deep trough, strong front, or a strong jet is approaching; forecast YES and stop.
- (2) If a strong ridge and surface high pressure system which will cause considerable drying is forecast to persist or intensify, forecast NO.
- (3) Forecast YES for all other cases above the curve on the nomogram.
- c. Forecast NO for all cases which fall below the curve on nomogram except when a deep trough, a strong front, or a strong jet is approaching, or when there is strong southeasterly flow. In these cases forecast YES.
- d. Initial Forecast.....YES/NO

3. Short Range Checklist:

a. To be applied between 1200Z and 1500Z:

- (1) Will forecast maximum temperature verify within 5°F or was it underforecast by any amount?.....
- (2) Has the Udine SSI decreased?.....
- (3) Has the surface temperature-dewpoint depression decreased?.....
- (4) Has the synoptic pattern remained the same?.....
- (5) Do present weather, RAREPs, or PIREPs verify convective activity?.....

b. Procedures:

- (1) If answer to all 5 questions is YES, continue original YES forecast, and reevaluate original NO forecast using 1200Z data entered in part 1.
- (2) If answer to any question is NO, continue original NO forecast, and reevaluate original YES forecast using 1200Z data entered in part 1.

c. Updated Forecast..... YES/NO

4. Verification Data:

a. Was TSTM reported at Aviano 00Z-24Z? _____ Time: _____

b. Other verification data:

(1) FROPA at LIPA 00Z-24Z? _____ Time: _____ Type: _____
Direction: _____

(2) 500mb Trough passage at LIPA? _____ Time: _____

5. Comments: _____

Frank P. Krovisky
FRANK P. KROVISKY, Captain, USAF
Commander

FROM: Det 7, 31WSq/ROT/Studies Monitor
AFO 09293

(REVISED TS STUDY WORKSHEET, 14 Oct 77)

SUBJ: Thunderstorm Study and ROT Verification

TO: Files

1. Data Collection:

Data Base Time: 00-03Z

- a. Maximum Temperature ($^{\circ}\text{F}$)..... (fcst) (Actual)
- b. Showalter Stability Index.....
- c. 0300Z LIPA (T-Td): ($^{\circ}\text{F}$)
- d. 500mb flow direction.....
- e. Is a 500mb trough approaching?.....
- f. Is a front approaching?.....
 If YES, Forecast frontal passage time.....
- g. Is a jet stream approaching LIPA?.....
- h. Lifted Index.....
- i. Total Totals.....
- j. Convective Condensation Level (CCL).....
- k. Wet Bulb Zero Height.....
- l. Maximum Wind Sfc-5000ft (direction/speed).....
- m. Maximum Wind 10000-18000ft (dir/spd).....

2. Procedures:

- a. Enter data from 1a, 1b, and 1c in thunderstorm nomogram.

- (1) If case falls above curve being used, proceed to part 2b.
- (2) If case falls below curve being used, proceed to part 2c.

- b. Case falls above curve:

(1) If 0000Z SSI is greater than or equal to plus 5, forecast NO and stop, unless a deep trough, strong front, or a strong jet is approaching; forecast YES and stop.

(2) If a strong ridge and surface high pressure system which will cause considerable drying is forecast to persist or intensify, forecast NO.

(3) Forecast YES for all other cases above the curve on the nomogram.

c. Forecast NO for all cases which fall below the curve on nomogram except when a deep trough, a strong front, or a strong jet is approaching, or when there is strong southeasterly flow. In these cases forecast YES.

d. Forecast.....YES/NO

3. Verification Data:

a. Was TSTM reported at Aviano 00Z-24Z? _____ Time: _____

b. ROT Verification (circle as appropriate)

(1) ROT A Applicable YES/NO Verified YES/NO

(2) ROT B Applicable YES/NO Verified YES/NO

(3) ROT C Applicable YES/NO Verified YES/NO

4. Comments: _____

Bruce D. Silliman
BRUCE D. SILLIMAN, TSgt, USAF
ROT/Studies Monitor

Change 1 to TS study:

14 Oct 1977

The thunderstorm worksheet completed in the afternoon was almost always after the fact. This is due primarily to the time of receipt of the 1200Z RAOB (Udine). By the time the data was received TS were already occurring.

Therefore, it was recommended that the afternoon portion of this study be discontinued. Final approval was received from 2WW/DN, Maj Gibleau. The revised TS Study worksheet has been added to this study.

Proposed Change to TS study:

20 Oct 1979

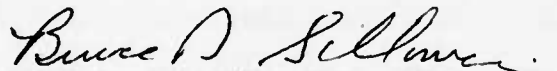
Based on TS study worksheets from May 1976 thru Sep 1979, only 17 occurrences out of a possible 175 TS days had a SSI of greater than plus 3.0. Therefore, the following change to sec 2b(1) was submitted for approval:

If SSI is greater than 3, forecast "no" and stop, unless a deep trough, strong front, or a strong jet is approaching; forecast "yes" and stop.

Memo For Record

21 February 1980

This change was approved by 31WSq/DON on 12 Feb 80.


BRUCE D. SILLIMAN, TSgt, USAF
Studies Monitor

APPENDIX 2

SUMMARY OF THUNDERSTORM STUDY VERIFICATION DATA 1962 - 1979

To better aid the forecaster in seeing the total effectiveness of this study, data from 1962 thru 1979 was gathered and an overall skill score was computed. In the future, yearly data will be added to continuously update the skill score

		Forecast	
		Yes	No
O B S E R V E D	Yes	595	216
	No	237	818

HSS = .506

% Correct = 76

VISIBILITY FORECAST STUDY WORKSHEET

PARAMETERS: 11Z LIPA SFC WND DRCTN _____ 11Z LIPA VISIBILITY _____

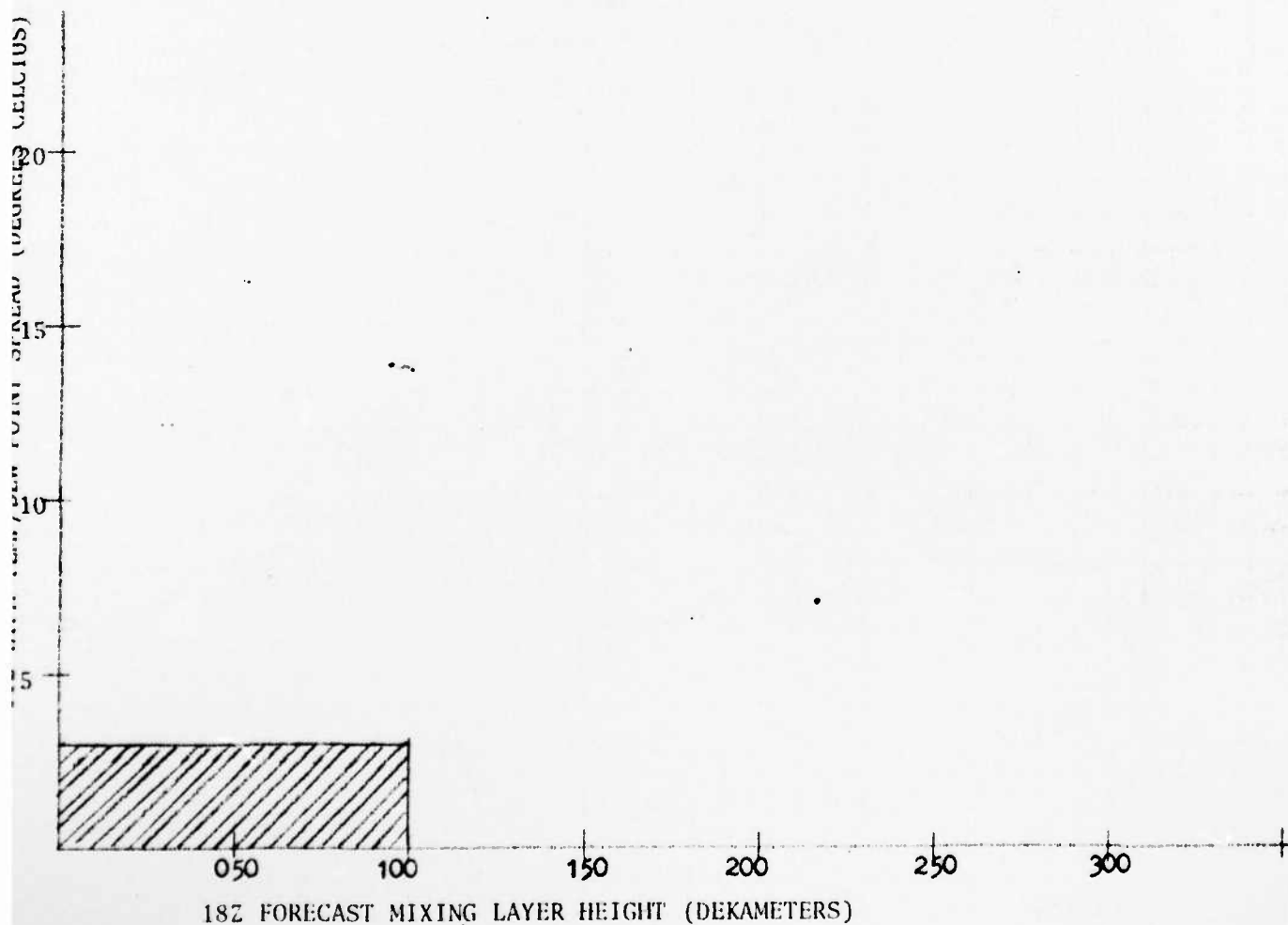
11Z LIPA TEMP/DEW PT SPREAD _____ °C

FKEU54 KGWC (OOZ) MIXING LVR HGT _____ DEKAMETERS

PROCEDURES: 1. IF THE LIPA 11Z VIS IS LESS THAN 3.0NM AND THE 11Z TEMP/DP SPREAD IS LESS THAN OR EQUAL TO 5°C FORECAST THE 17Z VIS TO BE LESS THAN 3.0NM.

2. IF THE LIPA SFC WIND DIRECTION AT 11Z IS FROM 220 TO 110 DEGREES FORECAST THE VISIBILITY AT 17Z TO BE GREATER THAN OR EQUAL TO 3.0NM.

3. IF THE LIPA SFC WIND DIRECTION AT 11Z IS FROM 120 TO 210 DEGREES OR CALM GO TO THE GRAPH BELOW. IF THE POINT ON THE GRAPH FALLS WITHIN THE HATCHED AREA FORECAST THE 17Z VISIBILITY TO BE LESS THAN 3.0NM. IF THE POINT FALLS IN ANY OTHER AREA FORECAST THE 17Z VISIBILITY TO BE EQUAL TO OR GREATER THAN 3.0NM.



VERIFICATION: 17Z FORECAST _____ 17Z OBSERVED _____

APPENDIX 3

SUMMARY OF RULES OF THUMB VERIFICATION DATA 1972 - 1979

ROT A:

# of times evaluated:	100
# of times verified:	82
correct verification:	82%

ROT B:

# of times evaluated:	158
# of times verified:	117
correct verification:	74%

ROT C:

# of times evaluated:	110
# of times verified:	106
correct verification:	90%

APPENDIX 4

CYCLOGENESIS AT AVIANO AB, ITALY

From late October to early May, Aviano experiences its worst weather. This inclement weather can be divided into two main groupings: (1) that caused by radiation fog and (2) rainy, foggy, weather with low ceilings and poor visibilities associated with cyclogenesis in the Gulf of Genoa or in the Gulf of Venice. During the cold months, low pressure systems form over the warm water bodies and transport large amounts of warm, moist air northward. Upslope flow and cooling on contact with the cold ground combine to give the Aviano area long periods of rain and fog.

Cyclogenesis is determined by several factors. Among the principal ones are: the topography of the area (the Alps), the presence of large, warm water bodies (the Gulfs of Genoa and Venice) and the proper type of upper-air flow. This last criterion is the one which will determine whether cyclogenesis will take place in areas that are otherwise suitable for it.

The type of flow conducive to cyclogenesis is illustrated by Types III-B and III-C. However, not every case of this flow will produce cyclogenesis. Troughing over central Europe, if preceded by westerly flow (Type II) and followed by strong ridging over the eastern North Atlantic, is most conducive to cyclogenesis. If the trough is fast moving, only one surface low will develop and it will most likely slip to the southeast affecting Aviano only marginally. A slow moving trough is likely to force the surface low into a more northerly path bringing it into the Aviano area. If the trough is stationary over the western Mediterranean, repeated cases of cyclogenesis will take place at about 24 hour intervals providing alternating periods of rain and fog in the Aviano area.

Graph I provides an idealized case-study of cyclogenesis associated with Type III-B flow with the surface low passing close to Aviano in a northeasterly direction. Station sea-level pressure is plotted as a function of time after cyclogenesis has begun in the Gulf of Genoa (this is usually first observed by the rapid pressure falls at Pisa, Genoa, San Remo, and Milano). Typical weather for Aviano is given for various times and pressures. When the weather passes through operational criteria such as visibilities of 5NM and 2NM and ceilings of 5000 ft and 1000 ft, this is so indicated. A total rainfall of from one to three inches can be expected from such a system as well as numerous thunderstorms. Similar conditions can be expected to prevail throughout north-eastern Italy.

AD-A132 121

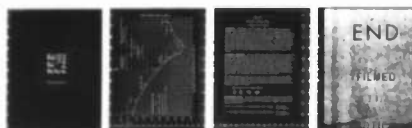
TERMINAL FORECAST REFERENCE NOTEBOOK FOR AVIANO AB
ITALY(U) WEATHER SQUADRON (31ST) APO NEW YORK 09293
DETACHMENT 7 B D SILLIMAN 15 NOV 81

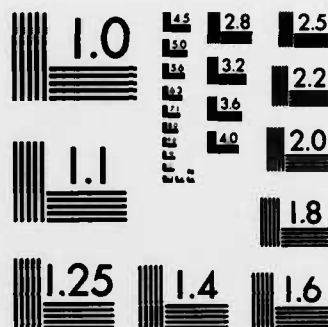
2/2

UNCLASSIFIED

F/G 4/2

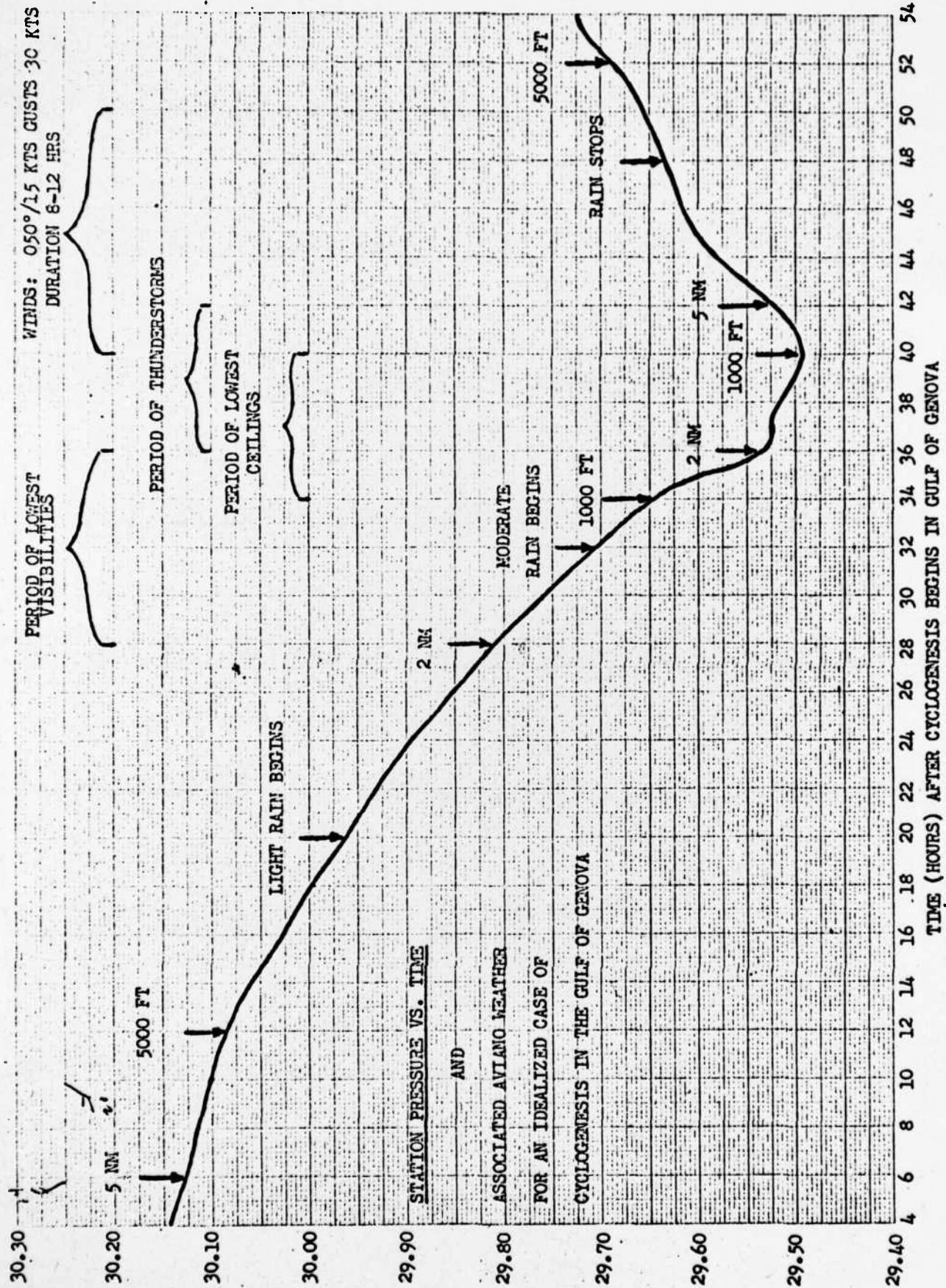
NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

WINDS: 050°/15 KTS GUSTS 30 KTS
DURATION 8-12 HRS



APPENDIX 5

VISIBILITY FORECAST STUDY

by MSgt Arnold Saunders

BACKGROUND: Detachment 7's forecasting skill scores have deteriorated steadily since September 1977. Internal efforts and Technical Visits (TCV's) since that time have been to no avail. Data research during this period have shown that visibility restrictions, not ceilings, have been the most difficult parameter to forecast and the category change from Category 3 to 4 was most difficult and occurs most frequently. RUSSWO statistics show that conditons less than 3000/3.0 occur 13.4% of the time on a yearly basis, while 1000/2.0 occur only 5.2% of the time. Further research has shown that pollution conditions are on the increase. Data during February and January 1980 indicated that conditons of less than 3000/3.0 occurred 40% of the time while the RUSSWO indicated only 27% historically. The most recent TCV to Aviano indicated a forecast study for visibility was needed.

PARAMETERS CONSIDERED: Since the most prevailing restriction to visibility at Aviano is haze/pollution due to the industrial areas in the Po Valley and the fact that Aviano is located at the eastern mouth of this vabley the FKEU54 KGWC stagnation bulletin was looked at closely. This bulletin was the only available bulletin that dealt with pollution forecasting parameters. Initially the depth of the mixing layer and vertical/horizontal wind transport speeds were looked at with inconclusive results. Then a moisture parameter (LIPA temperature/dew point spread) was added and later a consideration for winds since even in ideal situations for visibility restrictions if the surface wind was such as to blow the restriction away from Aviano, the visibility would remain above or at 3.0NM.

The FKEU54 KGWC has an 08Z file time so was not available for the 0500Z TAF. The next forecast issued was 1100Z and is also the only TAF issued by Aviano on the weekends. The 6 hour point was used for verification because the past years verification statistics indicated this was the most difficult frame to forecast.

FEB 79-FEB 80 SKILL SCORE AVERAGE

<u>3HR</u>	<u>6HR</u>	<u>12HR</u>	<u>24HR</u>
.07	-.09	.12	.08

PRELIMINARY RESULTS: The study utilizing the parameters on the worksheet was started on 5 Dec 79 and ran through 26 Mar 80. December and the first part of January data was sparse due to the holiday schedule worked by the Italian AF observers.

A total of 66 cases were evaluated with these results: 85% correct
.470 Heidke SS

The base weather station forecast for the same cases; 78% correct
.450 Heidke SS

END

FILMED

9-83

DTIC