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CLIMATOLOGY OF SELECTED AREAS OF WEST GERMANY AFFECTING SENSOR --ETC(U)
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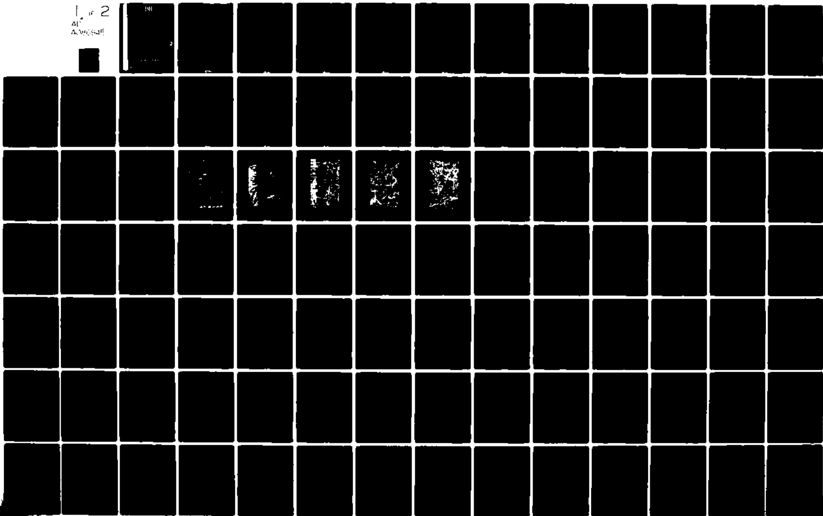

LEVEL II

138300-23-T

# CLIMATOLOGY OF SELECTED AREAS OF WEST GERMANY AFFECTING SENSOR PERFORMANCE

A. LAWSON

JUNE 1979





Prepared for
U.S. Army Mobility Equipment
Research and Development Command
Ft. Belvoir, VA
Contract DAAK70-78-C-0198



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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER ERIM 138300-23-T | 2. GOVT ACCESSION NO. AD-A086 945 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle) Climatology of Selected Areas of West Germany Affecting Sensor Performance | | 5. TYPE OF REPORT & PERIOD COVERED Technical Report |
| | | 6. PERFORMING ORG. REPORT NUMBER 138300-23-T |
| 7. AUTHOR(s) A. Lawson | | 8. CONTRACT OR GRANT NUMBER(s) DAAK70-78-C-0198 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS Environmental Research Institute of Michigan P. O. Box 8618 Ann Arbor, MI 48107 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Mobility Equipment Research & Development Command, Mine Detection Division, Ft. Belvoir, VA 22060 | | 12. REPORT DATE June 1979 |
| | | 13. NUMBER OF PAGES viii + 114 |
| 14. MONITORING AGENCY NAME AND ADDRESS (if different from Controlling Office) | | 15. SECURITY CLASS (of this report) UNCLASSIFIED |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Dr. J. R. Gonano was the contract monitor for this project.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

| | |
|---|---|
| Climate | Clouds |
| Weather | Fog |
| Temperature | Visibility |
| Precipitation | Sensors |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

(U) This report contains a body of climatological data on several areas in West Germany which are being used in scenarios for study of the technical and operational effectiveness of methods of detecting remote minefields. The weather to be considered in the technical screening and analysis is that typical of the North German Plain, the Fulda Gap, and the Hof Corridor.

(U) Climate affects the ability of the sensor to obtain a useful signal

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return from the target and affects the signal return from background i.e., the vegetation and terrain surface and subsurface materials.

(U) Temperature data given include mean temperatures and diurnal temperature variations. Precipitation data include monthly mean precipitation, precipitation rates, rainfall frequency and duration. Data are given on cloud types, fractional sky cover, and various types of statistics on cloud obscuration. Data on fog frequency and visibility provide further information affecting target obscuration. Representative weather sequences are also tabulated for use in scenarios.

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# 1
# INTRODUCTION

The objective of the minefield detection project is to determine the effectiveness of various methods of detecting and identifying mines, minefields, minelaying equipment, or minelaying operations, and to recommend continuing effort on the most promising methods.

Work under the project concerned with each of the concepts to be investigated is being performed in a sequence of four major tasks: (1) identification and screening of promising techniques; (2) preliminary systems analysis and definition of experimental or other data acquisition systems; (3) acquisition of critical data through experiment, literature survey, or access to SCI; and (4) evaluation of conceptual systems for technical and military usefulness.

The performance of mine detection sensor/carrier-vehicle combinations and the tactics which will be employed in scenarios representative of anticipated combat situations are heavily influenced by the climate and terrain in which the systems are to be employed. This report has been prepared to provide a unified and consistent documentation of those climatic characteristics which are needed for the analysis and evaluation of candidate mine detection systems.

The generic types of sensors which are being studied in the project as well as specific sensors representing these generic types have been selected through an identification and screening task which is discussed in Ref. 18. The identification and screening task has been conducted with reference to four scenarios which have been defined by BDM Corp. These scenarios are typical examples of doctrine, tactics, and methods of Soviet use, together with typical equipments, time frames and areas involved.

The technical implications of these scenarios which impact on the use of climate and terrain data may be summarized as follows:

1. Weather and terrain to be considered in technical screening and analysis are those typical of the North German Plain, the Fulda Gap and Hof Corridor.
2. There is a predominance of surface mines and minefields in the scenarios, but buried mines and minefields must also be considered.
3. Since the Soviet forces have a 24-hour fighting capability and the in-place times for the offensive minefields is relatively short, the sensors should ideally have a capability to operate both day and night.
4. An all-weather sensor capability is highly desirable in view of the short in-place times of the offensive minefields.

In the process of analyzing and evaluating minefield detection systems, both climate and terrain characteristics have a significant influence on system performance. These characteristics influence both the sensor/carrier-vehicle performance and the combat tactics. This report is particularly concerned with those aspects of climate which affect the sensor performance.

Figure 1-1 illustrates the general procedure used in the analysis of candidate minefield detection systems. The statistics of mine and minefield detection refer only to those areas actually observed by the sensor. It is necessary to account for areas not covered by the sensor because of obscuration by the terrain, vegetation, weather, etc. This characteristic is referred to here as target accessibility. A preliminary definition of target accessibility will be used for purposes of generic screening. After specific sensors have been selected for analysis, target accessibility will be defined separately for each candidate.

Climate and terrain affect sensor performance in two major ways:

1. They affect the accessibility of the target, that is, the ability of the sensor to obtain a useful signal return from the target. Weather primarily affects the transmission of radiation through the atmosphere, while topography and vegetative cover also affect target accessibility by interfering with the line-of-sight between target and sensor. (Accessibility of the target will also be affected by the extent of area coverage provided by the sensor, but this effect is not discussed in this report.)

2. They affect the signal return from the background, i.e., the vegetation and terrain surface and subsurface materials. Vegetation cover and topography affect the signal return of both optical and microwave sensors. Temperature and precipitation affect the background return in the visible and infrared wavelengths, and precipitation affects the soil moisture content which in turn affects the signal return in the microwave regions. Conditions which reduce the contrast between target and background or which increase background clutter will have the effect of degrading sensor performance.

The types of information on climate needed for sensor performance analysis include much of the information normally documented and used in climatic studies. Certain additional types of information are of special interest for sensor analysis.

The tabular and graphic data contained in this report can be adapted for use in analytical modeling of sensor performance to support the technical and operational evaluation of a variety of sensor/carrier vehicle combinations. Although prepared primarily for use in evaluating minefield detection sensor systems, the data are sufficiently general that they can be used for any other sensor applications. In addition, the effects of weather on combat tactics in West Germany can also be modeled using the weather data base contained herein.

Table 1-1 lists the major categories of weather data presented in the following sections of this report. Some of these categories are presented in more than one table, showing its relation to various other parameters, such as altitude, or using various methods of expressing probability. In all cases, the tables and figures show the variation of the parameters with respect to month or season in order to indicate seasonal effects. Also included in the Table 1-1 for most of the parameters listed are indications of the application of the data to technical and operational analysis of sensor performance and utility.

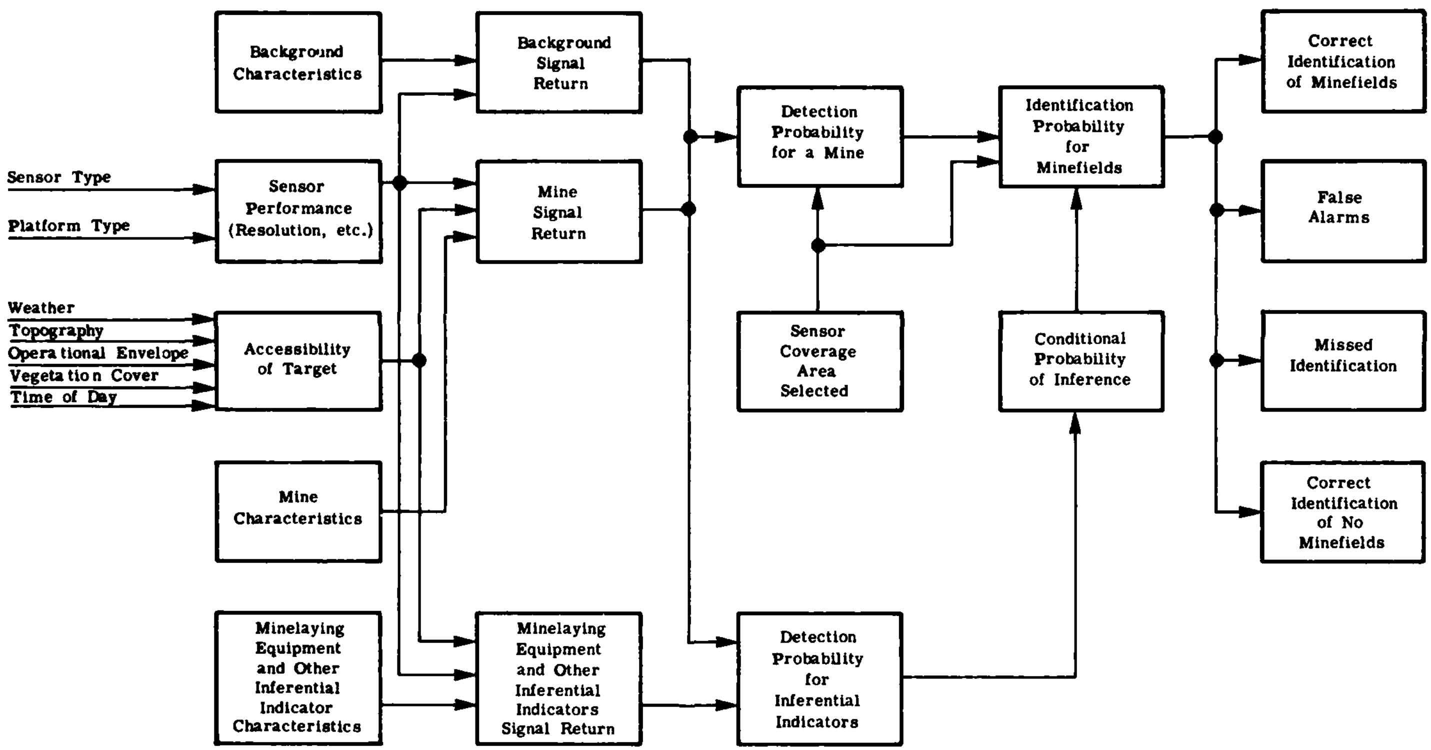


FIGURE 1-1. MINEFIELD DETECTION PROCESS

TABLE 1-1. TYPES OF DATA PRESENTED

| PARAMETER | APPLICATION |
|---|---|
| **Temperature** | |
| Monthly mean temperature | |
| Daily minimum temperature | Thermal IR sensor analysis |
| Diurnal and day-to-day temperature variations | Thermal IR sensor analysis |
| **Precipitation** | |
| Monthly mean precipitation | |
| Rain | Soil moisture content |
| Snow | Terrain background |
| Days precipitation per month | Mission availability |
| Thunderstorm frequency | Mission availability |
| Precipitation rate | Target obscuration (microwave) |
| Water concentrations within precipitation region at various altitudes | Target obscuration (microwave) |
| Rainfall duration | Mission delay |
| **Sky Cover** | |
| Fractional sky cover | Target obscuration (optical) |
| Vertical distribution of cloud cover | Aircraft altitude selection |
| Clear/partly cloudy/cloudy days | Target obscuration (optical) |
| Cloud types | |
| Cloud obscuration vs. depression angle | Flight path selection |
| Water content of clouds | Target obscuration (microwave) |
| Sky cover duration | Mission delay |
| **Fog** | |
| Frequency of fog, by month | Target obscuration (optical) |
| Frequency of fog (day/night) | Target obscuration (optical) |
| Effect of fog type on ceiling and visibility | Target obscuration (optical) |

TABLE 1-1. TYPES OF DATA PRESENTED (Cont.)

| PARAMETER | APPLICATION |
|---|---|
| **Visibility** | |
| Frequency of Visibility, by month | Target obscuration (optical) |
| Ceiling/visibility duration | Mission delay |
| **Other** | |
| Monthly precipitation-temperature relations | |
| Air mass incidence and statistics | Weather modelling |
| Height of 500 mB atmospheric pressure surface | Weather modelling |
| Representative weather sequences | Scenario for operational analysis |

# 2
# GENERAL CHARACTERISTICS OF GERMAN CLIMATE

## 2.1 Significant Climate Characteristics

Atmospheric effects can degrade or deny remote electromagnetic sensing from airborne platforms. Man contributes to some in the form of smoke or smog but most are natural in origin consisting generally of water in the liquid or solid phase.* These are represented by some form of cloud or fog and by falling or fallen precipitation. Meteorological phenomena may be severe enough to deny operation of the vehicle as well as degrading the performance of its sensors. Airborne vehicle operation can be hampered by high winds and turbulence as well as the phenomena already mentioned.

Several characteristics of a region and its climate impact the incidence of these weather phenomena. The "continentality" of a region influences the amount of water to be expected in the atmosphere. The temperature influences the amount and form of condensation and precipitation of that water. Temperature inversions influence cloud levels and smoke and haze build up. Air stability impacts atmospheric clarity and cloud forms. The topography influences cloud forms, precipitation, and turbulence. Proximity to the mean position of the polar front helps determine the frequency of its exposure to frontal weather patterns and cyclonic storm activity.

Regrettably, most climatological references concentrate on the data which are less applicable or presented in less useful forms. The three most-reported climatological parameters are mean monthly pressure, mean monthly temperature, and mean monthly precipitation. To the temperature data we would wish to have added the mean daily

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*One notable exception is the dust storm. Dust storms are not a significant problem in middle Europe however.

minimum and maximum for each month. We would also add the frequency of encountering days in which a significant amount of precipitation occurred and the statistics of duration and intensity of the rain for the rainy days. Distinctions should also be drawn between the shower activity associated with cumuliform clouds and the extended rain associated with the stratiform clouds.

Cloud cover is normally reported as a mean value of dawn-to-dusk percent sky cover. Cloudiness appears to be bimodally distributed, however, and we often find fewer days with percent cloudiness near the monthly average than clear days and heavily overcast days. For example with 50% mean cloudiness in January we would expect to find 12 clear days, 10 cloudy days, and only 9 partly cloudy days.

For many airborne sensors the height of cloud layers is of critical importance since if reasonably high, they may be underflown. But clouds often form in decks and we define "ceiling" as the height above ground level of the base of the lowest cloud deck which, combined with all lower clouds, obscures more than 50% of the sky. An unlimited ceiling means only that at least 50% of the sky is unobscured. Thus a ceiling reported as being above the desired operational altitude of a given platform (or even reported unlimited) may be an accurate description of a situation in which 40% of the terrain is denied by a partial low-altitude cloud deck.

The usual reports of visibility present similar problems. Horizontal visibility near the surface is routinely reported and recorded. For airborne sensor applications we would prefer visibility as a function of elevation angle or horizontal visibility as a function of altitude. Some measure other than visibility might also be preferable for describing the scattering/attenuation phenomena involved.

## 2.2 West German Climatology

Germany's topography along with that of its neighbors and its geographic placement dictate its particular climatic patterns. Its high latitude is considerably compensated by its proximity to large bodies of water to the north and west, especially to the Atlantic Ocean with its warming currents. There are no intervening highlands to block the flow of maritime air masses from these bodies of water. The mountain ranges (Alps, Pyrenees, etc.) partially isolate it from Saharan or Mediterranean influences. Thus its weather is primarily associated with those maritime influences and only occasionally (but dramatically) with the dry continental air masses from the great Russo-Siberian land mass.

Mean annual range of mean monthly temperatures is a reasonable index of continentality.* Figures 2-1 and 2-2 show the general temperature pattern to be expected in Central Europe in January and July. These show the impact of the maritime air masses. The effect of the west-to-east increasing continentality may be seen even more dramatically in Figure 2-3.

The general topography of Germany modifies the pattern shown in Figures 2-1 through 2-3. Figure 2-4 outlines these German regions of topographic significance. Figures 2-5 through 2-7 indicate the nature of that modification on temperature and precipitation. Table 2-1 gives temperature data for specific locations in Europe and the maxima and minima are mapped in Figure 2-8.

*This is not a primary index of continentality. Any standard reference on general climatology will provide good measures for this purpose (e.g. Ref. 1 or 3).

## 2.3 Selection of Climatic Zones for Systems Analysis

Various studies have used different divisions of Germany to try to better describe its climatic variations. Some U.S. Air Force documents* use the following climatic regions:

1.) Northern Lowland
2.) Rhine Valley
3.) Central Mountain Chain
4.) Eifel Mountain Range
5.) Southern Plateau
6.) Bavarian Alps

These regions are shown in Figure 2-9a. The report cited notes, however, that there is no one station that can be considered representative of any one area. Figure 2-9b shows another set of zones which is sometimes used but it is even less satisfactory than the first.

There is an E. German Climatic Atlas [ref. 5] that provides a sufficiently fine-grained analysis for our purpose. This is shown in Figure 2-10. Note that it conforms very well to the German topography as shown in Figure 2-11. The climatology of each of these regions can be fairly typified by a single weather station. The three regions for our study are suggested by the length and breadth of the arrows in Figure 2-10. These advances and the climatic regions are shown in more detail in Figures 2-12, 2-13, and 2-14.

For each of these study regions, Table 2-2 lists the primary climatic zones which are certain to be penetrated and nearby secondary zones which might be penetrated. Table 2-3 lists some of the stations which can be used to characterize each of these zones.

*e.g."Meteorological Aspects of All-Weather Interdiction in the Latter 80's", office of the Staff Meteorological, U.S.A.F.A.D.T.C., Eglin Air Force Base, Florida. Nov. 1978

Note that 7c is the one primary climatic zone present in all three regions. For some purposes we can reasonably use 7c to typify our climate. On the other hand, we see that 5a is really the predominant zone in the North German Plain attack region, 9b in the Hof region and that 7c is predominant only in the Fulda advance region and then, not overwhelmingly so.

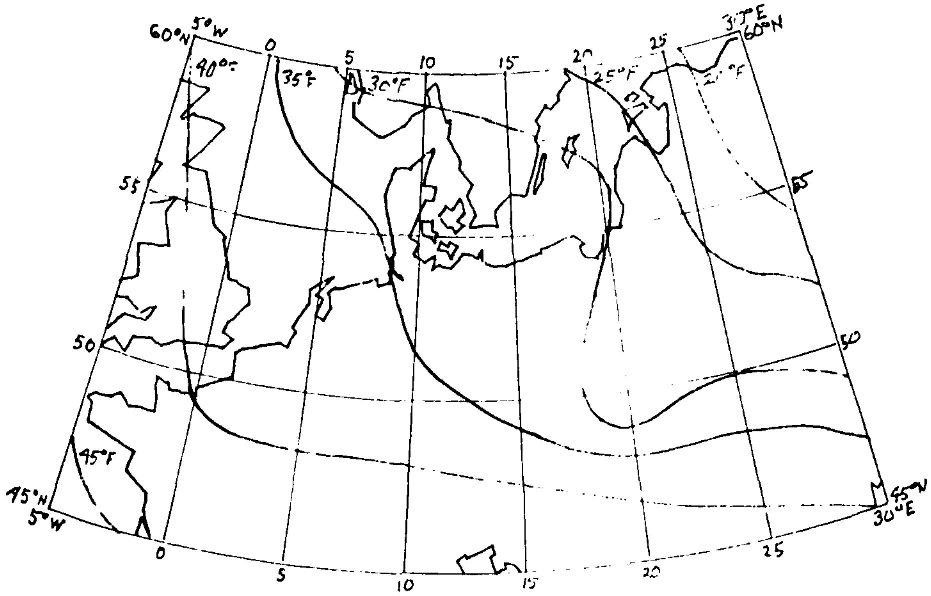



FIGURE 2-1. JANUARY MEAN SEA LEVEL ISOTHERMS (Detroit = 28°F.) (Ref. 1)

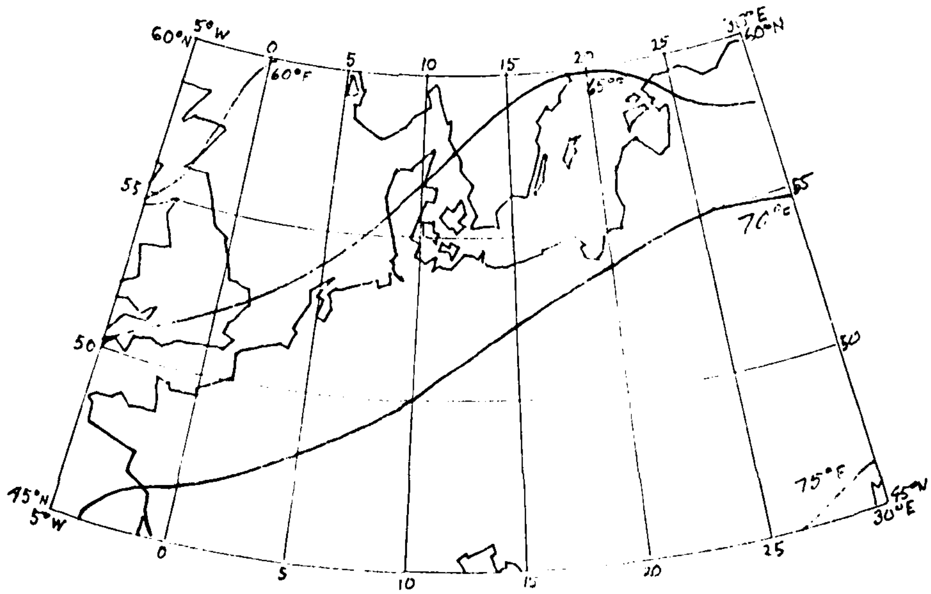



FIGURE 2-2. JULY MEAN SEA LEVEL ISOTHERMS (Detroit = 73°F.) (Ref. 1)

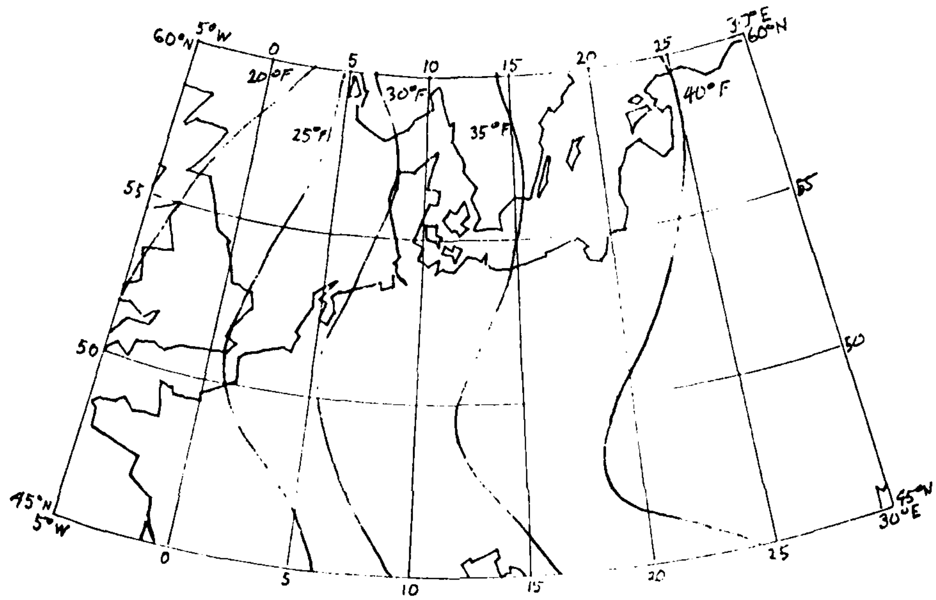



FIGURE 2-3. MEAN ANNUAL RANGE OF MEAN MONTHLY TEMPERATURE
(Detroit = 45°F.) (Ref. 1)

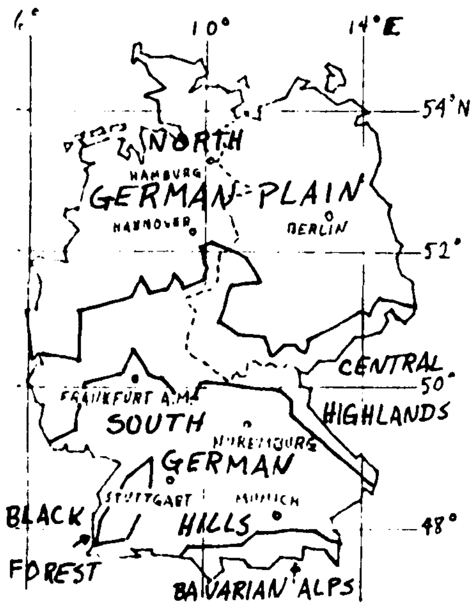



FIGURE 2-4. TOPOGRAPHIC REGIONS OF GERMANY (Ref. 2)

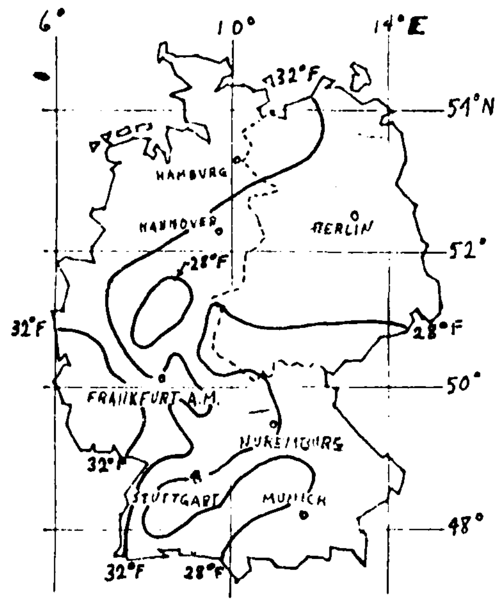



FIGURE 2-5. MEAN GERMAN TEMPERATURES, JANUARY ($^{o}$F.) (Ref. 2)

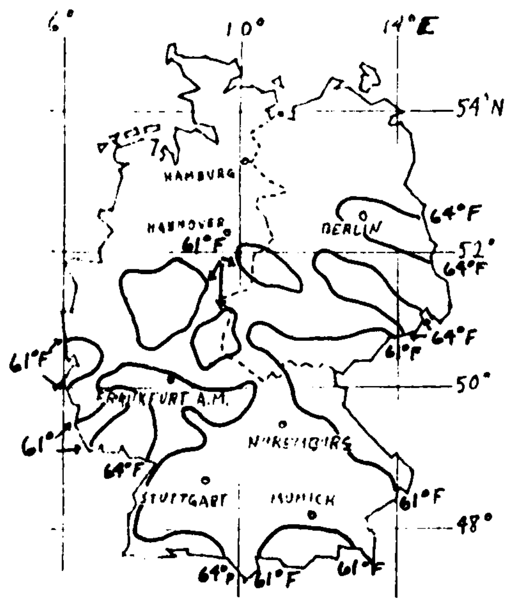



FIGURE 2-6. MEAN GERMAN TEMPERATURES, JULY ($^{o}$F.) (Ref. 2)

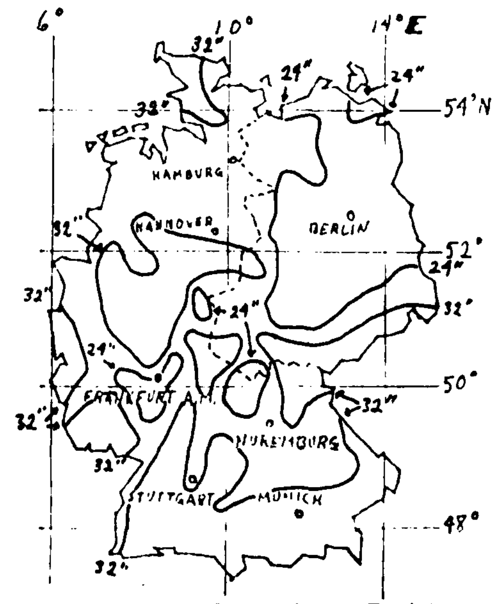
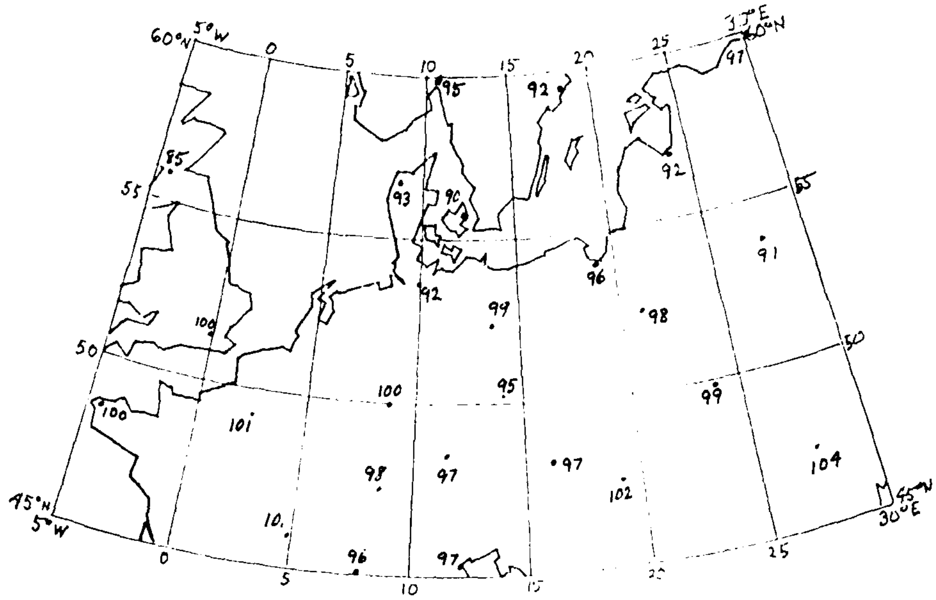
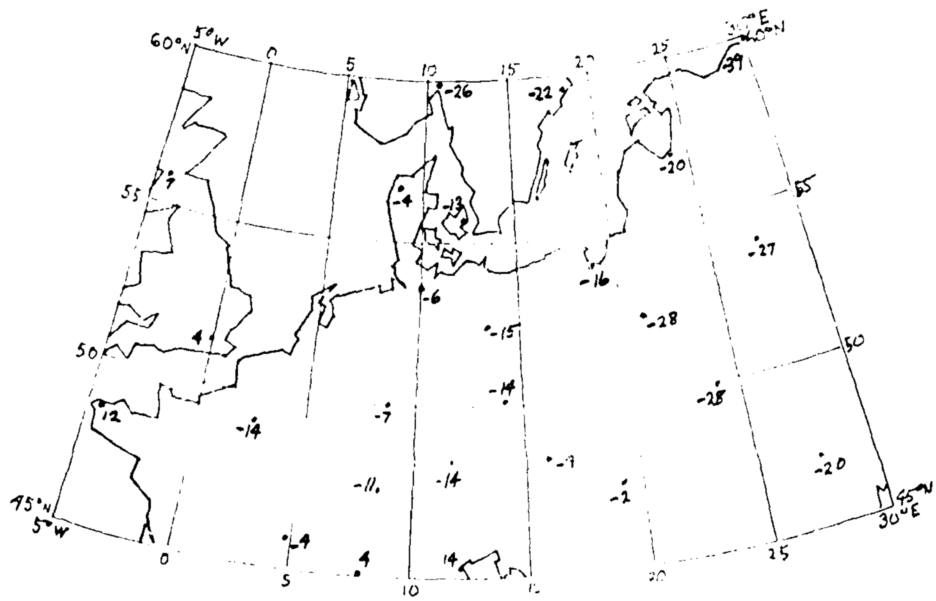



FIGURE 2-7. MEAN GERMAN PRECIPITATION, ANNUAL (inches) (Ref. 2)




a) (MAX) (Detroit = 105°F.)




b) (MIN) (Detroit = -24°F.)

FIGURE 2-8. TEMPERATURE EXTREMES (°F.)

TABLE 2-1. SELECTED EUROPEAN TEMPERATURES [°F] (Ref.4)

(5°W-30°E) x (45°N-60°N)

| | Jan. Mean | Absolute Minimum | Difference | July Mean | Absolute Maximum | Difference | July-Jan. | Max.-Min. |
|---|---|---|---|---|---|---|---|---|
| Austria | | | | | | | | |
| Vienna | 31.9 | -4.0 | 35.9 | 65.8 | 97.0 | 31.2 | 33.9 | 101.0 |
| Britain | | | | | | | | |
| Glasgow | 38.6 | 7.0 | 31.6 | 58.0 | 85.0 | 27.0 | 19.4 | 78.0 |
| London | 38.5 | 4.0 | 34.5 | 63.5 | 100.0 | 36.5 | 25.0 | 96.0 |
| Bulgaria | | | | | | | | |
| Sofia | 28.4 | -24.0 | 52.4 | 69.1 | 102.0 | 32.9 | 40.7 | 126.0 |
| Czechoslovakia | | | | | | | | |
| Prague | 30.0 | -14.0 | 44.0 | 66.6 | 95.0 | 28.4 | 36.6 | 109.0 |
| Denmark | | | | | | | | |
| Copenhagen | 30.5 | -13.0 | 43.5 | 61.8 | 90.0 | 28.2 | 31.3 | 103.0 |
| Vestervig | 34.0 | -4.0 | 38.0 | 60.2 | 93.0 | 32.8 | 26.2 | 97.0 |
| France | | | | | | | | |
| Brest | 44.9 | 12.0 | 32.9 | 64.2 | 100.0 | 35.8 | 19.3 | 88.0 |
| Lyon | 35.4 | -4.0 | 39.4 | 69.4 | 101.0 | 31.6 | 34.0 | 105.0 |
| Paris | 37.8 | -14.0 | 51.8 | 65.6 | 101.0 | 35.4 | 27.8 | 115.0 |
| Germany | | | | | | | | |
| Berlin | 30.2 | -15.0 | 45.2 | 64.4 | 99.0 | 34.6 | 34.2 | 114.0 |
| Danzig | 28.8 | -16.0 | 44.8 | 63.6 | 96.0 | 32.4 | 34.8 | 112.0 |
| Frankfurt AM | 32.4 | -7.0 | 39.4 | 66.4 | 100.0 | 33.6 | 34.0 | 107.0 |
| Hamburg | 31.7 | -6.0 | 37.7 | 62.6 | 92.0 | 29.4 | 30.9 | 98.0 |
| Munchen | 28.2 | -14.0 | 42.2 | 64.2 | 97.0 | 32.8 | 36.0 | 111.0 |
| Hungary | | | | | | | | |
| Budapest | 31.6 | -2.0 | 33.6 | 70.4 | 102.0 | 31.6 | 38.8 | 104.0 |
| Italy | | | | | | | | |
| Turin | 33.2 | 4.0 | 29.2 | 72.8 | 96.0 | 23.2 | 39.6 | 92.0 |
| Venice | 35.8 | 14.0 | 21.8 | 75.3 | 97.0 | 21.7 | 39.5 | 83.0 |

TABLE 2-1. SELECTED EUROPEAN TEMPERATURES [°F] (Ref.4) (Cont.)

(5°W-30°E) x (45°N-60°N)

| | Jan. Mean | Absolute Minimum | Difference | July Mean | Absolute Maximum | Difference | July-Jan. | Max.-Min. |
|---|---|---|---|---|---|---|---|---|
| Latvia | | | | | | | | |
| Riga | 24.3 | -20.0 | 44.3 | 64.8 | 92.0 | 27.2 | 40.0 | 112.0 |
| Netherlands | | | | | | | | |
| Amsterdam | 37.5 | 4.0 | 33.5 | 63.0 | 91.0 | 27.0 | 25.5 | 87.0 |
| Norway | | | | | | | | |
| Oslo | 24.1 | -26.0 | 50.1 | 62.6 | 95.0 | 32.4 | 38.5 | 121.0 |
| Poland | | | | | | | | |
| Lemburg | 25.2 | -28.0 | 53.2 | 66.2 | 99.0 | 32.8 | 41.0 | 127.0 |
| Warsaw | 25.7 | -28.0 | 53.7 | 65.4 | 98.0 | 32.6 | 39.7 | 126.0 |
| Rumania | | | | | | | | |
| Jassy | 25.8 | -20.0 | 45.8 | 70.4 | 104.0 | 35.6 | 44.6 | 124.0 |
| Sweden | | | | | | | | |
| Stockholm | 26.6 | -22.0 | 48.6 | 62.6 | 92.0 | 29.4 | 36.0 | 114.0 |
| Switzerland | | | | | | | | |
| Zurich | 31.5 | -11.0 | 42.5 | 64.8 | 98.0 | 33.2 | 33.3 | 109.0 |
| USSR | | | | | | | | |
| Leningrad | 18.3 | -39.0 | 57.3 | 63.5 | 97.0 | 33.5 | 45.2 | 136.0 |
| Minsk | 19.8 | -27.0 | 46.8 | 63.5 | 91.0 | 27.5 | 43.7 | 118.0 |
| Range | | | | | | | | |
| Maximum | 44.9 | 14.0 | 57.3 | 75.3 | 104.0 | 36.5 | 45.2 | 136.0 |
| Minimum | 18.3 | -39.0 | 21.8 | 58.0 | 85.0 | 21.7 | 19.3 | 78.0 |
| Mean | 30.8 | -11.2 | 41.9 | 65.4 | 96.4 | 31.1 | 34.6 | 107.6 |

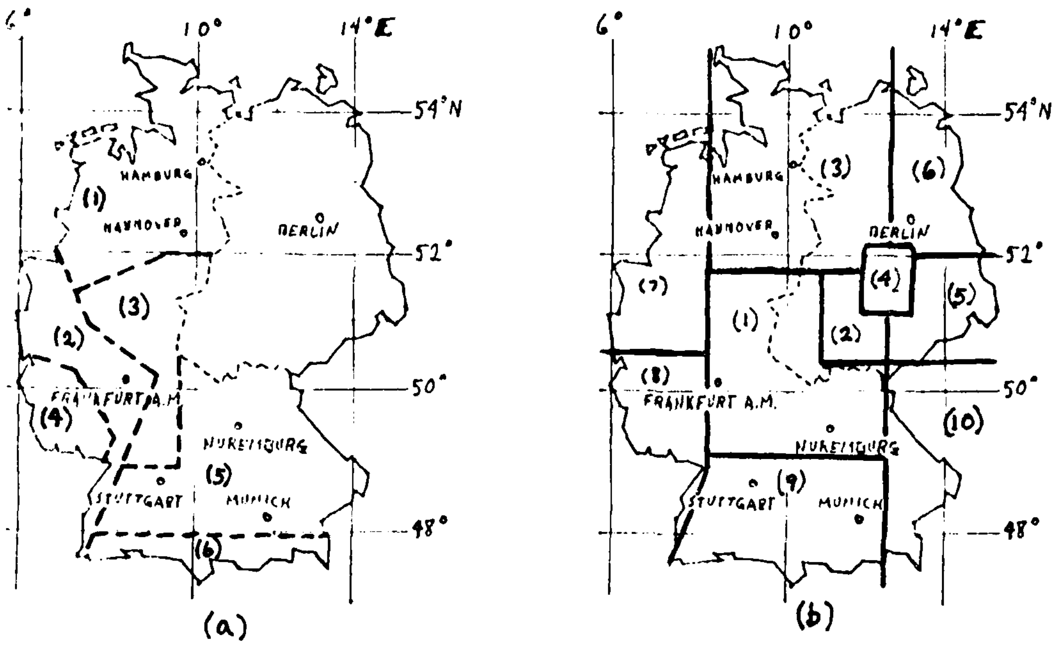



FIGURE 2-9. COARSE CLIMATIC DIVISIONS OF W. GERMANY

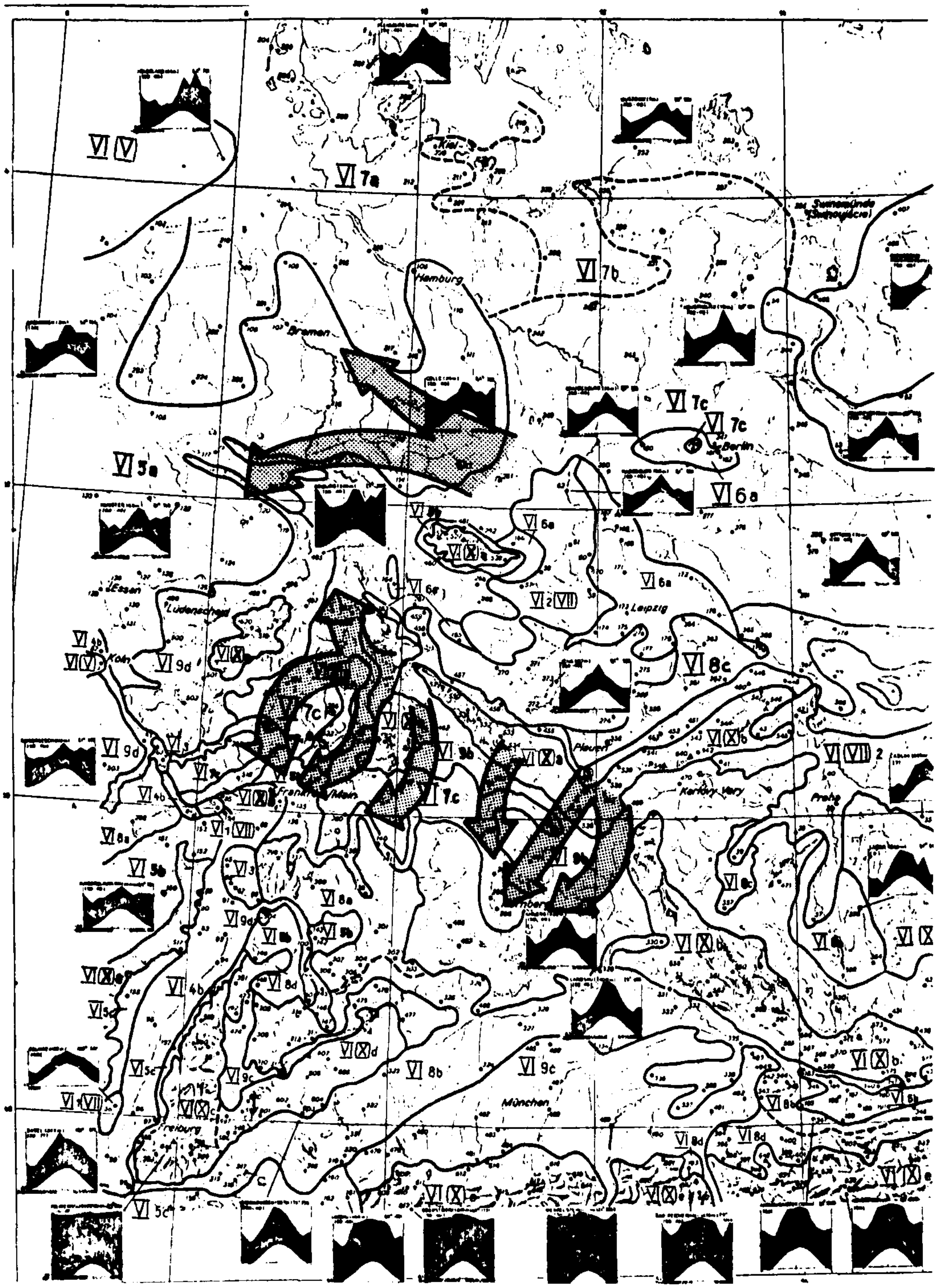



FIGURE 2-10. DETAILED CLIMATIC REGIONS OF GERMANY (Ref. 5)


FIGURE 2-11. GERMANY PHYSICAL MAP (Ref. 2)

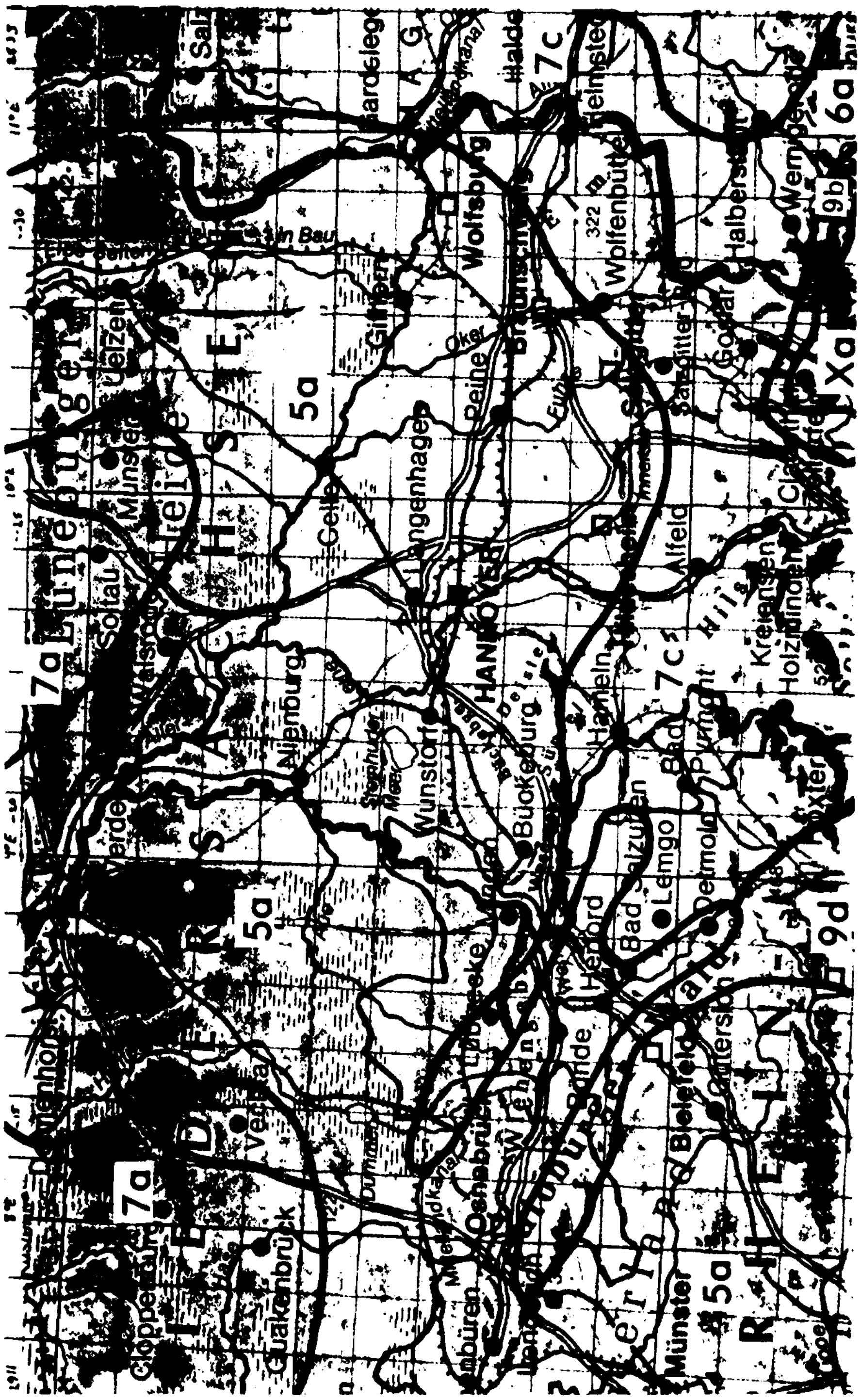



FIGURE 2-12. MAP - HELMSTEDT-MINDEN AREA

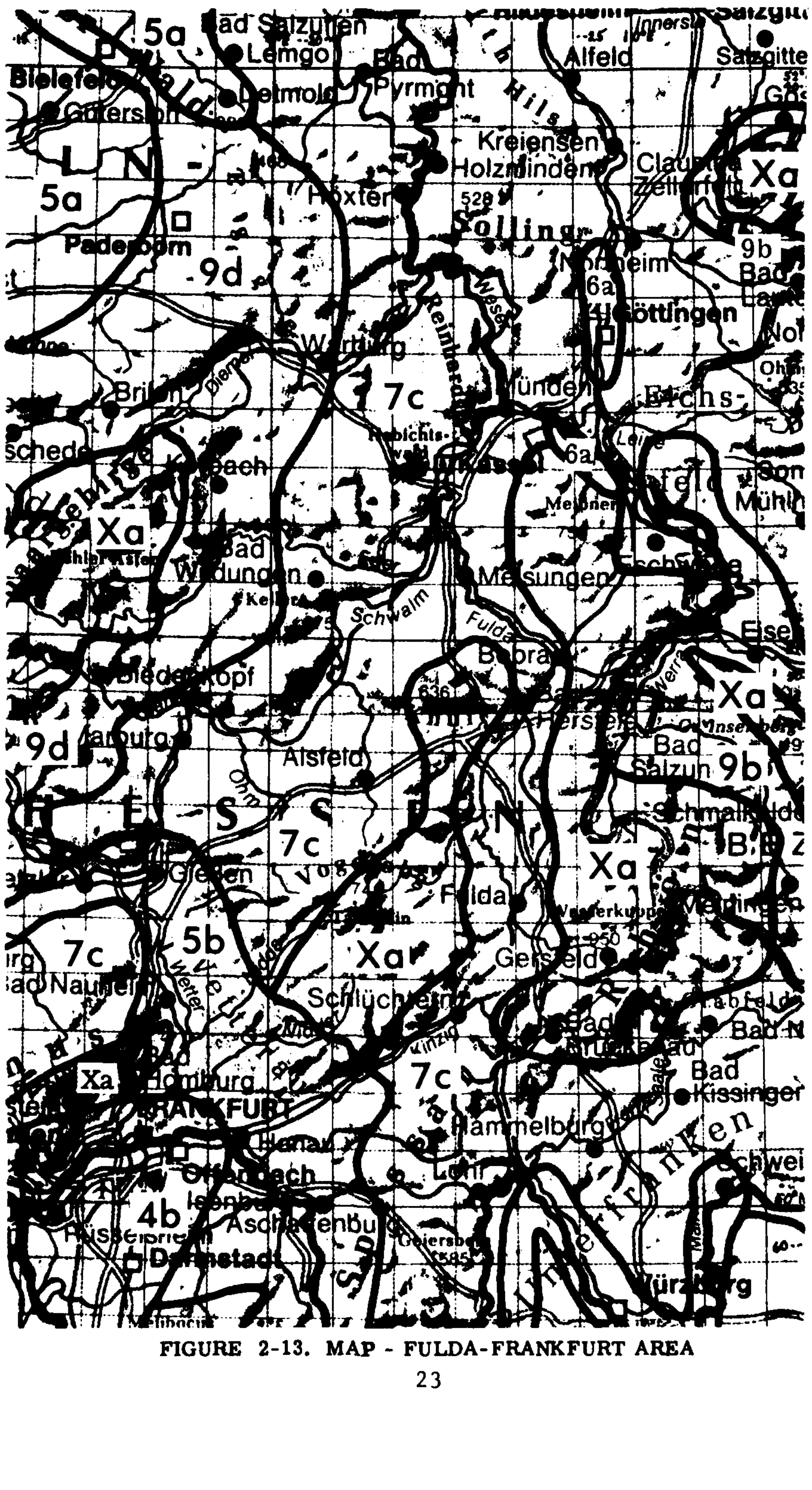



FIGURE 2-13. MAP - FULDA-FRANKFURT AREA

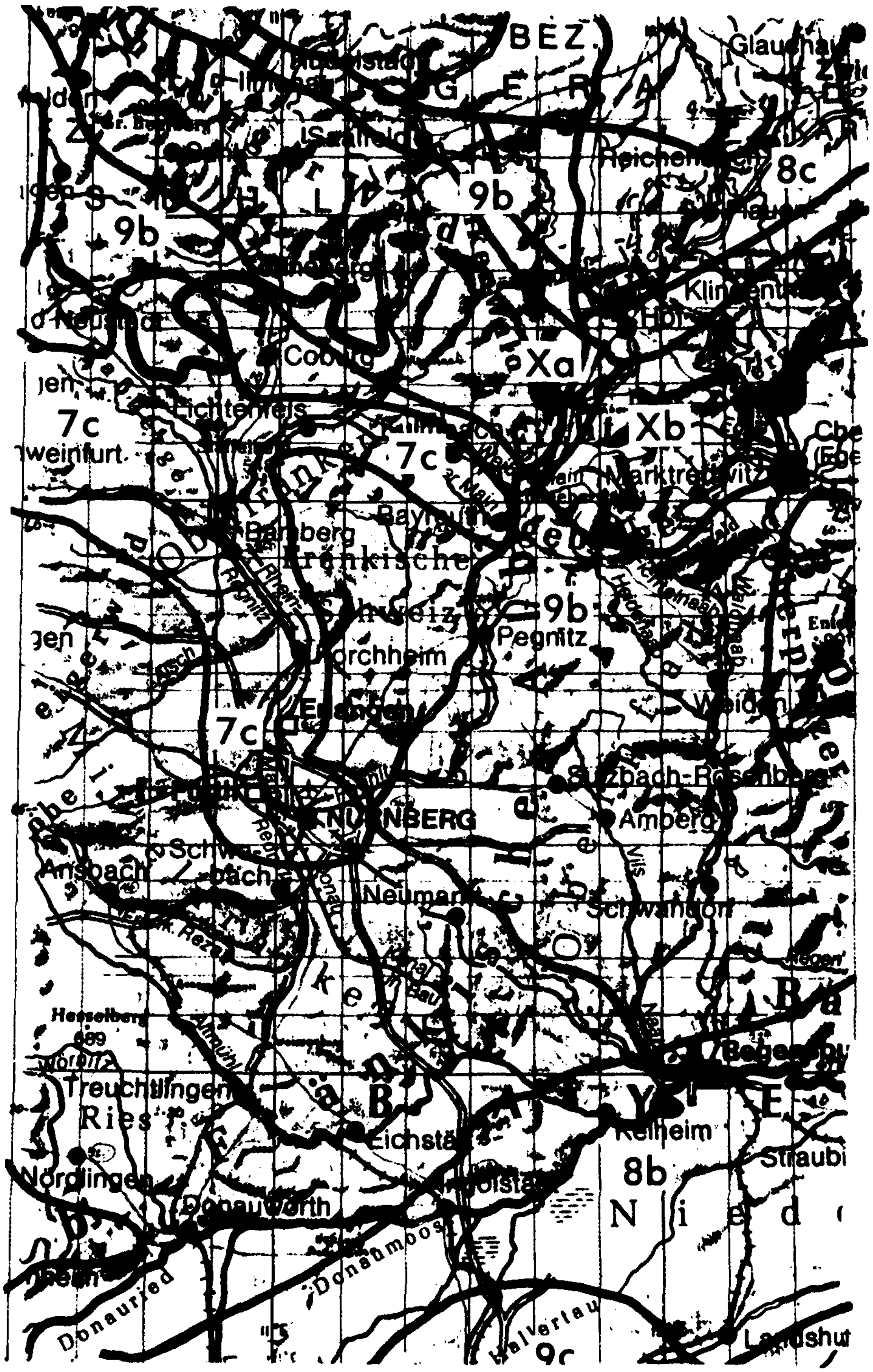



FIGURE 2-14. MAP - HOF-NURNBERG AREA

TABLE 2-2. CLIMATIC ZONES FOR THF STUDY REGIONS

| | N. German Plain | Fulda | Hof |
|---|---|---|---|
| Primary Zones | 5a | 4b | 7c |
| | 7c | 5b | 8c |
| | | 7c | 9b |
| | | 9b | Xa |
| | | Xa | Xb |
| Secondary Zones | 7a | 3 | 8a |
| | 9b | 5a | 8b |
| | 9d | 6a | 9c |
| | | 8a | Xd |
| | | 9d | |

TABLE 2-3. STATIONS TYPIFYING THE CLIMATIC ZONES

| | | |
|---|---|---|
| Primary Zones | 4b | Frankfurt AM, Freiburg 1B, Neuwied, Stuttgart, Wiesbaden |
| | 5a | Arnsberg, Bremen, Bremerhaven, Dusseldorf, Essen, Hamburg, Hannover, Kleve, Munster, Oldenburg |
| | 5b | Giessen |
| | 7c | Bayreuth, Fulda, Helmstedt, Kassel, Marburg ADL, Nürnberg |
| | 8c | Plauen |
| | 9b | Amberg, Coburg, Grafenwöhr, Hof, Kitzingen, Weiden |
| | Xa | Clausthal-Zellerfeld, Wasserkuppe |
| | Xb | Grosser Falkenstein |
| Secondary Zones | 3 | Heidelburg, Mannheim |
| | 6a | Berlin-Templehof |
| | 7a | Flensburg, Lübeck, Schleswig, Wyk |
| | 8a | Gerrabronn, Hahn AFB, Idar-Oberstein |
| | 8b | Augsburg, Eggenfelden, Passau, Regensburg, Ulm |
| | 9c | München |
| | 9d | Bitburg, Trier, Spangdahlem |
| | Xd | Donaueschingen |

# 3
# TEMPERATURE

A closer look at German temperatures shows the details of the variation from zone to zone, within zones, within the month, and from year to year.

Table 3-1 shows the monthly mean variations to be expected in the primary and secondary climatic zones. Six representatives of zone 7c are included because of the importance of this zone, but also to show the magnitude of the variation to be expected within a zone. Note that while variation is observed in each month it never exceeds 1° C.

Table 3-2 shows how much variation has been found in monthly means from year to year. The 4 representative zones all show a greater winter than summer variation. That large winter variation is concentrated on the low side of the mean. This rather clearly indicates the impact of the polar continental air mass from the USSR which occasionally flows from east to west across the land. Table 3-3 provides some additional temperature variation data from another source. Here the temperatures are in degrees Fahrenheit and a different time period has been covered. The shorter time span tends to reduce the max-to-min excursion.

These three last temperature tables suppressed the day-to-day variation within a month and the diurnal variation as well. Table 3-4 shows two types of minimum temperatures for each of our primary and secondary climatic zones. First the mean daily low to be expected in January. These are typically about 3°C below the monthly means. This table also shows the typical absolute minima; the lowest temperature which had been recorded. The last column records the lowest minimum recorded anywhere within the zone: an absolute absolute minimum, if you will.

Table 3-5 attempts to show the magnitude of both diurnal and day-to-day temperature variations. For three representative regions, the table shows, on a monthly basis, the frequency with which the temperature may be expected below a given level.

Cold air coupled with sufficient moisture may create the secondary problem of icing conditions at altitudes which might be used for sensor platforms. The probability of encountering icing conditions at the 850 mB level (~5000 ft.) over Germany exceeds 5% from December through March. It exceeds 5% at the 700mB level (~10,000 ft) from November through May.

TABLE 3-1. MONTHLY MEAN TEMPERATURES [°C] (Ref.5)

| Station | Zone | J | F | M | A | M | J | J | A | S | O | N | D | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frankfurt AM | 4b | 0 | 2 | 5 | 9 | 14 | 18 | 19 | 18 | 15 | 10 | 5 | 1 | 9.9 |
| Hannover | 5a | 1 | 2 | 5 | 8 | 13 | 16 | 17 | 16 | 14 | 9 | 5 | 2 | 9.0 |
| Giessen | 5b | 1 | 2 | 5 | 8 | 14 | 16 | 17 | 16 | 13 | 8 | 4 | 1 | 8.8 |
| Helmstedt | 7c | -1 | 0 | 4 | 7 | 13 | 16 | 17 | 16 | 12 | 7 | 3 | 1 | 8.4 |
| Kassel | 7c | -1 | 1 | 4 | 7 | 12 | 15 | 16 | 15 | 13 | 8 | 4 | 1 | 8.4 |
| Marburg ADL | 7c | -2 | 0 | 4 | 8 | 13 | 15 | 17 | 16 | 13 | 8 | 4 | 0 | 8.0 |
| Fulda | 7c | -1 | 0 | 4 | 7 | 12 | 15 | 16 | 15 | 12 | 7 | 3 | 1 | 8.0 |
| Bayreuth | 7c | -2 | 0 | 3 | 7 | 12 | 15 | 17 | 16 | 12 | 7 | 3 | 0 | 7.8 |
| Nurnberg | 7c | -1 | 0 | 4 | 8 | 13 | 16 | 18 | 16 | 13 | 8 | 4 | 1 | 8.7 |
| Plauen | 8c | -2 | -1 | 3 | 6 | 11 | 15 | 16 | 15 | 12 | 8 | 3 | 0 | 7.8 |
| Hof | 9b | -3 | -2 | 2 | 6 | 11 | 14 | 15 | 14 | 11 | 5 | 1 | -1 | 6.3 |
| Wasserkuppe | Xa | -3 | -3 | 0 | 3 | 7 | 11 | 13 | 12 | 9 | 5 | 0 | -2 | 4.4 |
| Alexandersbad | Xb | -3 | -3 | 0 | 5 | 10 | 13 | 15 | 14 | 11 | 5 | 1 | -2 | 5.7 |
| Heidelberg | 3 | 1 | 3 | 6 | 10 | 14 | 17 | 18 | 17 | 14 | 10 | 5 | 2 | 10.2 |
| Witzenhausen | 6a | 1 | 2 | 5 | 8 | 12 | 15 | 16 | 15 | 13 | 8 | 4 | 2 | 8.6 |
| Vechta | 7a | 0 | 1 | 4 | 7 | 12 | 14 | 16 | 15 | 13 | 8 | 4 | 2 | 8.2 |
| Gerrabronn | 8a | -2 | 0 | 4 | 7 | 12 | 15 | 16 | 15 | 12 | 7 | 3 | 0 | 7.6 |
| Regensburg | 8b | -2 | 0 | 4 | 8 | 12 | 15 | 17 | 16 | 12 | 6 | 2 | -1 | 7.7 |
| Munchen | 9c | -3 | -1 | 2 | 6 | 12 | 15 | 16 | 15 | 12 | 6 | 2 | -1 | 7.4 |
| Trier | 9d | 0 | 2 | 6 | 10 | 14 | 17 | 19 | 18 | 15 | 10 | 5 | 2 | 9.9 |
| Donaueschingen | Xd | -3 | -2 | 2 | 5 | 10 | 14 | 15 | 14 | 11 | 6 | 1 | -2 | 6.3 |

TABLE 3-2. MINIMUM, MEAN AND MAXIMUM MONTHLY TEMPERATURE MEANS [°C]

(Ref. 6 and 7)

| Month | 7c(Potsdam) | | | 4b(Frankfurt) | | | 6a(Berlin) | | | 9d(Trier)* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min. | Mean | Max. | Min. | Mean | Max. | Min. | Mean | Max. | Min. | Mean | Max. |
| January | -10.0 | -0.7 | 3.5 | -8.0 | 0.1 | 5.5 | -11.9 | -1.1 | 6.5 | -6.6 | 0.1 | 5.5 |
| February | -8.4 | 0.6 | 4.1 | -5.6 | 1.9 | 6.8 | -8.1 | 0.6 | 5.4 | -3.5 | 2.1 | 6.1 |
| March | -0.8 | 3.6 | 7.0 | -2.7 | 4.9 | 9.3 | -4.3 | 3.3 | 8.0 | 3.1 | 5.9 | 7.9 |
| April | 5.3 | 7.8 | 11.3 | 5.5 | 9.4 | 13.1 | 3.9 | 8.6 | 14.4 | 6.6 | 10.4 | 12.0 |
| May | 9.6 | 12.9 | 15.8 | 10.6 | 14.1 | 19.2 | 10.0 | 13.8 | 19.2 | 10.4 | 14.0 | 15.9 |
| June | 13.8 | 16.3 | 20.2 | 14.2 | 17.5 | 22.2 | 13.7 | 17.3 | 21.7 | 15.1 | 16.8 | 18.9 |
| July | 14.4 | 17.6 | 20.1 | 15.8 | 18.9 | 23.8 | 15.5 | 18.9 | 23.6 | 17.0 | 18.9 | 20.3 |
| August | 14.4 | 16.6 | 21.3 | 15.3 | 18.2 | 22.0 | 14.0 | 18.2 | 23.3 | 16.0 | 18.1 | 20.8 |
| September | 9.6 | 13.1 | 18.0 | 10.8 | 14.7 | 18.6 | 10.9 | 14.6 | 18.0 | 13.6 | 15.1 | 17.8 |
| October | 4.8 | 8.4 | 12.1 | 6.0 | 9.6 | 12.9 | 4.7 | 9.2 | 13.5 | 8.3 | 10.2 | 13.0 |
| November | -0.8 | 3.3 | 7.2 | -1.0 | 4.5 | 8.5 | -2.5 | 3.7 | 8.0 | 4.3 | 5.1 | 8.6 |
| December | -3.7 | 0.8 | 3.9 | -7.9 | 1.3 | 6.1 | -11.2 | 0.6 | 4.7 | -1.1 | 2.0 | 4.0 |

*Trier data represents only 13 years. Others 42 to 165 years.

TABLE 3-3. TEMPERATURE [°F] STATISTICS (Ref.8)

| Zone | Station | Parameter | J | F | M | A | M | J | J | A | S | O | N | D | Range/ Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6a | Berlin | Maximum | $36_L$ | 36 | 46 | 55 | 65 | 71 | $74_H$ | 73 | 66 | 56 | 44 | 40 | 38/55 |
| | | Minimum | 29 | $27_L$ | 33 | 40 | 48 | 55 | $59_H$ | 58 | 51 | 45 | 37 | 33 | 32/43 |
| | | Mean | 32 | $31_L$ | 38 | 47 | 56 | 63 | $66_H$ | 65 | 58 | 50 | 40 | 36 | 35/49 |
| | | Range | $7_L$ | 9 | 13 | 51 | $17_H$ | 16 | 15 | 15 | 15 | 11 | $7_L$ | 7 | -/12 |
| 5a | Hamburg | Maximum | $36_L$ | 38 | 44 | 52 | 61 | 66 | $69_H$ | 68 | 63 | 53 | 44 | 38 | 33/53 |
| | | Minimum | $29_L$ | 30 | 34 | 39 | 47 | 53 | $56_H$ | 55 | 51 | 44 | 36 | 32 | 27/42 |
| | | Mean | $33_L$ | 34 | 39 | 45 | 54 | 59 | $62_H$ | 61 | 57 | 49 | 40 | 35 | 29/47 |
| | | Range | 7 | 8 | 10 | 13 | $14_H$ | 13 | 13 | 13 | 12 | 9 | 8 | $6_L$ | -/11 |
| 5a | Hannover | Maximum | $38_L$ | 40 | 46 | 55 | 65 | 70 | $72_H$ | 71 | 66 | 54 | 45 | 40 | 34/55 |
| | | Minimum | $28_L$ | 29 | 33 | 37 | 44 | 50 | $53_H$ | 53 | 48 | 42 | 35 | 31 | 25/40 |
| | | Mean | $33_L$ | 34 | 39 | 46 | 54 | 60 | $62_H$ | 62 | 57 | 48 | 40 | 35 | 29/48 |
| | | Range | 10 | 11 | 13 | 18 | $21_H$ | 20 | 19 | 18 | 18 | 12 | 10 | $9_L$ | -/15 |
| 4b | Frankfurt AM | Maximum | $37_L$ | 42 | 49 | 58 | 67 | 72 | $75_H$ | 74 | 67 | 56 | 45 | 39 | 38/57 |
| | | Minimum | $29_L$ | 31 | 35 | 41 | 48 | 53 | $56_H$ | 55 | 51 | 43 | 36 | 31 | 27/42 |
| | | Mean | $33_L$ | 36 | 41 | 50 | 57 | 62 | $65_H$ | 65 | 56 | 50 | 40 | 35 | 32/49 |
| | | Range | $8_L$ | 11 | 14 | 17 | 19 | $19_H$ | 19 | 19 | 16 | 13 | 9 | $8_L$ | -/14 |

TABLE 3-4. TYPICAL TEMPERATURE MINIMA [°C] FOR A ZONE (Ref. 5)

| Zone | Mean Daily Minimum - Jan. | Typical Absolute Minimum | Absolute Minimum in Zone |
|---|---|---|---|
| 3 | -1.3°C | -22.2°C | -22.9°C |
| 4b | -1.7 | -21.9 | -28.4 |
| 5a | -1.7 | -25.0 | -28.0 |
| 5b | -2.5 | -28.8 | -30.3 |
| 6a | -2.4 | -26.1 | -31.0 |
| 7a | -2.4 | -22.0 | -30.3 |
| 7c | -3.5 | -28.0 | -35.1 |
| 8a | -4.1 | -26.6 | -30.0 |
| 8b | -5.1 | -28.8 | -35.4 |
| 8c | -4.4 | -29.7 | -35.8 |
| 9b | -6.0 | -32.3 | -37.2 |
| 9c | -5.0 | -25.4 | -31.8 |
| 9d | -3.6 | -24.4 | -36.4 |
| Xa | -6.0 | -25.5 | -29.0 |
| Xb | -6.9 | -23.1 | -37.0 |
| Xd | -6.9 | -33.6 | -33.6 |

TABLE 3-5. FREQUENCY (%) OF TEMPERATURES BELOW A SPECIFIED LEVEL (Ref. 9)

| Region Centered on | Month | 0°F | 15°F | 32°F | 50°F | 70°F | 85°F | 100°F |
|---|---|---|---|---|---|---|---|---|
| Hannover | Jan | <1% | 2% | 42% | 98% | >99% | | |
| | Feb | <1 | 5 | 35 | 97 | >99 | | |
| | Mar | | <1 | 20 | 86 | >99 | | |
| | Apr | | <1 | 2 | 61 | 99 | >99% | |
| | May | | | <1 | 30 | 92 | >99 | |
| | Jun | | | <1 | 5 | 81 | >99 | |
| | Jul | | | <1 | 1 | 74 | 98 | >99% |
| | Aug | | | <1 | 1 | 78 | 99 | >99 |
| | Sep | | | <1 | 10 | 90 | >99 | |
| | Oct | | <1 | 2 | 50 | >99 | | |
| | Nov | | <1 | 9 | 90 | >99 | | |
| | Dec | <1 | 2 | 32 | 96 | >99 | | |
| Fulda | Jan | <1 | 4 | 45 | 97 | >99 | | |
| | Feb | <1 | 3 | 38 | 96 | >99 | | |
| | Mar | | <1 | 11 | 80 | >99 | | |
| | Apr | | <1 | 1 | 58 | 98 | >99% | |
| | May | | | <1 | 26 | 90 | >99 | |
| | Jun | | | <1 | 3 | 78 | 99 | >99% |
| | Jul | | | <1 | 1 | 75 | 97 | >99 |
| | Aug | | | | <1 | 74 | 97 | >99 |
| | Sep | | | <1 | 10 | 86 | >99 | |
| | Oct | | <1 | 2 | 50 | >99 | | |
| | Nov | | <1 | 10 | 90 | >99 | | |
| | Dec | <1 | 3 | 33 | 95 | >99 | | |

TABLE 3-5. FREQUENCY (%) OF TEMPERATURES BELOW A SPECIFIED LEVEL (Ref. 9) (Cont'd)

| Region Centered on | Month | 9°F | 15°F | 32°F | 50°F | 70°F | 85°F | 100°F |
|---|---|---|---|---|---|---|---|---|
| Bayreuth | Jan | <1% | 8% | 49% | 97% | >99% | | |
| | Feb | <1 | 5 | 43 | 97 | >99 | | |
| | Mar | | <1 | 16 | 82 | >99 | | |
| | Apr | | <1 | 3 | 57 | 98 | >99% | |
| | May | | | <1 | 22 | 89 | >99 | |
| | Jun | | | <1 | 3 | 74 | 98 | >99% |
| | Jul | | | <1 | 1 | 60 | 97 | >99 |
| | Aug | | | | <1 | 75 | 98 | >99 |
| | Sep | | | <1 | 10 | 86 | >99 | |
| | Oct | | <1 | 3 | 55 | >99 | | |
| | Nov | | <1 | 15 | 91 | >99 | | |
| | Dec | <1 | 3 | 39 | 97 | >99 | | |

# 4
# PRECIPITATION

The month-to-month variation of precipitation in Germany is comparable in relative magnitude to the variation in temperature and both exhibit a distinctive pattern. Figure 4-1 shows the month-to-month variations to be expected in both for three representative North German Plain stations. Note a marked summer precipitation peak in July followed closely by a slightly lower peak in August. Two minima occur in November and February, with a small winter peak in January which exceeds December only slightly.

Table 4-1 shows the mean total precipitation to be expected in any month for all of our climatic zones. Note, again, that station-to-station variations within a zone are modest in magnitude.

Table 4-2 shows the variation in total monthly precipitation that has been recorded for four representative sites. These absolute variations are very large indeed. Examination of the original data also showed that a very dry month can occur immediately between two very wet months or between two years in which the corresponding months were very wet. Table 4-3 provides additional precipitation data which adds new stations and statistics on snow and thunderstorms (TSTM's) as well. A difference in time period covered explains the difference in Berlin & Frankfurt data between tables 4-2 and 4-3.

In Table 4-4, for two stations, we show the expectation for a given rainfall rate. It shows, for example, that the probability of an hour in Munich in which more than 0.18 inches of water falls is 0.3%. Similarly the probability of an instantaneous rate exceeding 0.06 inches per hour in Berlin, is 0.76%.

The greatest precipitation rates occur from thunderstorms. Instantaneous rates in excess of 12 inches per hour have been recorded. Fortunately the peak rate is not maintained long and the total period of precipitation from a single thunderstorm cell is typically about 25 minutes although this may vary from a few minutes to just under an hour.

Thunderstorms also provide strong, gusty surface winds, strong winds within and about the cloud, turbulence, great vertical development and electrical disturbance all in amounts sufficient to handicap most sensors and most platforms.

European thunderstorms tend to develop to lesser altitudes than those in the U.S. midwest. Most importantly, less development occurs above the freezing level which tends to inhibit their development and make the European thunderstorm somewhat less formidable. Winter thunderstorms in Europe are especially inhibited. They seldom develop to a height greater than 13,000 feet. They are infrequent, but, especially if a High sits over the British Isles and a Low sits in Russia with a cold front stretching between them, the moist maritime air is "pumped" over Scandinavia and down into Germany and thus frontal and prefrontal thunderstorms are generated.

Table 4-3 had provided the days of thunderstorms per month for four stations. Table 4-5 shows the probability of encountering a thunderstorm day at several additional stations by month. At all stations, the activity peaks in either June or July with a considerable concentration generally between May and August inclusive.

Many remote sensors are specifically handicapped by the amount of falling liquid water that is volumetrically distributed in a propagation path. Figure 4-2 shows as a function of altitude, the concentration of water expected within rain falls of different types and rates. Note that these do not include the stored water within the cloud itself.

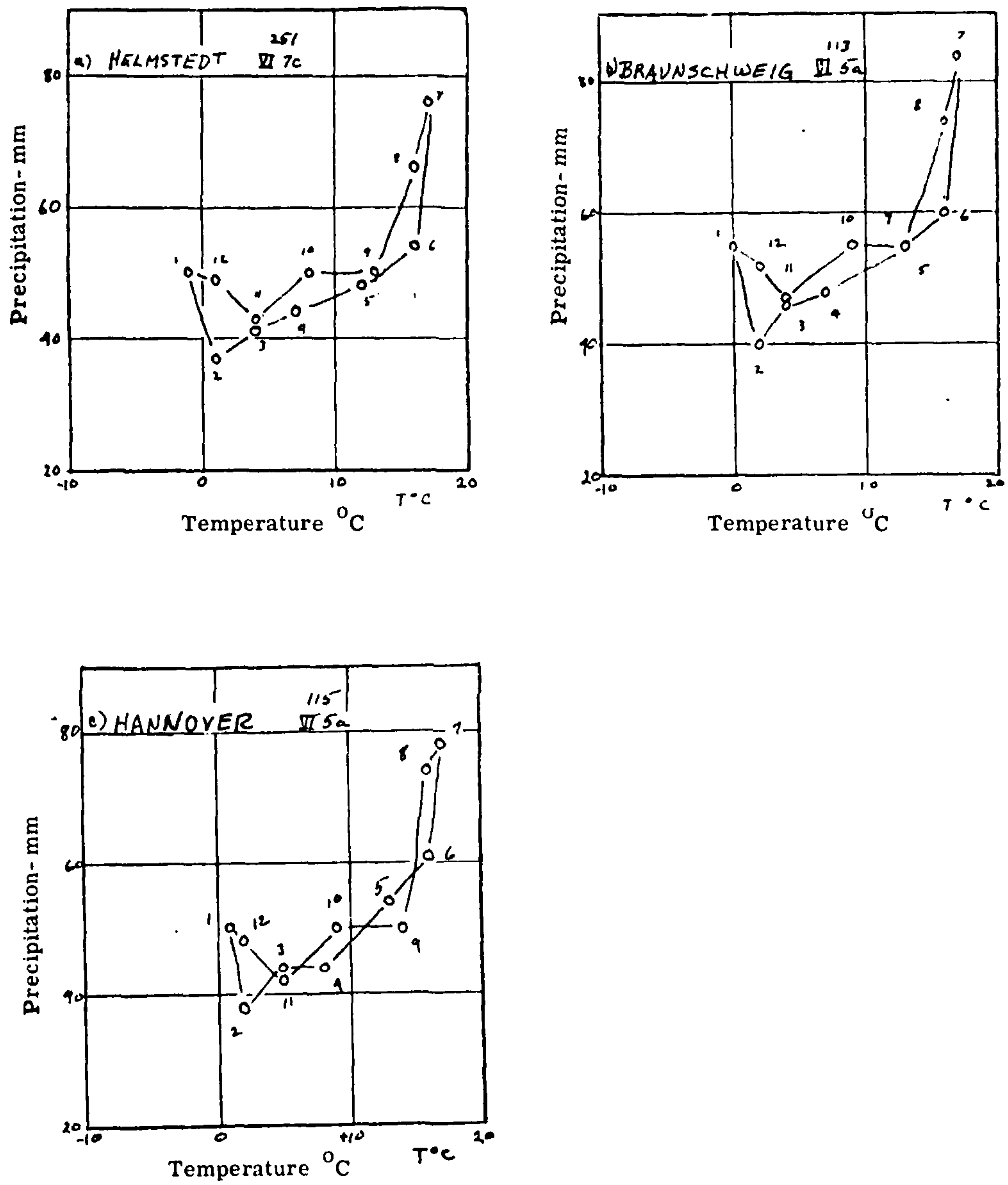



FIGURE 4-1. TEMPERATURE -PRECIPITATION DIAGRAMS (Ref. 5)

TABLE 4-1. MONTHLY TOTAL PRECIPITATION [mm] (Ref. 5, 6, & 7)

| Station | Zone | J | F | M | A | M | J | J | A | S | O | N | D | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frankfurt | 4b | 45 | 35 | 41 | 37 | 52 | 63 | 71 | 67 | 50 | 55 | 50 | 52 | 616 |
| Hannover | 5a | 50 | 38 | 45 | 44 | 54 | 61 | 78 | 73 | 49 | 50 | 42 | 49 | 644 |
| Giessen | 5b | 45 | 36 | 38 | 37 | 50 | 69 | 76 | 61 | 48 | 56 | 50 | 53 | 619 |
| Helmstedt | 7c | 50 | 38 | 42 | 44 | 50 | 55 | 76 | 66 | 51 | 51 | 44 | 49 | 613 |
| Kassel | 7c | 40 | 35 | 37 | 41 | 50 | 58 | 74 | 65 | 46 | 48 | 44 | 46 | 591 |
| Marburg A.D.L. | 7c | 51 | 41 | 43 | 43 | 51 | 60 | 69 | 64 | 50 | 60 | 51 | 56 | 637 |
| Fulda | 7c | 46 | 36 | 40 | 47 | 61 | 65 | 76 | 71 | 57 | 55 | 46 | 49 | 640 |
| Bayreuth | 7c | 47 | 35 | 37 | 44 | 55 | 60 | 70 | 69 | 47 | 46 | 45 | 49 | 595 |
| Nürnberg | 7c | 40 | 31 | 35 | 43 | 56 | 64 | 77 | 80 | 54 | 55 | 49 | 44 | 623 |
| Plauen | 8c | 38 | 37 | 44 | 51 | 76 | 82 | 87 | 77 | 57 | 44 | 40 | 40 | 665 |
| Hof | 9b | 51 | 40 | 47 | 49 | 59 | 73 | 81 | 75 | 54 | 49 | 49 | 55 | 679 |
| Wasserkuppe | Xa | 90 | 82 | 77 | 82 | 76 | 85 | 120 | 105 | 96 | 91 | 71 | 86 | 1076 |
| Alexandersbad | Xb | 67 | 51 | 58 | 70 | 80 | 81 | 90 | 100 | 70 | 70 | 66 | 81 | 882 |
| Heidelberg | 3 | 50 | 44 | 45 | 51 | 56 | 70 | 82 | 76 | 68 | 60 | 53 | 55 | 718 |
| Witzenhausen | 6a | 43 | 37 | 37 | 47 | 51 | 60 | 74 | 64 | 52 | 56 | 41 | 46 | 606 |
| Vechta | 7a | 55 | 45 | 50 | 48 | 55 | 69 | 79 | 71 | 58 | 59 | 51 | 60 | 695 |
| Gerrabronn | 8a | 63 | 52 | 56 | 62 | 70 | 76 | 84 | 80 | 70 | 61 | 63 | 77 | 818 |
| Regensburg | 8b | 40 | 32 | 33 | 43 | 59 | 68 | 82 | 71 | 51 | 40 | 36 | 42 | 591 |
| München | 9c | 44 | 36 | 51 | 71 | 81 | 120 | 125 | 110 | 80 | 58 | 48 | 49 | 866 |
| Trier | 9d | 49 | 43 | 48 | 44 | 58 | 67 | 71 | 68 | 57 | 62 | 57 | 62 | 684 |
| Donaueschingen | Xd | 50 | 38 | 47 | 56 | 70 | 81 | 81 | 76 | 67 | 58 | 51 | 56 | 732 |

TABLE 4-2. MINIMUM, MEAN, & MAXIMUM MONTHLY PRECIPITATION TOTALS* [mm, LIQUID] ( Ref. 6 & 7 )

| | 7c (Potsdam) | | | 4b (Frankfurt) | | | 6a (Berlin) | | | 9d (Trier) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | Min | Mean | Max | Min | Mean | Max | Min | Mean | Max | Min | Mean | Max |
| Jan | 14 | 43 | 97 | 5 | 45 | 123 | 6 | 42 | 100 | 1 | 49 | 127 |
| Feb | 13 | 41 | 99 | 1 | 35 | 102 | 7 | 36 | 124 | 3 | 43 | 123 |
| Mar | 10 | 34 | 69 | 5 | 41 | 110 | 4 | 41 | 134 | 7 | 48 | 125 |
| Apr | 13 | 43 | 77 | 0 | 37 | 146 | 1 | 39 | 106 | 0 | 44 | 129 |
| May | 17 | 48 | 73 | 2 | 52 | 156 | 7 | 48 | 145 | 2 | 58 | 142 |
| Jun | 25 | 60 | 124 | 12 | 63 | 196 | 8 | 59 | 142 | 13 | 67 | 138 |
| Jul | 28 | 66 | 118 | 1 | 71 | 208 | 20 | 76 | 230 | 6 | 71 | 168 |
| Aug | 17 | 69 | 152 | 6 | 67 | 214 | 8 | 58 | 202 | 13 | 68 | 166 |
| Sep | 7 | 42 | 72 | 1 | 50 | 126 | 7 | 43 | 97 | 1 | 57 | 239 |
| Oct | 6 | 46 | 108 | 2 | 55 | 147 | 1 | 44 | 134 | 1 | 62 | 153 |
| Nov | 15 | 48 | 116 | 11 | 50 | 153 | 1 | 42 | 118 | 3 | 57 | 181 |
| Dec | 10 | 35 | 86 | 1 | 52 | 130 | 3 | 49 | 117 | 2 | 62 | 154 |
| ANNUAL | 444 | 575 | 722 | 359 | 616 | 936 | 389 | 577 | 763 | 383 | 684 | 998 |

*Potsdam data represents only 12 yrs and is very unstable. Others represent 87-114 yrs.

TABLE 4-3. PRECIPITATION STATISTICS [INCHES & DAYS/MONTH] (Ref. 8)

| Zone | Station | Parameter | J | F | M | A | M | J | J | A | S | O | N | D | Tot. | Avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6a | Berlin | Rain, Total | 1.8 | 1.2 | 1.0L | 1.5 | 1.6 | 2.9H | 2.8 | 2.4 | 2.1 | 1.9 | 1.6 | 1.8 | 22.4 | 1.9 |
| | | Precip., Days | 17H | 13 | 13 | 14 | 13L | 13L | 14 | 14 | 13L | 14 | 15 | 17H | 171 | 14 |
| | | Snow, Total | 5.6 | 5.8H | 1.7 | 0.1 | - | - | - | - | - | 0.1 | 0.5 | 2.0 | 15.8 | - |
| | | TSTM's | - | - | 1 | 1 | 4 | 5 | 5H | 4 | 1 | - | - | - | 21 | - |
| 5a | Hamburg | Rain, Total | 2.3 | 1.9L | 1.9 | 2.0 | 2.1 | 2.8 | 3.3 | 3.4H | 2.4 | 2.6 | 2.1 | 2.4 | 29.0 | 2.4 |
| | | Precip., Days | 18H | 15 | 16 | 16 | 14L | 15 | 17 | 18H | 15 | 17 | 17 | 18H | 196 | 16 |
| | | Snow, Total | 4H | 3 | 1 | - | - | - | - | - | - | TR. | 1 | 3 | 12 | - |
| | | TSTM's | - | - | 1 | 2 | 3 | 4 | 5H | 5 | 2 | 1 | - | - | 23 | - |
| 5a | Hannover | Rain, Total | 1.7 | 1.4L | 1.6 | 1.5 | 2.0 | 2.7 | 3.0H | 2.7 | 1.8 | 1.9 | 1.7 | 1.9 | 24.0 | 2.0 |
| | | Precip., Days | 17H | 14L | 15 | 15 | 14L | 14 | 16 | 16 | 14L | 14 | 14 | 16 | 175 | 15 |
| | | Snow, Total | 5.9 | 6.8H | 2.0 | 0.2 | - | - | - | - | - | TR. | 1.0 | 2.9 | 18.9 | - |
| | | TSTM's | - | - | 1 | 1 | 4 | 4 | 5H | 4 | 2 | - | - | - | 21 | - |
| 4b | Frankfurt A.M. | Rain, Total | 1.7 | 1.4L | 1.6 | 1.5 | 1.9 | 2.2 | 2.5 | 2.7H | 2.0 | 2.2 | 1.9 | 2.1 | 23.7 | 2.0 |
| | | Precip., Days | 15 | 13 | 13 | 14 | 13 | 13 | 14 | 14 | 12L | 14 | 14 | 17H | 166 | 14 |
| | | Snow, Total | 5H | 4 | 1 | 1 | - | - | - | - | - | TR. | 1 | 3 | 14.5 | - |
| | | TSTM's | - | - | 1 | 1 | 4 | 5H | 5 | 4 | 2 | - | - | - | 22 | - |

TABLE 4-4. PRECIPITATION RATES [INCHES/HOUR], FREQUENCY [%] AT WHICH THEY ARE EXCEEDED (Ref. 10)

| Station | Zone | Average Precip. [in.] | No. of Days With Measurable Precip. | Clock Hourly Rates 0.06 | Clock Hourly Rates 0.12 | Clock Hourly Rates 0.18 | Instantaneous Rates 0.06 | Instantaneous Rates 0.12 | Instantaneous Rates 0.18 |
|---|---|---|---|---|---|---|---|---|---|
| a) Annual Data Based on Long-Term Statistics [Ref. 10 & 2] | | | | | | | | | |
| Berlin | 6a | 22.88 | 169 | 0.84 | 0.16 | 0.03 | 0.76 | 0.15 | 0.03 |
| München | 9c | 34.09 | 137 | 1.35 | 0.55 | 0.30 | 1.22 | 0.52 | 0.30 |
| b) Annual Data Based on Recent Short-Term Statistics [Ref. 8] | | | | | | | | | |
| Berlin | 6a | 22.4 | 171 | 0.81 | 0.13 | 0.01 | 0.73 | 0.12 | 0.01 |
| Hamburg | 5a | 29.0 | 196 | 0.89 | 0.19 | 0.05 | 0.80 | 0.18 | 0.05 |
| Hannover | 5a | 24.0 | 175 | 0.84 | 0.15 | 0.02 | 0.75 | 0.14 | 0.02 |
| Frankfurt | 4b | 23.7 | 166 | 0.87 | 0.17 | 0.04 | 0.78 | 0.16 | 0.04 |
| c) June, July, & August Data Based on Recent Short-Term Statistics [Ref. 8] | | | | | | | | | |
| Berlin | 6a | 8.1 | 41 | 1.15 | 0.37 | 0.17 | 1.03 | 0.35 | 0.17 |
| Hamburg | 5a | 9.5 | 50 | 1.11 | 0.34 | 0.16 | 1.00 | 0.32 | 0.16 |
| Hannover | 5a | 8.4 | 46 | 1.07 | 0.31 | 0.14 | 0.96 | 0.29 | 0.14 |
| Frankfurt | 4b | 7.4 | 41 | 1.06 | 0.31 | 0.13 | 0.95 | 0.29 | 0.13 |

TABLE 4-5. FREQUENCY [%]* OF DAYS WITH THUNDERSTORMS (Ref. 11)

| Zone | Station | J | F | M | A | M | J | J | A | S | O | N | D | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | Mannheim | 1 | 1 | 3 | 3 | 10 | 17 | 16 | 13 | 7 | 1 | 1 | 1 | 6 |
| 4b | Frankfurt | 1 | 1 | 3 | 3 | 13 | 17 | 16 | 13 | 7 | 1 | 1 | 1 | 6 |
| 4b | Wiesbaden | 1 | 1 | 3 | 3 | 10 | 13 | 13 | 10 | 3 | 1 | 1 | 1 | 5 |
| 5a | Bremen | 1 | 1 | 1 | 3 | 13 | 17 | 19 | 13 | 7 | 3 | 1 | 1 | 8 |
| 5a | Hannover | 1 | 1 | 3 | 3 | 13 | 13 | 16 | 13 | 7 | 1 | 1 | 1 | 6 |
| 5b | Giessen | 1 | 1 | 3 | 3 | 16 | 20 | 16 | 13 | 3 | 1 | 0 | 1 | 8 |
| 7a | Lübeck | 1 | 1 | 1 | 3 | 10 | 10 | 16 | 13 | 3 | 1 | 1 | 1 | 5 |
| 7c | Bayreuth | 1 | 3 | 3 | 7 | 19 | 20 | 23 | 19 | 7 | 3 | 1 | 1 | 9 |
| 7c | Fulda | 1 | 1 | 3 | 3 | 13 | 13 | 16 | 13 | 3 | 1 | 1 | 1 | 5 |
| 7c | Helmstedt | 1 | 1 | 3 | 3 | 13 | 17 | 16 | 13 | 3 | 3 | 1 | 1 | 6 |
| 7c | Kassel | 1 | 1 | 3 | 3 | 13 | 17 | 16 | 16 | 3 | 1 | 1 | 1 | 6 |
| 7c | Marburg A.D.L. | 1 | 1 | 3 | 3 | 13 | 20 | 19 | 13 | 7 | 3 | 1 | 1 | 7 |
| 7c | Nürnberg | 1 | 1 | 3 | 10 | 19 | 23 | 23 | 23 | 10 | 1 | 1 | 1 | 9 |
| 8a | Gerabronn | 1 | 1 | 3 | 3 | 13 | 17 | 16 | 13 | 7 | 1 | 1 | 1 | 6 |
| 8b | Regensburg | 1 | 1 | 1 | 3 | 16 | 17 | 16 | 13 | 7 | 1 | 1 | 1 | 6 |
| 9b | Hof | 1 | 1 | 1 | 3 | 13 | 13 | 16 | 13 | 3 | 3 | 1 | 1 | 5 |
| 9c | München | 1 | 1 | 3 | 7 | 19 | 27 | 23 | 19 | 7 | 1 | 1 | 1 | 9 |
| 9d | Trier | 0 | 1 | 3 | 3 | 13 | 17 | 16 | 13 | 3 | 3 | 1 | 1 | 6 |
| Xa | Clausthal-Zellerfeld | 1 | 1 | 3 | 3 | 13 | 17 | 16 | 13 | 3 | 1 | 1 | 1 | 6 |
| Xd | Donaueschingen | 1 | 0 | 1 | 3 | 13 | 17 | 16 | 13 | 7 | 1 | 1 | 1 | 6 |

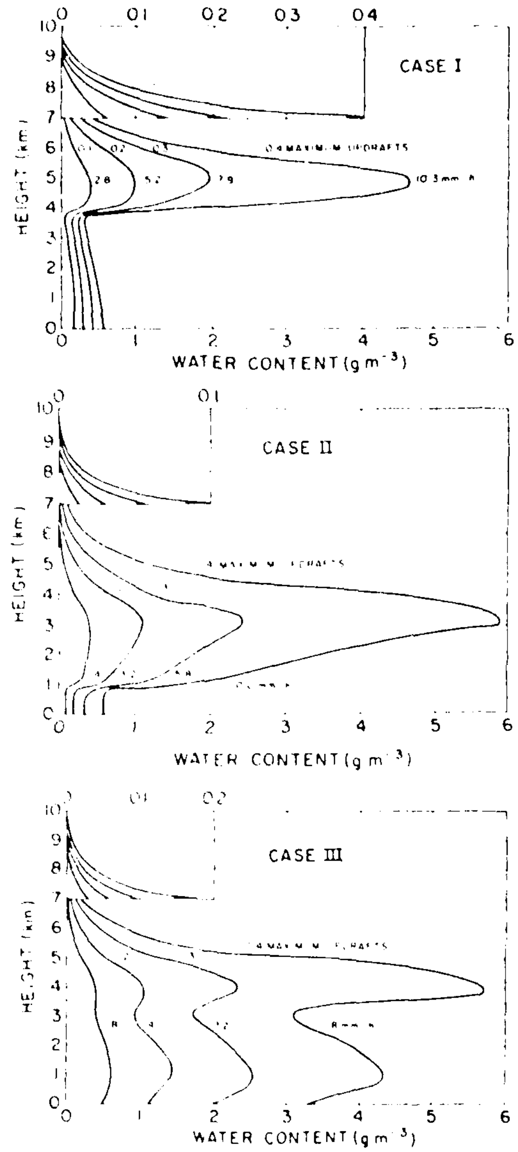



FIGURE 4-2. WATER CONCENTRATIONS EXPECTED WITHIN PRECIPITATION REGIONS (Ref. 10)

Case I Summer Rain
Case II Spring or Fall Rain
Case III Winter Rain or Severe Snowstorm

# 5
# CLOUDS & OTHER AEROSOLS

Fractional Sky Cover and Ceiling are the usual quantitative descriptors of cloudiness. Both are cumulative measures in altitude, that is, sky cover considers clouds in all decks and ceiling is the height of the base of the lowest cloud deck which, in combination with all lower cloud decks, brings the sky cover to 5/10 or more.

Table 5-1 shows how fractional sky cover varies during the year. The table also shows that the fraction may be misleading since it is obtained by averaging and that there are usually more clear days and cloudy days in a month than there are partly cloudy days. The number of clear, cloudy, and partly cloudy days are estimated using methods suggested by H. Landsberg in Reference 1.

Table 5-2 shows instead the frequency of obtaining a given sky cover. It also shows the probability of different cloud types. Note that Stratocumulus are the most likely clouds in any month for either zone, Stratus belong to the Fall and Winter, while Cumulus go with Spring and Summer in zone 5a. The appearance of Altostratus as a prominent cloud type complicates the pattern in zone 4b since it occurs with greater frequency than every cloud but the Stratocumulus.

With sensor platforms which operate at the middle altitudes, the vertical distribution of these clouds become very important. In Figures 5-1 through 5-22 we have shown the somewhat generalized expectation of a given sky cover by altitude bands over middle Europe for four different months.

In Table 5-3 we have extracted an example distribution for 10°E and 50°N, a position very close to Schweinfurt. The probability of total cloudiness but especially low altitude cloudiness in January is very marked. It is all part of the general lowering of the cloud processes in the winter as the altitude of the freezing level descends.

Table 5-4 shows cloudiness incidence at two altitudes, for four stations in important climatic zones as reported in Reference 8. The asterisks indicate four rows of highly suspect data. We are reasonably well satisfied that we understand the mechanical error apparently made while the data was being processed. With some confidence then we have made the required corrections and reproduce the corrected Table 5-5. Note again the high incidence of low altitude winter cloudiness.

A more concise, although more limited, descriptor for vertical cloud deck development is the ceiling. It is defined as the altitude (AGL) of the base of the lowest cloud deck which, along with all lower cloud decks, obscures at least half of the sky from the surface observer. Thus almost half tne sky could be densely covered and an unlimited ceiling would still be reported. Or if 4/10 of the sky were obscured at 500 ft and a few scattered clouds at 7,000 ft brought the total over 50%, then the ceiling would be reported at 7,000 ft.

Nonetheless it is such a compact statistic that it is useful. Table 5-6 shows the expectation of ceiling height by month for two primary climatic zones in the North German Plain study area. While they cannot tell anything of the vertical structure, they do clearly exhibit the winter lowering of the cloud processes. Note also that 7c and 5a are adjacent zones yet they show a rather marked difference in ceiling behavior, perhaps due to the greater elevation of 7c.

In Table 5-7 we display ceiling frequencies for eight stations each for zones 4 b and 5a. In any given month the variation from zone to zone are not markedly greater than that within a zone. That is not true for the annual average however. That strongly suggests that insufficient data have been accumulated for the monthly frequencies to be stable*. The annual frequency sample should be adequate however.

Fog is a special type of cloud. It can limit a ceiling but its most dramatic inpact is on visibility.

The incidence of fog in Germany is high. The strong maritime influence is responsible. The general fog occurrence in days per year is shown in Figure 5-23. This shows Germany to be foggier than her neighbors. It suggests more than 40 foggy days per year; actually, 78 days per year is typical. This varies with the season as shown in Table 5-8.

Ground fog is quite shallow and may markedly impede horizontal visibility while permitting good vertical visibility. Other fog however is rather like low stratus clouds and may reach or exceed 1,000 feet in depth. Ground fog shows a smaller, but similar seasonal variation compared to fog. Unlike fog, ground fog occurs most frequently at night, ground fog has the highest incidence in the higher altitudes of Germany; fog occurs most in the low altitude of the German Plain.

Directing our attention specifically to the Helmstedt-Hannover-Minden Corridor in the Plain, we offer the data of Table 5-9 as typical of the predominant central region identified as a 5a climatic zone.

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*The question of data length required for stability is discussed by Landsberg and Jacobs in Reference 3 and by others. In general, more data are required for short term statistics (e.g., monthly vs. monthly means) and more for extra tropical than tropical regions. Geographically, most is required for the mountains, less for plains, somewhat less still for shorelands, and the least for islands. As for parameters the most data are required for precipitation, less for temperature, still less for cloudiness, less for humidity, and least for visibility. About 50 years of data is required to develop a stable mean annual precipitation total in the mountains. One year may suffice to establish mean humidity for a Tropical island. All other annual measures lie between these two extremes.

Smoke and haze consist of solid particulate matter and their scattering properties may differ in detail from fog. Their similarities are great, however, so in Table 5-10 we summarize the monthly incidences of fog, ground fog, haze, and smoke.

When these fogs occur they may degrade ceilings and will degrade visibilities. The following Table 5-11 shows the percentile values of ceiling and visibility values (ft & st. mi) that are exceeded under particular fog conditions.

Table 5-12 shows the expectation for given visibility levels in two of our most important zones.

Ceiling and visibility vary with the time of day and all of the previous tables ignored this divisional variation. For five of our zones we show in Table 5-13 how the likelihood of a given low ceiling/visibility varies at three-hour intervals.

For many sensors, the presence of a cloud may or may not be serious depending on its water content. Figures 5-24 and 5-25 show the expected water content of stratiform clouds which are heavy enough to be producing rain at a given rate. Figure 5-26 shows the same for cumulonimbus clouds. Finally, Table 5-14 predicts the water content of cumulus clouds with different degrees of vertical development.

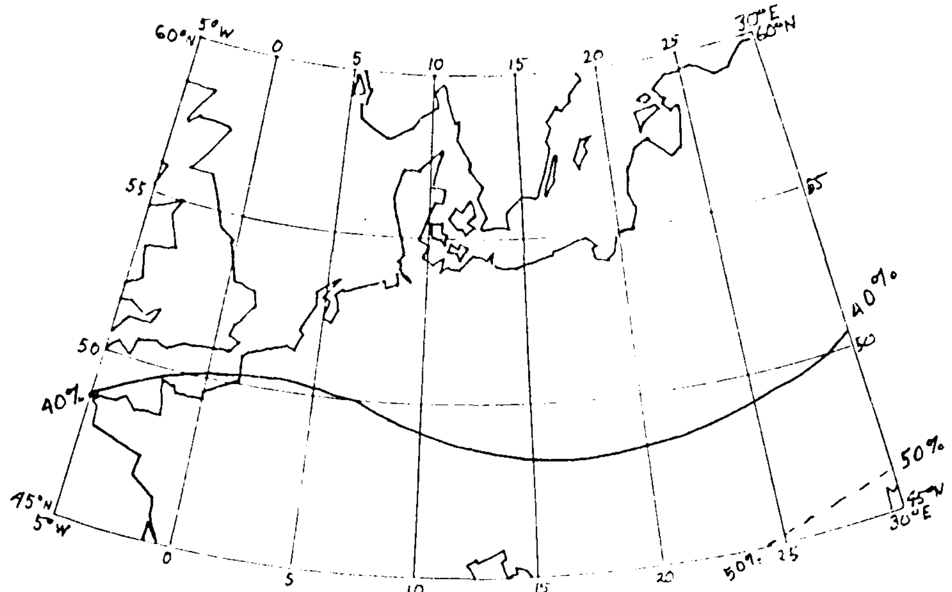
One special visibility problem concerns likelihood of seeing a given spot on the ground when looking at a given depression angle from a given altitude. We have extracted some altitudes under which a given cloud-free line of sight could be expected with a given probability (Table 5-15). It should be carefully noted that these values are obtained from some very small graphs in Reference 11. Thus the specific values should not be adopted uncritically. Nonetheless the values will not be greatly in error and will show the approximate performance to be expected by a cloud limited airborne sensor. Note also that this visibility measure is concerned only with airborne clouds. Haze, smoke, ground fog, etc., must be considered independently.

TABLE 5-1. CLOUDINESS TYPICAL OF NORTH GERMAN PLAIN (Ref.1)

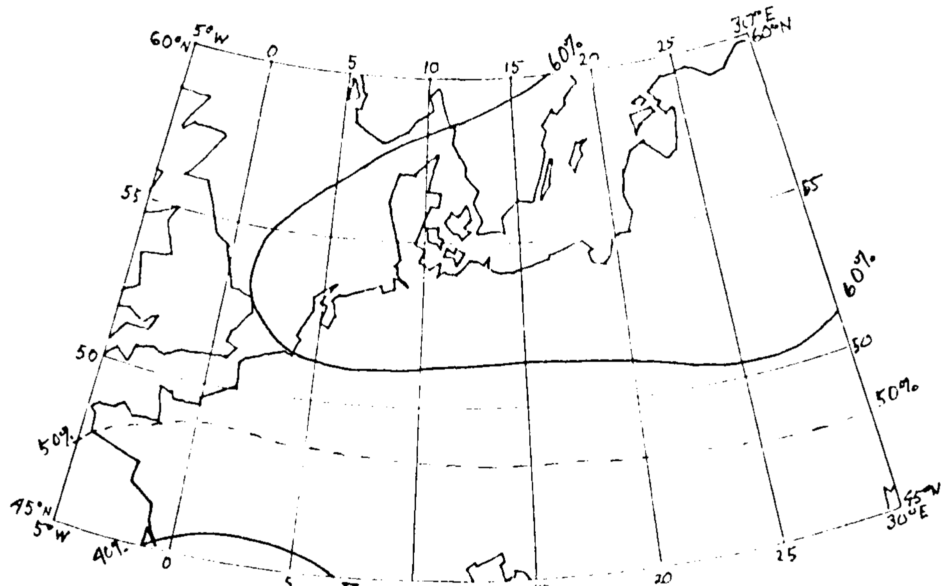
| | JAN | MAR | MAY | JUL | SEP | NOV |
|---|---|---|---|---|---|---|
| Fractional Sky Cover | .75 | .67 | .60 | .62 | .56 | .75 |
| No. of Clear Days, est. | 4 | 5 | 5 | 6 | 7 | 5 |
| No. of Cloudy Days, est. | 19 | 15 | 10 | 10 | 9 | 16 |
| No. of Partly Cloudy Days, est. | 8 | 10 | 16 | 15 | 14 | 9 |

TABLE 5-2. CLOUD COVER CHARACTERISTICS FOR CLIMATIC ZONES 5a (ESSEN) & 4b (STUTTGART) (Ref. 12)

| Stat. | Parameters | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5a (ESSEN) | Overcast, Freq. | 0.32 | 0.31 | 0.27 | 0.20 | 0.15 | 0.13 | 0.13 | 0.13 | 0.16 | 0.15 | 0.28 | 0.28 |
| | ≥ 7/8 Cover, Freq. | 0.59 | 0.56 | 0.53 | 0.38 | 0.37 | 0.31 | 0.33 | 0.32 | 0.33 | 0.34 | 0.51 | 0.62 |
| | ≥ 3/8 Cover, Freq. | 0.84 | 0.81 | 0.79 | 0.51 | 0.74 | 0.71 | 0.76 | 0.74 | 0.71 | 0.71 | 0.81 | 0.89 |
| | Stratus, Freq. | 0.23 | 0.25 | 0.20 | — | — | — | — | — | — | 0.14 | 0.25 | 0.32 |
| | Strato-Cumulus, Freq. | 0.48 | 0.50 | 0.47 | 0.41 | 0.40 | 0.40 | 0.46 | 0.47 | 0.45 | 0.47 | 0.45 | 0.46 |
| | Cumulus, Freq. | — | — | — | 0.22 | 0.26 | 0.26 | 0.22 | 0.19 | 0.19 | — | — | — |
| 4b (STUTTGART) | Overcast | 0.46 | 0.44 | 0.38 | 0.31 | 0.26 | 0.21 | 0.16 | 0.27 | 0.16 | 0.27 | 0.36 | 0.49 |
| | ≥ 7/8 Cover | 0.61 | 0.57 | 0.51 | 0.43 | 0.39 | 0.34 | 0.31 | 0.38 | 0.27 | 0.38 | 0.52 | 0.63 |
| | ≥ 3/8 Cover | 0.86 | 0.84 | 0.75 | 0.70 | 0.70 | 0.73 | 0.65 | 0.74 | 0.63 | 0.74 | 0.81 | 0.88 |
| | Stratus | — | — | — | — | — | — | — | — | — | 0.22 | — | 0.25 |
| | Alto-Stratus | 0.20 | 0.24 | 0.16 | 0.25 | 0.23 | — | — | 0.23 | — | — | 0.21 | — |
| | Strato-Cumulus | 0.38 | 0.44 | 0.47 | 0.40 | 0.35 | 0.30 | 0.34 | 0.29 | 0.32 | 0.32 | 0.39 | 0.38 |
| | Cumulus | — | — | — | — | — | 0.29 | 0.25 | — | 0.20 | — | — | — |

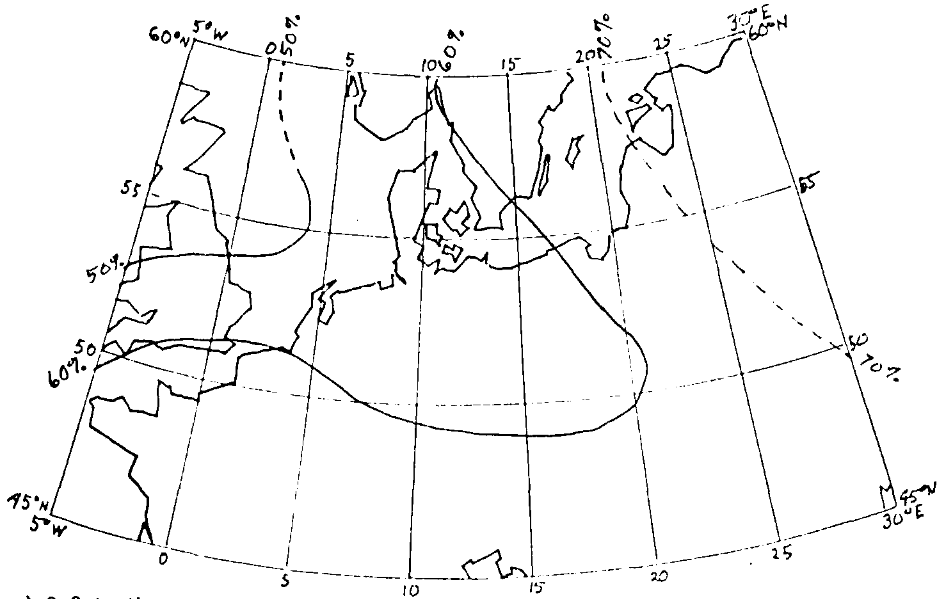



a) 0-3 tenths




b) 6-10 tenths

FIGURE 5-1. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. January, 0 to 5000 ft. AGL (Ref. 13)

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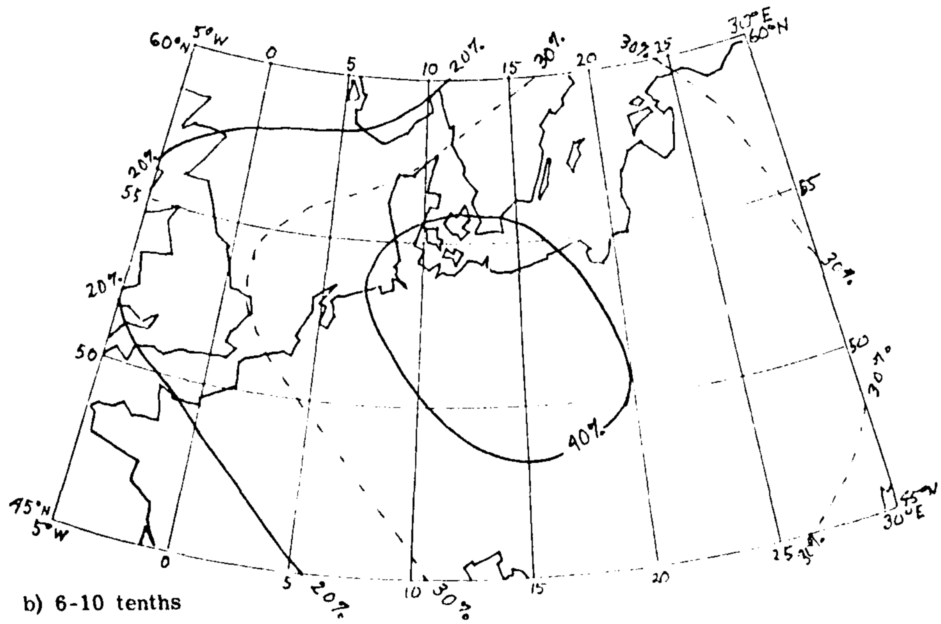
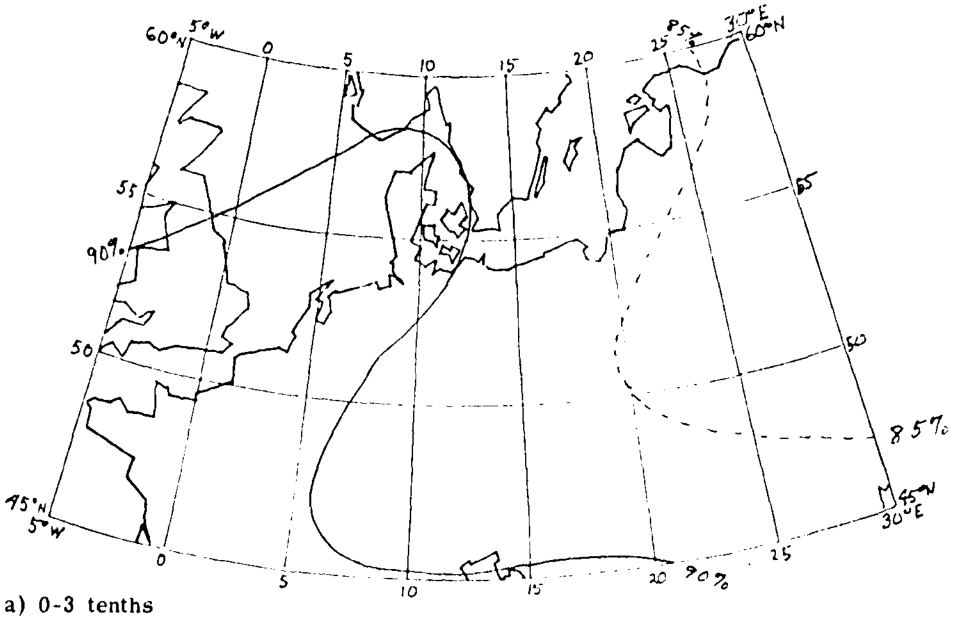



b) 6-10 tenths

FIGURE 5-2. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. January, 5,000 to 10,000 ft. AGL (Ref. 13)

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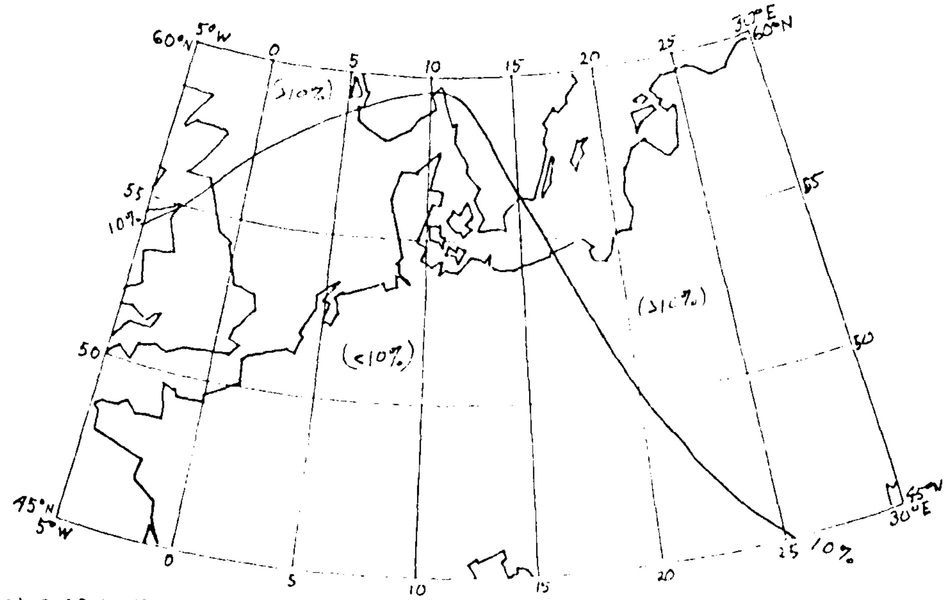
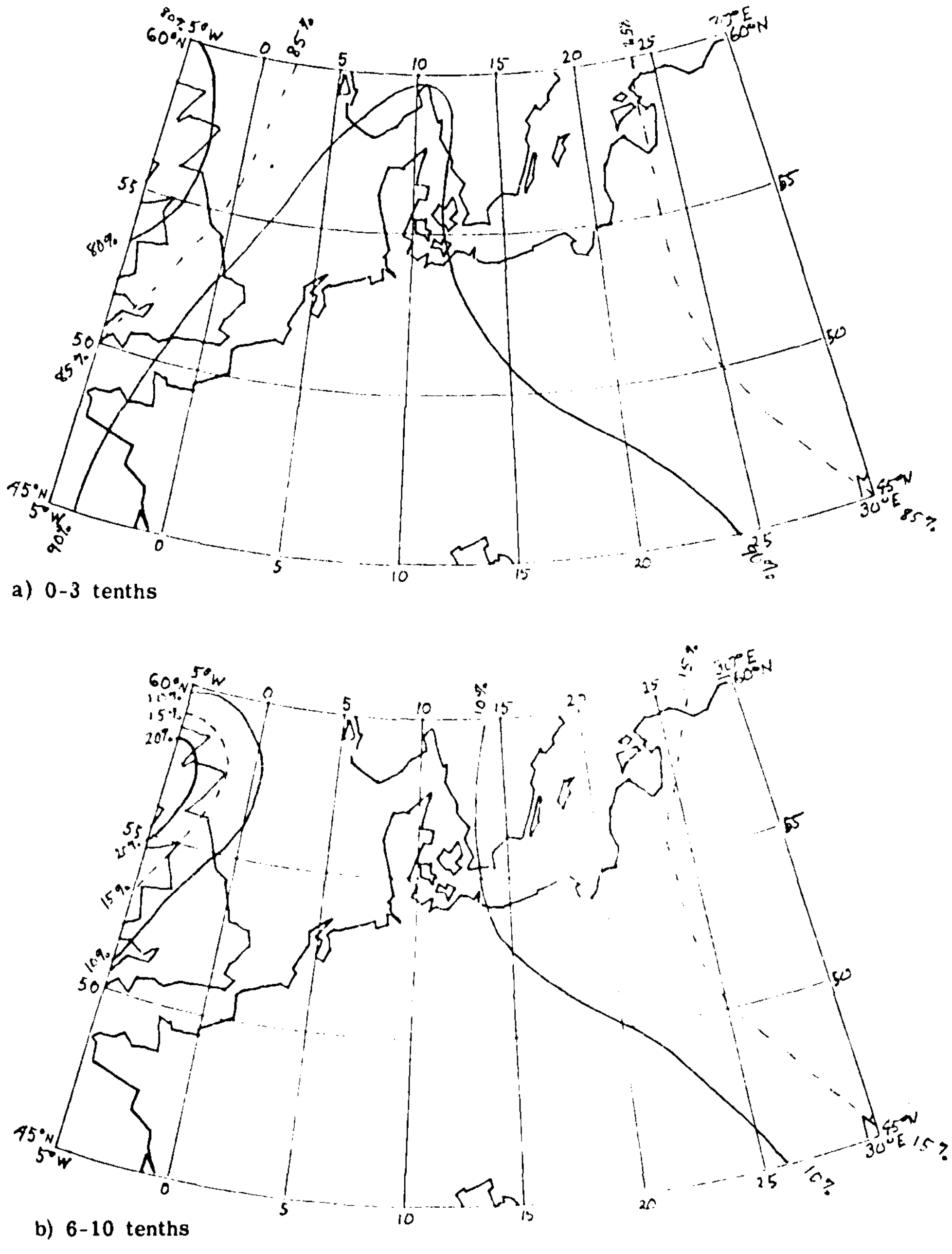



b) 6-10 tenths

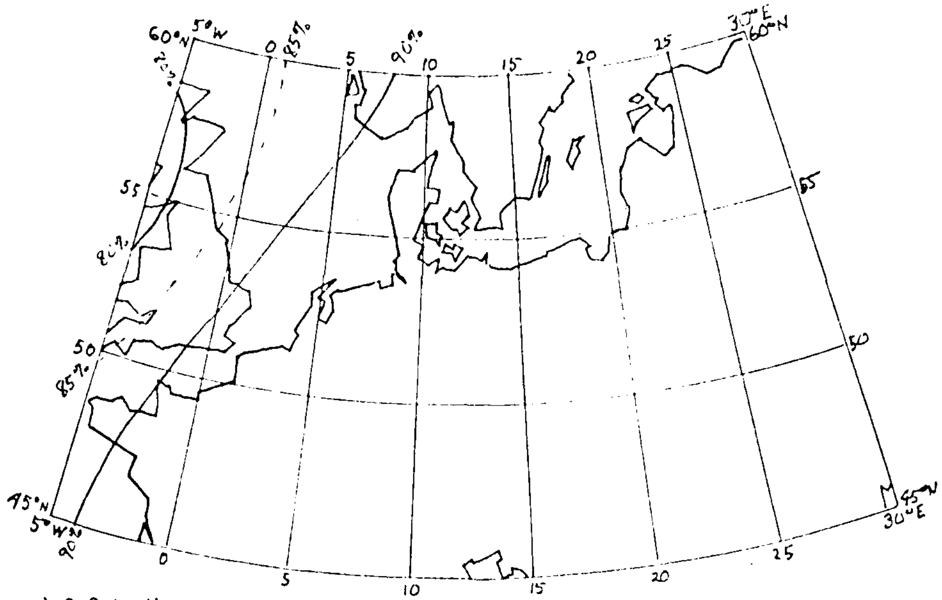
FIGURE 5-3. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. January, 15,000 to 20,000 ft. MSL (Ref. 13)



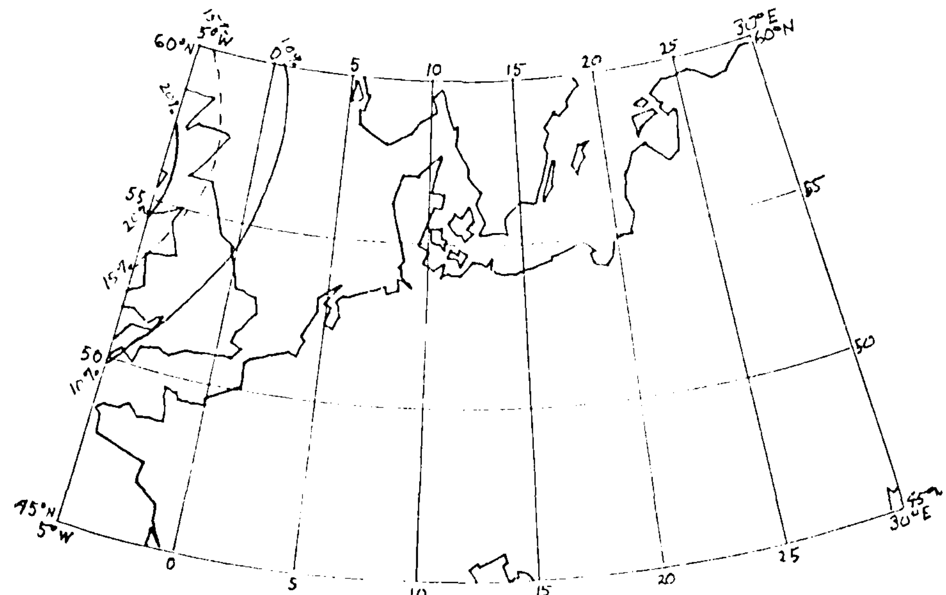
a) 0-3 tenths

b) 6-10 tenths

FIGURE 5-4. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. January, 20,000 to 30,000 ft. MSL (Ref. 13)

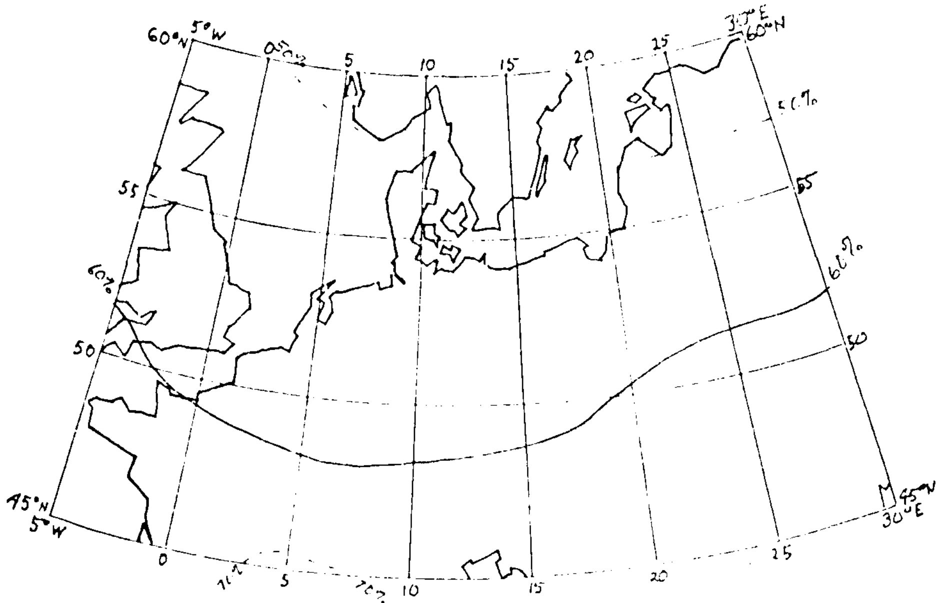



a) 0-3 tenths

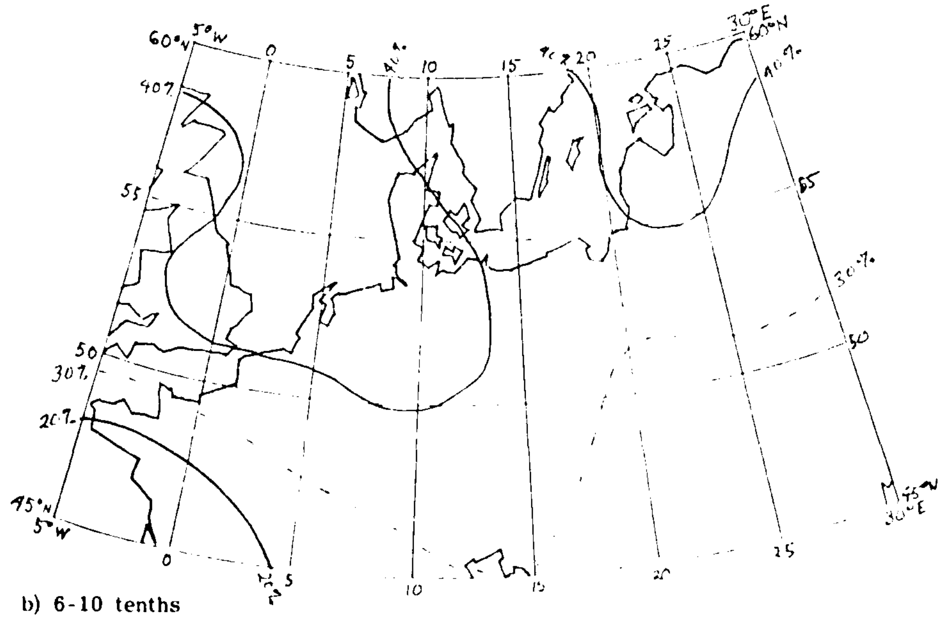



b) 6-10 tenths

FIGURE 5-5. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. January, 30,000 ft. MSL to U.L. (Ref. 13)

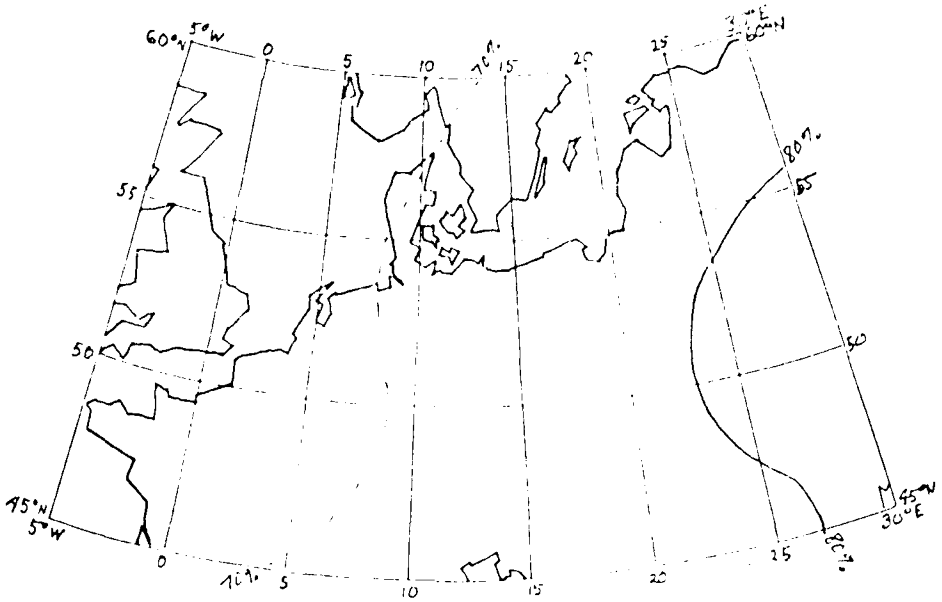



a) 0-3 tenths




b) 6-10 tenths

FIGURE 5-6. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. April, 0 to 5,000 ft. AGL (Ref. 13)

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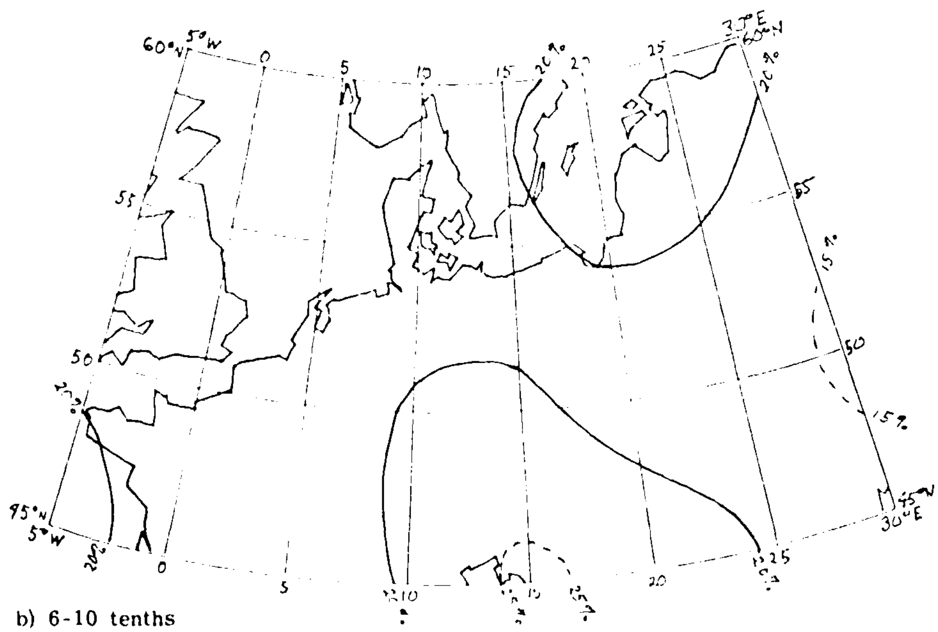
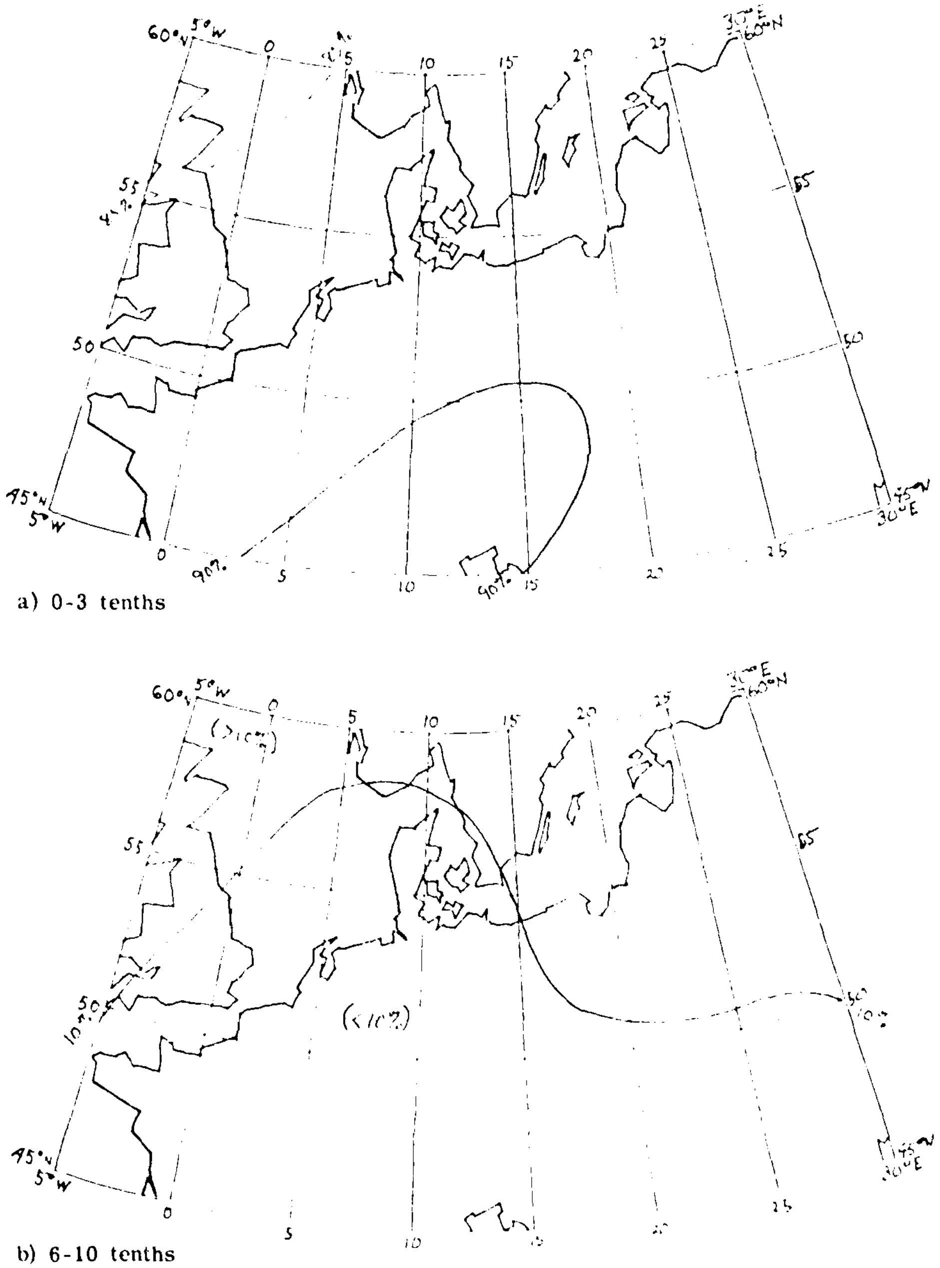



b) 6-10 tenths

FIGURE 5-7. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. April, 5,000 to 10,000 ft. AGL (Ref. 13)




a) 0-3 tenths

b) 6-10 tenths

FIGURE 5-8. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. April, 15,000 to 20,000 ft. MSL (Ref. 13)

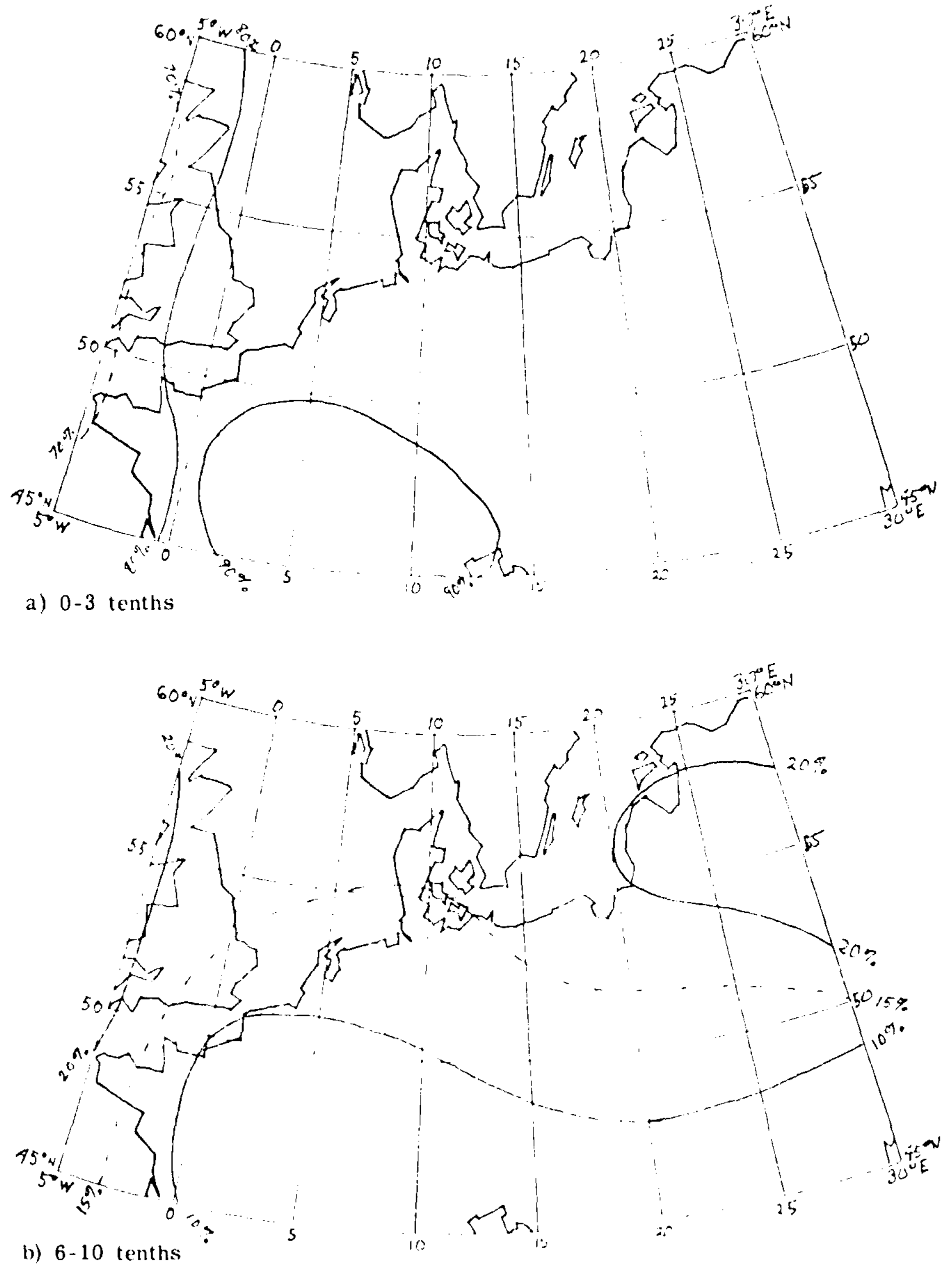
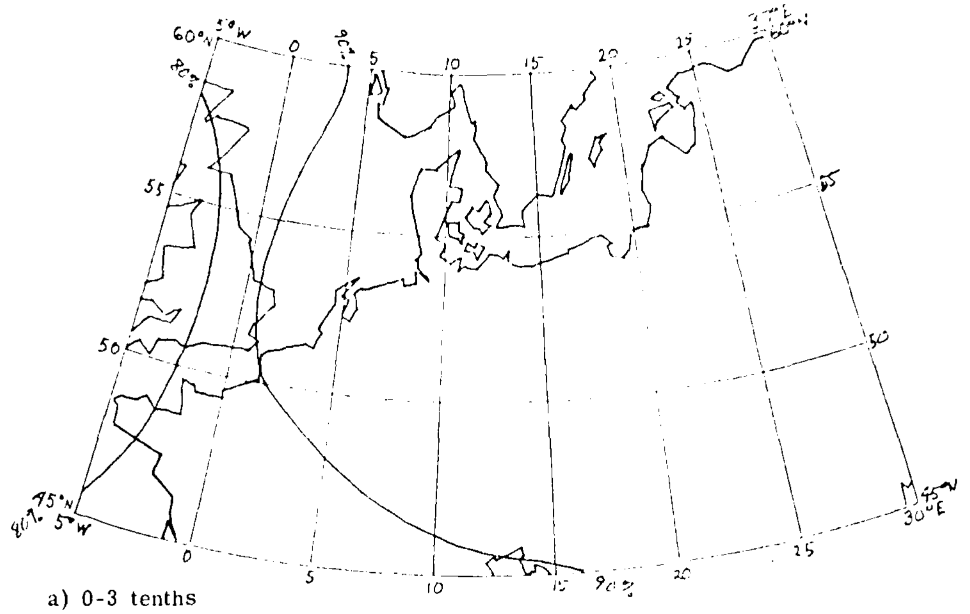
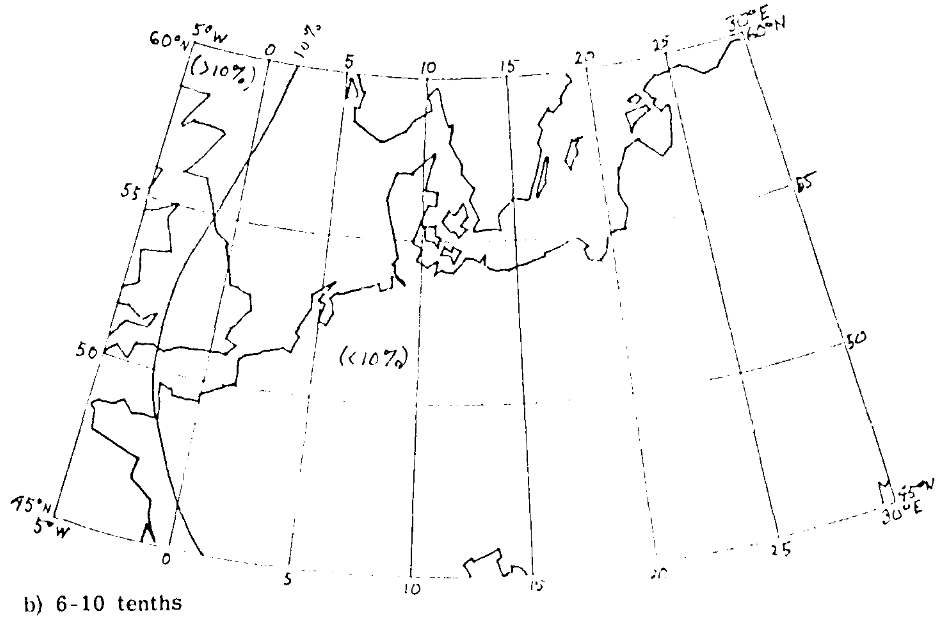



FIGURE 5-9. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. April, 20,000 to 30,000 ft. MSL (Ref. 13)

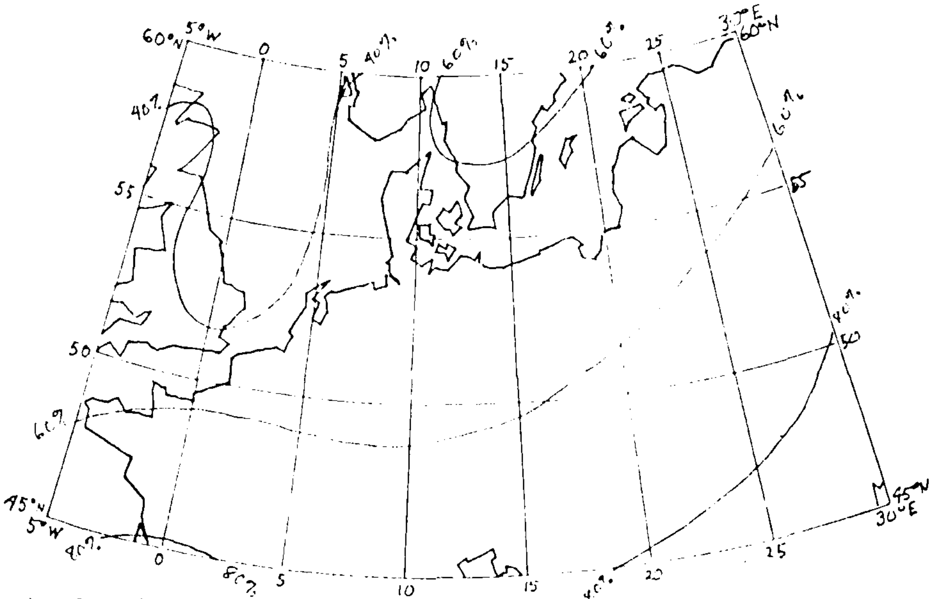



a) 0-3 tenths

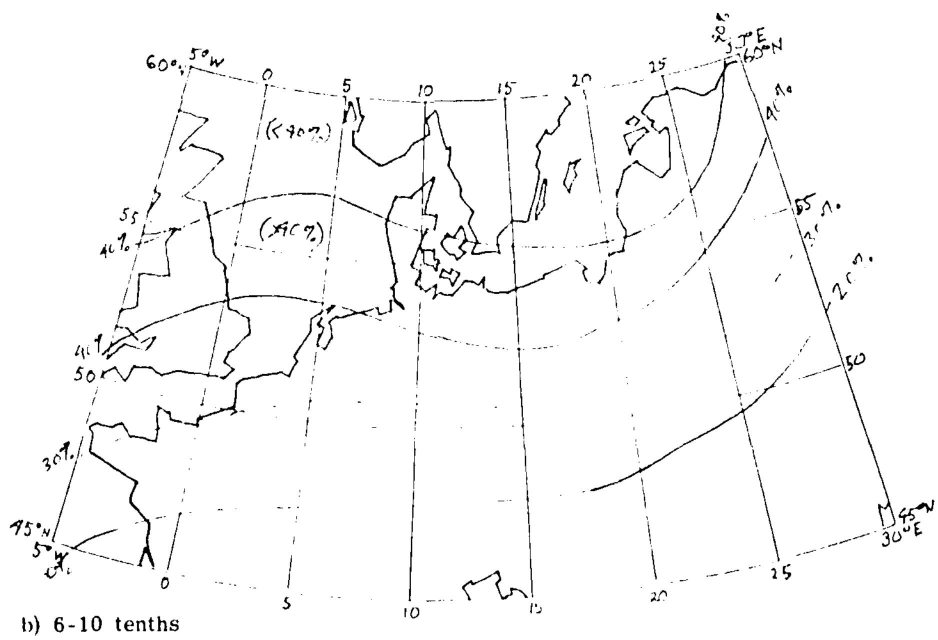



b) 6-10 tenths

FIGURE 5-10. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. April, 30,000 ft. MSL to U.L (Ref. 13)

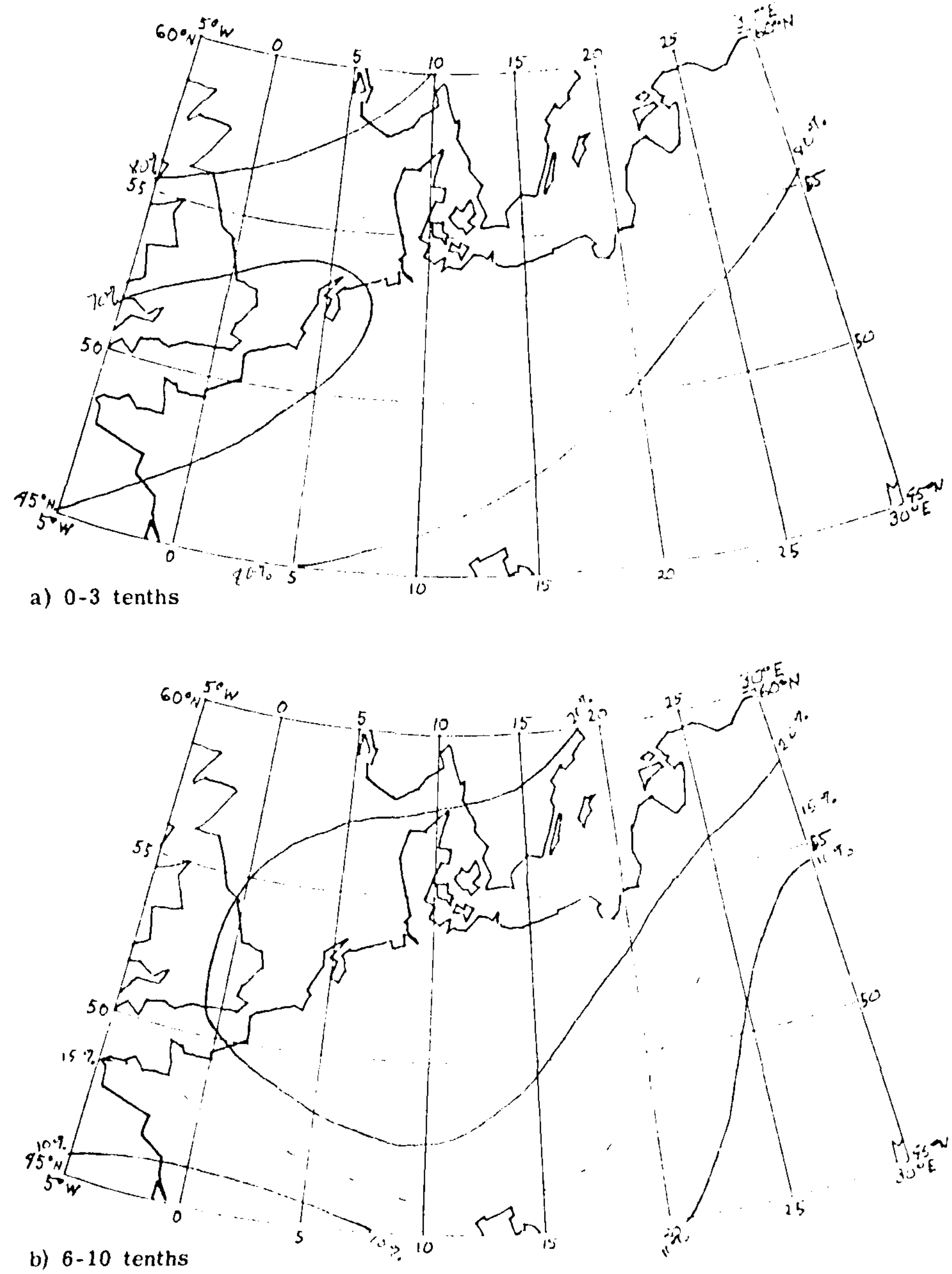



a) 0-3 tenths




b) 6-10 tenths

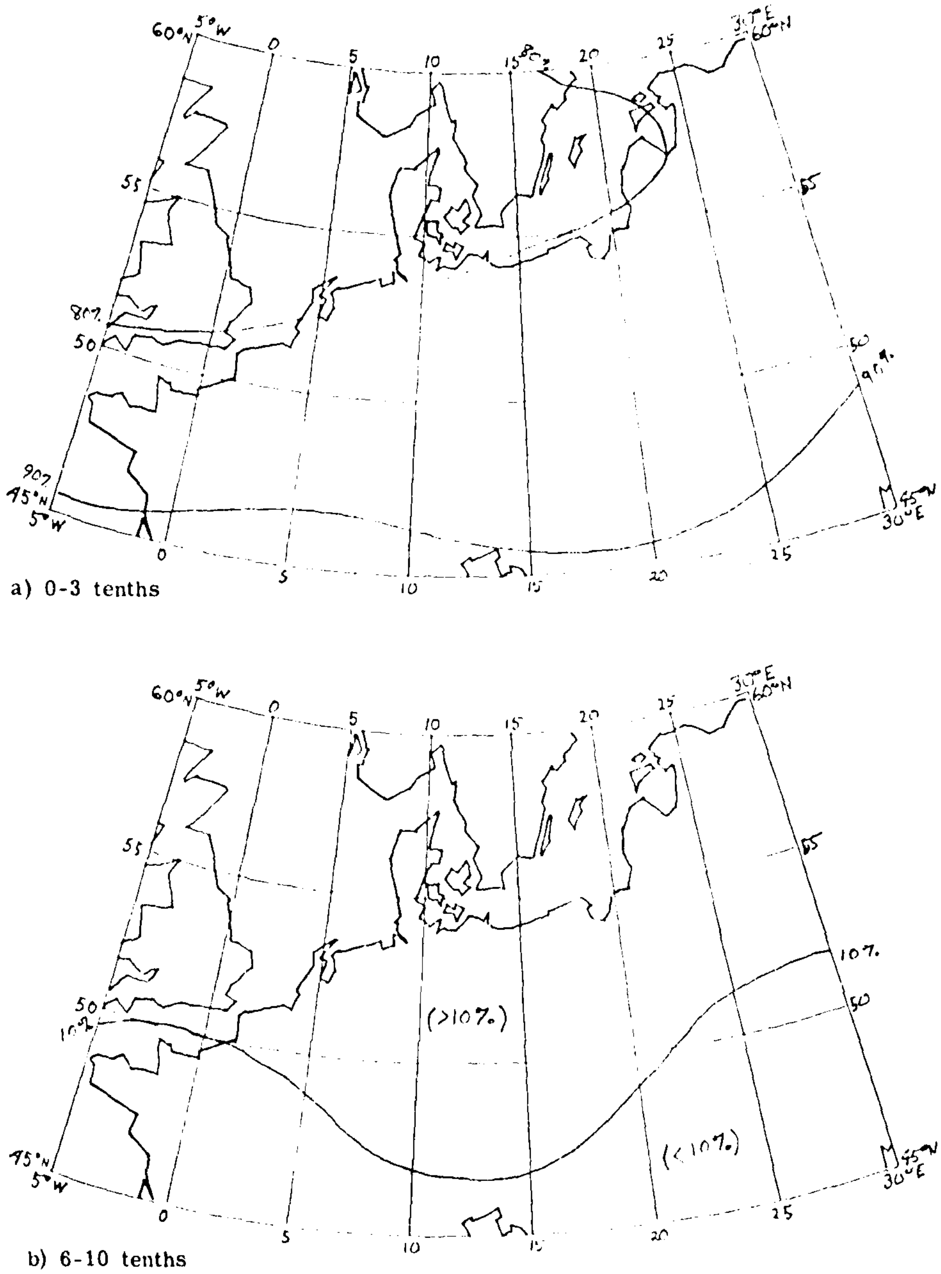
FIGURE 5-11. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. July, 0 to 5,000 ft. AGL (Ref. 13)




a) 0-3 tenths

b) 6-10 tenths

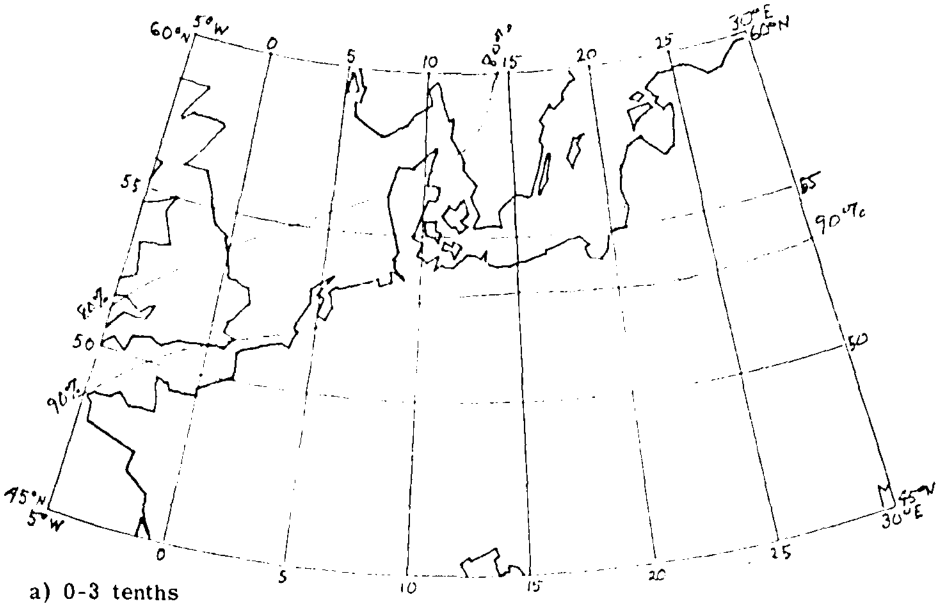
FIGURE 5-12. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. July, 5,000 to 10,000 ft. AGL (Ref. 13)



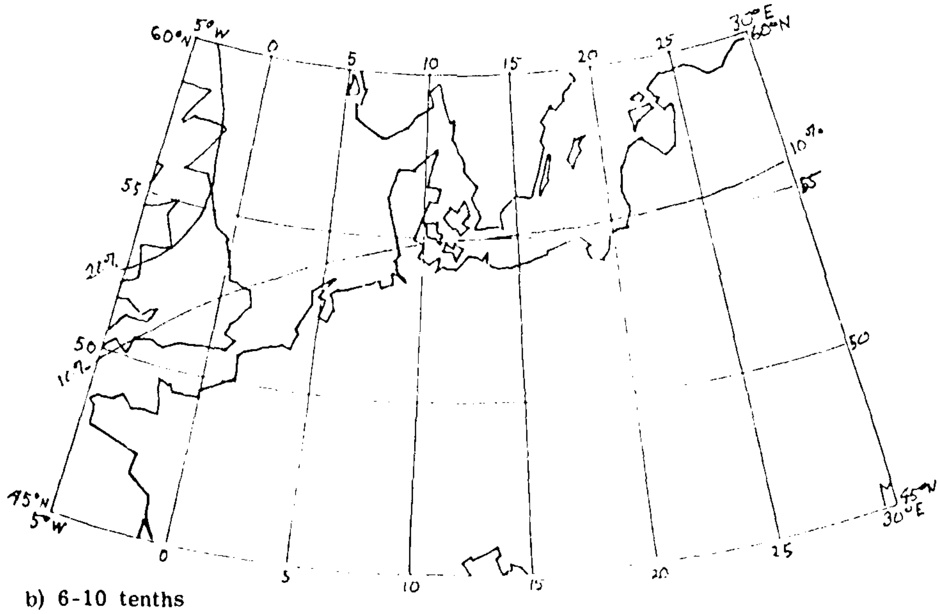

a) 0-3 tenths

b) 6-10 tenths

FIGURE 5-13. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. July 10,000 to 15,000 ft. MSL (Ref. 13)

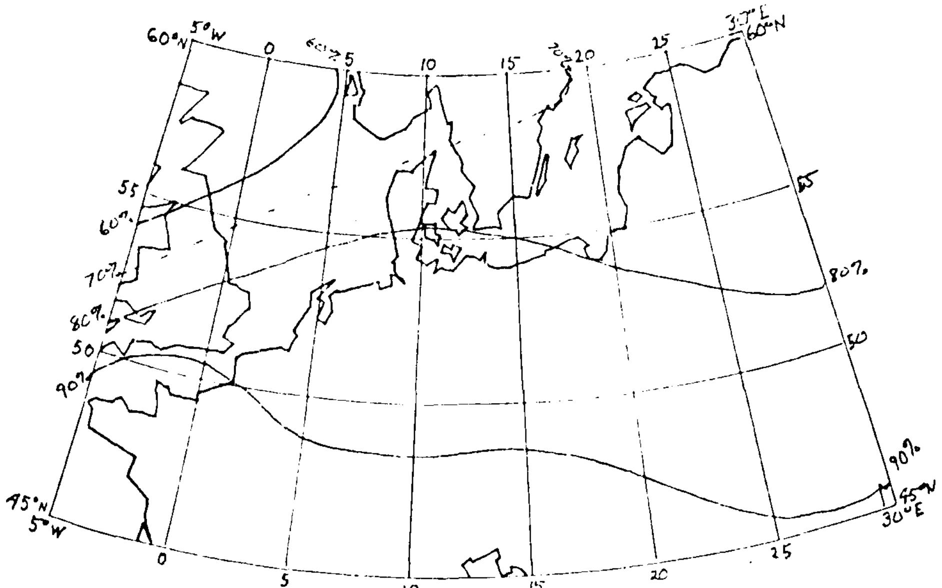



a) 0-3 tenths

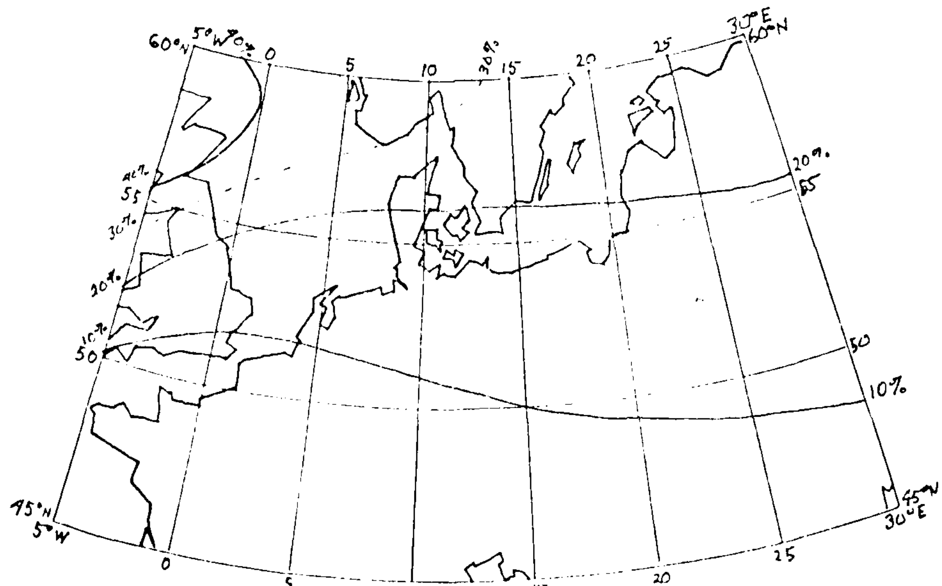



b) 6-10 tenths

FIGURE 5-14. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. July 15,000 to 20,000 ft. MSL (Ref. 13)

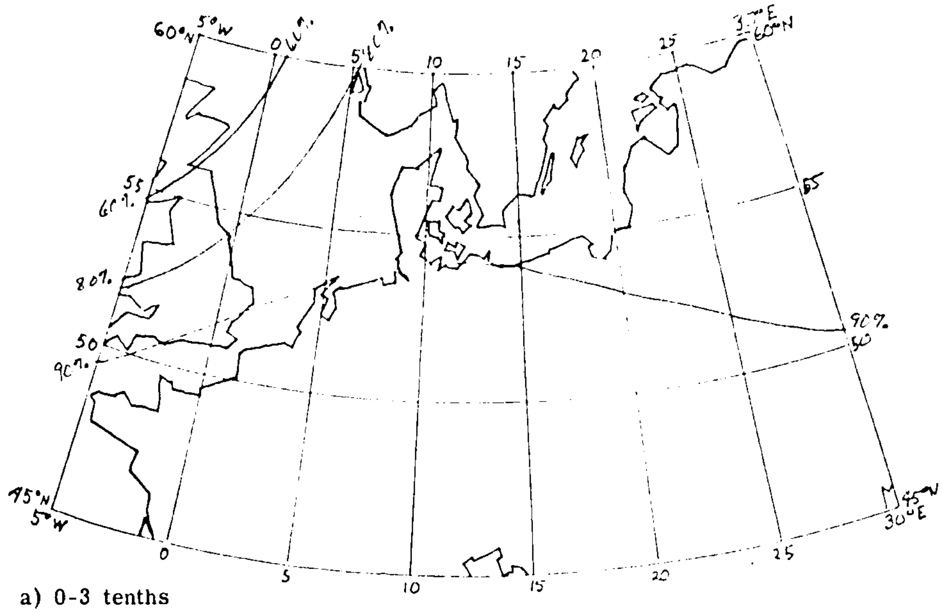


a) 0-3 tenths

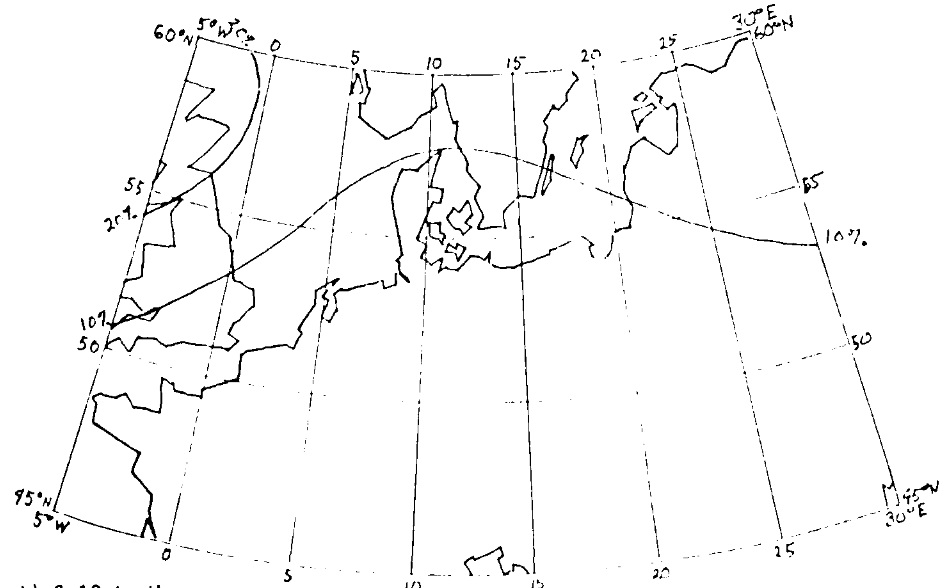


b) 6-10 tenths

FIGURE 5-15. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. July, 20,000 to 30,000 ft. MSL (Ref. 13)

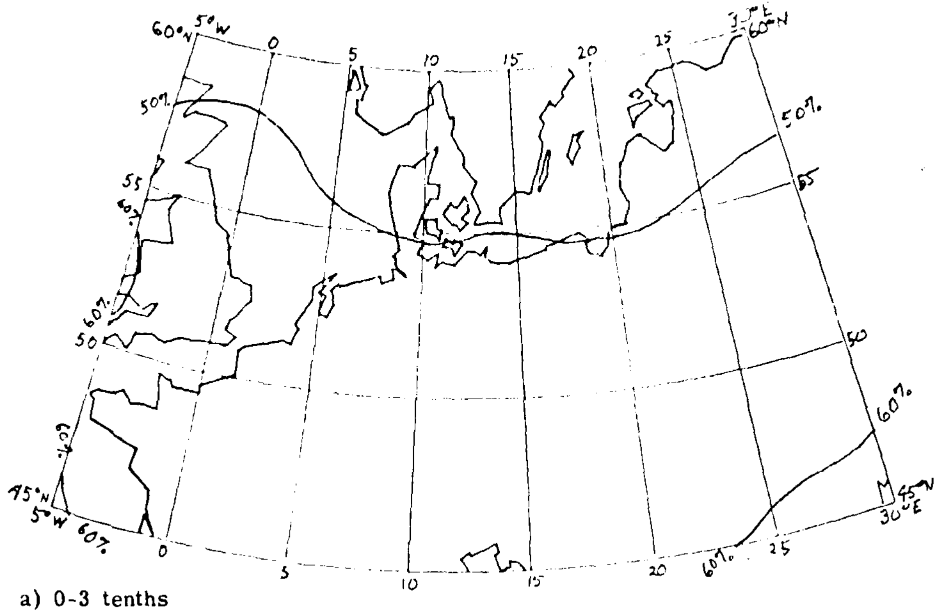



a) 0-3 tenths

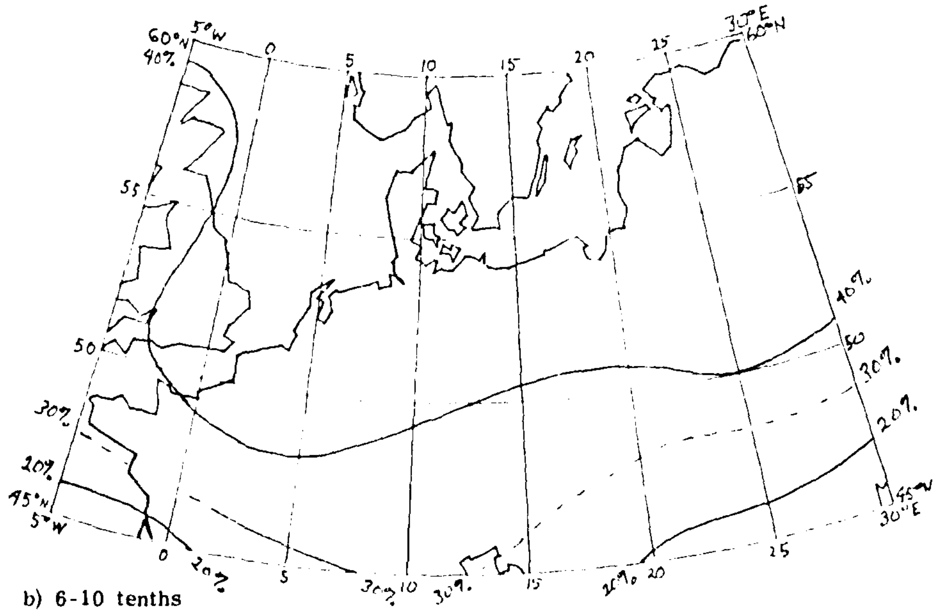



b) 6-10 tenths

FIGURE 5-16. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. July, 30,000 ft. MSL to U.L. (Ref. 13)

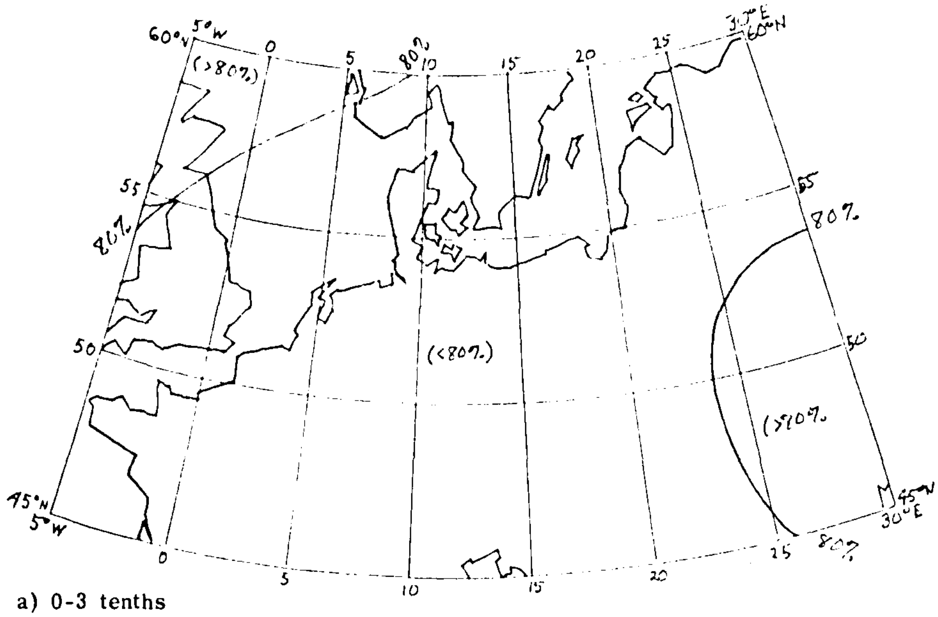



a) 0-3 tenths

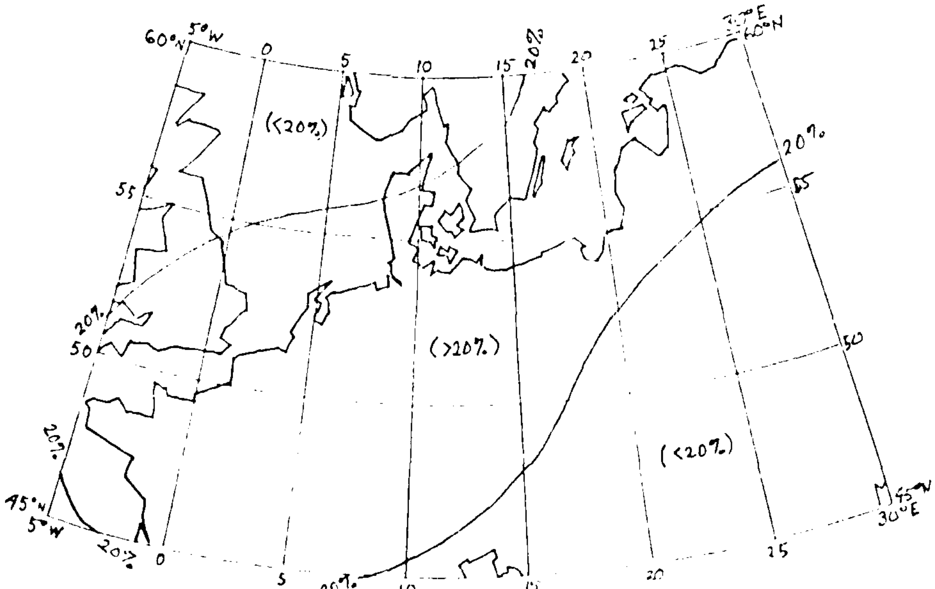



b) 6-10 tenths

FIGURE 5-17. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. October, 0 to 5,000 ft. AGL (Ref. 13)

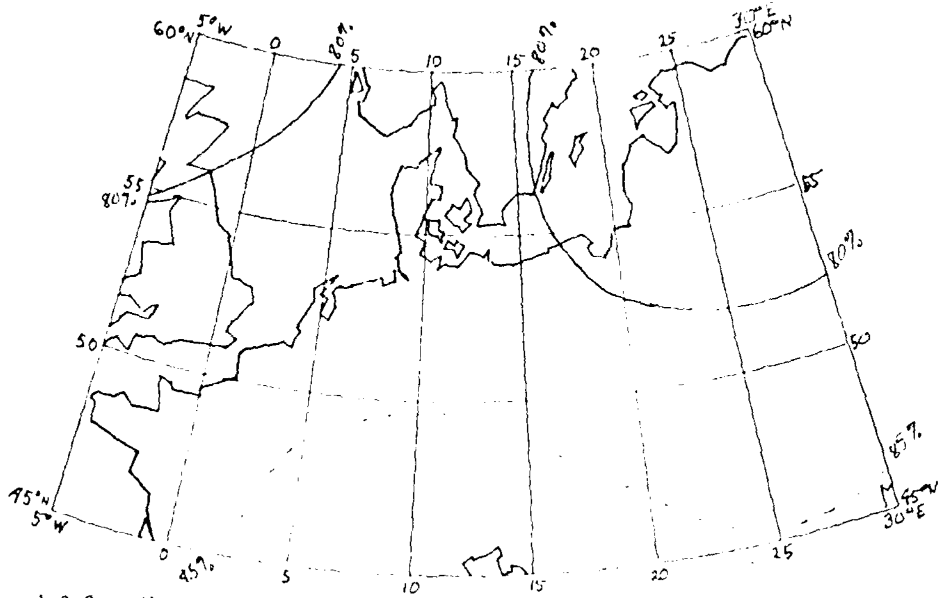



a) 0-3 tenths

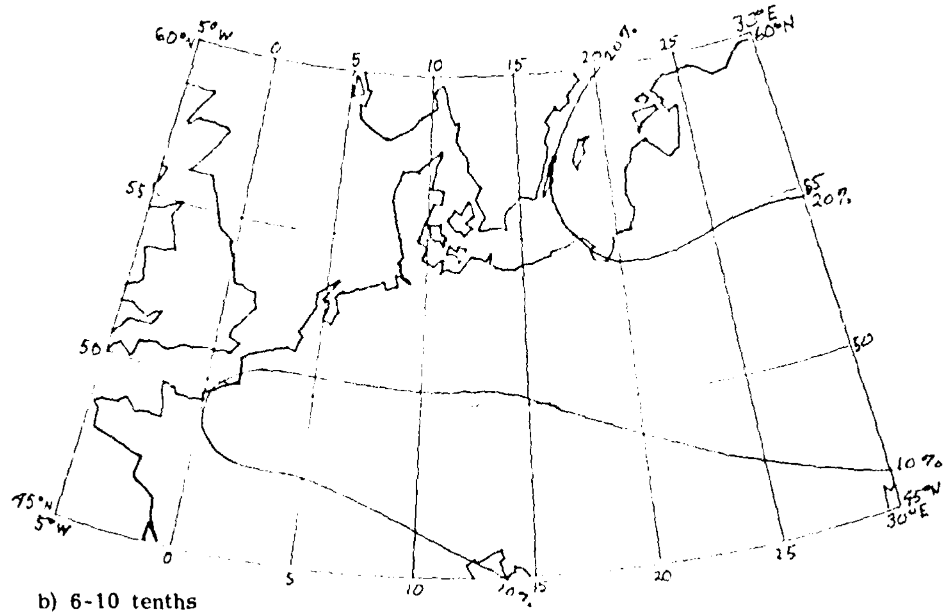



b) 6-10 tenths

FIGURE 5-18. **EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND.** October, 5,000 to 10,000 ft. AGL (Ref. 13)

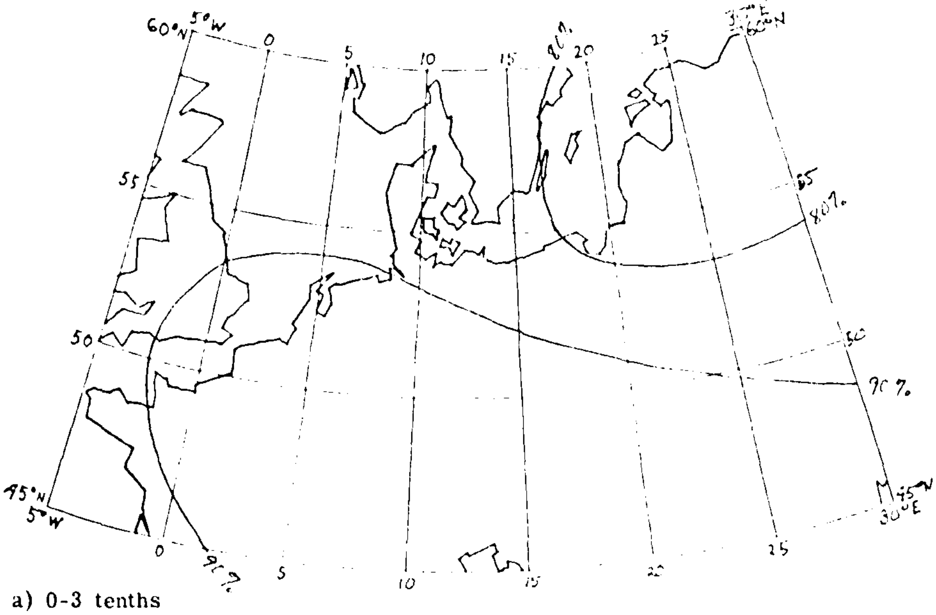



a) 0-3 tenths

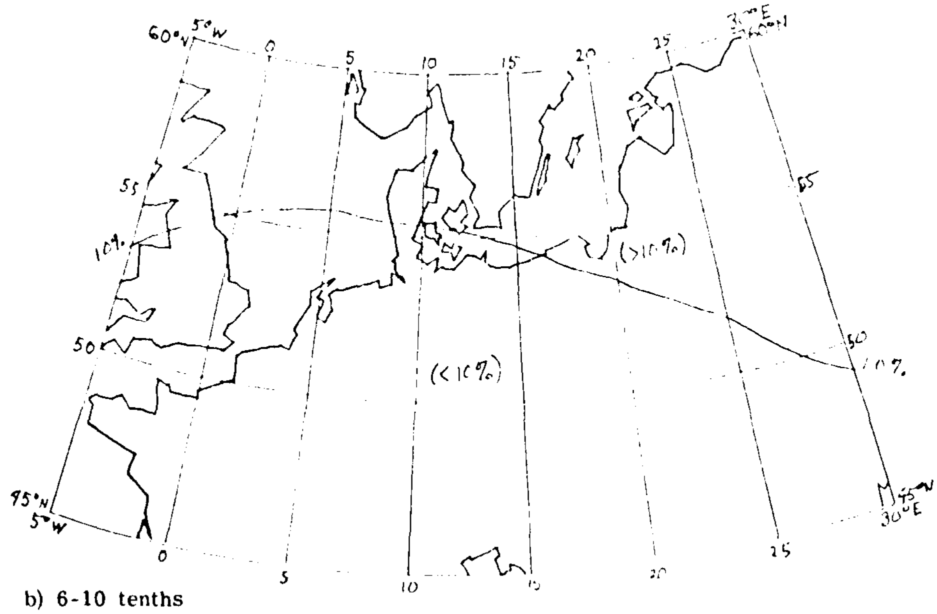



b) 6-10 tenths

FIGURE 5-19. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. October, 10,000 to 15,000 ft. MSL (Ref. 13)

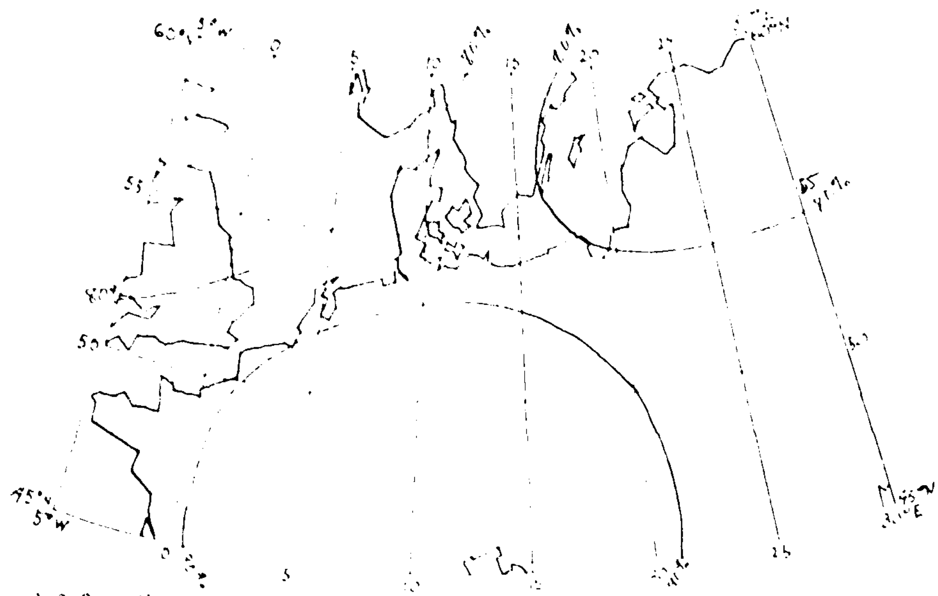



a) 0-3 tenths

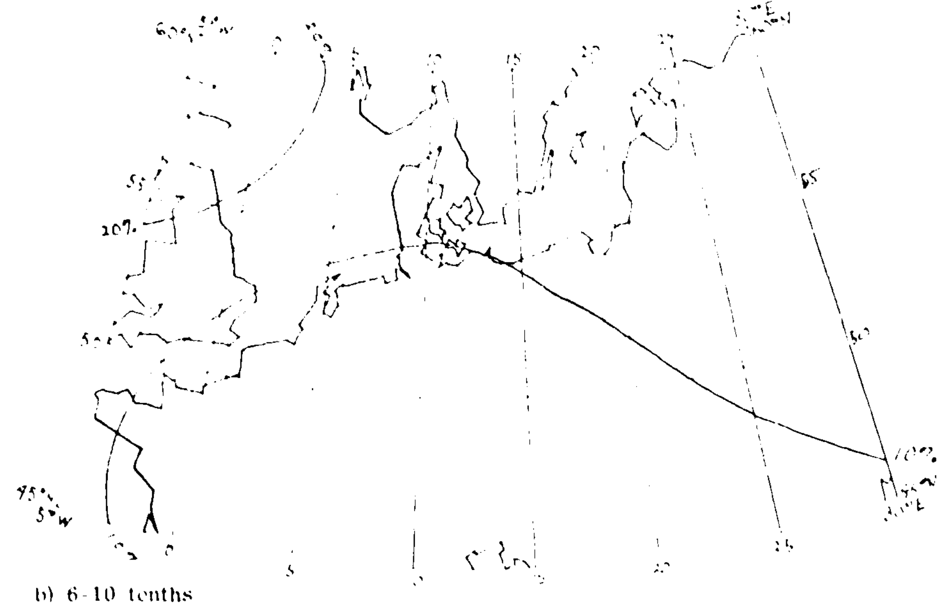



b) 6-10 tenths

FIGURE 5-20. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. October, 15,000 to 20,000 ft. MSL (Ref. 13)

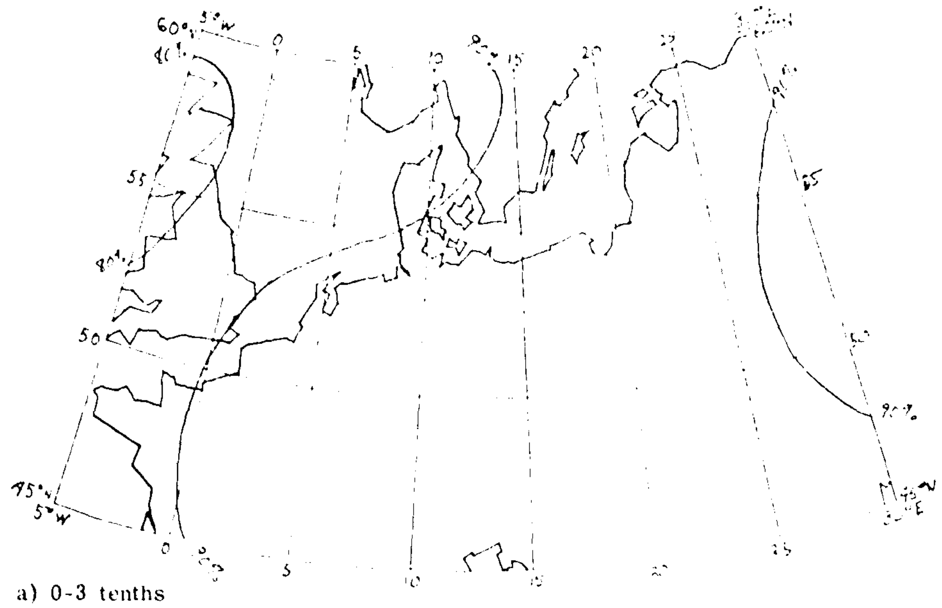


a) 0-3 tenths

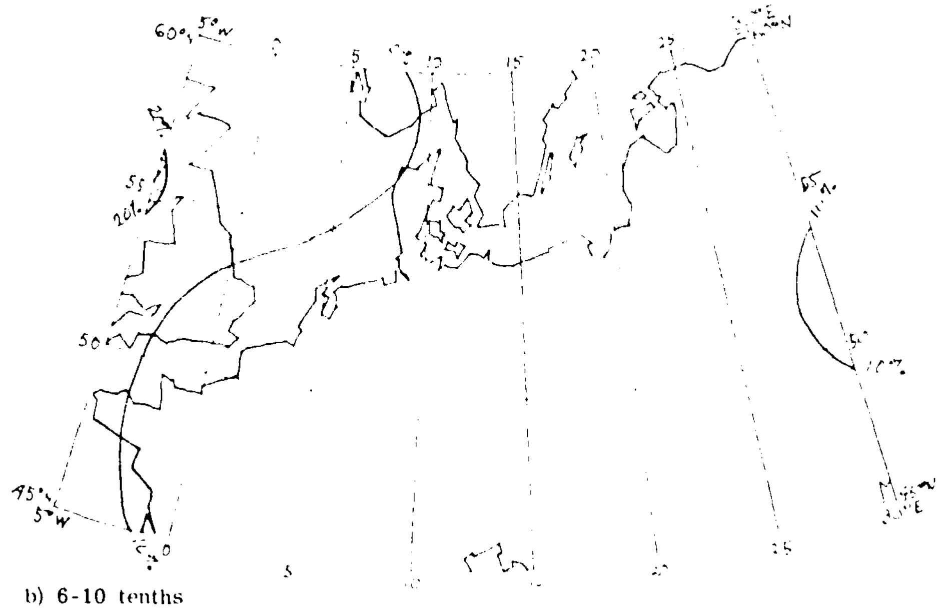


b) 6-10 tenths

FIGURE 5-21 EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. October, 20,000 to 30,000 ft. MSL (Ref. 13)



a) 0-3 tenths



b) 6-10 tenths

FIGURE 5-22. EXPECTED FREQUENCY (%) FOR A GIVEN SKY COVER IN A SPECIFIED ALTITUDE BAND. October, 30,000 ft MSL TO U.L. (Ref 13)

TABLE 5-3. PROBABILITY OF 4/10 OR MORE SKY COVER IN ALTITUDE BANDS 10°E 50°N (Ref. 13)

| Altitude Band | Jan | Apr | Jul | Oct |
|---|---|---|---|---|
| 0 AGL to 5,000 ft AGL | 61% | 42% | 44% | 46% |
| 5,000 ft AGL to 10,000 ft AGL | 41 | 29 | 27 | 25 |
| 10,000 ft AGL to 15,000 ft MSL | 14 | 14 | 16 | 15 |
| 15,000 ft MSL to 20,000 ft MSL | 11 | 10 | 5 | 8 |
| 20,000 ft MSL to 30,000 ft MSL | 8 | 11 | 13 | 8 |
| 30,000 ft MSL to UL | 5 | 5 | 5 | 5 |

TABLE 5-4. CLOUDINESS [DAYS/MO] & FREQUENCY OF CLOUDINESS AT INDICATED ALTITUDES [%] (Ref. 8)

| Zone | Station | Parameter | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6a | Berlin | Cloudy (≥0.6) Days | 22 | 19 | 18 | 18 | 17 | 17 | 18 | 19 | 16L | 21 | 22 | 24H | 231 | 19 |
| | | Clear (<0.6) Days | 7 | 7 | 11H | 9 | 10 | 9 | 8 | 8 | 10 | 7 | 6 | 5L | 97 | 8 |
| | * | Cloudy @ 1500' [%] | 36 | 34 | 58 | 77 | 89H | 86 | 87 | 85 | 78 | 52 | 31 | 28L | — | 62% |
| | * | Cloudy @ 5000' [%] | 17 | 19 | 40 | 56 | 66 | 67 | 67 | 68H | 62 | 34 | 17 | 15L | — | 44% |
| 5a | Hamburg | Cloudy (≥0.6) Days | 22 | 20 | 20 | 17 | 17 | 18 | 20 | 18 | 16L | 18 | 22 | 23H | 231 | 19 |
| | | Clear (<0.6) Days | 5 | 5 | 7 | 8 | 8 | 7 | 5 | 6 | 7 | 9H | 4L | 4 | 75 | 6 |
| | | Cloudy @ 1500' [%] | 68 | 70 | 55 | 49 | 30 | 26L | 30 | 34 | 41 | 57 | 77H | 74 | — | 51% |
| | * | Cloudy @ 5000' [%] | 49 | 50 | 67 | 77 | 80 | 77 | 79 | 89H | 82 | 77 | 52 | 48L | — | 69% |
| 5a | Hannover | Cloudy (≥0.6) Days | 24 | 21 | 19 | 14L | 18 | 18 | 19 | 18 | 19 | 19 | 24 | 26H | 239 | 20 |
| | | Clear (<0.6) Days | 4 | 5 | 9H | 9 | 8 | 7 | 6 | 7 | 7 | 8 | 4 | 3L | 77 | 6 |
| | | Cloudy @ 1500' [%] | 42H | 36 | 27 | 14 | 14 | 12 | 13 | 10L | 12 | 20 | 38 | 36 | — | 23% |
| | | Cloudy @ 5000' [%] | 63H | 53 | 41 | 36 | 32 | 29 | 29 | 20L | 28 | 26 | 52 | 55 | — | 39% |
| 4b | Frankfurt A.M. | Cloudy (≥0.6) Days | 24H | 20 | 17 | 18 | 17 | 17 | 16L | 17 | 18 | 18 | 24H | 24 | 230 | 19 |
| | | Clear (<0.6) Days | 5 | 6 | 10H | 8 | 8 | 7 | 8 | 7 | 8 | 9 | 3L | 4 | 89 | 7 |
| | * | Cloudy @ 1500' [%] | 40 | 40 | 22 | 7 | 5L | 7 | 6 | 9 | 18 | 35 | 43 | 50H | — | 24% |

* Suspect Data

TABLE 5-5. CLOUDINESS (DAYS/MO) & FREQUENCY OF CLOUDINESS AT INDICATED ALTITUDES (%). (Ref. 8)

| Zone | Station | Parameter | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6a | Berlin | Cloudy (≥0.6) Days | 22 | 19 | 18 | 18 | 17 | 17 | 18 | 19 | 16L | 21 | 22 | 24H | 231 | 19 |
| | | Clear (<0.6) Days | 7 | 7 | 11H | 9 | 10 | 9 | 8 | 8 | 10 | 7 | 6 | 5L | 97 | 8 |
| | | Cloudy @ 1500' (%) | 64 | 66 | 42 | 23 | 11L | 14 | 13 | 15 | 22 | 48 | 69 | 72H | — | 38% |
| | | Cloudy @ 5000' (%) | 83 | 81 | 60 | 44 | 34 | 33 | 33 | 32L | 38 | 66 | 83 | 85H | — | 56% |
| 5a | Hamburg | Cloudy (≥0.6) Days | 22 | 20 | 20 | 17 | 17 | 18 | 20 | 18 | 16L | 18 | 22 | 23H | 231 | 19 |
| | | Clear (<0.6) Days | 5 | 5 | 7 | 8 | 8 | 7 | 5 | 6 | 7 | 9H | 4L | 4 | 75 | 6 |
| | | Cloudy @ 1500' (%) | 68 | 70 | 55 | 49 | 30 | 26L | 30 | 34 | 41 | 57 | 77H | 74 | — | 51% |
| | | Cloudy @ 5000' (%) | 51 | 50 | 33 | 23 | 20 | 23 | 21 | 11L | 18 | 23 | 48 | 52H | — | 31% |
| 5a | Hanover | Cloudy (≥0.6) Days | 24 | 21 | 19 | 14L | 18 | 18 | 19 | 18 | 19 | 19 | 24 | 26H | 239 | 20 |
| | | Clear (<0.6) Days | 4 | 5 | 9H | 9 | 8 | 7 | 6 | 7 | 7 | 8 | 4 | 3L | 77 | 6 |
| | | Cloudy @ 1500' (%) | 42H | 36 | 27 | 14 | 14 | 12 | 13 | 10L | 12 | 20 | 38 | 36 | — | 23% |
| | | Cloudy @ 5000' (%) | 63H | 53 | 41 | 36 | 32 | 29 | 29 | 20L | 28 | 26 | 52 | 55 | — | 39% |
| 4b | Frankfurt A.M. | Cloudy (≥0.6) Days | 24H | 20 | 17 | 18 | 17 | 17 | 16L | 17 | 18 | 18 | 24H | 24 | 230 | 19 |
| | | Clear (<0.6) Days | 5 | 6 | 10H | 8 | 8 | 7 | 8 | 7 | 8 | 9 | 3L | 4 | 89 | 7 |
| | | Cloudy @ 1500' (%) | 40 | 40 | 22 | 7 | 5L | 7 | 6 | 9 | 18 | 35 | 43 | 50H | — | 24% |
| | | Cloudy @ 5000' (%) | 62 | 53 | 36 | 31 | 25 | 24 | 24 | 22L | 26 | 30 | 60 | 67H | — | 39% |

TABLE 5-6. FREQUENCY OF CEILINGS BELOW THE GIVEN LEVEL. ZONES 5a (DUSSELDORF) & 7c (BAYREUTH). (Ref. 11)

| Zone | Ceiling | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Ann. Avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5a | 2000 | .38 | .29 | .24 | .13 | .12 | .10 | .12 | .10 | .13 | .13 | .27 | .41 | .20 |
| | 1000 | .24 | .15 | .13 | .05 | .05 | .05 | .07 | .05 | .08 | .08 | .11 | .19 | .10 |
| | 700 | .12 | .08 | .09 | .03 | .03 | .04 | .05 | .03 | .05 | .06 | .09 | .11 | .07 |
| | 400 | .06 | .02 | .05 | .01 | .01 | .01 | .01 | .01 | .02 | .02 | .02 | .08 | .03 |
| 7c | 2000 | .60 | .54 | .30 | .28 | .21 | .20 | .12 | .11 | .26 | .27 | .56 | .67 | .34 |
| | 1000 | .30 | .26 | .21 | .15 | .09 | .08 | .07 | .06 | .10 | .19 | .24 | .40 | .18 |
| | 700 | .19 | .14 | .10 | .07 | .03 | .02 | .02 | .02 | .05 | .05 | .04 | .06 | .07 |
| | 400 | .03 | .03 | .03 | .02 | .01 | .01 | .01 | .01 | .01 | .02 | .02 | .03 | .02 |

TABLE 5-7. FREQUENCY [%] OF CEILINGS AT OR BELOW 2000 FT. (Ref. 11)

| Zone | Station | J | F | M | A | M | J | J | A | S | O | N | D | AVG. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4b | Freiburg I.B. | 33 | 21 | 11 | 12 | 10 | 8 | 5 | 7 | 11 | 18 | 26 | 32 | 16 |
| | Wiesbaden | 31 | 40 | 10 | 5 | 3 | 5 | 5 | 6 | 8 | 14 | 28 | 40 | 16 |
| 5a | Dusseldorf | 38 | 29 | 29 | 13 | 12 | 10 | 12 | 10 | 13 | 13 | 27 | 41 | 20 |
| | Hamburg | 46 | 46 | 30 | 17 | 16 | 14 | 17 | 8 | 13 | 17 | 47 | 46 | 26 |
| 6a | Berlin | 36 | 30 | 22 | 15 | 10 | 12 | 9 | 8 | 10 | 19 | 40 | 41 | 21 |
| 7c | Bayreuth | 60 | 54 | 30 | 28 | 21 | 20 | 12 | 11 | 26 | 27 | 56 | 67 | 34 |
| 9c | München | 36 | 29 | 15 | 16 | 11 | 7 | 6 | 7 | 9 | 18 | 30 | 40 | 19 |
| 9d | Bitburg | 51 | 44 | 20 | 15 | 10 | 16 | 16 | 18 | 21 | 36 | 45 | 59 | 29 |

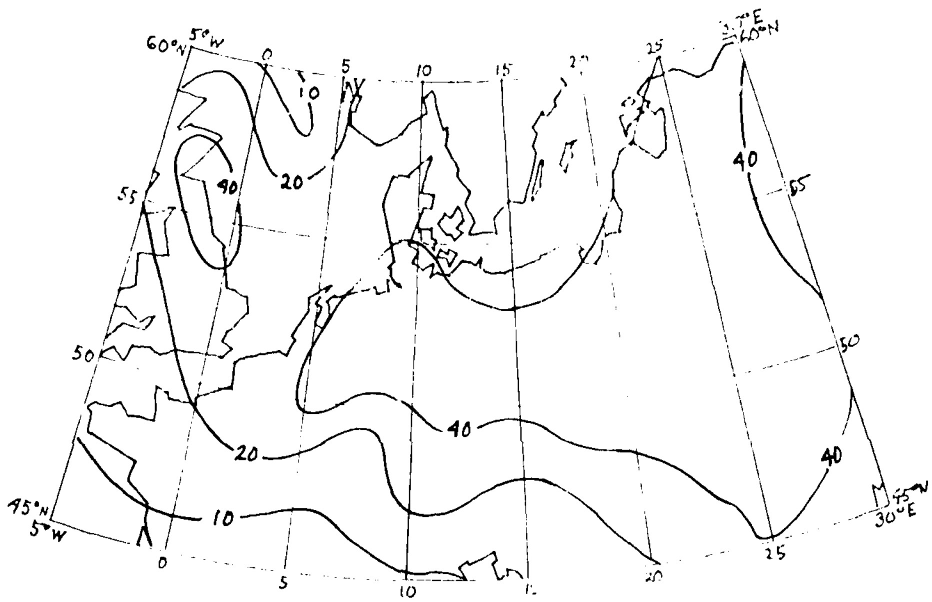


FIGURE 5-23. AVERAGE ANNUAL DAYS OF FOG (Ref. 1)

TABLE 5-8. FOG INCIDENCE,BRD (Ref. 14)

| Season | Probability of a Foggy Day | Fog Duration [Hours] |
|---|---|---|
| Spring | 0.12 | 3.6 |
| Summer | 0.04 | 3.2 |
| Fall | 0.33 | 5.0 |
| Winter | 0.37 | 6.0 |

TABLE 5-9. FOG CHARACTERISTICS ZONE 5a (Ref. 12 and 14)

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequency of days in which fog obscures the sky | .07 | .06 | .04 | .02 | .02 | .04 | .04 | .08 | .07 | .12 | .11 | .11 |
| Hour of Max. Frequency | 2400 | --- | --- | 0600 | --- | --- | 0600 | --- | --- | 0600 | --- | --- |
| Hour of Min. Frequency | 1500 | --- | --- | 1500 | --- | --- | 1500 | --- | --- | 1500 | --- | --- |
| Frequency of Fog-Day* | .37 | .36 | .20 | .10 | .06 | .06 | .04 | .07 | .11 | .26 | .48 | .55 |
| Frequency of Fog-Night* | .31 | .35 | .21 | .10 | .07 | .05 | .04 | .08 | .13 | .22 | .47 | .49 |
| Frequency of Ground Fog-Day | .03 | .02 | .02 | .01 | .01 | .01 | .01 | .01 | .01 | .02 | .02 | .03 |
| Frequency of Ground Fog-Night | .10 | .08 | .05 | .03 | .02 | .01 | .01 | .02 | .06 | .08 | .06 | .07 |

TABLE 5-10. FREQUENCY (%) OF FOGS AND HAZE BY MONTH (Ref. 11)

| | | Zone | Station | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FOG | DAY | 3 | Heidelberg | 12 | 12 | 5 | 3 | 2 | 1 | 1 | 2 | 4 | 8 | 12 | 13 |
| | | 6a | Berlin | 37 | 36 | 21 | 11 | 6 | 6 | 4 | 7 | 11 | 27 | 48 | 65 |
| | | 9b | Kitzingen | 8 | 7 | 5 | 2 | 1 | 2 | 2 | 3 | 6 | 13 | 10 | 11 |
| | | 9d | Spangdahlem | 15 | 14 | 6 | 4 | 4 | 3 | 3 | 4 | 7 | 16 | 19 | 22 |
| | NIGHT | 3 | Heidelberg | 12 | 11 | 4 | 2 | 1 | 1 | 1 | 3 | 5 | 11 | 15 | 13 |
| | | 6a | Berlin | 31 | 35 | 20 | 10 | 7 | 5 | 4 | 8 | 13 | 22 | 47 | 48 |
| | | 9b | Kitzingen | 7 | 7 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 8 | 13 | 11 |
| | | 9d | Spangdahlem | 15 | 12 | 5 | 4 | 3 | 2 | 3 | 5 | 9 | 15 | 19 | 21 |
| GROUND FOG | DAY | 3 | Heidelberg | 18 | 15 | 11 | 8 | 7 | 6 | 5 | 6 | 9 | 13 | 19 | 18 |
| | | 6a | Berlin | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| | | 9b | Kitzingen | 25 | 18 | 15 | 13 | 11 | 10 | 9 | 10 | 13 | 19 | 24 | 20 |
| | | 9d | Spangdahlem | 16 | 13 | 12 | 11 | 9 | 9 | 9 | 10 | 14 | 17 | 20 | 18 |
| | NIGHT | 3 | Heidelberg | 8 | 17 | 15 | 10 | 9 | 9 | 8 | 9 | 15 | 19 | 20 | 18 |
| | | 6a | Berlin | 10 | 7 | 4 | 2 | 2 | 1 | 1 | 2 | 5 | 8 | 5 | 6 |
| | | 9b | Kitzingen | 23 | 21 | 19 | 16 | 12 | 15 | 14 | 20 | 29 | 34 | 33 | 28 |
| | | 9d | Spangdahlem | 18 | 15 | 14 | 14 | 8 | 10 | 11 | 15 | 20 | 22 | 21 | 19 |
| HAZE & SMOKE | DAY | 3 | Heidelberg | 74 | 69 | 69 | 52 | 45 | 44 | 42 | 40 | 50 | 65 | 71 | 69 |
| | | 6a | Berlin | 9 | 11 | 8 | 4 | 3 | 2 | 2 | 3 | 5 | 8 | 7 | 7 |
| | | 9b | Kitzingen | 55 | 45 | 40 | 26 | 17 | 19 | 17 | 17 | 25 | 37 | 44 | 45 |
| | | 9d | Spangdahlem | 30 | 34 | 31 | 20 | 14 | 13 | 12 | 10 | 20 | 26 | 14 | 15 |
| | NIGHT | 3 | Heidelberg | 77 | 75 | 73 | 60 | 53 | 55 | 54 | 46 | 61 | 72 | 75 | 73 |
| | | 6a | Berlin | 4 | 6 | 5 | 2 | 1 | 1 | 1 | 1 | 2 | 4 | 3 | 3 |
| | | 9b | Kitzingen | 64 | 54 | 47 | 36 | 28 | 28 | 30 | 30 | 38 | 50 | 52 | 50 |
| | | 9d | Spangdahlem | 23 | 27 | 25 | 19 | 13 | 13 | 13 | 10 | 19 | 24 | 19 | 18 |

TABLE 5-11. IMPACT OF FOG ON CEILING AND VISIBILITY (Ref. 12)

| Fog Type | Percentile C/V's [ft./s. mi.] | | | | |
|---|---|---|---|---|---|
| | 10 | 25 | 50 | 75 | 90 |
| Fog - day | 4000/3 | 2000/2 | 1000/1 | 500/¼ | 200/¼ |
| Fog - night | 4000/3 | 4000/3 | 1000/1 | 500/¼ | 200/¼ |
| Ground Fog - day | 5000/4 | 4000/3 | 2000/2 | 2000/2 | 1000/1 |
| Ground Fog - night | 5000/4 | 4000/3 | 4000/3 | 2000/2 | 2000/1 |

TABLE 5-12. FREQUENCY OF VISIBILITY BEING REDUCED TO A GIVEN RANGE ZONES 5a (HANNOVER) AND 7C (BAYREUTH)

| Zone | Visibility | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Tot |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5a | 5/8 mi. | .05 | .05 | .06 | .01 | .03 | .01 | .01 | .01 | .02 | .06 | .06 | .08 | .04 |
| | 1¼ | .15 | .11 | .12 | .02 | .04 | .02 | .02 | .04 | .04 | .11 | .18 | .16 | .08 |
| | 2½ | .34 | .32 | .24 | .06 | .10 | .07 | .07 | .12 | .10 | .26 | .39 | .35 | .20 |
| 7c | 5/8 mi. | .02 | .05 | .03 | .01 | .01 | .01 | --- | --- | .02 | .05 | .03 | .05 | .02 |
| | 1¼ | .08 | .10 | .06 | .01 | .02 | .02 | .01 | .01 | .03 | .09 | .07 | .12 | .05 |
| | 2½ | .22 | .23 | .14 | .05 | .04 | .04 | .03 | .02 | .08 | .20 | .21 | .32 | .13 |

| | | ANN | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5a (Hamburg) | 0100 | 8.0 | 11.3 | 14.0 | 12.1 | 3.0 | 3.4 | 1.1 | 3.8 | 3.8 | 4.3 | 10.2 | 18.0 | 11.5 |
| | 0400 | 11.3 | 12.7 | 16.2 | 15.8 | 7.4 | 6.5 | 5.2 | 8.1 | 7.9 | 8.9 | 14.3 | 17.8 | 14.2 |
| | 0700 | 13.0 | 13.2 | 20.2 | 18.2 | 8.3 | 5.6 | 3.5 | 3.9 | 7.4 | 13.0 | 21.0 | 24.4 | 17.7 |
| | 1000 | 11.6 | 20.5 | 27.3 | 15.5 | 2.6 | 0.7 | 0.4 | 0.4 | 1.4 | 3.7 | 14.7 | 27.0 | 24.9 |
| | 1300 | 6.3 | 15.8 | 17.2 | 5.2 | 1.1 | 0.9 | 0.6 | 0.0 | 0.4 | 0.2 | 4.1 | 13.0 | 16.7 |
| | 1600 | 5.8 | 18.4 | 11.0 | 3.9 | 0.2 | 0.4 | 0.0 | 0.0 | 0.2 | 0.2 | 2.3 | 14.4 | 18.6 |
| | 1900 | 5.3 | 12.9 | 12.8 | 6.0 | 0.9 | 0.5 | 0.4 | 0.2 | 0.5 | 0.6 | 4.1 | 11.9 | 12.4 |
| | 2200 | 6.2 | 12.9 | 15.3 | 7.4 | 1.1 | 0.7 | 0.7 | 0.4 | 0.4 | 1.1 | 9.5 | 13.7 | 11.7 |
| 4b (Wiesbaden) | 0100 | 5.4 | 12.2 | 10.2 | 2.5 | 0.3 | 0.1 | 0.4 | 0.4 | 0.6 | 1.7 | 10.4 | 10.9 | 14.6 |
| | 0400 | 7.0 | 13.2 | 11.5 | 4.4 | 1.1 | 0.9 | 1.5 | 0.8 | 1.6 | 4.1 | 15.6 | 13.2 | 16.2 |
| | 0700 | 10.5 | 16.2 | 16.0 | 8.5 | 2.9 | 2.6 | 2.3 | 1.9 | 3.4 | 11.9 | 25.9 | 17.8 | 17.1 |
| | 1000 | 10.7 | 21.6 | 19.3 | 9.7 | 1.7 | 0.9 | 0.5 | 0.3 | 0.9 | 7.6 | 23.2 | 20.6 | 22.4 |
| | 1300 | 6.8 | 16.9 | 12.8 | 4.5 | 0.3 | 0.1 | 0.1 | 0.0 | 0.1 | 1.6 | 10.5 | 14.8 | 20.2 |
| | 1600 | 5.7 | 13.8 | 10.5 | 2.3 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.7 | 7.5 | 13.1 | 19.6 |
| | 1900 | 4.6 | 10.8 | 10.2 | 2.3 | 0.2 | 0.1 | 0.2 | 0.1 | 0.1 | 0.7 | 7.2 | 9.8 | 13.3 |
| | 2200 | 4.5 | 11.2 | 8.9 | 1.8 | 0.2 | 0.2 | 0.2 | 0.1 | 0.3 | 0.4 | 7.3 | 10.2 | 13.6 |
| Xa (Wasserkuppe) | 0100 | 44.1 | 67.7 | 60.4 | 34.9 | 33.5 | 25.8 | 29.4 | 29.0 | 25.8 | 43.6 | 45.2 | 64.4 | 69.4 |
| | 0400 | 48.8 | 67.7 | 60.9 | 40.0 | 40.6 | 31.7 | 41.7 | 36.6 | 33.7 | 48.9 | 45.2 | 65.6 | 73.1 |
| | 0700 | 50.7 | 79.4 | 62.7 | 38.5 | 40.0 | 37.6 | 44.4 | 42.2 | 35.3 | 52.5 | 45.7 | 69.8 | 70.4 |
| | 1000 | 44.2 | 71.7 | 61.9 | 37.6 | 30.0 | 24.2 | 27.8 | 26.9 | 23.1 | 49.4 | 43.5 | 66.5 | 67.7 |
| | 1300 | 33.9 | 67.2 | 55.6 | 29.0 | 18.3 | 12.4 | 15.6 | 15.1 | 13.5 | 26.1 | 30.1 | 59.8 | 64.5 |
| | 1600 | 31.4 | 61.6 | 52.7 | 24.7 | 17.2 | 11.3 | 11.7 | 13.4 | 10.8 | 22.9 | 25.3 | 58.3 | 66.5 |
| | 1900 | 34.8 | 65.1 | 54.4 | 28.1 | 19.6 | 15.1 | 16.2 | 15.1 | 12.4 | 29.4 | 33.9 | 58.9 | 69.7 |
| | 2200 | 39.7 | 67.2 | 58.9 | 32.3 | 24.6 | 20.4 | 20.7 | 25.7 | 16.2 | 37.2 | 40.9 | 61.7 | 71.0 |
| 8a (Hahn A.F.B.) | 0100 | 15.2 | 25.9 | 18.3 | 12.5 | 10.2 | 5.5 | 6.6 | 4.8 | 7.0 | 10.2 | 17.6 | 31.3 | 32.4 |
| | 0400 | 19.2 | 26.0 | 22.5 | 15.1 | 15.9 | 10.1 | 10.1 | 9.8 | 12.7 | 16.5 | 25.0 | 34.4 | 32.5 |
| | 0700 | 19.2 | 25.0 | 23.1 | 16.5 | 15.9 | 7.4 | 6.3 | 7.0 | 10.7 | 17.0 | 27.6 | 35.2 | 32.8 |
| | 1000 | 12.8 | 26.2 | 22.7 | 8.5 | 5.4 | 2.2 | 3.1 | 2.1 | 2.4 | 5.9 | 16.3 | 28.7 | 29.7 |
| | 1300 | 9.4 | 22.7 | 16.5 | 5.5 | 3.2 | 1.3 | 1.9 | 1.1 | 0.9 | 3.0 | 8.7 | 20.6 | 27.1 |
| | 1600 | 9.2 | 23.2 | 14.1 | 5.4 | 3.3 | 1.3 | 1.6 | 1.0 | 1.1 | 3.2 | 8.0 | 22.1 | 26.5 |
| | 1900 | 10.3 | 22.7 | 14.6 | 6.9 | 4.3 | 1.4 | 3.2 | 2.1 | 1.7 | 5.0 | 9.2 | 24.3 | 27.7 |
| | 2200 | 11.5 | 23.3 | 14.3 | 8.8 | 6.4 | 1.9 | 3.7 | 2.6 | 3.3 | 5.6 | 12.4 | 28.2 | 27.6 |
| 9b (Weiden) | 0100 | 6.1 | 6.3 | 10.6 | 5.3 | 2.7 | 4.5 | 3.3 | 1.3 | 1.3 | 5.3 | 9.0 | 7.3 | 15.9 |
| | 0400 | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | 0700 | 9.8 | 8.1 | 9.5 | 9.7 | 6.7 | 5.4 | 4.4 | 3.8 | 3.8 | 15.6 | 27.6 | 11.7 | 10.9 |
| | 1000 | 5.9 | 9.1 | 14.8 | 5.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 11.8 | 7.8 | 20.4 |
| | 1300 | 1.9 | 3.8 | 3.6 | 0.5 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.2 | 11.8 |
| | 1600 | 1.7 | 2.7 | 4.1 | 0.5 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 1.1 | 11.3 |
| | 1900 | 2.7 | 5.4 | 5.9 | 0.5 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 2.8 | 15.6 |
| | 2200 | 3.4 | 6.5 | 7.1 | 1.6 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 3.2 | 6.1 | 14.9 |

TABLE 5-13. FREQUENCY OF OCCURRENCE (%), CEILING VISIBILITY LESS THAN OR EQUAL TO 300 FEET/1 MILE (Ref. 12)

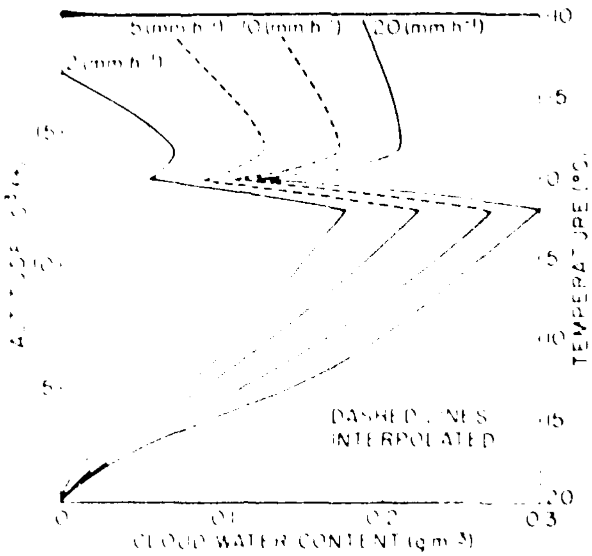



FIGURE 5-24. STORED WATER CONCENTRATION EXPECTED WITHIN SUMMER STRATIFORM RAINCLOUD (Ref. 10)

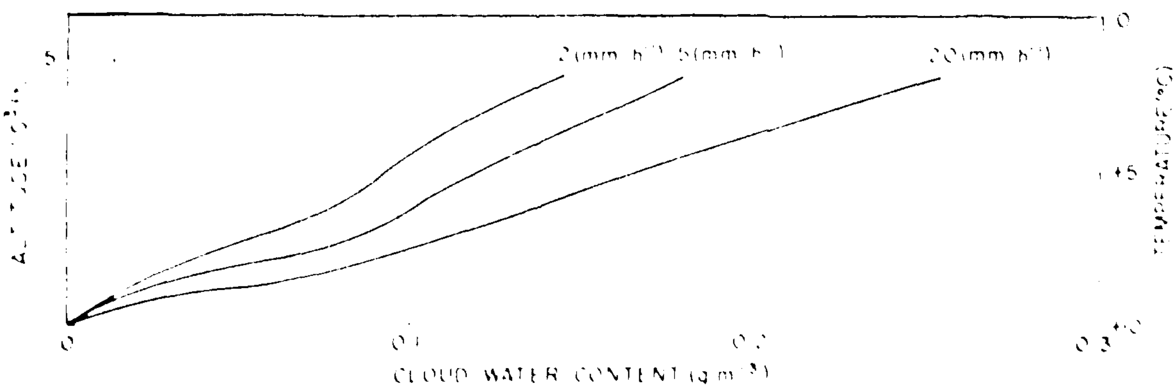



FIGURE 5-25. STORED WATER CONCENTRATION EXPECTED BELOW FREEZING LEVEL WITHIN SPRING OR FALL STRATIFORM RAIN CLOUDS (Ref. 10)

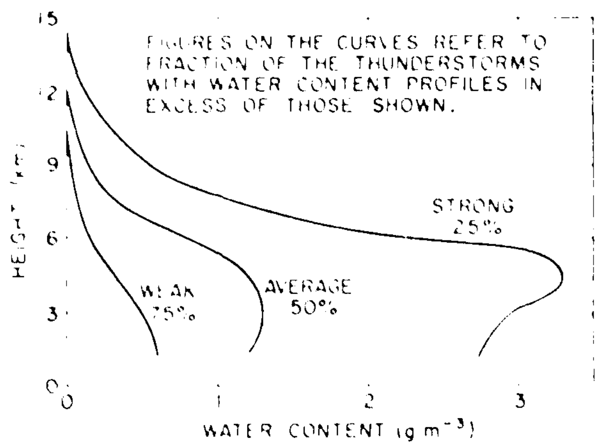



FIGURE 5-26. STORED WATER CONCENTRATION EXPECTED WITHIN CUMULONIMBUS CLOUDS (Ref. 10)

TABLE 5-14. LIQUID WATER EXPECTED WITHIN CUMULIFORM CLOUDS. (Ref. 10)

| Clouds | | Water Content ($gm^{-3}$) | |
|---|---|---|---|
| Type | Temp (°C) | Average | Maximum |
| Cumulus Humilis | 10 to 24 | 1.0 | 3.0 |
| Cummulus Congestus | 3 to 11 | 2.0* | 6.6 |
| Cummulonimbus | 10 to - 8 | 2.5 | 10.0 |

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CLIMATOLOGY OF SELECTED AREAS OF WEST GERMANY AFFECTING SENSOR --ETC(U)
JUN 79　A LAWSON　　DAAK70-78-C-0198
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TABLE 5-15. MAXIMUM ALTITUDE [km] FOR A GIVEN PROBABILITY OF A CLOUD-FREE LINE OF SIGHT (Ref. 11)

| DEPRESSION ANGLE [°] | | 30 | | | 45 | | | 60 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CFLOS PROBABILITY | | .33 | .50 | .67 | .33 | .50 | .67 | .33 | .50 | .67 |
| TIME | ZONE | | | | | | | | | |
| Winter | 4b | 5.6 | 2.2 | 0.1 | 5.6 | 1.6 | 0 | 5.7 | 1.4 | 0 |
| Daylight | 5b | 3.3 | 0.8 | 0 | 3.2 | 0.8 | 0 | 3.3 | 0.4 | 0 |
| Summer | 4b | >>10 | 7.0 | 2.0 | >>10 | 9.6 | 2.1 | >>10 | >10 | 2.7 |
| Daylight | 5b | 9.2 | 3.0 | 1.1 | > 10 | 3.7 | 1.2 | >>10 | 4.2 | 1.2 |
| Year Long | 4b | >>10 | 3.0 | 0.8 | >>10 | 3.6 | 0.6 | >>10 | 3.6 | 0.6 |
| 24 Hour | 5b | > 10 | 1.8 | 0.4 | > 10 | 2.0 | 0 | > 10 | 2.0 | 0 |

# 6
# COPING WITH CORRELATIONS

The frequency of incidence for the various weather elements which have been presented in the previous sections is an adequate measure for predicting the success of a "snap shot" type of sensor which is inhibited by only a single factor. Fortunately for the sensor (unfortunately for the analyst), there is some freedom in choosing its point of application in time and space For example, a brief delay of a mission may allow the rain to stop, the fog to clear, the front to pass, etc. The probable duration of these elements can thus be critical, also, there are correlations between those elements. The coincidence of precipitation and clouds is obvious. There is a strong negative correlation in incidence between haze/smoke and thunderstorms. Our ability to gather and display information of this type is somewhat limited.

A careful review of temperature or precipitation would disclose probabilities of a given condition lasting for a given period of time. As we will show later, these durations correlate so strongly with other parameters that the simple probabilities may not be of great use. One simple presentation that would be valuable has been used with precipitation data for England (Figure 6-1). This shows, for example, that we could expect an instantaneous rainfall rate as great as 30mm/hr to be sustained for 15 minutes or more only once each year. Regrettably comparable data have not been located for Germany and regrettably precipitation patterns differ too much between Germany and the U.K. to allow the use of the U.K. data. The curve does show the character of the relationship between duration, rate, and frequency. Such a presentation could be profitably developed for German climatic regions by season and by time of day.

Table 6-1 shows how often the ceiling and visibility will simultaneously be at or below 200 ft and 1¼ mi for a given number of hours for two climatic zones. In Table 6-2, we have presented the duration distribution in a somewhat more compact form. From Table 6-1, in

January in zone 8a, both ceiling and visibility will be equal to or less than 200 ft. and 1 1/4 mi. 29.4% of the time and 11.4% of the time it will be in a period when this condition lasts at least 12 hours. Table 6-2 shows that, also for January in 8a, 75% of these low CV periods will last at least 4 hours, 50% will last 9 hours and 25% will last at least 18 hours.

In Table 6-3 we show the likelihood of one fraction of total sky cover changing to another within a given period of time by season. Note that this data has been developed from satellite imagery for a $10^{\circ} \times 10^{\circ}$ area centered $10^{\circ}$ E and $45^{\circ}$ N. Thus southern Germany is included in the study region but so are portions of Italy, France, Switzerland, Austria, Czechoslovakia. The table shows that in Winter if the sky is clear (0/4), there is 0 probability of the sky remaining clear for 24 hours while if overcast (4/4), the probability of remaining overcast for at least 24 hours is 77%.

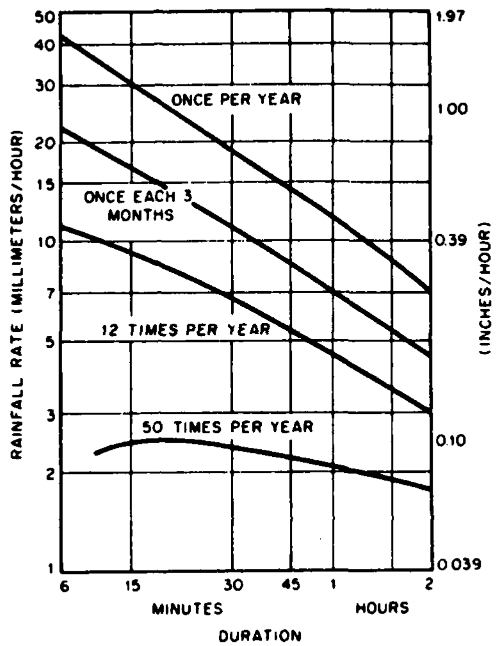
An air mass may often be usefully identified by the source region in which it acquired its present characteristics (A-arctic, P-polar, T-tropical, E-equatorial, etc.) and according to the continentality of that region (M-maritime, and T-tropical). Convention would call for representing a maritime polar air mass as mP. We have altered this convention to emphasize the continentality aspect and would represent that same air mass as Mp. The chart of Figure 6-2 shows the frequency of encountering specific air masses at Frankfurt A.M., zone 4b. Note the presence of air masses identified as M and C which have no clearly identifiable regional characteristics, as P and T whose absolute humidity suggests no marked continentality, and as O which is especially representative of the frontal regions which are such great weather generators.

Air mass frequencies would be useful because different air masses give rise to different weather characteristics. We attempt to show this in Figure 6-3. Note, for example, that even in Winter the polar continental, Pc, air masses from the USSR are not too frequent (2.6%), and last less than 1.5 days but when they come they drop the temperature dramatically, they bring very little moisture and far fewer overcast skies than we normally expect in German winters.

The use of such air mass statistics could lead to the generation of a reasonably good weather model. It would need some modification to provide frontal weather characteristics and for weather peculiar to cyclonic disturbances.

The contour lines that represent the height of the 500 mB atmospheric pressure are rather like the isobars found on a surface chart but are characterized by waves with ridges and troughs rather than closed highs and lows. These waves have different spatial wavelengths and speeds. There are slow moving long-wave ridges and troughs and short waves that migrate within the long waves. They may be of use because there are definite frequencies of occurrence associated with regions in these waves as shown in Table 6-4. Table 6-5 then shows the seasonal sky cover expectations to associate with each of the regions within the 500 mB structure. Note that the differences in frequencies are very marked. If, for example, you are in the forward portion of a migratory trough in winter, it will be overcast. If in the inner portion of a long wave ridge in Spring it will be clear. Table 6-6 is included to show the resulting impact on a satellite's ability to view a given spot on the ground.

One other useful way to model our weather is to adopt a family of representative, actual weather sequences. In Table 6-7 through 6-9 we include for zone 7c one representative month of weather for each of three seasons; summer, fall, and winter. If a somewhat more detailed sequence were simultaneously available from the climatic zones of interest, we could construct a catalog of typical sequences with associated frequencies and select from these to perform the sensor analyses.




—Rainfall duration in England. *From E. G. Bilham, "Climate of British Isles," Macmillan Company, Toronto, Canada; 1938.*

**FIGURE 6-1.**

**TABLE 6-1. PERCENTAGE FREQUENCY OF OCCURRENCE OF CEILING/VISIBILITY LESS THAN OR EQUAL TO 200 ft/1 1/4 mi. FOR A DURATION OF AT LEAST THE INDICATED NUMBER OF HOURS (Ref. 12)**

| Zone (Sta.) | MONTH | HOURS OF DURATION 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 | 26 | 30 | 33 | 36 | 39 | 42 | 45 | 48 | 51 | 54 | 57 | 60 | ALL OBS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9b (Grafenwohr) | JAN | 10.8 | 6.8 | 4.8 | 3.4 | 2.3 | 1.5 | 1.1 | 0.7 | 0.5 | 0.2 | 0.2 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15.4 |
| | FEB | 7.9 | 5.1 | 3.5 | 2.1 | 1.2 | 0.7 | 0.5 | 0.3 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 12.3 |
| | MAR | 3.4 | 1.8 | 0.9 | 0.3 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.6 |
| | APR | 1.0 | 0.7 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.8 |
| | MAY | 1.9 | 0.5 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.4 |
| | JUN | 1.4 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.2 |
| | JUL | 0.9 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.9 |
| | AUG | 3.1 | 1.2 | 0.4 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.3 |
| | SEP | 6.5 | 2.9 | 0.9 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 12.5 |
| | OCT | 11.6 | 7.4 | 4.3 | 2.0 | 0.6 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15.7 |
| | NOV | 9.3 | 6.3 | 4.4 | 3.2 | 2.5 | 2.1 | 1.8 | 1.5 | 1.3 | 1.1 | 1.0 | 0.9 | 0.8 | 0.7 | 0.6 | 0.5 | 0.4 | 0.3 | 0.3 | 0.3 | 13.7 |
| | DEC | 7.9 | 4.9 | 3.2 | 2.2 | 1.5 | 0.9 | 0.6 | 0.4 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 12.9 |
| 8a (Hahn A.F.B.) | JAN | 25.2 | 18.7 | 14.5 | 11.4 | 9.0 | 7.4 | 6.1 | 5.2 | 4.5 | 3.9 | 3.4 | 3.0 | 2.7 | 2.4 | 2.1 | 1.8 | 1.4 | 1.2 | 1.0 | 0.8 | 29.4 |
| | FEB | 14.9 | 9.9 | 6.9 | 4.9 | 3.5 | 2.2 | 1.7 | 1.3 | 1.1 | 0.8 | 0.5 | 0.3 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 22.3 |
| | MAR | 6.3 | 4.1 | 2.5 | 1.6 | 1.3 | 1.0 | 0.8 | 0.6 | 0.5 | 0.3 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 12.1 |
| | APR | 2.9 | 1.2 | 0.5 | 0.3 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.5 |
| | MAY | 2.1 | 1.0 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.9 |
| | JUN | 2.2 | 1.2 | 0.8 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.8 |
| | JUL | 1.4 | 0.6 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.7 |
| | AUG | 2.6 | 1.2 | 0.6 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.3 |
| | SEP | 3.8 | 1.6 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 9.5 |
| | OCT | 14.2 | 8.8 | 5.9 | 4.2 | 3.1 | 2.4 | 2.0 | 1.7 | 1.4 | 1.1 | 0.9 | 0.7 | 0.6 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 | 21.4 |
| | NOV | 18.1 | 13.2 | 9.7 | 7.2 | 5.5 | 4.3 | 3.4 | 2.6 | 2.0 | 1.6 | 1.2 | 1.0 | 0.8 | 0.6 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | 21.9 |
| | DEC | 26.8 | 21.1 | 17.2 | 14.3 | 12.3 | 10.6 | 9.2 | 8.2 | 7.4 | 6.7 | 6.0 | 5.1 | 4.4 | 3.9 | 3.6 | 3.4 | 3.1 | 2.9 | 2.7 | 2.5 | 29.3 |

TABLE 6-2. HOURLY DURATION PERCENTILES - C/V $\leq$ 200 ft/1 1/4 mi

| "Season" | Month | 9b (Grafenwöhr) | | | | | | 8a (Hahn A.F.B.) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 75 | | 50 | | 25 | | 75 | | 50 | | 25 | |
| "Winter" | Dec. | 2 | (2.0) | 4 | (5.7) | 9 | (9.7) | 6 | (4.0) | 12 | (8.7) | 27 | (18.7) |
| | Jan. | 2 | | 8 | | 10 | | 4 | | 9 | | 18 | |
| | Feb. | 2 | | 5 | | 10 | | 2 | | 5 | | 11 | |
| "Spring" | Mar. | <2 | (-1.5) | 8 | (5.0) | 13 | (8.0) | 2 | (-1.5) | 4 | (2.7) | 8 | (6.0) |
| | Apr. | <2 | | 5 | | 8 | | <2 | | 2 | | 5 | |
| | May | <<2 | | 2 | | 3 | | <2 | | 2 | | 5 | |
| "Summer" | Jun. | <2 | (-1) | 2 | (2.0) | 4 | (4.0) | 2 | (-1.5) | 3 | (2.3) | 6 | (5.0) |
| | Jul. | <<2 | | 1 | | 3 | | <2 | | 2 | | 4 | |
| | Aug. | -2 | | 3 | | 5 | | <2 | | 2 | | 5 | |
| "Fall" | Sep. | 2 | (2.3) | 3 | (5.0) | 6 | (9.0) | <2 | (3.0) | 2 | (5.0) | 4 | (9.3) |
| | Oct. | 3 | | 6 | | 9 | | 2.5 | | 5 | | 9 | |
| | Nov. | 2 | | 6 | | 12 | | 4 | | 8 | | 15 | |

TABLE 6-3. PROBABILITY (%) OF A SPECIFIC CHANGE IN FRACTIONAL OBSCURATION OVER A SPECIFIED TIME INTERVAL (10°E X 45°N)
(Ref. 15)

| Change (in 4ths) | | | Winter | | | | Spring | | Summer | | Fall | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | | To | $6^h$ | $12^h$ | $18^h$ | $24^h$ | $12^h$ | $24^h$ | $12^h$ | $24^h$ | $6^h$ | $12^h$ | $18^h$ | $24^h$ |
| 0 | → | 0 | 75 | 50 | 25 | 0 | 72 | 57 | 33 | 25 | 13 | 0 | 0 | 37 |
| | | 1 | 0 | 0 | 25 | 25 | 14 | 14 | 45 | 50 | 49 | 0 | 25 | 13 |
| | | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 25 | 0 | 25 | 37 | 25 |
| | | 3 | 25 | 50 | 50 | 75 | 14 | 29 | 0 | 0 | 25 | 50 | 25 | 25 |
| | | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 25 | 13 | 0 |
| 1 | → | 0 | 0 | 0 | 0 | 0 | 17 | 25 | 25 | 25 | 22 | 0 | 27 | 21 |
| | | 1 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 14 | 27 | 13 | 29 |
| | | 2 | 50 | 50 | 0 | 0 | 0 | 25 | 42 | 25 | 22 | 20 | 27 | 29 |
| | | 3 | 50 | 50 | 100 | 100 | 66 | 25 | 8 | 25 | 42 | 33 | 13 | 21 |
| | | 4 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 20 | 20 | 0 |
| 2 | → | 0 | - | 0 | - | 11 | 0 | 18 | 13 | 19 | 17 | 14 | 6 | 0 |
| | | 1 | - | 11 | - | 0 | 30 | 28 | 13 | 0 | 11 | 14 | 16 | 5 |
| | | 2 | - | 33 | - | 33 | 30 | 18 | 31 | 44 | 39 | 32 | 26 | 38 |
| | | 3 | - | 33 | - | 23 | 20 | 18 | 43 | 31 | 33 | 32 | 26 | 38 |
| | | 4 | - | 23 | - | 33 | 20 | 18 | 0 | 6 | 0 | 8 | 26 | 19 |
| 3 | → | 0 | 7 | 10 | 20 | 10 | 7 | 0 | 5 | 0 | 0 | 12 | 4 | 0 |
| | | 1 | 7 | 5 | 0 | 5 | 7 | 0 | 10 | 20 | 13 | 16 | 9 | 15 |
| | | 2 | 0 | 14 | 0 | 5 | 21 | 19 | 15 | 15 | 22 | 24 | 17 | 26 |
| | | 3 | 72 | 38 | 40 | 29 | 29 | 37 | 50 | 55 | 30 | 16 | 48 | 22 |
| | | 4 | 14 | 33 | 40 | 51 | 36 | 44 | 20 | 10 | 35 | 32 | 22 | 37 |
| 4 | → | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 4 | 3 | 0 |
| | | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 9 | 11 | 10 | 3 |
| | | 2 | 0 | 2 | 7 | 9 | 17 | 18 | 25 | 0 | 12 | 11 | 7 | 0 |
| | | 3 | 9 | 14 | 13 | 14 | 28 | 35 | 50 | 25 | 12 | 18 | 23 | 35 |
| | | 4 | 91 | 84 | 80 | 77 | 55 | 47 | 0 | 25 | 67 | 56 | 57 | 62 |

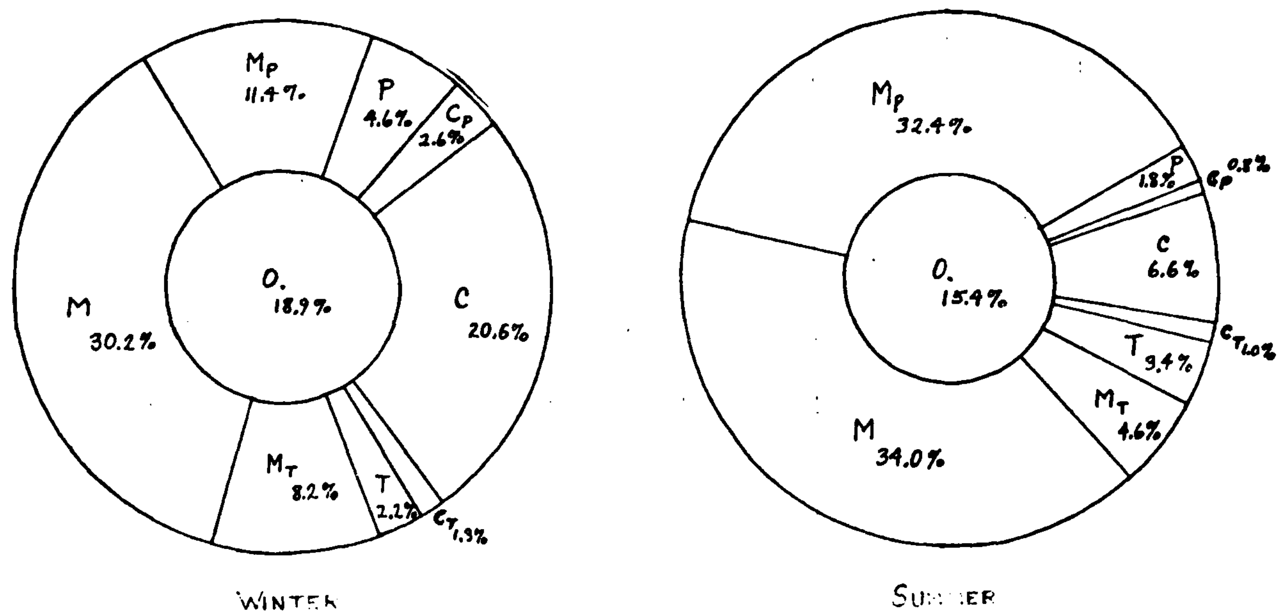



FIGURE 6-2. AIR MASS INCIDENCE - FRANKFURT A.M. - AFTER E. DINIES

M Maritime P Polar
C Continental T Tropical
O Other, Mixed, Ill-Defined, Frontal, Etc.

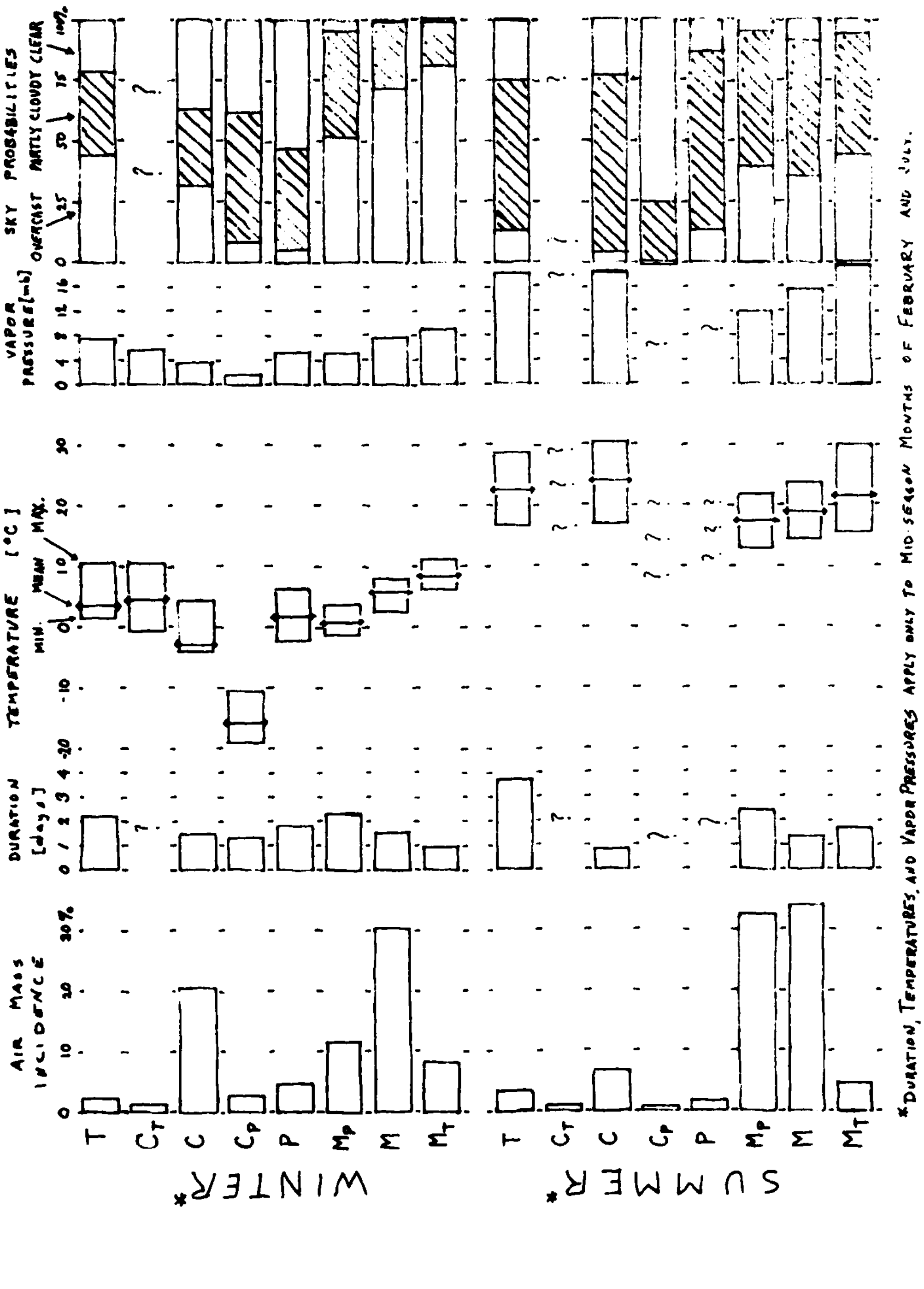



FIGURE 6-3. AIR MASS STATISTICS - FRANKFURT A.M.

TABLE 6-4. PROBABILITY OF OCCURRENCE OF A PARTICULAR FEATURE ON THE 500 mB CHART IN THE 10° X 10° SECTOR 10°E 45°N (Ref. 15)

| Feature | Winter | Spring | Summer | Fall |
|---|---|---|---|---|
| a. Forward portion of migratory trough, usually cloudy | 14% | 16% | 14% | 8% |
| b. Rear portion of trough in cold sector, usually cloudy | 12 | 22 | 15 | 2 |
| c. Forward portion of migratory ridge, usually clear | 10 | 8 | 15 | 23 |
| e. Center of ridge, often cloudy | 12 | 8 | 12 | 12 |
| f. Forward portion of long wave ridges, usually clear | 26 | - | 14 | 27 |
| g. Inner portion of long wave ridges, usually clear | 2 | 12 | 12 | - |
| h. Forward portion of long wave troughs, usually cloudy | 12 | 4 | - | 19 |
| i. Inner portion of long wave trough, usually cloudy | 10 | 30 | 18 | 9 |

TABLE 6-5. SEASONAL PROBABILITY OF LEVELS OF OBSCURATION IN DIFFERENT 500 mB FEATURES 10°E 45°N (Ref. 15)

| Season | Obscuration | a | b | c | e | f | g | h | i |
|---|---|---|---|---|---|---|---|---|---|
| Winter | 0 | 0% | 0% | 0% | 0% | 17% | 0% | 0% | 0% |
| | 1 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 20 | 0 | 25 | 0 | 33 | 0 |
| | 3 | 0 | 0 | 40 | 0 | 41 | 100 | 17 | 0 |
| | 4 | 100 | 100 | 40 | 100 | 0 | 0 | 50 | 100 |
| Spring | 0 | 0 | 0 | 25 | 0 | 0 | 100 | 0 | 0 |
| | 1 | 25 | 0 | 25 | 0 | 0 | 0 | 0 | 7 |
| | 2 | 13 | 9 | 50 | 50 | 0 | 0 | 0 | 20 |
| | 3 | 25 | 55 | 0 | 25 | 0 | 0 | 50 | 33 |
| | 4 | 37 | 36 | 0 | 25 | 0 | 0 | 50 | 40 |
| Summer | 0 | 0 | 0 | 13 | 0 | 57 | 33 | 0 | 0 |
| | 1 | 14 | 0 | 49 | 17 | 29 | 50 | 0 | 0 |
| | 2 | 29 | 50 | 13 | 33 | 14 | 17 | 0 | 33 |
| | 3 | 57 | 25 | 25 | 33 | 0 | 0 | 0 | 67 |
| | 4 | 0 | 25 | 0 | 17 | 0 | 0 | 0 | 0 |
| Fall | 0 | 0 | 0 | 16 | 20 | 13 | 0 | 0 | 0 |
| | 1 | 0 | 0 | 31 | 10 | 30 | 0 | 6 | 0 |
| | 2 | 14 | 50 | 21 | 20 | 13 | 0 | 31 | 0 |
| | 3 | 0 | 0 | 21 | 40 | 30 | 0 | 50 | 0 |
| | 4 | 86 | 50 | 11 | 10 | 13 | 0 | 13 | 100 |

TABLE 6-6. PROBABILITY OF CLEAR LINE OF SIGHT FROM SATELLITE TO A SPECIFIC SPOT ON THE GROUND, 10° X 10° AREA CENTERED ON 10°E 45°N (Ref. 15)

| Season | Winter | Spring | Summer | Fall |
|---|---|---|---|---|
| Month analyzed | (Dec 62) | (Apr 62) | (Aug 61) | (Oct 62) |
| CLOS Probability | 18% | 36% | 53% | 34% |

TABLE 6-7(1). REPRESENTATIVE WEATHER SEQUENCES FOR ZONE 7c
LEINEFELDE ($51^{o}23'$N $10^{o}19'$E 354 m.) (Ref. 16)

Summer
July '53

| | Day/Hr(LST) | Visibility (s. mi.) | Ceiling (100's of feet) | Sky Cover (Eighths) | Weather | Wind Speed(KTS) | Relative Humidity(%) | Absolute Humidity($g/m^3$) |
|---|---|---|---|---|---|---|---|---|
| 1 | 01 | 3 | 130 | 5 | H | 2 | 71 | 11 |
| | 07 | 6 | 130 | 8 | H | 4 | 76 | 13 |
| | 13 | 13 | 130 | 5 | - | 8 | 46 | 12 |
| | 19 | 13 | 130 | 8 | - | C | 89 | 15 |
| 2 | 01 | 6 | 31 | 6 | H | C | 76 | 12 |
| | 07 | 6 | 130 | 7 | H | 8 | 86 | 13 |
| | 13 | 2-1/2 | 17 | 6 | H | 4 | 54 | 14 |
| | 19 | 13 | 130 | 8 | F | 2 | 93 | 14 |
| 3 | 01 | 3 | U | 3 | H | C | 74 | 11 |
| | 07 | 2-1/2 | 130 | 8 | H | 2 | 83 | 13 |
| | 13 | 13 | 130 | 5 | - | 8 | 40 | 11 |
| | 19 | 13 | 130 | 7 | R | 8 | 52 | 11 |
| 4 | 01 | 3 | U | C | H | C | 79 | 12 |
| | 07 | 2-1/2 | U | C | H | 4 | 86 | 13 |
| | 13 | 6 | U | 3 | H | 4 | 63 | 14 |
| | 19 | 13 | 17 | 8 | - | 8 | 83 | 14 |
| 5 | 01 | 6 | U | 2 | H | 8 | 93 | 12 |
| | 07 | 6 | 4.6 | 7 | - | 8 | 93 | 11 |
| | 13 | 13 | 17 | 6 | - | 8 | 68 | 11 |
| | 19 | 13 | 130 | 7 | - | 12 | 76 | 11 |
| 6 | 01 | 6 | 17 | 7 | H | C | 89 | 11 |
| | 07 | 6 | 31 | 7 | H | 8 | 79 | 12 |
| | 13 | 13 | 17 | 8 | - | 16 | 56 | 12 |
| | 19 | 6 | 130 | 8 | - | 8 | 61 | 11 |
| 7 | 01 | 6 | 130 | 7 | H | 12 | 68 | 11 |
| | 07 | 13 | 130 | 8 | - | 12 | 79 | 12 |
| | 13 | 6 | 9 | 8 | L | 12 | 89 | 14 |
| | 19 | 13 | 31 | 8 | - | 16 | 76 | 14 |
| 8 | 01 | 3 | 130 | 7 | H | 8 | 79 | 12 |
| | 07 | 6 | 17 | 8 | - | 12 | 86 | 12 |
| | 13 | 2-1/2 | 9 | 8 | R | 16 | 86 | 13 |
| | 19 | 13 | U | 1 | - | 12 | 71 | 11 |

TABLE 6-7(2). REPRESENTATIVE WEATHER SEQUENCES FOR ZONE 7c
LEINEFELDE (51°23'N 10°19'E 354 m.) (Ref. 16)

Summer
July '53

| Day/Hr(LST) | | Visibility(s. mi.) | Ceiling(100's of feet) | Sky Cover (Eighths) | Weather | Wind Speed(KTS) | Relative Humidity(%) | Absolute Humidity (g/m³) |
|---|---|---|---|---|---|---|---|---|
| 9 | 01 | 6 | U | 3 | H | 4 | 74 | 8 |
| | 07 | 13 | 130 | 6 | - | 8 | 83 | 9 |
| | 13 | 13 | 130 | 6 | - | 12 | 46 | 8 |
| | 19 | 13 | 130 | 7 | - | 4 | 56 | 9 |
| 10 | 01 | 3 | 130 | 8 | - | 4 | 79 | 9 |
| | 07 | 13 | 130 | 5 | - | 2 | 79 | 9 |
| | 13 | 13 | 17 | 7 | - | 8 | 61 | 9 |
| | 19 | 13 | 17 | 7 | - | 4 | 76 | 9 |
| 11 | 01 | 3 | U | 1 | - | 8 | 93 | 9 |
| | 07 | 2-1/2 | 9 | 7 | H | 4 | 79 | 8 |
| | 13 | 13 | 130 | 7 | - | 12 | 66 | 9 |
| | 19 | 13 | 9 | 7 | - | 4 | 61 | 8 |
| 12 | 01 | 3 | U | 1 | H | 8 | 79 | 9 |
| | 07 | 13 | U | 2 | - | 8 | 74 | 8 |
| | 13 | 13 | 17 | 7 | - | 8 | 61 | 9 |
| | 19 | 13 | 17 | 8 | - | 4 | 54 | 9 |
| 13 | 01 | 3 | U | 3 | - | 2 | 61 | 9 |
| | 07 | 13 | 9 | 8 | R | 8 | 96 | 11 |
| | 13 | 13 | 130 | 8 | - | 12 | 76 | 11 |
| | 19 | 13 | 4.6 | 7 | RW | 8 | 83 | 11 |
| 14 | 01 | 3 | 4.6 | 8 | R | 12 | 93 | 10 |
| | 07 | 13 | 4.6 | 8 | - | 12 | 86 | 9 |
| | 13 | 13 | 130 | 6 | - | 16 | 66 | 9 |
| | 19 | 13 | U | 4 | - | 8 | 76 | 10 |
| 15 | 01 | 3 | 17 | 7 | - | 8 | 93 | 9 |
| | 07 | 13 | 9 | 7 | - | 16 | 86 | 9 |
| | 13 | 35 | 130 | 7 | - | 27 | 66 | 9 |
| | 19 | 13 | 9 | 8 | R | 12 | 93 | 10 |
| 16 | 01 | 3 | 17 | 5 | - | 8 | 100 | 10 |
| | 07 | 13 | 4.6 | 6 | - | 12 | 93 | 9 |
| | 13 | 13 | 130 | 6 | - | 12 | 58 | 9 |
| | 19 | 35 | 130 | 8 | - | 4 | 61 | 9 |
| 17 | 01 | 3 | 130 | 8 | - | 8 | 66 | 9 |
| | 07 | 13 | 130 | 8 | - | 12 | 71 | 10 |
| | 13 | 13 | 130 | 8 | - | 12 | 56 | 12 |
| | 19 | 35 | 130 | 5 | - | 4 | 76 | 12 |
| 18 | 01 | 3 | 2.3 | 8 | TRW | 8 | 93 | 11 |
| | 07 | 13 | 130 | 8 | - | 4 | 93 | 13 |
| | 13 | 6 | 4.6 | 8 | R | 4 | 100 | 13 |
| | 19 | 2-1/2 | 2.3 | 8 | L | 4 | 93 | 12 |

TABLE 6-7(3). REPRESENTATIVE WEATHER SEQUENCES FOR ZONE 7c
LEINEFELDE (51°23'N 10°19'E 354 m.) (Ref. 16)

Summer
July '53

| Day/Hr(LST) | | Visibility (s. mi.) | Ceiling (100's of feet) | Sky Cover (Eighths) | Weather | Wind Speed(KTS) | Relative Humidity(%) | Absolute Humidity(g/m³) |
|---|---|---|---|---|---|---|---|---|
| 19 | 01 | 3 | U | 4 | H | 8 | 96 | 11 |
| | 07 | 13 | 17 | 7 | - | 4 | 89 | 10 |
| | 13 | 13 | 17 | 6 | - | 16 | 50 | 8 |
| | 19 | 13 | 130 | 6 | - | 8 | 71 | 9 |
| 20 | 01 | 3 | U | 1 | - | 8 | 79 | 8 |
| | 07 | 13 | 130 | 8 | - | 12 | 79 | 9 |
| | 13 | 13 | 130 | 8 | R | 12 | 76 | 9 |
| | 19 | 13 | 130 | 8 | - | 8 | 83 | 11 |
| 21 | 01 | 3 | 130 | 7 | H | 8 | 86 | 11 |
| | 07 | 13 | U | 1 | - | 8 | 86 | 12 |
| | 13 | 13 | U | 1 | - | 12 | 54 | 13 |
| | 19 | 13 | U | 1 | - | 12 | 41 | 10 |
| 22 | 01 | 3 | U | 2 | - | 16 | 54 | 9 |
| | 07 | 13 | 130 | 8 | - | 16 | 71 | 11 |
| | 13 | 13 | 130 | 8 | - | 16 | 54 | 13 |
| | 19 | 13 | 130 | 8 | R | 12 | 86 | 13 |
| 23 | 01 | 3 | 31 | 5 | - | 8 | 79 | 11 |
| | 07 | 13 | 31 | 7 | - | 8 | 86 | 12 |
| | 13 | 13 | 9 | 8 | - | 12 | 93 | 14 |
| | 19 | 13 | 130 | 8 | - | 4 | 71 | 11 |
| 24 | 01 | 3 | 130 | 7 | H | 8 | 83 | 9 |
| | 07 | 6 | U | 3 | H | 8 | 89 | 10 |
| | 13 | 13 | 17 | 6 | - | 12 | 58 | 9 |
| | 19 | 13 | U | 4 | - | 2 | 46 | 9 |
| 25 | 01 | 3 | U | C | H | 2 | 66 | 9 |
| | 07 | 13 | U | C | - | 8 | 61 | 9 |
| | 13 | 13 | U | 1 | - | 12 | 48 | 11 |
| | 19 | 13 | U | C | - | 4 | 48 | 11 |
| 26 | 01 | 13 | U | C | - | 8 | 63 | 11 |
| | 07 | 13 | 130 | 6 | - | 8 | 63 | 11 |
| | 13 | 13 | 130 | 6 | - | 8 | 71 | 15 |
| | 19 | 13 | 130 | 6 | - | 4 | 61 | 12 |
| 27 | 01 | 13 | 48 | 7 | - | 8 | 76 | 11 |
| | 07 | 13 | 130 | 7 | - | 4 | 86 | 11 |
| | 13 | 13 | 130 | 7 | - | 8 | 89 | 11 |
| | 19 | 35 | 17 | 7 | TRW | 12 | 86 | 9 |

TABLE 6-7(4). REPRESENTATIVE WEATHER SEQUENCES FOR ZONE 7c
LEINEFELDE (51°23'N 10°19'E 354 m.) (Ref. 16)

Summer
July '53

| | Day/Hr(LST) | Visibility(s. mi.) | Ceiling(100's of feet) | Sky Cover (Eighths) | Weather | Wind Speed(KTS) | Relative Humidity(%) | Absolute Humidity(g/m³) |
|---|---|---|---|---|---|---|---|---|
| 28 | 01 | 13 | 17 | 6 | - | 16 | 100 | 11 |
| | 07 | 6 | 4.6 | 7 | - | 16 | 93 | 11 |
| | 13 | 13 | 130 | 5 | - | 16 | 54 | 9 |
| | 19 | 13 | 17 | 8 | - | 12 | 76 | 11 |
| 29 | 01 | 3 | 4.6 | 8 | R | 4 | 100 | 12 |
| | 07 | 2-1/2 | 1.2 | 7 | - | 4 | 100 | 12 |
| | 13 | 13 | 130 | 7 | - | 4 | 54 | 9 |
| | 19 | 13 | 130 | 5 | - | 4 | 61 | 9 |
| 30 | 01 | 3 | 17 | 5 | H | 2 | 66 | 8 |
| | 07 | 13 | 130 | 8 | - | 4 | 76 | 9 |
| | 13 | 13 | 17 | 8 | - | 8 | 58 | 9 |
| | 19 | 2-1/2 | 130 | 8 | - | 8 | 93 | 10 |
| 31 | 01 | 3 | U | C | H | 8 | 93 | 9 |
| | 07 | 2-1/2 | U | 2 | H | 8 | 93 | 9 |
| | 13 | 13 | 17 | 8 | - | 12 | 61 | 8 |
| | 19 | 2-1/2 | 130 | 8 | R | 4 | 93 | 10 |

Weather Symbols

| | |
|---|---|
| H | Haze |
| F | Fog |
| F- | Light Fog |
| L | Drizzle |
| R | Rain |
| RW | Rain Shower |
| TRW | Thunderstorm |
| S | Snow |

**TABLE 6-8(1). REPRESENTATIVE WEATHER SEQUENCES FOR ZONE 7c LEINEFELDE (5.°23'N 10°19'E 354 m.) (Ref. 16)**

Autumn
Oct. '60

| | Day/Hr(LST) | Visibility (s. mi.) | Ceiling (100's of feet) | Sky Cover (Eighths) | Weather | Wind Speed(KTS) | Relative Humidity(%) | Absolute Humidity($g/m^3$) |
|---|---|---|---|---|---|---|---|---|
| 1 | 01 | 3 | 130 | 8 | R | 14 | 93 | 7 |
| | 07 | 1 | 17 | 8 | R | 8 | 93 | 7 |
| | 13 | 4 | 17 | 8 | F- | 2 | 86 | 9 |
| | 19 | 2-1/2 | 130 | 7 | F- | C | 93 | 9 |
| 2 | 01 | 3 | U | 2 | F- | 2 | 93 | 8 |
| | 07 | 1/16 | 1.2 | 8 | F | 2 | 100 | 7 |
| | 13 | 8 | U | 3 | - | 6 | 66 | 9 |
| | 19 | 2-1/4 | U | C | F- | C | 93 | 9 |
| 3 | 01 | 3 | 130 | 8 | F- | 6 | 96 | 8 |
| | 07 | 1-7/8 | 130 | 8 | F- | 4 | 100 | 8 |
| | 13 | 7 | 130 | 5 | - | 6 | 71 | 9 |
| | 19 | 5 | 130 | 8 | F- | 2 | 89 | 10 |
| 4 | 01 | 4 | 130 | 6 | F- | 2 | 93 | 8 |
| | 07 | 3 | 130 | 6 | F- | 2 | 100 | 8 |
| | 13 | 7 | 130 | 6 | - | 8 | 63 | 10 |
| | 19 | 5 | 48 | 8 | F- | 2 | 83 | 10 |
| 5 | 01 | 11 | 130 | 5 | - | 6 | 83 | 10 |
| | 07 | 13 | U | 1 | - | 6 | 73 | 9 |
| | 13 | 19 | U | 3 | - | 6 | 54 | 9 |
| | 19 | 13 | 130 | 7 | - | C | 89 | 10 |
| 6 | 01 | 8 | U | C | F- | C | 100 | 9 |
| | 07 | 4 | U | 1 | F- | 2 | 100 | 8 |
| | 13 | 4 | 130 | 3 | H | 6 | 66 | 10 |
| | 19 | 4 | 130 | 5 | F- | C | 86 | 9 |
| 7 | 01 | 2-1/4 | 130 | 7 | F- | C | 100 | 9 |
| | 07 | 1-1/8 | 31 | 8 | F- | 4 | 100 | 10 |
| | 13 | 1-1/2 | 9 | 8 | F- | 6 | 96 | 11 |
| | 19 | 5/8 | 1.2 | 8 | R | 6 | 100 | 11 |
| 8 | 01 | 1/2 | 1.2 | 8 | R | 4 | 100 | 11 |
| | 07 | 3 | 17 | 8 | R | 4 | 100 | 10 |
| | 13 | 6 | 17 | 8 | F- | 6 | 86 | 9 |
| | 19 | 10 | 130 | 6 | - | 6 | 86 | 9 |

## TABLE 6-8(2). REPRESENTATIVE WEATHER SEQUENCES FOR ZONE 7c LEINEFELDE (51°23'N 10°19'E 354 m.) (Ref. 16)

Autumn
Oct. '60

| Day/Hr(LST) | | Visibility(s. mi.) | Ceiling(100's of feet) | Sky Cover(Eighths) | Weather | Wind Speed(KTS) | Relative Humidity(%) | Absolute Humidity (g/m³) |
|---|---|---|---|---|---|---|---|---|
| 9 | 01 | 9 | 130 | 6 | - | 2 | 89 | 8 |
| | 07 | 10 | 130 | 7 | - | 4 | 96 | 8 |
| | 13 | 22 | 130 | 8 | R | 8 | 74 | 8 |
| | 19 | 19 | 130 | 7 | - | 4 | 89 | 8 |
| 10 | 01 | 16 | U | 3 | - | 6 | 89 | 7 |
| | 07 | 14 | 31 | 8 | - | 8 | 89 | 7 |
| | 13 | 13 | 31 | 8 | - | 6 | 76 | 8 |
| | 19 | 11 | 31 | 8 | - | 8 | 89 | 8 |
| 11 | 01 | 8 | 17 | 8 | R | 12 | 96 | 8 |
| | 07 | 8 | 31 | 8 | - | 6 | 93 | 8 |
| | 13 | 8 | 31 | 7 | - | 10 | 86 | 9 |
| | 19 | 11 | 31 | 7 | - | 16 | 83 | 7 |
| 12 | 01 | 11 | 130 | 6 | - | 4 | 79 | 6 |
| | 07 | 16 | 17 | 6 | - | 14 | 76 | [illegible] |
| | 13 | 12 | 17 | 8 | R | 17 | 93 | 6 |
| | 19 | 4 | 17 | 8 | R | 8 | 93 | 7 |
| 13 | 01 | 8 | 17 | 8 | R | 12 | 93 | 7 |
| | 07 | 4 | 17 | 8 | - | 14 | 93 | 7 |
| | 13 | 10 | 17 | 8 | L | 8 | 93 | 7 |
| | 19 | 8 | 31 | 8 | - | 4 | 93 | 7 |
| 14 | 01 | 6 | 130 | 5 | F- | 4 | 86 | 6 |
| | 07 | 4 | U | 2 | F- | 4 | 93 | 6 |
| | 13 | 10 | U | 4 | - | 6 | 66 | 6 |
| | 19 | 6 | U | 2 | F- | C | 83 | 5 |
| 15 | 01 | 1-1/8 | U | C | F- | 2 | 93 | 5 |
| | 07 | 3/8 | U | 2 | F | C | 93 | 4 |
| | 13 | 4 | 130 | 8 | H | 10 | 76 | 6 |
| | 19 | 1 | 31 | 8 | F- | 4 | 79 | 6 |
| 16 | 01 | 2-1/4 | 17 | 8 | R | 2 | 86 | 6 |
| | 07 | 4 | 17 | 8 | R | 8 | 100 | 6 |
| | 13 | 2-1/2 | 17 | 8 | R | 10 | 100 | 7 |
| | 19 | 2-1/2 | 17 | 8 | R | 8 | 100 | 7 |
| 17 | 01 | 3 | 17 | 8 | R | 19 | 93 | 7 |
| | 07 | 3 | 9 | 8 | F- | 19 | 93 | 7 |
| | 13 | 3 | 4.6 | 8 | R | 23 | 100 | 7 |
| | 19 | 4 | 17 | 8 | F- | 14 | 93 | 6 |
| 18 | 01 | 5 | 17 | 8 | R | 12 | 100 | 6 |
| | 07 | 3 | 17 | 8 | R | 12 | 93 | 6 |
| | 13 | 2-1/2 | 17 | 8 | R | 10 | 93 | 7 |
| | 19 | 8 | 130 | 5 | - | C | 93 | 6 |

**TABLE 6-8(3). REPRESENTATIVE WEATHER SEQUENCES FOR ZONE 7c**
**LEINEFELDE ($51^{\circ}23'$N $10^{\circ}19'$E 354 m.) (Ref. 16)**

Autumn
Oct. '60

| Day/Hr(LST) | | Visibility (s. mi.) | Ceiling (100's of feet) | Sky Cover (Eighths) | Weather | Wind Speed(KTS) | Relative Humidity(%) | Absolute Humidity($g/m^3$) |
|---|---|---|---|---|---|---|---|---|
| 19 | 01 | 1-5/8 | 17 | 8 | F- | 2 | 93 | 6 |
| | 07 | 1-3/8 | 17 | 8 | R | C | 100 | 6 |
| | 13 | 10 | 130 | 8 | - | C | 83 | 7 |
| | 19 | 0 | 1.2 | 8 | F | 2 | 100 | 7 |
| 20 | 01 | 0 | 1.2 | 8 | [illegible] | C | 100 | 6 |
| | 07 | 1/16 | 1.2 | 8 | F | 4 | 100 | 5 |
| | 13 | 2 | 130 | 8 | F- | 4 | 96 | 8 |
| | 19 | 1/2 | 1.2 | 8 | F | 4 | 100 | 8 |
| 21 | 01 | 1-1/8 | 130 | 8 | F- | 16 | 100 | 7 |
| | 07 | 1-1/8 | 17 | 8 | R | 4 | 100 | 7 |
| | 13 | 1-1/8 | 17 | 8 | F- | 2 | 93 | 7 |
| | 19 | 3 | 130 | 7 | F- | C | 96 | 8 |
| 22 | 01 | 4 | U | 3 | F | 2 | 93 | 7 |
| | 07 | 8 | U | 4 | F | 4 | 93 | 7 |
| | 13 | 11 | 130 | 8 | - | 6 | 83 | 8 |
| | 19 | 11 | 130 | 8 | R | 4 | 96 | 8 |
| 23 | 01 | 9 | 31 | 8 | - | 4 | 100 | 8 |
| | 07 | 11 | 48 | 8 | - | 12 | 96 | 8 |
| | 13 | 11 | 82 | 8 | - | 4 | 86 | 9 |
| | 19 | 4 | 17 | 8 | R | 2 | 93 | 9 |
| 24 | 01 | 7 | 130 | 7 | - | 6 | 86 | 9 |
| | 07 | 9 | 130 | 6 | - | C | 93 | 8 |
| | 13 | 12 | 31 | 6 | - | 4 | 76 | 10 |
| | 19 | 12 | 130 | 8 | R | 2 | 93 | 9 |
| 25 | 01 | 14 | U | 3 | - | C | 93 | 9 |
| | 07 | 1/[illegible] | 130 | 8 | F | C | 100 | 8 |
| | 13 | 18 | 130 | 6 | - | 4 | 83 | 10 |
| | 19 | 8 | 130 | 6 | - | C | 93 | 9 |
| 26 | 01 | 3/16 | 1.2 | 8 | F | 6 | 100 | 9 |
| | 07 | 7/8 | 4.6 | 8 | F | 12 | 100 | 8 |
| | 13 | 1 | 4.6 | 8 | R | 6 | 93 | 8 |
| | 19 | 5 | 9 | 8 | R | 6 | 93 | 9 |
| 27 | 01 | 8 | 17 | 7 | - | 17 | 89 | 8 |
| | 07 | 19 | 130 | 7 | - | 14 | 89 | 7 |
| | 13 | 18 | 31 | 8 | R | 12 | 83 | 8 |
| | 19 | 11 | 31 | 6 | - | 6 | 96 | 8 |

### TABLE 6-8(4). REPRESENTATIVE WEATHER SEQUENCES FOR ZONE 7c LEINEFELDE (51°23'N 10°19'E 354 m.) (Ref. 16)

Autumn
Oct. '60

| | Day/Hr(LST) | Visibility(s. mi.) | Ceiling(100's of feet) | Sky Cover(Eighths) | Weather | Wind Speed(KTS) | Relative Humidity(%) | Absolute Humidity($g/m^3$) |
|---|---|---|---|---|---|---|---|---|
| 28 | 01 | 6 | U | C | F- | 4 | 93 | 7 |
| | 07 | 10 | 130 | 5 | - | C | 93 | 6 |
| | 13 | 11 | U | 3 | - | 2 | 66 | 8 |
| | 19 | 6 | 130 | 6 | F- | 2 | 93 | 8 |
| 29 | 01 | 6 | 130 | 8 | - | 4 | 89 | 7 |
| | 07 | 4 | 82 | 8 | F- | 6 | 83 | 7 |
| | 13 | 3 | 130 | 8 | F- | 12 | 79 | 8 |
| | 19 | 2-1/2 | 130 | 5 | F- | 2 | 93 | 8 |
| 30 | 01 | 1/16 | 1.2 | 8 | F | C | 100 | 8 |
| | 07 | 14 | 130 | 8 | - | 2 | 89 | 8 |
| | 13 | 16 | 31 | 8 | R | 4 | 86 | 8 |
| | 19 | 12 | 31 | 8 | R | 8 | 96 | 8 |
| 31 | 01 | 10 | 31 | 8 | R | 10 | 96 | 8 |
| | 07 | 11 | 31 | 8 | R | 2 | 96 | 8 |
| | 13 | 15 | 31 | 8 | R | 6 | 83 | 8 |
| | 19 | 11 | 130 | 8 | - | 6 | 93 | 8 |

<u>Weather Symbols</u>

| | |
|---|---|
| H | Haze |
| F | Fog |
| F- | Light Fog |
| L | Drizzle |
| R | Rain |
| RW | Rain Shower |
| TRW | Thunderstorm |
| S | Snow |

TABLE 6-9(1). REPRESENTATIVE WEATHER SEQUENCES FOR ZONE 7c LEINEFELDE (51°23'N 10°19'E 354 m.) (Ref. 16)

Winter
Dec. '59

| Day/Hr(LST) | | Visibility(s. mi.) | Ceiling (100's of feet) | Sky Cover (Eighths) | Weather | Wind Speed(KTS) | Relative Humidity(%) | Absolute Humidity($g/m^3$) |
|---|---|---|---|---|---|---|---|---|
| 1 | 01 | 3/16 | 1.2 | 8 | F | 6 | 93 | 5 |
| | 07 | 1/16 | 1.2 | 8 | F | 8 | 100 | 5 |
| | 13 | 7/8 | 9 | 8 | - | 6 | 100 | 6 |
| | 19 | 0 | 1.2 | 8 | F | 2 | 100 | 5 |
| 2 | 01 | 0 | 1.2 | 8 | F | C | 100 | 5 |
| | 07 | 0 | 1.2 | 8 | F | 4 | 100 | 5 |
| | 13 | 1/16 | 1.2 | 8 | F | 6 | 100 | 5 |
| | 19 | 1/4 | 1.2 | 8 | L | 2 | 93 | 5 |
| 3 | 01 | 1-1/2 | 17 | 8 | - | 6 | 93 | 5 |
| | 07 | 2-1/4 | 17 | 8 | F- | 6 | 93 | 5 |
| | 13 | 4 | 17 | 8 | F- | 6 | 93 | 6 |
| | 19 | 4 | 31 | 8 | F- | 6 | 83 | 5 |
| 4 | 01 | 4 | 31 | 6 | F- | 4 | 89 | 5 |
| | 07 | 4 | 31 | 8 | F- | 4 | 93 | 5 |
| | 13 | 6 | 130 | 6 | F- | 6 | 83 | 5 |
| | 19 | 11 | 31 | 7 | - | C | 86 | 5 |
| 5 | 01 | 8 | U | 3 | - | 4 | 86 | 5 |
| | 07 | 5 | 130 | 7 | F- | 2 | 93 | 5 |
| | 13 | 6 | 31 | 8 | F- | 2 | 89 | 5 |
| | 19 | 3 | 31 | 8 | F- | C | 89 | 5 |
| 6 | 01 | 1-5/8 | 31 | 8 | F- | C | 93 | 5 |
| | 07 | 1-3/4 | 17 | 8 | F- | C | 86 | 5 |
| | 13 | 3 | 17 | 7 | F- | 2 | 89 | 5 |
| | 19 | 5/8 | 1.2 | 8 | F | 6 | 91 | 5 |
| 7 | 01 | 5/8 | 1.2 | 8 | F | 6 | 93 | 4 |
| | 07 | 1 | 4.6 | 8 | F- | 16 | 100 | 4 |
| | 13 | 1/2 | 1.2 | 8 | F | 17 | 100 | 4 |
| | 19 | 1-3/8 | 9 | 8 | F- | 16 | 93 | 3 |
| 8 | 01 | 1-7/8 | 17 | 8 | F- | 16 | 93 | 3 |
| | 07 | 1-3/4 | 17 | 8 | F- | 14 | 93 | 3 |
| | 13 | 1-1/8 | 17 | 8 | F- | 12 | 93 | 3 |
| | 19 | 1-3/8 | 17 | 8 | F- | 12 | 93 | 3 |

TABLE 6-9(2). REPRESENTATIVE WEATHER SEQUENCES FOR ZONE 7c
LEINEFELDE ($51^{o}23$'N $10^{o}19$'E 354 m.) (Ref. 16)

Winter
Dec. '59

| | Day/Hr(LST) | Visibility(s. mi.) | Ceiling(100's of feet) | Sky Cover(Eighths) | Weather | Wind Speed(KTS) | Relative Humidity(%) | Absolute Humidity ($g/m^3$) |
|---|---|---|---|---|---|---|---|---|
| 9 | 01 | 1-3/8 | 9 | 8 | F- | 10 | 96 | 3 |
| | 07 | 2 | 17 | 8 | F- | 4 | 93 | 3 |
| | 13 | 2 | 17 | 8 | F- | 4 | 93 | 3 |
| | 19 | 1-1/2 | 17 | 8 | F- | 6 | 93 | 3 |
| 10 | 01 | 3/8 | 1.2 | 8 | F | 6 | 93 | 3 |
| | 07 | 3/4 | 17 | 8 | L | 6 | 100 | 4 |
| | 13 | 3/4 | 9 | 8 | - | 8 | 96 | 4 |
| | 19 | 1-1/2 | 17 | 8 | S | 21 | 100 | 4 |
| 11 | 01 | 1-1/8 | 17 | 8 | F- | 16 | 93 | 4 |
| | 07 | 1-3/4 | 17 | 8 | F- | 23 | 100 | 4 |
| | 13 | 1/2 | 1.2 | 8 | F | 17 | 93 | 4 |
| | 19 | 7/8 | 9 | 8 | L | 10 | 93 | 3 |
| 12 | 01 | 1-1/4 | 17 | 8 | S | 6 | 93 | 3 |
| | 07 | 2 | 17 | 8 | S | 2 | 93 | 3 |
| | 13 | 2-1/4 | 17 | 7 | - | 10 | 93 | 4 |
| | 19 | 2 | 17 | 8 | S | 4 | 93 | 4 |
| 13 | 01 | 2-1/2 | 17 | 8 | F- | 6 | 96 | 4 |
| | 07 | 2-1/4 | 17 | 8 | F- | 6 | 93 | 4 |
| | 13 | 2-1/2 | 17 | 8 | S | 2 | 93 | 4 |
| | 19 | 4 | 31 | 8 | F | 2 | 93 | 3 |
| 14 | 01 | 3 | 31 | 8 | F- | C | 86 | 3 |
| | 07 | 2-1/2 | 31 | 8 | F- | 2 | 93 | 3 |
| | 13 | 3 | 31 | 8 | F- | 4 | 86 | 3 |
| | 19 | 3 | 31 | 8 | F- | 6 | 79 | 3 |
| 15 | 01 | 3 | 130 | 7 | F- | 4 | 86 | 3 |
| | 07 | 3 | 31 | 8 | F- | 6 | 93 | 3 |
| | 13 | 3 | 31 | 8 | F- | 4 | 86 | 3 |
| | 19 | 3 | 31 | 7 | F- | 8 | 86 | 3 |
| 16 | 01 | 4 | 17 | 5 | F- | 6 | 86 | 3 |
| | 07 | 4 | 17 | 8 | F- | 2 | 89 | 4 |
| | 13 | 2 | 17 | 8 | F- | 6 | 93 | 4 |
| | 19 | 2-1/2 | 31 | 8 | F- | C | 86 | 4 |
| 17 | 01 | 3 | U | 3 | F- | 6 | 86 | 4 |
| | 07 | 3 | U | 3 | F- | 6 | 86 | 4 |
| | 13 | 5 | 130 | 7 | F- | 14 | 83 | 5 |
| | 19 | 4 | 17 | 8 | R | 14 | 93 | 6 |
| 18 | 01 | 3 | 17 | 8 | R | 16 | 93 | 7 |
| | 07 | 6 | 17 | 7 | F- | 8 | 86 | 6 |
| | 13 | 25 | 31 | 8 | - | 10 | 86 | 6 |
| | 19 | 16 | 31 | 8 | - | 12 | 83 | 5 |

TABLE 6-9(3). REPRESENTATIVE WEATHER SEQUENCES FOR ZONE 7c
LEINEFELDE (51°23'N 10°19'E 354 m.) (Ref. 16)

Winter
Dec. '59

| | Day/Hr(LST) | Visibility (s. mi.) | Ceiling (100's of feet) | Sky Cover (Eighths) | Weather | Wind Speed(KTS) | Relative Humidity(%) | Absolute Humidity(g/m³) |
|---|---|---|---|---|---|---|---|---|
| 19 | 01 | 9 | 31 | 8 | - | 16 | 93 | 6 |
| | 07 | 6 | 31 | 8 | R | 14 | 93 | 6 |
| | 13 | 5 | 31 | 8 | R | 6 | 89 | 5 |
| | 19 | 5 | U | 1 | F- | 8 | 79 | 4 |
| 20 | 01 | 3 | 17 | 8 | R | 8 | 93 | 5 |
| | 07 | 6 | 17 | 8 | F- | 16 | 96 | 5 |
| | 13 | 16 | 17 | 8 | - | 14 | 86 | 6 |
| | 19 | 10 | 31 | 8 | L | 14 | 93 | 7 |
| 21 | 01 | 4 | 130 | 8 | R | 6 | 86 | 7 |
| | 07 | 6 | 31 | 8 | R | 4 | 93 | 6 |
| | 13 | 16 | 31 | 8 | RW | 4 | 93 | 6 |
| | 19 | 9 | 31 | 8 | - | 2 | 93 | 5 |
| 22 | 01 | 10 | 31 | 7 | - | 2 | 86 | 5 |
| | 07 | 6 | 31 | 8 | F- | 2 | 93 | 5 |
| | 13 | 6 | U | 3 | F- | 2 | 83 | 5 |
| | 19 | 6 | U | 1 | F- | 8 | 79 | 4 |
| 23 | 01 | 4 | 130 | 8 | F- | 8 | 79 | 4 |
| | 07 | 4 | 130 | 7 | - | 7 | 89 | 5 |
| | 13 | 11 | 17 | 7 | - | 7 | 86 | 6 |
| | 19 | 13 | U | 2 | - | 2 | 74 | 6 |
| 24 | 01 | 3 | 31 | 8 | F- | C | 93 | 6 |
| | 07 | 6 | 130 | 8 | F- | 2 | 89 | 5 |
| | 13 | 13 | 31 | 7 | - | 4 | 83 | 5 |
| | 19 | 11 | U | 1 | - | C | 83 | 5 |
| 25 | 01 | 11 | U | 1 | - | 4 | 86 | 4 |
| | 07 | 10 | 48 | 6 | - | 4 | 89 | 5 |
| | 13 | 16 | 31 | 8 | - | 6 | 93 | 6 |
| | 19 | 9 | 130 | 8 | R | 10 | 86 | 6 |
| 26 | 01 | 7 | 31 | 8 | R | 12 | 93 | 6 |
| | 07 | 13 | 130 | 8 | - | 14 | 86 | 6 |
| | 13 | 18 | 31 | 8 | RW | 19 | 86 | 6 |
| | 19 | 19 | 130 | 7 | - | 23 | 71 | 5 |
| 27 | 01 | 10 | 17 | 8 | R | 25 | 89 | 7 |
| | 07 | 19 | U | 2 | - | 21 | 76 | 5 |
| | 13 | 38 | 130 | 6 | - | 23 | 71 | 5 |
| | 19 | 13 | 130 | 8 | - | 4 | 76 | 5 |

TABLE 6-9(4). REPRESENTATIVE WEATHER SEQUENCES FOR ZONE 7c
LEINEFELDE (51°23'N 10°19'E 354 m.) (Ref. 16)

Winter
Dec. '59

| Day | Hr(LST) | Visibility(s. mi.) | Ceiling(100's of feet) | Sky Cover(Eighths) | Weather | Wind Speed(KTS) | Relative Humidity(%) | Absolute Humidity(g/m³) |
|---|---|---|---|---|---|---|---|---|
| 28 | 01 | 4 | 31 | 8 | F- | 14 | 86 | 6 |
| | 07 | 3 | 31 | 8 | R | 10 | 89 | 5 |
| | 13 | 22 | 130 | 6 | - | 8 | 83 | 5 |
| | 19 | 13 | 31 | 8 | - | 2 | 89 | 5 |
| 29 | 01 | 11 | 31 | 8 | - | 4 | 96 | 5 |
| | 07 | 5 | 31 | 8 | R | 6 | 93 | 6 |
| | 13 | 14 | 31 | 8 | - | 12 | 93 | 6 |
| | 19 | 5 | 130 | 8 | F- | 6 | 89 | 5 |
| 30 | 01 | 4 | 130 | 8 | R | 10 | 89 | 5 |
| | 07 | 6 | 31 | 8 | R | 19 | 93 | 6 |
| | 13 | 22 | 31 | 7 | - | 19 | 79 | 6 |
| | 19 | 16 | 31 | 7 | - | 27 | 76 | 5 |
| 31 | 01 | 5 | 130 | 7 | F- | 14 | 83 | 5 |
| | 07 | 6 | 31 | 8 | F- | 4 | 89 | 5 |
| | 13 | 9 | 48 | 8 | - | 6 | 79 | 6 |
| | 19 | 8 | U | 2 | - | 2 | 93 | 6 |

Weather Symbols

| | |
|---|---|
| H | Haze |
| F | Fog |
| F- | Light Fog |
| L | Drizzle |
| R | Rain |
| RW | Rain Shower |
| TRW | Thunderstorm |
| S | Snow |

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