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REFRACTIVITY GRADIENTS IN THE NORTHERN HEMISPHERE

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REFRACTIVITY GRADIENTS IN THE NORTHERN HEMISPHERE

C.A. Samson*

The continued expansion of microwave radio links and the resulting congestion have increased the need for better performance estimates. In the evaluation of refractivity effects, the designer may wish to consider the average gradients at specific locations for different seasons, as well as diurnal changes. This report presents graphs showing the cumulative probability distributions of the atmospheric radio refractivity gradients in the ground-based 100-m layer for 87 stations in the Northern Hemisphere. These are based on climatological data from radiosonde observations, and show the average conditions in one month of each season. A limited number of diurnal comparisons are included, as well as information on the climate of each site.

Key words: Refractivity gradients, radiosonde data

1. INTRODUCTION

The increasing demand for radio services, particularly those requiring wide bandwidths, is a universal problem. In the United States, for example, there has been rapid development in recent years of the specialized common carrier industry and increased utilization of CARS** microwave links. Because of frequency congestion, many new systems are using frequencies above 10 GHz, which are more susceptible to various atmospheric effects than the lower microwave frequencies.

One of the most important influences on system performance is the bending of the radio beam caused by variations in the vertical refractivity gradient. This is a factor in the determination of the maximum feasible path length, the probability of multipath fading or ducting, and the ultimate reliability of a given link and system. The

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**Community Antenna Relay Service

radio path of most terrestrial line-of-sight microwave links is relatively close to the surface, and the gradients in the lowest 100-m layer are therefore more suitable for propagation estimates than the gradients over the lowest 1 km. Microwaves may be affected by atmospheric layers of rather limited vertical extent, and 1-km layer statistics tend to smooth out many of the extreme gradients.

Information on the refractivity gradients to be expected in any part of the world is available in the "World Atlas of Atmospheric Radio Refractivity" (Bean et al., 1966). This Atlas contains maps showing the 100-m gradients exceeded for selected percentages of time. For application to the design of radio links, many engineers prefer a complete cumulative time probability distribution of the gradients at specific locations. The Atlas contains such distributions of the 50-m gradients at 22 stations worldwide; the present report supplements the Atlas by providing distributions of 100-m gradients at 87 stations in the Northern Hemisphere (see map, figure 1, and station index, Appendix C). Data for four months of the year are shown on the same graph to facilitate seasonal comparisons. Accompanying each graph is information on the length of record analyzed, the hours at which observations were taken, and general climatic and topographic details in the vicinity of the station.

2. SOURCE OF DATA

Refractivity gradients can be calculated from the radiosonde observations (RAOBs) made by national meteorological services in the various countries (see Appendix A). Although these observations of the vertical changes in temperature, pressure, and humidity do not provide as much detail and accuracy as is desirable for studies of radio refractivity, they are the only available source of worldwide, long-term, upper-air data.

Climatological RAOB data for the U.S. and many foreign locations are on file at the National Climatic Center in Asheville, N.C. The analysis of these data to obtain refractivity statistics requires that the refractive index be calculated for the individual data points on

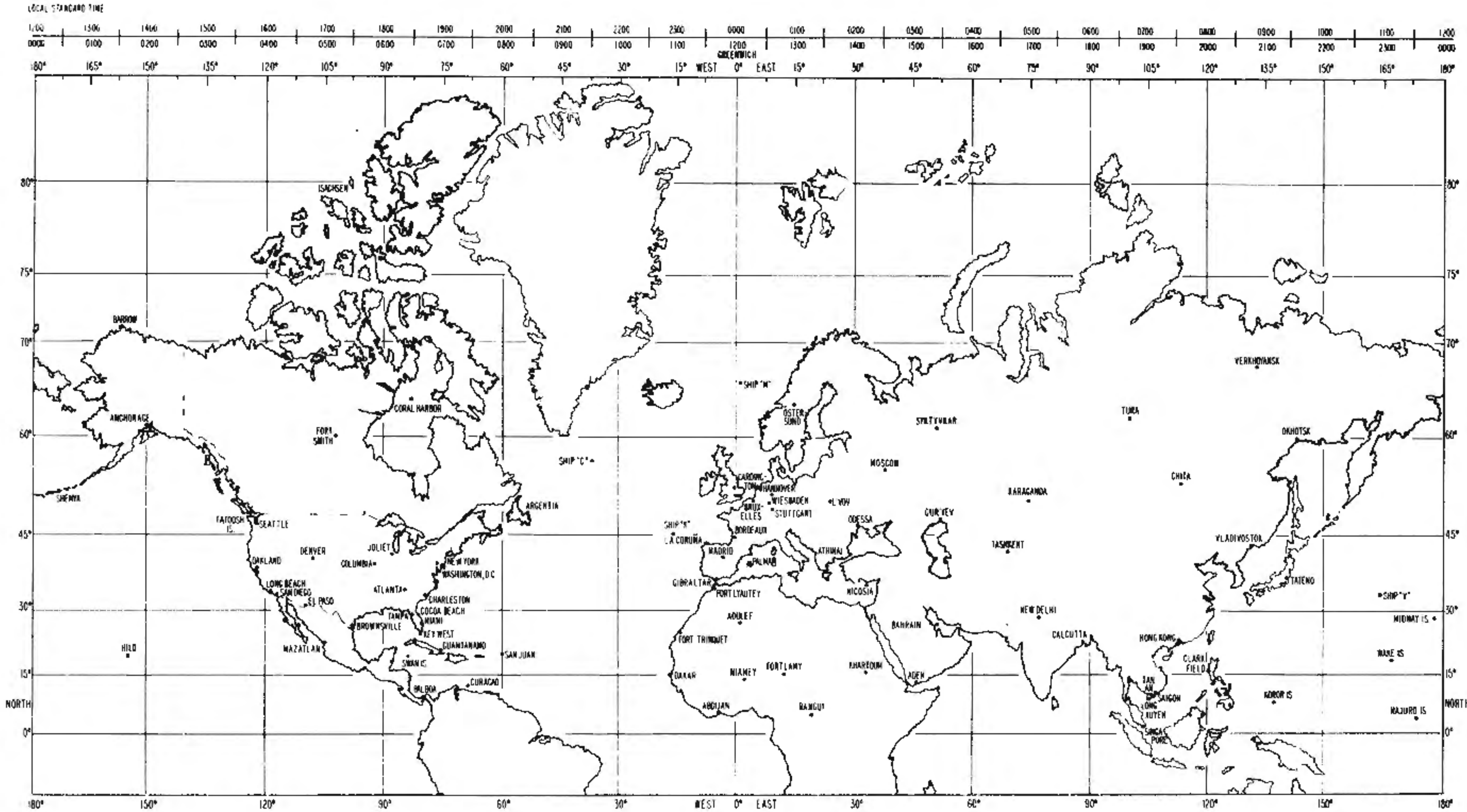

Figure 1. Location of stations for which refractivity gradient data are given in Appendix C.

each sounding; an interpolation must be made to obtain the refractivity value at the desired height (for example, 100 meters above ground); and the gradient over the interval (ground surface to 100 m) can then be calculated. To avoid possible misleading indications related to the year-to-year variations in weather conditions, data for a number of years must be considered if a good climatological average is to be obtained.

Most of the gradient distributions in this report were calculated at the Institute for Telecommunication Sciences (ITS) in Boulder as a part of a project sponsored by the U.S. Navy Weather Research Facility to prepare worldwide refractivity information in map format (Bean et al., 1966). To the extent possible at the time, climatic data for a 5-year period, including two observations per day, were used in this analysis. Only one month in each season was processed, and the observations at different times of day were not treated separately, with the exceptions of Aden and Nicosia. Stations were selected to provide wide geographical coverage, rather than to give a dense coverage in a few areas (i.e., funding limitations prevented any attempt to analyze all available RAOB data). In the U.S., for example, figure 1 shows that data from only 22 stations have been analyzed; figure 2 indicates a total of 85 stations in the domestic RAOB network of the National Weather Service as of October 1973 (NOAA, 1973). Thus, greatly increased density of coverage of refractivity information is possible in the U.S., but it should be noted that figure 2 indicates only locations where the basic data (temperature, pressure, humidity) would be available; refractivity is not routinely calculated at most RAOB stations.

This report includes additional refractivity data based upon work done in other projects or by institutes in other countries. Not all analyses cover periods of several years--a few are based on data for only one month. While these shorter periods do not provide good climatological statistics, the analyses have been included to illustrate the type of diurnal variations to be expected, to indicate a later verification of an earlier analysis, or to provide information on areas where no other refractivity data were available. Errata and supplementary

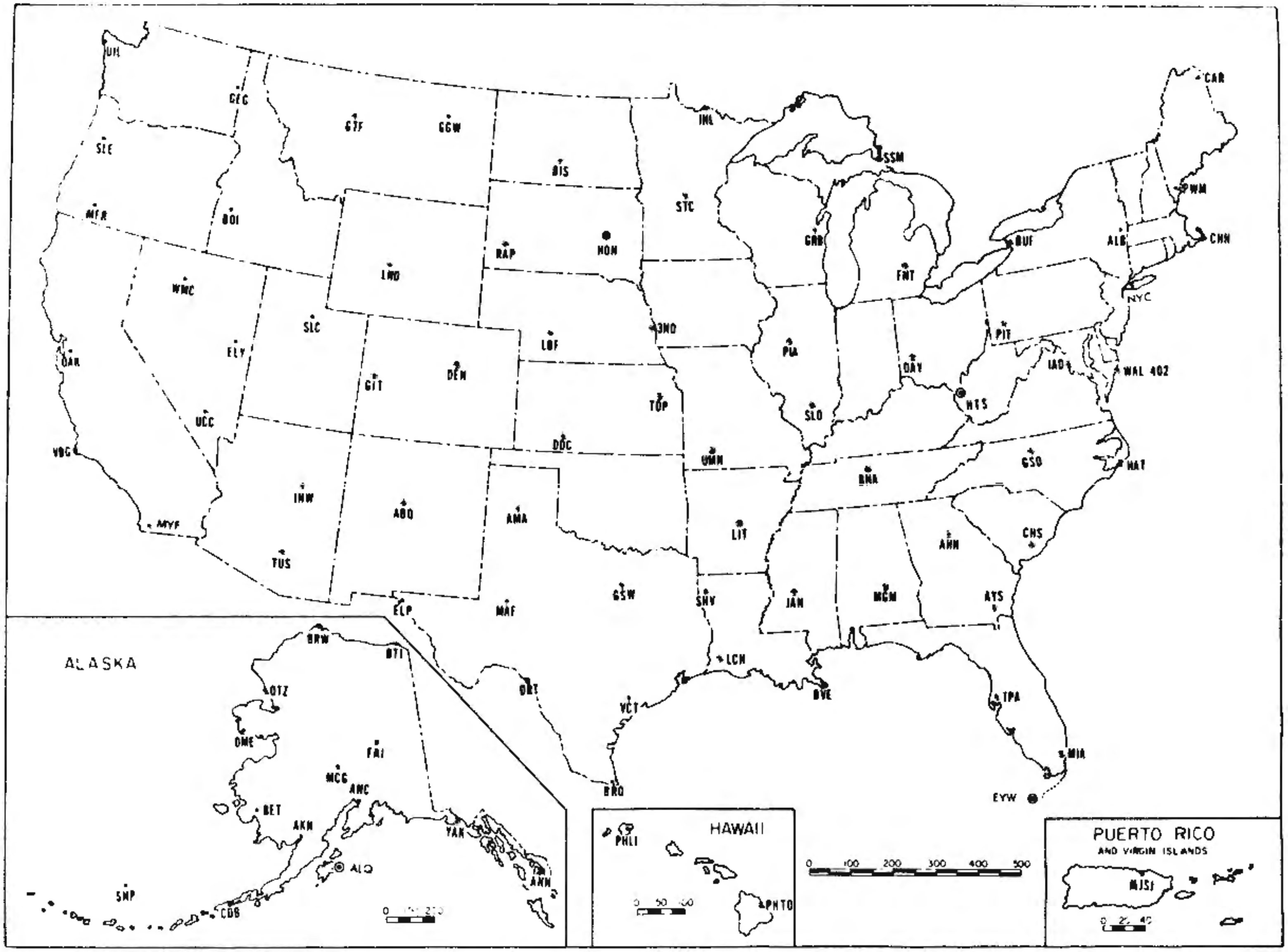

Figure 2. Domestic radiosonde network of the U.S. National Weather Service, October 1973.

information for "A World Atlas of Atmospheric Radio Refractivity" (Bean et al., 1966) are also included as Appendix D.

3. DATA PRESENTATION

Scale. Each graph has a dual scale on the ordinate to show both the refractivity gradient in N-units/km and the equivalent effective earth radius factor, "k", which is used to compensate for ray bending in terrain profile analysis of radio links. The factor "k" is related to the refractivity gradient $\Delta N/\Delta h$ in N-units/km by

$$k \simeq \left[1 + 6370 \frac{\Delta N}{\Delta h} \times 10^{-6}\right]^{-1}$$

where 6370 km represents the actual earth radius (Dougherty, 1968).

Time. Prior to 1957 the standard time of RAOBs was 0300Z and 1500Z; since then it has been 0000Z and 1200Z. In this report, all times of observation have been converted to an arbitrary "Local Standard Time" (LST) based on the assumption of zones exactly 15 degrees wide and centered on longitudes of 0°, 15°, 45°, etc. Figure 1 has a scale for comparing the local time of observation with the standard 0000Z and 1200Z observations based on the local time on the Greenwich meridian.

Refractivity Distributions. Unless otherwise indicated, the graphs show the cumulative distribution of the radio refractivity gradients in the ground-based 100-m layer, as calculated from radiosonde observations during the period specified under "Data". The analyses are by ITS, except where other agencies or individuals are referenced below the graph.

Each curve shown is based on all observations in a particular month for the period indicated, and includes data obtained from observations at more than one time of day, if available. For Aden and Nicosia, however, the data were analyzed separately for the different times of observation, and additional graphs are presented which indicate the characteristic differences between observations at different times of day at these stations. For shorter periods, diurnal characteristics are also shown for Calcutta, Clark Field, Tampa, and Tan An.

Three month's data were used in the analyses for each season for Gibraltar, La Coruña, and Palma, and gradients were calculated for the layer between the surface and the next data point on the individual RAOB rather than for the standard 100-m layer. Thus, the layer thickness varied from observation to observation. A study of the sub-refractive gradients included in these data showed that this surface-based layer was always less than 200 meters thick, and more than 50% of the layers were between 60 and 140 meters thick. Thus these analyses probably give a reasonably good indication of the type of gradients likely to occur in a 100-m layer. A similar analysis is shown for Madrid, in addition to the conventional 100-m analysis, but note that the data periods are different.

The distributions for Hannover, Stuttgart, and Brussels are based upon data for all months of the periods indicated, and include two observations per day. The Gross Rohrheim data were obtained from a 60-m meteorological tower equipped with psychrometers for measuring temperature and humidity.

The data for Long Xuyen were obtained with a "high resolution" radiosonde technique, which uses slow-rising balloons and transmits temperature and humidity data simultaneously (rather than in the alternately switched mode of the standard RAOB).

The Cardington data were obtained from psychrometer measurements using a tethered balloon, and show clearly the change in gradient probability as the layer thickness is varied.

Climatic Data. To simplify the presentation, no references are cited on the individual station entries, but the climatic data sources are included in the list of references. The English units used in the source documents have been retained, since the user of this report is likely to be most familiar with climate in such terms.

The following are listed for most stations:

Temperature	-	the average daily maximum and minimum for January and July.*
Mean Dewpoint	-	the mean dewpoint temperature at the surface for January and July.
Precipitation	-	the average annual total, and the average monthly total of the wettest and driest months.

At the ship stations, the "average" temperature is listed, i.e., the average of daily maximum and minimum readings. The dewpoint entry has been omitted at a number of locations where the data were not available. A brief description of the station location is given, and also a general climatic classification. These climatic data are intended only for preliminary comparisons of stations in different climatic regions; reference should be made to more complete climatic analyses when applying the refractivity data to performance estimates or link design.

4. DISCUSSION

The graphs show the percentage of the observations in which various refractivity gradients were found in the lowest 100 meters; they do not indicate the percentage of time in a year that such gradients can be expected. Although the latter statistics are desired for propagation and system performance estimates, the available data are insufficient to make such a determination. The radiosonde package rises through the lowest 100-m layer in less than 30 seconds, and this only twice a day at most stations. Thus, we have available two very brief samplings of atmsopheric structure daily, rather than frequent or continuous measurements. It seems unlikely that the extremes of the diurnal gradient variation would always occur at 0000Z and 1200Z (or 0300Z and 1500Z), therefore the refractivity gradient statistics based on RAOBs can be assumed to show a lower probability of occurrence of the extreme gradients than would be the case if observations were made hourly.

*Note that these are not the extremes for the period of record; for example, at Denver the average daily maximum and minimum temperatures in January are 42° and 15°F, but the extreme (or record) values for the month are 69° and -25°F.

The graphs are especially useful for station-to-station comparisons, such as estimating the probability of subrefraction in two areas with differing climates where performance data are available for only one of the areas. Thus, the relative probability of a certain k-value being exceeded can be estimated by reference to the graphs, as can strong superrefraction or ducting. In making such estimates, however, one should check both the length of record and the number of observations per day at a particular station. Also, the local time of the observations should be considered; for example, a distribution based primarily on nighttime (or only daytime) observations may give a distorted indication of the overall probability of occurrence of various gradients.

Variations in refractivity gradients tend to be closely related to the local or sun-referenced time, because of the influence of heating and cooling of the earth's surface on the stratification of air layers near the ground. For example, extreme gradients of refractivity often occur near sunrise, when nocturnal temperature inversions tend to be most pronounced, and near sunset, when there is a rapid shift from gain to loss of heat in the air layer near the ground. RAOBs, however, are taken at standard times which do not always coincide with the local time when extreme gradients are most likely to occur.

The variation of sunrise/sunset times during the year should also be considered, particularly at high-latitude stations. As an example, figure 3 shows the approximate time of sunrise and sunset at Fort Smith, N.W.T. (latitude 60°N), as compared to the normal release time of the standard 0000Z and 1200Z RAOB (i.e., about 30 minutes prior to the "standard" time of observation). In December both observations would effectively be night observations, while in mid-summer both observations are between sunrise and sunset. (This is also true of the 0300Z and 1500Z observations that were used in preparing the refractivity distributions for Fort Smith).

The atmospheric layers near the surface are greatly influenced by terrain features, ground moisture sources, and vegetation; thus, on most long overland paths, low-level refractivity gradients can be

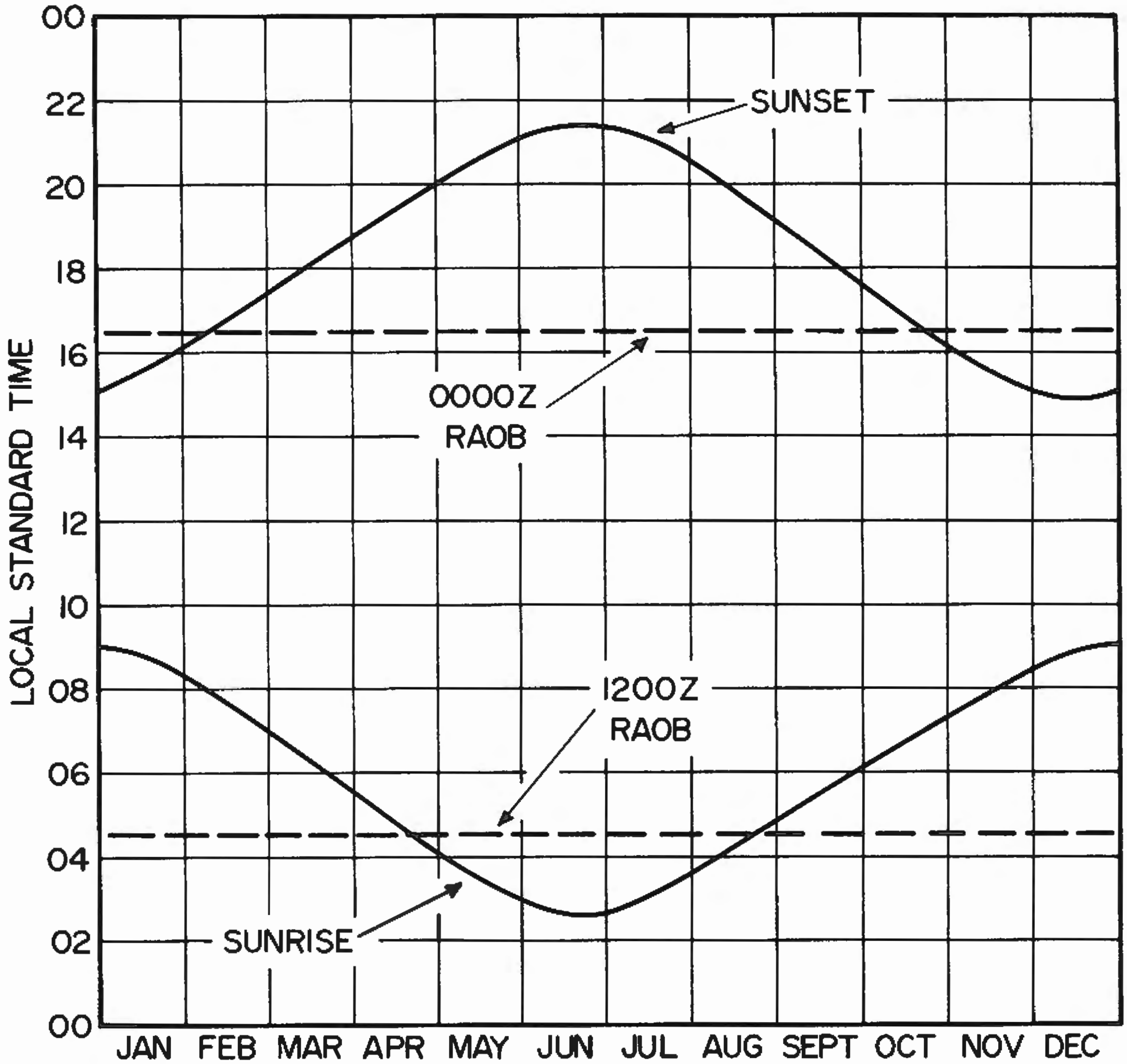

Figure 3. Relationship between sunrise/sunset times and the standard RAOB release time at Fort Smith, N.W.T.

expected to vary by appreciable amounts over distances on the order of a few kilometers. The net result of this variation in space should be to produce less extreme effective path gradients than might be assumed from consideration of radiosonde data at one point on the path. On the other hand, the RAOB data are likely to yield conservative indications of gradient intensity because of the very limited sampling period per day. This poses a dilemma that is not easily resolved. The relationship between point and path refractivity is not known, and the total time per year in which certain gradients will affect a given path must be estimated from the statistics of occurrence during two very brief observations each day at some weather station possibly hundreds of kilometers from the radio path.

Relative to the relationship between point and effective path refractivity gradients, Boithias and Battesti (1967) suggest that the minimum effective value of k varies considerably with the path length, as shown in figure 4. The general relationship is consistent with the idea that the more extreme positive refractivity gradients near the surface are greatly influenced by local conditions of terrain, moisture sources, etc., and are not likely to extend over wide areas. A further comment from a microwave design handbook (Lenkurt, 1970) is as follows:

> Experience has indicated that, for actual microwave paths, the effective k over the entire path reaches a very high or very low value for a much smaller percentage of time than would be indicated by the distribution of k values as found by meteorological measurements at single points. The most probable explanation is that the unusual conditions causing these extreme values are unlikely to occur over more than a small part of the path at any given instant.

The CCIR (1970) reports that a study of 300,000 hours of chart recordings from 21 radio relay stations in the United Kingdom, on links designed more or less for 0.6 of the first Fresnel zone clearance with k = 0.7, showed <u>no</u> instances of diffraction or "earth bulge" fading. This appears to indicate that the design criteria may be too conservative, and that smaller clearance might be adequate. There is at present, however, insufficient evidence to suggest by how much the clearance can be reduced with safety.

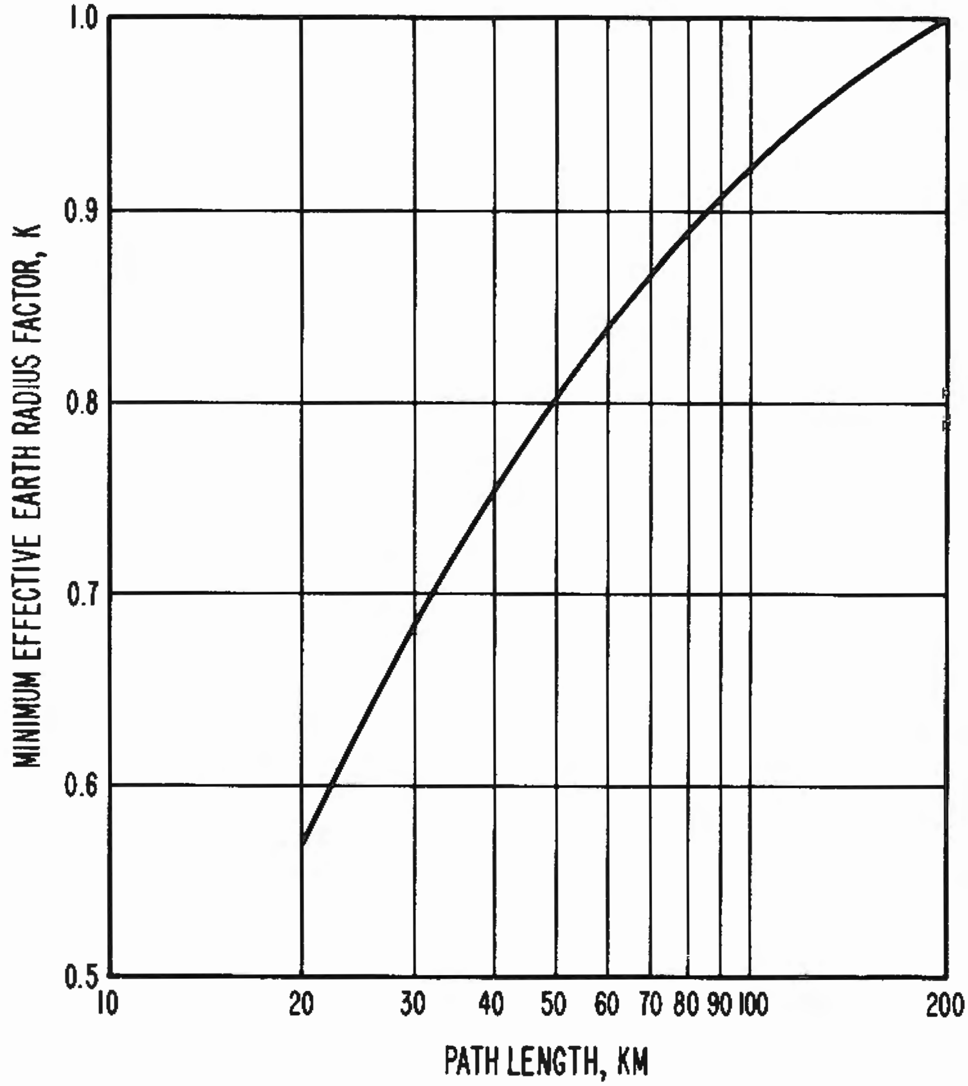

Figure 4. Minimum effective value of "k" exceeded for approximately 99.9% of the time in a continental temperate climate (CCIR, 1970).

Coastal areas and river valleys are especially likely to have anomalous propagation related to air stratification, and extreme refractivity values are most likely to occur in layers of rather limited vertical extent. The decrease in probability of extreme gradients that occurs as the averaging interval is increased is illustrated by the distribution for Cardington (see Appendix C).

Tropical and sub-tropical regions generally have larger diurnal and interdiurnal variations in refractivity gradients than do temperate regions (Hart et al., 1971). Extreme gradients are also much more common in the tropics, and over layers of limited thickness (up to a few tens of meters) may at times exceed ±1000 N-units/km. Use of the data from the nearest RAOB station is not always a satisfactory approach to radio-climatological estimates in the tropics, unless local modifications of the indicated refractivity are considered. A radio-meteorological investigation in the Mekong Delta of Viet Nam (Samson and Maloney, 1971) showed that significant long-term differences existed even over distances on the order of 100 km.

The refractivity is highly sensitive to humidity, which can change rapidly over comparatively limited horizontal or vertical distances in the tropics. Such changes often occur in land/sea breeze circulations, trade-wind subsidence regions, and monsoonal flows. At higher latitudes, however, the movement of air masses involved in large-scale weather systems may effectively produce a temporary "tropical" environment in a normally "temperate" region, as when warm, moist air masses move over the central U.S. from the Gulf of Mexico. Thus the extreme gradients common to many tropical regions can also be expected to occur at times in more temperate regions.

5. CONCLUSIONS

Refractivity data from RAOBs can be of value in link design and performance estimates, but its applicability is subject to the limitations discussed in the preceding section. The data in Appendix C must therefore be applied with considerable engineering judgment.

6. ACKNOWLEDGMENT

Support for the completion of this report was provided by the Deputy Chief of Staff for Plans and Operations, U.S. Army Communications Command, Fort Huachuca, Arizona under Project Order ACC-408-74.

Most of the refractivity distributions in Appendix C were prepared from computer listings that were originally obtained as part of an analysis at ITS for the "World Atlas of Atmospheric Radio Refractivity", a project sponsored by the U.S. Navy Weather Research Facility at Norfolk. Present availability of the working files is largely due to the foresight of Burgette Cahoon Hart of the Office of Telecommunications, who was one of the analysts on this project and a co-author of the Atlas.

Data for Brussels, Hannover, Stuttgart and Gross Rohrheim were furnished by Dr. L. Fehlhaber of the Fernmeldetechnisches Zentralamt in Darmstadt. Stan Doran of Telcom, Inc. analyzed the Wiesbaden data. Analyses for Palma, Madrid, La Coruña, and Gibraltar were by A.R. Davis and Capt. R.C. Wagner of the USAF Environmental Technical Applications Center. The Cardington distributions were derived from data published by M.P.M. Hall and C.M. Comer of the Radio and Space Research Station, Ditton Park, England.

The maps, graphs, and figures used in this report were prepared by Mary E. McClanahan of ITS.

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*Climatic and geographic source.

#NTIS: National Technical Information Service, Springfield, Va. 22151.

APPENDIX A. CALCULATION OF REFRACTIVITY

The speed of a radio wave varies inversely with the density of the medium through which it travels, and the radio refractive index of air is the ratio of the speed of propagation in a vacuum to its speed in the atmosphere under given conditions of pressure, temperature, and humidity. This ratio, n, is approximately 1.0003 under standard conditions near the earth's surface. For convenience, a scaled-up value, N, or refractivity, is normally used in propagation studies; this may be obtained from the following relationship (Smith and Weintraub, 1953):

$$N = (n - 1)10^6 = \frac{77.6}{T}\left[P + \frac{4810\, e_s RH}{T}\right]$$

where P = pressure in millibars

T = temperature in degrees kelvin

e_s = saturation vapor pressure in millibars

RH = relative humidity in percent

Values of the saturation vapor pressure are available in the Smithsonian Meteorological Tables (List, 1958).

Although the relative humidity is the parameter measured by most radiosondes, the RAOB humidity as transmitted on the national and international meteorological teletypewriter circuits is in terms of the dewpoint temperature. Figure A-1 is a useful nomogram for deriving refractivity values directly from the parameters given in the RAOB reports available at domestic and foreign weather stations (pressure in millibars, temperature in °C, dewpoint in °C).

Calculations of the refractivity gradient from RAOB reports should be based upon both the standard (or mandatory) levels (e.g., the 1000, 850, and 700 mb pressure levels) and the significant levels (those which are included because of a change in temperature or humidity exceeding specified limits). The significant levels include the surface data, the data at the bases and tops of significant temperature inversion layers, any other points where the departure of temperature equals or exceeds ±1°C from the preceding trend of the recorder trace, and points where the relative humidity deviates by 10% or more from linearity on the recorder trace (Federal Meteorological Handbook No. 3, 1971).

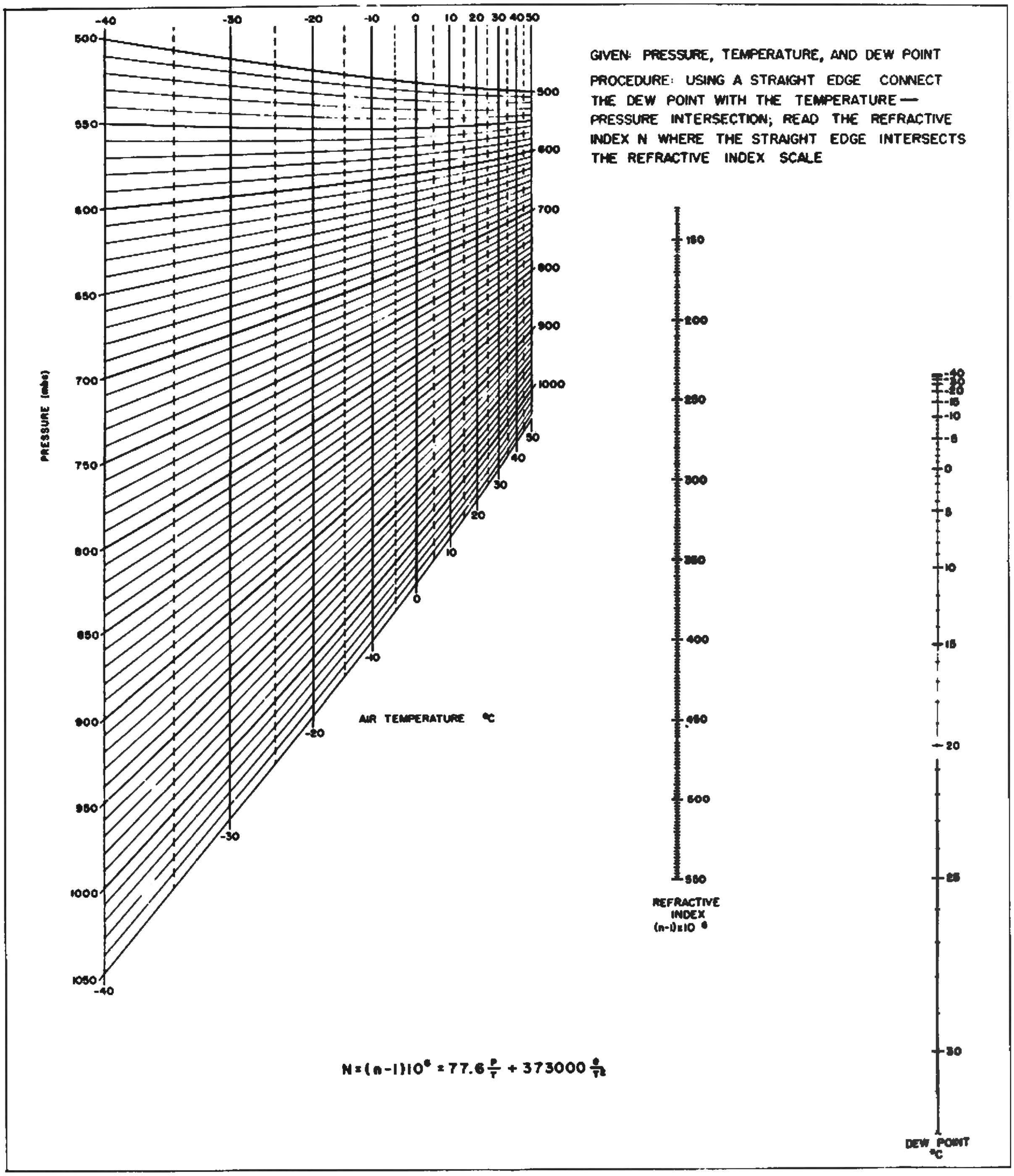


Figure A-1. Refractive index nomogram (Moreland, 1965).

APPENDIX B. THE NORMAL REFRACTIVITY GRADIENT

The 4/3 earth radius concept used in radio propagation estimates is based on a decrease of refractivity (N) with height of about 39 N-units/km. When one considers a layer of less than one kilometer thickness, however, this decrease (normalized to 1 km) tends to be somewhat more than 39 N-units/km. For 100-m layers the "normal" gradient values are more likely to be -50 or more (i.e., the refractivity decreases at the rate of 50 N-units/km over the 100-m interval).

Median values of the refractivity for most of the stations shown in figure 1 (based on the 100-m layer analyses) were used to prepare figures B-1 and B-2. Figure B-1 shows an annual value of the 100-m gradient, obtained by averaging the four monthly-median values from the distributions (February, May, August, November). Figure B-2 shows the February and August values (Feb./Aug.) to provide some indication of the winter/summer differences. For example, the median values at Barrow, on the Arctic coast of Alaska, are -39 (annual), -43 (February), and -41 (August).

The average of all Northern Hemisphere annual values is -57 N-units/km; the February average is -55 N-units/km and the August average is -61 N-units/km. The median gradient generally tends to be lower in the drier interior of large land masses (at temperate latitudes) than in the coastal regions where humidity is consistently higher. Note the very large values at Dakar, Bahrain, Ft. Lamy, and Niamey; all these locations have high surface dewpoints (absolute humidity) with drier air aloft.

The effect of seasonal changes in low-level moisture are reflected at many interior stations shown in figure B-2. Some of the arctic stations, however, show more intense gradients in winter, probably because of the very strong temperature inversions that persist during the months when the sun is below the horizon.

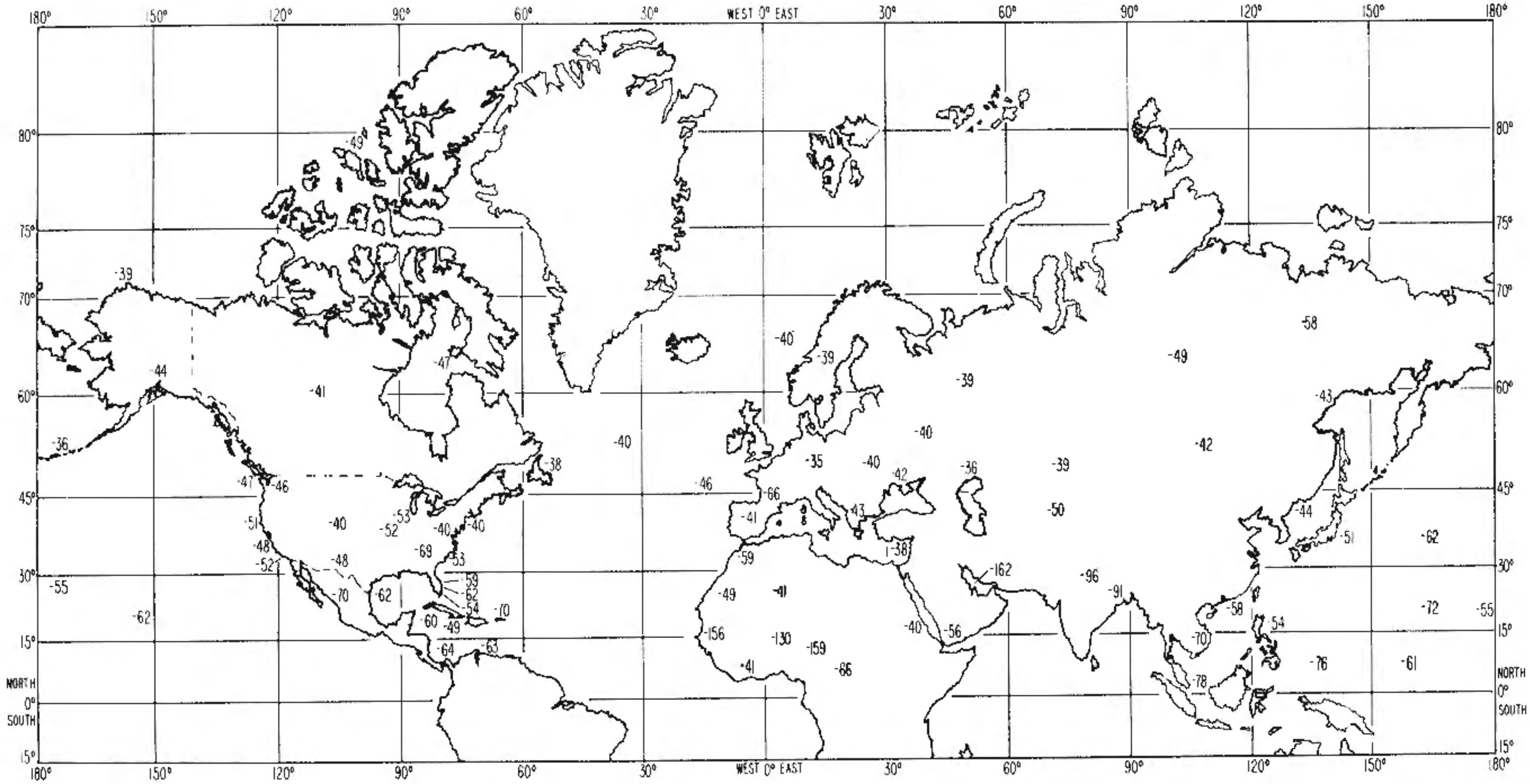


Figure B-1. Annual median 100-m refractivity gradient (average of seasonal medians).

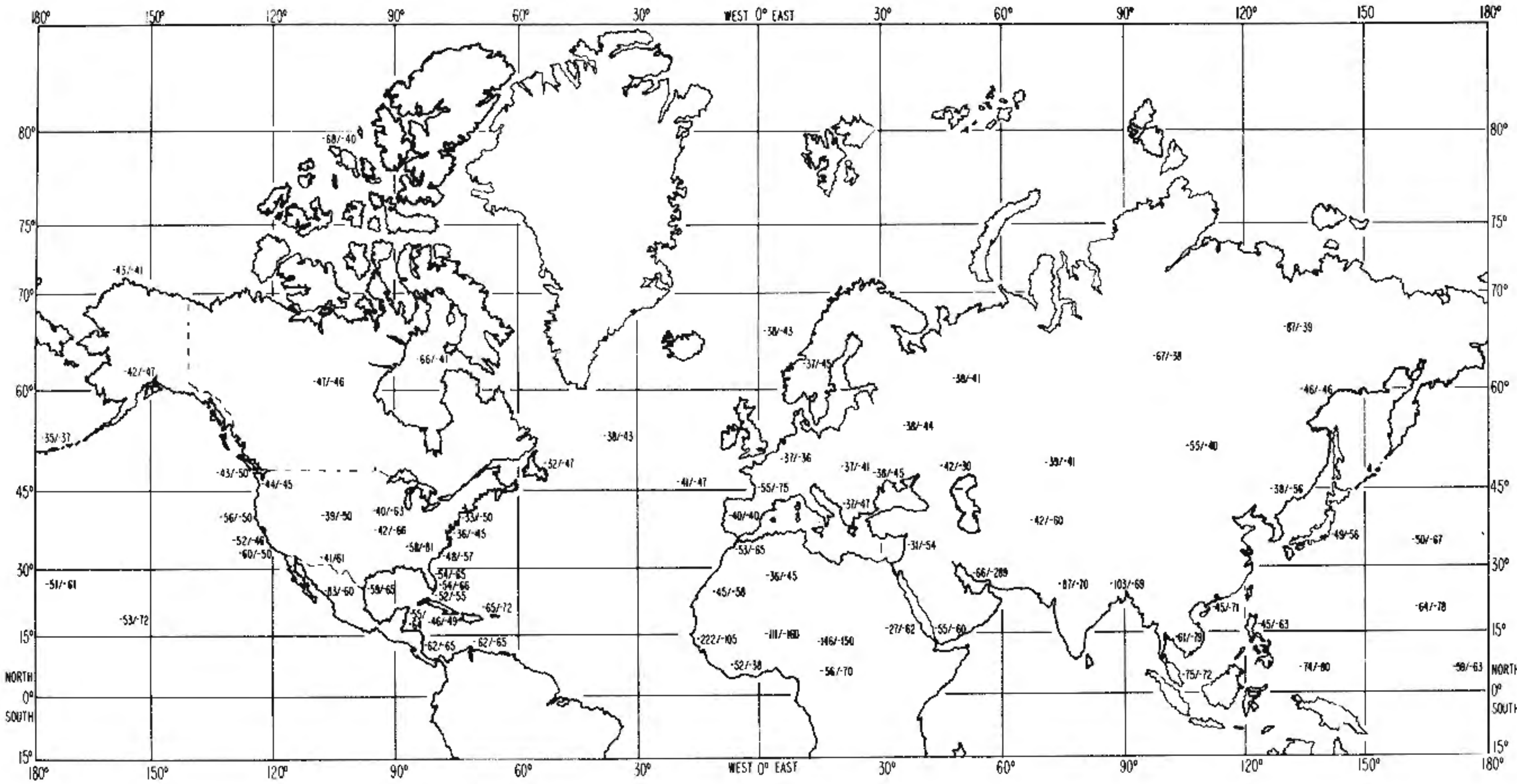
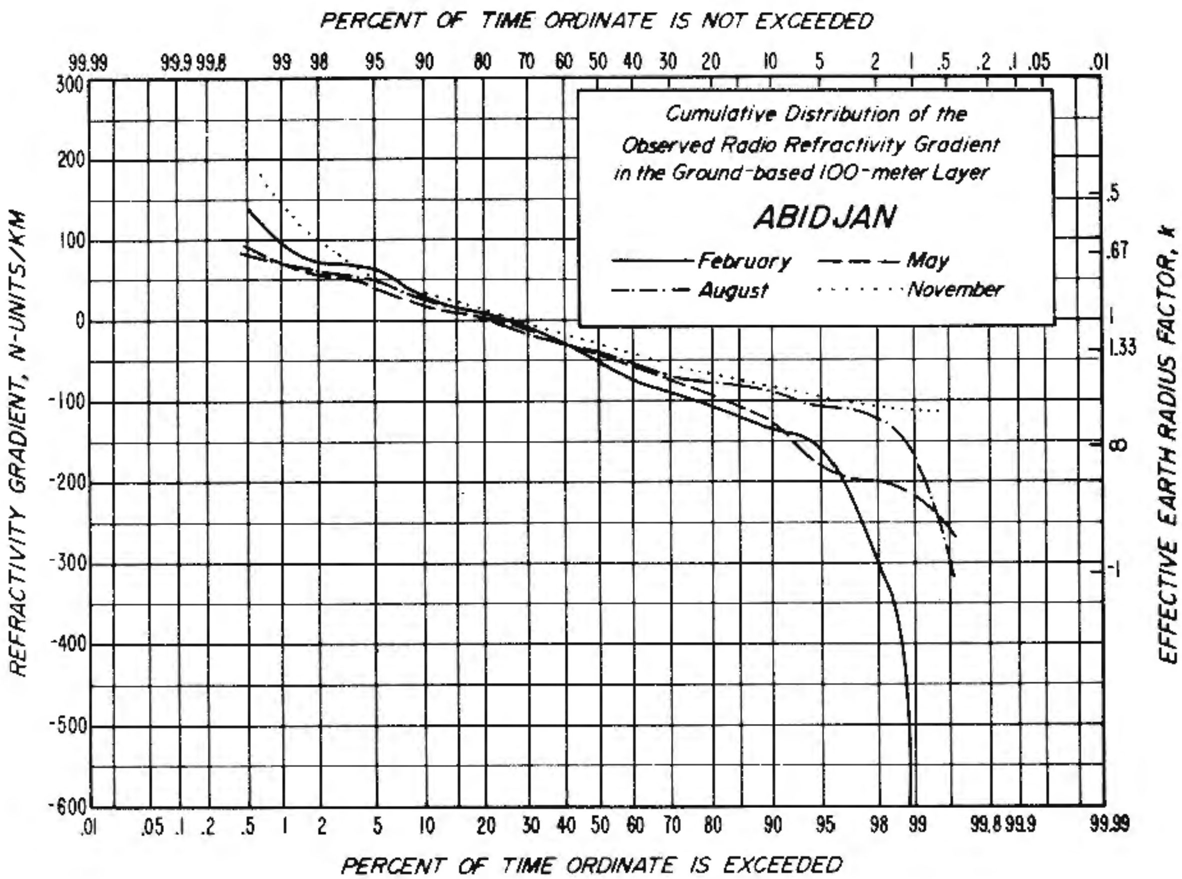


Figure B-2. February and August median values of 100-m refractivity gradient (Feb./Aug.).

APPENDIX C. CUMULATIVE DISTRIBUTIONS OF THE OBSERVED RADIO REFRACTIVITY GRADIENT IN THE GROUND-BASED 100-METER LAYER.

Stations are listed in alphabetical order, with the geographical coordinates, height above mean sea level, period of record, and climatological data. Unless otherwise indicated, temperatures listed are the average daily maximum and the average daily minimum, while precipitation data are the annual totals and the averages for the wettest and driest months. In most cases, the refractivity distributions are based upon radiosonde observations made only once or twice daily; note particularly that the graphs do <u>not</u> show the percentage of a year in which certain gradients may be expected to occur.

STATION INDEX. CUMULATIVE DISTRIBUTIONS OF REFRACTIVITY GRADIENT AND CLIMATOLOGICAL DATA



<u>Abidjan/Port Bouet, Ivory Coast</u> (W. Africa)

05-15 N, 03-56 W. 15 meters MSL

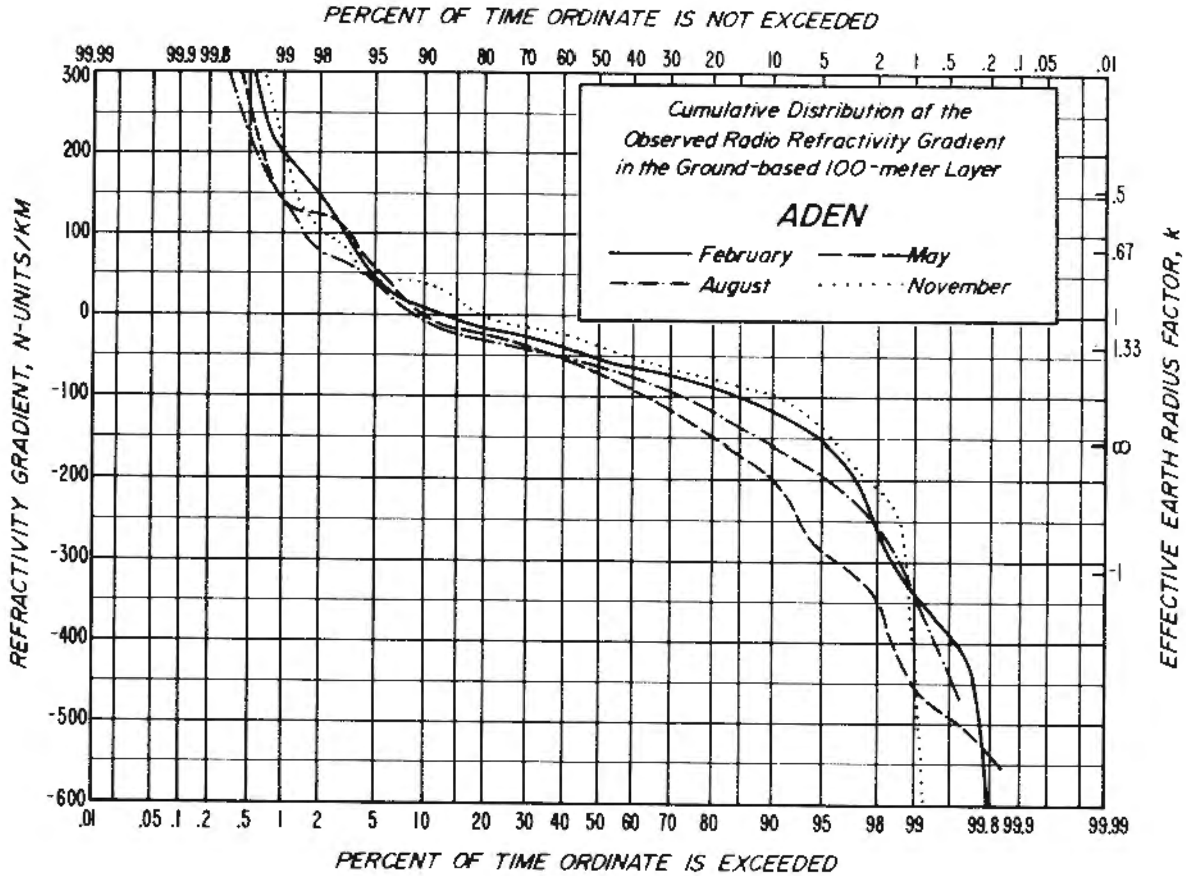
Data: Radiosonde. 0600Z (0600 LST)
8/58 - 8/62, 2/63 - 5/63

Temperature (°F): January 88/73; July 83/73

Mean Dewpoint (°F): January 75; July 71

Precipitation (inches): Annual 81.5; June 21.73; January 1.22

Located on the north shore of Ebrie lagoon; separated from the Atlantic Ocean by a sand bar. A humid tropical maritime climate.

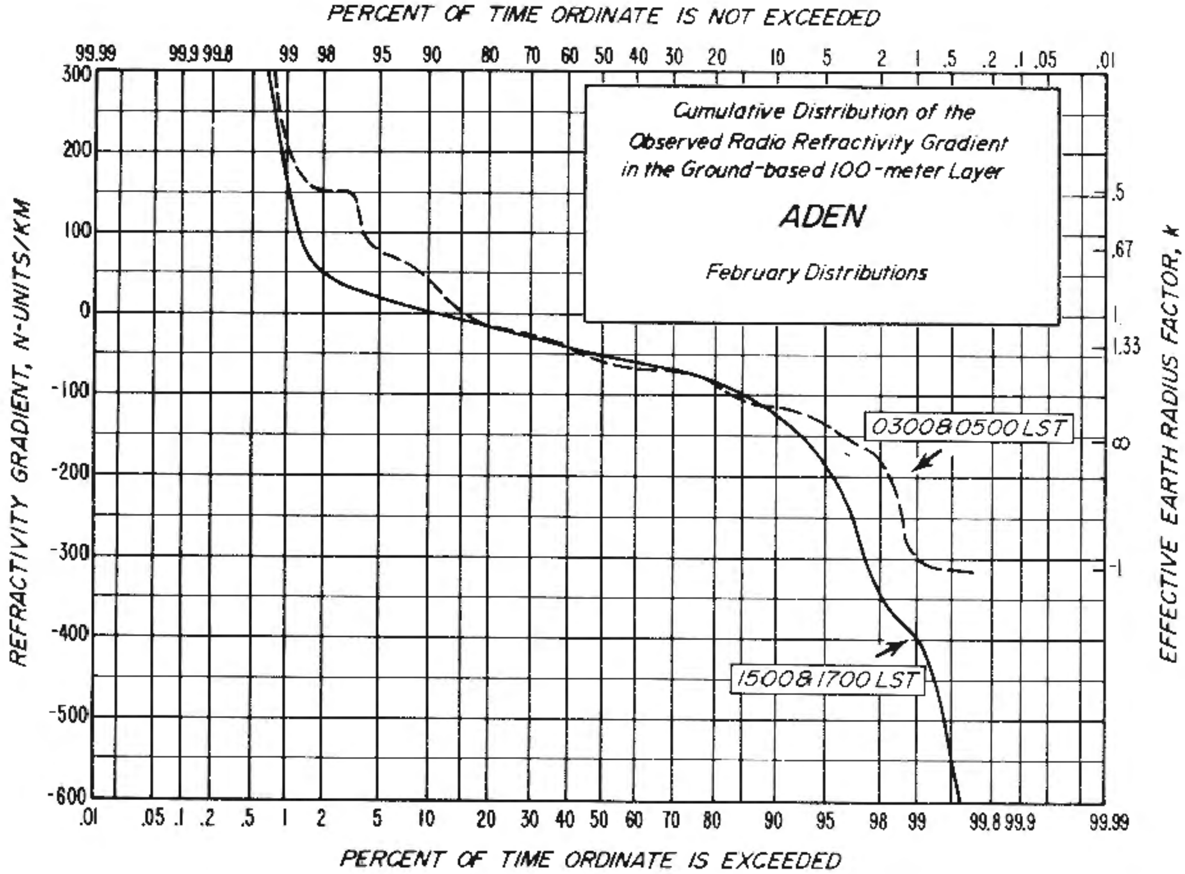


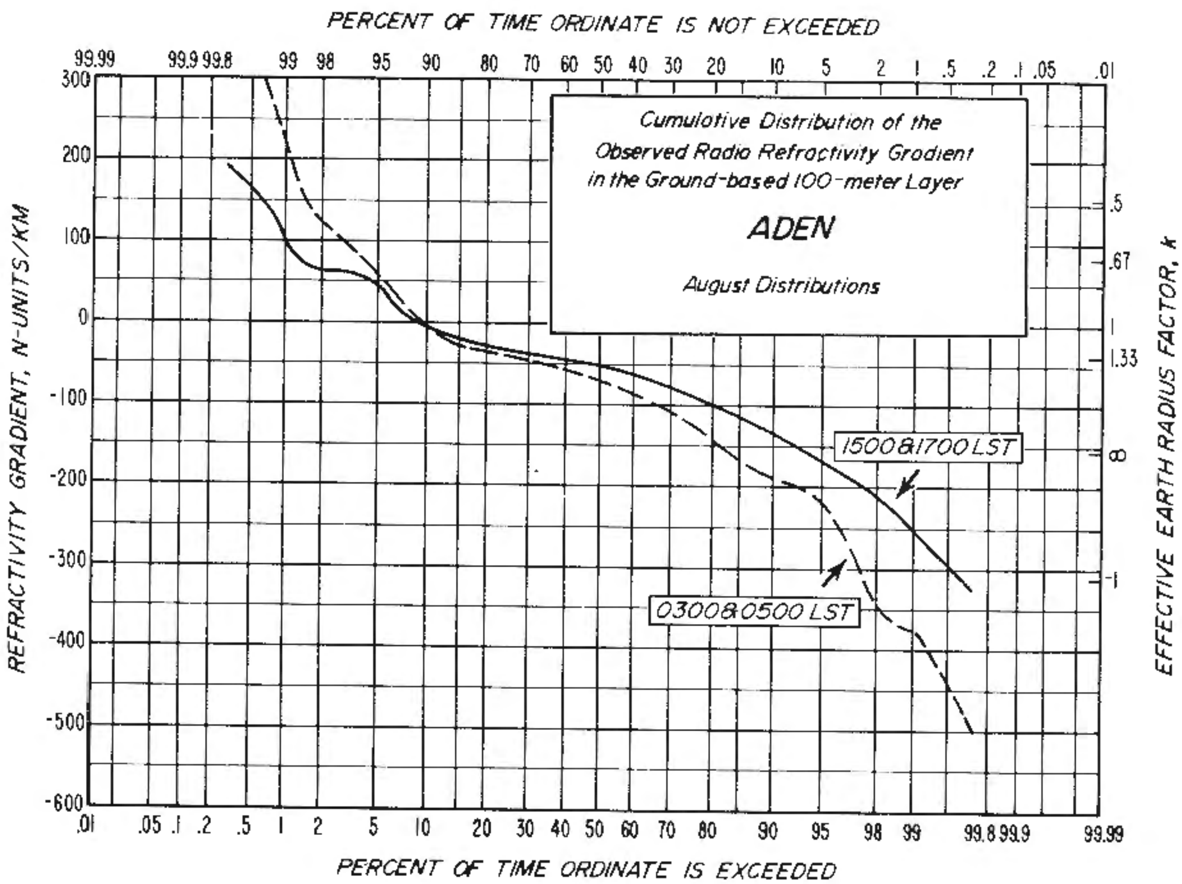
Aden, Yemen

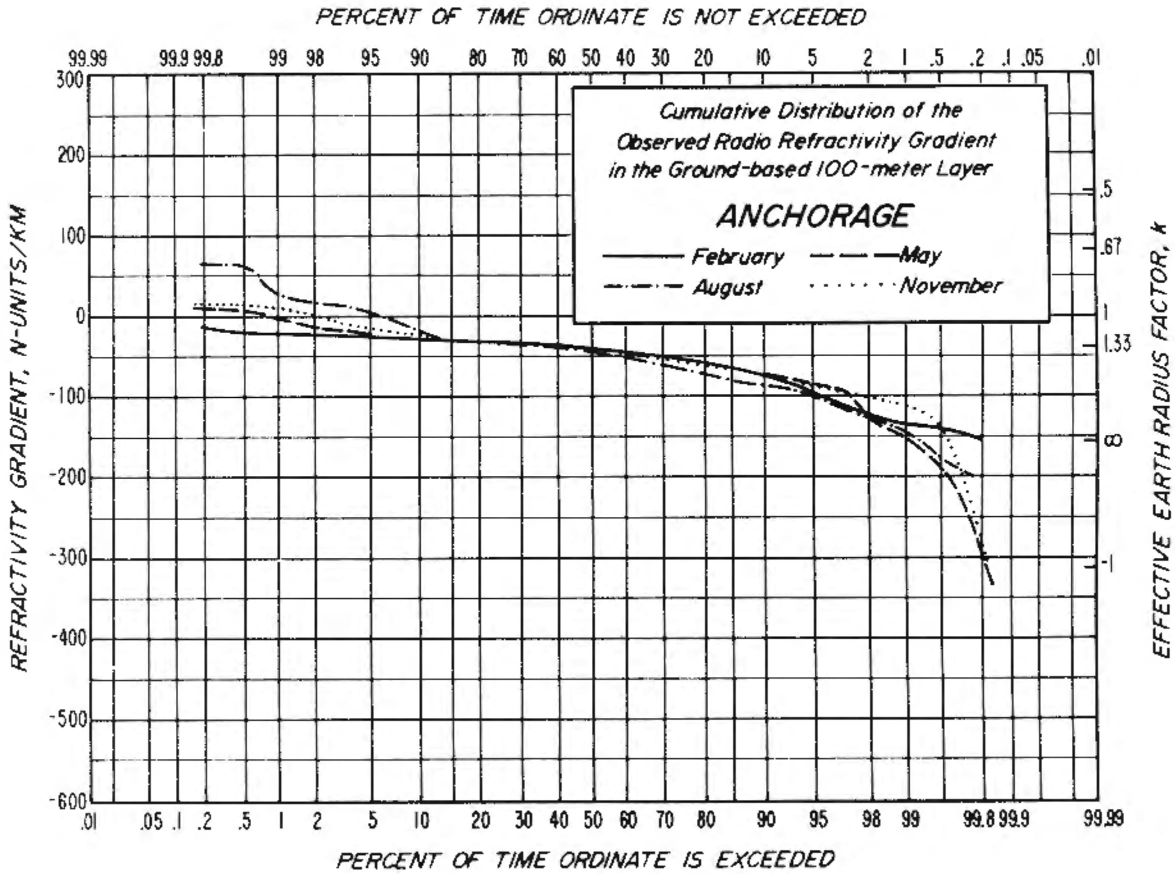
12-50 N, 45-01 E. 4 meters MSL

Data: Radiosonde.	0200 and 1400Z (0500 and 1700 LST) 2/55 - 2/57 0000 and 1200Z (0300 and 1500 LST) 5/57 - 8/60
Temperature (°F):	January 82/72; July 97/83
Mean Dewpoint (°F):	January 67; July 73
Precipitation (inches):	Annual 1.1; Jan., Mar., July, Dec. 0.20; Feb., Apr., May, June, Sept., Oct., Nov. 0.03

Located on the coast of southwest Arabian peninsula. An arid tropical climate; hot and humid April to October; cooler during rest of year in the northeast monsoon. No rainfall some years.


PERCENT OF TIME ORDINATE IS NOT EXCEEDED
Cumulative Distribution of the
Observed Radio Refractivity Gradient
in the Ground-based 100-meter Layer
ADEN
February Distributions
0300&0500 LST
1500&1700 LST
REFRACTIVITY GRADIENT, N-UNITS/KM
EFFECTIVE EARTH RADIUS FACTOR, k
PERCENT OF TIME ORDINATE IS EXCEEDED


PERCENT OF TIME ORDINATE IS NOT EXCEEDED
Cumulative Distribution of the
Observed Radio Refractivity Gradient
in the Ground-based 100-meter Layer
ADEN
August Distributions
1500&1700 LST
0300&0500 LST
REFRACTIVITY GRADIENT, N-UNITS/KM
EFFECTIVE EARTH RADIUS FACTOR, k
PERCENT OF TIME ORDINATE IS EXCEEDED



Anchorage, Alaska

61-10 N, 149-59 W. 40 meters MSL

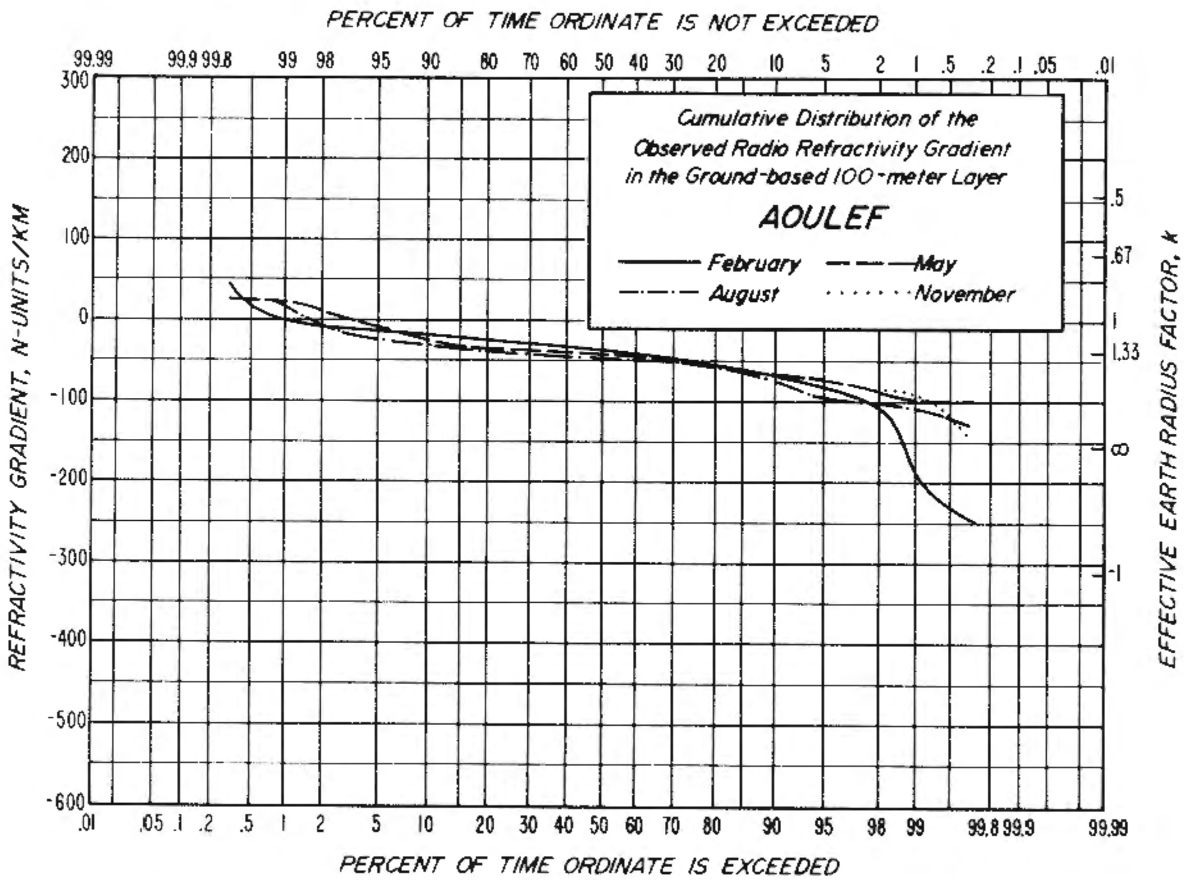
Data: Radiosonde 0300 and 1500Z (1700 and 0500 LST)
8/52 - 5/57

Temperature (°F): January 20/4; July 66/50

Mean Dewpoint (°F): January 7; July 48

Precipitation (inches): Annual 14.7; August 2.57; April 0.42

Anchorage is in a broad valley with adjacent narrow bodies of water; Cook Inlet is approximately 2 miles west, north, and south. Alaska Mountains 100 miles to north form a barrier against extreme cold air masses. Cool maritime climate with considerable fog in winter months.



Aoulef, Algeria

26-58 N, 01-05 E. 290 meters MSL

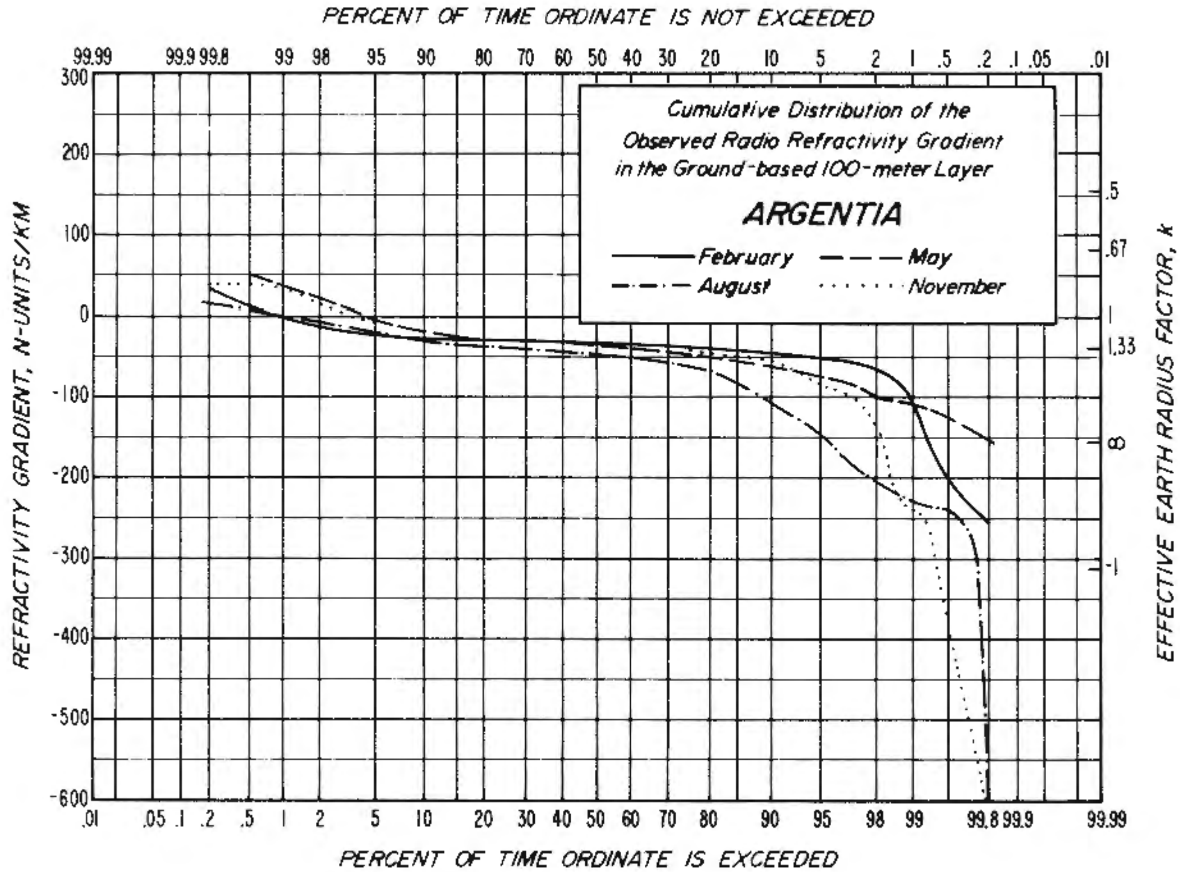
Data: Radiosonde. 1400Z (1400 LST)
2/57
1200Z (1200 LST)
5/57 - 2/62

Temperature (°F): January 71/44; July 113/85

Mean Dewpoint (°F): January 31; July 36

Precipitation (inches): Annual 0.6; November 0.20; July 0.01

An oasis in the Sahara; a desert climate with scanty rainfall and very hot summers.



Argentia, Newfoundland

47-18 N, 54-00 W.   17 meters MSL

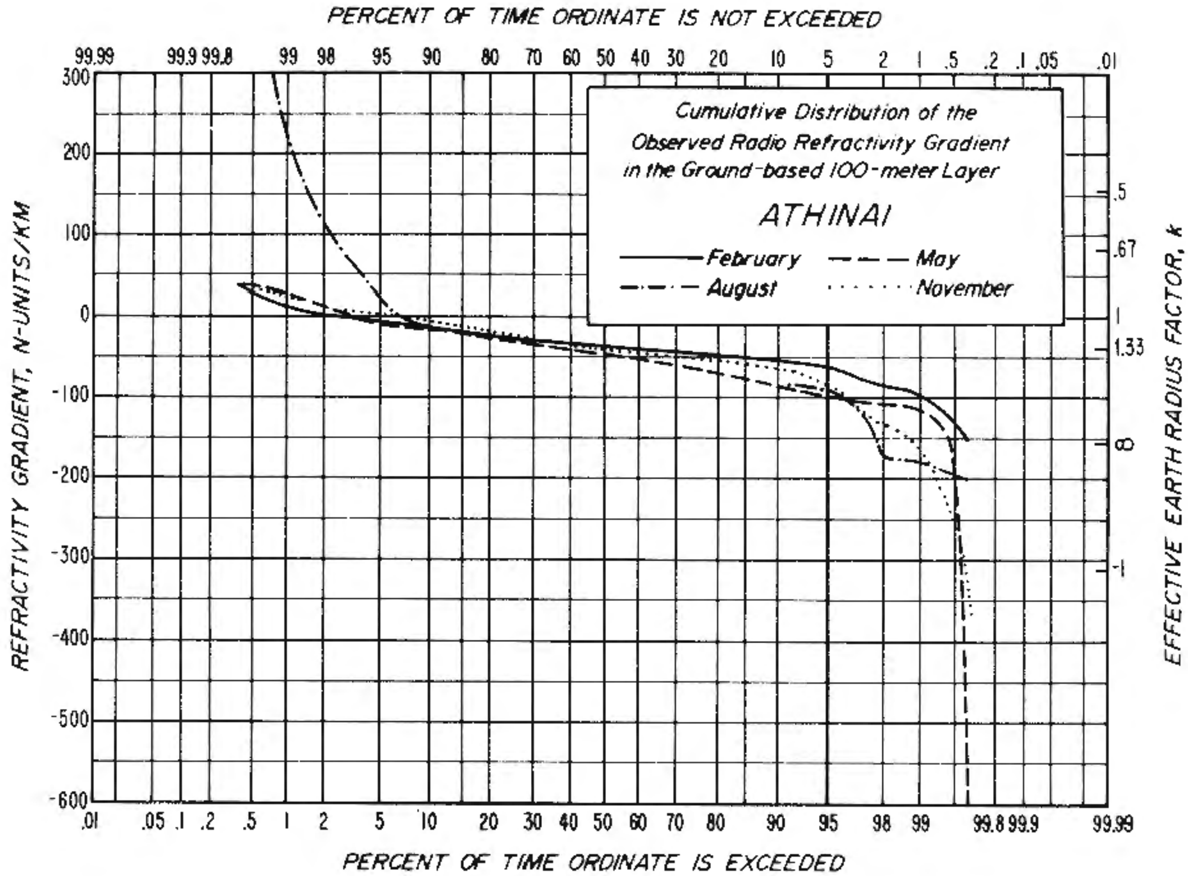
Data: Radiosonde.   0300 and 1500Z (2300 and 1100 LST)
8/52 - 5/57

Temperature (°F): January 34/24; July 62/53

Mean Dewpoint (°F): January 25; July 53

Precipitation (inches): Annual 42.6; November 4.98; June 2.41

Located on a peninsula extending into Placentia Bay in southwest Newfoundland. It is a maritime location but the climate is essentially continental because air masses affecting the area usually come from the west.



Athinai (Athens), Greece

37-58 N, 23-43 E. 27 meters MSL

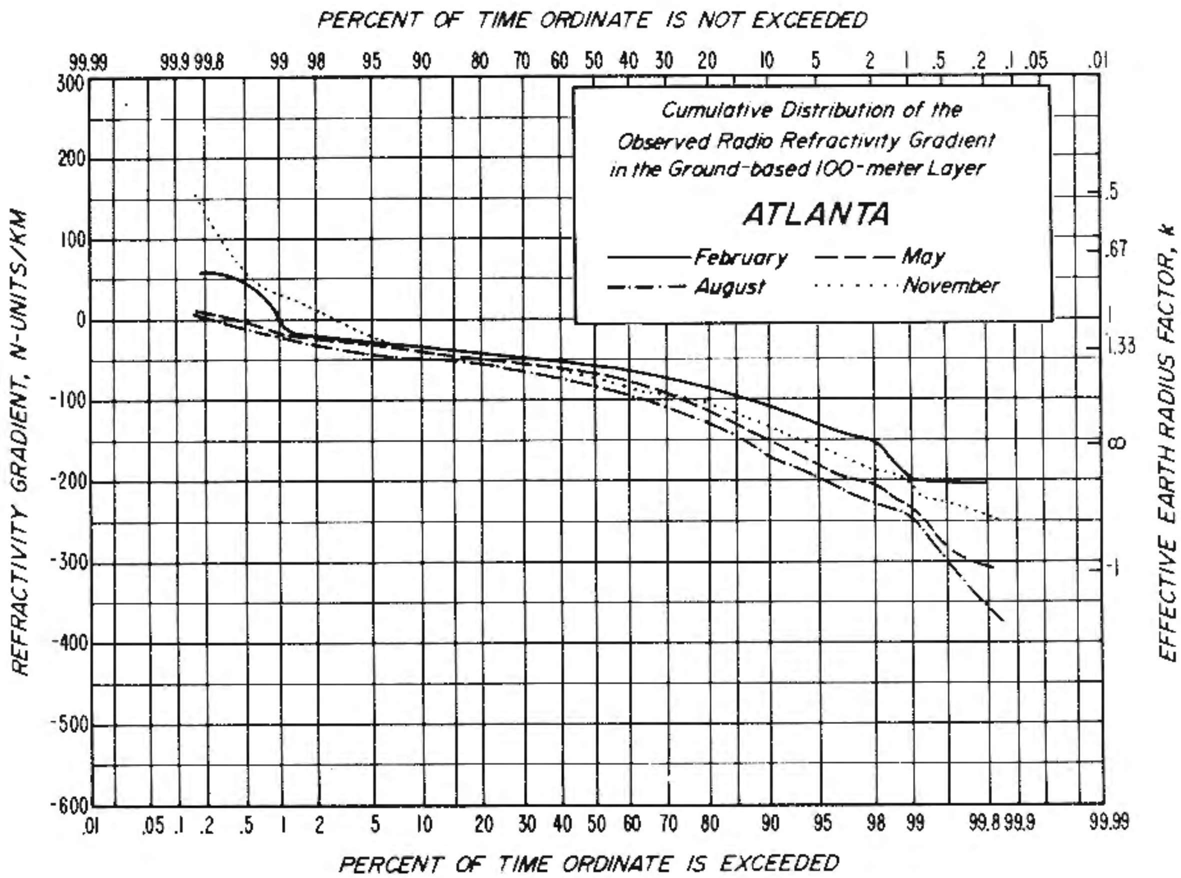
Data: Radiosonde. 0000Z (0200 LST)
8/58 - 5/63

Temperature (°F): January 54/42; July 90/72

Mean Dewpoint (°F): January 37; July 58

Precipitation (inches): Annual 15.9; Nov., Dec. 2.80; July 0.20

Located near the Saronic Gulf on the Attic plain; enclosed on three sides by hills. Temperate climate with mild winters and hot, dry summers.



Atlanta, Georgia

33-39 N, 84-26 W. 315 meters MSL

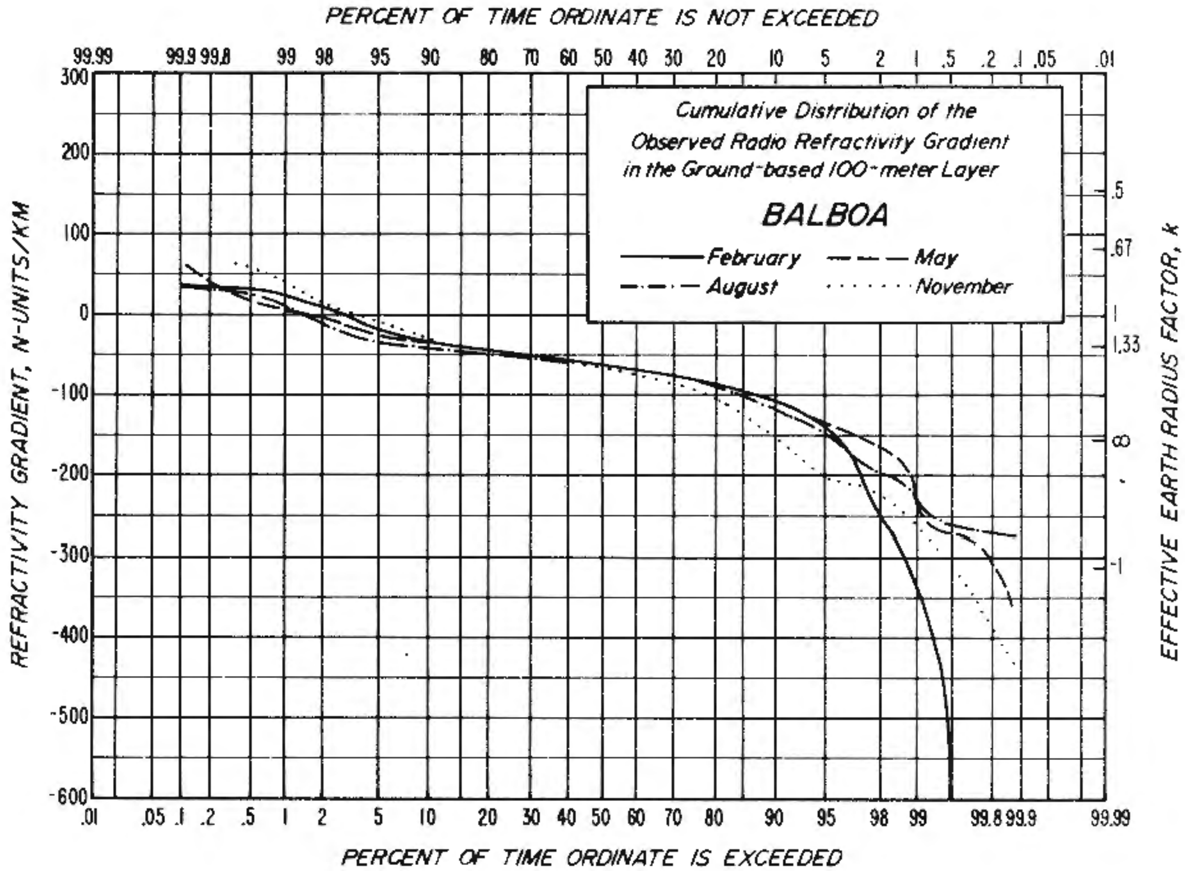
Data: Radiosonde. 0300 and 1500Z (2100 and 0900 LST) 8/52 - 5/57

Temperature (°F): January 52/37; July 87/71

Mean Dewpoint (°F): January 35; July 68

Precipitation (inches): Annual 47.1; March 5.37; October 2.44

Located at the foot of the Blue Ridge Mountains; rolling to hilly terrain nearby. Generally mild temperate climate, approaching humid sub-tropical in summer.



Balboa, Canal Zone

08-56 N, 79-34 W. 9 meters MSL

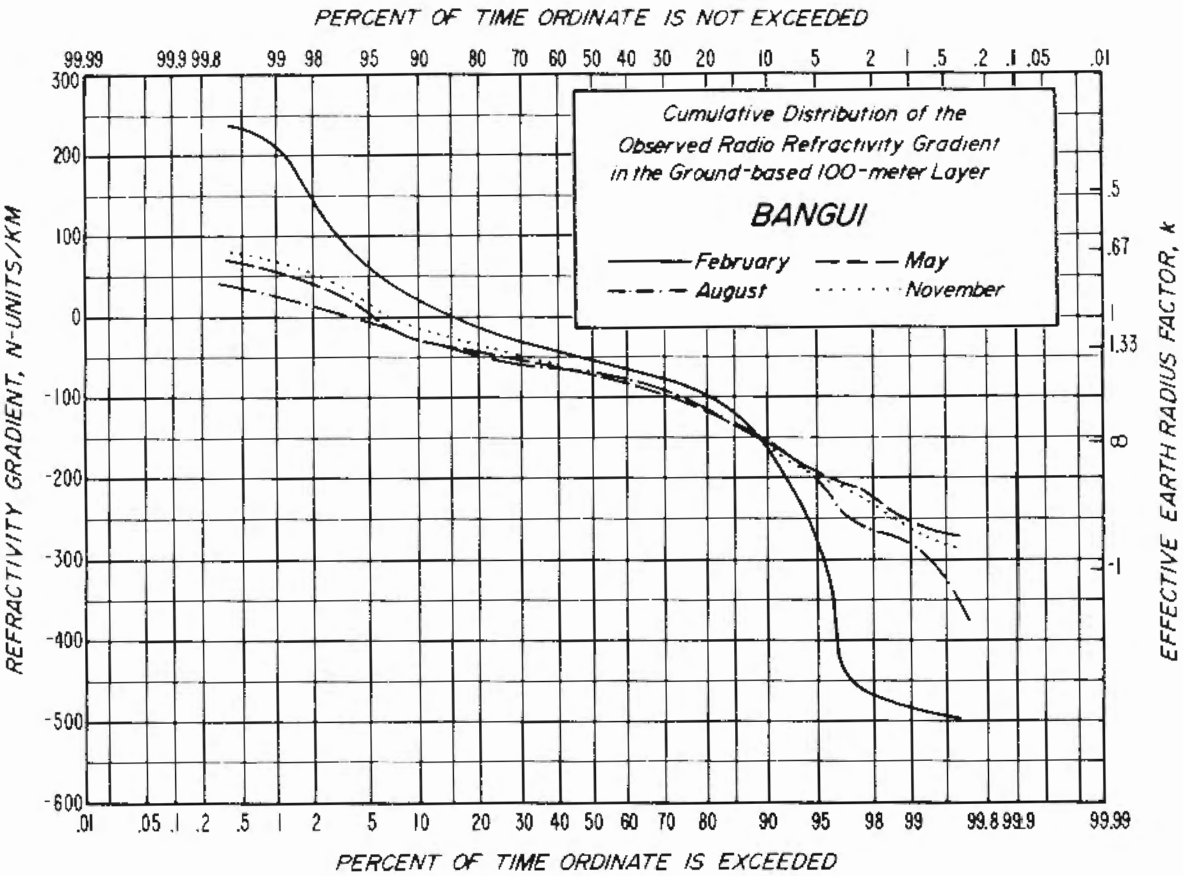
Data: Radiosonde. 0300 and 1500Z (2200 and 1000 LST)
1/51 - 6/57
0000 and 1200Z (1900 and 0700 LST)
7/57 - 12/57

Temperature (°F): January 89/74; July 87/75

Mean Dewpoint (°F): January 71; July 74

Precipitation (inches): Annual 59.3; November 9.78; March 0.68

Located on the Pacific coast side of the Panama Canal Zone. A hot, humid maritime tropical climate with wet and dry seasons.



Bangui, Central African Republic

04-23 N, 18-34 E. 385 meters MSL

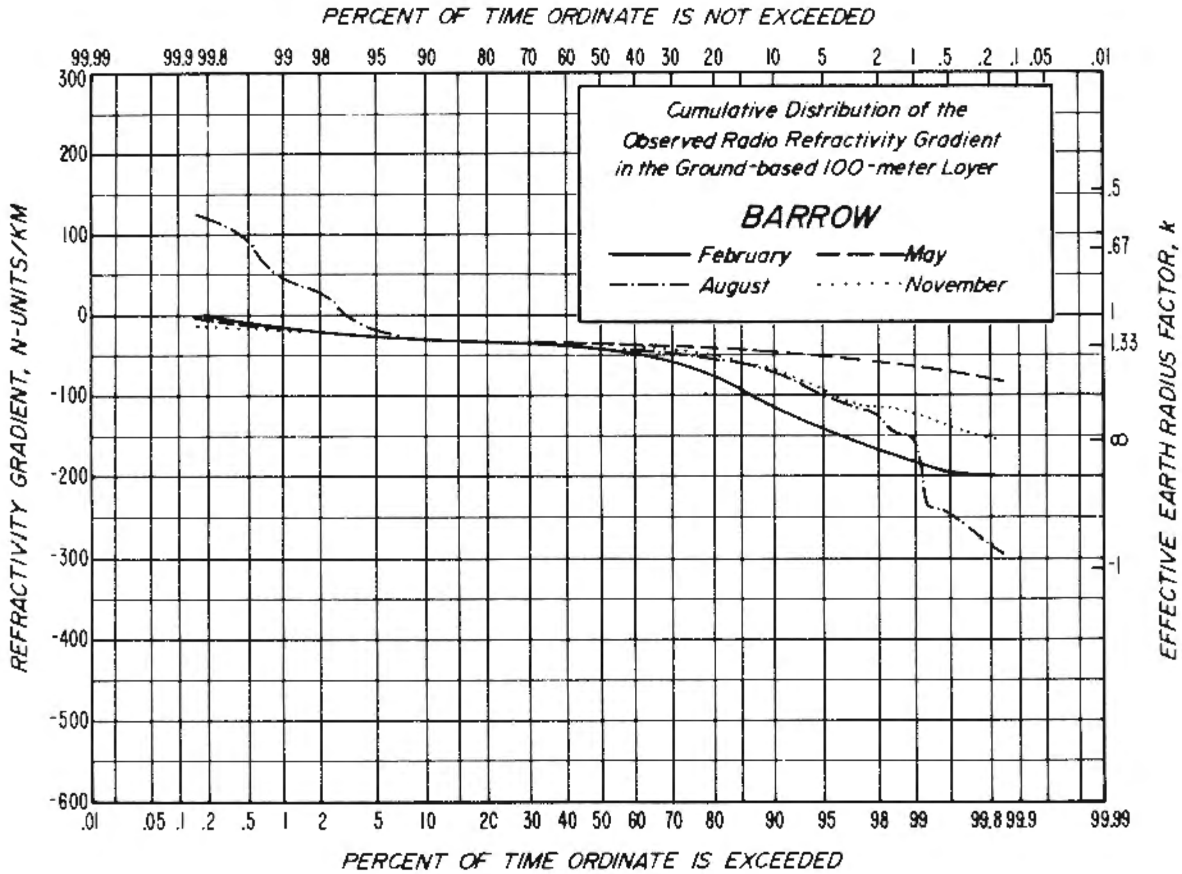
Data: Radiosonde. 0300Z (0400 LST): 8/52 - 2/53
0400Z (1500 LST): 5/53 - 11/55
0500Z (0600 LST): 2/56 - 11/59
0600Z (0700 LST): 2/60 - 8/60
Note: Last 3 periods observations only every other day.

Temperature (°F): January 91/67; July 86/69

Mean Dewpoint (°F): January 69; July 73

Precipitation (inches): Annual 61.4; August 8.86; January 0.83

Located on the Ubangi River; a wooded, hilly area but some marshy areas in vicinity. A hot and humid monsoon climate with June-October rainy season in southwest monsoon and the dry season October-March in the northeast trade winds.



Barrow, Alaska

71-18 N, 156-47 W   4 meters MSL

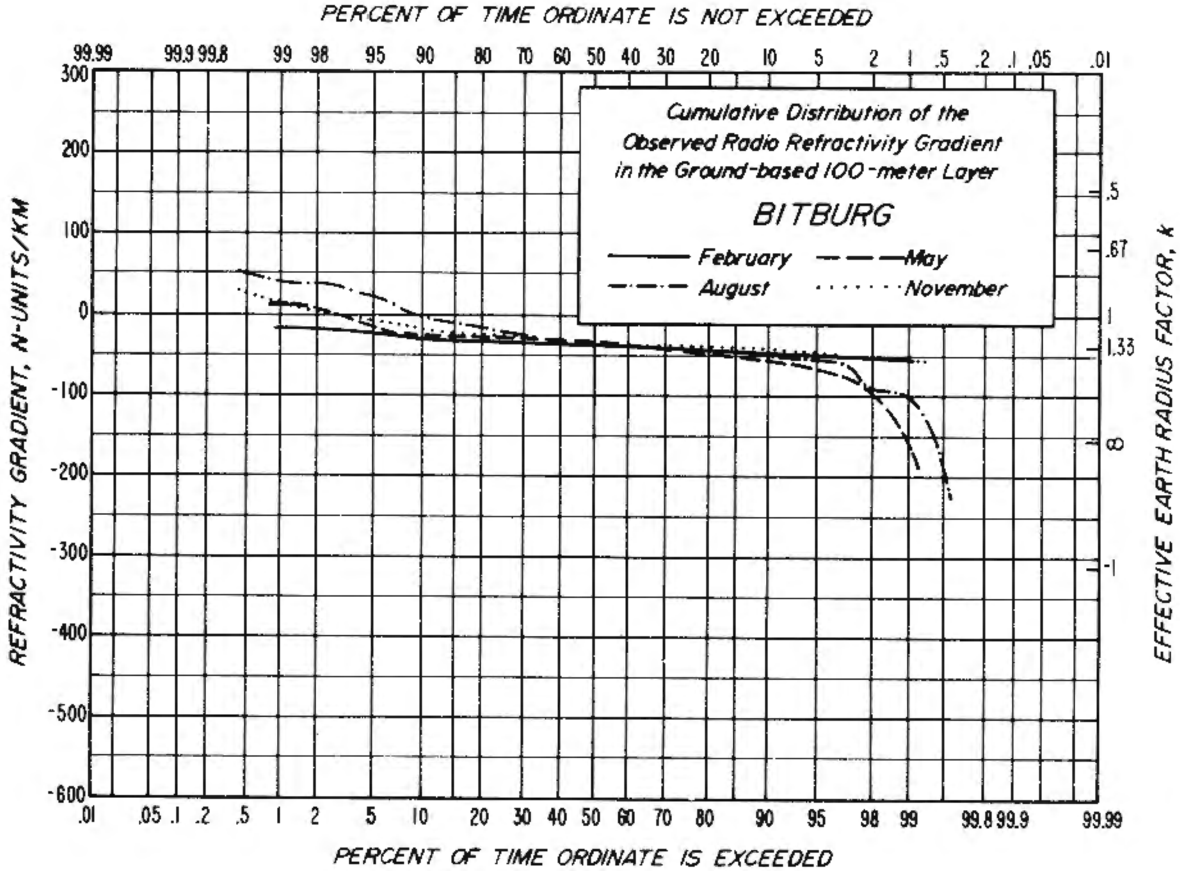
Data: Radiosonde.   0300 and 1500Z (1700 and 0500 LST)
8/52 - 5/57

Temperature (°F): January -9/-23; July 45/33

Mean Dewpoint (°F): January -25; July 37

Precipitation (inches): Annual 4.3; August 0.90; March and April 0.11

The Arctic Ocean lies to the north, east, and west; level tundra stretches 200 miles to the south. There are no natural wind barriers nearby. Temperatures are below freezing most of the year, but inversions are not as marked as in the interior of Alaska. The ocean generally becomes ice-free in late July or early August. There is considerable fog in summer.



Bitburg, Germany (Federal Republic)

49-57 N, 06-31 E. 374 meters MSL

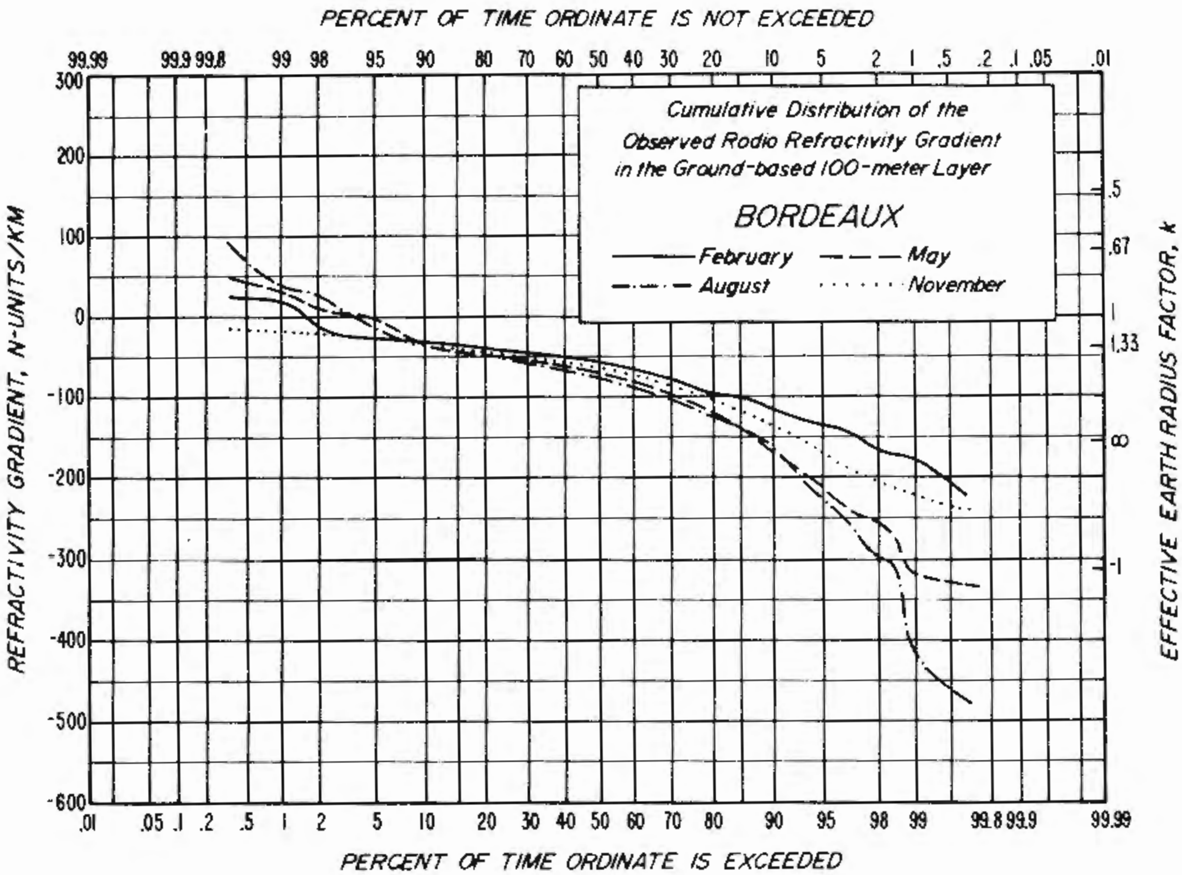
Data: Radiosonde. 0300 and 1500Z (0300 and 1500 LST) 12/54 - 12/55

Temperature (°F): January 35/27; July 69/53

Mean Dewpoint (°F): January 27; July 53

Precipitation (inches): Annual 24.9; July 2.77; April 1.48

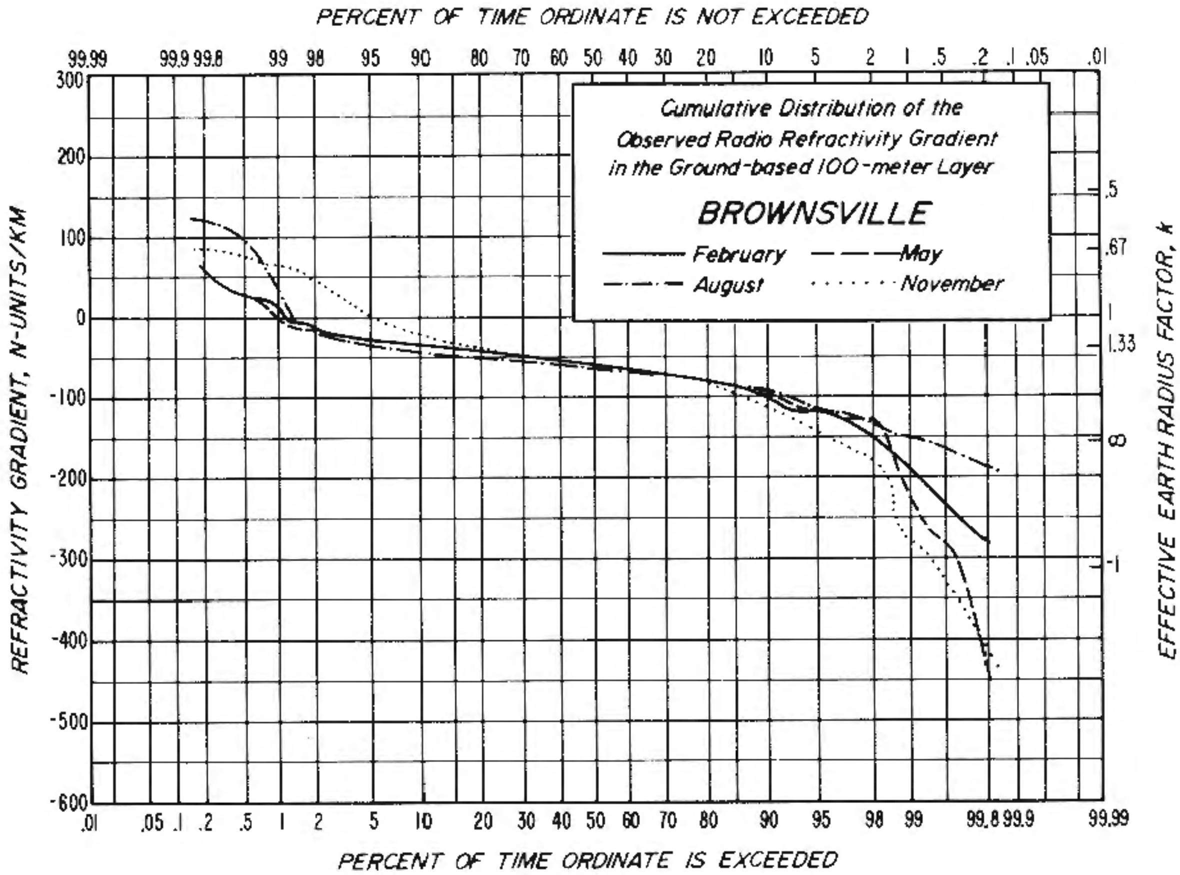
Located in rolling terrain of western Germany, about 15 miles from the Moselle River. A cool continental climate modified by frequent exposure to maritime air masses.



Bordeaux, France

Data: Radiosonde.	0200Z (0200 LST) 2/56 - 2/57 0000Z (0000 LST) 5/57 - 11/60
Temperature (°F):	January 48/35; July 80/58
Mean Dewpoint (°F):	January 36; July 57
Precipitation (inches):	Annual 32.7; Nov., Dec. 3.90; August 1.90

Located in southwest France just above the confluence of the Garonne and Dordogne rivers; about 30 miles from the Atlantic Ocean. A relatively mild maritime climate.



Brownsville, Texas

25-55 N, 97-28 W. 6 meters MSL

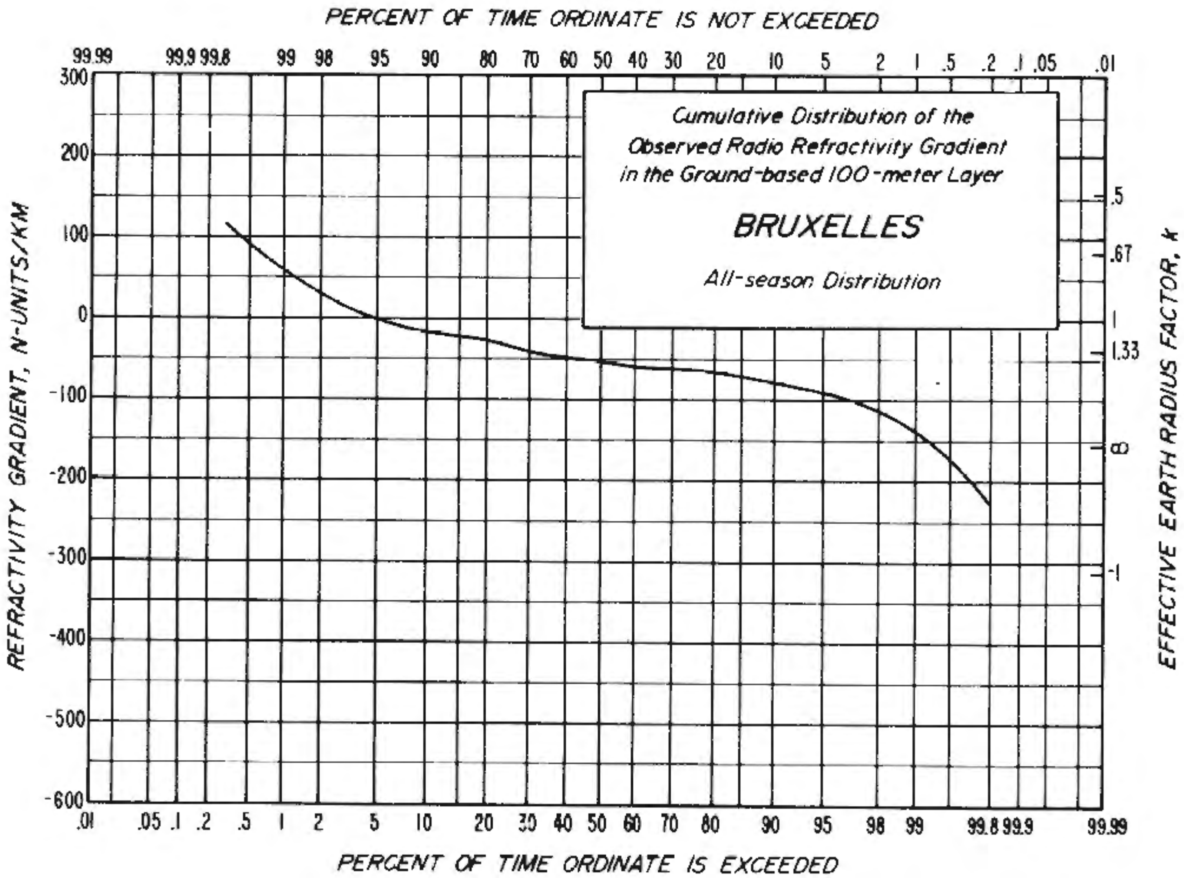
Data: Radiosonde. 0300 and 1500Z (2100 and 0900 LST) 8/52 - 5/57

Temperature (°F): January 71/52; July 93/76

Mean Dewpoint (°F): January 55; July 73

Precipitation (inches): Annual 26.8; September 4.99; March 1.04

Located in a relatively flat area in the Rio Grande valley; the Gulf of Mexico is only 18 miles to the east, with intervening tidal marshlands. The prevailing winds are from the Gulf. There are low mountains about 100 miles to the west, and extensive irrigated croplands in the vicinity. Humid sub-tropical climate



Brussels (Bruxelles), Belgium

50-54 N, 04-29 E. 55 meters MSL

Data: Radiosonde. 0000 and 1200Z (0000 and 1200 LST)
1961 and 1962

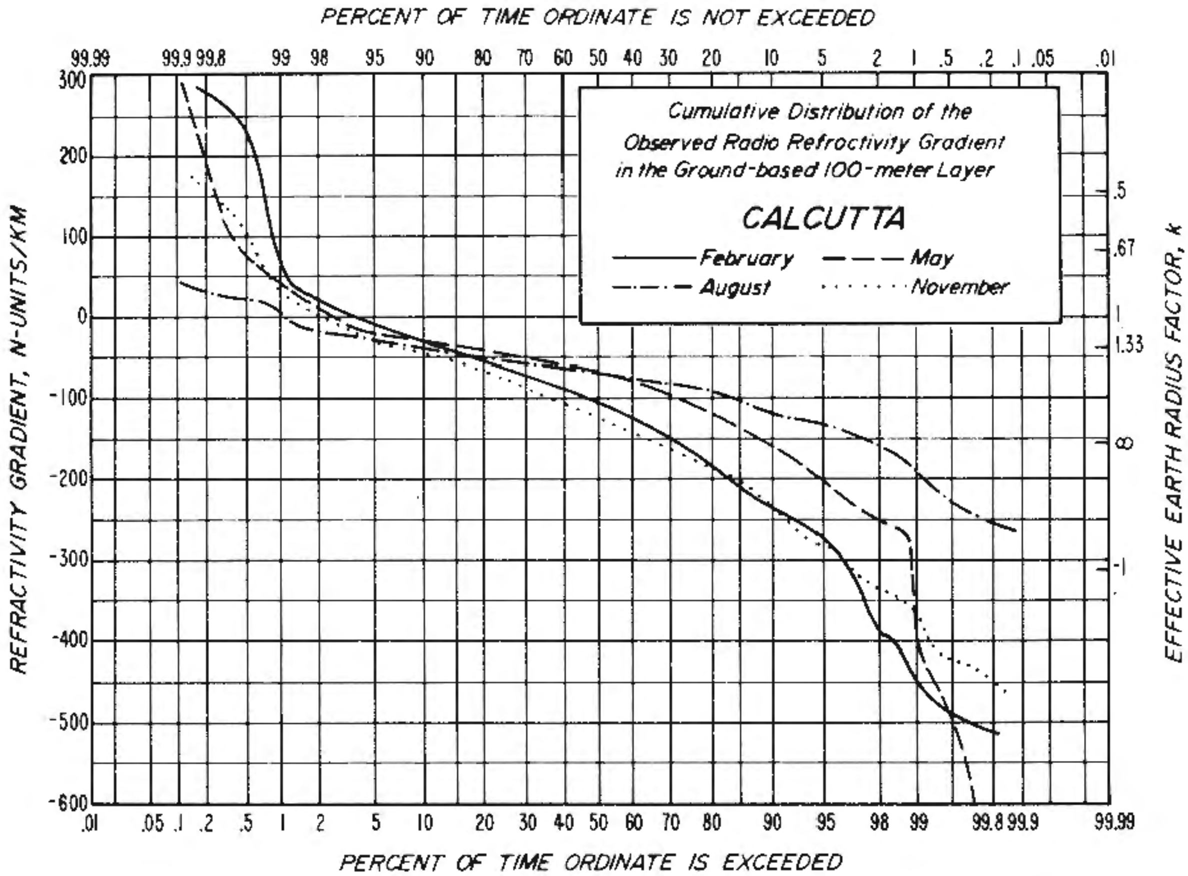
Analyzed by: Dr. L. Fehlhaber, Fernmeldetechnisches Zentralamt, Darmstadt

Temperature (°F): January 40/33; July 73/56

Mean Dewpoint (°F): January 32; July 58

Precipitation (inches): Annual 29.7; November 3.20; June, Oct. 1.70

Located in the valley of the Senne River. Moderate maritime climate; cool summers and mild winters.



Calcutta, India

22-39 N, 88-27 E. 6 meters MSL

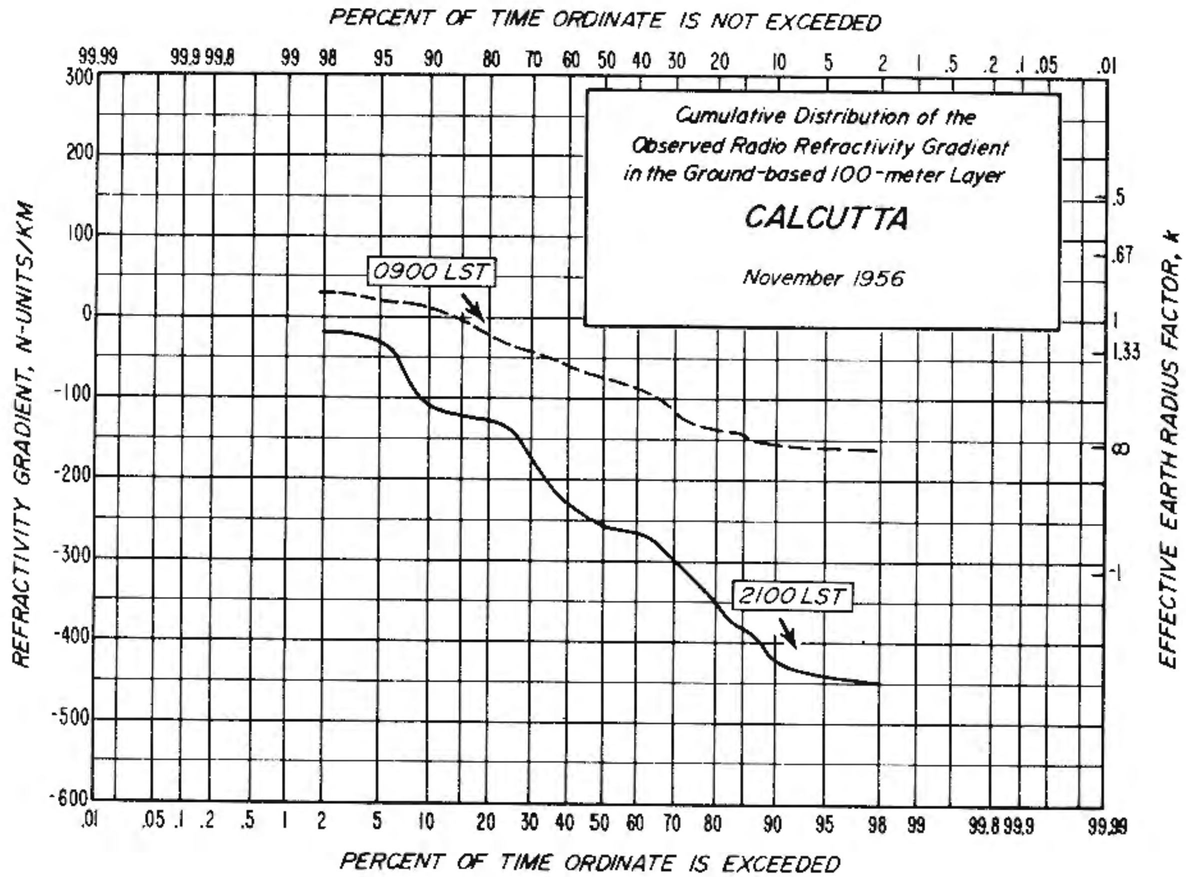
Data: Radiosonde. 1500Z (2100 LST): 8/52 - 2/55; 0300 and 1500Z (0900 and 2100 LST): 5/55 - 2/57; 0000 and 1200Z (0600 and 1800 LST): 5/57 - 11/59; 1200Z (1800 LST): 2/60 - 8/60

Temperature (°F): January 80/55; July 89/79

Mean Dewpoint (°F): January 63; July 80

Precipitation (inches): Annual 63.0; August 12.9; December 0.2

Located on the Hooghly River, about 100 km from the Bay of Bengal in northeast India. A humid sub-tropical monsoon climate, with cool dry winters and hot humid summers.



PERCENT OF TIME ORDINATE IS NOT EXCEEDED
99.99
99.9 99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
.5
.2
.1
.05
.01
Cumulative Distribution of the
Observed Radio Refractivity Gradient
in the Ground-based 100-meter Layer
CALCUTTA
November 1956
0900 LST
2100 LST
300
200
100
0
-100
-200
-300
-400
-500
-600
REFRACTIVITY GRADIENT, N-UNITS/KM
.5
.67
1
1.33
∞
-1
EFFECTIVE EARTH RADIUS FACTOR, k
.01
.05
.1
.2
.5
1
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20
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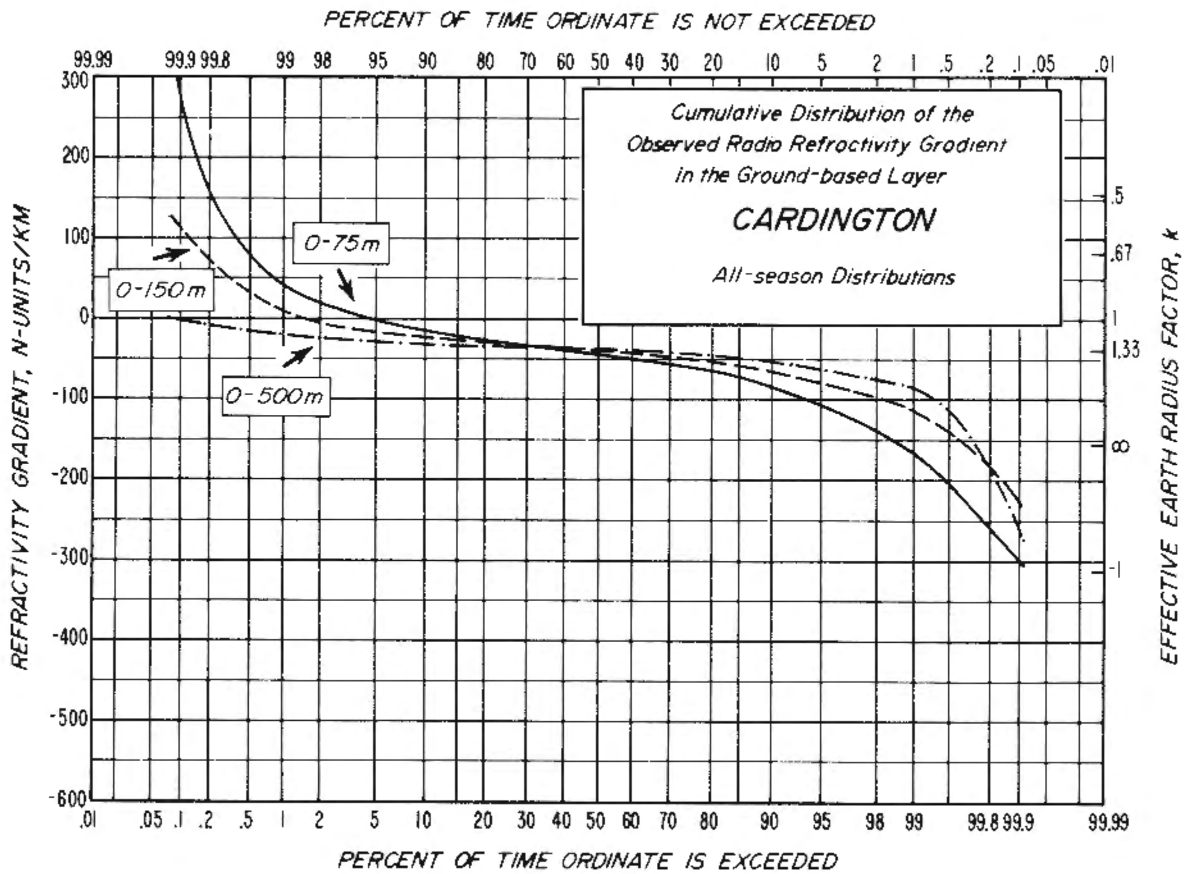
70
80
90
95
98
99
99.8
99.9
99.99
PERCENT OF TIME ORDINATE IS EXCEEDED



Cardington, England

52-06 N, 00-25 W. 28 meters MSL

Data: Tethered sonde ("Balthum" psychrometer soundings); 1273 soundings in 3 years, 1963 - 1965, by the Meteorological Office. Observations made at 75-meter intervals, surface to 1200 meters, at 0000, 0600, 1200, and 1800Z (LST), except in adverse weather conditions (high winds, lightning, etc.).

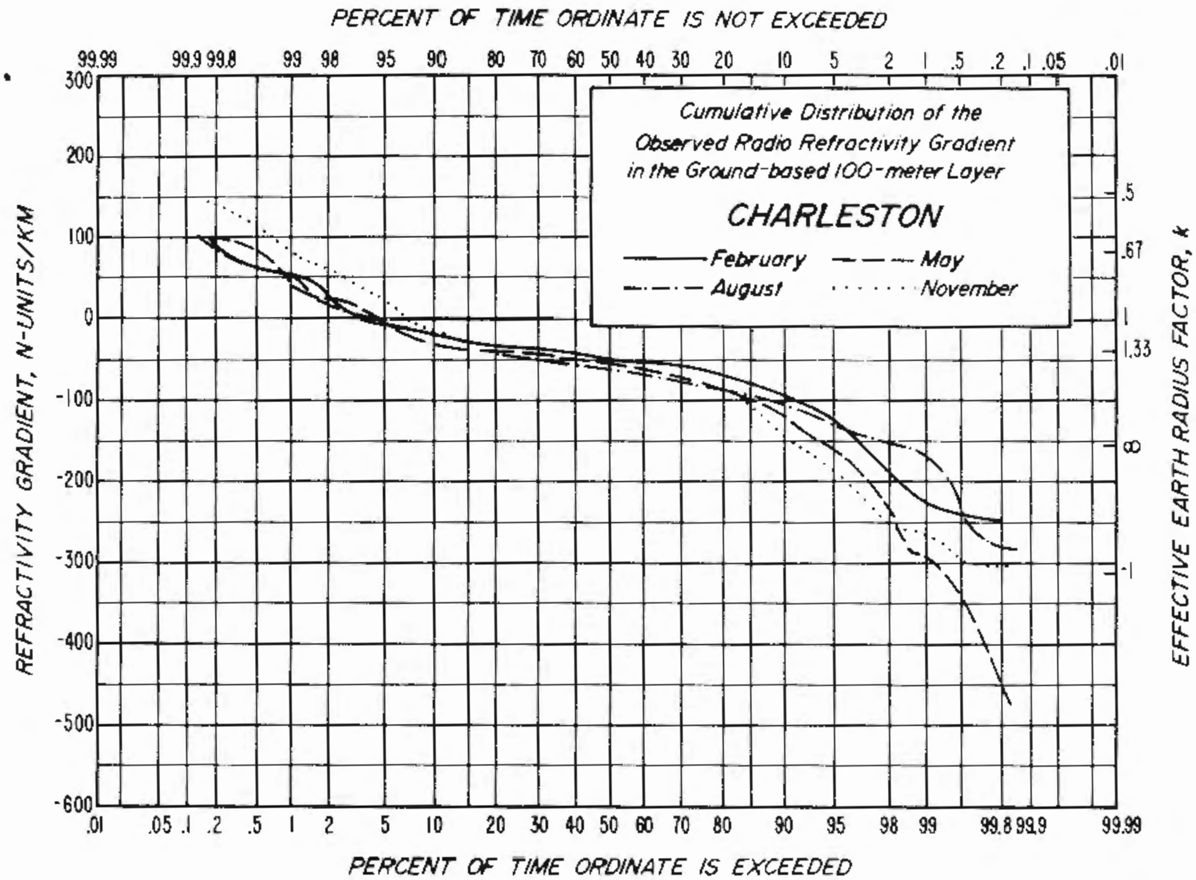
Analyzed by: M.P.M. Hall and C.M. Comer, Radio and Space Research Station, Ditton Park, Slough, Bucks, England

Temperature (°F): January 42/34; July 68/53 (Bedford)

Mean Dewpoint (°F): January 35; July 51 (Bedford)

Precipitation (inches): Annual 19.8; December 2.42; March 0.66 (Bedford)

Located in central lowlands area. Maritime climate with cool summers and relatively mild winters.



Charleston, South Carolina

32-54 N, 80-02 W. 15 meters MSL

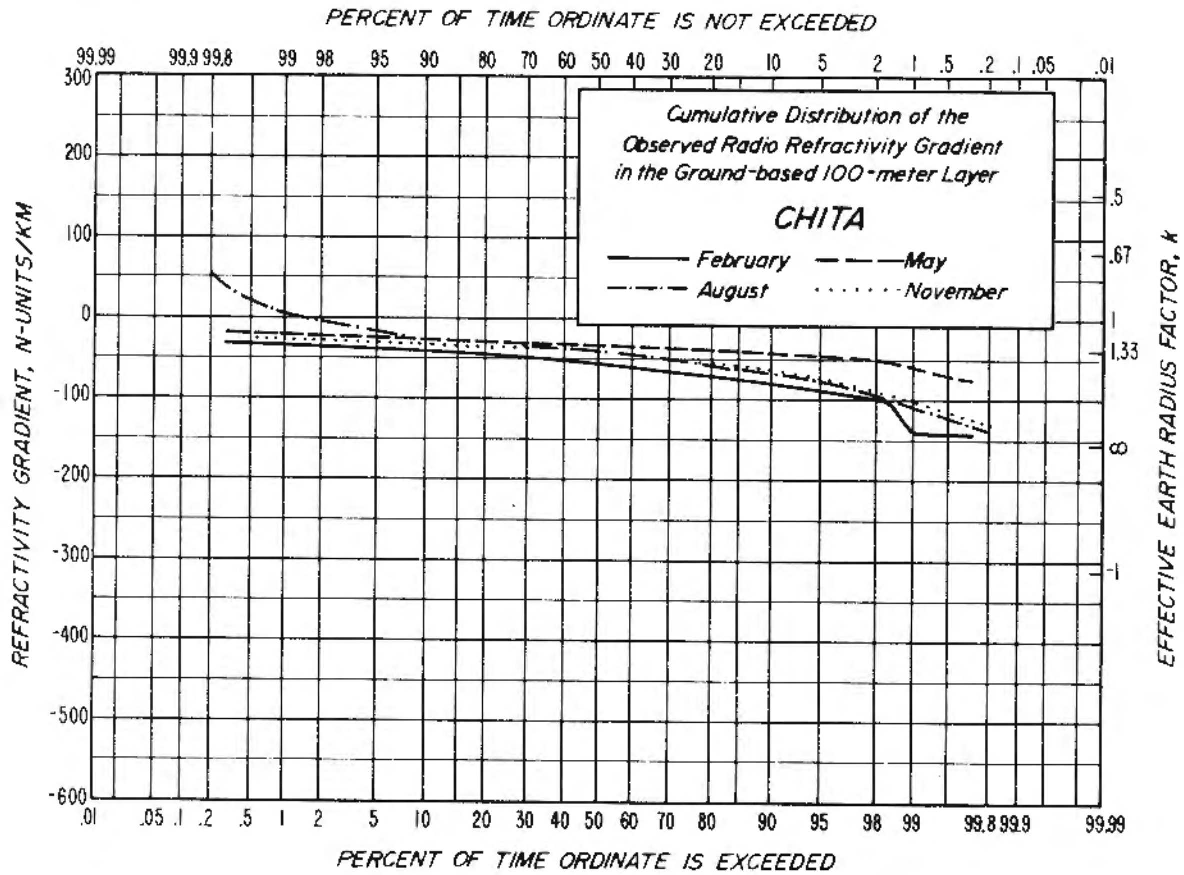
Data: Radiosonde. 0300 and 1500Z (2200 and 1000 LST)
8/52 - 5/57

Temperature (°F): January 61/38; July 89/72

Mean Dewpoint (°F): January 40; July 72

Precipitation (inches): Annual 49.2; July 7.71; November 2.09

Generally level terrain in vicinity; located on a peninsula bounded by the Ashley River and Cooper River, with a large harbor to the southeast. The prevailing winds are northerly in fall and winter; southerly in spring and summer. Mild, temperate climate approaching the sub-tropical humid in summer.



<u>Chita, U.S.S.R.</u>

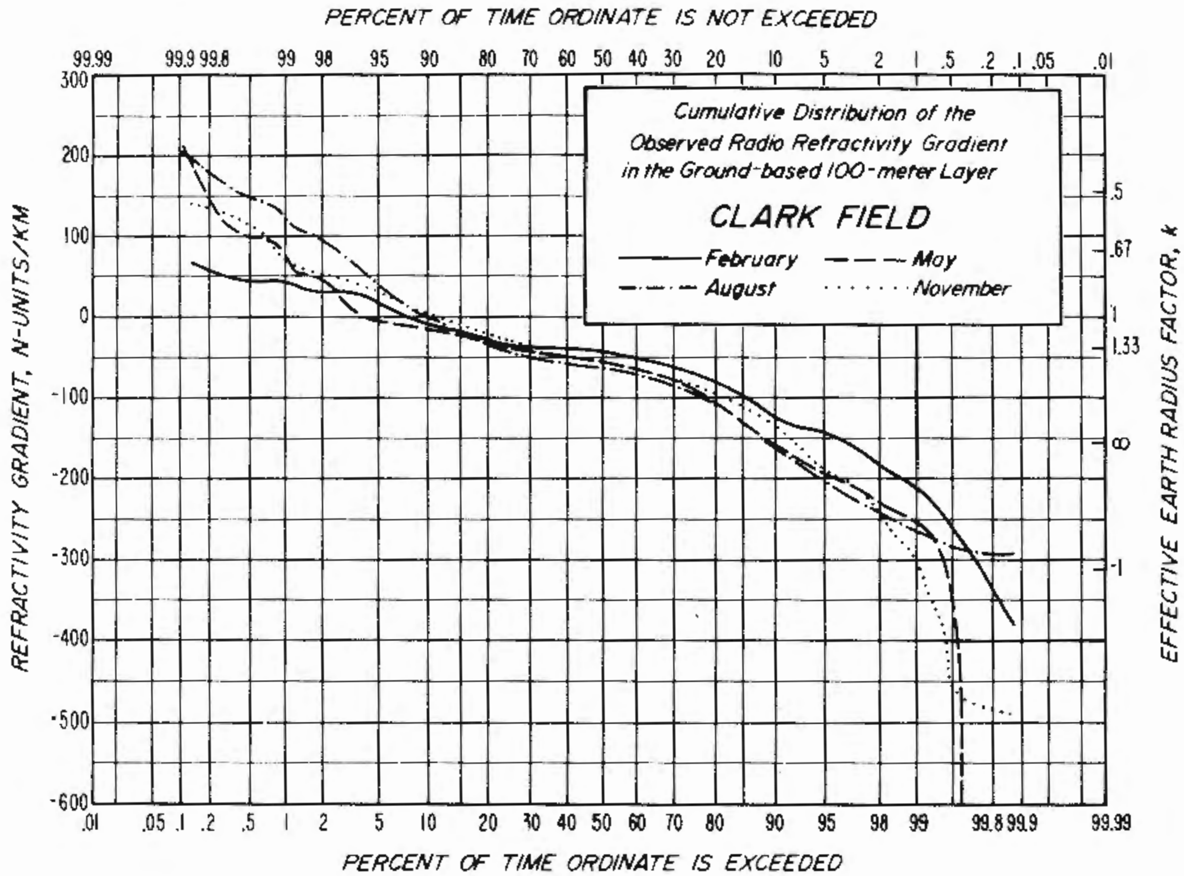
52-05 N, 113-29 E. 671 meters MSL

Data: Radiosonde. 0000 and 1200Z (0800 and 2000 LST)
8/57 - 11/59
0000Z (0800 LST)
2/60 - 11/61

Temeprature (°F): January -10/-27; July 75/51

Precipitation (inches): Annual 12.3; July, August 3.3; January, February, March 0.1

Located on the Chita River near its confluence with the Ingoda; mostly rough, forested region in vicinity. Severe continental climate with extremely cold winters.



<u>Clark Field, Luzon, Philippines</u>

15-08 N, 120-35 E. 170 meters MSL

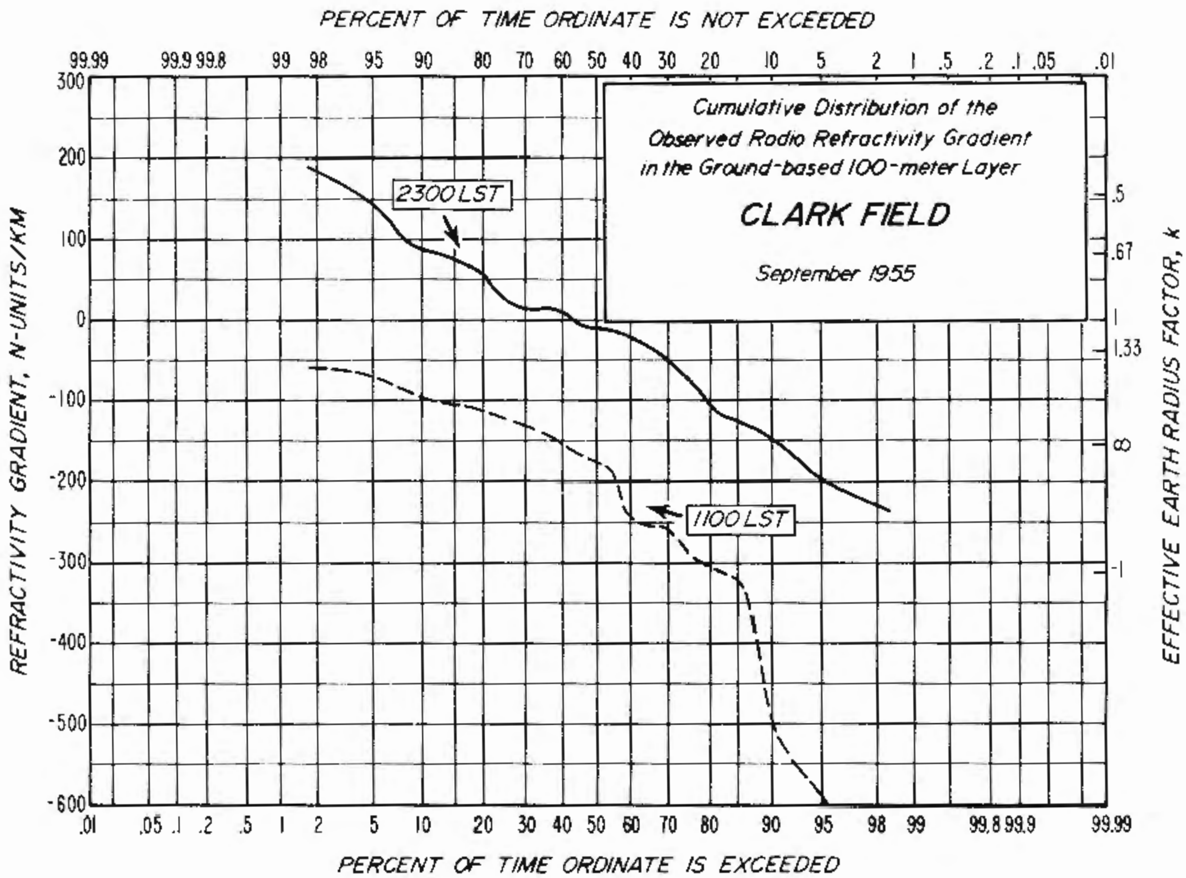
Data: Radiosonde. 0300 and 1500Z (1100 and 2300 LST)
1/51 - 3/57
0000 and 1200Z (0800 and 2000 LST)
4/57 - 12/57

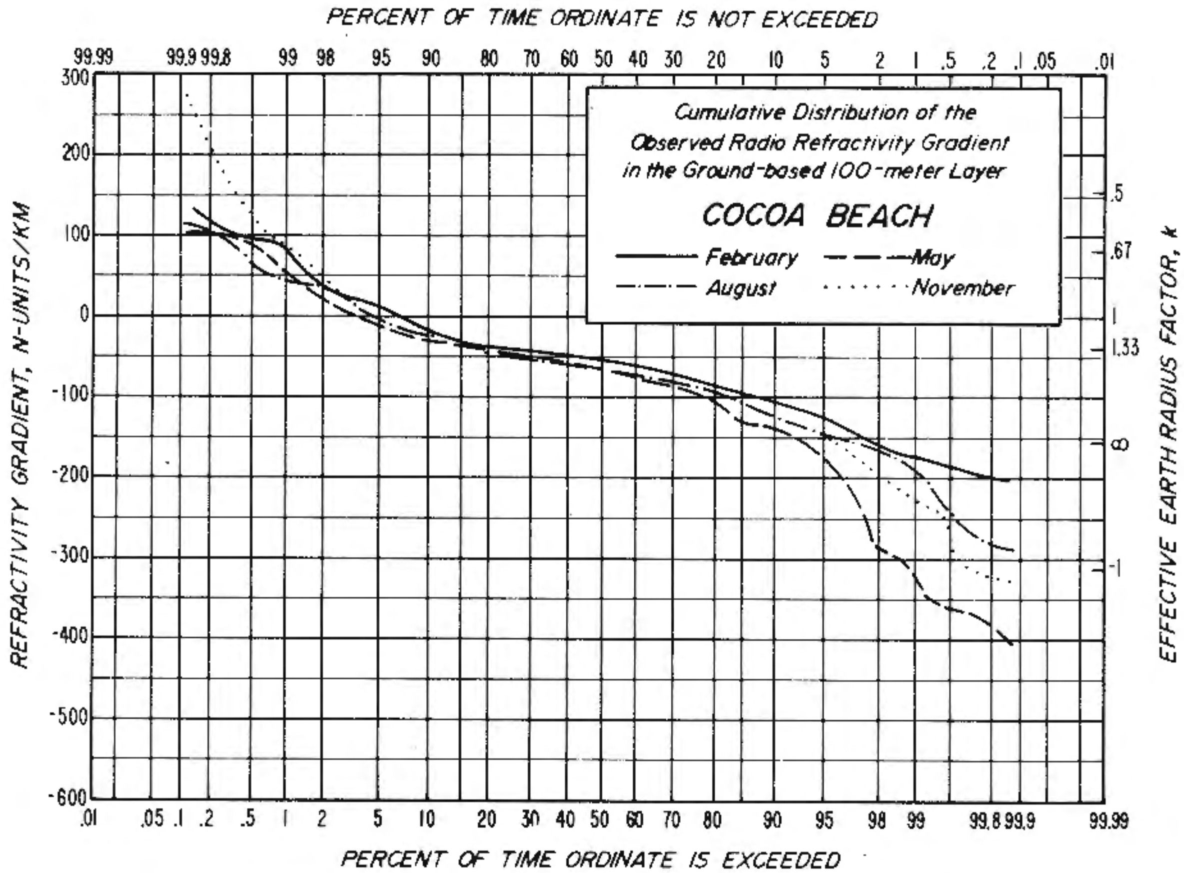
Temperature (°F): January 85/70; July 87/74

Mean Dewpoint (°F): January 64; July 73

Precipitation (inches): Annual 68.3; August 16.14; February 0.67

Located about 50 miles northwest of Manila. A hot, humid tropical maritime climate; normally dry January through April and rainy the rest of the year.


PERCENT OF TIME ORDINATE IS NOT EXCEEDED
Cumulative Distribution of the
Observed Radio Refractivity Gradient
in the Ground-based 100-meter Layer
CLARK FIELD
September 1955
2300 LST
1100 LST
REFRACTIVITY GRADIENT, N-UNITS/KM
EFFECTIVE EARTH RADIUS FACTOR, k
PERCENT OF TIME ORDINATE IS EXCEEDED



<u>Cocoa Beach, Florida</u> (Patrick Air Force Base)

28-14 N, 80-36 W. 3 meters MSL

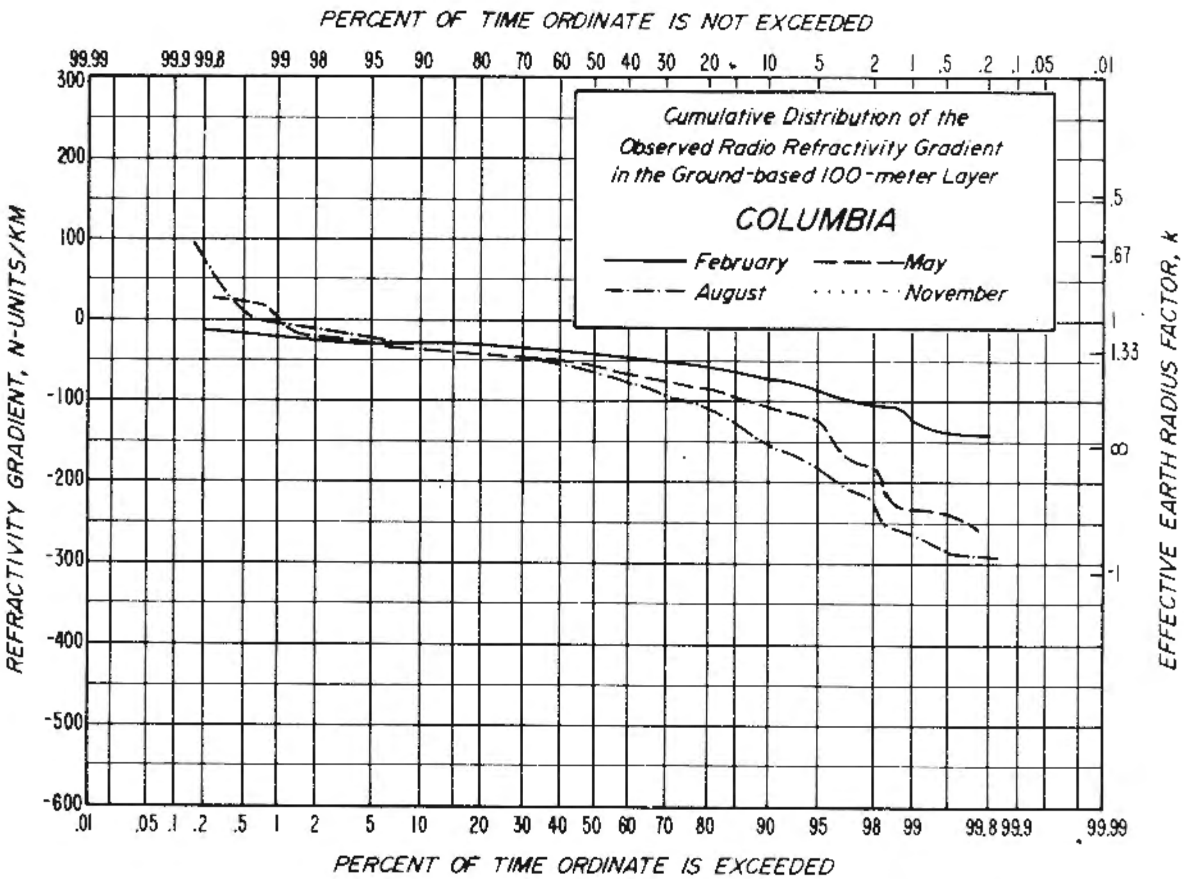
Data: Radiosonde. 0300 and 1500Z (2200 and 1000 LST)
1/51 - 5/57
0000 and 1200Z (1900 and 0700 LST)
6/57 - 12/57

Temperature (°F): January 69/55; July 87/76

Mean Dewpoint (°F): January 55; July 73

Precipitation (inches): Annual 46.6; September 7.82; December 1.59

Station is on a narrow strip of land between the Indian River and the Atlantic Ocean, and is nearly surrounded by water. Land and sea breeze effects are modifying factors in the humid sub-tropical climate; the rainy season is normally June - October.



Columbia, Missouri

38-58 N, 92-22 W. 239 meters MSL

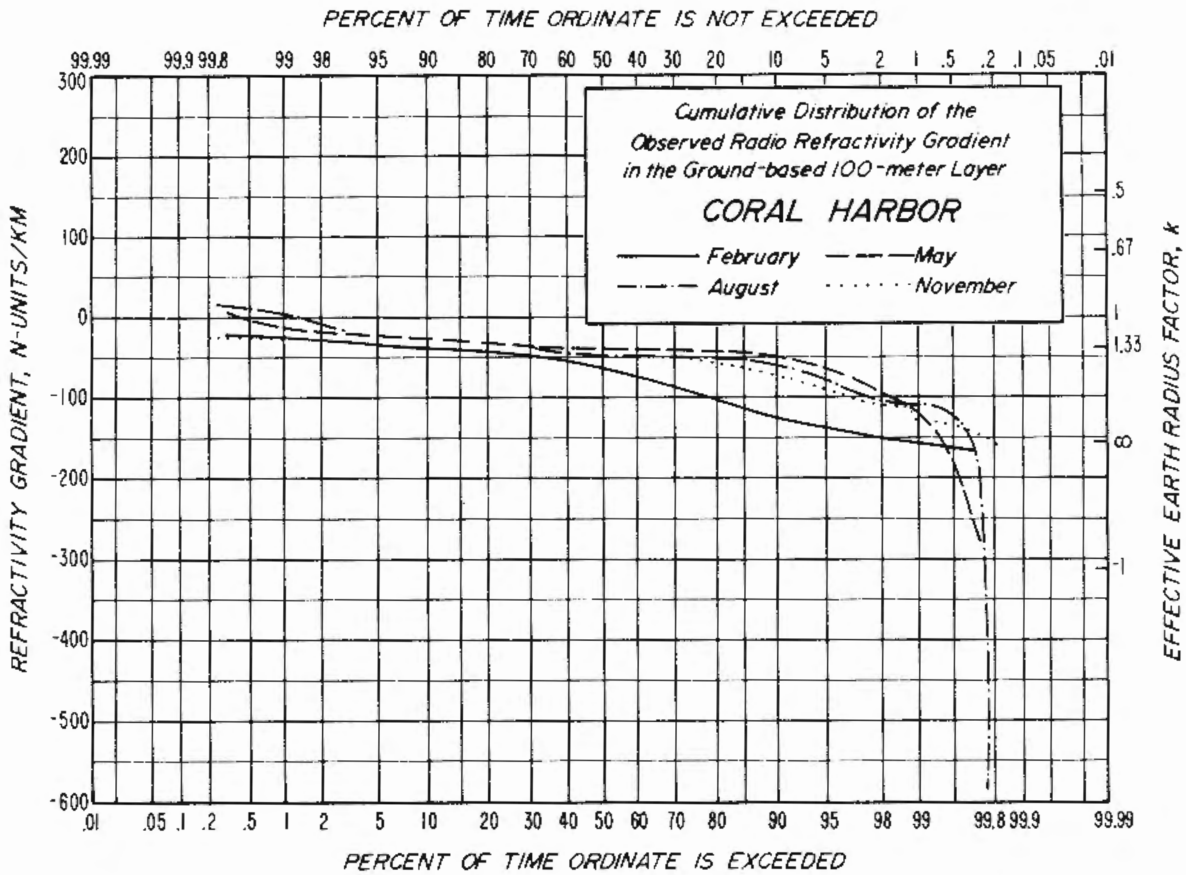
Data: Radiosonde. 0300 and 1500Z (2100 and 0900 LST) 8/52 - 5/57

Temperature (°F): January 38/21; July 87/67

Mean Dewpoint (°F): January 21; July 65

Precipitation (inches): Annual 37.0; May 4.70; January 1.71

Located about 10 miles from the Missouri River; rolling terrain in vicinity. This continental interior station has cold winters and hot, humid summers.



Coral Harbor, Northwest Territories, Canada

64-12 N, 83-22 W. 59 meters MSL

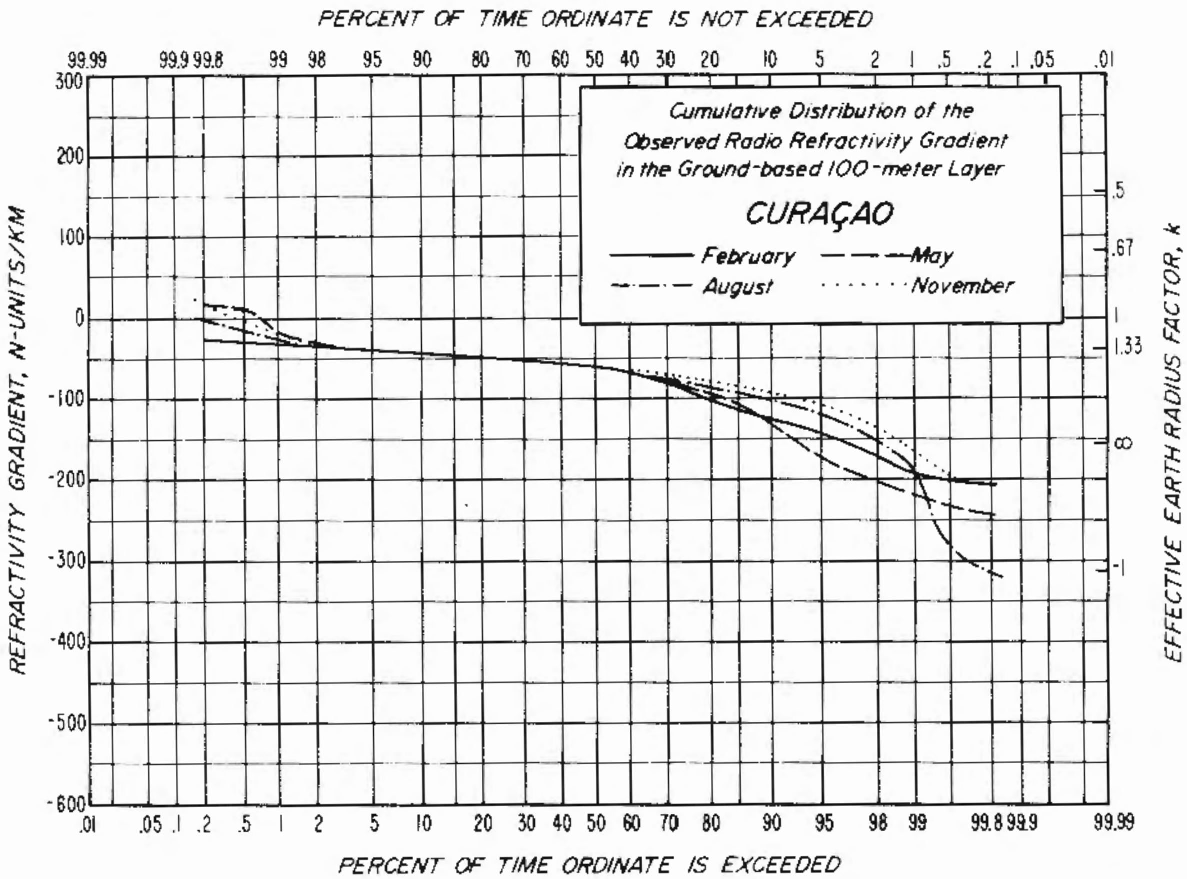
Data: Radiosonde. 0400 and 1600Z (2200 and 1000 LST)
8/45 - 11/46
0300 and 1500Z (2100 and 0900 LST)
1/47 - 8/47, 11/47 - 12/47, 4/48 - 12/48
0300Z (2100 LST)
9/47 - 10/47, 1/48 - 3/48

Temperature (°F): January -12/-27; July 54/39

Mean Dewpoint (°F): January (M); July 39

Precipitation (inches): Annual 9.9; July 1.58; March 0.27

The station is on an inlet on the south coast of Southhampton Island in the northern part of Hudson Bay. Severe continental climate.

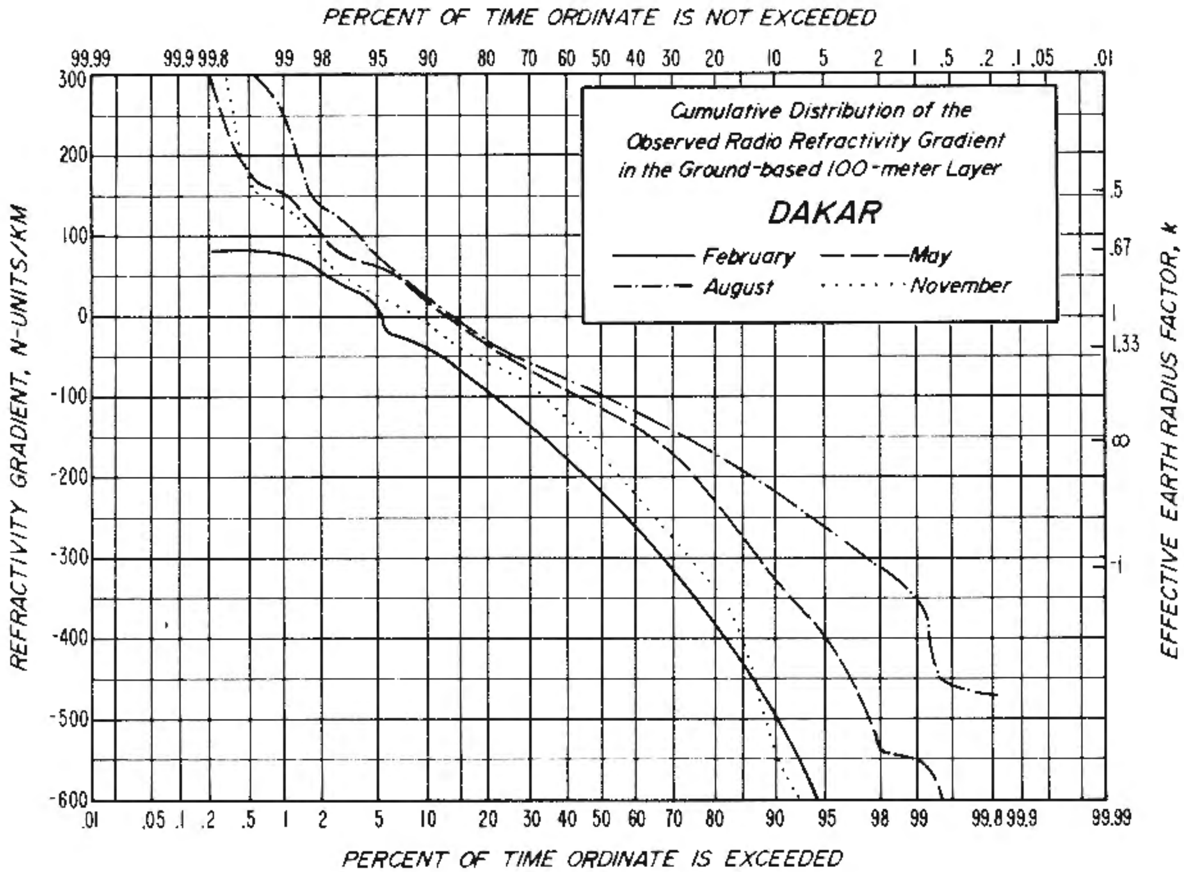


Curaçao, Netherlands West Indies

12-11 N, 68-59 W. 16 meters MSL

Data: Radiosonde.	1500Z (1000 LST) 2/57 - 5/57 0000 and 1200Z (1900 and 0700 LST) 8/57 - 2/58; 8/58 - 11/61 0000Z (1900 LST) 5/58
Temperature (°F):	January 84/75; July 88/79
Mean Dewpoint (°F):	January 71; July 75
Precipitation (inches):	Annual 21.3; November 4.18; February 0.44

Located on a large, generally flat island (36 miles by 8 miles) 60 miles off the coast of northwest Venezuela. Sparse vegetation. A humid tropical climate.



Dakar, Senegal

14-44 N, 17-30 W. 22 meters MSL

Data: Radiosonde. 0600Z (0500 LST)
11/52 - 8/60

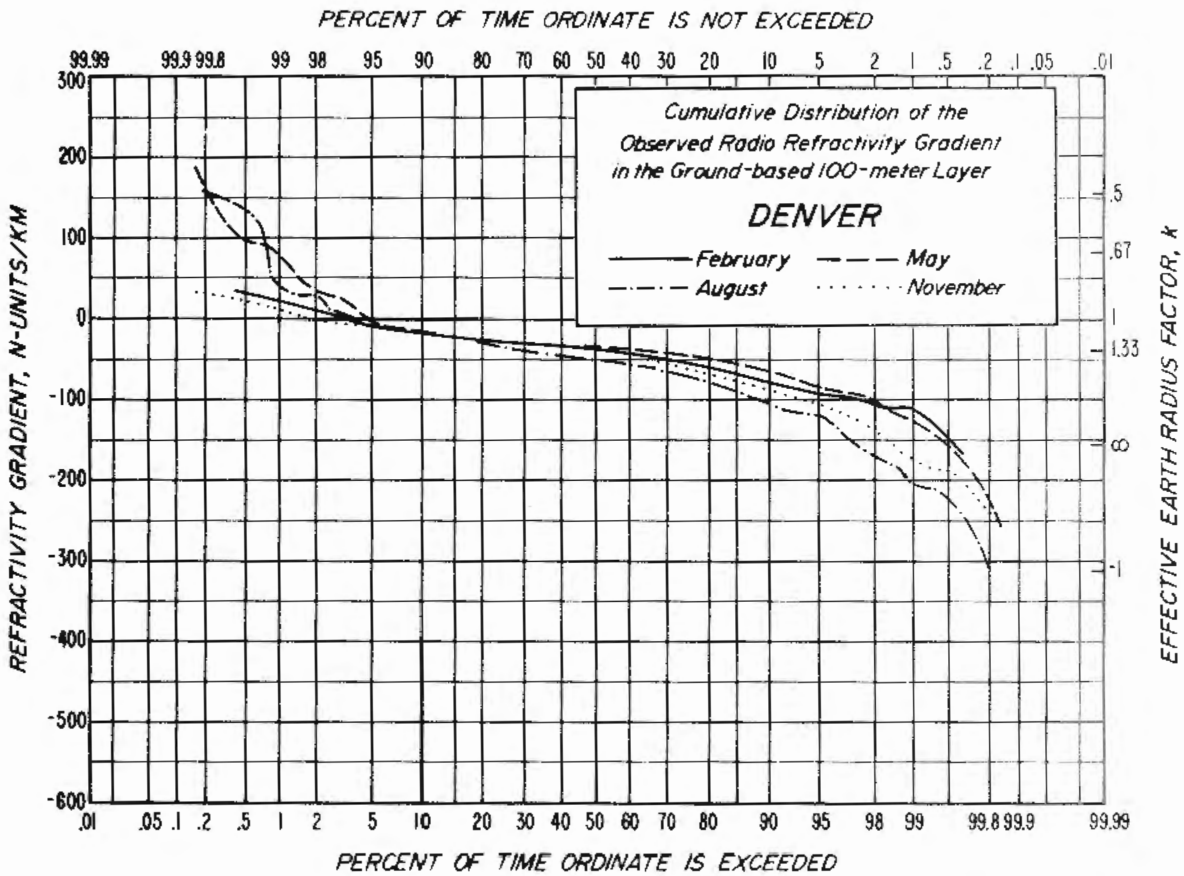
Note: Observations predominantly at 0600Z, but some other times included (February, 0600 and 1200Z; May, 0600 and 1200Z; August, 0000, 0600, and 1400Z; November, 0600, 0700, 1200, and 1400Z)

Temperature (°F): January 79/64; July 88/76

Mean Dewpoint (°F): January 55; July 71

Precipitation (inches): Annual 22.8; August 9.80; Jan., Mar., Apr. 0.00

Located on the west coast of Africa; tropical maritime climate with marked wet and dry seasons. Temperatures moderated by winds off the Atlantic Ocean.

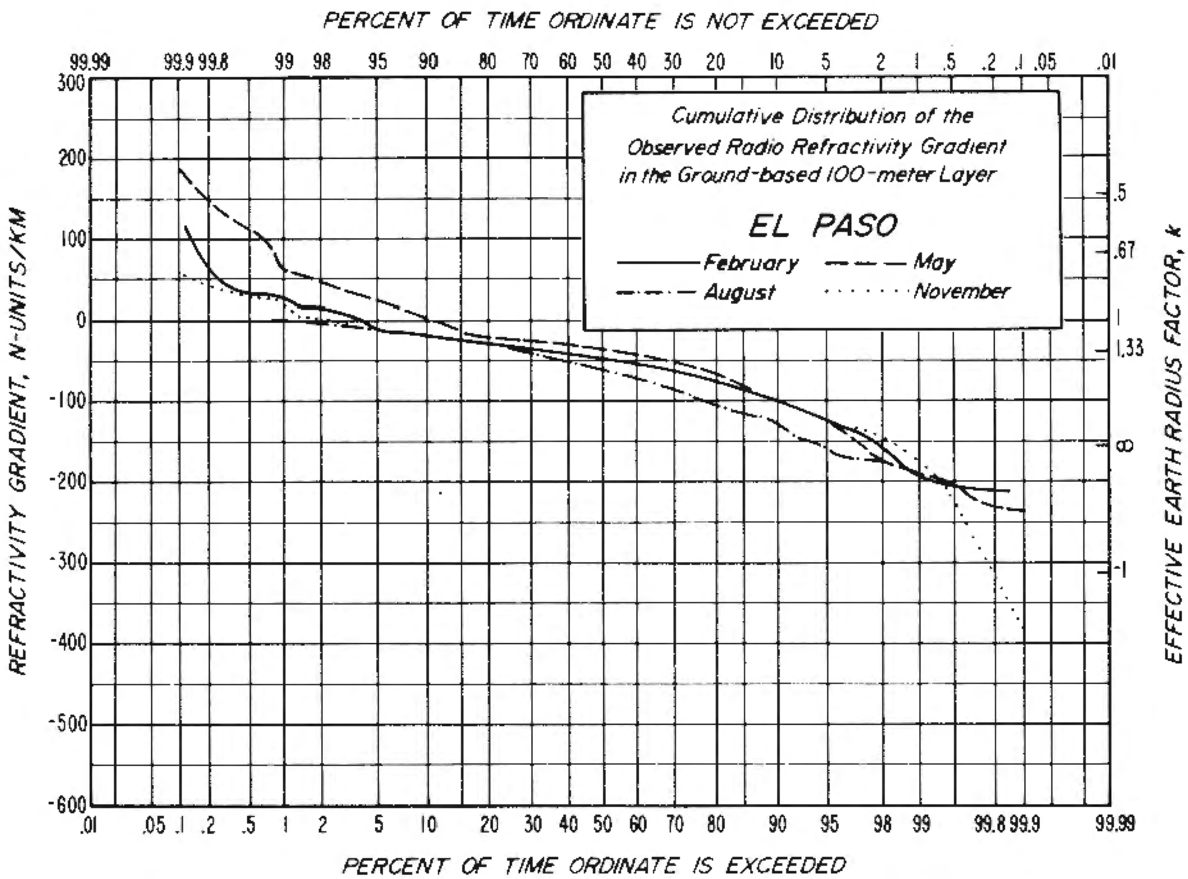


<u>Denver, Colorado</u>

39-46 N, 104-53 W. 1625 meters MSL

Data: Radiosonde.	0300 and 1500Z (2000 and 0800 LST) 8/51 - 5/56
Temperature (°F):	January 42/15; July 88/57
Mean Dewpoint (°F):	January 12; July 46
Precipitation (inches):	Annual 14.8; May 2.70; December 0.47

Located in gently rolling terrain about 25 miles east of the foothills and 45 miles east of the 13000 to 14000 ft peaks of the Continental Divide of the Rocky Mountains. A semi-arid continental interior climate.



El Paso, Texas

31-48 N, 106-24 W. 1194 meters MSL

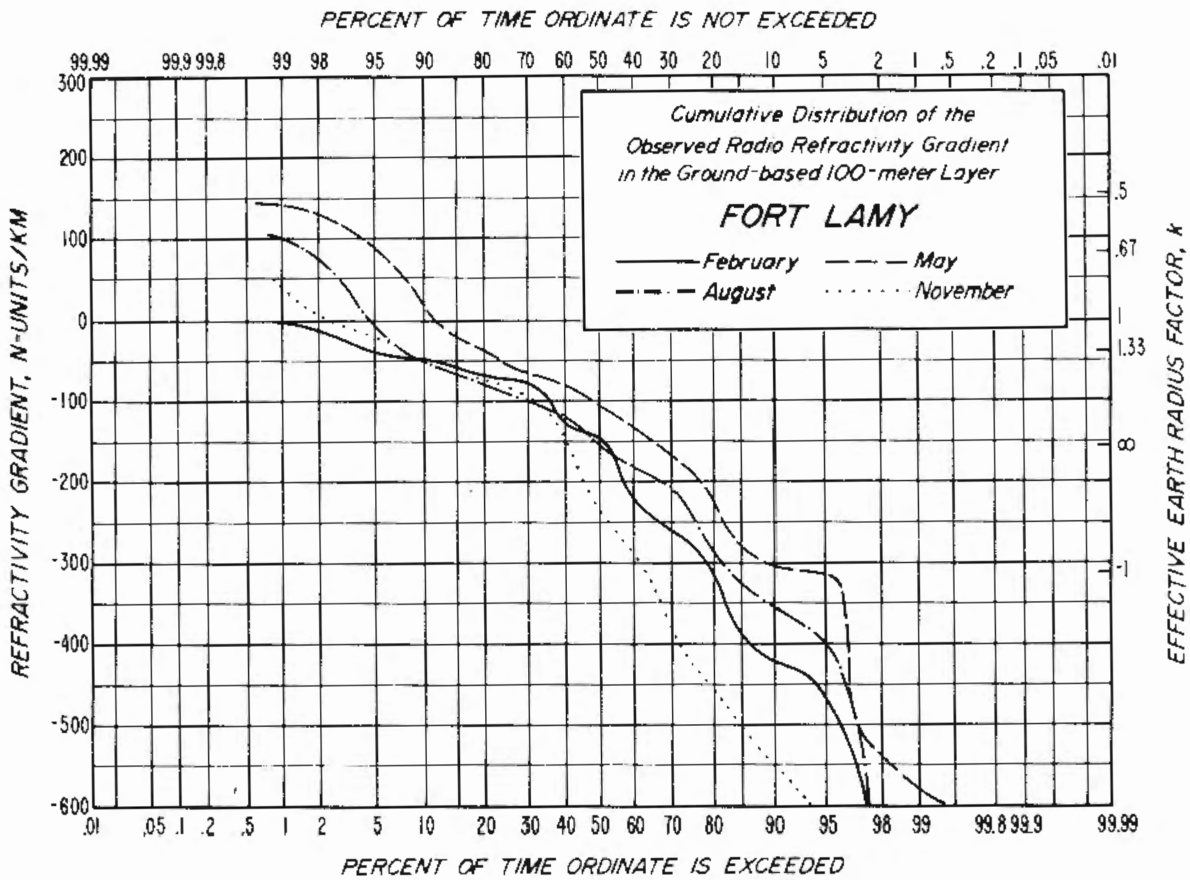
Data: Radiosonde. 0300 and 1500Z (2000 and 0800 LST)
1/51 - 5/57
0000 and 1200Z (1700 and 0500 LST)
6/57 - 12/57

Temperature (°F): January 56/30; July 95/69

Mean Dewpoint (°F): January 24; July 54

Precipitation (inches): Annual 7.9; July 1.29; April 0.29

This station is on a mesa about 200 ft above the flat, irrigated land in the Rio Grande valley; a relatively low range of mountains lies to the north. The prevailing winds are from the north in winter and from the south in summer. Arid climate with mild winters and hot summers.



Ft. Lamy, Chad

12-08 N, 15-02 E. 300 meters MSL

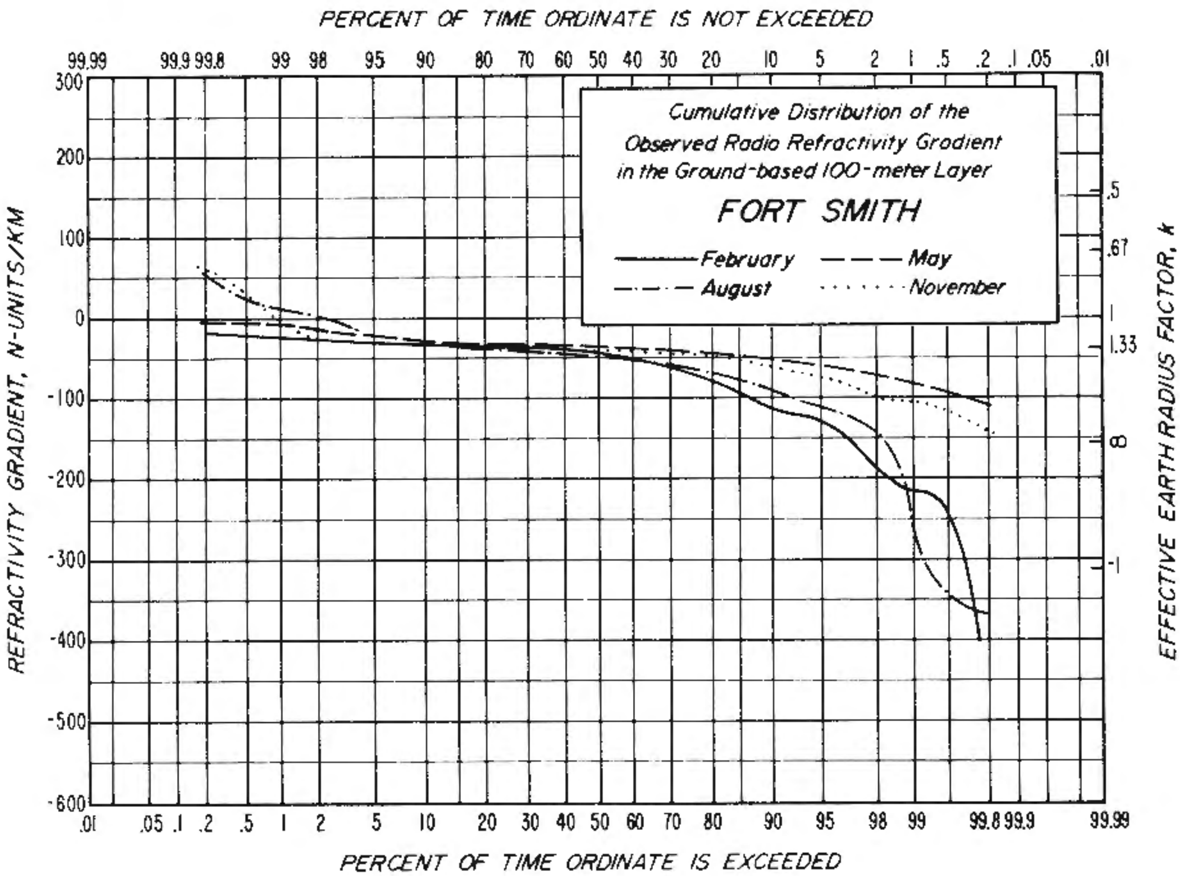
Data: Radiosonde. 0300Z (0400 LST)
5/59 - 5/63

Temperature (°F): January 93/57; July 93/73

Mean Dewpoint (°F): January 46; July 73

Precipitation (inches): Annual 25.5; August 10.12; Jan., Feb., Mar., Dec. 0.00

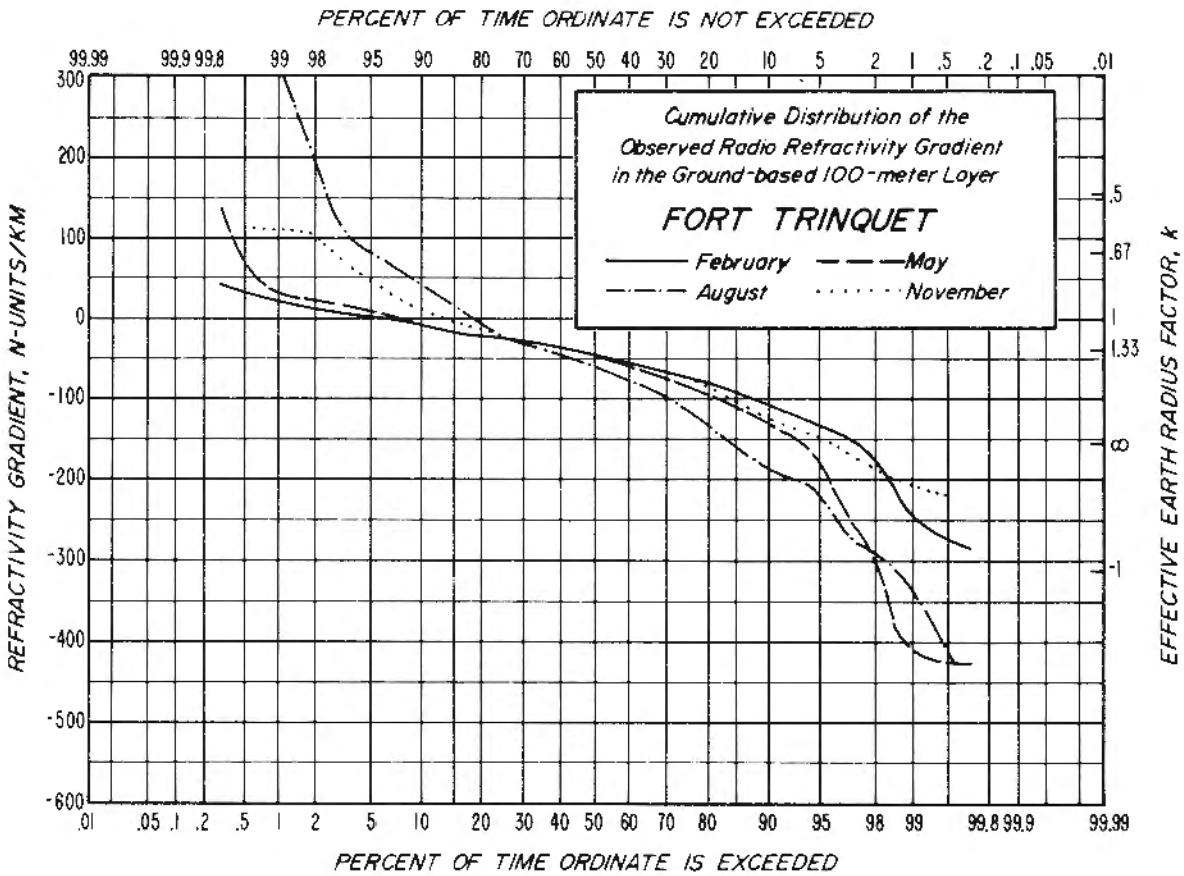
Located on the Shari River in southwest Chad; alluvial plain in vicinity is flooded in rainy season. Tropical continental climate with hot, dry winters and hot, humid, rainy summers.



Fort Smith, Northwest Territories, Canada

60-01 N, 111-58 W		203 meters MSL
Data:	Radiosonde.	0300 and 1500Z (2000 and 0800 LST) 1/45 - 8/46, 10/46 - 3/47, 10/48 - 12/49 0300Z (2000 LST) 9/46, 4/47 - 9/48
Temperature (°F):		January -5/-22; July 74/48
Mean Dewpoint (°F):		January (M); July 51
Precipitation (inches):		Annual 12.6; July 1.99; April 0.52

Located on the Slave River. A severe continental climate.



<u>Ft. Trinquet(Bir Mogrein), Mauritania</u>

25-14 N, 11-37 W. 359 meters MSL

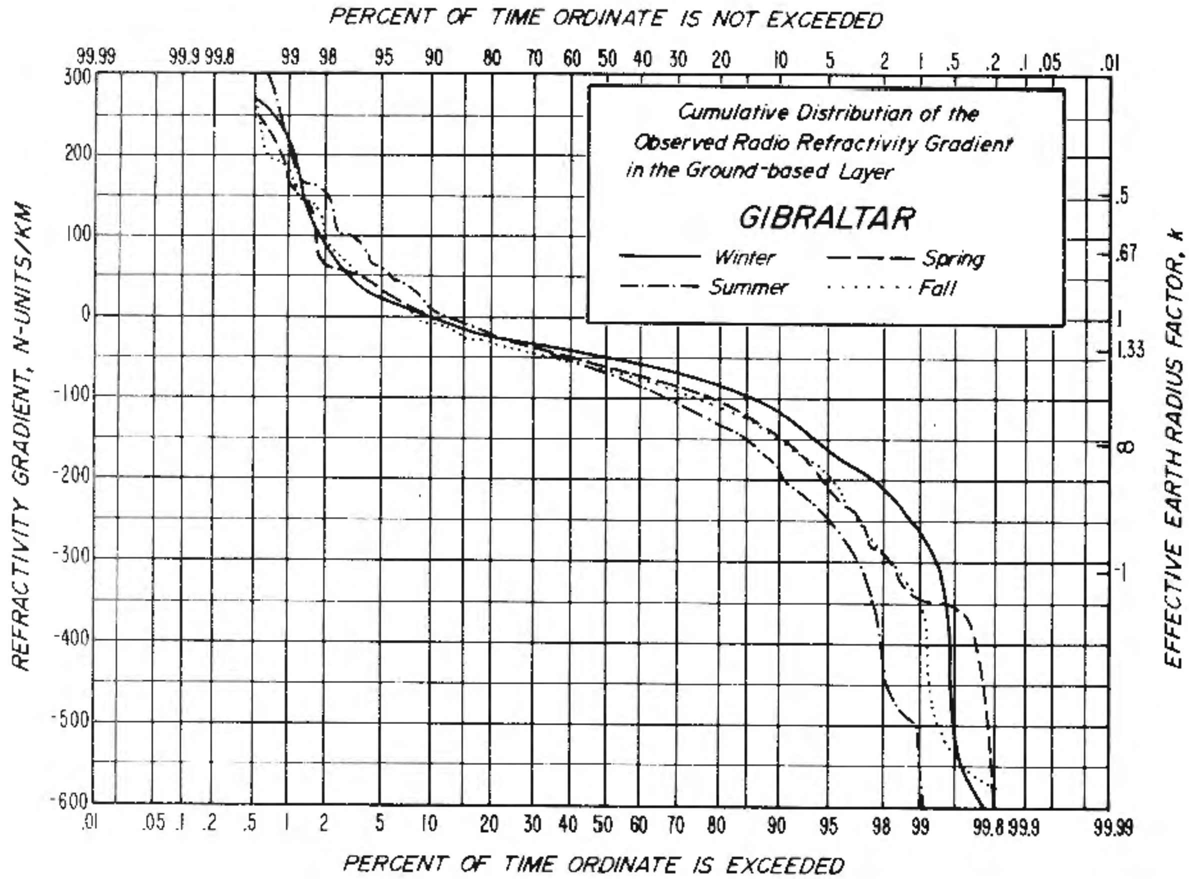
Data: Radiosonde. 1100Z (1000 LST)
2/58 - 11/59
1200Z (1100 LST)
2/60 - 5/63

Temperature (°F): January 79/M; July 111/M

Mean Dewpoint (°F): January 32; July 51

Precipitation: Less than 4 in/yr.

In the Sahara region; very hot, dry, desert climate.



Gibraltar (British Colony)

36-09 N, 05-21 W. 3 meters MSL

Data: Radiosonde. 0000 and 1200Z (0000 and 1200 LST) 1/68 - 12/70

Note: Calculated refractivity gradient between surface and next higher level. See text.

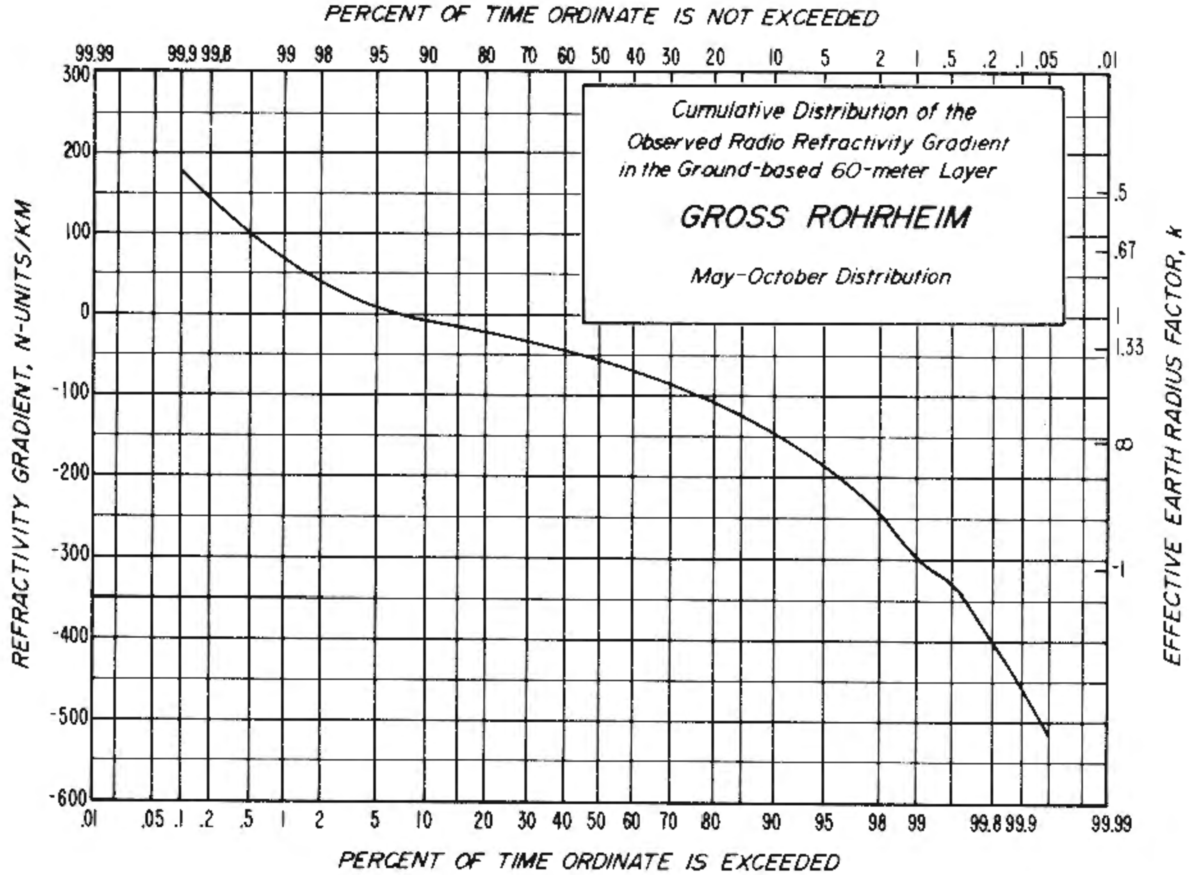
Analyzed by: Davis and Wagner, Environmental Technical Applications Center, U.S. Air Force, Washington, D.C.

Temperature (°F): January 60/50; July 83/68

Mean Dewpoint (°F): January 48; July 63

Precipitation (inches): Annual 32.1; January 6.06; July 0.04

Located on a 2.25 sq. mile peninsula on the southern tip of Spain. Maritime climate with hot and nearly rainless summers and warm, rainy winters.



<u>Gross Rohrheim, Germany</u> (Federal Republic)

49-43 N, 08-28 E. 90 meters MSL

Data: 60-meter gradients based on 3-hrly dry- and wet-bulb temperature measurements on a 65-meter tower 20 km southwest of Darmstadt. June - October 1966; May - October 1967

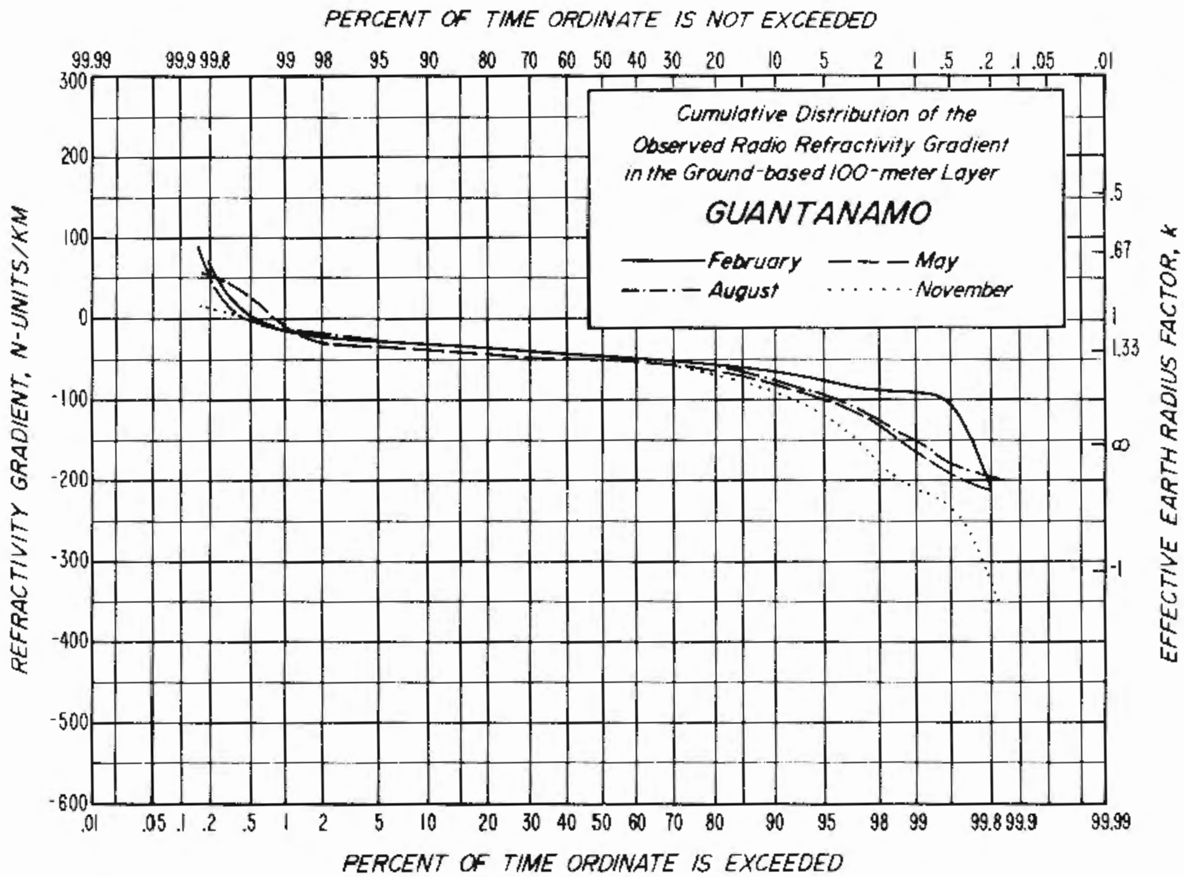
Analyzed by: Dr. L. Fehlhaber, Fernmeldetechnisches Zentralamt, Darmstadt

Temperature (°F): January 38/29; July 75/56

Mean Dewpoint (°F): January 29; July 54

Precipitation (inches): Annual 25.0; July 2.80; February 1.58

Located in the Rhine Valley. A continental climate modified by exposure to maritime air masses.



Guantanamo, Cuba

19-54 N, 75-09 W. 23 meters MSL

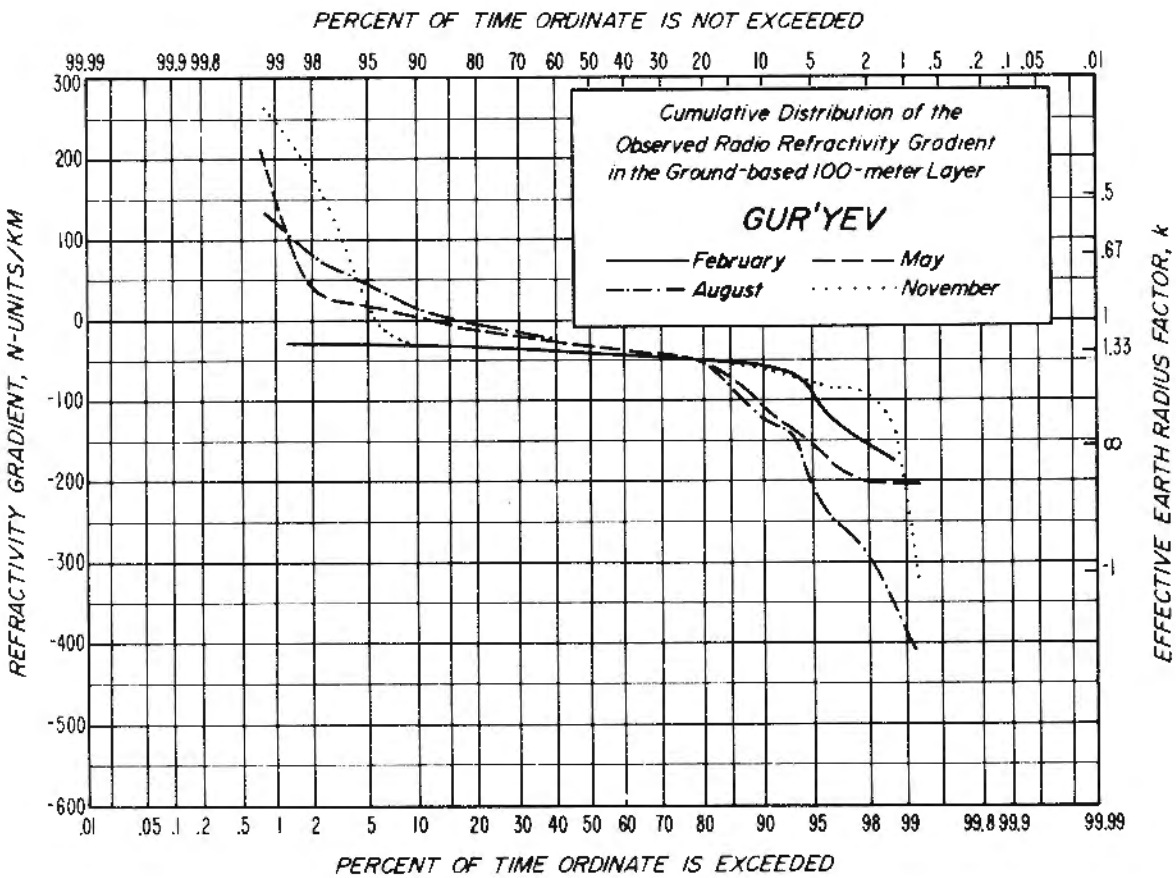
Data: Radiosonde. 0300 and 1500Z (2200 and 1000 LST)
8/52 - 5/57

Temperature (°F): January 84/68; July 92/76

Mean Dewpoint (°F): January 65; July 73

Precipitation (inches): Annual 23.4; October 6.68; February 0.70

Located on a bay on southeast coast of Cuba. A maritime sub-tropical climate.



Gur'yev, Kazakh, U.S.S.R.

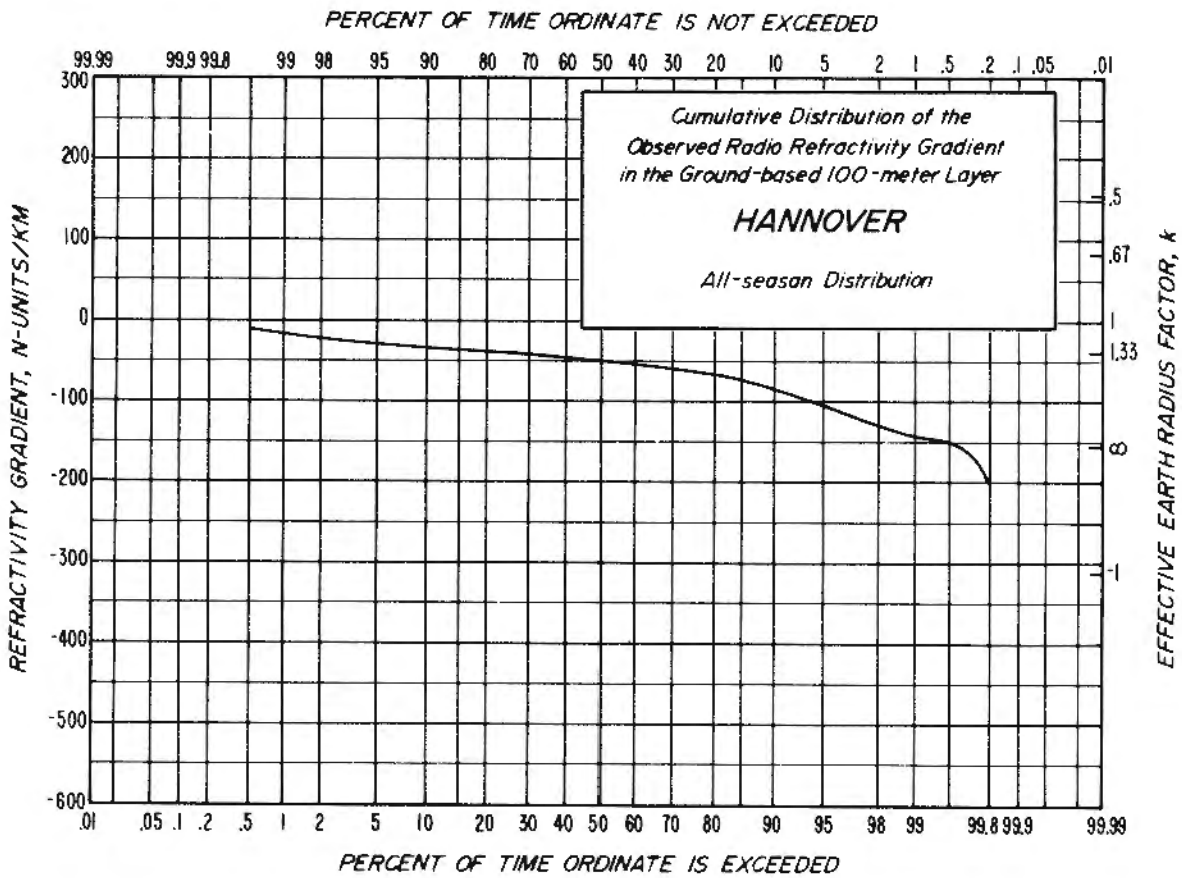
47-07 N, 51-55 E. 21 meters below MSL

Data: Radiosonde. 0200Z (0500 LST)
2/57
0000Z (0300 LST)
5/57 - 11/60

Temperature (°F): January 17/6; July 86/66

Precipitation (inches): Annual 6.2; June 0.8; Feb., March 0.3

Located at the northern end of the Caspian Sea at the mouth of the Ural River; the surrounding country is largely marsh and desert. An arid continental temperate climate with occasional severe droughts.



<u>Hannover, Germany</u> (Federal Republic)

52-27 N, 09-41 E. 55 meters MSL

Data: Radiosonde. 0000 and 1200Z (0100 and 1300 LST)
1961 and 1962

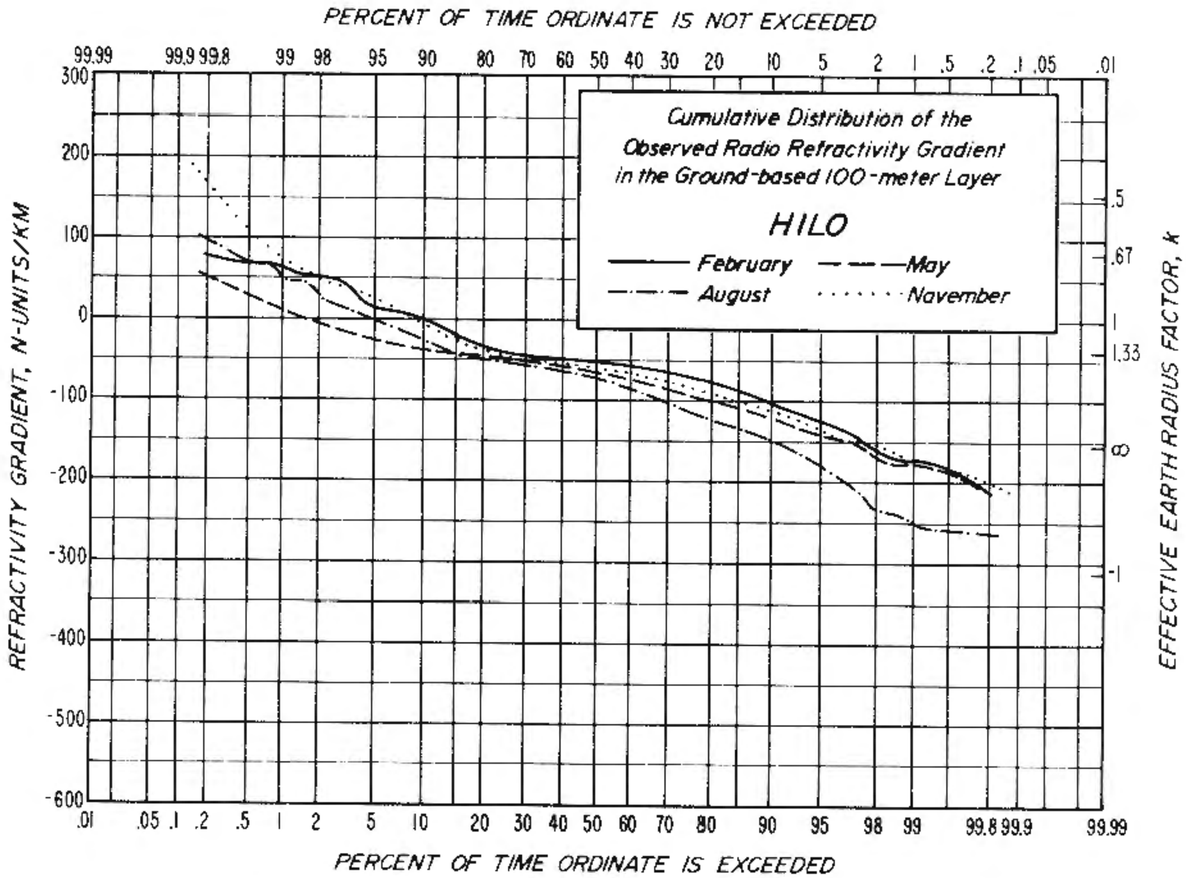
Analyzed by: Dr. L. Fehlhaber, Fernmeldetechnisches Zentralamt, Darmstadt

Temperature (°F): January 38/28; July 72/53

Mean Dewpoint (°F): January 31; July 55

Precipitation (inches): Annual 23.9; July 3.00; February 1.40

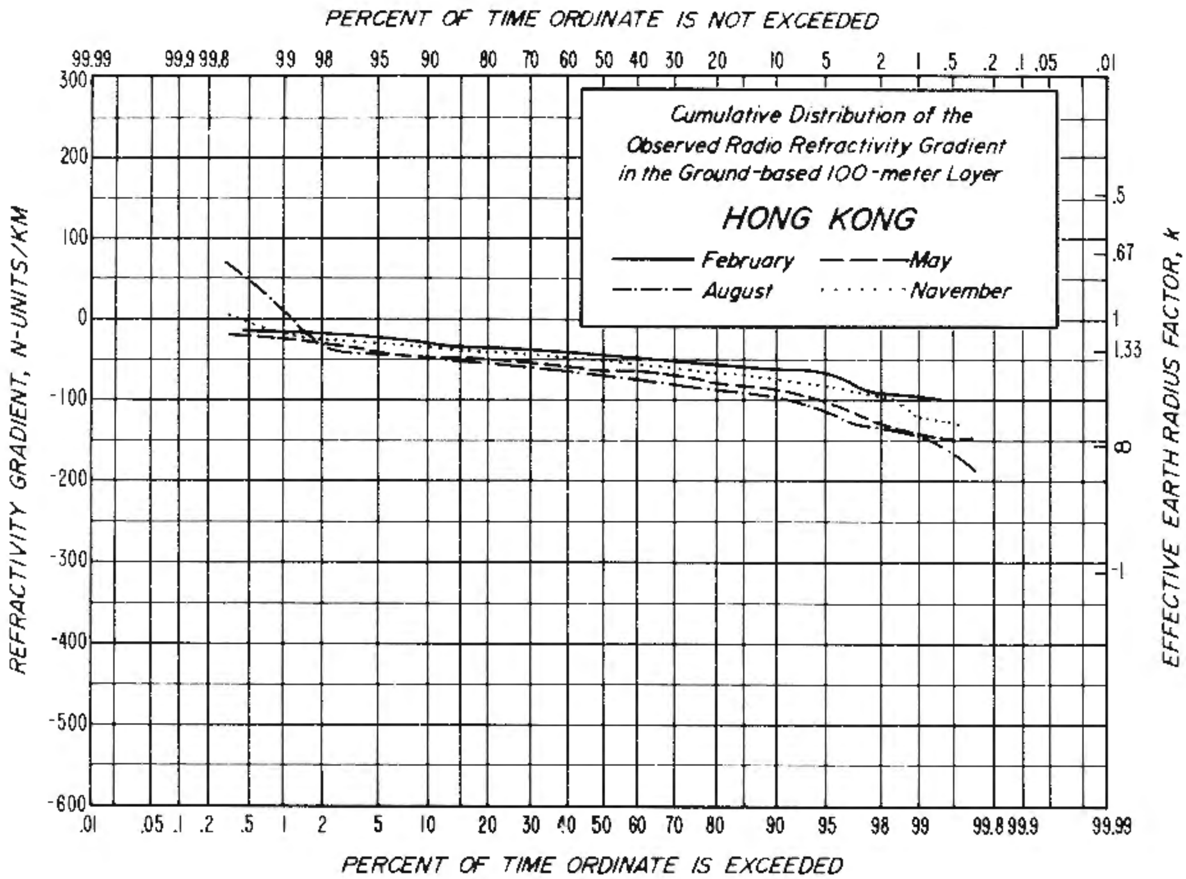
Located in the valley of the Leine River where spurs of the Harz and Mittelgebirge Mountains merge into the north German plain. A largely maritime climate; cool summers and relatively mild but humid winters.



<u>Hilo, Hawaii</u>

19-44 N, 155-04 W.	11 meters MSL
Data: Radiosonde.	0300 and 1500Z (1700 and 0500 LST) 8/52 - 8/54 and 2/55 - 5/57 (Also 0300, 0900, 1500, and 2100Z for 11/54 only)
Temperature (°F):	January 79/63; July 82/67
Mean Dewpoint (°F):	January 62; July 68
Precipitation (inches):	Annual 136.6; December 15.18; June 6.79

Station is located near the eastern shore of a large, mountainous island (area 4038 sq. miles; peaks above 13600 ft); it is within the northeast trade wind belt. Day-to-day and seasonal weather changes generally small at locations near sea level, but temperatures, precipitation, and cloudiness in vicinity vary greatly with elevation and degree of exposure to the trade winds.



Hong Kong (British Crown Colony, SE China)

22-18 N, 114-10 E. 33 meters MSL

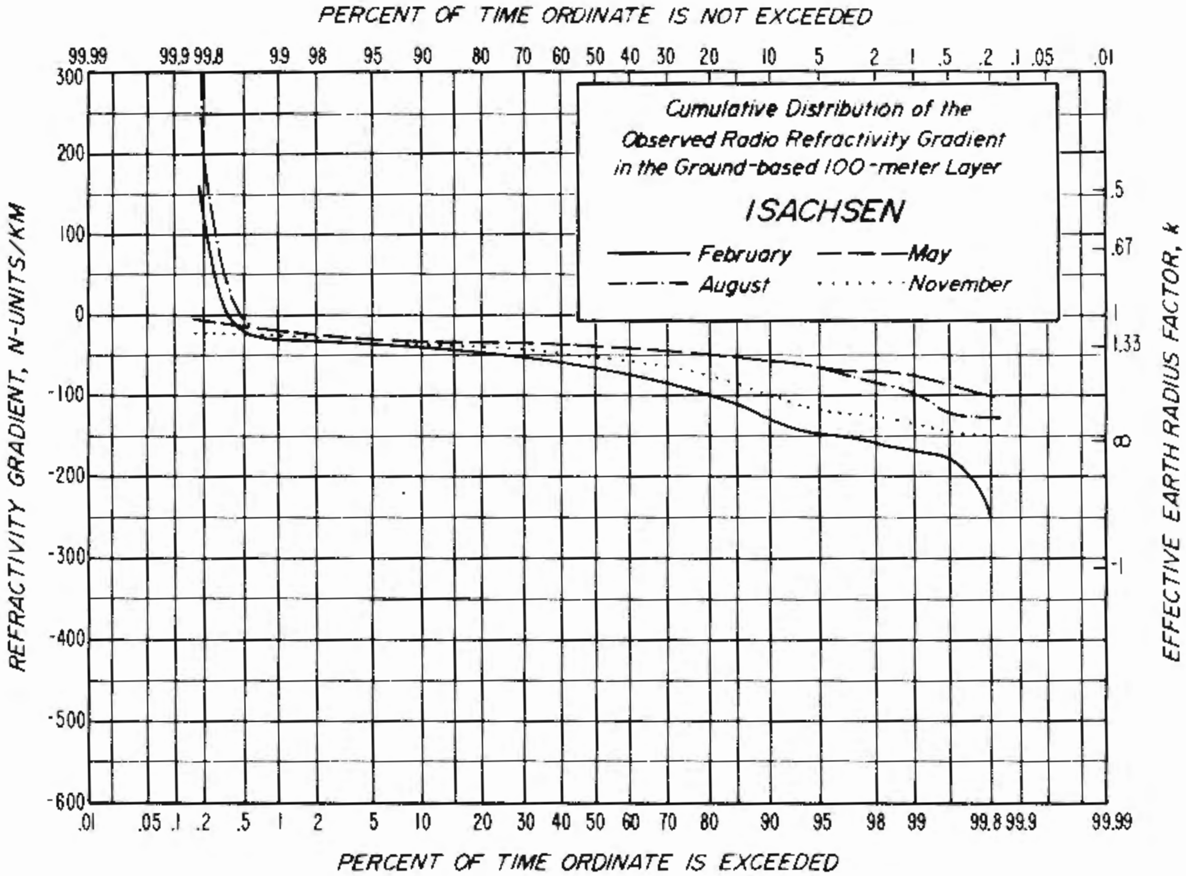
Data: Radiosonde. 0300Z (1100 LST)
5/56 - 2/57
0000Z (0800 LST)
5/57 - 11/60

Temperature (°F): January 64/56; July 87/78

Mean Dewpoint (°F): January 51; July 77

Precipitation (inches): Annual 85.1; June 15.5; December 1.2

An island located east of the mouth of the Pearl River about 90 miles south of Canton, China. The summer monsoon brings hot, humid weather; the winter monsoon is cold and dry. Located in the typhoon belt.



Isachsen, Northwest Territories, Canada

78-47 N, 103-32 W. 25 meters MSL

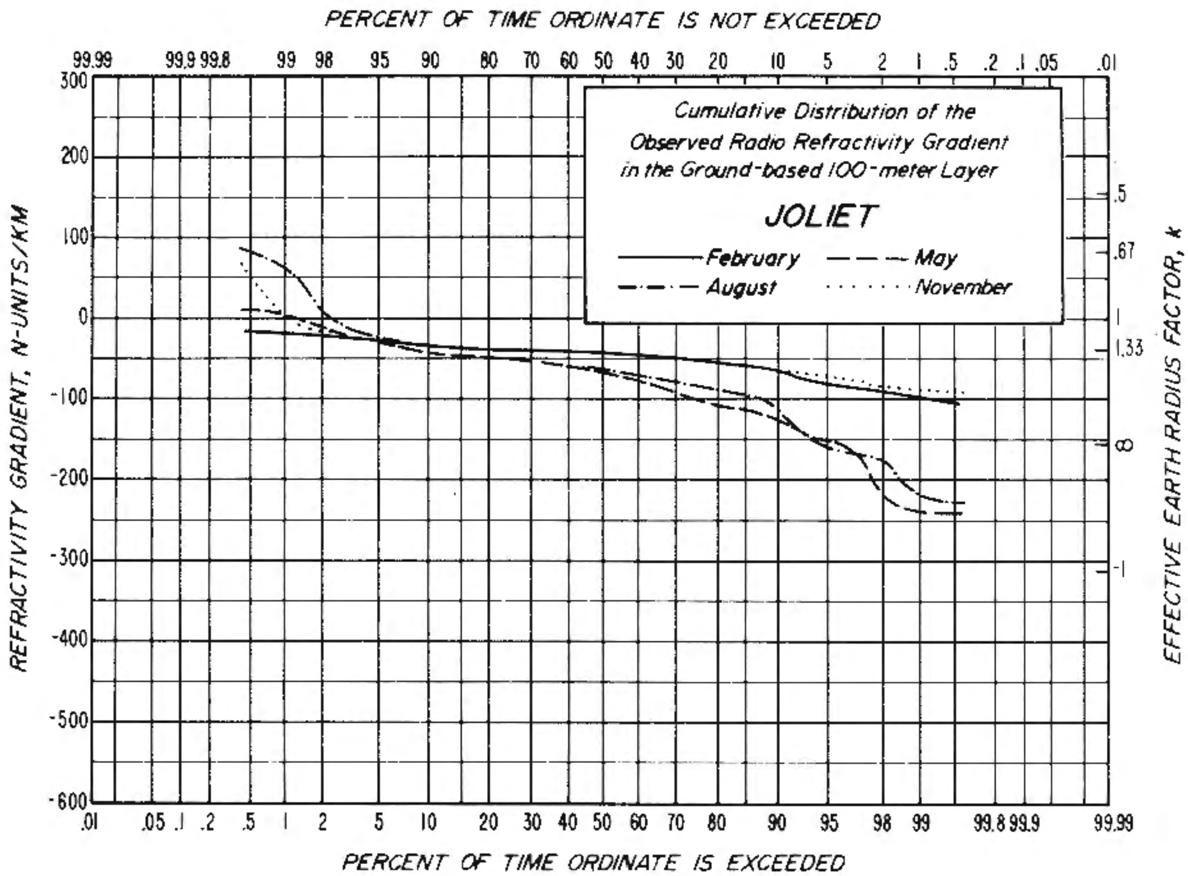
Data: Radiosonde. 0000Z (1700 LST)
8/52 - 5/57

Temperature (°F): January -27/-37; July 43/34

Mean Dewpoint (°F): January (M); July 35

Precipitation (inches): Annual 3.8; August 0.91; March 0.04

Located on a peninsula of Ellef Ringnes Island. Arctic climate.



Joliet, Illinois

41-30 N, 88-10 W. 179 meters MSL

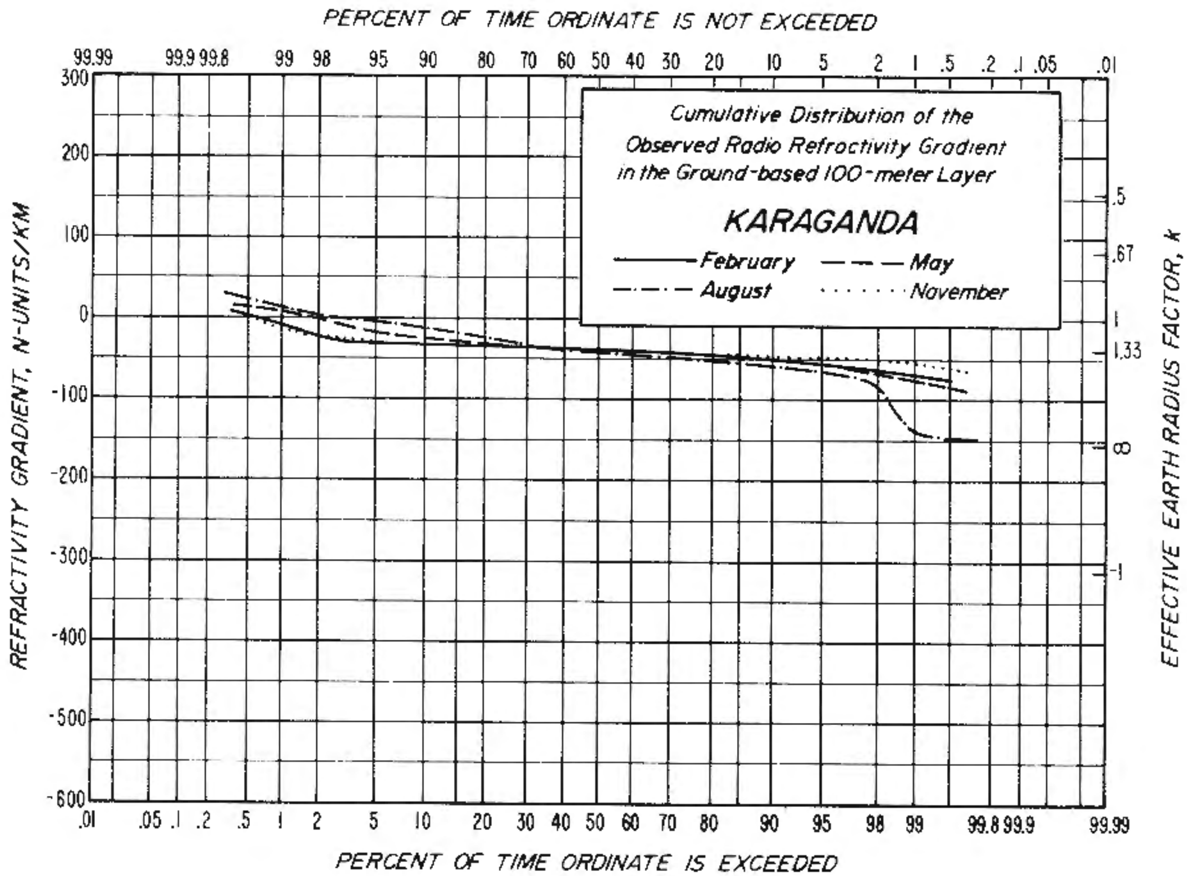
Data: Radiosonde. 0300 and 1500Z (2100 and 0900 LST)
7/50 - 6/52

Temperature (°F): January 33/16; July 86/62

Mean Dewpoint (°F): January 20; July 62

Precipitation (inches): Annual 35.2; June 4.31; February 1.68

Located in gently rolling terrain about 35 miles southwest of Lake Michigan. Continental temperate climate with relatively cold winters and hot, humid summers.

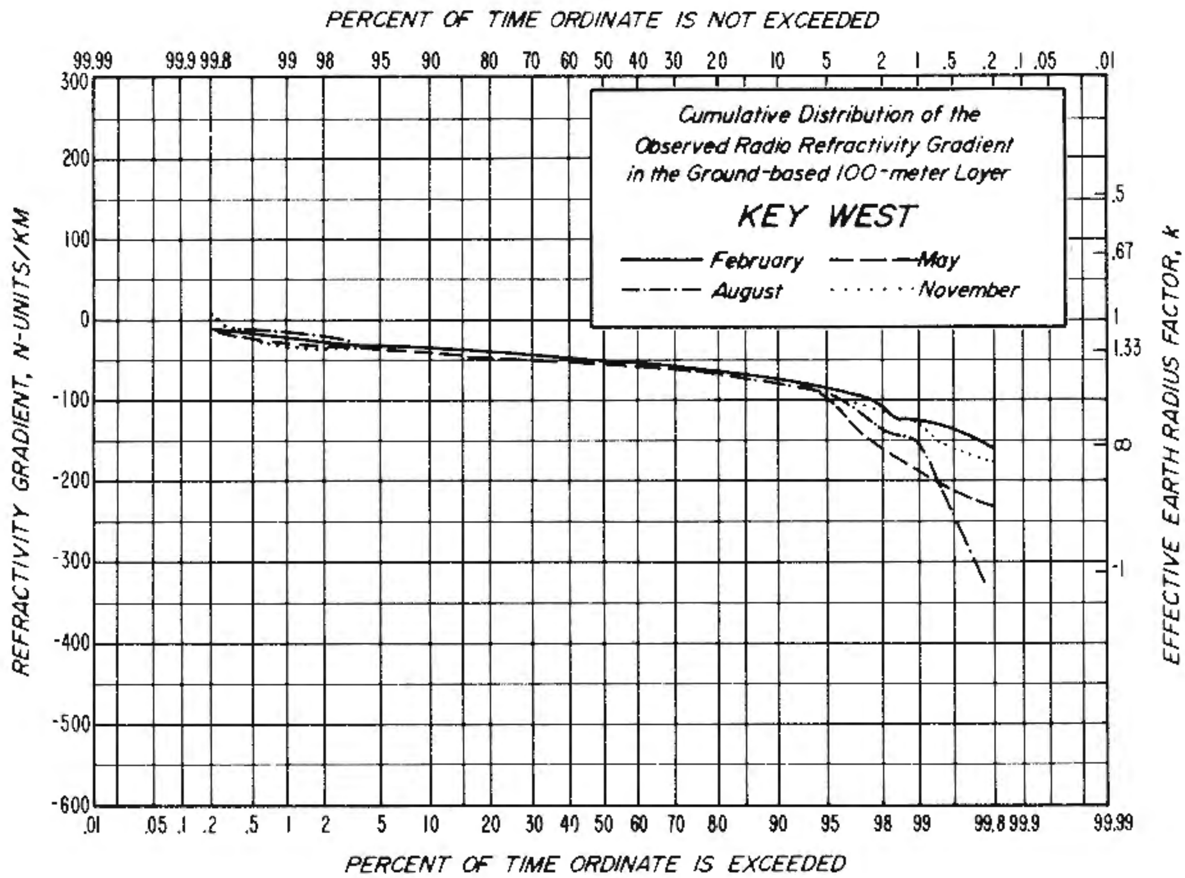


<u>Karaganda, Kazakhstan, U.S.S.R.</u>

49-48 N, 73-08 E. 555 meters MSL

Data:	Radiosonde.	0200Z (0700 LST) 2/56 - 2/57 0000Z (0500 LST) 5/57 0000 and 1200Z (0500 and 1700 LST) 8/57 - 11/59 0000Z (0500 LST) 2/60 - 8/60

Located in an extensive steppe region northwest of Lake Balkhash. A continental climate with hot, dry summers and cold, windy winters.



Key West, Florida

24-33 N, 81-45 W. 6 meters MSL

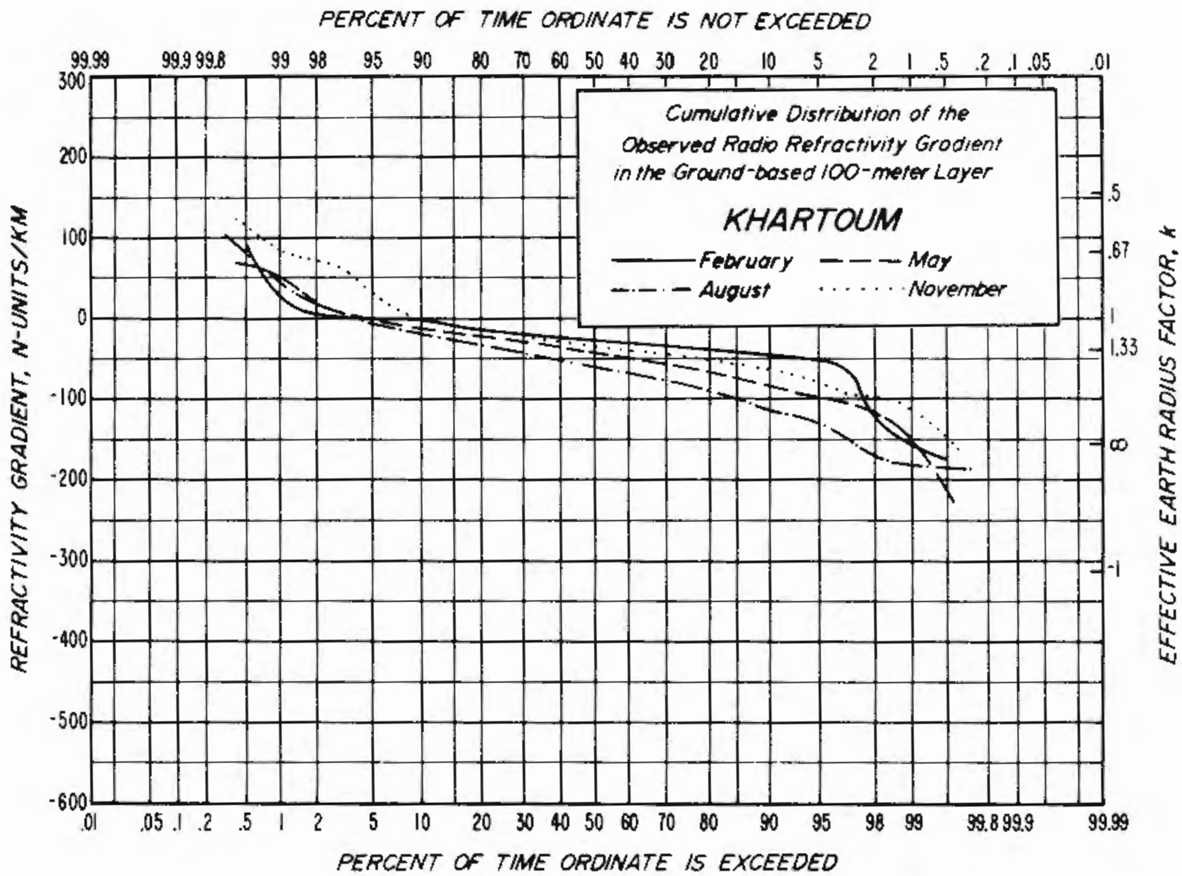
Data: Radiosonde. 0300 and 1500Z (2200 and 1000 LST)
5/54 - 5/57
0000 and 1200Z (1900 and 0700 LST)
8/57 - 2/59

Temperature (°F): January 74/65; July 87/79

Mean Dewpoint (°F): January 61; July 74

Precipitation (inches): Annual 40.0; September 6.73; January 1.53

Located about 60 miles from the mainland on a small low island; the surrounding water is shallow. Station is about 12 miles north of the Gulf Stream, and has prevailing easterly trade winds. A sub-tropical maritime climate.



Khartoum, Sudan

15-36 N, 32-33 E. 385 meters MSL

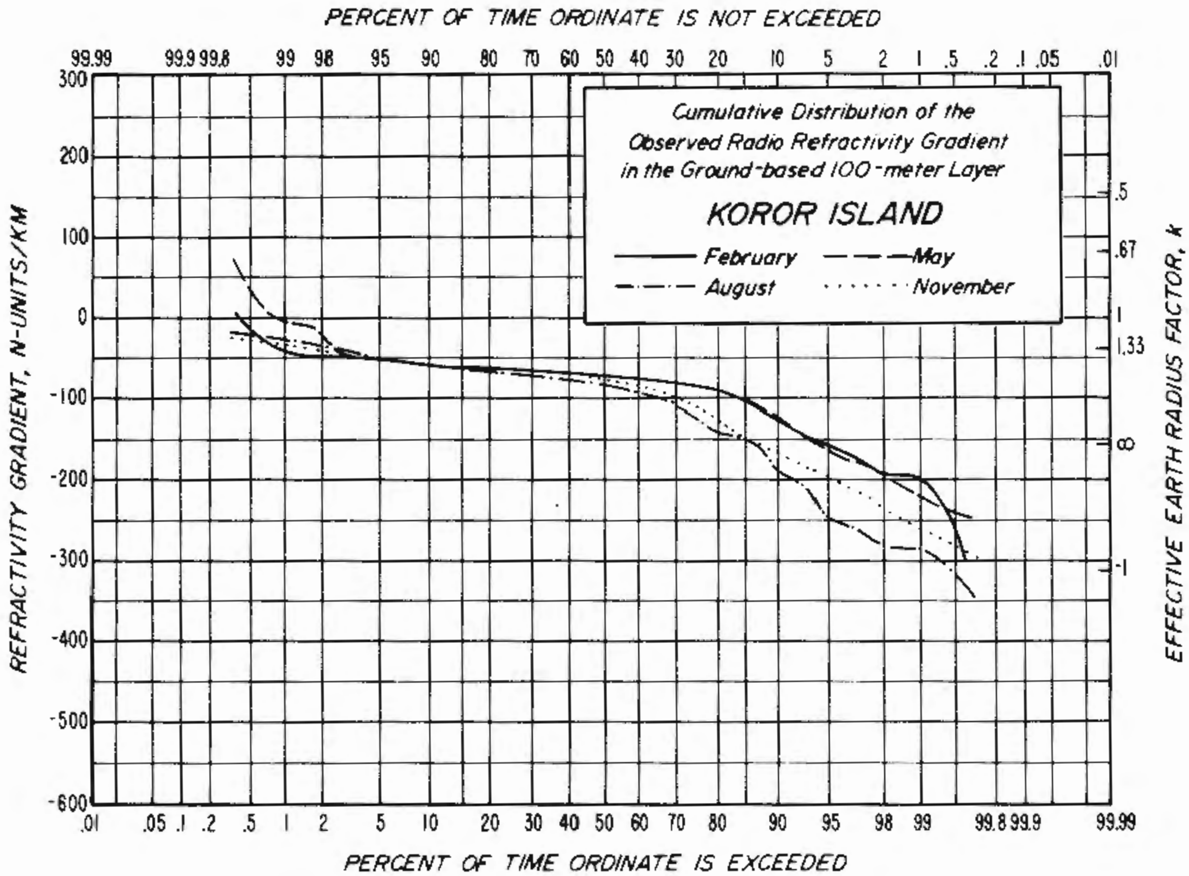
Data: Radiosonde. 0500Z (0700 LST)
2/56 - 11/60

Temperature (°F): January 90/59; July 101/77

Mean Dewpoint (°F): January 39; July 64

Precipitation (inches): Annual 6.4; August 2.80; December 0.00

Located at the junction of the White Nile and the Blue Nile Rivers. Tropical continental semi-desert type climate; hot, dry season September to June with intermittent light rains July to early September.



Koror Island, Pacific (Palau Group of the Carolines)

07-20 N, 134-29 E. 29 meters MSL

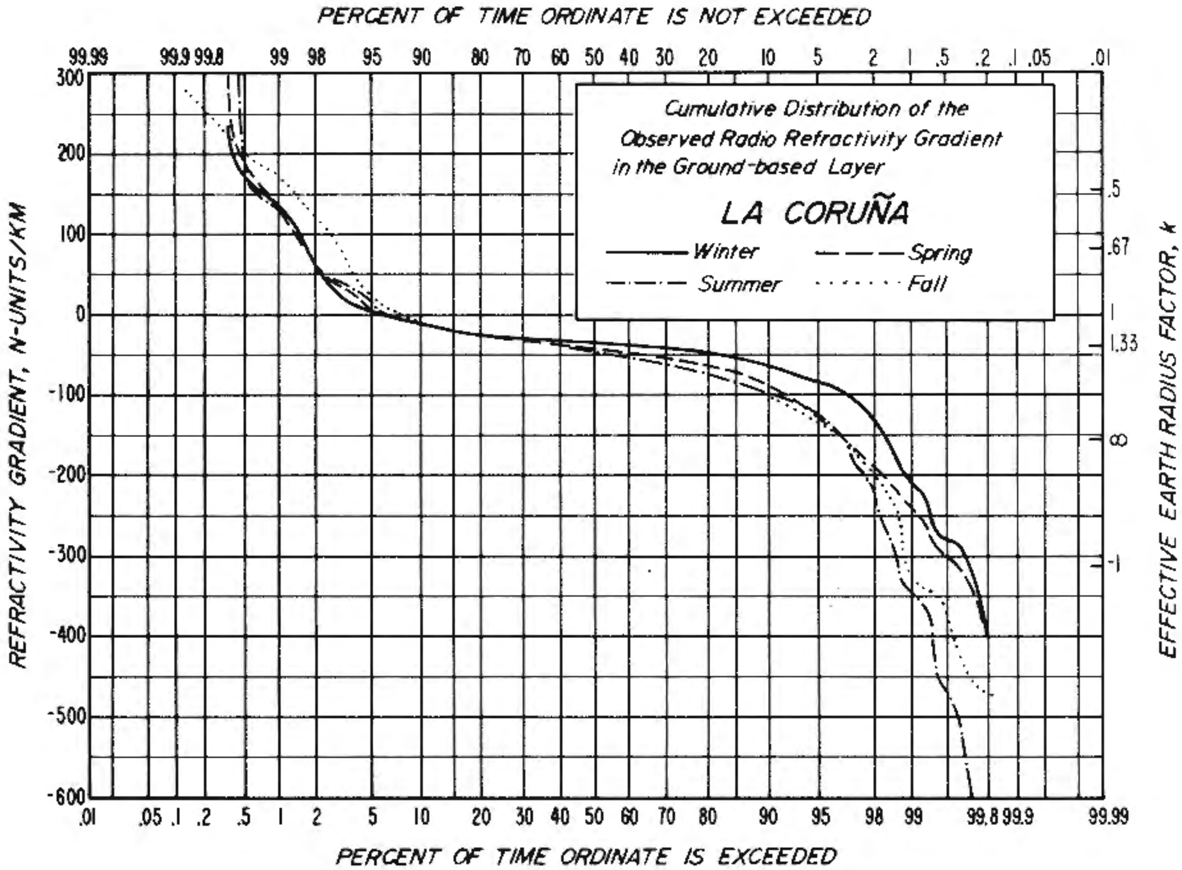
Data: Radiosonde. 1200Z (2100 LST)
8/58 - 5/63

Temperature (°F): January 86/75; July 87/75

Mean Dewpoint (°F): January 75; July 76

Precipitation (inches): Annual 147.5; August 15.76; February 7.13

Located in the eastern part of the Philippine Sea on a hilly island in a lagoon; there is a 610-ft hill within 3 miles of the weather station. Northeast trade winds prevail December through March; the convergence zone moves across the island in about June and remains in the vicinity through about October, with a high frequency of calms and light winds in November. A tropical maritime climate.



La Coruña, Spain

43-22 N. 08-25 W. 58 meters MSL

Data: Radiosonde. 0000 and 1200Z (2300 and 1100 LST)
1/68 - 12/70

Note: Calculated refractivity gradient between surface and next higher level. See text.

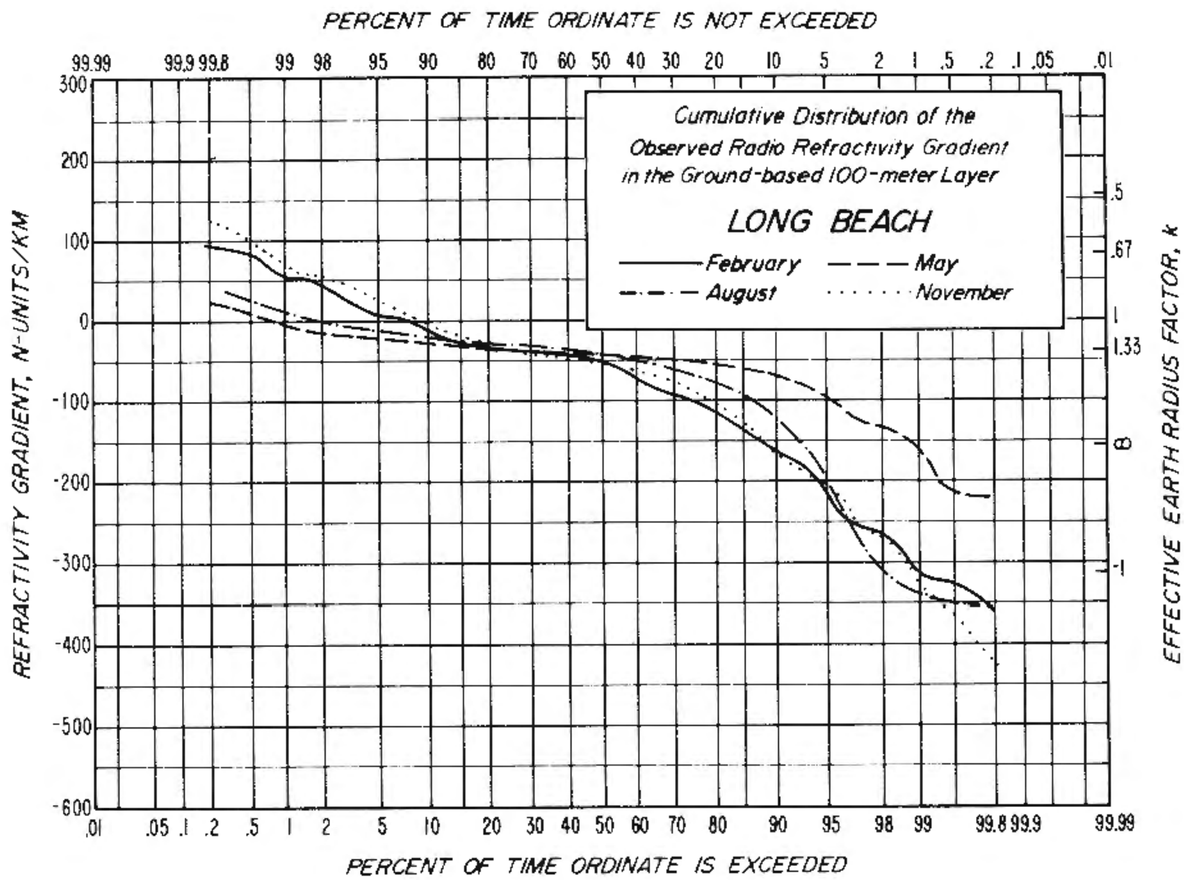
Analyzed by: David and Wagner, Environmental Technical Applications Center, U.S. Air Force, Washington, D.C.

Temperature (°F): January 55/44; July 71/58

Mean Dewpoint (°F): January 43; July 58

Precipitation (inches): Annual 37.9; December 5.20; July 1.30

Located on the Atlantic coast in northwest Spain. Relatively cool maritime climate.



Long Beach, California

33-49 N, 118-09 W. 12 meters MSL

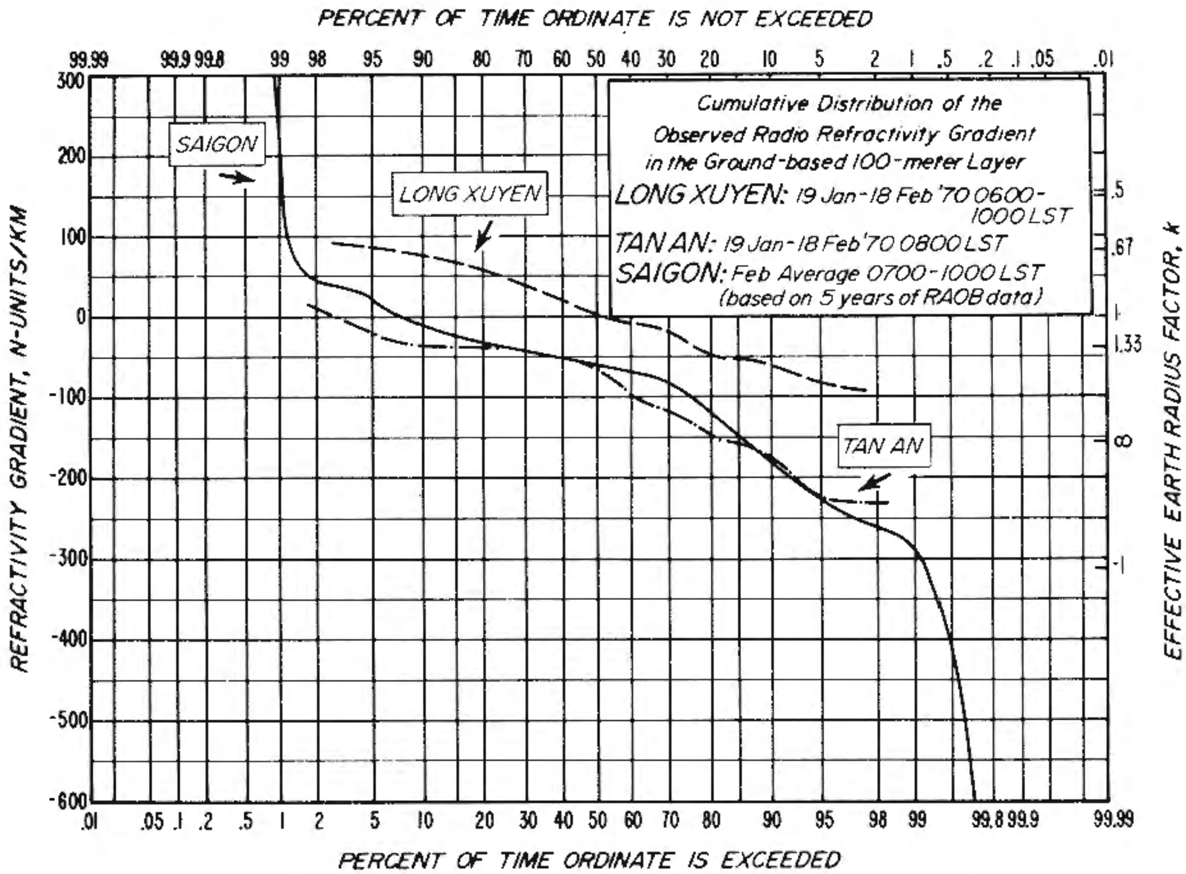
Data: Radiosonde. 0300 and 1500Z (1900 and 0700 LST)
5/51 - 2/56

Temperature (°F): January 65/41; July 82/61

Mean Dewpoint (°F): January 43; July 60

Precipitation (inches): Annual 9.8; February 2.31; July (Trace)

The Pacific Ocean is 4 miles south and 12 miles west of the station; there are low coastal hills between the station and the sea. Summers are dry with only 0.40 inches of rain May to October inclusive, and there are frequent low clouds at night and early morning. There is considerable fog in winter.



Long Xuyen, Viet Nam

10-23 N, 105-26 E. 3 meters MSL

Data: High-resolution Radiosonde. 0600 - 1000 LST, 19 Jan.-18 Feb. 1970

Temperature (°F): January 86/70; July 88/75

Mean Dewpoint (°F): January 66; July 72

Precipitation (inches): Annual 63.4; September 11.30; February 0.10

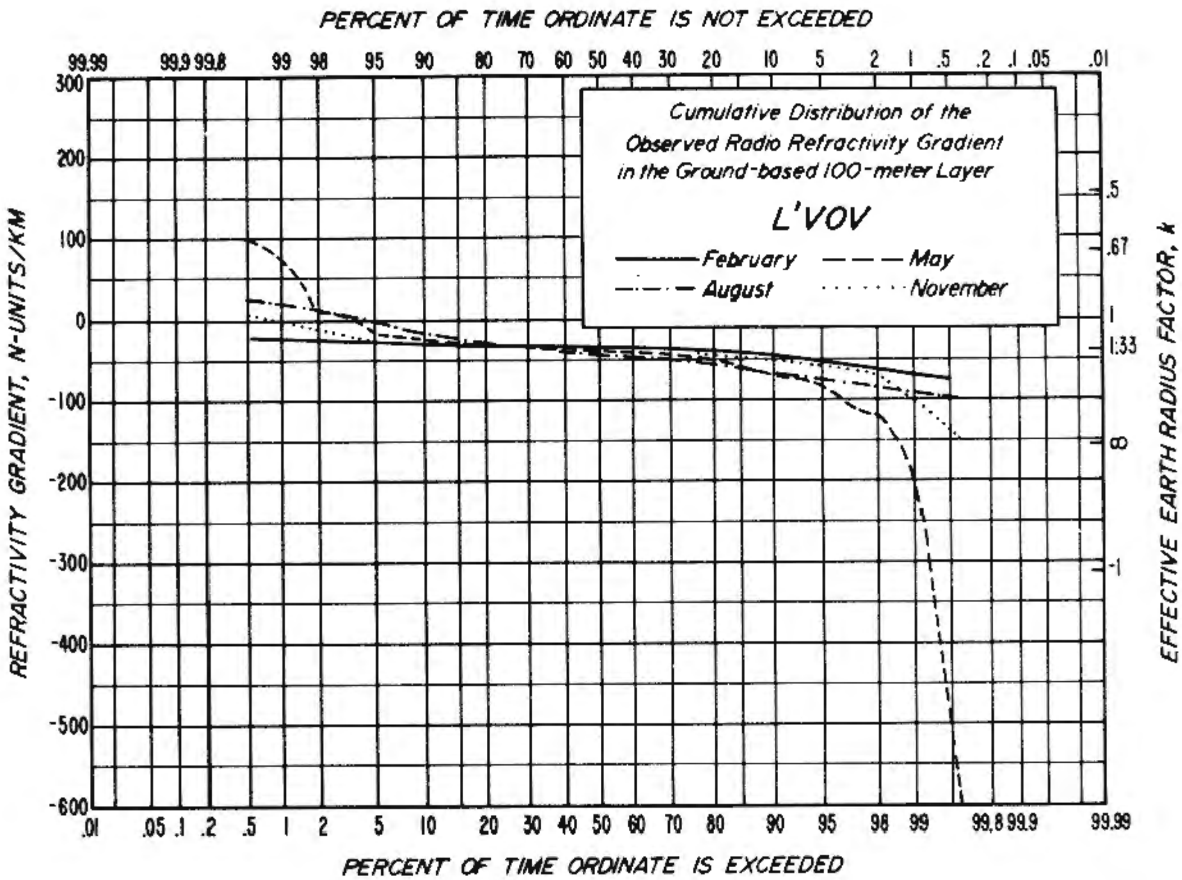
Located 100 miles west of Saigon in Mekong Delta region; humid, tropical monsoon climate.

Tan An, Viet Nam

10-32 N, 106-23 E. 10 meters MSL

Data: Radiosonde. 0800 LST, 19 Jan. - 18 Feb. 1970

In delta region about 25 miles southwest of Saigon.



L'vov, Ukraine, U.S.S.R.

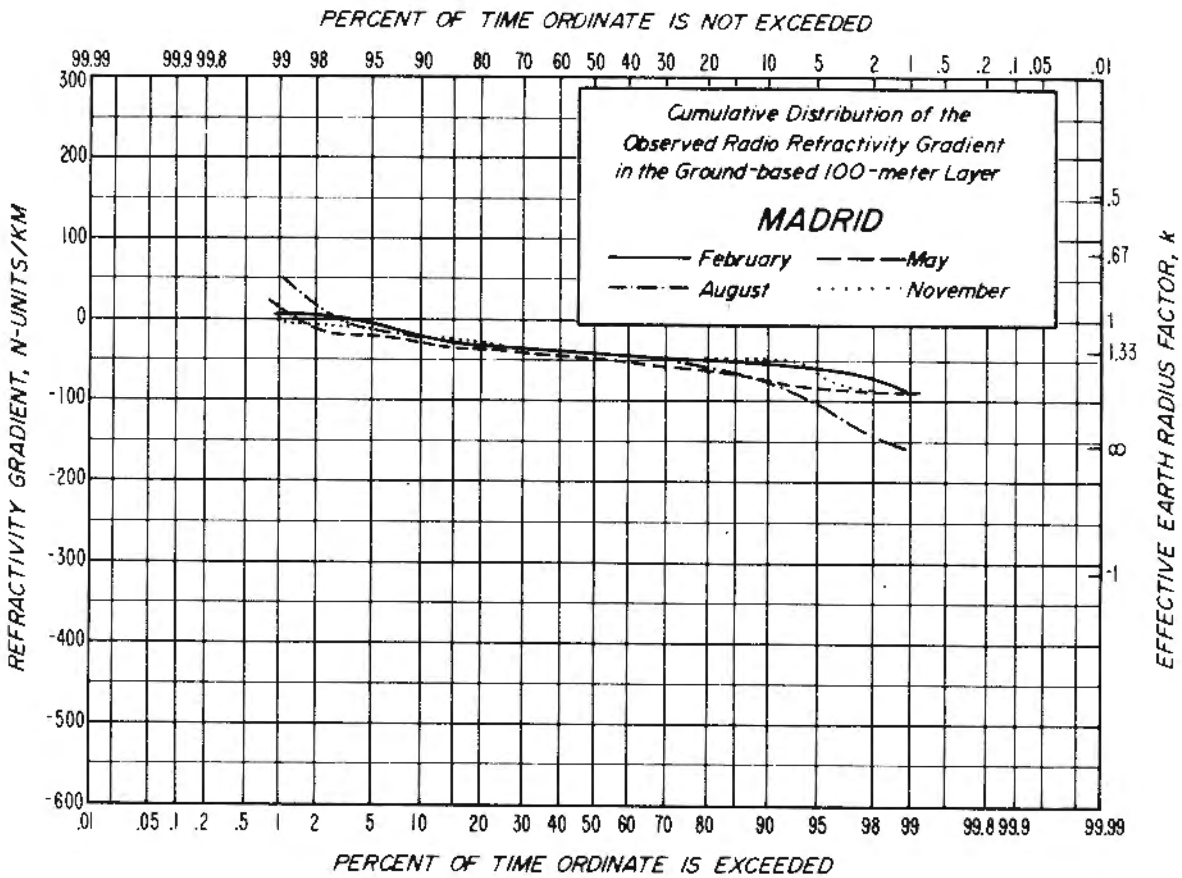
49-49 N, 23-57 E. 329 meters MSL

Data: Radiosonde. 0000Z (0200 LST)
8/58 - 5/63

Temperature (°F): January 31/22; July 77/59

Precipitation (inches): Annual 23.6; June 3.4; January 0.9

Located in the western Ukraine near the source of the Bug River. A moderate continental temperate climate.



Madrid, Spain

40-24 N, 03-41 W. 657 meters MSL

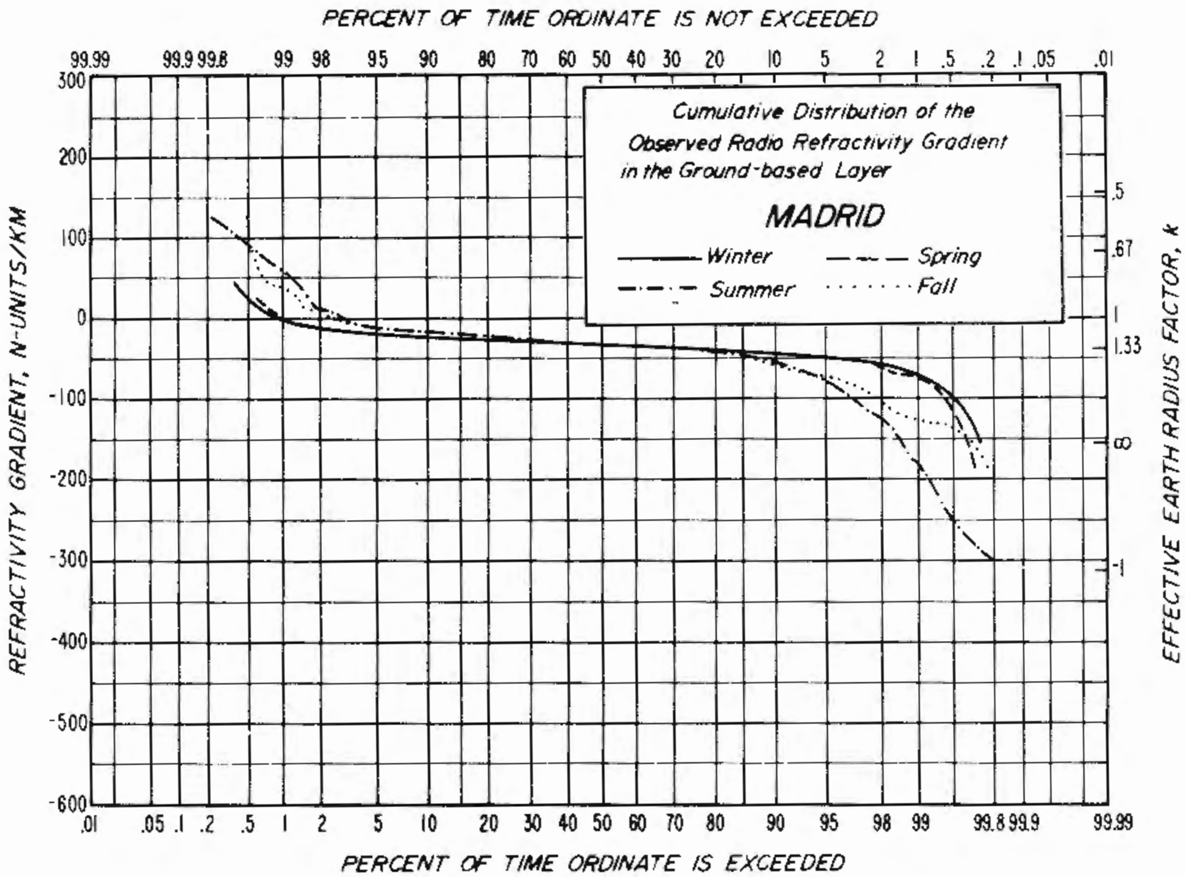
Data: Radiosonde. 0000Z (0000 LST)
8/57 - 11/59

Temperature (°F): January 47/33; July 87/62

Mean Dewpoint (°F): January 35; July 48

Precipitation (inches): Annual 16.5; November 2.2; August 0.3

Located on a rolling plateau near the center of the Iberian peninsula. A dry, temperate climate.



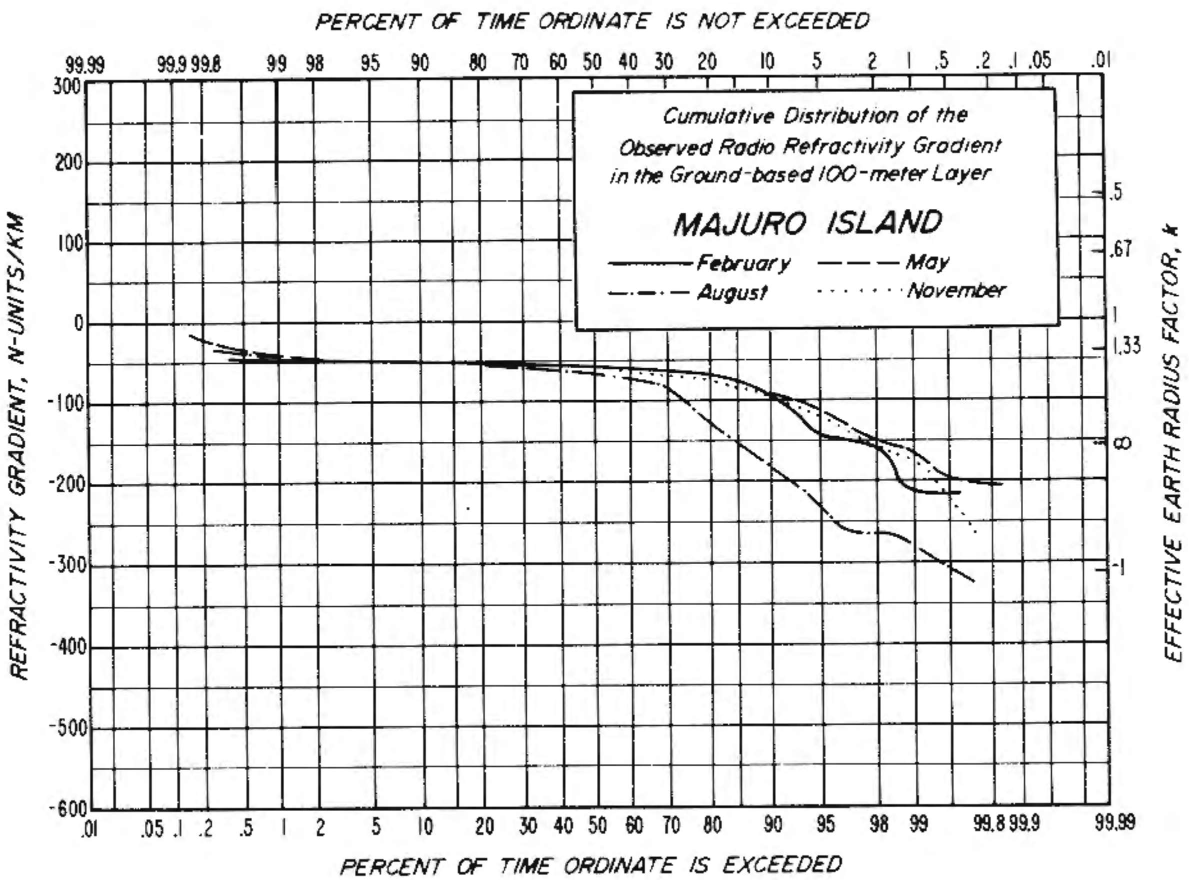
Madrid, Spain

40-24 N, 03-41 W. 657 meters MSL

Data: Radiosonde. 0000 and 1200Z (0000 and 1200 LST)
1/68 - 10/71 (3/71 - 6/71 missing)

Note: Calculated refractivity gradient between surface and next higher level. Winter season December through February; Spring season March through May; etc. See text.

Analyzed by: Davis and Wagner, Environmental Technical Applications Center, U.S. Air Force, Washington, D.C.



<u>Majuro, Marshall Islands, Pacific</u>

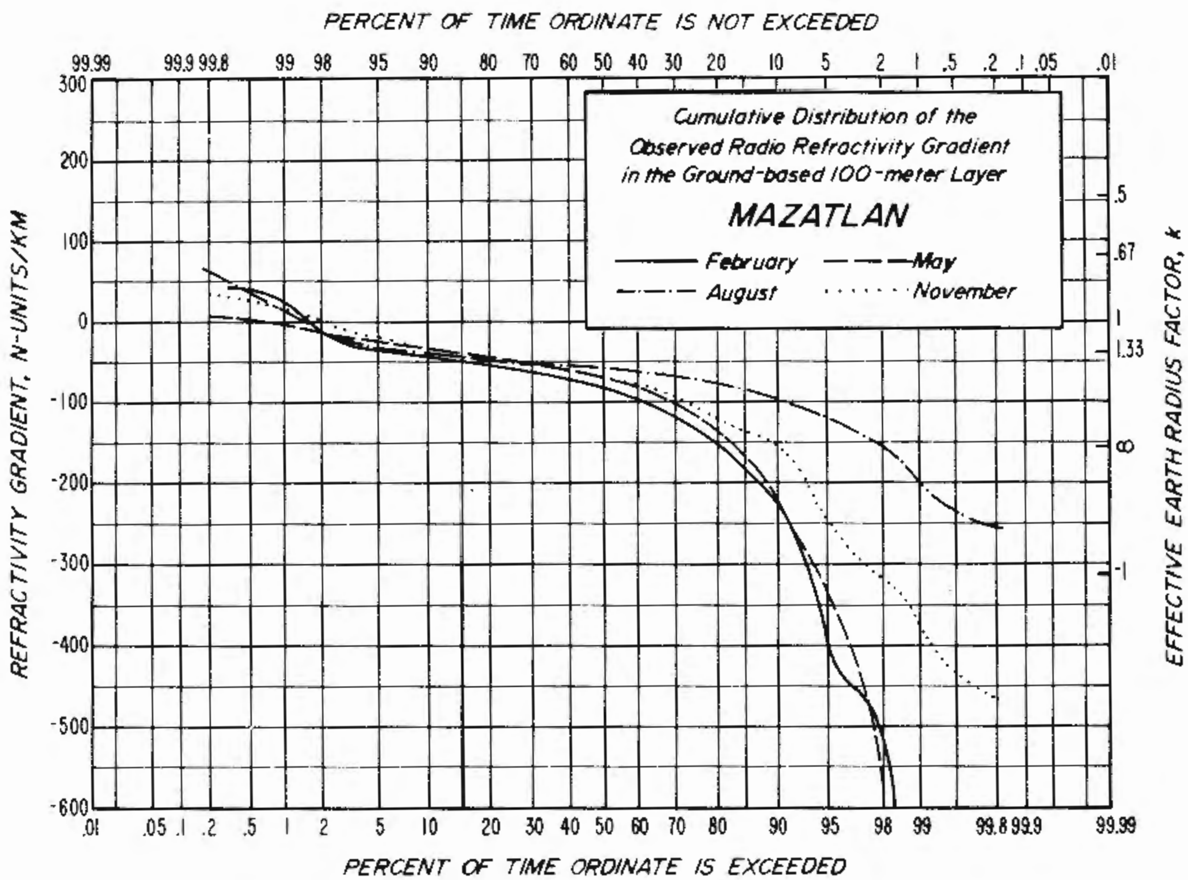
07-05 N, 171-23 E. 3 meters MSL

Data: Radiosonde. 0000Z (1100 LST): 8/57; 1200Z (2300 LST): 11/57-2/58; 0000, 0600, 1200, 1800Z: 5/58-8/58; 1200Z: 8/58-2/62; 0000, 0600, 1200, 1800Z:5/62

Temperature (°F): January 84/76; July 85/76

Precipitation (inches): Annual 143.6; November 15.92; January 6.98

Located on the southeastern end of Majuro Atoll (area 160 sq. miles) on Dalap Island. Easterly trade winds prevail throughout the year; typhoons are rare. Cloudiness averages 9/10 coverage in daytime; mostly cumulus type. A tropical maritime/trade wind climate.



Mazatlan, Mexico

23-11 N, 106-26 W. 78 meters MSL

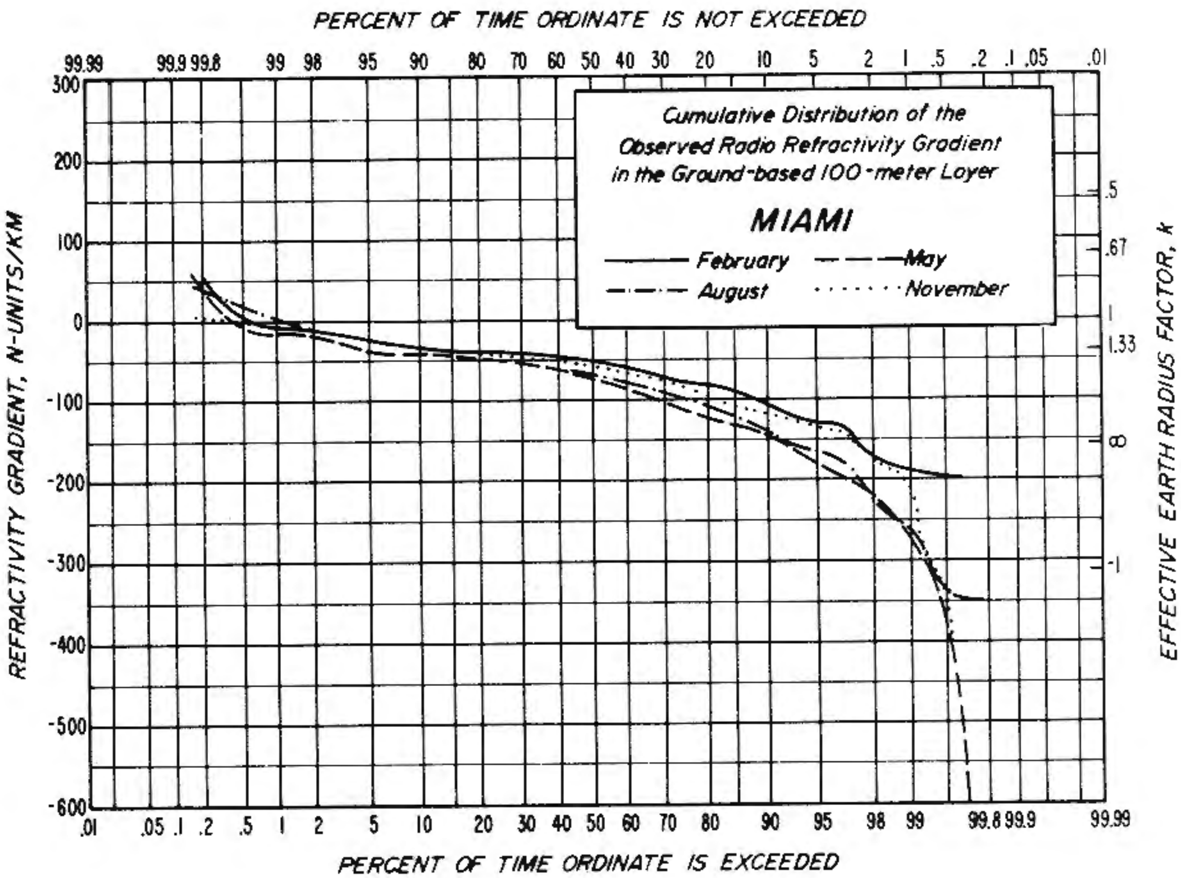
Data: Radiosonde. 0300Z (2000 LST)
8/52 - 6/57
0000Z (1700 LST)
7/57 - 8/61

Temperature (°F): January 71/61; July 86/77

Mean Dewpoint (°F): January 59; July 73

Precipitation (inches): Annual 30.1; August 8.27; April 0.08

Located on the Pacific coast of Mexico. A maritime tropical climate with wet and dry seasons.



Miami, Florida

25-49 N, 80-17 W. 4 meters MSL

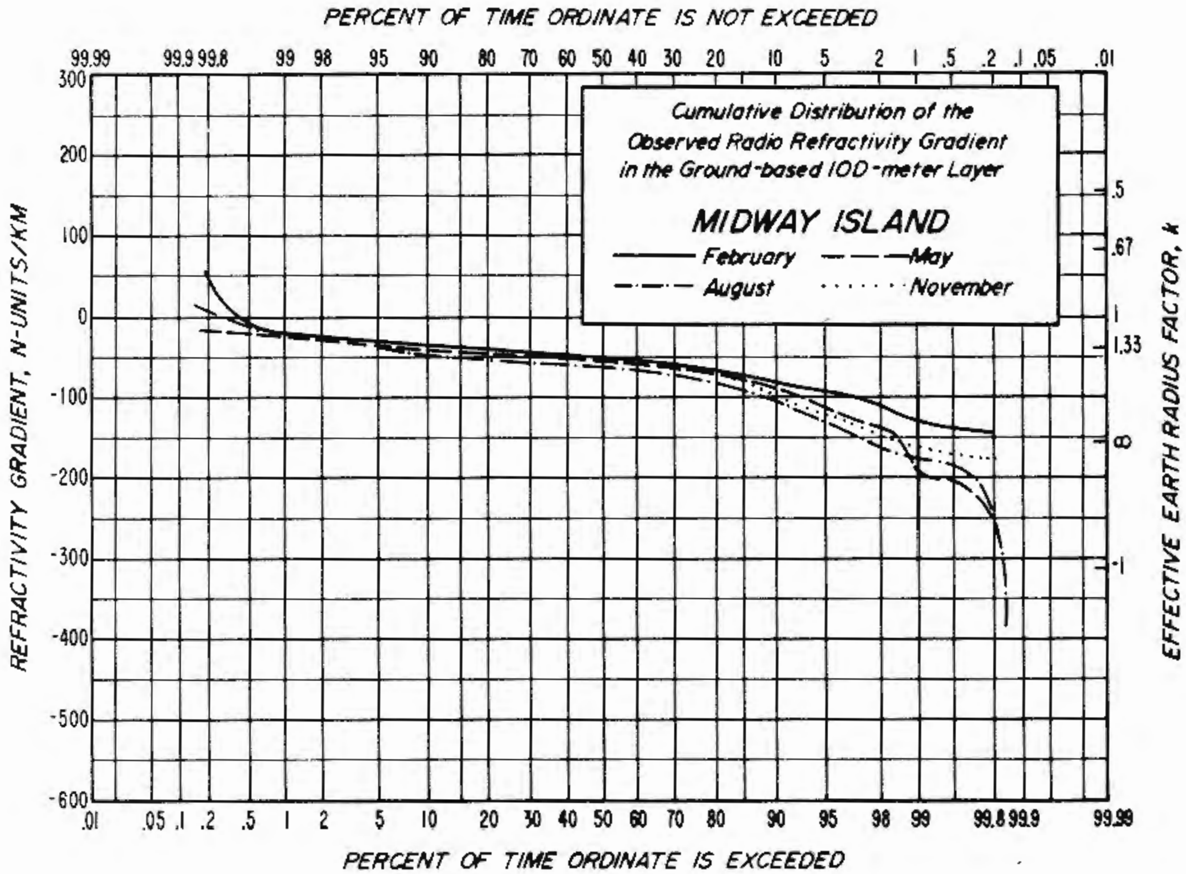
Data: Radiosonde. 0300 and 1500Z (2200 and 1000 LST) 8/52 - 5/57

Temperature (°F): January 76/58; July 89/75

Mean Dewpoint (°F): January 57; July 73

Precipitation (inches): Annual 59.8; September 9.47; December 1.67

Located on level ground about 10 miles from the Atlantic Ocean, with sparsely wooded countryside to the west. A sub-tropical maritime climate, with warm, showery summers and mild, dry winters. Prevailing east to southeast winds.

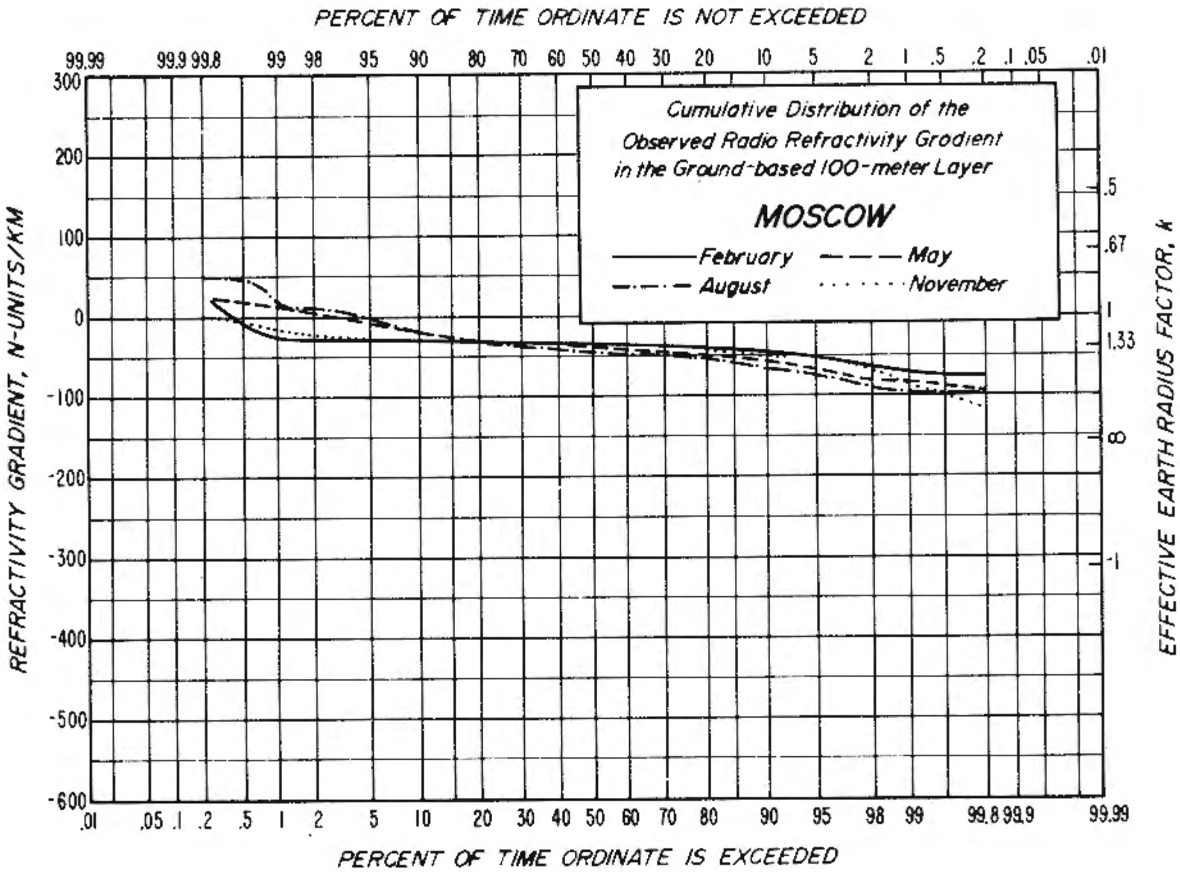


Midway Island, Pacific

28-13 N, 177-22 W. 6 meters MSL

Data: Radiosonde.	0300 and 1500Z (1500 and 0300 LST) 8/50 - 5/53 0000 and 1200Z (1200 and 0000 LST) 8/57 - 11/59
Temperature (°F):	January 72/60; July 84/71
Mean Dewpoint (°F):	January 57; July 70
Precipitation (inches):	Annual 46.3; October 5.2; November 1.7

Station is located on a small island in the central Pacific; part of a low coral atoll. Sub-tropical maritime climate.



Moscow, U.S.S.R.

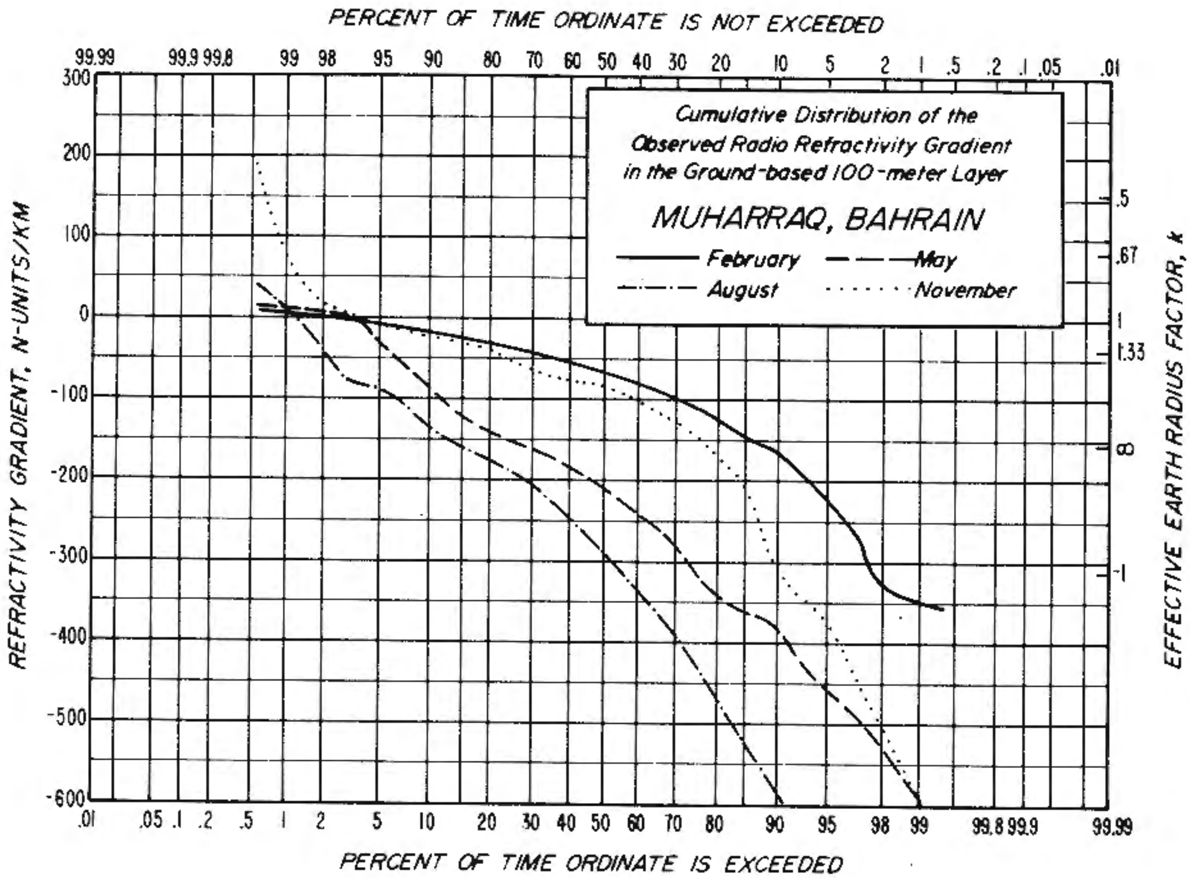
55-49 N, 37-37 E. 156 meters MSL

Data: Radiosonde. 0200Z (0500 LST)
8/55 - 2/57
0000Z (0300 LST)
5/57 and 2/60 - 11/60
0000 and 1200Z (0300 and 1500 LST)
8/57 - 11/59

Temperature (°F): January 21/9; July 76/55

Precipitation (inches): Annual 24.8; July 3.0; March 1.1

Located on the Moskva River. Rather severe continental temperate climate. Deep snow in area much of the winter.



<u>Muharraq, Bahrain</u> (Persian Gulf)

26-16 N, 50-37 E. 2 meters MSL

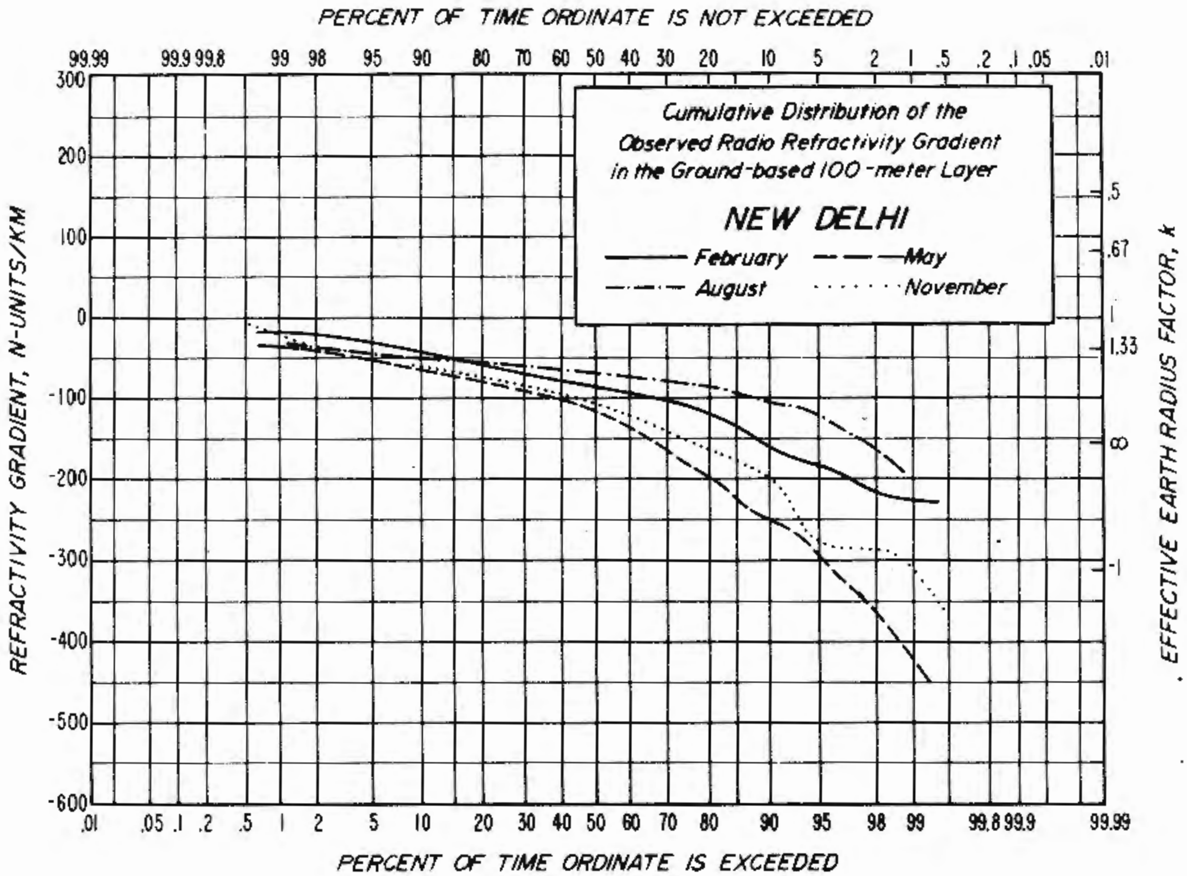
Data: Radiosonde. 0000Z (0300 LST)
2/58 - 11/60

Temperature (°F): January 68/57, July 99/85

Mean Dewpoint (°F): January 56; July 77

Precipitation (inches): Annual 3.2; Feb., Nov., Dec. 0.70; May, June, July, Aug., Sept., Oct. 0.00

On an island in the western Persian Gulf about 25 miles off the coast of the Arabian peninsula. Semi-tropical arid climate with hot, humid summers and relatively cool winters with scanty winds.

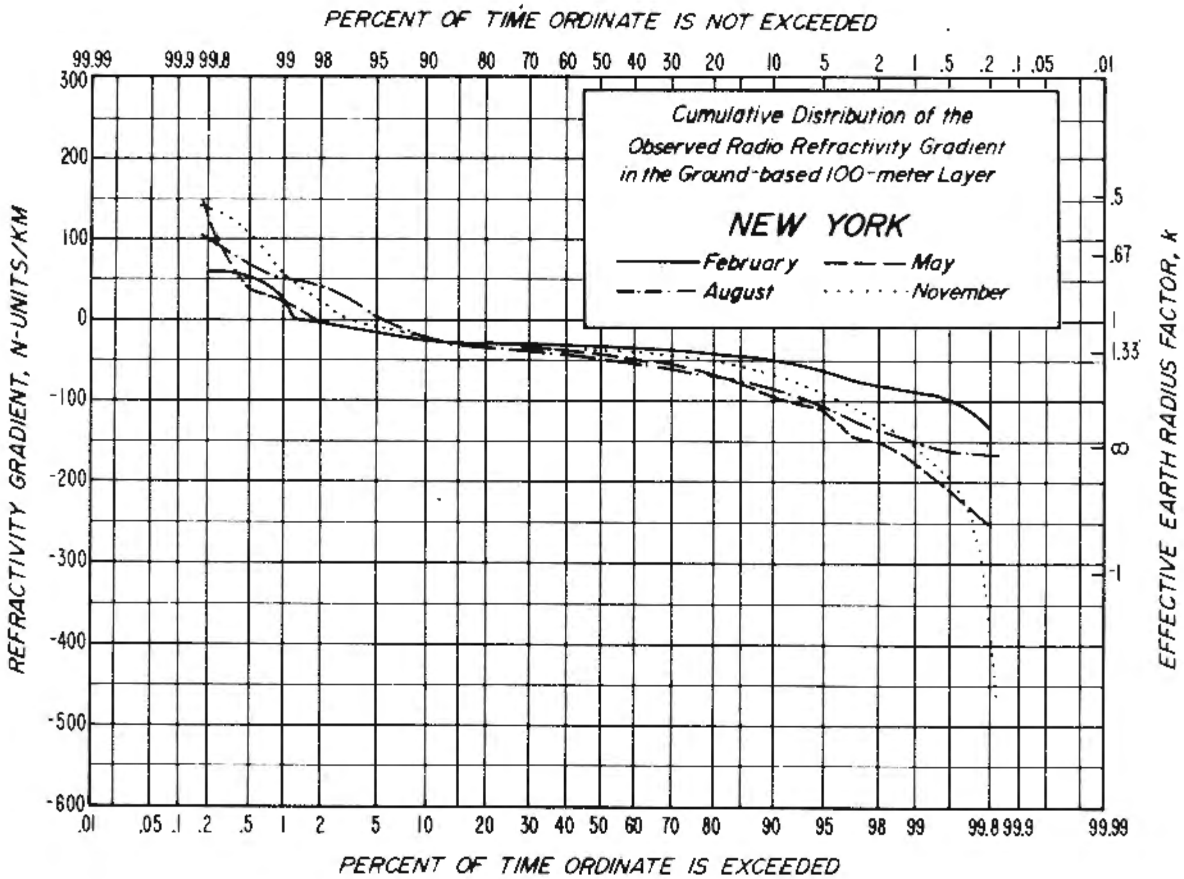


New Delhi, India

28-35 N, 77-12 E. 216 meters MSL

Data: Radiosonde.	0300Z (0800 LST) 2/57 0000Z (0500 LST) 5/57 - 8/61
Temperature (°F):	January 70/44; July 96/81
Mean Dewpoint (°F):	January 44; July 76
Precipitation (inches):	Annual 25.2; July 7.1; November 0.1

Located on the Jumna River in northern India; near the center of the Indian subcontinent. A monsoon-type climate, with cool, dry winters and warm, wet summers.

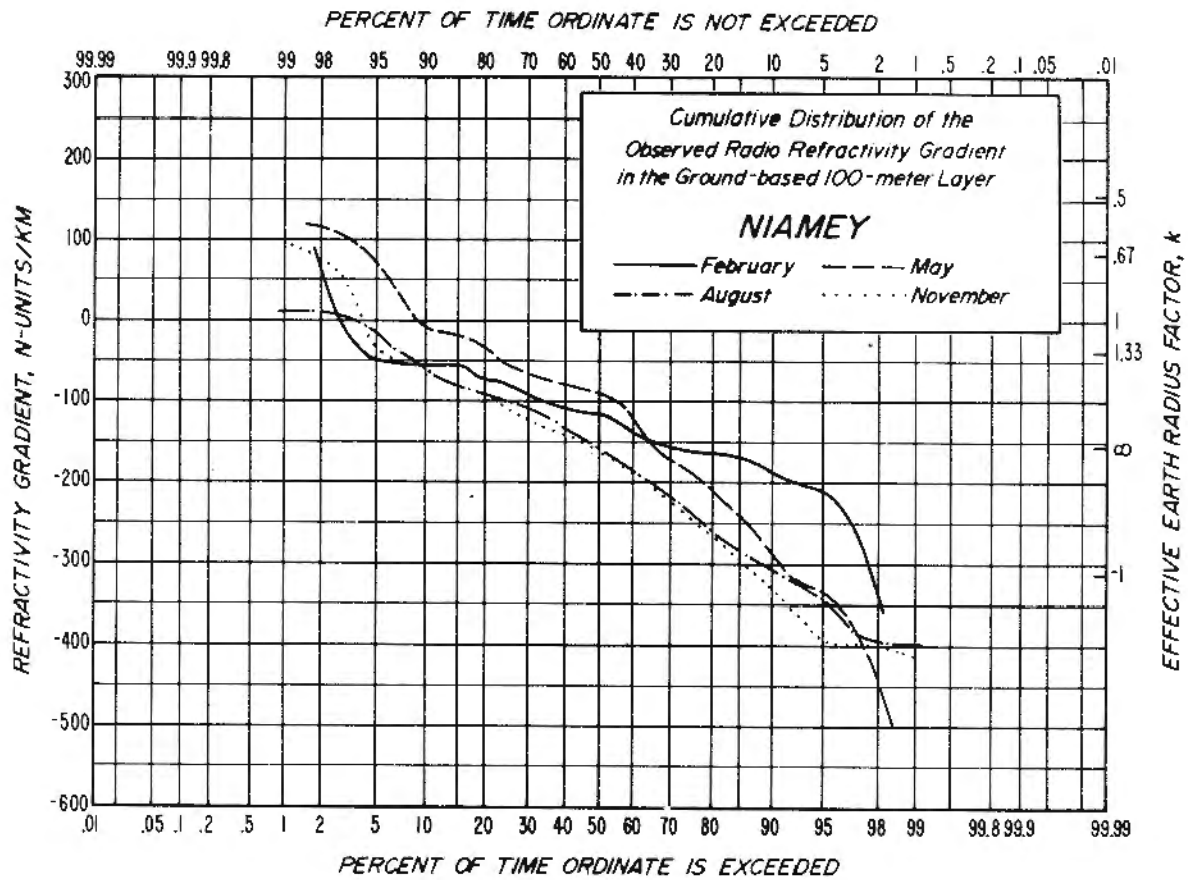


New York, New York

40-46 N, 73-52 W. 16 meters MSL

Data: Radiosonde.	0300 and 1500Z (2200 and 1000 LST) 8/52 - 5/57
Temperature (°F):	January 40/28; July 85/69
Mean Dewpoint (°F):	January 22; July 63
Precipitation (inches):	Annual 44.2; August 5.08; February 3.09

Station is located on Flushing Bay, Long Island to the east of Manhattan. The climate more closely resembles continental than maritime, because weather conditions usually approach the area from a westerly direction, rather than from the ocean. The nearby water areas have an important local modifying influence.

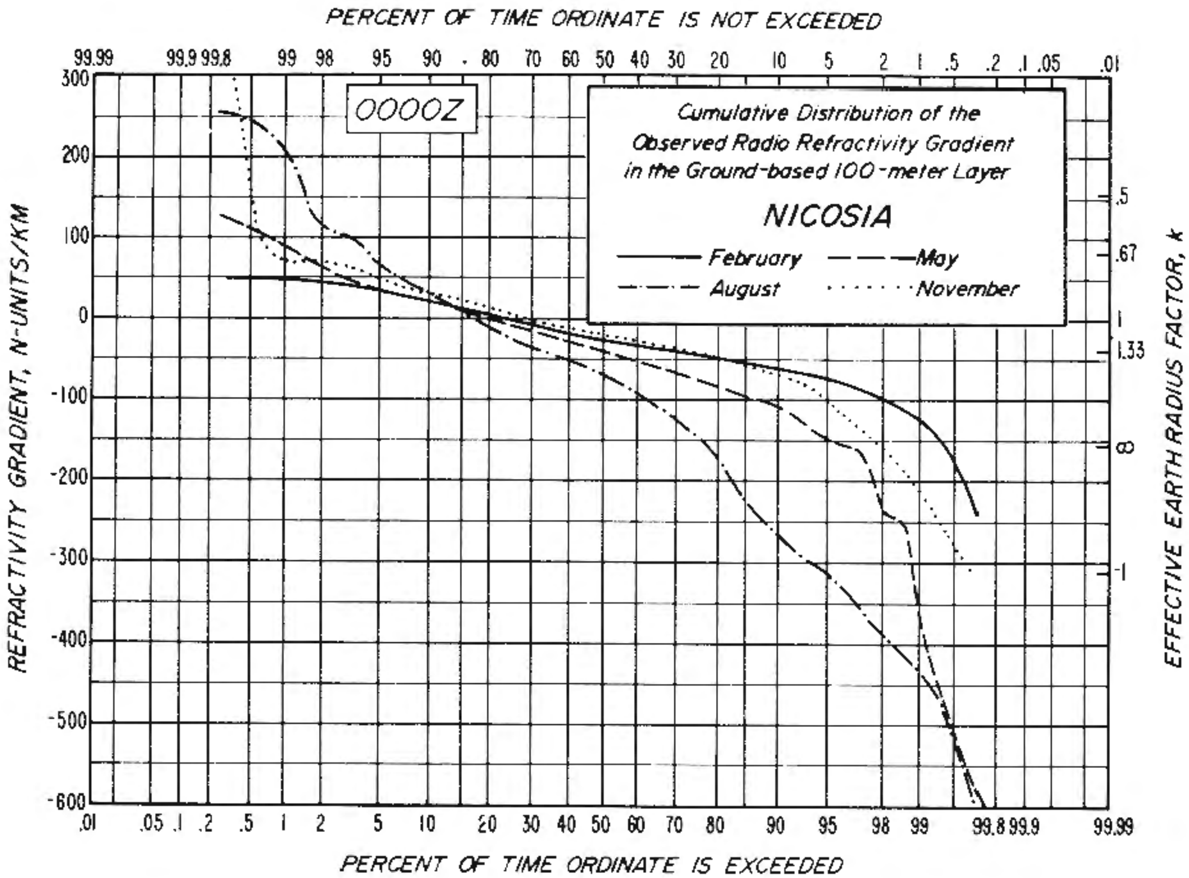


Niamey, Niger

13-29 N, 02-10 E. 226 meters MSL

Data: Radiosonde.	0600Z (0600 LST) 8/57 - 11/59
Temperature (°F):	January 93/58; July 94/74
Mean Dewpoint (°F):	January 35; July 70
Precipitation (inches):	Annual 23.4; August 8.62; Jan., Feb, Dec. 0.00

Located on the Niger River in west Africa. A tropical monsoon climate with hot, rainy summers and hot, dry winters.

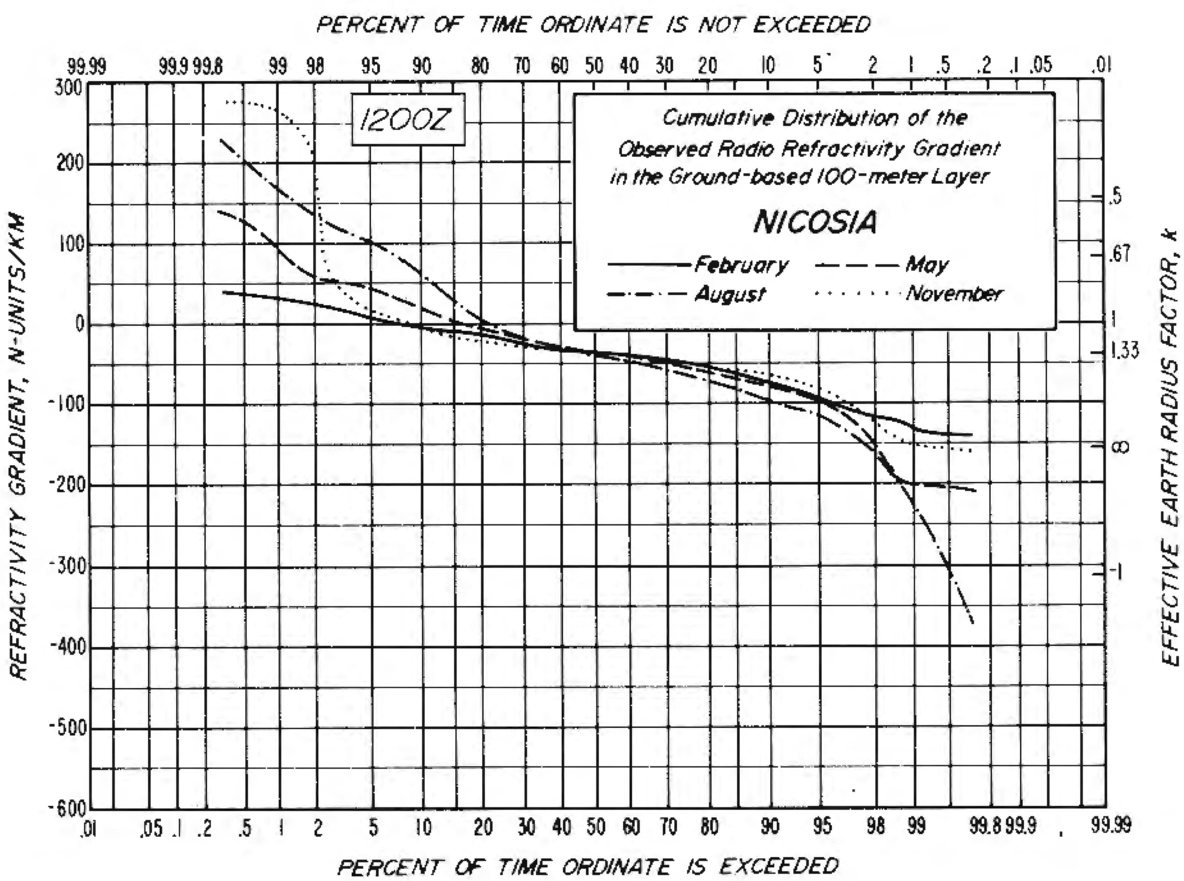


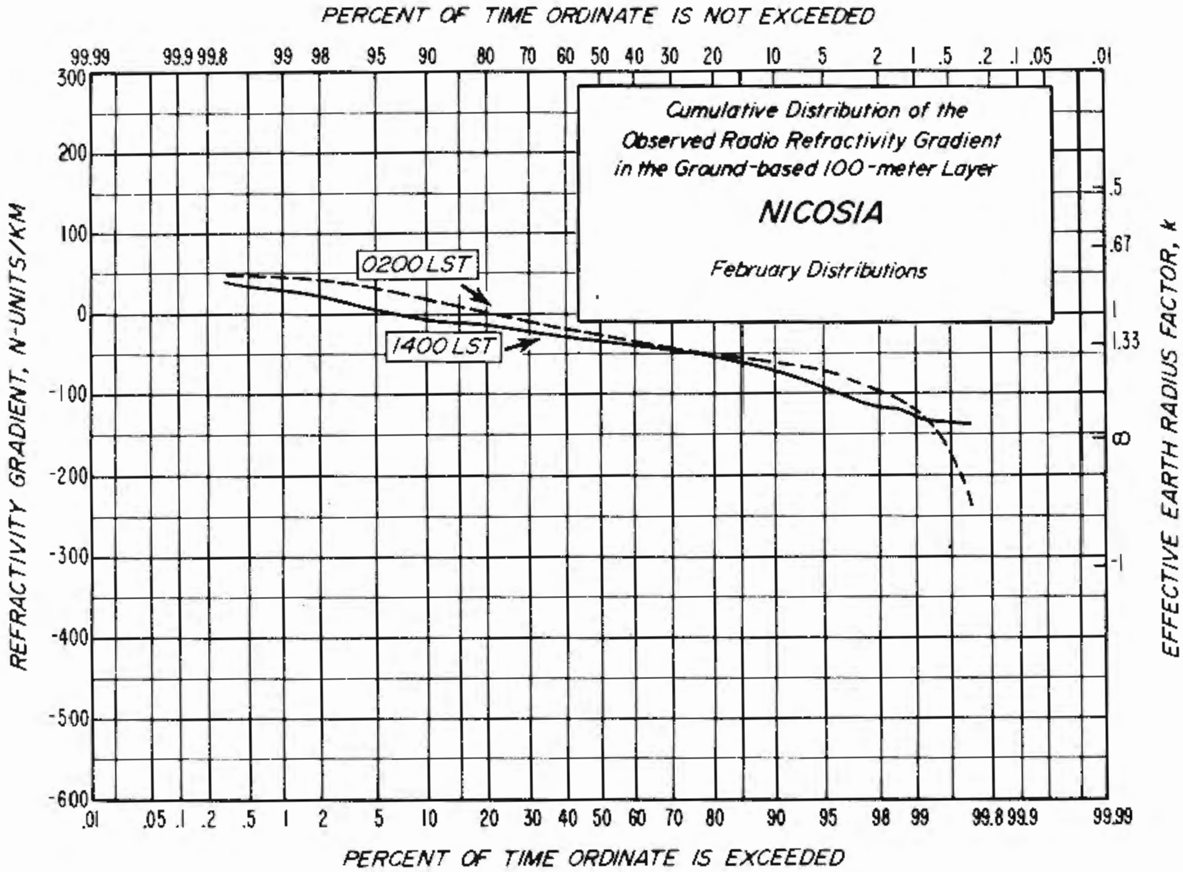
Nicosia, Cyprus

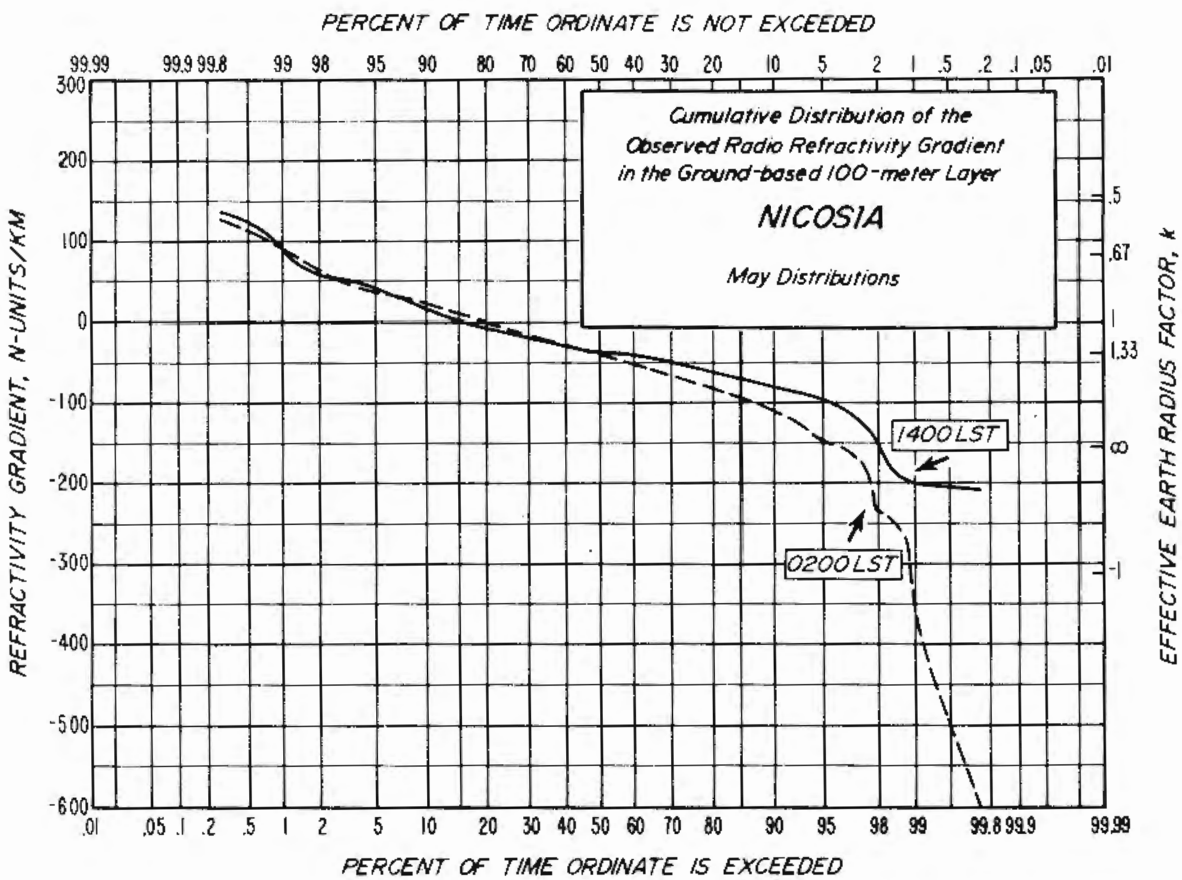
35-09 N, 33-17 E. 218 meters MSL

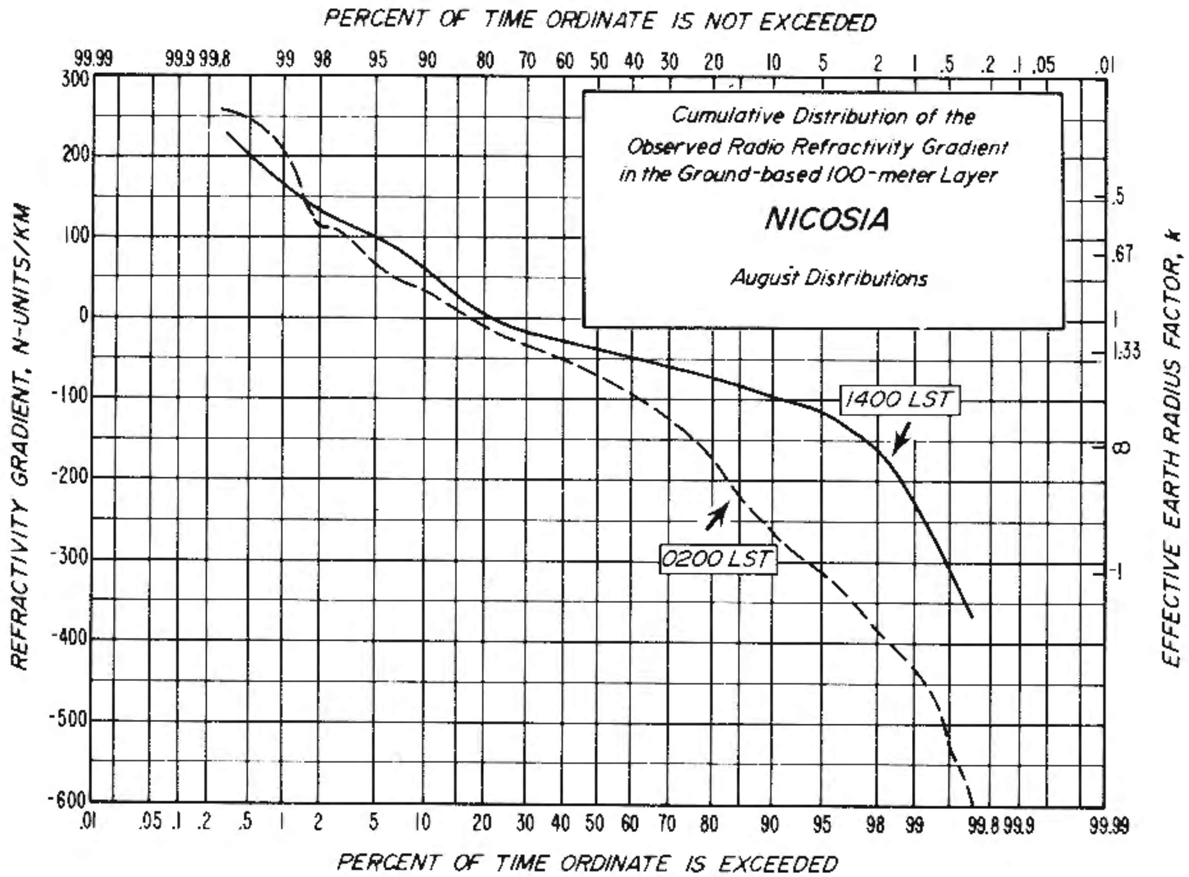
Data: Radiosonde.	0200 and 1400Z (0400 and 1600 LST) 2/55 - 2/57 0000 and 1200Z (0200 and 1400 LST) 5/57 - 8/60
Temperature (°F):	January 58/42; July 97/69
Mean Dewpoint (°F):	January 43; July 59
Precipitation (inches):	Annual 14.4; December 3.00; July, Aug. 0.03

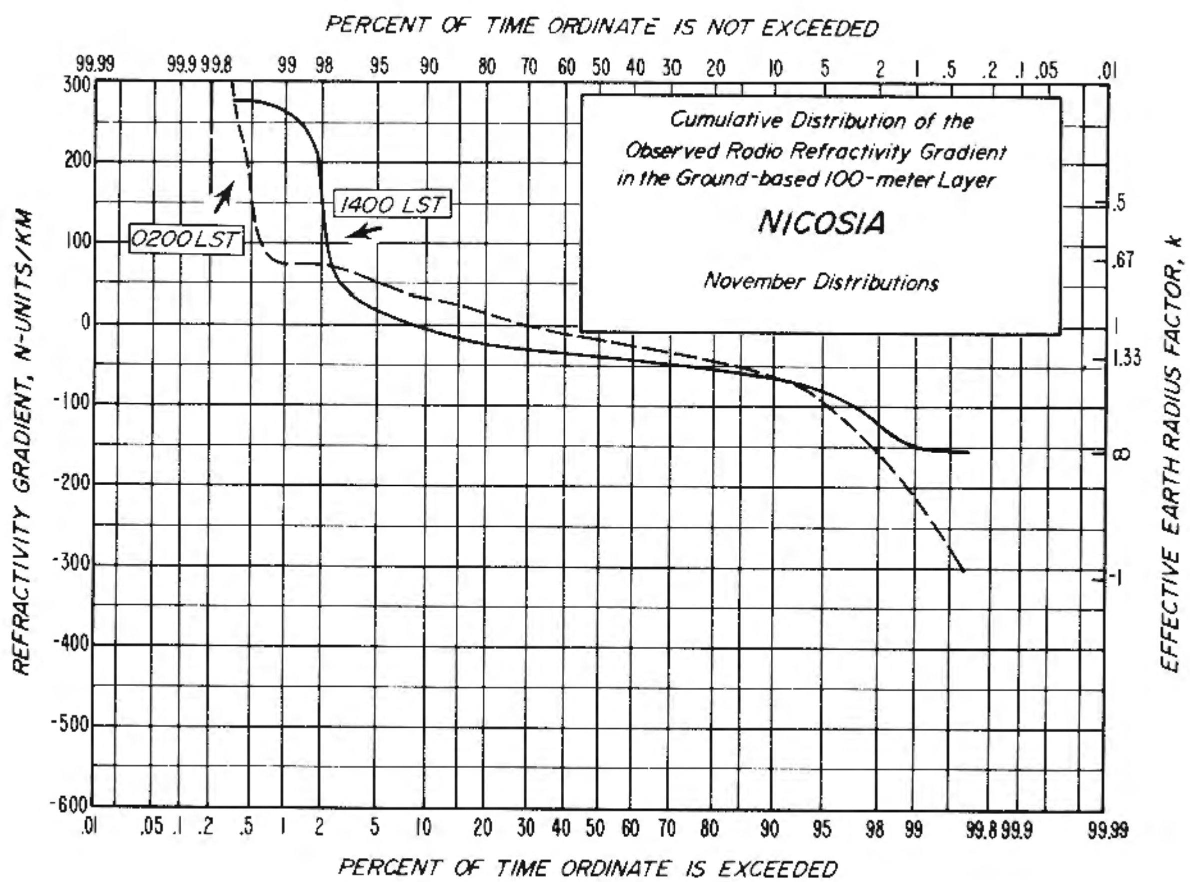
Station is in the central part of a large island (1048 sq. miles) in the eastern Mediterranean Sea. Hot, dry summers and mild winters.

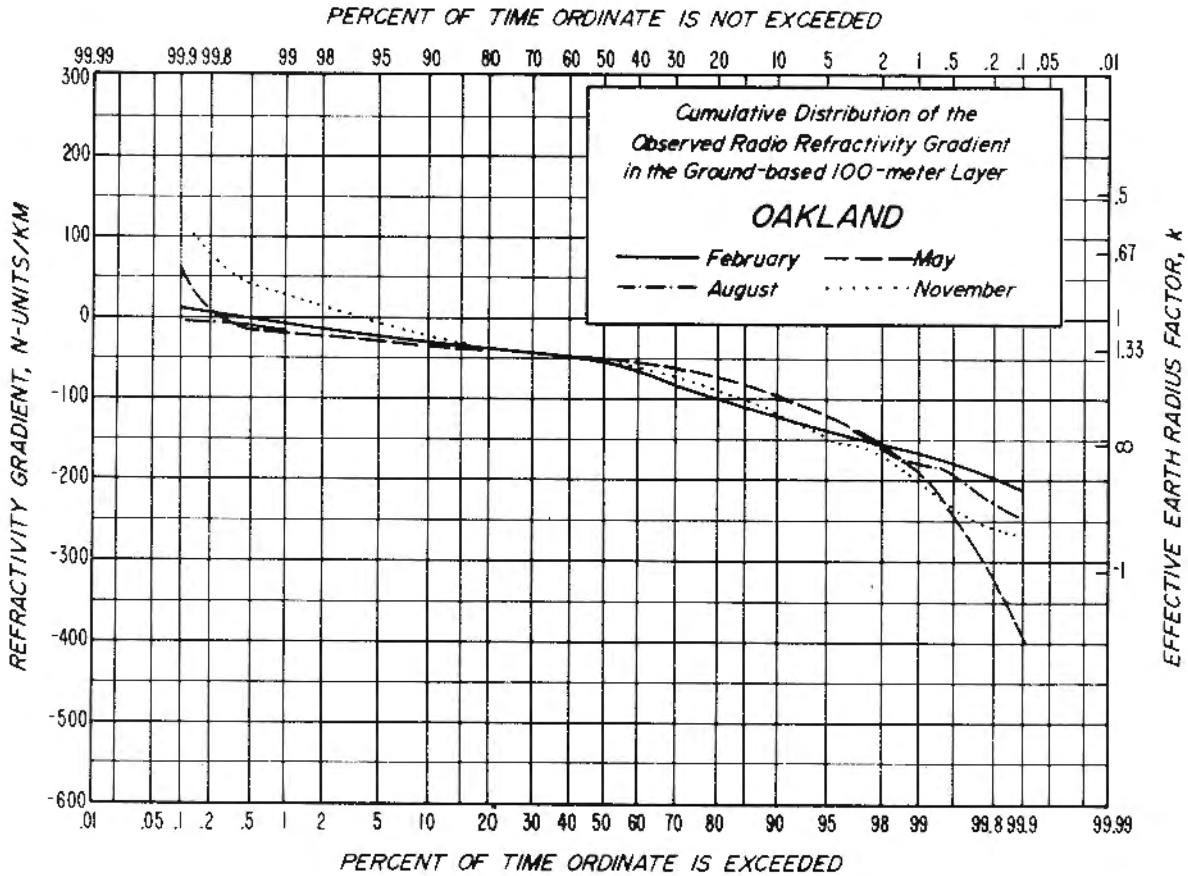

PERCENT OF TIME ORDINATE IS NOT EXCEEDED
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 .5 .2 .1 .05 .01
1200Z
Cumulative Distribution of the Observed Radio Refractivity Gradient in the Ground-based 100-meter Layer
NICOSIA
February
May
August
November
REFRACTIVITY GRADIENT, N-UNITS/KM
300 200 100 0 -100 -200 -300 -400 -500 -600
EFFECTIVE EARTH RADIUS FACTOR, k
.5 .67 1 1.33 ∞ -1
.01 .05 .1 .2 .5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
PERCENT OF TIME ORDINATE IS EXCEEDED


PERCENT OF TIME ORDINATE IS NOT EXCEEDED
Cumulative Distribution of the Observed Radio Refractivity Gradient in the Ground-based 100-meter Layer
NICOSIA
February Distributions
0200 LST
1400 LST
REFRACTIVITY GRADIENT, N-UNITS/KM
EFFECTIVE EARTH RADIUS FACTOR, k
PERCENT OF TIME ORDINATE IS EXCEEDED


PERCENT OF TIME ORDINATE IS NOT EXCEEDED
Cumulative Distribution of the Observed Radio Refractivity Gradient in the Ground-based 100-meter Layer
NICOSIA
May Distributions
1400 LST
0200 LST
REFRACTIVITY GRADIENT, N-UNITS/KM
EFFECTIVE EARTH RADIUS FACTOR, k
PERCENT OF TIME ORDINATE IS EXCEEDED


PERCENT OF TIME ORDINATE IS NOT EXCEEDED
Cumulative Distribution of the
Observed Radio Refractivity Gradient
in the Ground-based 100-meter Layer
NICOSIA
August Distributions
1400 LST
0200 LST
REFRACTIVITY GRADIENT, N-UNITS/KM
EFFECTIVE EARTH RADIUS FACTOR, k
PERCENT OF TIME ORDINATE IS EXCEEDED


PERCENT OF TIME ORDINATE IS NOT EXCEEDED
Cumulative Distribution of the
Observed Radio Refractivity Gradient
in the Ground-based 100-meter Layer
NICOSIA
November Distributions
1400 LST
0200 LST
REFRACTIVITY GRADIENT, N-UNITS/KM
EFFECTIVE EARTH RADIUS FACTOR, k
PERCENT OF TIME ORDINATE IS EXCEEDED



Oakland, California

37-44 N, 122-12 W.　　　6 meters MSL

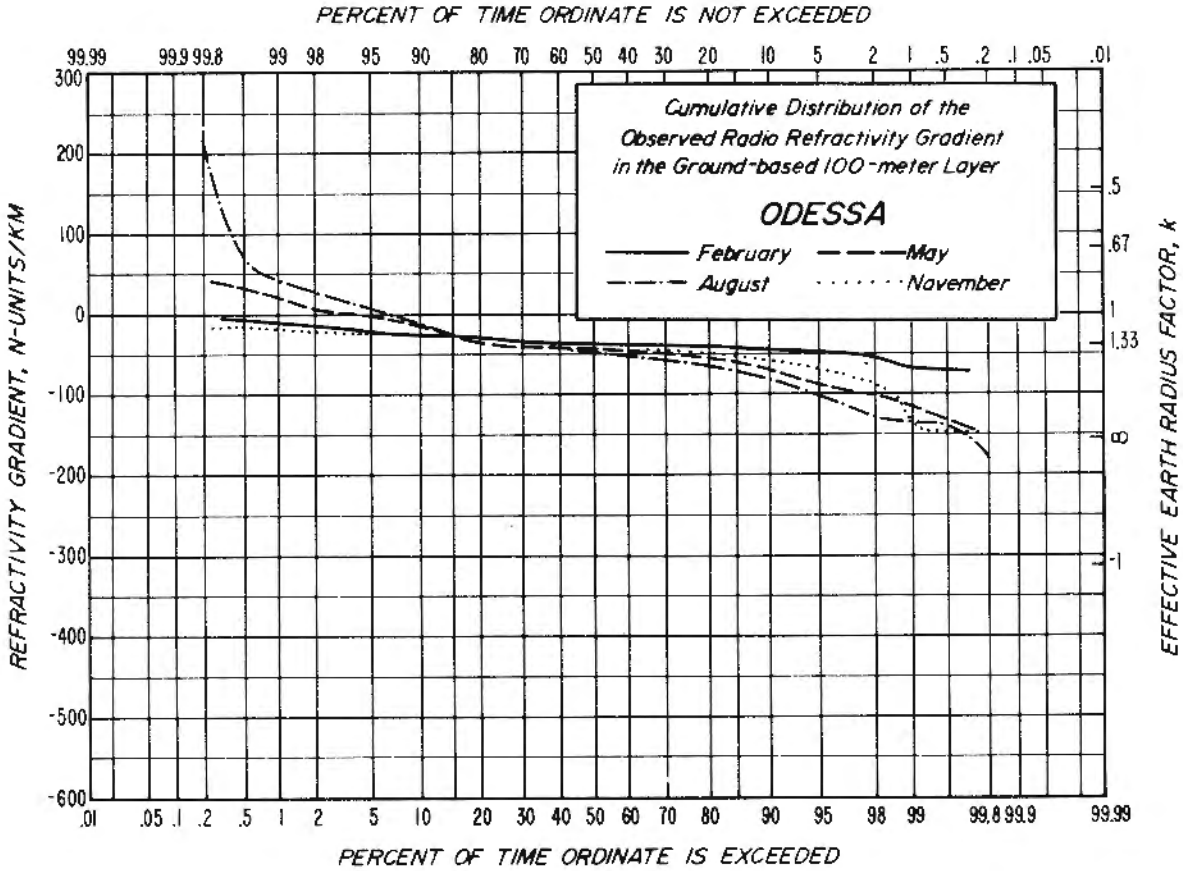
Data: Radiosonde.　　0300 and 1500Z (1900 and 0700 LST)
8/52 - 8/54
0300, 0900, 1500, 2100Z
11/54 - 5/57

Temperature (°F):　　January 55/41; July 73/56

Mean Dewpoint (°F):　　January 41; July 53

Precipitation (inches):　　Annual 17.9; January 3.83; July (Trace)

Located on the east side of San Francisco Bay, with prevailing westerly winds off the Pacific Ocean. A mild maritime climate, with rainy winters and cool and dry summers. Often cloudy in the mornings during the summer.



<u>Odessa, Ukraine, U.S.S.R.</u>

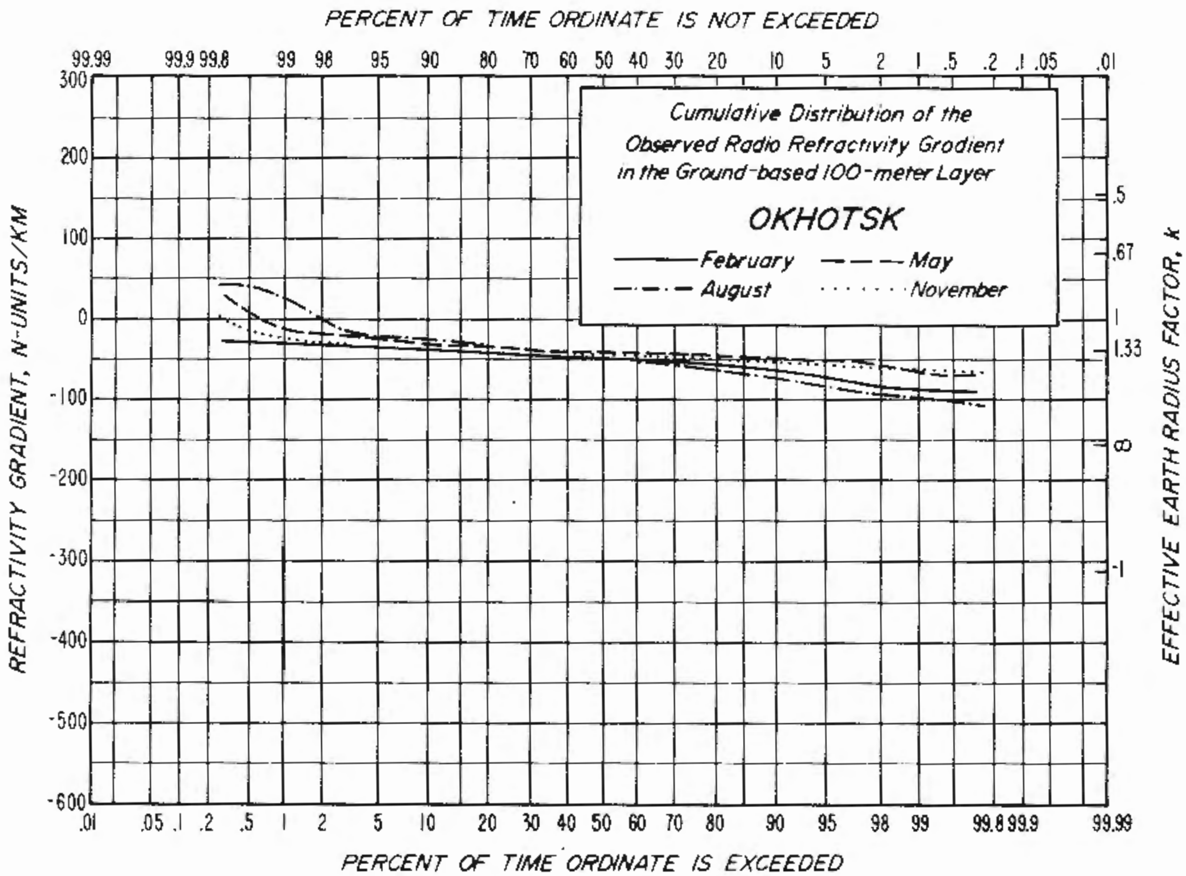
46-29 N, 30-38 E. 64 meters MSL

Data: Radiosonde. 0000Z (0200 LST)
5/53 - 2/57 and 2/60 - 11/60
0000 and 1200Z (0200 and 1400 LST)
8/57 - 11/59

Temperature (°F): January 28/22; July 79/65

Precipitation (inches): Annual 14.3; June 1.9; Feb., March 0.7

Located near the mouth of the Dneister River on Odessa Bay of the northwest shore of the Black Sea. Steppe area. Moderate continental climate; semi-arid.



Okhotsk, Khabarovsk Territory, U.S.S.R.

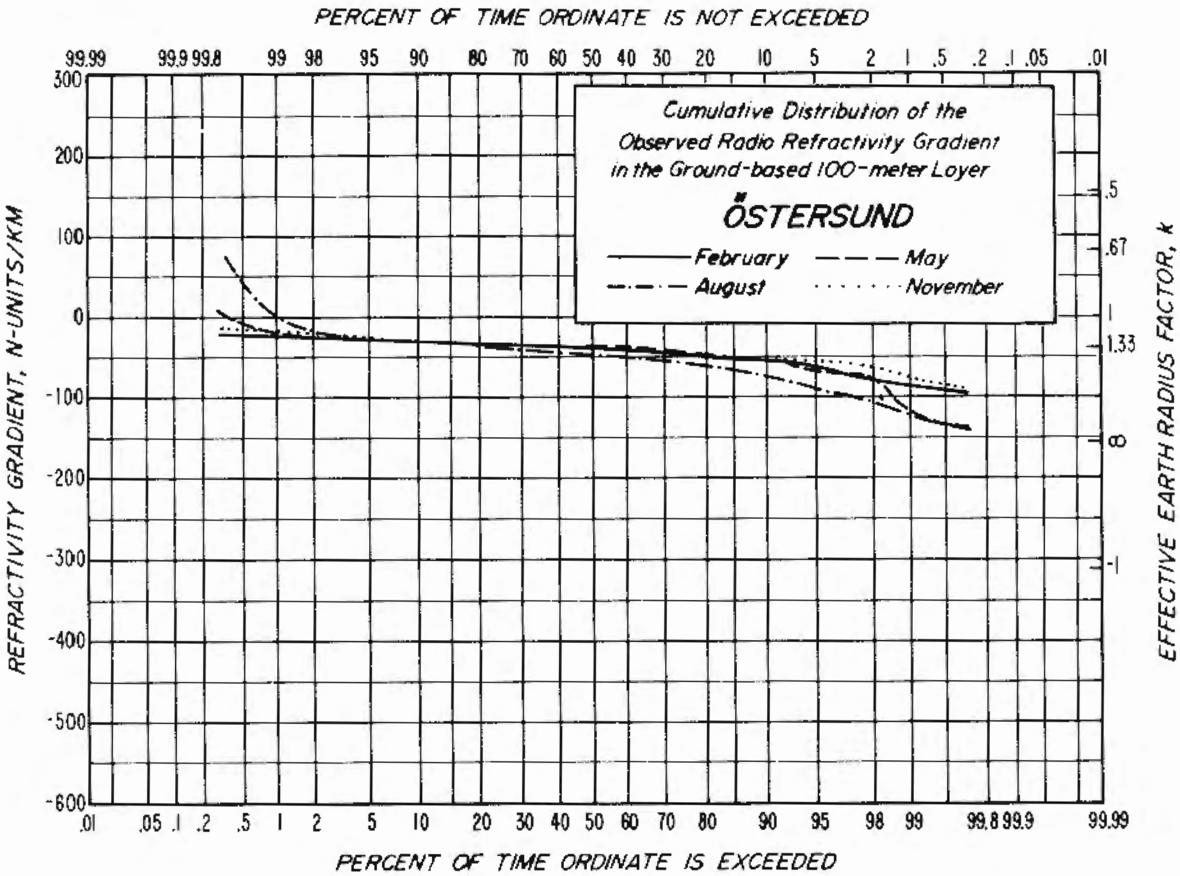
59-22 N, 143-12 E. 7 meters MSL

Data: Radiosonde. 0200Z (1200 LST)
2/53 - 2/57
0000 and 1200Z (1000 and 2200 LST)
8/57 - 11/59
0000Z (1000 LST)
2/60 - 5/61

Temperature (°F): January -6/-17; July 57/48

Precipitation (inches): Annual 11.8; August 2.6; Dec., Jan., and Feb. 0.1

Located on the northwest coast of the Sea of Okhotsk; the port is closed by ice for more than half of the year. A cold, dry, continental climate.



Östersund, Sweden

63-11 N, 14-37 E. 309 meters MSL

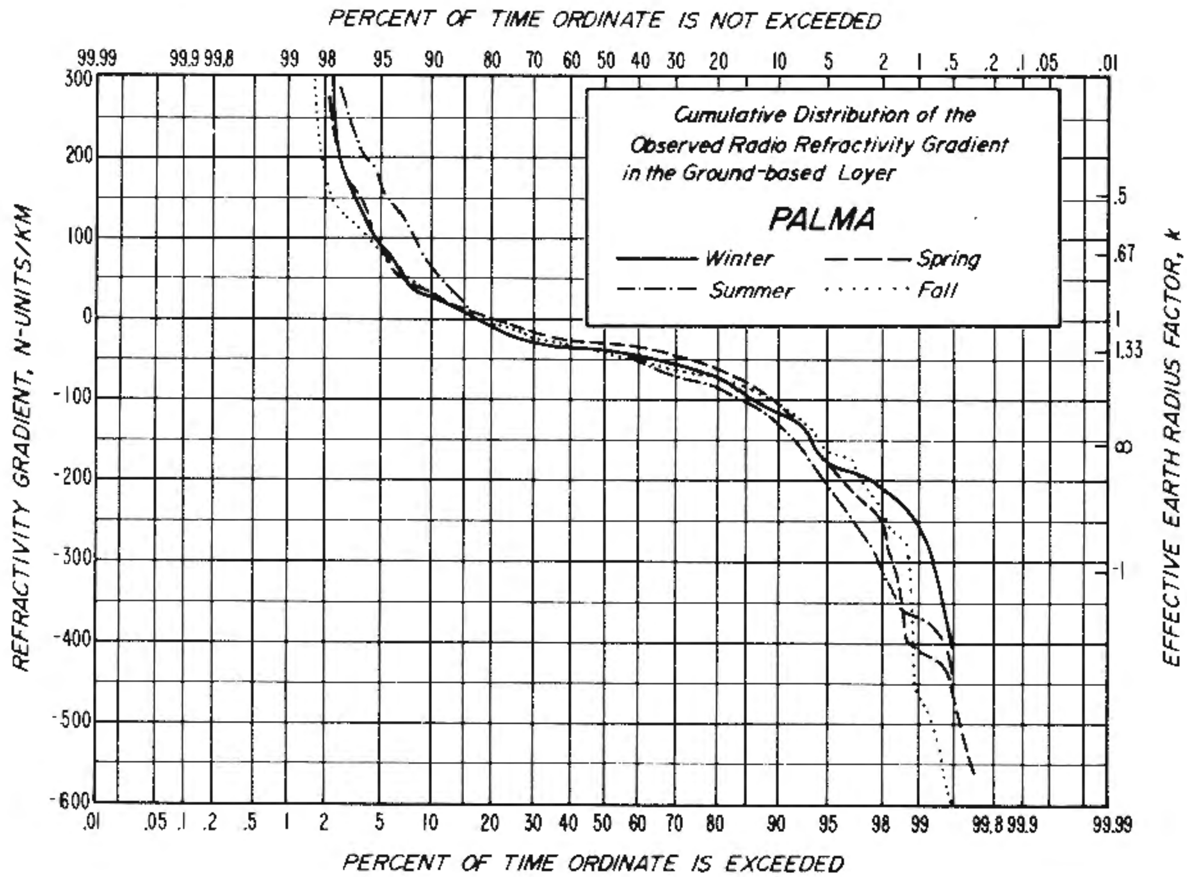
Data: Radiosonde. 0200Z (0300 LST)
2/57
0000Z (0100 LST)
5/57 - 5/62

Temperature (°F): January 26/15; July 67/50

Mean Dewpoint (°F): January 18; July 50

Precipitation (inches): Annual 20.6; August 3.0; February 0.8

Located on Lake Storsjon in north-central Sweden. A cool, primarily maritime climate.



Palma, Majorca

39-36 N, 02-42 E. 54 meters MSL

Data: Radiosonde. 0000 and 1200Z (0000 and 1200 LST)
1/68 - 12/70

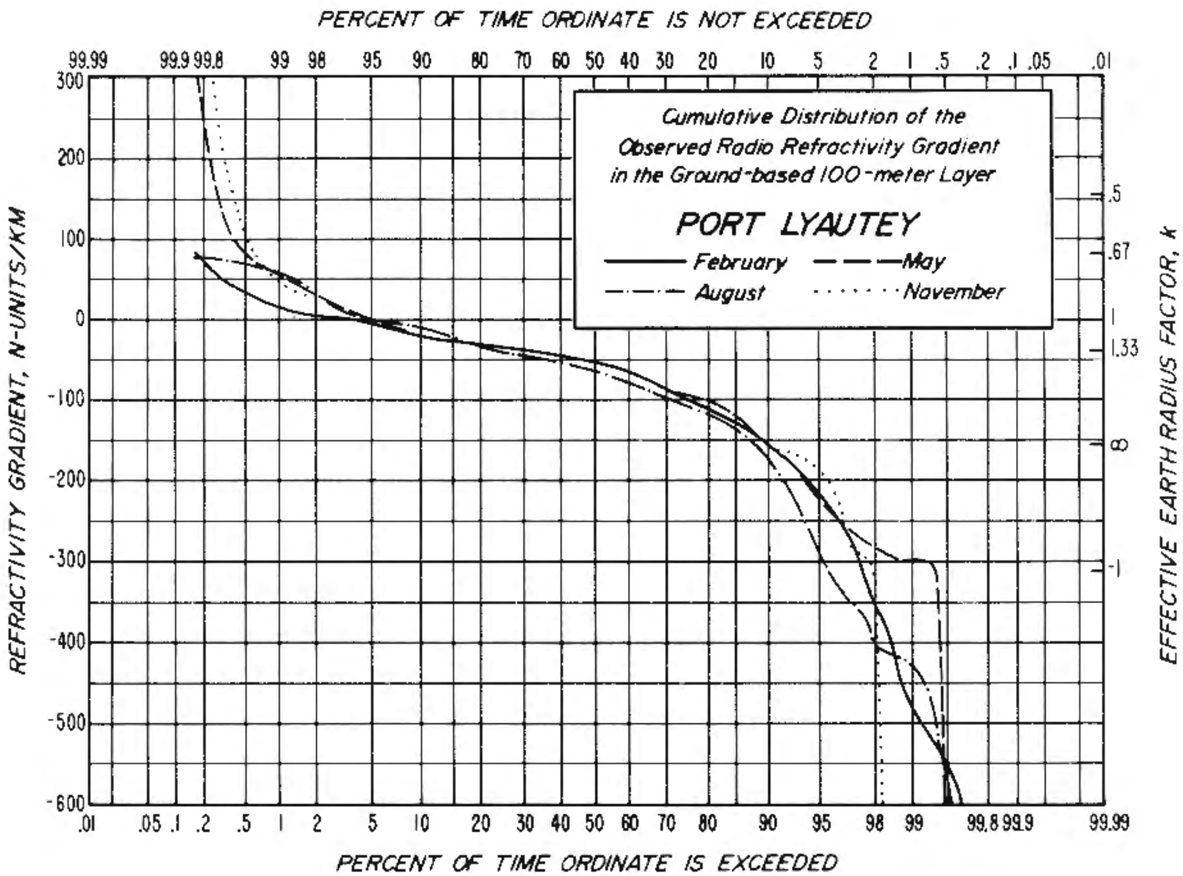
Note: Calculated refractivity gradient between surface and next higher level. See text.

Analyzed by: Davis and Wagner, Environmental Technical Applications Center, U.S. Air Force, Washington, D.C.

Temperature (°F): January 57/42; July 84/66

Precipitation (inches): Annual 19.4; October, November 2.8; July 0.2

Located on southwest side of a large mountainous island (1405 sq. miles) in the Mediterranean Sea; 145 miles east of the Spanish coast. A maritime climate with mild winters and hot, dry summers.



Port Lyautey (Kenitra), Morocco

34-18 N, 06-36 W. 12 meters MSL

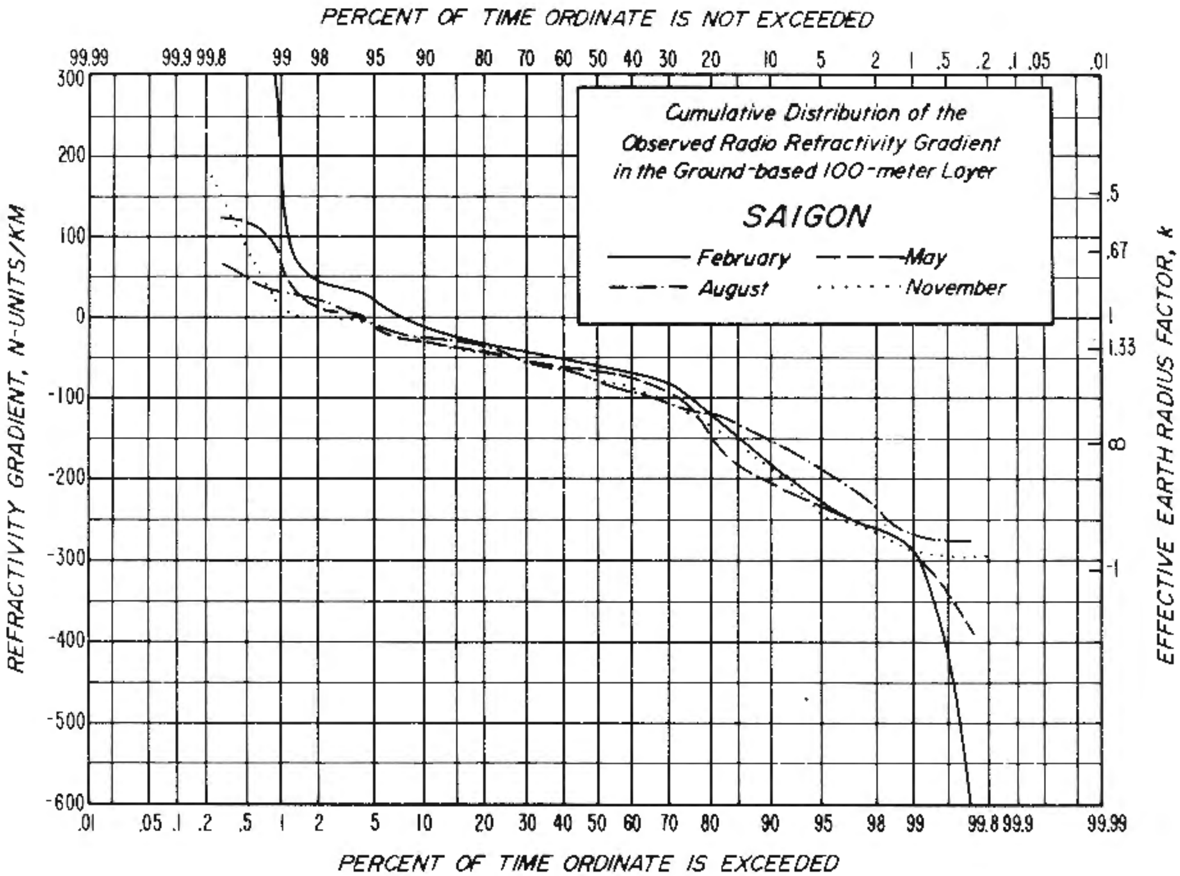
Data: Radiosonde. 0300 and 1500 LST
8/52 - 5/57

Temperature (°F): January 63/47; July 80/66

Mean Dewpoint (°F): January 50; July 65

Precipitation (inches): Annual 23.9; December 5.53; July 0.00

Located about 10 miles from the Atlantic Ocean on a river in northwest Morocco. A maritime temperature climate with warm, dry summers and mild, wet winters.



Saigon, Viet Nam

10-49 N, 106-40 E. 10 meters MSL

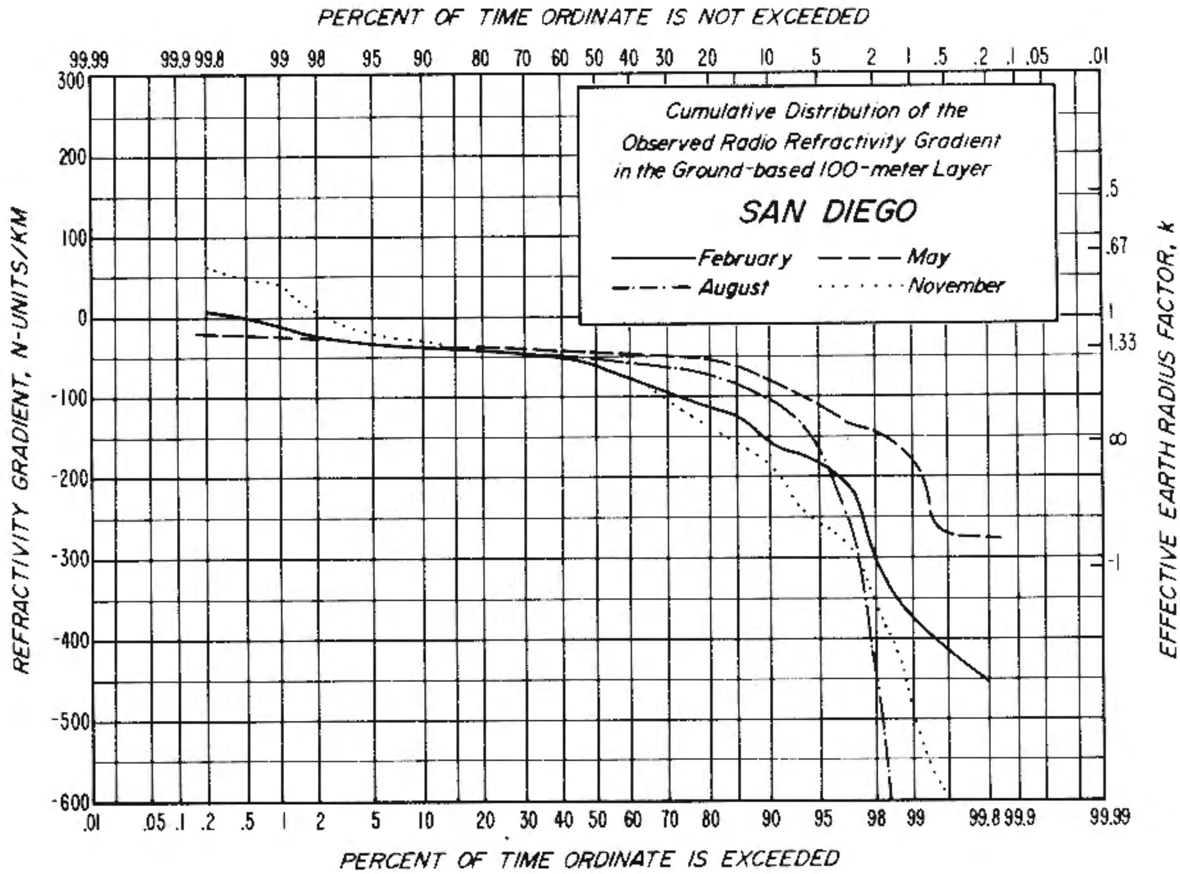
Data: Radiosonde. 0200Z (0900 LST): 8/52 - 8/53; 0100Z (0800 LST): 11/53 - 2/54; 0000Z (0700 LST): 5/54 - 11/54; 0300Z (1000 LST): 8/55 - 2/57

Temperature (°F): January 89/70; July 88/75

Mean Dewpoint (°F): January 68; July 75

Precipitation (inches): Annual 78.1; September 13.2; February 0.1

Located on the Saigon River; a port city about 60 miles from the South China Sea. A humid, tropical monsoon climate.



San Diego, California

32-44 N, 117-10 W. 9 meters MSL

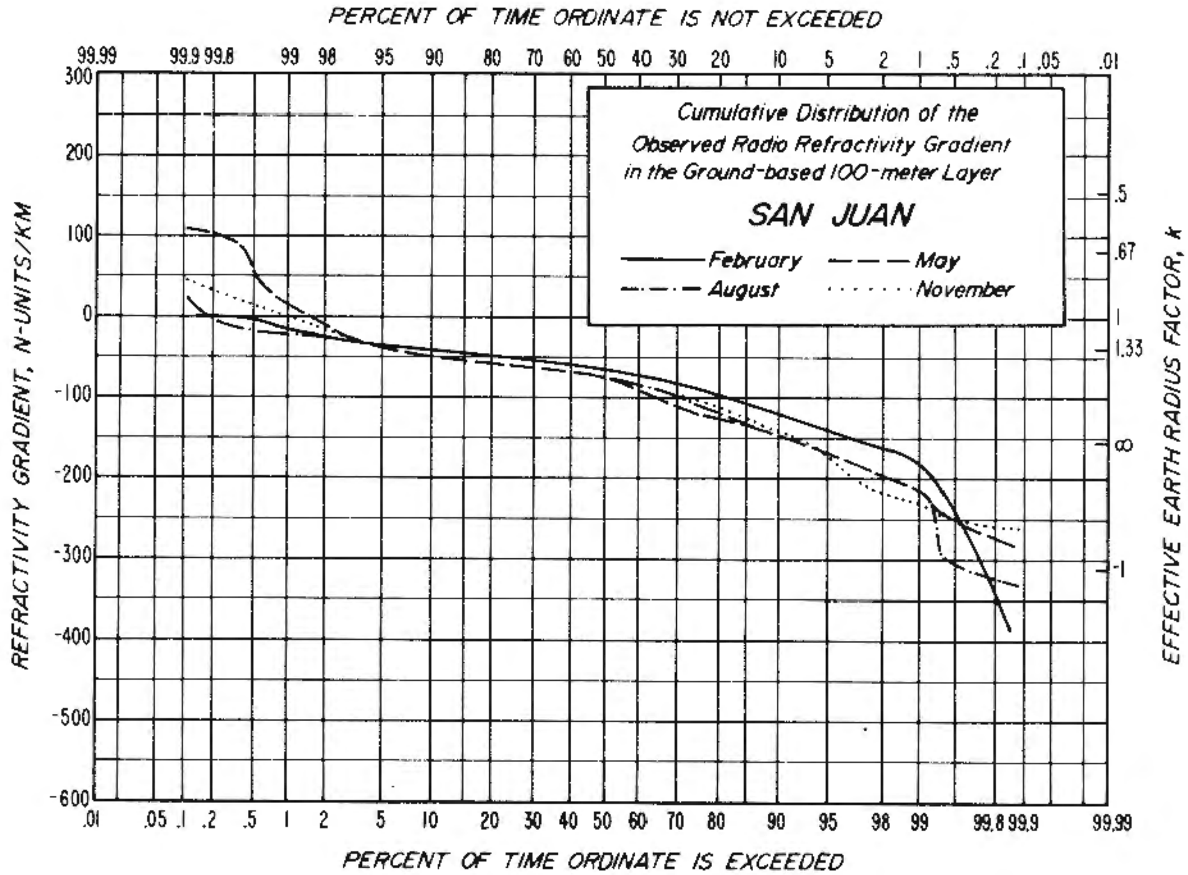
Data: Radiosonde. 0300 and 1500Z (1900 and 0700 LST) 8/52 - 5/57

Temperature (°F): January 65/45; July 77/63

Mean Dewpoint (°F): January 45; July 61

Precipitation (inches): Annual 10.4; February 2.15; July 0.01

Located near San Diego Bay, with prevailing winds off the Pacific Ocean. A mild maritime climate, with cool dry summers and relatively mild winters. Night and early morning low cloudiness is common in spring and summer, and there is considerable fog in winter.



San Juan, Puerto Rico

18-26 N, 66-00 W. 19 meters MSL

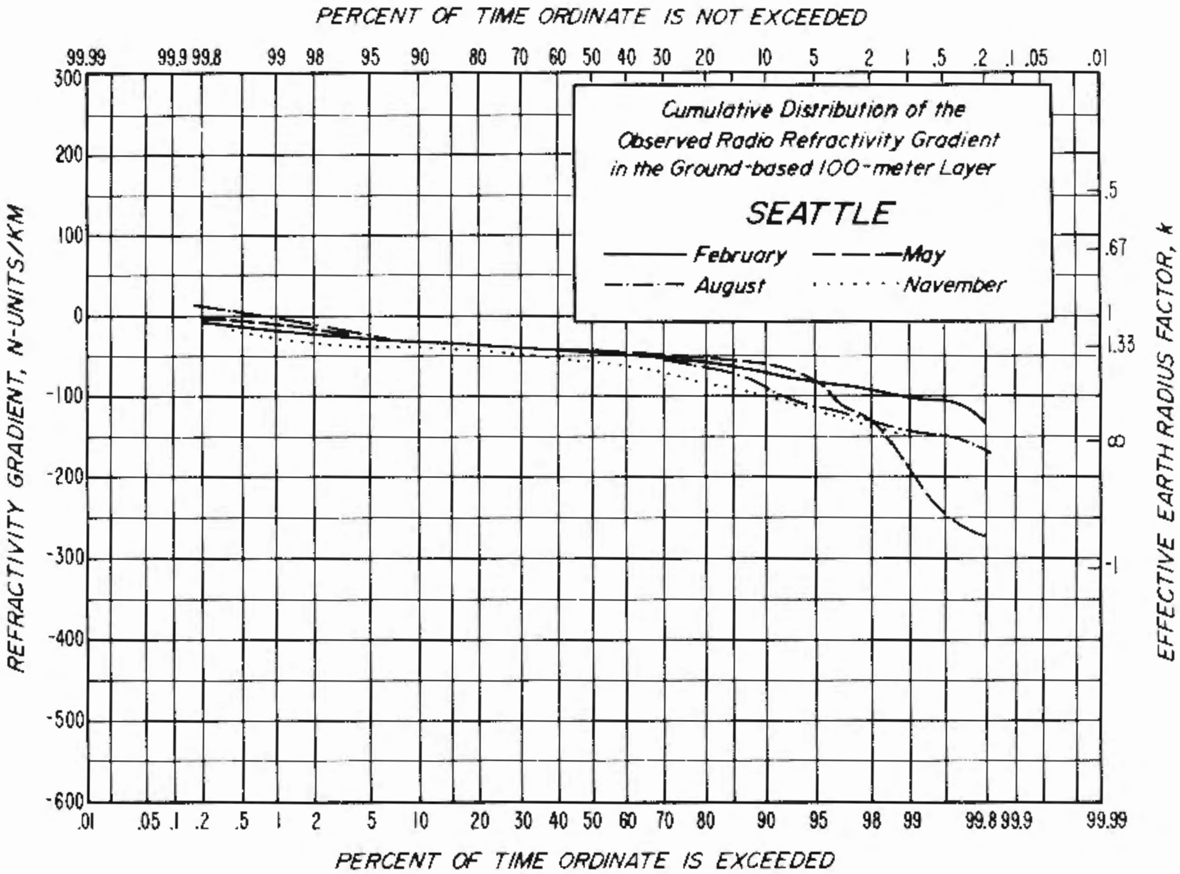
Data: Radiosonde. 0300 and 1500Z (2300 and 1100 LST) 1/51 - 5/57
0000 and 1200Z (2000 and 0800 LST) 6/57 - 12/57

Temperature (°F): January 81/70; July 86/76

Mean Dewpoint (°F): January 68; July 74

Precipitation (inches): Annual 68.0; August 7.42; March 2.23

Located on the northeast coast of a large island (3423 sq. miles) and surrounded by the Atlantic Ocean and San Juan Bay. A tropical marine climate in the easterly trade wind belt.



Seattle, Washington

47-27 N, 122-18 W. 130 meters

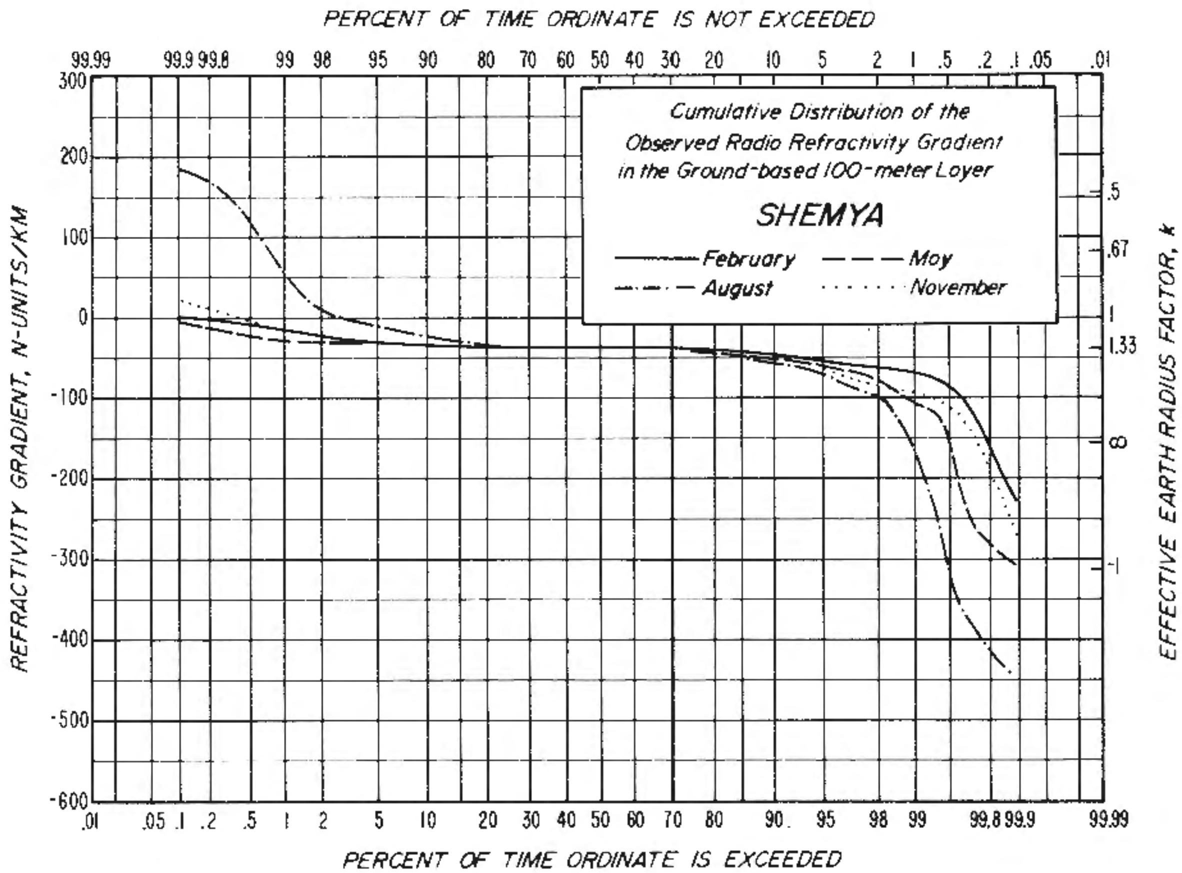
Data: Radiosonde. 0300 and 1500Z (1900 and 0700 LST) 8/52 - 5/57

Temperature (°F): January 44/33; July 76/54

Mean Dewpoint (°F): January 33; July 52

Precipitation (inches): Annual 38.9; December 6.29; July 0.81

The station is located on a low north-south ridge between Puget Sound and the Green River-White River valleys. Puget Sound is about 2 miles to the west, the Olympic Mountains about 50 miles west, and the Cascade Mountains about 40 - 50 miles east. The maritime coastal climate is modified by the nearby mountain ranges; there is considerable cloudiness and rain in winter but summers are relatively dry and mild with light winds.



<u>Shemya, Alaska</u>

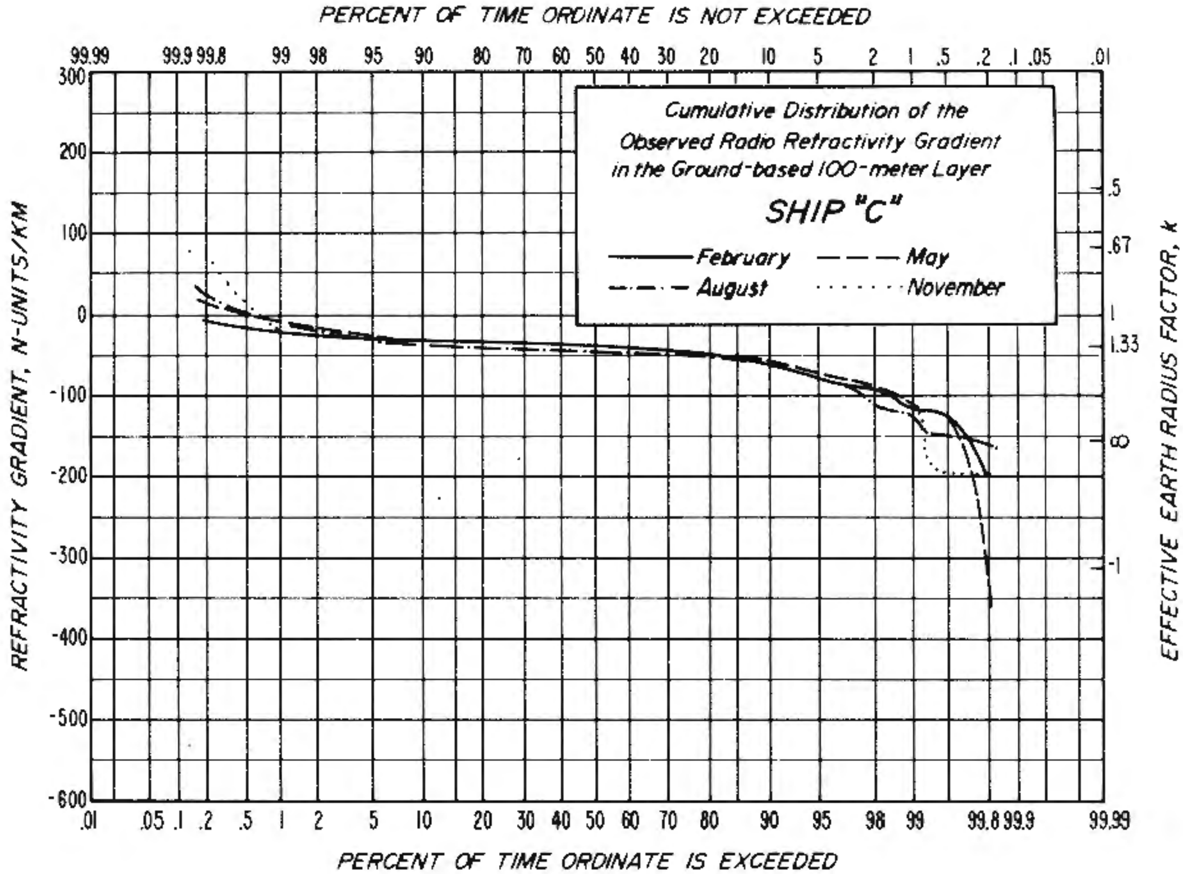
52-43 N, 174-06 E. 37 meters MSL

Data: Radiosonde. 0300 and 1500Z (1500 and 0300 LST)
7/52 - 7/57
0000 and 1200Z (1200 and 0000 LST)
8/57 - 5/60

Temperature (°F): January 34/29; July 49/44

Precipitation (inches): Annual 27.3; October 2.76; June 1.32

Station is located on a small island in the Aleutians; the highest elevation on the island is about 400 ft. A cool, maritime climate with abundant cloudiness. Precipitation falls on 3 out of 5 days during the year. There is considerable fog in summer. The wind averages over 18 mph the year around, and only about 2.5% of the observations show a calm.



Ship "C" (Atlantic Ocean)

52-45 N, 35-30 W.

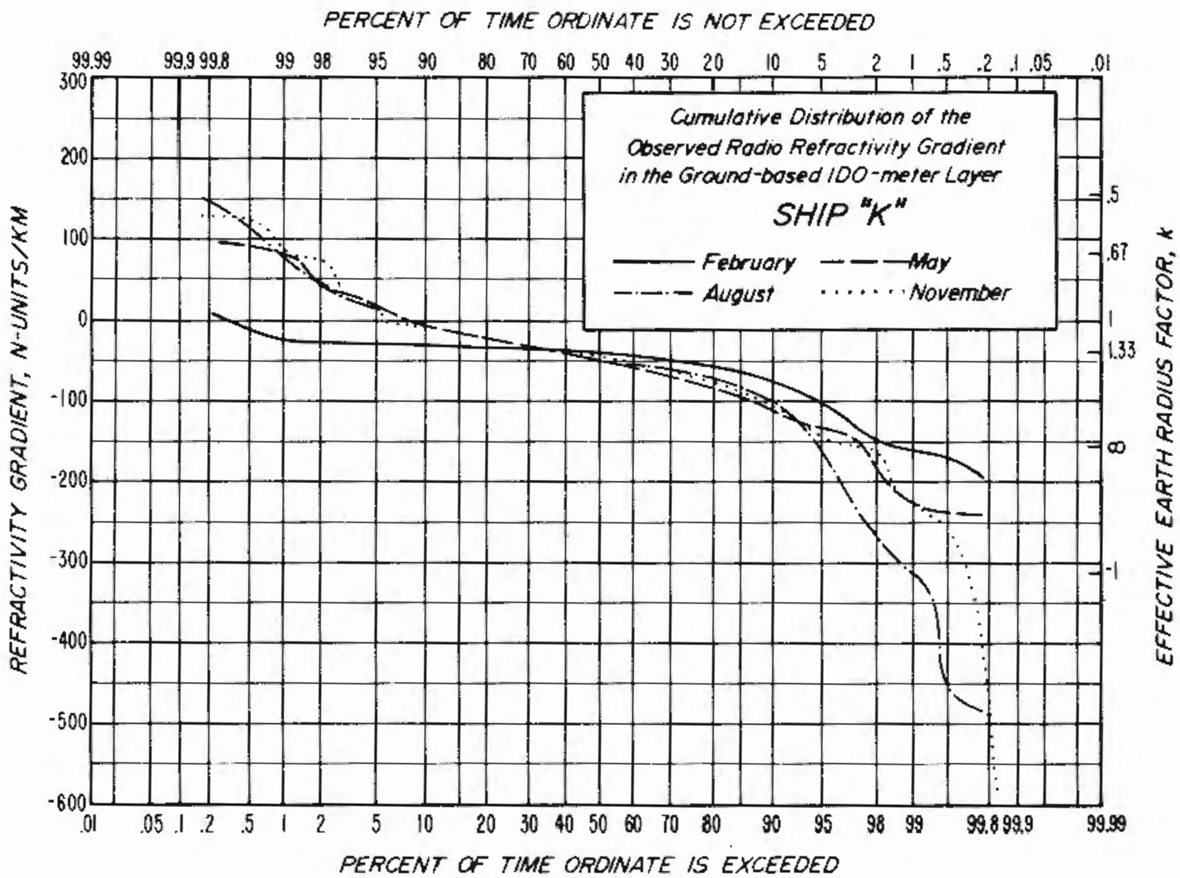
Data: Radiosonde. 0300 and 1500Z (0100 and 1300 LST)
8/52 - 5/57

Average Temperature: January 42°F; July 54°F

Average Dewpoint: January 36°F; July 50°F

Relative humidity (average): January 80%; July 88%

Sea Surface Temperature: January 44°F; July 53°F



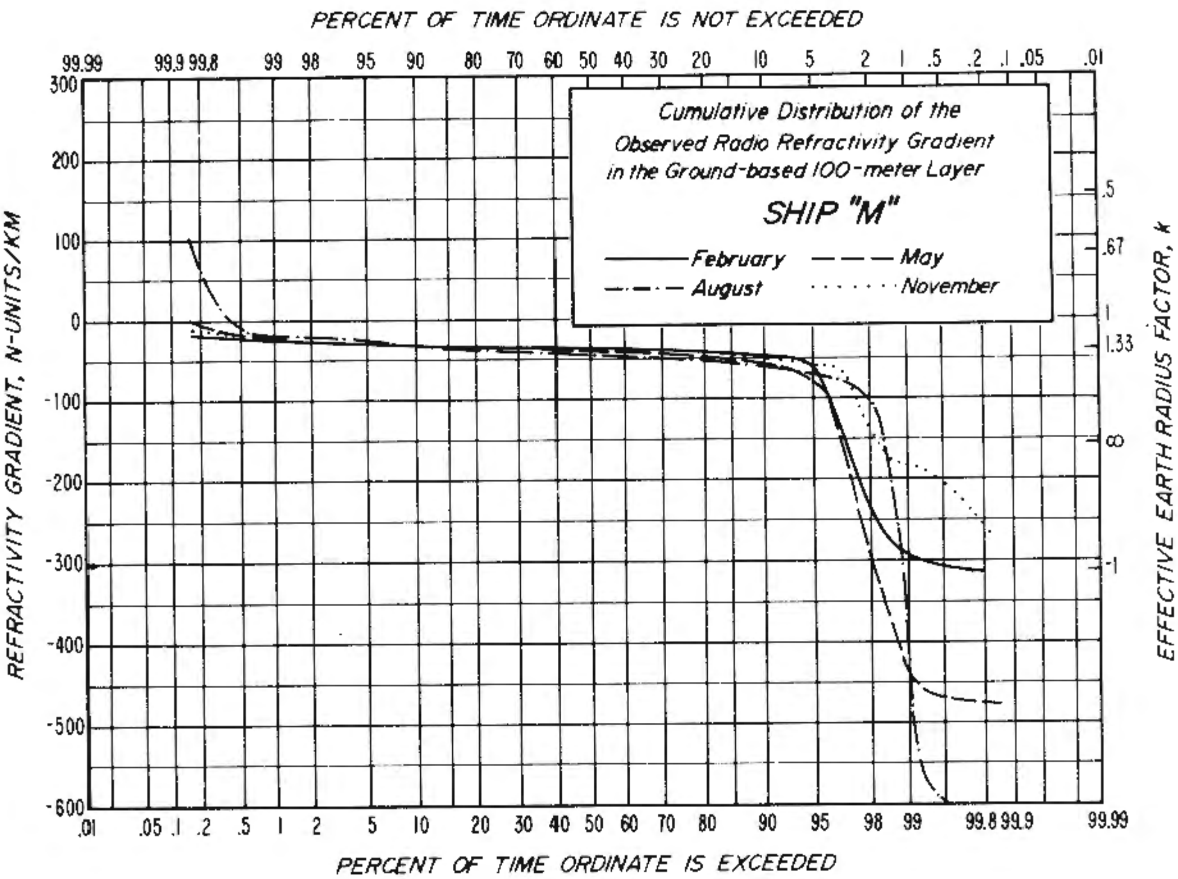
Ship "K" (Atlantic Ocean)

45-00 N, 16-00 W.

Data: Radiosonde. 0200 and 1400Z (0100 and 1300 LST)
8/52 - 11/56

Average Temperature: January 54°F; July 65°F

Relative Humidity (average): January 80%; July 82%



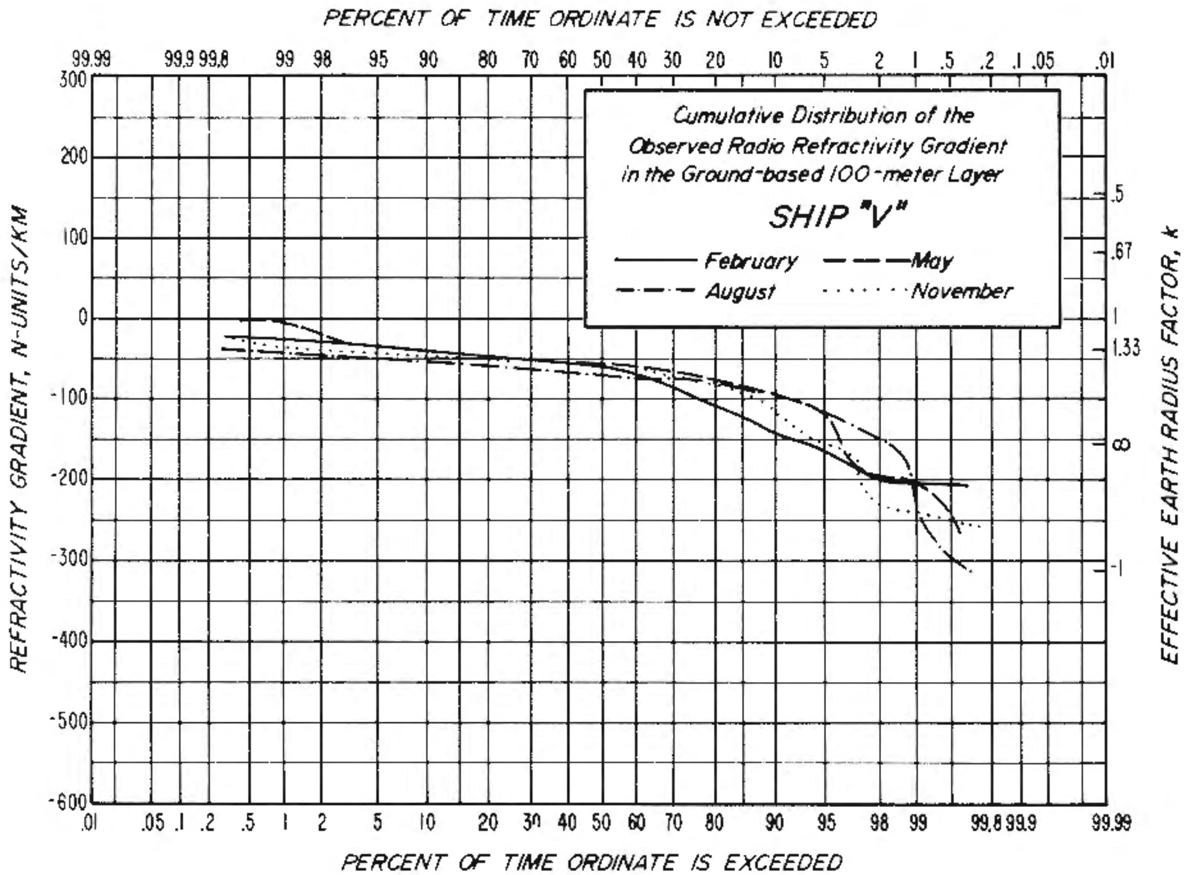
Ship "M" (Norwegian Sea)

66-00 N, 02-00 E.

Data: Radiosonde. 0300 and 1500Z (0300 and 1500 LST)
8/52 - 5/57

Average Temperature: January 38°F; July 50°F

Relative Humidity (average): January 77%; July 86%



Ship "V" (Pacific Ocean)

34-00 N, 164-00 E.

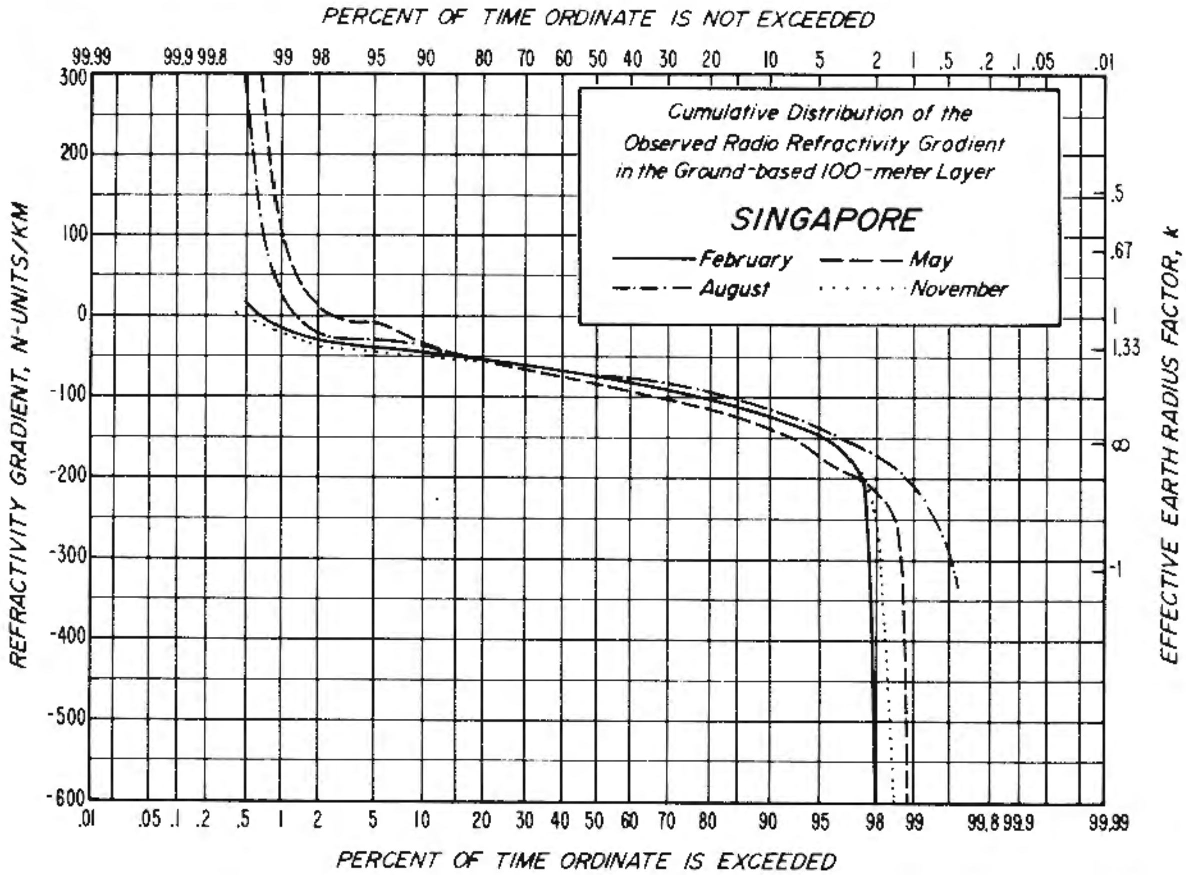
Data: Radiosonde. 0300 and 1500Z (1400 and 0200 LST)
5/52 - 8/60

Average Temperature: January 59°F; July 75°F

Average Dewpoint: January 49°F; July 71°F

Relative Humidity (average): January 70%; July 88%

Sea Surface Temperature: January 65°F; July 75°F



Singapore (South of Malay Peninsula)

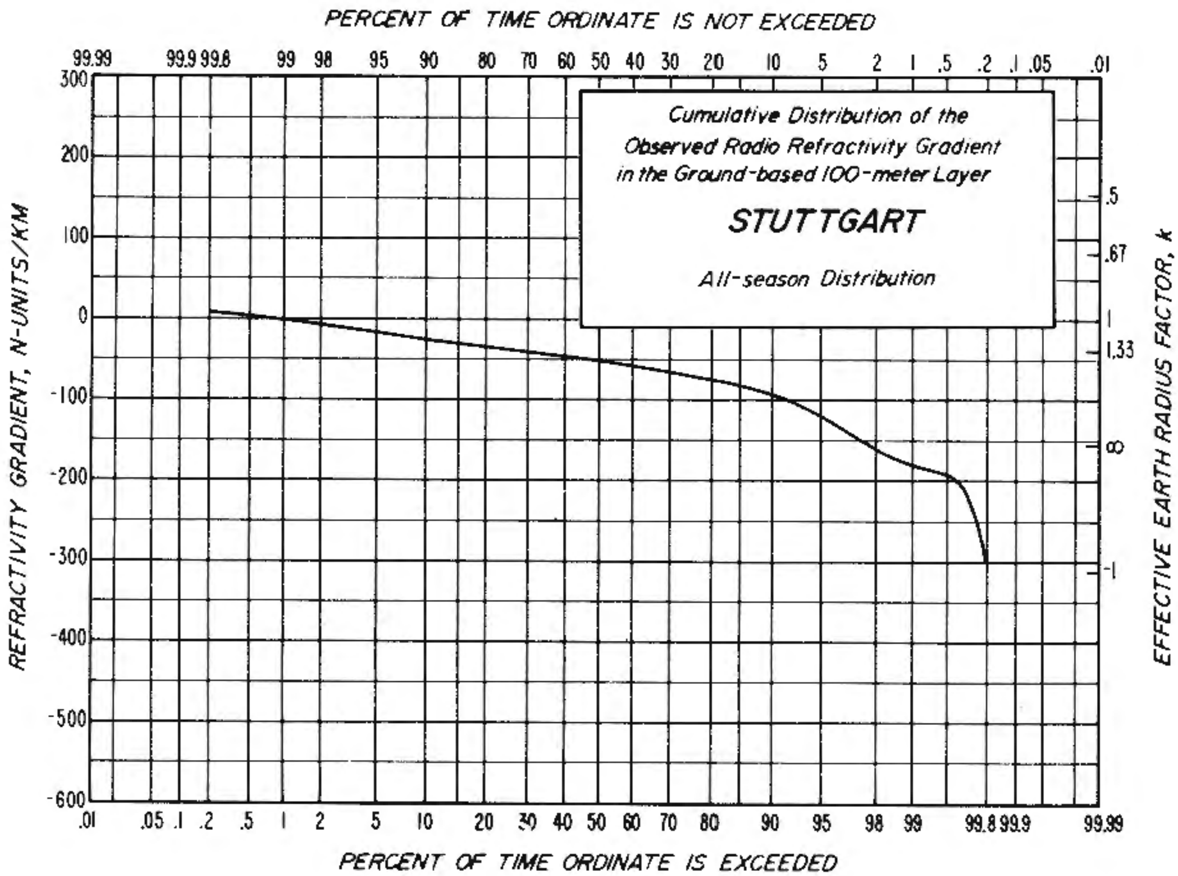
01-21 N, 103-54 E. 18 meters MSL

Data: Radiosonde. 0000Z (0700 LST)
8/57 - 5/62

Temperature (°F): January 86/73; July 88/75

Precipitation (inches): Annual 95.0; December 10.1; July 6.7

Station is on an island between Johore Strait and Singapore Strait. A hot, humid, tropical climate.



Stuttgart, Germany (Federal Republic)

48-50 N, 09-12 E. 325 meters MSL

Data: Radiosonde. 0000 and 1200Z (0100 and 1300 LST)
1961 and 1962

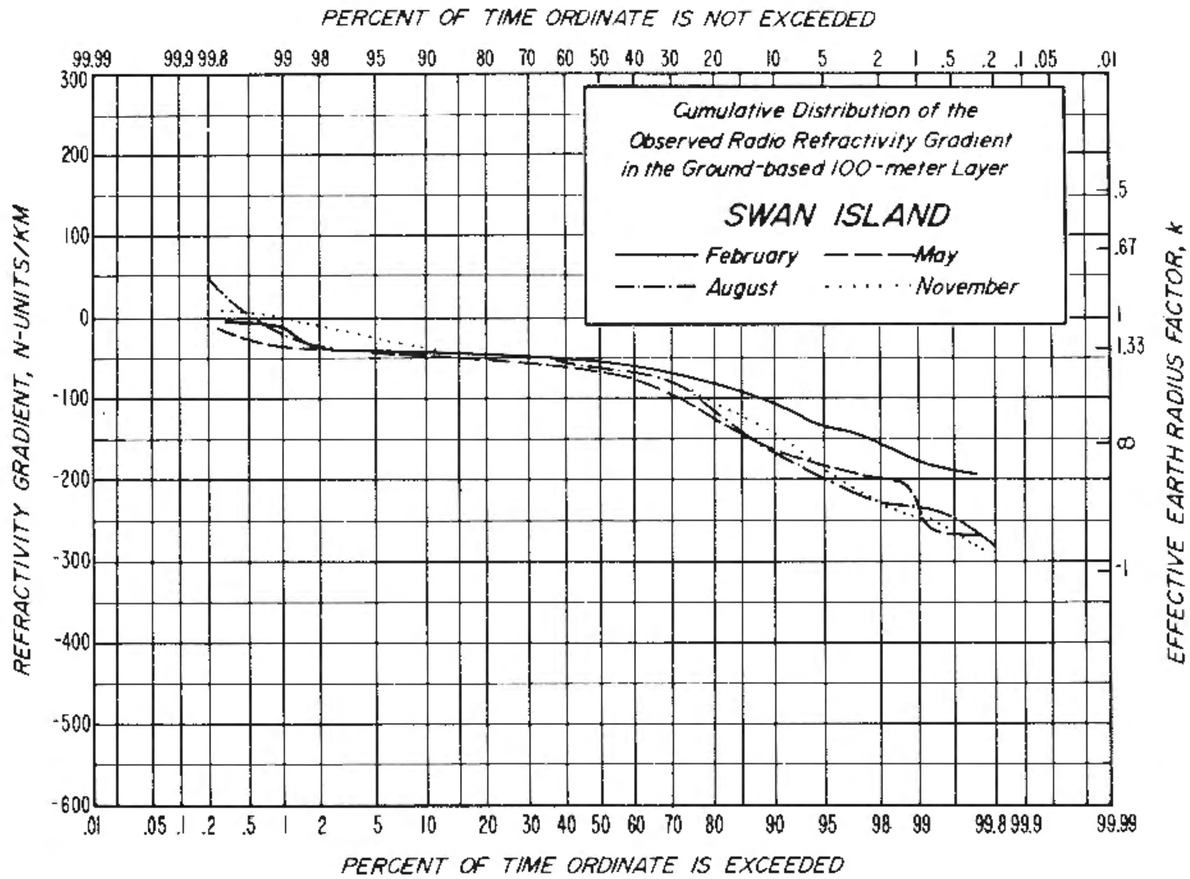
Analyzed by: Dr. L. Fehlhaber, Fernmeldetechnisches Zentralamt, Darmstadt

Temperature (°F): January 38/28; July 75/57

Mean Dewpoint (°F): January 27; July 53

Precipitation (inches): Annual 26.5; June 3.30; February 1.30

Located in the valley of the Neckar River; woods, orchards, and vineyards in vicinity. A continental climate modified by the exposure to maritime air masses.



<u>Swan Island, West Indies</u>

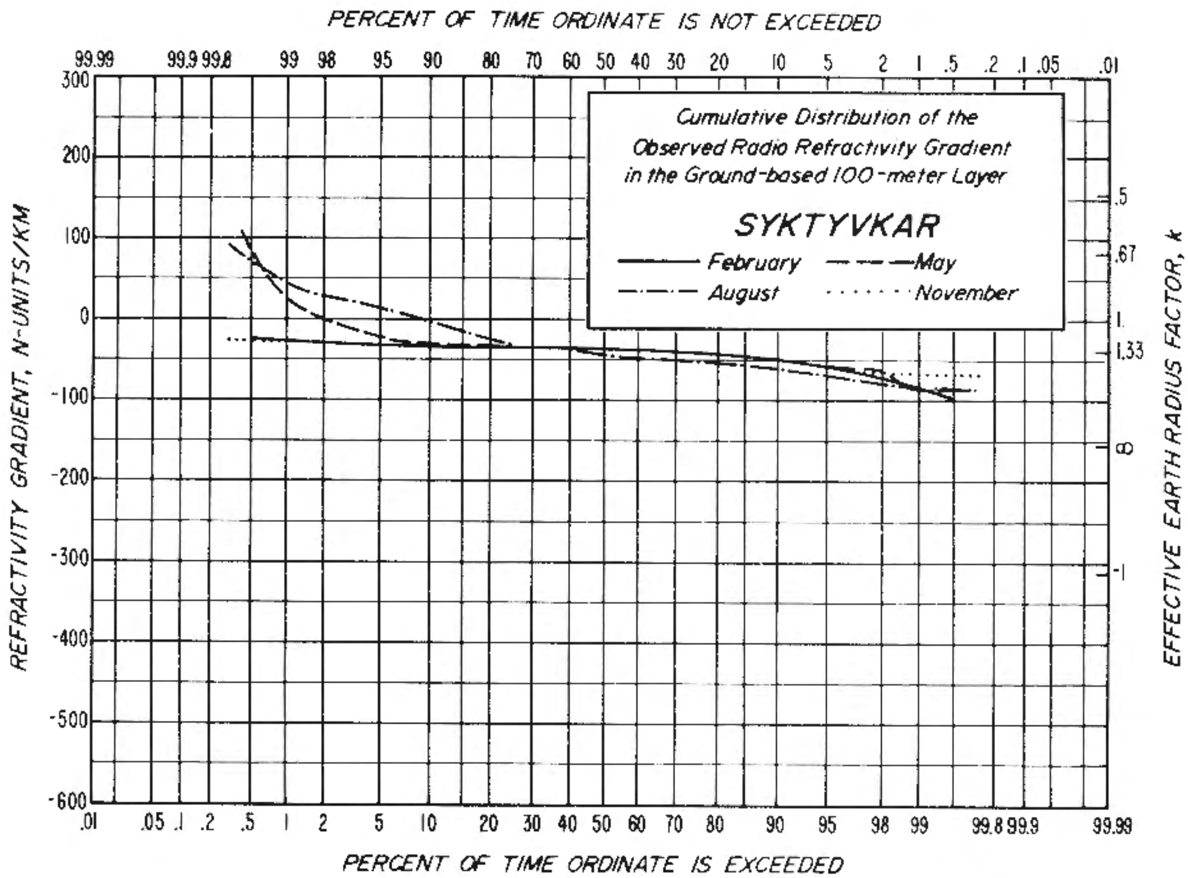
17-24 N, 83-56 W. 10 meters MSL

Data: Radiosonde. 0300 and 1500Z (2100 and 0900 LST)
7/52 - 9/55

Temperature (°F): January 83/74; July 87/78

Precipitation (inches): Annual 51.6; October 9.70; March 0.63

Great Swan Island is about 3/4 mile wide and 2 miles long; the maximum elevation is 52 ft MSL. Weather station is on a clearing near the west end of the island. A tropical maritime climate.



Syktyvkar, Komi, U.S.S.R.

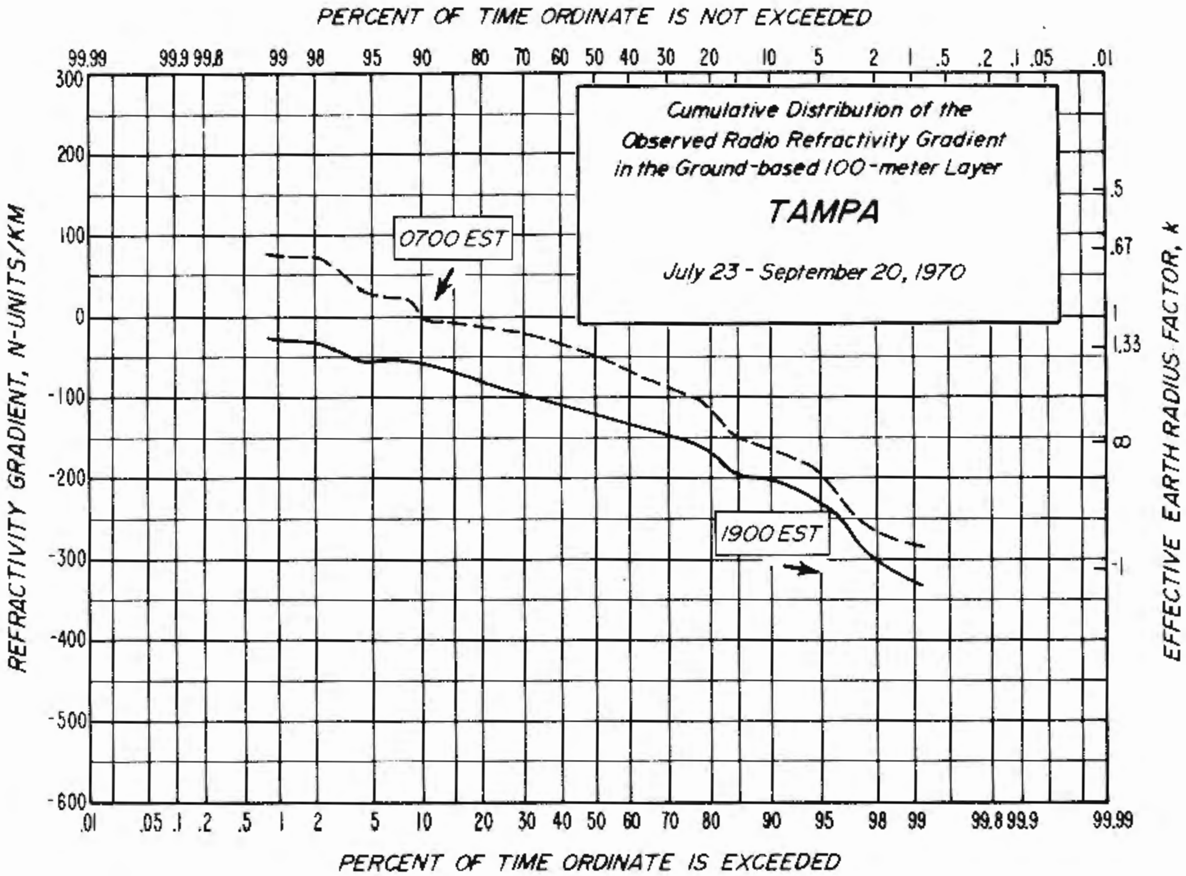
61-40 N, 50-51 E. 96 meters MSL

Data: Radiosonde. 0000 and 1200Z (0300 and 1500 LST) 8/57 - 11/59

Average Temperature: January 4°F; July 62°F

Precipitation (inches): Annual about 15

Located on the Sysola River just above the junction with the Vychegda, in a taiga forest area. Prolonged, cold winters and cool summers.



Tampa, Florida

27-58 N, 82-32 W. 3 meters MSL

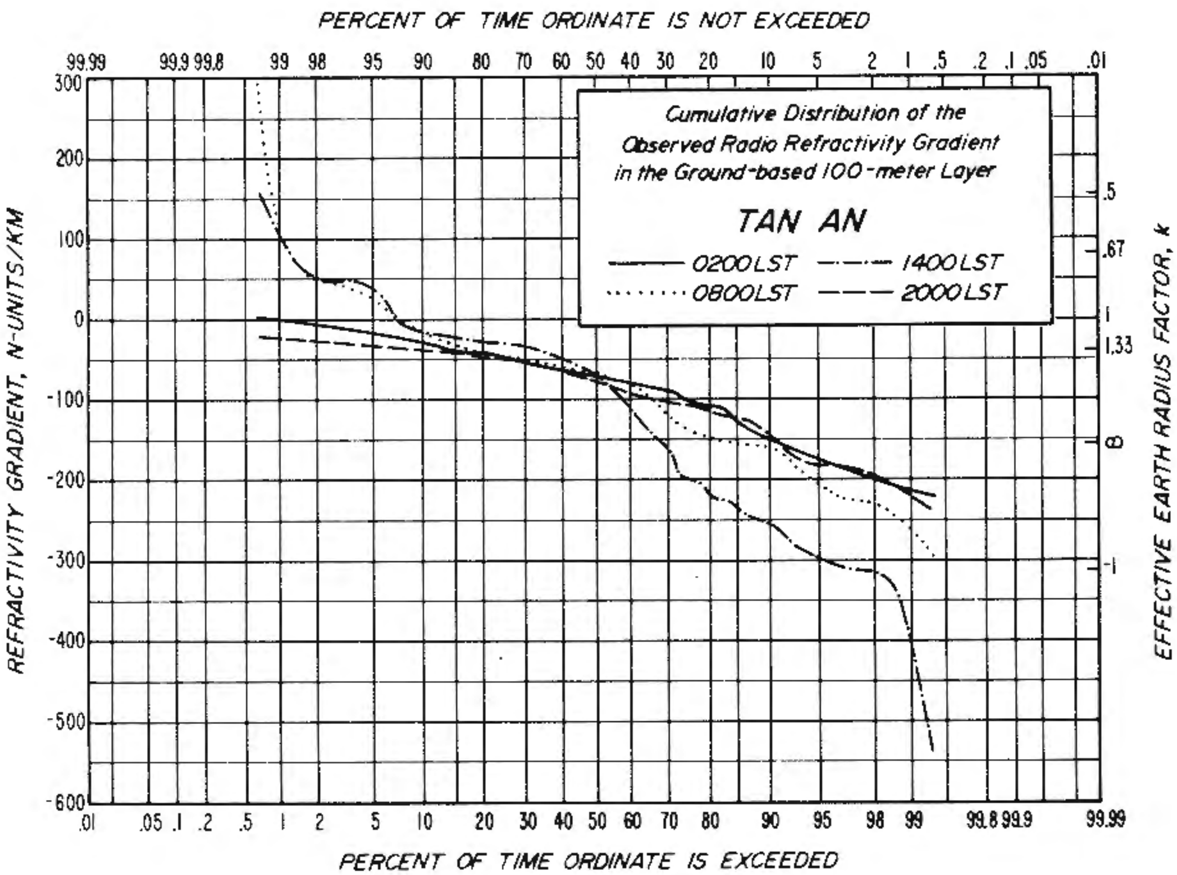
Data: Radiosonde. July 23 - Sept. 20, 1970

Temperature (°F): January 71/51; July 90/73

Mean Dewpoint (°F): January 51; July 72

Precipitation (inches): Annual 51.6; July 8.62; November 1.46

Located on Tampa Bay about 20 miles from the Gulf of Mexico. Subtropical climate, with 60% of annual rainfall June-September. Frequent winter fogs; 87 days/yr with thunderstorms.



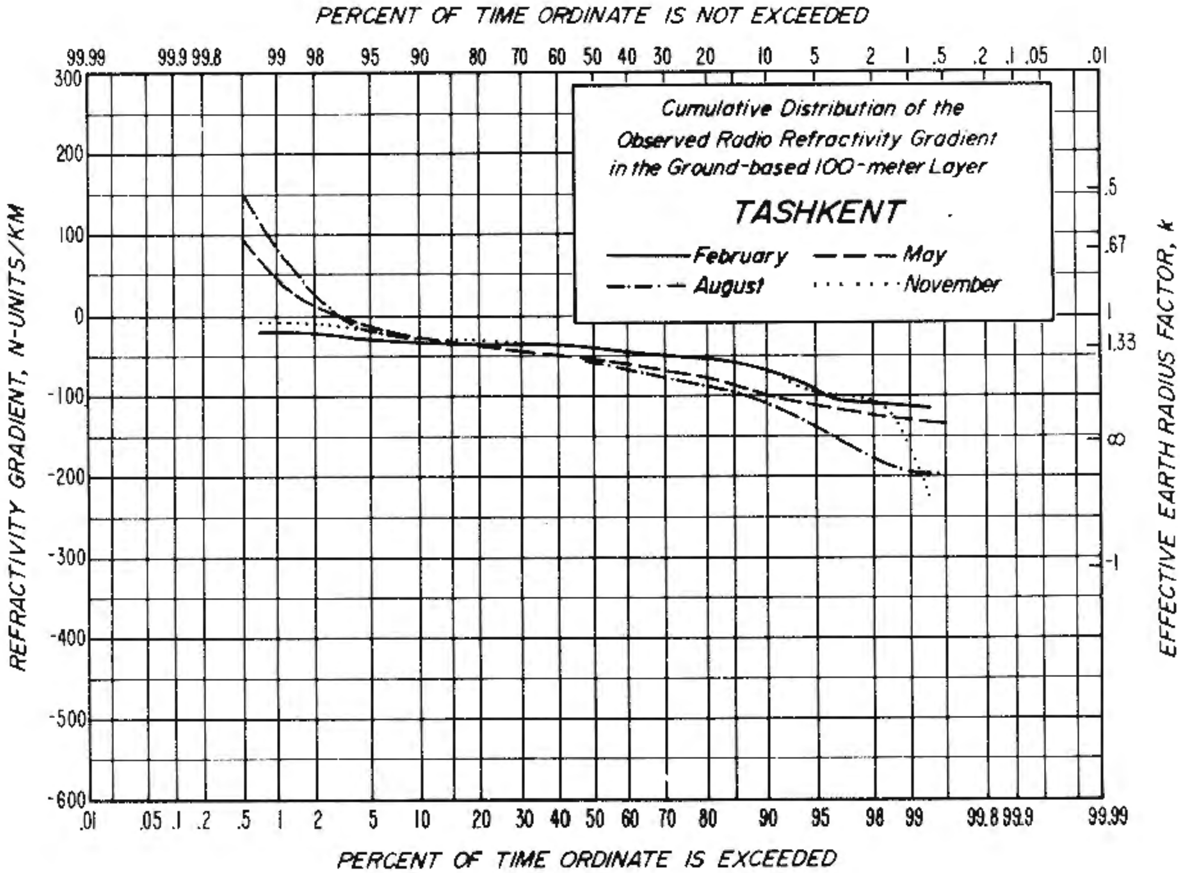
Tan An, Viet Nam

10-32 N, 106-23 E. 10 meters MSL

Data: Radiosonde. 19 Jan. - 5 April 1970

Located in the delta region about 25 miles southwest of Saigon. A humid, tropical monsoon climate.

(See Long Xuyen and Saigon)



Tashkent, Uzbekistan, U.S.S.R.

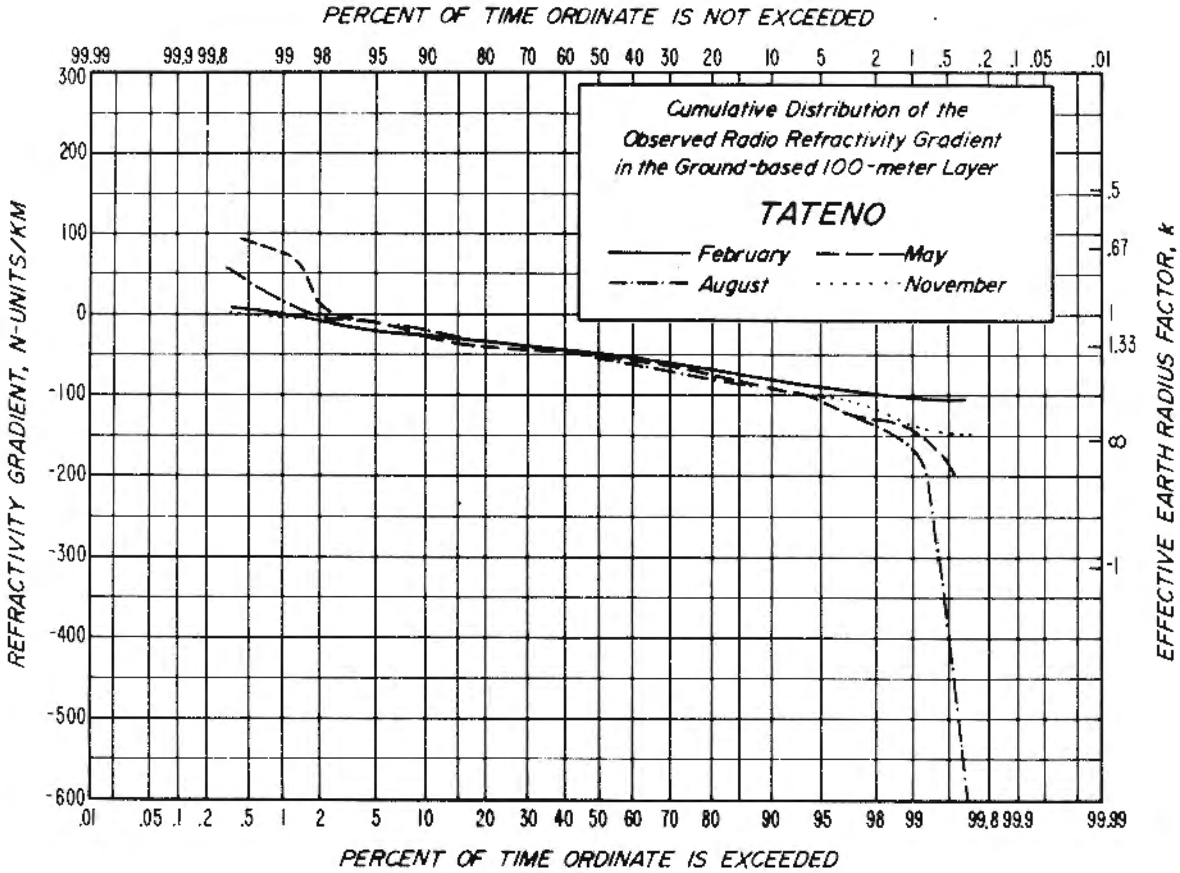
41-20 N, 69-18 E. 478 meters MSL

Data: Radiosonde. 0000Z (0500 LST)
5/59 - 8/62

Temperature (°F): January 37/21; July 92/64

Precipitation (inches): Annual 14.7; March 2.6; August and Sept. 0.1

Located on Chirchik River, on the northwestern edge of the Tien Shan Mountains, in the basin of the middle course of the Syrdarya. A continental climate, semi-arid, with mild winters and hot, dry summers.



<u>Tateno, Japan</u>

36-03 N, 140-08 E. 27 meters MSL

Data: Radiosonde. 0000Z (0900 LST)
8/58 - 2/62 and 8/62 - 5/63

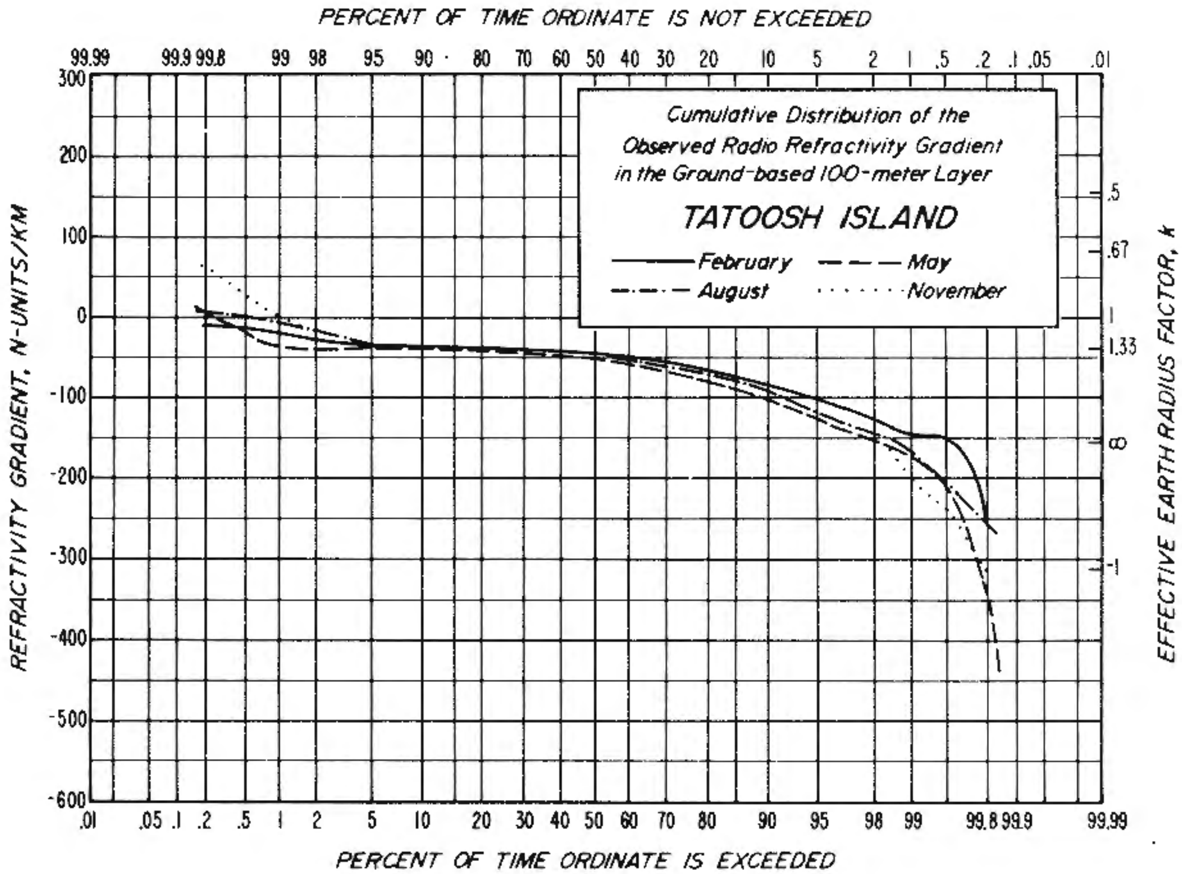
(Data below are for Tokyo International Airport: 35-33 N, 139-45 E)

Temperature (°F): January 47/29; July 83/70

Mean Dewpoint (°F): January 31; July 72

Precipitation (inches): Annual 61.6; September 9.20; January 1.90

Station at air base near Tokyo; on east side of Honshu Island. Low alluvial plains in vicinity. Humid temperate climate.



Tatoosh Island, Washington

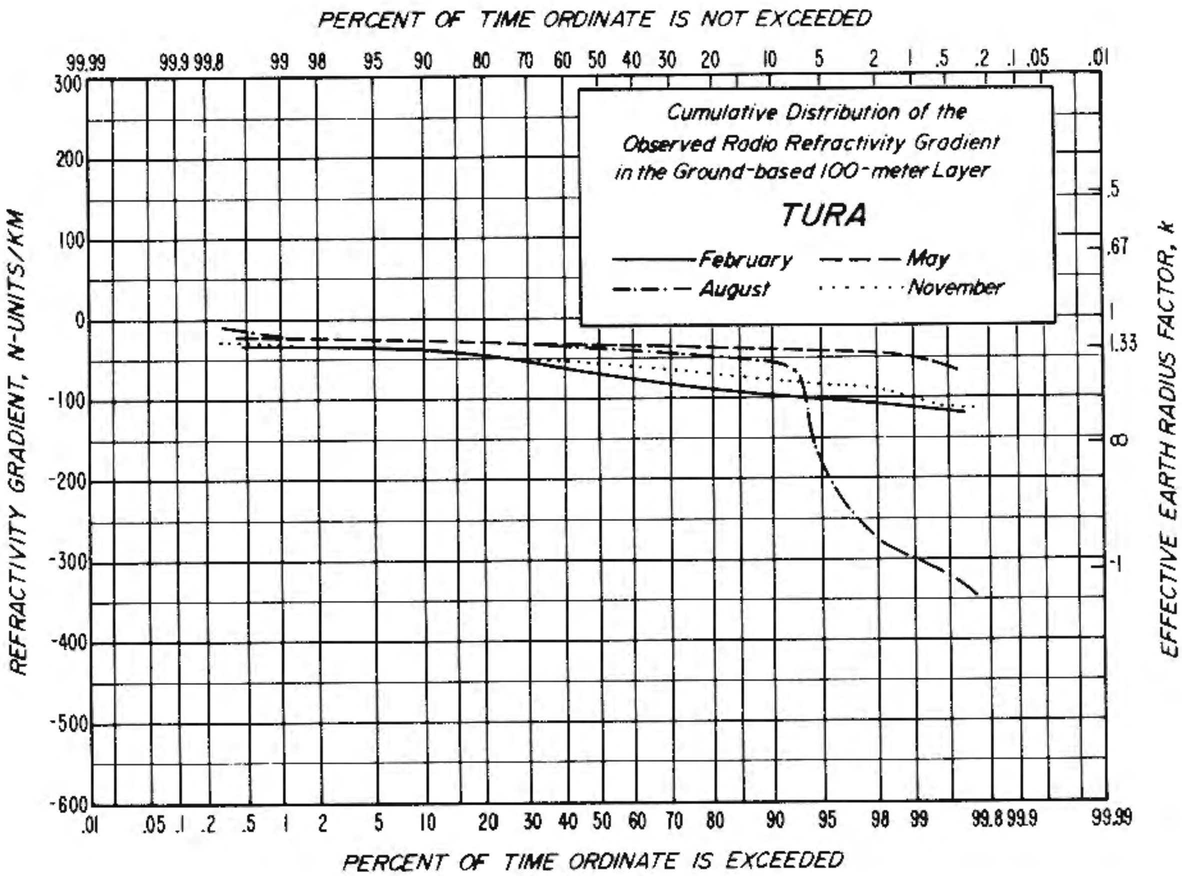
48-23 N, 124-44 W. 26 meters MSL

Data: Radiosonde. 0300 and 1500Z (1900 and 0700 LST)
8/52 - 5/57

Temperature (°F): January 45/39; July 59/51

Precipitation (inches): Annual 80.7; December 12.7; July 1.8

Station is located on a small island off Cape Flattery on the northwest coast of Washington. A cool, maritime climate with rainy winters.

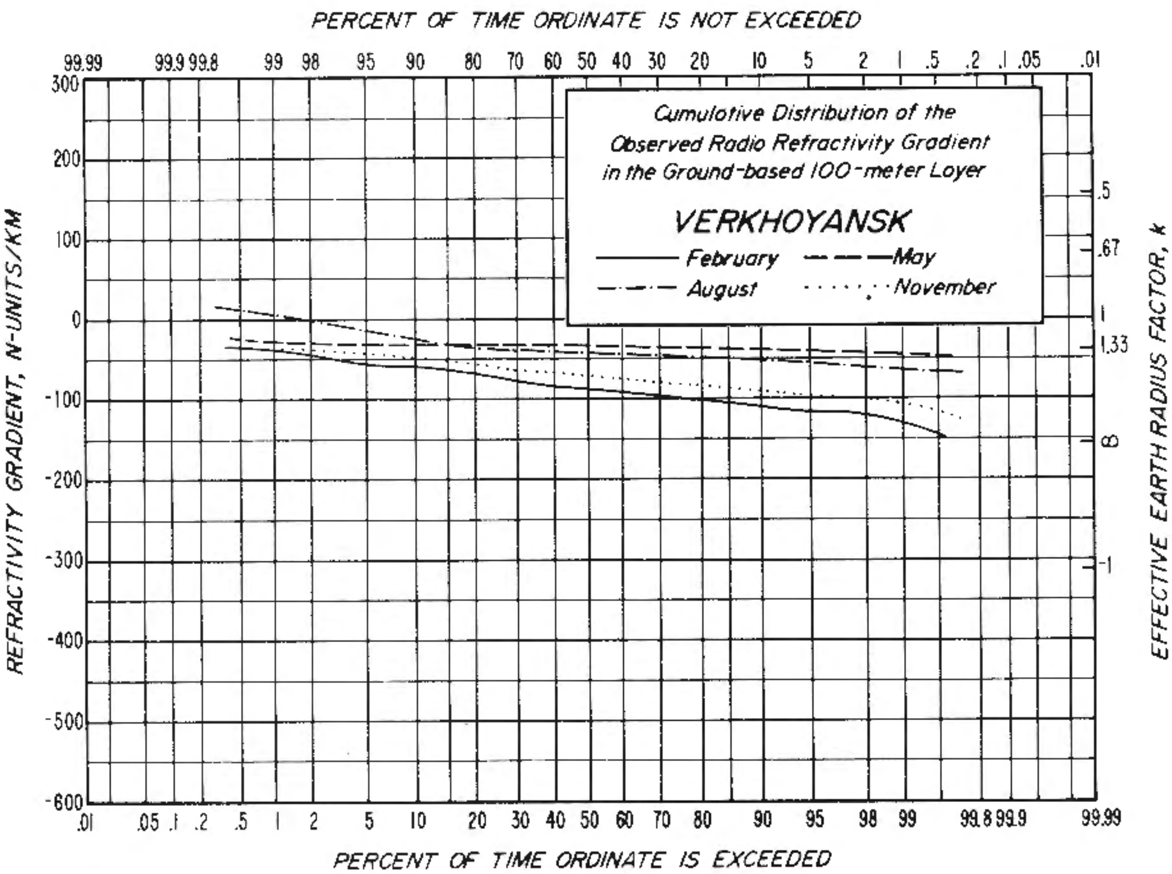


Tura, Krasnoyarsk Territory, U.S.S.R.

64-16 N, 100-14 E. 147 meters MSL

Data: Radiosonde. 0000 and 1200Z (0700 and 1900 LST)
8/57 - 11/59

Station is located on the bank of the Lower Tunguska River. Severe continental climate. Precipitation 10 to 16 inches/yr.



Verkhoyansk, North Yakut, U.S.S.R.

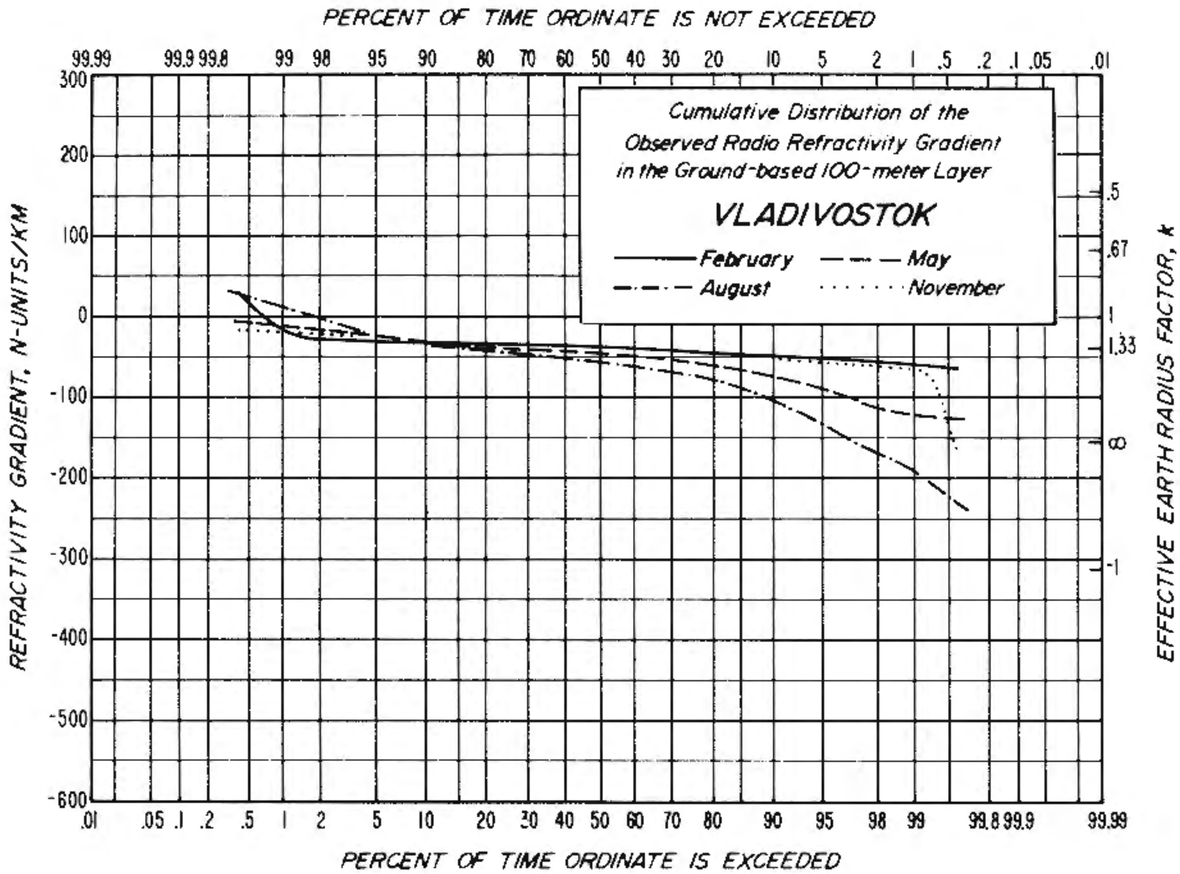
67-33 N, 133-23 E. 135 meters MSL

Data: Radiosonde. 0000 and 1200Z (0900 and 2100 LST)
8/57 - 11/59

Temperature (°F): January -54/-63; July 66/47

Precipitation (inches): Annual 5.3; July 1.1; March 0.1

Located on the bank of the Yana River, 385 miles north-northeast of Yakutsk. This station is north of the Arctic Circle in one of the earth's coldest areas--the lowest recorded temperature is -90°F. A severe continental climate.



<u>Vladivostok, U.S.S.R.</u>

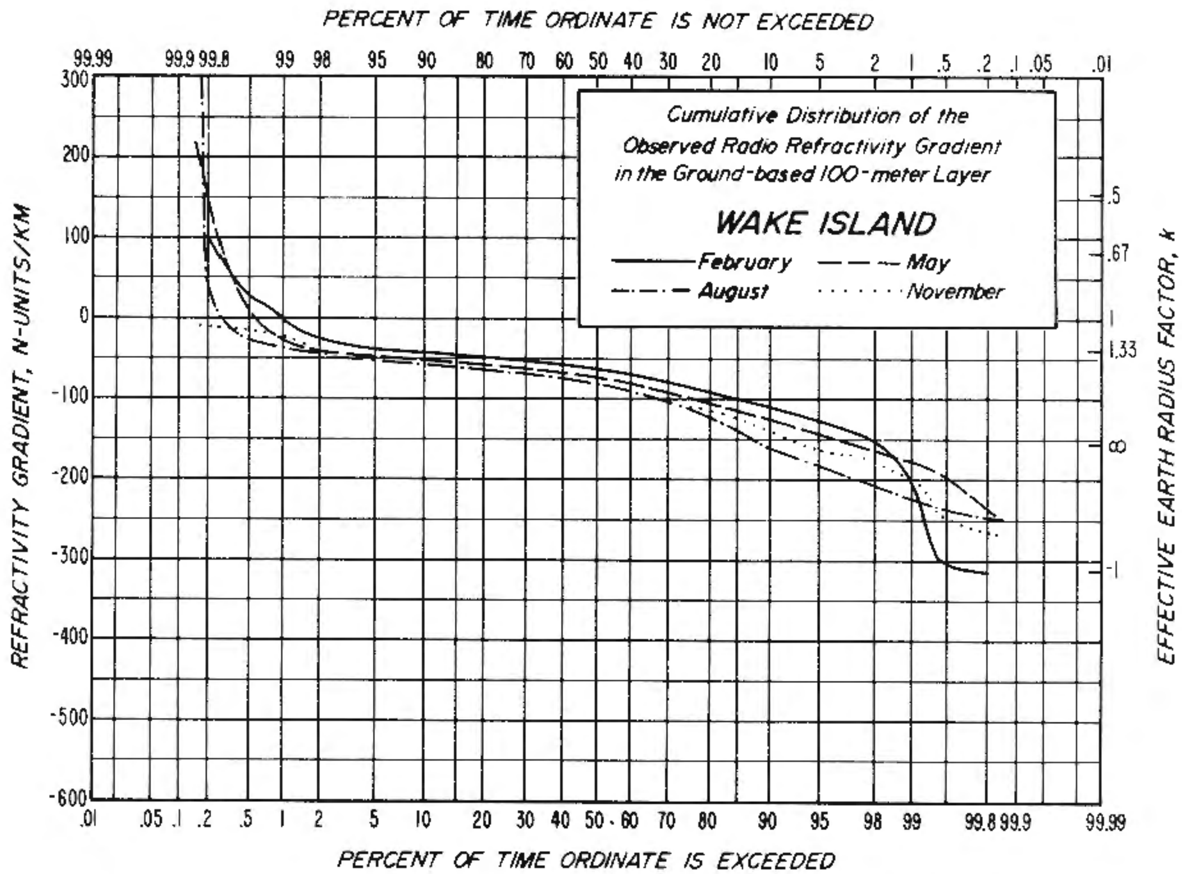
43-07 N, 131-54 E. 138 meters MSL

Data: Radiosonde. 0000Z (0900 LST)
8/52 - 8/62

Temperature (°F): January 13/0; July 71/60

Precipitation (inches): Annual 23.6; August 4.7; January 0.3

Located at the southern tip of a peninsula extending into Peter the Great Bay. The harbor freezes in winter, but is kept open by icebreakers. Temperate climate, affected by monsoon in summer and Siberian air masses in winter; warm, wet summers and very cold, dry winters.



Wake Island, Pacific

19-17 N, 166-39 E. 4 meters MSL

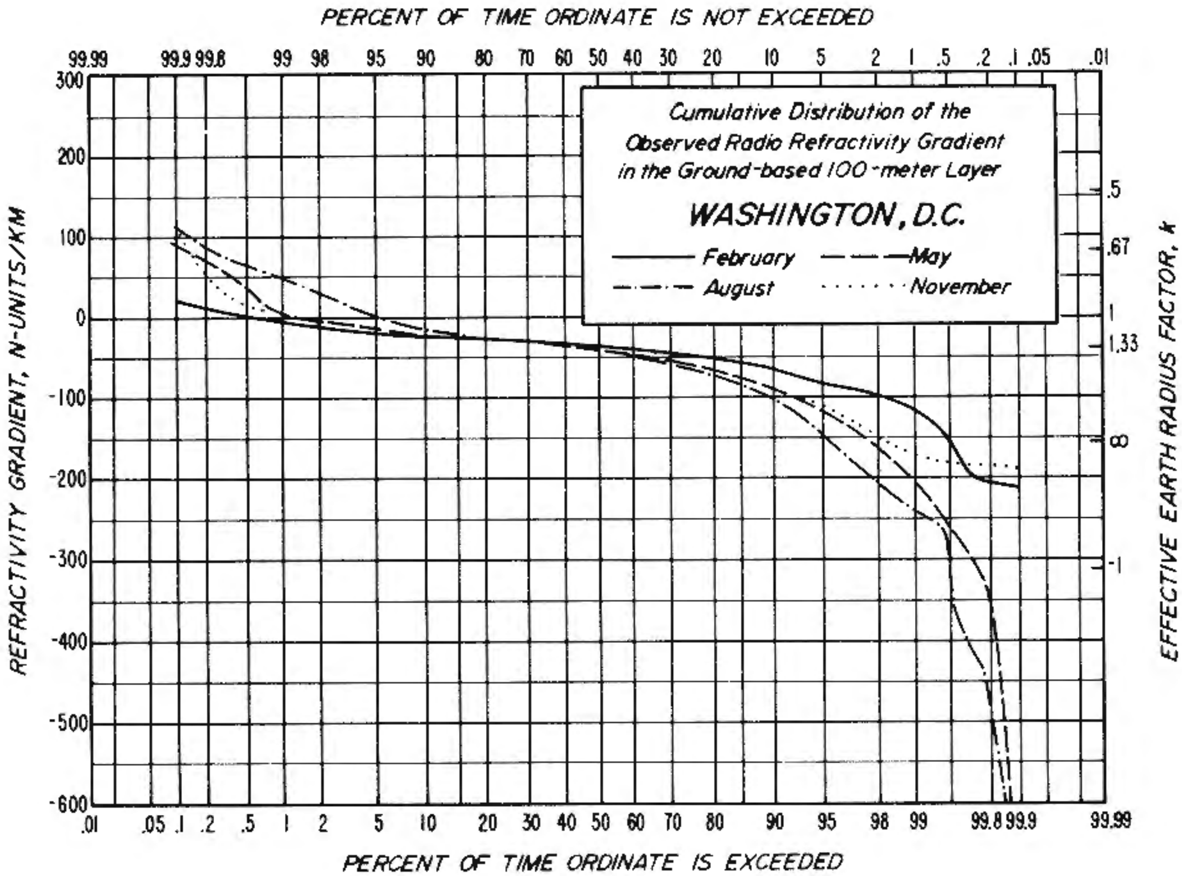
Data: Radiosonde. 0000 and 1200Z (1100 and 2300 LST)
8/58 - 5/63

Temperature (°F): January 82/73; July 87/77

Mean Dewpoint (°F): January 67; July 74

Precipitation (inches): Annual 36.9; August 7.08; January 1.14

This is part of a coral atoll; the three islands (Wake, Peale, and Wilkes) total less than 3 sq. miles in area; highest terrain only 20 ft. Maritime climate with prevailing easterly trade winds of 12 mph or higher throughout the year. Sky seldom completely overcast or clear. No fog.

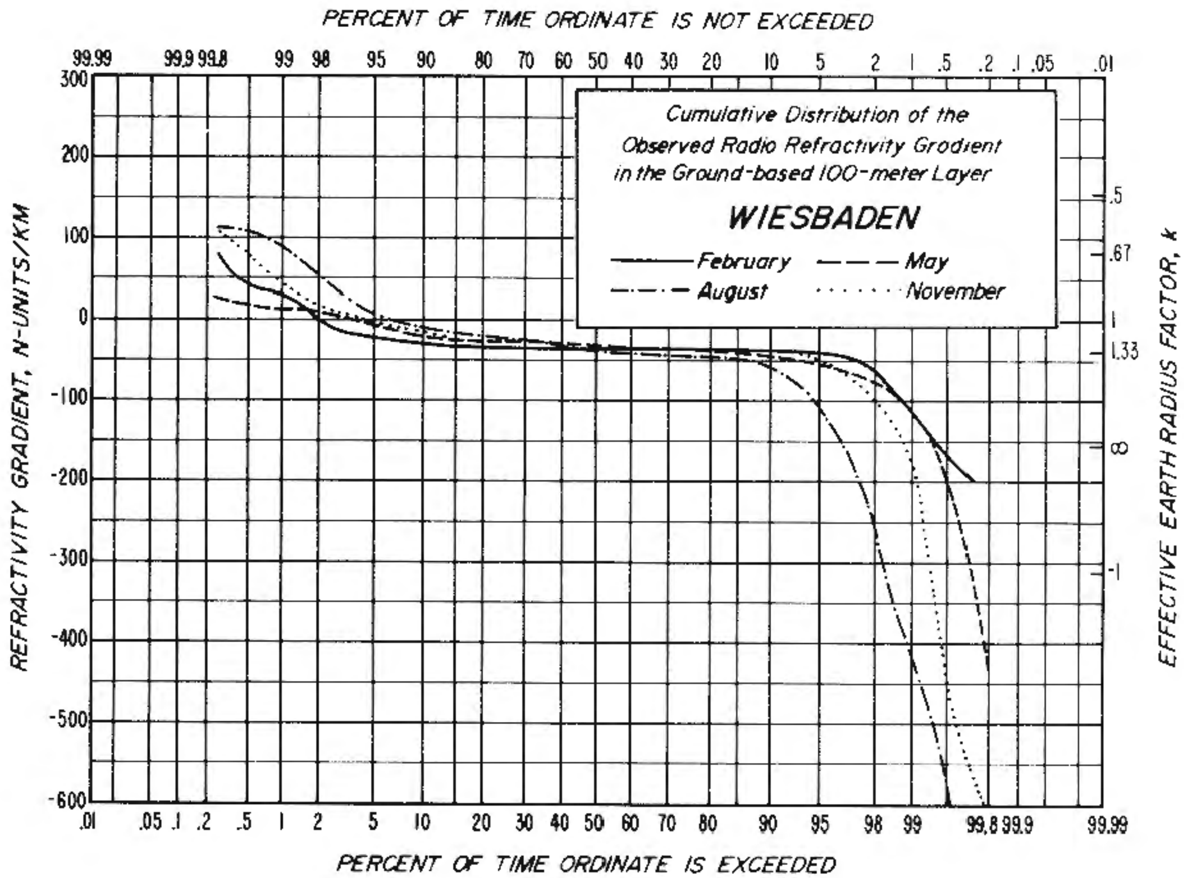


Washington, D.C.

38-51 N, 77-02 W. 20 meters MSL

Data: Radiosonde.	0300 and 1500Z (2200 and 1000 LST) 8/52 - 11/52 0300, 0900, 1500, 2100Z 2/53 - 5/57
Temperature (°F):	January 44/30; July 87/69
Mean Dewpoint (°F):	January 26; July 65
Precipitation (inches):	Annual 40.8; August 4.90; February 2.47

Located at the junction of the Potomac and Anacostia Rivers about 30 miles from Chesapeake Bay; the surrounding country is rolling and wooded. Mainly a continental temperate climate, but influenced by proximity to large bay and the Atlantic Ocean, as well as the Appalachian Mountains to west. Warm, humid summers and relatively mild winters, but occasionally severe winter storms bring very cold temperatures and snow.



<u>Wiesbaden, Germany</u> (Federal Republic)

50-03 N, 08-20 E. 140 meters MSL

Data: Radiosonde. 0300 and 1500Z (0400 and 1600 LST)
8/50 - 5/57

Analyzed by Stan Doran, Telcom, Inc., McClean, Virginia

Temperature (°F): January 37/28; July 74/57

Mean Dewpoint (°F): January 27; July 54

Precipitation (inches): Annual 18.5; August 2.52; April 0.91

Located on the north side of the Rhine Valley, just below the junction of the Rhine with the Main River. A continental climate modified by exposure to maritime air masses.

APPENDIX D. ERRATA AND SUPPLEMENTARY REMARKS FOR "A WORLD ATLAS OF ATMOSPHERIC RADIO REFRACTIVITY

C.A. Samson and B.A. Hart

1. In the original analysis of radiosonde data for the Atlas, no lag corrections were used, and linear interpolation was used to obtain the 50- and 100-m points on the soundings.
2. On page 13, 12th line from the bottom of the right-hand column, "western Mediterranean Sea" should be changed to "eastern Mediterranean Sea".
3. Add to Table 1, page 20:

   Mediterranean, 4 stations, February 1.2 N-units, August 1.6 N-units, 12 month estimate 1.4 N-units, 12-month rms 0.4
4. In figure A-1, page 32, change station No. 64 in Mexico to No. 63 (Mazatlan).
5. The gradient data in Appendix C are based upon records of radiosonde observations made only once or twice daily. All references to "percent of time" should be interpreted as "percent of the observations".
6. Figures C-1 through C-4 refer to positive gradients, or <u>sub</u>-refractive conditions.
7. In figures C-5 through C-12, "Gradient exceeded" indicates that for the given percentage of the observations the gradients were more positive (or less negative).
8. On page 70, figure C-13, Coral Harbor (64-12 N, 83-22 W) was mistakenly plotted as 9.8 on the original map; it should have been 19.7. This would alter the contour lines in that area.
9. Figure C-41 through C-56 refer to negative gradients, or a decrease of refractivity with height (normal gradients to superrefractive and ducting conditions).
10. In table C-1 on page 92, change the Fort Smith February median to 1019 (instead of 872) and the minimum to 464 (instead of 9).
11. Pages 93-116, figures C-57 through C-78: On all of these figures, the title should read "Cumulative probability distributions of dN/dh for ground based <u>50-m</u> layer:". Note, however, that figures C-1 through C-56 all refer to <u>100-m</u> layers.

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The continued expansion of microwave radio links and the resulting congestion have increased the need for better performance estimates. In the evaluation of refractivity effects, the designer may wish to consider the average gradients at specific locations for different seasons, as well as diurnal changes. This report presents graphs showing the cumulative probability distributions of the atmospheric radio refractivity gradients in the ground-based 100-m layer for 87 stations in the Northern Hemisphere. These are based on climatological data from radiosonde observations, and show the average conditions in one month of each season. A limited number of diurnal comparisons are included, as well as information on the climate of each site.

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Refractivity gradients, radiosonde data

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