Arctic Water Vapor Characteristics from Rawindsondes

Information in this document has been derived from:
Serreze, et al. 1994. A climatological data base of Arctic water vapor characteristics. *Polar Geography and Geology*. 18(1)63-75.

Summary

The **Arctic Water Vapor Characteristics Data Set** contains climatological data suitable for validating Arctic climate simulations from general circulation models (GCMs) and improving the retrieval of Arctic surface properties from satellite remote sensing. The data were compiled from existing rawinsonde archives into a gridded monthly-mean data set of water vapor characteristics and related parameters.

The data set is based on records from approximately one-half million soundings taken in the Arctic region from 1954 through 1991 including:

- fixed station soundings from the Historical Arctic Rawinsonde Archive distributed by the National Snow and Ice Data Center (NSIDC)
- ship soundings obtained from National Center for Atmospheric Research (NCAR) data tapes
- drifting ice station soundings obtained through the U.S.-Russian Joint Committee on Environmental Protection

Users can download individual monthly-mean data files from an index of all data set files in the data set. For more information about the data set, please contact NSIDC User Services.

Compilation of this data set was supported by the NSF Arctic System Science (ARCSS) program. Distribution of the data set is supported through the NASA Earth Observing System Data and Information System (EOSDIS) program.

Table of Contents

1.Data Set Overview

Data Set Identification

Arctic Water Vapor Characteristics

Data Set Introduction

Arctic rawinsonde data were processed into a gridded monthly-mean data base of water vapor characteristics that includes fields of temperature, winds, humidity, vapor flux, and other parameters.

Objective/Purpose

The data were compiled to facilitate the validation of Arctic climate simulations from GCMs and for satellite remote sensing of surface properties.

Summary of Parameters

The parameters compiled include:

- temperature
- sea level pressure
- specific humidity
- zonal vapor flux
- meridional vapor flux
- zonal wind speed
- meridional wind speed

- vertically integrated meridional vapor flux

Please refer to Units of Measurement.

Discussion

Previously, a record of all rawinsonde ascents from fixed stations north of 65 degrees north was compiled. The resulting Historical Arctic Rawinsonde Archive (HARA) has been used to assess water vapor transports across 70 degrees north and improve precipitation minus evaporation (P-E) estimates for the Arctic Basin (Serreze et al. 1995a). To complement the HARA, a gridded monthly-mean data set of Arctic water vapor characteristics was compiled using the HARA and two additional sources of raw sounding data: NCAR data tapes containing ship soundings and archives from the Russian "North Pole" (NP) series of drifting ice stations.

HARA data used to compile the Arctic Water Vapor Characteristics Data Set include approximately one-half million soundings taken at about 50 different stations from 1974 through 1991. The NCAR data comprise approximately 16,500 rawinsonde launches over the Barents and Norwegian Seas from 1976 through 1991. The NP archive includes 16,850 ascents made primarily over the Pacific side of the Arctic from 19 drifting ice stations from 1954 through 1990.

Individual soundings in the HARA and NCAR archives typically contain data and associated quality codes for 20 to 40 levels and usually extend to at least 300 mb. For the NP soundings, data for most parameters are reported over 10 to 20 levels that generally extend only to 700 mb. NP soundings provide no quality codes. The gridded Arctic Water Vapor Characteristics Data Set provides data over 15 levels extending from the surface to 300 mb at 50 mb intervals as well as vertically integrated moisture variables.

For background information about the HARA project, please refer to the HARA project description document.

2.Investigators

Investigator Names and Titles

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Title of Investigation

Arctic Water Vapor Characteristics Compilation

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3.Theory of Measurements

Please refer to the HARA document on radiosonde systems.

4.Equipment

Rawinsondes were used to gather the data compiled in the Arctic Water Vapor Characteristics Data Set. Rawinsondes are balloon-borne sensors used to collect temperature, pressure, humidity and wind data that are transmitted to receiving stations.

The HARA data represent rawinsonde ascents at fixed land stations. The NCAR data represent rawinsonde launches from ships. The NP data represent rawinsonde ascents from drifting ice stations. For more information on radiosondes, see the Historical Arctic Rawinsonde Archive (HARA) instrument document for radiosonde systems and the HARA platform description document for balloons.

5.Data Acquisition Methods

Please see the Data Sources section.

6.Observations

Data Notes

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Field Notes

This section is not relevant to this document and is intentionally left blank.

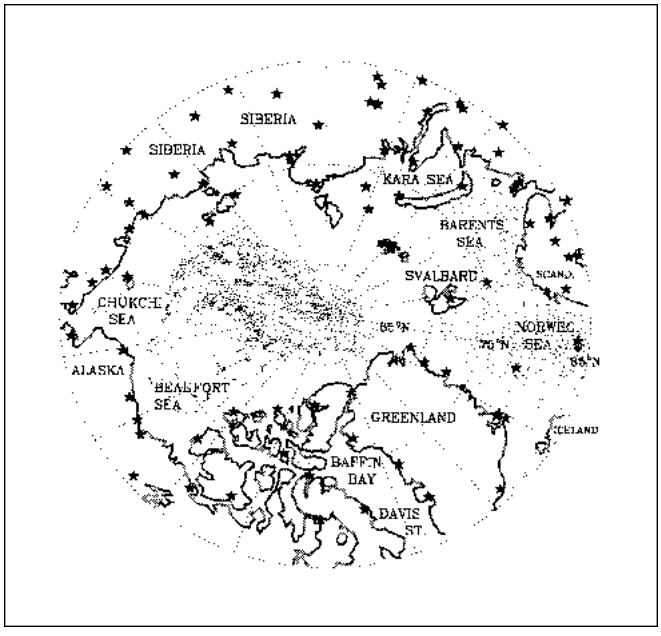
7.Data Description

Spatial Characteristics

Data are reported for both mandatory and significant pressure levels. The mandatory levels (e.g., surface, 1000 mb, 850 mb, 700 mb, and 500 mb) are fixed for every sounding. The significant levels are irregular levels reported on the basis of whether the change with height of a given variable exceeds a predetermined threshold.

Spatial Coverage Map

This map shows the spatial coverage of sounding data over the Arctic. Fixed station data are represented by stars. Drifting station and ship data are depicted by dots; one dot is plotted for every tenth sounding.



Spatial Resolution

Temperature, specific humidity, zonal vapor flux, meridional vapor flux, zonal wind speed, and meridional wind speed data are available at 15 levels from the surface to 300 mb. Geopotential height is provided for 850 mb, 700 mb, 500 mb, and 300 mb. Sea level pressure is also provided. Precipitable water and vertically integrated zonal and meridional vapor fluxes are available for the following five layers:

- surface to 850 mb
- 850 mb to 700 mb
- 700 mb to 500 mb
- 500 mb to 400 mb
- 400 mb to 300 mb

Projection

The gridded data are referenced to a polar stereographic projection that is true at 60 degrees north.

Grid Description

All data parameters were interpolated to a subsection of the NMC octagonal grid centered over the Pole. The grid reaches about 65 degrees north on each side and approximately 55 degrees north at its corners. The grid size is 381 km X 381 km at 60 degrees north and expands to 408 km X 408 km at the Pole.

A map shows the subsection of the NMC Octagonal Grid centered over the pole. The spatial coverage map shows the distribution of the fixed station, drifting station, and ship data used to assemble the archive.

Temporal Characteristics

Temporal Coverage

The Arctic Water Vapor Characteristics Data Set is based on data collected from 1954 through 1991; each source archive has a different temporal coverage:

- The HARA soundings were taken from 1974 through 1991. (Most of the HARA sounding records began in 1958 and some began as early as 1947; however, data for the years preceding 1974 were not included because the Eurasian data were often missing significant level data.)
- The NCAR data were taken primarily from 1976 through 1991.
- The North Pole (NP) data were collected from 1954 through 1990. NP stations contain records for several months to as many as ten years; at some times only one NP station was in operation while during other periods there were overlapping records from multiple stations.

Temporal Coverage Map

A temporal coverage map is not included in this document.

Temporal Resolution

All data in the Arctic Water Vapor Characteristics Data Set are presented in monthly data arrays. Because limited significant levels were recorded by Eurasian HARA stations prior to 1974, only data for 1974 through 1991 are used at both 0000 and 1200 UTC. NCAR data soundings are available for either 0000 or 1200 UTC. The NP data includes soundings taken

Parameters/Variables

Variables compiled in the gridded data set include temperature, specific humidity, zonal vapor flux, meridional vapor flux, zonal wind speed, meridional wind speed, sea level pressure and geopotential height, precipitable water, vertically integrated zonal vapor flux, and vertically integrated meridional vapor flux.

Variable Description/Definition

No variable descriptions are included in this document.

Units of Measurement

Please refer to the Units of Measurement document.

Data Sources

The data were obtained from the National Snow and Ice Data Center (NSIDC), the National Center for Atmospheric Research (NCAR), and Working Group VIII (Influence of Environmental Change on Climate) of the U.S.-Russian Joint Committee on Environmental Protection. Additional information is available for the HARA data sources.

Data Range

Please refer to the data set for the range of data values for each of the parameters.

Sample Data Record

A sample data record is provided for the grid location (5,10) in June.

Related Data Sets

Other polar atmospheric data sets distributed by the NSIDC Distributed Active Archive Data Center (DAAC) include:

- Historical Arctic Rawinsonde Archive
- TOVS Pathfinder Path-P Daily and Monthly Polar Gridded Atmospheric Parameters

The Langley DAAC distributes a Precipitable Water Data Set.

8.Data Organization

Granularity

A granule is the smallest aggregation of data that is independently managed (i.e., described, inventoried, retrievable). Granules may be managed as logical granules and/or physical granules. The data in this data set are presented in monthly files.

Data Format

The data are presented in 12 separate files, one for each month of the year. Each file name identifies the month; for example, the February file is named feb-cwv.dat.Z ("cwv" indicating climatological water vapor).

The data are sorted by grid row number and column number. The grid is numbered from the top left at grid (1,1) to the bottom right at grid (17,17) according to the orientation of the grid subsection map. Each record includes a header line followed first by rows of data for each of the 15 pressure levels and then for each of the five layers for the vertically integrated parameters. In addition to the grid row and column numbers, the header line indicates the month, the latitude and the longitude of the grid point. In the sample data record provided, the grid location is (5,10), the month June (6), the latitude 74.95 degrees north, and the longitude 85.96 degrees.

Each row of data for the 15 pressure levels includes eight columns. The first column identifies the pressure levels. (The surface level is arbitrarily set at 1000 mb.) The next seven columns indicate the following parameters respectively:

- temperature
- specific humidity
- zonal vapor flux
- meridional vapor flux
- zonal wind speed
- meridional wind speed
- sea level pressure or geopotential height

The rows corresponding to the five layers over which vertically integrated data were computed (surface to 850 mb; 850 mb to 700 mb; 700 mb to 500 mb; 500 mb to 400 mb; and 400 mb to 300 mb) include four columns each. The first column identifies the layer for which the integrals were carried out while the next three columns indicate the following respectively:

- precipitable water
- vertically integrated zonal vapor flux
- vertically integrated meridional vapor flux

Please refer to Units of Measurement.

9.Data Manipulations

Formulae

Derivation Techniques and Algorithms

Data Processing Sequence

Processing Steps

The following description of quality control is summarized from:

- **Serreze, et al. 1995b**. The distribution and transport of atmospheric water vapour over the Arctic. *International Journal of Climate* 15:709-727.
- **Serreze, et al. 1994**. A climatological data base of Arctic water vapor characteristics. *Polar Geography and Geology*. 18(1)63-75.

Data identified as questionable by the provided quality codes and obviously erroneous data flagged through a series of limits and vertical consistency checks were first coded as missing. Obviously erroneous data included, for example, negative wind speeds. HARA data for the years preceding 1974 often had few reports at significant levels and thus were excluded. Because the NP archive included no quality codes, errors were flagged solely through limits and vertical consistency checks. The quality control procedures and treatment of missing data are described in more detail by Serreze et al. (1994) and Serreze et al. (1995b).

On the basis of the various quality control checks, roughly 15 percent of all soundings were discarded. Finally, the missing variables were refilled through vertical interpolation.

Because of computational limitations, a two-step process was used to interpolate all data parameters to the Arctic subset of the NMC grid. Long-term monthly means were determined at fixed locations over the ocean and then passed through a second Cressman interpolation that included the fixed station means. The water vapor computations and interpolation methods are described in detail by Serreze et al. (1994) and Serreze et al. (1995b).

Processing Changes

No processing changes were involved in the compilation of the data set.

Calculations

Quality control, water vapor computations and interpolation procedures are discussed in detail in Serreze et al. (1994) and Serreze et al. (1995b).

The Clausius-Clapeyron equation was used to convert the humidity data into specific humidity.

The trapezoidal method was used to compute the vertically integrated vapor fluxes and precipitable water.

The Cressman equations were used to interpolate the parameters to the Arctic subset of the octagonal grid.

Special Corrections/Adjustments

No special corrections were made. One adjustment was made in the water vapor computations. For soundings with missing dewpoint depression values where the temperature was less than minus 40 degrees Celsius, the dewpoint depression was defined as 30 K.

Calculated Variables

Calculated variables include specific humidity, zonal and meridional wind speeds, vertically integrated zonal and meridional vapor fluxes, and precipitable water. The equations used to calculate these variables are included above in the calculations section.

Graphs and Plots

Water vapor data maps are available as browse images for the following parameters for January and July from the surface to 300 mb:

- precipitable water
- meridional vapor flux
- zonal vapor flux

10.Errors

Sources of Error

Because different types of rawinsondes and different methods of calculating saturation vapor pressure have been used over time, there are inhomogeneities in the historical rawinsonde record. Errors also occur because of differences in measurement accuracy that accompany new or improved instruments. In compiling the data set, no attempt was made to adjust for these differences with the exception that if the temperature was below minus 40 degrees Celsius and the dewpoint depression was missing, the dewpoint depression was set to 30K.

The most significant sources of error are associated with humidity measurements. These errors are primarily attributable to temporal variations in both measurement accuracy and reporting at low pressures and low humidity. Other errors include round-off errors introduced during data transmission and errors caused by the effect of spatial and temporal data distribution on the Cressman interpolations.

These sources of error are discussed in detail by Serreze et al. (1995b). Rawinsonde system changes that have influenced humidity reports are documented by Gaffen (1993). Rawinsonde network changes in North America are discussed in detail by Elliot and Gaffen (1991) and Garand et al. (1992).

Quality Assessment

Data Validation by Source

Please refer to Serreze et al. (1995b) for a complete description of the data validation efforts.

Confidence Level/Accuracy Judgement

Please see the section on errors and the notes section.

Measurement Error for Parameters

Measurement errors may cause potential problems in early NP data; however, these problems do not seriously affect the data quality (Serreze 1995b).

Additional Quality Assessments

Inadequate sampling over the Arctic ocean may have affected the portion of the total integral for the 700 to 300 mb layer. Also, the vertical integrals are influenced some by the variable elevations of the land stations (Serreze 1995b).

11.Notes

Limitations of the Data

Good spatial and temporal coverage are provided by the land data. In a climatological sense, the ocean data are reasonably well distributed in space. On an annual basis, however, the ocean data provide sparse spatial coverage. There is a moderate spatial coverage gap in the area roughly bounded by 75 through 85 degrees north and 60 through 120 degrees east.

Known Problems with the Data

Please see the section on errors.

Usage Guidance

Interior Greenland grid locations that are circled on the spatial coverage map should be treated cautiously because data values below about the 650 mb level lie below the local surface. Additionally, sampling problems over the central Arctic Ocean discussed by Serreze et al. (1995b) should be considered when interpreting the gridded fields.

Any Other Relevant Information about the Study

There are no other notes to make about either the data set or its compilation.

12.Application of the Data Set

The HARA soundings have previously been used to evaluate water vapor transports across 70 degrees north and improve precipitation minus evaporation (P-E) estimates for the Arctic Basin (Serreze et al. 1995a). The NP soundings have been used to examine tropospheric temperature trends over the Arctic Ocean (Kahl et al. 1993).

The Arctic Water Vapor Characteristics Data Set is suitable for validation of Arctic climate simulations from GCMs. Water vapor data from the Arctic are also necessary to improve estimates of sea ice surface albedo taken from satellite data (Rossow et al. 1989). Arctic water vapor distribution data are also needed to improve satellite derived estimates of ice surface temperatures (Key and Haeflinger 1992; Lindsay and Rothrock 1994).

13.Future Modifications and Plans

Future plans include updating the data set.

14.Software

A sample FORTRAN program is available. In this example, the program reads the data set into memory and outputs precipitable water for the surface to 300 mb layer in June.

15.Data Access

Contact Information

For data set information, please contact:

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form: Contact NSIDC User Services
e-mail: nsidc@nsidc.org

Data Center Identification

National Snow and Ice Data Center (NSIDC)

Procedures for Obtaining Data

To obtain data, download individual monthly-mean data files from an index of all data set files. The index contains 12 files listed alphabetically, one file for each month of the year. The first file listed is the April file, which is named apr-cwv.dat.Z ("apr" indicating April and "cwv" indicating climatological water vapor). The files are compressed and can be uncompressed using the UNIX "uncompress" command.

Data Center Status/Plans

Future plans include updating the data set.

16.Output Products and Availability

The data set is available via FTP. At the time this document was created, no tape products, film products, or other products were available.

17.References

Cressman, G. P. 1959. An operational objective analysis system. *Mon. Wea. Rev.* 87:367-374.

Elliot, W. P., and D. J. Gaffen. 1991. On the utility of radiosonde humidity archived for climate studies. *Bull. Amer. Meteor. Soc.* 72:1507-1520.

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Key, J., and M. Haeflinger. 1992. Arctic ice surface temperature retrieval from AVHRR thermal channels. *J. Geophys. Res.* 97:5885-5893.

Lindsay, R. W., and D. A. Rothrock. 1994. Arctic sea ice surface temperature from AVHRR. *J. Climate* 7(1):174-183.

Murray, F. W. 1967. On the computation of saturation vapor pressure. *J. Appl. Meteor.* 6(1):203-204.

Rossow, W. B., C. L. Brest, and L. C. Garder. 1989. Global, seasonal surface variations from satellite radiance measurements. *J. Climate* 2:214-247.

Serreze, M. C., J. D. Kahl and R. C. Schnell. 1992. Low-level temperature inversions of the Eurasian Arctic and comparisons with Soviet drifting station data. *J. Climate* 5(6):615-629.

Serreze, M. C., M. C. Rehder, R. G. Barry, and J. D. Kahl. 1994. A climatological data base of Arctic water vapor characteristics. *Polar Geography and Geology* 18:63-75.

Serreze, M. C., R. G. Barry, and J. E. Walsh. 1995a. Atmospheric water vapor characteristics at 70 degrees north. *J. Climate* 8(4):719-731.

Serreze, M. C., M. C. Rehder, R. G. Barry, J. D. Kahl, and N. A. Zaitseva. 1995b. The distribution and transport of atmospheric water vapour over the Arctic. *International Journal of Climate* 15:709-727.

Walsh, J. E., X. Zhou, D. Portis, and M. C. Serreze. 1994. Atmospheric contribution to hydrologic variations in the Arctic. *Atmosphere-Ocean* 32(4):733-755.

Data Center/DBMS Usage Documentation

At the time this document was created, there was no additional documentation for the data.

18. Acronyms and Abbreviations

The following acronyms and abbreviations are used in this document.

ARCSS	Arctic System Science
AVHRR	Advanced Very High Resolution Radiometer
CD-ROM	Compact Disk-Read Only Memory
CIRES	Cooperative Institute for Research in Environmental Sciences
DAAC	Distributed Active Archive Data Center
DBMS	Data Base Management System
EOSDIS	Earth Observing System Data and Information System
ftp	File Transfer Protocol
gpm	Geopotential Meters
HARA	Historical Arctic Rawinsonde Archive
hPa	Hectopascal
http	Hypertext Transfer Protocol
K	Kelvin
mb	Millibar
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NMC	National Meteorological Center
NP	North Pole
NSF	National Science Foundation
NSIDC	National Snow and Ice Data Center
P-E	Precipitation Minus Evaporation
TIROS	Television Infrared Operational System
TOVS	TIROS-N Operational Vertical Sounder System
URL	Uniform Resource Locator
UTC	Universal Time Convention
WMO	World Meteorological Organization
WWW	World Wide Web

19.Document Information

Revision Date: January 3, 1995
Review Date: August 9, 1995
Document ID: nsidc-0033

Citation:

The following example shows how to cite the use of this data set in a publication. For more information, see our Use and Copyright Web page.

Serreze, M., R. Barry, and J. Kahl. 1995. *Arctic water vapor characteristics from rawindsondes*. Boulder, CO: National Snow and Ice Data Center. Digital media.

Document Curators: NSIDC Writers
Document URL: http://nsidc.org/data/docs/daac/nsidc0033_arctic_water_vapor.gd.html

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