GES DISC DAAC Data Guide: Microwave Sounding Unit Daily Deep Layer Temperatures and Oceanic Precipitation Data Set Guide Document

Summary:

This document supports the Daily Deep Layer Temperatures and Oceanic Precipitation data sets derived from the Microwave Sounding Unit (MSU) flown aboard the NOAA polar orbiting satellites. The NOAA satellites contributing to these data sets are, in order of their launch, TIROS-N, NOAA-6, NOAA-7, NOAA-9, NOAA-10, NOAA-11, and NOAA-12. NOAA-8 data were not used due to poor data quality.

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1. Data Set Overview:

Data Set Identification:

Microwave Sounding Unit Daily Deep Layer Temperatures and Oceanic Precipitation Data Set

Data Set Introduction:

The temperature data set contains the Limb 93 correction and is stored in a native binary format as well as in the Hierarchical Data Format (HDF). The NOAA satellites contributing to these data sets are, in order of their launch, TIROS-N, NOAA-6, NOAA-7, NOAA-9, NOAA-10, NOAA-11, and NOAA-12. NOAA-8 data were not used due to poor data quality. The data set period of record is January 1979- December 1993 for the temperatures, and 1979 thru May 1994 for oceanic precipitation.

Objective/Purpose:

The MSU was designed to be used together with the High Resolution Infrared Sounder (HIRS) and Stratospheric Sounding Unit (SSU) to obtain vertical atmospheric temperature profiles from space.

Summary of Parameters:

The Daily Deep Layer data sets include daily 2.5 degree grids derived from the Microwave Sounding Units for:

1) the Lower Troposphere Temperatures (LTT)
2) the (tropical) Upper Troposphere Temperatures (UTT)
3) the Lower Stratosphere Temperature (LST)
4) Oceanic Precipitation (OP)

Discussion:

The MSU was designed to be used together with the High Resolution Infrared Sounder (HIRS) and Stratospheric Sounding Unit (SSU) to obtain vertical atmospheric temperature profiles from space. Compared to the HIRS channel weighting functions, the MSU has poorer vertical resolution in the troposphere and better vertical resolution in the stratosphere. It has considerably poorer spatial resolution than the HIRS, but this gives the advantage of a much lower data rate and thus a more manageable data volume for analyses of the fifteen year data archive. The MSU is essentially insensitive to non-precipitating cirriform clouds, and so should provide a more robust air temperature signal than the HIRS. It is considerably less sensitive to liquid phase clouds than the HIRS. Neither instrument can measure air temperatures within precipitation.

Related Data Sets:

MSU Limb 90 (Global Hydrology and Climate Center, NASA/MSFC)

2. Investigator(s):

Investigator(s) Name and Title:

These data sets were produced by Dr. Roy Spencer and Ms. Vanessa Griffin of the Global Hydrology and Climate Center (GHCC), NASA Marshall Space Flight Center (MSFC), Huntsville, Al.

Title of Investigation:

MSU Daily Deep Layer Temperatures and Oceanic Precipitation Limb 93 HDF and Native Data Sets

Contact Information:

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3. Theory of Measurements:

The MSU was designed to be used together with the High Resolution Infrared Sounder (HIRS) and Stratospheric Sounding Unit (SSU) to obtain vertical atmospheric temperature profiles from space.

Compared to the HIRS channel weighting functions, the MSU has poorer vertical resolution in the troposphere and better vertical resolution in the stratosphere. It has considerably poorer spatial resolution than the HIRS, but this gives the advantage of a much lower data rate and thus a more manageable data volume for analyses of the fifteen year data archive. The MSU is essentially insensitive to non-precipitating cirriform clouds, and so should provide a more robust air temperature signal than the HIRS. It is considerably less sensitive to liquid phase clouds than the HIRS. Neither instrument can measure air temperatures within precipitation.

MSU channel 1 (50.3 GHz) has only weak oxygen absorption and therefore is sensitive to air temperature in only the lowest few kilometers of the atmosphere. However, this temperature information is heavily contaminated by other influences such as surface temperature and emissivity, as well as water vapor, liquid water and precipitation-size ice hydro-meteors in the troposphere. This limits the utility of channel 1 for monitoring lower tropospheric temperatures. MSU channel 2 (53.74 GHz) is sensitive to deep layer average tropospheric temperatures with a weighting function peaking near 500 hPa. It is very slightly affected by variations in tropospheric humidity (Spencer et al., 1990), but is contaminated by precipitation-size ice in deep convective clouds, which can cause Tb depressions of up to 15 degrees C in mid-latitude squall lines. High elevation terrain protruding into the MSU channel 2 weighting function results in proportionally less of its measured radiation coming from thermal emission by the air and more coming from the surface. The MSU channel 3 (54.96 GHz) weighting function peaks near 250 hPa and so often straddles the extra-tropical tropopause, but lies mostly within the tropical upper tropospheric. MSU channel 4 (57.95 GHz) has its peak weighting at 70 hPa and provides a good measure of lower stratospheric deep-layer temperatures.

Because the four MSU weighting functions overlap, they can be combined to retrieve information over shallower layers than the individual weighting functions represent (Conrath, 1972). This is the fundamental basis of satellite temperature retrieval schemes. For instance, a fraction of channel 3 can be subtracted from channel 2 to eliminate the lower stratospheric influence on channel 2 for middle and lower tropospheric temperature monitoring. Similarly, a fraction of channel 4 can be subtracted from channel 3 for monitoring of upper tropospheric temperatures in the tropics, where the tropopause is near 100 hPa. The MSU scans across the satellite subtrack at eleven different beam positions: six different Earth incidence angles symmetric about the center footprint. Therefore, each channel actually has six slightly different weighting functions due to the variations of the view angle through the atmosphere. These different view angles can also be combined into a new weighting function. This is done, however, at the expense of any information about temperature gradients across the swath. Under most conditions, the resulting retrieval represents an average temperature for the entire swath (Spencer et al., 1992b). This technique is more useful for grid-point temperature monitoring over long time scales or zonal averages over short time scales.

The lower tropospheric air temperature influence on channel 1 is small compared to other influences, such as land emissivity and oceanic air mass humidity and liquid water path. In particular, channel 1 is used to retrieve oceanic precipitation since its variability over the ocean is dominated by cloud and rain water activity.

4. Equipment:

Sensor/Instrument Description:

Collection Environment:

The Microwave Sounding Units (MSU) were built by the Jet Propulsion Laboratory for NOAA to fly as part of the TIROS Operational Vertical Sounder (TOVS) instrument complement aboard the TIROS-N series of sun-synchronous polar orbiting satellites.

Source/Platform:

The NOAA satellites contributing to these data sets are, in order of their launch, TIROS-N, NOAA-6, NOAA-7, NOAA-9, NOAA-10, NOAA-11, and NOAA-12.

Source/Platform Mission Objectives:

The MSU was designed to be used together with the High Resolution Infrared Sounder (HIRS) and Stratospheric Sounding Unit (SSU) to obtain vertical atmospheric temperature profiles from space. The MSU is an integral member of the payload on the advanced TIROS-N spacecraft and its successors in the NOAA series, and as such contributes data required to meet a number of operational and research-oriented meteorological objectives.

Key Variables:

Microwave Radiances.

Principles of Operation:

The MSU scans across the satellite subtrack at eleven different beam positions: six different Earth incidence angles symmetric about the center footprint. Therefore, each channel actually has six slightly different weighting functions due to the variations of the view angle through the atmosphere. These different view angles can also be combined into a new weighting function. This is done, however, at the expense of any information about temperature gradients across the swath. Under most conditions, the resulting retrieval represents an average temperature for the entire swath (Spencer et al., 1992b). This technique is more useful for grid-point temperature monitoring over long time scales or zonal averages over short time scales.

Sensor/Instrument Measurement Geometry:

The instrument measurement geometry for the MSU sensor is summarized in the following table:

INSTRUMENT PARAMETER	**MSU**
Cross track scan angle (+/- degrees from nadir)	47.4
Number of steps	11
Angular FOV (degrees)	7.5

Step Angle (degrees)	9.5
Ground IFOV (km) - at nadir	109.3
Ground IFOV (km) - scan end	323 x 179
Swath width (+/- km)	1174

Manufacturer of Sensor/Instrument:

Jet Propulsion Laboratory

Calibration:

Specifications:

The MSU is externally calibrated, with the warm target and cold deep space radiation traveling through the same instrumental paths as the earth-view radiation.

Tolerance:

Each of the four channels has a noise equivalent of 0.2 - 0.3 C.

Frequency of Calibration:

Once every scan, the instrument makes calibration measurements, viewing deep space, assumed to be near 2.7 K, and high emissivity warm targets. There is one target for the two lower frequencies, channels 1 and 2, and another for the two highest frequencies, channels 3 and 4. The temperature of each target is monitored with redundant platinum resistance thermometers (PRT's). Conversion of the instrument digital counts into brightness temperatures (Tb) is a linear interpolation of the Earth-viewing measurements between the space and warm target measurements.

Other Calibration Information:

This information is not available at this time.

5. Data Acquisition Methods:

The input data for the MSU data processing is the NOAA Level 1B data. It is obtained from NOAA's National Environmental Satellite Data and Information Service (NESDIS), World Weather Building, Washington, DC 20233.

The *NOAA Polar Orbiter Data User's Guide* (Kidwell 1991) gives a detailed description of the content and format of the NOAA Level 1B data product.

6. Observations:

Data Notes:

Not available at this time.

Field Notes:

Not available at this time.

7. Data Description:

Spatial Characteristics:

Spatial Coverage:

Lower Tropospheric Temperature : Global
Lower Stratospheric Temperature: Global
Upper Tropospheric Temperature : 30N - 30S
Oceanic Precipitation : 60N - 60S

Spatial Coverage Map:

Not available at this time.

Spatial Resolution:

Spatial resolution is 2.5 degree by 2.5 degree for both the temperature and ocean precipitation data.

Projection:

Projection is rectilinear (lat-lon).

Grid Description:

The MSU data set uses a rectilinear, or straight-lined, (longitude-latitude) grid with each grid box corresponding to an equal interval of latitude and longitude.

Temporal Characteristics:

Temporal Coverage:

Temperatures : January 1979 - December 1993
Precipitation : January 1979 - May 1994

Temporal Coverage Map:

Not available at this time.

Temporal Resolution:

Daily

Data Characteristics:

PARAMETER	**DESCRIPTION**	**UNITS**	**DATA RANGE**
LTT	Lower Tropospheric Temperature	K	170 - 300
UTT	Upper Tropospheric Temperature	K	150 - 290
LST	Lower Stratospheric Temperature	K	150 - 290

OP	Oceanic Precipitation	mm/day	0 - 100

Sample Data Record:

HDF FORMAT:

The MSU Limb 93 HDF files contain a daily gridded objects of each product for each day covering the data period. The HDF objects and the HDF object types for the Limb 93 HDF files are shown below:

ITEM HDF OBJECT TYPE Day 88001 Scientific Data Set Day 88002 Scientific Data Set Day 88003 Scientific Data Set

...   ...

...   ...

Day 88366 Scientific Data Set Sample file names and corresponding products for the MSU LIMB 93 HDF files are as follows:

L93ch23.88daygrd_temp_msu.hdf Lower Troposphere Deep Layer Temperatures L93ch34.88daygrd_temp_msu.hdf Upper Troposphere Deep Layer Temperatures L93ch44.88daygrd_temp_msu.hdf Lower Stratosphere Deep Layer Temperatures L93rain.88daygrd_msu.hdf Oceanic Precipitation NATIVE FORMAT:

Each of the MSU daily temperature files and oceanic precipitation files is a gridded product that was produced from the full resolution orbit data and consists of 2.5 degree latitude by 2.5 degree longitude grids.

The data are temporally binned by local days with ascending and descending orbits combined. See Table 2 for a definition of a local day. Each scan line of the full resolution data contains 11 scan positions, or footprints. For the spatial gridding, all footprints that partially cover a particular 2.5 X 2.5 degree grids are included in the average for that grid.

All temperature and precipitation values are multiplied by 10 and stored as integers to retain a 0.1 K and 0.1 mm/day accuracy. Therefore, to obtain the true temperature or precipitation value, divide the stored value by 10. Missing data are identified by a missing data flag. The approximate data ranges, precisions, scale factors, and missing data flags are given below:

Product Range Accuracy /   Missing Scale Factor LTT 170.0 - 300.0 K 0.1 K   -999 UTT 170.0 - 250.0 K 0.1 K   -999 LST 150.0 - 290.0 K 0.1 K   -999 OP 0.0 - 100.0 mm/day 0.1 mm/day -999 The MSU LTT, UTT, and LST binary files share the same file structure.

Each compressed file contains the global gridded temperature data for the period 1979-1994. The file names and corresponding products are identified below:

File Name Product L93ch23.7994daygrd_temp_msu.nat Lower Troposphere Deep Layer Temperatures L93ch34.7994daygrd_temp_msu.nat Upper

```
Troposphere Deep Layer Temperatures L93ch4.7994daygrd_temp_msu.nat
Lower Stratosphere Deep Layer Temperatures
```

8. Data Organization:

Data Granularity:

A general description of data granularity as it applies to the IMS appears in the EOSDIS Glossary. For the MSU data in HDF format, the granularity is 1 file per year of data (365 daily arrays in a single file) for both the temperature and precipitation data. For the data in native format, the granularity is 1 file per year for the precipitation data, and 1 file per 16 years for the temperature products (i.e., all daily arrays for the full 16 years of data in a single file).

Data Format:

The temperature and precipitation data sets are both stored in a native binary format as well as in the Hierarchical Data Format (HDF).

9. Data Manipulations:

Formulae:

Derivation Techniques and Algorithms:

Please refer to **Processing Sequence and Algorithms** in the MSU LIMB93 Readme that accompanies the data files

Data Processing Sequence:

Processing Steps:

Please refer to **Processing Sequence and Algorithms** in the MSU LIMB93 Readme that accompanies the data files

Processing Changes:

Please refer to **Processing Sequence and Algorithms** in the MSU LIMB93 Readme that accompanies the data files

Calculations:

Special Corrections/Adjustments:

Please refer to **Processing Sequence and Algorithms** in the MSU LIMB93 Readme that accompanies the data files

Calculated Variables:

Please refer to **Processing Sequence and Algorithms** in the MSU LIMB93 Readme that accompanies the data files

Graphs and Plots:

Not available at this time.

10. Errors:

Sources of Error:

Please refer to **Processing Sequence and Algorithms** in the MSU LIMB93 Readme that accompanies the data files

Quality Assessment:

Data Validation by Source:

Please refer to **Validation of the Data** in the MSU LIMB93 Readme that accompanies the data files

Confidence Level/Accuracy Judgement:

Please refer to **Processing Sequence and Algorithms** in the MSU LIMB93 Readme that accompanies the data files

Measurement Error for Parameters:

Not available at this time.

Additional Quality Assessments:

Not available at this time.

Data Verification by Data Center:

The metadata accompanying each data file are checked for consistency and valid ranges during the archive process. Checksums for each file are computed during the archive process and stored in the database for future comparison upon retrieval of the file from the archive.

11. Notes:

Limitations of the Data:

Not available at this time.

Known Problems with the Data:

Not available at this time.

Usage Guidance:

Not available at this time.

Any Other Relevant Information about the Study:

Not available at this time.

12. Application of the Data Set:

Please refer to **Scientific Potential of the Data** in the MSU LIMB93 Readme that accompanies the data files

13. Future Modifications and Plans:

Not available at this time.

14. Software:

Software Description:

Please refer to **Companion Software** in the MSU LIMB93 Readme that accompanies the data files

Software Access:

Please refer to **Companion Software** in the MSU LIMB93 Readme that accompanies the data files.

15. Data Access:

Contact Information:

EOS Distributed Active Archive Center (DAAC)
Code 610.2
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771
USA

(301) 614-5224 (voice)
(301) 614-5268 (fax)
email: daacuso@daac.gsfc.nasa.gov

Data Center Identification:

NASA/Goddard Distributed Active Archive Center

Procedures for Obtaining Data:

The MSU LIMB93 temperature and oceanic precipitation can be accessed either through the EOSDIS Information Management System (IMS) or via the GSFC DAAC anonymous FTP server. You may access the files from this document,

MSU DEEP LAYER TEMPERATURES AND OCEANIC PRECIPITATION

You can find the data at the following URL:

http://disc.sci.gsfc.nasa.gov/data/lim93/

You can also search and download the data using the GES DISC interface

http://disc.gsfc.nasa.gov/uui/datasets

Data Center Status/Plans:

Not available at this time.

16. Output Products and Availability:

Data sets are available on 8mm tape, 4mm DAT or via FTP.

17. References:

Conrath, B.J., 1972: Vertical resolution of temperature profiles obtained from remote sensing measurements. J. Atmos. Sci., 29, 1262- 1271.

Eischeid J.K., H.F. Diaz, R.S. Bradley, and P.D. Jones, 1991: A Comprehensive Precipitation Dataset for Global Land Areas. Department of Energy Carbon Dioxide Research Program Report TR051. Oak Ridge National Laboratory, Oak Ridge, Tennessee

Smith, W.L., H.M. Woolf, C.M. Hayden, D.Q. Wark, and L.M. McMillin, 1979: The TIROS-N operational vertical sounder. Bull. Amer. Meteor. Soc., 60, 1177-1187.

Spencer, R.W. and J.R. Christy, 1990: Precise monitoring of global temperature trends from satellites. Science, 247, 1558-1562.

Spencer, R.W., J.R. Christy, and N.C. Grody, 1990: Global atmospheric temperature monitoring with satellite microwave measurements: Methods and results 1979-84. J. Climate, 3, 1111-1128.

Spencer, R.W. and J.R. Christy, 1992a: Precision and radiosonde validation of satellite gridpoint temperature anomalies, Part I: MSU channel 2. J. Climate, 5, 847-857.

Spencer, R.W. and J.R. Christy, 1992b: Precision and radiosonde validation of satellite gridpoint temperature anomalies, Part II: A tropospheric retrieval and trends 1979-90. J. Climate, 5, 858-866.

Spencer, R.W. and J.R. Christy, 1993: Precision lower stratospheric temperature monitoring with the MSU: Technique, validation, and results 1979-91. J. Climate, 6, 1194-1204.

Spencer, R.W., 1993: Global oceanic precipitation from the MSU during 1979-91 and comparisons to other climatologies. J. Climate, 6, 1301-1326.

18. Glossary of Terms:

See the EOSDIS Acronyms for a more general listing of terms related to the Earth Observing System project.

19. List of Acronyms:

See the EOSDIS Acronyms for a more general listing of terms related to the Earth Observing System project.

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