Nimbus-7 SMMR Pathfinder Daily EASE-Grid Brightness Temperatures, Version 1

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

Knowles, K., E. G. Njoku, R. Armstrong, and M. J. Brodzik. 2000. *Nimbus-7 SMMR Pathfinder Daily EASE-Grid Brightness Temperatures, Version 1.* [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/36SLCSCZU7N6. [Date Accessed].

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National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

This data set consists of brightness temperatures acquired from the Scanning Multichannel Microwave Radiometer (SMMR) on board the Nimbus-7 Pathfinder satellite. The brightness temperatures have been gridded onto the Equal-Area Scalable Earth Grid (EASE-Grid) and are presented in three different projections: Northern Hemisphere, Southern Hemisphere, and global. The SMMR EASE-Grid data were derived from Level-1B SMMR brightness temperatures data in swath format.

Coverage is global, and data are available from 25 October 1978 through 20 August 1987. The spatial resolution is 25 km for all channels (6.6, 10.7, 18, 21, and 37 GHz for both vertical and horizontal polarizations). Both brightness temperature and time files are provided for a given projection in flat binary format for each day. The brightness temperatures are provided in tenths of kelvins and the time files are in minutes since 0:00 Coordinated Universal Time (UTC) of the date of the enclosing file.

1.1 Format

SMMR EASE-Grid brightness temperature data are composed of daily brightness temperature files and time files for each projection in flat binary format (little-endian). The files have been compressed with gzip.

The brightness temperature files contain 2-byte, unsigned integer arrays. Each brightness temperature file represents gridded data for a single channel and polarization derived from either ascending or descending passes (such as 6.6 GHz, horizontal, ascending) for one day. All temperatures are stored in tenths of kelvins.

The time files contain 2-byte, signed integer arrays. Each time file represents the corresponding time of the swath samples used for the interpolation of the given grid cell, for either ascending or descending passes for that day. The time files are in minutes since 0:00 Coordinated Universal Time (UTC) of the date of the enclosing file; negative time values indicate data collected prior to midnight.

The grid array dimensions for the Northern and Southern Hemisphere grids are 721 x 721 pixels, and the global grid dimensions are 1383 x 586 pixels.

1.2 File Naming Convention

Brightness temperature files are named according to the following convention:

`EASE-SMMR-zzyyyydddp.ccc.gz`

Where:

Table 1. Naming Convention for the Brightness Temperature Files

Variable	Description
EASE	Identifies this file as an EASE-Grid product
SMMR	Identifies that this data was acquired with the SMMR instrument
zz	EASE-Grid ID (NL: Northern Hemisphere low resolution, SL: Southern Hemisphere low resolution, ML: Global low resolution)
yyyy	4-digit year
ddd	3-digit day of year
p	Direction of pass (A: ascending pass, D: descending pass)
ccc	Channel (06H: 6 GHz horizontal, 06V: 6 GHz vertical, 10H: 10 GHz horizontal, 10V: 10 GHz vertical, 18H: 18 GHz horizontal, 18V: 18 GHz vertical, 21H: 21 GHz horizontal, 21V: 21 GHz vertical, 37H: 37 GHz horizontal, 37V: 37 GHz vertical)
gz	Identifies this as a gzip compressed file

Note: There are two time files per day (one for the ascending passes and one for the descending passes) for each projection.

Time Files are named according to the following convention:

`EASE-SMMR-zzyyyydddp.TIM.gz`

Where:

Table 2. Naming Convention for the Time Files

Variable	Description
EASE	Identifies this file as an EASE-Grid product
SMMR	Identifies that this data was acquired with the SMMR instrument
zz	EASE-Grid ID (NL: Northern Hemisphere low resolution, SL: Southern Hemisphere low resolution, ML: Global low resolution)
yyyy	4-digit year
ddd	3-digit day of year
p	Direction of pass (A: ascending pass, D: descending pass)
TIM	Identifies this as a time file

Variable	Description
`gz`	Identifies this as a gzip compressed file

1.3 File Size

The compressed files range in size from 1.2 KB - 528 KB per file, and the uncompressed files range in size from 1.0 MB - 1.6 MB per file.

1.4 Spatial Coverage

These data files are provided in three different spatial coverages: Northern Hemisphere, Southern Hemisphere, and global. Please see the Projection and Grid Information Tab on the EASE-Grid web page for specific latitude and longitude values.

1.4.1 Spatial Resolution

The spatial resolution is 25 km for all channels.

1.4.2 Projection and Grid Description

The SMMR EASE-Grids are a set of three equal-area, 25 km projections: two azimuthal equal-area projections, one for the Northern and one for the Southern Hemisphere; and a global cylindrical equal-area projection. Please see the What are the EASE Grids? web page for more information on the EASE-Grid.

1.5 Temporal Coverage

This data set spans 25 October 1978 to 20 August 1987. The SMMR instrument operated continuously during the three-week checkout period from 25 October 1978 to 16 November 1978. After that, the instrument was switched on and off on alternate days due to power sharing constraints among the instruments onboard the spacecraft. From 2 April 1986 to 23 June 1986, a special operation took place during which SMMR was switched off more frequently. During this period, data from the Northern and Southern Hemispheres were collected on alternate days.

Intermittently, the sensor remained switched on for consecutive days. These dates include:

- 1978: 25 October to 15 November
- 1979: 27 February to 1 March, and 4 May to 6 May
- 1980: 23 June to 25 June

After 12 March 1985, the 21 GHz radiometer was turned off, due to a large calibration drift in the 21 GHz horizontal channel since the beginning of the mission. SMMR EASE-Grid files for 21 GHz data are not available after this date.

Near-global coverage was obtained every six days at a resolution of 25 km for all channels. Details of the SMMR instrument, the data processing algorithms, and early geophysical results are provided by Gloersen and Barath (1977), Njoku et al. (1980), Swanson and Riley (1980), Njoku (1980), Gloersen et al. (1984), Gloersen (1987) and Fu et al. (1988).

1.5.1 Temporal Resolution

For most of its mission, SMMR collected data every other day. SMMR was routinely turned on close to midnight UTC (corresponding to a descending node equator crossing near 0 longitude), and turned off at approximately the same time the following day. Each Level 3 grid file covers a time period of approximately 24 hours of continuous data. Orbits are split into separate grids for ascending (local noon) and descending (local midnight) passes.

1.6 Parameter or Variable

The parameter of this data set is brightness temperature.

1.6.1 Parameter Description

Theoretically, brightness temperature is the effective temperature of a blackbody radiating the same amount of energy per unit area at the same wavelengths as the observed body. Empirically, brightness temperature is the apparent radiant temperature of a non-blackbody determined by measurement with an optical pyrometer or radiometer. The brightness temperature (T_b) at a given wavelength (λ) is the product of the physical temperature (T_p) and the emissivity (ε) of the surface viewed by the radiometer:

$$T_b(\lambda) = \varepsilon T_p \qquad \text{(Equation 1)}$$

1.6.2 Parameter Range

Brightness temperature data values are scaled by 10; divide the stored values by 10 to get kelvins. They range from 650 (representing 65.0 K) to 3200 (representing 320.0 K); missing data are indicated by the value 0. Time values range from -720 (1200 UTC of the previous day) to 2160 (1200 UTC of the following day); missing data are indicated by the value -32768. Latitude and longitude values vary depending upon the grid used. Values are in decimal degrees scaled by

100000, divide the stored values by 100000 to get actual values. Latitude values range from -9000000 to 9000000, and longitude values range from -18000000 to 18000000. Missing data values are indicated by 1431655765. Table 3 summarizes these data ranges.

Table 3. Data Value Range

Parameter	**Unit of Measurement**	**Data Range**	**Missing Data Value**
Brightness Temperatures (T_b)	Tenths of kelvins	650 (representing 65.0 K) to 3200 (representing 320.0 K)	0
Time	Minutes since midnight of the date of the enclosing file	-720 (1200 UTC of the previous day) to 2160 (1200 UTC of the following day)	-32768
Latitude/Longitude	Hundred thousandths of degrees (1 meter precision)	Latitude values range from -9000000 to 9000000 Longitude values range from -18000000 to 18000000	1431655765

1.6.3 Sample Data Record

Figure 1 shows a sample browse image of SMMR data for the Northern Hemisphere 25-km EASE-Grid, 37 GHz, horizontally polarized brightness temperatures for ascending passes only acquired on 1 January 1980.

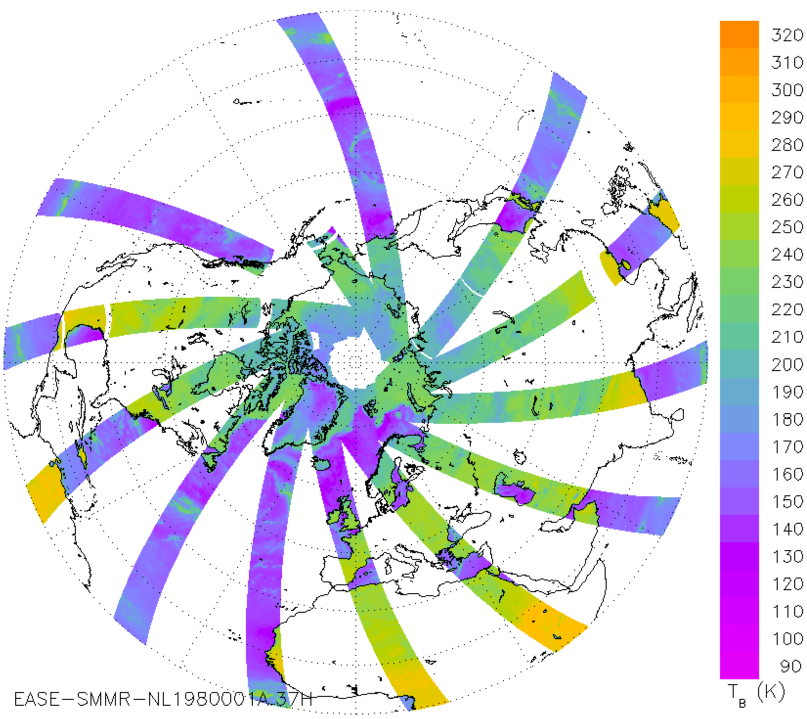

Figure 1. SMMR Browse Image for 1 January 1980

1.7 Error Sources

A discussion of expected residual errors, based on analysis of the processed data, is given by Njoku et al. (1998). No comparisons with independent data sources were performed.

1.8 Quality Assessment

Quality indicator flags were provided in the Level-1B data for the scan status word of each scan. These flags indicated conditions in the original data or in the data processing that may have given rise to reduced-quality calibrated output. None of these data were eliminated from the gridded product (Eni Njoku, personal communication with Ken Knowles).

1.9 Limitations of the Data

SMMR operated continuously during the initial three-week checkout period that occurred from launch to 16 November 1978, at which time it began alternate-day operation due to power sharing constraints among the instruments on the spacecraft. Time gaps in the SMMR data of varying durations also occurred during the mission. Table 4 summarizes the total instrument on and off times each year, with percentage estimates of missing data during on time. The tabulated values were estimated from data times recorded on the input antenna temperature tapes. The high percentage of data missing during 1987 is due to the presence of several large data gaps in the 8- to 20-hour range. At this stage in the mission, the Nimbus-7 spacecraft began to exhibit power supply degradation; and the instrument on-off cycling modes were changed to conserve power and to focus on priority science objectives between the instruments. A Special Operations Period (SOP) occurred from 2 April 1986 to 23 June 1986, during which the SMMR was switched on and off more frequently.

Table 4. Nimbus-7 SMMR Operations Summary

Time Period	Off Time (Days)	On Time (Days)	% Data Missing (During on Time)
1978-10-25 to 1978-11-16	0	22.04	7.51
1978-11-17 to 1978-12/31	24.32	20.68	4.17
1979	187.14	177.86	3.14
1980	186.69	179.31	0.98
1981	186.84	178.16	0.69
1982	187.90	177.10	0.87
1983	180.61	184.39	1.66
1984	188.56	177.44	1.32

Time Period	Off Time (Days)	On Time (Days)	% Data Missing (During on Time)
1985	187.85	177.15	0.64
SOP *	62.57	20.43	*
1986 (excluding SOP)	147.77	134.23	0.50
1987	101.58	130.42	17.00
Total	1612.71	1608.33	2.60
*SOP - Special Operations Period: 2 April to 23 June 1986			

1.10 Known Problems with the Data

During data processing, ground track errors occasionally occurred at low latitudes. Examples include ascending records appearing in descending files and duplication in the time of two adjacent scan records. Although this was handled in most of the data by ignoring the second record, the problem was not discovered until data for January 1981 through May 1983 had already been processed. Duplicated scans resulted in very small differences (on the order of 0.1 K) in the interpolated brightness temperatures so reprocessing of this period was not justified.

Swath data had another inconsistency characterized by one or more scan times that were out of sequence. Swath record processing was sequential; so when this condition was detected during processing, it was assumed that the first records encountered were correct and records that were out of sequence were skipped until record times were in sequence again.

In spite of efforts to remove errors in the data, files for the dates shown in Table 5 are known to contain brightness temperature errors in the specified regions.

Table 5. Brightness Temperature Errors

Year	Day	Error Type	Description
1985	132	brightness temperature calibration	Descending data only, all channels: calibration errors near the coast of Portugal
1985	070	brightness temperature calibration	Descending data only, all channels: calibration errors near the coast of Morocco
1985	258	brightness temperature geolocation	Ascending and descending data, all channels: geolocation errors occurred for approximately the first half of the day's orbits

1.11 Usage Guidance

It is recommended that the brightness temperature delta values shown in Table 6 be added as a calibration offset to all ocean brightness temperatures subsequent to 4 January 1984 due to a small but significant discontinuous jump in the mean values of SMMR incidence angles and some of the brightness temperatures on that day. Please see Section 3.3 “Derivation Techniques and Algorithms” of this document for more information.

2 SOFTWARE AND TOOLS

Geolocation tools for this data set are available via the Tools tab on the EASE-Grid web page.

2.1 Volume

The total volume of the compressed data files is approximately 25 GB. The total volume of the uncompressed data files is approximately 116 GB.

The volume of one full day of uncompressed data is approximately 23 MB for hemispheric grids and 37 MB for the global grids. This includes 20 data files per day per projection (5 channels, 2 polarizations each, ascending and descending passes) plus two time files (one for each pass). The total data volume for all three projections is 83 MB per day.

3 DATA ACQUISITION AND PROCESSING

3.1 Theory of Measurements

On the Nimbus-7 platform, the SMMR instrument measured passive microwave radiances. For more details, please refer to the SMMR, SSM/I, and SSMIS Sensors Summary.

3.2 Data Acquisition Methods

The input data for the Pathfinder EASE-Grid SMMR brightness temperature data processing were produced by Eni Njoku of the Jet Propulsion Laboratory (Njoku et al. 1998) and are archived at NSIDC. Please see the Nimbus-7 SMMR Pathfinder Brightness Temperatures guide document for more information.

3.3 Derivation Techniques and Algorithms

Due to the processing method used for the Level 1B SMMR data, NSIDC determined that the inverse distance squared interpolation technique best suited the resampling of SMMR data to the EASE-Grid format. Please see Section 3.3.1 “Data Processing Steps” for more information.

A description of the theory and implementation of the processing of brightness temperatures from the radiometric data is given in Njoku et al. (1998).

When regridding Njoku's brightness temperatures from swath format to the EASE-Grid format, NSIDC reviewed several methods for resampling SMMR Pathfinder data to the EASE-Grid format. NSIDC favored a method that caused the least amount of smoothing to the data while adding as little noise as possible.

The interpolation scheme chosen was the inverse distance squared method. This is a weighted average of brightness temperatures from all samples within 25km of the grid cell center. This method only requires forward navigation from satellite coordinates to grid coordinates. The weight of a sample is determined by finding the distance to the cell center, then squaring and inverting it.

Users should be aware that offset adjustments were not applied to the gridded data. Based on recommendations in the Nimbus-7 SMMR Pathfinder Brightness Temperatures data set guide document, users should apply the delta values from Table 6 below to ocean brightness temperature data beginning 4 January 1984.

On 4 January 1984, the recorded SMMR incidence angles and some of the brightness temperatures (predominantly the vertical polarizations) exhibited small but significant discontinuous jumps in their mean values. The mean recorded incidence angle changed from 50.2 degrees to 49.8 degrees. The nature and magnitudes of these jumps appeared to be consistent with the possibility that a discontinuous change in the mean spacecraft attitude had occurred. However, these jumps were not discovered in the SMMR data until after the mission when long-term trend analyses were performed; the cause could not be determined retrospectively and conclusively from the spacecraft and instrument data records. For this reason, the long-term trend polynomial fits were computed and applied in two segments - before and after 4 January 1984. Discontinuities in the magnitudes of the fitted trends between these two segments are shown in Table 6. NSIDC recommends that these brightness temperature delta values be added as a calibration offset to all ocean brightness temperatures subsequent to the 4 January 1984 date. These offset adjustments were not applied automatically during reprocessing of the data since there was uncertainty as to whether their cause was in fact instrument-related, software-related, or geophysical in nature.

Table 6. Offset Adjustments

Channel (GHz)	Delta (K)
6.6V	1.04
10.7V	0.81
18V	0.79
21V	0
37V	0.88

Delta values are 0.0 for horizontal polarizations of all channels.

3.3.1 Processing Steps

The steps performed in reprocessing the SMMR data from the calibrated brightness temperatures (Level 1B) to gridded brightness temperatures included the following:

1. Extract HDF orbit files from daily tar file.
2. Uncompress HDF orbit files and extract brightness temperatures, times, and locations of swath data.
3. Segregate data into nominal one day on periods (noon previous day to noon following day for alternating day operation, midnight to midnight for continuous operation).
4. For each projection, separate data into ascending and descending passes. Note this is done relative to the sensor footprint, not the satellite.
5. Eliminate samples less than 65 K and greater than 320 K.
6. For a given cell, select the orbit with local time nearest to the local equator crossing time for the satellite. Record this time in the time file.
7. For each channel, calculate the brightness temperature value for the grid cell as a weighted average of all samples from the selected orbit within 25 km of the cell center. Weights are equal to the inverse of the distance (cell center to sample center) squared. Cells with total weights less than the threshold value (1.0) are set to the missing data value (0).
8. Compress the individual brightness temperature and time files with gzip.

3.3.2 Special Corrections/Adjustments

Due to problems with antenna angles in the original antenna temperature tapes, occurrences of zero-value antenna angles were seen for various days in 1980. As a result, no data were processed on these dates:

- 5, 7, and 9 January
- 28 February
- 1, 3, 17, 19, and 21 March
- 10 and 12 April

A record of data requiring special processing is provided in Table 7.

Table 7. Data Requiring Special Processing

Dates	Day of Year	Grids Affected	Anomaly Occurrence	Start Time (UTC)	Missing Channels (GHz)
25 Oct 78 to 15 Nov 78	298/1978 to 319/1978	NL, SL, ML	Daily	0:00	none
17 Nov 78 - 26 Feb 79	321/1978 to 057/1979	NL, SL, ML	Alternate days	12:00	none
27 Feb 79 - 28 Feb 79	058/1979 to 059/1979	NL, SL, ML	Daily	0:00	none
1 Mar 79 to 3 May 79	060/1979 to 123/1979	NL, SL, ML	Alternate days	12:00	none
4 May 79 to 6 May 79	124/1979 to 126/1979	NL, SL, ML	Daily	0:00	none
7 May 79 to 22 June 80	127/1979 to 174/1980	NL, SL, ML	Alternate days	12:00	none
23 June 80 to 25 June 80	175/1980 to 177/1980	NL, SL, ML	Daily	0:00	none
26 Jun 80 to 11 Mar 85	178/1980 to 070/1985	NL, SL, ML	Alternate days	12:00	none
13 Mar 85 to 28 Mar 86	072/1985 to 087/1986	NL, SL, ML	Alternate days	12:00	21V, 21H
2 Apr 86 to 14 Apr 86	092/1986 to 104/1986	NL, SL	Alternate days	12:00	6.6V, 6.6H, 10.7V, 10.7H, 21V, 21H
2 Apr 86 to 14 Apr 86	092/1986 to 104/1986	ML	Daily	0:00	6.6V, 6.6H, 10.7V, 10.7H, 21V, 21H
15 Apr 86 to 23 Jun 86	105/1986 to 174/1986	NL, SL	Alternate days	12:00	21V, 21H

Dates	Day of Year	Grids Affected	Anomaly Occurrence	Start Time (UTC)	Missing Channels (GHz)
15 Apr 86 to 23 Jun 86	105/1986 to 174/1986	ML	Daily	0:00	21V, 21H
25 Jun 86 to 20 Aug 87	176/1986 to 232/1987	NL, SL, ML	Alternate days	12:00	21V, 21H

3.4 Sensor or Instrument Description

These data were acquired using the Nimbus-7 SMMR instrument. SMMR was launched by NASA on the Nimbus-7 satellite on 25 October 1978, and measured the Earth's microwave radiation at five frequencies (6.6, 10.7, 18, 21, and 37 GHz) in both horizontal and vertical polarizations. The orbital period was approximately 104 minutes, resulting in approximately 13.8 orbits per day. For more details, please refer to the SMMR, SSM/I, and SSMIS Sensors Summary.

4 REFERENCES AND RELATED PUBLICATIONS

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4.1 Related Data Collections

- Nimbus-7 SMMR Pathfinder Brightness Temperatures
- Nimbus-7 SMMR Polar Radiances and Arctic and Antarctic Sea Ice Concentrations
- Nimbus-5 ESMR Polar Gridded Brightness Temperatures and Sea Ice Concentrations
- DMSP SSM/I-SSMIS Pathfinder Daily EASE-Grid Brightness Temperatures
- DMSP SSM/I-SSMIS Daily Polar Gridded Brightness Temperatures

4.2 Related Documents

Table 8. Related Documents

Document	Description	URL
EASE-Grid: A Versatile Set of Equal-Area Projections and Grids	A detailed description of the Equal-Area Scalable Earth Grid.	https://nsidc.org/data/ease
SMMR, SSM/I, and SSMIS Sensors Summary	A description of the SMMR, SSM/I, and SSMIS instruments.	https://nsidc.org/sites/nsidc.org/files/technical-references/SMMR-SSMI-SSMIS-Sensors.pdf

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6 DOCUMENT INFORMATION

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