USER'S MANUAL: SSM/I Brightness Temperature, Version 7

1. INTRODUCTION

This document describes the Version-7 (V7) SSM/I Brightness Temperature (T_B) Dataset produced by Remote Sensing Systems (RSS). This document should be read in conjunction with the earlier versions of RSS SSM/I Users Manuals, which give more details on the SSM/I data, including:

- User's Manual: SSM/I Antenna Temperature Tapes, Rev. 1, December 1991
- User's Manual: SSM/I Antenna Temperature Tapes, Rev. 2, December 1993
- SSMI Version 6 Calibration.doc October 24, 2010

These documents are available from Remote Sensing Systems. This current document is primarily intended to describe the format and content of the V7 TB dataset.

The V7 T_B dataset incorporates improved geolocation, calibration, and quality control procedures in a consistent manner for the entire 25-year SSM/I dataset. In addition, the six SSM/Is (F08, F10, F11, F13, F14, and F15) have been carefully inter-calibrated among themselves and with WindSat, AMSR-E, and the F17 SSMIS. This allows investigators to confidently use these SSM/I products for detailed interannual and decadal trend studies.

We are in the process of writing a V7 Calibration Report that will describe the improvements in geolocation and calibration.

2. DATA FORMAT

The SSM/I data are stored in orbital files. The file names have the form:

f@@_r#####.dat (see note at end of document)

where @@ is the SSM/I satellite number (i.e. 08, 10, 11, 13, 14, or 15) and ##### is the orbit number (i.e., 00001 to 99999). By definition, an SSM/I orbit begins near the South Pole at the point where the z-component (i.e., north-south) of the spacecraft velocity vector changes from a negative value to a positive value. <u>Note that this is a different convention than used in previous versions</u>. For example, for the V6 SSM/I dataset, orbits began at the spacecraft ascending equatorial node. This change in convention of V7 brings uniformity to SSM/I, SSMIS, WindSat, and AMSR-E.

Each orbital file contains additional scans at the beginning and end of each orbit. For example, the file for orbit 10000 contains scans starting with orbit position 9999.95 and ending with orbit position 10001.05. The data at the end of orbit file 10000 are then given again in orbit file 10001. This 5% overlap of the orbit files facilitates user requirements that involve scan averaging.

In order to reduce the downlink telemetry data rate, the SSM/I only takes measurements for the 3 lower frequencies (19, 22, and 37 GHz) every other scan. The 85 GHz measurements are taken every scan. Likewise, the lower frequency measurements are only taken at every other along-scan position. The 85 GHz measurements are taken at all scan positions. For example, an orbital file typically has about 3546 scans, and the total number of observations taken during the Earth-viewing portion of the scan is 128. Thus the arrays of 85 GHz observations are 128 by 3546. However, the arrays for the lower-frequency observations are 64 by 1773. The 85-GHz grid is called hi-res, and the lower-frequency grid is called lo-res.

In the V7 T_B orbital files, all parameters are given on the hi-res grid except for the lower-frequency brightness temperatures, which are given on the lo-res grid. In order to associate a hi-res value (i.e., latitude and longitude) with a lo-res T_B, the following mapping is used. Let *icel_lo*,*iscn_lo* denote the indices for a lo-res T_B. The indices for the corresponding hi-res value are

$$icel\_hi = 2*icel\_lo - 1$$

$$iscn\_hi = 2*iscn\_lo - 1$$

In other words, the lo-res grid corresponds to the odd-numbered elements in the hi-res grid. In this way, the User can assign a latitude, longitude, incidence angle, etc. to the lo-res T_Bs.

The maximum number of scans in an orbital file is about 3546. To be safe, we allow for a maximum value of 3600. The vectors and arrays in the data file are a fixed dimensional size, with 3600 being the scan dimension.

3. Description of Variables

Each file contains the following scalars, vectors, and arrays.
Scaling and offsets are applied as follows: *Actual_Value (in units given) = Scale*Stored_value + Offset*

Scalars

Type	Name	Scale	Offset	Description
Integer(4)	ksat	1	0	Satellite number (08, 10, 11, 13, 14, or 15)
Integer(4)	iorbit	1	0	Integer orbit number
Integer(4)	numscan	1	0	Number of hi-res scans
Character(24)	astart_time	n/a	n/a	Date and time for first scan in file (see **Note 1**)

Vectors: Dimension is max number of hi-res scans

Type	Name	Scale	Offset	Description
Real(8)	scan_time(3600)	1	0	Scan time (seconds from begin of January 1 2000, 0Z)
Real(8)	orbit(3600)	1	0	Orbit position (eg. 9999.95)
Real(4)	sc_lat(3600)	1	0	Spacecraft nadir geodetic latitude at time=scan_time (deg.)
Real(4)	sc_lon(3600)	1	0	Spacecraft nadir east longitude at time=scan_time (deg.)
Real(4)	sc_alt(3600)	1	0	Spacecraft nadir altitude at time=scan_time (meters)
Integer(4)	iqual_flag(3600)	1	0	scan quality flag (see **Note 2**)

Arrays: 1st dimension is hi-res cell number; 2nd dimension is max number of hi-res scans

Type	Name	Scale	Offset	Description
Integer(2)	cel_lat(128,3600)	0.01	0	observation geodetic latitude (deg.)
Integer(2)	cel_lon(128,3600)	0.01	180	observation east longitude (deg.)
Integer(2)	cel_eia(128,3600)	0.002	45	observation earth incidence angle (deg.)
Integer(2)	cel_azm(128,3600)	0.01	180	observation earth azimuth angle (clockwise from North, deg.)
Integer(2)	cel_sun(128,3600)	0.01	0	observation sun glint angle (deg., see **Note 3**)
Integer(2)	cel_lnd(128,3600)	0.4	0	observation land percentage (%, see **Note 4**)
Integer(2)	cel_ice(128,3600)	1	0	observation sea ice flag (see **Note 4**)
Integer(2)	cel_85v(128,3600)	0.01	100	85GHz V-pol T_B (Kelvin)
Integer(2)	cel_85h(128,3600)	0.01	100	85GHz H-pol T_B (Kelvin)

Arrays: 1st dimension is lo-res cell number; 2nd dimension is max number of lo-res scans

Type	Name	Scale	Offset	Description
Integer(2)	cel_19v(64,1800)	0.01	100	19GHz V-pol T_B (Kelvin)
Integer(2)	cel_19h(64,1800)	0.01	100	19GHz H-pol T_B (Kelvin)
Integer(2)	cel_22v(64,1800)	0.01	100	22GHz V-pol T_B (Kelvin) (see **Note 5**)
Integer(2)	cel_37v(64,1800)	0.01	100	37GHz V-pol T_B (Kelvin)
Integer(2)	cel_37h(64,1800)	0.01	100	37GHz H-pol T_B (Kelvin)

Note 1. Alpha-numeric time:
Astart_time is a 24-byte character string formatted as follows:

READ(astart_time,'(I4,I3.3,4I2.2,F9.6)') LYEAR,IDAYJL,IMON,IDAYMO,IHOUR,IMINUTE,SECOND

LYEAR	year (1987–2003)
IDAYJL	Julian day (1–366)
IMON	month (1–12)
IDAYMO	day of month (1–31)
IHOUR	hour of day (0-23)
IMINUTE	minute of hour (0-59)
SECOND	second of minute (0-59.999999)

Note 2. Quality Control Bits:
Iqual_flag indicates the quality of the scan. If it is not zero, then there is a problem with the scan, and we advise Users to look at the individual bits to decide if the scan should be used. In general, if iqual_flag is not zero, the scan should be skipped. However, there are situations where simply filtering on iqual_flag not equal zero will discard too much data. For example for the F08 SSM/I, the 85 GHz channels for the most part are erroneous and bits 9, 10, and 12 will usually be set. For this case, if the User does not need 85 GHz observations, then bits 9, 10, and 12 should be ignored. (The acronym oob denote 'out of bounds'.)

Bit 0: Scan is missing, there are no data. Missing scans that occur in the middle of an orbit are included in the orbital file as zero-filled spacers. However, missing scans that occur at the beginning or end of the orbit are not included. Scan_time is set to -1.e30.

Bit 1: Scan occurs during a period of erroneous data. This problem only occurs for the early SSM/I data (F08, F10, F11, and F13) before 1999. See SSM/I T_A User's Manual, Revision 2, December 1993.

Bit 2: Scan affected by calibration errors due to NRL scan averaging. This problem only occurs for the early SSM/I data between October 9, 1990 and August 29, 1992. See SSM/I T_A User's Manual, Revision 2, December 1993.

Bit 3: Thermistor readings for scan are out-of-bounds

Bits 4-10: These indicate a problem with the calibration data for the scan. These 7 bits refer to channels 19V, 19H, 22V, 37V, 37H, 85V, and 85H, respectively. The following types of anomalies will trigger this flag:
a. Cold calibration counts and/or hot calibration counts are out of bounds.
b. Automatic gain control setting is currently changing

Bit 11: Removal of moon contamination in cold mirror not possible for lower frequency channels (19-37 GHz)

Bit 12: Removal of moon contamination in cold mirror not possible for 85 GHz channels

Note 3. Sun Glint:
The sun-glint angle is defined as the angle between two vectors **a** and **b**. Vector **a** is the vector going from the SSM/I footprint to the SSM/I antenna. Vector **b** is the vector pointing in the direction of sunlight reflected off the Earth surface at the location of the SSM/I footprint, assuming that the earth surface is a specular reflector. Low sun-glitter angles mean that reflected sunlight is being received by the SSM/I.

Note 4. Land and Sea Ice:
Percentage land contamination is defined as the percentage of the power received by the SSM/I 19 GHz antenna pattern that comes from land.

The sea-ice flag is based on a monthly climatology. A value of cel_ice=0 means that we have never seen sea ice at that location and month since the first SSM/I was launched in 1987. Hence, it is extremely unlikely that the footprint will contain ice. The one exception to this is icebergs, particularly off the East Coast of Argentina, which sometimes pass through areas of cel_ice=0.

Note 5. 22 GHz Brightness Temperature:

The SSM/I sensor is not dual-polarization at 22.235 GHz. Hence, the conversion from antenna temperature to brightness temperature needs to be done differently. This problem is discussed on page 13 of the User's Manual: SSM/I Antenna Temperature Tapes, Rev. 1. For V7 we use the following:

tb22v=1.01911*ta22v + 1.93574 (for earth incidence angle of 52.7^o)
tb22v=1.01865*ta22v + 2.05980 (for earth incidence angle of 53.7^o)

These two incidence angles bracket the incidence angle variation experienced the SSM/Is. For incidence angles between 52.7^o and 53.7^o, a linear interpolation is used to find tb22v. Note that the array corresponding to tb22v is called cel_22v.

4. Zero T_B Values

A T_B value of zero indicates no T_B value is available to the User. Zero T_B values occur when then the following events occur:

a. If bits 0, 1, 2 and/or 3 in the scan quality flag are set, then all T_Bs in the scan for all channels are set to zero.

b. If either the v-pol or h-pol calibration-problem bit is set for a particular frequency, then all T_Bs in the scan for that frequency, both v-pol and h-pol, are set to zero.

c. If the Earth viewing count is out of bounds or if the recovered Earth viewing count is not an integer, then the T_B just for that observation is set to zero.

The User must check if T_B = 0 and exclude these missing values.

5. Advice on Quality Filtering

For a given observation cell, look at the T_B values required for your particular applications. If any of these is zero, skip the cell. Also if your application requires the low frequency channels (19-37 GHz) and bit 11 is set, skip the cell. Likewise, if your application requires the high frequency channels (85 GHz) and bit 12 is set, skip the cell.

6. Reading Variables

The orbital files are simple binary files. Each file is exactly 9,561,636 bytes because a fixed number of scans (3600) is always used for the arrays. For example, if there are 3546 actual scans for the orbit, then bit 0 of the quality flag is set for scans 3547-3600. Also, the scan time is set to -1.e30 for these scans at the end. When reading the file contents, the order of the variables is the same as that shown in the table in Section 3.

7. Copyright Notice

Organizations wanting this dataset should directly contact Remote Sensing Systems. It is our intention to freely provide this dataset to the research community, notwithstanding the marginal cost of reproduction and delivery.

** note: file name as originally listed in this document dated May 22. 2012 was incorrect. The file name format has been changed in this document, March 2014 by D.Smith