USER'S MANUAL: SSM/IS V7 BRIGHTNESS TEMPERATURES

1. Introduction

This document describes the format and reading procedure for the SSM/IS V7 Brightness Temperature (T_B) Dataset produced by Remote Sensing Systems (RSS). This dataset is a fully calibrated, accurately geolocated time series of Earth brightness temperatures. The SSM/IS temperature data records are first reverse engineered back to the raw telemetry data which is the starting point for our data processing. We process the raw counts to T_B using a standard set of proven algorithms. This data handling process is the same that we use for all microwave imagers, including SSM/I, TMI, AMSR, and WindSat. In this way, we maintain consistency among the various sensors and platforms. The SSM/IS dataset described herein is a subset of the complete SSM/IS channel set. It includes the following 7 channels: 19.35V, 19.35H, 22.235V, 37V, 37H, 91.7V, and 91.7H.

Two sets of geolocation parameters are provided: one for the lower channels (19-37 GHz) and the other for the 91.7 GHz channels. Each 1.9 second scan contains 90 lower channel observations and 180 91.7 GHz observations. The odd numbered 91.7 GHz observations are in close proximity to the lower channel observation locations, but there is some difference so we provide locations for both types of observations. Note that the locations of the 19 and 22 GHz observations are slightly different from those of the 37 GHz observations. Fortunately the footprints of the 19 and 22 GHz observations have sufficient overlap so that optimum interpolation can be used to move the 19 and 22 GHz footprints to the location of the 37 GHz footprints thereby avoiding the need to have a third set of geolocation parameters. The adjustment of the locations via optimum interpolation is highly accurate and should be of no concern to most (if not all) users.

A number of adjustments and corrections are applied to the data to achieve full calibration. These include:

1. Adjustments applied to the SSM/IS pointing angles to achieve proper geolocation.
2. Corrections applied to remove the effects of the SSM/IS emissive antenna. The emissive antenna affects all SSM/IS channels.
3. Corrections applied to remove the Moon intrusion into the cold mirror.
4. Corrections applied to remove the Sun intrusion into the hot load.
5. Flagging of anomalous jumps in the radiometer counts.
6. Application of extensive quality control with respect to geolocation information and radiometer performance.
7. Adjustments to the antenna pattern coefficients to provide precise (0.1K or better) inter-calibration with all other microwave imagers.

2. Converting Version-7 to the Version-6 Calibration Reference

RSS has recently transitioned to this new Version-7 processing for both brightness temperatures and geophysical products with regards to in-house data processing. The Version-7 products benefit from a completely consistent set of sensor calibration methods, radiative transfer model, and geophysical retrieval algorithms. It is our intention to provide Users with a complete set of Version-7 products for all sensors in the near future (probably near the end of 2010). In the meantime, for SSM/IS instruments, we are providing the Users with software for converting the V7 brightness temperatures to the V6 calibration reference. The conversion to V6 is done by setting the input argument *iver* to 1 (see Section 3). The V7-to-V6 conversion is quite simple:

$$T_{B6} = a_0 + a_V T_{B7,V} + a_H T_{B7,H}$$

where subscripts *V* and *H* refer to v-pol and h-pol, and subscripts *6* and *7* denote version number. Each channel has its own set of *a* coefficients. It should be noted that the retrograde V6 brightness temperatures still have all of the V7 adjustments listed above. The only difference is that the absolute calibration has been adjusted to match our V6 calibration. So until Version-7 data become available for all sensors, Users can use the Version-6 retrograde product to maintain consistency with their previous research that was based on the Version-6 SSM/I T_B.

3. Data Format for Complete Orbital Files

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

f@@_r#####.dat

where @@ is the SSM/IS satellite number (i.e. 16, 17, …) and ##### is the orbit number (i.e., 10000). By definition, an SSM/IS orbit begins at the spacecraft southern most latitude near the South Pole. Note that this convention is different than that used for Version-6 SSM/I (which had the orbit numbering starting at the ascending equatorial node). Each orbit file contains 5% redundant data at both the beginning and end of each orbit. For example, the file for orbit 10,000 contains scans starting with orbit position 9,999.95 and ending with orbit position 10,001.05. The data at the end of orbit file 10,000 are then given again in orbit file 10,001. This 5% overlap of the orbit files facilitates User requirements that involve scan averaging.

Each file contains a header record that gives the satellite number and the number of scans in the file. The scan records then follow. All records are in simple binary format with no record marks. The file should be opened as a binary, unformatted file, depending on compiler. A typical file will contain the header record plus a maximum of about 3800 scan records, and hence the total file size should be around 17,000 Kb.

All data words within a file are signed integers except for the scan time which is a 24-byte character sting. The data files were generated on an Intel-PC-based system and hence have little-endian convention in which the least-significant byte is stored first in the integer.

4. Subroutine *read_l1b_file.f*

The subroutine ***read_l1b_file.f*** is a Fortran tool for reading the data files. It has two input arguments: *ilu* and *iver*. The argument *ilu* is the logical unit number of the L1b file. Before calling this routine the L1b file must be opened by the user. The argument *iver* is the version option. Setting iver=0 will provide V7 T_B; setting it to 1 will provide V6 T_B. The subroutine does all the necessary conversions and stores the data in the common /L1B_DATA/. The next section describes the content of this common.

5. Description of Variables

The first two variables in the common /L1B_DATA/ come from the header record and are:

KSAT	integer(4)	satellite number (16 ,17, …)
NUMSCAN	integer(4)	number of scans in the file

The remaining variables come from the scan records which are all arrays with the last dimension corresponding to the scan number. We have set this last dimension to maxscan=10000, which is much larger than needed for a single orbit file. The maximum number of scans in a single orbit file is about 3800. However, we use a value of 10000 because the real-time data files can sometimes be this large. The User can set maxscan=3800 if only processing orbital files (not real-time files). The scan records consist mostly of integer(2) values which are scaled by the read routine into the common data listed in the following table.

Description of Common /L1B_DATA/

(NOTE: Notation for the scan number dimension (last index) is suppressed)

Arrays that do not depend on scan position

ATIME	char(24)	Time for the begin of the scan (see below for alpha-numeric format)
ITIME_2000	integer(4)	Time for the begin of the scan (integer seconds for Jan 1 2000 0Z)
ORBIT	real(8)	Orbit position
SCLAT	real(4)	Spacecraft geodetic latitude at time=ATIME (deg)
SCLON	real(4)	Spacecraft east longitude at time=ATIME (deg)
SCALT	real(4)	Spacecraft altitude at time=ATIME (km)
ISCN_FLAG	integer(4)	Scan quality flag (see below)
ICAL_FLAG	integer(4)	T_B quality flag, 19-37 GHz (see below)
ICAL_FLAG_HI	integer(4)	T_B quality flag, 92 GHz (see below)

Arrays that depend of the 90 scan positions for the lower channels (19-37 GHz)

LAT(90)	real(4)	Geodetic latitude of footprint (deg)
LON(90)	real(4)	East longitude of footprints(deg)
EIA(90)	real(4)	Earth incidence angle for footprint (deg)
EAZ(90)	real(4)	Earth azimuth angle for footprint (deg)
SUN(90)	real(4)	Sun glitter angle for footprint (deg)
LND(90)	integer(4)	Land flag: 0=open ocean, 1=near coast, 2=land (0,1,2)
ICE(90)	integer(4)	Sea-ice flag: 0=very unlikely, 1=possible (0,1)
TB(5,90)	real(4)	Brightness temperatures: 19V, 19H, 22V, 37V, 37H (Kelvin)

Arrays that depend of the 180 scan positions for the higher channels (92 GHz)

LAT_HI(180)	real(4)	Geodetic latitude of footprint (deg)
LON_HI(180)	real(4)	East longitude of footprint (deg)
EIA_HI(180)	real(4)	Earth incidence angle for footprint (deg)
EAZ_HI(180)	real(4)	Earth azimuth angle for footprint (deg)
SUN_HI(180)	real(4)	Sun glitter angle for footprint (deg)
LND_HI(180)	integer(4)	Land flag: 0=open ocean, 1=near coast, 2=land (0,1,2)
ICE_HI(180)	integer(4)	Sea-ice flag: 0=very unlikely, 1=possible (0,1)
TB_HI(2,180)	real(4)	Brightness temperatures: 92V, 92H (Kelvin)

Notes:

1. The time ATIME is a 24-byte character string formatted as follows:

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

LYEAR	year (1987-2050)
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)

2. The earth azimuth angle is measured clockwise from North

3. The sun-glitter angle is defined as the angle between two vectors **a** and **b**. Vector **a** is the vector going from the earth footprint to the sensor antenna. Vector **b** is the vector pointing in the direction of sunlight specularly reflected off the Earth surface at the footprint. Low sun-glitter angles mean that reflected sunlight is being received by the sensor.

4. The sea-ice flag is based on a monthly climatology. A value of 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 ice=0.

5. The flag ISCN_FLAG indicates the quality of the scan. If it is not zero, then there is a problem and we advise Users in general to skip the scan. The definition of the bits in ISCN_FLAG is the following, where the stated condition is true if the bit is turned on: (oob=out of bounds)

Bit 0: not used
Bit 1: scan is missing or no time for scan is available, scan time is set to 0
Bit 2: time for ephemeris data is oob
Bit 3: thermistor mux index oob
Bit 4: insufficient information to compute spacecraft position
Bit 5: location for ephemeris is oob
Bit 6: ephemeris time more that 90 sec from scan time)
Bit 7: ephemeris times are not bracketing scan time
Bit 8: ephemeris times are too close in time
Bit 9: inconsistent ephemeris times vs location
Bit10: hot load thermistor values are oob

6. The T_B quality flags ICAL_FLAG and ICAL_FLAG_HI indicate the quality of the T_B for the lower channels and higher channels respectively. If it is not zero, then there is a problem and we advise Users in general not to use the set of T_B. The definition of the bits for the T_B quality flags is the following, where the stated condition is true if the bit is turned on:

Bit 0: scan position index out of sync (so far as never happened)
Bit 1: reverse-engineered counts not integer (extremely rare)
Bit 2: anomalous jump in counts
Bit 3: removal of moon contamination in cold mirror not possible

7. Other problems can affect the quality of the TB. These include oob calibration counts and/or oob Earth counts. If any of these conditions occur, including the conditions in item 6 above, the T_B value is set to zero. **THE USER MUST CHECK IF TB=0 AND EXCLUDE THESE MISSING VALUES.**

5. Near-Realtime Data Files

In addition to the orbital files, RSS also offers near-realtime data files. These files correspond to a single telemetry dump from the spacecraft to a ground station. As such, these files do not correspond to any particular orbit. They may be very small (an orbit segment) or very large (multiple orbits).

The format for these realtime files is identical to the orbital files. The only thing that is different is the file naming convention and the length of the files (which varies with each file). The files are named according to the time of the first scan in the file, using the following convention:

```
write(filename,9001) ksat,lyear,imon,idaymo,ihour,iminute,isecond,suffix
9001 format('\rss_tb_f',i2.2,'y',i4.4,'m',i2.2,'d',i2.2,'h',i2.2,'m',i2.2,'s',i2.2,a1,'.dat')
```

where suffix is a single character, usually “a”. If there are multiple downlinks having the same start time, then the suffix will be “b” for the second one, and so on.

7. Copyright Notice

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