SAFARI 2000 SSM/I GPROF 6.0 Precipitation Data, 0.5-Deg, 1999-2001

Abstract

The GPROF 6.0 Pentads data set contains 5-day (pentad) averages of the GPROF 6.0 Gridded Orbits. The GPROF(Goddard Profiling Algorithm) data set contains a suite of 9 products providing instantaneous, gridded values of precipitation totals for each granule of the SSM/I (Special Sensor Microwave/Imager) data over the roughly 14-year period July 1987 through the present. Even though there have been at least two satellites for the entire period, sampling is sufficiently sparse that the data are averaged for pentads, then the pentads are smoothed with a 1-2-3-2-1 time-weighting. The last two pentads are unevenly weighted since the last (or last two) pentads in the average are not yet available. Consequently, the last two pentads must be recomputed when the next pentad becomes available.

Most of the publicly available data sets based on SSM/I are already aggregated into pentad or monthly averages. This choice is partly governed by the very sparse sampling of SSM/I on the global grid at the daily time scale, and partly governed by the large volume of data involved in providing orbit data.

The data set prepared for SAFARI covers the years 1999, 2000, and 2001.

Background Information

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Project: TRMM

Data Set Title: • SAFARI 2000 SSM/I GPROF 6.0 Precipitation Data, 0.5-Deg, 1999-2001

Site: Southern Africa
 Westernmost Longitude: 20° E
 Easternmost Longitude: 50° W
 Northernmost Latitude: 10° N
 Southernmost Latitude: 50° S

Data Set Citation:

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GPCP Home Page: http://orbit-net.nesdis.noaa.gov/arad/gpcp/ [Internet Link]
TRMM home page: http://trmm.gsfc.nasa.gov/ [Internet Link]

Data File Information

The data files are stored as annual files of pentad (5-day) images. The pentads are stored in band sequential [BSQ] format (one image after the other) within the yearly files. There may be some trailing bytes at the end of the monthly files, these are an artifact of the image processing system that produced the files and can be ignored.

The annual files of 0.5 degree by 0.5 degree GPROF V6 data were provided by Eric Nelkin of the GSFC Mesoscale Atmospheric Processes Branch. The global half-degree images provided were 720 sample by 360 line images. The files were oriented with an upper left corner of 90 degrees North at the Prime Meridian. The yearly files were ingested into the PCI image processing package, where the Eastern and Western Hemispheres were switched so that the Prime Meridian was at the center of the images. Southern Africa subsets were then extracted from the global images at starting sample 321, starting line 161, with a size of 142 samples by 122 lines. Each image pixel is stored as a 4-byte real value of precipitation rate in units of millimeters/hour. The data set prepared for SAFARI cover the years 1999, 2000, and 2001.

The images provided here are subsets 142 samples by 122 lines in size that were extracted from the global images. Each half-degree image pixel is stored as a 4-byte real value and the units are mm/hr. The data set prepared for SAFARI covers the years 1999, 2000, and 2001.

Image Parameters

Number of samples	142
Number of lines	122
Number of bands (pentads) per file	73
Bytes per pixel	4 (REAL*4 big-endian)
Fill Value (missing or not valid)	-99999. or -0.1

Data Units	millimeters/hr
Pixel size	0.5 degree by 0.5 degree
Projection	Cylindrical Equal Distance

Pentad Table (dates associated with each of the 73 pentads)

Month	days	pentad #
January	1 - 5	1
	6 - 10	2
	11 - 15	3
	16 - 20	4
	21 - 25	5
	26 - 30	6
	31 - 4	7
February	5 - 9	8
	10 - 14	9
	15 - 19	10
	20 - 24	11
	25 - 1	12 *
March	2 - 6	13
	7 - 11	14
	12 - 16	15
	17 - 21	16
	22 - 26	17
	27 - 31	18
April	1 - 5	19
	6 - 10	20
	11 - 15	21
	16 - 20	22
	21 - 25	23
	26 - 30	24

Month	days	pentad #
May	1 - 5	25
	6 - 10	26
	11 - 15	27
	16 - 20	28
	21 - 25	29
	26 - 30	30
	31 - 4	31
June	5 - 9	32
	10 - 14	33
	15 - 19	34
	20 - 24	35
	25 - 29	36
	30 - 4	37
July	5 - 9	38
	10 - 14	39
	15 - 19	40
	20 - 24	41
	25 - 29	42
	30 - 3	43
August	4 - 8	44
	9 - 13	45
	14 - 18	46
	19 - 23	47
	24 - 28	48

Month	days	pentad #
September	3 - 7	50
	8 - 12	51
	13 - 17	52
	18 - 22	53
	23 - 27	54
	28 - 2	55
October	3 - 7	56
	8 - 12	57
	13 - 17	58
	18 - 22	59
	23 - 27	60
	28 - 1	61
November	2 - 6	62
	7 - 11	63
	12 - 16	64
	17 - 21	65
	22 - 26	66
	27 - 1	67
December	2 - 6	68
	7 - 11	69
	12 - 16	70
	17 - 21	71
	22 - 26	72
	27 - 31	73

	29 - 2	49

*** Note:** for all three years, pentad number 12 covers February 25-March 1, but for the year 2000, this includes leap day and thus contains six days instead of five.

The GPROF Algorithm

GPROF stands for "Goddard Profiling Algorithm". This data set is computed using version 6 of GPROF, and further versions are under development. The technique is described in Kummerow et al. (1996). It is a multichannel physical approach for retrieving rainfall and vertical structure information from satellite-based passive microwave observations (here, SSM/I). A Bayesian inversion method is applied to the observed microwave brightness temperatures using an extensive libraryof cloud-model-based relations between rainfall rates and microwave brightness temperatures. GPROF includes a procedure that accounts for inhomogeneities of the rainfall within the satellite field of view.

Over ocean, convective/stratiform classification is performed, and convective rain rates are assigned in concentric rings, as described in Olson et al. (1999). Over land and coastal surface areas, the algorithm employs extensive screening, then selects the most applicable of a limited number of hydrometeor profiles, using a scheme developed at NOAA (McCollum and Ferraro, 2000).

Temporal and Spatial Coverage and Resolution

Up through 31 December 1999 the input SSM/I data were taken from the Remote Sensing Systems (RSS) packed tapes (Wentz 1988). The granule was defined as one SSM/I orbit, starting when the ascending node nadir point crosses the equator, and ending upon the next ascending node nadir point equatorial crossing. In many cases orbits that cross a month boundary are broken into two granules (corresponding to the segments of the orbit in the respective months).

After 31 December 1999 the input SSM/I data were taken from the NASA Marshall Space Flight Center Global Hydrology Resource Center (GHRC) Web page (http://microwave.msfc.nasa.gov/ims/data/ssmi-f13/current-tb/ [Internet Link] hdf-swath for F13, for example). These data are provided in half-orbit granules separated by node (ascending or descending), so the data start at the south or north turning point of the orbit and end at the following opposite turning point. There are no breaks at month boundaries.

Due to the change in granule definition, the first granule of 1 January 2000 only covers the period from 0000 UTC to the next north or south turning point of the orbit. There is no duplication or loss of data as a result of the change-over.

Production and Updates

The precipitation research group at NASA/GSFC Code 912 led by R.F. Adler is responsible for production and updates of the GPROF 6.0 Gridded Orbit-by-Orbit Precipitation Data Set.

The data set is updated in-house on a three-days-after delivery schedule, except when processing exceptions occur. Updates are sent to the GSFC DAAC on a monthly basis. It is expected that the complete SSM/I record will be reprocessed when future versions of GPROF are released or in the event that significant errors are discovered in the processing stream.

Sensors

The SSM/I is a multi-channel passive microwave radiometer that has flown on selected Defense Meteorological Satellite Program (DMSP) platforms since mid-1987. The DMSP is placed in a sun-synchronous polar orbit with a period of about 102 min. The SSM/I provides vertical and horizontal polarization values for 19, 22, 37, and 85.5 GHz frequencies (except only vertical at 22) with conical scanning. Pixels and scans are spaced 25 km apart at the suborbital point, except the 85.5-GHz channels are collected at 12.5 km spacing. Every other high-frequency pixel is co-located with the low-frequency pixels, starting with the first pixel in the scan and the first scan in a pair of scans. The channels have resolutions that vary from 12.5x15 km for the 85.5 GHz (oval due to the slanted viewing angle) to 60x75 km for the 19 GHz.

The polar orbit provides nominal coverage over the latitudes 85 deg N-S, although limitations in retrieval techniques prevent useful precipitation estimates in cases of cold land or sea ice. The SSM/I is an operational sensor, so the data record suffers the usual gaps in the record due to processing errors, down time on receivers, etc. Over time the coverage has improved as the operational system has matured.

Error Detection and Correction

SSM/I error detection/correction has several parts. Built-in hot- and cold-load calibration checks are used to convert counts to Antenna Temperature (Ta). An algorithm has been developed to convert Ta to Brightness Temperature (Tb) for the various channels (eliminating cross-channel leakage). As well, systematic navigation corrections are performed. All pixels with non-physical Tb and local calibration errors are deleted. These checks are applied locally to the SSM/I data on the RSS packed tapes (up to 31 December 1999), and are applied by the GHRC in the process of creating the half-orbit granules (starting 1 January 2000).

Accuracies in the Tb's are within the uncertainties of the precipitation estimation technique. For the most part, tests show only small differences among the SSM/I sensors flying on different platforms.

GPROF error detection/correction is accomplished by providing the number of ambiguous pixels and a measure of retrieval confidence for each pixel and advising users on likely thresholds in these for gauging the quality of the associated GPROF estimates. At present there is no practical scheme for correcting the data other than simple deletion of suspect values.

Post-production checks perform time error detection/correction on the whole-orbit granules (the pre-January 2000 data). The start_time variable for the first orbit in virtually every month had to be repaired, good to the nearest minute. In a small subset of the cases where long runs of scan data are missing at the start of the granule the time variable had to be repaired by hand. In these cases the values might be off by a minute.

Quality and Confidence Estimates

The accuracy of the precipitation variables can be broken into systematic departures from the true answer (bias) and random fluctuations about the true answer (random error), as discussed in Huffman (1997). The former are the biggest problem for climatological averages, since they will not average out. However, on the instantaneous time scale the random error is likely more important. The errors cannot be corrected,but the bias can be estimated from climatological studies, and the typical RMS random error can be estimated (Huffman 1997).

GPROF has shown strong intercomparison results in various intercomparison projects. Summary statistics from a comprehensive validation against gauge and atoll data are shown in Table 5.

Table 5. Summary statistics for the multiple-SSM/I era (January 1992 through July 2000 for land, August 2000 for ocean).

Location	Bias (mm/mo)	Ratio	RMS Error (mm/mo)	Correlation Coefficient
Land OVERALL	-3.9	0.95	65.0	0.77
WITHIN 15N-15S	9.7	1.07	94.5	0.77
OUTSIDE 15N-15S	-6.5	0.91	57.5	0.74
Atoll	-32.6	0.87	95.3	0.79

Additional Sources of Information

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References

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Huffman, G.J., 1997: Estimates of root-mean-square random error contained in finite sets of estimated precipitation. J. Appl. Meteor., 36, 1191-1201.

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McCollum, J.R., and R.R. Ferraro, 2000: Development of PM-1 AMSR and TMI land precipitation algorithms. Preprint volume of the Tenth Conference on Satellite Meteorology and Oceanography, Long Beach, California, 9-14 January, 2000.

Nelkin, E.J., G.J. Huffman, 2001: GPROF6.0 Orbit-by-Orbit Precipitation Data Set. NASA/GSFC, Greenbelt, MD. ftp://lake.nascom.nasa.gov/data/TRMM/Ancillary/ssmi/ [Internet Link], 9 fields in orbit or half-orbit files, 1987-present, and 15 pp. documentation.

Olson, W.S., C.D. Kummerow, Y. Hong, and W.-K. Tao, 1999: Atmospheric latent heating distributions in the tropics derived from satellite passive microwave radiometer measurements. J. Appl. Meteor., 38, 633-664.

Wentz, F.J., 1988: User's manual SSM/I antenna temperature tapes. Remote Sensing Systems, Santa Rosa, CA, 36 pp (and revisions).

Other Links

DAAC home page:
http://daac.gsfc.nasa.gov [Internet Link]

GPROF 6.0 Gridded Orbit-by-Orbit Precipitation Data Set Documentation:
ftp://lake.nascom.nasa.gov/data/TRMM/Ancillary/ssmi/gprof_doc [Internet Link]

GSCAT2 precipitation data set:
http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/hydrology/readme_html/ssmi_dai ly_readme.html
[Internet Link]

GHRC home page:
http://microwave.msfc.nasa.gov [Internet Link]

NOAA Scattering Index precipitation data set:
http://orbit35i.nesdis.noaa.gov/arad2/html/microwave_daily.html [Internet Link]

TRMM home page:
http://trmm.gsfc.nasa.gov/ [Internet Link]