TRMM VAR (3B41RT)

George J. Huffman

15 April 2004

DESCRIPTION

This algorithm provides precipitation estimates from geostationary infrared (IR) observations using spatially and temporally varying calibration by the HQ. The algorithm is a probability-matched threshold approach that ensures that the histogram of gridbox-average IR precipitation rates matches the histogram of gridbox-average HQ precipitation rates locally. As such, the colder an IR pixel is than the zero-precipitation threshold brightness temperature, the higher the rainrate it receives. We refer to this as the variable-rainrate (VAR) infrared algorithm.

Digital data:
ftp://aeolus.nascom.nasa.gov/pub/merged/calibratedIR

Example GIF images and QuickTime movies:
http://trmm.gsfc.nasa.gov/

Detailed documentation (3B4XRT_doc) and programming examples:
ftp://aeolus.nascom.nasa.gov/pub/merged/software

Reference:

Huffman, G.J., R.F. Adler, E.F. Stocker, D.T. Bolvin, and E.J. Nelkin, 2003: Analysis of TRMM 3-Hourly Multi-Satellite Precipitation Estimates Computed in Both Real and Post-Real Time. Combined Preprints CD-ROM, 83rd AMS Annual Meeting, Poster P4.11 in: 12th Conf. on Sat.Meteor. and Oceanog., 9-13 February 2003, Long Beach, CA, 6 pp.

SPECTRAL INTERVALS AND APPLICABLE SATELLITES

The input to VAR (3B41RT) consists of the TRMM real-time HQ merged passive microwave precipitation estimates and the National Oceanic and Atmospheric Administration Climate Prediction Center (NOAA CPC) merged global geosynchronous 11-micron infrared (geo-IR) brightness temperatures. The latter are provided half-hourly on a 4×4-km-equivalent Cylindrical Equidistant Grid for the latitude belt 60N-S based on merging all available images from:

- GOES-E,
- GOES-W,
- GMS (currently covered by GOES-9),
- METEOSAT 5, and
- METEOSAT 7.

The approach is equally applicable to other gridded "high-quality" precipitation estimates and/or other sources of gridded 11-micron IR data. It would be key to ensure that enough coincident samples were available to the calibration that the coefficients were stable.

SPATIAL SCALE

0.25×0.25-deg latitude/longitude

TEMPORAL SCALE

1 hour

ANCILLARY DATA

None

ADDITIONAL COMMENTS

Introduction

The VAR is the second stage of a system to produce the "TRMM and Other Data" estimates in real time. The system was developed to apply new concepts in merging quasi-global precipitation estimates and to take advantage of the increasing availability of input data sets in near real time. The overall system is referred to as the real-time Multi-Satellite Precipitation Analysis (MPA-RT). The MPA-RT is run quasi-operationally on a best-effort basis at the TRMM Science Data and Information System (TSDIS), with on-going scientific development by the research team led by Dr. Robert Adler in the GSFC Laboratory for Atmospheres. Estimates are posted to the web about 6 hours after observation time, although processing issues may delay or prevent this schedule. Due to the experimental nature of these estimates, users are encouraged to report their experiences with the data, and they should expect episodic upgrades or outages as the system develops.

File Contents

Each file starts with a header that is one 2-byte-integer row in length, or 2880 bytes. The header is ASCII in a "PARAMETER=VALUE" format that makes the file self-documenting (e.g., "algorithm_id=3B41RT").
Thereafter three data fields follow. All the fields are on a 0.25-deg lat./long. grid that increments most rapidly to the east (from the Prime Meridian) and then to the south (from the northern edge). Grid box edges are on multiples of 0.25 deg. The data fields are written as binary data in big-endian byte order. The data fields are:

Precipitation	(2-byte integer)
precipitation_error	(2-byte integer)
total_pixels	(1-byte integer)

All fields are 1440×480 gridboxes (0-360 deg. E, 60 deg. N-S). The first grid box center is at (0.125 deg. E, 59.875 deg. N). Files are produced every hour from the on-hour IR image (except for the half-past image for GMS), with fill-in by the half-past image (except for GMS, where the on-hour image is used for fill-in). Valid estimates are only provided in the band 50 deg. N-S.
Note that we use the term "gridbox" to denote the values on Level 3 data (i.e., gridded data), while we use the term "pixel" to denote individual values of Level 2 data (i.e., instrument footprints). Thus, there can be many pixels contributing to a gridbox.
Both precipitation and random error are scaled by 100 before conversion to 2-byte integer. Thus, units are 0.01 mm/h. To recover the original floating-point values in mm/h, divide by 100. Missings are given the 2-byte-integer missing value, -31999. The remaining field is in numbers of pixels.
Currently the random error fields are all set to the 2-byte-integer missing value, -31999. This placeholder will be replaced with actual estimates as development proceeds.
The originating machine on which the data files are written is a Silicon Graphics, Inc. Unix workstation, which uses the "big-endian" IEEE 754-1985 representation of 4-byte floating-point unformatted binary numbers. Some CPUs, including PCs and DEC machines, might require a change of representation (i.e., byte swapping) before using the data. In some cases, the gunzip routine, used to uncompress the

Dataset Validation
These datasets represent a new initiative and should be considered experimental. Formal validation studies are underway, but are not yet available. The infrared results (3B41RT) are designed to emulate the microwave results as closely as possible, so known deficiencies in the microwave will likely be reflected in the infrared as well. In addition, it is well-known that infrared algorithms of the kind used here have large random errors at the fine time and space scales provided. However, we expect the infrared estimates to match the histogram of microwave estimates, so that user-specified averaging should yield approximately unbiased results.

Dataset Status
Beta testing began in early December 2001. An official (experimental) version was instituted in late January 2002. Processing changes occurred on 6 February and 12 March 2002. The ambiguous screening was upgraded for the HQ (3B40RT) as of 09Z 28 February 2003 and for the VAR (3B41RT) as of 00Z 2 March 2003. The GPROF estimates for SSM/I over land and coast were upgraded on 12 February 2004. Fractional coverage by precipitation, volume rain, and ambiguous screening upgrades were made to the calibration of other microwave estimates to the TMI starting 00Z 6 April 2004, and cold land and high rainrate improvements were made to the IR calibration beginning 04Z 15 April 2004.
Users should anticipate a series of versions as the algorithm is developed further. We definitely plan to transition to the new TRMM versions of input (which governs calibration of the SSM/I and IR) when they become available in early 2005. As well, an improved non-real-time MPA is being instituted in the official Version 6 TRMM operational product 3B42.

Example Programs
The data fields are all written with C-language code as blocks of bytes, so there are no extraneous bytes in the files. Because the first two fields are 2-byte integers and the rest are 1-byte integers in each file (to save space), users must exercise care in using FORTRAN direct access to read the data. The FORTRAN example programs read all fields with a single OPEN. Alternatively, the files can be opened with different logical record sizes depending on whether one is reading 2-byte-integer or 1-byte-integer fields. Note as well that the units of the logical record size is not part of the FORTRAN 77 standard. On SGI machines it is in 4-byte words, but some other systems expect it in bytes. Also, to repeat an earlier comment, the originating machine on which the data files are written is a

Silicon Graphics, Inc. Unix workstation. It uses the "big-endian" IEEE 754-1985 representation of 4-byte floating-point unformatted binary numbers, and some CPUs, such as PCs and DEC machines, might require a change of representation (i.e., byte swapping) before using the data.

The FTP site ftp://aeolus.nascom.nasa.gov/pub/merged/software provides several example programs:

read3B4XRT.c	C example
read_header.f	FORTRAN header-read example
read_rt_file.f	FORTRAN single-read example
read_rt_file.pro	IDL example
read_rt_lines.f	FORTRAN line-by-line example

CONTACT PERSON

George J. Huffman
huffman@agnes.gsfc.nasa.gov