STATUS AND RESULTS OF THE TRMM MULTI-SATELLITE PRECIPITATION ANALYSIS

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ABSTRACT

The TRMM Multi-satellite Precipitation Analysis (TMPA) provides 0.25x0.25° 3-hourly estimates of precipitation in the latitude band 50°N-50°S in two product sets. First, it is computed 6-9 hours after real time using precipitation estimates from TMI, SSM/I, AMSR-E, AMSU-B, and geosynchronous-orbit IR (geo-IR) data, all intercalibrated to a single TRMM-based standard. Second, it is computed about two weeks after the end of each calendar month using the same satellite data as in the real time as well as monthly rain gauge analyses and the TRMM Combined Instrument product. Respectively, these are referred to as the real-time TMPA-RT (3B42RT) and research TRMM Version 6 TMPA (V.6 3B42) products. The RT suite also includes a combined microwave product (3B40RT) and a microwave-calibrated geo-IR product (3B41RT). The current version of the RT data starts in March 2005, while the research product has been reprocessed, although using a progressively changing set of input estimates, back to January 1998. Recent development work has focused on calibrating the RT product to the higher-quality research product, and on developing a new AMSU-IR product that inserts recalibrated geo-IR precipitation estimates into zero-rain areas in AMSU swaths over ocean to compensate for light-rain detection problems with the current operational AMSU-B precipitation algorithm.

The time series of the RT and research products are similar, although they apply different calibrating satellites, and the gauge influence typically reduces both the bias and some of the apparently random scatter of the research product. In both products and in common with other satellite-based precipitation estimates, the validation statistics at full resolution are modest, while time/space averaging (of the user's own choosing) tends to reveal progressively more skill at progressively larger scales. Typically skill emerges first for more intense events. Analysis shows that the TMPA succeeds in creating precipitation estimates whose distribution of rainrates replicates the distribution of the original calibrating instrument (currently TRMM-based). The TMPA is seeing use in a number of applications, including flood and landslide diagnoses within the authors' group.

1. DESIGN GOALS

The Tropical Rainfall Measuring Mission (TRMM) Multi-sensor Precipitation Analysis (TMPA) was developed following several design goals. We wanted a system that took advantage of "all available" data, in contrast to the selective use of data in the Global Precipitation Climatology Project (GPCP) monthly and daily products, for whose designs we had had major responsibility. In common with the GPCP approaches, we wanted to maintain a traceable and consistent calibration throughout the analysis. We wanted to minimize statistical changes in the final product in the face of on-going changes to the inventory of available sensor data (Fig. 1). And, looking toward a new research-quality product that would be produced as the standard TRMM products 3B42 and 3B43 in Version 6, we wanted to develop a Real Time (RT) product that was consistent with them.

2. IMPLEMENTATION

Referring to Fig. 2 throughout this section, the instantaneous microwave input data are composited onto 0.25° lat./long. grids at 3-hour intervals centered at the synoptic times (00, 03, …, 21 UTC). The spatial scale was chosen to exceed the typical satellite pixel size, while the time interval was chosen to resolve the diurnal cycle. [Subsequent work seems to show that the time interval needs to be shorter to quantify daily precipitation totals.] All of the microwave sensors are intercalibrated to the "TRMM Best", which is defined as the TRMM Microwave Imager (TMI)–Precipitation Radar (PR) combination product for

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Additional graphics are available in the PowerPoint of this presentation.

Version 6, while it is the Goddard Profiling algorithm (GPROF) applied to TMI for the RT. The calibration is implemented as histogram matching for accumulations of matched data, typically a month or longer depending on the instrument. Note that this scheme provides no constraint on the pattern. Even after intercalibration, non-trivial differences remain between different sensors due to sensor/algorithm characteristics and offsets in the time and viewing angle of observations.

The merged geosynchronous infrared (geo-IR) data are averaged to the same 0.25° grid and calibrated with the combined microwave fields, using a “colder clouds rain more” histogram matching. Again, this scheme places no constraints on the geo-IR pattern, just the gridbox statistics. It is well-known that this approach does rather poorly for such fine scales, but is quite useful for averages of 2.5x2.5° and a day and larger. We use month-long match-ups for stability. In regions of cold/frozen land and sea ice, where the microwave estimates fail, a backup scheme of smooth-filling histograms from surrounding areas is used to establish the geo-IR calibration.

The microwave-IR combination is implemented as using the geo-IR estimates to fill gaps in the combined microwave coverage. Although this approach allows heterogeneous statistics in the shapes of precipitation patterns, including data boundaries, we chose it over other blending schemes, which tend to skew the basic precipitation rate statistics.

In the research product we are able to take the additional step of incorporating precipitation gauge data: The individual 3-hourly multi-satellite fields are summed for the calendar month, then combined with monthly gauge analyses as in Huffman et al. (1997), then the individual satellite fields are scaled so that their sum in each grid box approximately matches the monthly satellite-gauge analysis. Thus, the bias of the individual rescaled fields approximately matches the large-area bias of the (wind-corrected) gauge analysis, but there is negligible dependence on the gauges where they do not exist.

3. RESULTS

Most of the results discussed in the talk are contained in Huffman et al. (2007), which is posted at ftp://meso.gsfc.nasa.gov/agnes/huffman/papers/TMPA_jhm_07.pdf.gz. The key points are: Different sensors “see” different physical scenes, resulting in their placement of precipitation differently. The final combined microwave-IR estimates approximately match the histograms of validation data, for example for the Kwajalein Island radar, but the scatter plots of precipitation tend to be quite noisy. In general, not just for the TMPA, such scatter diagrams tend to show better skill at the high precipitation rates first as some averaging is applied. The implication is that users must assess whether their particular application can successfully use the TMPA data; applications that apply some explicit or implicit averaging are more likely to find the TMPA useful.

4. FUTURE ACTIVITIES

We are currently working toward a climatological calibration of the RT product to the research product. This would allow users to treat the 3B42RT-3B42 suite as a continuous record. As well, we are testing the use of rescaled geo-IR precipitation estimates in areas where Advanced Microwave Sounding Unit B (AMSU-B) precipitation estimates are zero to overcome issues that AMSU-B has with detecting light precipitation over ocean. Currently this issue causes our final estimates to be low over ocean whenever AMSU-B data are used. Finally, we plan to start computing an “early” RT run to satisfy user requests for a more timely product. It is unlikely that we can satisfy truly operational requirements for latencies less than 3 hours, but it is likely that we can develop a 3-pass suite of an “early RT” run around 4 hours after observation time, a “final RT” run around 9 hours after observation time, and a research product (the standard TRMM product) around 2 weeks after the end of the month.

5. REFERENCES

Huffman, G.J., R.F. Adler, P. Arkin, A. Chang, R. Ferraro, A. Gruber, J. Janowiak, A. McNab, B. Rudolf, U. Schneider, 1997: The Global Precipitation Climatology Project (GPCP) Combined Precipitation Data Set. *Bull. Amer. Meteor. Soc.*, **78**(1), 5-20 (incl. cover).

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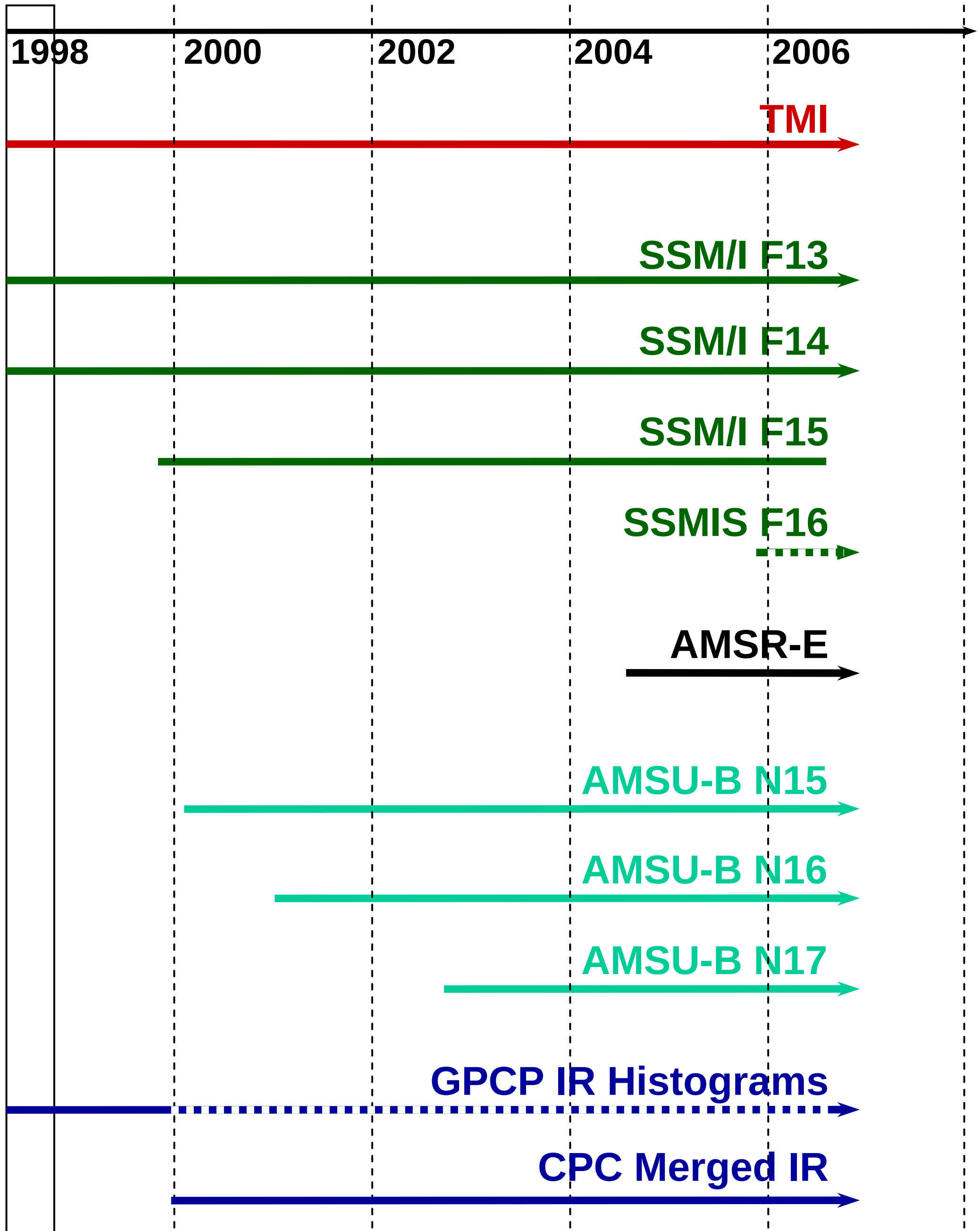

Figure 1 Time history of satellite sensors contributing to the TMPA. In some cases the time series extends beyond the record used in the TMPA. In particular, the GPCP IR Histograms continue to be computed, but not used here.

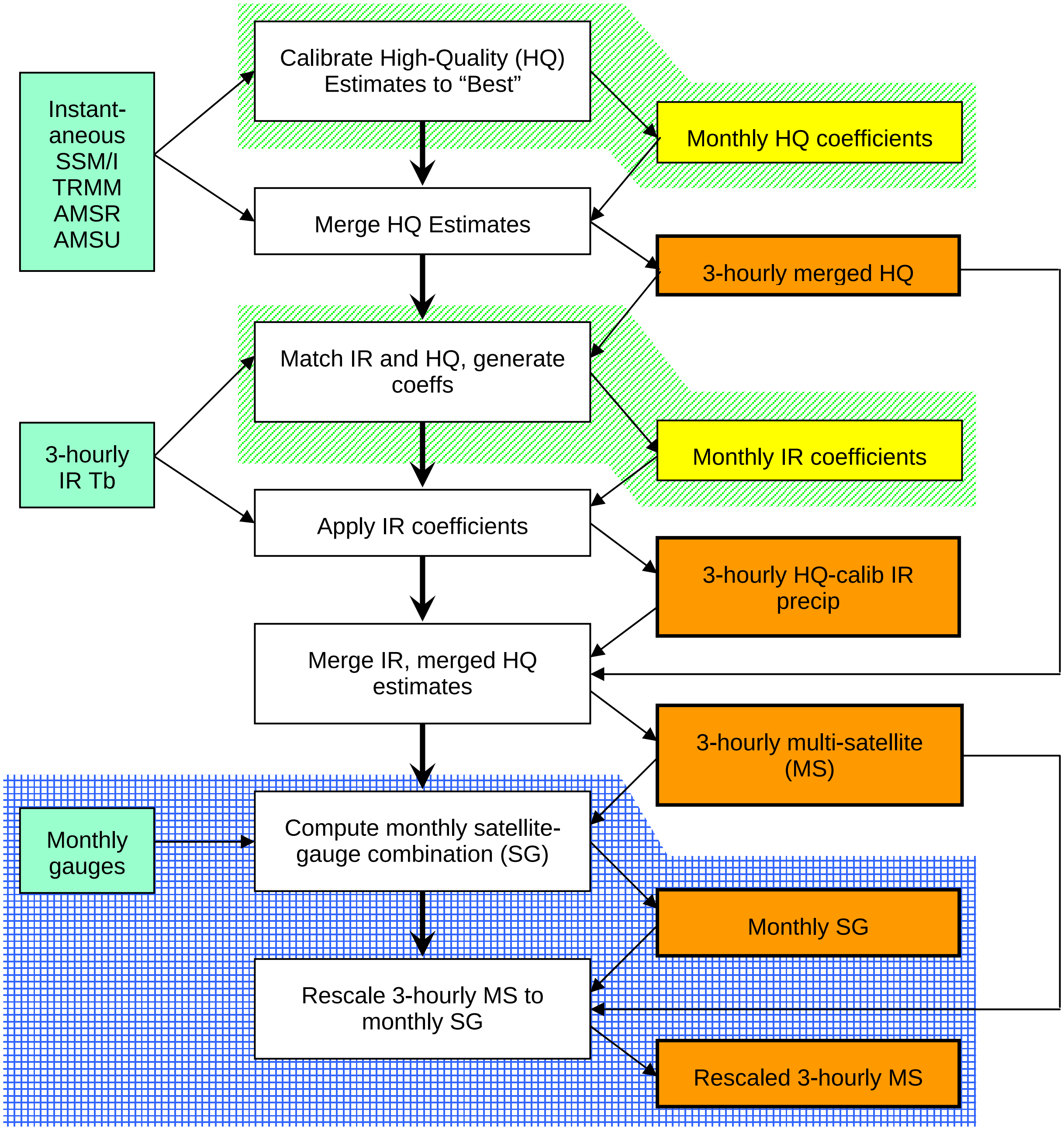

Figure 2 Block diagram for both the RT and research TMPA algorithms, showing input data (left side), processing (center), output data (right side), data flow (thin arrows) and processing control (thick arrows). The items backed by green slanted hatching run asynchronously for the RT, and the items backed by blue cross-hatching are only performed for the research algorithm. “Best” in the top center shaded box is the GPROF-TMI for the RT, but is the TRMM combined TMI-PR precipitation estimate for the research algorithm.