Multi-Satellite Algorithms
(Integrated Multi-satellitE Retrievals for GPM: IMERG)

The GPM Multi-Satellite Team

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1. INTRODUCTION (1/2)

A diverse, changing, uncoordinated set of input precip estimates, with various

- periods of record
- regions of coverage
- sensor-specific strengths and limitations

	infrared	microwave
latency	15-60 min	3-4 hr
footprint	4-8 km	5-30+ km
interval	15-30 min (up to 3 hr)	12-24 hr (~3 hr)
"physics"	cloud top weak	hydrometeors strong

- additional microwave issues over land include
  - scattering channels only
  - issues with orographic precip
  - no estimates over snow

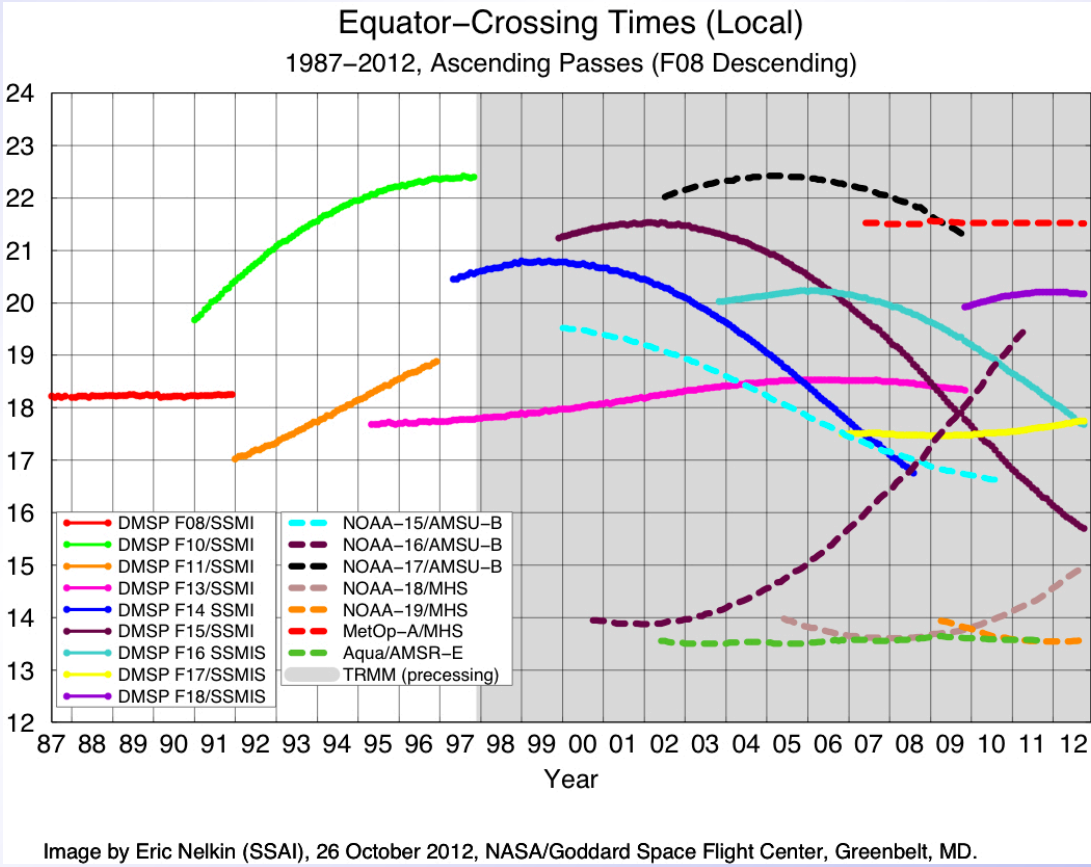


Image by Eric Nelkin (SSAI), 26 October 2012, NASA/Goddard Space Flight Center, Greenbelt, MD.

1. INTRODUCTION (2/2)

The GPM multi-satellite product goals:

- seek the longest, most detailed record of "global" precip
  - don't use regional data sets
  - do use gauge data
- combine the input estimates into a "best" data set
  - not a Climate Data Record
  - but we strive for relatively uniform input data

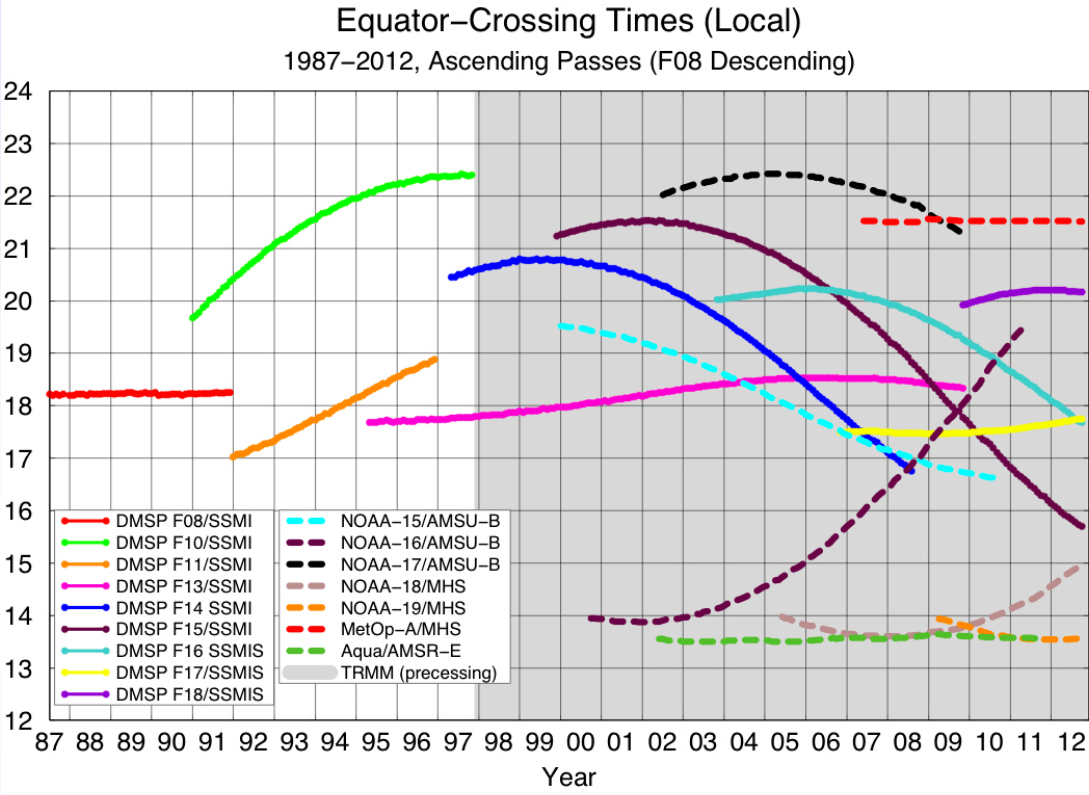
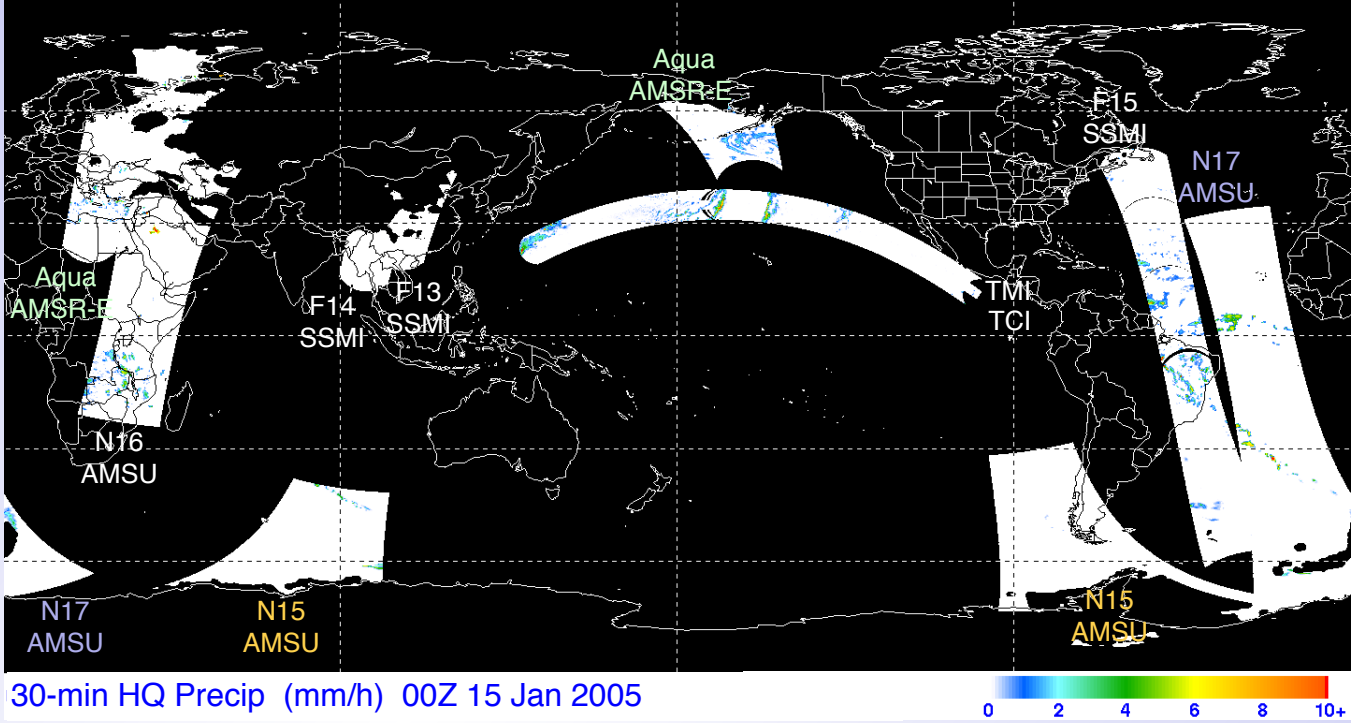


Image by Eric Nelkin (SSAI), 26 October 2012, NASA/Goddard Space Flight Center, Greenbelt, MD.

1. INTRODUCTION – Combination Concepts

The “good stuff” (microwave) is sparse

- 30 min has lots of gaps
- extra gaps due to snow in N. Hemi.
- 4 imagers (2 more getting ready), 3 sounders



IMERG is a unified U.S. algorithm that takes advantage of

- Kalman Filter CMORPH (lagrangian time interpolation) – NOAA
- PERSIANN with Cloud Classification System (IR) – U.C. Irvine
- TMPA (inter-satellite calibration, gauge combination) – NASA
- all three have received PMM support
- PPS (input data assembly, processing environment) – NASA

2. IMERG DESIGN – Requirements/Goals

Resolution – 0.1° [i.e., roughly the resolution of microwave, IR footprints]

Time interval – 30 min. [i.e., the geo-satellite interval]

Spatial domain – global, initially covering 60°N-60°S

Time domain – 1998-present; later explore entire DMSP era (1987-present)

Product sequence – early sat. (~4 hr), late sat. (~12 hr), final sat.-gauge (~2 months after month) [more data in longer-latency products]

Sensor precipitation products intercalibrated to TRMM before launch, later to GPM

Global, monthly gauge analyses including retrospective product – explore use in submonthly-to-daily and near-real-time products

Error estimates – still open for definition

Embedded data fields showing how the estimates were computed

Precipitation type estimates – probability of liquid

Operationally feasible, robust to data drop-outs and (strongly) changing constellation

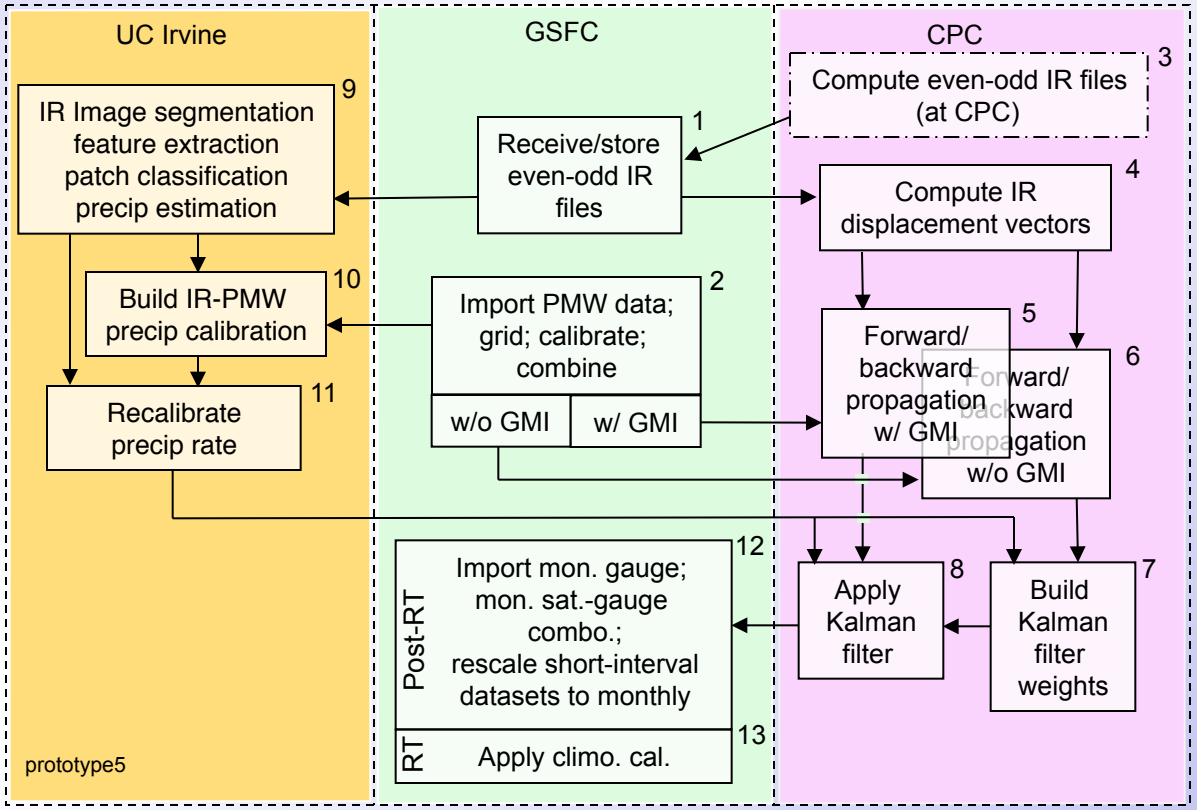
Output in HDF5 v1.8 – compatible with NetCDF4

Archiving and reprocessing for near- and post-RT products

2. IMERG DESIGN – Processing

Institutions are shown for module origins, but

- package will be an integrated system
- goal is single code system appropriate for all three runs
- "the devil is in the details"



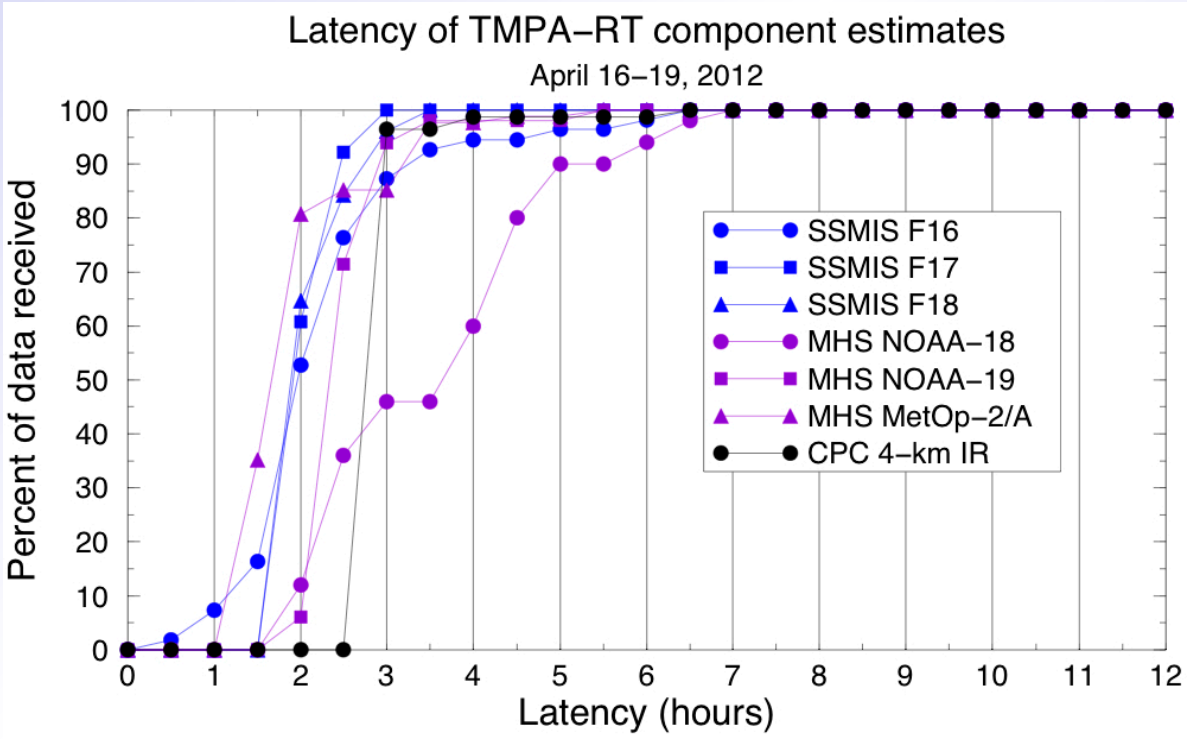
2. IMERGE DESIGN – Multiple Runs

Multiple runs serve different users' needs for timeliness

- more delay usually yields a better product
- pioneered in TMPA

Early – first approximation; flood, now-casting users

- current input data latencies at PPS support ~4-hr delay
- truly operational users (< 3 hr) not well-addressed



Late – wait for full multi-satellite; crop, flood, drought analysts

- driver is the wait for microwave data for backward propagation
- expect delay of 12-18 hr

Final – after the best data are assembled; research users

- driver is precip gauge analysis
- GPCC gauge analysis is finished ~2 months after the month

2. IMERG DESIGN – Data Fields

Output dataset includes intermediate data fields

- users and developers require
  - processing traceability
  - support for algorithm studies

0.1° global CED grid

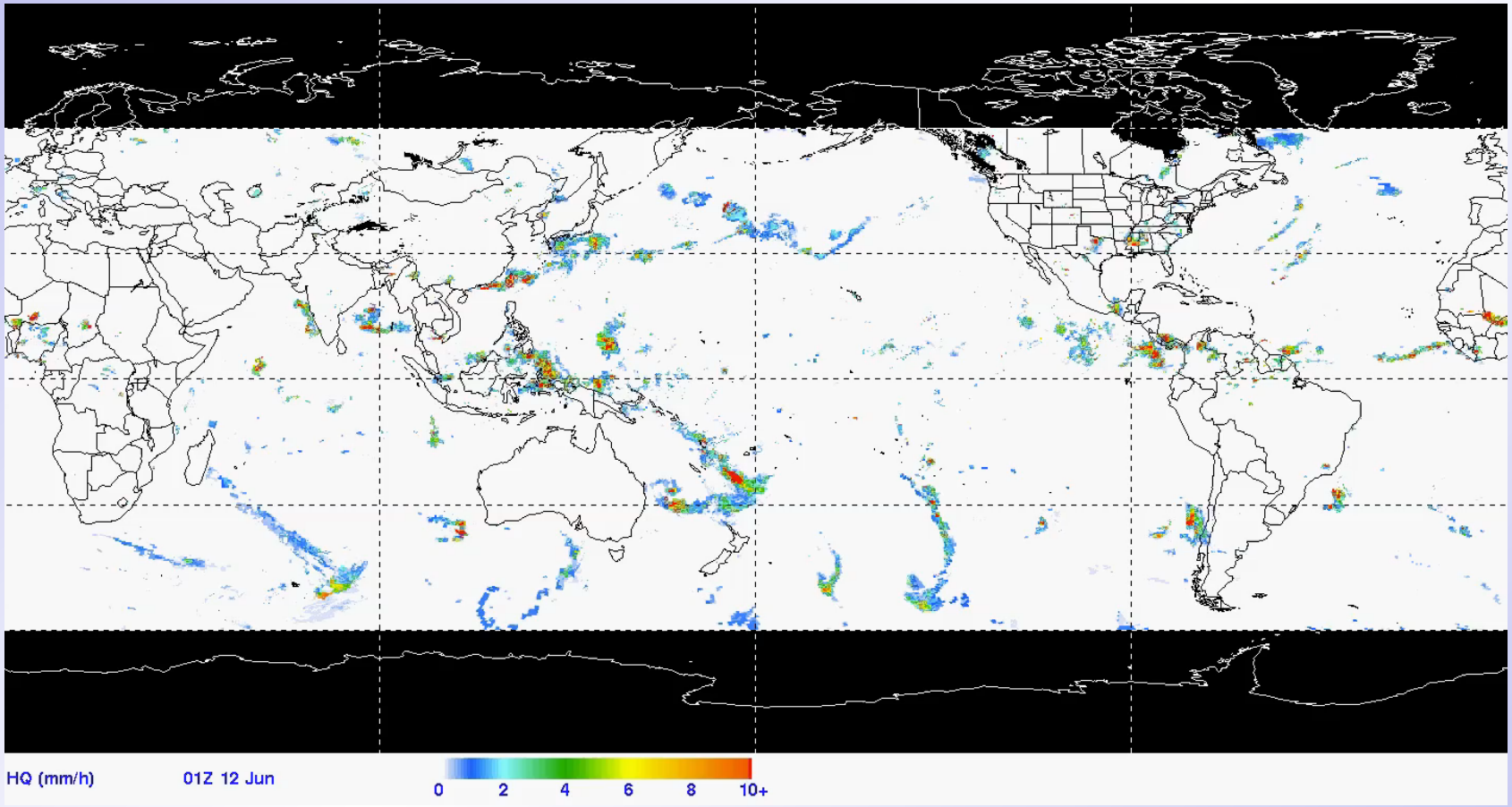
- 3600x1800 = 6.2M boxes
- fields are 1-byte integer, and scaled 2-byte integer or 4-byte real
- but dataset compression means smaller disk files
- PPS will provide subsetting

"User" fields in italics, darker shading

	Half-hourly data file (early, late, final)	***Size (MB) 96 / 161***
1	*Calibrated multi-satellite precipitation*	*12 / 25*
2	*Uncalibrated multi-satellite precipitation*	12 / 25
3	*Calibrated multi-satellite precipitation error*	*12 / 25*
4	PMW precipitation	12 / 25
5	PMW source 1 identifier	6
6	PMW source 1 time	6
7	PMW source 2 identifier	6
8	PMW source 2 time	6
9	IR precipitation	12 / 25
10	IR KF weight	6
11	*Probability of liquid-phase precipitation*	*6*
	Monthly data file (final)	***Size (MB) 36 / 62***
1	*Satellite-Gauge precipitation*	*12 / 25*
2	*Satellite-Gauge precipitation error*	*12 / 25*
3	Gauge relative weighting	6
4	*Probability of liquid-phase precipitation*	*6*

3. IMPLEMENTATION – (Very) Preliminary IMERG Version 3.0

June 12-15, 2012



3. IMPLEMENTATION – Testing

"Baseline" Version 2 code delivered November 2011

"Launch-ready" Version 3 code delivered November 2012

Code will "freeze" in September 2013 for operational testing

Plan to bring up IMERG first on a single run

- shake out bugs and conceptual problems
- start quasi-operational production of "proxy" GPM data
- likely we can release parallel products

Use lessons learned to upgrade the production code

PMM focus on validation is key

- refine physical concepts
- demonstrate level of confidence

3. IMPLEMENTATION – Transitioning from TRMM to GPM

IMERG will be computed at launch (February 2014) with TRMM-based coefficients

About 6 months after launch expect to re-compute coefficients and run a fully GPM-based IMERG

- compute the first-generation TRMM/GPM-based IMERG archive, 1998-present
- all runs will be recomputed for the entire data record
- when should we shut down the TMPA legacy code?

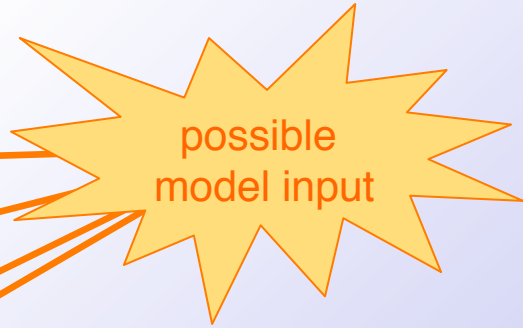
Contingency plan if TRMM ends before GPM is fully operational:

- institute climatological calibration coefficients for the legacy TMPA code and TRMM-based IMERG
- continue running
- particularly true for Early, Late

4. FUTURE – What Next?

The clear goal for Day-1 is operational code meeting GPM deadlines; after that …

- implement a high-latitude scheme
  - develop high-latitude precip estimates — science project
  - calibration schemes for high-latitude precip estimates
  - leo-IR–based displacement vectors
  - parallel observation-model combined product
- use sub-monthly (daily, pentad, or dekad) gauge analyses
- refined precipitation type estimates
- alternative scheme for computing displacement vectors — science project
- address cloud growth — science project
- convective/stratiform classification
- address orographic enhancement — science project
- error estimates — science project
  - bias and random
  - scale and weather regime dependence
  - user-friendly formats and cutting-edge science
- intercalibrate across sensors with different capabilities — science project
- revise precipitation gauge wind-loss corrections



4. FUTURE – In Particular …

Error estimation is a major issue

- combined-satellite errors are an amalgamation of errors from
  - input retrievals
  - sampling
  - combination algorithm
- monthly random error estimate is reasonable
- monthly bias has some draft concepts
- short-interval error is a work in progress
- user requirements tend to be fuzzy
  - cdf or quantiles seem like a natural approach
  - how to do this compactly?
  - likely need to have "expert" and "simple" estimates
- the grand challenge is aggregating errors in space and time

Need to keep pushing user-oriented services

- interactive analysis (TOVAS)
- alternate formats (KMZ, KML, …)
- area averages (political and geographical subdivisions, river basins)
- new publicity

5. FINAL COMMENTS

The Day-1 GPM multi-satellite precipitation algorithm is planned as a unified U.S. algorithm

IMERG will provide fine-scale estimates with three latencies for the entire TRMM/GPM era

The system is planned to meet GPM requirements and to provide the hooks for future extensions

There are still lots of interesting combination and science projects to address

Error representations are still a work in progress

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Draft 1 Agenda
Multi-Satellite Working Group Meeting
George Huffman

Thursday, 21 March 2013
8:30 a.m. – noon (or sooner)
Windjammer Room

Note: I'm hoping for presentations of 15 min or less each, with time in between for discussion. To quote Chris Kummerow, "Value to the team will not be measured in minutes of presentation."

Finalize agenda

Day 1
- Things we're learning from TMPA for GPM – Bolvin
- Introduction to IMERG (reprise) – Huffman
- IMERG software status – Bolvin
- Expected sequence of processing through GPM acceptance – Huffman

Day 1.5
- Precipitation type diagnostic – Liu, Huffman
- Applications and EPO – Kirschbaum

Day 2 Options
- CMORPH bias correction against daily gauge analysis – Sun
- Updates on the pole-to-pole CMORPH development – Xie
- Upgrades to the PERSIANN-CCS – Hsu
- Error estimation – Kidd, Tian, Maggioni, Adler, Huffman
- Other possible items – Huffman

Issues - discussion

Summary, action items