Integrated Multi-satellitE Retrievals for GPM – IMERG

GPM Multi-Satellite Team

George J. Huffman	SSAI and NASA/GSFC, Chair
David T. Bolvin	SSAI and NASA/GSFC
Daniel Braithwaite	Univ. of California Irvine
Kuolin Hsu	Univ. of California Irvine
Robert Joyce	Wyle Scientific and NOAA/NWS/CPC
Chris Kidd	ESSIC and NASA/GSFC
Soroosh Sorooshian	Univ. of California Irvine
Pingping Xie	NOAA/NWS/CPC
Soo-Hyun Yoo	Wyle Scientific and NOAA/NWS/CPC

Topics

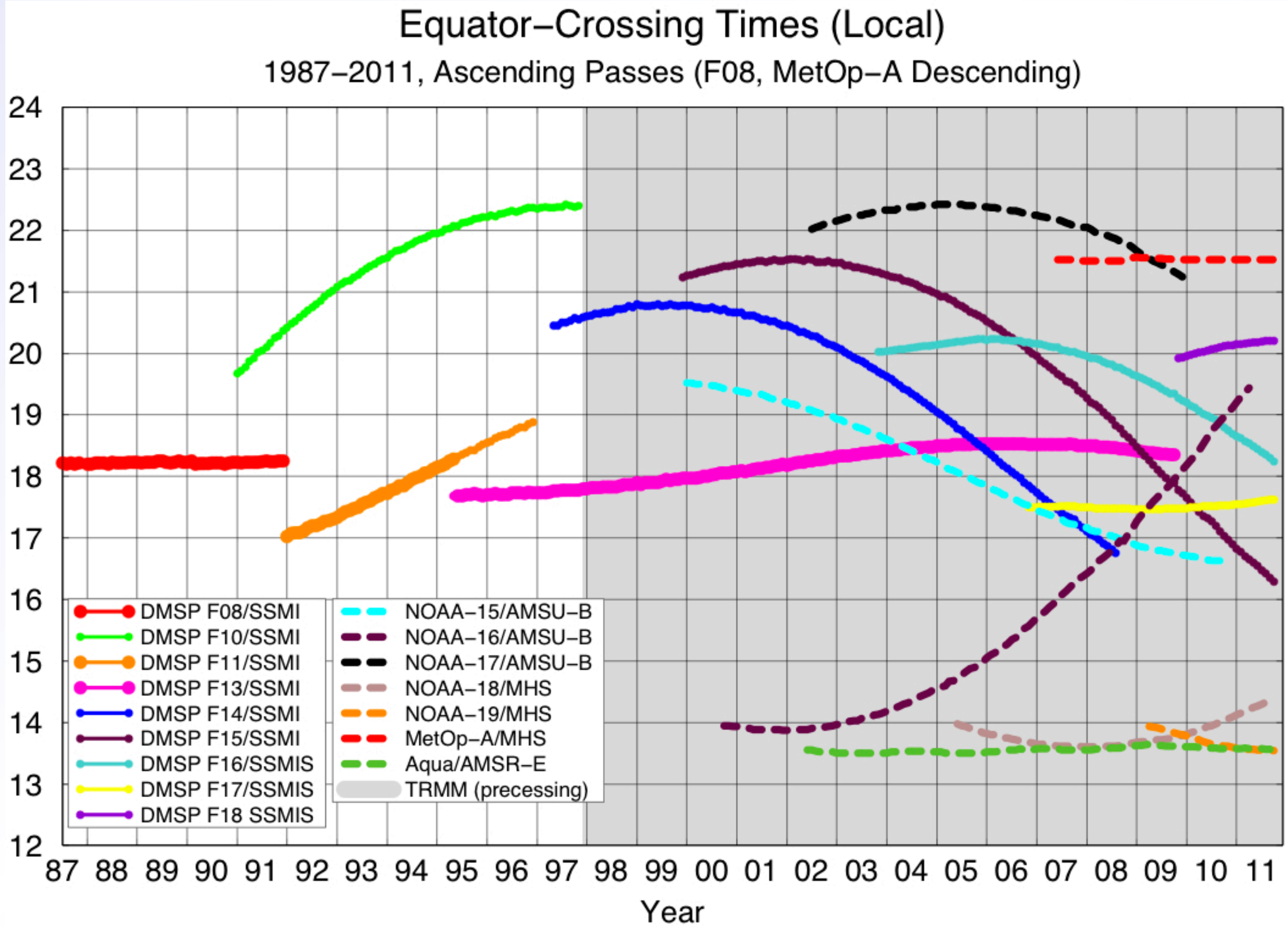
1. INTRODUCTION

How can GPM leverage the international constellation of precipitation-relevant satellites?

A diverse, changing, uncoordinated set of <u>input precip estimates,</u> with various

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

[Aside: much richer data set than the other water cycle variables have!]



Thickest lines denote GPCP calibrator.

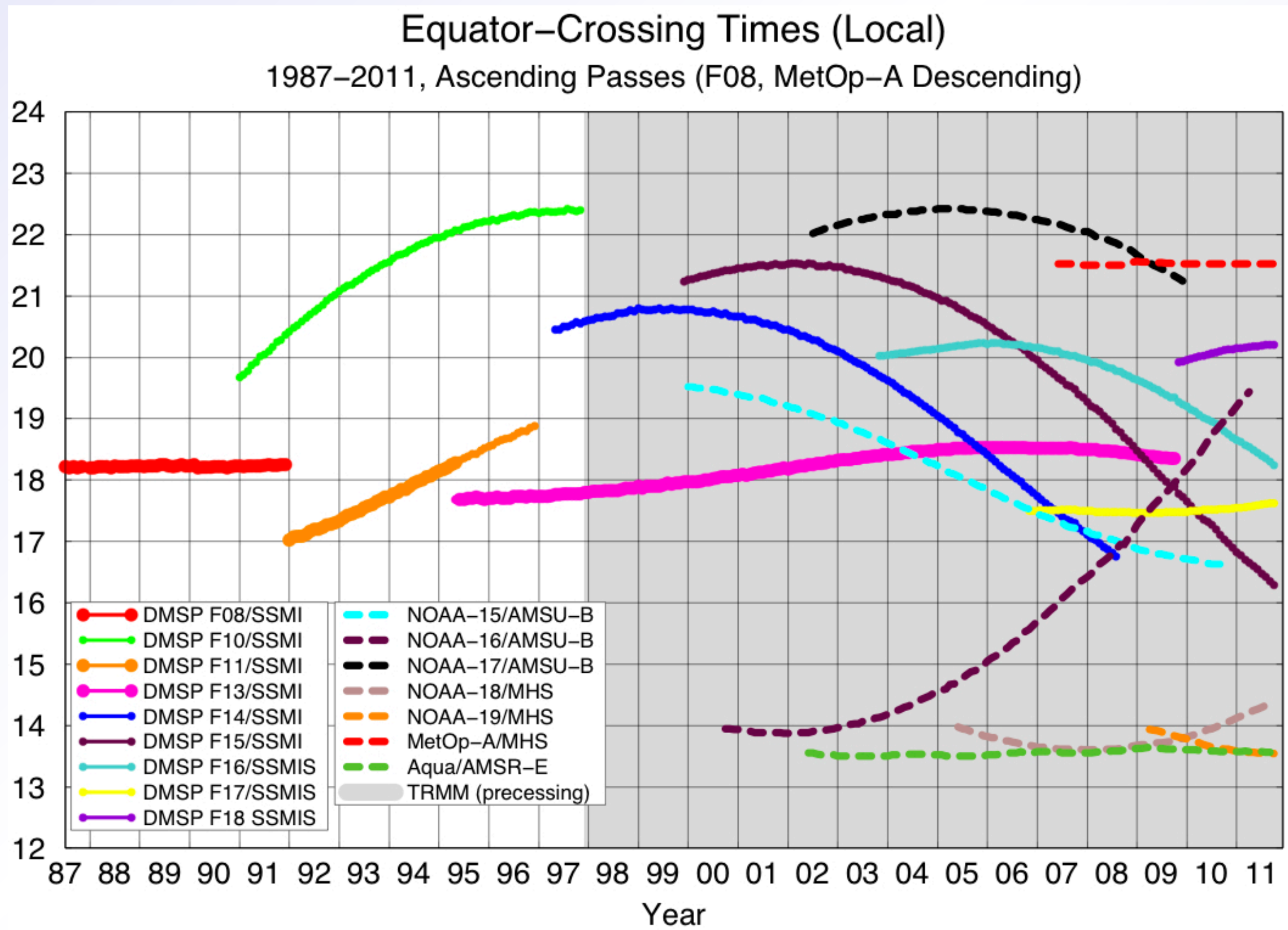
Image by Eric Nelkin (SSAI), 27 October 2011, NASA/Goddard Space Flight Center, Greenbelt, MD.

1. INTRODUCTION

The GPM multi-satellite product goals:

- seek the longest, most detailed record of “global” precip
- combine the input estimates into a “best” data set
  - *not* a Climate Data Record

Combined datasets are critical to non-expert users



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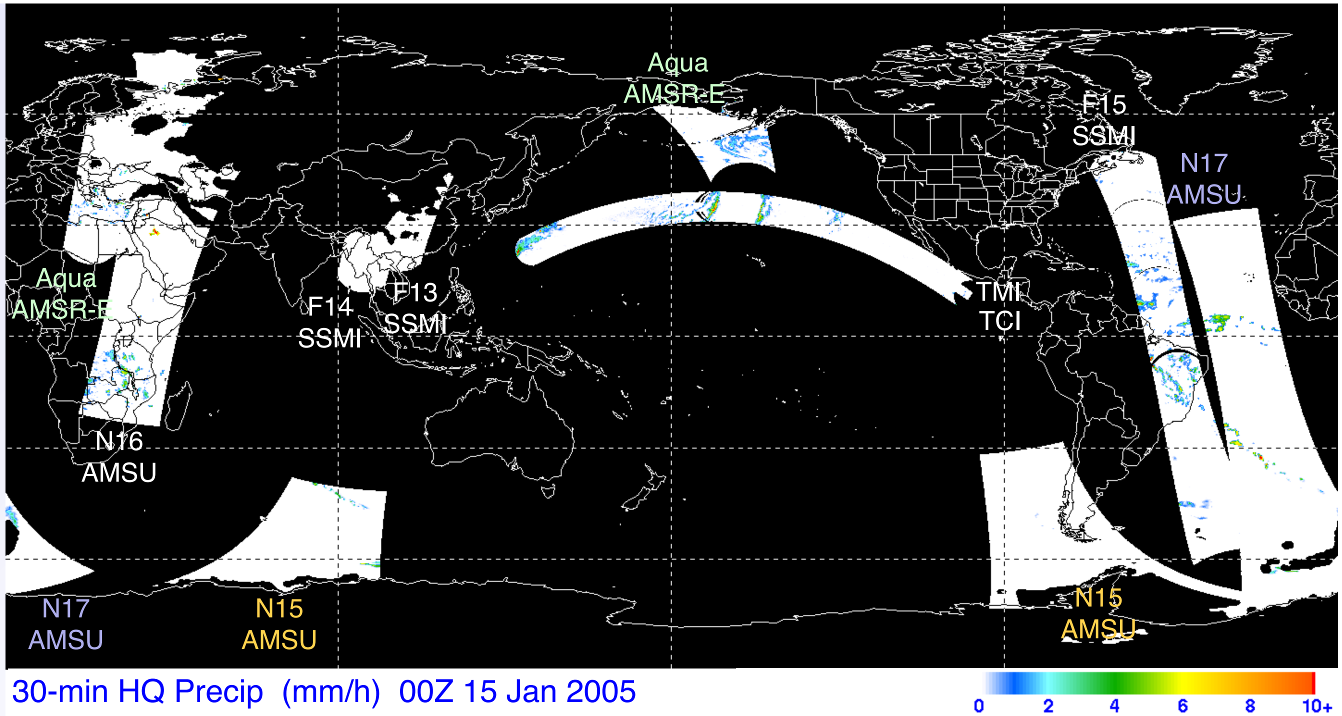
1. INTRODUCTION – Combination Concepts

The "good stuff" (microwave) is sparse

- 30 min has lots of gaps



GPM developed the concept of 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

Integrated Multi-satellitE Retrievals for GPM

2. IMERG DESIGN – Notional Requirements

Resolution – 0.05°~0.1° [i.e., roughly the resolution of microwave, IR footprints]

Time interval – 30 min. [i.e., the geo-satellite interval, then aggregated to 3 hr]

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

Time domain – 1998-present; later explore entire SSM/I 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] unique in the field

Instantaneous vs. accumulated – accumulation for monthly; instantaneous for half-hour

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; unique in the field

Error estimates – still open for definition; nearly unique in the field

Embedded metadata fields showing how the estimates were computed

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

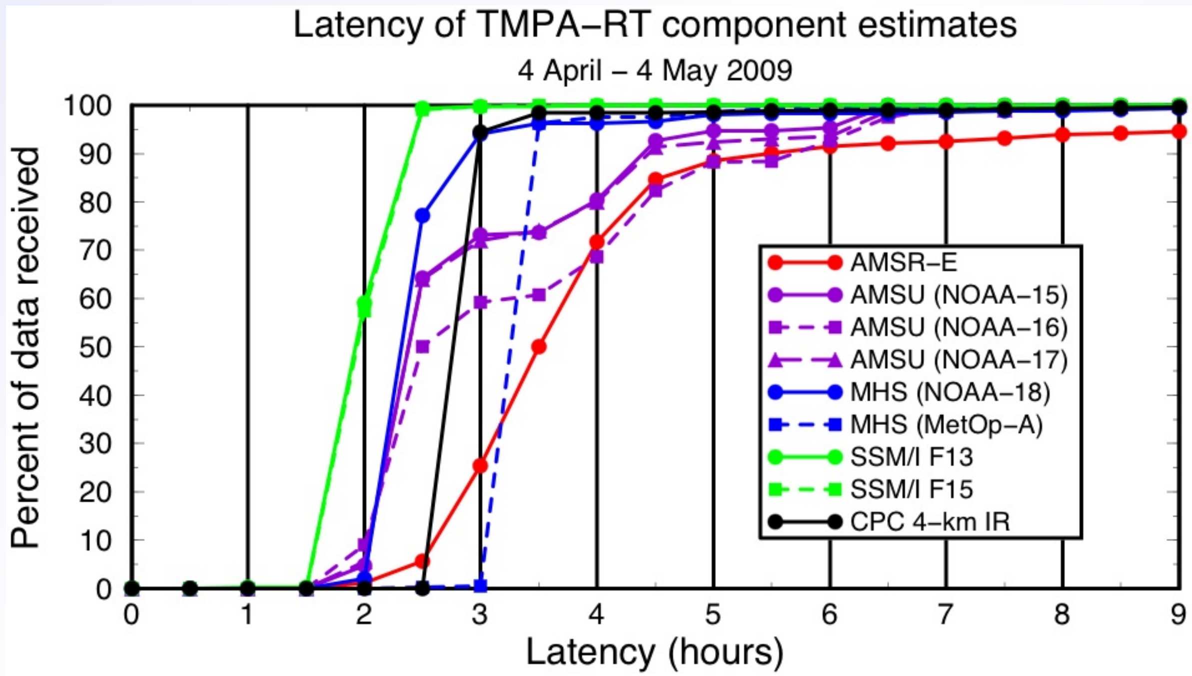
Output in HDF5 v1.8 – compatible with NetCDF4

Archiving and reprocessing for near- and post-RT products; nearly unique in the field

2. IMERGE DESIGN – Multiple Runs

Multiple runs serve different users' needs for timeliness

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



Final – after the best data are assembled; research users

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

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

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

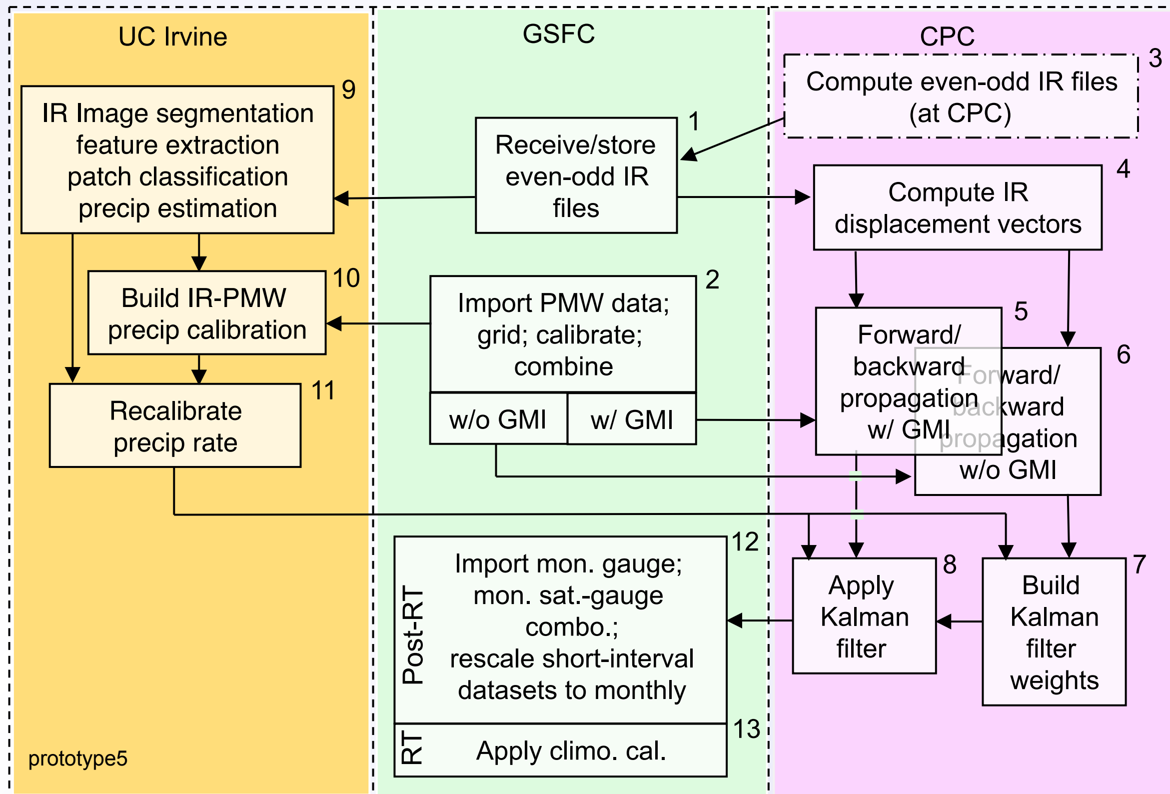
Early – get a first approximation; flood, short-range forecasting users

- current input data latencies support ~4-hr delay
- can't support truly operational users (flash flood, nowcasting), who need < 3 hr

2. IMERG DESIGN – Box Diagram

The flow chart shown is for the final product

- institutions are shown for module origins, but
- package will be an integrated system
- "the devil is in the details"
- (near-)RT products will use a cut-down of this processing
- we should examine the utility of climatological calibrations for the (near-)RT products



2. IMERG DESIGN – Data Fields

Output dataset needs to include intermediate data fields

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

0.1° global CED grid

- 3600x1800 = 6.2M boxes
- Fields are 1-byte integer or or scaled 2-byte integer / 4-byte real

"User" fields in italics, darker shading

	Half-hourly data file (early, late, final)	***Size (MB) 93 / 155***
1	*Instantaneous precipitation: gauge-calibrated multi-satellite*	*12 / 25*
2	Instantaneous precipitation: multi-satellite	12 / 25
3	*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
	Monthly data file (final)	***Size (MB) 31 / 56***
1	*Sat-Gauge precipitation*	*12 / 25*
2	*Sat-Gauge precipitation error*	*12 / 25*
3	*Gauge relative weighting*	*6*

3. IMPLEMENTATION – Testing

"Baseline" code is due November 2011

Plan to bring up IMERG first in (more-flexible) PPS RT system

- 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 Final run code

"Launch-ready" code is due November 2012

PMM focus on validation is key

- refine physical concepts
- demonstrate level of confidence

3. IMPLEMENTATION – Transition from TRMM to GPM

IMERG will be computed at launch 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 GPM-based IMERG archive
- 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

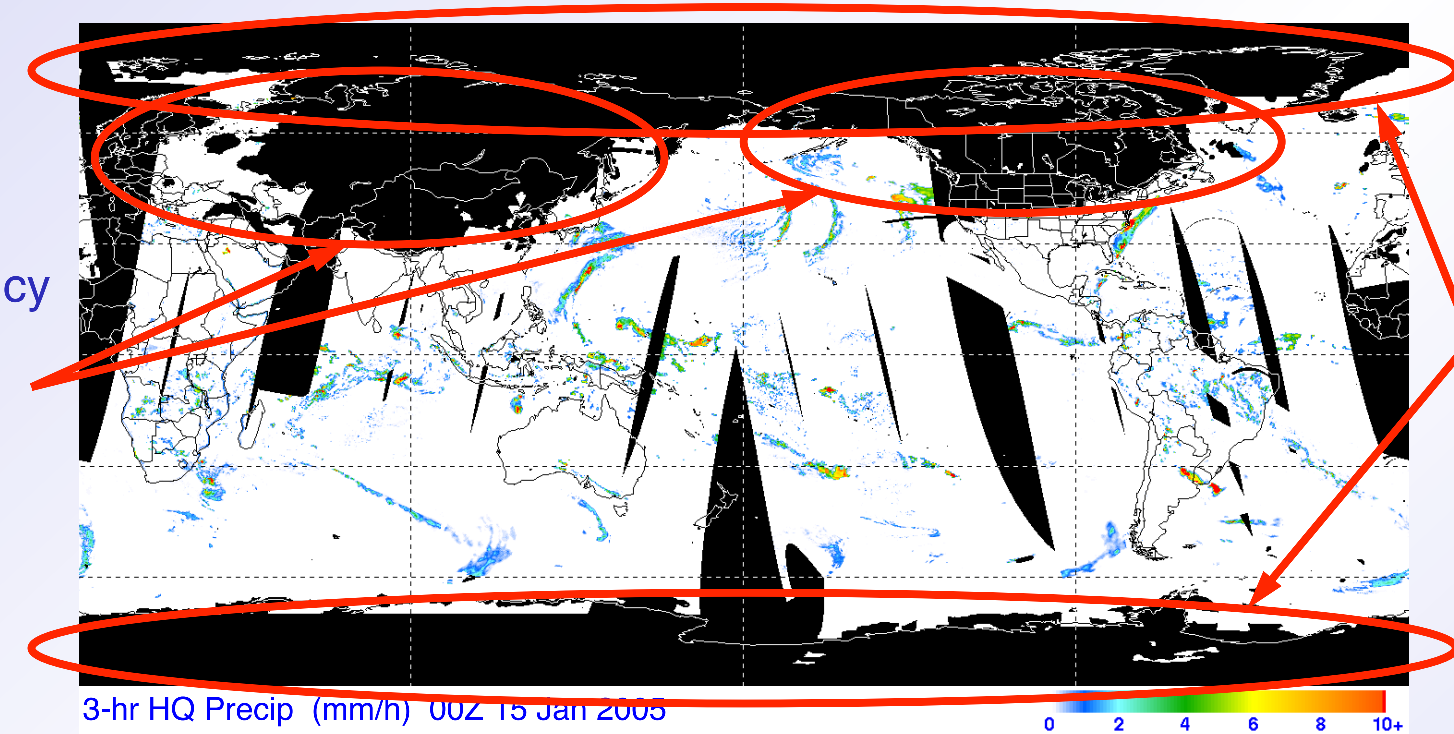
4. FUTURE – What Next?

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

- implement a high-latitude scheme
  - leo-IR–based displacement vectors
  - develop high-latitude precip estimates — science project
  - calibration schemes for high-latitude precip estimates
- use sub-monthly (daily, pentad, or dekad) gauge analyses
- parallel observation-model combined product
- alternative scheme for computing displacement vectors
- address cloud growth — science project
- shorter-interval estimates to reduce sampling issues
- 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

4. FUTURE – Outstanding Issues

snowy/icy places that people live



polar regions in general

High-quality estimates in snowy/icy regions

- not yet operational
- when snow estimates appear, we hope they will work with legacy sensors, at least back to the start of AMSU in 2000

5. FINAL COMMENTS

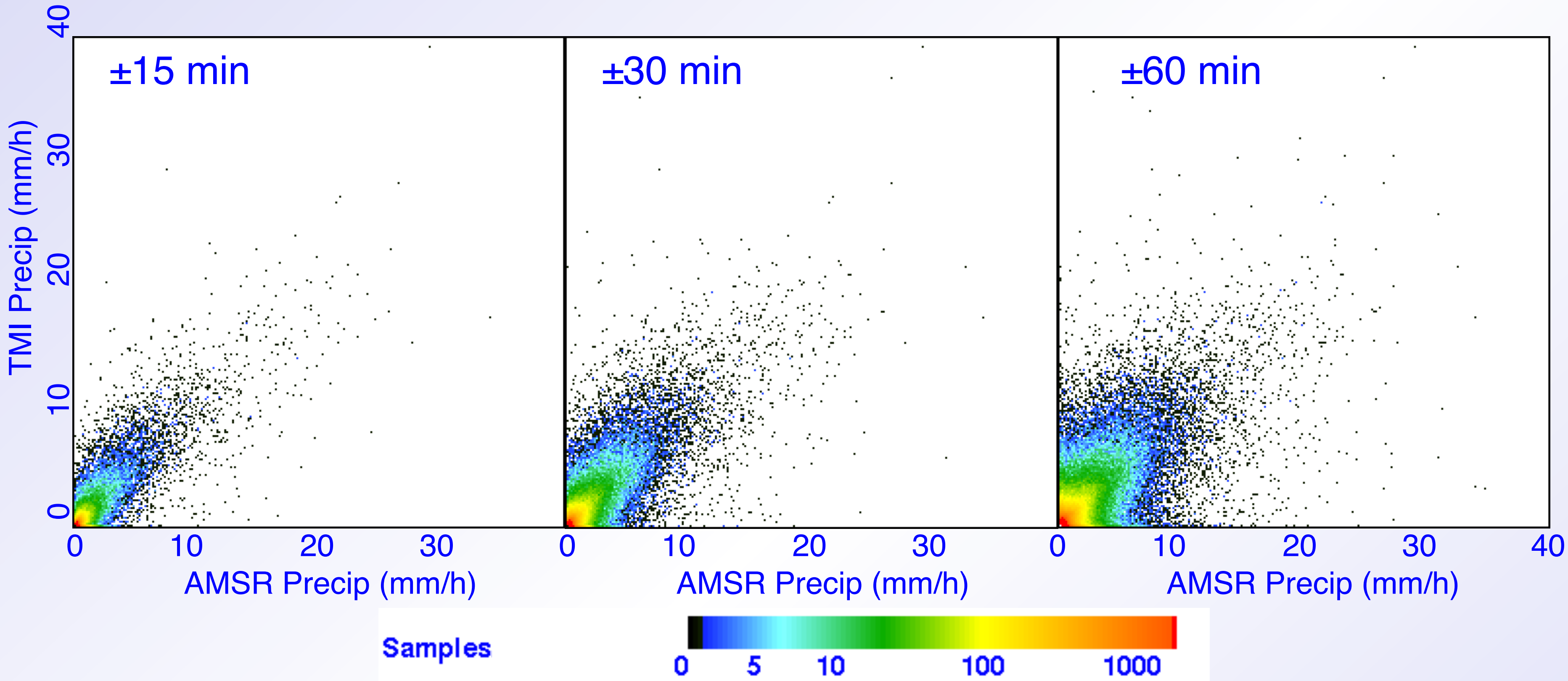
The day-1 GPM multi-satellite precipitation algorithm is planned as a unified U.S. algorithm

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

1. INTRODUCTION – Combination Concepts



The TMPA 3-hr time window for coincidence introduces error

- same 0.25° grid box for spatial coincidence
- ±15-, ±30-, ±60-minute windows of time coincidence
- spreading (particularly points near axes) result from advection into/ out of box and/or growth/decay
- time interpolation, such as morphing, helps avoid advection error

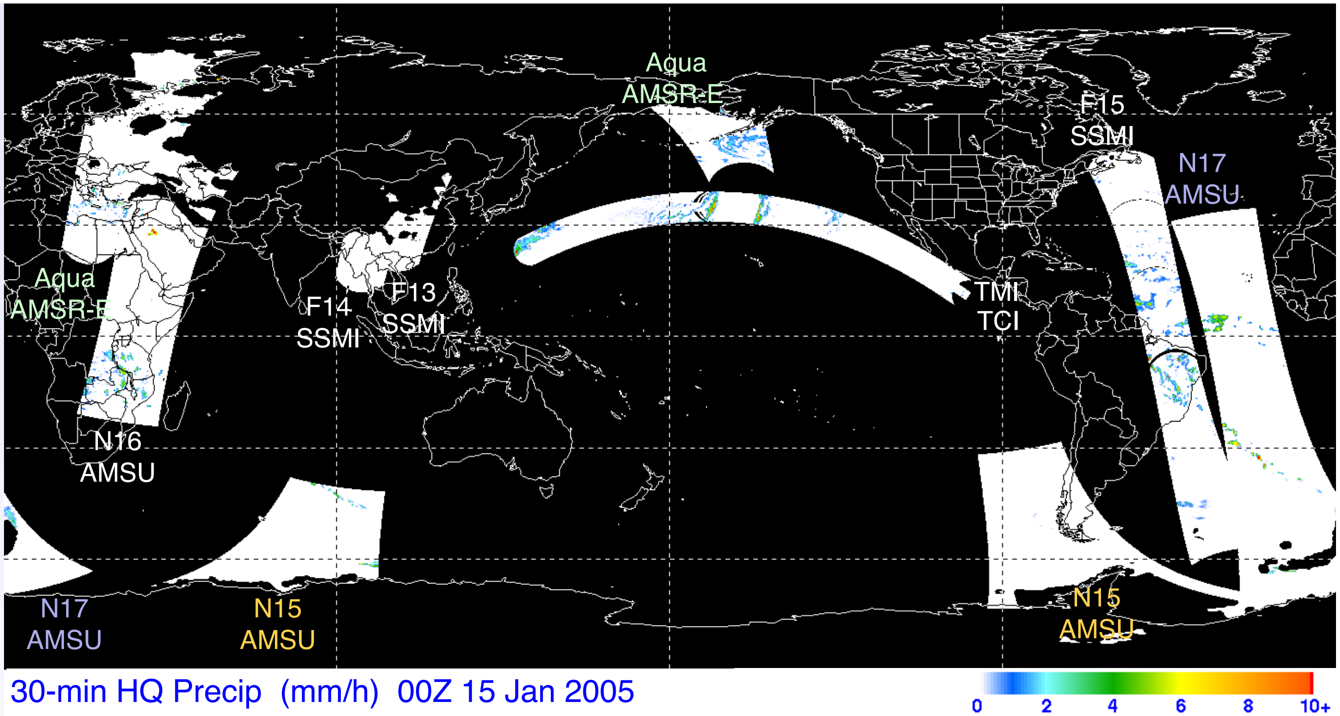
1. INTRODUCTION – Combination Concepts

The "good stuff" (microwave) is sparse

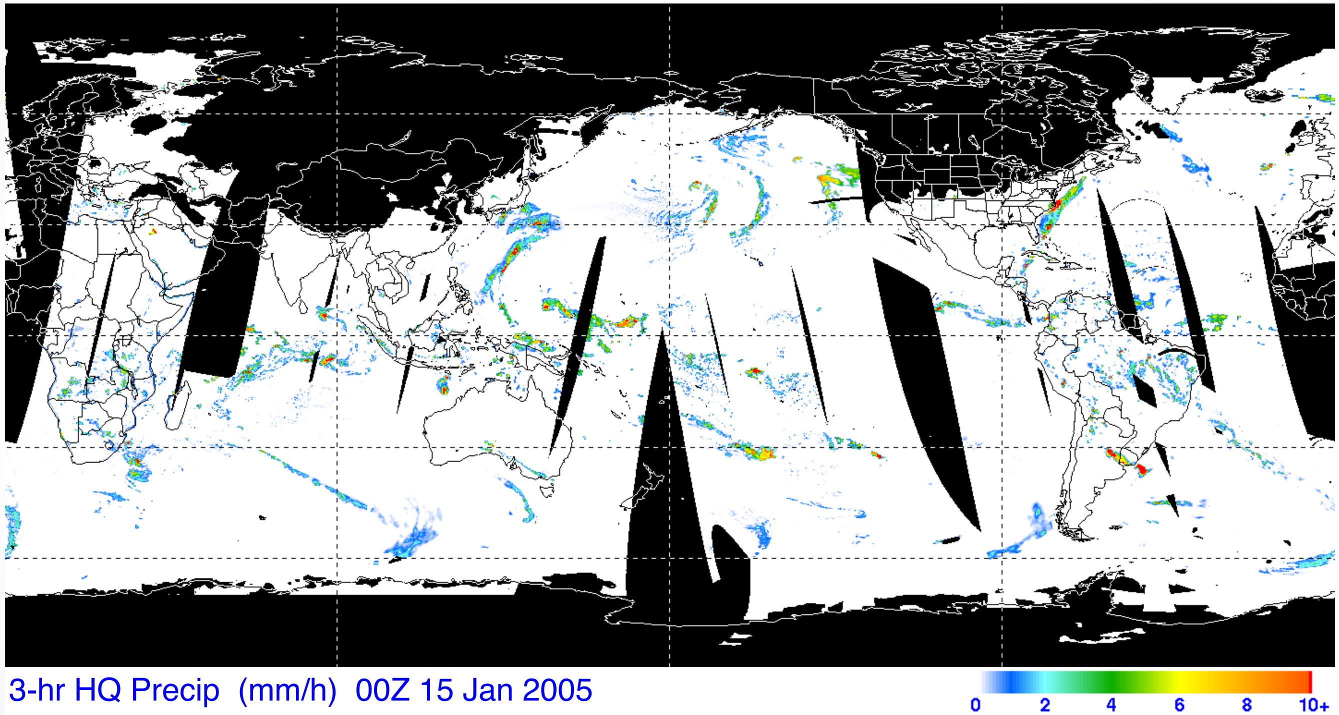
- 30 min has lots of gaps

Options:

- take a longer time span – TMPA (3-hr)
  - robust and simple
  - sparse-in-time data creates errors in time averages
  - users want a finer time interval



30-min HQ Precip (mm/h) 00Z 15 Jan 2005



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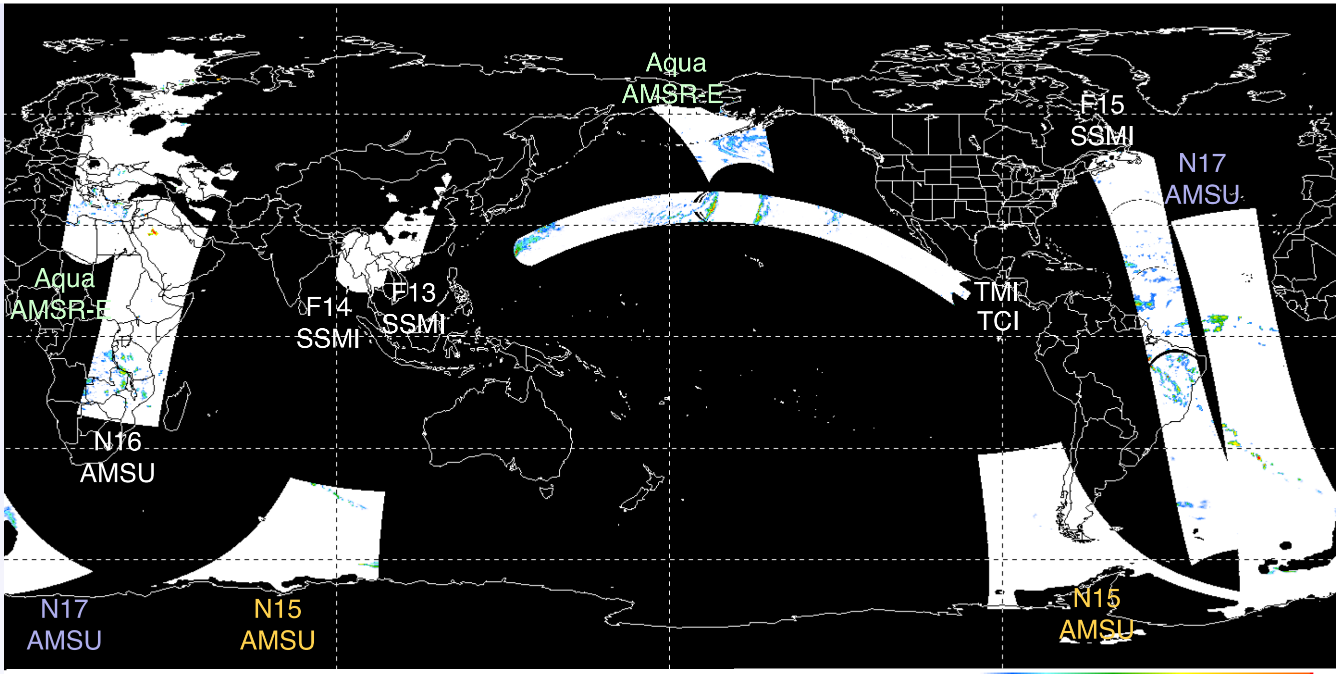
1. INTRODUCTION – Combination Concepts

The "good stuff", microwave, is sparse

- 30 min has <u>lots</u> of gaps

Options:

- take a longer time span – TMPA (3-hr)
- time-interpolate – CMORPH, GSMaP
  - needs to be lagrangian
  - good for ±3 hr
  - solves advection, but not growth/ decay



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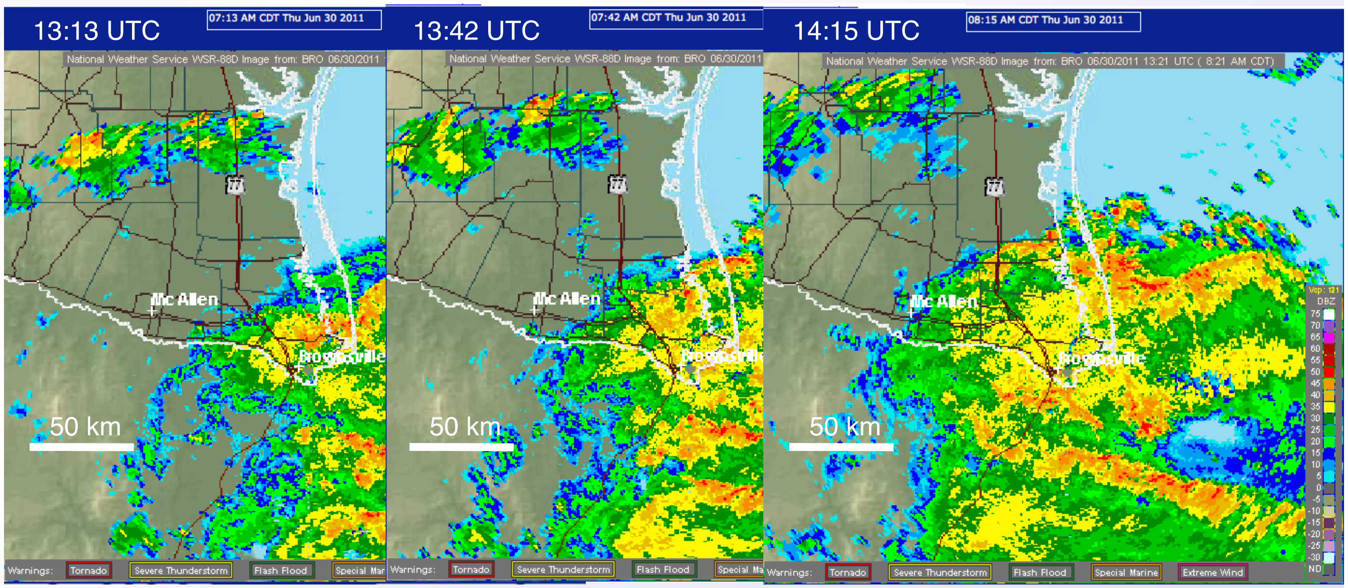

Brownsville, TX NWS radar – T.S. Arlene, 30 June 2011

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The “good stuff”, microwave, is sparse

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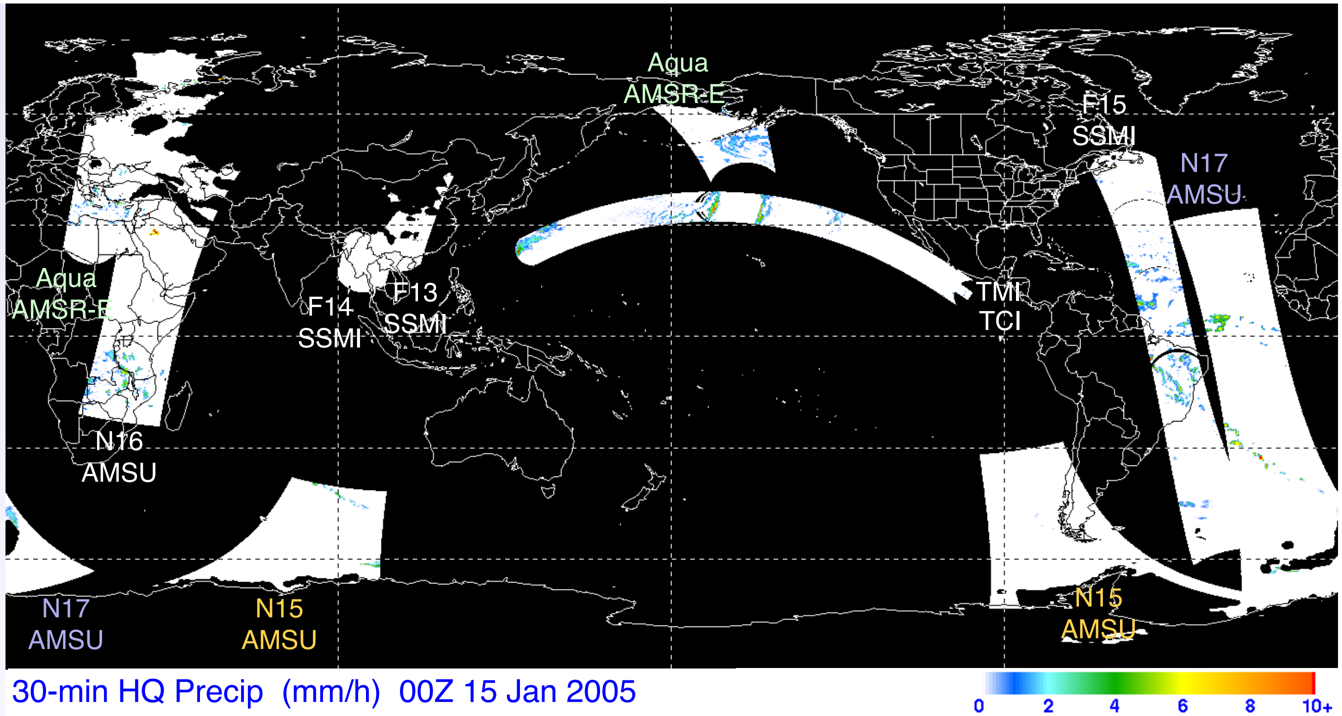
Options:

- take a longer time span – TMPA (3-hr)
- time-interpolate – CMORPH, GSMaP
- use geo-IR – PERSIANN, TMPA, variants of CMORPH
  - available every 30 min (or less)
  - lower quality
  - limited to tropics, subtropics



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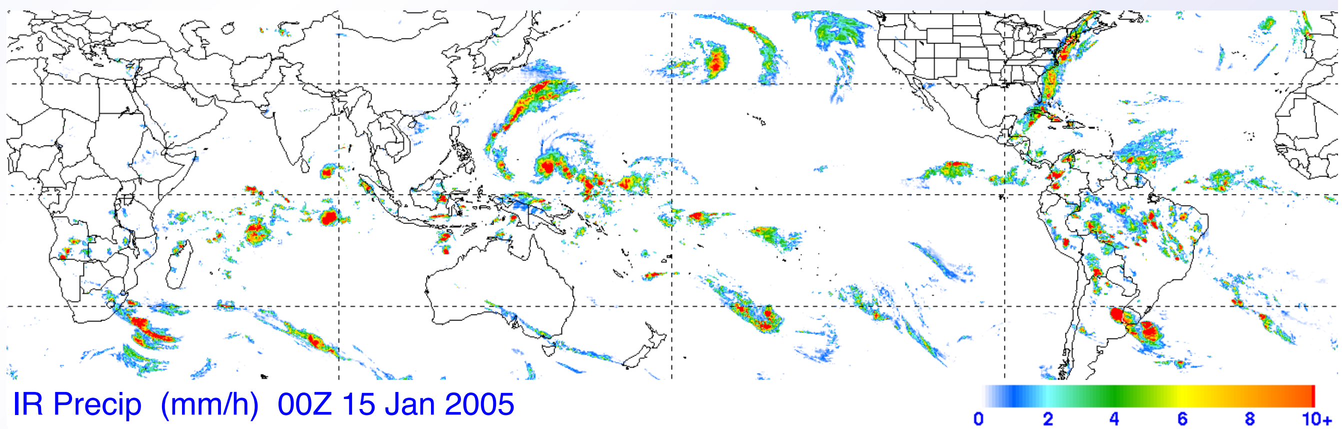

IR Precip (mm/h) 00Z 15 Jan 2005

2. IMERG DESIGN – The Next Generation

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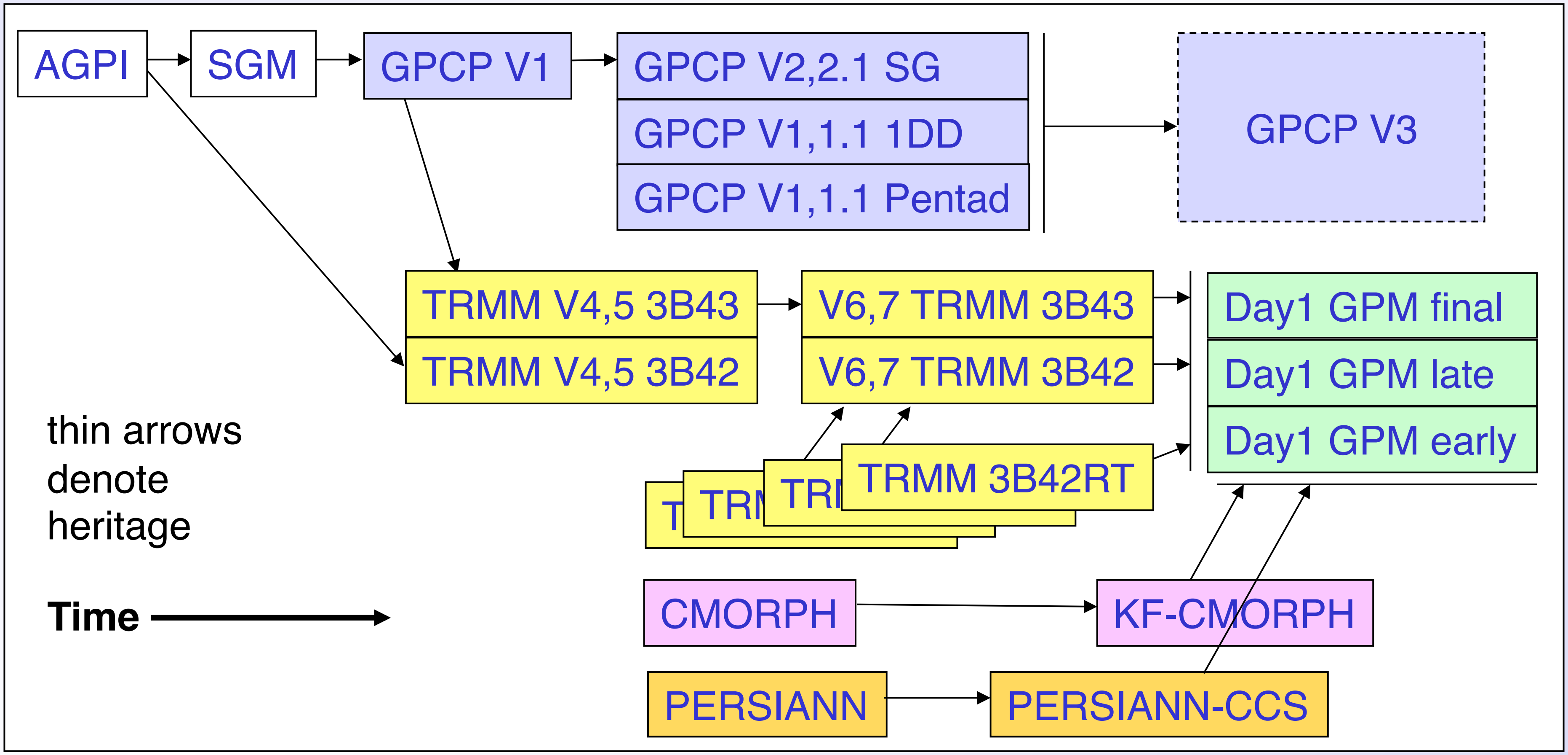

4. FUTURE – Outstanding Issues

Input data sources: alternative sensors and/or algorithms, high-latitude estimation, viewing angle corrections to geo-satellite data, sub-monthly rain gauge data sources, gauge coverage/location

Intercalibration of input data: the dilemma of merging estimates with varying low-end detectability limits and native Level 2 resolutions, channel sensitivities, and algorithm differences

Schemes for computing propagation vectors: assimilation or model winds or precipitation proxies; accounting for orographically forced storms

Error estimates for propagated precipitation fields ("decay functions"): possible sensitivity to weather regime (convective/stratiform, cold season, orographic, tropical cyclone)

Precip system initiation/decay between microwave overpasses from geo-satellite data as an additional input to the data merger step

Schemes for merging propagated fields: focus on the Kalman smoother (bidirectional Kalman filter)

Error estimation for input and final products: skill in the propagated fields is scale-dependent – small features lose skill first, but carrying them along is important if we want to maintain realistic histograms; errors partly depend on underlying surface and weather regime