Status of IMERG, the U.S. Multi-Satellite Algorithm

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1. INTRODUCTION

A diverse, changing, uncoordinated set of input **precip** (GPROF2014) estimates

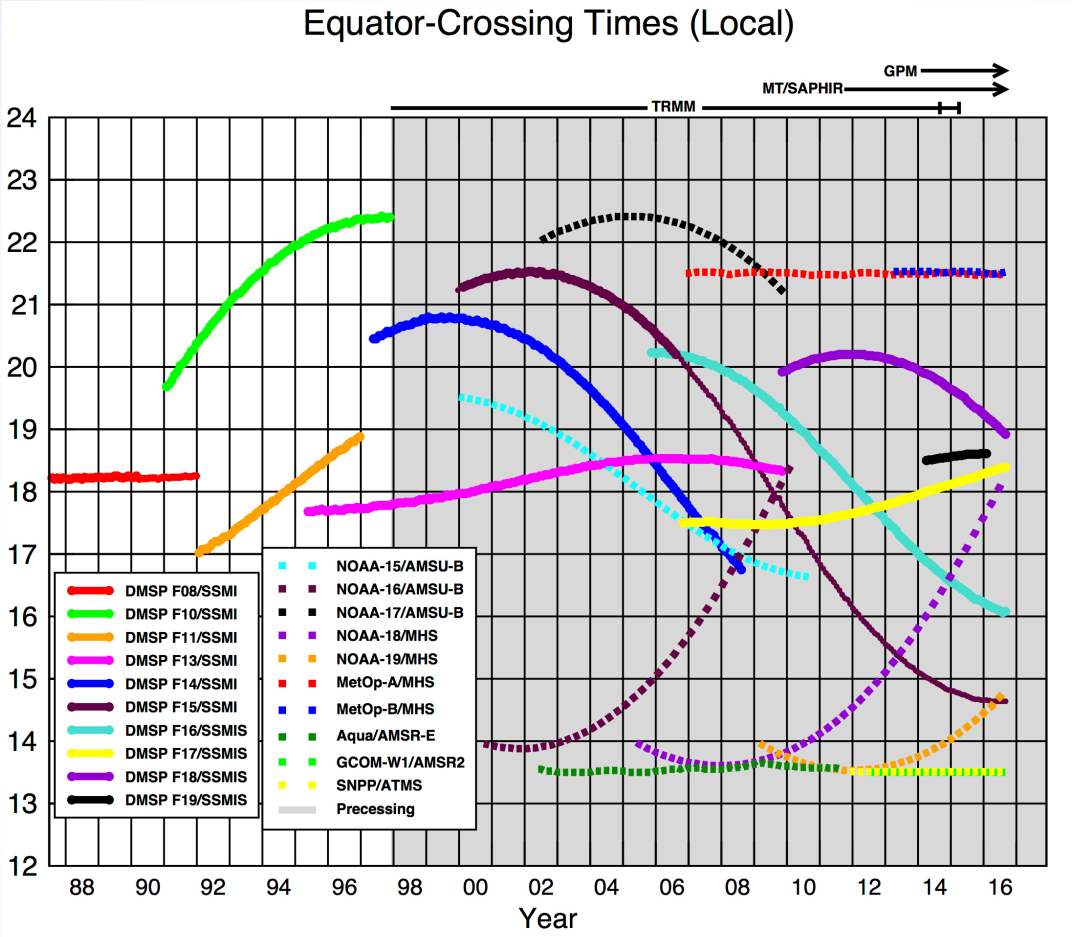
Goal: seek the longest, most detailed record of "global" precip

Integrated Multi-satellitE Retrievals for GPM (IMERG) is a High-Resolution Precipitation Product

- best snapshot precipitation
- not a Climate Data Record

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

- KF-CMORPH – NOAA
- PERSIAN-CCS – U.C. Irvine
- TMPA – NASA
- PPS production – NASA



Ascending passes (F08 descending); satellites depicted above graph precess throughout the day.
Image by Eric Nelkin (SSAI), 22 September 2016, NASA/Goddard Space Flight Center, Greenbelt, MD.

http://precip.gsfc.nasa.gov/times_allsat.jpg

2. IMERG Data Sets

Multiple runs accommodate different user requirements for latency and accuracy

- "Early" – 4-5(4) hours (flash flooding)
- "Late" – 15-15.5(12) hours (crop forecasting)
- "Final" – 3.5(2.5) months (research data)

Time intervals are half-hourly and monthly (Final only)

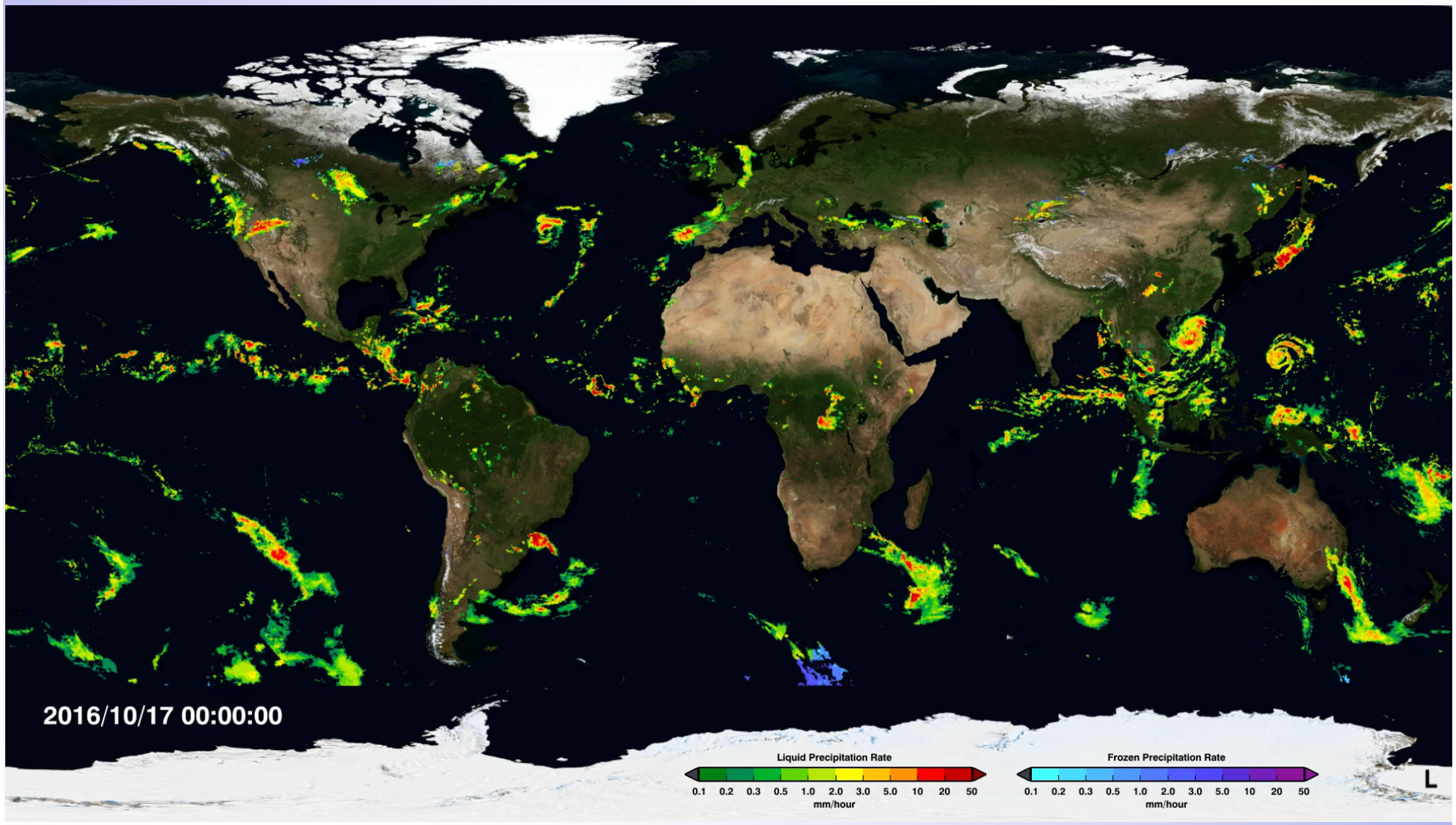
0.1° global CED grid

- PPS will provide subsetting by parameter and location
- initial release covers 60° N-S

	Half-hourly data file (Early, Late, Final)
1	*[multi-sat.] precipitationCal*
2	[multi-sat.] precipitationUncal
3	*[multi-sat. precip] randomError*
4	[PMW] HQprecipitation
5	[PMW] HQprecipSource [identifier]
6	[PMW] HQobservationTime
7	IRprecipitation
8	IRkalmanFilterWeight
9	*probabilityLiquidPrecipitation [phase]*
	Monthly data file (Final)
1	*[sat.-gauge] precipitation*
2	*[sat.-gauge precip] randomError*
3	GaugeRelativeWeighting
4	*probabilityLiquidPrecipitation [phase]*

3. EXAMPLE – Recent Week of Late/Early IMERG

Ending 161024 0730Z



[Courtesy Sci. Vis. Studio; http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4285]

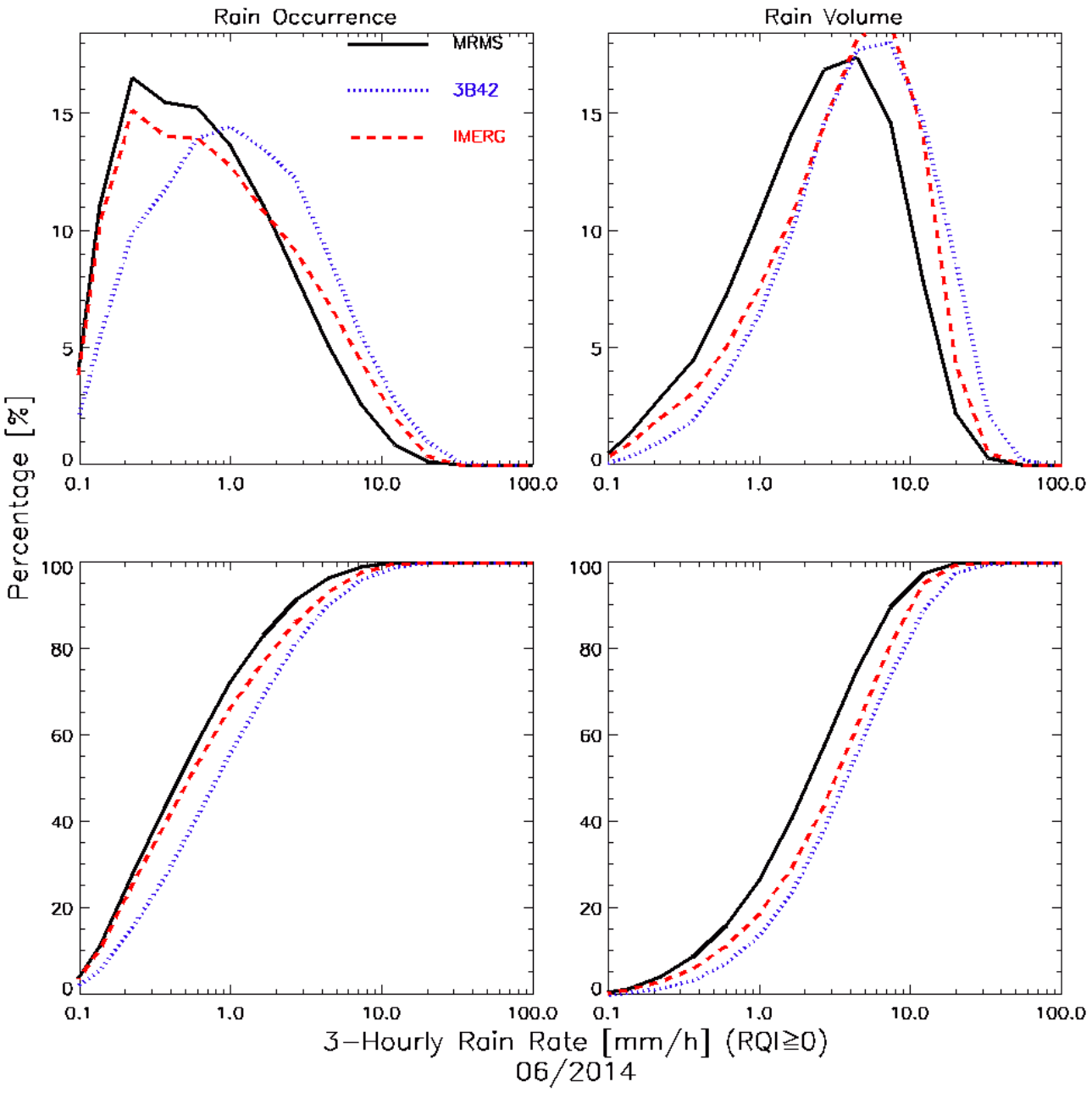
4. VALIDATION – 3-Hourly, 0.25° IMERG, 3B42, MRMS for 15 June 2014

IMERG better than 3B42 for precip occurrence

IMERG performs modestly better for precip volume

Note: Original footprint GPROF retrievals below 0.1 mm/hr are thresholded to zero

- how this affects IMERG depends on the resolution of the input sensor and subsequent averaging (here 0.25°)



[Courtesy J. Wang (SSAI; NASA/GSFC 612)]

4. VALIDATION – Half-Hourly V03 IMERG Sources and MRMS Grid

"Violin diagram" for individual sources inside the half-hourly IMERG estimates

- width shows relative contribution for each difference bin
- only showing the sources that get chosen
- restricted to "good" MRMS data

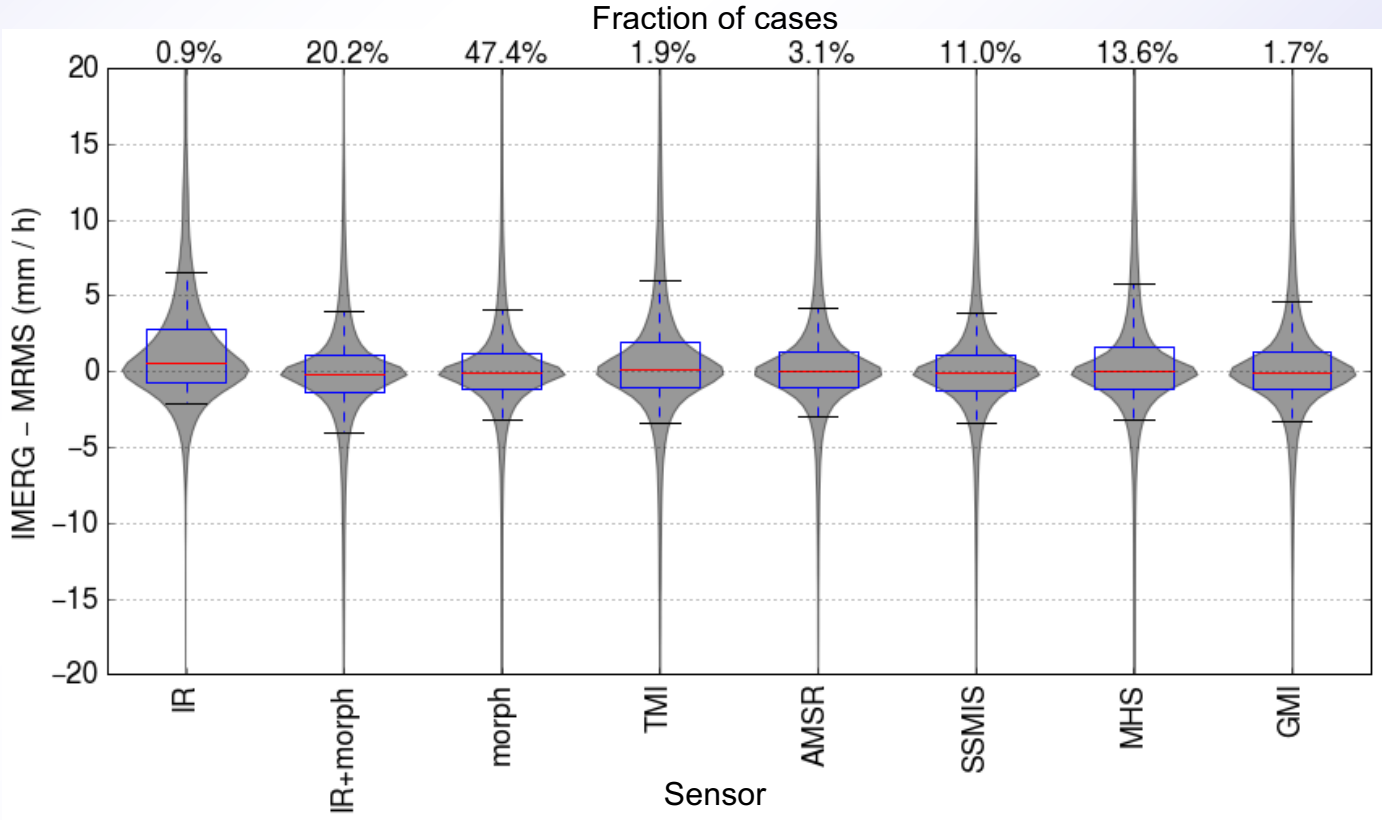
Unlike Pokomoke result I've shown earlier, not much difference

- many more samples
- diverse surfaces and climate regimes
- IR smearier

Mostly morphed!

No-PMW (interpolated) data are competitive with the PMW data

This is pre-launch calibration! the shift to Version 4 should give more consistency



[Courtesy J. Tan (UMBC; GSFC)]

June 2014–May 2015

4. VALIDATION – Half-Hourly IMERG vs MRMS Radar/Gauge Product 2-4 October 2015, South Carolina Floods

Actual accumulations of rain were up to 24”

- IMERG overestimated some totals by a factor of 2

This diagram focuses solely on heavy rain

All sensors are positively biased

- MHS is particularly biased due to an IMERG error
- “no PMW” (morphed and IR) is better
- again, low number of samples

This is pre-launch calibration! the shift to Version 4 should give more consistency

5. VERSION 4 IMERG – Upgrades

Use new Version 4 precip from sensors using GPROF2014v2 algorithm

Reduce Final Run latency from 3.5 to 2.5 months

- change how ancillary data are handled

Shift from static to dynamic calibration of PERSIANN-CCS by microwave precip

Extend gridders to 90° N-S

Reduce blockiness

- turn off volume adjustment in gauge analysis
- screen off-shore gauge influence
- spatially average GCI-GMI calibrations

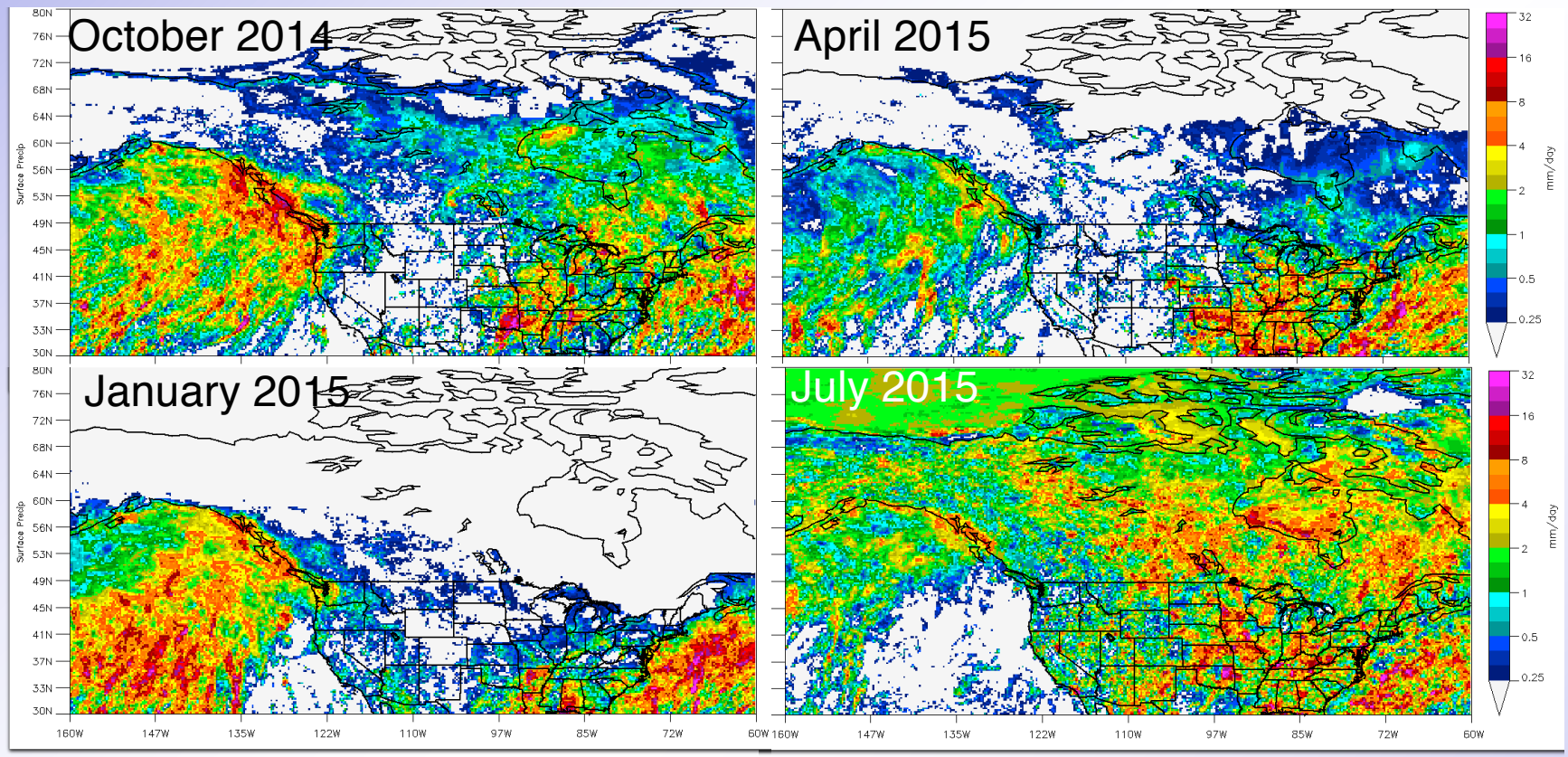
Correct bug that placed morphed values one gridbox south of actual location

- found thanks to a user's question

Adjust land and high-latitude ocean retrievals to the mean of GPCP

Calibrate all microwave sensors to 2BCMB using latest adjusted datasets

5. VERSION 4 IMERG – High-Latitude Seasons for GPROF2014V2 AMSR2



David Randel

Warm-season estimates appear useful at high latitudes

Input precip estimates are still deficient in snow/ice-covered surface regions

- still plan to screen out microwave estimates in snow/ice areas and use microwave-calibrated PERSIANN-CCS estimates

5. VERSION 4 IMERG – GPM Products Trend Low in the Extratropical Oceans

Version 4 GPM products similar (by design)

- Version 3 IMERG somewhat similar
  - Day 1 (pre-launch calibration)

GPCP is higher in the extratropics

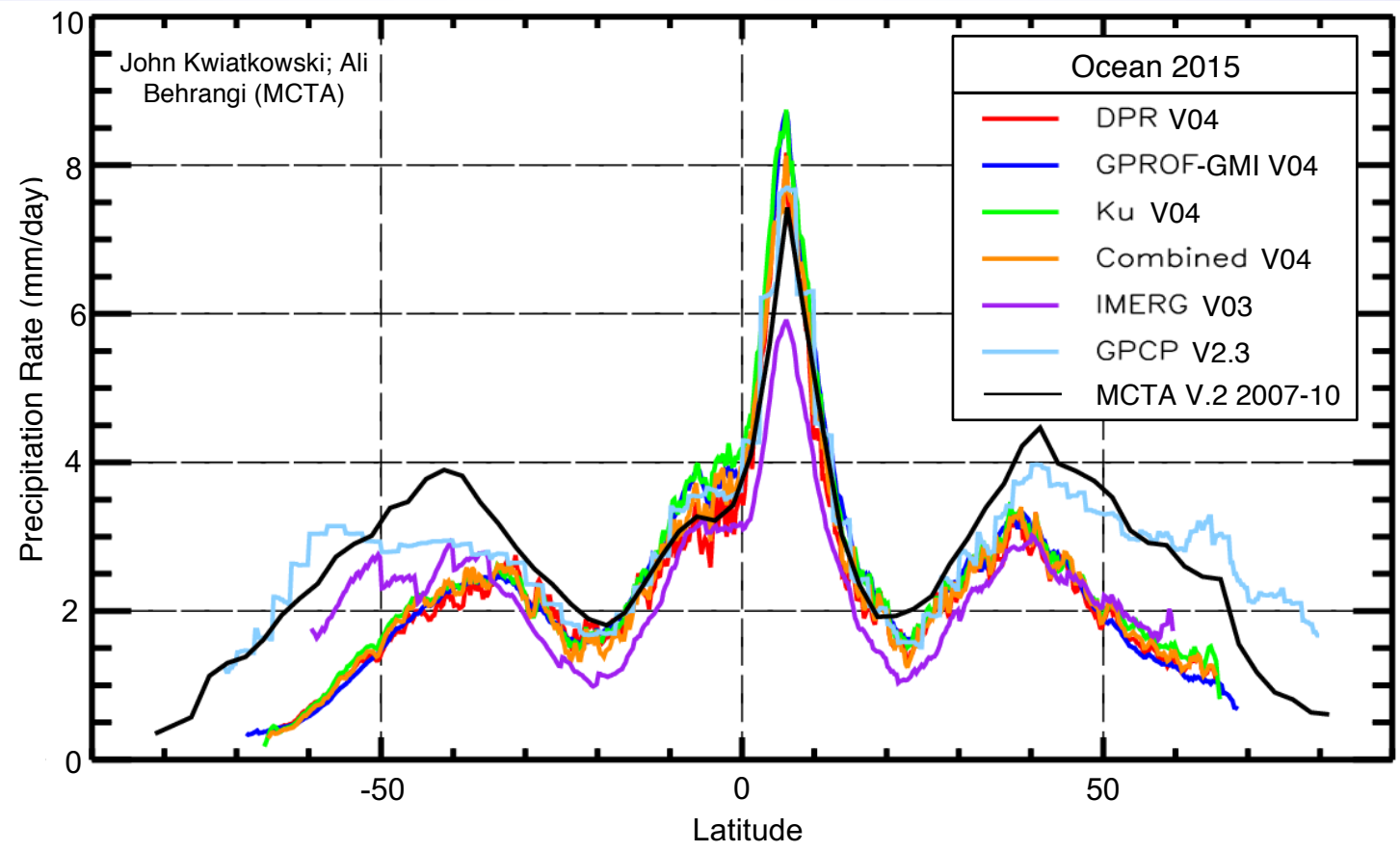
- new Version 2.3 close to global water cycle balance in NEWS

Behrangi Multi-satellite CloudSat, TRMM, Aqua product

- includes rain, snow, mixed
- roughly agrees with GPCP at high latitudes
- higher in mid-latitudes

Adjust high-lat. ocean to GPCP in Version 4

- allows seasonal calibration
- keep 2BCMB "as is" in 35° N-S



5. VERSION 4 IMERG – Calibration to GPCP over Land Introduces (Average) Gauge Bias

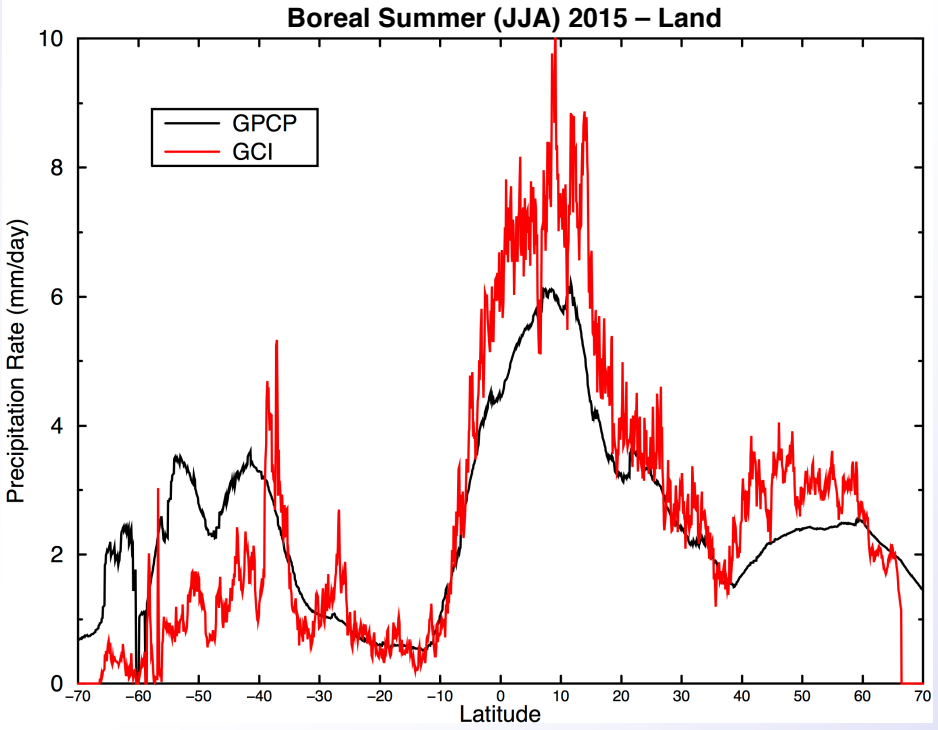
2BCMB is

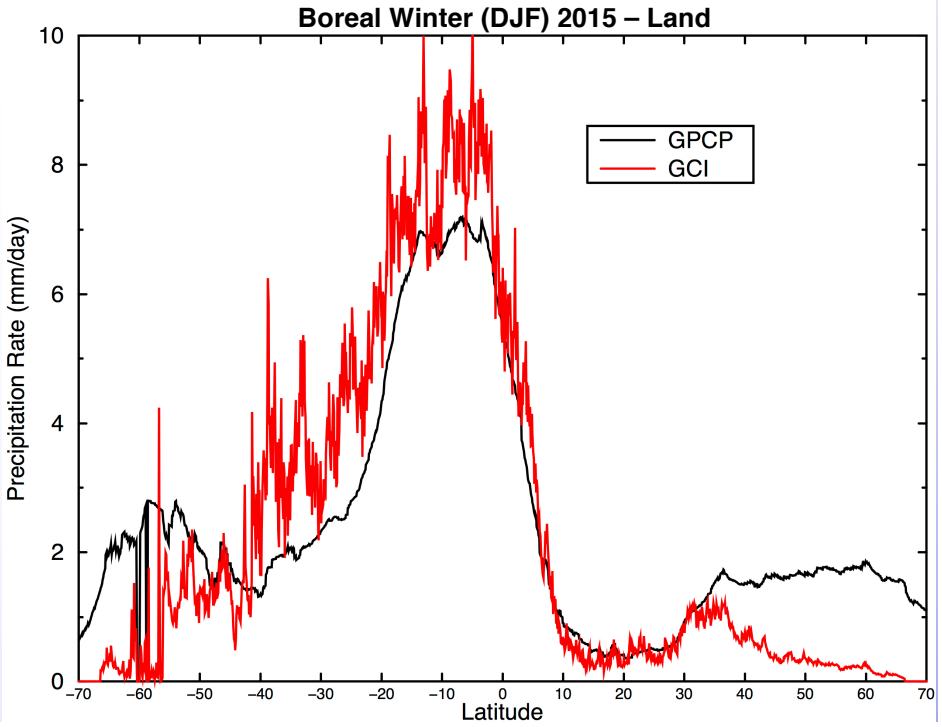
- high in the deep tropics and summer
- low in winter
  - zonal average obscures near-total drop- out in snow/ice-covered regions
  - adjustments tuned to “reasonable” behavior in non-snow/ice-covered regions

Still dealing with a very sparse sample for calibration

We are still doing gauge-based adjustment at the end, so this is just a first cut at the “right” adjustment

- unlike the ocean, where no gauge adjustment is possible





6. FUTURE – Transitioning from TRMM to GPM

Version 3 IMERG is available, new versions are coming

- V.3 Final Run from mid-March 2014 to February 2016
- V.3 Late Run from 7 March 2015
- V.3 Early Run from 1 April 2015
- Late November 2016: Version 4, first GPM-based IMERG, March 2014–present
- Mid-2017: Version 5 IMERG, March 2014–present
- Late 2017: TRMM V.8/GPM V.5 TRMM/GPM-based IMERG archive, 1998–present

What happened to TMPA when the TRMM satellite de-orbited?

- PR products stopped 8 October 2014
- TMI was shut down 8 April 2015
- TMPA-RT uses climatological calibration, so continues to run "as is"
- production TMPA partly depended on PR for calibration
  - production switched to climatological calibration with October 2014
  - gauge calibration over land should continue to yield consistent results
  - climatological calibration over ocean is likely to cause a discontinuity
- plan to continue TMPA into Winter 2017-18 to support users
  - loss of server or legacy sounder estimates could raise issues

6. FUTURE – The Big Challenges in Multi-Satellite

Extending the analysis to the poles

Estimating the fine-scale errors

- perhaps express “expert” estimate as quantiles
- then the grand challenge is aggregating the errors in space/time
- also need a “simple” quality index

Precipitation system growth and decay

Orographic enhancement

Accounting for differences in what different sensors “see”

Creating a merged observation-model product

Creating an NWP-based assimilation system

6. FUTURE – And Further Down the Road …

It takes a llooonng time to develop missions

Core Observatory fuel should last 10-15+ years

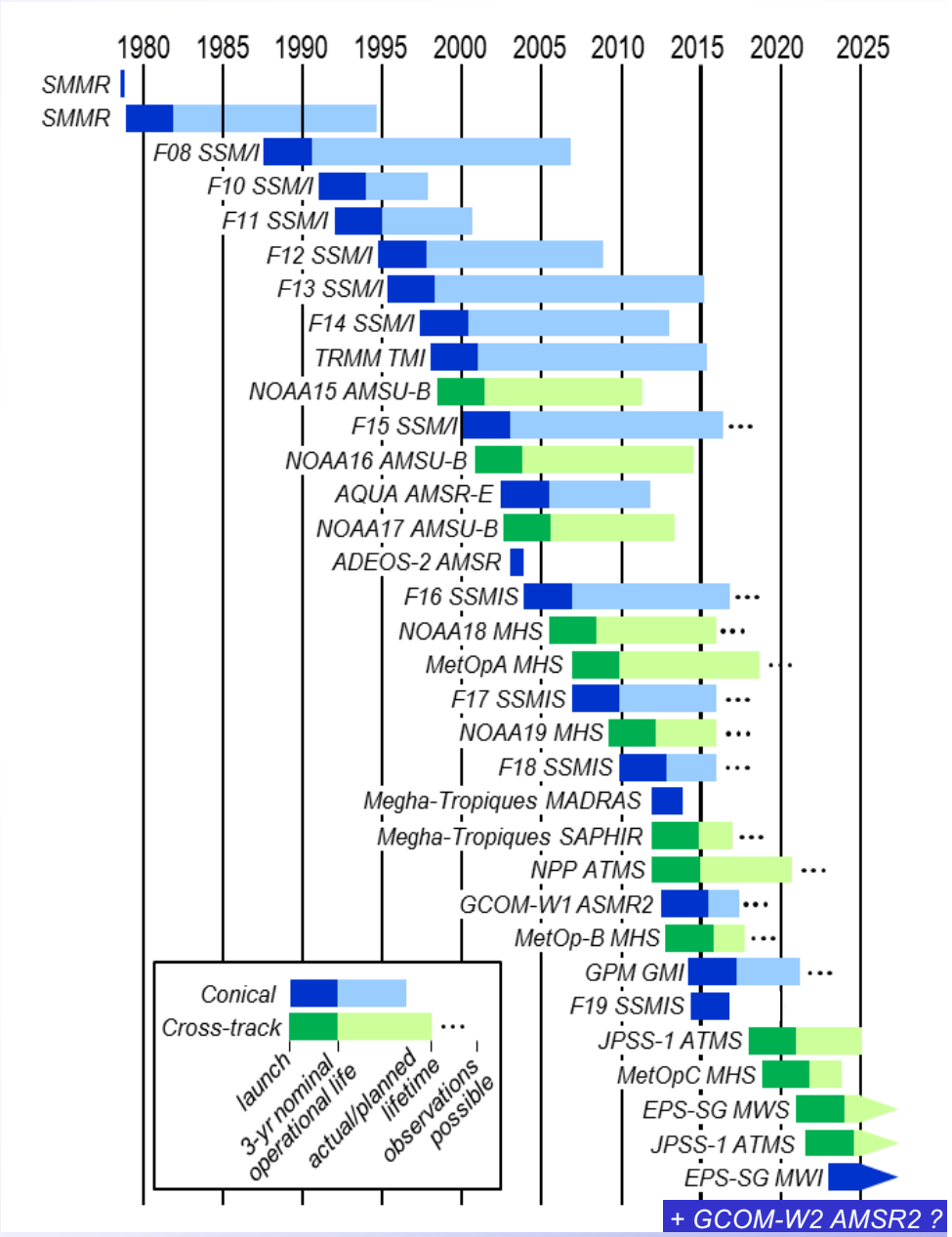
- but something could break

What will be the key research topic in 10-15 years? [Decadal Survey]

- Clouds and Precipitation Processes

Users assume that the agencies will maintain the microwave constellation and keep providing data for societal benefits

- many fewer launches planned
- need to recognize and support multi-disciplinary uses
- new generation of smaller sensors?
- alternatives of small sats or geo sats have to satisfy requirements



[Courtesy C. Kidd (ESSIC; GSFC)]

7. FINAL COMMENTS

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

IMERG is available as Version 3

- Final Run for mid-March 2014 to January 2016
- Late Run starts 7 March 2015
- Early Run starts 1 April 2015
- GPM era reprocessed in November 2016 as Version 4
- TRMM-GPM eras reprocessed in late 2017
- TMPA to be run until Winter 2017-18

Even the Day-1 (Version 3) datasets are typically an improvement over TMPA

The future holds some “interesting” challenges, technical and institutional

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Reserve Slides

2. IMERG DESIGN – Processing

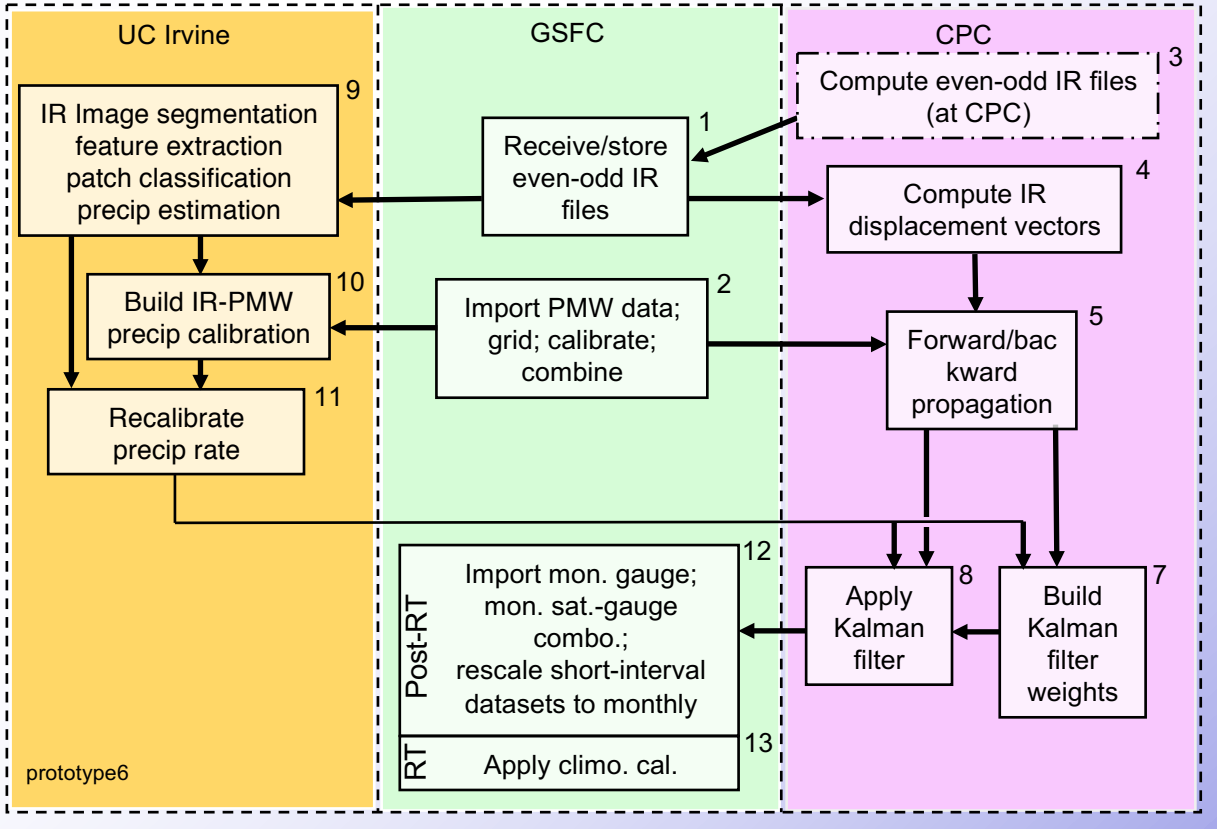
IMERG is a unified U.S. algorithm that takes advantage of

- 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

The Japanese counterpart is GSMaP

Institutions are shown for module origins, but

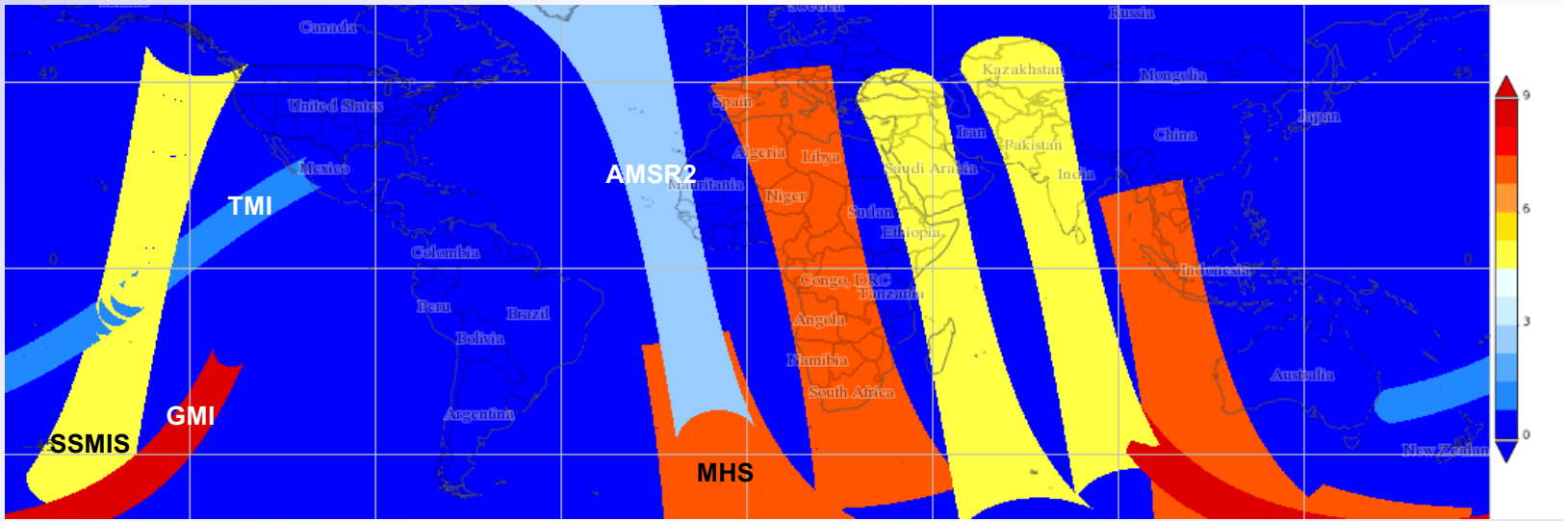
- package will be an integrated system
- goal is single code system appropriate for near-real and post-real time
- "the devil is in the details"



3. EXAMPLES – Data Fields from IMERG Test Data

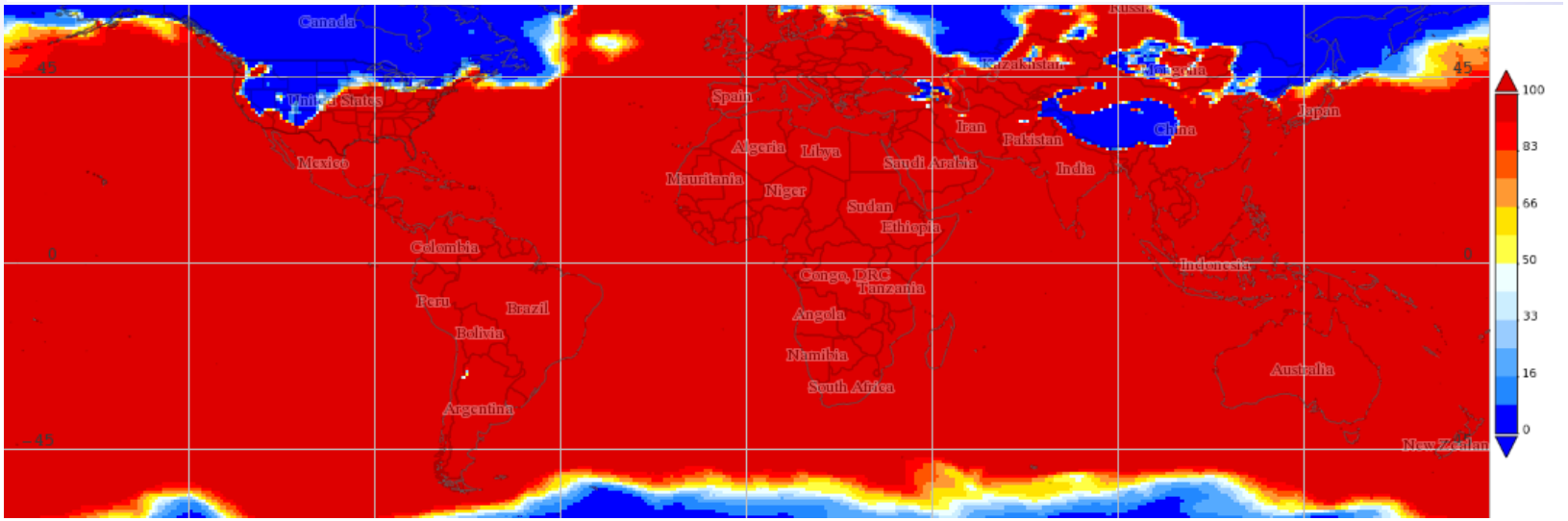
PMW sensor contributing the data, selected as imager, then sounder, then closest to center time

1430-1500Z 3 April 2014



[PMW] HQprecipSource [identifier]

<u>probability</u> that precipitation <u>phase</u> is <u>liquid</u>; <u>diagnostic</u> computed from ancillary data



probabilityLiquidPrecipitation [phase] (%)