

# NASA Precipitation Datasets for High-Latitude Applications

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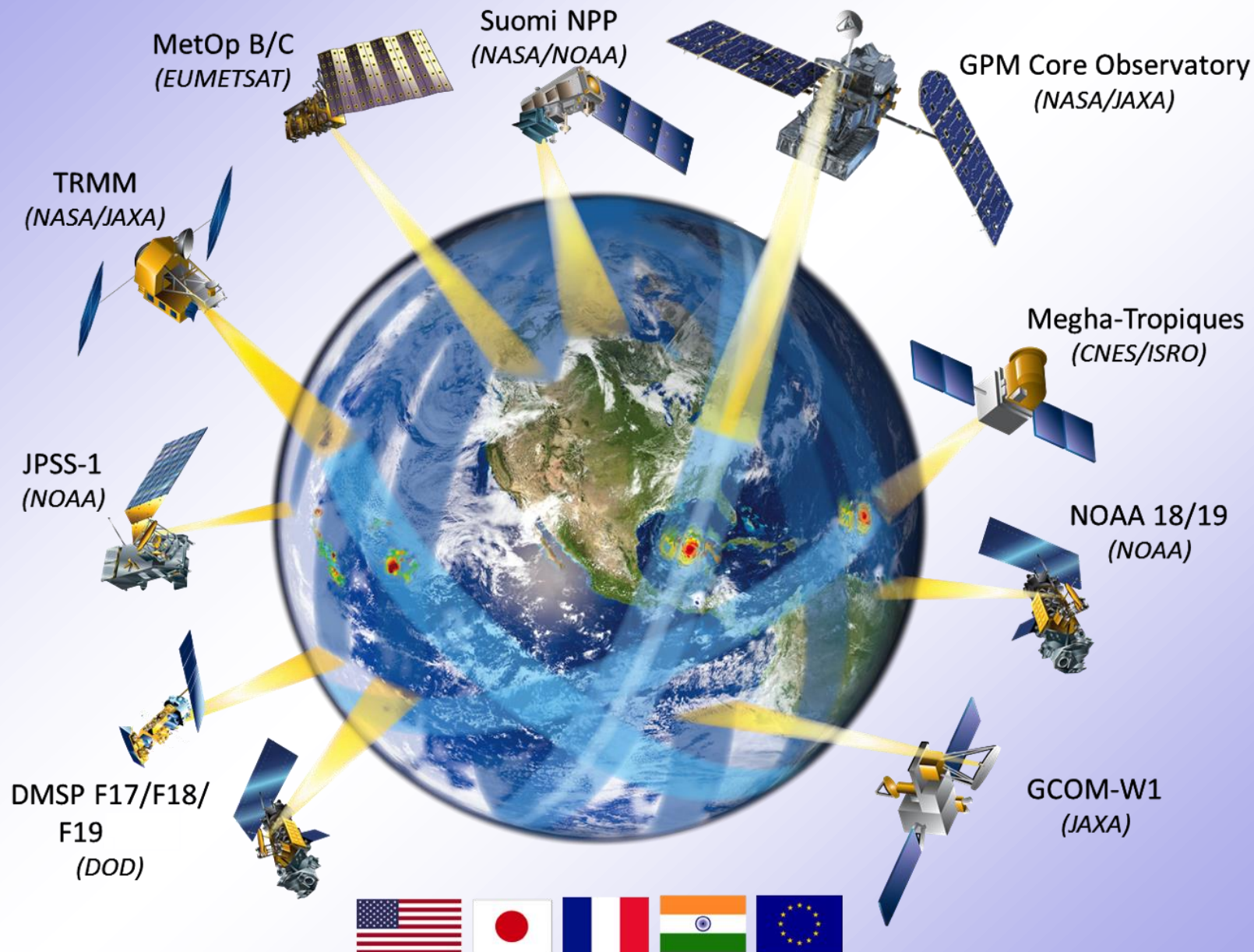
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(5) NOAA/NWS Climate Prediction Center

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# Global Precipitation Measurement (GPM) Mission



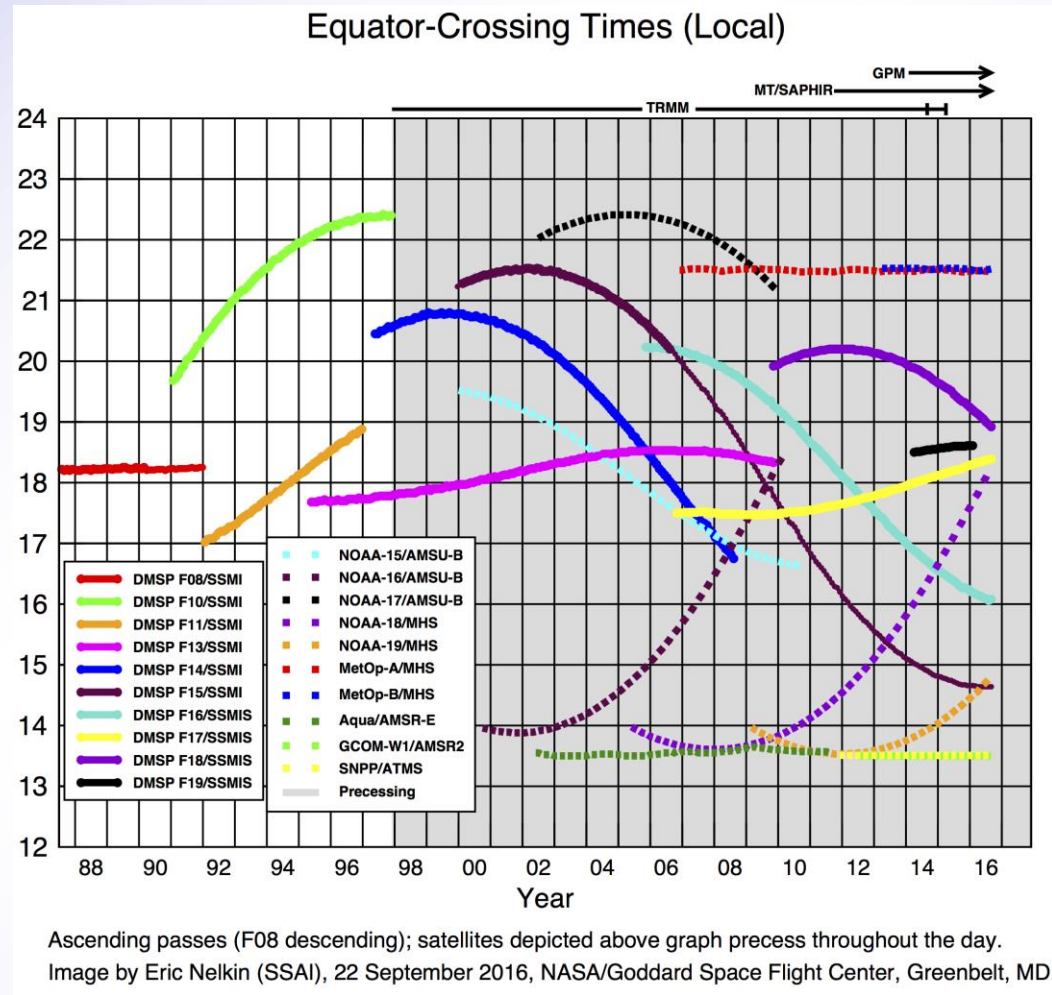
# 1. INTRODUCTION

Input precip (GPROF2014)  
estimates from a diverse, changing,  
uncoordinated set of satellites

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

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
- PPS (input data assembly,  
processing environment) –  
NASA



## 2. IMERG DESIGN – Data Sets

Multiple runs accommodate different user requirements for latency and accuracy

- “Early” – 5(4) hr (flash flooding)
- “Late” – 15(12) hr (crop forecasting)
- “Final” – 2.5 months (research)

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

0.1° global CED grid

- merged microwave precip 90° N-S
- morphed precip 60° N-S for now
- probability of liquid precip 90° N-S

User-oriented services by archive sites

- interactive analysis (GIOVANNI)
- alternate formats (TIFF files, ...)
- area averages
- and SPoRT!

In V05

	<b><i>Half-hourly data file (Early, Late, Final)</i></b>
1	<i>[multi-sat.] precipitationCal</i>
2	<i>[multi-sat.] precipitationUncal</i>
3	<i>[multi-sat. precip] randomError</i>
4	<i>[PMW] HQprecipitation</i>
5	<i>[PMW] HQprecipSource [identifier]</i>
6	<i>[PMW] HQobservationTime</i>
7	<i>IRprecipitation</i>
8	<i>IRkalmanFilterWeight</i>
9	<i>[phase] probabilityLiquidPrecipitation</i>
1 0	<i>precipitationQualityIndex</i>
	<b><i>Monthly data file (Final)</i></b>
1	<i>[sat.-gauge] precipitation</i>
2	<i>[sat.-gauge precip] randomError</i>
3	<i>GaugeRelativeWeighting</i>
4	<i>probabilityLiquidPrecipitation [phase]</i>

### 3. VERSION 04 IMERG – Upgrades

Use new Version 04 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 2BCMB-GMI calibrations

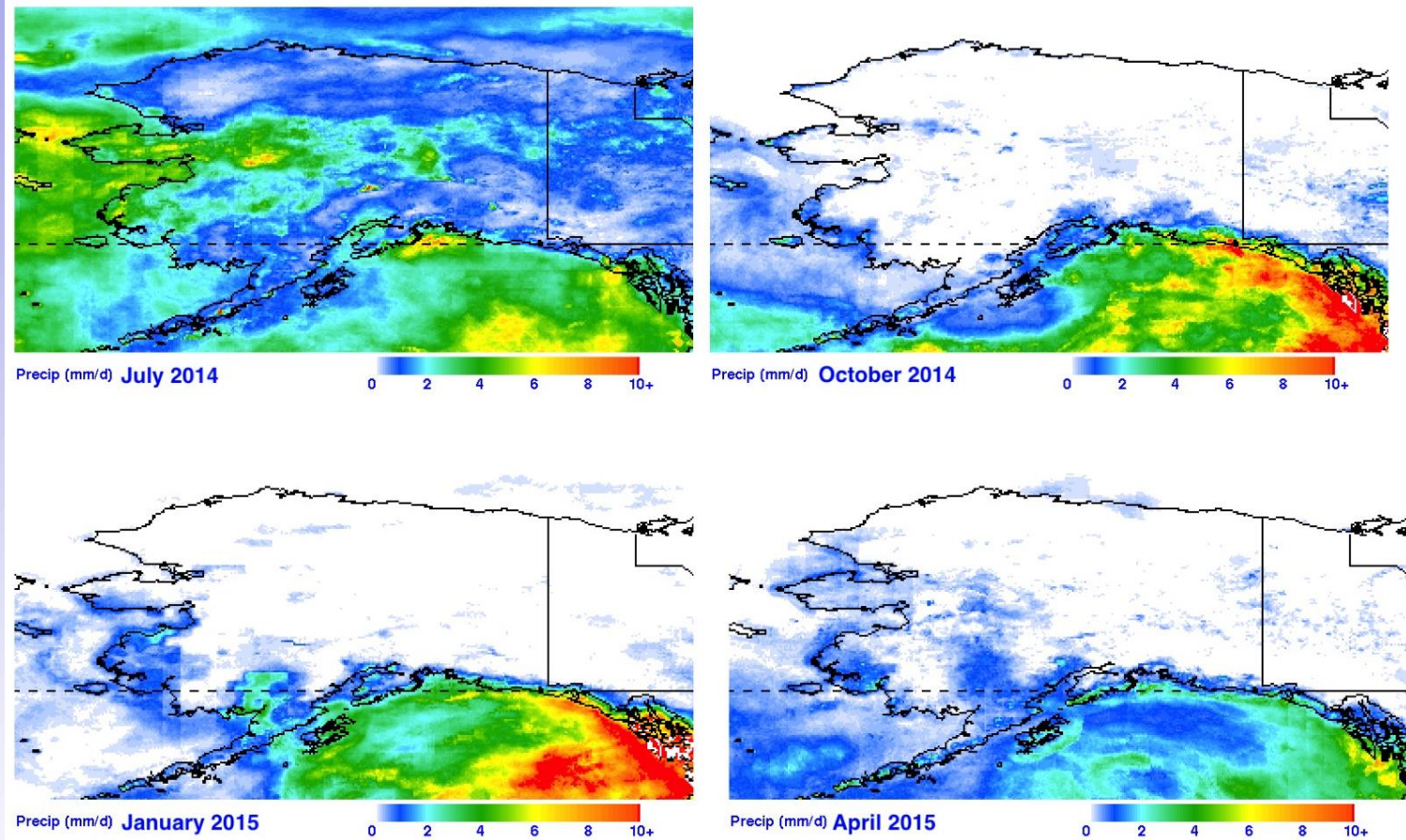
Correct bug that placed morphed values one gridbox south of actual location

- found thanks to a user's question

Adjust 2BCMB to the zonal-mean GPCP (land and ocean, except low-latitude ocean)

Calibrate all microwave sensors to 2BCMB

### 3. VERSION 04 IMERG – High-Latitude Seasons for Merged Microwave (HQ)



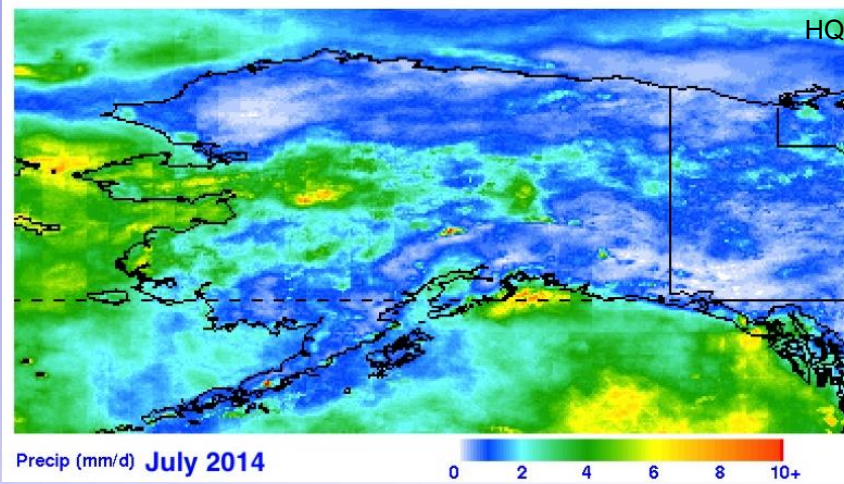
David Bolvin

Warm-season estimates appear useful at high latitudes

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

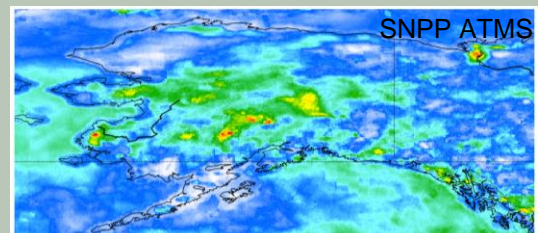
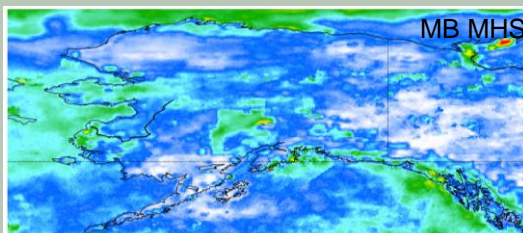
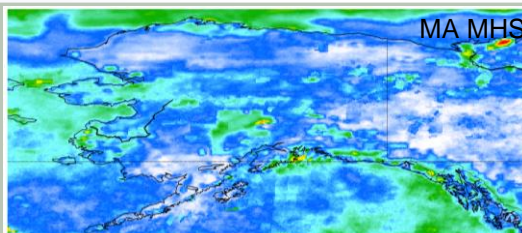
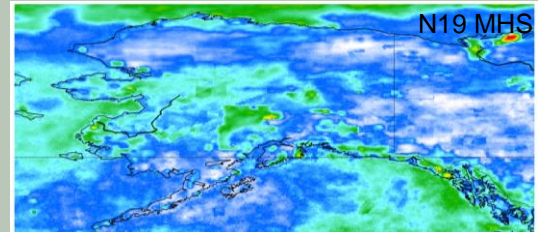
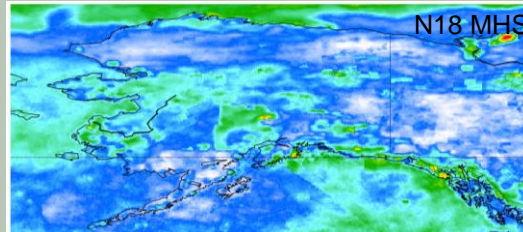
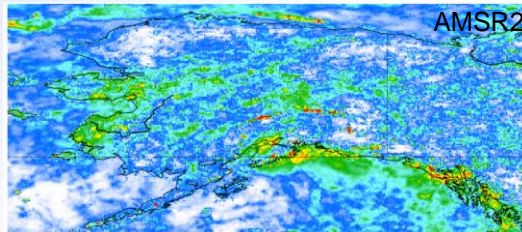
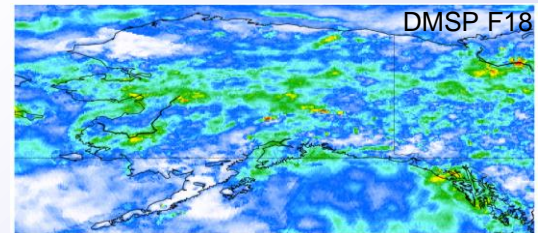
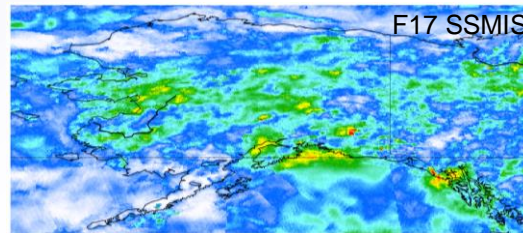
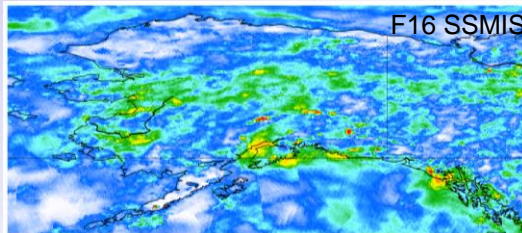
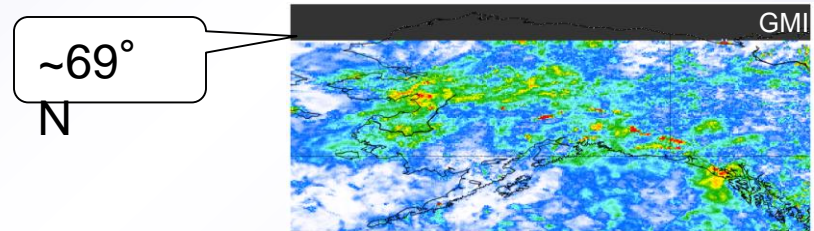
- still screening out microwave estimates in snow/ice areas and use microwave-calibrated PERSIANN-CCS estimates

### 3. VERSION 04 IMERG – Individual Sensors, July 2014



Retrievals reflect sensor types

- cross-track scanners smoother than conical scanners
- some systematic coastal issues

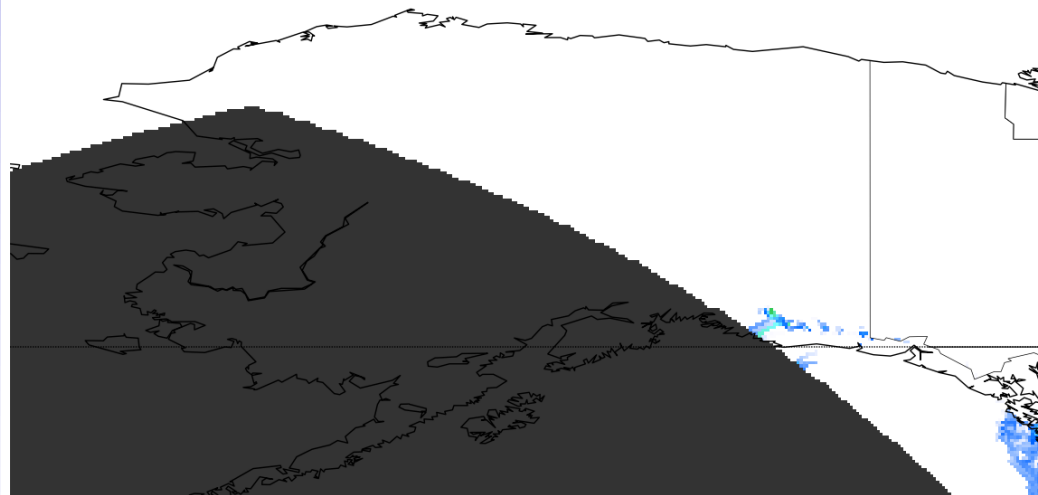


### 3. VERSION 04 IMERG – Individual Sensors, July 2014

Above 60° there is no morphing, only the half-hourly “HQ” merged microwave

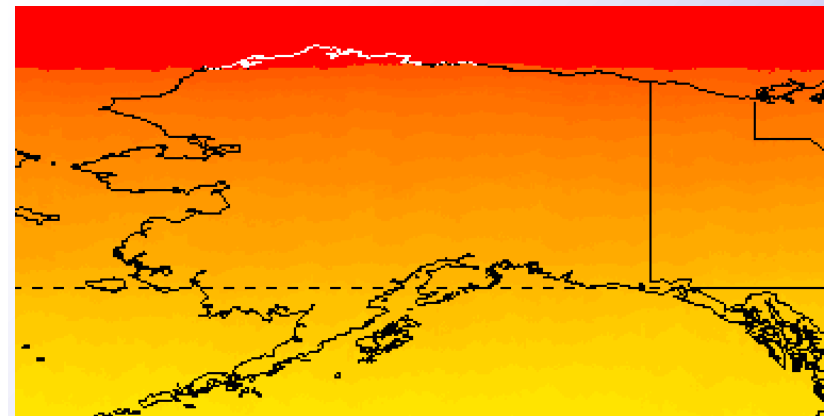
- coverage is about half the times around the day, on the average
- the flashing in and out is hard to watch, but
- accumulations (say, daily) should be useful

IMERG Final HQ Precipitation



0000Z 2014 03 12

Precipitation Rate (mm/day)



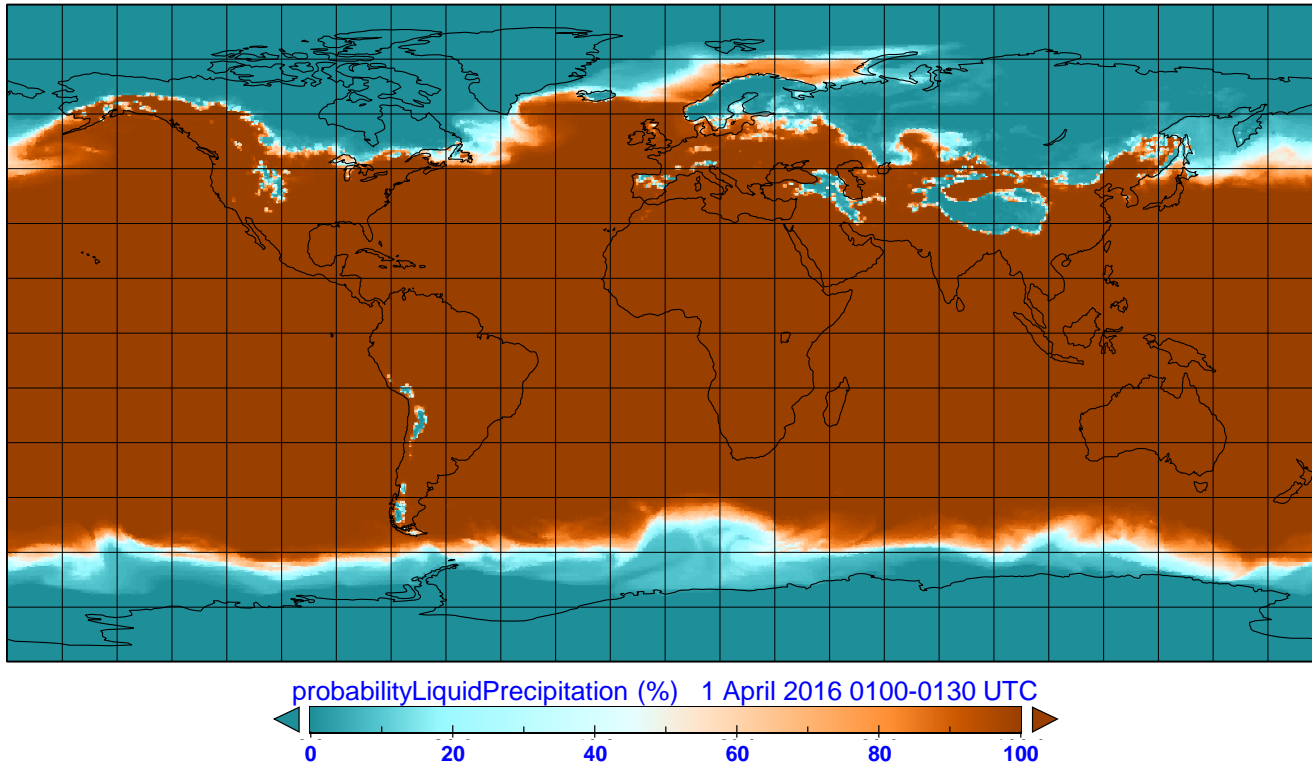
Number of Overpasses July 2014 0 200 400 600 800 1000+

1488 half hours in the month

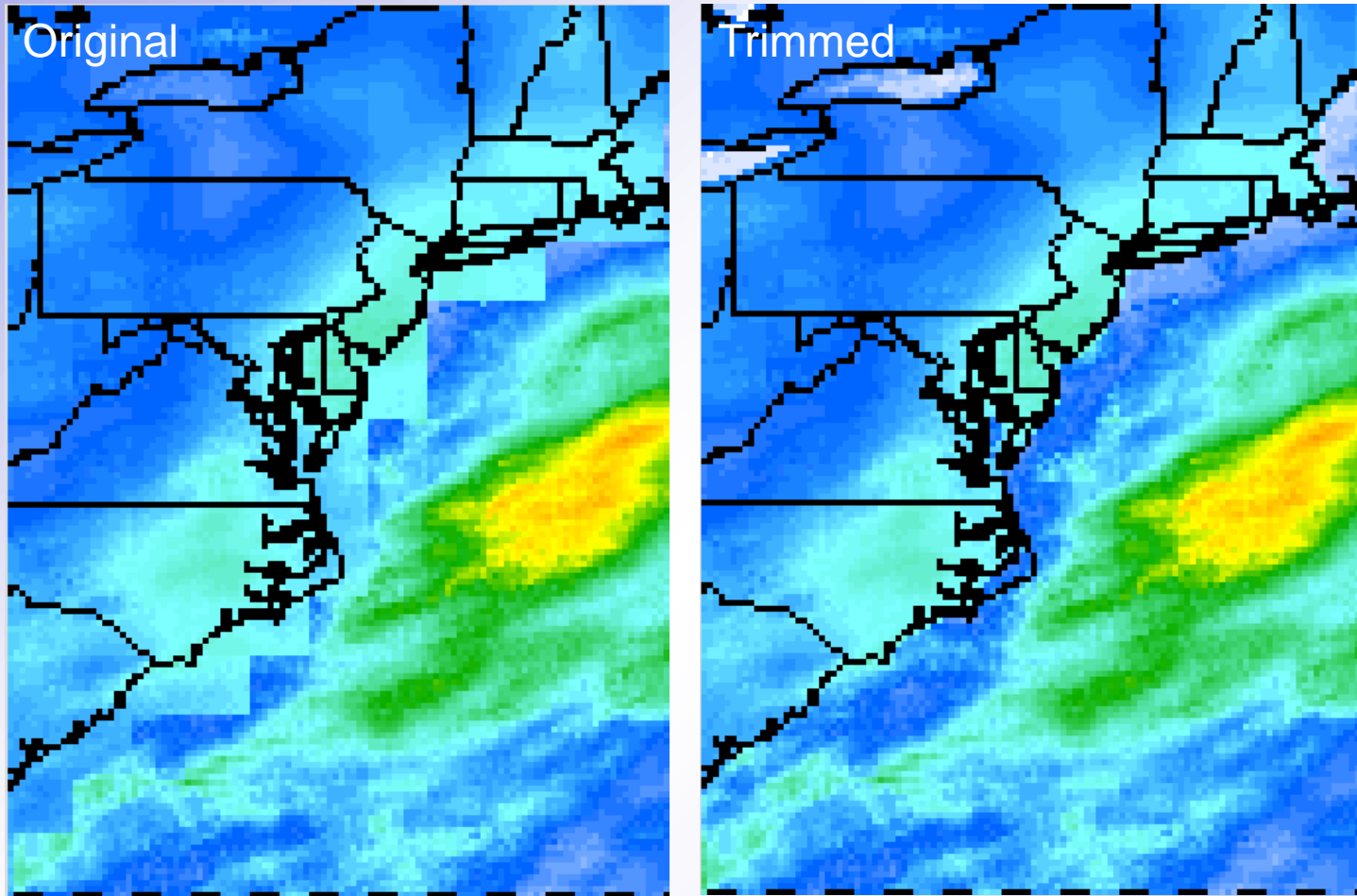
### 3. VERSION 04 IMERG – Precip Phase

Precip phase is available for the whole globe

- probability that the precip phase is liquid or mixed
  - mixed is rare and likely to melt, which then acts like liquid
- diagnostic based on NWP analysis of surface temperature, humidity, pressure



### 3. VERSION 04 IMERG – Trimming Gauge Contributions Along Coasts



January 2015

David Bolvin

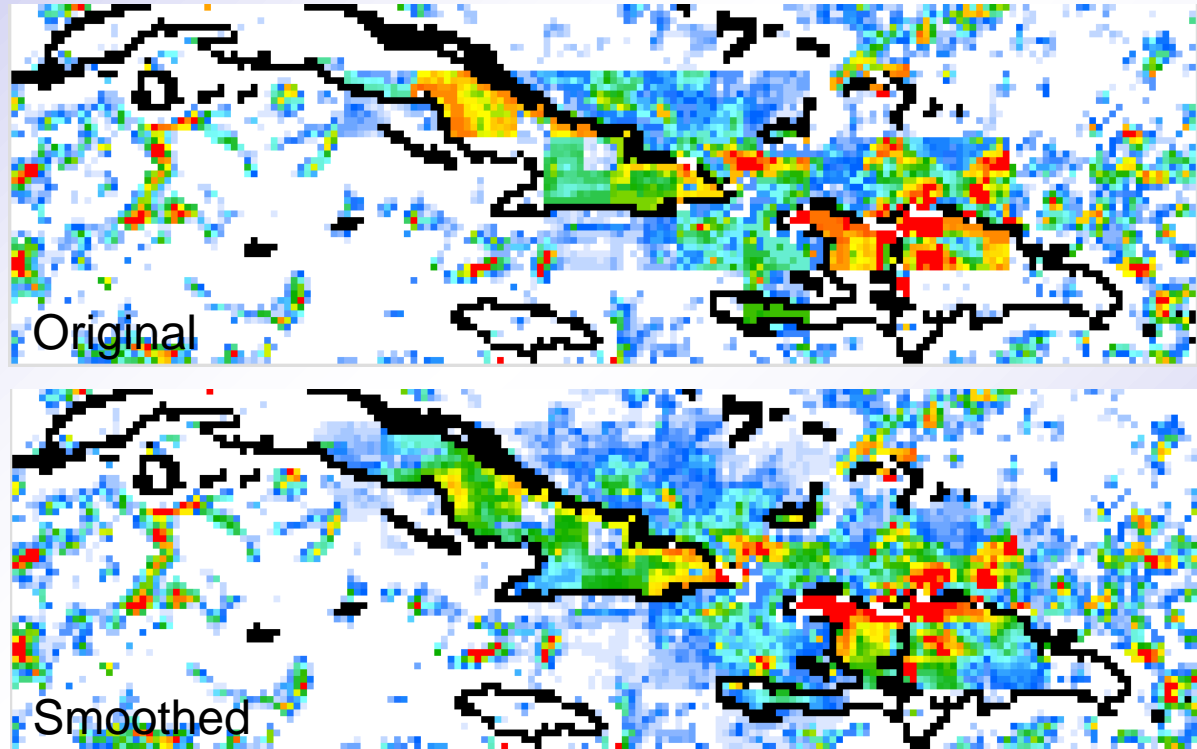
At the  $0.1^\circ$  IMERG resolution the  $1^\circ$  GPCP resolution causes unphysical blockiness along coasts where satellites and gauges disagree (Final Run)

The transition off-shore is now a jump, but perhaps should be a taper

### 3. VERSION 04 IMERG –2BCMB-GMI Calibration Smoothing

2BCMB-GMI calibration is a  
 $1^\circ \times 1^\circ$  grid based on a  
 $3^\circ \times 3^\circ$  template

- when gradients in GMI and 2BCMB are not similar, jumps between boxes are intrusive (top)
- a distance-weighted average of the four adjacent calibration values improves performance (bottom)
- all Runs



January 2015

David Bolvin

### 3. VERSION 04 IMERG – GPM Products Are Low in the Extratropical Oceans

Ocean-only zonals for 2015

V04 GPM products are similar, by design

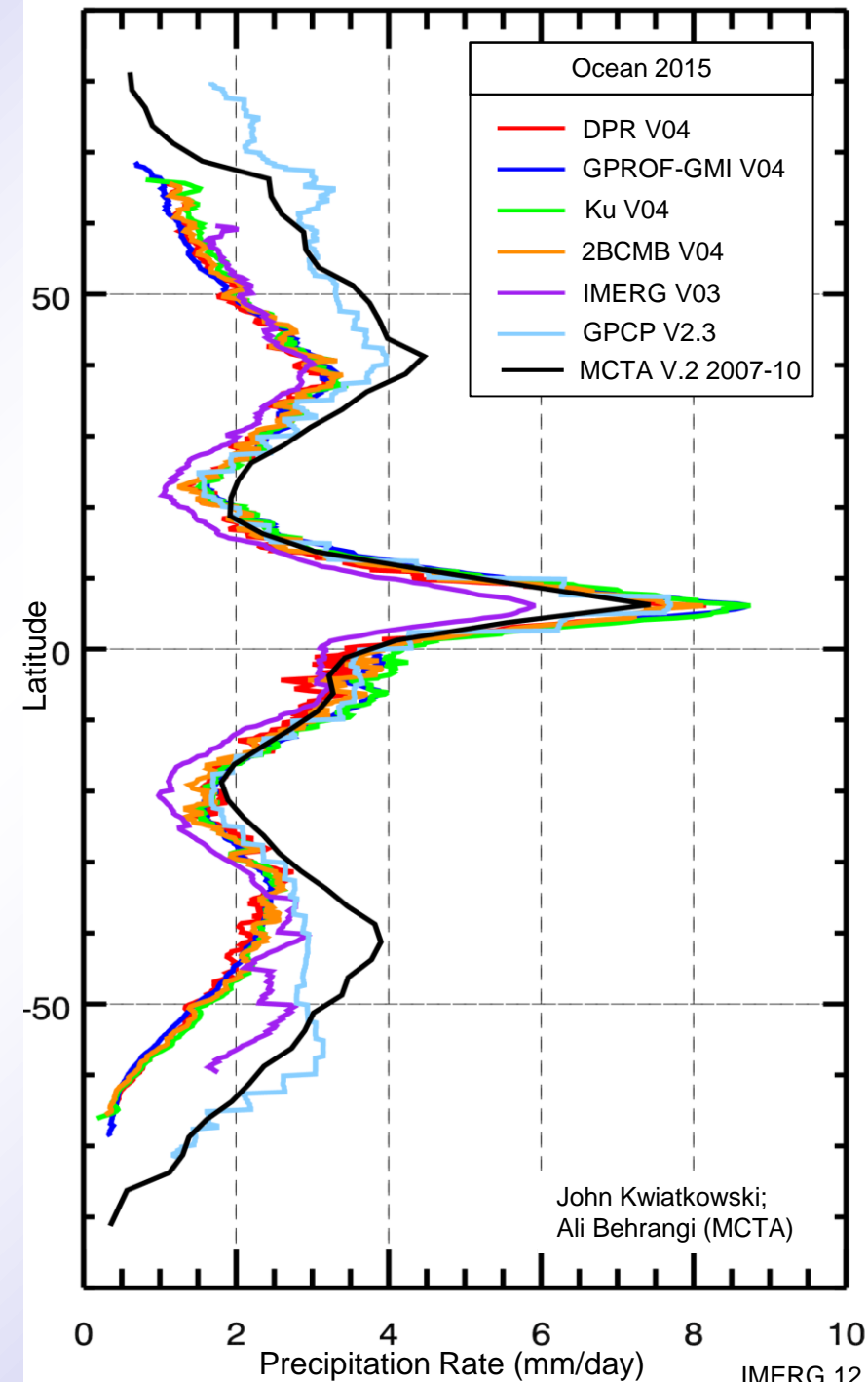
- V03 IMERG somewhat similar
  - Day 1 (pre-launch calibration)

GPCP is higher in the extratropics

- new Version 2.3 of community standard
- Behrangi Multi-satellite CloudSat, TRMM, Aqua (MCTA) product confirms GPM bias
  - includes CloudSat rain, snow, mixed
  - higher than GPCP in mid-latitudes
  - roughly agrees at high latitudes

Adjust IMERG V04 to GPCP at higher latitudes with seasonal “climatology”

- known low biases in GPM products being addressed in V05
- provides reasonable IMERG bias in V04



### 3. VERSION 04 IMERG – GPM Product Biases Vary by Latitude

Land-only zonals for 2015

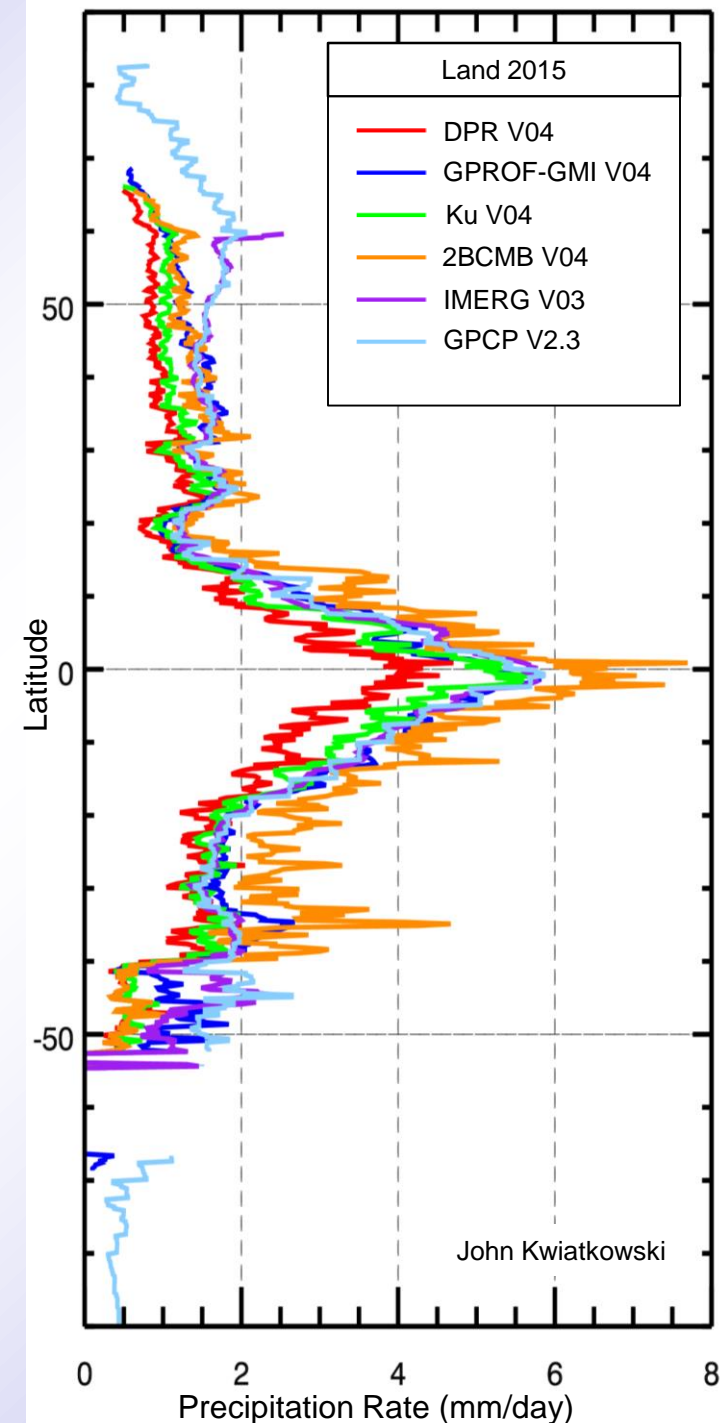
V04 GPM products tend to show more spread

GPCP is higher in the extratropics

- V03 IMERG similar (both use GPCC gauge analysis)
- MCTA n/a over land

Adjust IMERG to GPCP for V04 at all latitudes with a seasonal “climatology”

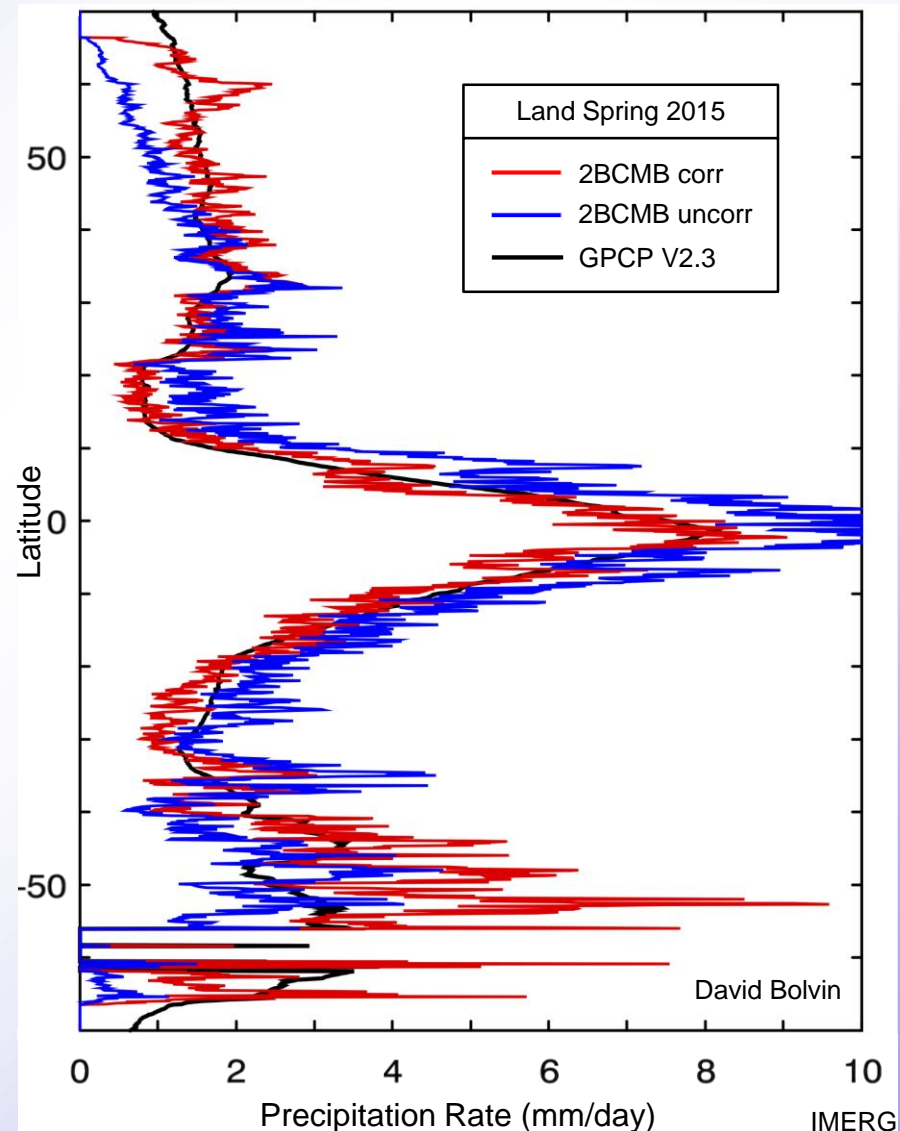
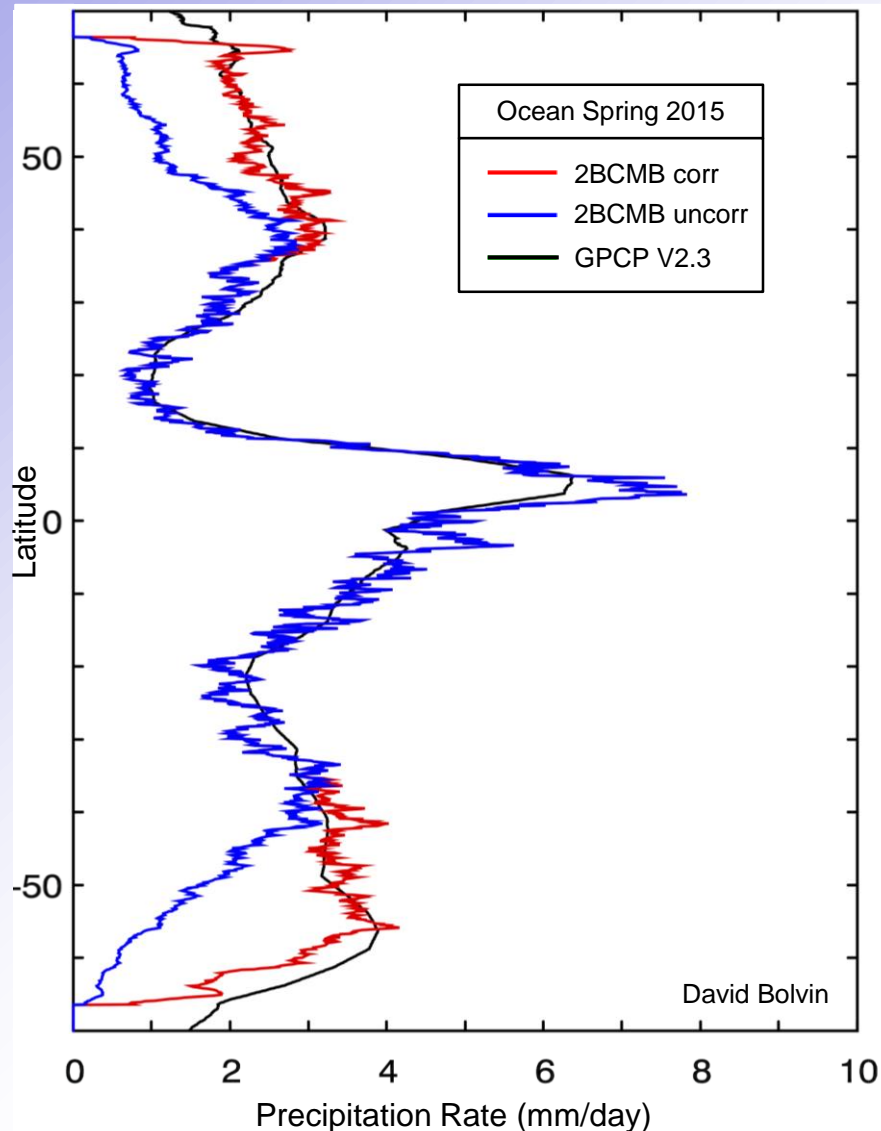
- known biases in GPM products being addressed in V05
- first cut at the adjustment to gauges that the final calibration in IMERG enforces



### 3. VERSION 04 IMERG – 2BCMB Largely Behaves as Expected for Spring 2015

Low-latitude ocean not adjusted; highest latitudes still show deficits

- regional biases are modest



## 4. FUTURE – Version Transitions

Version 04, first-generation GPM-based IMERG archive, March 2014–present

- all data are available March 2014–mid-2016
- Early and Late Run data are also available from 5 February 2017
- approximately one month of data for each day of processing
  - reach December 2016 by April 8
- remaining months depend on data arrival
  - January 2017 — April after January ECMWF arrives (expected momentarily)
  - February 2017 — May after February ECMWF arrives (only 4 days in Early and Late)

Mid-2017: Version 05 IMERG, March 2014–present

- DPR calibration change
- “minor” upgrades to other algorithms

Winter 2017-18: TRMM V.8/GPM V.5 TRMM/GPM-based IMERG archive, 1998–present

Spring 2018: Legacy TMPA products retired

## 5. FINAL COMMENTS

Version 04 IMERG addresses a number of issues uncovered in Version 03

- swaths gridded over entire globe

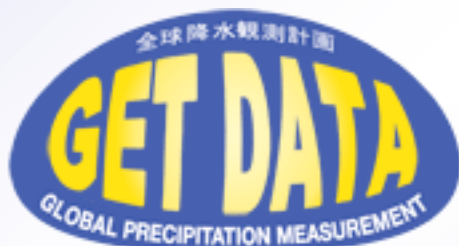
Versions will move quickly over the next 18 months

- GPM era being upgraded to Version 04, then 5 months later in Version 05
- TRMM-GPM eras reprocessed in Version 05 in late 2017
- TMPA to be run until Spring 2018

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

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[pmm.nasa.gov](http://pmm.nasa.gov)



New Users Start Here

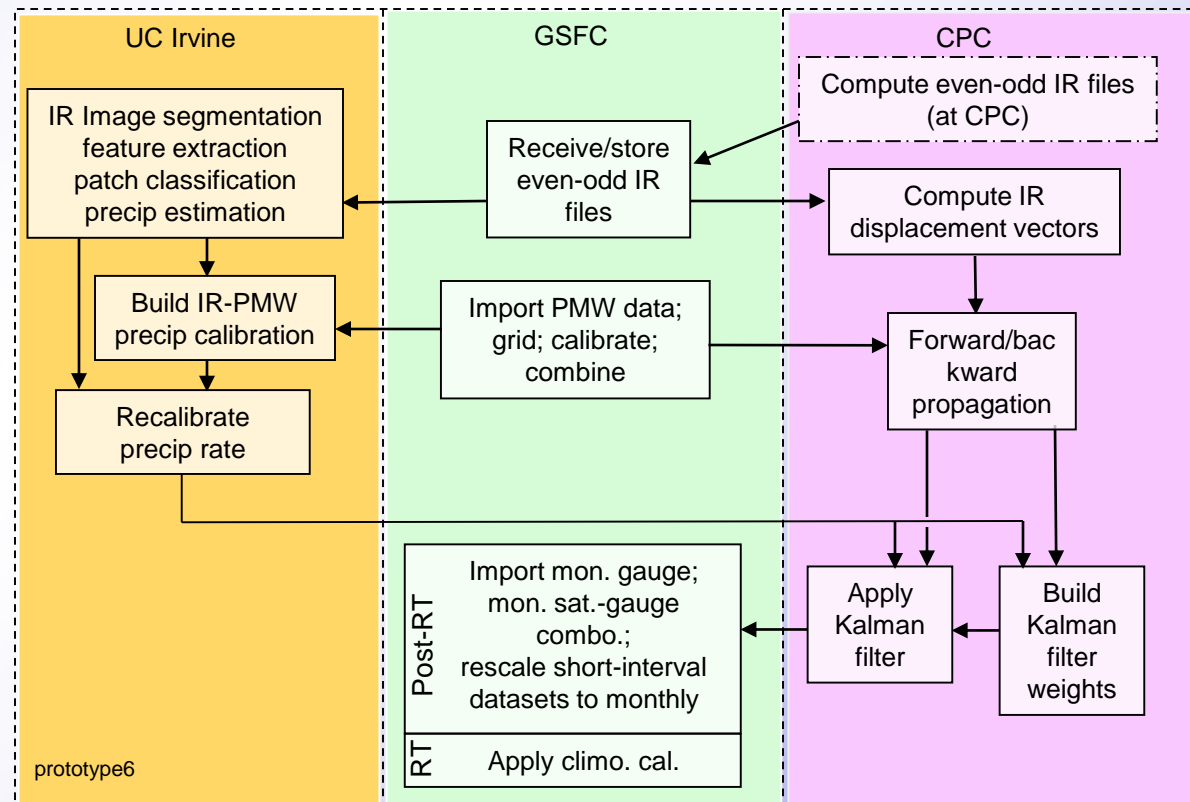
## 2. IMERG DESIGN – Processing

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

Institutions are shown for module origins, but

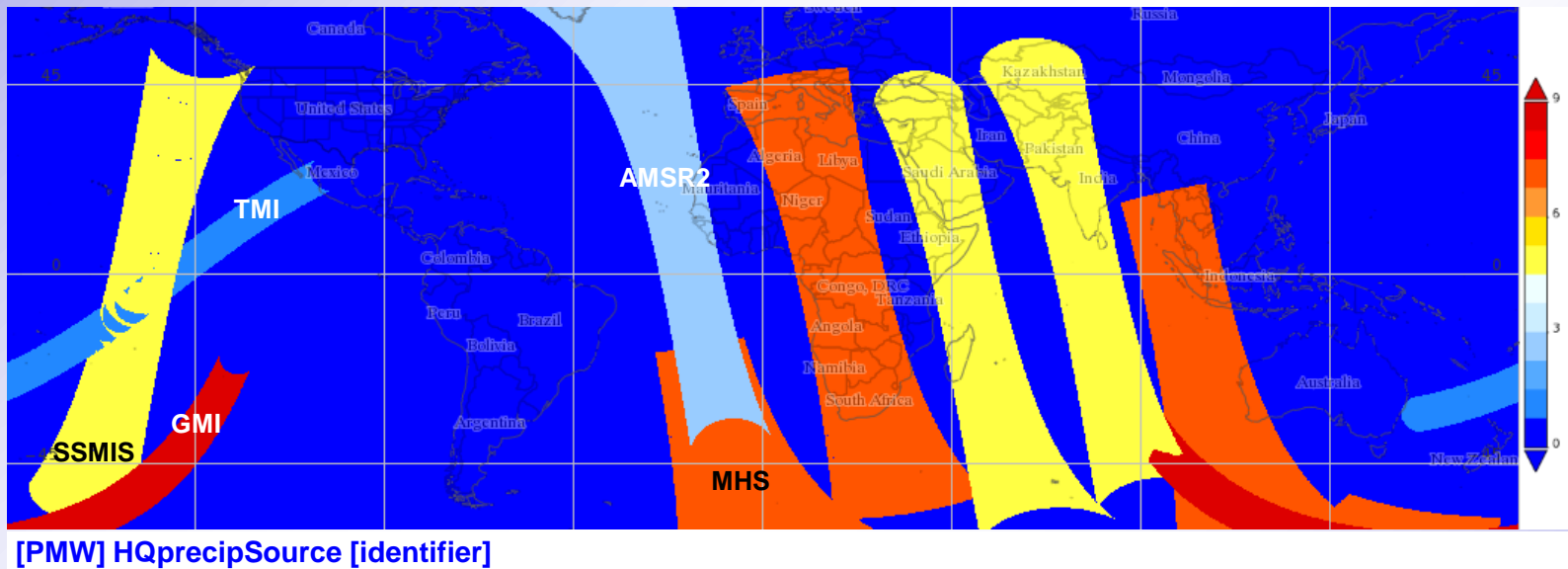
- package is an integrated system
- goal is single code system appropriate for near-real and post-real time
- “the devil is in the details”



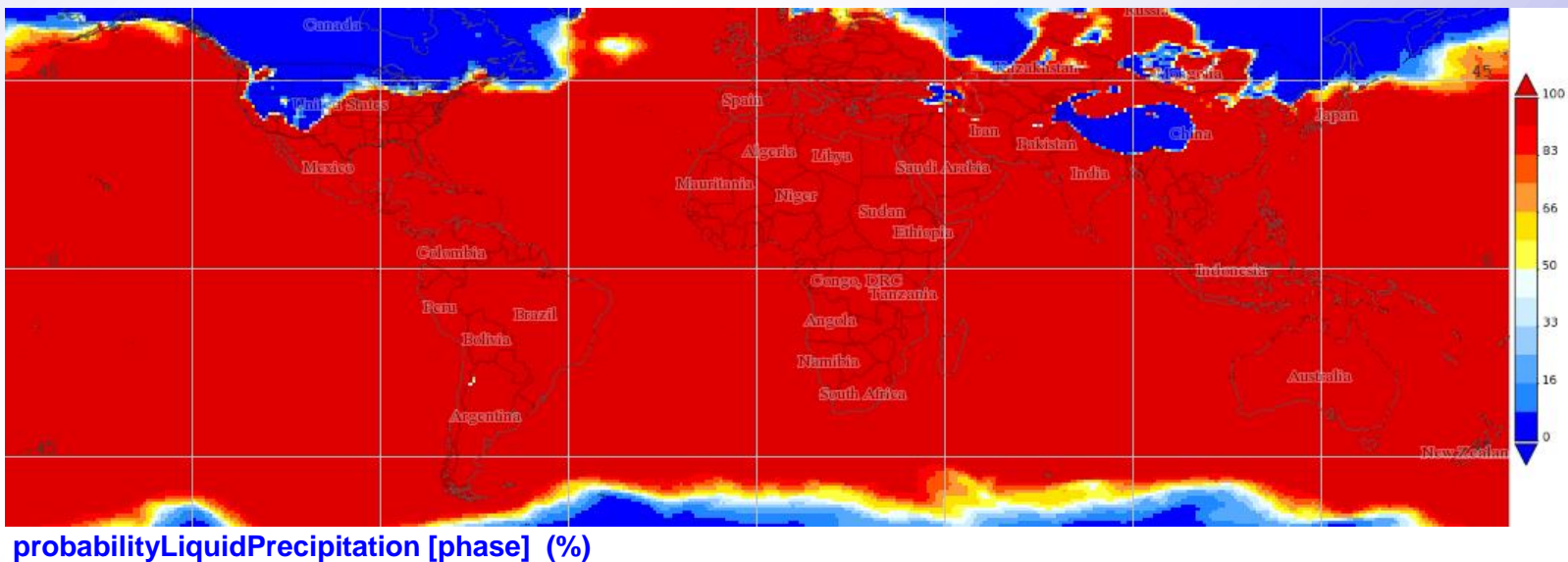
## 2. IMERG DESIGN – Data Field Maps

1430-1500Z 3 April 2014

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



probability  
that  
precipitation  
phase is  
liquid;  
diagnostic  
computed  
from  
ancillary  
data



### 3 VALIDATION – Half-Hourly IMERG Sources and Pocamoke Fine-Scale Grid, April 2014 – March 2015

“Violin diagram” for individual sources of the half-hourly IMERG estimates

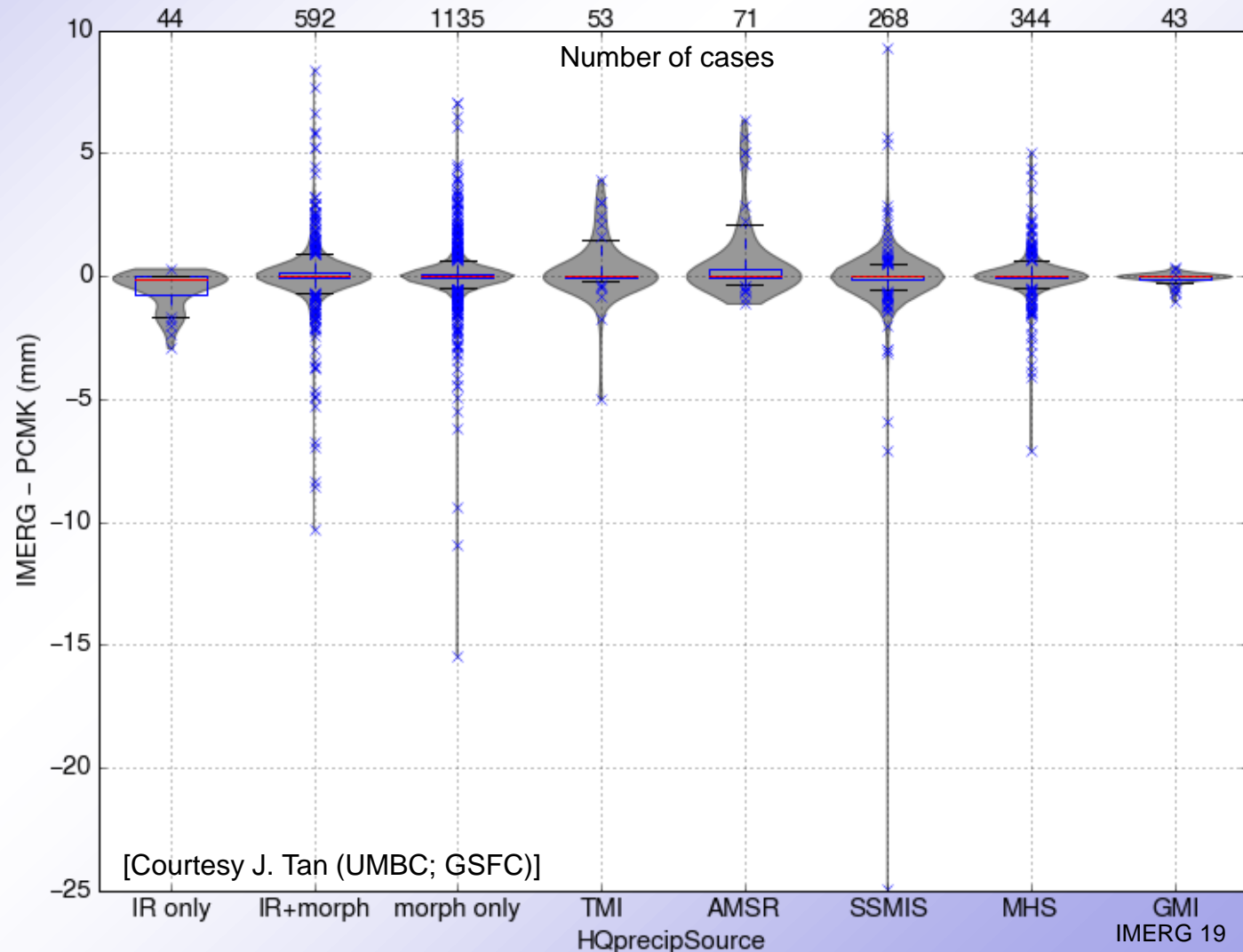
- width shows relative contribution for each difference bin

GMI is best; AMSR and SSMIS less so

The extra scatter for no-PMW (interpolated) is partly driven by the large number of cases

No-PMW (interpolated) data are competitive with the skill for most of the sensors

This is pre-launch calibration! The shift to Version 04 should give more consistency



# VALIDATION – Half-Hourly IMERG vs MRMS Radar/Gauge Product

## October 2015, South Carolina Floods

2-4

Actual accumulations of rain were up to 24"

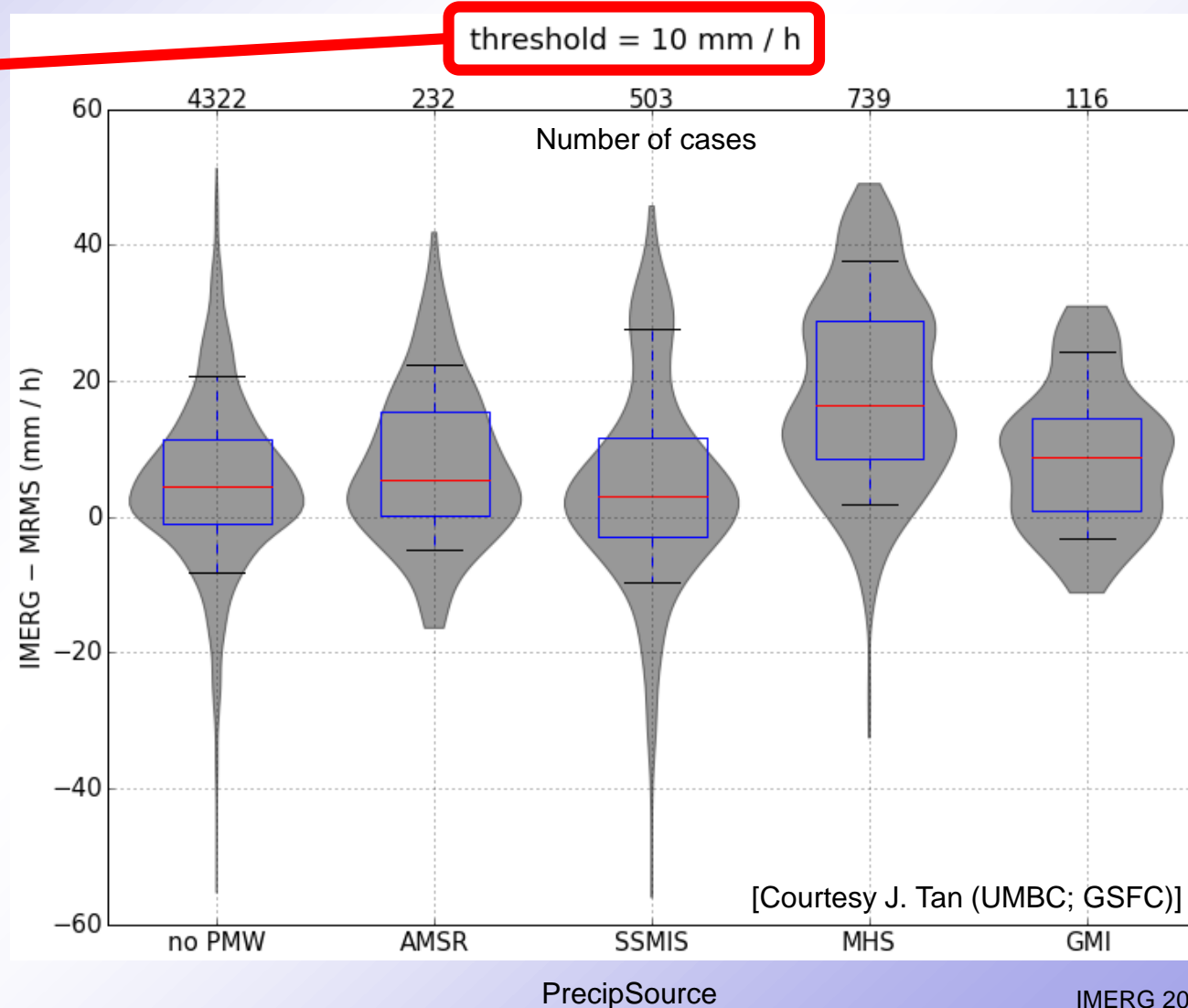
- IMERG overestimated some totals by a factor of 2

This diagram focuses solely on heavy rain

All sensors are positively biased

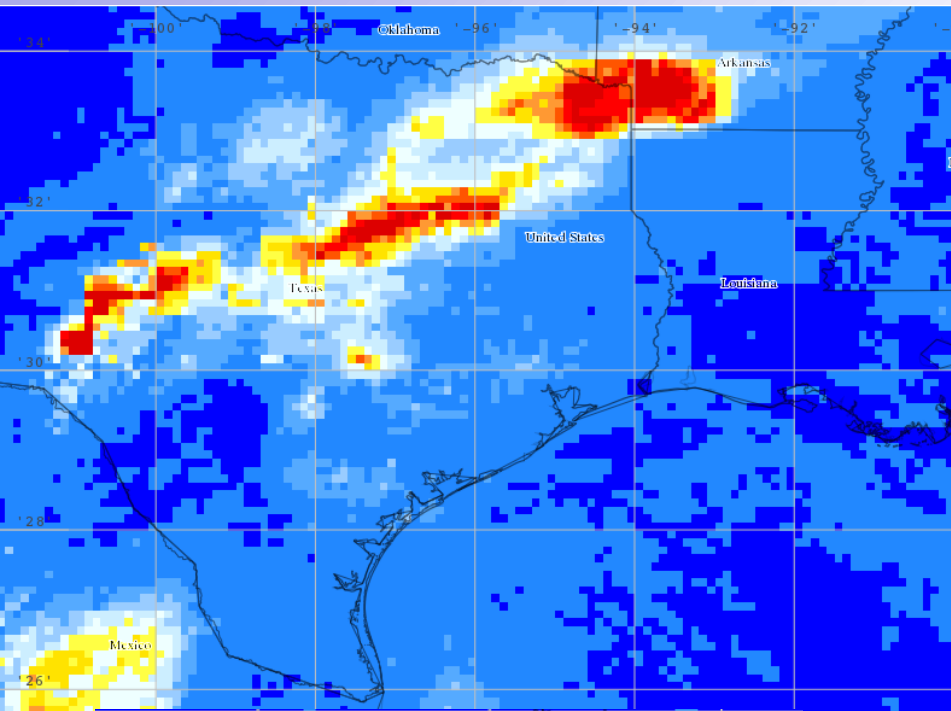
- MHS is particularly biased due to an IMERG error
- “no PMW” (morphed and IR) is better
- again, low number of samples

This is pre-launch calibration! The shift to Version 04 should give more consistency

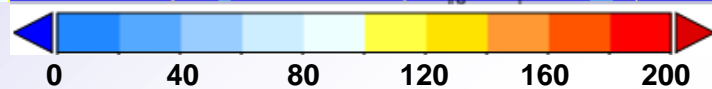
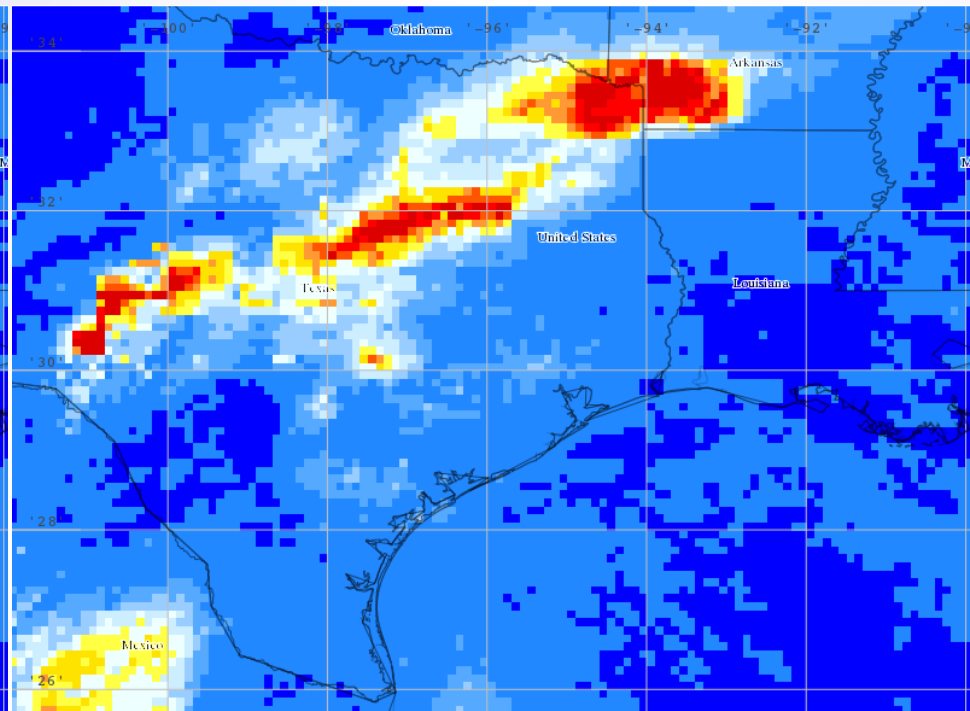


## 4. VALIDATION – Pre-Patricia Rains in Texas, 2015 October 23/12Z–24/12Z

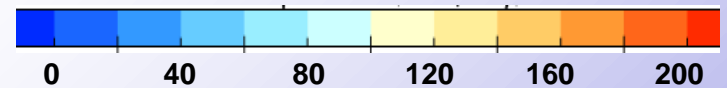
IMERG Early Run



CPC Gauge Analysis

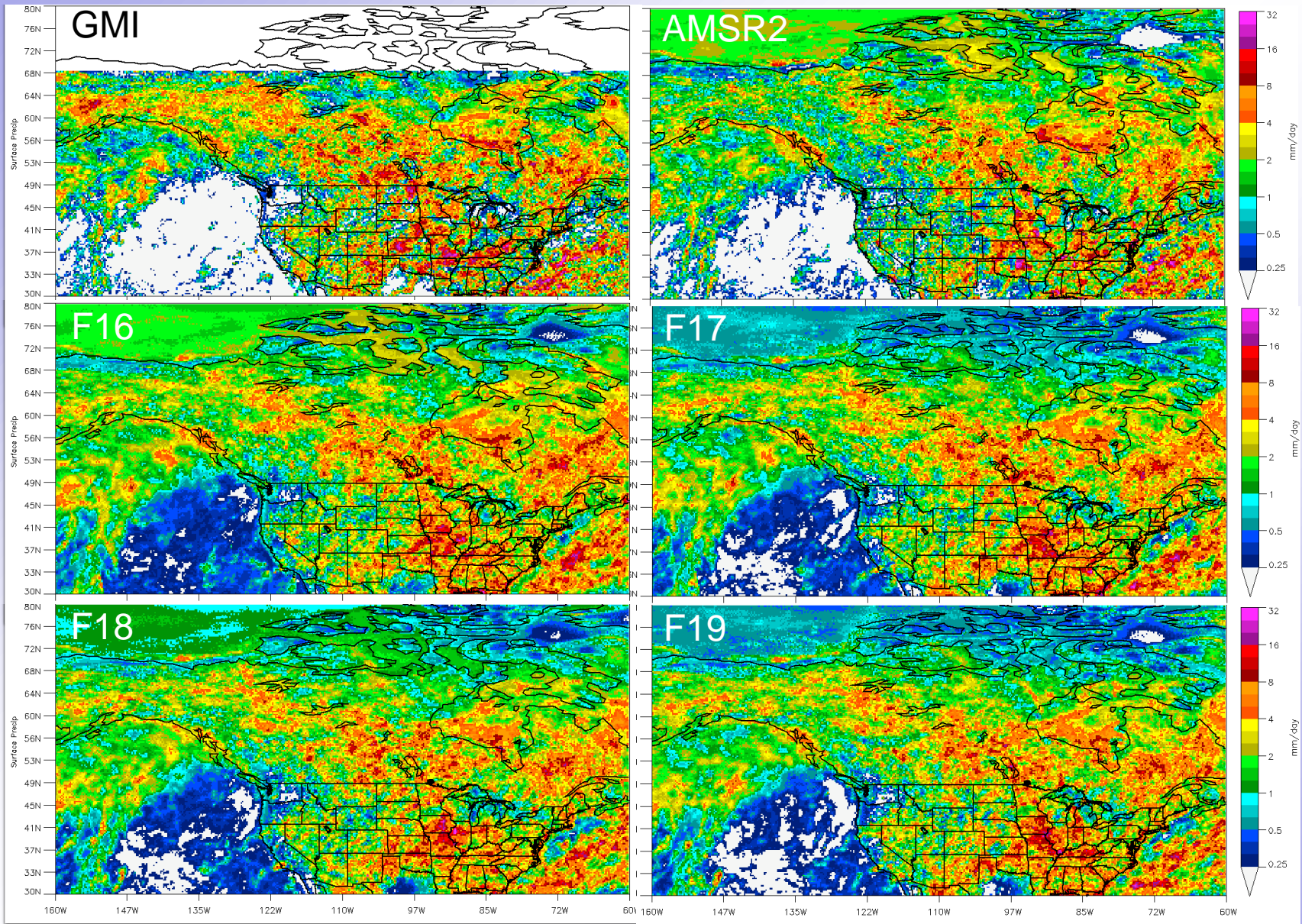


(mm/d)



- General area of heavy rain is captured by IMERG, but extends further east and west
- are there sufficient gauge data to the west?

### 3. VERSION 04 IMERG – High Latitude GPROF2014V2, July 2015

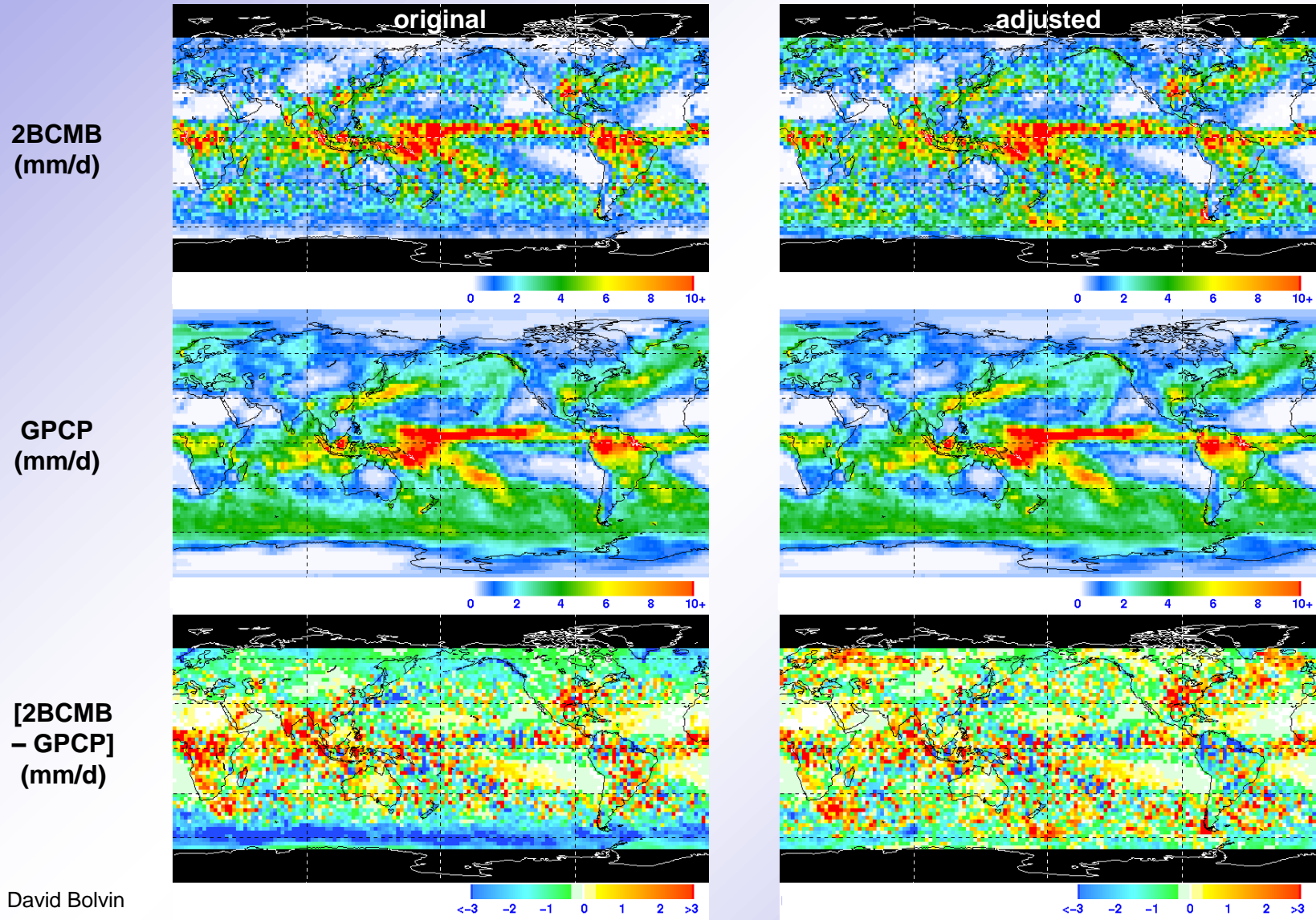


David Randel

Input precip estimates are fairly similar across sensors, and look useful

### 3. VERSION 04 IMERG – Regional Biases in Adjusted 2BCMB are Modest for Spring 2015

Sampling noise in 2BCMB makes direct comparison challenging



## 4. FUTURE – The Big Challenges in Multi-Satellite

Extend the analysis to the poles

Create a merged observation-model product

Orographic enhancement

Precipitation system growth and decay between satellite overpasses

Account for differences in what different sensors “see”

Estimate 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

Create an NWP-based assimilation system

Maintain the constellation

## 5. 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

