Update on IMERG, the U.S. Multi-Satellite Algorithm

Upgrading IMERG from Version 03 to 04 to 05

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1. INTRODUCTION

Input **precip** estimates

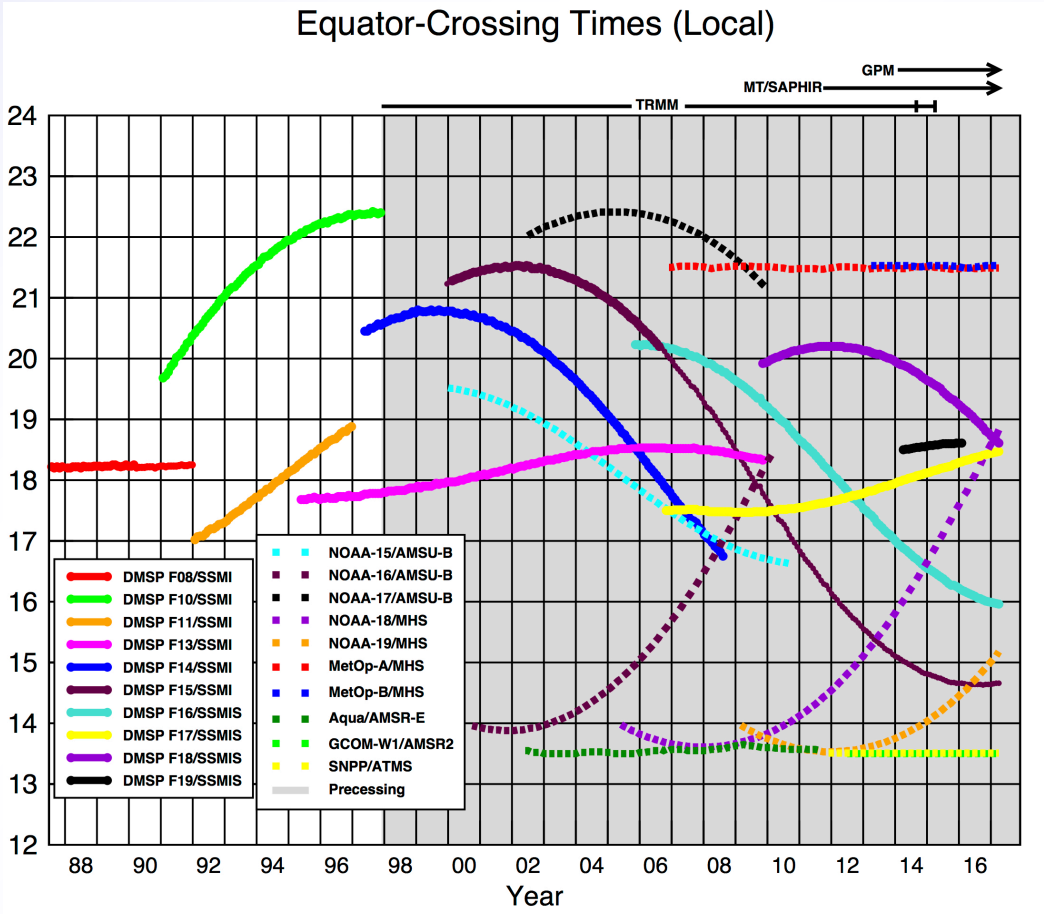
- GPROF (LEO passive microwave [PMW])
- PERSIANN-CCS (GEO infrared)

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-CCS (IR) – U.C. Irvine
- TMPA (inter-satellite calibration, gauge combination) – NASA
- PPS (input data assembly, processing environment) – NASA

GSMaP is Japan's merged product



Ascending passes (F08 descending); satellites depicted above graph precess throughout the day. Image by Eric Nelkin (SSAI), 25 April 2017, NASA/Goddard Space Flight Center, Greenbelt, MD.

2. IMERG DESIGN – Data Sets

Multiple runs accommodate different user requirements for latency and accuracy

- "Early" – 4 hr (flash flooding)
- "Late" – 14 hr (crop forecasting)
- "Final" – 3 months (research)

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

0.1° global CED grid

- merged PMW 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, …)
- value-added products

New in V05

	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	*[phase] probabilityLiquidPrecipitation*
10	*precipitationQualityIndex*
	Monthly data file (Final)
1	*[sat.-gauge] precipitation*
2	*[sat.-gauge precip] randomError*
3	GaugeRelativeWeighting
4	*probabilityLiquidPrecipitation [phase]*
5	*precipitationQualityIndex*

3. VERSION 04 IMERG – Upgrades

Use 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 PMW precip

Extend PMW gridders to 90° N-S

Reduce blockiness

- turn off volume adjustment in gauge analysis
- screen off-shore gauge influence
- spatially average 2BCMB-GMI calibrations

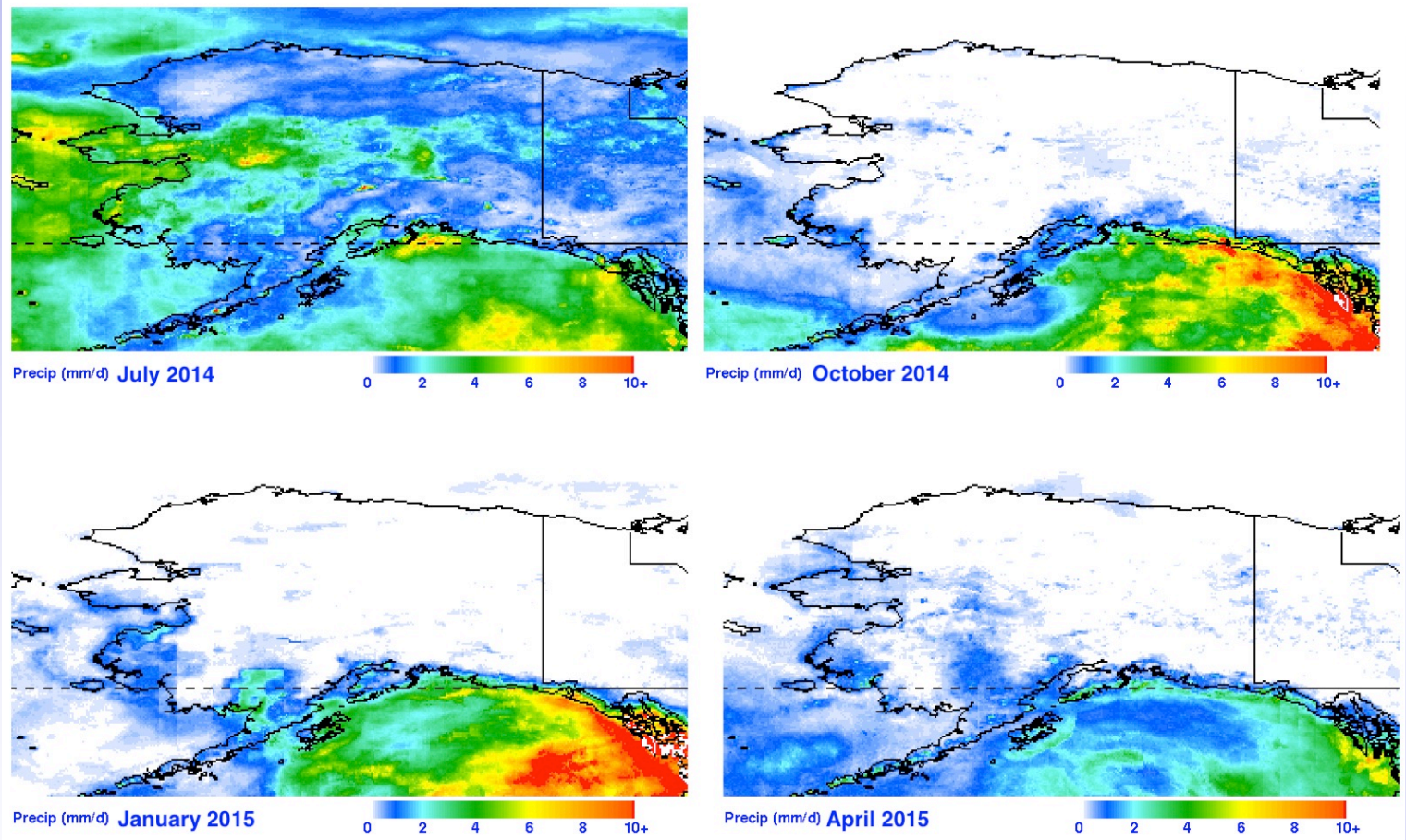
Correct bug that placed morphed values one gridbox south of actual location

- 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 (SSAI; GSFC)

Warm-season estimates appear useful at high latitudes

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

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

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

Ocean-only zonals for 2015

V04 GPM products are similar, by design

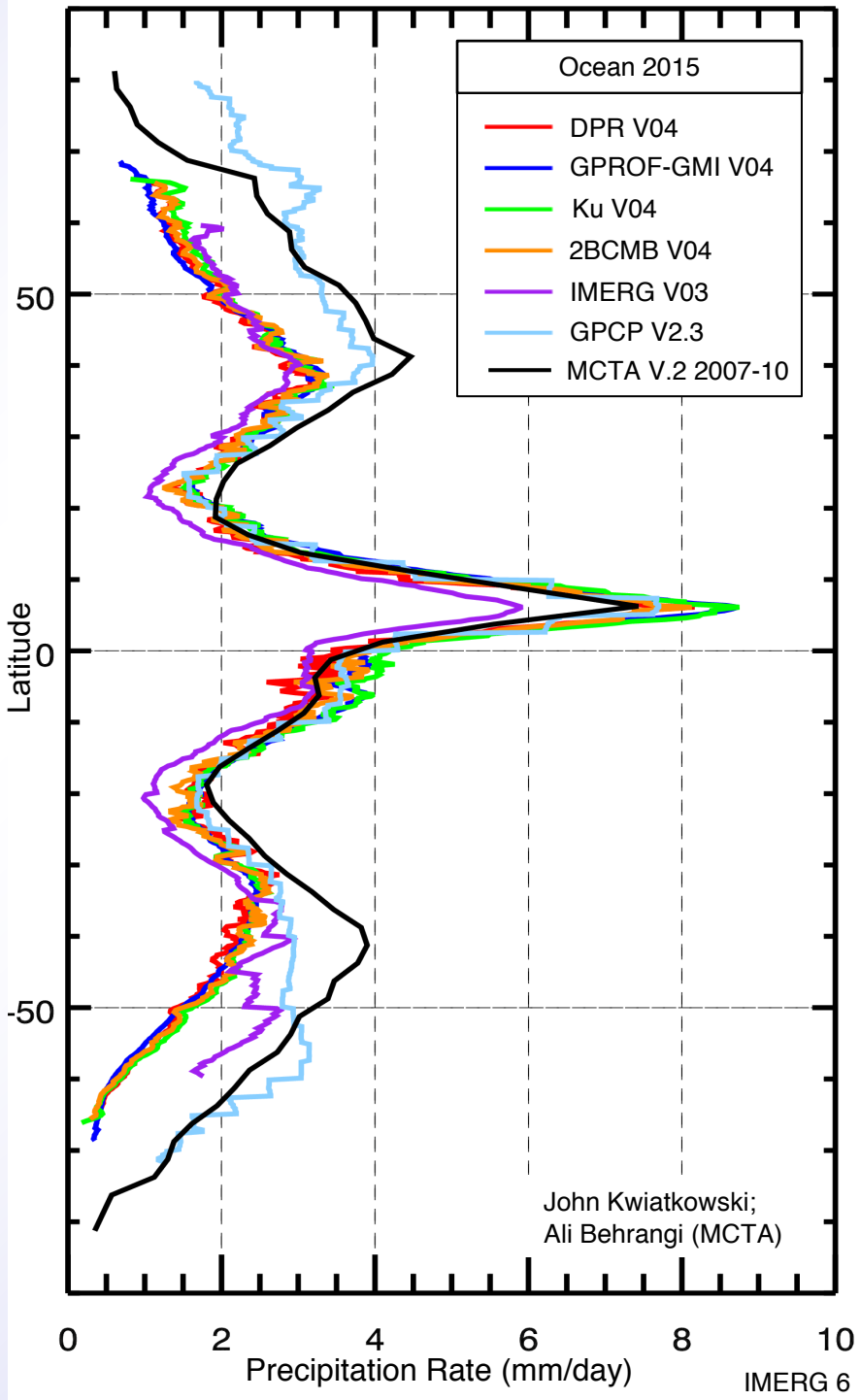
- V03 IMERG somewhat similar
  - Day 1 (pre-launch calibration)

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"

- provides reasonable IMERG bias in V04
- low biases in GPM products addressed in V05, but still low, still require GPCP



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

Land-only zonals for 2015

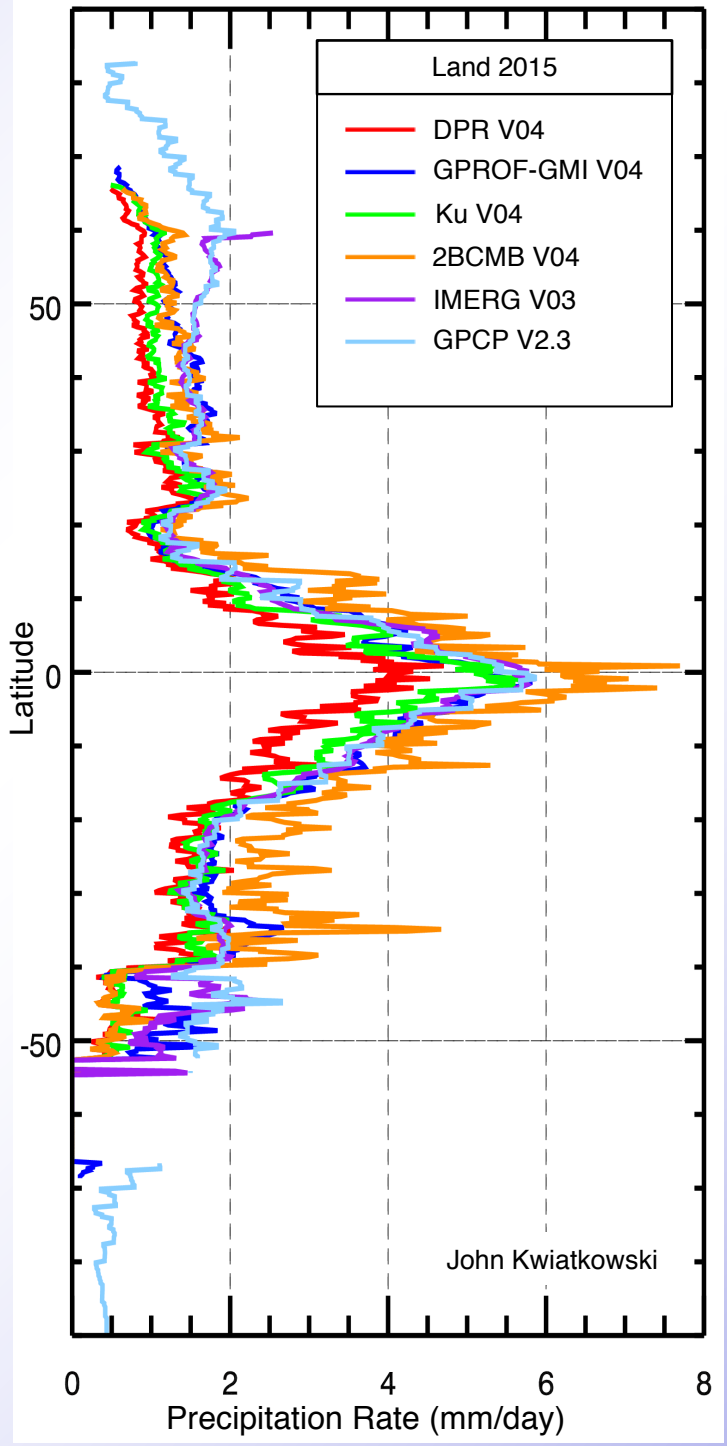
V04 GPM products tend to show more spread

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"

- first cut at the adjustment to gauges that the final calibration in IMERG enforces
- biases in GPM products addressed in V05, but still low, still require GPCP

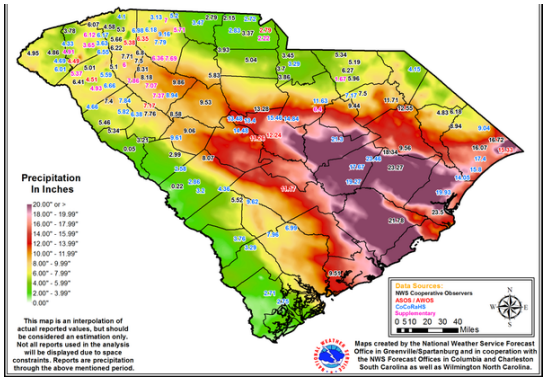


4. VALIDATION – Accumulations over South Carolina, 1-5 October 2015

V04 has a much smaller overestimate than V03 compared to MRMS

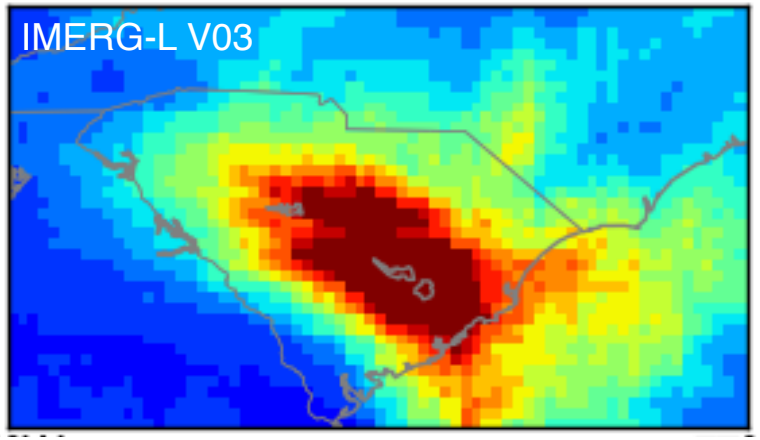
- the gauge-only analysis shows more than MRMS
- both IMERG versions lack the split near the coast
- IMERG higher over the ocean, but need to consider radar range artifacts for MRMS

NWS Gauge Analysis

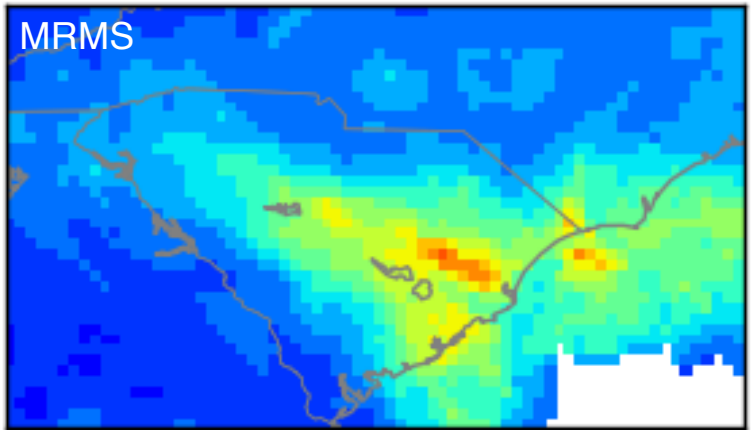


mm 0 100 200 300 400 500

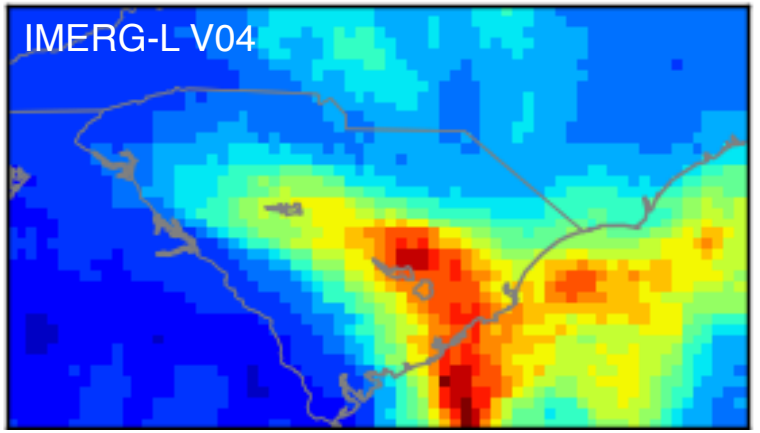
IMERG-L V03



MRMS



IMERG-L V04



mm 0 0.1 1 10 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750

4. VALIDATION – Half-Hourly V04 IMERG Sources and MRMS over South Carolina, 2-4 October 2015

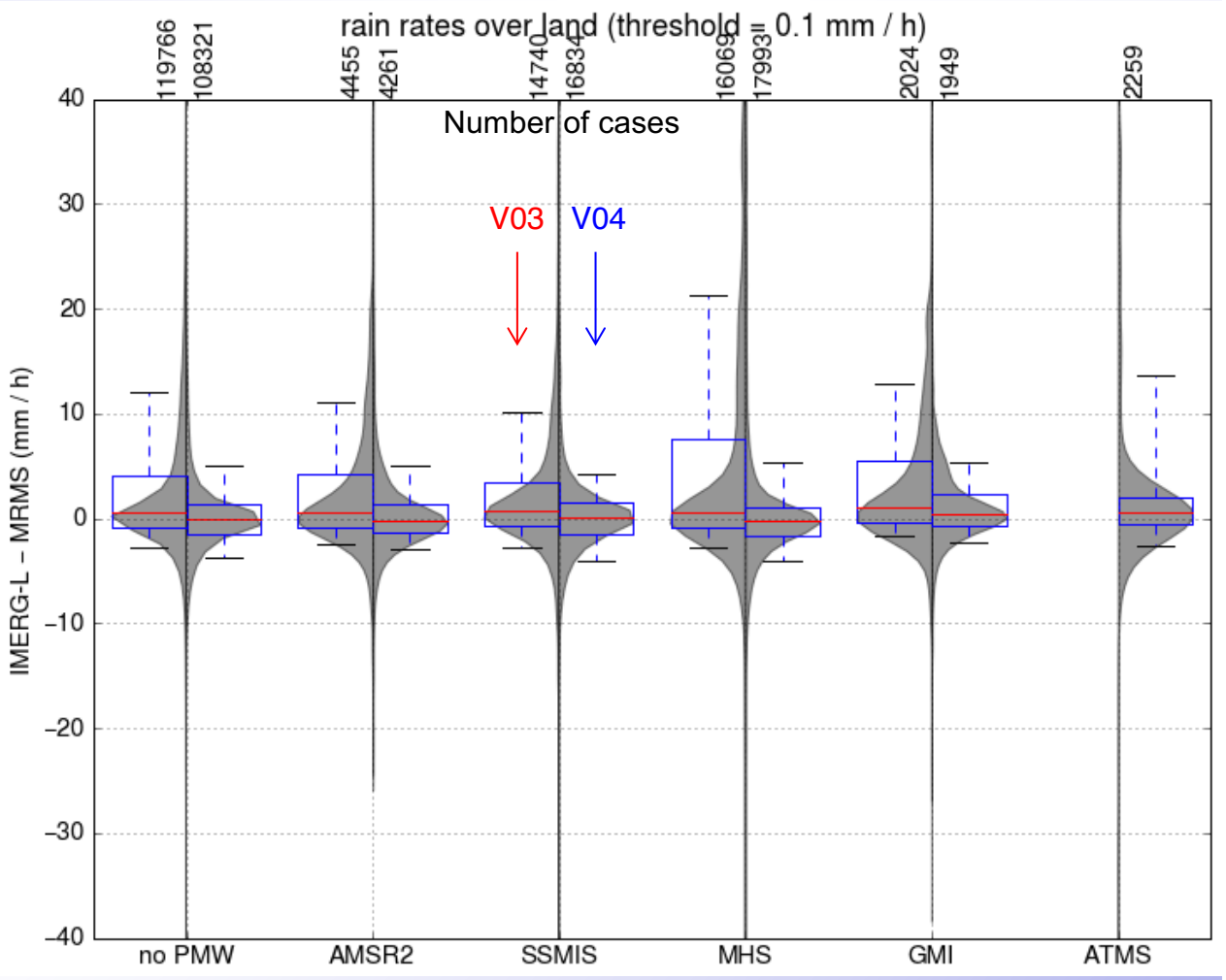
"Violin diagram" for individual sources of the half-hourly IMERG estimates

- width shows relative contribution for each difference bin
- V03(V04) on left(right)

All rainfall rates, over land

V04 is an improvement for all sensors

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



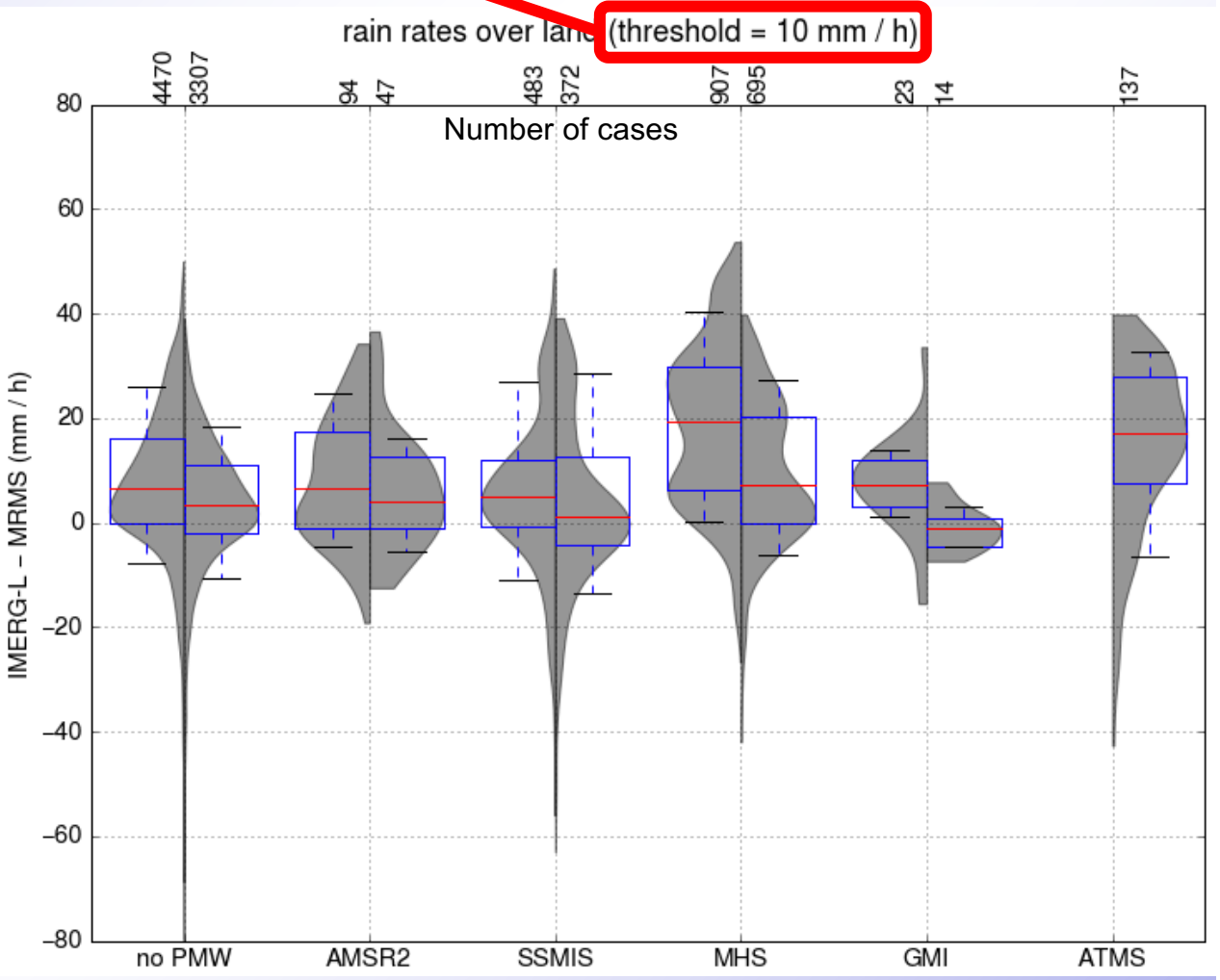
[J. Tan (UMBC; GSFC)]

4. VALIDATION – Half-Hourly V04 IMERG Sources and MRMS over South Carolina, 2-4 October 2015

This diagram focuses solely on heavy rain
- both ≥ 10 mm/h

- small sample size for AMSR2, GMI, ATMS
- V04 better than V03
- GMI and SSMIS are near zero bias
- new ATMS has issues (but low number of samples)

V05 CMB has a better PDF at high rates
- recall: it is the calibrator
- expect improved IMERG performance in flood situations

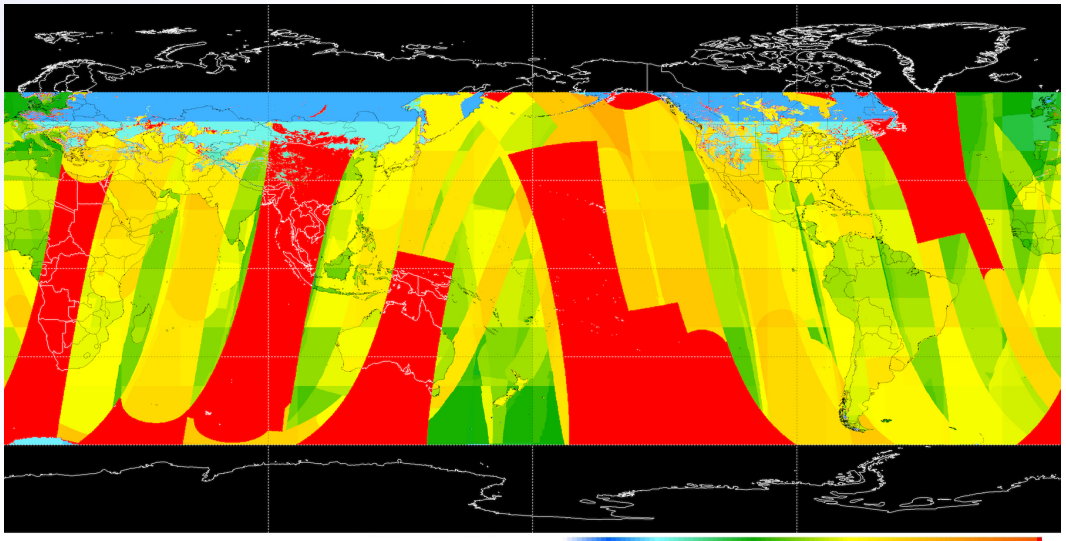


[J. Tan (UMBC; GSFC)]

4. VERSION 05 IMERG – Quality Index (QI)

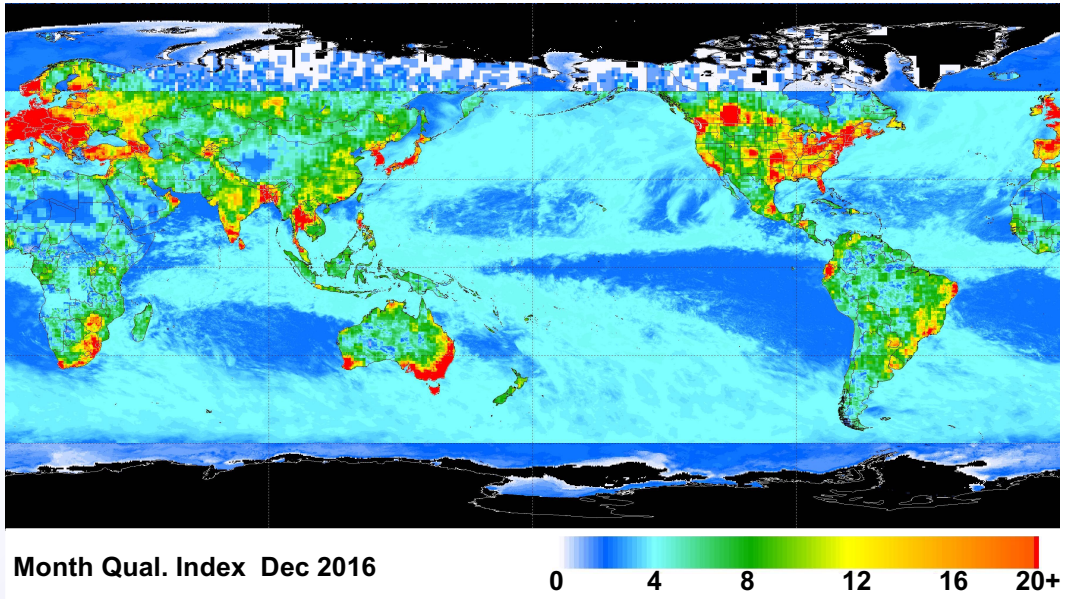
Half-hourly QI

- approx. Kalman Filter correlation
  - time to nearest PMWs
  - IR at time (when used)
  - set to 1 when a PMW is used
- thin strips due to inter-swath gaps
- blocks due to regional variations
- low values at high lat. due to using IR with PMW masked out over snow



Monthly QI

- Equivalent Gauge (Huffman et al. 1997) in gauges / 2.5° x2.5°
- invert random error equation
- largely tames the non-linearity due to rain amount
- some residual issues at high values



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5. FUTURE – Version Transitions

Early Spring 2017: Version 04, first-generation GPM-based IMERG archive, March 2014–present

Fall 2017: Version 05 IMERG, March 2014–present

- DPR calibration change
- "minor", but important upgrades to other algorithms
- IMERG Quality Index
- still no morphing outside 60° N-S

Spring 2018: TRMM V.8/GPM V.05 TRMM/GPM-based IMERG archive, 1998–present

Late Spring 2018: Legacy TMPA products retired

~2 years later: Version 06

6. FINAL COMMENTS

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

- swaths gridded over entire globe
- GPCP calibration in many locations

Versions will move quickly over the next 12 months

- GPM era being upgraded to Version 05
- TRMM-GPM eras reprocessed in Version 05 in Spring 2018
- TMPA to be run through Spring 2018

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

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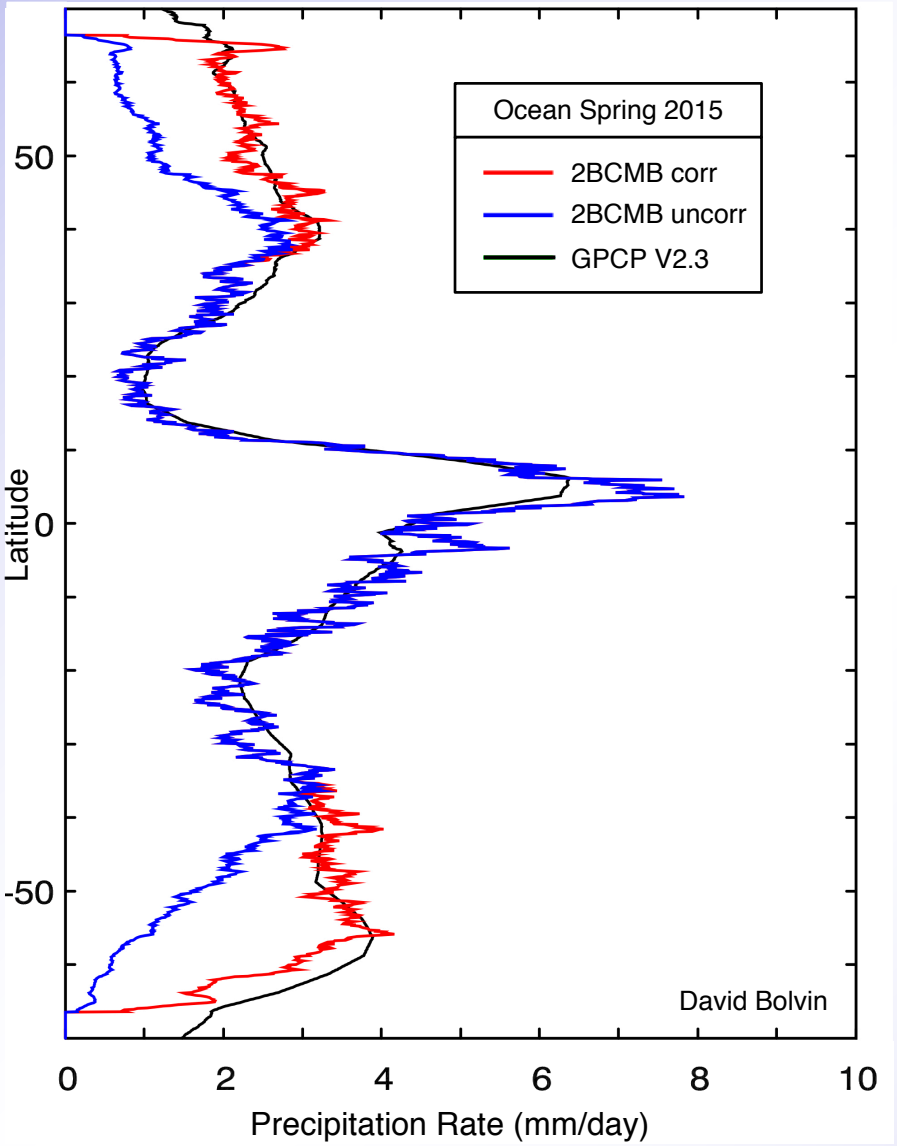
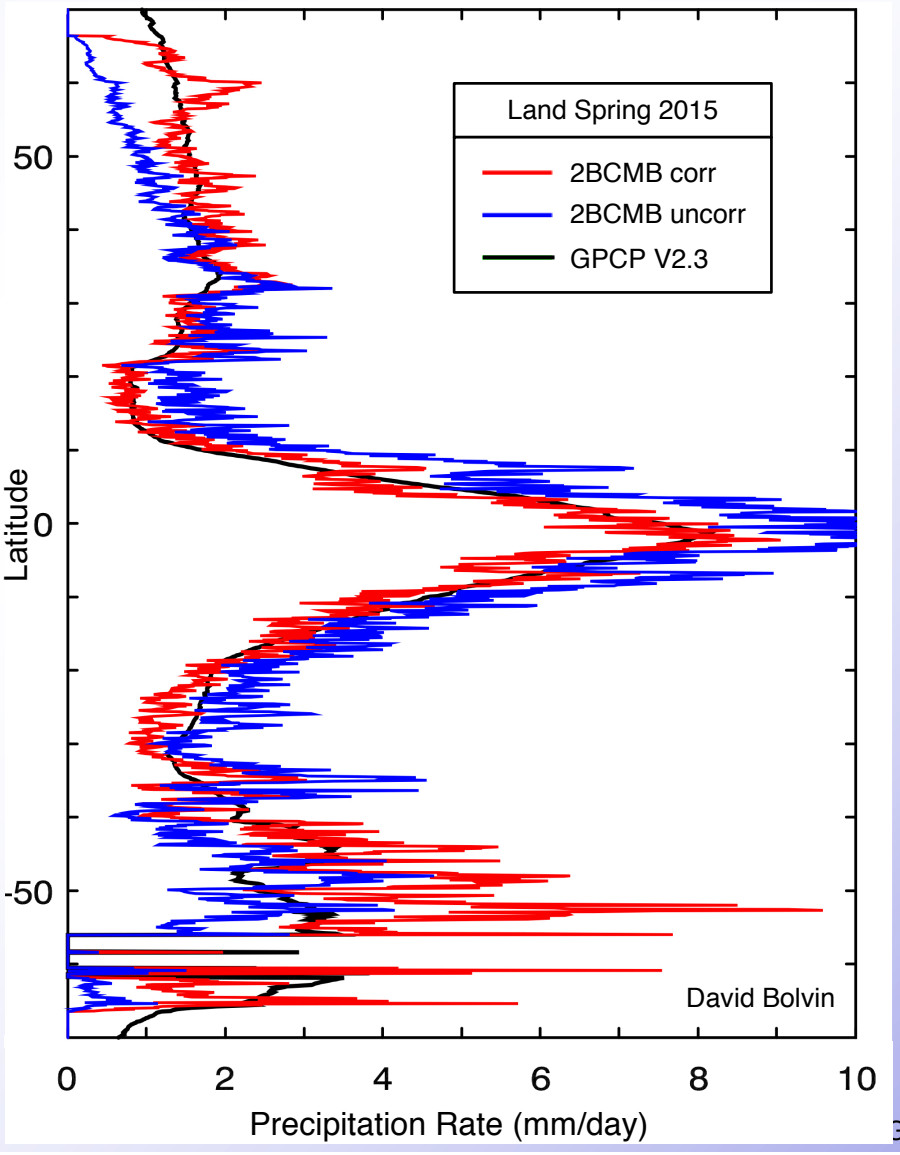
3. VERSION 04 IMERG – 2BCMB Largely Behaves as Expected for Spring 2015

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

- regional biases are modest

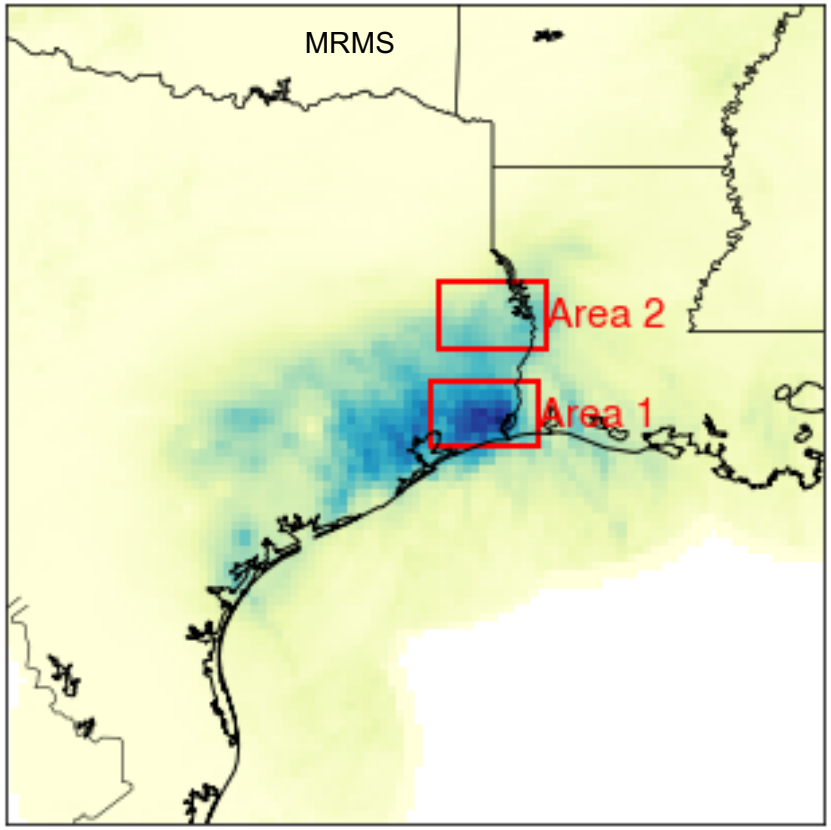


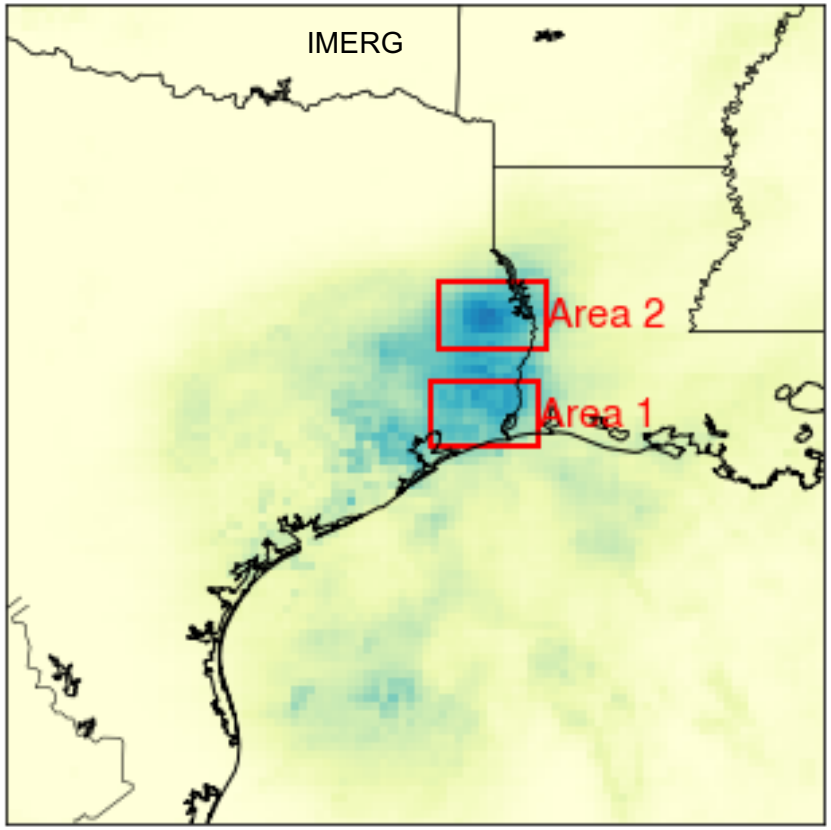


4. VALIDATION – Hurricane Harvey, 25-31 August 2017, IMERG and MRMS (1/2)

Harvey loitered over southeast Texas for a week

- Multi-Radar Multi-Sensor (MRMS) considered the best estimate
  - some questions about the details of the gauge calibration of the radar estimate
  - over land
- Late Run IMERG V04 under(over)-estimated in Area 1(2)





J. Tan (USRA; GSFC)

4. VALIDATION – Hurricane Harvey, 25-31 August 2017, IMERG and MRMS (2/2)

The differences between MRMS (blue) and IMERG (orange) tend to be of the same sign as the event-average difference

- less true in Area 2
- some jumpiness in IMERG is due to overpasses by different sensors
- opposite-sign differences occurred at the same time in the two areas
- PMW-calibrated IR (green) is mostly less than MRMS in both areas

This presumably tells us about the meteorology

- "juicy", liquid-process tropical convection in Area 1
- drier, more continental convection in Area 2
- deviations from global calibration are regionally correlated