The Global Precipitation Measurement (GPM) mission and its implications for SWOT lake monitoring and prediction

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Workshop on

Lakes and climate: The role of remote sensing

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Observatoire Midi-Pyrénées, CESBIO

Toulouse

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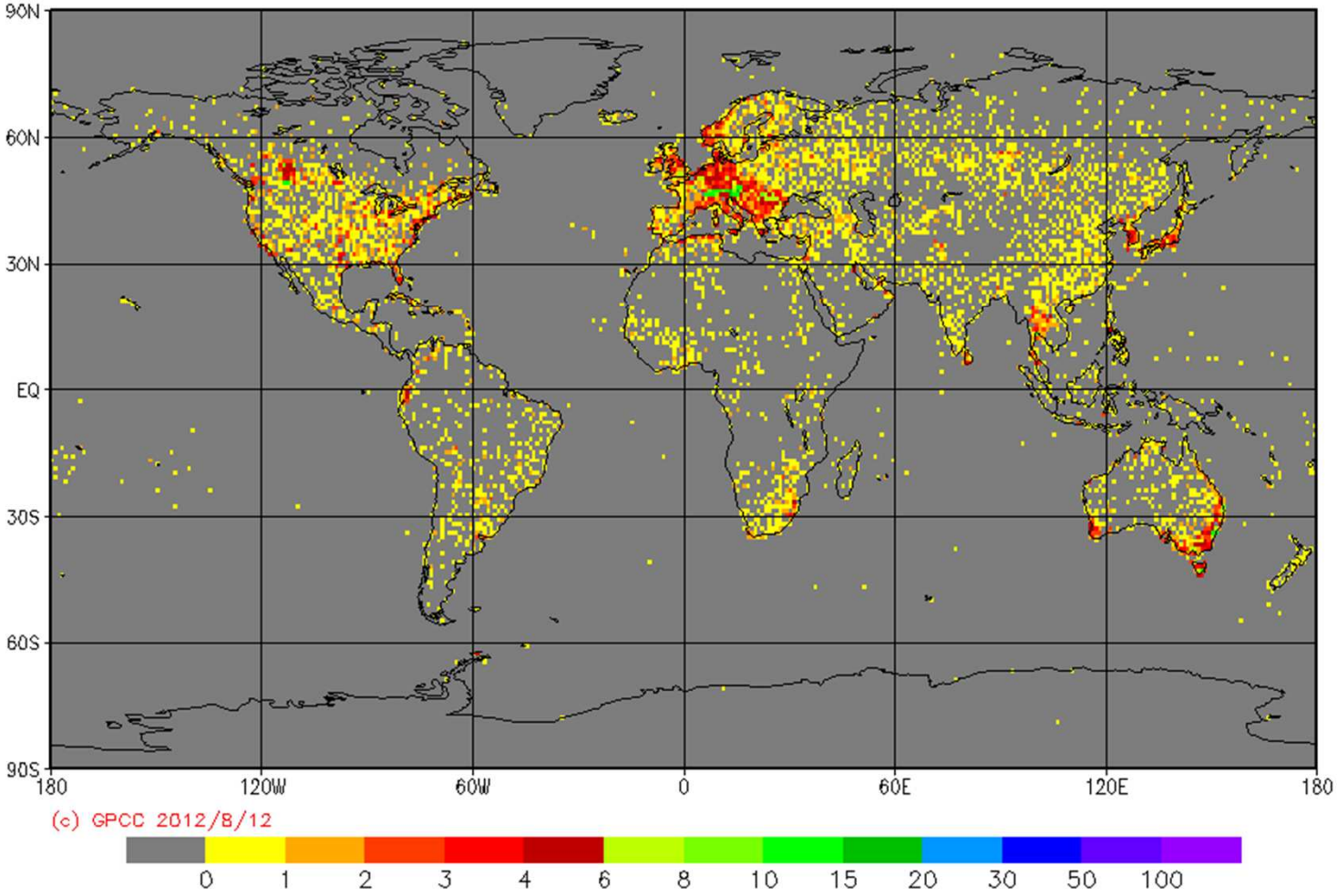
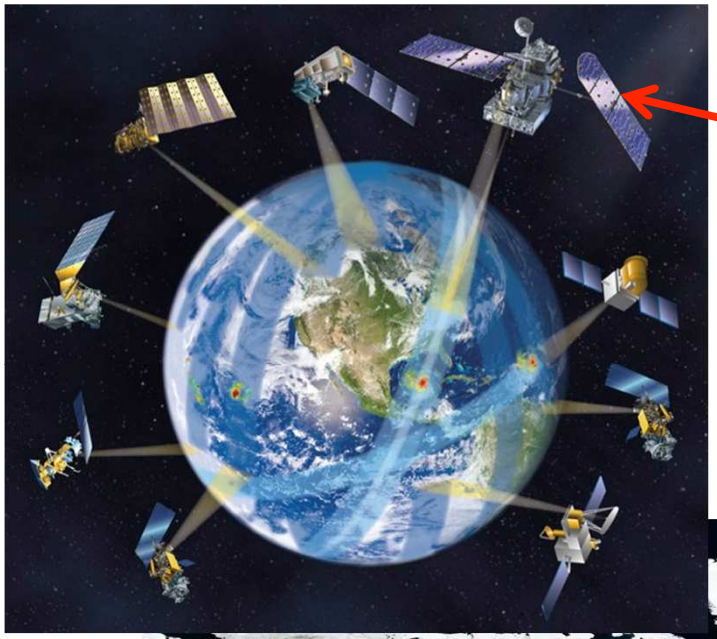
UCLA DEPARTMENT OF Geography

GPCC number of stations per 1 degree lat-long grid box for August, 2012



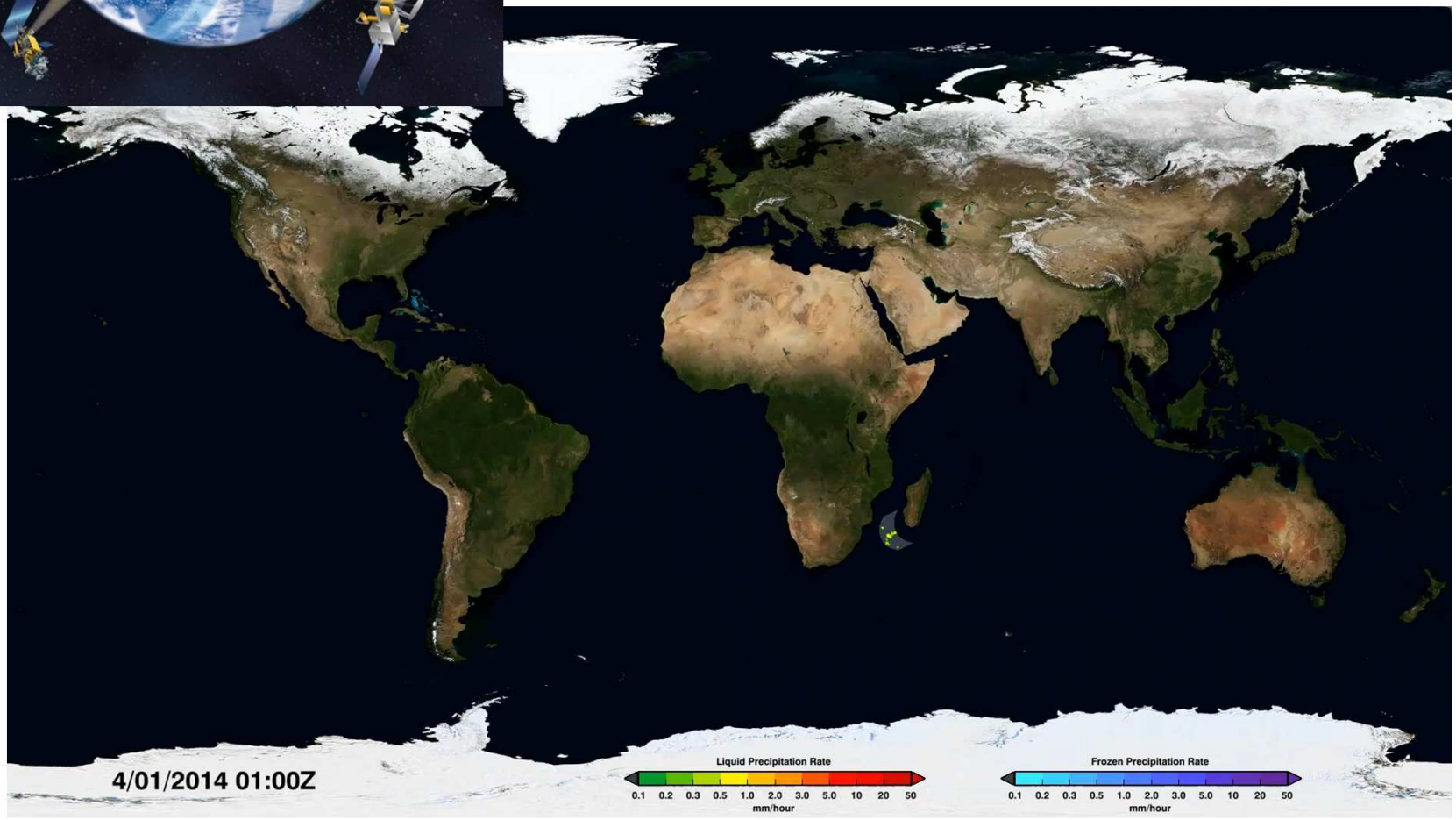
GPM Constellation Concept



GPM Core Observatory
(NASA/JAXA, 2014)
DPR (Ku & Ka band)
GMI (10-183 GHz)
65º Incl, 407 km altitude
5 km best footprint
0.2 – 110 mm/hr and snow
Lifetime: 3, 5, 15 years

Next-Generation Unified Global Precipitation Products Using GPM Core Observatory as Reference

Precipitation rates everywhere in the world every three hours



Core Observatory Measurement Capabilities

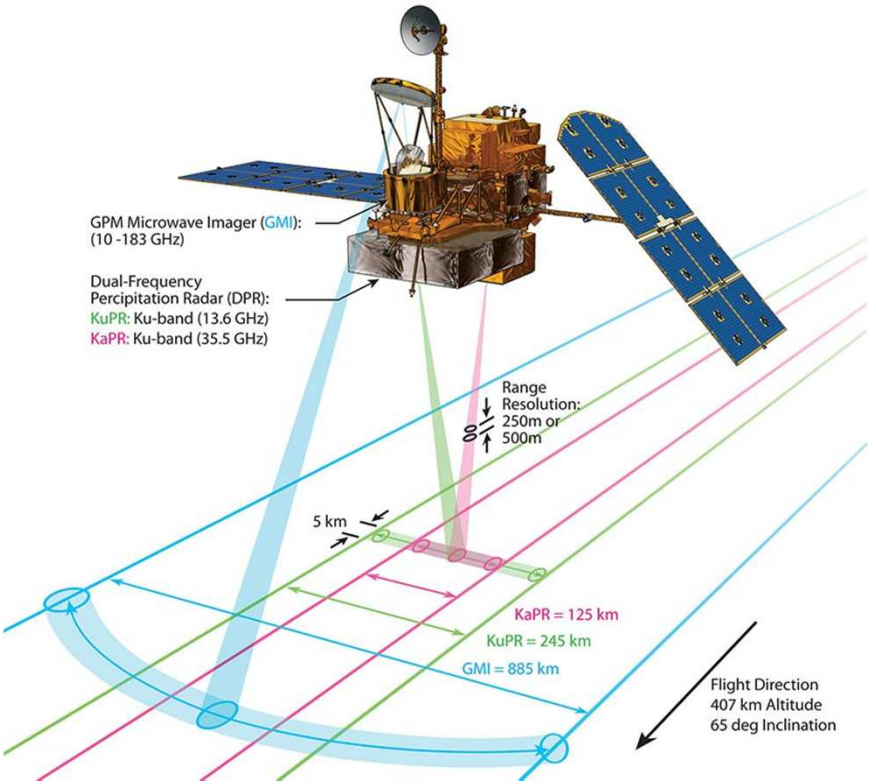
GLOBAL PRECIPITATION MEASUREMENT

Dual-Frequency (Ku-Ka band) Precipitation Radar (DPR):

- *Increased sensitivity (~12 dBZ) for light rain and snow detection relative to TRMM*
- *Better measurement accuracy with differential attenuation correction*
- *Detailed microphysical information (DSD mean mass diameter & particle no. density) & identification of liquid, ice, and mixed-phase regions*

Multi-Channel (10-183 GHz) GPM Microwave Imager (GMI):

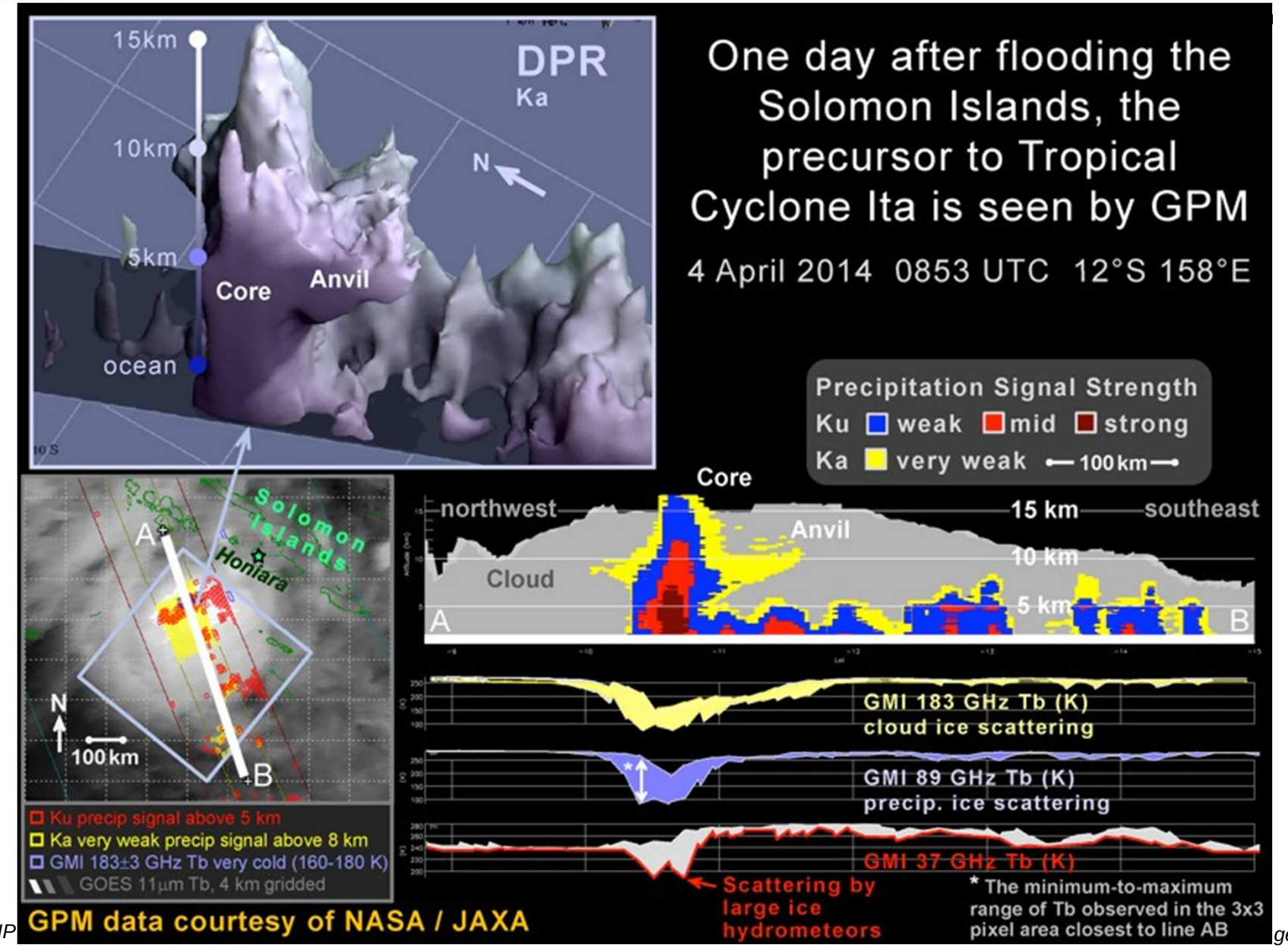
- *Higher spatial resolution (IFOV: 6-26 km)*
- *Improved light rain & snow detection*
- *Improved signals of solid precipitation over land (especially over snow- covered surfaces)*
- *4-point calibration to serve as a radiometric reference for constellation radiometers*

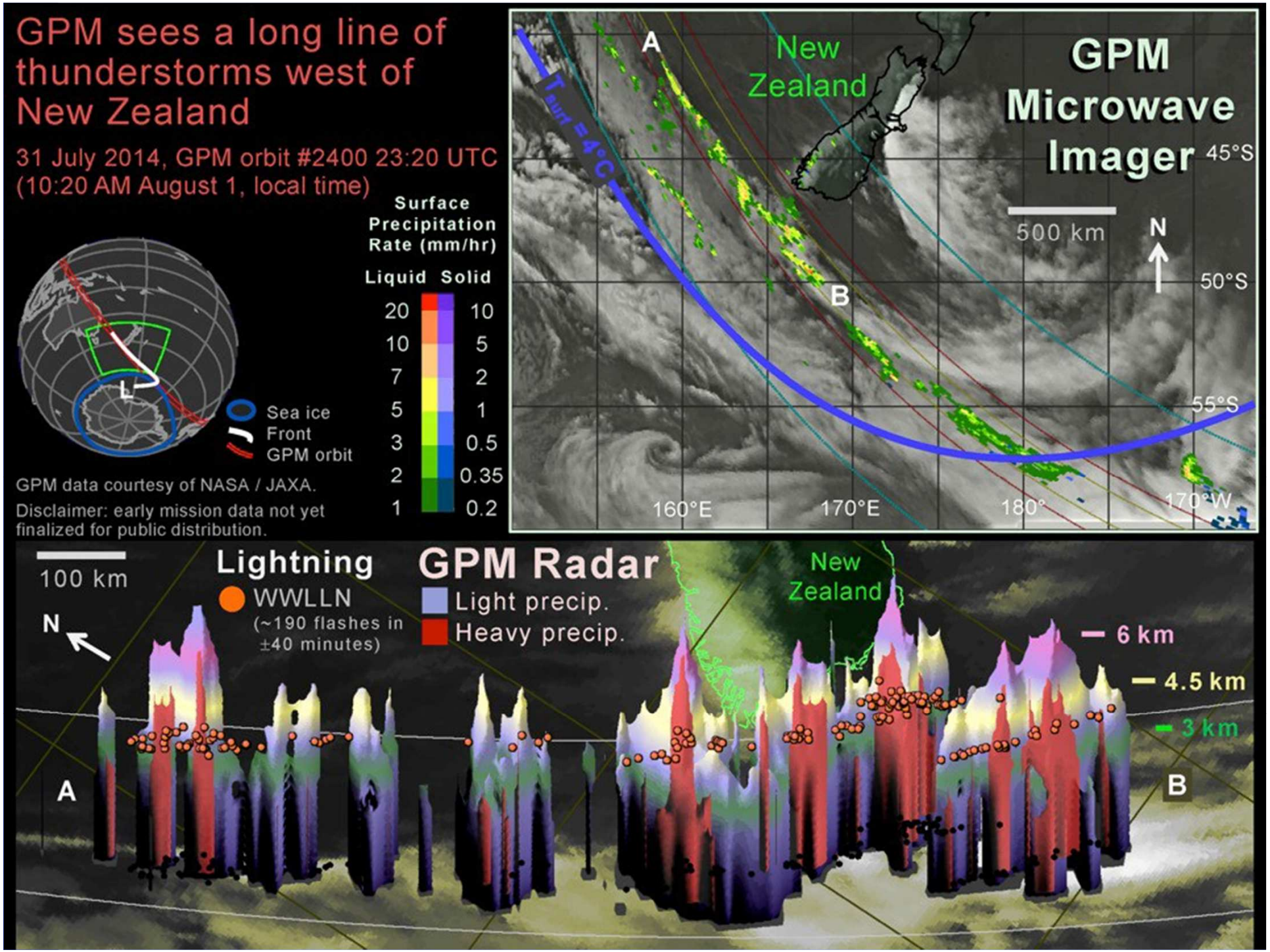


Combined Radar-Radiometer Retrieval

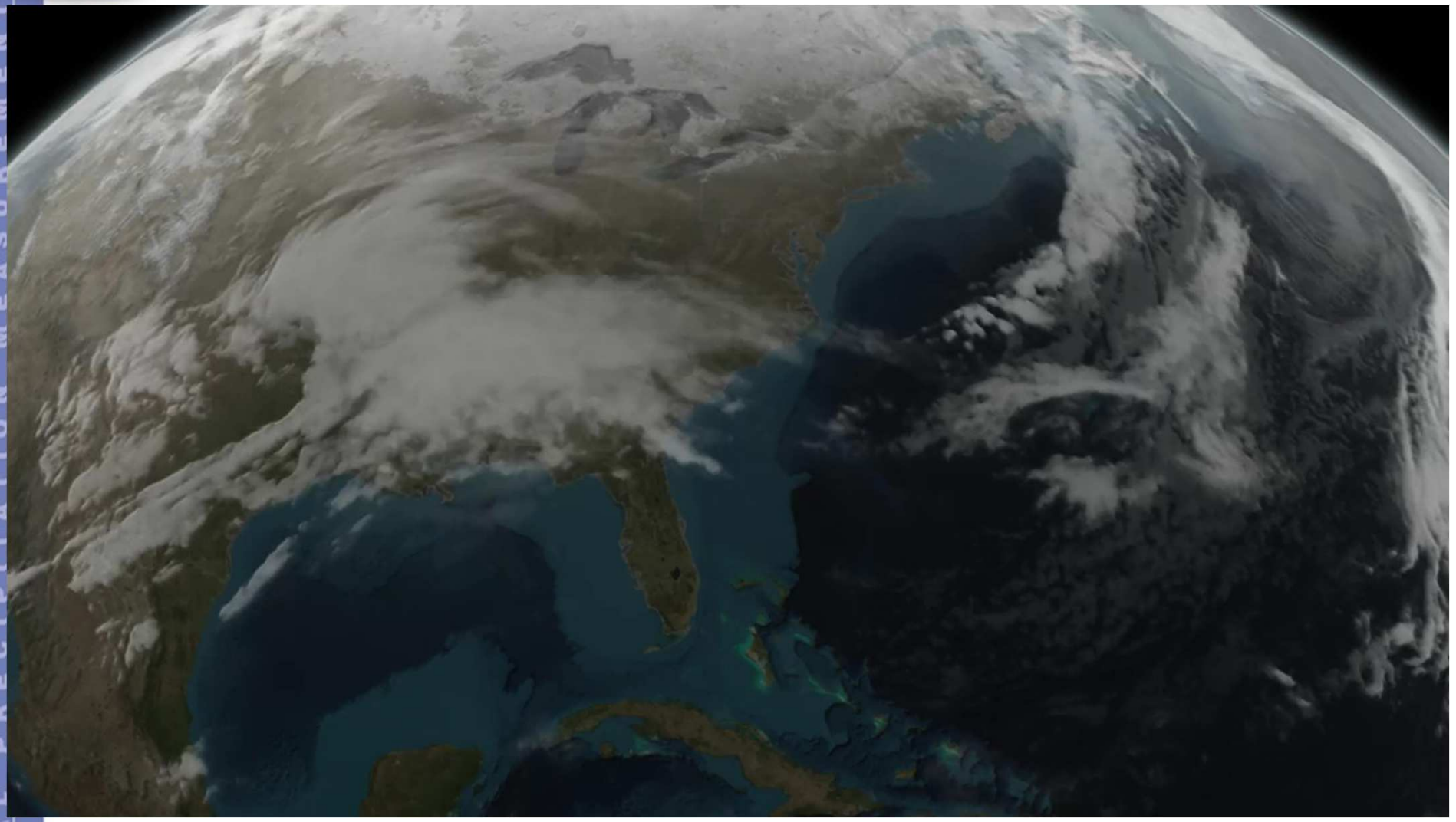
- *DPR & GMI together provide greater constraints on possible solutions to improve retrieval accuracy*
- *Observation-based a-priori cloud database for constellation radiometer retrievals*

GPM Core Observatory: New Scientific Capabilities




GPM sees a long line of thunderstorms west of New Zealand
31 July 2014, GPM orbit #2400 23:20 UTC
(10:20 AM August 1, local time)
Surface Precipitation Rate (mm/hr)
Liquid Solid
20 10
10 5
7 2
5 1
3 0.5
2 0.35
1 0.2
Sea ice
Front
GPM orbit
GPM data courtesy of NASA / JAXA.
Disclaimer: early mission data not yet finalized for public distribution.
A
New Zealand
GPM Microwave Imager
T Surf = 4°C
B
500 km
N
45°S
50°S
55°S
160°E
170°E
180°
170°W
100 km
N
Lightning
WWLLN
(~190 flashes in ±40 minutes)
GPM Radar
Light precip.
Heavy precip.
New Zealand
6 km
4.5 km
3 km
A
B

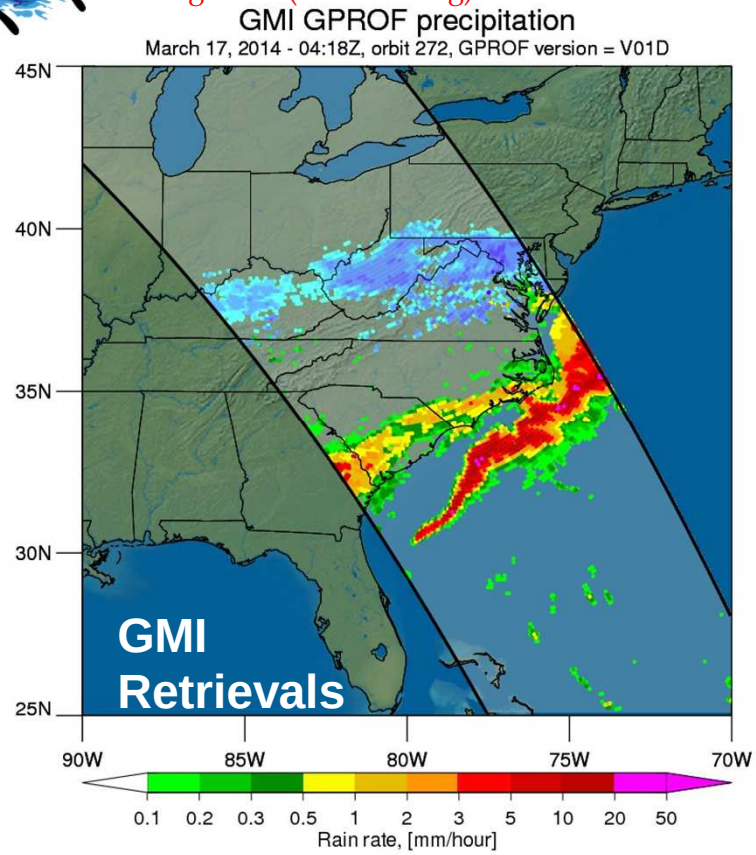
March 17, 2014 Snow Storm



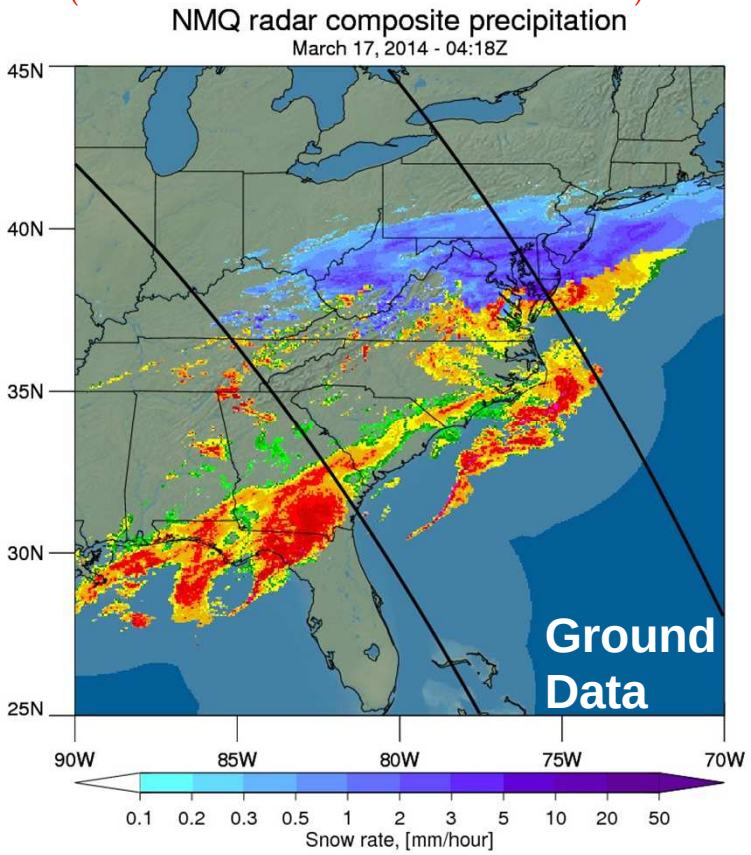
Falling Snow as Observed by GMI

NASA's GPM Microwave Imager (GMI) was specifically designed to detect falling snow. This snow event occurred March 17, 2014 and deposited more than 7" of snow in the Washington, DC metro area.

Bottom Left: GMI retrievals of liquid rain (greens to reds indicate light to heavy rain) and falling snow (blue shading).



Bottom Right: Ground measurements from NOAA's National Mosaic & Multi-Sensor QPE (CONUS 3D radar mosaic at 1km resolution).

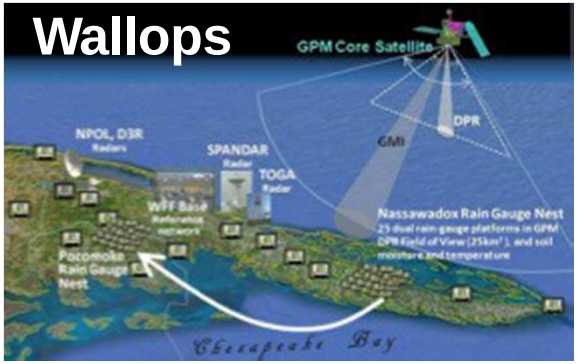


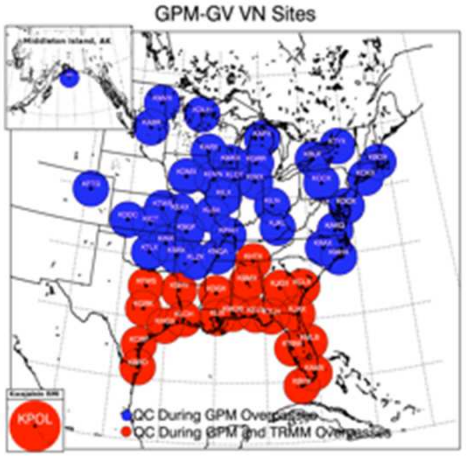
Courtesy Kummerow/Berg

Ground Validation Activities

GLOBAL PRECIPITATION MEASUREMENT

Direct Validation





A Global View of Precipitation with a Global Team

Field campaigns for physical and hydrological validation

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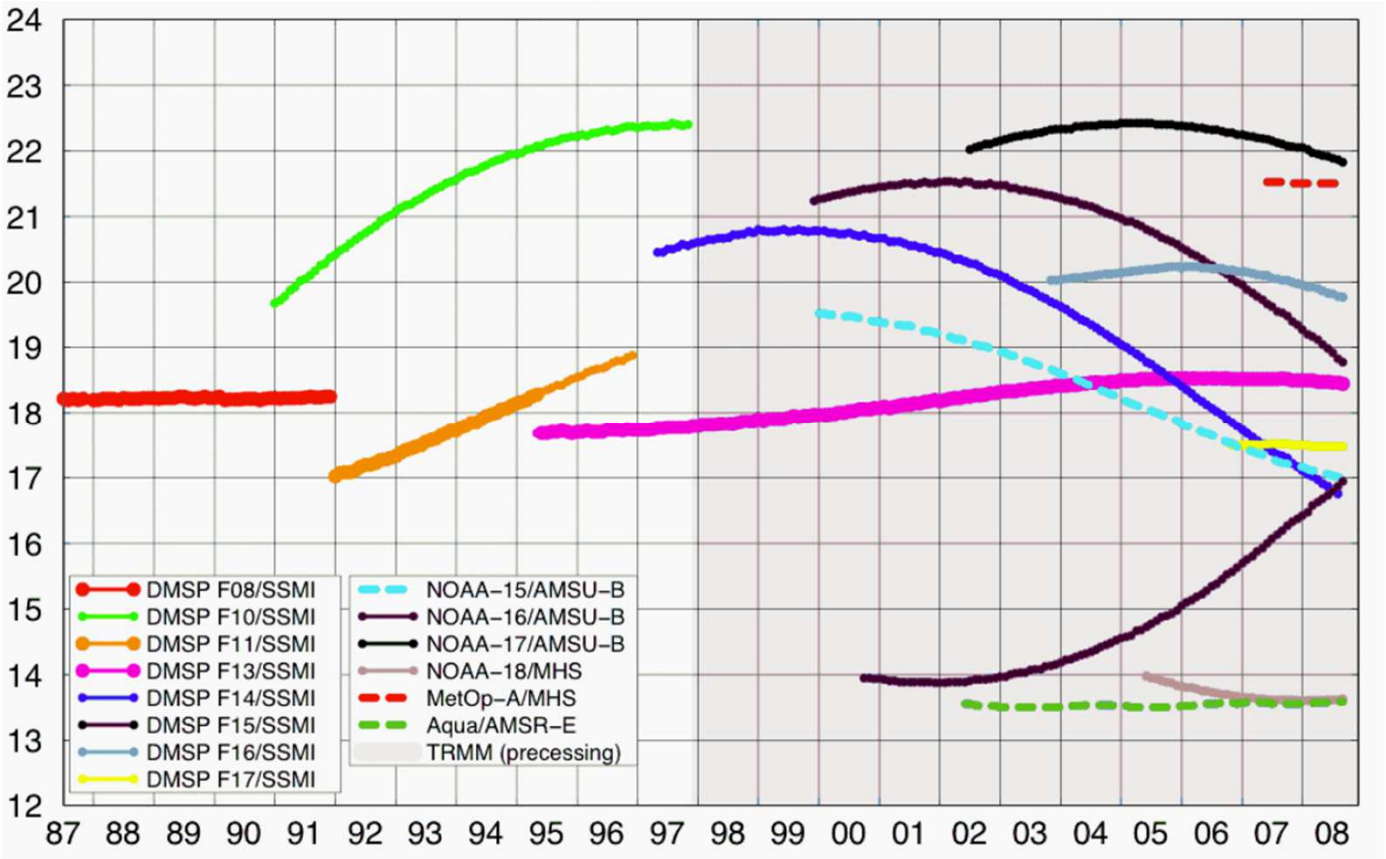
TRMM and TMPA

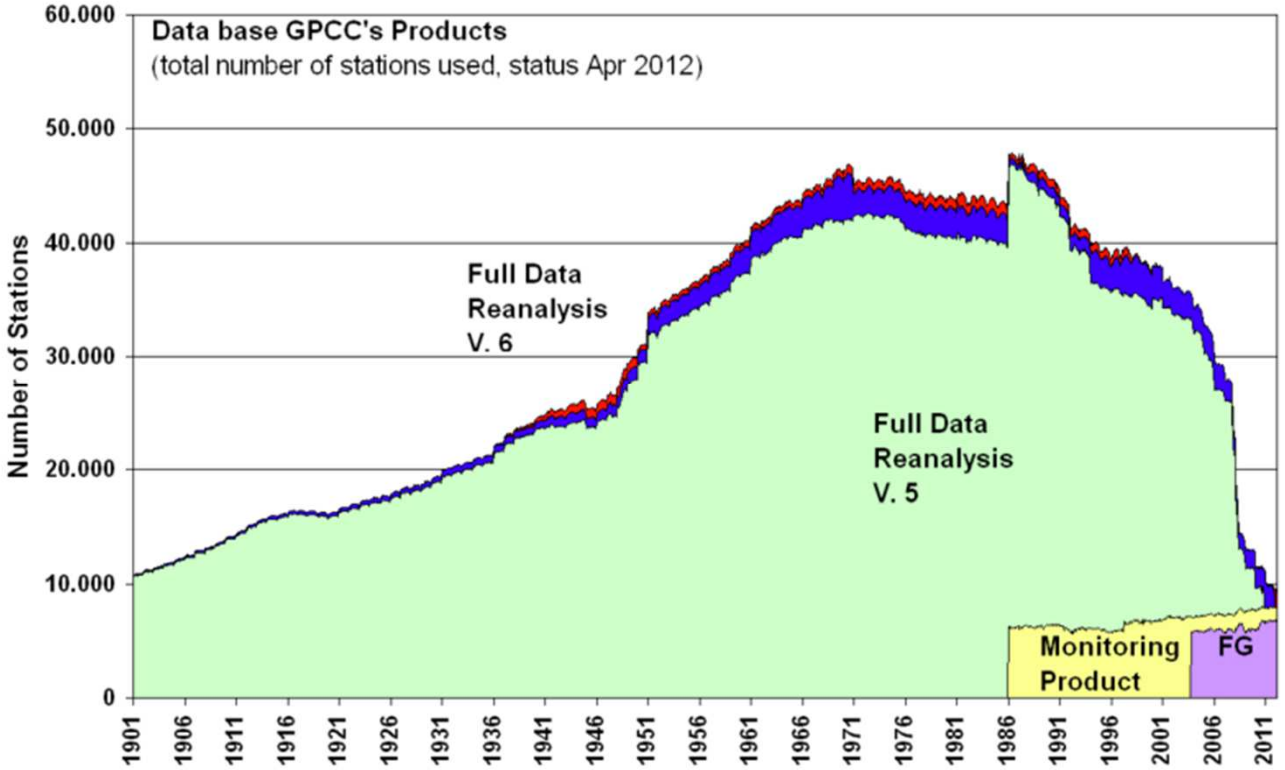
TMPA is the TRMM Multi-satellite Precipitation Analysis



Equator-crossing times of precipitation-sensing microwave satellites

RT and RP products

TMPA Version 7 provides two 3-houly data sets: near-real-time data (RT) (4-5 hrs after observation) and research quality data (RP) (approx. 1 month after, with ground observation from GPCC). Both data have 0.25°× 0.25° resolutions (50° N to 50° S).



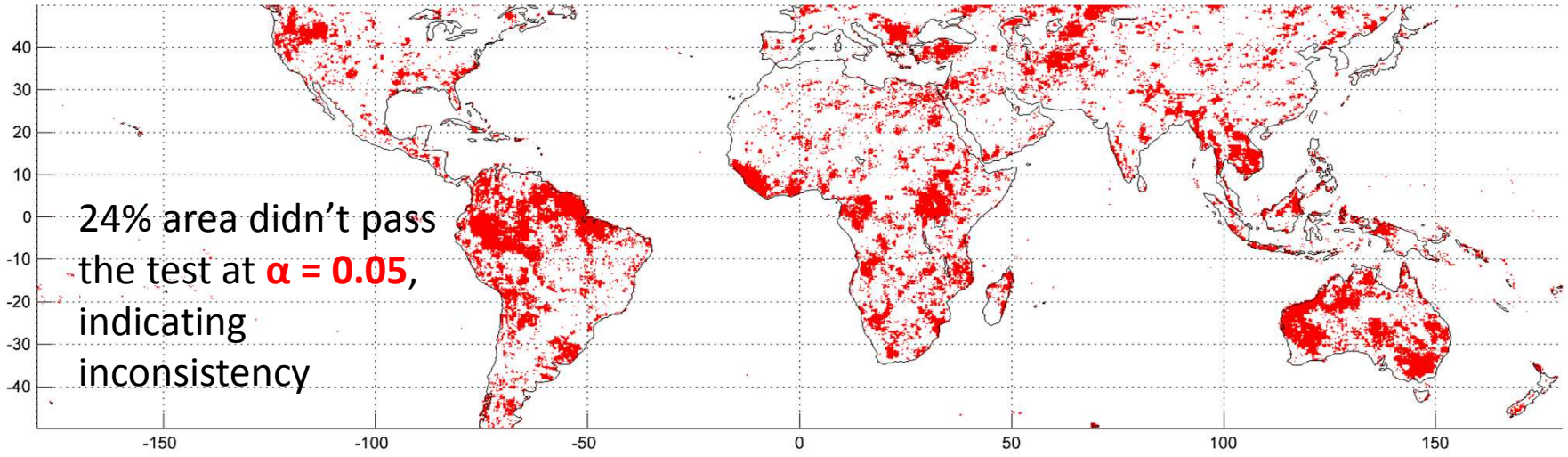
Number of gauges used in GPCC products

Questions

- Are RT and RP data systematically consistent from 2000 (the date RT released) to 2012?

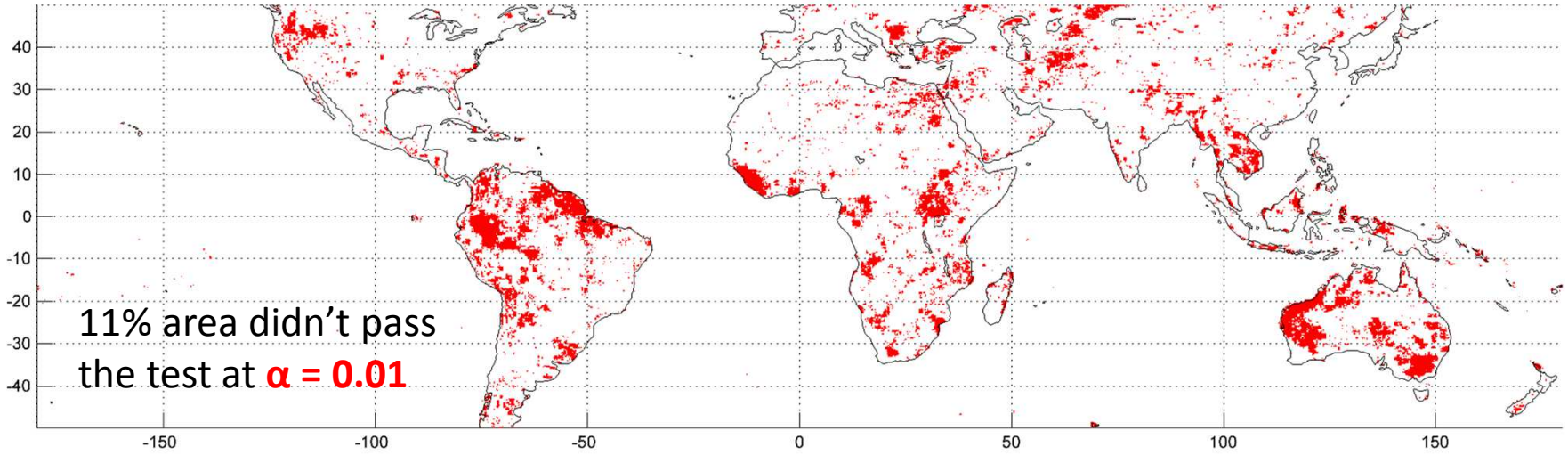
- If not, spatial distribution of the inconsistent area?

Results: Inconsistent areas



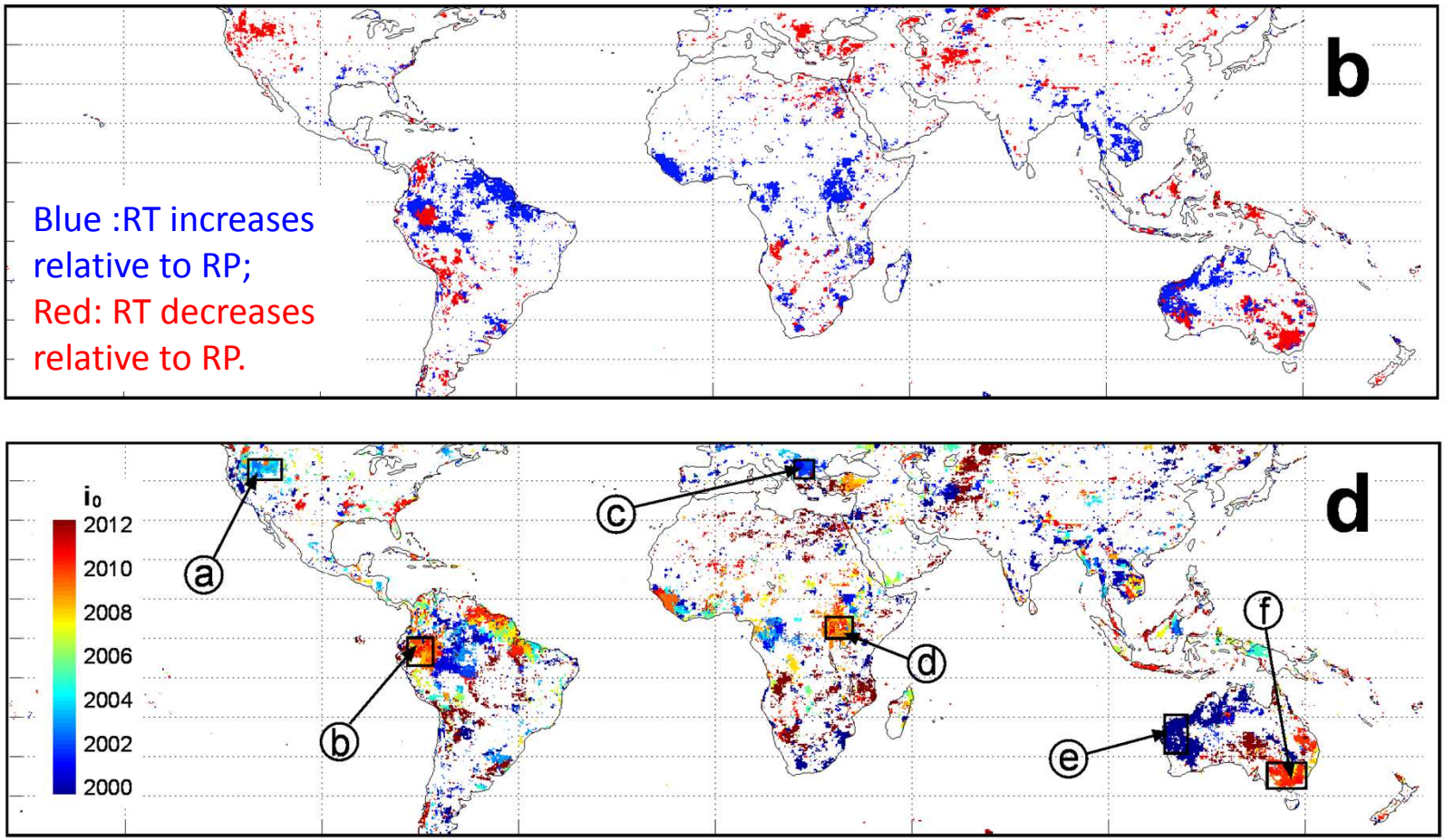
24% area didn't pass the test at **α = 0.05**, indicating inconsistency

The test statistics in these areas are quite close to the 0.05 critical level. It is useful to focus on the areas in which the null hypothesis was rejected at a higher significance level.

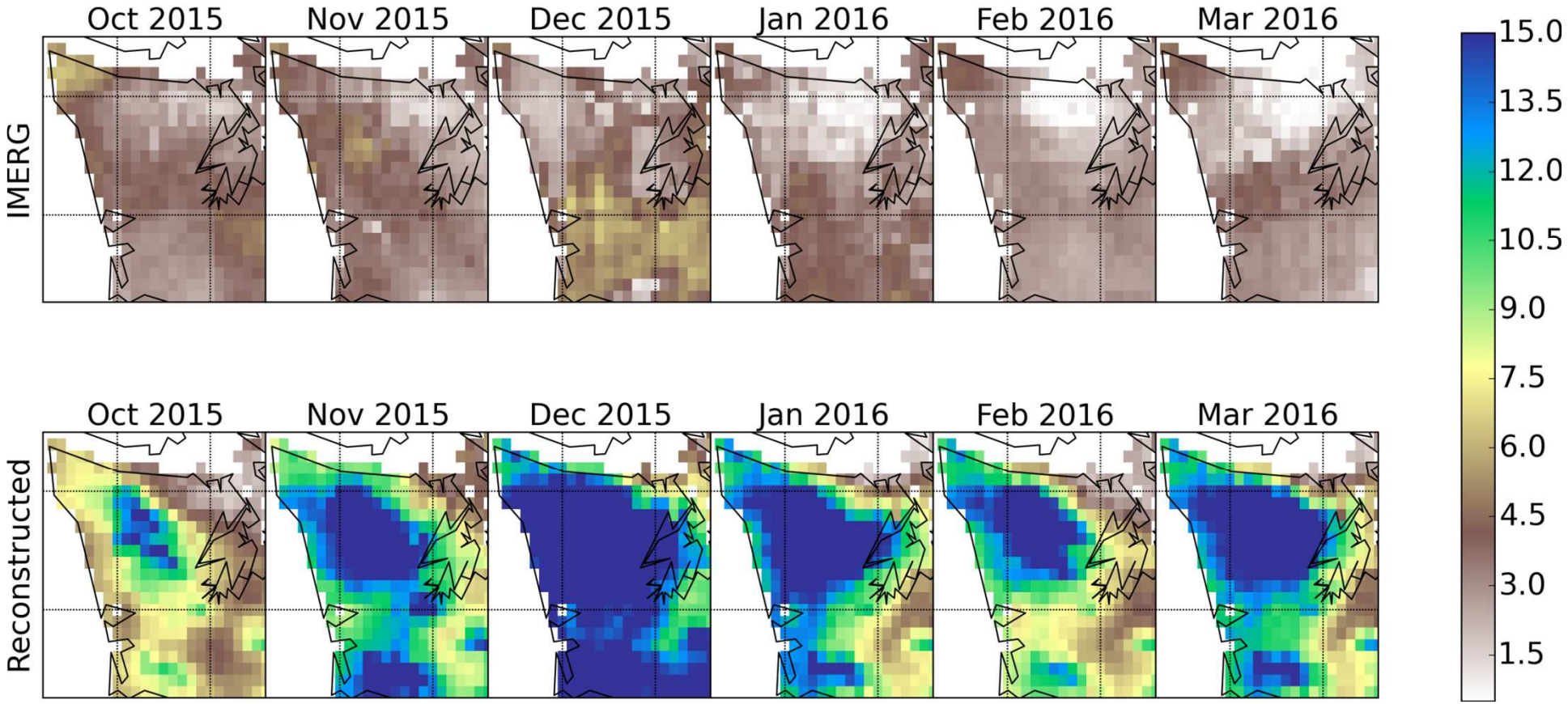


11% area didn't pass the test at **α = 0.01**

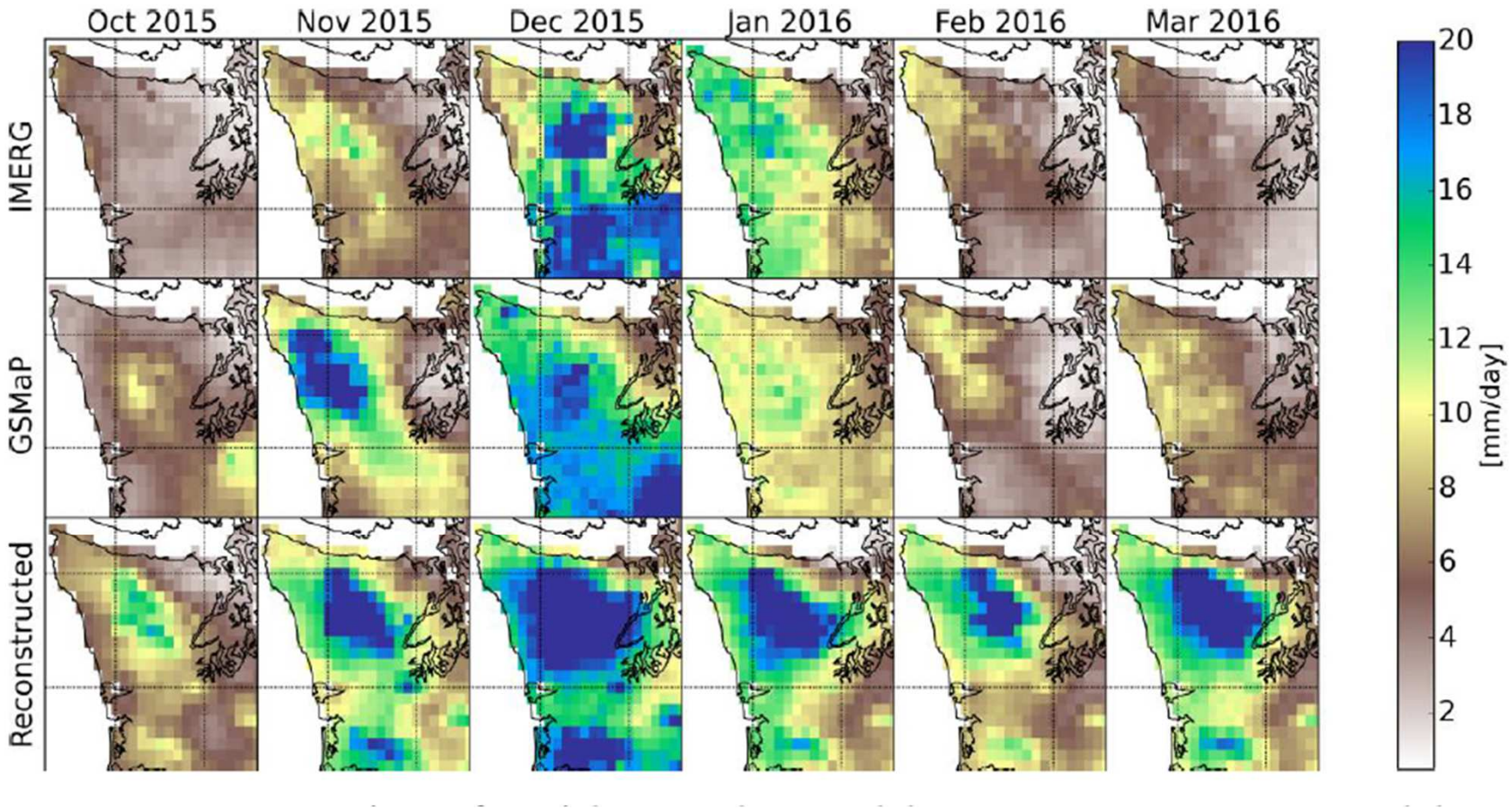
Results: RT changes relative to RP



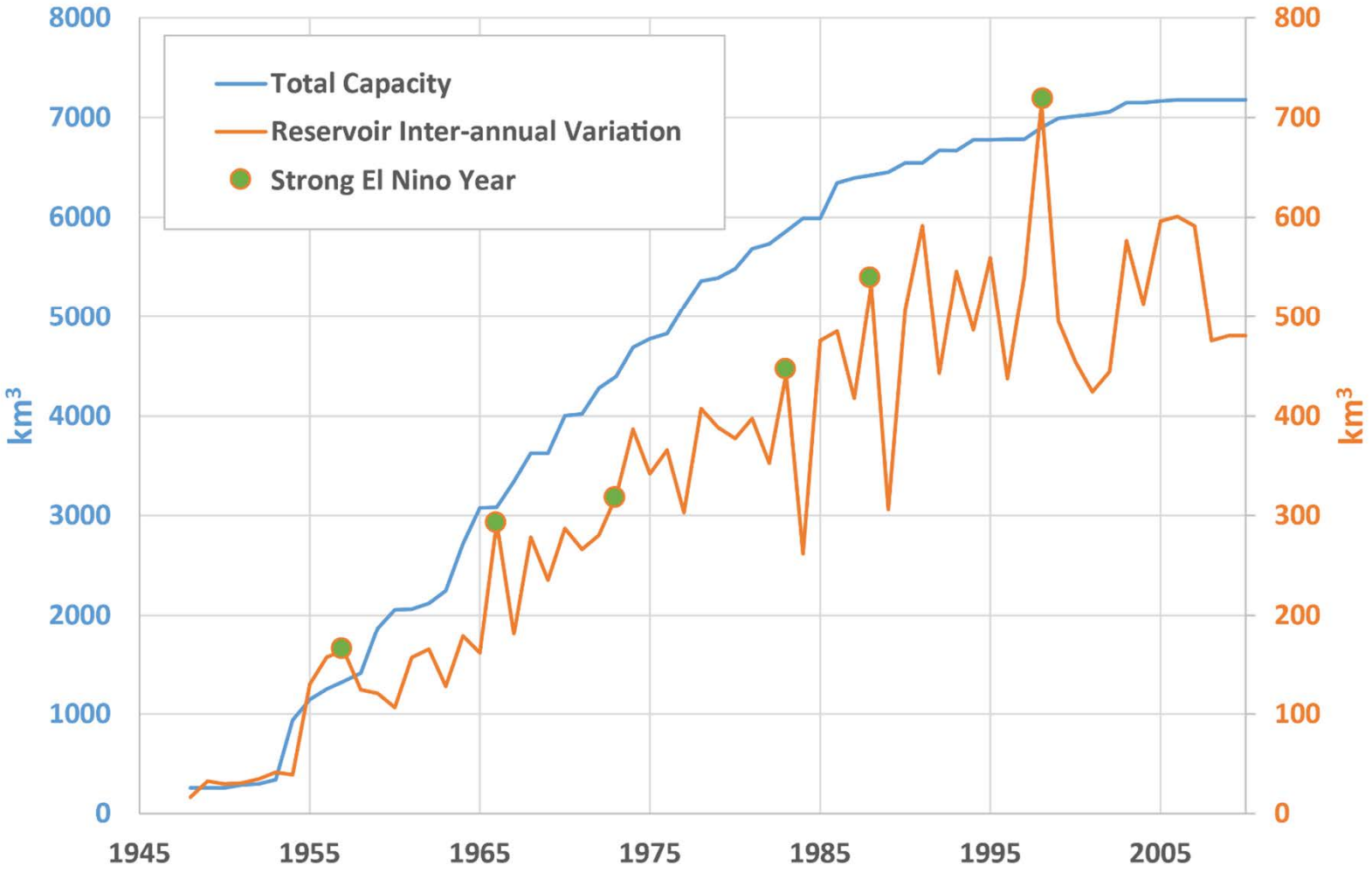
Spatial comparison by month



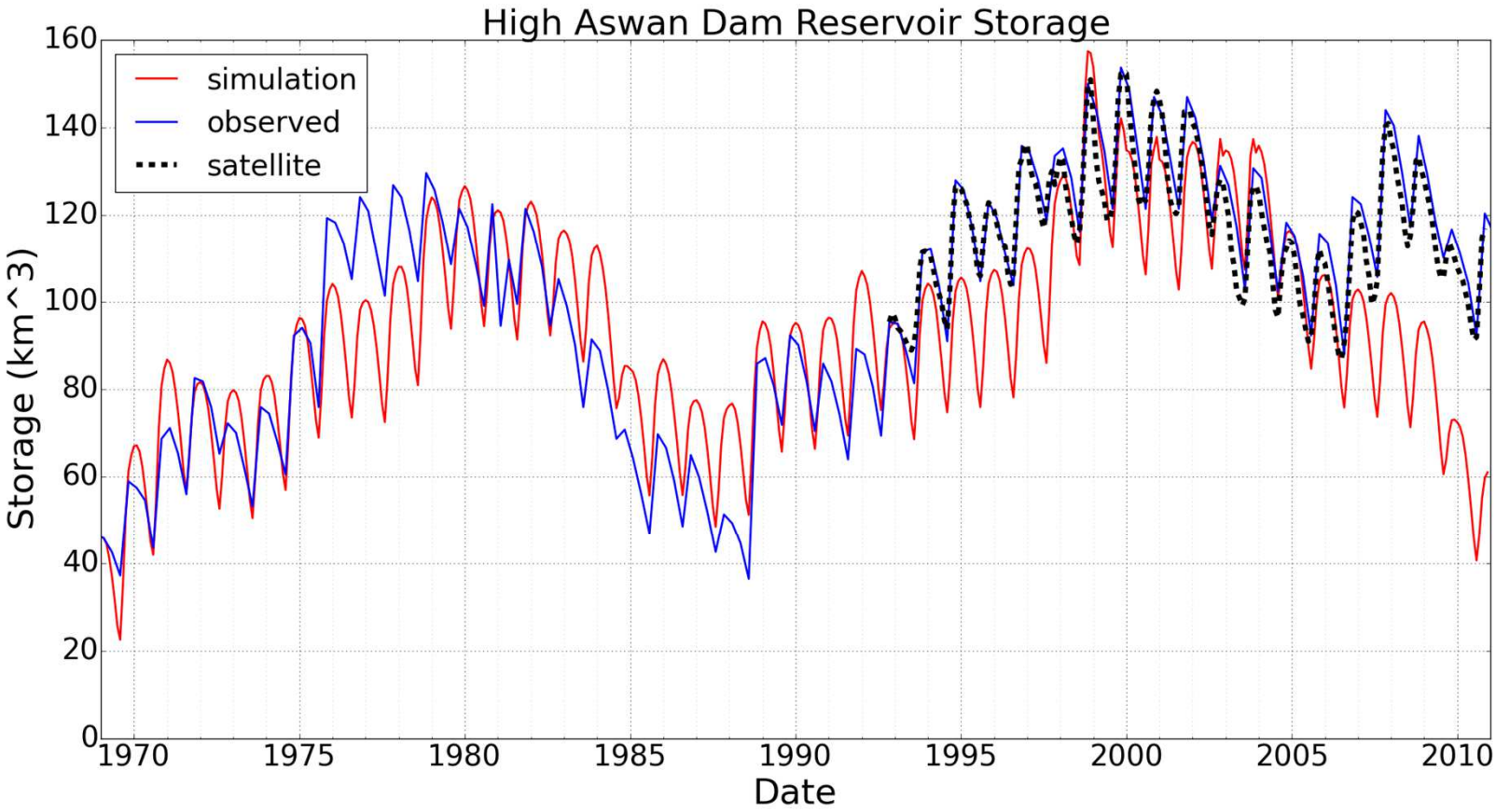
IMERG and GSMAP over OLYMPEX domain, Apr, 2017



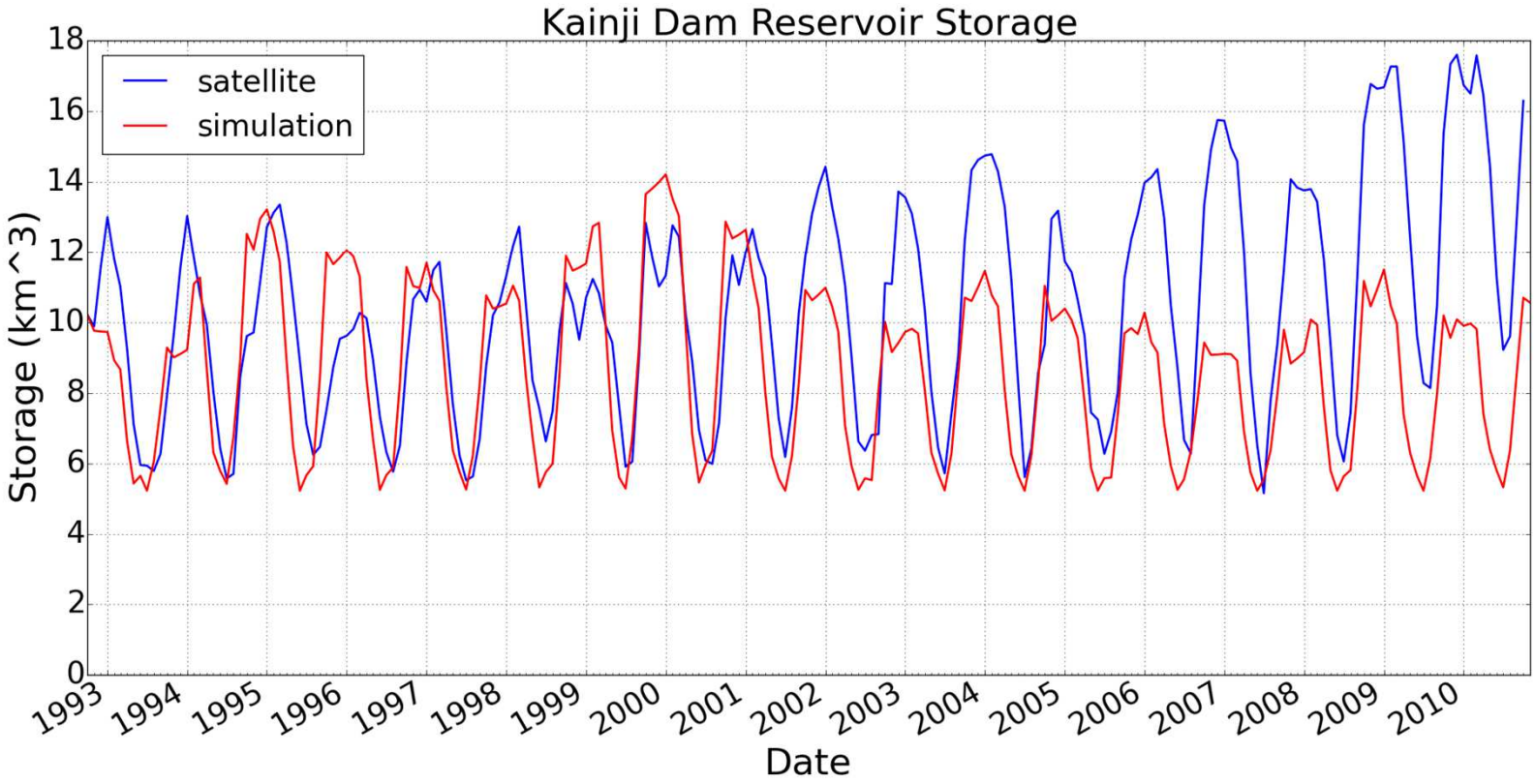
Inter annual storage variation along with the global total reservoir capacity change



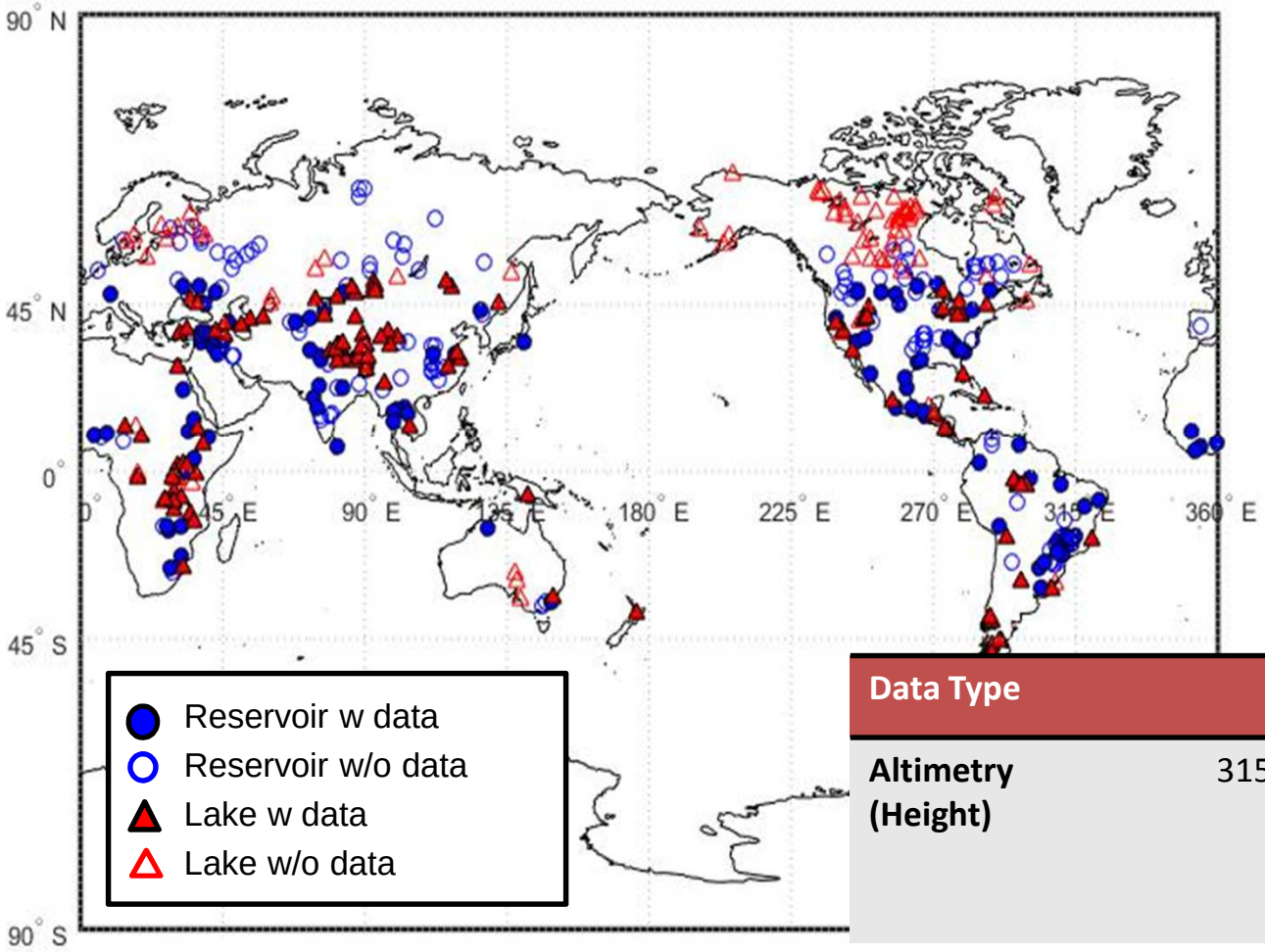
Modeled and observed storage, Lake Nasser



Modeled and observed storage, Kainji Reservoir



Current Status of Global Reservoirs/Lakes Storage Estimate



- 424 reservoirs/lakes (>100km^2) will cover diverse sizes, target shape, and surrounding environment in global.

Data Type	Reservoir + Lake	
Altimetry (Height)	315/424	G-REALM10: 167/424 G-REALM35: 146/424 LEGOS: 133/424 DAHITI: 144/424
Surface Extent	319/424	
Storage	251/424	

(last updated Dec. 2016)

Why does this matter?

- For lakes and reservoirs, understanding why storage variations are as observed requires replication of the water balance (can also be used to “reverse engineer” reservoir operating policies.
- The main terms in the water balance of lakes and reservoirs (usually) are a) inflows, and b) releases (instream and to meet external demand)
- On a global basis, the places where we have the poorest information about lake and reservoir storage variations generally are places where the in situ precipitation network also is the worst (e.g., developing countries, and high latitudes)
- Remote sensing (e.g. GPM) offers one source of precipitation data that don’t require (at least in estimates like TMPA-RT) surface observations
- An alternative source is analysis fields (or reanalysis) from numerical weather prediction models. At this point, we don’t know which is better (where).