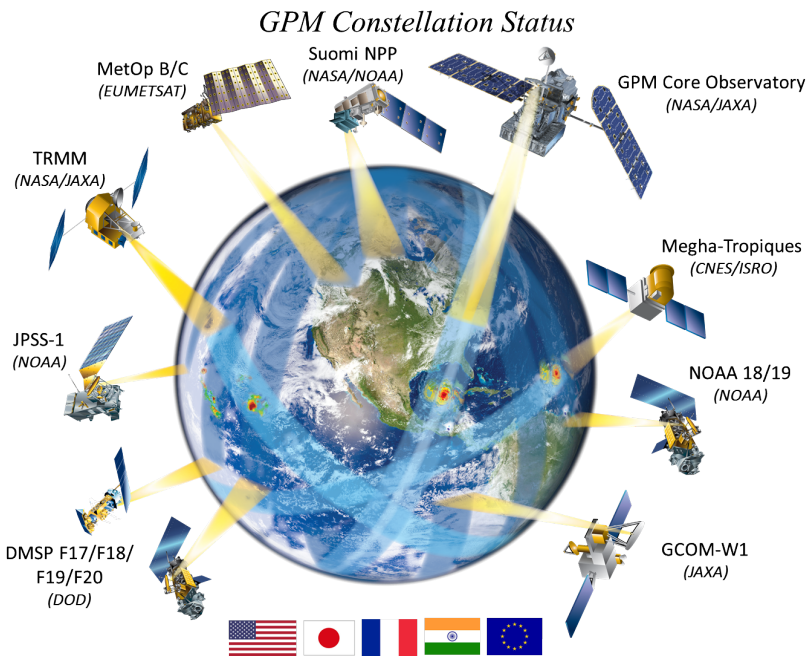
The GPM Microwave Imager & Constellation : Algorithm Status



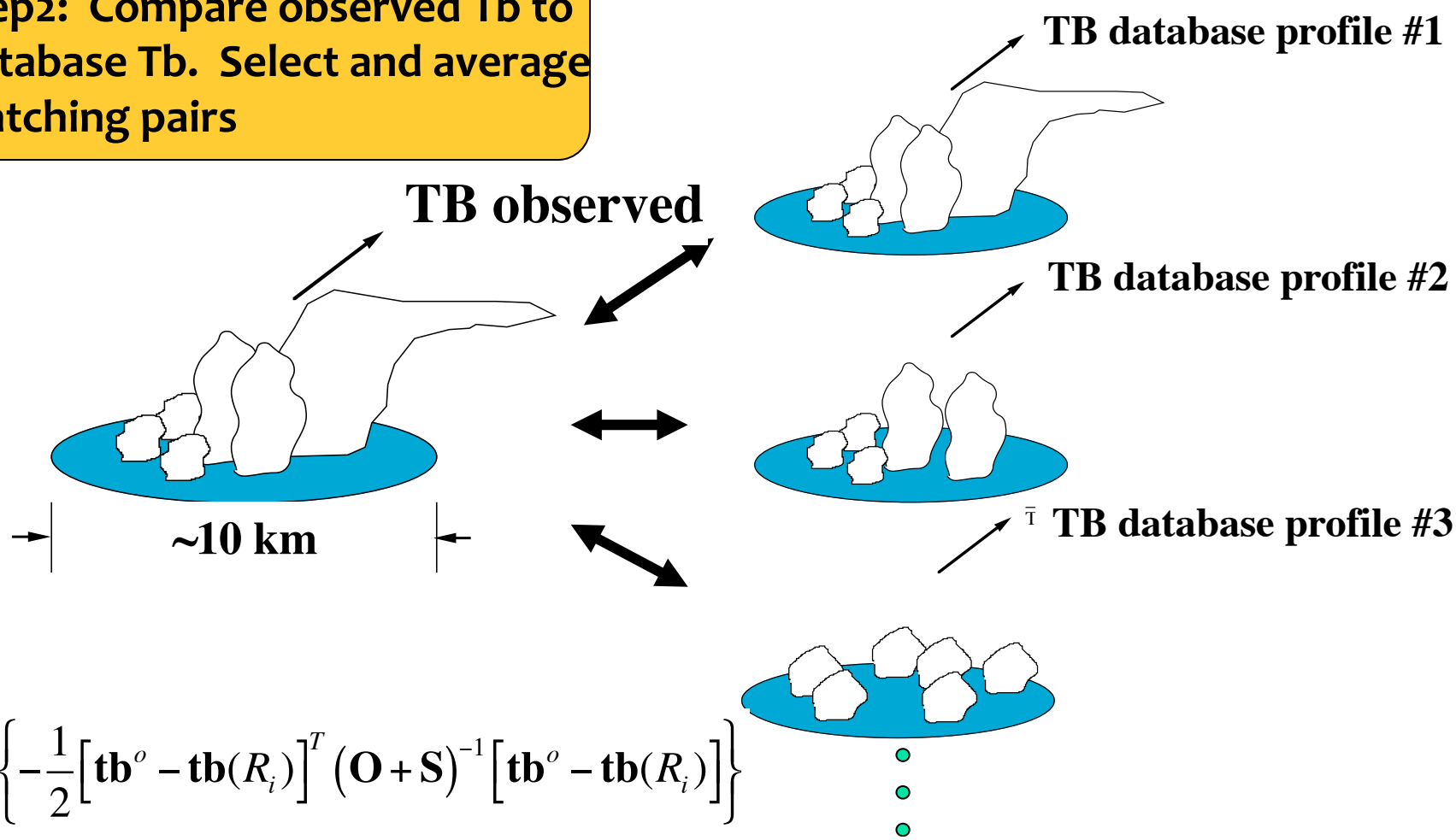
Christian Kummerow
Dave Randel
Sarah Ringerud
David Duncan
VeljkoPetkovic
Pierre Kirstetter

PMM Science Team Meeting
October 17, 2017
San Diego, CA

The GPM radiometer algorithm

Step 1: Use GPM Satellite to derive set of "Observed" profiles that define an a-priori database of possible rain structures.

Step2: Compare observed Tb to Database Tb. Select and average matching pairs



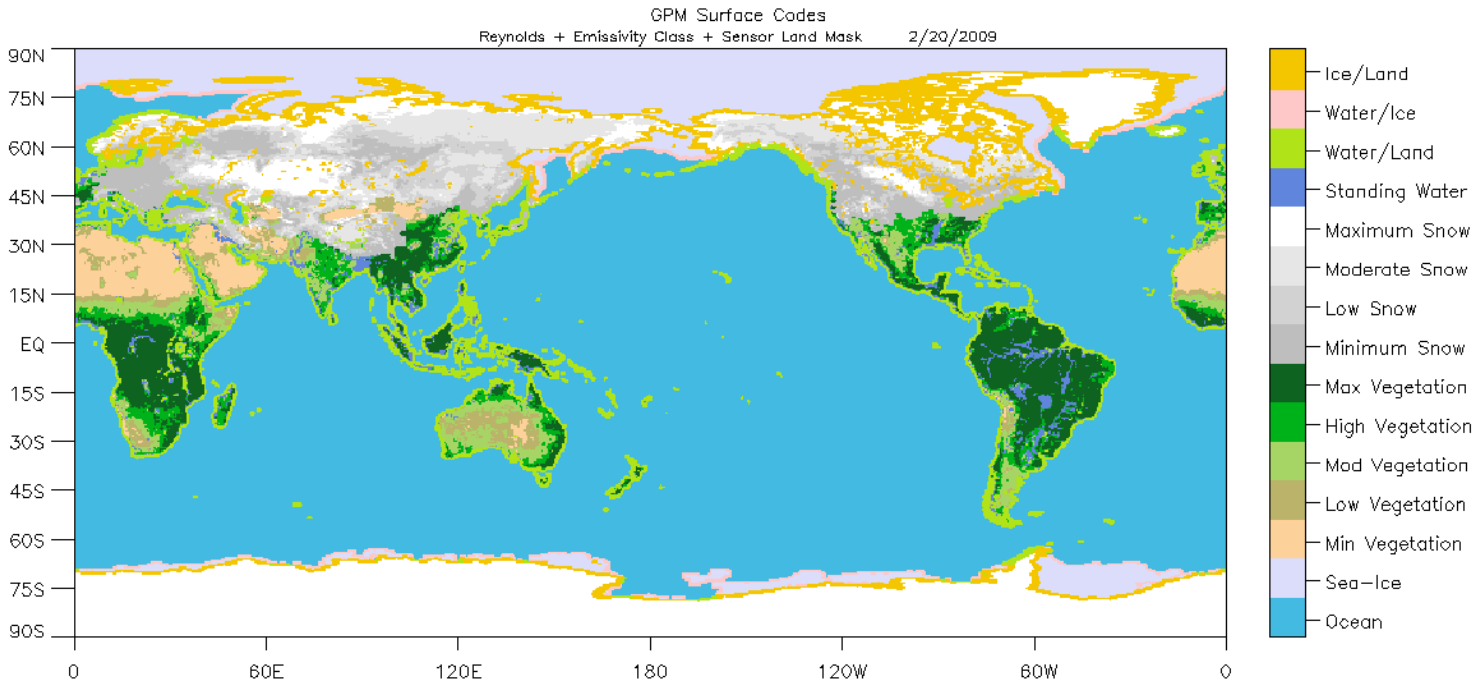
$$J_i = \exp\left\{-\frac{1}{2}\left[\mathbf{tb}^o - \mathbf{tb}(R_i)\right]^T \left(\mathbf{O}+\mathbf{S}\right)^{-1}\left[\mathbf{tb}^o - \mathbf{tb}(R_i)\right]\right\}$$

GPROF 2014 Database Divisions

For Operational Algorithm:

Do not to mix different surface types

Do not to mix different T_{2m} or TPW

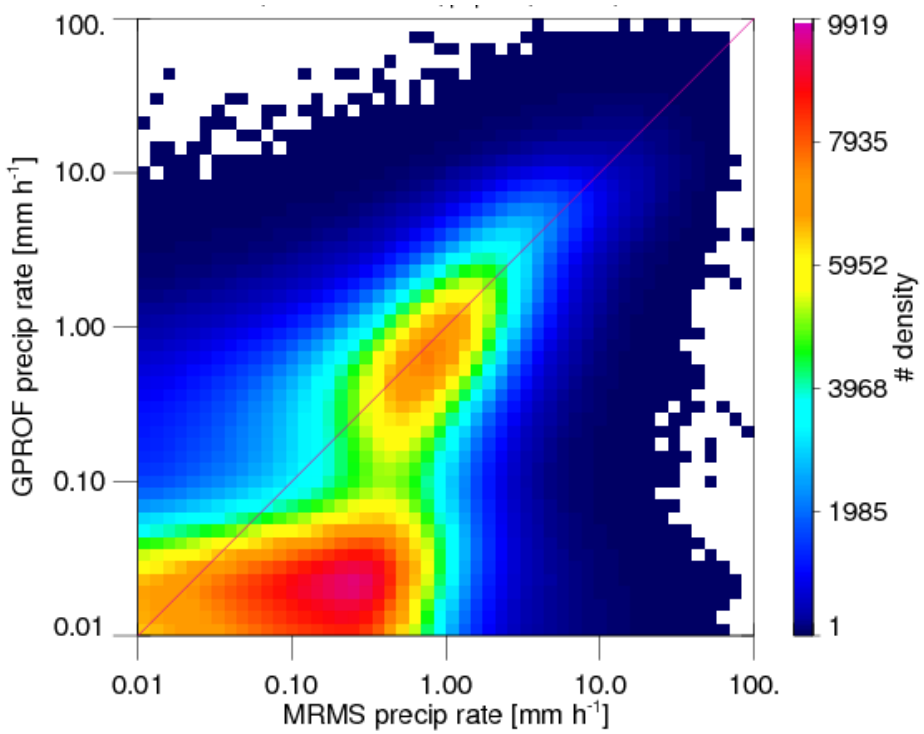


GPROF 2017: aka GMI version 5

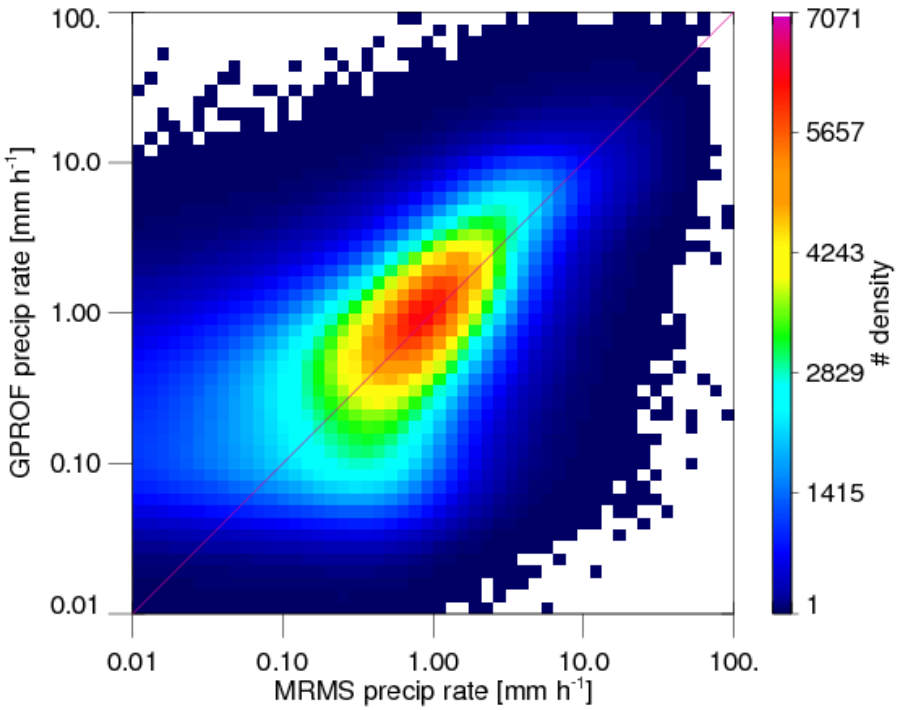
- Over oceans, uses “Combined V04” rainfall + additional hydrometeor adjustments to get better Tb match at higher GMI frequencies.
- Uses GMI to extend rain rates to lower thresholds than detectable by DPR. Cloud Water is converted to drizzle to match CloudSat rain occurrence.
- Over land, uses “DPR Ku V04” rainfall + additional hydrometeor adjustments to get better Tb match at higher GMI frequencies.
- Over snow covered surfaces, uses “MRMS matchups with individual satellites” for a-priori databases
- Sets precipitation threshold to match rain occurrence in a-priori database.

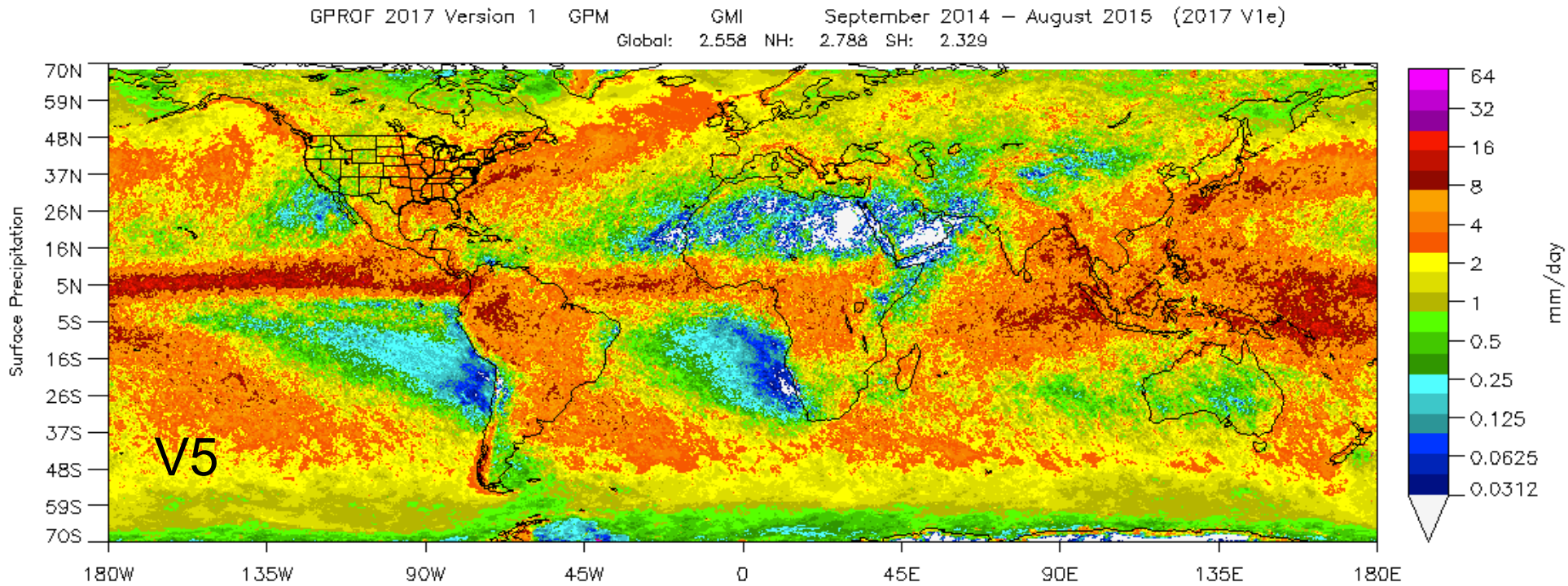
GPROF V4 vs V5

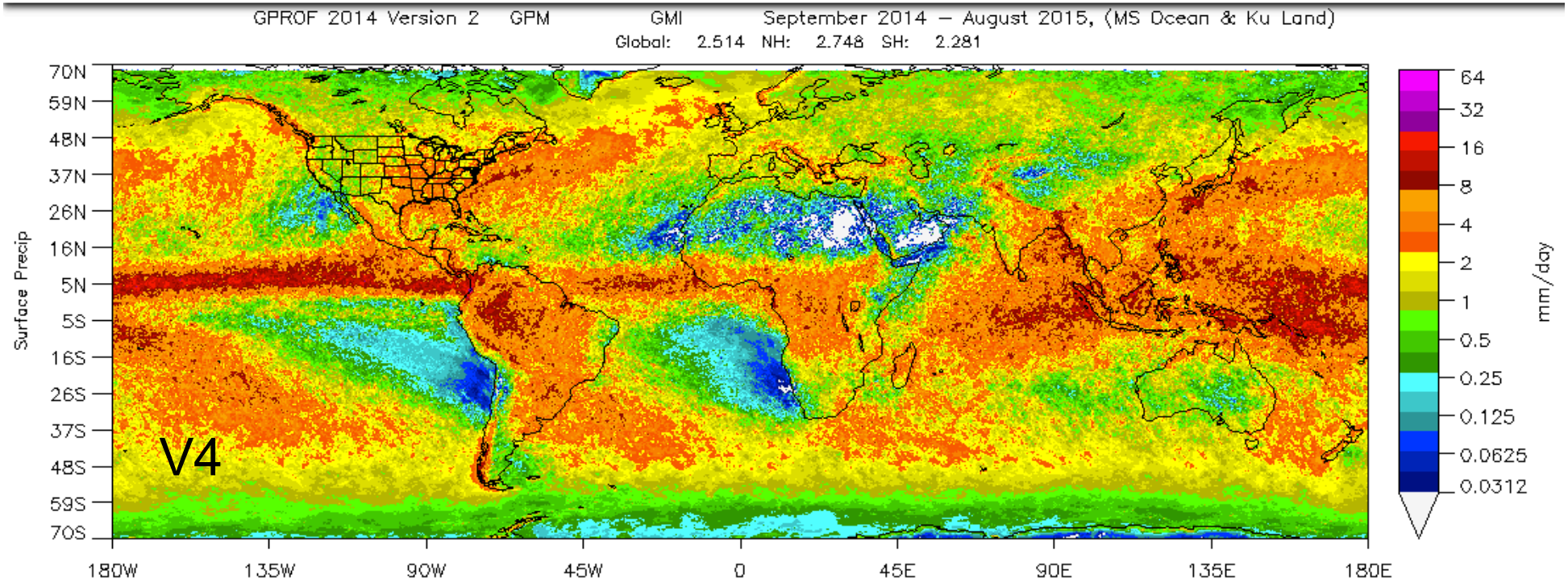
V4



V5




GPROF 2017 Version 1 GPM GMI September 2014 – August 2015 (2017 V1e)
Global: 2.558 NH: 2.788 SH: 2.329
Surface Precipitation
70N
59N
48N
37N
26N
16N
5N
5S
16S
26S
37S
48S
59S
70S
180W
135W
90W
45W
0
45E
90E
135E
180E
V5
64
32
16
8
4
2
1
0.5
0.25
0.125
0.0625
0.0312
mm/day


GPROF 2014 Version 2 GPM GMI September 2014 – August 2015, (MS Ocean & Ku Land)
Global: 2.514 NH: 2.748 SH: 2.281
Surface Precip
70N
59N
48N
37N
26N
16N
5N
5S
16S
26S
37S
48S
59S
70S
180W
135W
90W
45W
0
45E
90E
135E
180E
V4
64
32
16
8
4
2
1
0.5
0.25
0.125
0.0625
0.0312
mm/day

Quantitative validation over central US

V04A and ITE114 2AGPROF GMI, and L1 Rain Rate vs. GV MRMS

V4

Footprint:
Correlation 0.47, bias +24.6%- non-uniform and with modes;

L1:
Bias is high but in spec. NMAE behavior outside L1 spec.

ITE 114

Footprint:
Correlation 0.57, bias +20 %; Some modes, but smoother/better-behaved bias and reduced random error; greater extension to light rain;

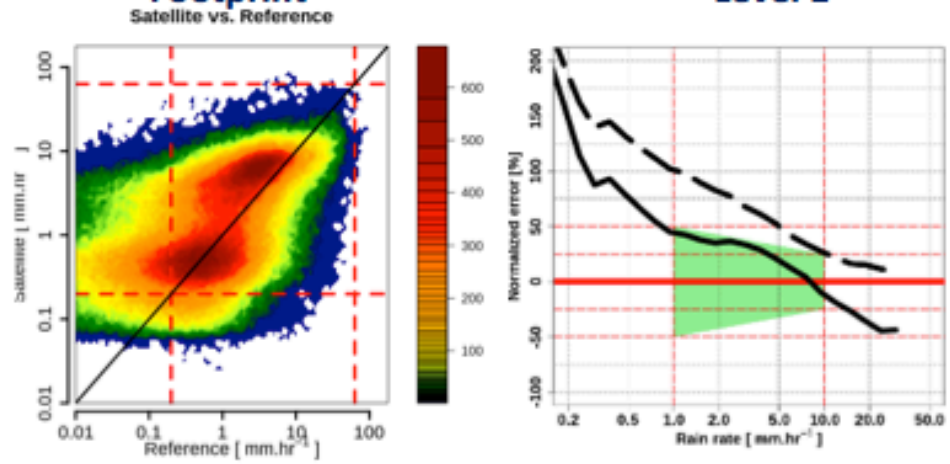
L1:
Bias a bit better, still high but within L1 spec; NMAE is improved but still a bit high for L1 on low rain rate end.

Snow:

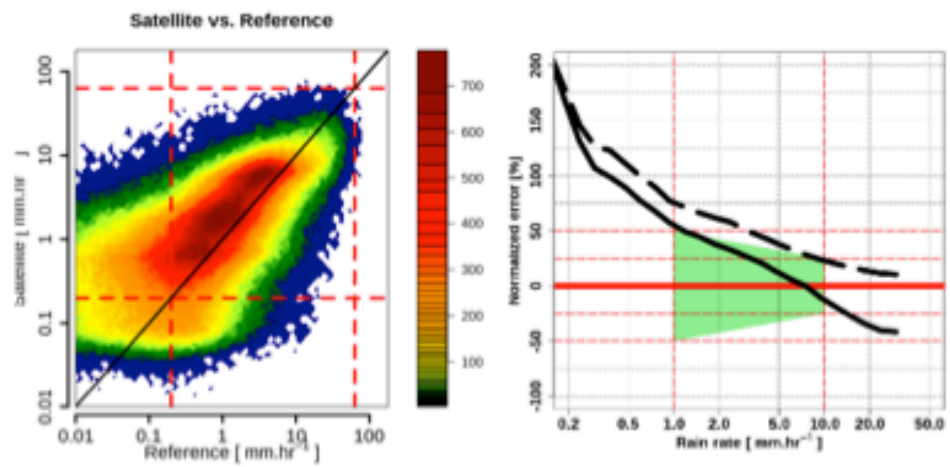
Detection HSS= 0.43 at 0.63 mm/hr
Delineation from Rain: HSS = 0.77

Footprint | **Level 1**

V4

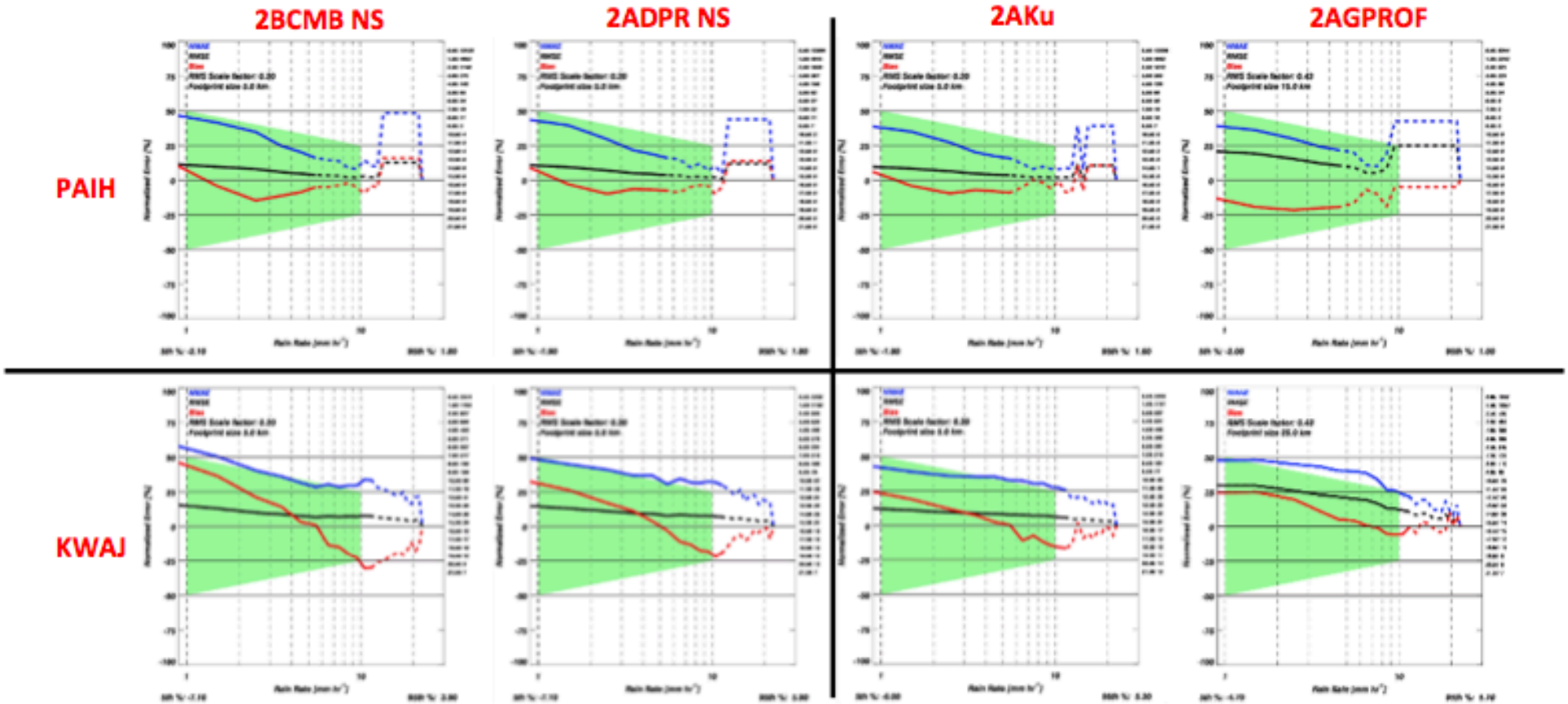


ITE114



Quantitative validation over Alaska and Kwajalein

Ocean (PAIH and KWAJ) **L1 (50 x 50 km) Rain Rates for ITE114**



All meet L1 and most improved from V4 to some degree (*in the net*). DPR NS/MS over Kwaj about the same between versions.
Regime and/or sampling affects the trends between PAIH and KWAJ. (Kwaj sampling less robust)
Beam filling impacts these trends.....more so for GPROF.....

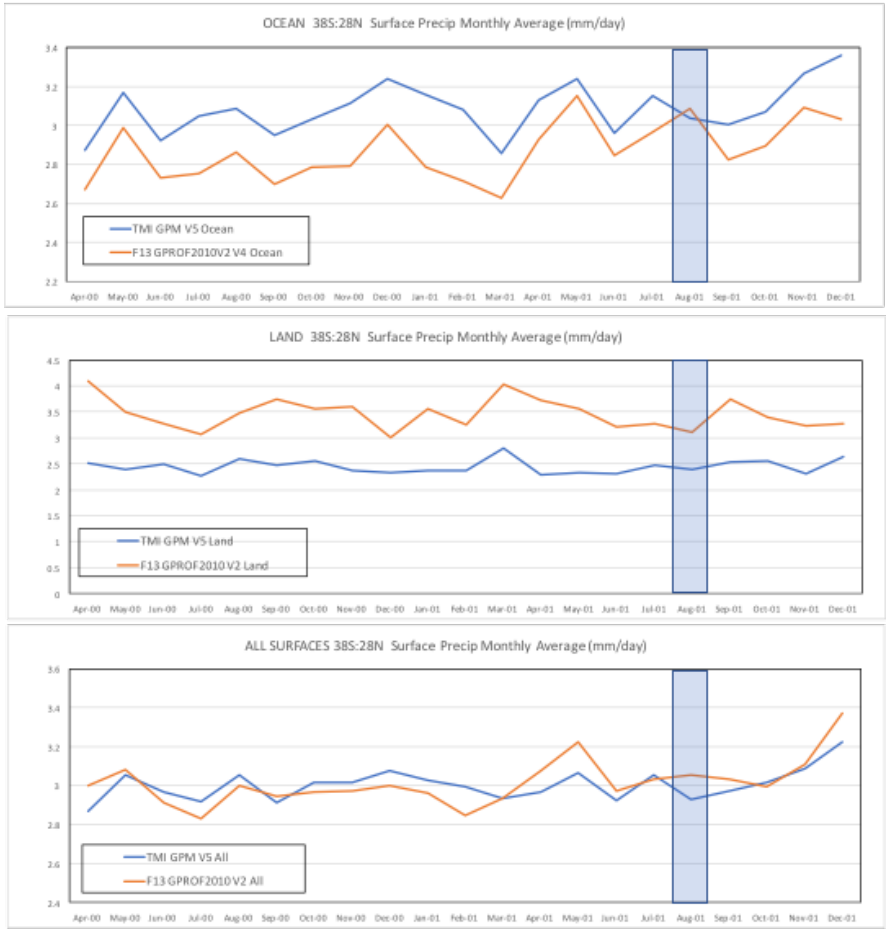
V5 Constellation

For GPM and TRMM eras

GMI	Feb 2014	Active
AMSR2	May 2012	Active
SSMIS-F16	Oct. 2003	Active
SSMIS-F17	Nov 2006	Active
SSMIS-F18	Oct 2009	Active
SSMIS-F19	Mar 2014	Jul 2016
AMSU-B/NOAA-16	Sep 2000	Active
MHS/NOAA-18	Aug 2005	Active
MHS/NOAA-19	Jun 2009	Active**
MHS/MetOp-A	May 2007	Active
MHS/MetOp-B	Sep 2012	Active
ATMS/NPP	Oct 2011	Active
TMI	Nov 1997	Apr 2014
AMSR-E	May 2002	Oct 2011
SSMI-F11	Nov 1991	May 2000
SSMI-F13	Mar 1995	Nov 2009
SSMI-F14	Apr 1997	Aug 2008
SSMI-F15	Dec 1999	Active*
AMSU-B/NOAA-15	May 1998	Jun 2014
AMSU-B/NOAA-17	Jun 2002	Jun 2002

Verifying TMI consistency across orbit boost

TMI GPM V5 Pre, and Post Boost Compared to
GPROF2010V2 SSMI (F13)



August 2001 TMI Boost month

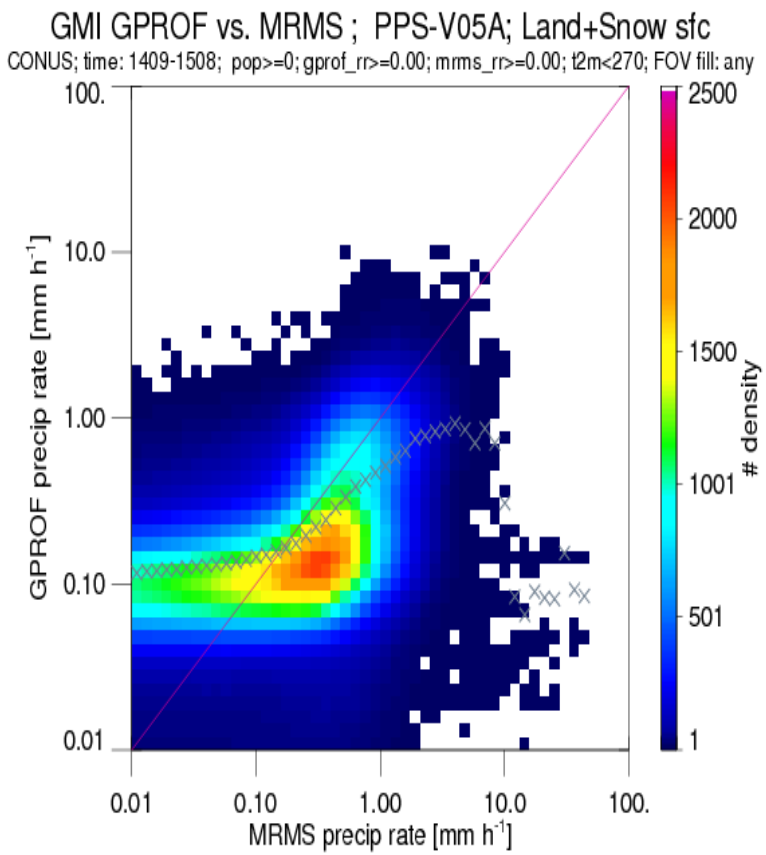
Version 6 Issues

- ✧ Snow over land
- ✧ Orographic precipitation
- ✧ High latitude oceanic drizzle
- ✧ Precipitation over sea ice

- ✧ Climate consistency with radar

- ✧ Sheer number of radiometers

Precipitation rate ≥ 0 mm h^{-1}

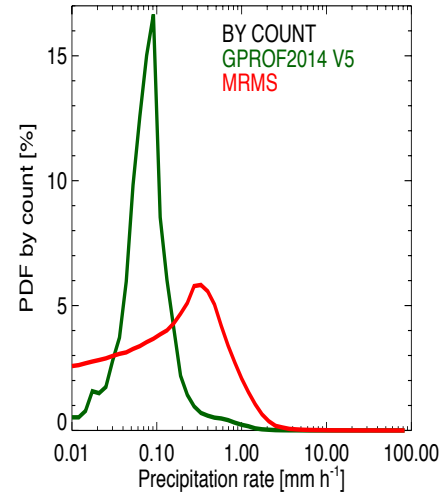


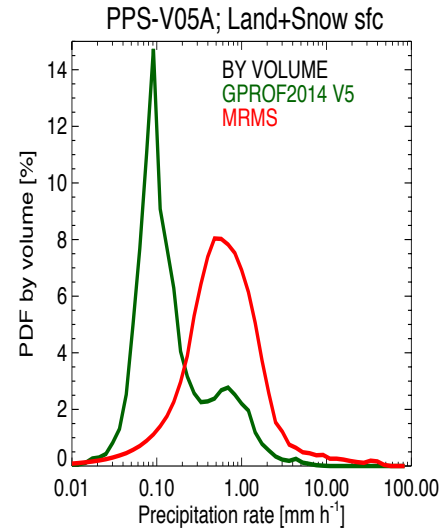
GPROF Bias : -2. % Correlation: 0.31

Gprof bias: -2. %

Number of pixels: 7828857

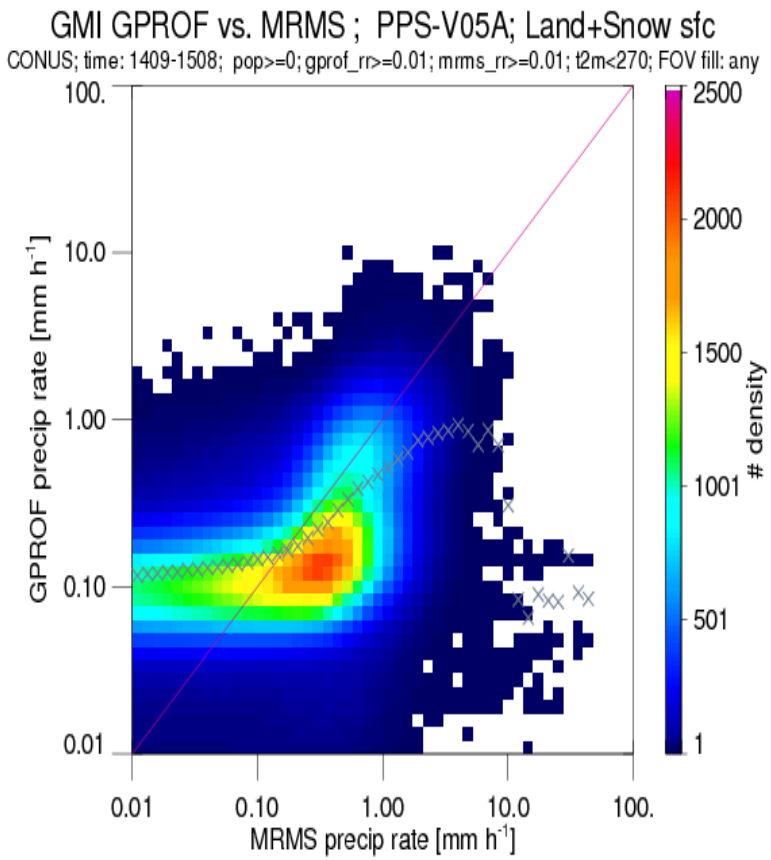
% of total: 17.5 %





pop>=0; gprof_rr>=0.00; mrms_rr>=0.00; t2m<270; FOV fill: any

Precipitation rate ≥ 0.01 mm h^{-1}

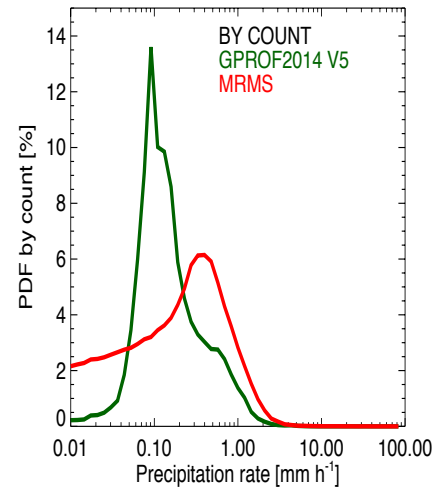


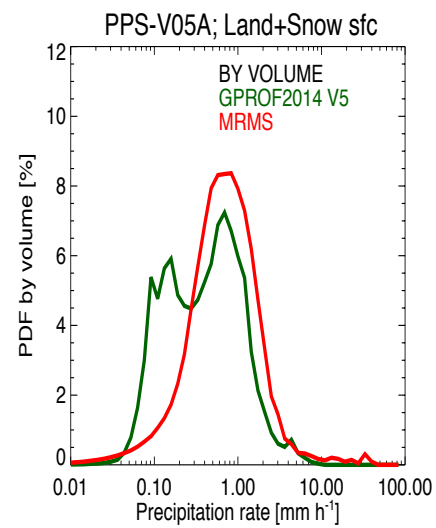
GPROF Bias : -35 % Correlation: 0.34

Gprof bias: -35 %

Number of pixels: 362138

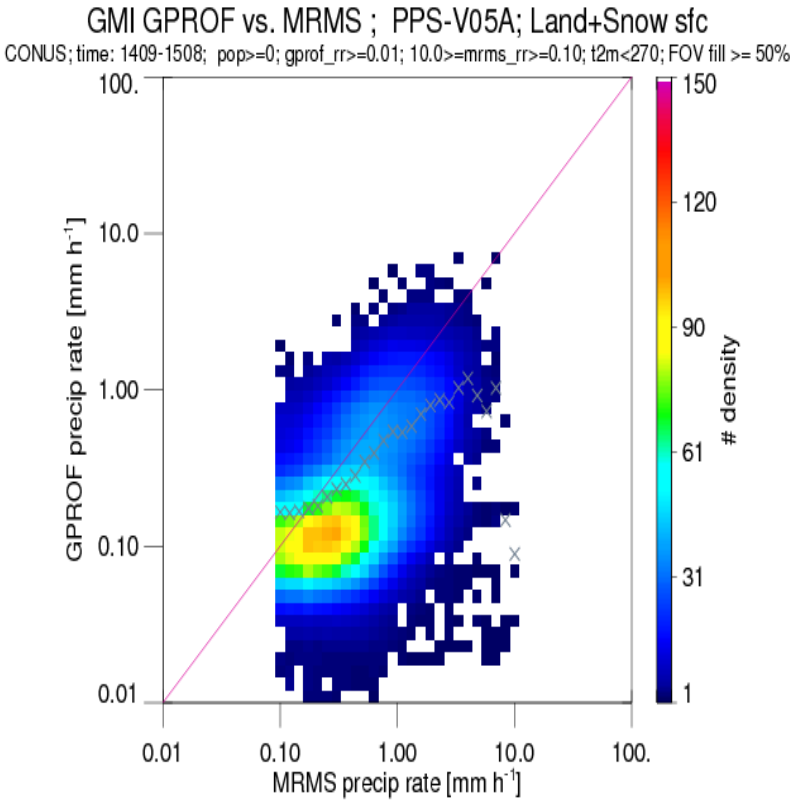
% of total: 0.81 %





pop>=0; gprof_rr>=0.01; mrms_rr>=0.01; t2m<270; FOV fill: any

NASA's criteria

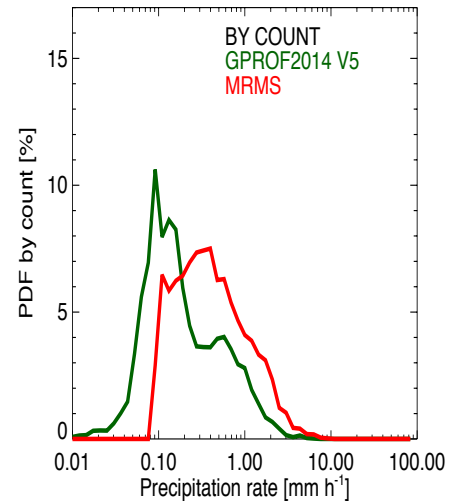


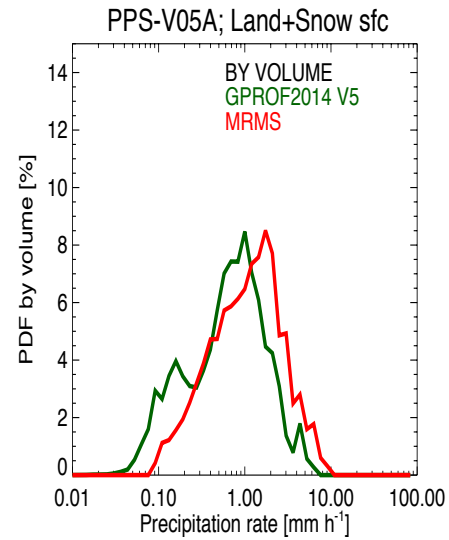
GPROF Bias : -47 % Correlation: 0.38

Gprof bias: -47 %

Number of pixels: 14031

% of total: 0.03 %

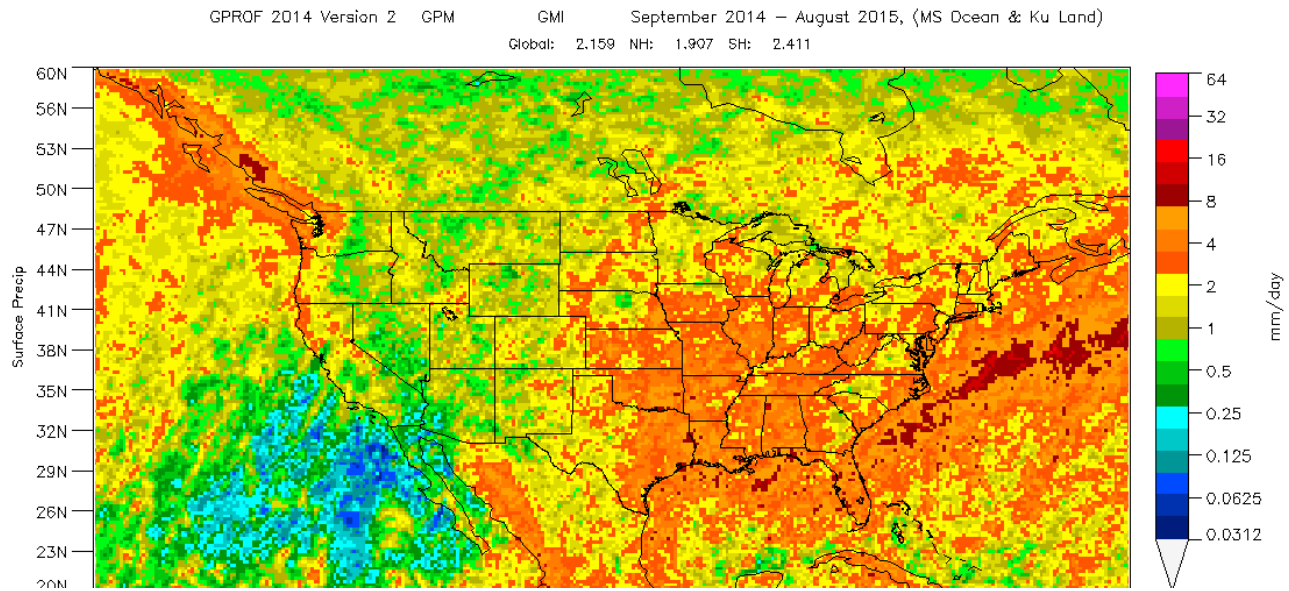




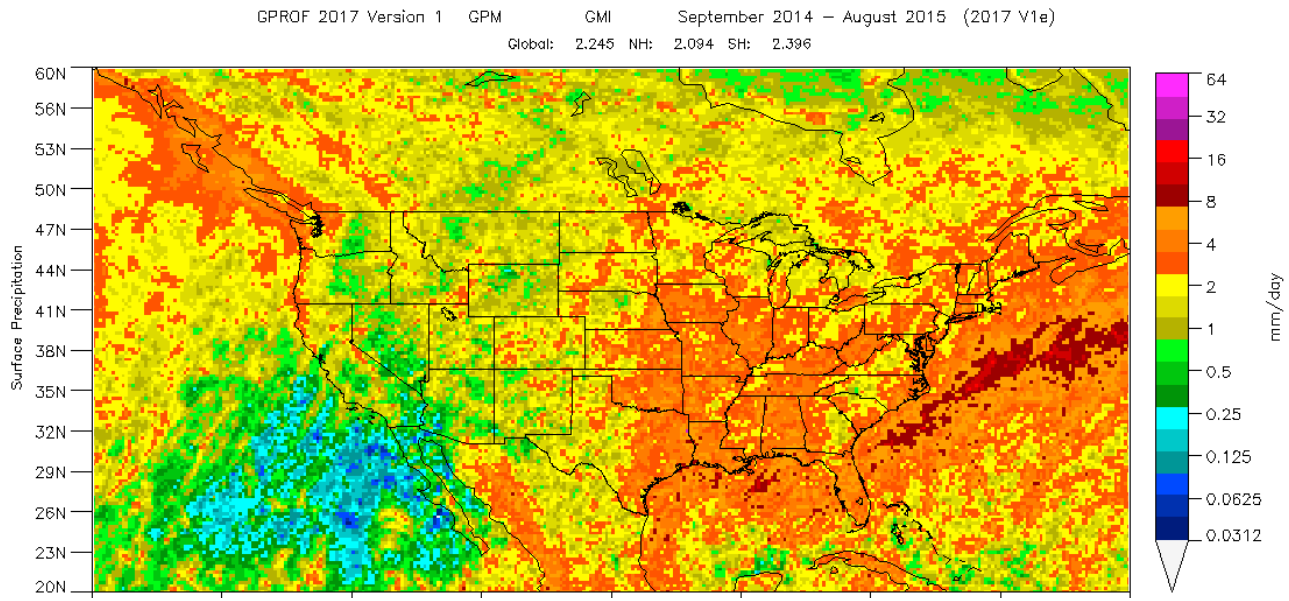
pop>=0; gprof_rr>=0.01; 10.0>=mrms_rr>=0.10; t2m<270; FOV fill >= 50%

Additional snow from MRMS database

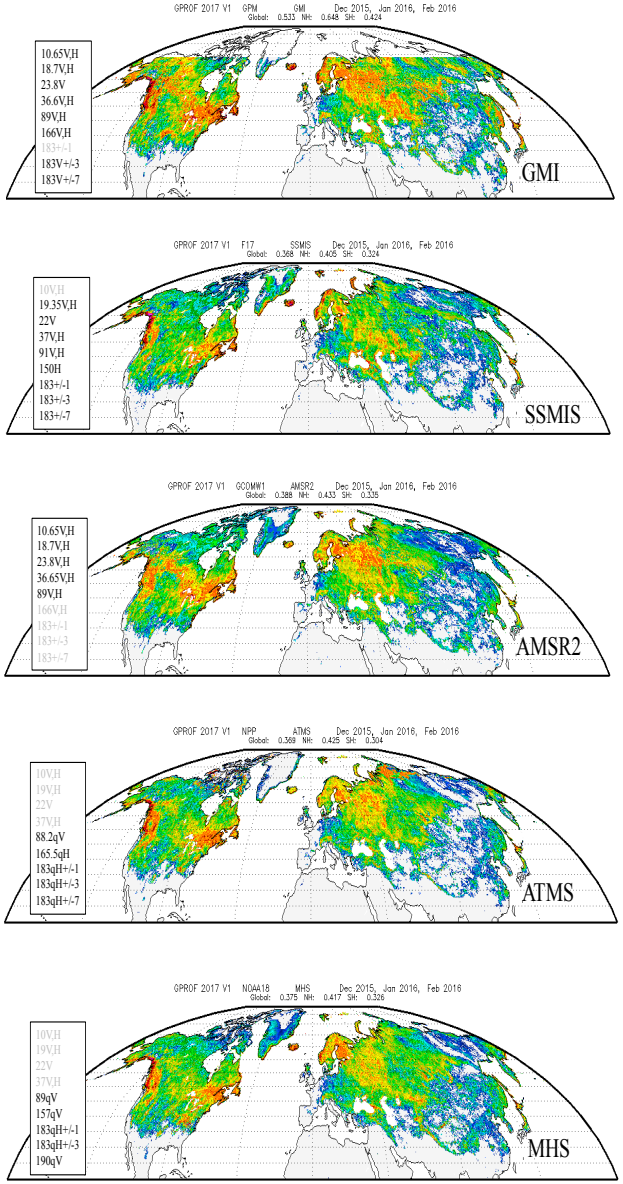
V4

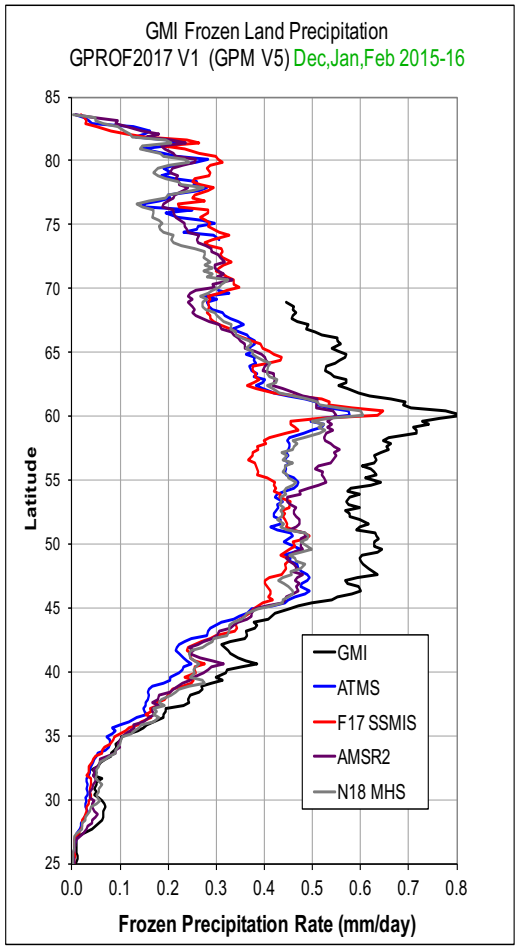


V5

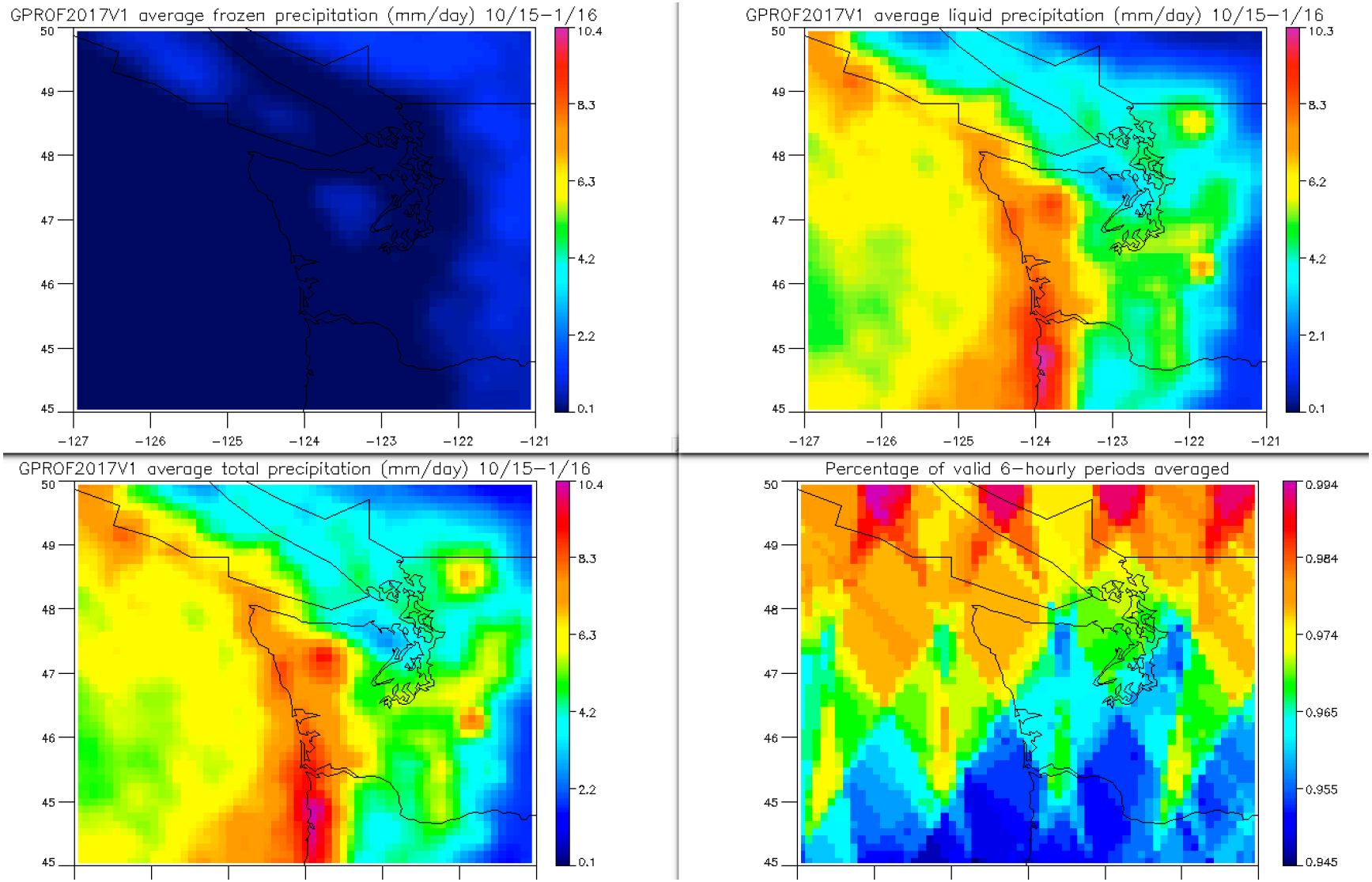


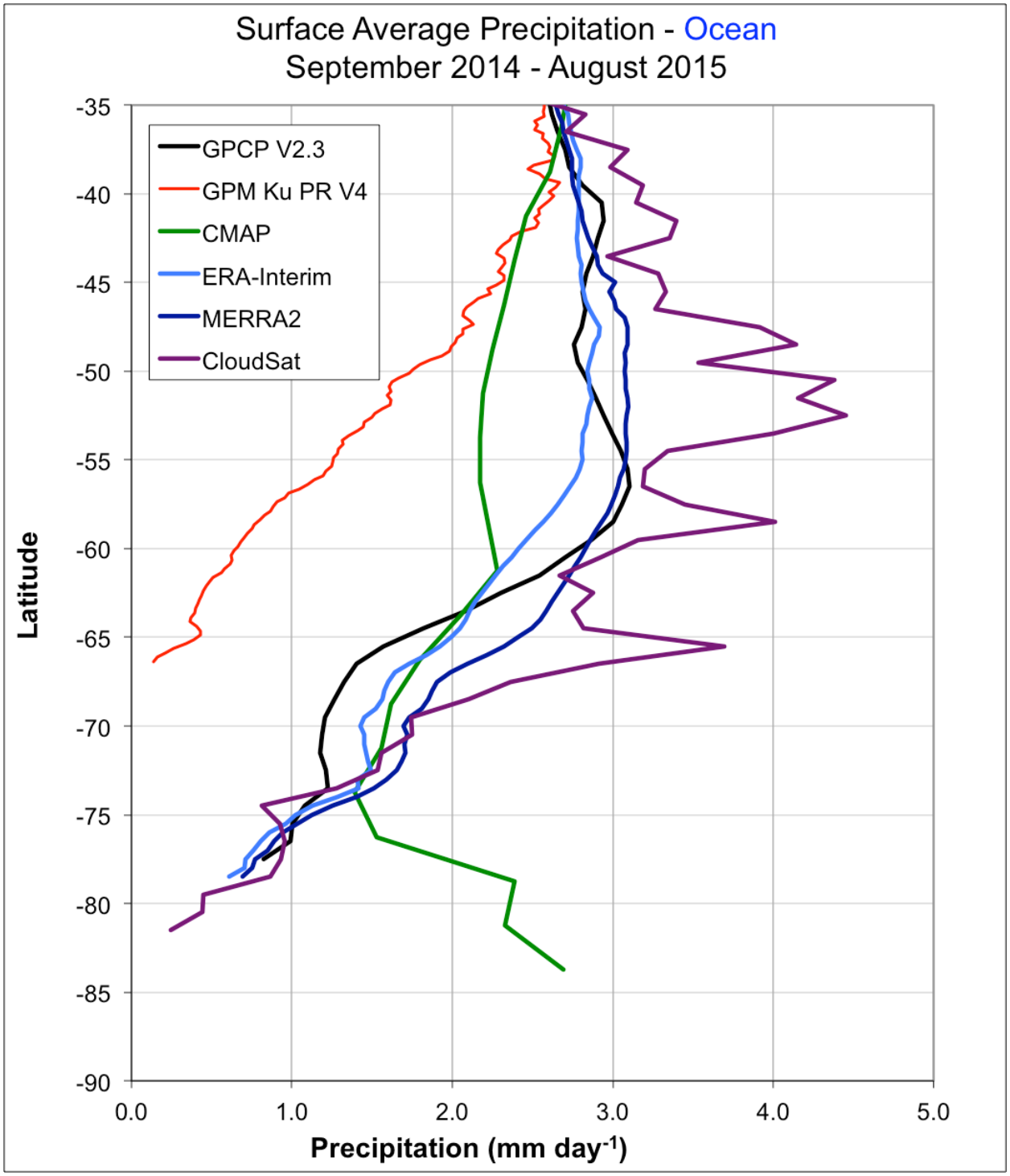
Snow from the constellation

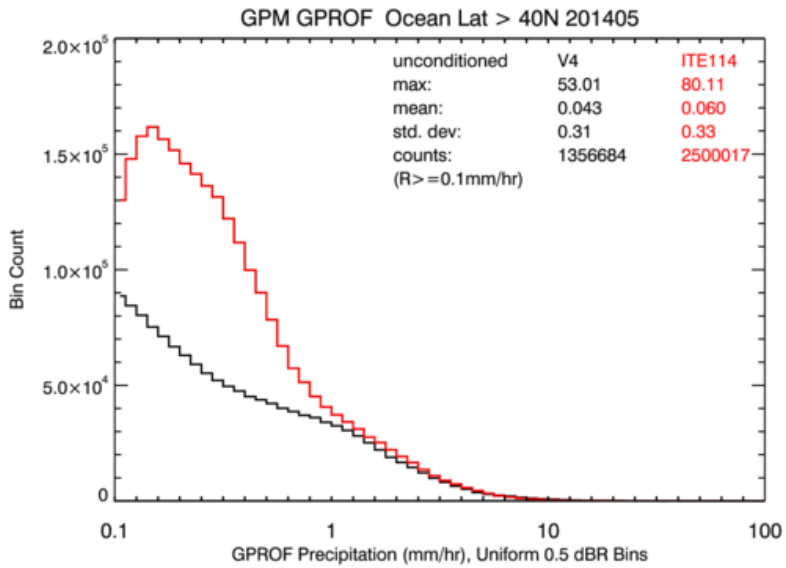


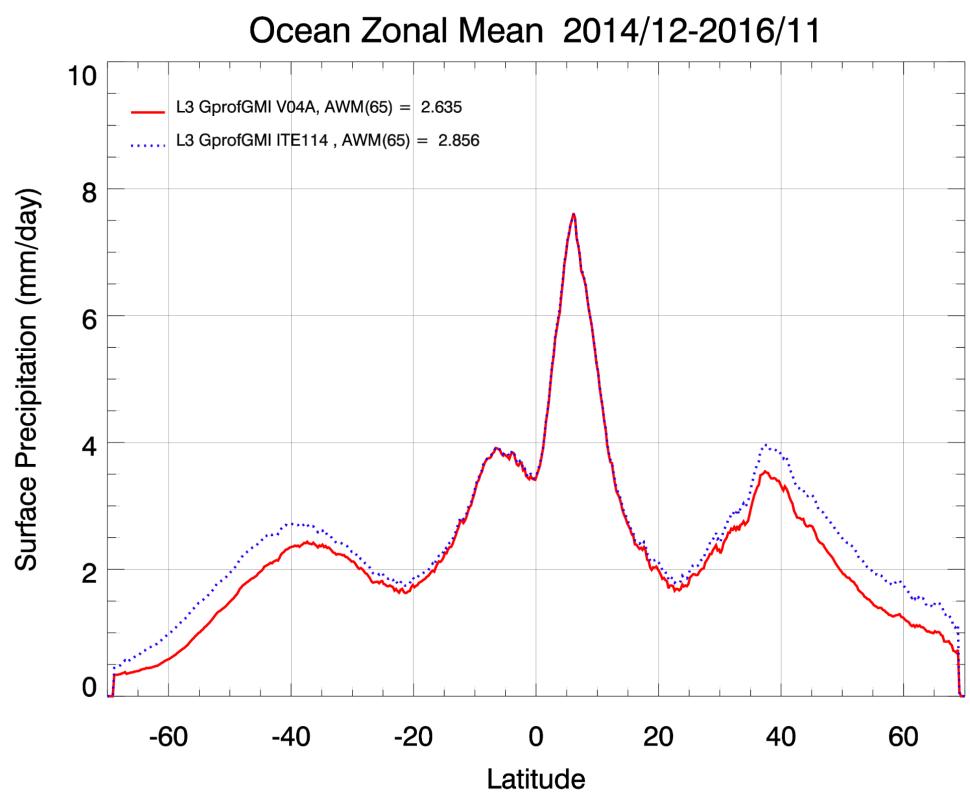


V5 comparisons w. Olympex snow

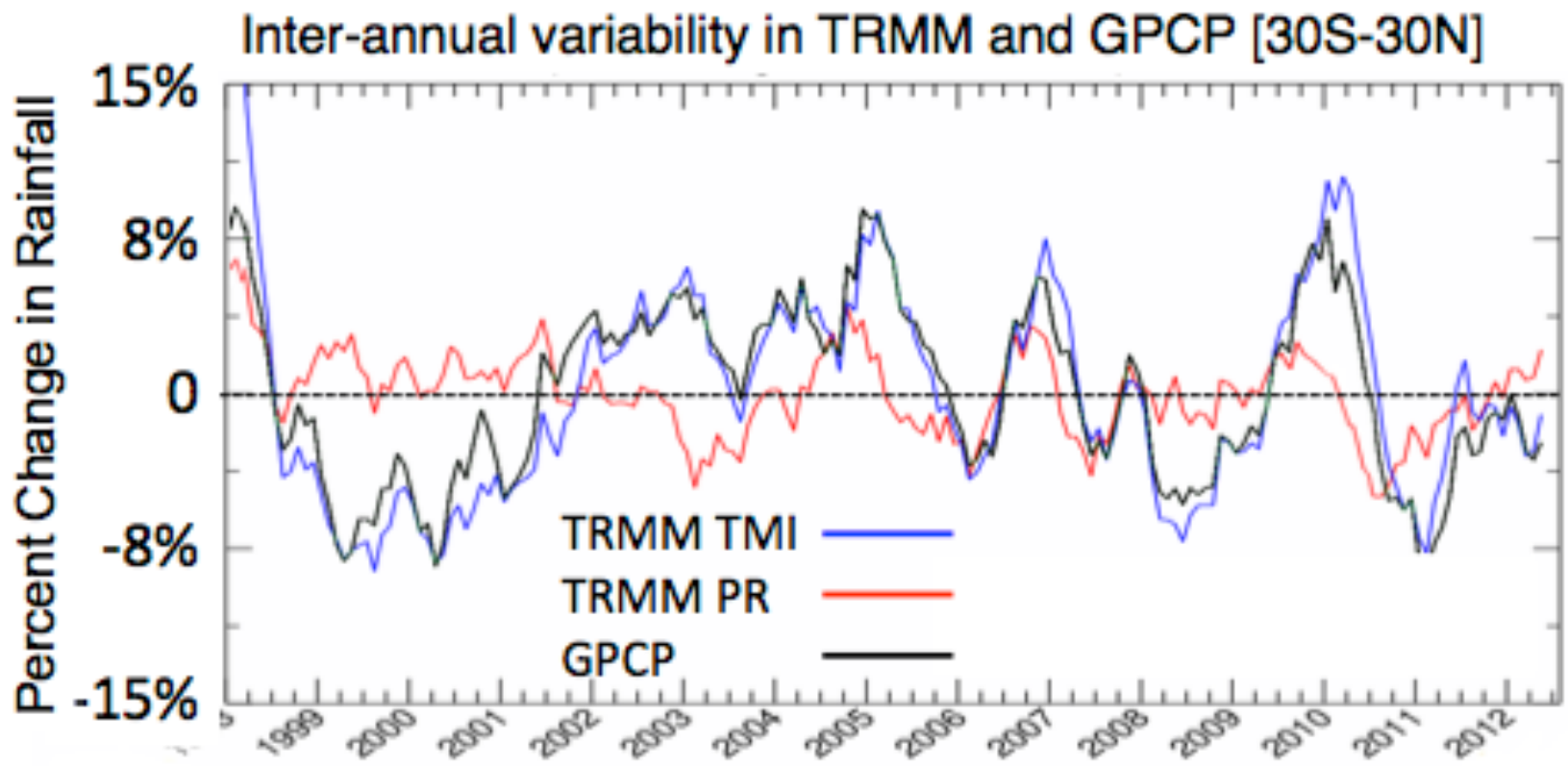



Surface Average Precipitation - Ocean
September 2014 - August 2015
GPCP V2.3
GPM Ku PR V4
CMAP
ERA-Interim
MERRA2
CloudSat
Latitude
-35
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
0.0
1.0
2.0
3.0
4.0
5.0
Precipitation (mm day-1)


GPM GPROF Ocean Lat > 40N 201405
unconditioned V4 ITE114
max: 53.01 80.11
mean: 0.043 0.060
std. dev: 0.31 0.33
counts: 1356684 2500017
(R>=0.1mm/hr)
Bin Count
2.0×10^5
1.5×10^5
1.0×10^5
5.0×10^4
0
0.1
1
10
100
GPROF Precipitation (mm/hr), Uniform 0.5 dBR Bins


Ocean Zonal Mean 2014/12-2016/11
L3 GprofGMI V04A, AWM(65) = 2.635
L3 GprofGMI ITE114 , AWM(65) = 2.856
Surface Precipitation (mm/day)
10
8
6
4
2
0
-60
-40
-20
0
20
40
60
Latitude

Inter-annual variability of oceanic precipitation
(TRMM Era)



GPROF V6 goals

Validate V5 of DPR/COMB and prepare for new database

Better treatment of high latitude precip

Homogeneous FOVs. What to do with high frequency?

Convective/Stratiform (spatial variability) Partitioning?

Statistical treatment of orographic enhancement of precipitation?

Radiometer Team Meeting Goals

Roundtable discussion of what folks are planning to do and if that has a way to make its way into Version 6 (say Oct. 2019) or if ever.

Talk about assessments – the need to say something about quality in areas w/o GV.

Talk about future of these algorithms – is the PI model rational if there are 25 satellites and corresponding codes.

Assessments

A rules based, quantitative extrapolation of known validation statistics to other regions of the world.

Basic thoughts #1: We better start by defining what characteristic of the product we are assessing is being assessed. CloudSat might be pretty good for climate variability but lousy for for 3 hr snow accumulation.

Basic thought #2: We better also define immediately what we mean by pretty good and lousy.

Basic thought #3: The validation of the technique should be something like this: If you have access to all the GPROF and MRMS data, can you predict the performance of GPROF over the Kanto Plain?