Appendix 10

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Evaluation of TRMM PR 2A25 v.7 (ITE233)

Incidence-angle dependency check

Summarized results:

This is dedicated to the internal-validation of PR2A25 data with respect to the incidence-angle dependency of estimated surface rainfall rate V6 and V7(ITE233).

- Improved points: slight reduction of the beam mismatch effect, decrease of 10-deg. rainfall over ocean, increase of off-nadir rainfall over land
- Deteriorated points: shallow rain detection (< 1%), anomalous nadir rainfall > 50 mm/h
- The self-consistency has been improved over land and oceans.

[Bias to the near-nadir statistics] V6 → V7
After the boost (2008-2010)
Total rain bias: -4.6% → -5.4%, -3.1% → -5.0% (Ocean), **-9.5% → -6.7% (Land)**
Before the boost (2000)
Total rain bias: 0.7% → -0.9%, **2.7%→ -0.2% (Ocean)**, **-6.1% → -3.4% (Land)**

The incidence-angle differences remain but v7 is taking a turn for the better.

Data and method

Data: 2A25 v6 and v7(ITE233) for 5 years (2000-2001, 2008-2010)
Global data: areal weighted average of each 2.5-deg. grid dataset over 35° N/S.

Reference data: Near-nadir data (23 and 24 bins over land, 23-25 bins over ocean)

Def. Shallow and non-shallow storms: storm top height =< or > 3 km

Angle bin differences of rainfall: Rain bias (1) = the beam mismatch effect (2) + rain deficiency (3) + residual errors (4)

Here, (1) total difference, (2) asymmetric bias, (3) difference due to the storm detection, (4) residue. (3) and (4) were based on data in the first half scan.

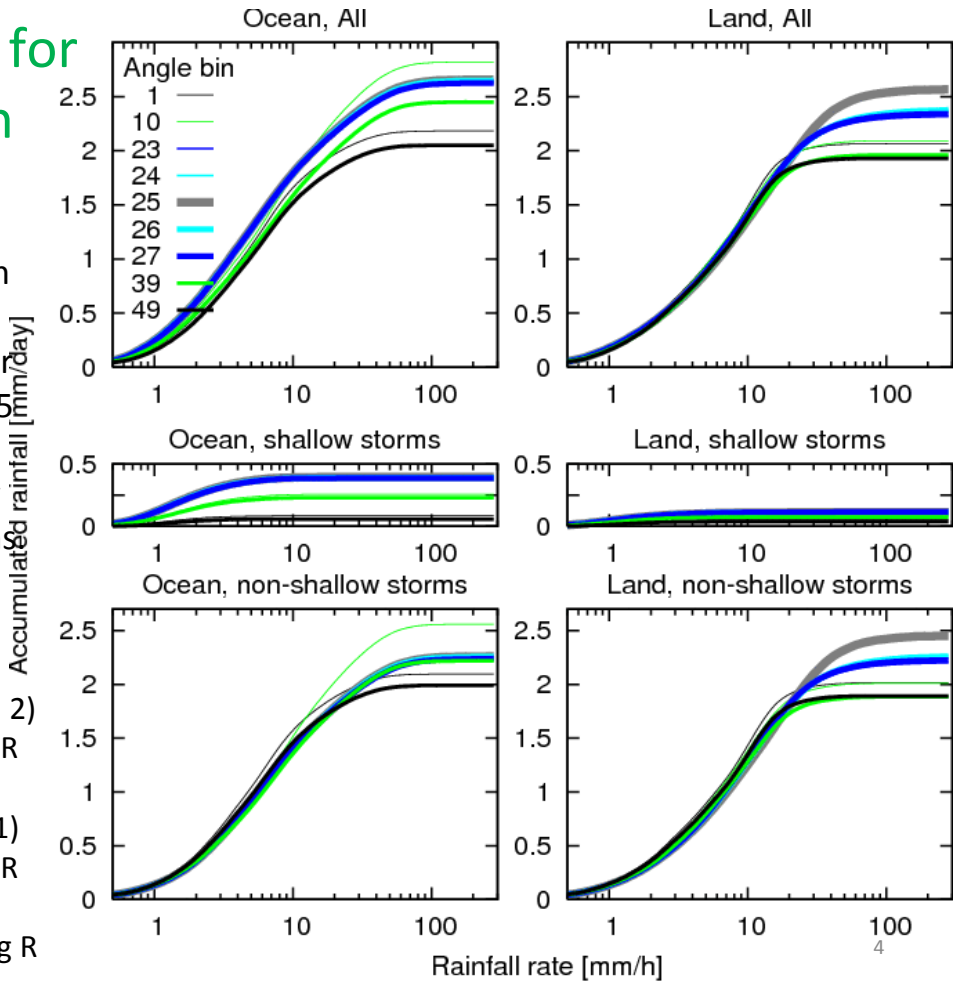
The methodology is described in a paper entitled "Incidence-angle dependency of TRMM PR rain estimates" submitted to JTECH (in review) by Hirose, Shimizu, Oki, Iguchi, Short and Nakamura.

Rain statistics for each angle bin

V6 (2008-2010)

Cumulative distribution functions of rainfall over ocean and land for each angle bin during 5 years. The statistics were made for shallow and non-shallow storms.

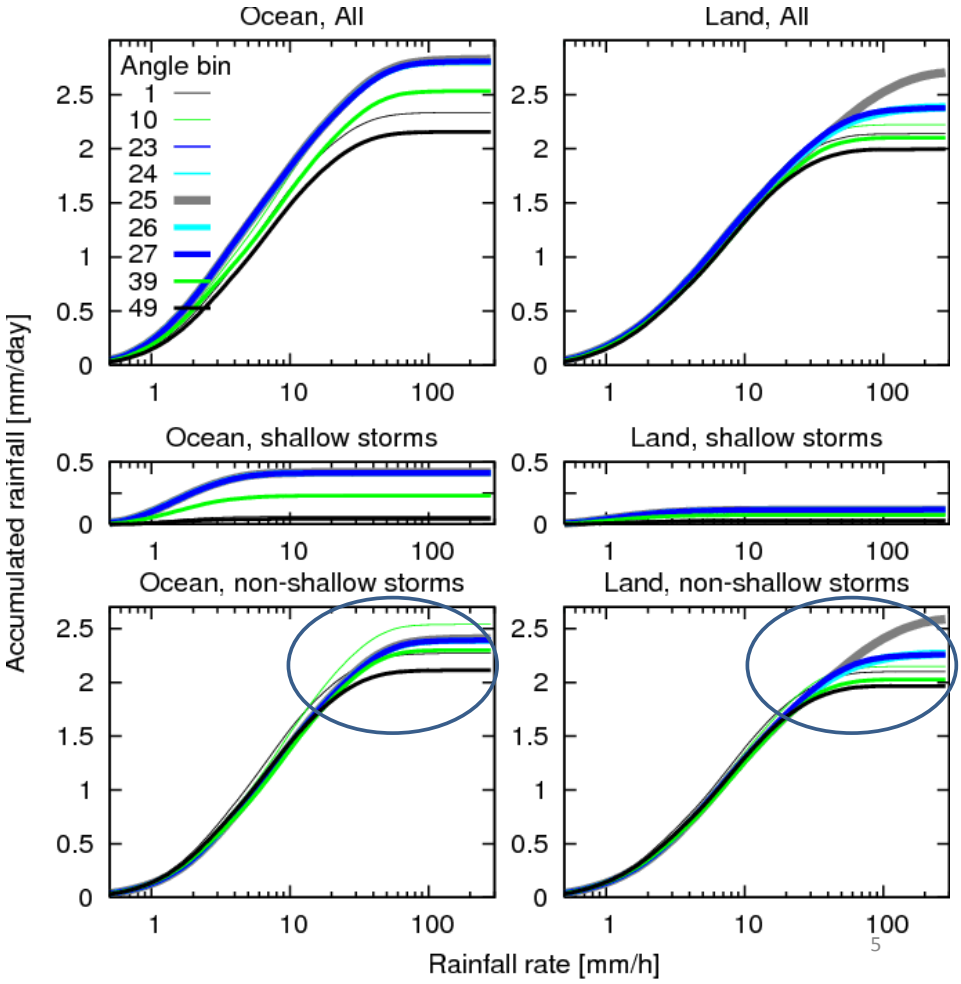
Major issues of v6:
Over ocean: 1) Missing shallow storms off nadir. 2) Overestimates of strong R around 10 deg., i.e., 10th and 39th bin. Over land: 1) Overestimates of strong R at nadir. 2) Underestimates of strong R off nadir



Same but for v7

The most significant difference → strong R

Major issues of v6 → change in v7:
Over ocean: 1) Missing shallow storms at off nadir. → slightly deteriorated. 2) Overestimates of strong R around 10 deg., i.e., 10th and 39th bin. → the error was reduced. Over land: 1) Overestimates of strong R at nadir. → better for R < 50 mm/h, worse for R > 50 mm/h. 2) Underestimates of strong R off nadir. → The error was reduced.



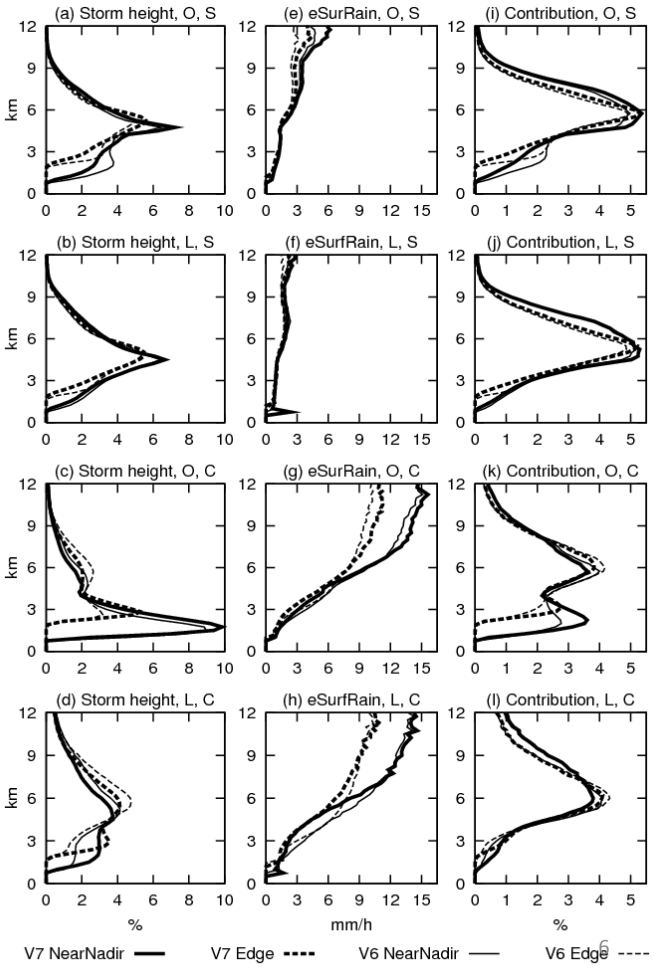
Storm top height dependency

on e_SurfRain for Stratiform (S) and Convective (C) rain over ocean (O) and Land (L), respectively.

Left: Storm top height histogram, Middle: averaged e_SurfRain, Right: Contribution from each storm top height to total rainfall at near nadir, for V7 (thick lines) and V6 (thin lines), respectively.

Data: PR2A25 2008-2010

Change in V7
- Stratiform shallow rain → Convective shallow rain & partly missing.
- e_SurfRain from deep convective storms has been intensified over ocean



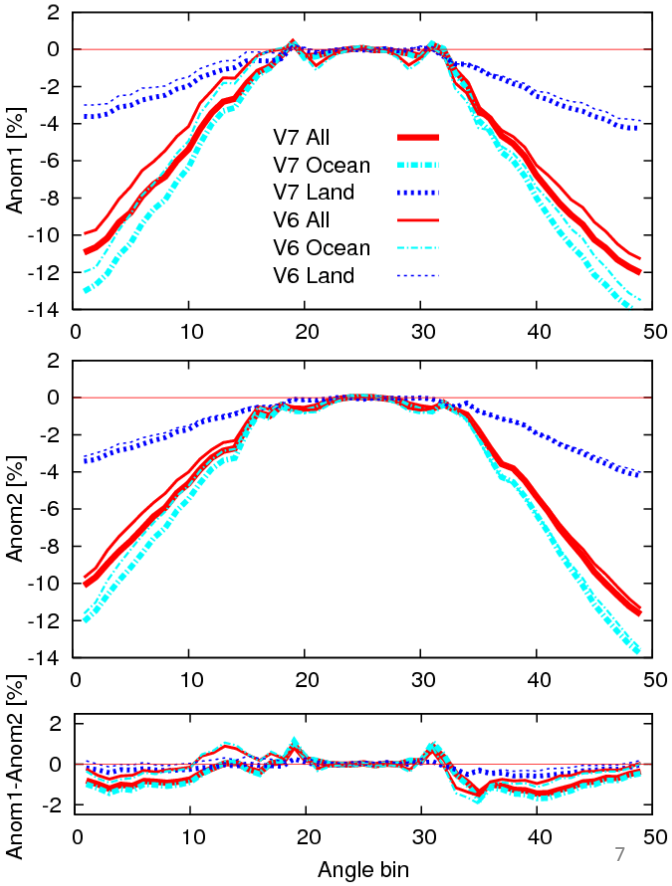
Differences from near-nadir rainfall

Each-angle shallow rain bias (top), shallow rain deficiency (middle), and the difference (bottom)
2008-2010

V6 → V7

Detection of shallow storms has been deteriorated over ocean and land. But the difference is only -0.6%.

Shallow rain bias:
-4.0% → -4.6%
-4.8% → -5.4% (Ocean)
-1.4% → -1.6% (Land)



Same but for non-shallow storms

V6 → V7

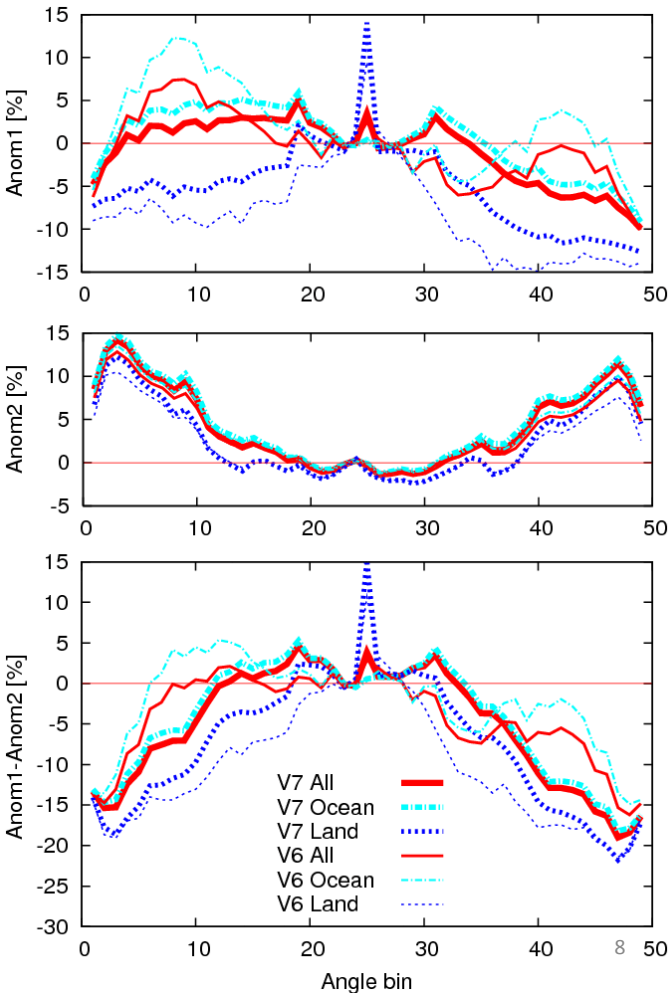
Asymmetric bias is slightly reduced:
-2.7% → -2.3%
-2.8% → -2.4% (Ocean)
-2.0% → -1.9% (Land)

The number of storms around the swath edge is increased.

Singular peak at nadir remains.

Over ocean, the bias around 10-deg is reduced. Over land, off nadir rainfall becomes better consistent with the near-nadir data.

Non-shallow rain bias:
-0.6% → -0.8%
1.7% → 0.4% (Ocean)
-8.2% → -5.0% (Land)



Anomalies of R [%] compared to the near-nadir statistics 2008-2010

	V7_ITE233			V6			V7-V6		
	All	Ocean	Land	All	Ocean	Land	All	Ocean	Land
A	-0.4	-0.5	-0.2	-0.7	-0.8	-0.3	0.3	0.3	0.1
B	**-3.8**	**-4.5**	-1.3	**-3.4**	**-4.0**	-1.2	-0.4	-0.4	-0.1
C	-0.4	-0.4	-0.1	0.0	0.0	0.1	-0.4	-0.5	-0.2
D	-2.3	-2.4	-1.9	-2.7	-2.8	-2.0	0.4	0.4	0.1
E	**4.9**	**5.4**	**3.2**	**4.4**	**4.9**	2.8	0.5	0.5	0.4
F	**-3.4**	-2.6	**-6.3**	-2.2	-0.3	**-9.0**	-1.1	-2.3	2.6
Sum$_s$	**-4.6**	**-5.4**	-1.6	**-4.0**	**-4.8**	-1.4	-0.5	-0.6	-0.3
Sum$_{ns}$	-0.8	0.4	**-5.0**	-0.6	1.7	**-8.2**	-0.3	-1.3	**3.1**
Sum	**-5.4**	**-5.0**	**-6.7**	**-4.6**	**-3.1**	**-9.5**	-0.8	-1.9	2.8

A: effects of the beam mismatch correction errors for shallow storm, B: Shallow rain deficiency, C: the residue bias on shallow storms. D-F = A-C but for non-shallow storms. Sum$_s$, Sum$_{ns}$, Sum is accumulated % of A-C for shallow storms, D-F for non-shallow storms, and A-F for all storms, respectively.

Next slide explains the table by referring the number of ☆

Summarized results for 2008-2010

Ocean: Total rain bias was about 2% increased [1] due to deteriorated shallow storm detection [2] & improvement in incidence-angle differences for non-shallow rain [3].

Land: The bias was about 3% reduced [4] due to improvement in incidence-angle differences for non-shallow storm [5].

All: As a result, the total bias was slightly increased [6].

The internal consistency, i.e., differences of e_SurfR between incidence angles, is improved over ocean and land. Shallow storm detection became worse but not serious (< 1%). Highest impact was found in the increase of off-nadir rainfall for non-shallow storms over land.

Same with Slide 9 but on the basis of ITE225 for 2008-2009

	V7_ITE225			V6			V7-V6		
	All	Ocean	Land	All	Ocean	Land	All	Ocean	Land
A	-0.4	-0.5	-0.2	-0.7	-0.8	-0.3	0.3	0.4	0.1
B	**-4.0**	**-4.6**	-1.6	**-3.5**	**-4.1**	-1.3	-0.5	-0.5	-0.4
C	-0.3	-0.2	-0.6	0.1	0.1	0.2	-0.4	-0.3	-0.8
D	-1.9	-2.1	-1.1	-2.6	-2.8	-1.7	0.7	0.7	0.7
E	**4.3**	**5.0**	1.8	**3.7**	**4.4**	1.3	0.6	0.6	0.6
F	-1.6	-1.1	**-3.3**	-1.4	0.5	**-7.4**	-0.2	-1.5	**4.2**
Sum_s	**-4.6**	**-5.2**	-2.4	**-4.0**	**-4.8**	-1.4	-0.6	-0.4	-1.0
Sum_{ns}	0.9	1.8	-2.5	-0.2	2.1	**-7.9**	1.1	-0.3	**5.4**
Sum	**-3.7**	**-3.4**	**-4.9**	**-4.3**	-2.8	**-9.3**	0.5	-0.6	**4.4**

A: effects of the beam mismatch correction errors for shallow storm, B: Shallow rain deficiency, C: the residue bias on shallow storms. D-F = A-C but for non-shallow storms. Sum_s, Sum_{ns}, Sum is accumulated % of A-C for shallow storms, D-F for non-shallow storms, and A-F for all storms, respectively.

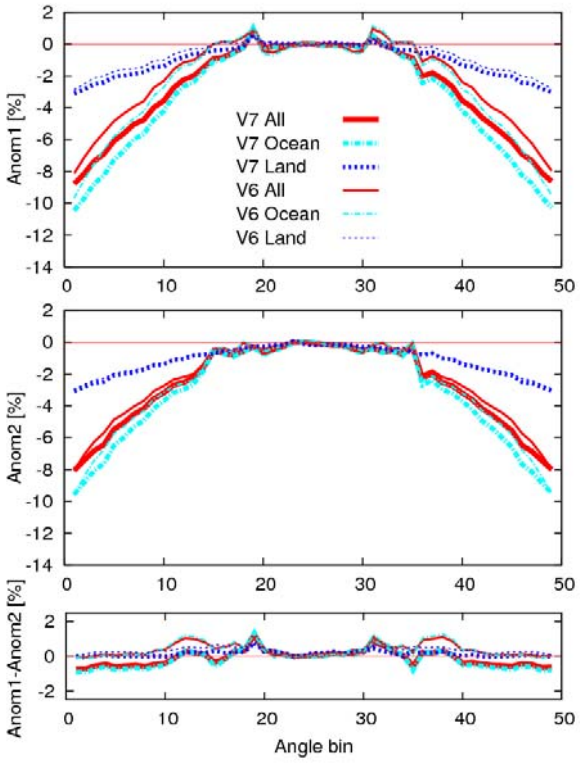
Total rain bias: -4.3% → -3.7%, -2.8% → -3.4% (Ocean), **-9.3% → -4.9% (Land)**

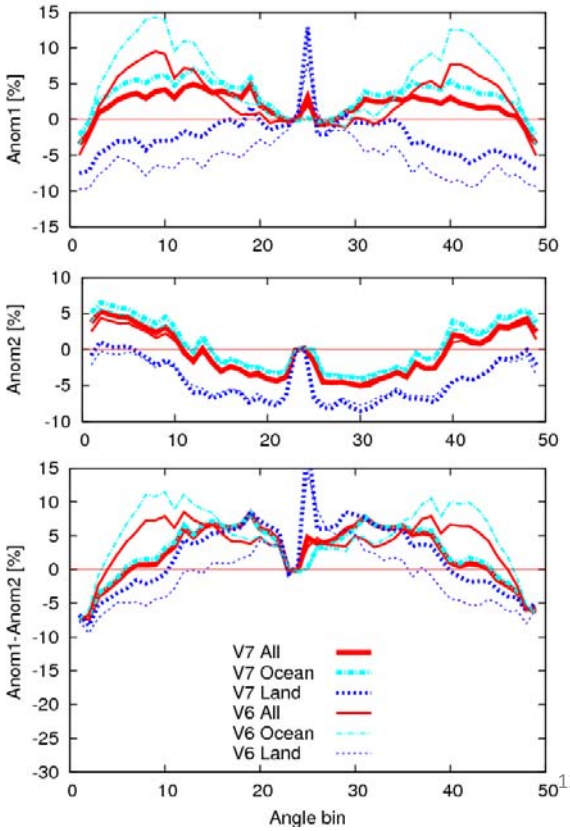
The improvement over land is less in the case of ITE233 for 2008-2010.

Before the boost

Same with Slide 7 and 8 but for 2000

The total bias pattern (upper panel) is almost same as for 1998-2000. But the lower right panels were different . It would be attributable to the few sampling near the nadir.





Same with Slide 9 but for 2000

	V7_ITE233			V6			V7-V6		
	All	Ocean	Land	All	Ocean	Land	All	Ocean	Land
A	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	0.0
B	**-2.8**	**-3.2**	-1.1	**-2.5**	**-2.9**	-1.1	-0.3	-0.3	-0.1
C	-0.1	-0.2	0.1	0.3	0.3	0.3	-0.5	-0.5	-0.2
D	-0.5	-0.5	-0.4	-0.5	-0.6	-0.2	0.1	0.2	-0.2
E	0.2	1.3	**-3.5**	-0.1	1.0	**-3.6**	0.3	0.3	0.1
F	2.2	2.4	1.5	**3.4**	**4.9**	-1.5	-1.2	**-2.5**	**3.1**
Sum_s	**-2.9**	**-3.4**	-1.0	-2.1	**-2.6**	-0.7	-0.7	-0.9	-0.3
Sum_{ns}	1.9	**3.2**	-2.4	**2.8**	**5.3**	**-5.3**	-0.9	-2.1	**2.9**
Sum	-0.9	-0.2	**-3.4**	0.7	**2.7**	**-6.1**	-1.6	**-2.9**	**2.7**

Same table as before but for the period before the boost

The statistics "Sum" based on V.6 in 2000 is almost identical to that for 1998-2000.

Ocean: Missing shallow-storm effect is negligibly small. Off-nadir overestimated rain was significantly reduced.
Land: The internal consistency has been improved.
→ The problems are better.

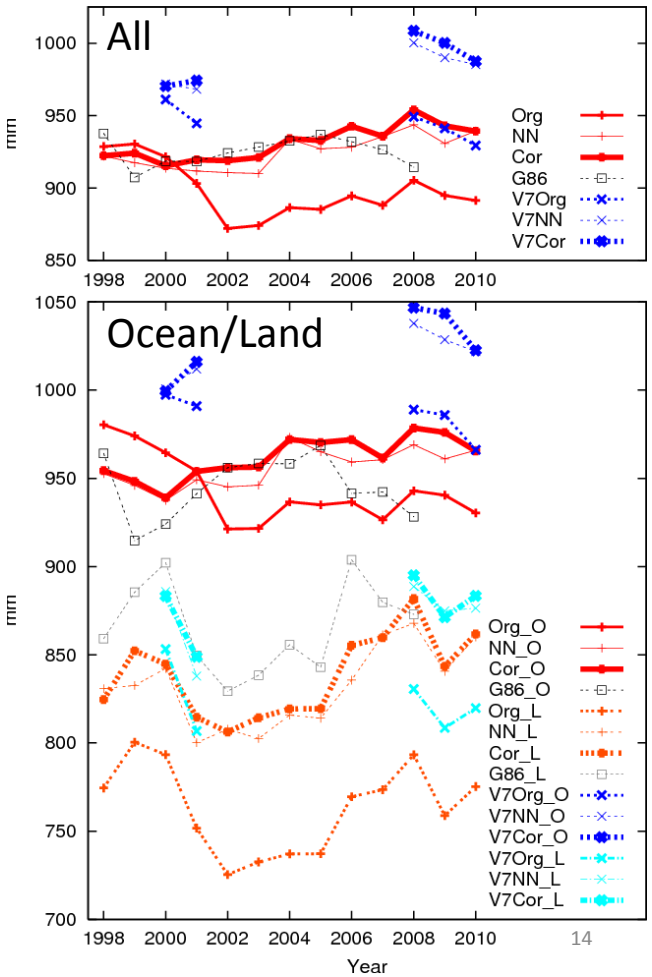
Tentative results

Implications for annual variation (35° N/S)

PR2A25 V6 1998-2010
PR2A25 V7 2000-2001, 2008-2010
GPCP v2.1 1998-2008

Org: original PR2A25 data
NN: Near-nadir data
Cor: Bias corrected Org (see next slide)
G86: GPCPv2.1 times 0.855 for comparisons with 10-year V6 data

- Bias correction → Increasing trend
- Significant increase of "V7Cor" over ocean
- V7 is closer to GPCP than V6, but the differences in the year-to-year variation and amount still remain.



Bias correction

incidence-angle differences before/after the boost
+ 0.5% sensitivity down effect after the boost

		All	Ocean	Land
Before the boost 2000	V6	0.68%	**2.72%**	**-6.08%**
	V7	-0.95%	-0.21%	**-3.41%**
After the boost 2008-2010	V6	**-5.10%**	**-3.64%**	**-10.03%**
	V7	**-5.89%**	**-5.52%**	**-7.20%**

Need
[Before the boost]
V6: 6% Increase in rainfall (R) over land + 3% Decrease in R over ocean
V7: 3% Increase in R over land <improved>
Totally, the difference between angles is less than 1% both for V6 and V7.
[After the boost]
V6: 10% Increase in R over land + 4% Increase in R over ocean
V7: 7% Increase in R over land <improved> and 6% Increase in R over ocean
Totally, 5% Increase for V6, 6% Increase for V7