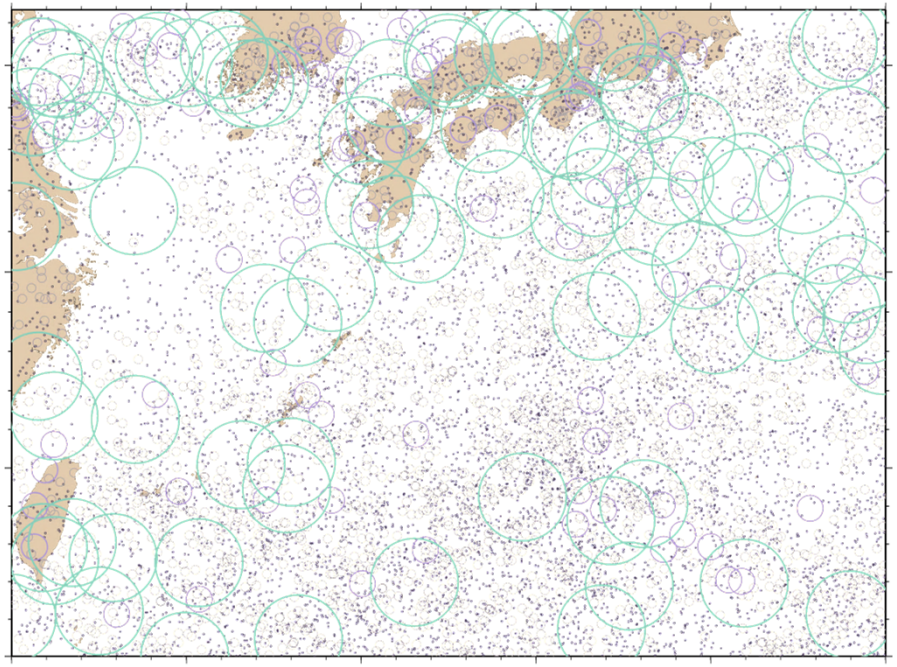
Joint PI WS, PMM session, January 16, 2014

Evaluation of rainfall climatology from the long-term spaceborne radar data

Masafumi Hirose
Meijo Univ.



Introduction

Further understandings of local bias & unique features of the long-term spaceborne radar data are necessary to show and utilize dynamic precipitation climatology.

Accumulated TRMM PR data

Quantitative evaluation on rain estimates

Qualitative detection of various rain features

More accurate climatology & its application

How robust? What is new?
What is the impact on other databases and subjects?
How about substitutability?

Uncertainties in rain climatology

Local rain characteristics at fine scales

Evaluation of the long-term TRMM PR data & Development of better climatological uses

Research challenges:

1. External and internal VAL on retrieval properties
- Uncertainties and advantages against ground truths
- Correction on incidence angle dependency

2. Progress assessment of the precipitation climatology
- Sampling performance at multi scales (e.g., Regional impact of rare but significant events)
- Detection of fine-scale storm features

3. Other themes
- Disclosure of research product and visual tools
- Comparative verification of the GPM DPR data

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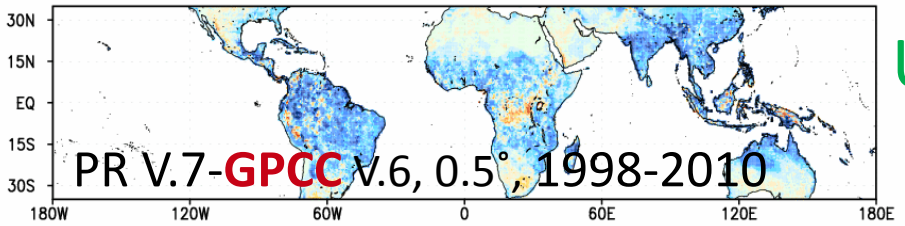
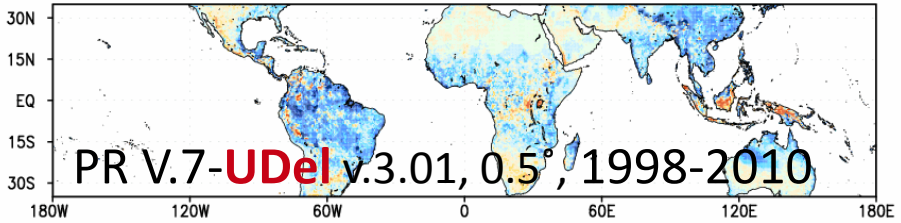
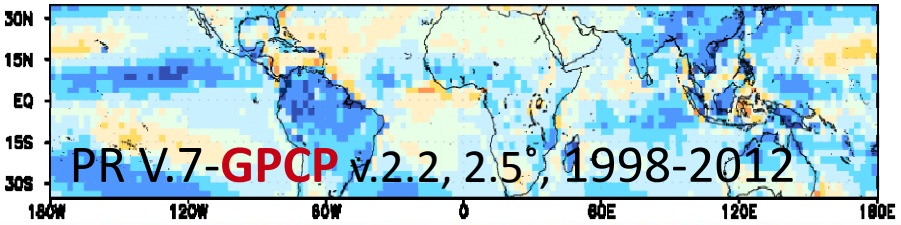
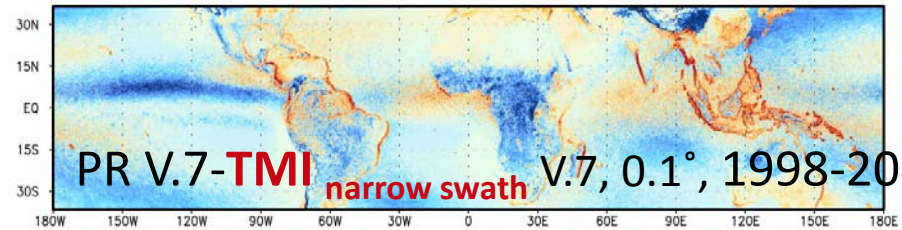
Uncertainties in rain climatology

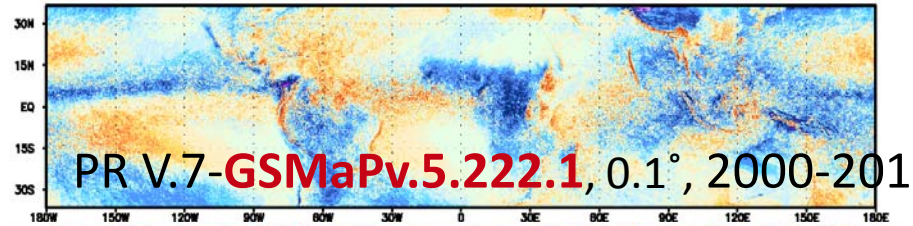
Comparison with global rainfall datasets

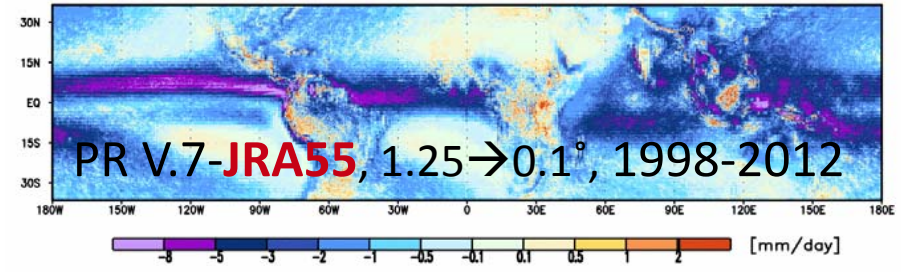




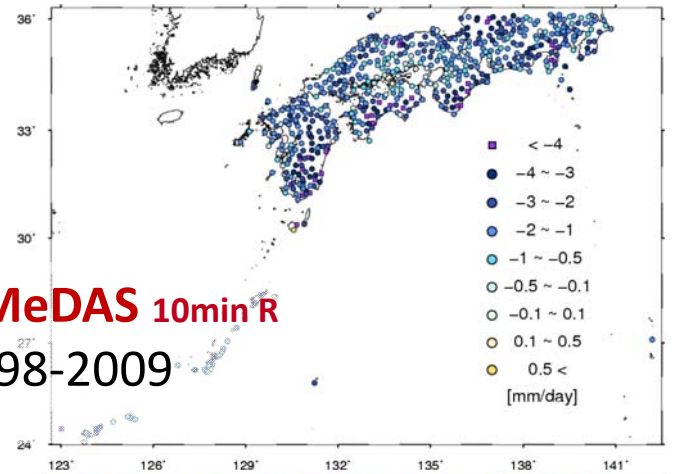




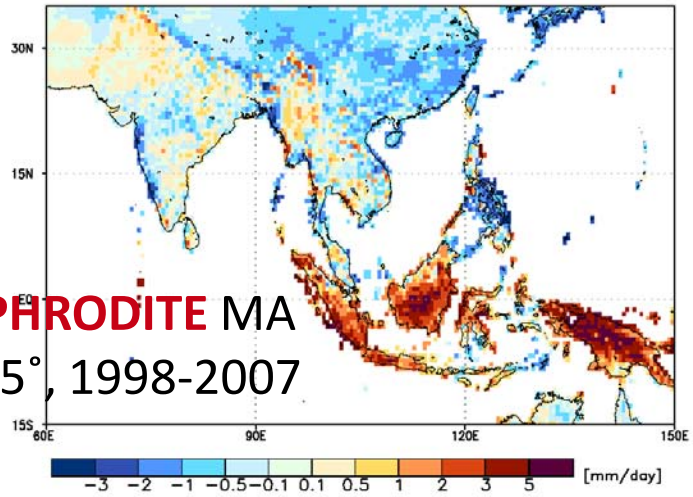




PR Underestimates Overestimates



PR V.7- **AMeDAS** 10min R match-up 1998-2009



PR V.7-**APHRODITE** MA v.1101, 0.5˚, 1998-2007

All datasets include local intrinsic biases.

Year-to-year variation

Corrected* (original)

TRMM PR v7

GPCP v2.2

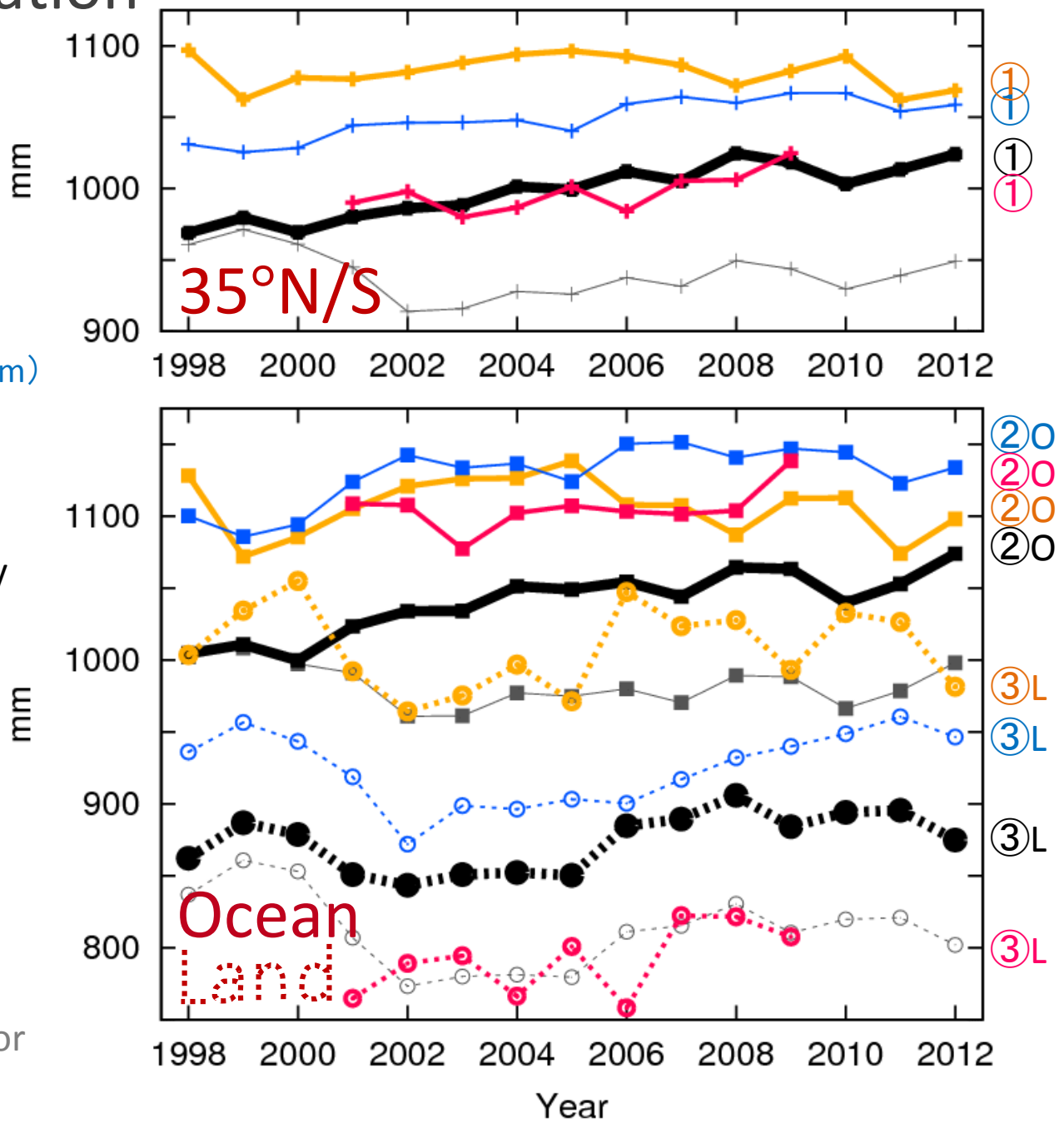
JRA55 (①-400mm, ②-500mm)

GSMaP v.5.222.1

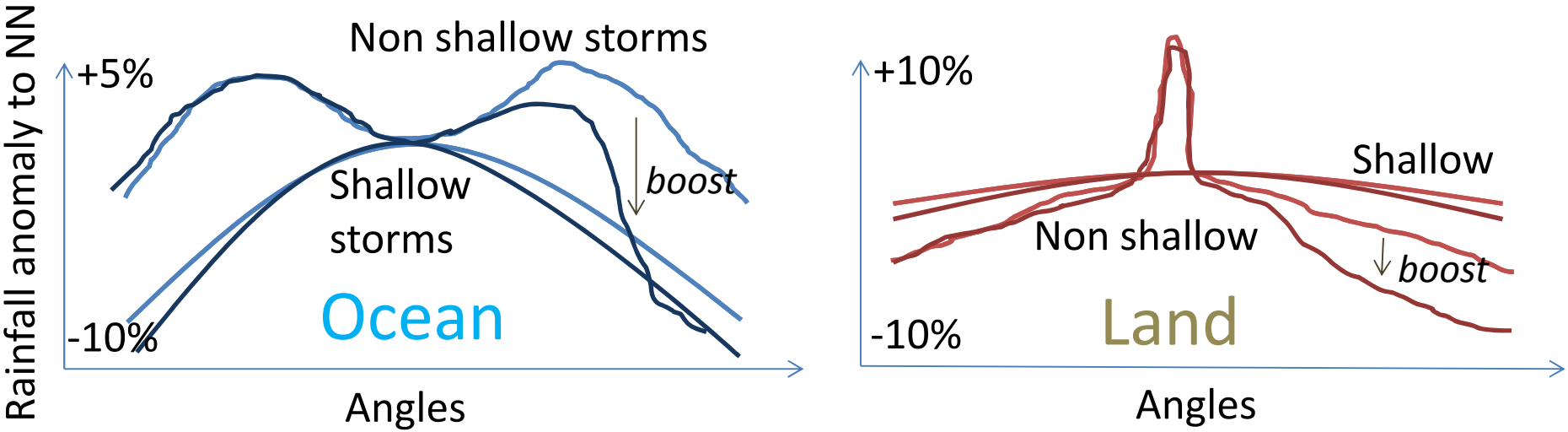
* Incidence angle dependency
(Hirose et al. 2012)
+ sensitivity degradation
(Kida et al. 2013)

e.g., correction factor
over **land**: +**3** (+**8**) %
before (**after**) the boost

Systematic bias → key issues or strength of PR climatology



Data integrity between incidence angles



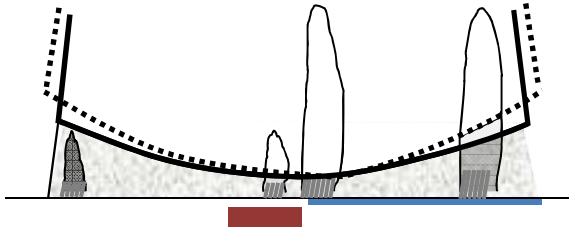
Potential biases on the near-surface rainfall at the invisible levels under the clutter-free bottom

A. Retrieval errors: **Low-level profile model**

B. Sampling errors: **Missing shallow storms**

→Utilization of the near-nadir statistics

Other major REs: Off-nadir overestimates over ocean, Beam-mismatch issues, Peak at the nadir over land



The **Near-Nadir** statistics*

* 23-25th bins over ocean, 23-24th bins over land

A. Retrieval errors: **Low-level profile model**

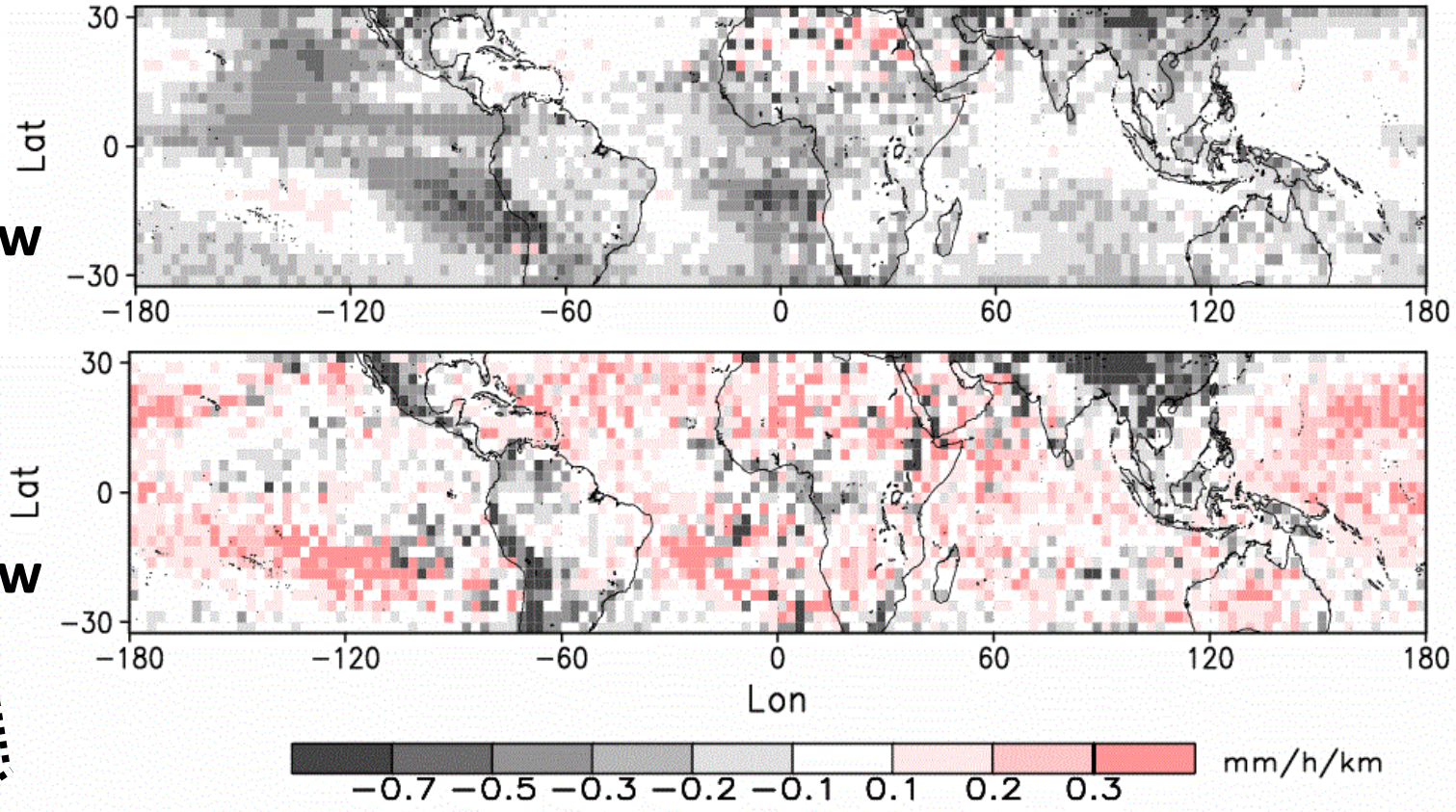
Vertical gradient of rainfall rate in the lower atmosphere

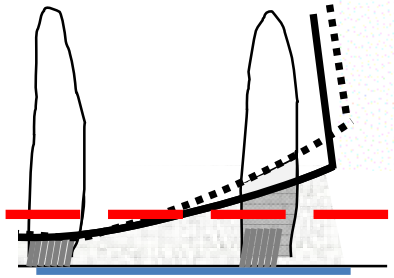
Near Nadir
2A25 V7 1998-2000

dR/dH around 1km levels [mm/h/km]

Shallow

Non-shallow





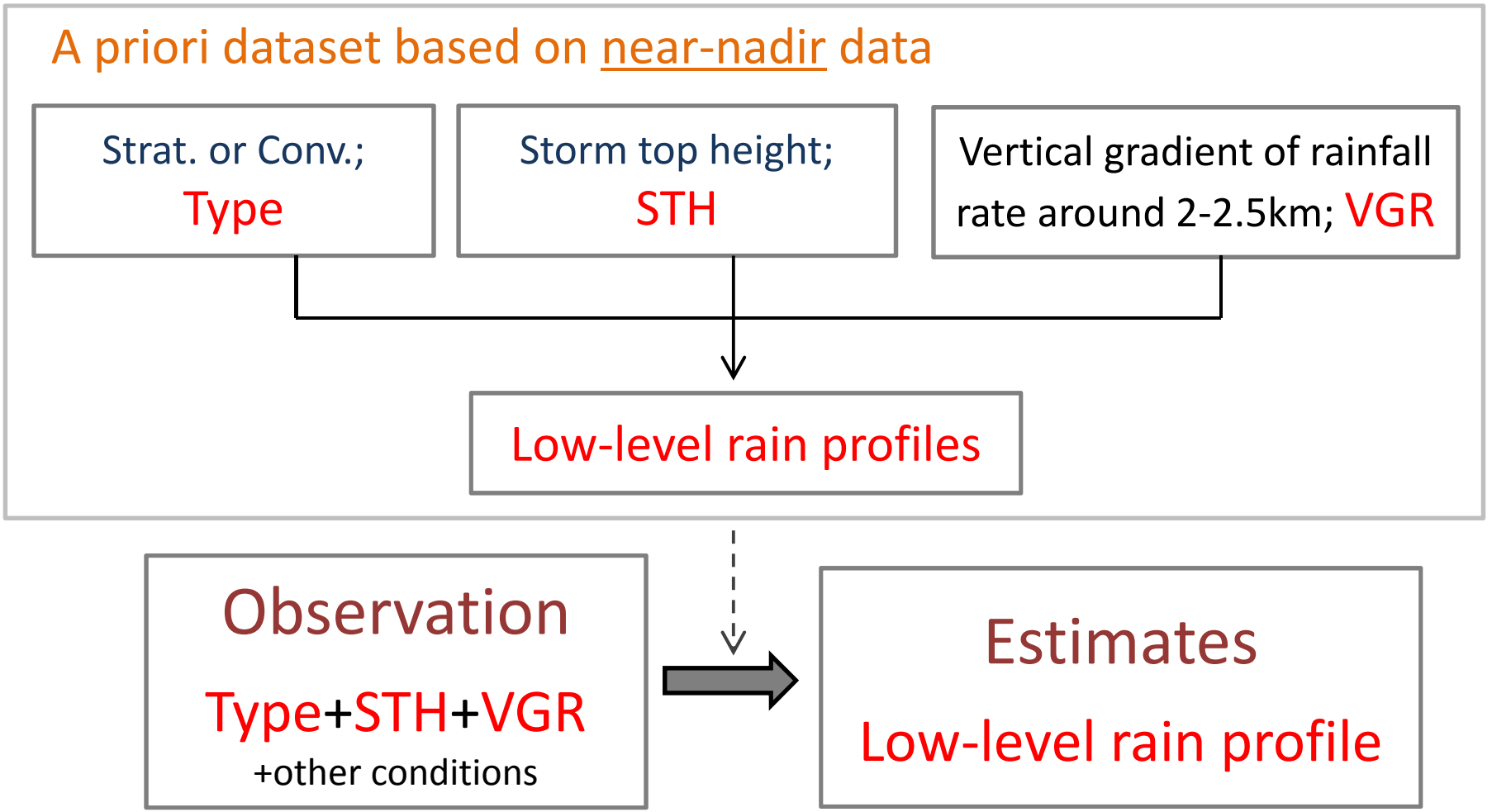
Downward increasing

Downward decreasing

(rev. Hirose et al. 2012)

Estimates on the off-nadir rain profiles at the clutter levels

Reduction of internal inconsistency in view of the incidence angle dependency



Preliminary analysis:

Target area: Asia 60-150E, 0-37N, Data: 2A25 v.7, 1998-2012 （c. Kondo）

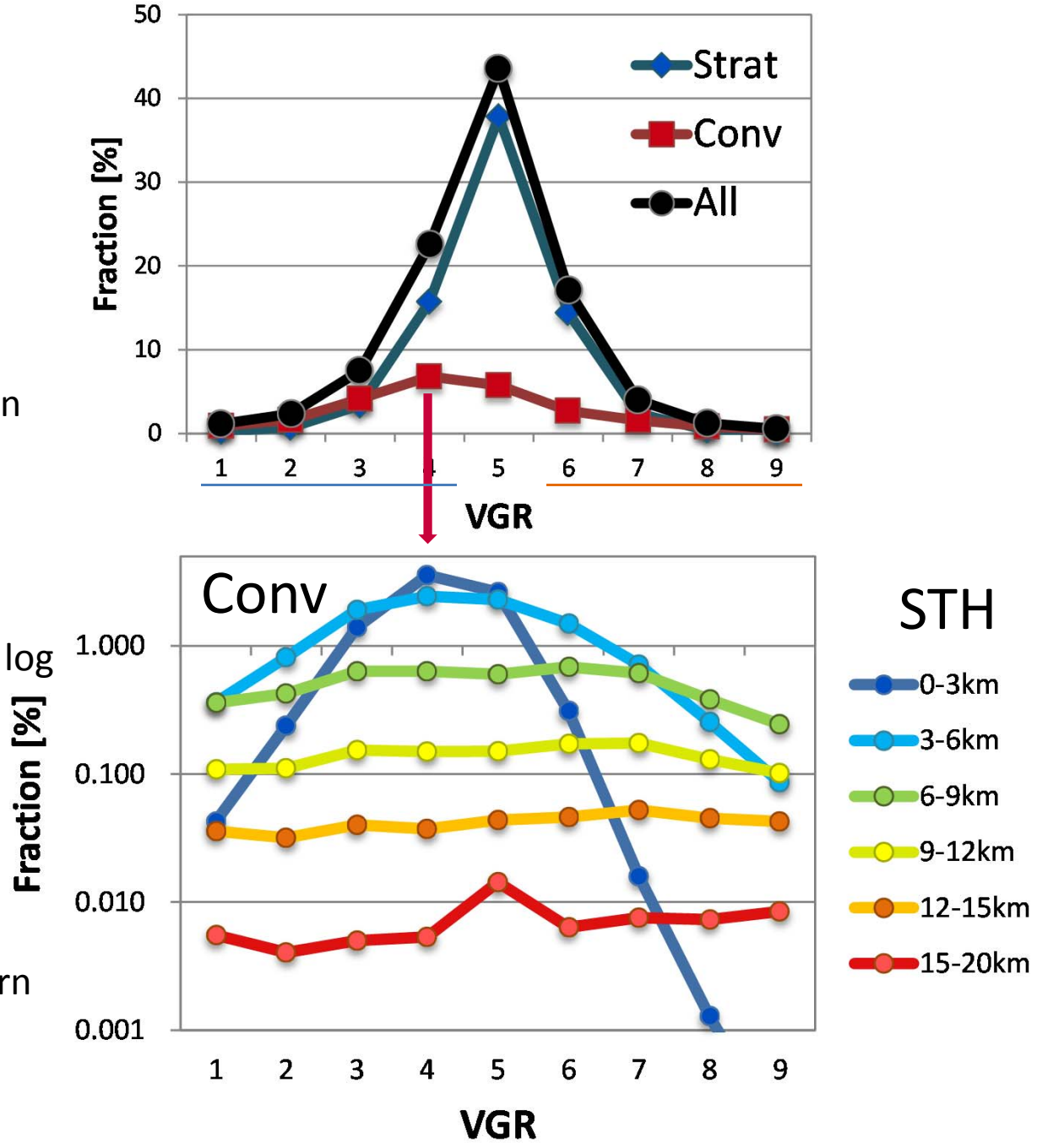
Histogram of VGR

VGR [mm/h/km]
2-2.5km

Downward **increasing** pattern

1		VGR < -10
2		-10 -- -5
3		-5 -- -2
4		-2 -- -0.5
5		-0.5 -- 0.5
6		0.5 – 2
7		2 – 5
8		5 – 10
9		≧ 10

Downward **decreasing** pattern



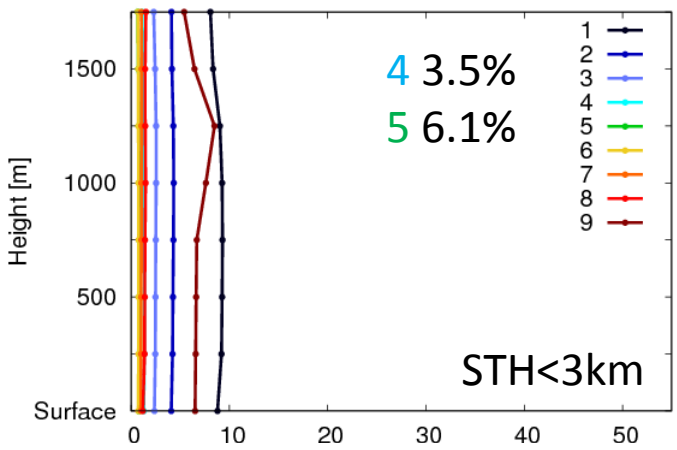
Near-surface rain profiles at near nadir

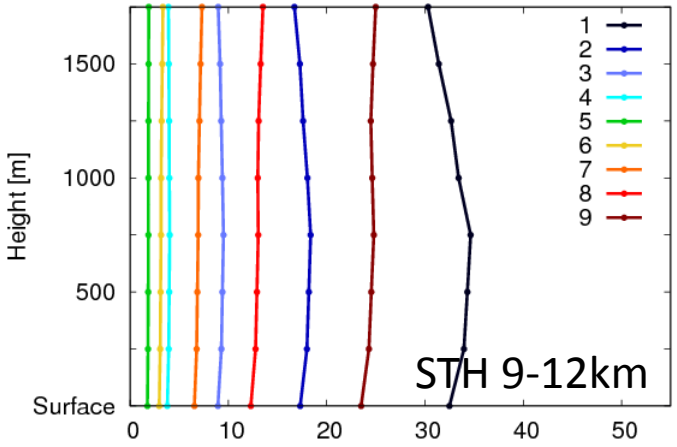
Stratiform rain

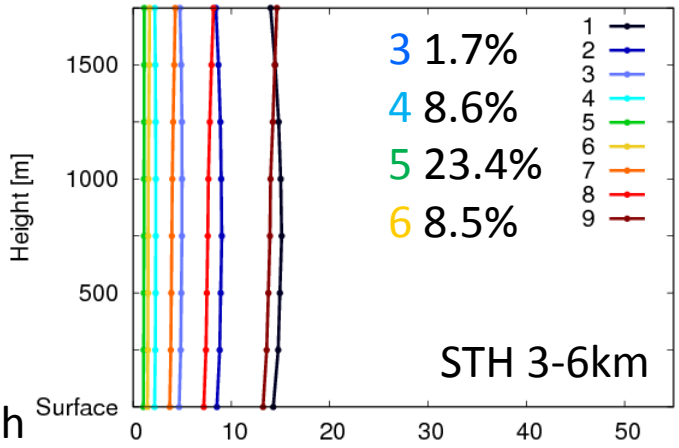
Sorted by STH and VGR

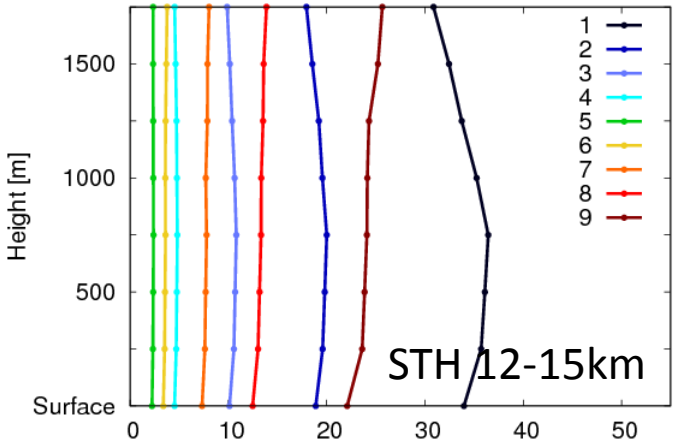
VGR [mm/h/km] dR/dh

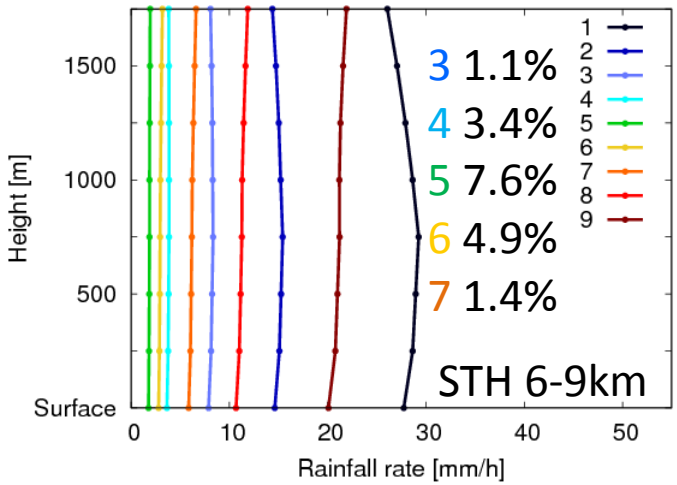
1 VGR < -10
2 -10 -- -5
3 -5 -- -2
4 -2 -- -0.5
5 -0.5 -- 0.5
6 0.5 – 2
7 2 – 5
8 5 – 10
9 ≥ 10

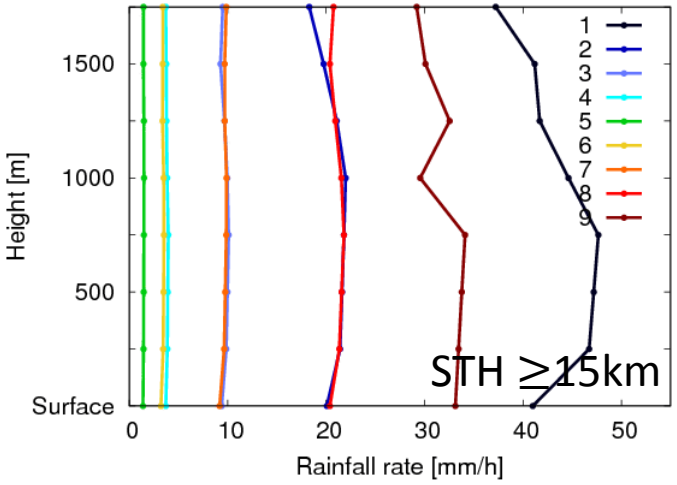












Near-surface rain profiles at near nadir

Convective rain

Sorted by STH and VGR

VGR [mm/h/km] dR/dh

1 VGR < -10
2 -10 -- -5
3 -5 -- -2
4 -2 -- -0.5
5 -0.5 -- 0.5
6 0.5 – 2
7 2 – 5
8 5 – 10
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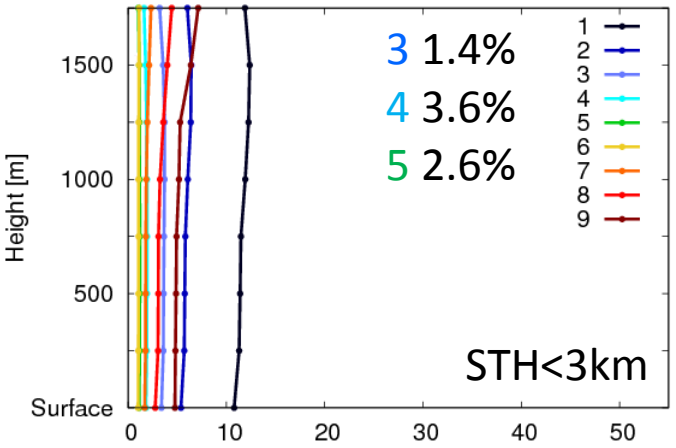
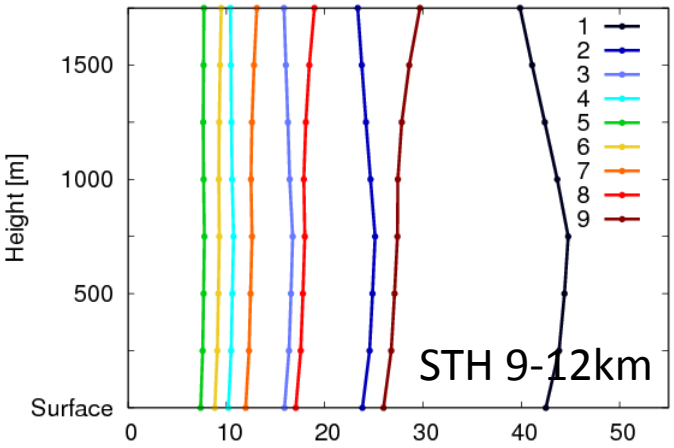
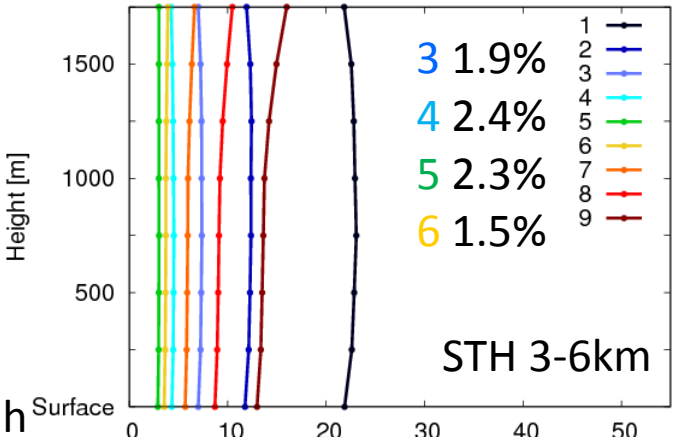
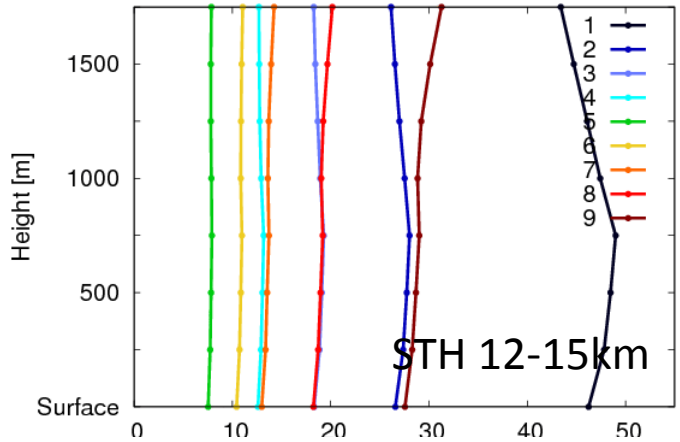
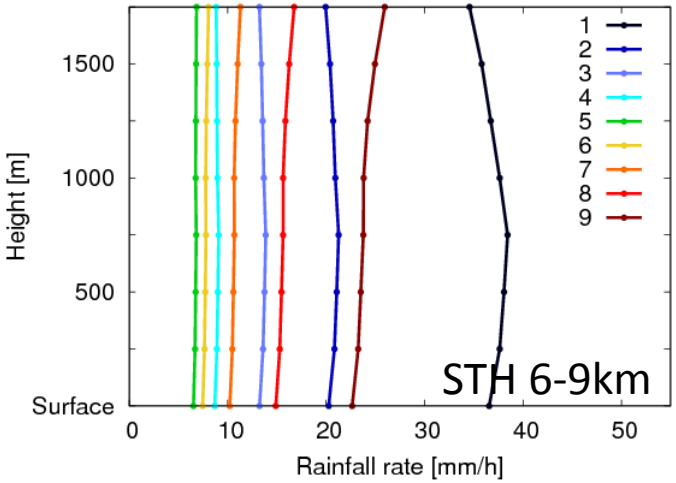
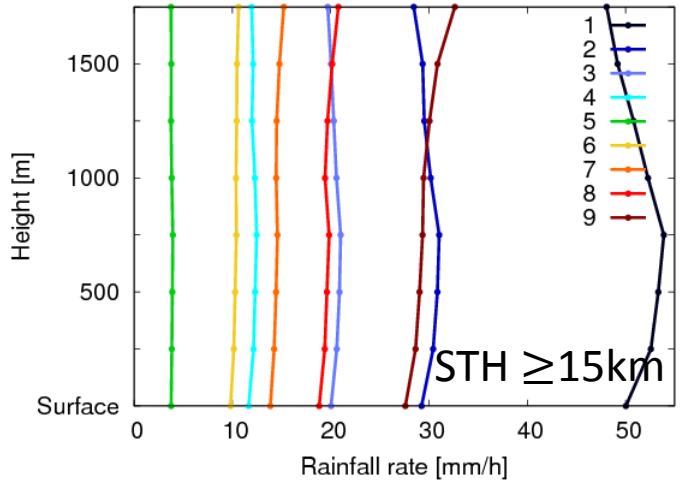








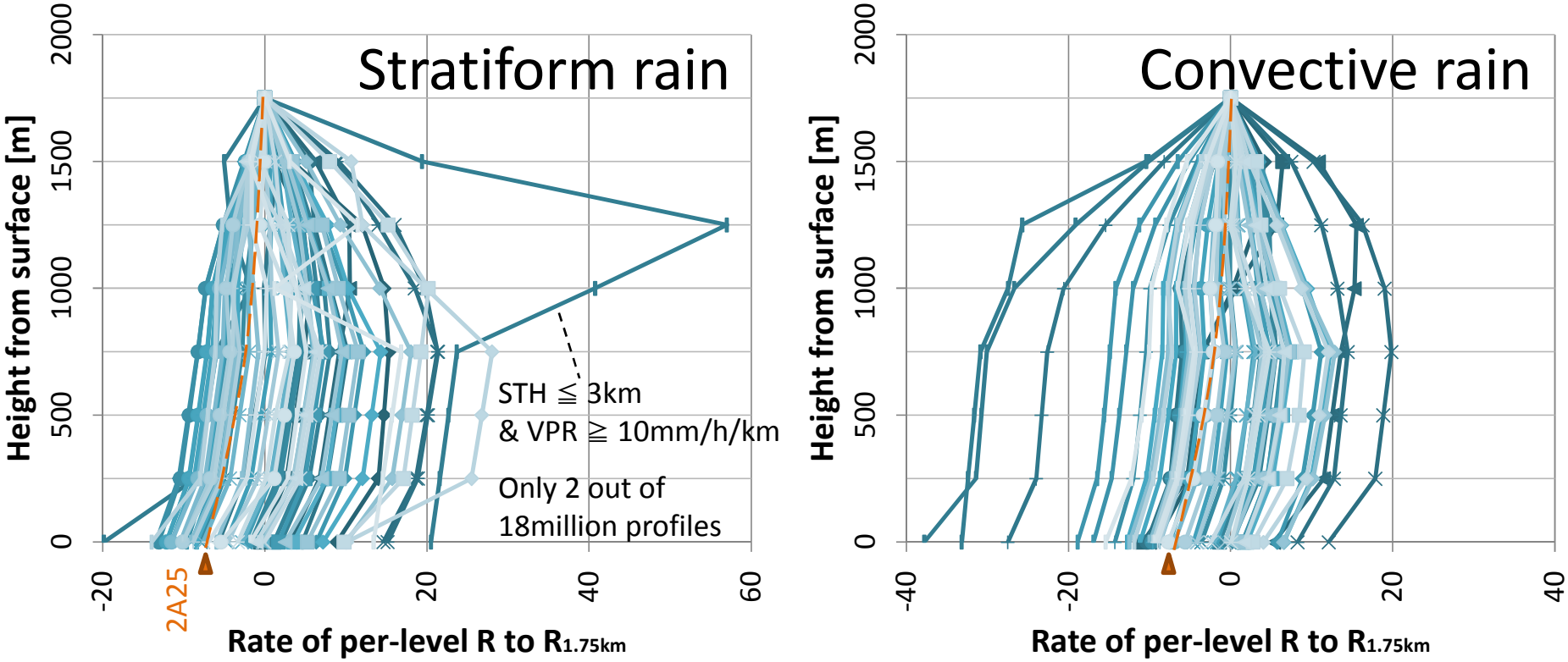




A near-surface rain profile dataset

STH 6types
dR/dh 9types

This example is calculated for the case with
the clutter free bottom is 1.75 km



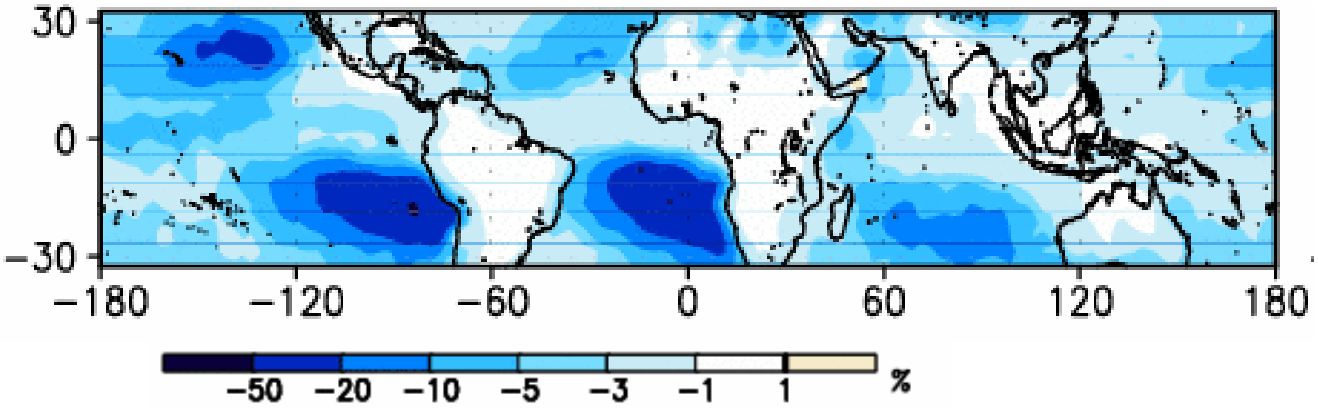
Next Step:

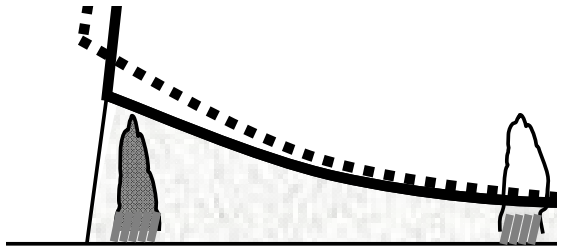
- Asia→Globe. Further classification for Ocean/Land, Rain/Snow, etc.
- Seamless and robust connection between obs. and model
- VAL on consistency of rain between angles and the boost effect
- Specify the remaining bias

B. Sampling errors: **Missing shallow storms**

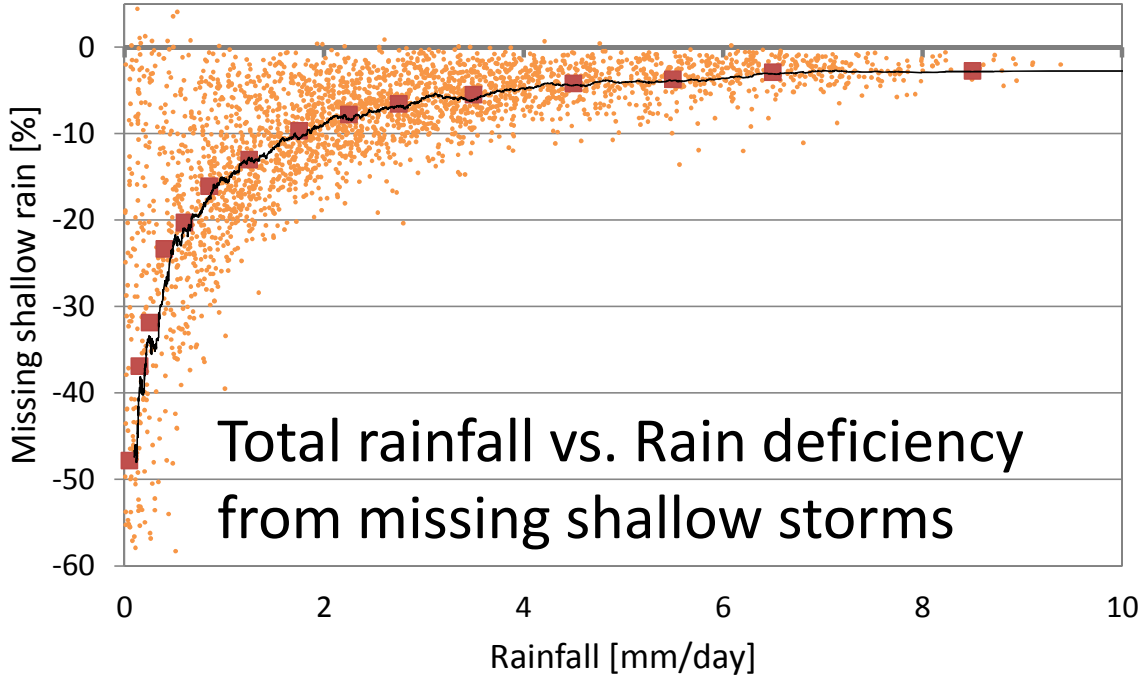
Uncertainty estimate on detection of shallow storms

Bias due to the undetected number of shallow storms between angles 1998-2000

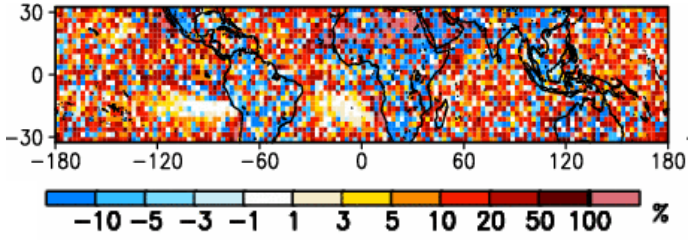




Underestimates



Bias for detectable systems (>3km) 1998-2000



Overestimates

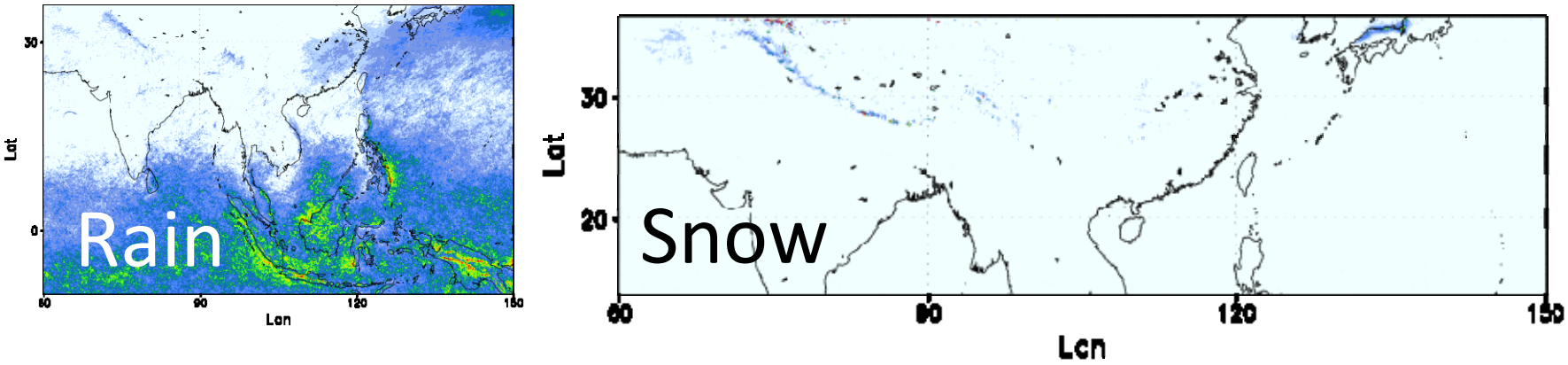
+ Further evaluation on the local residual bias

How about for snow detectability?

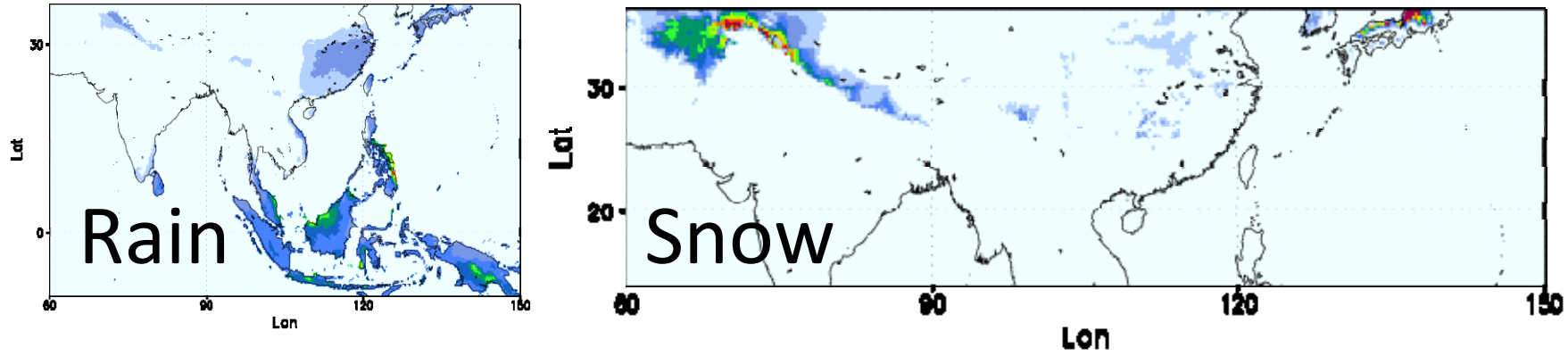
Orographic rain? （c. Kondo）

Rain/Snow by 1.5^{0}C at surf

TRMM PR v.7 DJF 1998-2012



APHRO_MA_V1101R2



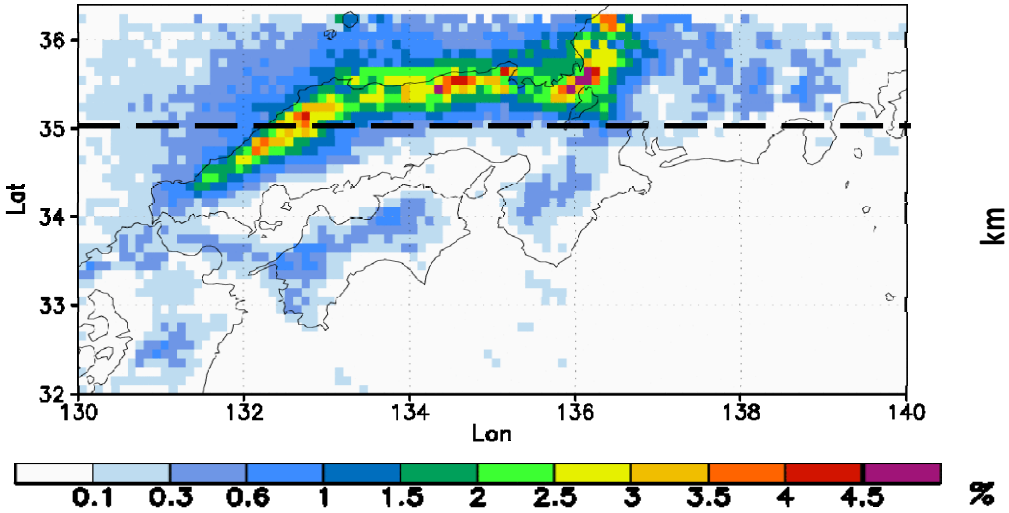
Rain 1 2 4 6 8 10 12 14 16 18 20 22 [mm/day]

Snow 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4

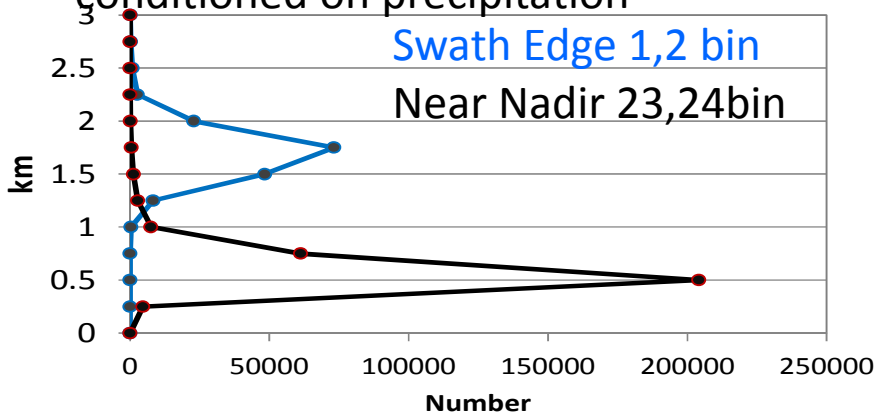
Undetectable precipitation due to the main-lobe clutter

Target: Japan 128-150E, 30-35N, DJF for 15 years

Occurrence frequency of snow



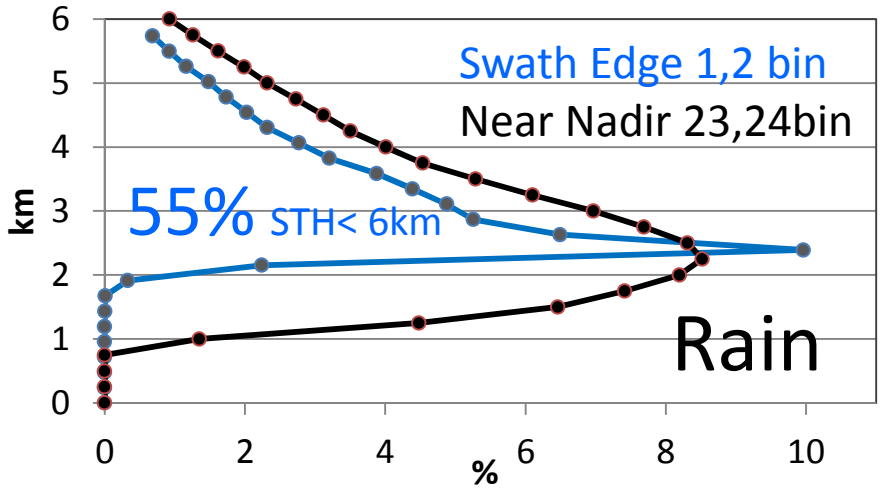
Histogram of Clutter free bottom conditioned on precipitation

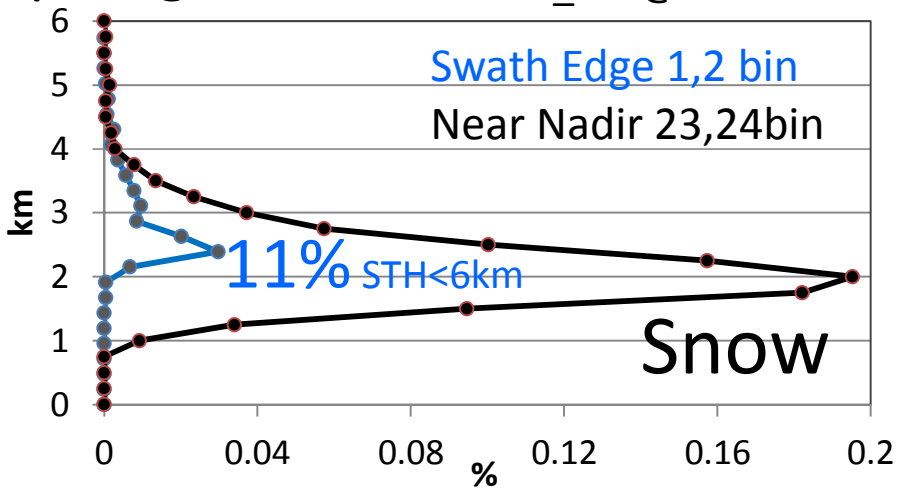


44% underestimates at the swath edge

Histogram of storm top height

100%=Num_rain@Near Nadir





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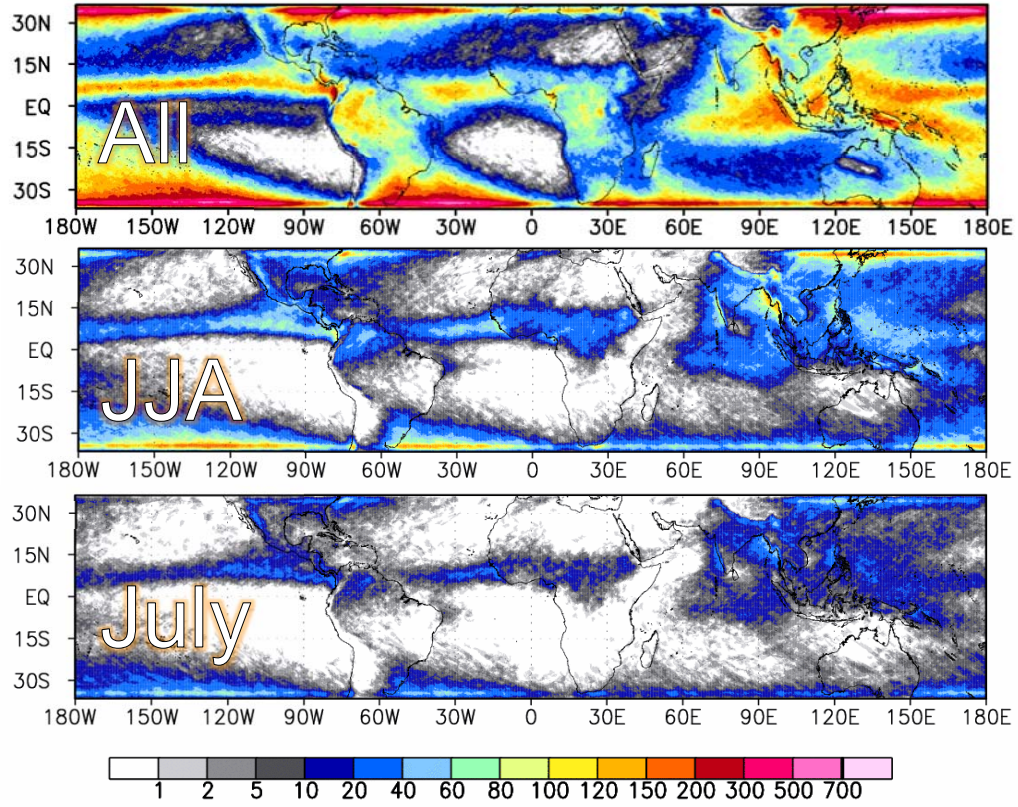
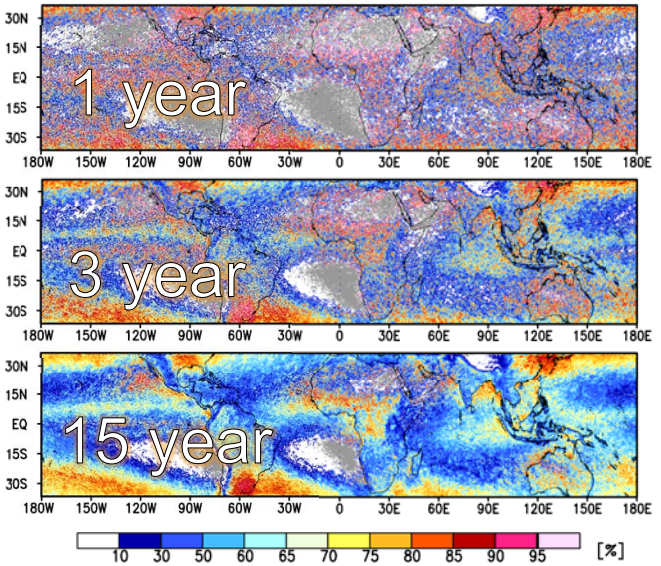
Impact of the long-term data accumulation

of high-impact systems (Large PRPSs) for 15 years [/0.1˚]

a proxy of sampling sufficiency



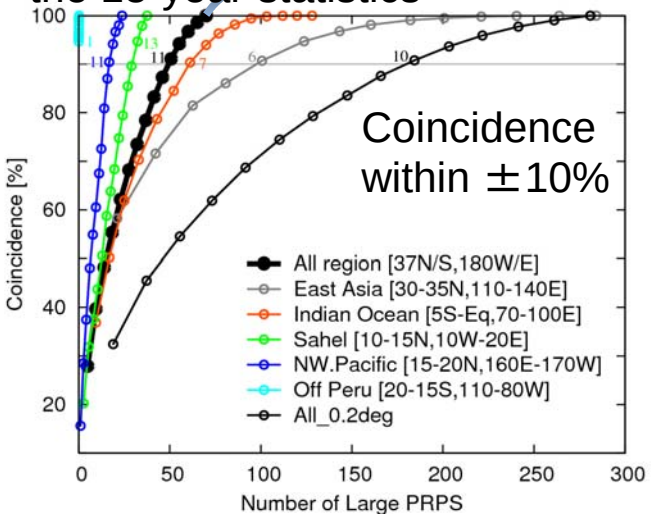
Rain fraction of Large PRPSs during 1998, 1998-2000, and 1998-2012



[/0.1˚]

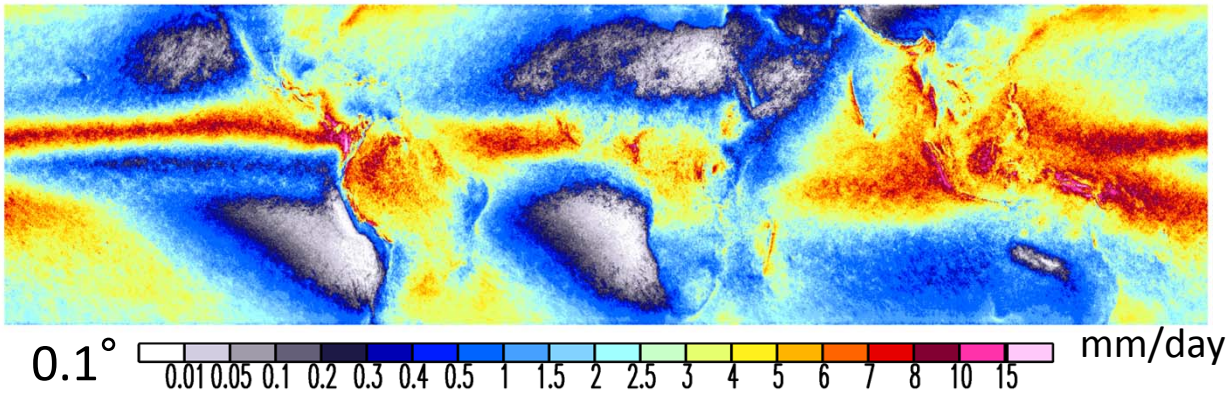
Gray shadings: Small PRPSs > 90%

Coincidence ratio of the L-system rain fraction by integrated years against the 15-year statistics

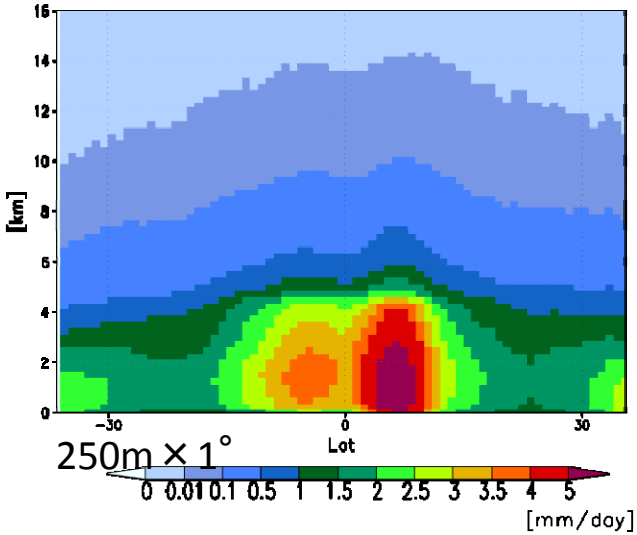


Fine-scale precipitation system climatology

Rain climatology 1998-2012



Latitudinal cross section

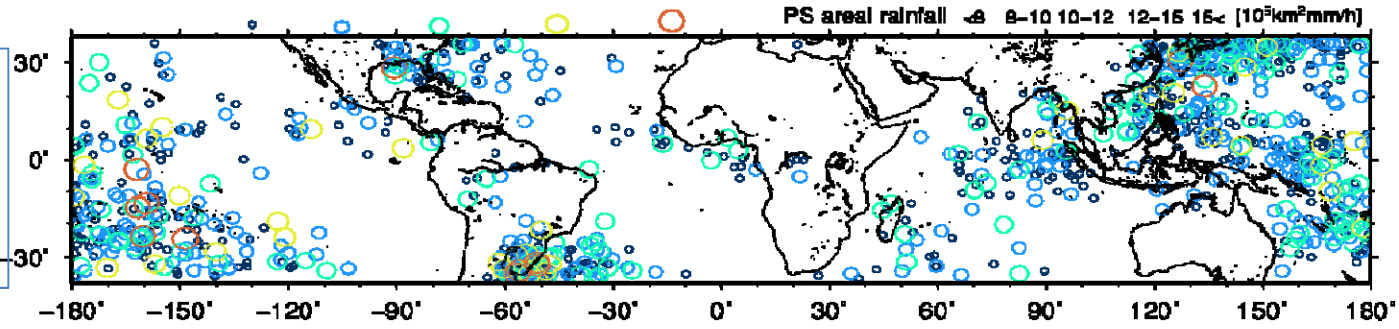


1.8 (38) billion of rain samples (all samples)

PR captured Precipitation Systems; PRPS (Hirose et al. 2009)

104 million PRPSs for 15 years

Top 1000 PRPSs sorted by Areal rainfall [km^{2}mm/h] 15yrs



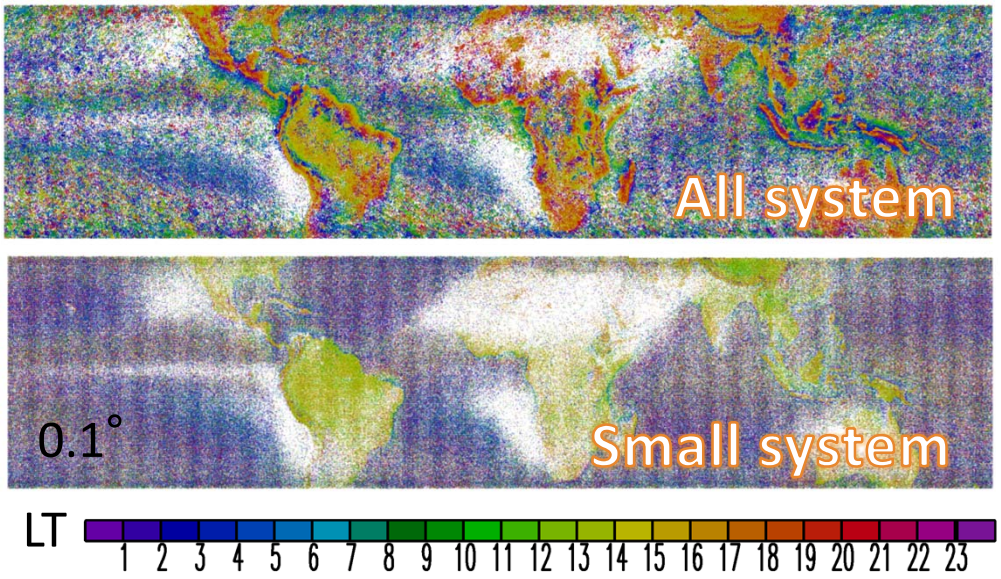
Small PRPSs: < 10 km

Medium PRPSs: S-L

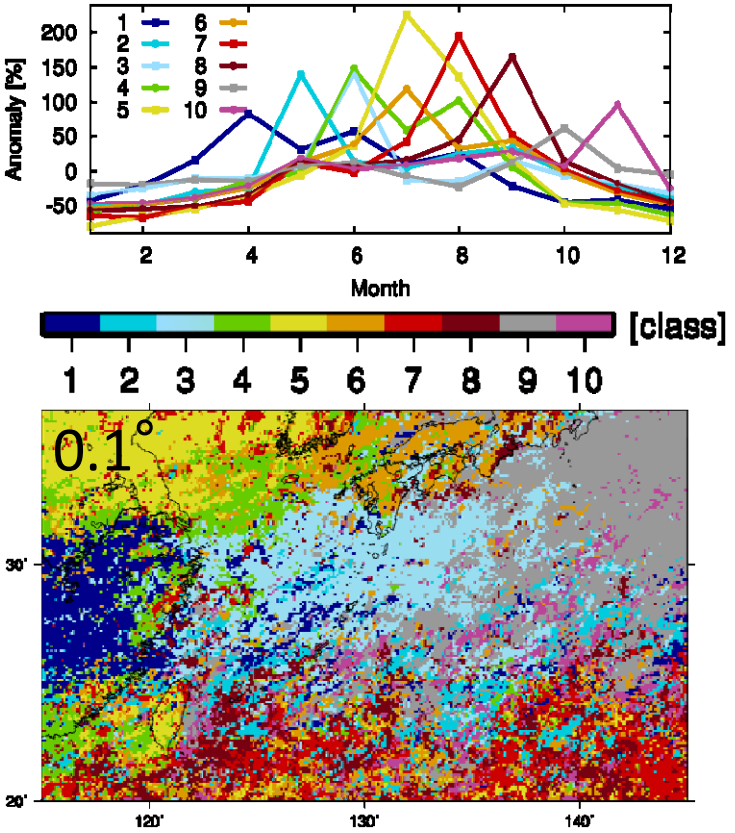
Large PRPSs: > 100 km

Temporal variation of local rainfall

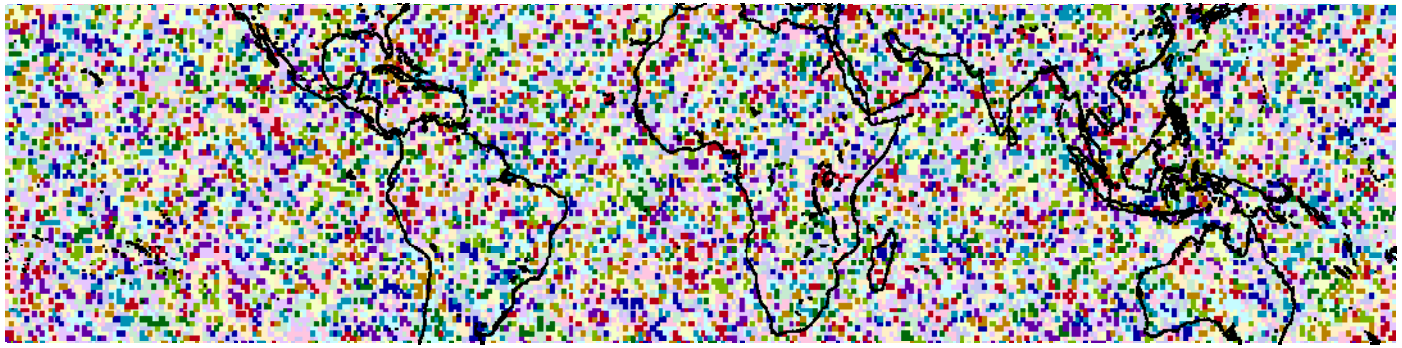
Diurnal variation



Seasonal variation



Weekly variation?



JJA, 1°

D_Rmax≠D_Rmax3
D_Rmax=D_Rmax3

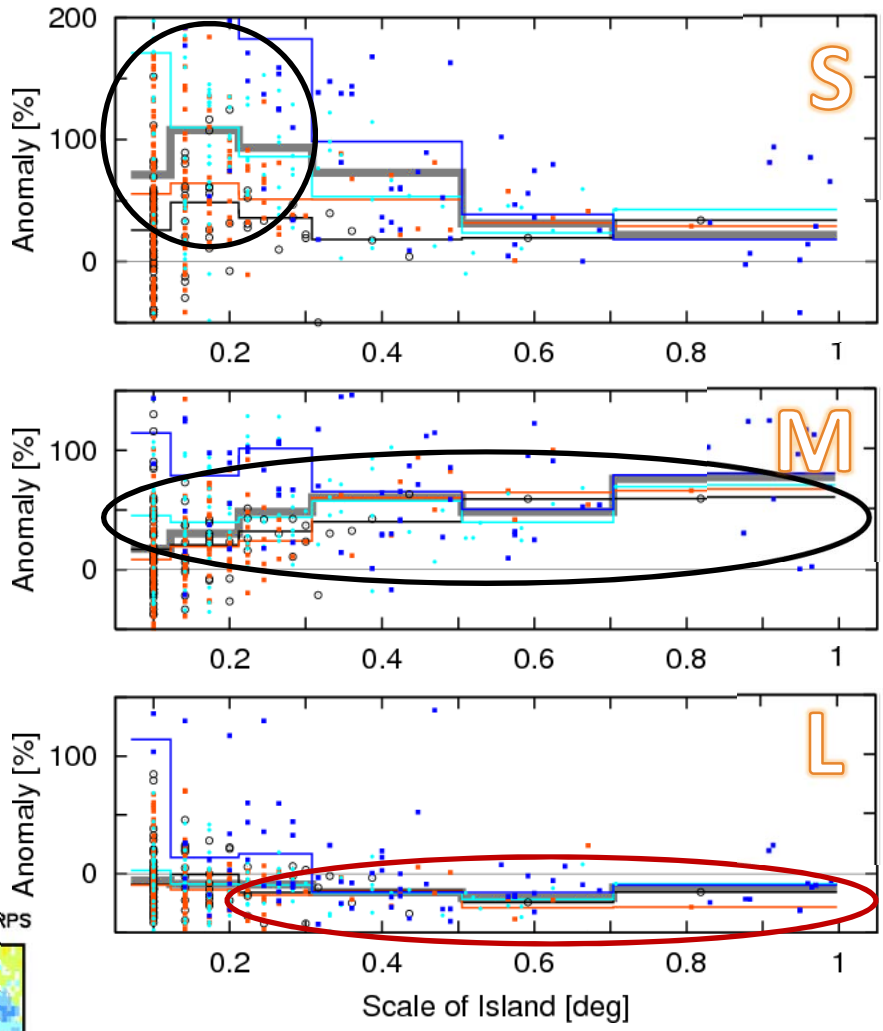
Fine-scale features

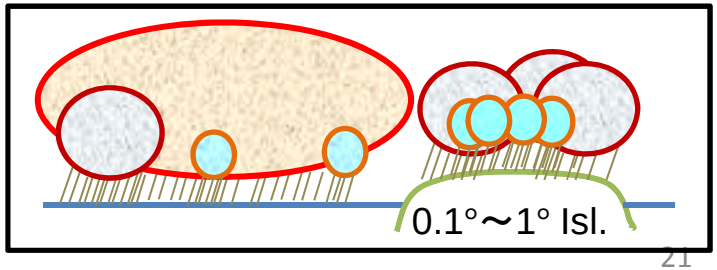
Rainfall of scale-based PRPSs over 468 small islands

max altitudes
- 0-100m
- 100-500m
- 500-1000m
- 1000-m

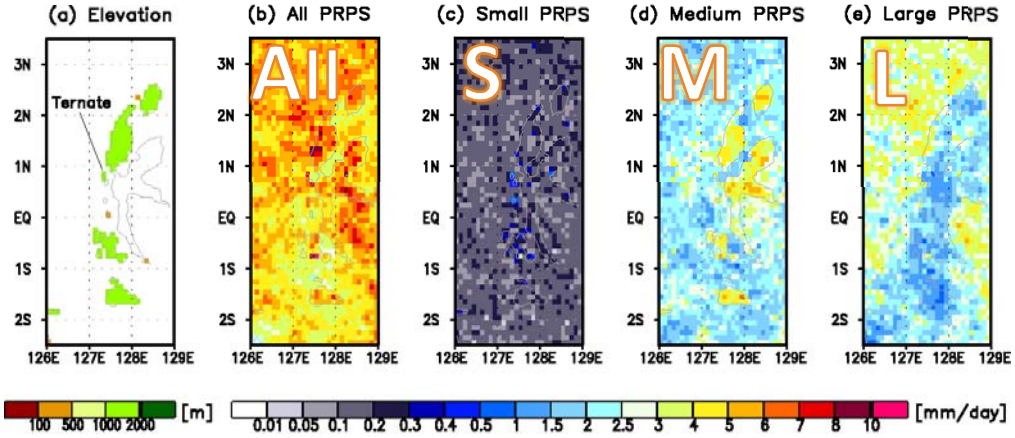
Even for flat 0.1˚ islands, rainfall was 26% increased for S systems. Larger islands had positive RE by M systems. In contrast, L systems brought negative anomaly.

Rain anomaly against the surrounding ocean

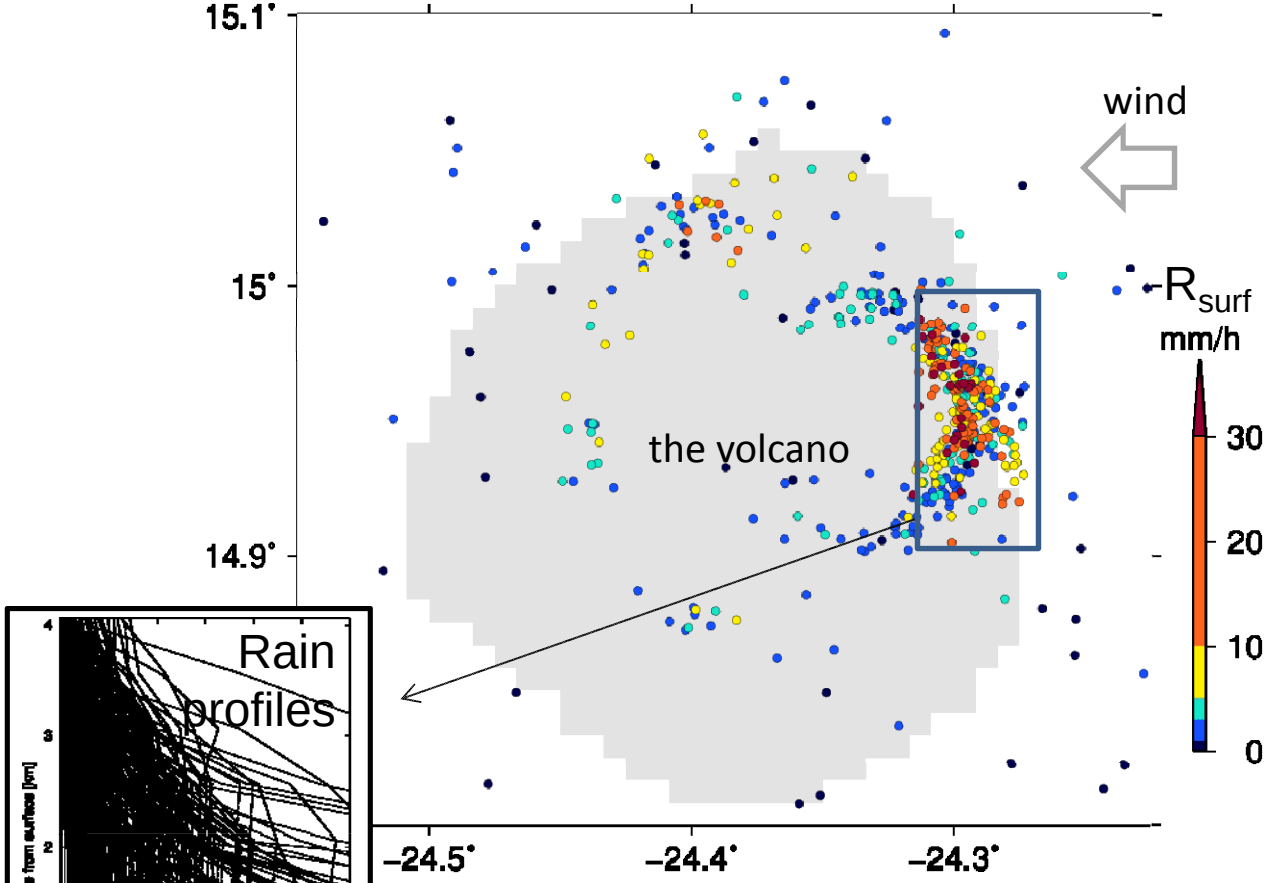


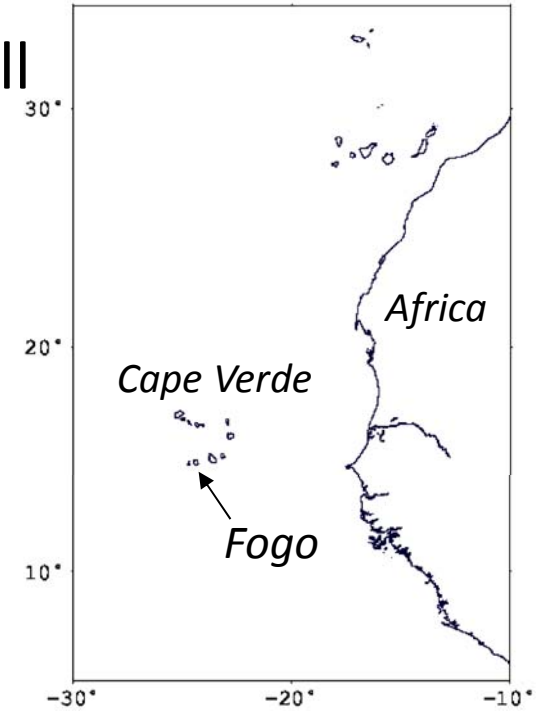


Rain sorted by scale-based PRPSs over Indonesia

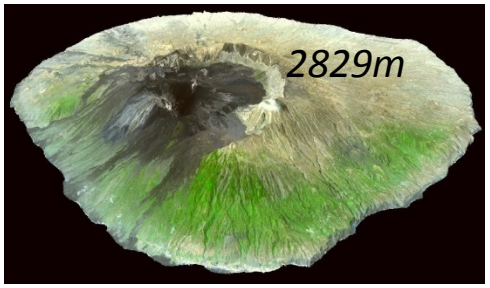


Locations of the centroid of instantaneous Small PRPSs around the Fogo island, Cape Verde

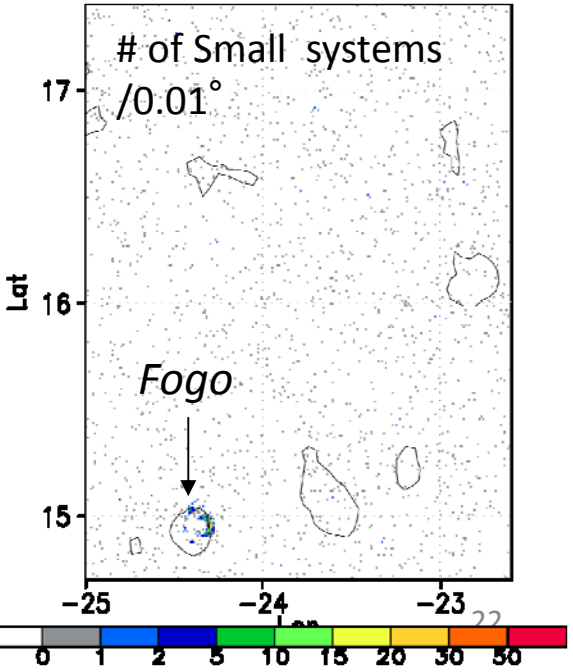




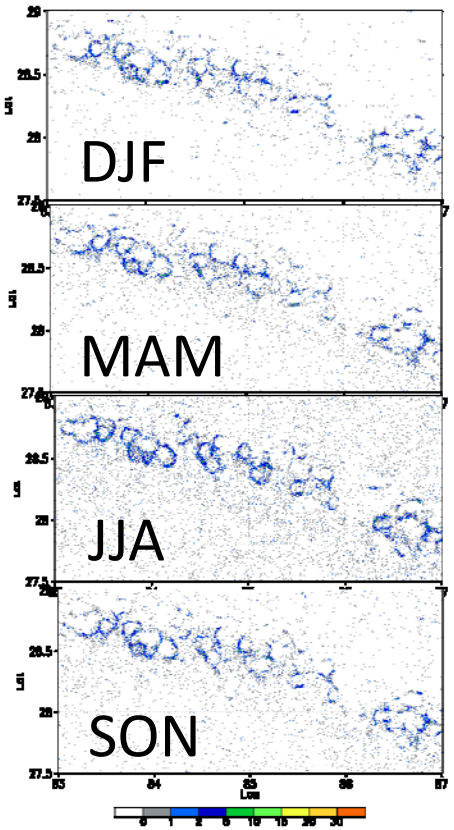
295 cases/15yrs



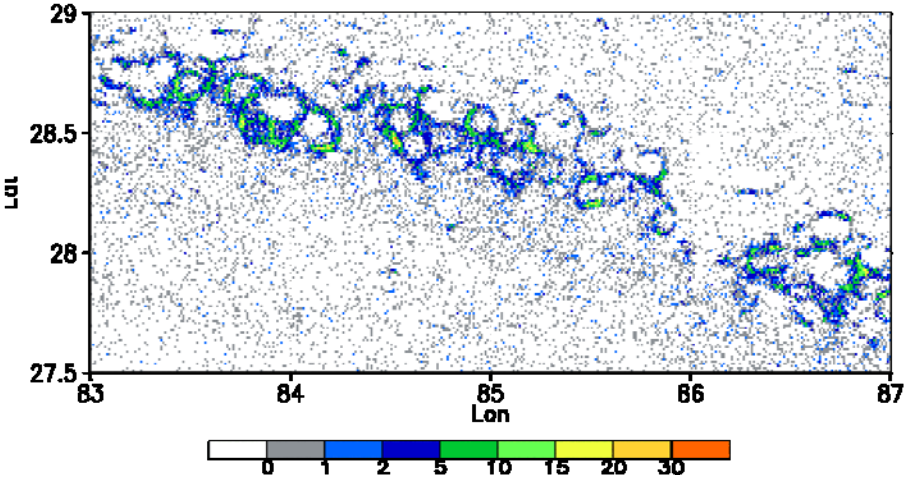
Fogo isl. from ASTER (c NASA)

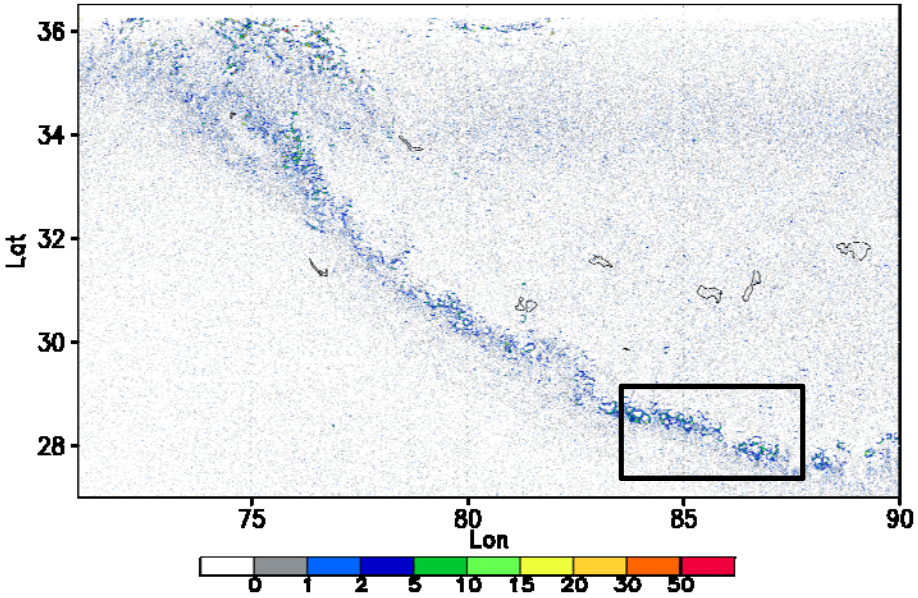


Number of small PRPSs over the Himalayas

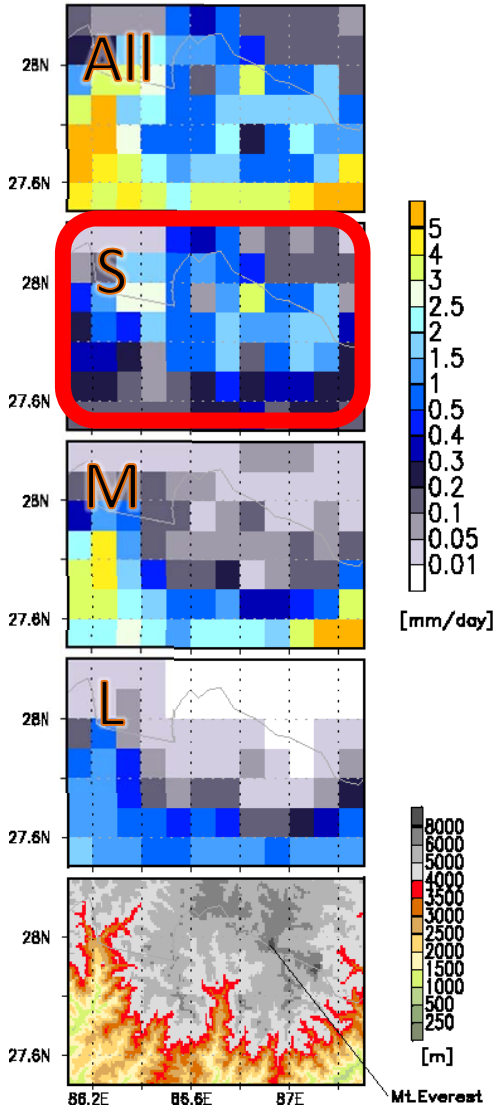


Number/0.01˚





Rain from scale-based PRPSs around the Everest



Evaluation of the long-term TRMM PR data & Development of better climatological uses

Research challenges:

1. External and internal VAL on retrieval properties
- Uncertainties and advantages against ground truths
- Correction on incidence angle dependency

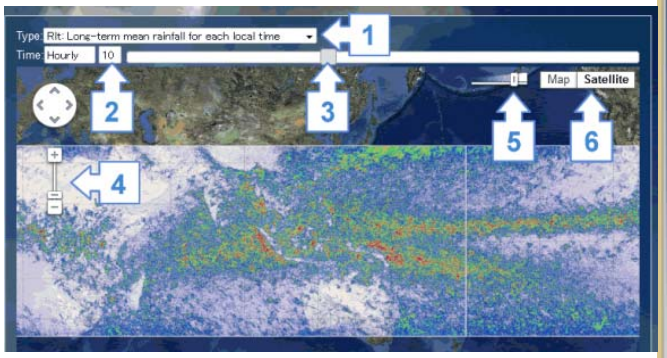
2. Progress assessment of the precipitation climatology
- Sampling performance at multi scales (e.g., Regional impact of rare but significant events)
- Detection of fine-scale storm features

3. Other themes
- **Disclosure of research product and visual tools**
- Comparative verification of the GPM DPR data

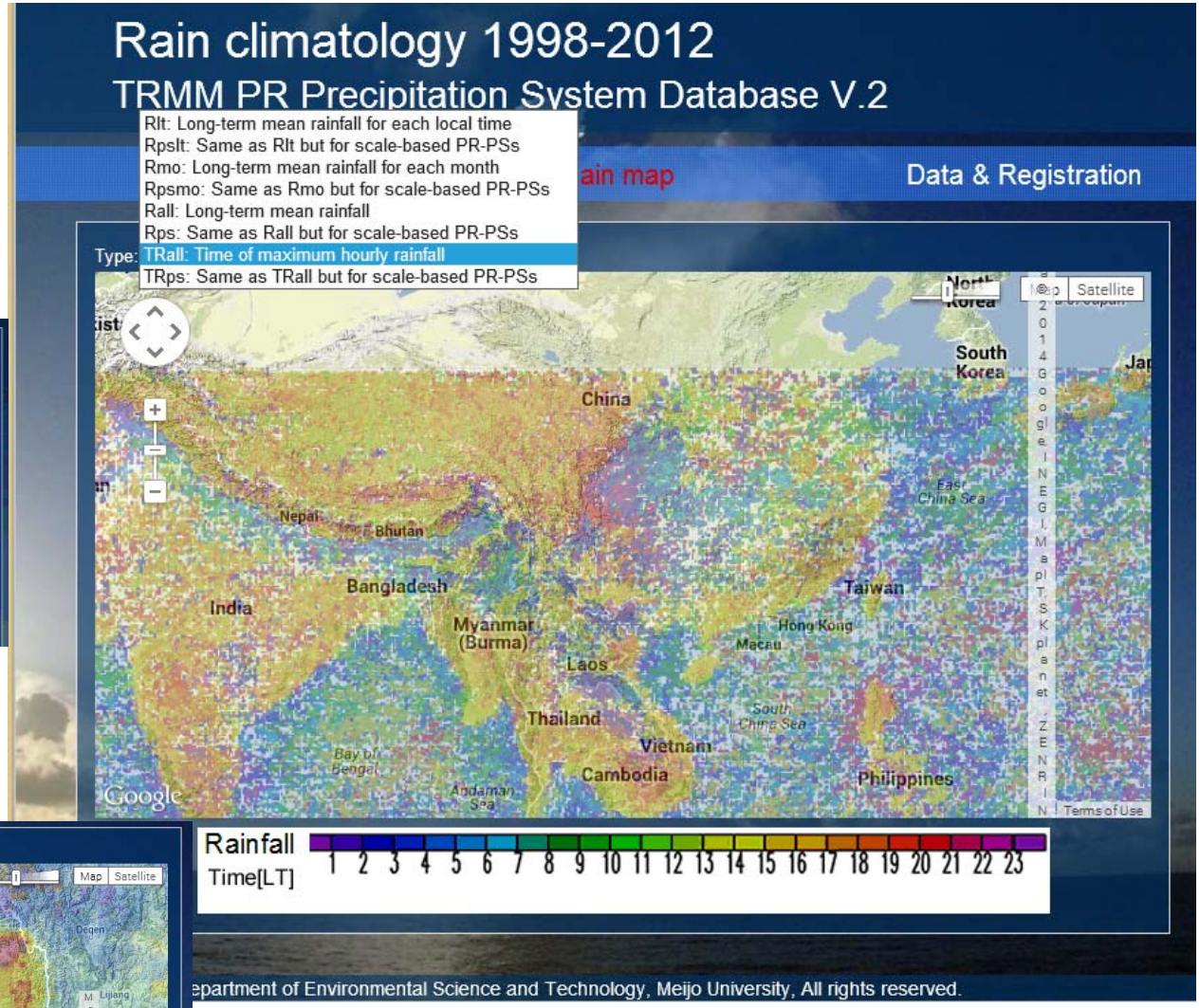
Web site

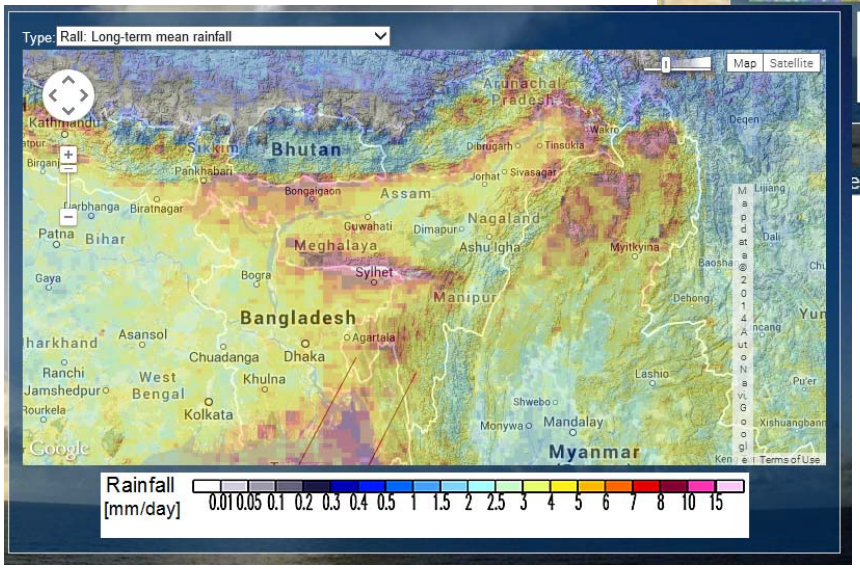
V1→V2

Still prerelease…



1.Type Selector, 2.Time Indicator,
3.Time Slider, 4.Zoom Slider,
5.Opacity Slider, 6.Map Selector

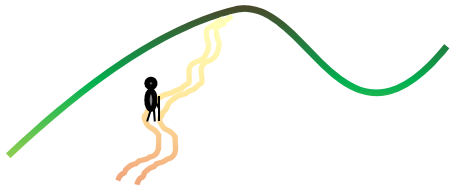




Upgrades

- Revision of database and 144 figures from 13-year V6 to 15-year V7
- New 8 maps (Ave. and Time of max Rain)
- Improvements in the batched process

→ FY2014



Ongoing efforts toward the robust estimate & advancing climate research

Search for a self-consistent TRMM PR data as the current best estimate

Dynamic correction of systematic biases

→ A better understanding of remaining local uncertainties between observational data incl. DPR

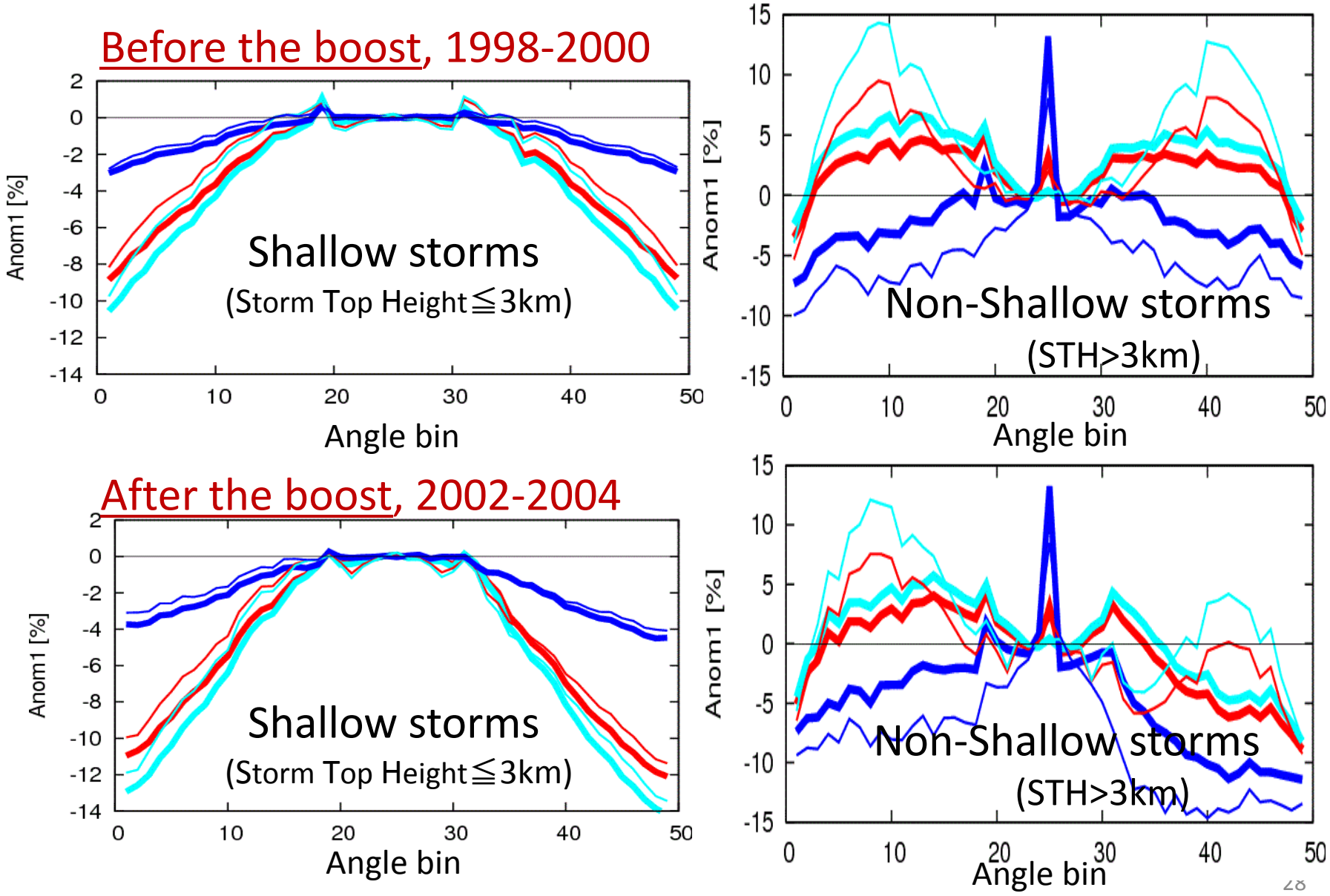
→ Further clarification of strengths/limitation of the spaceborne radar data

+Timely initial evaluation of the DPR data

Backup slides

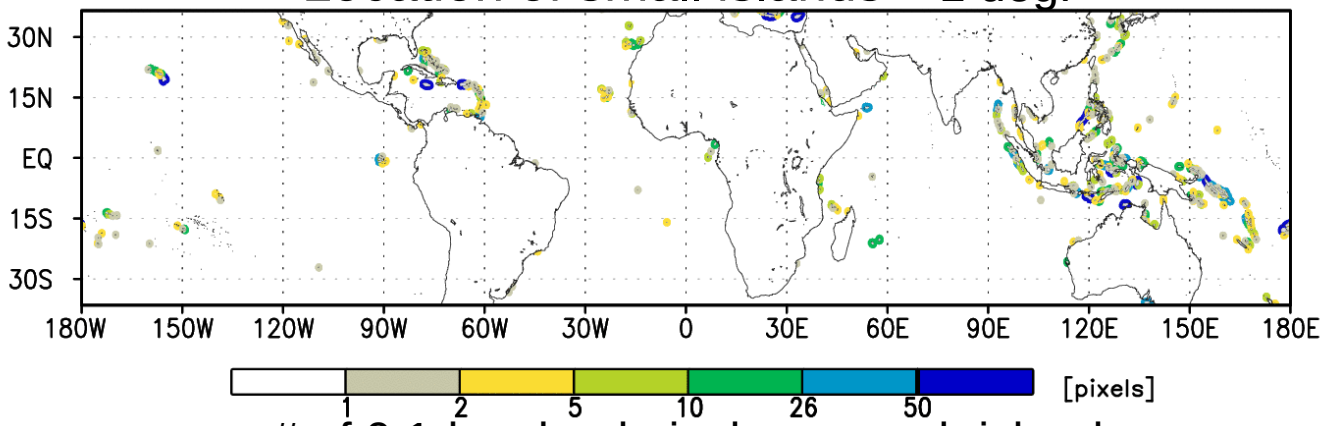
Anomaly of each-angle rainfall against the near-nadir statistics

All (35°N/S), **Ocean**、**Land**, **Thick** (thin) **lines**：**V7** (V6)



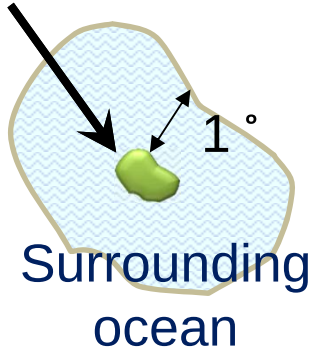
Rainfall over small islands

Location of small islands < 1 deg.



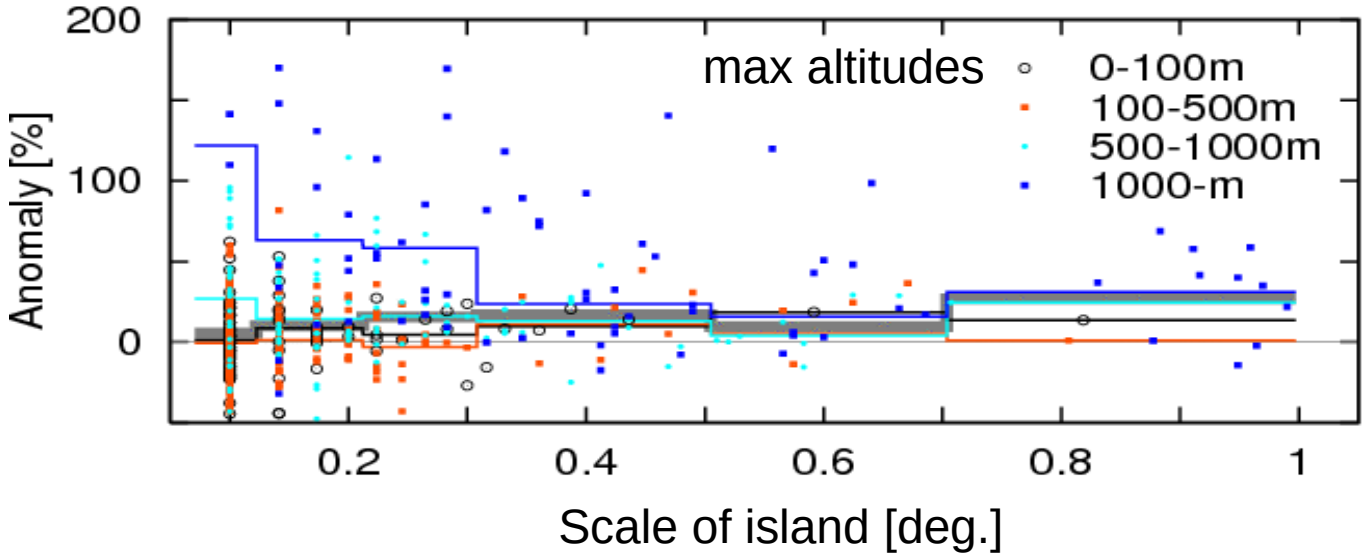
# of 0.1deg. land pixel over each island

Small island
with area-equivalent diameter **< 1 ˚**



<u>468 small islands</u>
over 36˚ N/S

Rain enhancement (RE) against the surrounding ocean, sorted by the horizontal scale & max altitude of islands



Even for very small islands (<u>0.1 ˚</u>), particularly with high mountains, RE was detected.

Scale-based PRPSs over the Maritime continent

Rainfall amount

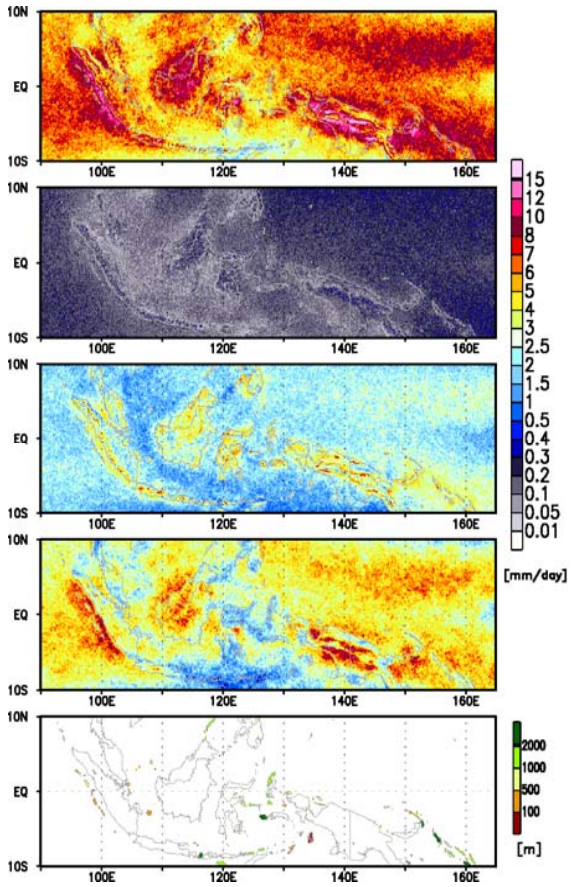
Time of maximum rainfall

All

S

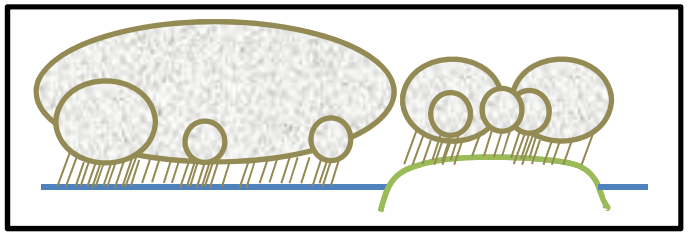
M

L

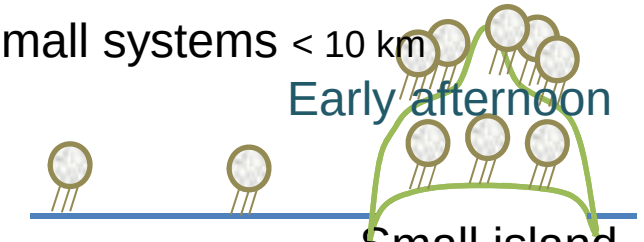


Max altitude of small islands

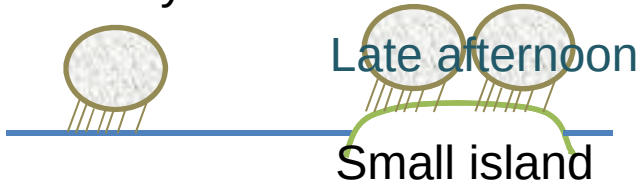
Storm features around small island (0.1˚~1˚ scale)



Small systems < 10 km



Medium systems 10-100 km



Large systems > 100 km