TRMM Tropical Rainfall Measuring Mission

JAXA

JAXA TRMM Science

Yukari N. Takayabu (Univ. Tokyo, JAXA)
& PMM Science Team

Activities in FY2012 (Feb2012-Mar2013)

- Improvements in TRMM PR algorithm (V7)
- Reduction of discounuity in TRMM PR product
- Analyses of precipitation characteristics, extreme rainfall
- Classification of precipitation regimes
- GSMaP validations and applications
- Proposal of End of Mission Experiments

IMPROVEMENTS IN TRMM PR ALGORITHMS

T. IGUCHI, J. AWAKA, T. KOZU, S. SETO, B. MENEGHINI

Major changes in TRMM PR V7 and their effects

(Only those that affect the rainfall estimates)

Toshio Iguchi (NICT)

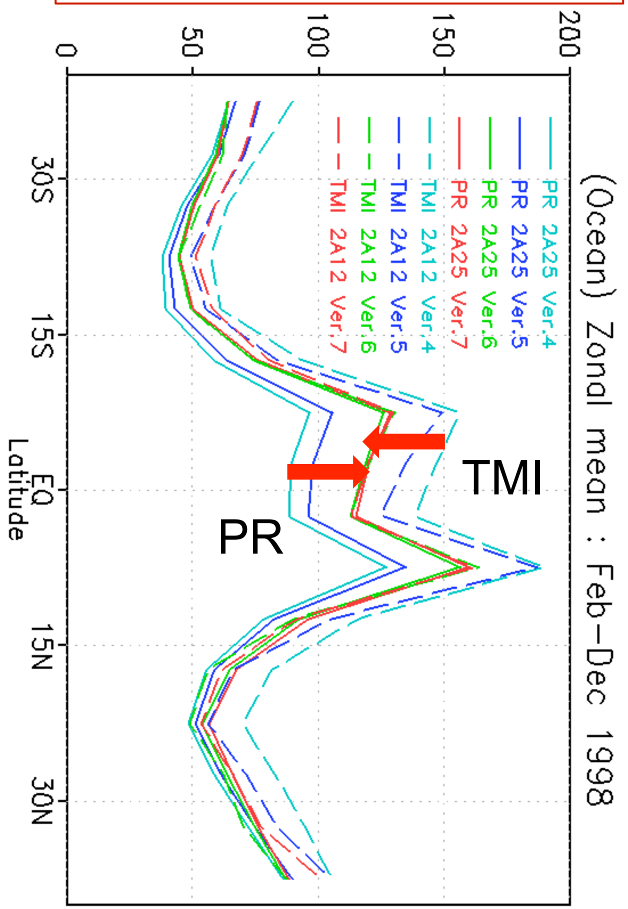
- New Path Integrated Attenuation (PIA) from improved SRT and removal of some angle-bin dependence.
- Addition of 0.5 dB to PIA: increase in heavy rain over land
- Improved profile of microphysics : 100% solid ice above -20 degree C: increase for high profile rain, but decrease in light rain
- Use of GANAL for 0 deg. C and change in the vertical model: (effect not clear)
- Introduction of non-spherical rain drop model: decrease
- New Ze-R relation for stratiform rain: increase
- Increase of convective rain cells: increase
- Introduction of NUBF correction: increase in heavy rain
- Change from expected value to ML estimate: increase in heavy rain

Note: Increase or decrease of the estimates depends on the structure of rain and other parameters, and cannot be judged in all cases.

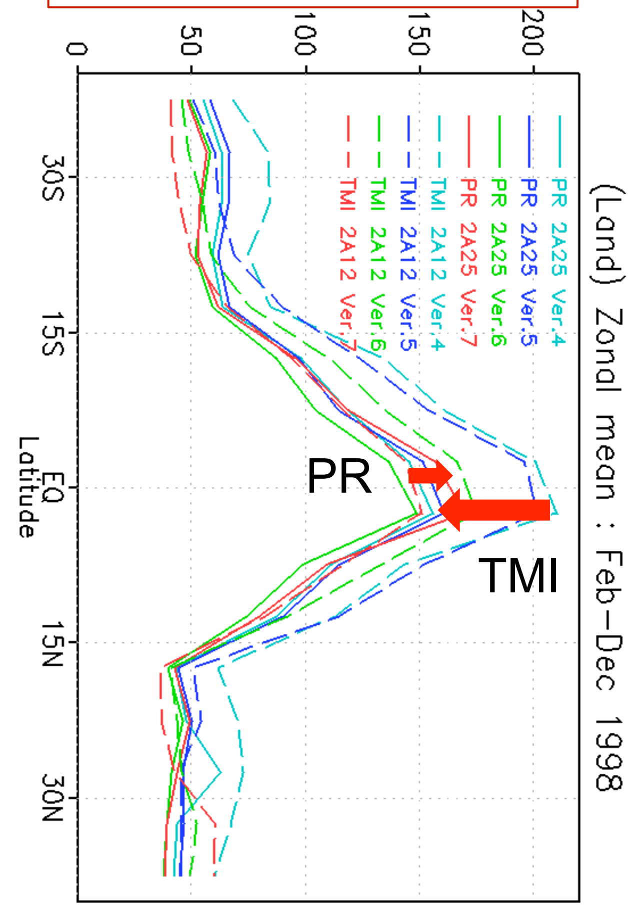
A history of TRMM rainfall estimates

- Rainfall estimates from TMI and PR have become closer to each other in version 7

Z-Ave over the Oceans



Z-Ave over Land

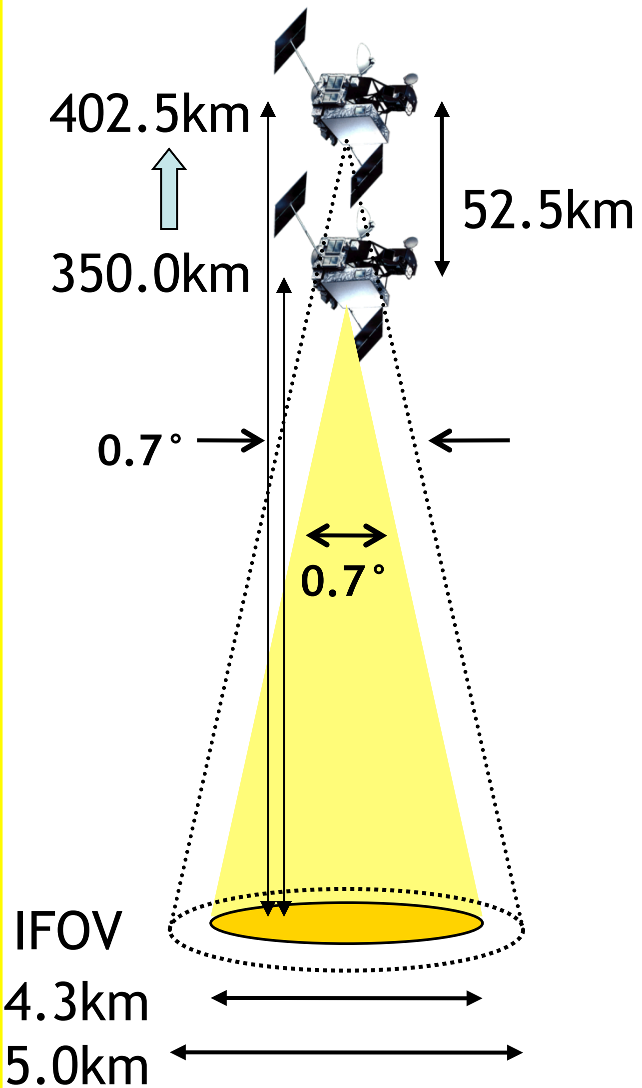


DISCONTINUITY-REDUCED TRMM PR PRODUCT

SATOSHI KIDA[1], TAKUJI KUBOTA[1], MISAKO KACHI[1], RIKO OKI[1], TOSHIO IGUCHI[2], YUKARI N. TAKAYABU[3]

A reduction of discontinuity in PR rainfall product due to the orbit boost

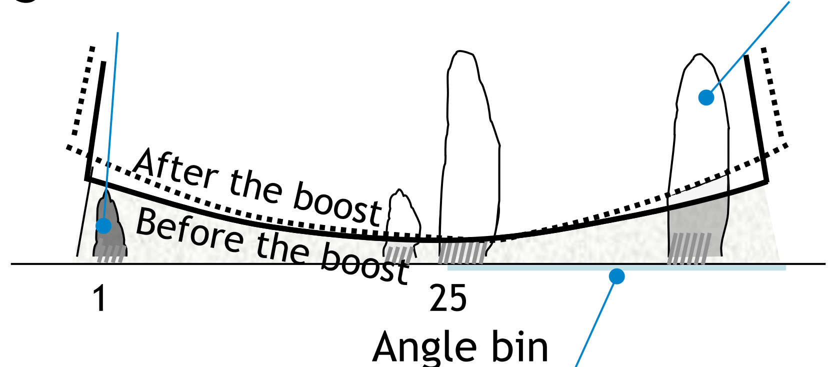
Schematic of the orbit boost



It has been indicated that the amount of weak convective rainfall in PR product decreased after the altitude boost in Aug. 2001.

② an increase in the range of surface clutter

① a sensitivity degradation

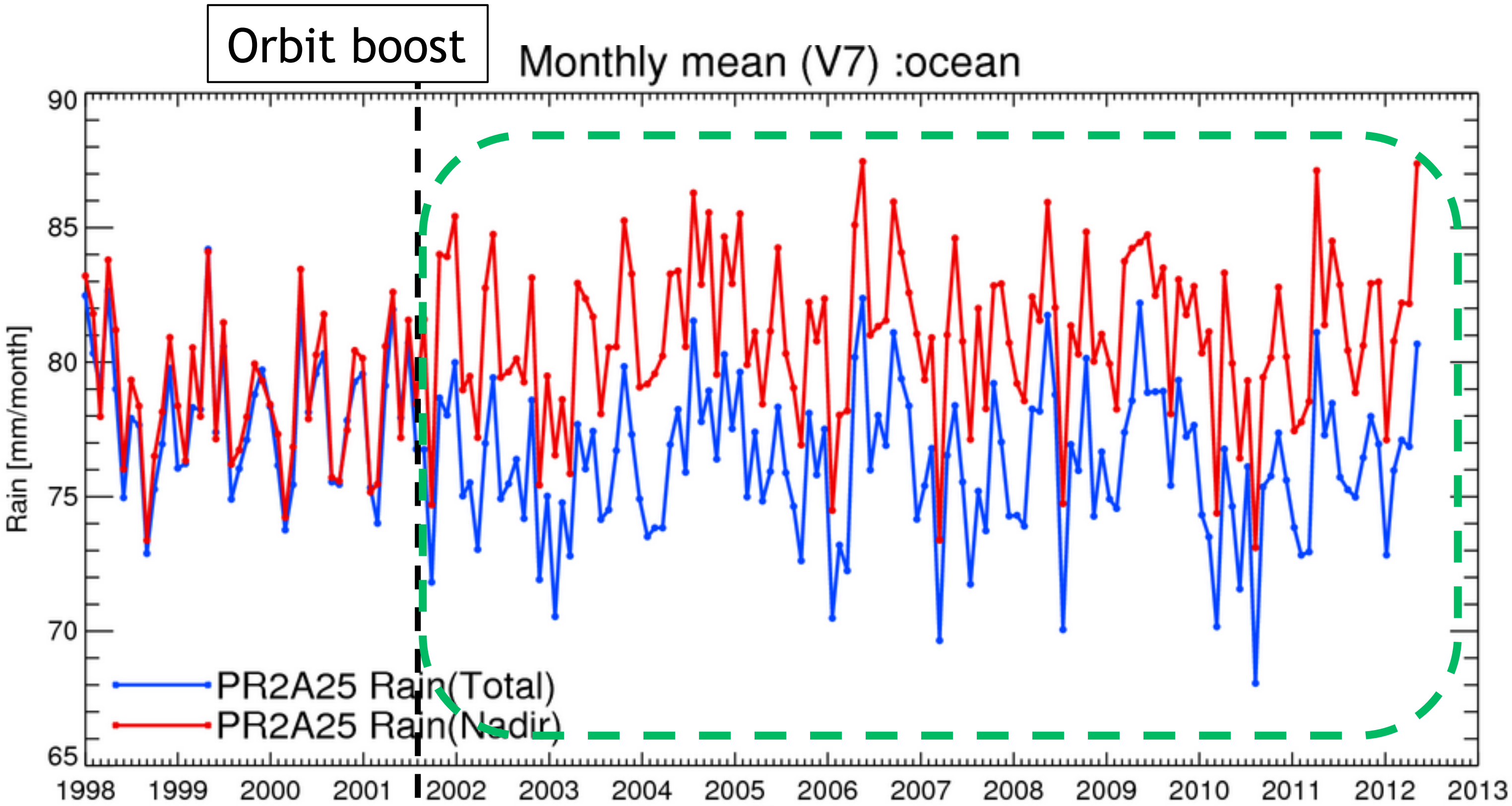


③ a beam mismatch

(which is a mismatch between the transmission and reception angles of adjacent radar beams for one in every 32 pulses .)

(Shimizu et al. 2009, Hirose et al. 2012).

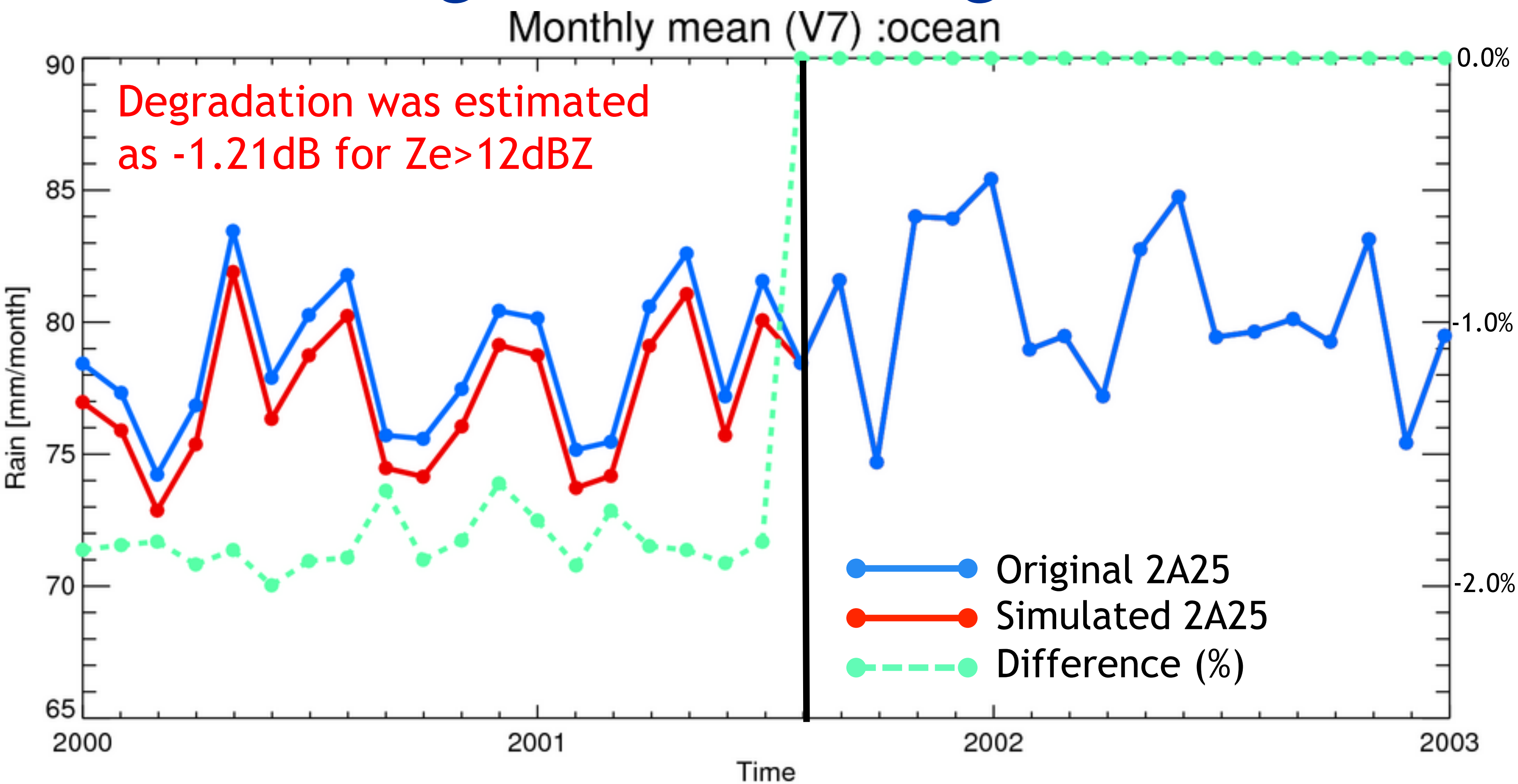
A reduction of discontinuity



The effects by an increase in the range of surface clutter and a beam mismatch are mitigated by use of the data at the inner swath.

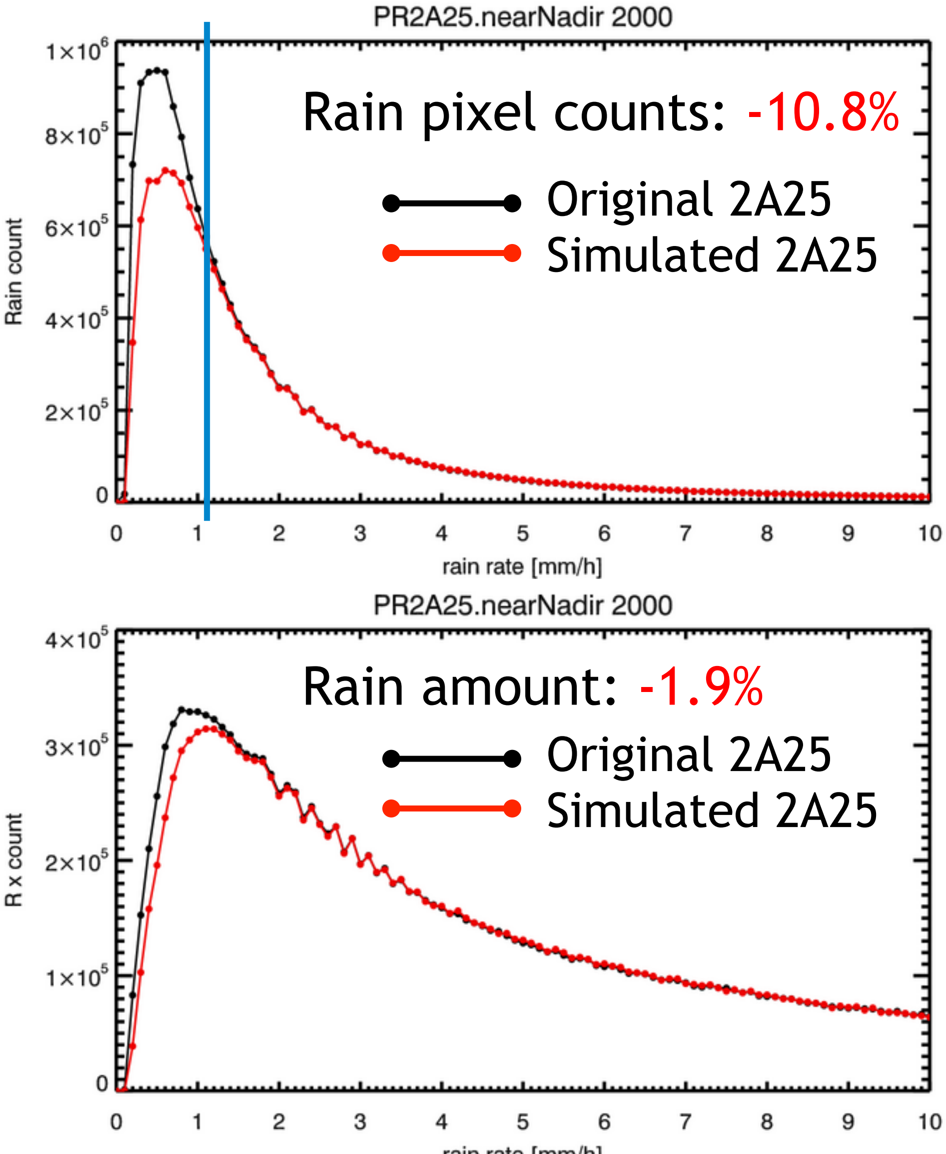
But the sensitivity degradation due to the altitude change must be separately simulated.

Time series of monthly rainfall including simulated degradation



Differences of the monthly rainfall amounts between original and simulated 2A25 are from -1.64% to -1.92%.

Histogram change against rainfall rate

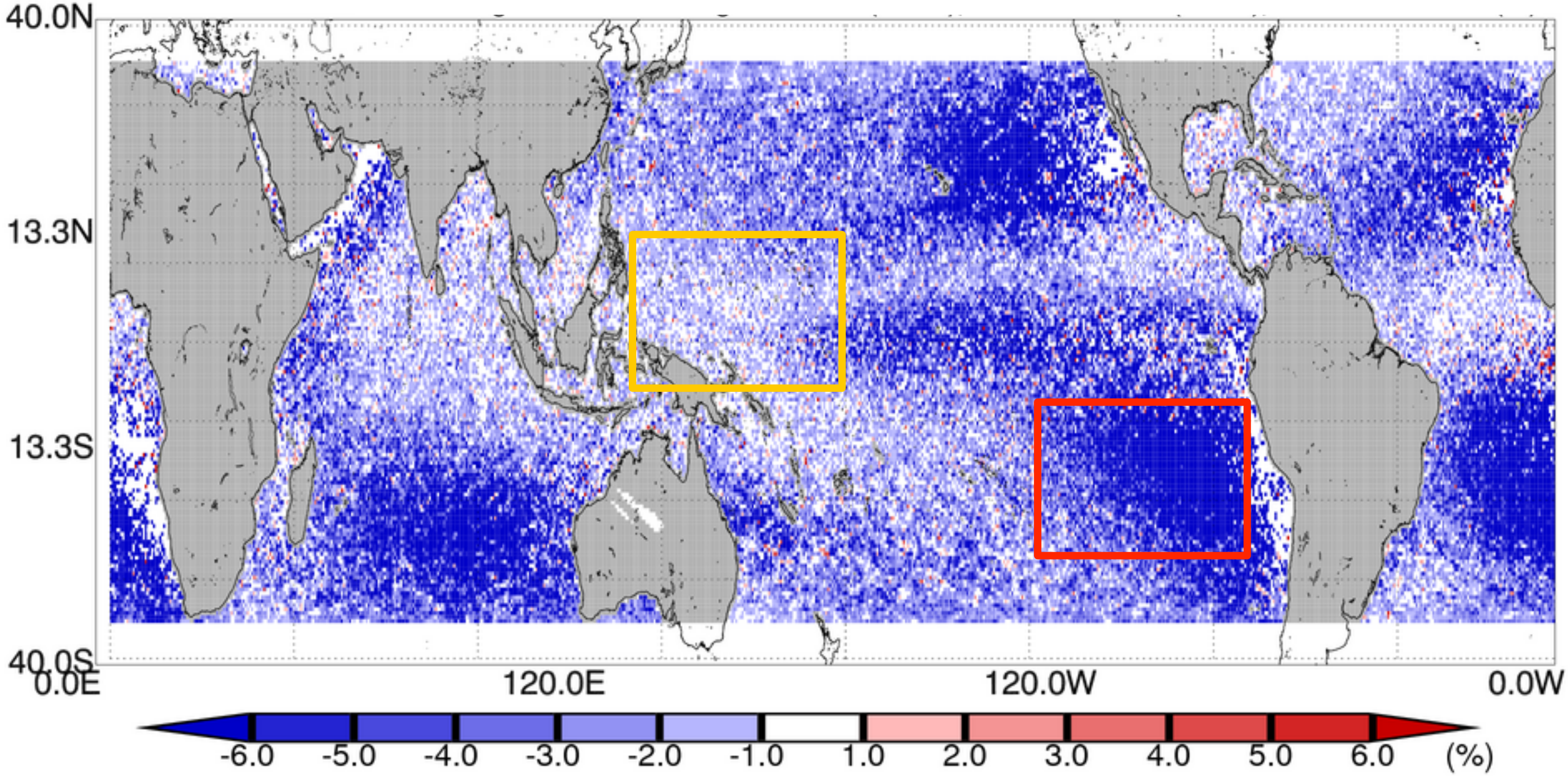


- Most of missing pixel are found in the rainfall rate < ~1 mm/h.

- Rainfall amount of simulated data decreases by ~1.9 %, while the number of the rain pixel decreases by ~10.8%.

Original 2A25	78.64 [mm/month]
Simulated 2A25	77.14 [mm/month]
Difference	-1.90 [%]

Percent Difference of rainfall amount



… shows consistent results as the histograms. In a weak rain region of the subtropical eastern Pacific, the difference is about -5.27% and in a heavier rain region of the western Pacific, it is -1.30%.

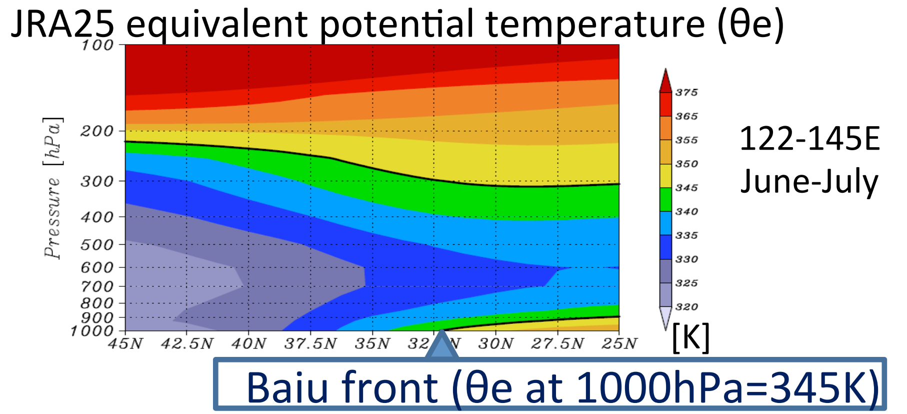
Visit Poster 131

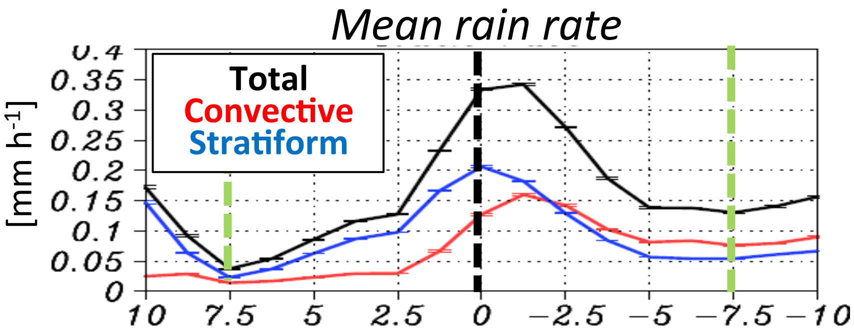
ANALYSES OF PRECIPITATION CHARACTERISTICS, EXTREME RAINFALL, CLASSIFICATION OF PRECIPITATION REGIMES

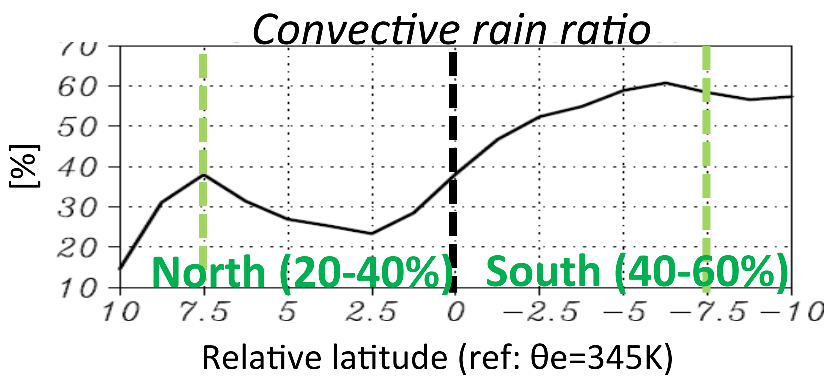
PI: YUKARI N. TAKAYABU
CHIE YOKOYAMA, SACHIE KANADA, ATSUSHI HAMADA

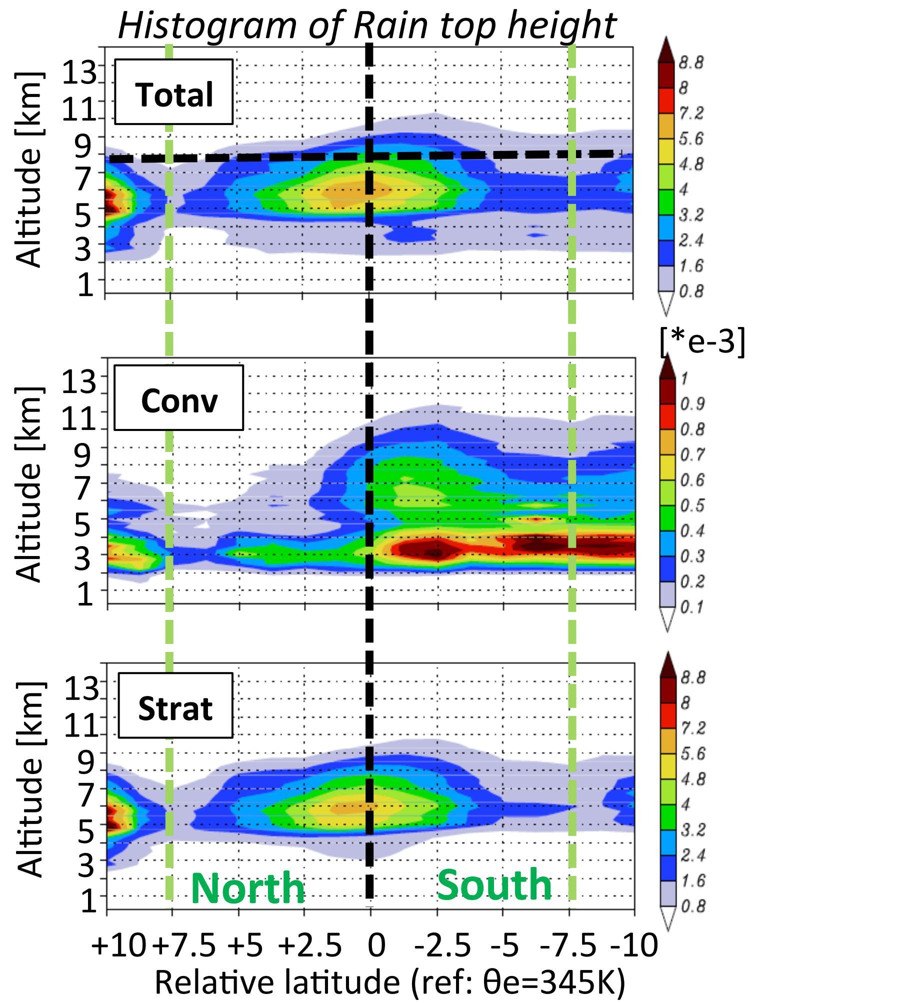
Contrast in PR-observed precipitation characteristics across the Baiu front

Yokoyama, Takayabu, Kanada, Poster 142





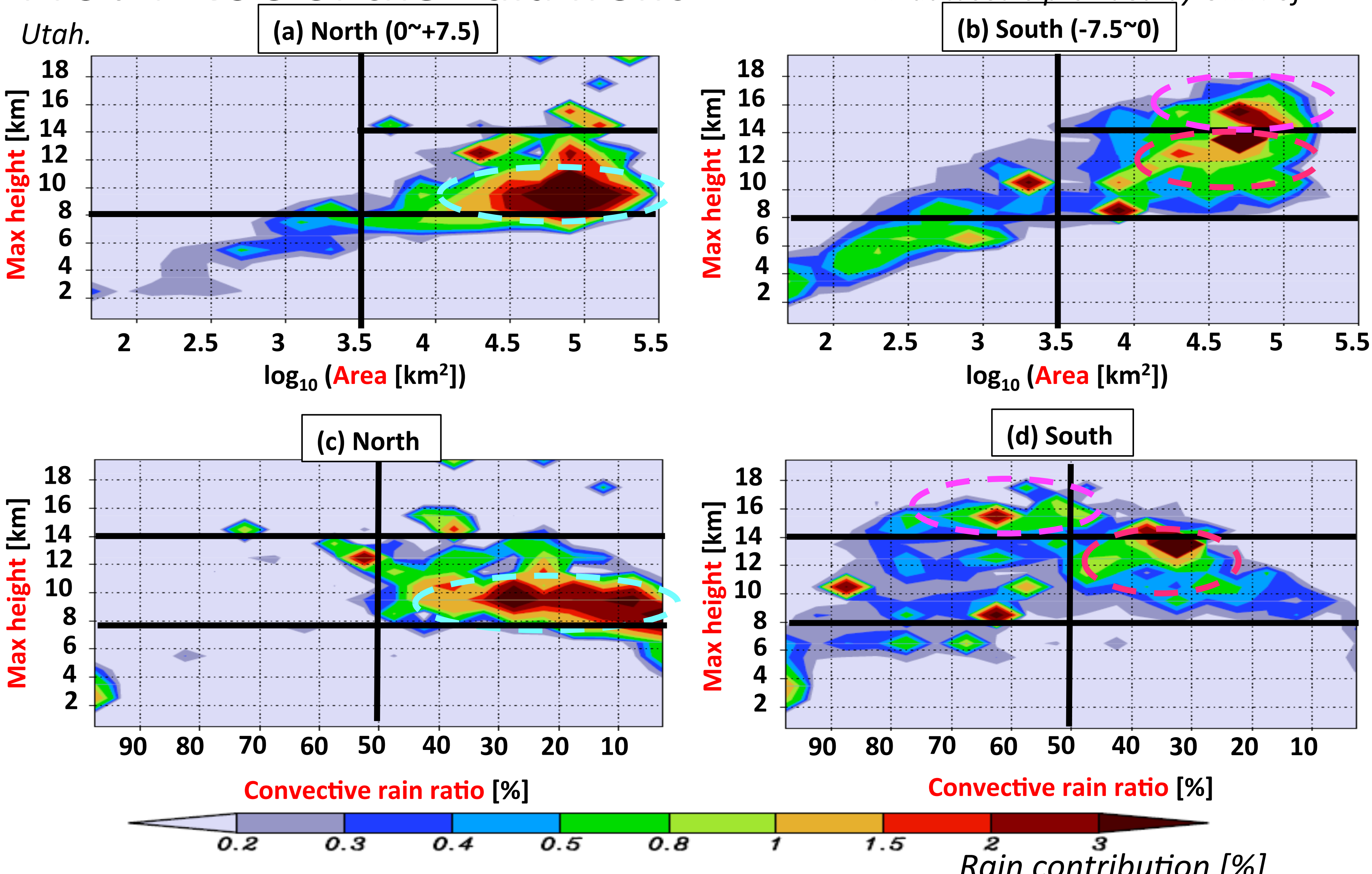




Precip characteristics are different between the south and north sides. Especially, significant differences are found for conv rain.

Rainfall contributions in Area-RTHmax and CRR-RTHmax PFs : N vs S of the Baiu front

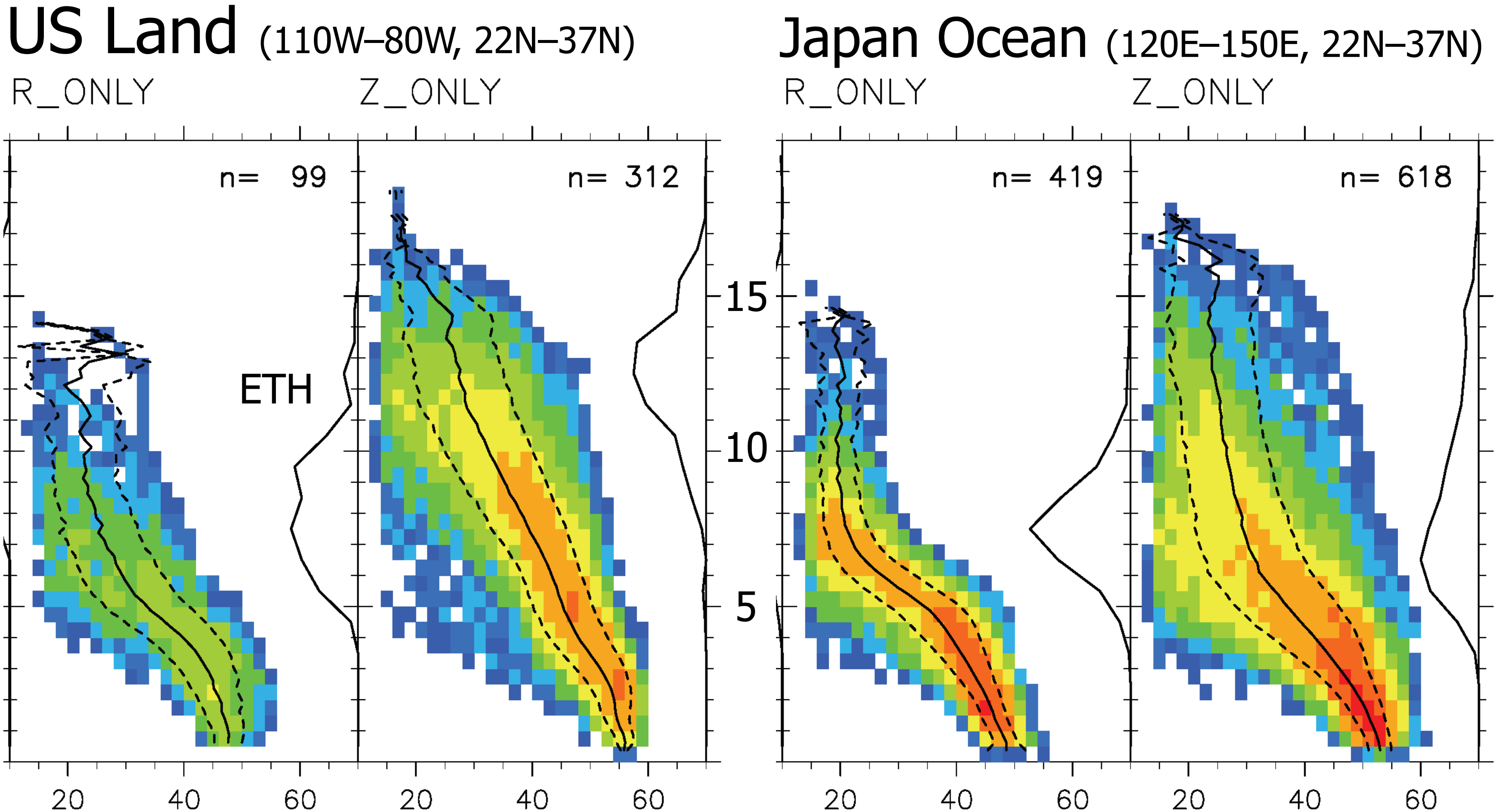
PF dataset is provided by Univ. of Utah.



The N/S contrast in precipitation regimes across the Baiu front comes from differences in characteristics of PFs that are dominant. Yokoyama et al. Poster

Extreme Rainfall: R-extreme vs Z-extreme

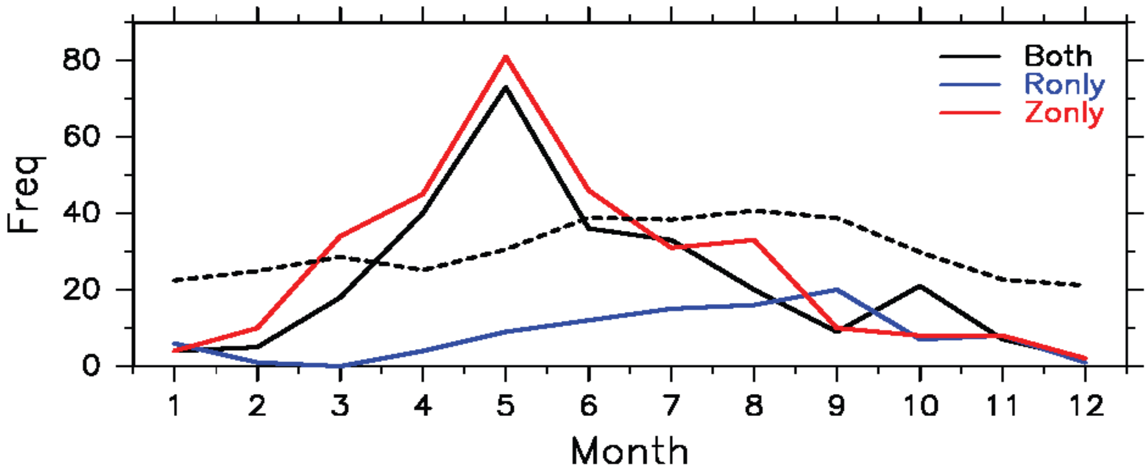
Hamada, Takayabu, Iguch
with Zipser and C. Liu



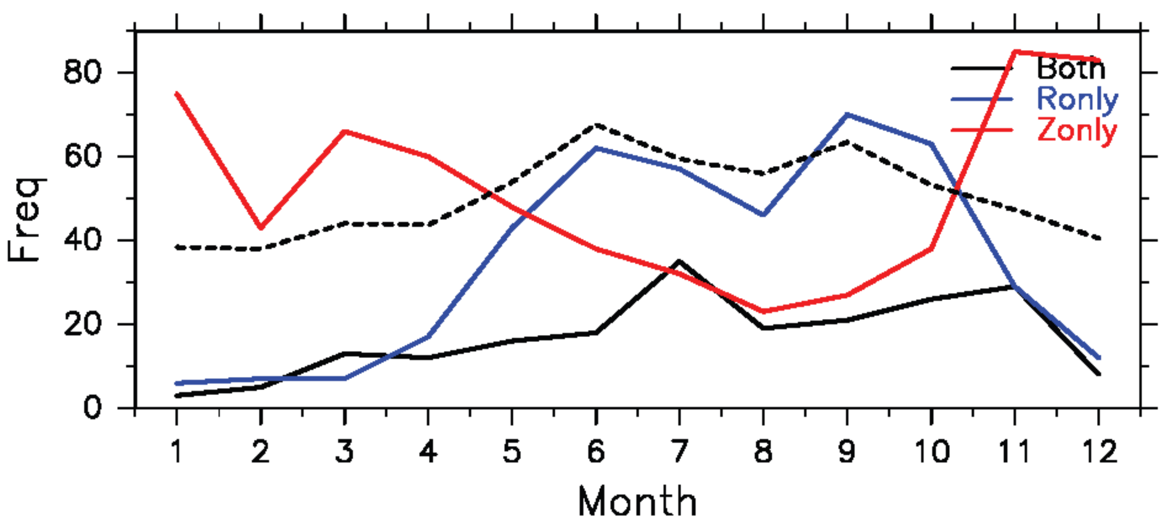
- Z-only extremes dominate in US Land, while similar numbers of R- and Z- are found in Japan Ocean. (cf. B.J. Sohn)
- Z-extreme echo-tops in JP reg are found at lower levels than R-extreme
- R-extreme structures are not significantly different

Seasonal variation, US-L region vs Japan-O region

US Land (110W–80W, 22N–37N)



Japan Ocean (120E–150E, 22N–37N)

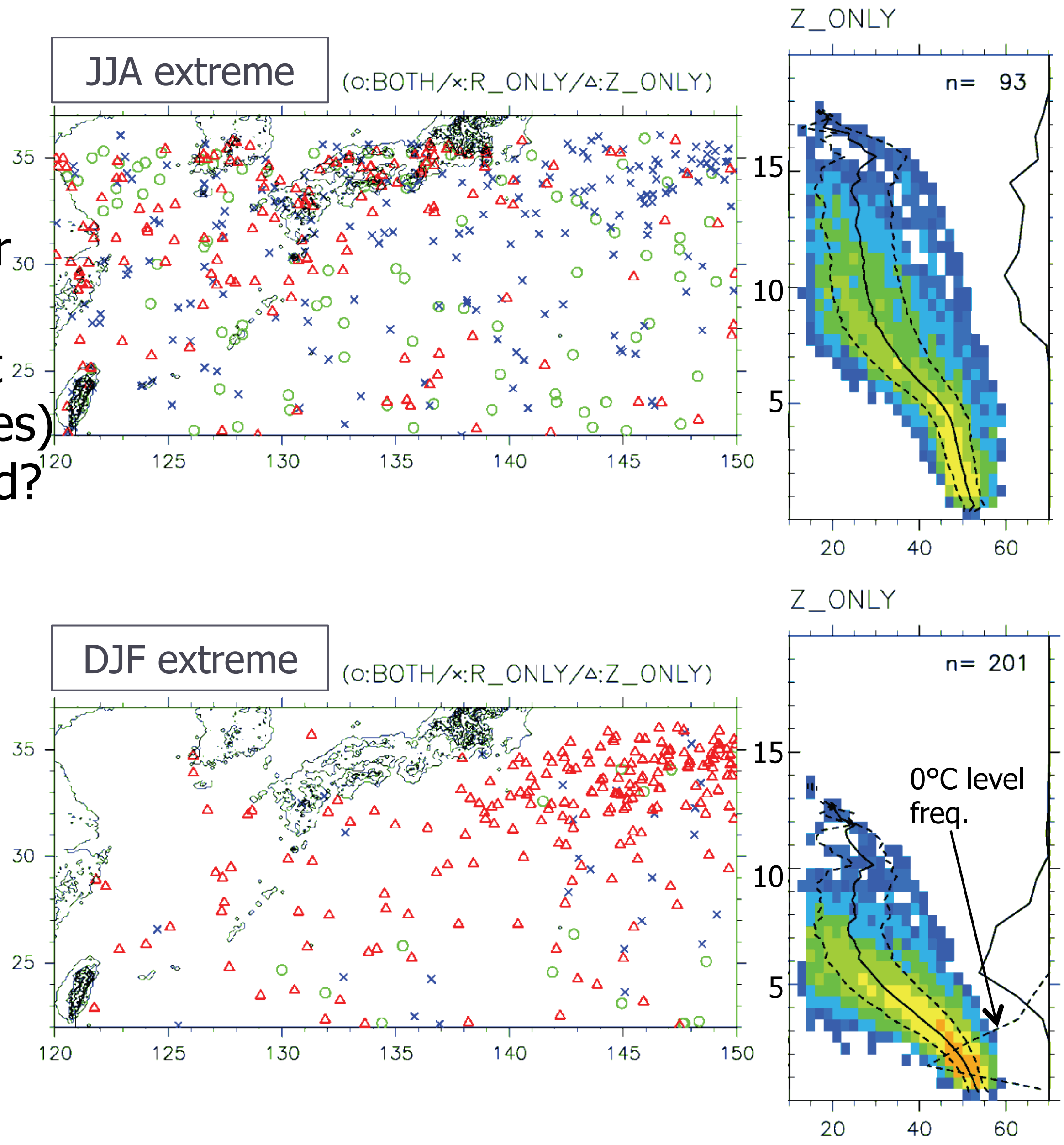


- Over US Land region, Z-extremes dominate in early summer
- Over Ocean region around Japan, Z-extremes dominate in mid-winter.

This is why Z-extremes in this region have lower ETH.

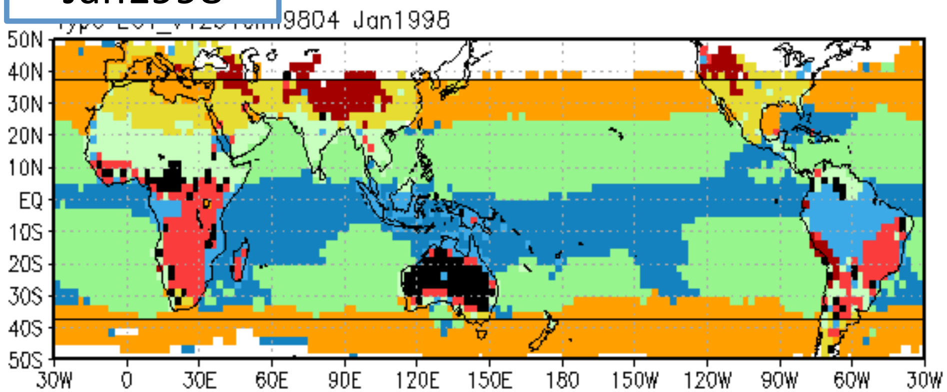
Extremes in storm track regions

- Z-extremes in storm track regions have distinctive characteristics
- More Z-extremes in winter
- Winter Z-extremes have much lower echo-top (but still higher than R-extremes)
- Low 0°C level; bright band?

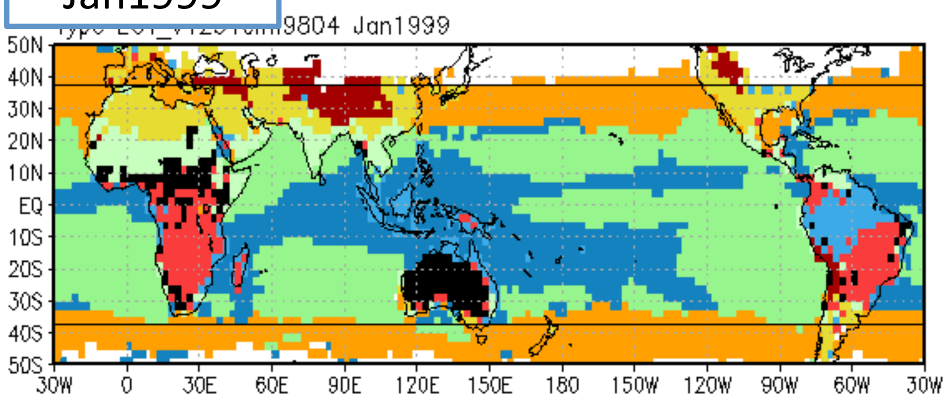


Classification of precipitation regimes with environmental variables

Jan1998



Jan1999



- 35N-35S oceans: utilizing SST, dp/dt 500hPa, v'T' 850hPa, and LTS, an LUT is produced from TRMM PR-based statistics.
- LUT trained with Jan.98-04 performed well with Possibility of Detection (POD) scores 60-90% for all seasons.
- Land: Precip. modestly reconstructed by 3-D LUT with env. Variables. But LUTs over land are highly dependent on the region. Needs more study.
- Mid-lat regime: transient disturbances and monsoon outflows are well separated with the ratio of high-freq/low-freq meridional heat fluxes (R:=|vT_{h850}/vT_{s850}|)

Hamada and Takayabu
(visit the poster 124)

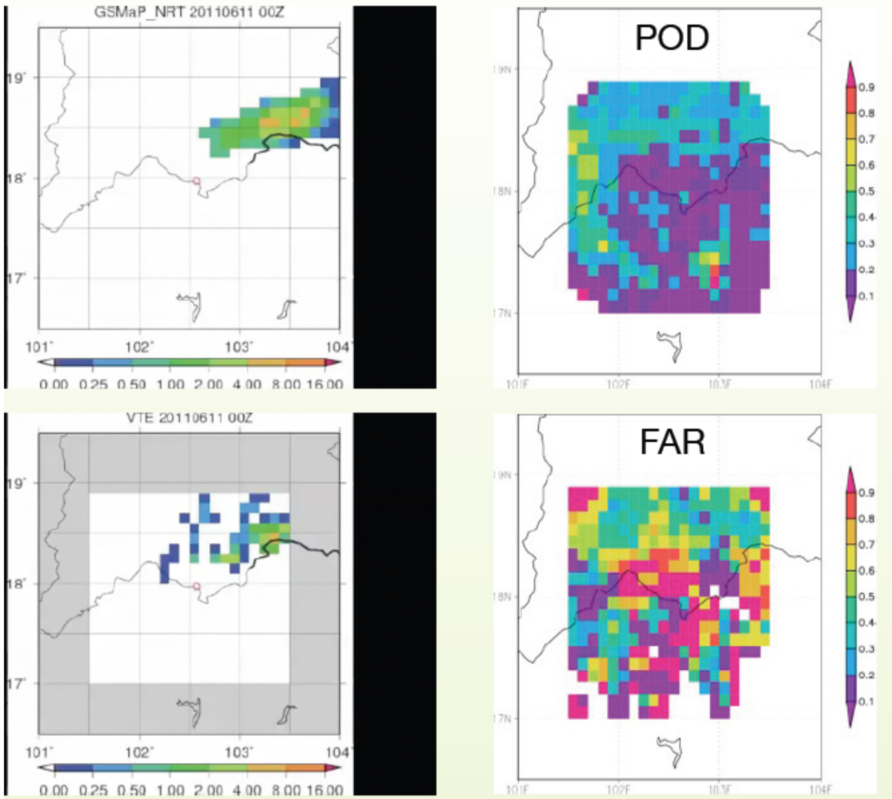
GSMAP VALIDATIONS AND APPLICATIONS

Combination of radar precipitation data with precipitation estimation by satellites in Lao

PI: T. Satomura (Kyoto Univ.)
CI: S. Shige, N. Nishi (Kyoto Univ.)
M. Katsumata (JAMSTEC)
S. Phonevilay, B. Sysouphanthavong (DMH, Lao)

1. Determination of a Z-R relation using disdrometer data installed at Phonghong about 60 km NNW to Vientiane
2. Compare rainfall derived by surface radar with GSMaP

Verification Scores (accumulated ge 0.25 mm h^{-1} for VTE)



- Verification scores (POD and FAR) become worse around radar site
  → VTE radar does not observe rain near the radar site
- GSMaP_NRT generally underestimates from VTE radar but largely depends on satellite pass

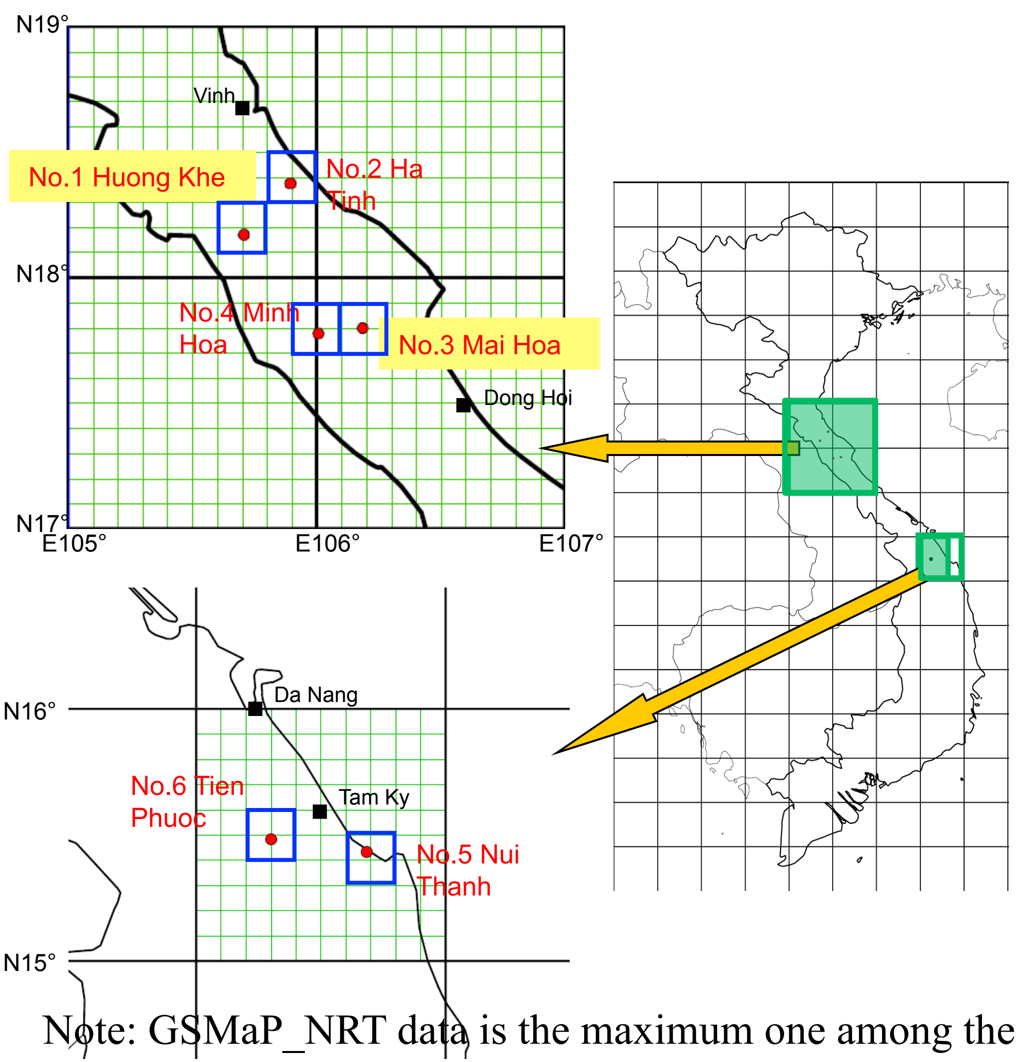
✓ More considerations for VTE radar data processing method and long-term comparisons should be needed.

Satomura, Shige et al. (Kyoto Univ.)

For Improvement of Global Flood Alert System

Correlations between ground-observed rainfall and GSMaP precipitation Case study in Vietnam

PI: Tatsuya Ikeda (IDI)



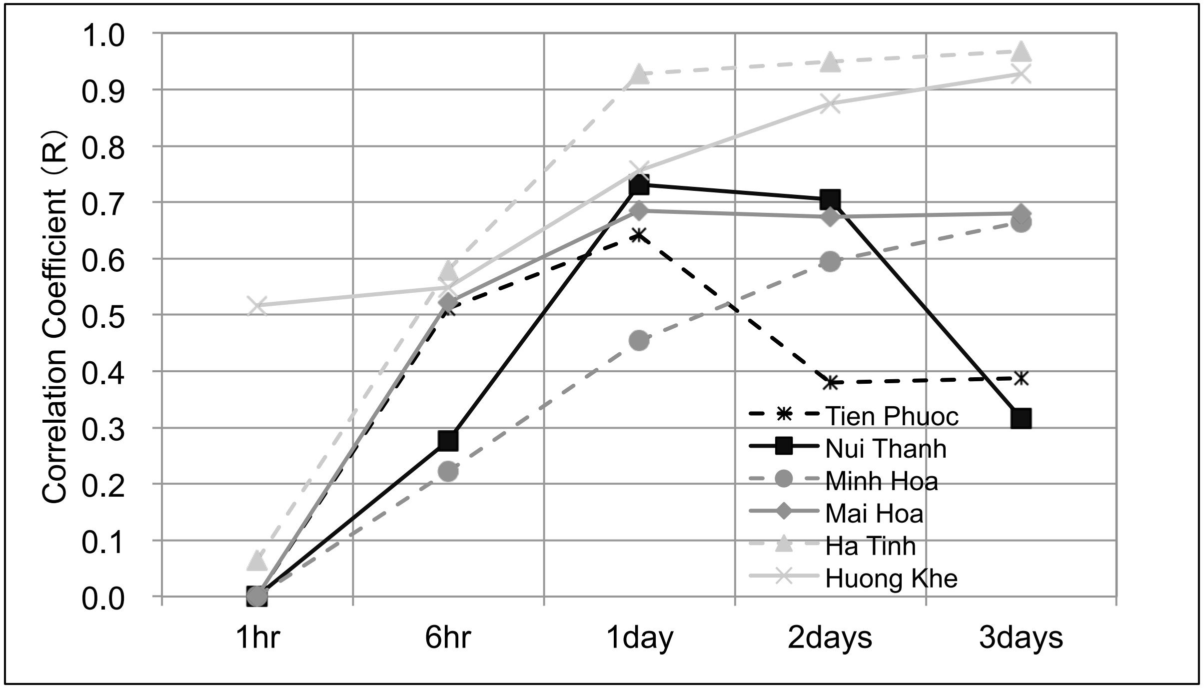
Rainfall/ Precipitation data for case study

(A) 2010/10/11-20
(B) 2011/10/12-17
(C) 2011/10/14-19
(D) 2011/11/4-9

Rain-gauge station	Rain data
No. 1 Huong Khe	(A), (B), (D)
No.2 Ha Tinh	(A), (B), (D)
No.3 Mai Hoa	(A), (B), (D)
No.4 Minh Hoa	(A), (B), (D)
No. 5 Nui Thanh	(C), (D)
No. 6 Tien Phuoc	(C), (D)

Note: GSMaP_NRT data is the maximum one among the four mesh data. (□)

Correlation dependency on timescales



- *The correlation coefficients of the long-period (2-days, 3-days) precipitation are higher at four stations with 2 years' data (2010-2011) compared to those of the short-period (1-hour, 6-hours).*
- *The coefficients of 3-days of Huong Khe and Ha Tinh exceed 0.9 (good correlation), but those of other four stations are not so high.*
- *Although these results need to further investigate, two stations with only 1 year's data (2011) show different behaviors from the other four*

Performance of the Global Satellite Mapping of Precipitation (GSMaP) data over Vietnam and a case study of its correction using artificial neutral networks
(To be submitted soon)

Thanh Ngo-Duc[1], Jun Matsumoto[2,3],

Hideyuki Kamimera[3], and Hiroshi Takahashi[2,3]

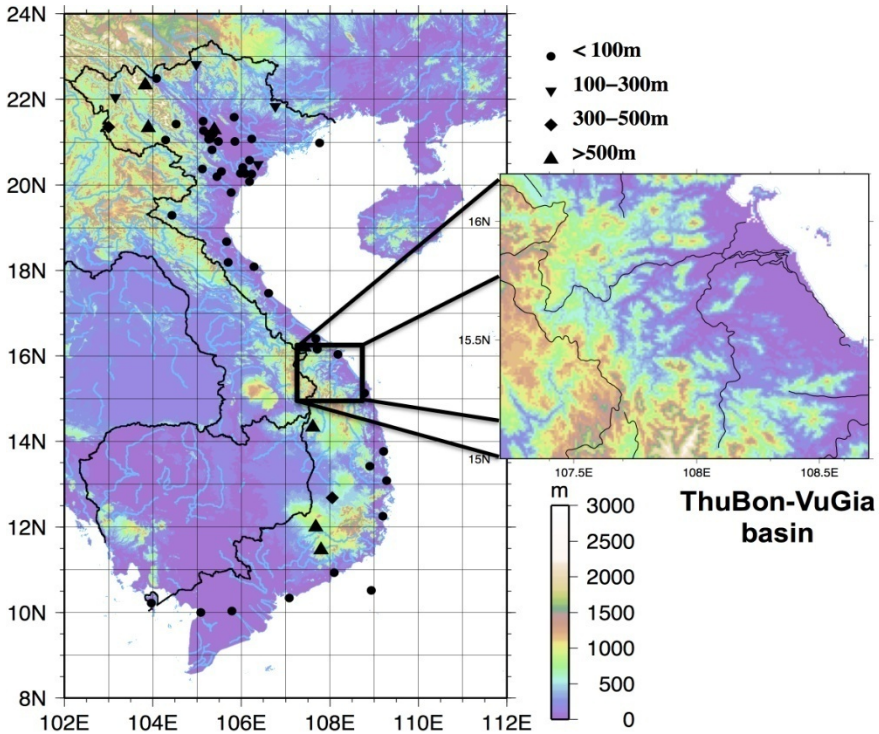
[1]Department of Meteorology, Hanoi University of Science

[2]Department of Geography, Tokyo Metropolitan University

[3]Research Institute for Global Change, JAMSTEC

[4] National Research Institute for Earth Science and Disaster Prevention

Data and method



- **GSMaP_MVK** data, version 5.222.1, available in August 2012 (8N-24N, 102E-112E)

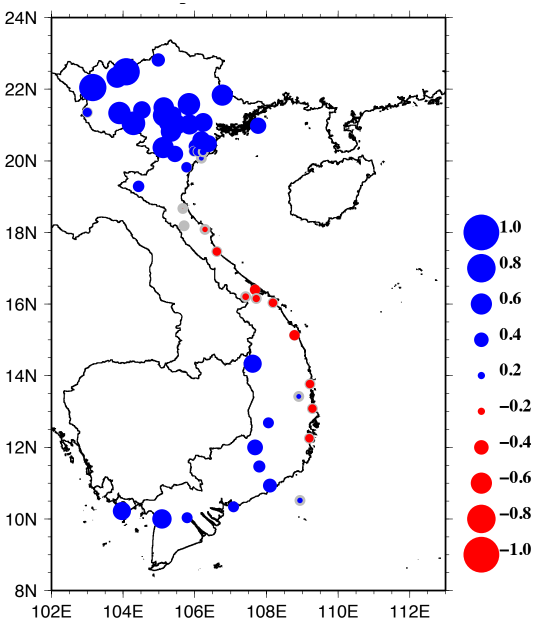
- **Daily rainfall** from 2001-2007 at 57 stations of Vietnam

- **APHRODITE** (Yatagai et al., 2009) V1003R1, 0.25º and covers the period of 1951-2007

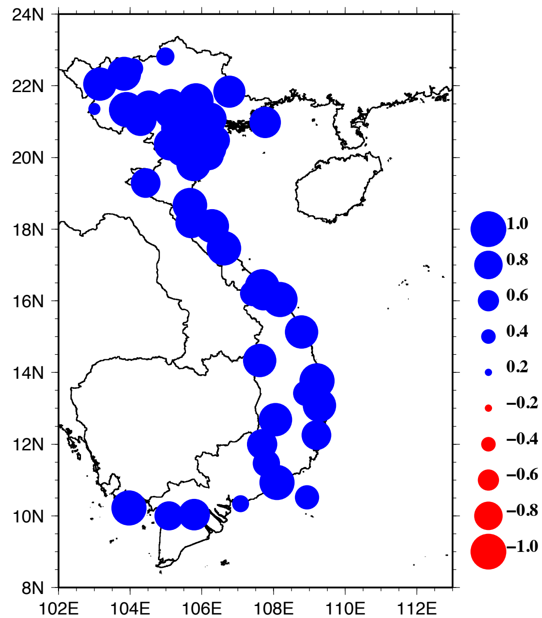
1. Examine the performance of GSMaP over Vietnam
2. Case study: GSMaP adjustment for the ThuBon-VuGia basin

Correlation of 2001-2007 monthly data

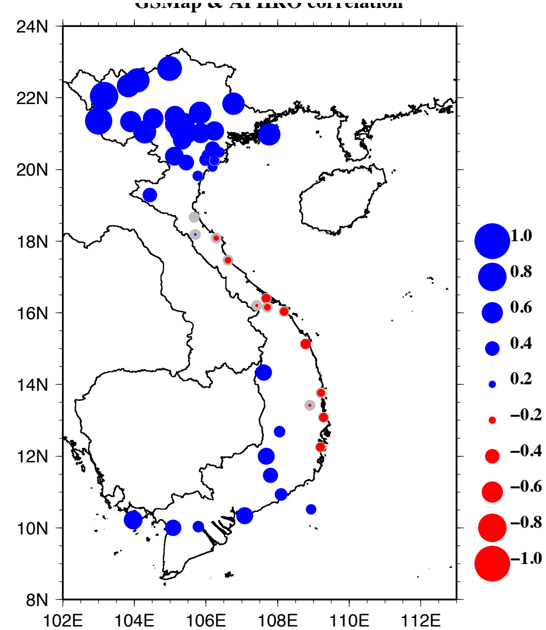
GSMaP & OBS



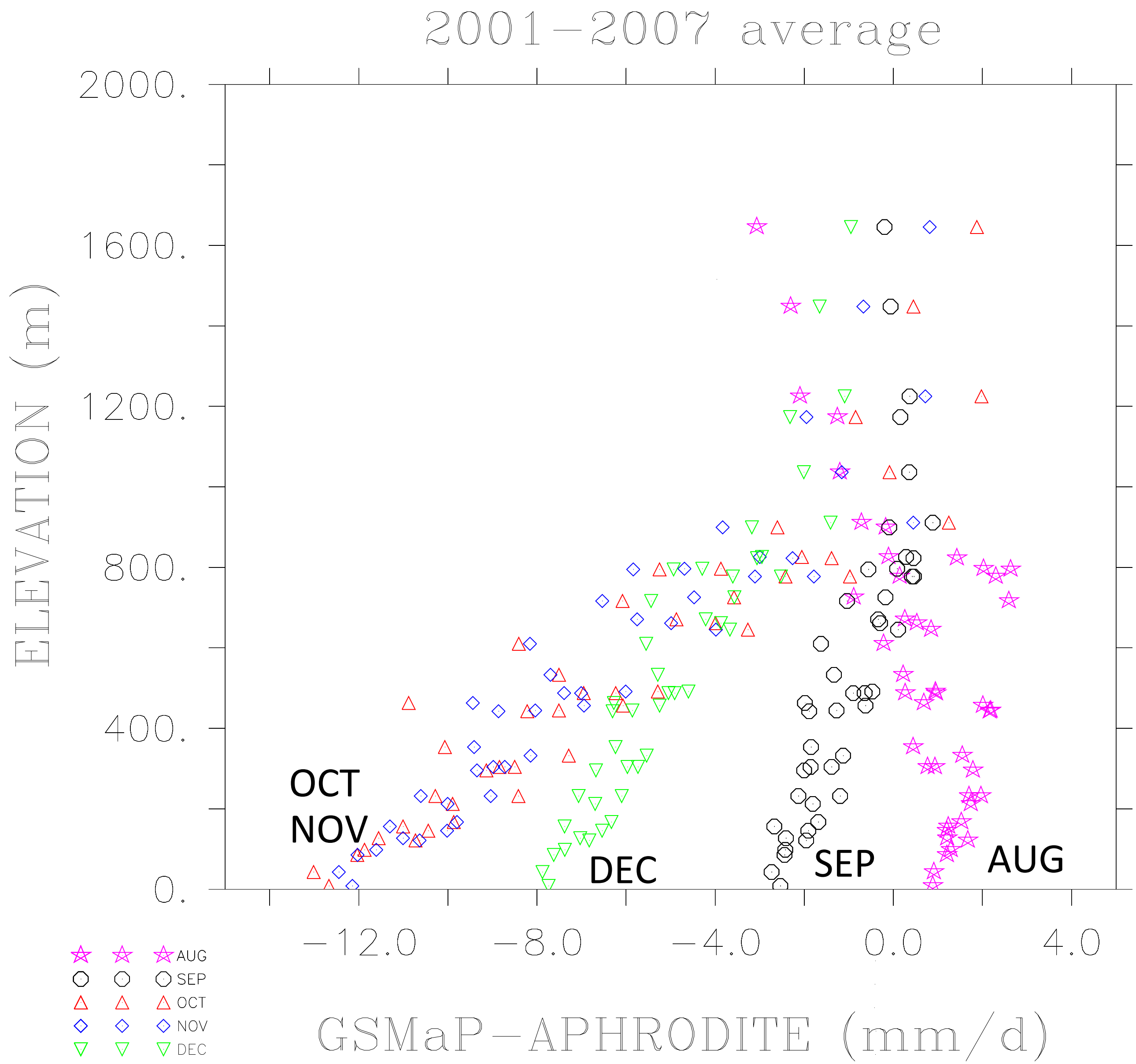
APHRO & OBS



GSMaP & APHRO



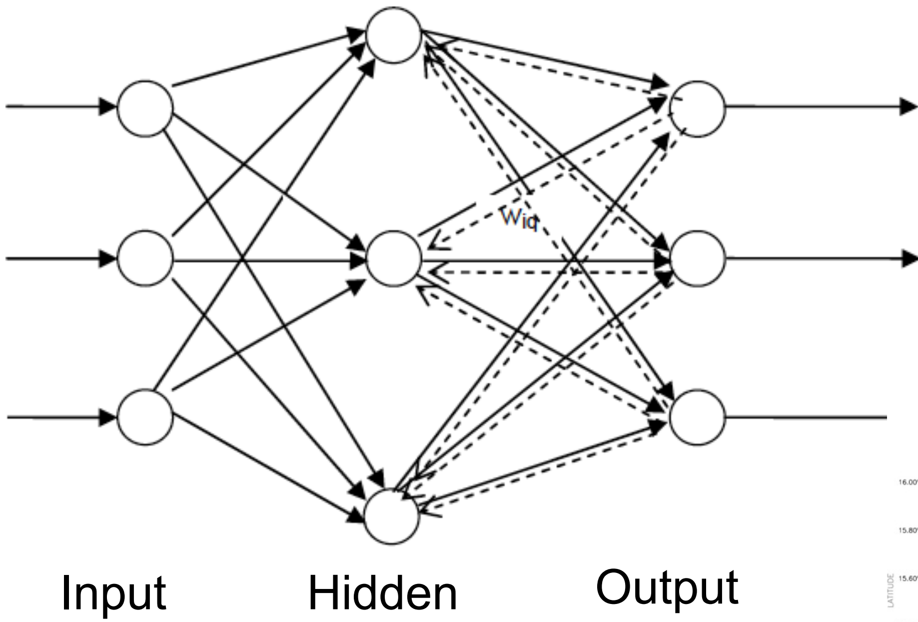
- low quality of GSMaP in the coastal zone of the Central Vietnam
- APHRODITE → considered as observations



- 2001-2007 differences between GSMaP and APHRODITE for different months from August to December versus the elevation over each grid point of the ThuBon-VuGia basin

Artificial Neutral Network (ANN) technique for GSMaP adjustment

- Feed-forward multi-layer structure
  1 input, 1 hidden, & 1 output layers

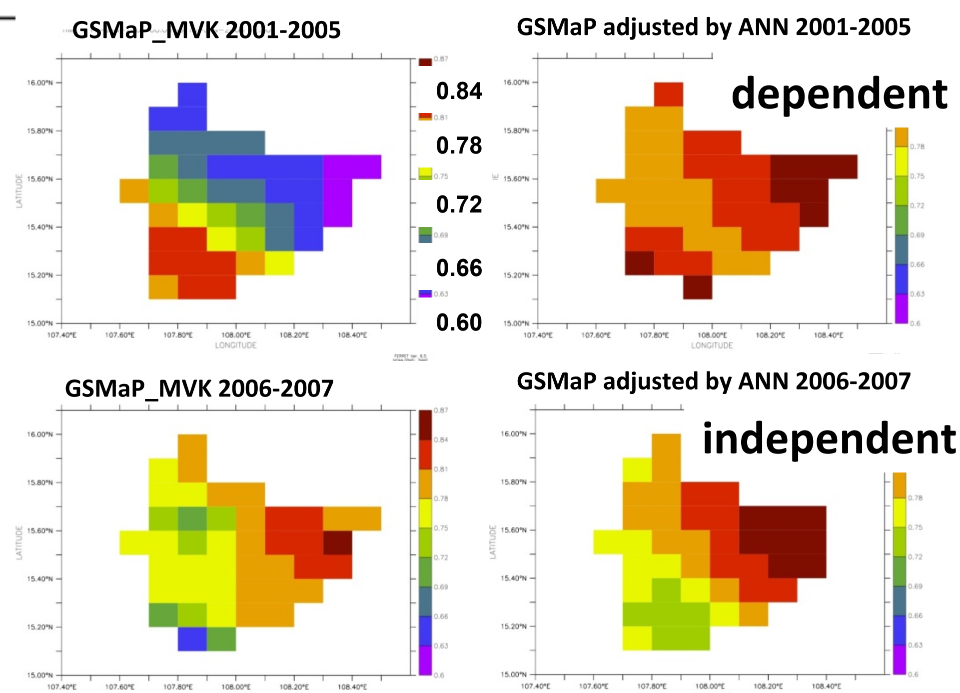


Monthly data, 44 points over the basin

Monthly data, 44 points over the basin

- Training period: 2001-2005
- Testing period: 2006-2007
- Weight coeffs are estimated for each month

Spatial correlation with APHRODITE monthly data over the ThuBon-VuGia basin

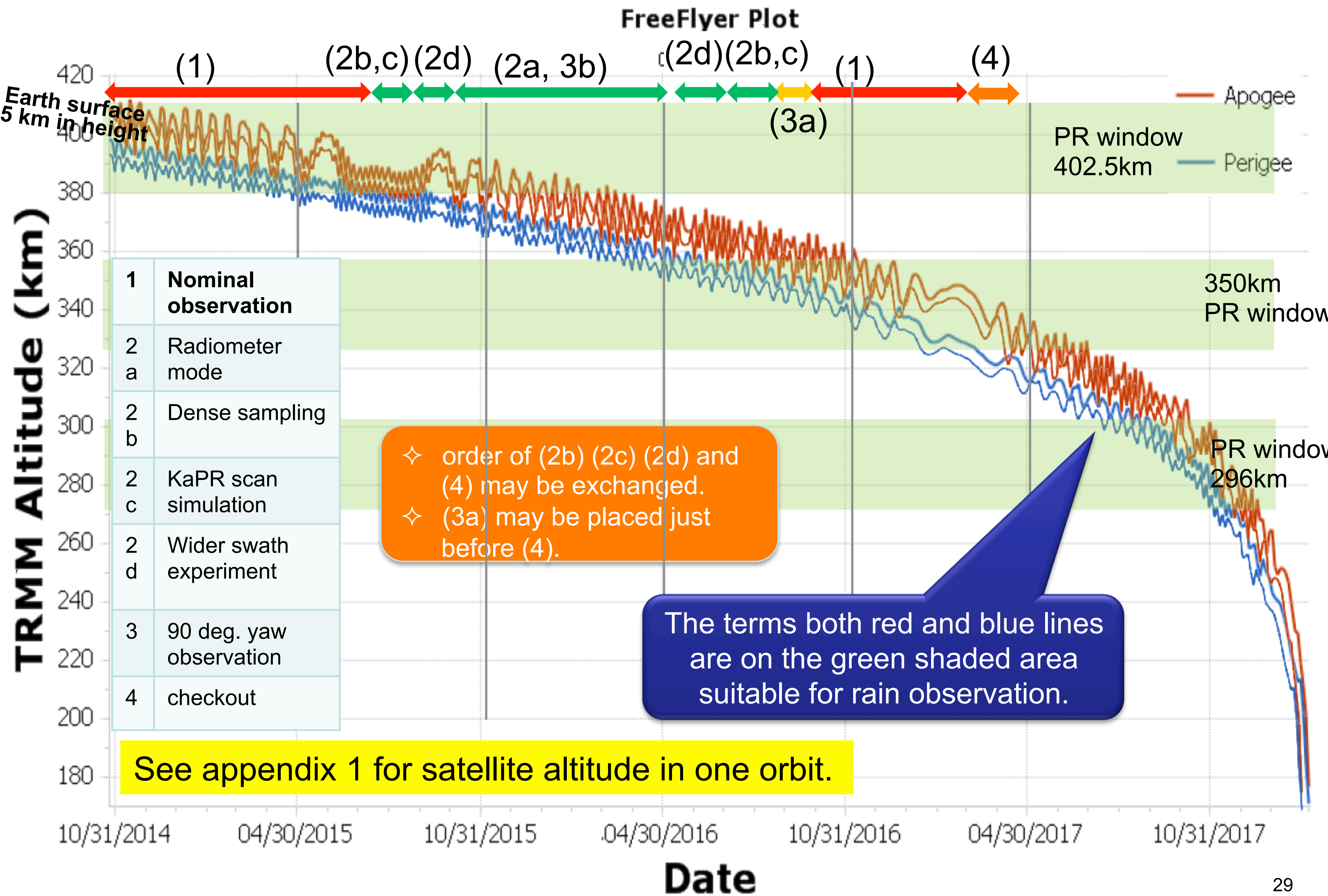


GSMaP vs APHRODITE correlation for independent period is improved →

A PROPOSAL OF TRMM EOM EXPERIMENTS

NOBU TAKAHASHI ET AL.

Satellite altitude and EoM experiment proposal



1	**Nominal observation**
2 a	Radiometer mode
2 b	Dense sampling
2 c	KaPR scan simulation
2 d	Wider swath experiment
3	90 deg. yaw observation
4	checkout

See appendix 1 for satellite altitude in one orbit.

TRMM PR algorithm improvements
Toshio Iguchi (NICT)

- PR L2 algorithm development (V7)
  - PI leads the PR algorithm development team:
    - NICT, JAXA, Awaka, Kozu, Seto, Meneghini
  - V7 algorithm was developed and products were released on July 2011.
- Improvement of PR algorithm
  - Evaluation of V7 products.
    - TRMM data users started using V7 data and some compared V7 with V6.
  - Preparation for V8

Evaluation of each items

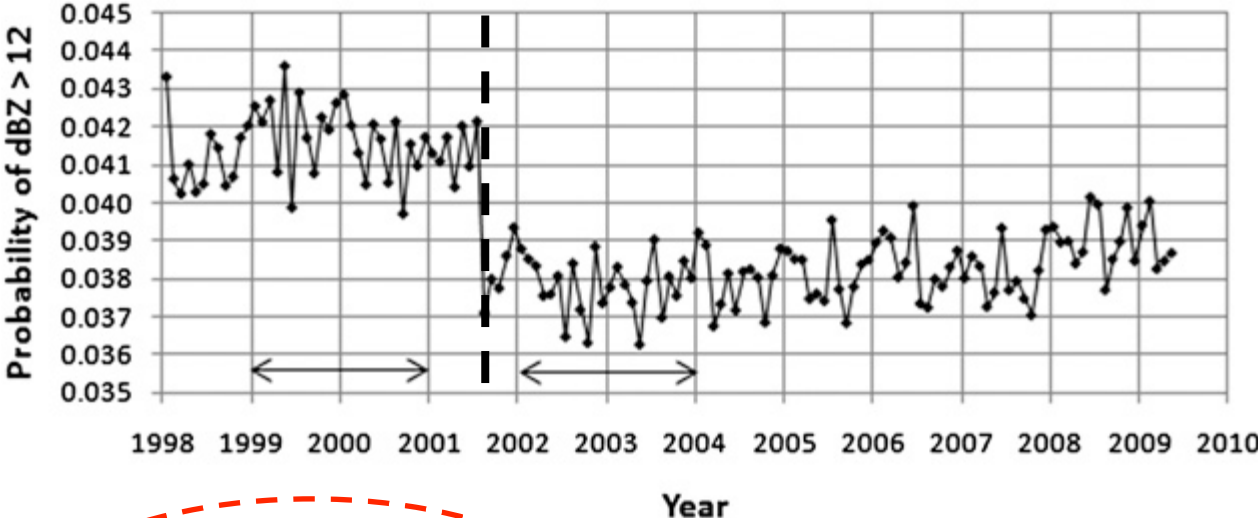
			purpose	operation	risks	note
Normal observation	1	Nominal observation	1.Comparison with GPM/ DPR. 2. Increase the rain record by radar. 3. Testing GSMaP.	Nominal observation	No risk.	Retrieved data may be valid until the radar observed up to 5 km in height.
Experimental observation	2 a	Radiometer mode	Use the PR as high resolution radiometer to compare with TMI.	Nominal obs. and RF off.	Medium risk on the RF on/off*.	During obs. window is out of the rain layer.
Experimental observation	2 b	Dense sampling	Increase the data on the non uniform beam filling effect.	External cal. mode	No risk. This mode is part of nominal obs. chain.	Need to have certain depth of rain layer.
Experimental observation	2 c	KaPR scan simulation	To obtain the reference data of KaPR scanning with Ku-band radar.	Nominal obs. Mode with modified phase code	Minor risk. Need to upload the phase data.*	Need to have certain depth of rain layer.
Experimental observation	2 d	Wider swath experiment	To check the possibility to enlarger the swath	External cal. mode or Nominal obs. Mode	Minor risk. Need to upload the phase data.	This mode is available when the obs. Window covers only near surface.
Experimental observation w/ modified satellite operation	3 a	90 deg. yaw observation	To obtain the detailed rain structure and sigma zero	Nominal obs. mode with satellite yaw angle of 90 deg.	Unknown risks for 90 deg. yaw operation.	Unknown impacts to other instruments (TMI, VIRS, LIS)
Experimental observation w/ modified satellite operation	3 b	Pitch maneuver	To obtain the clutter data against pitch angle.	Nominal obs. mode with pitch angle of 0.5 to 4 degrees w/ 0.5 deg. intervals.	Less risk to S/C. Negligible impact to TMI algorithm.	Useful for the antenna design of spaceborne radar
Engineering experiment	4	checkout	To obtain the engineering information of PR	Various modes	Unknown risk.	Need to limit the checkout items to avoid risks.

*: This mode was tried and succeeded in the previous experiment.

Rating of each items

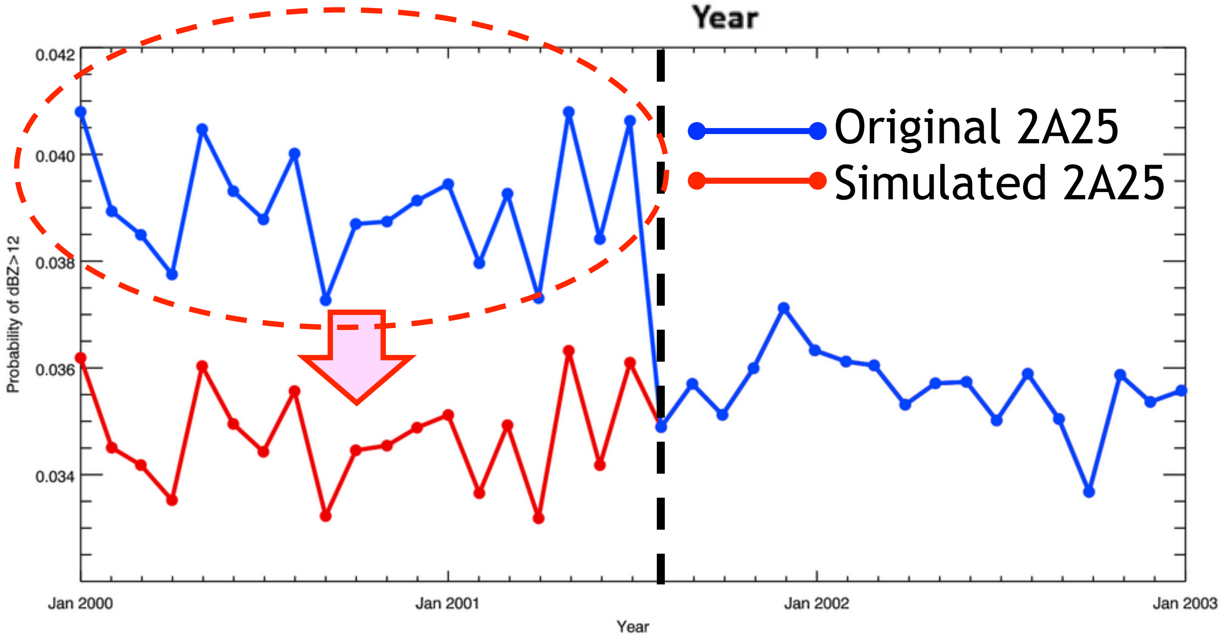
		purpose (scientific significance)	operation (duration)	impact to S/C and instruments (risks)	note	Priority
1	Nominal observation	1.Comparison with GPM/DPR. 2. Increase the rain record by radar. 3. Testing GSMaP. **(High)**	Nominal observation (As long as the obs. window covers surface to 5km)	No risk. **(Low)**	Retrieved data may be valid until the radar observed up to 5 km in height.	**1**
2 a	Radiometer mode	Use the PR as high resolution radiometer to compare with TMI. **(Medium)**	Nominal observation and RF off. (see note)	Medium risk on the RF on/off. (Medium)	During obs. window is out of the rain layer.	**3**
2 b	Dense sampling	Increase the data on the non uniform beam filling effect for DPR L2. **(High)**	External cal. mode (10 days)	No risk. This mode is part of nominal obs. chain. **(Low)**	Need to have certain depth of rain layer.	**1**
2 c	KaPR scan simulation	To obtain the reference data of KaPR scanning with Ku-band radar. **(Medium)**	Nominal obs. Mode with modified phase code. (10 days)	Minor risk. Need to upload the phase data. **(Low)**	Need to have certain depth of rain layer.	**2**
2 d	Wider swath experiment	To check the possibility to enlarger the swath for future radar design.**(High)**	External cal. mode or Nominal obs. Mode (10 days)	Medium risk. Need to upload the phase data. **(Medium)**	This mode is available when the window is out of the rain layer.	**2**
3 a	90 deg. yaw observation	To obtain the detailed rain structure and sigma zero **(High)**	Nominal obs. mode with satellite yaw angle of 90 deg. (total 10 days)	Unknown risks for 90 deg. yaw operation for S/C. **(High)**	Unknown impacts to other instruments (TMI, VIRS, LIS)	**3**
3 b	Pitch maneuver	To obtain the clutter data against pitch angle. **(Medium)**	Nominal obs. mode with pitch angle of 0.5 to 4 degrees w/ 0.5 deg. intervals. (minimum 2 days)	Less risk to S/C. Negligible impact to TMI algorithm. **(Low)**	Useful for the antenna design of spaceborne radar	**2**
4	checkout	To obtain the engineering information of PR. **(Low)**	Various modes (1 -2 weeks)	Unknown risk. **(Medium to High)**	Need to limit the checkout items to avoid risks. (implement at the end of the PR experiments)	**4**

Area-weighted probability of path-averaged dBZ>12



Monthly time series of the probability of path-averaged reflectivity greater than 12 dBZ from 3A25.

(as shown in Short and Nakamura, 2010)



The time series of the simulated 2A25 reduce discontinuity before and after the orbit boost.

Case study on Japanese river basins

Study areas

No.	Name of the river	Basin area (km2)	Stations	Upper basin area (km2)
No. 1	Shinano River	11,900	Ojiya	9,719
			Tategahana	6,442
No. 2	Yoshino River	3,750	Iwazu	2,710
			Ikeda	1,940

Target floods for the Shinano River

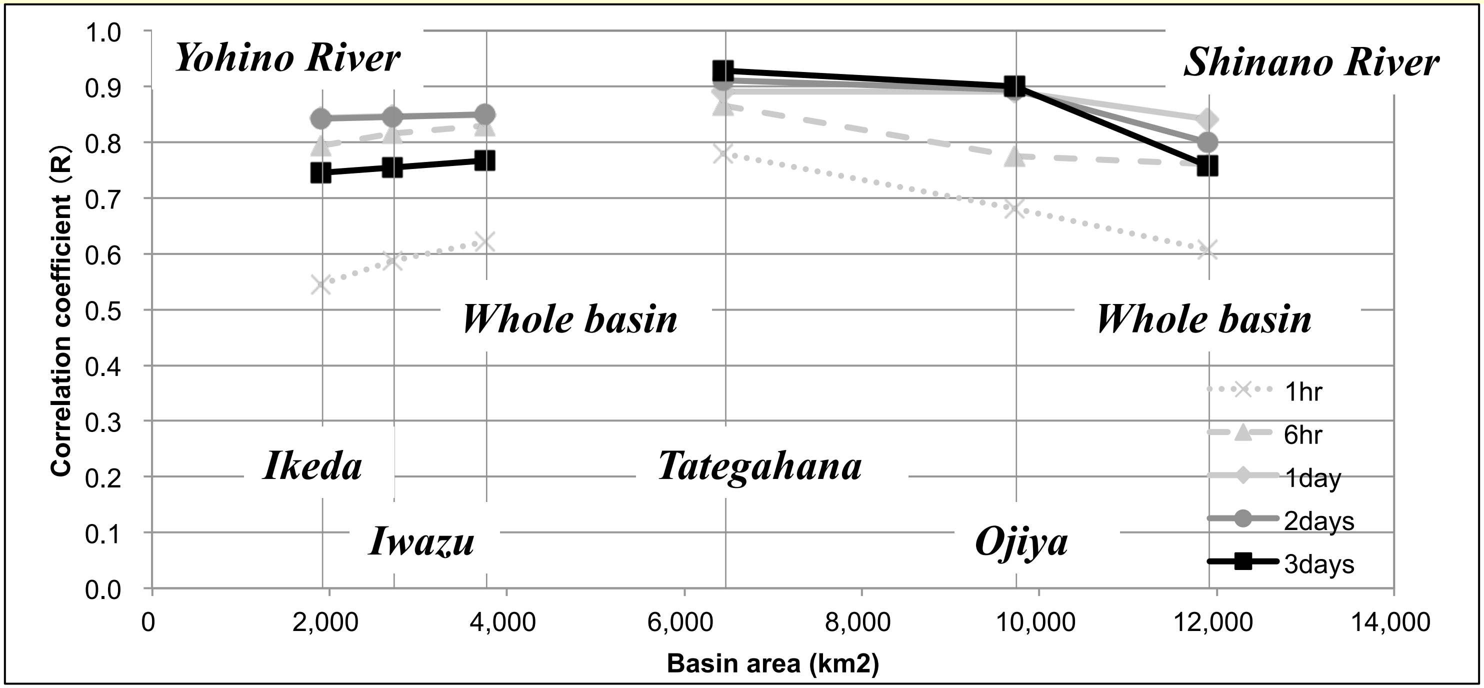
	Water level (m)	**Causes**
2011/07/30	49.09	Rain front
2006/07/20	48.60	Rain front
2004/10/21	47.93	Typhoon
2005/06/28	46.77	Rain front
2004/07/17	45.77	Rain front

Target floods for the Yoshino River

	Water level (m)	**Causes**
2004/10/20	7.18	Typhoon
2004/08/31	6.72	Typhoon
2005/09/07	6.49	Typhoon
2011/09/21	6.09	Typhoon
2010/06/26	4.53	Rain front

Five biggest floods in these 10 years were selected for case study.

Result of comparisons <2/2>

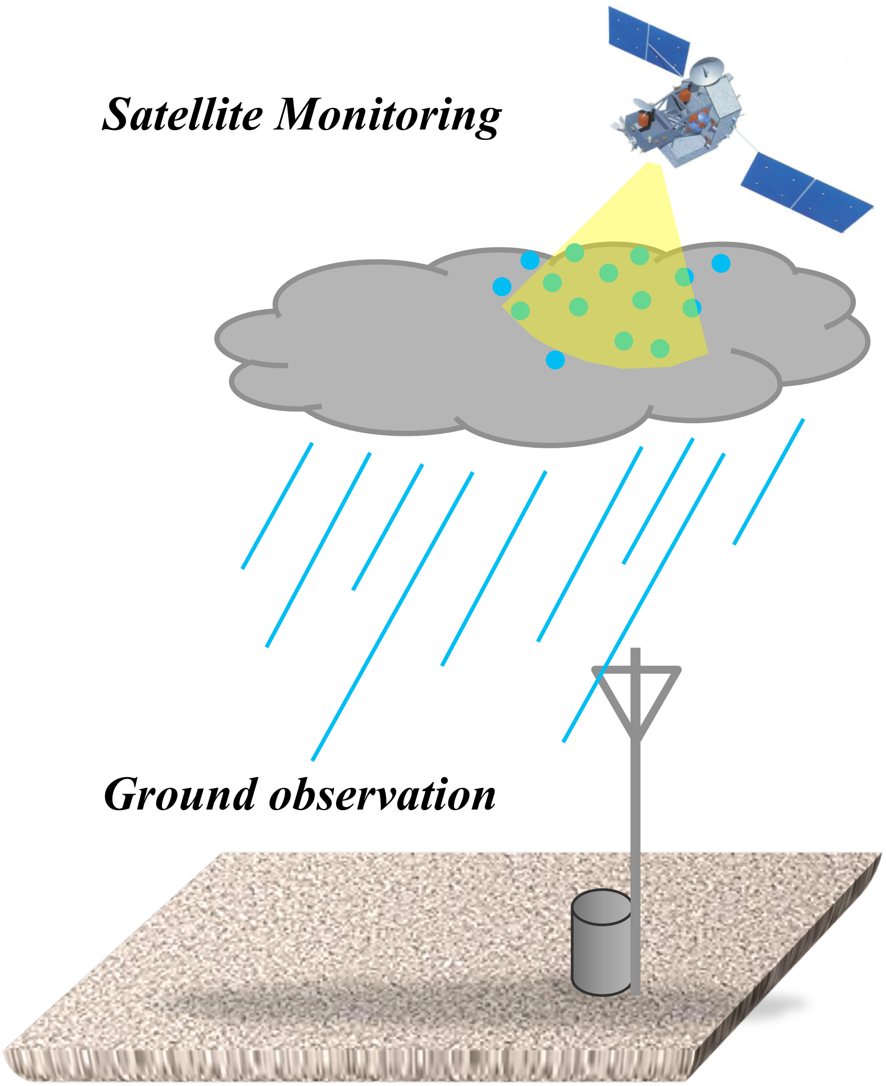


- *The* ***correlation coefficients of long-period (1~3-days) precipitation are higher*** *than those of short-period (1~6-hours), as is the same with Vietnam.*
- ***Any significant difference cannot be seen*** *in the correlation coefficients between different causes of flood and different river basin areas.*
- *The correlation coefficients of the Shinano river is relatively higher than those of the Yoshino river. But in the case of the Shinano river,* ***the correlation coefficient of the whole basin is not so high compared to those of Tategahana and Ojiya****.*

2. Study on correlation between ground-observed rainfall and satellite-monitoring precipitation

(2) Case study on Japanese river basins

Objective of case study



In order to estimate ground rainfall, correlation between ground observed rainfall data and satellite monitoring precipitation data has been studied both at the station level and at the river basin level.

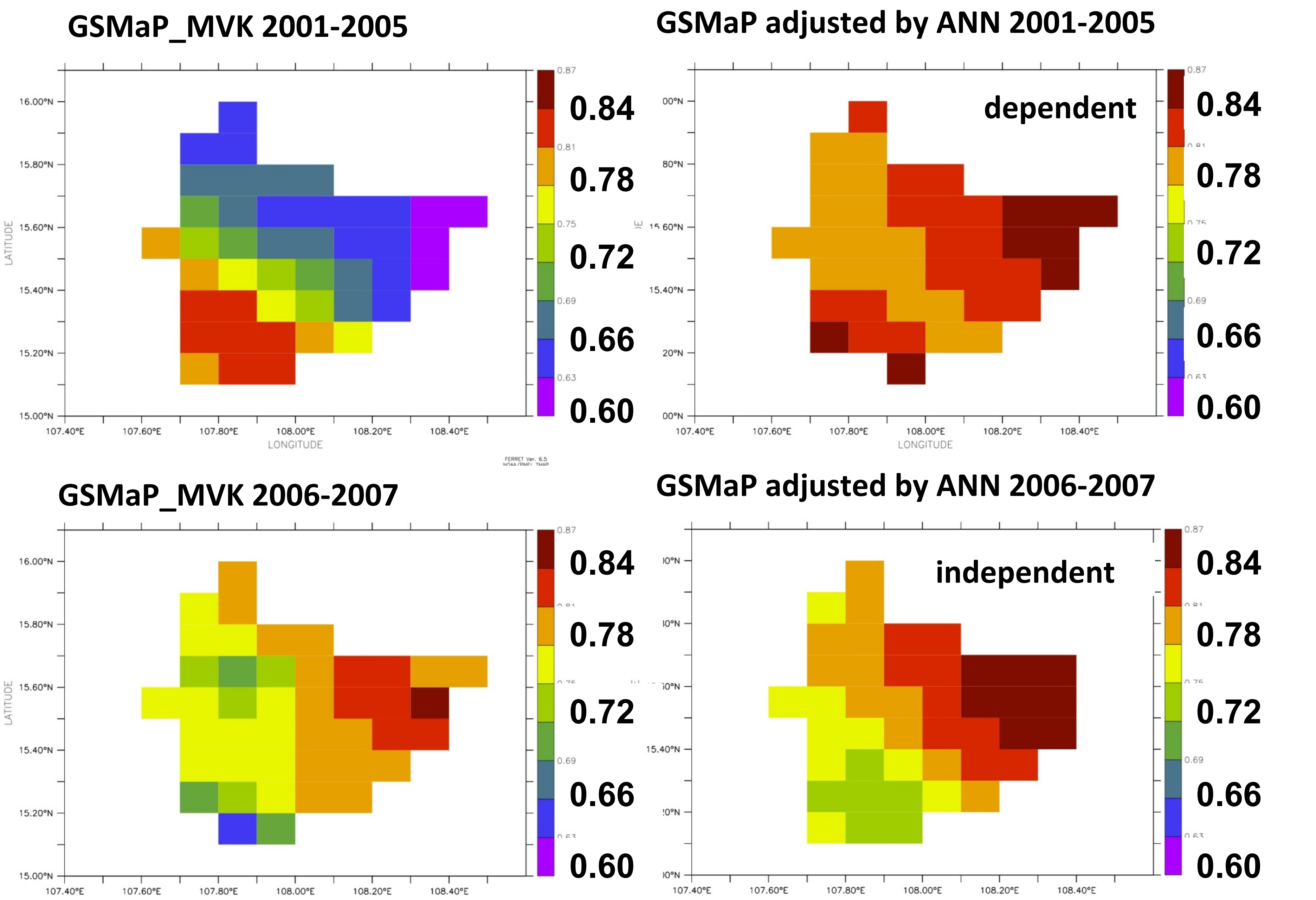
- 本研究は詳細な陸面過程(土壌水分等)の状態を推定することによって、全球気候
- モデルにおける大気陸面相互作用の改善および
- 水文気象予測精度の向上を図ることを目的としております。

- 陸面状態は直接衛星観測がされるようになりましたが、長期間の安定したデータ
- は乏しい現状です。
- また北米のオガララ帯水層やインダス川、黄河流域などでは地下水の汲み上げが
- 灌漑活動に与える影響は大きく、結果として表層の土壌水分量は影 響を受けます。
- しかし、地球規模で地下水の汲み上げ量データは先進国においても時空間スケー
- ルで高解像度の情報はなかなか存在しません。
- 発展途上国では全く情報がつかめない状況です。
- そのため、人工衛星による降水データを灌漑等の人間活動を考慮した陸面過程モ
- デルに適用することで、表層水では足りない水資源は
- 地下から補われていると考えらえれ、最終的に各流域の地下水くみ上げ量が推定
- されます。
- この地下水くみ上げ量は全球気候モデル内でグリッドごとに与えられ、その結果
- として人間活動の影響を考慮した地球水循環が再現できるように なったという
- 研究です。

- 本研究は人工衛星による降水情報の特徴を直接議論するものではありませんが、
- 今後GPMによって高緯度まで降水データが得られると、現在よりも広範囲かつ高
- い時空間スケールで流域ごとの地下水利用を含む水循環の扱いが
- 可能になるというメッセージをもったものです。

Conclusions and future works

- Clouds and rainfall activity is different between autumn (October, November) and winter (December to February) in Vietnam, even in both seasons it is affected by northeast monsoon.
- Comparisons of TRMM-PR, TRMM-3B42, and GSMaP revealed rainfall amount of TRMM-3B42 and GSMaP data, in particular, in coastal and central mountainous regions seemed to be not accurate.
- ANN technique for adjusting GSMaP before using for hydrological purposes over the regions will be promising when applying these data in Central Vietnam, but need more effort for operational use.
- In future, correction method for the whole Vietnam in various time-scales will be considered ,and river discharge validation will also be applied for preparing operational use.



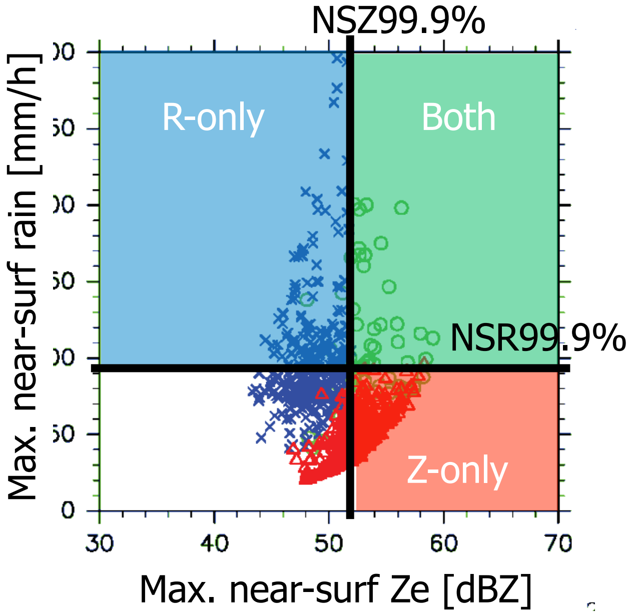
Spatial correlation with APHRODITE monthly data over the ThuBon-VuGia basin

Different characteristics between extreme events defined by surface rain rate and reflectivity

Atsushi Hamada, Yukari N. Takayabu, and Toshio Iguchi

Definition of extreme events

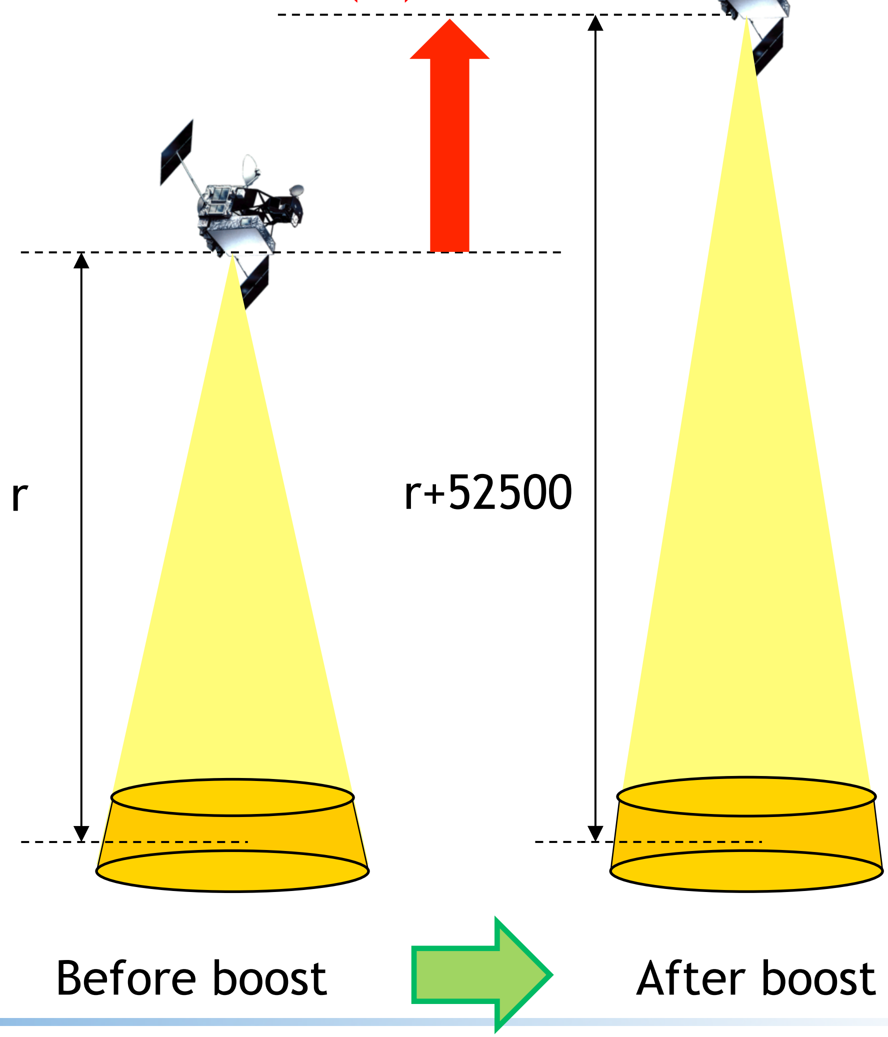
- Construct a rain-area database
  - Rain area: A contiguous pixels of 2A25 surface rain rate > 0.5mm/h
  - Location: Location at which max. surface rain observed in the rain area
- Definition of extreme event
  - Determined on each 2.5° x 2.5° grid cell: "Regional extreme"
  - Rain areas with max. surface rain rate of uppermost 0.1% in the grid where the rain area located
  - Extreme events for near-surface Z_e are also determined in the same way
- Categorize extreme events
  - R (Z)-only extreme: Only max. surface rain (near surf Z) exceeding threshold values
  - Note: Rain type (conv/strat) is not considered since more than 90% are convective
- Data: PR 2A25 version 6, 1998-2008



TRMM Tropical Rainfall Measuring Mission

The simulation of a degradation

After the boost, the altitude increases in 52500(m).



Radar equation

$$P_r(r) = \frac{C|K|^2}{r^2} Z_m$$

If a distance of a target is changed from *r* m to *r+52500* m, a degradation of the radar sensitivity ΔP:

$$\Delta P = [P_r(r+52500)] - [P_r(r)]$$

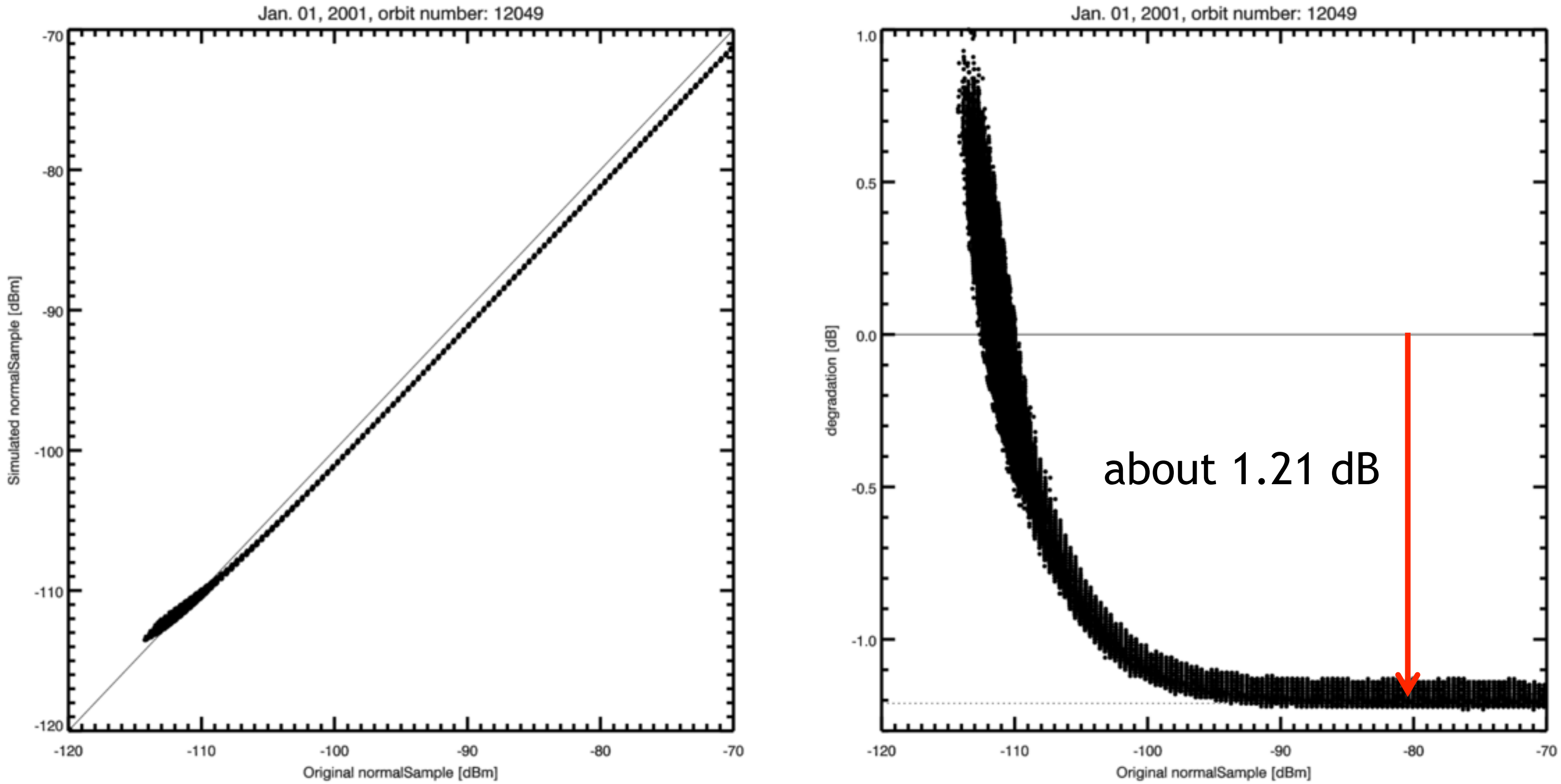
$$= [r^2] - [(r+52500)^2]$$

$$= 20\log_{10}\left(\frac{r}{r+52500}\right)$$

where P_r is a received power.

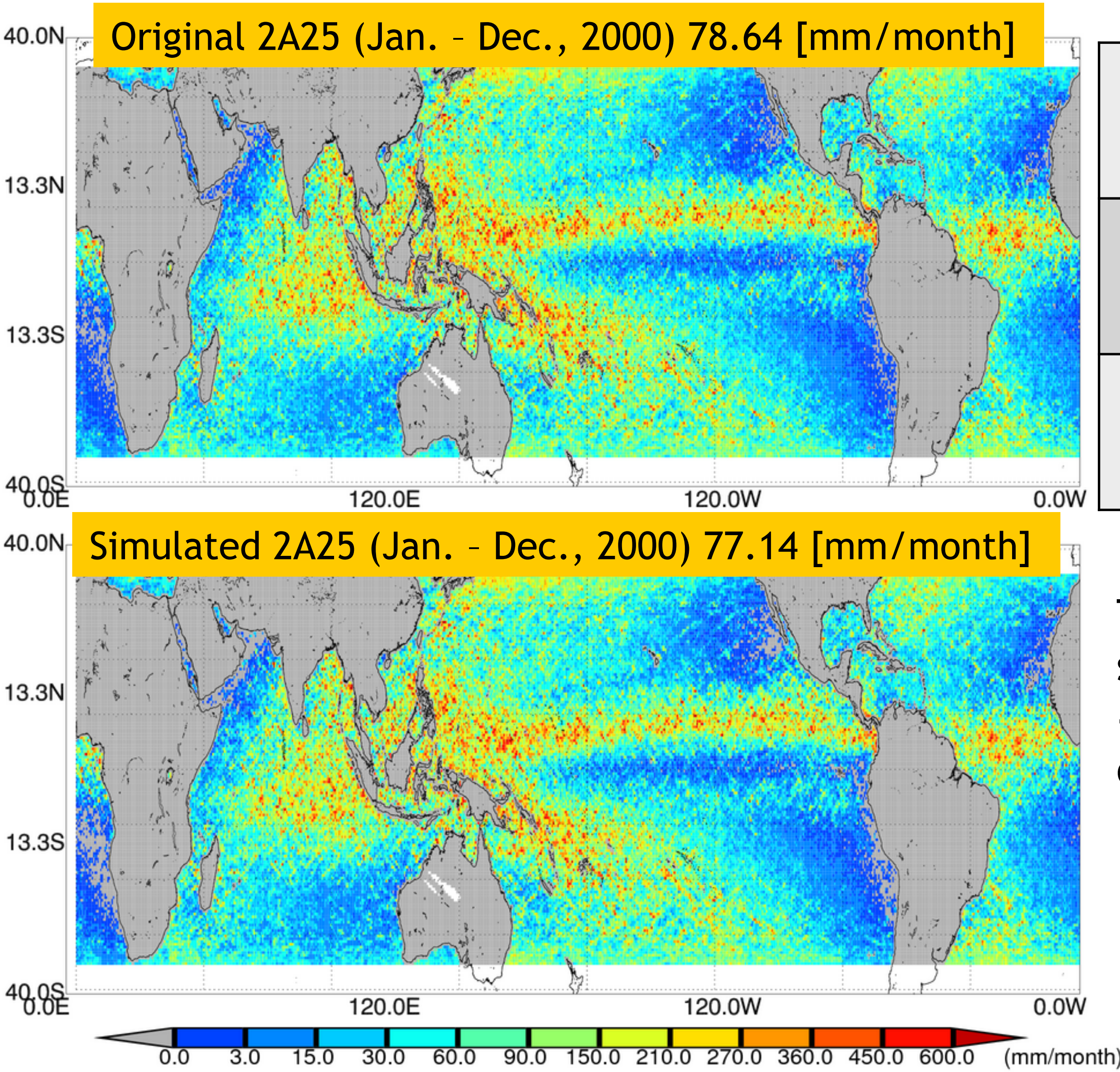
(cf. if r=350000 [m], ΔP ≒-1.21 [dB])

Comparison of original and simulated 1B21 products



Left panel shows a scatter plot of normalSample (received power) between original and simulated 1B21 in one granule data (Jan. 1st, 2001, orbit number 12049). Right panel shows the difference of normalSample. The simulated received power decreases about 1.21 dB.

Difference of rainfall amount

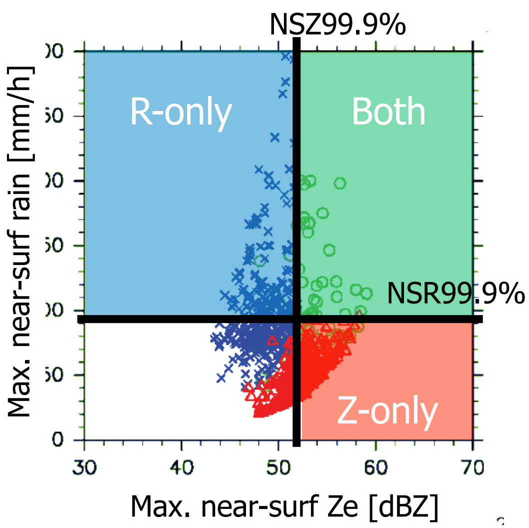


Original 2A25	**78.64 [mm/month]**
Simulated 2A25	**77.14 [mm/month]**
Difference	**-1.90 [%]**

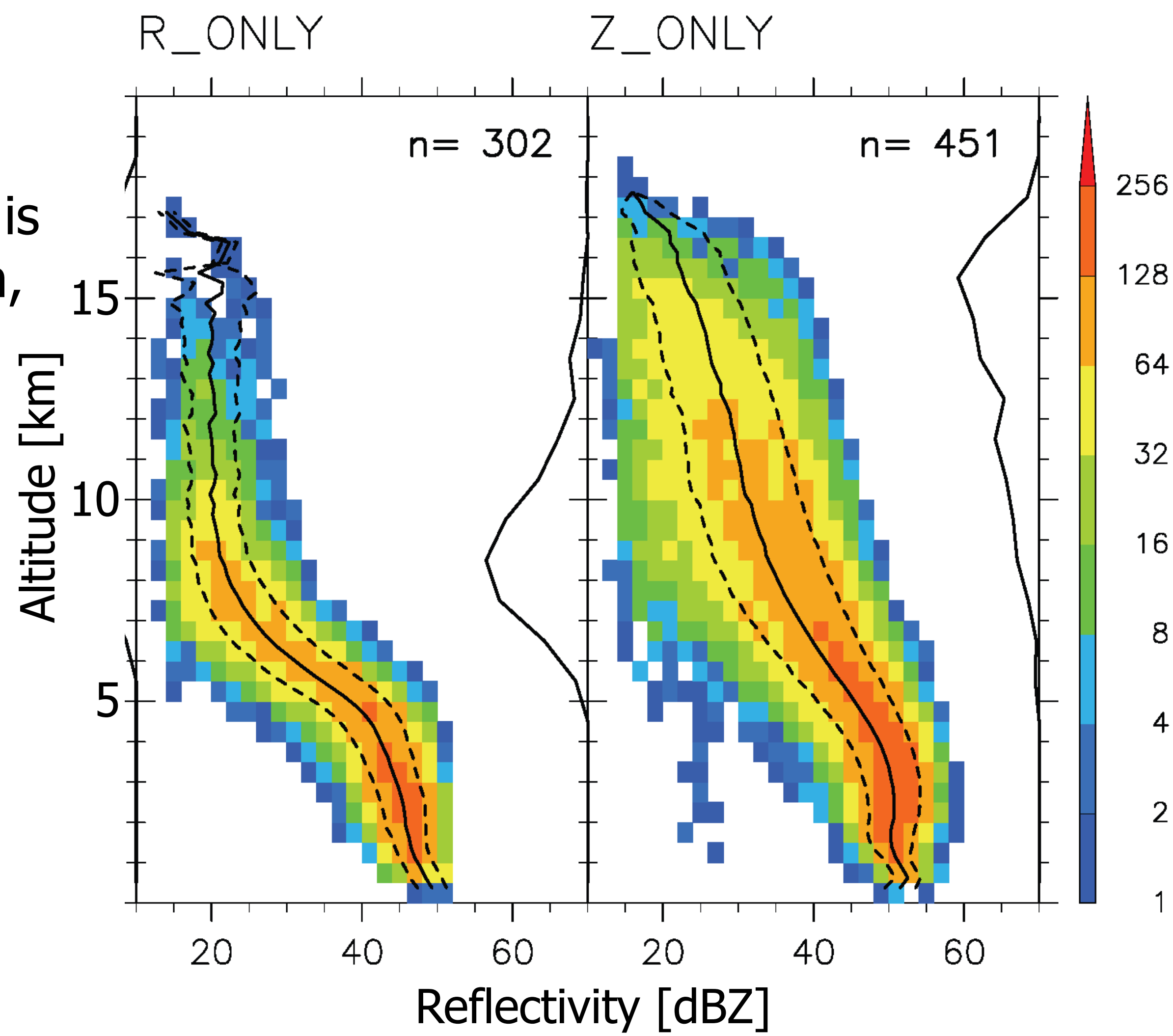
Total rainfall amount of simulated products is about -1.9 % lower than that of original products.

Differences of echo vertical structure: R-extreme vs Z-extreme

- R-extremes: having lower echo-top and more constricted than Z-extremes, still increasing around the echo bottom
- Qualitative characteristics is little dependent on season, region, and surface type (land/sea), except for storm-track regions

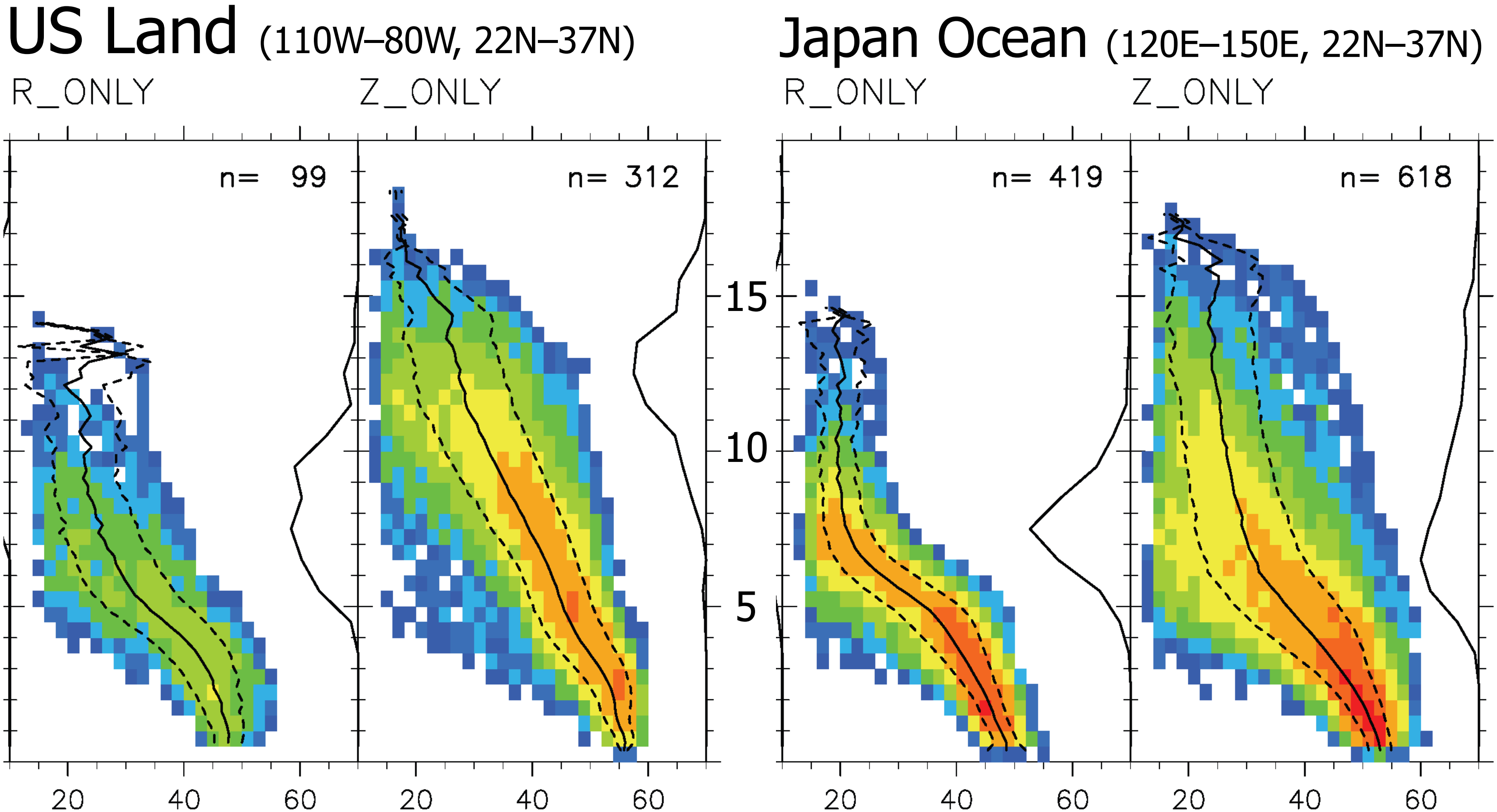


Z_e–height 2D histogram (color, ave±1σ) and echo-top height freq. (along right axis)
Amazon (65W–35W, 15S–0S), 2A25 V6



Extreme Rainfall: R-extreme vs Z-extreme

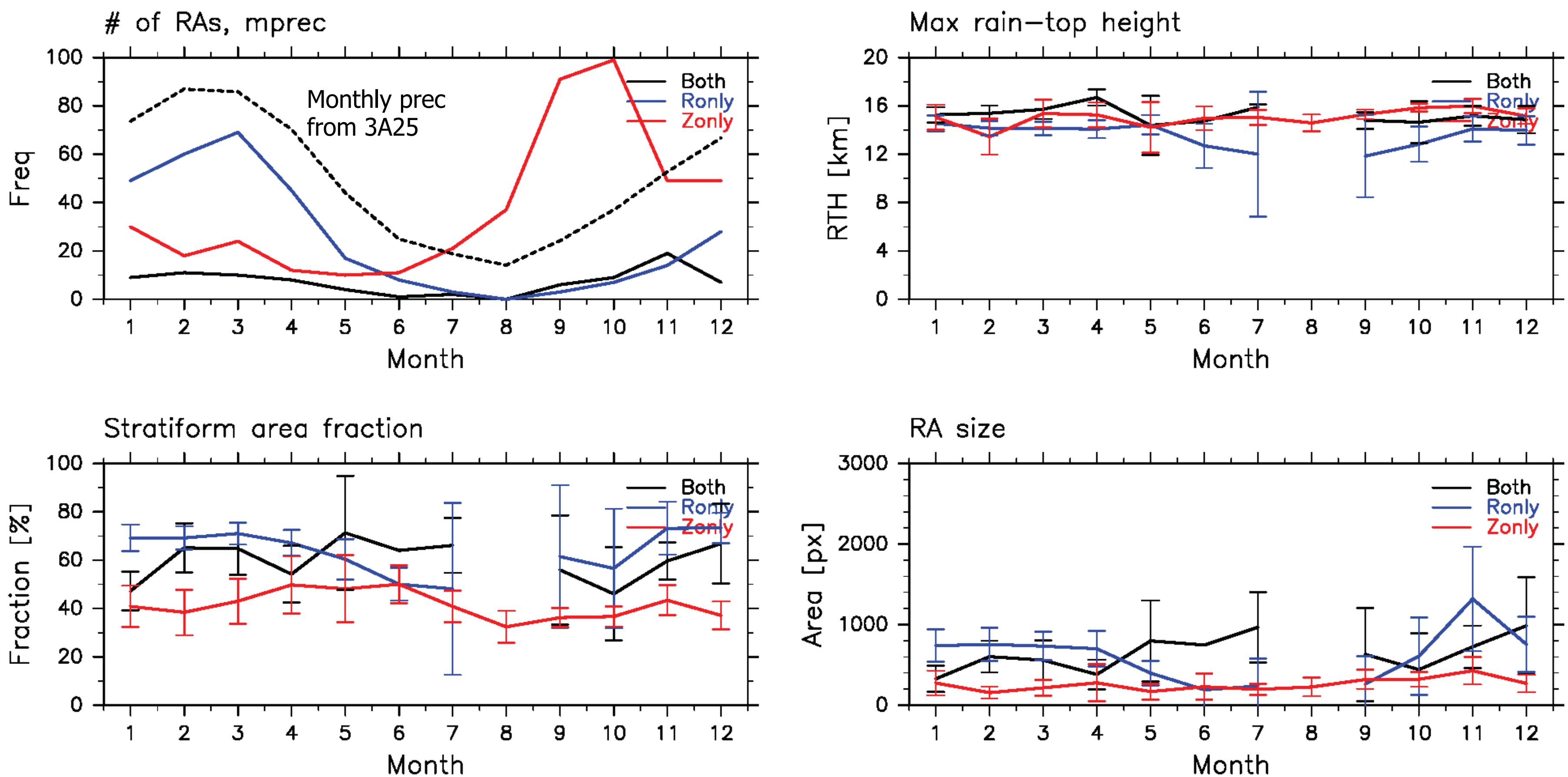
Hamada et al.



- Z-extremes in US region show more linear echo structure
- Z-extreme echo-tops in JP region are most frequent at lower level than R-extreme
- R-extreme structures are not significantly different

Seasonal variation

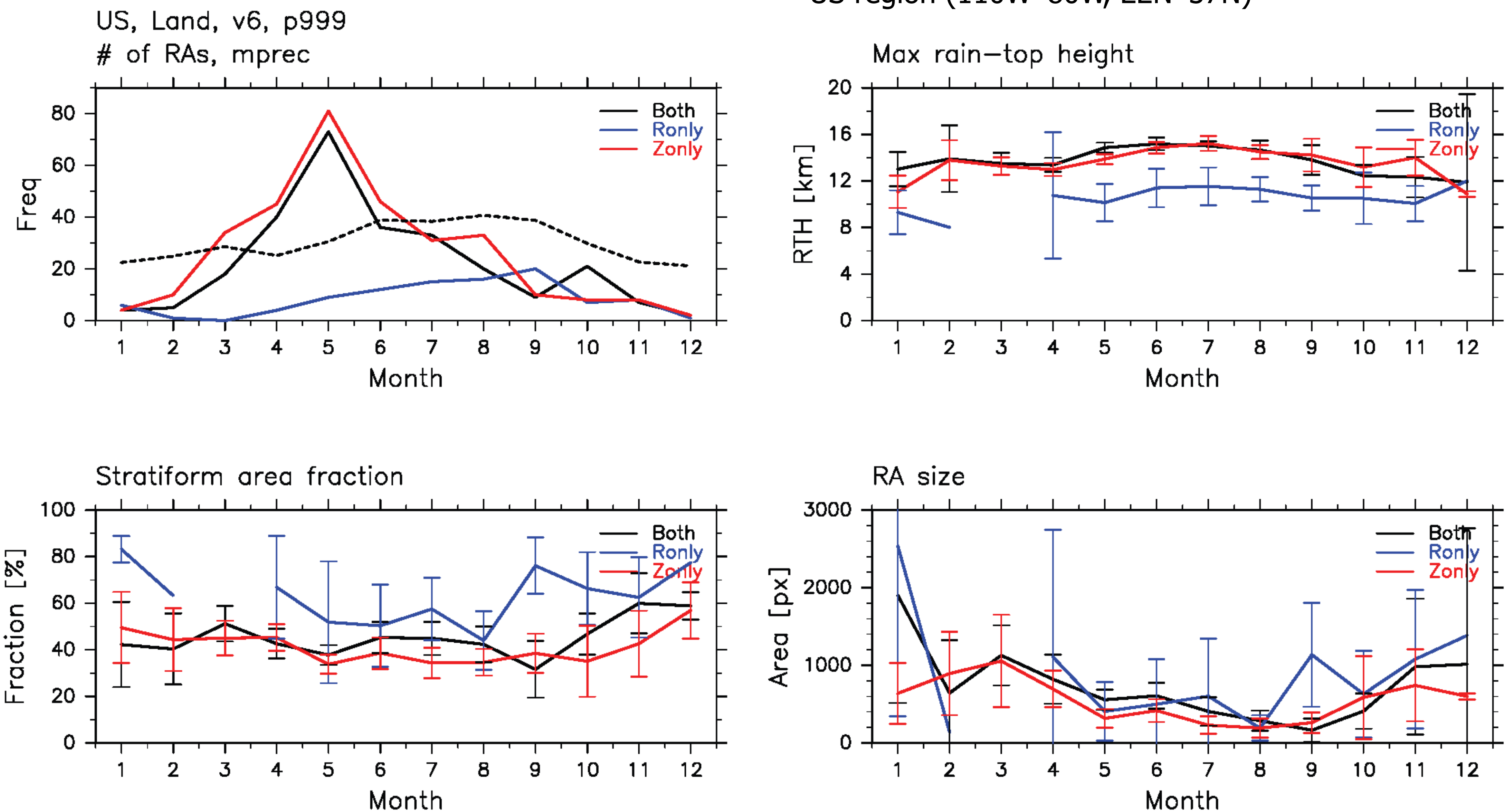
Monthly values for Z (red) and R (blue) extremes (ave±95% confidence level)
Amazon (65W–35W, 15S–0S)



• R (Z)-extremes are more frequent during monsoon (premonsoon) months
• R-extremes: lower echo-top, higher stratiform area fraction, larger size
• Differences in structural characteristics between R-ext and Z-ext are little dependent on season, region, and surface type;
only monthly relative frequencies differs in regions w/ different monsoon

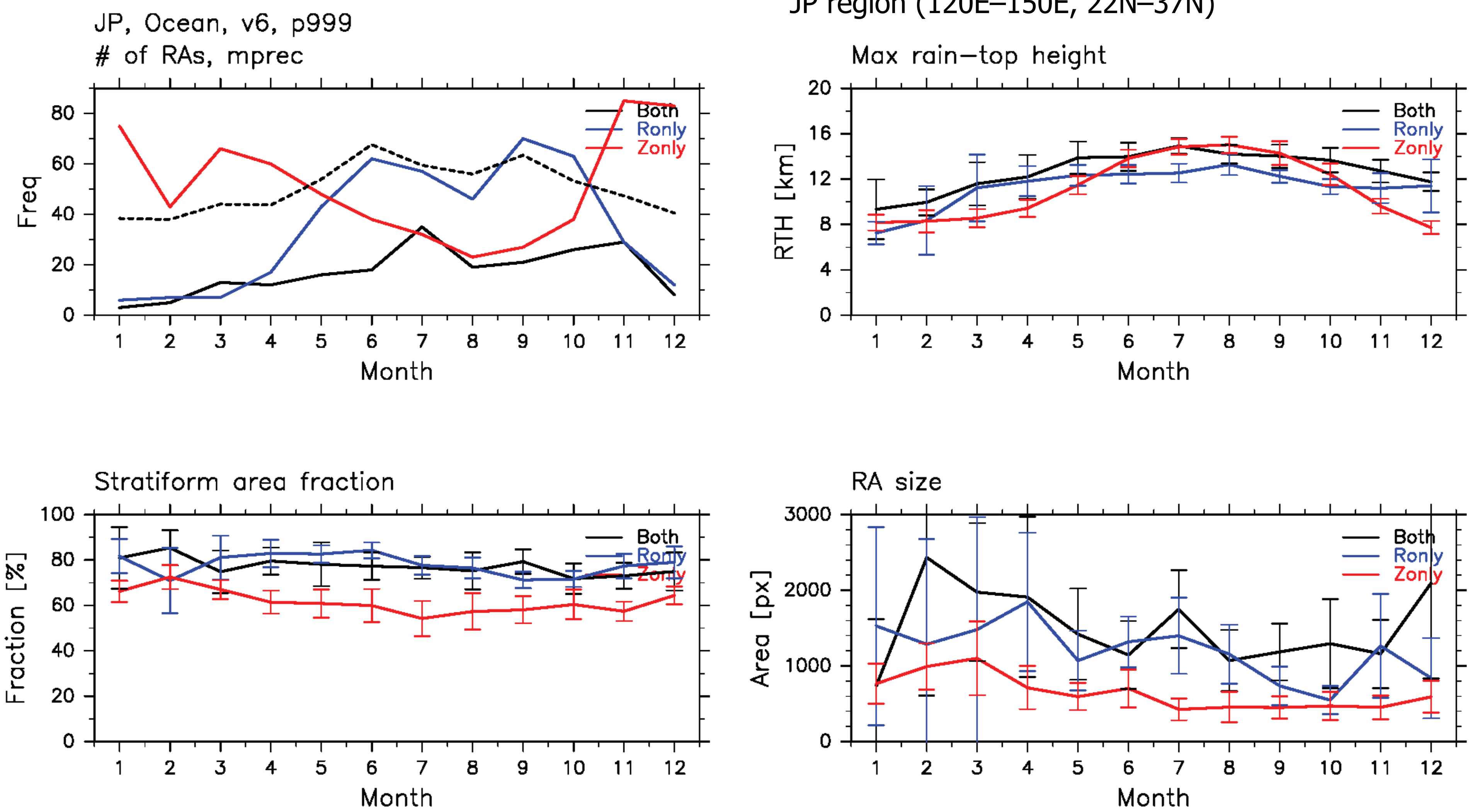
Seasonal variation, US region

Monthly values for Z (red) and R (blue) extremes
(ave±95% confidence level)
US region (110W–80W, 22N–37N)



Seasonal variation, JP region

Monthly values for Z (red) and R (blue) extremes
(ave±95% confidence level)
JP region (120E–150E, 22N–37N)



- In spring and fall, R-extremes are higher than Z-extreme

Data and Process

Data

- VTE radar (17.970°N, 102.570°E)
  - Rain rate at 2 km with Z-R relationship from DSD at Phonghong every 15 minute in11–12 June 2011
  - Horizontal resolution 1 km

- GSMaP_NRT
  - Hourly global rainfall map in near-real-time, called GSMaP_MVK ver. 5.222
  - Horizontal resolution: 0.1° lat./lon.

Data Process

- VTE radar data are fitted in 0.1° lat./lon. to average in a grid.
- The fitted data are averaged in a hour
- GSMaP_NRT are diagnosed using some verification scores with VTE radar data as ground truth.

Verification indices of rain data

Rain detection

- Probability of detection (POD)

  $POD = a / (a + c)$
- False-alarm ratio (FAR)

  $FAR = b / (a + b)$
- Frequency bias (FB)

  $FB = (a + b) / (a + c)$
- Threat Score (TS)

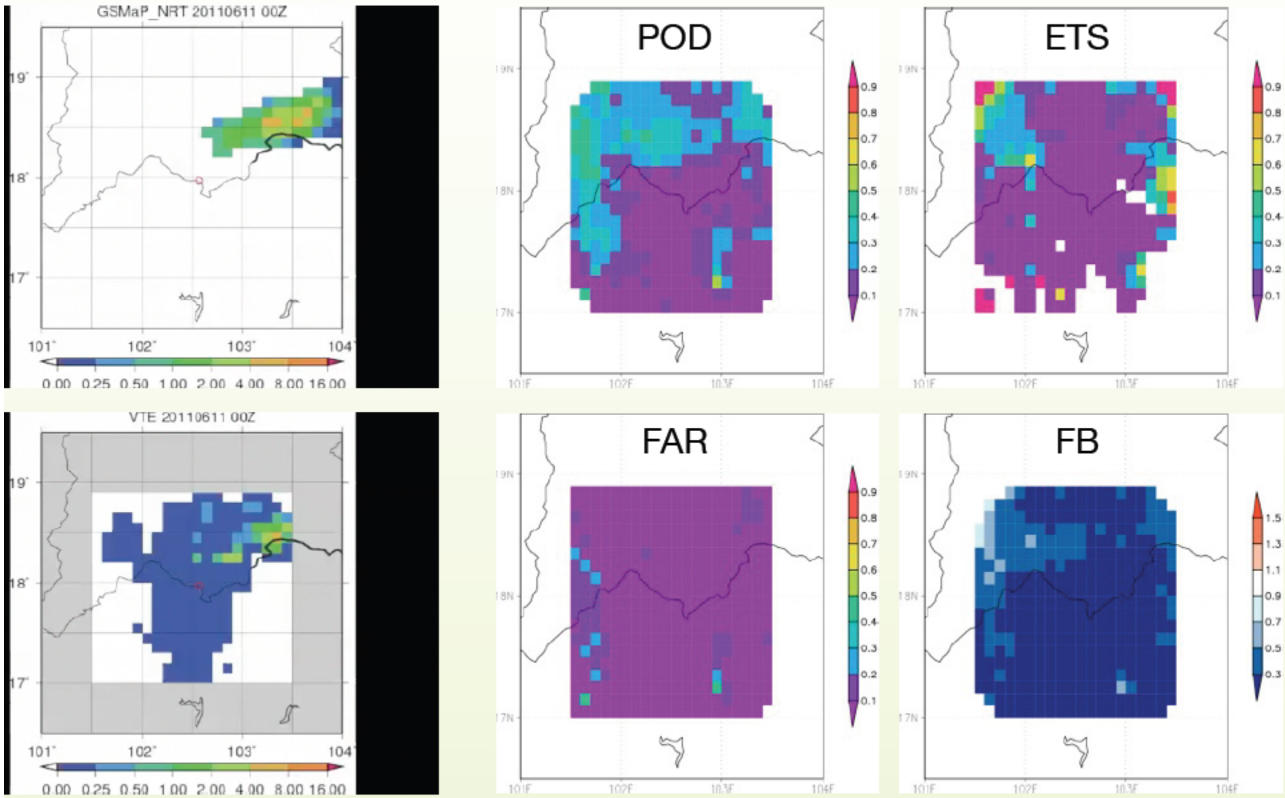
  $TS = a / (a + b + c)$
- Equitable threat score (ETS)

  $ETS = (a - a_{ref}) / (a - a_{ref} + b + c)$

  where $a_{ref} = (a + b)(a + c) / n$

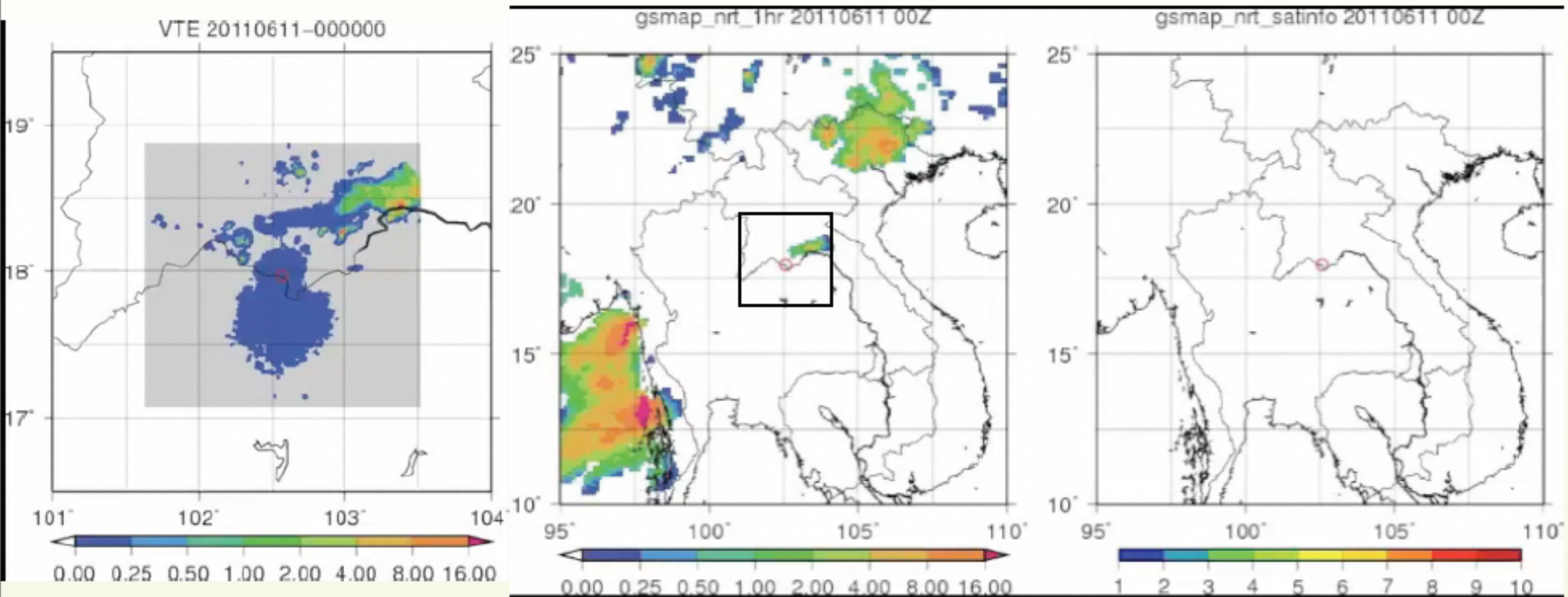
	radar observed rain	radar observed no-rain
satellite estimate giving rain	a	b
satellite estimate giving no rain	c	d

Verification Scores



VTE radar vs GSMaP_NRT

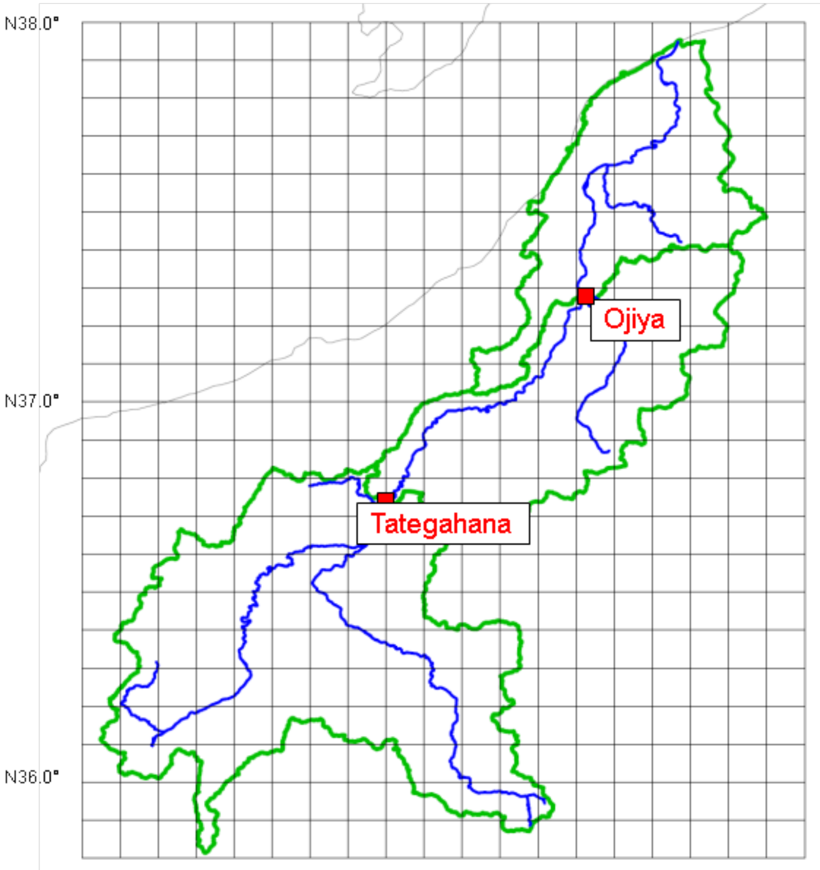
Satomura, Shige et al. (Kyoto Univ.)

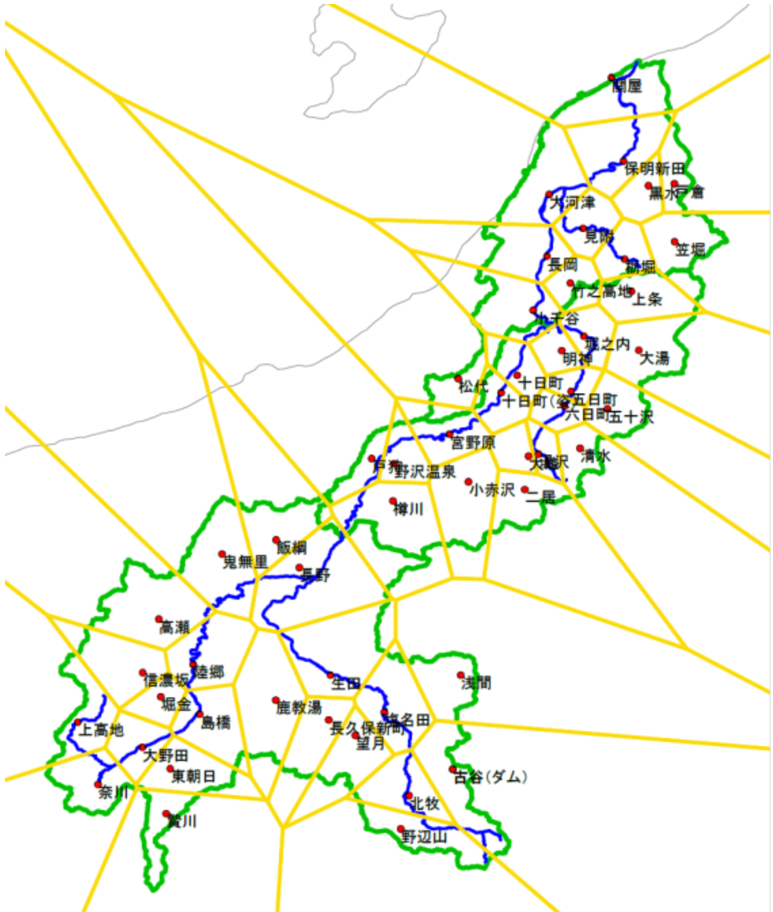


- Weak rain are stationary are found around VTE radar site (noise or ground clutter).
- Rain distribution are replaced as satellite overpass.

1: TRMM/TMI
2: Aqua/AMSR-E
3: DMSP-F13/SSM/I
4: DMSP-F14/SSM/I
5: DMSP-F15/SSM/I
6: DMSP-F16/SSMIS
7: DMSP-F17/SSMIS
8: NOAA-19/AMSU-A/MHS
9: MetOp-A/AMSU-A/MHS

Study area of Shinano River basin



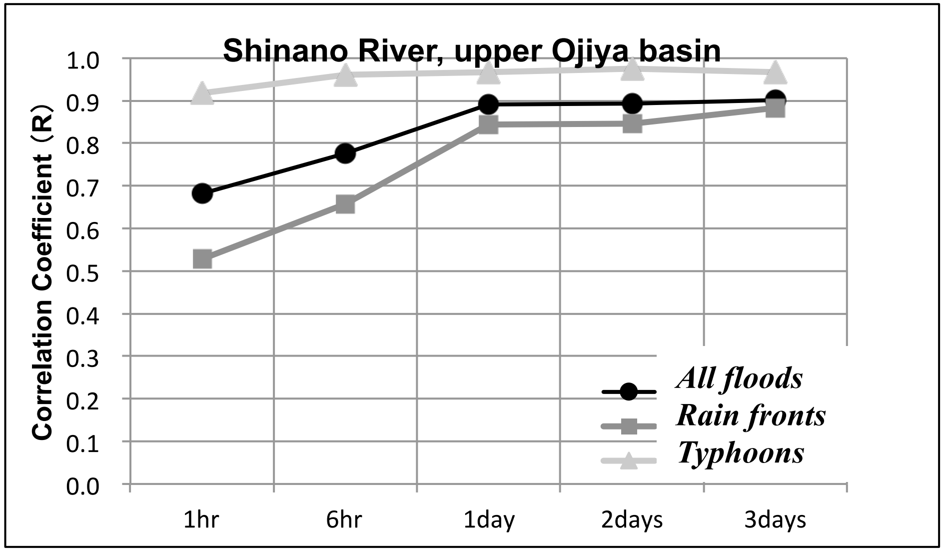


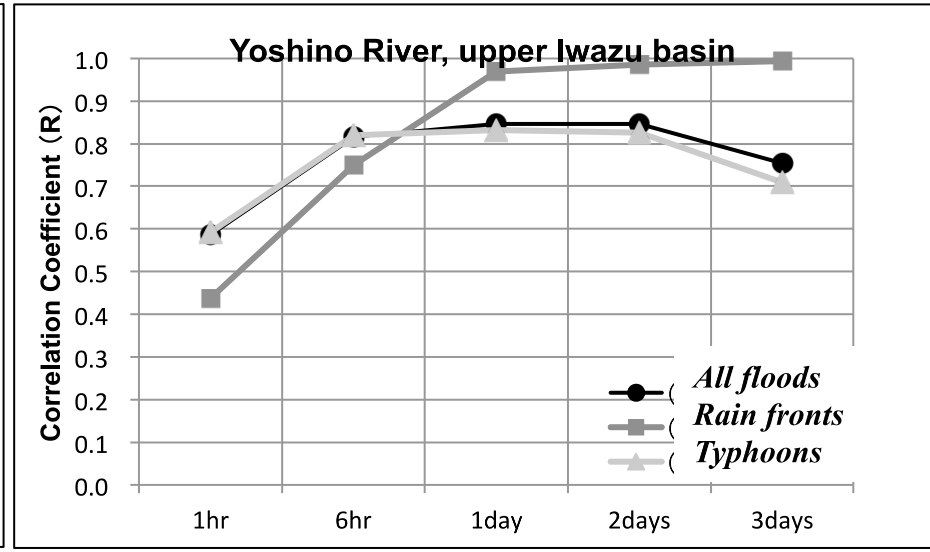
Satellite monitoring meshes of GSMaP

Ground-observed rainfall data at all the stations was calculated as the river basin mean precipitation data by using the Thiessen method.

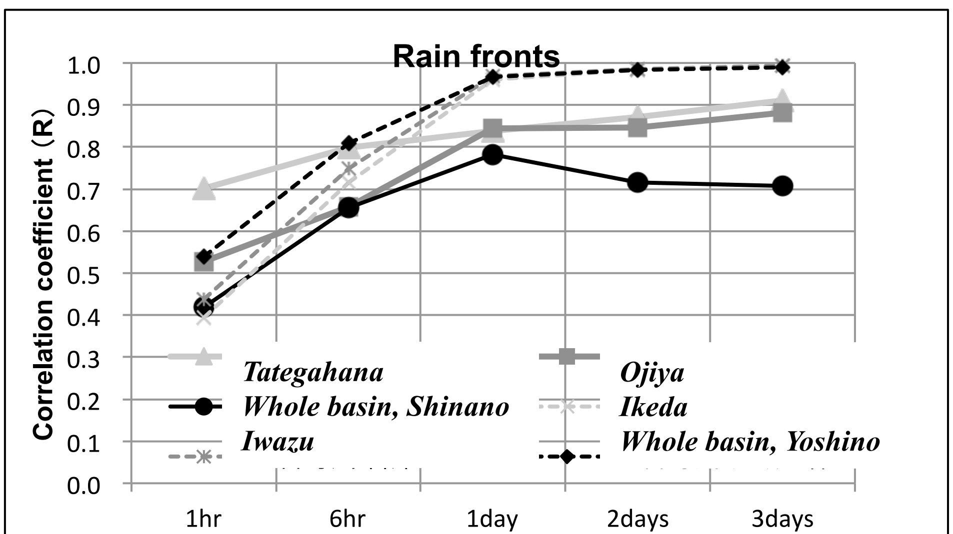
Result of comparisons <1/2>

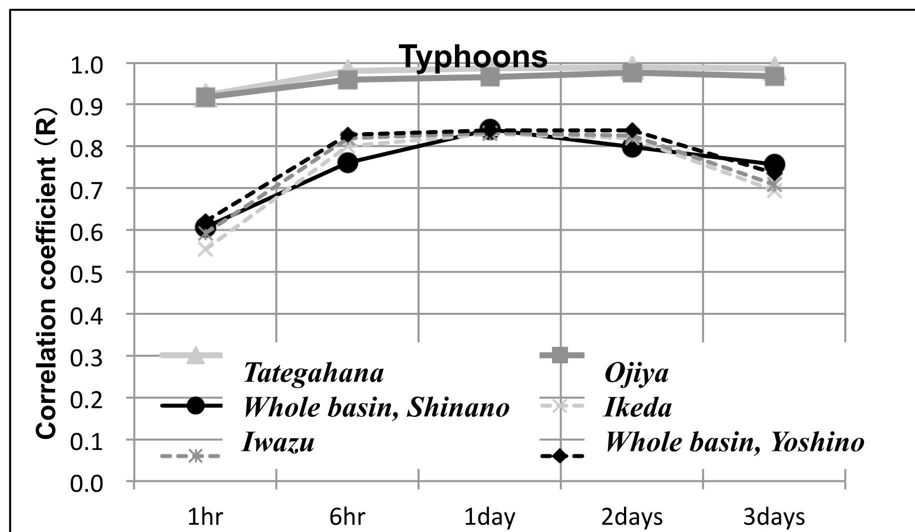
Comparison by the causes of floods





Comparison by the river basin areas



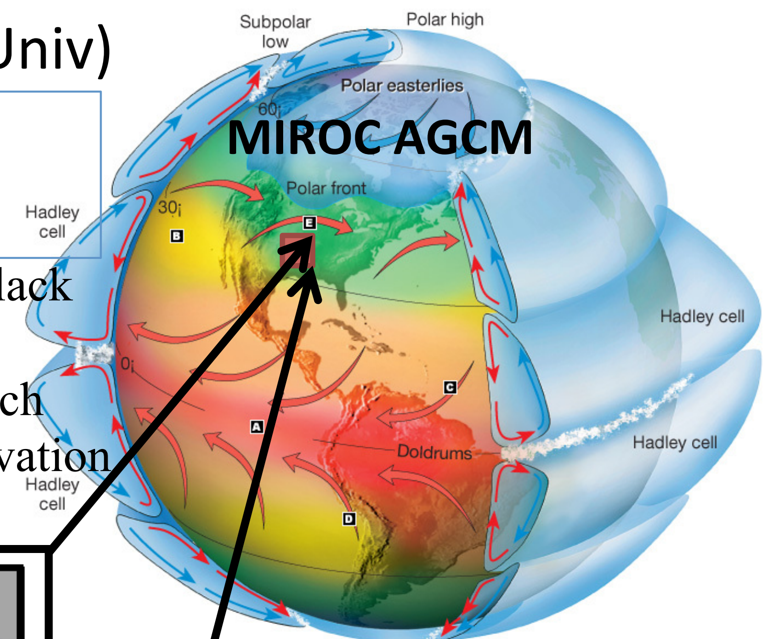


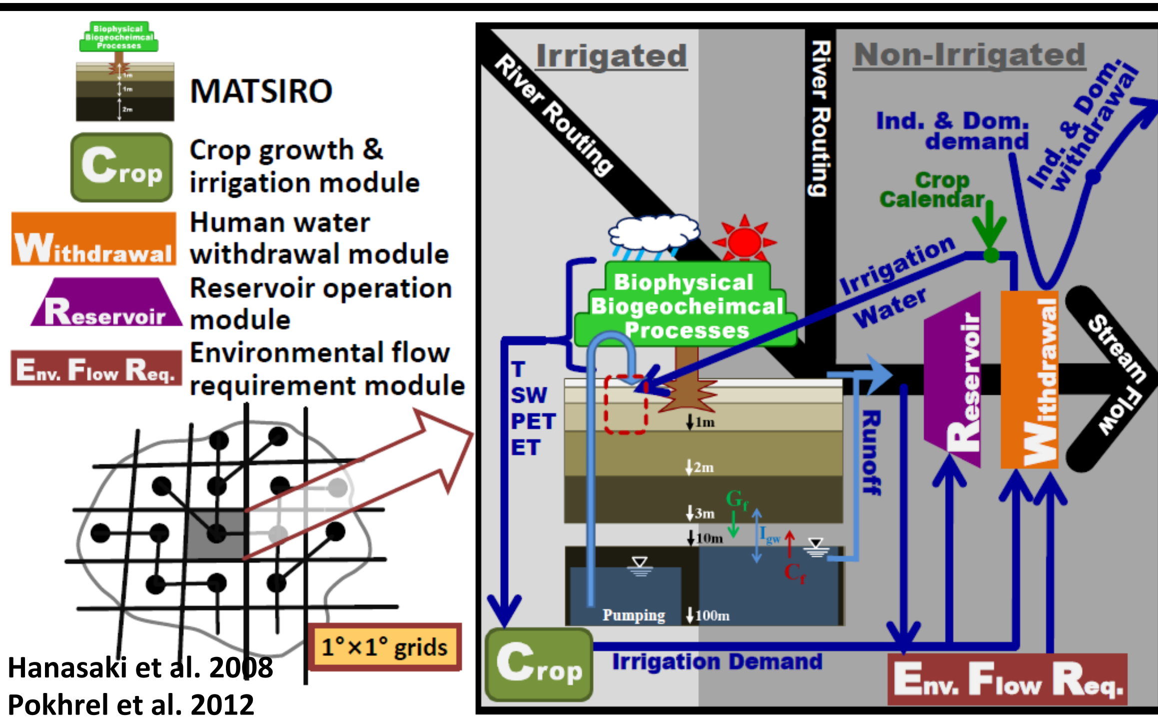
Coupled MIROC AGCM with MATSIRO land surface model including several human impact modules. Land-atmosphere interactions and hydromet prediction skills

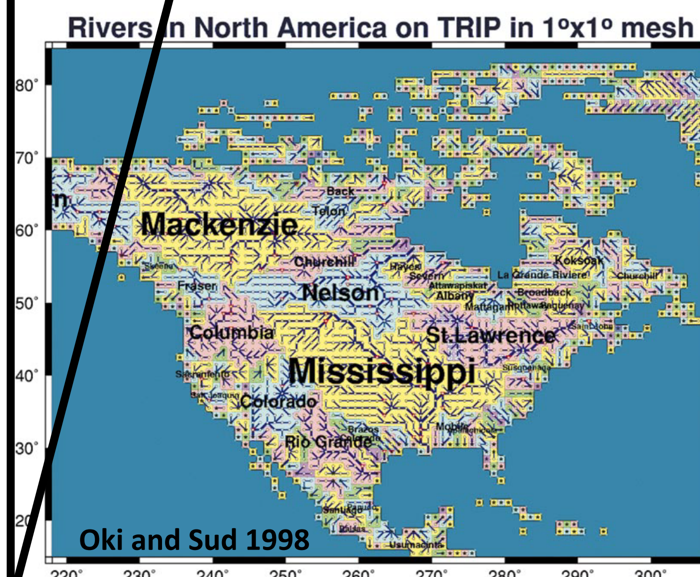
PI: Yamada (Hokkaido Univ)

MIROC AGCM + MATSIRO including human impact modules (irrigation, groundwater pumping dam operation, domestic and industrial water use, environmental flow).

Groundwater pumping (GWP) data is lack globally. Therefore GWP data was prescribed by offline LSM output, which was simulated with atmospheric observation including satellite precipitation.







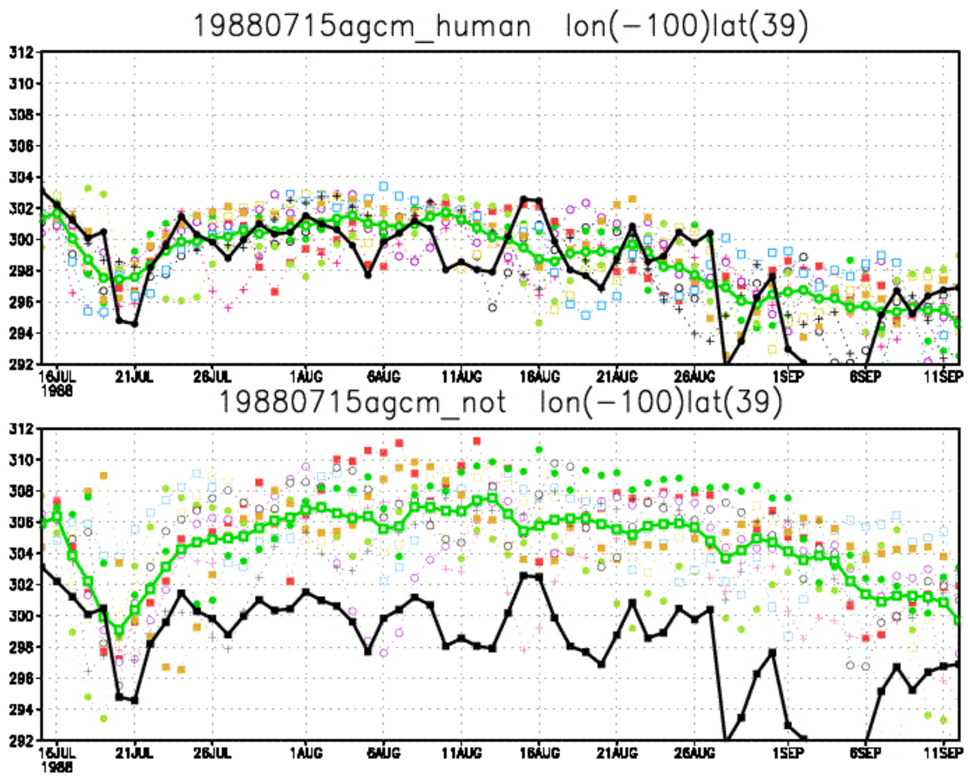
Forecast results and spreads among 10 ensemble members with a) human impact (mainly irrigation) and b) without human impact modules

Colder colors indicate that forecast results (T2m) have small spread among ensemble members.

The MIROC with MATSIRO including human impact modules reduces degree of spread among members.

With human activities

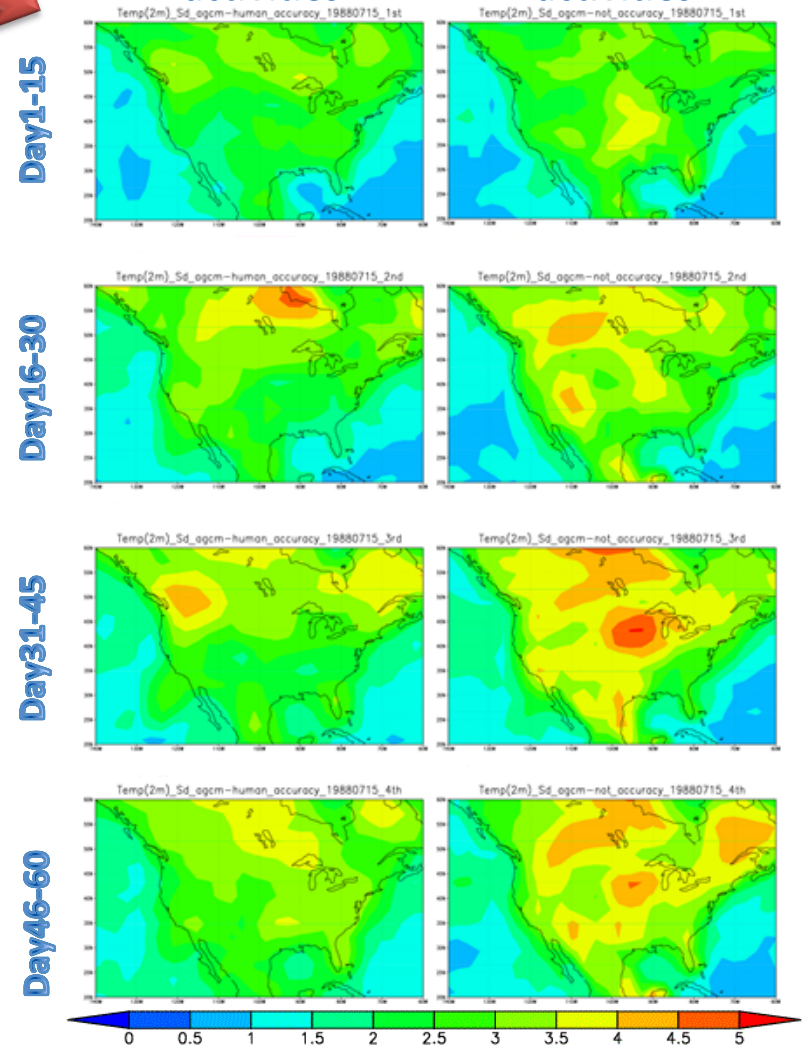
Without human activities



T2m forecast results (colors, green: ensemble mean and **observation: black**)

With human activities

Without human activities



Spread among ensemble members for T2m.

Yamada et al. (to be submitted)