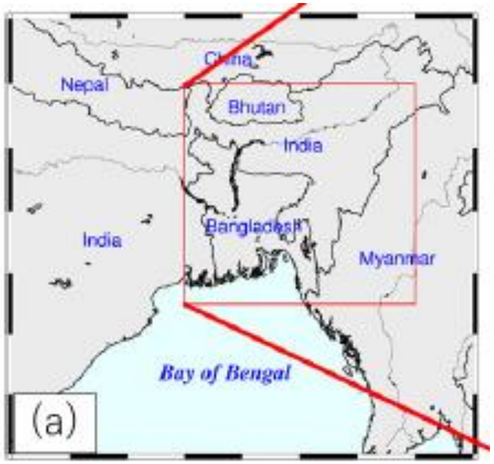
10 Oct. 2018: Annual Workshop on Science of Climate Change @ IITG/Pune

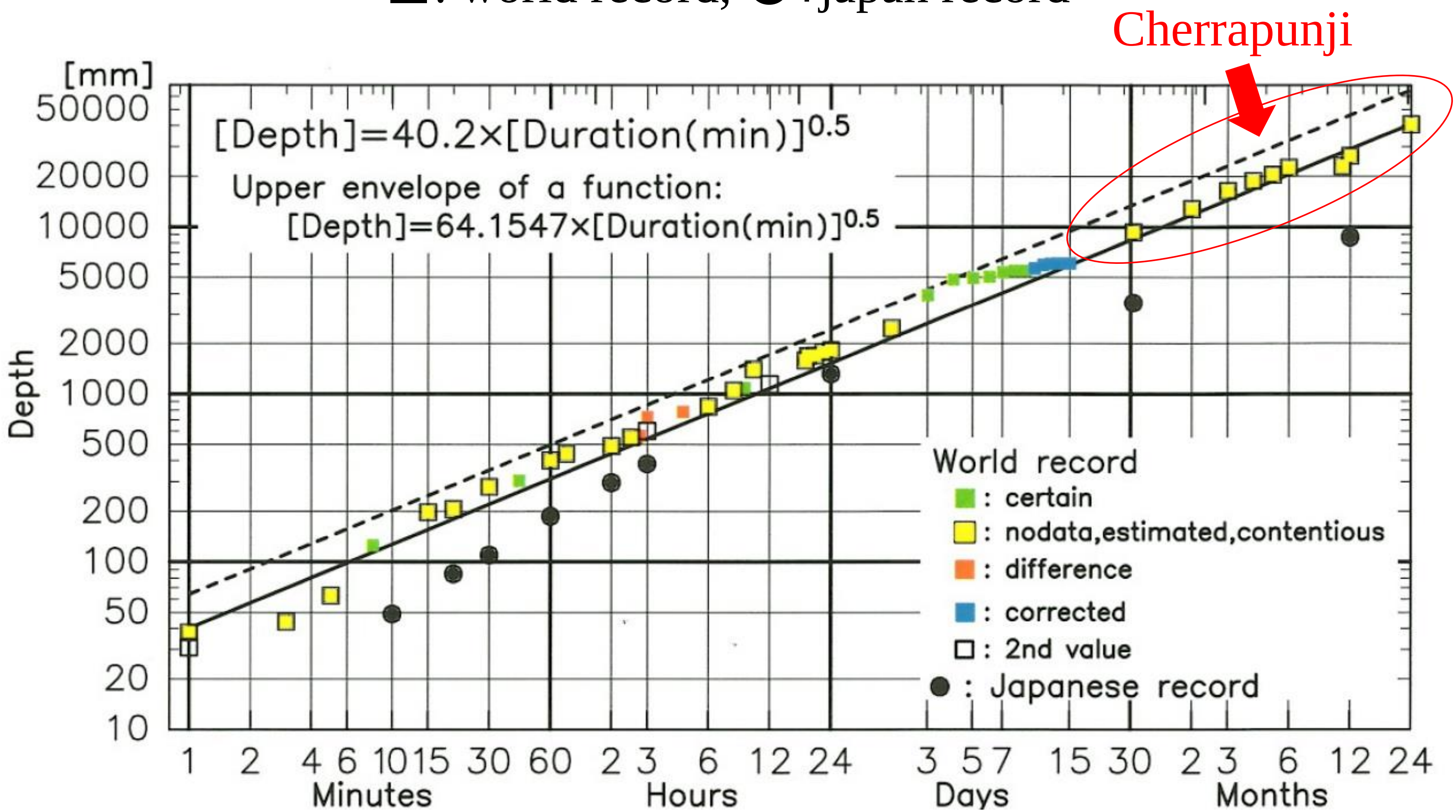


Reliable Precipitation Measurements for Validation of Regional Climate Simulations

Toru Terao (Kagawa Univ.)

Rainfall duration vs. Maximum accumulated rainfall

■: world record, ●: japan record



Kiguchi and Oki (2010)

Bangladesh Floods

- Devastating monsoon floods occur frequently in Bangladesh

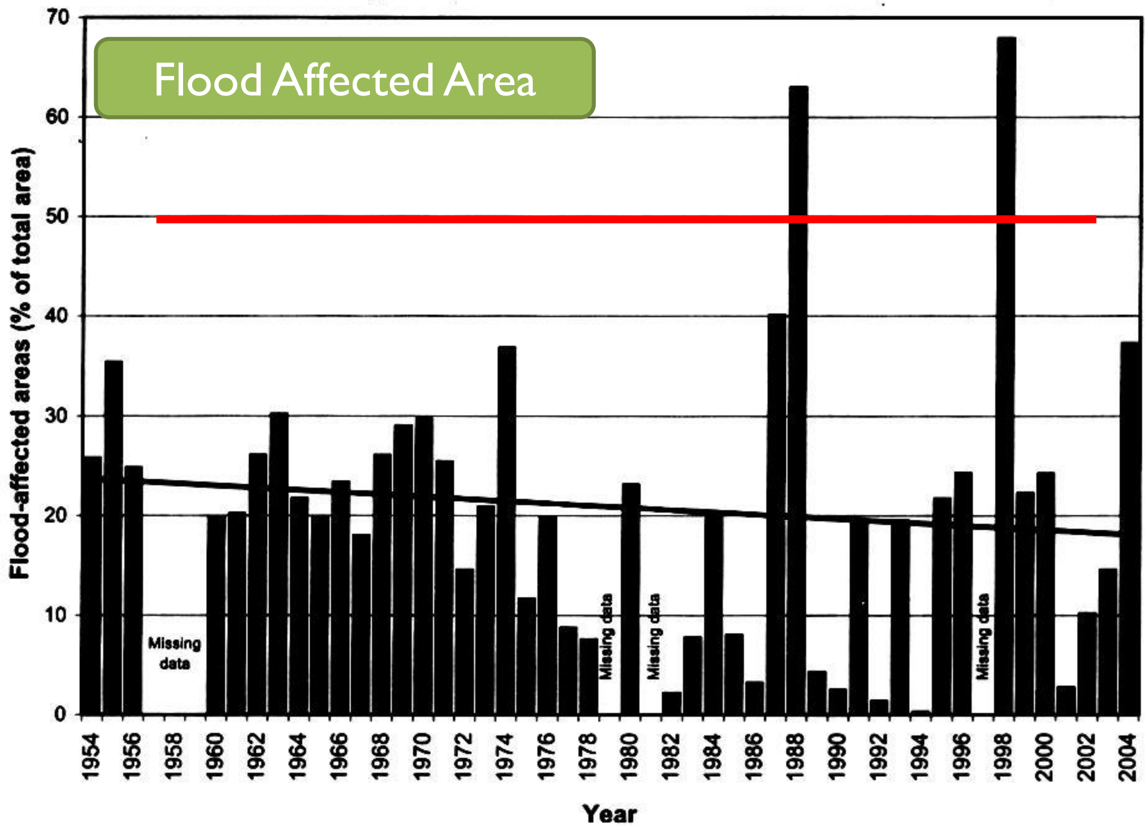


Figure 4.7 Extent of flood-affected areas in Bangladesh, 1954–2004.
Sources: BWDB (1991a, 1998a, n.d.[a]).

Hofer and Messerli, 2006

Floods and Rice Production

- After severe floods, rice production increases
- Fertilization of Soil over Bangladesh

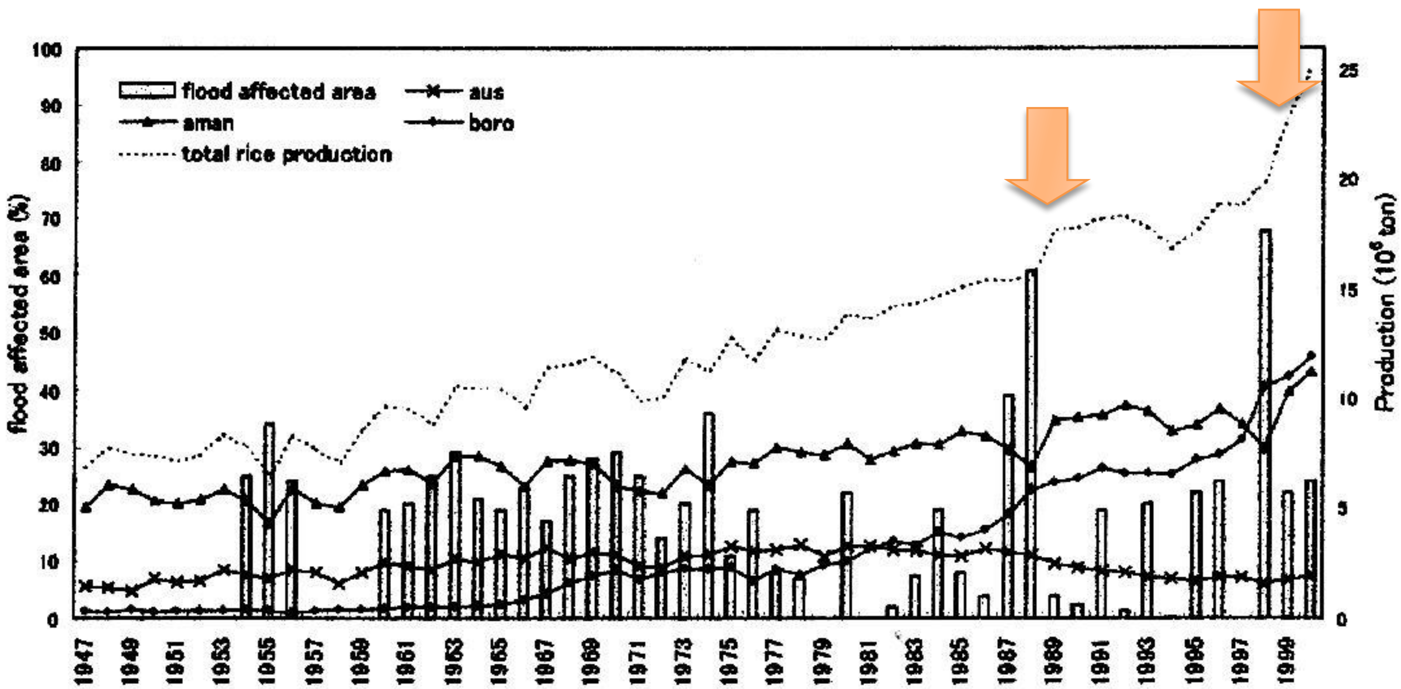
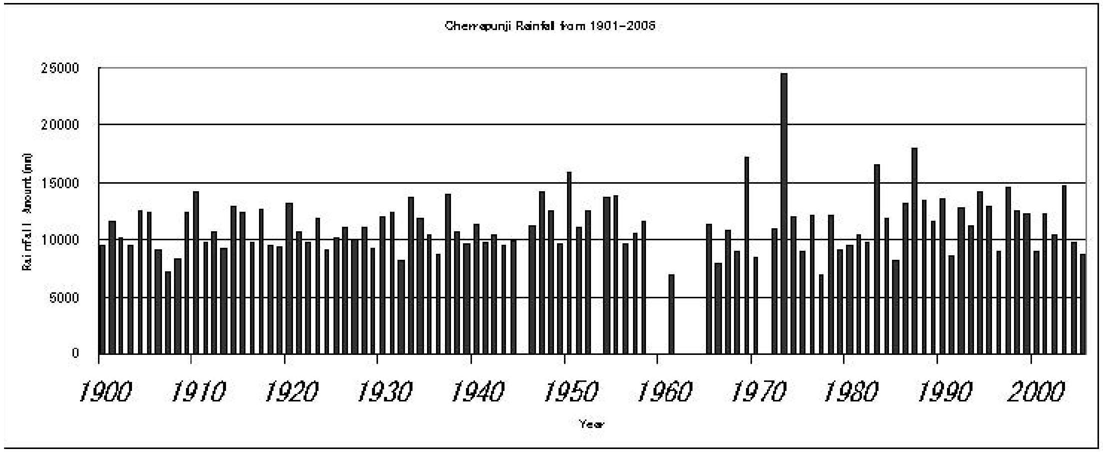


Fig. 4. The inter-annual variation of rice production and flood affected area from 1947 to 2000

Asada et al., 2005

Northeastern India Project

- The largest amount of rainfall in the world in the Northeastern region of Indian Subcontinent.



Annual Rainfall at Cherrapunjee IMD observatory from 1900-2006
From Murata (2017)

- This rainfall benefits people as water resources for agricultural product, drinking water, etc.
- However, the excess rainfall sometimes causes disaster, like serious flood.

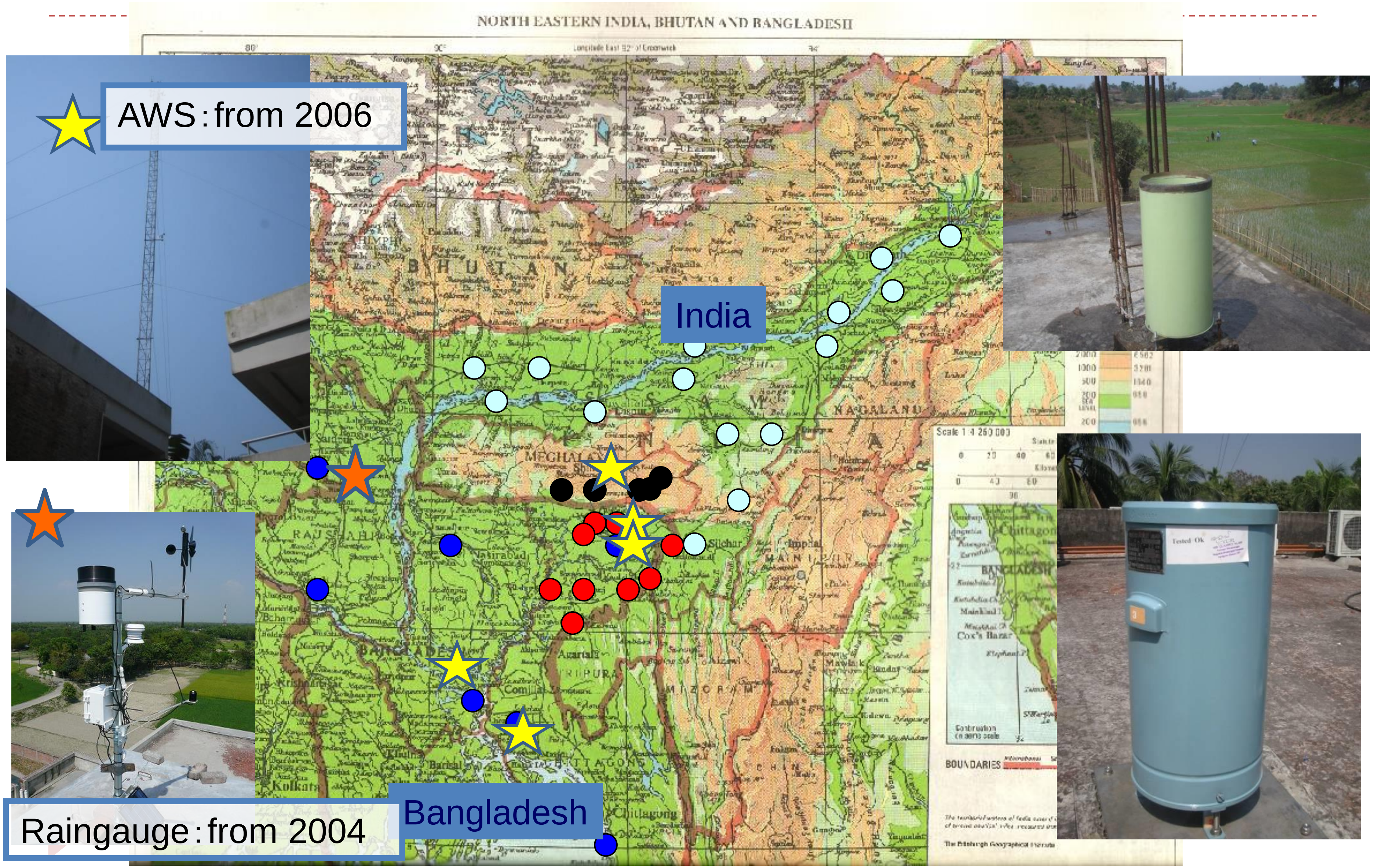
The History of Our field research

- 1987 Flood(JSPS)
- 1991 “Killer”Cyclone(JSPS)
- 1992-1994 Flood(JICA)
- 1996 Tornado in Tangail（private)
- 1995-1997 Flood and Cyclone(JSPS)
- 1999-2001 Flood(JSPS)
- 2000-2002 Flood(JICA)
- 2000-2002 Summer Monsoon(JSPS)
- 2002-2007 Infectious Diseases(KAGI21, DPRI)
- 2005-2007 Heavy rainfall monitoring(JEPP,GEOSS)
- 2006-2008 Brahmaputra River and Rural development（JSPS）
- 2006-2008 Infectious diseases(JSPS）
- 2007 Cyclone “Sidr”(JSPS)
- 2006-2015 MAHASRI Project
- 2014-2018 Data Rescue (JSPS)
- 2016-2018 TRMM Validation by Raingauge Network (JAXA)

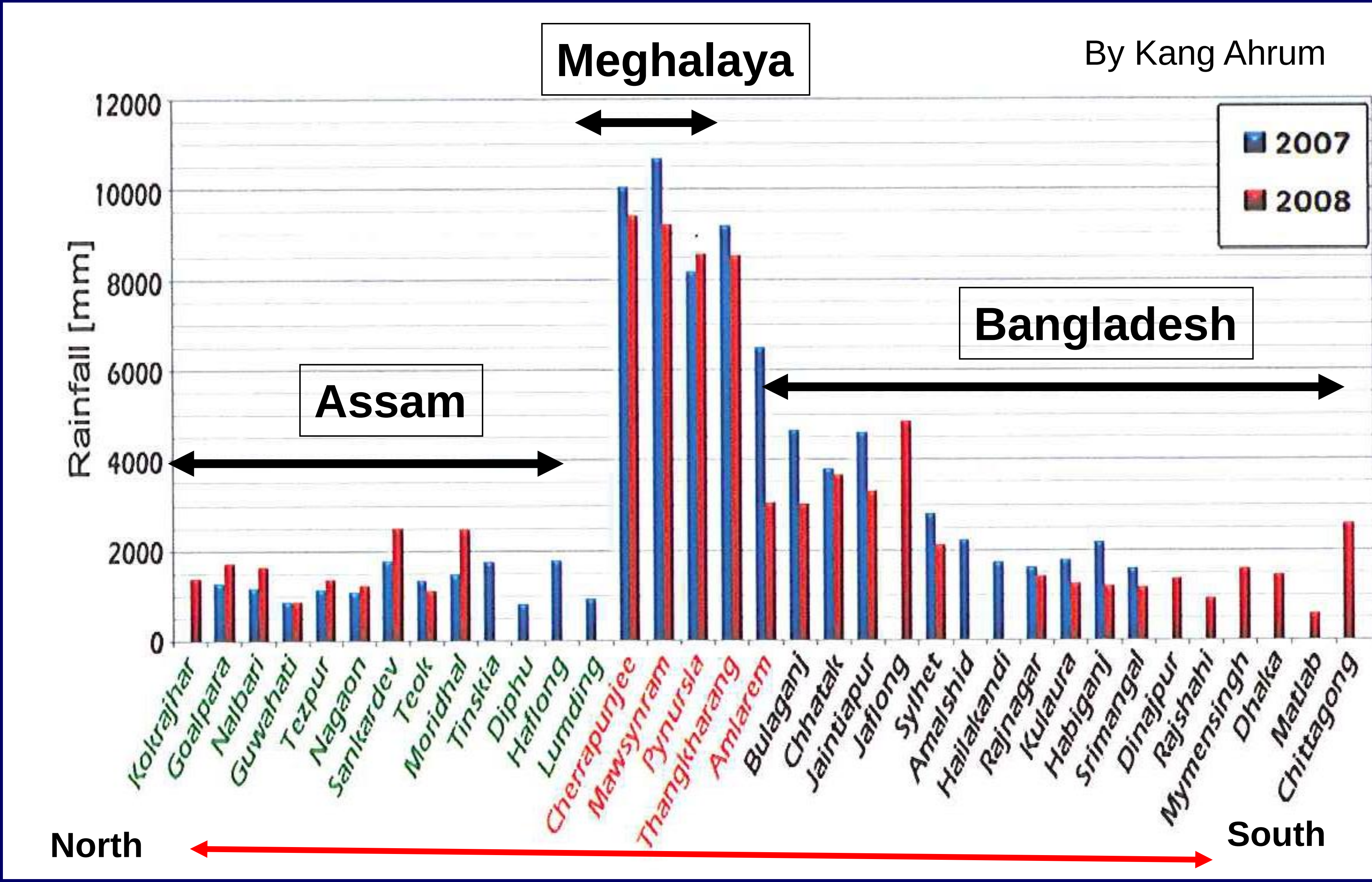
Time scales of disturbances

- Characteristic Time Scales
  - Climate Change
  - Interannual variation
  - Seasonal variation
  - Intraseasonal variation
  - Diurnal variation
- Phenomena
  - Monsoon River Floods, Active/Break Cycle
  - Premonsoon: Tornado, Nor-wester
  - Cyclone

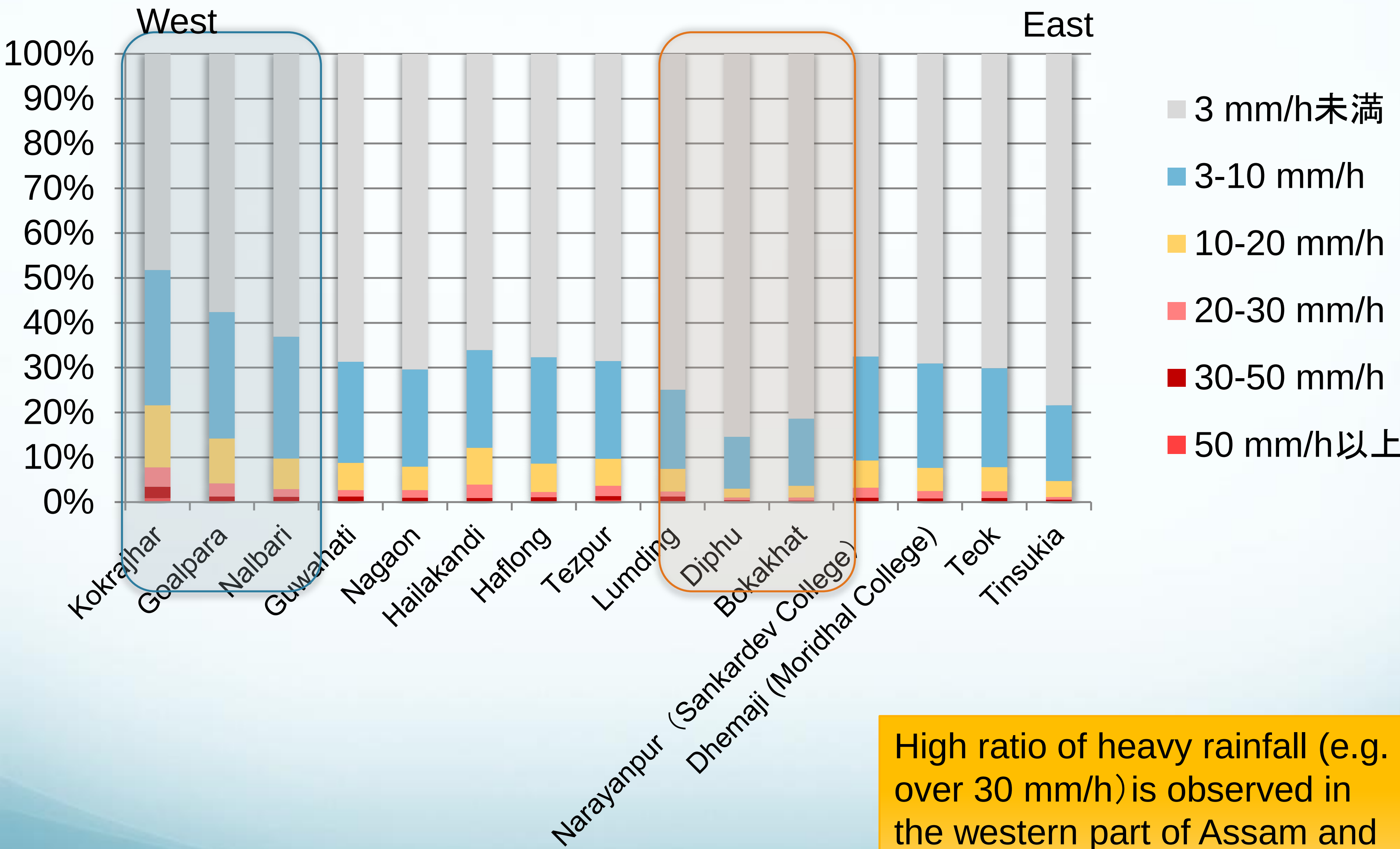
Observation Network



Spatial Distribution of Annual Rainfall



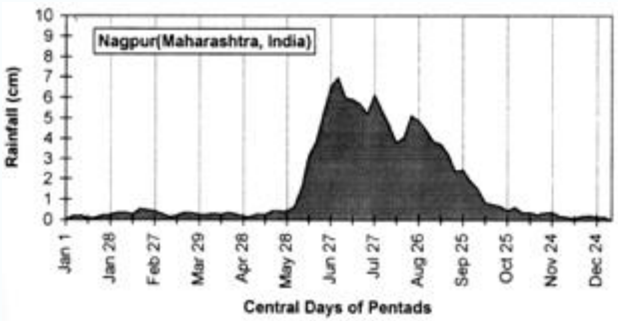
Ratio of rainfall rank



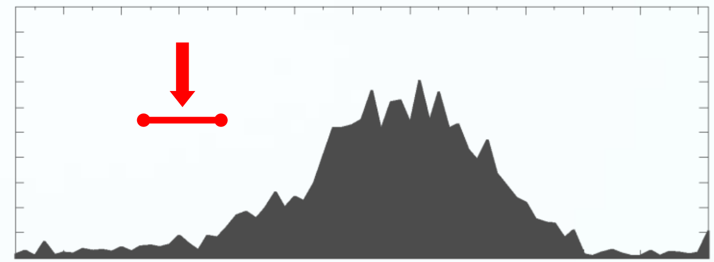
Fukushima (2017)

High ratio of heavy rainfall (e.g. over 30 mm/h）is observed in the western part of Assam and northern bank of the Brahmaputra river.

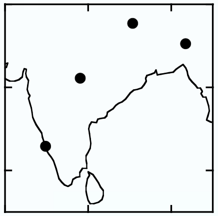
Regional differences upon the seasonal transition of mean-pentad precipitation

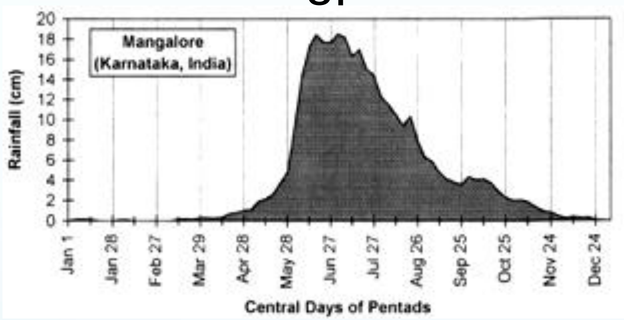


Nagpur

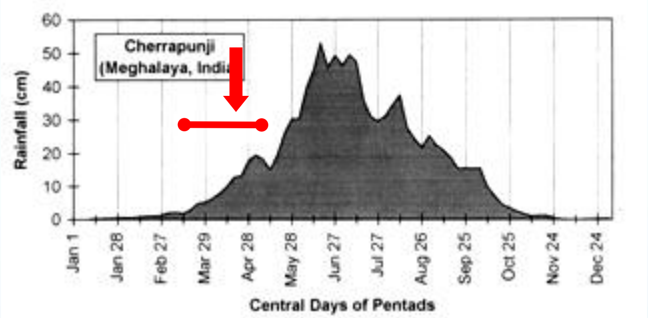


Kathmandu





Mangalore



Cherrapunji

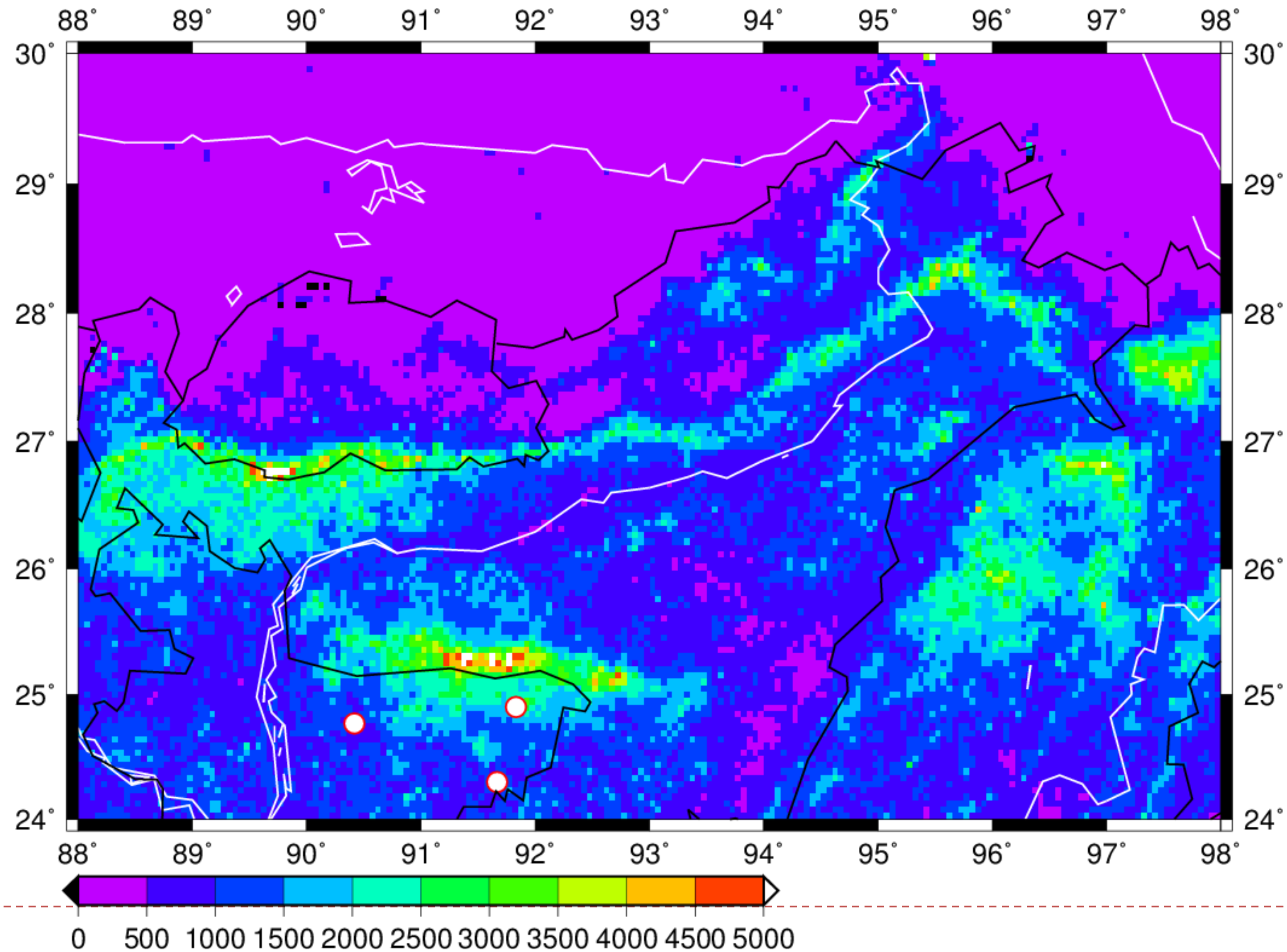
The seasonal progression of precipitation in South Asia. （Pant and Kumar, 1997 ）

Why the regional differences appear in NE part of Indian subcontinent?

Fukushima (2017)

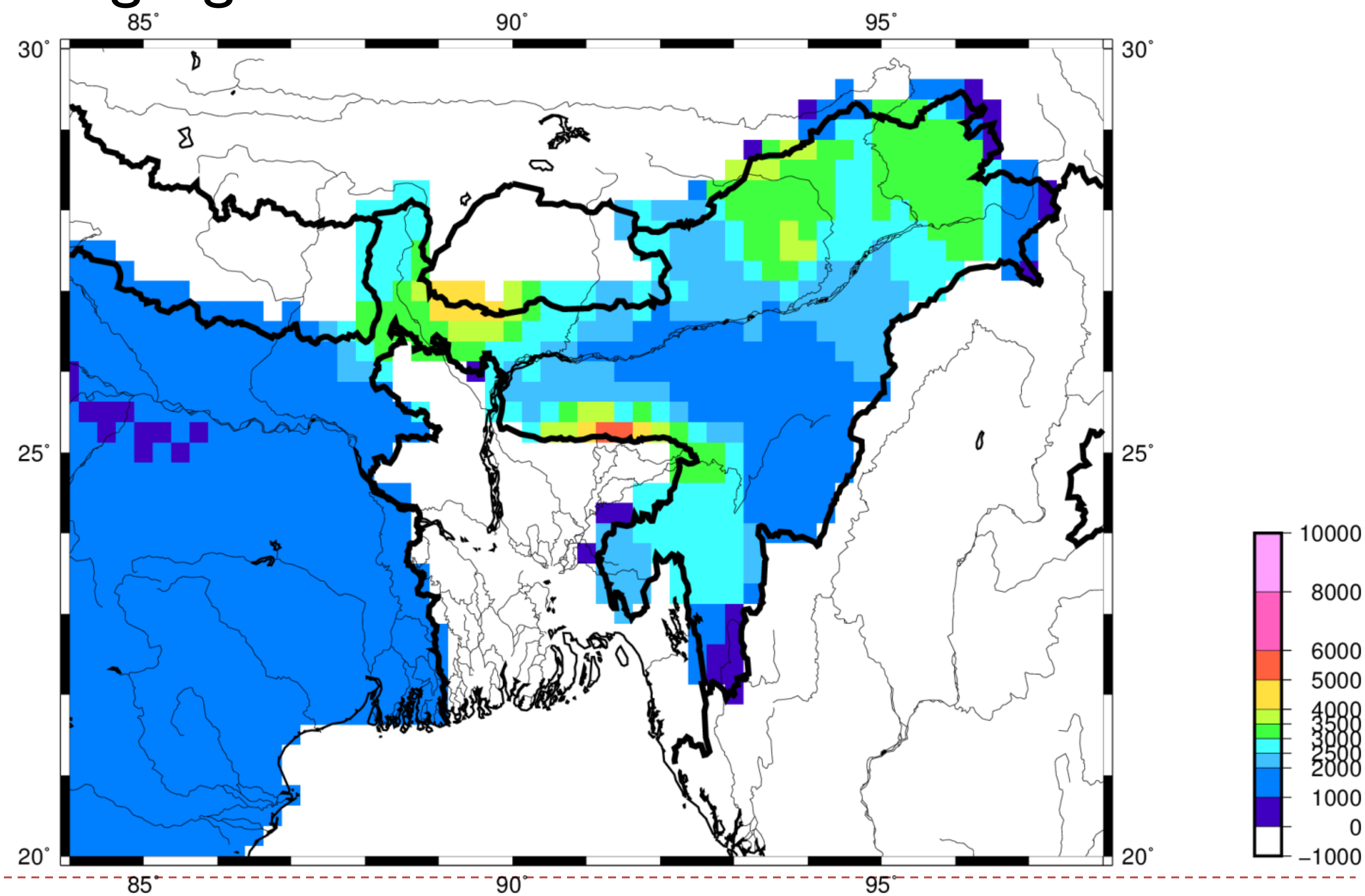
Monsoon TRMM NSR Climatology

1998-2011 Jun.-Sep.



Rainfall estimation

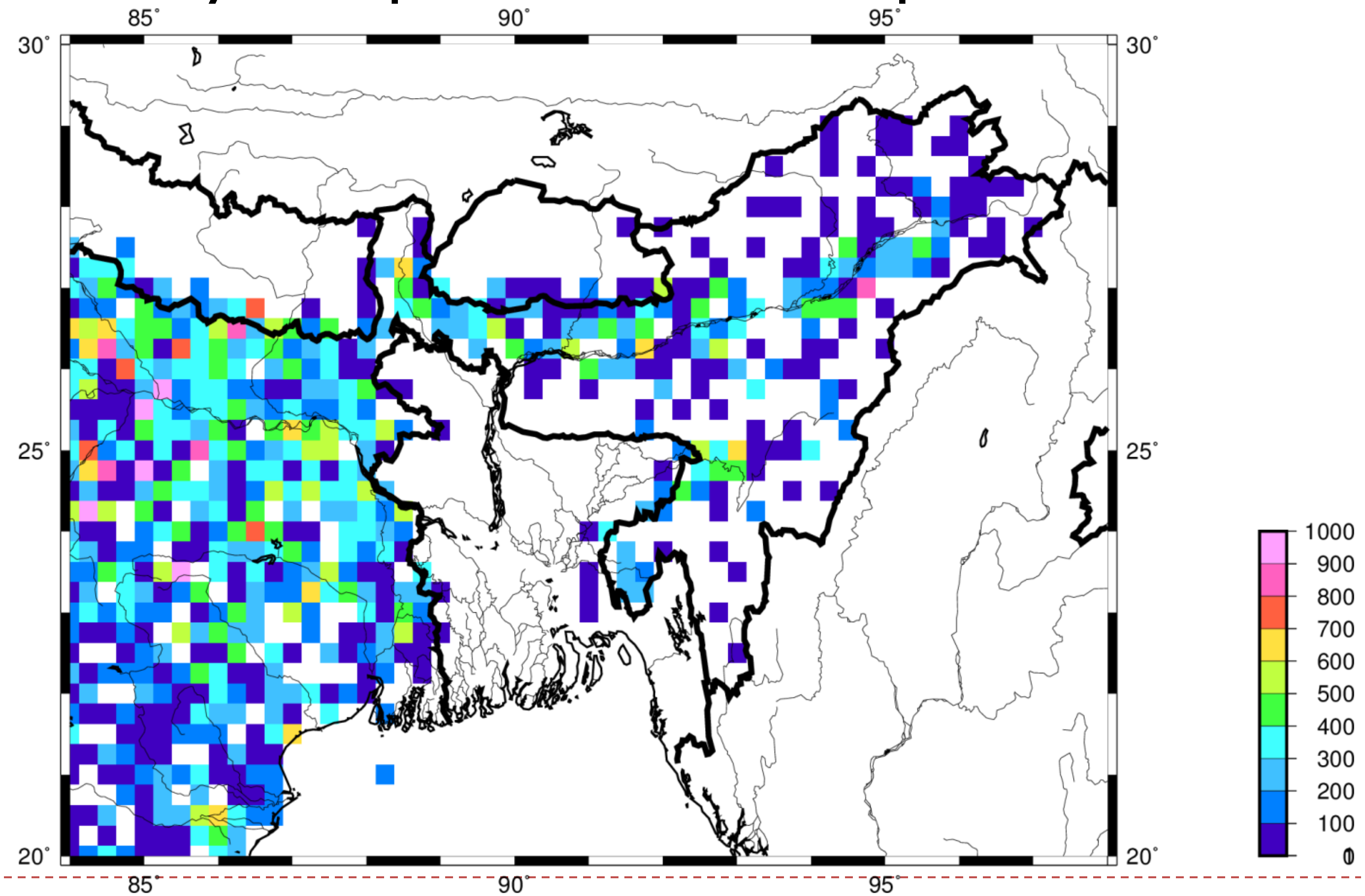
- IMD Gridded Rainfall (0.25deg x 0.25deg), 1901-
- Based on raingauge observations



1901-2013 ave

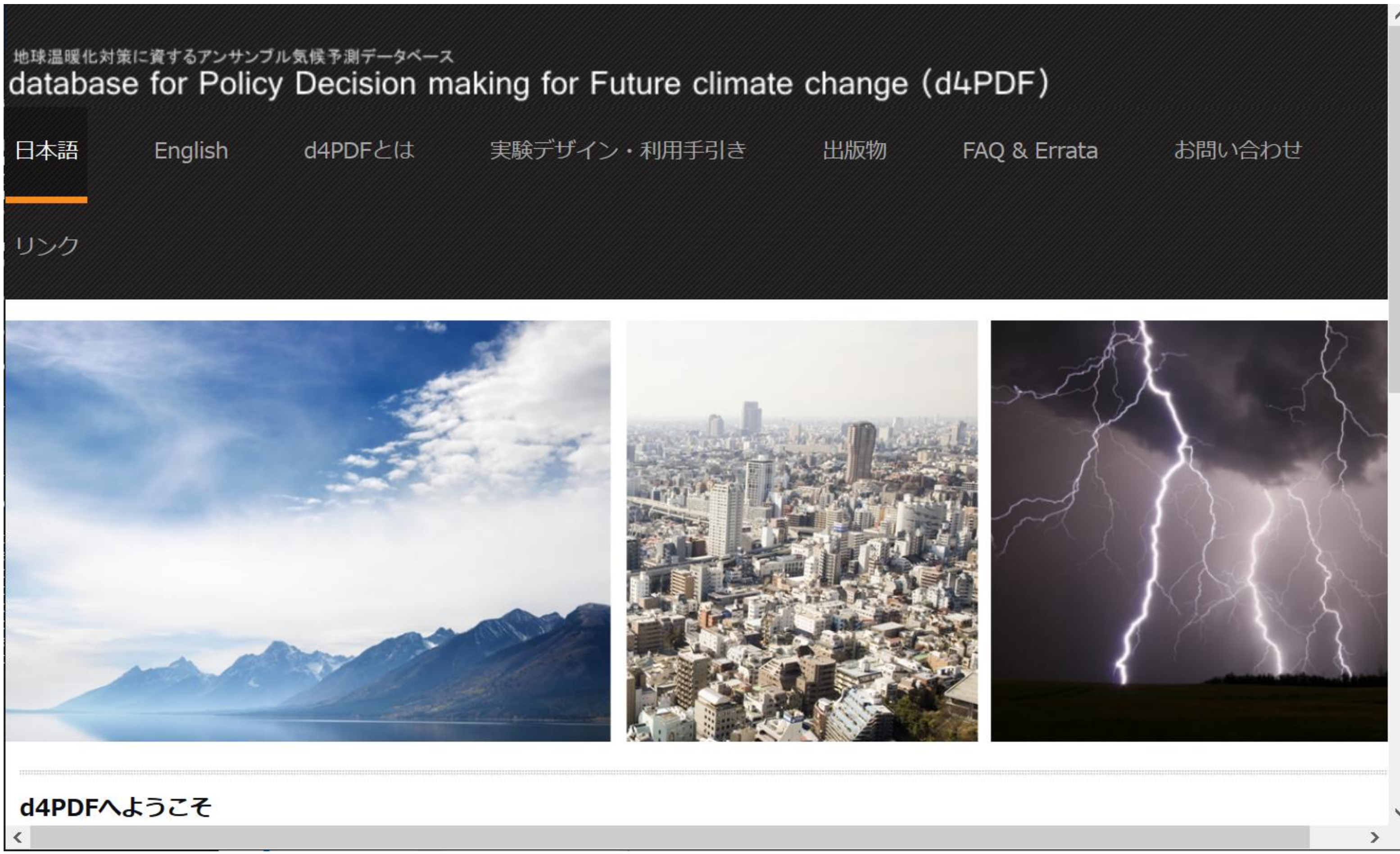
Accuracy of rainfall gridded data

- Averaged number of observation in each grid
- Data is created by interpolation and extrapolation



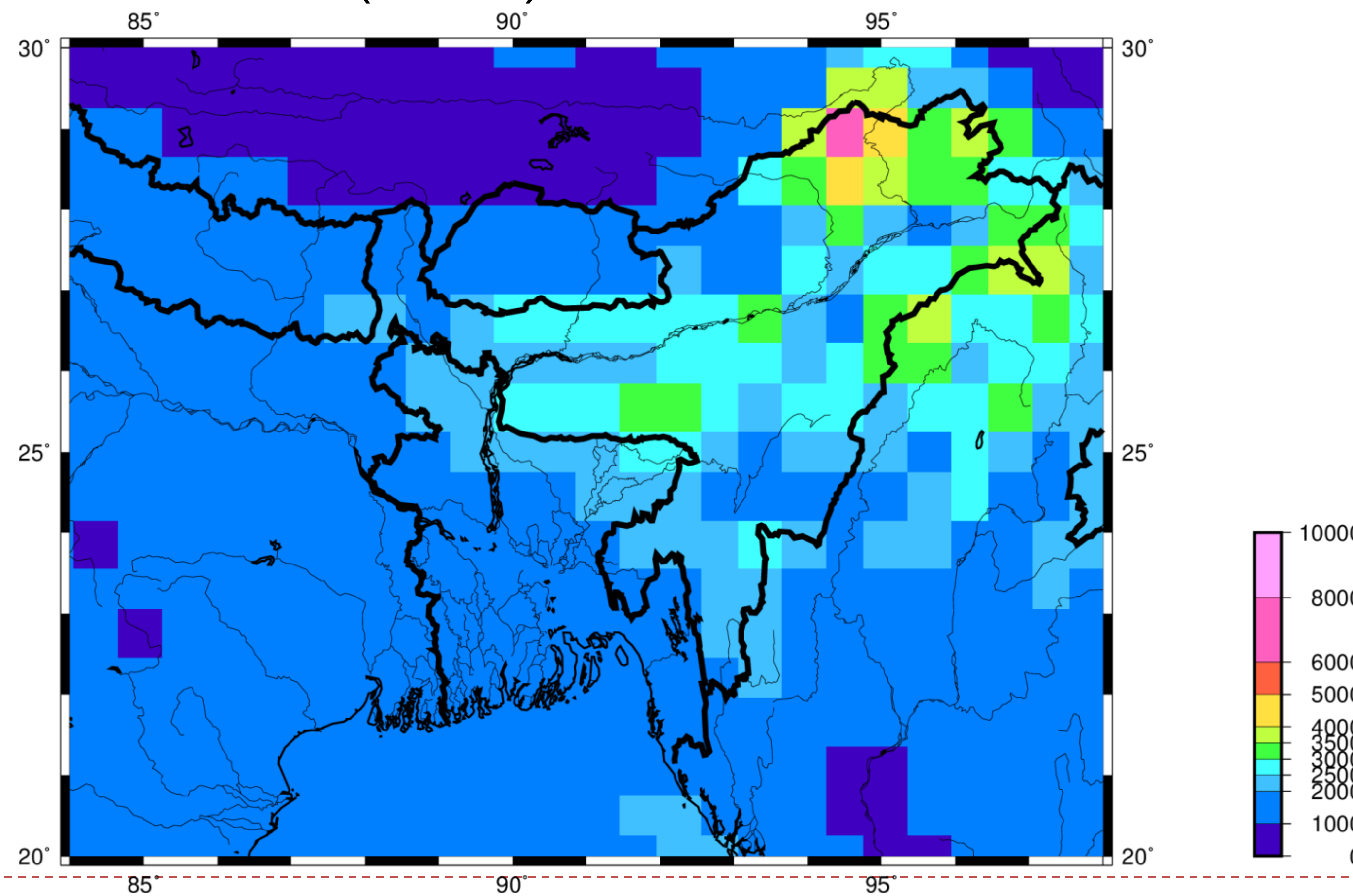
d4pdf

- Output of the Earth Simulator



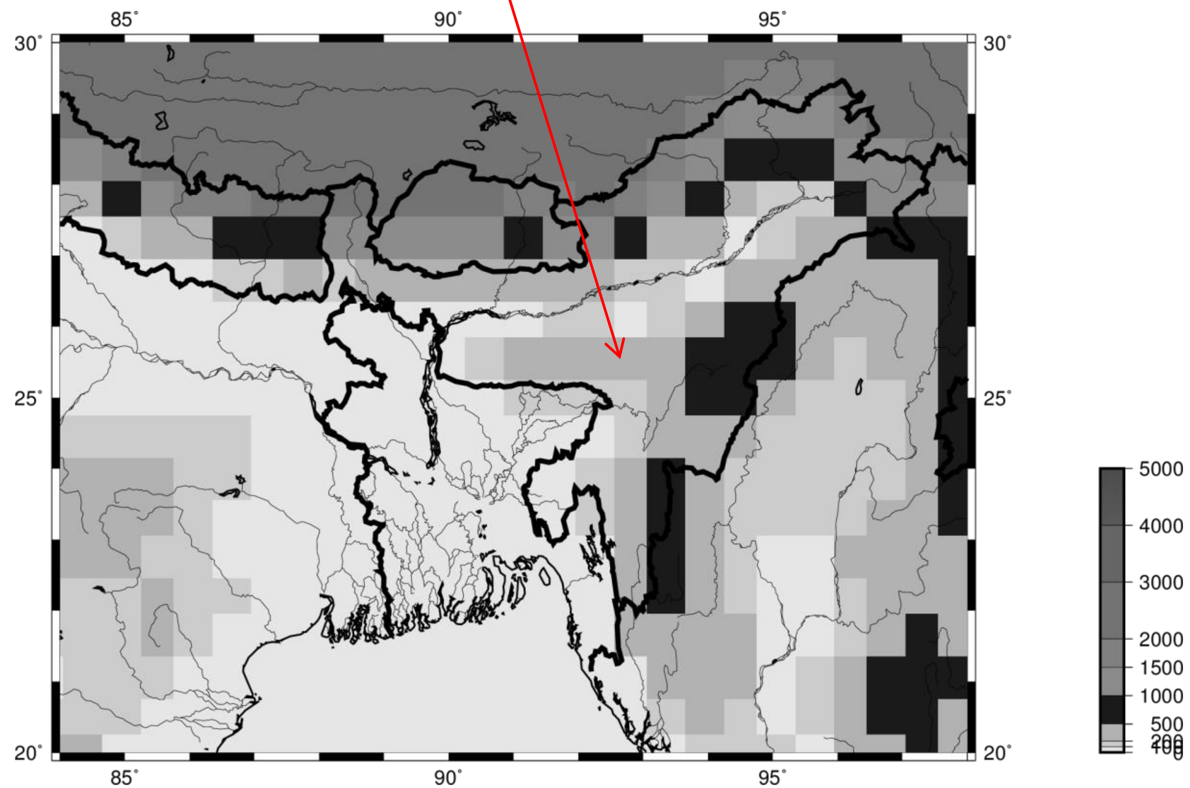
Annual rain in d4pdf climatic model

- Local maximum of annual rain at Meghalaya, but weak
- Resolution is too low (60km)



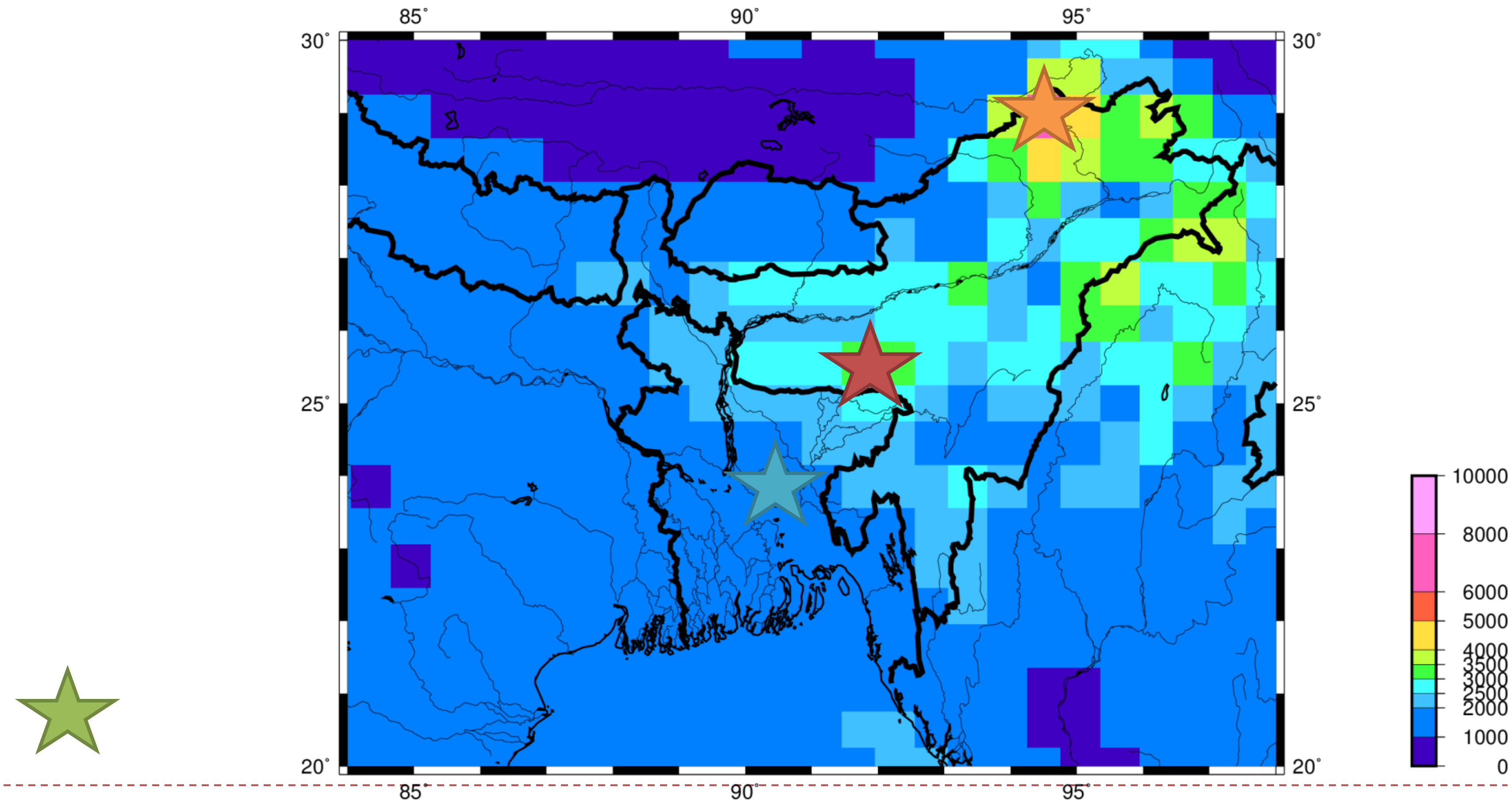
Topography in d4pdf model

- Real height of Meghalaya Plateau: 2,000 m
- Height in d4pdf model: below 500 m



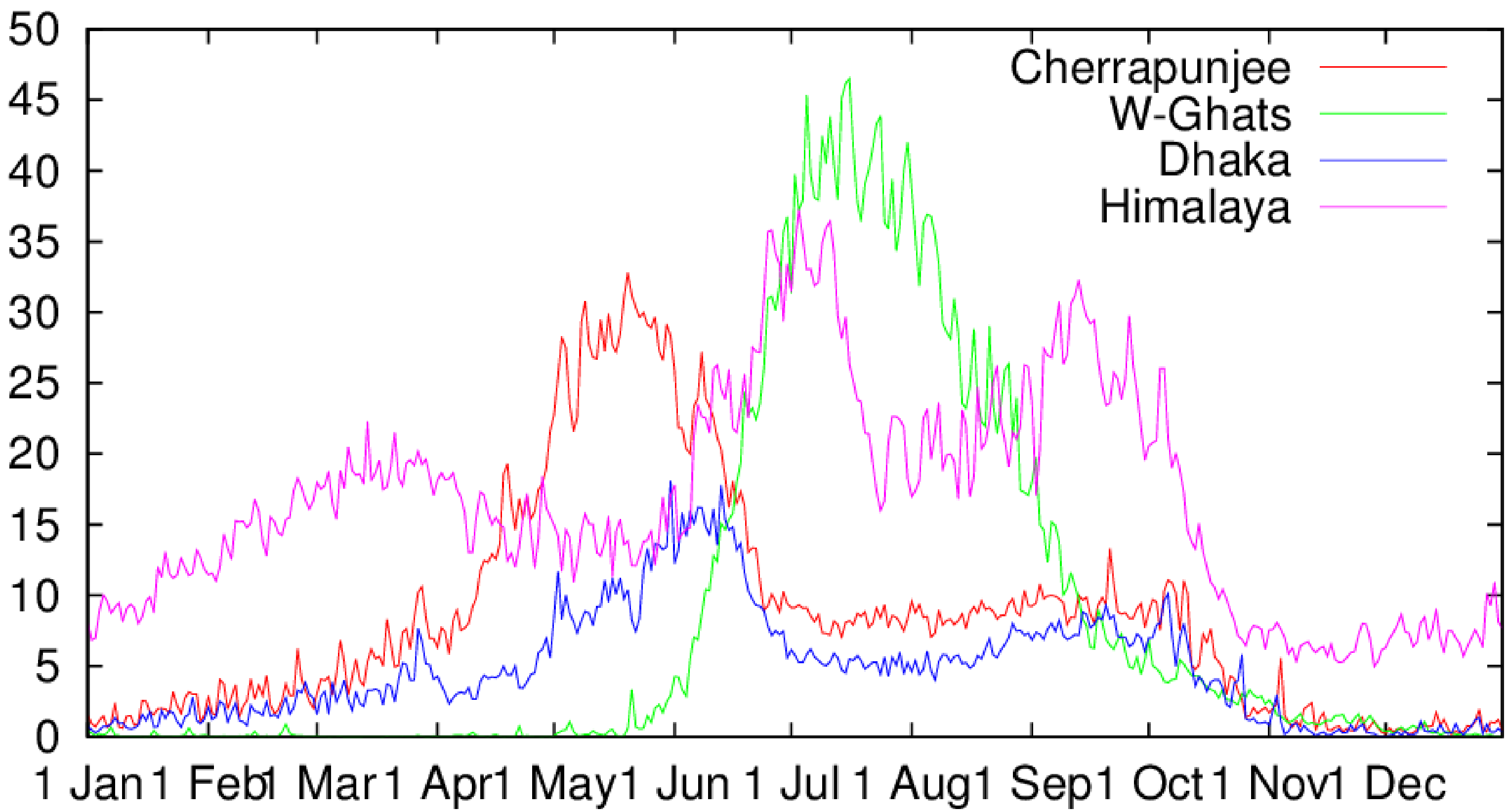
Annual rainfall variation in d4pdf

- We checked annual variations at selected points



d4pdf Climatology

- Climatological Annual Variation of Daily Rainfall
  - Cherrapunjee, Dhaka, Himalaya, W-Ghats



How TRMM/PR is reliable?

- TRMM/GPM observation is highly useful and reliable in many areas
- We validated TRMM/PR estimation using our raingauge network covering NE Indian subcontinent
- We detected severe underestimation of rainfall in Meghalaya and Sylhet area.

We Published Results in SOLA

- Validation of TRMM/PR by R-G Network in NE India

SOLA, 2017, Vol. 13, 157−162, doi:10.2151/sola.2017-029 157

Direct Validation of TRMM/PR Near Surface Rain over the Northeastern Indian Subcontinent Using a Tipping Bucket Raingauge Network

Toru Terao[1], Fumie Murata[2], Yusuke Yamane[3], Masashi Kiguchi[4], Azusa Fukushima[5], Masahiro Tanoue[4], Shamsuddin Ahmed[6], Sayeed Ahmed Choudhury[6], Hiambok Jones Syiemlieh[7], Laitpharlang Cajee[7], Abani Kumar Bhagabati[8], Prasanta Bhattacharya[8], Subashisa Dutta[9], Rahul Mahanta[10], and Taiichi Hayashi[11]

[1]*Faculty of Education, Kagawa University, Takamatsu, Kagawa, Japan*
[2]*Faculty of Science and Technology, Kochi University, Kochi, Japan*
[3]*Faculty of Education, Tokoha University, Shizuoka, Japan*
[4]*Institute of Industrial Science, The University of Tokyo, Tokyo, Japan*
[5]*Faculty of Humanity, Kobe Gakuin University, Kobe, Japan*
[6]*Bangladesh Meteorological Department, Dhaka, Bangladesh*
[7]*Department of Geography, North Eastern Hill University, Shillong, Meghalaya, India*
[8]*Department of Geography, Gauhati University, Guwahati, Assam, India*
[9]*Department of Civil Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam, India*
[10]*Department of Physics, Cotton University, Guwahati, Assam, India*
[11]*Center for Southeast Asian Studies, Kyoto University, Kyoto, Japan*

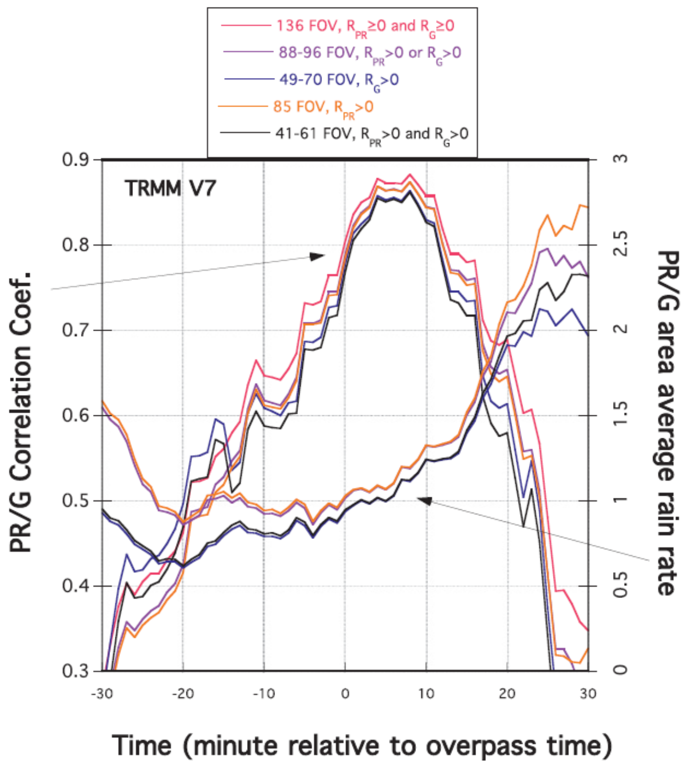
TRMM-2A25(V7) dataset

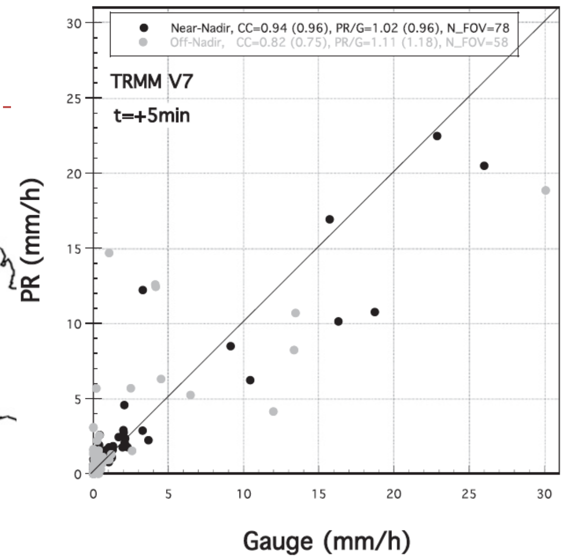
- TRMM
  - Sun async., 36N-36S, 402.5km
- TRMM-PR
  - Precipitation Radar
  - Swath: 247km
  - Resolution: 5km
  - vertical 250m(0-20km)
- TRMM 2A25(V7)
  - Renovation of algorithms for vertical rain profile (V6→V7)
  - rain, surface_rain were utilized.

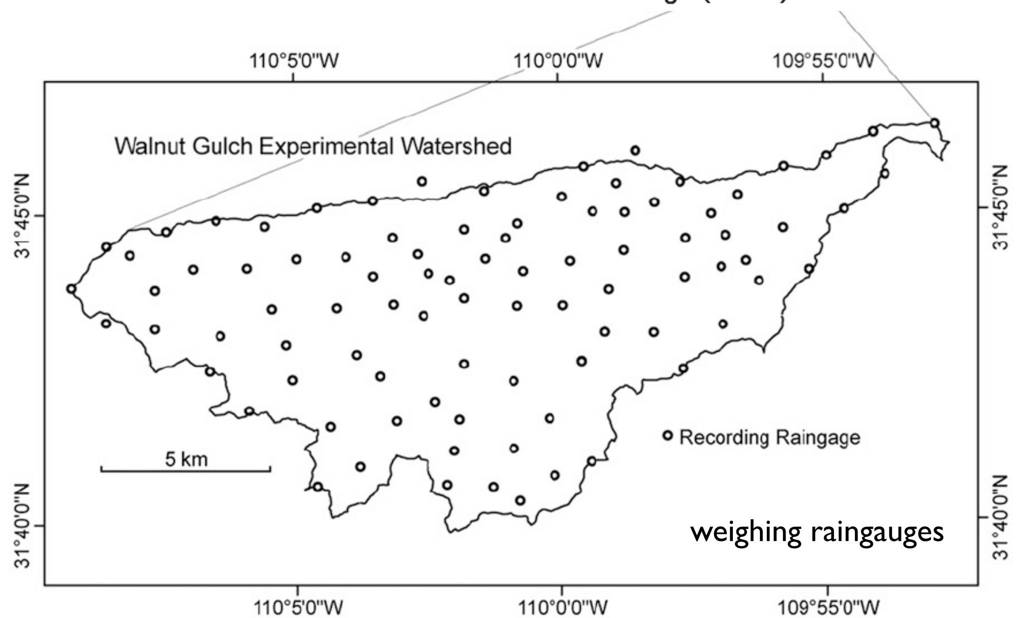
Review:

TRMM/RG comparison

- Amitai et al. (2012/JH)
  - Arizona WGEW
  - TRMM 2A25



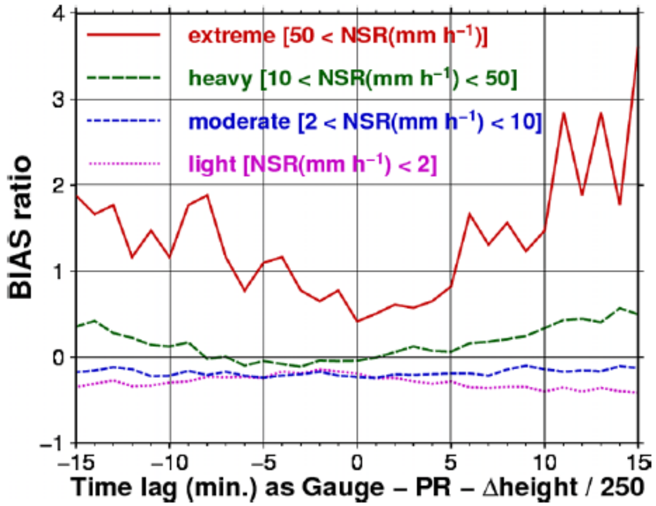


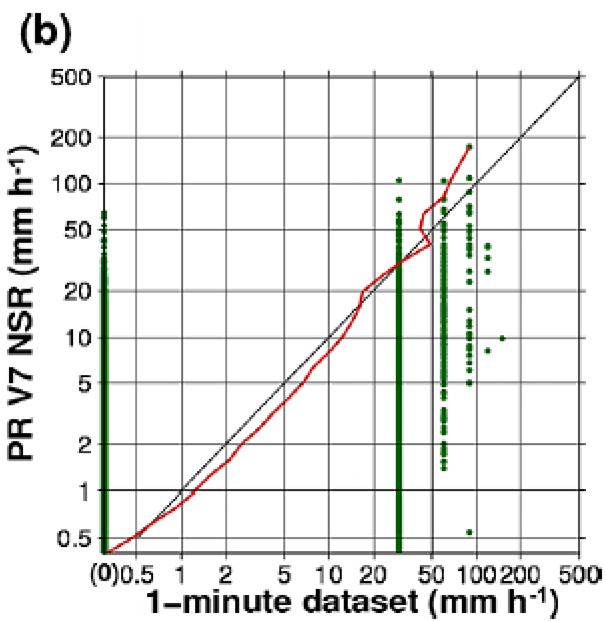


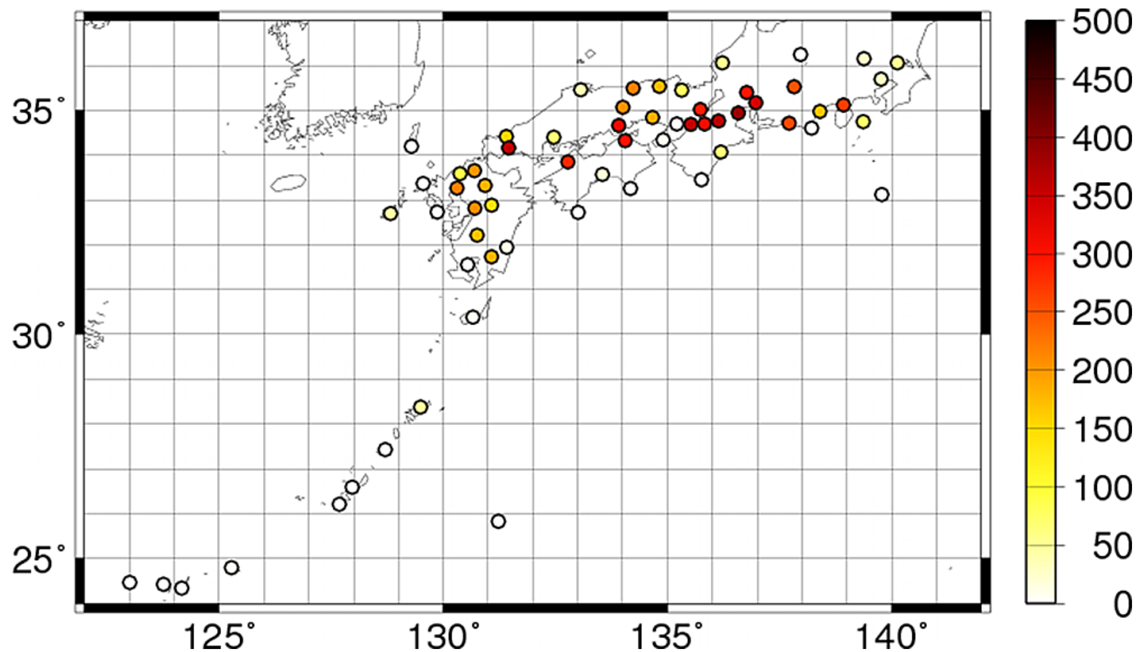
Review:

TRMM/RG comparison

- Seto et al. (2013)
  - JMA 1-minute, 10-minute
  - TRMM 2A25 near surface rain







Radar observation and limitation

- Radar reflectivity (z) and rainfall estimation (R)
  - R is not a function only of z. Dependency of R on z (z-R relationship) changes due to many factors associated with drop size distribution and some other.
  - For examples, drop size distribution changes regarding the cloud type (stratified, convective, cold, warm, ...), seasons, and geographical regions.
  - We should change the z-R relationship for different cloud type, season, and locations, determining the drop size distribution in each case. However, in many cases, we can not determine DSD only from observable parameters.
  - Other information on DSD have to be given by different empirical studies.
  - Errors can be detected from the comparison with raingauges.

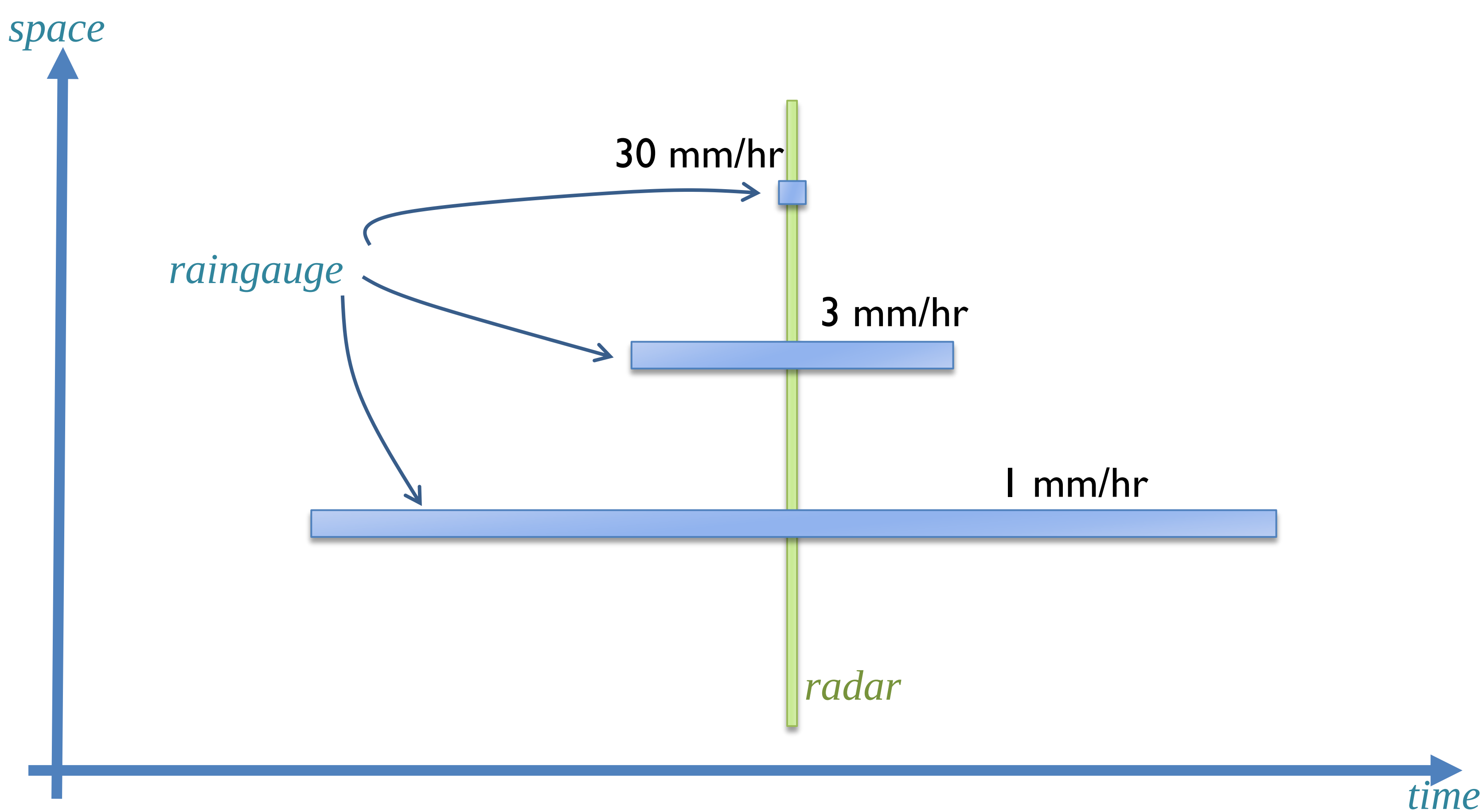
However, ...

Temporal Resolution of Raingauge

- Temporal resolution of tipping bucket raingauge (0.5 mm bucket size) rainfall estimation corresponds with the tipping interval. That is, it depends on averaged rainfall intensity of a time scale of tipping interval.
  - Tipping interval:
    - For 1 mm/hr -> 30 minutes
    - For 3 mm/hr -> 10 minutes
    - For 6 mm/hr -> 5 minutes
    - For 30 mm/hr -> 1 minute
    - For 60 mm/hr -> 30 seconds
    - For 180 mm/hr -> 10 seconds

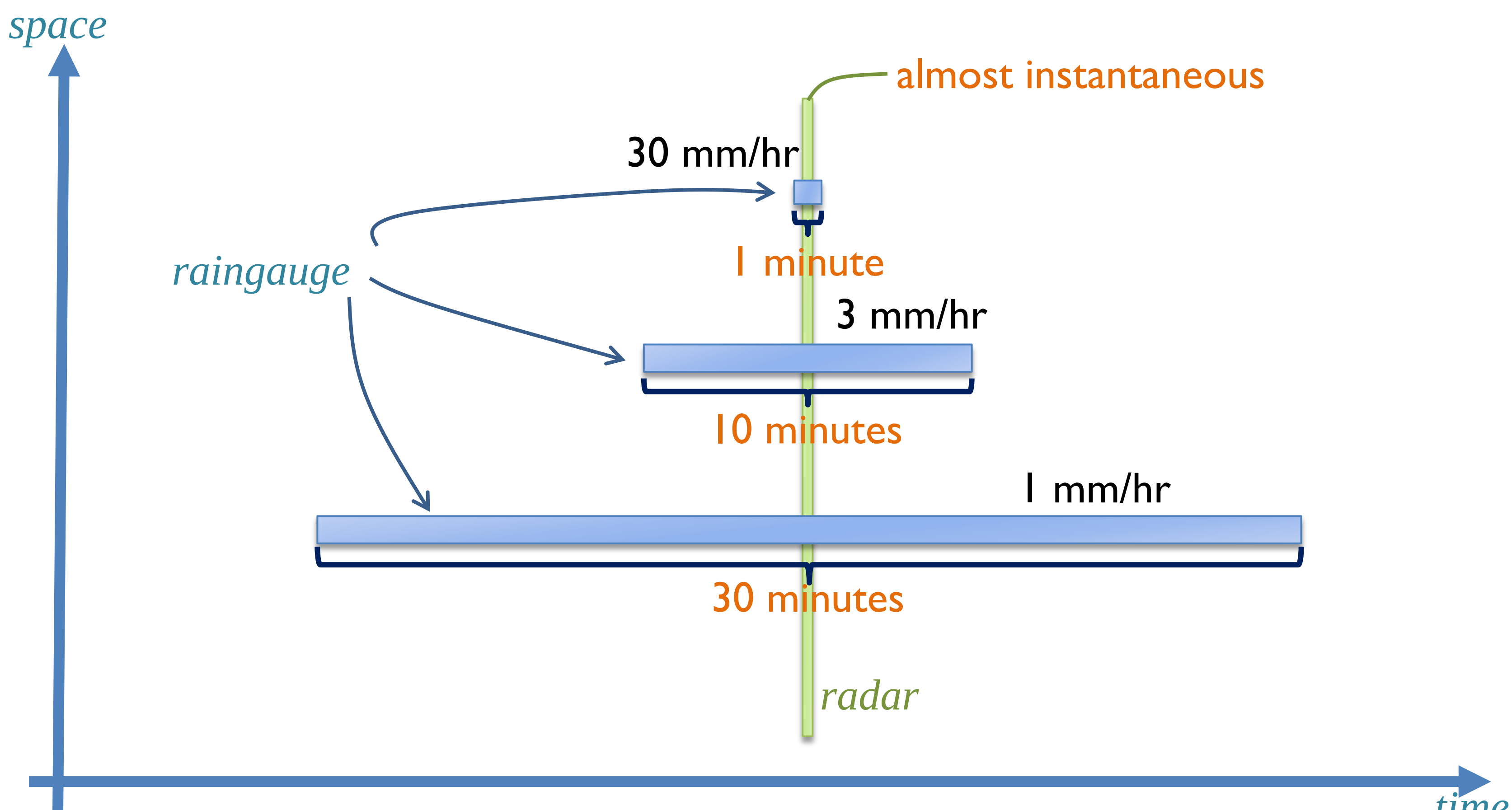
Raingauge and FOV of TRMM radar

- Space-time diagram of raingauge and radar observation



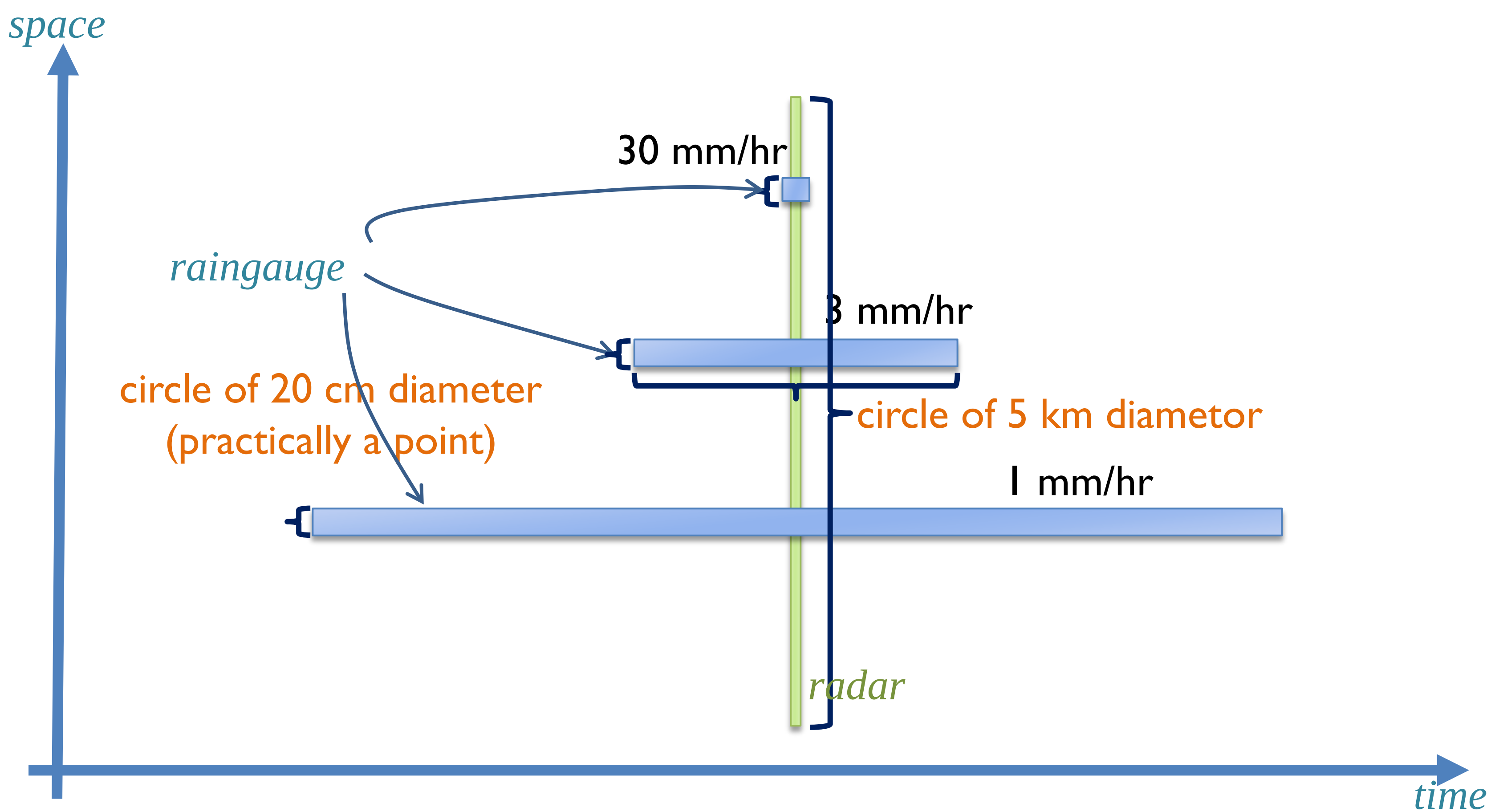
Raingauge and FOV of TRMM radar

- Space-time diagram of raingauge and radar observation



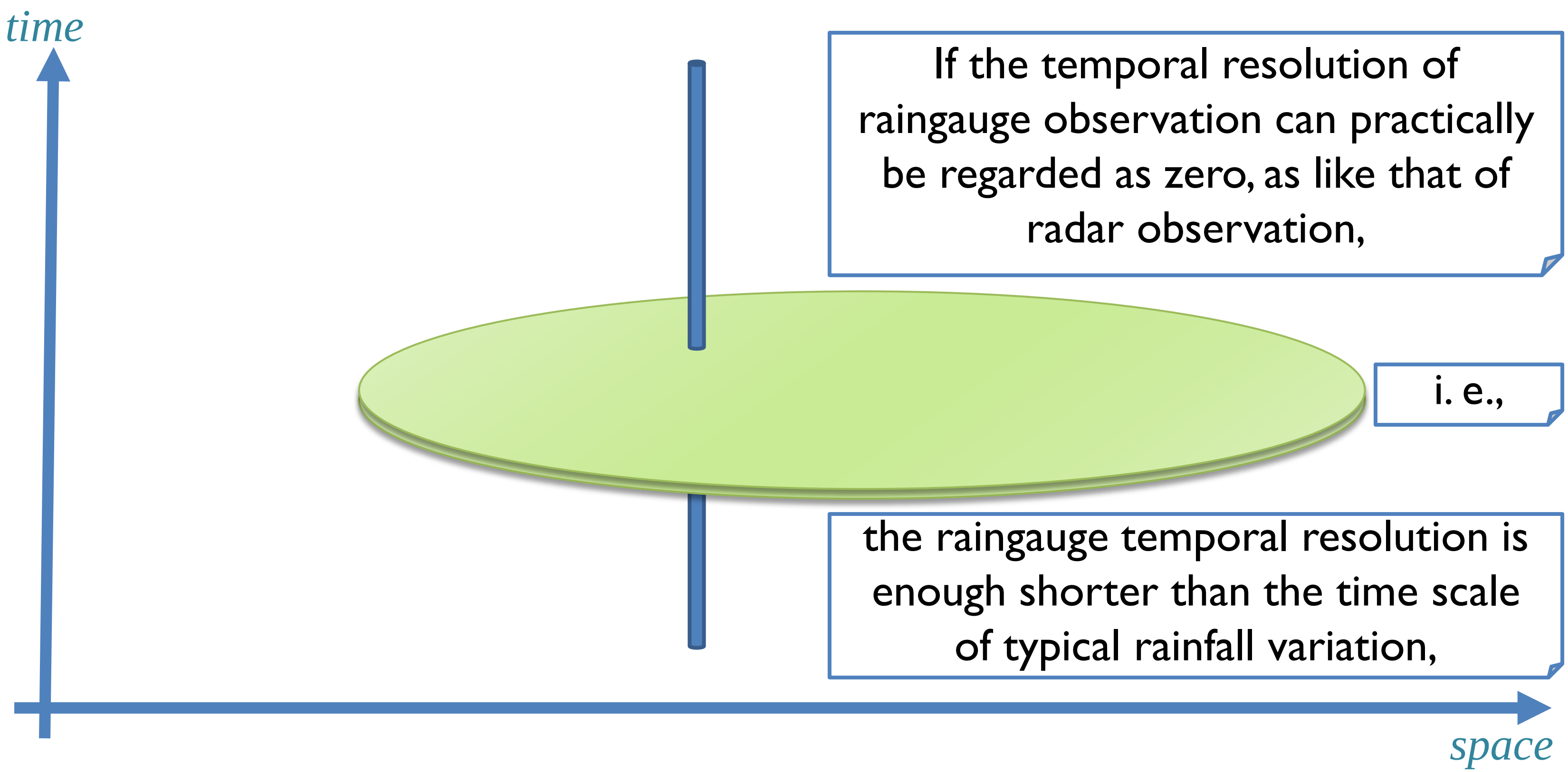
Raingauge and FOV of TRMM radar

- Space-time diagram of raingauge and radar observation



Raingauge and FOV of TRMM radar

- Schematic image of radar FOV and temporal coverage of raingauge observation



Raingauge and FOV of TRMM radar

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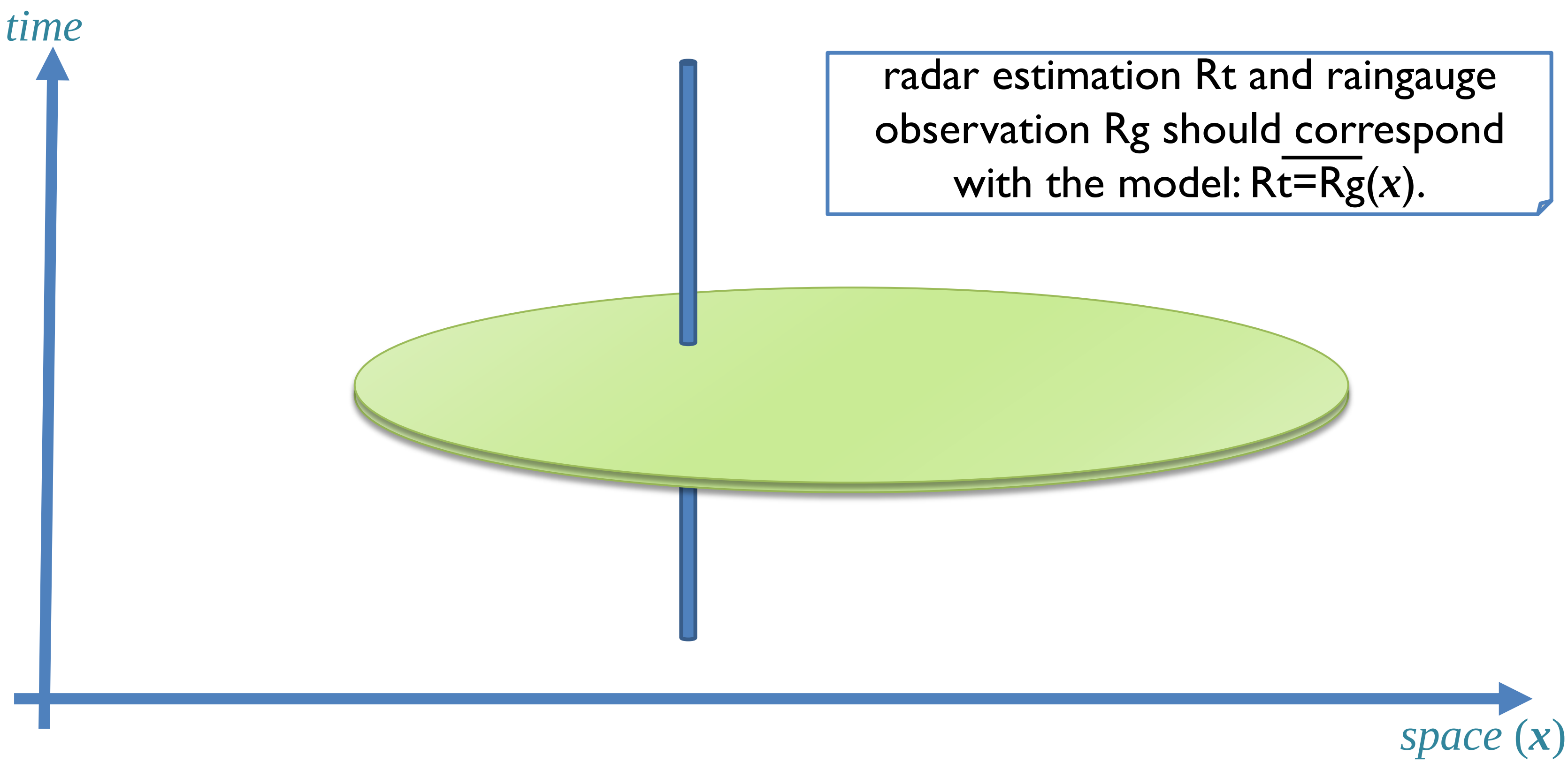

Raingauge and FOV of TRMM radar

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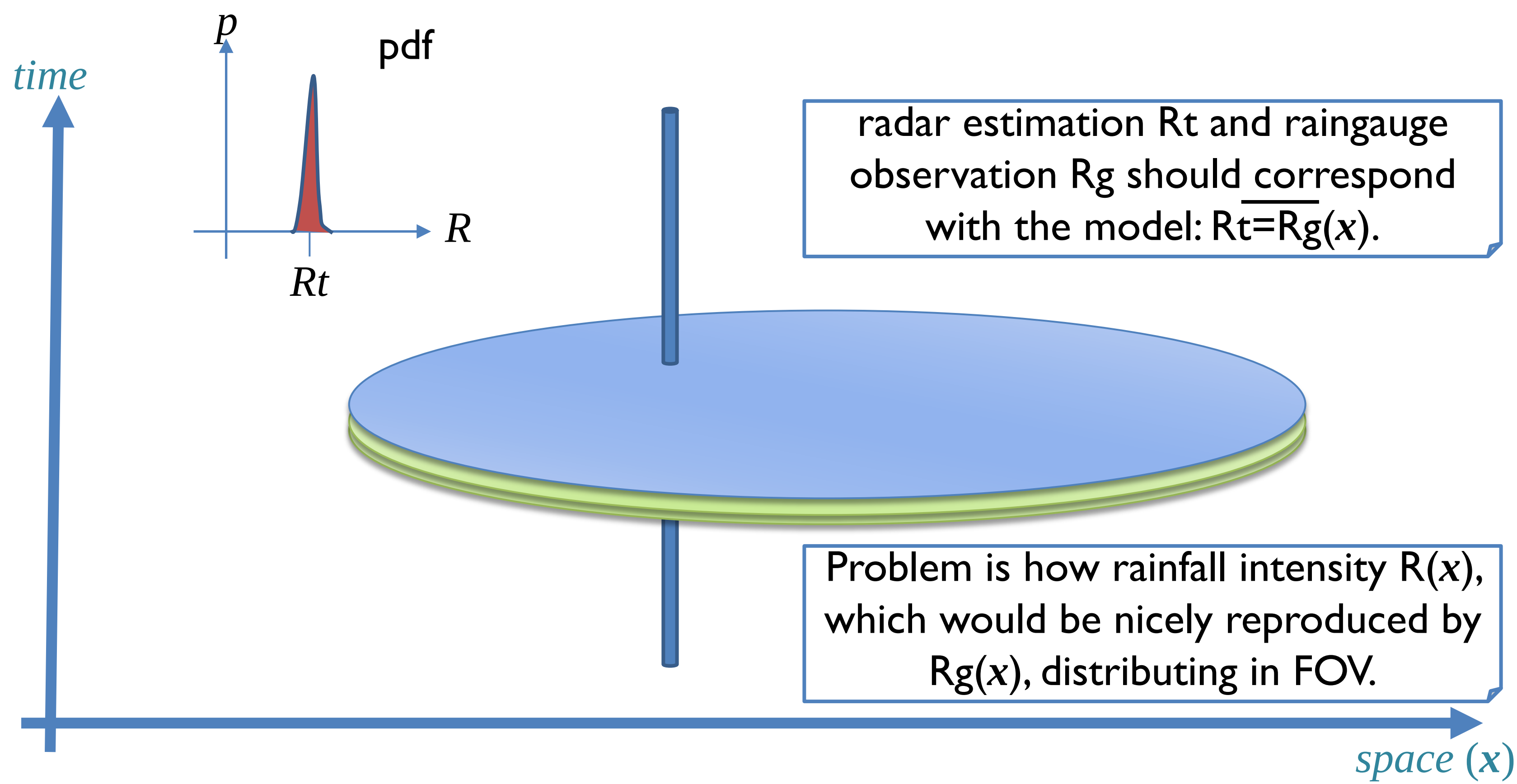
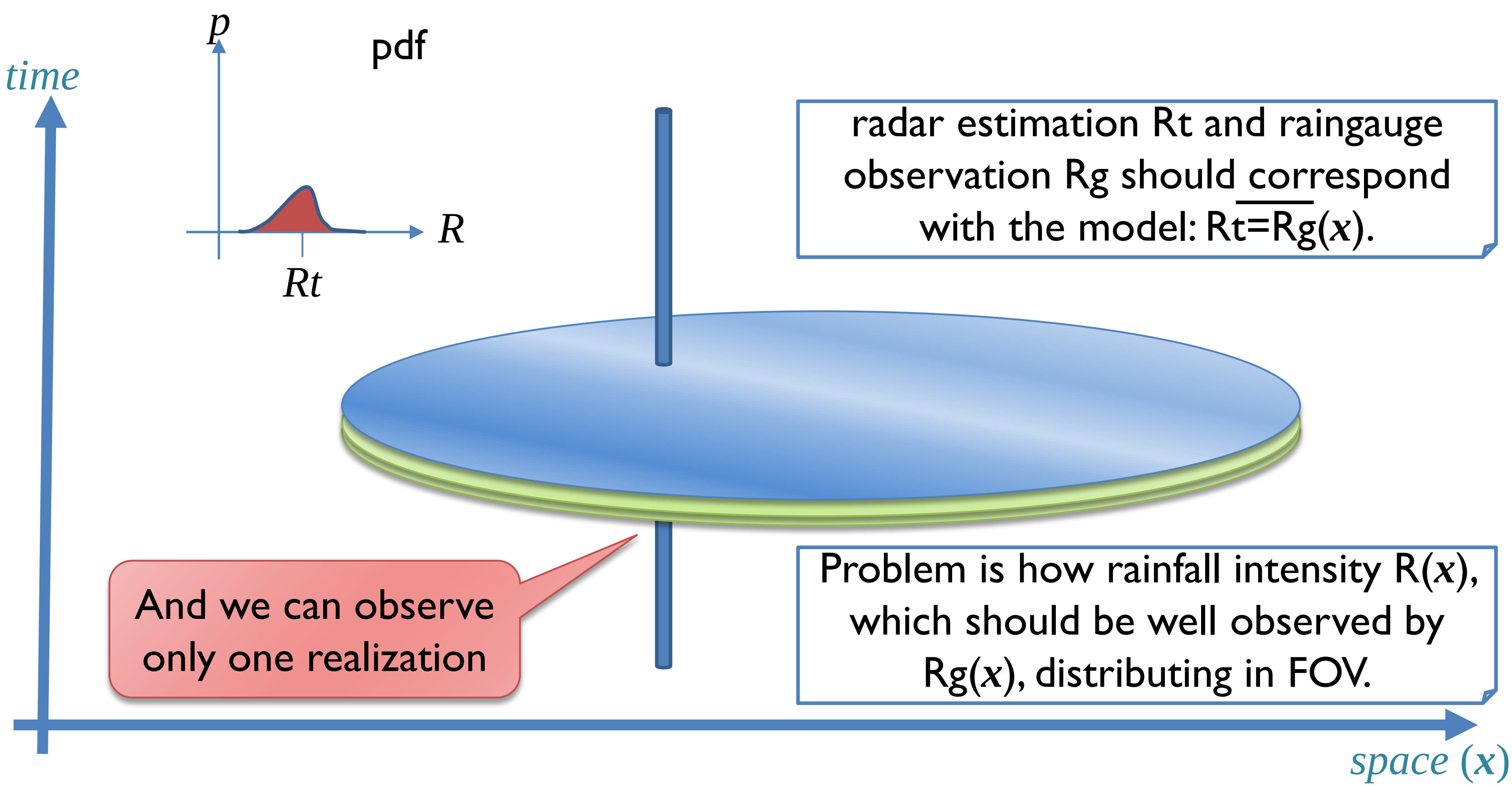


Raingauge and FOV of TRMM radar

- Schematic image of radar FOV and temporal coverage of raingauge observation



Hypothesis to be rejected

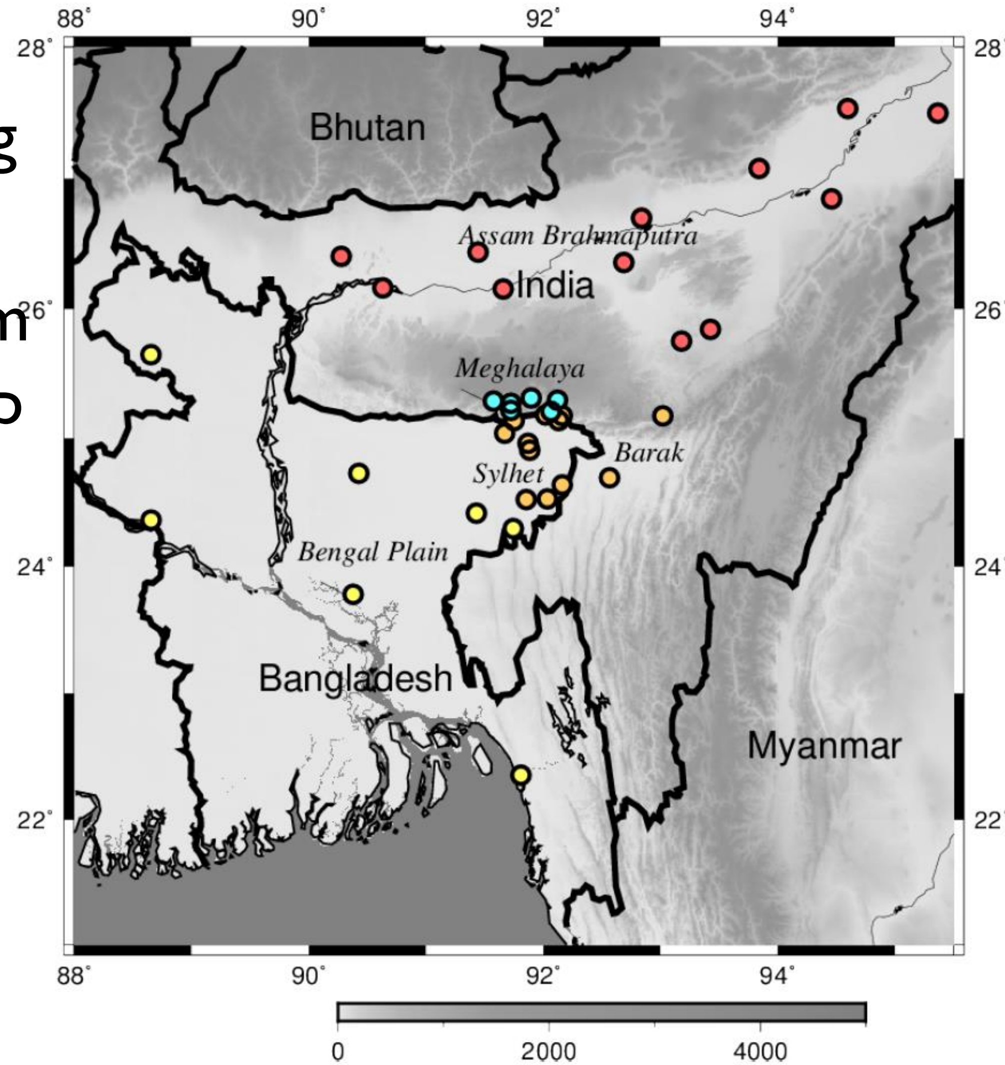
- Definition:
  - Rt: TRMM observation of rainfall
  - Rg: matchup raingauge observation estimated by tipping occurrence frequency for specific time window $2\Delta t$ (we used 5 minutes (300 seconds) in this paper)
- We evaluate the difference, d=Rt-Rg, for matchups.
  - all matchups / matchups for specific areas / matchups for specific ranges of Rt values, or other criteria
- Confidence interval of d should include {0}.
- Otherwise, we conclude that Rt overestimates or underestimates real rainfall intensity.

Confidence interval of Rt-Rg

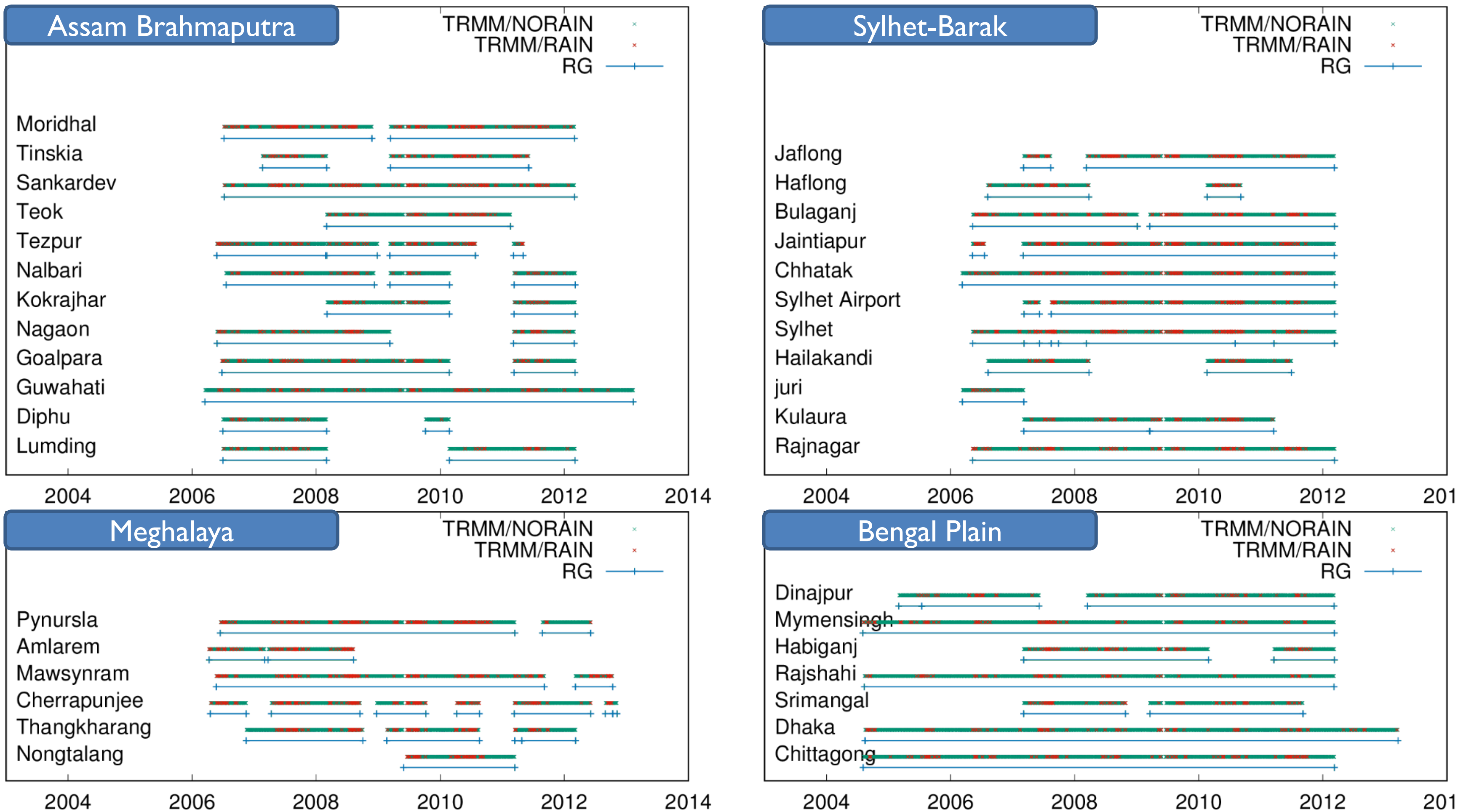
- Percentile method of bootstrap test (Efron 1979) was utilized in the present study
  - Start from samples {di|i=1, 2, ..., n}, Ave({di}).
  - We make B resamples {dj|j=ab1, ab2, ..., abn}b (b=1, 2, ..., B)
    - abi is determined by sampling with replacements.
    - Here we calculated Ave({dj})b for B=10,000.
  - An interval defined by 2.5 and 97.5 percentiles of calculated Ave({dj})b is defined as the 95% confidence interval. That by 0.5 and 99.5 percentiles is 99% confidence interval.

RG network in NE Indian subcontinent

- We conducted direct TRMM validation using 37 raingauges.
- They are Installed from 2004 and continued up to now.
- We obtained 29,172 matchups including 2,245 rainy cases.



Data Availability of Raingauges



List of raingauges

station	location °E/°N	observation period from-to	matchups rainy/all	number of data gaps
		Assam Brahmaputra		
Moridhal	27.53°N/94.60°E	7 Jul 2006-1 Mar 2012	105/1044	2
Tinskia	27.50°N/95.36°E	19 Feb 2007-5 Jun 2011	55/633	2
Sankardev	27.08°N/93.84°E	9 Jul 2006-1 Mar 2012	85/1083	1
Teok	26.84°N/94.46°E	3 Mar 2008-17 Feb 2011	38/551	1
Tezpur	26.70°N/92.84°E	26 May 2006-4 May 2011	60/766	4
Nalbari	26.44°N/91.44°E	20 Jul 2006-5 Mar 2012	47/797	3
Kokrajhar	26.40°N/90.28°E	5 Mar 2008-5 Mar 2012	33/536	2
Nagaon	26.36°N/92.69°E	27 May 2006-29 Feb 2012	47/699	2
Goalpara	26.16°N/90.63°E	25 Jun 2006-4 Mar 2012	58/836	2
Guwahati	26.15°N/91.66°E	17 Mar 2006-10 Feb 2013	63/1257	1
Diphu	25.84°N/93.42°E	30 Jun 2006-23 Feb 2010	15/366	2
Lumding	25.75°N/93.18°E	1 Jul 2006-4 Mar 2012	32/657	2

List of raingauges

station	location °E/°N	observation period from-to	matchups rainy/all	number of data gaps
		Meghalaya		
Pynursla	25.31°N/91.90°E	15 Jun 2006-4 Jun 2012	97/960	1
Amlarem	25.29°N/92.12°E	11 Apr 2006-7 Aug 2008	49/399	1
Mawsynram	25.29°N/91.58°E	23 May 2006-11 Oct 2012	119/1030	1
Cherrapunjee	25.27°N/91.72°E	18 Apr 2006-7 Nov 2012	108/793	5
Thangkharang	25.21°N/91.72°E	15 Nov 2006-8 Mar 2012	82/749	2
Nongtalang	25.21°N/92.07°E	29 May 2009-16 Mar 2011	37/301	0

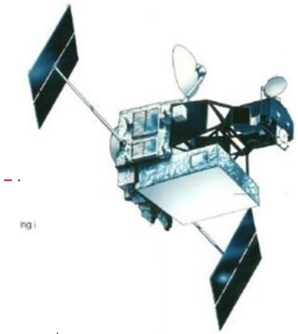
List of raingauges

station	location °E/°N	observation period from-to	matchups rainy/all	number of data gaps
		Sylhet-Barak		
Jaflong	25.18°N/92.02°E	6 Mar 2007-9 Mar 2012	88/757	1
Haflong	25.17°N/93.02°E	7 Aug 2006-5 Sep 2010	32/374	2
Bulaganj	25.14°N/91.75°E	11 May 2006-11 Mar 2012	99/972	1
Jaintiapur	25.14°N/92.13°E	9 May 2006-9 Mar 2012	107/899	1
Chhatak	25.04°N/91.67°E	10 Mar 2006-10 Mar 2012	92/1019	0
Sylhet Airport	24.96°N/91.87°E	9 Mar 2007-11 Mar 2012	62/825	1
Sylhet	24.91°N/91.88°E	11 May 2006-11 Mar 2012	80/812	2
Hailakandi	24.69°N/92.57°E	9 Aug 2006-30 Jun 2011	31/509	2
Juri	24.64°N/92.16°E	11 Mar 2006-8 Mar 2007	8/163	0
Kulaura	24.53°N/92.03°E	8 Mar 2007-18 Mar 2011	39/663	1
Rajnagar	24.52°N/91.85°E	10 May 2006-11 Mar 2012	67/971	0

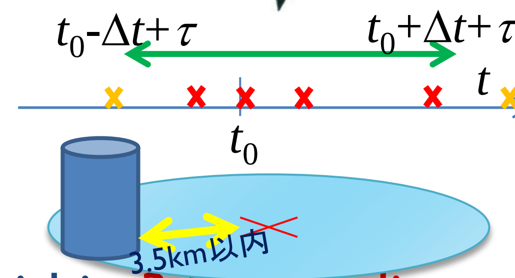
List of raingauges

station	location °E/°N	observation period from-to	matchups rainy/all	number of data gaps
		Bengal Plain		
Dinajpur	25.65°N/88.65°E	1 Mar 2005-8 Mar 2012	47/1112	3
Mymensingh	24.73°N/90.43°E	2 Aug 2004-9 Mar 2012	62/1296	1
Habiganj	24.41°N/91.43°E	7 Mar 2007-10 Mar 2012	44/654	1
Rajshahi	24.36°N/88.65°E	11 Aug 2004-7 Mar 2012	52/1259	1
Srimangal	24.30°N/91.74°E	7 Mar 2007-6 Sep 2011	46/685	1
Dhaka	23.78°N/90.38°E	15 Aug 2004-19 Mar 2013	67/1415	1
Chittagong	22.35°N/91.81°E	4 Aug 2004-10 Mar 2012	79/1190	1

TRMM/RG validation method



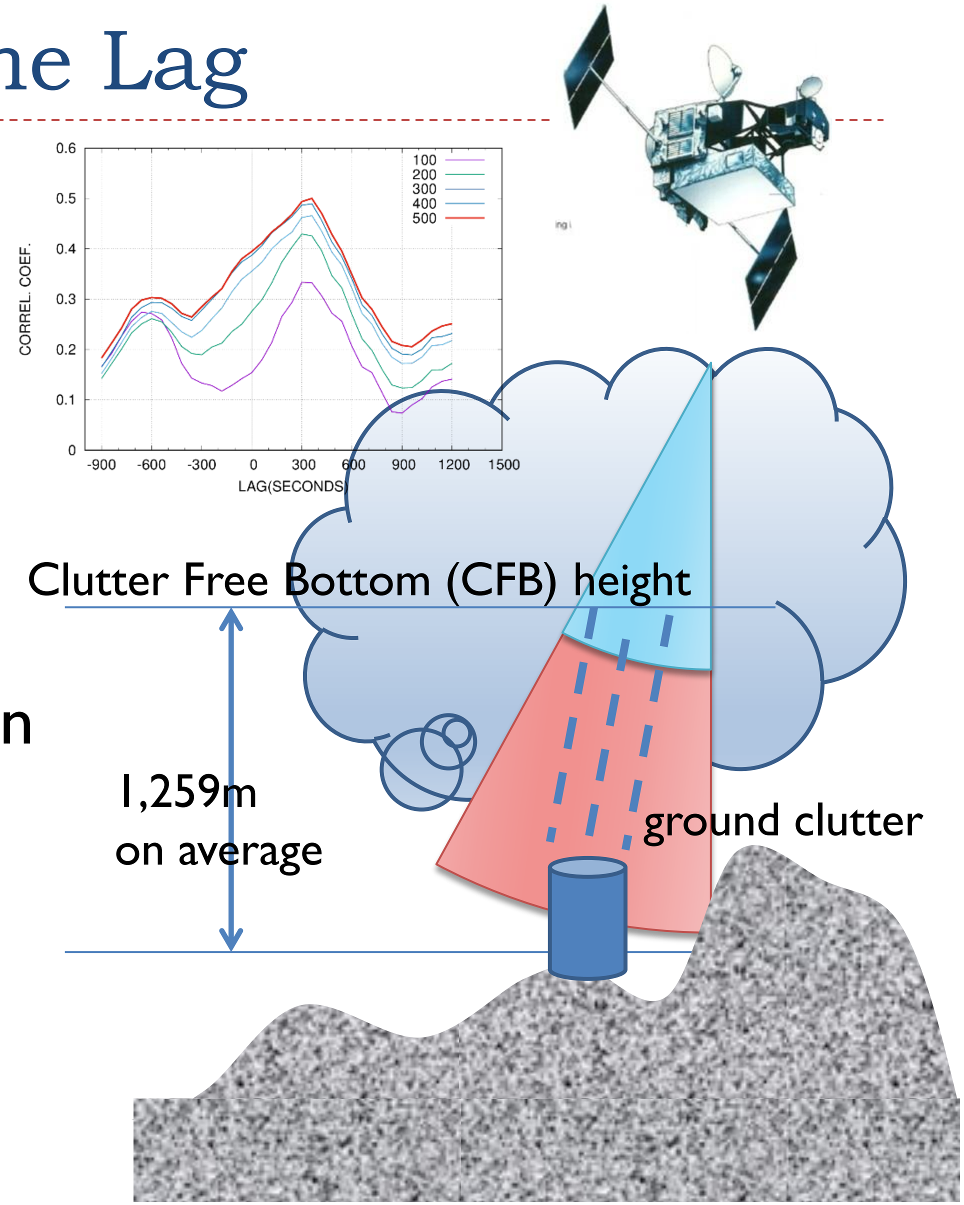
- TRMM data
  - TRMM-2A25(V7) 1998-2013
  - Swath passes over RG almost once a day.



- Rainfall amount estimation
  - Cases when the FOV passed over the area within 3.5km radius are analyzed.
  - RG tipping events within the $2\Delta t$ seconds (Δt=150s) centered by the scanning time t_0 are counted.
  - Considering the rain drop descending time, a lag τ was applied for the estimation (Amitai et al. 2012).
  - Rain intensity (mm/h) was estimated and compared.

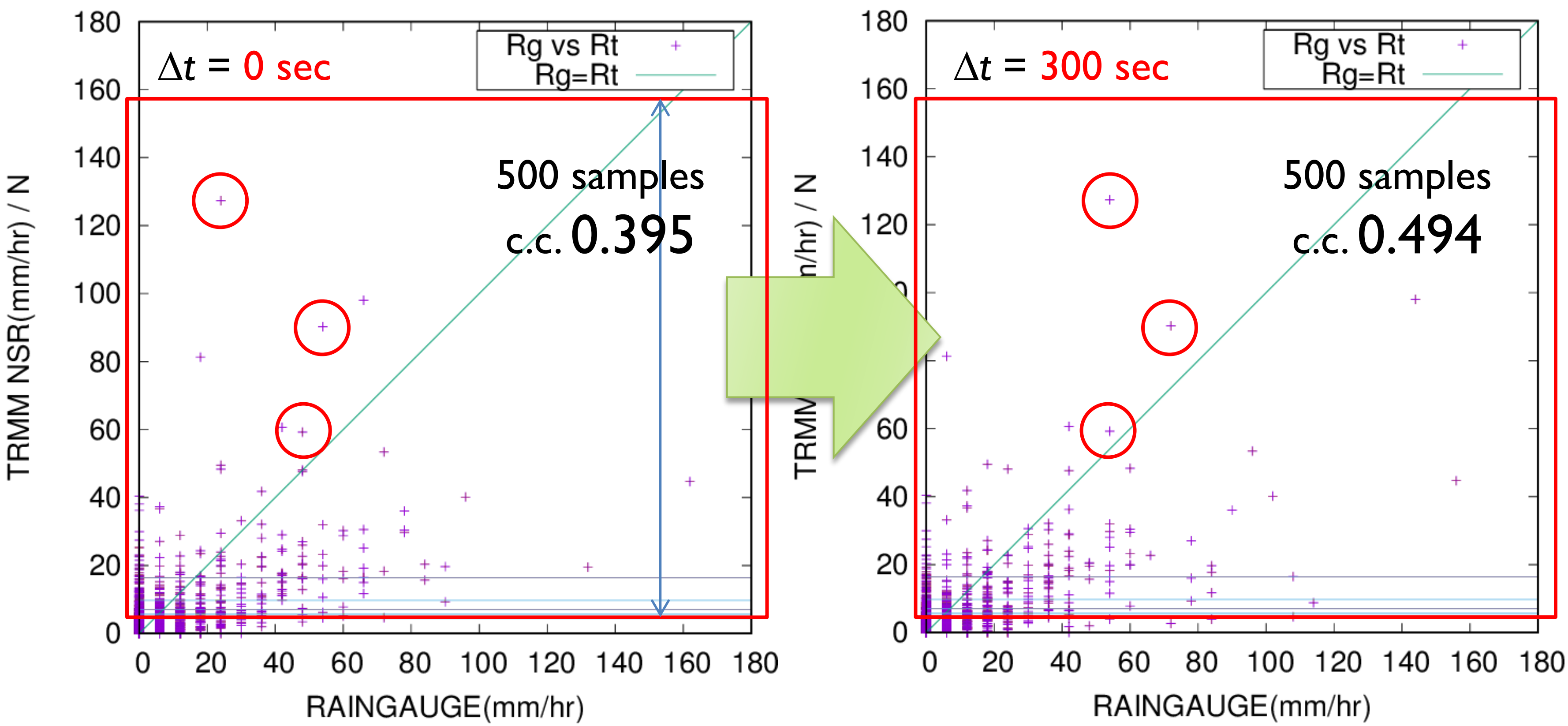
CFB Height and Time Lag

- Time lag is expected between the TRMM/PR and raingauge observations.
- Rt and Rg must best match if we consider appropriate time lag of Rg behind Rt.
- We calculate the correlation coefficient between Rg and Rt with different lags.



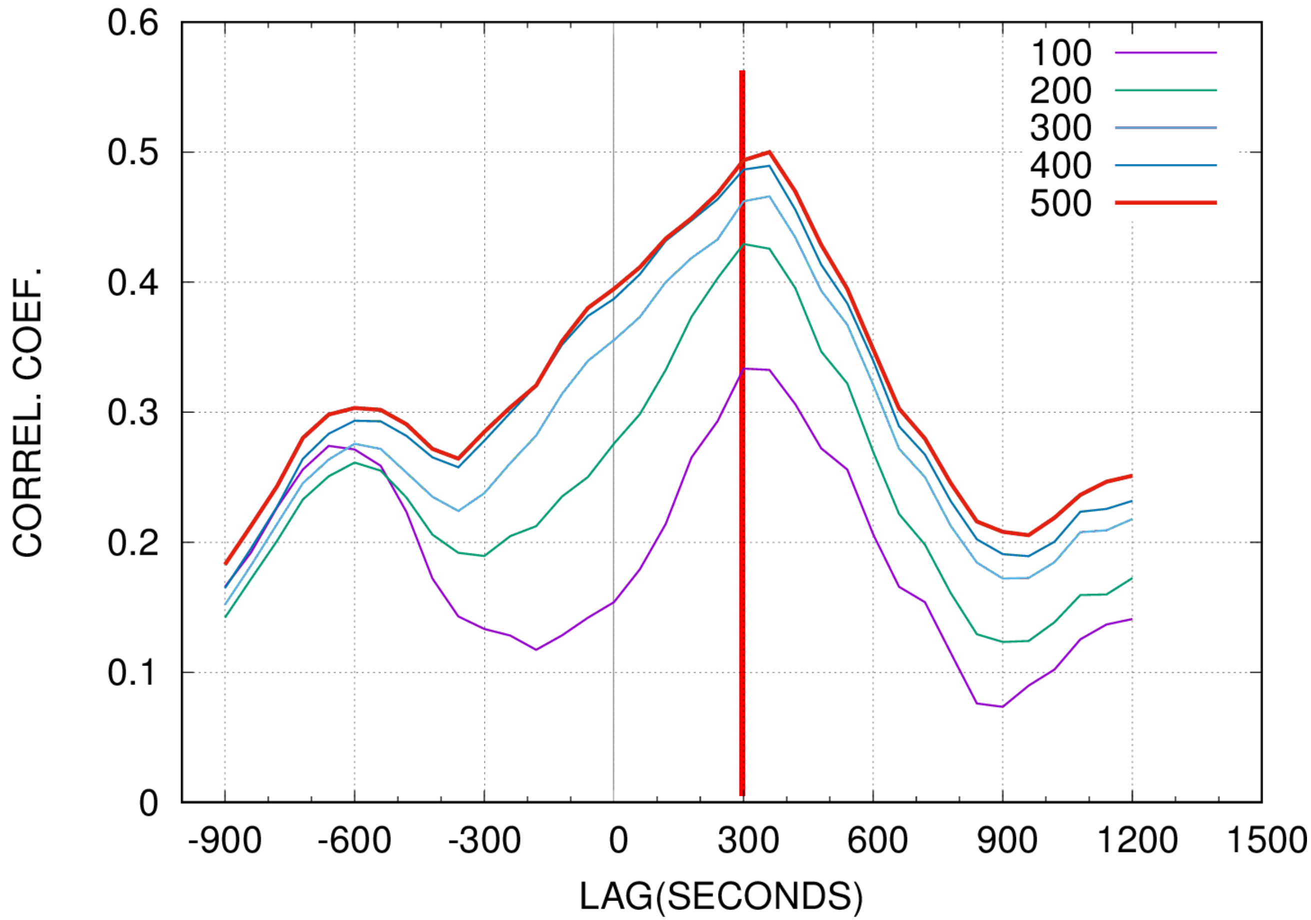
Matching with lags

- Some become better, some become worse …
- But it improved if we consider time lag Δt=300 sec

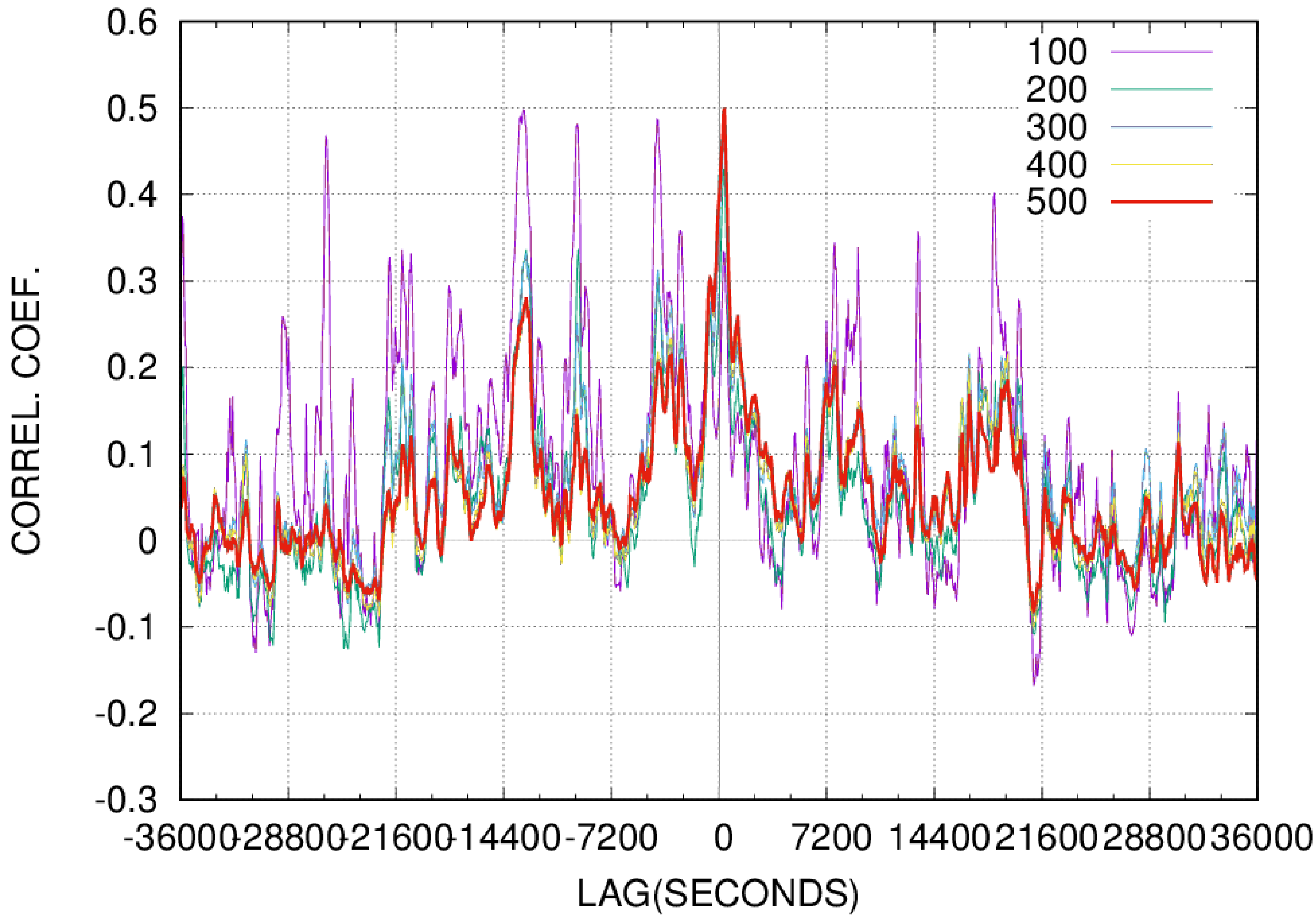


Detection of the Best Lag

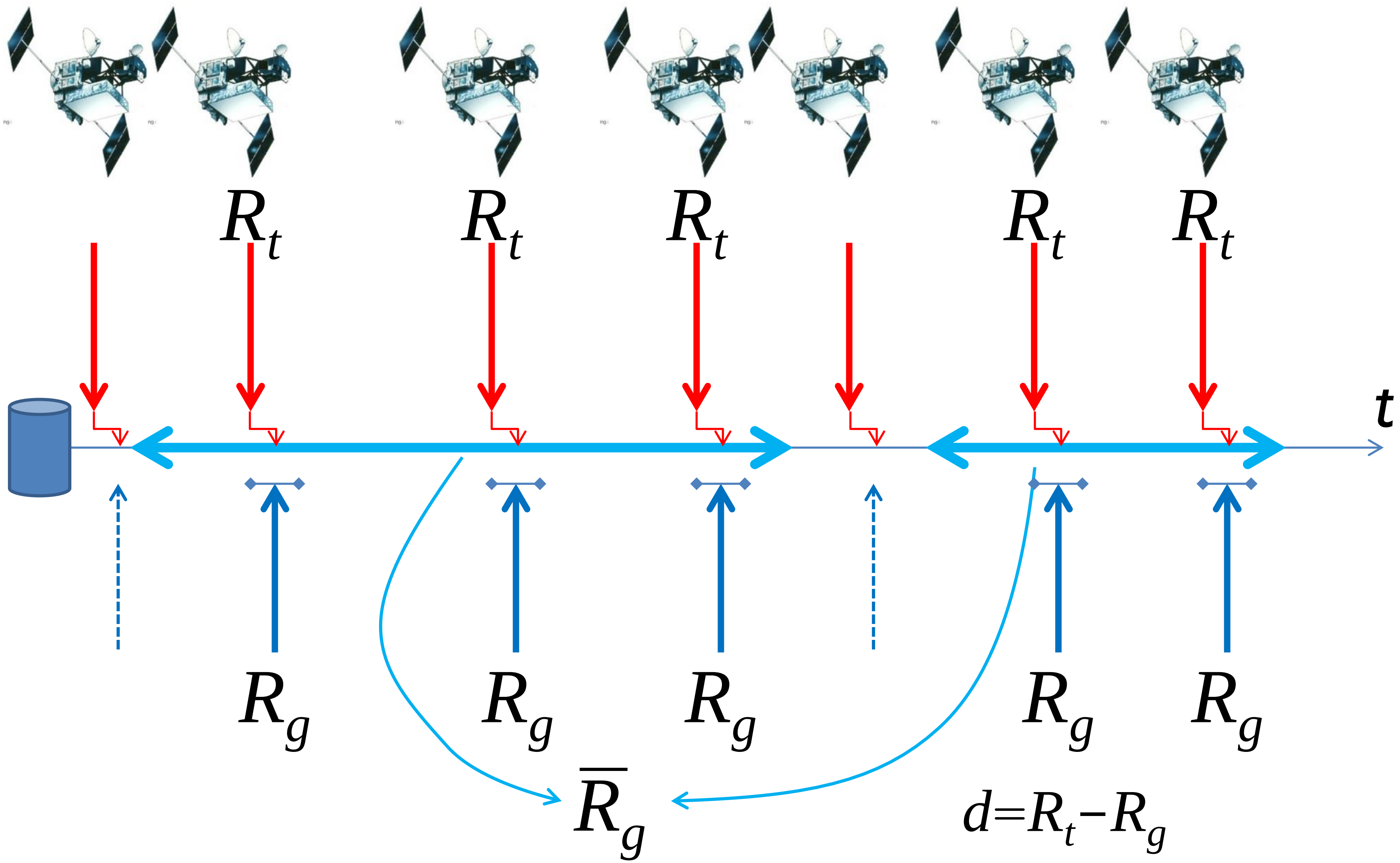
- We detected appropriate time lag of 300 seconds.



Full calculation -10hour – 10hour lag

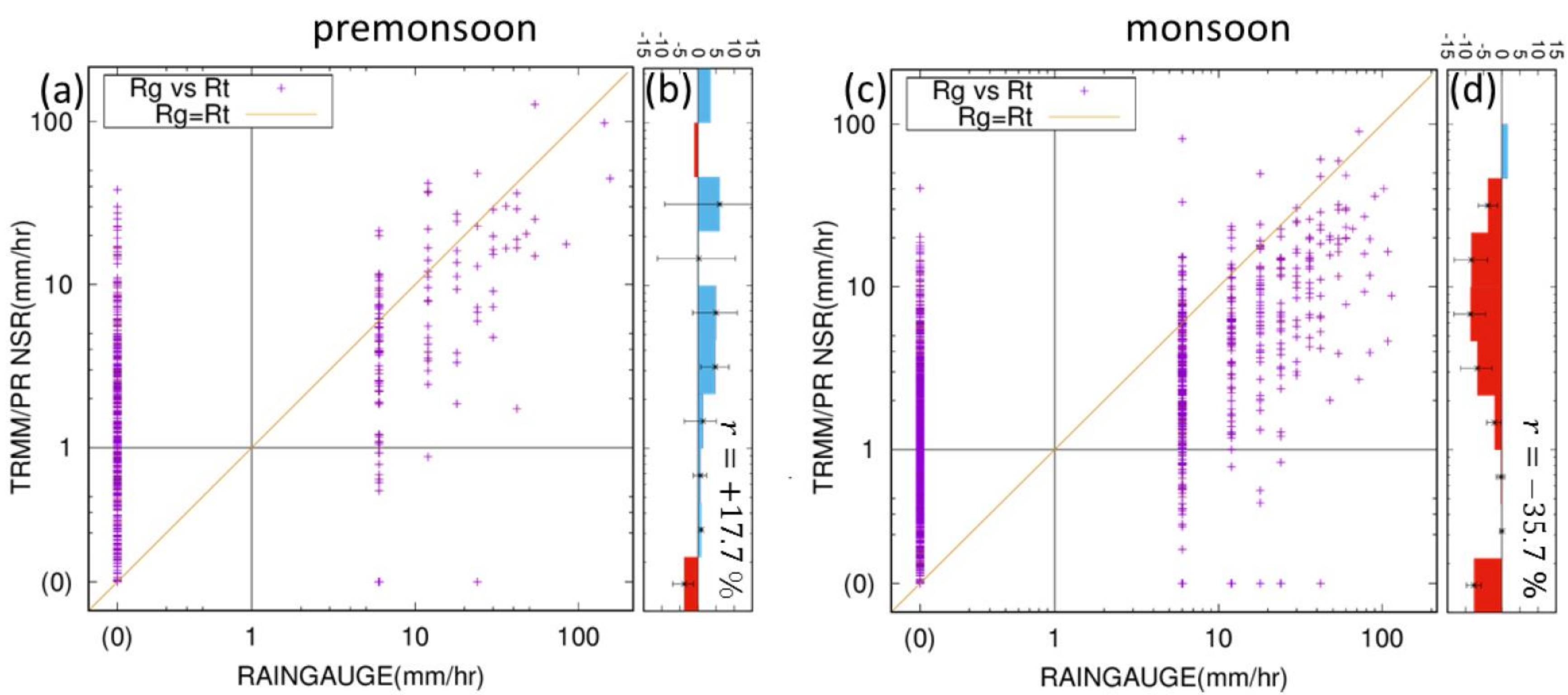


Raingauge (R_g) and TRMM (R_t)



Rg-Rt Diagram for Premonsoon & Monsoon

- Premonsoon (Apr.-May): No significant difference
- Monsoon (Jun.-Sep.): Significant underestimation



Summary of results

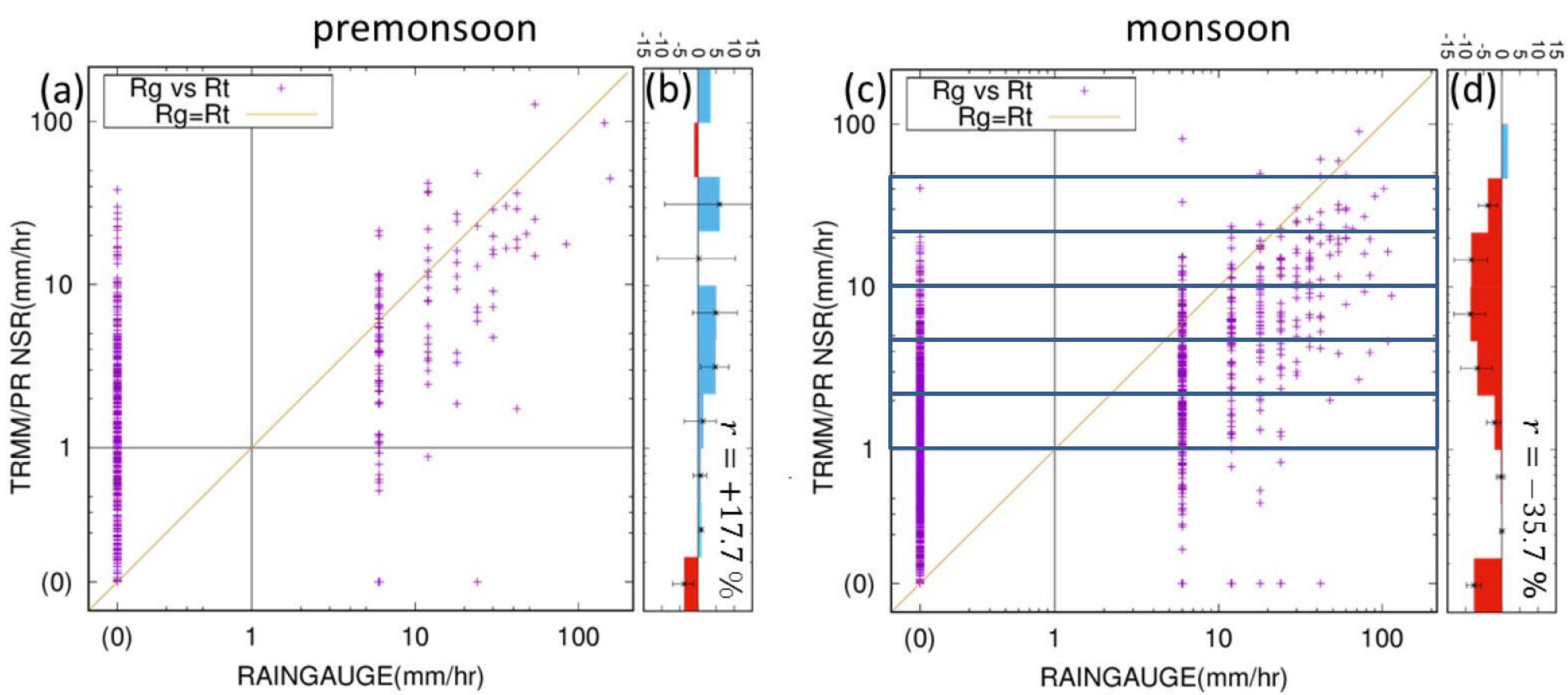
Table 1. List of statistics for the matchups between TRMM/PR NSR and raingauge over four subregions for monsoon and premonsoon seasons. The bias ratio r and its 99% and 95% bootstrap confidence intervals, which were identified by 0.5, 2.5, 97.5 and 99.5 percentiles, were tabulated. Statistically significant bias ratios at 95% and 99% confidence levels were indicated by italic and bold faces, respectively.

subregion	0.5%	2.5%	average	97.5%	99.5%	bias ratio
			premonsoon			
Assam Brahmaputra	0.011	0.028	0.083	0.141	0.162	**49.4%**[a]
Meghalaya	−0.517	−0.381	−0.026	0.300	0.403	−2.9%
Sylhet-Barak	−0.066	−0.032	0.068	0.163	0.198	24.2%
Bengal Plain	−0.001	0.009	0.041	0.073	0.083	*57.0%*[b]
all	−0.037	−0.014	0.051	0.111	0.127	17.66%
			monsoon			
Assam Brahmaputra	−0.159	−0.132	−0.059	0.011	0.033	−13.8%
Meghalaya	−1.701	−1.584	−1.205	−0.844	−0.752	**−51.3%**
Sylhet-Barak	−0.609	−0.543	−0.363	−0.202	−0.154	**−35.2%**
Bengal Plain	−0.172	−0.132	−0.031	0.056	0.084	−8.1%
all	−0.428	−0.398	−0.314	−0.236	−0.212	**−35.7%**

[a] not significant for $D = 2.5$ km case.
[b] not significant for $\tau = 360$ seconds case.

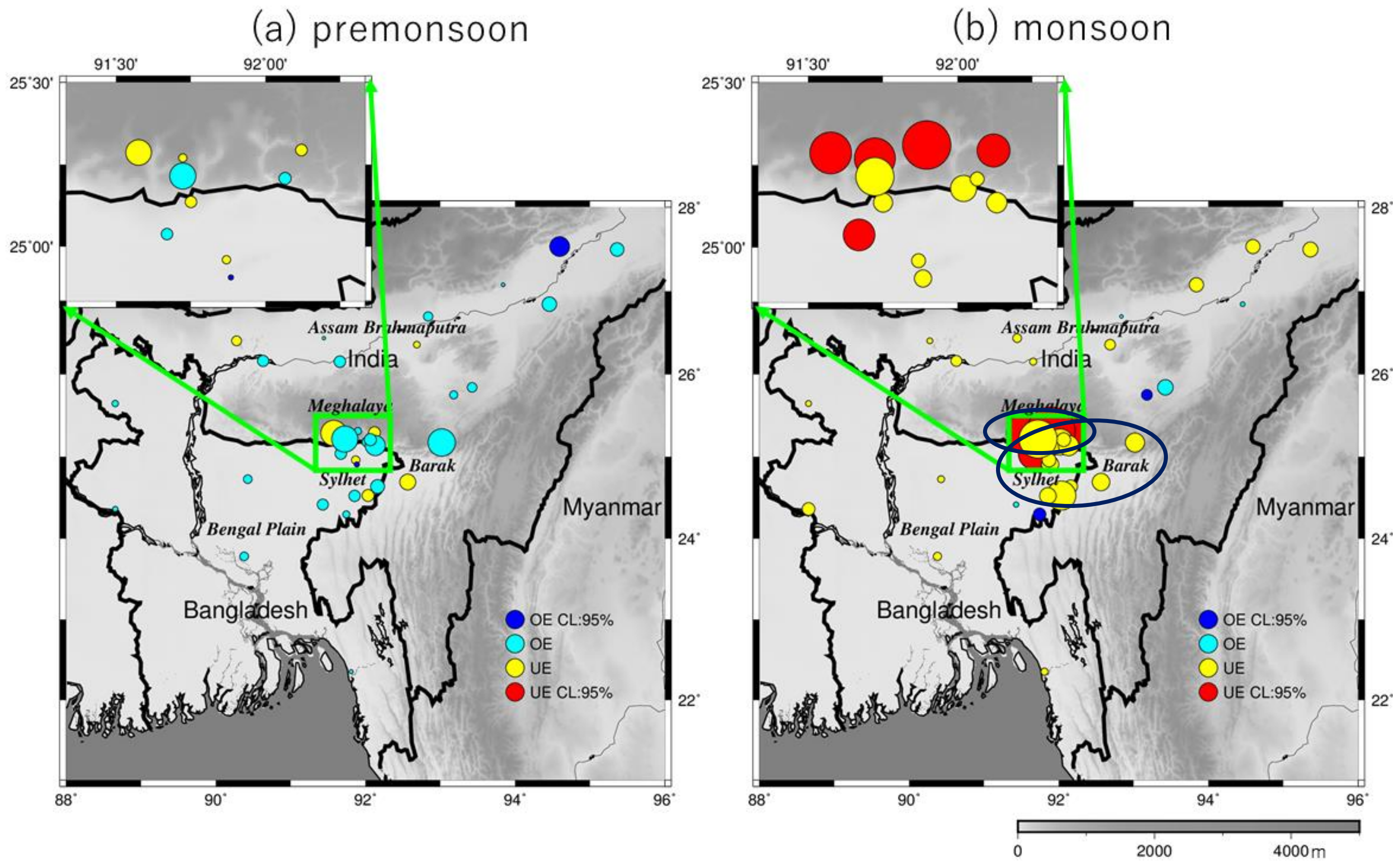
Rg-Rt Diagram for Premonsoon & Monsoon

- Premonsoon (Apr.-May): No significant difference
- Monsoon (Jun.-Sep.): Significant underestimation



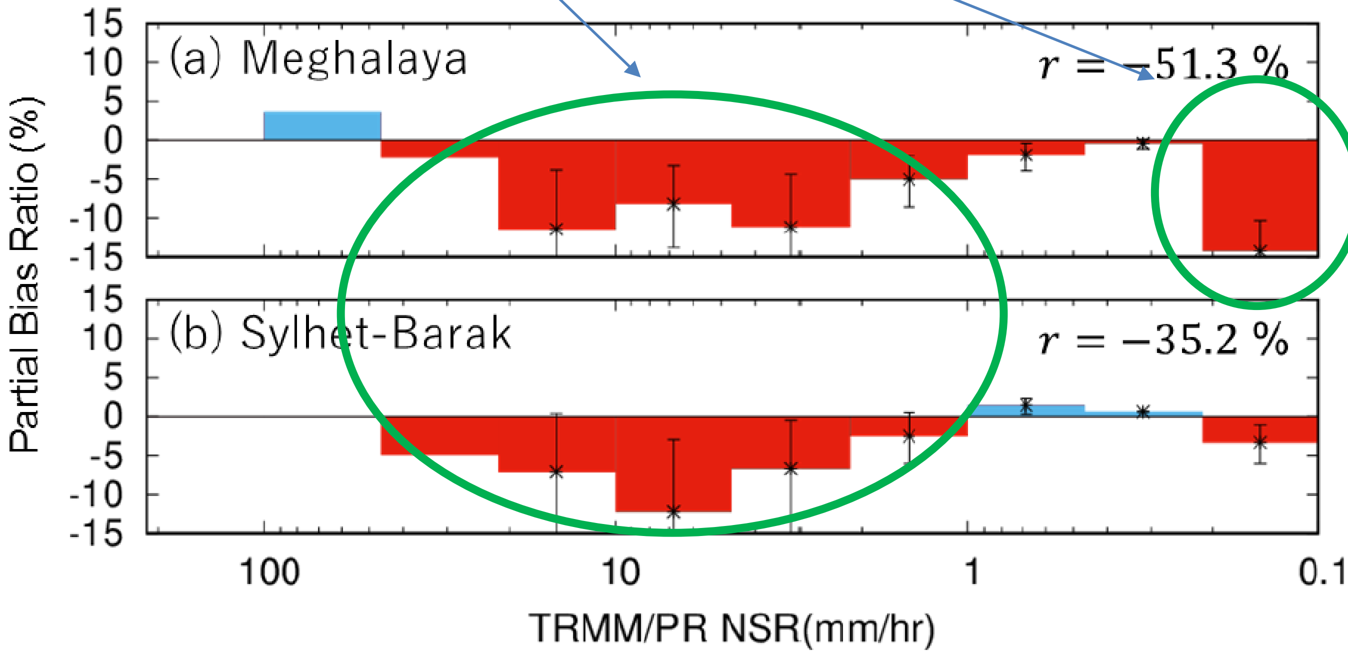
Locations and Season of Underestimate

- Larger negative bias ratio (=($\overline{R_t - R_g}$)/$\overline{R_g}$) were found over Meghalaya and Sylhet-Barak region in monsoon season



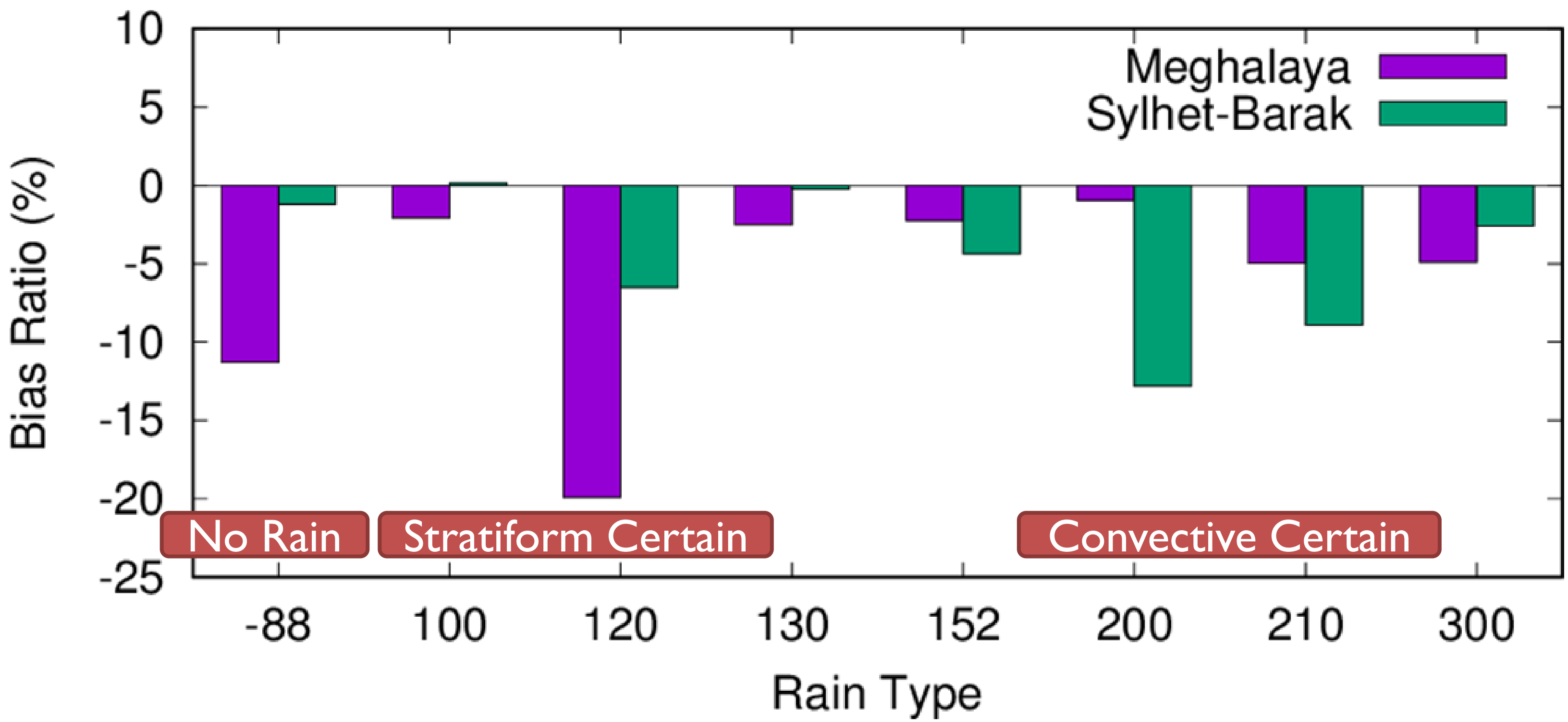
Underestimation of TRMM/PR

- Bias Ratio: Meghalaya: -51.3%, Sylhet-Barak: -35.2%
  - Significant at 99% Confidence Level
  - 2-20 mm/h (TRMM/PR)
  - Weak rainfall (especially for Meghalaya)



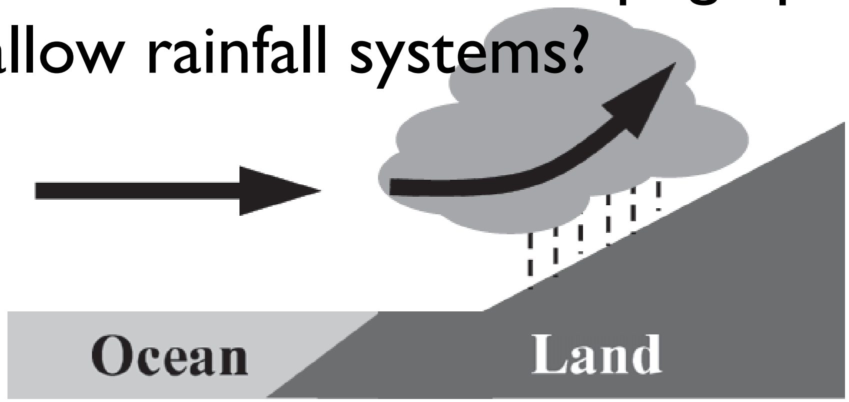
Underestimation and Rainfall Type

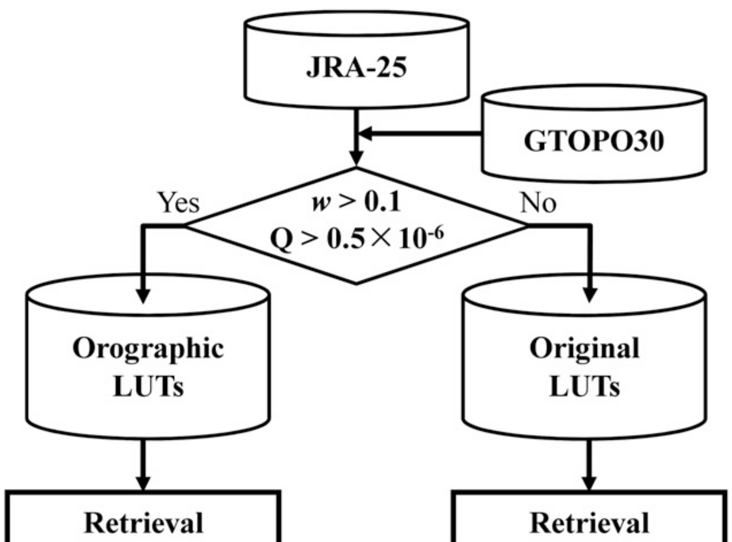
- Meghalaya: Stratiform cloud, No rain detected cases
- Sylhet-Barak: Convective cloud

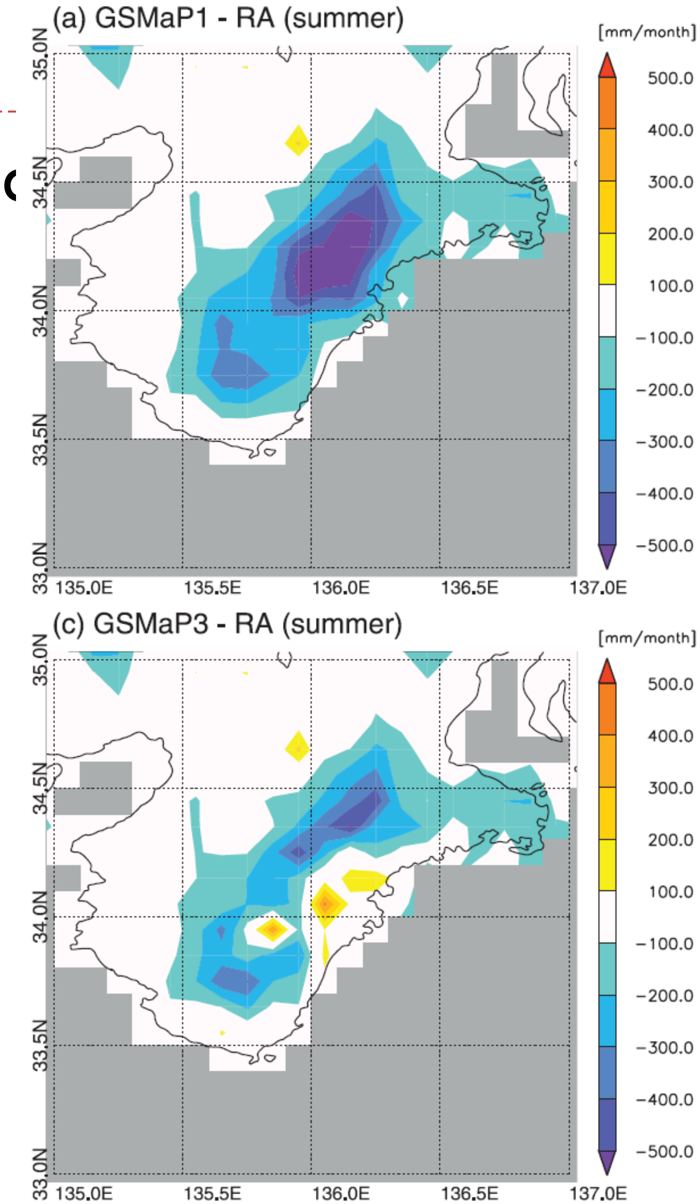


Shige et al. (2013)

- Underestimate due to topographic shallow rainfall systems?





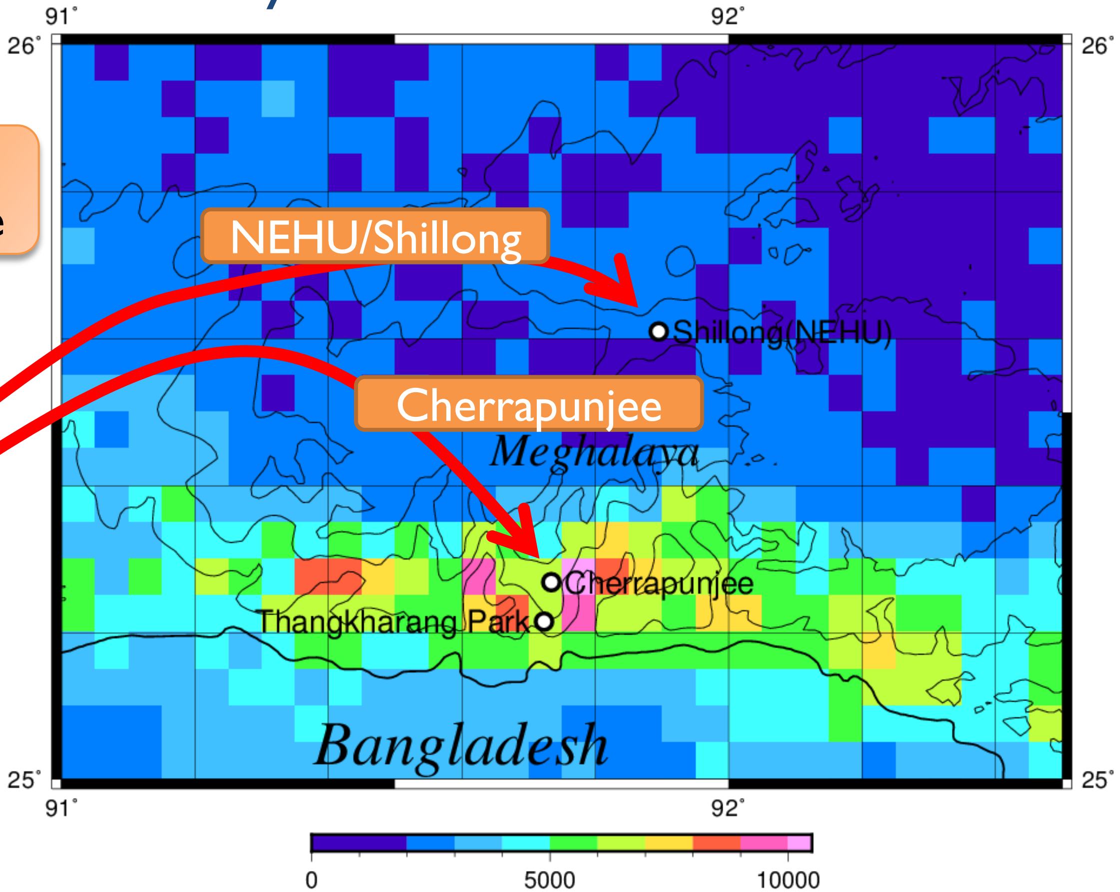


Disdrometer Observation Project

- Disdrometers were installed on the Meghalaya Plateau
  - Observation started in this May

Parcivel-2

Solar Power,
Self-sustainable

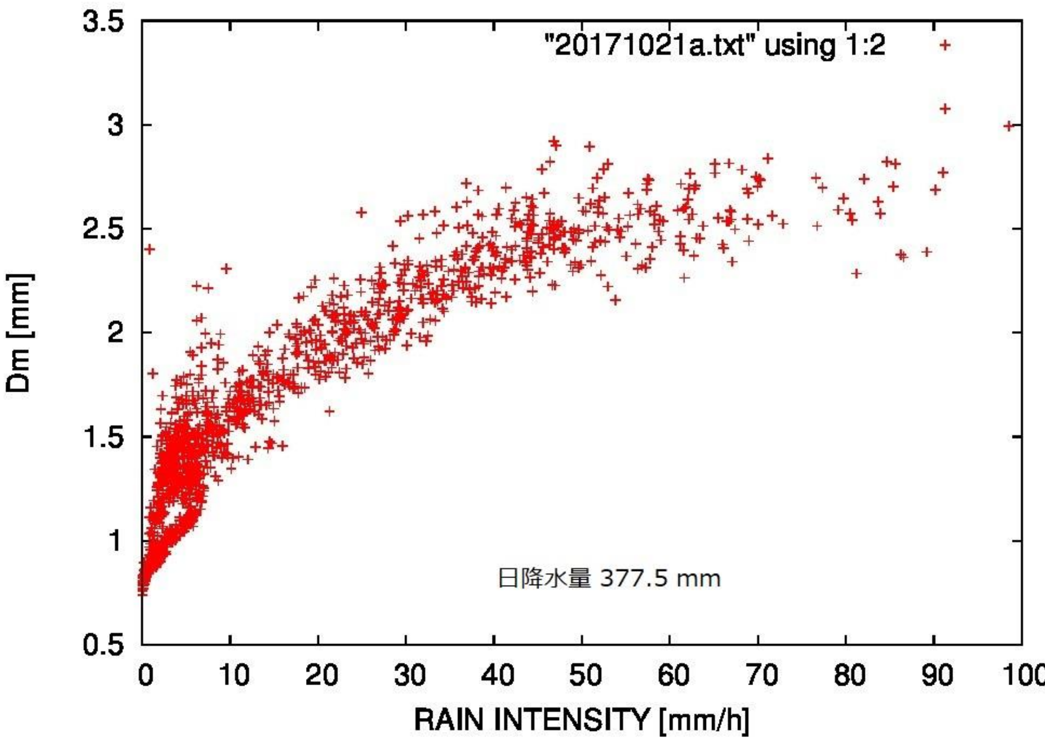


First Result of Disdrometer Observation

- Three visits to observatories
  - May 2017
    - Installation of Disdrometer and Raingauge
  - Aug. 2017
    - Data acquisition
  - Nov. 2017
    - Data acquisition
    - Decision to continue observation
- Planned visit
  - Mar. 2018
    - Data acquisition

Rain Intensity-Diameter (D_m) Diagram

- Heavy Rain Cases:
  - 8 Aug. (236 mm), 11 Aug. (237.5 mm), 14 Aug. (118 mm)
- Target for Comparison: 21 Oct 2017 (377.5 mm)

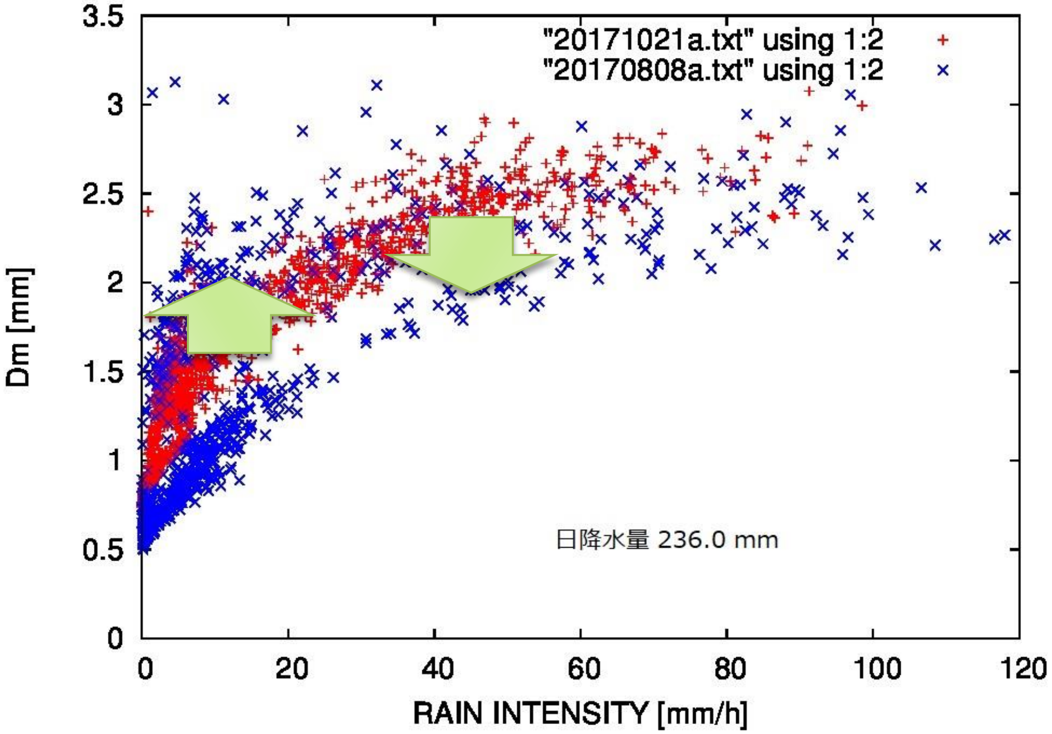


21 Oct. 2017

Steady rainfall up to 100 mm/hr associated with cyclonic system was located over the Bengal Plain.
As the rain intensity-diameter relationship is stable in this case, we selected this case for a target of comparison.

Rain Intensity-Diameter Diagram

- Heavy Rain Cases:
  - 8 Aug. (236 mm), 11 Aug. (237.5 mm), 14 Aug. (118 mm)
- Target for Comparison: 21 Oct 2017



Rain Intensity-Diameter Diagram

- Heavy Rain Cases:
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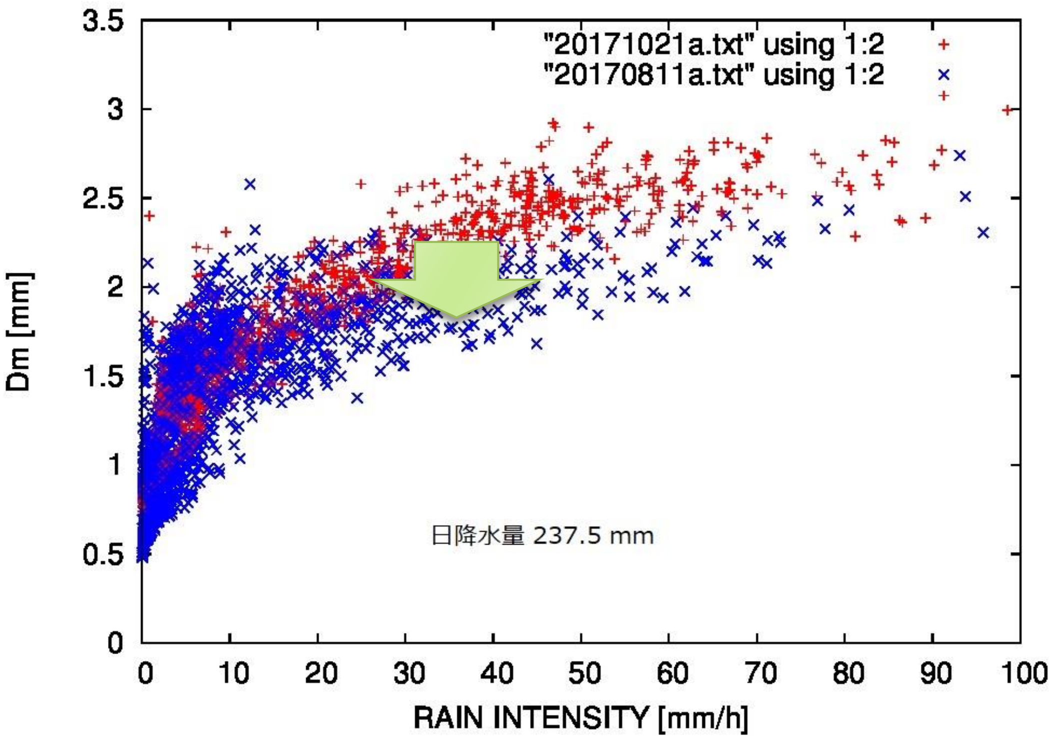
- Target for Comparison: 21 Oct 2017



Rain Intensity-Diameter Diagram

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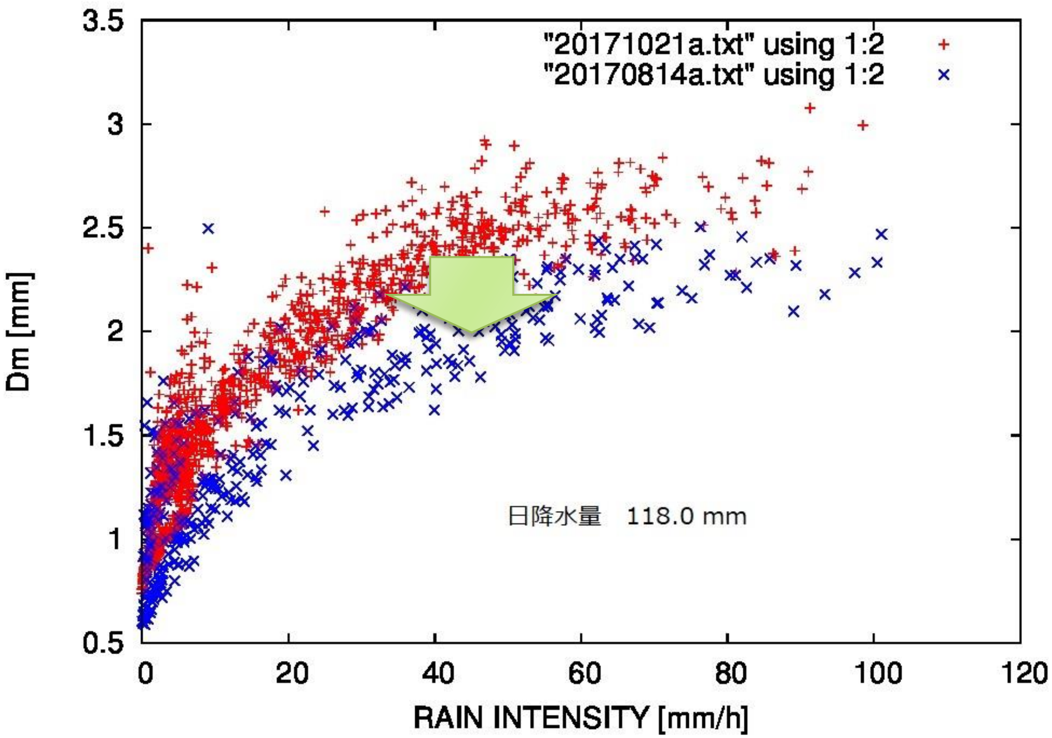
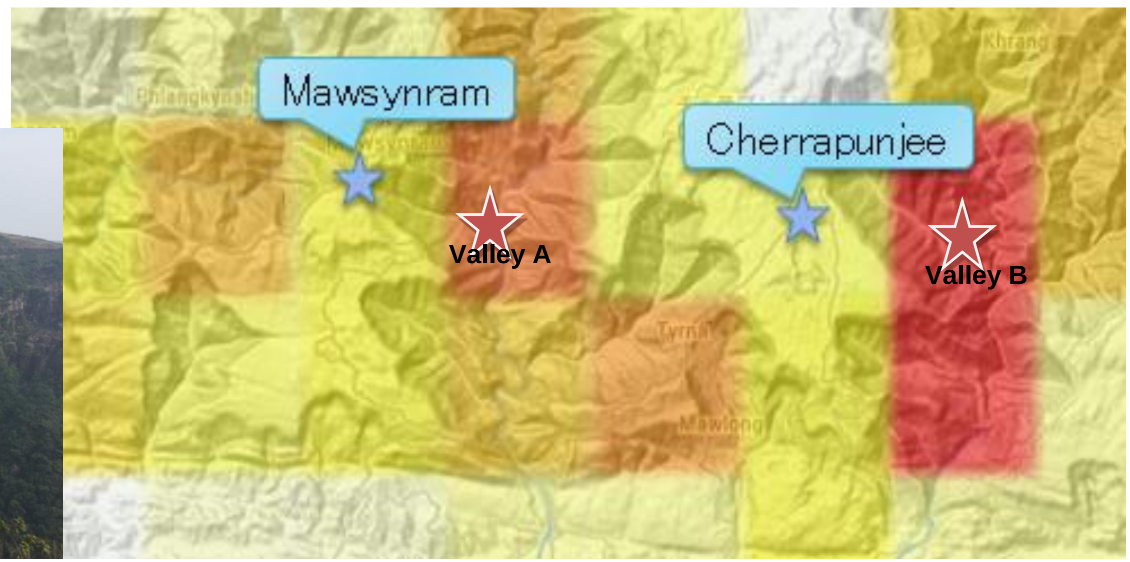


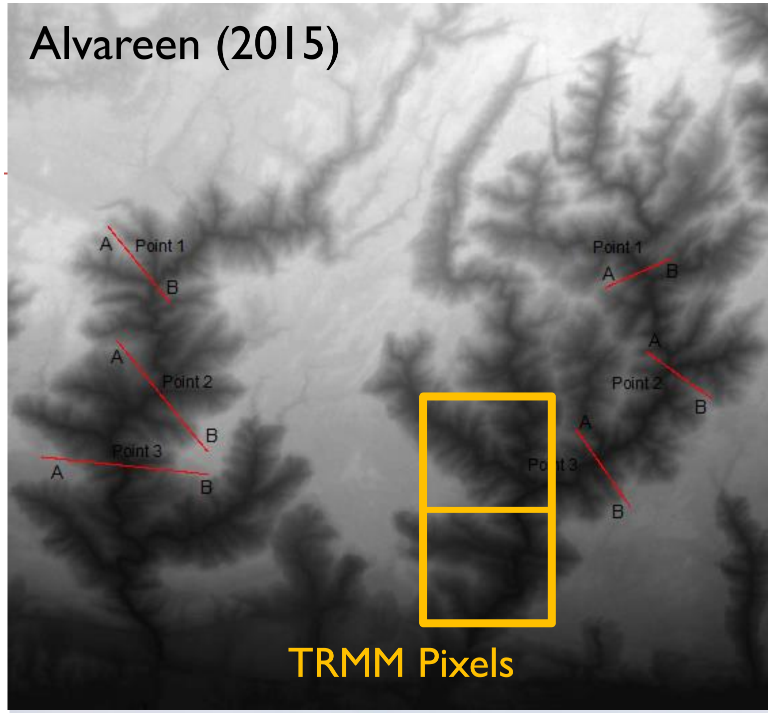
New Raingauges to Find TRMM Peaks

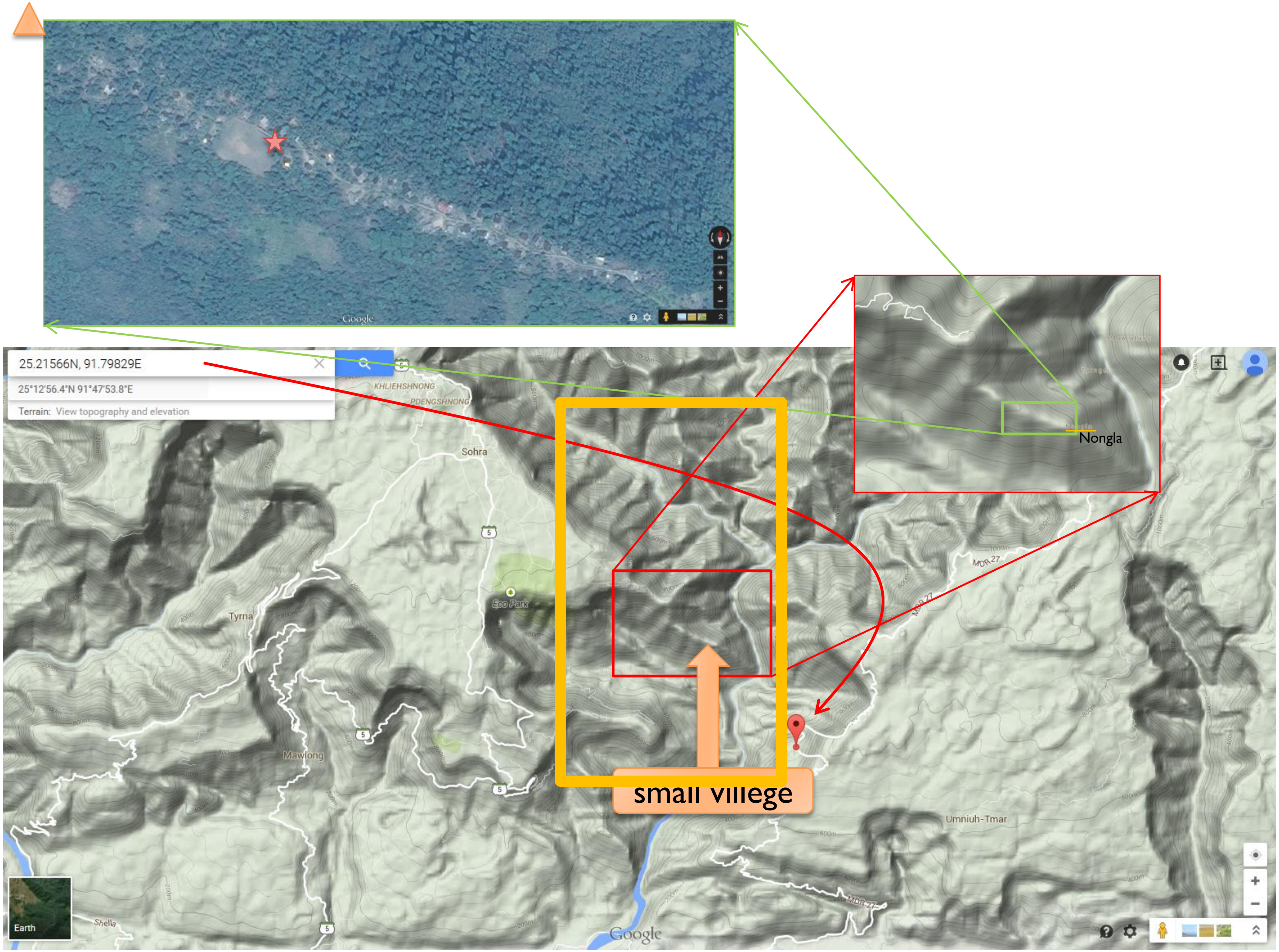
- Estimation of Rainfall in the Southern Slope of the Meghalaya Plateau with TRMM 2A25 NSR
  - TRMM NSR: Underestimate ?
  - Where is the Center of the World Record Rainfall over Meghalaya?
  - Going down to Valleys??



Valleys and TRMM

- Deep Dissected Valleys in the Southern Side of Plateau





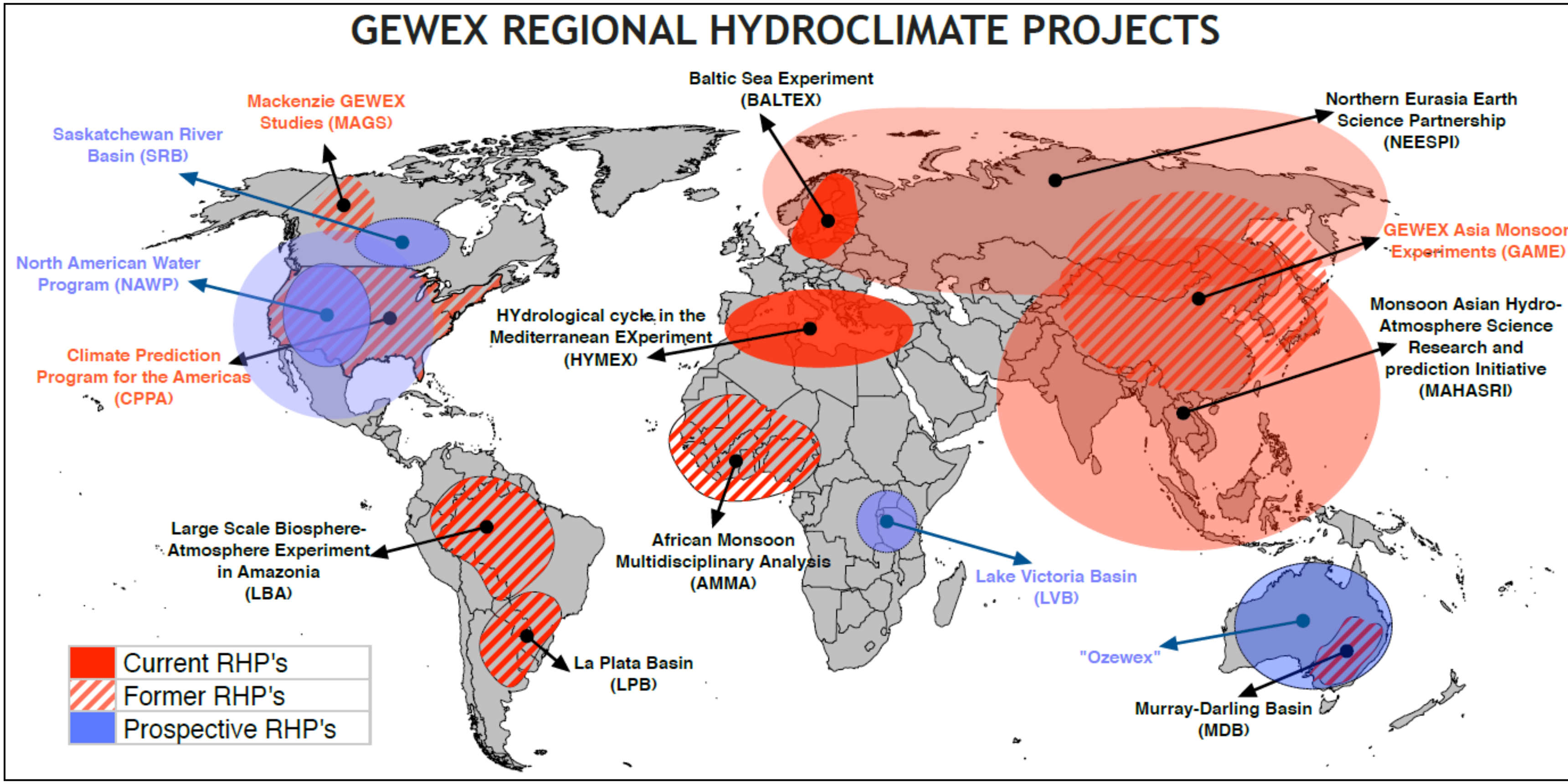
Google
25.21566N, 91.79829E
25°12'56.4"N 91°47'53.8"E
Terrain: View topography and elevation
KHLIEHSHNONG
PDENGSHNONG
Sohra
Eco Park
Tyrna
Mawlong
Nongla
MDR 27
small villege
Umniuh-Tmar
Earth
Shella
Google

Summary

- Successfully directly validated the TRMM-2A25 NSR using tipping bucket raingauge network.
- TRMM-2A25 NSR underestimate monsoon rainfall over the Meghalaya Plateau and Sylhet-Barak regions.
- Due to
  - Misdetection of shallow rain cloud?
- Further Comparisons … ?
  - We can expect additional information from further comparisons
    - Ambient Temperature/Humidity/Water Vapor Flux, Echo Top Height, TRMM Version 6 vs 7 …
  - Disdrometer may give us some other information
  - New Raingauges are installed in the valley

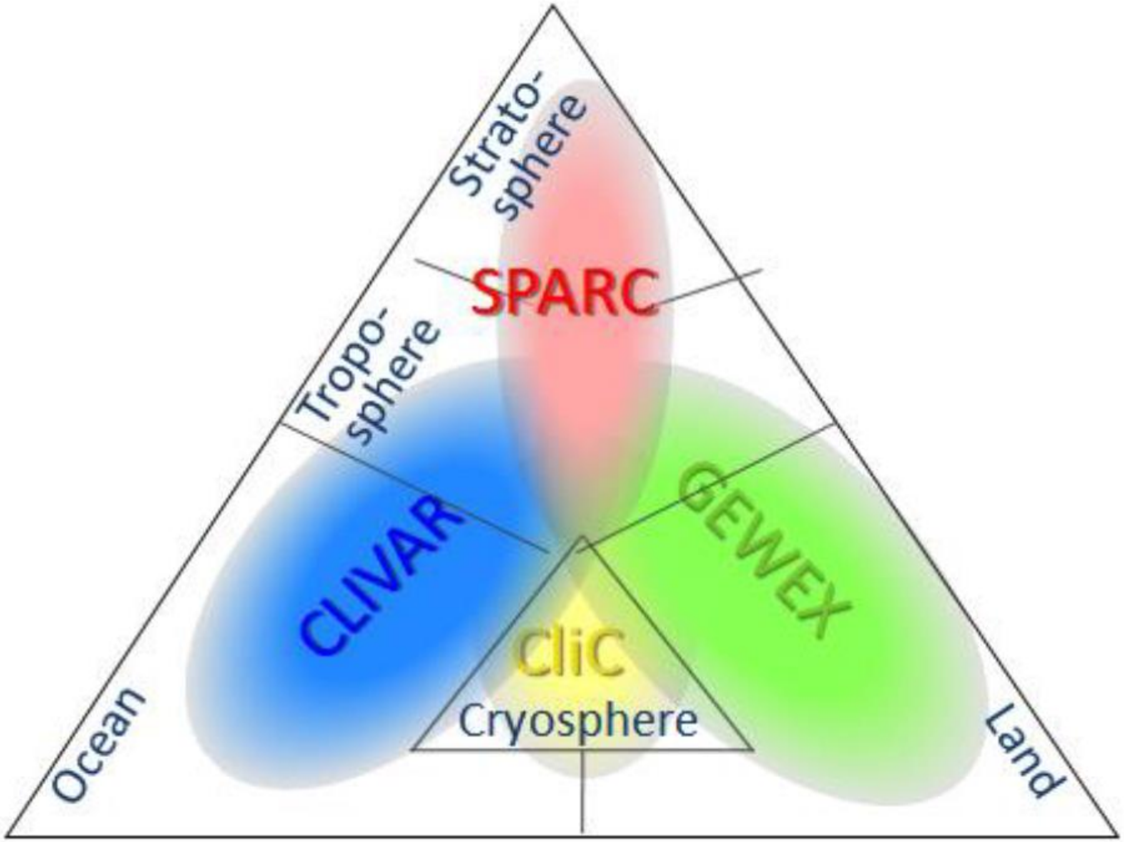
PostMAHASRI is now under planning

- New GEWEX RHP covering Asian monsoon region



WCRP / GEWEX

GEWEX within WCRP



松本さんのスライドから

WCRP Grand Challenges

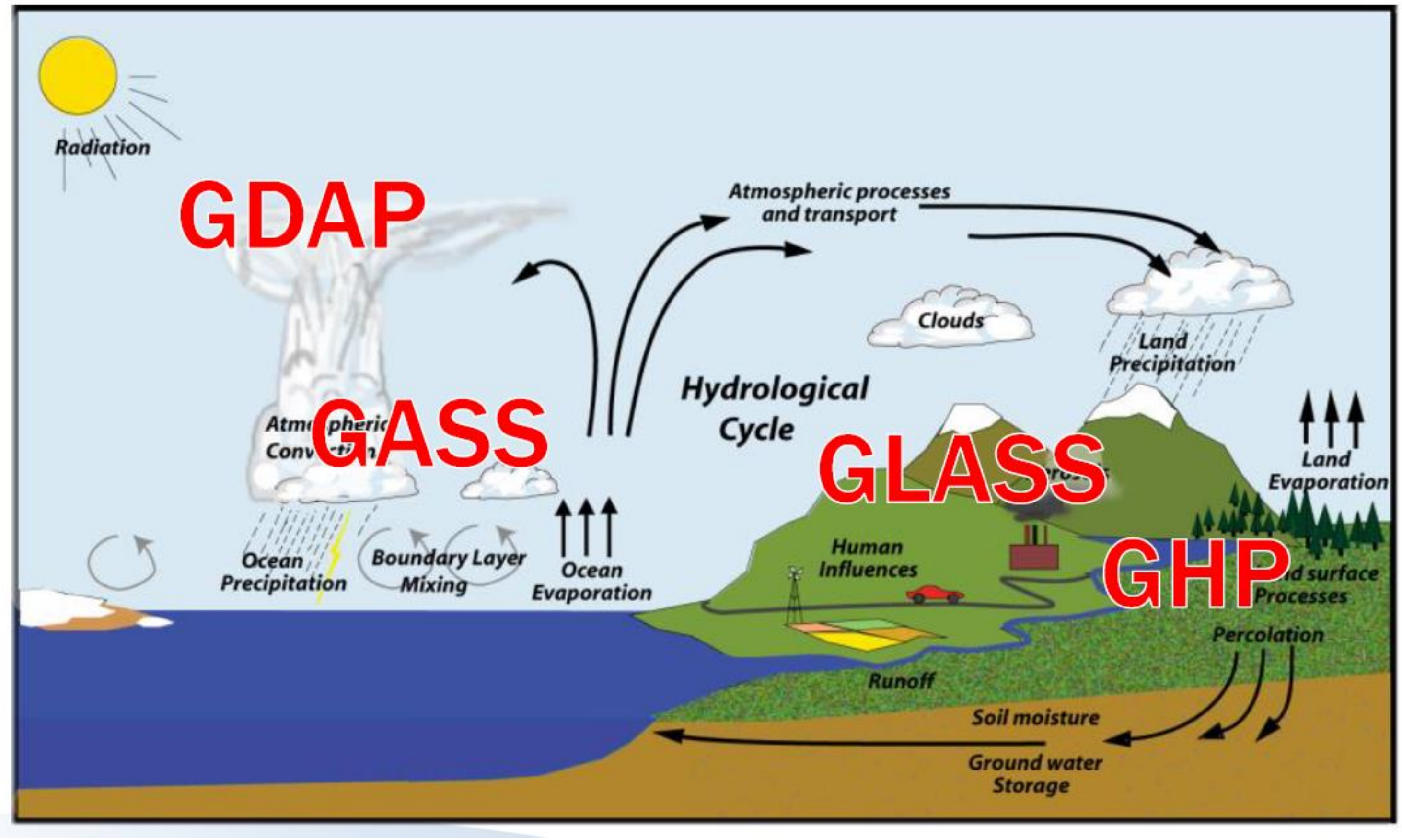
- Melting Ice and Global Consequences
- Clouds, Circulation and Climate Sensitivity
- Carbon Feedbacks in the Climate System
- Weather and Climate Extremes
  - Are existing observations sufficient to underpin the assessment of extremes?
  - What are the relative roles of large-scale, regional and local scale processes, as well as their interactions, for the formation of extremes?
  - Are models able to reliably simulate extremes and their changes, and how can this be evaluated and improved?
  - What are the contributors to observed extreme events and to changes in the frequency and intensity of the observed extremes?
- Water for the Food Baskets of the World
- Regional Sea-Level Change and Coastal Impacts
- Near-term Climate Prediction

Next 5 to 10 years

GEWEX Science Questions (2013)

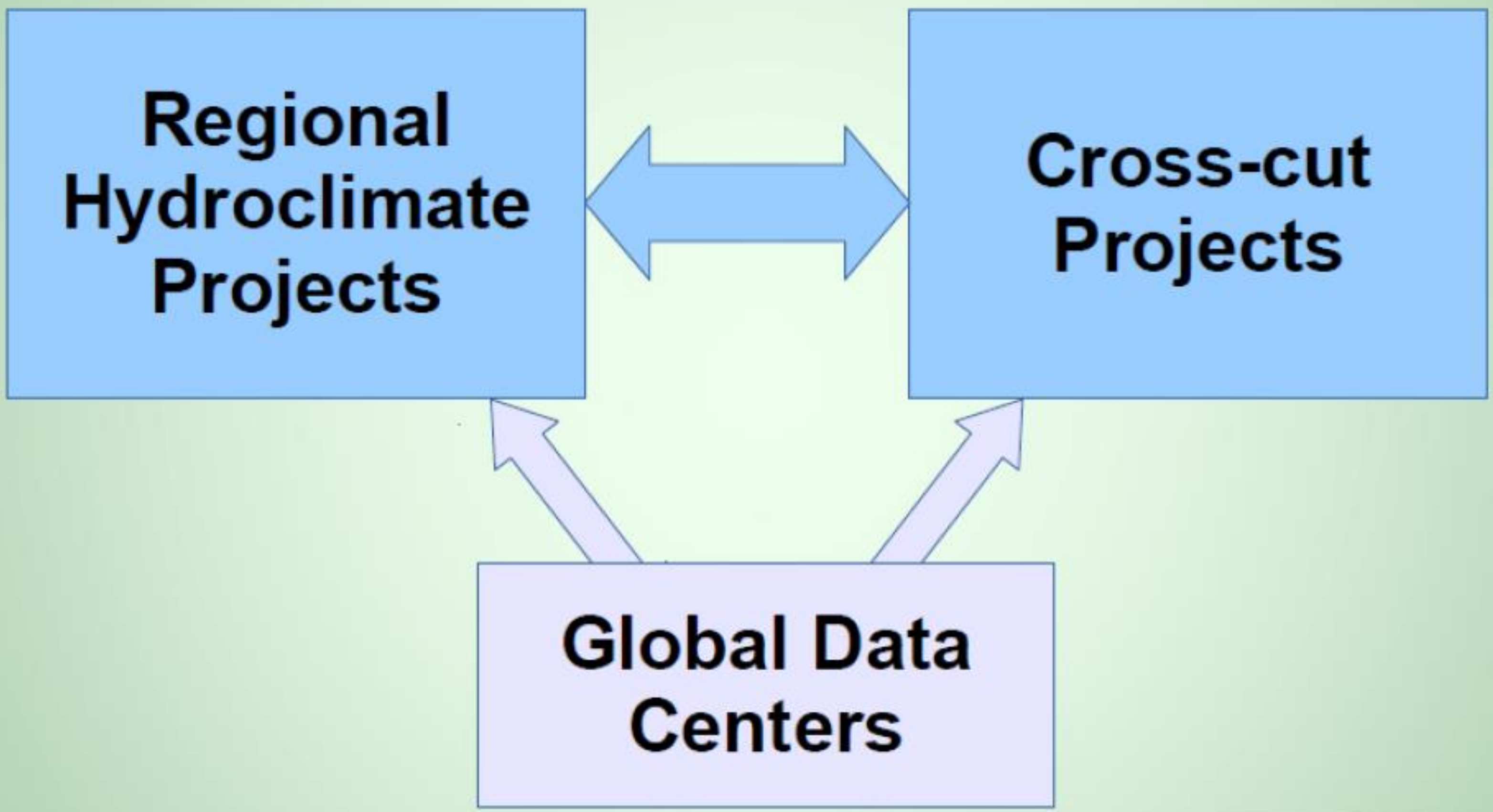
- Observations and Predictions of Precipitation:
  - How can we better understand and predict precipitation variability and changes?
- Global Water Resource Systems:
  - How do changes in land surface and hydrology influence past and future changes in water availability and security?
- Changes in Extremes:
  - How does a warming world affect climate extremes, esp. droughts, floods, and heat waves, and how do land area processes, in particular, contribute?
- Water and Energy Cycles and Processes:
  - How can understanding of the effects and uncertainties of water and energy exchanges in the current and changing climate be improved and conveyed?

GEWEXのサブコンポーネント



松本さんのスライドから

GHP Structure



(Courtesy of Prof. Jason Evans, Co-chair of GHP)

RHP Status

Active in 4 continents:

Europe: ***HymEx*** (2010-2020) ======> High-impact weather events, societal response
Baltic Earth (2016-) ======> Sea and land changes, biogeochemical processes
Australia: ***OzyWex*** (2015-) =======> Water and energy cycle in Australia
Africa: ***HyVic*** (2015-2024) ========> Hydroclimatic variability over Lake Victoria basin
North America: ***CCRN*** (2014-2018) => Cryospheric, ecological, hydrological interactions

Recently finished:

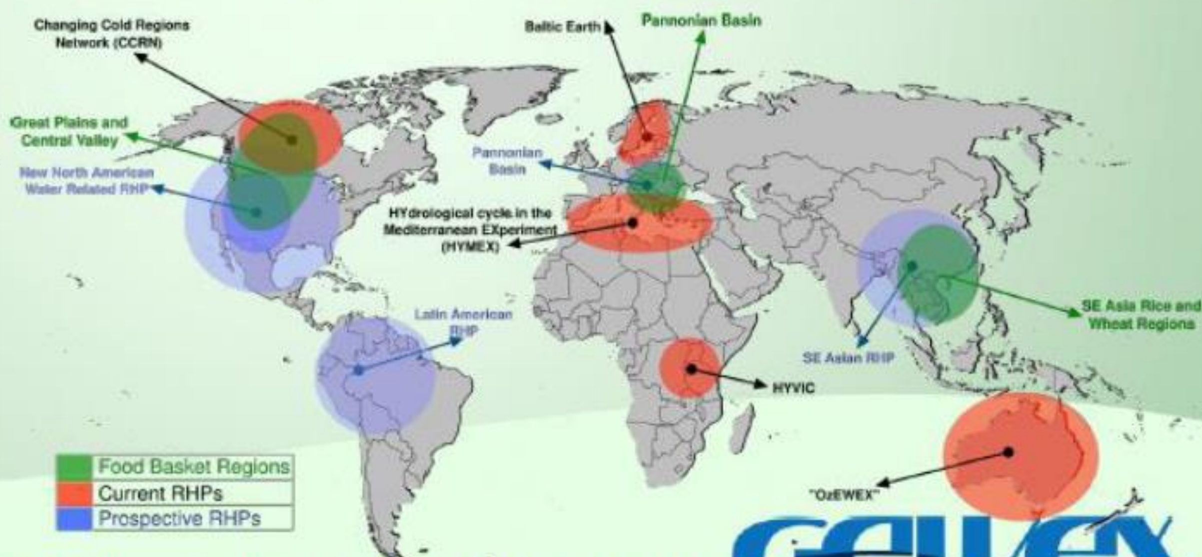
Asia: ***MAHASRI*** (2007-2016) ======> Asian Monsoon
Eurasia: ***NEESPI*** (2004-2015) =====> Northern Eurasian climate-ecosystem-societal interac

Prospective:

Europe: ***PannEx*** (end 2017?) =====> Agronomy, air quality, sustainability & water mgnt

In discussion:

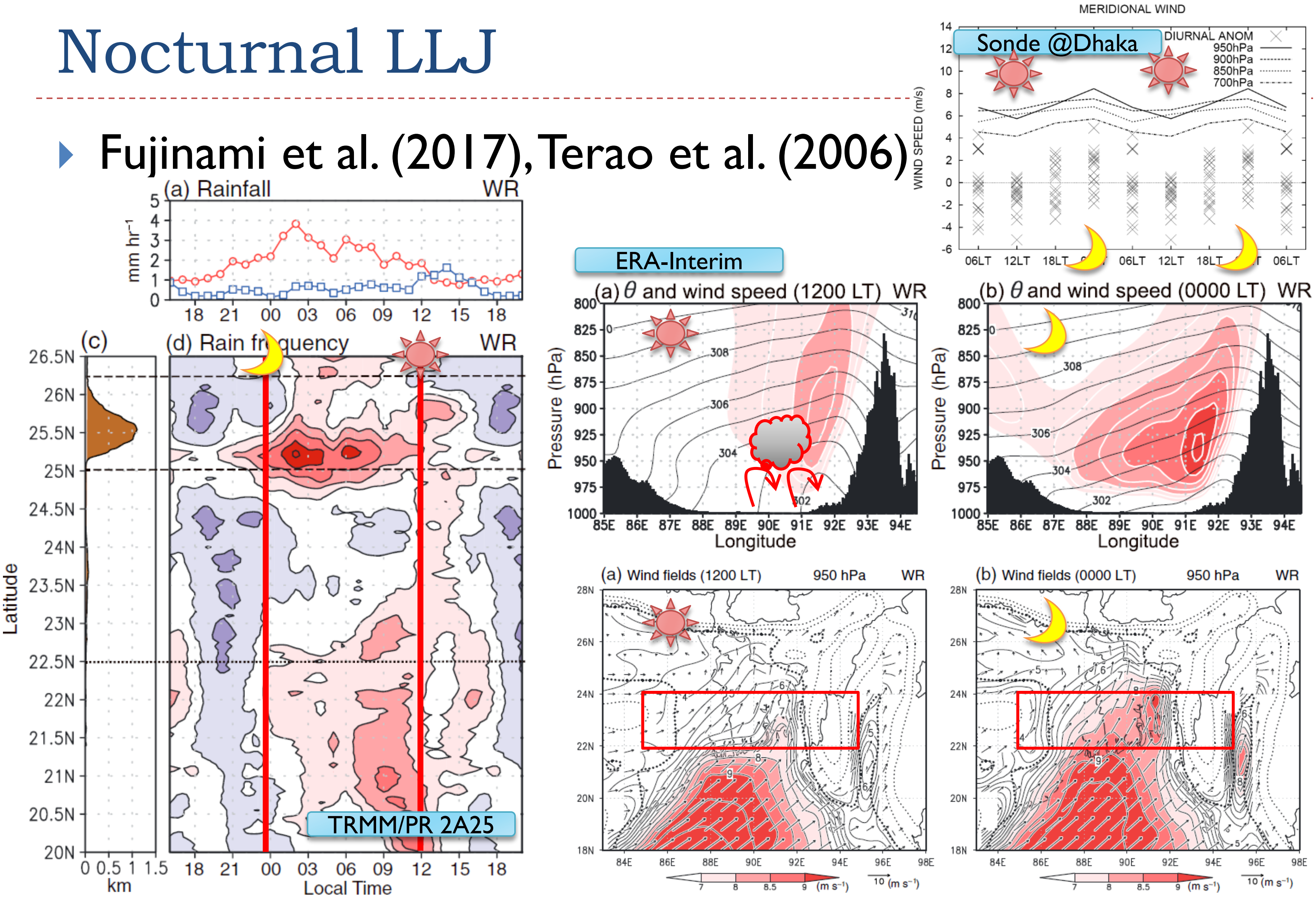
Exploring possibilities
in the Americas and Asia.



(Courtesy of Prof. Jason Evans, Co-chair of GHP)

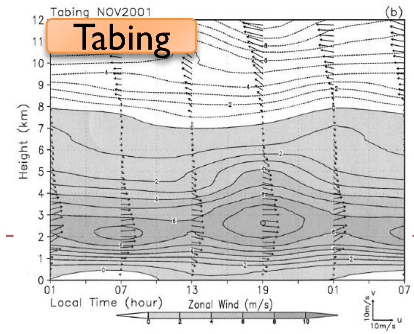
Nocturnal LLJ

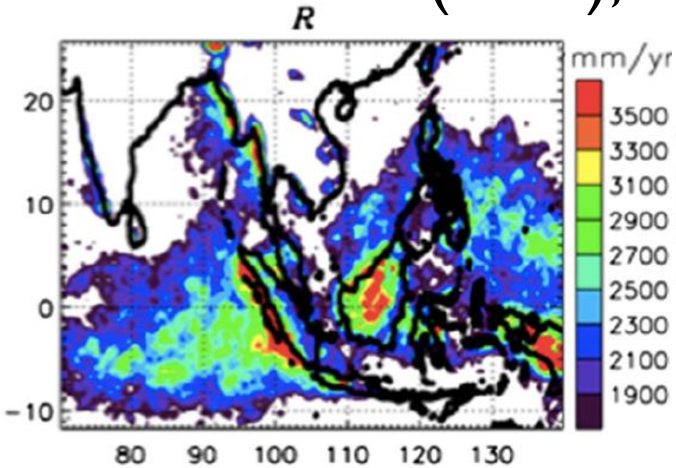
- Fujinami et al. (2017), Terao et al. (2006)

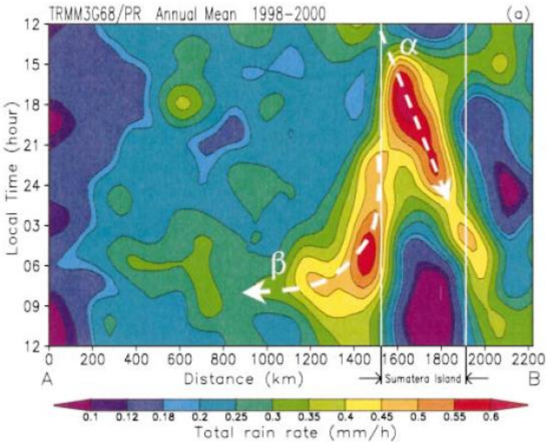


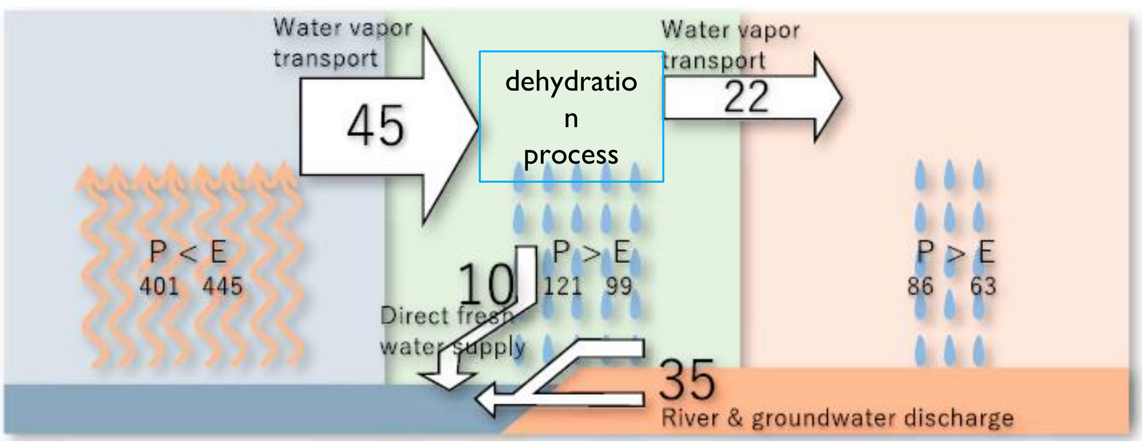
Coast Line and Water Budget

- Mori et al. (2004), Ogino et al. (2016, 2017)

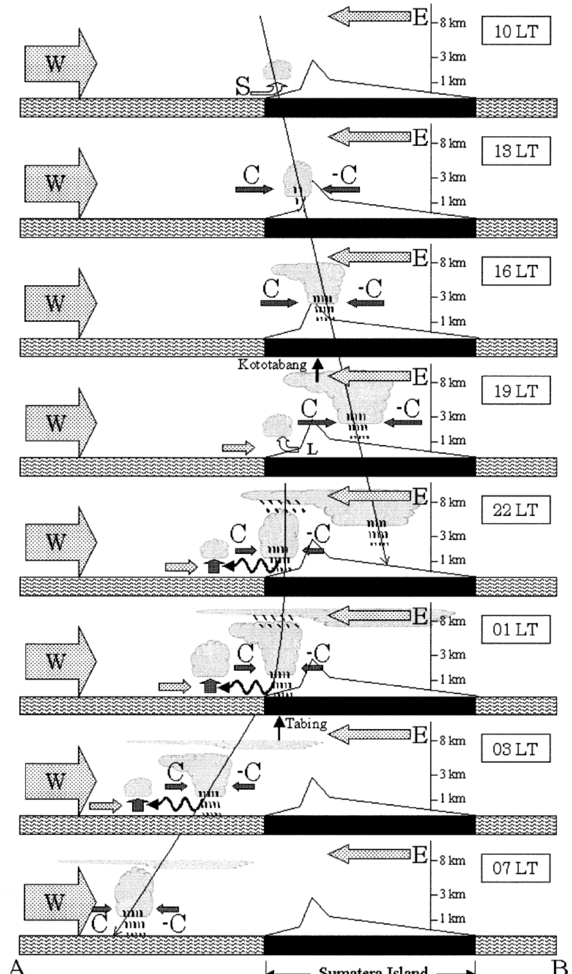








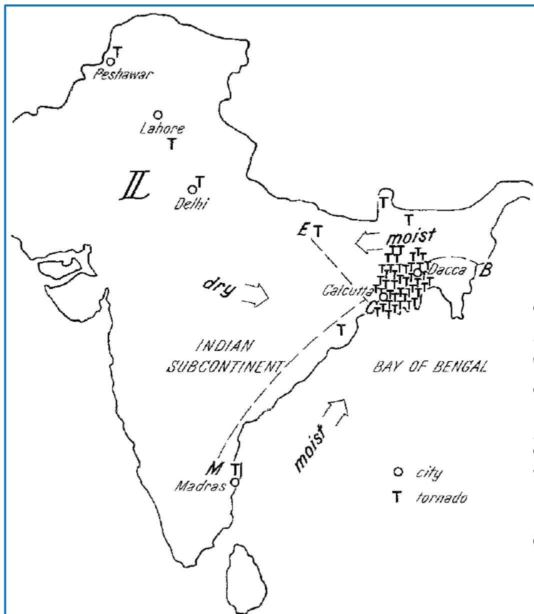
open ocean coastal region inland



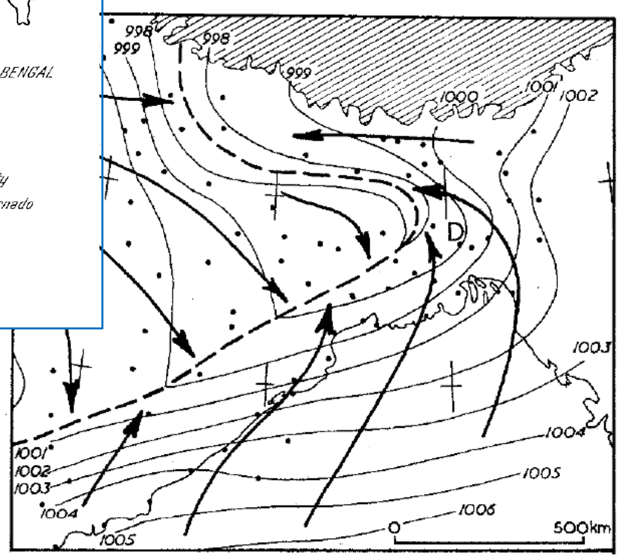
Pre-monsoon Dry Line over Bangladesh

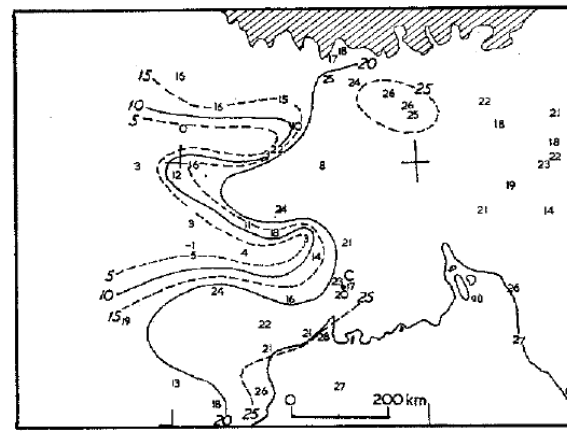
- Dr. Yamane is leading this research

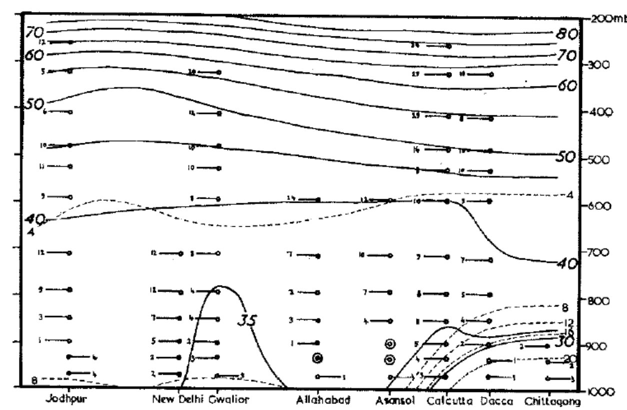
Watson (1972)



Peterson and Mehta (1981)

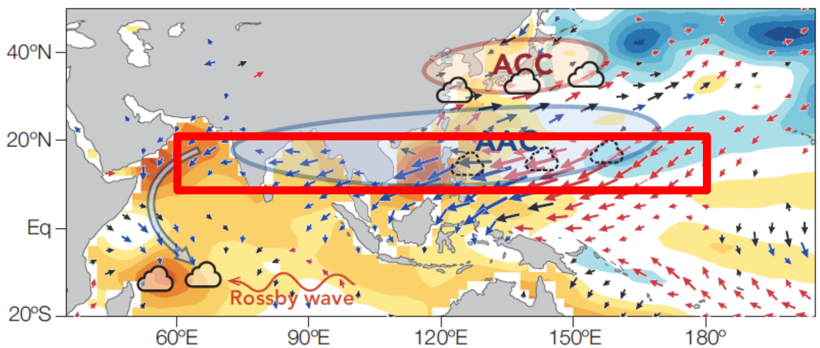




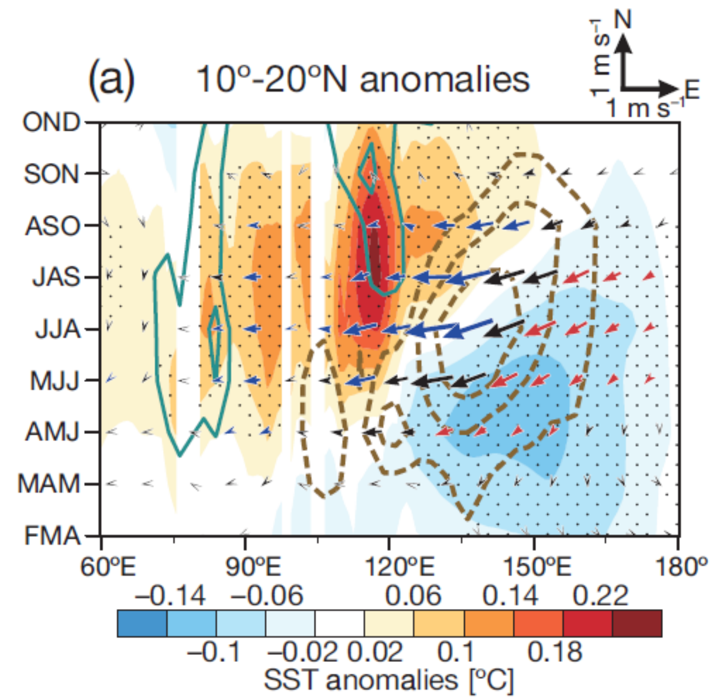


PJ pattern, ENSO-Monsoon, IPOC

- Indian-Pacific Ocean Combined feedback mode
  - SST anom.⇒Easterly anom.⇒Reduction of WS⇒SST anomaly



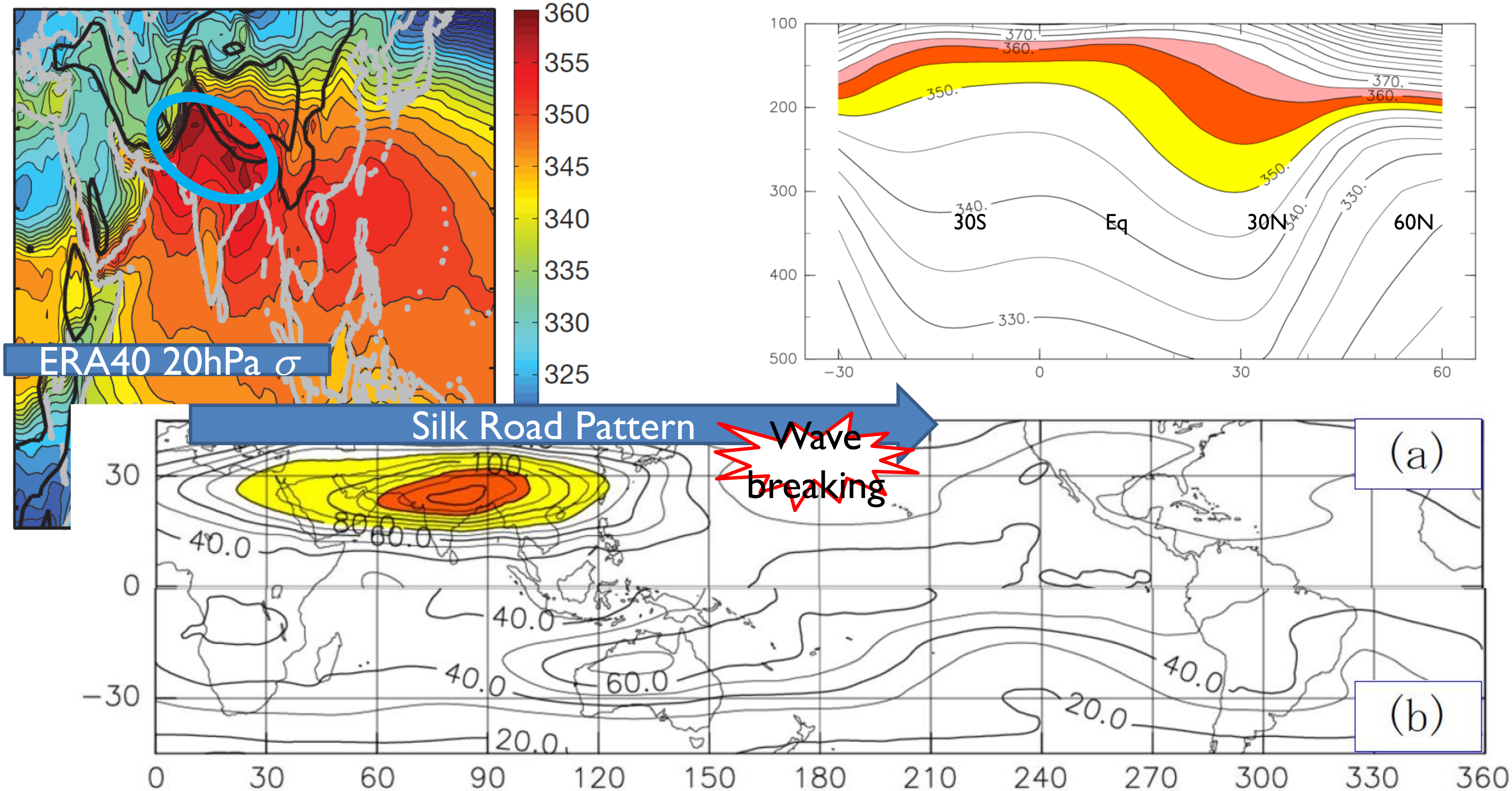
Xie et al. (2016)



- How is land mass impact?
  - Is it only passive?

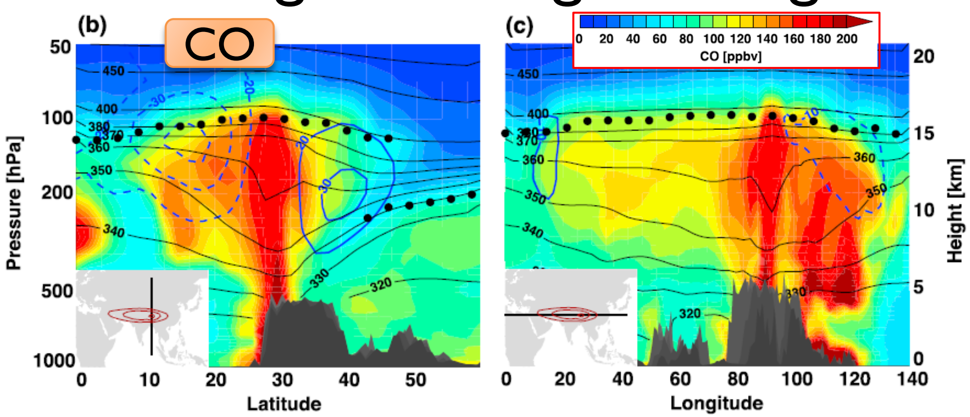
Boundary Layer⇒Tibetan High

- Boos and Kuang (2010)

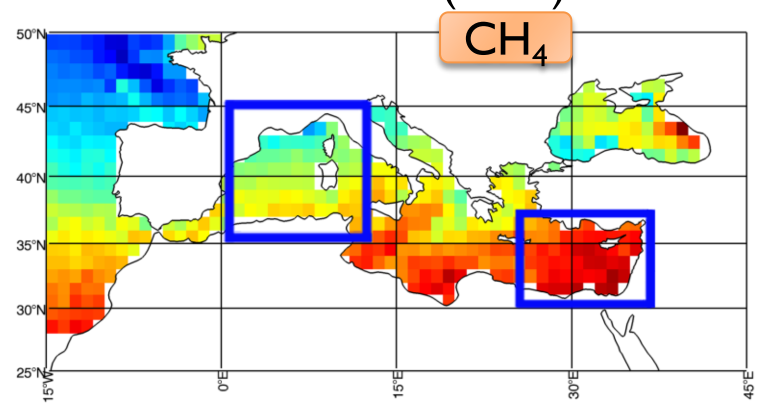


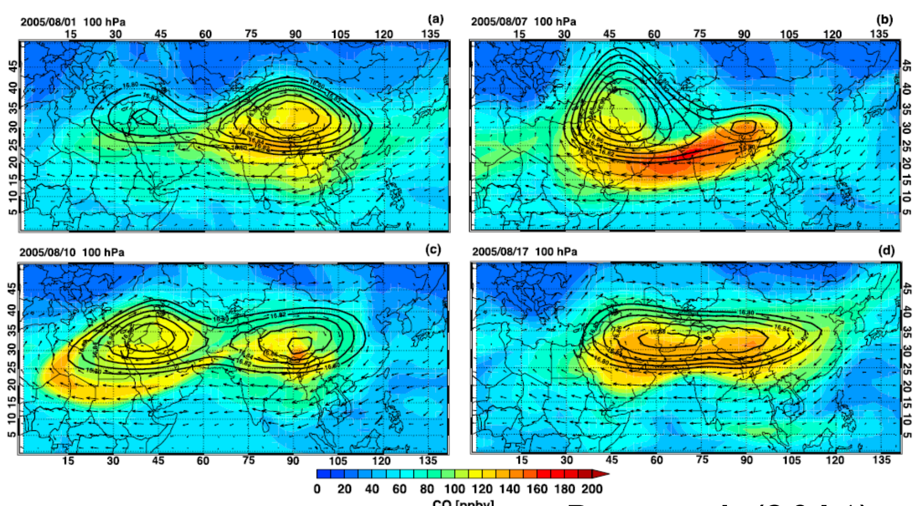
Mass: Boundary Layer->Tibetan High

- Investigated using tracer gas

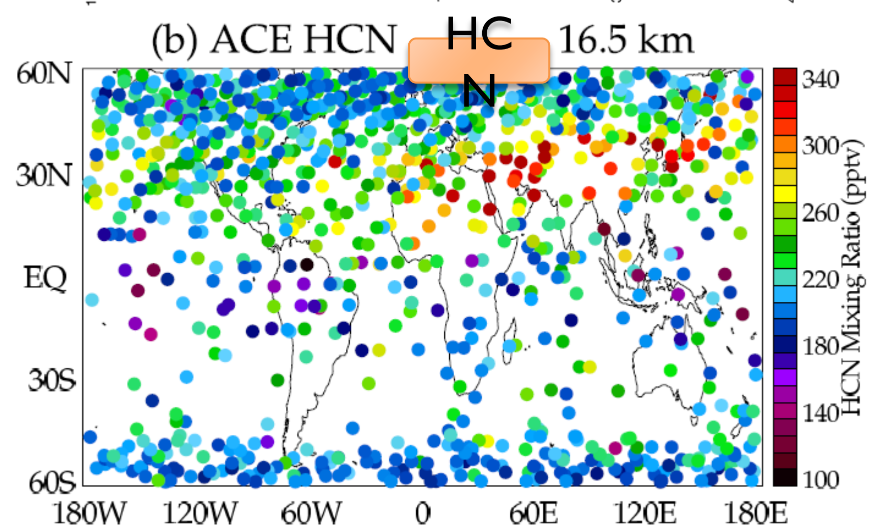


Ricaud et al. (2014)





Pan et al. (2016)



Park et al. (2008)

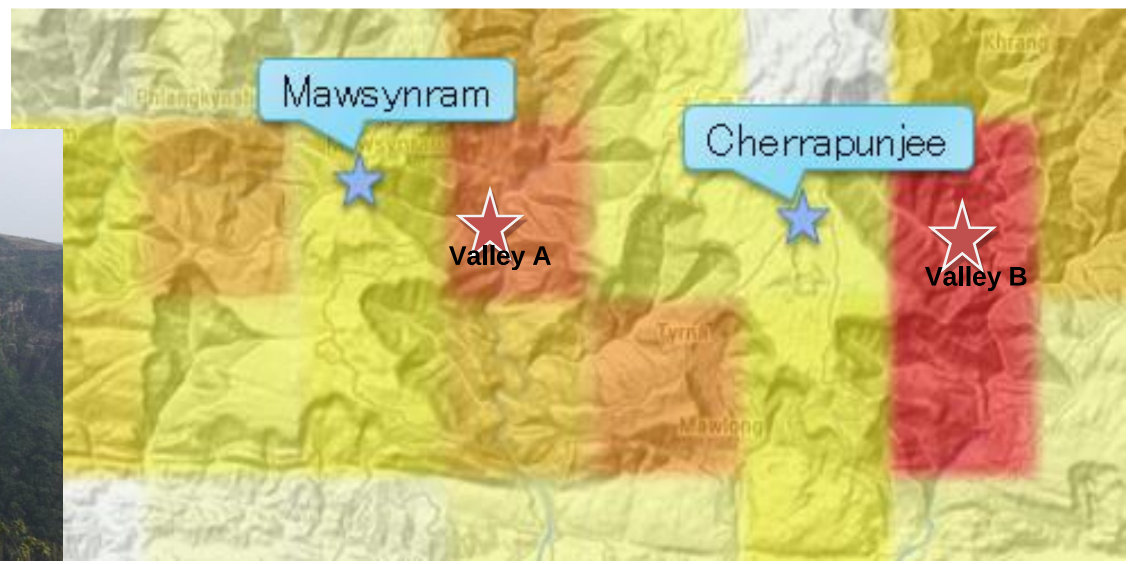
Drafting Science Plan of Post-MAHASRI

- Internaional PostMAHASRI Workshop (15-16 Mar, Tokyo)
- Science Steering Group (SSG)
- GEWEX Conference
  - 6-11 May 2018 @Canmore/Canada
- JpGU session on 20 May 2018
- Submission of proposal of new RHP to WCRP SSG
  - Nov. 2018?

Thank you!

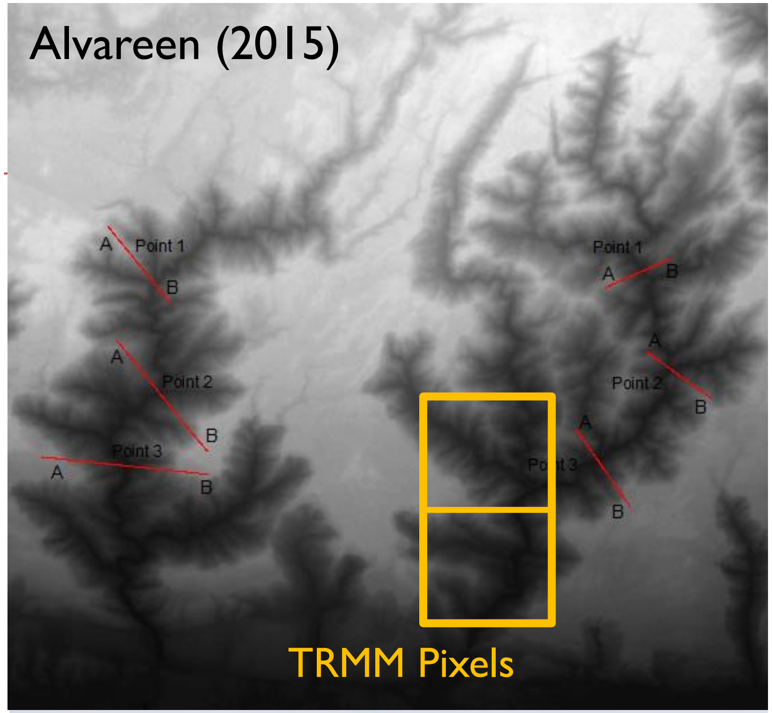
Research Proposal

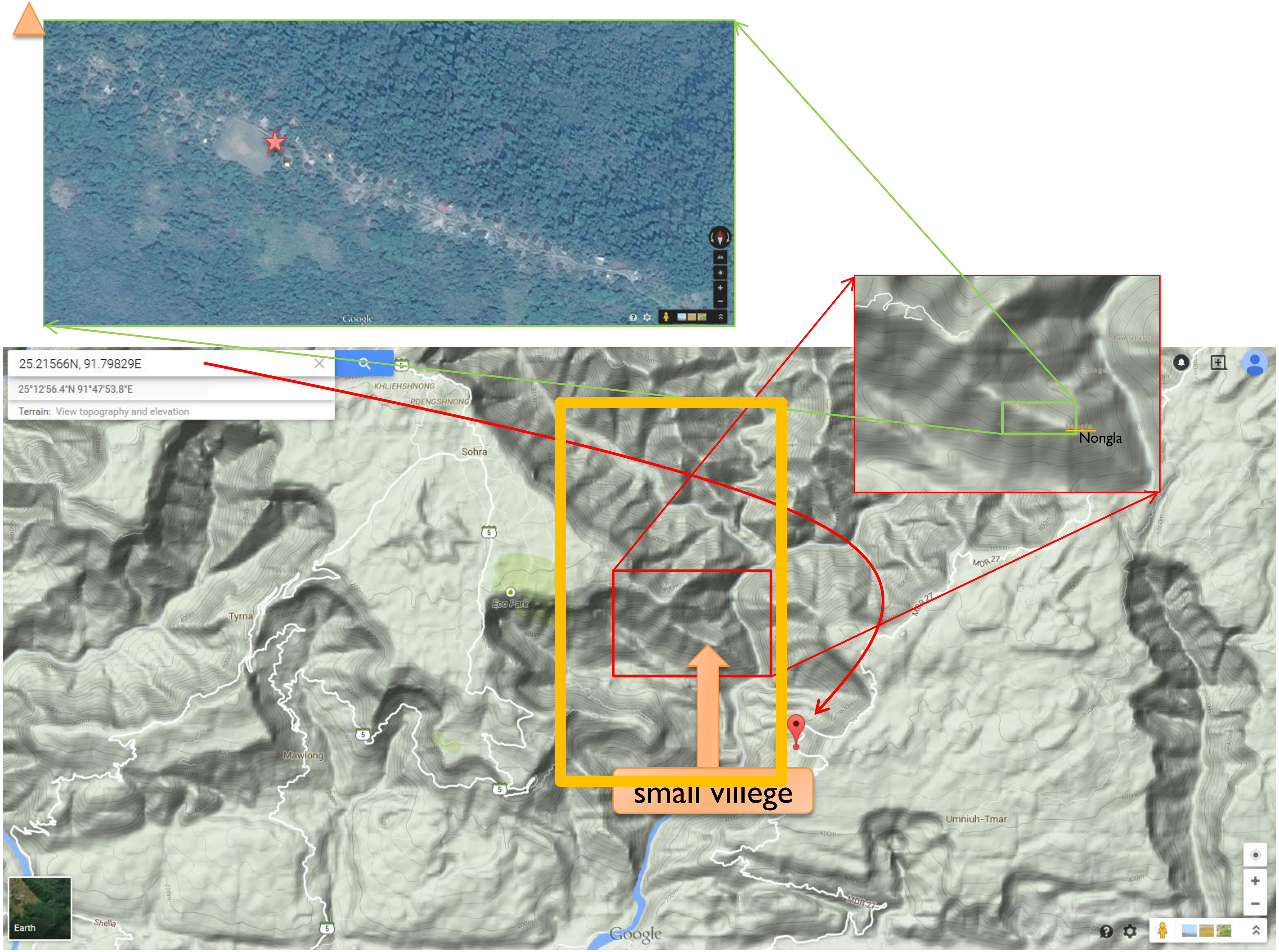
- Estimation of Rainfall in the Southern Slope of the Meghalaya Plateau with TRMM 2A25 NSR
  - TRMM NSR: Underestimate ?
  - Where is the Center of the World Record Rainfall over Meghalaya?
  - Going down to Valleys??



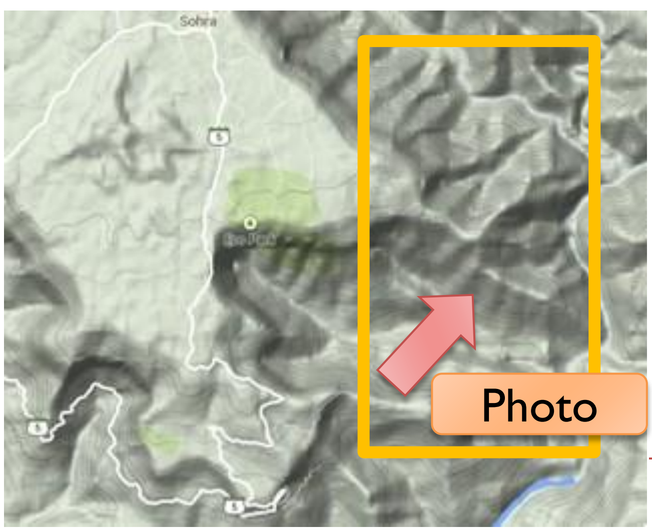
Valleys and TRMM

- Deep Dissected Valleys in the Southern Side of Plateau

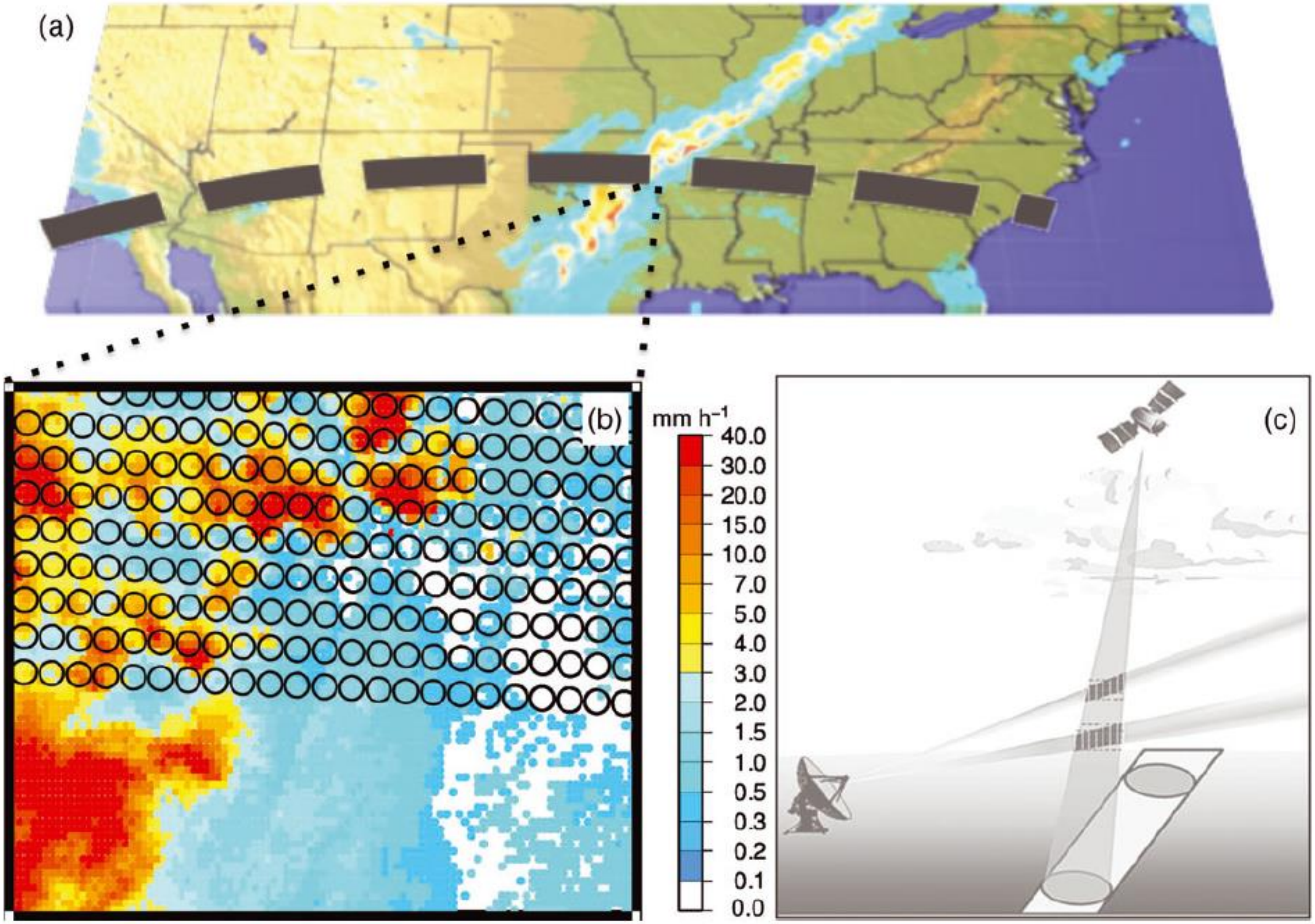




25.21566N, 91.79829E
25°12'56.4"N 91°47'53.8"E
Terrain: View topography and elevation
KHLIEHSHNONG
PDENGSHNONG
Sohra
Eco Park
Tyrna
Mawlong
small villege
Umniuh-Tmar
MDR 27
Nongla
Shella
Earth
Google

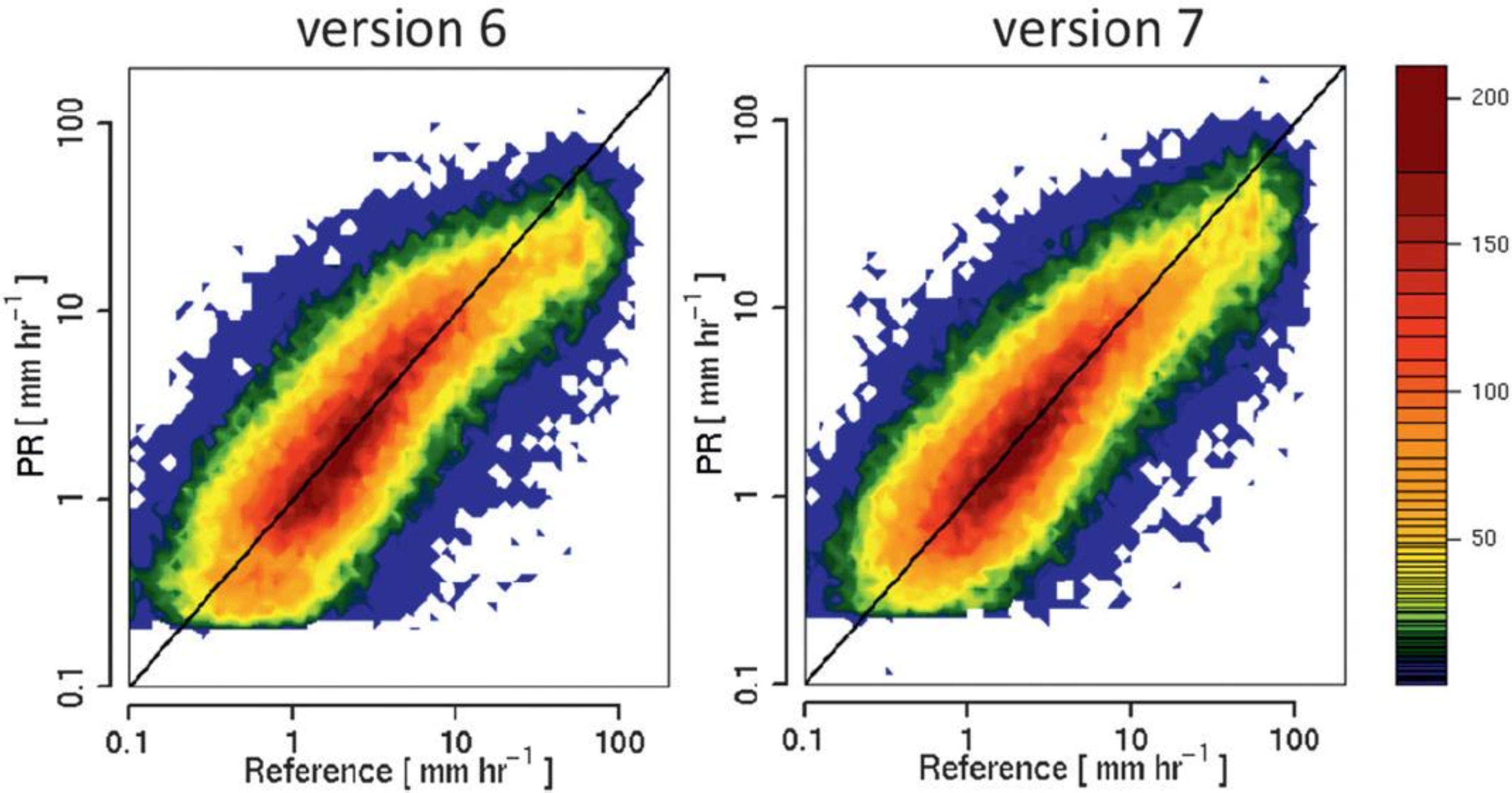

Sohra
Photo

Comparison with Surface Radar System



Kirstetter et al. (2013)

- Comparison TRMM Ver. 6 and 7



まとめ

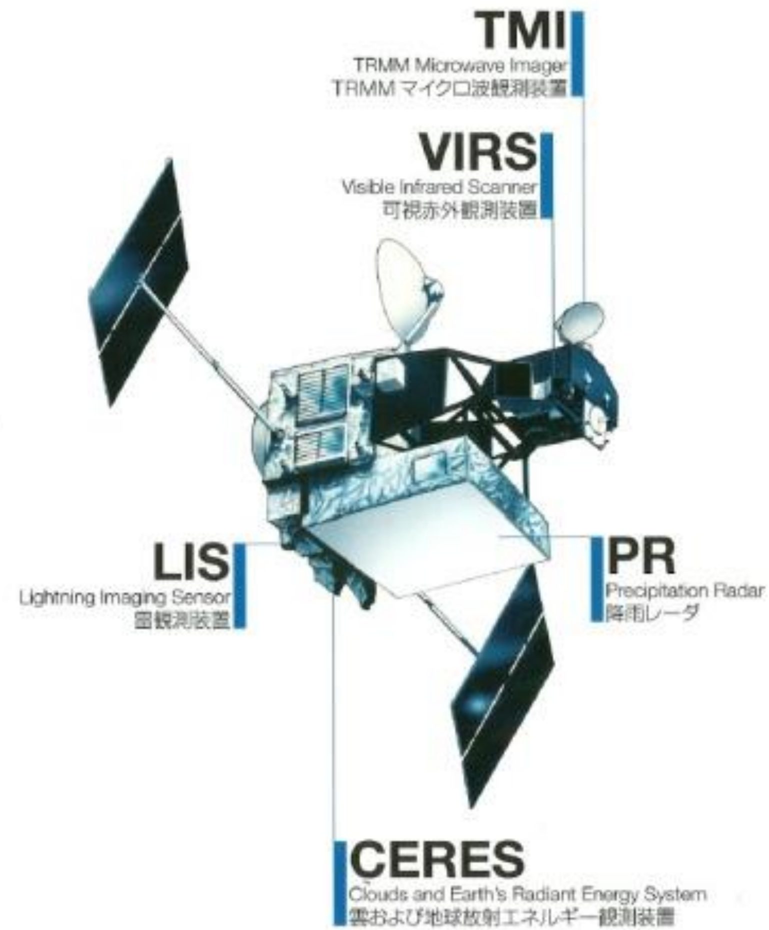
- TRMM 2A25 surface rainをNEインド雨量計網と比較
  - 1938回の降水有り観測機会について、雨滴の落下によると思われる時間のずれを検出することができた
  - 平均すると約300秒であり、一般的に1000～2000m上空の反射強度をsurface rainの推定に用いていることと整合的
- TRMM 2A25に過小評価がみられた
  - 過小評価が見られるのはMeghalaya山脈及びその南麓のSylhet域
  - 過小評価は特にJJASに顕著である
  - 過小評価が見られる地域・季節と、1000-2000mあるいは2000-3000mの層での降水強度の増加が対応している
  - NEインド雨量計網(京大防災研)の活用が課題

謝辞

- 雨量計のメンテナンスに協力をいただいているすべての数え切れない関係者の皆さま方に感謝申し上げます。

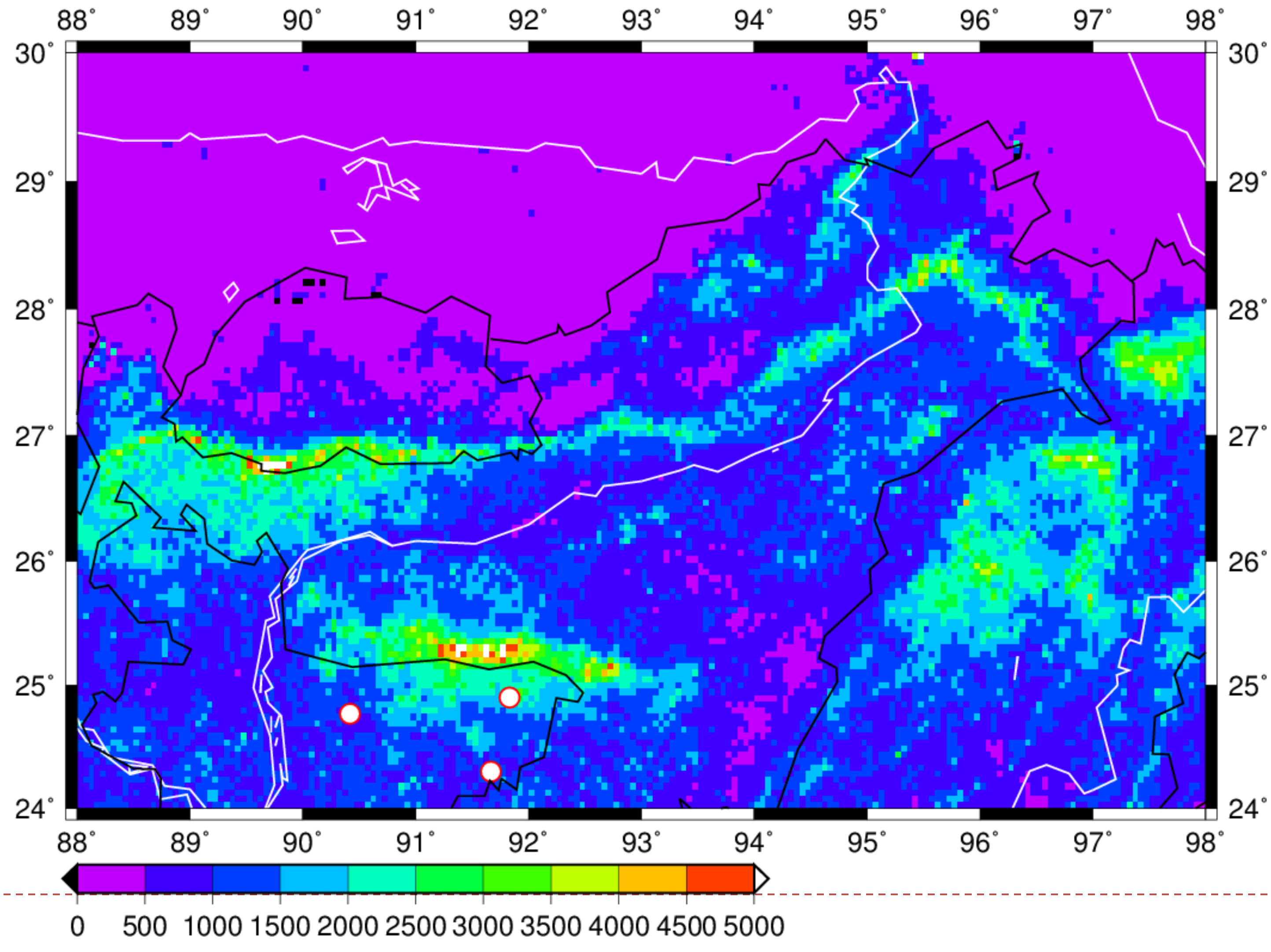
TRMM-2A25(V7) dataset

- TRMM
  - Sun async., 36N-36S, 402.5km
- TRMM-PR
  - Precipitation Radar
  - Swath: 247km
  - Resolution: 5km
  - vertical 250m(0-20km)
- TRMM 2A25(V7)
  - Renovation of algorithms for vertical rain profile (V6→V7)
  - Rain, near surface_rain (NSR)

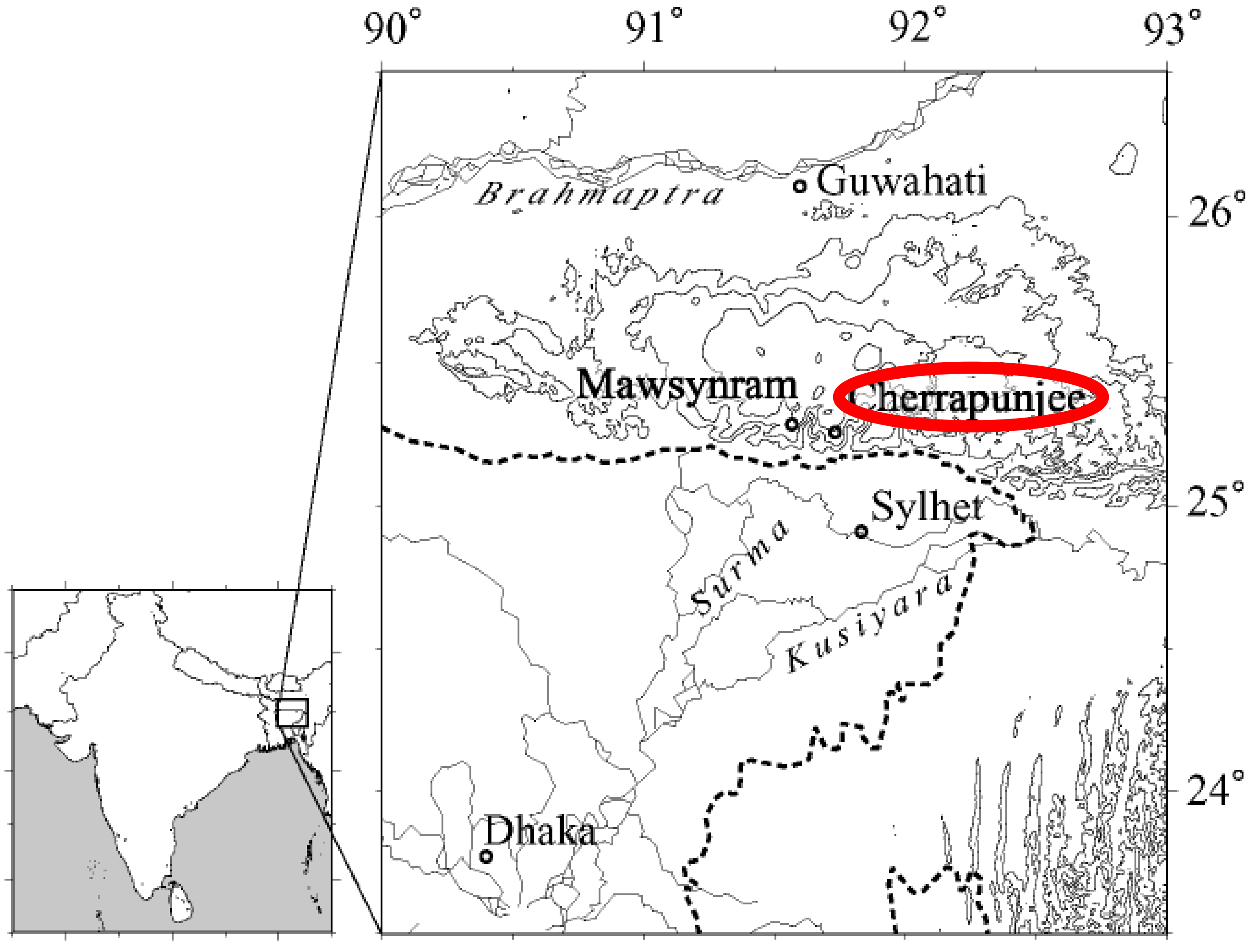


Monsoon TRMM NSR Climatology

1998-2011 Jun.-Sep.

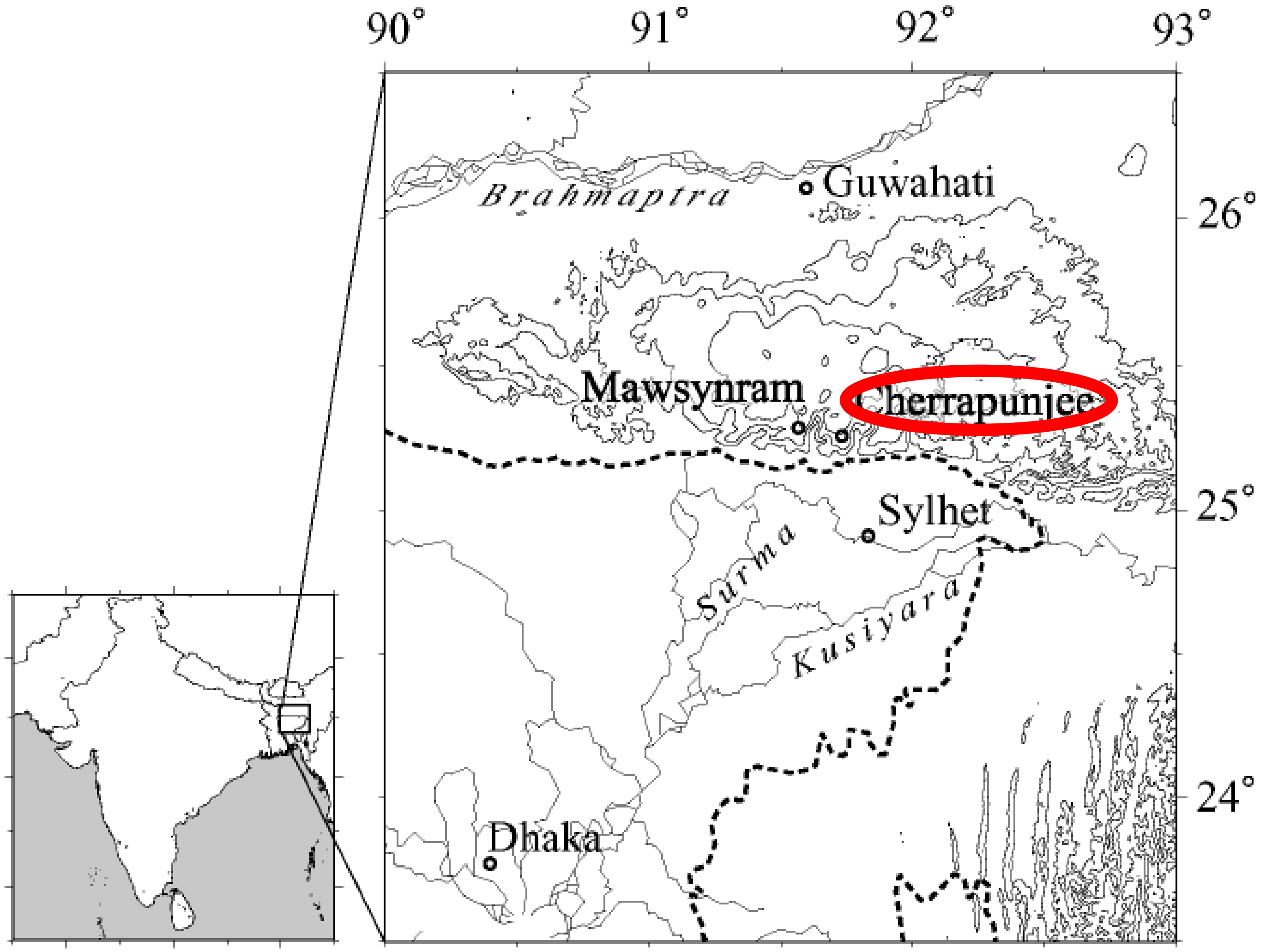


Location



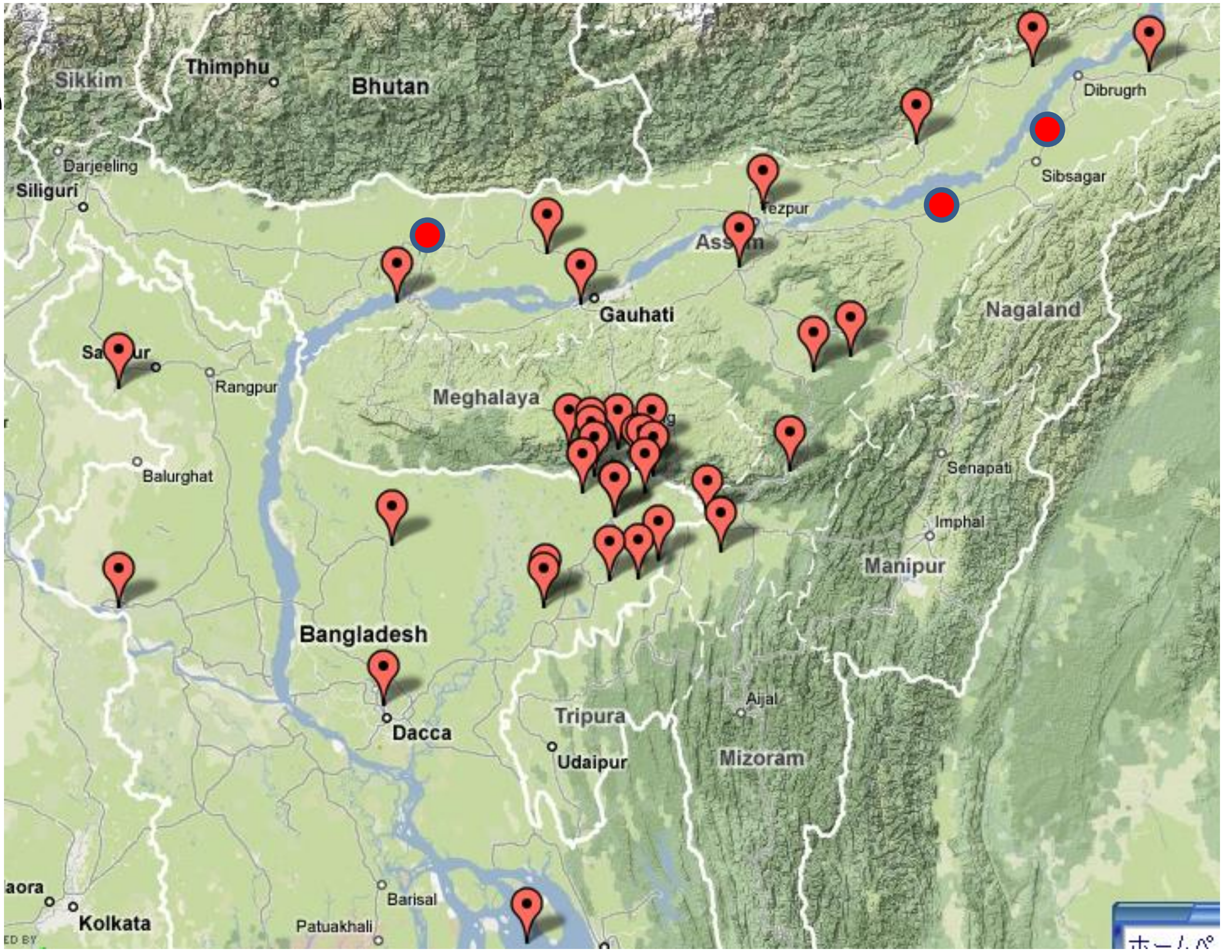
90°
91°
92°
93°
26°
25°
24°
Guwahati
Brahmaptra
Mawsynram
Cherrapunjee
Sylhet
Surma
Kusiyara
Dhaka

Location


90°
91°
92°
93°
26°
25°
24°
Guwahati
Brahmaptra
Mawsynram
Cherrapunjee
Sylhet
Surma
Kusiyara
Dhaka

Raingauge Network in NE India

- We have



21 Feb. 2014・千葉大学
第16回環境リモートセンシングシンポジウム

インド亜大陸北東部の転倒ます型雨量計網による
TRMM-2A25降水量気候値の検証

TRMMを用いたインド亜大陸北東部の降水特性微細構造の解析

寺尾　徹（香川大学教育学部）・村田文絵・山根悠介
・木口雅司・福島あずさ・林　泰一

今日の話

- インド亜大陸北東部の雨量計とTRMM-2A25(V7)の比較
  - 展開した雨量計との比較結果
  - 気候値の微細構造
    - surface_rain
    - rain(鉛直分布含む)
- 降水強度鉛直分布の特徴
  - 季節変化
  - 南北構造

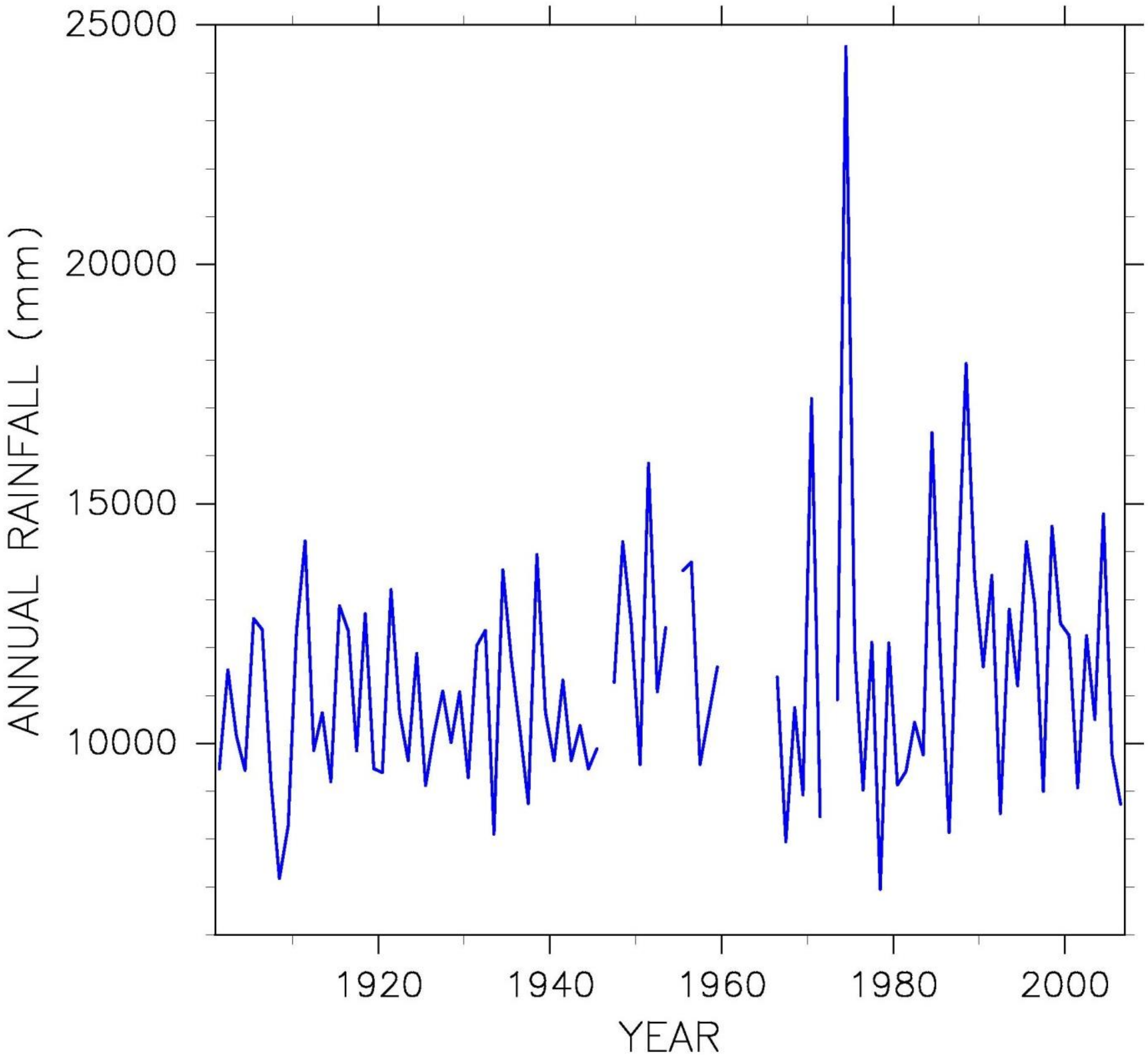
How much is the world record?

26,461 mm @Cherrapunjee
(August 1860 – July 1861)

9,360 mm @Cherrapunjee
(July 1861)

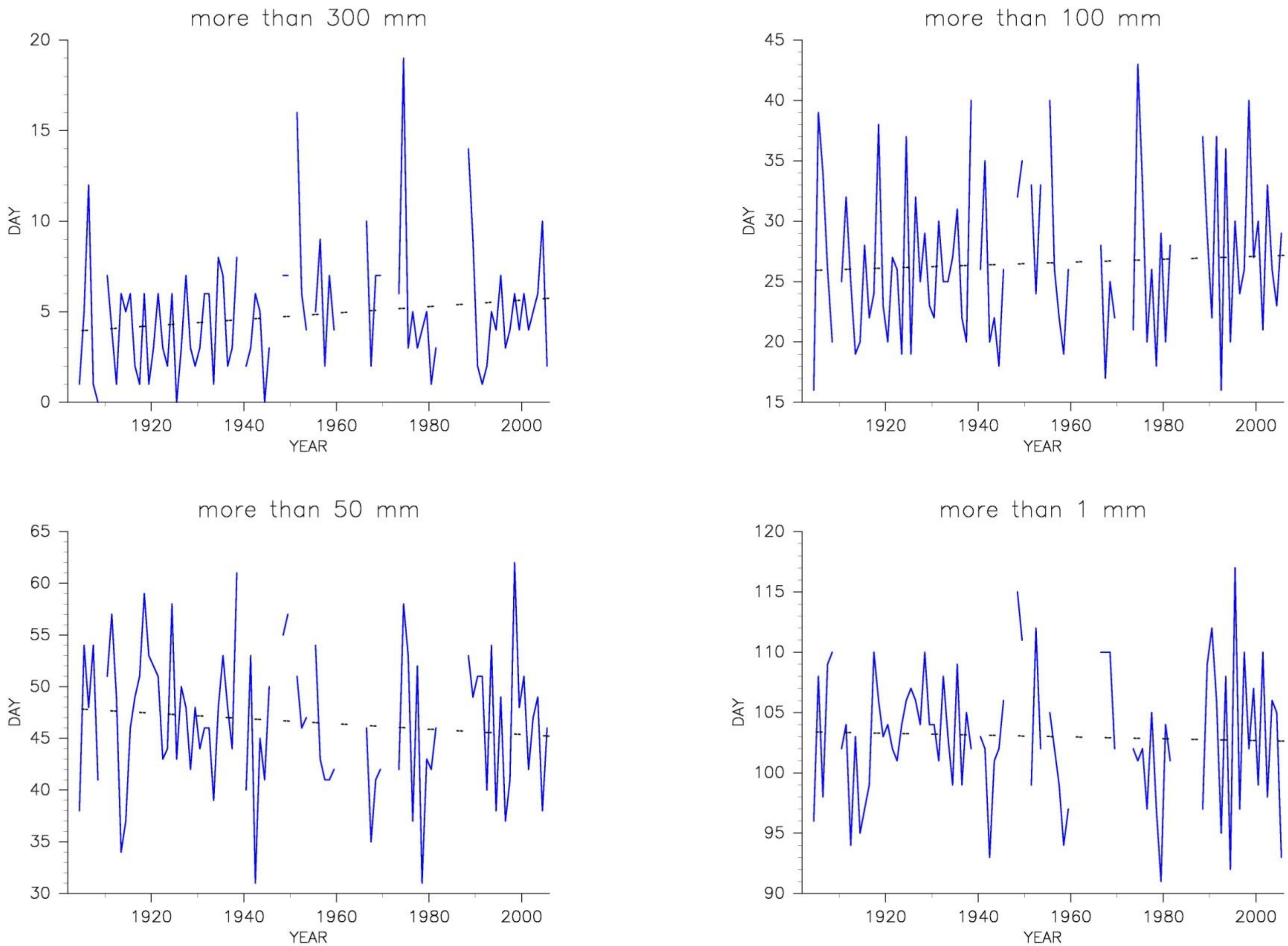
Observation field at IMD, Cherrapunji(2006)

Annual rainfall (1901-2006)



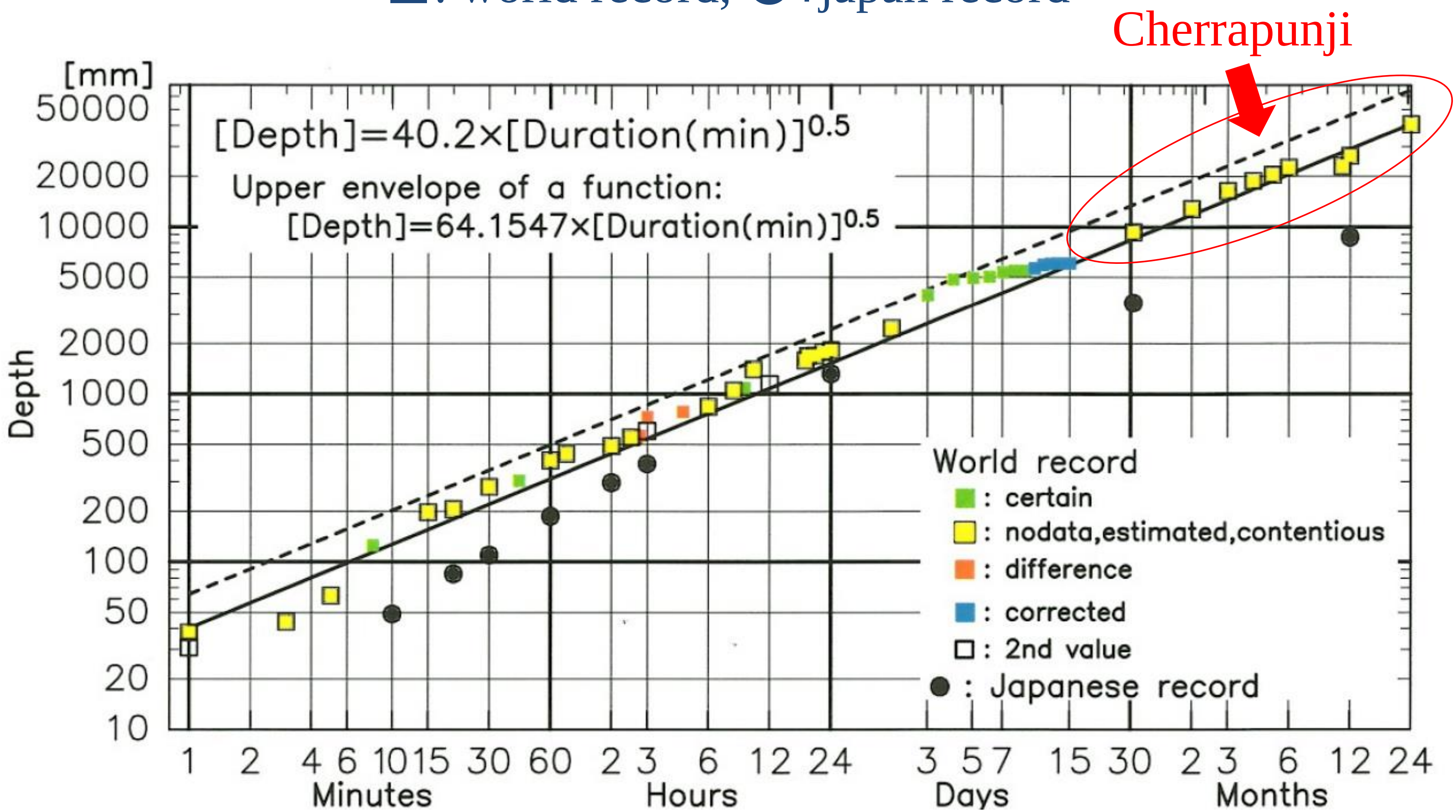
average :11,266 mm

Interannual variation of rainy days (1902-2005)



Rainfall duration vs. Maximum accumulated rainfall

■: world record, ●: japan record



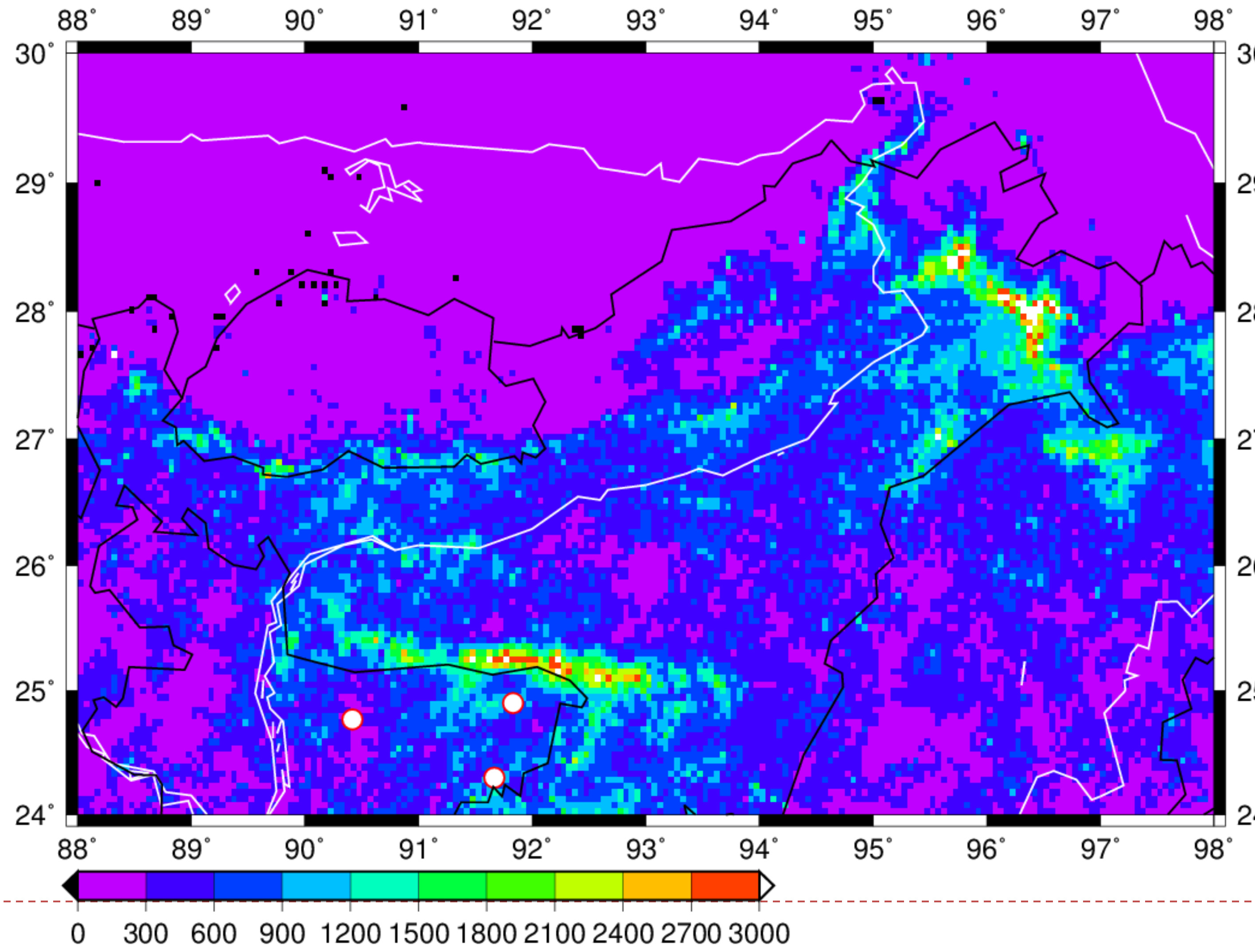
Kiguchi and Oki (2010)

TRMM-2A25(V7) dataset

- TRMM
  - 太陽非同期・36N-36S・402.5km
- TRMM-PR
  - 降雨レーダー
  - 観測幅約247km
  - 解像度約5km
  - 鉛直分解能250m(0-20km)
- TRMM-PR(V7)
  - 降水鉛直分布推定アルゴリズムの改良(V6→V7)
  - 各高度のrain, surface_rain利用

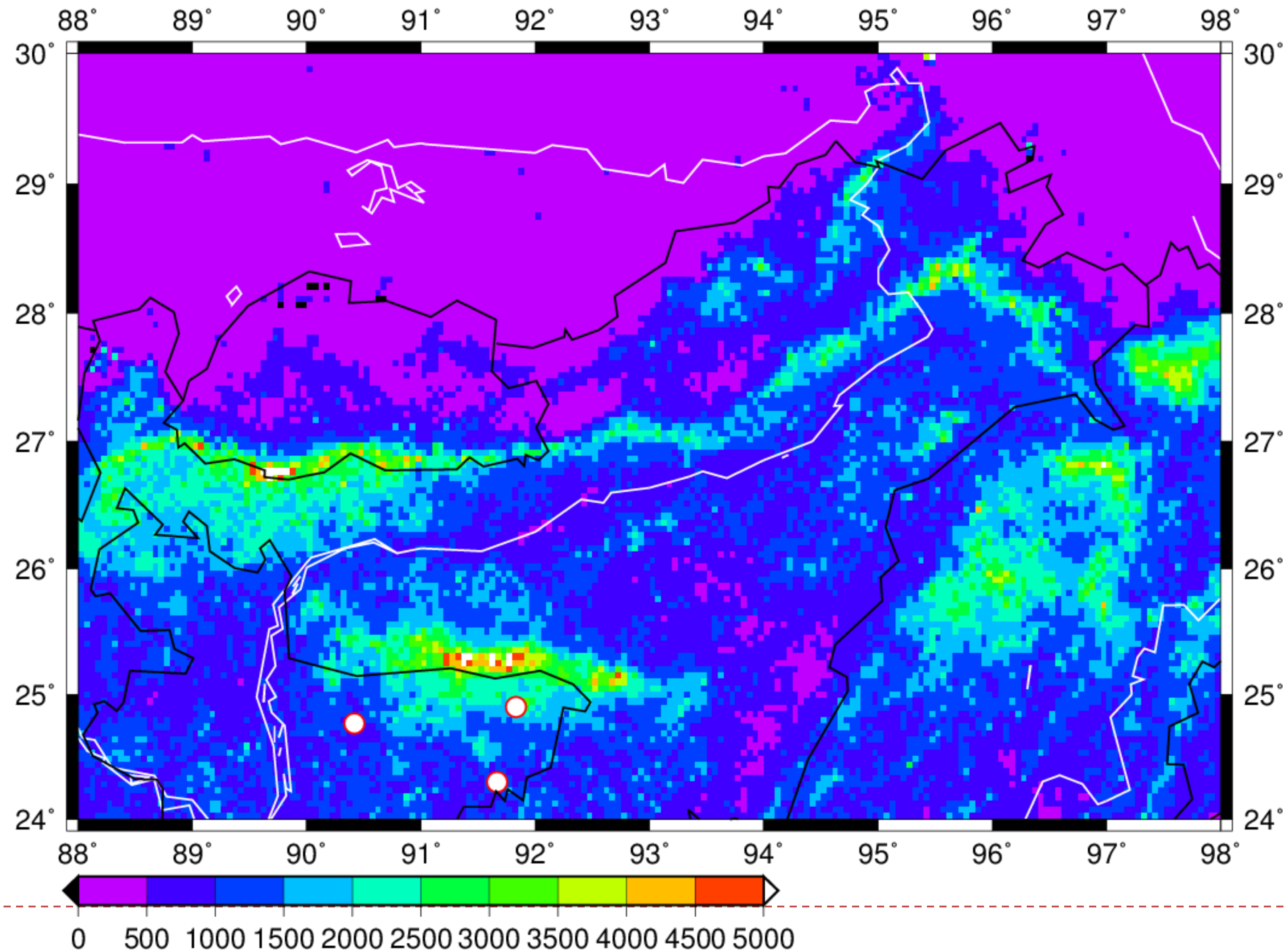
Premonsoon Climatology (TRMM-2A25)

1998-2011 Mar.-May



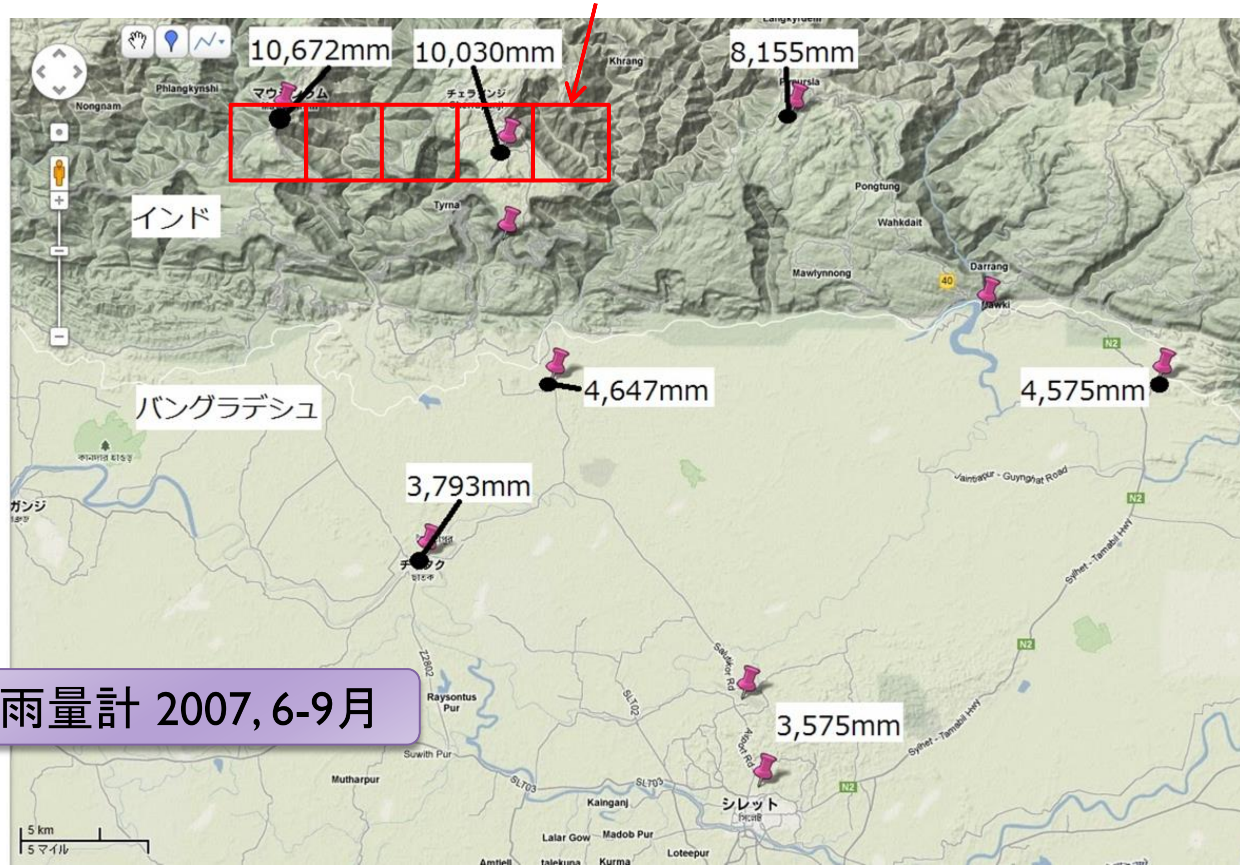
Monsoon Climatology (TRMM-2A25)

1998-2011 Jun.-Sep.



雨量計の位置でのTRMM気候値(6-9月)

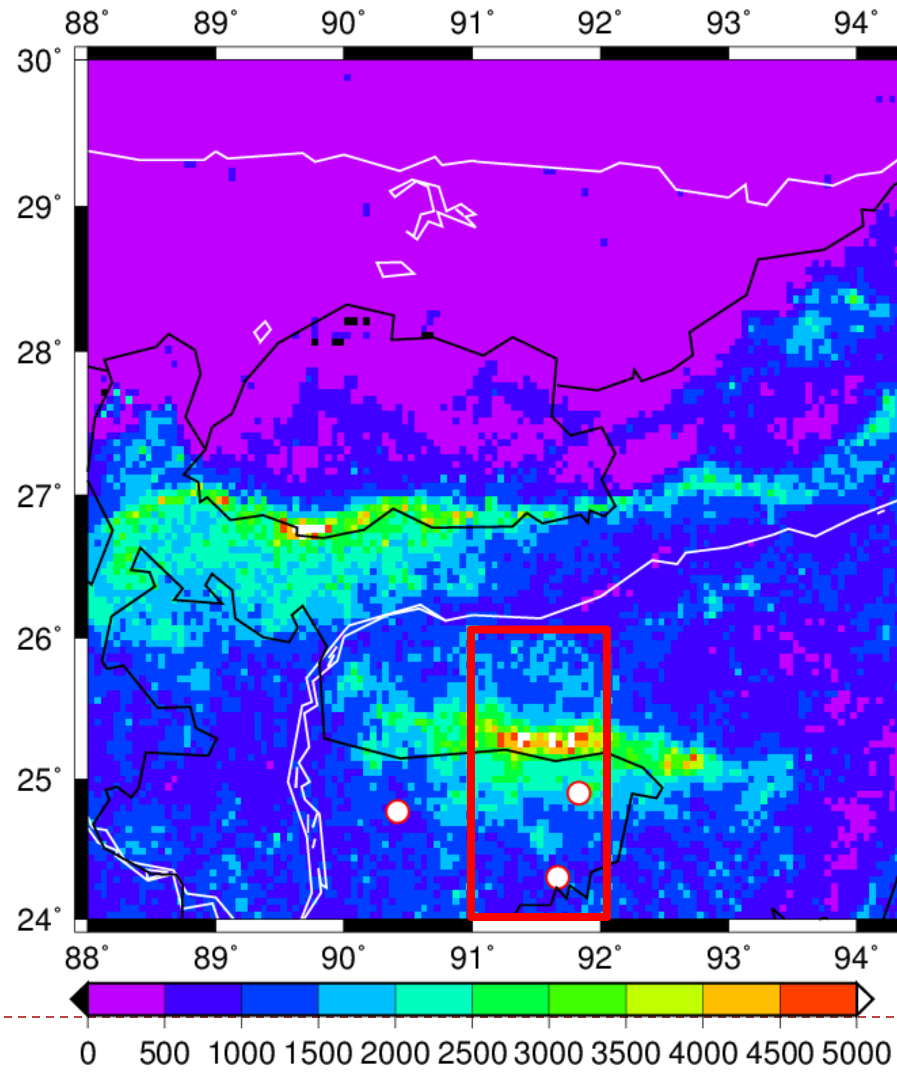
- Cherrapunjee　　　3680mm
- Cherrapunjeeの東隣　6710mm



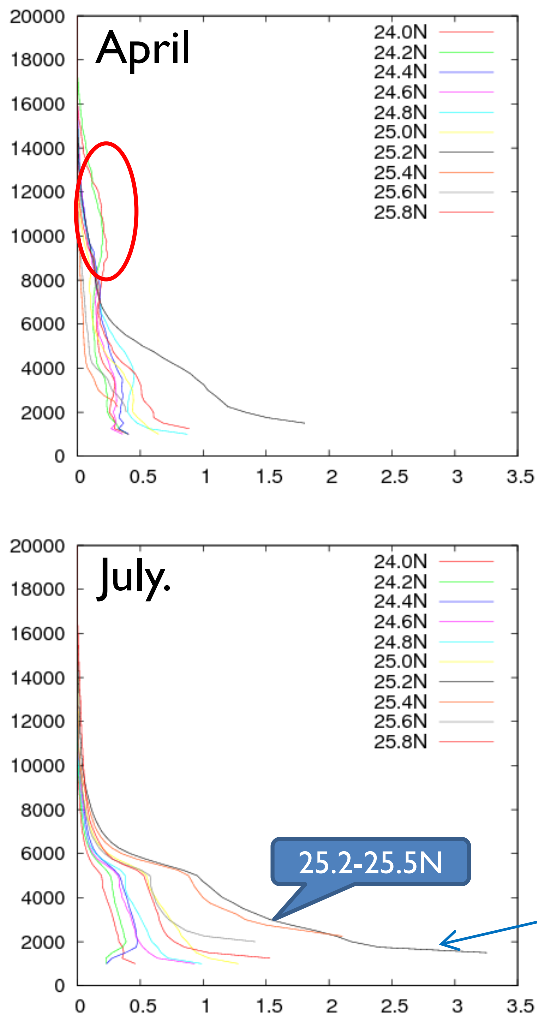
雨量計 2007, 6-9月

Monsoon Climatology (TRMM-PR)

1998-2011 Jun.-Sep.



Vertical Section



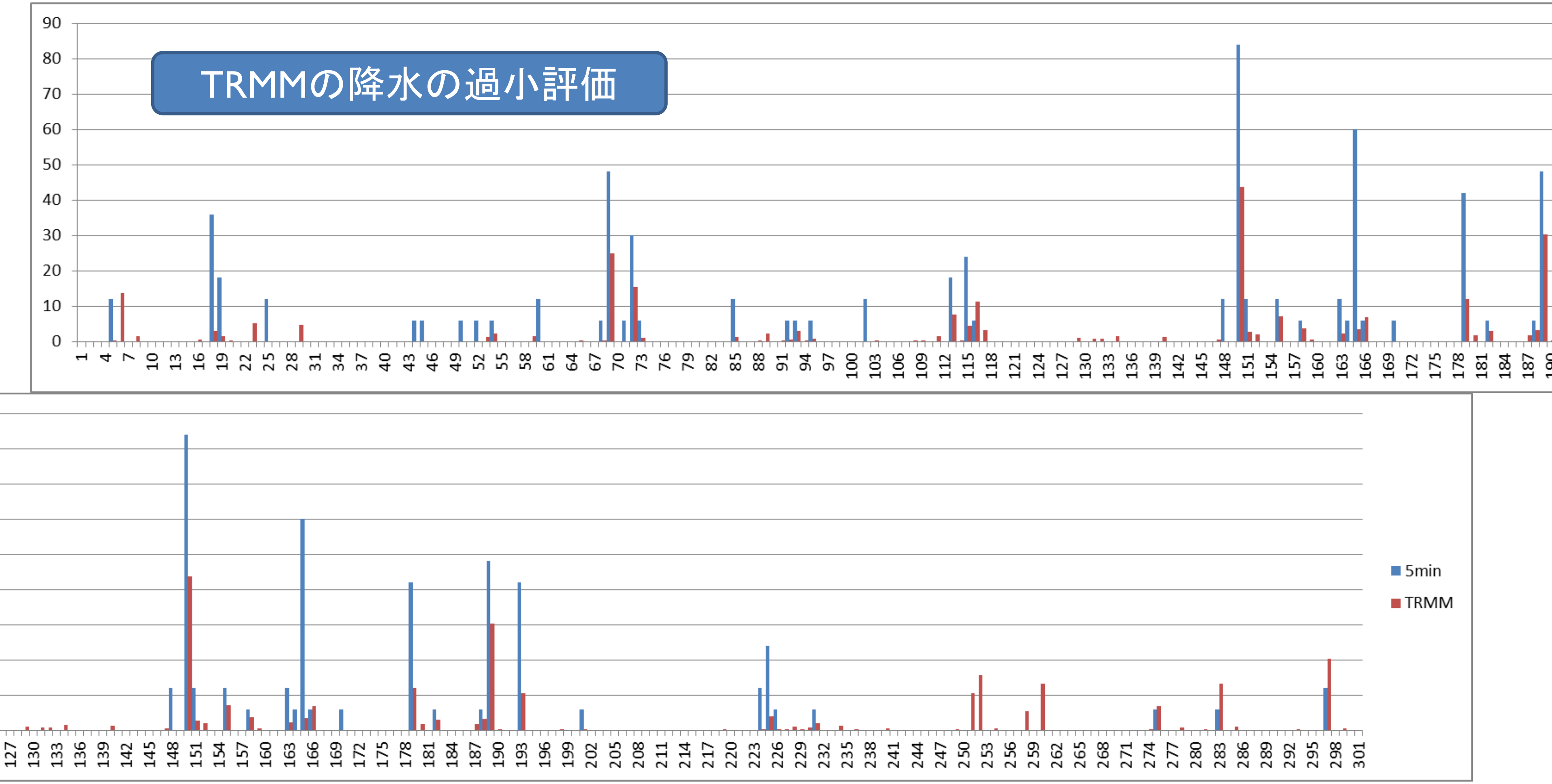
４月にベンガル平野上空に多量の降水
（５月には見られなくなる）

７月の降水の南北幅は広くなる

降水強度の鉛直勾配大きい

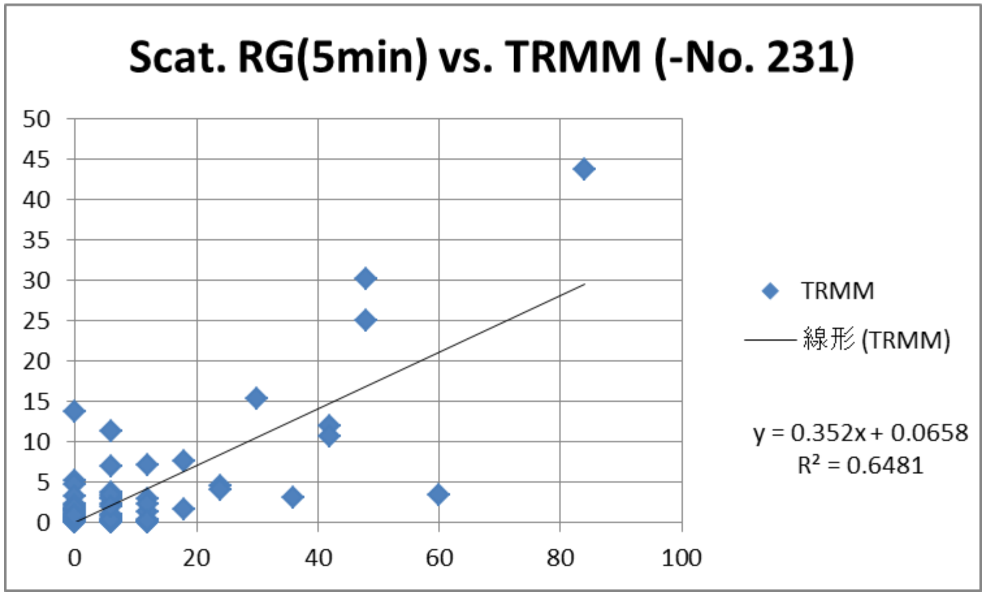
Cherrapunjee RG vs. TRMM 2A25

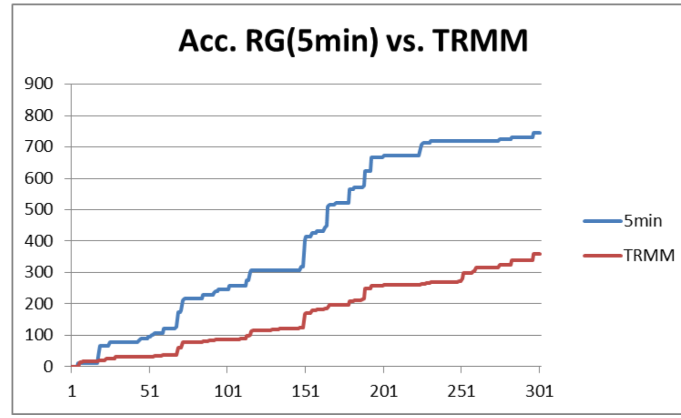
- RG-5min total vs. TRMM 0.1deg rect. average

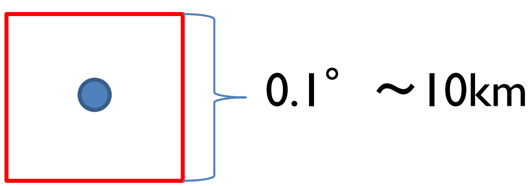


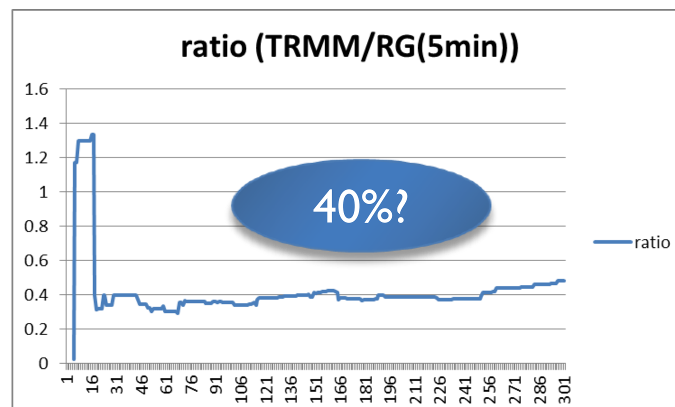
Cherrapunjee RG vs. TRMM-2A25

- RG-5min total vs. TRMM 0.1deg rect. average





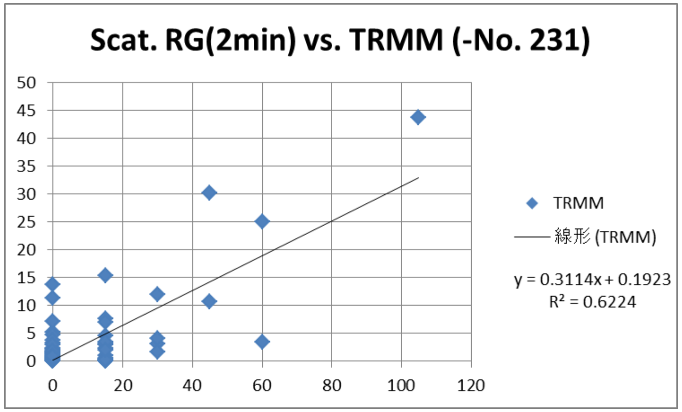




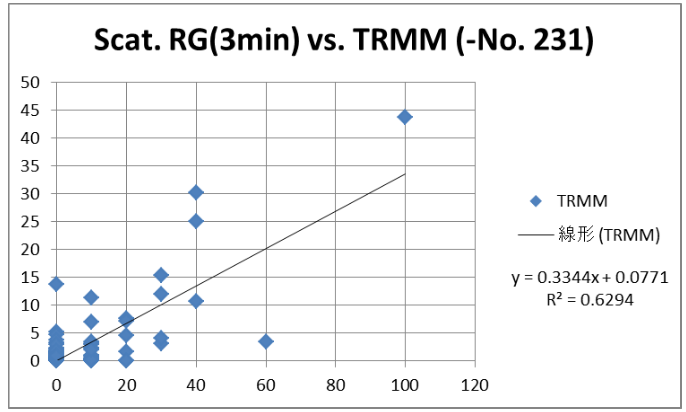
TRMMの降水の過小評価

雨量計降水評価時間(τ)と対TRMM相関・比

- 過小評価は評価時間にはあまりよらない

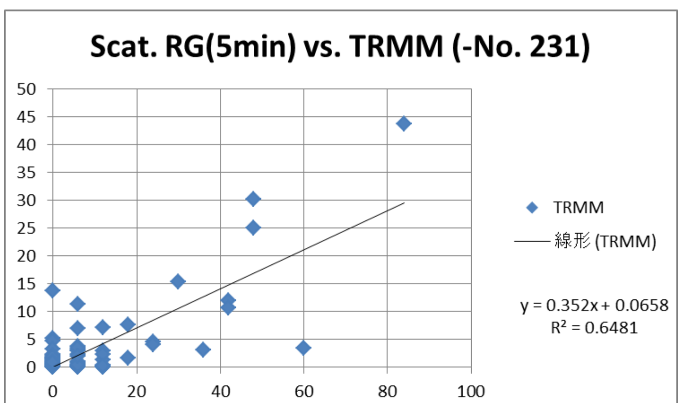


r=0.789

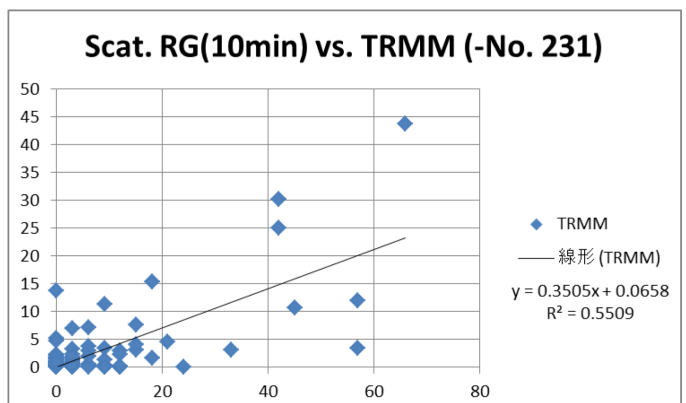


r=0.793

τ	r
2	0.789
3	0.793
5	0.805
10	0.742
20	0.644
40	0.571
60	0.565



r=0.805

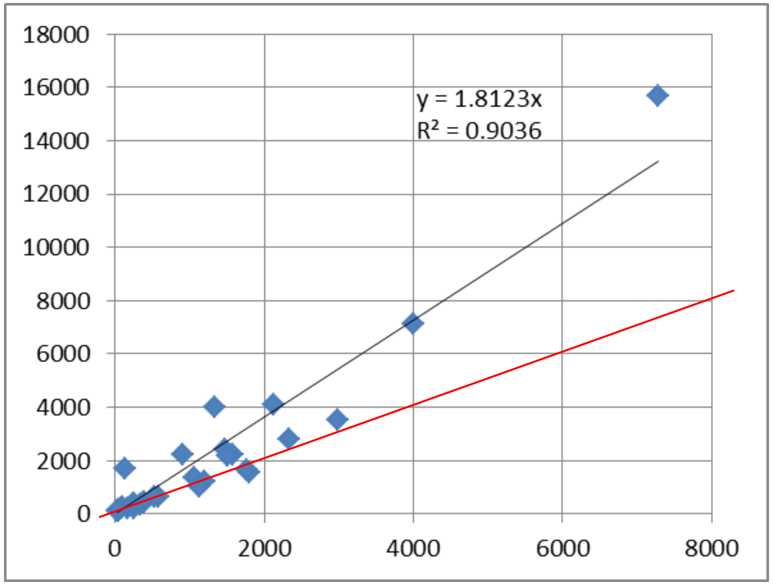


r=0.742

τ	f
2	0.373
3	0.358
5	0.373
10	0.372
20	0.374
40	0.376
60	0.392

降水強度の増加

- 高度が下がると降水が増加する
  - 3000m → 2000m



まとめ

- Cherrapunjeeの雨量計とTRMM比較
  - 空間パターン
    - Meghalaya山脈の多量の降水が再現されている
  - 雨量計との関係
    - 観測機会ごとの比較から大きな過小評価(40%)
    - Cherrapunjeeのグリッドでは3680mm/4ヶ月(1998-2011)
    - 雨量計のあるグリッドの隣で降水量は6710mm/4ヶ月(1998-2011)
  - 降水強度の鉛直勾配が大きい・・・surface_rainの取扱い?
- 降水強度の鉛直断面
  - プレモンスーン期:　25.2-25.3N
    - ベンガル湾上の10000mあたりに4月に大きな降水強度
  - モンスーン期:　25.2-25.5N(広がる)

雨量計の位置でのTRMM気候値(6-9月)

- Cherrapunjee　3680mm
- Cherrapunjeeの東隣　6710mm