2nd MAHASRI WS, 6 March 2009, Danang

Diurnal features of scale-based precipitation systems observed by TRMM PR

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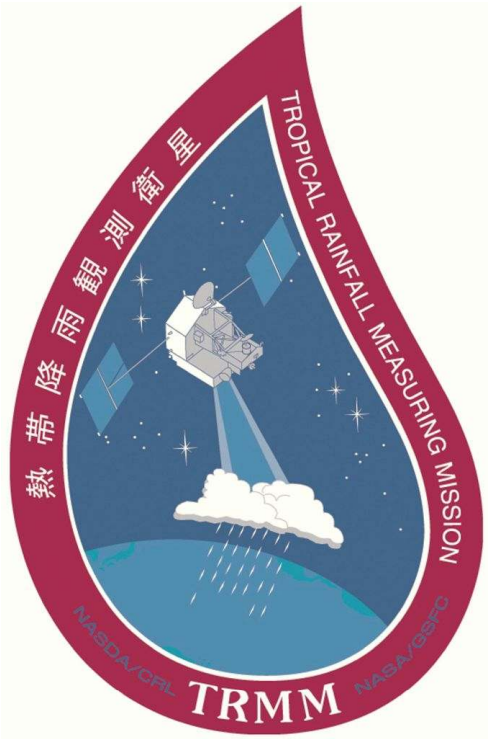
Outline

1. Precipitation climatology
2. Precipitation-system database
3. Diurnal features as the precipitation-system aggregate

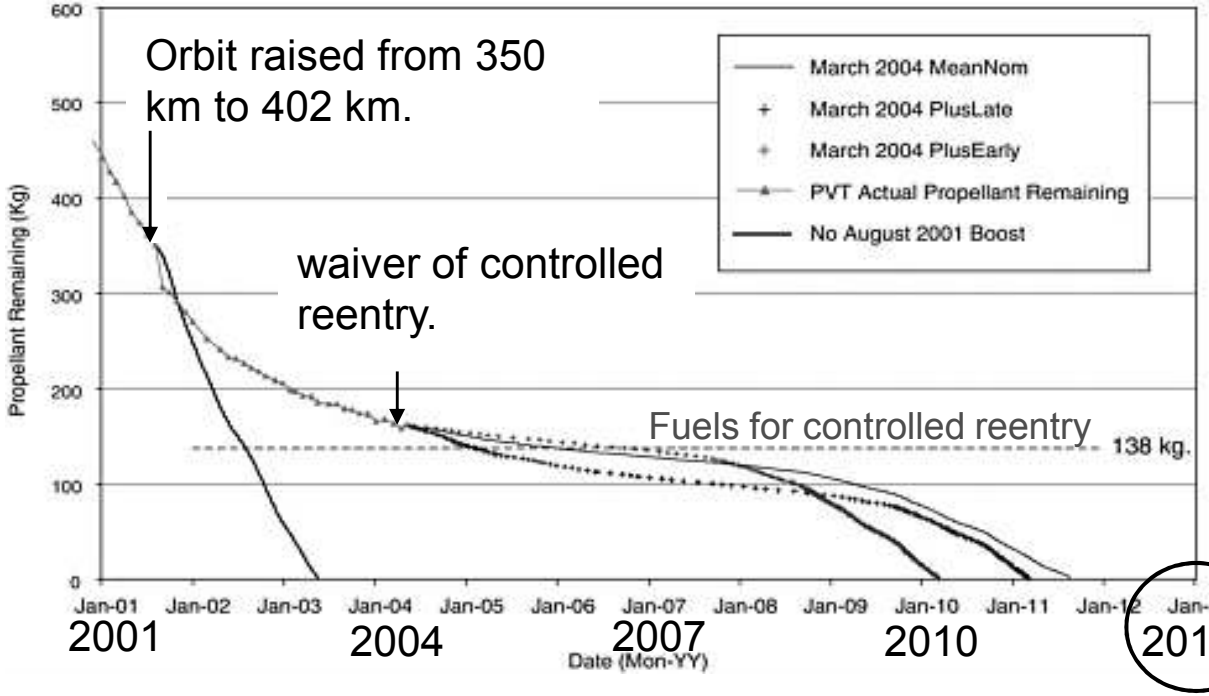
Photo: Clouds over the coastal area near Ho Chi Minh, 3 March 2009

1. Precipitation climatology

More than 11 years have past since the Tropical Rainfall Measuring Mission satellite was launched. The large volume of accumulated TRMM PR data is useful to understand the multi-scale climatological features.

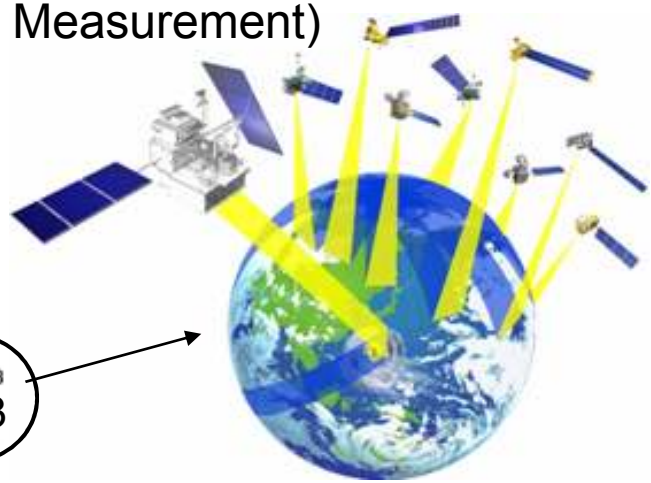


Observation period of TRMM and propellant remaining

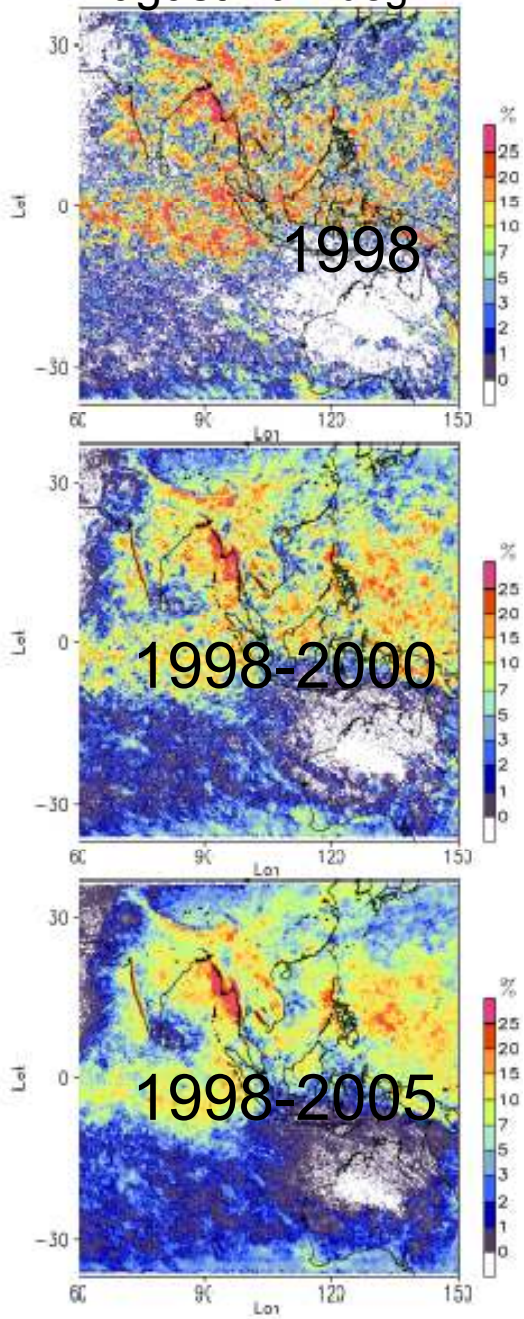


cNASA

GPM (Global Precipitation Measurement)

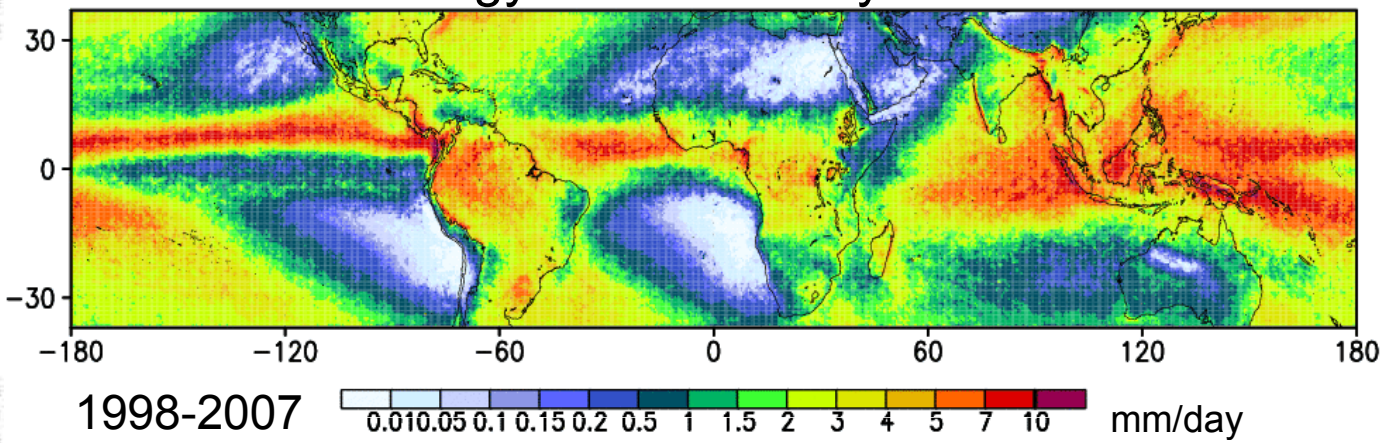


Rain frequency in August 0.2 deg.

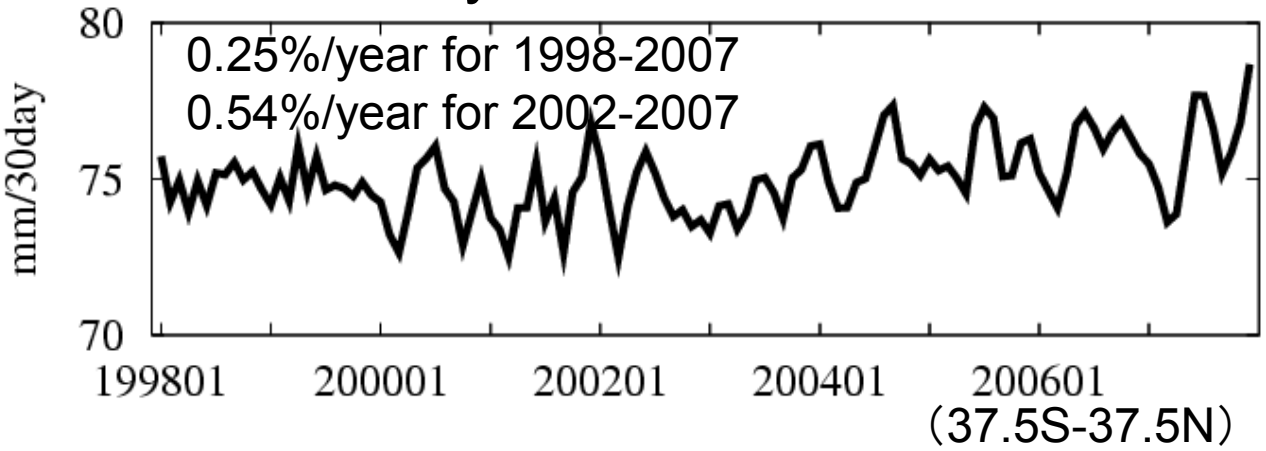


The decadal data enabled us to study the rainfall distribution at fine scales and the temporal variation.

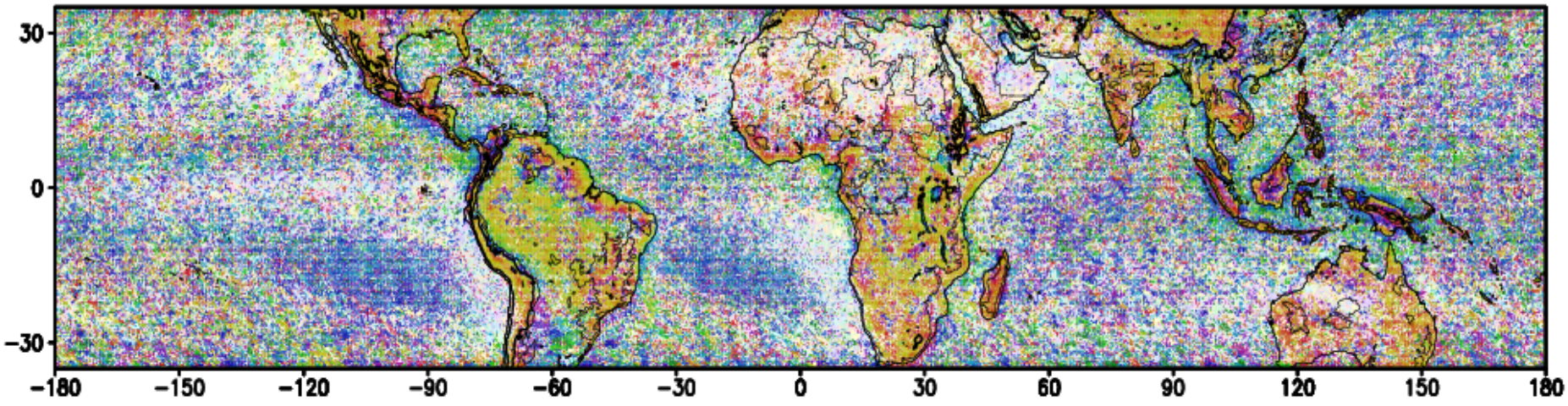
Rainfall climatology based on 10-year TRMM PR data

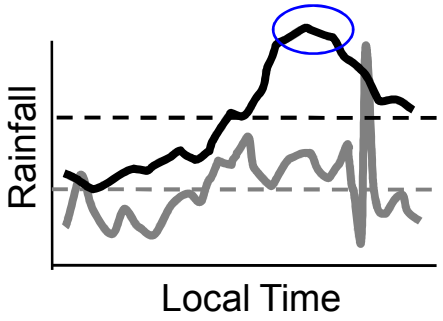


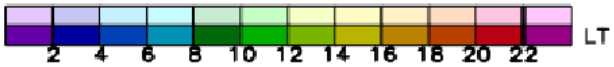
Year-to-year variation of rainfall



Time of maximum rainfall 1998-2005, 0.2deg



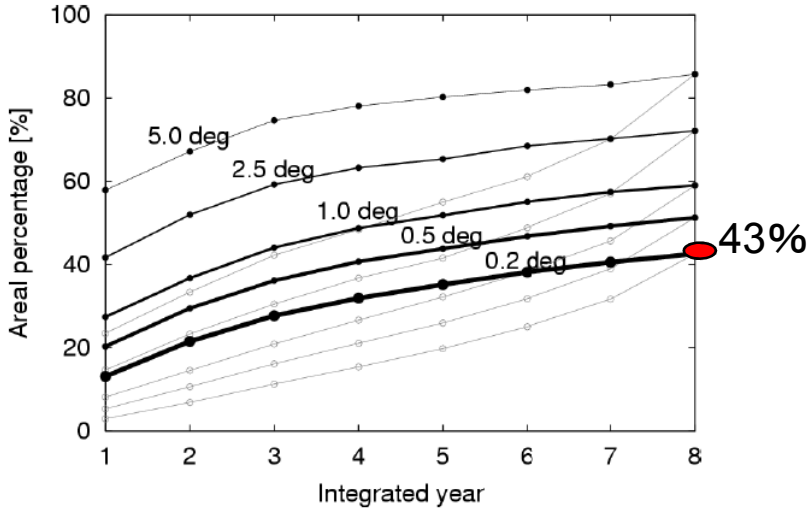




Def. of a distinct diurnal peak (3h-significant peak, dark color): the time of maxR with consecutive positive anomalies for at least 3 h. (Hirose et al. 2008, JAMC)

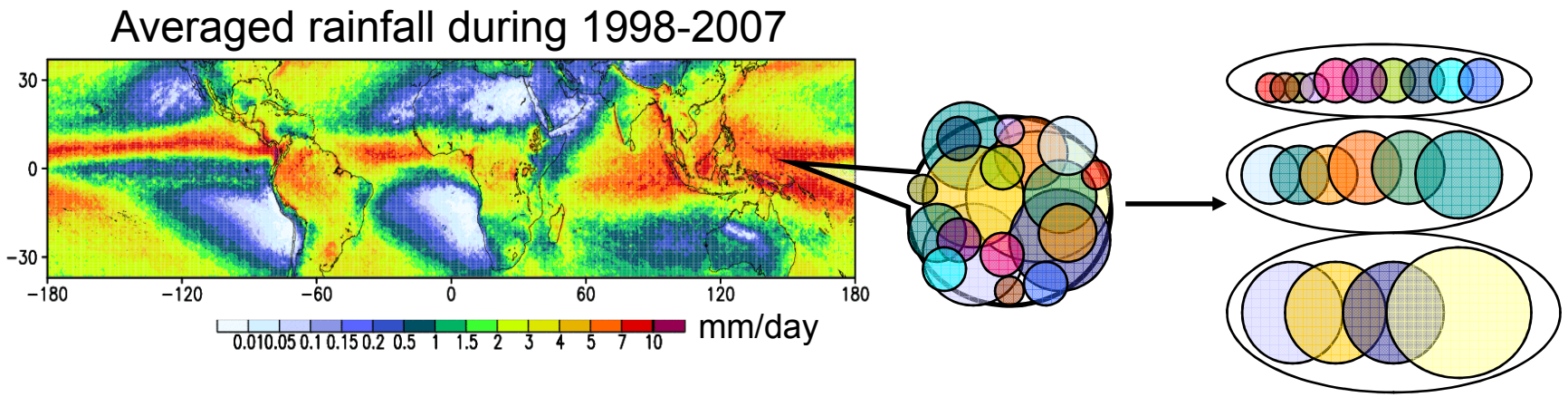
Year-to-year variations in the areal % of 3h-significant peaks for each resolution

Thin lines indicate areal % of 3-h-significant peak that is consistent with a corresponding peak in the 8-yr data



2. Precipitation-system database

Precipitation climatology ⟷ Precipitation system climatology

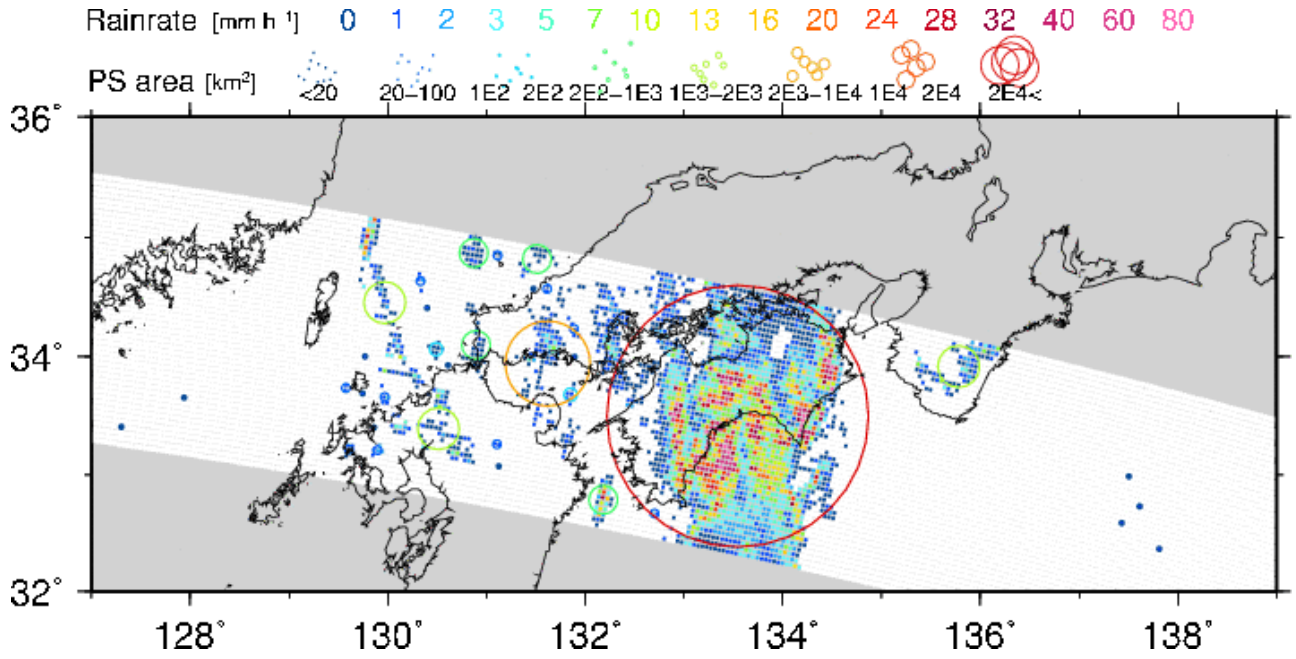


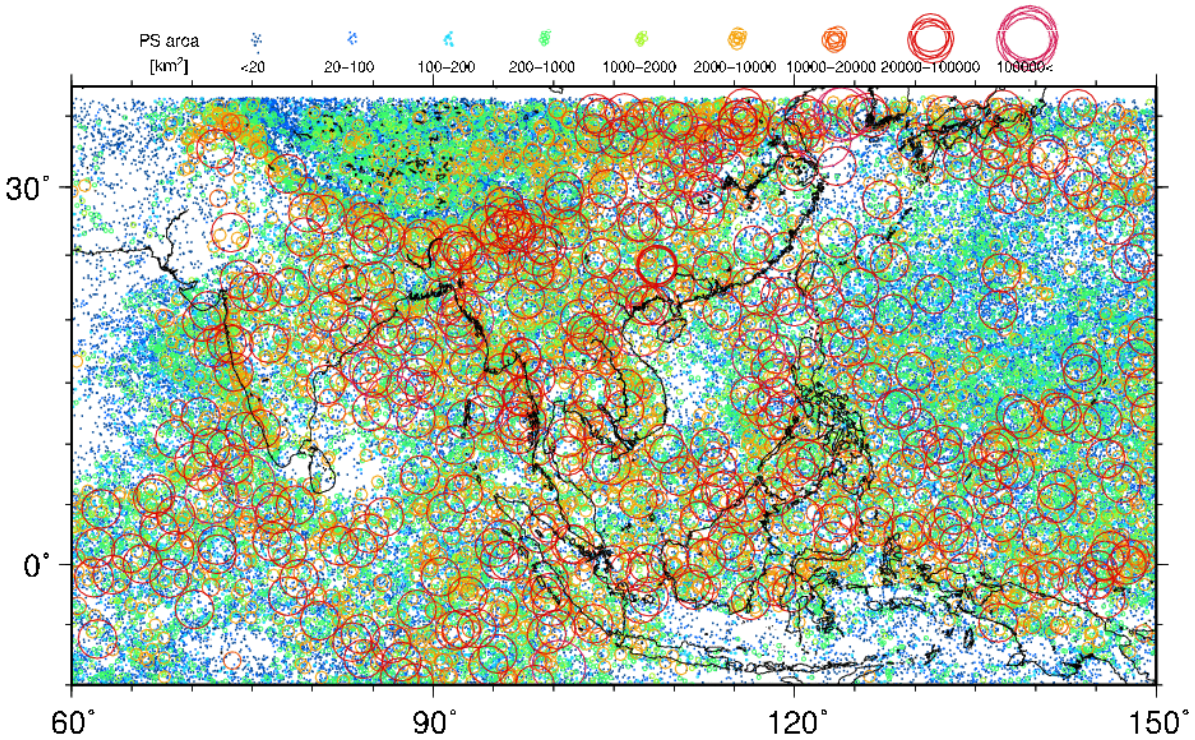
Objective

to clarify the regional variety of the group characteristics of diurnal-varying precipitation systems embedded in average rainfall.

A database of parameters of the individual storm for 10 years was generated to gain understanding on the variety of prevailing precipitation regime that possesses consistent morphological characteristics.

Snapshot of a group of PR-captured Precipitation Systems (PR-PSs)



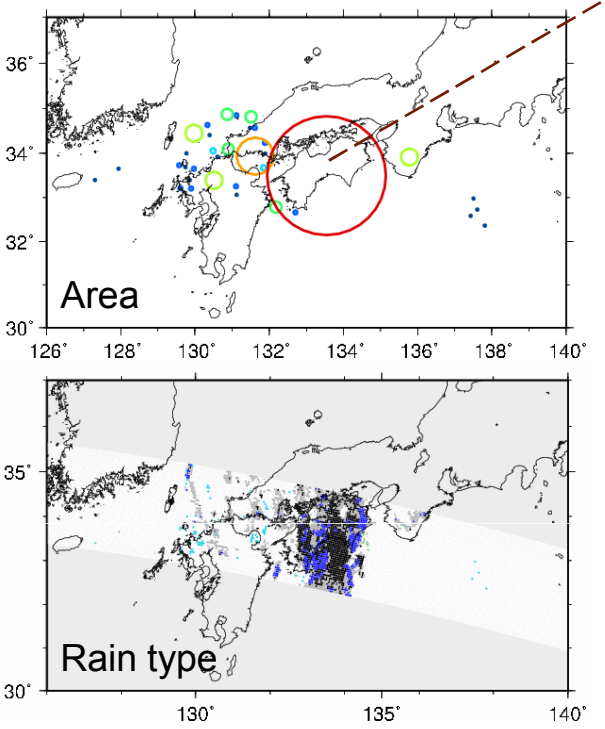


PR-PSs over Asia in July 2004

For 10 years, more than 60 million PR-PSs were stratified.

(Hirose et al. 2009, JMSJ)

Parameters of a PR-PS



182th PR-PS in orbit 38245_Asia

Location: 133.55E, 33.60N
Date and time: August 1, 2004, 2:47LT
Elevation: 102 m
Freezing level: 5028 m
Flag: ocean type, truncated by the swath edge

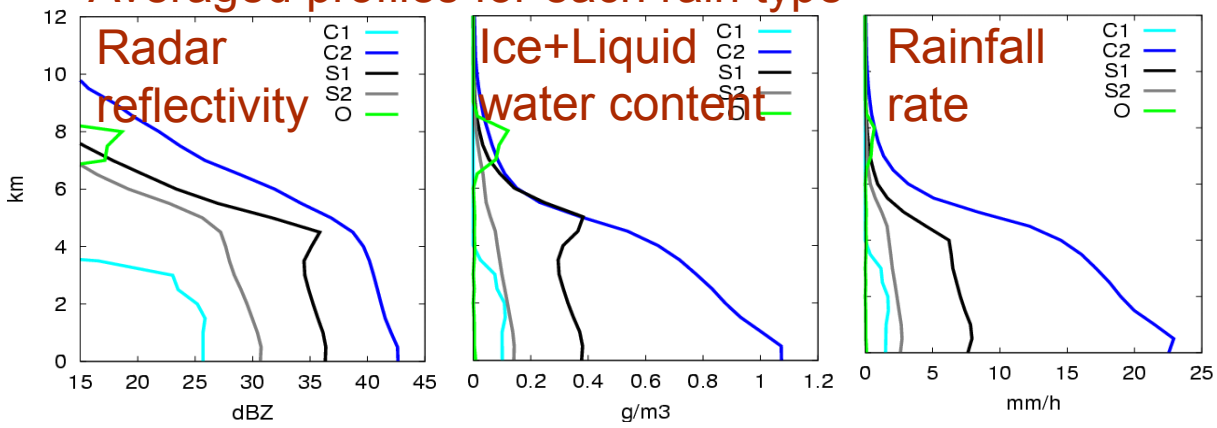
Area [km^2]: $C_1$86 (**0**%), $C_2$9030 (**22**%), $S_1$17415 (**42**%), $S_2$14470 (**36** %), O129 (0%)

Areal rain [mm h^{-1}km^2]: $C_1$129 (**0**%), $C_2$203570 (**54**%), $S_1$132771 (**35**%), $S_2$37785 (**10**%), O13 (0%)

Max. storm height [km]: $C_1$3.6, $C_2$13.9, $S_1$11.9, $S_2$12.2, O8.5

Rain type:
C_1: Shallow and isolated convection
C_2: Deep convection
S_1: Stratiform rain w/ BB
S_2: Stratiform rain w/o BB
O: Others

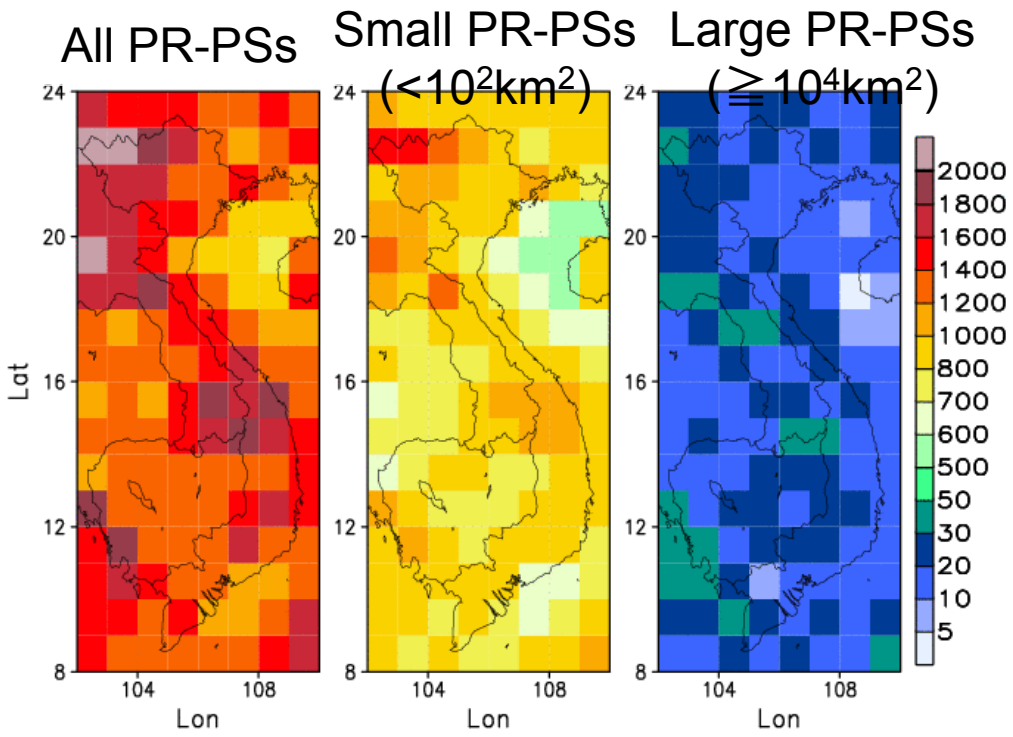
Averaged profiles for each rain type

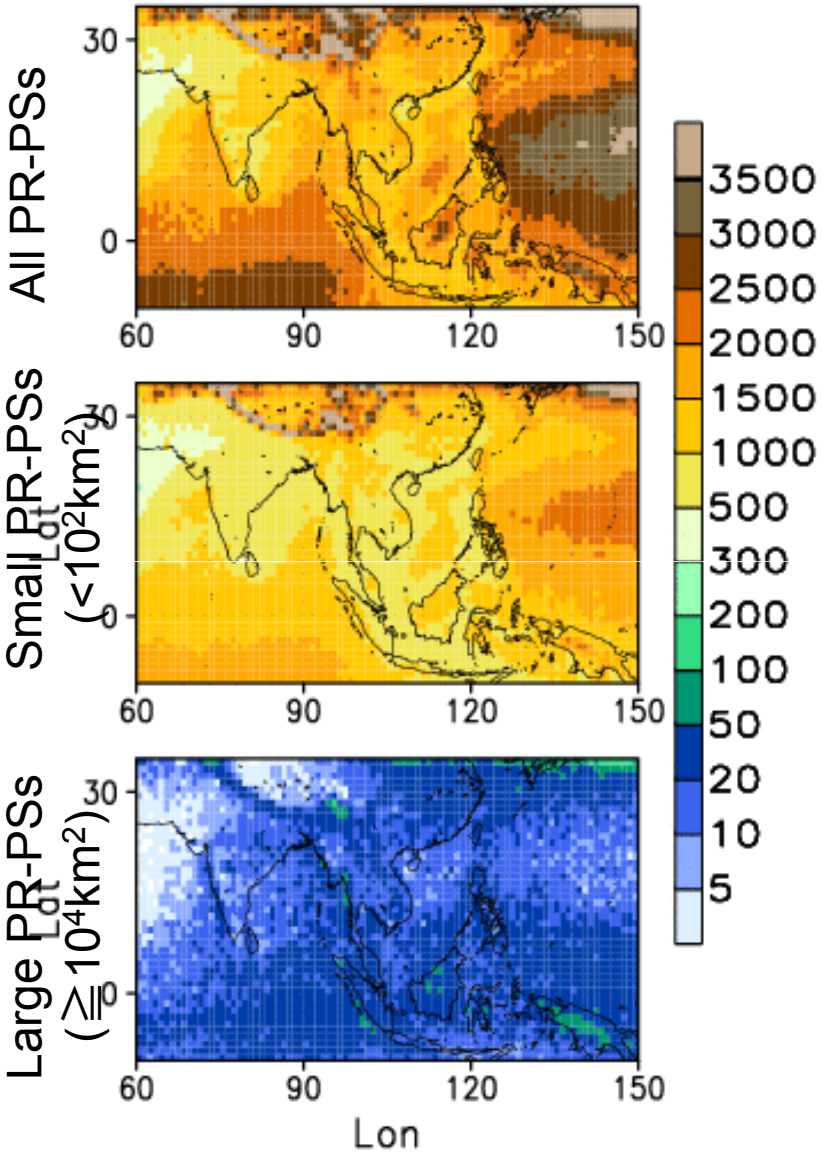


Number of scale-based PR-PSs over Asia 1998-2007, 1deg.

Ten years of TRMM PR operation enabled us to examine tens of large PR-PSs in each 1 degree region over the most global tropics.

Over Vietnam



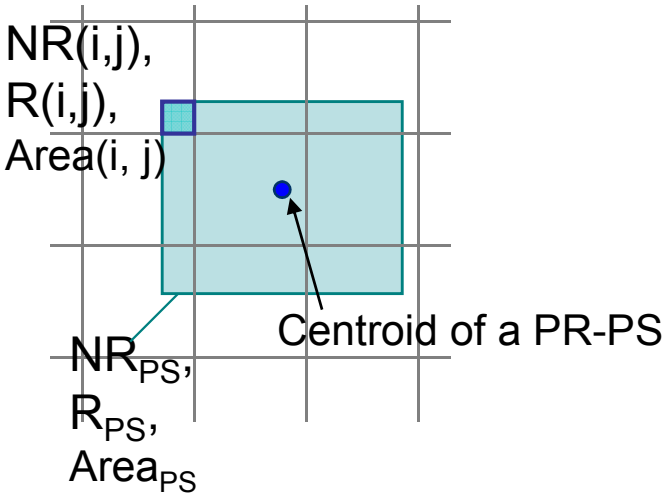


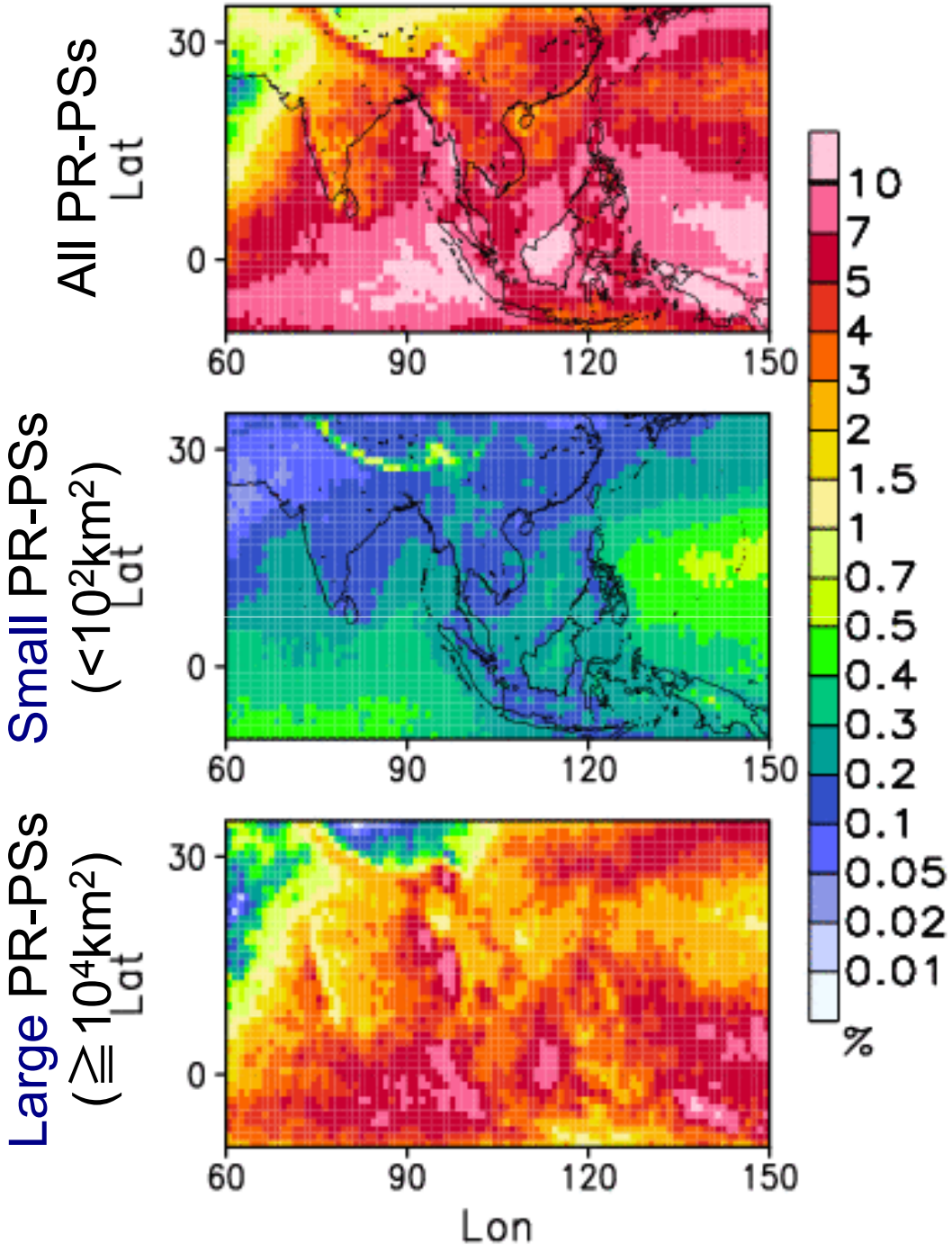
Occurrence frequency of scale-based PR-PSs over Asia

1998-2007, 1deg.

Areal coverage of rain:
100Nrain(i,j)/Nsample(i,j)

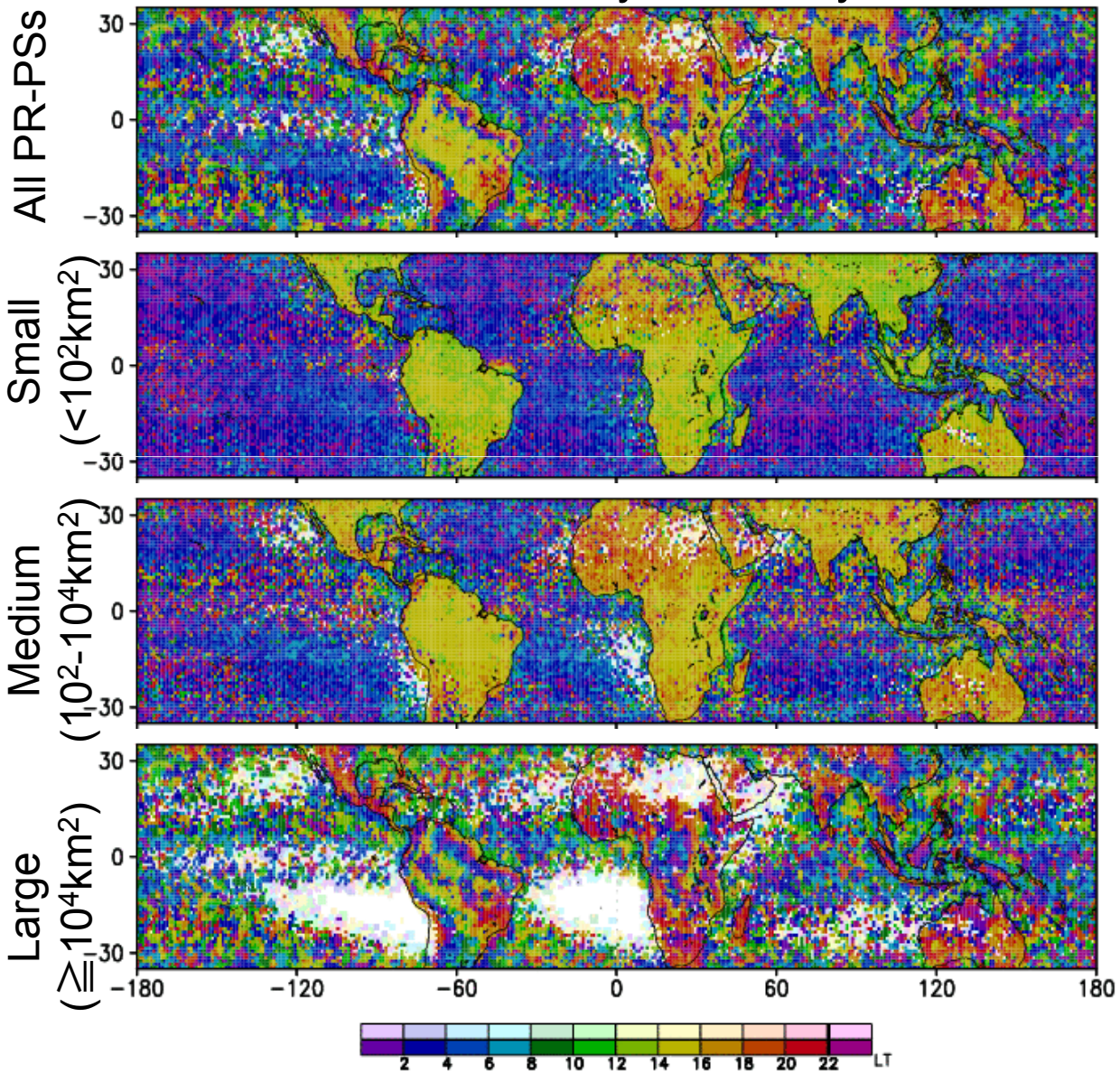
The number of rain pixels and rainfall of a PR-PS are converted into each 1° grid according to gridded rain area.





3. Diurnal features as the precipitation-system aggregate

Time of maximum hourly rainfall by scale-based PR-PSs



Jan1998-Dec2007,

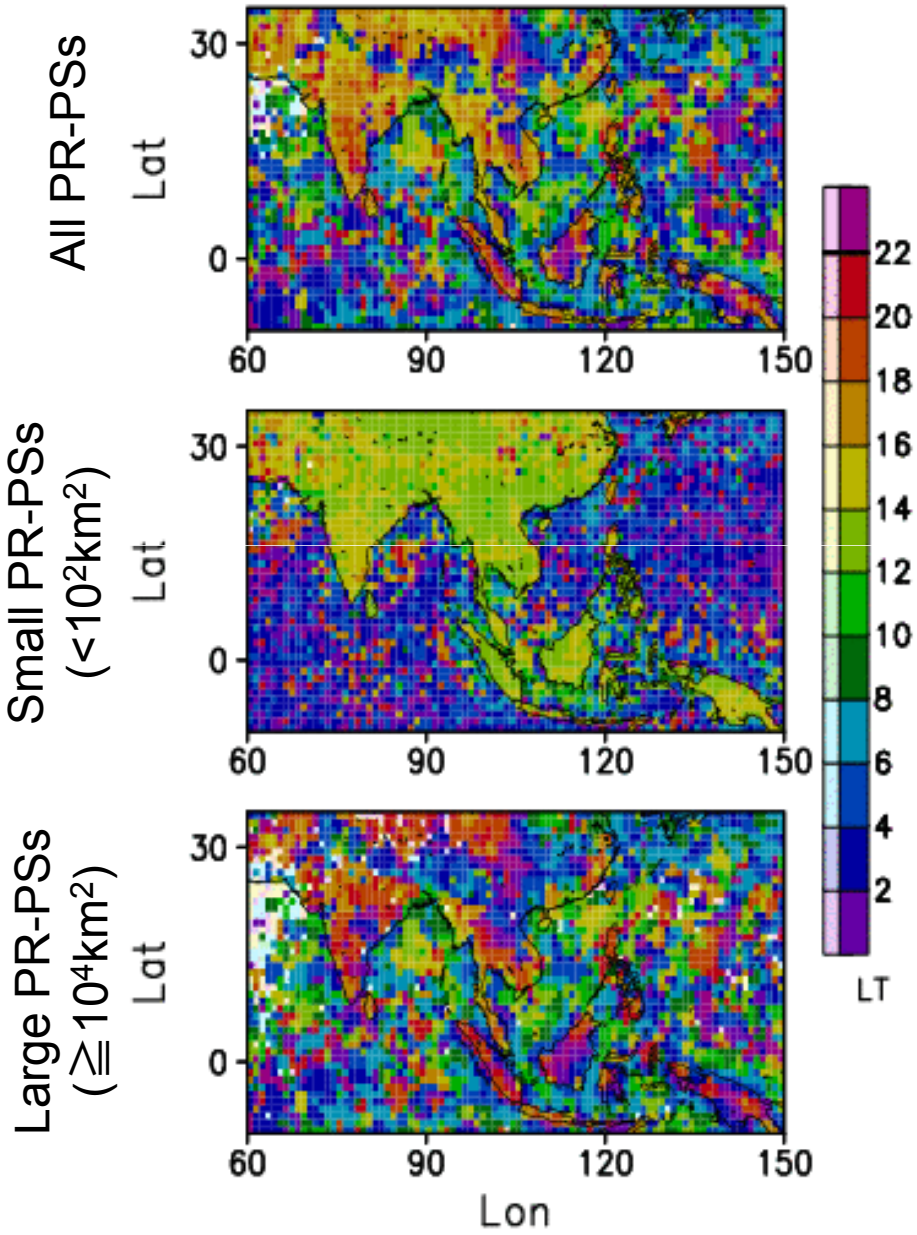
⊿x=1deg., ⊿t=2h

Clear land/ocean contrast in the enhancement of small convection shows the difference of the solar insolation effect.

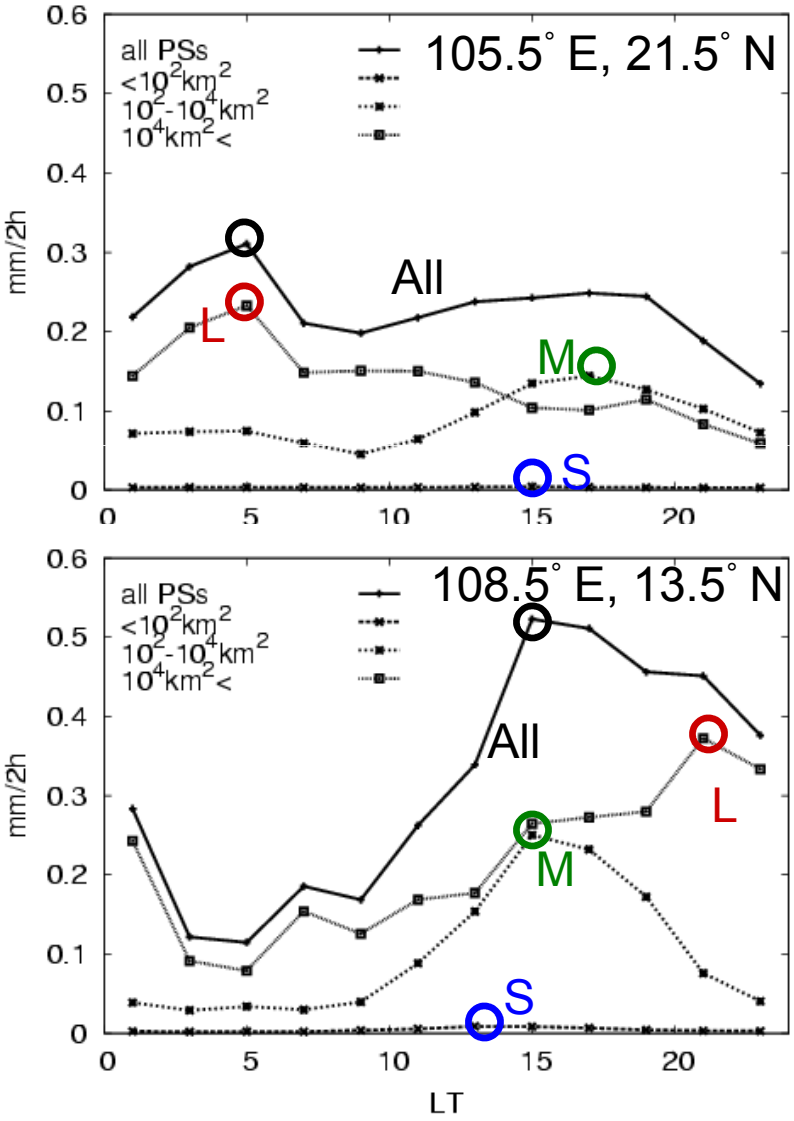
Development of convection according to the ABL development is indicated.

Development of MCS is strongly affected by orography.

Time of maximum hourly rainfall by scale-based PR-PSs over Asia



Diurnal variation of rainfall of scale-based PR-PSs over the northern part (top) and the eastern part of Vietnam (bottom)



Time of maximum hourly rainfall for each rain type

ALL

Shallow convection

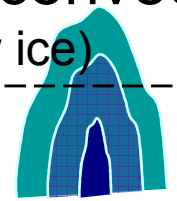
(Conv w/o ice)

0℃

Deep convection

(Conv w ice)

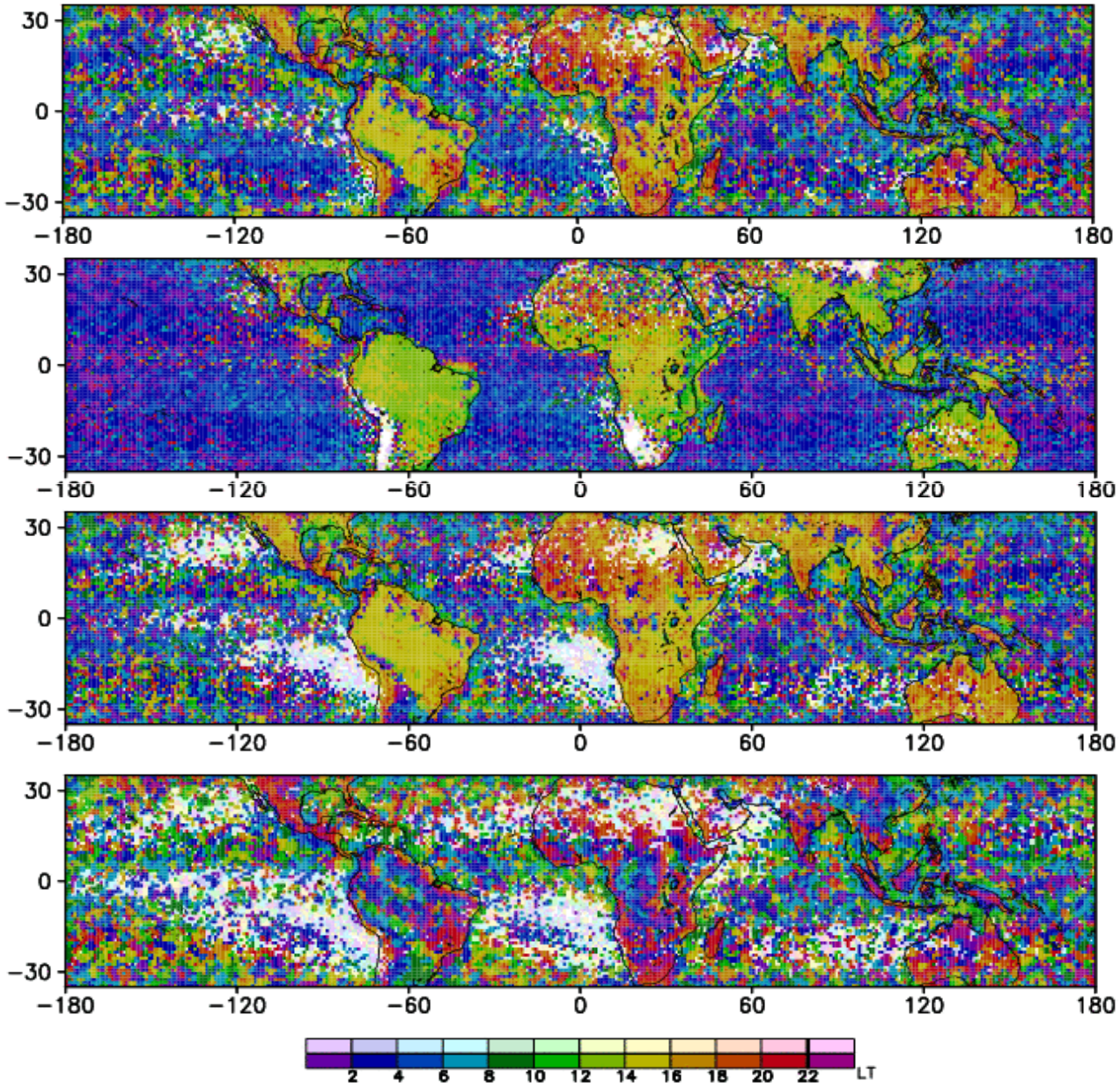
0℃



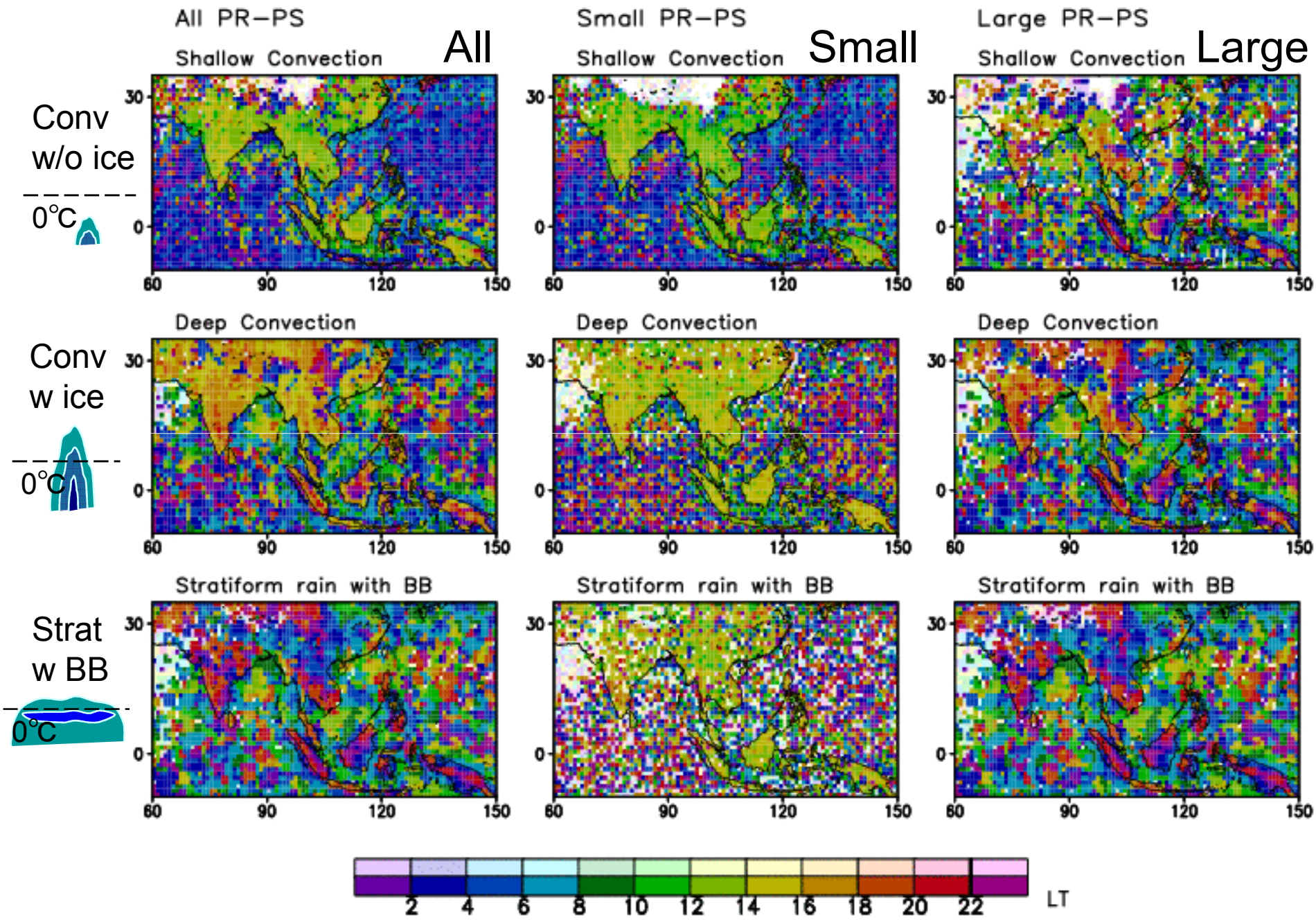
Stratiform rain

(Strat w BB)

0℃

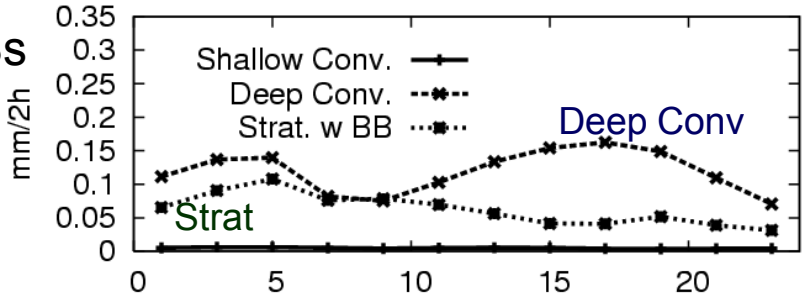


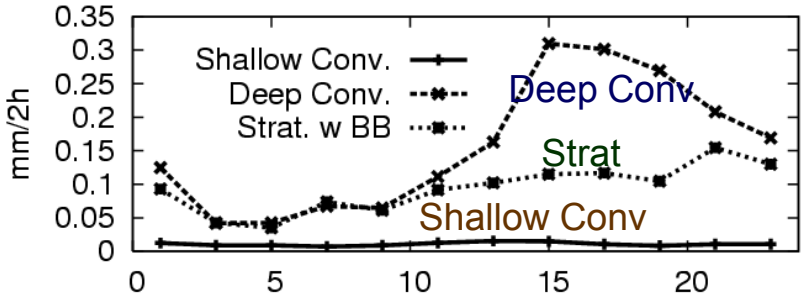
Time of maximum hourly rainfall for each rain type of scale-based PSs



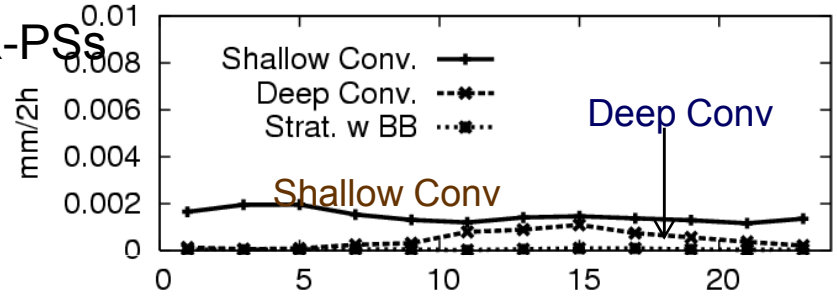
Diurnal variation of rainfall of scale-based PR-PSs over the northern part (left) and the eastern part of Vietnam (right) for each rain type

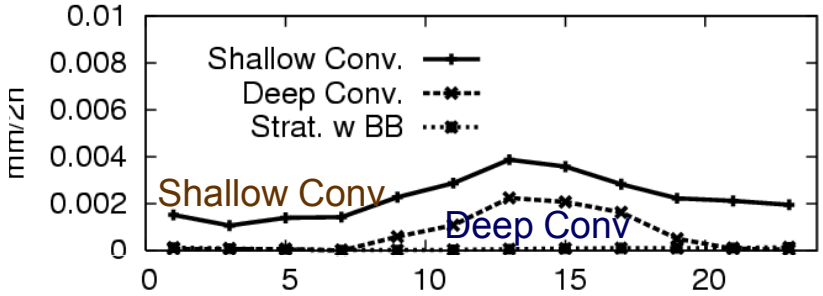
All PR-PSs



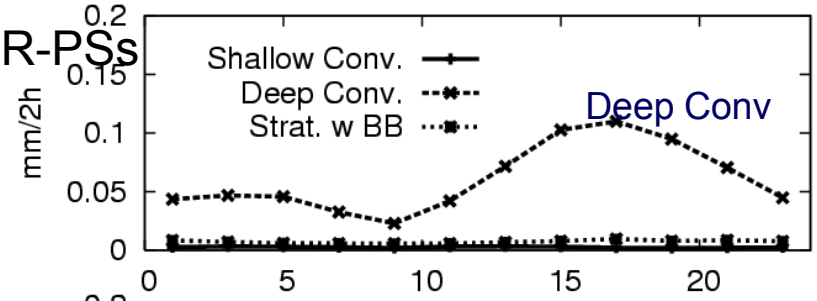


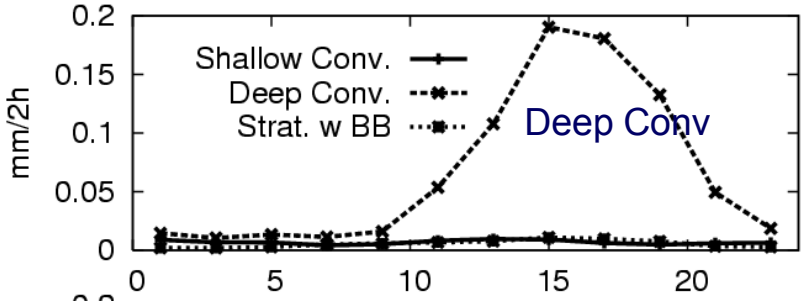
Small PR-PSs



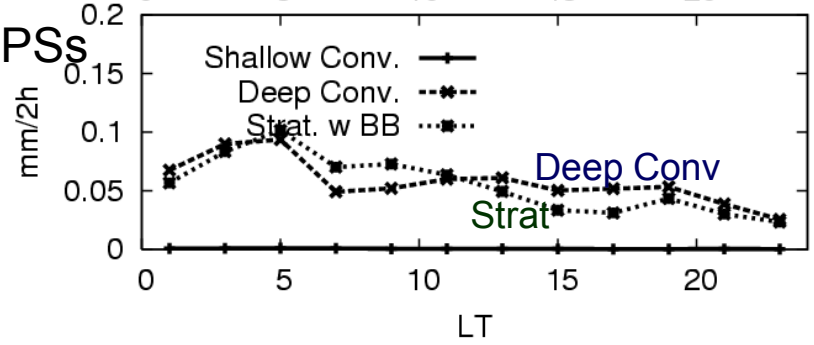


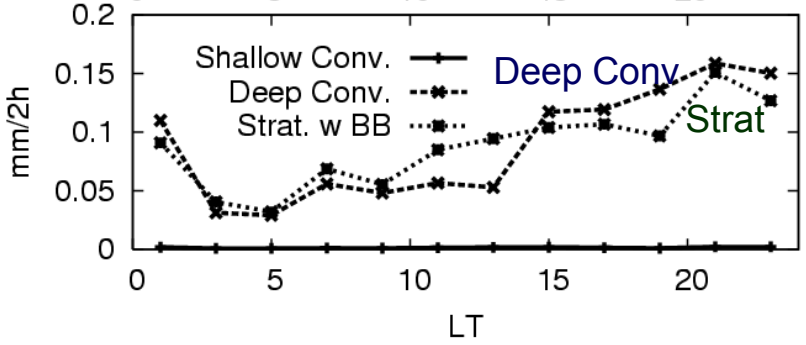
Medium PR-PSs



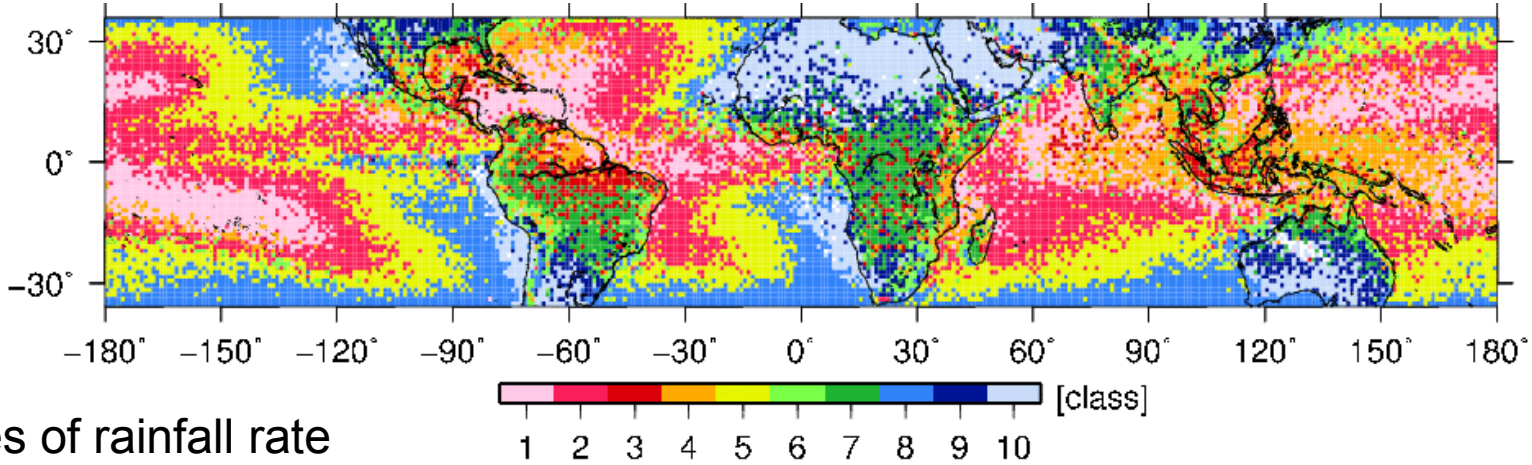


Large PR-PSs

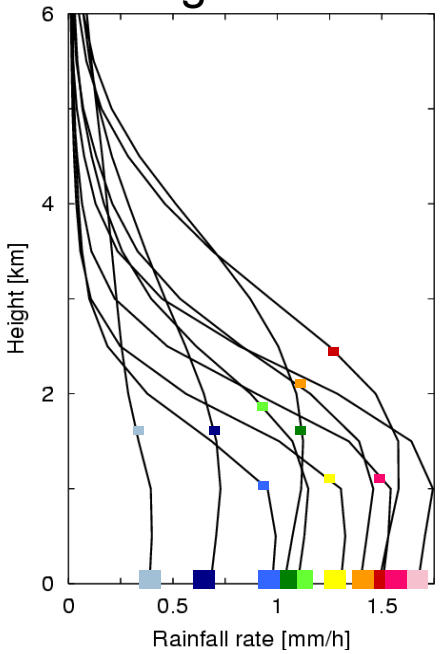




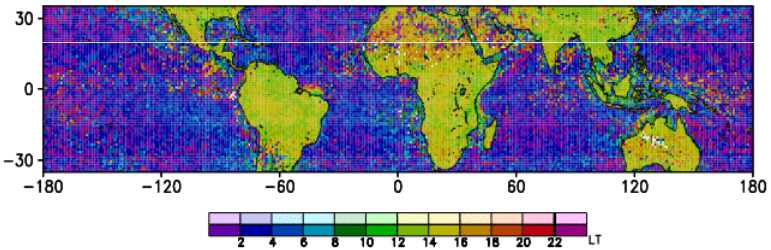
Rainfall-rate profile patterns of small-scale PR-PSs (<10^2km^2) at the time of maximum rainfall clustered into 10 classes



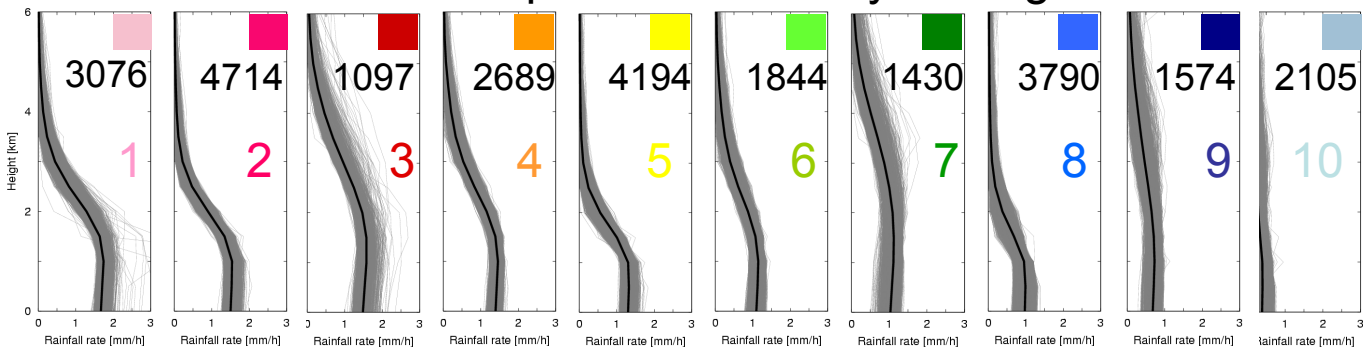
Profiles of rainfall rate averaged for each class



Time of maximum hourly rainfall (D<10km) [LT]



Clustered rainfall-rate profiles sorted by averaged surface Rc



Summary

- A database of PR-captured Precipitation Systems was generated by 10-year TRMM PR data.

- Ten-year TRMM PR data include tens of large precipitation systems in each 1° region over the most global tropics.

- Large overland precipitation systems developed mostly in the evening, following the time of maximum rainfall of small systems.

- The large systems showed a clear time shift in maximum rainfall, while the small systems had rain peaks nearly the same local time.

- Morning rainfall near high mountains such as the Himalayas consists of both stratiform rain and deep convection. This observation shows that precipitation climate can be considered as an accumulation of convective complexes.

- The vertical profiles of rainfall rates obtained for small systems, which the diurnal features of precipitation systems were almost uniform over land or oceans, exhibited regional variations.

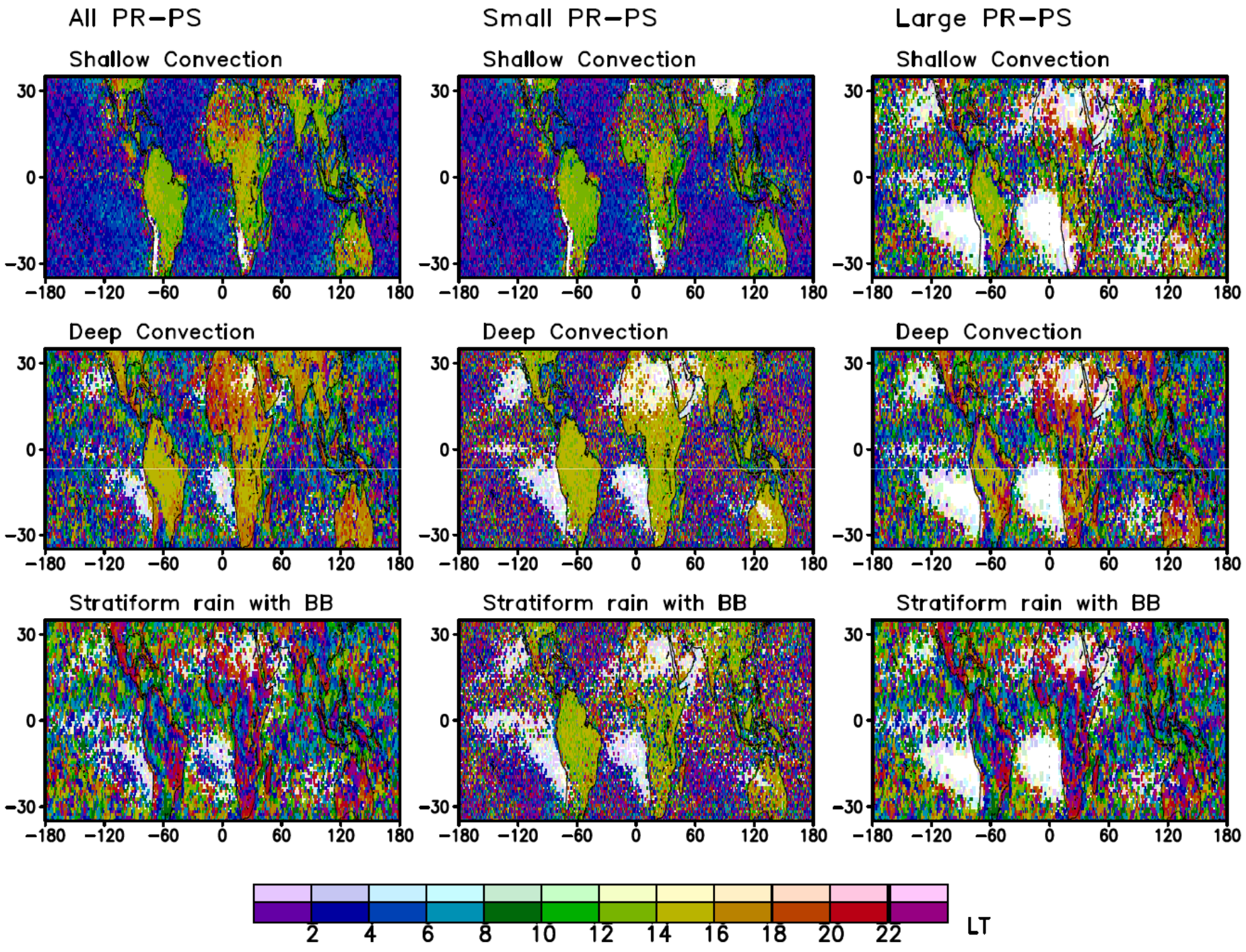
Future

Interpretation of the various mechanisms of convection embedded in the climatic conglomerates requires further analysis of the recognition of congregations of precipitation-system types.

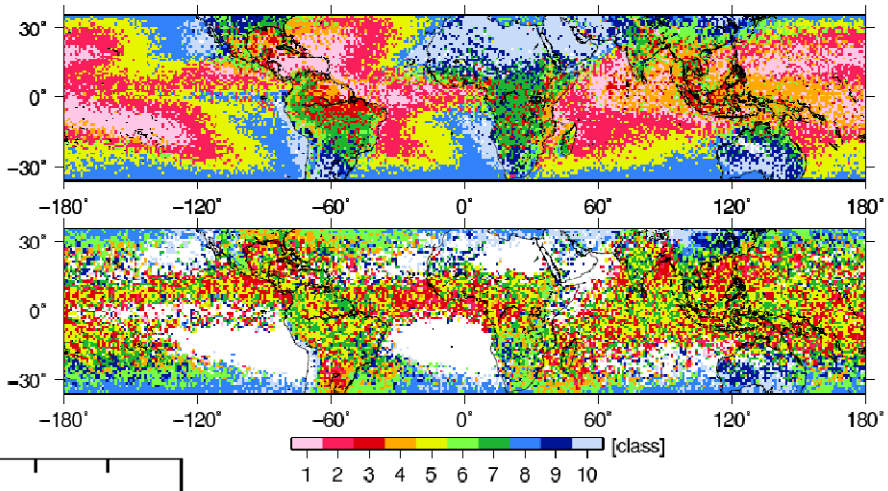
Possible applications of the storm database

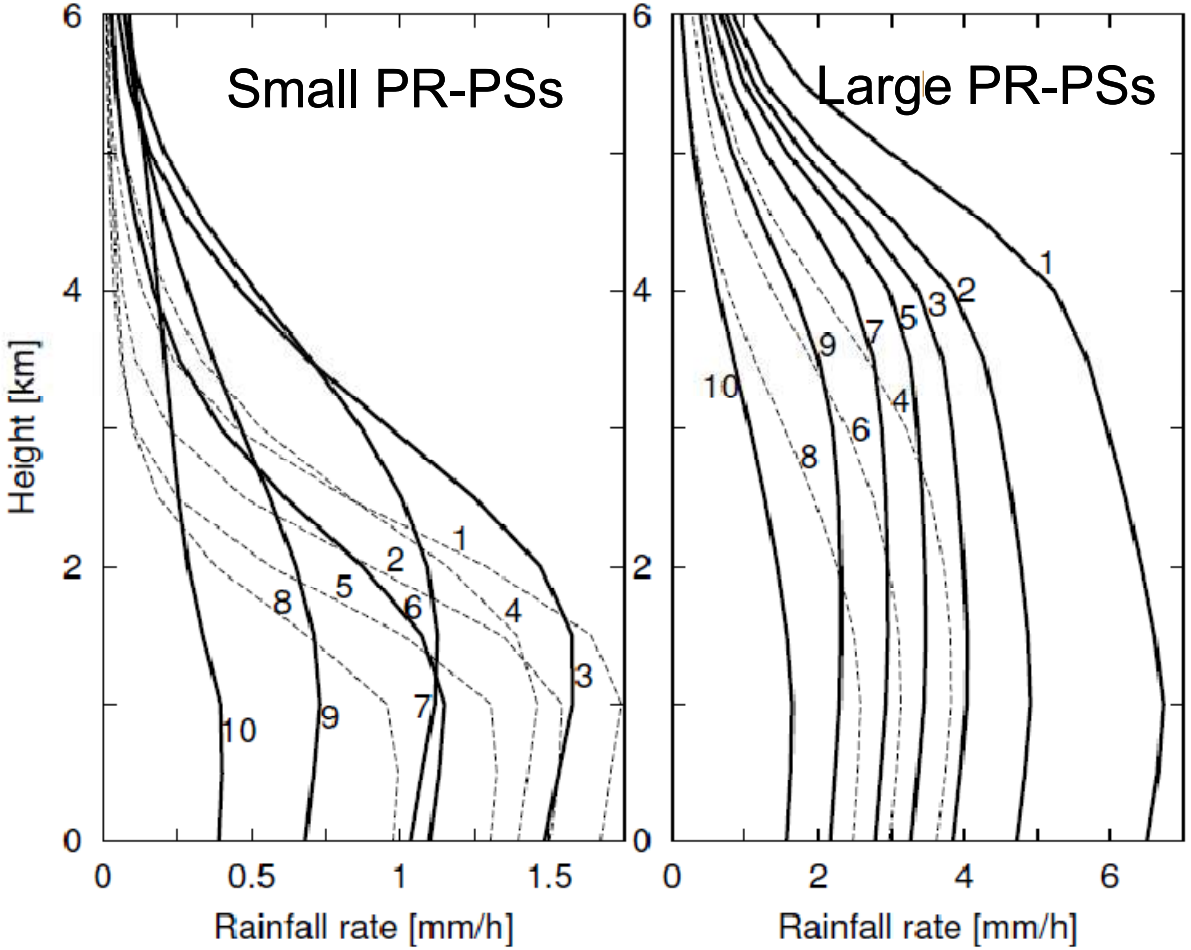
- Statistical representation of Z or DSD profiles used in the MWR algorithms
- Estimates of various vertical structures of precipitation systems identified with/without the spaceborne radar data
- Assessment of observation limits and retrieval errors inherent to sensors for each groups of precipitation systems
- Comparison of the group statistics with model outputs
- etc

Extra slides


All PR−PS
Small PR−PS
Large PR−PS
Shallow Convection
Deep Convection
Stratiform rain with BB
30
0
−30
−180 −120 −60 0 60 120 180
2 4 6 8 10 12 14 16 18 20 22
LT

Ten-class rainfall-rate profiles at the time of maximum rainfall of small and large PR-PSs





Major differences in the classified profiles are observed in the intensity near the surface and the vertical gradient near 2 km.

The profiles of small PR-PSs with the early afternoon peak over the northern part of Brazil are found to be one of most well-developed patterns over the land.

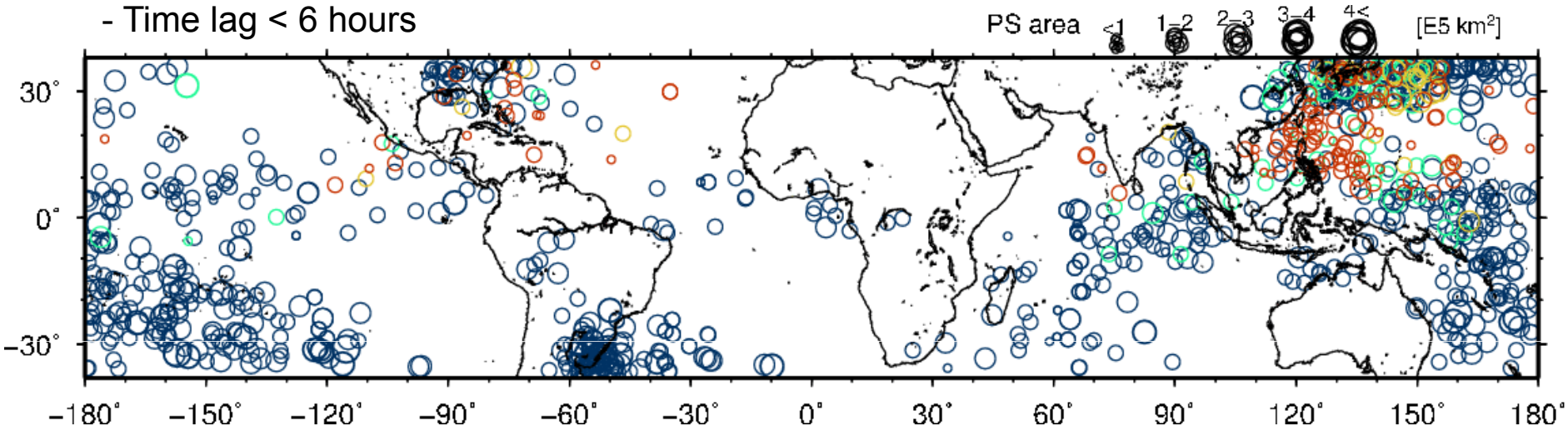
Toward understanding the regional characteristics of PR-PSs with 1000 largest areal rainfall

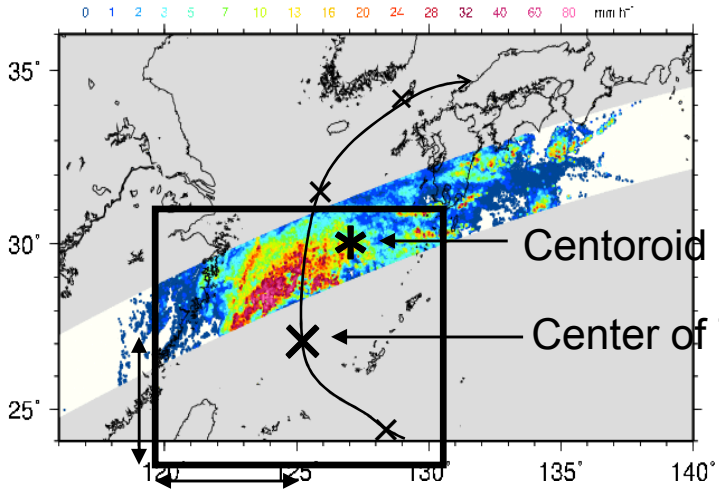
TC-related high-impact precipitation systems

1998-2007

- Distance between centers of TC and PS: 5 deg., 10 deg., 20 deg.
- Time lag < 6 hours

Size of circles: each rain area

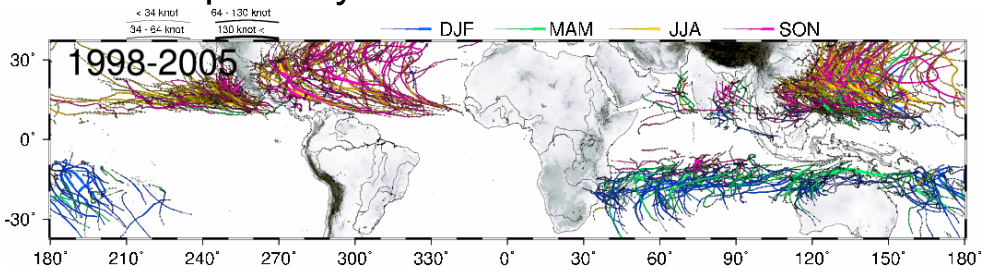




Significant storms with abundant rainfall over the NW Pacific are often brought by TCs.

Ratio of TC-PS<5deg(20deg): G 12.1(20.7)%, WP 28.4(43.9)%

Tropical Cyclone Track 1998-2005



TC track data:
http://www.solar.ifa.hawaii.edu/Tropical/tropical.html