2010 International Workshop of TCCIP Project on Climate Change

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Taipei County 231, Taiwan (R.O.C.)
11:25-11:50, 1 Nov 2010 (Mon.)

A-1 ： Climate Variability: Observation, Simulation, and Projection

Future changes in precipitation characteristics projected by the 20-km-grid MRI-AGCM

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Purpose of this study

To statistically analyze the future changes in precipitation characteristics with using the KAKUSHIN model (20-km-grid MRI-AGCM)

Will extreme precipitation increase in the warmer climate ?

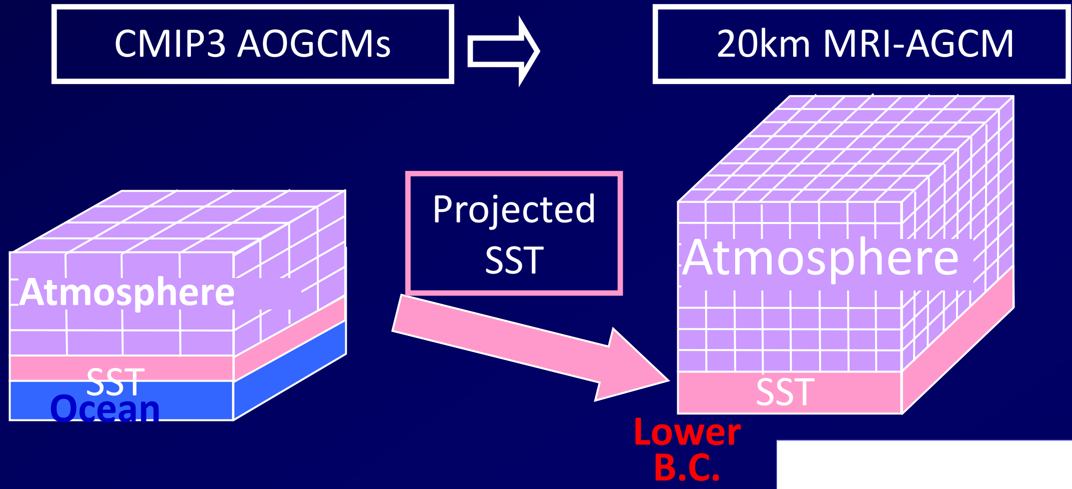
How does spacial and temporal properties of precipitation changes in the future ?

How much good can the model simulate real precipitation?

Model and experimental design

model: 20-km-grid MRI-AGCM (KAKUSHIN model)

Time-Slice Experiments



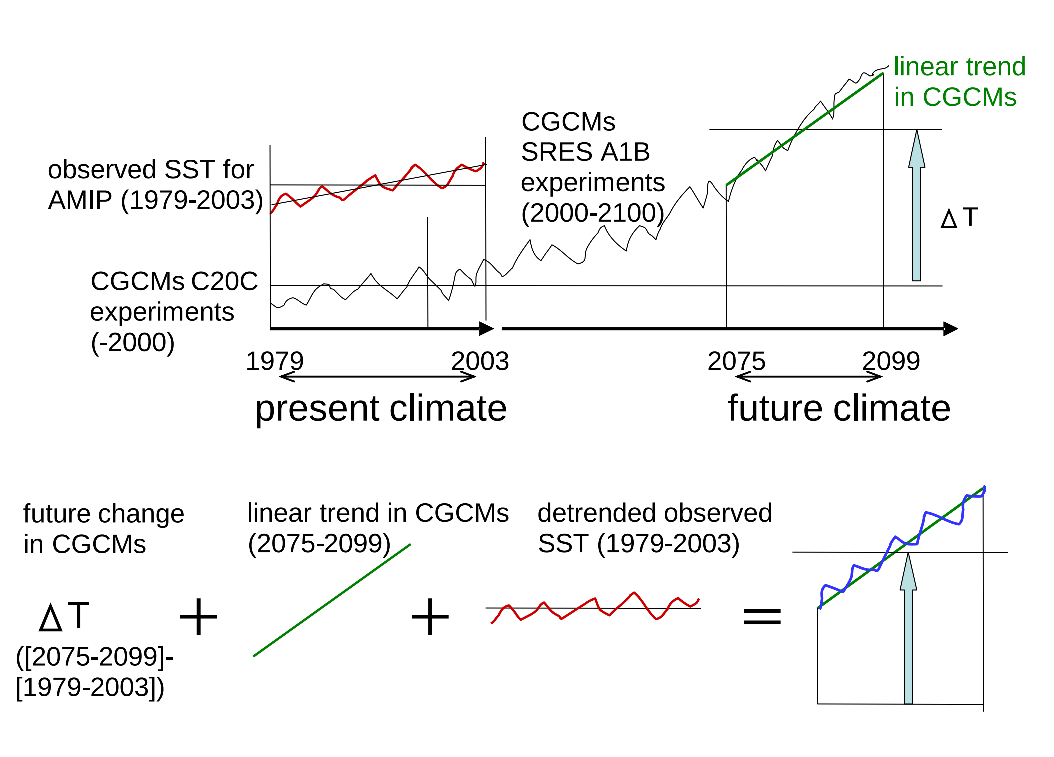
MRI-AGCM is a climate model version of the JMA operational NWP models

Present (1979-2003)

the observed sea surface temperature (SST) and sea-ice concentration

Future (2075-2099)

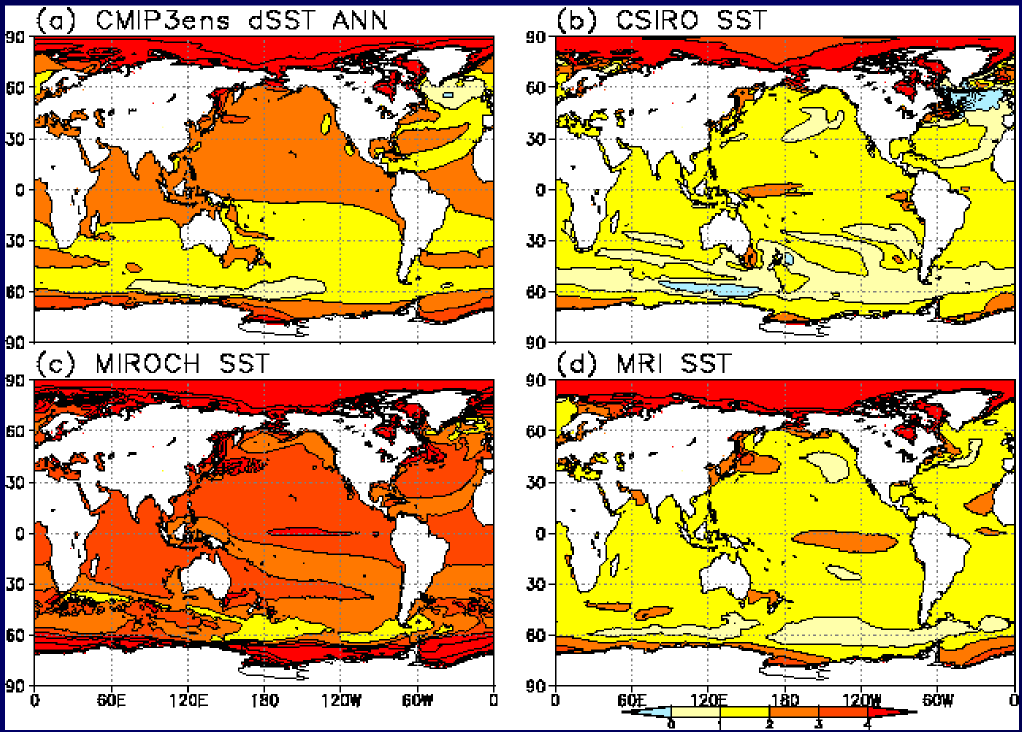
the SST and sea-ice anomalies of the CMIP3 multi-model ensemble mean are added to the observations, retaining the present interannual variability



Model and experimental design

external forcing

	present	Future (end of the 21th century)
Target period	1979-2003	2075-2099
SST, Sea ice	Observation (HadISST)	Obs + Change (WCRP CMIP3 MME)
Greenhouse gasses	Observation	SRES A1B
Aerosol	Aerosol Chemical Transport Model (CTM) climatology	Aerosol Chemical Transport Model (CTM) climatology
Ozone	Ozone CTM climatology	CTM A1B projection
Volcanic eruption	none	none
Solar activity	constant	constant

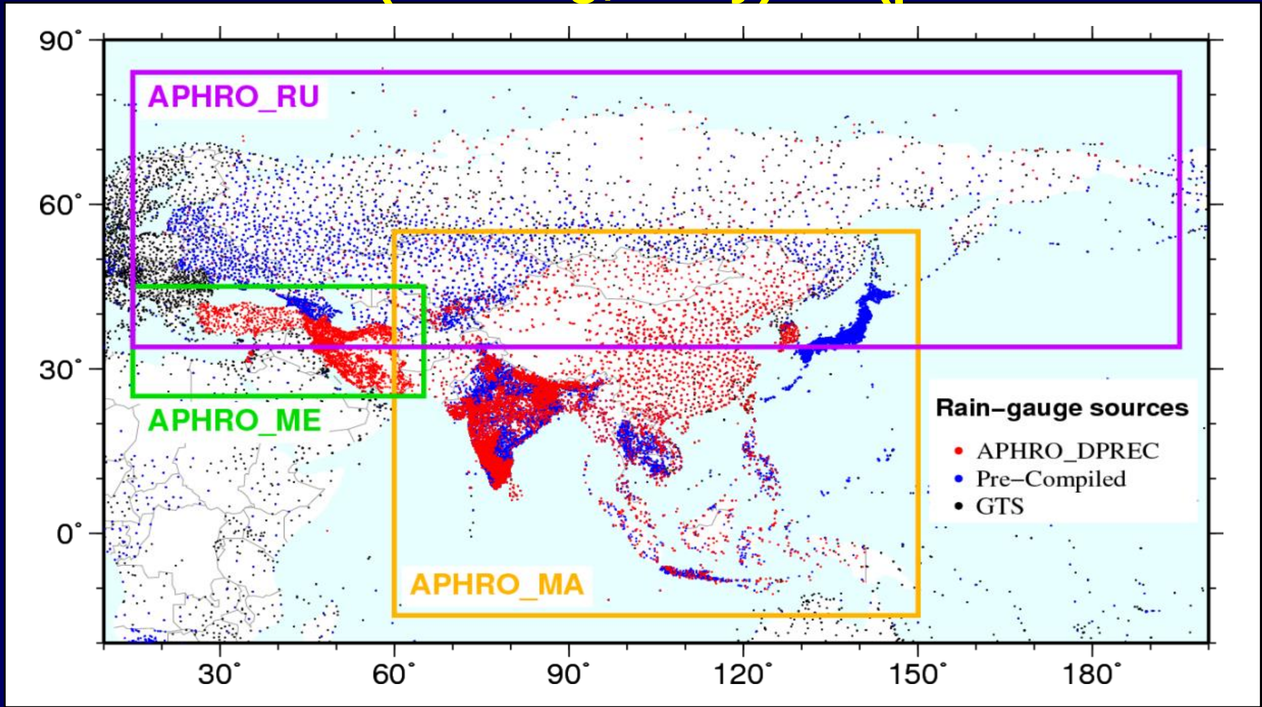


20-km model uses this CMIP3 ensemble mean SST anomalies

Observation data used for model evaluation

Observation:

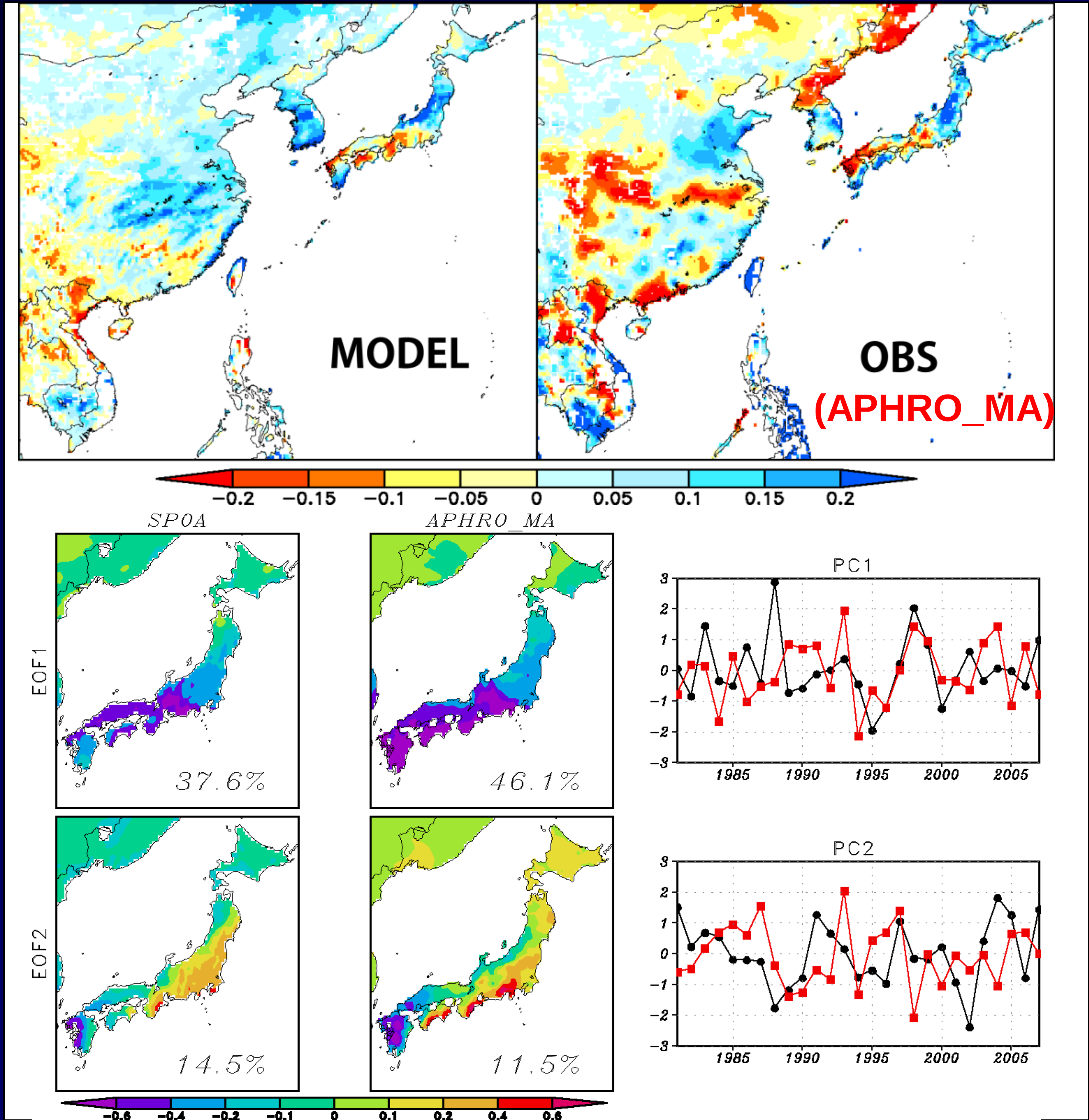
GPCP-1DD (1deg, daily)
TRMM3B42 (0.25deg, 6-hourly)
APHRO_MA_V1003 (0.25deg, daily) (period: 1951-2007)



Kamiguchi et al. (in preparation),
"APHRO PR, A New Rain-Gauge-Based Historical Daily Precipitation Dataset with Long-term and High-Resolution-Grid"

Maximum of rain-gauge density:
Japan 1 station per 17km (1977-2007)
Taiwan 1 station per 28km (1961-2006)

Evaluation (trend and annual variation)



linear trend of annual precipitation (1979-2007)

Grids with high confidence of observation are colored

EOF and PC of the annual precipitation anomaly

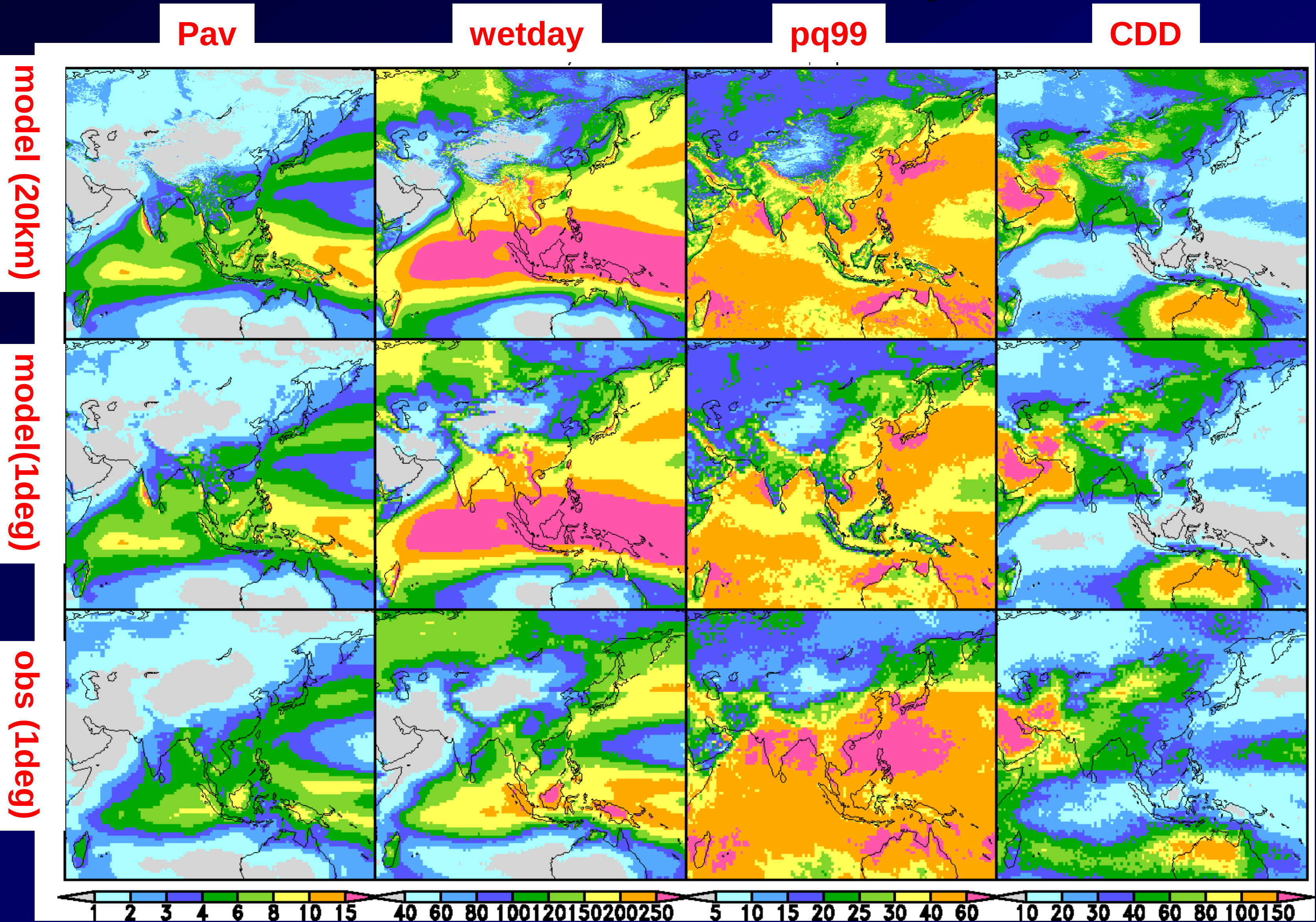
black: OBS (APHRO_MA)
red: MODEL(SP0A)

The value in the left figure means the contribution ratio

The model simulate well in the trend and annual variation

Evaluation of the model;

comparison of the Extremes indices



Pav: annual mean precipitation (mm/d)

wetday: number of days with precipitation (>1mm/d)

pq99: 99 percentile of daily precipitation (mm/d)

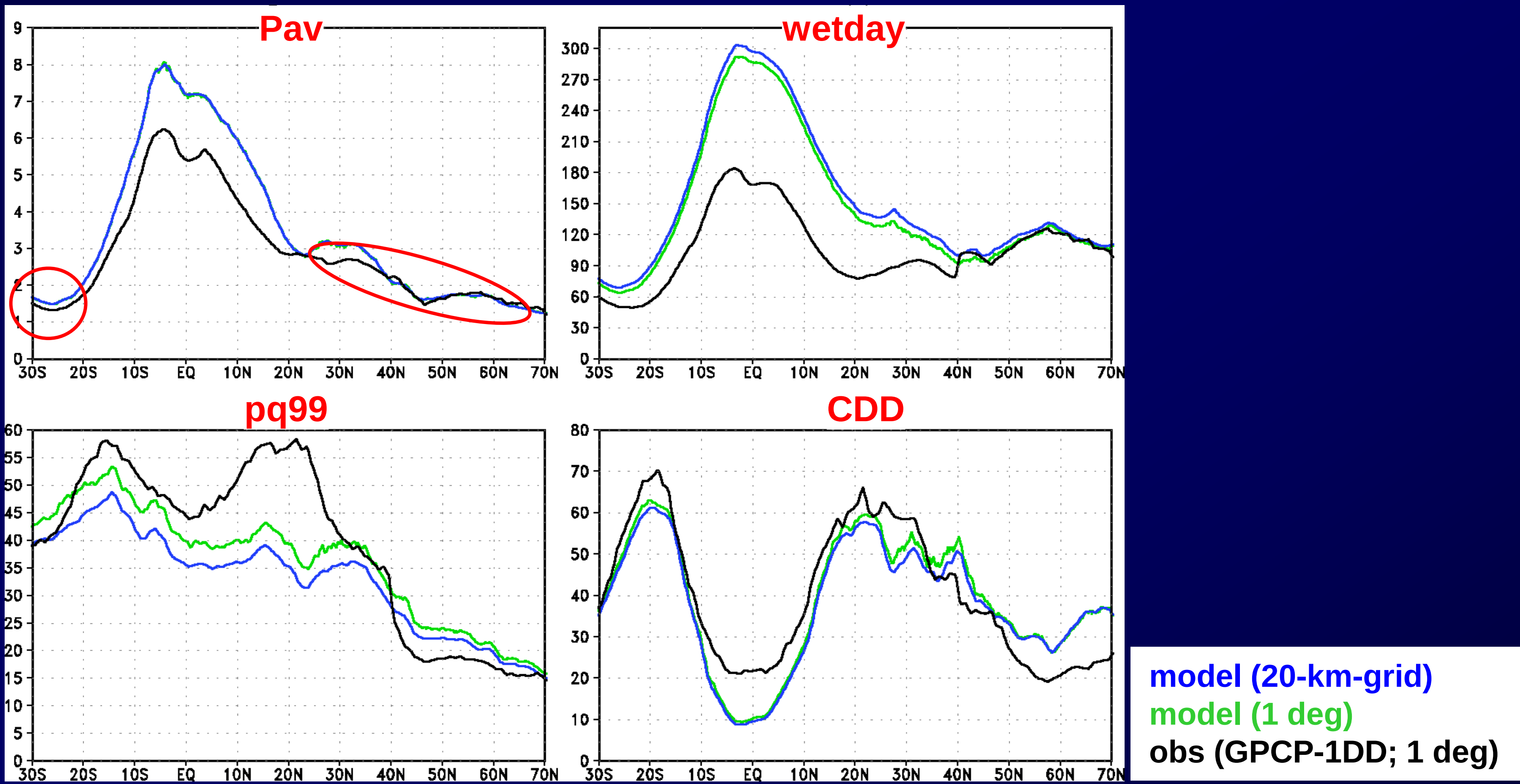
CDD: the maximum number of consecutive dry days (day)

model: present-run
obs: GPCP-1DD

Distribution pattern of the model is good
The model overestimates / underestimates wetday / pq99

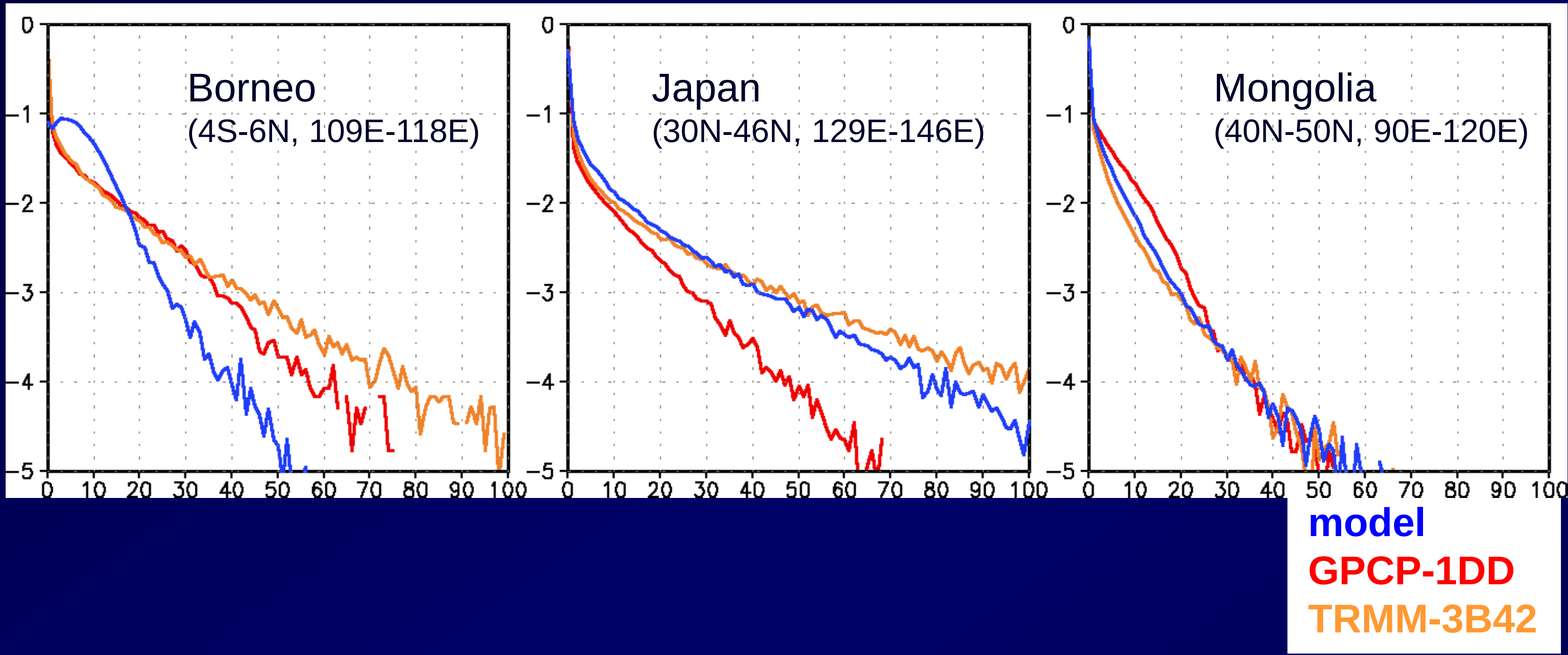
Evaluation of the model

longitudinal average (40E-170E)



Profile is well reproduced by the model, but amount should be improved for tropics and sub tropics

Evaluation: PDF of daily precipitation (JJA)

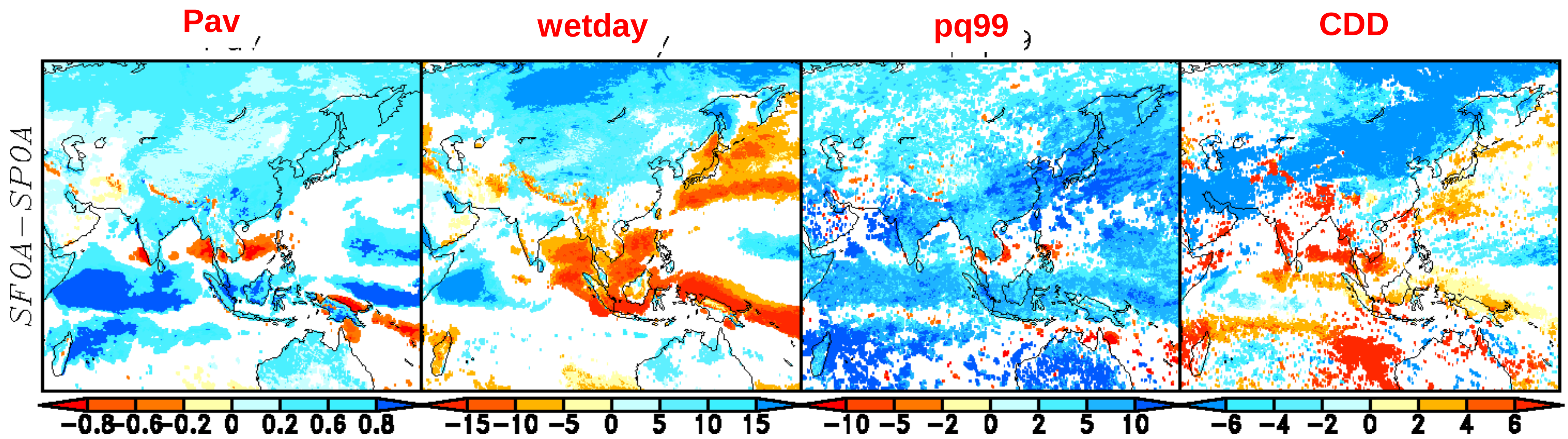


Even in observation data, PDF is largely different (especially in Japan).

Frequency of weak precipitation in Borneo shows much difference from observations.

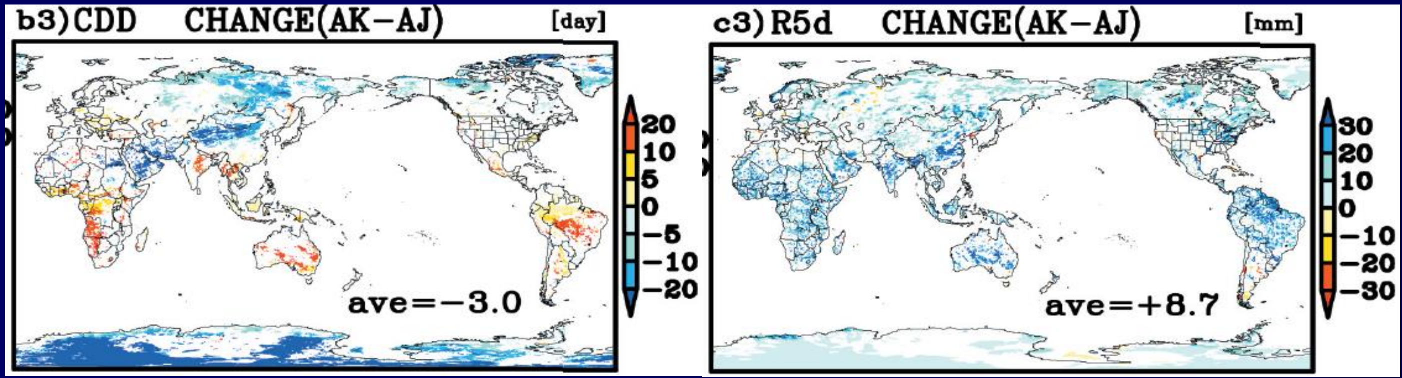
In the latter simulation under the KAKUSHIN project , the cumulous parameterization has changed (Arakawa-Schubert to Yoshimura) .
This problem (too much drizzle problem) is improved.

Future Changes in the Extremes indices



colored: changes are statistically significant at the level of 90% by Welch's t-test

- Precipitation amount increases in land
- Heavy precipitation (pq99) notably increases India, Yangtze Basin (China) and Japan
- Meteorological dryness (CDD) increases Maritime continent, India and so on.



This result is consistent to the previous study in Kyosei project

Kamiguchi et al., 2006

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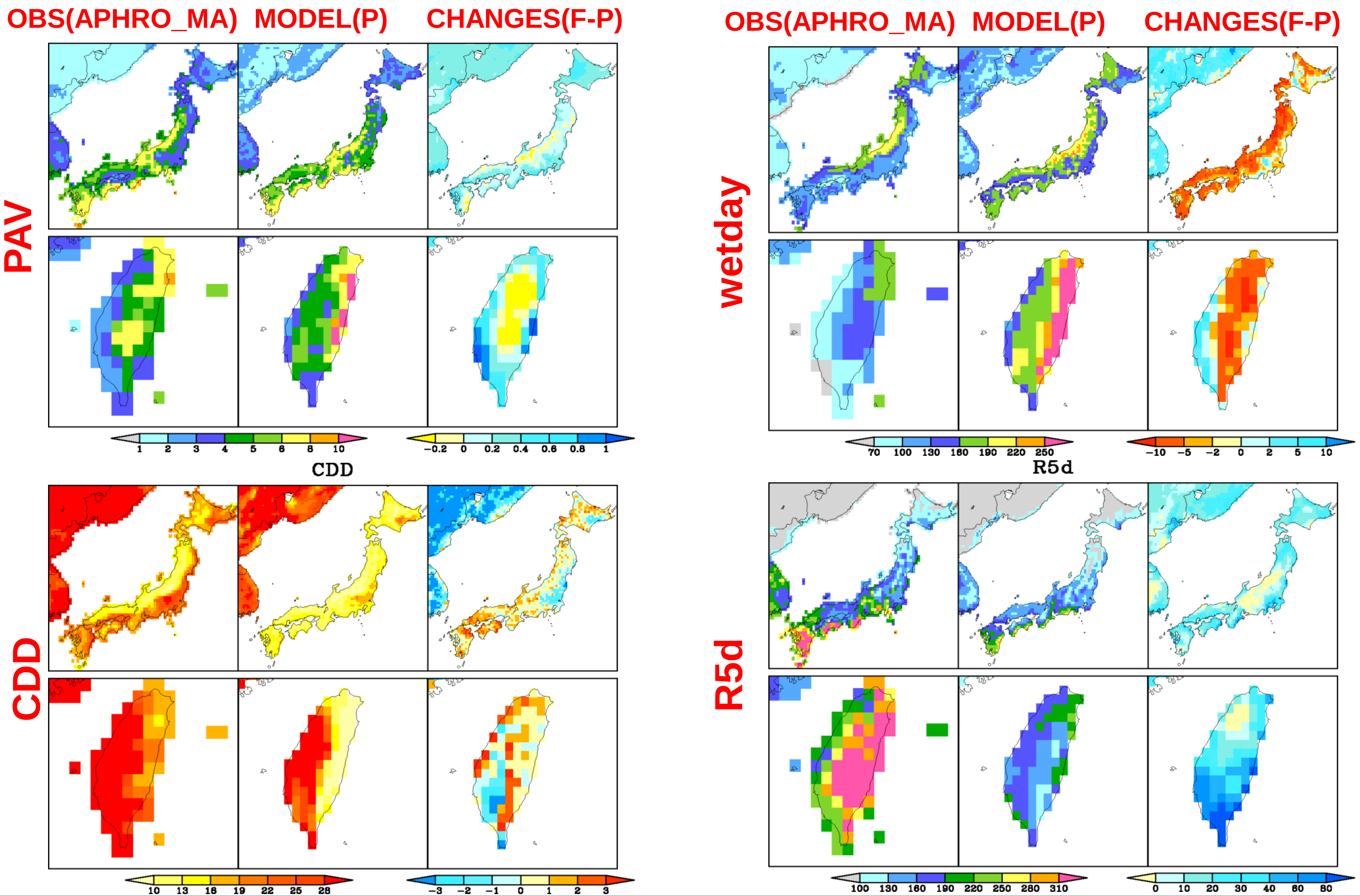
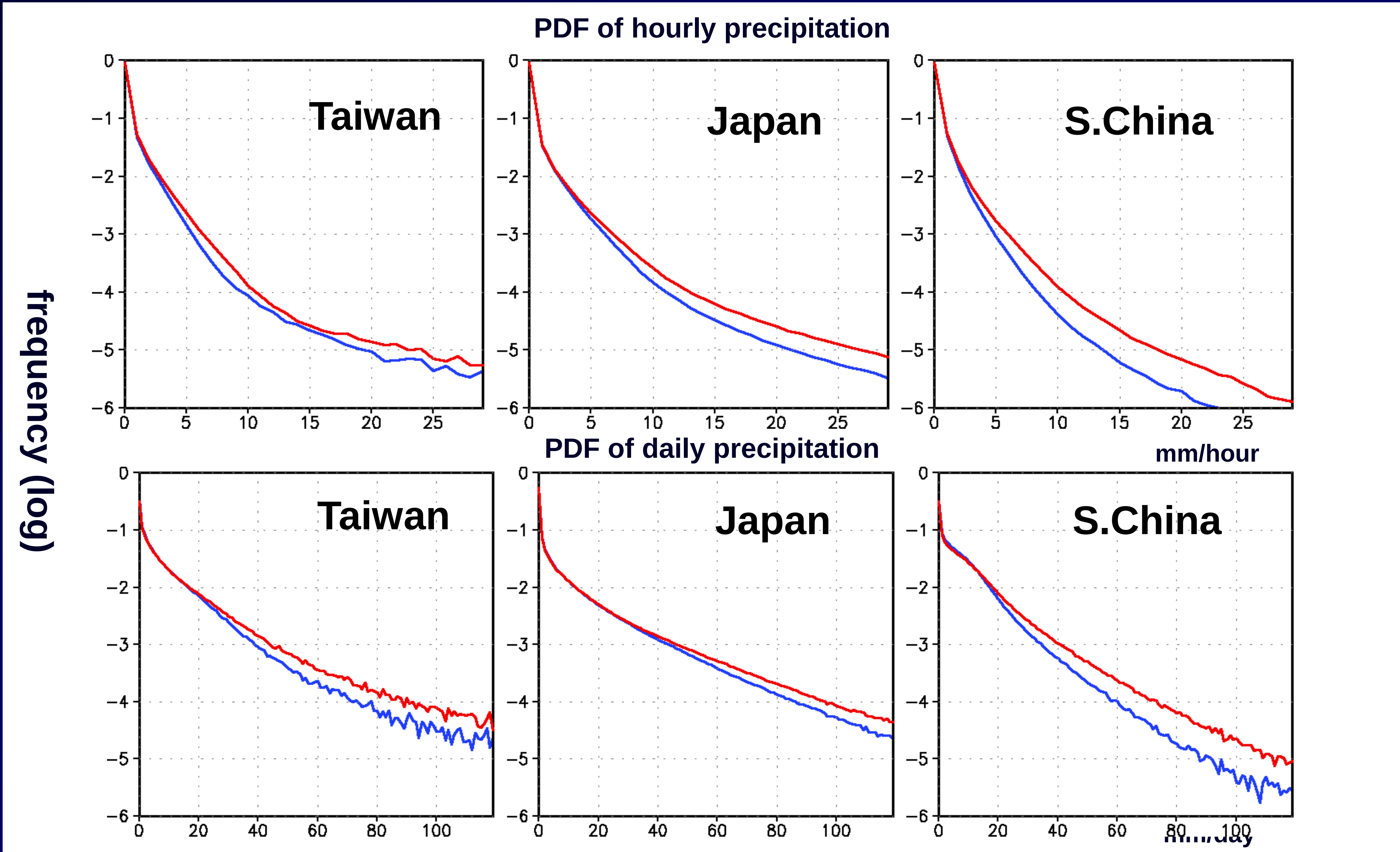


Future change (PDF of daily and hourly precipitation in JJA)



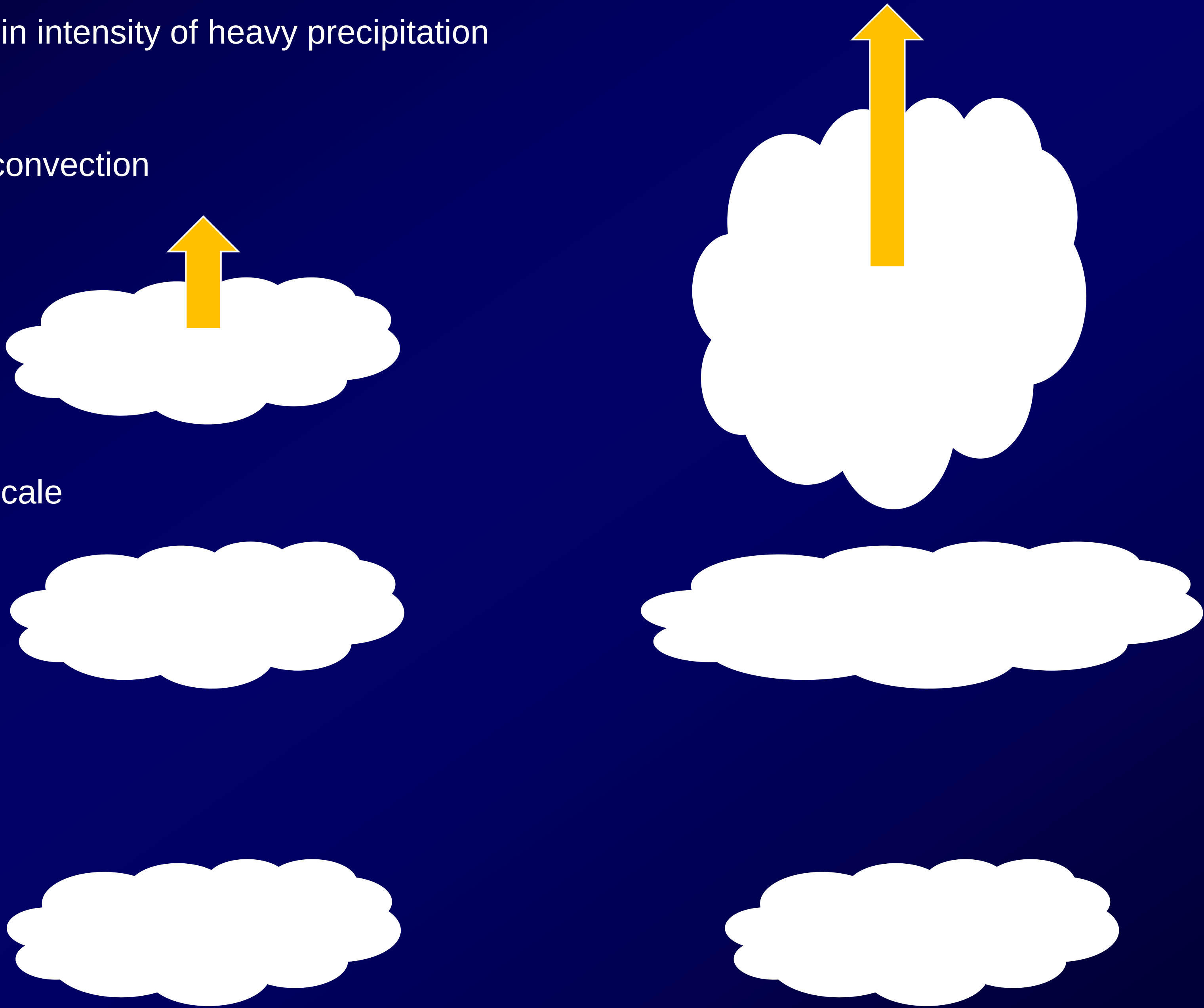
Spatial and Temporal characteristics of precipitation system

Main reasons for changes in intensity of heavy precipitation

1: Change in strength of convection

2: Change in horizontal scale

3: Change in lifetime

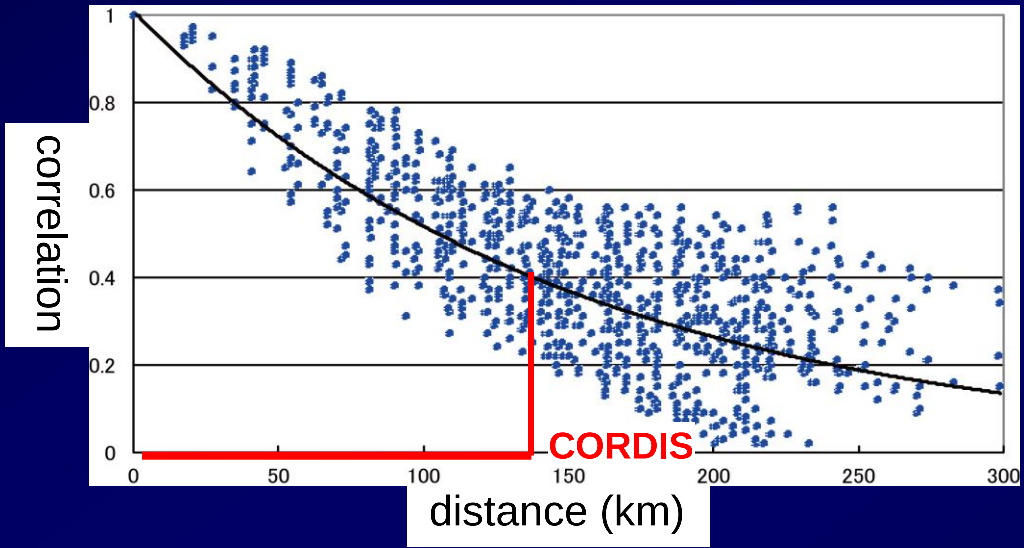


spatial scale of precipitation system

How spatial scale of precipitation system will be in the warmer climate ?

Correlation length analysis was done for daily and hourly precipitation

Target season: JJA



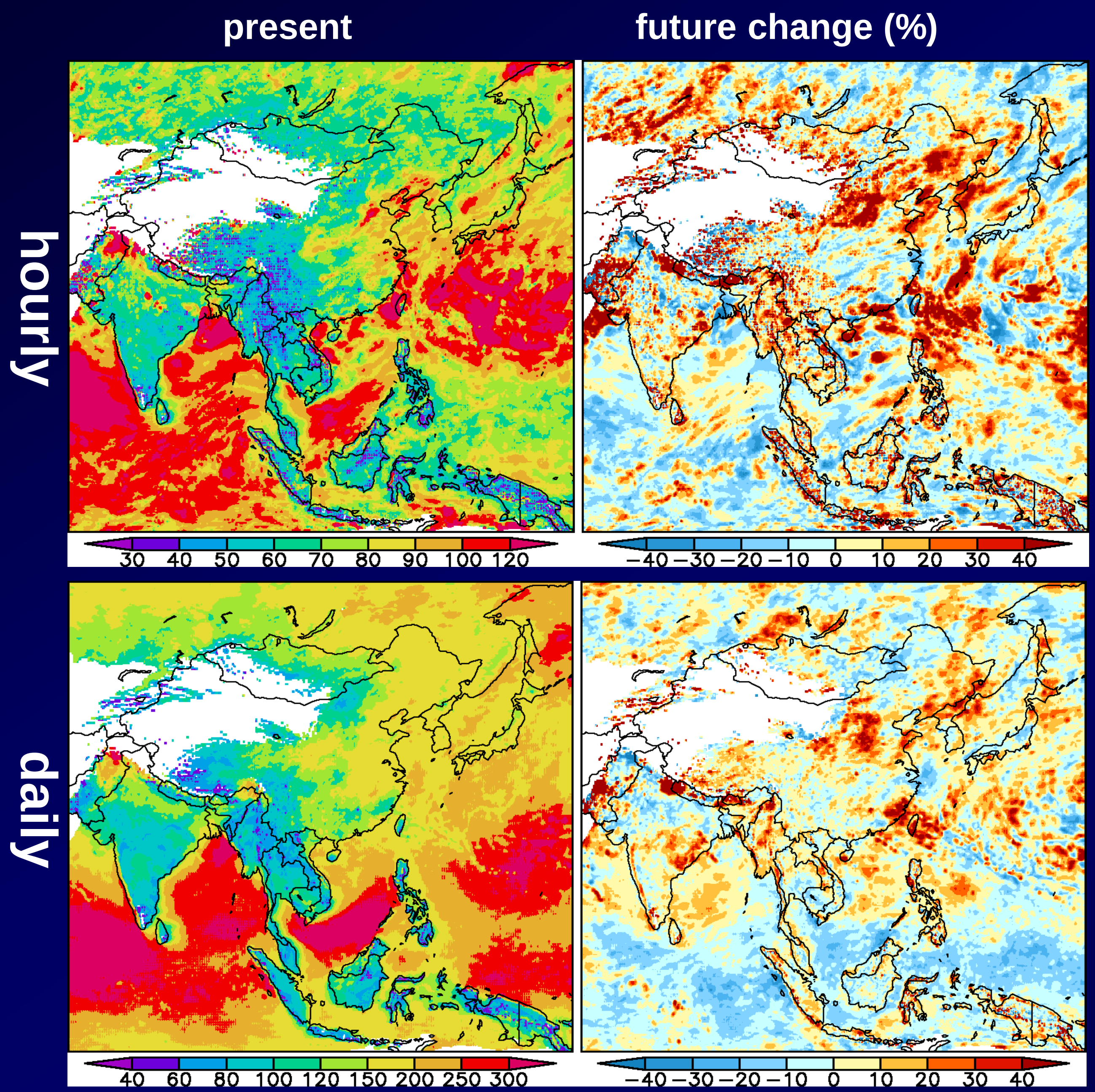
$$y = \exp(-(x/a)^b)$$

y: correlation
X: distance

The parameters (a and b) were estimated by Levenberg-Marquardt method

CORDIS; the distance which correlation length drops to 0.4

Present and future change in CORDIS in JJA



(non-color: less than 1mm/day in present)

PRESENT:
CORDIS is larger/smaller in ocean/land

Spatial scale of precipitation system is small over land due to non-homogeneity of terrain

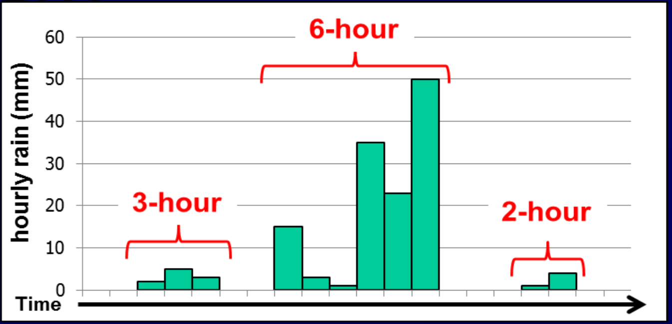
FUTURE
CORDIS increases over most of land.

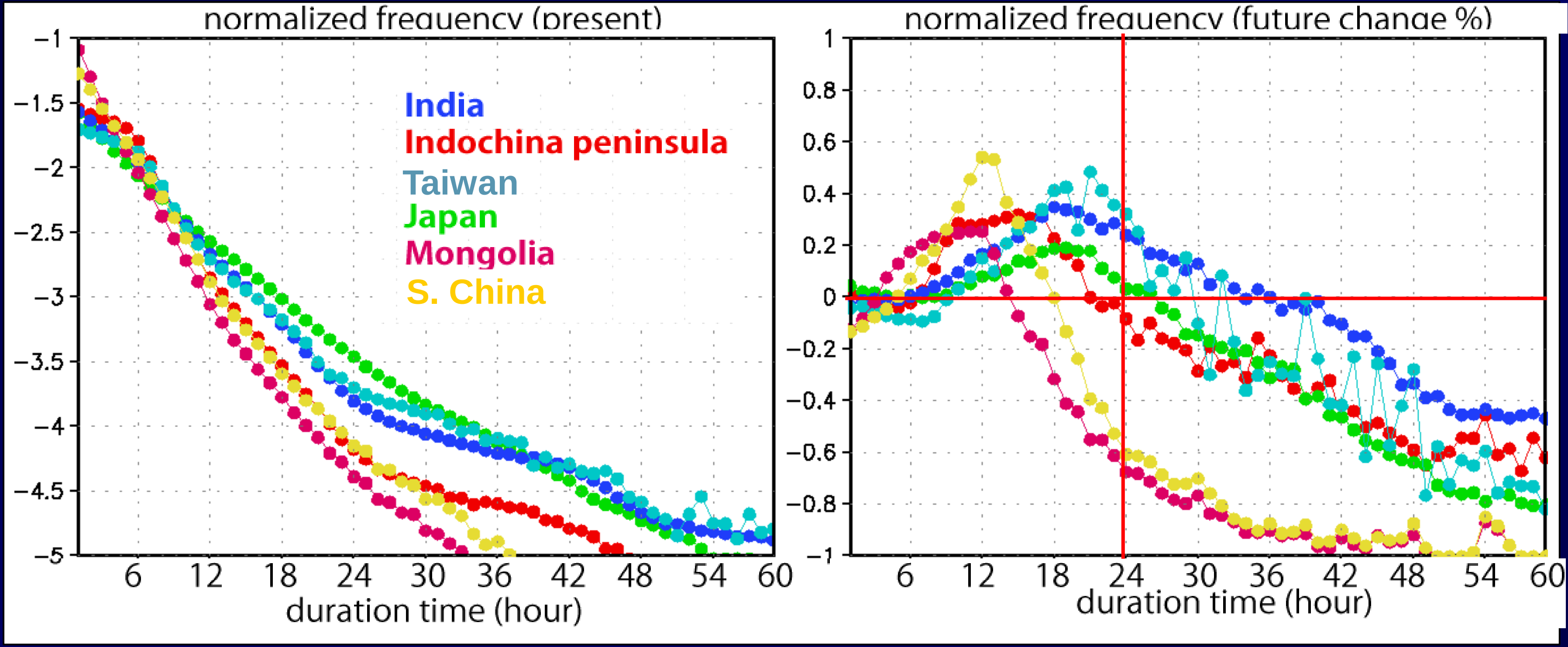
Will spatial scale of precipitation system be larger in the warmer climate ?

Duration time of precipitation system

Duration time; Consecutive hour with continuing precipitation event
(precipitation event ; ≧0.5mm/hour)

Normalized frequency;
(number of occurrence of precipitation event) / (total precipitation hour)

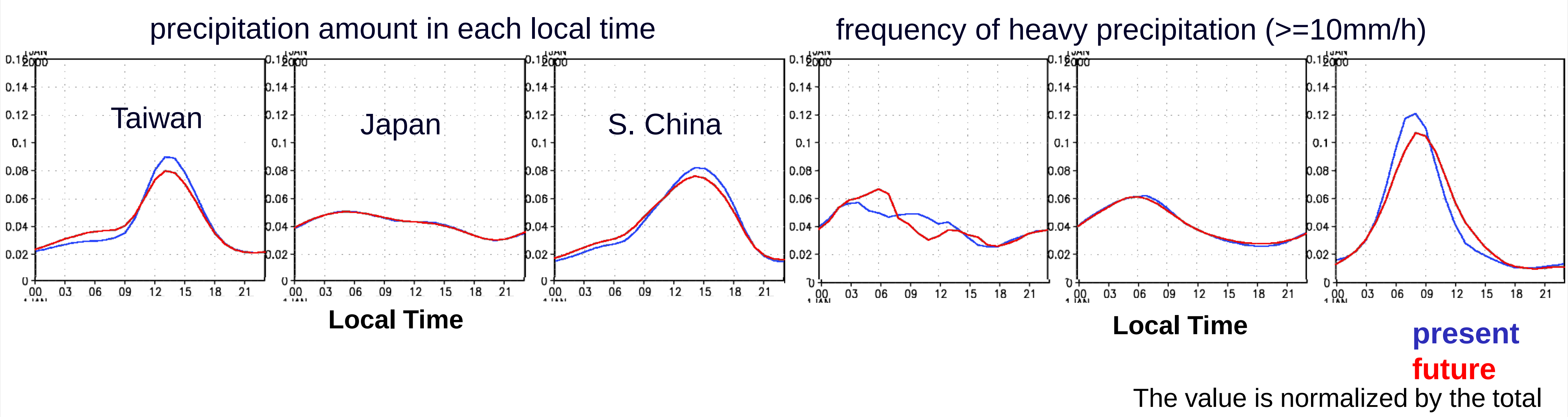




Taiwan: short-time (1-9 hour) precipitation decreases
9-30 hour precipitation increases

Frequency of precipitation event with duration time is longer than 36 hours decreases in the future.
-> precipitation of sub-daily time scale will be more active ?

Changes in diurnal cycle



Taiwan: Diurnal cycle of mean precipitation decreases in the future

Peak time of early morning heavy rain shifts to few hours later

Reason:
In a sub daily scale, life time of precipitation system will be longer.
This might be the reason for reduction of diurnal cycle.

In the warmer climate, beginning of convection will be difficult, due to enhancement of vertical stability. However, once convection begins, vertical instability will be reduced rapidly by short-term heavy rain.

summary

- Reproduction skill of the 20-km-grid MRI-AGCM was evaluated.

  (extreme precipitation; high skill in middle and high latitude, but too much drizzle in low latitudes, underestimation of heavy precipitation)

  (trend and annual variation are well simulated (depends on area))

- Future changes in extreme precipitation was projected

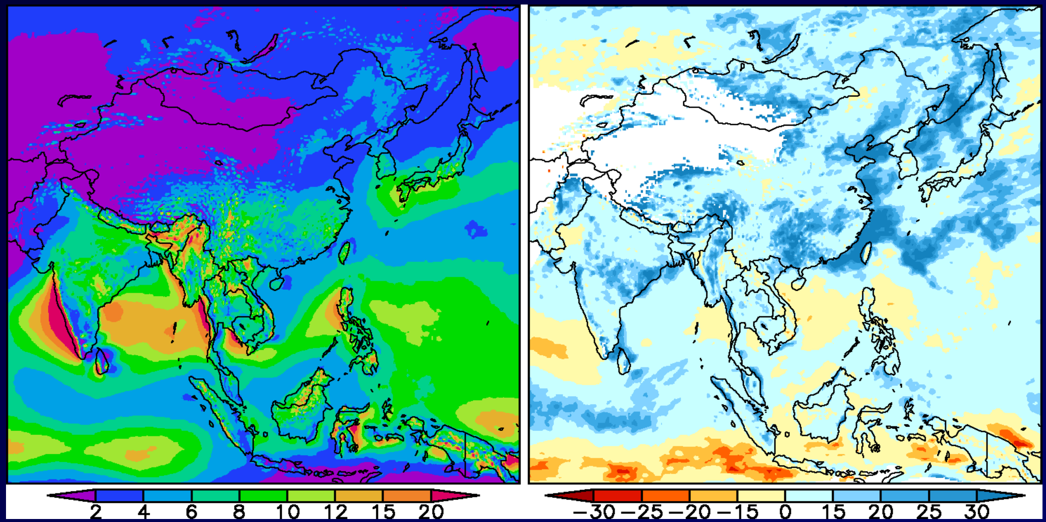
  (precipitation will be mode extreme; both heavy rain and dry-day increase)

- Correlation length of hourly and daily precipitation becomes larger in the warmer climate (spatial scale of precipitation system will be wider?)

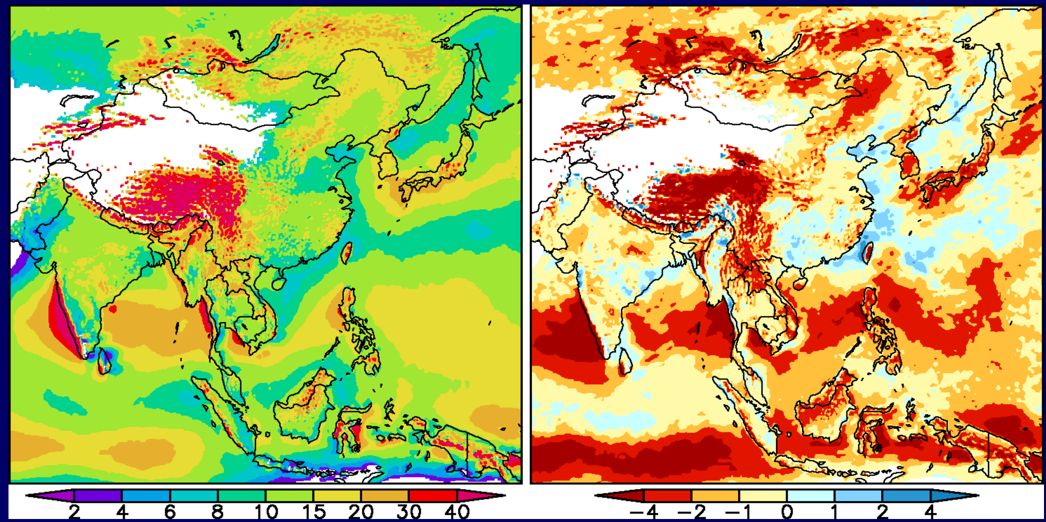
- Precipitation event with sub daily time scale becomes more active.

  (In a daily time scale, lifetime of precipitation system might be longer)

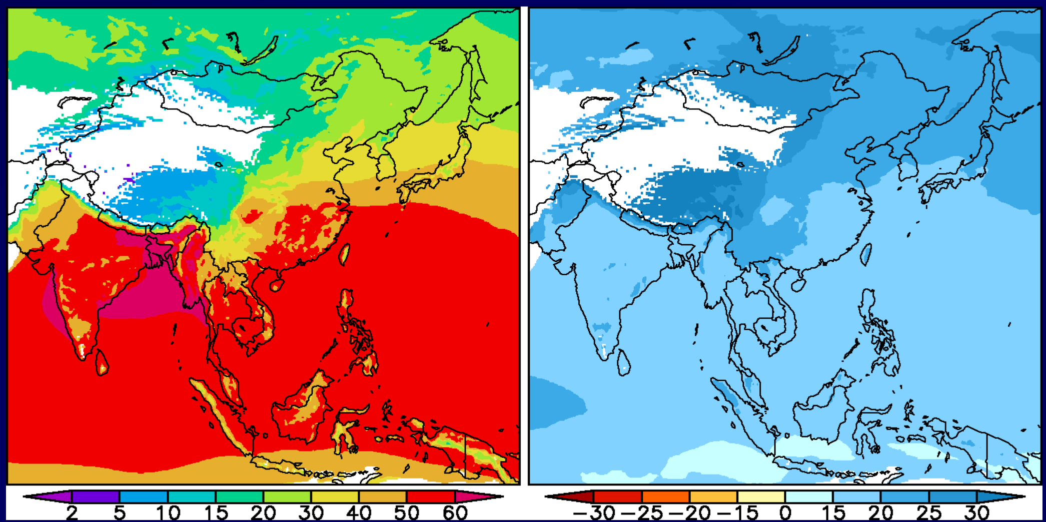
Precipitation (mm/day)



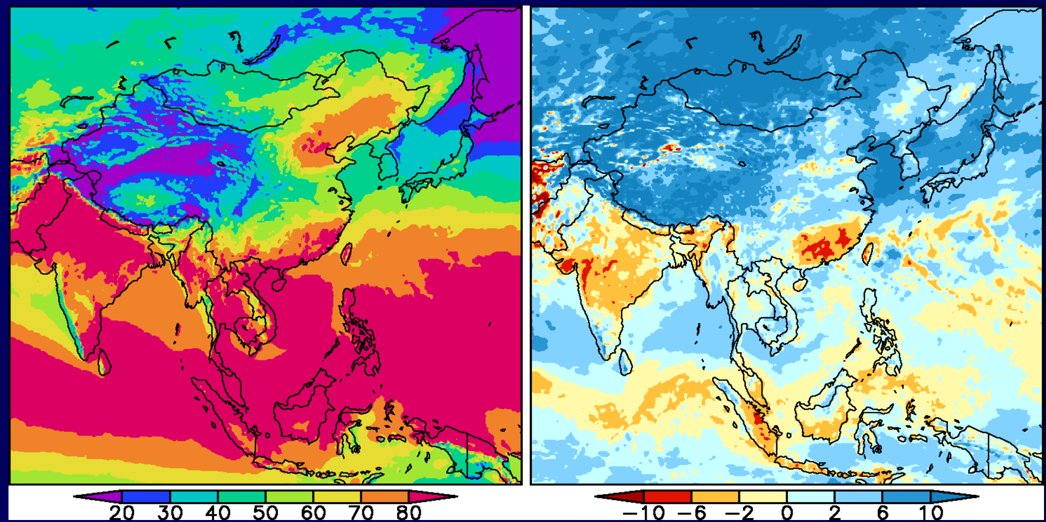
precipitable water / precipitation (%)



Precipitable water (mm/day)



Convective precipitation ratio (%)



Duration time of precipitation system

precipitation ratio = (precipitation amount of each duration time) / (total precipitation)