Future projection of Meiyu rainfall over Taiwan: results of dynamical downscaling for the TCCIP project

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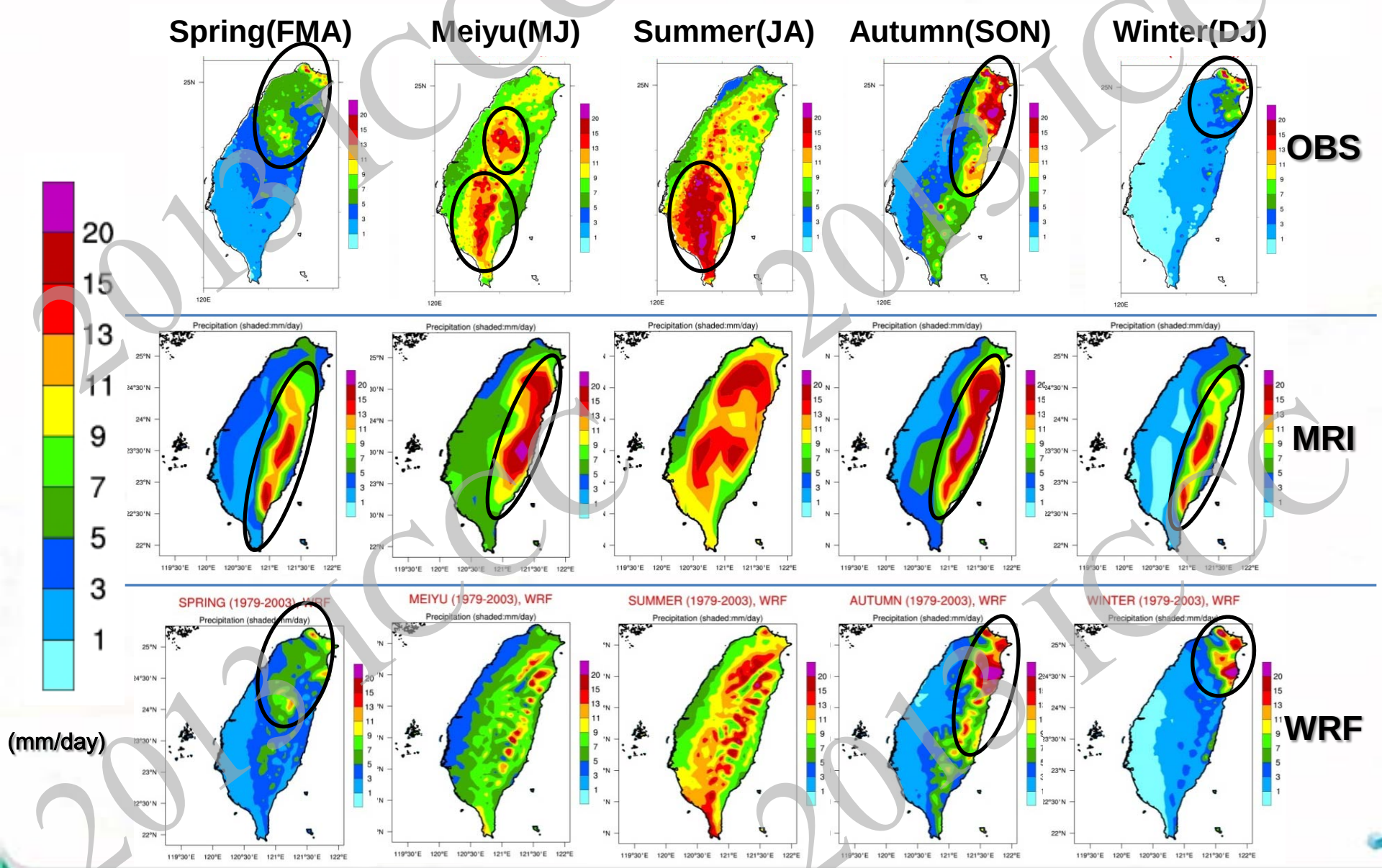
Outline

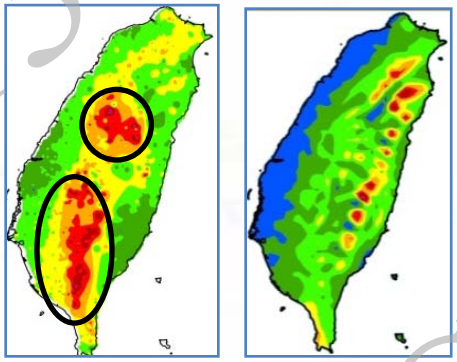
- Motivation
- Model & Data
- Results
  - Bias of Meiyu precipitation
  - Change of Meiyu precipitation
  - Extreme rainfall
- Summary

Seasonal Mean Precipitation



Motivation

- Torrential rain events occasionally occur in Meiyu season, May and June, causing severe damage and property loss.

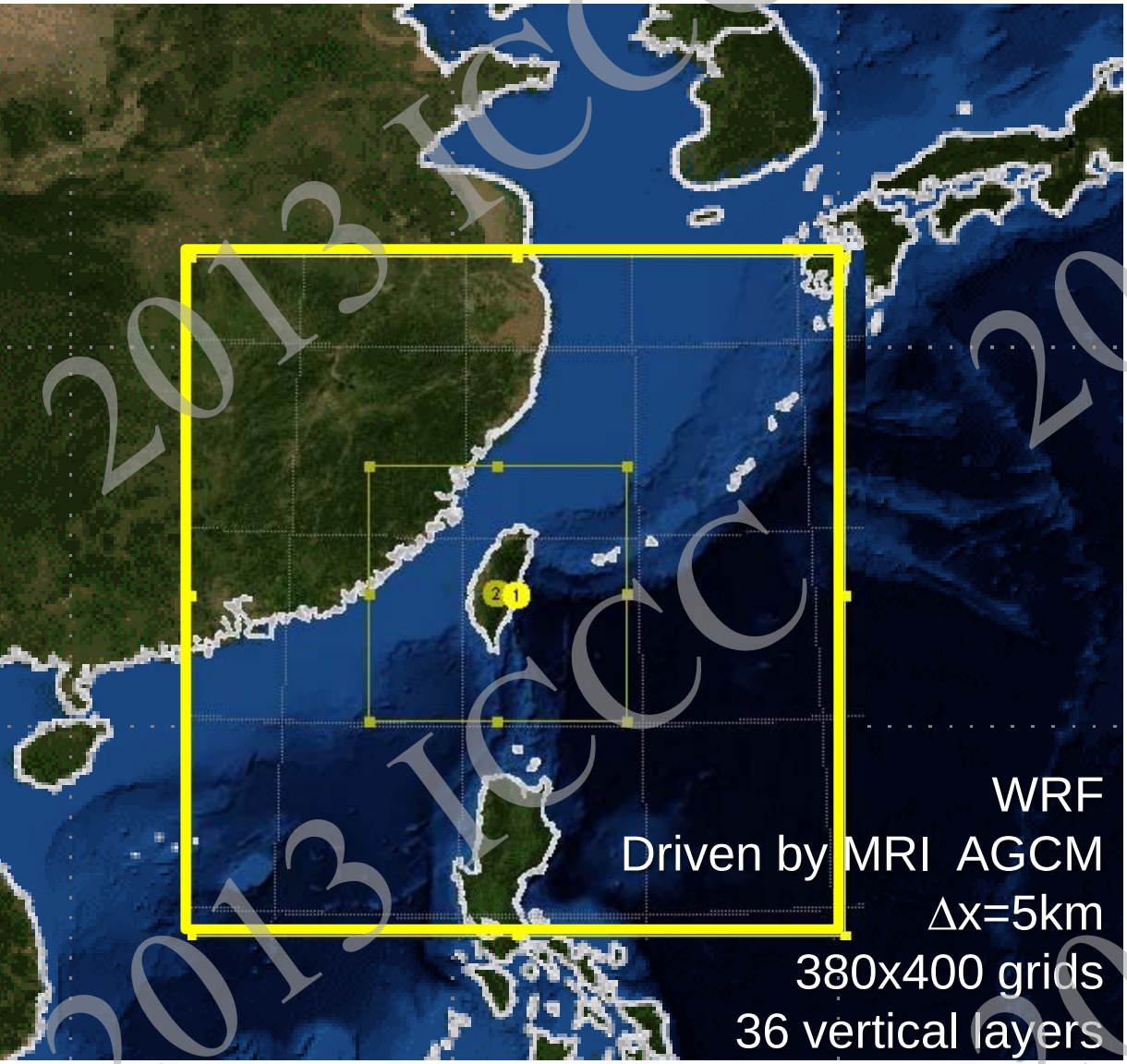


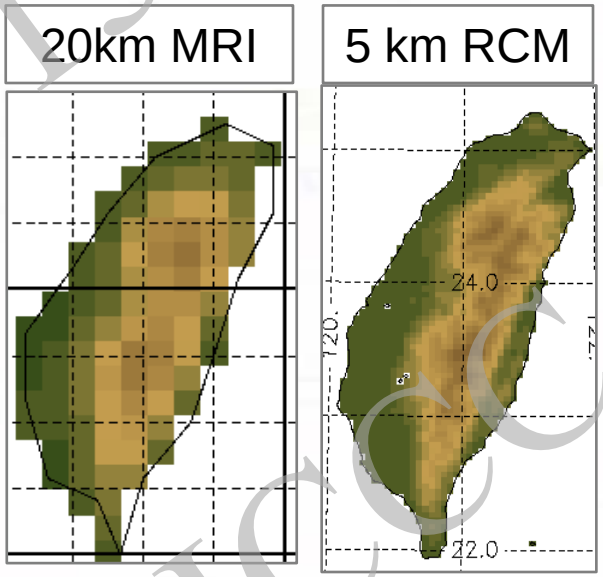
- The needs of accurate simulation
  - Amount: Underestimated
  - Location: two hot spots are not found
- Questions about model setting.
- Conduct experiments to evaluate model performance.

Model & Data – OBS data

- TCCIP gridded data set
  - Monthly T. & Preci., Δx=1 & 5 km, 1960-2010
  - 1500 Stations of CWB, WRA, Taipower Co, Air Force…….
- Data from ~400 Central Weather Bureau rain gauges
  - Hourly, Δx=5 km, 1992-2010
- TRMM - for bigger precipitation picture around Taiwan
- NCEP CFSR – circulation info

Model & Data – Model domain





Model & Data – Model setting

WRF model simulation

- 5 km downscaling for climate projections of 3 time slices:
  Present day (1979-2003)
  Near future (2015-2039)
  End of century (2075-2099)

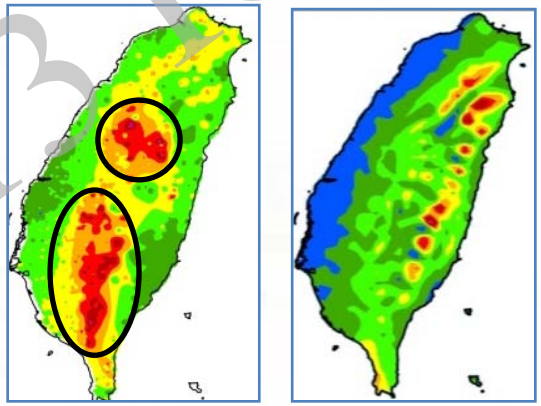
Physical Option

- Noah land surface module
- YSU Boundary scheme
- Monin-Obukhov surface layer scheme
- CAM3 radiation scheme
- WSM 5-class microphysics
- **KF cumulus parameterization**

- **Spectral nudging** is applied to U, V, Φ and T to prevent climate drift. (enforce GCM environment to RCM environment)
- A1B scenario is considered
- Taiwan land use are replaced with CTCI-MODIS-USGS data set

Model & Data – Experiment Design

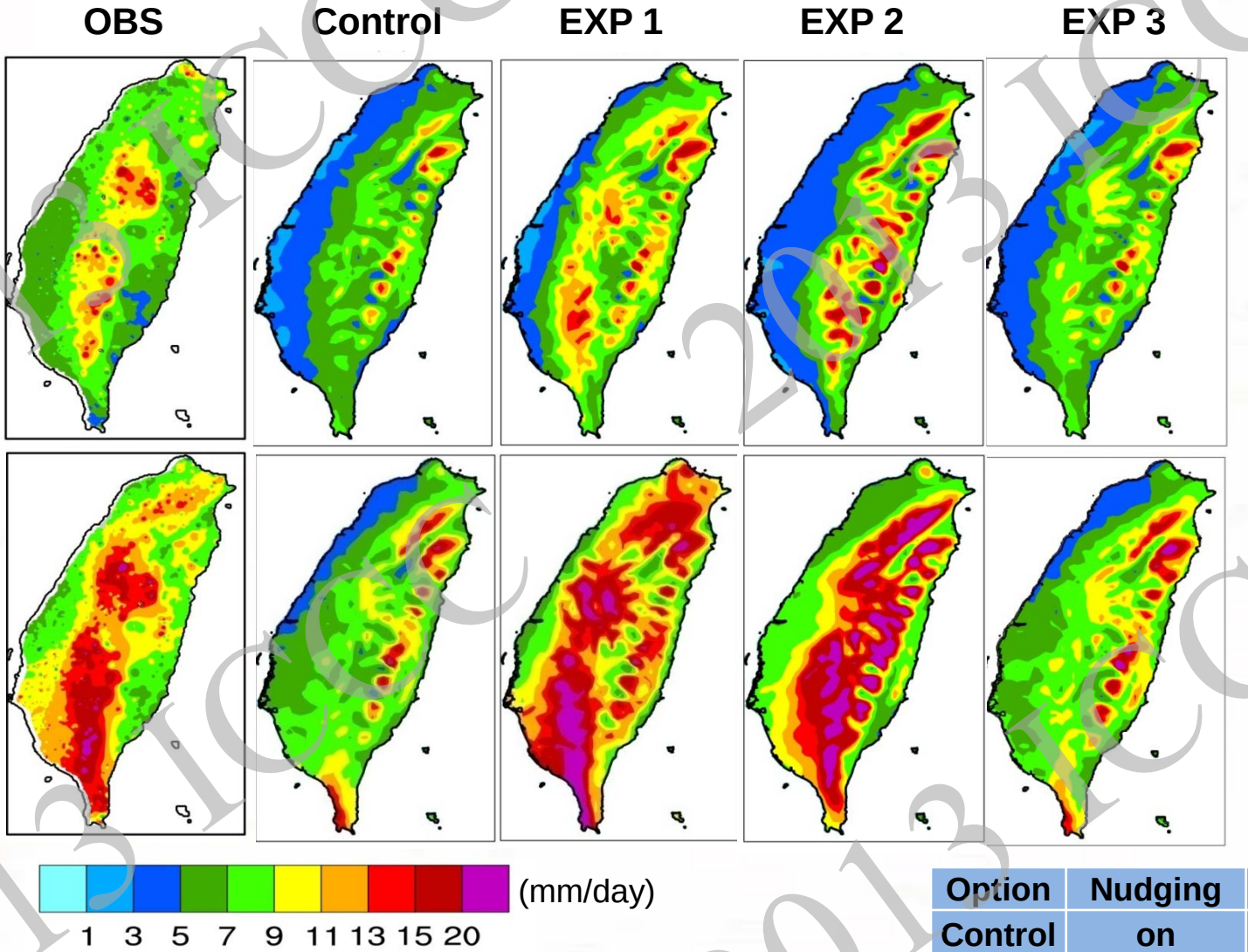
- Questions about Model setting
  - Does spectral nudging inhibit deep convection?
  - Is cumulus parameterization necessary for Δx=5km?
- Conduct experiments to evaluate model performance.



Option	Spectral Nudging	Cumulus parameterization
Control	on	on
EXP 1	off	on
EXP 2	off	off
EXP 3	on, but only for 300 hPa↑	on

- Results
  - Bias of Meiyu precipitation
  - Changes of Meiyu precipitation
  - Ability to simulate extreme rainfall

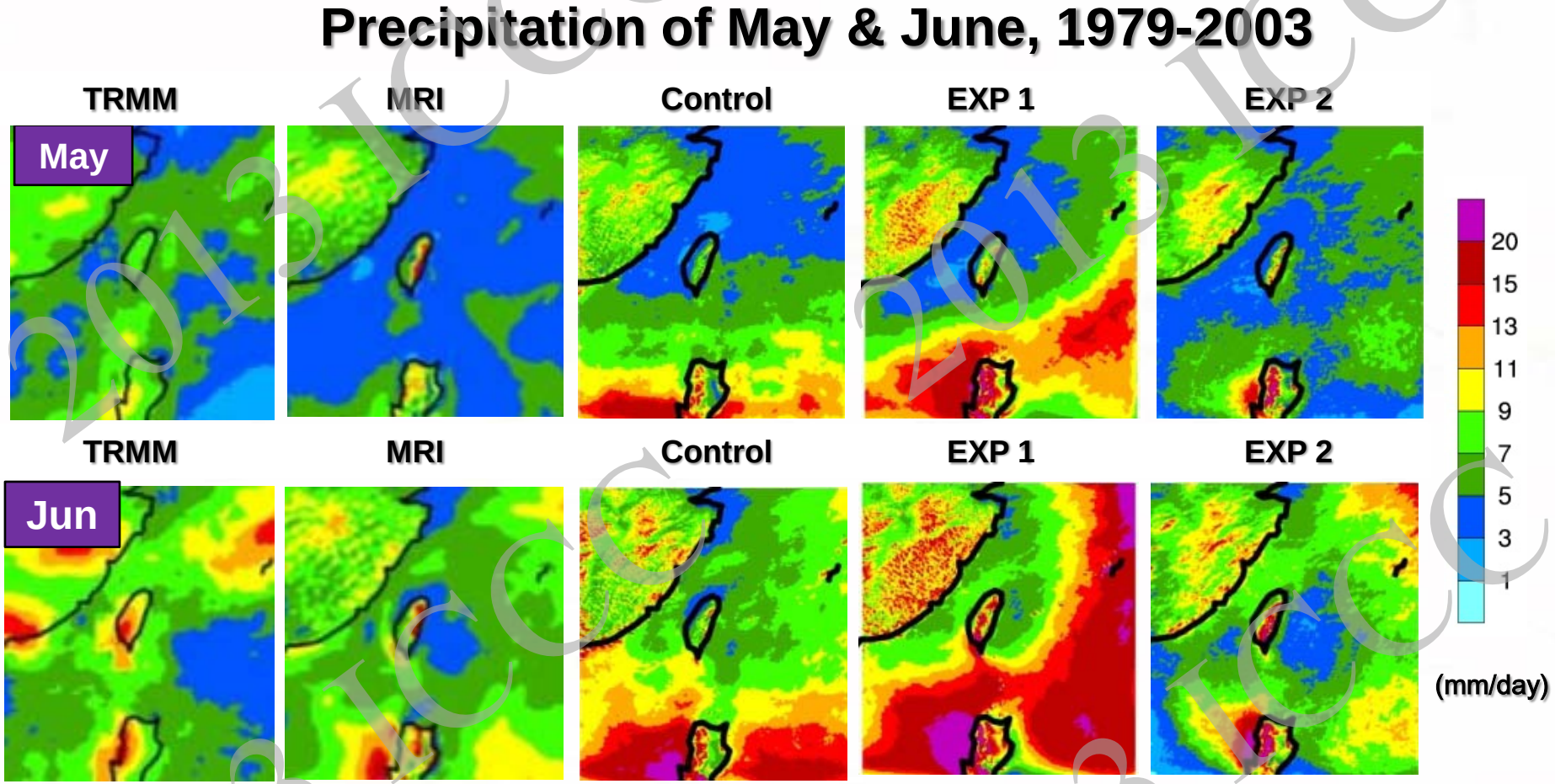
Result –Rain over Taiwan



Nudging cause less rainfall, even for applying to upper troposphere only.

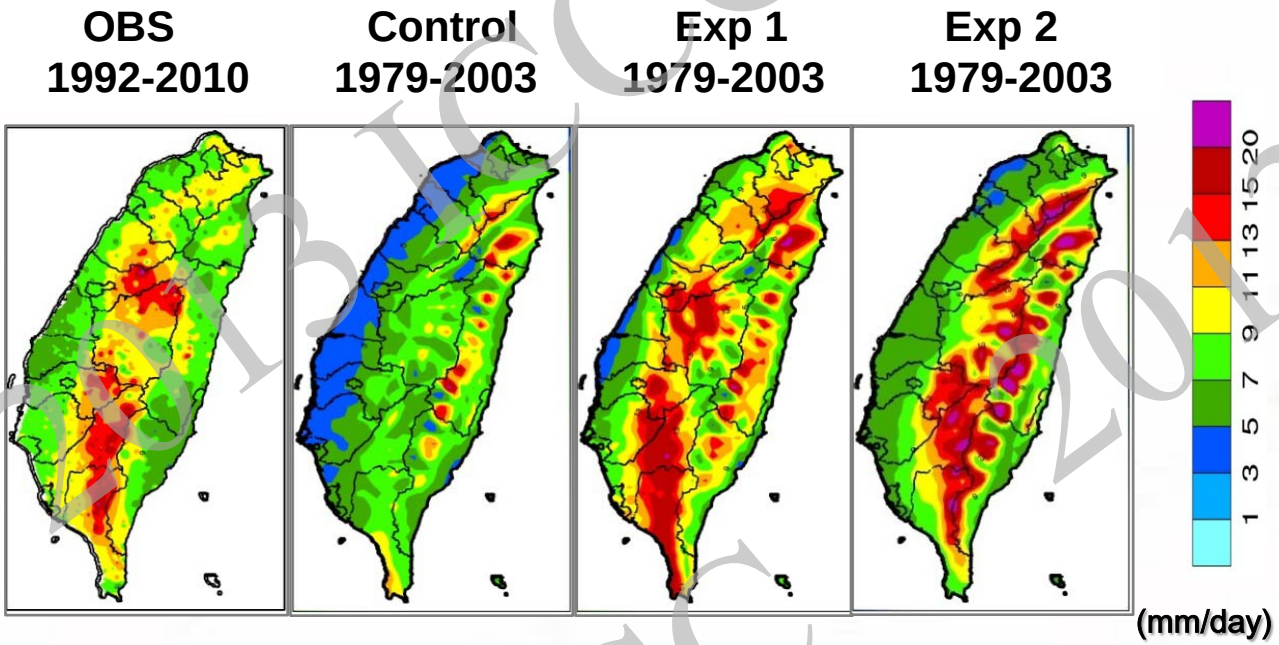
Option	Nudging	Cumulus
Control	on	on
EXP 1	off	on
EXP 2	off	off
EXP 3	300 hPa↑	on

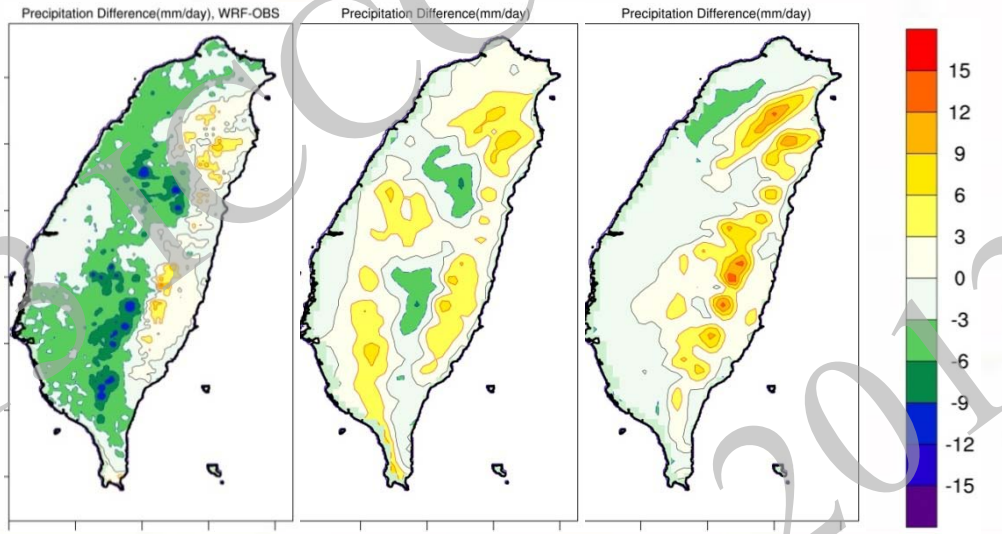
Result –Rain in model domain



- **Cumulus parameterization causes too much rain in south**

Result – Meiyu Rainfall bias





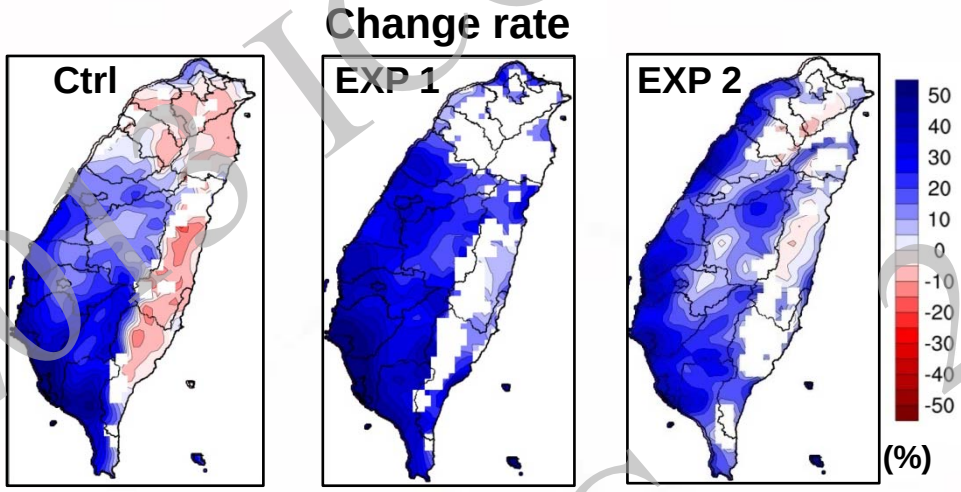
Exp 2 gives the best result, although rain of rain in east is overestimated.

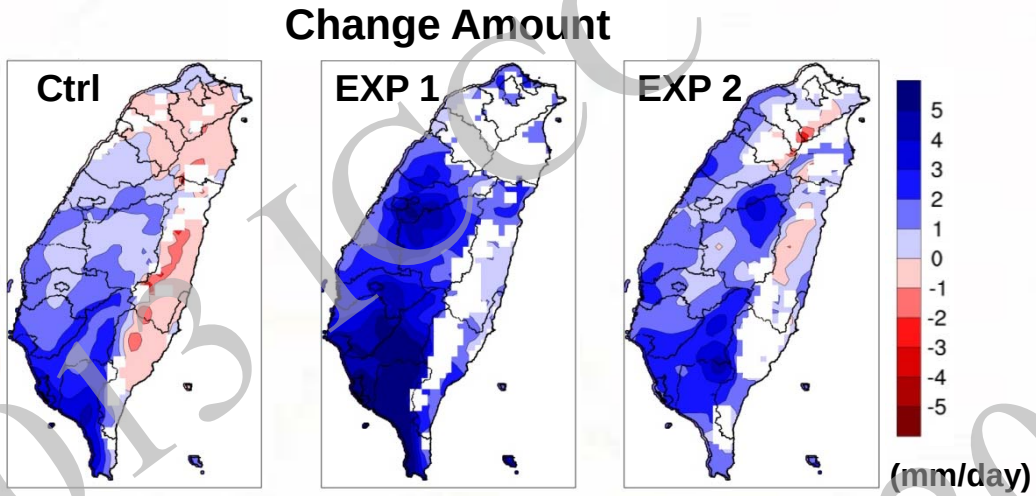
Correct location is a big improvement.

Intensity bias can be fixed via bias correction.

Option	Nudging	Cumulus
Ctrl	on	on
EXP 1	off	on
EXP 2	off	off

Result –Meiyu Rainfall change in the future





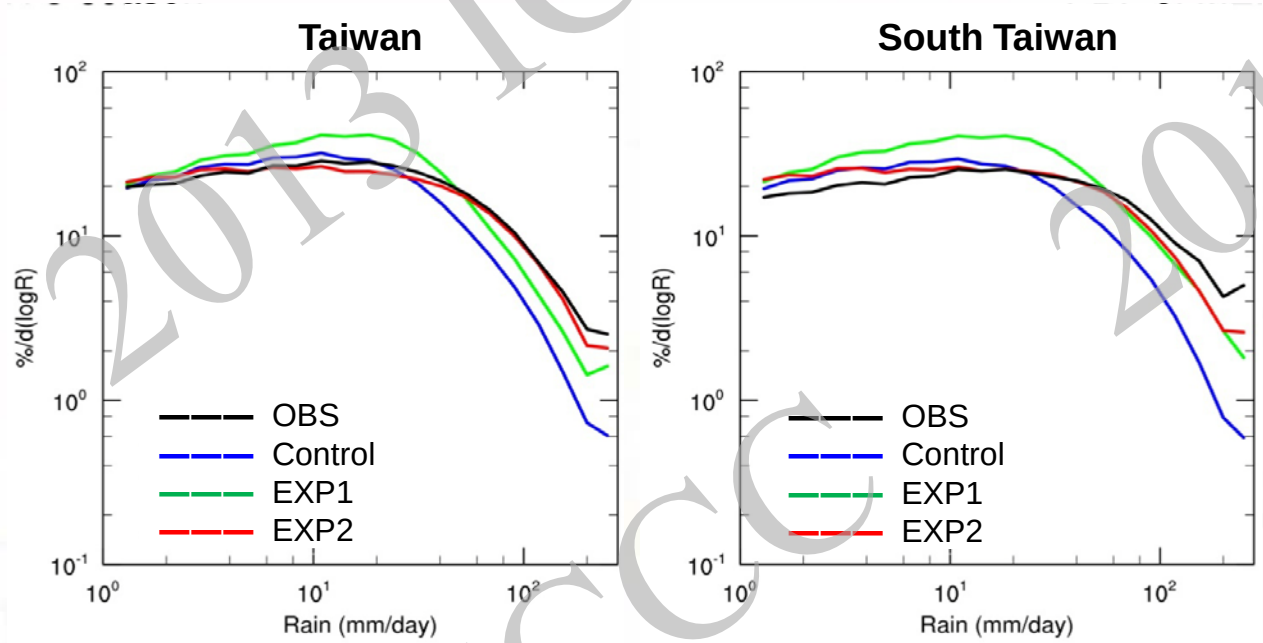
Meiyu rainfall increase in south and central Taiwan in all experiments.

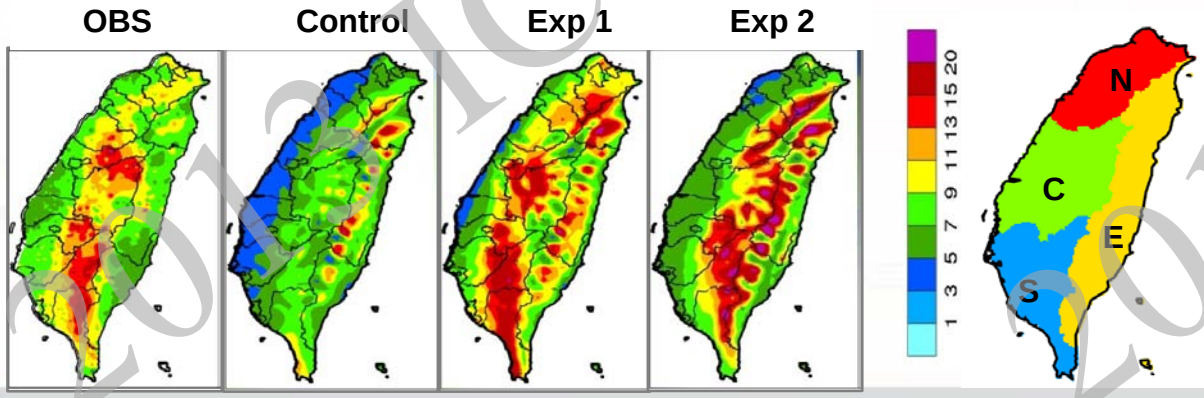
Hot spots are different in EXP1 & 2

The rainfall decrease in north and east Taiwan may be questionable. It can be insignificant.

Result – PDF of daily rainfall

PDF: Probability density function; spectrum of rainfall intensity
Sampled from all grid points of interested area





Ctrl:
too few R>20mm/day

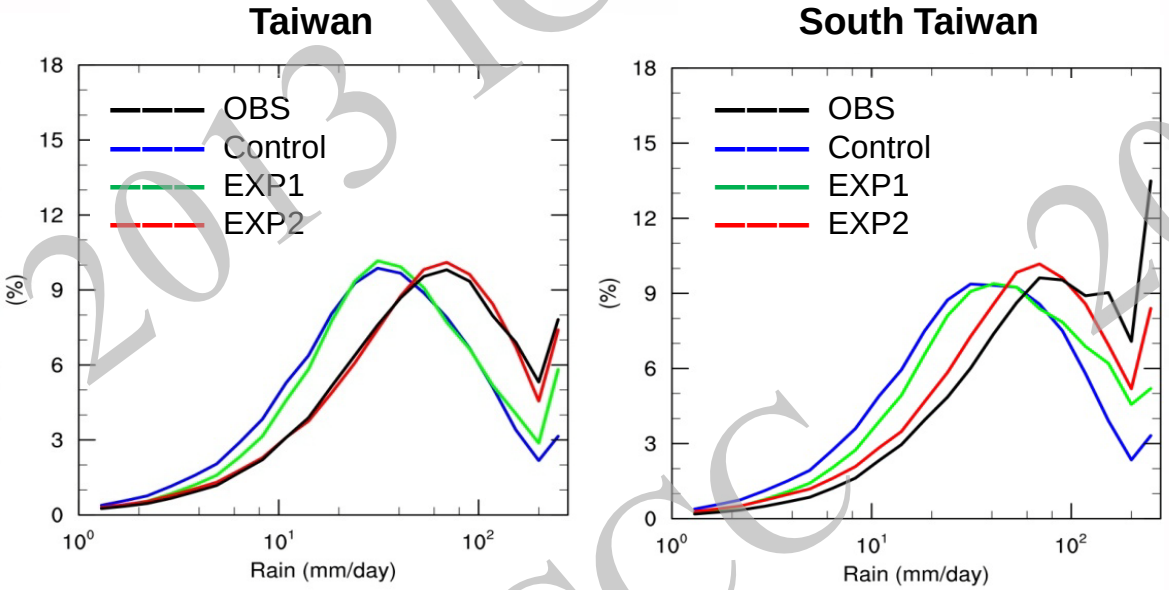
EXP1:
too much R<50mm/day

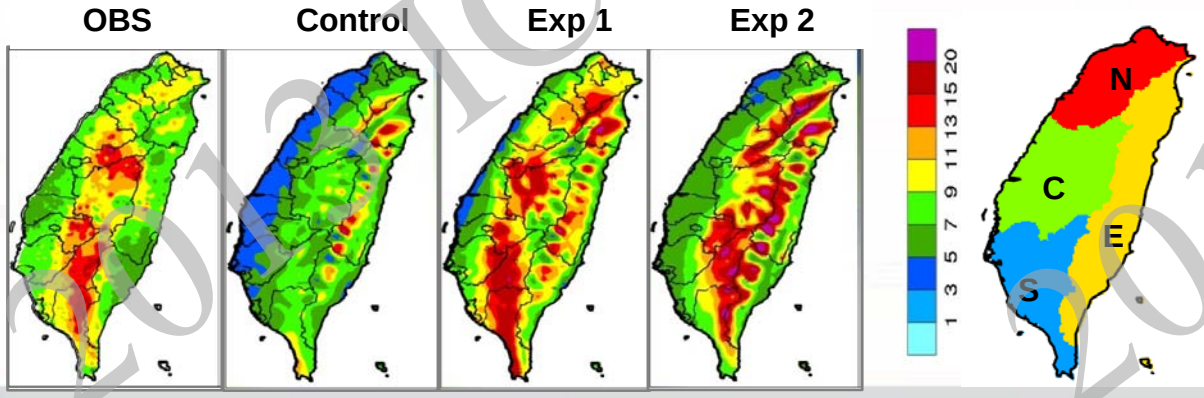
EXP2:
Close to observation, but still too small for R>100mm/day & too large for R<10 mm/day in south Taiwan

Option	Nudging	Cumulus
Ctrl	on	on
EXP 1	off	on
EXP 2	off	off

Result – Weighted PDF, contribution to total rain

PDF weighted by intensity. Contribution of rainfall of each rainfall intensity bin.





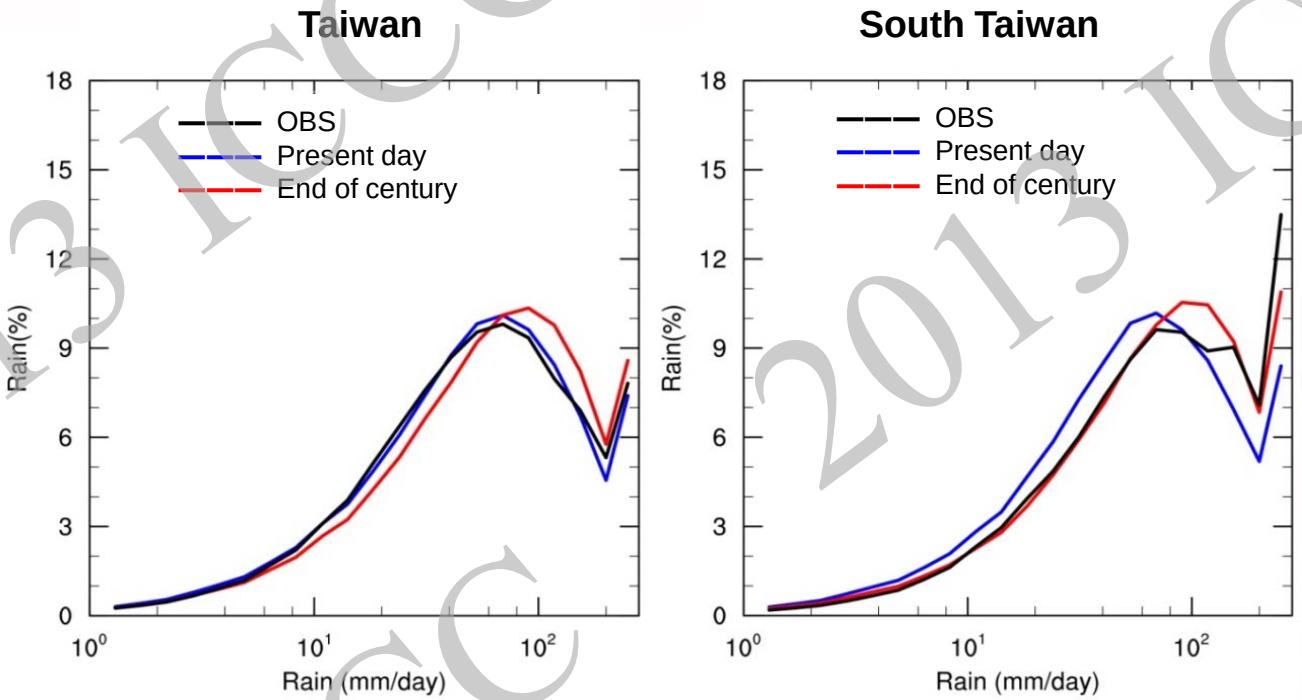
Ctrl & EXP1 are similar. 10<R<40 mm/day contribute most to total rain (~10%). This could be dominated by cumulus parameterization.

EXP2:

- 60<R<80 mm/day contribute most to total rain
- Taiwan area
  - close to observation
- South Taiwan
  - too much for R<100 mm/day
  - too few R>100 mm/day
  - OBS R>200mm/day contribute most (~14%)

Option	Nudging	Cumulus
Ctrl	on	on
EXP 1	off	on
EXP 2	off	off

Result – EXP2: Changes of PDF in the future



- R<90mm/day decrease, R>90mm/day increase. Spectrum shifts to right.
- Change in south Taiwan is more remarkable than the whole Taiwan
- Frequency of R>90 mm/day increase from 2.1% to 3.2%. (50% more in the future)

Summary - 1/2

- High resolution (5km) gridded data can be obtained by dynamical downscaling. Extreme events can also be simulated directly.
- A few experiments are designed to evaluate simulation of Meiyu rainfall. In term of *spatial distribution*, *intensity*, and *PDF* of precipitation, best results are delivered by turning off both spectral nudging and cumulus parameterization.
- Spectral nudging (imposing GCM environment to RCM) seems to suppress precipitation. Stability may be altered?
- Cumulus parameterization results in high frequency but low intensity precipitation (improvement in exp1 may be caused by wrong mechanism). The location of precipitation is also incorrect.

Summary - 2/2

- More accurate present-day Meiyu simulation ensures the confident to provide quality future projection.
- Model still doesn't do good job for R>200 mm/day.
- Meiyu rainfall increase in south Taiwan is related to more water vapor and stronger southwesterly moisture flux. Precipitation of extreme events may increased by 25% in south Taiwan.
- Aforementioned finding is based on the dynamical downscaling results from the climate projection of MRI AGCM. This may not be good enough to jump into any conclusion. Uncertainty is unknown. Using more reliable GCMs for dynamical downscaling may be necessary in future work.

Thanks for your attention!