Results of 5-km resolution dynamical downscaling from MRI-JMA AGCM output for the TCCIP project

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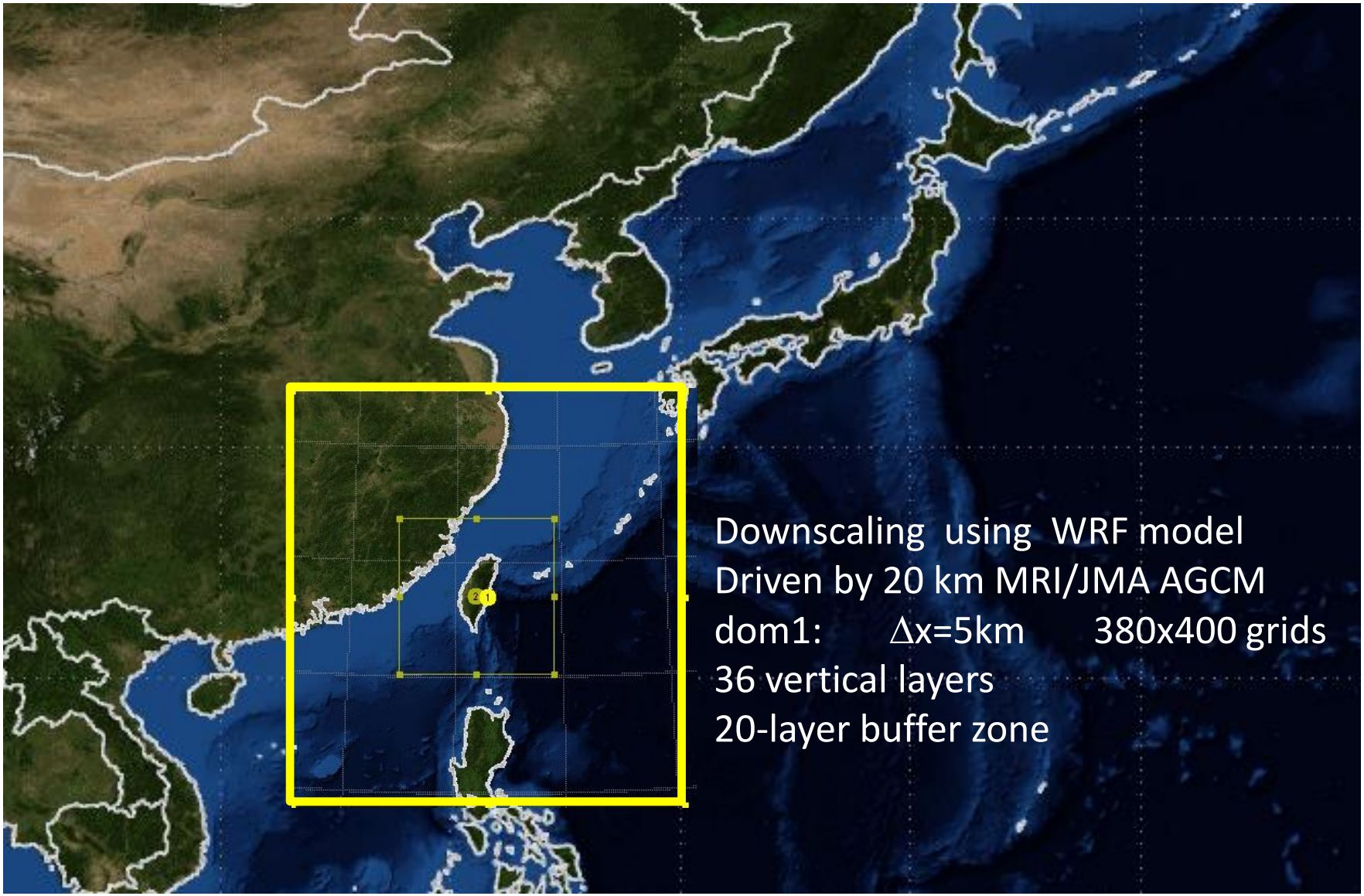
Outline

- Model and data
- Evaluation of circulation
- Evaluation of seasonal precipitation
- Changes in seasonal precipitation
- Summary

RCM for dynamical downscaling: WRF



WRF model simulation

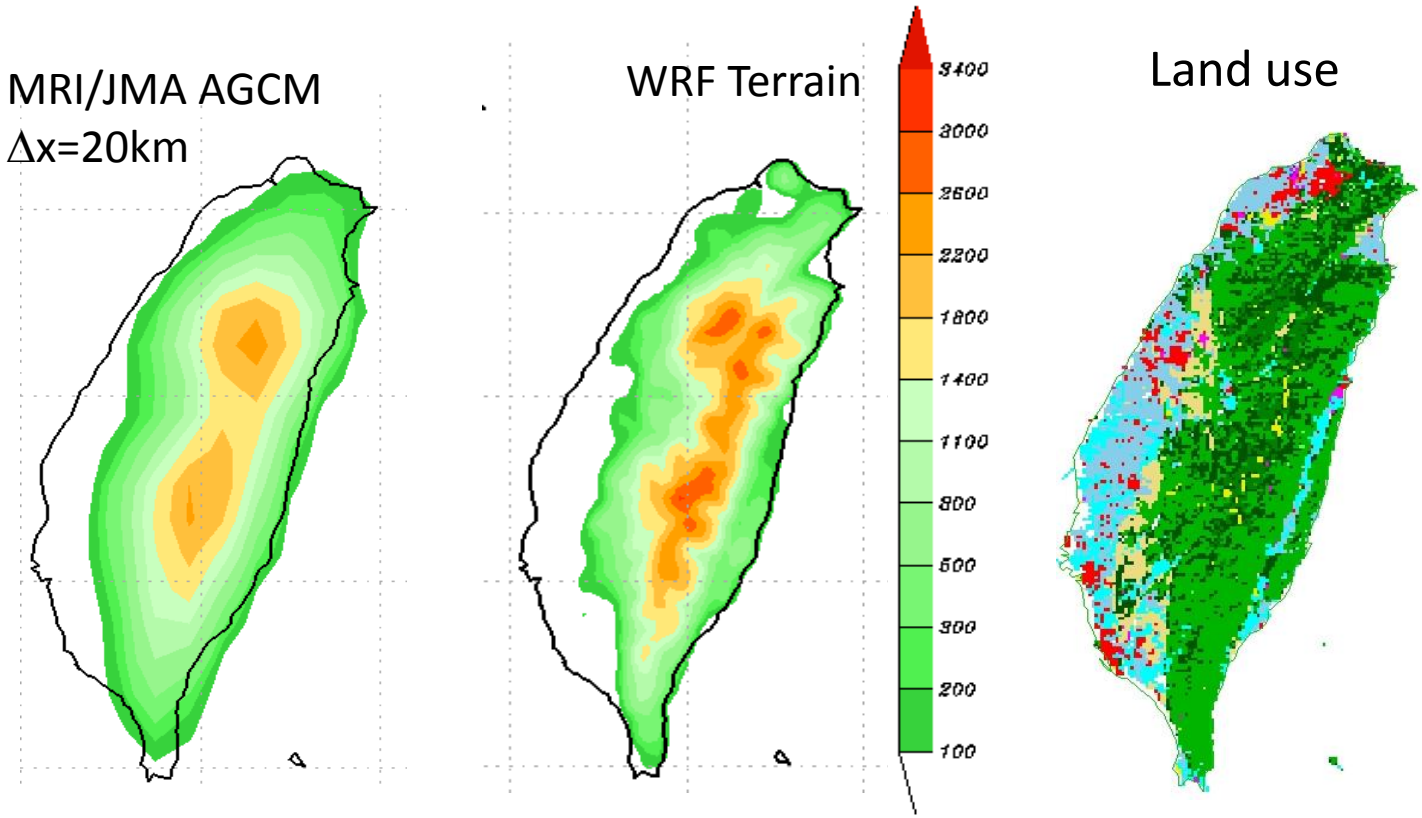
- 5 km downscaling for climate projections of:
  Present day (1979-2003),
  Near future (2015-2039),
  End of century (2075-2099)

Physical Option

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

- Spectral nudging is applied to U, V, Φ and T to prevent climate drift. However, nudging is not applied to PBL.
- A1B scenario is considered
- Taiwan land use are replaced with CTCI-MODIS-USGS data set

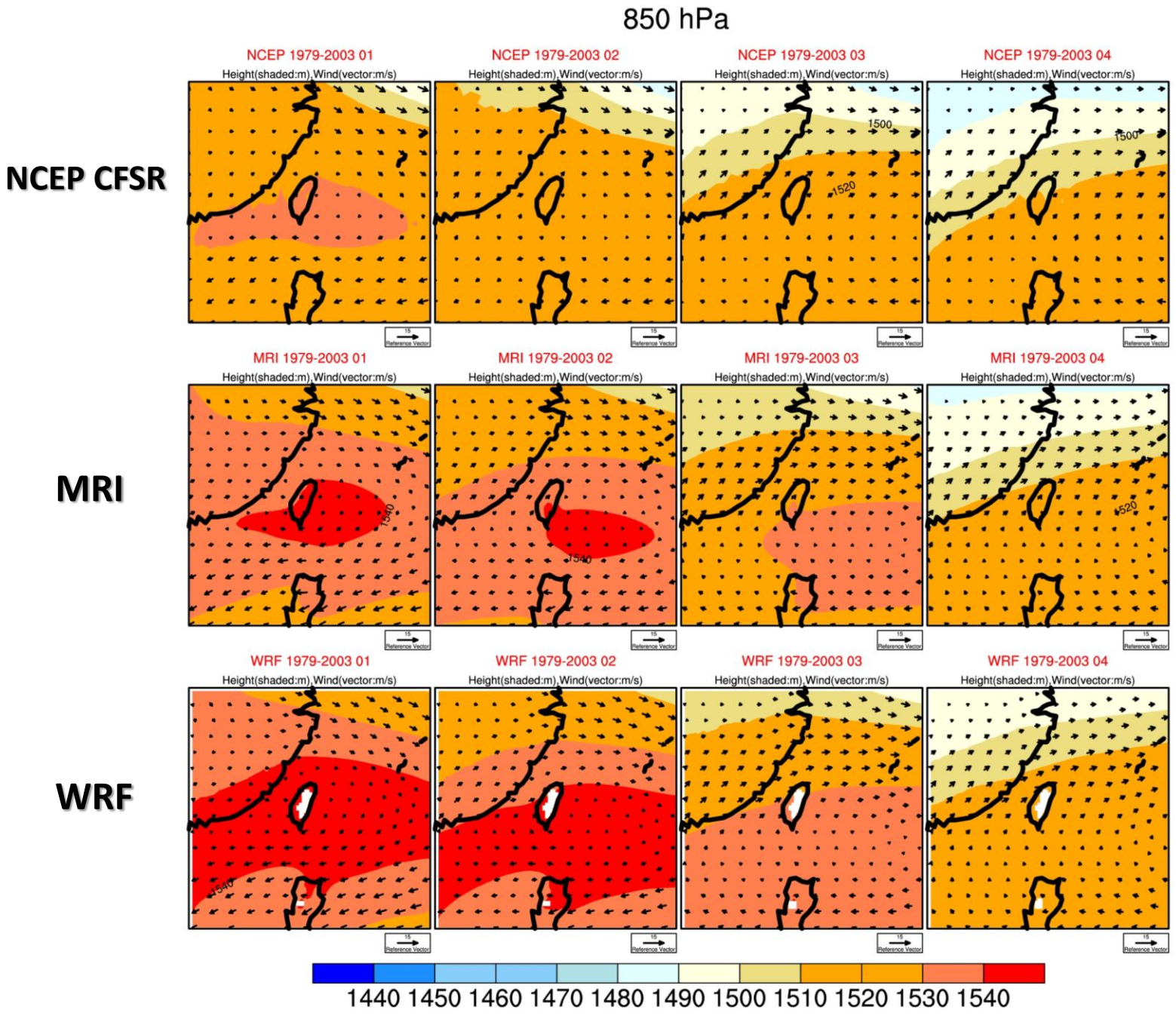
Land use & Terrain of Taiwan

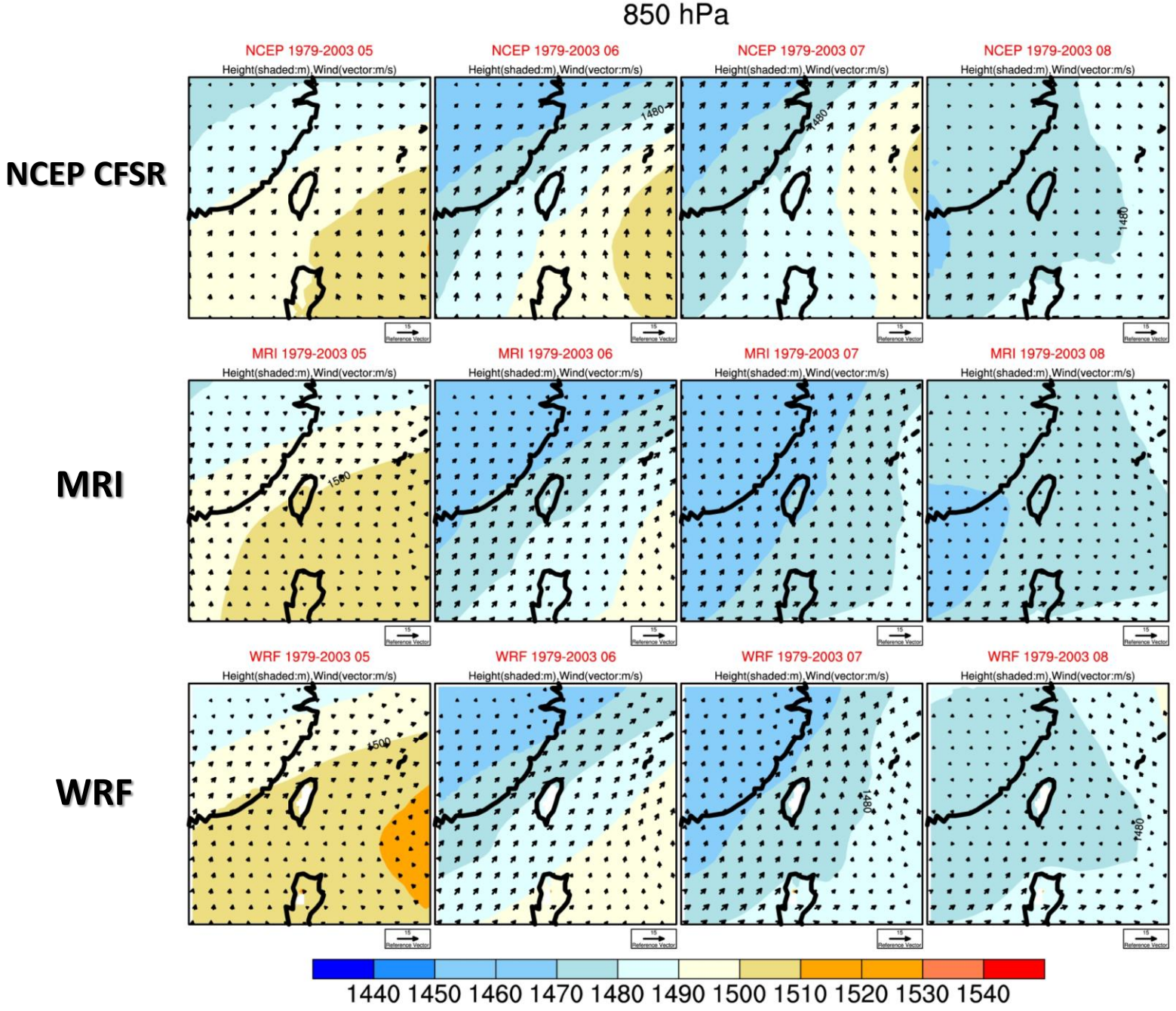


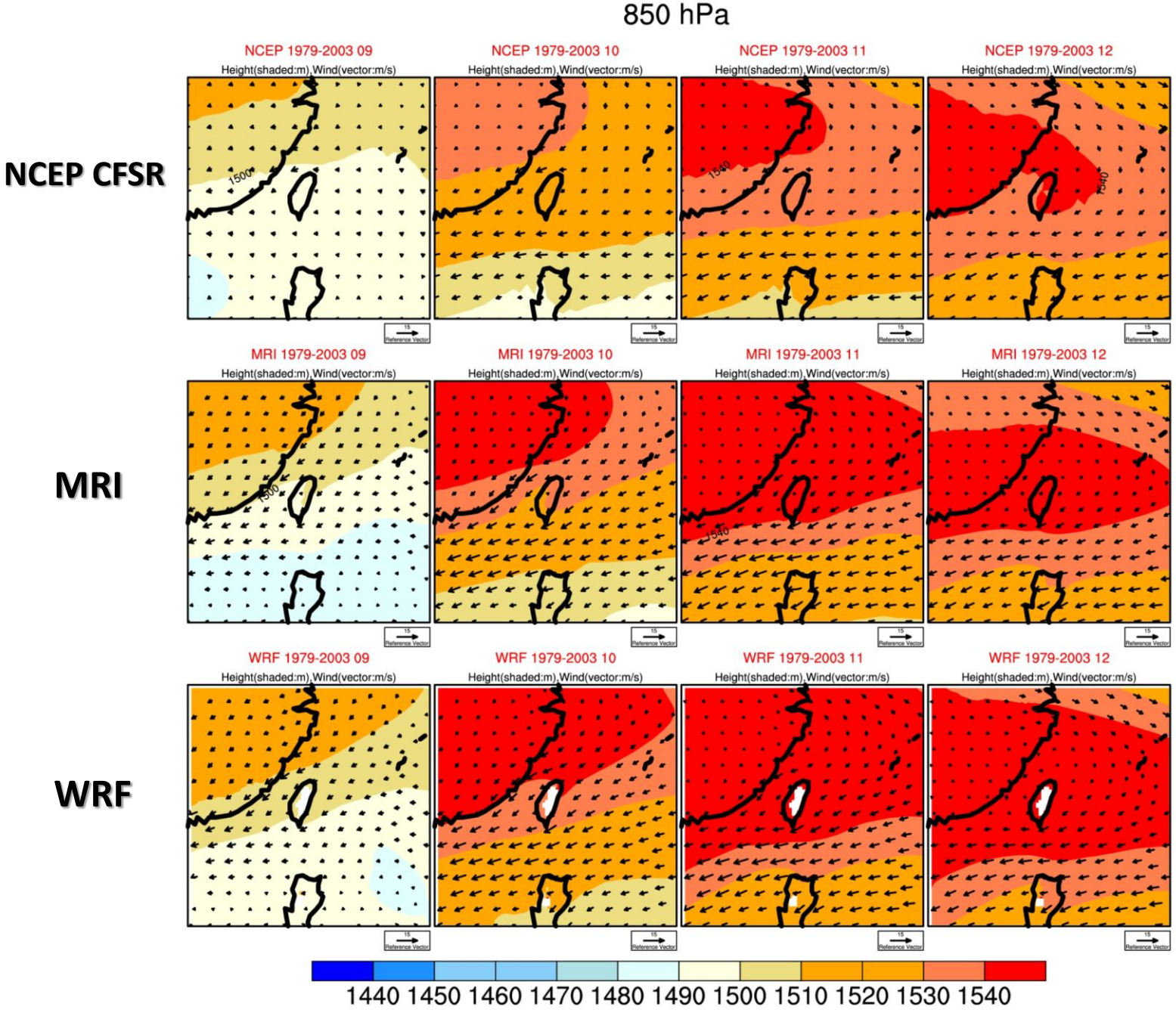
Complicated terrain and land use allows dynamical downscaling to add detailed information

Data for validation

- NCEP CFSR 1979-2003
- TCCIP gridded data set
  - Monthly T. & Preci., Δx=1 & 5 km, 1979-2003
  - Stations of CWB, WRA, Taipower Co.……
- CWB rain gauges (~400s)
  - Hourly, Δx=1.3 km, 1992-2010
- TRMM estimated preci. 1998-2010
- JMA best track

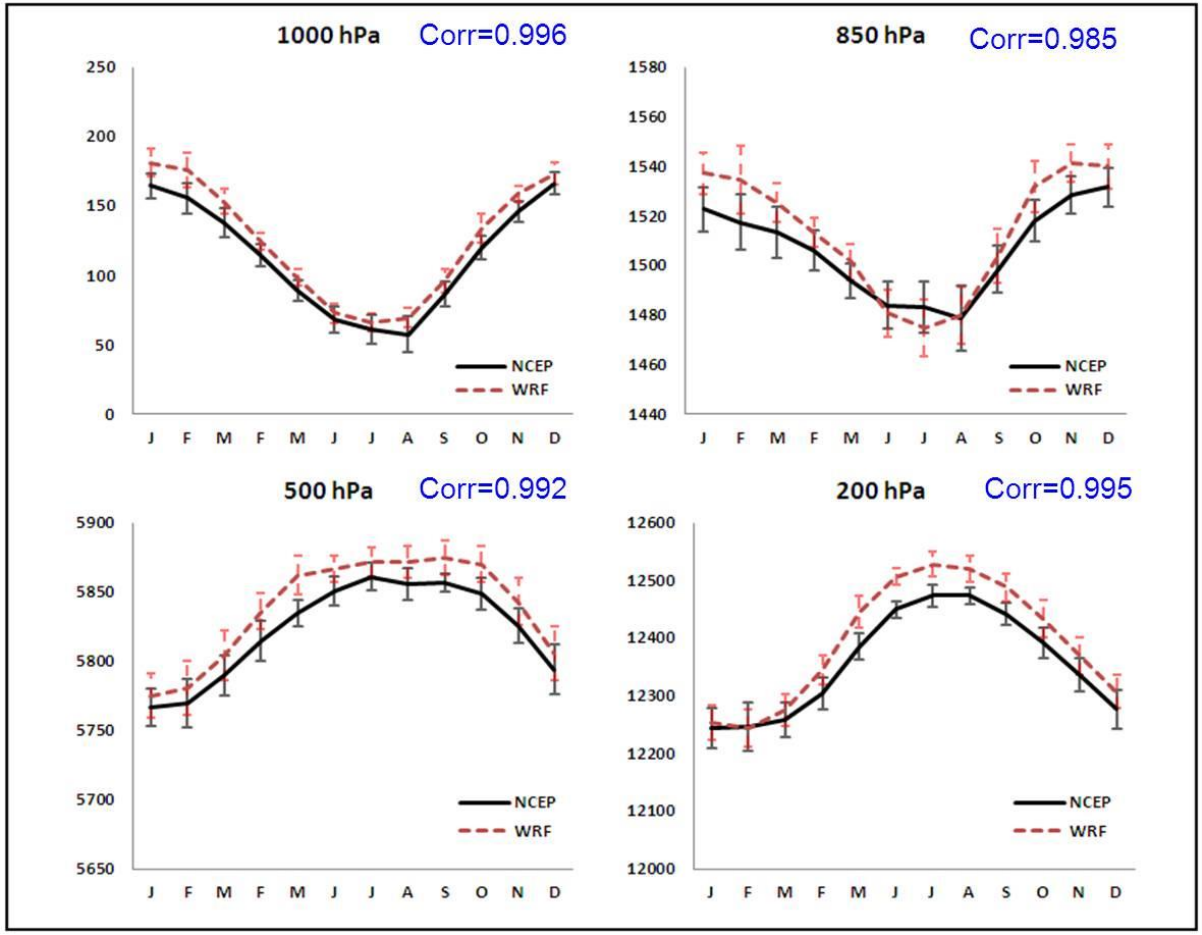

850 hPa
NCEP CFSR
MRI
WRF
NCEP 1979-2003 01
NCEP 1979-2003 02
NCEP 1979-2003 03
NCEP 1979-2003 04
MRI 1979-2003 01
MRI 1979-2003 02
MRI 1979-2003 03
MRI 1979-2003 04
WRF 1979-2003 01
WRF 1979-2003 02
WRF 1979-2003 03
WRF 1979-2003 04
Height(shaded:m),Wind(vector:m/s)
1440 1450 1460 1470 1480 1490 1500 1510 1520 1530 1540


850 hPa
NCEP CFSR
MRI
WRF
NCEP 1979-2003 05
NCEP 1979-2003 06
NCEP 1979-2003 07
NCEP 1979-2003 08
MRI 1979-2003 05
MRI 1979-2003 06
MRI 1979-2003 07
MRI 1979-2003 08
WRF 1979-2003 05
WRF 1979-2003 06
WRF 1979-2003 07
WRF 1979-2003 08
Height(shaded:m),Wind(vector:m/s)
1440 1450 1460 1470 1480 1490 1500 1510 1520 1530 1540

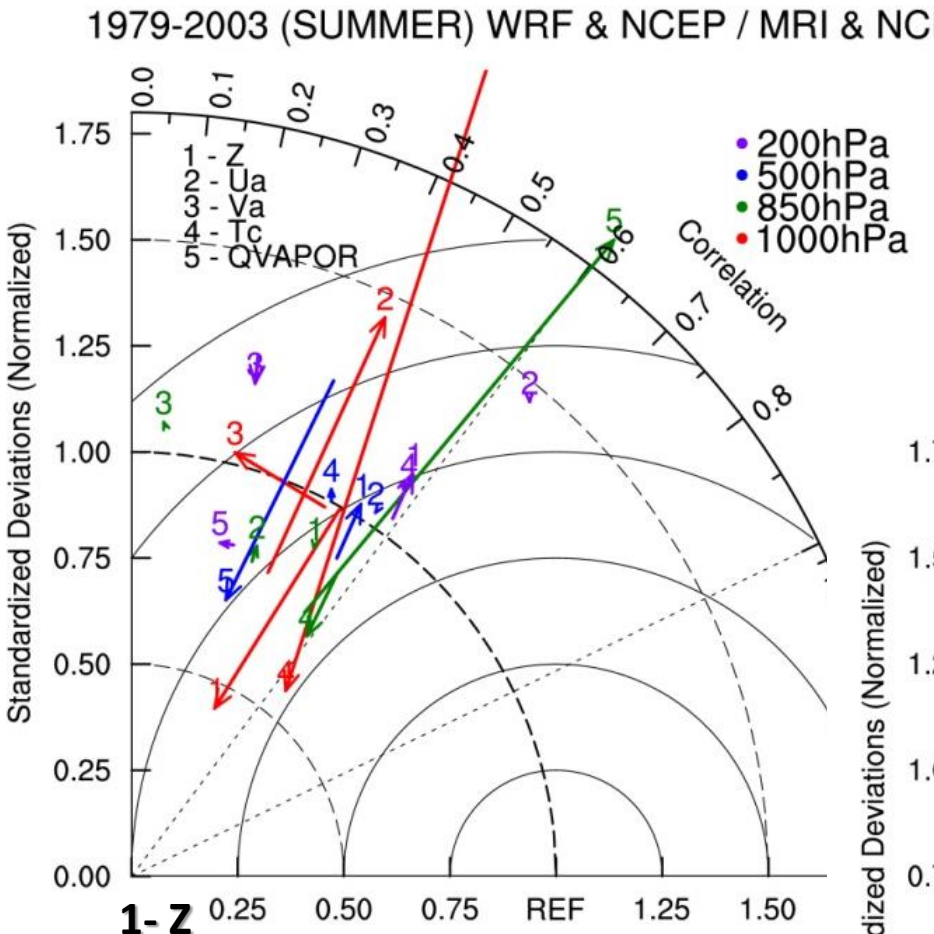

850 hPa
NCEP CFSR
MRI
WRF
NCEP 1979-2003 09
NCEP 1979-2003 10
NCEP 1979-2003 11
NCEP 1979-2003 12
MRI 1979-2003 09
MRI 1979-2003 10
MRI 1979-2003 11
MRI 1979-2003 12
WRF 1979-2003 09
WRF 1979-2003 10
WRF 1979-2003 11
WRF 1979-2003 12
Height(shaded:m),Wind(vector:m/s)
1500
1540
Reference Vector
1440 1450 1460 1470 1480 1490 1500 1510 1520 1530 1540

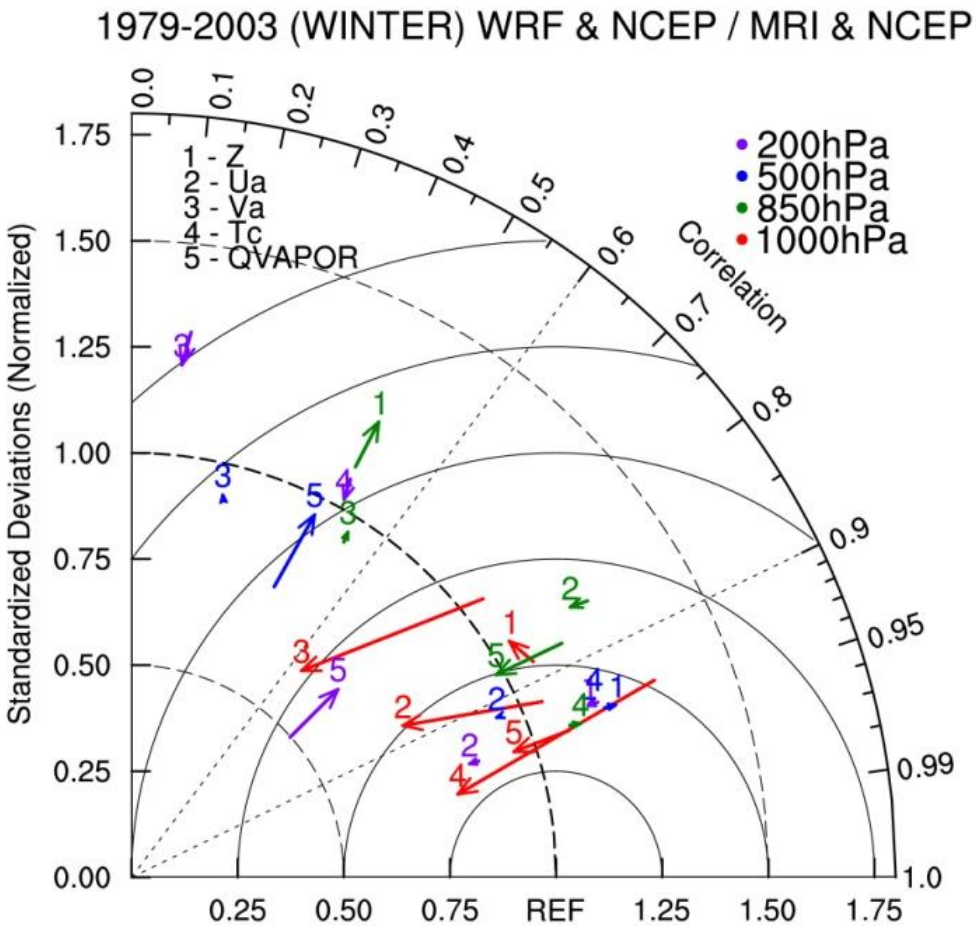
1979-2003 NCEP CFSR (black) and WRF(red dashed lines)

Annual cycle of area-averaged geopotential height on 1000, 850, 500, and 200 hPa pressure levels.



Taylor Diagram Present Day



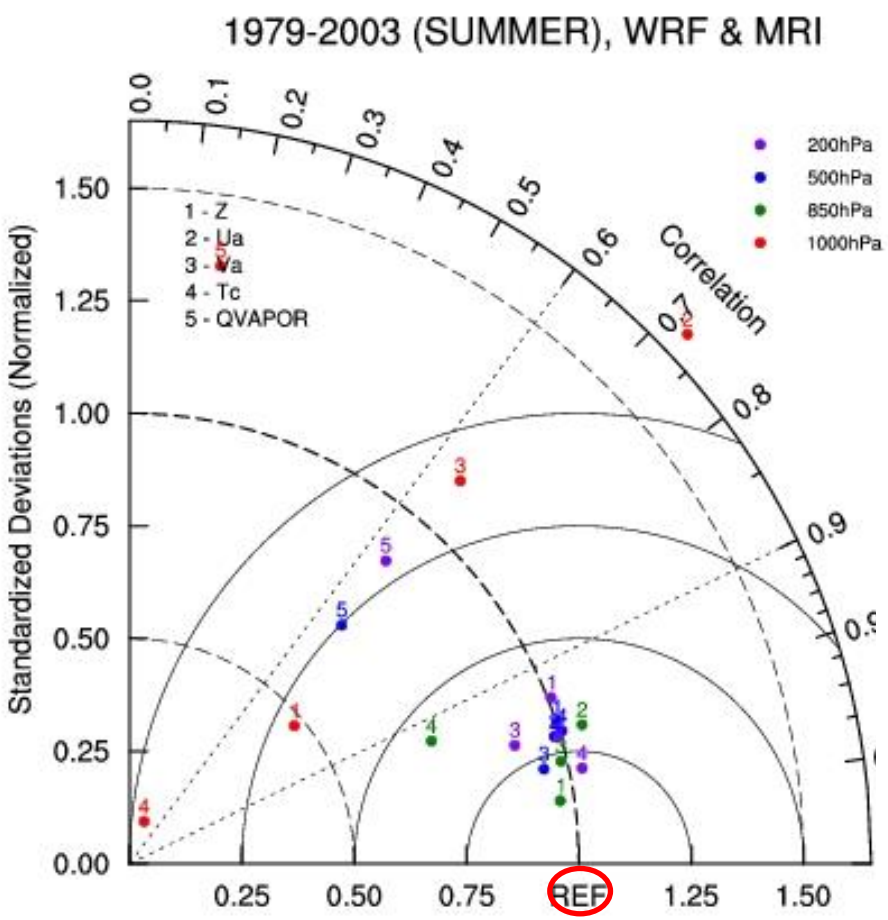


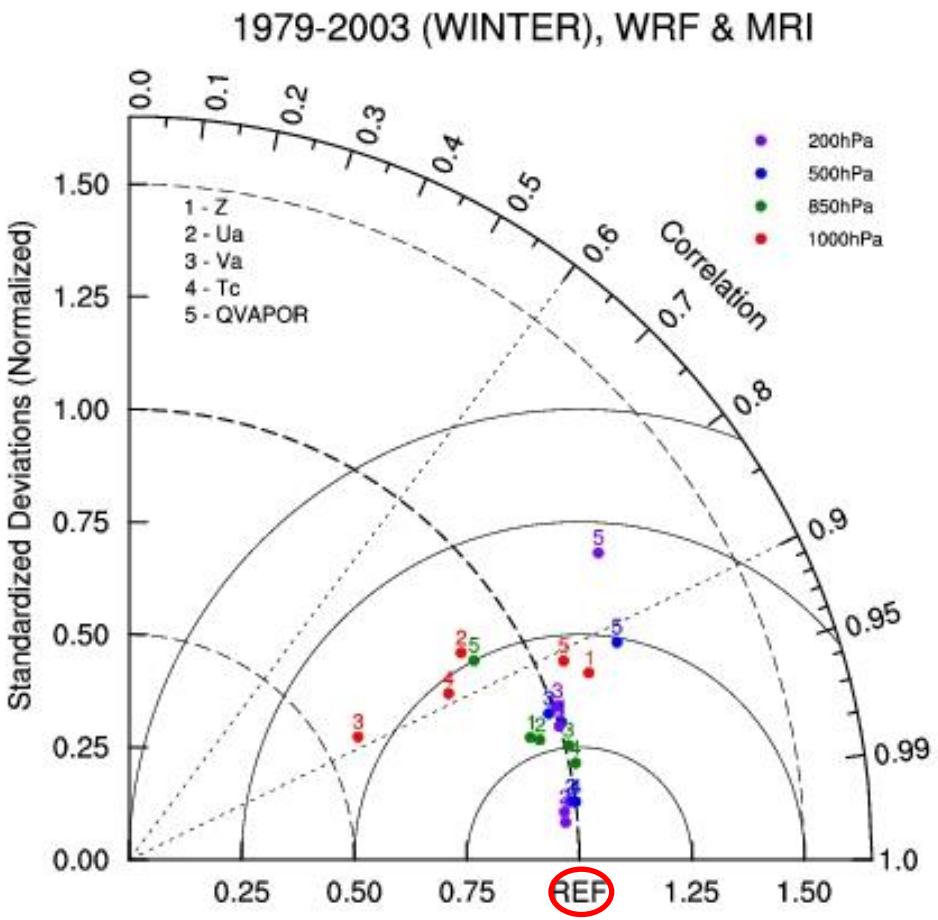
1- Z
2- Ua
3- Va
4- Tc
5- QVAPOR

200hPa
500hPa
850hPa
1000hPa

- **Change is larger on 1000 hPa**
- **Change is smaller in cold season than in warm season**
- **Change does not guarantee smaller rmse**

Taylor Diagram Present Day



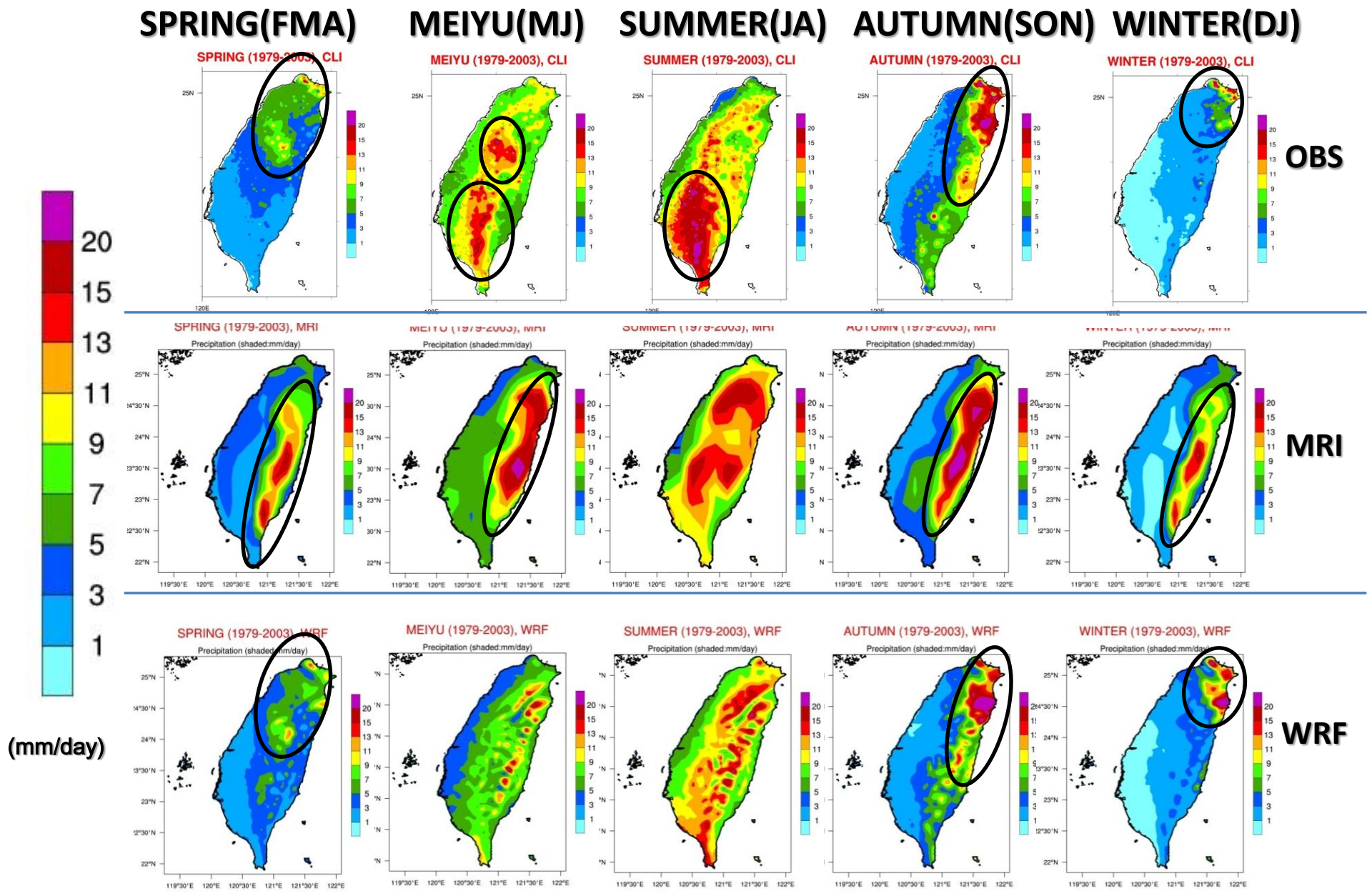


1- Z
2- Ua
3- Va
4- Tc
5- QVAPOR

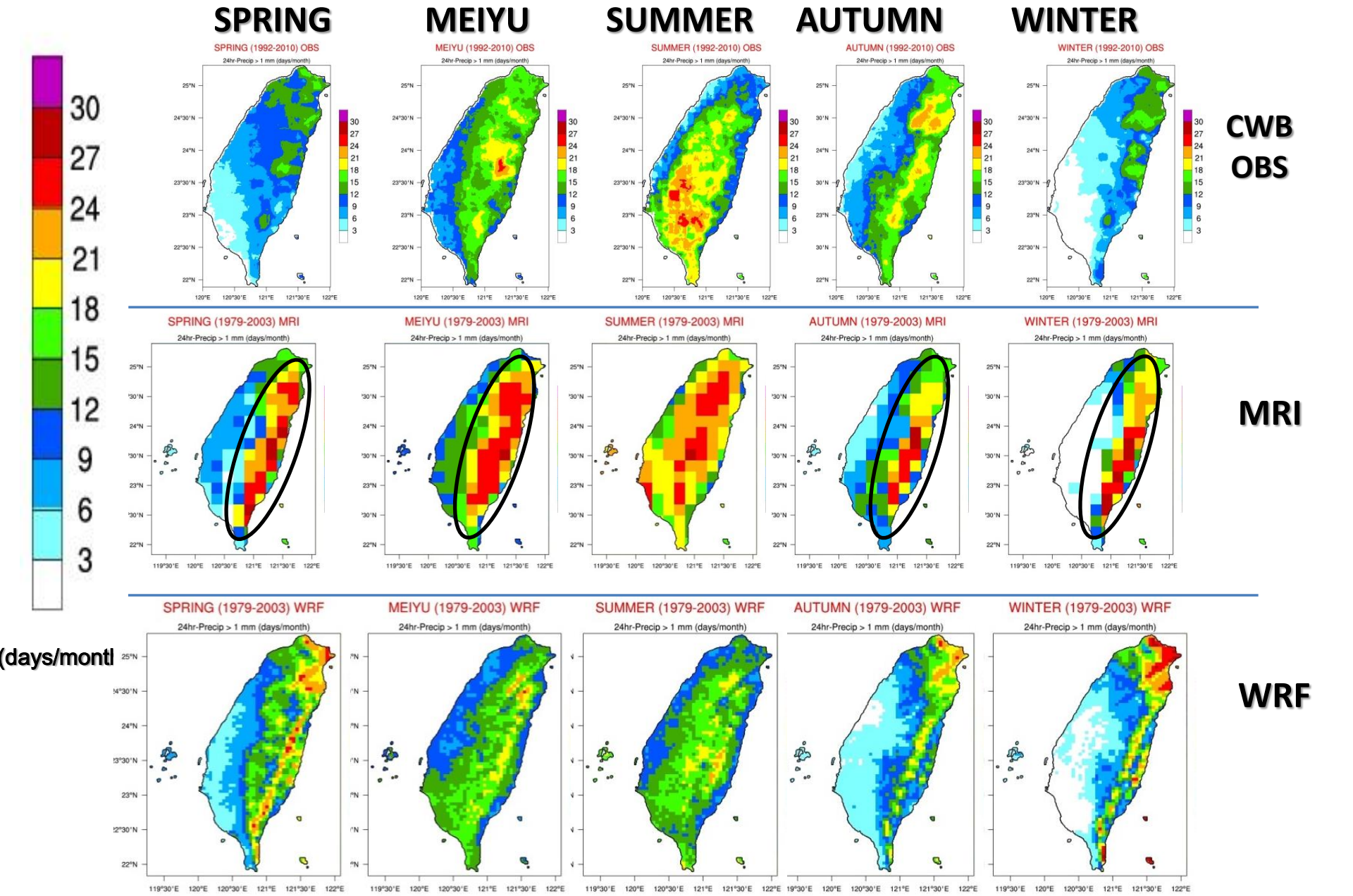
- **200hPa**
- **500hPa**
- **850hPa**
- **1000hPa**

- **Difference is larger for vapor & 1000 hPa (no nudging is allpied)**
- **Difference is smaller in cold season than in warm warm season**

Seasonal Mean Precipitation

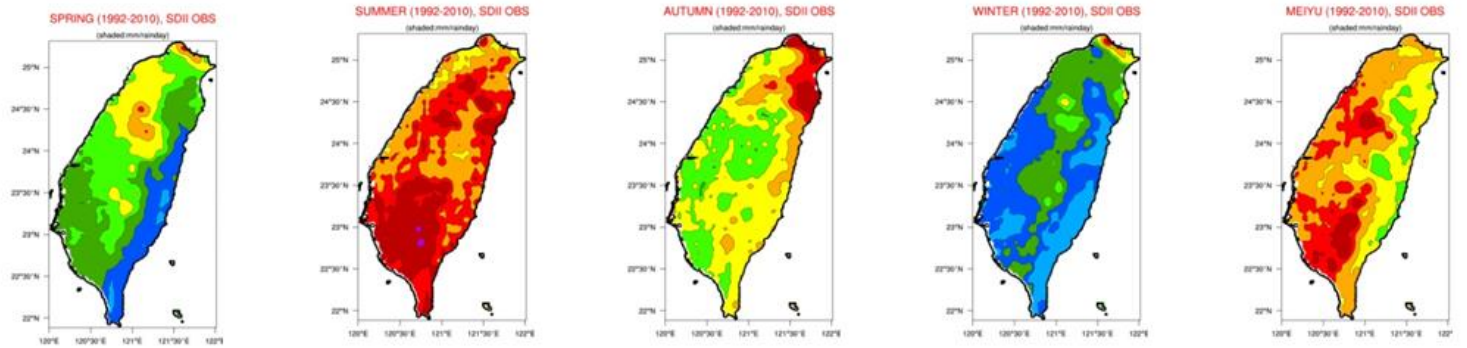


Wet Day (Daily Precipitation > 1mm/day) **--- Present**

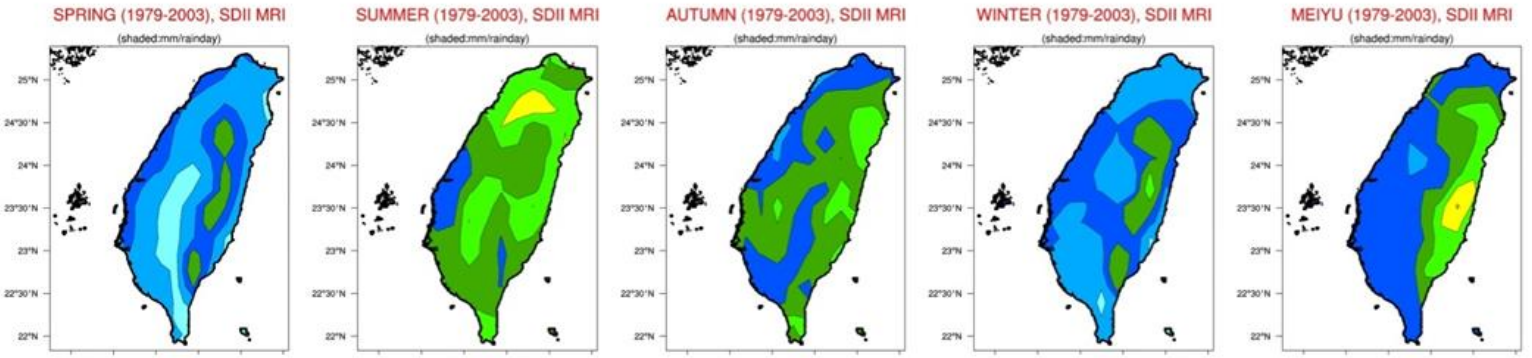


SDII (Precipitation/wet day) **--- Present**

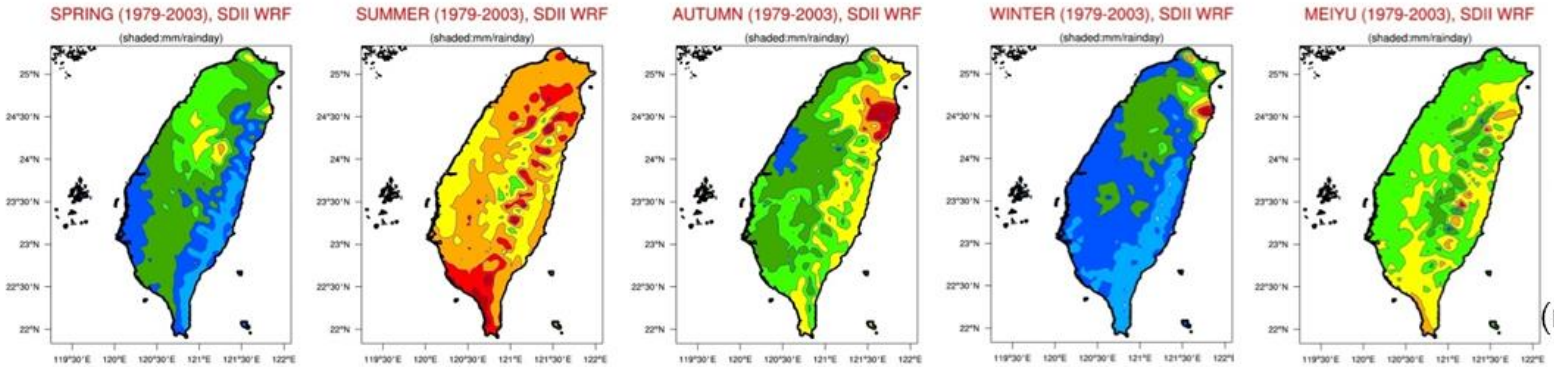
OBS

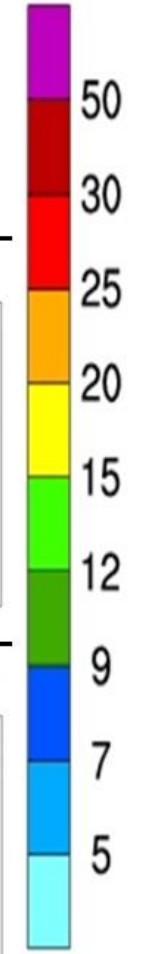


MRI

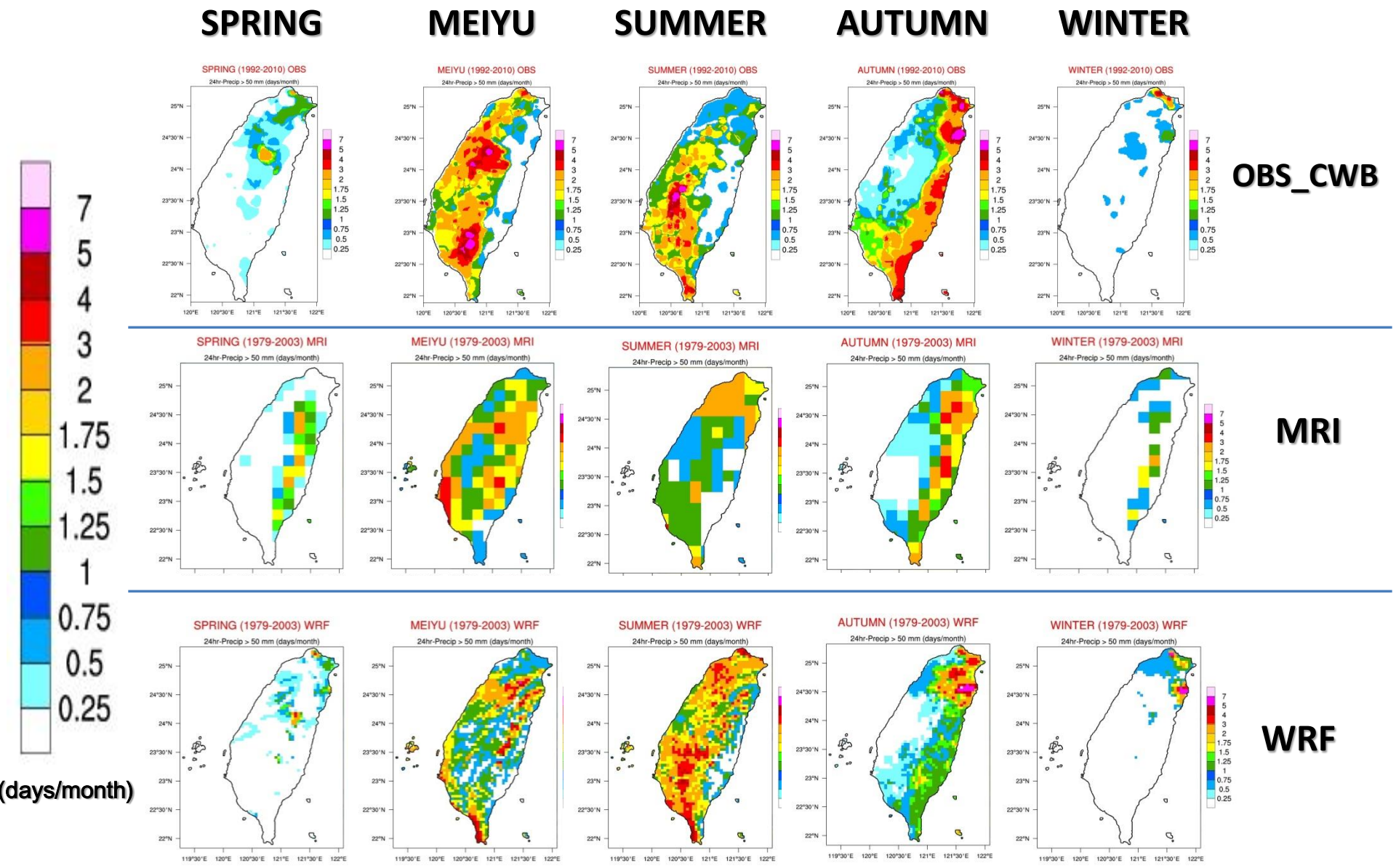


WRF

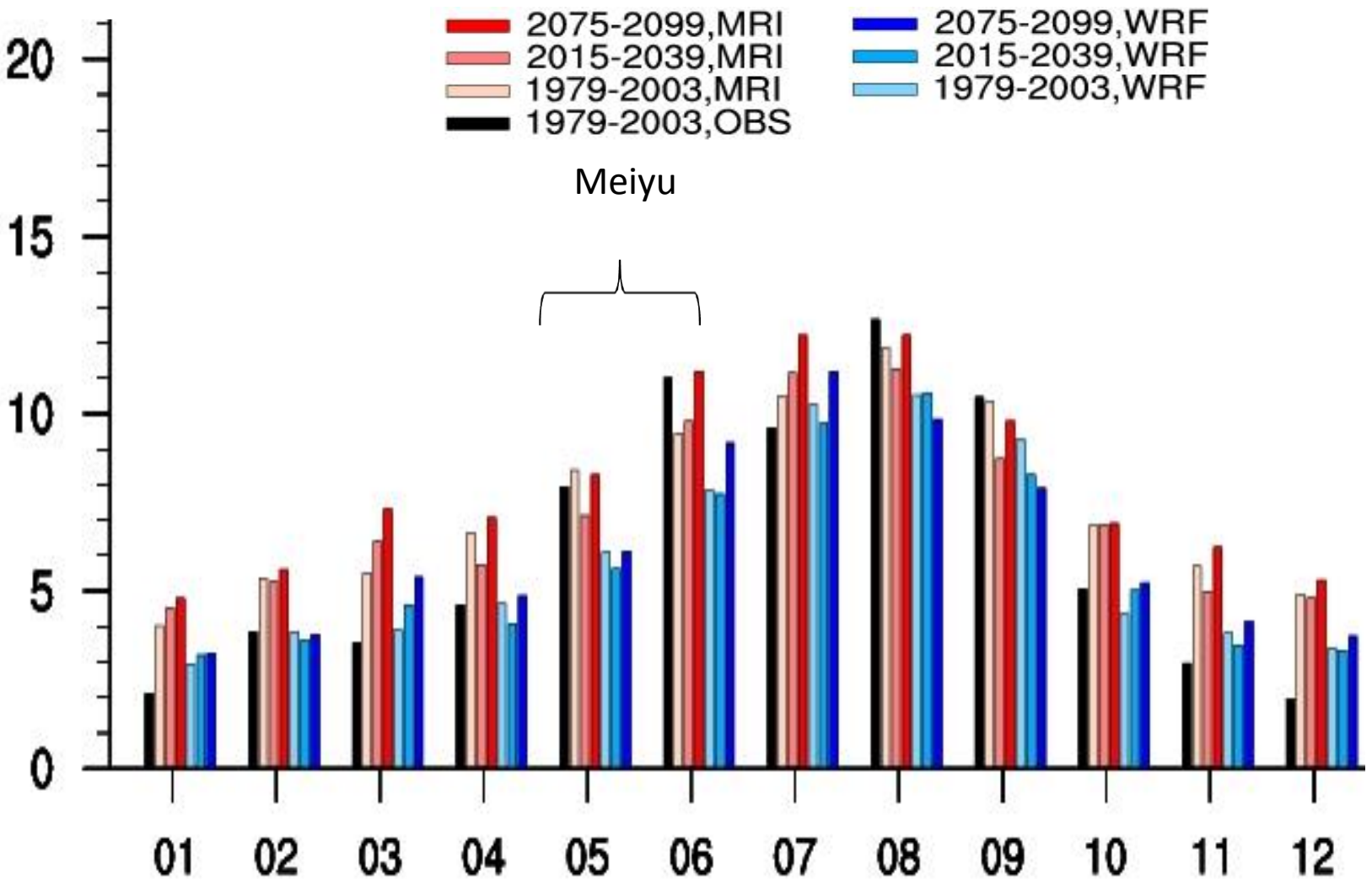




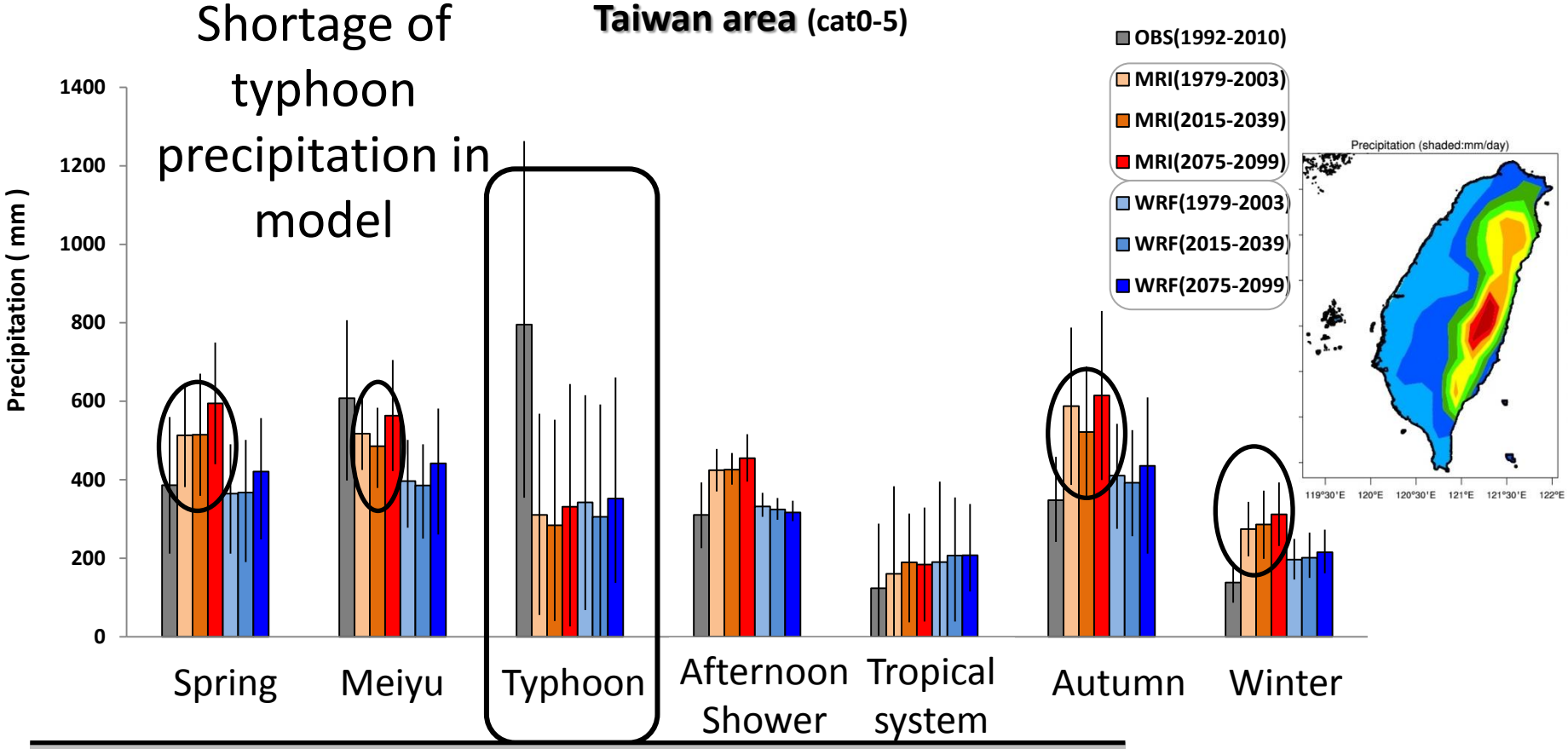
Daily Precipitatin > 50mm --- Present



Monthly mean precipitation (mm/day)



Shortage of typhoon precipitation in model



Mean Precipitation (mm/year)	MRI	WRF	OBS
Present	2728.6	2173.6	2709.6
Near future	2642.9	2125.2	
End of century	2953.6	2288.6	

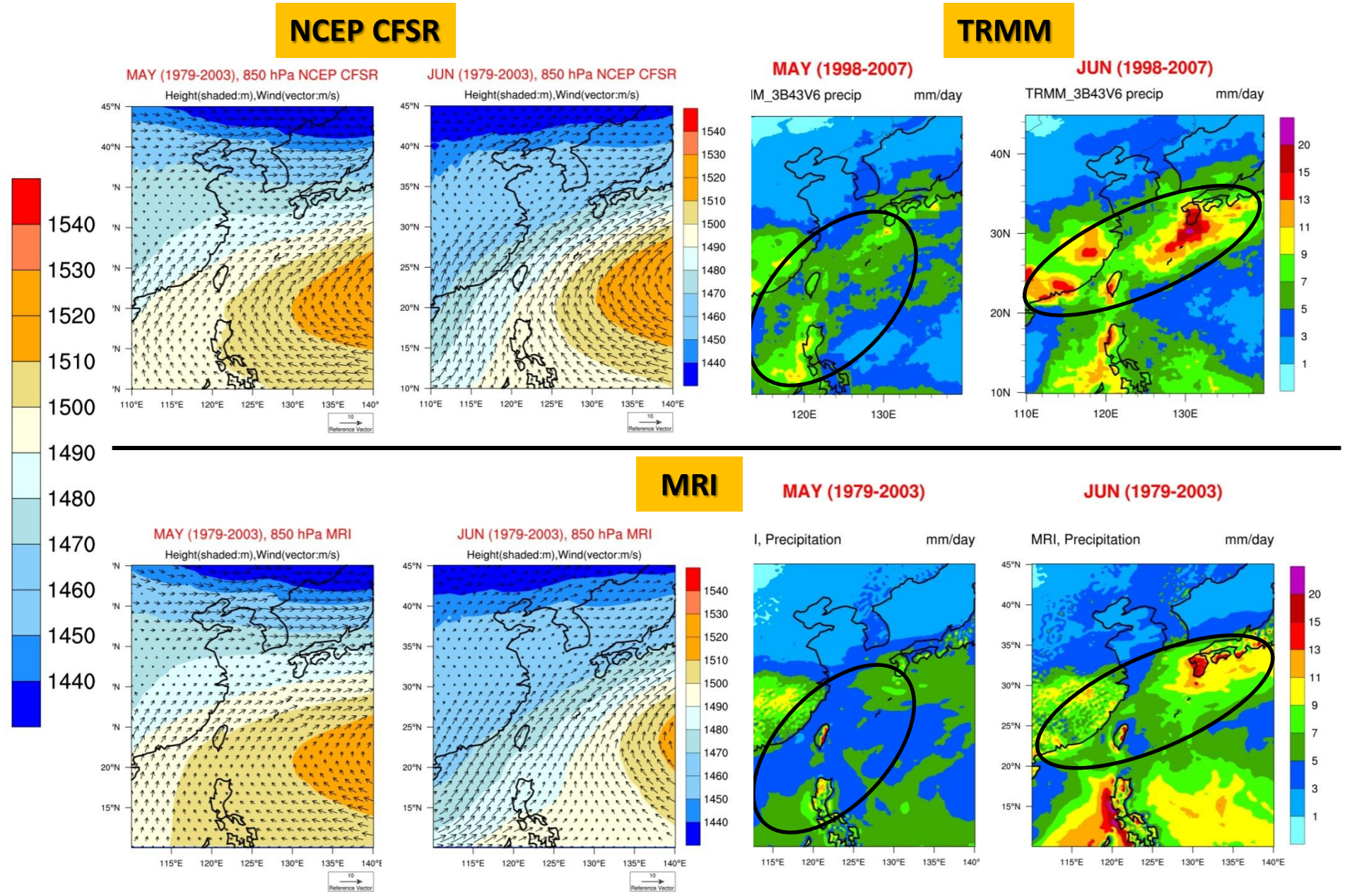
Not much time is influenced by typhoons in simulation

Total hours of Tropical Cyclone's life span during 1979-2003 Percentage in brackets : the ratio of the life span to the life span of all TCs				
Strength		Category 0 and above	Category 1 and above	Category 3 and above
West North Pacific	Observation	84393 (100%)	32958 (39.1%)	3441 (4.1%)
	MRI	57782 (100%)	29878 (51.8%)	14561 (25.2%)
Affecting Taiwan	Observation	16812 (100%)	6033 (35.9%)	612 (3.6%)
	MRI	2725 (100%)	1526 (56.0%)	580 (21.3%)

$$\frac{2725}{16812} \sim \frac{1}{6} \qquad \frac{1526}{6033} \sim \frac{1}{4}$$

In term of life span

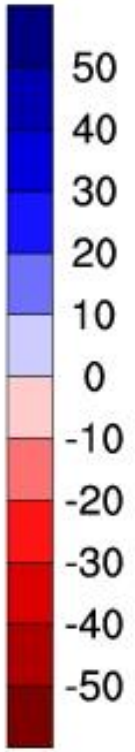
- There are too many strong tropical cyclones in simulation
- There are too few tropical cyclones affecting Taiwan in simulation



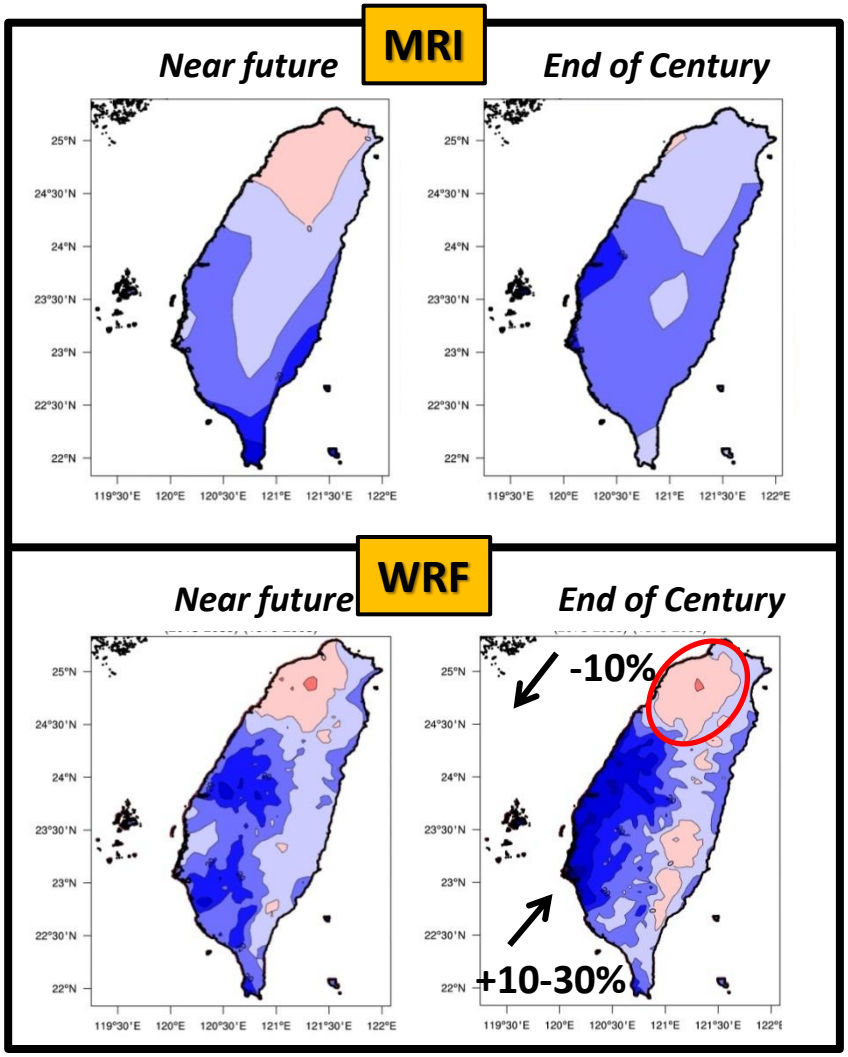
Weaker circulation, eastward-shifted circulation in June

Preci. of different types in Taiwan and the change rates in the future (Unit : mm and %)			
	Present day (mm)	Near future (%)	End of 21 century (%)
Typhoon	342.7	-10.86	2.76
Spring	364.4	0.73	15.47
Meiyu	396.9	-2.92	11.22
Summer time afternoon shower	332.1	-2.44	-4.72
Summer time others	190.4	8.73	9.06
Autumn	410.4	-4.34	6.06
Winter	196.5	2.54	9.64
Total	2173.6	-2.22	5.29

Changes in annual precipitation (%)



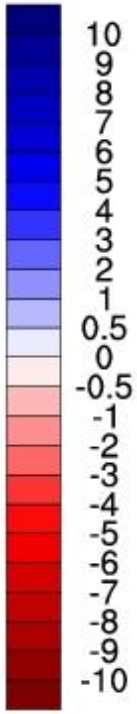
(%)

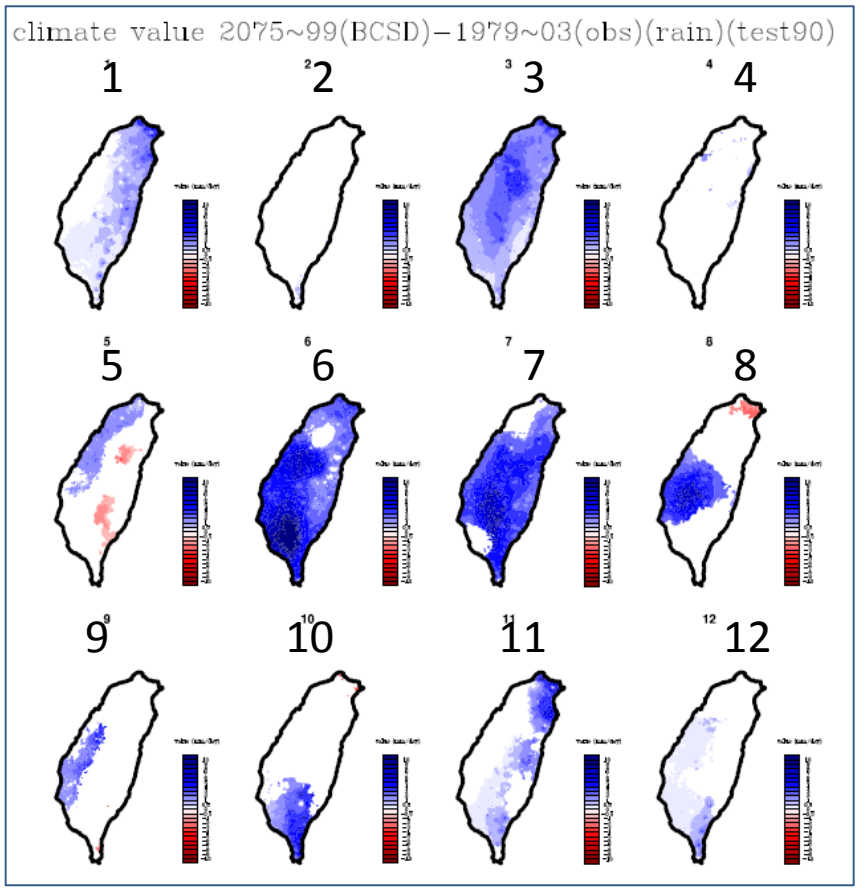


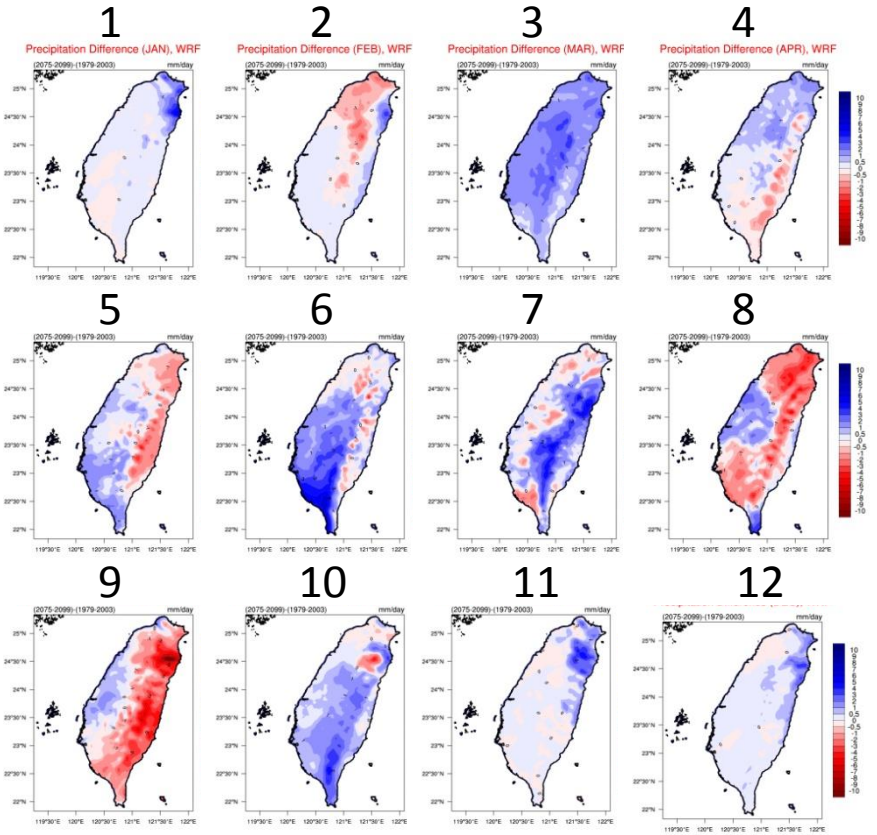
Trends in MRI & WRF are similar overall with small difference

Precipitation Change

End of Century – Present Day (mm/day)

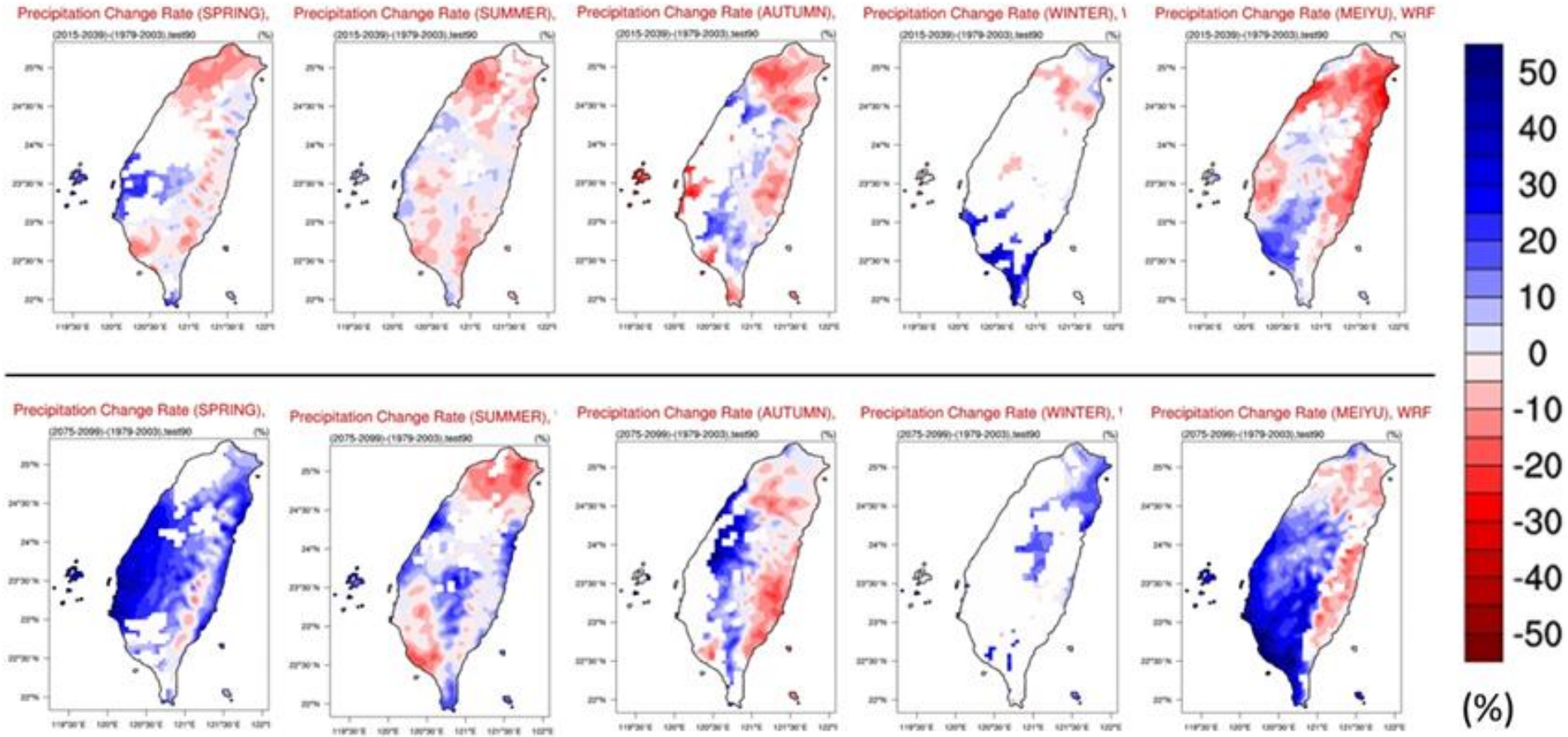


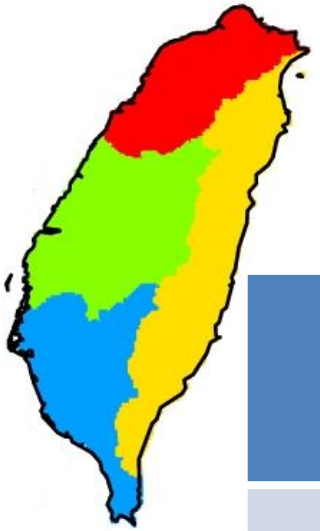




Precipitation Change Rate (%)

SPRING	SUMMER	AUTUMN	WINTER	MEIYU





Change rates of preci. in the end of 21st century & mean preci. in present day (mm/day)					
	Spring	Meiyu	Summer	Autumn	Winter
North	**10.2%** / 5.7	-1.0% / 6.3	**-6.9%** / 10.6	-0.9% / 6.4	7.4% / 5.1
Central	**18.6%** / 4.1	**13.9%** / 6.5	6.8% / 9.9	6.4% / 3.3	**10.6 %**/ 1.7
South	**14.0%** / 2.9	**31.8%** / 6.9	0.9% / 11.6	6.0% / 3.7	6.9% / 1.3
East	**9.9%** / 4.3	-1.8% / 8.3	1.9% / 10.6	**-5.3%** / 9.9	**12.0%** / 4.8
Taiwan	**13.2%** / 4.1	**9.8%** / 7.0	1.2% / 10.4	-1.0% / 5.8	**9.9%** / 3.2

Decreases : in autumn for east TW and in summer for north TW
Increase : in spring and winter

Summary

- Dynamical downscaling from 20km to 5 km are performed for 3 time-slices, 25 years each.
- Before and after downscaling Circulation does not change, larger differences in vapor and 1000 hPa.
- For precipitation in Taiwan, the spatial distribution is improved and the annual cycle is better presented. However, preci. in warm seasons is not well simulated .
- Trends of seasonal precipitation in most areas are similar in MRI and WRF.
- To the end of 21st century, annual precipitation decreases by ~10% in north Taiwan and increases by 10~30% in central and south Taiwan. However, the cause (mainly preci. of typhoon and Meiyu) of uncertainty need to be examined.

Thank you for your attention!