Preliminary Results of Dynamical Downscaling for TCCIP project Phase 2





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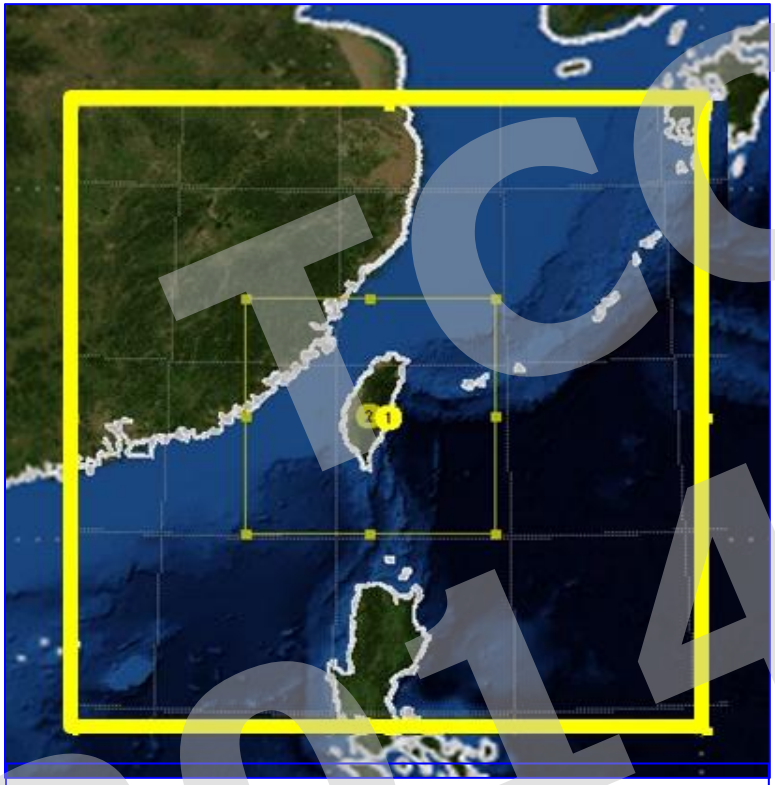
Using WRF 3.5.1 as RCM



Thick yellow box indicates the domain of RCM. Resolution is 5 km. There are 380 × 400 grid points, covering an area of ~20° × 20°.

WRF 3.5.1 as RCM

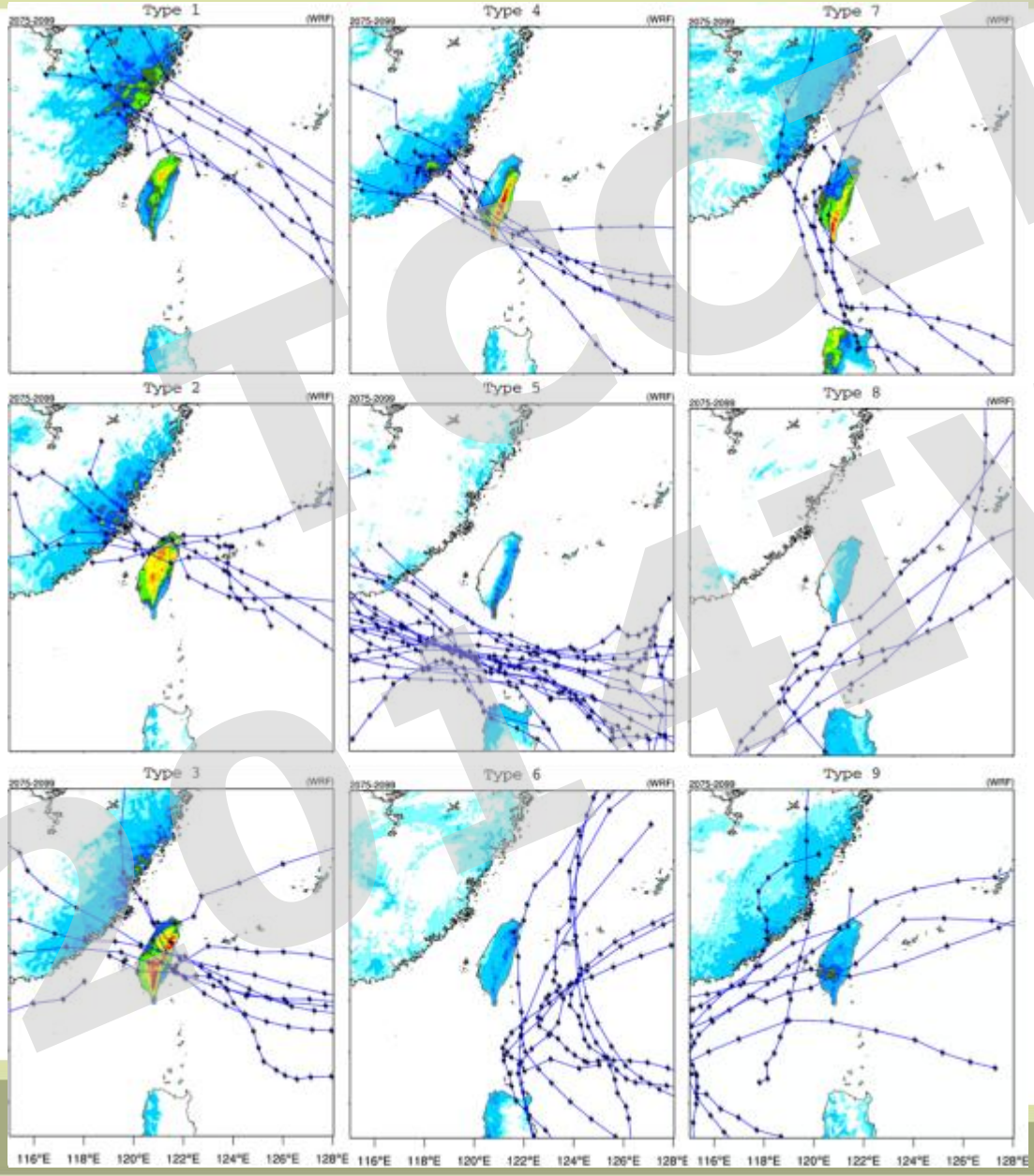
- 5 km downscaling for climate projections of super high resolution AGCM: MRI-AGCM3.2S, HiRAM, and CAM5.
- 2 time slices, 1979-2003 and 2075-2099, will be simulated.

Physical Option

- Noah land surface
- YSU Boundary Layer
- Monin-Obukhov surface layer
- CAM3 radiation
- WSM5 microphysics
- No cumulus

- Spectral nudging is applied to U, V, Φ and T, but not to PBL.
- Use RCP8.5 GHG in radiatoin scheme.
- Taiwan land use replace MODIS/USGS data.

Advantage of using super high resolution AGCM data

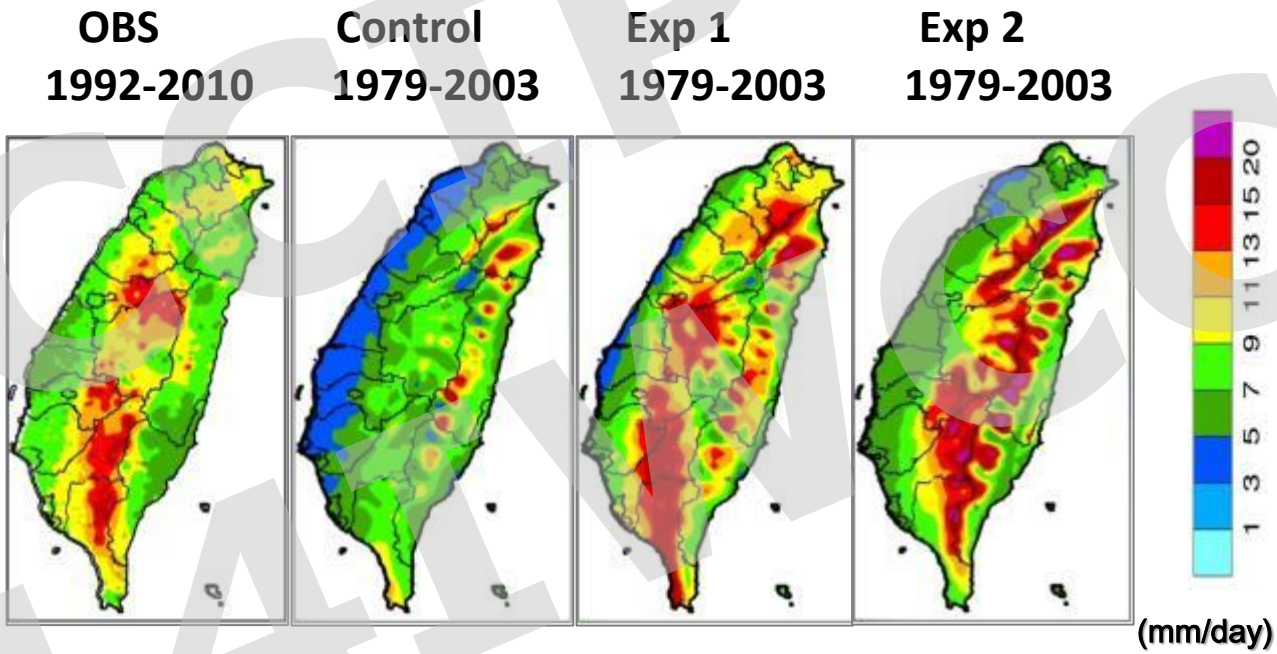


Typhoons can be explicitly simulated by super high resolution AGCM.

Extreme precipitation events associated with Meiyu fronts are expected to be simulated.

Why turn off cumulus parameterization? Meiyu Rainfall simulation


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



- Exp 2 (no cumulus parameterization) gives the best result.
- Correct location is a big improvement.
- Intensity bias may be fixed via post process (bias correction).

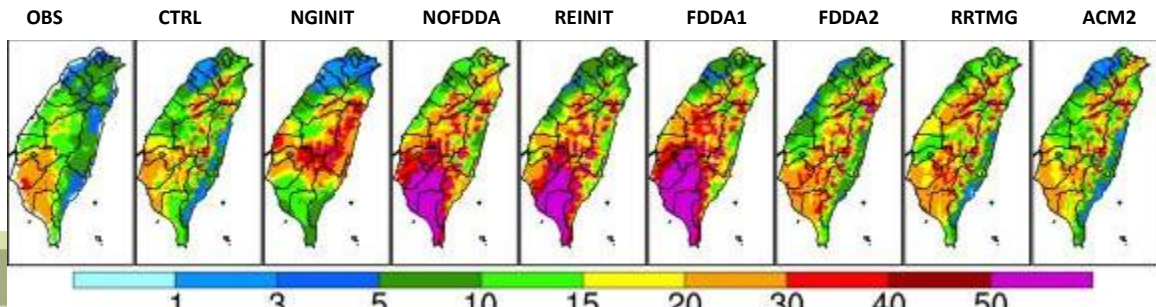

Test RCM performance

RCM setting test

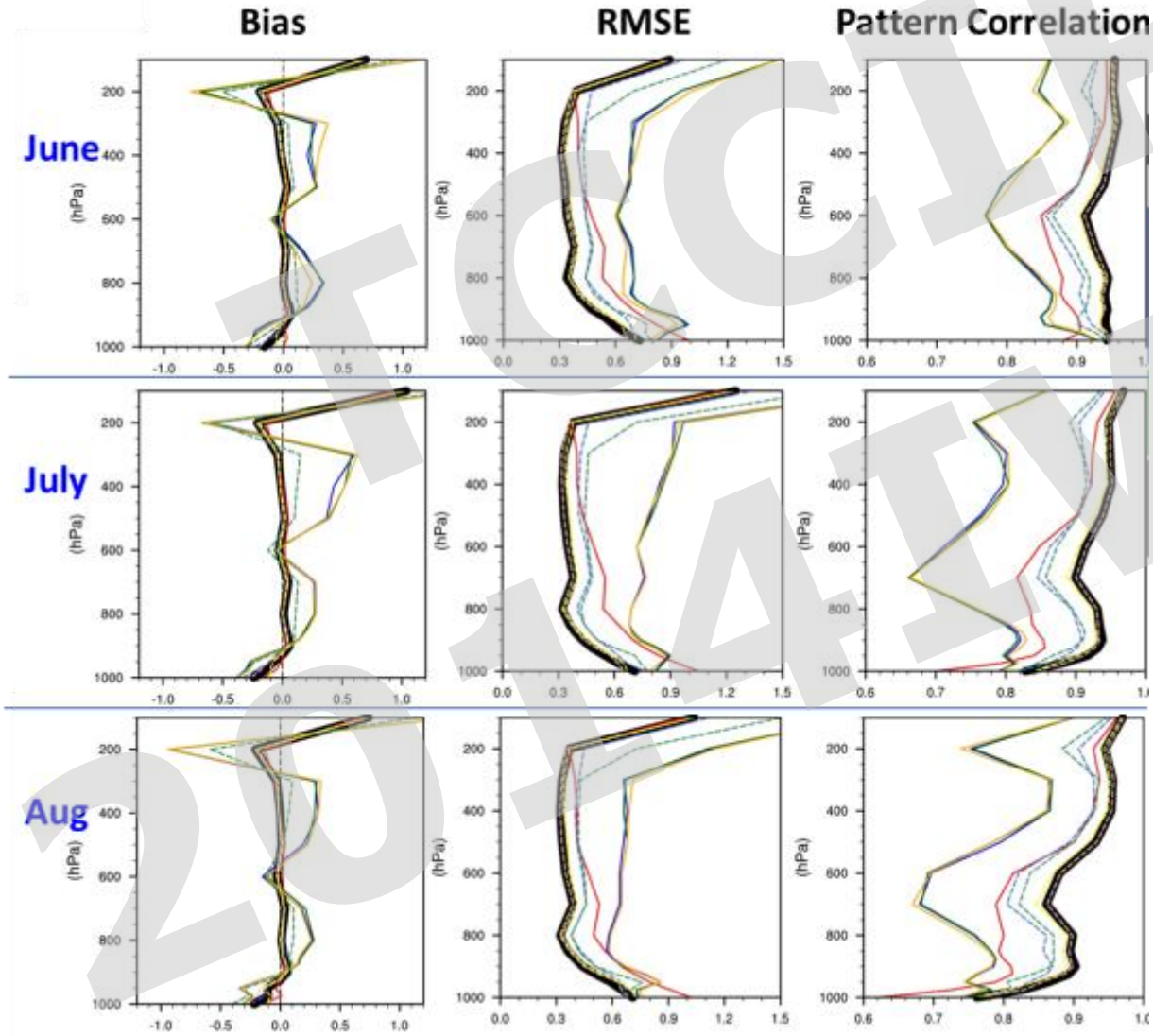

Exp. ID	Test type	Model Setting
CTRL		Control run, warm start + wave #4 spectral nudging + CAM3 radiation + YSU PBL + no cumulus + WSM5 microphysics.
NG_INIT	No Nudging all the time	Strong nudging for the 1st hour at beginning, then no nudging.
NOFDDA		No nudging is applied.
REINIT		No nudging, reinitialize (cold start) at beginning of every month.
FDDA01	Less Nudging	Apply wave # 2 spectral nudging.
FDDA02		Apply smaller nudging coefficient (x 0.1).
RRTMG	Other Physics	Use RRTMG radiation scheme.
ACM2		Use ACM2 PBL scheme.

Before large amount calculation for dynamical downscaling, 1999 NCEP-CFSR data is used to test RCM performance.

Overall, control run doing best.

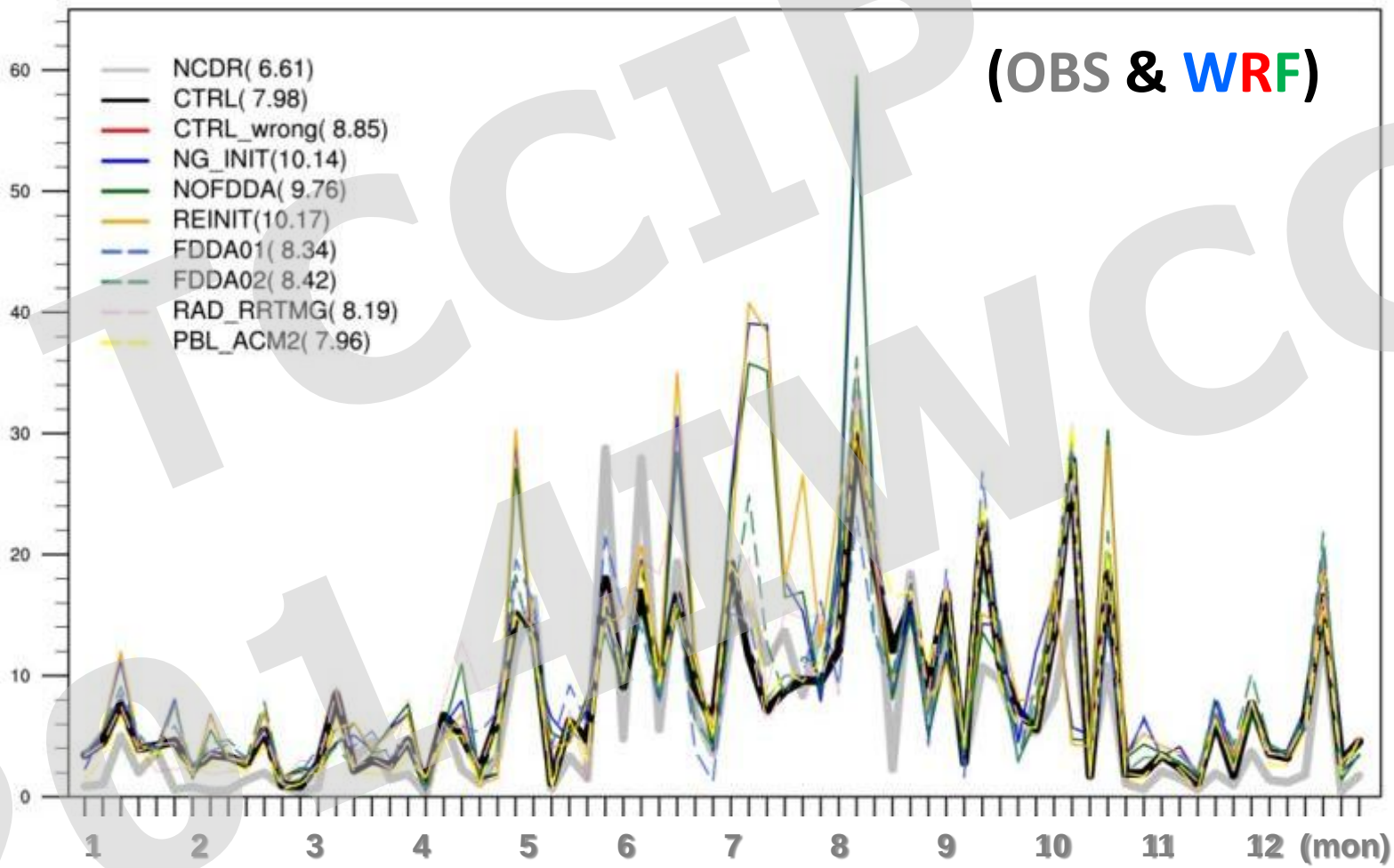



Temperature Profiles of JJA



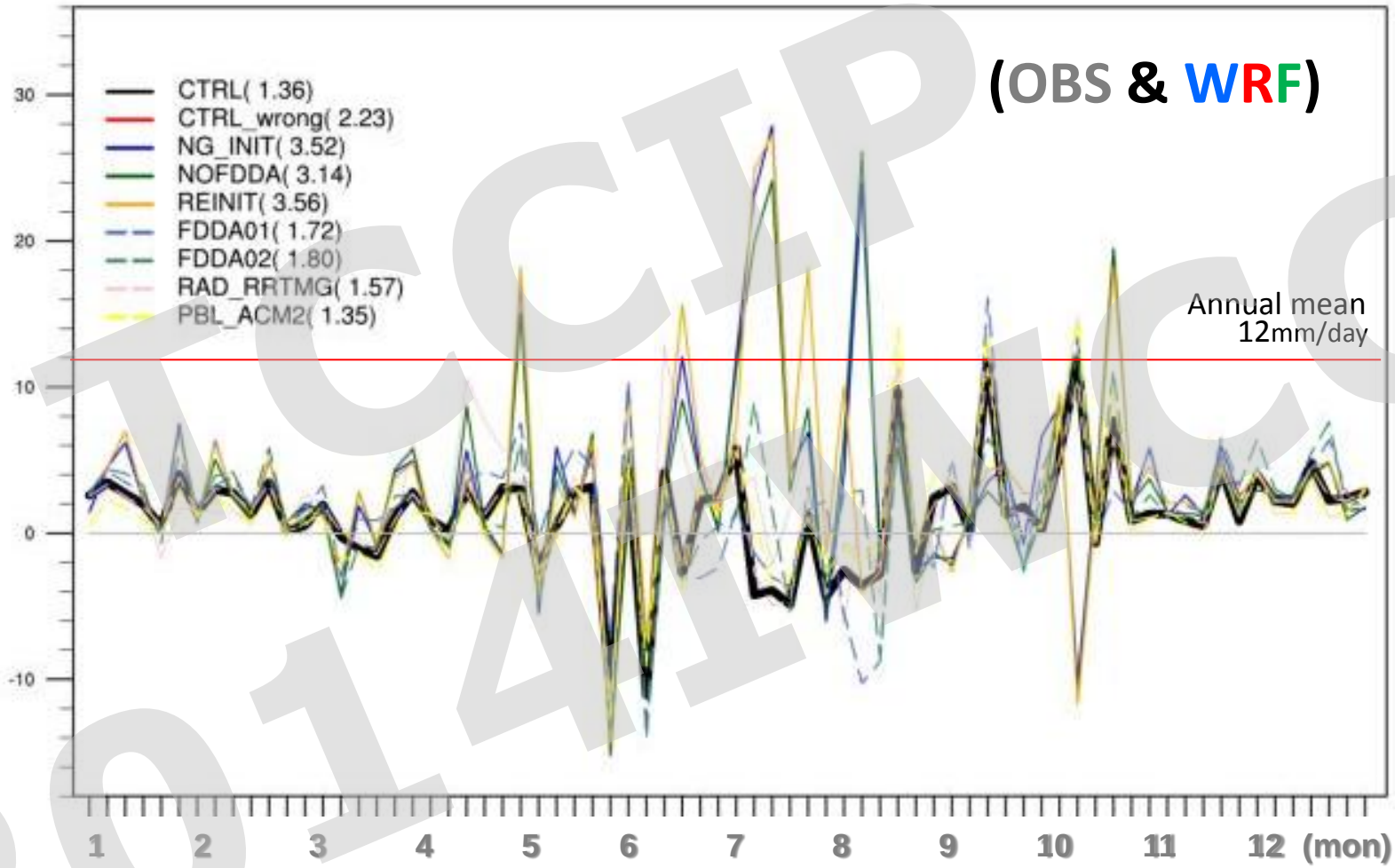
- Winter time is better than summer time.
- Results also can be classified to 3 groups, with no, less, and normal nudging.
- Large biases in experiments with no nudging.

Time series of area-averaged precipitation over Taiwan



Make sure individual rain events are simulate with comparable amount.

Time series of area-averaged precipitation bias



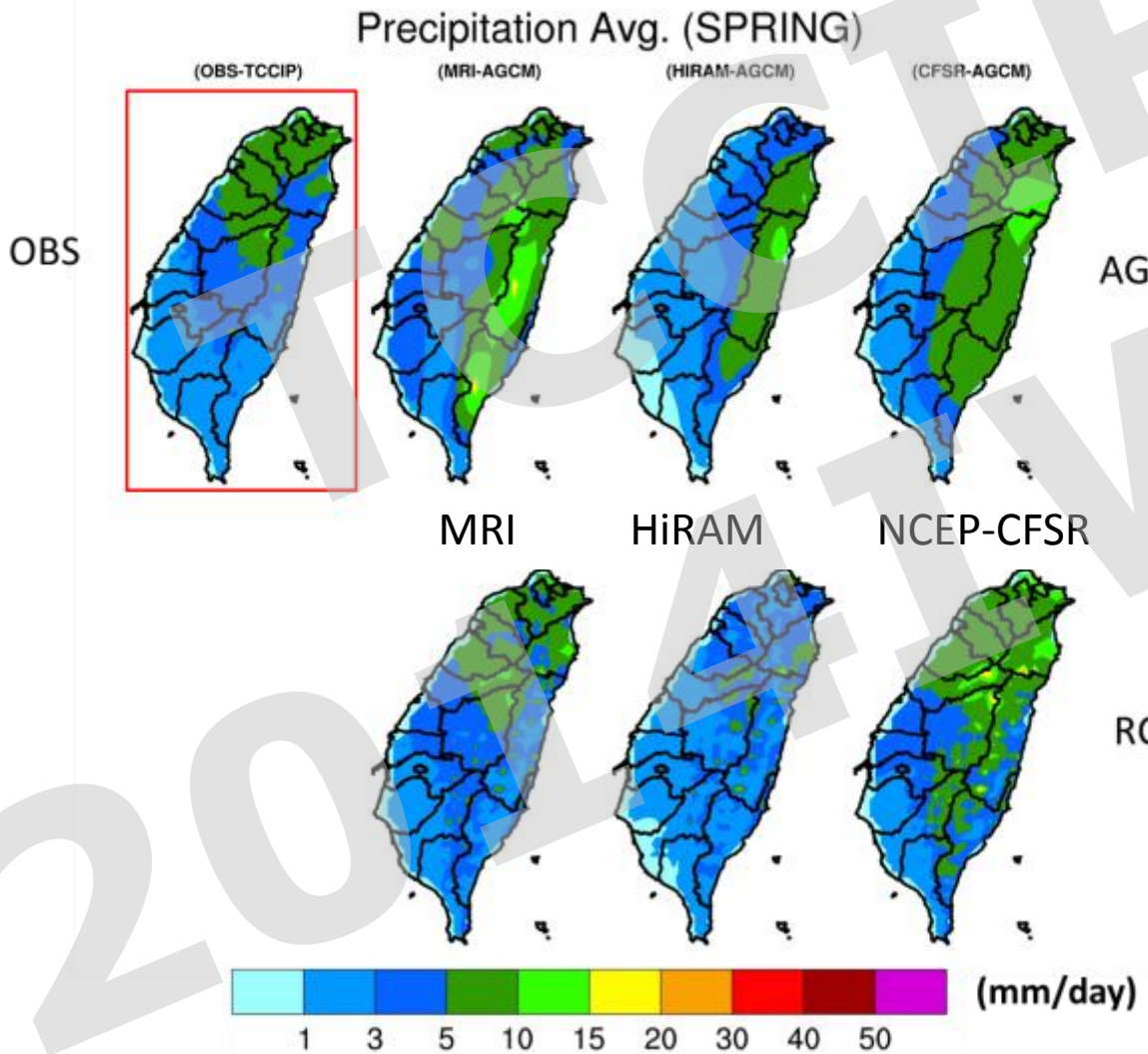
No nudging group produce too much precipitation.

Normal nudging group still does better in precipitation simulation.

Not much different when different physic options were chosen.


Preliminary results of dynamical downscaling on NCEP-CFSR, HiRAM, and MRI-AGCM (1980-1988)

Precipitation of Spring
(FMA,1980-1988, mm/day)

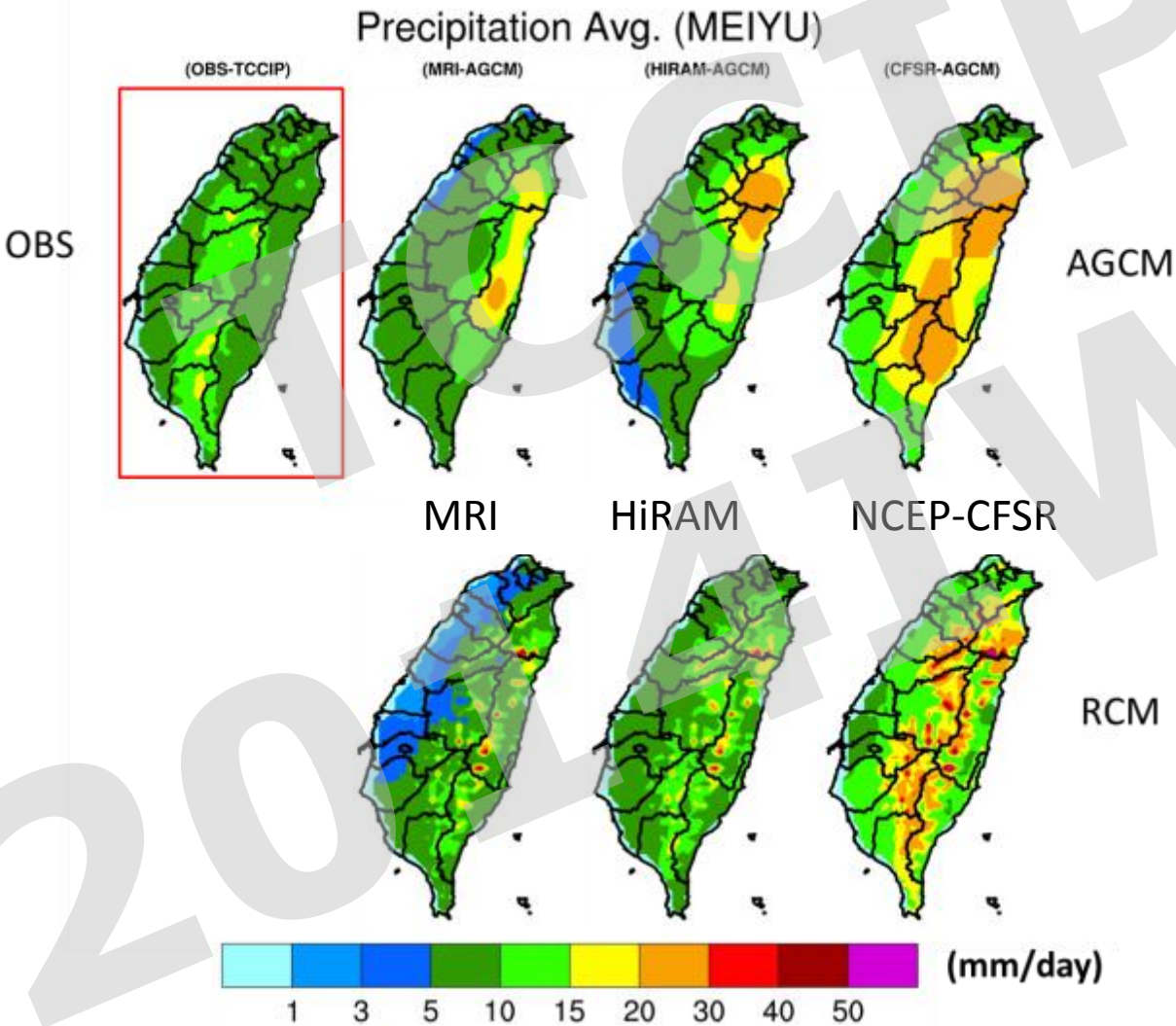



Precipitation patterns for all AGCMs are similar. Patter of biases also are similar.

All got improved after downscaling.

WRF-CFSR → too much
WRF-HiRAM → too little
WRF-MRI → OK

Precipitation of Meiyu season
(MJ,1980-1988, mm/day)

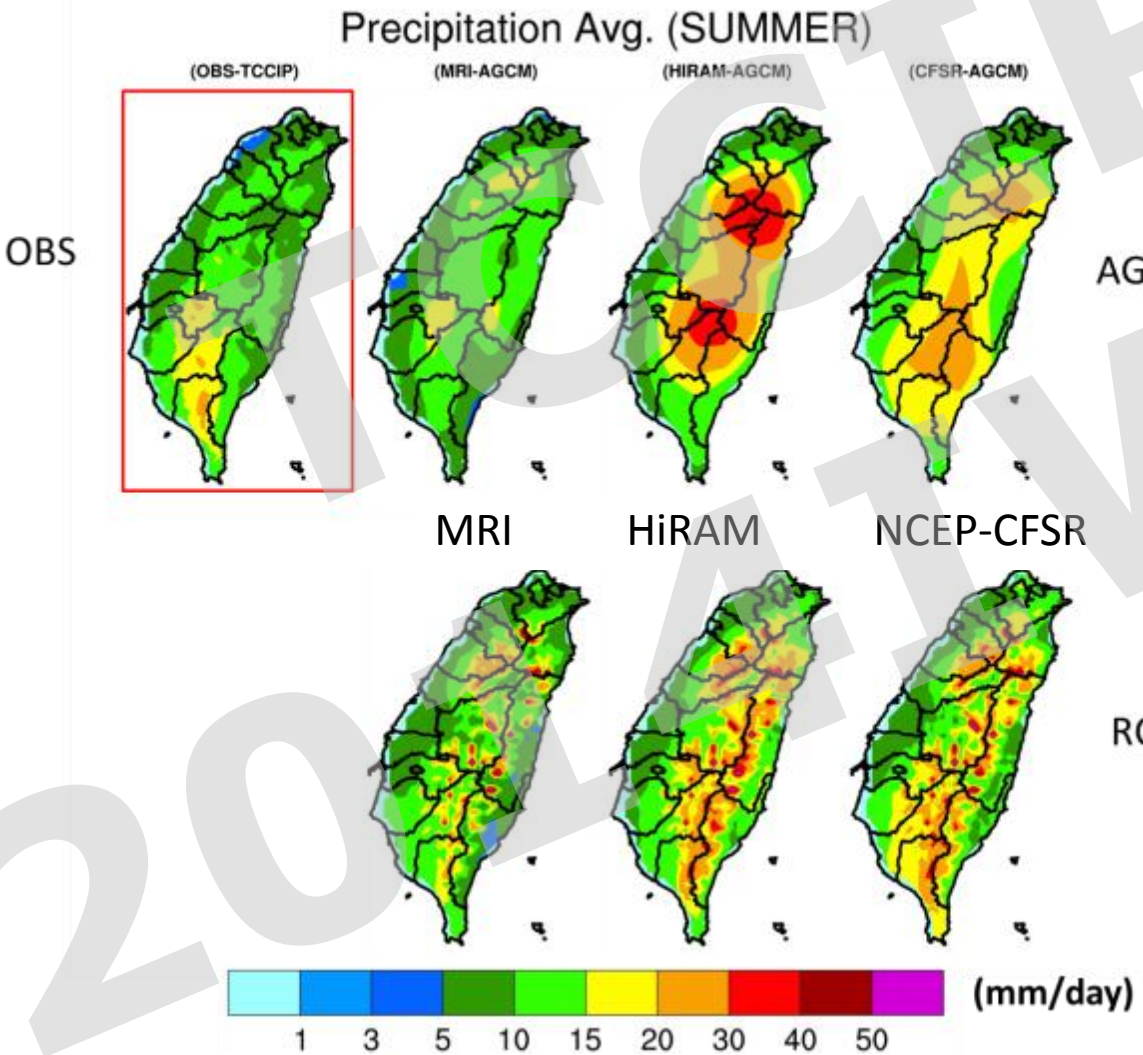



Precipitation patterns for all AGCMs are similar. Rains stay at east coast under southwesterly monsoon is not right.

All got improved after downscaling.

WRF-CFSR → too much
WRF-HiRAM → OK
WRF-MRI → too little

Precipitation of Summer
(JA, 1980-1988, mm/day)

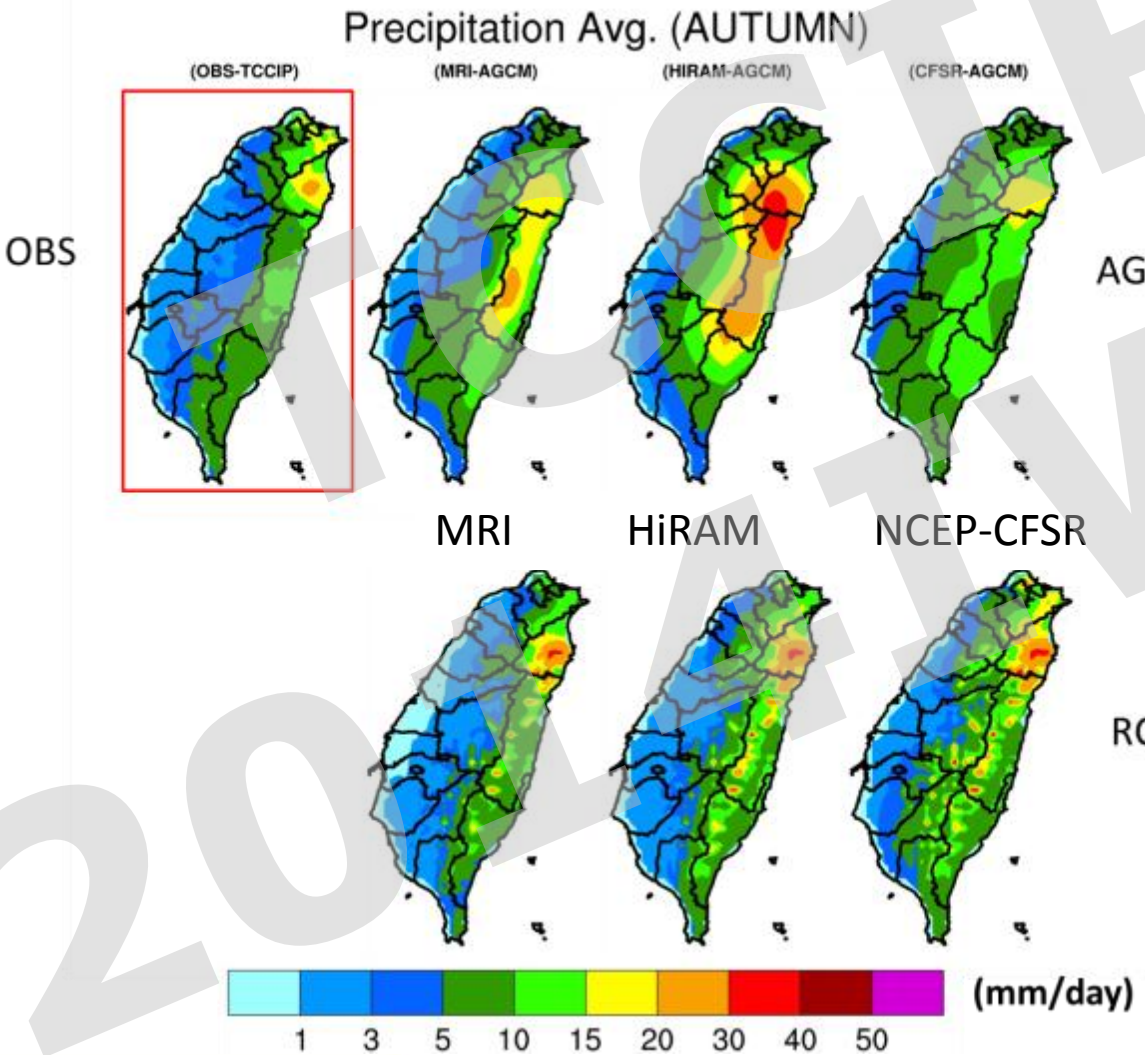



Precipitation tend to stay at top of mountains in AGCMs and RCMs.

Peak value in southwest is not represented well.

WRF-CFSR → too much
WRF-HiRAM → too much
WRF-MRI → OK

Precipitation of Autumn
(SON, 1980-1988, mm/day)

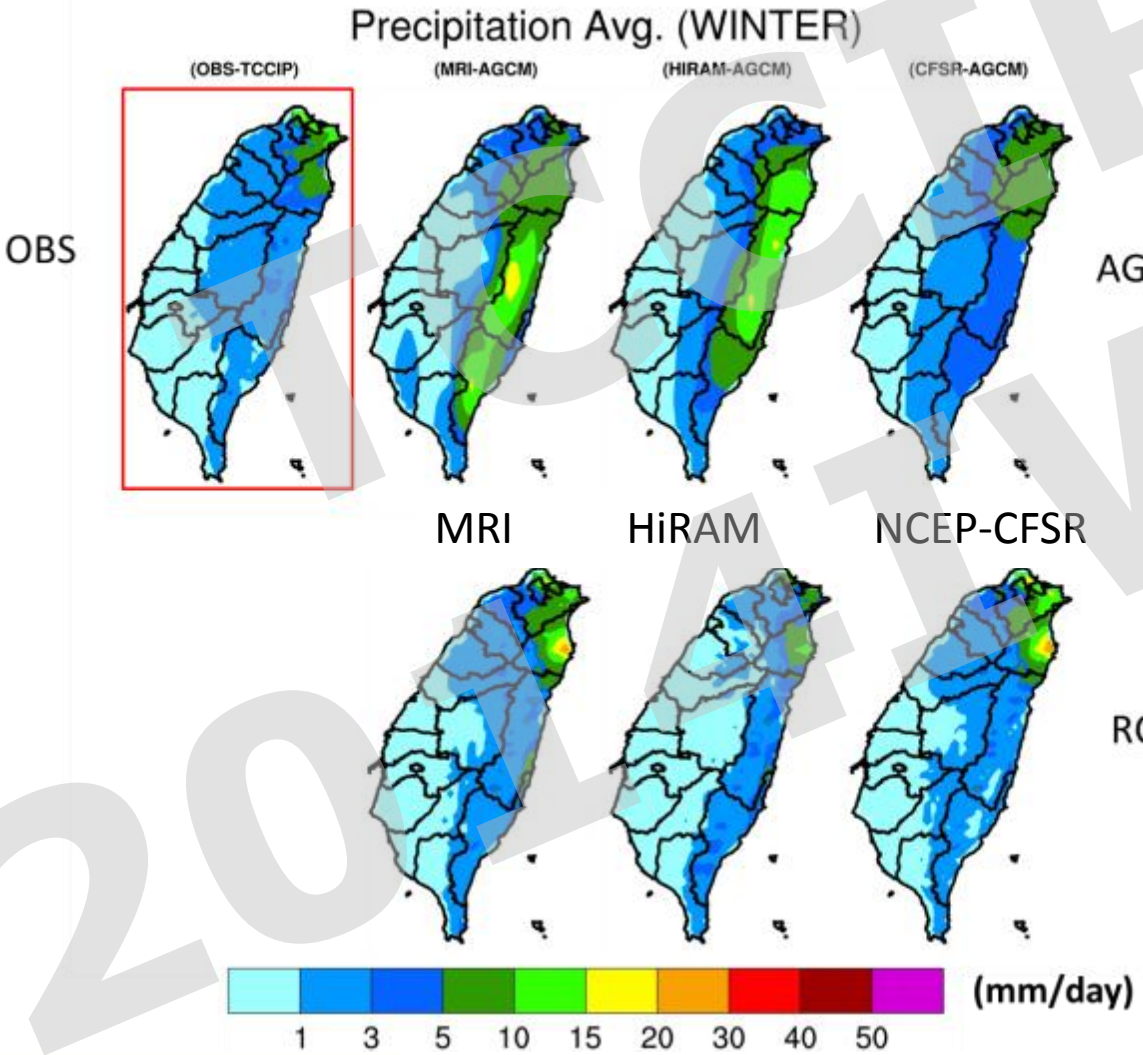


Precipitation in east Taiwan are well simulated in AGCMs and RCMs.

Peak value in southwest is not represented well.

WRF-CFSR → too much
WRF-HiRAM → too much
WRF-MRI → OK

Precipitation of Winter
(DJ, 1980-1988, mm/day)

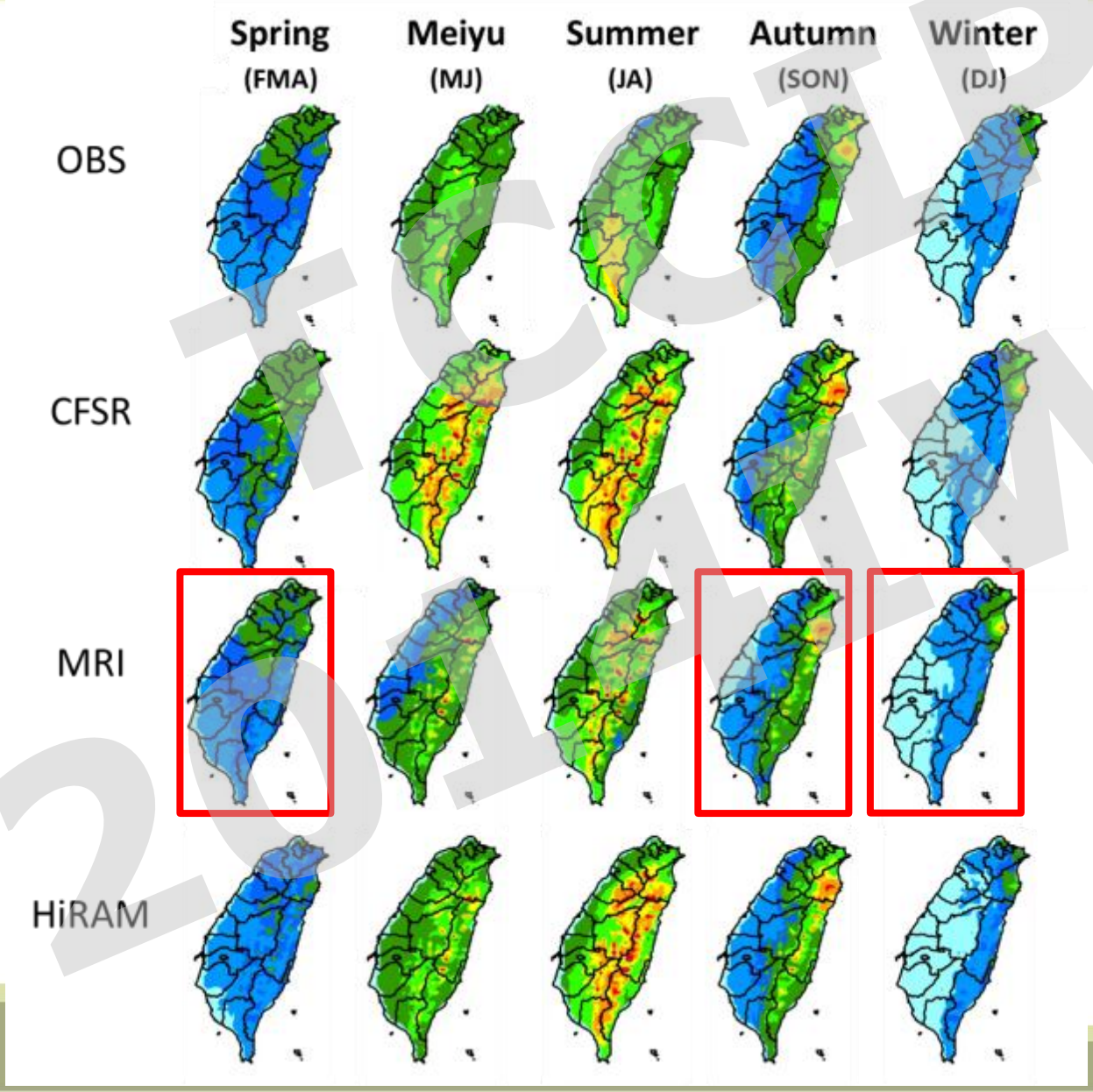



Precipitation concentrated in northeast Taiwan are well simulated by RCMs.

WRF-CFSR → too much
WRF-HiRAM → too little
WRF-MRI → OK

Seasonal Mean of Precipitation

(1980-1988, mm/day)



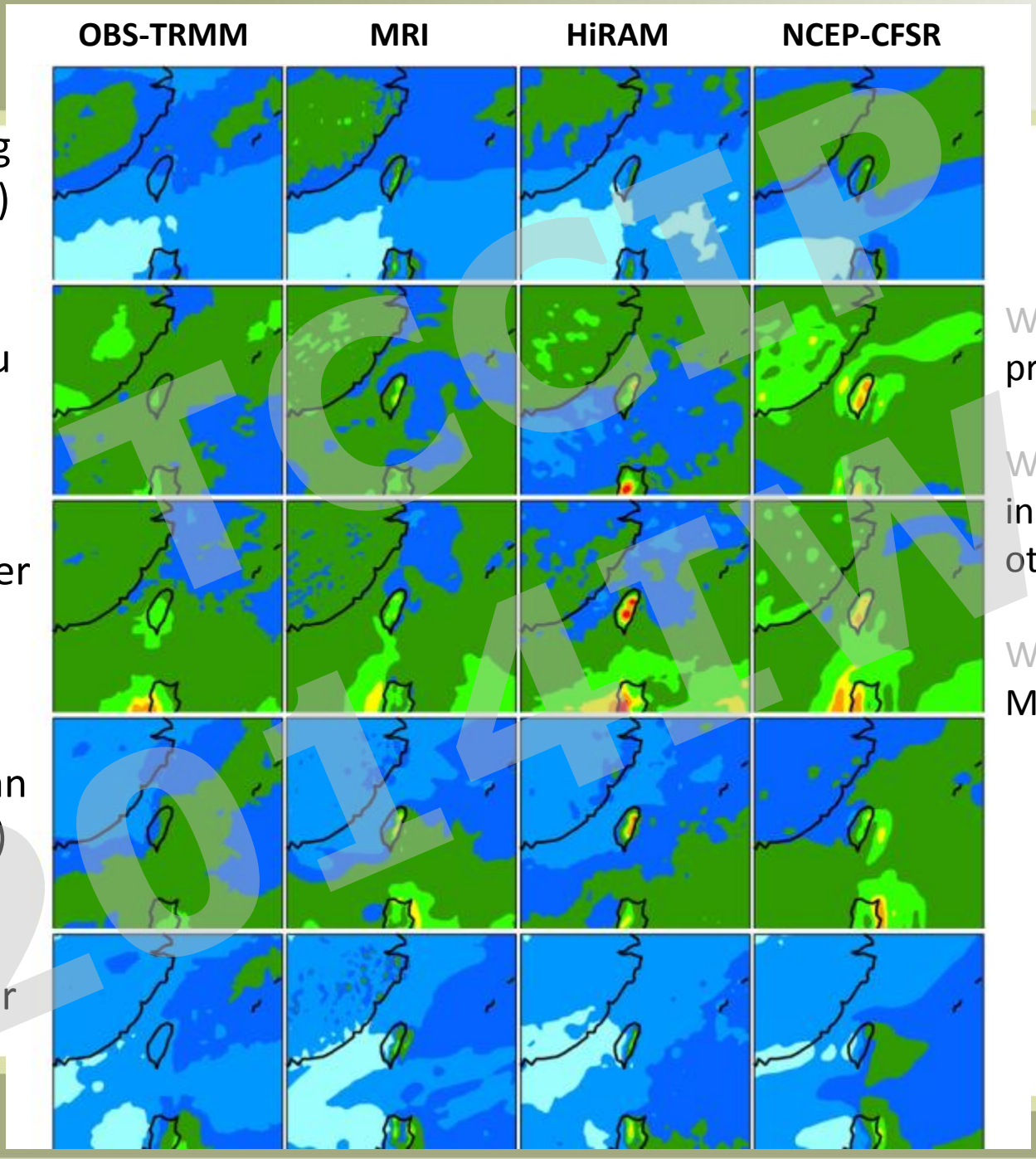
Large biases still happen in warm seasons (May to Aug).

WRF-CFSR overestimates precipitation all year round.

WRF-HiRAM overestimates in JASON, underestimates in other months.

WRF-MRI underestimates in Meiyu season.

Patterns of warm seasons are not well represented.

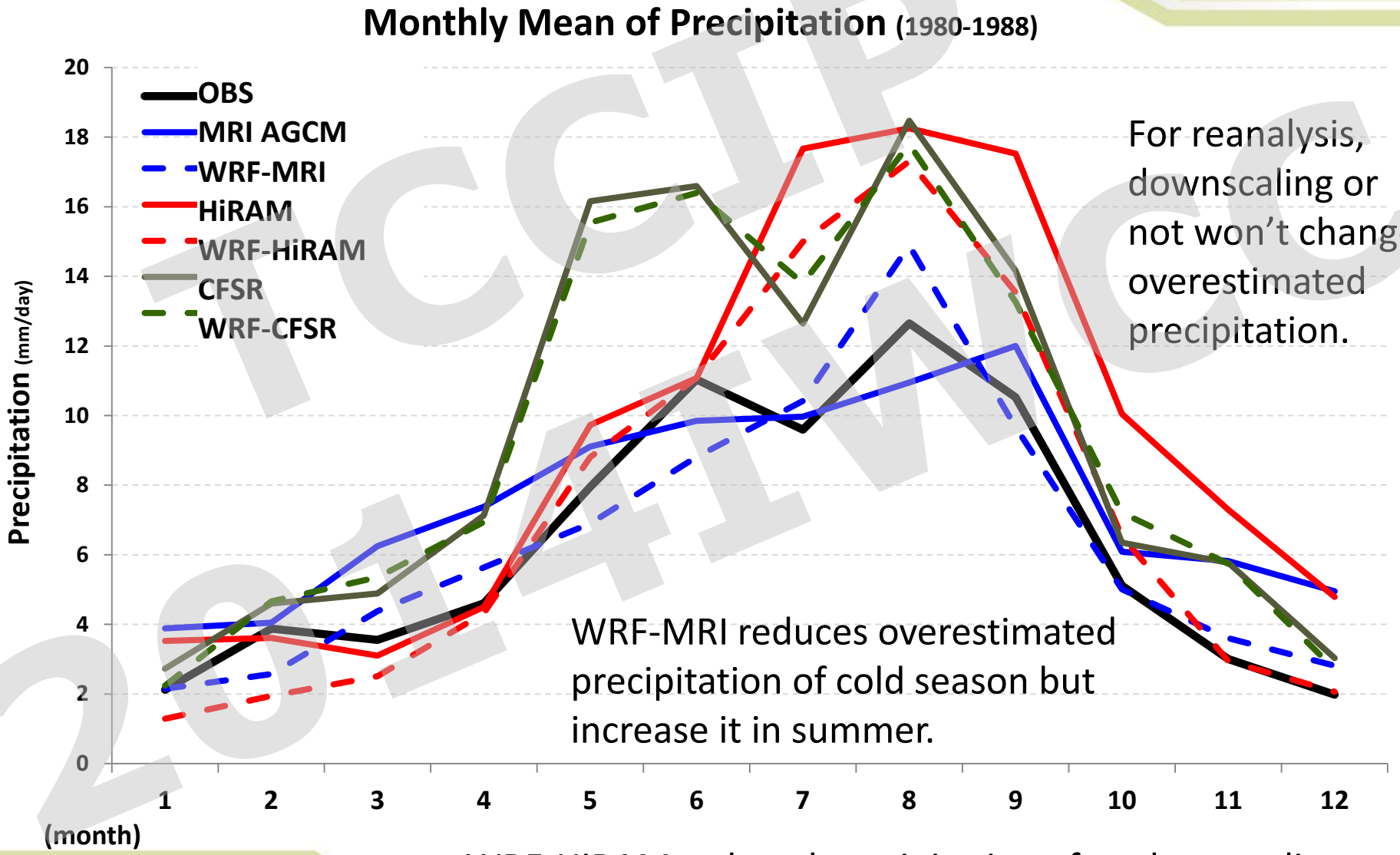


WRF-CFSR overestimates precipitation all year round.

WRF-HiRAM overestimates in JASON, underestimates in other months.

WRF-MRI underestimates in Meiyu season.

Annual cycle of precipitation over Taiwan

For reanalysis, downscaling or not won't change overestimated precipitation.

WRF-MRI reduces overestimated precipitation of cold season but increase it in summer.

WRF-HiRAM reduced precipitation after downscaling..

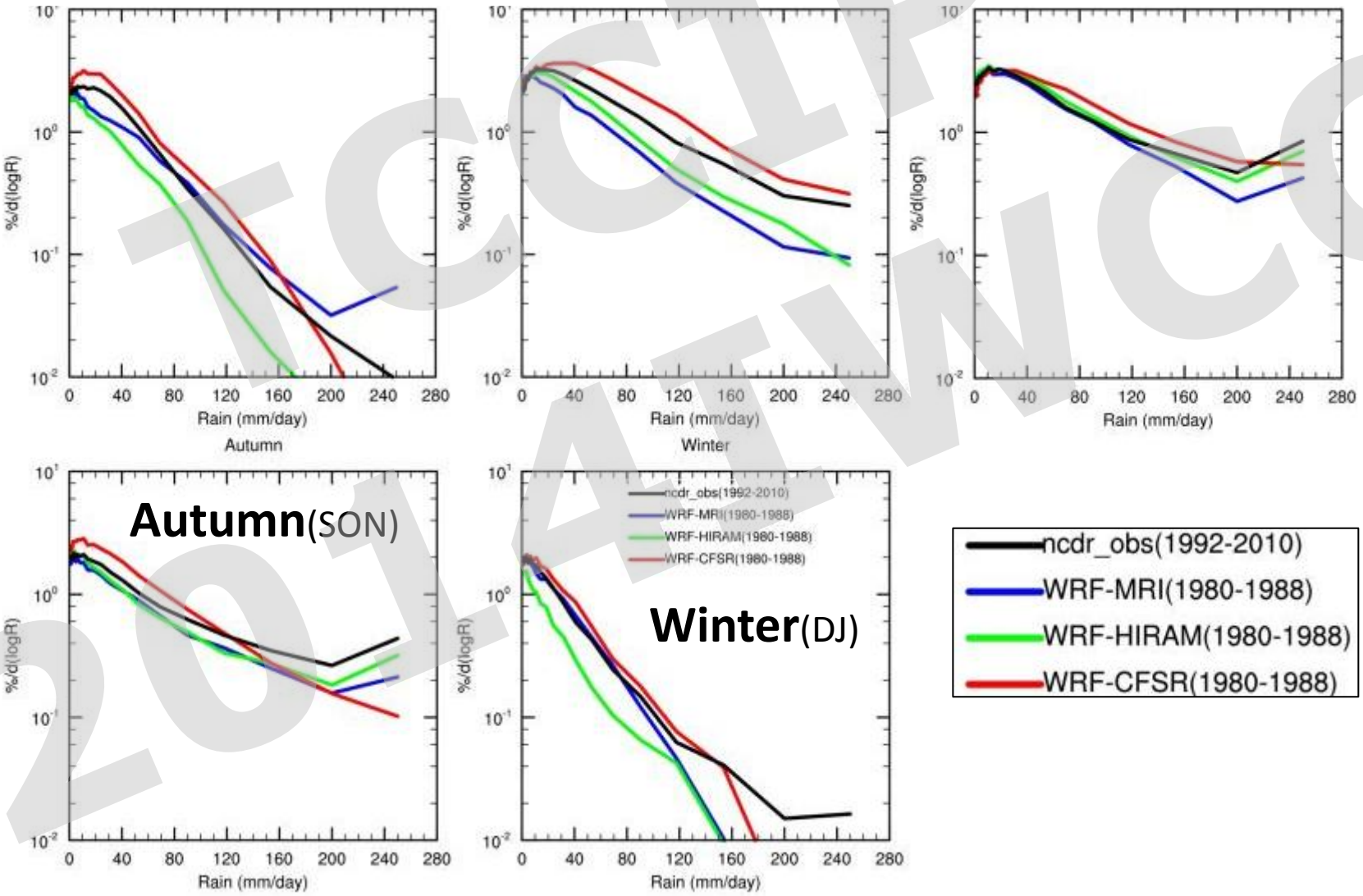
Seasonal precipitation biases of different areas

	Spring (FMA)			Meiyu (MJ)			Summer (JA)			Autumn (SON)			Winter (DJ)		
	CFSR	MRI	HIRAM	CFSR	MRI	HIRAM	CFSR	MRI	HIRAM	CFSR	MRI	HIRAM	CFSR	MRI	HIRAM
North	19.3%	-11.3%	-48.1%	49.5%	-41.6%	-6.0%	49.3%	32.7%	52.1%	20.6%	-25.4%	7.1%	21.8%	8.8%	-48.0%
Center	26.3%	0.4%	-34.0%	53.4%	-38.3%	-9.3%	33.1%	16.1%	39.1%	76.6%	-8.6%	31.9%	-11.9%	-14.2%	-50.3%
South	45.7%	20.5%	-20.6%	40.9%	-30.4%	-17.3%	19.0%	-9.2%	0.5%	39.2%	-19.0%	-8.0%	17.9%	11.3%	8.7%
East	76.6%	17.4%	-0.1%	115.9%	32.7%	44.4%	62.2%	19.0%	84.6%	34.6%	13.2%	35.1%	32.5%	45.3%	14.5%
Taiwan	38.6%	3.1%	-28.5%	64.7%	-19.3%	2.7%	38.7%	11.6%	41.0%	36.4%	-5.3%	19.4%	18.5%	18.1%	-20.0%

OBS

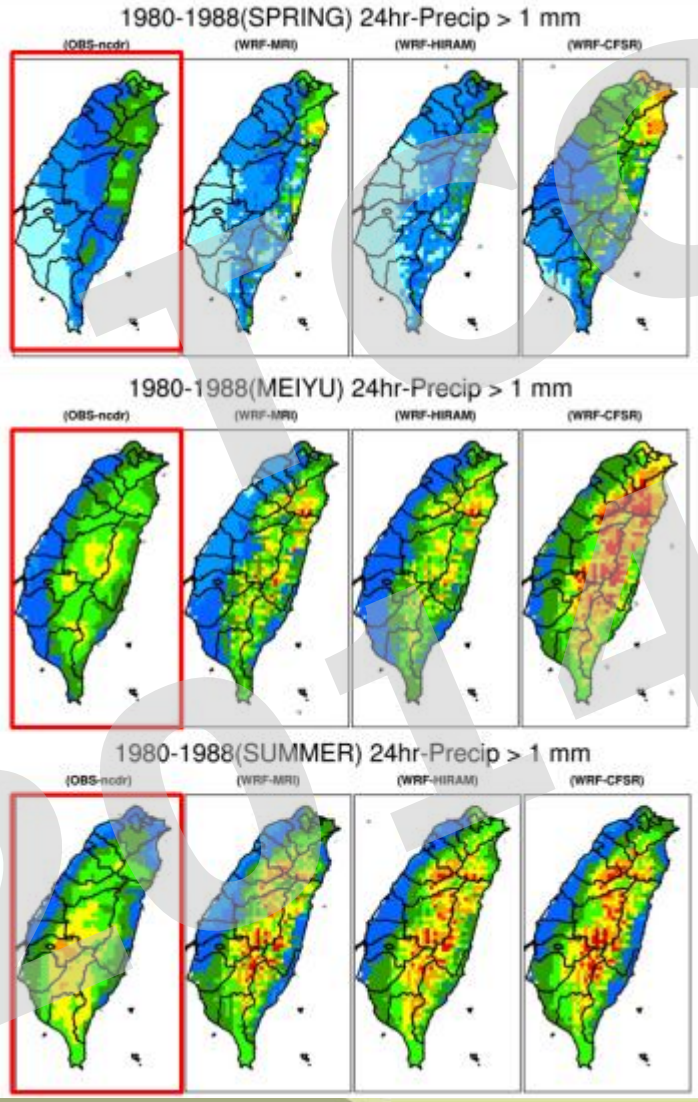
WRF-MRI outperformes others except in Meiyu season.
WRF-HiRAM is better in Meiyu season.

PDF of Daily Rainfall over Taiwan area



Seasonal Mean of Rain Days
(24hr Preci. > 1 mm)


Left to right: OBS MRI HiRAM NCEP-CFSR

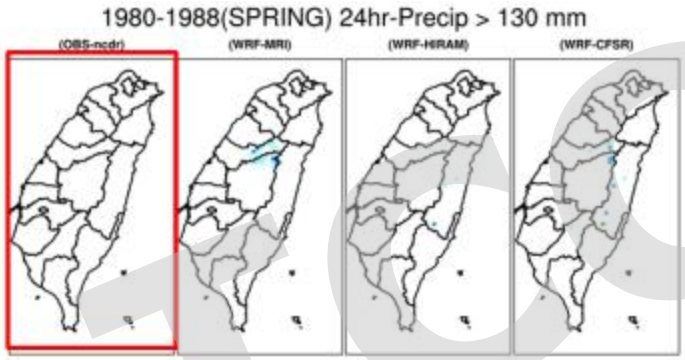


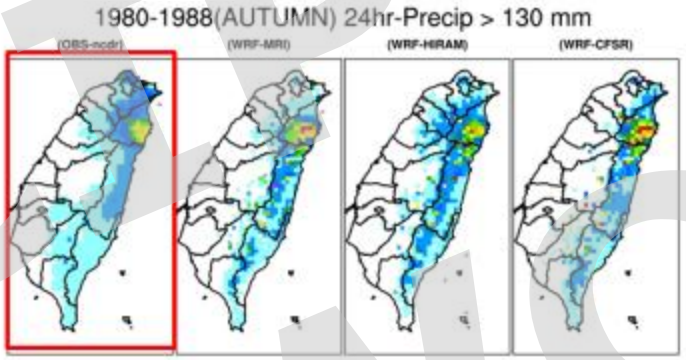
WRF-CFSR: too many all year round
WRF-HiRAM: too many in JASON
WRF-MRI: too many in JASONDJ

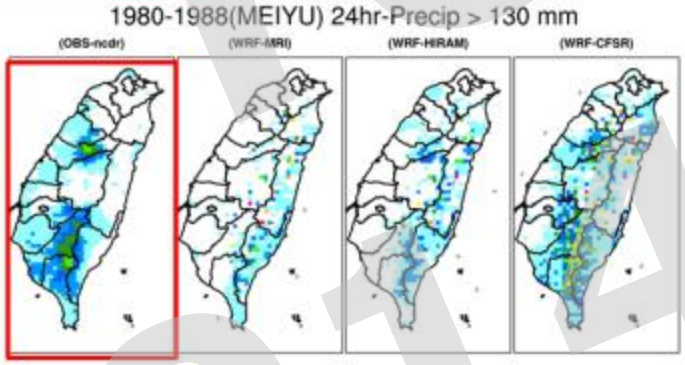
Seasonal Mean of Extreme Rain Days

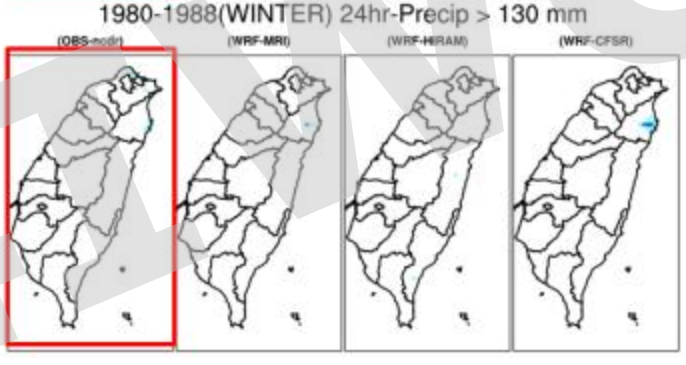
(24hr Preci. > 130 mm)

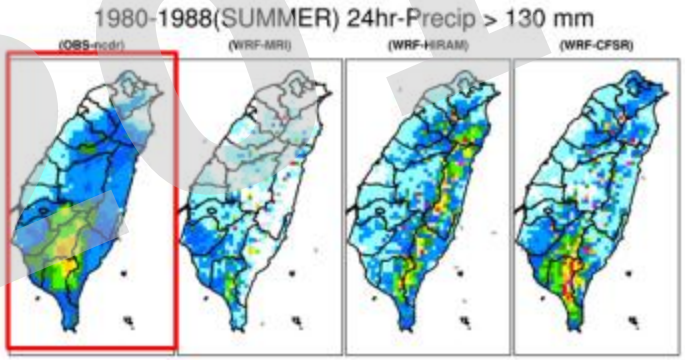
Left to right: OBS MRI HiRAM NCEP-CFSR

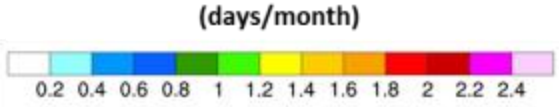












WRF-CFSR: best among all

WRF-HiRAM: OK in JASON

WRF-MRI: too few in MJJA

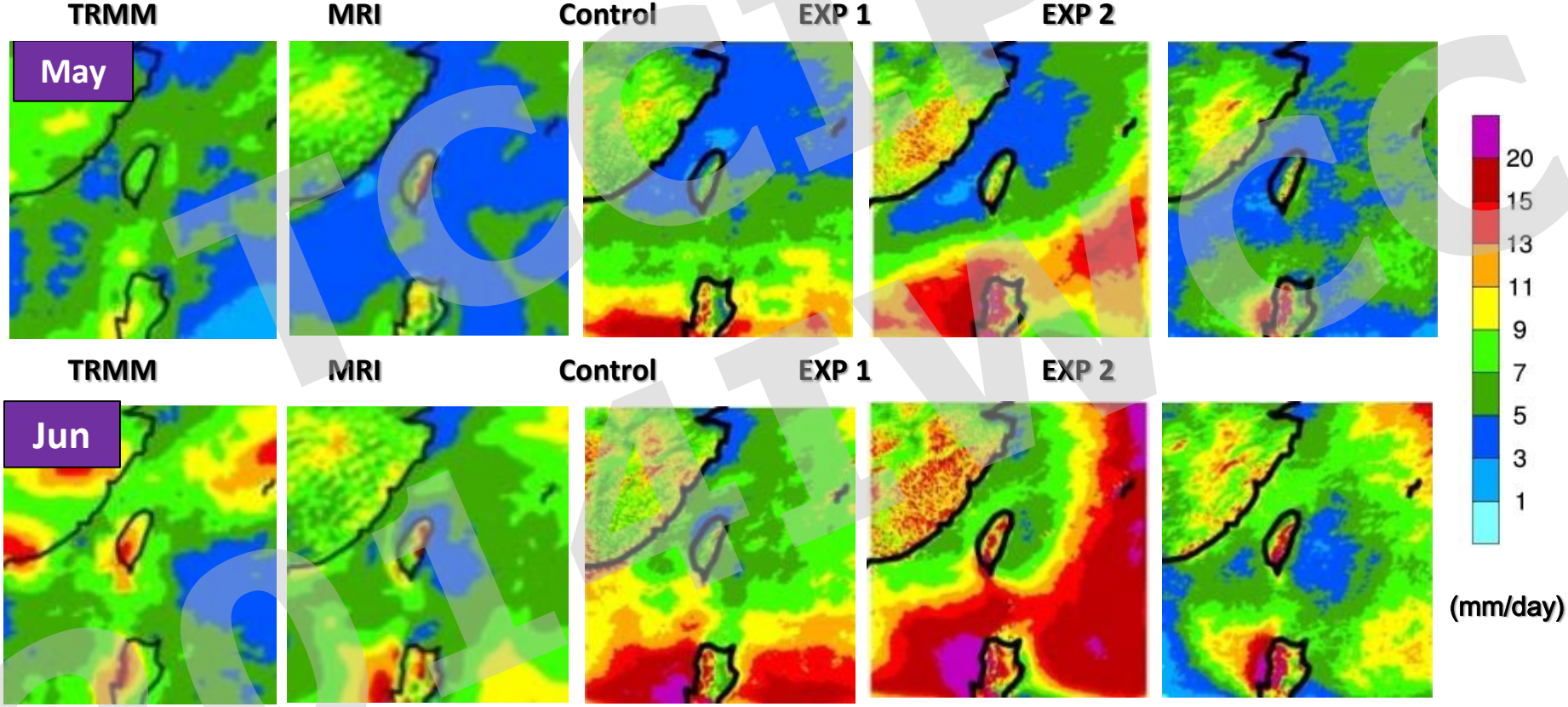
Summary


- WRF model is used as RCM to downscale data of NCEP-CFSR reanalysis, MRI AGCM and HiRAM climate simulation over Taiwan area.
- Preliminary results show significant improvement in spatial distribution of climate variables. 3 AGCMs show similar spatial biases of precipitation, all of them can be corrected.
- WRF-HiRAM and WRF-MRI downscaling both improve precipitation amount.
- Although precipitation of reanalysis data sets before and after downscaling show good annual cycle, both are overestimated too much.
- In term of precipitation amount, WRF-MRI data outperformed others except in Meiyu season. Precipitation of WRF-HiRAM data is better in Meiyu season.
- Difference between GCM is larger than that between RCM and GCM. RCM performance pretty much depends on GCM.


Thanks for your Attention

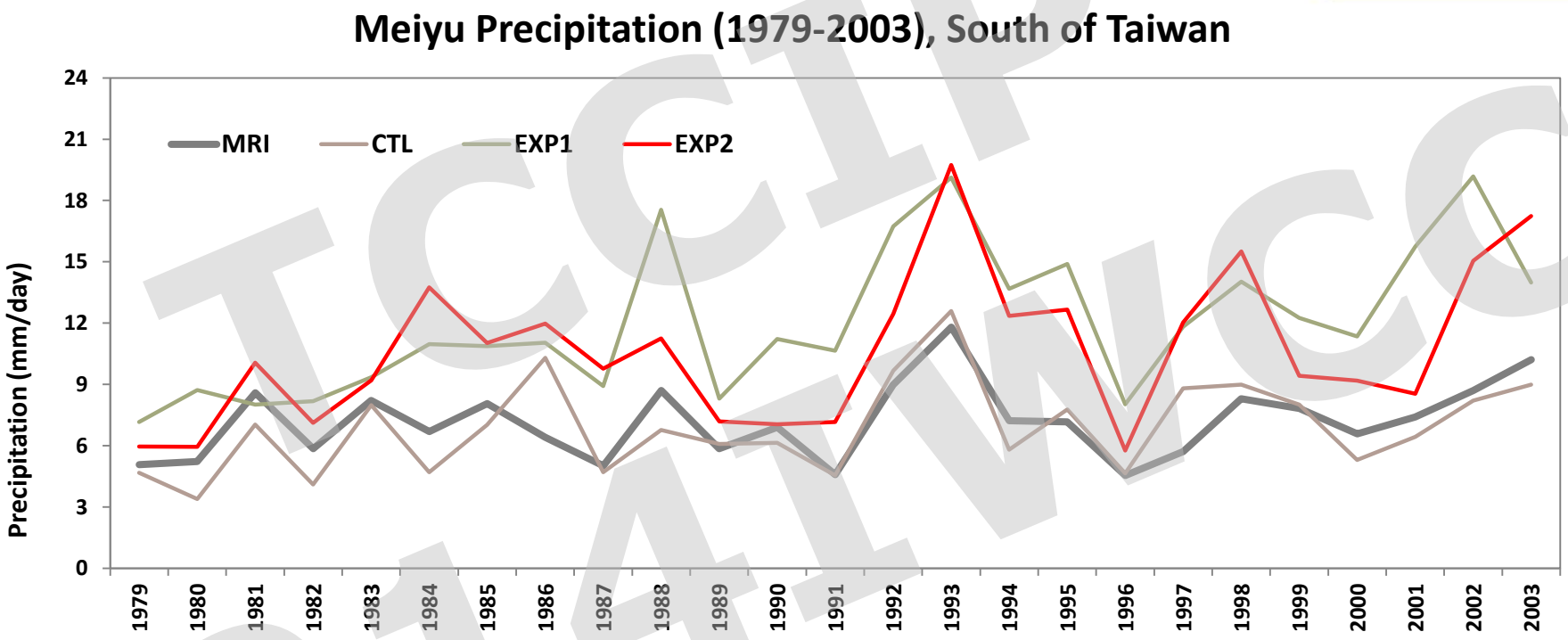
Result –Rain in model domain


Precipitation of May & June, 1979-2003



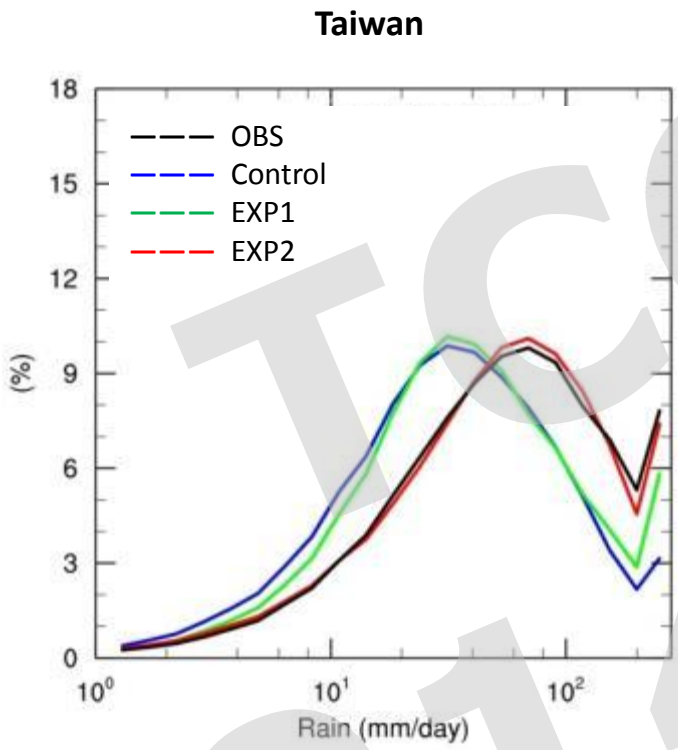
- Cumulus parameterization causes too much rain in south & east

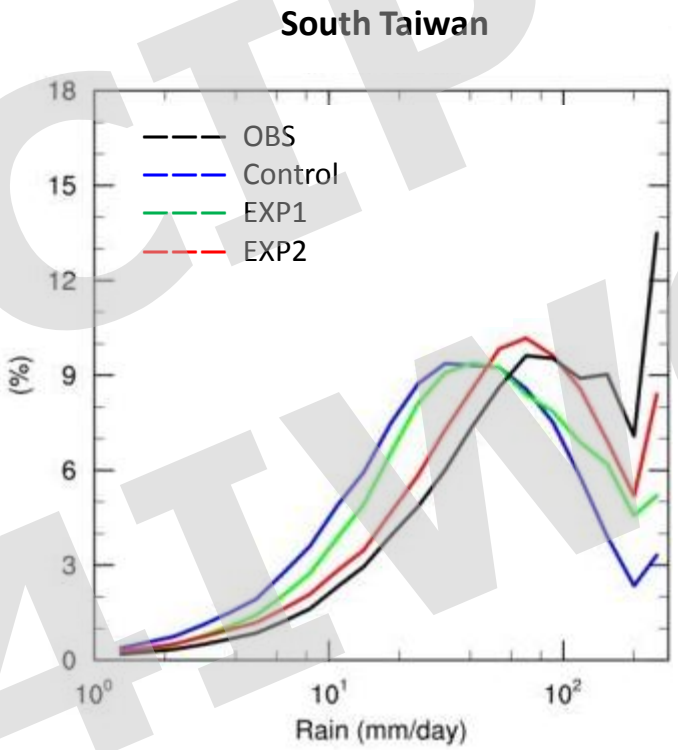
Option	Nudging	Cumulus
Ctrl	on	on
EXP 1	off	on
EXP 2	off	off

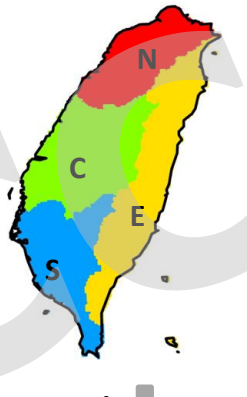



Inter-annual variation is similar but with larger amplitude (closer to observation). Still dominated by large scale circulation

PDF weighted by intensity. Rainfall % from each intensity bin.







Option	Nudg.	Cu.
Ctrl	on	on
EXP 1	off	on
EXP 2	off	off

Ctrl & EXP1 : similar, more moderate rain, 20<R<60 mm/day. Cumulus?

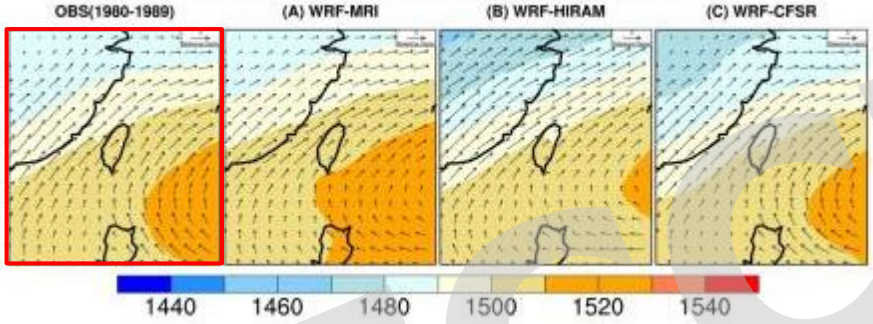
EXP2:

- More rain in 40<R<100 mm/day, closer to observation
- In south Taiwan : OBS R>200mm/day contributes most (~14%) ;
  too much for R<100 mm/day ; too few R>100 mm/day

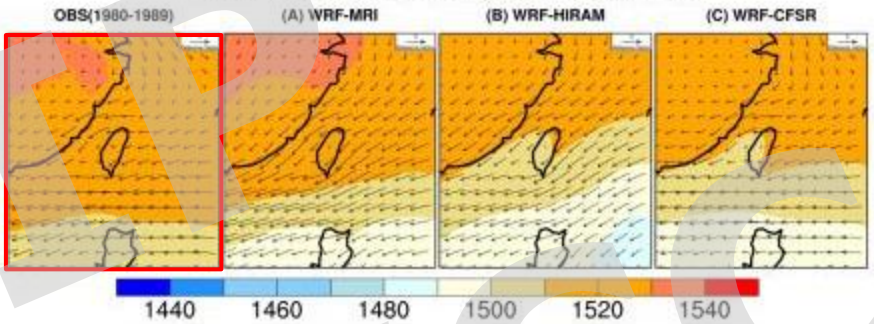
Circulation at 850hPa

OBS & RCMs

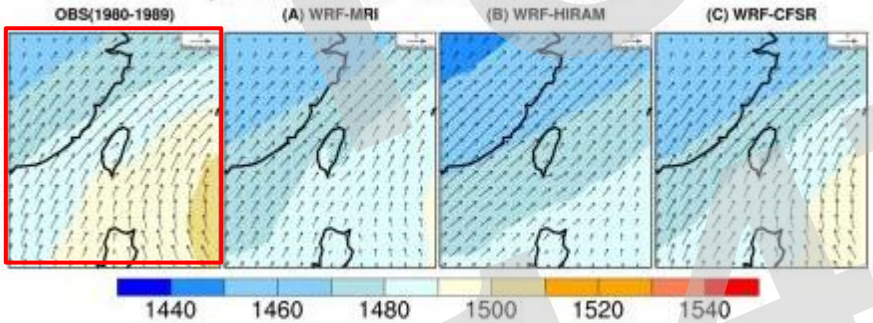
1980-1988 SPRING, ZUV 850hPa



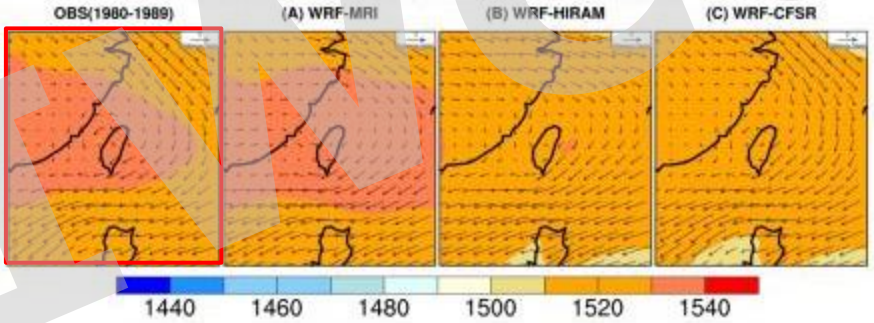
1980-1988 AUTUMN, ZUV 850hPa



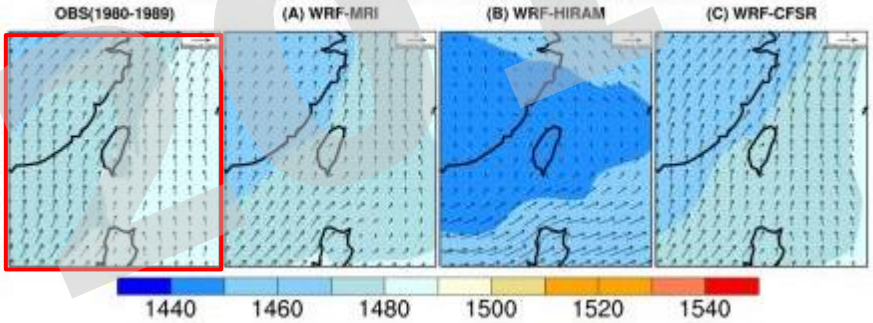
1980-1988 MEIYU, ZUV 850hPa



1980-1988 WINTER, ZUV 850hPa



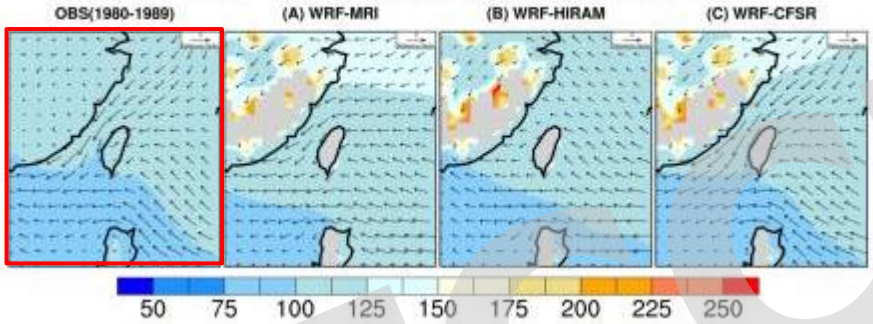
1980-1988 SUMMER, ZUV 850hPa



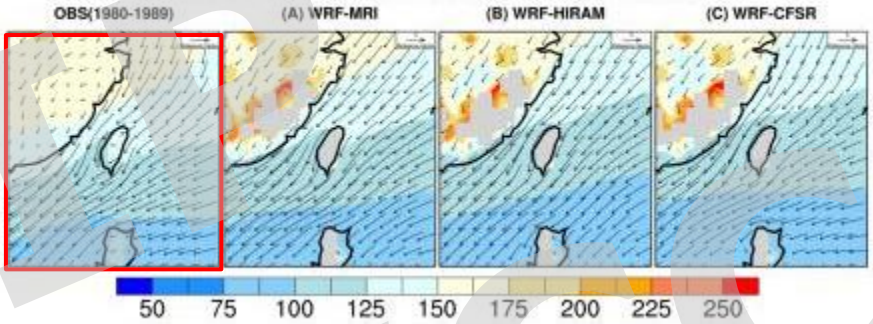
Circulation at 1000hPa

OBS & RCMs

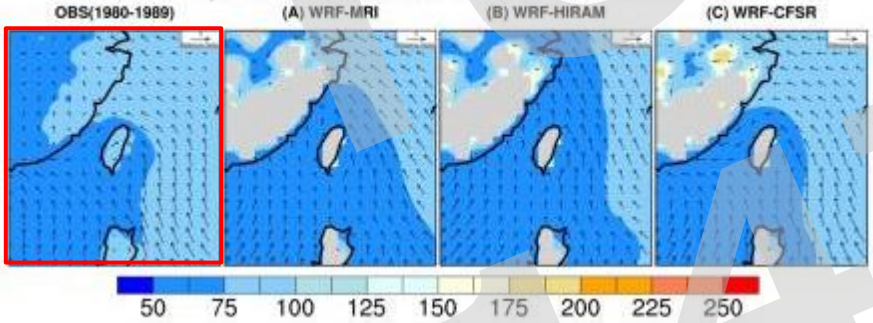
1980-1988 SPRING, ZUV 1000hPa



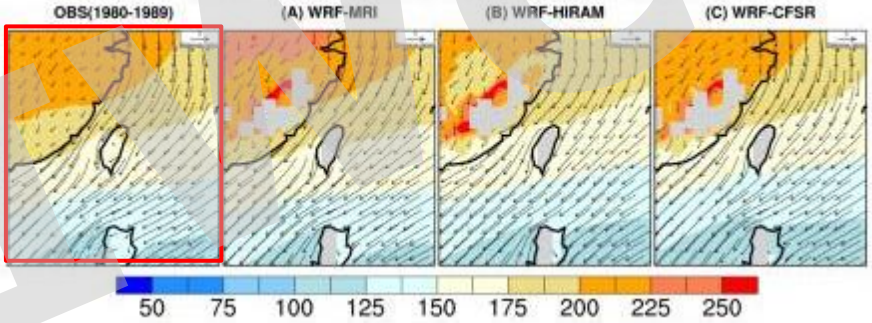
1980-1988 AUTUMN, ZUV 1000hPa



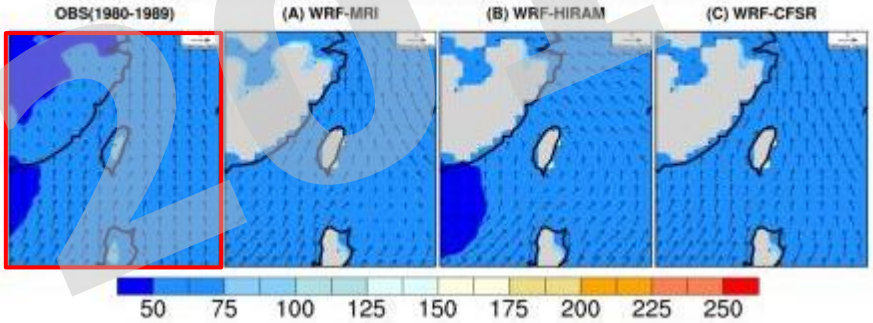
1980-1988 MEIYU, ZUV 1000hPa



1980-1988 WINTER, ZUV 1000hPa



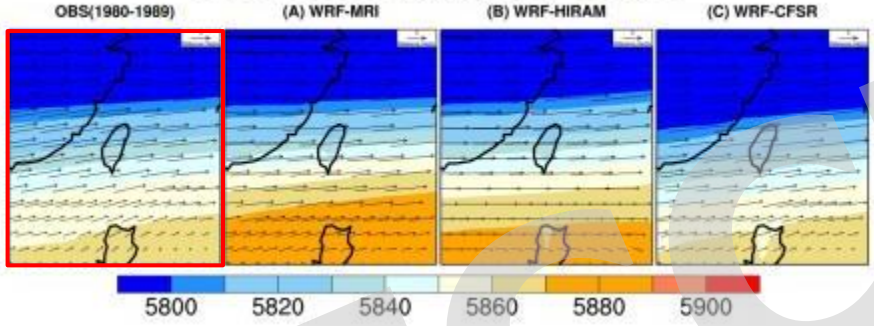
1980-1988 SUMMER, ZUV 1000hPa



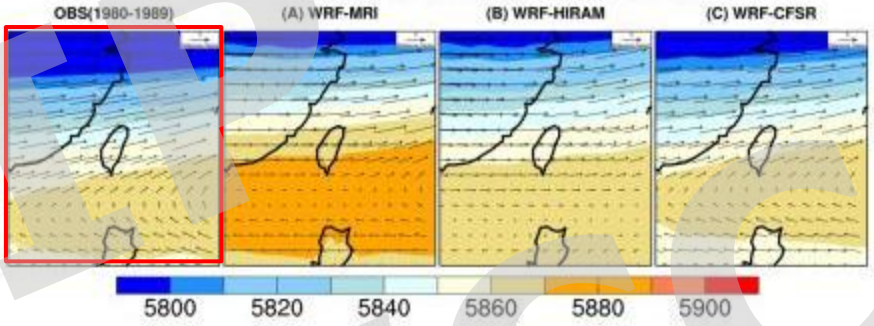
Circulation at 500hPa

OBS & RCMs

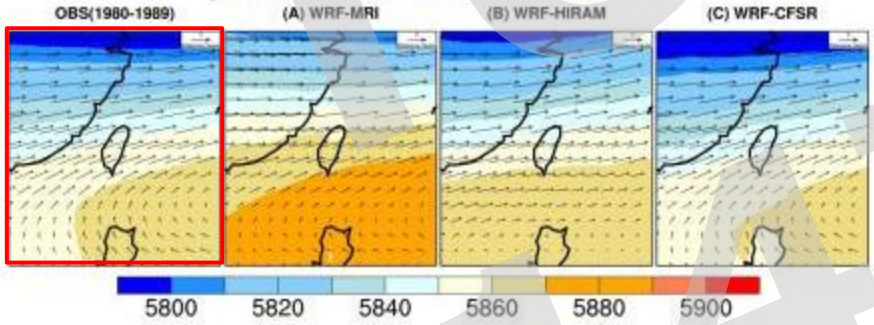
1980-1988 SPRING, ZUV 500hPa



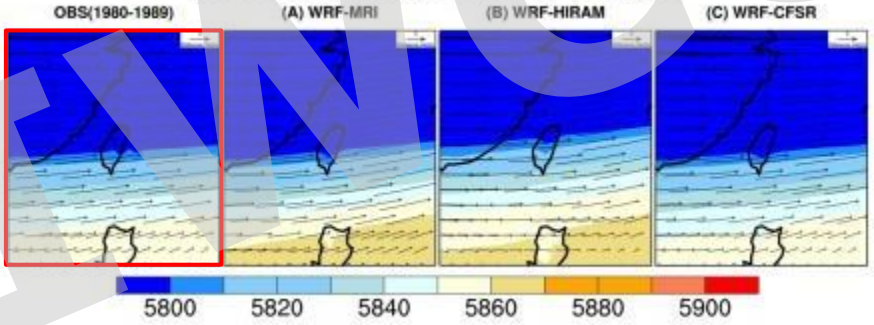
1980-1988 AUTUMN, ZUV 500hPa



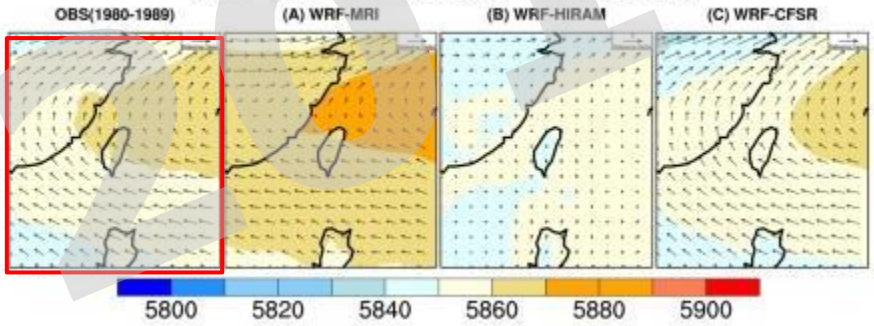
1980-1988 MEIYU, ZUV 500hPa



1980-1988 WINTER, ZUV 500hPa



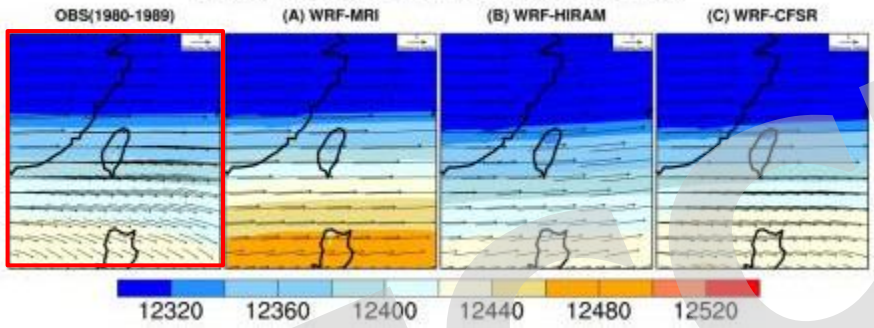
1980-1988 SUMMER, ZUV 500hPa



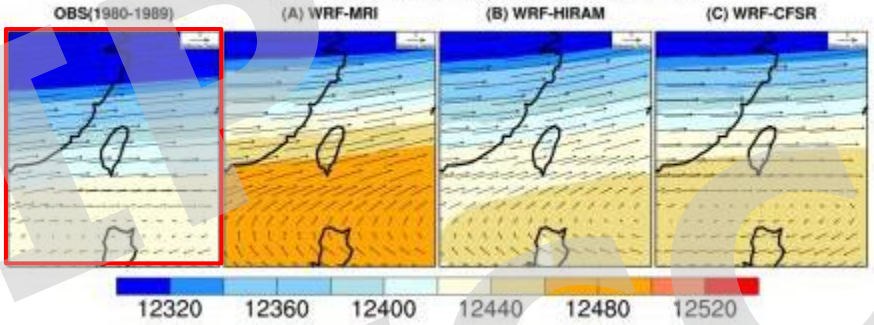
Circulation at 200hPa

OBS & RCMs

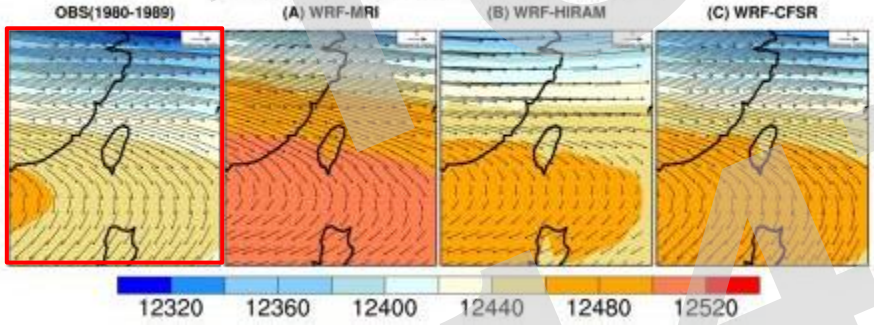

1980-1988 SPRING, ZUV 200hPa



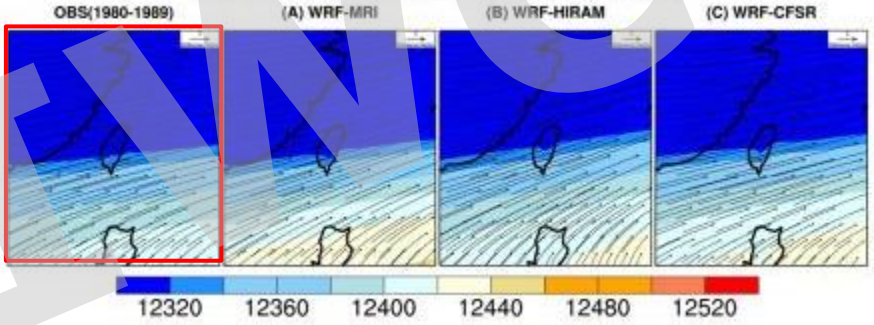
1980-1988 AUTUMN, ZUV 200hPa



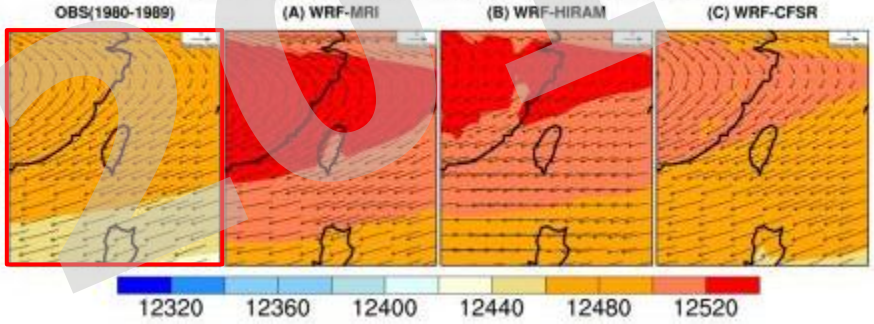
1980-1988 MEIYU, ZUV 200hPa



1980-1988 WINTER, ZUV 200hPa



1980-1988 SUMMER, ZUV 200hPa



Seasonal mean, area-averaged Precipitation
(1980-1988, mm/day)


Taiwan area