Test of dynamical downscaling for TCCIP project

Seasonal precipitation simulation of WRF model driven by ECHAM5 and MRI/JMA data

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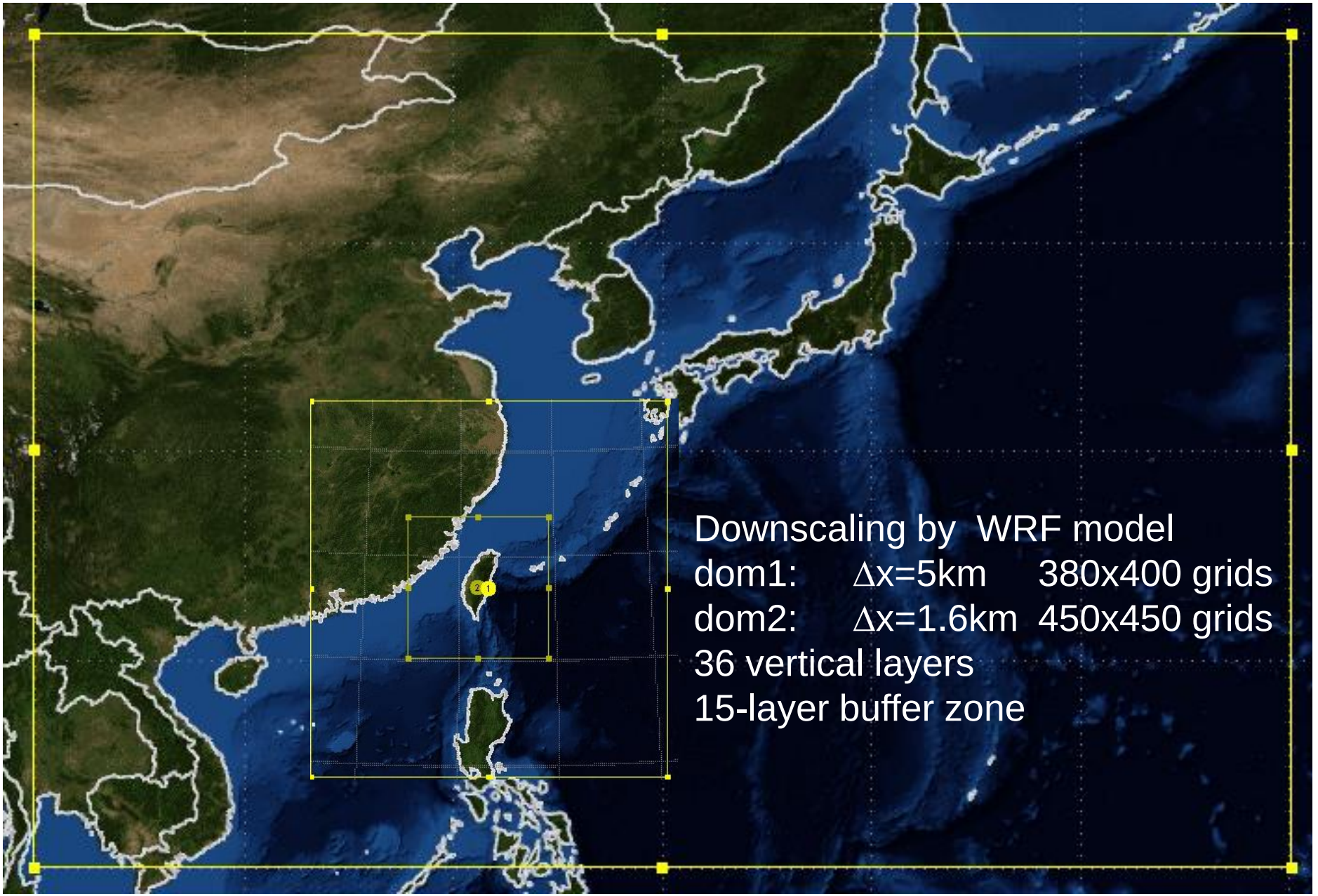
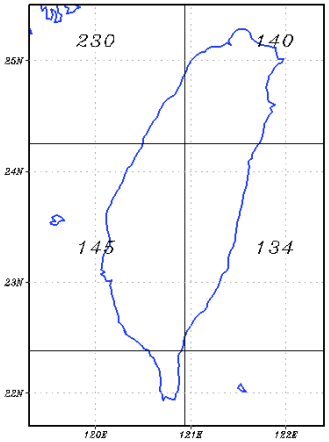

Downscaling by WRF model
dom1: Δx=5km 380x400 grids
dom2: Δx=1.6km 450x450 grids
36 vertical layers
15-layer buffer zone

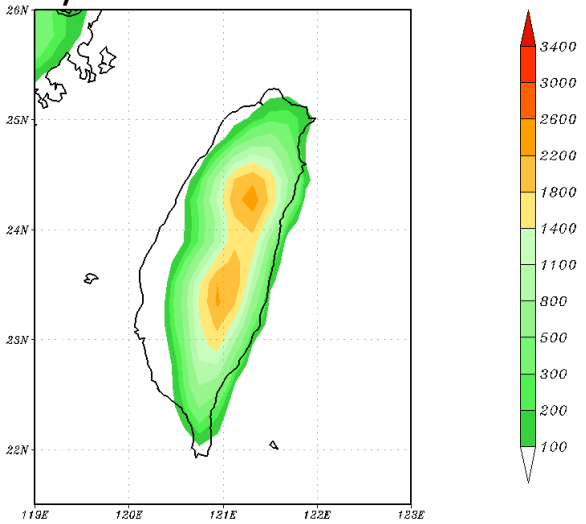
- Initial and Boundary conditions are provided by :
  - MRI/JMA 20km AGCM
  - ECHAM5/MPI-OM ~180km AOGCM
- 5 km WRF is used to do downscaling for climate simulation of present (1979-2003), near future (2015-2039), and end of century (2075-2099)
- 1.6 km WRF is used to do downscaling for extreme precipitation cases (typhoon and Meiyu)
- Results of seasonal precipitation of year 1985 are presented, and rain gauge measurements since 1990 is used as reference.

Terrain in models

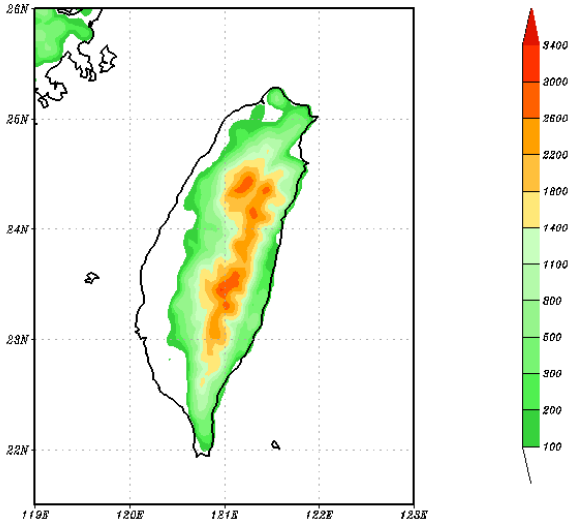
ECHAM5 AOGCM Δx=~180km



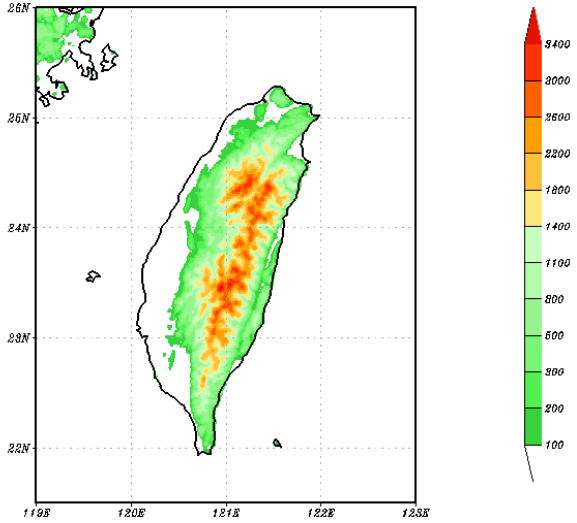
MRI/JMA GCM Δx=20km



WRF D01 Δx=5km

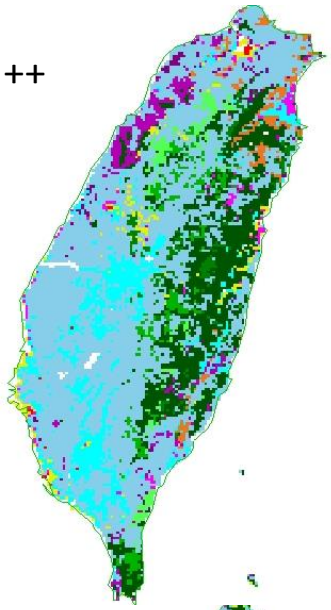


WRF D02 Δx=1.66km

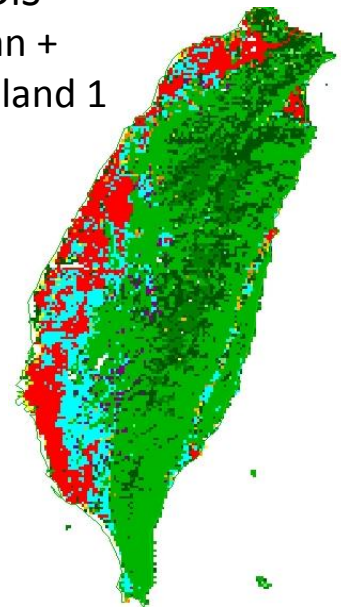


Land Use for dynamical downscaling

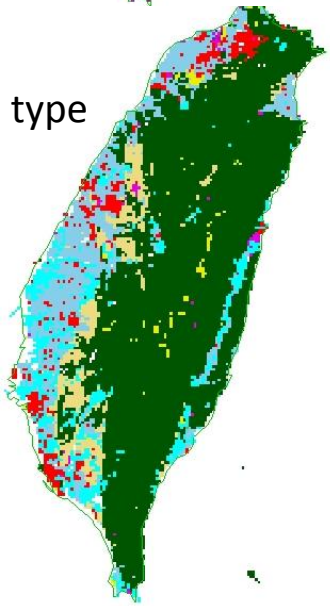
USGS
Cropland ++
Urban --
Forest --



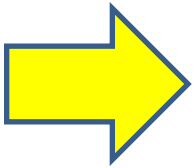
MODIS
Urban +
Cropland 1 type

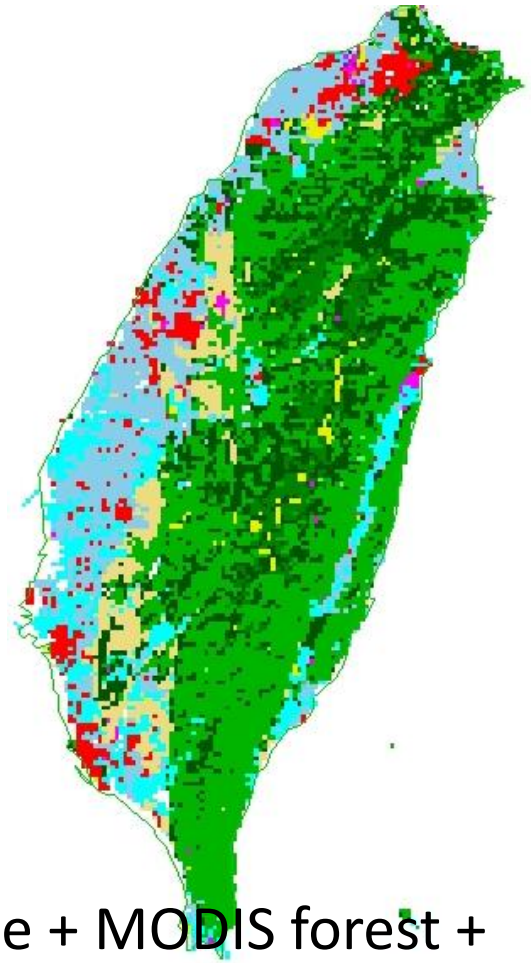


CTCI
Forest 1 type



30 sec ~1 km resolution





- CTCI land use + MODIS forest + USGS croplands for Taiwan
- MODIS land use + USGS croplands outside Taiwan

Physical Option

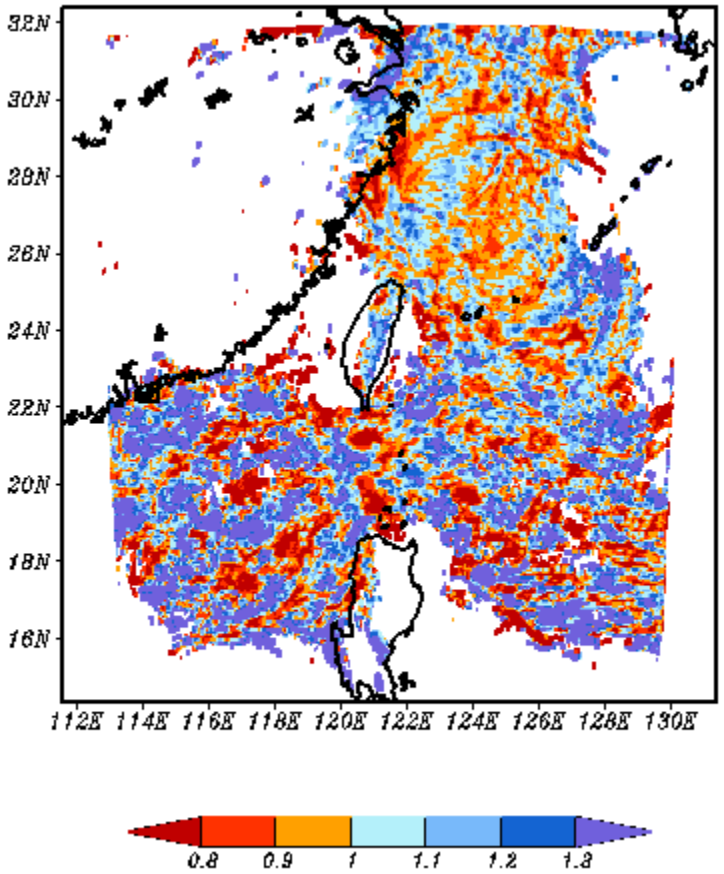
- ❑ Noah land surface module
- ❑ YSU Boundary scheme
- ❑ WSM 6-class microphysics
- ❑ no cumulus scheme
- ❑ RRTM LW scheme
- ❑ Dudhia SW scheme
- ❑ Monin-Obukhov surface layer scheme

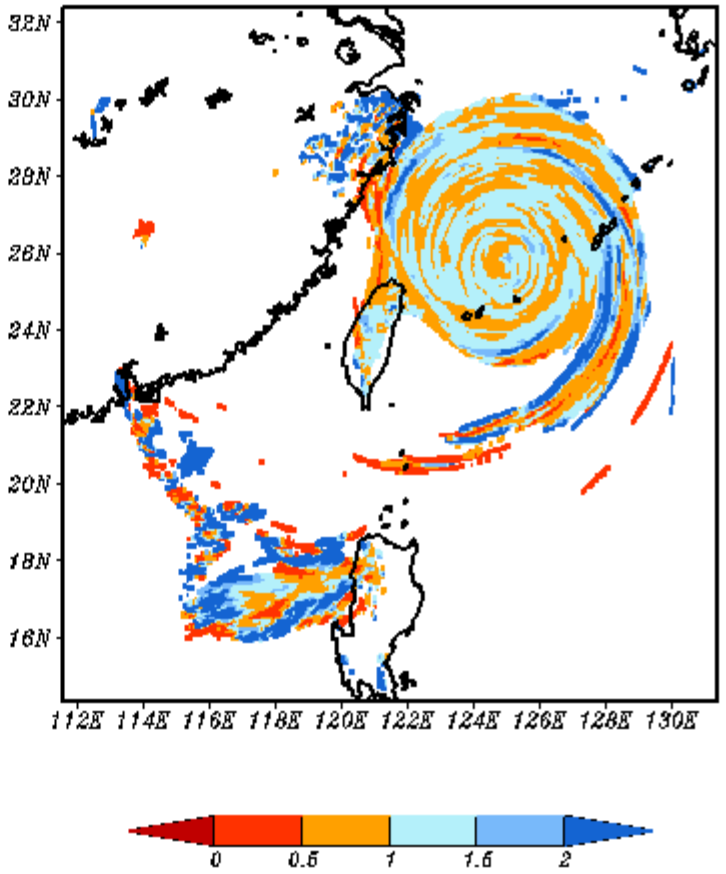
- ❑ Strategy for preventing climate drift
  - — Spectral nudging (wave # 4) for U, V, and Φ. No nudging for T and q (MRI-WRF & ECHAM5-WRF)
  - — Cold start for every 3 day (ECHAM5-WRF)

1985AUG14_06Z, d01

August 1985 *With FDDA spectral nudging wave # 4*

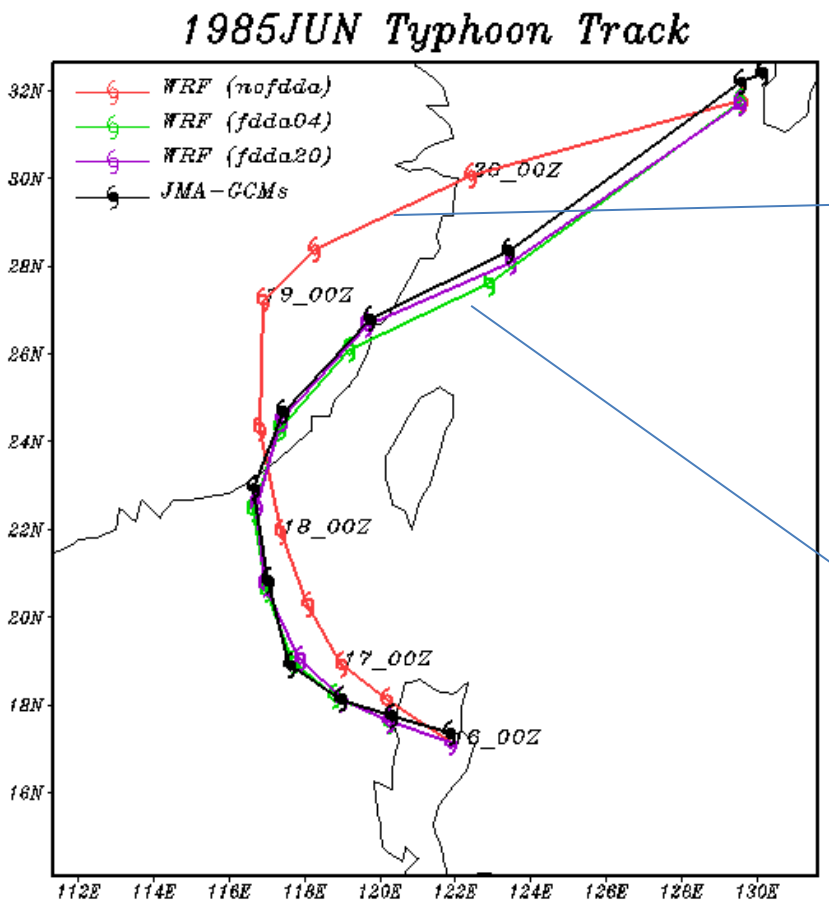
8/14 1985

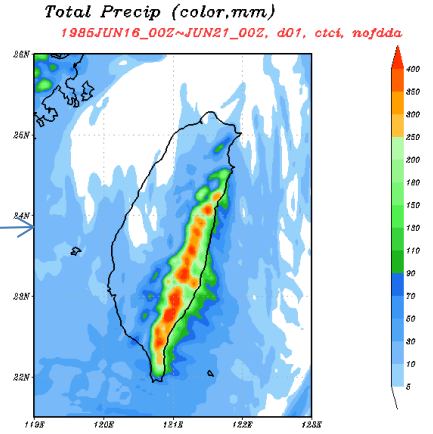


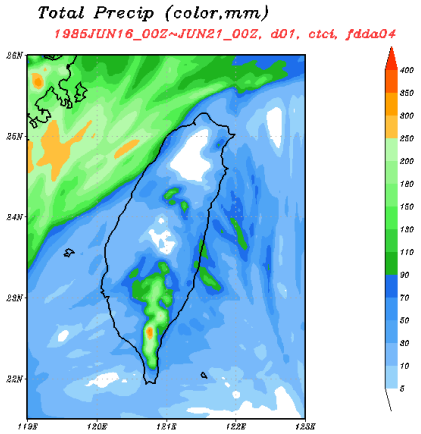


- Mean ratio for cu/nocu is 1.028
- Mean ratio for cu1/nocu is 0.978

With or without cumulus parameterization





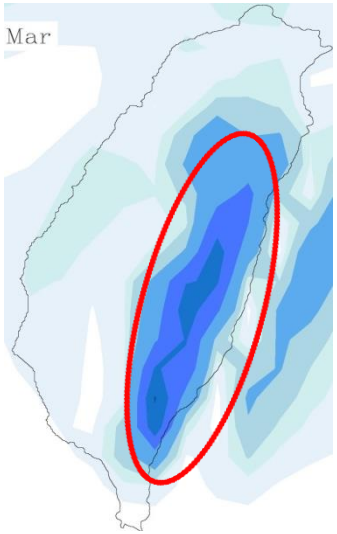


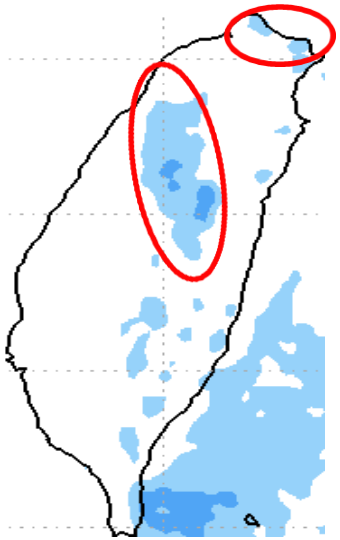
With or without nudging

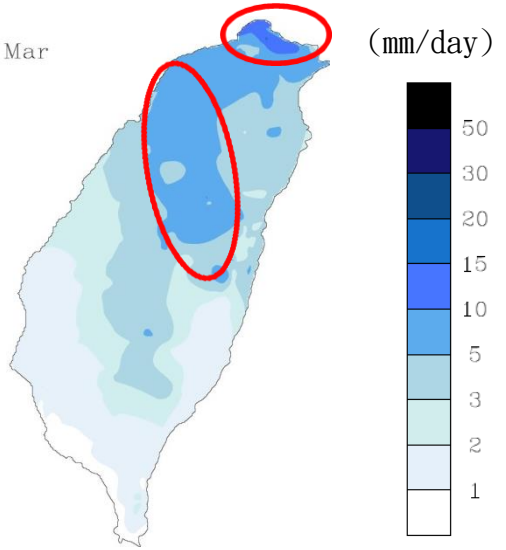
Monthly Precipitation of MRI-WRF

MRI 1985 Δx=20km | MRI-WRF 1985 Δx=5km | Climatology (1996~2005)

March – Dominated by passing fronts

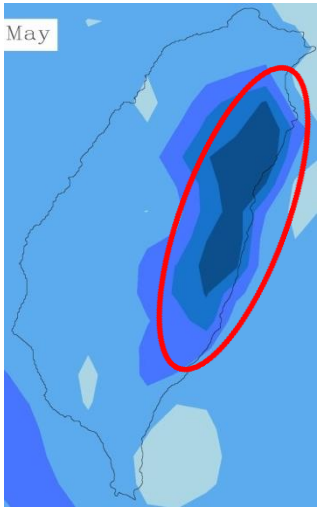


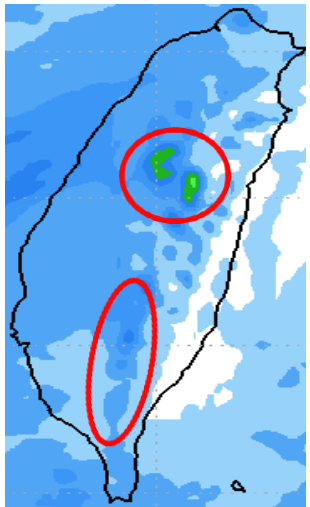




MRI 1985 Δx=20km | MRI-WRF 1985 Δx=5km | Climatology (1996~2005)

May – Dominated by Meiyu, southwesterly





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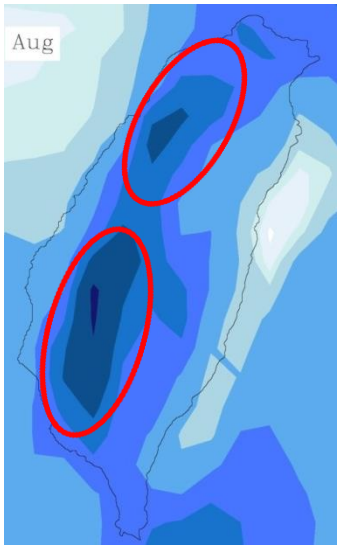
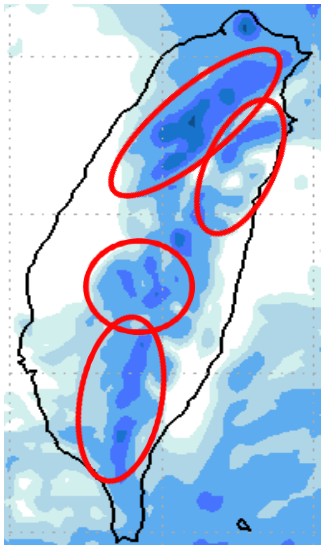
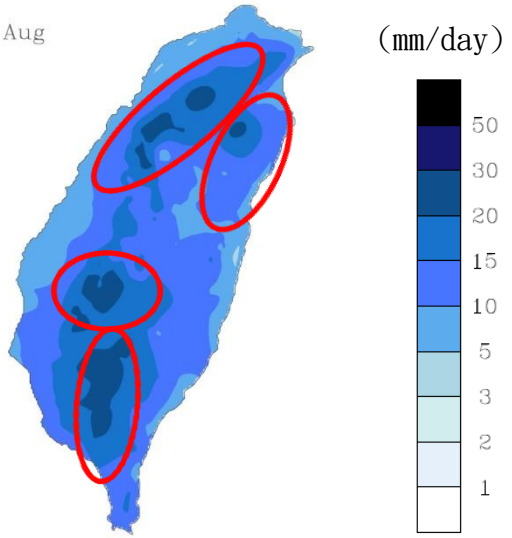
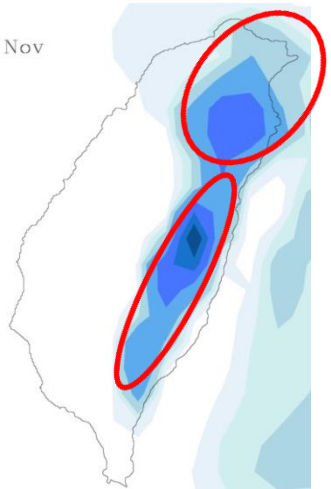


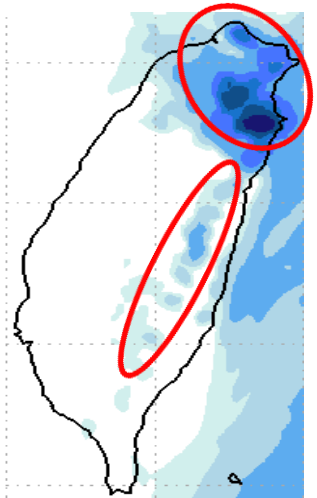


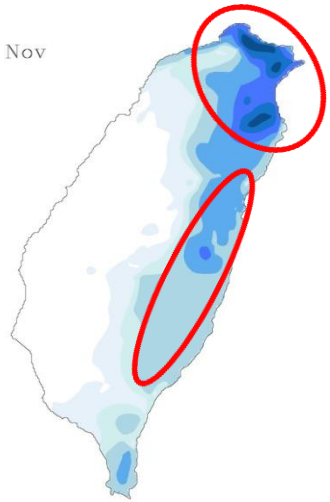


MRI 1985 Δx=20km	MRI-WRF 1985 Δx=5km	Climatology (1996~2005)

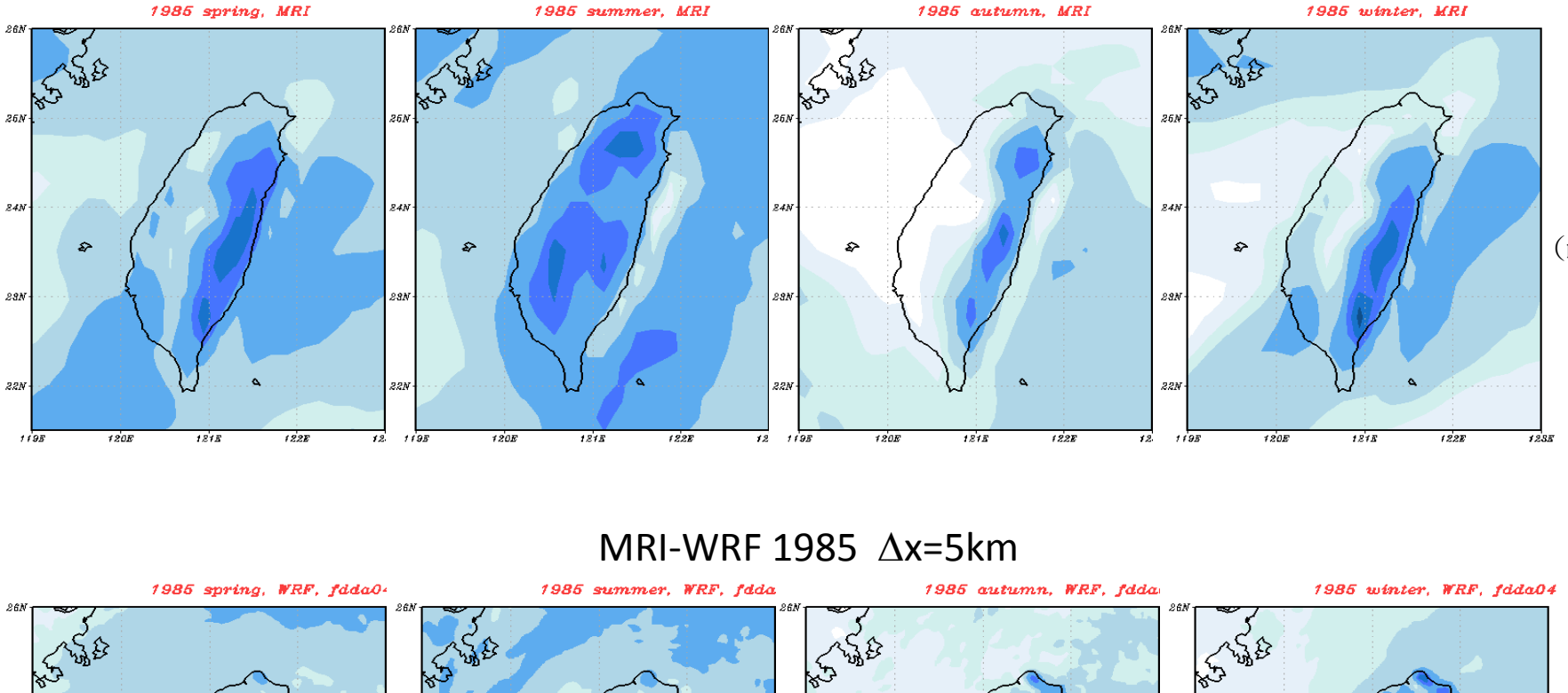
November – Dominated by Winter Monsoon (northeasterly)



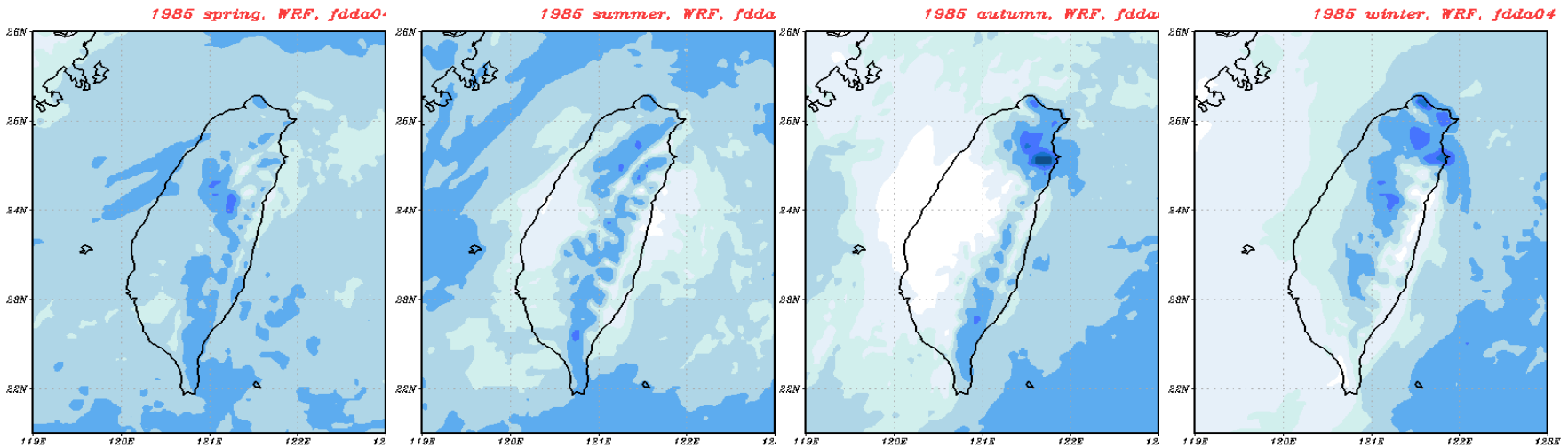




MRI 1985 Δx=5km



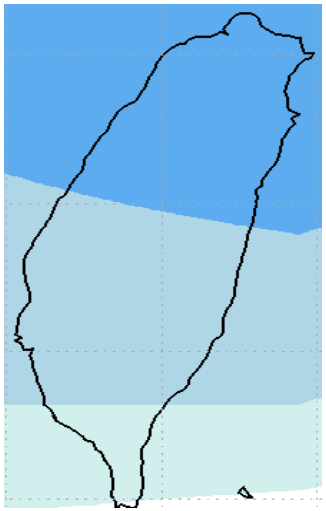
MRI-WRF 1985 Δx=5km

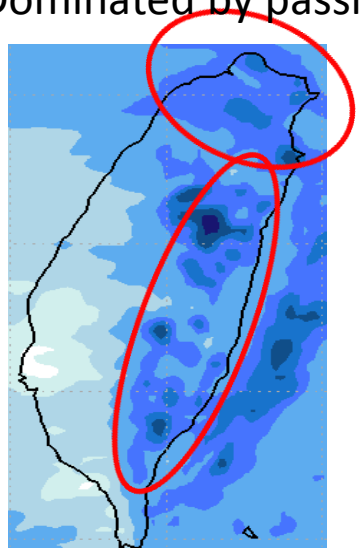


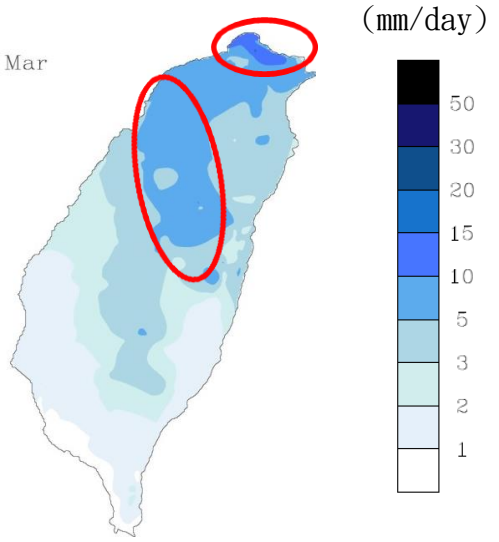
Monthly Precipitation of ECHAM5-WRF

ECHAM5 1985 Δx=200km | ECHAM5-WRF 1985 Δx=5km | Climatology (1996~2005)

March – Dominated by passing fronts

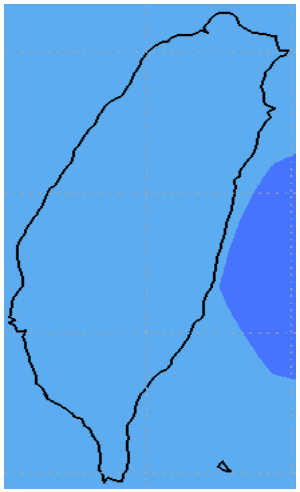


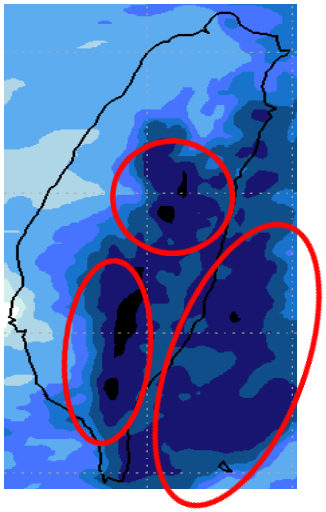


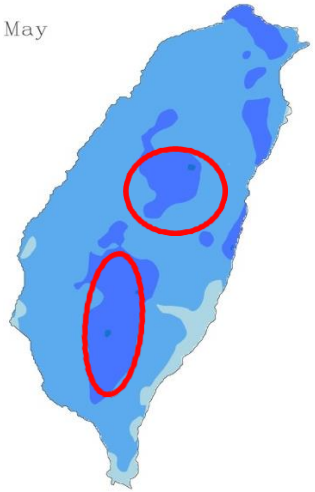


ECHAM5 1985 Δx=200km | ECHAM5-WRF 1985 Δx=5km | Climatology (1996~2005)

May – Dominated by Meiyu, southwesterly



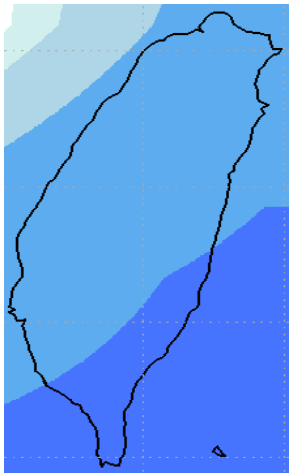


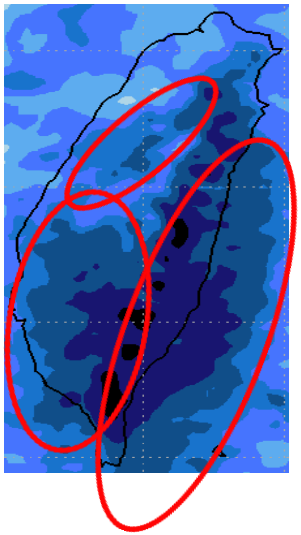


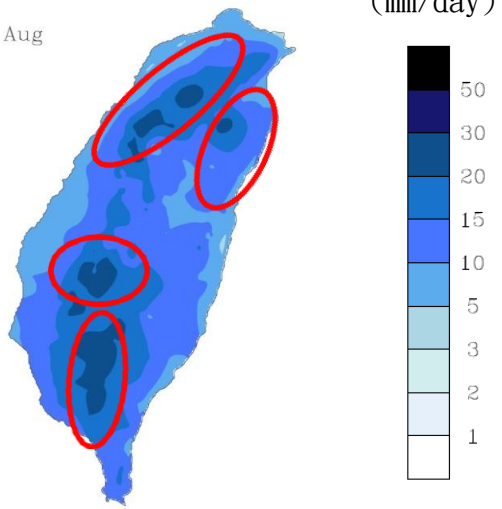
Monthly Precipitation of ECHAM5-WRF

ECHAM5 1985 Δx=200km | ECHAM5-WRF 1985 Δx=5km | Climatology (1996~2005)

August – Dominated by Typhoon

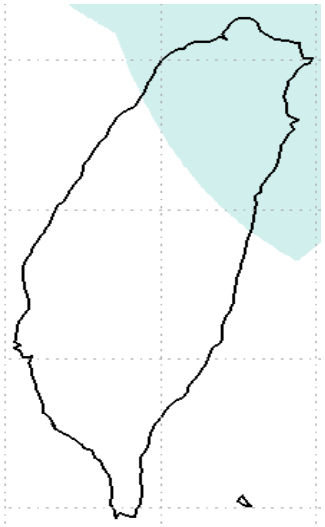


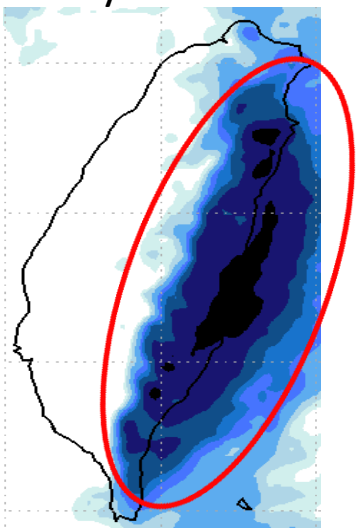


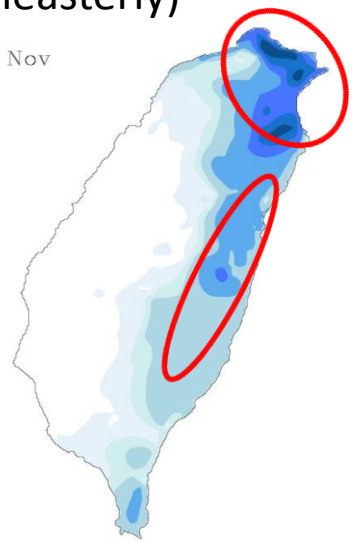


ECHAM5 1985 Δx=200km | ECHAM5-WRF 1985 Δx=5km | Climatology (1996~2005)

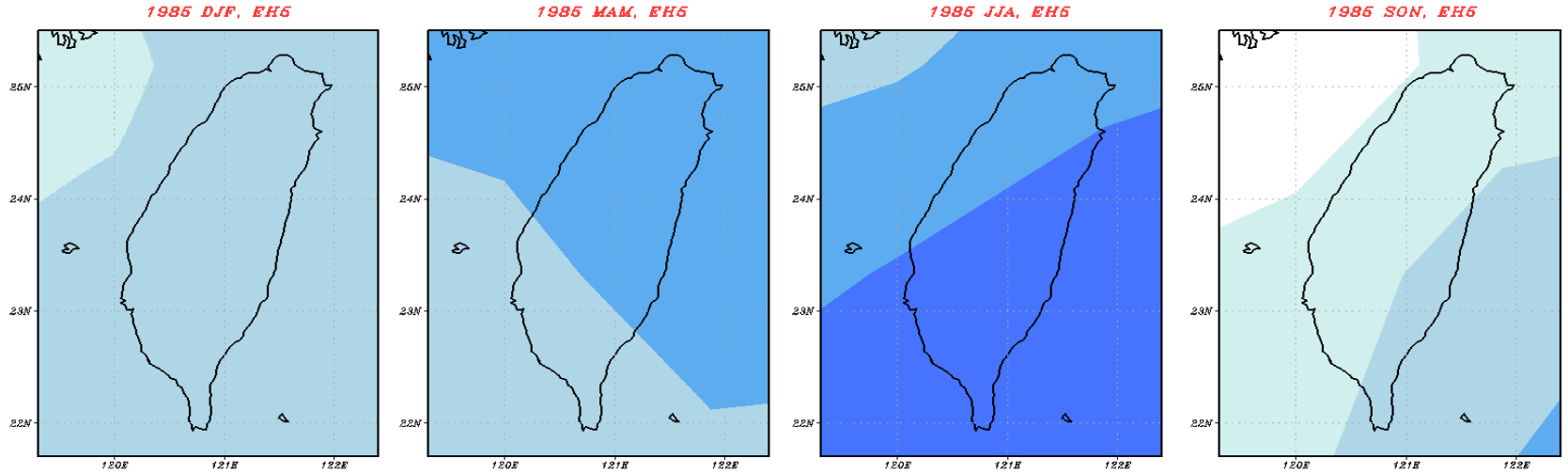
November – Dominated by Winter Monsoon (northeasterly)



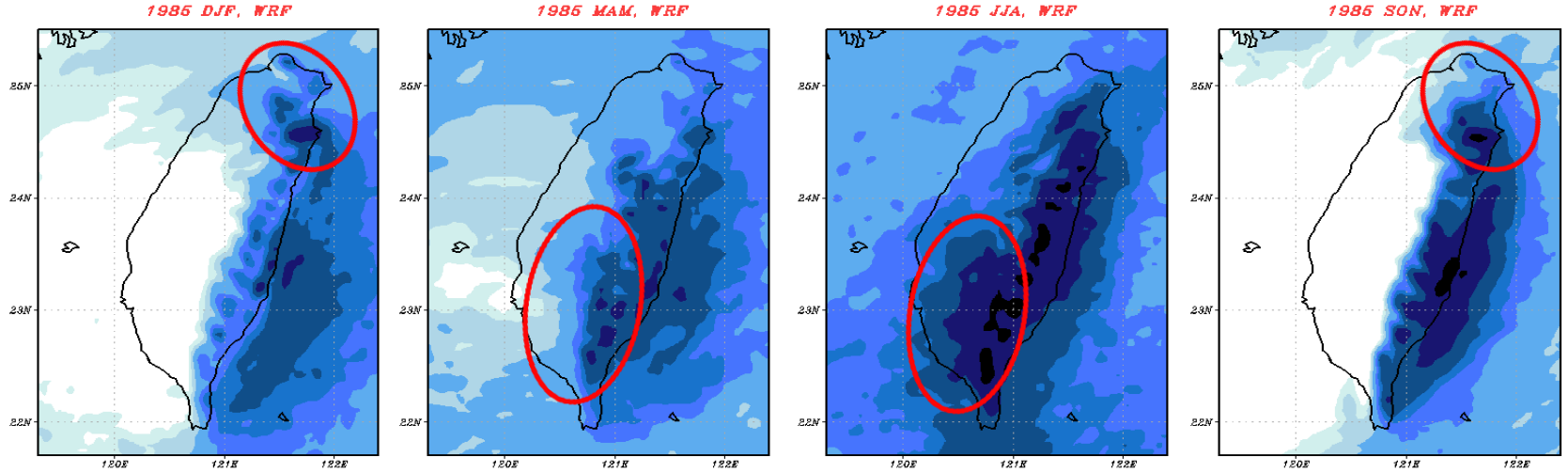


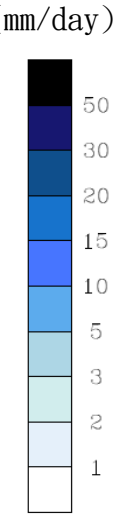


ECHAM5 1985 Δx=200km

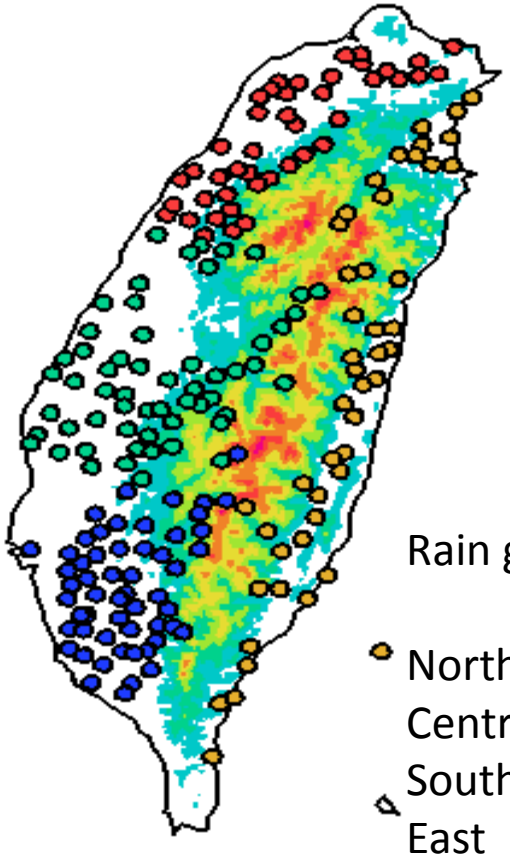


ECHAM5-WRF 1985 Δx=5km



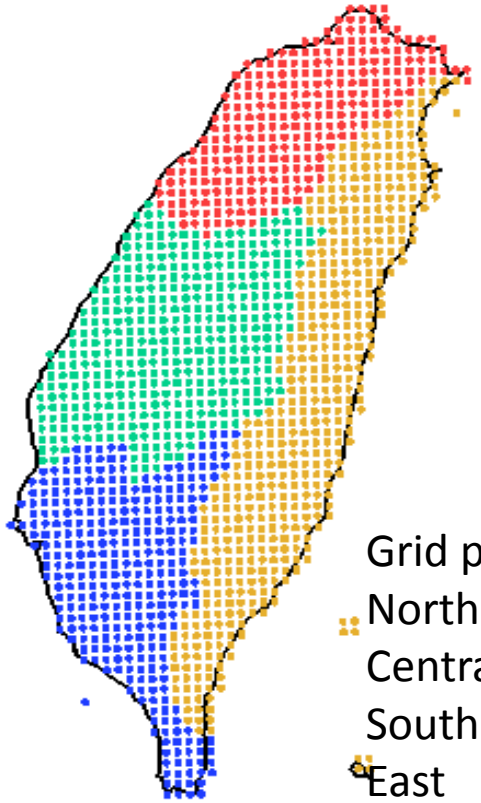


4 areas of Taiwan for analysis



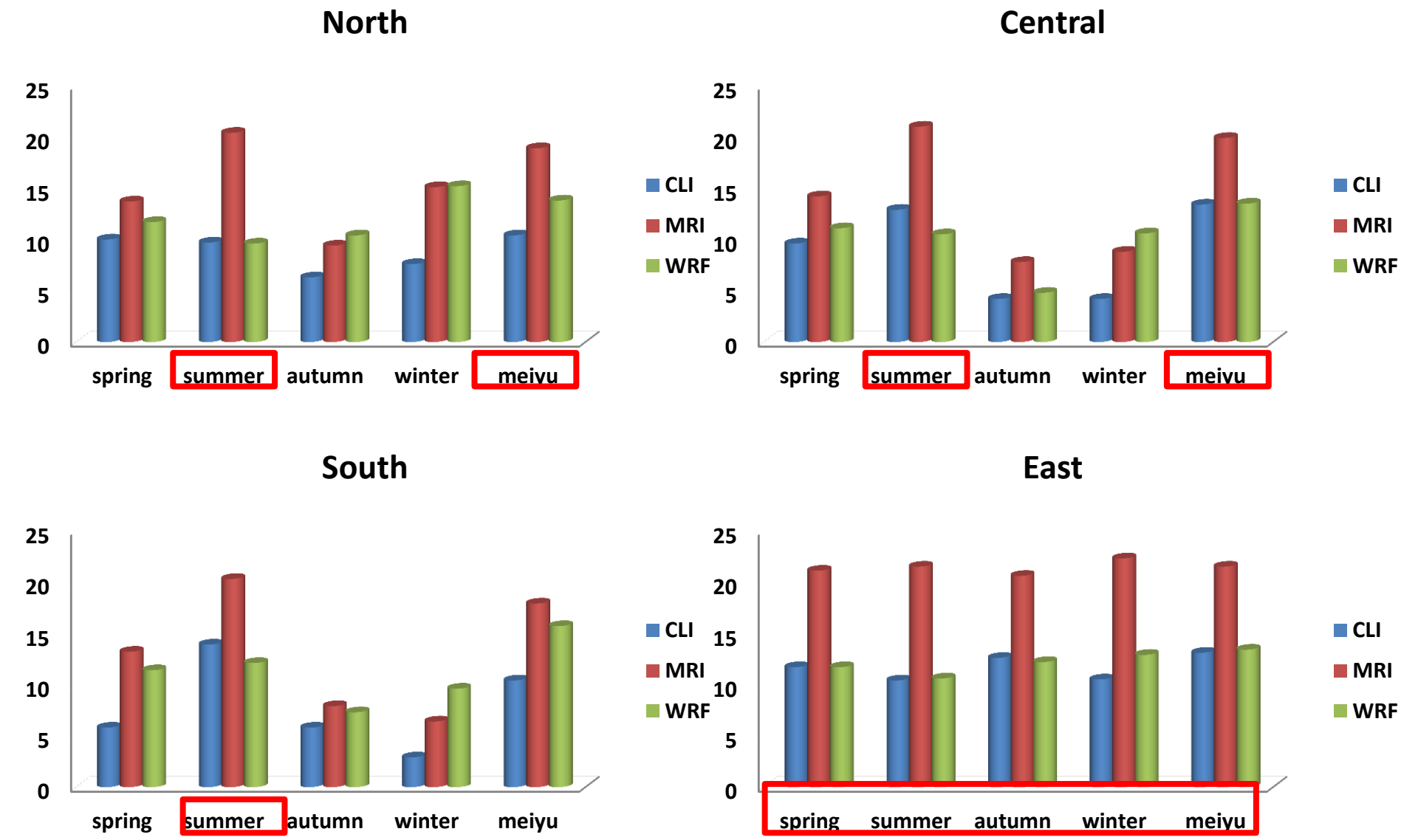
Rain gauge of 4 areas

North : 45
Central : 57
South : 55
East : 47
*concentrate on plains

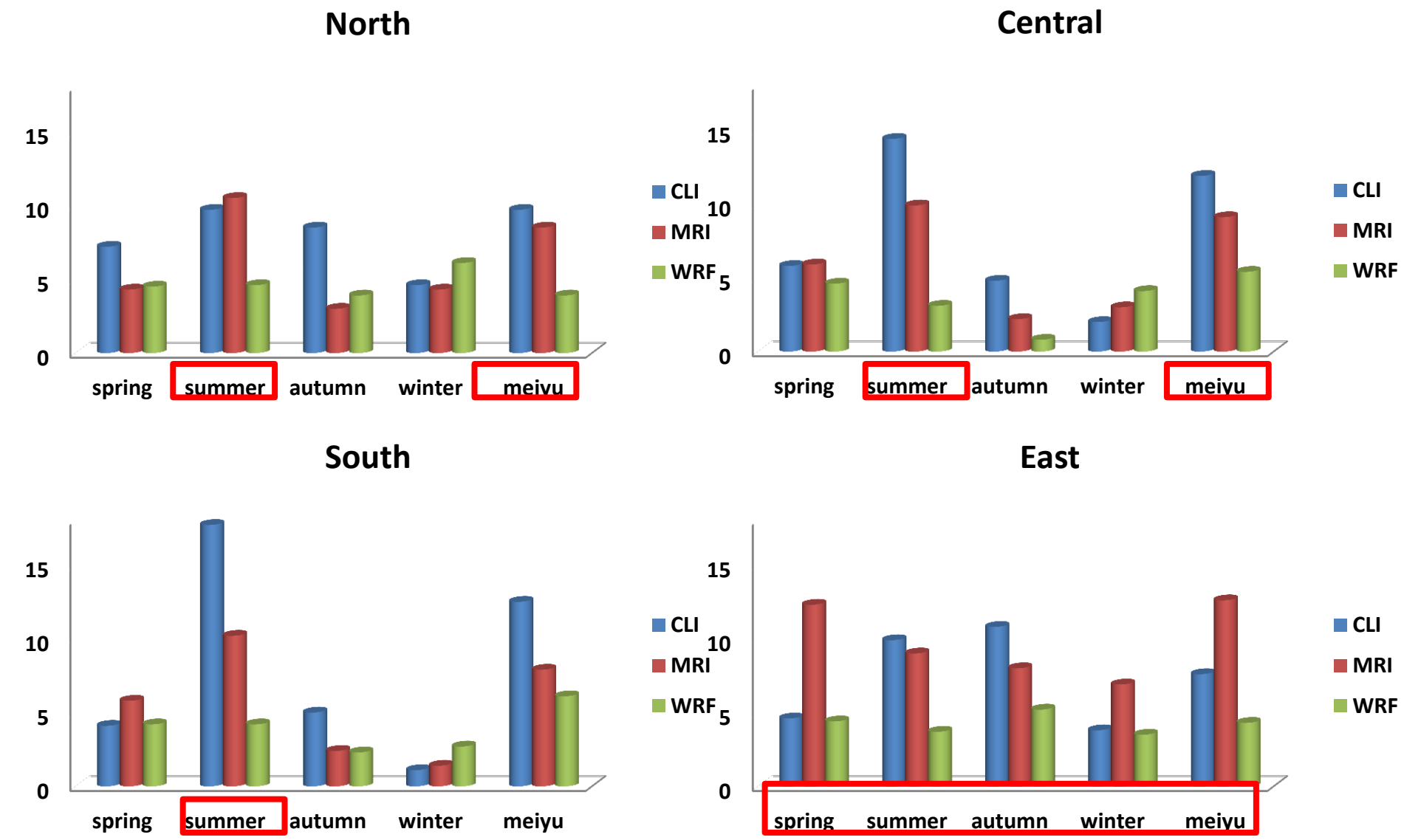


Grid points of 4 areas
North :328
Central : 483
South : 371
East : 504

Number of wet days (>1 mm/day) in CLIMATOLOGY / MRI / WRF



Seasonal Mean Precipitation (mm/day) in CLIMATOLOGY / MRI / WRF

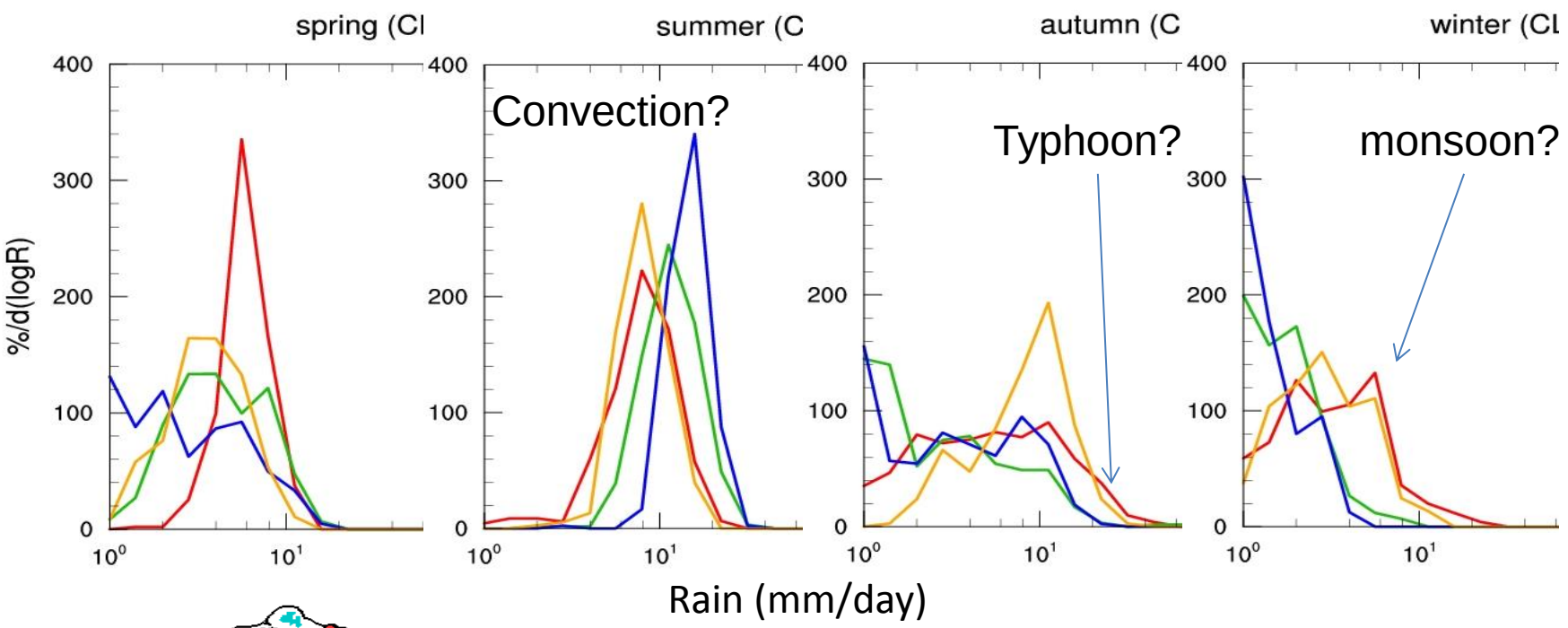


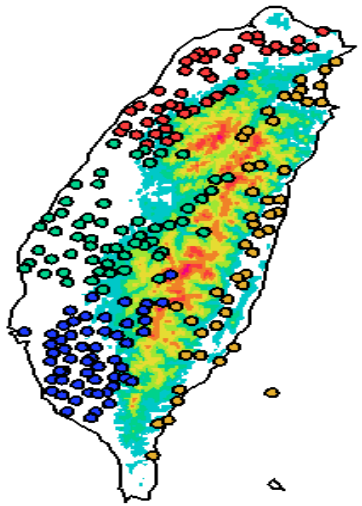
Number of wet days (>1 mm/day) per month and seasonal mean precipitation (mm/day) in ECHAM5- WRF

	North	Central	South	East
	Rain / Wet day	Rain / Wet day	Rain / Wet day	Rain / Wet day
Spring	9.0 / 15.1	10.4 / 12.8	11.3 / 13.6	**22.1 / 22.5**
Summer	14.5/ 16.9	**20.7/ 19.4**	**32.4 / 22.1**	**36.8 / 23.9**
Autumn	6.6 / 13.1	2.2 / 4.7	3.7 / 7.8	**26.5 / 24.7**
Winter	7.7 / 15.6	2.2 / 6.4	2.8 / 7.6	**14.3 / 21.1**
Meiyu	14.4 / 19.5	**23.4 / 20.2**	**31.5 / 21.4**	**39.8 / 25.5**

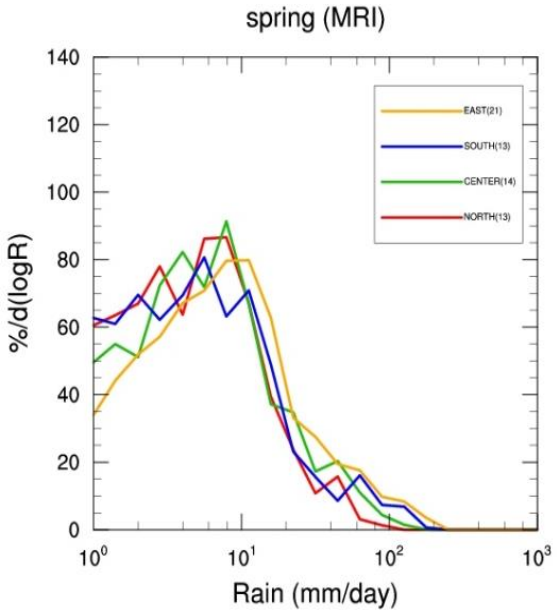
- Nudging is necessary to reproduce the main precipitation pattern
- Except summer time, MRI tend to produce more rain in east Taiwan
- Spatial distribution of monthly precipitation of MRI-WRF is more close to that of observation.
- Not only add spatial details of precipitation, but also fix some precipitation bias of GCM
- MRI-WRF produce less rain than MRI in all 4 areas of Taiwan
- ECHAM5-WRF produce too much precipitation to the east of Taiwan all year round, which could be caused by the easterly in ECHAM5 and the terrain in WRF.

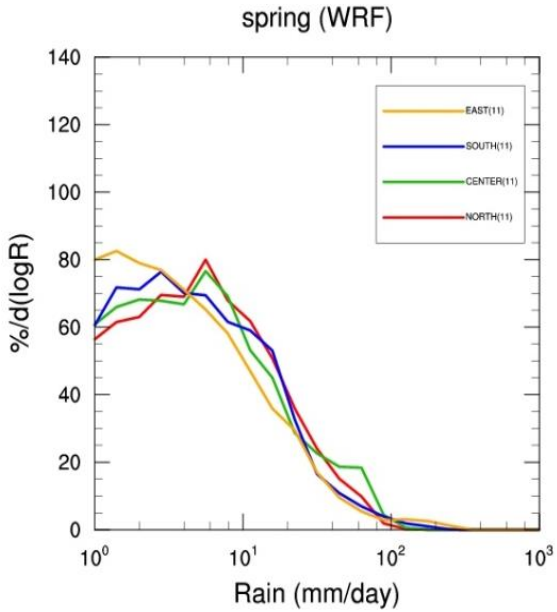
Characteristic of precipitation PDF

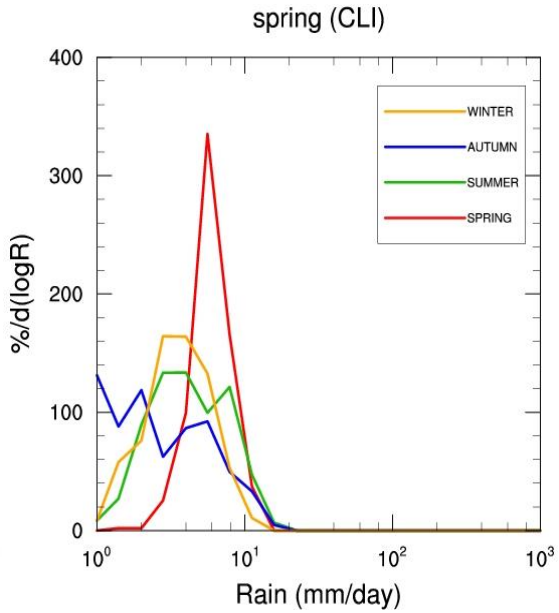


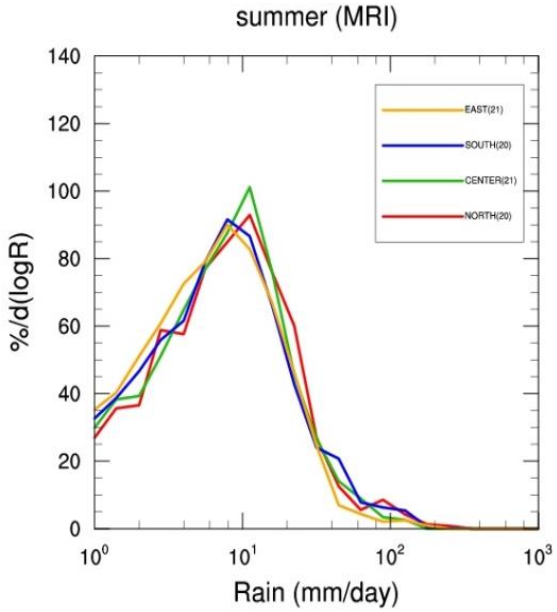


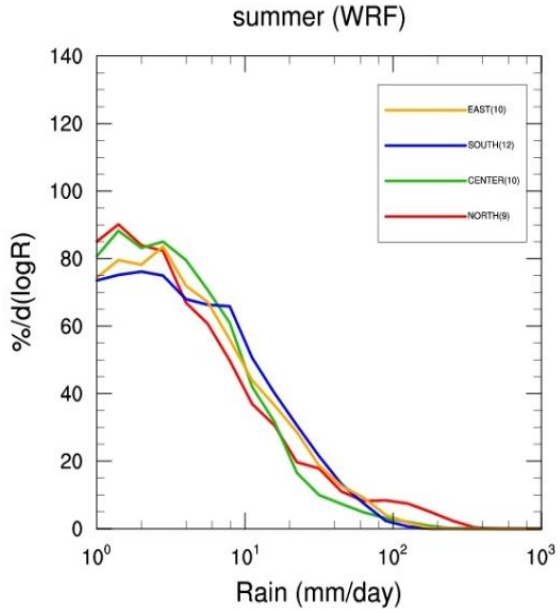
- North and east areas are similar
- Central and south areas are similar

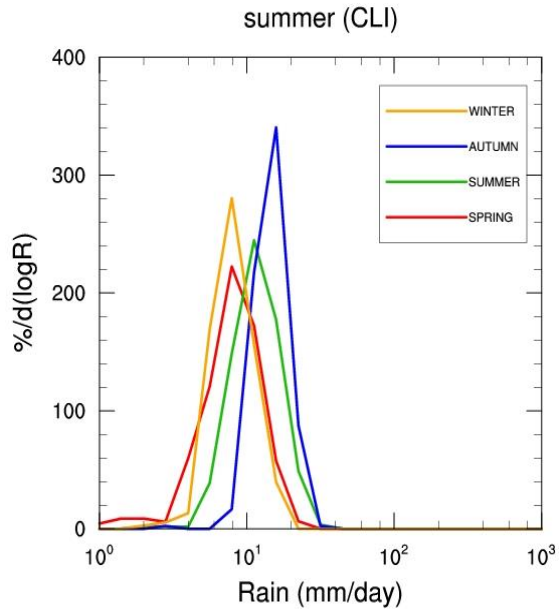

spring (MRI)
EAST(21)
SOUTH(13)
CENTER(14)
NORTH(13)
%/d(logR)
Rain (mm/day)

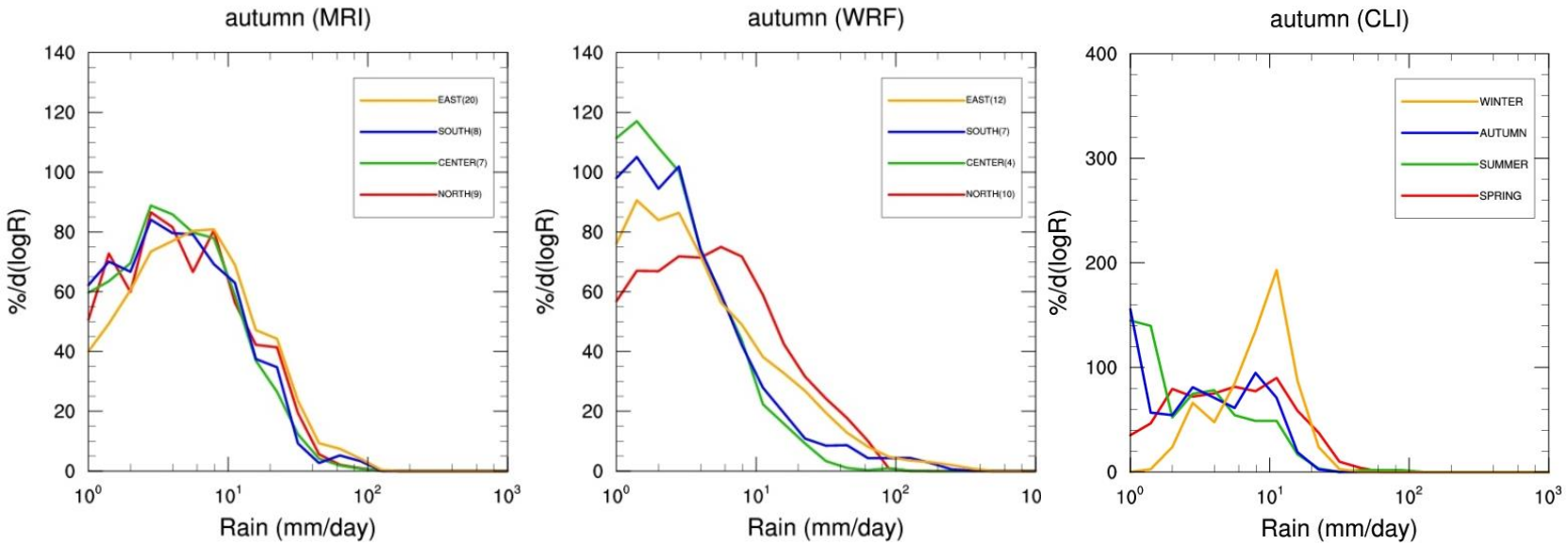

spring (WRF)
EAST(11)
SOUTH(11)
CENTER(11)
NORTH(11)
%/d(logR)
Rain (mm/day)

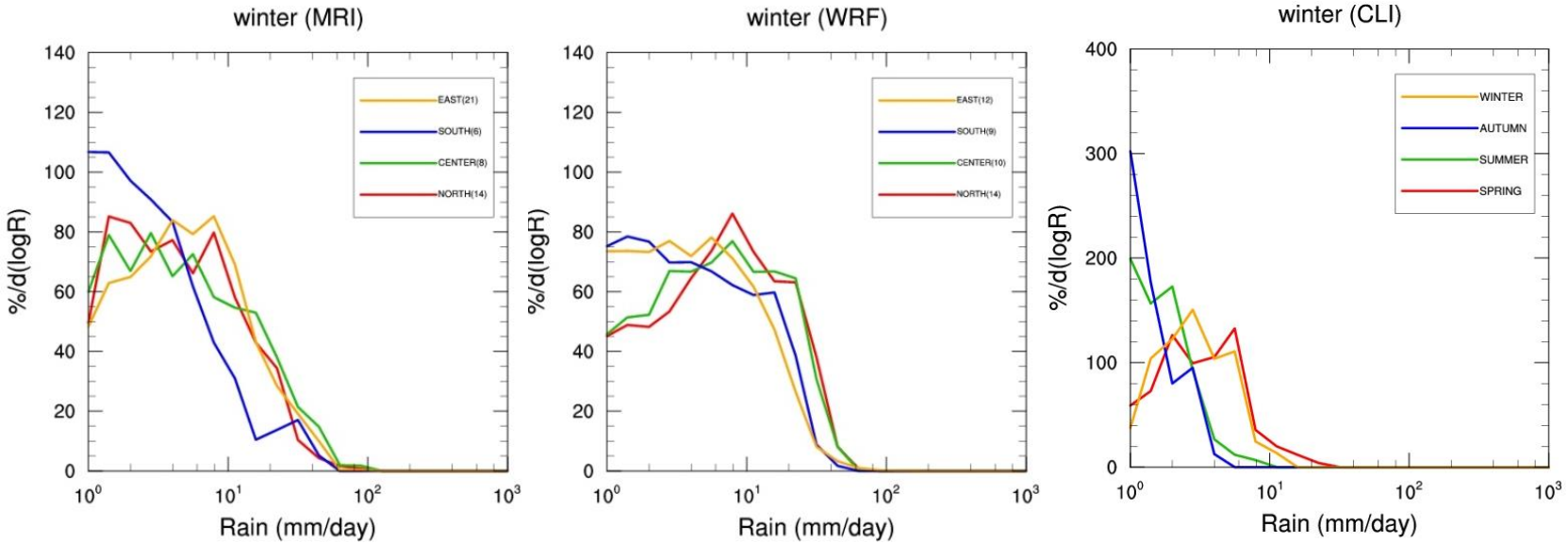

spring (CLI)
WINTER
AUTUMN
SUMMER
SPRING
%/d(logR)
Rain (mm/day)


summer (MRI)
EAST(21)
SOUTH(20)
CENTER(21)
NORTH(20)
%/d(logR)
Rain (mm/day)

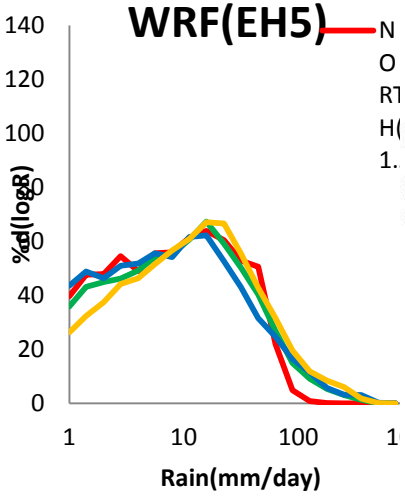

summer (WRF)
EAST(10)
SOUTH(12)
CENTER(10)
NORTH(9)
%/d(logR)
Rain (mm/day)

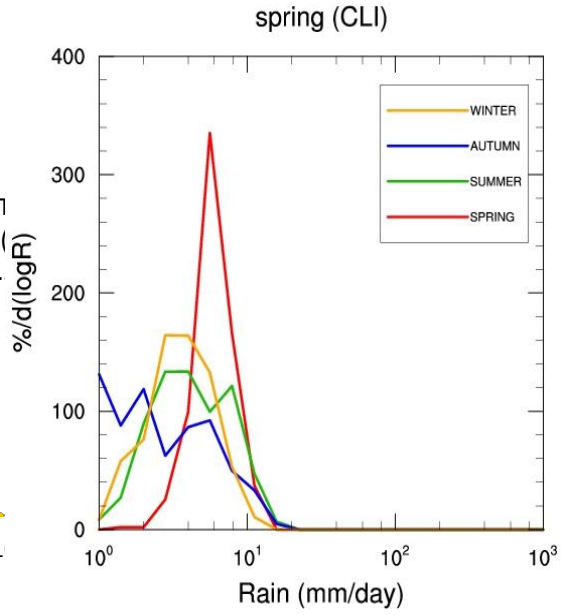

summer (CLI)
WINTER
AUTUMN
SUMMER
SPRING
%/d(logR)
Rain (mm/day)


autumn (MRI)
EAST(20)
SOUTH(8)
CENTER(7)
NORTH(9)
%/d(logR)
Rain (mm/day)
autumn (WRF)
EAST(12)
SOUTH(7)
CENTER(4)
NORTH(10)
%/d(logR)
Rain (mm/day)
autumn (CLI)
WINTER
AUTUMN
SUMMER
SPRING
%/d(logR)
Rain (mm/day)

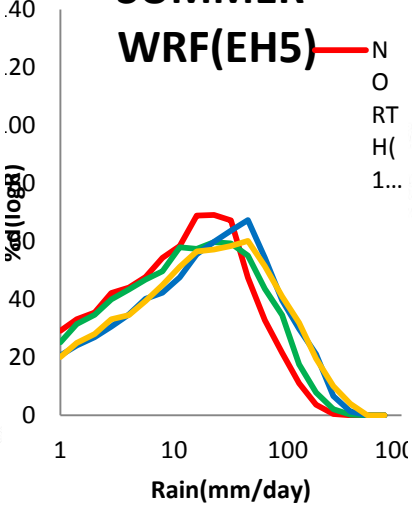

winter (MRI)
EAST(21)
SOUTH(6)
CENTER(8)
NORTH(14)
%/d(logR)
Rain (mm/day)
winter (WRF)
EAST(12)
SOUTH(9)
CENTER(10)
NORTH(14)
%/d(logR)
Rain (mm/day)
winter (CLI)
WINTER
AUTUMN
SUMMER
SPRING
%/d(logR)
Rain (mm/day)

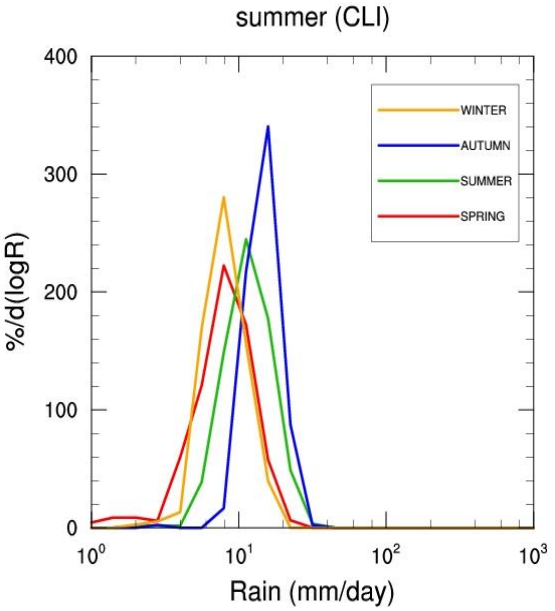
SPRING-WRF(EH5)



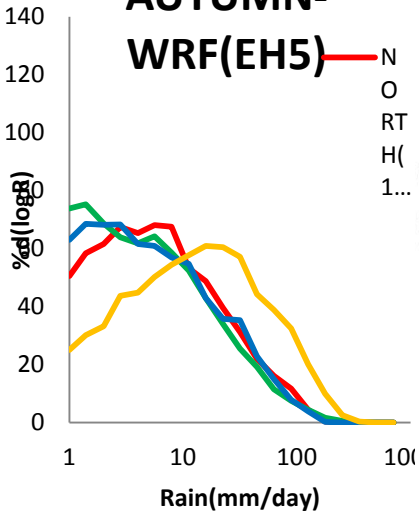


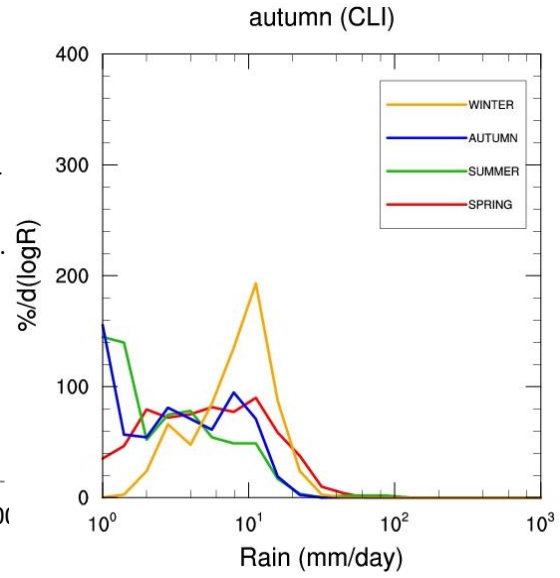
SUMMER-WRF(EH5)



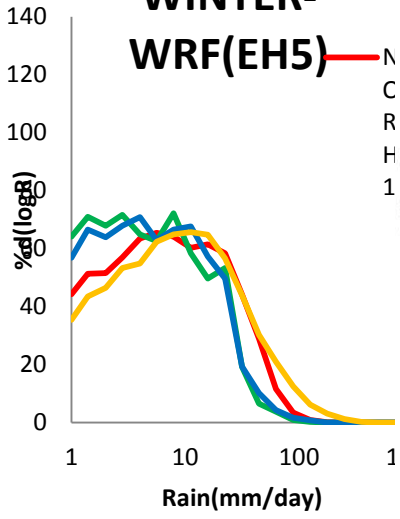


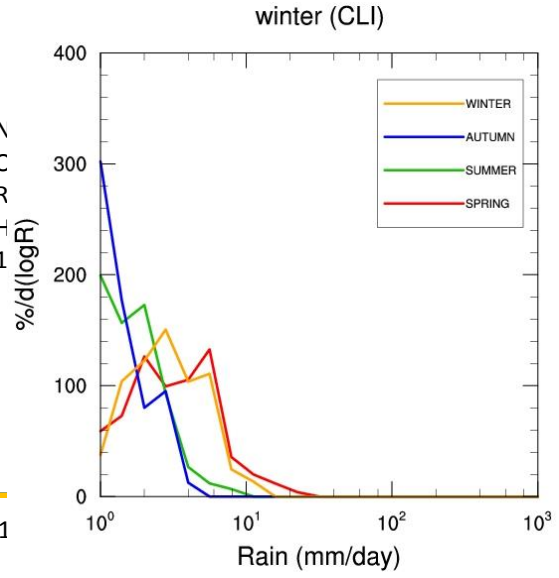
AUTUMN-WRF(EH5)





WINTER-WRF(EH5)





Conclusion based on simulation of year 1985

- Two sets of GCM output (MRI and ECHAM5) with different spatial resolution are used to initialize and force the boundary of the WRF model.
- Although the magnitude is lower, the precipitation of MRI-WRF seems to be more realistic than that of MRI in term of spatial distribution.
- Te precipitation PDF of MRI-WRF shows too much light rain than rain gauge observation of 15~19 years.
- The results of ECHAM5-WRF need to be investigated more. If necessary, its downscaling strategy (cold start for every 3 days) may have to be reconsidered.

Thank you for your attention!