Evaluation of the effects of a multiphysics ensemble on the simulation of an extremely hot summer in 2003 over the CORDEX-EA-II Region

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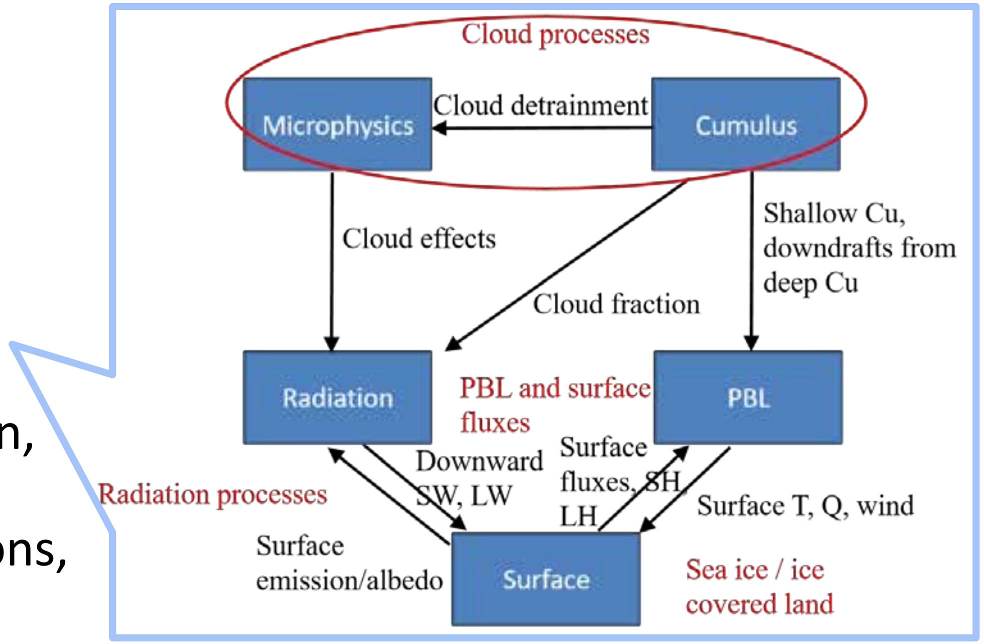
outline

- Background
- Experiments design
- Results
- Conclusion

Background

- Model structure, dynamical core, physical processes and parameterization
- Simulation configuration, domain position/size, initial/boundary conditions, resolution

Typical Climate Model Framework



✓ The model becomes more sophisticated, contains more processes, and provides options of physical parameterization.

✓ Super ensemble of multiple schemes or best combination of physical options can improve the model performance.

- The **cumulus and microphysics schemes** can have a direct influence on the precipitation pattern and intensity(Zittis, 2014; Katragkou et al., 2015; Clark et al., 2009; Huang et al., 2011; Pieri et al., 2015).

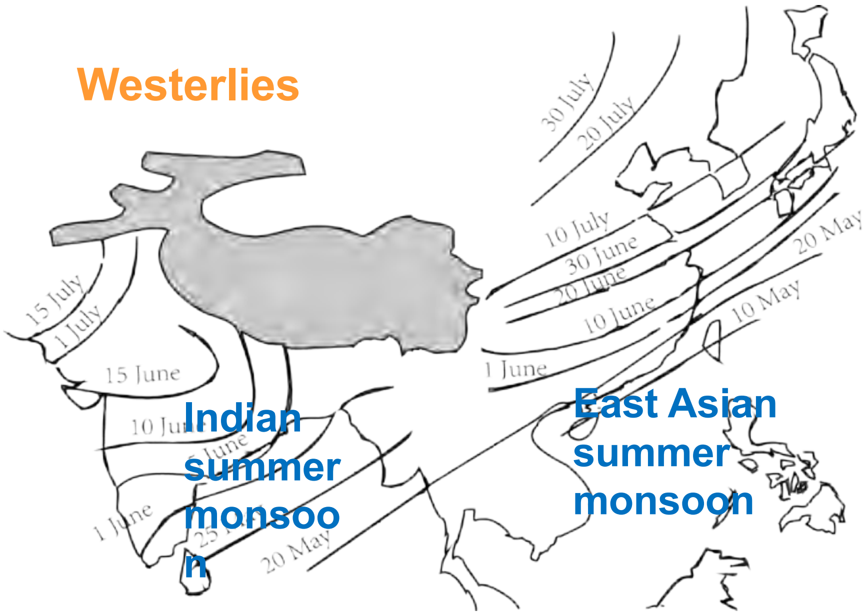
- Mooney et al. (2013) argued the choice of **land surface model** can affect the simulation of surface temperature as well as precipitation.

- The sensitivity of RCMs to the choice of physical parameterization shows **dependence** on the regions of interest (Chen et al., 2010; Choi and Ahn, 2017).

- The **coupling** and **interaction** of **physical processes** makes it difficult to give a best physical combination in sensitivity study of short-term climate, especially extreme heavy precipitation and hot weather.

Motivation

- Can we identify a best set of model physical schemes to reproduce precipitation and temperature extremes for CORDEX-EA-II domain?

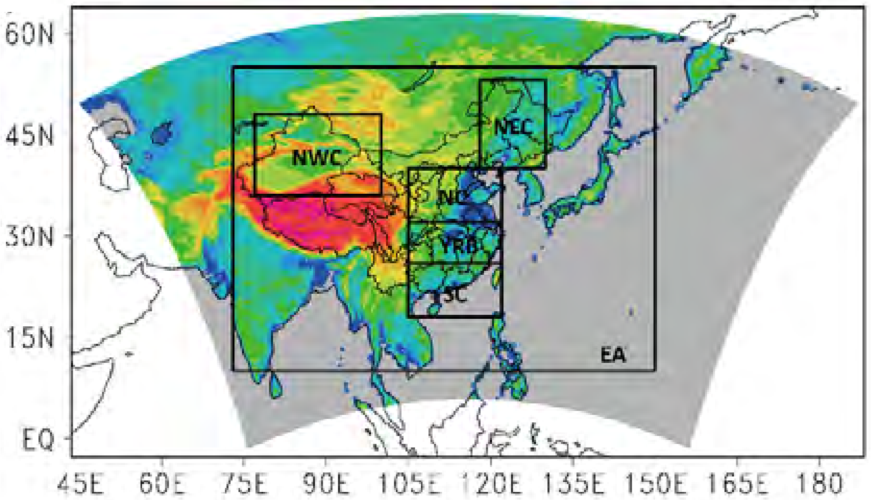


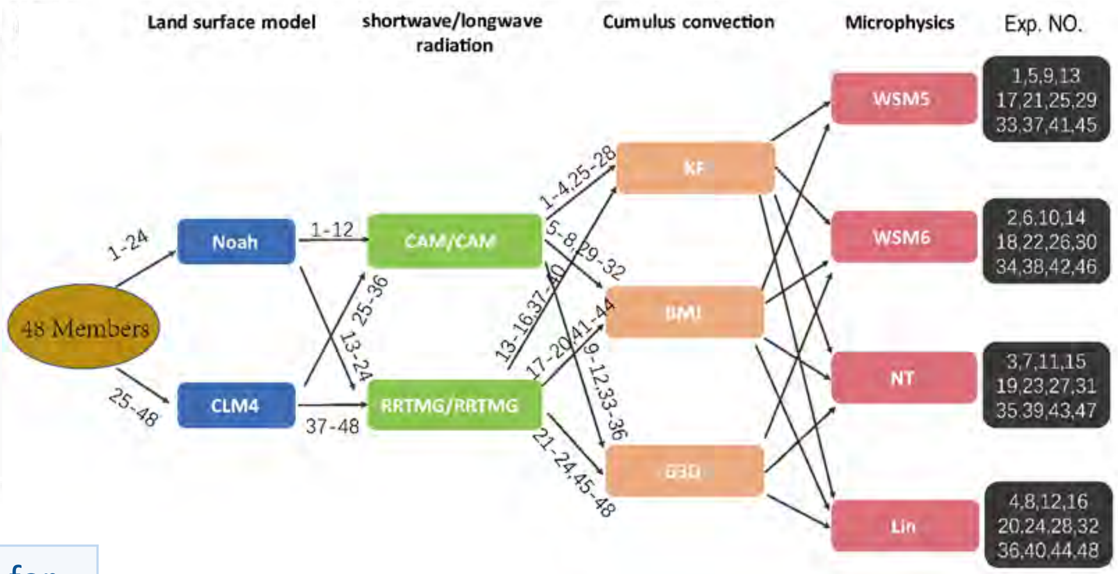
In 2003 summer, Southern part of China was influenced by both **temperature and precipitation extremes**.

According to China Climate Bulletin, during **the Meiyu period** (June 21-July 22), six heavy rainfall episodes occurred across the Huaihe River Basin.

More than **580 million** people were affected by the flood disaster, and direct economic losses was more than **35 billion yuan**. http://www.gov.cn/test/2005-07/01/content_11651.htm

Experiments design



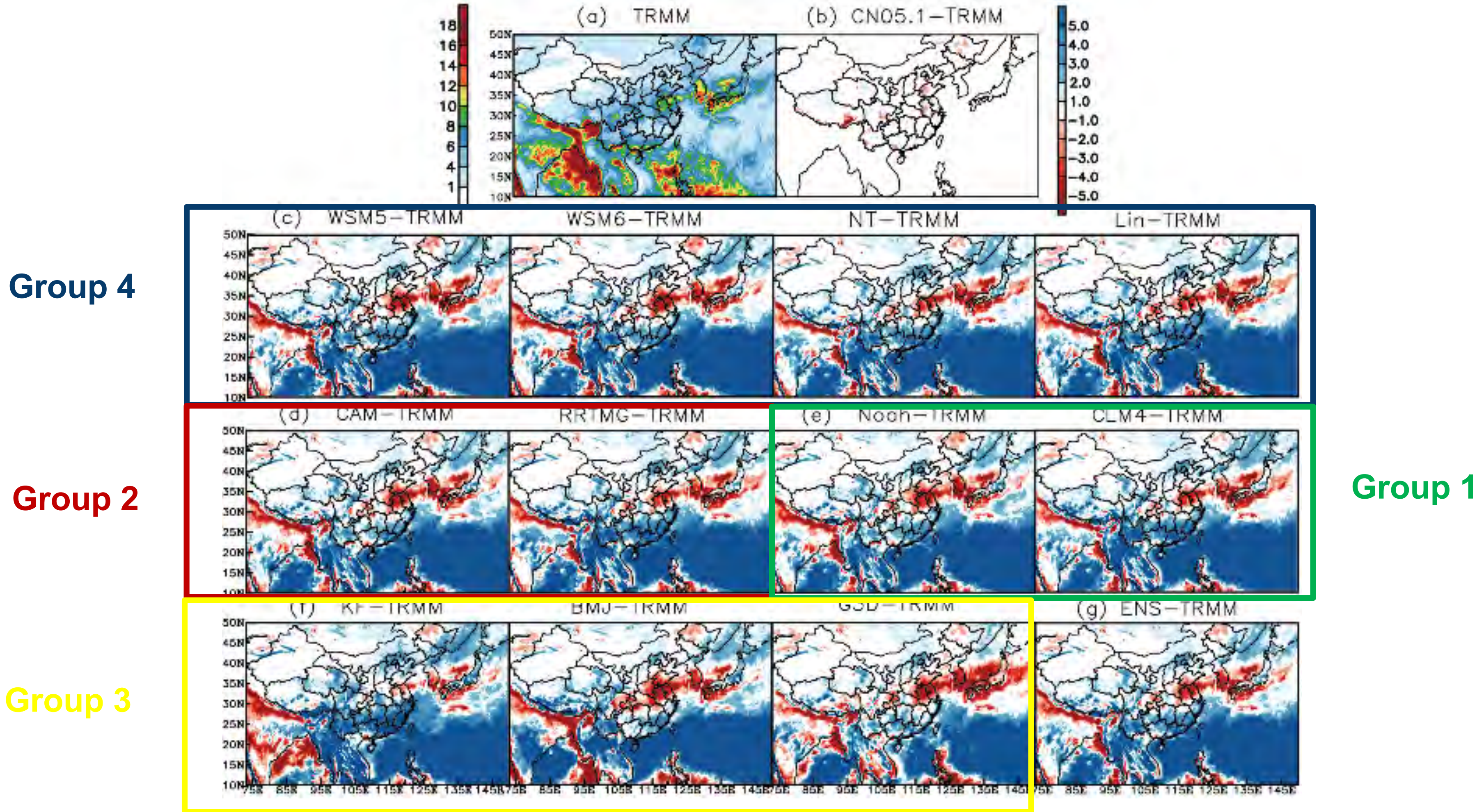


Time period	May 16- August 31 (first 16 days for spin-up)
Model	WRF Version3.6.1
Driving fields	ERA-interim 0.75×0.75°
Horizontal resolution	25 km
Model validation	TRMM for pre. and CN05.1 for land pre. and temp.

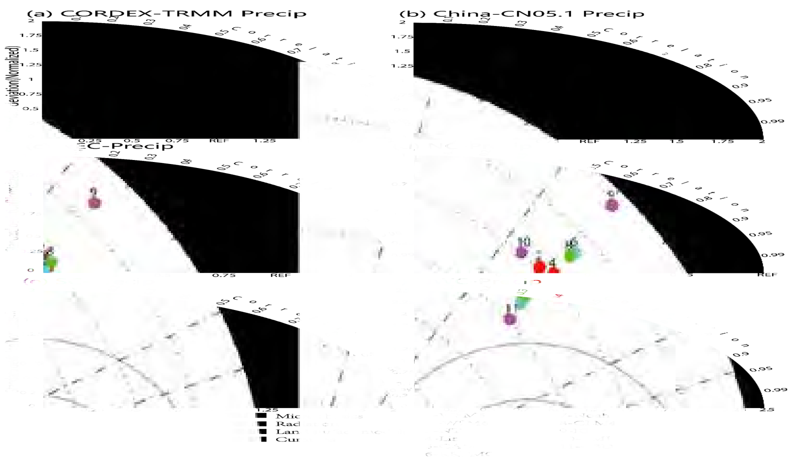
To describe the differences between the 48 physical combinations clearly, we divided them into **four major groups** and **eleven subgroups** according to their **physics option**.

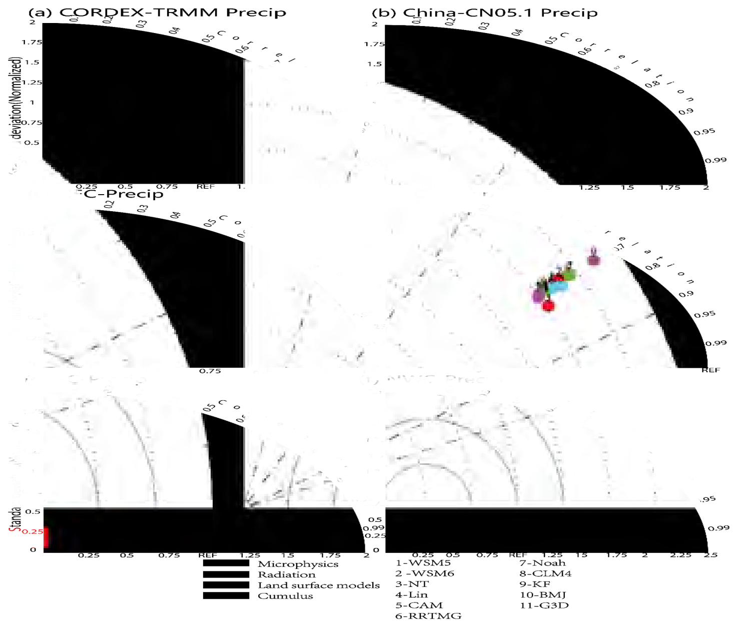
Results

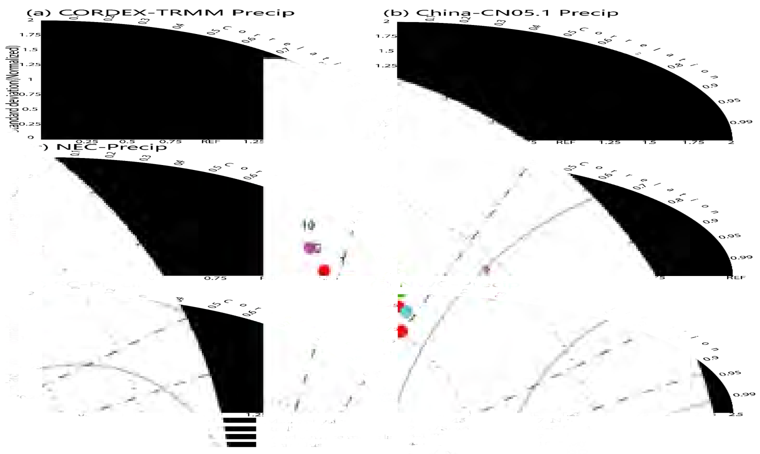
Spatial distribution of JJA mean precipitation biases against TRMM (mm/day)



Taylor diagram for JJA mean precipitation over subregions





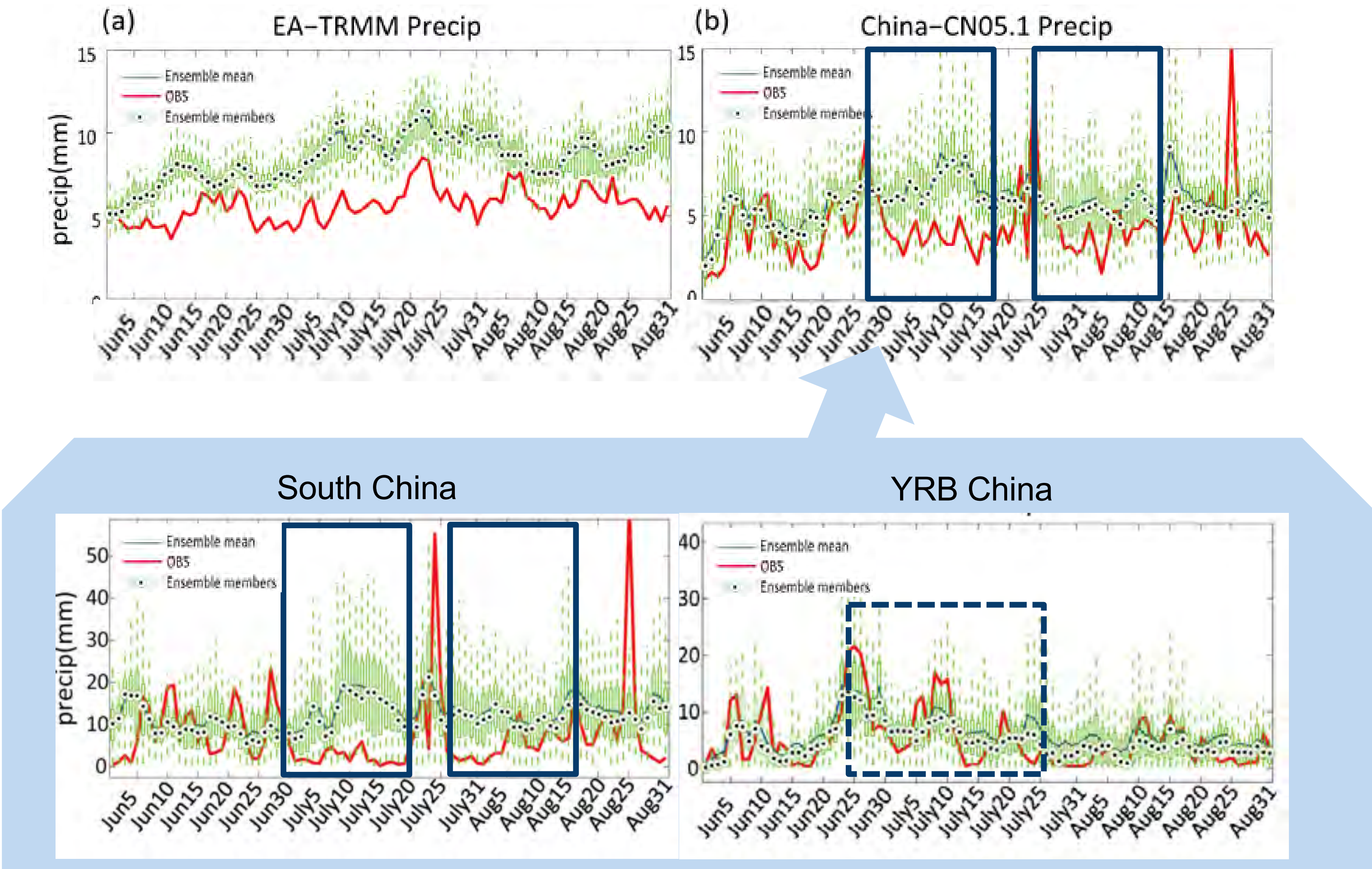


- ✓ **Dependence of physical schemes is scale-and-region related**
- ✓ **More pronounced effect of CU schemes**

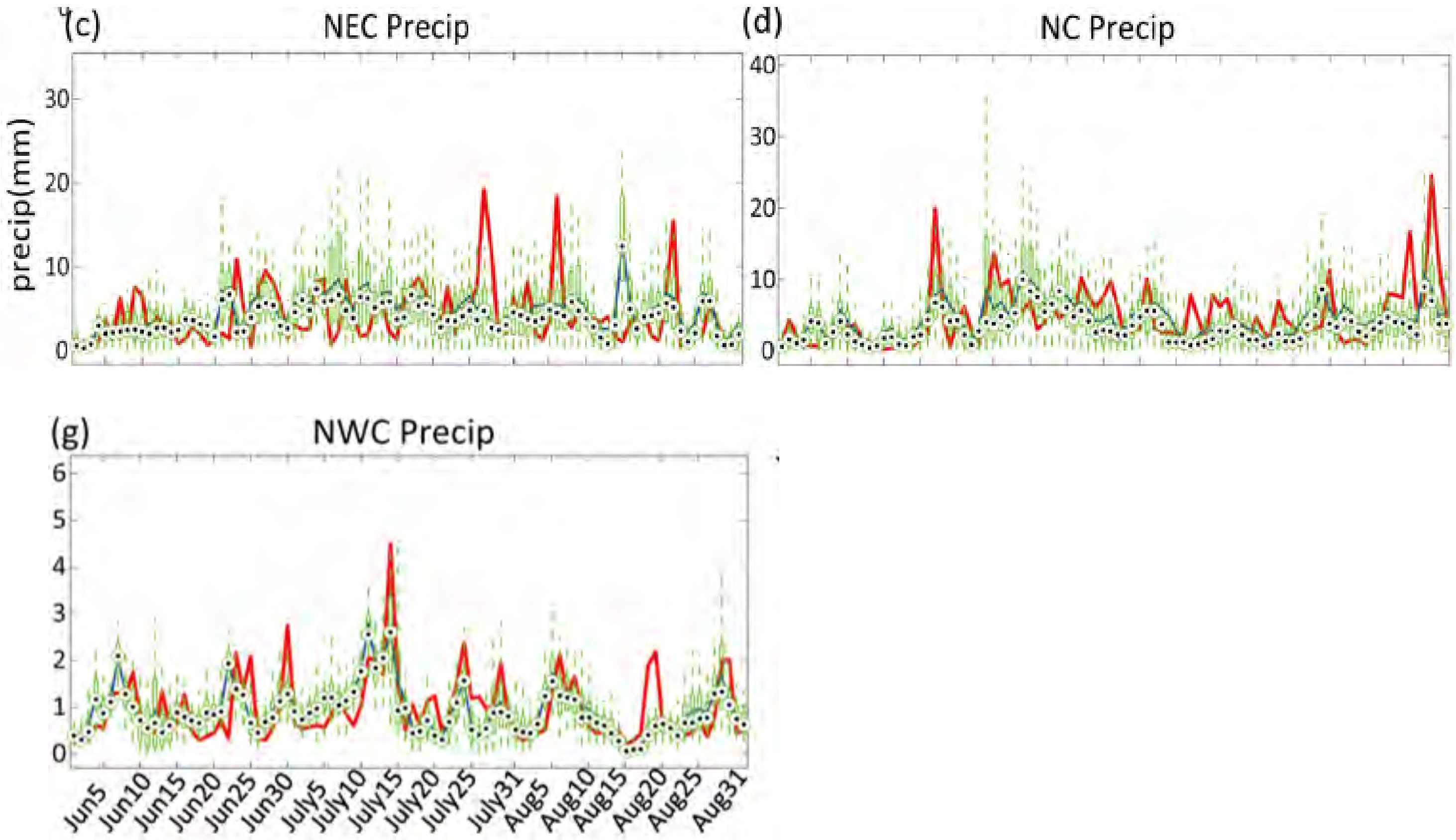
11 Subregional correlation coefficients and RMSE for JJA precipitation

	Regions	MP schemes				RA schemes		LSMs		Cu schemes		
		WSM5	WSM6	NT	Lin	CAM	RRTMG	Noah	CLM4	KF	BMJ	G3D
Correlation	CORDEX	0.69	0.68	0.70	0.69	0.67	0.70	0.68	0.70	0.68	0.53	0.68
	China	0.71	0.70	0.76	0.72	0.72	0.72	0.72	0.72	0.71	0.65	0.73
	NEC	0.47	0.47	0.61	0.72	0.70	0.48	0.52	0.63	0.36	0.58	0.75
	NC	0.35	0.24	0.54	0.60	0.29	0.57	0.35	0.52	0.71	0.18	0.19
	YRB	-0.34	-0.23	-0.22	-0.41	-0.25	-0.37	-0.32	-0.32	-0.30	-0.33	-0.17
	SC	0.49	0.58	0.57	0.49	0.52	0.55	0.56	0.50	0.22	0.54	0.67
	NWC	0.81	0.80	0.83	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
RMSE	CORDEX	1.08	1.11	1.07	1.05	1.10	1.05	1.07	1.09	1.37	1.37	1.03
	China	1.05	1.09	0.99	1.07	0.93	1.17	0.96	1.15	1.41	1.15	[illegible]
	NEC	[illegible]	0.96	[illegible]	[illegible]	[illegible]	1.00	[illegible]	[illegible]	1.22	[illegible]	[illegible]
	NC	0.96	1.02	[illegible]	[illegible]	0.98	[illegible]	0.94	[illegible]	[illegible]	1.07	1.02
	YRB	1.47	1.49	1.47	1.75	1.39	1.65	1.44	1.59	1.86	1.54	1.42
	SC	1.28	1.23	1.35	1.38	1.32	1.29	1.31	1.34	1.98	1.55	1.15
	NWC	1.42	1.47	1.31	1.52	1.45	1.41	1.52	1.37	1.66	1.33	1.34

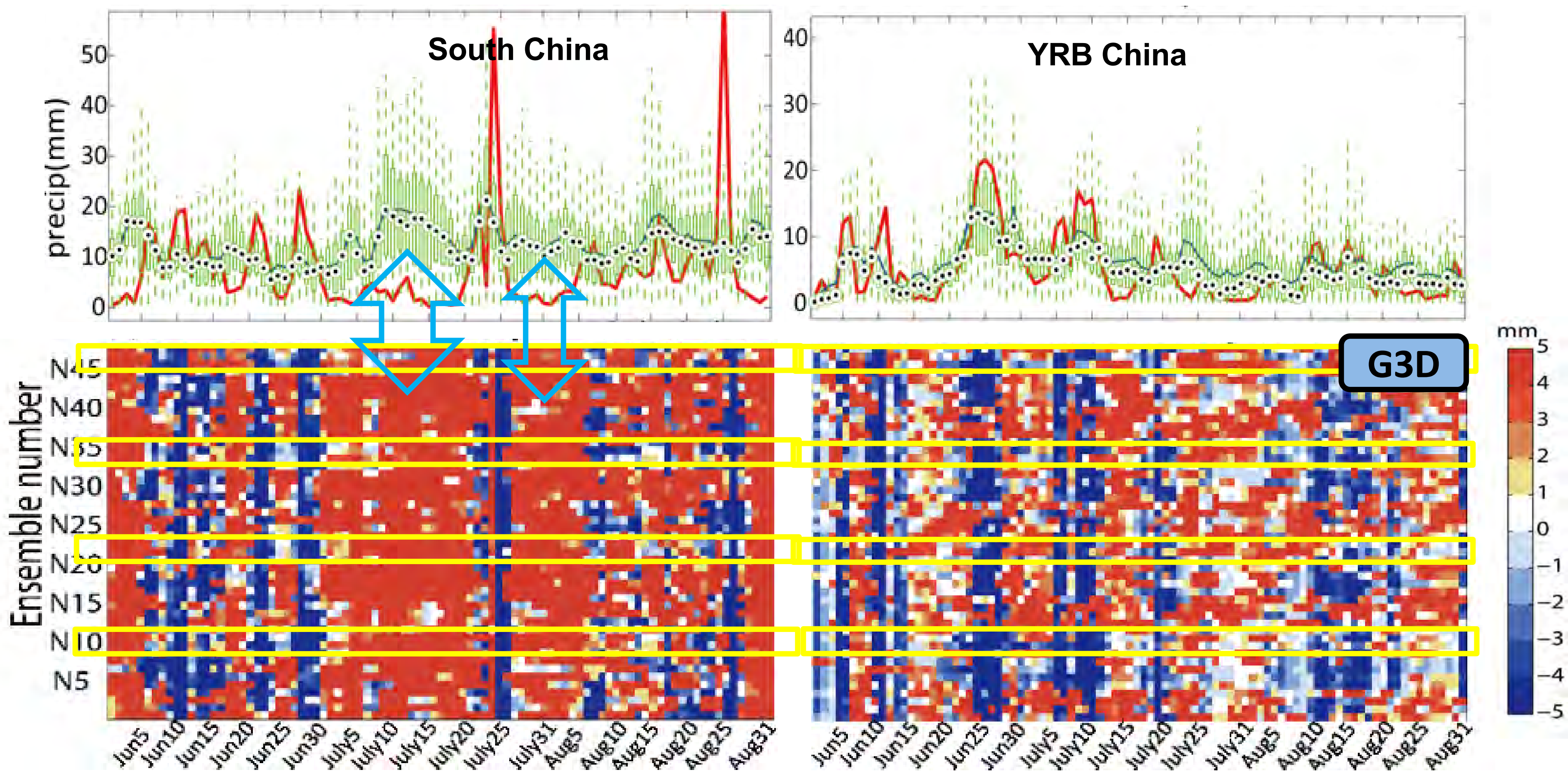
Temporal evolution of daily precipitation over CORDEX-EA and southern subregions



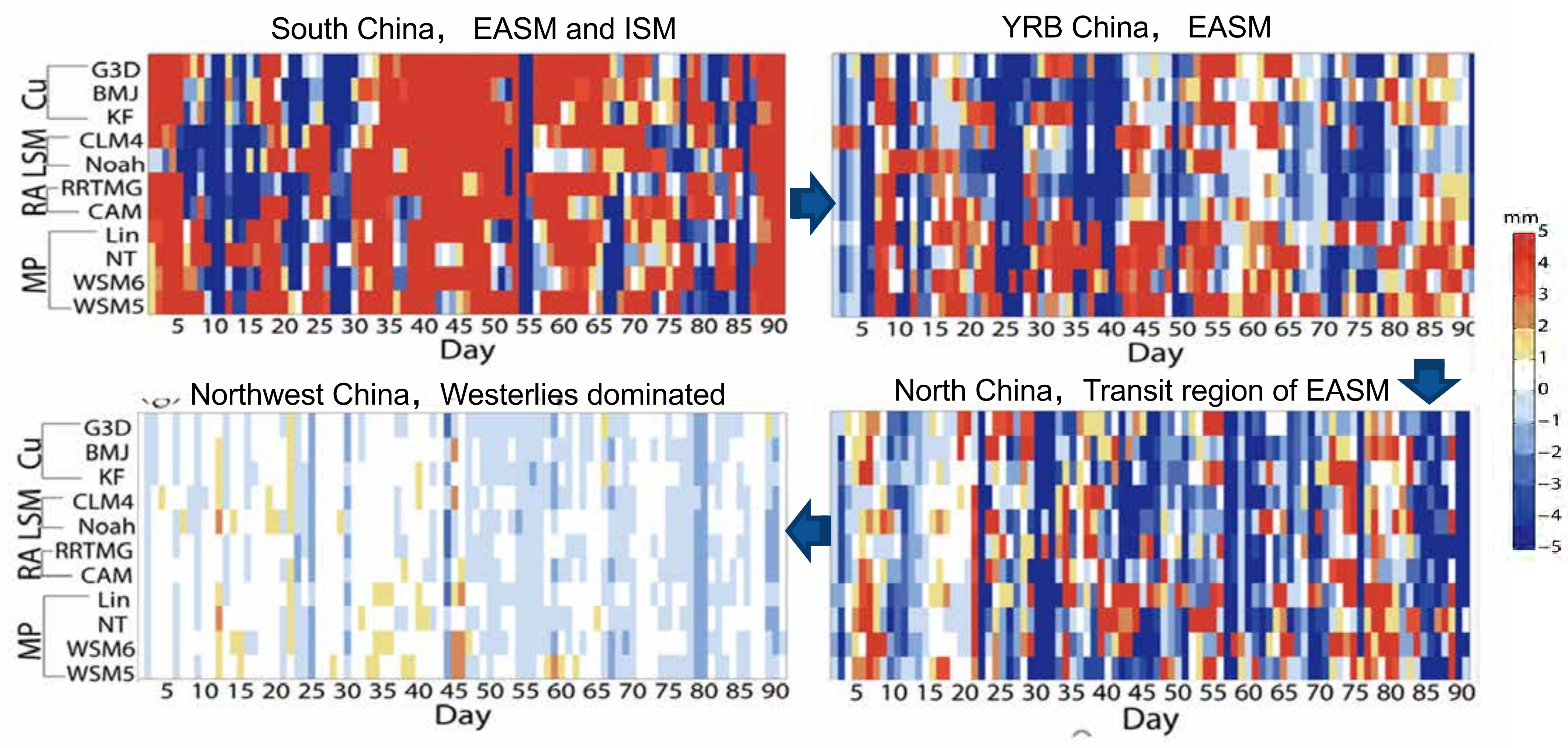
Temporal evolution of daily precipitation over northern subregions



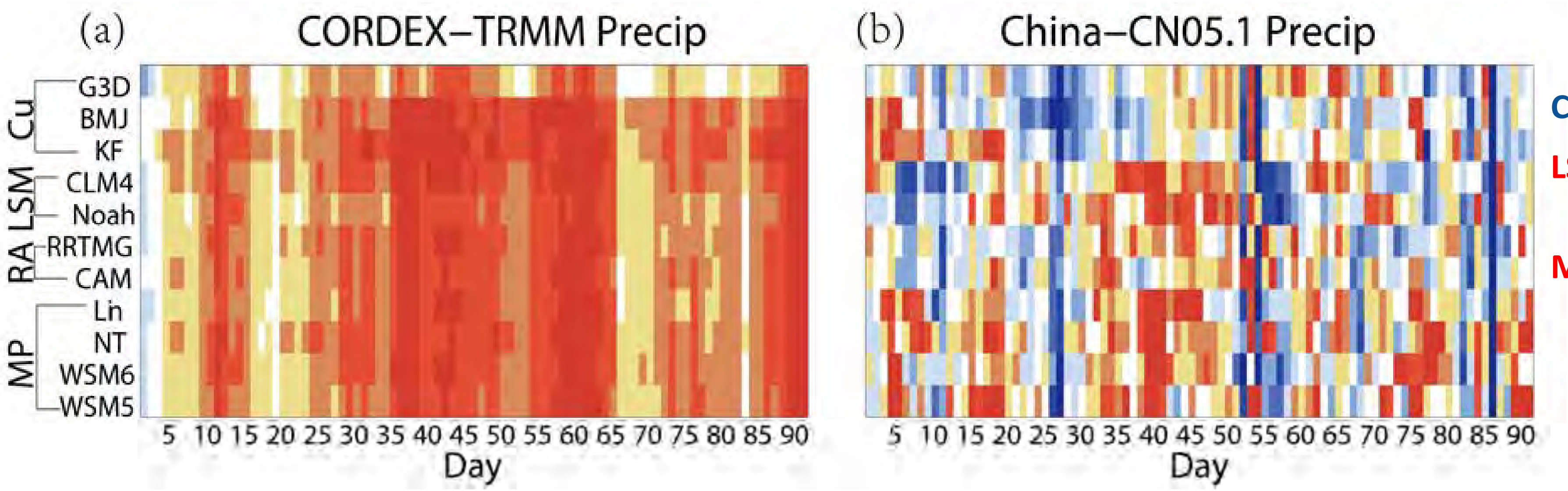
Impact of model physical schemes on temporal evolution of daily precipitation over southern subregions



The sensitivities of daily precipitation to model physics



Subgroups' performance for daily precipitation



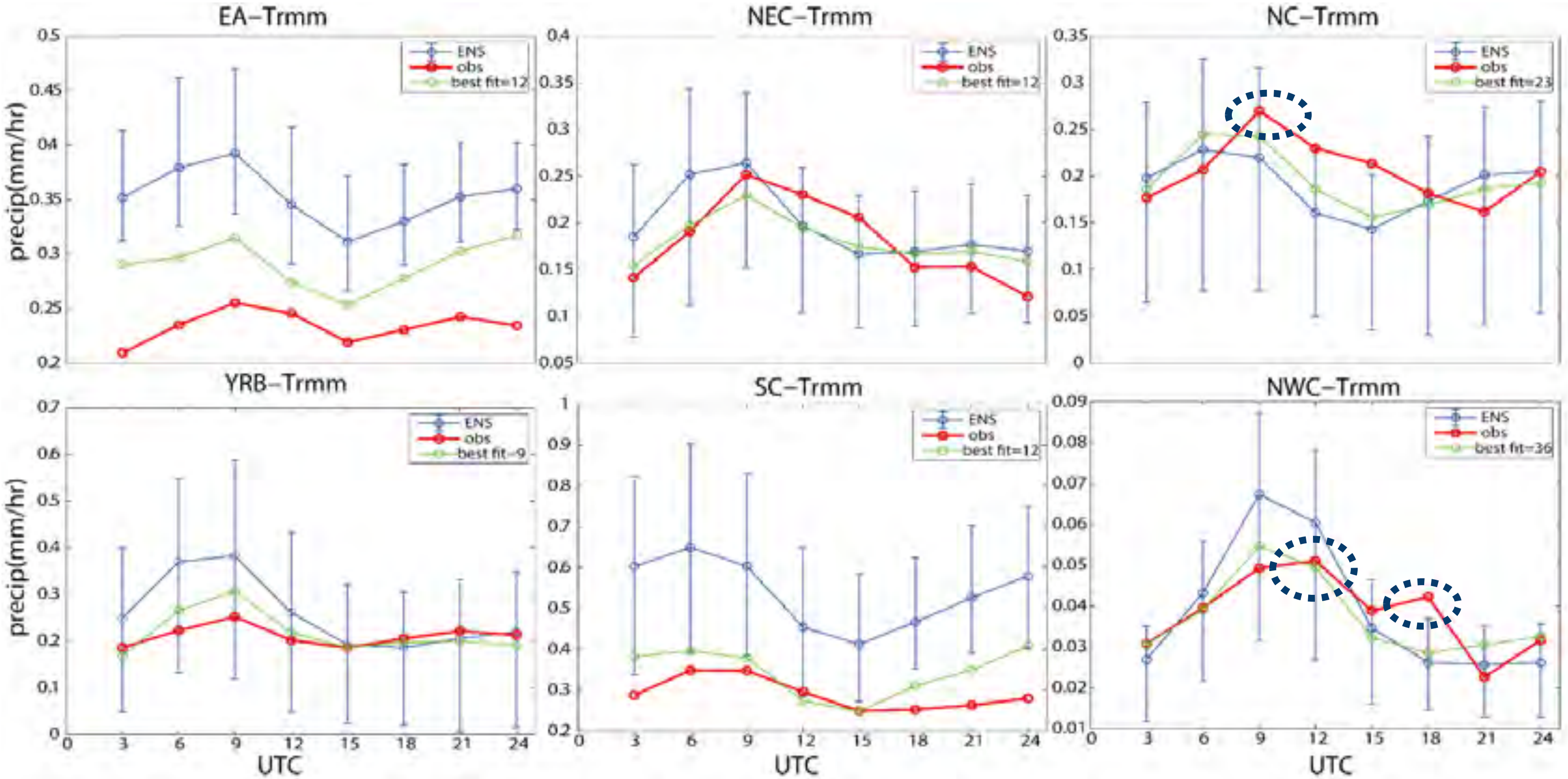
Cu underestimat

LSM overestimat

MP overestimate

- The sensitivities of daily precipitation to model physics

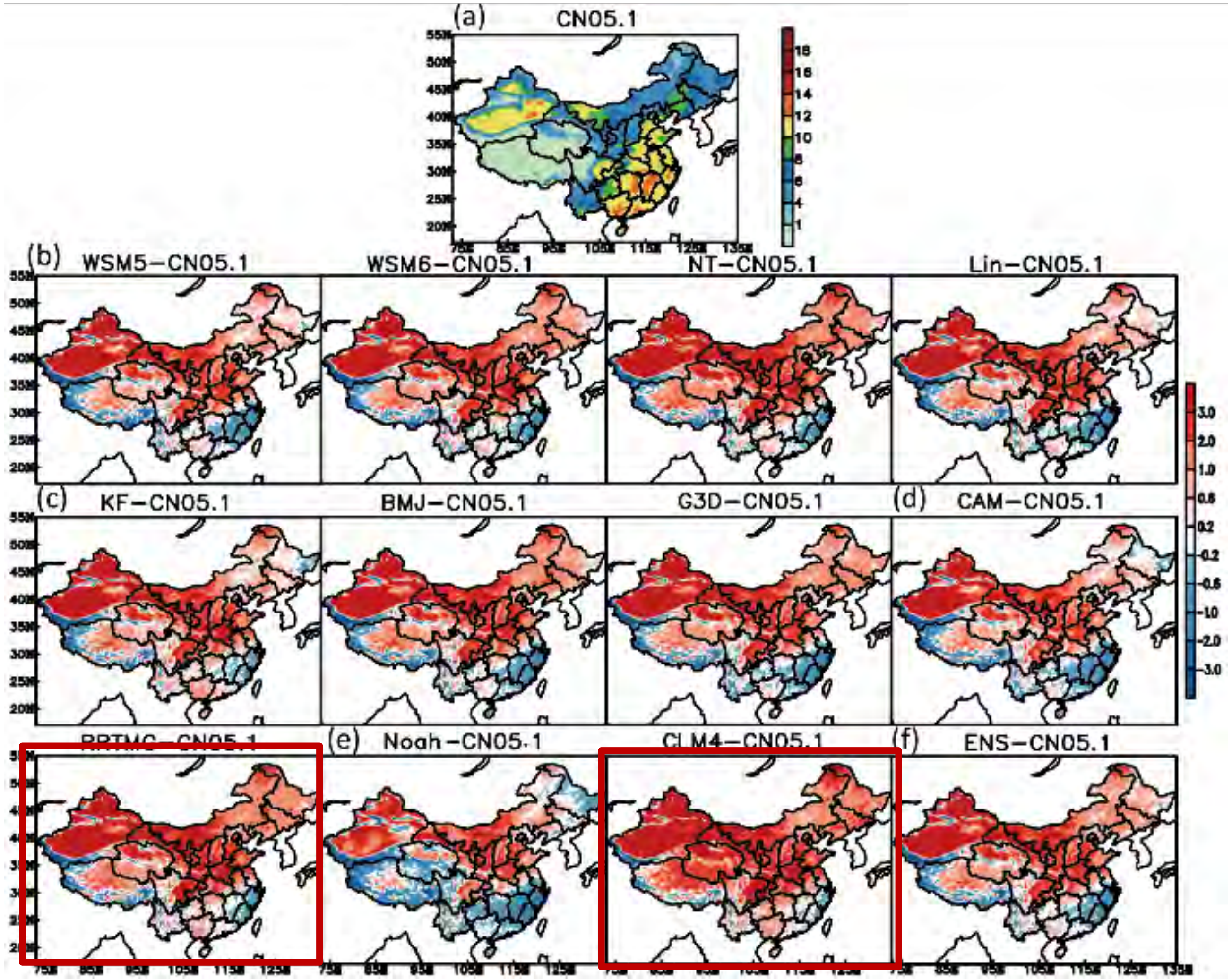
Diurnal cycle



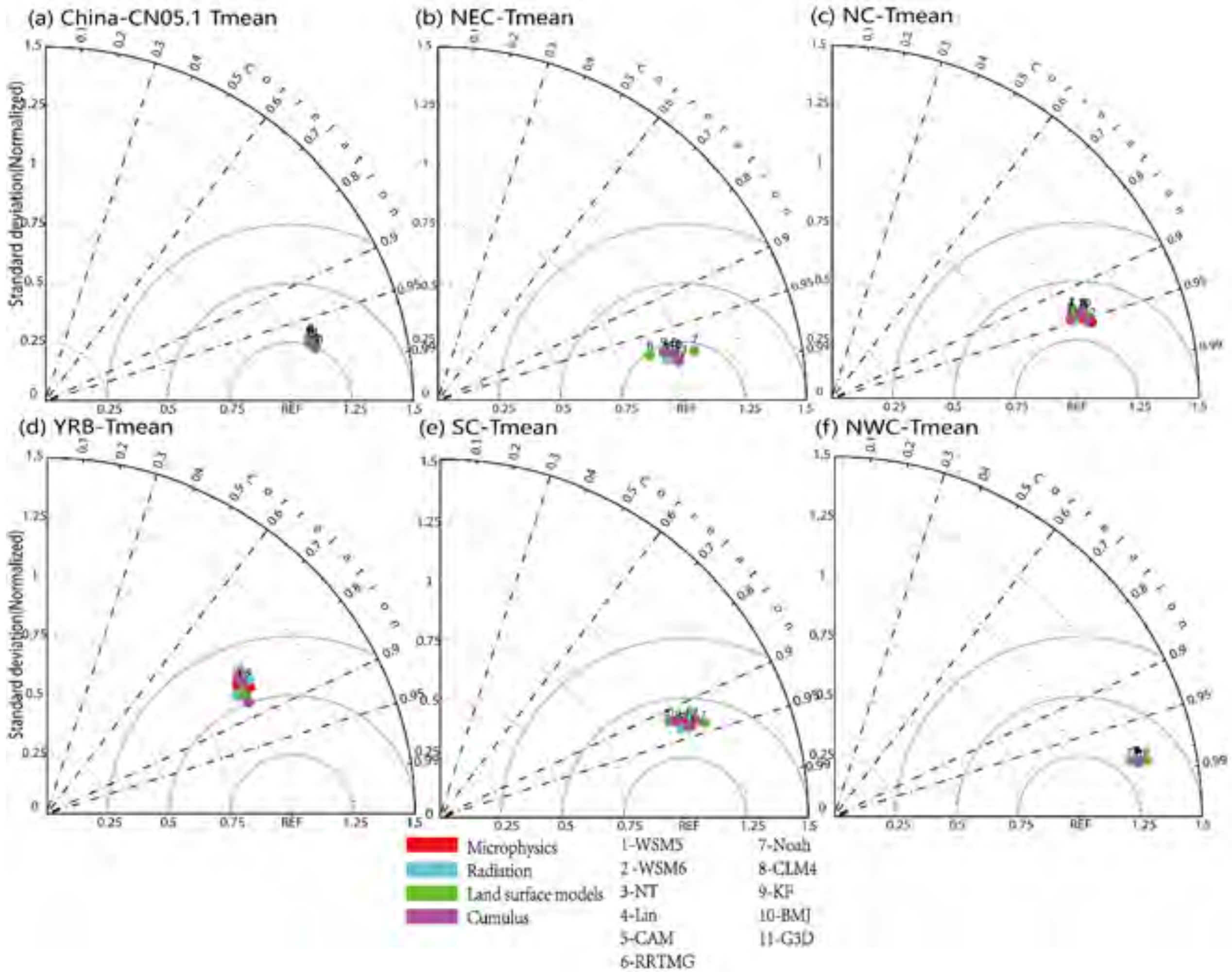
- Diurnal cycle of 2003 JJA precipitation averaged over China and five subregions

✓ The experiments with **CAM radiation and G3D microphysics** schemes, namely Exp.12 and 36, present the best simulation of precipitation **diurnal variation** over most sub-regions and CORDEX-EA domain.

Spatial distribution of JJA mean T_{2m} Bias (°C)



Taylor diagram for JJA mean T_{2m} over subregions

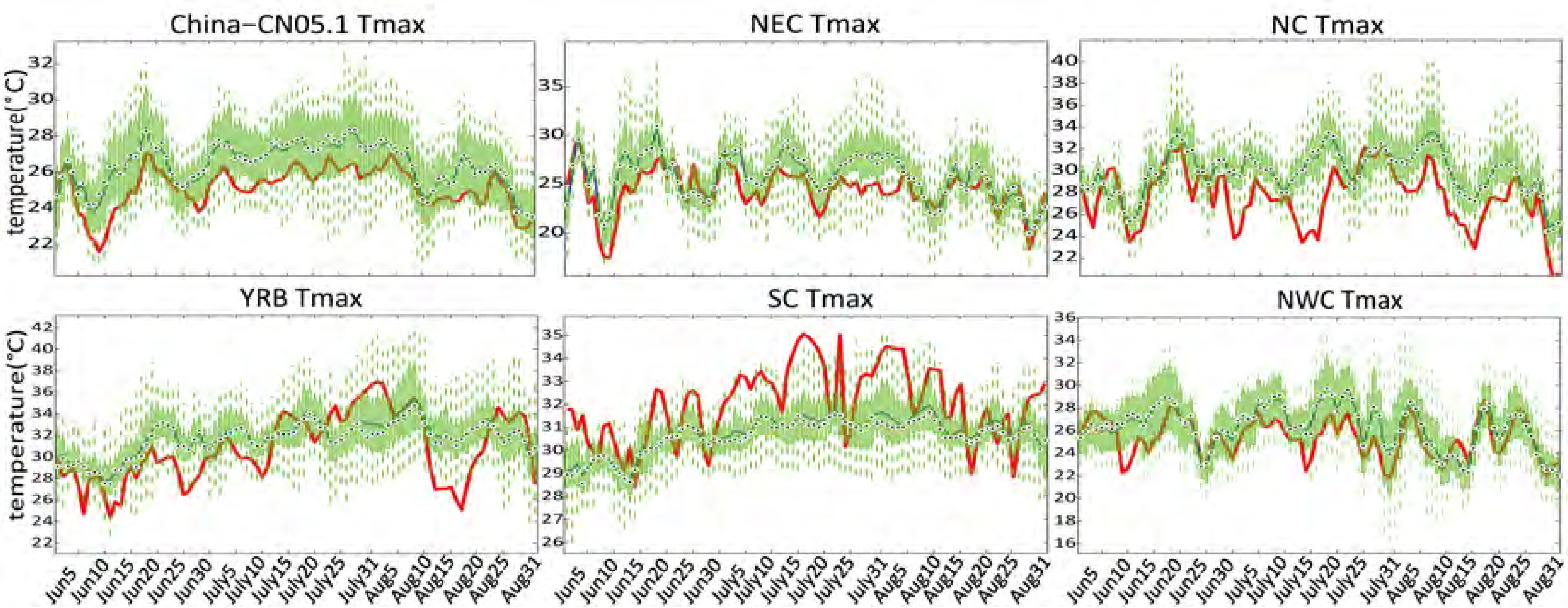


✓ JJA precipitation is **more sensitive** to physics than temperature.

Subregional correlation coefficients and RMSE 11 subgroups for JJA T2m

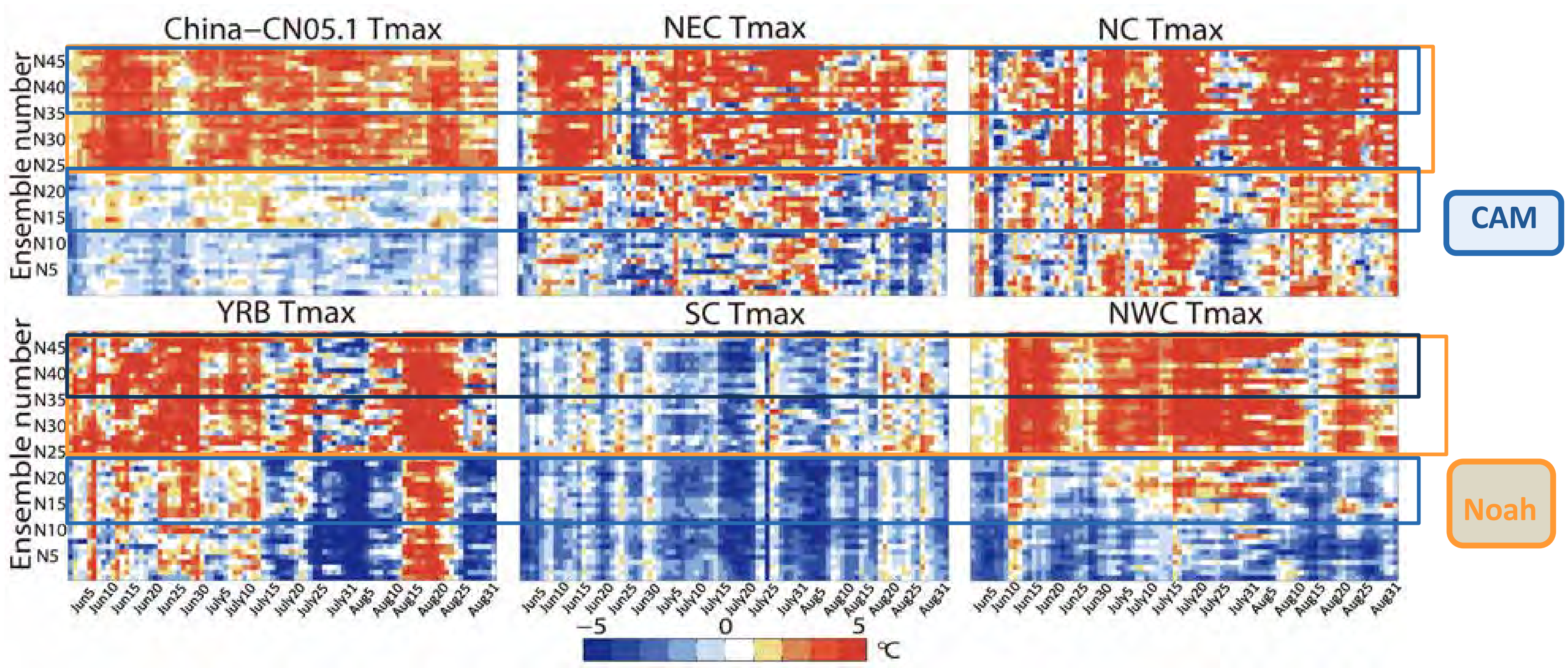
	Regions	MP schemes				RA schemes		LSMs		Cu schemes		
		WSM5	WSM6	NT	Lin	CAM	RRTMG	Noah	CLM4	KF	BMJ	G3D
Correlation	China	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.97	0.98	0.98	0.97
	NEC	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.99
	NC	0.95	0.96	0.94	0.94	0.95	0.95	0.94	0.95	0.95	0.94	0.94
	YRB	0.84	0.84	0.82	0.82	0.84	0.82	0.85	0.82	0.87	0.80	0.82
	SC	0.93	0.94	0.93	0.93	0.94	0.93	0.94	0.92	0.93	0.92	0.94
	NWC	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
RMSE	China	0.25	0.25	0.26	0.26	0.25	0.26	0.25	0.28	0.25	0.26	0.26
	NEC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.24	[illegible]	[illegible]	[illegible]
	NC	0.34	0.33	0.35	0.37	0.33	0.36	0.37	0.36	0.34	0.37	0.34
	YRB	0.54	0.56	0.59	0.59	0.55	0.59	0.55	0.60	0.50	0.62	0.59
	SC	0.39	0.38	0.39	0.40	0.37	0.42	0.40	0.41	0.41	0.40	0.38
	NWC	0.33	0.33	0.33	0.34	0.33	0.34	0.31	0.36	0.33	0.33	0.33

Temporal evolution of Tmax



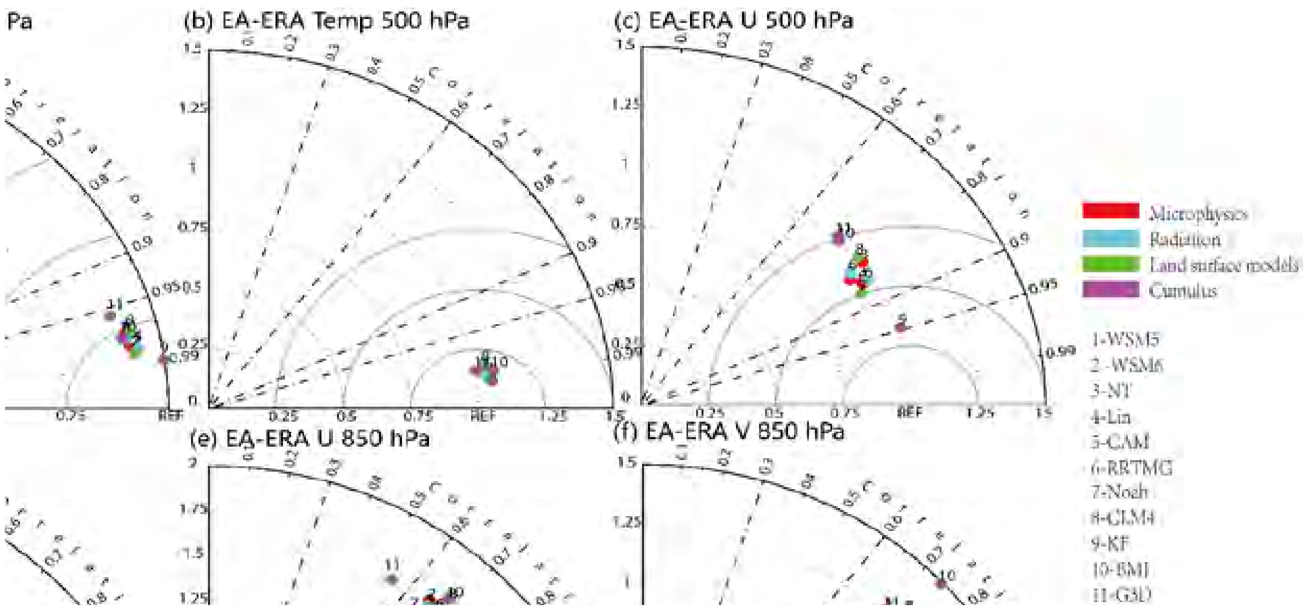
- ✓ The responses of model's temporal evolution of temperature to the physical parameterizations can be region-dependent.

Daily bias of Tmax



✓ The influences of **land surface and radiation** being the two top dominating parameterizations for model to reproduce the **Tmax** in China.

Large-scale fields at lower-to-midle level atmosphere



✓ **Cumulus activity** and **land surface process** can both influence the atmospheric heating and temperature distribution of **middle-level atmosphere**, which further induces a distinctly response of **circulation**.

Conclusion

- ✓ The performances for the combinations of physical schemes in WRF for JJA precipitation in 2003 depend observably on the regions.
- ✓ Cumulus convection is the controlled factor for precipitation simulation while the land surface model and radiation can affect hot weather efficiently over EA.
- ✓ Noah land surface model, G3D cumulus and CAM radiation scheme are the most reliable physical combination for JJA 2003 climate in China.
- ✓ The low-mid atmosphere shows strong sensitivity to land surface model and cumulus schemes when there were active convective systems.

Thank you