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Evaluation of routed-runoff from land surface models and reanalyses using observed streamflow in China river basins

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Background

- China, **continental monsoon climate**
- Offline, land surface models (**LSMs**), reproduce **streamflow** in large river basins
- Many runoff products exist, but **quantitative evaluation and inter-comparisons** are very few for China

Flood events in China, 2018

7.6-12, Gansu

7.18-22, Inner Mongolia

8.16-20, Anhui

8.27-9.1, Guangdong

Source: *2018 Major natural disasters report*
National disaster reduction office

Runoff products

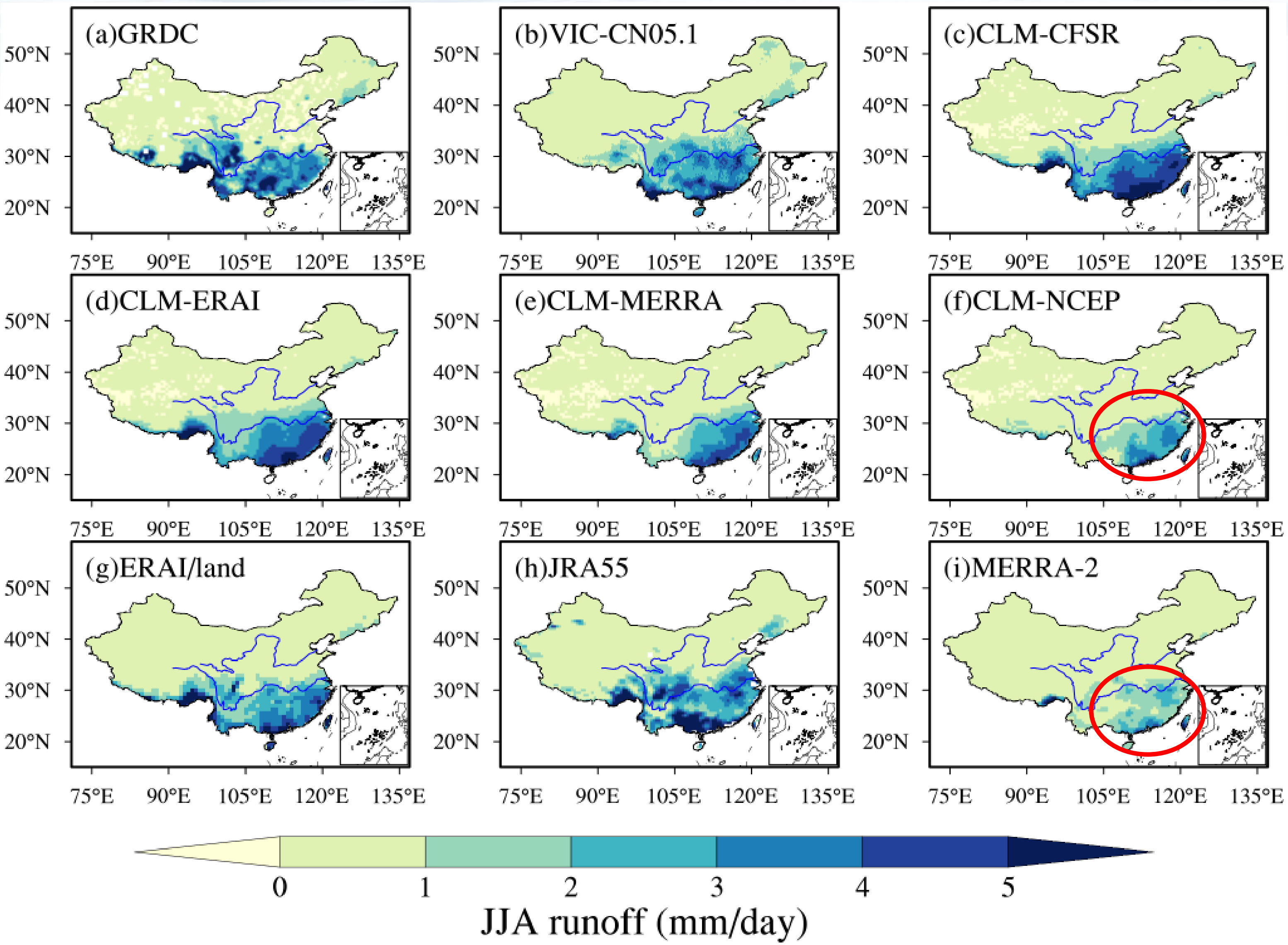
No.	Name	LSMs	Forcing	Prec.	Resolution	Duration	Source
1	VIC-CN05.1	VIC4.2.d	CN05.1	--	0.25°x0.25°	1961-2017	(Miao and Wang 2019)
2	CLM-CFSR	CLM4.5	CFSR	GPCP v2.2	0.5°x0.5°	1979-2009	(Wang, et al. 2016)
3	CLM-ERAI		ERAI				
4	CLM-MERRA		MERRA				
5	CLM-NCEP		NCEP-NCAR	CRU TS v3.1			
6	ERAI/Land	HTESSEL	ERAI	GPCP v2.1	0.75°x0.75°	1979-2010	(Balsamo, et al. 2015)
7	JRA55	SiB	JRA55	--	T319(~55km)	1958-2012	(Ebita, et al. 2011)
8	MERRA-2	Catchment	MERRA-2	CPCU, CMAP	0.5°x0.625°	1980-now	(Gelaro, et al. 2017)

- No. 1 → Offline, **observational** forcing data
- No. 2–5 → Offline, **reanalysis** forcing data
- No. 6 → Offline, **land-only** reanalysis product
- No. 7–8 → Offline, with **weakly coupled** LDASs

VIC-CN05.1 runoff, VIC4.2.d which has the **newest** parameterization schemes, driven by **station-based** atmospheric forcing data, and **soil parameters** from high resolution soil datasets based on field survey.

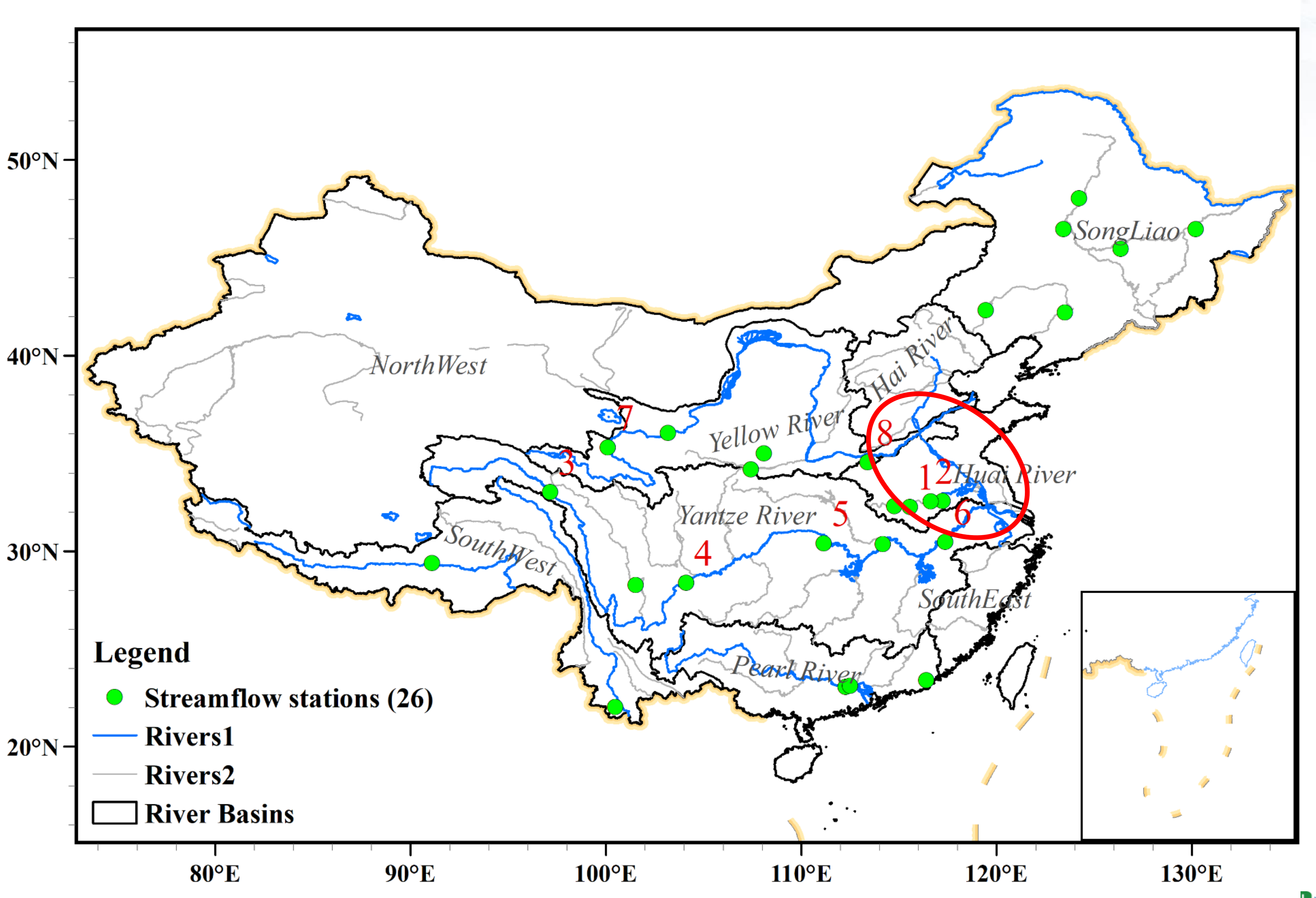
More details about it seeing poster - ***Estimates of the terrestrial hydrology for the conterminous China during 1961-2017***

Simulated runoff vs GRDC in JJA during 1980-2009



- GRDC **composite runoff field** (Fekete, et al. 2002)
- Spatial patterns, **similar**
- **CLM-NCEP and MERRA-2**, much smaller, in **southeast** China

Hydrological stations in China during 1980-2008



Total drainage area (10^4 km^2) :

Huai river basin: 27;

Yangtze river basin: 180;

Yellow river basin: 75.

Which are prone to floods

Selected stations:

1-Huai_Wangjiaba

2-Huai_Bengbu

3-Yangtze_Zhimenda

4-Yangtze_Pingshan

5-Yangtze_Yichang

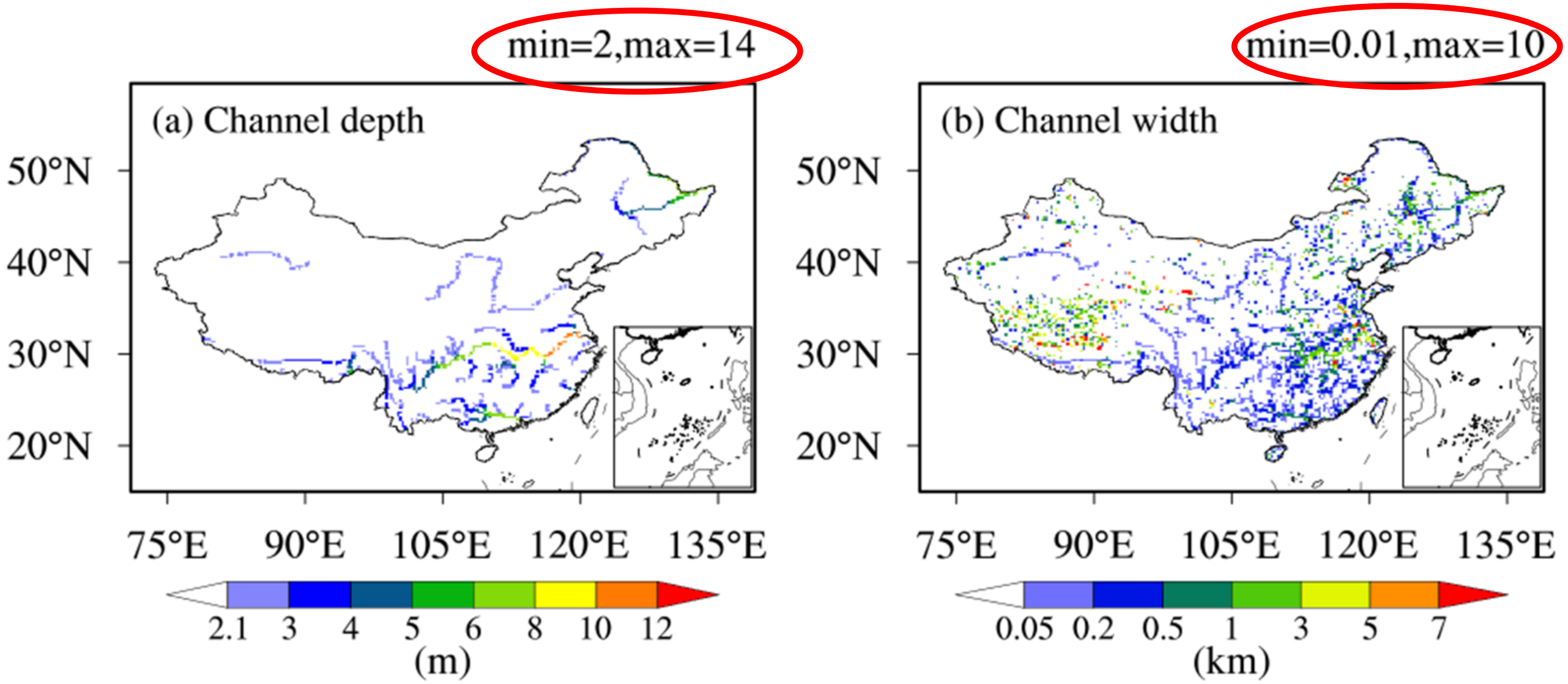
6-Yangtze_Datong2

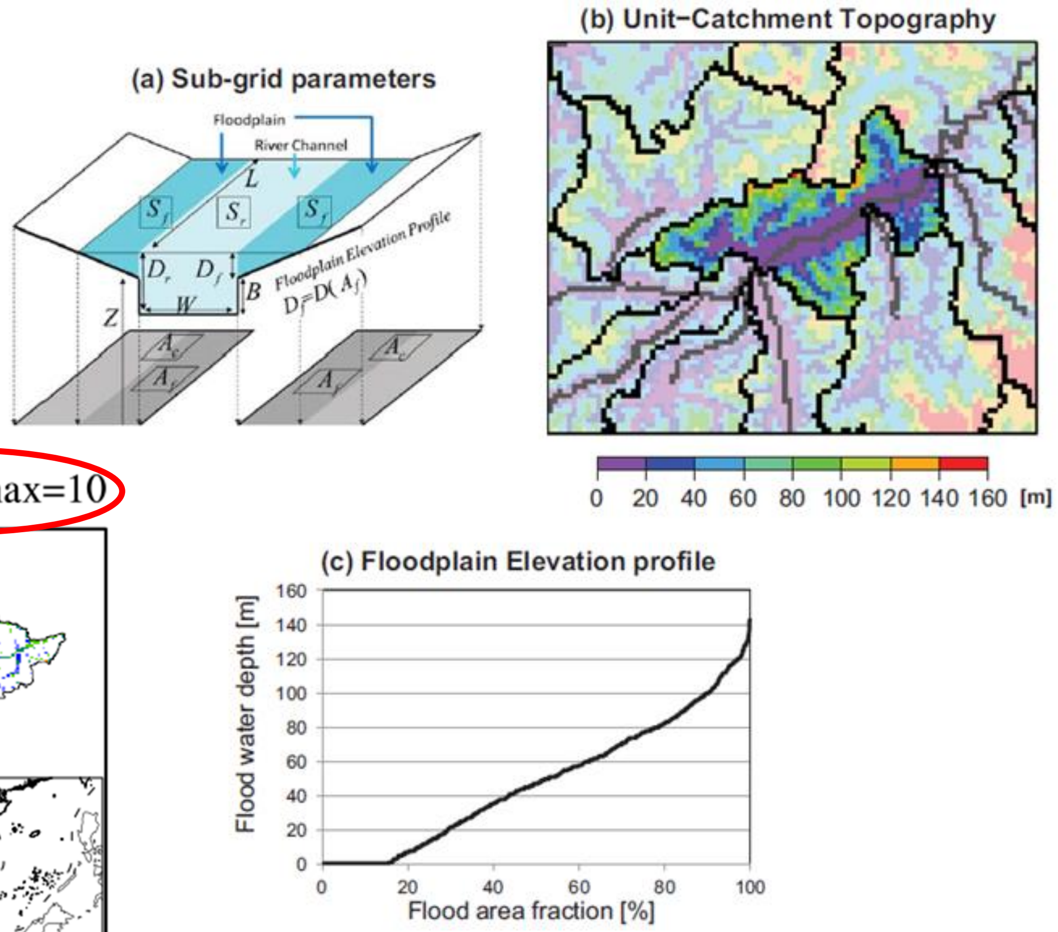
7-Yellow_Tangnaihai

8-Yellow_Huayuankou

The CaMa-Flood routing model

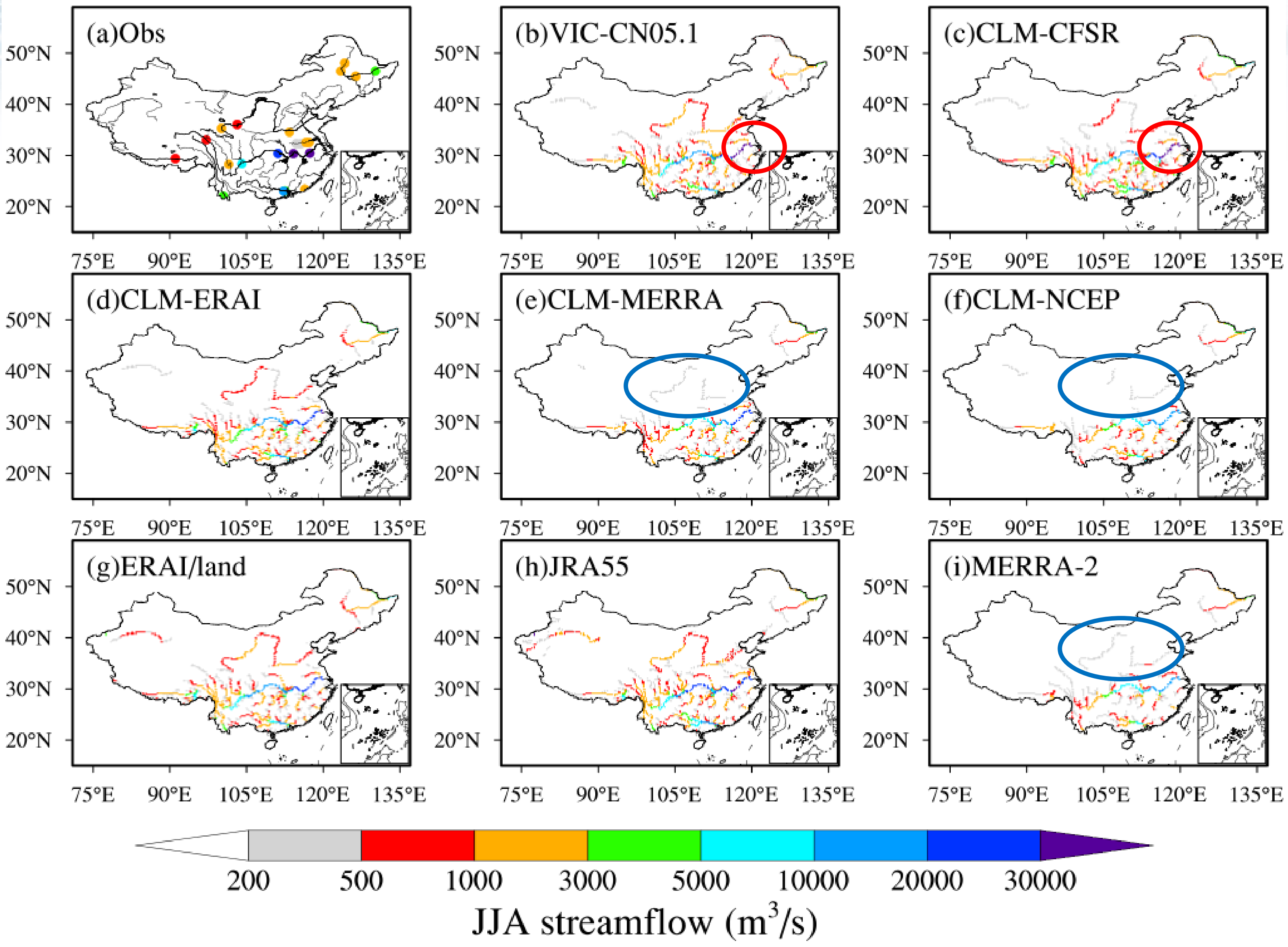
- Driven by **daily runoff** (surface + subsurface)
- Horizontal water transport: **diffusive wave equation**
- Floodplain **inundation** dynamics
- Channel depth and width: **empirical equations** + **satellite**-based river width dataset (GWD-LR).





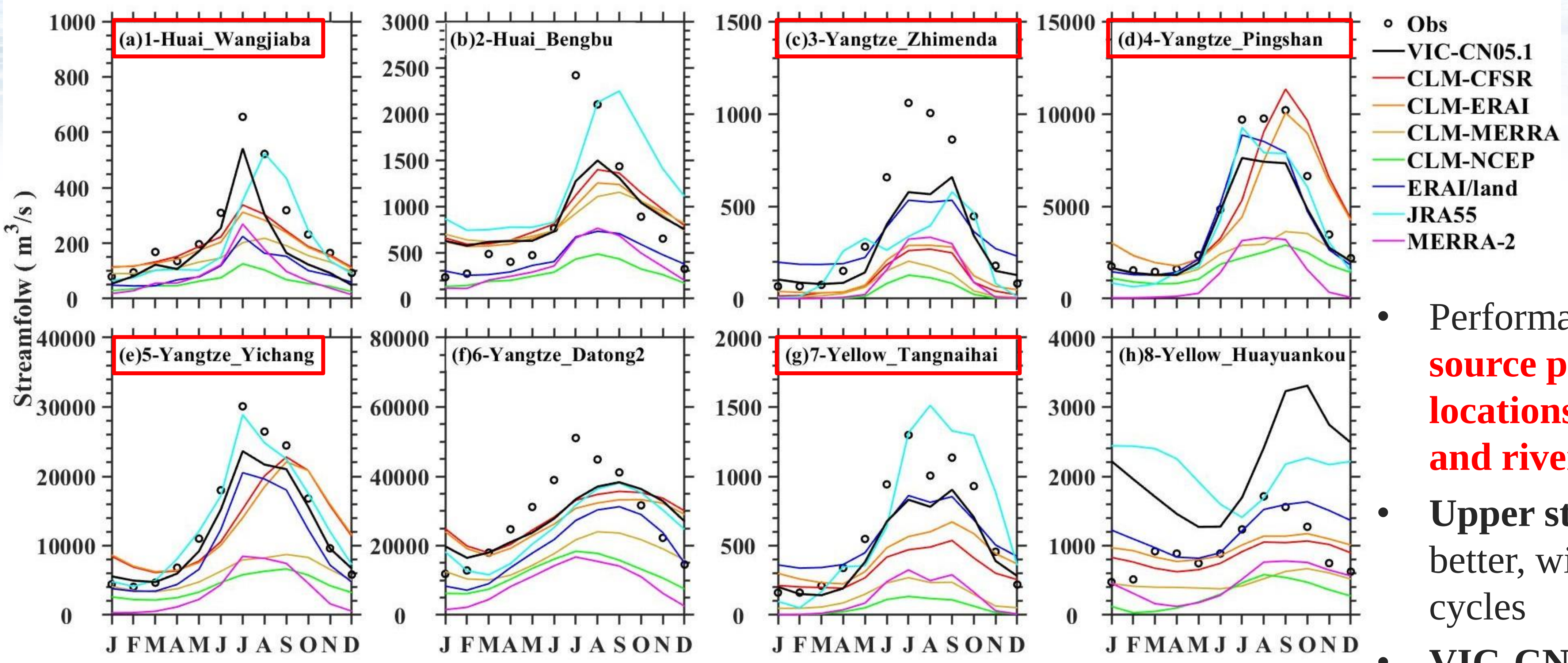
(Yamazaki, et al. 2013)

Simulated streamflow vs Obs in JJA during 1980-2008



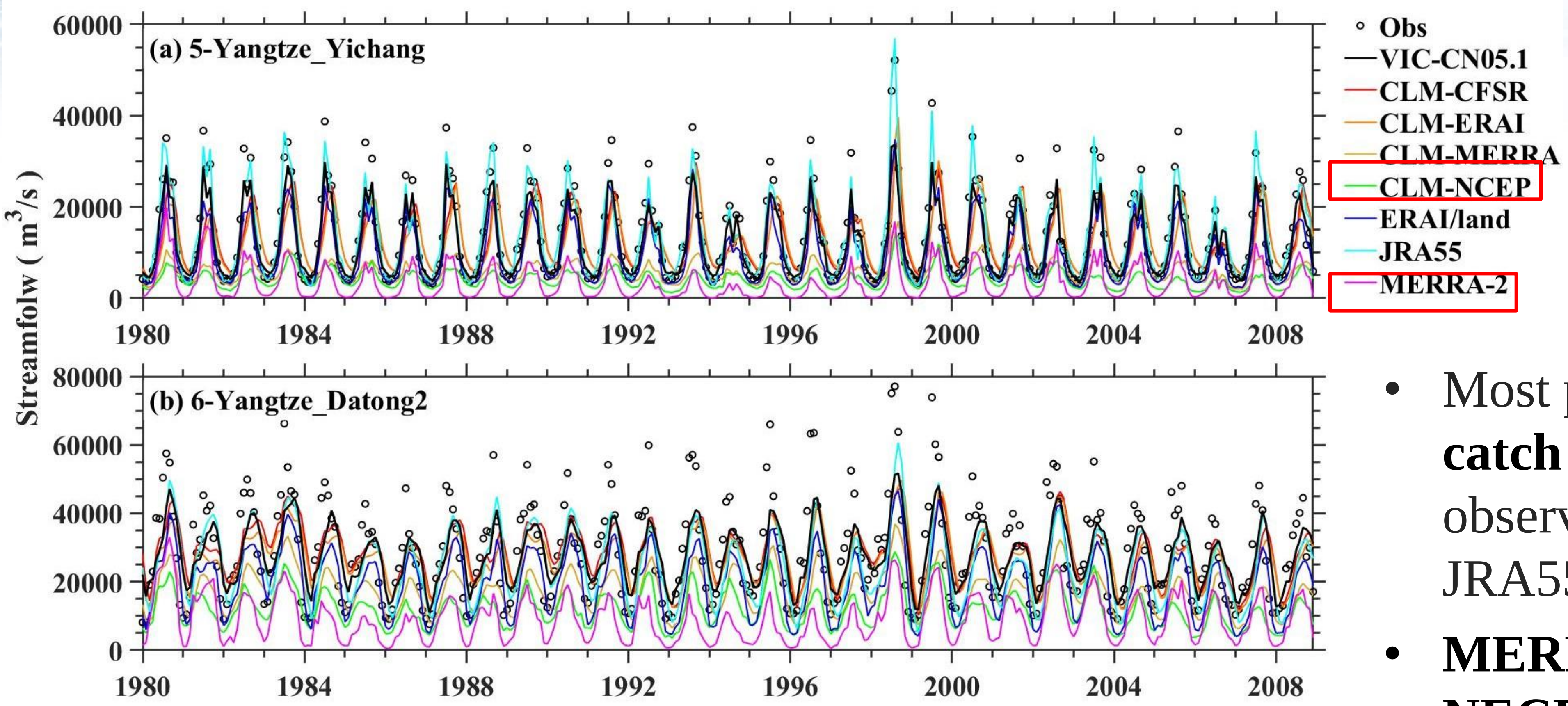
- Only **VIC-CN05.1 and CLM-CFSR**, catch **magnitude** of observed streamflow, in the middle and lower reaches of the Yangtze, in purple
- The **CLM-MERRA, CLM-NCEP, and MERRA-2** **underestimate** the streamflow in the Yellow river

Seasonal cycles during 1980-2008



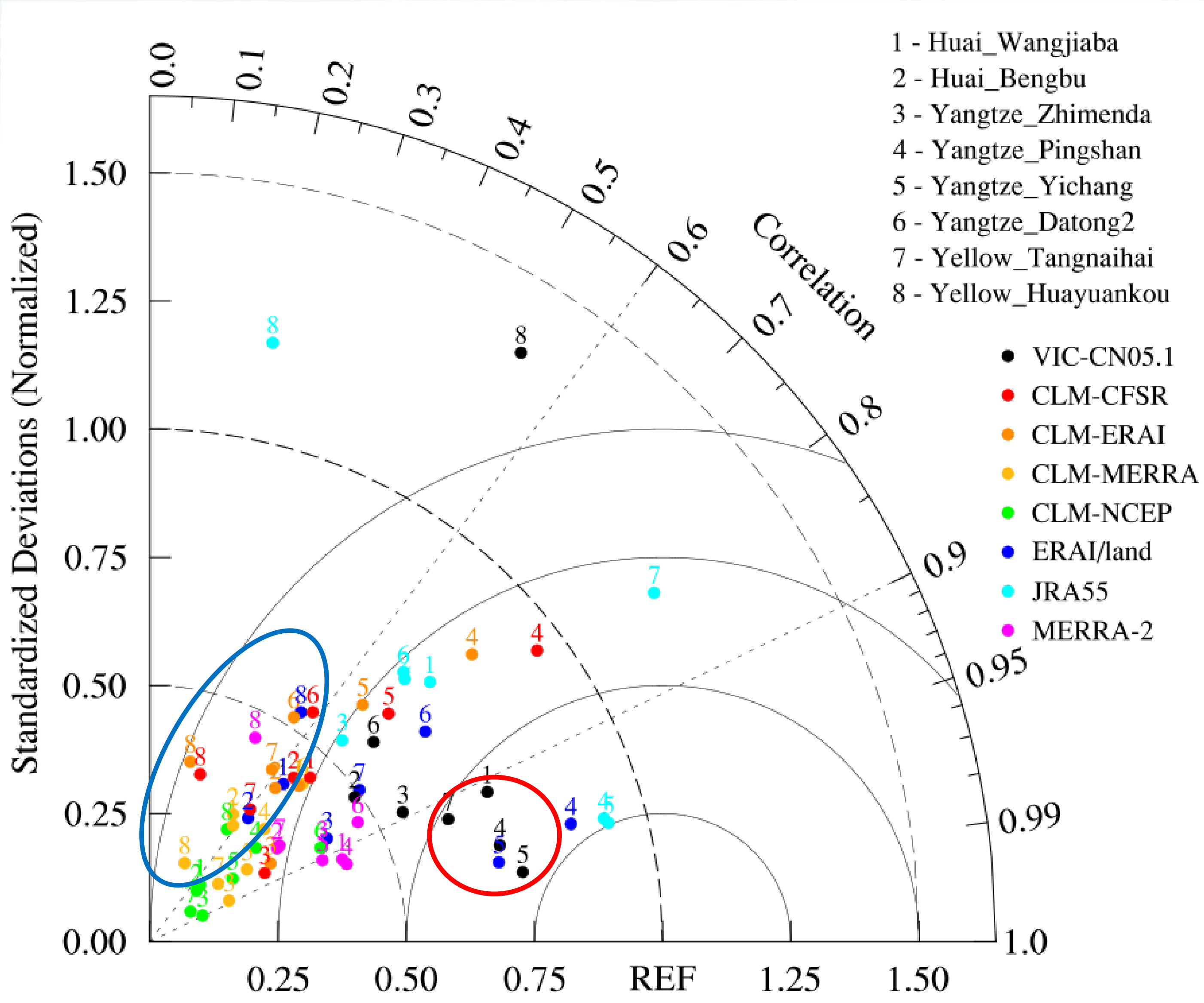
- Performances vary with **source products, station locations (upper/lower), and river basins**
- **Upper stream** stations, better, with clear seasonal cycles
- **VIC-CN05.1, JRA55, and ERAI/land**, better
- **Huai and Yangtze** river, better

Monthly streamflow in Yangtze river



- Most products **cannot catch the amplitude** of observations, except JRA55
- **MERRA-2 and CLM-NECP**, significantly smaller

Taylor diagram for monthly streamflow



- The **variabilities** of simulated streamflow are smaller than observations (std dev <1)
- Most **correlations** within 0.6-0.9
- Upper stream stations better than outlet stations (2,6,8)
- **VIC-CN05.1, best,** correlations in half stations over 0.9

NSE and RE

The best two performances, red, while the worst two, blue;

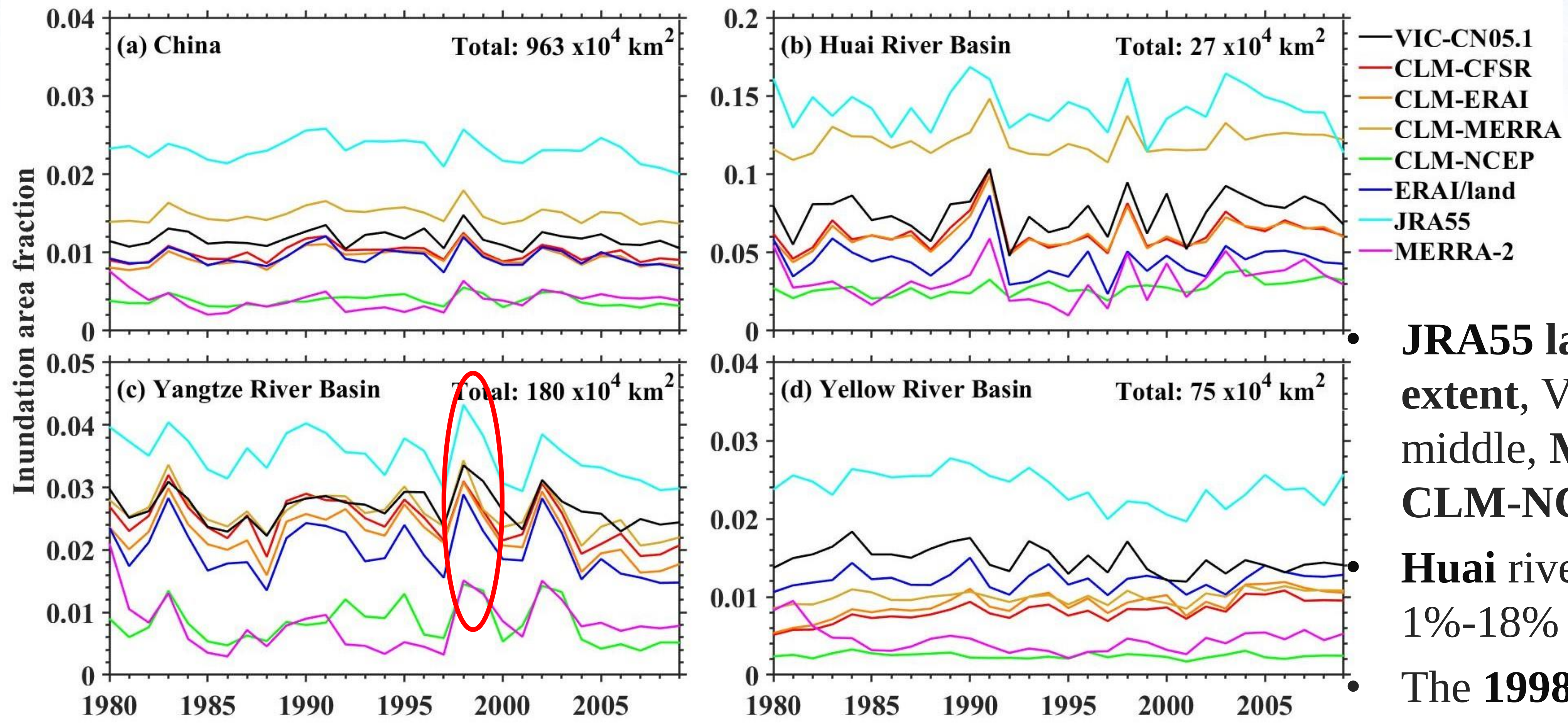
Stations		VIC-CN05.1	CLM-CFSR	CLM-ERAI	CLM-MERRA	CLM-NCEP	ERAI/land	JRA55	MERRA-2
1-Huai_Wangjiaba	NSE	0.73	0.38	0.35	0.11	-0.25	0.10	0.51	0.27
	RE	-0.30	-0.24	-0.27	-0.44	-0.76	-0.60	-0.20	-0.66
2-Huai_Bengbu	NSE	0.56	0.38	0.34	0.23	-0.10	0.16	0.38	0.22
	RE	0.01	0.03	-0.05	-0.04	-0.69	-0.48	0.42	-0.57
3-Yangtze_Zhimenda	NSE	0.58	-0.12	-0.05	-0.35	-0.56	0.48	0.28	0.01
	RE	-0.33	-0.74	-0.69	-0.83	-0.91	-0.22	-0.43	-0.75
4-Yangtze_Pingshan	NSE	0.80	0.60	0.55	-0.05	-0.30	0.88	0.88	-0.28
	RE	-0.20	0.09	0.00	-0.51	-0.64	-0.15	-0.18	-0.75
5-Yangtze_Yichang	NSE	0.88	0.51	0.43	-0.29	-0.64	0.72	0.94	-0.56
	RE	-0.11	-0.06	-0.08	-0.56	-0.69	-0.28	0.01	-0.75
6-Yangtze_Datong2	NSE	0.53	0.33	0.27	-0.25	-0.82	0.22	0.40	-1.26
	RE	-0.03	-0.01	-0.07	-0.41	-0.58	-0.32	-0.13	-0.69
7-Yellow_Tangnaihai	NSE	0.69	-0.03	0.16	-0.63	-1.03	0.55	0.51	-0.51
	RE	-0.24	-0.47	-0.32	-0.78	-0.91	-0.10	0.13	-0.80
8-Yellow_Huayuankou	NSE	-2.86	0.06	0.03	-0.30	-0.57	0.18	-3.18	-0.24
	RE	1.23	-0.12	0.01	-0.50	-0.70	0.27	1.17	-0.52

Nash-Sutcliffe efficiency (NSE): →1, better; <0, unreliable;

Relative error (RE): → 0, better.

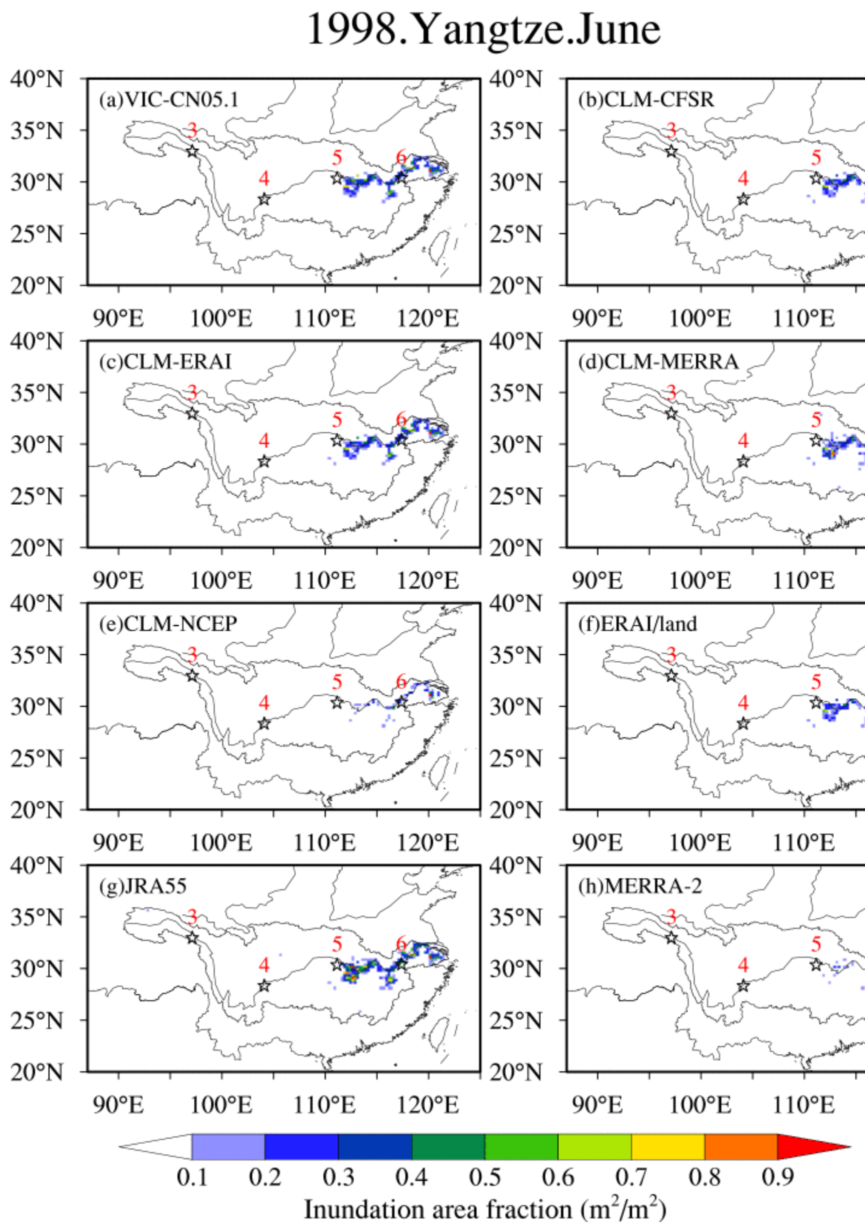
- The **VIC-CN05.1, JRA55, ERAI/land, and CLM-CFSR** products are relatively **better**
- While the **CLM-NCEP and MERRA-2** products are relatively **worse**

Annual floodplain inundation area fraction



- **JRA55 largest flooded extent**, VIC-CN05.1 in the middle, **MERRA-2 and CLM-NCEP smallest**
- **Huai** river basin, largest, 1%-18%
- The **1998** flood event on the Yangtze river basin is clear

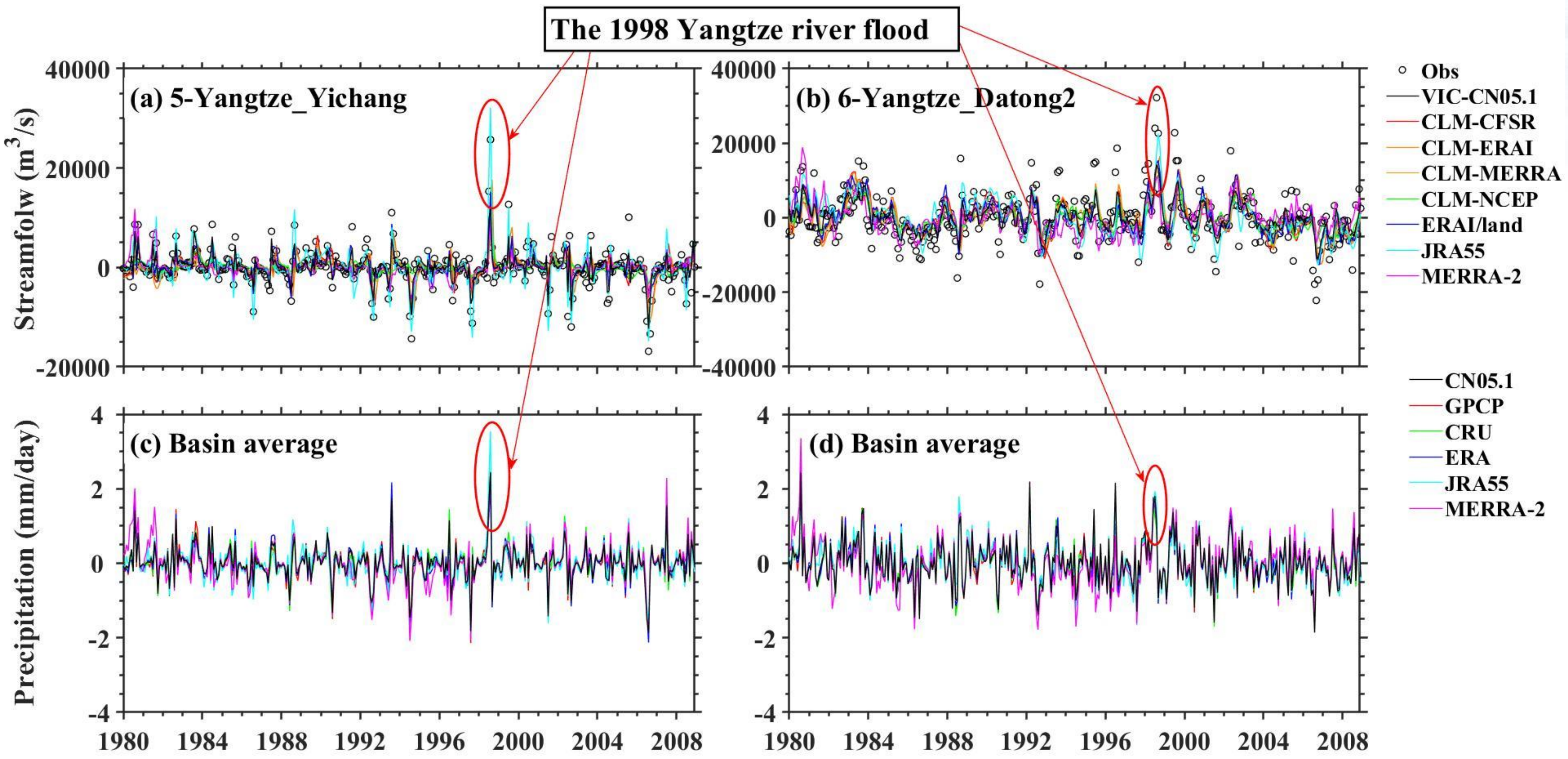
The 1998 Yangtze river flood in JJA



☆ **represents hydrological stations:**
3-Yangtze_Zhimenda
4-Yangtze_Pingshan
5-Yangtze_Yichang
6-Yangtze_Datong2

- Flood happened in the **middle and lower** reaches of the Yangtze, consistent with the reality;

Monthly streamflow and precipitation anomalies



- The **breakout** of streamflow anomalies in Yichang and Datong2 stations represents the 1998 flood event, which can be partly explained by the **increased** precipitation

Conclusions

- Compared to the gauged streamflow in China river basins, the simulations of **VIC-CN05.1, JRA55, and ERAI/land** are better, while **MERRA-2 and CLM-NCEP** are relatively worse;
- The simulated streamflow of eight products perform better in the **upper stream stations and large river basins** with abundant water resources;
- Although **large uncertainties** exist in the simulated inundation area of eight products, **the timing and spatial pattern** of the 1998 Yangtze river flood can be well simulated.

THANK YOU

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