

Using MOSART and Flow Metrics to Diagnose Soil Hydrology in Earth System Models

Hong-Yi Li
Research Scientist III, PNNL

Ruby Leung, Tony Craig, Sean Swenson, David Lawrence

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Current status of coupling MOSART within ACME and CESM

▶ ACME v1

- CLM4.5 (VSFM) soil hydrology for runoff
- Qgwl sent directly to basin outlets

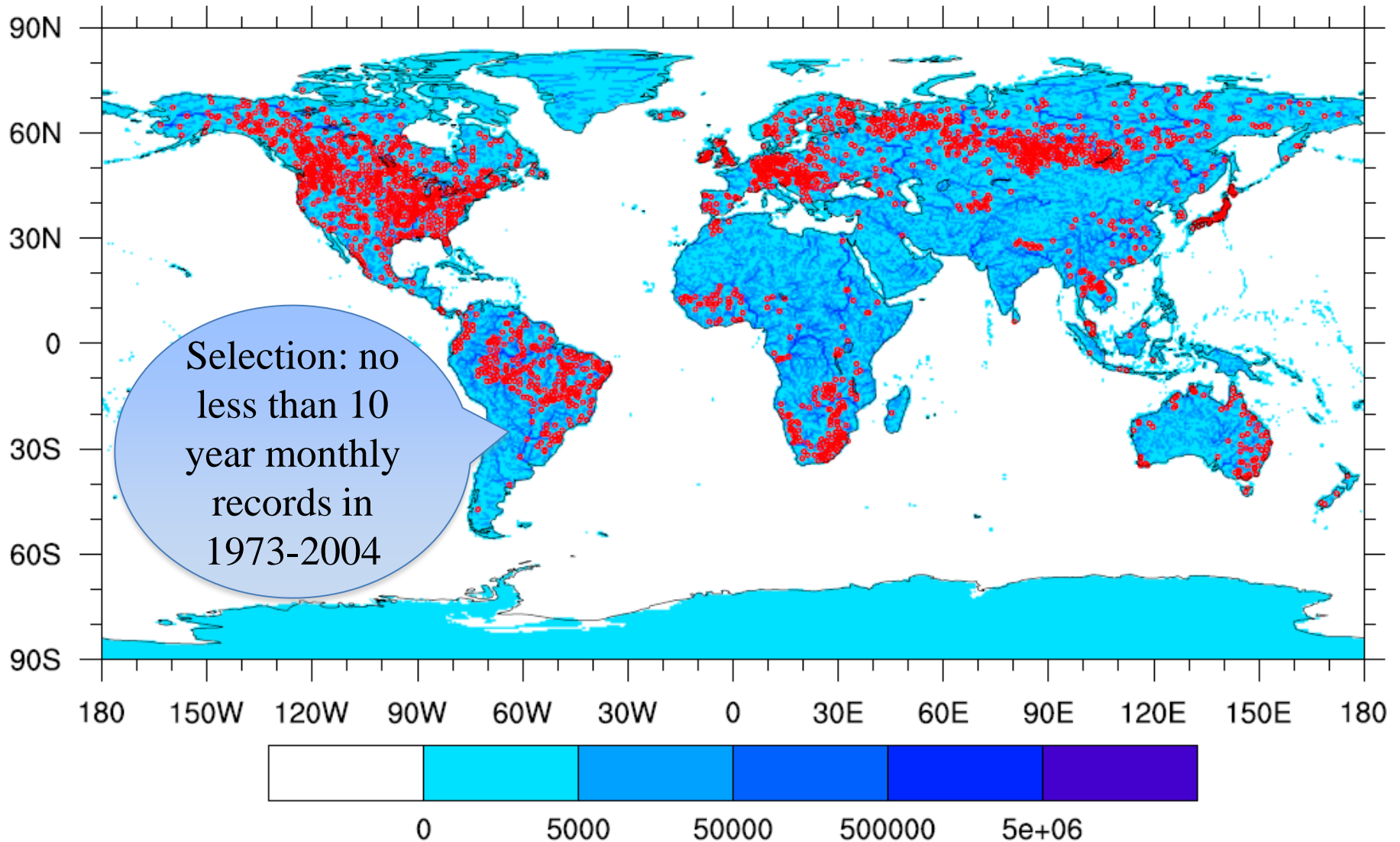
▶ CESM2

- CLM5 soil hydrology for runoff
- Various ways to eliminate negative Qgwl

RTM in ACME v1
and CESM2 is still
routing Qgwl in
rivers

- ▶ QIAN_CLM45 (coupled to MOSART/RTM)
 - 1972-2004
 - Limited soil depth
- ▶ QIAN_CLM50 (coupled to MOSART)
 - 1972-2004
 - Limited soil depth
- ▶ QIAN_CLM50_deepSoil (coupled to MOSART)
 - 1972-2004
 - Deep (variable?) soil depth
- ▶ GSWP3_CLM50 (coupled to MOSART)
 - 1985-2010
 - Fixed soil depth

Streamflow observations from over 2500 GRDC stations



Proposed key flow metrics from MOSART simulation and observation

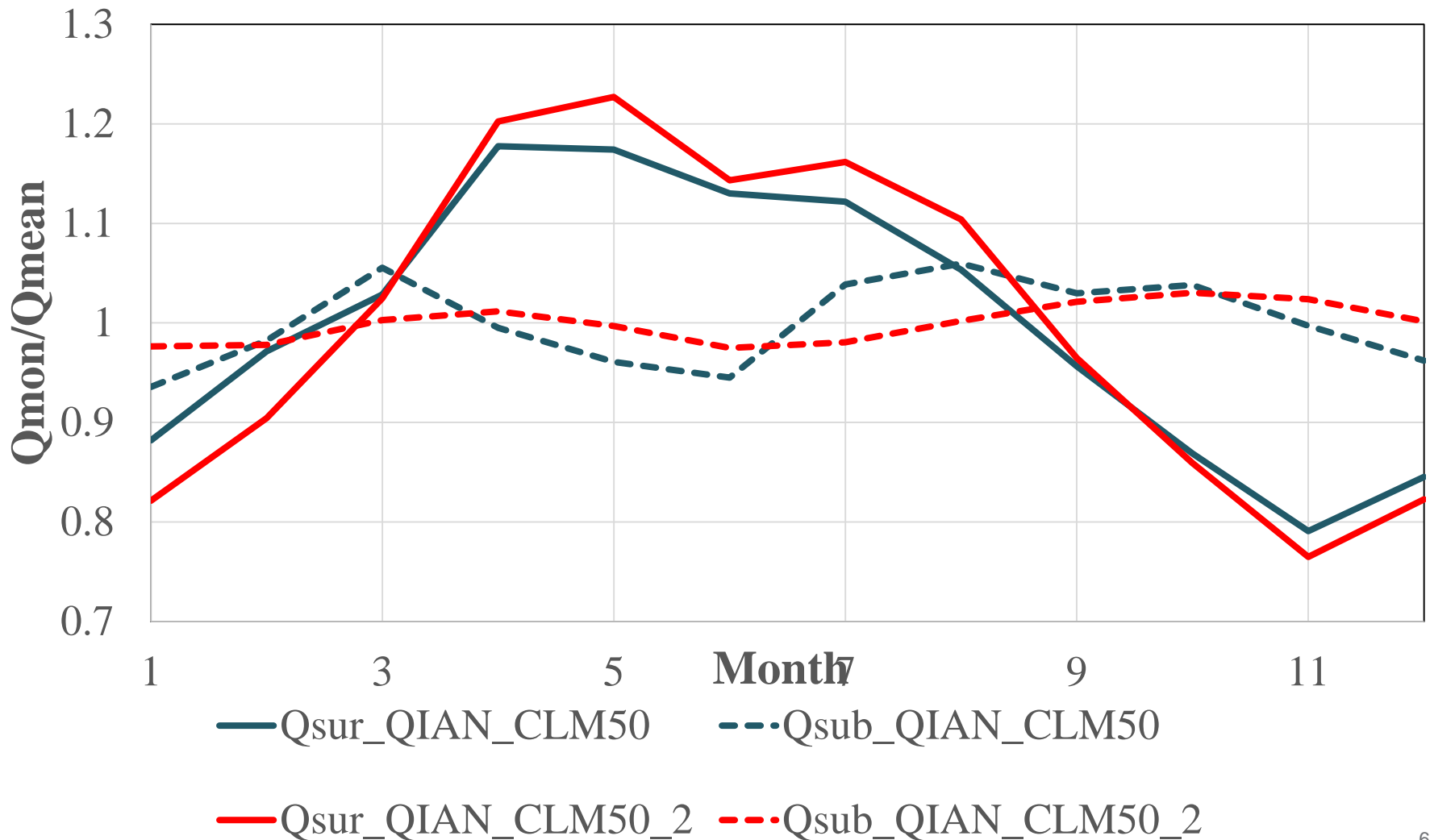
- ▶ Always NO negative flow in space-time
 - Sourced from negative runoff (Q_{gw1} , Q_{sub})
 - Limiting simulation of associated heat and BGC fluxes

- ▶ Annual flow
 - Long-term mean (mass balance, effects of landuse,, water transferring)
 - Nash-Sutcliffe coeff. for annual flow series (Inter-annual var.)

- ▶ Seasonal variation of flow
 - Soil hydrology (precipitation and runoff partitioning)
 - Forcing seasonality (interplay between precipitation and evaporative energy seasonality)
 - Human impacts (reservoir operation)

Seasonality of flow reduced by more subsurface runoff

Global monthly mean runoff component



Seasonality of flow reduced by reservoir regulation

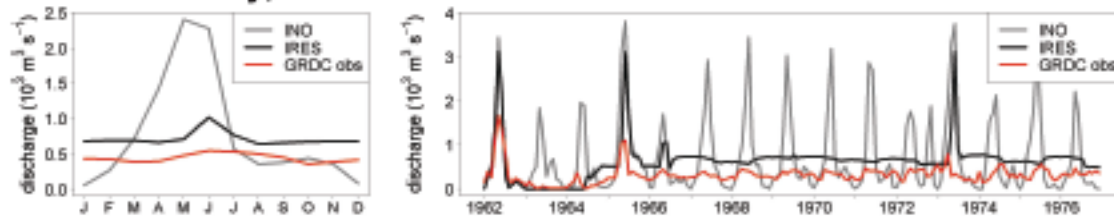


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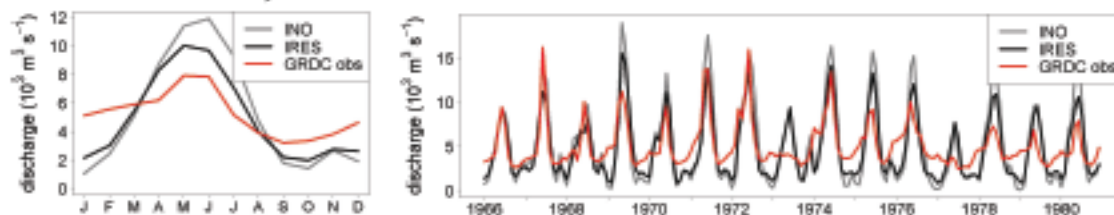
BIEMANS ET AL.: IMPACT OF RESERVOIRS ON DISCHARGE AND IRRIGATION

- Qsim_nat.
- Qsim_res.
- GRDC obs

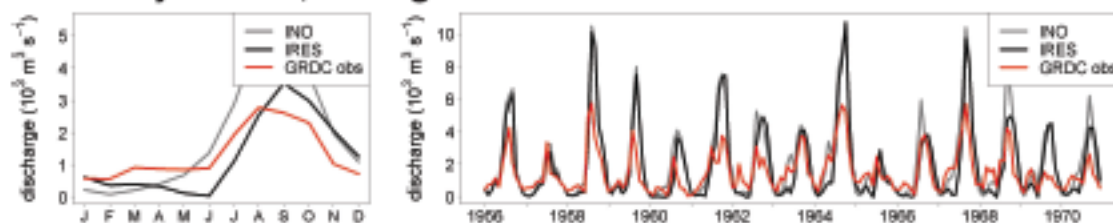
Lees Ferry, Colorado basin



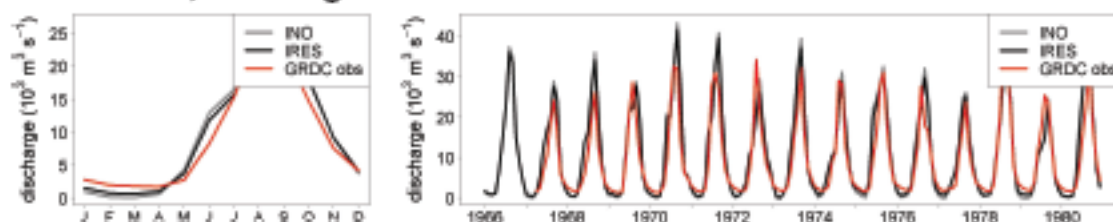
The Dallas, Columbia basin



Huayuankou, Huang He basin



Pakse, Mekong basin



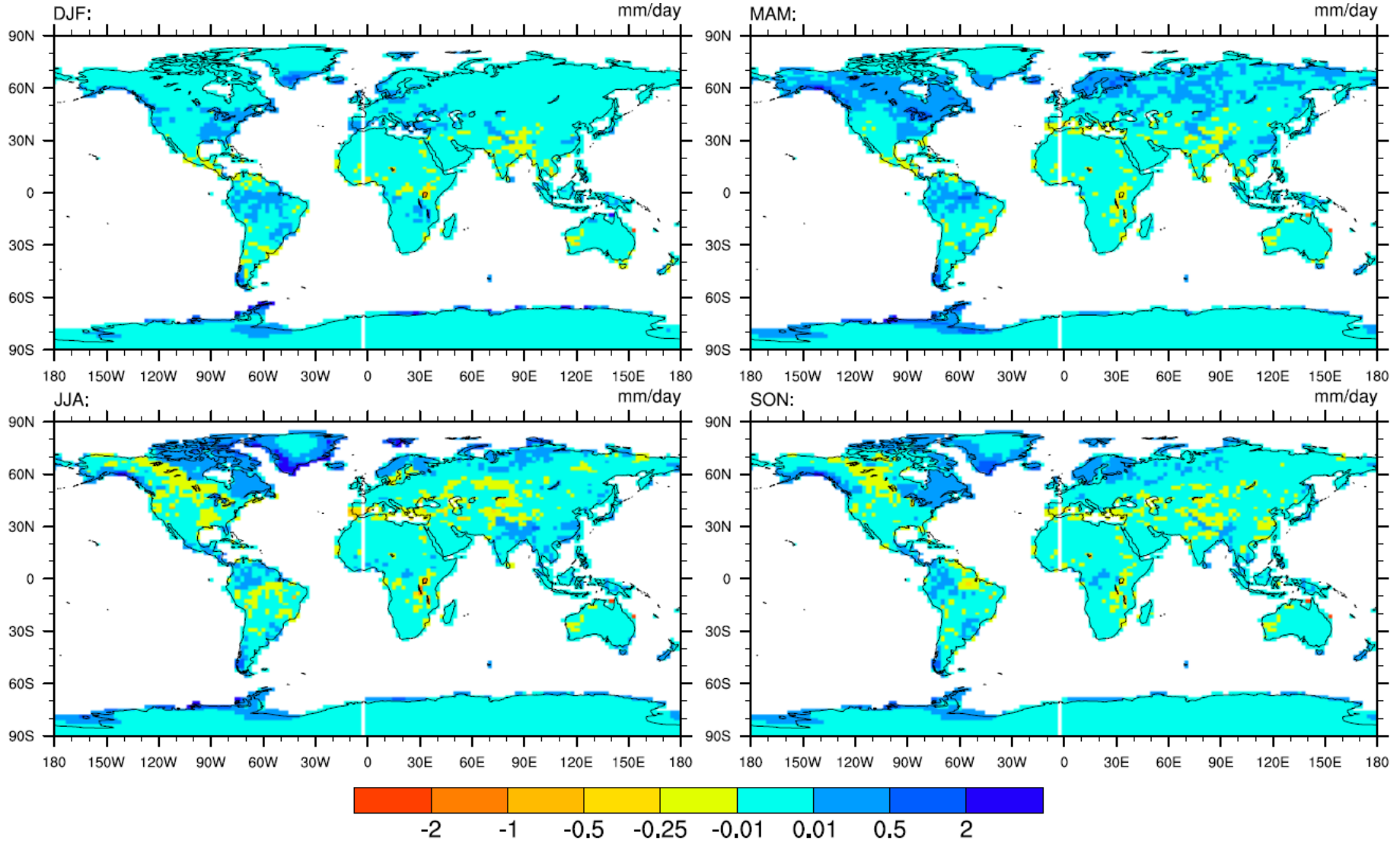
*Bieman et al.,
WRR, 2009*

Negative Qgwl simulated by CLM4.5



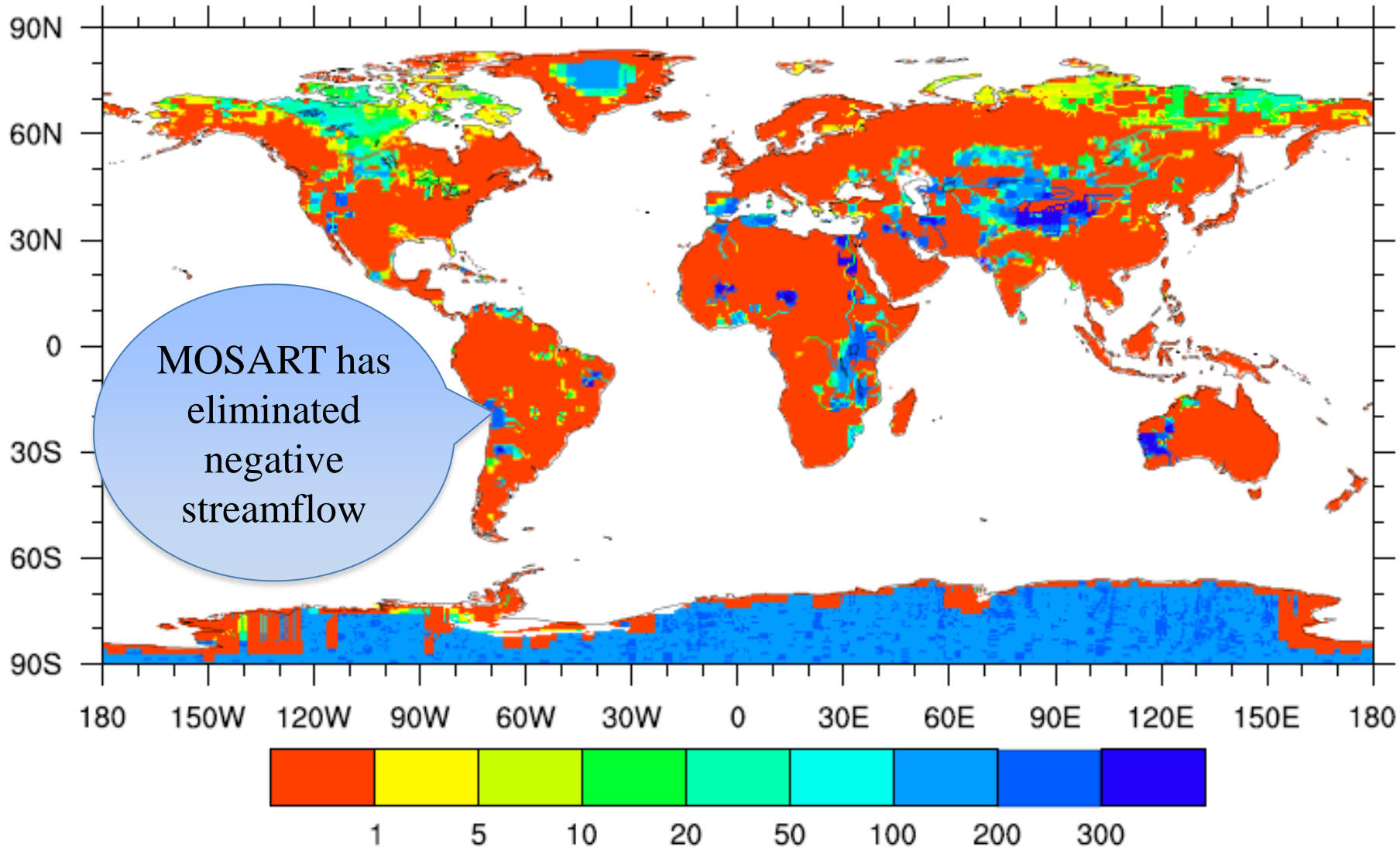
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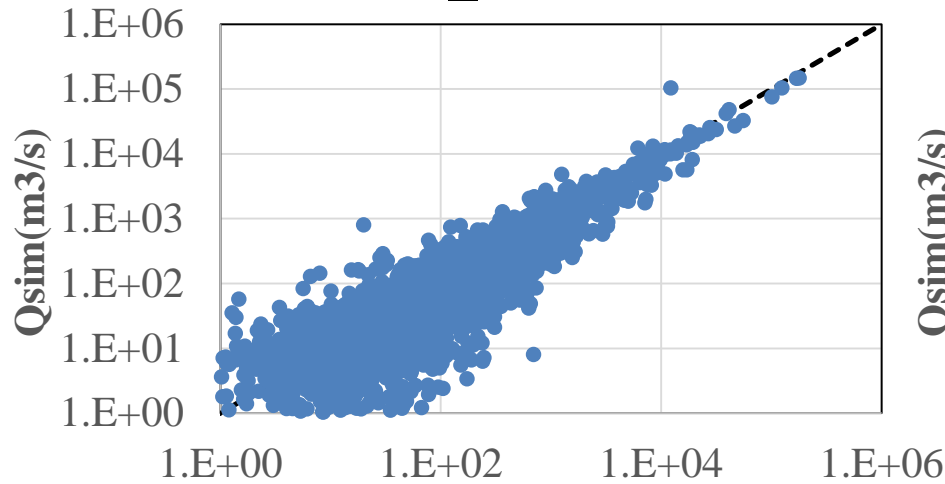
Negative Q_{gw} leads to negative streamflow simulated by RTM

Num. of months with negative river flow in 1973-2004

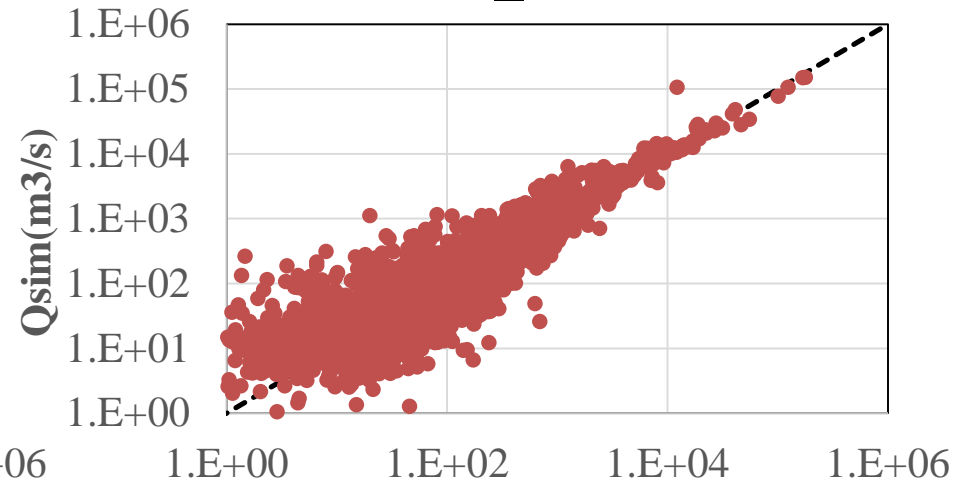


MOSART annual mean streamflow validation at over 2500 GRDC river stations

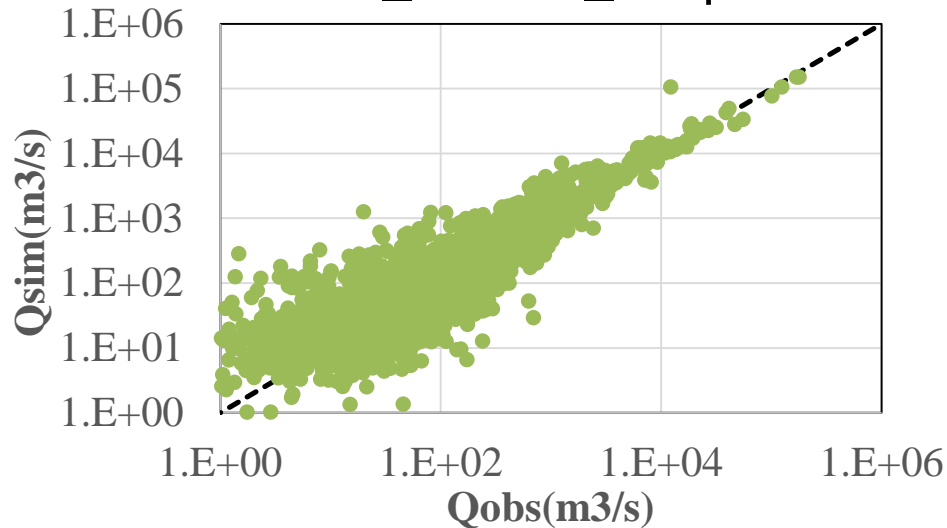
QIAN_CLM45



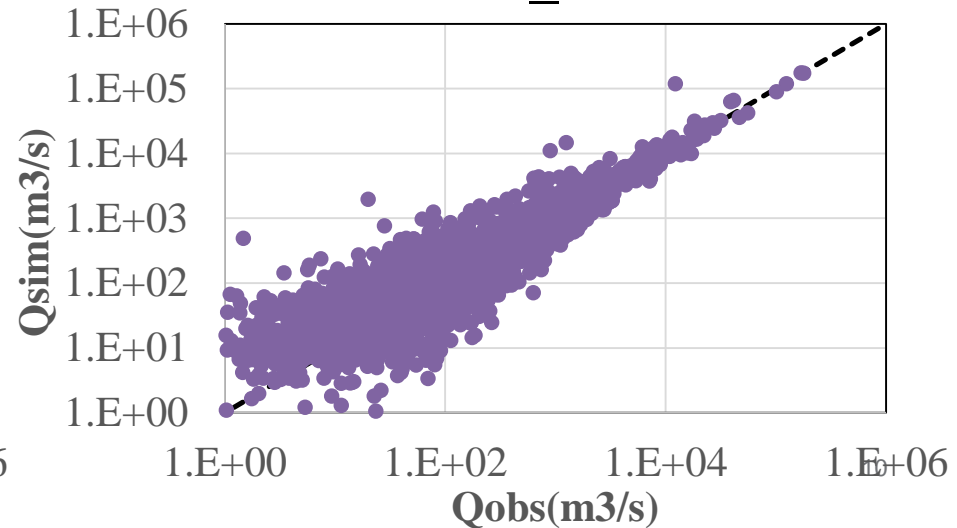
QIAN_CLM50



QIAN_CLM50_deepSoil



GSWP3_CLM50



N-S for annual streamflow series at over 2500 GRDC river stations

	Nash-Sutcliffe coefficients		Normalized RMSE	
	≥ 0	< 0	≤ 0.25	> 0.25
QIAN_CLM45	521	1998	491	2028
QIAN_CLM50	421	2098	392	2127
QIAN_CLM50_2	361	2158	343	2176
GSWP3_CLM50	449	2070	443	2076

Seasonal variation of streamflow

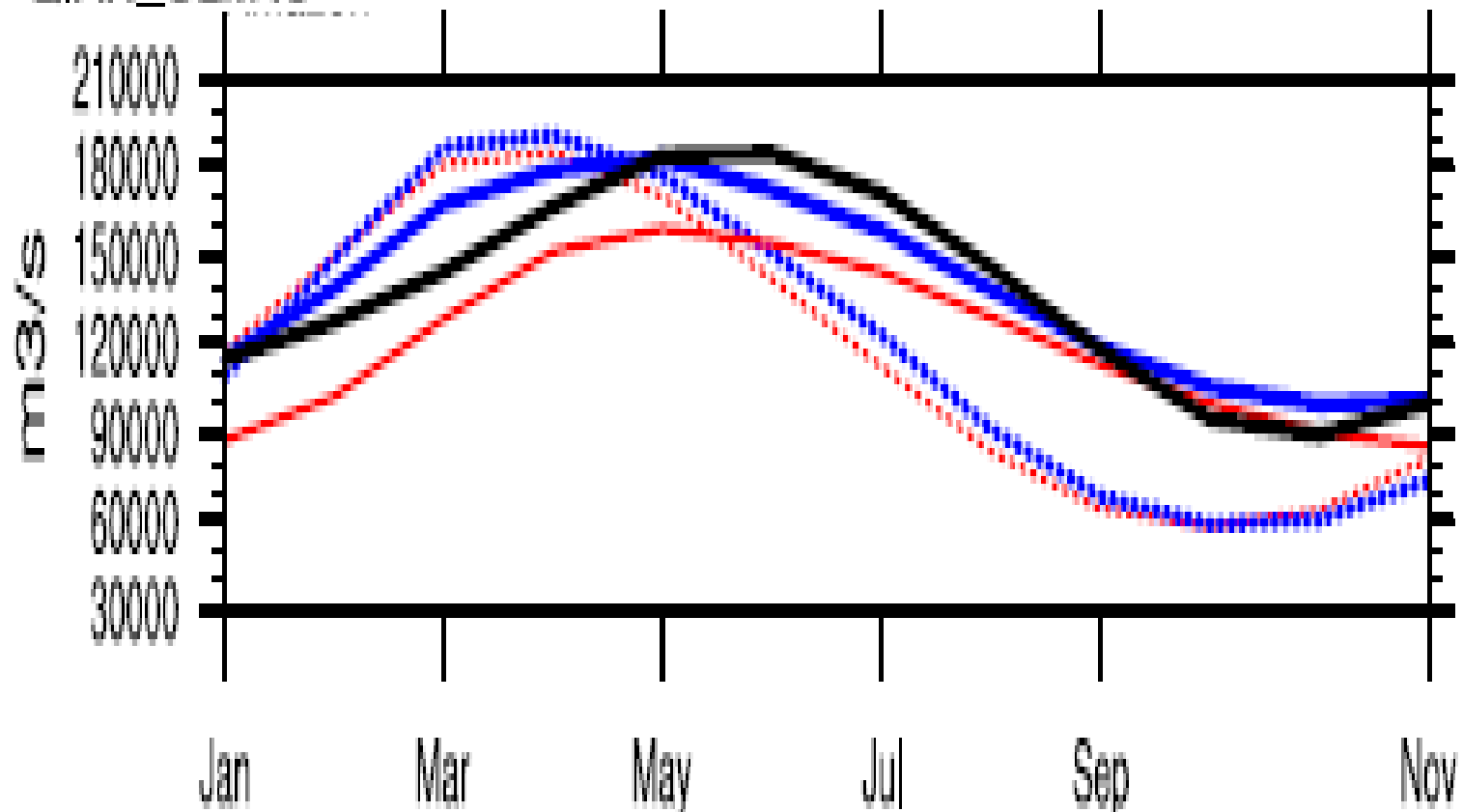
-- Amazon River System



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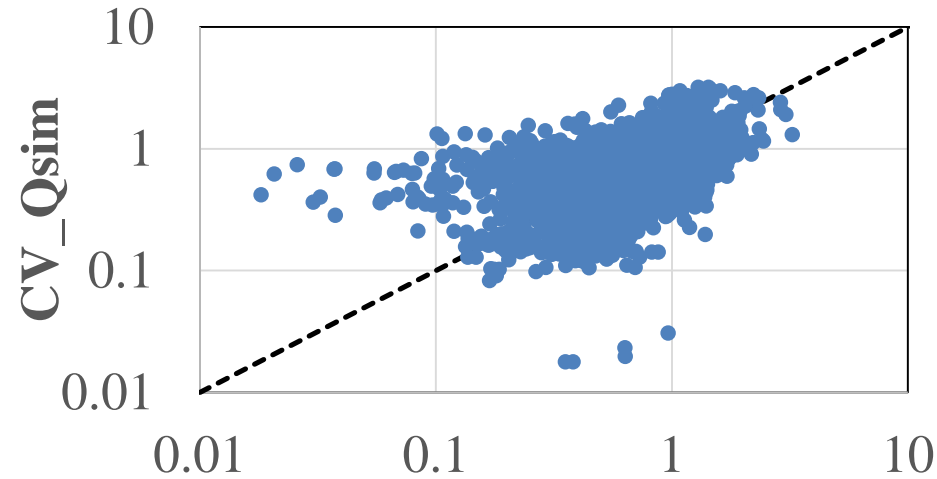
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- Obs
- GWSP3_CLM50
- QIAN_CLM50_2
- QIAN_CLM50
- - - QIAN_CLM45

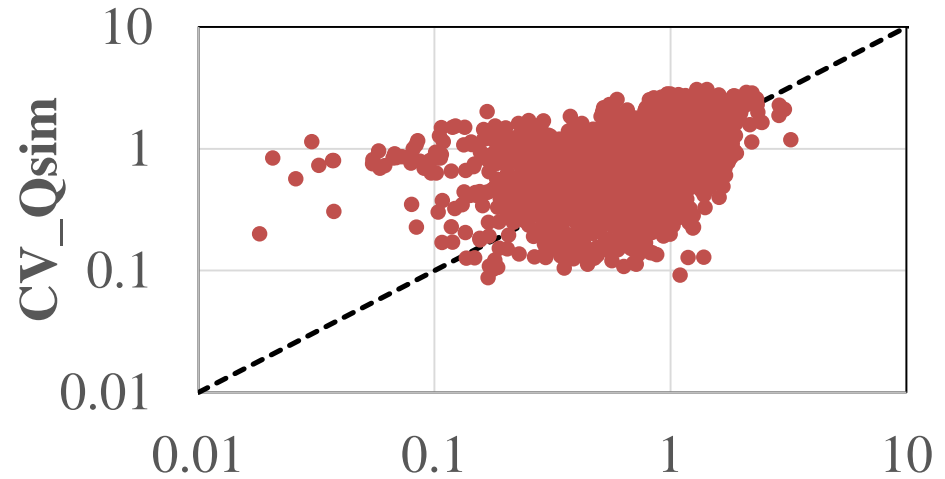


Seasonal variation at over 2500 GRDC river stations (CV of mean monthly flow)

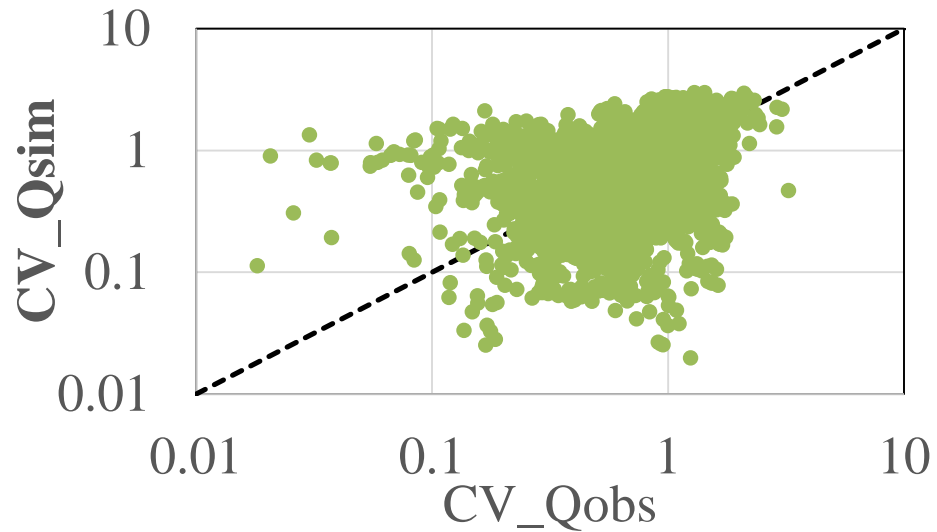
QIAN_CLM45



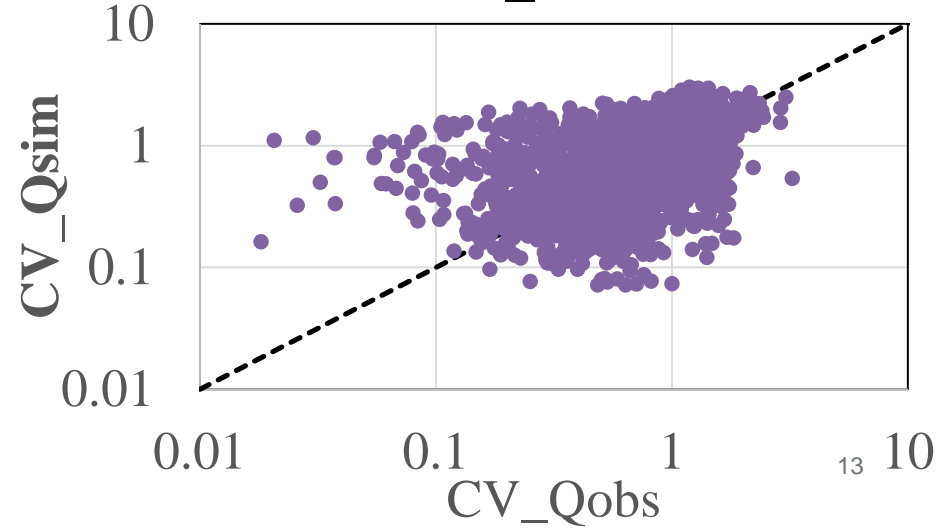
QIAN_CLM50



QIAN_CLM50_2 (deep Soil)



GSWP3_CLM50



Summary

- ▶ In ACME and CESM, MOSART eliminated negative flow to facilitate riverine heat and BGC simulations
- ▶ Streamflow seasonal variation sensitive to soil hydrology, but effects of forcing and human activities must be considered

Future directions

- ▶ Classification of land grids in terms of relative dominance of forcing or soil hydrology on streamflow seasonality (local scale)
- ▶ Classification of river gages in terms of flow regulation level of human activities (local to regional scales).



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Funding supports

- ▶ DOE: Accelerated Climate Model for Energy (ACME) project