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

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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

Selection: no less than 10 year monthly records in 1973-2004
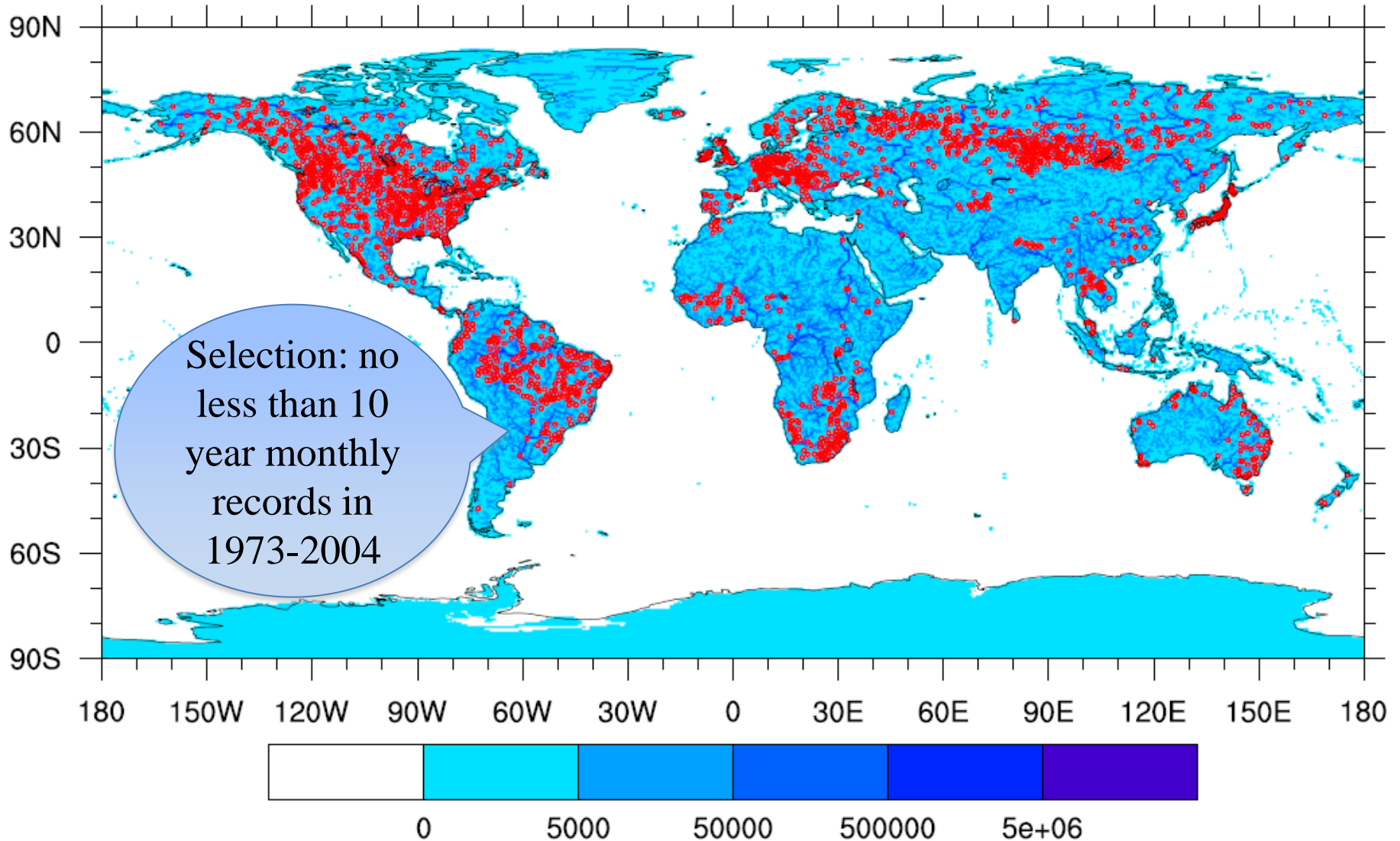
Proposed key flow metrics from MOSART simulation and observation

▶ Always NO negative flow in space-time

- Sourced from negative runoff (Qgwl, Qsub)
- 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
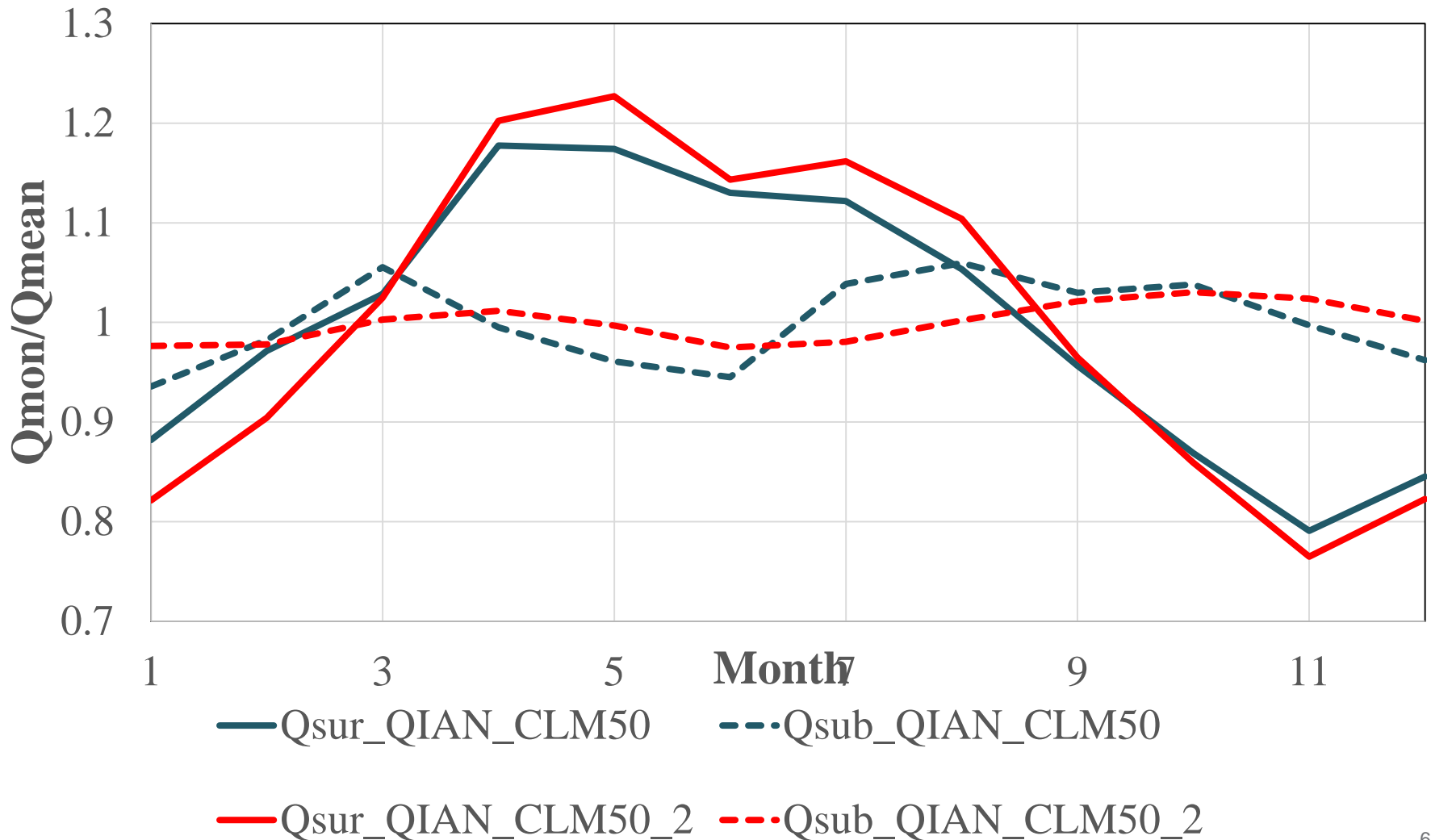
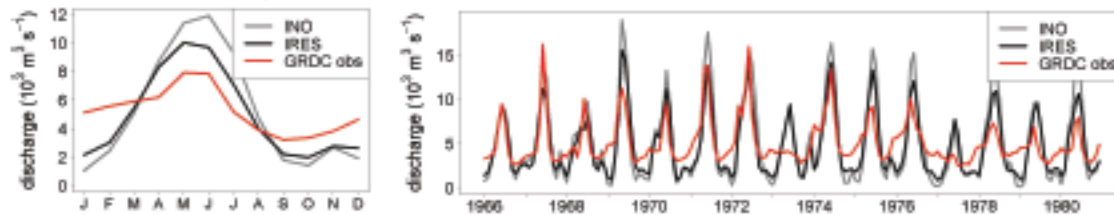# Seasonality of flow reduced by reservoir regulation

— Qsim_nat.
— Qsim_res.
— GRDC obs
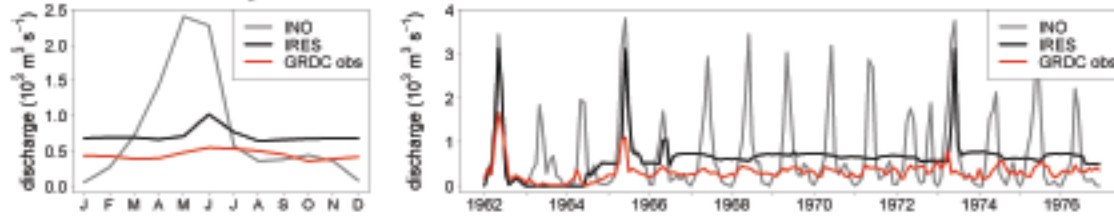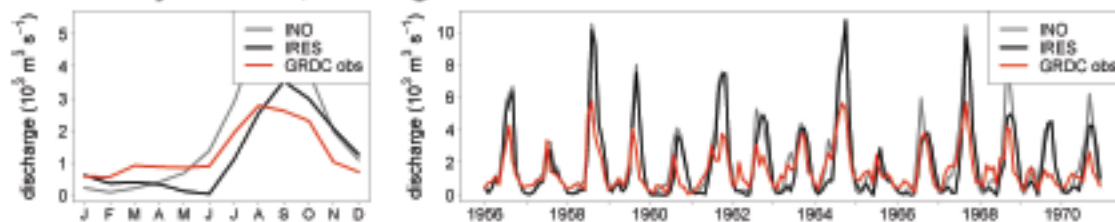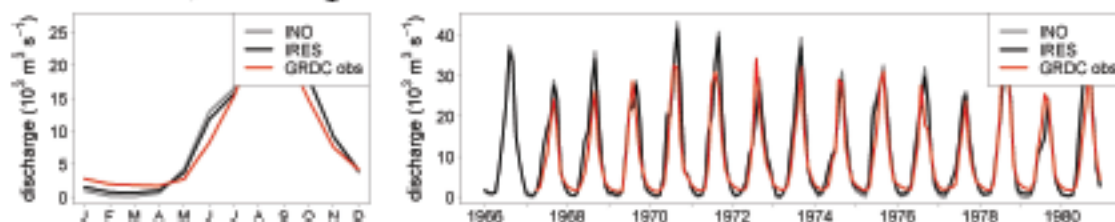
Bieman et al., WRR, 2009

Negative Qgwl simulated by CLM4.5
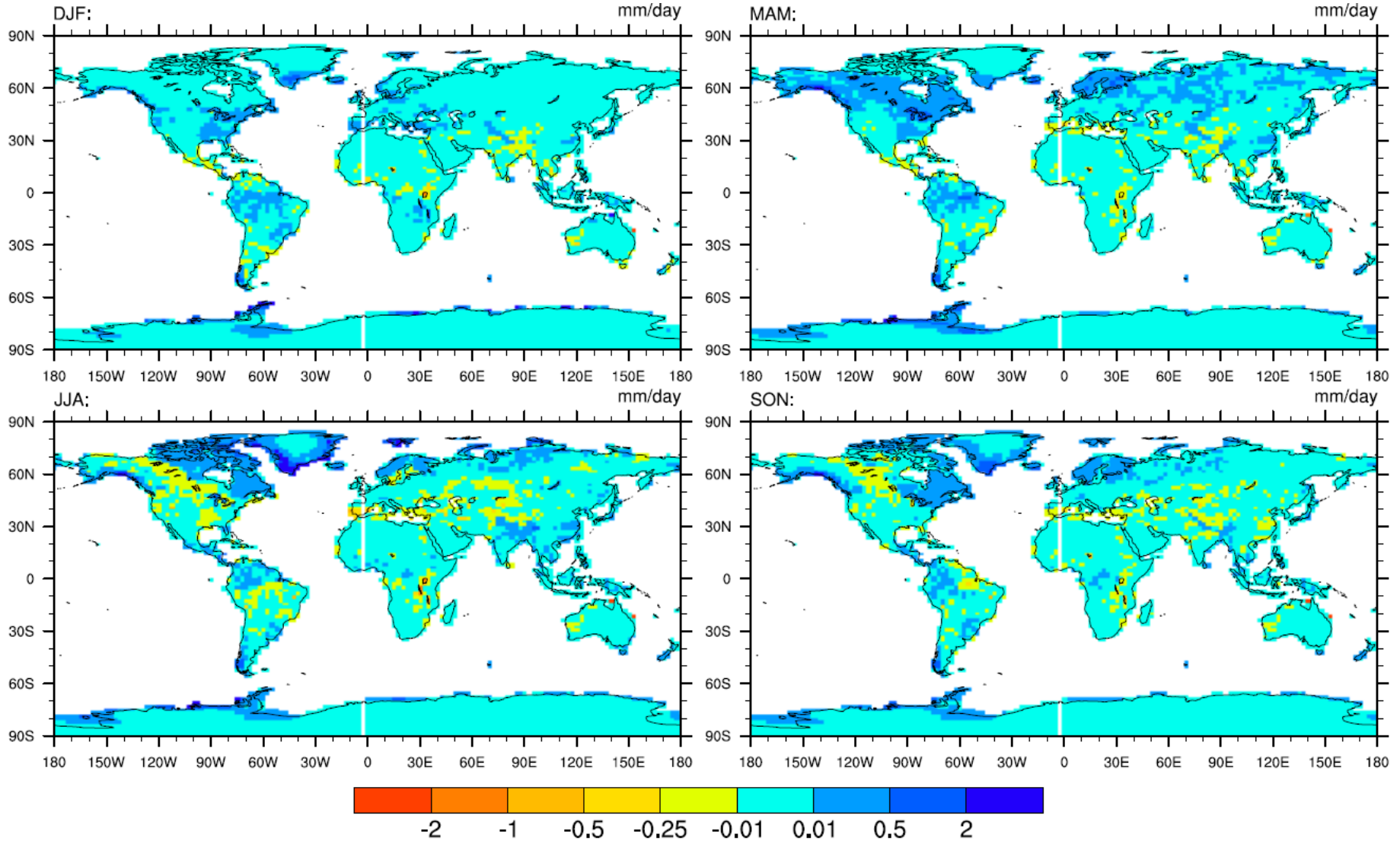
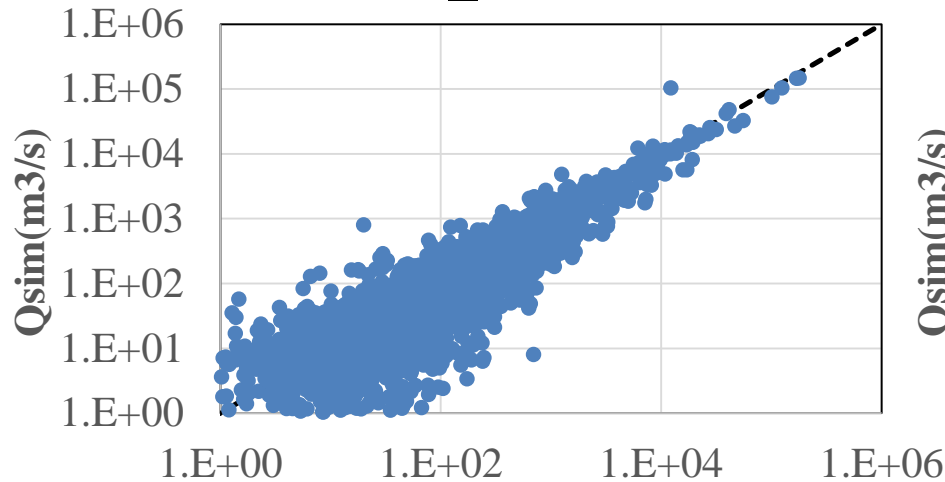# Negative Qgwl leads to negative streamflow simulated by RTM

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

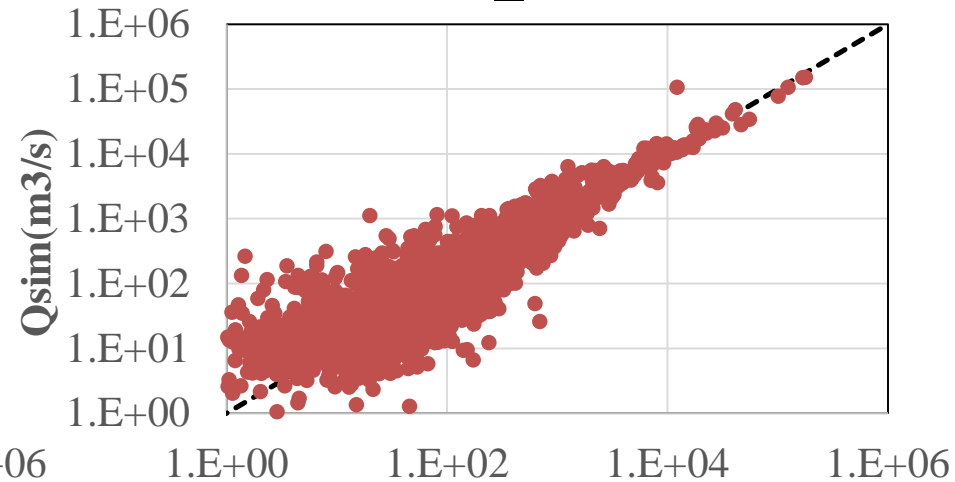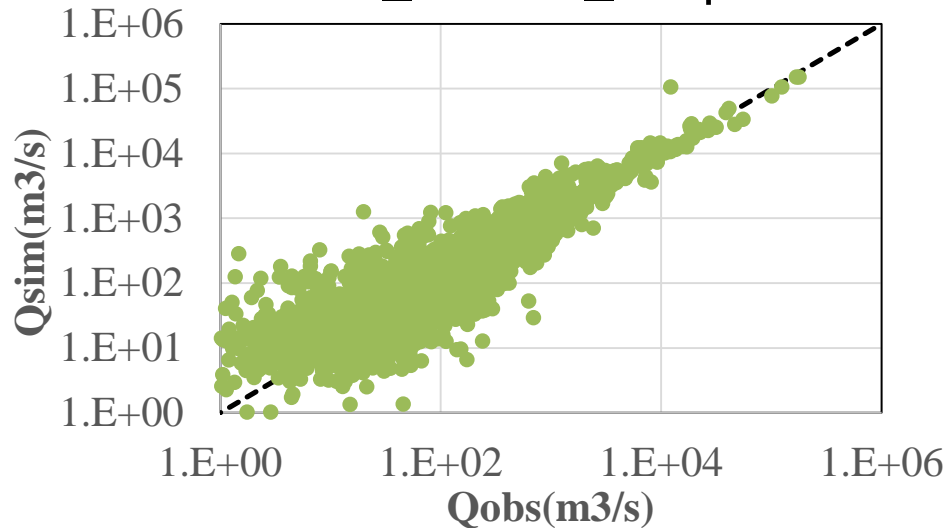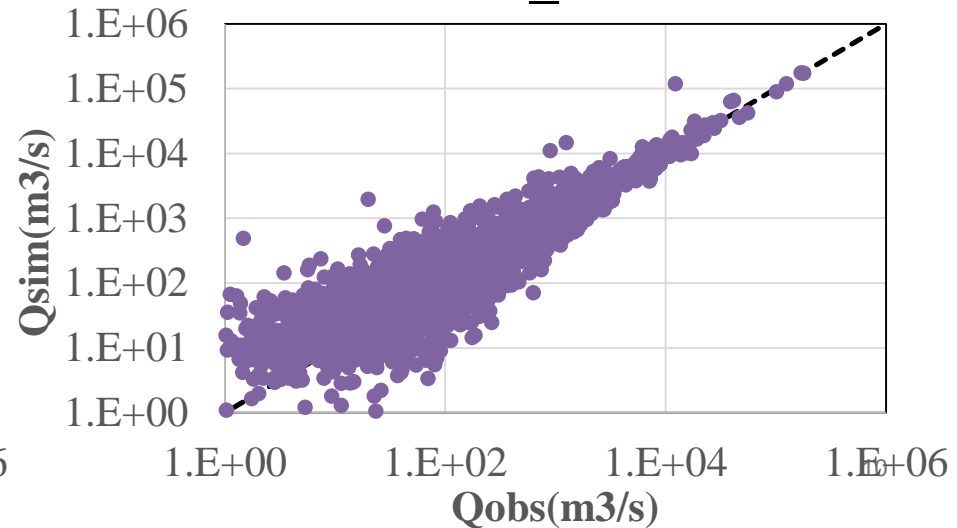MOSART has eliminated negative streamflow

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
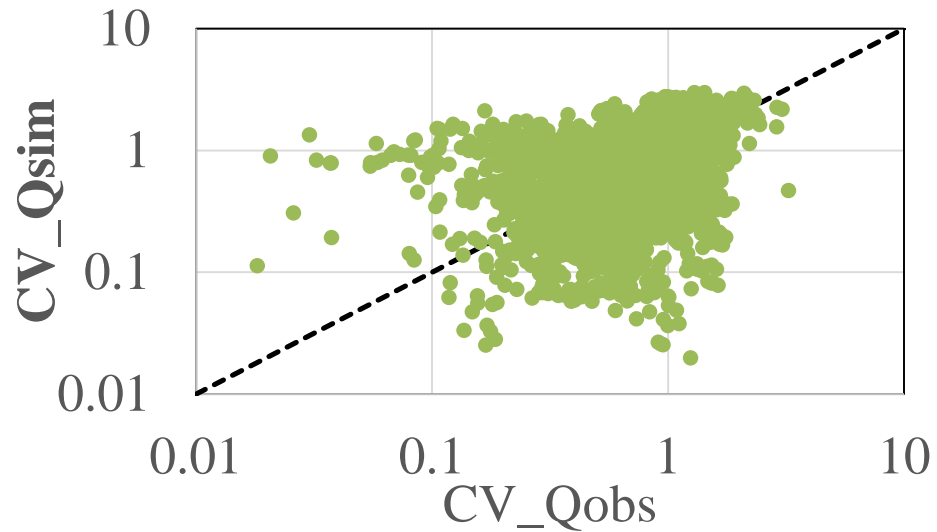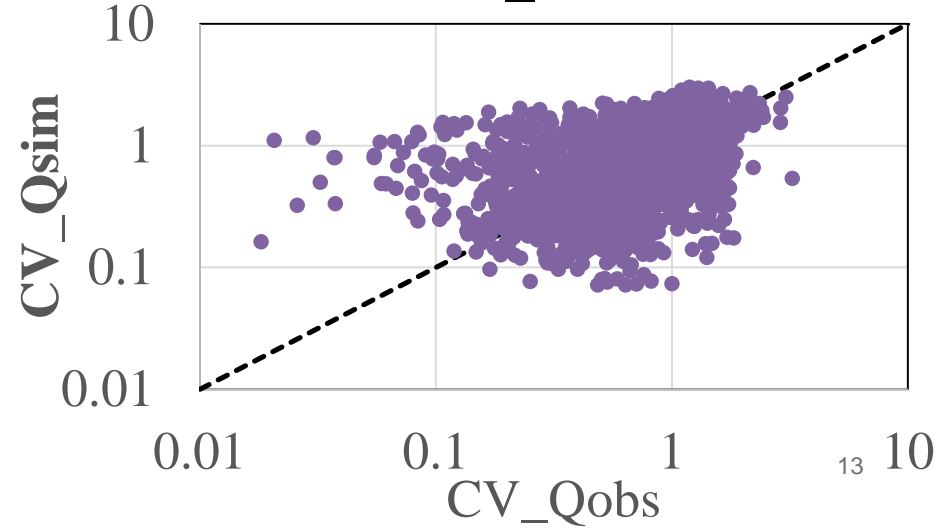# -- Amazon River System
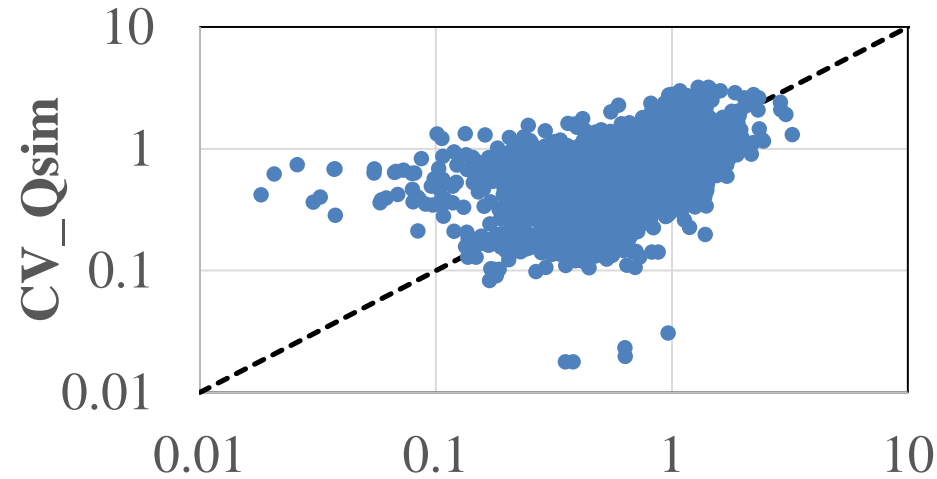
QIAN_CLM45
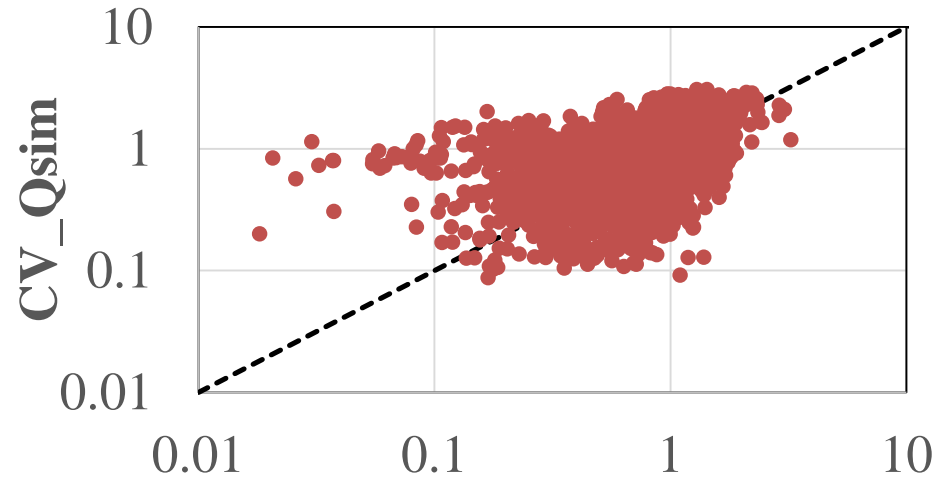
QIAN_CLM50

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