

# Evaluating Global Streamflow Simulations by a Physically-based Routing Model Coupled with the Community Land Model

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# Outline

## ▶ Model and Data

- Model for Scale Adaptive River Transport
- Global hydrography database and forcing datasets
- Observations for evaluation

## ▶ Model Evaluation

- Impacts of model structure
- Impacts of forcing uncertainty
- Impacts of human influences

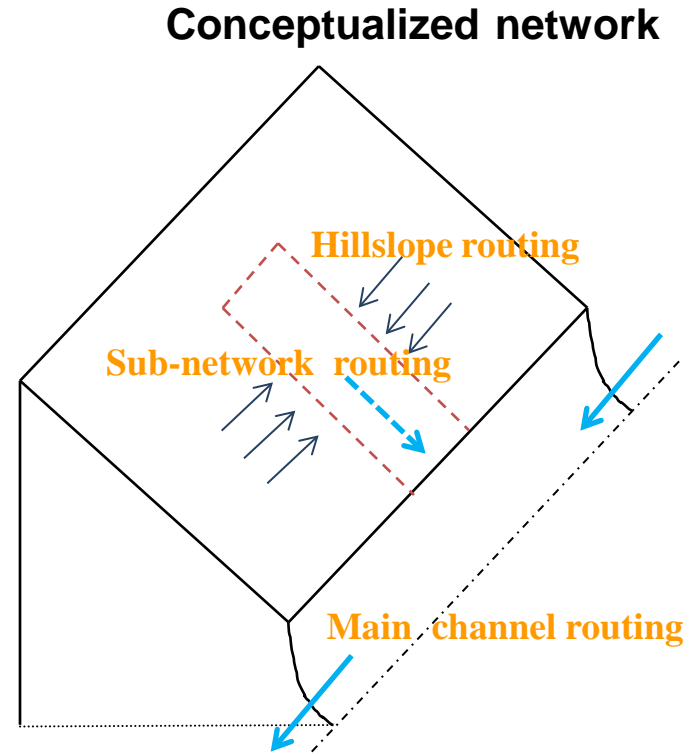
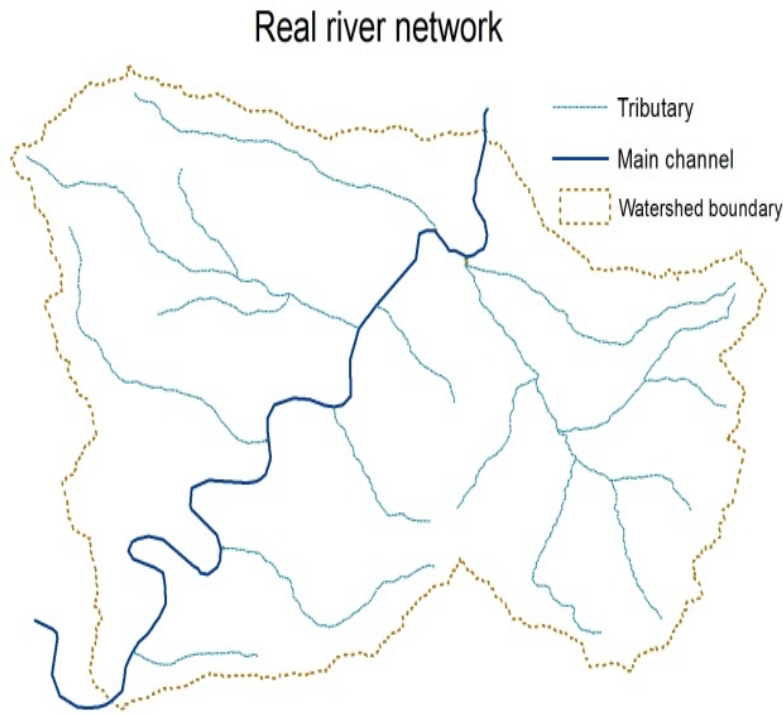
## ▶ Summary and Future Work



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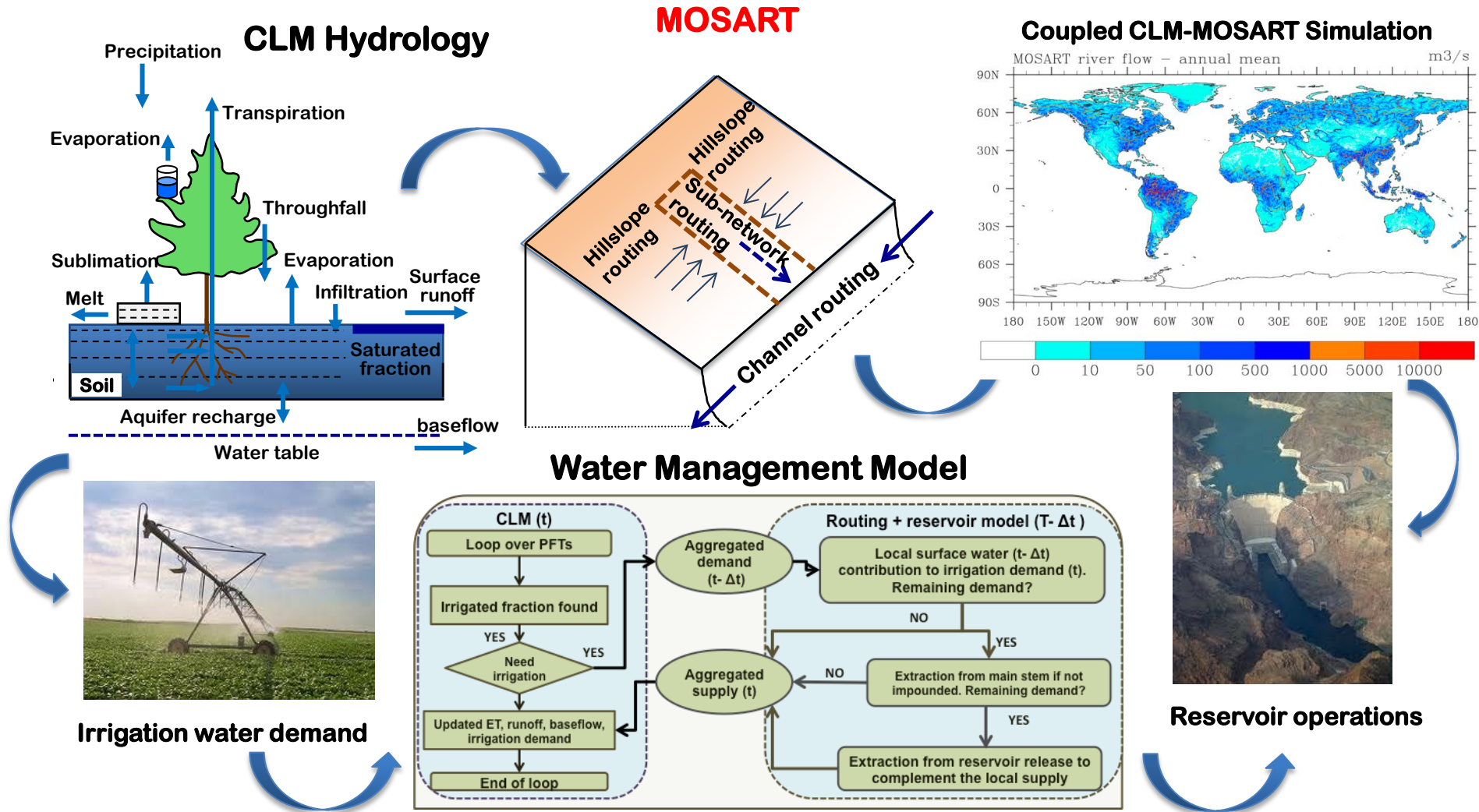
# Model for Scale Adaptive River Transport (MOSART)



- ▶ Hillslope routing to account for impacts of overland flow on soil erosion, nutrient loading etc.;
- ▶ Sub-network routing: scale adaptive across different resolutions to reduce scale dependence;
- ▶ Main channel routing: explicit estimation of in-stream status (velocity, water depth etc.)

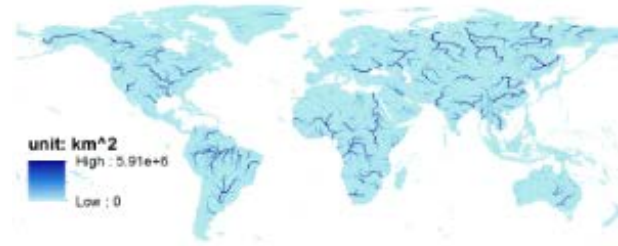
# Coupling MOSART to Community Land Model

- ▶ Cornerstone of a modeling framework to represent hydrology and human – water cycle interactions at multiple time and space scales



# A comprehensive global hydrography database

Drainage area



Channel bankfull width



Drainage density



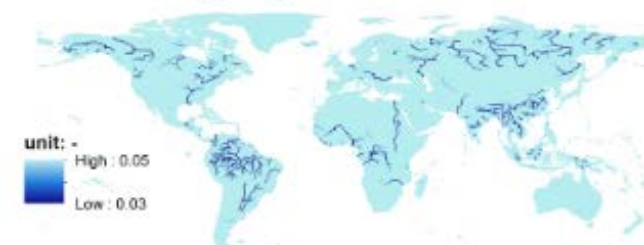
Channel bankfull depth



Channel slope



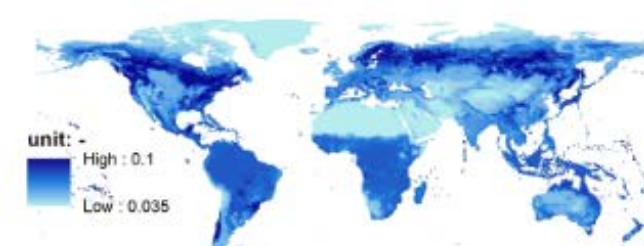
Manning's roughness coeff. for channel flow



Topographic slope



Manning's roughness coeff. for overland flow

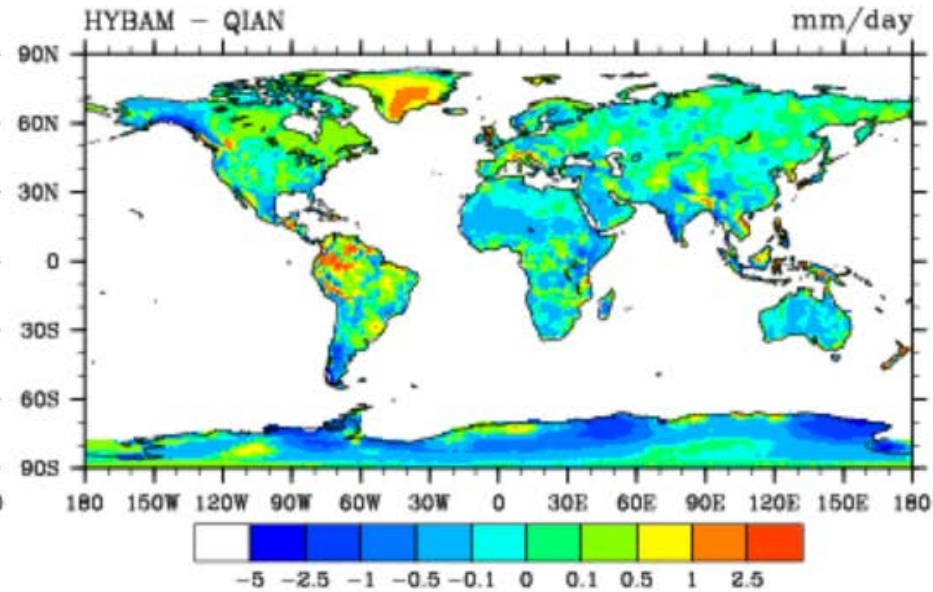
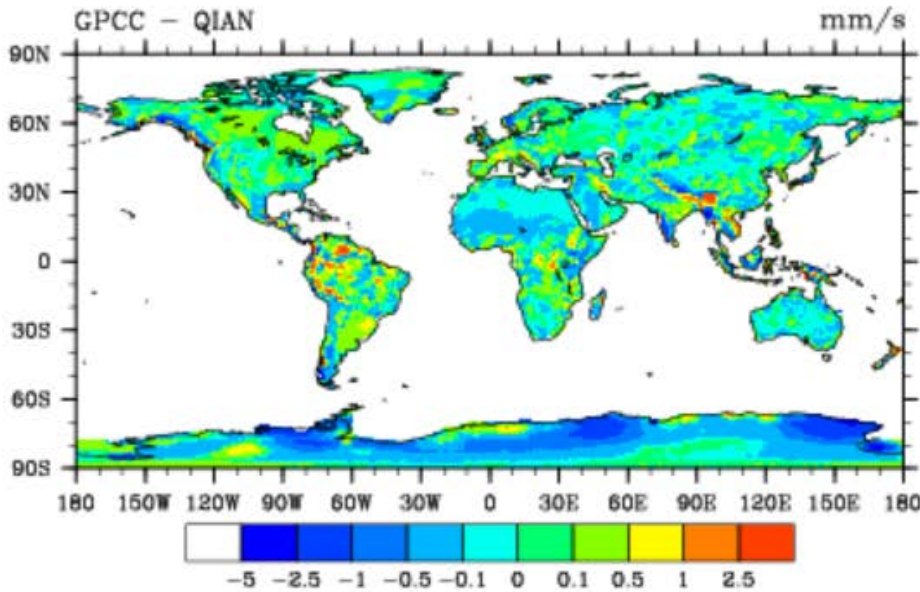
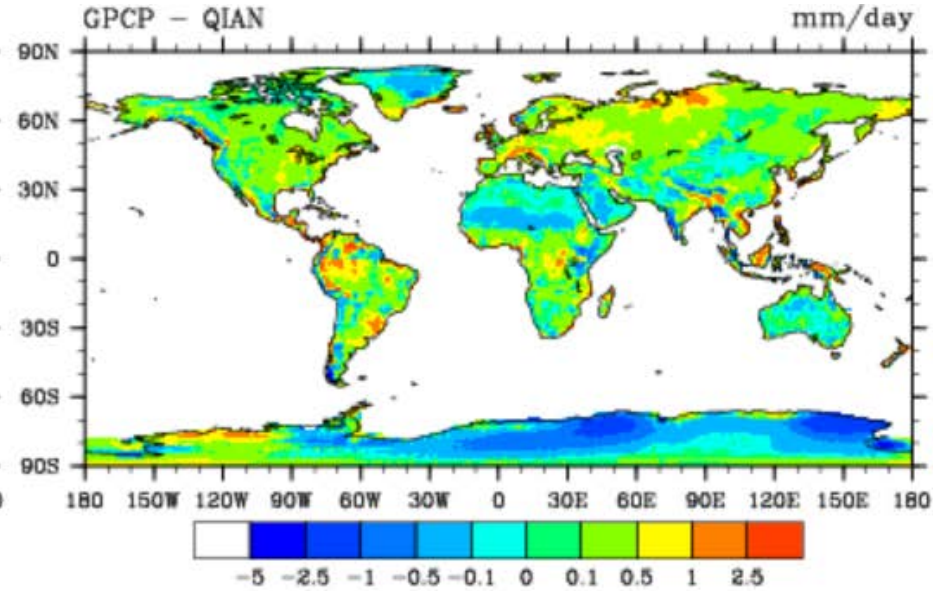
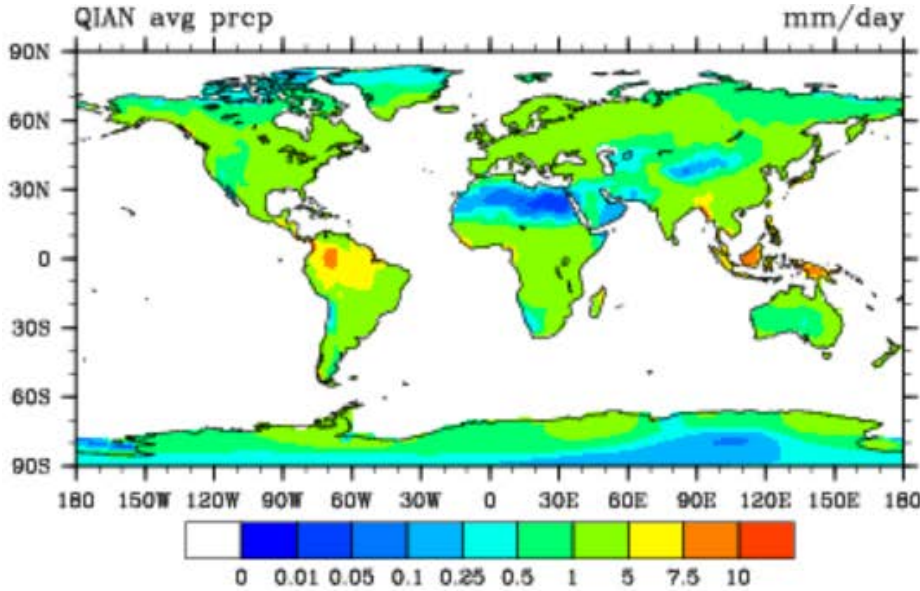


Collaboration with NASA

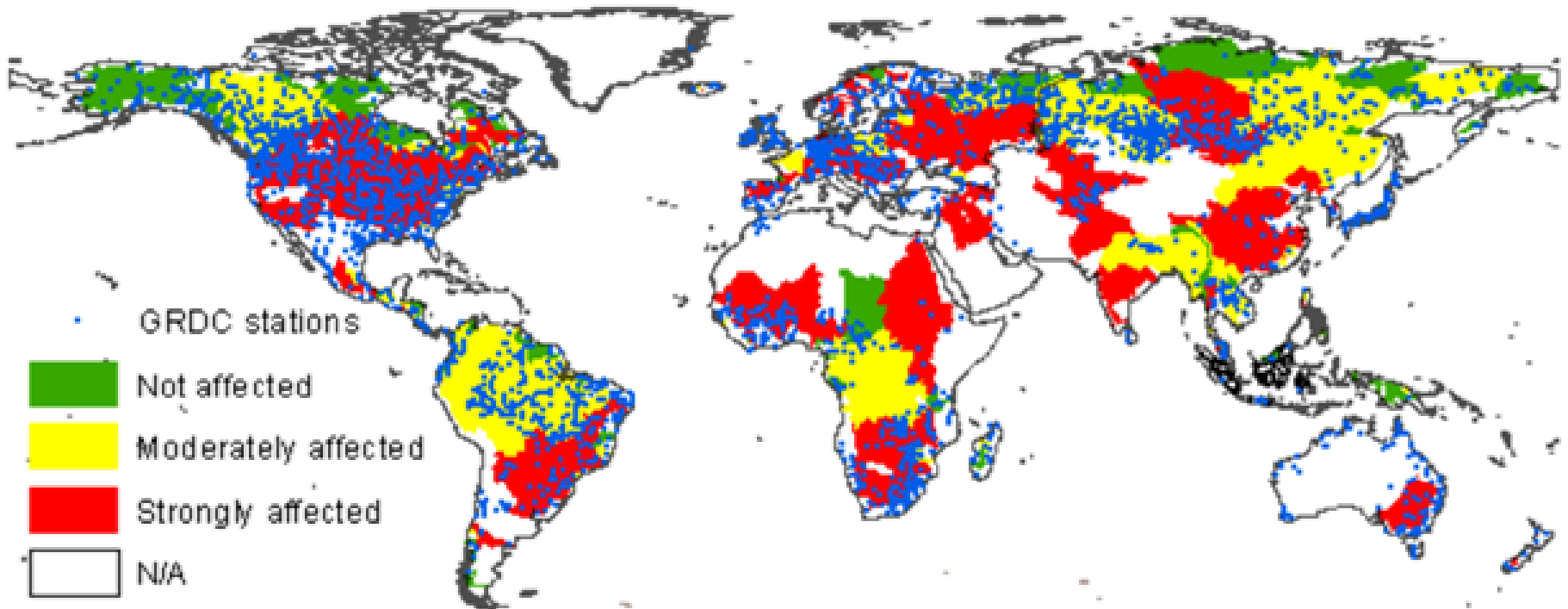
All parameters available  
at 7 resolutions

Wu et al., WRR, 2012;  
Getirana et al., JHM,  
2012

# Four different forcings to drive CLM-MOSART



# Flow observations from GRDC



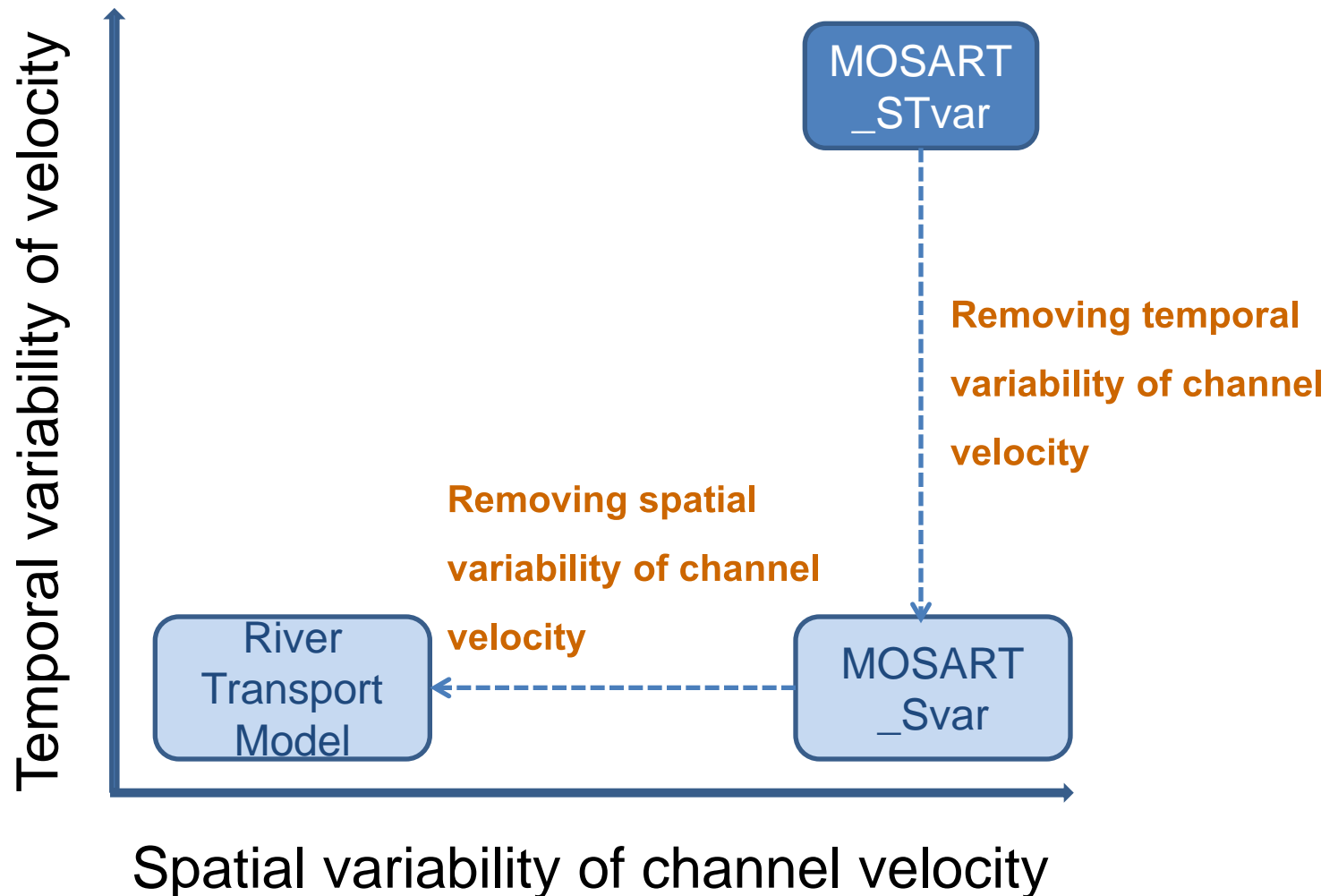
- ▶ 1674 GRDC stations with good daily flow records
- ▶ Classified into three groups based on the level of flow regulation after Nilsson et al. (2005)



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# Global Evaluation--Impacts of Model Structure



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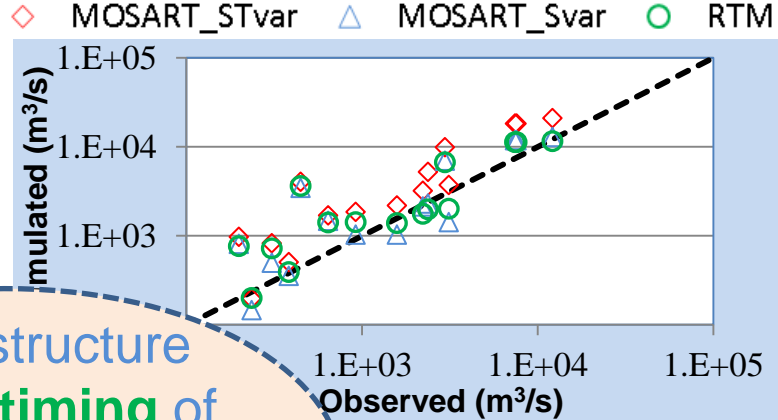
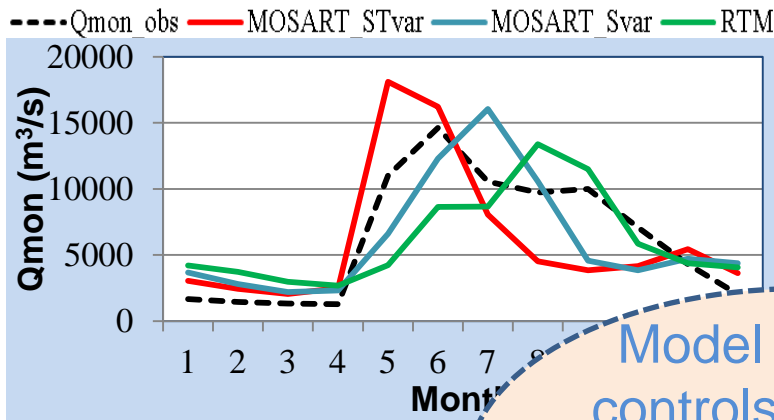
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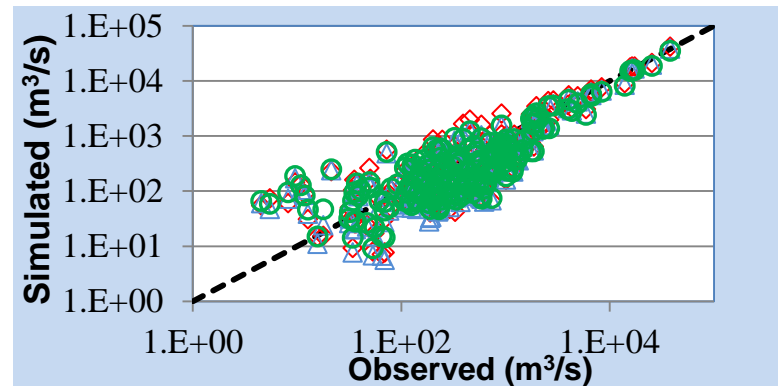
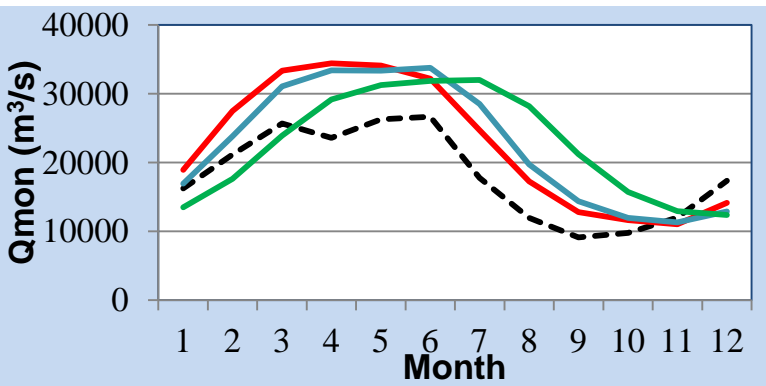
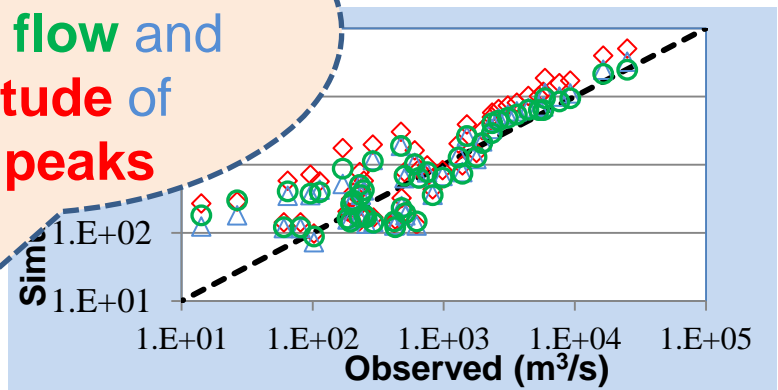
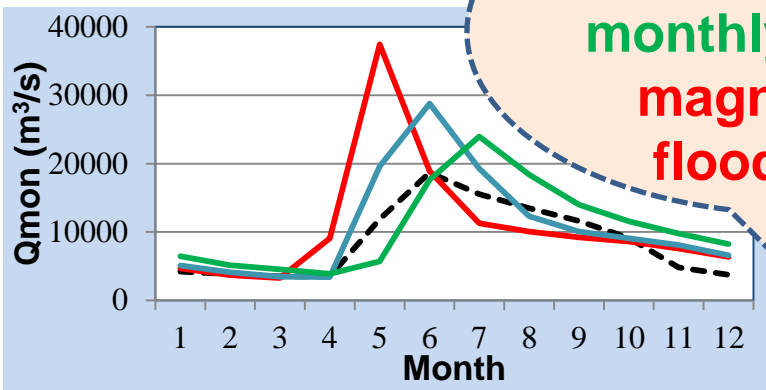
# Global Evaluation--Impacts of Model Structure

## Monthly Mean Flow

## Annual Maximum Daily Flow (flood)



Model structure controls timing of monthly flow and magnitude of flood peaks

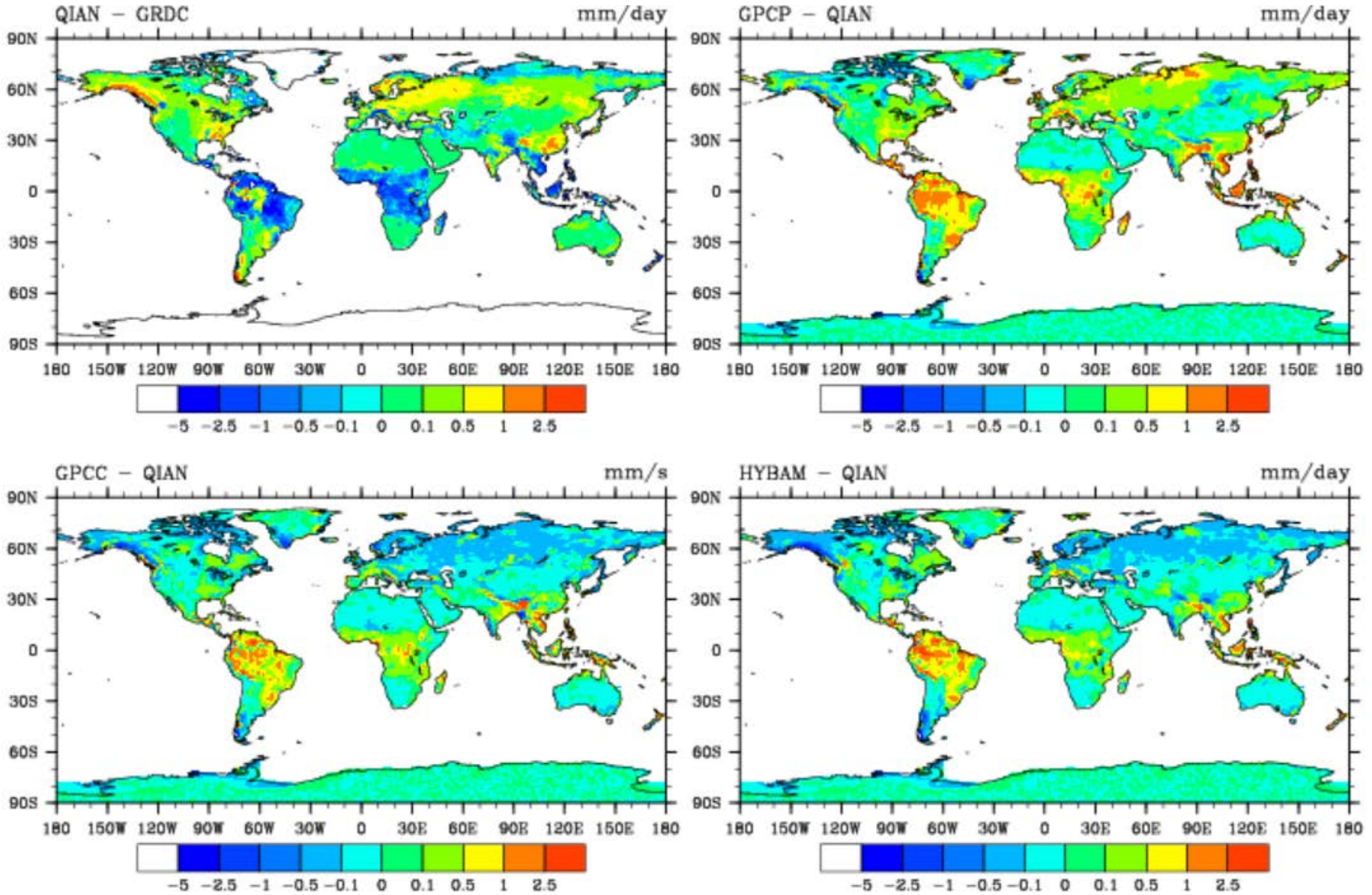


Yukon River System (not affected)

Mackenzie River System (moderately affected)

Mississippi River System (strongly affected)

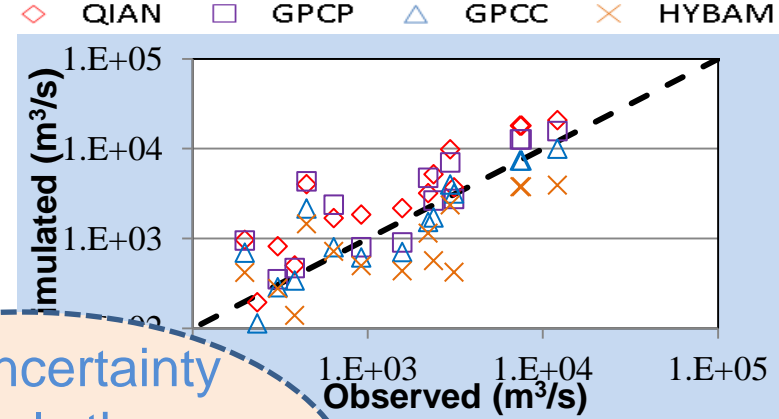
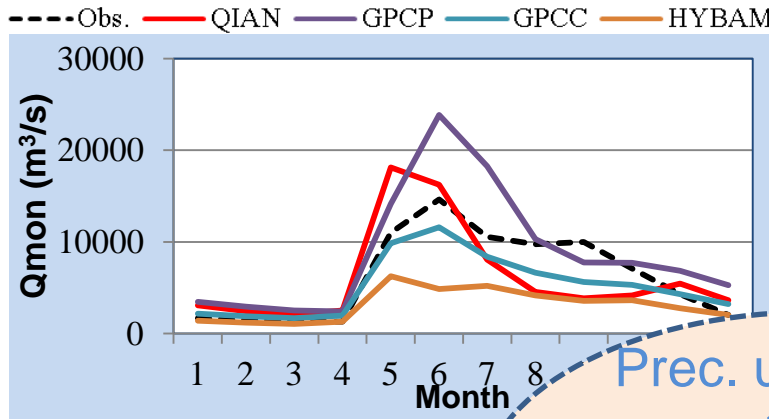
# Global Evaluation—Impacts of Forcing Uncertainty



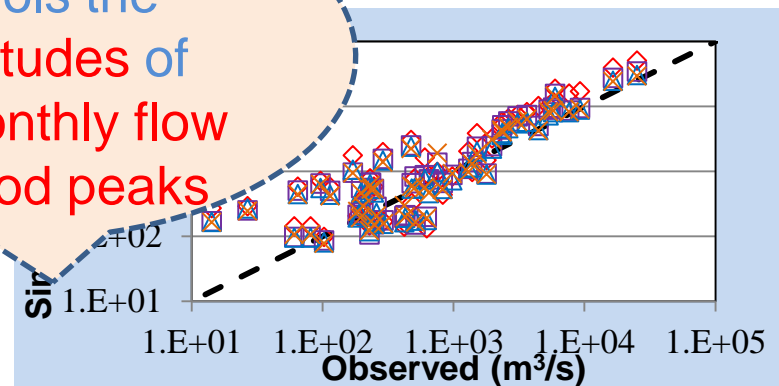
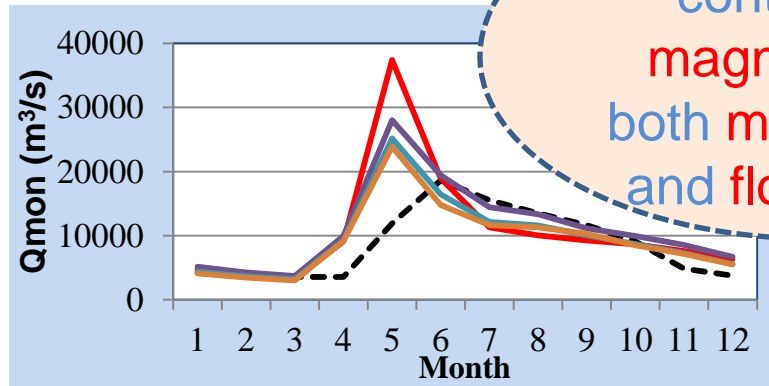
# Global Evaluation—Impacts of Forcing Uncertainty

## Monthly Mean Flow

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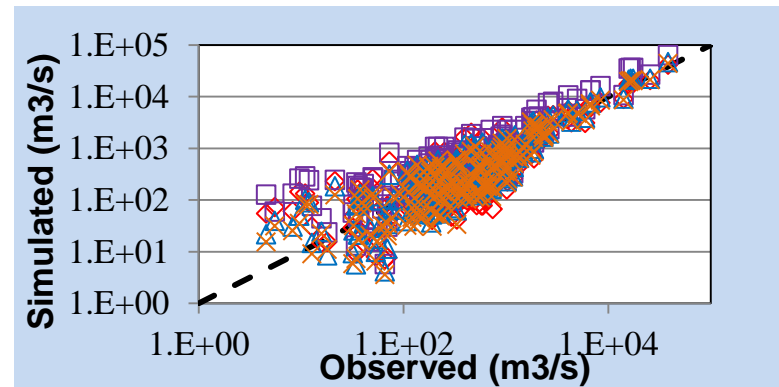
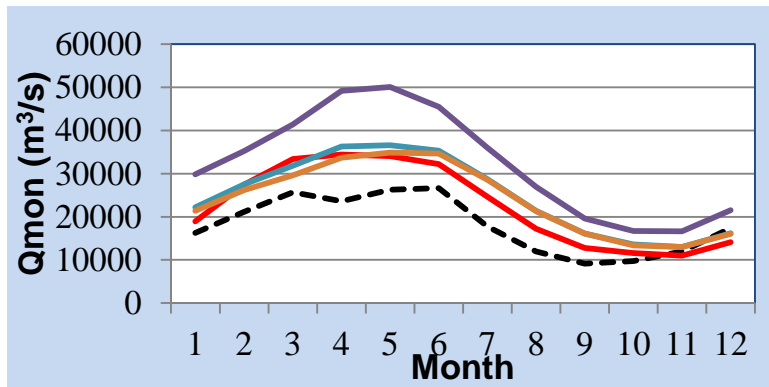


Yukon River System (not affected)



Prec. uncertainty controls the magnitudes of both monthly flow and flood peaks

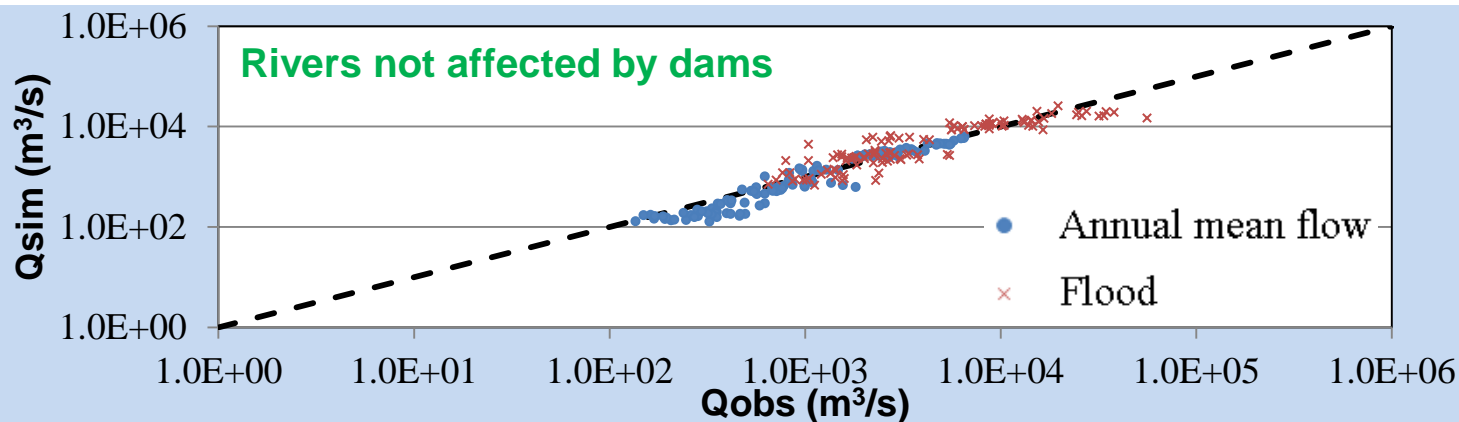
Mackenzie River System (moderately affected)



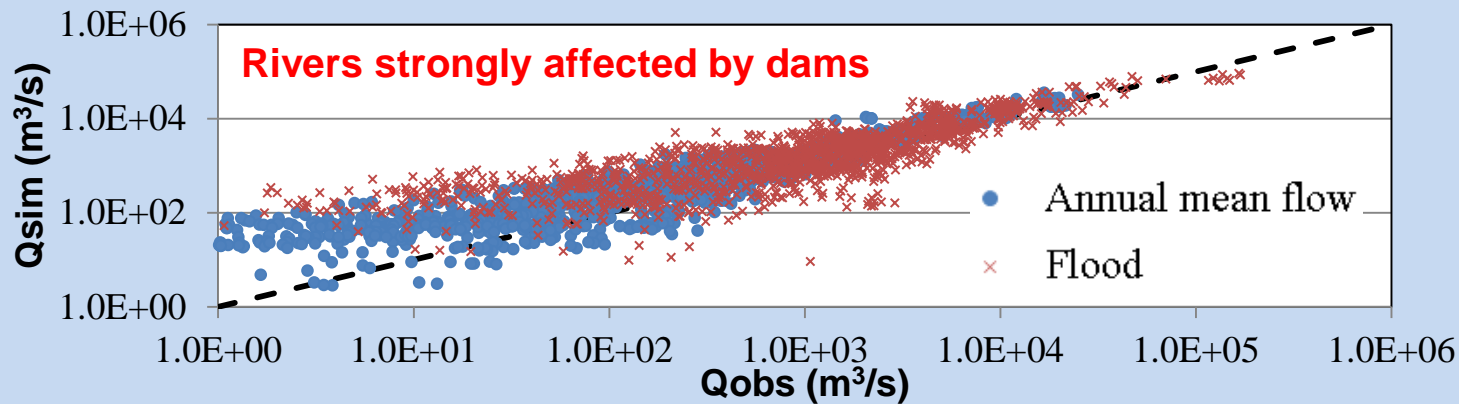
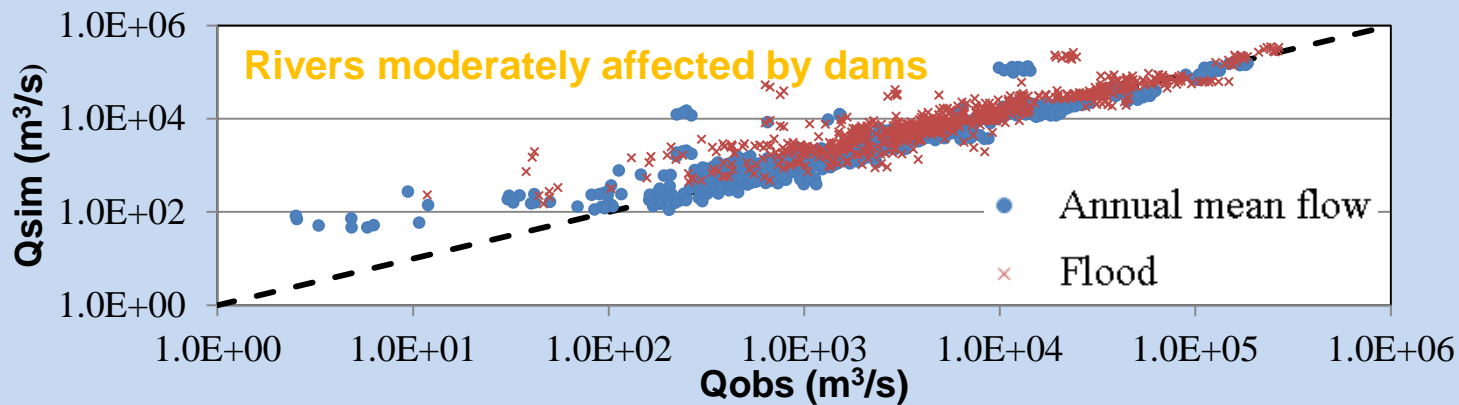
Mississippi River System (strongly affected)

# Global Evaluation--Impacts of Dam Regulations

Each dot  
for a large  
station with  
good records



Ensemble  
mean of  
simulations  
under four  
forcings



# Summary

- ▶ MOSART satisfactorily reproduces the observed mean and maximum streamflow worldwide under different atmospheric forcings
- ▶ Spatiotemporal variabilities of river velocity are important for capturing the timing of monthly streamflow and magnitude of flood peaks
- ▶ The impacts of dam regulations are detectable with a combination of modeling and data analysis

# Future work

- ▶ Global simulation with explicit reservoir representation to further elucidate impacts of dam regulation
- ▶ Extend MOSART to incorporate riverine energy and biogeochemical cycling.

# Acknowledgement

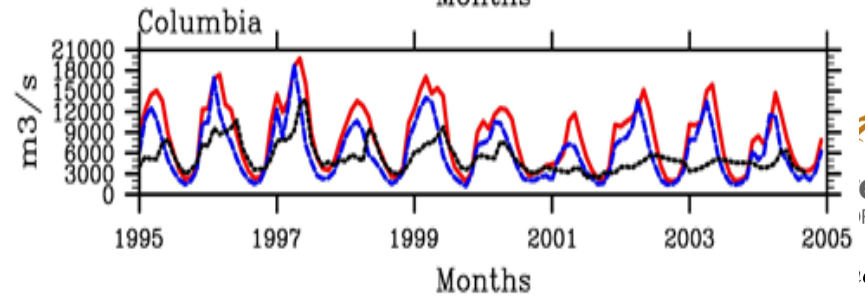
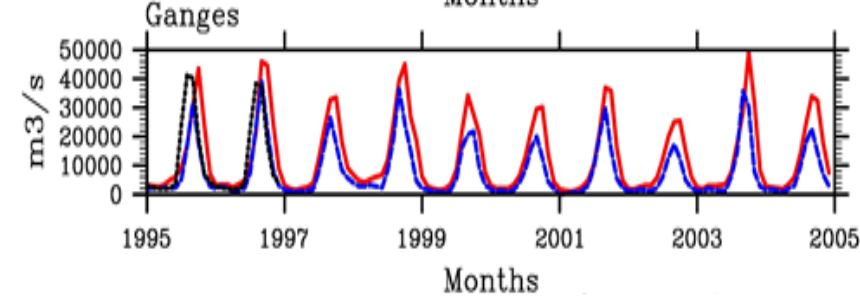
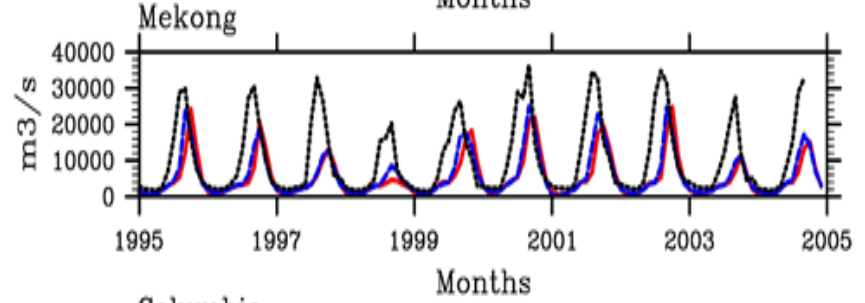
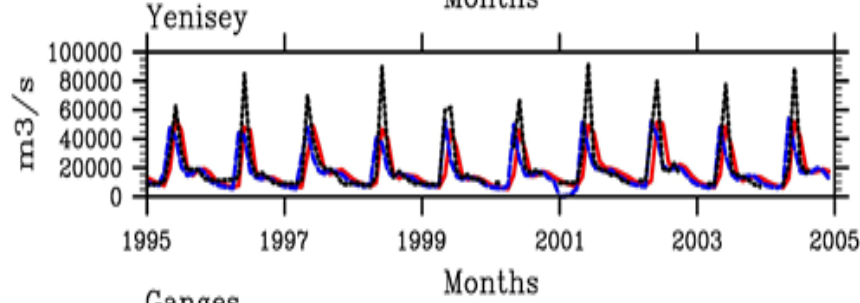
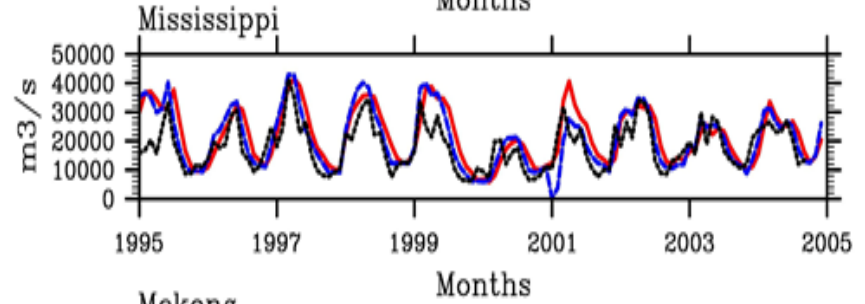
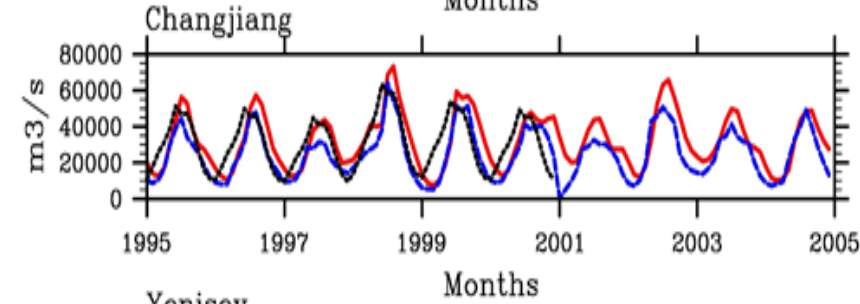
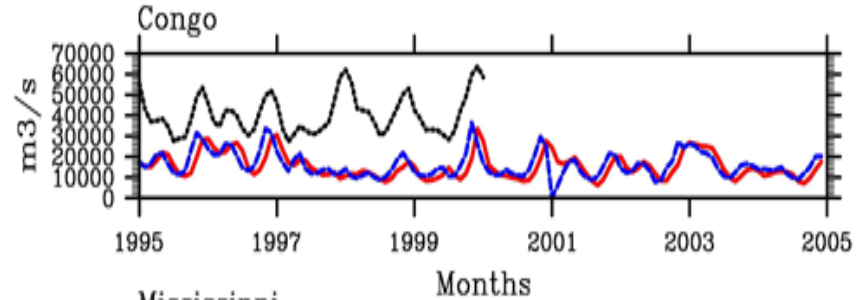
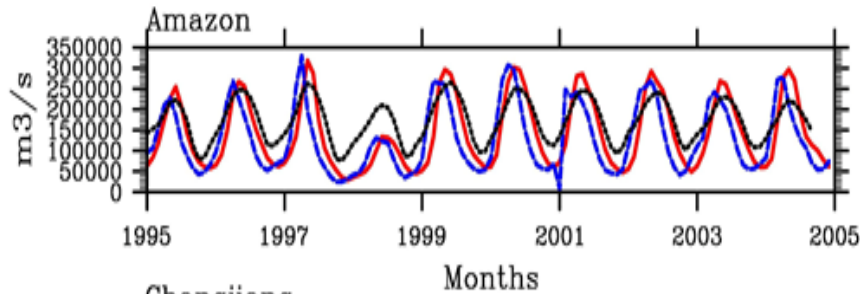
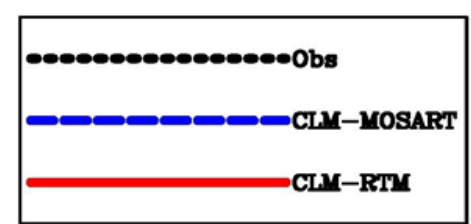
- ▶ DOE: Strengthening the Coupling between Climate and Earth System Models (ESMs) and Integrated Assessment Models (IAMs)
- ▶ DOE: Climate Science for Sustainable Energy Future (CSSEF)
- ▶ PNNL: Platform for Regional Integrated Modeling and Analysis (PRIMA) Initiative



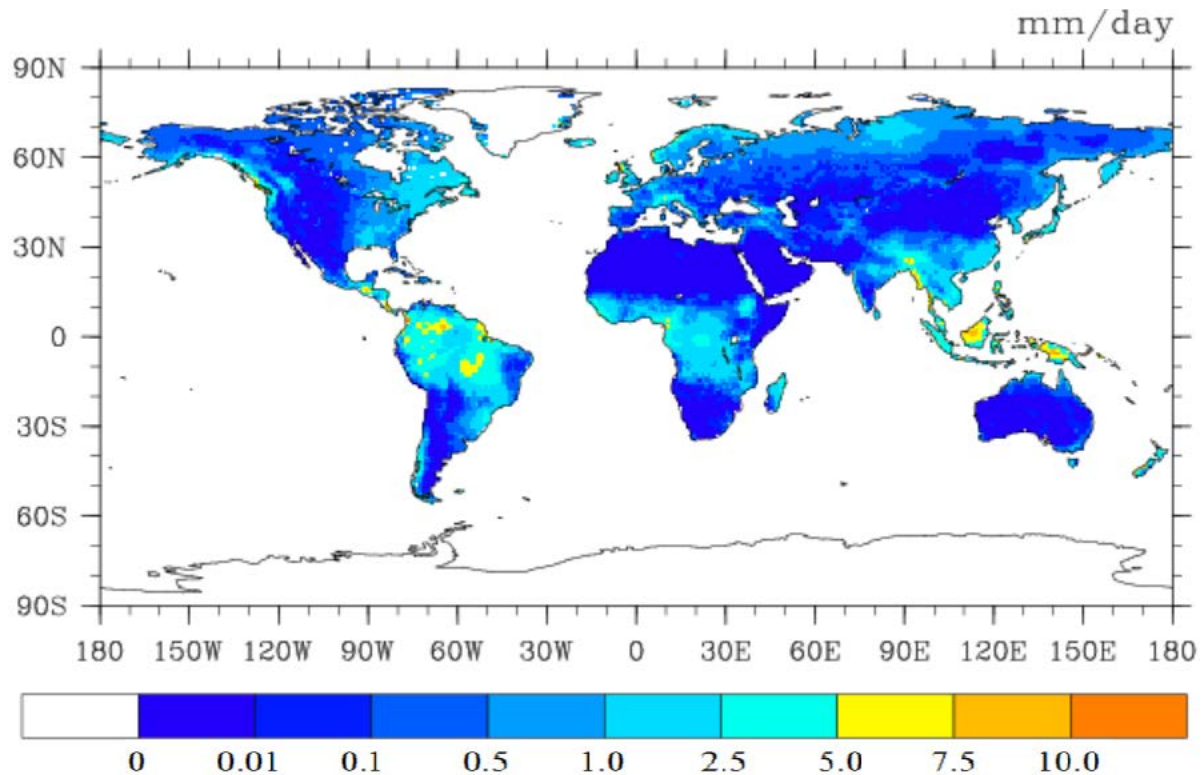
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# Simulated monthly streamflow



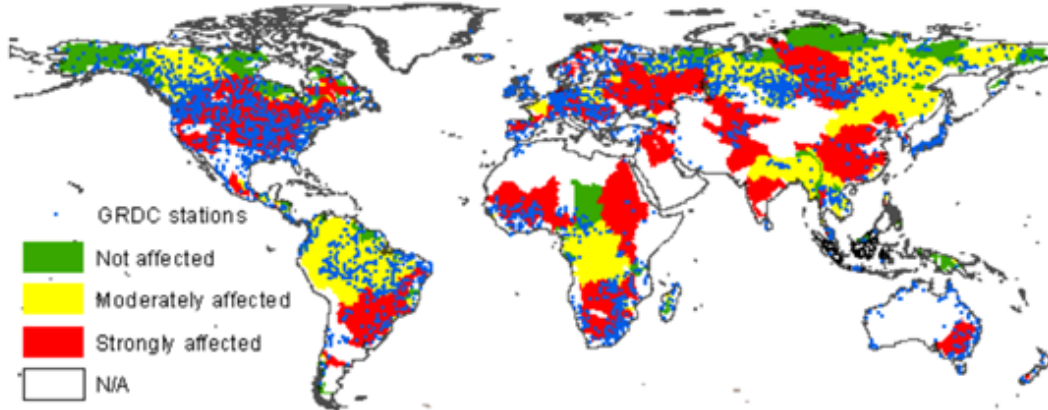
# GRDC/UNH composite runoff field (1986-1995)



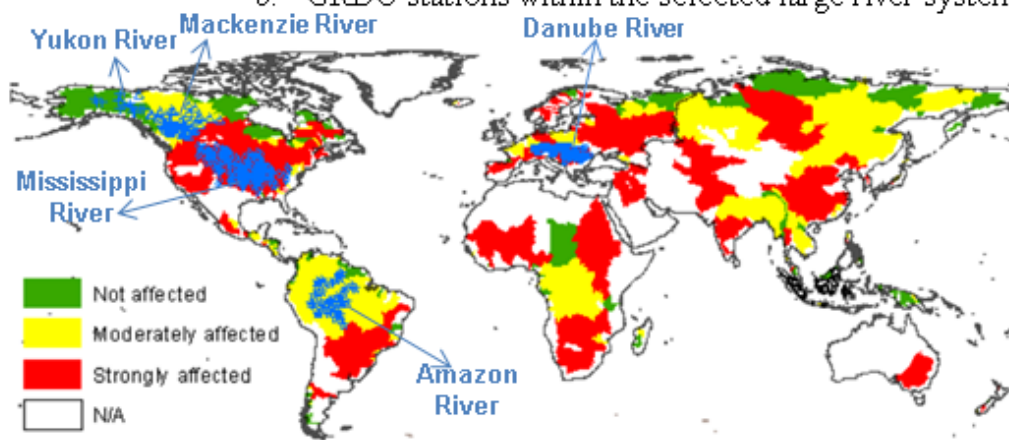
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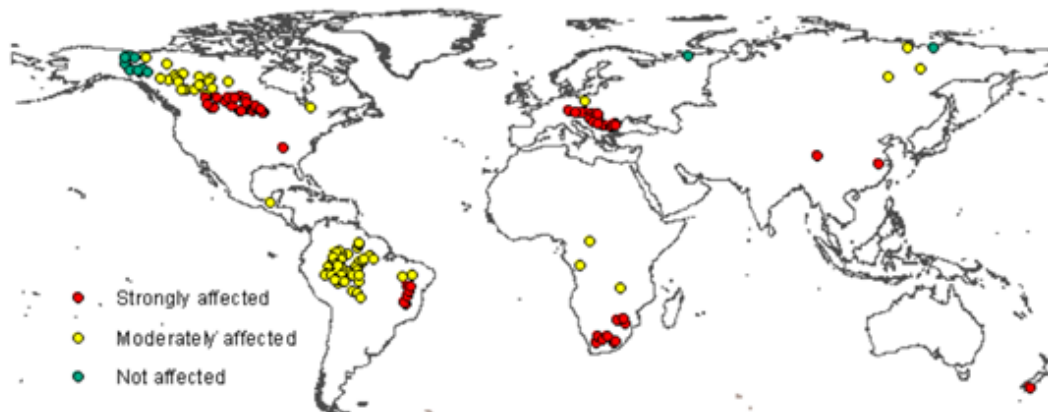




b. GRDC stations within the selected large river systems only



c. GRDC stations with upstream drainage areas larger than 20,000km<sup>2</sup>



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