



# New Features in E3SM V2 to Address Human Impacts on Extreme Hydrologic Events

Tian Zhou<sup>1</sup>, L. Ruby Leung<sup>1</sup>, Hong-Yi Li<sup>2</sup>,  
Nathalie Voisin<sup>1</sup>, Teklu Tesfa<sup>1</sup>

<sup>2</sup>University of Houston, Houston, TX

<sup>1</sup>Pacific Northwest National Laboratory, Richland, WA

## V2 Scientific Question:

# What are the relative impacts of global forcing versus regional effects of human activities on flood and drought in North America?

Extreme hydrologic events such as floods and droughts are often perceived as natural hazards, but human activities may alter their characteristics by perturbing the water and energy fluxes in the earth system through changes in

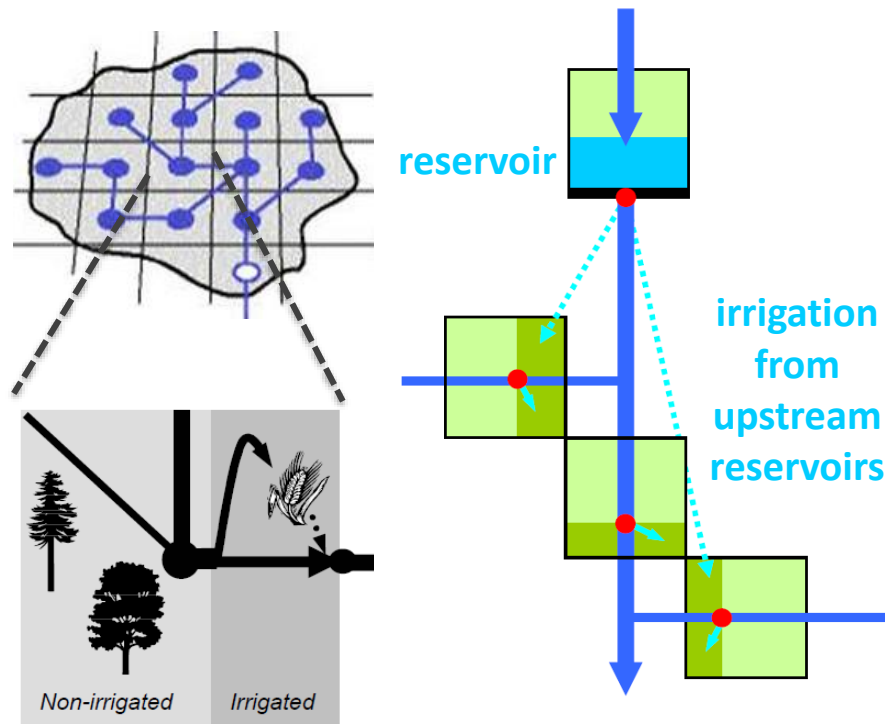
- Land use and land cover
- Water use such as irrigation
- Water management

# New V2 features to address the scientific question

- MOSART-Water Management (WM)
  - Irrigation water supply is provided by local river and upstream reservoirs
  - Dam regulation reshapes hydrograph
- Two-way coupled irrigation scheme
  - Irrigation application in E3SM land model (ELM) is constrained by the water availability from the river model (MOSART-WM)
- MOSART-inundation
  - A floodplain storage along the river channel to represent floodplain inundation if the river discharge exceeds bankfull discharge

# MOSART-Water Management (WM)

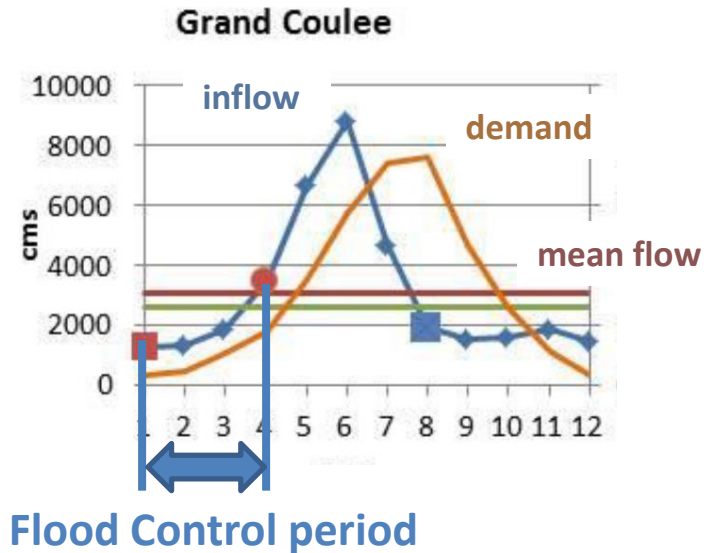
## Irrigation Water Distribution Scheme



irrigation from local river

MOSART-Water Management model simulates irrigation water distributions across river network and dam regulations

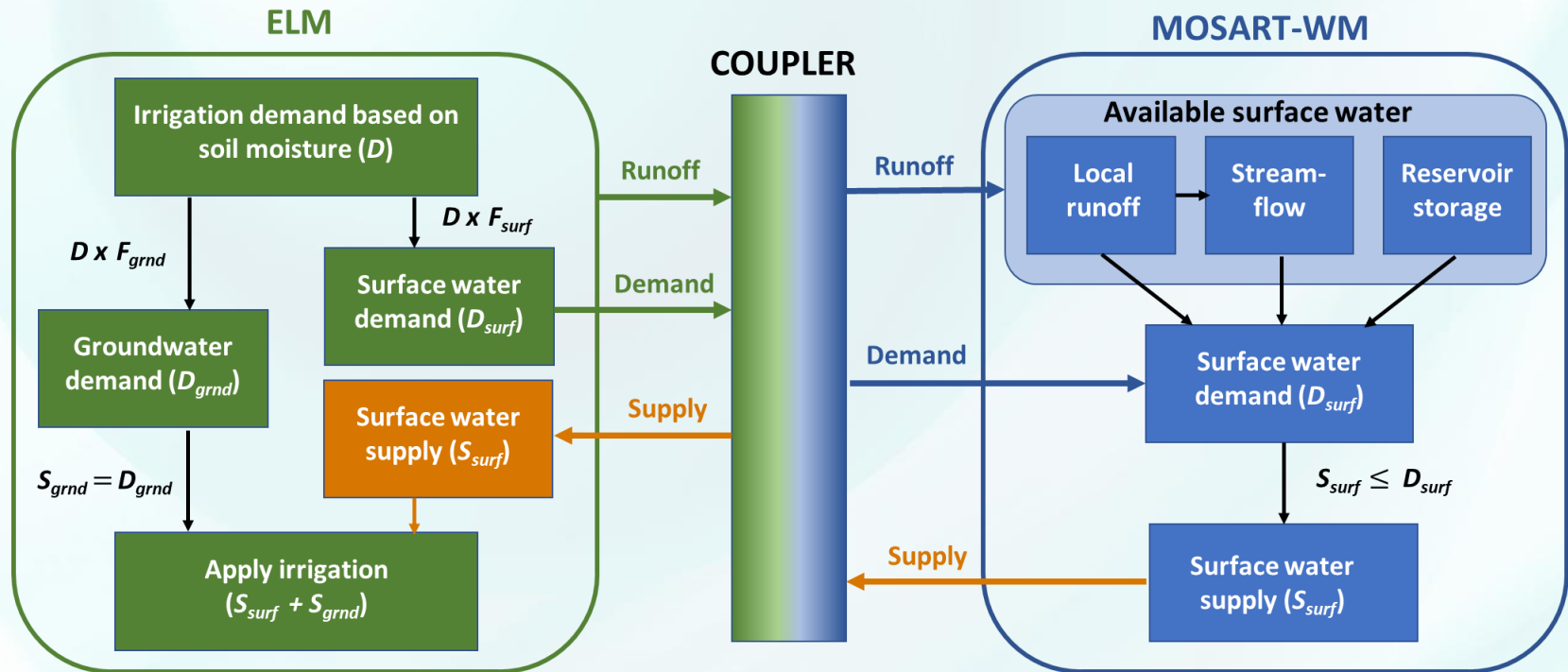
## Dam Regulation scheme



Dam regulation scheme combines flood control and irrigation needs

Voisin, N., Li, H. Y., Ward, D., Huang, M., Wigmosta, M., & Leung, L. R. (2013). On an improved sub-regional water resources management representation for integration into earth system models. *Hydrology and Earth System Sciences*, 17, 3605-3622.

# Two-way coupled irrigation scheme

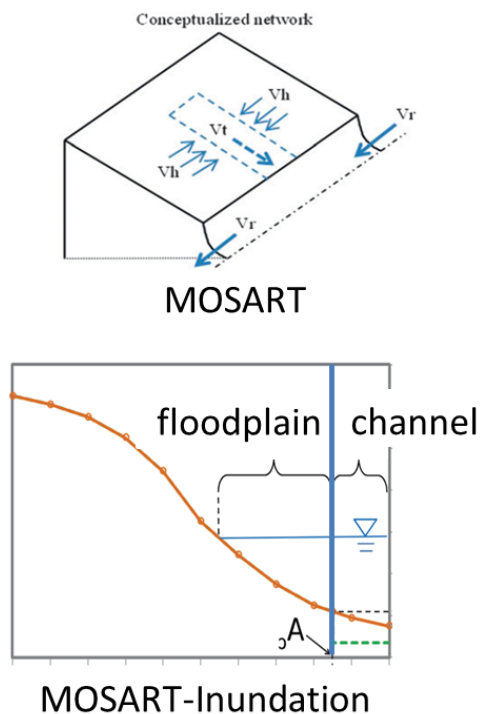


Two-way coupled irrigation scheme allows the E3SM Land Model (ELM) to receive dynamic surface water availability information (**supply in the figure**) from the E3SM river and water management models (MOSART-WM) for irrigation

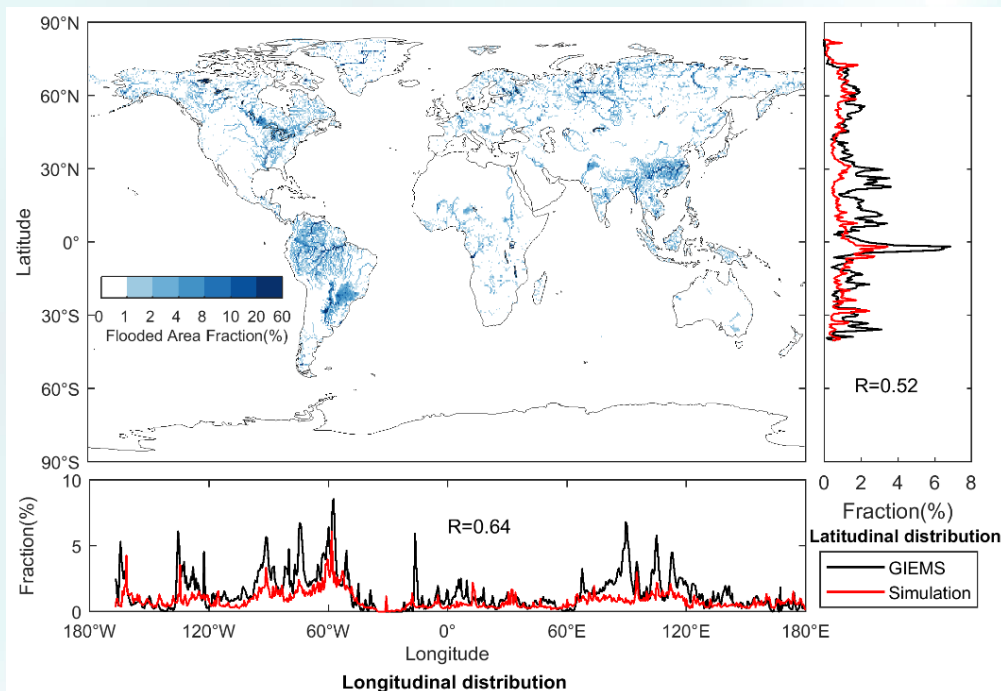
Zhou, T., Leung, L. R., Leng, G., Voisin, N., Li, H. Y., Craig, A. P., et al. (2020). Global Irrigation Characteristics and Effects Simulated by Fully Coupled Land Surface, River, and Water Management Models in E3SM. *Journal of Advances in Modeling Earth Systems*, 12(10).



# MOSART-inundation



MOSART-inundation scheme adds a floodplain storage component along the river channel to better represent the flood inundation processes



## Simulated flood inundation fraction compared with satellite observations

Luo, X., Li, H. Y., Ruby Leung, L., Tesfa, T. K., Getirana, A., Papa, F., & Hess, L. L. (2017). Modeling surface water dynamics in the Amazon Basin using MOSART-Inundation v1.0: Impacts of geomorphological parameters and river flow representation. *Geoscientific Model Development*

Mao, Y., Zhou, T., Leung, L. R., Tesfa, T. K., Li, H. Y., Wang, K., et al. (2019). Flood Inundation Generation Mechanisms and Their Changes in 1953–2004 in Global Major River Basins. *Journal of Geophysical Research: Atmospheres*.

<https://doi.org/10.1029/2019JD031381>

# Summary & next steps

- ❖ **With MOSART-WM and two-way coupled irrigation, E3SM V2 is able to represent some critical human activities and processes in the land and river components**
- ❖ **With MOSART-inundation, the model has better representation in simulating flood events**
- ❖ **These new features will help us understand the human impacts on hydrologic extremes and human perturbations on the interacting processes within a coupled earth system**