The impact of human activities on drought and flood severity across the U.S.

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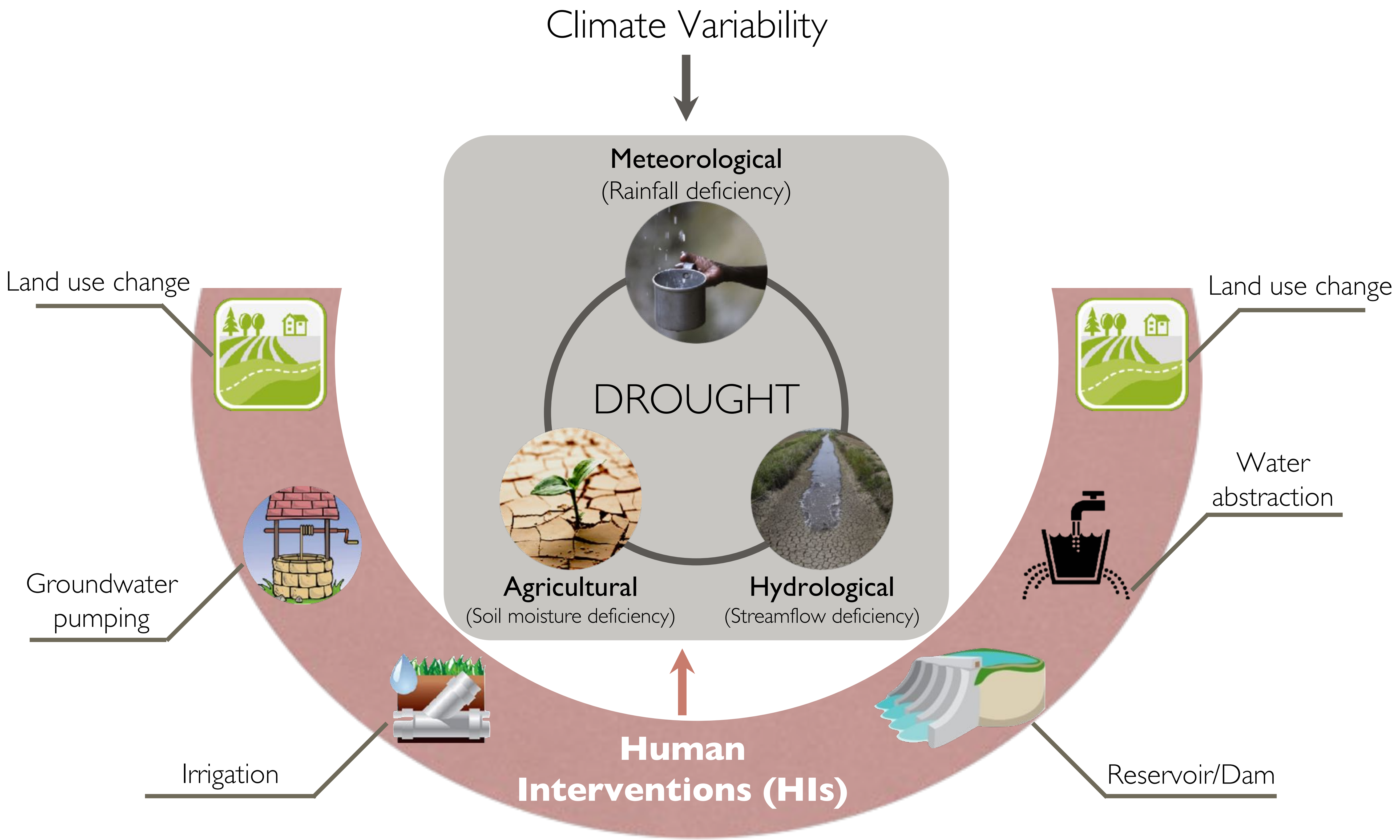
Drought and human activities



Drought and human activities

Attribution of HIs ?→ Drought Resilience

Scientific Questions:

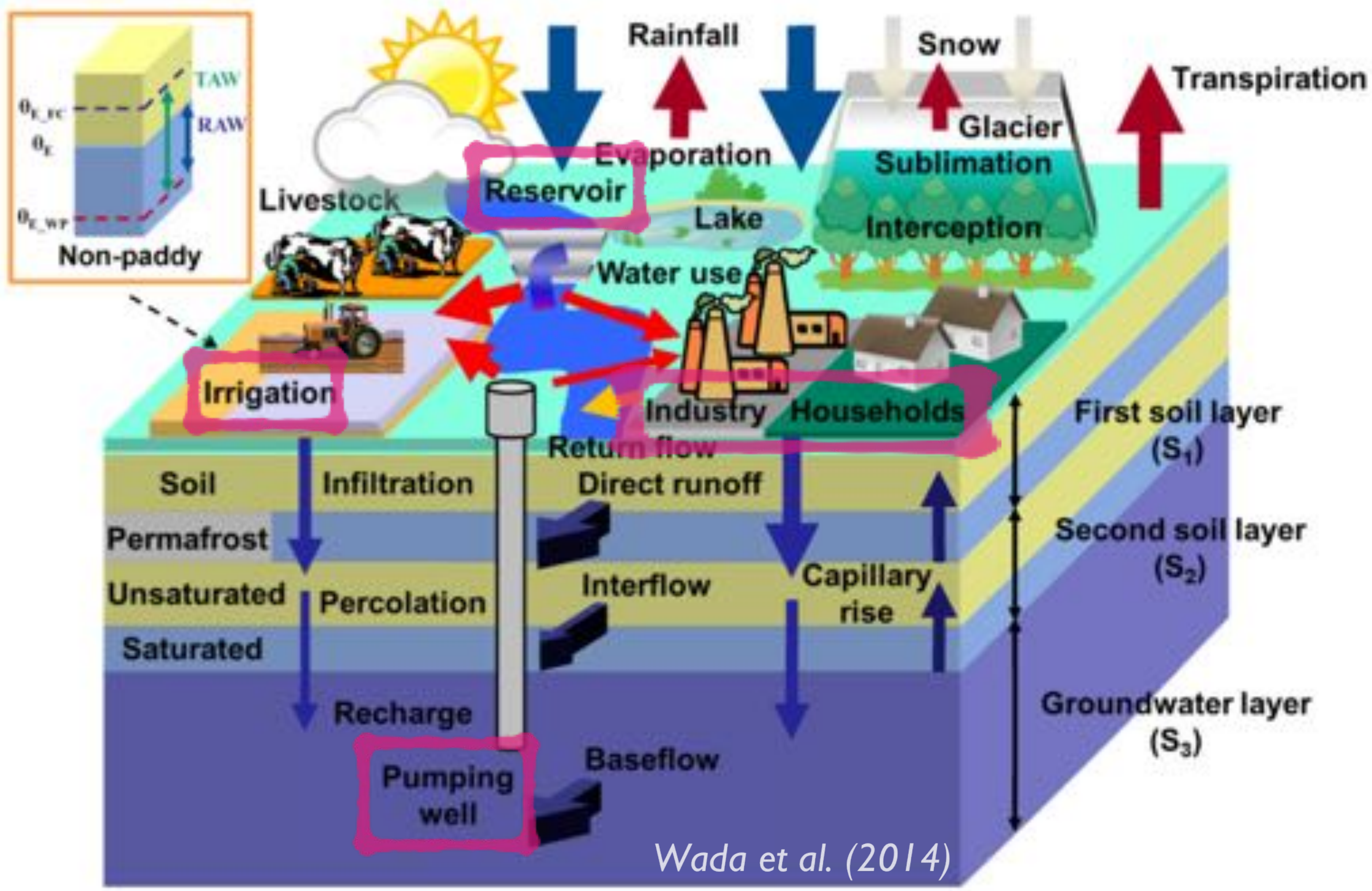
1. Can we quantitatively assess how different types of human interventions (HIs) contribute to U.S. (hydrological) drought risk?

2. Where do HIs amplify drought and where do they cancel out?

3. What are the trade-offs/relationships between upstream and downstream due to HIs (e.g., reservoir operation)?

4. How does this compare with impacts on flood risk?

Methodology: PCR-GLOBWB model



- Simulation period
  - 1980-2016
  - 5 year spin up
- Resolution
  - 5 min, ~10 km
- Input forcing
  - NLDAS2, Prec, T

Control Experiment

- Only natural variability

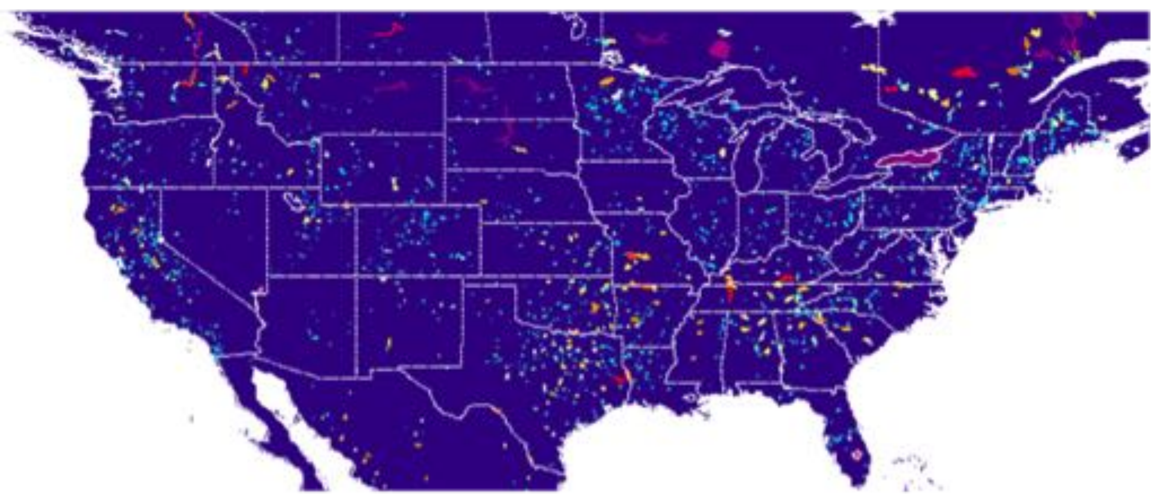
VS

Contrast Experiments

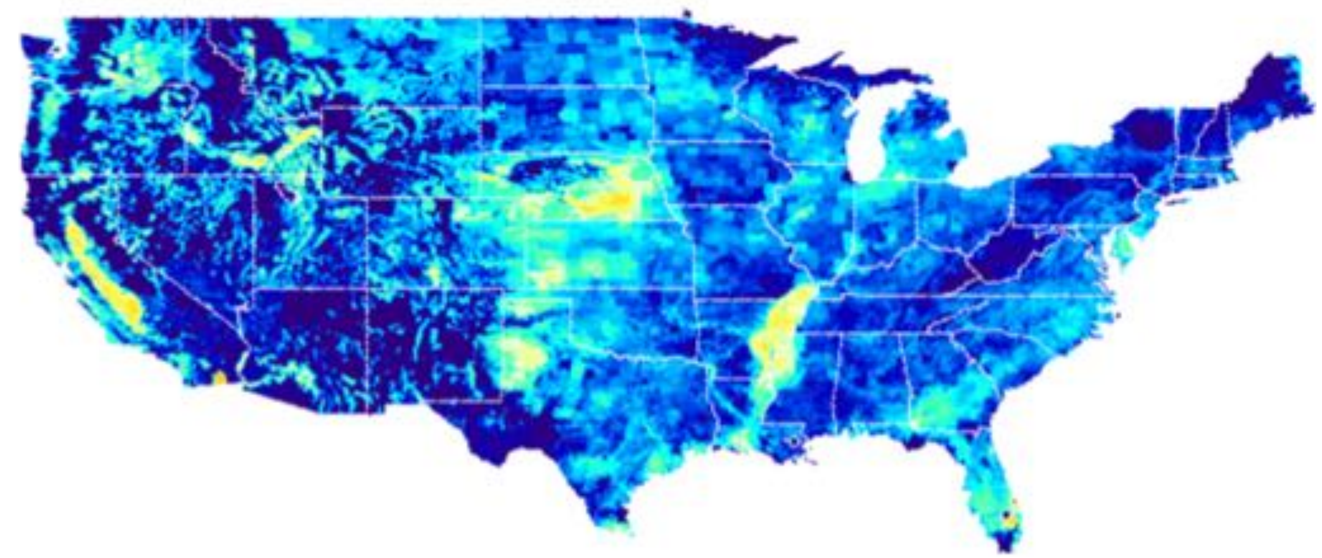
- Include different types of human activities (e.g., irrigation, reservoir, sectoral water use)

Human Intervention Data

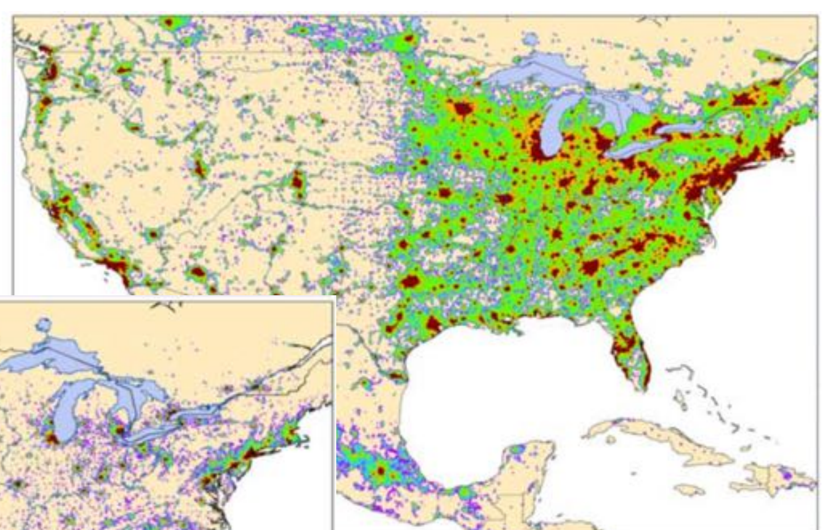
Reservoir capacity



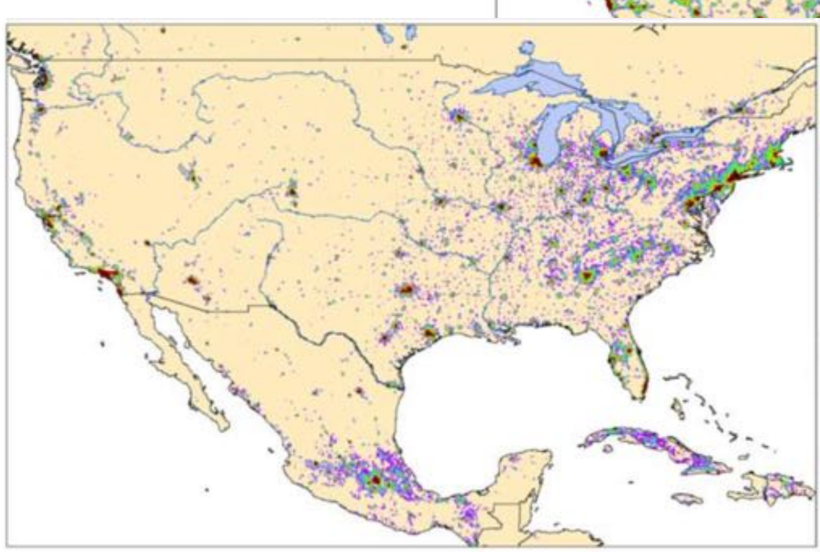
Irrigation area



Sectoral water use



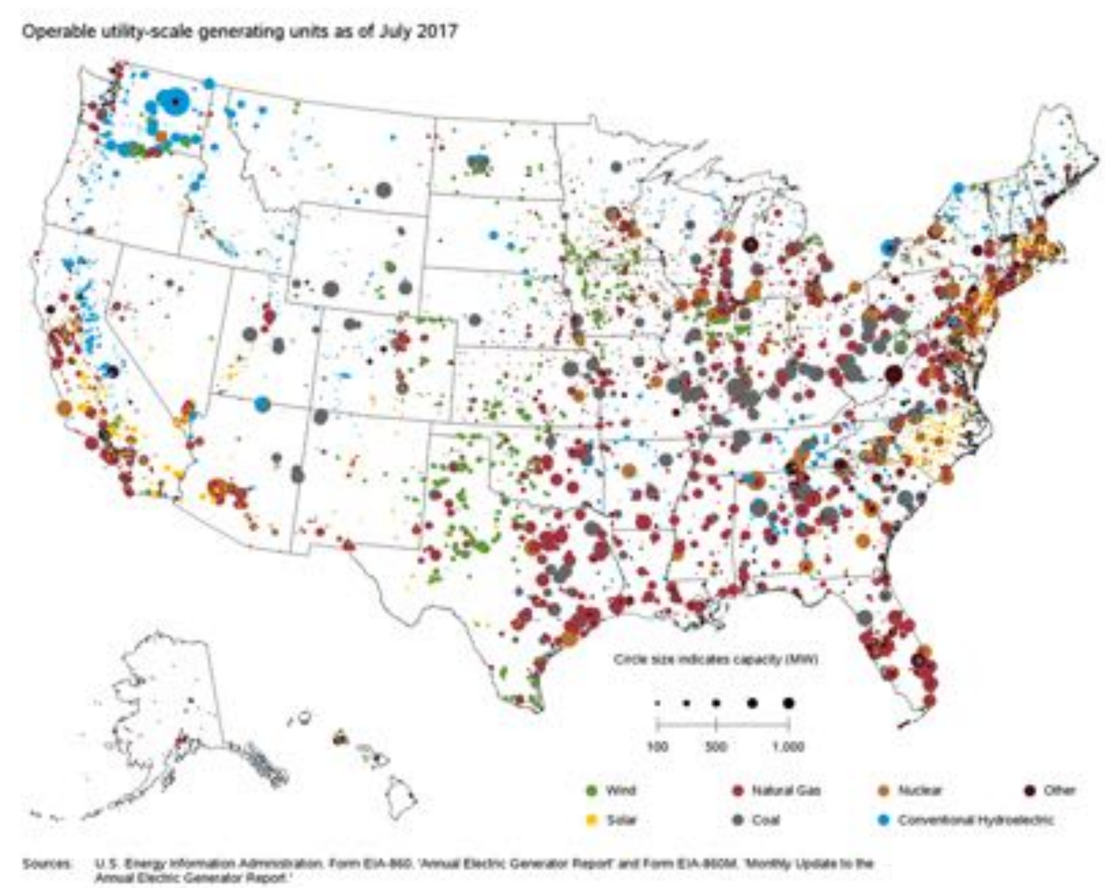
Domestic



Industrial

Wada et al. (2016)

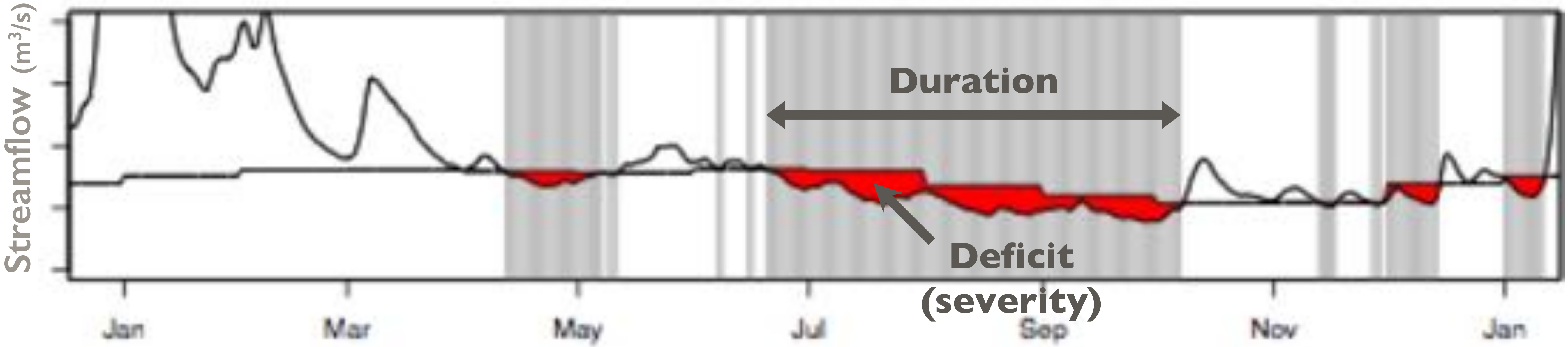
Distribution of Power Stations



Experiment design

Scenarios \ Activities	Irrigation	Domestic water use	Industrial water use	Livestock water use	Reservoir operation	Groundwater pumping	
Natural	✗	✗	✗	✗	✗	✗	☆
Human	✓	✓	✓	✓	✓	✓	☆
Irrigation (+Reservoir+GW)	✓	✗	✗	✗	✓	✓	☆
Irrigation (-Reservoir+GW)	✓	✗	✗	✗	✗	✓	
Non-Irrigation (+Reservoir+GW)	✗	✓	✓	✓	✓	✓	☆
Non-Irrigation (-Reservoir+GW)	✗	✓	✓	✓	✗	✓	

Drought Characteristics



Drought duration

$$S(t,n) = \begin{cases} 1 & if\ Q(t,n) < Q_{90}(t,n) \\ 0 & if\ Q(t,n) \geq Q_{90}(t,n) \end{cases}$$

$$Dur(n) = \sum_{t=T_f}^{T_l} S(t,n)$$

Drought severity

(Standardized drought deficit volume (StDef))

$$Def(t,n) = max(0,\ Q_{90}(t,n) - Q(t,n))$$

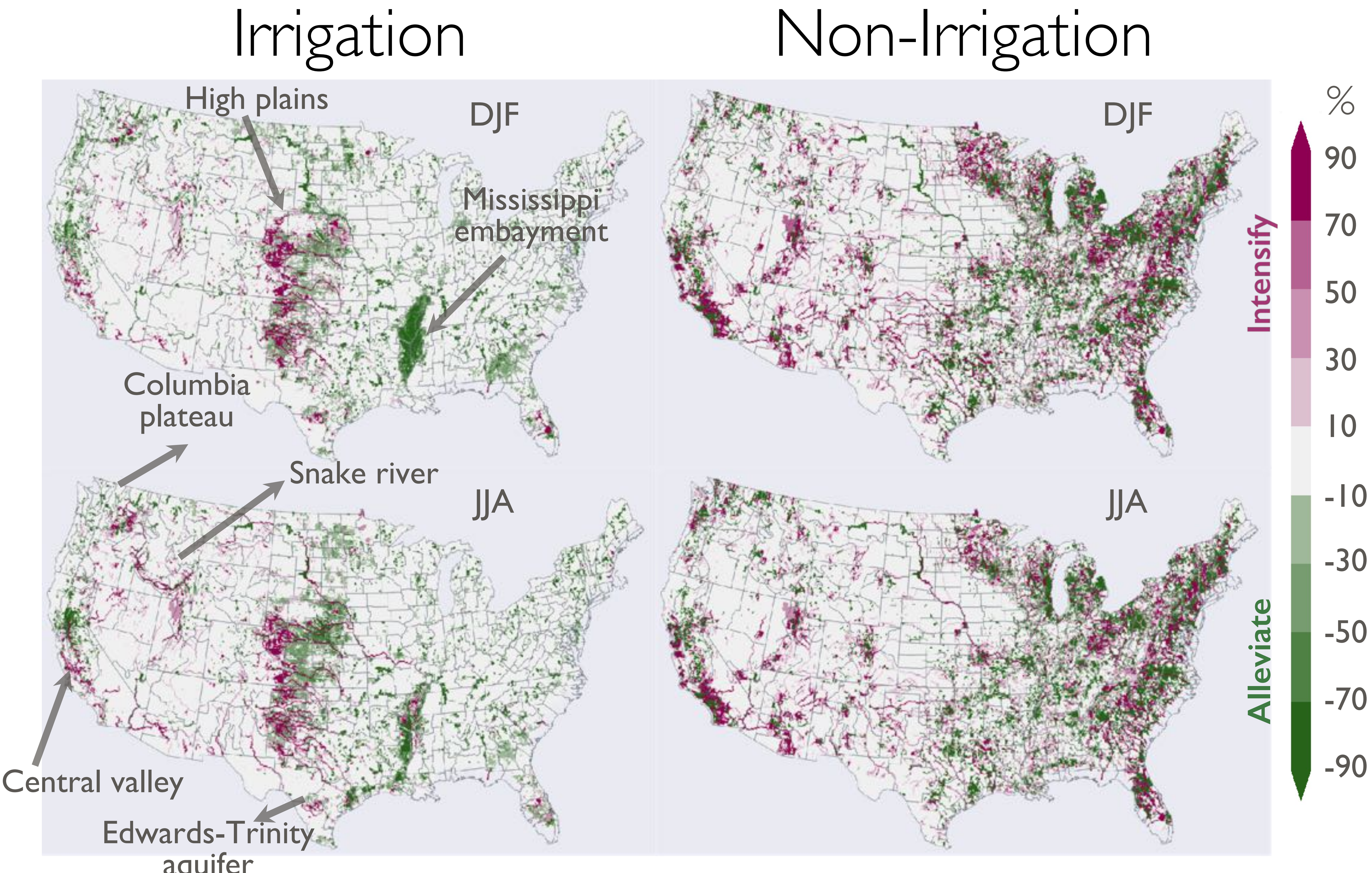
$$StDef(t,n) = \frac{Def(t,n)}{Q_{90}(t,n)}$$

Impacts on floods characterized by standardized excess (*StExcess*)

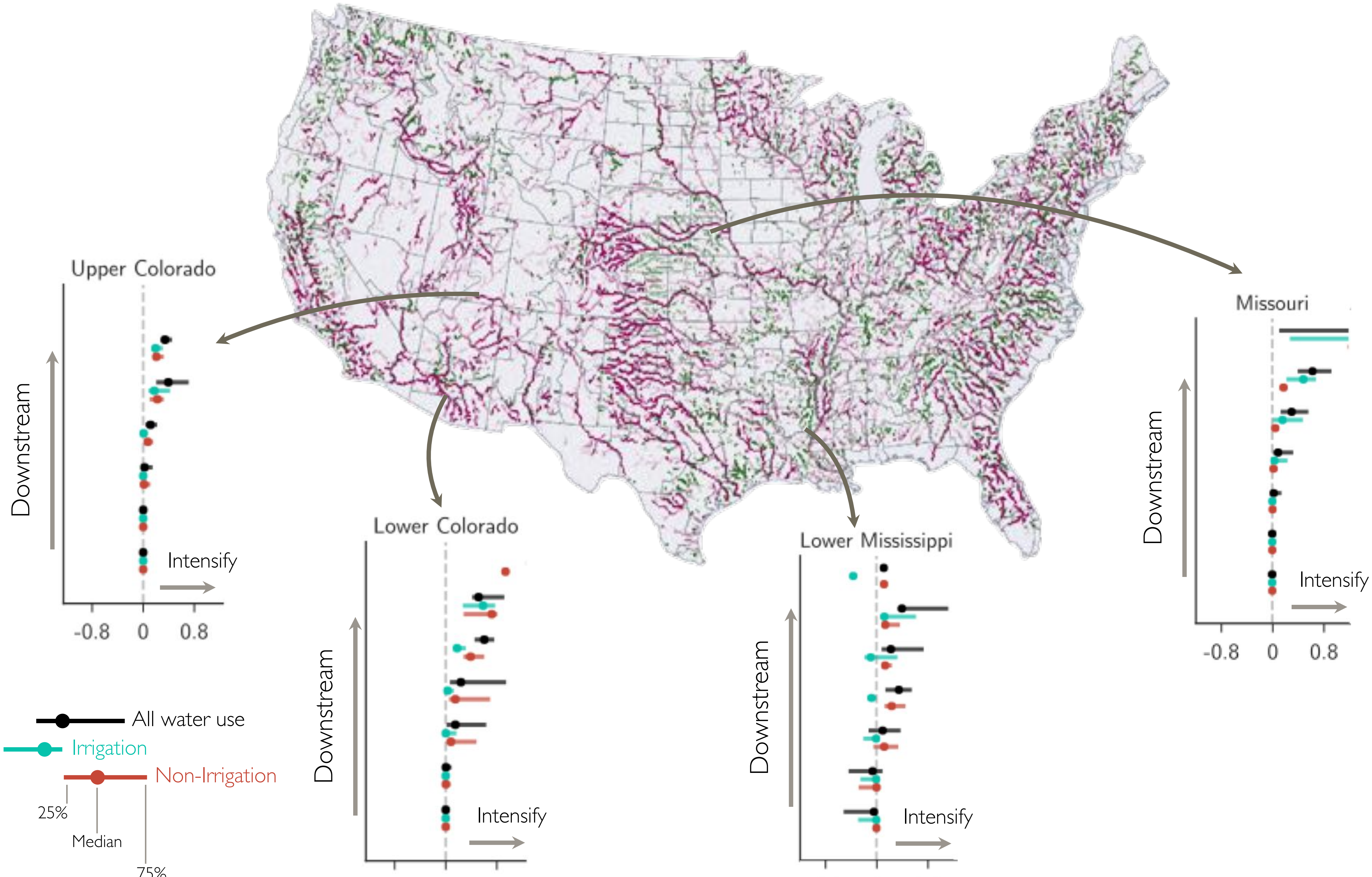
Results - Relative contribution to Drought Severity

All Human activities

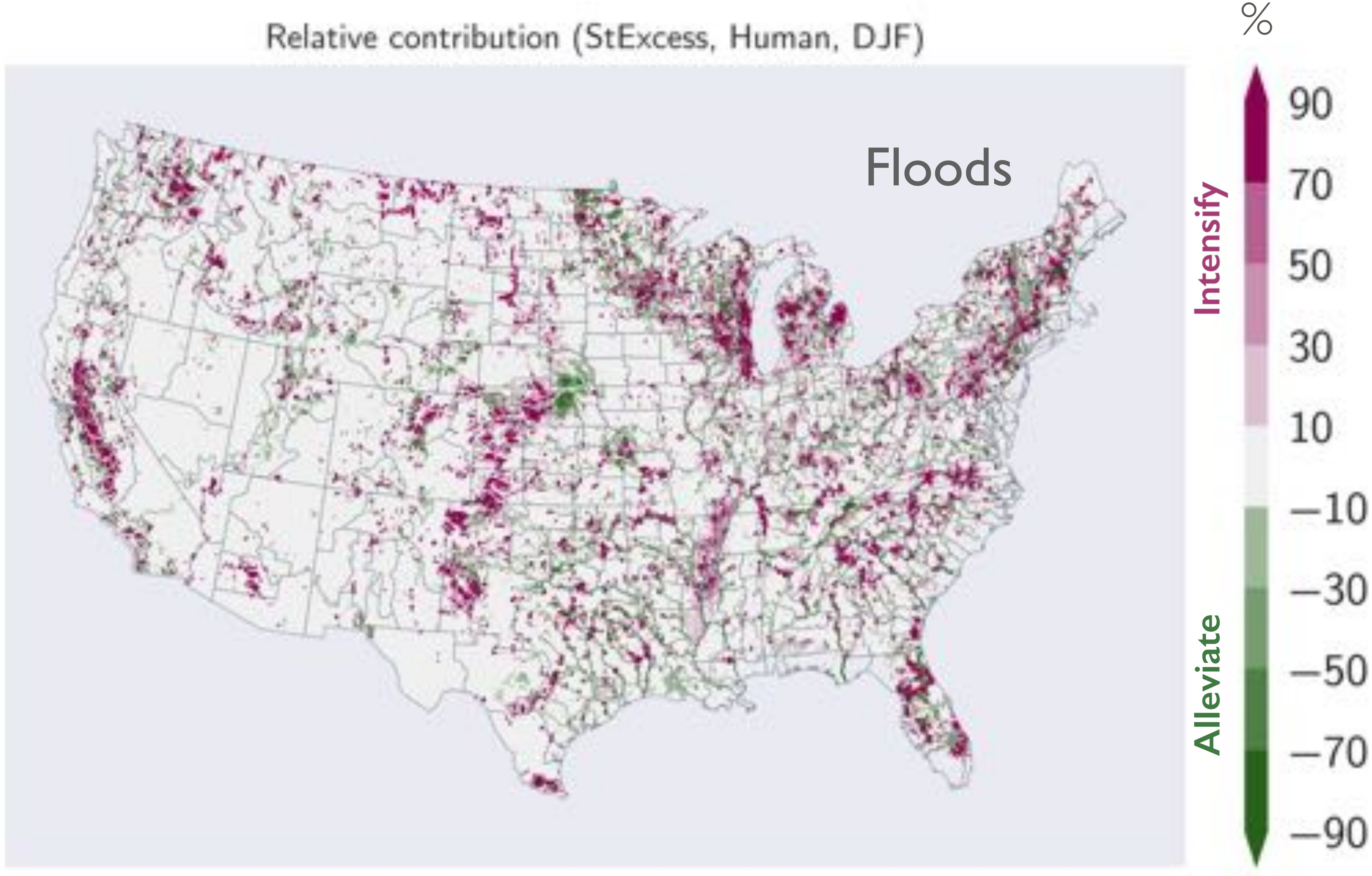
Results – Irrigation versus Non-irrigation Interventions



Results - Does drought travel downstream?

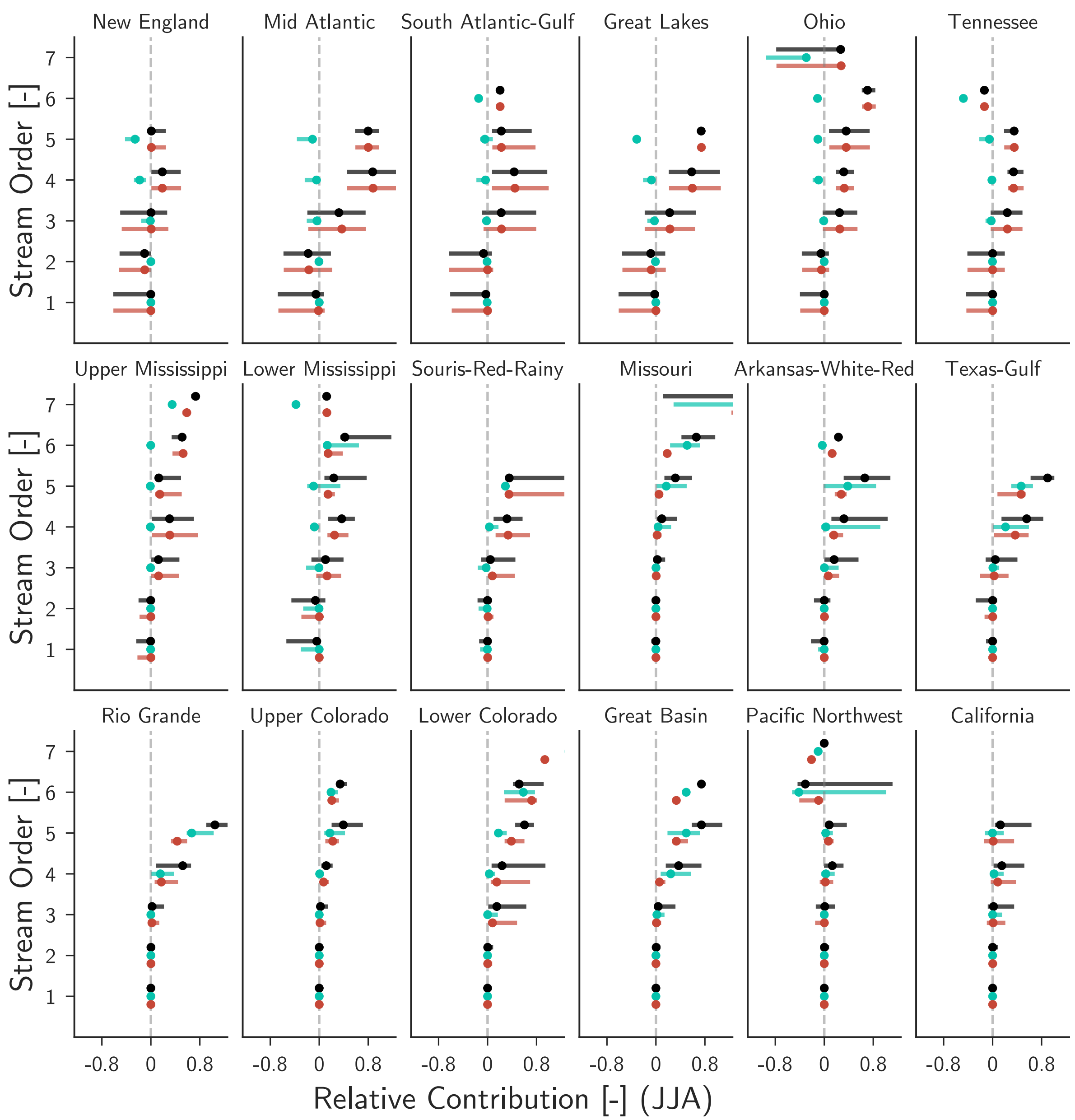


Results - Comparing with HI impacts on Flood Severity

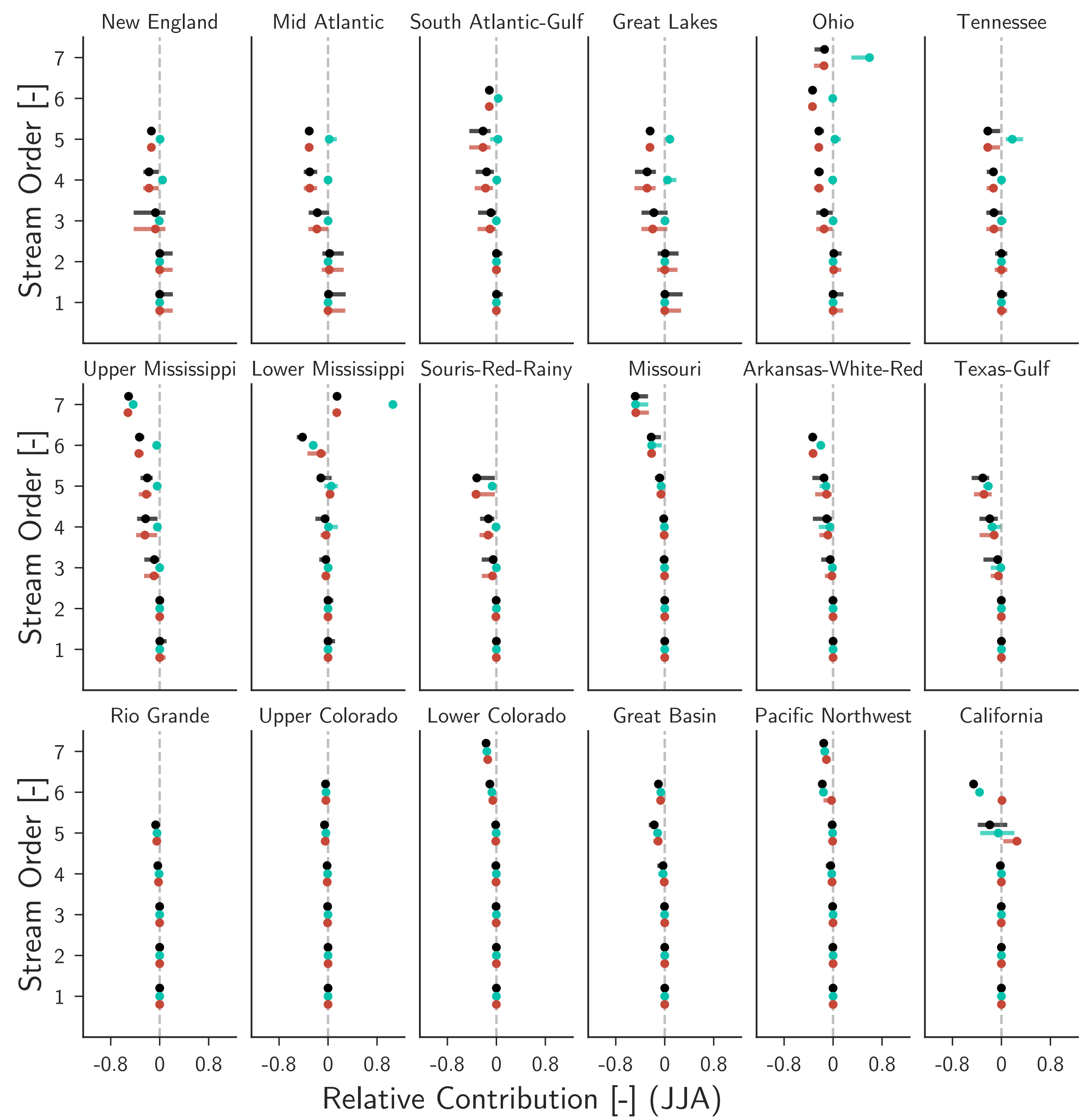


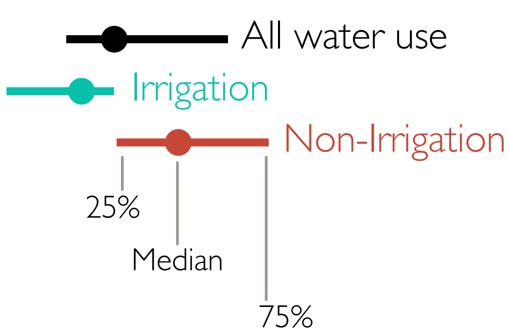
Comparing Drought and Flood Downstream Effects

Droughts



Floods





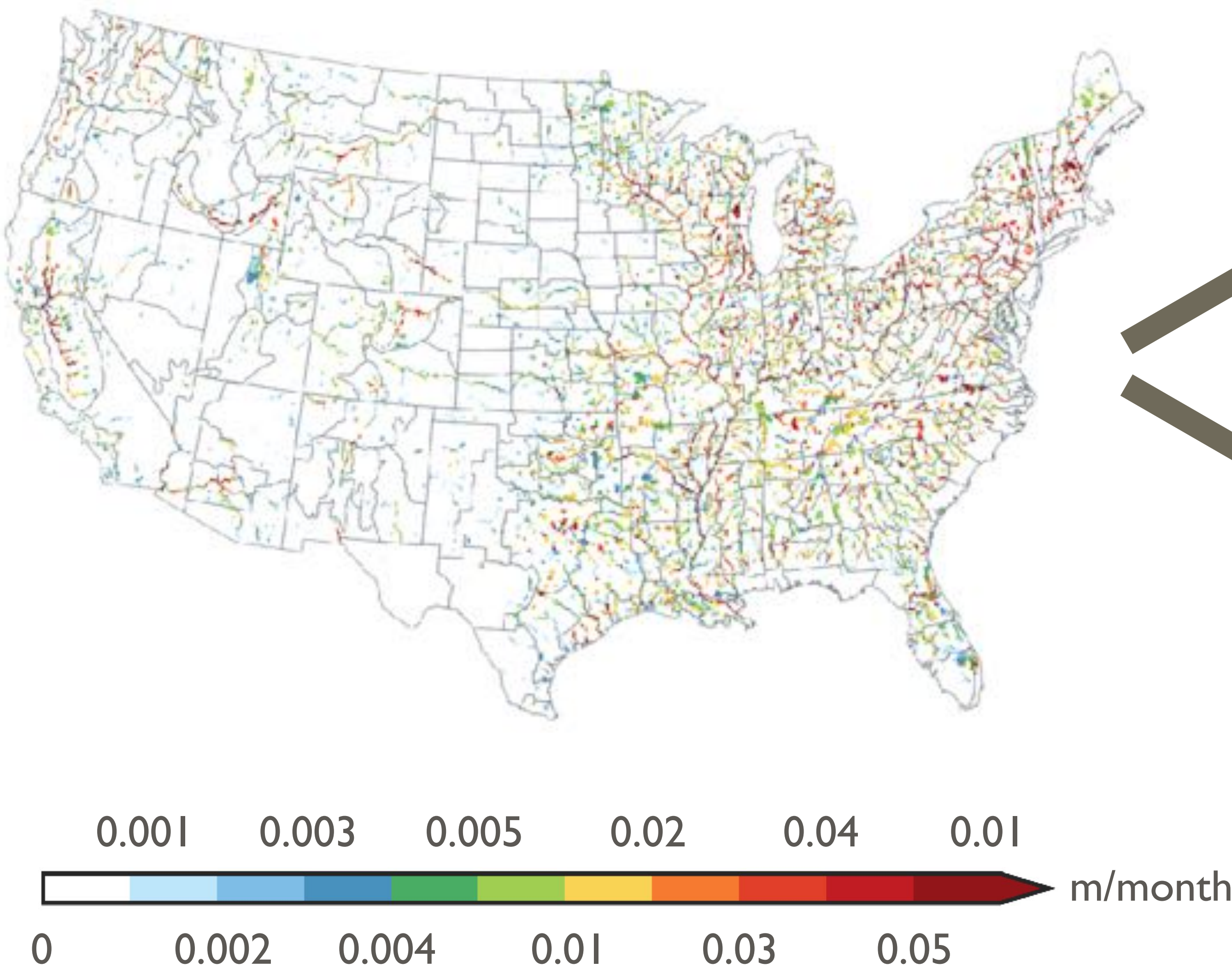
- Impacts on droughts are much higher and tend to have stronger downstream effects.
- Floods tends to be alleviated downstream

Summary

- Using a macroscale hydrological and water resources model, we try to unravel the relative contribution of human interventions to drought and flood severity over the US.
- Irrigation reduces hydrological drought in areas of intensive irrigation, while shallow groundwater pumping can increase hydrological drought. Non-irrigation water use has more spatially diverse impacts.
- Downstream accumulation effects add another layer of complexity to assess the impacts of HIs on drought severity. Droughts are not just local.
- Floods are also affected: mostly intensification but less relative impact
- Work needed to corroborate with ground observations and knowledge

Water source to meet different demand - Surface water abstraction

All human activities

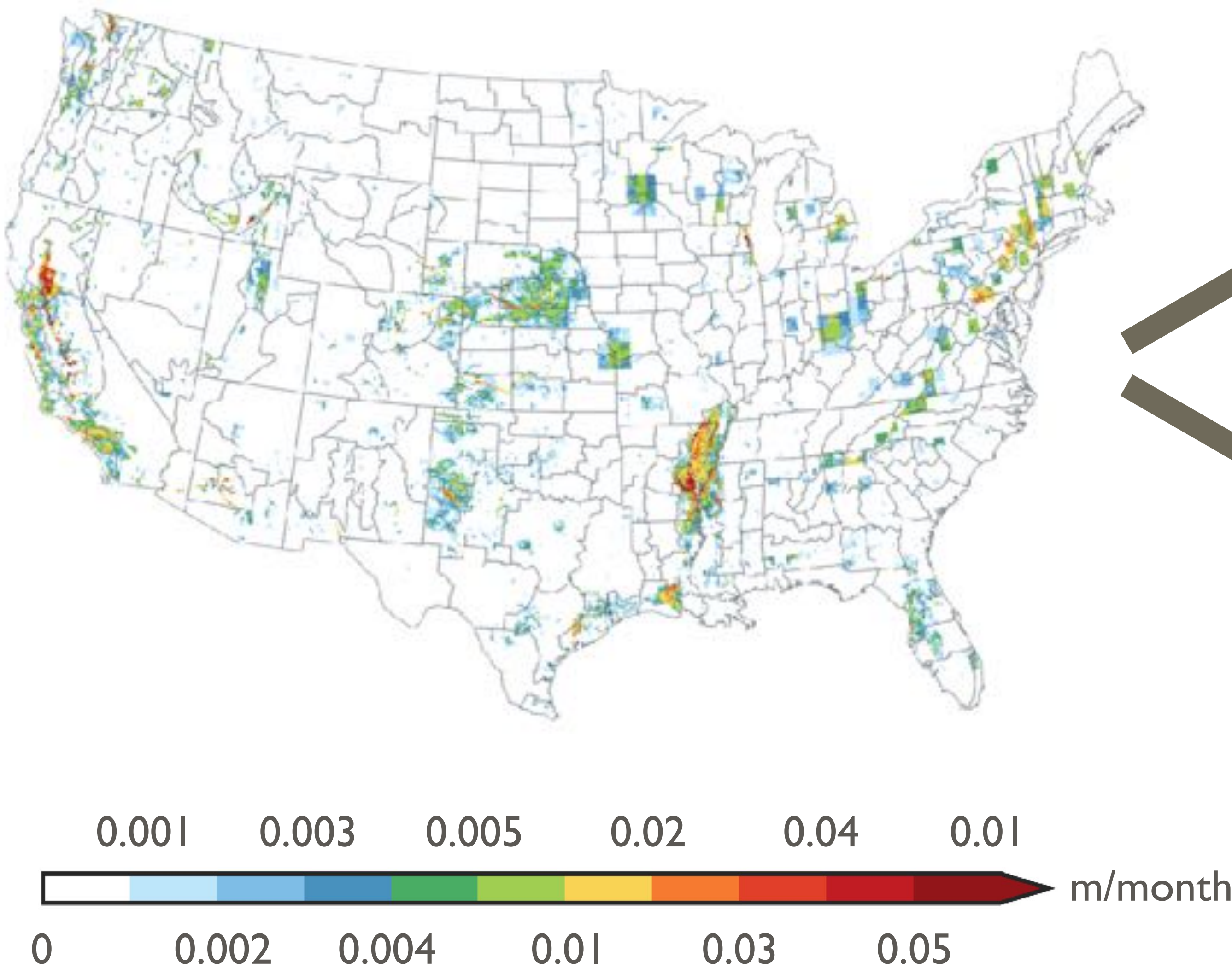


Irrigation water use

Non-Irrigation water use

Water source to meet different demand - Non-fossil GW abstraction

All human activities

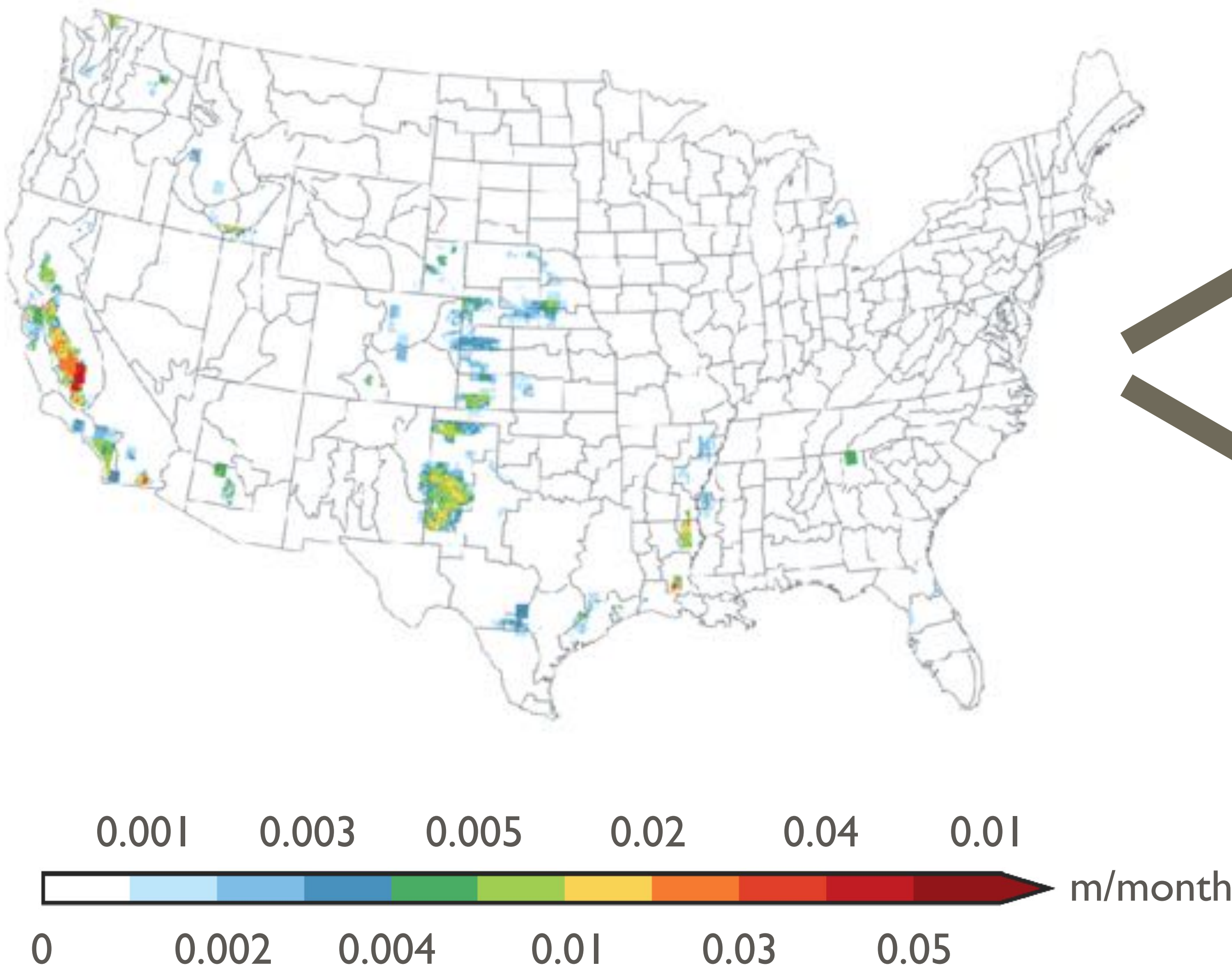


Irrigation water use

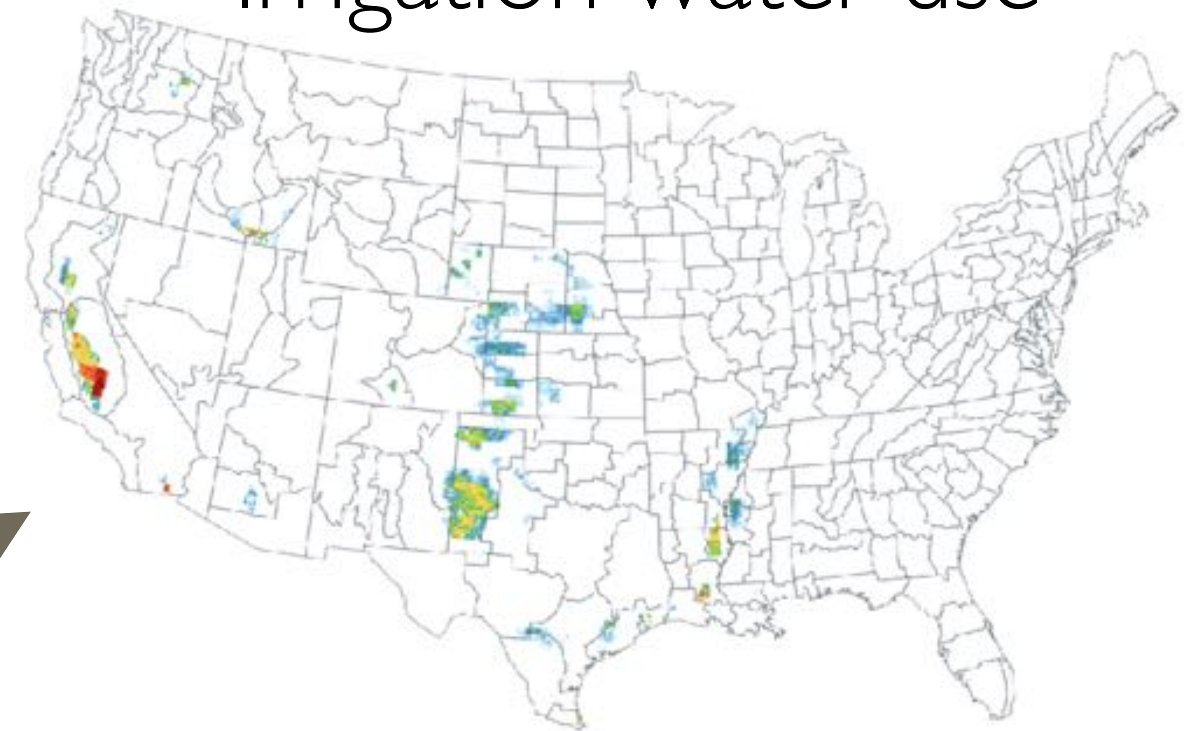
Non-Irrigation water use

Water source to meet different demand - Fossil GW abstraction

All human activities



Irrigation water use



Non-Irrigation water use