R: Hydrologic signatures from human activities in ESM: insights from one-way coupled experiments

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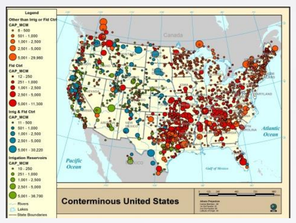
Objective

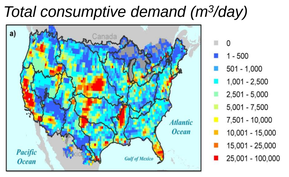
To advance understanding of the interactions between human activities and the water cycle:

Human influence on the hydrologic cycle includes: regulation and storage from reservoirs, consumptive use and withdrawal from multiple sectors (irrigation and non-irrigation) and overall redistribution of water resources in space and time. An integrated terrestrial water cycle component has been developed for Earth system models to simulate natural and regulated flows;

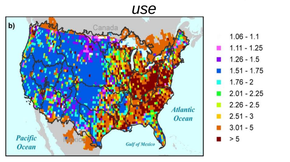
Reservoirs



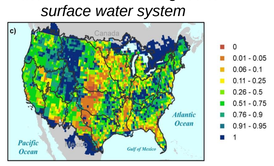
Total consumptive demand (m^3/day)



Withdrawals as fraction of consumptive use



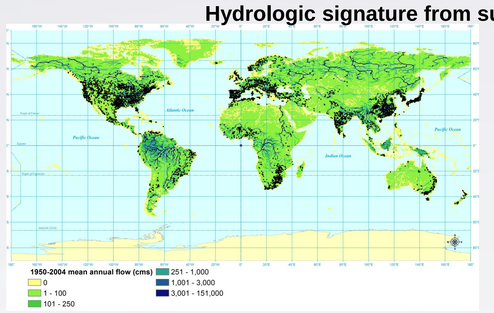
Fraction of demand assigned to surface water system

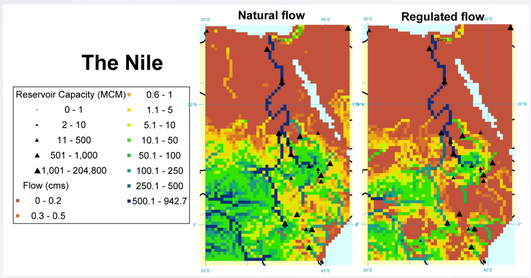


- CLM-MOSART
- a large scale water management model WM
- water demand from a global integrated assessment model
- use of groundwater as an additional supply source, and
- return flow from differences between withdrawals and consumptive u

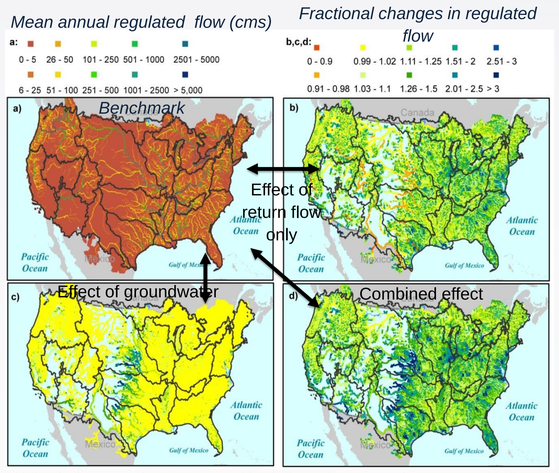
To characterize the hydrologic signatures on surface hydrology

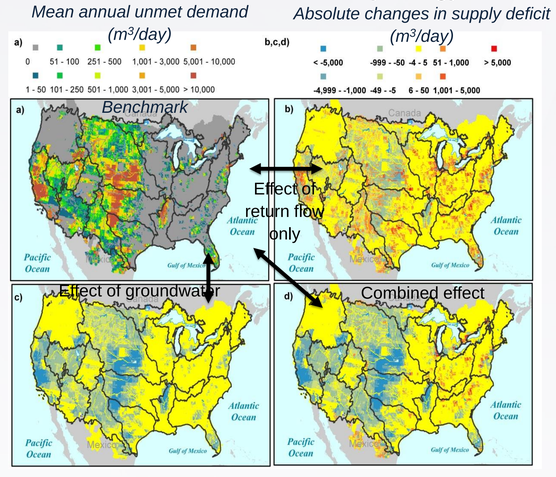
Hydrologic signature from surface water management on flow





Hydrologic signature from use of groundwater and return flow on surface hydrology





** Yellow indicates no change, green to blue indicates increase and orange to red indicates drying.*

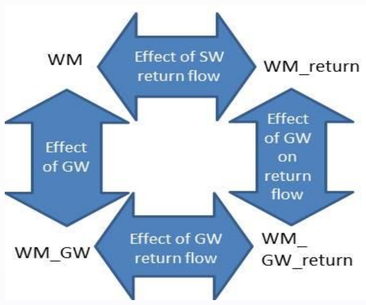
Approach

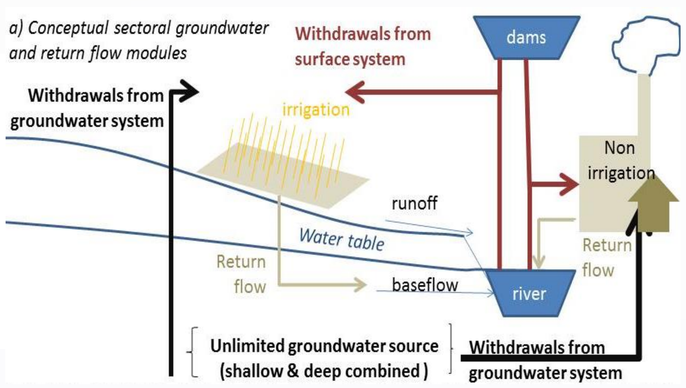
Isolate the effect of water resources management on surface hydrology

Compare global applications of CLM-MOSART without irrigation , with CLM-MOSART-WM and CLM irrigation demand

Isolate the effect of using groundwater and return flow modules on managed surface hydrology

- Application over the contiguous US
- Evaluate CLM-MOSART-WM-GCAM with and without groundwater and return flow modules,
- Assess impact on flow and unmet demand





Impact

Water management redistributes water in space and time

Signature of groundwater and return flow :

- Groundwater pumping increases the regulated flow where significant demand relies on it.
- Return flow decreases (increases) the flow in upstream (downstream) river segments.
- Signature remains at the sub-regional scale: the overall effects do not necessarily transfer to the outlet of the HUC 2 region
- US east-west contrast due to sector-dependent relationships between water withdrawals and actual consumptive use, combined with different hydroclimate conditions, storage infrastructures, sectoral water uses and dependence on groundwater.

Highlight of uncertainties:

- Distribution of the demand into surface and groundwater layers
- Stationarity of the distribution
- Spatial distribution of reservoir storage supply
- Constraint of groundwater availability

2-way coupling between CLM-MOSART and WM will:

- Constrain irrigation supply by water availability, and water demand, which influences ET;
- Affect soil moisture and groundwater table because of water redistribution and partitioning between surface and groundwater.
- Create mixing of waters with different qualities

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