Low Temporal Variability in Noah-MP Simulated Groundwater (findings based on WLDAS simulation runs)

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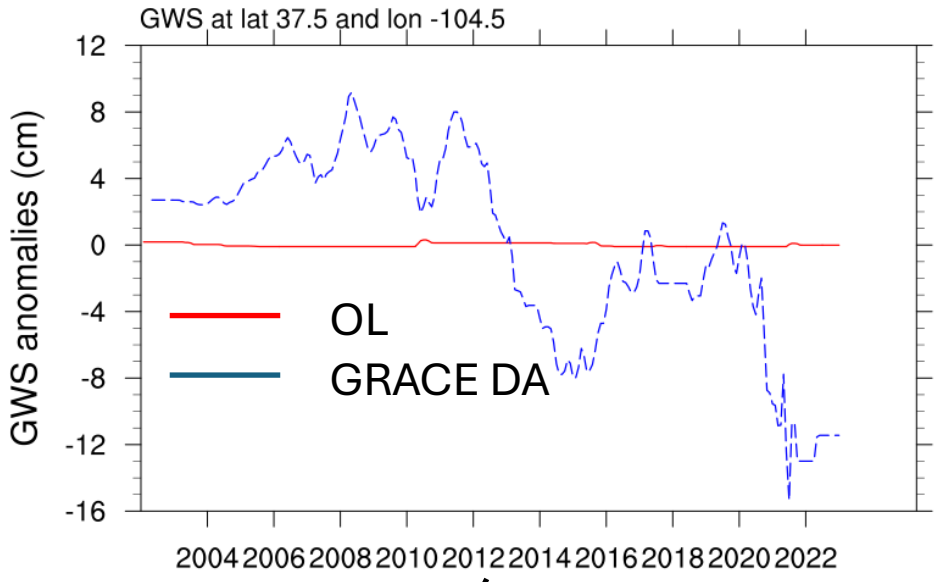
Low groundwater variability in dry conditions

Western Land Data Assimilation System (WLDAS):

- Noah-MP4.0.1
- NLDAS-2 forcing data
- Downscaled to 1 km using LIS capabilities
- Simple groundwater scheme
- Dynamic vegetation
- GRACE data assimilation using LIS/EnKS



Impacts on drought identification

Groundwater drought percentile maps for Colorado
based on different climatology

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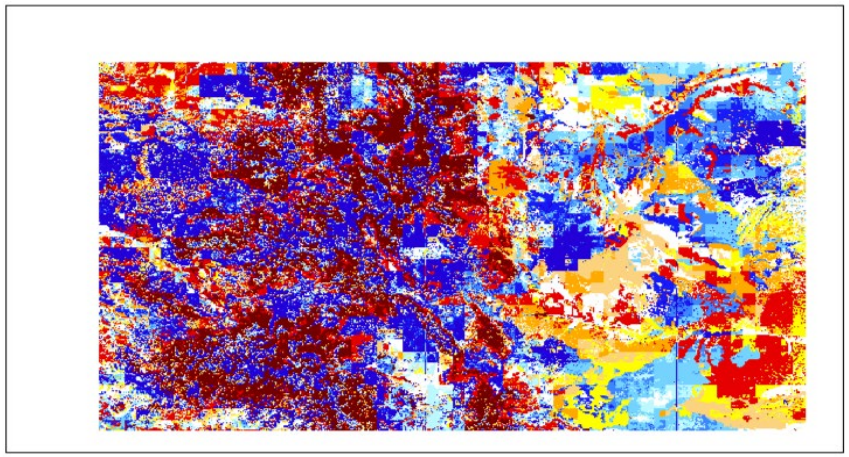

Climatology: open loop
(1979-2022)

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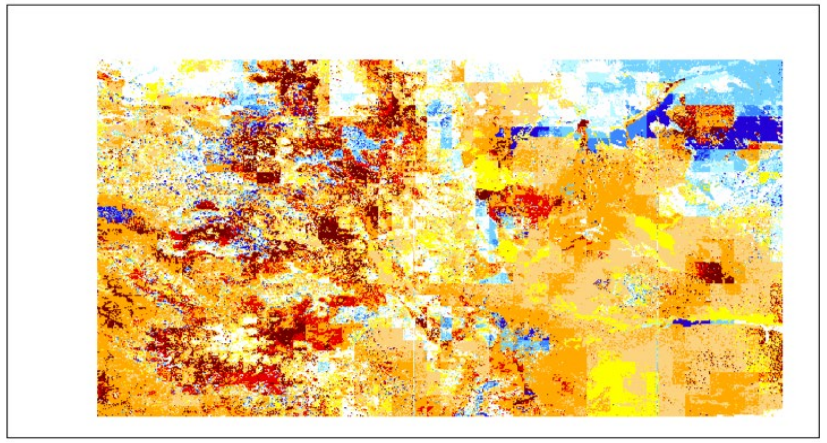
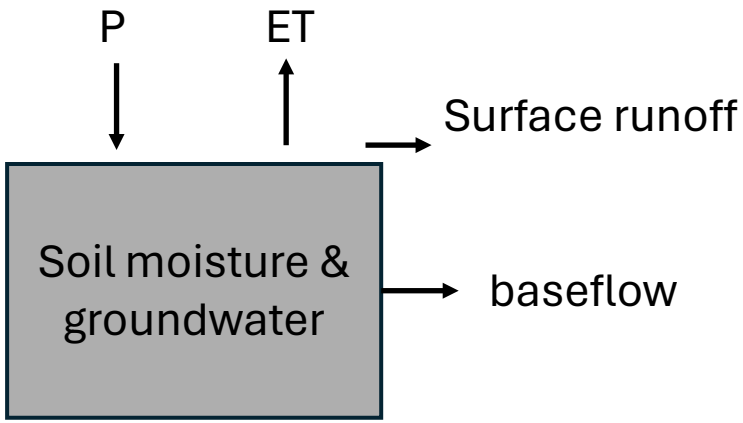


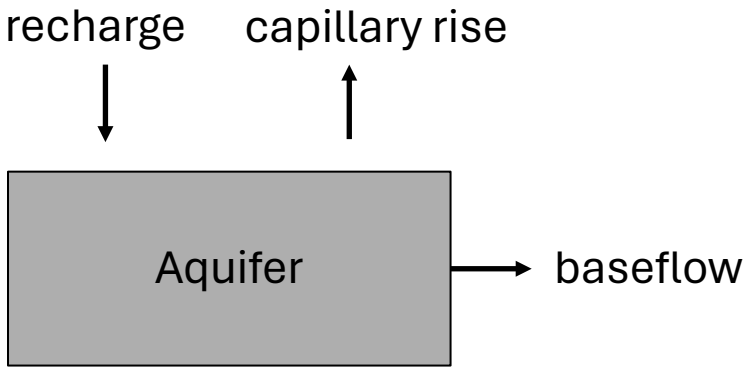
Climatology: GRACE DA
(2002-2022)

Maps are based on groundwater estimates from GRACE data assimilation into Noah-MP

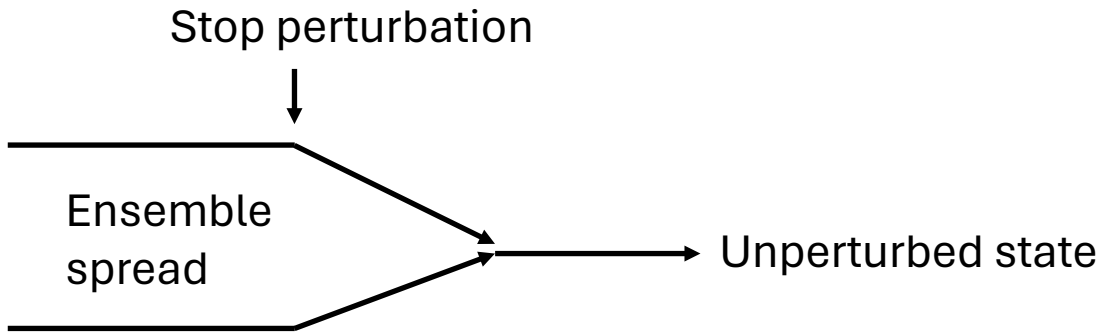
Impacts on configuring a Kalman filter

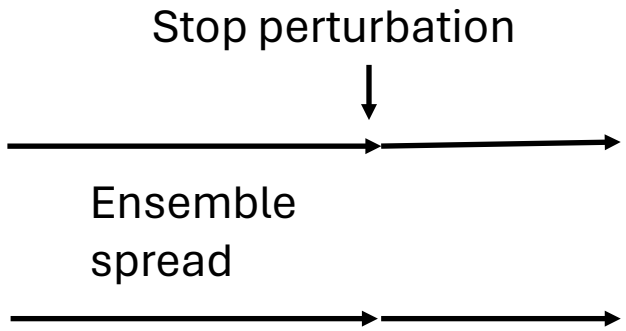


Dynamic system



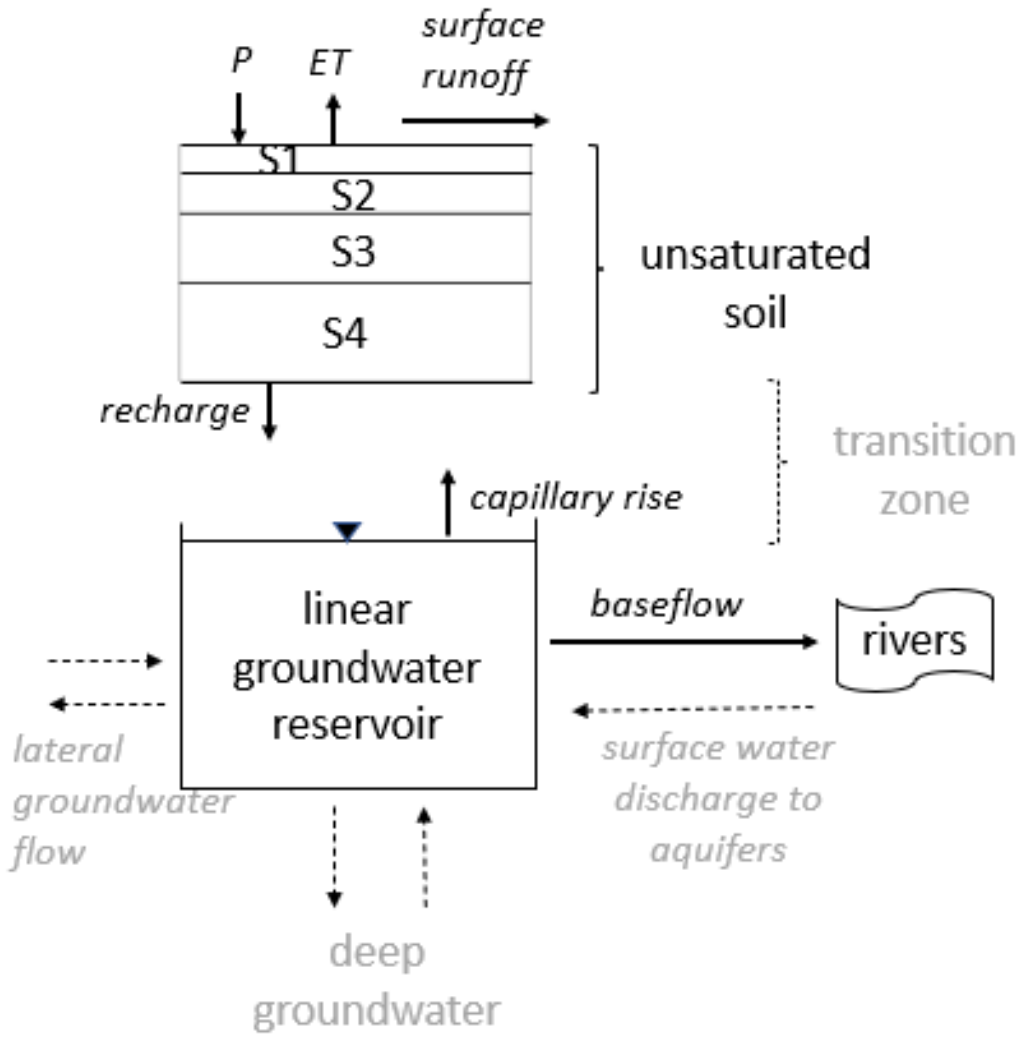
Less dynamic system





Difficult to control model errors

Root cause: weak capillary rise



Fluxes between unsaturated and saturated zone are calculated based Darcy's Law (Niu et al., 2007):

$$Q = -K_a \frac{-z_\nabla - (\psi_{bot} - z_{bot})}{z_\nabla - z_{bot}}$$

- Darcy's Law is only applicable with dynamic states (soil moisture and hydraulic heads).
- Due to weak capillary rise, temporal variability of groundwater is mainly driven by recharge.

Diagram from Li et al., 2021. "Groundwater recharge estimated by land surface models: an evaluation in the conterminous U.S." J. of Hydrometeorolog, [https://doi.org/10.1175/JHM-D-20-0130.1]

Summary

1. Noah-MP simulates low groundwater variability in dry climate conditions.
2. Low temporal variability, especially lack of seasonality, affects drought identification and poses a challenge for ensemble-based data assimilation methods.
3. Weak capillary rise is the underlining cause for low variability and makes groundwater inaccessible to near surface processes (e.g., soil moisture and ET).