Earth & Environmental Systems Modeling

Water Cycle and Hydroclimate

1) Natural Systems
2) Managed Systems (i.e., water resources)

U.S. DEPARTMENT OF ENERGY | Office of Science

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What gaps in research/infrastructure/coordination prevent advances?

Natural Systems

- Observations of convective-scale properties
- Lack of understanding of what processes govern changing weather-scale precipitation and extremes
- Lack of coordination between model development and process-based analyses
- Lack of evaluation/development/benchmarking in coupled land-atm configurations
- Land surface models lack important details on lateral flow
- Lack of exploration in how plant functional/vegetation types assumptions shape model biases
- Lack of exploration on cloud microphysics representation influence simulated precipitation

Managed Systems

- Lack of available datasets for water demand and use with fine temporal and spatial resolution.
- Groundwater
- Lack of foundational research needed for utilizing water demand control in drought risk management.
- Merging models across scales
- Better strategies of varying complexity of models (not just spatial)
- Software infrastructure that allows hierarchical modeling

What opportunities exist to overcome each of those gaps?

- AI/ML and extensive ground-based and satellite observations
- Sensitivity analysis to changes in different sectoral water demands
- Emergent constraints applied to estimates of future change
- High-resolution modeling, feature tracking, and Perturbed Parameter Ensembles (PPEs)
- Isolate order of importance of atmospheric drivers in extremes
- Sub-seasonal to seasonal temporal scales as “trusted” benchmarking relative to climate models
- Streamflow and other hydrologic observations to constrain water balance (e.g., CAMELS, GRDC, etc)
- Storyline methods to isolate important high-resolution (i.e., convection permitting) model insights
- Integrate from high-resolution to regional to global models (enter AI/ML)
- State-of-the-art 4D observations (e.g. GEWEX global cloud product?)
- Differentiable ML methods to build hybrid data- and process-driven modeling.
- Mountains: testbeds investigate land-atmosphere interactions and link natural and managed systems
- Incorporate dynamic lakes to faithfully represent the integrated water balance.