SAND2018-13780C

GC33G-1435: How Model Coupling Influences the Perceived Vulnerabilities of Connected Energy-Water Systems

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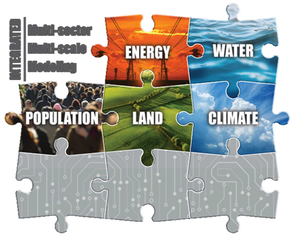
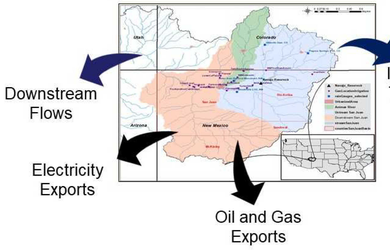
INTRODUCTION



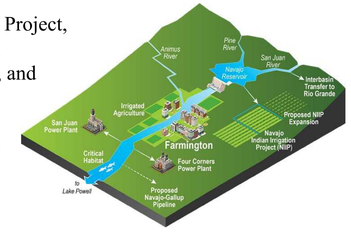
- Develop a flexible and integrated modeling framework that captures the dynamic multi-scale interaction among climate, energy, water, land socioeconomics, critical infrastructure, and other sectors.
- Use this framework to study the vulnerability and resilience of coupled human and natural systems from local to continental scales under scenarios that include short-term shocks, long-term stresses, and feedbacks associated with human decision-making.
- Explore how different model configurations, levels of complexity, multi-model coupling strategies, and spatiotemporal resolutions influence simulation fidelity and the propagation of uncertainties across a range of sectors, scales, and scenarios.
- Focus here is on the watershed or asset scale.

CASE STUDY AREA

San Juan River in Four Corners USA

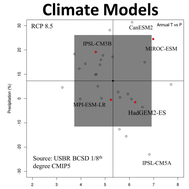


- The San Juan basin serves as an important provisioning watershed producing water, energy and food largely for downstream consumption.
- Runoff originates in San Juan Mountains (83%). Largely snow melt dominated system.
- Primary management feature is Navajo Reservoir (1.7 MAF)
- Water deliveries managed by system of shortage sharing. Major water users include:
  - Native American:
    - Navajo Indian Irrigation Project,
    - Navajo-Gallup Pipeline,
    - Animas-LaPlata Project, and
    - Others.
  - Irrigation,
  - Multiple power plants and limited hydropower,
  - Municipalities,
  - Instream flows,
  - Interbasin transfers:
    - Colorado River (~15% of Upper Basin contribution),
    - San Juan-Chama deliveries to Rio Grande Basin (105,200 AF/yr.)

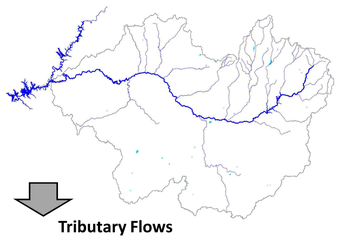


METHODS

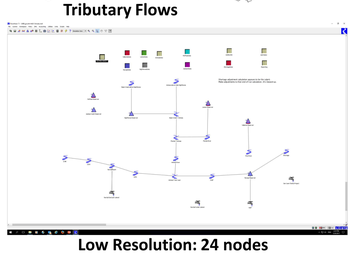
Climate Models



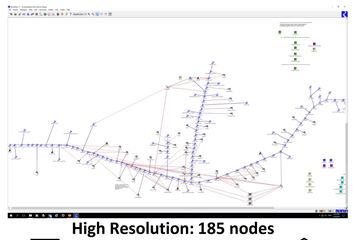
Climate Divers



Tributary Flows



Low Resolution: 24 nodes



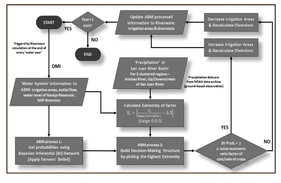
High Resolution: 185 nodes

Local
- Storage
- Instream Flows
- Water Deliveries

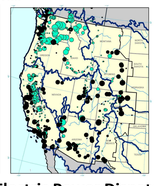
Non-Local
- Colorado River
- Rio Grande

Water Demand

Water Deliveries



Agent Based Modeling (ABM)



Electric Power Dispatch

Experimental Variates

- Six Earth System Models (RCP 8.5) ranging from warm to hot and wet to dry.
- Five metrics selected to explore broad changes, three that measure local impacts and two focused on external basin impacts.
- Two coupled model frameworks at distinctly different resolutions.

Natural System

- Downscaling using Multivariate Adaptive Constructive Analogues (MACA) data set (Livneh et al. 2015).
- Variable Infiltration Capacity (VIC) model at 1/16th degree.
- Calibrated at the HUC4 and HUC8 levels.
- For higher resolution simulation, water rights administration within State of Colorado is explicitly modeled using StateMod and StateCU.

Engineered System

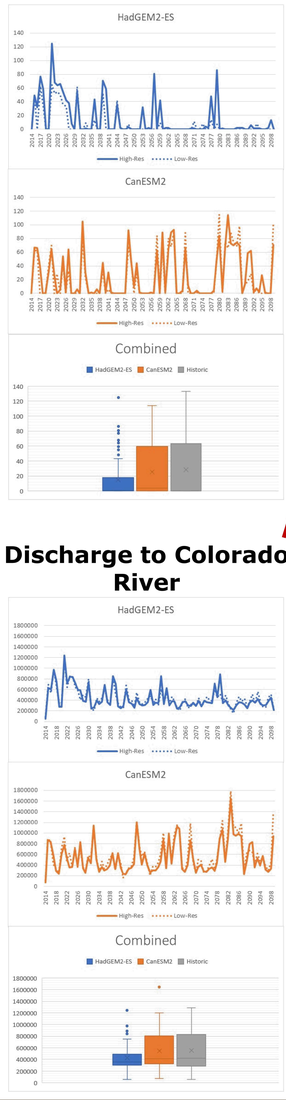
- RiverWare models developed by the U.S. Bureau of Reclamation for water management and planning are utilized to simulate deliveries to water users under variable climate conditions. Simulations consider Navajo Reservoir operations, all major water users and interbasin transfers via the San Juan-Chama project.
- Two different RiverWare models for San Juan River operations are compared. Models differ in the level of aggregation and representation of the operational rules.

Human System

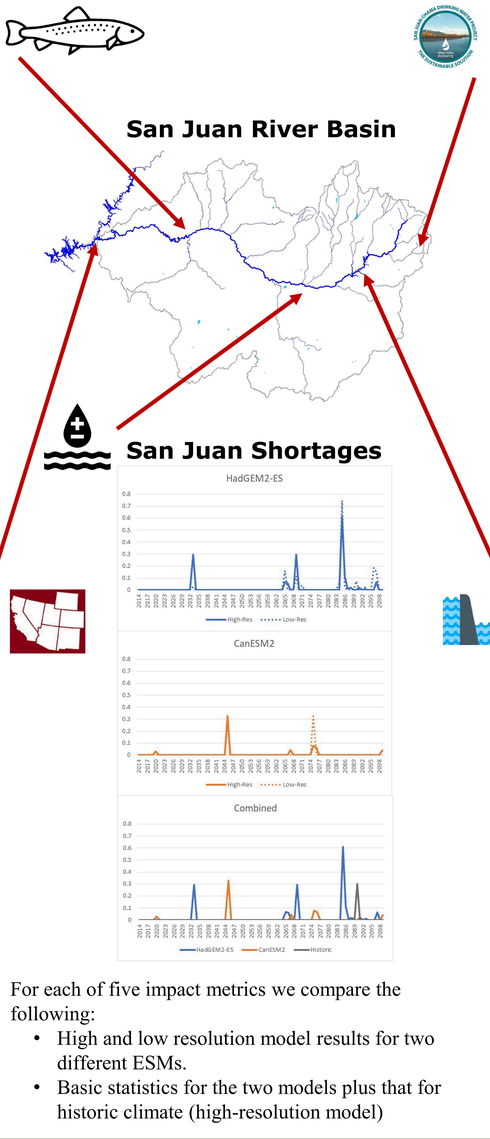
- Two-way coupling between RiverWare and ABM that simulates irrigator response to changing climate conditions (changes in cultivated acreage).
- RiverWare output is also utilized in electric production-cost modeling (PLEXOS) to understand how shortages in water deliveries to power plants impacts West-wide power generation.

RESULTS & DISCUSSION

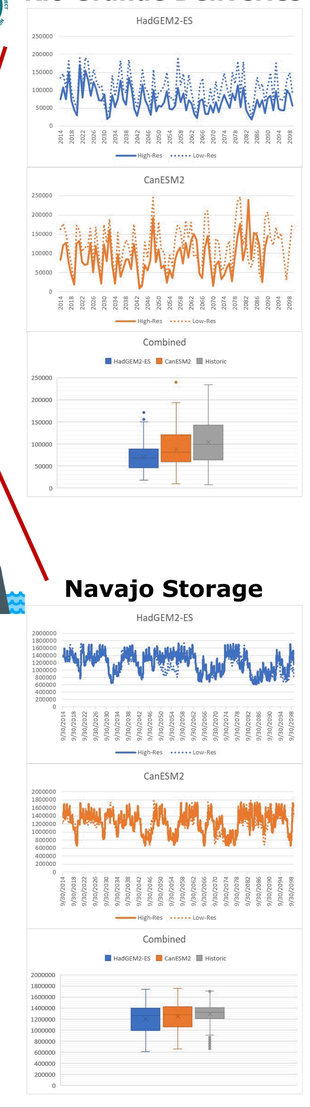
Instream Flows



San Juan River Basin



Rio Grande Deliveries



San Juan Shortages

Discharge to Colorado River

Navajo Storage

For each of five impact metrics we compare the following:

- High and low resolution model results for two different ESMs.
- Basic statistics for the two models plus that for historic climate (high-resolution model)

ACKNOWLEDGEMENTS

Support was provided by the Office of Science of the U.S. Department of Energy as part of the Multisector Dynamics Program. The authors recognize the valuable insight and input of Katrina Bennett and Richard Middleton (LANL). Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525.