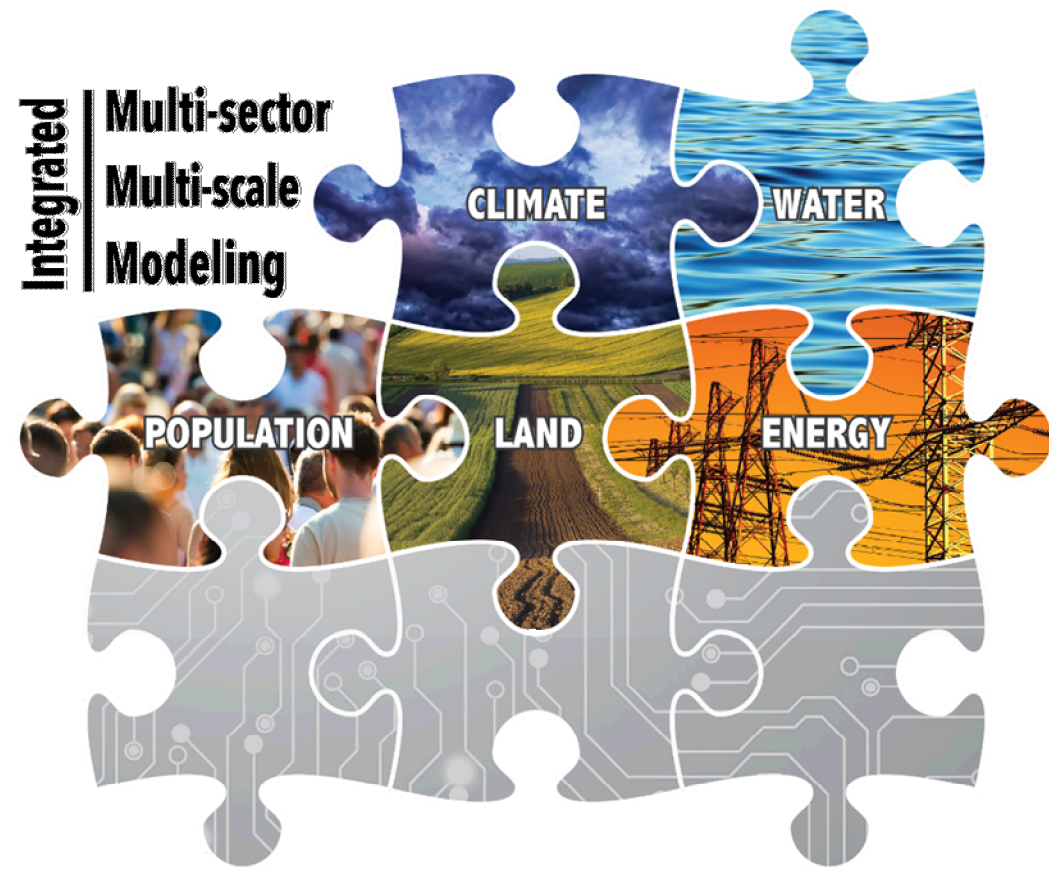# GC31D-1030: The Role of Model Fidelity in Understanding the Food-Energy-Water Nexus at the Asset Level

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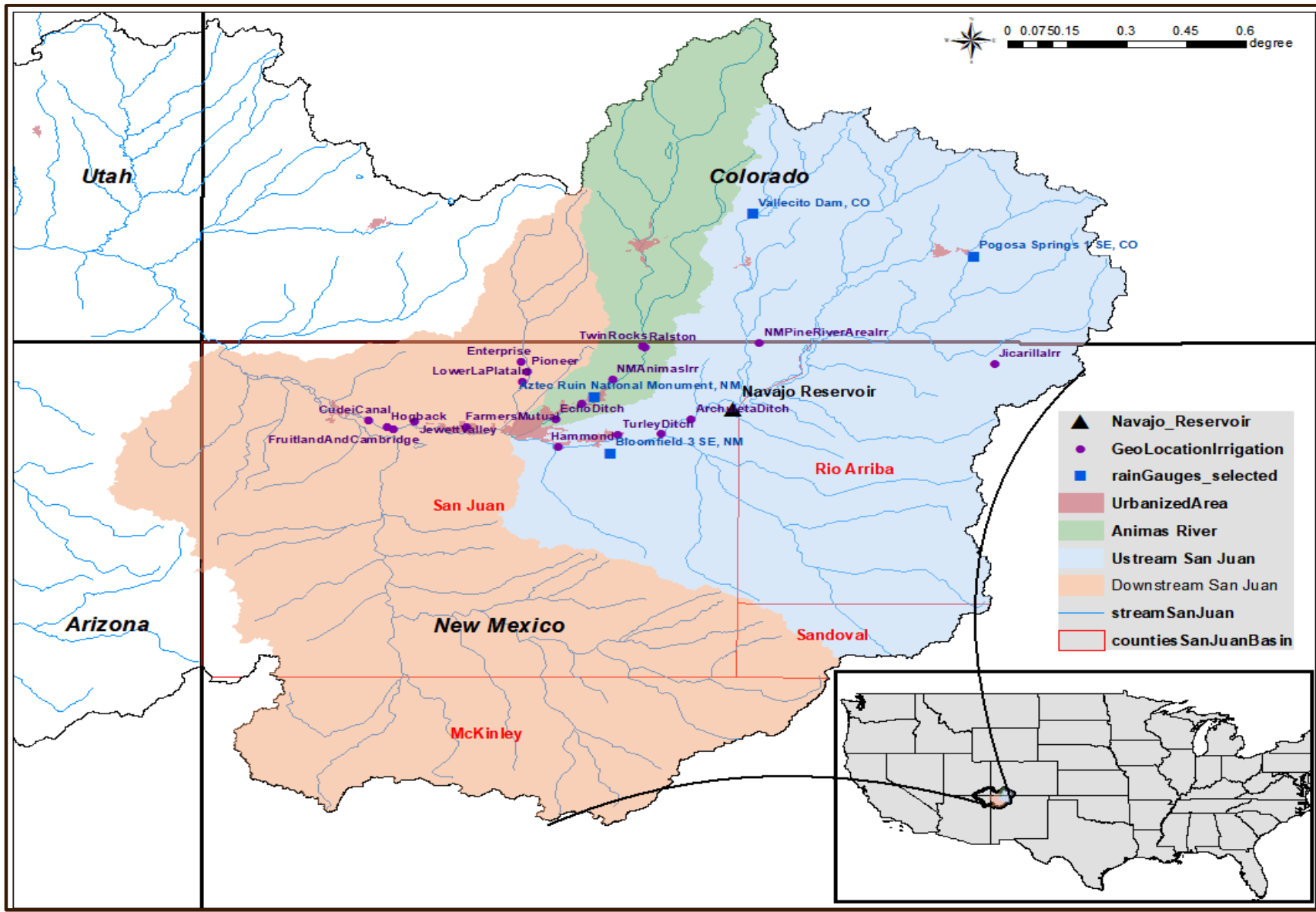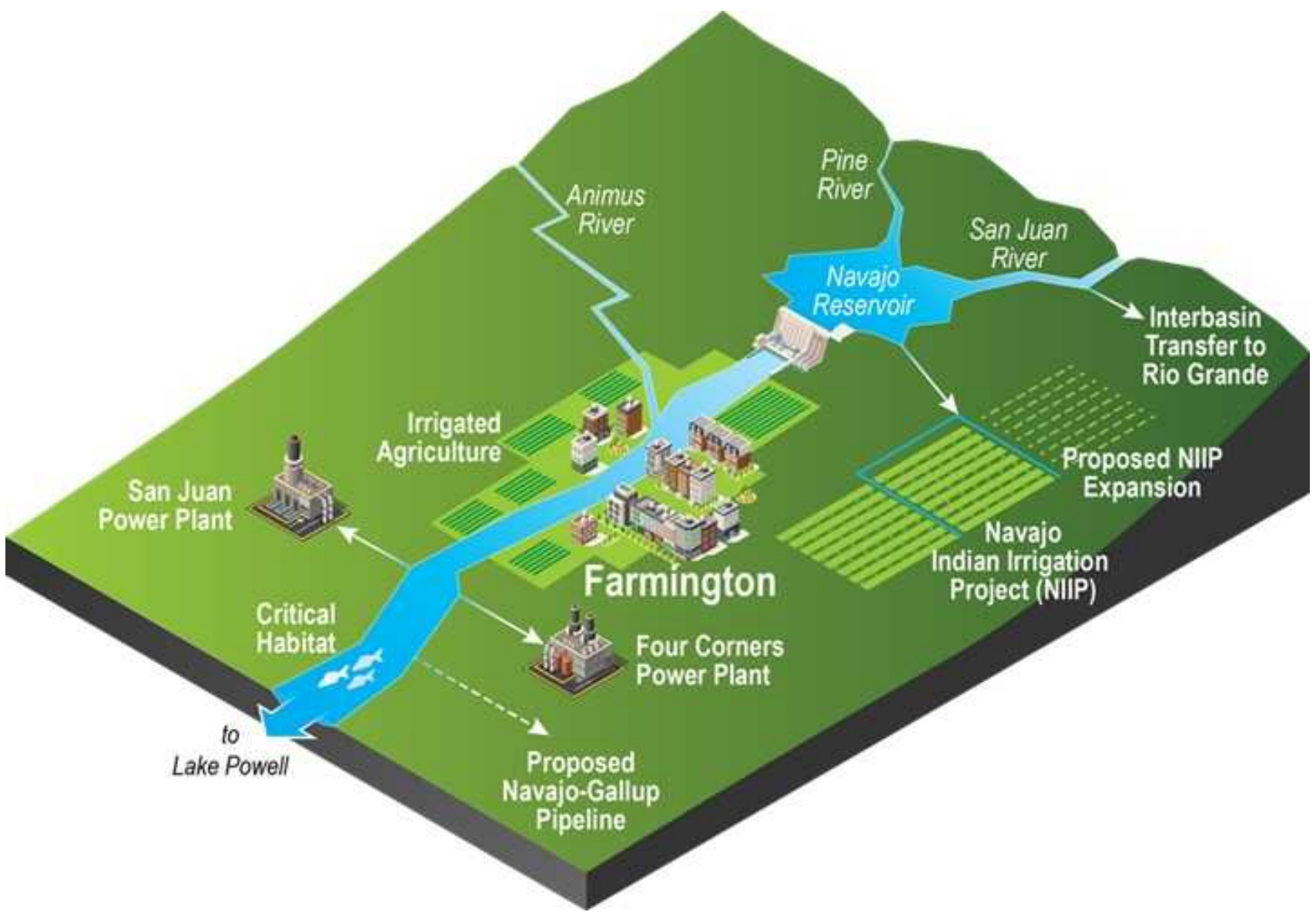
INTRODUCTION

- Develop a flexible and integrated modeling framework that captures the dynamic multi-scale interactions 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.

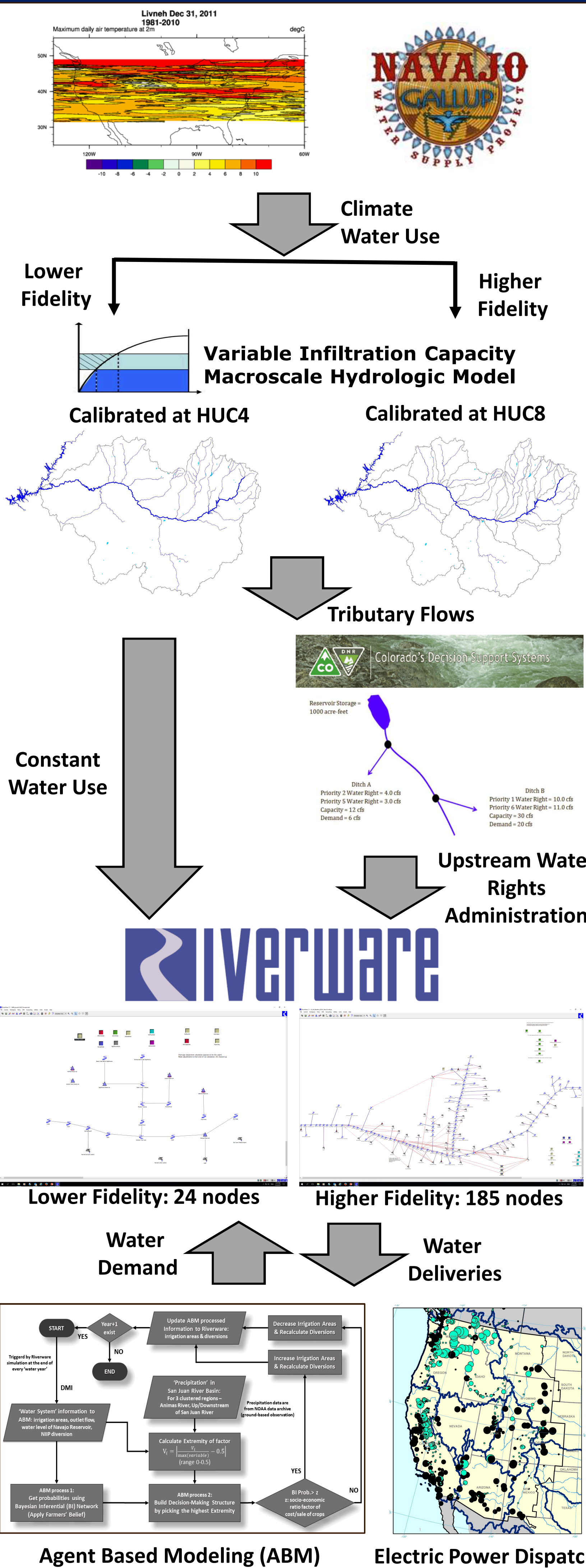Integrated Multi-sector Multi-scale Modeling

CASE STUDY AREA

- San Juan River in Four Corners Region of Southwestern United States
- 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   Water Use

Lower Fidelity   Higher Fidelity

Variable Infiltration Capacity Macroscale Hydrologic Model

Calibrated at HUC4   Calibrated at HUC8

Tributary Flows

Constant Water Use   Upstream Water Rights Administration

Lower Fidelity: 24 nodes   Higher Fidelity: 185 nodes

Water Demand   Water Deliveries

Agent Based Modeling (ABM)   Electric Power Dispatch

Scenarios

- Six Earth System Models (RCP 8.5) ranging from warm to hot and wet to dry.
- Two water use scenarios, current use and one where all tribal water rights are fully utilized.

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.

Engineered System

- For higher fidelity simulation, water rights administration within State of Colorado is explicitly modeled using StateMod and StateCU.
- Two different RiverWare models for San Juan River operations are compared. Both include Navajo Reservoir operations, all major water uses and interbasin transfers via the San Juan-Chama project. The difference is in the level of aggregation and representation of the operational rules.

Human System

- RiverWare-ABM coupling. See poster *H33H-1807-Quantifying human behavior uncertainties in a coupled agent-based model for water resources management* (Wed. pm)
- RiverWare-PLEXOS coupling. See poster *GC31D-1037-High-resolution integration of water, energy and climate models to assess electricity grid vulnerability to climate change* (this session)
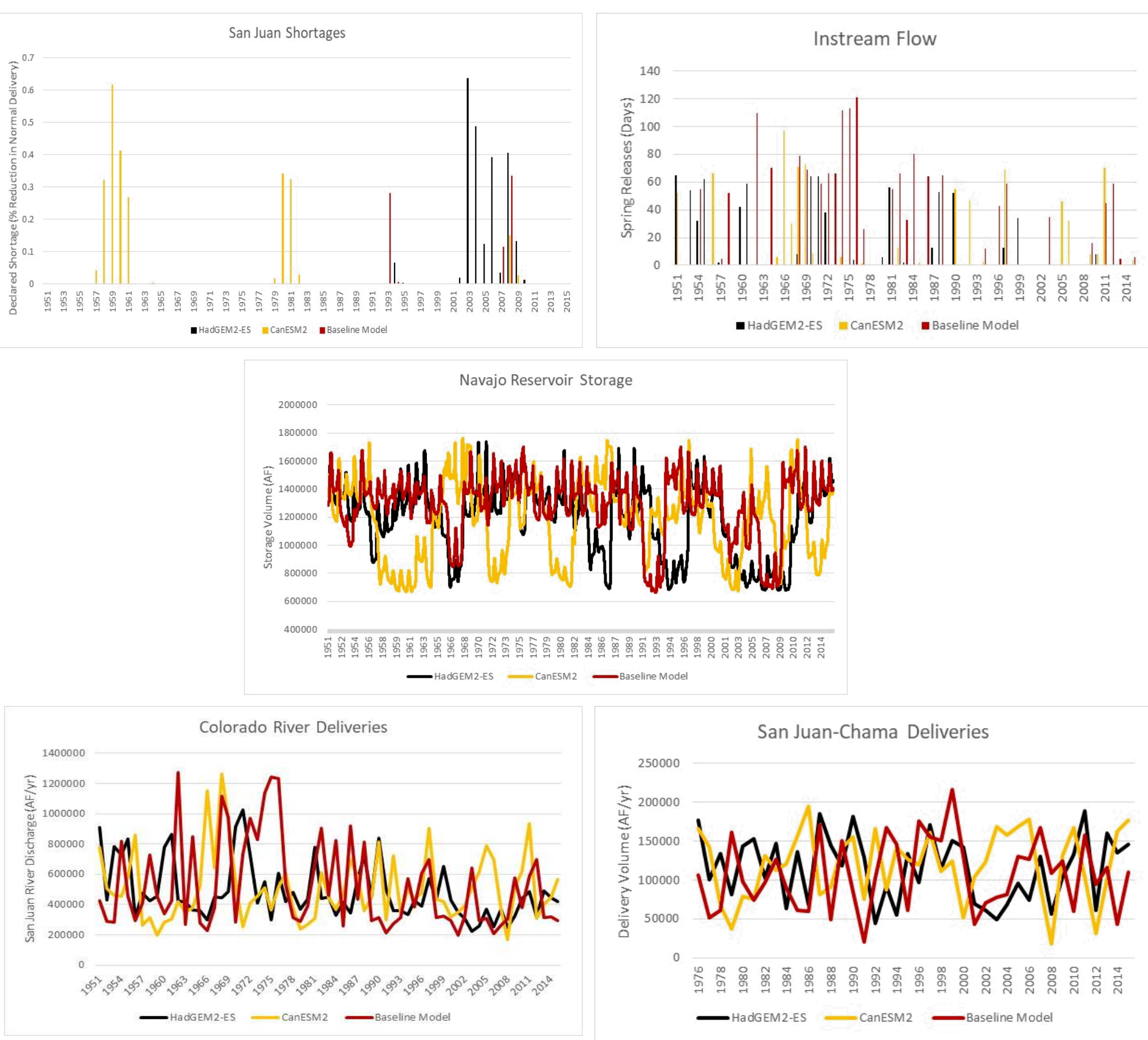
RESULTS & DISCUSSION

Local
- Storage
- Instream Flows
- Water Deliveries

Non-Local
- Colorado River
- Rio Grande

- Full scenario analysis completed for lower fidelity system. Key results include the following:
- San Juan is example of Food-Energy-Water provisioning watershed.
- Big difference among climate simulations.

Lower Fidelity Model

- Together changes in climate and use could exceed system thresholds requiring changes to water operations.
- Non-additive impacts reflecting interplay of interannual variability, geography and policy.

Impact Metrics

- Five metrics selected to explore broad changes, three that measure local impacts and two focused on external basin impacts.

- Paper in review: Bennett et al., *Threats to Long-term Food-Energy-Water Security of a Provisioning Watershed in the Southwest: An Analysis of Potential Climate Disturbances and Water Rights Impacts on the San Juan River Basin*

Model Comparison

- Initial results are available for one scenario—historical climate with full water right utilization. Climate scenario runs are under preparation.
- Higher fidelity model yielded similar trends but with reduced impacts:
  - 11% higher storage,
  - 69% fewer shortages but with similar intensity,
  - 61% more days with instream compliance,
  - 5% higher Colorado River deliveries, and
  - 8% less San Juan-Chama deliveries.

ACKNOWLEDGEMENTS