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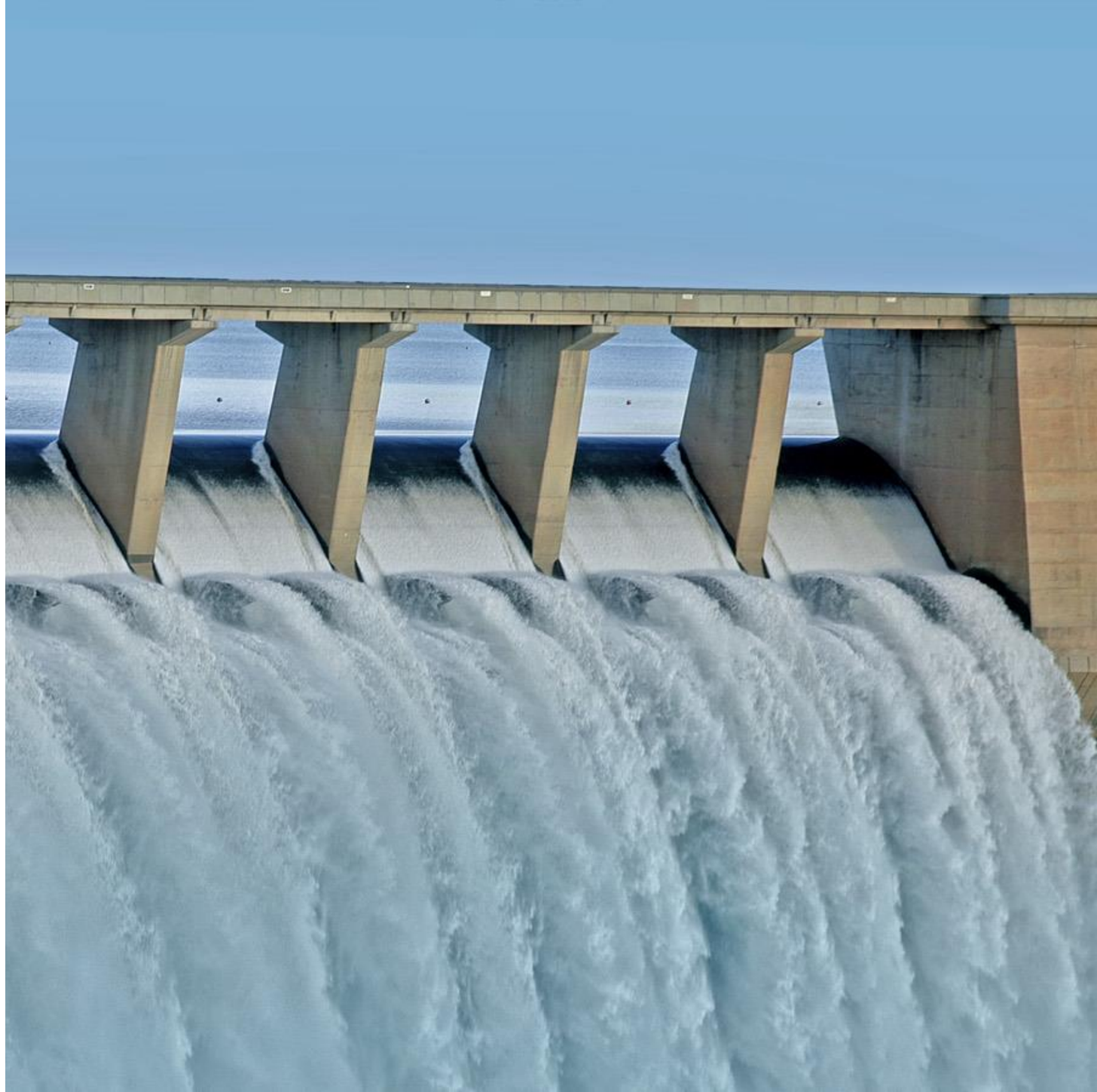
Advances in Modeling Water-Dependent Power Capacity at Risk

March 29, 2022

Sean Turner, Nathalie Voisin



U.S. DEPARTMENT OF ENERGY BATTELLE

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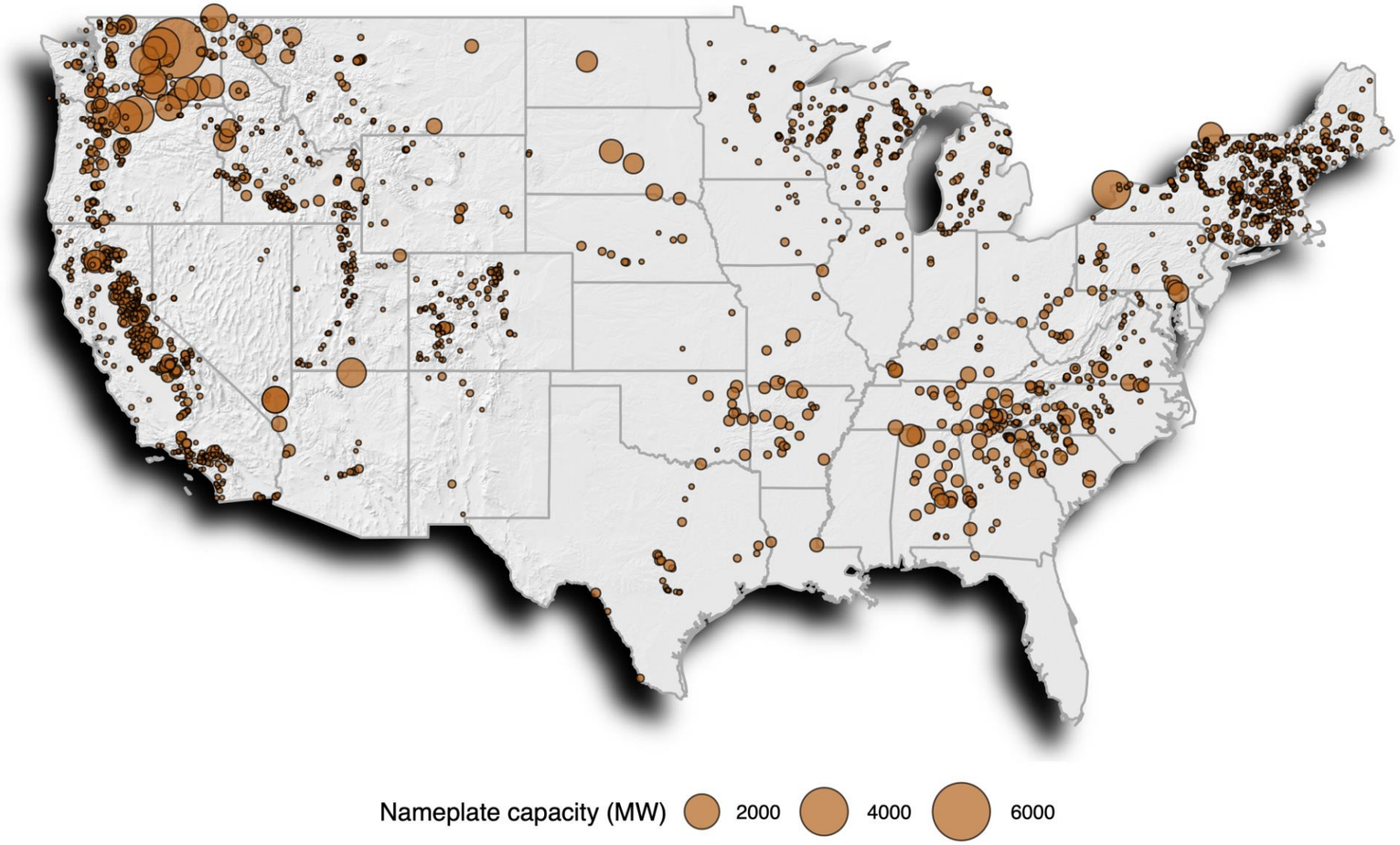
Hydroelectric power in the USA

Contributes ~ **7%** of total U.S. electricity generation

… and ~**40%** of total U.S. renewable generation

Provides **reserve** and **flexibility** as well as generation

Often **highly constrained** by competing operating objectives, river regulations, and water availability



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Hydrology adds **complexity** to power systems analysis

None
D0 (Abnormally Dry)
D1 (Moderate Drought)
D2 (Severe Drought)
D3 (Extreme Drought)
D4 (Exceptional Drought)
No Data

U.S. drought monitor for final week of July in each year

2001 2002 2003 2004 2005 2006 2007

2008 2009 2010 2011 2012 2013 2014

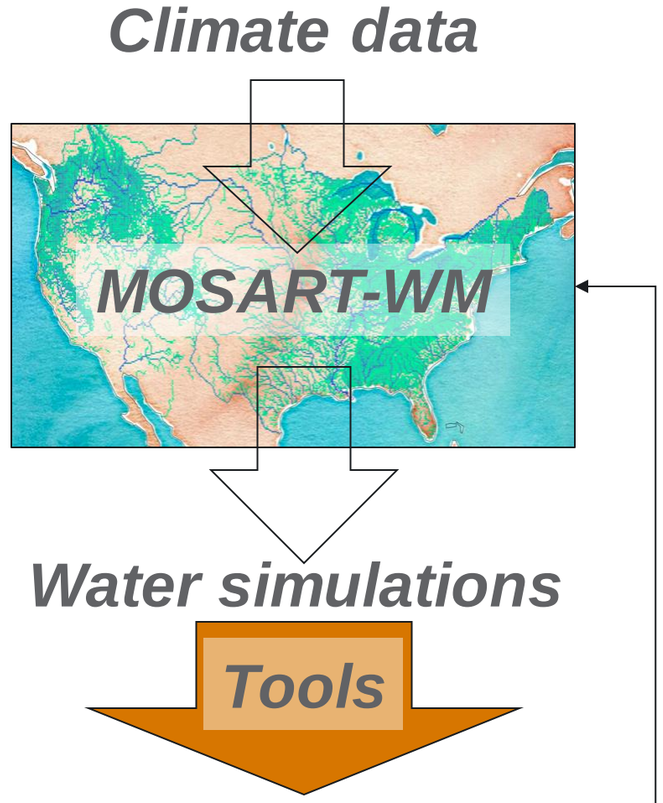
2015 2016 2017 2018 2019 2020 2021

How is PNNL addressing the challenge of analyzing water-dependent capacity at risk?

1. Enhancing a **US-scale hydrological model** to capture realistic water infrastructure operations.

2. Developing **supplemental tools** to interpret water simulations to analyze risk at scales of individual plant to grid.

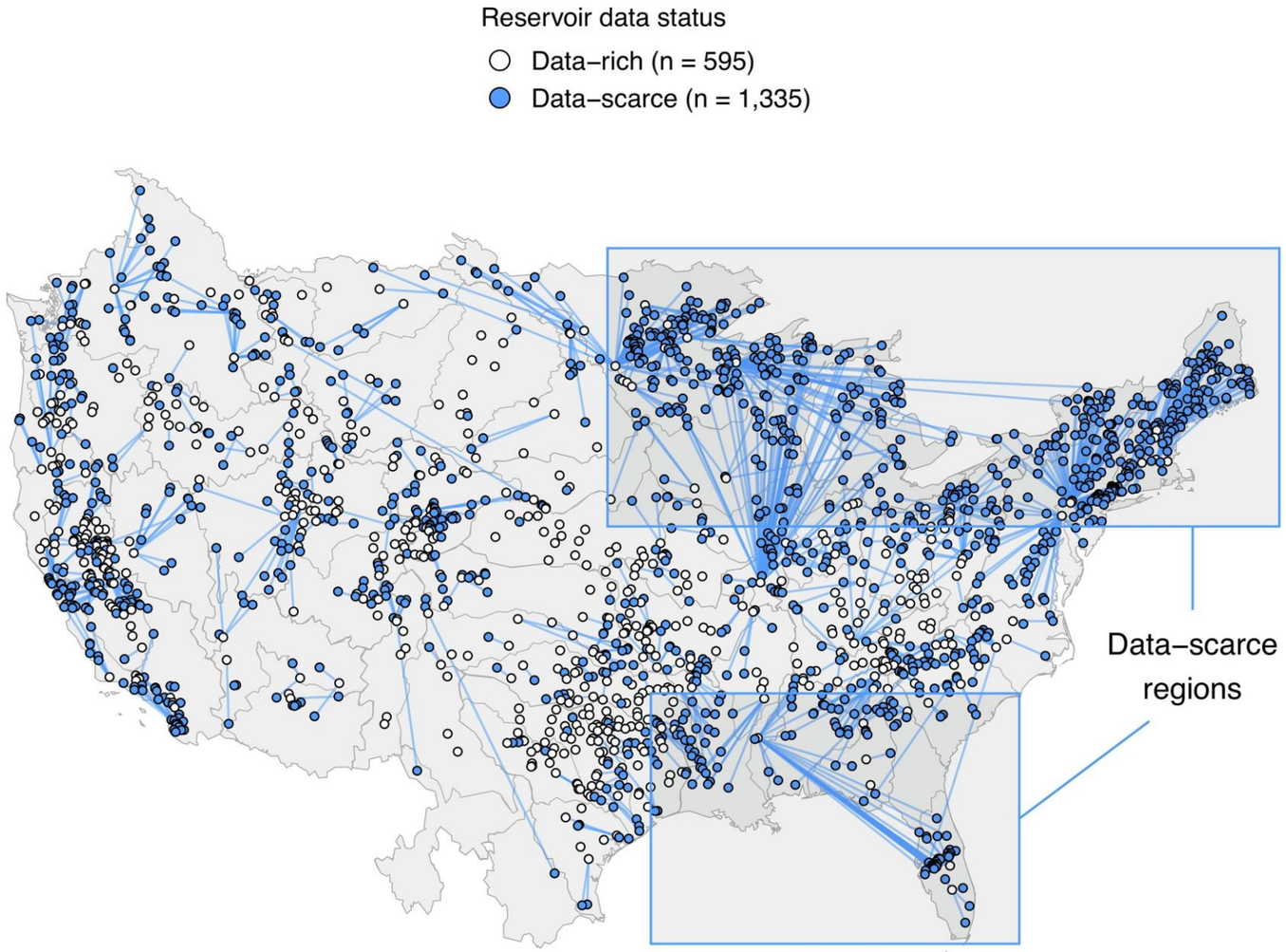
3. Publishing **new datasets** that enable the community to inform power grid capacity expansion and operations models with realistic water constraints.



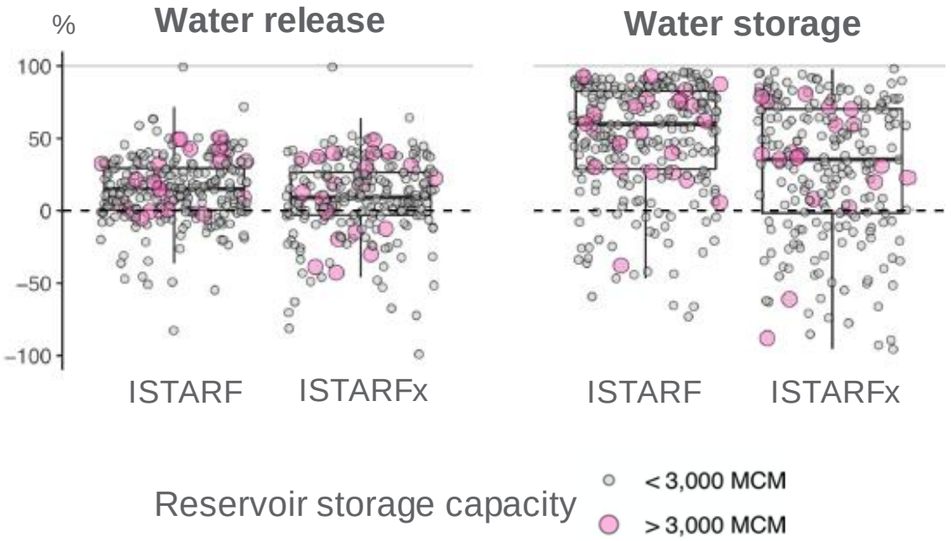
Voisin, et al., 2016. Vulnerability of the US Western Electric Grid to Hydro-Climatological Conditions: How bad can it get?, *Energy*, 115(1), 1-12.

Data-driven reservoir operations improve national scale water simulations

Hydrological model
↓
Tools
↓
Datasets



Error reduction relative to conventional method



Turner, Voisin, et al., 2021. Water storage and release policies for all large reservoirs in CONUS, *Journal of Hydrology*, 603, p.126843.

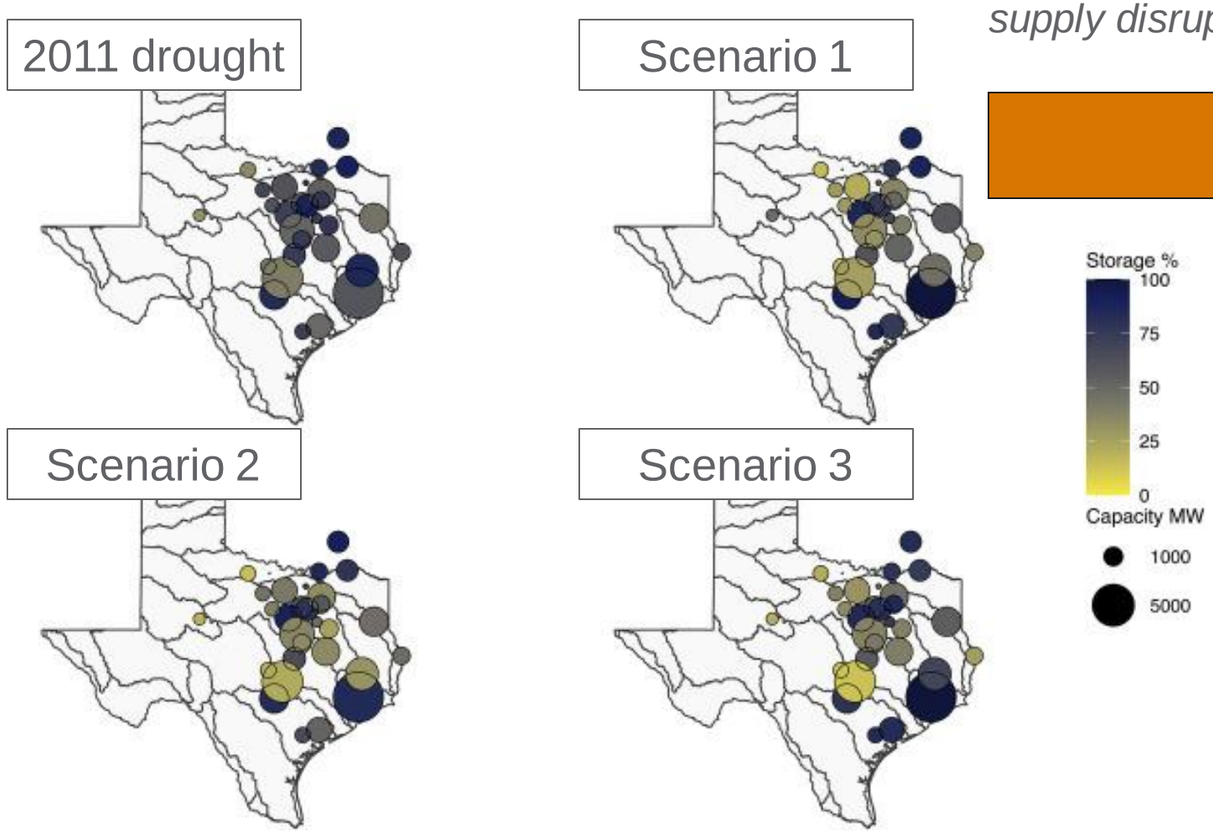
Main sponsor: **DoE Office of Science** (IM3)

Collaborator: University of Arizona

capratTX: An open-source tool for analyzing thermoelectric capacity-at-risk in Texas

Hydrological model → **Tools** → Datasets

*What would **drought Scenario 1** mean electricity supply disruption?*



Assumed critical reservoir threshold (% full)	Thermoelectric capacity at risk (% total thermoelectric capacity in TX)
50%	30%
40%	22%
30%	18%
20%	4%
10%	0%

Turner, Voisin, et al., 2021. A multi-reservoir model for projecting drought impacts on thermoelectric disruption risk across Texas, *Energy* 231, p.120892.

Main sponsor: **DoE Office of Electricity**

Collaborators: ERCOT, Sandia, NREL, ORNL

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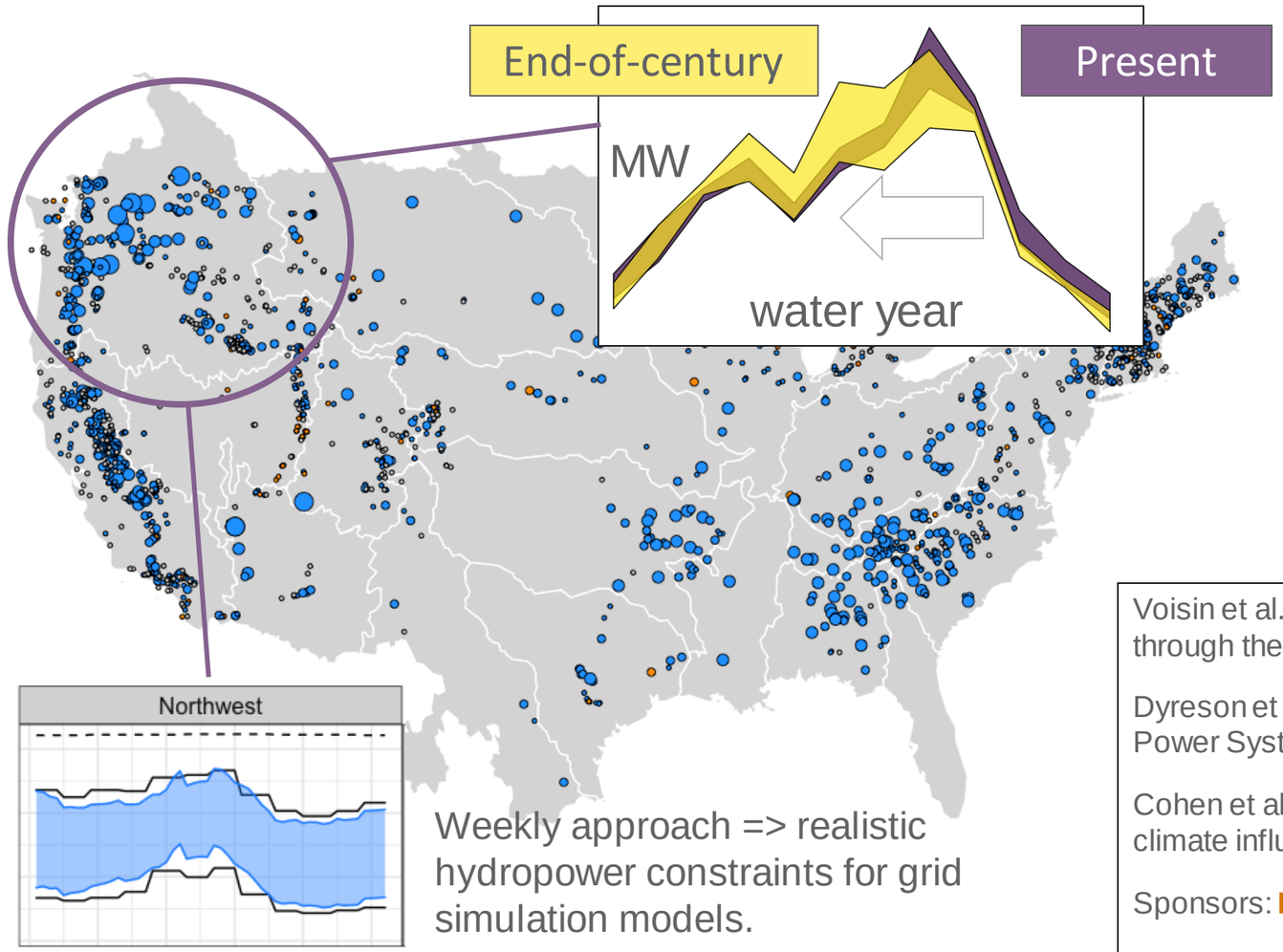
Plant-level monthly and weekly generation for alternative **droughts** and **climate futures**

Hydrological model → Tools → **Datasets**

Shifting seasonal hydro profile in NW



Weekly approach => realistic hydropower constraints for grid simulation models.

Monthly or **weekly** generation driven by water conditions at individual plants.

Coherence in space and time across grids or nationally.

Captures **shifting seasonality** with climate change.

Voisin et al., 2020. Impact of climate change on water availability and its propagation through the Western US power grid, *Applied Energy*.

Dyreson et al., in review. The role of regional connections in Planning for Future Power System Operations under Climate Extremes. *Earth's Future*.

Cohen et al., in review. A multi-model framework for assessing long- and short-term climate influences on the electricity grid. *Applied Energy*.

Sponsors: **EERE WPTO** (HydroWIRES) | **Office of Electricity** | **Office of Science**

Collaborators: Sandia, NREL, WECC.

Takeaways

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Reliability of the current and future grid **depends on water**—which is complex.

PNNL is advancing capabilities for simulating water resources and converting to **electricity-relevant datasets** at grid-scale.

These data enable the PNNL and others in the power systems community to quantify risks relating to **drought** and **climate change**.