Process-Based Modeling Approaches for Attribution Science: Panel 2 “Small/Local Scale Modeling

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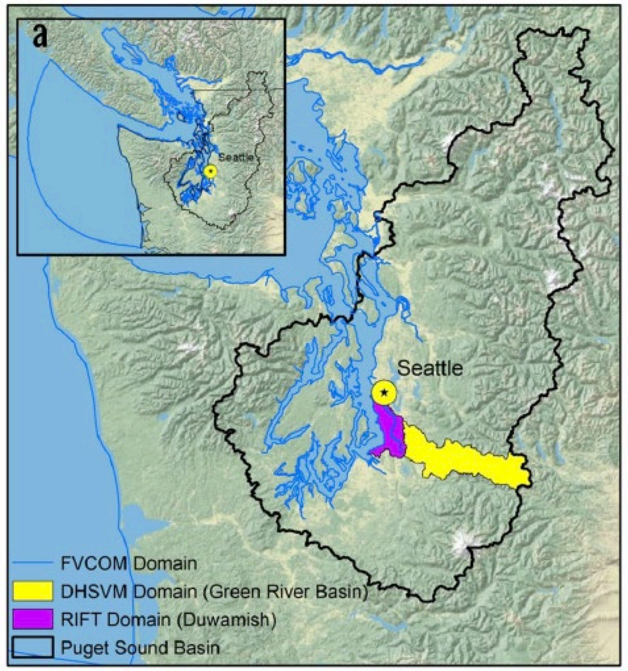
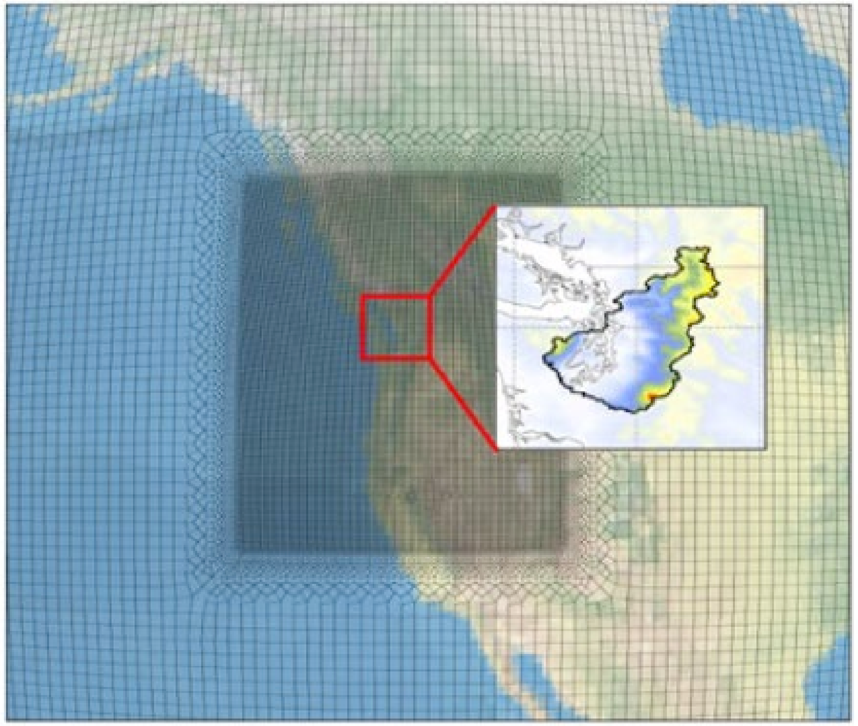
The regional refined SCREAM can be very skillful for storyline simulations of extreme weather events and their impacts

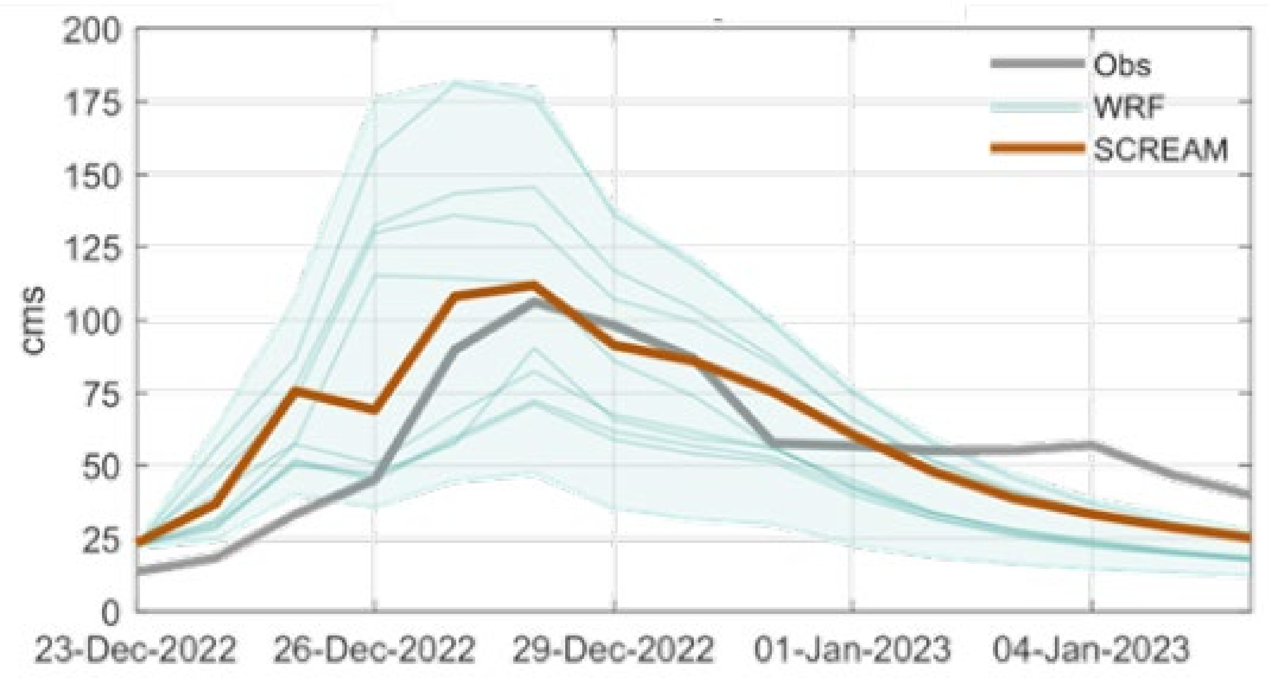
During the atmospheric river events between 12/21/22 – 1/5/23, the Puget Sound experienced widespread flooding from a combination of king tides, storm surge, and river flooding caused by rain-on-snow.



Regional refinement to 3.25 km



Streamflow at the outlet of Green River Basin

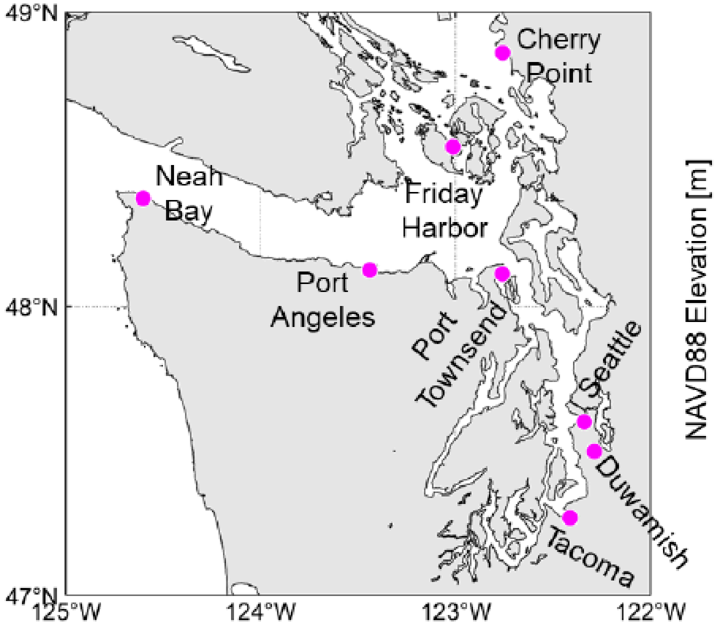


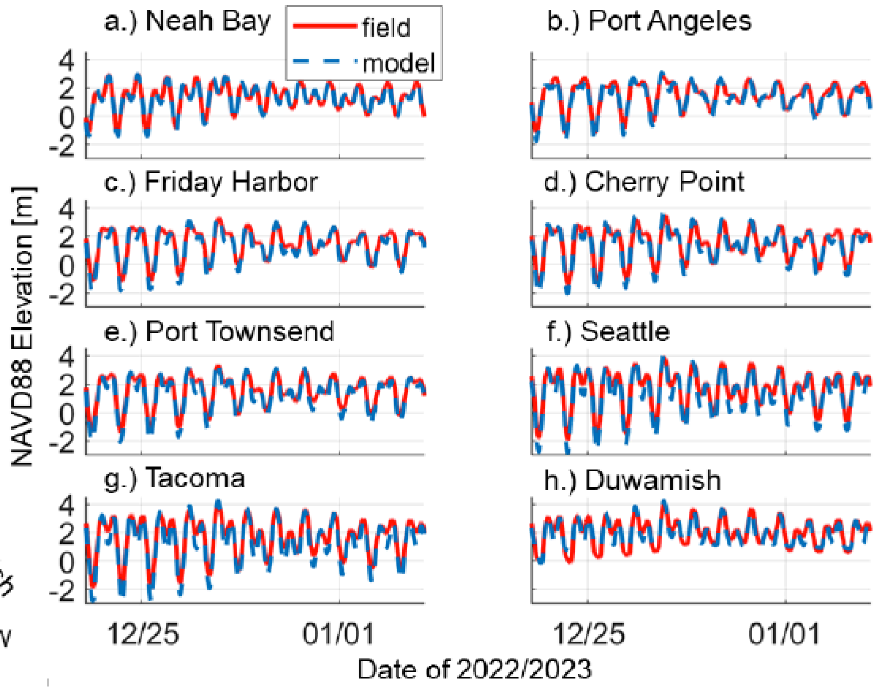
SCREAM (3 – 25 km) (Atmosphere) → **DHSVM** (90 – 150 m) (Hydrology) → **FVCOM** (100 m – 10 km) (Coastal Hydrodynamics) → **RIFT** (10 – 30 m) (Urban Hydrodynamics)

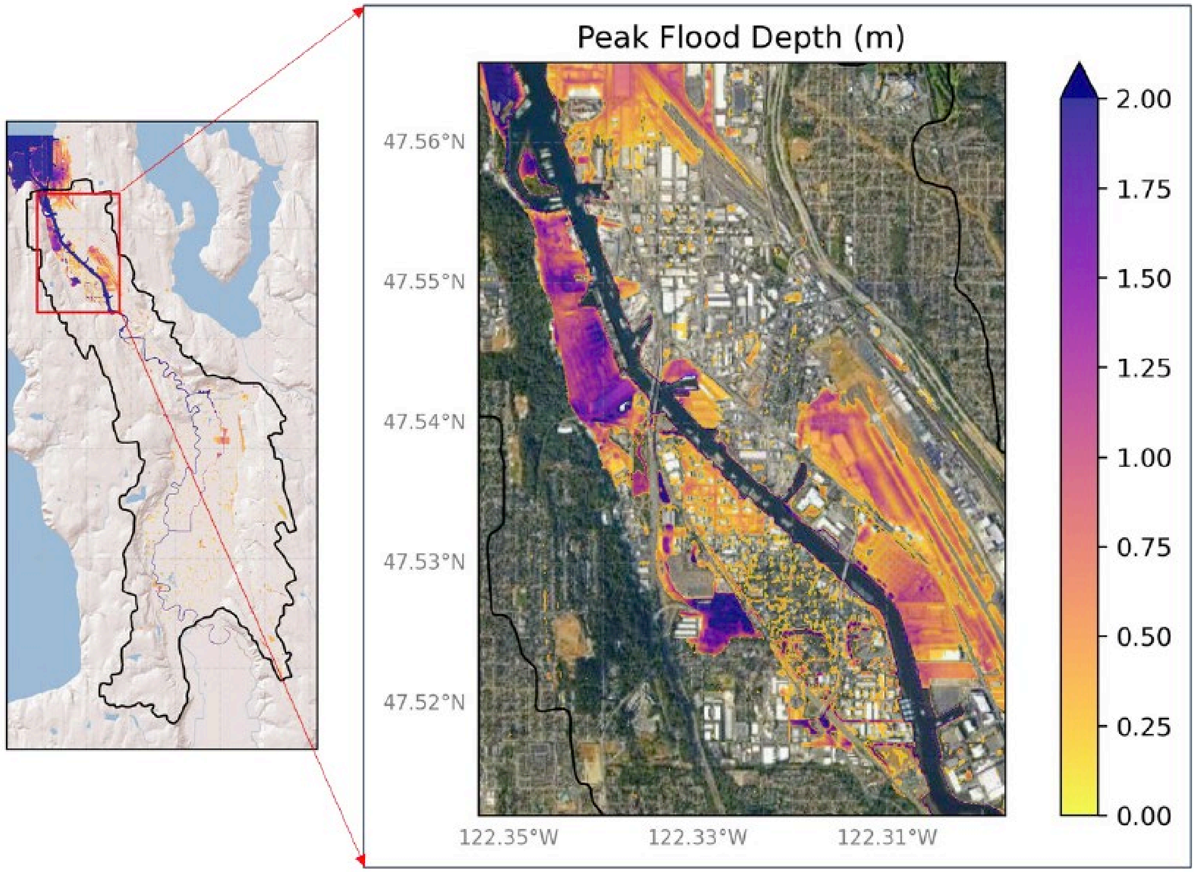
Modeling the impacts of storms: urban flooding is well simulated at the local scale (10 m) using the model chain

Tidal ranges and timing are accurately captured, as well as the influence of storm surges and river discharge

Simulation aligns broadly with publicly available reports that indicate approximately two feet of flooding in the Seattle neighborhoods



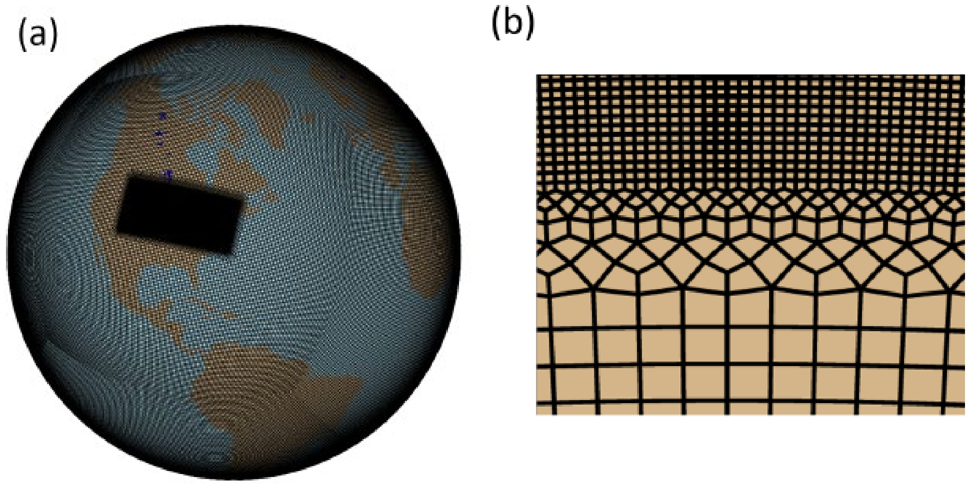


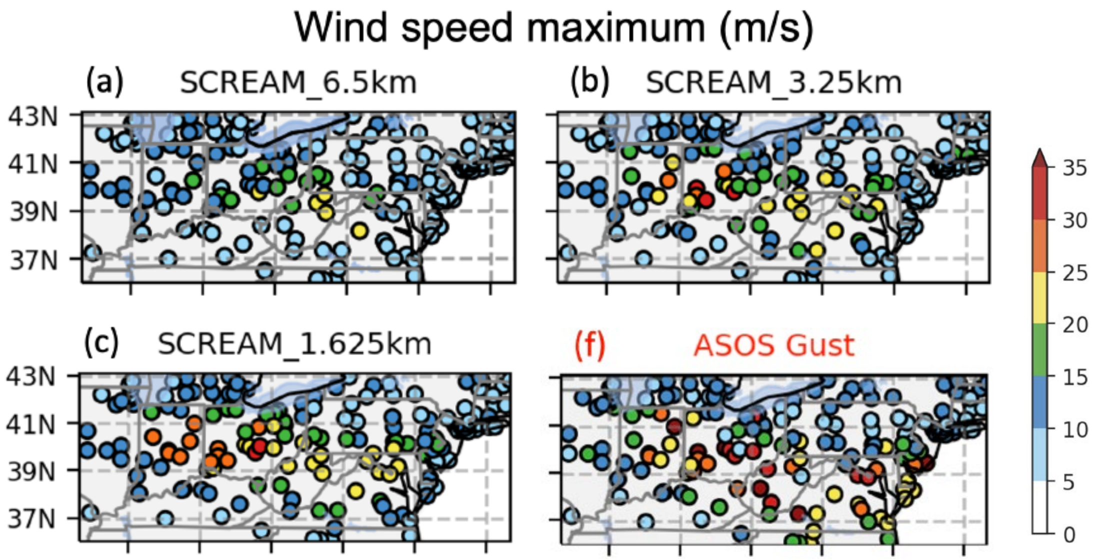


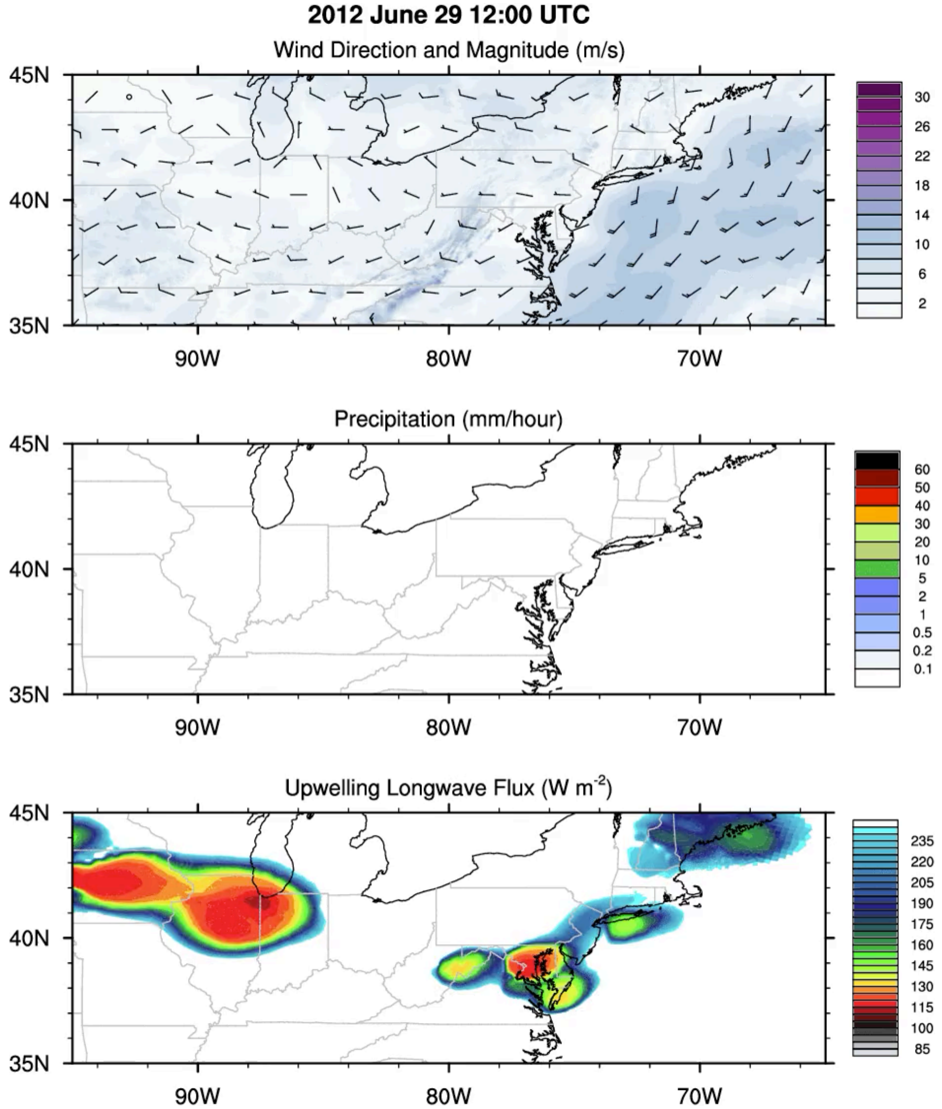
(Spicer et al. Earth's Future, in review; Taraphdar et al. JAMES, in prep)

Modeling the 2012 North American derecho

Both SCREAM and WRF can realistically simulate the 2012 North American derecho that caused major wind damage along its path



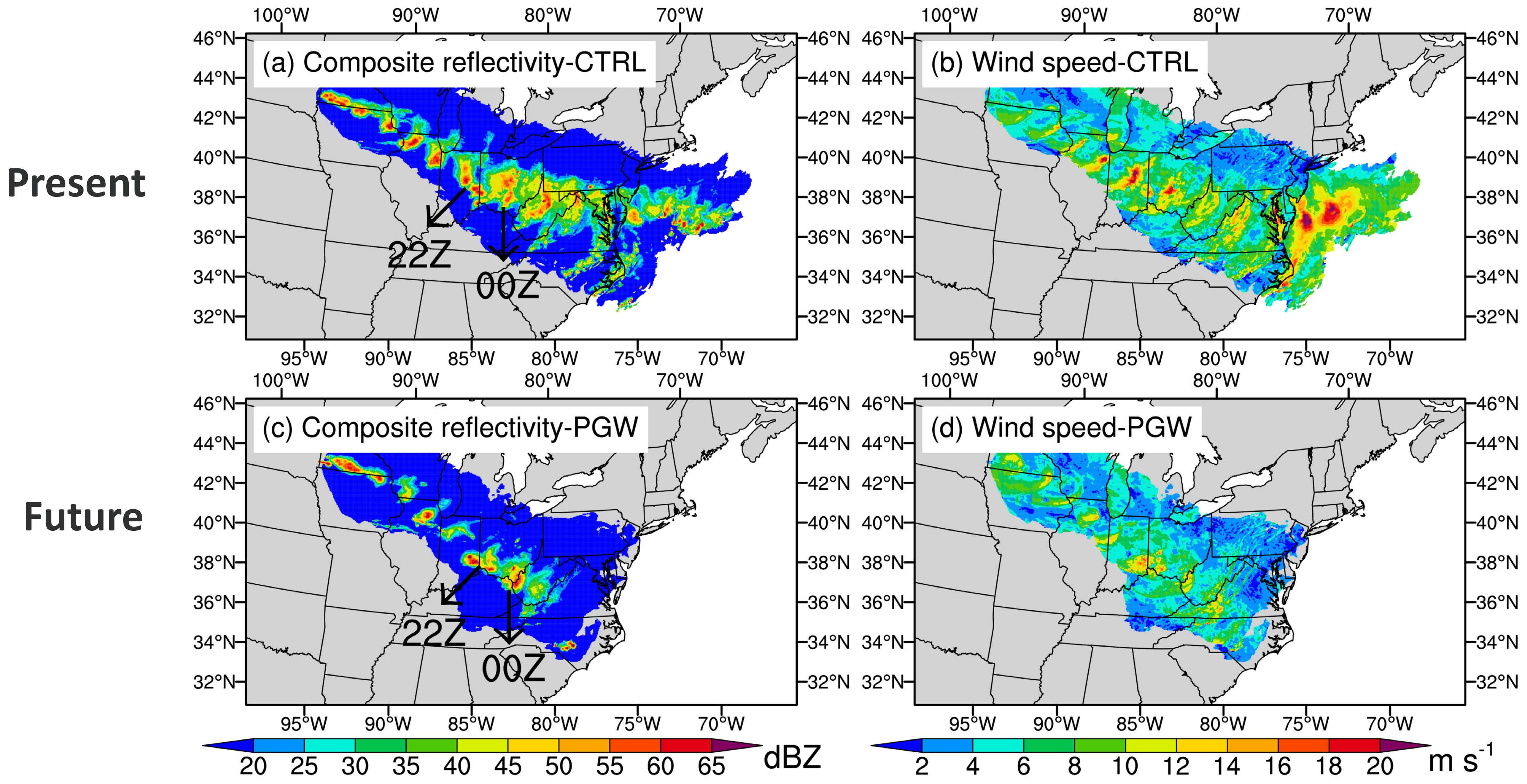




(Liu et al. 2023 JAMES)

The derecho weakens with warming

- **Smaller areas** with high reflectivity and surface wind
- **Dissipate earlier** before reaching the mid-Atlantic region



(Li et al. 2023 JGRA)

How well can convective storms be simulated climatologically

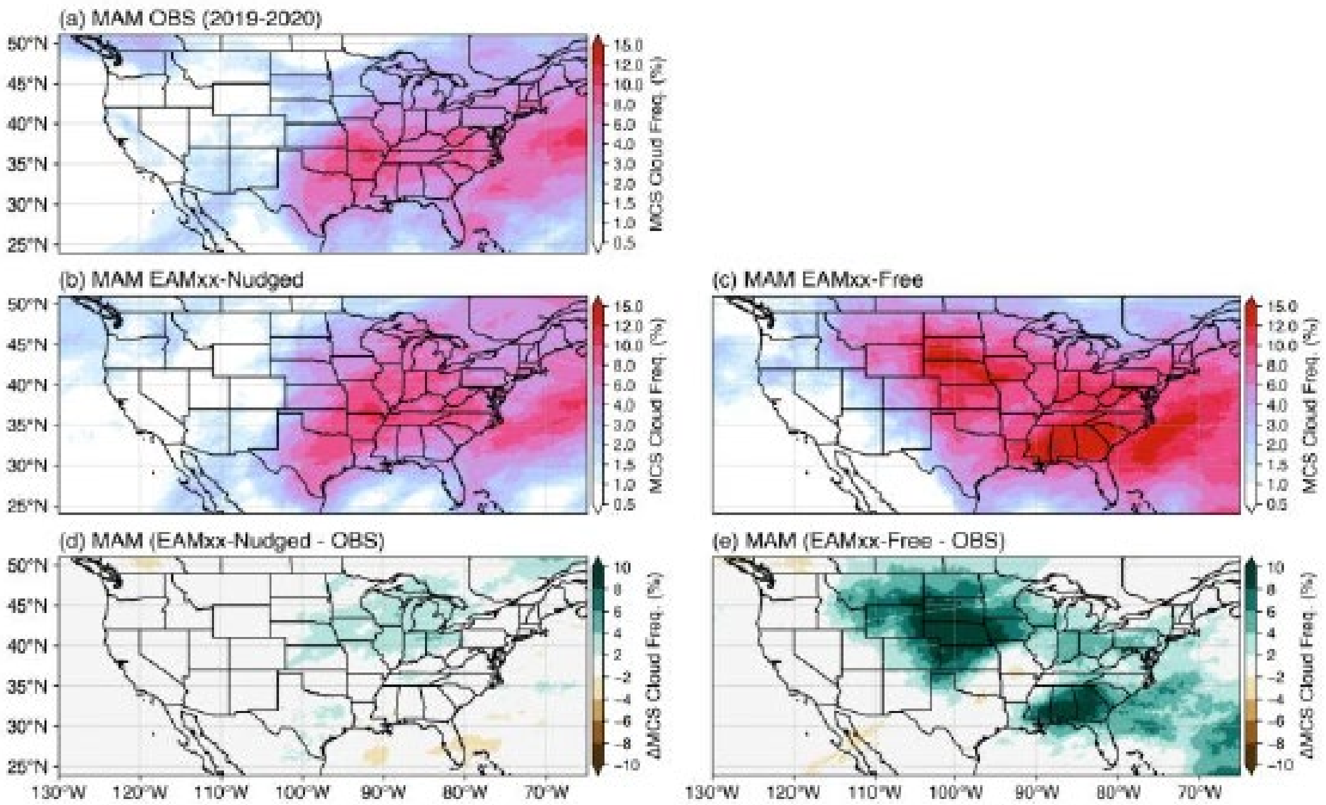
Comparison of free-running and nudged simulations shows the impact of large-scale biases on the model's ability to reproduce the storm climatological features

MCS frequency in spring

OBS

SIM

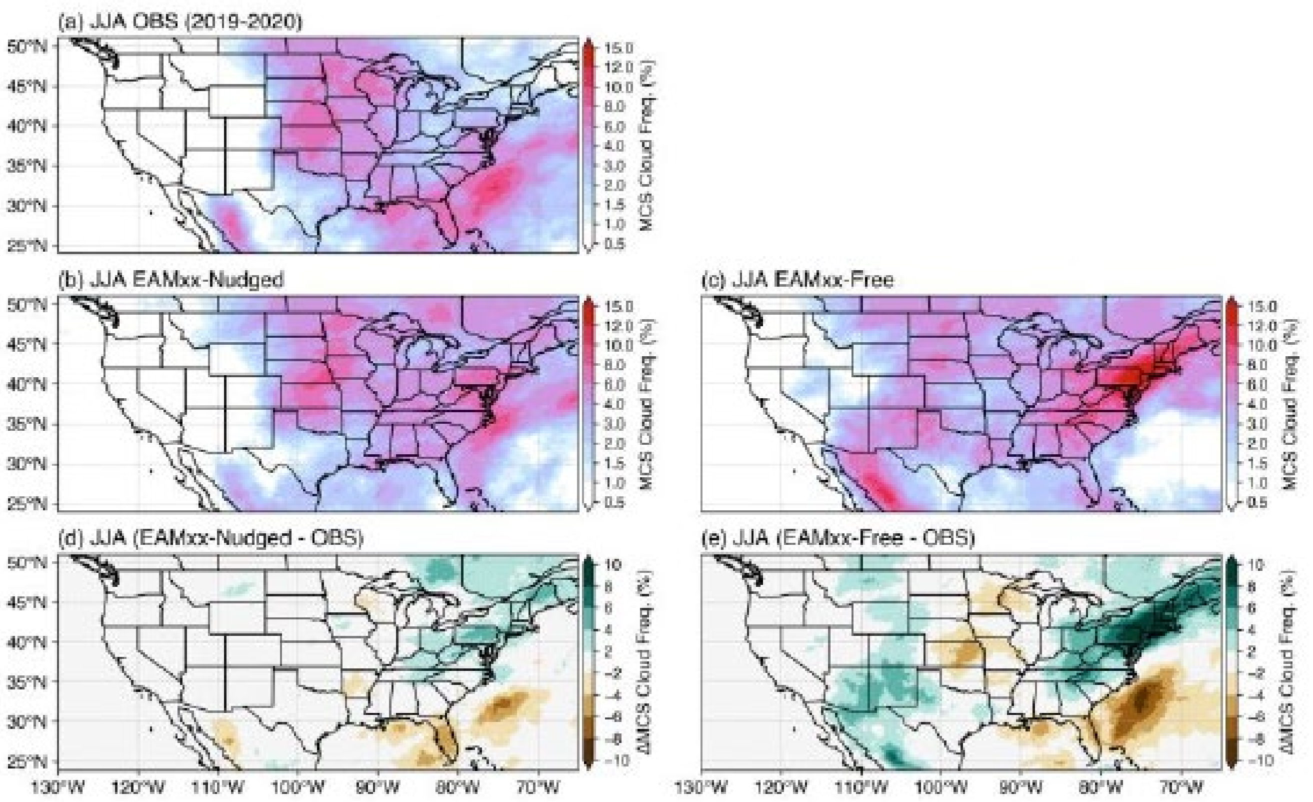
BIAS



NUDGED

FREE-RUNNING

MCS frequency in summer



NUDGED

FREE-RUNNING

Modeling extreme events at small/local scales

- Kilometer-scale models are generally skillful in modeling extreme precipitation associated with large-scale systems (e.g., atmospheric rivers)
  - Local hydrologic impacts (e.g., urban flooding) can also be well simulated using a model chain down to 10 m resolution
- Similarly, km-scale models can be skillful in modeling severe convective storms (e.g., squall lines, derechos). However,
  - model skill is more variable from event to event and sensitive to physics parameterizations and initial and boundary conditions
  - how these events respond to warming are also more variable
- Challenges in modeling convective storms climatologically and the variable responses to warming present difficulties in attributing convective storms as a class of extreme events