Pacific Northwest NATIONAL LABORATORY

EESM PI Meeting
Aug 7, 2024

COMPASS – Great Lakes Modeling

Overview

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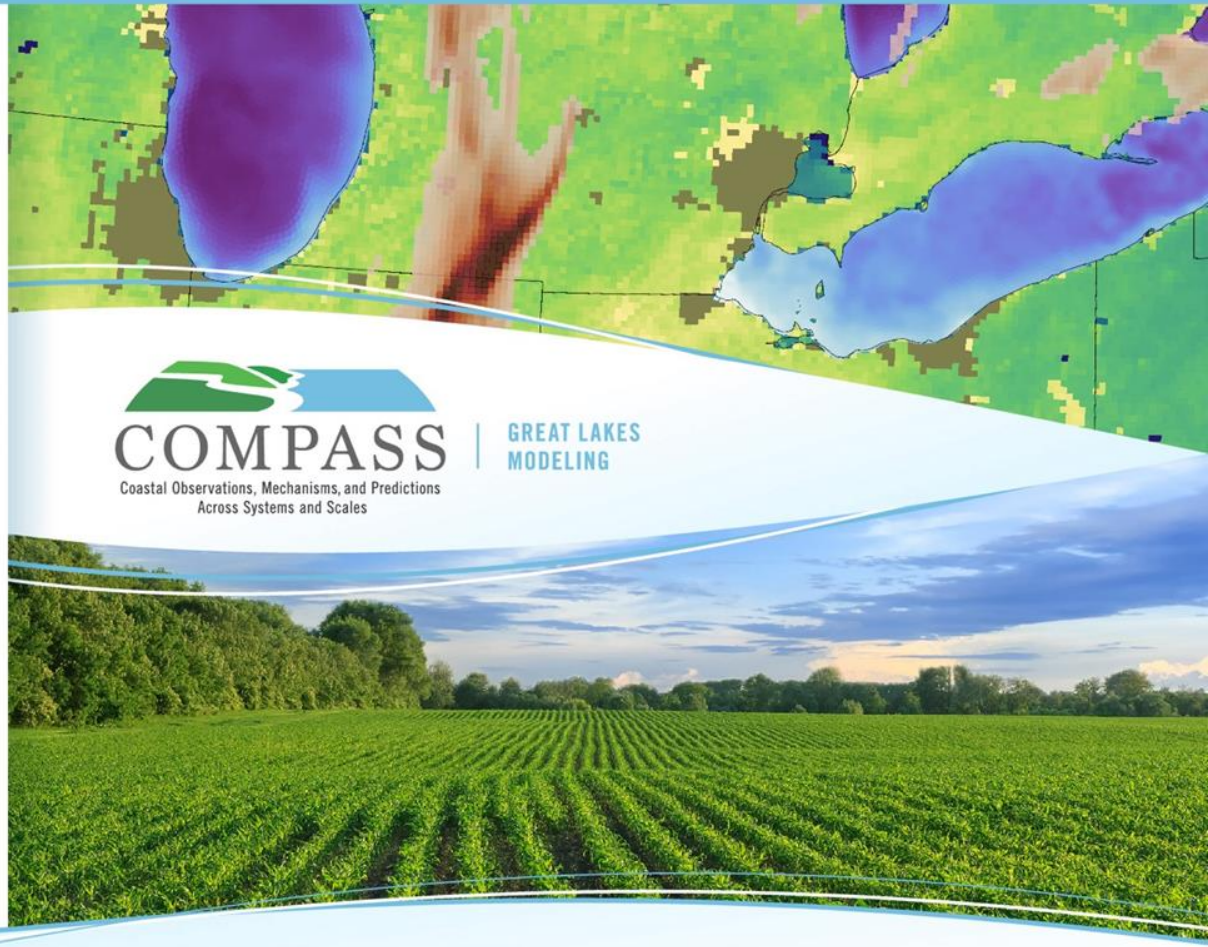


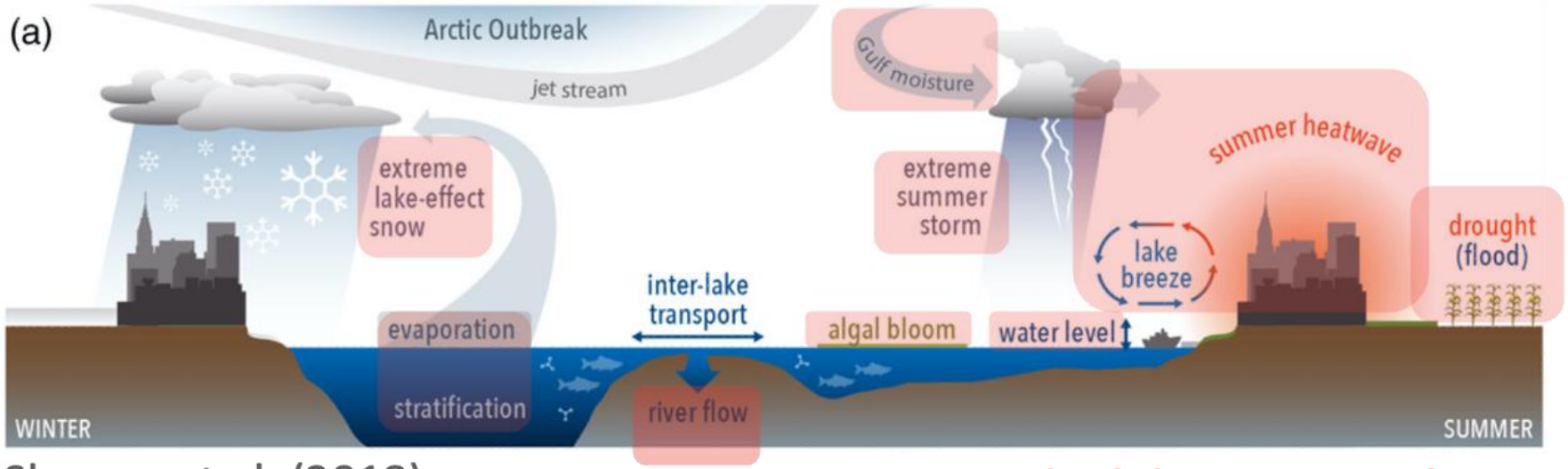
U.S. DEPARTMENT OF ENERGY

COMPASS is a multi-institutional program led by PNNL and funded by the Earth and Environmental Systems Science Division of the U.S. Department of Energy's Office of Science

Pacific Northwest · Argonne · Baylor University · Heidelberg · Los Alamos · Oak Ridge · PennState · The University of Toledo · Michigan Technological University

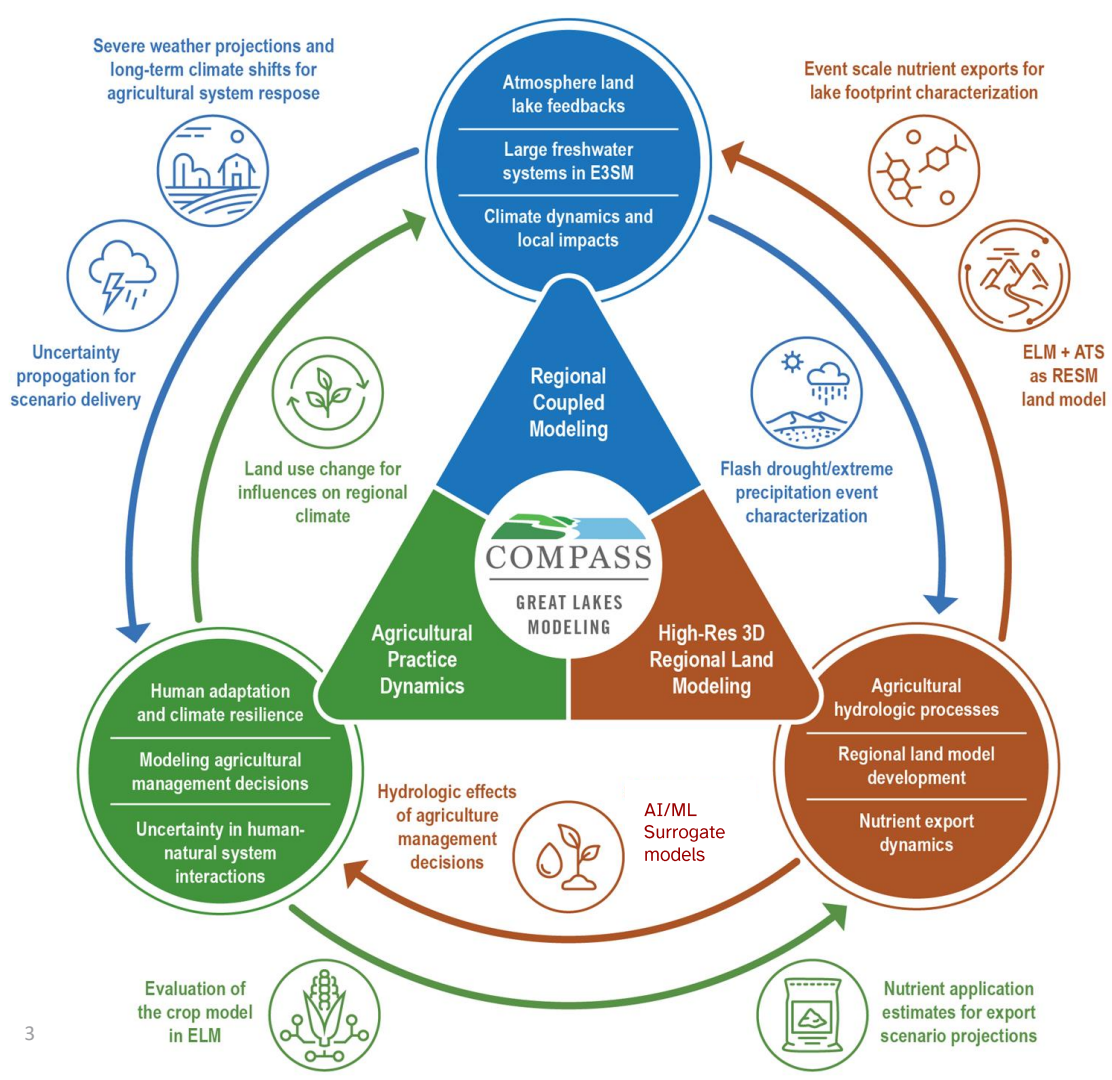
***Decadal Vision*:** Improving predictive understanding of coastal systems by coupling human and Earth system components, each with application-appropriate detail, to understand the co-evolution and interdependencies of coastal regional processes and human systems, using the Great Lakes Region as a test bed.

Phase 1 highlights:



Sharma et al. (2018)

Topics studied during GLM Phase 1



The three ***Project Themes*** are organized around existing modeling communities of practice, modeling tools, and capability development.

Together, the themes will address **science questions** such as:

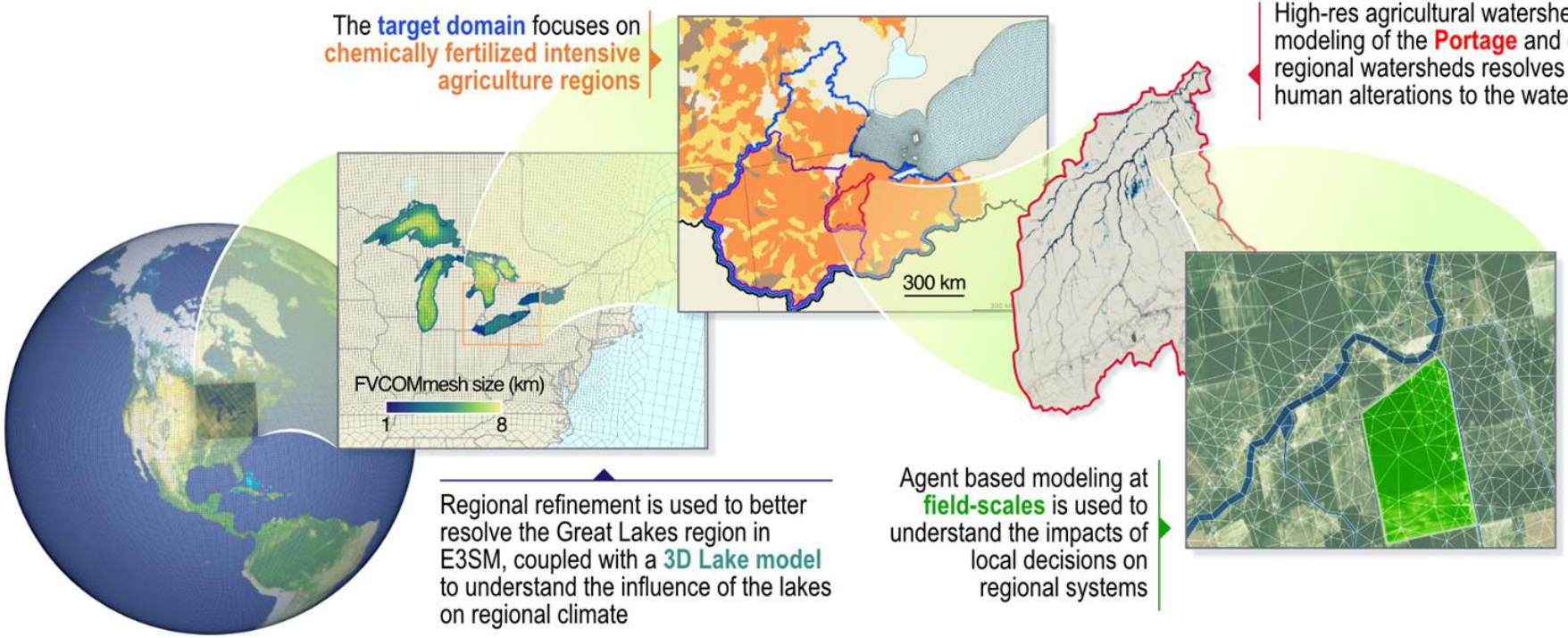
What are the strongest feedbacks between regional Earth system components, and how will these feedbacks be altered in a future climate?

How will nutrient exports change in the future given changing land use/land cover change, farm practices, regional warming trends, and more intense hydrological events?

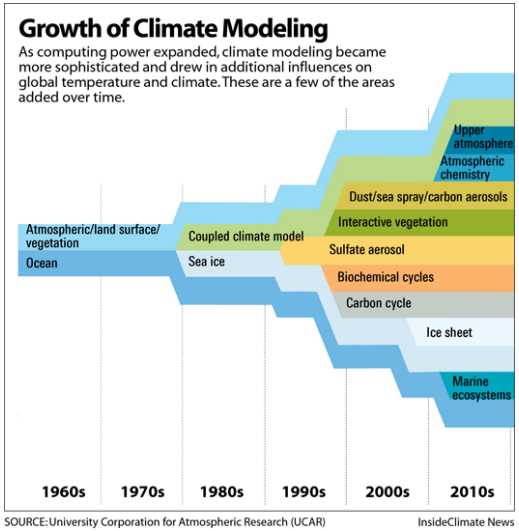
How will human–natural systems coevolve in response to climate change? Which crops and agricultural practices will be viable in a future climate?

Which processes are most critical to understanding the response to climate change in the Great Lakes Region, and how do we best include these processes in a RESM?

COMPASS-GLM brings together a hierarchy of models with a broad range of resolution



A robust predictive understanding of coastal systems requires both interacting earth system components and application-appropriate detail



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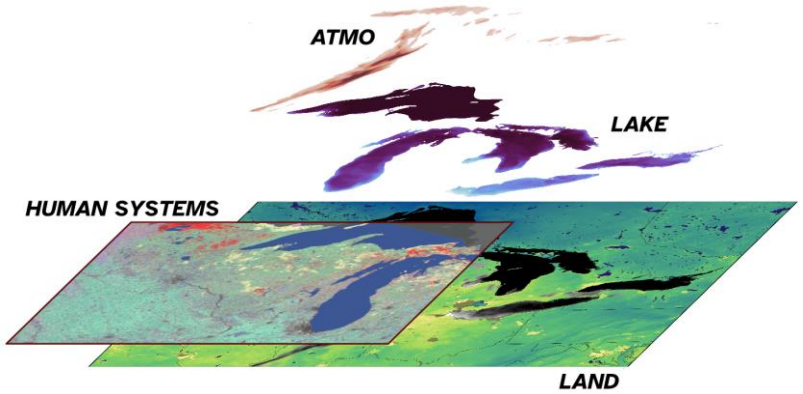


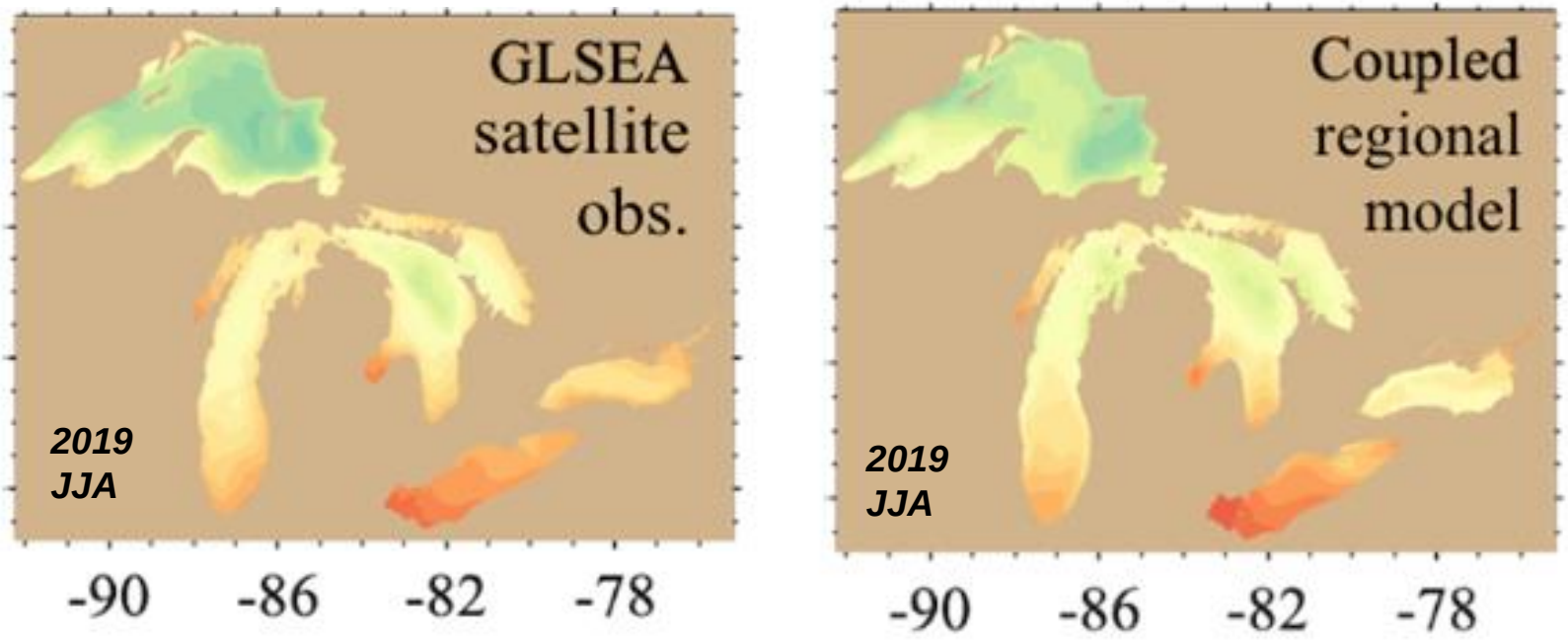
Global ESMs have evolved to contain many interacting earth system components

Coastal models include many detailed processes, but often do not contain interacting earth system components.

Coastal regions are characterized by strong gradients in transition, e.g., across land/lake boundaries, which are challenging for global ESMs to correctly simulate. The processes that are influenced by, and set, these gradients determine the appropriate level of detail that must be resolved for robust simulation.

A coupled atmosphere-lake model (WRF/FVCOM) can reproduce observed SSTs better than a standalone model without nudging to observations.

Seasonal mean lake surface temperature

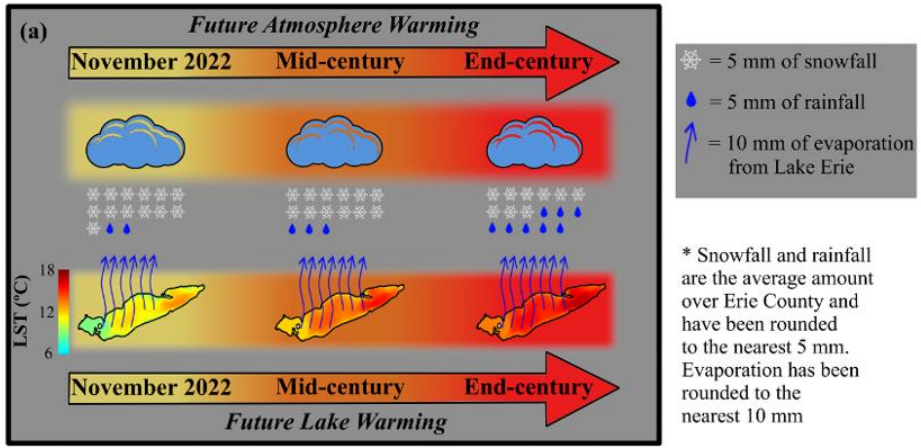


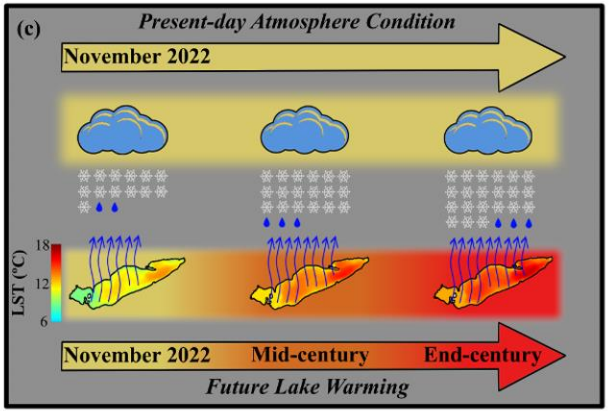
Kayastha *et al.*, 2023

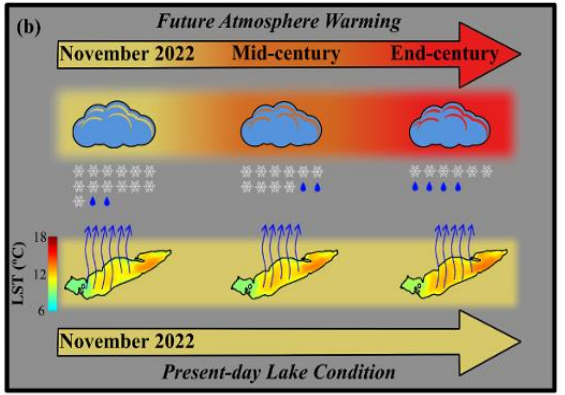
This allows us to more confidently study lake influences on the atmosphere.

In the warmer climate, we will see more winter storm precipitation, but with more rain and less snow.

If you hold one component constant, results are incorrect



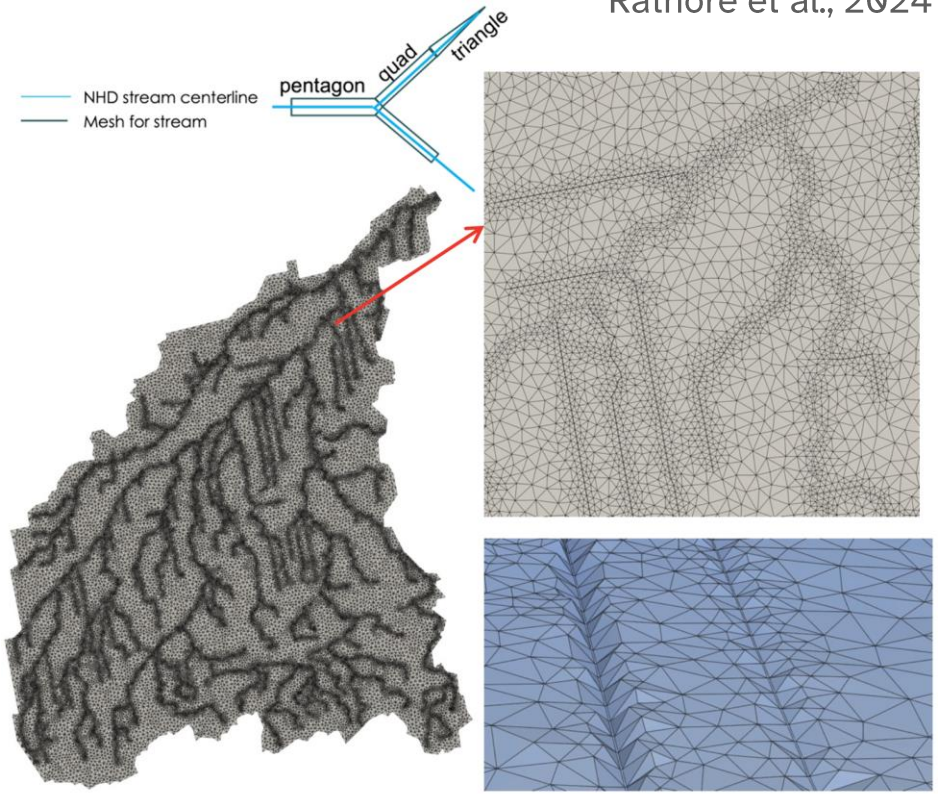


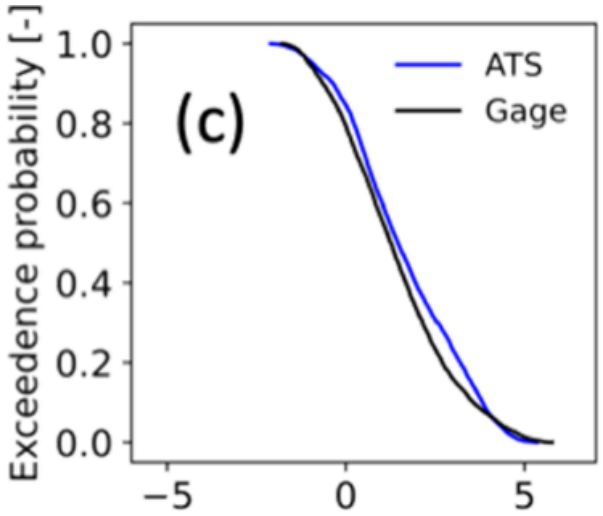


Kayastha et al., Earth's Future, 2024

Similarly, accurately representing hydrologically relevant features (drainage ditches, tile drains) in an ag. dominated region allows for high model skill without training.

Rathore et al., 2024

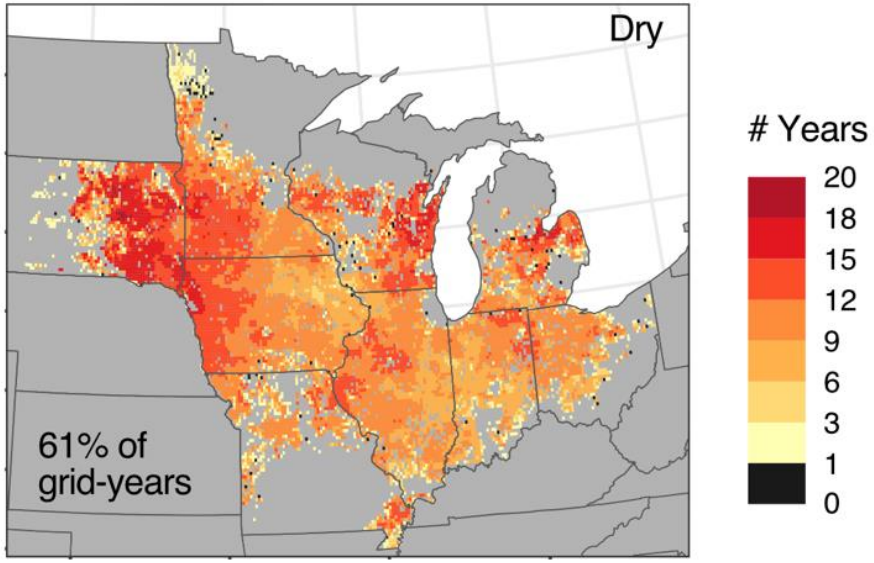




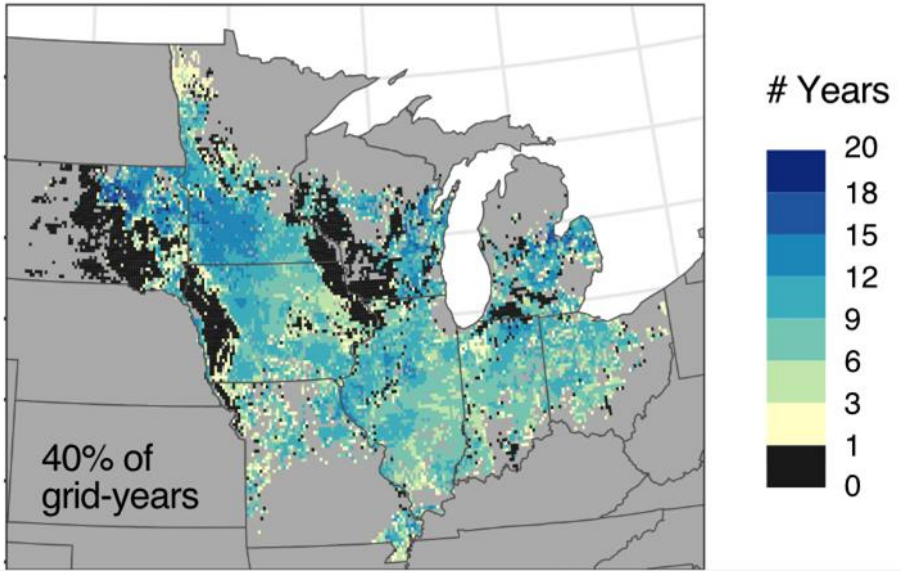
Uncalibrated ATS (above) significantly outperforms a calibrated SWAT model.

Soil moisture and access to ground water can impact crop yield.
In northern Ohio, soil moisture is enhanced by blocking tile drains.

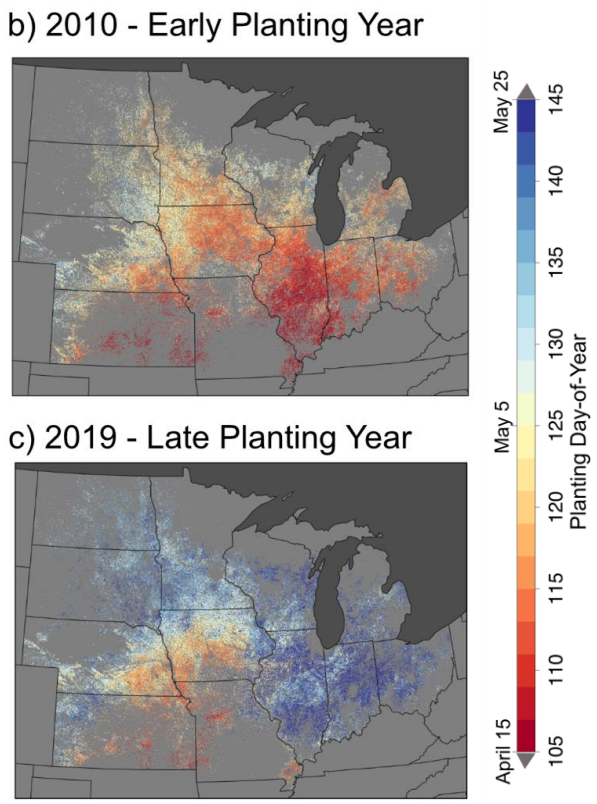
Frequency of yield-limiting climate conditions



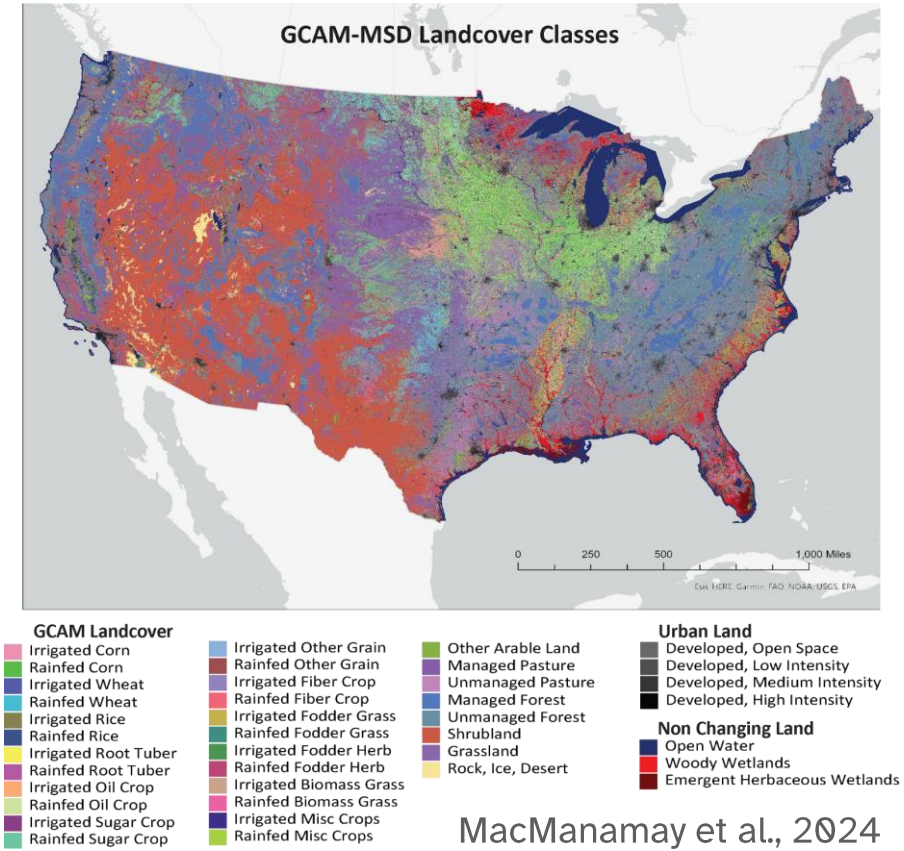
Frequency of root uptake of groundwater



All of this can influence land use, both temporally and spatially.



Deines et al., 2023



MacManamay et al., 2024

Connections

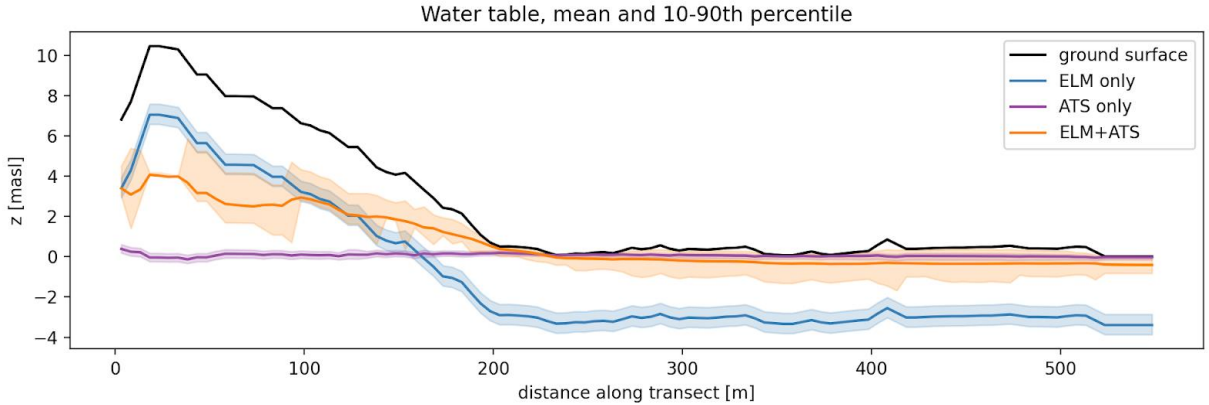
Coupled components and *application appropriate resolution* improve predictability by taking into account both feedbacks and human modifications to the earth system.

Nested regional modeling allows us to understand regional climate impacts driven by global signals in a consistent way.

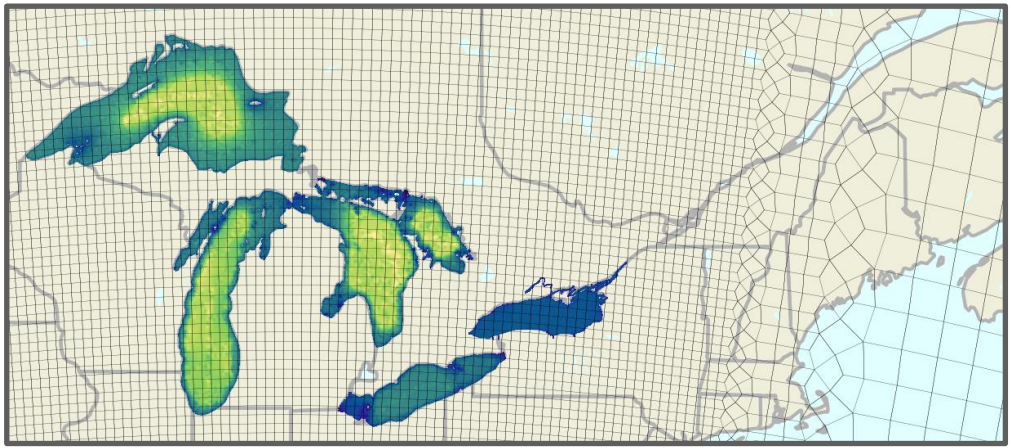
This is important because making informed decisions on mitigation strategies often requires *hyper-local information*.

Connections to E3SM – Connecting regional and global modeling

ELM-ATS coupling

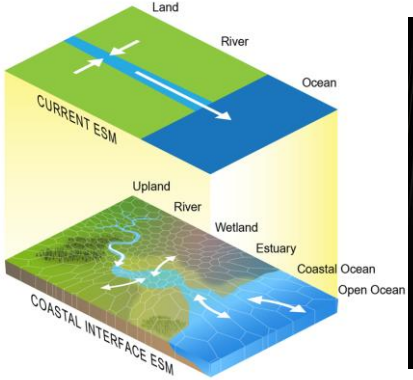


FVCOM coupling into E3SM



The COMPASS-HPC enables intensive model simulations and large data storage, *freely available to the BER coastal research community*

- Address mid-range HPC needs
  - 92 dual-CPU compute nodes
  - Each node has 48 cores, 392GB RAM
  - 100Gbps Infiniband
  - 4PB shared storage + 2TB local flash
- Current software includes:
  - ATS, WRF, Paraview, pflotran, Jupyter, petsc, WPS, R, esmf, gdal, hdf5, netcdf, QIIME, and more
  - Users can request additions
- Short job queue times
- Small, responsive team provides expert technical support for new users
- SLURM batch jobs over ssh and interactive OpenOndemand web UI



Request access :

https://compass.pnnl.gov/Compass/COMPASSHPC