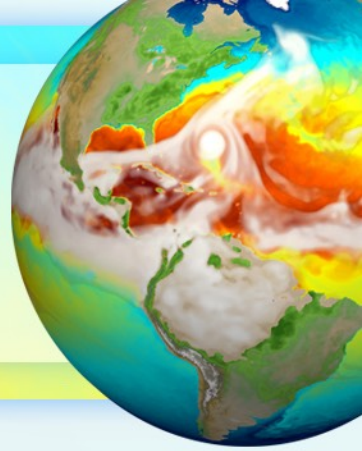

Connecting Earth system models to national security decision-making: Examples, opportunities and research needs

Todd Ringler, Jessica Conrad, James Cooley, Sara Del Valle, Eric Dors, Jeanne Fair, Geoff Fairchild, Nick Generous, Elizabeth Hunke, Matthew Heavner, Carrie Manore, Nidhi Parikh, Joel Rowland, Jonathan Schwenk, Nathan Urban, Cathy Wilson, Amanda Ziemann

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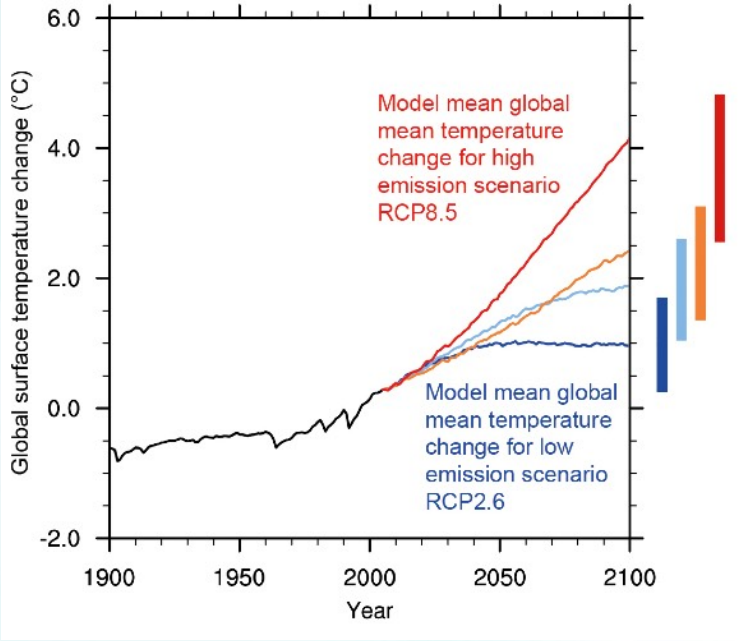
LA-UR-18-24766

What are Earth System Models (ESMs) and how have we used them?

Earth system models integrate the interactions of atmosphere, ocean, land, ice, and biosphere to estimate the state of regional and global climate under a wide variety of conditions[1].

application: basic research into how the earth works.



application: impact of greenhouse gas emissions on global surface air temperature

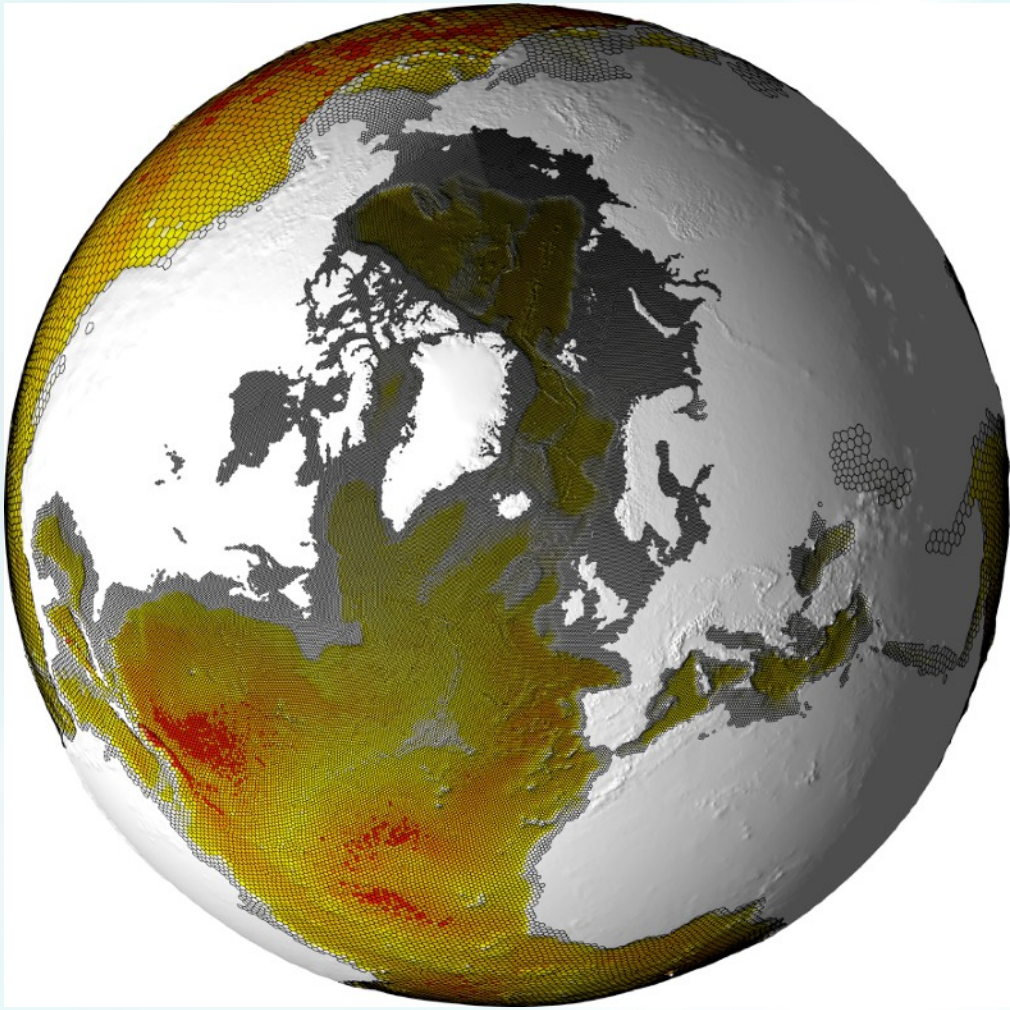
1. Heavens, N.G., Ward, D.S. and Natalie, M.M., 2013. Studying and projecting climate change with earth system models. *Nature education knowledge*, *4*(5), p.4.

New mission space for ESMs: Informing security decision making.

Nearly two dozen ESMs are in use around the world to support the six-year cycle of assessment reports produced by the UN Intergovernmental Panel on Climate Change.

A small subset of these models are now positioned to take on more focused, mission-specific tasks, for example, to help manage environmentally driven security risks.

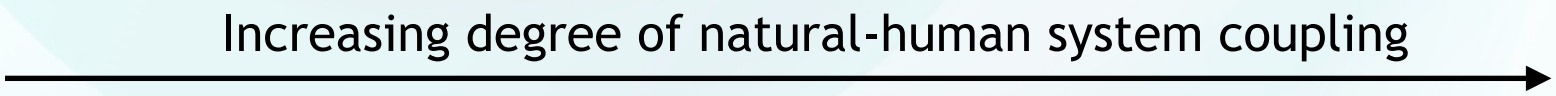
DOE's Energy Exascale Earth System Model (E3SM) is the first ESM to seamlessly support the regional refinement necessary to help inform the most pressing environmentally driven national security issues.



Example of an Arctic refined mesh for supporting security analysis of an ice-free summertime Arctic.

Environmentally driven national security risks **always** involve an interaction between natural and human systems. But this coupling varies from one risk to the next.

What follows are four examples that 1) highlight where ESMs can contribute to national security planning and 2) highlight the varying degree of natural-human system coupling.



Sea-level rise

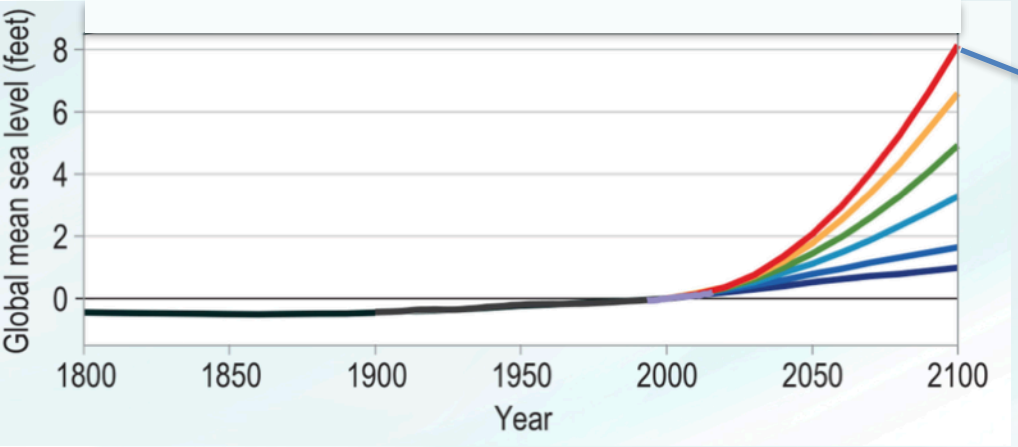
An ice-free summertime Arctic

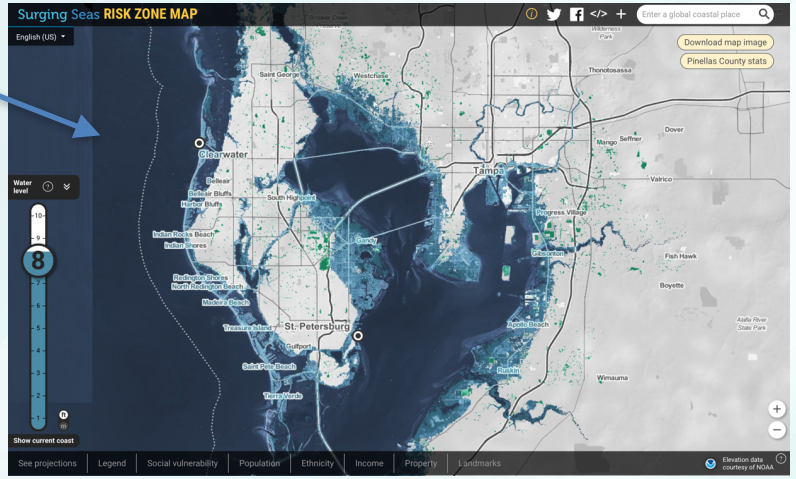
Vector-borne infectious disease

Scarcity of fresh-water supply

Example: Likelihood and timeline for abrupt sea-level rise

NCA4: "Global average sea levels are expected to continue to rise—by at least several inches in the next 15 years and by 1–4 feet by 2100. **A rise of as much as 8 feet by 2100 cannot be ruled out.** Sea level rise will be higher than the global average on the East and Gulf Coasts of the United States."





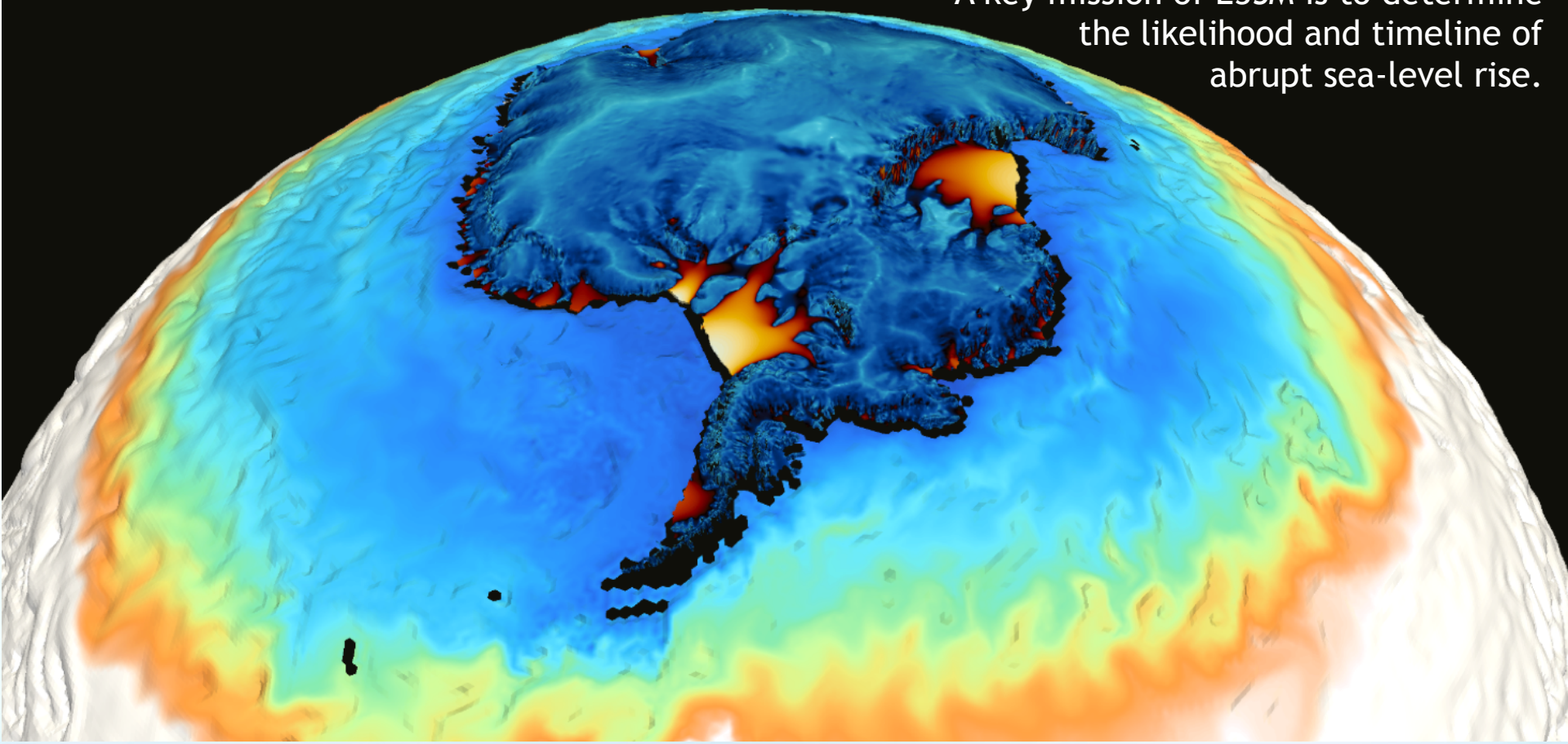
What is the probability of 8 ft by 2100? One in ten? One in a thousand?
What are the indicators that this trajectory is being realized?
What is the timeline if this trajectory is initiated?

USGCRP, 2017: *Climate Science Special Report: Fourth National Climate Assessment, Volume I* [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 470 pp.

Example: Likelihood and timeline for abrupt sea-level rise

If 8 ft of sea-level rise is observed during this century, it will be initiated by the collapse of the ice shelves that buttress the Antarctic Ice Sheet.

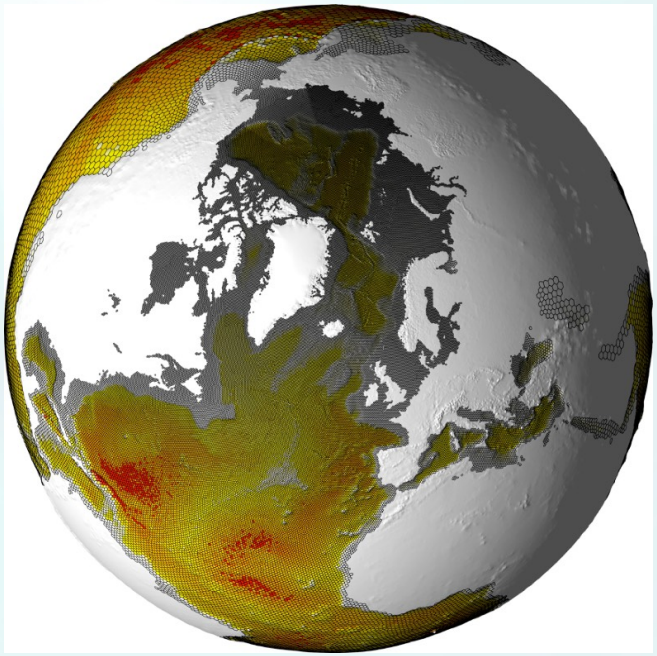
A key mission of E3SM is to determine the likelihood and timeline of abrupt sea-level rise.

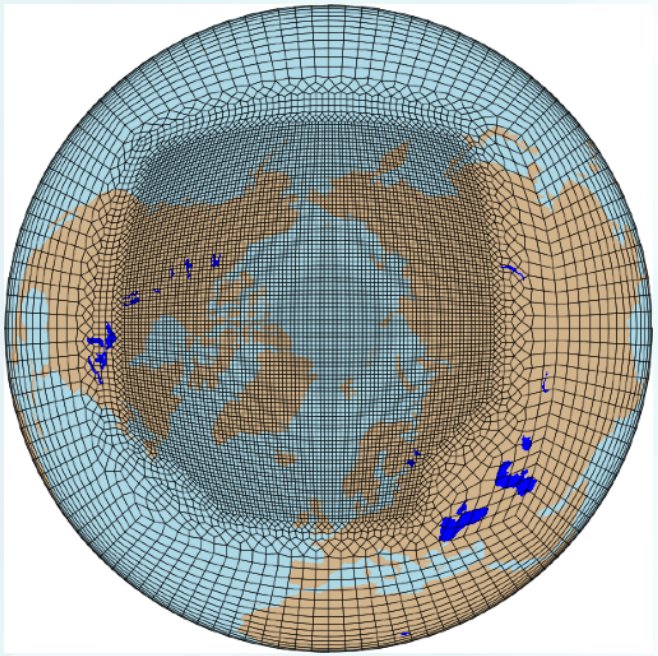


Example: Navigating an Arctic in transition

The next 30 years will be a period of dramatic environmental change and associated human use in the Arctic. New shipping routes will lead to both new economic opportunities and security risks.

Example: Navigating an Arctic in transition





E3SM configured to support Arctic planning.

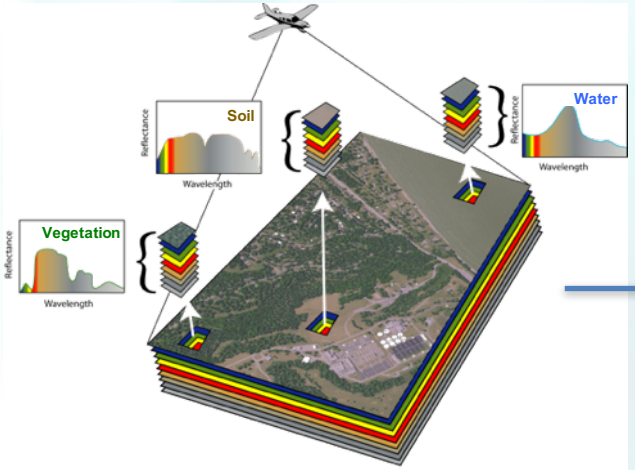
What are the operating conditions of a mostly ice-free Arctic in September?

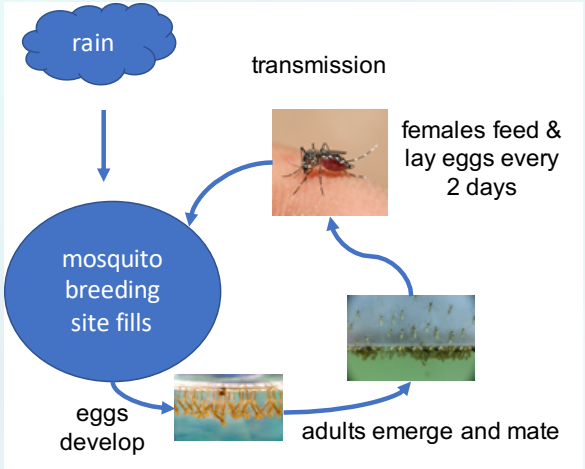
For example, what does a “typical” Arctic September storm look like in 2050?

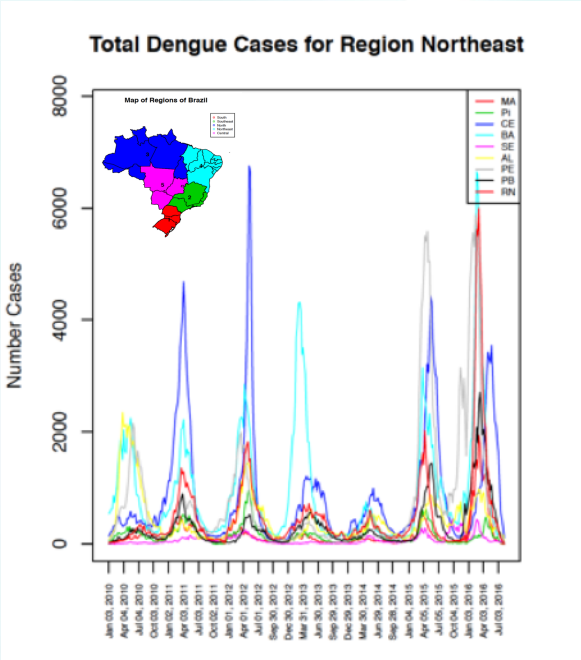
Or what is the “typical” patterns for the opening and closing of the shipping routes?

What support/rescue resources are needed to maintain 1 or 2 or 3 NW Passage routes?

Example: Forecasting at short- and long-time scales for the emergence of vector-borne infectious disease







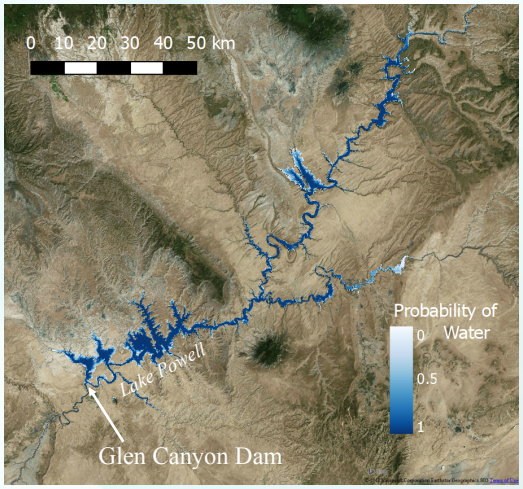
Remotely sensed plant water content (NDWI) provides predictive skill with a 5 week lead time for the number of dengue cases.

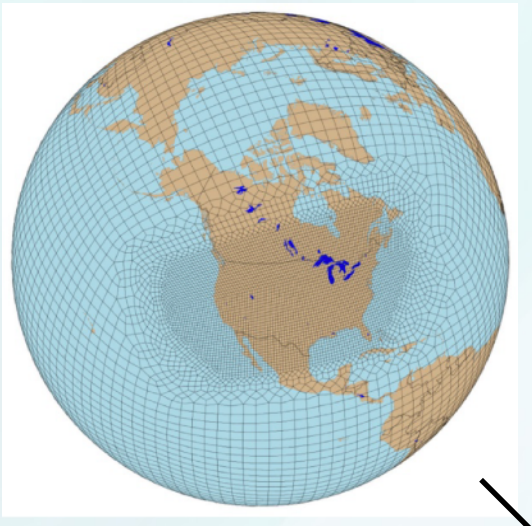
Short term: Additional predictive skill is easily achievable through use of extended range weather forecasts of rainfall.

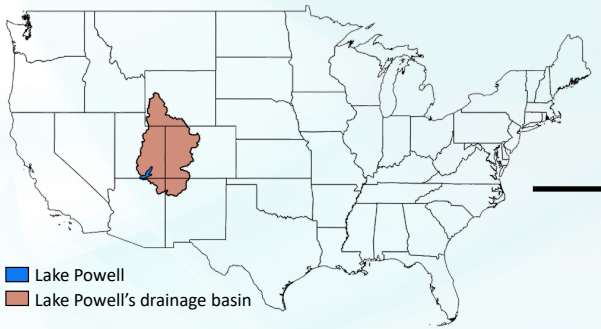
Long term: ESMs can help identify changes in habitat for various mosquito species and the associated vector-borne infectious diseases.

Example: Foresight into Regional Water Scarcity

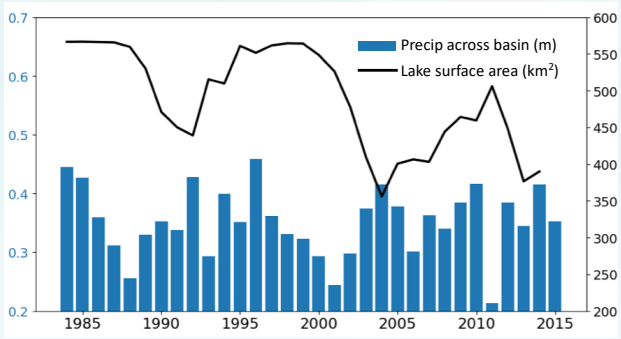
pick any reservoir or lake







determine drainage area using River and Basin Profiler (RaBPro)



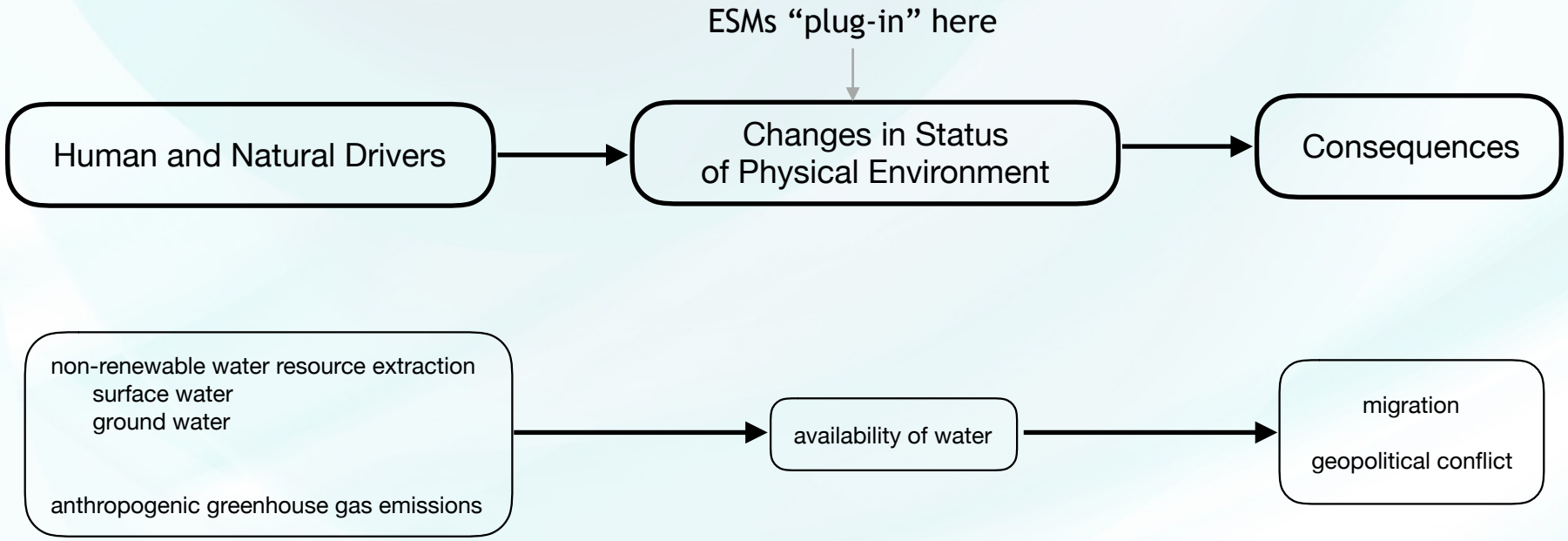
satellite imagery and re-analysis to build time history of reservoir

use high-resolution ESM data to project reservoir level forward in time, including uncertainty.

Research Needs: Improved communication of environmentally driven security risks. Separating drivers, environmental change, and consequences.

Environmentally driven risks to national security are complicated, typically interact with other drivers of risk, and evolve by crossing tipping points.

We have been working to develop communication tools that allow us to clearly explain how and where environmentally driven national security risks fit into the bigger picture of security planning.



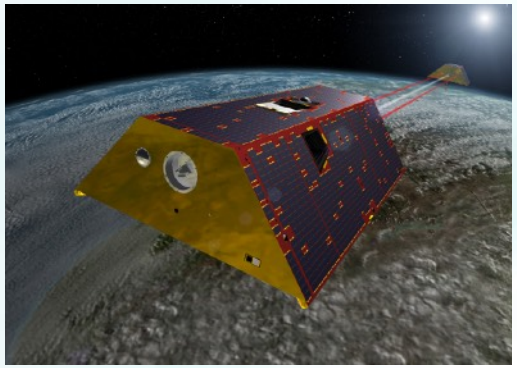
Research Needs: Feeding ESM information streams into the broader security information system.

Historically, application of ESMs has ended at the assessment of environmental change. To grow their role in assessing security issues, we will have to feed the valuable data streams produced by ESMs into the much broader “ecosystem” of national security information sources.

examples of the diversity of data streams that ESMs already have extensive experience with.

in-situ data streams

visible and infrared imagery



Gravity Recovery and Climate Follow-On (GRACE-FO)

Overarching opportunity offered by Earth system models: Elucidating the pathways through inevitable environmental change.

Earth system models have helped us identify a host of inevitabilities, e.g., an ice-free summertime Arctic, parts of the world running out of water, and rising sea level (just to name a few).

Earth system models are poised to help us understand and manage the possible pathways through these inevitabilities.

Success depends on building and sustaining long-term relationships between the environmental prediction and national security communities.

Thank you!