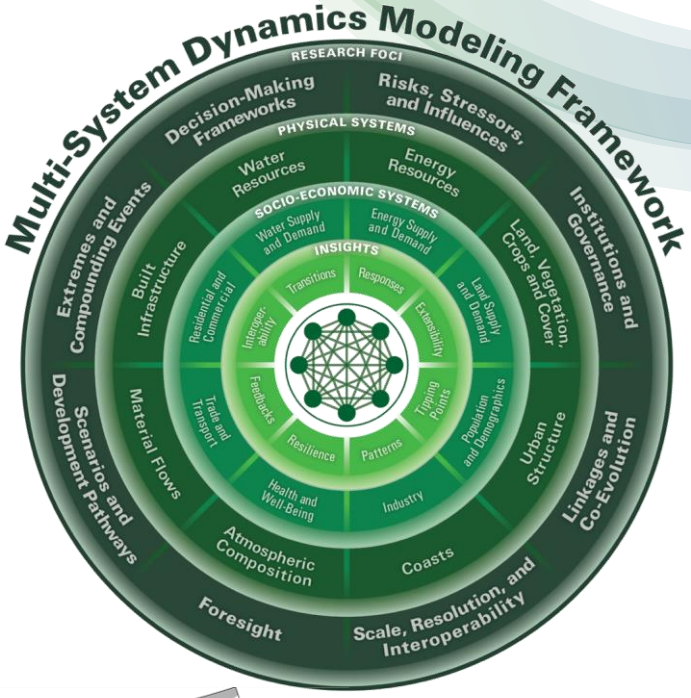
Sectoral Interactions, Compounding Influences and Stressors, and Complex Systems: Understanding Tipping Points and Non-Linear Dynamics

PI: Ron Prinn Co-Pis: Jen Morris, Sergey Paltsev, and Adam Schlosser Lead Investigators: Angelo Gurgel and Xiang Gao

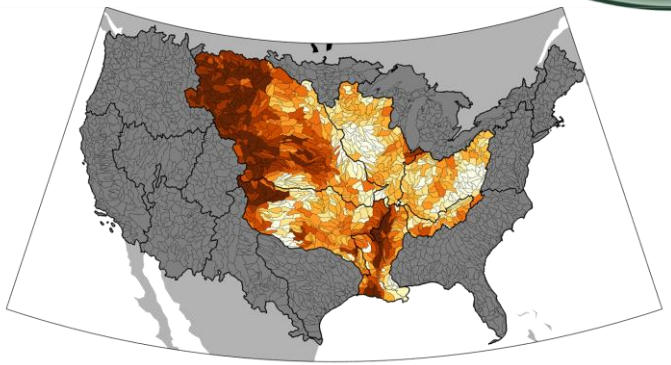
Research Aims:

- Advance and utilize a multi-system, multi-sector model framework.
- Explore stressors, risks and responses of complex, interconnected physical and socioeconomic systems.
- Focus on Mississippi River Basin.



Research Foci to Assess Upstream-Downstream Dynamics and Human-Natural System Interactions:

- Co-existence/evolution of linked systems and responses
- Cross-sector & cross-scale interactions
- Extreme events and stress testing
- Uncertainty, risk, and potential "tipping points"



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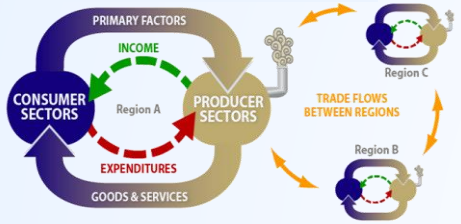
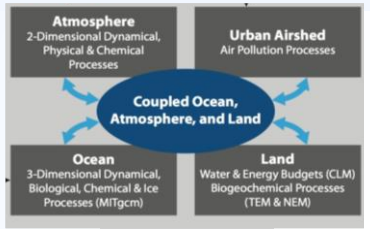
Building a Toolbox of Methods and Models to Answer Key Questions Across Multi-Sector Dynamics

Human System

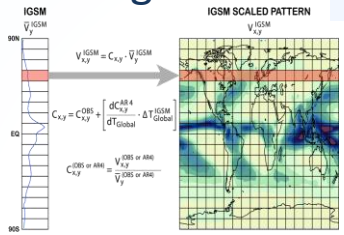


Natural Systems

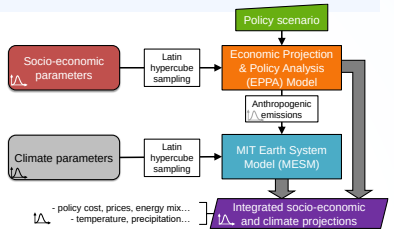


CAM3 & WRF

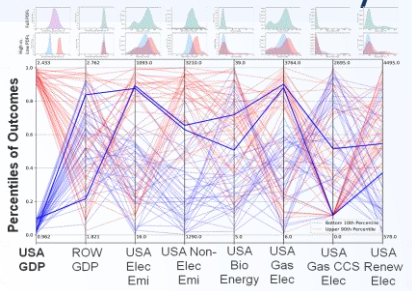
ML-based Pattern Scaling Extremes



Probabilistic Ensembles

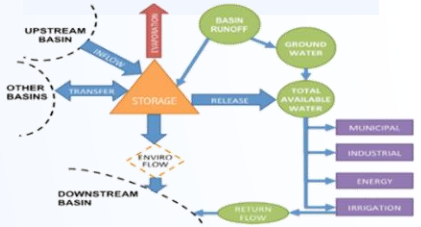


Scenario Discovery

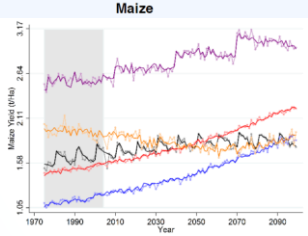


Electricity Models

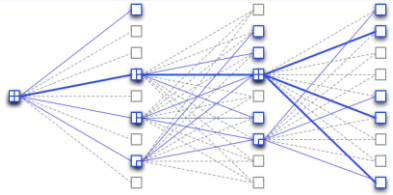
Water Resources



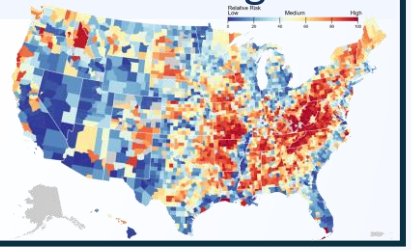
Emulators



Decision Frameworks

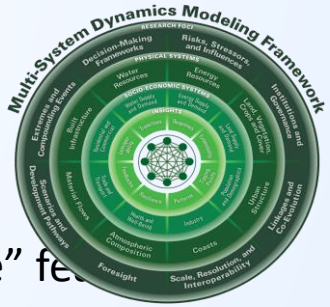


Risk Triage



Major Tasks:

- Human-Natural System Interactions
- Transportation Infrastructure
- Stress-Testing Paired Systems



Key Science Questions

1. How can different tools / methods / scales be combined to provide new, transferable insights?
2. What combinations of tools and capabilities are best aligned with different types of questions and “use case” fe
3. How can MSD methods improve understanding of risks and stressors and their implications for physical and socio-economic systems?
4. Are there differential responses of complex, interconnected physical and socioeconomic systems to slowly evolving stressors

Scenario Discovery and Linked Data Visualization Tools

Oral Presentation by Jennifer Morris in Model Uncertainty/Biases Breakout Session (Thursday)

Interactive Web-Based Platform to:

- Visualize results
- Elucidate how different outcomes and inputs are related
- Identify individual scenarios of interest for particular studies

  → Connect to STRESS platform

Steps:

- Create database of large ensembles of model scenarios
- Create flexible web-based platform that calls from database and allows users to visualize results and relationships among selected variables

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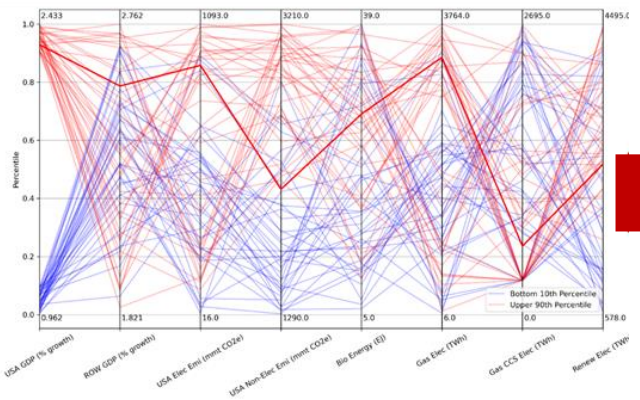
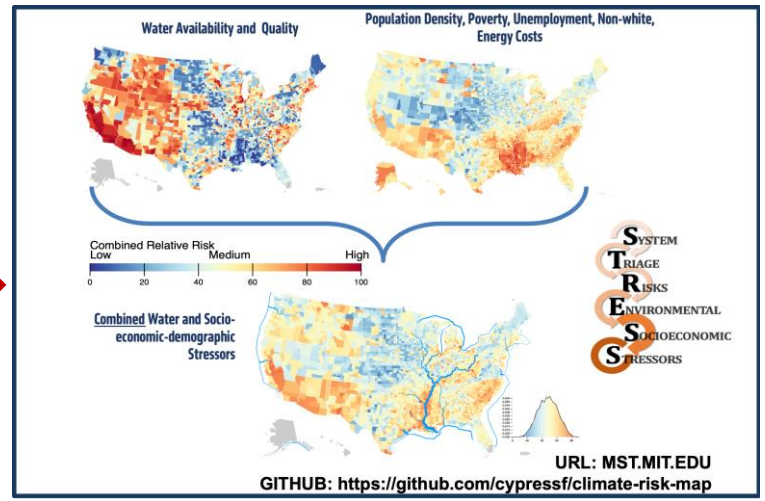




Future spatially explicit patterns of land transitions in the United States with multiple stressors

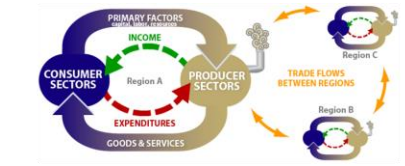
Oral Presentation by Angelo Gurgel in Energy-Water-Land Breakout Session (Wednesday)

Pacific Northwest NATIONAL LABORATORY

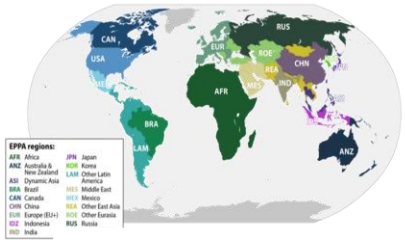
MIT JOINT PROGRAM ON THE SCIENCE AND POLICY OF GLOBAL CHANGE

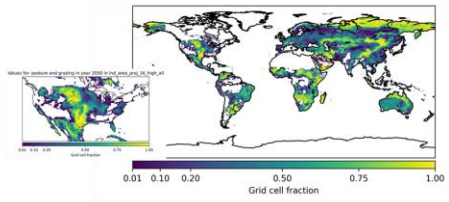
Motivation and Approach:

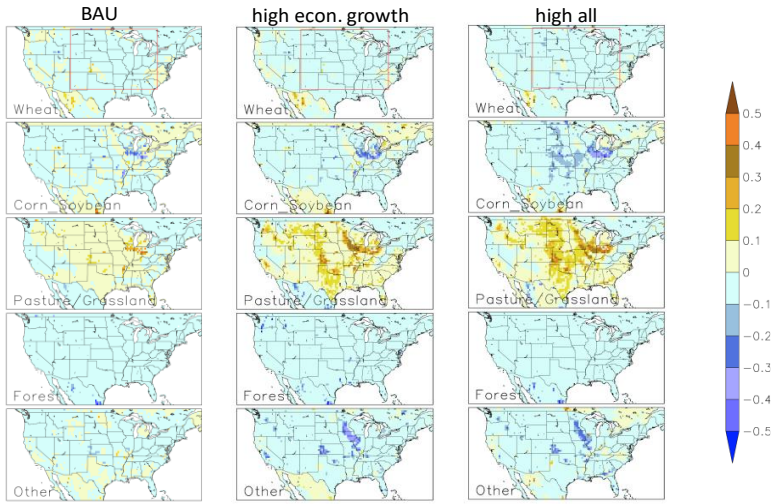
- Land use in U.S. directly affected by domestic and global forces;
- Link a multi-sectoral and multi-regional socio-economic model to an open-source downscaling model
- We apply the framework over the U.S. for a range of "high" and "low" global drivers affecting the world food system:
  - income growth
  - yield improvements
  - climate change
  - population growth
  - trade policy
  - changing diets



Land use projections







Key Takeaways:

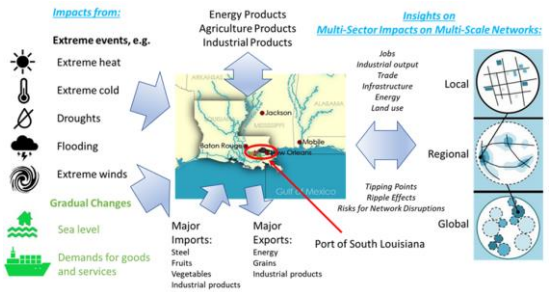
- Comparative advantage in livestock production leads to shifts from cropland to pastures in the U.S. under high pressures.
- Key differences at the sub- basin scale.
- Highlight the need to combine human and natural systems into "high resolution" details to assess environmental impacts (carbon storage, soil erosion, chemical use, hydrology, and water quality)

Research Featured in Poster Sessions

Designing Resilience for Multi-System Dynamics of Future Transportation (Wed Poster)

Sergey Paltsev, John Reilly, Angelo Gurgel, Jennifer Morris, Adam Schlosser (MIT) *in collaboration with* Sonia Yeh (Chalmers University of Technology), David Daniels (Swedish Road and Transport Research Institute), Pedro Linares (Universidad Pontifica Comillas)

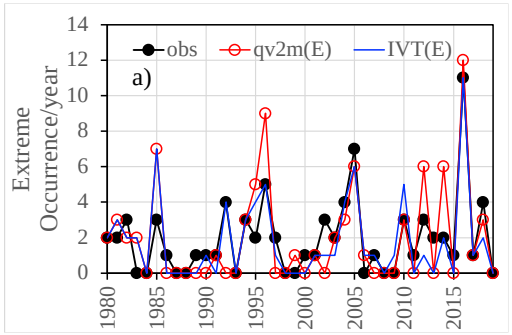
- Identify risks and opportunities introduced by the adoption of low-carbon technologies and the inter-connectedness of modern energy and transportation infrastructure



Prediction of Extreme Precipitation Occurrence with Convolutional Neural Networks (CNNs): Insights from Multiple Reanalysis Data (Wed Poster)

Xiang Gao and Shray Mathur (Brookhaven National Laboratory)

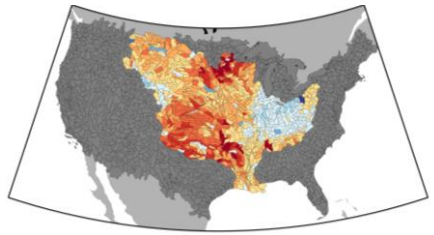
- We use CNN to identifying extreme-causing large-scale meteorological patterns (LSMPs) for prediction of the regional extreme precipitation Occurrence (EPO). California winter season is used as a study case to demonstrate a proof of concept for our framework.



Disentangling the Changing Nature of Water Quality, Availability, and Equity in United States (Wed Poster)

C. Adam Schlosser, Chas Fant (IEc), Xiang Gao, Angelo Gurgel, Jennifer Morris, and Sergey Paltsev

- Combine our STRESS platform with a suite of simulations with a linked model system that includes a water management module and a parsimonious water-quality model. The models resolves the contiguous United States at over 2,100 basins.



Tipping Points – Workshop Series

Motivated by growing concerns of unchecked risks of dramatic and abrupt global impacts to natural systems from climate change.

The concept of tipping points goes beyond Earth systems and has also been applied to disruptive changes across multiple disciplines including economics, natural ecosystems, epidemiology and managed resources.

Commonly associated with “failures,” “breakpoints,” “thresholds,” “unintended consequences” and “cascading and compounding risks” across multiple systems.

Yet other tipping point examples also highlight how “little changes” and seemingly “small actions” can make “big differences” and improvements in our lives.

Despite many compelling cases, key scientific challenges remain in the metrics, models and supporting analyses needed to reliably represent, simulate and predict the complex, multi-system relationships and abrupt behaviors that define a tipping point.

Inaugural Workshop (Early September)

Co-hosted with colleagues at the Joint Global Change Research Institute (JGCRI) of the Pacific Northwest National Laboratory (PNNL), and feature a literature-based assessment by Chris Vernon to explore:

- How and the extent to which science has evolved under the nomenclature of “tipping points,”
- What are the most promising and perhaps unrealized synergies and collaborations,
- How can we align these with key research priorities.

This (virtual) workshop series aims to provide an interactive and

Thank you from our Research Team!

Ron Prinn
Earth Systems
Atmospheric Chemistry

Adam Schlosser
Extremes, Hydroclimate, Land Biogeophysics

Jen Morris
Uncertainty, Energy, Economic Modeling

Sergey Paltsev
Energy Economics, Transportation

Anne Slinn
Executive Director of Research

Mark Dwortzan
Communications Officer

Angelo Gurgel
Land, Agriculture, Energy-Economics

Xiang Gao
Land-Climate, Extremes, Water

Seb Eastham
Atmospheric Chemistry, Air Quality, Health

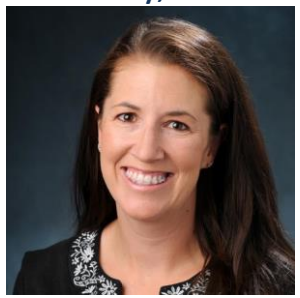
John Reilly
Economics, Model Coupling

Cypress Frankenfeld
Software Development

Mei Yuan
Regional Economic Modeling

Henry Chen
CGE Modeling

Andrei Sokolov
Climate, Ocean-Atmosphere



Alyssa McCluskey
GIS, Spatial Analysis

Dominic White
Human-Systems Modeling

Student Researchers

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