

Integrated Assessment Research: Past and Future

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October 20, 2014

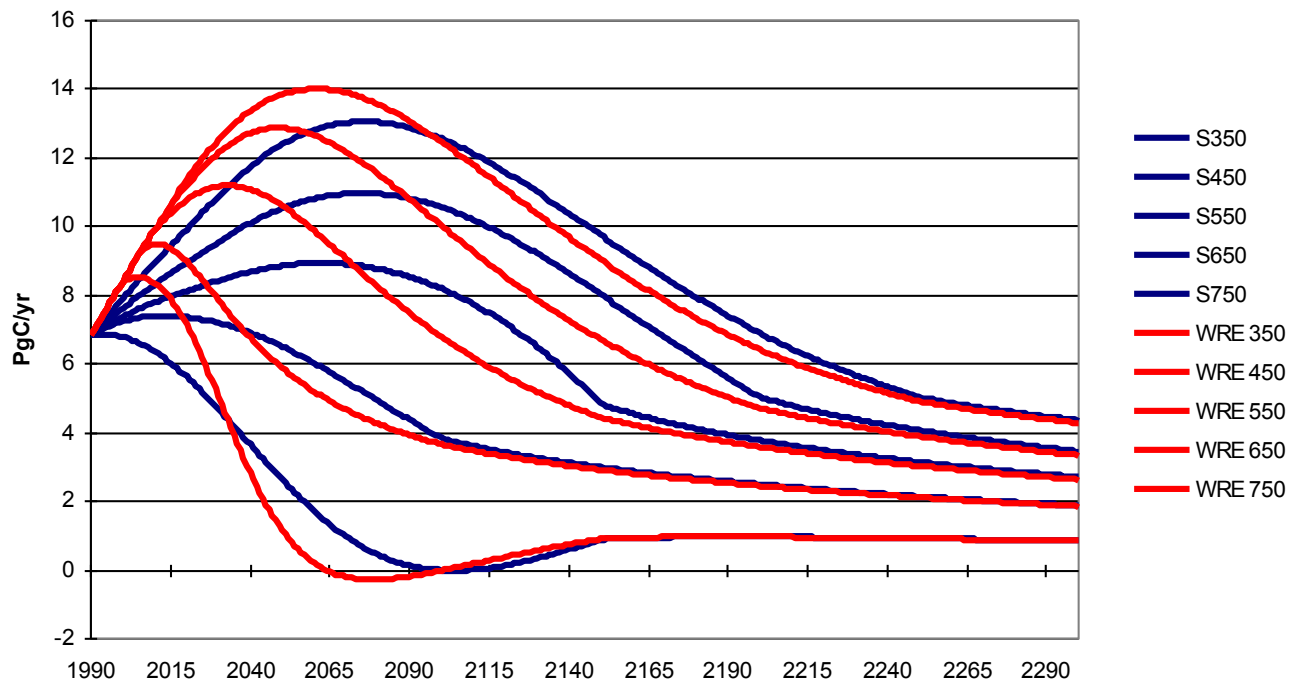
Trends in IA Research and Development

Integrated Assessment Research and Model Development is Problem Driven

energy-economy-climate

1980's

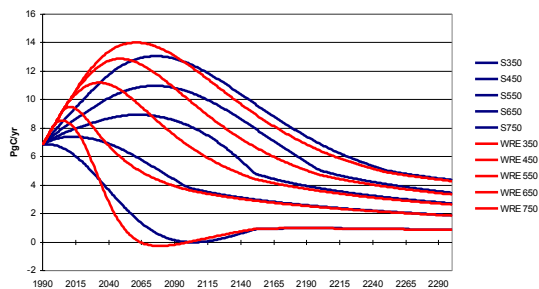
Projections of emissions and concentrations



Integrated Assessment Research and Model Development is Problem Driven

1980's

Projections of emissions and concentrations

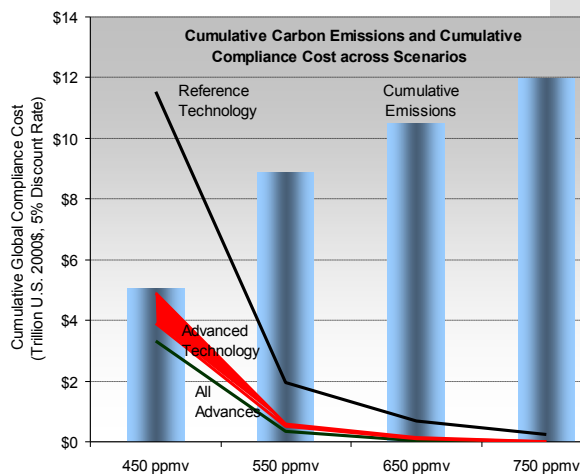


ENERGY-ECONOMY-climate

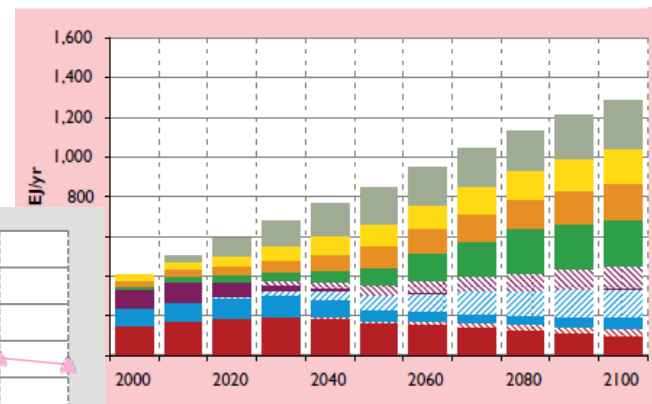
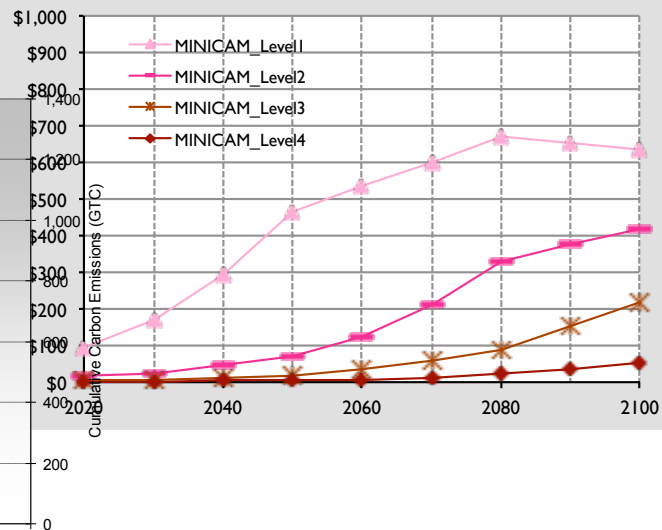
1990's through 2000's

Energy, Technology, and Mitigation

Value of Technology



Carbon Prices

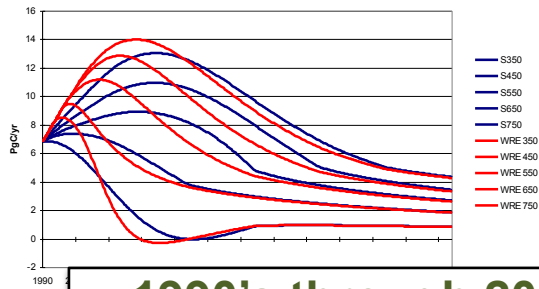


Energy Systems

Integrated Assessment Research and Model Development is Problem Driven

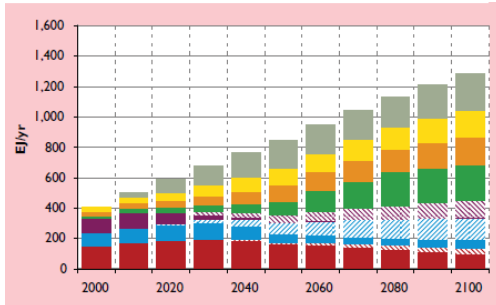
1980's

Projections of emissions and concentrations



1990's through 2000's

Energy, Technology, and Mitigation

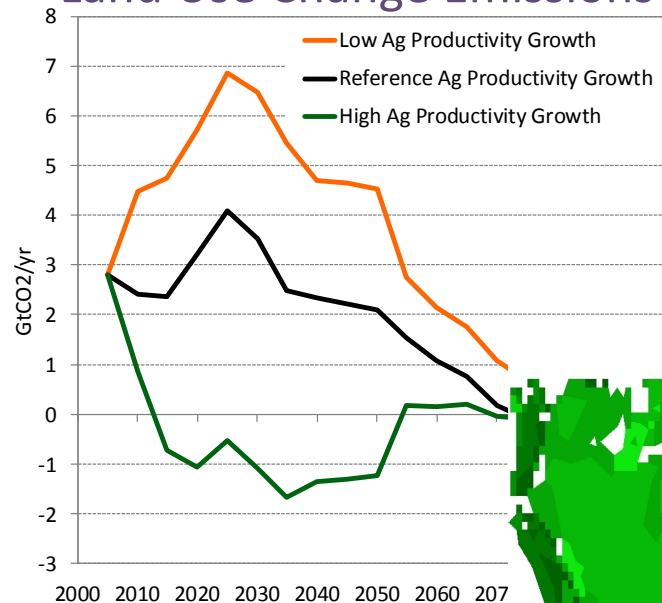


ENERGY-ECONOMY-land-climate

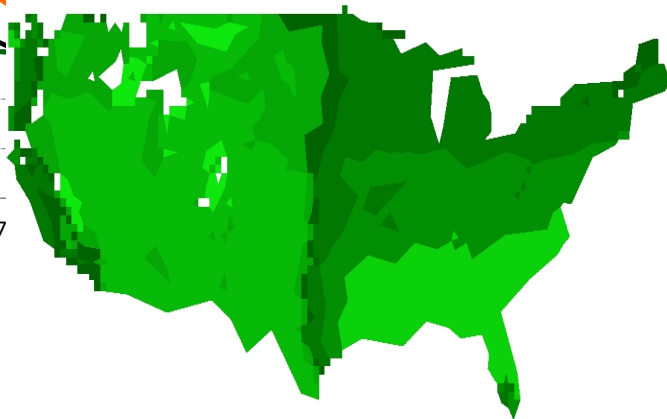
2000's

Mitigation and land use

Land Use Change Emissions



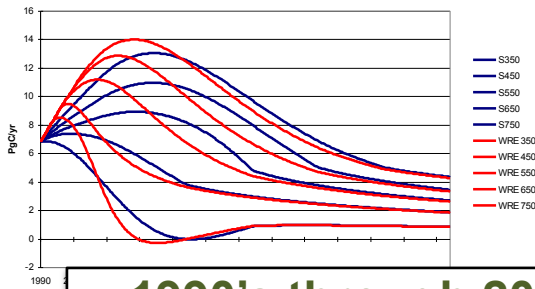
Crop production and land use changes



Integrated Assessment Research and Model Development is Problem Driven

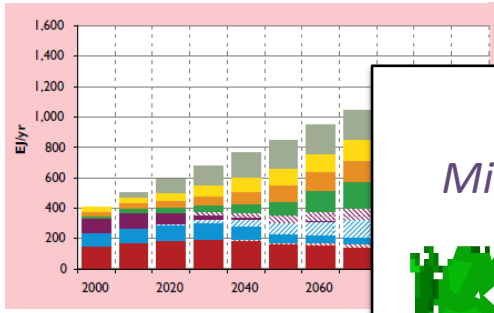
1980's

Projections of emissions and concentrations



1990's through 2000's

Energy, Technology, and Mitigation



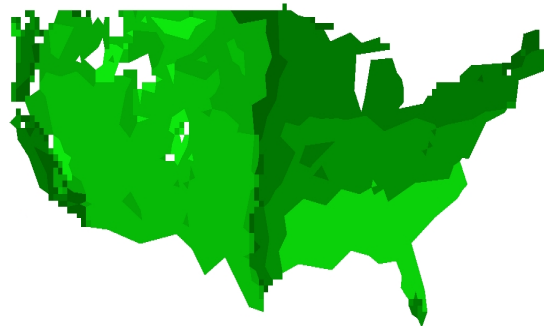
ENERGY-ECONOMY-LAND-WATER-CLIMATE

TODAY

*Integrating Impacts,
adaptation, and
vulnerability*

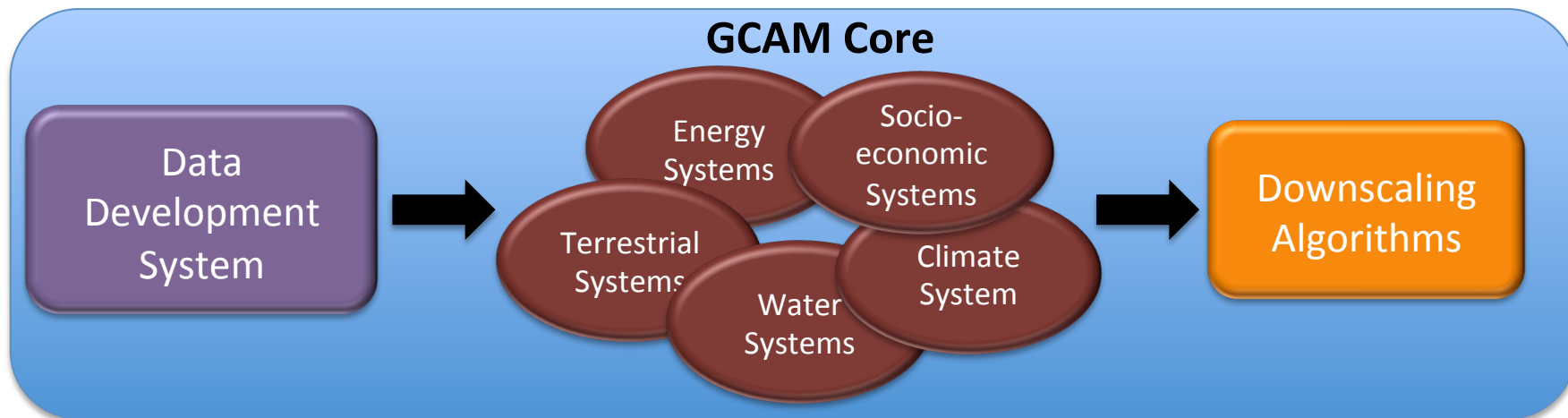
2000's

Mitigation and land use



The Current Research Frontiers in Integrated Assessment Research and Development

Integrated assessment models are increasingly comprehensive and complex

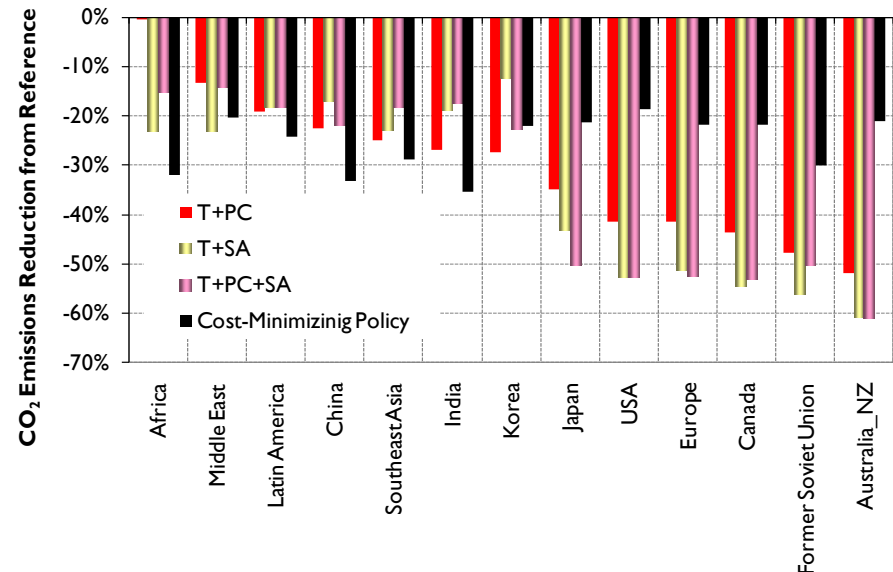


- ▶ Data processing and analysis along with downscaling algorithms and processes are key elements of comprehensive IA frameworks
- ▶ Full-scale IA modeling requires large, interdisciplinary teams. Only six groups globally attempt to undertake the level of IA research at JGCRI.
- ▶ A key challenge facing large-scale IA groups is how to manage the expanded scope of data needs, of output results, and of the complexity of the modeling itself..... particularly for a community model.

Mitigation research is increasingly focused on the start-up to mitigation

- ▶ Greater confidence in near-term projections.
- ▶ A better understanding of regional opportunities and approaches.
- ▶ Social, institutional, and other barriers to technology deployment.
- ▶ Realistic policy implementations (not just a global or national carbon price).
- ▶ The implications of climate change on energy supply and demand.

Fossil and Industrial CO₂ Emissions Relative to Reference Under Different Regional Policy Commitments and Sectoral Agreements (2035)

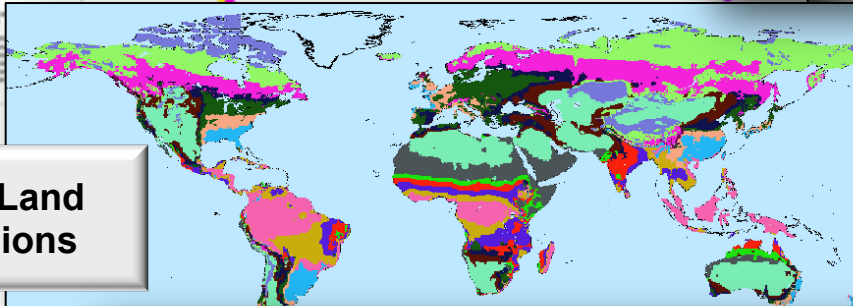


Adaptive spatial and temporal resolution is critical for understanding climate impacts and for regional analysis

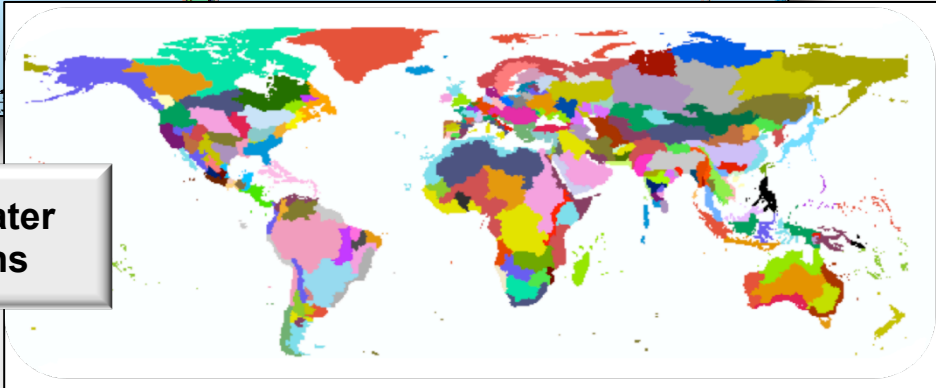
**32 Energy
Economy
Regions**



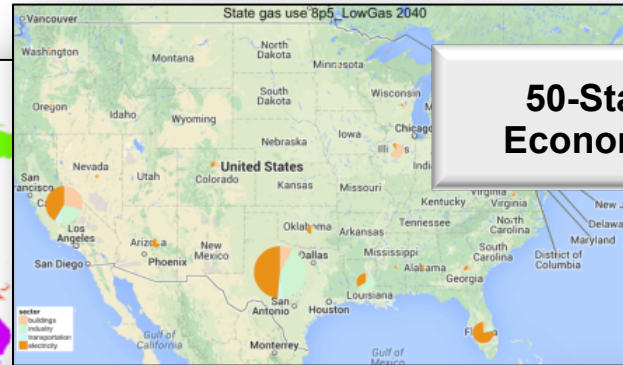
**283 Land
Regions**



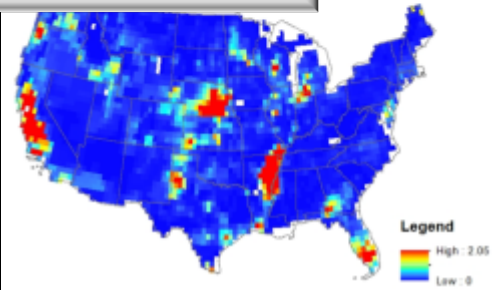
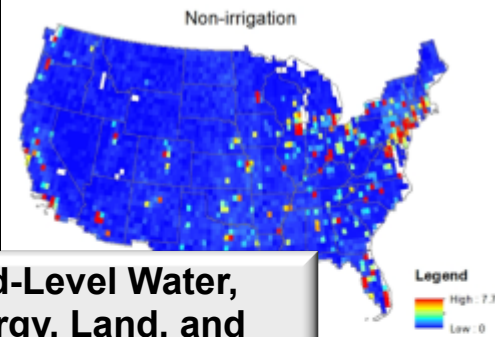
**233 Water
Basins**



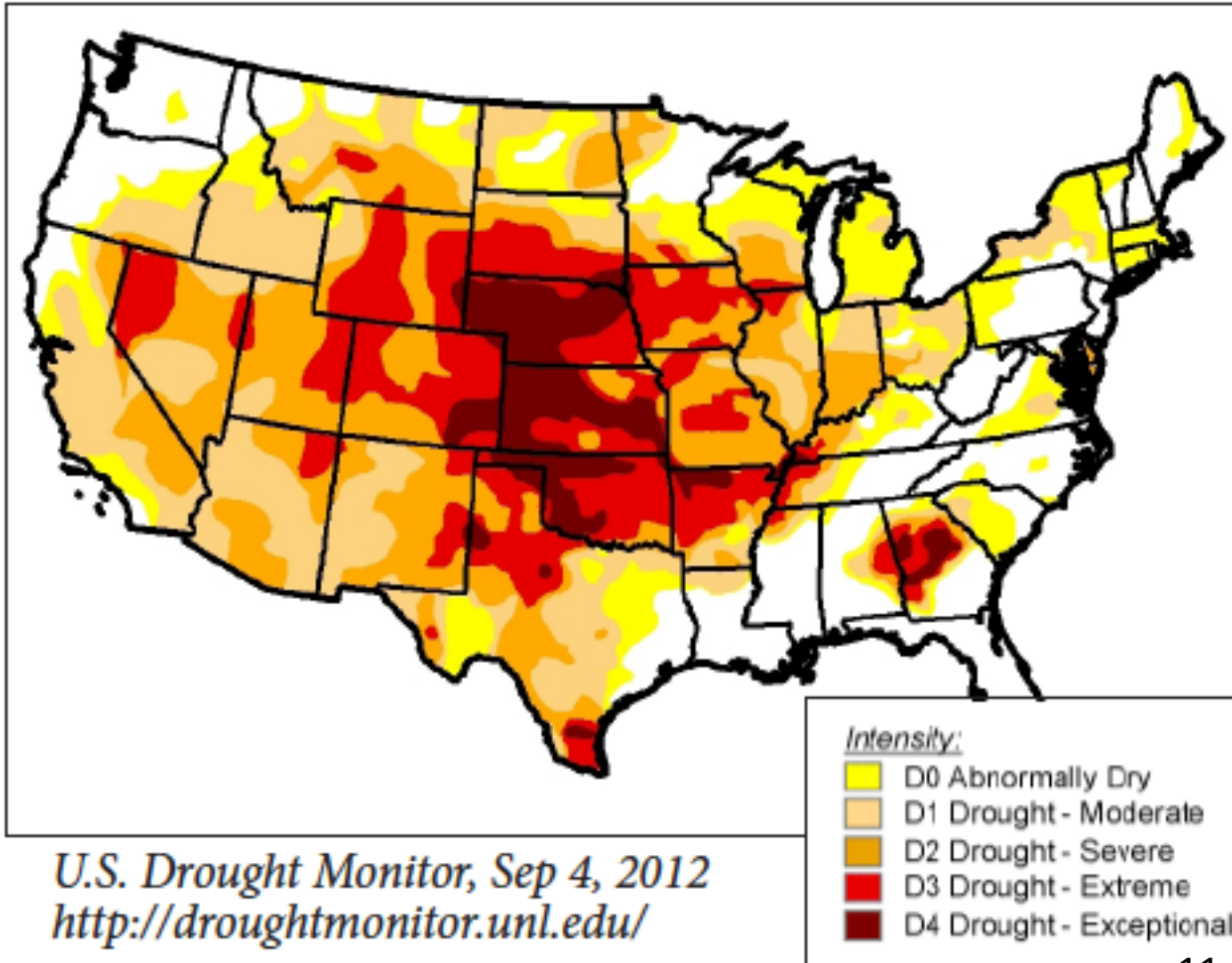
**50-State Energy
Economy Regions**



**Grid-Level Water,
Energy, Land, and
Emissions**



Improved temporal resolution is just as important

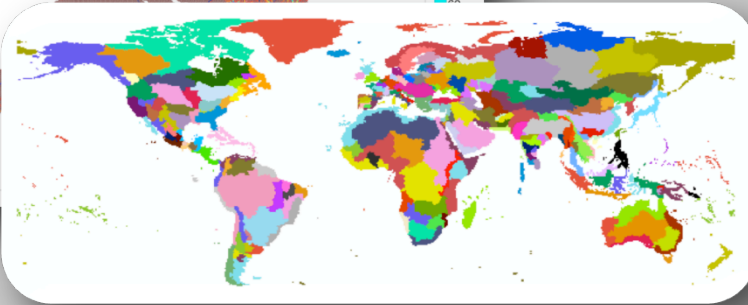


IA models will need to address shorter-term variability and extreme events to effectively capture climate impacts.

Integrated water models to understand climate impacts and the role of energy and land in mitigation

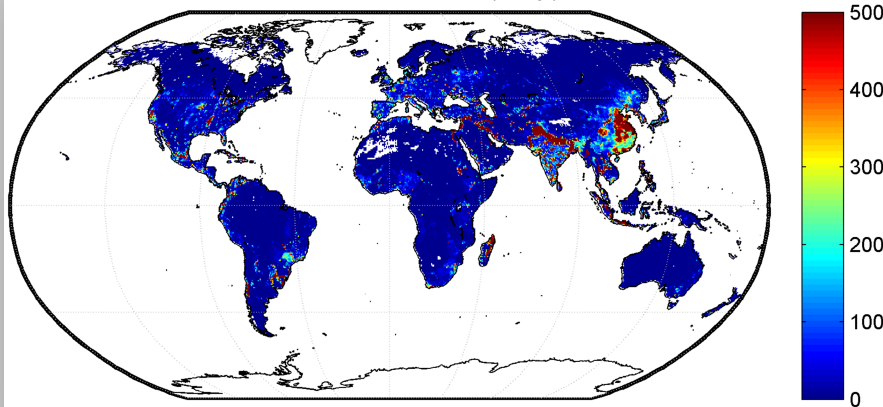
Water Supplies

Ensemble Mean Annual Streamflow in 2095 (km^3/yr)



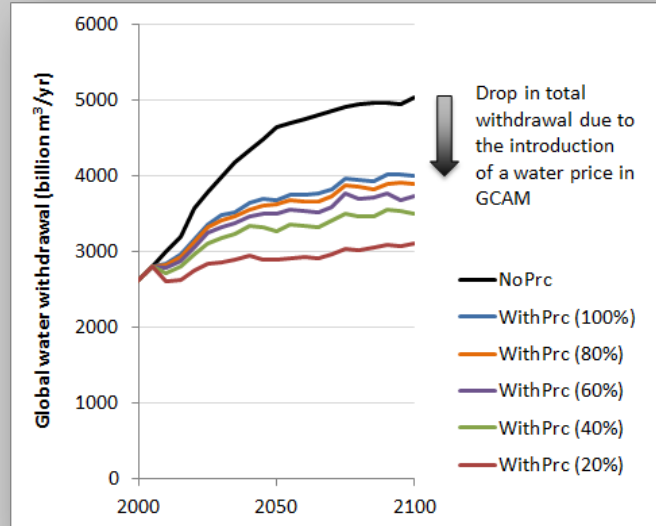
Water Demands

Total Water Demand in 2050 (mm/yr)



Water Use

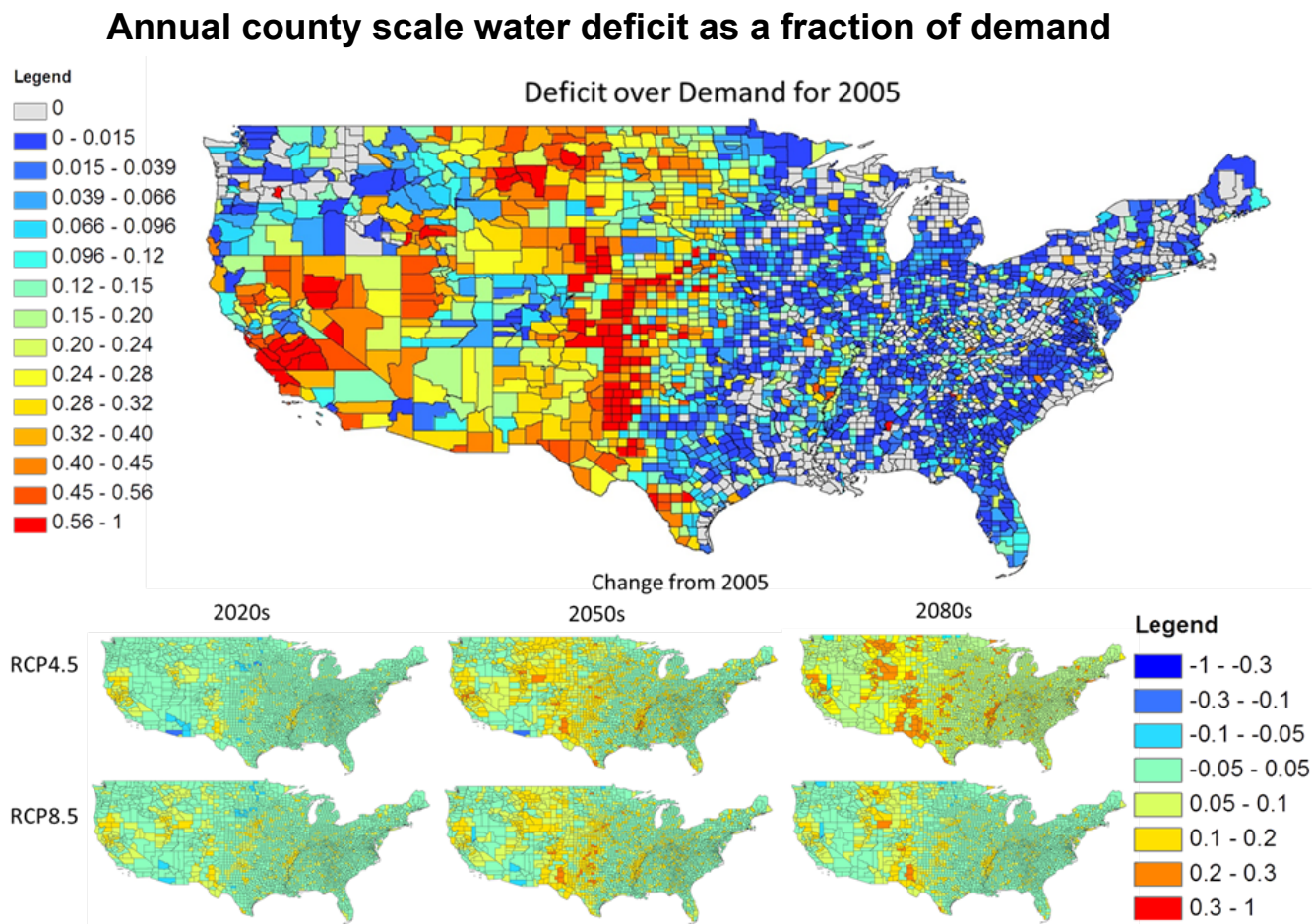
Global Annual Water Withdrawals



Preliminary Results: Reconciling water demands and supplies alters water withdrawals and alters the distribution of food production.

IA models must be interoperable to bridge spatial, temporal, and process scales

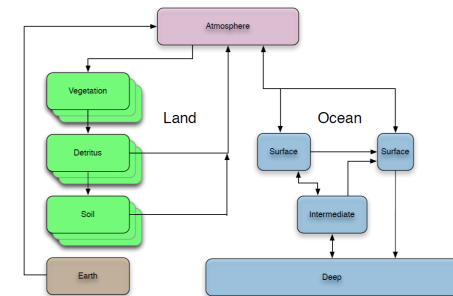
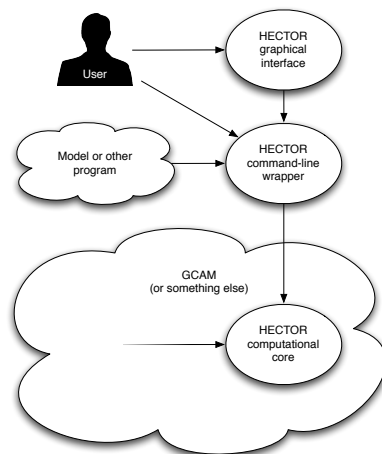
- ▶ Using an integrated modeling framework that includes GCAM-USA, a regional Earth system model, and a coupled hydrology-water management model, surface water deficit is projected to increase in both duration and magnitude in the future, with larger increase in RCP4.5 compared to RCP8.5



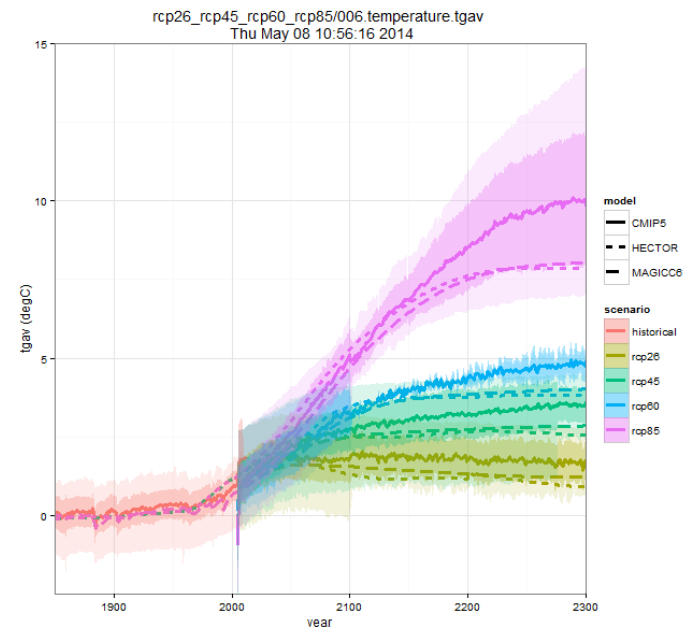
IA models needs more facile and sophisticated climate emulators for “fast” analysis of climate and climate impacts

- *Fast-executing* newly developed global climate and carbon cycle model
- *Open source* and community oriented
- Capable of replicating some outputs of more complex models
- Being expanded to facilitate research on energy-water-land interactions and integrated impacts within GCAM

Modular, open-source C++ codebase. Central coupler enforces message passing and unit checking.

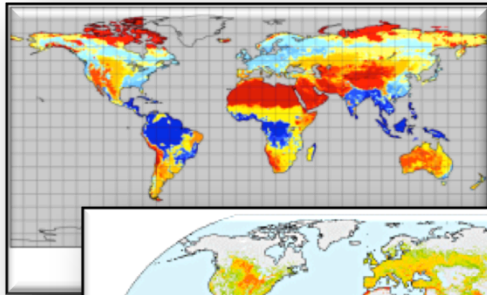


Fast, flexible emulation CMIP5 global to biome-scale outputs

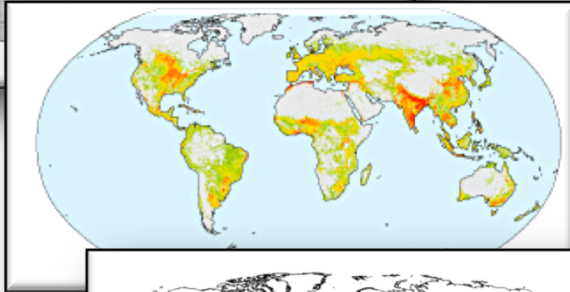


An emphasis on data processing and data products is now core to IA, not just an input.

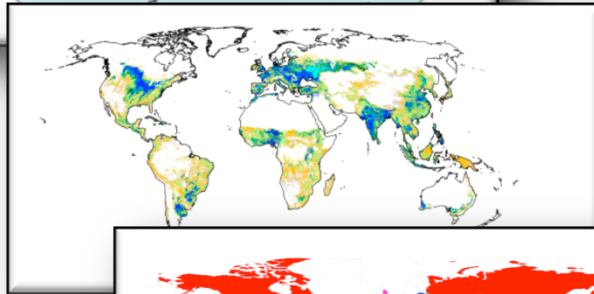
Potential
Vegetation



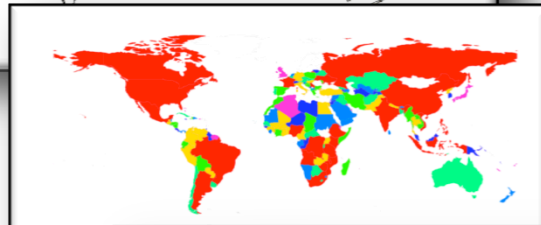
+ Cropland area



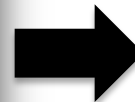
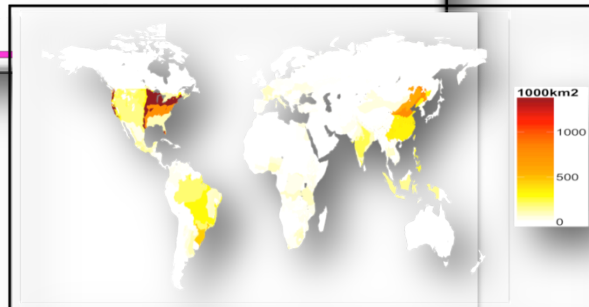
+ Rainfed area



+ Crop-specific
harvested areas

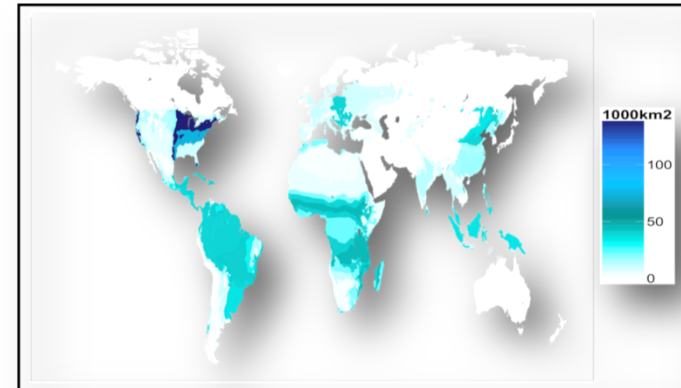


+ Sub-national
Harvested areas



- ▶ **GCAM needs land cover by type (e.g., forest, grass, maize, wheat, etc.) and management practice (e.g., irrigated/rainfed) for each region/AEZ combination in each historical year.**

Rainfed Maize Area in 2010



- ▶ **We have similar methodologies in other sectors:**
 - Population: IIASA, US Census
 - Energy: IEA, EIA, country studies
 - Agriculture: FAO, GTAP, MIRCA
 - Emissions: EDGAR, EPA, RCP

Discussion