The Evolving Integrated Assessment Modeling Community Research Agenda

LEON CLARKE

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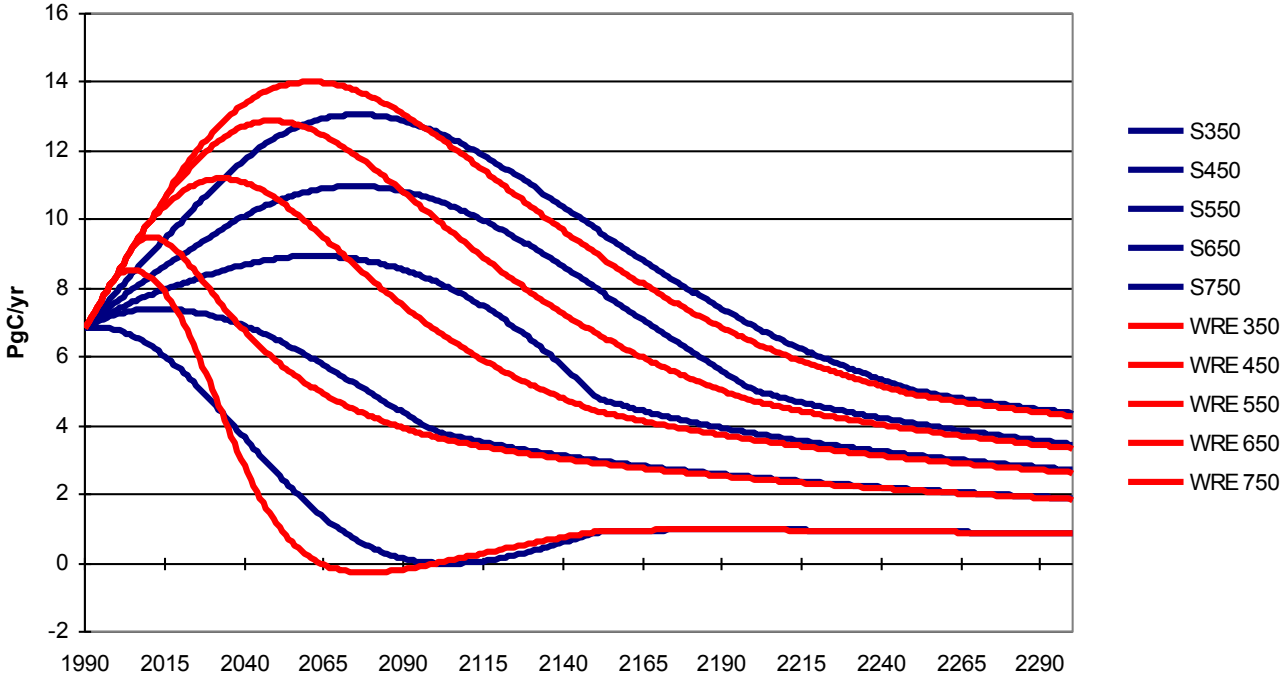
Trends in IA Research and Development

Integrated Assessment Research and Model Development is Problem Driven

energy-economy-climate

1980's

Projections of emissions and concentrations



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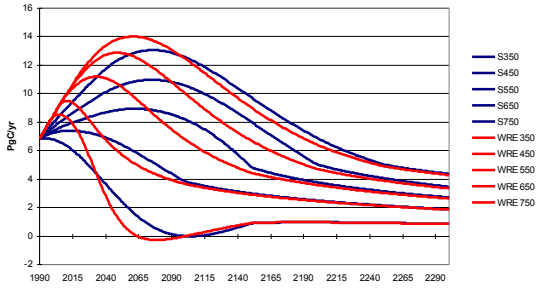
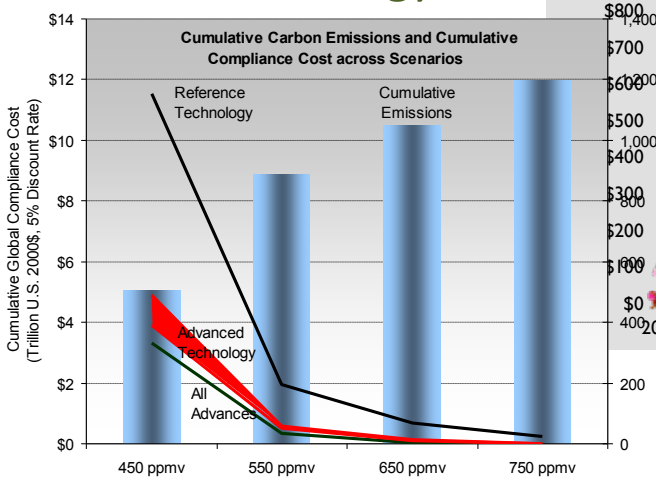


ENERGY-ECONOMY-climate

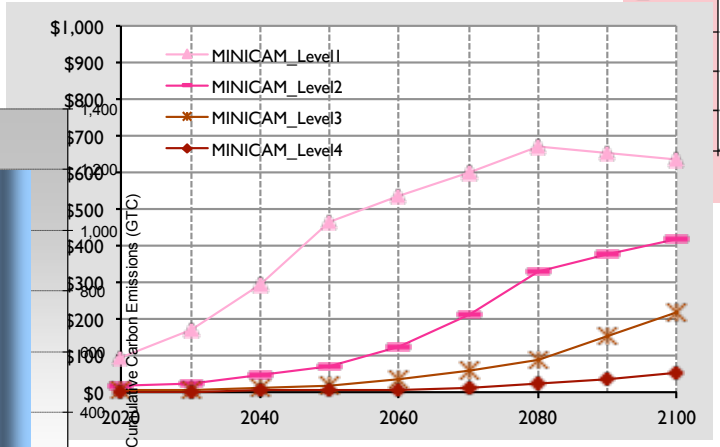
1990's through 2000's

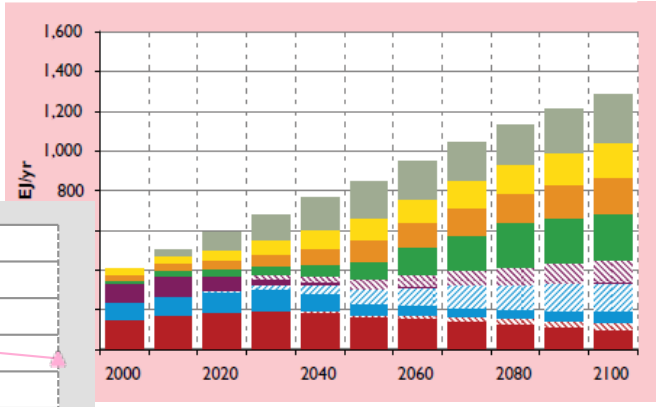
Energy, Technology, and Mitigation

Value of Technology



Carbon Prices





Energy Systems

Integrated Assessment Research and Model Development is Problem Driven

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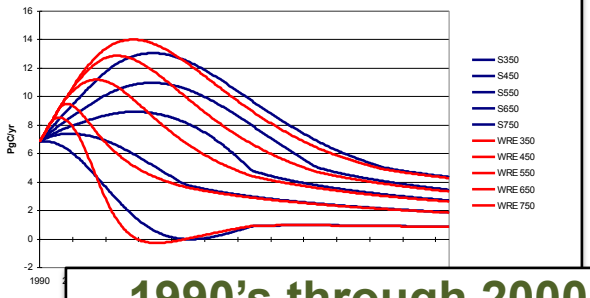

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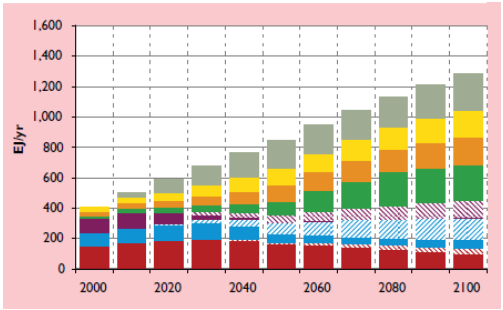
Energy, Technology, and Mitigation

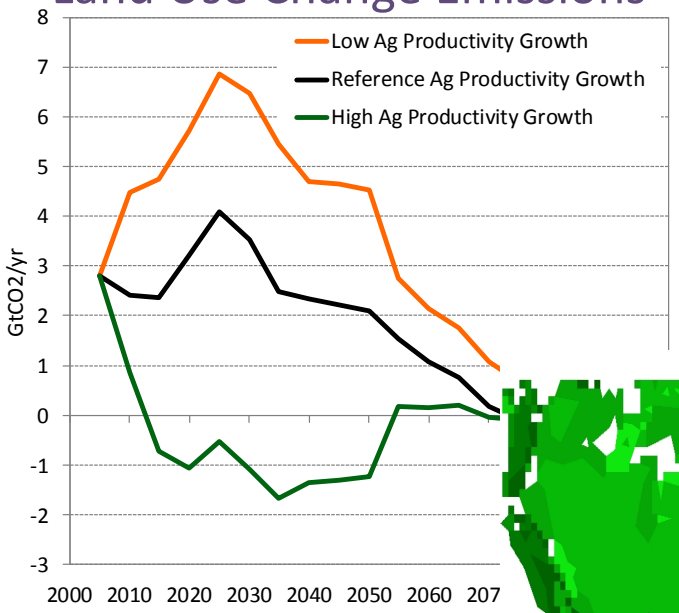


ENERGY-ECONOMY-land-climate

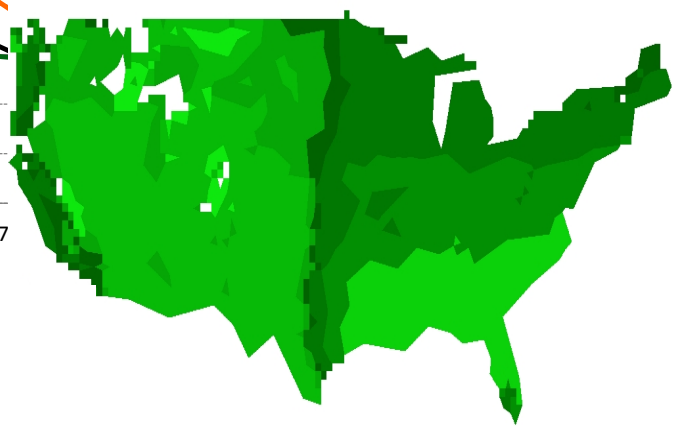
2000's

Mitigation and land use

Land Use Change Emissions



Crop production and land use changes



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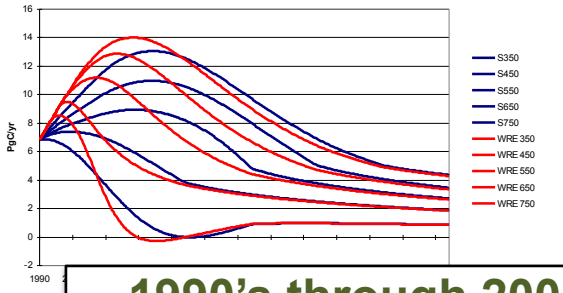
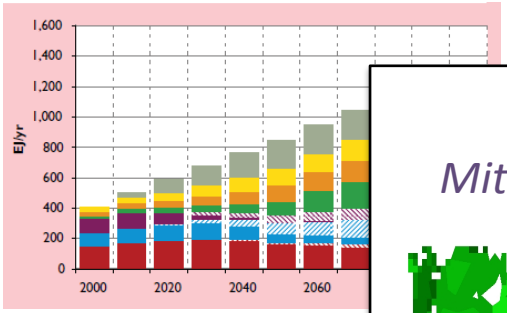


1990's through 2000's

Energy, Technology, and Mitigation



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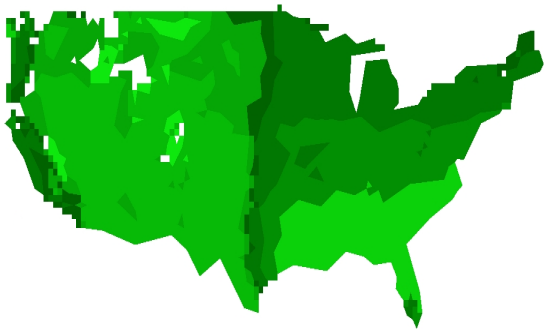
Mitigation and land use



TODAY

????

What are some current user questions we're being asked?

- Type 1: Where are the NDCs taking us? How to implement and ramp up action? What's actually realistic for different countries?
- Type 2: How will these mitigation activities link to the other societal goals (e.g., SDGs)? Will they be limited by energy-water-land constraints?
- Type 3: How can we plan investments and strategy taking into account climate impacts and a broad range of additional stressors and dynamics?
- Type 4: Where are the biggest future climate-related national security risks, domestically and internationally?
- Can you help us interpret and understand this stuff? What's the confidence in any of this?

Incorporating climate impacts, adaptation, and vulnerability

Increased "realism", particularly with regards to regional dynamics

Part 1: The Challenge

- The value of IA models is that they try to look at everything at once in a single platform that can look at a broad range of futures as a matter of course rather than as one offs.

- This requires tradeoffs in resolution and linkages.

- Both of the key driving themes are pushing against these limitations

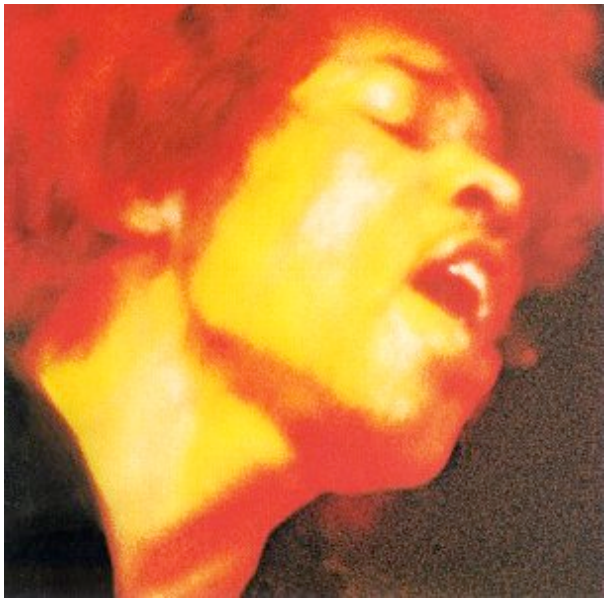
Part 2: Needs

- Higher-resolution is needed
  - *How is the electricity system operated minute to minute? How do we manage reservoirs in a water basin? What are regulations or rules or methods for allocating water among users? What are the existing policies with respect to energy or agricultural subsidies? How easy would it be to alter these? Are the vested interests associated with particular technologies or policies? How many people are living in poverty? How many are in flood-prone regions?*

- More linkages are needed
  - *Link from climate to the human systems represented in IA models.*
  - *New linkages among sectors*

Part 3: Methods

- So IA models can participate in these areas of inquiry in a couple of ways
- Way #1: Increasing their resolution and the linkages and systems they represent, still within a single platform
- Way #2: Or linking one way or another with other modeling tools of greater resolution



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Current Research Frontiers in Integrated Assessment Research and Development

Incorporating water is a major emphasis for IA modeling

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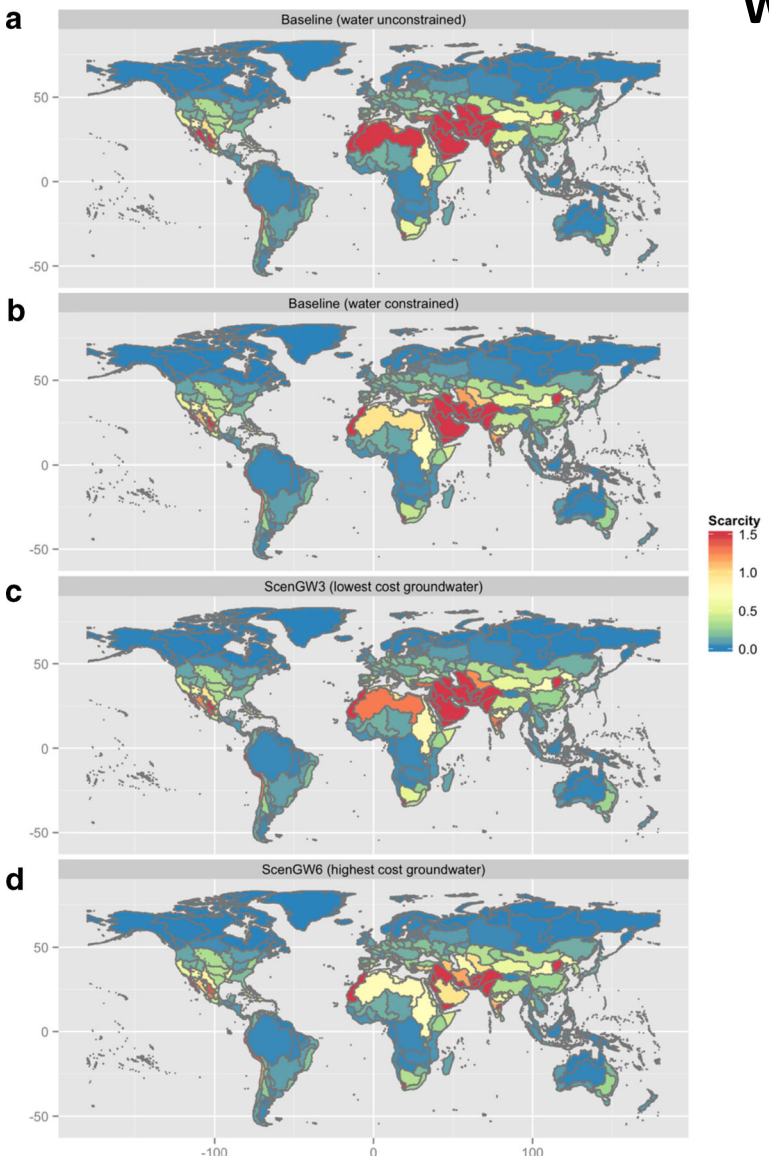

Water scarcity in year 2100 at the basin scale

Unconstrained Water

Constrained Water

Constrained Water with lowest-cost non-renewable groundwater

Constrained Water with highest-cost non-renewable groundwater

Kim, S.H., Hejazi, M., Liu, L., Calvin, K., Clarke, L., Edmonds, J., Kyle, P., Patel, P., Wise, M. and Davies, E., 2016. Balancing global water availability and use at basin scale in an integrated assessment model. *Climatic Change*, *136*(2), pp.217-231.

Increasing spatial and temporal resolution

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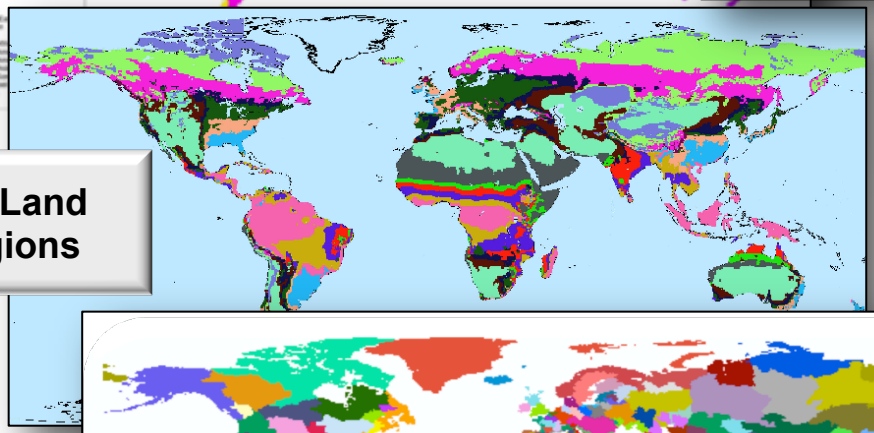
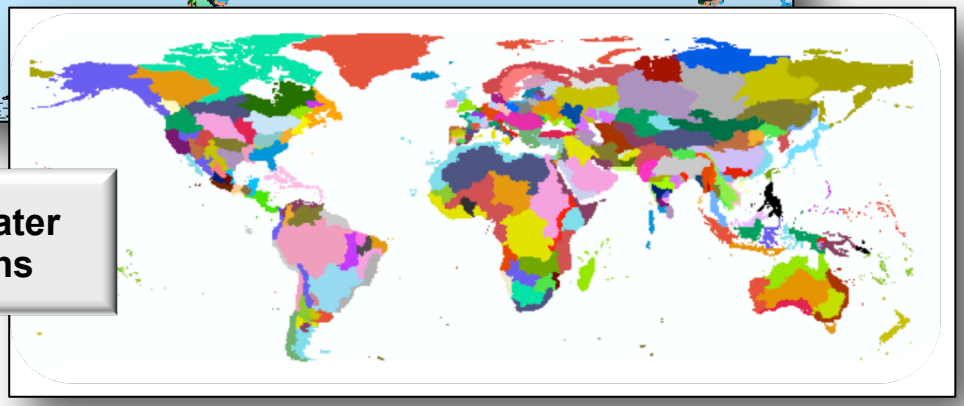
32 Energy Economy Regions

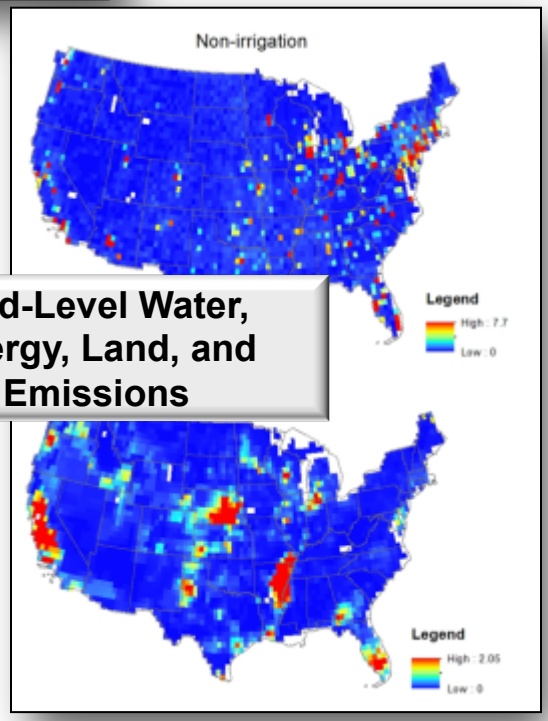
50-State Energy Economy Regions



283 Land Regions

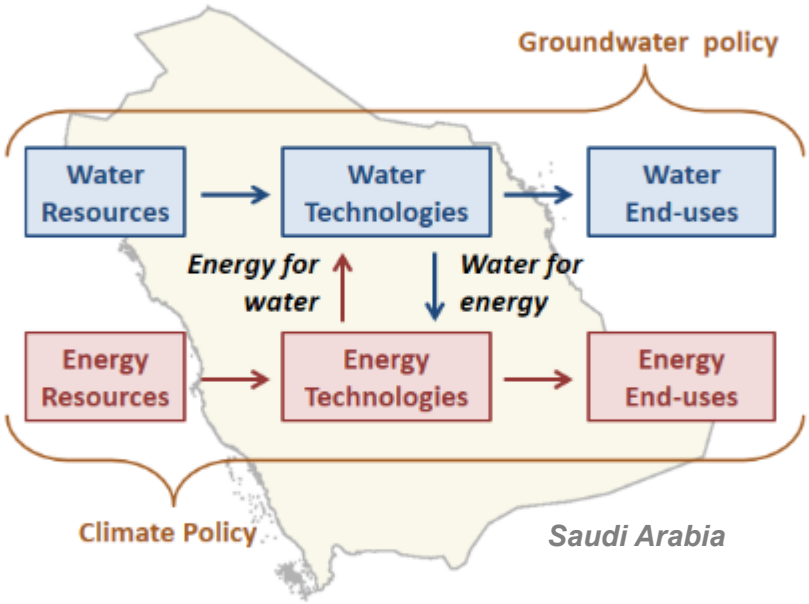


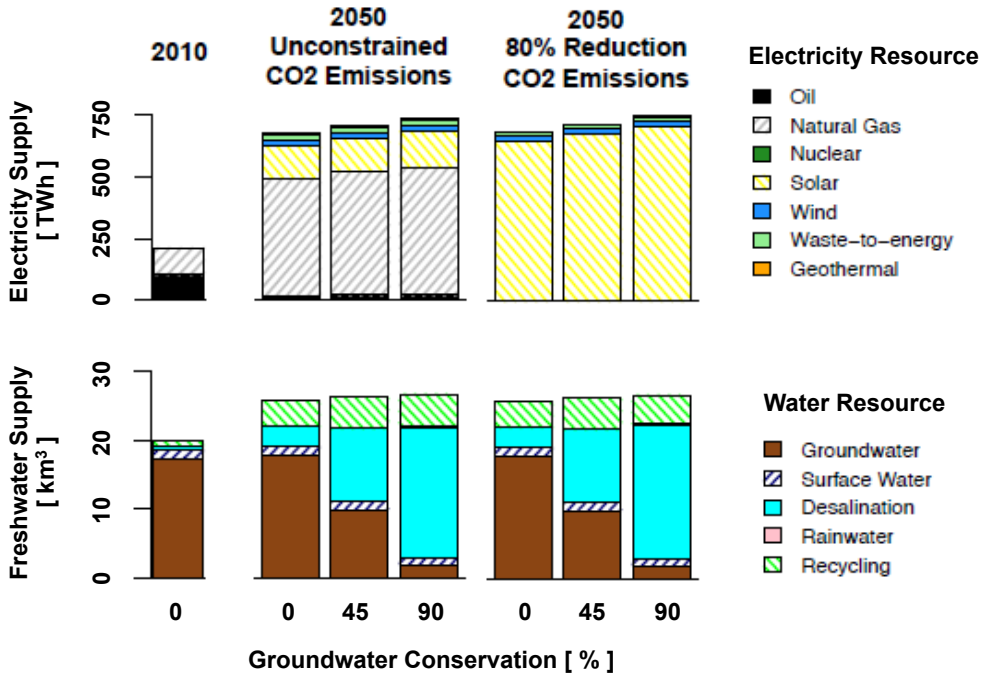
233 Water Basins



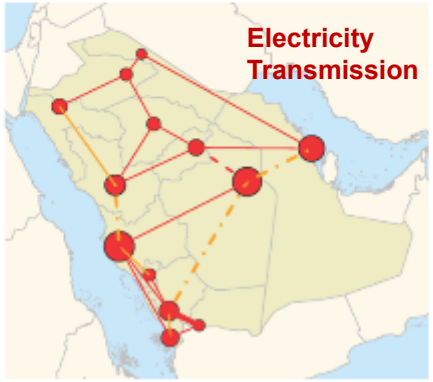
Grid-Level Water, Energy, Land, and Emissions

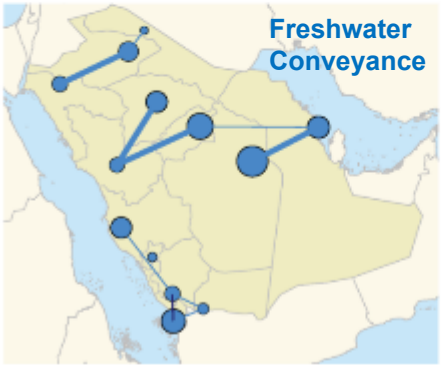
Water constrained low-carbon energy pathways





- Integrated long-term development scenarios



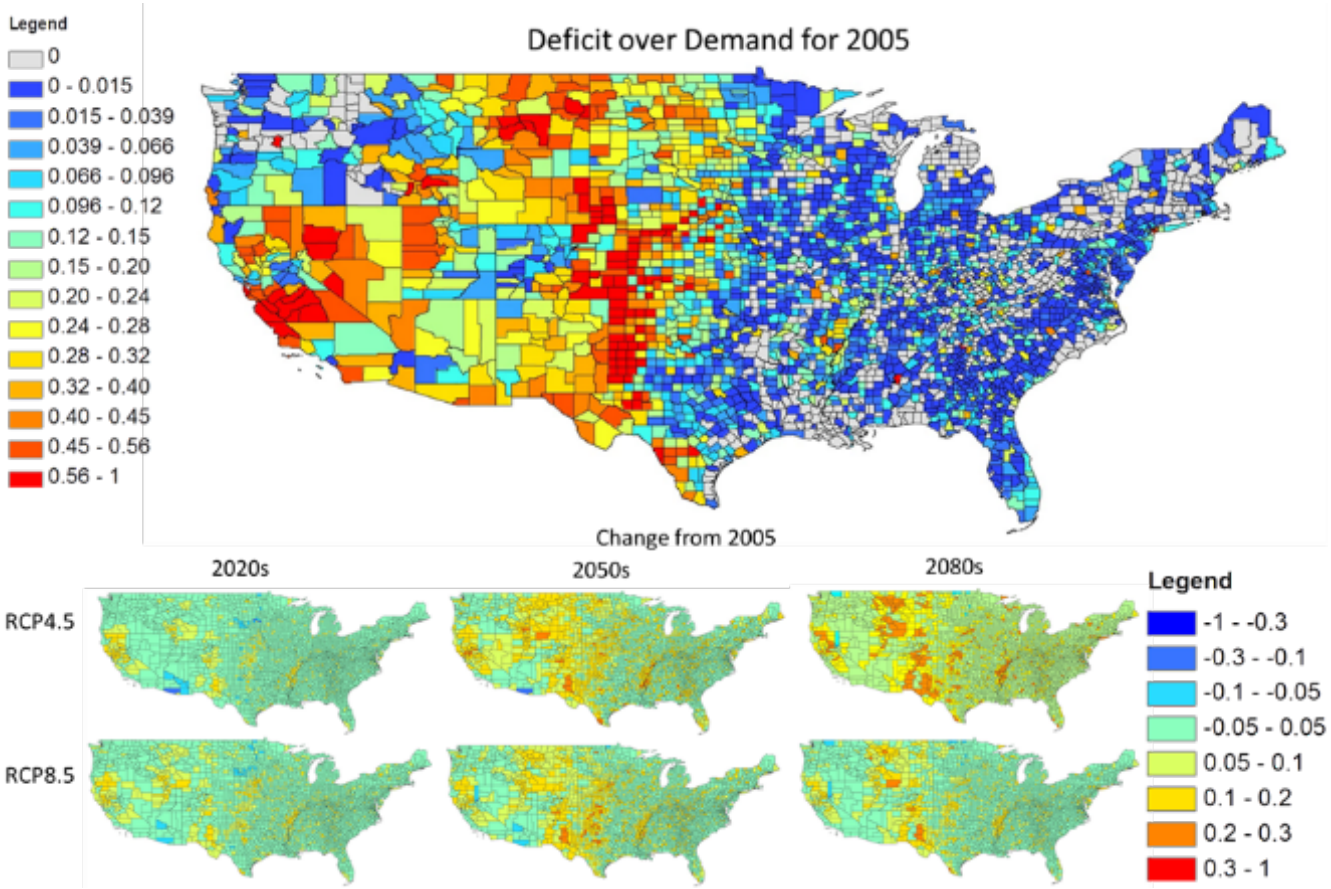


S.C. Parkinson et al. (2016), *Environmental Science & Technology*

IA modeling teams are increasingly conducting multi-model analysis

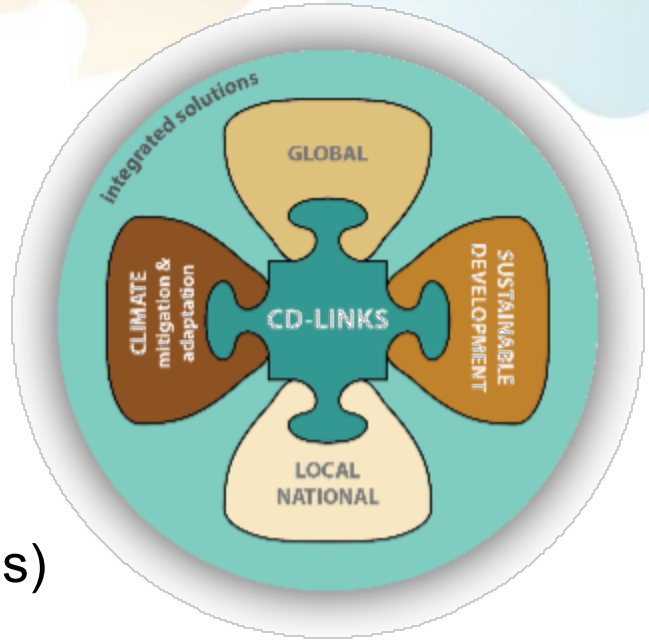
- Using an integrated modeling framework that includes GCAM-USA, a regional Earth system model, and a coupled hydrology-water management model, surface water deficit is projected to increase in both duration and magnitude in the future, with larger increase in RCP4.5 compared to RCP8.5

Annual county scale water deficit as a fraction of demand



CD-LINKS

- 18 International Partners
- Identify solutions for Climate Change AND Sustainable Development
- Develop globally consistent, national low-carbon development pathways
- Broaden evidence base (policy case-studies)
- Establish capacity building platform



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

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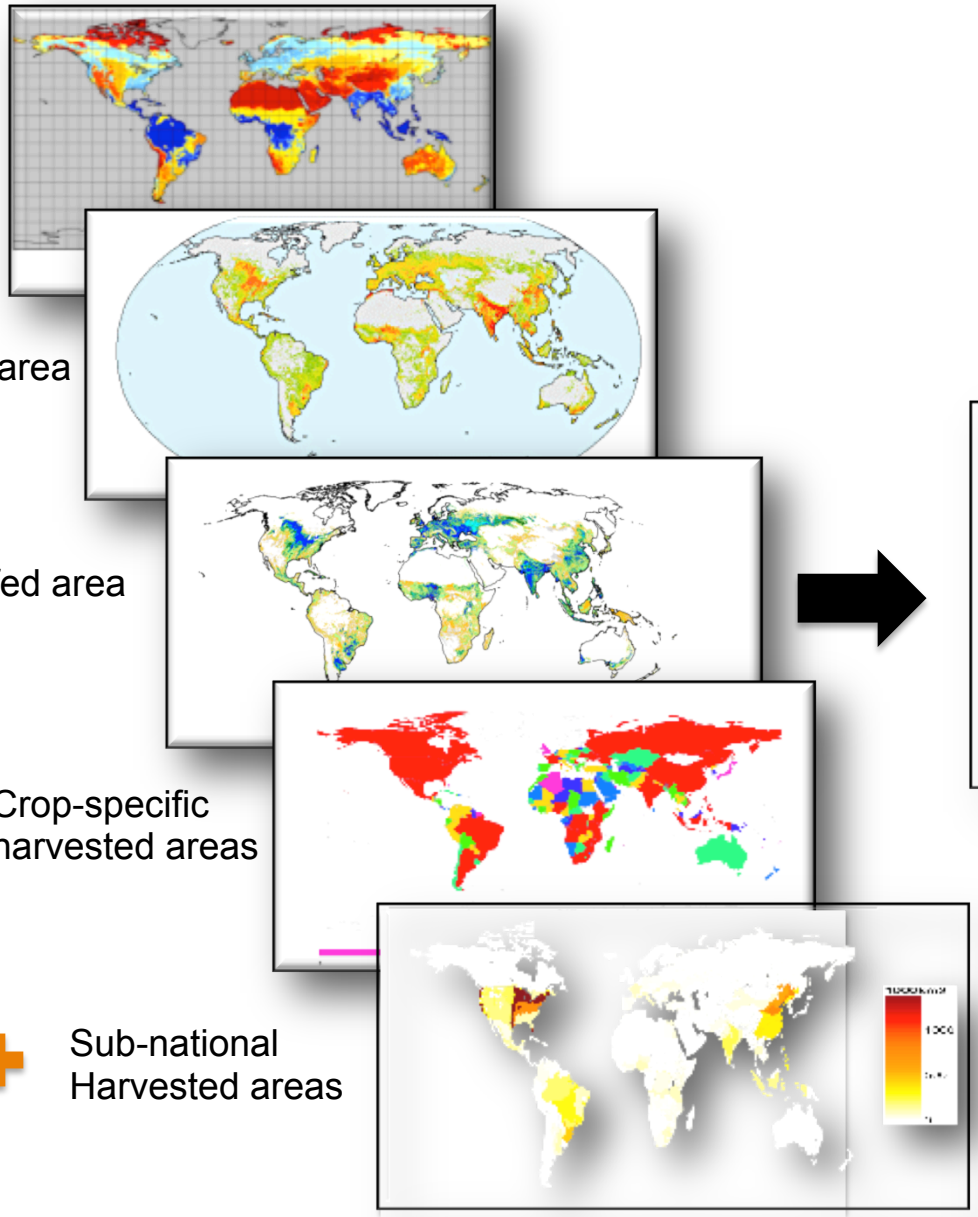
Potential Vegetation



+ Cropland area

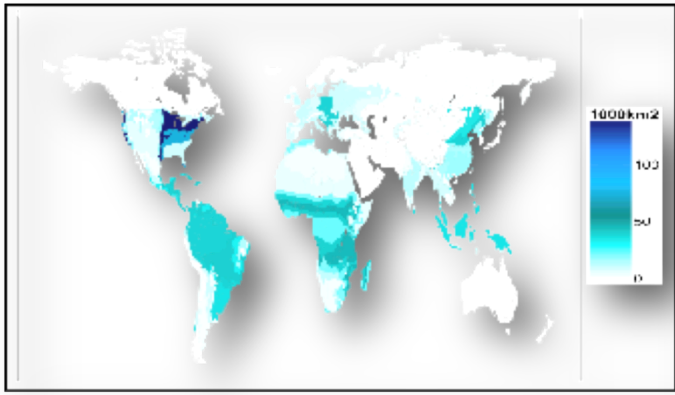
+ Rainfed area

+ 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**

IA research and modeling frameworks are increasingly comprehensive and complex

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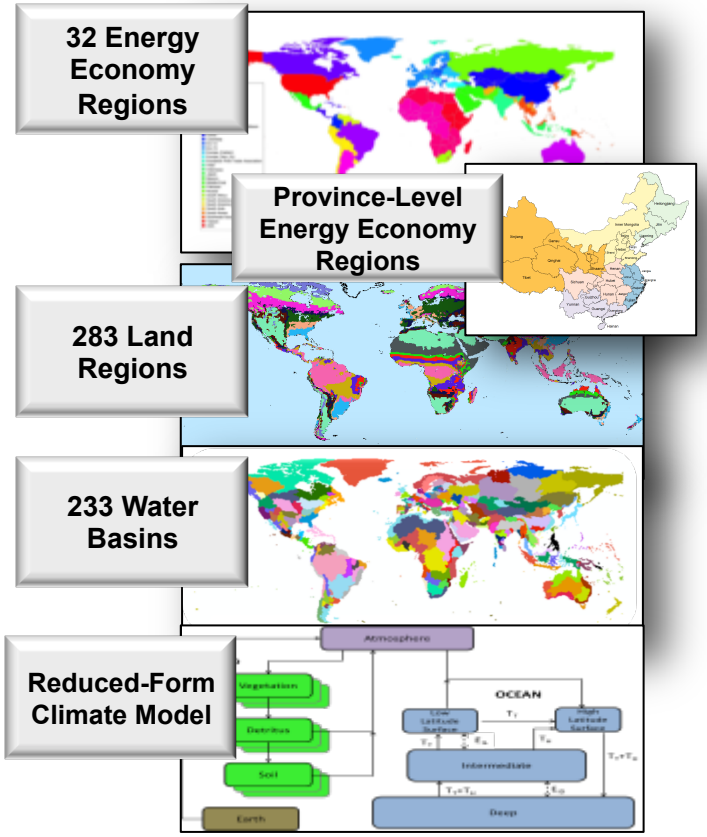
Automation System

Data Development System

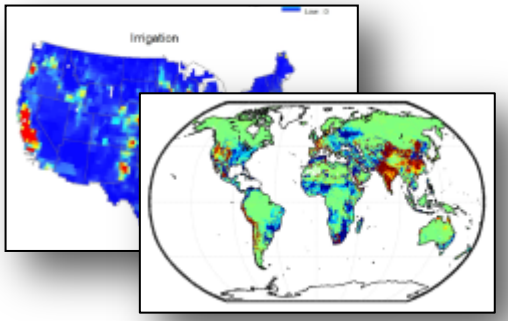
- EIA
- IEA
- GTAP
- HYDE
- SAGE
- OECD
- FAO
- IMAGE
- MIRCA
- Aquastat
- USDA
- USGS
- CDIAC
- IIASA
- Others

Papers: Houghton, Rogner, others

GCAM Core: Dynamic Integration



Disaggregation Models



- Digital Map of Irrigated Areas
- MODIS
- Union of Concerned Scientists
- Gridded Livestock of the World
- Others

Papers: Friedl, Portmann, Sleeter, Radeloff, others

Discussion

What is an Integrated Assessment Model