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IAM as a coordinating mechanism to integrate impacts across sectors and regions

KATE CALVIN

July 25, 2016

Snowmass, CO

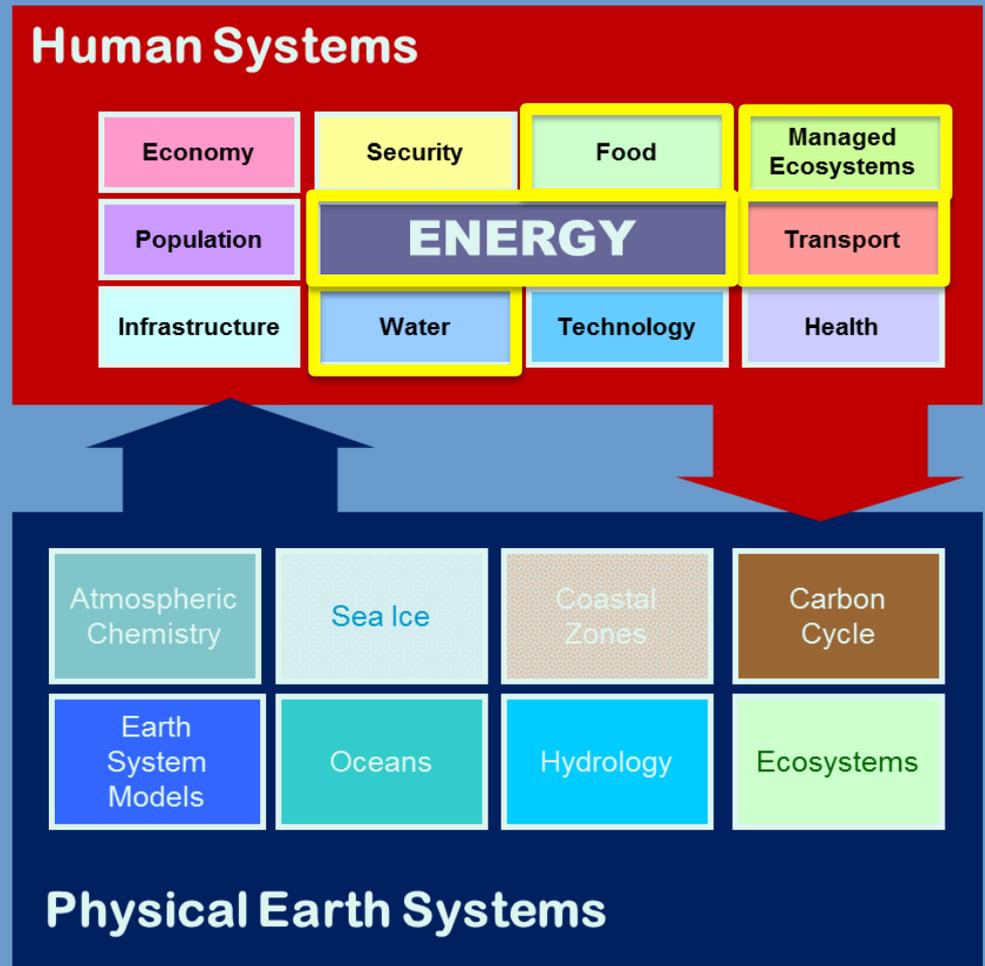
Integrated Assessment Models (IAMs)

IAMs integrate human and natural Earth system climate science.

- IAMs capture interactions between complex and highly nonlinear systems. IAMs provide insights that would be otherwise unavailable from disciplinary research.
- IAMs provide physical science researchers with information about human systems such as GHG emissions, land use and land cover.

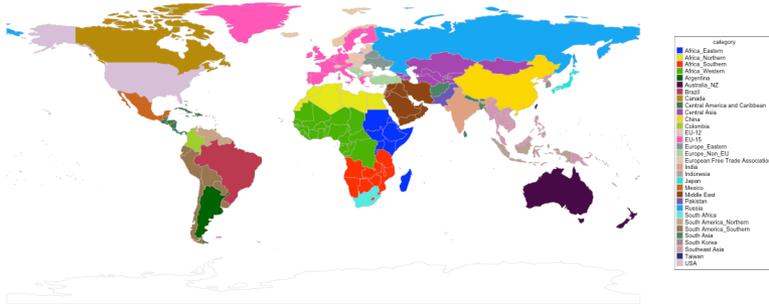
IAMs provide important, science-based decision support tools.

- IAMs support national, international, regional, and private-sector decisions.

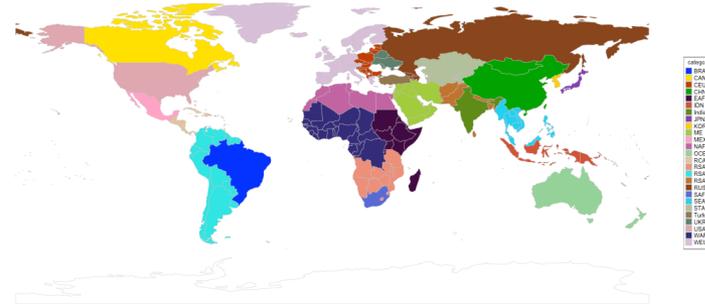


Integrated Assessment Models (IAMs)

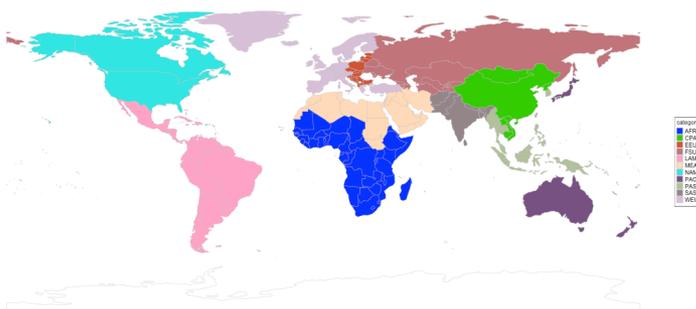
GCAM



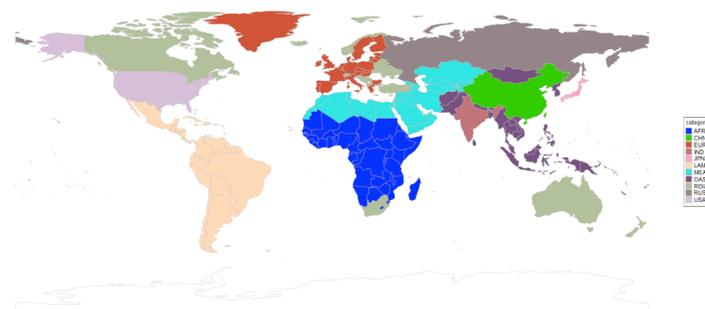
IMAGE



MESSAGE



REMIND



- ▶ Methodology:
 - Adjust climate-sensitive parameters/variables to reflect impacts

- ▶ In order to estimate the effect of climate change impacts on various systems, IAMs need some means of translating changes in climate into physical impacts. Several options exist, including:
 - Using output from a climate model directly
 - Using output from an intermediate, process model
 - Developing response functions, either from process model output or from the empirical literature

- ▶ In many cases, including climate presents challenges such as:
 - Translating across spatial, temporal, and process resolutions
 - Bias correction
 - Incomplete information

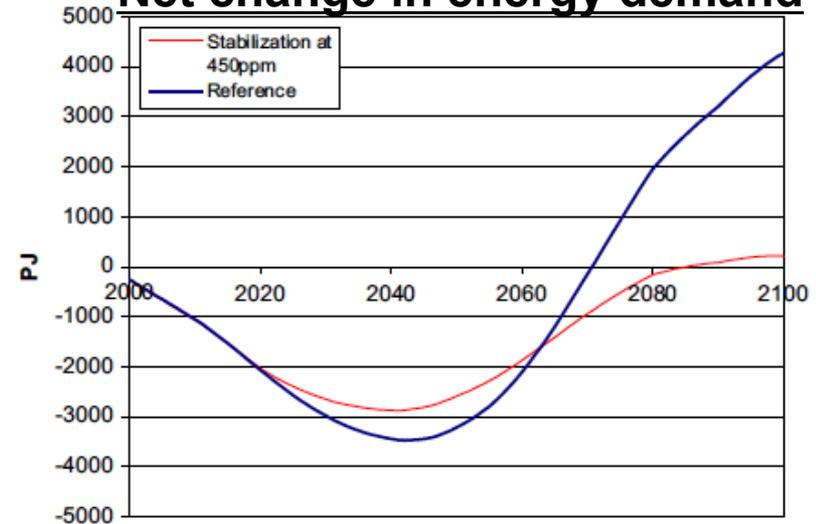
Climate change impacts in IAMs

Impact Sector	Climate Variables	Implications	Current Studies	Focus of Current Studies
Demand for heating and air conditioning	Temperature	Energy use, grid reliability	Isaac and van Vuuren (2009), Mima and Criqui (2009), Labriet et al. (2013), Zhou et al. (2013)	Energy use and CO ₂ emissions
Hydropower	Stream flow	Electricity generation, grid reliability	Mima and Criqui (2009), Labriet et al. (2013)	Electricity generation
Thermal power cooling	Temperature, precipitation	Electricity generation, water use	Mima and Criqui (2009)	Electricity generation and water use
Bioenergy	Temperature, precipitation, CO ₂ concentration, ozone, pests, etc.	Energy production (electricity, liquids, etc.)	Kyle et al. (2013)	Effect of climate on bioenergy production
Agriculture	Temperature, precipitation, CO ₂ concentration, ozone, pests, etc.	Land cover, agricultural production, bioenergy, food prices, etc.	Reilly et al. (2007), Kyle et al. (2013), Nelson et al. (2014)	Effect of climate on agricultural production and land cover
Water	Temperature, precipitation	Water availability for energy, agriculture, etc.	Hanasaki et al. (2013), Hejazi et al. (2014), Schlosser et al. (2014), Kim et al. (2016)	Water scarcity, Water constraints

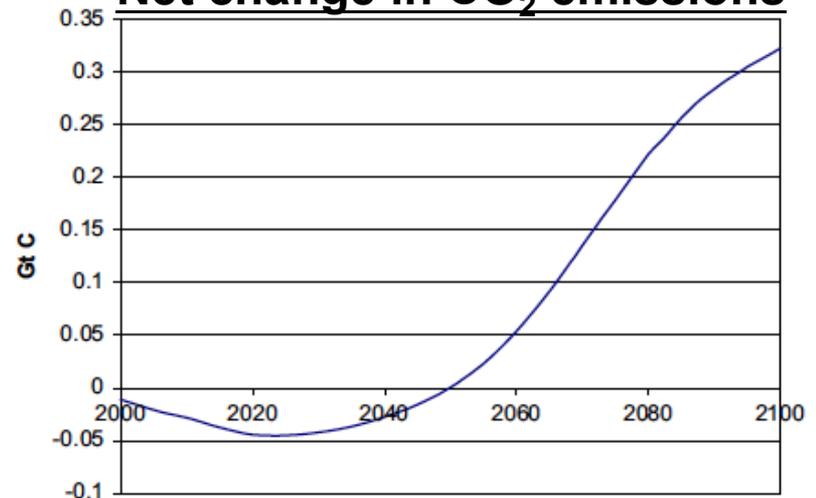
Impacts on Energy Demand: Climate change increases demand for cooling and decreases demand for heating. The net effect is small.

- ▶ Increased temperatures lead to a 70% increase in demand for cooling energy and a 30% decrease in demand for heating energy.
- ▶ Changes are unevenly distributed across space and time.
- ▶ Net effect on energy is small, as is effect on CO₂ emissions.
- ▶ Results are sensitive to a number of factors, including population, income, climate, etc.
- ▶ Source: IMAGE model, Isaac and van Vuuren (2009)
- ▶ See also: Mima and Criqui (2009), Labriet et al. (2013), Zhou et al. (2013)

Net change in energy demand



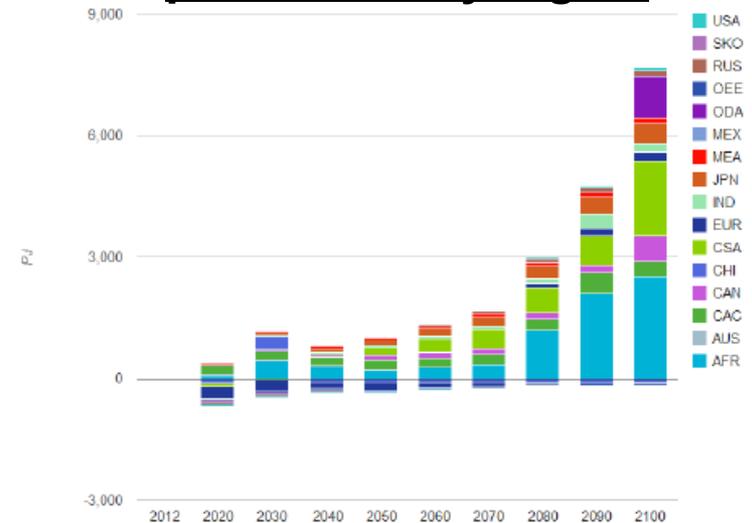
Net change in CO₂ emissions



Impacts on Hydropower: **Climate change increases hydropower production globally.**

- ▶ Changes in precipitation in the future result in small increases in hydroelectricity production globally.
- ▶ Changes are unevenly distributed across space and time.
- ▶ The impact on total electricity production and on CO₂ emissions is small.
- ▶ Source: TIAM model, Labriet et al. (2013)
- ▶ See also: Mimi and Criqui (2009)

Change in hydropower production by region



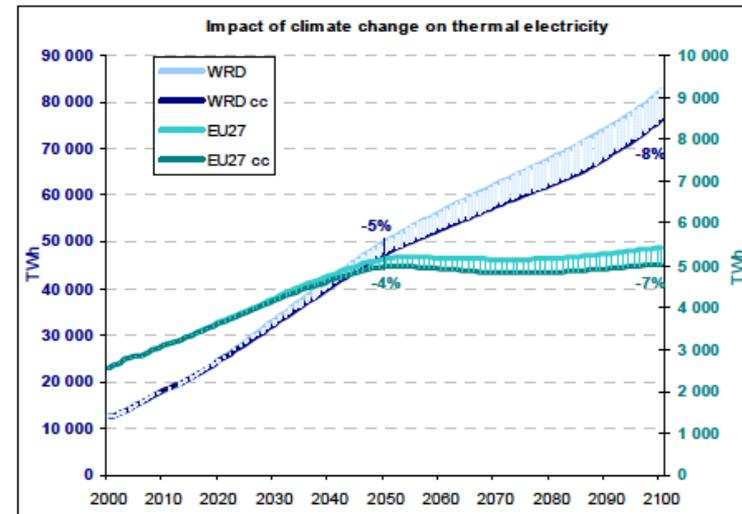


Impacts on Thermal Power Production:

Climate change decreases thermal power production globally.

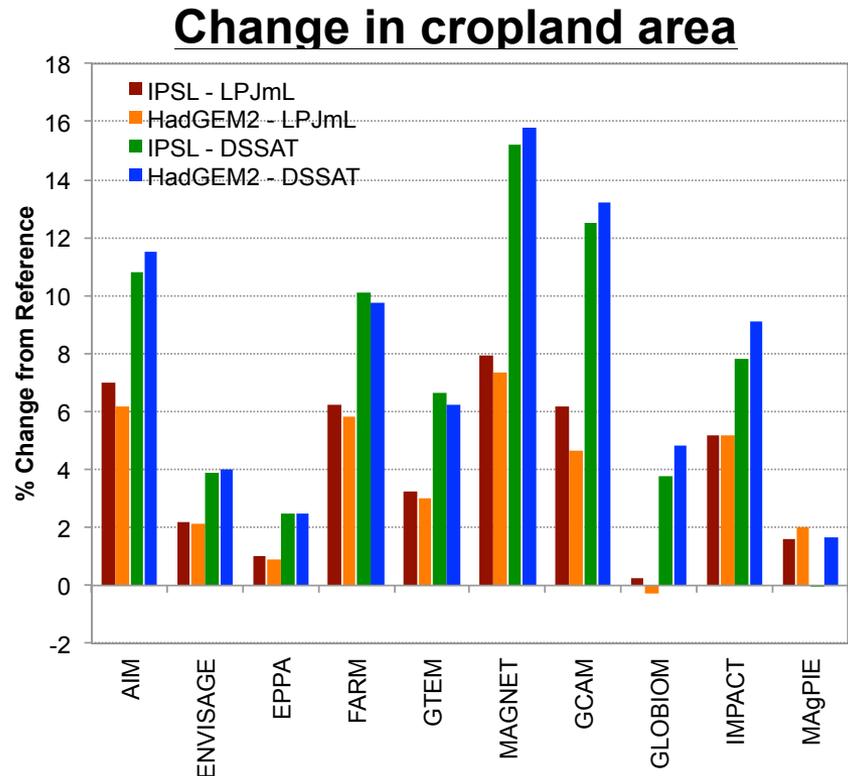
- ▶ Increases in temperature result in a decrease in thermal power efficiency and thus production.
- ▶ The impact on total electricity production is small, reducing global electricity generation by ~8% in 2100.
- ▶ Source: POLES model, Mimi and Criqui (2009)

Change in thermal power



Impacts on Agriculture: Climate change could increase or decrease the amount of cropland area needed.

- ▶ Changes in climate, CO₂, and ozone affect the productivity of crops and other land types.
- ▶ The effect on cropland area varies in both sign and magnitude, depending on climate model, crop model, IAM, CO₂ fertilization, and ozone effects.
- ▶ Source: AgMIP Global Economics Team, Nelson et al. (2014)
- ▶ See also: Reilly et al. (2007), Kyle et al. (2013)

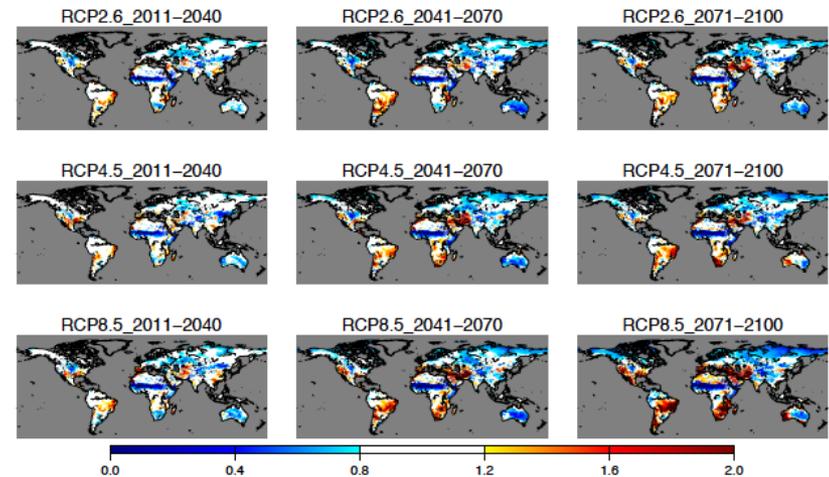


Note: Data is from Nelson et al. (2014), but figure has been redrawn.

Impacts on Water Supply: **Water scarcity/stress will increase in the future in many parts of the world, but much of this increase is due to increases in demand.**

- ▶ Changes in climate affect water supply, and changes in socioeconomics (e.g., GDP, population, technology, etc.) affect water demand.
- ▶ The effect on water scarcity varies regionally and is very sensitive to climate model selection.
- ▶ Source: AIM model, Hanasaki et al. (2013)
- ▶ See also: Hejazi et al. (2014), Schlosser et al. (2014)

Change in water scarcity



Integrating Impacts Sectors using an IAM



Energy Demand



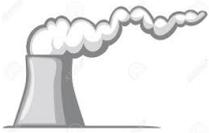
Increases in electricity demand,
decreases in natural gas demand



Hydropower



Changes in production of hydropower



Thermal Power



Decreases in thermal power production



Agriculture



Changes in productivity of land,
bioenergy supply, crop production, carbon
sequestration



Water Supply



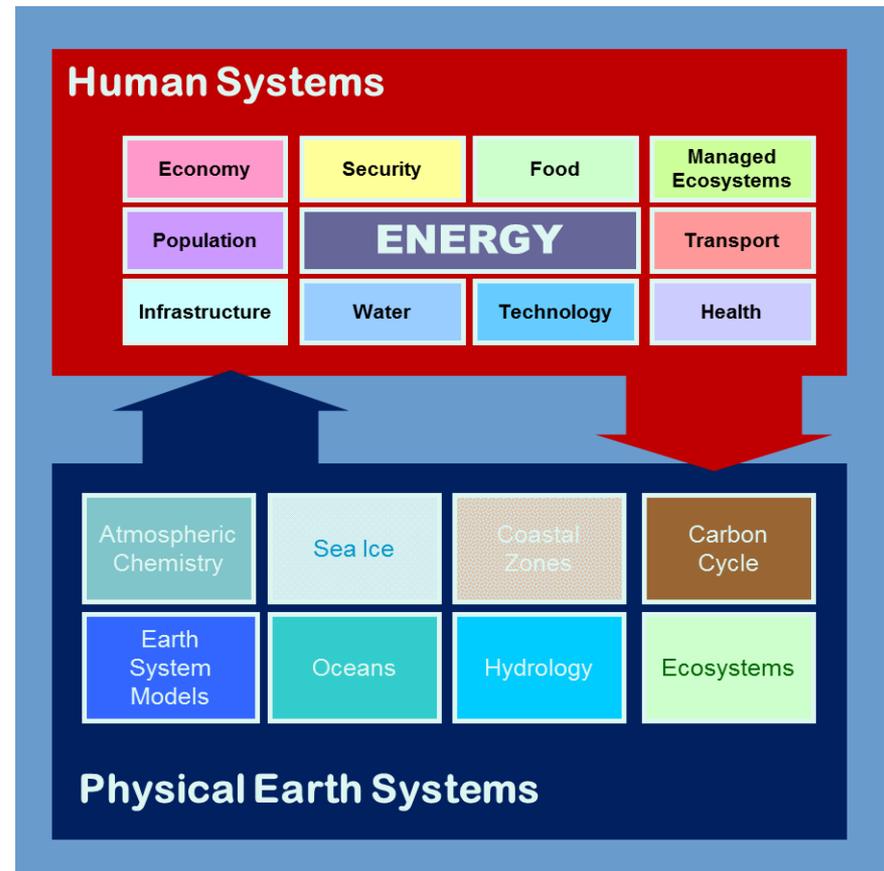
Changes in water availability (globally
and regionally)



Integrating Impacts Sectors using an IAM

► Pros:

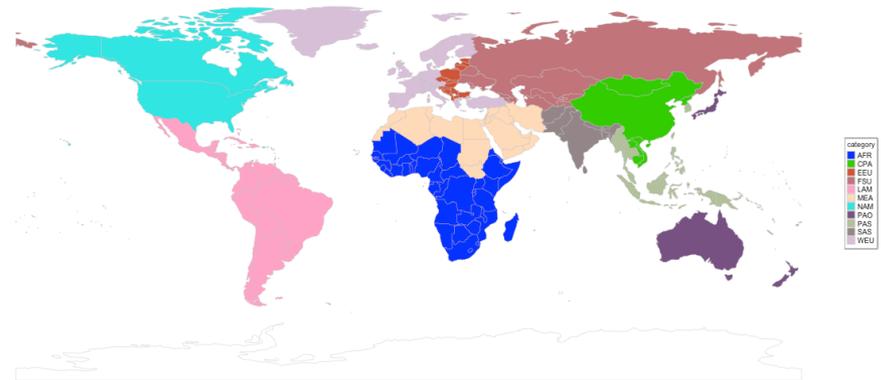
- Models already exist
- Can look at interactions between sectors and regions
- Can look at interactions between mitigation and impacts/adaptation
- Can add *extra* effects (e.g., GE, etc.)
- Potential for consistency with climate model projections if integrated models (or iterative models) are used
- Others??



► Cons:

- Relatively new area for many IAMs
- Can only integrate sectors that are present in an IAM
- Coarse spatial resolution
- Coarse temporal resolution
- Often need information from other models (e.g., physical IAV models)
- Others???

IAMs are often coarse resolution





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Discussion