

Overview of the Global Change Assessment Model (GCAM)

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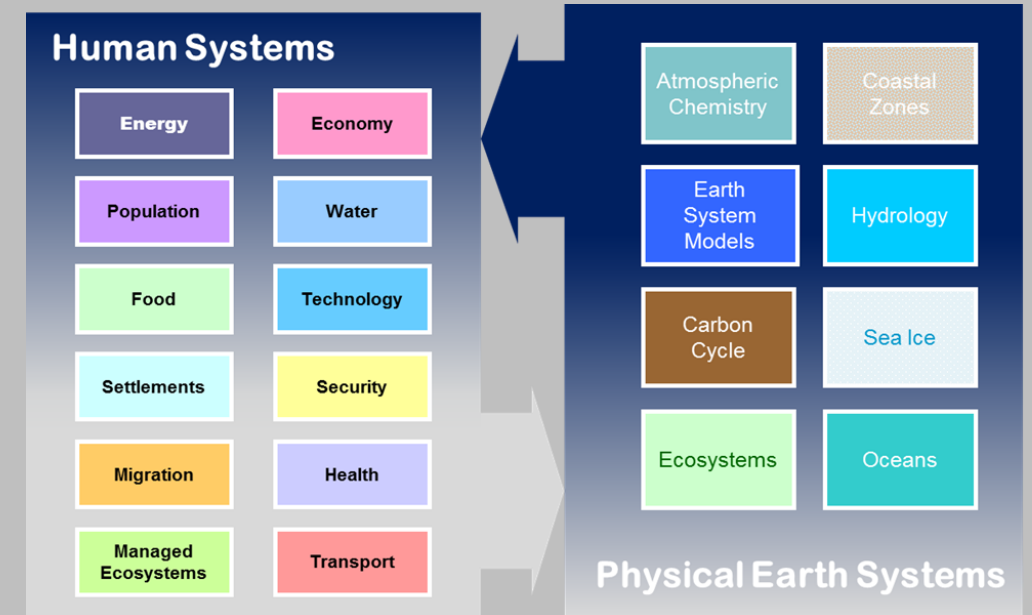
Integrated Assessment Models

IAMs integrate human and natural Earth system climate science.

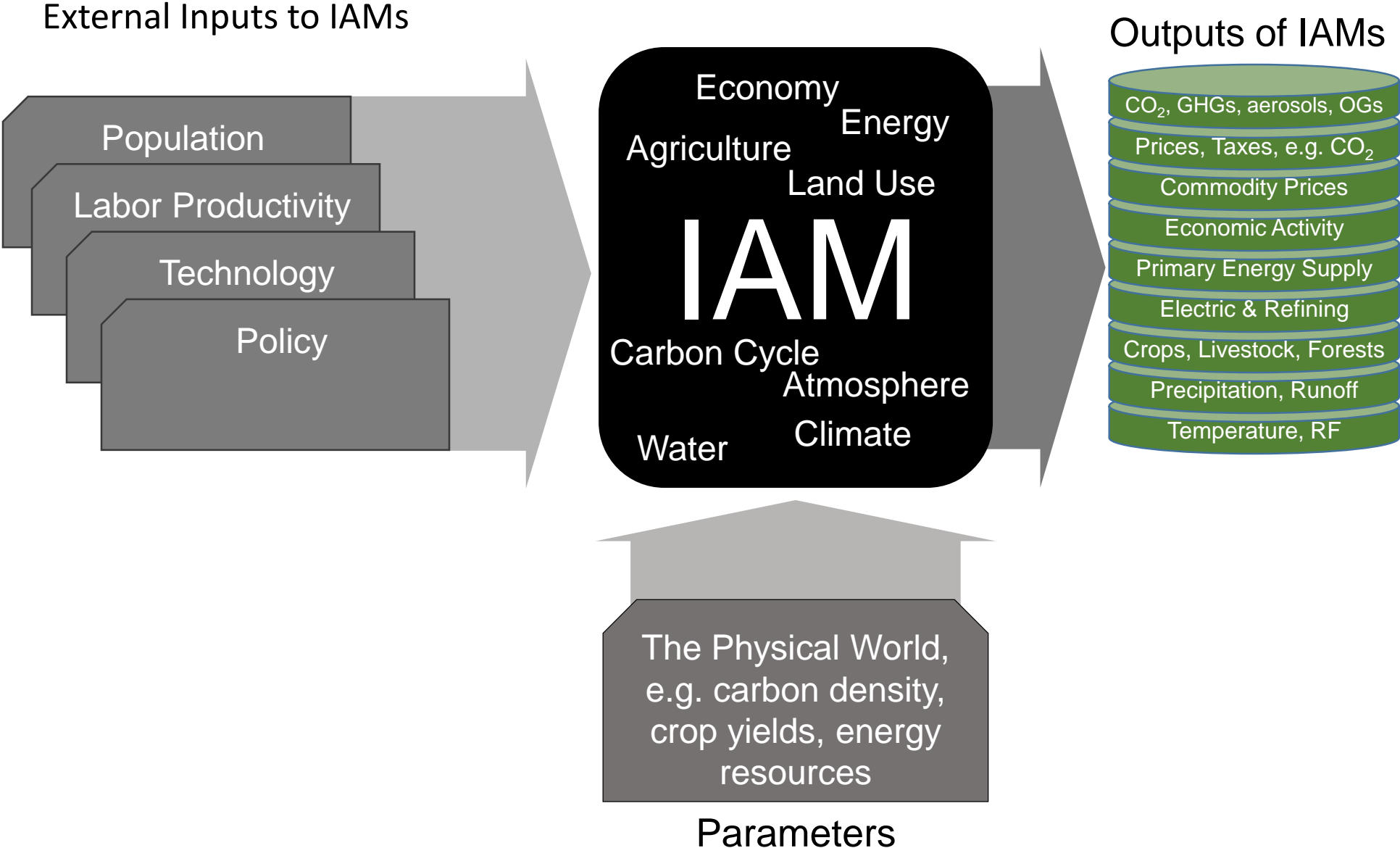
- IAMs link human economic, technological, policy and social systems with physical Earth systems.
- IAMs provide insights that would be otherwise unavailable from disciplinary research alone.
- IAMs capture interactions between complex and highly nonlinear systems.
- IAMs provide natural science researchers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

IAMs provide important, science-based decision support tools.


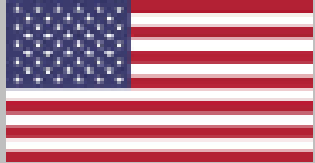




- IAMs support national, international, regional, and private-sector decisions.



Inputs and Outputs in IAMs



Higher Resolution Integrated Assessment Models are developed by interdisciplinary teams, for example

Model	Home Institution	
<p>AIM Asia Integrated Model</p>	<p>National Institutes for Environmental Studies, Tsukuba Japan</p>	
<p>GCAM Global Change Assessment Model</p>	<p>Joint Global Change Research Institute, PNNL, College Park, MD</p>	
<p>IGSM Integrated Global System Model</p>	<p>Joint Program, MIT, Cambridge, MA</p>	
<p>IMAGE The Integrated Model to Assess the Global Environment</p>	<p>PBL Netherlands Environmental Assessment Agency, Bilthoven, The Netherlands</p>	
<p>MESSAGE Model for Energy Supply Strategy Alternatives and their General Environmental Impact</p>	<p>International Institute for Applied Systems Analysis; Laxenburg, Austria</p>	
<p>REMIND Regionalized Model of Investments and Technological Development</p>	<p>Potsdam Institute for Climate Impacts Research; Potsdam, Germany</p>	

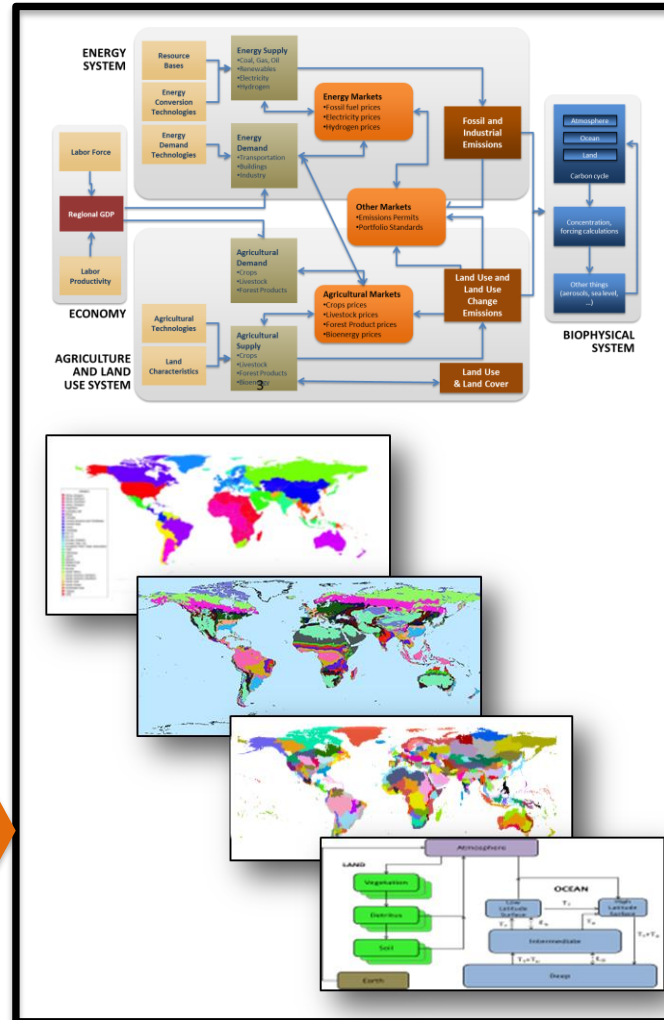
Inputs and Output in GCAM produce conditional forecasts

Scenario Assumptions

- ▶ Socioeconomic assumptions (population, GDP)
- ▶ Energy, land use, and water technologies
- ▶ Policies
- ▶ Resources

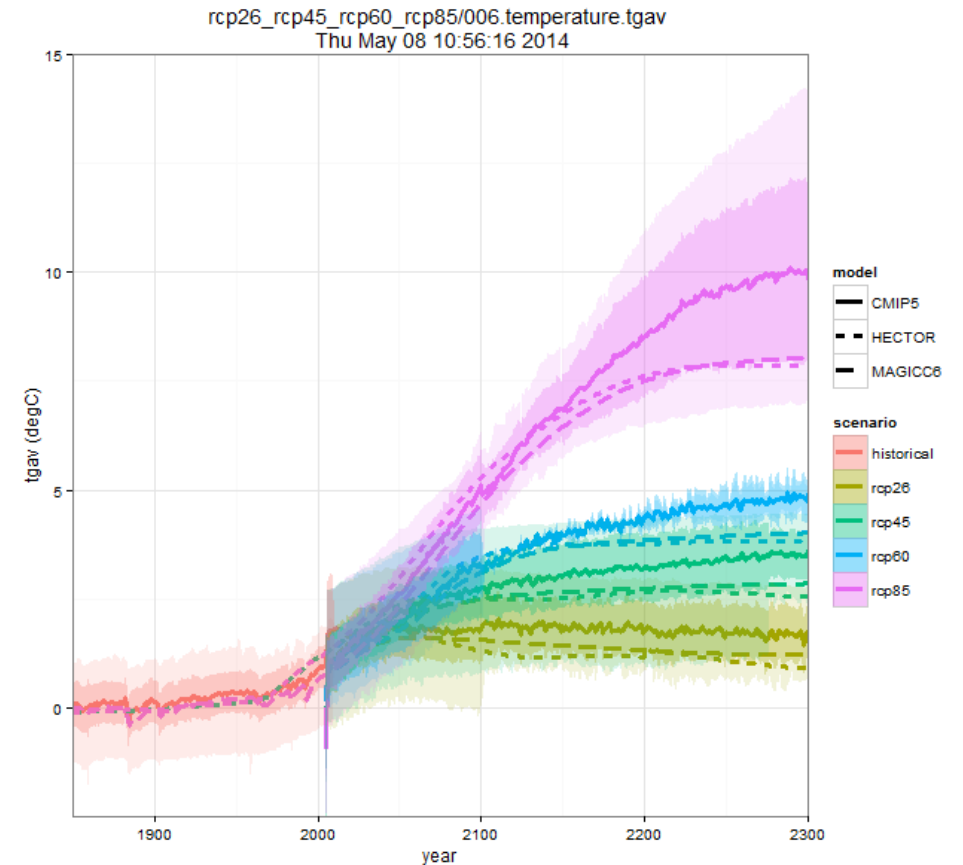
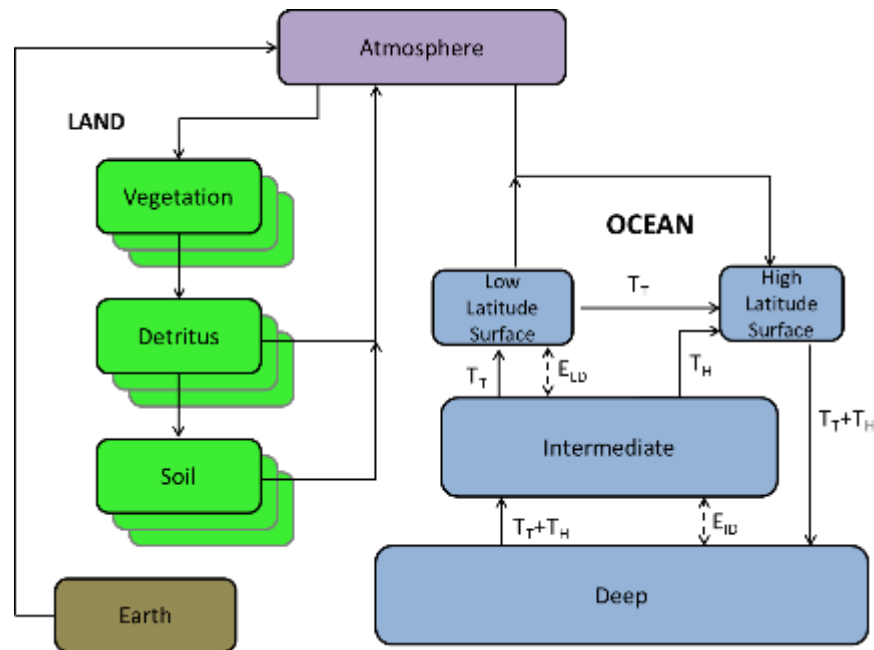
Scenario Outputs

- ▶ Prices and production quantities:
 - Energy sectors
 - Transportation
 - Primary energy resources
 - Agricultural products
- ▶ Land use
 - Crops (by type)
 - Pasture
 - Unmanaged
- ▶ Water demand
 - Raw demand by sector
 - Response to scarcity
- ▶ Atmosphere-Climate
- ▶ Economic indicators
 - Economic losses
 - Income transfer

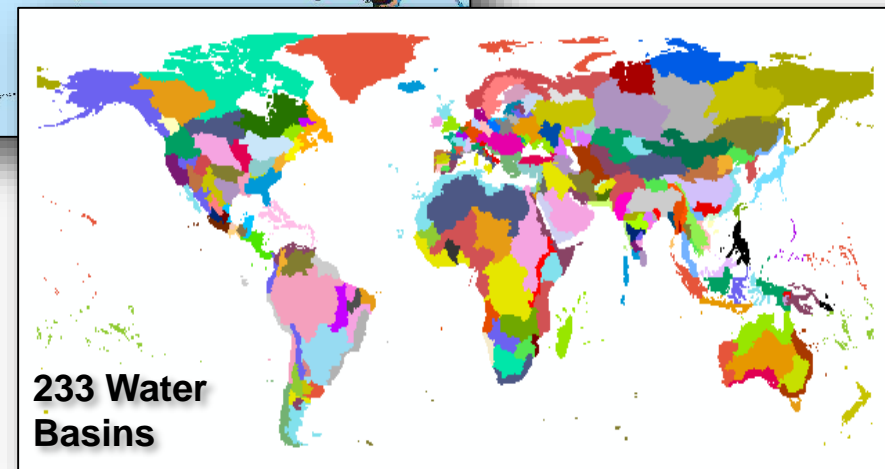
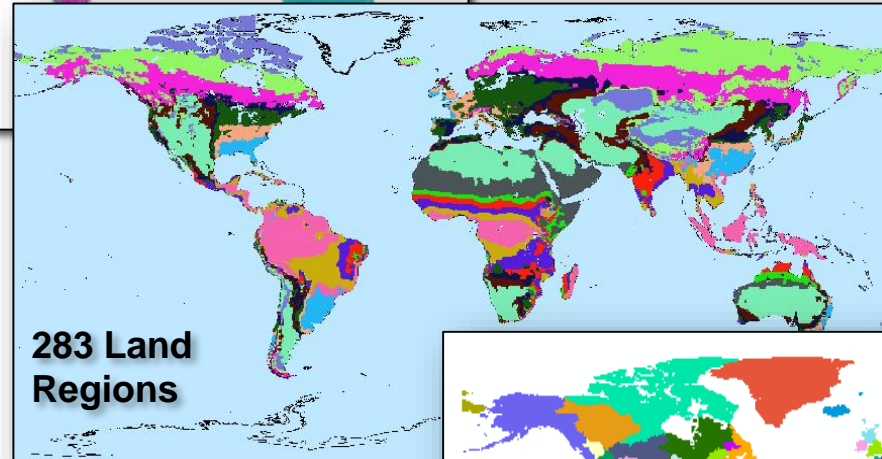
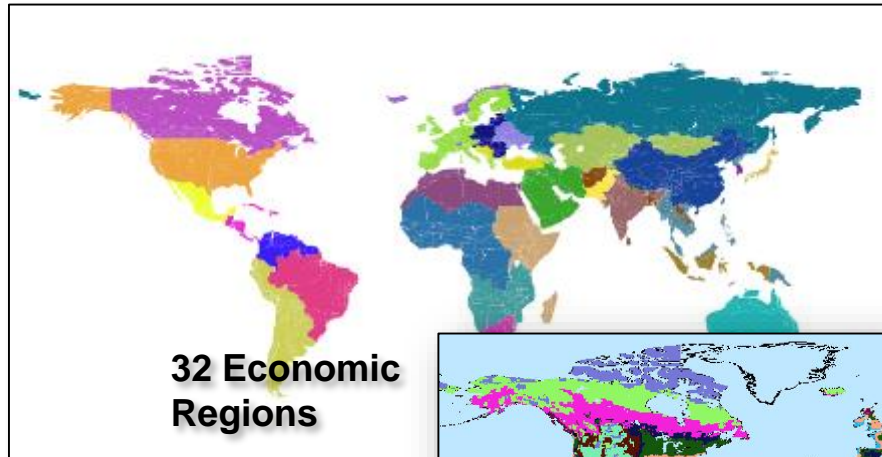


Atmosphere & Climate: Hector

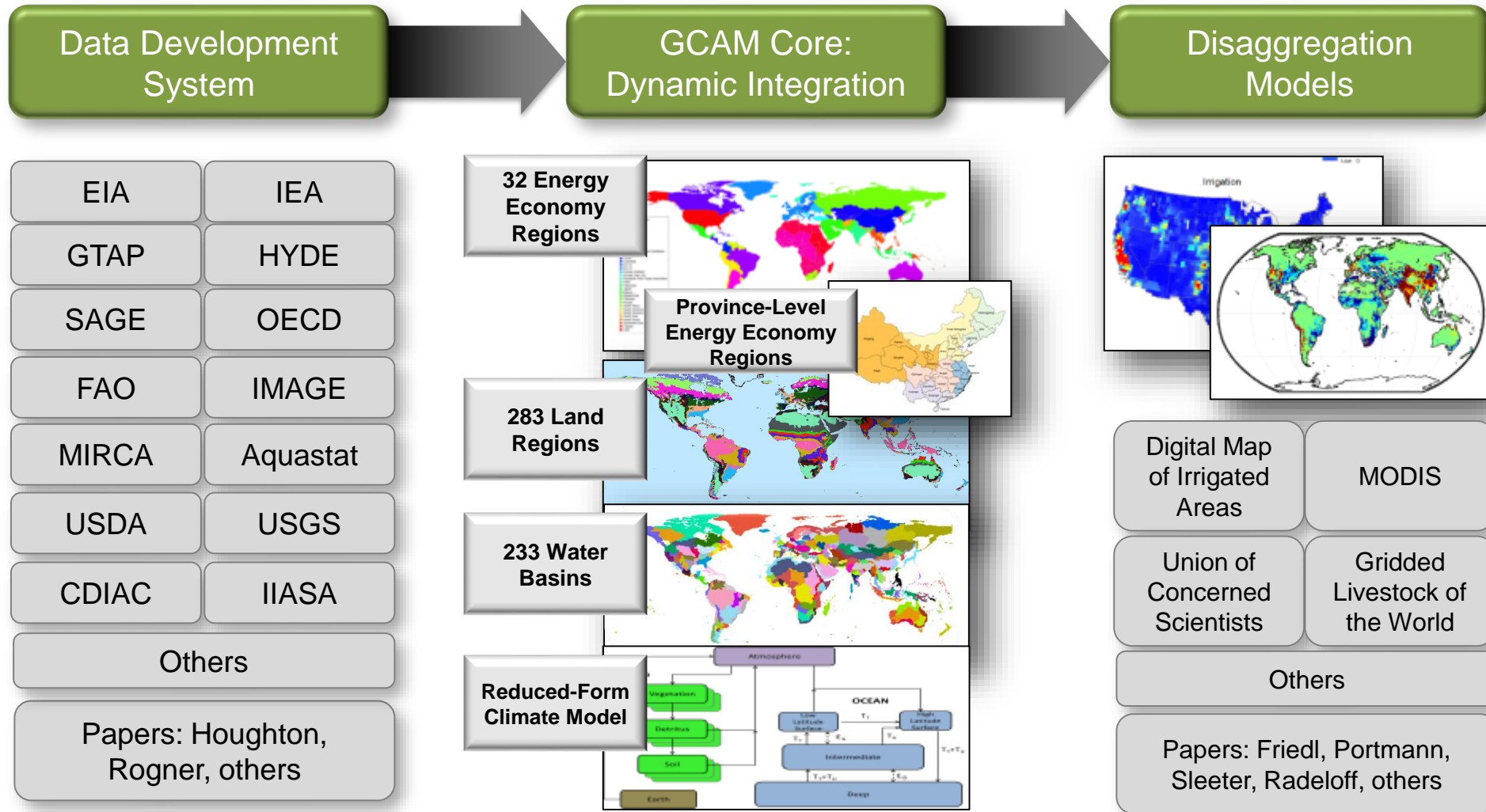
- ▶ Fast-executing global climate, atmosphere and carbon cycle model
- ▶ Open source and community oriented
- ▶ Capable of replicating outputs of more complex models



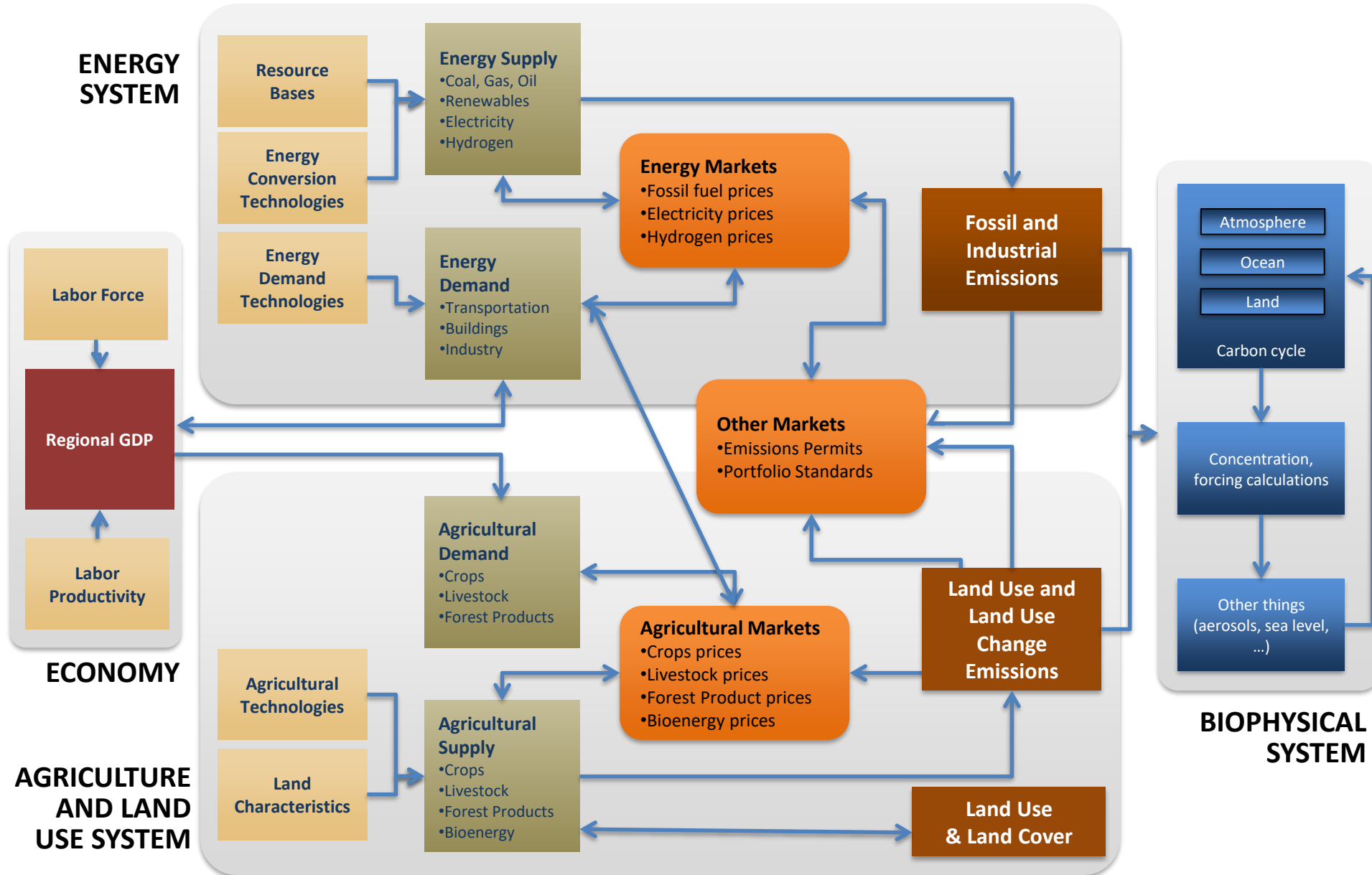
GCAM regional disaggregation



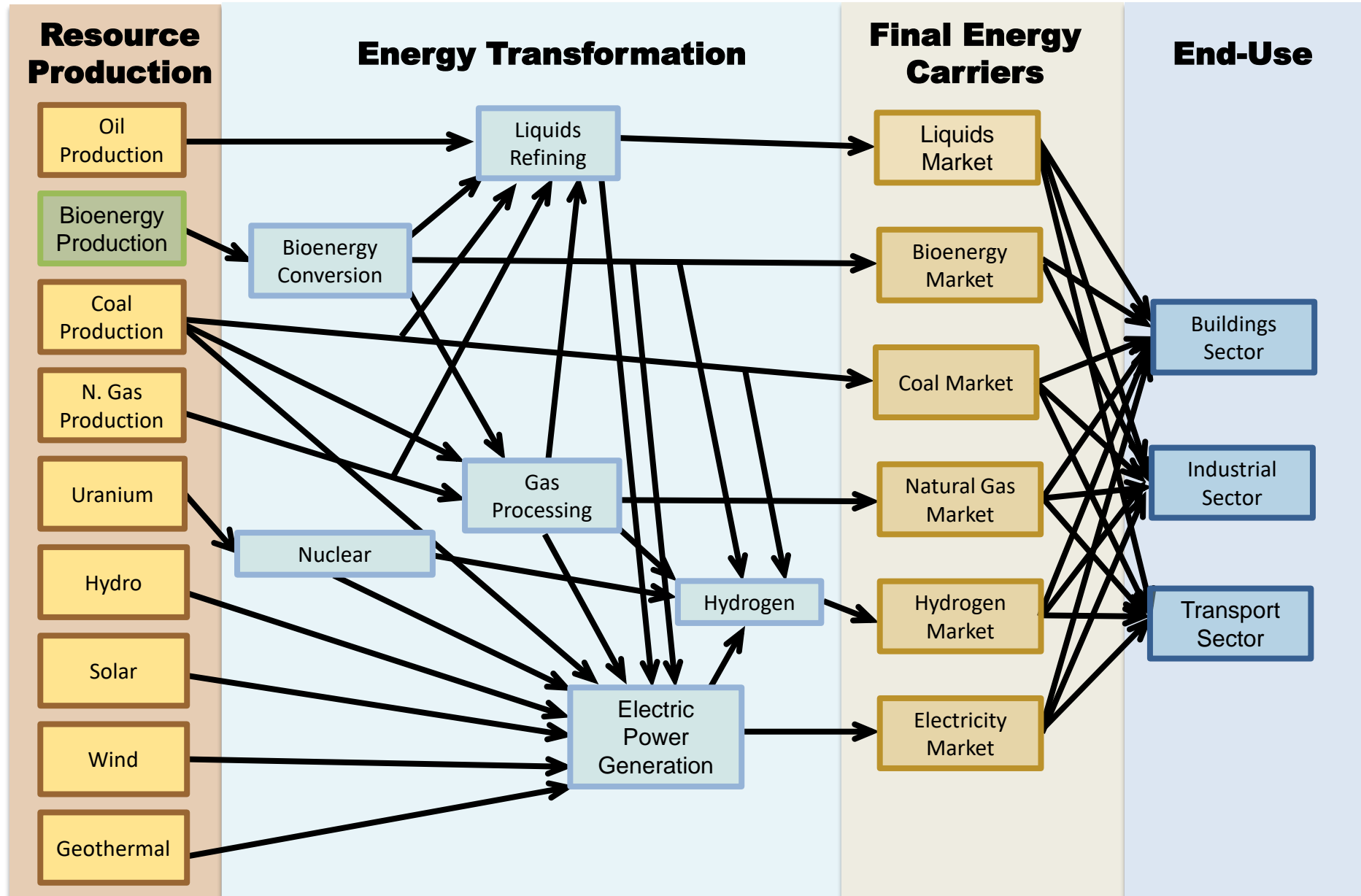
The Global Change Assessment Model



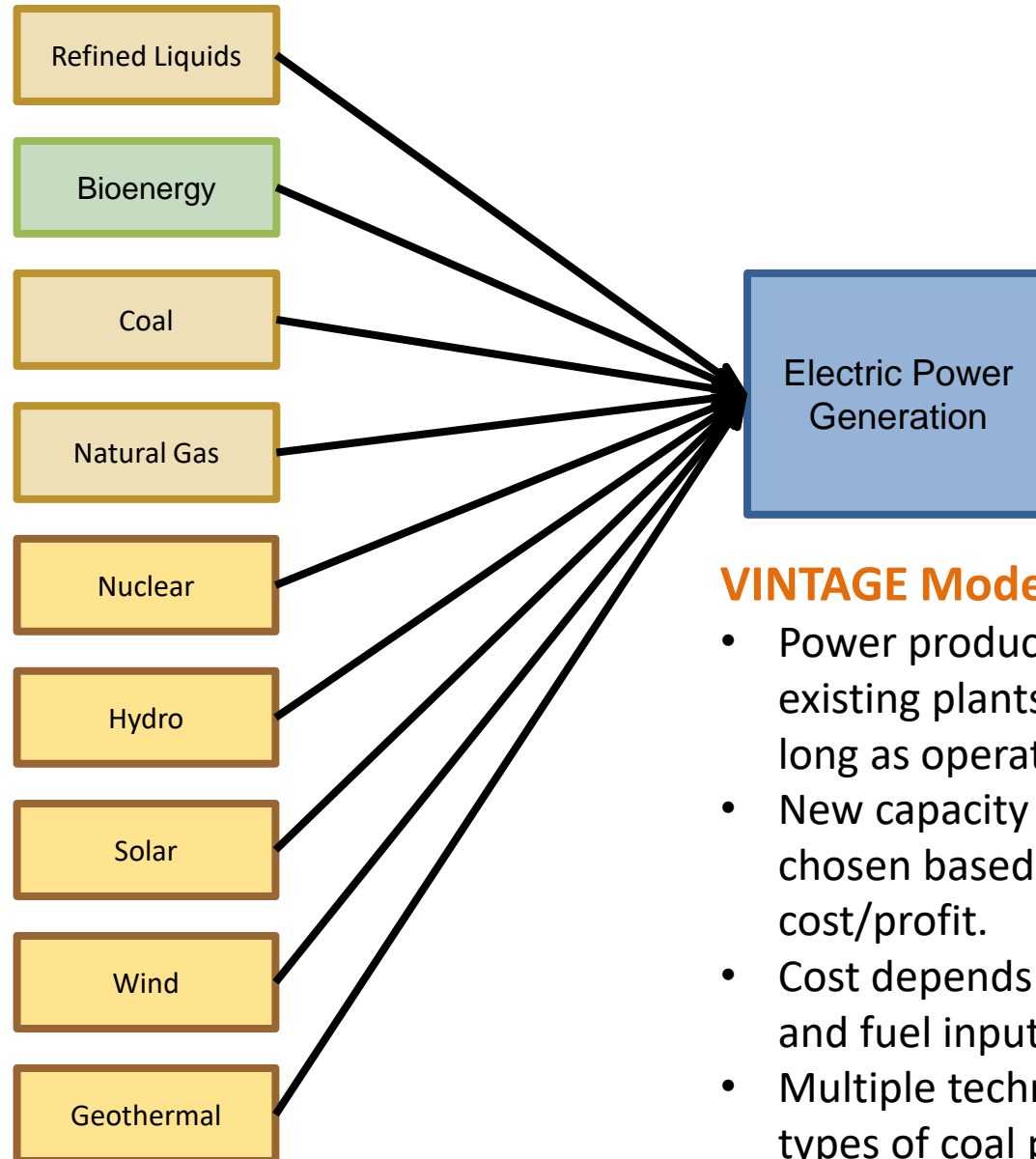
The Global Change Assessment Model



The Energy System: Structure



The Energy System: Electricity Generation

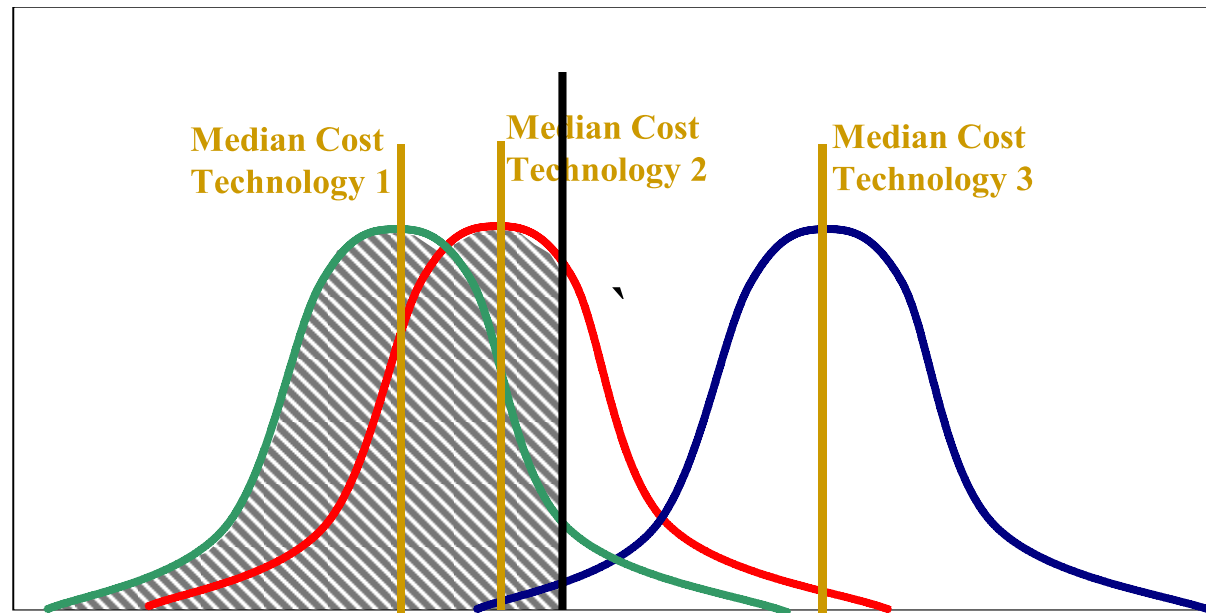


VINTAGE Model of Power

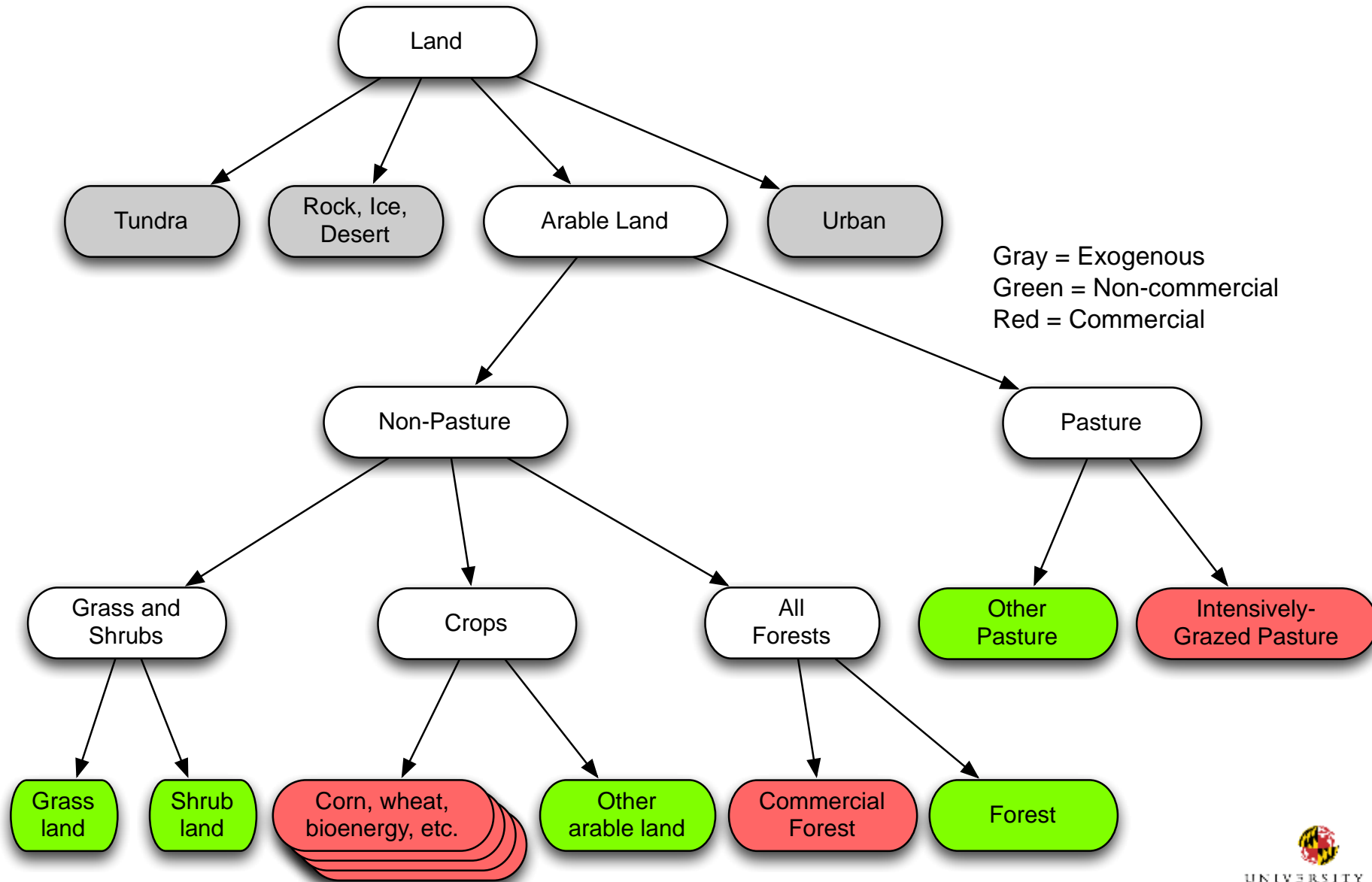
- Power production depends on existing plants—run full lifetime as long as operating costs are covered
- New capacity coming on line—chosen based on expected cost/profit.
- Cost depends on capital and O&M and fuel input prices
- Multiple technology options, e.g. 4 types of coal plants.

GCAM technology choice: Logit approach

- ▶ GCAM uses a **LOGIT** approach to determine technology choice
- ▶ Technologies compete for market share based on expected cost/profit
 - Median technology cost/profit
 - Cost/profit distribution
 - Lower expected cost (higher profit) → higher market share



Example: Land System Structure



Frequently Asked Questions

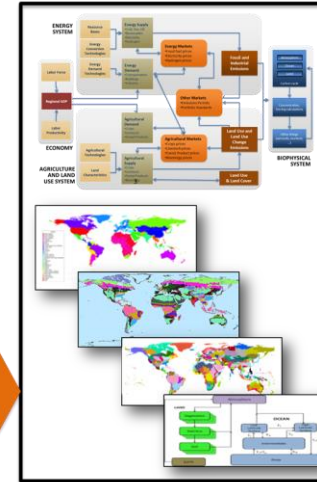
▶ Does GCAM optimize?

▶ Answer:

- Not exactly.
- GCAM is a market equilibrium model, so it adjusts prices until supplies and demands are equal
- However, GCAM assumes that producers maximize profit and consumers minimize cost
- And, under certain conditions, welfare economics tells us that market equilibria are (Pareto) optimal
- GCAM is not intertemporally optimizing

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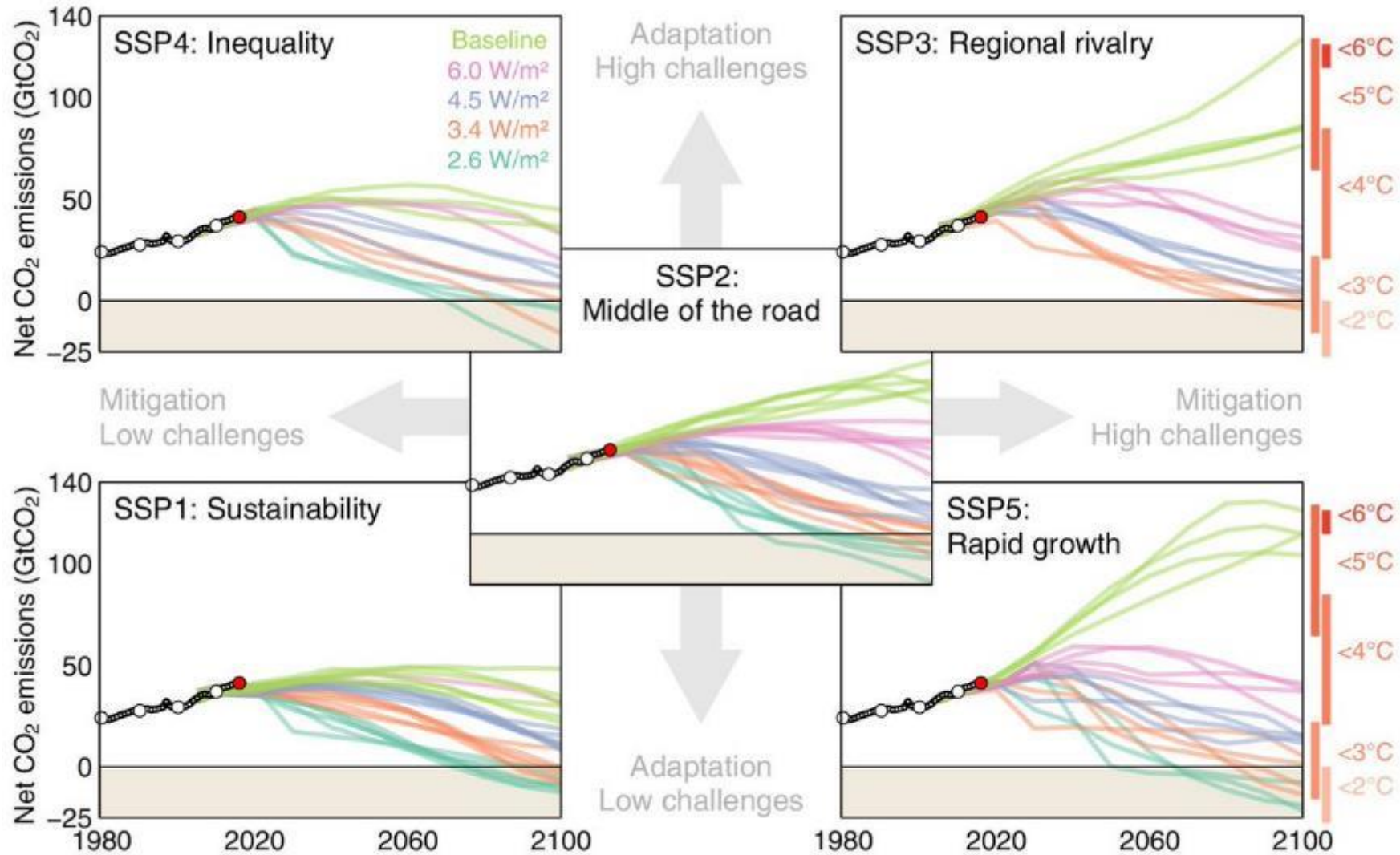
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DISCUSSION

BACKUP

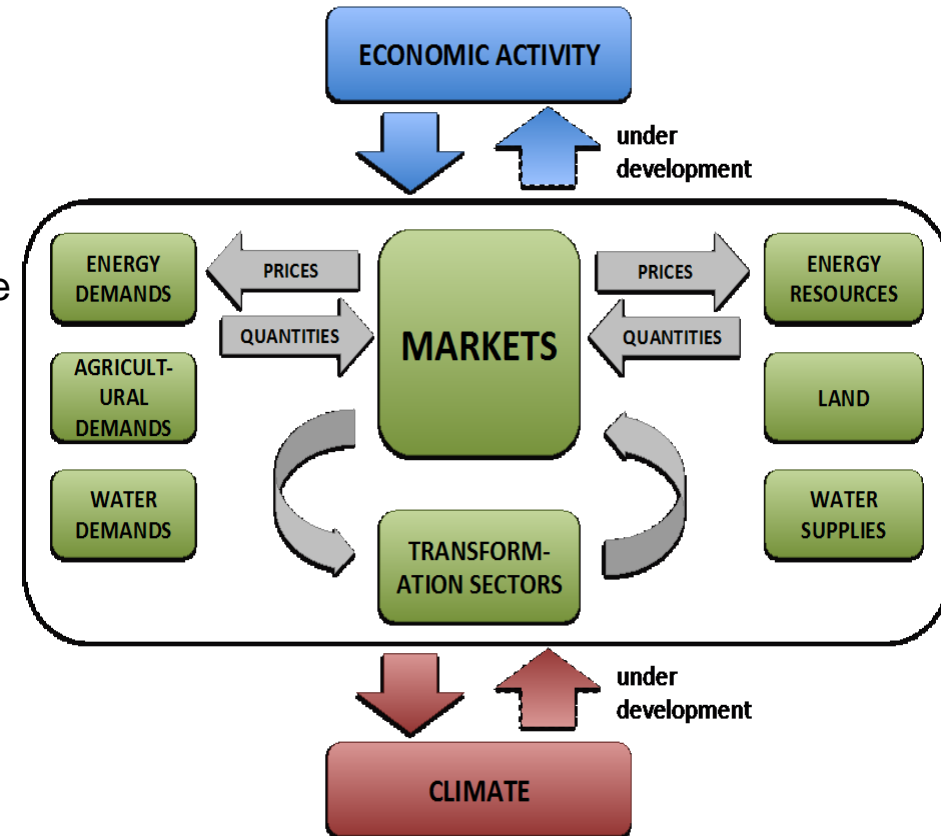
Shared Socioeconomic Pathways (SSPs)



Major component relationships

- ▶ At its heart GCAM is an economic model.
- ▶ GCAM is coupled in code.
- ▶ GCAM solves energy, commodity, land, and water markets **simultaneously**.
 - Finds the **PRICE** at which **QUANTITIES** supplied and demanded for goods and services are equal in all markets
- ▶ Supplies and demands are shaped by physical and technological limits
 - Resources
 - Technology
- ▶ GCAM tracks international trade among trading regions
 - The user determines which commodities trade and
 - Identifies the regions/commodities in markets

I think you can take out the “under development” note here, because this version uses it.



GCAM is a powerful research tool for exploring a wide range of research questions

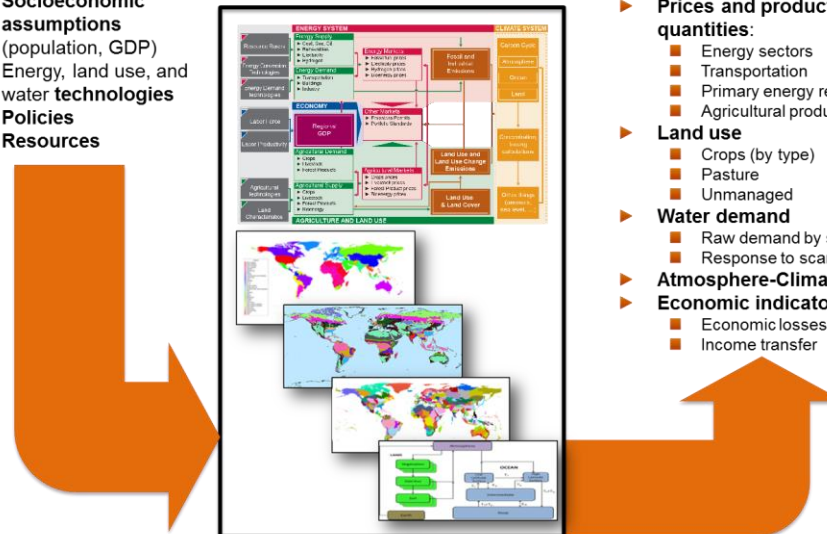
- ▶ GCAM can explore a wide range of research questions that consider interactions between human and physical Earth systems
- ▶ Ensemble simulations can be used to explore uncertainty
- ▶ Coupling to external models has been used to allow GCAM to explore problems with finer temporal and spatial scales.

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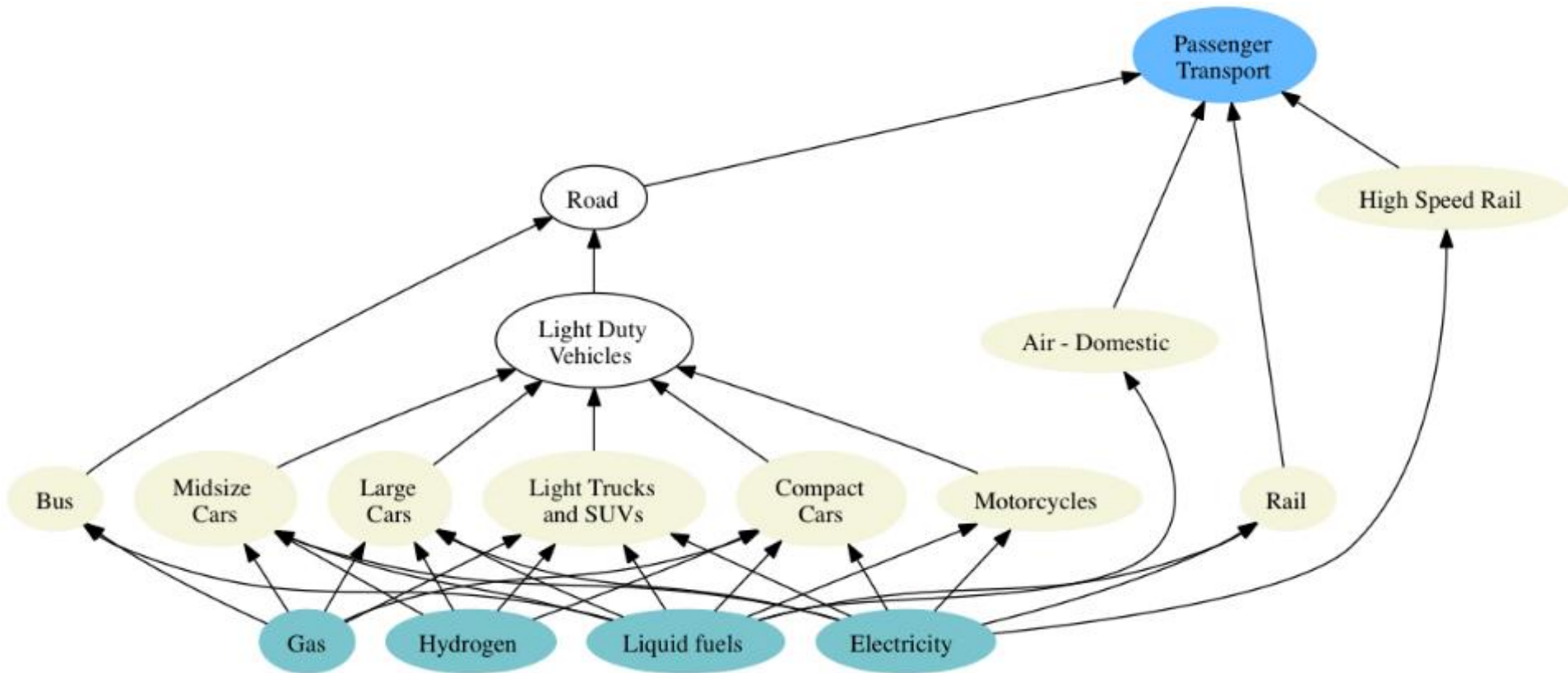
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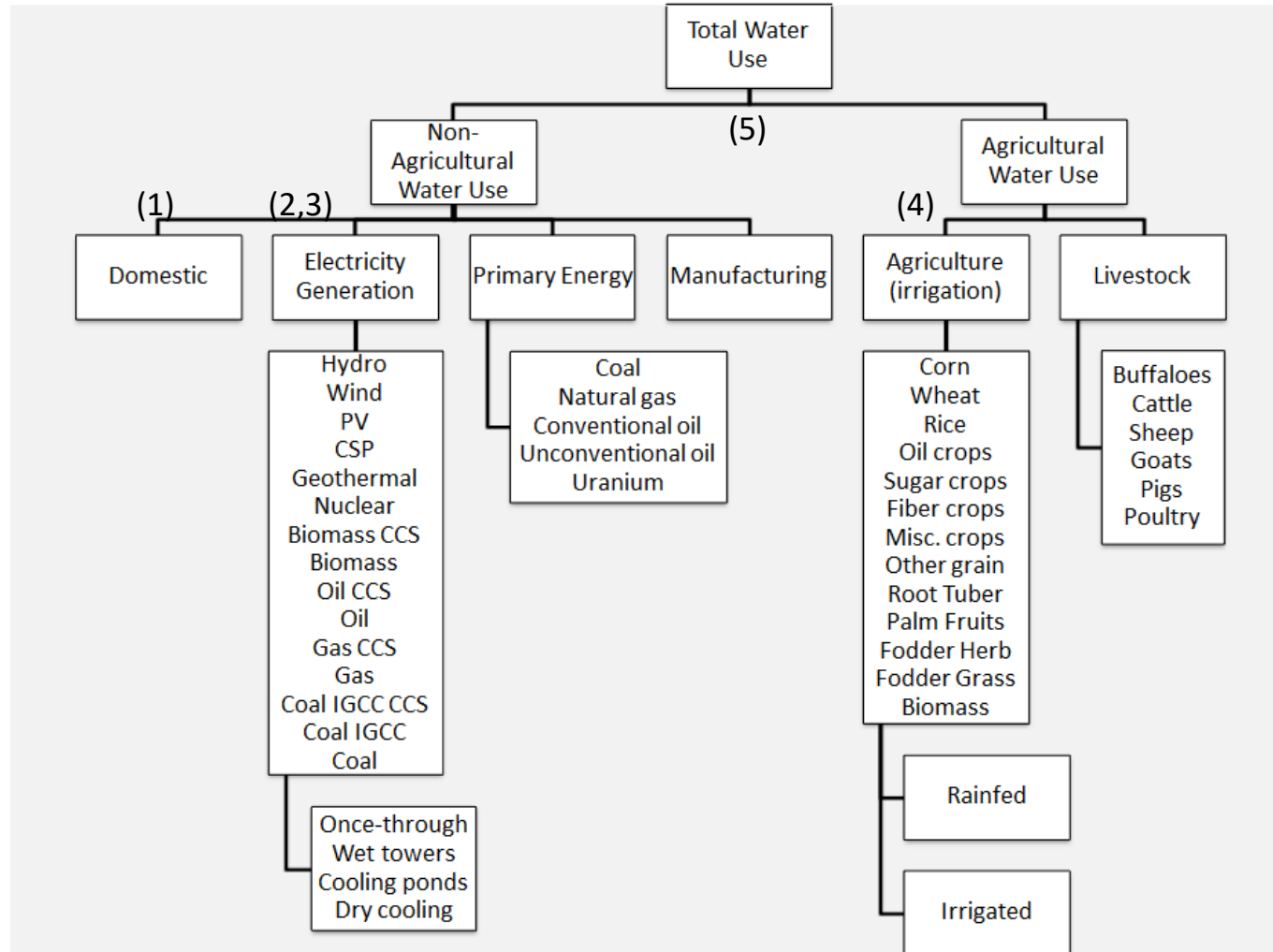


Final energy users make technology choices too

- ▶ The choice among modes of transportation in the passenger sector is a function of the cost of travel, the time it takes, and income.



Modeling Water Demands in GCAM



- ▶ Technologically detailed representation of water demand sectors
- ▶ Tracks water demands for several sectors, subsectors, and technologies
- ▶ Tracks water demands at various spatial scales (regions, state, agro-ecological zones)
- ▶ Tracks both annual withdrawal and consumptive water use
- ▶ Endogenously incorporated in GCAM

(1) Hejazi et al. (2013). Hydrological Sciences Journal.

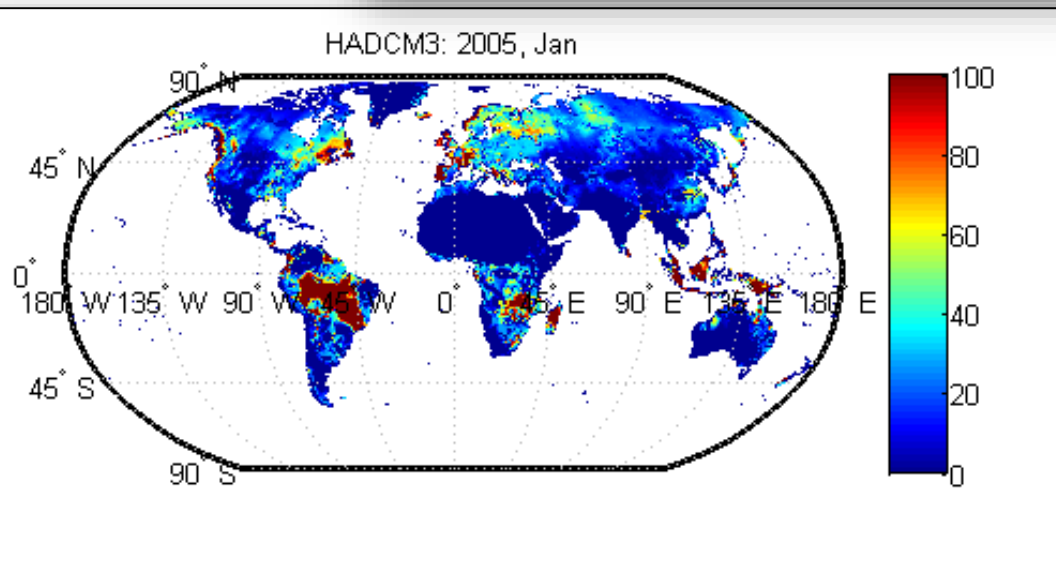
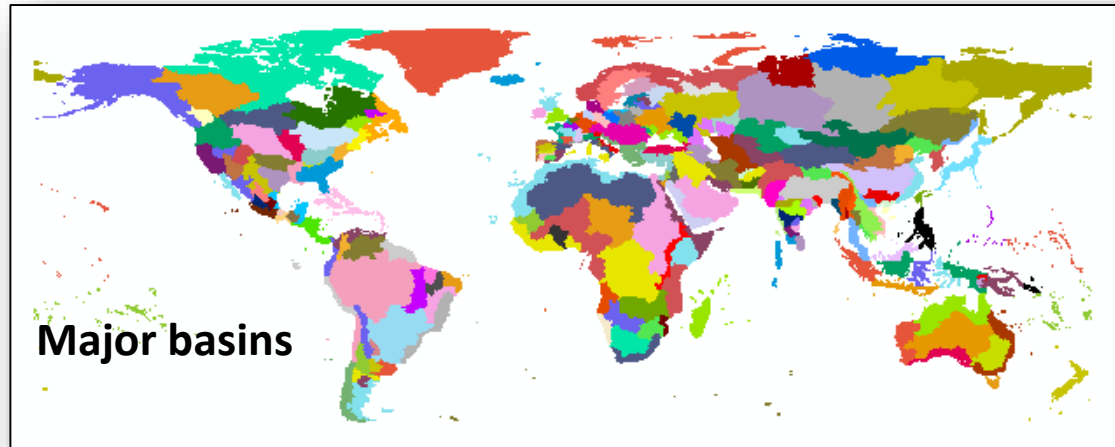
(2) Kyle et al. (2013). International Journal of Greenhouse Gas Control.

(3) Davies et al. (2013). Advances in Water Resources.

(4) Chaturvedi et al. (2013). Mitigation and Adaptation Strategies for Global Change.

(5) Hejazi et al. (2014). Technological Forecasting and Social Change

The GCAM Global Hydrologic Model



- ▶ GCAM has a global hydrologic model
- ▶ Modified River Transport Model scheme
- ▶ Simulates runoff and streamflow (1901-2100)
- ▶ Requires climate information from GCMs as inputs
- ▶ 233 basins globally
- ▶ 18 basins in the US consistent with the USGS WRRs
- ▶ Monthly temporal scale
- ▶ 0.5x0.5 degree spatial resolution

GCAM also accounts for non-renewable water sources such as fossil groundwater and desalinated water