Air-climate-energy investigations with a state-level Integrated Assessment Model: GCAM-USA

Office of Research and Development

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Abstract

The Global Change Assessment Model (GCAM) is a global integrated assessment model used for exploring future scenarios and examining strategies that address air pollution, climate change, and energy goals. GCAM includes technology-rich representations of the energy, transportation, building, and agricultural sectors, which are linked to representations of the economy, climate, and land use systems. For various scenarios, GCAM produces estimates of technology adoption, fuel use, and climate and air pollutants.

GCAM has been used in high-profile applications, including the production of the Representative Concentration Pathway 4.5 W/m^2 scenario. A new version, GCAM-USA, represents the U.S. at the state-level within the coupled global model.

We describe GCAM-USA and highlight updates to more fully account for U.S. air quality regulations, as well as to generate scenarios exploring the air-climate-energy nexus. Finally, we describe efforts to integrate GCAM-USA into the Office of Research and Development's GLIMPSE project.

Science questions

How can we simultaneously achieve air quality management, ecosystem conservation, and climate change mitigation goals?

What are the implications of state-level energy efficiency and renewable energy measures on greenhouse gas emissions and air quality?

What are the broader health and environmental impacts of different pathways for meeting society's energy needs?

Impacts under consideration include

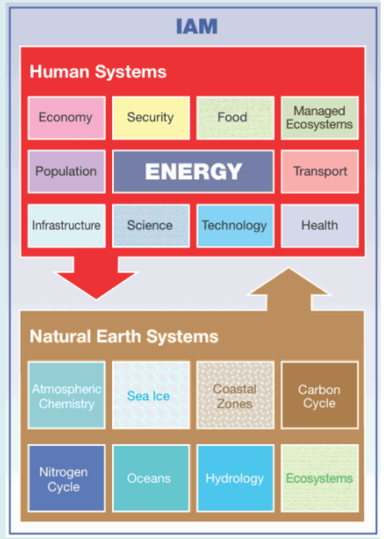
- **Air quality and resulting human health effects**
- **Agricultural damage to crops/timber**
- **Ecosystem impacts from N and S deposition**
- **Water use by agricultural and energy sectors**

What is an integrated assessment model?

Integrated Assessment Models (IAMs) provide a computational framework for evaluating future global and societal changes, such as:

- **Population growth and migration**
- **Economic growth and transformation**
- **Technology development**
- **Energy resource costs**
- **Climate change**
- **Land use change**
- **Energy, climate and environmental policy**

IAMs have a long track record, including application to climate change mitigation studies.

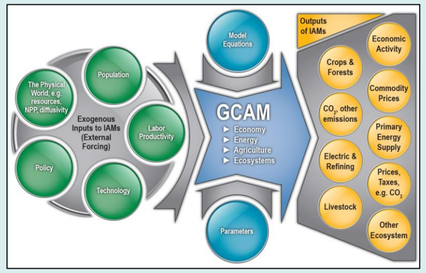


Why GCAM-USA?

Attributes of GCAM-USA that align with project goals include:

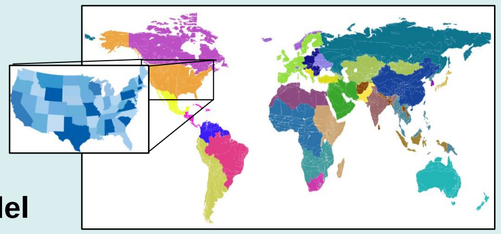
Sectoral coverage

- **Electricity production**
- **Buildings**
- **Industry**
- **Transportation**
- **Agriculture**
- **Land use**
- **Land cover**



Spatial coverage

- **Global, 32 regions**
- **U.S. region sub-divided by state**
- **Scenarios can model U.S. in global context**



Pollutant coverage

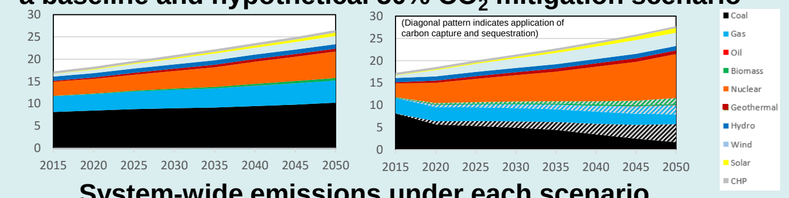
- **Greenhouse gases: CO_2, CH_4, N_2O, HFCs**
- **Short-lived forcers:**
- **BC, OC, SO_2**
- **Criteria pollutants NOx, SO_2, PM, CO, NH_3**

Other factors

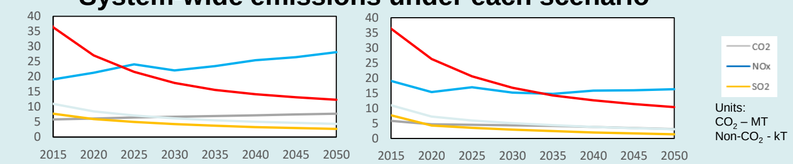
- **Models through 2100**
- **Open source**
- **Freely available**
- **Typically < 1hr runtime**
- **Readily extensible, incl. graphical interface**

Illustrative GCAM results

U.S. electricity production (EJ) for a baseline and hypothetical 50% CO_2 mitigation scenario



System-wide emissions under each scenario

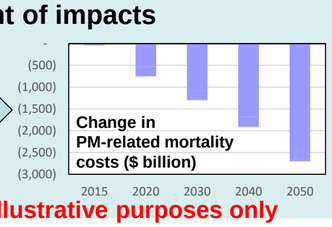


Assessment of impacts

PM mortality risk estimate, $thousand (3% fiscal discount rate) per ton of emissions

	Area Source Carbon	Mobile Source Carbon	EGU & Non-EGU Carbon	Area Source SO_2	EGU SO_2	Non-EGU SO_2	VOC	EGU NOx	Non-EGU NOx	Mobile Source NOx
2015	820	630	520	46	94	67	2.8	17	11	1
2020	910	700	570	50	100	74	3.1	19	12	13
2030	1,100	830	660	60	120	87	3.6	22	14	15

Source: (Updated Fann *et al.*, 2009)

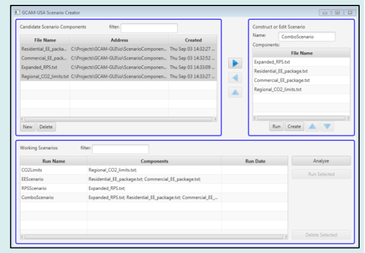


Results provided for illustrative purposes only

Ongoing enhancements to GCAM-USA

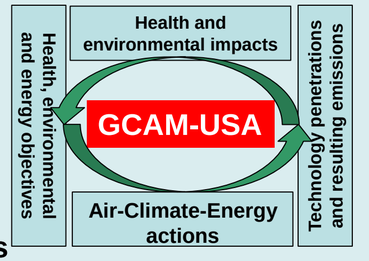
Interface for scenario development

- **Develop and manage scenario components:**
  e.g., state-level energy efficiency and renewable energy measures
- **Construct and execute scenarios**



Exploring optimal technology pathways

- **Harmonize emission factors with EPA assumptions**
- **Incorporate impact factors**
  e.g., health effects, water use, agricultural and ecosystem impacts
- **Optimize actions over impacts**



For more information

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