Exploring Air-climate-energy impacts with GCAM-USA

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Objectives

The Global Climate 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 (ACE) goals. My research focuses on integration of impact factors in GCAM-USA and application to multi-pollutant/multi-media impact analyses, including

- human health (PM and ozone mortality),
- water demands, and,
- climate-related damages (health, environment, e.g., acidification, and eutrophication)
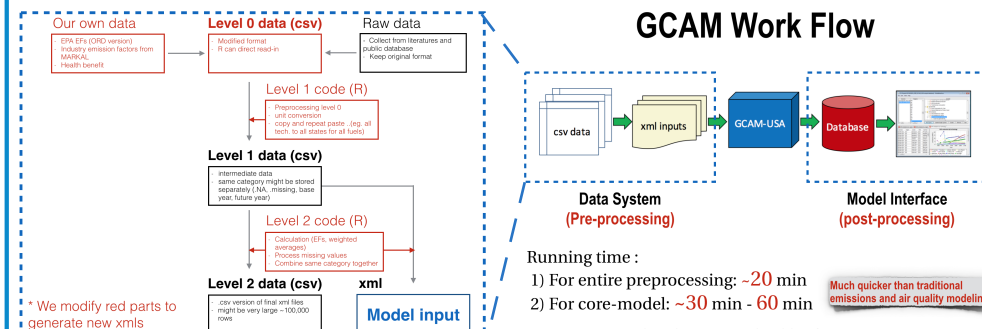
What is an IAM?

Integrated Assessment Models (IAMs) have a long history in climate change mitigation studies. Unlike traditional Chemical Transport Models (e.g. CMAQ), IAMs feature a comprehensive computation framework to reveal the interaction across multiple sectors.

Human activities → Natural climate changes
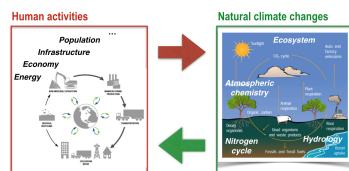
* Source: (left) Wikipedia, (right) Schoolworkhelper

Integrating Impact Factors into GCAM-USA Data System

* We modify red parts to generate new xmls

GCAM Work Flow

csv data → xml inputs → GCAM-USA → Database

Data System (Pre-processing)   Model Interface (post-processing)

Running time :
1) For entire preprocessing: ~20 min
2) For core-model: ~30 min - 60 min

Much quicker than traditional emissions and air quality modeling

NOTE: Running time depends on system and model configurations

Method

Integration of impact factors in GCAM-USA uses a **first-order approximation** to relate changes in emissions to marginal damages. Such reduce-form technique relies on a limited number of full-scale photochemical modeling scenarios yet focuses on a more computationally efficient representation.

$$\Delta Emission(ton) \times Marginal\ Damage\ (\$/ton)$$
$$= Total\ Damages\ (\$)$$

Integrated Assessment Tools
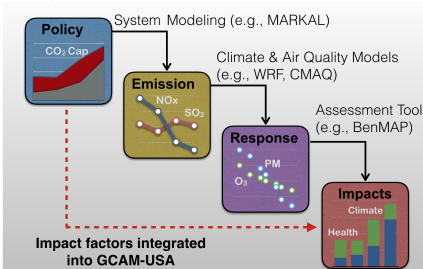
Why GCAM-USA?

Source: PNNL (http://prima.pnnl.gov/)
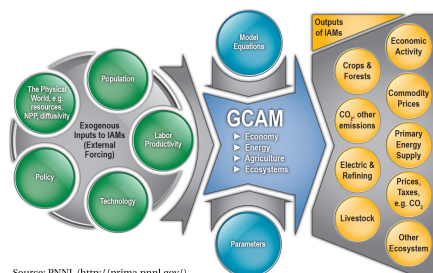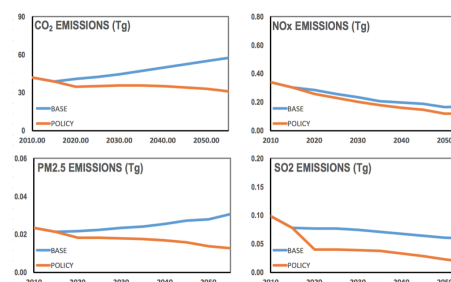
GCMA-USA is a fully global integrated assessment model with additional detail for the fifty U.S. states. Thus,
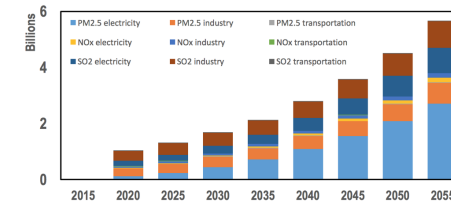
- State-level resolution
- Within a consistent global modeling framework
- Higher level of detail in electricity, transportation, etc.
- State-level policy representation, e.g. CPP, CSAPR

Illustrative State-level Results (North Carolina)

EMISSION TRAJECTORY

PM-RELATED HEALTH BENEFITS ($)

Scenario	Description
BASE	Model default (GCAM reference)
POLICY	Global CO_2 emissions are constrained to meet a trajectory consistent with a 450 ppm CO_2 concentration in 2100

∗ NC only

Findings:

- Under a comprehensive climate policy (policy case), CO_2 and other non-GHG emissions in NC show significant decreasing among all sectors;
- The decreasing PM and its precursors lead to an increasing overall health benefit, among which the emission reduction in the industry sector obtains the largest health benefits.

∗ Results provided for illustrative purposes only

References

[1] F. H. Akhtar R. W. Pinder D. H. Loughlin, D. K. Henze. Glimpse: A rapid decision framework for energy and environmental policy. *Environmental Science and Technology*, 2013.

Future Research

This work is part of the EPA's ongoing GLIMPSE project[1]. Future work includes integrating other impact factors into GCAM-USA, like ozone-related mortalities, life-cycle impacts and climate impacts, so that we are able to better understand more comprehensive co-benefits related to ACM policies in the U.S. in the future.

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