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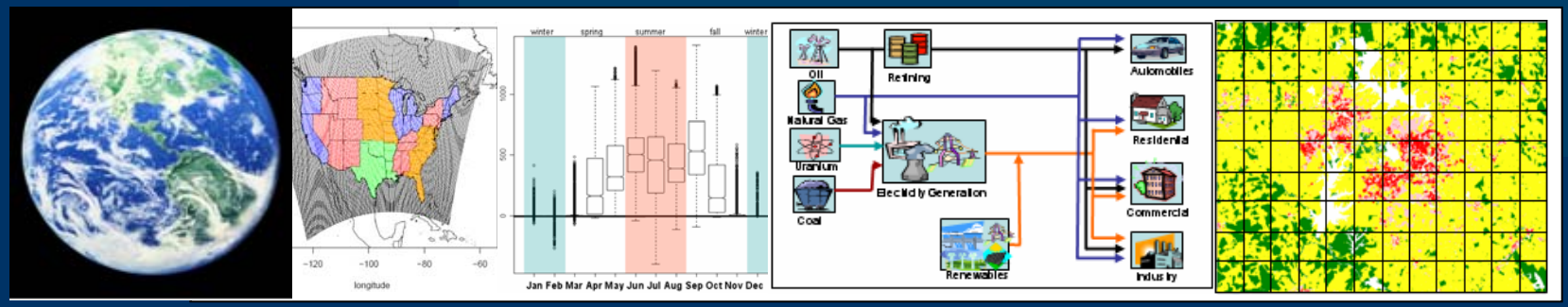
Emissions Projection Developments From the ORD Global Change Air Quality Assessment

Dan Loughlin, Tim Johnson, Carol Shay
Britta Bierwagen, Anne Grambsch and Brooke Hemming
William Benjey



Office of Research and Development
National Risk Management Research Laboratory, RTP, NC

Affiliations

Dan Loughlin, Tim Johnson and Carol Shay

National Risk Management Research Laboratory

Office of Research and Development, U.S. EPA

Britta Bierwagen, Anne Grambsch and Brooke Hemming

National Center for Environmental Assessment

Office of Research and Development, U.S. EPA

William Benjey*

NOAA Air Resources Laboratory

Atmospheric Sciences Modeling Division

*On assignment to the National Exposure Research Laboratory, U.S. EPA

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ORD Global Change Air Quality Assessment

Goal

- Support the U.S. Global Change Research Program and U.S. Climate Change Science Program
- Assess the impacts of global change on future year (e.g., out to 2050) *ambient air quality*
- Consider factors such as:
  - Population growth
  - Economic growth
  - Land use changes
  - Resource constraints
  - Technology and fuel use changes
  - Climate changes (temperature and precipitation)
  - Current and expected national, regional, and state actions

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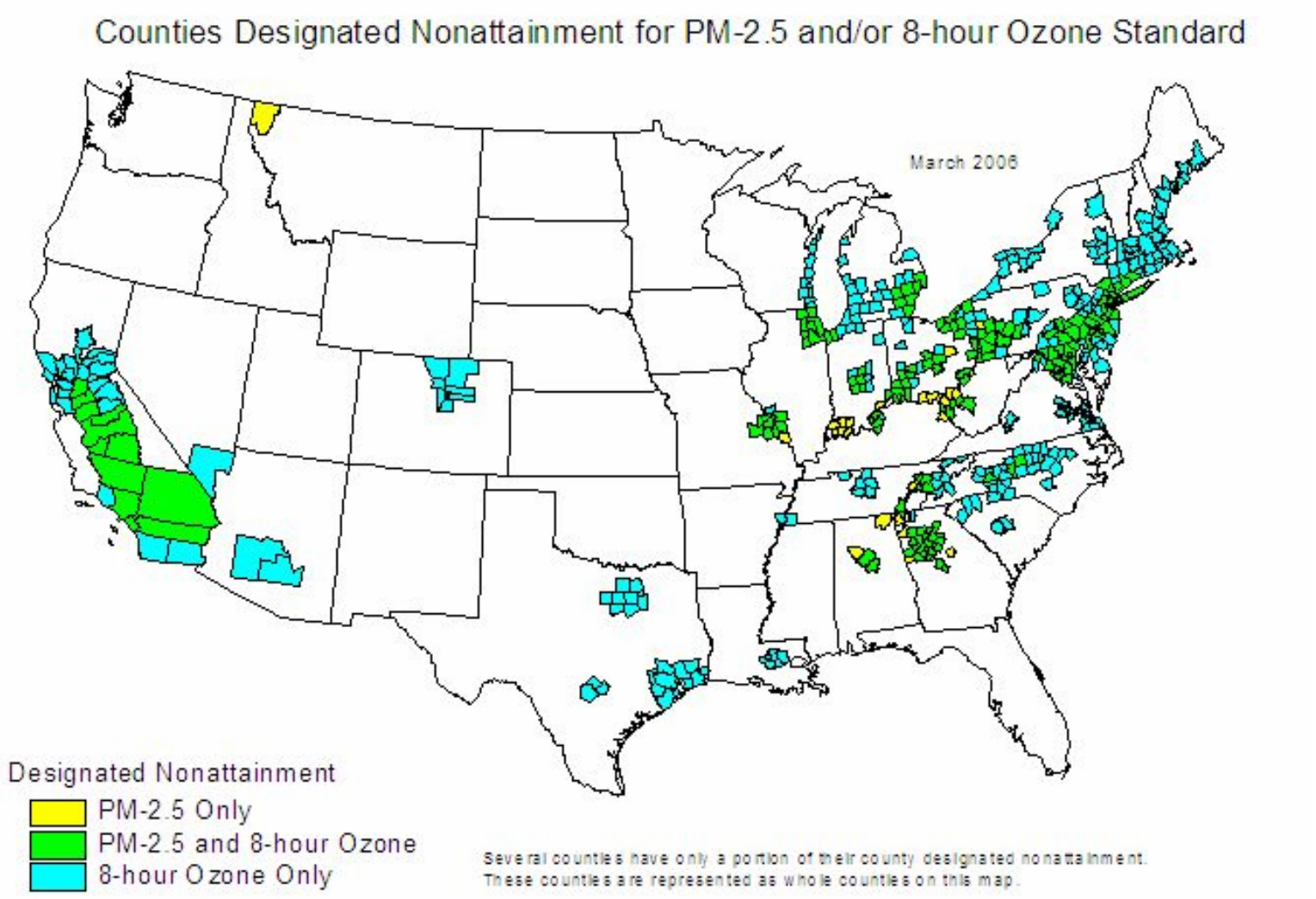
ORD Global Change Air Quality Assessment

Additional Goals

- Serve as a “learning laboratory”
  - Assess and improve state-of-the-art in meteorological, emissions, land use, air quality, and integrated modeling
  - Improve EPA’s ability to assess mid-to-long-range emissions and air quality scenarios
- Develop tools that will assist EPA, regional, state, and local decision-makers
  - Assess options for reducing ambient pollutant concentrations
  - Identify robust approaches for adaptation to global change

Current Non-Attainment Areas



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How clean will our air be in the future?

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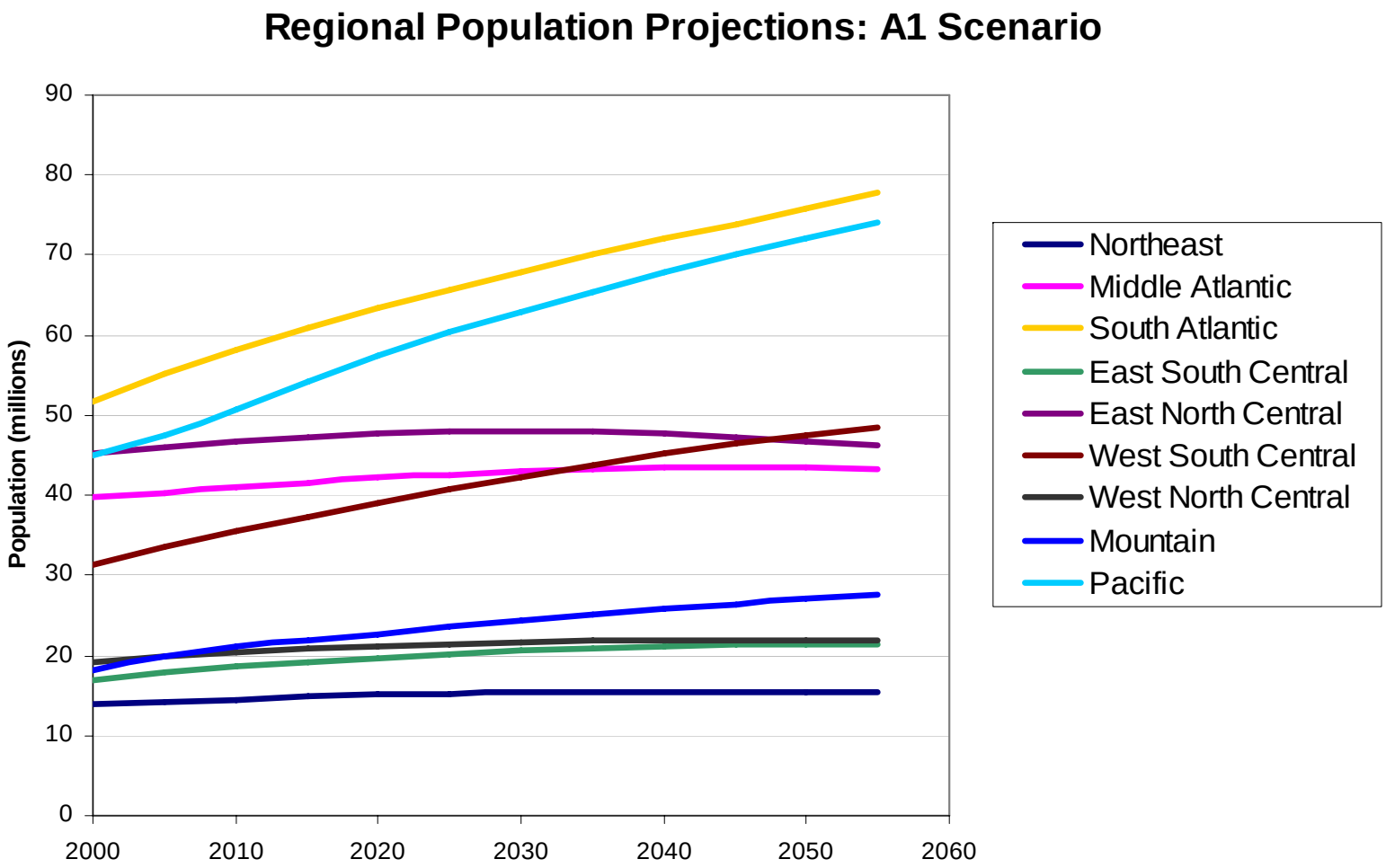
Population Growth Projections



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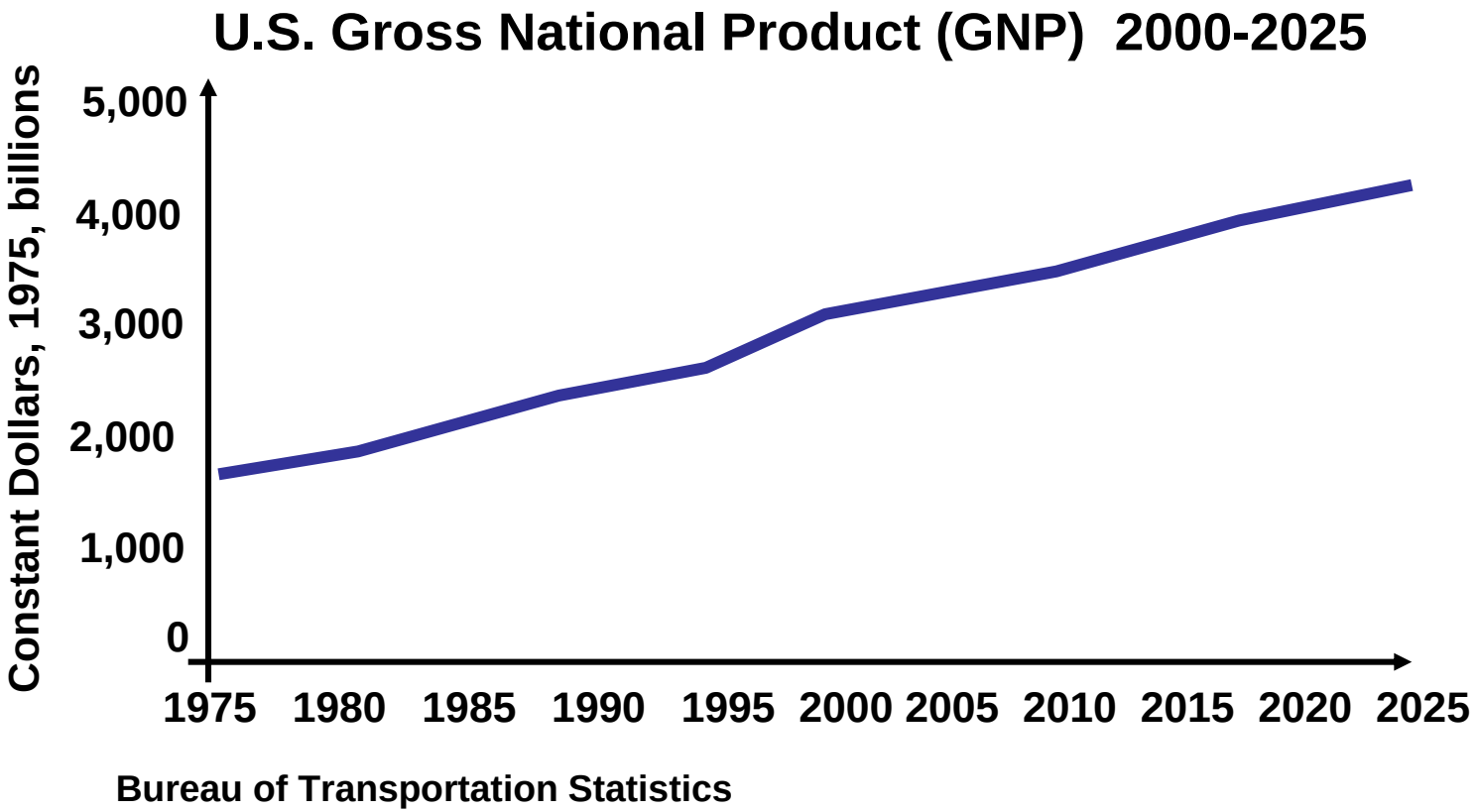
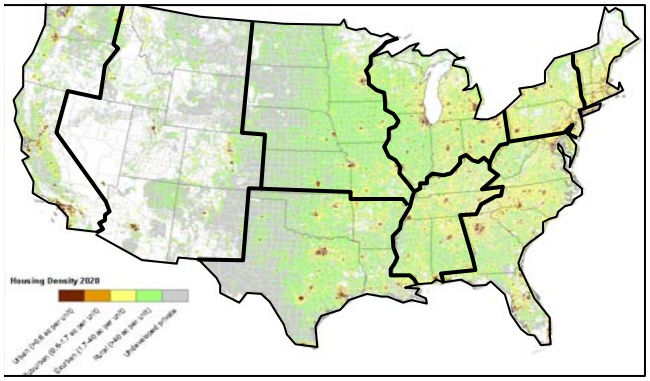
Growth of the Economic Output

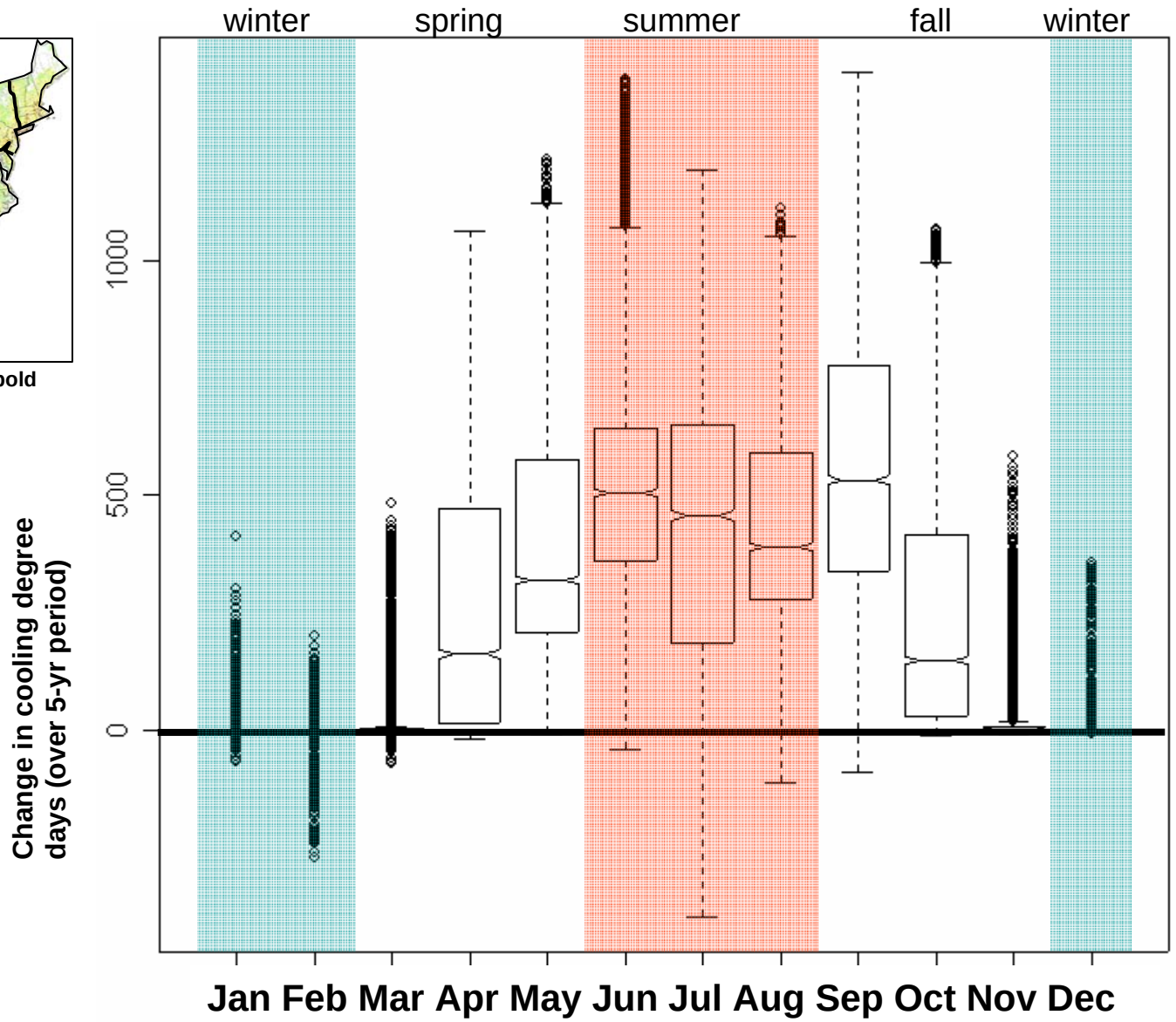


Climate Change Impacts on Demands

Change in cooling degree days: 2000 to 2050



Dave Theobold



Hotter temperatures lead to increased cooling degree days.

Illustrative Results

What is the Future of Air Quality?

From 2000 to 2030:

- Residential cooling demand increase by 115%
- Commercial cooling demand increase by 60%
- Residential heating demand increase by 37%
- Commercial heating demand increase by 30%
- Light duty travel demand increase by 85%

(from DOE's Annual Energy Outlook)

Is air pollution destined to worsen?

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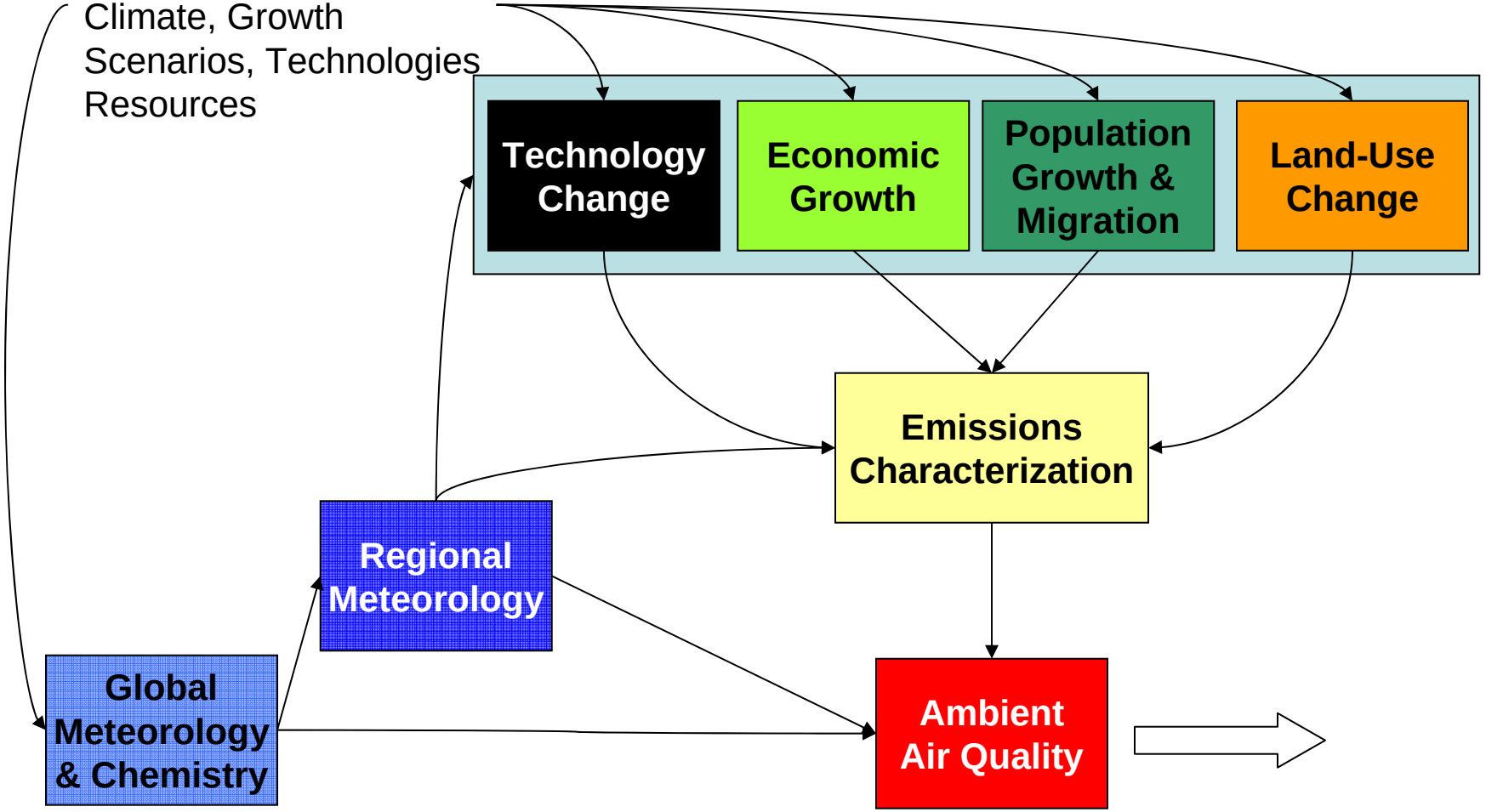
Conceptual Framework

1st Order Effects

Scenario Assumptions

Climate, Growth Scenarios, Technologies Resources



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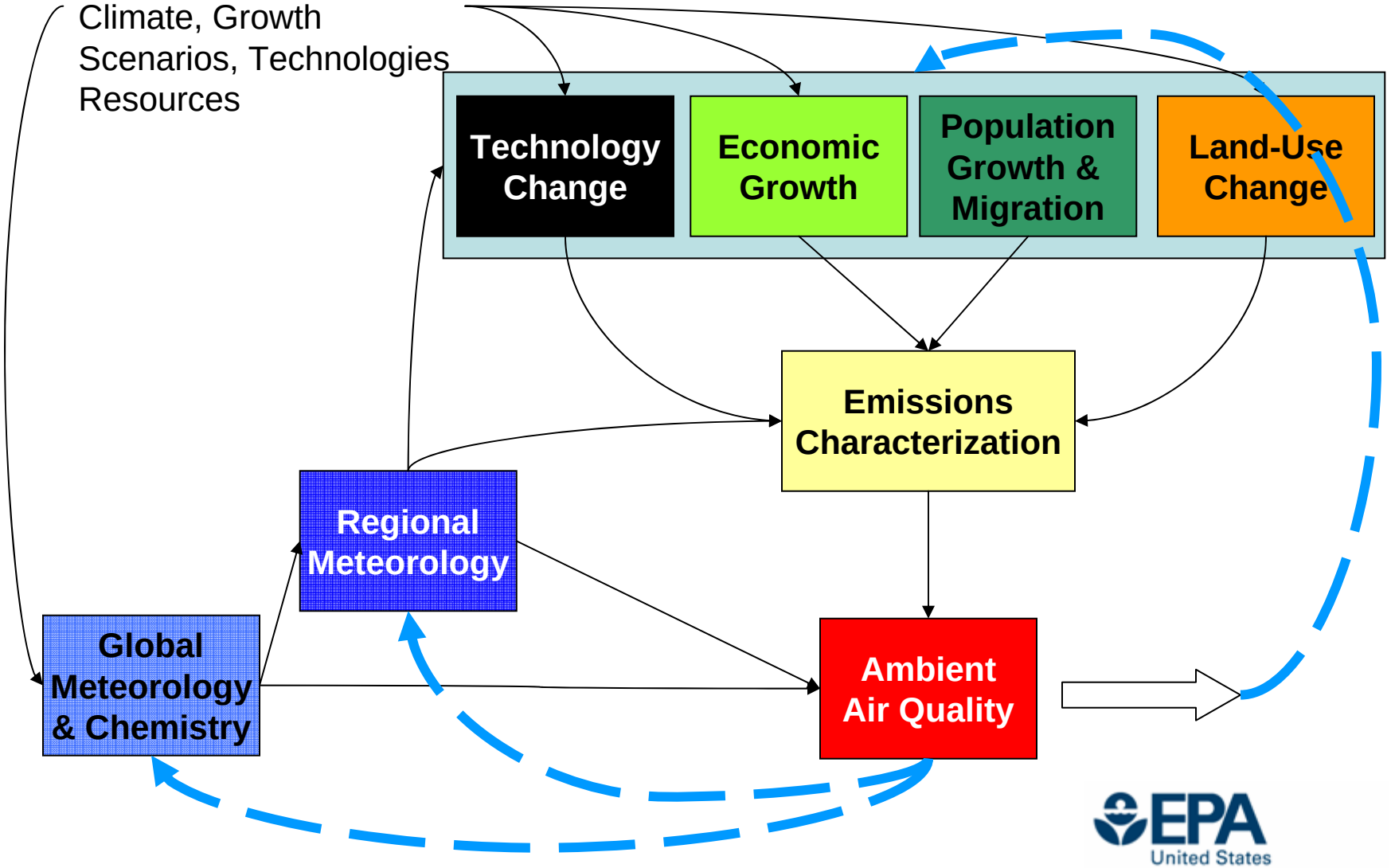
Conceptual Framework

Feedbacks



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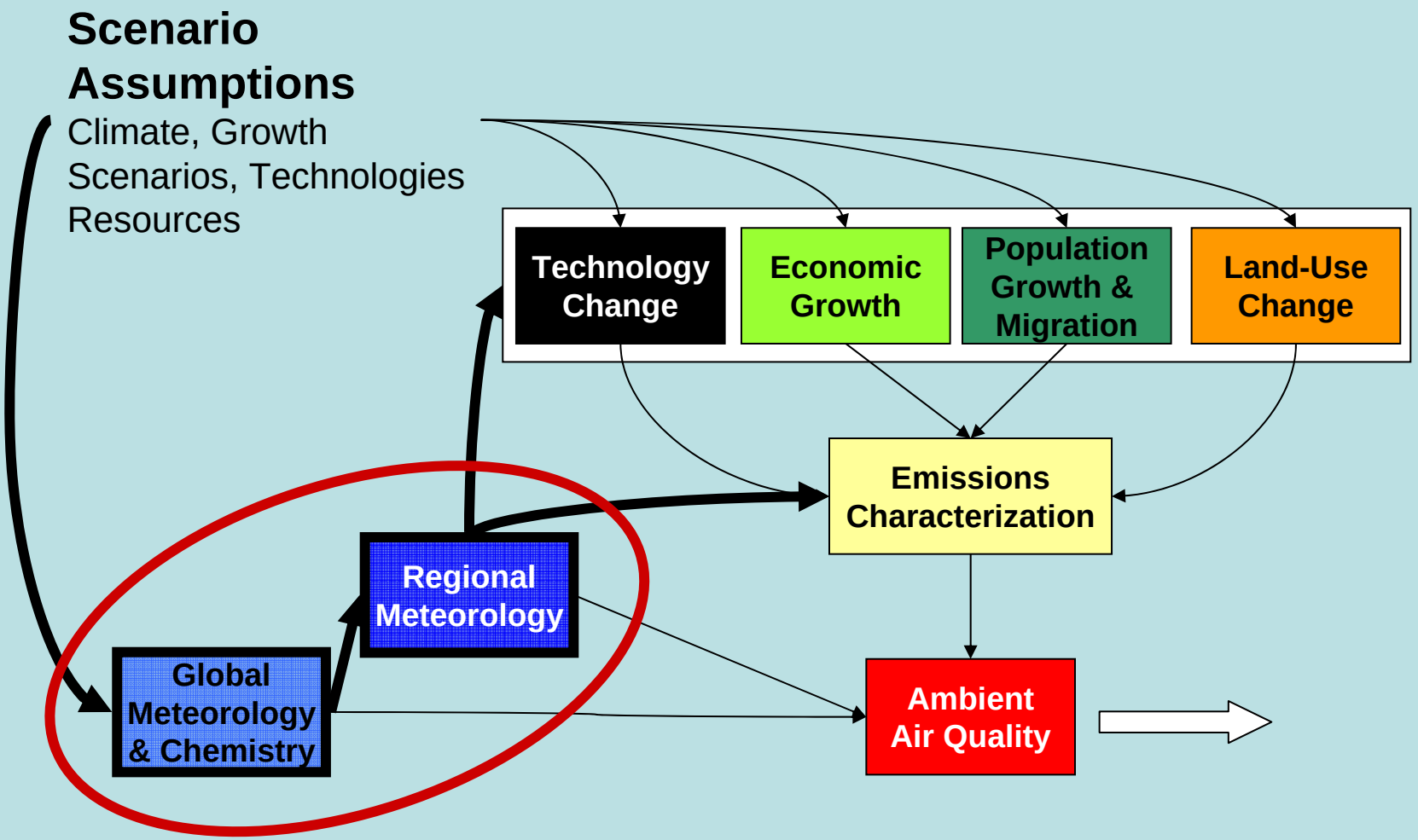
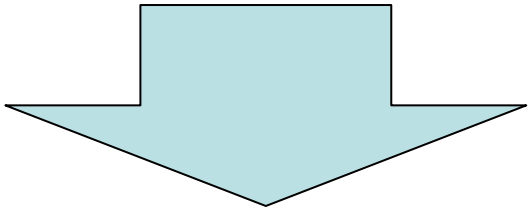
Climate Change Impacts

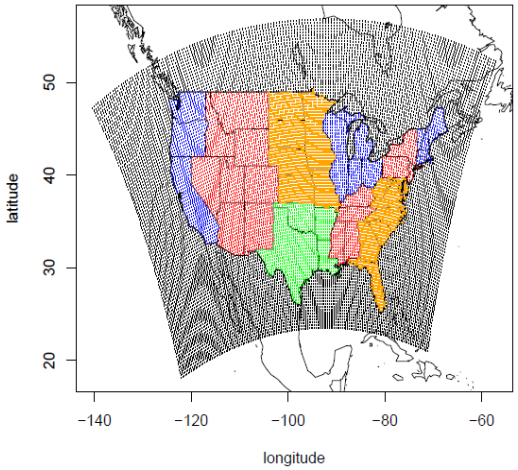
Projecting changes in meteorology and heating and cooling demands by region



Climate Change Impacts

A **global circulation model** (GCM) was used to characterize global meteorology for 2050. An IPCC A1B GHG emissions trajectory was assumed.





GCM results were down-scaled and used as boundary conditions within a **regional-scale meteorological model**, MM5. Runs were made for the 10 years surrounding both 2000 and 2050. MM5 is run at the 36 km grid scale.

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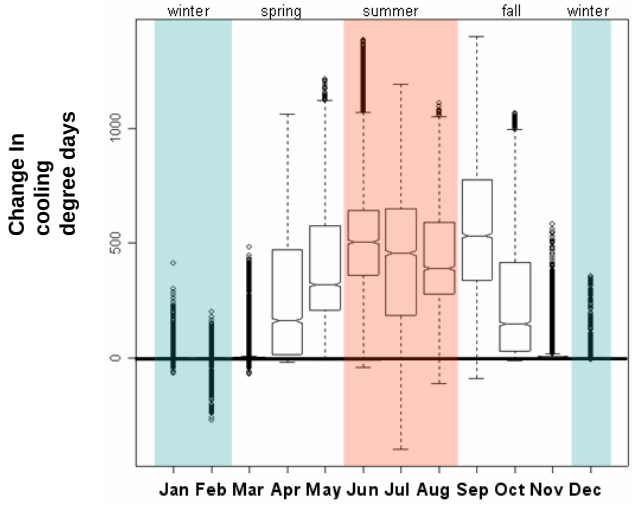
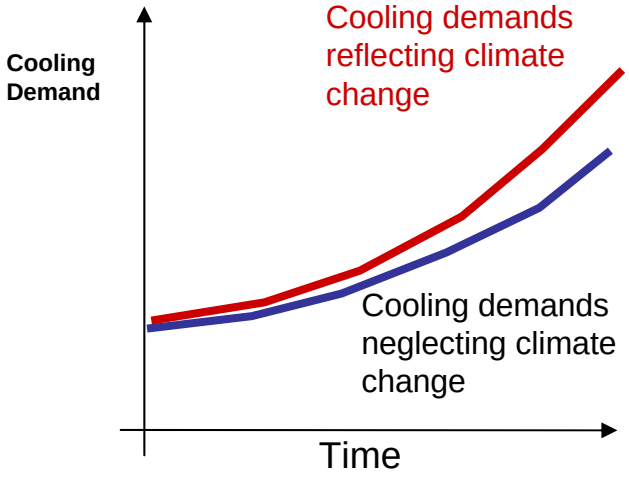
Climate Change Impacts



Temperature values for each grid cell were extracted from the MM5 results and used to calculate the change in **heating and cooling degree days** for each grid-cell in the region



Heating and cooling degree days for each region are being combined with population and housing projections to generate **regional heating and cooling energy service demands**.

(Ongoing work)

Illustrative Results

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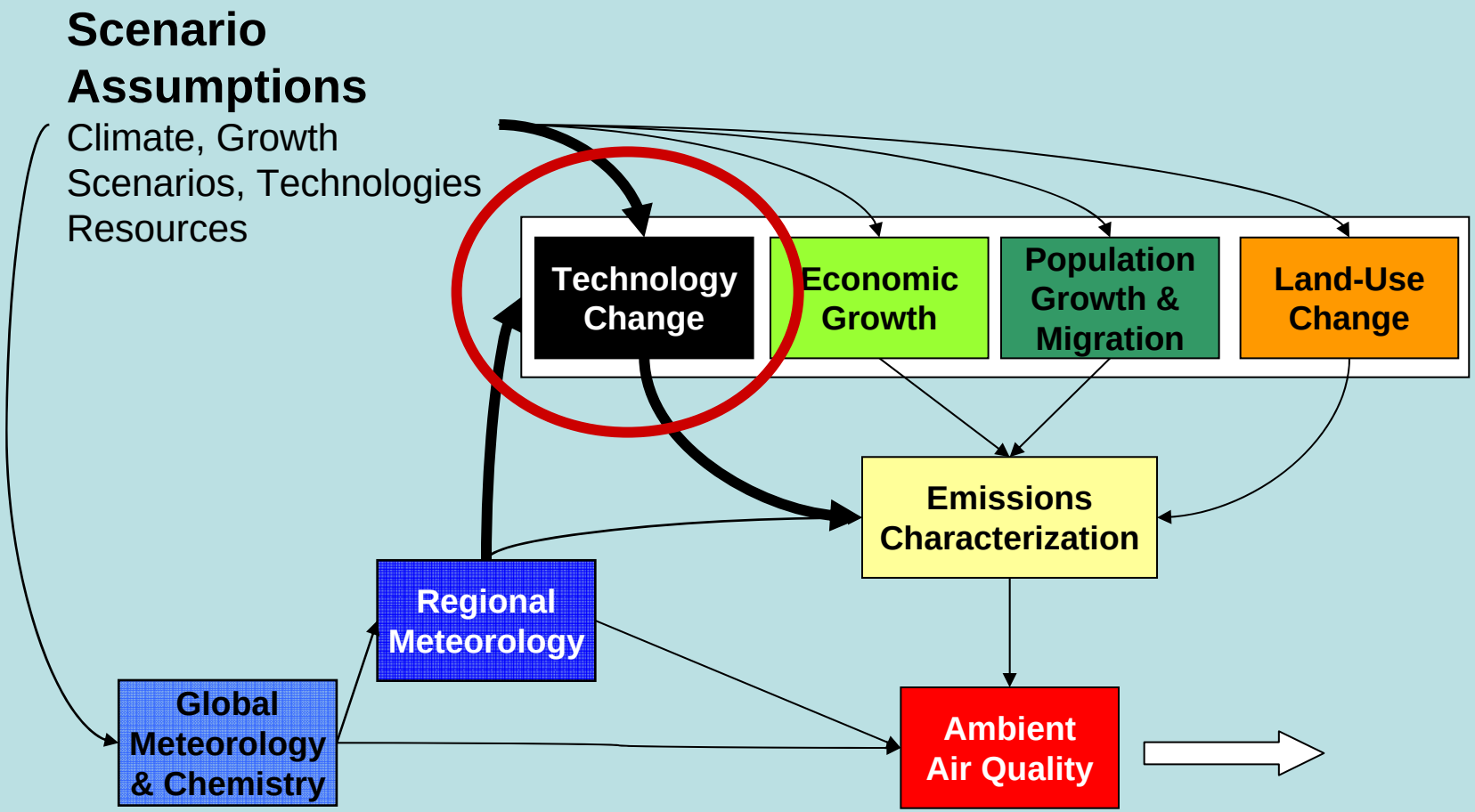
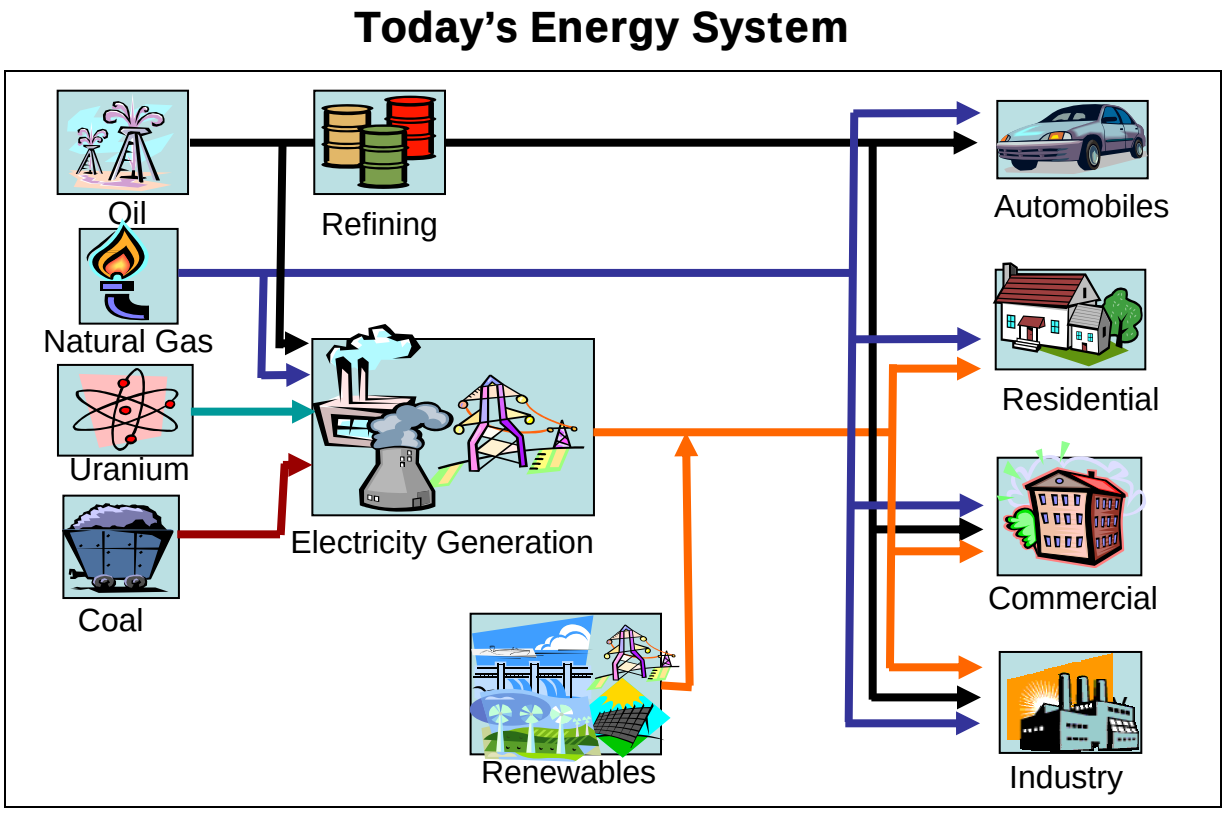
Technology Change & Emissions

Modeling technology change with MARKAL



Why Energy and Air Quality?



Air Pollution

Contribution to anthropogenic emissions:

NOx ~ 95%
SOx ~ 89%
CO ~ 95%
Hg ~ 87%

Air Quality Concerns:
Ozone
PM2.5
Acid deposition
Toxics

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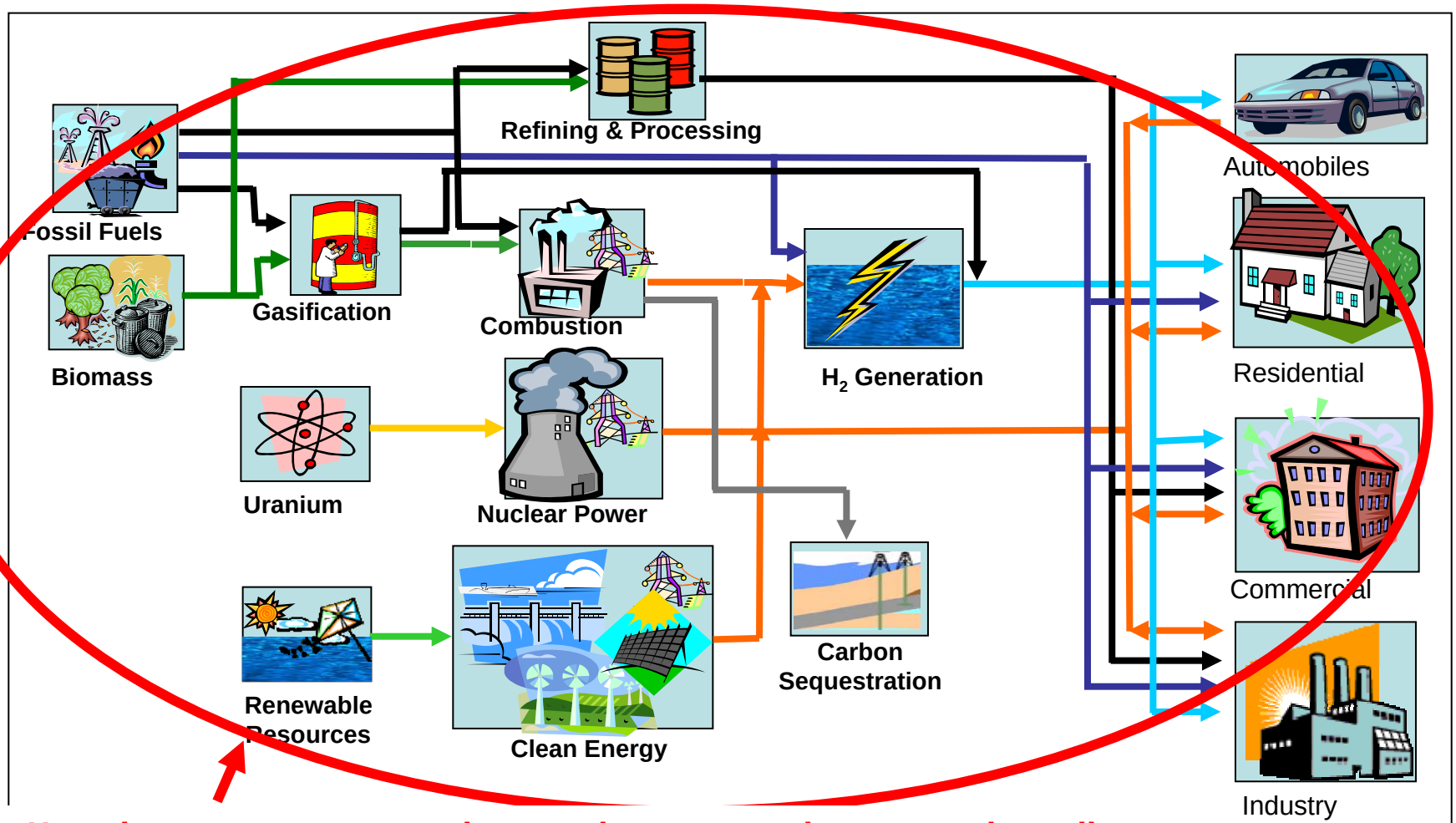
Potential Role of Energy System Technologies



How the energy system evolves can have a great impact on air quality…

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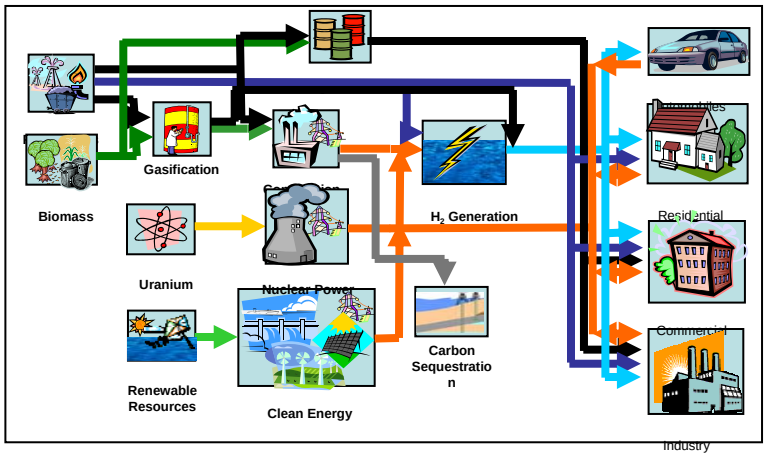
Technology Change Modeling: MARKAL



Future-year energy service demands, current and future technology characteristics, and emissions regulations are modeled in **MARKAL**

MARKAL outputs are processed to generate the following out to 2050:

- **Technology penetrations** for meeting electricity generation, industrial, residential, commercial, and transportation demands
- **Emissions growth factors** at the aggregated SCC level
- **Fuel use** by type and region

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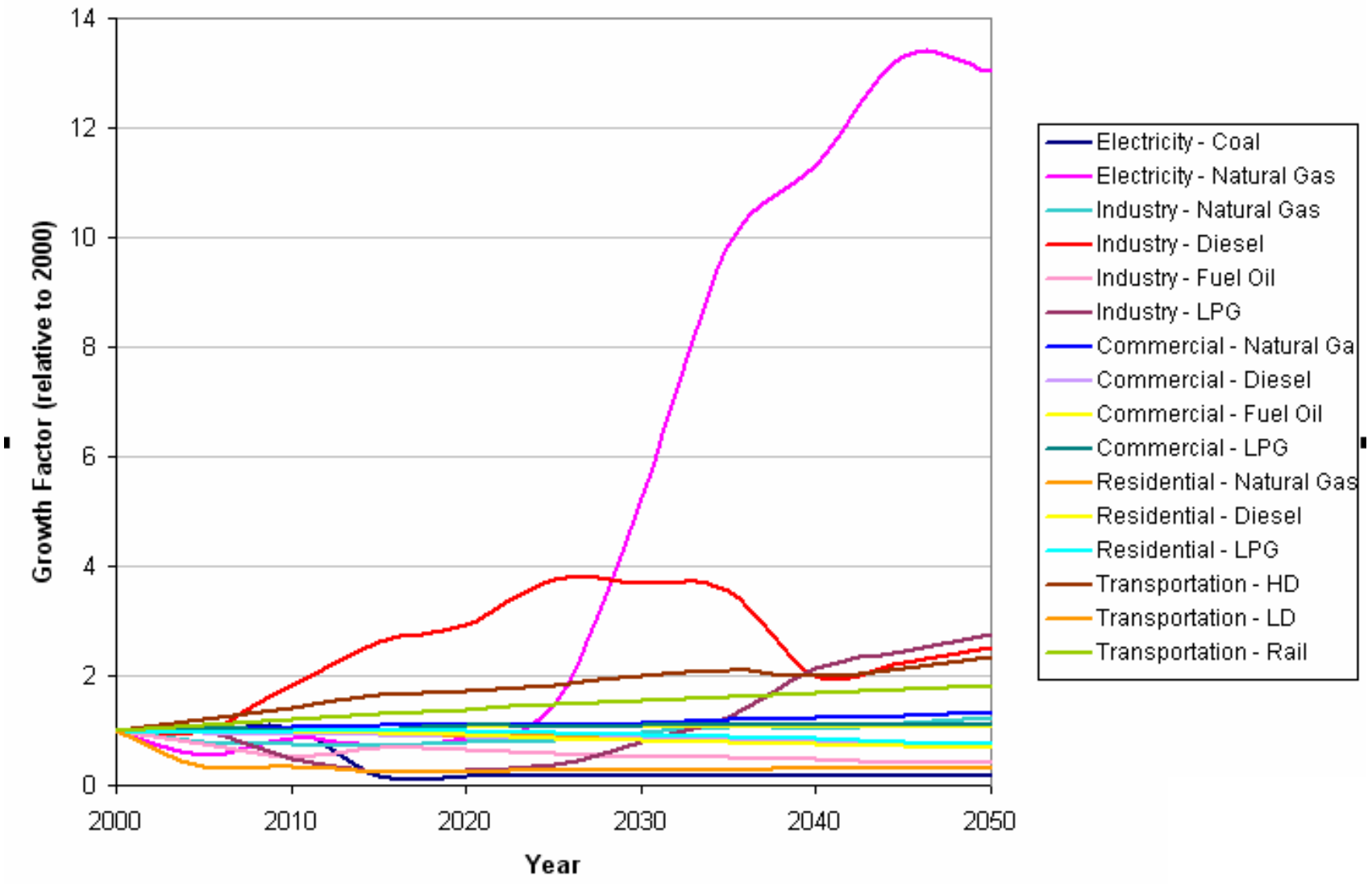
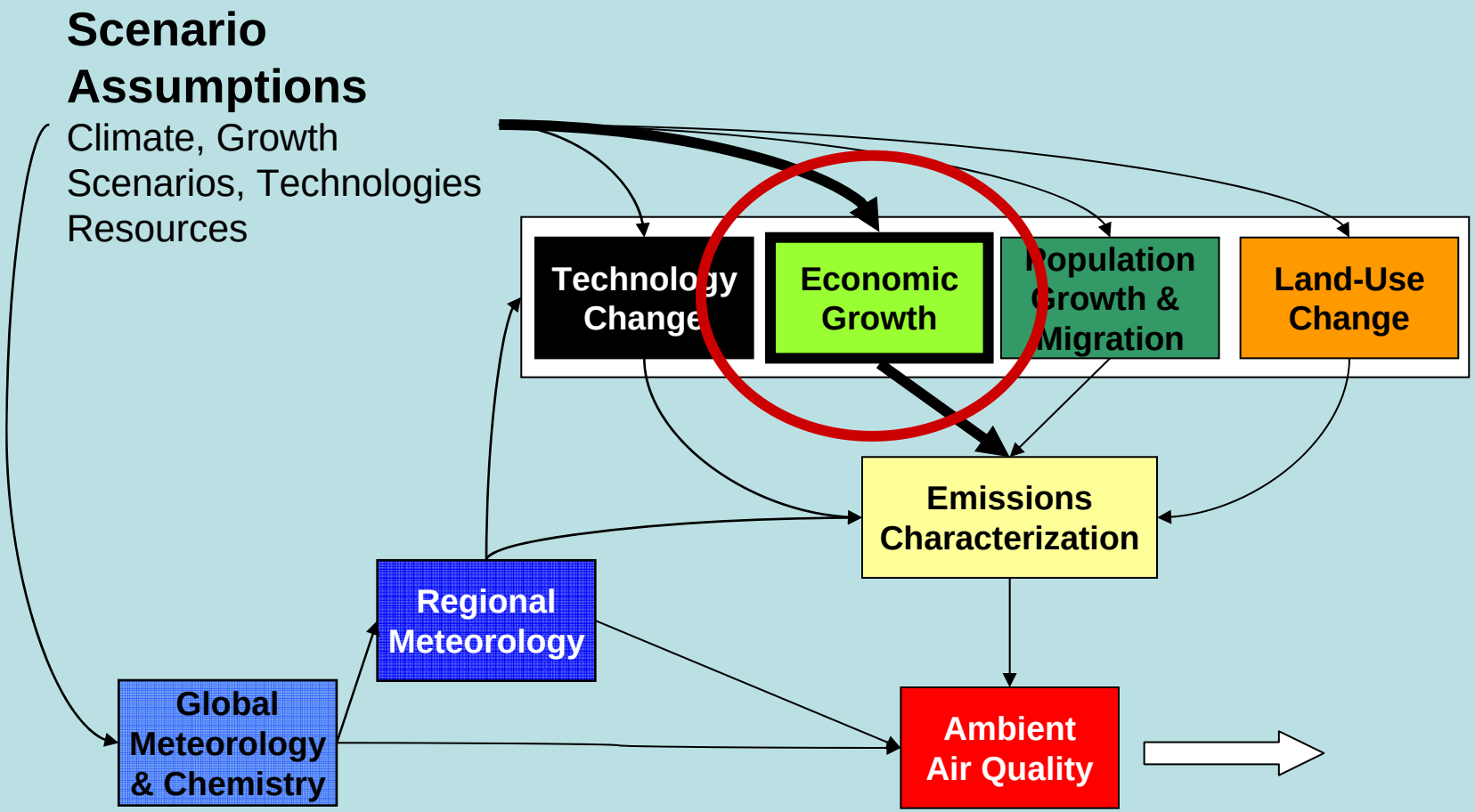
Emissions Growth Factors from MARKAL



Illustrative Results

Economic Growth & Emissions

Projecting economic growth with EMPAX

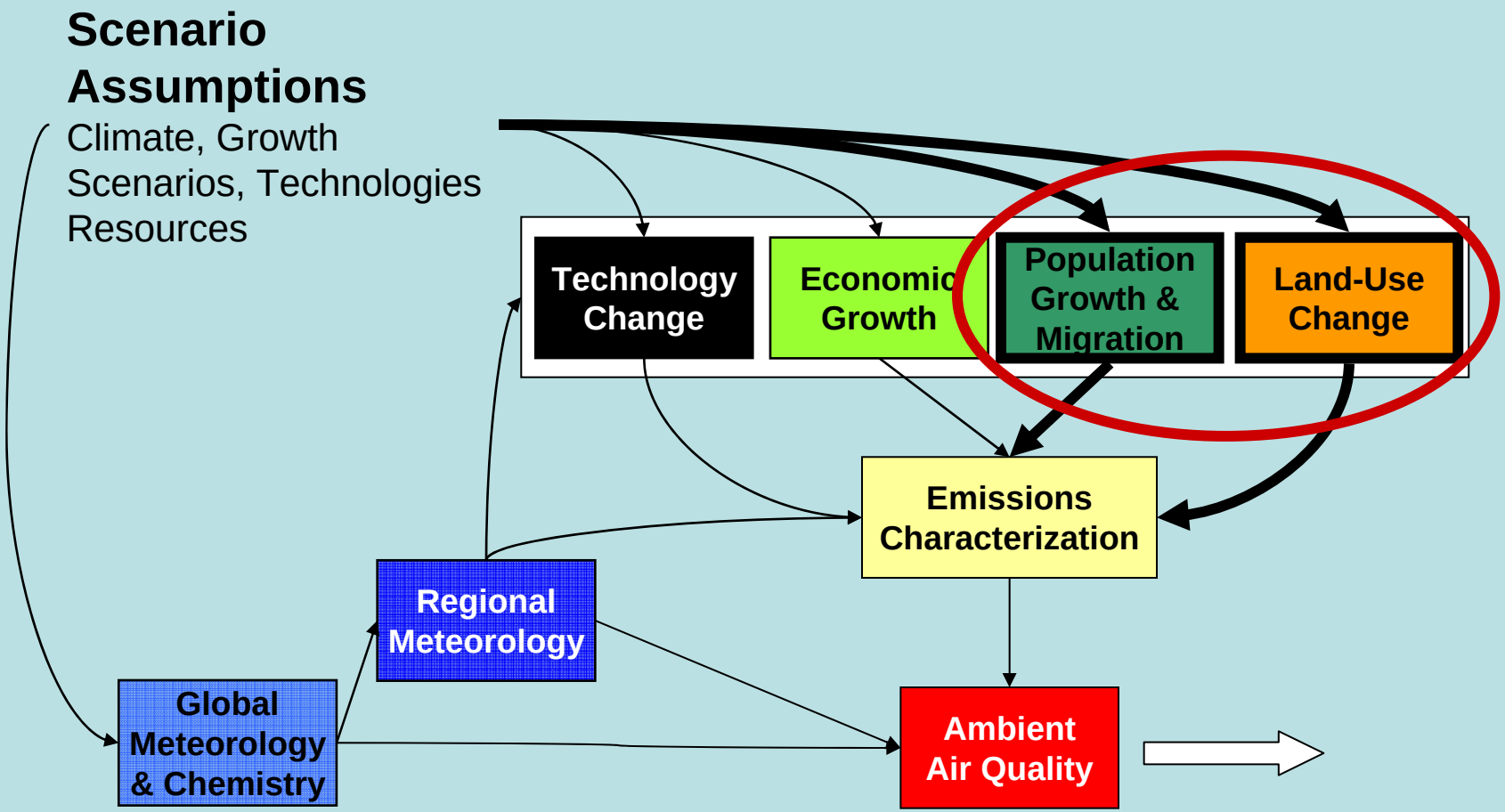


Economic Growth & Emissions

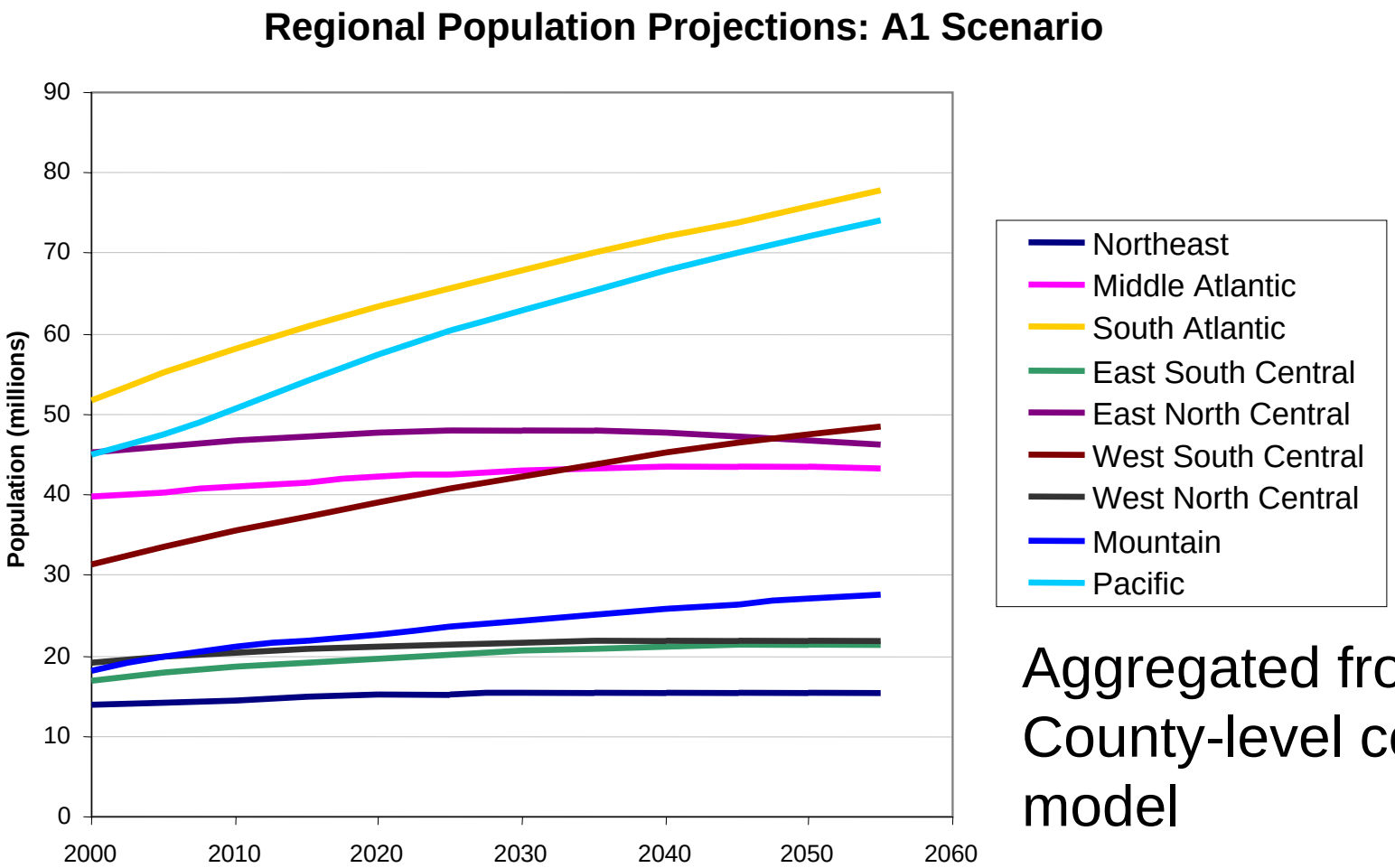
- Options for representing impacts of economic growth
  - Built into tech modeling energy service demands
  - For non-energy emissions?
    - As a function of a surrogate… such as population?
    - Using an economic model to develop surrogates
      - REMI?
      - EMPAX?
    - Address consistency with energy system assumptions
- How do we consider issues such as population movement, industrial location (and shift over time), capital costs and impacts of regulation?

Land Use Modeling

Projecting population growth and migration and land use with ICLUS



Population Growth Projections



Aggregated from County-level cohort model

Illustrative Results

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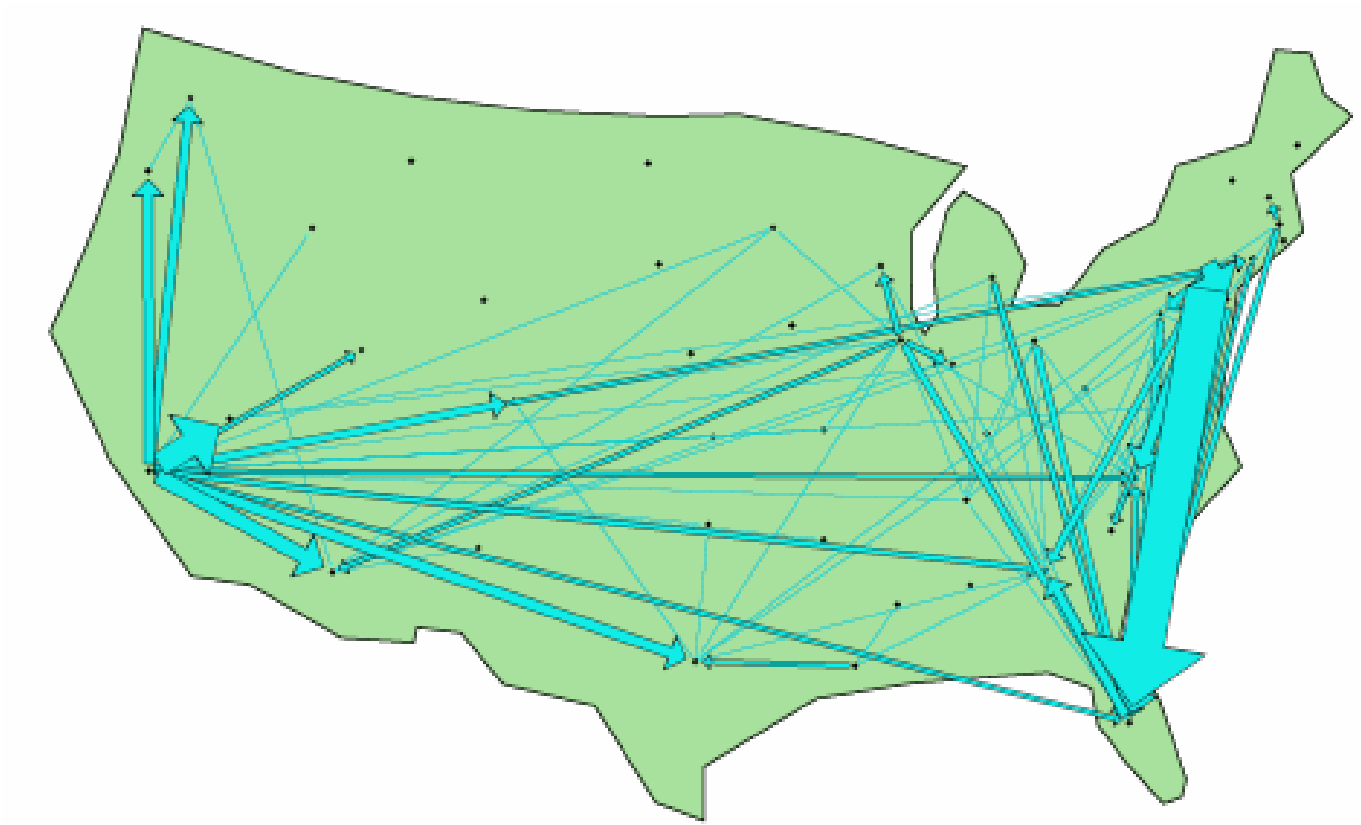
Domestic migration patterns



Net migration: 1995-2000

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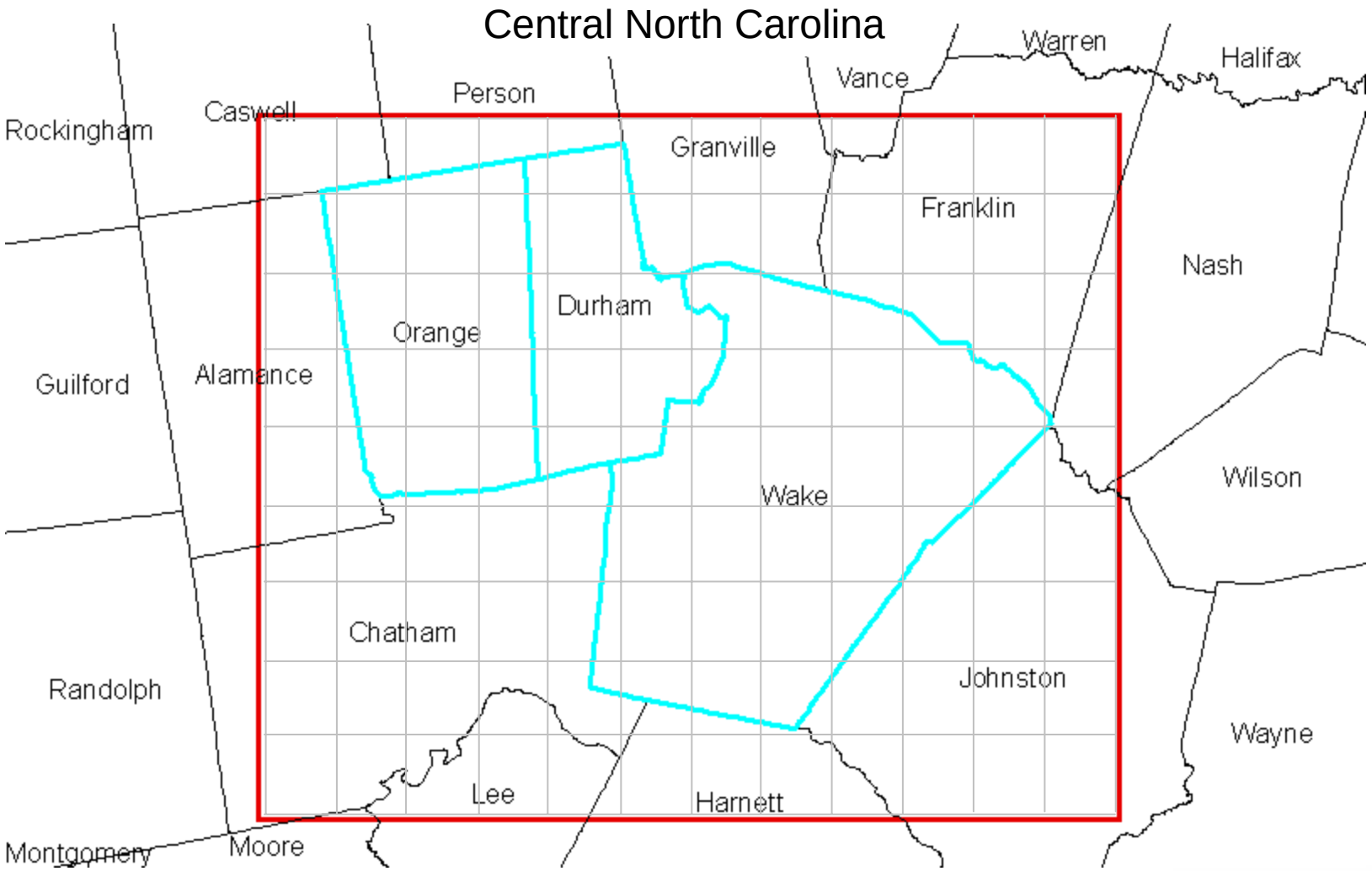
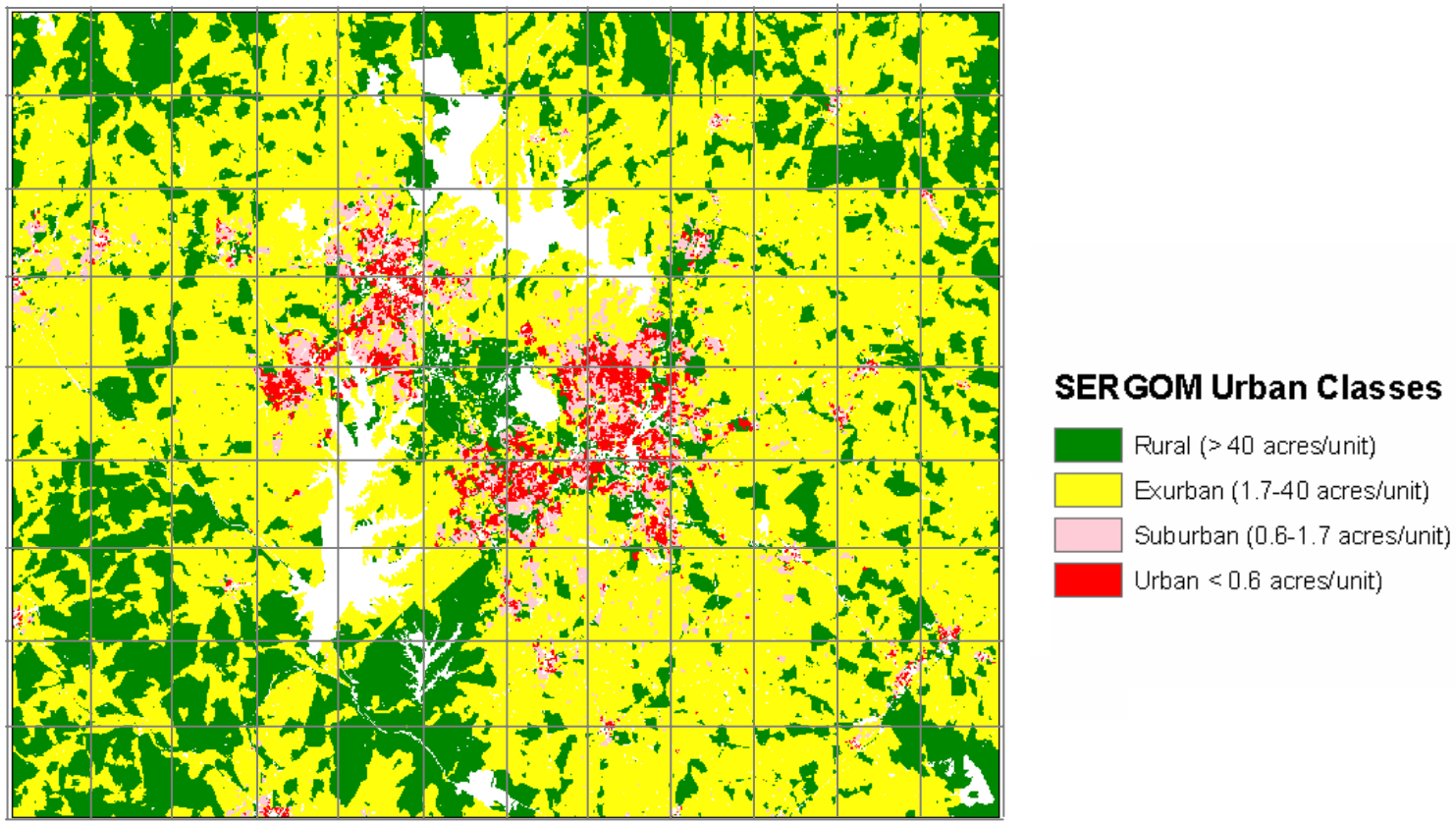
How much does Land Use Change?



How much does Land Use Change? (Grid shown is 12km Resolution)

2000 SERGOM Model Data Urban Classes



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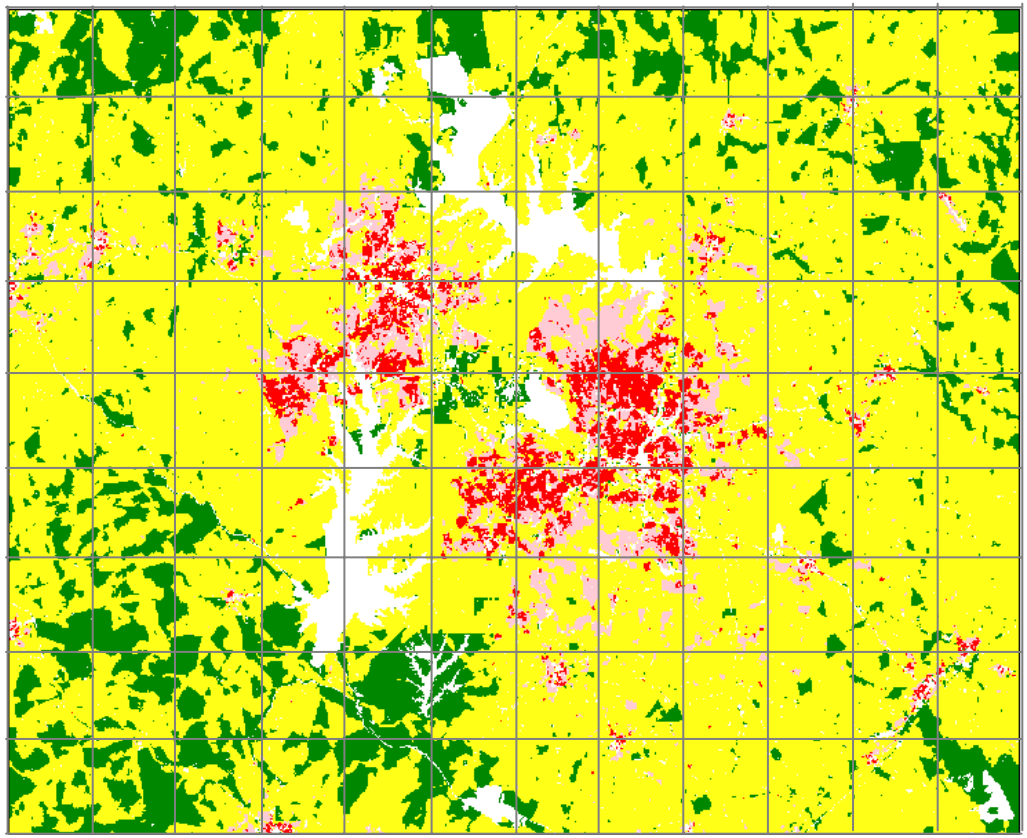
How much does Land Use Change?

2010 SERGOM Model Data Urban Classes



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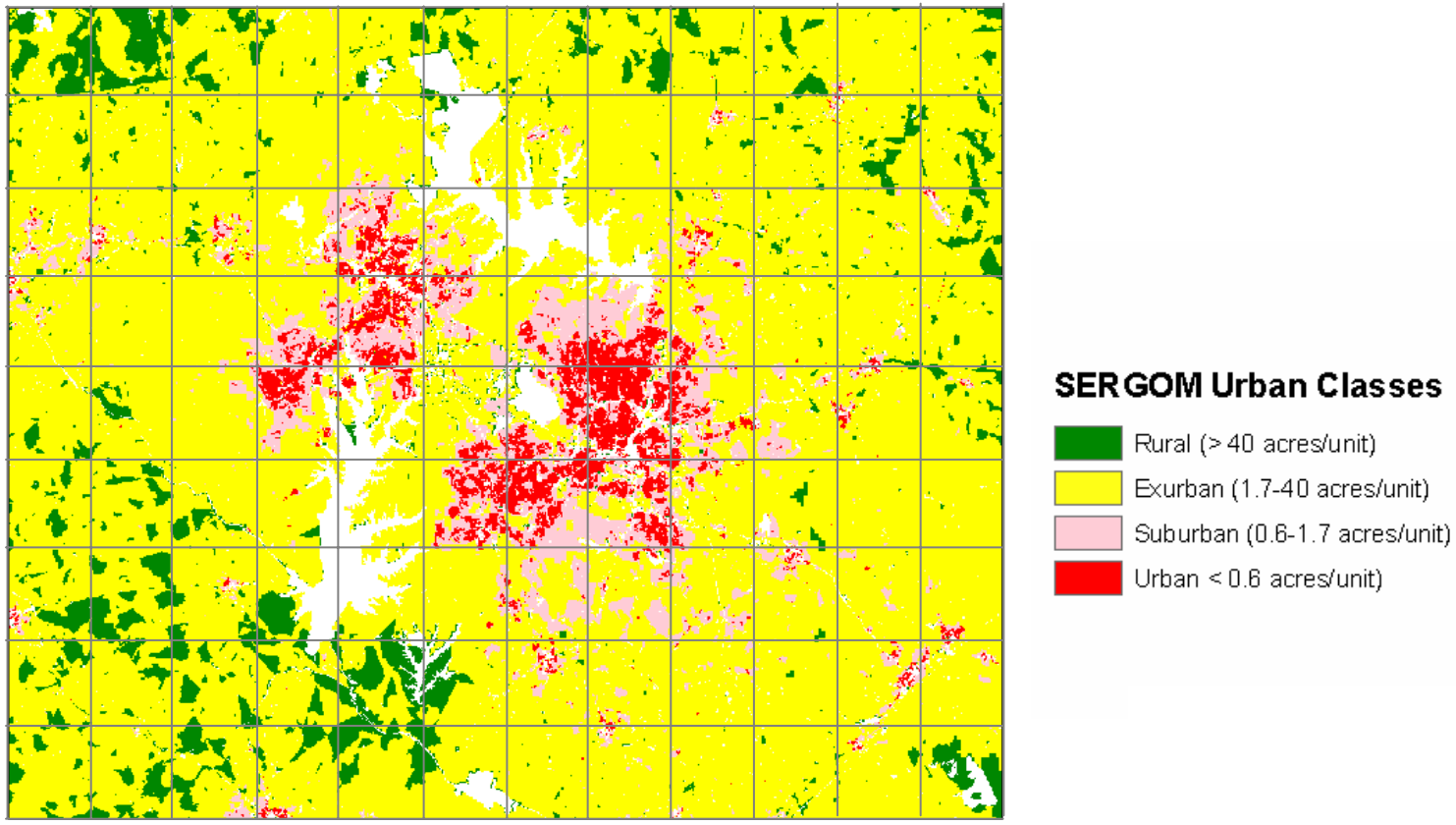
How much does Land Use Change?

2020 SERGOM Model Data Urban Classes



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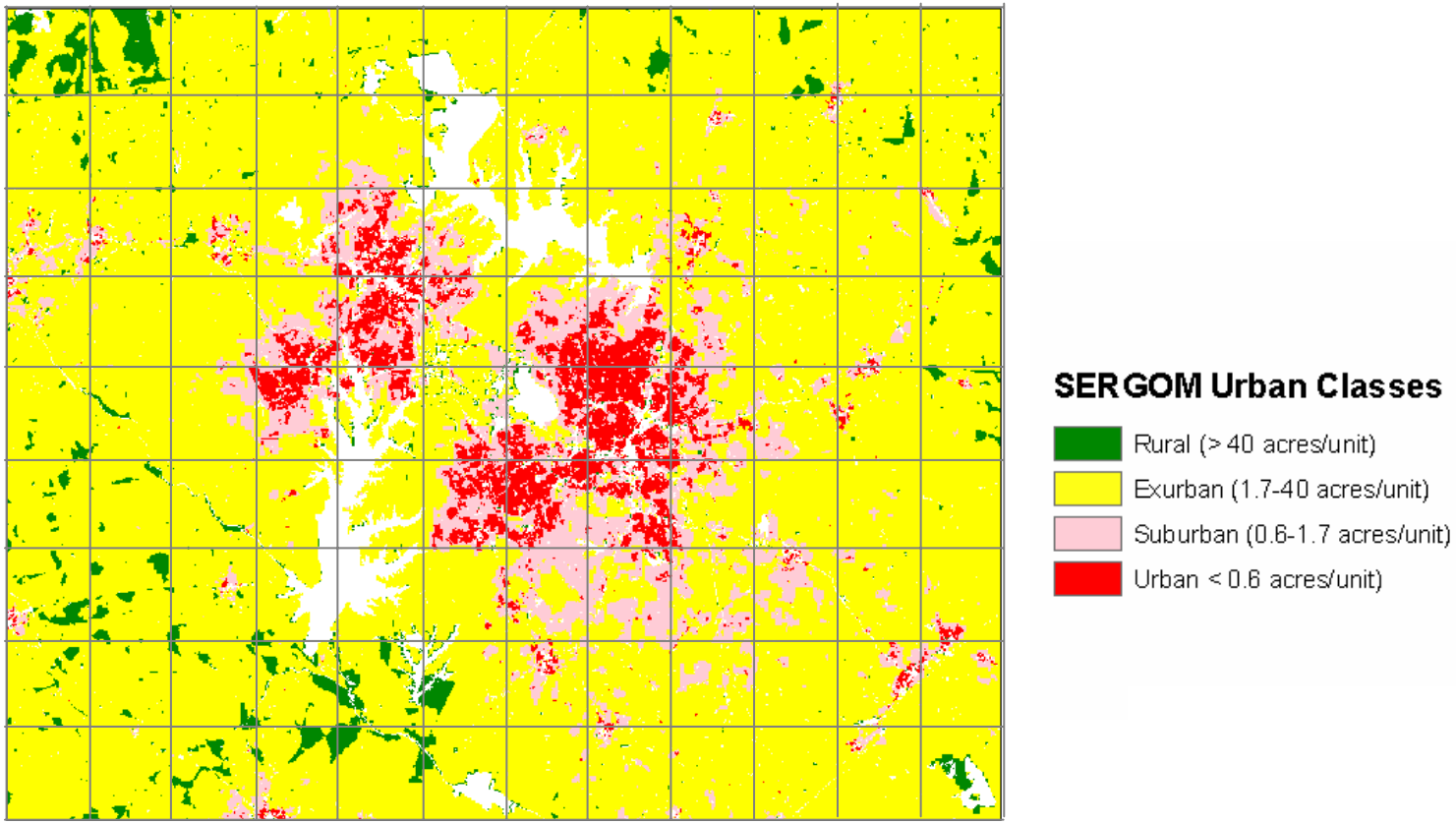
How much does Land Use Change?

2030 SERGOM Model Data Urban Classes



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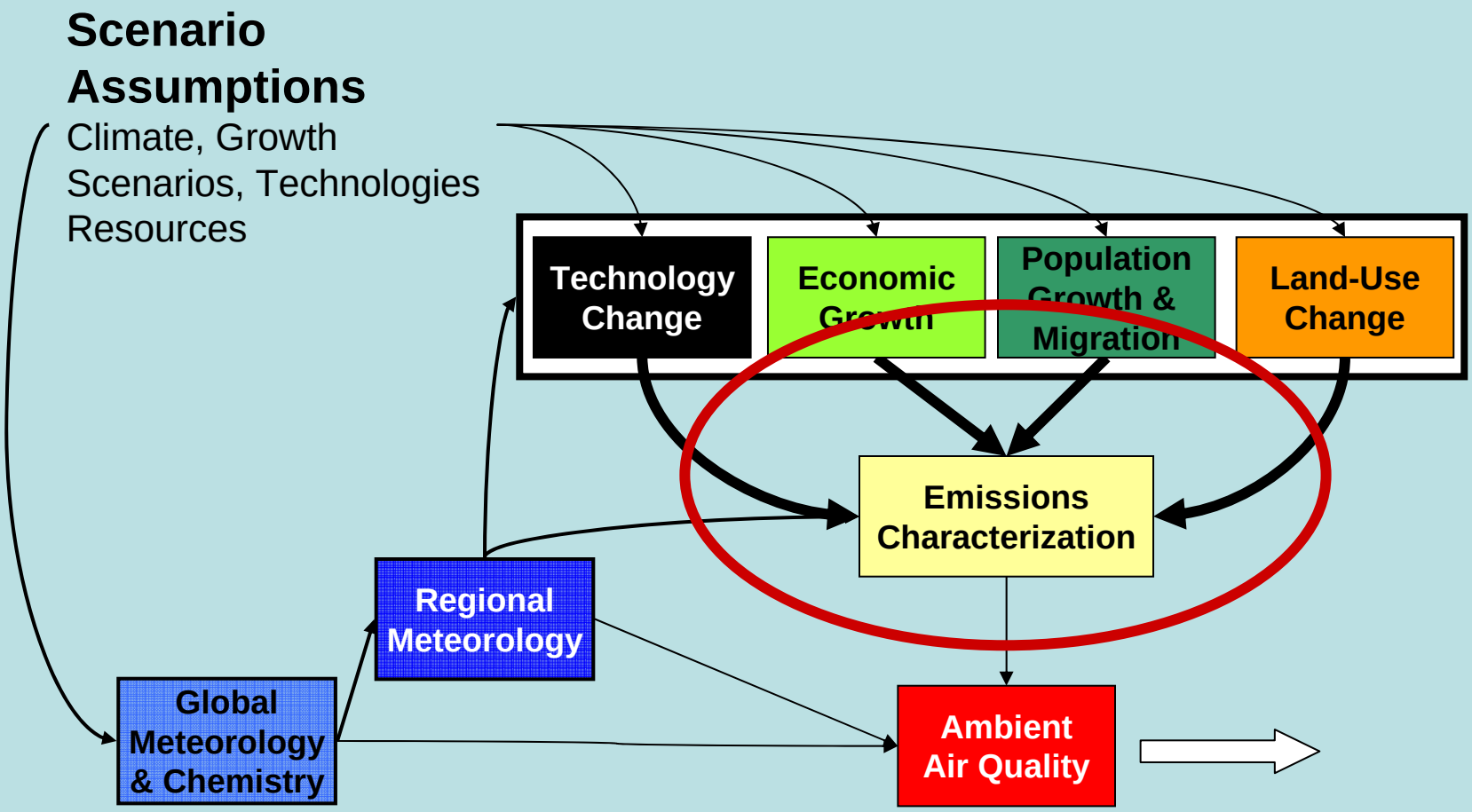
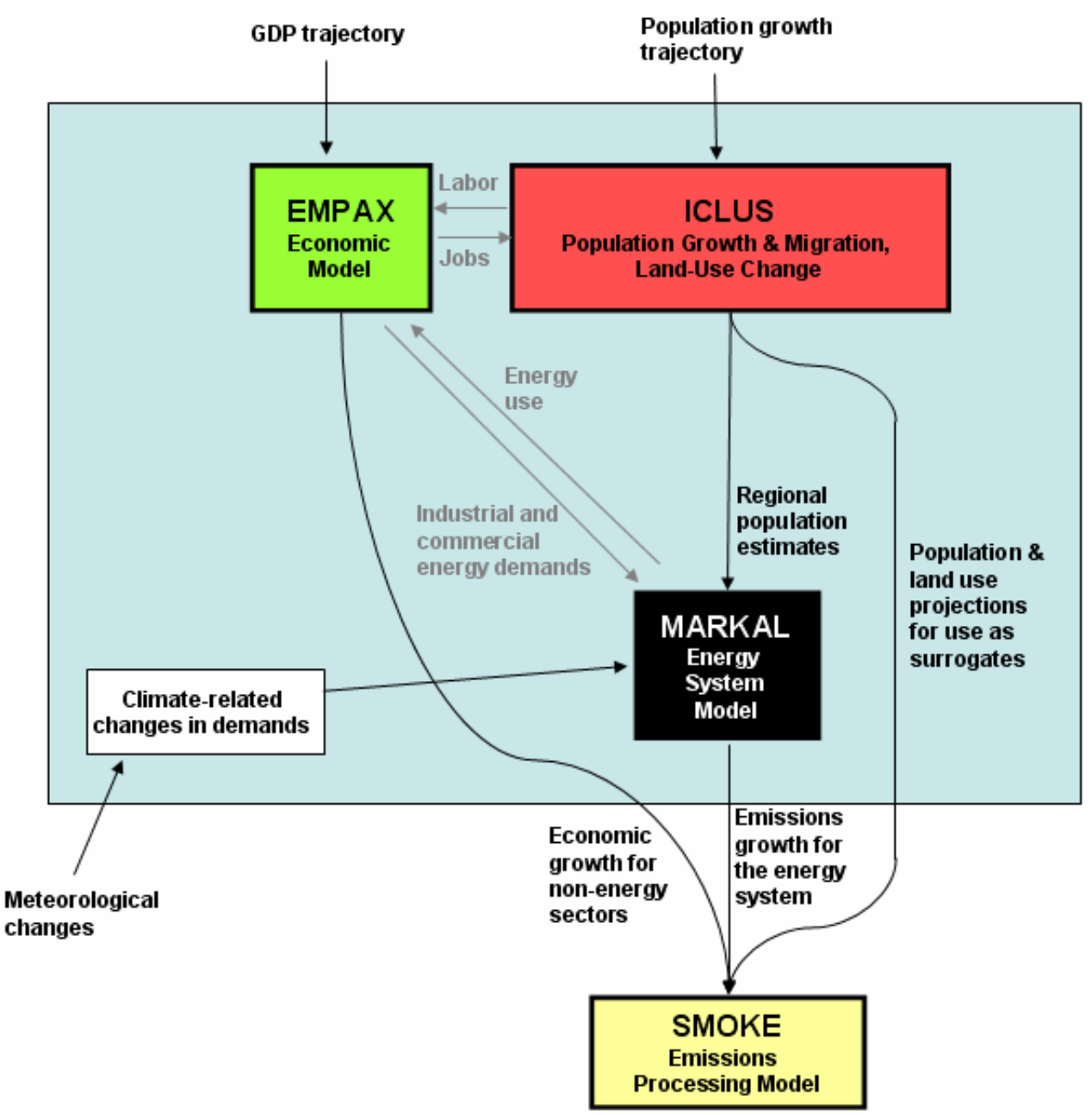
Tying it all Together

Developing internally consistent, realistic future-year spatially allocated emissions projections



Emissions Projection



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Remaining Challenges

- Consistent assumptions across modeling components
- Data “handoffs” between models that may operate at different spatial and temporal scales
- How do we site new sources?
- Support state and local modeling by:
  - incorporating local details (e.g., planned road networks)
  - providing guidance regarding the applicability/utility of these methods for specific applications
- Sensitivity and Uncertainty Analyses
  - are we reducing or increasing uncertainty?

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Expected Applications

- ORD Global Change Air Quality Assessment

  Generate emissions scenarios with alternative assumptions about:

  - U.S. population growth & migration
  - U.S. economic growth
  - Technology change

- Technology Transfer

  Evaluate the utility of this methodology (or components) for OAQPS, regional, and state applications

  - Long-term planning
  - Other modeling applications

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Contact:

Dan Loughlin

Loughlin.Dan@epa.gov

919-541-3928

Disclaimer:
The research presented here was performed under the Memorandum of Understanding between the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) and under agreement number DW13921548. This work constitutes a contribution to the NOAA Air Quality Program. Although it has been reviewed by EPA and NOAA and approved for publication, it does not necessarily reflect the policies or views of these organizations.

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