Integrated Analysis of Climate Impacts

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UNIVERSITY OF
MARYLAND

Outline

- INTRODUCTION AND BACKGROUND
- INTEGRATED ASSESSMENT MODELS (IAMS)
- ANALYSES EXAMPLES
- EVOLUTION OF CLIMATE SCIENCE AND IAMS
- A CASE STUDY- INTENDED NATIONALLY DETERMINED COMMITMENTS

Integrated Assessment Models (IAMs) Provide Strategic Insight

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- IAMs are designed to provide strategic insights about the interaction between complex systems elements, Human-Earth System.
- IAMs are analogous to climate models in providing mostly future projections.
  - They do not forecast short-term conditions
  - They were designed to describe long-term, multi-decades to centennial time scales scenarios.
  - And, like climate models, they have been evolving to include more details needed to address more sophisticated science question and future scenarios.
- IAMs were not designed to model the very fine details, e.g.
  - Electrical grid operation
  - Daily oil market price paths.
  - However, they have been coupled with highly detailed models.
- IAMs also span a wide range with highly varied levels of complexity, spatial and temporal resolution.

IAMs Original Focus- Costs-Benefits Analyses

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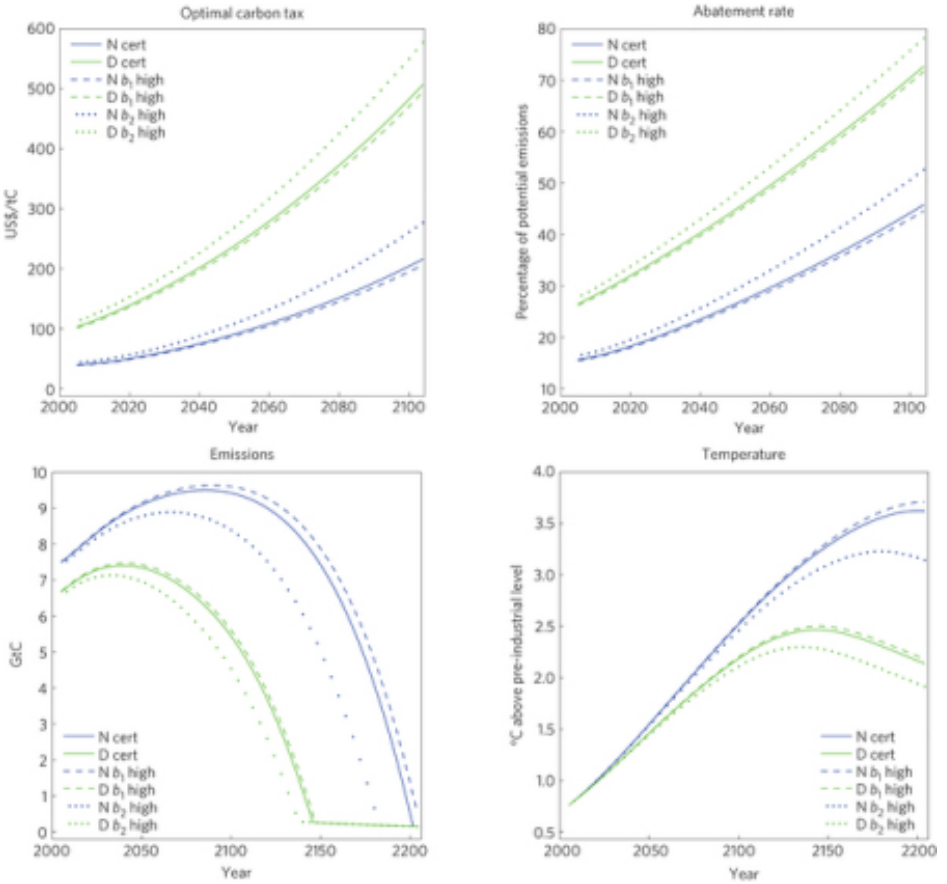
- What is the socially optimal emissions paths?
- What is the optimal global carbon tax/price?
- What is the optimal change in climate conditions for differing development pathways?
- How do we monetize climate damages, many of which do not pass through markets?
- How do we discount costs and benefits?

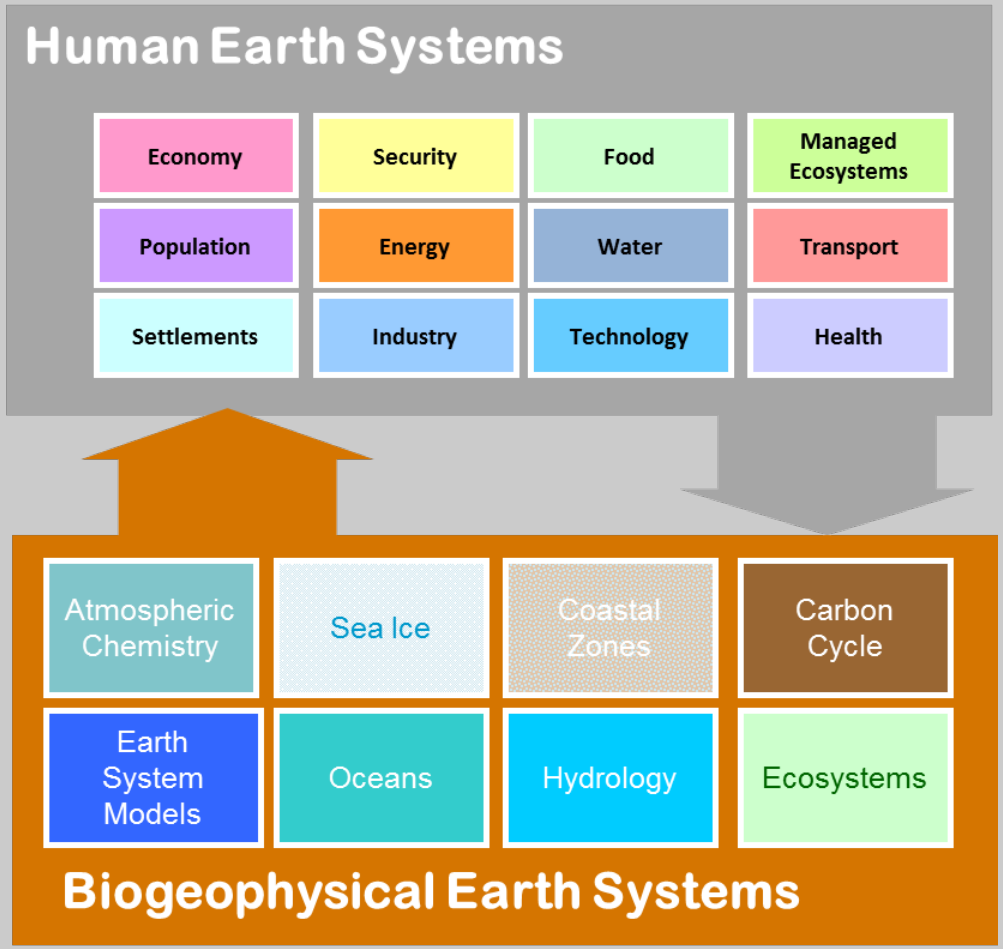


Source: Crost, Benjamin, and Christian P. Traeger. "Optimal CO2 mitigation under damage risk valuation." *Nature Climate Change* (2014).

Integrated Assessment Models (IAMs)

IAMs integrate Human and natural Earth system science.

- Provide insights that would be otherwise unavailable from disciplinary research alone.
- Capture interactions between complex and highly nonlinear systems.
- Provide natural Earth System models with information about human systems such as GHG emissions, land use and land cover.
- Support national, international, regional, and private-sector assessments and decisions.
- Serve as science-based decision support tools.



The Major Integrated Assessment Models

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

The Global Change Assessment Model (GCAM) – An Example

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Automation System

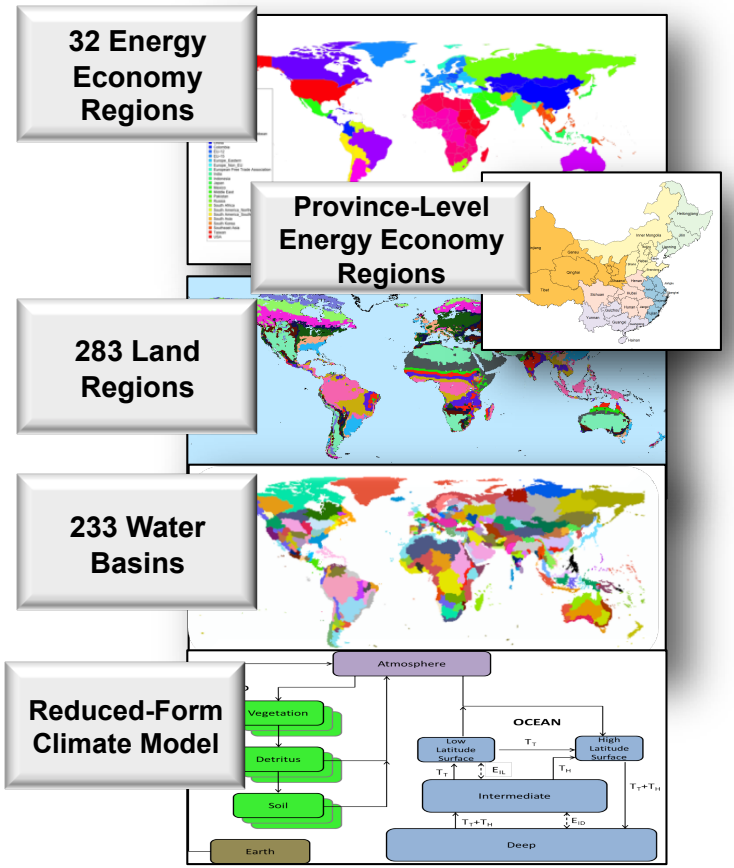
Data Development System

EIA	IEA
GTAP	HYDE
SAGE	OECD
FAO	IMAGE
MIRCA	Aquastat
USDA	USGS
CDIAC	IIASA

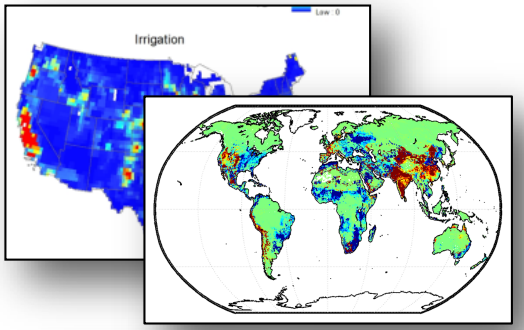
Others ……

Papers: Houghton, Rogner, …….

GCAM Core: Dynamic Integration



Disaggregation Models/Methods

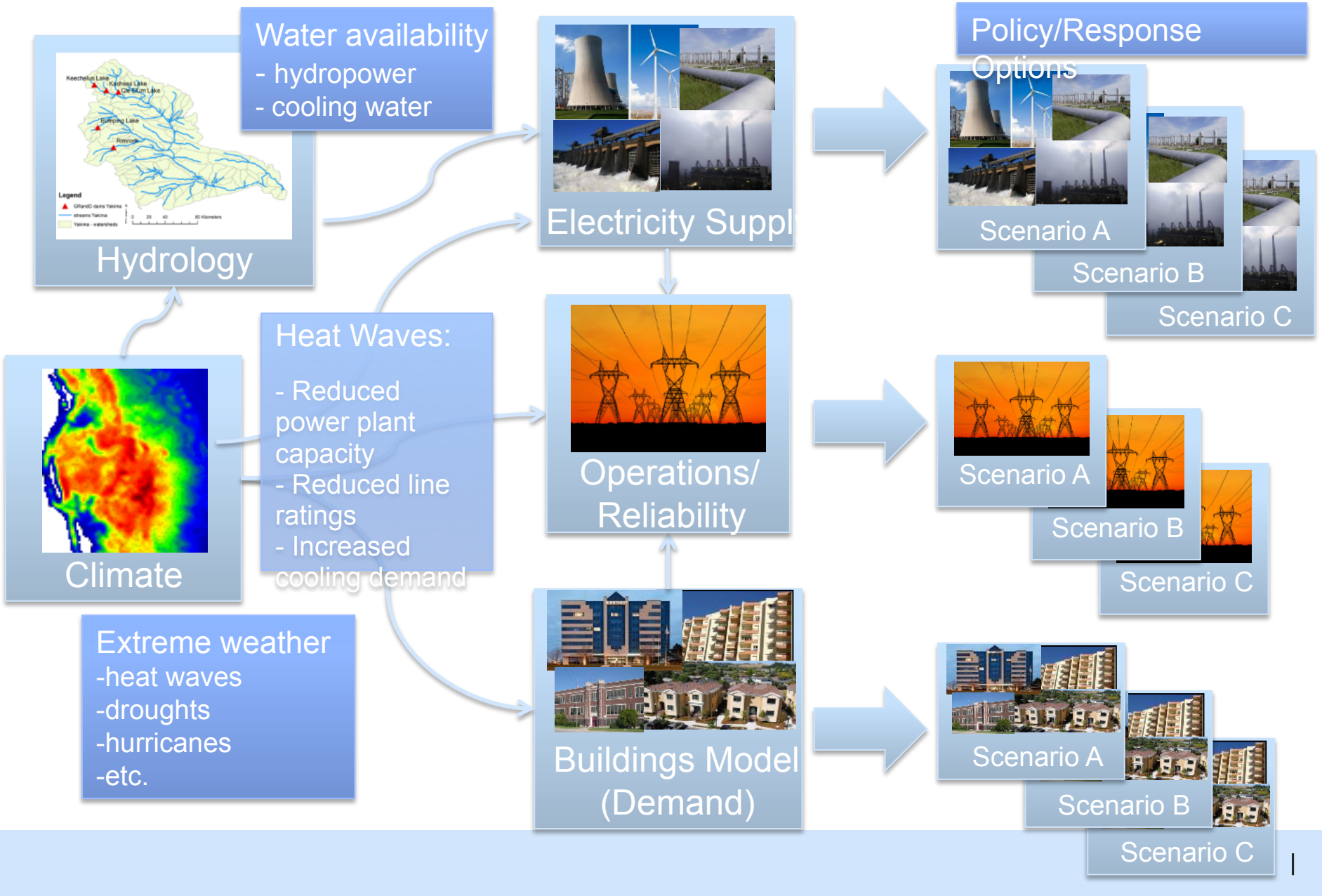


Geospatial models and methods	Remote sensing data, e.g.MODIS
Down scaling	Pattern scaling

Others ……

Papers: Friedl, Portmann, Sleeter, Radeloff, …..

Integrated analyses of impacts, vulnerabilities, and adaptation options



Example: Analysis of Infrastructure Vulnerability to Extreme Events.

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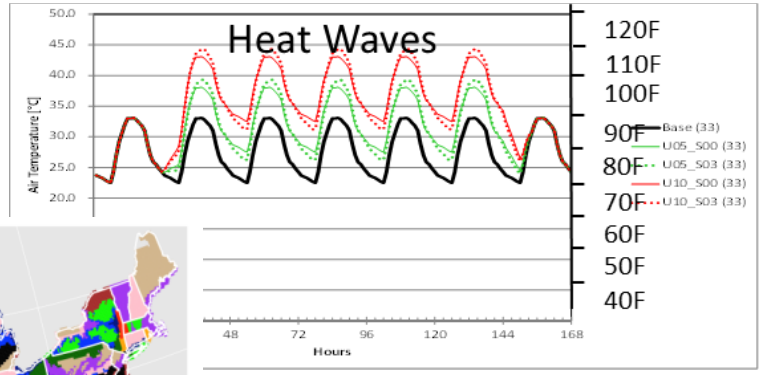
Coincident heat wave and drought : Impacts on electricity supply and demand

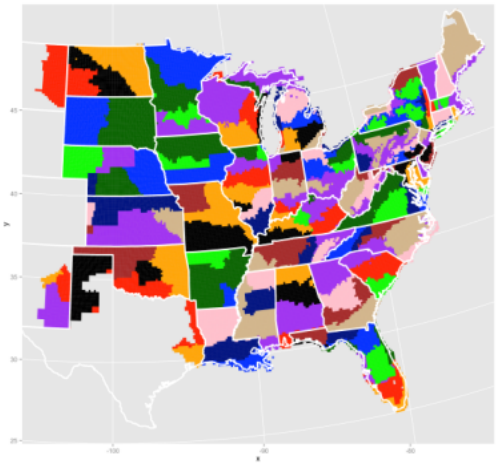
Demand:

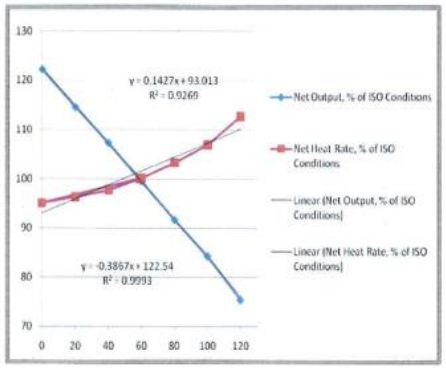
- Severe heat wave weather scenarios (hourly data)
- Building energy demand modeled for ~2000 representative buildings in each of 120 climate-similar regions across the Eastern Interconnection

Supply:

- High ambient temperature impacts on combustion turbine (CT) output in each zone
- Once-through cooling (OTC) plant de-ratings simulated under multiple drought scenarios







Eastern Interconnection
5600 units: 850 GW
657 OTC: 160 GW
1486 CT: 108 GW

Example: Future Projections of Regional Water supply and Demand, and Deficit.

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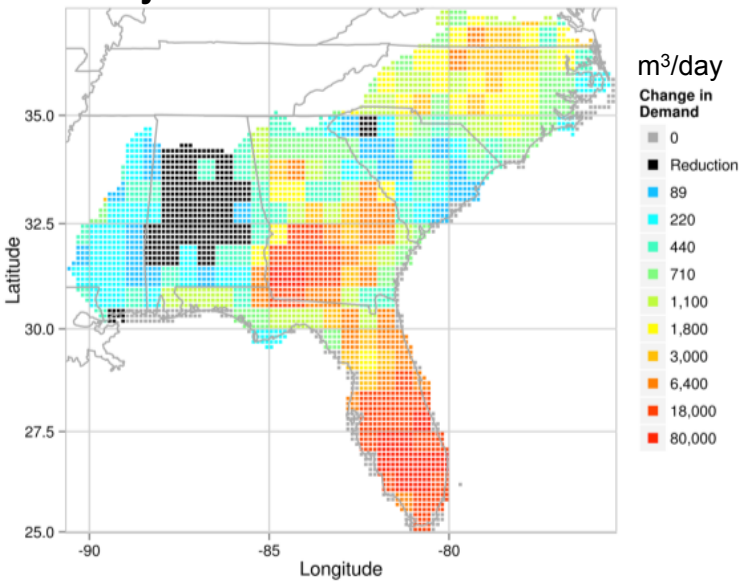
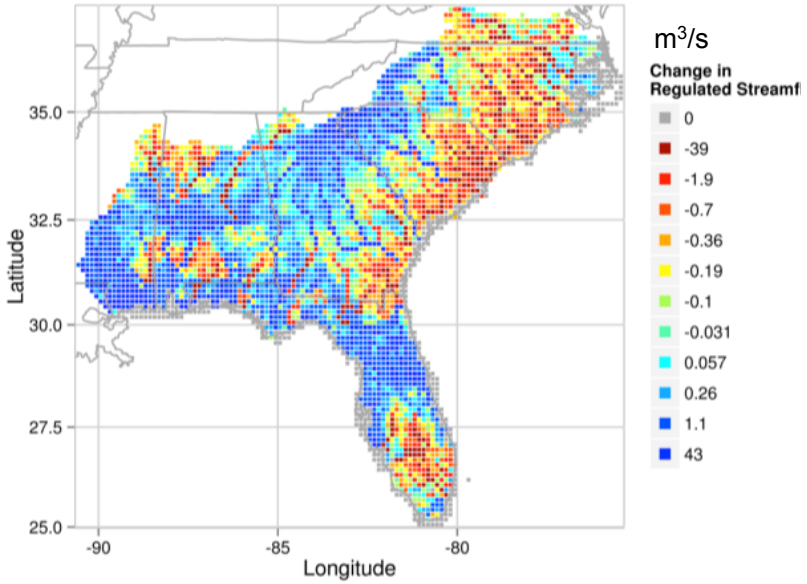
Projected water demand

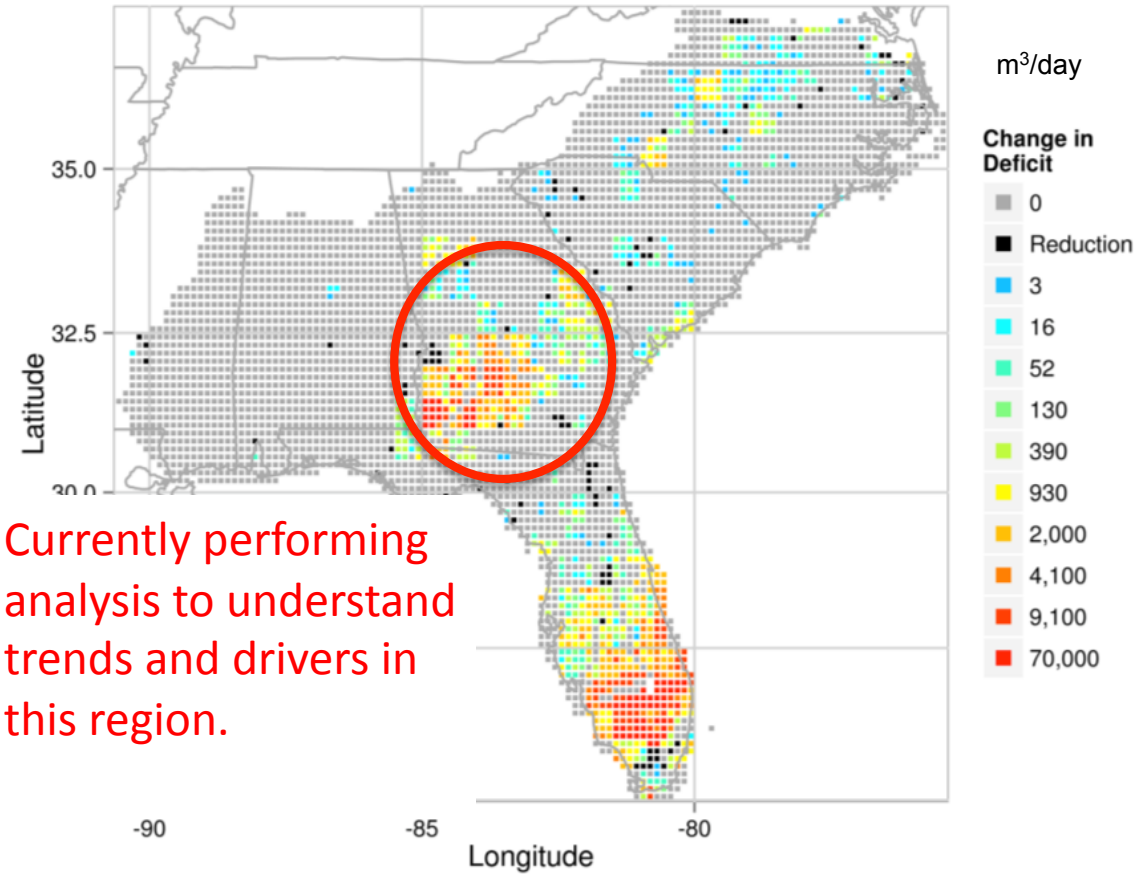


Projected water supply



Change in August daily averages for 2020-2039 compared to historical period (1985-2004); RCP8.5 Scenario; 1/8th degree; Does not account for groundwater or saline water withdrawals

Projected deficit



Currently performing analysis to understand trends and drivers in this region.

Example: What is Bioenergy Role in Future Energy Systems in a Changing Climate?

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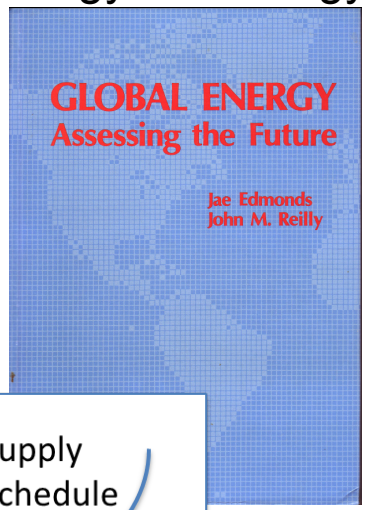
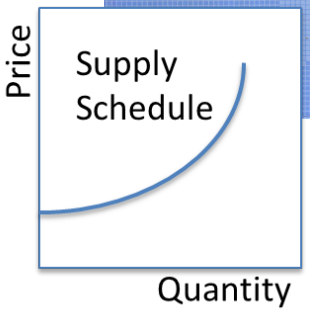
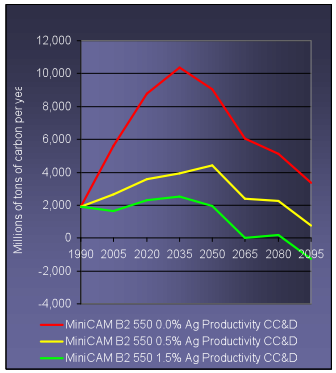
Bioenergy in 1985—a very simple zero emission renewable energy technology



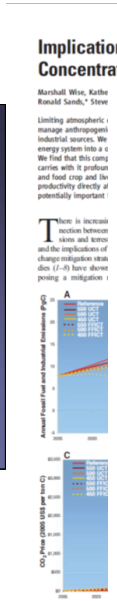


9-region land use

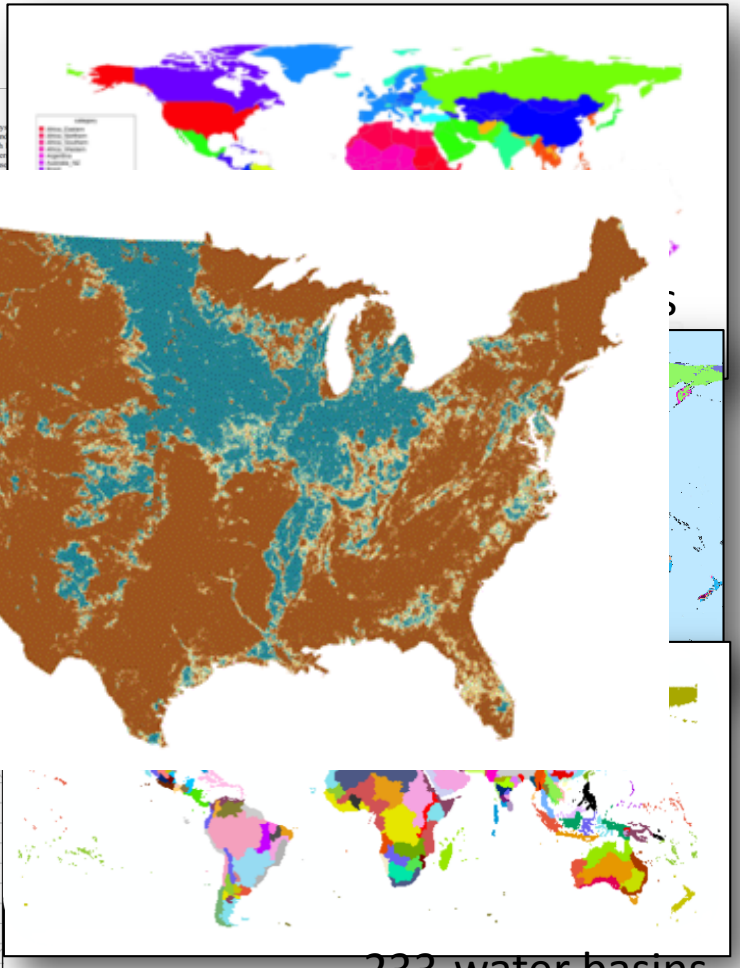
Bioenergy in 2001—1st paper on indirect land-use change emissions

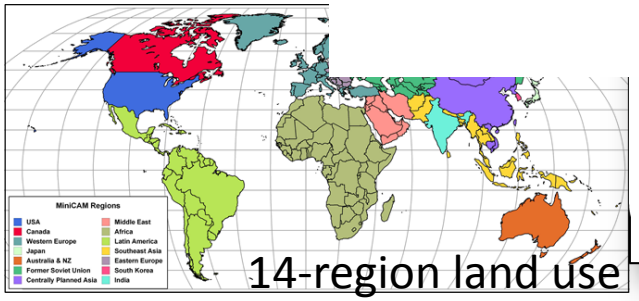


Bioenergy in 2009—Wise, et al. ***Science*** paper; land policy matters


Implications of Limiting CO_2 Concentrations for Land Use and Energy

Bioenergy in 2015—Energy, land and water interactions; BECCS, high-res spatial mapping





14-region land use

233-water basins

Example: Future Projections of Energy Use and CO_2 Emissions- Considering technological progress, with/without climate policies

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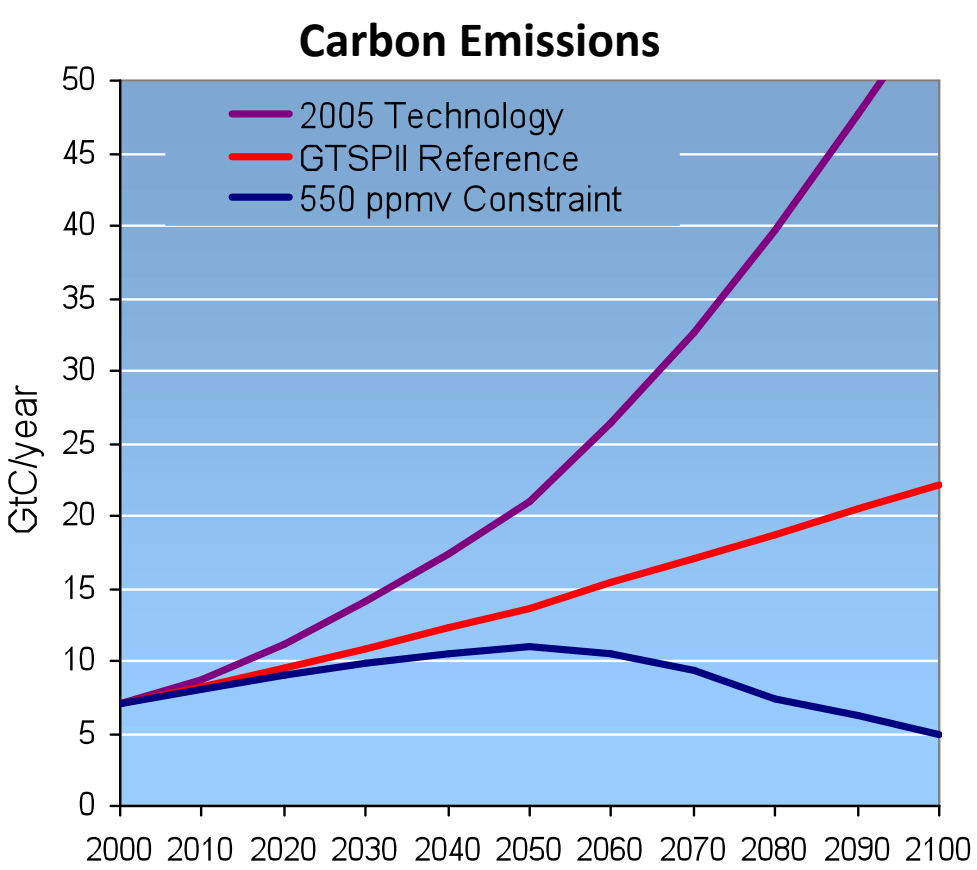

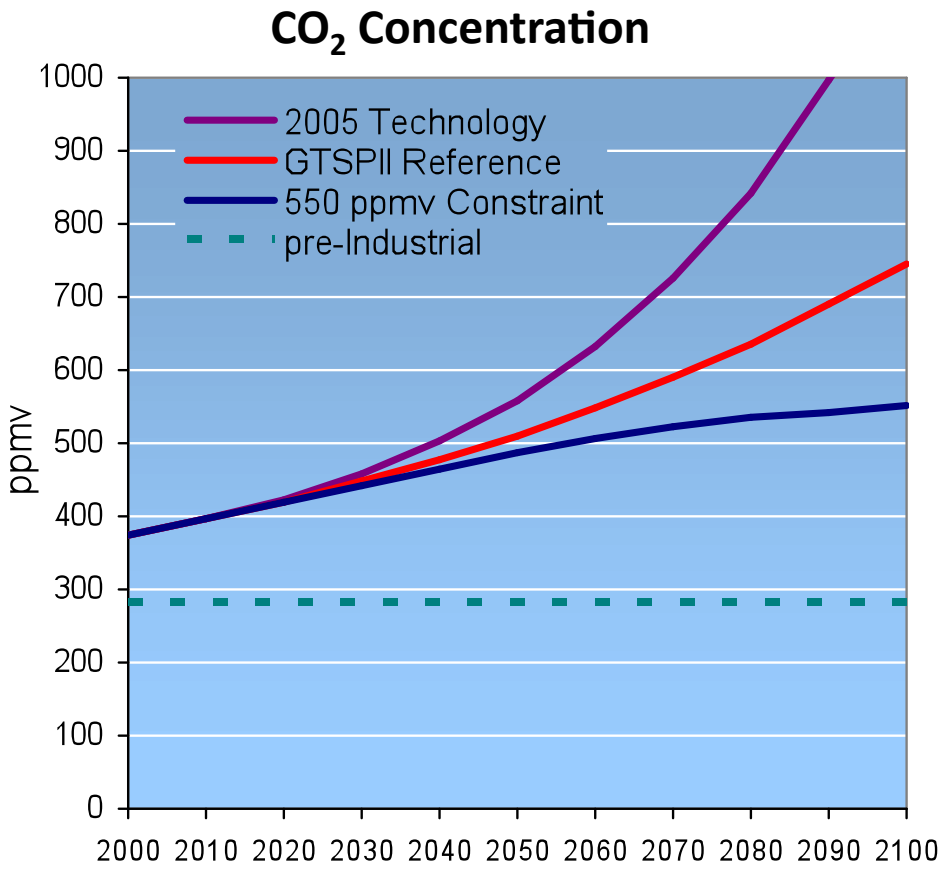

Integrated Assessment Research is an Integral Part of Human-Earth Systems Science

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The 1988 Question
What will be future baseline fossil fuel emissions be?

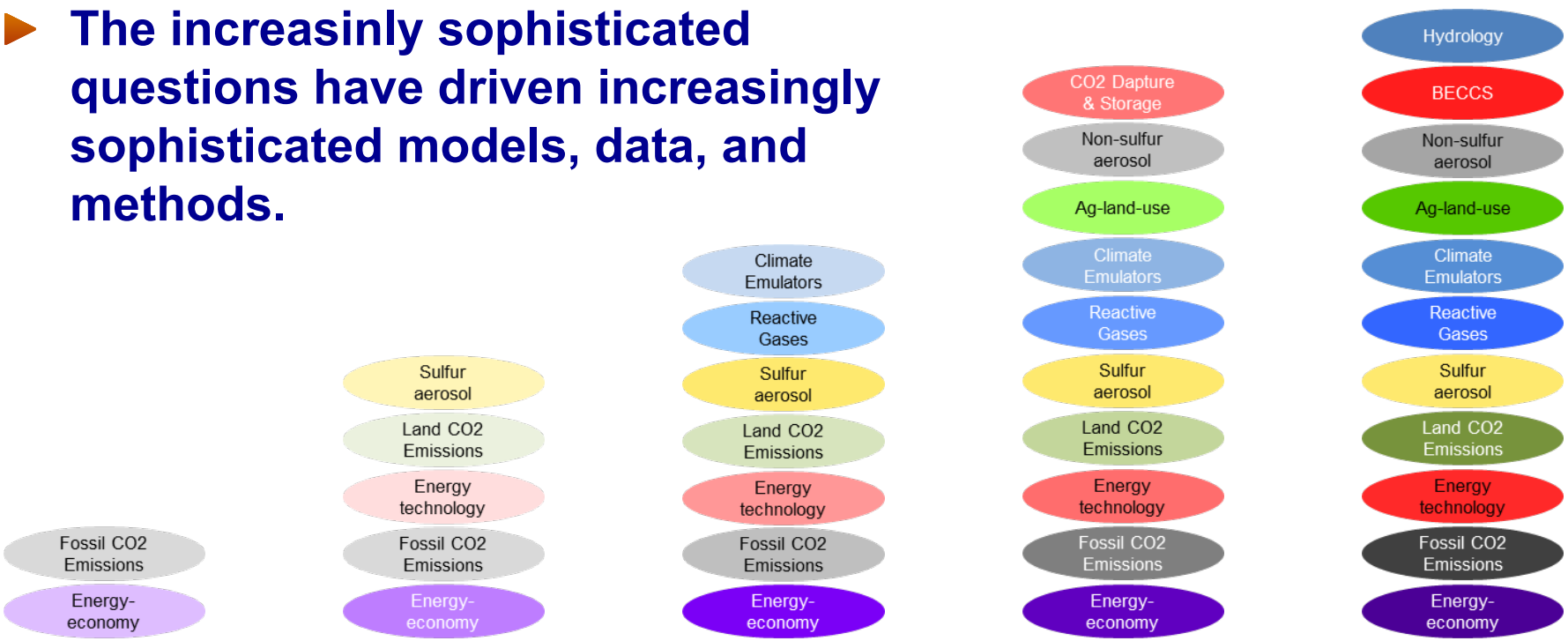
The 1992 Question
What will be future baseline fossil fuel and **land-use change greenhouse gas emissions**?

The 2000 Question
What and **where** will be future baseline fossil fuel and land-use change, greenhouse gas and **short-lived climate forcings?**

The 2011 Question
What and **where** will be future fossil fuel and land-use change, greenhouse gas and short-lived emissions, **with and without mitigation policy**?

The 2015 Question
What and where will be future fossil fuel and land-use change, greenhouse gas emissions, with and without mitigation policy, **and their implications for Impacts Adaptation, Vulnerability?**

- **The increasinly sophisticated questions have driven increasingly sophisticated models, data, and methods.**



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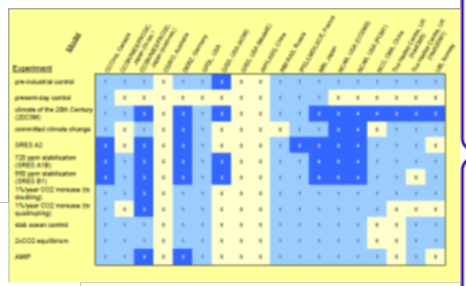
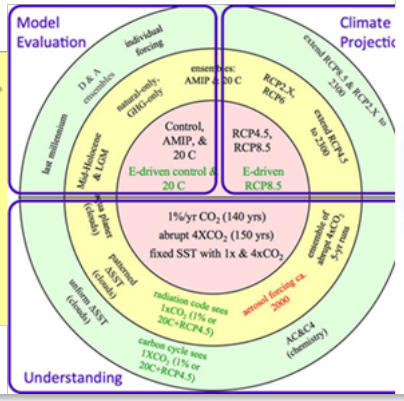
The 2011 Question
What and **where** will future fossil fuel and land-use change greenhouse gas and short-lived forcer emissions be, **with and without mitigation policy**?

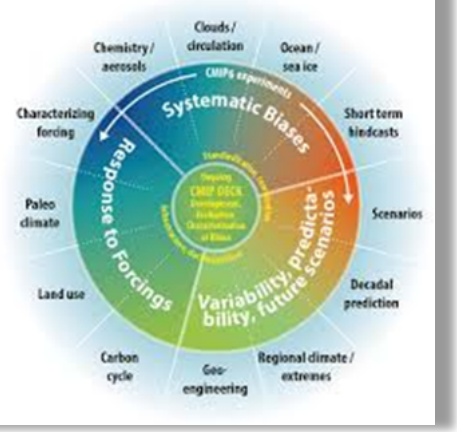
The 2015 Question
What and where will future fossil fuel and land-use change greenhouse gas and short-lived forcer emissions, with and without mitigation policy, be **and with what implications for IAV?**

- And, closer collaboration with other climate science research communities, e.g. climate modelers
- ….But, now including the impacts adaptation and vulnerability (IAV) community.

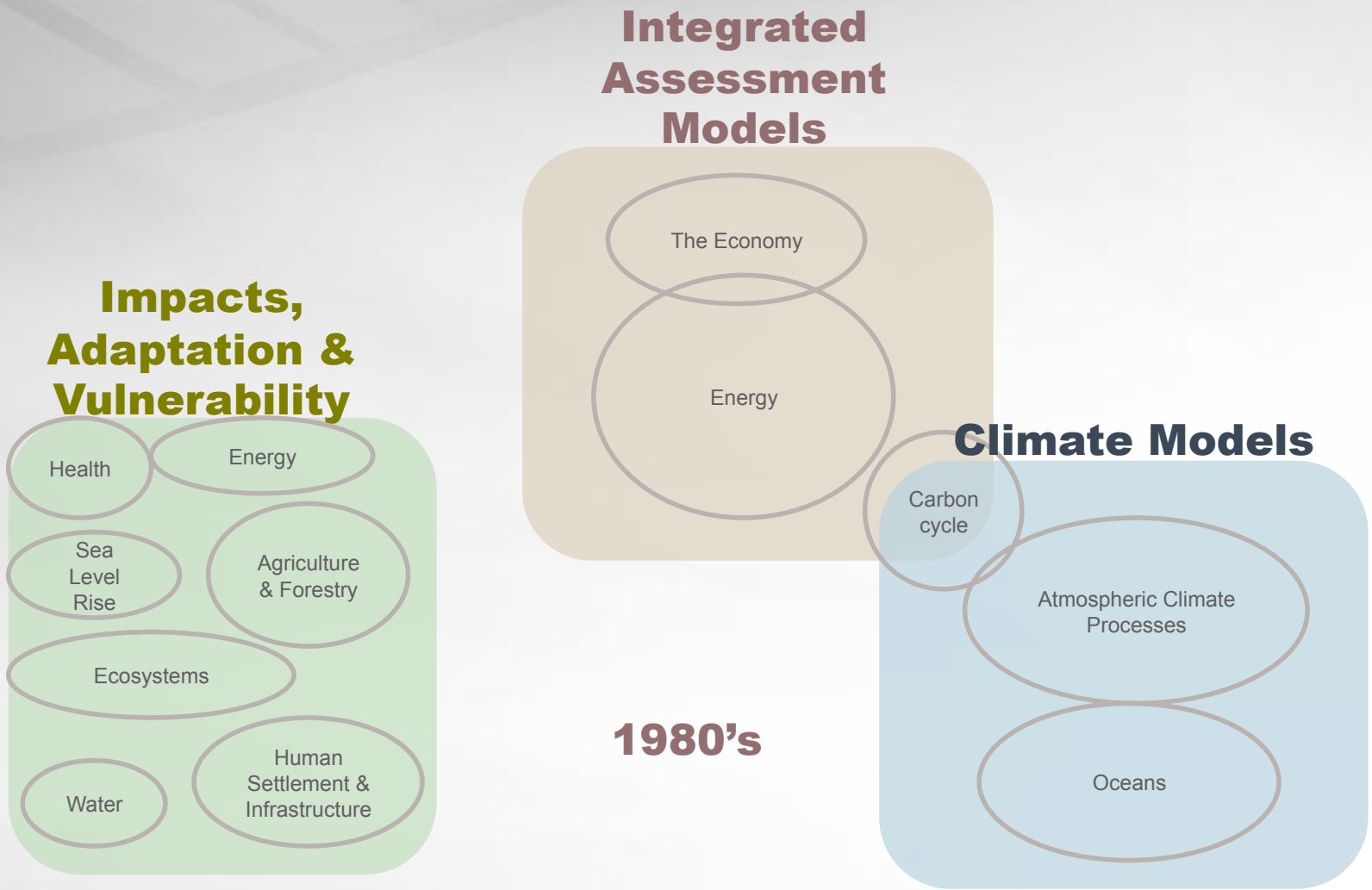
PCMDI
Program for Climate Model Diagnosis and Intercomparison



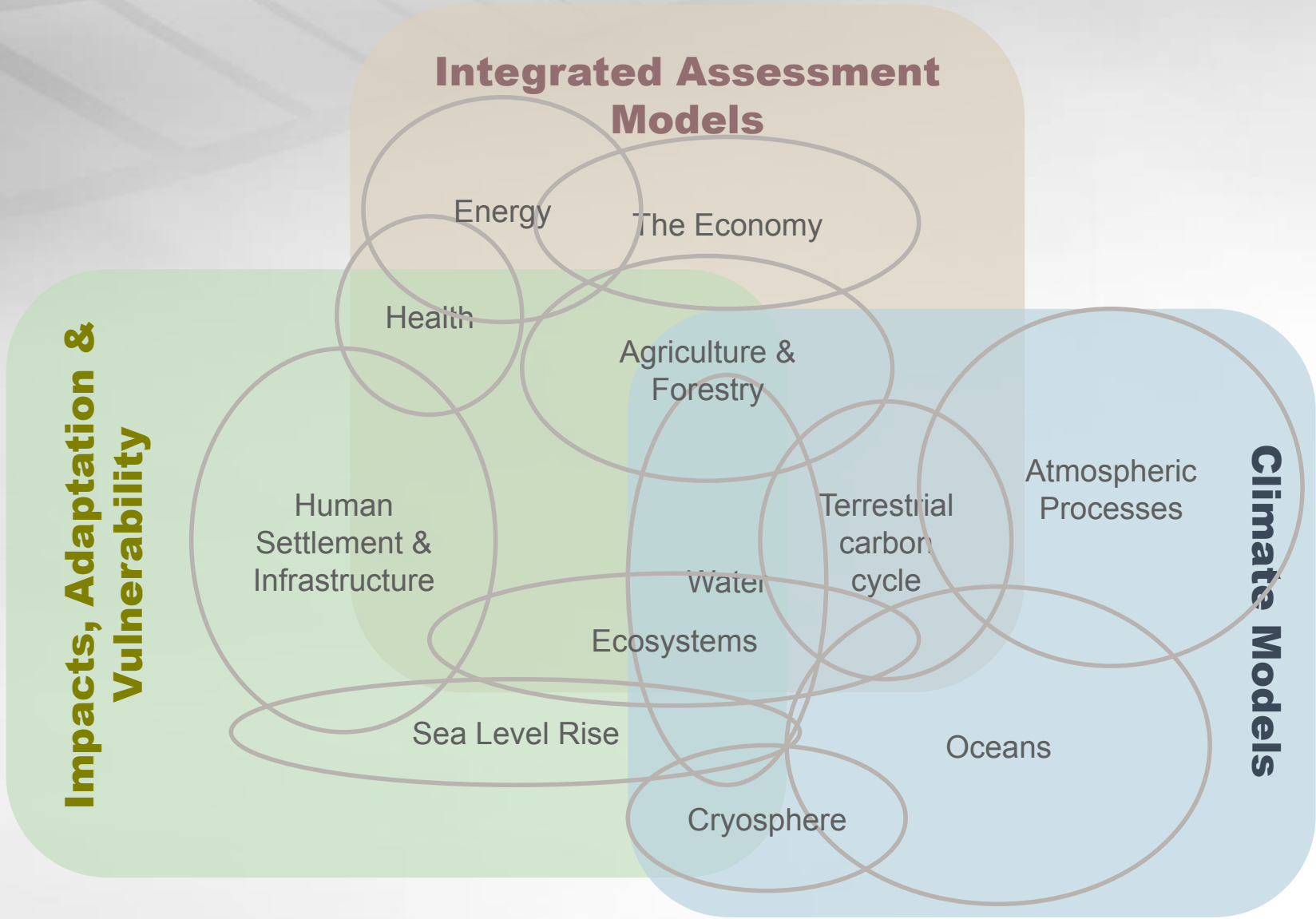




Evolution of Research Domains/Communities



Future Directions in IA Research and Modeling



Today

Regional and Global Focus

Example – Energy-Water-Land-Climate

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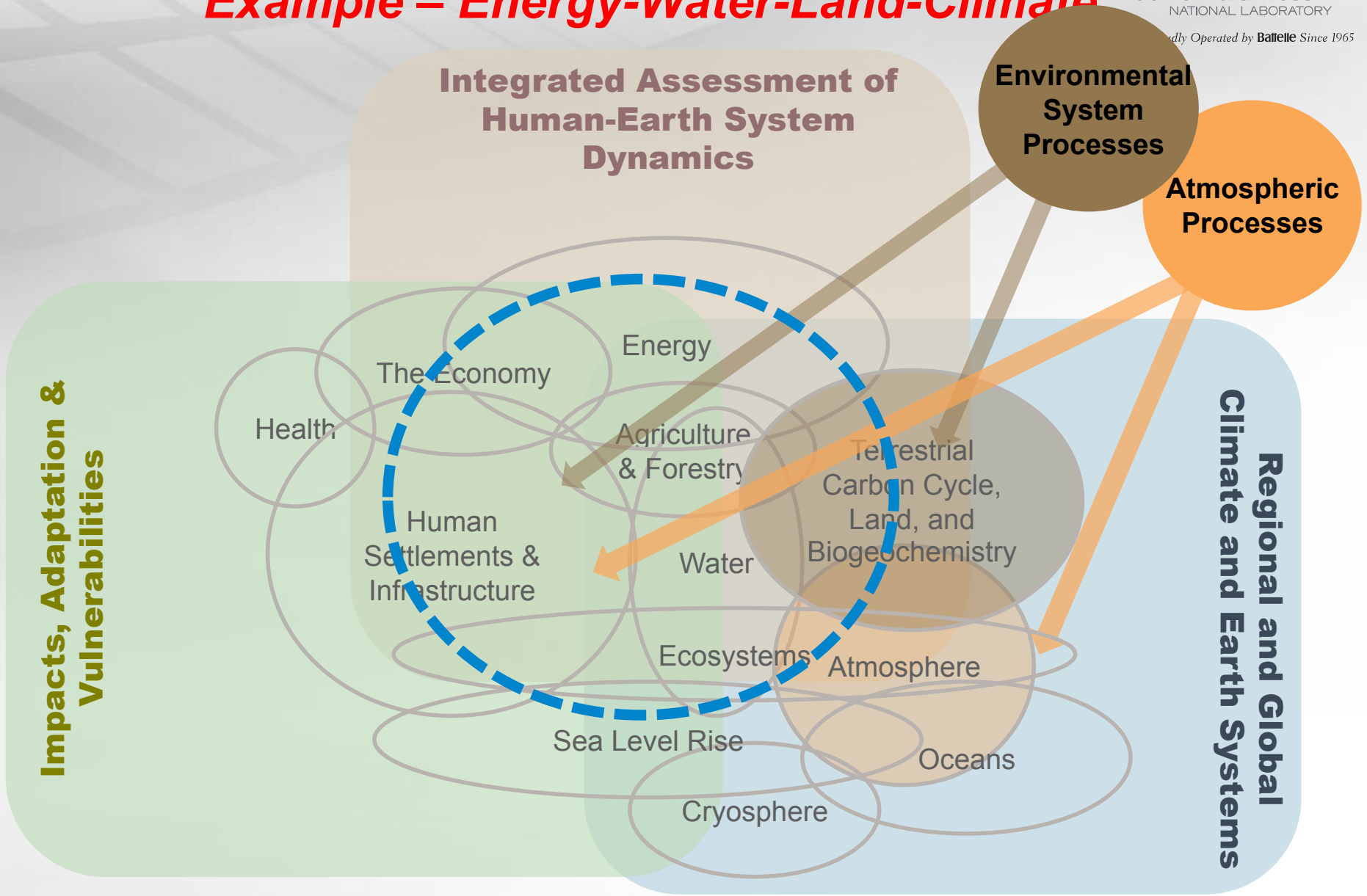

Regional and Global Focus

Example – Integrated Urban Systems

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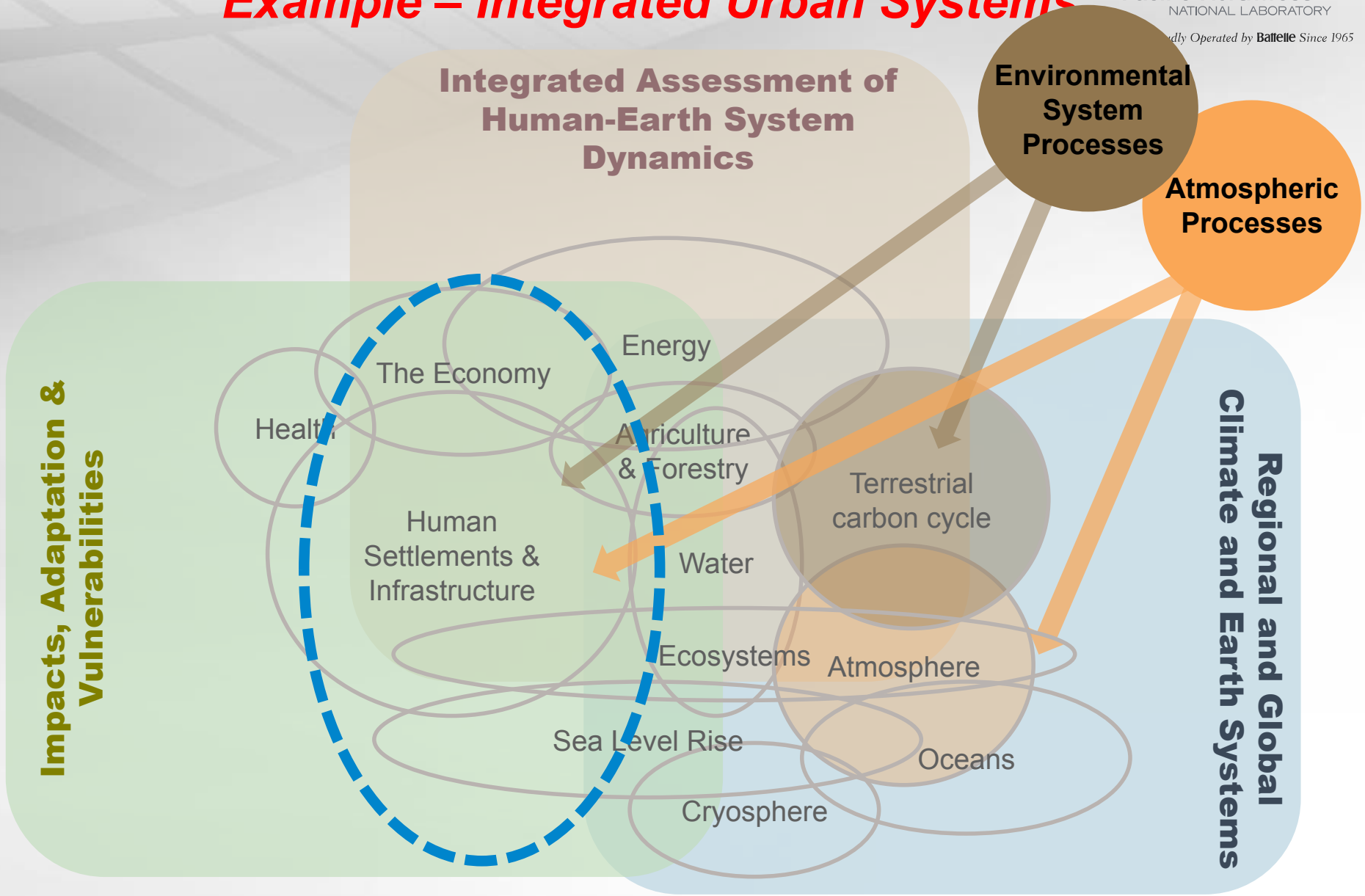

The Intended Nationally Determined Commitments (INDCs)

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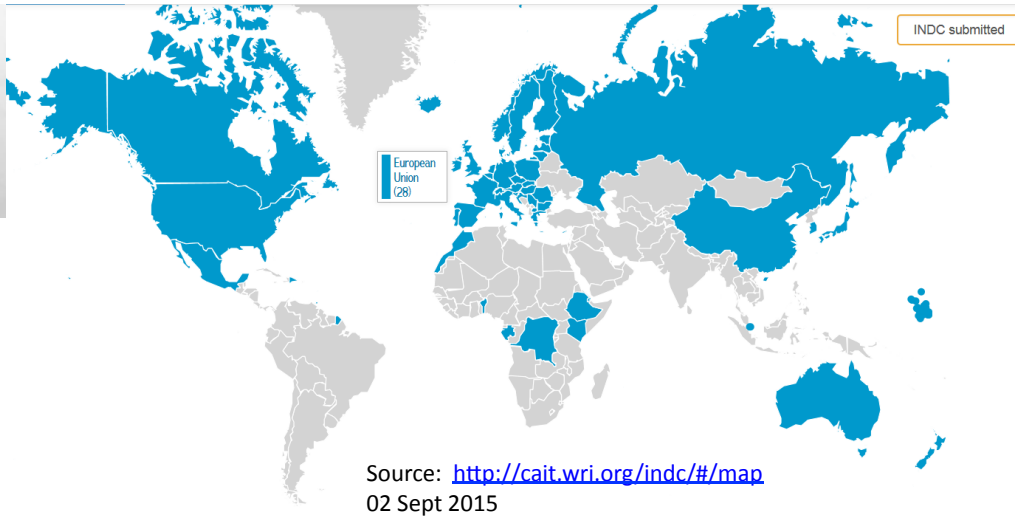
- The new international architecture that will emerge from Paris will be substantially different than the architecture created by the Kyoto Protocol.
  - Based on cap and trade
  - Capped emissions in Annex I parties
  - Included non-Annex I parties only through Joint Implementation and CDM

- The heart of the new international emissions limitation architecture is the **INDC (Intended Nationally Determined Commitment).**
- As of 02 September 2015
  - **29 submissions** representing **57 parties** (28 EU members in 1 submission)
  - Covering ~65% of emissions (http://cait.wri.org/indc/)

Submissions to date: 29 ; Parties Represented: 57

Major Commitments!



Source: http://cait.wri.org/indc/#/map
02 Sept 2015

- **China** will achieve the
  - Peaking of carbon dioxide emissions around 2030 with best efforts to peak early;
  - Lower carbon dioxide emissions per unit of GDP by 60% to 65% from the 2005 level;
  - Increase the share of non-fossil fuels in primary energy consumption to around 20%; and
  - Increase the forest stock volume by around 4.5 billion cubic meters on the 2005 level.
- **EU** will impose a binding target of at least 40% domestic reduction in greenhouse gas emissions by 2030, compared to 1990.
- **Japan** will reduce GHG emissions in 2030 to 26% of its emissions in 2013.
- **United States** will reduce its greenhouse gas emissions by 26-28% below 2005 level in 2025, and to make best efforts to reduce its emissions by 28 percent.

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Thank you.