Additional Research Directions

The Joint Global Change Research Team
May 23, 2011
Cosmos Club
Washington, DC
We’ve been focusing today on international and domestic policy dimensions and the associated research issues.

JGCRI is undertaking a range of additional research that focuses on the intersection of climate, energy, technology, and policy.
The GTSP Research Agenda

Impacts, Adaptation, and Mitigation
Integrating Impacts, Adaptation, and Mitigation

Example: Integrated Earth System Model
The PNNL, ORNL and LBNL iESM Collaboration

Improving the Representations of Human-Earth System Interactions

Principal Investigators:
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Three Primary Tasks

► Create a first generation integrated Earth System Model (iESM) with both the human components of an IAM and a physical ESM;

► Further develop components and linkages within the iESM and apply the model to improve our understanding of the coupled physical, ecological, and human system;

► Add realistic hydrology, including freshwater demand, allocations, and demands to hold stocks of water as well as representations of freshwater availability from surface water, ground water, and desalinization
Approach

Four state of the art modeling systems:

- GCAM1
- CLM4
- GLM1
- CCSM4

Run inside CCSM4 (CESM1)
Integrating Impacts, Adaptation, and Mitigation

Example: Building energy demands
Scenarios design

Emissions scenarios
- Ref*
- ~ 550 ppmv*

Climate models
- CCSM3
- GISS
- Hadley

Population distribution scenarios
- A2r
- B1
- Fixed

* Reference represented by SRES A2 emissions pathway; 550 ppmv scenario represented by the SRES B1 scenario
Population Weighted HDD 2000-2100 (CCSM-ref-A2r)

Current Year: 2000

[Map and chart showing population weighted HDD for different regions around the world.]
Global Population Weighted HDD

Effect of Population Distribution

Ref emissions scenario

550 ppm emissions scenario

Effect of Climate Change
Changes in Building Final Energy Use in China (cumulative energy in EJ, 2005-2095)

Climate change effect on China buildings' cumulative fuel use [EJ]: Reference Scenarios

- CCSM-Ref-Fix
- GISS-Ref-Fix
- HADLEY-Ref-Fix

Bar chart showing changes in fuel use categories (Total, Biomass, Coal, Gas, Heat, Electricity, Oil, Trad-Biomass) over the 2005-2095 period for different climate models.
Integrating Impacts, Adaptation, and Mitigation

Example: Feedbacks on agricultural productivity
Regional Disaggregation: Agro-ecological zone approach
Climate impacts interact with mitigation policy.

By 2095, ILUC emissions go below 0 with climate policy cases.
Integrating Impacts, Adaptation, and Mitigation

Example: Water supply and demand
We are developing a supply and demand framework for water at a global level.

GCAM Fresh Water Supply Model

GCAM Domestic Water Consumption
The GTSP Research Agenda

Impacts, Adaptation, and Mitigation
Regional Research

Example: Buildings Research in China
Exploring the Effect of Building Codes in China: Separating China Buildings into Distinct Climate Zones

<table>
<thead>
<tr>
<th>Region</th>
<th>Zone</th>
<th>Climate Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>IA</td>
<td>Cold</td>
</tr>
<tr>
<td></td>
<td>IB</td>
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<td>ID</td>
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<tr>
<td>IV</td>
<td>IA</td>
<td>Warm Winter</td>
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<tr>
<td></td>
<td>IB</td>
<td>Hot Summer</td>
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<td>IC</td>
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<td>ID</td>
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<td>V</td>
<td>IA</td>
<td>Hot Summer</td>
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<td>ID</td>
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</tbody>
</table>

Diagram: China Building Climate Zones

- Cold
- Severe Cold
- Hot Summer
- Cold Winter
- Warm Winter

Table: Climate Requirements

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Temperature Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>0°C to 10°C</td>
</tr>
<tr>
<td>IB</td>
<td>10°C to 15°C</td>
</tr>
<tr>
<td>IC</td>
<td>15°C to 20°C</td>
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<tr>
<td>ID</td>
<td>20°C to 25°C</td>
</tr>
<tr>
<td>IA</td>
<td>25°C to 30°C</td>
</tr>
<tr>
<td>IB</td>
<td>30°C to 35°C</td>
</tr>
<tr>
<td>IC</td>
<td>35°C to 40°C</td>
</tr>
<tr>
<td>ID</td>
<td>40°C to 45°C</td>
</tr>
<tr>
<td>IA</td>
<td>45°C to 50°C</td>
</tr>
<tr>
<td>IB</td>
<td>50°C to 55°C</td>
</tr>
<tr>
<td>IC</td>
<td>55°C to 60°C</td>
</tr>
<tr>
<td>ID</td>
<td>60°C to 65°C</td>
</tr>
</tbody>
</table>

Diagrams: China Building Climate Zones

- Cold
- Severe Cold
- Hot Summer
- Cold Winter
- Warm Winter

Legend:
- Cold
- Severe Cold
- Hot Summer
- Cold Winter
- Warm Winter
The Twelve Buildings Sectors

- China
  - Cold
    - Urban Residential
    - Rural Residential
    - Commercial
  - Hot Summer Cold Winter
    - Urban Residential
    - Rural Residential
    - Commercial
  - Hot Summer Warm Winter
    - Urban Residential
    - Rural Residential
    - Commercial
  - Severe Cold
    - Urban Residential
    - Rural Residential
    - Commercial

9 Provinces Beijing, Tianjin, Hebei, Shanxi, Shandong, Henan, Tibet, Shaanxi, Gansu
9 Provinces Shanghai, Jiangsu, Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Chongqing, Sichuan
6 Provinces & 2 countries Fujian, Guangdong, Guangxi, Hainan, Guizhou, Yunnan Cambodia, Vietnam
6 Provinces & 2 countries Inner Mongolia, Jilin, Heilongjiang, Qinghai, Xinjiang, Liaoning, Mongolia, DPRK
We constructed a building stock model that specifies building construction, building code development and enforcement, and retrofits and retirement. Based on this, three distinct shell efficiency scenarios were developed.

The improvement in building envelope is likely to have a sizeable impact on total building energy consumption in China.

The impact varies across climate regions in China.
Regional Research

Example: iRESM (integrated Regional Earth System) Project
iRESM Conceptual Framework

iRESM Initiative

Separate project (PNNL, LBNL, ORNL)

Global Earth System Model (CESM)

Global Change Assessment Model (GCAM)

Boundary Conditions

Feedback

Boundary Conditions

Regional Earth System Model

Atmosphere
Land
Ocean
Biogeochemistry

Integrated Analysis of:
- Energy-Economics
- Agriculture and Land Use
- Water
- Socioeconomics

Regional-Global Change Assessment Model

Integrated Analysis of:
- Energy-Economics
- Agriculture and Land Use
- Water
- Socioeconomics

Regional Sectoral Models

Building Energy Demand
Crop Productivity
Water Supply
Energy Infrastructure
Water Management
Land Use, Land Cover

Key Attributes:
- Modularity
- Portability
- Open-Source
- Integrated Regional Analyses

Data Exchange
RGCAM – Regional Global Change Assessment Model

- Current effort includes
  - 50-state building and electricity modules within GCAM.
  - Regional water.
- Creating a flexible architecture to be able to link scales in other parts of the framework.
- The Agriculture and Land Use (AGLU) already operates at different regional scales than the GCAM 14 regions.
Regional Research

Developing a Regional Integrated Assessment Modeling Framework
Developing a Regional Integrated Assessment Model Framework

Principal Investigators:
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Proposal to the U.S. Department of Energy, Office of Science
Climate and Environmental Sciences Division
LAB 10-06
Regional Models for Climate Change Integrated Assessment
The GTSP Research Agenda

Core Model Development

Technology Analysis
Regional Analysis
Technology & Institutions
Scenarios

Impacts, Adaptation, and Mitigation
Technology Research

Global Wind Energy Supplies
Overview of Methodology for Wind Supply Curve

- Roughness Length
- Technology
- Exclusion & Suitability
- Turbine & Transmission Cost
- Win Speed (10m)
- Win Speed (80m)
- Raw Wind Energy
- Adjusted Wind Energy
- Generation Costs
- Supply Curve
Wind Energy Potential in cost categories
Technology Research

Example: Value of Technology
Carbon Capture and Storage (CCS)
Having CCS Compresses the Distribution

The availability of CCS truncates the upper tail – CCS provides a hedge against higher abatement costs.
Smaller Additional Compression from Cost Reduction

![Graph showing the distribution of stabilization costs for different CCS scenarios.](image)

- **F0**: No CCS
- **L0**: High Cost CCS
- **R0**: Low Cost CCS

**X-axis**: Stabilization Cost (2005 constant trillions of dollars)

**Y-axis**: Frequency
Early Availability of Low Cost CCS Induces Small but Noticeable Additional Compression

- F0: No CCS
- R0: Low Cost CCS
- R1: Low Cost CCS 15y delay
- R2: Low Cost CCS 30y delay

Stabilization Cost (2005 constant trillions of dollars)
Early Availability of High Cost CCS Induces Much Smaller Additional Compression

High Cost CCS is not widely used as a competitive abatement option under less stringent constraint in early periods. Only in the later periods when the constraint is stringent enough, does High Cost CCS becomes a viable option.
The Galaxy of 161k Technology Combinations

2005-2095 Cumulative Primary Energy Consumption (Thousand Es of Fossil Energy Equivalent)

2005-2095 NPV of Stabilization Cost (2005 Constant Trillions of Dollars)
Technology Research and Scenarios

- Characterizing the Role and Character of Mitigation Technologies
  - Carbon Dioxide Capture and Storage
  - Bioenergy [Technical Workshop]
  - Nuclear Energy [Technical Workshop]
  - Buildings and Transportation [Technical Workshop]

- We are Taking a Leadership Role in a Range of Community Scenario Exercises
  - EMF 24 International Scenarios
  - EMF 24 U.S. Scenarios
  - The Asian Modeling Exercise
  - The LINKS Project
  - The RoSE Project
  - The RCP and SSP Processes [Technical Workshop]