Air pollution in Integrated Assessment Models
Update on the Shared Socio Economic Pathways

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HTAP meeting, Feb 17-19, Potsdam
Integrated Assessment models

- Integrated assessment models generally include both physical and social science models that consider demographic, political, and economic variables that affect greenhouse gas emission scenarios in addition to the physical climate system.
- IAMs are not predictive models.
- Usually consist of a set of models that are linked to model different variables.
- In the context of climate change, have a long-term perspective of 100 years.
- Provide key inputs to GCMs and climate modelers for assessing climate impacts.
IPCC-IS92, SRES, and literature ranges
Representative Concentration Pathway (RCP)

- First attempt by IAMs to provide trajectories of a set of pollutants in addition to GHGs
- Developed with consultation with climate modelers
- Resulted in 4 sets of air pollutant trajectories based on pre-defined radiative forcing levels.
- Synchronized base year inventories
- No attempt to harmonize assumptions on air pollution control
RCP inventory and future projections
Sulfur to Carbon Ratio
1900-2100

BC to Carbon Ratio
1900-2100

Climate Policy
CCS!
Range of future global emissions
GAINS policy scenarios vs RCP

**SO₂**

**NOₓ**

**BC**

**Source:** GAINS model; ECLIPSE V5 scenario
Other Examples

- Global Energy Assessment
- PEGASOS (Pan-European Gas-Aerosol-Climate Interaction Study)
- Chuwah, C. and T.v.V. van Noije, Detlef P.; Hazeleger, Wilco; Strunk, Achim; Deetman, Sebastiaan; Beltran, Angelica Mendoza; van Vliet, Jasper, Atmospheric Environment. 2013. 79: p. 787-801
First International Model Comparison on *Climate-Air Pollution-Energy Security LINKAGES*

<table>
<thead>
<tr>
<th>Institution</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEEM, Italy</td>
<td>WITCH</td>
</tr>
<tr>
<td>ERI, China</td>
<td>IPAC</td>
</tr>
<tr>
<td>PIK, Germany</td>
<td>ReMIND</td>
</tr>
<tr>
<td>ECN, Netherlands</td>
<td>TIAM-ECN</td>
</tr>
<tr>
<td>IIM, India</td>
<td>GCAM, Markal</td>
</tr>
<tr>
<td>PBL, Netherlands</td>
<td>IMAGE</td>
</tr>
<tr>
<td>PNNL, US</td>
<td>GCAM</td>
</tr>
<tr>
<td>IIASA, Austria</td>
<td>MESSAGE</td>
</tr>
<tr>
<td>JRC, EU</td>
<td>FASST</td>
</tr>
</tbody>
</table>
## World SO$_x$

<table>
<thead>
<tr>
<th>Year</th>
<th>Share of Coal in PE</th>
<th>Share of solids in FE (Res. &amp; Com.)</th>
<th>Share of Liquids in Transport FE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base</td>
<td>MIT</td>
<td>Base</td>
</tr>
<tr>
<td>2010</td>
<td>26-30%</td>
<td>26-30%</td>
<td>26-32%</td>
</tr>
<tr>
<td>2030</td>
<td>27-35%</td>
<td>13-25%</td>
<td>8-23%</td>
</tr>
<tr>
<td>2050</td>
<td>28-40%</td>
<td>1-17%</td>
<td>0-14%</td>
</tr>
<tr>
<td>2100</td>
<td>30-60%</td>
<td>0-28%</td>
<td>0-5%</td>
</tr>
</tbody>
</table>

### Diagram Description

- **Base**: Baseline scenario with no significant changes.
- **CLE**: Cleaner Energy scenario focusing on renewable energy.
- **SLE**: Sustainable Lifestyle scenario emphasizing energy efficiency and reduced fossil fuel use.

- **Base FLE**: Baseline scenario with Flue Gas Desulfurization.
- **Base CLE**: Baseline scenario with Low Sulfur Fuel and Euro Fuel Standards.
- **Base SLE**: Baseline scenario with Improved Cookstoves.

- **MIT FLE**: MIT scenario with Flue Gas Desulfurization.
- **MIT CLE**: MIT scenario with Low Sulfur Fuel and Euro Fuel Standards.
- **MIT SLE**: MIT scenario with Improved Cookstoves.

**Key Changes**:
- **Flue Gas Desulfurization**: Reduces SO$_x$ emissions significantly.
- **Low Sulfur Fuel**: Decreases SO$_x$ emissions in power plants.
- **Improved Cookstoves**: Reduces SO$_x$ emissions in residential areas.

**Model Abbreviations**:
- A -> AIM/CGE
- G -> GCAM
- I -> IMAGE
- M -> MESSAGE
- R -> REMIND
- W -> WITCH
The Shared Socioeconomic Pathways (SSPs) are part of the new framework adopted by the climate change research community to facilitate the integrated analysis of future climate impacts, vulnerabilities, adaptation, and mitigation…

Global Environmental Change, 2015, Available online 12 February 2015
Create a set of consistent qualitative and quantitative storylines for pollution in the future that reflect our current understanding of how pollution has evolved so far historically and the possible directions it could take in the future.
• Pollution is increasingly a concern all over the world
• Legislations increased in many developing countries and emission declines happening at lower income levels than before
• Compliance and enforcement remains a problem.
• The actual outcomes in terms of pollution will critically depend on energy demand, access to energy and a number of other policies.
<table>
<thead>
<tr>
<th>Policy Strength</th>
<th>Policy Targets</th>
<th>High Income countries</th>
<th>Medium and Low income countries</th>
<th>Technological Innovation</th>
<th>SSP link</th>
<th>Key characteristics of SSPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong</td>
<td>Polices over the 21st century aim for much lower pollutant levels than current targets in order to minimize adverse effects on the general population, vulnerable groups, and ecosystems.</td>
<td>Comparatively quick catch-up with the developed world (relative to income)</td>
<td>Pollution control technology costs drop substantially with control performance increasing.</td>
<td>SSP1, SSP5</td>
<td>Sustainability driven; rapid development of human capital, economic growth and technological progress; prioritized health concerns</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>Lower than current targets</td>
<td>Catch-up with the developed world at income levels lower than when OECD countries began controls (but not as quick as in the strong control case).</td>
<td>Continued modest technology advances.</td>
<td>SSP2</td>
<td>Middle of the road scenario</td>
<td></td>
</tr>
<tr>
<td>Weak</td>
<td>Regionally varied policies.</td>
<td>Trade barriers and/or institutional limitations substantially slow progress in pollution control.</td>
<td>Lower levels of technological advance overall.</td>
<td>SSP3, SSP4</td>
<td>Fragmentation, Inequalities</td>
<td></td>
</tr>
</tbody>
</table>
- Level of ambition
- Speed and Effectiveness of Control
• Relatively aggregate nature of IAMs.
• All IAMs linked to GAINS
• Use precursor to the ECLIPSE dataset
• Use FLE, CLE, MFR terminology to guide emission factor development
Thank you!