Interaction of IAMs and ESMs & EMICs

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Challenge: Rationalize exchange of IAM trajectories of forcing agents w/ ESMs & EMICs

![Graph showing energy reduction and other categories over years]

![Graph showing emissions from different sources over years]

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## CMIP5: The RCP Handshake Process

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>Spatial scale</th>
<th>Regional and sectoral emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Greenhouse gases</strong></td>
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<td></td>
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<tr>
<td>CO(_2) (fossil fuel, industrial, land use change)</td>
<td>ppm and Pg/yr</td>
<td>Global average</td>
<td>Sum</td>
</tr>
<tr>
<td>CH(_4)</td>
<td>ppb and Tg/yr</td>
<td>Global average</td>
<td>Grid(^1)</td>
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<tr>
<td>N(_2)O</td>
<td>ppb and Tg/yr</td>
<td>Global average</td>
<td>Sum</td>
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<tr>
<td>HFCs(^2)</td>
<td>ppb and Tg/yr</td>
<td>Global average</td>
<td>Sum</td>
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<tr>
<td>PFCs(^2)</td>
<td>ppb and Tg/yr</td>
<td>Global average</td>
<td>Sum</td>
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<tr>
<td>CFCs(^2)</td>
<td>ppb and Tg/yr</td>
<td>Global average</td>
<td>Sum</td>
</tr>
<tr>
<td>SF(_6)</td>
<td>ppb and Tg/yr</td>
<td>Global average</td>
<td>Sum</td>
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<tr>
<td><strong>Aerosols(^2)</strong></td>
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<tr>
<td>Sulfur (SO(_2))</td>
<td>Tg/yr</td>
<td>Generated by CM community(^3)</td>
<td>Grid</td>
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<tr>
<td>Black Carbon (BC)</td>
<td>Tg/yr</td>
<td>Generated by CM community(^3)</td>
<td>Grid</td>
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<tr>
<td>Organic Carbon (OC)</td>
<td>Tg/yr</td>
<td>Generated by CM community(^3)</td>
<td>Grid</td>
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<tr>
<td><strong>Chemically active gases</strong></td>
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</tr>
<tr>
<td>CO</td>
<td>Tg/yr</td>
<td>Generated by CM community(^3)</td>
<td>Grid</td>
</tr>
<tr>
<td>NO(_x)</td>
<td>Tg/yr</td>
<td>Generated by CM community(^3)</td>
<td>Grid</td>
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<tr>
<td>VOCs(^2)</td>
<td>Tg/yr</td>
<td>Generated by CM community(^3)</td>
<td>Grid</td>
</tr>
<tr>
<td>NH(_3)</td>
<td>Tg/yr</td>
<td>Generated by CM community(^3)</td>
<td>Grid</td>
</tr>
</tbody>
</table>

Van Vuuren et al, 2008
Multi-phase coupling of IAMs and ESMs / EMICs

- IAM
- RCP Handshake
- ESMs / EMICs

CMIP5
Coupling of IAMs to ESMs and EMICs: Example: land-use / land-cover change

Van Vuuren et al, 2008
**Issue with forcing associated with RCPs**

- **Structural issue:** The forcing associated with RCPs is forcing by atmospheric RF species only – not LULCC effects.

- **Science question:** For different policy but same concentration pathway, does the evolution of the climate system differ?

- **Experiment:** Contrast two pathways:
  - RCP4.5 – carbon price on all carbon (UCT)
  - RCP4.5 – carbon price ONLY on fossil carbon (FFICT)
Implications for definition of RCPs

- The two scenarios have the **same** radiative forcing from GHGs.

- Yet they are **substantially different** in the evolution of the climate: the equivalent of 1.5 W/m$^2$, or about 0.5°C global annual average.

- The **actual policy chosen matters** – in this case the very large land-use change associated with FFICT.

- **Atmospheric radiative forcing is not a complete metric** for evaluating the evolution of the climate system.
Science gaps in current paradigm

- In the present world, emissions mitigation analysis is undertaken under the assumption that the climate is not changing.

- Climate impacts analysis is undertaken with the assumption that no resources are being diverted to address climate change.

- Changes in response of the coupled climate-energy-land model are significantly different than in the un-coupled models.

- Tighter integration of IAMs and ESMs could provide fully consistent analysis of potential future climate change, emissions mitigation options, and impacts and adaptation options will be possible.
Feedback coupling of IAMs and ESMs / EMICs?

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IAM ➞ RCP Handshake ➞ ESMs / EMICs

C stocks, productivity ➞ Climate

Up/down scaling (space and time) ➞ Atm CO₂

CMIP6 ?
Motivation for integrating IAMs and ESMs

- **Opportunities:** Build unified framework for water/energy/climate

- **Possible solution:** Unite IA and climate in single framework

- **Potential upsides:** Quick “look-see”, inclusion of feedbacks, and stronger IA foundations

- **Prototype:** Initial release of an iESM built on CESM

Mitigation  Adaptation  Technology pathways
Opportunities afforded by integration

- **Immediate** tests of climate impacts for future scenarios.
- Tool to enable “no regrets” scenario/path development.
- Advances in internally consistent treatment of water, energy, and climate in mitigation pathways.
- Quantification of impacts of feedbacks and interactions *that are yet to be treated under current protocols and yet could be significant on mitigation timescales.*