Energy and emissions
Community scenario framework and scenarios

- **Purpose:** provide research community with framework, storylines and quantified scenarios that enable linkages across research disciplines.

RCPs (climate forcing axis)
Link between IAM → CM → IAV
- 4 alternative projections of radiative forcing and climate change
  - Span the full literature range (mitigation and baseline)
  - Includes a wide set of variables to drive new ESMs (emissions, aerosols, land use)
  - Consistent with recent emission trends
- Used for climate research (e.g. land use) and for impact research

SSP framework
Relevant for IAM ←→ IAV
- Alternative socio-economic development
  - Should allow IAV community to assess climate impacts (in combination with RCPs)
  - Should allow IAM community to look at costs of mitigation (in combination with RCPs)
  - SSP-RCP combination also input for new climate runs?
Available tools

- 2 Frameworks (RCP/SSP + SSP concept)
- Storylines
- Quantified scenarios

Shared Socio-economic Pathway (SSP)

<table>
<thead>
<tr>
<th>SSP1</th>
<th>SSP2</th>
<th>SSP3</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Representative concentration pathways

- Grey area = literature range; colour lines = RCPs

- RCPs cover the full range of GHG emissions 😊
A first look at the SSP (IAM results – draft):

- 1. Energy
- 2. GHG emissions
- 3. Air pollutants
SSP1: Sustainability
- Rapid technology
- High environmental awareness
- Low energy demand
- Medium-high economic growth
- Low population

SSP2: Middle of the road
- Medium

SSP3: Fragmentation
- Slow technology development (dev-ing)
- Reduced trade
- Very slow economic growth
- Very high population

SSP4: Inequality
- Slow technology
- High inequality
- Low energy demand
- Slow economic growth
- High population

SSP5: Conv. Dev.
- Rapid technology for fossil
- High demand
- High economic growth
- Low population

Challenge to adaptation

Challenge to mitigation
Translation into energy system (2100)
1. Energy
2. GHG emissions
3. Air pollutants
**CO₂ emissions (per team)**

**AIM**

**IMAGE**

**GCAM**

**MESSAGE**

**REMIND**
Challenge to mitigation

Greenhouse Gas emissions

4.5 W/m²

SSP5 baseline

SSP2

SSP1

SSP3

SSP4

Challenge to adaptation
CO2 increases more in baseline, and decreases more in mitigation in long-run 

CH4/N2O emission increase less – but are also constrained in reduction.
Reduction strategy interesting

- Overall timing (overshoot $\rightarrow$ next session)
- Contribution of short-lived gases $\rightarrow$ methane
  - Alternative strategy Shindell
    $\rightarrow$ CH4 emissions, about half energy sector; other half agriculture.
  - (how much would alternative strategy matter )
- SSP/RCP models use GWPs (average emphasis on methane)
1. Energy
2. GHG emissions
3. Air pollutants
### Emission scenarios and historic inventories

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{CO}_2 )</td>
<td>1. Air Transportation</td>
</tr>
<tr>
<td>( \text{CH}_4 )</td>
<td>2. International Shipping</td>
</tr>
<tr>
<td>( \text{N}_2\text{O} )</td>
<td>3. Other transportation</td>
</tr>
<tr>
<td>( \text{SO}_y )</td>
<td>4. Energy production / conversion.</td>
</tr>
<tr>
<td>( \text{BC} )</td>
<td>5. Solvents</td>
</tr>
<tr>
<td>( \text{OC} )</td>
<td>6. Waste (landfills, waste water)</td>
</tr>
<tr>
<td>( \text{NO}_x )</td>
<td>7. Industry (combustion and process emissions)</td>
</tr>
<tr>
<td>( \text{VOC} )</td>
<td>8. Buildings (Residential and Commercial)</td>
</tr>
<tr>
<td>( \text{NH}_3 )</td>
<td>9. Ag. waste burning on fields</td>
</tr>
<tr>
<td>( \text{HFCs} )</td>
<td>10. Agriculture</td>
</tr>
<tr>
<td>( \text{PFCs} )</td>
<td>11. Savannah burning</td>
</tr>
<tr>
<td>( \text{CFCs} )</td>
<td>12. Land use change</td>
</tr>
<tr>
<td>( \text{SF}_6 )</td>
<td></td>
</tr>
</tbody>
</table>

Data from 1750 to 2100/2300, for 10 sectors at 0.5 x 0.5 degree.

J.F. Lamarque
EDGAR-team
IAM teams
Others

RCPs did not span full literature range

All groups aimed to include best estimates of environmental policy

Maybe not a problem for climate research, but not attractive for people looking into air pollution (and the need for policy)
Story about too high S emissions

Global Anthropogenic Sulfur Emissions

World

China

India

RCPs
Sulphur emissions

Baseline

4.5 W/m²
Challenge to mitigation

Challenge to adaptation

BC emissions

baseline

4.5 W/m²
Relationships between air pollution and climate policy interesting

- Air pollutant as forcing agent (ozone, BC, sulphur)
  - Considerable impacts on forcing
- Co-benefits of climate policy
- Climate policy as co-benefit of air pollution policy
Simple analytical scheme
Scenarios used
Ozone concentrations
PM2.5 concentrations

2005,
2030 baseline,
2030 climate policy + air pollutant policy
Some conclusions and thoughts

SSPs – first results promising, but not done

Interesting to vary air pollution and land use across the SSPs a bit – also in a way that makes sense from the perspective of the overall assessment

Seems important to rerun RCP-type scenarios to span the range for IAV research (e.g. SSP3-8.5, SSP2-6, SSP2-4.5, SSP1-2.6)

And in addition several “research runs”:
Overshoot scenario RCP4.5 → RCP2.6,
More focus on short-lived forcers: RCP2-4.5 with more BC/CH4 red.
Pollution scenario: RCP2-4.5 with less stringent air pollution contro
Land use scenario: RCP2-4.5 with alternative land use pattern
Four important reasons to develop new community scenarios for climate assessment:

1. Need to cover a wider range of GHG concentrations (SRES only included baseline scenarios).
2. Need for a wider set of parameters (Climate models have become more complex; higher information need).
3. Need for scenarios that cover mitigation & adaptation issues (need for more collaboration between “WG’s”).
4. Use more recent insight into trends in scenario drivers (update).

However, scenario range has broadened and policy questions have changed scope (from baseline to mitigation).

RCP inventory and future projections
Air pollution policy more important

Climate policy
More important

Both equally important