Importance of Scenarios for CCIAV

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AR5 and NCA are not even finished. And yet, it's time to ...

...plan scenarios for the next round of research and assessment

- Are we already behind?
- What have we learned in the first round of the new scenario process?
- What are the policy and science questions that will need to be addressed in the AR6 and other assessments?
- What research design for scenarios is appropriate for these questions?
Topics I will cover

1. Drivers of scenarios development
2. How have RCPs been used?
3. Areas for improvement and potential next steps in improving scenarios for CCIAV
1. Scenarios as method to coordinate synthesis

| WATER            | Increased water availability in moist tropics and high latitudes 1  
|                 | Decreasing water availability and increasing drought in mid-latitudes and semi-arid low latitudes 2  
|                 | 0.4 to 1.7 billion 3  
|                 | 1.0 to 2.0 billion 3  
|                 | 1.1 to 3.2 billion 3  
|                 | Additional people with increased water stress  
| ECOSYSTEMS      | Increasing amphibian extinction 4  
|                 | About 20 to 30% species at increasingly high risk of extinction 4  
|                 | Major extinctions around the globe 4  
|                 | Increasing coral bleaching 5  
|                 | Most corals bleached 6  
|                 | Widespread coral mortality 6  
|                 | Increasing species range shifts and wildfire risk 7  
|                 | Terrestrial biosphere tends toward a net carbon source, as: 8  
|                 | ~15%  
|                 | ~40% of ecosystems affected  
| FOOD            | Crop productivity  
|                 | Low latitudes  
|                 | Decreases for some cereals 9  
|                 | Increases for some cereals 9  
|                 | Mid to high latitudes  
|                 | All cereals decrease 9  
|                 | Decreases in some regions 9  
| COAST           | Increased damage from floods and storms 10  
|                 | Additional people at risk of coastal flooding each year 0 to 3 million 12  
|                 | 2 to 15 million 12  
| HEALTH          | Increasing burden from malnutrition, diarrhoeal, cardio-respiratory and infectious diseases 13  
|                 | Increased morbidity and mortality from heatwaves, floods and droughts 14  
|                 | Changed distribution of some disease vectors 16  
|                 | Substantial burden on health services 16  
| SINGULAR EVENTS | Local retreat of ice in Greenland and West Antarctic 17  
|                 | Long term commitment to several metres of sea-level rise due to ice sheet loss 17  
|                 | Leading to reconfiguration of coastlines world wide and inundation of low-lying areas 18  
|                 | Ecosystem changes due to weakening of the meridional overturning circulation 19  

Global mean annual temperature change relative to 1980-1999 (°C)

IPCC AR4, WGII, Table 20.8
Source: IPCC AR4 WG II Ch 11, Fig 11.4
2. Scenarios as inputs to ESMs: Representative Concentration Pathways (RCPs)

The climate modeling community wanted 4 levels of radiative forcing that would span the emissions literature.

- 8.5 Wm\(^{-2}\) (RCP 8.5, 1350ppm CO\(_2\)-e)
- 6.0 Wm\(^{-2}\) (RCP 6.0, 850ppm CO\(_2\)-e)
- 4.5 Wm\(^{-2}\) (RCP 4.5, 650ppm CO\(_2\)-e)
- 2.6 Wm\(^{-2}\) (RCP 2.6, 450ppm CO\(_2\)-e)
Content of RCP database

Data for climate modelers or atmospheric chemists
http://www.iiasa.ac.at/web-apps/tnt/RcpDb/

FORCING AGENTS

GHG Emissions and Concentrations from IAMs

- Greenhouse gases: CO₂, CH₄, N₂O, CFCs, HFC’s, PFC’s, SF₆
- Emissions of chemically active gases: CO, NOₓ, NH₄, VOCs
- Derived GHG’s: tropospheric O₃
- Emissions of aerosols: SO₂, BC, OC
- Land use and land cover [NEW]

EXTENSIONS

- Extension of scenarios to 2300—ECPs.

WHAT YOU WON’T FIND

- You will not find an integrated set of detailed socioeconomic storylines and scenarios (e.g., no common reference scenario)
### 3. Scenarios as inputs to diverse CCIAV research

<table>
<thead>
<tr>
<th></th>
<th>Impact</th>
<th>Vulnerability</th>
<th>Adaptation</th>
<th>Integrated</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scientific objectives</strong></td>
<td>Impacts and risks under future climate</td>
<td>Processes affecting vulnerability to climate change</td>
<td>Processes affecting adaptation and adaptive capacity</td>
<td>Interactions and feedbacks between multiple drivers and impacts</td>
</tr>
<tr>
<td><strong>Practical aims</strong></td>
<td>Actions to reduce risks</td>
<td>Actions to reduce vulnerability</td>
<td>Actions to improve adaptation</td>
<td>Global policy options and costs</td>
</tr>
<tr>
<td><strong>Research methods</strong></td>
<td>Standard approach to CCIAV</td>
<td>Vulnerability indicators and profiles</td>
<td>Past and present climate risks</td>
<td>Integrated assessment modelling</td>
</tr>
<tr>
<td></td>
<td>Drivers-pressure-state-impact-response (DPSIR) methods</td>
<td></td>
<td>Livelihood analysis</td>
<td>Cross-sectoral interactions</td>
</tr>
<tr>
<td></td>
<td>Hazard-driven risk assessment</td>
<td></td>
<td>Agent-based methods</td>
<td>Integration of climate with other drivers</td>
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<td>Narrative methods</td>
<td>Stakeholder discussions</td>
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<td></td>
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<td></td>
<td>Risk perception including critical thresholds</td>
<td>Linking models across types and scales</td>
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<td></td>
<td></td>
<td>Development/sustainability policy performance</td>
<td>Combining assessment approaches/methods</td>
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<td>Relationship of adaptive capacity to sustainable</td>
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<td></td>
<td></td>
<td></td>
<td>development</td>
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<tr>
<td><strong>Spatial domains</strong></td>
<td>Top-down</td>
<td>Bottom-up</td>
<td>Linking scales</td>
<td></td>
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<tr>
<td></td>
<td>Global → Local</td>
<td>Local → Regional</td>
<td>Commonly global/regional</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(macro-economic approaches are top-down)</td>
<td></td>
<td>Often grid-based</td>
<td></td>
</tr>
<tr>
<td><strong>Scenario types</strong></td>
<td>Exploratory scenarios of climate and other factors (e.g., SRES)</td>
<td>Socio-economic conditions</td>
<td>Baseline adaptation</td>
<td>Exploratory scenarios: exogenous and often endogenous (including feedbacks)</td>
</tr>
<tr>
<td></td>
<td>Normative scenarios (e.g., stabilisation)</td>
<td>Scenarios or inverse methods</td>
<td>Adaptation analogues from history, other locations,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>other activities</td>
<td></td>
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<tr>
<td><strong>Motivation</strong></td>
<td>Research-driven</td>
<td>Research-/stakeholder-driven</td>
<td>Stakeholder-/research-driven</td>
<td>Research-/stakeholder-driven</td>
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</tbody>
</table>

Source: IPCC AR4, WG2, CH2
Content of DDC data base for CCIAV research

<table>
<thead>
<tr>
<th>DDC-Variable</th>
<th>Acronym</th>
<th>PCMDI-Variables</th>
<th>Table/Nr</th>
</tr>
</thead>
<tbody>
<tr>
<td>2m surface air temperature</td>
<td>TEMP2</td>
<td>tas</td>
<td>A1a/3</td>
</tr>
<tr>
<td>2m mean max. air temperature</td>
<td></td>
<td>taamin</td>
<td>A1f/5</td>
</tr>
<tr>
<td>2m mean min. air temperature</td>
<td></td>
<td>tasmax</td>
<td>A1f/6</td>
</tr>
<tr>
<td>total precipitation</td>
<td></td>
<td>pr</td>
<td>A1a/2</td>
</tr>
<tr>
<td>total incident solar radiation</td>
<td></td>
<td>Rred</td>
<td>A1a/13</td>
</tr>
<tr>
<td>mean scalar wind speed</td>
<td></td>
<td>uas/vas</td>
<td>A1a/26+27</td>
</tr>
<tr>
<td>humidity</td>
<td></td>
<td>huss</td>
<td>A1a/28</td>
</tr>
<tr>
<td>mean sea level pressure</td>
<td></td>
<td>pel</td>
<td>A1a/1</td>
</tr>
<tr>
<td>global mean sea level change (th. exp.)</td>
<td></td>
<td>zostoga</td>
<td>O1c/2</td>
</tr>
</tbody>
</table>

- **Core data**
  - frost days
  - extreme temperature range
  - growing season length
  - heat wave duration
  - fraction of time (90th percentile min temp)
  - rain > 10 mm/d
  - consecutive dry days
  - max. 5 day precipitation
  - simple daily intensity index
  - fraction of annual total prec. > 95th percentile

- **Optional variables**
  - ~20 variables

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Proudly Operated by Battelle Since 1965
Scenarios for CCIAV intercomparison: ISI-MIP

Multiple Climate Models + Multiple Impact Models

- Warming scenarios
- Socio-economic scenarios

Quantitative estimate of impacts and their uncertainty (Different sectors and scales)

- Mitigation targets
- Adaptation policies

Common Background Scenarios
Quantitative Impact Models
Policy-relevant, society-focused metrics

Source: Katja Frieler
II. If we’re re-examining scenarios for future research/assessment, a reasonable question is how have the RCPs been used?
**Preliminary** RCP citation analyses

<table>
<thead>
<tr>
<th></th>
<th>Citation (web of science)</th>
<th>Using CMIP5 data</th>
<th>Using RCP data</th>
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<tbody>
<tr>
<td>Moss</td>
<td>267</td>
<td>45</td>
<td>31</td>
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<tr>
<td>Van Vuuren overview</td>
<td>101</td>
<td>25</td>
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<tr>
<td>van vuuren 2.6</td>
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<td>Masui 6.0</td>
<td>16</td>
<td>?</td>
<td>4</td>
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<td>Riahi 8.5</td>
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<tr>
<td>Meinhausen extension</td>
<td>84</td>
<td>?</td>
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<tr>
<td>Hurtt Land Use</td>
<td>30</td>
<td>2</td>
<td>3</td>
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</table>

-> Total using RCP data: 67
Spatial scale

- Global: 52
- Region: 11
- National and <: 3

Data used

- GHG and pollutant emissions: 60
- Landuse: 9
- Socio-economics: 3

Papers also using ESM data

47
Main topic of papers using RCP data

- Climate (precip, temp, hurricanes, ...): 24%
- Atmosphere (aerosols, chemistry, ...): 14%
- Land (permafrost, snow, biodiversity, ...): 20%
- Ocean (acidification, sea ice, ...): 20%
- Society (GHG intensity, air quality, health, ...): 47%
III. Areas for improvement and potential next steps
Improving use of scenarios in assessments and decision support

- Assessment: scenarios are not widely used
  - NCA experience (careful strategy, climate “outlooks”)
  - IPCC WG II (is WG III a different story?)

- Supporting decisions: many end users can’t relate to the substance of current global scenarios
  - Survey uses and needs (e.g., higher resolution, more ‘near-term’ information)
  - Test what communicates effectively, including evaluating the “climate outlooks” and SLR scenarios
  - Experiment with scenario planning methods and evaluate experience
Some specific areas of improvement needed

- Broader range of designs (e.g., Tony’s normative approach)
- Continue developing SSPs, extensions, and alternatives
- Guidance on scenario matching and integration for specific uses:
  - Socioeconomic, climate, land use, etc.
- Guidance on pattern scaling
- Better advertising of availability
- Better user support
- Advance methods for nesting scenarios – cross-scale dynamics
- Make progress on relatively likelihood of pathways (e.g., IPCC issue)
- Closer connection with users and importance of storylines, scenario planning
Snowmass scenarios workshop:
Assessing recent experience and planning next scenarios for research and assessment

- Three issues that are expected to be important to national and international policy formulation:
  - land use
  - emissions of short-lived species, and
  - “overshoot” futures

- Needs for national or subnational assessments which require nesting and integration of different types of scenarios (e.g., climate, socioeconomic, land use, sea level) – several US cases

- Scenario recommendations for CMIP6

- Improvements to coordination across the three research communities.

- Other topics or ideas for scenarios: short presentations by participants

- Feeds into AGCI workshop on CMIP6 the week following
Conclusions

- Now is a good time to examine our use of scenarios
- Develop a plan that addresses specific questions or decision needs and goes beyond coordination of modeling
- Engage users in development of scenarios
- Improve integration of different types of scenarios
- Increase effort to disseminate and support proper use
Improve integration and data sharing

**GENERAL CHARACTERISTICS**
- Uncertainty range of forcing in 2100
- Shape of radiative forcing over time

**REPRESENTATIVE CONCENTRATION PATHWAYS (RCPs)**
(Four pathways from existing literature)
- GHGs
- Short-lived gases and aerosols
- Land cover/use

**NEW SOCIO-ECONOMIC and EMISSIONS SCENARIOS; VULNERABILITY STORYLINES**
- Adaptation
- Mitigation
- Stabilization
- Overshoots
- ... (RCP-related)
- Independent of RCPs

**INTEGRATION OF CLIMATE AND SOCIO-ECONOMIC SCENARIOS**
- Integrated scenarios
- Pattern scaling (climate)
- Downscaling of climate and socio-economic scenarios
- ... (RCP-related)
- Independent of RCPs

**CLIMATE SCENARIOS**
- Near-term (2035)
- Long-term (2100+)
- Regional climate modeling
- Pattern scaling methods

**NEW RESEARCH AND ASSESSMENTS**
- Impact, adaptation, and vulnerability studies
- Feedbacks
- Model development
- ...

2008 2009 2010 2011 2012 2013

Source: Moss et al. 2010
Improve framework for linking socio-economic and climate scenarios

Needed for impact and regional mitigation assessments: integrated socioeconomic and climate scenarios in an accessible format from a distributed scenario archive.

- **Socio-economic Scenarios**
  - SSPs (reference scenarios)
  - Shard Policy Scenarios (stabilization policies)

- **ESM runs with RCPs**
  - Long-term ensemble runs

- **Infrastructure and process needed to archive and disseminate new integrated scenarios**
  - Stabilization

- **Consistent socio-economic-climate change scenarios for use in IAV research and assessment**

- **Institution for archiving SSPs and stabilization scenarios?**

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<table>
<thead>
<tr>
<th>RCP Replication</th>
<th>SSP 1</th>
<th>SSP 2</th>
<th>SSP 3</th>
<th>SSP 4</th>
<th>SSP 5</th>
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<td>8.5 Wm²</td>
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<td>6.0 Wm²</td>
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<td>X</td>
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<tr>
<td>4.5 Wm²</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>2.6 Wm²</td>
<td>X</td>
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CMIP5 Archive (PCMDI)