SCENARIO DEVELOPMENT FOR THE IPCC FIFTH ASSESSMENT REPORT: RCPs AND THE PARALLEL PROCESS

GTSP Technical Workshop

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Scenarios are images of the future… . They are neither predictions nor forecasts. Rather, each scenario is one alternative image of how the future might unfold. A set of scenarios assists in the understanding of possible future developments of complex systems.


Scenarios (in a climate context) can consist of:
- Demographic, Social, and Economic Characteristics
- Technology Availability and Performance
- Emissions and Land-Use Changes
- Atmospheric Composition and Air Pollution
- Physical Climate Changes
- Climate Impacts

RCPs
WHY NEW SCENARIOS

The current set of scenarios (SRES) used for coordinated, international analysis were constructed in the late 1990s.

New scenarios are needed because:
- Starting data for the scenarios is outdated
- IA models that produced the SRES scenarios have advanced
- New scenario data are needed for analysis
  - Greater sectoral disaggregation and spatial resolution of emissions
  - Land-Use and Land-Use Change Information

There have been some major changes to the process:
- The research community will produce new scenarios, not IPCC.
- A “parallel process” enables more timely research and ultimately improve consistency between scenario elements.
- A full range of scenarios, policy and non-policy, will be included.
SCENARIOS: FOR WHOM?

Three major research communities

- Earth System/Climate Modeling (ESM/CM) community—need scenarios to provide a coherent, internally consistent, time-path for emissions and concentrations.

- Impacts, Adaptation and Vulnerability (IAV) modeling community—need scenarios to provide socio-economic variables and climate outcomes to assess the consequences of potential climate changes and to set the context for adaptive strategies.

- Emissions mitigation community, which includes Integrated Assessment Modeling (IAM)—provide a coherent, internally consistent, time-path to assess the costs of emissions mitigation.
IAMs, ESMs, AND IAV RESEARCH PROCESS

Given the substantial uncertainty in climate outcomes from earth system models, and the lead-time and expense to run them, the scenario process contains the following elements:

- The development of a set of “Representative Concentration Pathways” (RCPs) that span the range of potential climate forcing, including policy and no-policy scenarios.
- Climate and Earth-System Model (CM/ESM) simulations using these pathways, thereby generating a suite of model outputs that can be used for impacts, adaptation, and vulnerability analysis
  - To match RCP results with any particular socio-economic/IAM scenario (existing or future), Impacts, Adaptation, and Vulnerability (IAV) analysis can either use pattern scaling, or pick a “closest match” RCP scenario.
- Improved interaction between the various research communities.
  - Improve physical system representations within IAMs
  - Improve social and technological representations within ESMs
  - Ultimately extend these interactions to IAV research communities
# The Integrated Assessment Modeling Consortium

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<tbody>
<tr>
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# The Sequential and Parallel Approaches

**(a) Sequential approach**

1. Emissions & socio-economic scenarios (IAMs)
2. Radiative forcing
3. Climate projections (CMs)
4. Impacts, adaptation & vulnerability (IAV)

**Previous (AR1-4)**

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**(b) Parallel approach**

1. Representative concentration pathways (RCPs) and levels of radiative forcing
2a. Climate, atmospheric & C-cycle projections (CMs)
2b. Emissions & socio-economic scenarios (IAMs)
3. Impacts, adaptation, vulnerability (IAV) & mitigation analysis

**AR5 Approach**
TIMELINE FOR SCENARIO DEVELOPMENT AND ANALYSIS

Product 1: RCPs delivered to CMC

Product 2: RCP-based CMC ensembles & pattern scaling

Product 3: New IAM Scenarios

Product 4: Story Lines

Product 5: Integration of CMC Ensembles with New IAM Scenarios Available

12 months
Fall 2007
Preparatory Phase

24 months
Fall 2008
Parallel Phase

18 months
Fall 2010
Integration Phase

12 month
Spring 2012
Publication Lag

2013
AR5 WG I Report

2013
AR5 WG II & III Reports

2014

THE PREPARATORY PHASE AND RCPs
REPRESENTATIVE CONCENTRATION PATHWAYS (RCPs)

Anthropogenic Emissions from IAMs
- Greenhouse gases: CO₂, CH₄, N₂O, CFCs, HFC’s, PFC’s, SF₆
- Emissions of chemically active gases: CO, NOₓ, NH₄, VOCs
- Emissions of aerosols and precursors: SO₂, BC, OC

Land-Use
- Anthropogenic land uses and land cover change

Atmospheric Abundances from Chemistry Models and/or Climate-Chemistry Models
- Short-lived Gases (CH₄, some HFC’s, etc.)
- Derived GHG’s: tropospheric O₃
- Aerosol Loadings (Sulfate, Others?)
THE RCP SCENARIOS

CO₂ Emissions and Total Radiative Forcing

Graphs: Detlef van Vuuren
## FOUR RCPs

<table>
<thead>
<tr>
<th>RCP8.5</th>
<th>RCP6</th>
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<tr>
<td>● &gt;8.5 W/m² in 2100,</td>
<td>● ~6 W/m² at stabilization after 2100</td>
</tr>
<tr>
<td>● Rising</td>
<td>● Stabilization without exceeding target</td>
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<tr>
<th>RCP4.5</th>
<th>RCP3-PD</th>
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<tr>
<td>● ~4.5 W/m² at stabilization after 2100</td>
<td>● &lt;3 W/m² in 2100</td>
</tr>
<tr>
<td>● Stabilization without exceeding target</td>
<td>● peak &amp; decline stabilization</td>
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**RCPs needed SEPTEMBER 2008!**

*This means that the underlying scenario must come from the existing literature.*
2.6 W/m² or 2.9 W/m²?

Which scenario for the low (<3W/m²) RCP?

Noordwijkerhout debate over what it means to be:

“compatible with the full range of stabilization, mitigation, and baseline emissions scenarios available in the current literature”

Van Vuuren et al. published a 2.9 W/m² and explored the potential of bioenergy with CCS to reduce 2100 radiative forcing to still lower levels.

– The authors emphasized the experimental nature of the 2.6 W/m² scenario and indicated that they were uncomfortable with providing it as an RCP absent further review on their part.

– Some members of the policy user community argued strongly that 2.6 W/m² was absolutely essential.

The IAMC is conducting a process to review the robustness of a revised 2.6 W/m² scenario.
RCP “HANDOFF”

The four IAM teams who have agreed to supply RCP scenarios are currently preparing scenario data, to be delivered in September 2008.

- IAM teams are updating historical data and producing additional information requested by Earth System Models (ESM), particularly regarding land-use.
- A draft “handshake” protocol has been developed detailing the data to be delivered to the earth-system modeling community
- The development of a consensus set of base year 2000 emissions and historical emissions from at least 1850 forward.
  ✶ IAM, emissions inventory, and chemical modeling communities
  ✶ Goal: Seamless transition between history and future scenarios

The IAM data will be used by chemistry models to produce future scenarios for atmospheric chemistry (oxidants, ozone, and, in some cases, aerosols) in preparation for ESM model runs starting in early 2009.
A goal of the RCP development process is to produce a consistent estimate of historical emissions along with four future RCP projections that start from a common year 2000 data set.

- A similar process is taking place for land-use and land-use change.
The RCP emissions data will be provided in greater sectoral detail than for previous scenario exercises:

- Ground Transportation
- International Shipping
- Aviation
- Power Plants, Energy Conversion, Extraction, and Distribution
- Solvents
- Waste (landfills, wastewater, non-energy incineration)
- Industry (combustion & processing)
- Residential and Commercial
- Ag waste burning on Fields
- Agriculture (e.g. Animals, Rice, & Soil)
- Savannah Burning
- Land-Use Change (Deforestation)

Greater detail is due to spatial, chemical, temporal, and differing sectoral coverage within ESM models.
Land-use and land-use change data will also be provided on a gridded basis:

- Cropland
- Harvested forest area (secondary forests)
- Deforested area (primary forests)
- Pasture and grazing land
- Urban land

Supplementary data that has also been requested includes:

- Irrigated area
- Timber and wood harvest amounts (and disposition)
- Standard of living indicator
- Fertilizer use
RCP Land-Use

Spatially distributed information will be a fundamental part of new scenarios.

Forest Cover
Emissions and land-use for the RCP scenarios will be extended to 2300 to allow for long-term climate simulations.

- Emissions (RCP 2.9/2.6 and 8.5) or concentrations (RCP 4.5 & 6) past 2100 will be held constant (consistent with forcing stabilization in 4.5 and 6 scenarios).
- Cropland and pasture areas past 2100 will be scaled with global population.

The extension procedure is very simple, and is intended to produce a consistent data set for ESM modeling. These are not full 300-year scenarios!
RCP Land-Use

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THE PARALLEL PHASE
**SCENARIO DEVELOPMENT TIME LINE**

- **Product 1**: RCPs delivered to CMC
- **Product 2**: RCP-based CMC ensembles & pattern scaling
- **Product 3**: New IAM Scenarios
- **Product 4**: Story Lines
- **Product 5**: Integration of CMC Ensembles with New IAM Scenarios Available

- **Fall 2007**: 12 months
- **Fall 2008**: 24 months
- **Fall 2010**: 18 months
- **Spring 2012**: 12 month Publication Lag
- **Spring 2013**:
PARALLEL PHASE

During the parallel phase, all scenario elements will be examined and new scenarios produced.

Scenarios (in a climate context) can consist of:
- Demographic, Social, and Economic Characteristics
- Technology Availability and Performance
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While ESM scenarios are being completed, new research will be conducted to examine multiple dimensions of mitigation, adaptation, and impacts.

As new modeling results using the RCPs become available from a wide range of models (CMs, ESMs, Ecosystem Models, Models of Intermediate Complexity) further iteration and integration will occur.

- The use of consistent scenarios for a variety of model simulations will allow for detailed comparisons between all classes of models.
- The state of modeling on all levels is likely to improve, although many new research questions will also arise.
SUMMARY

IAV research based on new CM and IAM scenarios

Continued Development and Application of IAM Scenarios

Integration of CMC Ensembles with IAM NEW Scenarios

Development of New IAM Scenarios

CMC Develops RCP-based Ensemble Runs

Story Lines

IAV Research Based on AR4 Climate and SRES IAM scenarios

Time line of products

- Preparatory Phase: Fall 2007, 12 months
- Parallel Phase: Fall 2008, 24 months
- Integration Phase: Fall 2010, 18 months
- Publication Lag: Spring 2012, 12 months
- Spring 2013

RCPs Selection, Extension to 2300, Downscaling

RCPs delivered to CMC

New IAM Scenarios

Story Lines

Integration of CMC Ensembles with New IAM Scenarios Available

Fall 2007

Fall 2008

Fall 2010

Spring 2012

Spring 2013
DISCUSSION

IAV research based on new CM and IAM scenarios

Continued Development and Application of IAM Scenarios

Integration of CMC Ensembles with IAM NEW Scenarios

Development of New IAM Scenarios

CMC Develops RCP-based Ensemble Runs

Story Lines

IAV Research Based on AR4 Climate and SRES IAM scenarios

Integration of CMC Ensembles with IAM NEW Scenarios

RCPs Selection, Extension to 2300, Downscaling

Time line of products

Fall 2007

12 months Preparatory Phase

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Integration of CMC Ensembles with New IAM Scenarios Available
END OF SLIDES