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INFORMATION PAPER

Representative Concentration Pathways (RCPs)

Authors: Imogen Jubb, Pep Canadell and Martin Dix

The impacts of climate change on the environment and society will depend not only on the response of the Earth system but also on how humankind responds through changes in technology, economy, lifestyle and policy. These responses are uncertain, so future scenarios are used to explore the consequences of different options.

The scenarios provide a range of options for the world's governments and other institutions for decision making. Policy decisions based on risk and values will help determine the pathway followed.

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) has introduced a new way of developing scenarios. These scenarios span the range of plausible radiative forcing scenarios, and are called representative concentration pathways (RCPs).

What are RCPs?

RCPs are concentration pathways used in the IPCC AR5. They are prescribed pathways for greenhouse gas and aerosol concentrations, together with land use change, that are consistent with a set of broad climate outcomes used by the climate modelling community.

The pathways are characterised by the radiative forcing produced by the end of the 21st century. Radiative forcing is the extra heat the lower atmosphere will retain as a result of additional greenhouse gases, measured in Watts per square metre (W/m²).

The complexity of humanity's possible future emissions has been reduced to just four representative pathways.

RCPs take into account the impact of atmospheric concentrations of carbon dioxide and other greenhouse gases and aerosols (such as sulfate and soot). Each of the RCPs covers the 1850–2100 period.

Each of the RCPs represents a larger set of scenarios in the scientific literature. The full range of emissions scenarios, with and without climate policy, is included within the range of the RCPs.

They include one mitigation scenario leading to a very low forcing level (RCP2.6), two medium stabilisation scenarios (RCP4.5 and RCP6) and one very high baseline emission scenario (RCP8.5).

The 8.5 pathway arises from little effort to reduce emissions and represents a failure to curb warming by 2100. It is similar to the highest-emission scenario (A1FI) in the IPCC Fourth Assessment Report (AR4).

The 6.0 pathway stabilises total radiative forcing shortly after 2100 by the application of a range of technologies and strategies for reducing greenhouse gas emissions.

RCP4.5 is similar to the lowest-emission scenario (B1) assessed in the IPCC AR4.

RCP 2.6 is the most ambitious pathway. It sees emissions peak early, then fall due to active removal of atmospheric carbon dioxide. This pathway is also referred to as RCP3PD (representing the mid-century peak radiative forcing of ~3W/m² followed by a decline). RCP 2.6 needs early participation from all the main emitters, including those in developing countries. It has no counterpart in IPCC AR4.

The four pathways

Radiative forcing	*Atmospheric CO_2 equivalent (parts per million)	When
8.5	>1370	By 2100, but rising
6	850	Stabilisation after 2100
4.5	650	Stabilisation after 2100
2.6	490	Peak before 2100 then decline

Table 1. Four global radiative forcing pathways from greenhouse gas emissions from human activities, with radiative forcing of 2.6, 4.5, 6.0 and 8.5 W/m² by 2100. The corresponding respective greenhouse gas concentrations in the year 2100 are equivalent to 490, 650, 850 and more than 1370 parts per million (ppm) carbon dioxide. Source IGBP. http://www.igbp.net/download/18.1b8ae20512db692f2a680007120/NL75_one-planet.pdf

Climate researchers use the four RCPs as inputs into climate models to determine likely global temperature, rainfall and other climate possibilities. Coupled carbon-cycle climate models can then calculate associated emission levels. Specialists in ecosystems, agriculture, water, city planning and economics use the projected climate information to assess impacts and costs of likely change.

Why were they introduced?

The new scenarios help the climate research community in a number of ways. They provide more detailed and better standardised greenhouse gas concentration inputs for running climate models than those provided by any previous scenario sets. The RCP scenarios explicitly explore the impact of different climate policies to allow cost-benefit evaluation of long-term climate goals. They also allow more detailed exploration of the role of adaptation and further integration of scenario development across the different disciplines involved in climate research.

How were RCPs developed?

An international group led by the International Geosphere-Biosphere Programme's earth system modelling project, the World Climate Research Programme's Working Group on Coupled Modelling (WGCM) and the Integrated Assessment Modelling Consortium coordinated the work to develop RCPs.

The pathways were developed for the climate modelling community as a basis for modelling experiments. The RCPs are the product of an innovative collaboration between integrated assessment modellers, climate modellers, ecosystem modellers as well as social scientists working on emissions, economics, policy, vulnerability and impacts. Moss et al (2010) describes the process by which RCPs were developed.

RCPs specify concentrations, from which climate modellers and integrated assessment modellers find the corresponding climates and emissions and policy circumstances that would produce them. This is different from AR4, in which the starting point was emissions.

The RCP development process includes calculation of scenarios of future emissions and policies that can lead to the specified levels of radiative forcing.

How do they differ from the Special Report on Emissions Scenarios (SRES)?

The RCPs span a wider range of possibilities than the SRES marker scenarios used in the modelling for the IPCC 3rd and 4th Assessment.

RCPs start with atmospheric concentrations of greenhouse gases rather than socioeconomic processes. This is important because every modelling step from a socioeconomic scenario to climate change impacts adds uncertainty. By starting with concentrations, there are fewer steps to impacts and therefore less cumulative uncertainty in impact assessments. This way uncertainty is shared more evenly among the various components.

The RCPs are not a complete package of socioeconomic, emission and climate projections. Rather, they are internally consistent sets of projections of the components of radiative forcing that are used in subsequent phases of climate modelling.

In contrast to SRES, some of the RCPs also include mitigation and adaptation policies.

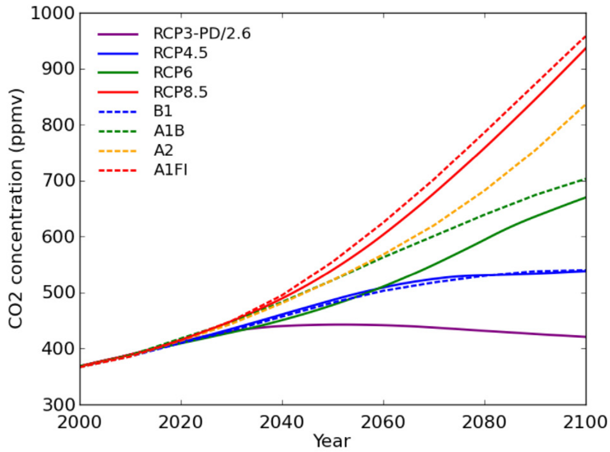

Figure 1. Comparison of carbon dioxide concentrations for the 21st century from the RCPs and SRES scenarios. RCP8.5 is closest to A1FI, RCP6 is closest to A1B, RCP4.5 is similar to B1, and RCP2.6 is lower than any of the standard SRES scenarios (Data from Meinshausen et al 2011 and IPCC TAR WG1 Appendix 2).

SRES	RCP	Approximate CO_2 equivalent concentrations by 2100 (ppm)
A1FI		1550
	8.5	>1370
A1B		850
	6	850
B2		800
	4.5	650
B1		600
	2.6	490

Table 2. Approximate carbon dioxide equivalent concentrations in ppm by 2100 for both SRES and RCP scenarios. Carbon dioxide equivalent concentrations include aerosols and other greenhouse gases. Source: Meinshausen et al, Moss et al, IPCC 2007.

Benefits of using RCPs

The RCPs are an important development in climate research and provide a foundation for emissions mitigation and impact analysis.

RCPs will facilitate the exchange of information among physical, biological and social scientists. Researchers working on impacts, adaptation and vulnerability will obtain model outputs sooner and have more time to complete their part of the AR5. Climate-model scenarios can also be developed without constraining future work on integrated assessments.

As climate models improve, newer models can employ the same pathways, allowing modellers to isolate the effects of changes in the climate models themselves.

The RCPs are supplemented with extensions (Extended Concentration Pathways, ECPs), which allow climate modelling experiments through to the year 2300.

Development of the RCPs also brings together a diverse range of research communities that will help create fully integrated Earth-system models that include representation of the global economy and society, impacts and vulnerabilities.

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For further information

Telephone: 1300 363 400

Email: enquiries@csiro.au

Website: www.cawcr.gov.au/projects/climatechange/