The Science Policy Nexus:
Assessing Climate Policy in an Imperfect World

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Climate Change Working Paper No. 18
Centre for Strategic Economic Studies
Victoria University
Melbourne

November 2013

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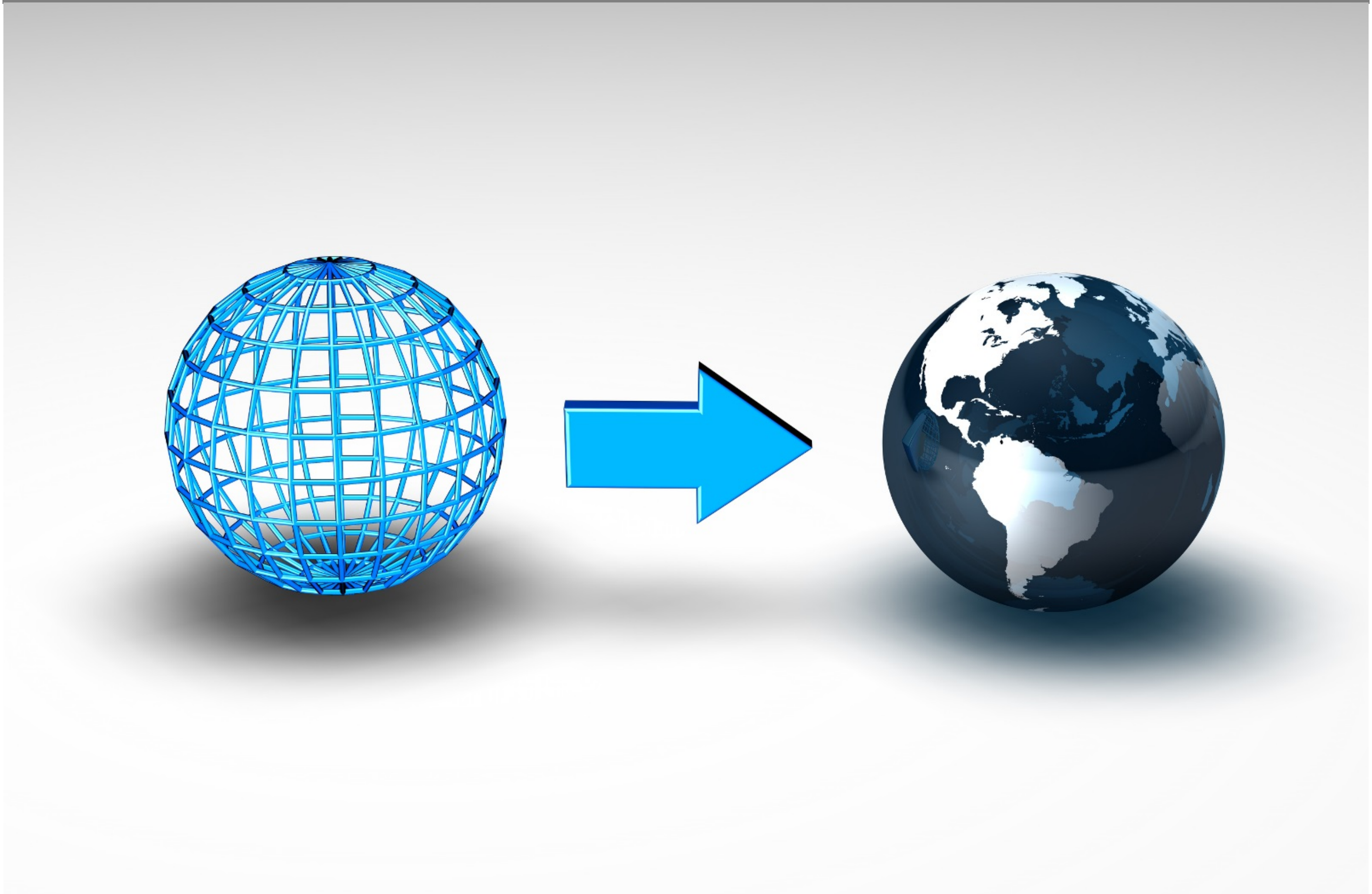

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This context paper was prepared for the workshop, “The science policy nexus: assessing climate policy in an imperfect world” held by the Centre for Strategic Economic Studies, Victoria University, 22 November 2013. This paper provides context and background information for the workshop participants.

Acknowledgements

Page 6 photo original courtesy NASA, variations by J. Wybrow; all other photos sourced from Bigstock. Peter Rayner and David Karoly for contributions to the original climate modelling presented.

Suggested citation

Bodman, R.W., Jones, R.N. and Young, C.K. (2013) *The science policy nexus: assessing climate policy in an imperfect world.* Climate Change Working Paper No. 18, Centre for Strategic Economic Studies, Victoria University, Melbourne, Australia.

Project overview

This workshop is part of a research project *Exploring science-policy links for the new generation of climate scenarios* being conducted at the Centre for Strategic Economic Studies, Victoria University. The project is funded by a research grant from Victoria University that supports postdoctoral research work being undertaken by Roger Bodman.

The project objective is to better understand the role for policy in using the research outputs derived from the new types of scenario tools developed for the IPCC’s Fifth Assessment Report (AR5) and beyond. These tools have been produced as part of an extensive process of building the new generation of climate scenarios, which has yet to be completed (Ebi et al., 2013). The main building blocks within that process are the Representative Concentration Pathways (RPCs). For AR5, the main purpose of the RCPs has been to provide a standard set of inputs for climate and integrated assessment modelling.

The RCPs describe a set of future greenhouse gas concentrations and radiation changes in the atmosphere. They differ from the previous greenhouse gas scenarios, which described future emissions; these differences are important as we will explain later. The RCPs were largely constructed to support the climate research work of Working Group I, but their wider application to climate policy is still being explored.

The key research question: To what extent does the next generation of scenarios, as represented by the RCPs, meet the needs of climate policy and decision makers?

This research will:

- Assess how the RCPs are being applied and evaluate their appropriateness for translation into policy-relevant findings;
- Seek to distinguish the ‘science-for-policy’ research agenda as distinct from the ‘science-for-science’ research agenda.

Workshop aims

The overall aim of this workshop is to understand how the results from climate modelling research work, as exemplified by the AR5, are understood by users outside of the climate modelling community.

The workshop will consider:

- How are the uncertainties associated with projecting future climate, as represented by the RCPs, being understood?
- Whether the RCPs meet the information needs of policy and decision makers or if not, what are the information and knowledge gaps that need to be addressed?

- What 'science-for-policy' research would assist climate policy and decision makers to address the demands of climate change mitigation and adaptation?

Policy and science background

The 15th and 16th meetings of the Conference of Parties (COP15: 2009, COP16: 2010) of the United Nations Framework Convention on Climate Change (UNFCCC) reached agreement that global warming be limited to no more than 2°C higher than pre-industrial levels. This sets a policy target consistent with the central objective of the UNFCCC, of "stabilising greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (United Nations, 1992). This goal was re-emphasized at COP17 in 2011.

The COP18 (2012) meeting agreed on a work plan to negotiate a new binding agreement by 2015 TO BE implemented by 2020. This has led to a focus on individual countries setting target emissions for 2020. COP19 in Warsaw, from November 11–22 2013, is continuing that discussion.

Complementing the 2°C temperature target, work has developed around the carbon budget concept, which links this temperature goal to total emissions over a specific time period. A budget of 1,000 billion tonnes of carbon (GtC) emitted from all human sources is assessed as the maximum amount required as being 'likely' (>66% likelihood) to avoid the 2°C limit (IPCC, 2013). However, considerable uncertainties make it difficult to accurately calculate the likelihood of meeting or exceeding this budget. An estimated 545 (460 to 630) GtC of this budget has been consumed between 1750 and 2011 (IPCC, 2013).

Although the RCPs have been developed for use by the climate modelling community in preparation for AR5, they are not explicitly structured around achieving these policy goals. Instead, they are designed to explore all plausible futures (Ebi et al., 2013).

The other major building block being developed as part of the scenario development process are the Shared Socioeconomic Pathways (SSPs). The RCPs and SSPs describe future biophysical and socioeconomic uncertainties, respectively.

The RCPs were developed first, to provide climate modelling inputs for AR5. They describe four concentration pathways that indicate possible outcomes ranging from low to high levels of *radiative forcing* in 2100. Radiative forcing is the added level of outgoing radiation trapped in the atmosphere by increasing greenhouse gases, after accounting for natural factors and aerosols, and is measured in Watts per square metre (Wm^{-2}).

These pathways were developed to provide a standard set of inputs for a range of modelling experiments covering climate change, climate impacts and integrated assessment. The timing was organised to produce climate change projections in time for AR5. This can be considered as addressing the ‘science for science’ agenda.

How the RCPs can potentially address the ‘science for policy’ agenda is a question this paper aims to inform. It does so by exploring how the RCPs are being used to estimate global mean temperature change to 2100, especially in the AR5, and contrasting this to previous assessments.

Two issues for assessing the ‘science for policy’ agenda, concern:

1. Uncertainty in projecting future climate, and
2. Consistency between successive assessments.

Addressing future uncertainty is a constant concern when dealing with climate change. We explore it here by how it affects projected mean global warming. However, the methods used to develop the RCPs, along with changes in scientific understanding between the Fourth (AR4) and Fifth Assessment Reports introduce a level of inconsistency between the two reports. These differences need to be understood before the question of ‘science for policy’ can be adequately addressed.

Development of the Representative Concentration Pathways

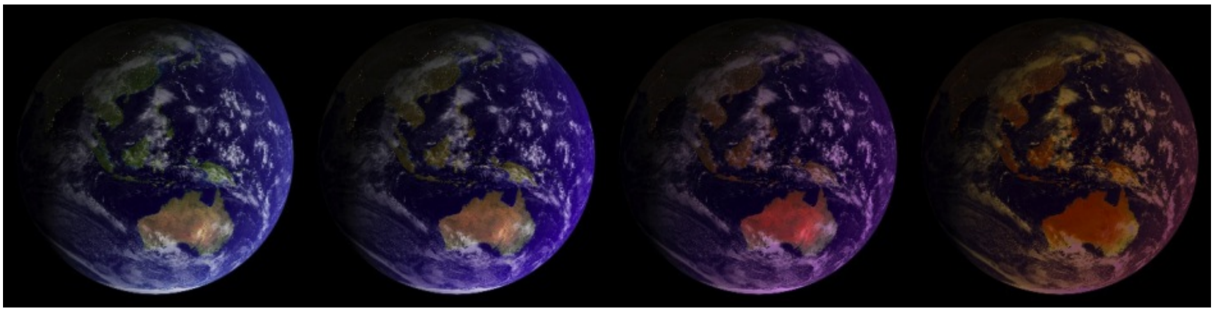
The RCPs are designed to meet the needs of three different but related modelling groups:

- the Climate Modelling (CM) community,
- the Integrated Assessment Modelling (IAM) community, and

- the Impacts, Adaptation and Vulnerability (IAV) community.

They were selected from existing emission scenarios and were then harmonized by four different IAM groups (see Meinshausen et al., 2011) to provide a consistent set of inputs for a range of model experiments (Moss et al., 2008):

- ‘Representative’ indicates that each scenario is only one of many possible pathways resulting from the designated radiative forcing;
- ‘Concentration’ refers to the level of atmospheric greenhouse gases in the atmosphere over time; and
- ‘Pathway’ points to the importance of the concentration trajectory over both the short- and long-term (the next few decades, century’s end and beyond; Moss et al., 2010).



The RCPs depart from the earlier Special Report on Emission Scenarios (SRES; Nakicenovic and Swart, 2000) on how they represent climate policy (van Vuuren et al., 2012). Unlike the SRES scenarios, three of the RCPs explicitly represent varying degrees of mitigation policy. The exception to this, RCP8.5, is a high end, business-as-usual, or ‘worst case’ scenario. The four scenarios represent four possible future worlds, with no scenario being any more likely than the others. Four scenarios were chosen to prevent a central scenario being selected, encouraging users to consider the full range of uncertainty.

The RCPs have been named according to their radiative forcing level in 2100, as summarised in Table 1 (van Vuuren et al., 2011b). This measure was selected because the modelling community wanted to assess long-term changes to 2300 and the socioeconomic projections required to estimate emissions that far into the future were considered to be too uncertain (van Vuuren et al., 2008). Standardised data sets across the RCPs provide a consistent set of drivers for all models and types of models. The RCPs are used to drive the AOGCMs (Atmosphere Ocean General Circulation Models) and ESMs (Earth System Models), taking part in the fifth climate model intercomparison project (CMIP5). This provides the source data for AR5.

The lowest, RCP2.6, peaks at 3 Wm^{-2} before declining to 2.6 Wm^{-2} in 2100. RCP4.5 and RCP6.0 represent moderate to high levels of forcing, while RCP8.5 has the highest level of radiative forcing.

Table 1: Characteristics of the RCPs (Moss et al., 2008). Wm^{-2} is Watts per square metre and concentrations are in CO_2 equivalents*.

Name	Radiative Forcing	Concentration	Pathway shape
RCP8.5	>8.5 Wm^{-2}	>1,370 CO_2-eq in 2100	Rising
RCP6.0	6 Wm^{-2} at stabilisation after 2100	850 CO_2-eq (at stabilisation after 2100)	Stablilisation without overshoot
RCP4.5	4.5 Wm^{-2} at stabilisation after 2100	650 CO_2-eq (at stabilisation after 2100)	Stablilisation without overshoot
RCP2.6	Peak at 3 Wm–2 before 2100 and then decline	Peak at 490 CO_2-eq before 2100 and then decline	Peak and decline

* (Additional details on the RCPs are included in Appendix A.)

Uncertainty

Projections of future climate change are subject to uncertainties arising from:

1. Scientific uncertainty – the response of the Earth's climate system to those greenhouse-gases, and
2. Socioeconomic uncertainty – drivers such as population, economic growth and energy technology that generate greenhouse-gas emissions.

Scientific uncertainty

Climate change projections are generated using computer-based simulations of the climate system. Scientific uncertainties affecting how the results can be interpreted include:

- Observations, against which models can be verified and model parameters calibrated, have measurement limitations (e.g., different instruments, length of observation and spatial data coverage);
- Model-based uncertainties, which include missing or partially known physical processes and parameterisations (where a complex process is simplified);
- Climate response uncertainties that include feedbacks, non-linear responses and potential sudden threshold changes;
- Differences in how models portray physical processes within the climate system.

Some of these uncertainties can be examined by using simple climate models that include the major climate processes, although greatly simplified. As a result, these models do not represent internal climate variability but do represent the uncertainties linked to externally forced change.

For a simple climate model, such as the MAGICC model being used in this project, around two-thirds of the uncertainty in global-mean temperature change for a given emission scenario is due to climate sensitivity. Approximately a quarter stems from carbon cycle uncertainties, with a small contribution from aerosol radiative forcing (see Figure 1).

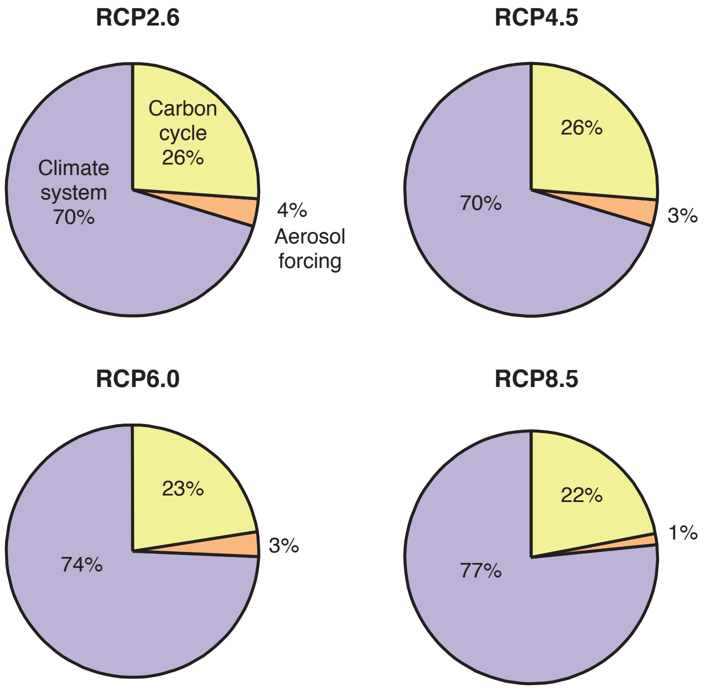


Figure 1: Pie chart illustrating relative sources of uncertainty for temperature change in 2100 for given emission scenarios (refer Bodman et al., 2013 for methodology).

These uncertainties are scenario-dependent, depending on the mix of emissions over time. Carbon cycle uncertainties are particularly important to consider, because they have not been managed consistently between AR4 and AR5.

Socioeconomic uncertainty

Socioeconomic uncertainties attached to future greenhouse gas emissions depend on policies, levels of economic activity, demographics, land-use and energy technologies. Using multiple emission scenarios is one way of exploring such uncertainties.

The SRES scenarios were developed from *storylines* that incorporated the above characteristics. They were then quantified to produce greenhouse gas emissions through to 2100. The storylines contained no explicit climate policies and all were considered to be plausible (Nakicenovic and Swart, 2000).

The RCPs represent socioeconomic uncertainty through four different levels of radiative forcing in 2100, however, this is not explicit. They are more policy-oriented that the SRES scenarios in that three achieve a level of stabilisation, and one avoids 2°C warming at a median level of climate sensitivity. These scenarios are not intended to be policy-prescriptive (Moss et al, 2008). However, while the RCPs span a broad range of possible outcomes, they are not projected from present day trends. As a result the near-term characteristics of those scenarios do not necessarily represent the current policy-economy-technology mix. This is a limitation when assessing policy needs over the next two decades.

Scientific and socioeconomic uncertainties are also interrelated. Scientific uncertainty is larger at higher emission levels. The mix over time also differs, depending on time elapsed and rate of emissions. Most of the uncertainty out to about 2040 is scientific. Socioeconomic uncertainty increases over time as the difference between emission scenarios becomes larger.

Representation of uncertainty

This section explores how uncertainty is represented in projected mean global warming between the AR4 and AR5 assessments. However, inconsistencies between these assessments mean that both the uncertainties themselves and how they are being represented in the AR5, as contrasted with the AR4, need to be understood before they can contribute to policy in a meaningful way.

Temperature Projections

The key issues of uncertainty and consistency in the 'science for policy' agenda can be illustrated using projected ranges of mean global warming at the end of this century. Table 2 shows temperature change from both AR4 and AR5. The SRES-driven temperatures from AR4 show a range from 1.1 to 6.4°C and the RCP-driven temperatures from AR5 show a range of 0.3 to 4.8°C.

At first glance, it would appear that estimated warming has been reduced between AR4 and AR5 (Table 2). However, this is not the case. Instead, the difference is due to different periods being used for measuring the amount of change (see Table 2) and the way the input emission scenarios were constructed.

Table 2: SRES projected global mean warming (IPCC AR4 WG1 Table SPM.3) and RCP projected global mean warming (IPCC AR5 WG1 Table SPM.2).

SRES	Temperature Change (SRES) (°C at 2090–2099 relative to 1980–1999)[a]	
Case	Mean	*Likely* range
B1 scenario	1.8	1.1 – 2.9
A1T scenario	2.4	1.4 – 3.8
B2 scenario	2.4	1.4 – 3.8
A1B scenario	2.8	1.7 – 4.4
A2 scenario	3.4	2.0 – 5.4
A1FI scenario	4.0	2.4 – 6.4
RCP	Temperature Change (RCP) (°C at 2081–2100 relative to 1986–2005)	
Case	Mean	*Likely* range
RCP2.6	1.0	0.3 – 1.7
RCP4.5	1.8	1.1 – 2.6
RCP6.0	2.2	1.4 – 3.1
RCP8.5	3.7	2.6 – 4.8

Issues arising from the differences between the AR4 and AR5 climate model results, include:

- The base period and averaging intervals differ. Results in AR5 are calculated for slightly different time periods than in AR4. Warming is also sometimes assessed from a pre-industrial baseline and sometimes from the late 20th century, a 0.5–0.6°C difference.
- Choice of central values differ, e.g., median and mean, as do how distributions of likelihood around the central value are calculated.
- Different types of input scenarios are used that represent different parts of the physical process. This can mean that important processes, such as the carbon cycle, may or may not be represented in the results.
- The range of processes or forcings (e.g., greenhouse gases, volcanic, solar, ozone) differ from model to model, although there is a prescribed minimum set.
- Using the likely range alone may be inadequate for risk assessment purposes – the low probability/high consequence outcome may be worth considering.

- The types of uncertainty quantified in projections may differ from one assessment to the next.

SRES projections

The temperature ranges from the SRES scenarios were presented in AR4 (Table 2). The mean for each scenario is averaged from a set of coupled climate models. The likely range from Table 2 is also represented by the grey vertical bars on the right of Figure 2. ‘Likely’ is defined as >66% probability (according to IPCC, 2007, Box TS.1). These ranges were developed from a large range of climate model runs accounting for climate sensitivity, aerosol emissions and internal climate variability. An added amount, largely accounting for carbon cycle uncertainty was added as a component of expert judgement (IPCC, 2007).

These ranges of uncertainty were given with no information as to how those uncertainties were distributed – whether the mean was much more likely than the extremes, or whether uncertainty was spread across the whole distribution. The extreme, but most unlikely outcomes were omitted, and the range restricted to the likely (<90%) component of the total.

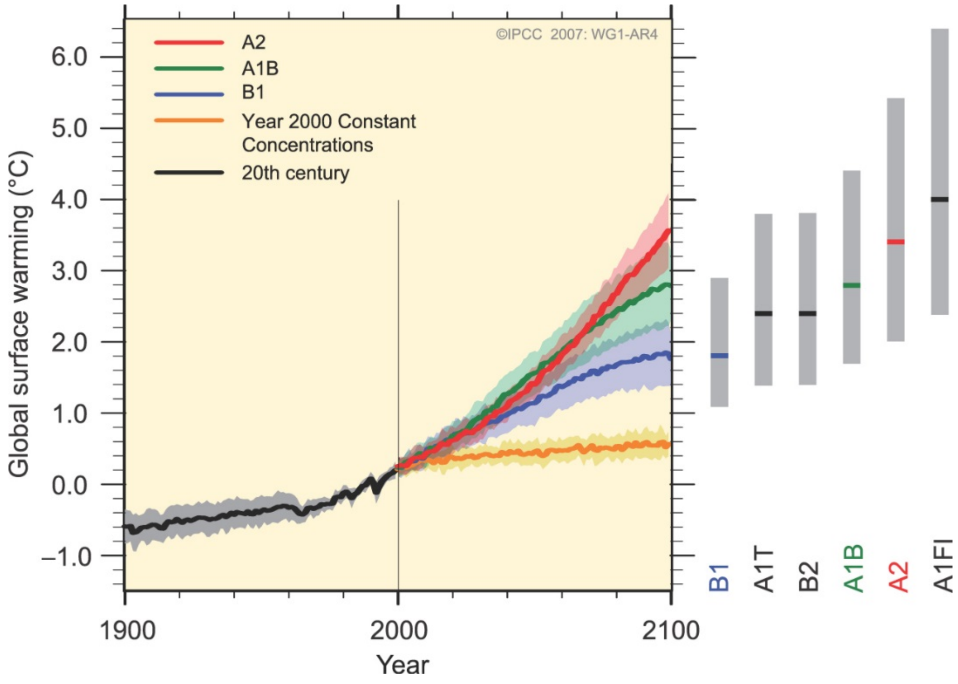


Figure 2: Solid lines are multi-model global averages of surface warming (relative to 1980–1999) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. The orange line is for the experiment where concentrations were held constant at year 2000 values. The grey bars at right indicate the best estimate (solid line within each bar) and the likely range assessed for the six SRES marker scenarios. Source: IPCC (2007) AR4 WG1 Figure SPM.5.

RCP projections

Global-mean temperature projections from AR5 (IPCC, 2013) are presented in Table 2. As described earlier, these are not directly comparable to those presented in AR4.

The most important difference is that they are also not based on emissions of greenhouse gases into the atmosphere but use atmospheric concentrations as their starting point. This omits carbon cycle uncertainties, which constitute approximately one quarter of the total uncertainty (see section on Scientific uncertainty). Starting with emissions requires carbon cycle modelling to account for how the atmosphere, biosphere and ocean deal with greenhouse gases, especially CO_2. These projections also have different reference and averaging periods, which has less of an effect on the outcomes.

The RCP estimates are therefore lower than those from AR4; not because of new scientific knowledge, but instead because of model limitations and changes in assessment methodologies.

MAGICC projections

Simple climate models can be used to overcome some of these limitations. They have long been used in projecting mean global warming and diagnosing the uncertainties inherent in those projections (see Climate uncertainty). This project uses the simple model MAGICC, with fully integrated carbon-cycle uncertainties built in (see Bodman et al., 2013), to calculate the RCP projections with carbon cycle uncertainties built in.

Table 3 shows ranges of mean global warming in 2100 with carbon cycle uncertainties added. These temperatures are somewhat more relevant to assessing policy targets because they measure change from the pre-industrial baseline. However, they are about 0.5–0.6°C higher than those in Table 2, which are referenced to a late 20th century baseline.

Table 3: RCP projected global average surface warming based on emissions, from a simple Earth System Model (MAGICC, methodology as per Bodman et al, 2013).

	Temperature Change (°C at 2100 relative to pre-industrial)	
Case	Mean	*Likely* range[a]
RCP2.6	1.6	1.0 – 2.4
RCP4.5	2.8	1.9 – 4.0
RCP6.0	3.6	2.5 – 4.9
RCP8.5	5.1	3.6 – 6.8

[a] In this case, a 66% confidence interval.

Figure 3 illustrates 21st century temperature change projections for the RCPs, plotting the results as relative to the pre-industrial era. Out of the four RCPs, only RCP2.6 has a *median value* (mid-point in a probability distribution) below the policy target of 2°C warming.

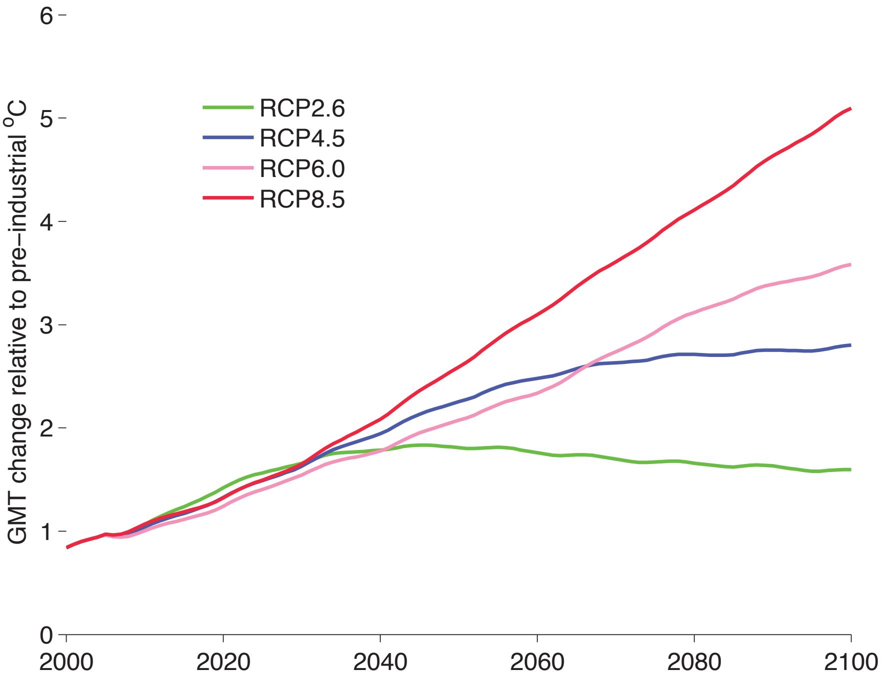


Figure 3: Temperature change projections relative to pre-industrial for the four RCPs: emission driven changes according to MAGICC (methodology based on Bodman et al., 2013). Lines are median values.

These projections may be considered more policy relevant than those presented in the recent AR5, because they include the carbon cycle and are referenced to the pre-industrial temperature baseline. In particular, RCP2.6 achieves a level of policy 'success' in avoiding the 2°C policy target for much of its range (1.0–2.4°C). However, the methodology used here produces higher ranges of uncertainty than that produced by the more complex climate models, so emphasises the difficulty in different assessment methods.

This brief example shows that further work may be needed to ensure that the RCPs can be made more policy relevant.

Integrating scientific and socioeconomic uncertainty

The lack of socioeconomic information informing the RCPs is also a drawback. However, as part of the scenario process, a parallel development of socioeconomic characteristics is currently underway: the Shared Socioeconomic Pathways (SSPs). Although the RCPs provide input essential for climate modelling, they need to be complemented by key socioeconomic and ecological data required by the IAM (Integrated Assessment Modelling) and IAV (Impacts, Adaptation and Vulnerability) groups. By combining RCPs and SSPs in different ways, it is possible to develop a wide variety of scenarios that address both physical and socioeconomic uncertainties.

Researchers can use such scenarios to project impacts, to explore the extent to which adaptation and mitigation could reduce projected impacts, and to estimate the cost of action and inaction (Ebi et al., 2013). This process is ongoing, with the planning process largely completed, while modelling work is currently underway. Initial results will be reported in AR5, but most of this work will become available after the current IPCC assessment process has been completed.

Climate policy and information needs

To date, the development of scientific tools and knowledge has largely been a ‘science-for-science’ endeavour, which at times, has led to confusion as to the how the resulting outputs should be used. How that development can become ‘science for policy’, remains unclear.

Issues that need to be properly accounted for include the lack of clear continuity between IPCC assessment reports, the changing nature of how the scenarios are being developed and the changing needs of policy makers. In particular, keeping up with the rate of change required to support proactive decision making as part of the policy process poses a problem for scientific programs that take many years to plan and execute.

It is important to understand the current level of understanding of policy and decision-makers and what their key knowledge needs are, so these can be integrated into what science is offering now or is planning to deliver in the near future. This way, we can better identify important modifications and additions to the research portfolio that will help develop the ‘science-for-policy’ agenda.

Appendix A: RCP Outlines

No mitigation: RCP8.5

RCP8.5 has the highest level of greenhouse-gas emissions, more than tripling the pre-industrial carbon dioxide concentration by 2100. It is a business as usual, non-mitigation scenario similar to the SRES A1FI scenario. RCP8.5 has similar total CO_2, higher methane emissions and much lower sulfate, CO, NMVOC and NOx emissions, with a net higher radiative forcing that produces more warming by the end of the 21st century. This pathway does not include a mitigation target, instead allowing greenhouse-gas emissions to increase substantially.

The associated storyline of a "relatively conservative business as usual case" allows the world population to grow steadily to 12 billion by 2100, with relatively slow income growth and little convergence between high and low income countries (Riahi et al., 2011). Global GDP reaches about US$250 trillion in 2100. There is little progress in energy efficiency and international trade in energy and technology is also limited. The energy system concentrates on coal-intensive technologies with high GHG emissions. Energy intensity continues to improve slowly, round 0.5% per year, down from a historical rate of about 1% per year (Riahi et al., 2011). There is also some growth in renewables and nuclear power.

The area of cultivated land increases, mostly in Africa and South America. Yield improvements and intensification however are the main sources for growing agricultural production. Significant reductions in sulfate emissions reflect continuing improvements in air quality. So, although RCP8.5 has the highest level of GHG emissions, it is not a high pollution scenario as well.

Medium mitigation: RCP6.0

The RCP6.0 pathway is a stabilisation scenario as detailed in Masui et al. (2011). According to the modelling work done with the Asia-Pacific Integrated Model (AIM) the energy intensity improvement rate increases from 0.9%/yr to 1.5%/yr by around 2060. The long-term stabilisation temperature is reported as 4.9°C, with a CO_2-equivalent concentration of 855 ppm.

The world population expands to 9.8 billion people, peaking around 2085, and global GDP grows to $225 trillion by 2100. The total primary energy supply for RCP6.0 is 838 EJ/yr by 2100, although after 2060 the growth in this supply slows as GHGs stabilise. The energy supply in RCP6.0 moves away from coal to more gas, while non-fossil fuel power including nuclear grows to over 30% by 2100. CCS (Carbon Capture and Storage) is also deployed, with close to 75% of thermal power plants using this technology by the end of this century.

High mitigation: RCP4.5

The RCP4.5 pathway aims to stabilise radiative forcing at 4.5 Wm^{-2} (approximately 650 ppm CO_2-equivalent) in 2100 (Thomson et al., 2011). Achieving this relatively modest level still requires significant assumptions about developments in energy technologies, including CCS and large increases in nuclear power. GHG emissions increase until mid-century, with declines thereafter.

The RCP4.5 pathway is achieved by:

- Moving to lower emissions energy technologies;
- Deploying carbon capture and storage (CCS);
- Achieving bioenergy with CCS that is carbon negative to the atmosphere;
- Increasing nuclear power generation;
- Expanding forested areas;
- Assuming all nations mitigate and share a common carbon price;
- Allowing for a peak and decline in world population, with 9 billion people by 2065, then 8.7 billion by 2100;
- Significant GDP growth and a tripling of global primary energy production.

CO_2 emissions were ‘backed out’ from the radiative forcing target using an integrated assessment model (GCAM). This is one of many possible solutions that allows for industrial/fossil fuel CO_2 emissions to peak at 11.3 GtC in 2040, then reducing to 50% below present levels, while land use emissions decline to near zero by 2100. RCP4.5 achieves these reductions by allowing limited growth in fossil fuels but with CCS to remove the CO_2 emissions. Renewable energy is significantly increased, notably from wind power, along with a massive increase in nuclear power.

RCP4.5 is a ‘second-best’ world scenario that, despite a peak and decline in CO_2 emissions, leads to GMT changes greater than the UNFCCC’s 2°C goal to avoid ‘dangerous climate change’.

Extreme mitigation: RCP2.6

RCP2.6 is an overshoot scenario whereby emissions peak in 2020 and then decline, with CO_2 fossil-fuel emissions actually going negative from 2080 and land use CO_2 reaching zero emissions by 2125. Greenhouse-gas emissions and net radiative forcing are comparable to a stabilisation scenario such as a 450ppm CO_2-equivalent scenario of the type discussed by, for example, Garnaut, (2008). RCP2.6 is detailed in van Vuuren et al. (2011b).

This scenario allows for medium developments in population, income, energy use and land use. The emission reduction in 2100 is more than 95% compared to the baseline. CO_2

emissions are reduced by more than 100% from improvements in energy efficiency and fossil fuels using CCS, along with significant growth in renewables and nuclear power. Net negative CO_2 from fossil fuels relies on BECCS (Bioenergy and Carbon Capture and Storage) and hydrogen in the transport sector.

Key terms and acronyms

AIM	Asia-Pacific Integrated Model
AOGCM	Atmosphere-Ocean General Circulation Model
AR4	Fourth Assessment Report of the IPCC (2007)
AR5	Fifth Assessment Report of the IPCC (2013)
BECCS	Bioenergy and Carbon Capture and Storage
CCS	Carbon Capture and Storage
CH_4	Methane
CM	Climate Model or Climate Modelling
CMIP5	Coupled Model Intercomparison Project Phase 5
CO	Carbon monoxide
CO_2	Carbon Dioxide
COP	Conference of the Parties
ESM	Earth System Model
GCAM	Global Change Assessment Model
GHG	Greenhouse Gas
GMT	Global-mean temperature
GtC	Gigatonne of Carbon (a billion tonnes)
IAM	Integrated Assessment Model
IAV	Impacts, Adaptation and Vulnerability
IPCC	Intergovernmental Panel on Climate Change
MAGICC	Model for the Assessment of Greenhouse gas Induced Climate Change
Median	Mid-point in a probability distribution; the 50th percentile

NMVOC	Non-Methane Volatile Organic Compounds
N_2O	Nitrous Oxide (NO_x – nitrous oxides)
Overshoot	The term given when atmospheric concentrations of greenhouse gases peak and then decline, rather than rising towards a stable limit
Radiative forcing	Is the change in the net (incoming minus outgoing) energy at the top of the atmosphere due a change in the climate system.
RCP	Representative Concentration Pathway
SPM	Summary for Policy Makers (of the IPCC’s WGI report)
SRES	Special Report on Emission Scenarios
SSP	Shared Socioeconomic Pathway
Storylines	Narrative elements of scenarios, often used to aid quantification of future changes
TS	Technical Summary (of the IPCC’s WGI report)
UNFCCC	United Nations Framework Convention on Climate Change
WGI	Working Group I (of the IPCC, the first volume on the physical climate).
Wm^{-2}	Watts per square metre, the measure of additional energy provided by *radiative forcing*.

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