

SECTION 3

Making Sense of the New Climate Change Scenarios

The speed with which the climate will change and the total amount of change projected depend on the amount of greenhouse gas emissions and the response of the climate to those emissions. To make projections, climate scientists use greenhouse gas scenarios – “what if” scenarios of plausible future emissions – to drive global climate model simulations of the earth’s climate. Both the greenhouse gas scenarios and global climate models are periodically updated as the science of climate change advances. The most recent projections for 21st century climate change (IPCC 2013)^[1] align with and confirm earlier projections (e.g., IPCC 2007).^[2]

1. How much and how fast climate changes occur depends on both the amount of greenhouse gas emissions and how the climate changes in response to those emissions.

As a result, projecting future climate requires making assumptions about future greenhouse gas emissions and then modeling the climate’s response to those emissions. Irreducible uncertainty in both climate and future greenhouse gas emissions means that projections of future climate will always involve a range of scenarios.

- *Since it is impossible to predict exactly how much greenhouse gases will be emitted, scientists use greenhouse gas scenarios to consider the implications of a range of different future conditions.*
- *We can’t know which scenario is more likely.* Since we are unable to predict the future, we can’t say with certainty which scenario is most likely to occur.
- *It is important to consider a range of potential outcomes.* There is no “best” scenario, and the appropriate range of scenarios depends on the specific climate impact under consideration. Deciding which scenario(s) to use involves clarifying how climate affects a particular decision and what level of risk is acceptable.
- *Projections will continue to be updated over time.* As the science of climate change progresses, new greenhouse gas scenarios and updated climate models will inevitably replace the current climate projections.

2. New greenhouse gas scenarios used in IPCC 2013^{[1][3]} range from an extremely low emissions scenario involving aggressive emissions reductions to a high “business as usual” scenario with substantial continued growth in greenhouse gases.

Although these scenarios were created in a different way and span a wider range of possible 21st century emissions, many of them are similar to scenarios used in previous assessments (Table 3-1, Figures 3-1 and 3-2).^{[A][4]}

^A The newest scenarios, used in the 2013 IPCC report, are referred to as Representative Concentration Pathways (RCPs; Van Vuuren et al. 2011^[3]). The previous greenhouse gas scenarios, used in the 2001 and 2007 IPCC reports, are described in the Special Report on Emissions Scenarios (SRES; Nakicenovic et al. 2000^[4]).

Table 3-1. Previous greenhouse gas scenarios have close analogues in the new scenarios.

<i>New scenarios</i>	<i>Scenario characteristics</i>	<i>Comparison to old scenarios</i>	<i>Description used in this report</i>
<i>RCP 2.6</i>	An extremely low scenario that reflects aggressive greenhouse gas reduction and sequestration efforts	No analogue in previous scenarios	“Very Low”
<i>RCP 4.5</i>	A low scenario in which greenhouse gas emissions stabilize by mid-century and fall sharply thereafter	Very close to B1 by 2100, but higher emissions at mid-century	“Low”
<i>RCP 6.0</i>	A medium scenario in which greenhouse gas emissions increase gradually until stabilizing in the final decades of the 21 st century	Similar to A1B by 2100, but closer to B1 at mid-century	“Medium”
<i>RCP 8.5</i>	A high scenario that assumes continued increases in greenhouse gas emissions until the end of the 21 st century	Nearly identical to A1FI ^[B]	“High”

- *The old scenarios have close analogues in the new scenarios.* For example, the A1B scenario – used as the high-end scenario in many Pacific Northwest impacts assessments – is similar to the newer RCP 6.0 scenario by 2100, though closer to the RCP 8.5 scenario at mid-century.
- *In both cases, the high end is a “business as usual” scenario (RCP 8.5, SRES A1FI) in which emissions of greenhouse gases continue to increase until the end of the 21st century, and atmospheric CO₂ concentrations more than triple by 2100 relative to pre-industrial levels.*
- *The new scenarios include an aggressive mitigation scenario (RCP 2.6), which would require about a 50% reduction in global emissions by 2050 relative to 1990 levels, and near or below zero net emissions in the final decades of the 21st century.*
- *All scenarios result in similar warming until about mid-century.* Prior to mid-century, projected changes in climate are largely driven by the warming that is “in the pipeline” – warming to which we are already committed given past emissions of greenhouse gases. In contrast, warming after mid-century is strongly dependent on the amount of greenhouse gases emitted in the coming decades.
- *Greenhouse gas scenarios are consistent with recent global emissions.* Globally, greenhouse gas emissions are higher and increasing more rapidly since 2000 than during the 1990s (Figure 3-1).^[1]

^B The A2 greenhouse gas scenario is between the RCP 6.0 and 8.5 scenarios.

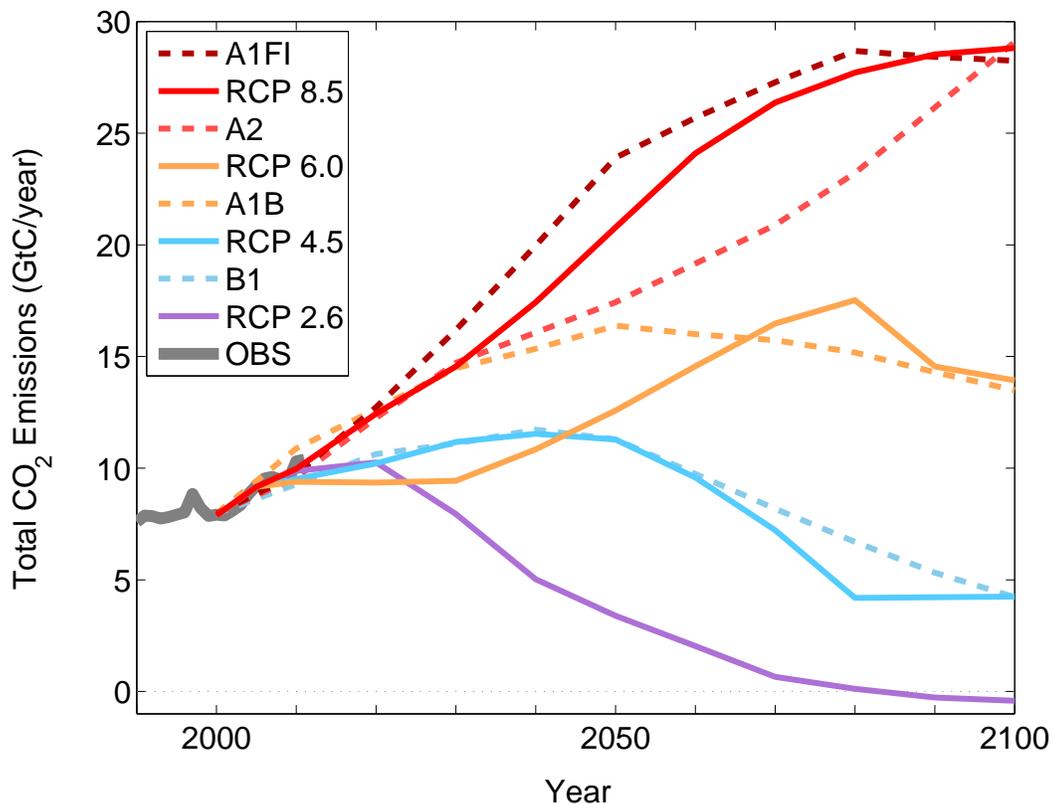


Figure 3-1. Future greenhouse gas scenarios range from aggressive reductions to large increases in greenhouse gas emissions. The figure shows annual total CO₂ emissions in Gigatons of Carbon (GtC). Though not the only greenhouse gas, CO₂ emissions are the dominant driver of global warming. The old greenhouse gas scenarios (dashed lines) have close analogs in the new scenarios (solid lines) – similar scenarios are plotted using similar colors. Actual emissions for 1990-2010 are shown in grey. Year-to-year emissions of greenhouse gases, shown in this graph, accumulate in the atmosphere, causing CO₂ concentrations to rise, as shown in Figure 3-2. Scenarios with higher emissions cause atmospheric concentrations to rise rapidly, while lower scenarios cause concentrations to rise more slowly or decline. *Figure source: Climate Impacts Group, based on data used in IPCC 2007 and IPCC 2013 (<http://tntcat.iiasa.ac.at:8787/RepDb>)^[3] and <http://sedac.ciesin.columbia.edu/ddc/sres/>)^[4].*

3. New climate change projections (IPCC 2013) also use new versions of climate models that simulate changes in the Earth’s climate. More models are included in the new projections, and they are improved relative to older models.^{[5][6]}

- *New climate models project similar climate changes for the same amount of greenhouse gas emissions.* Differences between warming projections for the 2007 and 2013 IPCC reports are mostly due to differences in greenhouse gas scenarios.^{[5][7]}
- *The range among climate model projections may not encompass the full range of potential future climate changes.* The range among climate model simulations provides an estimate of the uncertainty in projections, but it is important to note that future changes in climate could be outside of the range projected by existing climate models.

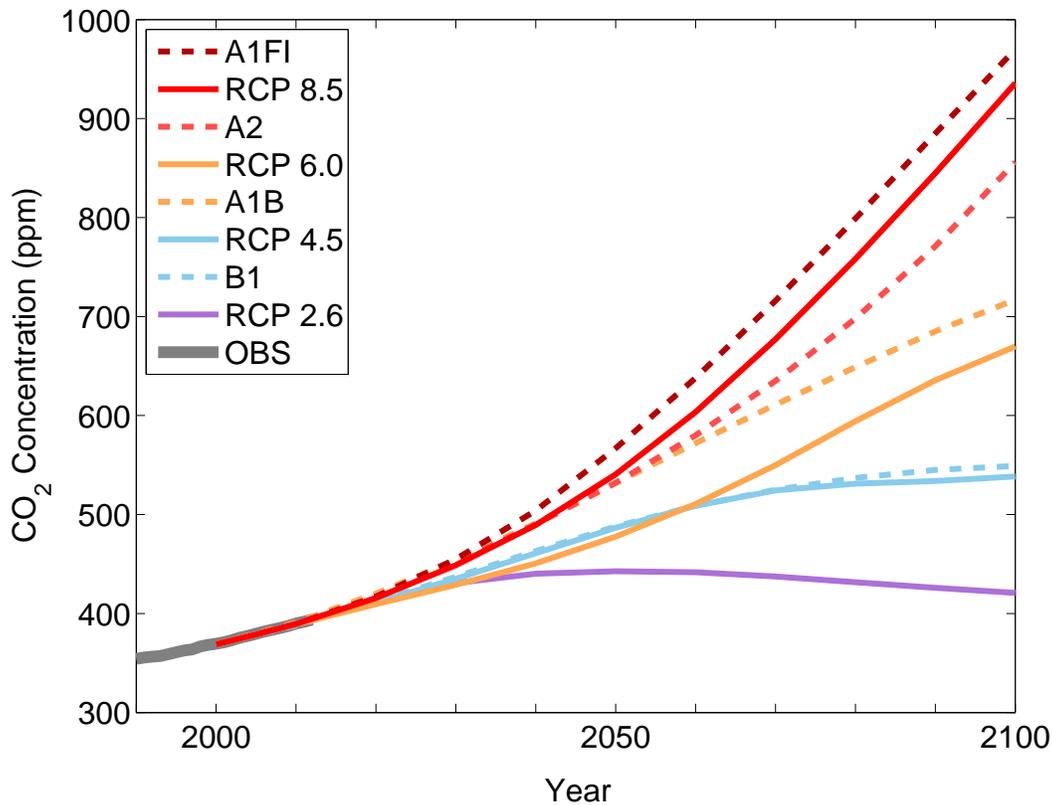


Figure 3-2. All scenarios assume continued growth in atmospheric levels of greenhouse gases for the next few decades. The figure shows total CO₂ concentration, in parts per million (ppm), for each greenhouse gas scenario. Though not the only greenhouse gas, CO₂ emissions are the dominant driver of global warming. The old greenhouse gas scenarios (dashed lines) have close analogs in the new scenarios (solid lines) – similar scenarios are plotted using similar colors. Actual concentrations for 1990-2010 are shown in grey. *Figure source: Climate Impacts Group, based on data used in IPCC 2007 and IPCC 2013 (<http://tntcat.iiasa.ac.at:8787/RcpDb>^[3] and <http://sedac.ciesin.columbia.edu/ddc/sres/>^[4]).*

4. Implications for Pacific Northwest climate projections and climate impacts assessments.^[C]

- *Projected Pacific Northwest climate change is similar for new (IPCC 2013) and old (IPCC 2007) scenarios of medium and low greenhouse gas emissions. The Washington Climate Change Impacts Assessment (WACCIA)^[8] and many regional climate impact studies largely used the A1B and B1 greenhouse gas scenarios. These are comparable to RCP 6.0 and RCP 4.5, respectively, at the end of the century, in terms of both greenhouse gas concentrations (Table 3-1) and resultant changes in Pacific Northwest climate (Section 5, Figure 5-2).*

^C See Section 5 (Figure 5-2) for a comparison of projected Pacific Northwest temperature change under the old and new scenarios.

- *Newer scenarios for very low and high greenhouse gas emissions result in a wider range in projected late-century warming for the Pacific Northwest. Previous regional assessments have typically considered a narrower range of greenhouse gas scenarios.*
 - The new scenarios include an aggressive greenhouse gas mitigation scenario (RCP 2.6), which assumes much lower emissions than in other scenarios. The older projections do not include a comparable scenario.
 - The highest scenarios commonly used in many previous climate impacts assessments (A1B, A2) are much lower than the high-end scenario in the new projections (RCP 8.5).
- *The importance of differences between the old and new climate change projections will depend on the specific impact under consideration and the sensitivity of the decision being made.* For example, projected changes in annual average temperature are likely to differ by less than 1°F under similar greenhouse gas scenarios from IPCC 2007 and 2013, while projected changes in annual average precipitation are likely to differ by only a few percentage points (Section 5, Figure 5-2). Other differences between the scenarios have not yet been explored.

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- [1] (IPCC) Intergovernmental Panel on Climate Change. 2013. *Working Group I, Summary for Policymakers*. Available at: http://www.climatechange2013.org/images/uploads/WGIAR5-SPM_Approved27Sep2013.pdf
- [2] (IPCC) Intergovernmental Panel on Climate Change. 2007. *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- [3] Van Vuuren, D. P. et al., 2011. The representative concentration pathways: An overview. *Climatic Change* 109(1-2): 5-31.
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- [7] Andrews, T. et al., 2012. Forcing, feedbacks and climate sensitivity in CMIP5 coupled atmosphere-ocean climate models. *Geophysical Research Letters*, 39(9). doi: 10.1029/2012GL051607
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