UNDERSTANDING SEA LEVEL

Projections

Empirical Projections

Projections of global sea level rise by 2100, the year upon which climate modelers typically focus, vary widely depending on modeling methods and on assumptions—the rate of increase in greenhouse gas emissions, for example, and especially how ice sheets will respond to warming air and ocean water. Recent projections range from 0.2 meters to 2.0 meters (0.66 to 6.6 feet) [Melillo et al., 2014; see sections 13.5.1 and 13.5.2 of the 2013 IPCC report for detailed discussion].

The projections for the century ahead focus on the two largest contributors: thermal expansion of seawater and melting land ice. The consensus projections in the most recent IPCC report, called the Fifth Assessment or AR5, include dynamic changes in the great ice sheets—an improvement over the previous assessment, AR4, although much remains uncertain in the young field of ice sheet modeling [Church et al., 2013].

The latest assessment provides a range of projections for a variety of greenhouse gas emissions scenarios and associated radiative forcing (the energy injected into the climate system by the action of these gases). The four Representative Concentrated Pathway scenarios, or RCPs, rise from low to high emissions, each applied to CMIP 5 models to produce possible future sea-level changes.

AR5 expresses "medium confidence" in these projections, derived from process-based models—that is, attempts to simulate the mechanics and interactions of the factors driving sea level rise and land ice changes. But coupled general circulation numerical models—considered "process-based"—explain 90 percent of the observed sea level rise between 1971 and 2010, as well as that observed during a shorter period, 1993 to 2010 (see "By the Numbers"). This increases confidence that these models are reliable under present-day conditions, despite the fact that the models' current rate of

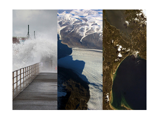
By the Numbers

Sea level budget as seen by NASA observations. Find the latest numbers of all contributions and references to respective publications.

› view the numbers

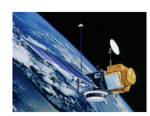
More About Projections

New NASA-Sea Level Change Team and team leader announced



Rising seas bring a rising nuisance: coastal flooding

25 years of global sea level data, and counting



rise, 3.7 millimeters per year, is significantly higher than shown by observations. Since these coupled models do not include ice sheet instabilities, their projections very likely represent a “lower bound” for future sea level rise.

Process-based models project a rise of 0.26 to 0.55 meters, with a median value of 0.4, for the RCP 2.6 scenario, in which gas emissions decline after a peak, while carbon dioxide levels remain below 500 parts per million. For the RCP 8.5 scenario, with its higher concentrations of greenhouse gases and with carbon dioxide above 700 parts per million, the projected rise is 0.52 to 0.98 meters, with a median value of 0.6. [Church et al., 2013].

Ocean warming and ice-sheet losses are “very likely” to drive the rate of sea level rise higher in the 21st century than the rate measured from 1971 to 2010, according to AR5 [Church et al., 2013]. For the 2081-2100 period, compared to 1986-2005, the report considers it likely, with medium confidence, that global mean sea-level rise will fall between five and 95 percent of the range projected by process-based models. Only the collapse of marine-based portions of the Antarctic ice sheet could drive sea level above these “likely” ranges, the authors concluded, and no more than a few tenths of a meter [Church et al., 2013].

And while the IPCC report acknowledges a newer, alternative approach known as semi-empirical modeling, its projections earn only “low confidence” from the IPCC [Church et al., 2013]. The report’s authors could not evaluate the probability that semi-empirical models, or SEMs, would come true, and believed the scientific community lacked consensus on their reliability.

SEMs [Rahmstorf et al., 2012 and references therein] take a simple approach—a kind of shortcut—to simulating future sea level rise. Instead of trying to model the processes underlying sea level change, these models rely on sea-level changes observed in previous decades and their relationship to global temperature. Then they apply that same relationship to the century to come. The resulting projections tend to be significantly higher than those derived from process-based modeling.

An illustrative example can be found in a recent study contrasting the projections of process-based and semi-empirical models [Perrette et al., 2013]. Global mean sea level rise from major sources—thermal expansion, glaciers, and the Greenland and Antarctic ice sheets—total 0.42 meters by

2100 in the process based RCP 6.0 model, considered a mid-range, standard-type emission scenario. But updated with the semi-empirical approach, the same model yields a total of 0.86 meters, more than twice the process-based value.

For scenario RCP 2.6, the median projection of the SEMs is about 0.75 meters by century's end, and about one meter for scenario RCP 8.5. At the high end of the confidence intervals (95%), sea level reaches above 1.5 meters for the latter scenario, mostly based on the works of Rahmstorf and of Jevrejeva. Another study of modeling reliability, in which Rahmstorf et al. performed an extensive analysis of their SEMs [[Rahmstorf et al., 2012], concluded that a rise of about one meter, produced by a warming of 1.8 degrees Celsius, represented a robust result, derived from published data and their model.

Since the publication of AR5, newer ice-sheet observations also are suggestive of the higher values for sea level rise. Measurements of grounding line retreat in West Antarctic glaciers, as we have seen [Rignot et al., 2014], yielded evidence of rapid retreat between 1992 and 2011. More importantly, the researchers did not find a "major bed obstacle that would prevent the glaciers from further retreat and draw down the entire basin [Rignot et al., 2014]." Bedrock along the discharge channels grows deeper in the inland direction, helping the grounding line move farther inland. A complementary study [Morlighem et al., 2014] found that the glacial valleys through which Greenland discharges ice to the ocean are deeper than previously believed, making them more vulnerable to melting by adjacent, warmer ocean waters.

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Wind, warm water revved up melting Antarctic glaciers

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