PCIC SCIENCE BRIEF: ADJUSTMENTS TO UPPER BOUNDS OF SEA LEVEL RISE PROJECTIONS

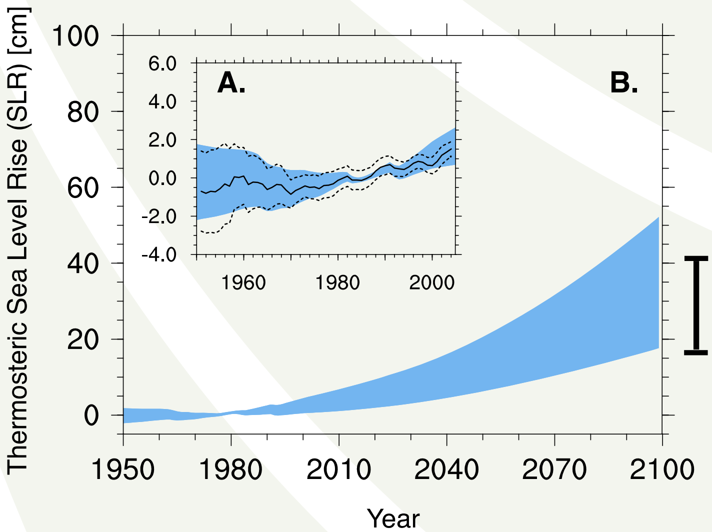
This is part of of a regular series of brief reports on recent climate science literature relevant to stakeholders in the Pacific and Yukon Region of Canada. The PCIC Science Briefs contextualize and explain the results and implications of important scientific findings.

Recent work by a group of scientists from several American research centres, using UVic's Earth System Climate model suggests that the upper bound of physically plausible sea level rise is larger than once thought, owing to thermal expansion and ocean heat uptake. These results have potential implications for flood risk analysis and planning.

Data from both tide gauges and satellites shows that sea level has been rising over the instrumental record. Climate models project that it will continue to rise as a consequence of the human influence on the Earth's climate system.

Global sea level rise has two main contributing factors, the expansion of water as it warms and the melt runoff from land-based ice, such as glaciers and the Greenland and Antarctic ice sheets. Local sea levels are impacted by these changes in global sea level, but also changes in local ocean temperature (which can vary from the global mean), changes in the Earth's gravitational field due to ice loss in polar regions, changes in ocean circulation patterns and geological processes, such as land slowly "rebounding" after the weight of ice sheets is removed from it at the end of glacial periods and the movement of the Earth's tectonic plates.

Changes in sea level affects coastal regions, ranging from flooding and erosion, with associated impacts on coastal habitats and infrastructure, to changes in groundwater, soil and surface water quality. In some cases, a small change in sea level can have a large effect on consequent events, such as the frequency of storm surge and inundation. Therefore, the amount of projected sea level rise and the plausible upper bound on sea level rise are important information for risk analysis and planning in coastal regions.



A) A comparison between the sea level rise from climate models (blue shading) and observations over the period of 1950-2003 (solid line is the mean, the dotted lines represent two standard deviations from the mean of the observations). B) Climate model projections (blue shading) of the thermosteric (i.e. due to thermal expansion) sea level rise for the period of 1950-2100 relative to the 1950-2003 average. The thick, vertical black line to the right indicates the range of thermosteric sea level rise from the A1FI Scenario from the Intergovernmental Panel on Climate Change's Fourth Assessment Report for the year 2100.
Figure modified from Sriver et al. (2012).

Sriver (2012) and colleagues recently examined the plausible upper bound of sea level rise for the year 2100, in an article published in the journal *Climatic Change*. They found that, while most of the sea level rise due to thermal expansion comes from warming in the upper 700 metres, the deep ocean also contributes, due to heat uptake. Their study found an upper bound of 0.55 metres for the thermal expansion component of sea level rise (Figure B), which is about 0.1 metres larger

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than the estimate for the A1FI Scenario from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007).

The present upper bound in global sea level rise that is used in estimates for local sea level changes in BC is taken to be 1 metre[1]. For historical reference, 0.1 metres is roughly the total amount of sea level rise seen in the last 50 years[2].

Methodology

The authors used the University of Victoria's Earth System Model, with a range of plausible values, constrained by prior analyses, for three parameters: (1) climate sensitivity (the amount of warming that eventually results when the atmospheric carbon dioxide concentration is doubled), (2) vertical ocean mixing and (3) the effectiveness of aerosols at reflecting incoming sunlight, in order to determine the contribution of thermal expansion to sea level rise. In order to do this, the authors worked from a high emissions scenario, in which the atmospheric carbon dioxide concentration by the year 2100 is just over four times what it was in the early 1800s by the end of the 21st century.

To restrict their analysis to plausible scenarios, the authors selected from the model results only those runs for which values for climate sensitivity were between 1.5 °C and 6 °C. They also removed from their consideration model results from runs where the model's output did not closely match observed sea level rise due to thermal expansion over the period of 1950 to 2003. The inset figure on the front page (A) illustrates this, showing the overlap between the selected model results and a range of two standard deviations[3] of observed sea level rise from the mean observed sea level rise.

Sriver et al. examined the range of model projections from the runs that they had selected based on these criteria, in order to arrive at the plausible upper bound for sea level rise.

Sriver, R.l., N.M. Urban, R. Olson and K. Kellar, 2012: Toward a physically plausible upper bound of sea-level rise projections. Climatic Change, 115, 893–902.

1. See: Thomson, R.E., B.D. Bornhold and S. Mazzotti, 2008: An examination of the factors affecting relative and absolute sea level in coastal British Columbia. Canadian Technical Report of Hydrography and Ocean Sciences, 260.
2. See: Church, J.A. and N.J. White, 2011: Sea-Level Rise from the Late 19th to the Early 21st Century. Surveys in Geophysics 32, 4-5, 585-602.
3. Standard deviation is a statistical term which indicates the amount of variation from the mean (average) value in a given set of data.

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