

A wide-angle photograph of a massive, flat-topped ice shelf in Antarctica, with several large icebergs floating in the dark blue water in the foreground. The sky is a clear, pale blue.

Insights into updating and using sea-level rise projections

A 1.1 metre rise in sea-level could put more than A\$226 billion (2008\$) of Australian commercial, industrial, transport and residential assets at risk from erosion and flooding hazards.

Up-to-date and relevant sea-level rise projections are therefore required to help identify and mitigate the risks for coastal societies and infrastructure into the future.

Earth Systems and Climate Hub researchers have contributed to international research to better understand and estimate future sea-level rise, including revised contributions from melting Antarctic icesheets.

Hub researchers have also investigated how sea-level rise projections are used, and the best approaches to developing, tailoring and communicating these projections based on the needs of users.

What causes sea-levels to rise?

Mean sea-level is influenced by a range of factors, including changes in the amount of water in the ocean, the density of seawater (determined in part by its temperature) and planetary forces, such as gravitational pull. Ocean currents and weather patterns that vary on daily (e.g. storms), seasonal (e.g. trade and monsoonal winds) and multi-year (e.g. El Nino Southern Oscillation) time scales also influence regional sea level.

The amount of water in the ocean is affected by the water distribution between land and oceans, such as frozen water in glaciers, the Antarctic and Greenland ice sheets, groundwater and water stored in dams and floodwater.

Global warming due to increases in greenhouse gas emissions causes ice sheets and glaciers to melt, adding water to the ocean. In addition, about 90% of the resulting excess heat uptake in the Earth system is absorbed by the oceans, causing them to warm. Warm water expands and causes sea-levels to rise; a process called thermal expansion. Sea levels are currently rising at a rate of 3.5 mm/year, with slightly over half of this rise due to the melting of land ice and most of the remainder due to thermal expansion.

Weather patterns, gravitational pull and warm and cold ocean currents are examples of some of the forces which move water around the oceans. This

means that sea-level rise is not uniform across the ocean. Local and regional vertical land motions also influence relative sea-level change at any given location.

Antarctica's contribution to sea-level rise

The largest uncertainty in estimating future sea-level rise is how the Antarctic ice sheets will respond to continued warming. The West Antarctic ice sheet is currently contributing positively to sea level rise whereas it is uncertain whether East Antarctica is or will contribute positively to sea-level rise over coming decades.

Newly proposed mechanisms that could speed up the contribution from Antarctica to future sea-level rise include the disintegration of marine sectors of the ice sheet due to melting from warm waters below, and the fracturing of ice cliffs as meltwater in fissures refreezes causing the ice cliffs to collapse.

Initially it was thought that these Antarctic processes could contribute as much as 2.5 m to global sea-level rise by 2100 under a high emissions pathway. However in 2019, the Intergovernmental Panel on Climate Change (IPCC) Special Report on Ocean and Cryosphere in a Changing Climate (SROCC) assessed various studies and models of Antarctic ice sheet loss. It concluded that these large-scale changes were unlikely to occur this century but should be considered in longer term estimates of global sea-level rise.

Updating sea-level rise projections

Earth Systems and Climate Change (ESCC) Hub researchers have developed global and regional sea-level rise projections under various scenarios which include the increased Antarctic contribution. The updated sea-level rise projections therefore provide more accurate information about future sea-levels.

For example, when compared to earlier projections of sea-level rise for Melbourne, the inclusion of a potentially higher Antarctic contribution raises the sea-level projections by approximately 10cm by 2100 under a high emission scenario (RCP8.5). There is little change between earlier and new projections under mid and low emission scenarios (RCP4.5 and RCP2.6).

Developing and presenting sea-level rise projections for specific uses

ESCC Hub researchers have also investigated how different end-users utilise sea-level rise projections and the best approaches to developing, tailoring and communicating these projections. This will help ensure that the sea-level rise data and information produced is useable and relevant for its intended use by decision-makers, managers and researchers. Examples of different sea-level rise projections, and their most appropriate uses, include:

1. Projections based on physical models of sea-level rise.

Estimates of the different contributing factors derived from climate and other models are combined and presented as a central estimate and uncertainty range for different greenhouse gas emission scenarios (Figure 1 presents an example of this method for Melbourne).

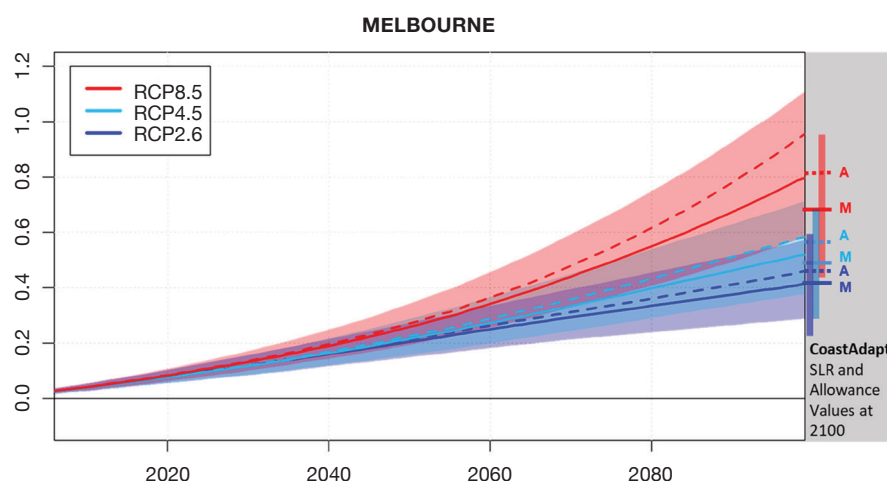


FIGURE 1 Mean sea-level rise projections for Melbourne relative to a 1986-2005 baseline including the Antarctic contribution to sea-level rise. Solid lines represent the median value for each emissions scenario (RCP), the shading represents the 5-95% model range, and dashed lines represent the allowance. All other contributions to sea-level rise are the same as for the earlier NCCARF CoastAdapt projections at 2100, shown in the grey inset at the right indicating the median value (M), the 5-95% sea-level rise range (vertical bar) and allowance (A). Average sea-level rise around Australia over the period 1966-2009 was 2.7 mm yr⁻¹.

The IPCC uses this method and it is also widely used for the production of regional sea-level projections in Australia. These projections are relevant for use in research and risk assessments.

2. High- or low-end sea-level rise scenarios.

Projections which present the high- or low-end of the projected range are useful when considering different levels of risk tolerance. These projections are best used to test the resilience of planned critical infrastructure to future sea-level rise.

3. Sea-level rise allowances.

Sea-level rise projections, their uncertainty and the behaviour of local extreme sea-levels are combined into a single value to represent the height assets need to be raised to afford the same level of protection in the future as they presently have under current sea-levels. These projections can be used by coastal engineers and practitioners when planning and building new or updated coastal infrastructure.

Using projections to plan for future sea-level rise

Users of sea-level rise information need to consider various factors when selecting projections. These include the purpose for which the projections are being used (e.g. assessments of vulnerability or risk, policy development, project designs, etc), the risk tolerance (low or high) and the time horizon of relevance (2050, 2100 etc). These factors will also influence the choice of emission scenario and probability levels to focus on. While most sea-level rise scenarios are available only to 2100, it is important to consider that sea-level rise will continue beyond this time horizon, possibly at a faster rate. In addition to mean sea-level rise, extreme sea-levels caused by tides and storm surges are an important additional consideration when planning for sea-level rise, together with how they may change as a result of changing weather patterns and sea-level rise due to global warming.