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Coastal flooding and coral bleaching: what the latest IPCC Special Report means for Australia

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On 24 September, the Intergovernmental Panel on Climate Change (IPCC) published the latest of three Special Reports in the Sixth Assessment Cycle, this time focussing on the Ocean and Cryosphere. Our Briefing Note 377 outlined some of the key points of the previous Special Report on Global Warming.

The focus of the third Special Report is of particular relevance to Australia, given the importance of the ocean in modulating Australia's climate; the large portion of the population exposed to coastal hazards; and the significance of the Great Barrier Reef to the tourist industry. This briefing note highlights some of the key findings of the report[1] and relevance for Australia.

Sea level rise

Global mean sea level (GMSL) is rising and accelerating due to increased ice loss from the Greenland and Antarctic ice sheets, as well as land-based glacier mass loss and thermal expansion of the ocean. The rate of GMSL rise over the past decade was 3.6 mm/yr, about 2.5 times greater than the average rate over the past century. Mass loss from Antarctica over the past decade has tripled relative to the previous decade and doubled for Greenland over the same period.

Figure 1. Ice sheet melt in Antarctica is a major source of uncertainty for global sea level rise projections. Source: Reuters/Pauline Askin (2019).

[1] The Special Report uses CMIP5 climate model projections and mainly RCP2.6 and RCP8.5 (RCP2.6 represents low greenhouse gas (GHG) emission, high mitigation future, which in CMIP5 gives a two in three chance of limiting global warming to below 2 °C by 2100. RCP8.5 is a high GHG, low mitigation scenario).

While Greenland is currently contributing more to GMSL than Antarctica, Antarctica could become a larger contributor by the end of the 21st century because of ongoing, rapid ice sheet retreat. Beyond 2100, the increasing divergence between Greenland and Antarctica's relative contribution to sea level rise, if global greenhouse gas (GHG) emissions continue unabated, has important consequences for the pace of relative sea level rise around Australia.

In Australia, the rate of sea level rise is lower than the global average (1.6 mm/yr at Sydney between 1966 and 2009, when ENSO is removed). Similarly, projections are lower: 0.38 m under Representative Concentration Pathway (RCP) 2.6 and 0.66 m under RCP8.5 for Sydney for the end of the 21st century (CSIRO, 2015), compared to 0.39 m and 0.71 m globally. This is because land is still rising from post-glacial rebound and atmospheric pressure is increasing around Australia, suppressing relative sea levels. However, there are large uncertainties attached to these projections, mainly associated with Antarctic contribution to future GMSL but also the longevity of the "suppression effect" around Australia (e.g. Sniderman et al. 2019).

Another component of sea level rise is thermal expansion of the ocean. It is virtually certain that the global ocean has warmed since 1970 and has taken up more than 90 % of the excess heat in the climate system, and up to 30 % of total anthropogenic CO_2 emissions since the 1980s. This has several additional consequences, including; acidification of the ocean; higher energy potential for the formation of tropical cyclones (noting other factors also influence formation); and, a higher number, length and severity of marine heatwave events associated with coral bleaching.

Coastal flooding

Sea level rise impacts coastal communities by contributing to an increased frequency of extreme sea level events resulting in coastal flooding. Extreme sea level events that are historically rare (once per century in the recent past) are projected to occur frequently (at least once per year) at many locations by 2050 in all RCPs, especially in the tropics. As a result, annual coastal flood damages are projected to increase by 2-3 orders of magnitude by 2100 compared to today.

In tropical Australia, this effect is compounded by changes to storm surges associated with tropical cyclones. While the sign and magnitude of changes to tropical cyclones in the Australian region remains uncertain, some research indicates they may track further south (Sharmila and Walsh, 2018) with the poleward extension of warmer SSTs, and slow down as tropical circulation changes (Kossin, 2018), although there is only limited evidence to suggest this is occurring at present. Other research suggests a decrease in the number of tropical cyclones forming in the Australian region (Knutson et al., 2015).

Outside the tropics, coastal vulnerability is associated with changes in ocean waves in addition to sea level rise. In the Southern Ocean, a strong trend of increasing wave heights is observed (Young and Ribal, 2019), resulting from a 'spin-up' in the mid-latitude westerly winds, with potential consequences for coastal flooding and erosion along Australia's southern margin. As the tropics expand, it is expected that changes in wave direction will also occur, which can be hugely impactful for sub-tropical coastlines (Goodwin et al., 2016). Erosion caused by the 2016

East Coast Low along Sydney's Northern Beaches (Figure 2) was an example of the impact of an 'unusual' storm wave direction for the coast (Mortlock et al., 2017).

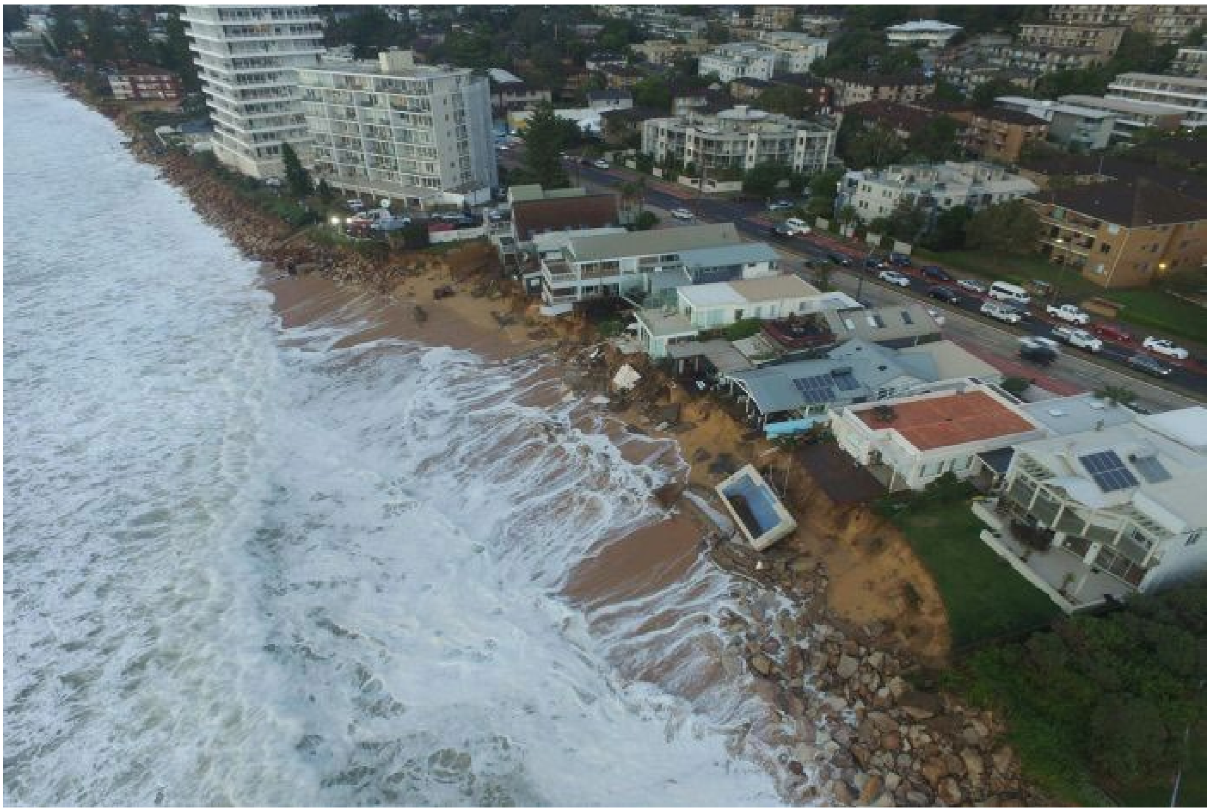

Figure 2. Coastal erosion and flooding on Sydney's Northern Beaches associated with the June 2016 East Coast Low. Source: UNSW WRL (2016).

Overall, attribution of current coastal impacts on people to sea level rise remains difficult in most locations since impacts are exacerbated by human-induced non-climatic drivers (e.g. groundwater extraction, habitat degradation and sand mining).

Coral bleaching

A major impact of ocean warming and acidification for Australia is the impact of marine heatwave events on coral bleaching and mortality, particularly for the Great Barrier Reef. Marine heatwaves have doubled in frequency and have become longer-lasting, more intense and more extensive.

Climate model-based attribution studies suggest it is very likely that up to 90 % of all marine heatwaves that occurred between 2006 and 2015 are attributable to anthropogenic temperature increases. By 2081-2100, climate models project increases in the frequency of marine heatwaves by approximately 50 times under RCP8.5 and 20 times under RCP2.6 for the tropical oceans.

Because of the sensitivity of tropical corals to sea surface temperatures, marine heatwaves often result in coral bleaching or mortality. When bleaching occurs, recovery is slow (more than 15 years) and may be impeded if the next bleaching event follows too soon.

Figure 3. Extreme coral bleaching on the Great Barrier Reef. Source: Australian Marine Conservation Society (2019).

Tangible impacts on the Great Barrier Reef extend from losses to the tourist and associated industries, and degradation of an important coastal defence. Research suggests the Great Barrier Reef dissipates up to 90 % of all offshore wave energy (Gallop et al., 2014), acting effectively as an underwater breakwater. As this defence reduces, increased wave energy and coastal erosion may be expected for the North Queensland region.

Uncertainties and risk appetite

A particularly important component of sea level rise for Australia is ice sheet instabilities in Antarctica. Acceleration of ice flow and retreat has been observed in both West and East Antarctica and may be the onset of irreversible ice sheet instability. Processes controlling the timing of future ice-shelf loss and the extent of ice sheet instabilities could increase Antarctica's contribution to sea level rise to values substantially higher than the IPCC's *likely* range on century and longer timescales.

Ice sheet instabilities pose a difficult question for coastal planning because there is no time horizon or probability assigned to ice sheet collapse. Uncertainties related to the onset of ice sheet instability arise from limited observations, inadequate modelling and understanding of processes.

Despite the large uncertainties about the magnitude and rate of sea level rise post 2050, many coastal decisions with time horizons of decades to over a century are being made now. The sea level rise range that needs to be considered for planning depends on the stakeholder's risk tolerance.

Stakeholders with higher risk tolerance (e.g. planning for adaptable investments) may adequately use the *likely* range of IPCC projections, while it may be prudent for those with a lower risk tolerance (i.e. planning for critical coastal infrastructure) to also consider sea level rise above the upper end of the likely range (i.e. typically > 1 m by 2100). We argued in our recent article in The Conversation that planning for many airports in Australia should include consideration of extreme sea level rise associated with Antarctic ice sheet collapse.

In summary, the IPCC's latest report highlights that coastal erosion, flooding and coral bleaching are the three main coastal hazards likely to be experienced with either greater frequency or intensity over the coming century. Given that over 80 % of Australia's population lives within 50 km of the coast, these changes are likely to have a significant financial and economic impact for business and government.

Risk Frontiers has recently launched its ClimateAUS framework to assist business to understand physical climate change risks. For more information contact info@riskfrontiers.com.

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