Tracking bigger wave action

Considering Australia is an island continent with a largely coastal population, little attention has so far been paid to how ocean and wave behaviour influenced by shifting and more intense storm systems under climate change will re-shape our 30 000 kilometre coastline. Information from a range of sources is now giving us strong clues.

Past studies of the effects of climate change on wave behaviour have generally centred on the high traffic shipping regions of the North Atlantic, although it is widely understood from a mid-1960s study that the swell waves generated in the Southern Ocean during intense storms propagate widely and may influence much of the world's coastlines.

A new study, led by Dr Mark Hemer from CSIRO's Wealth from Oceans National Research Flagship, has reviewed 50 years of ocean observations from wave-rider buoys, global wave models and satellites. The result is a baseline against which to measure past and future change.

Among key findings are that the Southern Ocean storms which generate irregularly large wave events along the southern Australian coast are increasing in frequency, and that wave direction has changed with the increasing dominance of an atmospheric feature in the Southern Ocean called the Southern Annular Mode.

Does this mean the swell at Bells Beach, traditional home of the Australian surfing championships, will be bigger? Not necessarily, says Dr Hemer, but there does appear to have been an increase in frequency of the large swell events along this stretch of coast.

'This project is really about managing both opportunities and risks associated with climate change,' he says.

'We can now identify coastal locations which are most susceptible to changes in waves around the Australian coastline,' Dr Hemer says.

'As surface ocean waves propagate from the deep water zone towards the coast, they undergo a range of transformations – the waves get steeper, change direction, potentially scour the seabed before finally losing all energy when they break near the shore.

'As a consequence, the impact of a changing offshore wave climate is not always experienced at the coast and some sections of coast may be more sensitive to changes in the offshore wave climate than others.

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Driving the wave climate review were two factors: a quest to better understand the potential of wave energy for Australia's electricity grid, especially with our proximity to the Southern Ocean; and a desire to identify how vulnerable Australian coasts and tidal ecosystems are to waves generated by more powerful storms in a world of warming atmospheric and ocean temperatures.

Funded by the Department of Climate Change and CSIRO the study describes Australia's ocean wave climate and identifies the trends and year-to-year changes in Australia's offshore wave climate, including an estimate of the range of the extremes.

Dr Hemer says the changes observed during the study are consistent with a warming climate influenced by greenhouse gases.

Bells Beach, Victoria. The trend of increases in storm-driven large swell events along Australia's southern coast may require mitigation planning for our coastal urban areas. iStockphoto

A wave-rider buoy being transported out to sea to begin recording swell events off Queensland. Courtesy of the Environmental Protection Agency, Queensland

Coastal flooding during severe storm events is expected to become more frequent through the combined effects of sea-level rise, storm surges and ocean waves. iStockphoto/bjeayes

'There is no question that our oceans are warming, and joint Australian–US research published in July 2008 [Domingues *et al.*, *Nature*] confirms a corresponding rising trend in sea levels. In the Northern Hemisphere the latest research indicates a greater intensity of storm activity.

'With sea-level rise such an issue of interest to Australians as a nation of coast-dwellers, identifying likely impacts and types of coastline that are more vulnerable is important to many communities.

'These changes must be quantified to enable coastal managers and researchers to determine how any changes will impact on Australia's coastal infrastructure and environment, and to assess the ocean wave resources available for renewable wave energy generation,' he says.

The study identified possible impacts of changing ocean waves in the coastal zone as:

- coastal flooding during severe storm events through the combined effects of sea-level rise, storm surges and ocean waves;
- chronic coastal erosion brought about by large wave events, or changes in wave direction shifting coastal sand and sediment; and
- seabed disturbance impacting sub-tidal habitats.

Dr Hemer, and his colleagues at CSIRO, Drs Kathy McInnes, John Church and Julian O'Grady, and Dr John Hunter from the Antarctic Climate and Ecosystem Cooperative Research Centre, also developed models to include the effects of surface waves in coastal flooding models along the eastern Victorian coast.

The basis of researching changes in Australia's offshore ocean wave climate has been available through wave data sourced from the network of Australian wave-rider buoys managed by state marine authorities, the Bureau of Meteorology, and industry, global and regional ocean wave models and satellite altimeter data.

Dr Hemer says analysis shows wave conditions in the Southern Ocean correlating closely with the Southern Annular Mode regional atmospheric climate feature, particularly during the southern hemisphere autumn and winter months.

When the Southern Annular Mode is at its height, wave direction along the southern and western coasts of Australia shifts from westerly to southerly with the intensification of the Southern Ocean storm belt. Along Australia's eastern coast, a similar rotation of wave direction is observed during El-Niño events, such that wave direction shifts from easterly to southerly.

The Cape Sorell wave-rider buoy site, 10 kilometres west of Macquarie Harbour on Tasmania's west coast, was chosen as an indicator location for the variability of large wave events on Australia's southern margin. Managed by the Bureau of Meteorology, it has recorded waves exceeding 18 metres.

Many large waves were identified in the study's wave-rider buoy record, which spans more than 20 years. Storms associated with these events were analysed using sea-level pressure records. The occurrence of these patterns over the full 45 to 50-year review were tallied as an indicator of the trends and changes in the occurrence of large wave events.

A significant percentage of wave events observed at Cape Sorell can be tracked between wave records along the full length of Australia's southern coastline. The positive trend in the frequency of observed weather events leading to large wave events is therefore expected to apply to the whole southern coastline.

While the research has identified some key drivers of wave climate in the Australian region, there is much work to be done to determine how waves will change under a future climate.

'Whichever way you look at it, swell will keep rolling in, but now we might just be able to predict the source, the direction and the likely impacts of any changes,' Dr Hemer says.

● **Craig Macaulay**

More information:
www.climatechange.gov.au/impacts/publications/pubs/wave-climate-summary.pdf