PREDICTING EXTREME WATER LEVELS AROUND AUSTRALIA

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INTRODUCTION

Throughout history, coastal settlers have had to adapt to periodic coastal flooding. However, as a society we have become increasingly vulnerable to extreme water level events as our cities and our patterns of coastal development become more intricate, populated and interdependent. In addition to this, there is now a real and growing concern about rising sea levels. Accurate estimates of extreme water levels are therefore critical for coastal planning and emergency planning and response. The occurrence of extreme water levels along low-lying, highly populated and/or developed coastlines can lead to considerable loss of life and billions of dollars of damage to coastal infrastructure. Therefore, it is vitally important that the exceedance probabilities of extreme water levels be accurately evaluated to inform risk-based flood management, engineering and future land-use planning. This objectives of this study was to estimate present day extreme sea level exceedance probabilities due to combination of storm surges, tides and mean sea level (including wind-waves) around the coastline of Australia.

Coastal regions experience rise and fall of sea level that vary at timescales of hours, days, weeks, months, annually and so on, governed by the astronomical tides, meteorological conditions, seismic events, local bathymetry and a host of other factors. Extreme events occur when many of these processes occur at the same time. Globally, the astronomical forces of the Sun and the Moon result in tidal variability with periods of 12 and 24 hours as well as tidal modulations with periods up to 18.6 years. Meteorological conditions lead to extreme events through the generation of (1) storm surges both locally and remotely (through the generation of continental shelf waves); (2) generation of surface gravity waves which increases the mean water level at the coastline through wave set-up. Thus the inclusion of physical processes that contribute to extreme water levels are important in any simulations. In addition, as the 18.6 year nodal cycle has a significant contribution around Australia simulations should include several cycles of the nodal tide. In this study we used an unstructured grid, hydrodynamic-wave model to simulate water levels around Australia over a 59 year period from which annual recurrence intervals were calculated.

METHODS

The 3D finite element hydrodynamic modeling system SCHISM (Zhang et al., 2016) was used for this study. The model grid included the whole of the Australian continent with a resolution ~100m at the shoreline. Wave dynamics were simulated using the Wind Wave Model (WWM-III) spectral model (Roland et al. 2009). The SCHISM–WWMIII modeling system is capable of two-way information exchange between the circulation model and wave model, with feedback in both directions at each time step during the whole simulation (Roland et al., 2012). The two-way coupled system accounts for the wave induced momentum flux from waves to currents and water levels, based on the radiation stress formulations. The JRA-55 reanalysis atmospheric model provided wind and mean sea level (MSL) pressure fields at 0.5 degree resolution at 3-hour intervals and were used to force the model. Model simulations were undertaken in hindcast mode over the period 1958 to 2016 (59 years) in parallelised mode, on the supercomputer Magnus at the Pawsey Centre (https://www.pawsey.org.au).

RESULTS

The simulated water levels over the 59-year period were used to estimate exceedance probabilities around the entire coastline of Australia at 1 km intervals (Figure 1) and included the effects of astronomical tides, storm surges due to wind and pressure (including tropical cyclones), and seasonal and interannual mean sea level (MSL) variability. A website was developed that makes the extreme sea level data readily available. In addition to the hourly time series at each numeric tide gages (at 1 km intervals along the coast) plots of ARI curves, seasonal variability and submergence curves are made available. As would be expected the maximum water levels were predicted in the northern regions that are subject to tropical cyclones. In contrast, the southern region that experience extra-tropical cyclones experience lower extreme water levels.

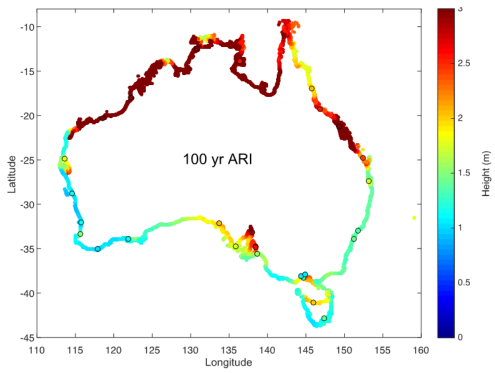

Figure 1 - Extreme water levels (1:100 ARI) around Australia (http://sealevelx.ems.uwa.edu.au/)

REFERENCES

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