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Past and future storm surge climates around New Zealand

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In New Zealand, which is surrounded by oceans, the largest storm-tide events tend to be a combination of wave impacts, storms and high spring tides. Although not as severe as storm surges from hurricanes or cyclones, extra-tropical storm surge in combination with spring tides is still a major hazard to our increasingly developed coastal margins causing coastal erosion and inundation of low-lying areas. Taking into account sea-level rise and possible changes in the frequency and intensity of storms due to climate change only increases this risk. To fully characterise the risk posed by extra tropical storm surge at a given location, it is necessary to have a long record of sea-level height. In places where these records exist, such as major ports, statistical methods can be used to probabilistically quantify the risk using statistics such as Annual Exceedance Probabilities. In many places, however, these records do not exist or are for short periods (<10 years). Furthermore, these statistical methods assume that the distribution of occurrence of storms is static: they do not take into account possible changes in weather patterns such as might be caused by climate change.

This study fills these gaps by providing a spatially complete hindcast and forecast of storm surge around New Zealand. First, a 40-year long hindcast of storm surge around New Zealand was created using meteorological forcing from ECMWF's ERA-40 dataset. The storm surge was calculated using RiCOM (River and Coastal Ocean Model), with tides added using constituents generated by Tide2D, a harmonic tidal model with boundary conditions taken from the NAO global tide model. In conjunction with this, a wave hindcast has been completed using the Wavewatch III™ model. The resulting sea-level hindcast (storm surge and tides) has been compared against observed sea-level from a national network of tide gauges. Direct comparisons were made where observed and modeled data were both available. Elsewhere, where data existed but were not contemporaneous, statistical characteristics of the modeled and observed data were compared. Sea-level comparisons were generally good, although in some places the model showed reduced variability. A second hindcast using dynamically downscaled forcing from a Regional Climate Model over a thirty year period (1970-2000) has also been performed. This has been used to identify systematic biases in the Regional Climate Model.

The ultimate goal of this study is to produce forecast of storm surge under various future climate scenarios. The climate model will be run through to 2100 based on IPCC Special Report on Emissions Scenarios A1B, A2 and B2. The storm surge model will then be run forced by dynamically downscaled atmospheric data for the period 2070-2100 and bias corrected according to the results from hindcast. These sea-level records scenarios will be processed to provide statistics about the possible storm surge risk the New Zealand will face over the next century. Results from these studies will be available on a website to enable end users, such as regional council, quick access in order to use them in planning for future risk.