# Potential Impacts of Climate Change in Modifying the Queensland Storm Tide Hazard

Thomas Hardy[1], Bruce Harper[2] and Luciano Mason[1]
[1] School of Engineering, James Cook University, Townsville, Qld.
[2] Systems Engineering Australia Pty Ltd, Bridgeman Downs, Qld.
E-mail: thomas.hardy@jcu.edu.au

## 1 Introduction

The *Queensland Climate Change and Community Vulnerability to Tropical Cyclo*nes project was instigated in 1999/2000 through the combined efforts of the Bureau of Meteorology in Queensland and the Queensland Departments of Emergency Services, Natural Resources and Mines and the Environmental Protection Agency. Part A of the project seeks to assess the magnitude of the present and future ocean threat from tropical cyclones in Queensland and is intended to update and extend the present understanding of the threat of storm tide inundation in Queensland on a state-wide scale, including the effects of extreme wave conditions in selected areas, and estimates of potential enhanced Greenhouse climate impacts.

## 2 The Study Approach

The project represents the first major update of State-wide storm tide hazard estimates since the mid-1980s (Harper 1999) and proceeded within the context of a Stage 1 technical blueprint that set out the essential methodologies and data requirements for a state-of-the-art assessment of the ocean hazards from tropical cyclones. This initial stage (Harper 2001; Figure 1) identified the need for improved climatological descriptions of the tropical cyclone threat, the application of proven hydrodynamic models and a robust statistical methodology, within which climate change impacts could be realistically embedded. In preparation for detailed modelling, the entire 3,600 km of the Queensland coast was subdivided into 12 numerical domains at a base resolution of 2.8 km (Figure 2). The highly-developed James Cook University storm surge model MMUSURGE (Bode and Mason 1994), with its ability to accurately model coral reef regions, was then applied to a number of historical cyclone events to demonstrate the deterministic accuracy possible with such a model, subject to good representation of the cyclone winds. Subsequent stages of the study have progressed the essential Stage 1 recommendations, leading to the adoption of an updated synthetic cyclone track population model (after James and Mason 1999) and the inclusion of simultaneous spectral wave modelling using the WAMGBR model (Hardy *et al.* 2003a) for estimating breaking wave setup in specific areas.

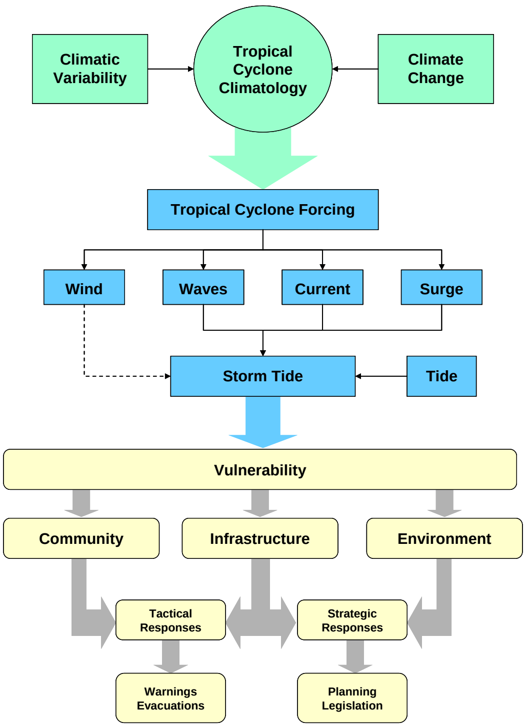


**Figure 1 The overall study approach.**

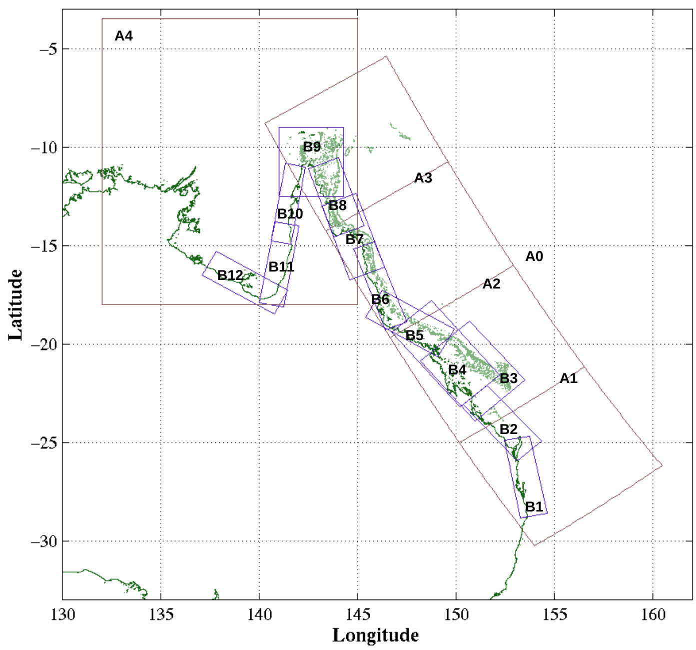


**Figure 2 Numerical model coverage.**

## 3 Modelling Climate Change Impacts within Natural Climatic Variability

One of the enduring problems in assessing the potential impacts of climate change is that the expected magnitude of changes within the next 50-100 years are often relatively subtle when compared with the annual variability of the natural climate. It is therefore important that impact studies firstly accurately replicate present climate conditions and provide consistent mechanisms for incorporating potential climate change effects. In the present study an empirical-statistical cyclone track and intensity model was developed based on historical records and expanded by Monte Carlo to represent 3,000 years of synthetic cyclone activity along the entire coastline, generating about 10,000 separate model cyclones. All of these storms were numerically modelled at a coarse grid resolution to obtain storm surge and peak wave conditions and then stratified into specific regions. Within each region, the nominal "top 10%" magnitude storms were then re-modelled at a finer scale, thus obtaining results for all magnitudes beyond the 10 y return period. These were then randomly phase-sampled against 50 tidal records to build a 150,000 y synthetic storm tide record representing "present" climate.

The process was then repeated for enhanced-Greenhouse conditions based on recommendations from Henderson-Sellers *et al*. (1998) and Walsh and Katzfey (2000), namely: (i) an increase in maximum intensity (MPI) of 10%; (ii) a poleward shift in tracks of 1.3°; (iii) a (prudent) nominal increase in frequency of tropical cyclones of 10% and (iv) a Mean Sea Level rise of 300 mm. Results will be presented from Hardy *et al.* (2003b) comparing and contrasting the statistical estimates of extreme storm tide using each method.

## 4 Conclusions

The study has focused on updating and extending present estimates of storm tide statistics for long-term planning and emergency response purposes and in developing near-shore extreme wave statistics for coastal management and design needs. Importantly, potential impacts of future climate change through the enhanced Greenhouse effect have also been able to be assessed within the full context of the naturally complex climatic variability of tropical cyclones, rather than as a standalone phenomenon.

## 5 References


Bode, L. and Mason, L.B., 1994: Application of an implicit hydrodynamic model over a range of spatial scales. Computational Techniques and Applications: CTAC93, D. Stewart, H. Gardner and D. Singleton, Eds., World Scientific Press, 112–121.

Hardy, T.A., McConochie, J.D., and Mason, L.B., 2003a: Modeling tropical cyclone wave population of the Great Barrier Reef, Journal of Waterway, Port, Coastal and Ocean Engineering, ASCE, Vol. 129, No. 2, 104-113.

Hardy T.A., Mason, L.B., Astorquia, A. and Harper B.A., 2003b: Queensland climate change and community vulnerability to tropical cyclones - ocean hazards assessment - stage 2: tropical cyclone-induced water levels and waves : Hervey Bay and Sunshine Coast. Report prepared by James Cook University Marine Modelling Unit in association with Systems Engineering Australia Pty Ltd, Queensland Government, Nov (draft), 80pp.

Harper B.A., 1999: Storm tide threat in Queensland: History, prediction and relative risks. Conservation Technical Report No. 10, Dept of Environment and Heritage, Jan, ISSN 1037-4701.

Harper B.A. (Ed.), 2001: Queensland climate change and community vulnerability to tropical cyclones - ocean hazards assessment - stage 1, Report prepared by Systems Engineering Australia Pty Ltd in association with James Cook University Marine Modelling Unit, Queensland Government, March, 375pp.

Henderson-Sellers A., Zhang H., Bertz G., Emanuel K., Gray W., Landsea C., Holland G., Lighthill J., Shieh S-L.,Webster P. and McGuffie K. 1998: Tropical cyclones and global climate change: a post-IPCC assessment. Bull. of the Amer Met. Soc., 79, 1, January, 19-38.

James M. and Mason L., 1999: Generation of a synthetic tropical cyclone database. Proc. 14th Australasian Conf. Coastal and Ocean Engineering, IEAust, Perth, Apr, 407-412.

Walsh, K.J.E and Katzfey, J.J., 2000: The impact of climate change on the poleward movement of tropical cyclone-like vortices in a regional climate model, J. of Climate, American Meteorological Society, Vol. 13, 1116-32.