Applying the palaeo-tropical cyclone record

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Palaeo-tropical cyclone records have to date been predominantly used to depict long-term trends as well as attempting to understand the causes of these trends. These records can also be useful for more immediate timescales such as reliably deriving the frequency and magnitude of events for present day planning purposes and also for assessing whether tropical cyclones are responding to global climate change. Two examples of these uses of long-term cyclone records are presented here. The first involves the development of a robust statistical technique to derive the return periods of various magnitude tropical cyclone generated marine inundation events using beach ridge sediments. The second application is the use of high-resolution isotope records to assess whether tropical cyclone (TC) activity over the past few decades has changed substantially compared to the past 1,500 years.

Tropical cyclone generated marine inundations have had substantial impacts on buildings and infrastructure globally in recent years (Hurricane Sandy – USA, TC Yasi – Australia). There is mounting pressure in Australia to have a national standard for the engineering design of buildings in storm surge / inundation zones. Beach ridge sedimentary records of marine inundations document a millennial scale history of total inundations not just the storm surge / tide. The development of a statistical model using a Generalized Extreme Value distribution and Bayesian analysis of the beach ridge sediment record provides more accurate estimates of the return period of events which can be used to determine the extent of coastal land likely to be subject to new engineering standards for future buildings.

High-resolution isotope records of TCs can be preserved within limestone stalagmites. Two records, one from Western Australia and the other from Queensland, provide insight into the nature of landfalling TC activity across the Australian continent. These records can be used to assess the role of humans in influencing the behavior of TCs is the brevity and less than robust nature of the record of these events. We developed a new index (Cyclone Activity Index - CAI), which calibrates the high-resolution, long-term isotope record of TC activity against the instrumental TC record. The CAI allows for a direct comparison between the past and present, and enables an examination of TC climatology at higher temporal resolution and on annual, decadal or millennial scales simultaneously, without the need to interpolate or extrapolate to account for missing data, which is a problem with the existing historical record of TCs. The CAI is the average accumulated energy expended over the TC season within range of the site, accounting for the number of days since genesis and the intensity and size of the storm relative to its distance from the site at each point along its track.

Our CAI for Australia shows that seasonal TC activity is at its lowest level since the year 500AD in Western Australia and 1400AD in Queensland and this decline in activity has been most pronounced since about 1960AD. This reduction in activity reflects the forecasts of TC behaviour for the Australian region from a suite of the most recent global climate models except this decrease appears to be occurring many decades earlier than expected.