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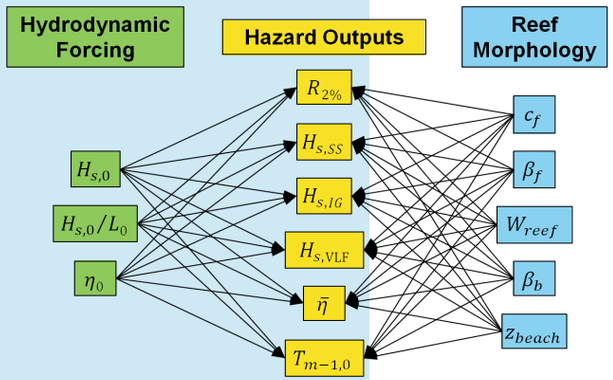
Bayesian Estimator of Wave Attack in Reef Environments

Wave-induced flooding on Roi-Namur, Republic of the Marshall Islands. Photo credit: Curt Storlazzi, USGS.

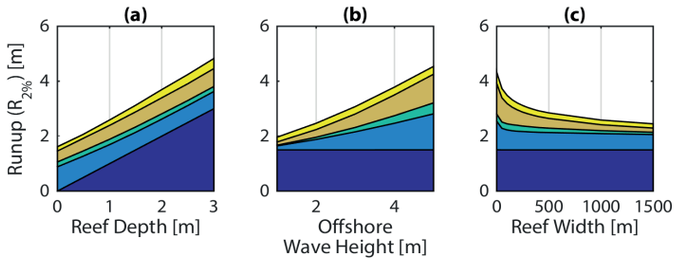
Low-lying tropical islands are highly vulnerable to the effects of sea-level rise and climate change. Most pressing is the threat posed to their freshwater supplies by flooding linked to extreme swell waves. These "blue sky" events originate from distant storms and they are completely independent of local weather conditions. There can therefore be very little warning and time to organise a response.

The impacts of extreme swell wave events can be reduced with effective prediction tools. However, one of the problems is that the flood risk is difficult to quantify because it is dependent on the geometry of the islands and on the variability in wave and sea level conditions to which they are exposed.

Deltares collaborated with the U.S. Geological Survey to generalise previous site-specific studies of flooding on coral atolls and to develop a new approach to estimating flood risk on low-lying tropical islands. Using the wave model XBeach (which is open source), we developed a large synthetic database of numerical simulations representing a large range of realistic reef geometries, and wave and sea-level conditions.



We then entered the model results in the Bayesian BEWARE (Bayesian Estimator of Wave Attack in Reef Environments) network, a probabilistic model which estimates a range and distribution of likely outputs for a given set of inputs. The resulting tool allows us to make real-time flood predictions based on predicted offshore wave or sea-level conditions, and the unique characteristics of a given island.



Lighter colours correspond to higher wave frequencies and darker colours to lower frequencies.

We found that islands with narrow, smooth reefs with steep fore-reef slopes are the most vulnerable to runup and flooding. Furthermore, analysis of the results revealed that offshore wave conditions, water levels, and reef width are the most essential variables for predicting runup. Future research efforts should therefore focus on collecting those data from wave and surge prediction models and earth observation sources.

In addition to its potential for use in early warning systems, BEWARE also serves as a useful tool for assessments of the impacts of climate change such as sea-level rise or coral bleaching. This model can be used to answer questions such as 'which islands will be most severely affected by rising sea levels?', or 'can we increase flood resilience for a given island by restoring its coral reefs?'. It is therefore also potentially useful as a guide for decisions about the allocation of limited funding to, and plan adaptations in, the places where they will have the most impact.

Further reading:
http://repository.tudelft.nl/islandora/object/uuid:c3988f4b-99f8-4936-9504-261b32bb0cd1?collection=education