ENSEMBLE BASED UNCERTAINTY QUANTIFICATION FOR NOWCASTING AND FORECASTING EXTREME COASTAL FLOODING

Ian Cluckie[1], Richard Hewston[2], Dominic Reeve[1], Qingping Zou[3], Yongping Chen[4], Shunqi Pan[5], Zhong Peng[4]

[1]College of Engineering, Swansea University, UK, [2]Department of Meteorology, University of Hawaii, USA, [3]Department of Civil and Environmental Engineering, University of Maine, USA, [4]School of Marine Science and Engineering, University of Plymouth, UK, [5]School of Engineering, Cardiff University, UK

ABSTRACT

This paper describes a 'Cloud to Coast' framework for understanding, Nowcasting and forecasting uncertainty in extreme storm impact on coastal infrastructure. The UK NERC funded EPIRUS (Ensemble Prediction of Inundation Risk and Uncertainty arising from Scour) project and the UK EPSRC funded FRMRC (Flood Risk Management Research Consortium) projects in order to contribute to the improvement of the quantification of the likelihood of incipient defense failures during extreme storm events through the integration of NWP models.

Evidence suggests worldwide trends in extreme high water levels are dominated by mean sea levels. Over the last 100 years an upward trend in the mean sea level of approximately 1.85mm/year has been identified in the English Channel. In conjunction, an increase in population and wealth along the UK coastline has occurred, substantially increasing society's exposure to coastal flooding and so significantly increasing the flood risk. Furthermore, with projections of future sea level rise and changes in the intensity and frequency of extreme storms, future coastal flooding is a significant threat to human life and property (see Fig 1).

Figure 1: Storm induced wave overtopping of coastal defenses at Portmellon in Cornwall,UK.

This project has been an exercise in estimating the uncertainty of various impacts but in an operational sence the methodology is appropriate for 'Nowcasting' or 'Forecasting' extreme events and their impact on coastal defenses or major coastal infrastructure such as tidal barrages. Inherent uncertainties stemming from the model structure, including parameterisation of complex physical interactions, combined with uncertainties in initial conditions propagate through the model cascade. It is important to have an appreciation of these uncertainties, and an ability to quantify them, in order to have confidence in a modelling system that may be used in decision-making. An ensemble modelling technique allows uncertainty to be sampled, and provides a reasonable way forward for "Whole System Modelling" as applied to the Climate Impact domain. As a downscaling tool, this study utilises the WRF model (see Fig 2). European Centre for Medium-range Weather Forecasts (ECMWF) Ensemble Prediction System (EPS) data was used to define the boundary conditions for WRF, in order to generate high-resolution wind and atmospheric pressure fields. The EPS comprises of one deterministic forecast and a 50 perturbed forecasts, each initialised with slightly different atmospheric conditions, and each with subtly different parameterisations of sub-grid scale physical

processes. The forecasts run for 10-days, at 6- hour time steps.

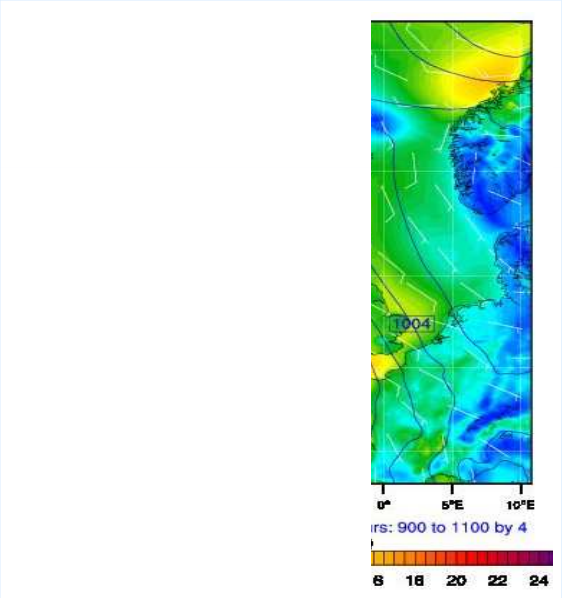

Figure 2: Wind and Pressure from WRF for 27 October 2004.

Initially a control dataset was defined, comprising of 6-hourly analyses derived from the 00:00 analysis and 6-hour deterministic forecast, and 12:00 analysis and 6-hour deterministic forecast. This dataset was subsequently referred to as the "control". The downscaled meteorological data subsequently drives the surge and wave models, whose output in turn is used to initialise the surf zone models (see Fig.3).

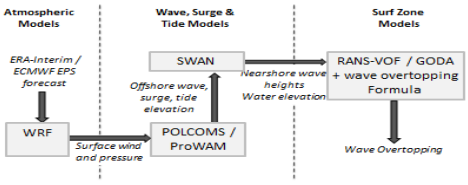

Figure 3. Integrated 'Cloud to Coast' model framework

The intensity and frequency of extra-tropical cyclones over the UK is likely to be affected by future climate change. While the October 2004 storm was a significant event for the southern region of the UK, it is possible that the return period for extreme wind speeds may be reduced in future climates. Current UK coastal flood defenses have typically been designed to cope with severe storm events with a return period of 50-100 years, and in the future may be inadequate to protect the coastal areas under threat. In addition, major new infrastructure (Barrages and Lagoons) are currently being considered for energy generation given the extremely high tidal regime around most parts of the UK Coastline. Using the methodology developed, it will be possible to begin to estimate the potential impact of climate change on coastal flooding in the UK, provide a Nowcasting and Forecasting capability in extreme storms allowing the beach and structure response to potential future storms to be simulated or their impact to be guarded against.

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