Statistical Framework for Utilisation of Modelled Data for Tropical Cyclones

We are increasingly asked to produce extreme wind and wave criteria for 100-year or 10,000-year return period values for tropical cyclones in regions where such events occur relatively infrequently.

Multiple model runs of individual storms with small differences in the input parameters and model physics can produce a large enough data sample from which to estimate extremes.

However, we would like to explore the statistical validity of this approach, and to see whether there is a rigorous way of deciding how many of the multiple model runs for an individual storm can be included in the database.

At present, for regions where tropical cyclones are frequent:

- Use an existing hindcast database, e.g. South China Sea.

- South China Sea hindcast includes tropical cyclones between 1956 and 2012.

- Pooling of data from neighbouring grid points is used to maximise the number of events included in the extreme value analysis.

- Measures of extremal dependence are used to determine the geographical extent of the data pool.

- A recent project offshore southern Vietnam, which used the extremal dependence test, yielded on the order of 419 events pooled from 6 grid points with which to perform EVA.

TRS EVA in Data Poor Regions

In 2014 the number of TRS that occurred worldwide was:

- West Pacific; 23

- East Pacific; 23

- Atlantic; 9

- South Pacific; 10

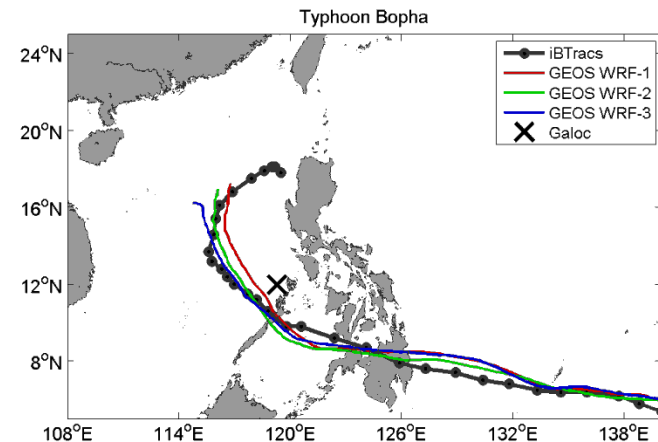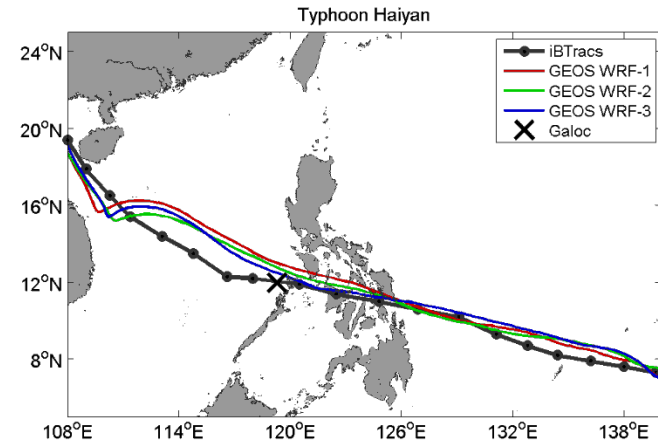- North Indian; 5

- South Indian; 14

So for certain areas where there is oil industry interest and the frequency of TRS per year is low, there is no existing fine-scale hindcast model, e.g.:
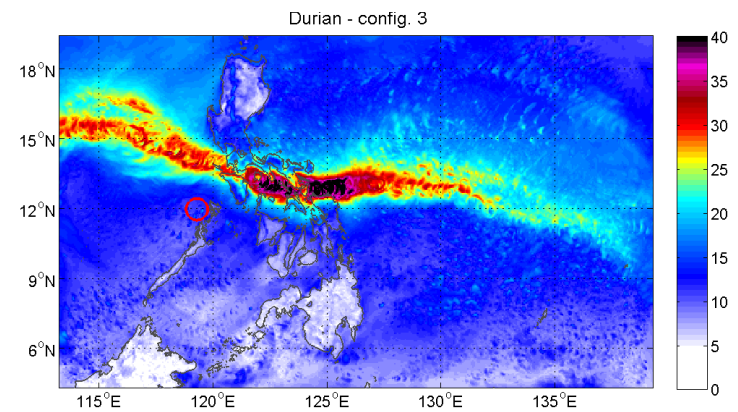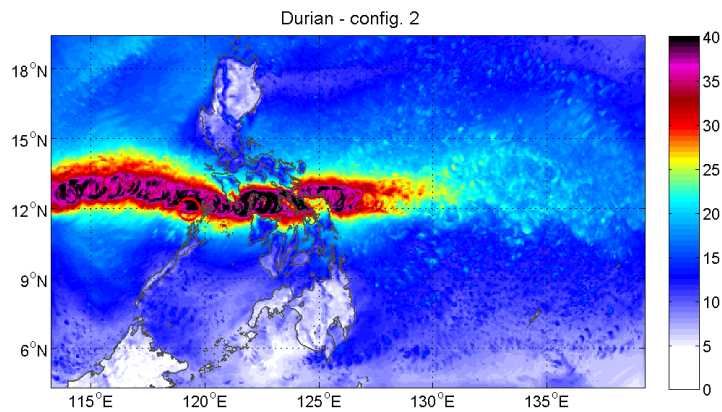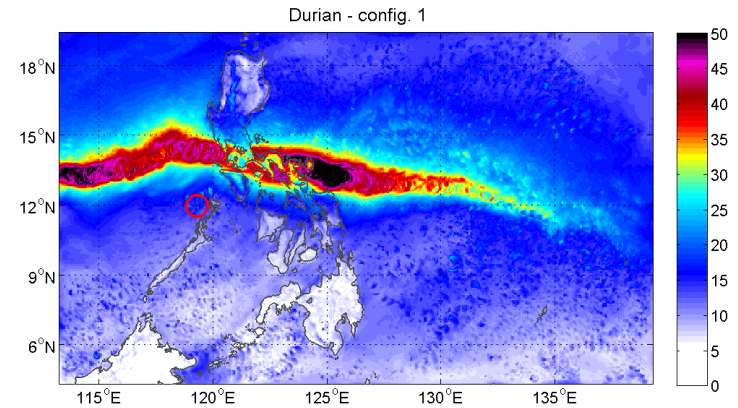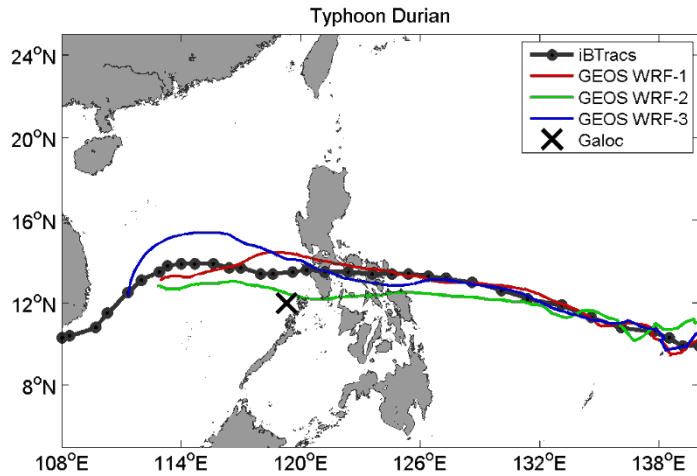
- East and West India

- NW Australia

- East Africa

In this case it is necessary to carry out site-specific TRS modelling.

The problem facing us is how many individual TRS to model and how many ensembles to run for each event in order to produce statistically valid extreme values.

- Modelling carried out using WRF-ARW.

- Typical setup 18 km outer domain (large geographic extent), 6 km inner domain (smaller geographic extent, but larger computational domain).

- Simulation times typically 7-10 days.

- In areas where tropical cyclones are rare, some form of ensemble modelling is required to generate a suitable dataset:

- Perturbed physics ensembles: parameterizations of physics which are not explicitly resolved in the model can be altered between runs (microphysics, boundary-layer, air/sea enthalpy transfer, etc).

- IC/BC ensembles: ensembles of a forcing model can be used to provide different initial/boundary conditions.

- IC ensembles: directly perturbing initial conditions.

Typhoon Haiyan

Typhoon Bopha

Typhoon Durian

Durian - config. 1

Durian - config. 2

Durian - config. 3

Between 2005 and 2014 there were 40 cyclones in the BoB, 4 per year.

Project required an estimate of the worst case tropical cyclone conditions, not extremes.

Four tropical cyclones selected:

- Cyclone #2; 3 to 11 May 1990
- TS 03B; 12 to 15 Dec 2003
- Cyclone-1 JAL; 4 to 7 Nov 2010
- Cyclone-5 PHAILIN; 9 to 12 Oct 2013

11 ensembles modelled for each event giving a total of 44 realisations. Worst case conditions provided by ensemble 10 of Cyclone #2.

Time series of Hs, Tp, Mdir, Ws and Wdir is available for all 44 realisations.
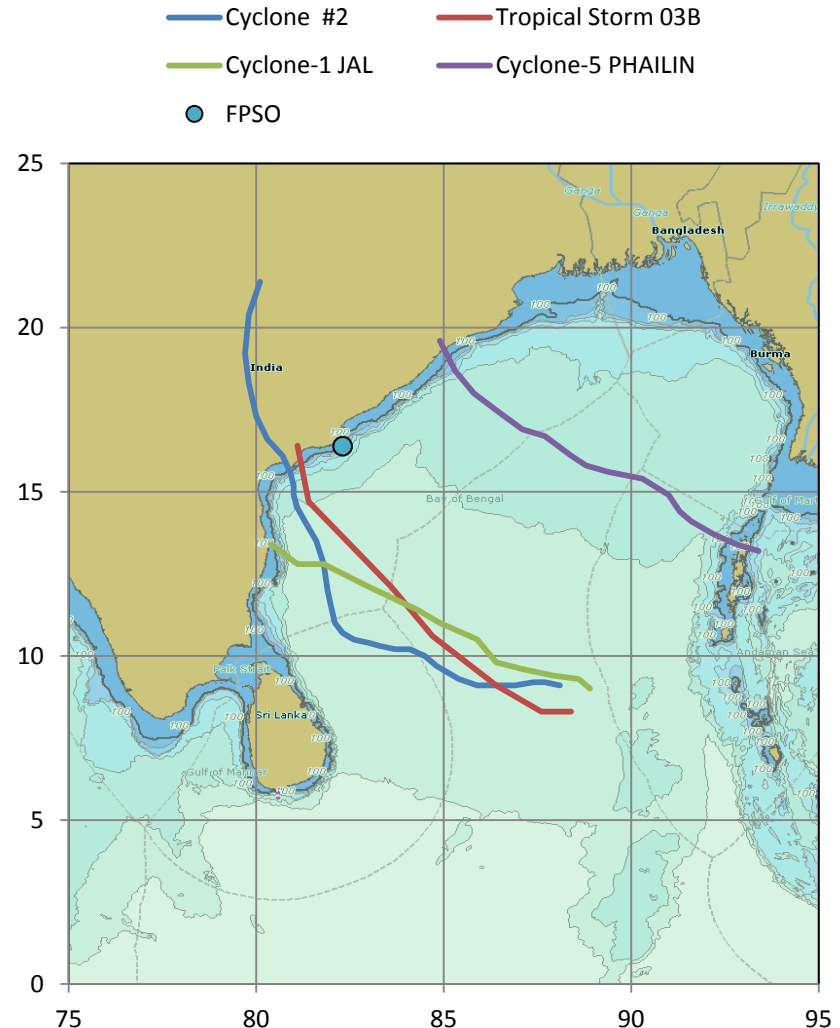
Proprietary hindcast model.

76 tropical cyclones between 1970 and 2007.

7 grid points giving a total pool of 532 events.

Time series of peak Hs and peak Ws is available for all 532 events.

8552
5982
3750
2329
1357
5952
2754