The sensitivity of probabilistic convective-scale forecasts of an extratropical cyclone to atmosphere-ocean-wave coupling

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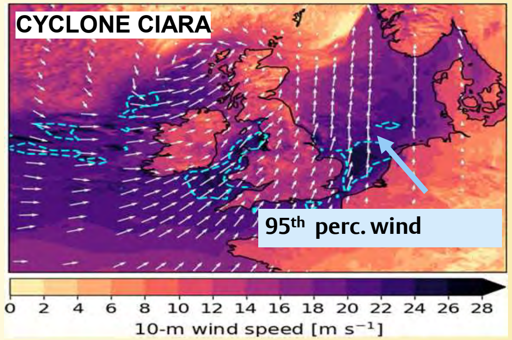
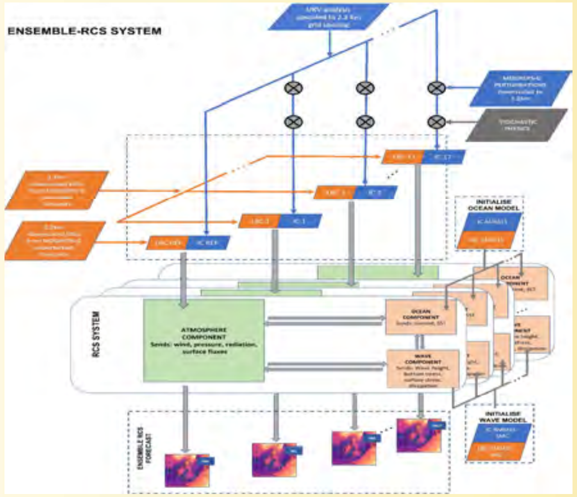
Aim of the study

- Investigate the impact and the relative importance of coupling compared to other sources of model uncertainty in midlatitude cyclone extreme surface wind forecasts using the probabilistic regional coupled Ensemble-RCS modelling system.
- Cyclone Ciara was selected as a case study because it is the most intense cyclone striking the UK since 2013.



The air-sea coupled Ensemble-RCS

The Ensemble-RCS framework integrates the Met Office Regional Atmosphere-Ocean-Wave Coupled System with the km-scale atmosphere-only ensemble system MOGREPS-UK. It downscales the 17 global ensemble members IC and LBC perturbations to 2.2 x 2.2 km resolution and adds them to the UKV analysis to initialise the 17 MetUM forecasts. Focused over the UK.

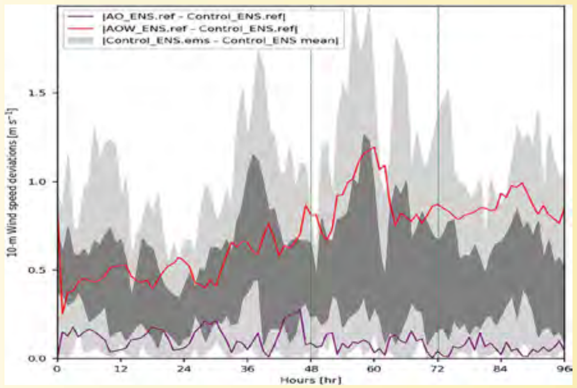


- $U = \frac{u_*}{k}\left[\log\left(\frac{z}{z_{0m}}\right) - \Psi_m\right]$
- $z_{0m}(sea) = \frac{0.11\nu}{u_*} + \frac{\alpha}{g}u_*^2$
- $C_D = \left[\frac{k}{\log\left(\frac{z}{z_{0m}}\right)-\Psi_m}\right]^2$

Modelling air-sea momentum flux

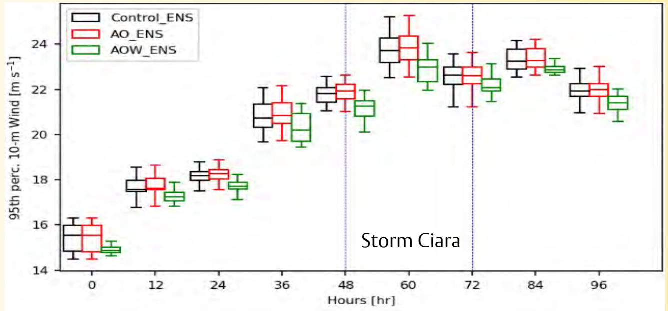
Sensitivity to coupling to ocean and waves

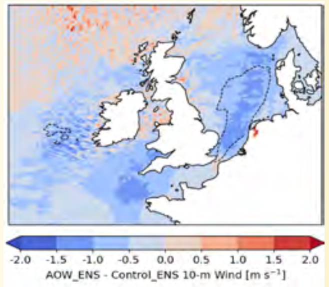
- For gale-force cyclone 10-m wind speeds, the impact of coupling the atmospheric model to both NEMO ocean and WAVEWATCH wave models is comparable to that of adding IC, LBC and stochastic physics perturbations to the ensemble system.

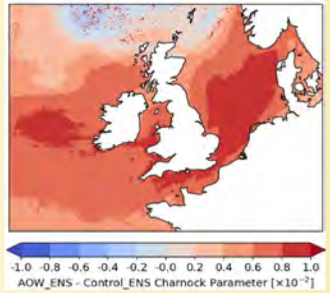


Sensitivity to air-sea momentum flux plays an important role in model uncertainty

- Ensemble median and mean reduced by 1 m/s on coupling to waves.
- The impact of coupling to ocean is negligible.
- The ensemble mean of 10-m wind is mostly reduced in high wind speed regions, by up to 1.5 m/s.
- The wave growth is more pronounced where the fully coupled ensemble 10-m wind reductions from control values are larger.
- Growing waves extract air-sea momentum from airflow, as in deterministic case studies.

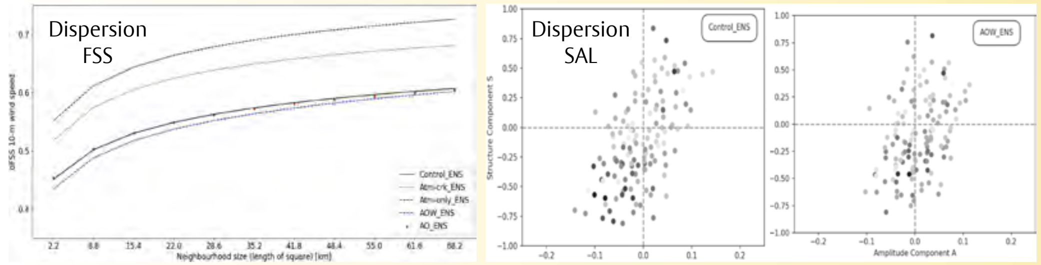






Coupling preserves the ensemble spread at all spatial scales

- Neighbourhood-based Fraction Skill Score (FSS) and the object-based Structure, Amplitude, Location (SAL) metrics show that the good spread characteristics of the atmosphere ensemble are preserved when modelling with higher fidelity the air-sea interactions by incorporating coupling in Ensemble-RCS.



Implications

To better represent model uncertainty in extreme weather events forecasts, operational convective-scale systems could improve the accuracy of air-sea fluxes parametrization by coupling atmosphere, ocean, and wave models.

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