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The impact of atmosphere-ocean-wave coupling on extreme surface wind forecasts

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Accurate modelling of air-sea surface exchanges is crucial for reliable extreme surface wind forecasts. While atmosphere-only weather forecast models represent ocean and wave effects through sea-state independent parametrizations, coupled multi-model systems capture sea-state dynamics by integrating feedbacks between atmosphere, ocean and wave model components.

Here, we present the results of studying the sensitivity of extreme surface wind speeds to air-sea exchanges at kilometre scale using coupled and uncoupled configurations of the Met Office's UK Regional Coupled Environmental Prediction (UKC4) system. The case period includes the passage of extra-tropical cyclones Helen, Ali, and Bronagh, which brought maximum gusts of 36 ms^{-1} over the UK.

Compared to the atmosphere-only results, coupling to ocean decreases the domain-average sea surface temperature by up to 0.5 K. Inclusion of coupling to waves decreases the 98th percentile 10-m wind speed by up to 2 ms^{-1} as young, growing wind waves decrease wind speed by increasing the sea aerodynamic roughness. Impacts on gusts are more modest, with local reductions of up to 1$ms^{-1,}$ due to enhanced boundary-layer turbulence which partially offsets air-sea momentum transfer.

Using a new drag parametrization based on the COARE~4.0 scheme, with a cap on the neutral drag coefficient and decrease for wind speeds exceeding 27 ms^{-1} , the atmosphere-only model achieves equivalent impacts on 10-m wind speeds and gusts as from coupling to waves. Overall, the new drag parametrization achieves the same 20% improvement in forecast 10-m wind skill as coupling to waves, with the advantage of saving the computational cost of the ocean and wave models.