Local forecasts for winds and waves

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A new model that will provide the wind-energy industry with predictions of local winds and waves in the North Sea is being developed by scientists at Uni Research Computing.

The researchers are downscaling from regional to local forecasts, as a more detailed prediction for much smaller areas than in today's regional forecasts is needed. At the same time, it is important to retain a key aspect of these forecasts, the quantification of the uncertainty associated with the prediction, along with the prediction itself. In order to achieve this goal, senior scientist Angus Graham and his colleagues in the Environmental Flow Group are working with a large dataset provided by the European Centre for Medium-Range Weather Forecasts (ECMWF).

The ECMWF forecasts have a low horizontal resolution, on the scale of tens of kilometres. This is suitable for regular weather forecasts, but not for companies conducting offshore wind operations at a specific wind farm, where the effects of coastal or seabed terrain in the locality may be important. The new resolution will be 3 km for the atmosphere and around 300 m for the waves, Graham says. Getting the waves right is particularly important for offshore operations. With better predictions, stay-or-go decisions on maritime operations will be improved, leading to fewer curtailed or unnecessarily postponed missions, and thus a reduction in costs passed onto the energy consumer. Marine safety should also be improved. Everybody involved in offshore wind knows the need for improvements here, says Graham. The methodology is not limited to offshore wind applications, however – it could be used to support decision-making for any site-specific offshore operation.

In modern weather forecasting, the uncertainty of prediction is quantified by perturbing a control or baseline version of the weather model a number of ways, and parameterising the spread in predictions that results. Perturbations reflect uncertainties in the initial state, as a result of partial and statistically noisy observations; amplification of these uncertainties through nonlinearities in the model physics; and uncertainties in the model physics itself. If the perturbations accurately reflect the sum of these uncertainties, their mean – the best single prediction – will lie on average a standard error from the state of the winds and waves that later actually comes to pass. The model prediction system is then wholly consistent with reality.

The research involves an ensemble of perturbed short-term forecasts supplied by the ECMWF at the regional scale being downscaled one by one, using the Weather Research and Forecasting (WRF) mesoscale model of the atmosphere. An example showing the effect of the downscaling is shown in Fig. 1. Additional physical processes are simulated at the smaller scales in the downscaling, and additional degrees of freedom are introduced, which validation work with observations has shown increases the sensitivity and reduces the bias, but also increases the spread of values. The results shown are consistent with this. The downscaled winds are then used, along with high-resolution maps of water depth, to downscale the waves with a wave model (WAM).

In the atmospheric downscaling, the researchers are looking to simulate small-scale variations in characteristics of the sea surface, which would otherwise remain smoothed out (these were not taken into account in deriving Figs. 1c and 1d). This is the current focus of PhD student Torge Lorenz, who is funded

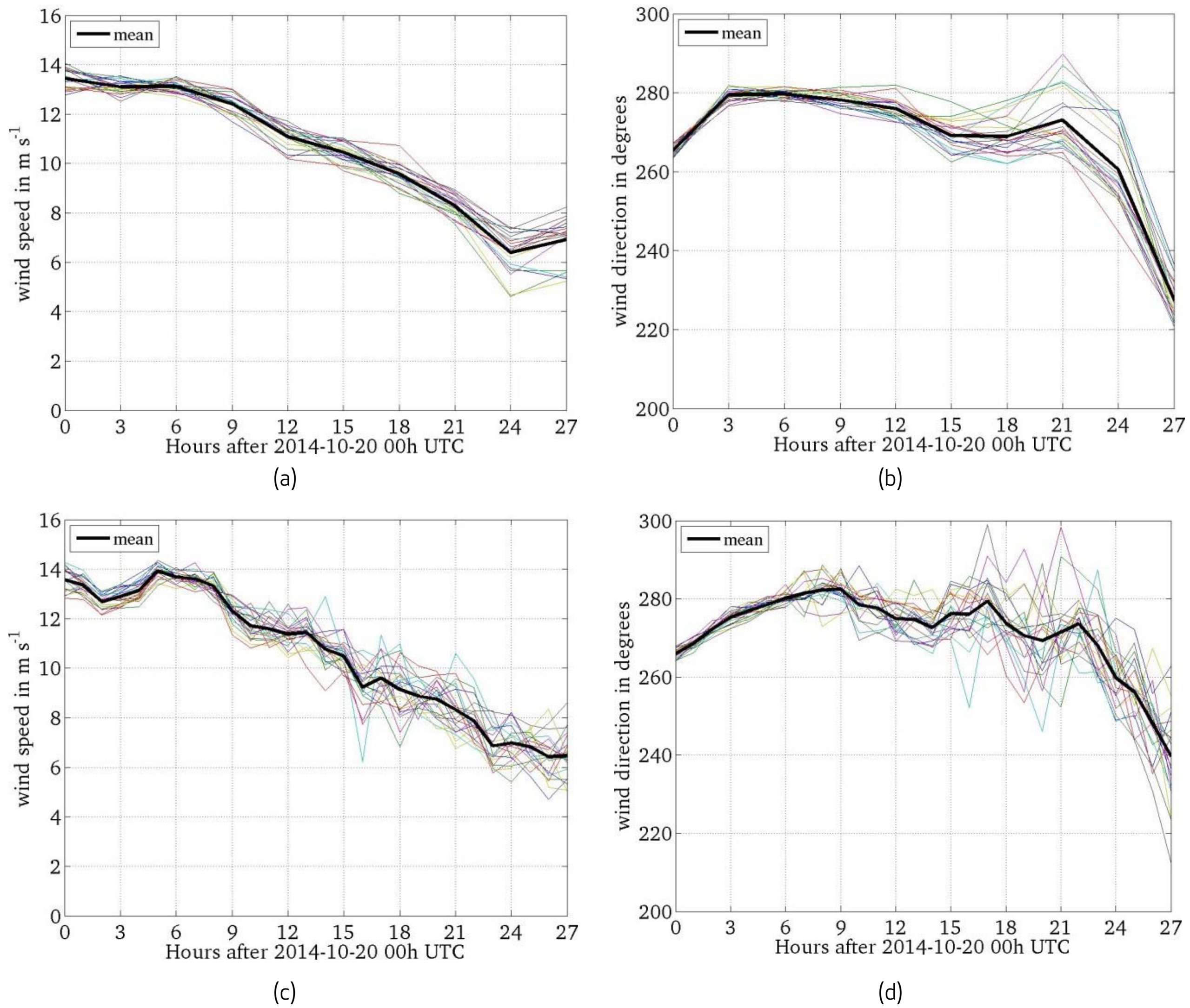

FIG. 1: Ensemble forecast of the wind 10 m above mean sea level at the location of the FINO 3 met mast in the German Bight, from midnight 20th October 2014: a) wind speed from 21 runs of the ECMWF model, b) wind direction from the ECMWF runs, c) as per (a) after downscaling using WRF, d) as per (b) after downscaling using WRF.

by NORCOWE. Fluctuations in sea-surface temperature (SST) and the associated heat fluxes may be key here, says Lorenz. The fluctuations are partly random in character, and partly related to the SST pattern seen at larger scales – archived satellite infrared measurements show exactly how. When this downscaling has been completed, and some comparison with accurate site measurements of winds and waves has been made, the researchers will be able to assess how far down the road to full consistency with reality the model has come.

The work at Uni Research is also contributing to a three-year project, "Decision Support for Installation of Offshore Wind Turbines", co-financed by the Research Council of Norway and Statoil. The aim of the project is to reduce the cost of installing offshore wind turbines, where waiting for suitable weather windows is a significant cost contributor. Other scientific partners on the project are Marintek, Met.no, Aalborg University, CMR and the Universities of Bergen, Stavanger and Agder. Reinertsen Engineering and Fred Olsen Windcarrier are associated partners.