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Highlight results

- **An example of successful bridging between wind power and meteorological communities**
- **High-resolution (deterministic) and ensemble prediction system (probabilistic) 100-meter wind fields=**

Background:

In previous European projects in the field of wind power forecasting, the implication of meteorologists has been often limited to the level of data provision. Although meteorologists do intensive research to improve their models, their research priorities do not target the wind energy application. The vision of this project has been and remains to put the two communities work together towards the direction of improving wind and wind power forecasting.

Vertical resolution of ECMWF model:

Properly depicting the vertical structure of the atmosphere leads to better forecasts by Numerical Weather Prediction (NWP) models. The vertical resolution should be finest in geometrical height in the planetary boundary layer and coarsest near the model top. The ECMWF utilises the so-called “σ-levels” that follow the earth’s surface in the lower-most troposphere, where the Earth’s orography displays large variations [1]. In the upper stratosphere and lower mesosphere they are surfaces of constant pressure with a smooth transition in between [2]. ECMWF model levels “x-ray” the surface layer as shown in Figure 1.

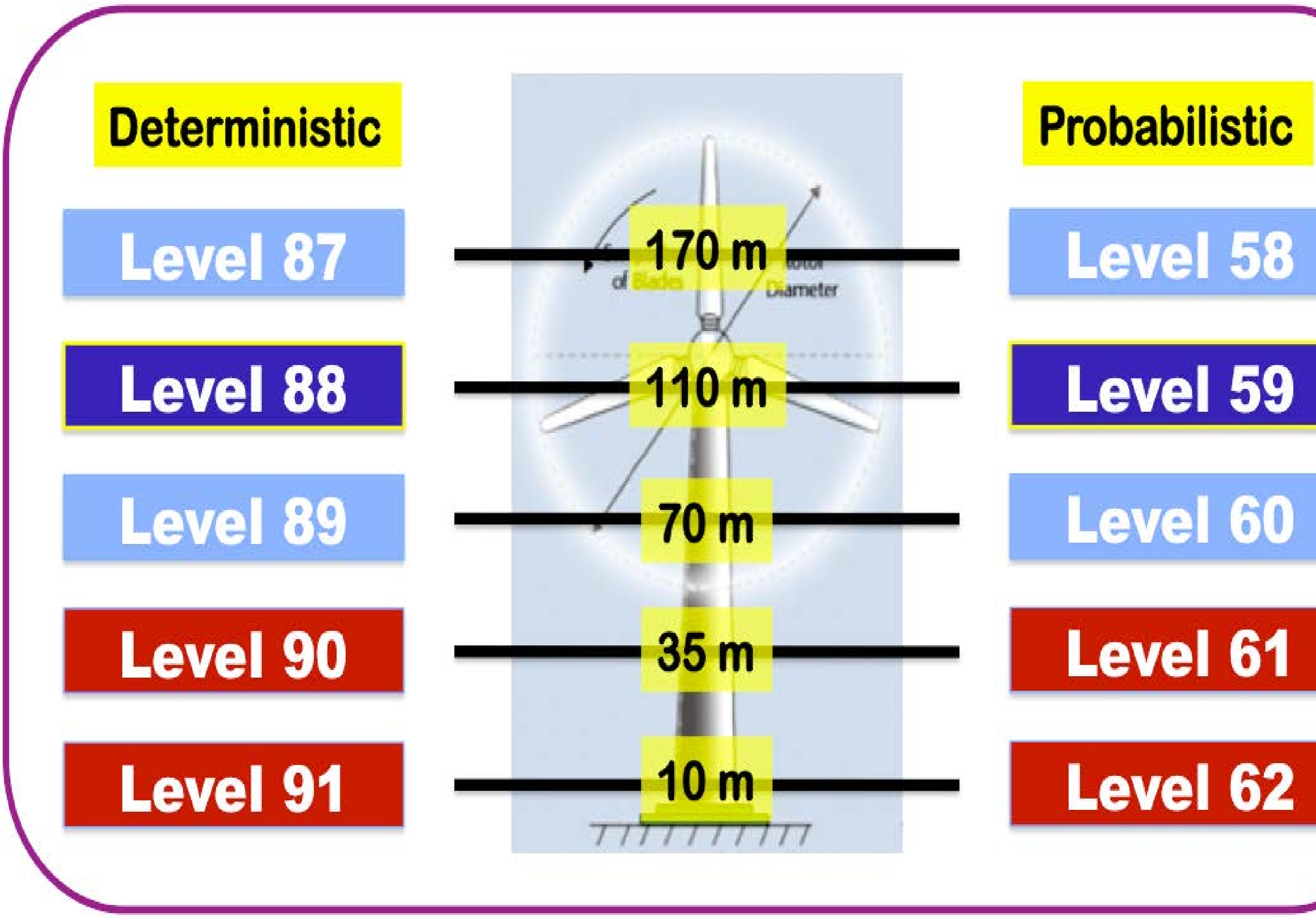


Figure 1: ECMWF model levels for IFS T799L91 (deterministic) and EPS T399L62 (probabilistic) platforms.

Derivation of winds at hub height:

A series of inter-comparisons were performed concerning the accuracy of various wind fields at hub height. It is well documented that winds in the surface layer (up to about 100 meters) are mainly dominated by friction exerted by the ground and turbulent mixing. Under certain assumptions a logarithmic vertical wind profile can be derived referring to the Neutral Surface Layer (NSL) [3]. This means that speed increase roughly logarithmically with height, but the shape of this profile depends on the surface roughness parameter (z0).

Superiority utilising model level winds instead of surface winds:

Based on the NSL log profile “synthetic” estimations of wind speed at 103 meters were derived using 10-meter wind fields. Three different values of z0 were considered. All synthetic values were validated against FINO1 observations at 103 meters utilizing RMS and Absolute Error scores. Similarly, IFS analysis fields at model level 88 (at ~110 meters) were also evaluated against FINO1 observations (103 meters).

From Figure 2, it becomes obvious that IFS analysis speed values at model level 88 (noted by yellow color) exhibit the smallest errors. IFS level 88 analysis also found to have the smallest RMS Error compared to all other “synthetic” methods.

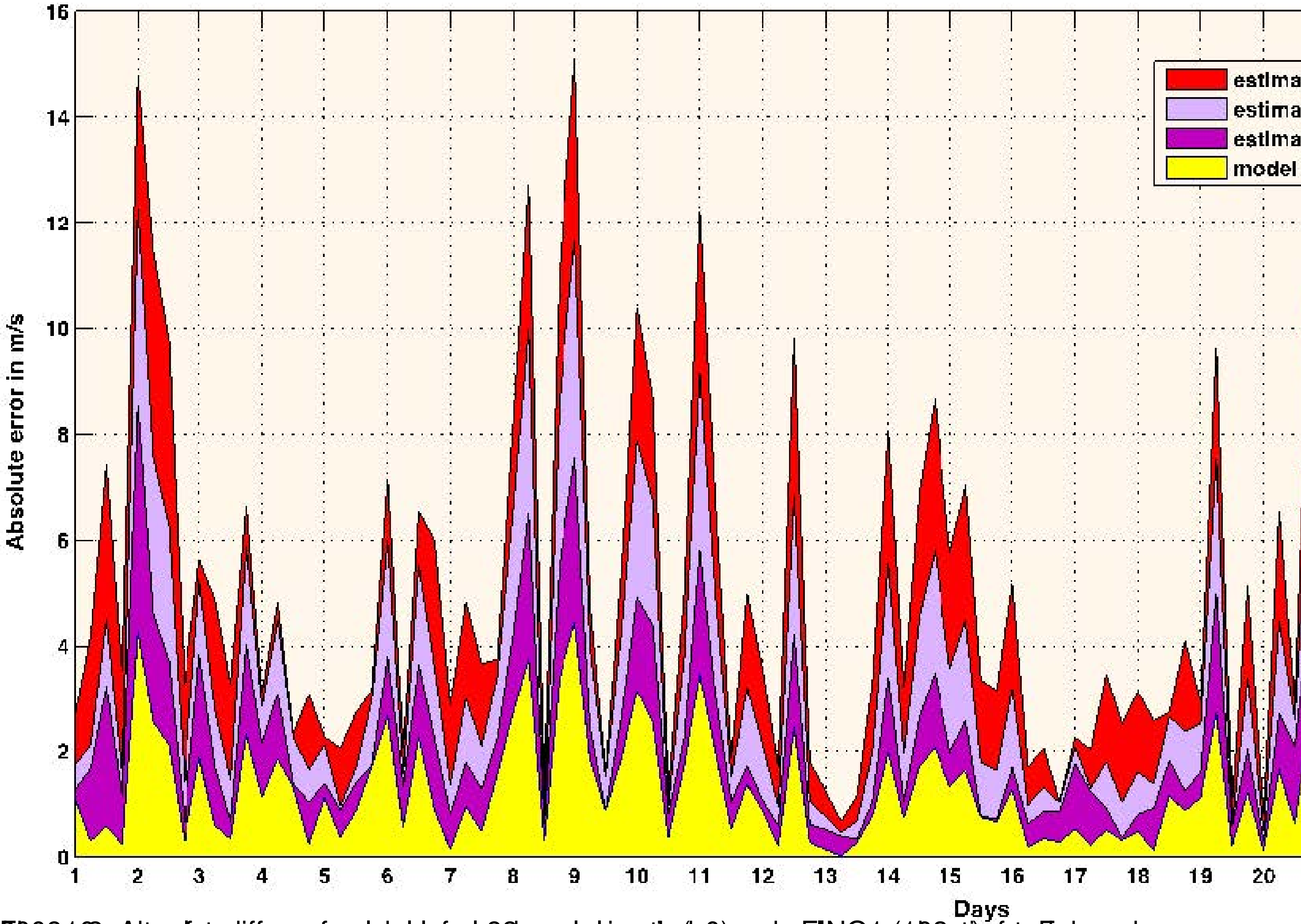


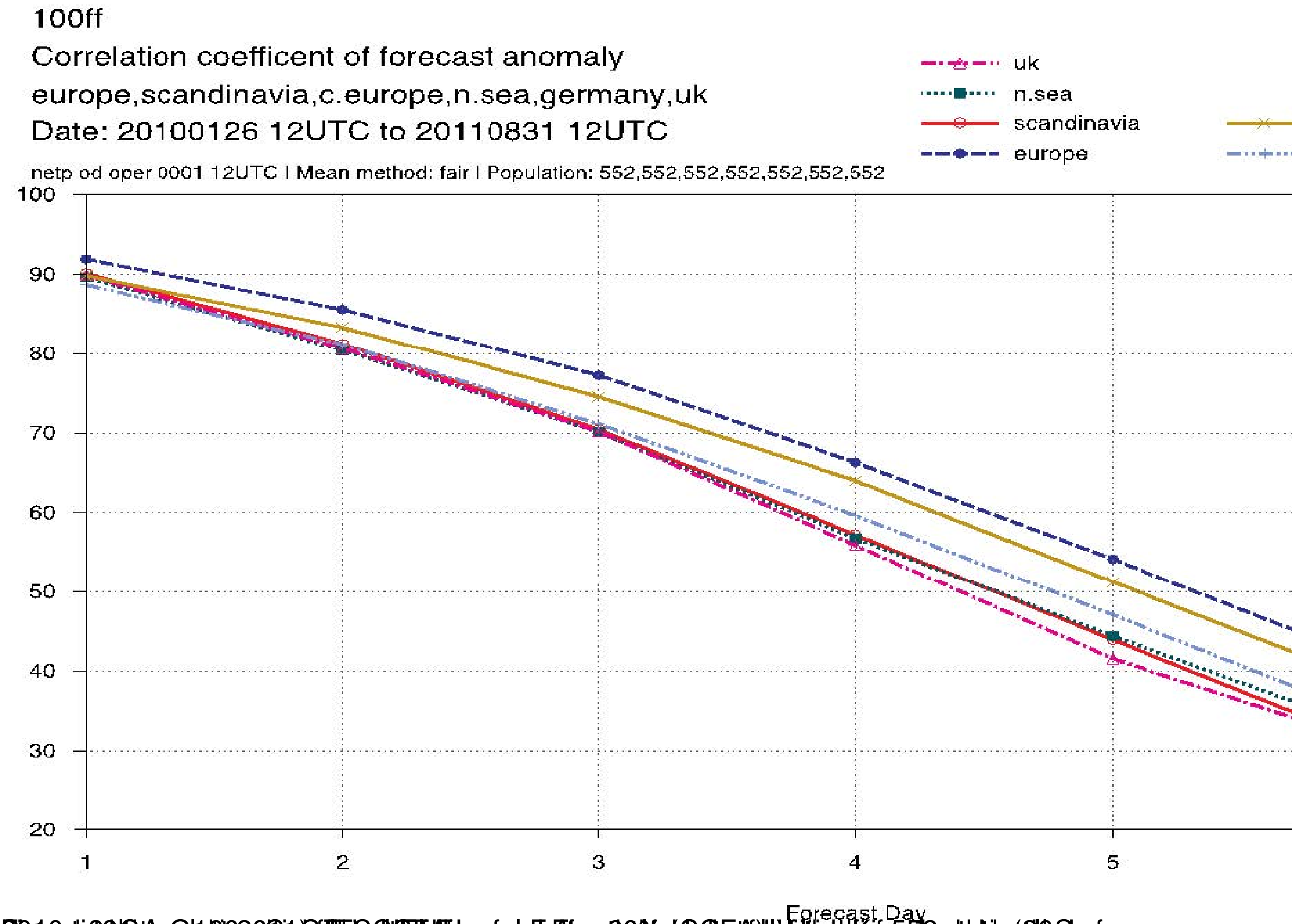
Figure 2: Absolute error of model level 88 analysis wind speed values at FINO1 (103m), and estimated spreads 2008 10-m ... for different values of roughness length (z0) ... February

Skill of the new ECMWF fields:

The new ECMWF 100-meter wind fields are estimated by interpolating model level values. Both the new deterministic and probabilistic 100-meter winds have found skilful during the medium-range interval. The CCFA (Correlation Coefficient of Forecast Anomaly) score has been used for assessing the skill of operational high-resolution forecast while the CRPSS (Continuous Rank Probability Skill Score) was utilised for the probabilistic fields [4]. Positive values of CRPSS (linked to useful forecasts) have found for most of the medium-range interval. Same wise, the mean UFI (Useful Forecasting Interval) for the deterministic fields for Europe has found to reach 4,5 days as seen in Figure 3.

Further work:

The research strategy of ECMWF is defined in common with the meteorological organisations of member states. SafeWind has aimed to favour a flow-down at the level of the member states of the common research objectives for improved wind predictability. In the near future, emphasis should be given on further improving forecast techniques and methodologies, since forecasting errors are very costly in the integration of wind generation and reduce the value of wind energy for end-users.



Bibliography:

[1] Petroliagis T.I., 2009: Wind power prediction using ECMWF IFS and EPS model level winds. ECMWF Forecast Products: Users Meeting, ECMWF, Reading, UK

[2] Simmons A.J., Burridge D.M., Jarraud M., Girard C. and W. Wergen, 1989: The ECMWF medium-range prediction models: development of the numerical formulations and the impact of increased resolution. Meteorol. Atmos. Phys., 40, 28-60.

[3] Justus C.G., Hargraves W.R. and A. Yalcin, 1976: Nationwide Assessment of Potential Output from Wind- Powered Generators. J. Appl. Meteor., 15, 673-678.

[4] Petroliagis T.I., Denhard M., Tambke J., Hagedorn R. and D. Heinemann, 2010: How well we can forecast winds at different heights? An assessment of ECMWF IFS & EPS skill of forecasting wind fields at different model levels. EWEC Conference, 20-23 April 2010, Warsaw, Poland.