WIND ENERGY RISK MANAGEMENT:

STATE-OF-THE ART WIND FORECASTING FROM 1 MONTH - 30 YEARS

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Abstract

Throughout the life of a wind energy project, it is currently unknown how much the climate could vary from one month, season, year or decade to the next. An assumption is therefore made that long-term wind resource availability is constant. The risk that future wind resources could be significantly different over space and time is currently not assessed, nor have tools been made available to deal with this risk. This uncertainty affects investment and operations for wind projects and the grid network. State-of-the-art climate science and technology can now seamlessly predict, in a probabilistic way, the variability of wind resources over near-future timescales from 1 month to 30 years (known as sub-seasonal to decadal climate forecasts). Such wind forecasts have recently shown useful levels of skill at regional scales. This research aims to understand and manage the risk of climate variability on wind resource assessments, across the complete life of a wind energy project. In turn, this can generate innovative business opportunities, via the development of an operative climate forecasting service for long-term wind resources, which builds upon existing short-term weather forecasting services.

Objectives

i) Predict wind variability from 1 month to 30 years using the latest generation of global climate products.

ii) Assess the usefulness and usability of seasonal to decadal climate forecasts over space and time for the wind energy sector.

Methods

Seasonal to decadal predictions of wind variability are based on global dynamical and statistical climate forecast systems. Seasonal wind forecasts are divided into two stages: first, a climate forecast system produces predictions for as many cases in the past as possible. These predictions include an estimate of uncertainty, which are used to assess the forecast quality of the system. The wind speed forecast quality is typically computed using both predictions and observational estimates of climate for a baseline period of 1981-2012; second, operational predictions are issued that enables probabilistic future information to be produced. The credibility of these operational predictions is partially based upon the system forecast quality (stage 1), but a detailed analysis of the ability of the forecast system to reproduce the resource availability is needed for a full assessment of its value.

Further Investigation: Potential sources of wind speed predictability can be assessed by linking the seasonal and inter-annual variations of the resource to inter-annual and decadal modes of climate variability (e.g. El Niño Southern Oscillation, Atlantic Multidecadal Oscillation etc.). This is also used to assign a degree of trustworthiness to the operational predictions.

The sensitivity to and vulnerability of wind energy planning, investment and operational risk management strategies to the identified variations in wind resources is evaluated. This information is used to assess the value of an operative, downstream climate forecasting service for the wind energy sector.

Initial Results

Seasonal Wind Forecasts: Spring example (March, April, May)

STAGE 1: An estimate of the climate forecast system quality is made, by producing wind predictions for as many cases in the past as possible.

Figure 1a. ECMWF S4 ensemble mean 10m wind speed (m/s) anomaly forecast

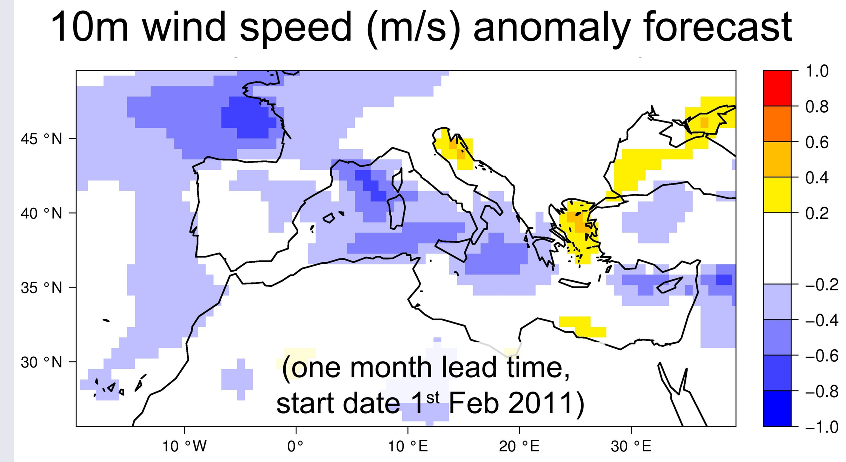


Figure 1b. ERA-Interim 10m wind speed (m/s) reanalyses "observations"

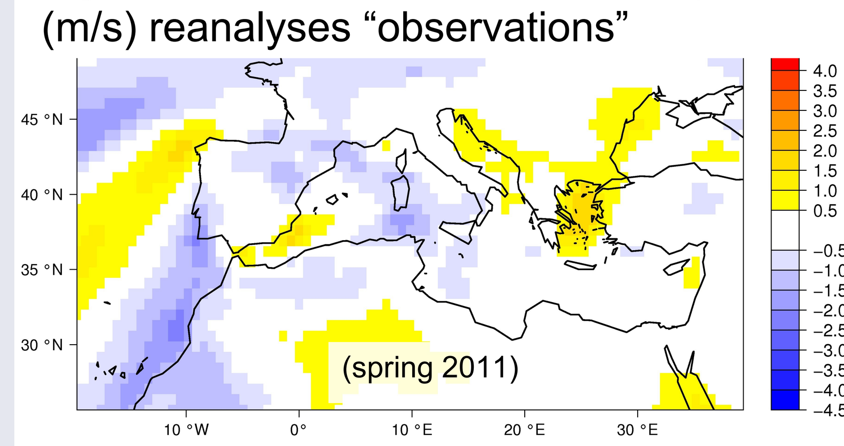
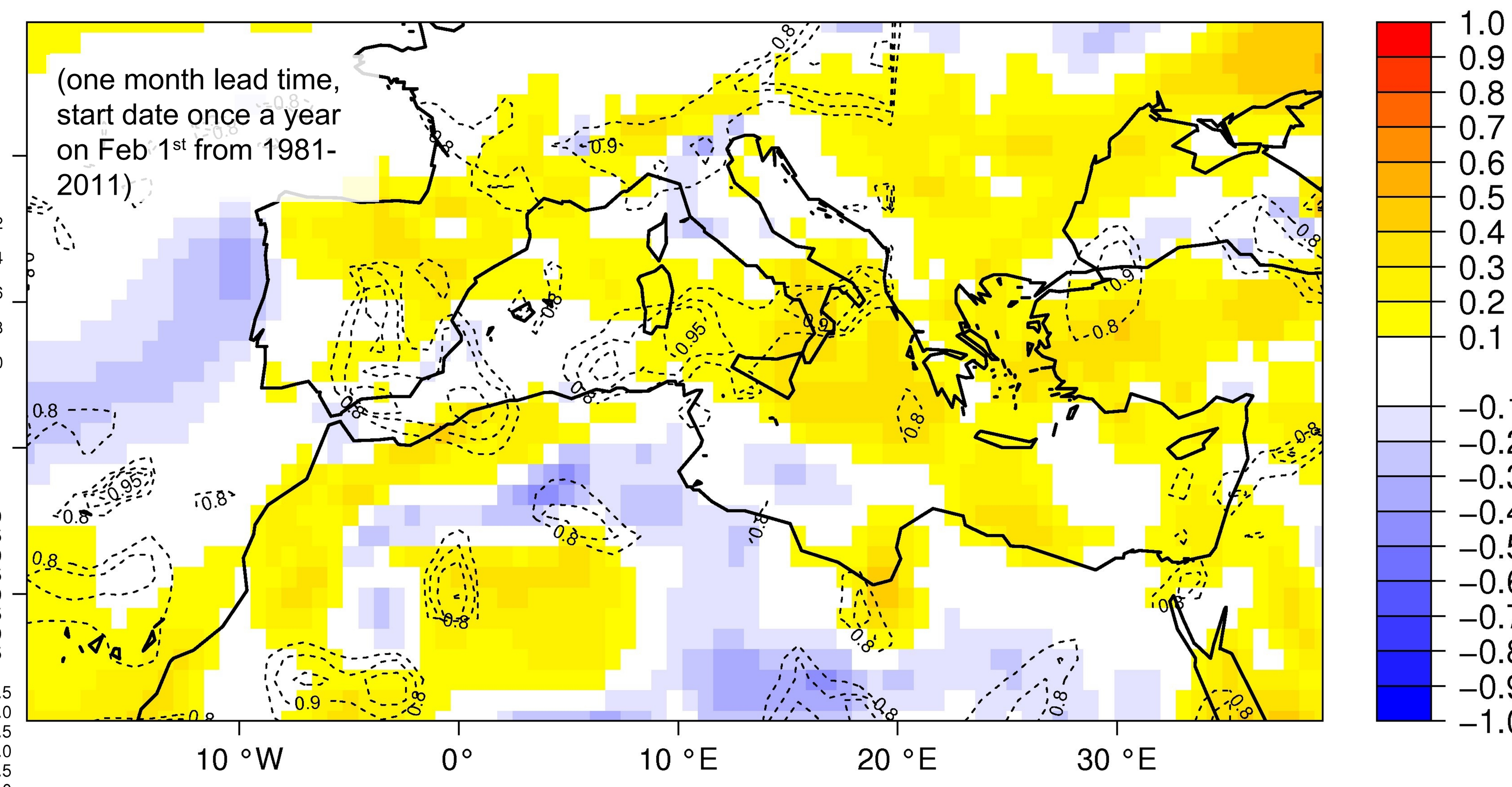


Figure 2. 10m Wind speed re-forecast anomaly correlation (AC) skill of the ensemble mean of ECMWF S4 (fig.1a) vs. the ERA-Interim reanalyses (fig. 1b)

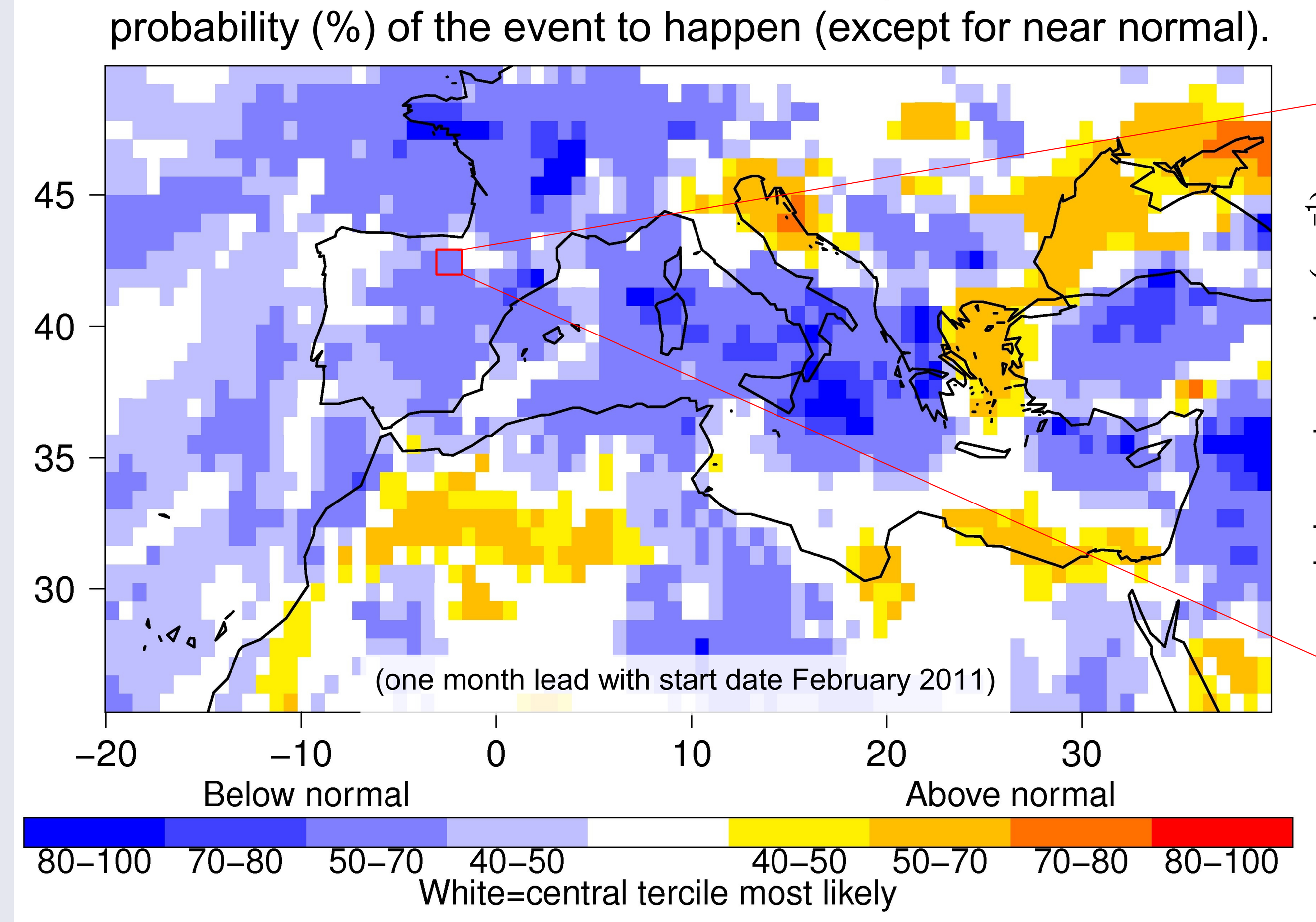


Result: Low, but predominantly positive skill is observed across the Mediterranean where the direct model output reaches approximately AC 0.3.

STAGE 2: Operational predictions are issued that enables probabilistic future wind information.

- Regional -

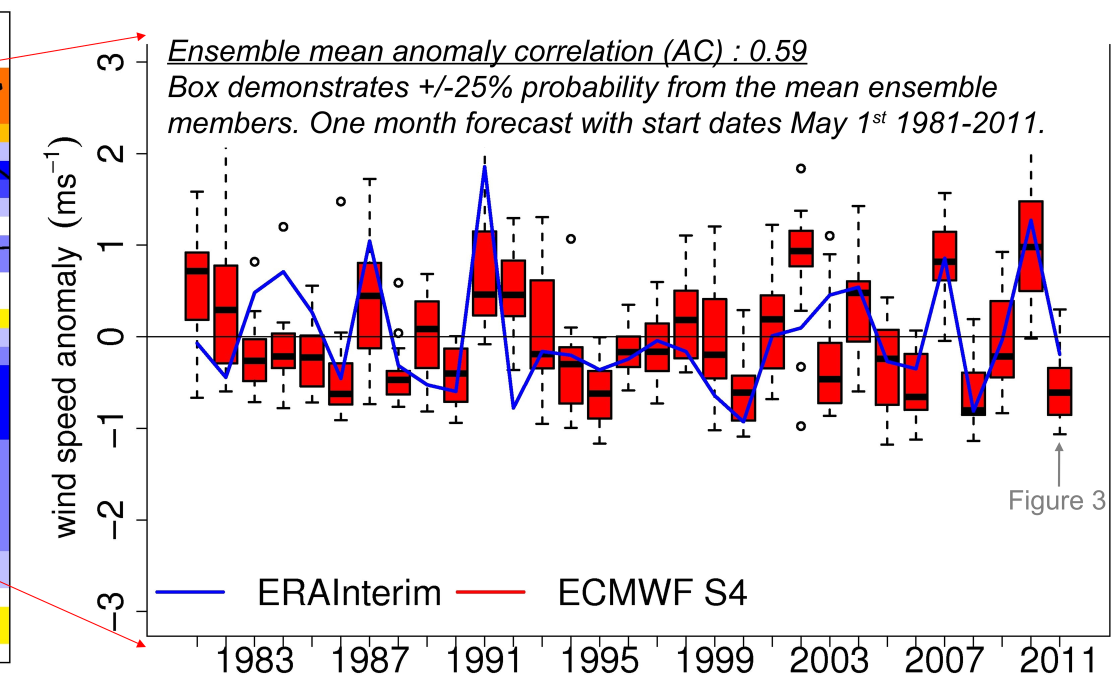
Figure 3. Probabilistic three category, spring 2011 forecast for 10m wind speed from ECMWF S4. The colour shows the tercile that contains more forecast members than any of the other two and the probability (%) of the event to happen (except for near normal).



Result: The system generally predicts below normal winds in western Europe in spring 2011, with a probability of 70% and higher.

- Site Specific -

Figure 4. The distribution of the 15 ECMWF S4 forecast members for 1 month (May only) vs. ERA-Interim at a grid point in Pamplona, Spain (a region with operational wind farms).



Result: Good skill (AC) is seen, when predicting the wind variations for the following month of May each year, of 0.59 (where 1 corresponds to a perfect forecast and 0 to a no informative system), although this fit varies from year to year.

Initial Conclusions

In Western Europe, the ECMWF S4 ensemble mean 10m wind anomaly forecast in spring (figure 1a) is close to zero or negative, as is also seen with the ERA-Interim 10m wind speed reanalyses in spring 2011 (figure 1b). This correspondence is associated with the positive, although low, forecast quality (ensemble mean) for seasonally-averaged wind speeds of one month lead predictions in spring in the Mediterranean region, based on the ECMWF S4 forecast system when compared against the ERA-Interim (figure 2). A low skill does not mean that there is no useful wind information in the forecast. The best way to extract this information is using probabilistic forecasts, as shown in figure 3 for spring 2011 (March, April, May). In this operational forecast, the predicted wind speed is consistently below normal over western Europe, in agreement with figure 1. The correspondence between forecasts and observational estimates suggests that a probabilistic seasonal forecast (figure 3) contains useful information for risk management when planning and operating wind energy projects over certain geographical regions.

An operational forecast for the month of May 2011 in Pamplona (figure 4) shows promising skill and correspondence between the observational reference (ERAInterim) and the predictions (ECMWF S4). Recent years, in particular, demonstrate a reasonable forecast (e.g. 2007, 2008, 2010), although other years show little or no correspondence. The skill of 0.59 for a one month forecast over all years (1981-2011) demonstrates good potential for using sub-seasonal wind forecast information in wind energy risk management for a given project site.

REFERENCES: F.Lienert, F.J. Doblas Reyes: Regional Mediterranean seasonal climate forecast information for the renewable energy sector, 2013, in preparation.

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