Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 76 (2015) 216 – 222

Energy Procedia

European Geosciences Union General Assembly 2015, EGU

Division Energy, Resources & Environment, ERE

Operational Evaluation of a Wind-Farm Forecasting System

Enda O'Brien*, Adam Ralph

Irish Centre for High-End Computing, IT Building, NUI Galway, Ireland

Abstract

Performance of a wind-forecasting system for a wind-farm in Ireland is reported. Forecasts were based on ensembles constructed from HARMONIE model runs every 6 hours, along with extra high-resolution HARMONIE runs every 12 hours. Statistical post-processing with Bayes Model Averaging (BMA) removed bias very effectively. The "raw" incremental skill provided by each extra ensemble member was negligible, but the net value, after BMA post-processing, was significantly larger. Thus, a small ensemble with BMA is more skillful than a larger ensemble with simple averaging only. A larger ensemble is still more skillful than a smaller one, if both use BMA.

Peer-review under responsibility of the GFZ German Research Centre for Geosciences

Keywords: Bayes Model Averaging; Wind-farm; Mean Absolute Error

1. Introduction

This article reports on the ability and skill of a prototype forecasting system, developed at the Irish Centre for High-End Computing (ICHEC), to make routine, fully automated wind and power forecasts for each of the 4 x 2.3MW turbines in a wind-farm on mountainous terrain in southwest Ireland.

* Corresponding author. Tel.: 353-91-495946.
E-mail address: enda.obrien@ichec.ie

Peer-review under responsibility of the GFZ German Research Centre for Geosciences
doi:10.1016/j.egypro.2015.07.903

The main component of the system is the HARMONIE Numerical Weather Prediction (NWP) model [1]. An "ensemble" of several different model runs (using different configurations, or starting at different times) all contribute to the final forecast.

The second key component is the "ensemble-BMA" (or Bayes Model Averaging) package from the R statistical programming language [2,3]. This package measures how the interpolated forecasts verify against observations over a past "training set" (e.g., the prior 20 days) and tries to detect any systematic errors, or biases, from such comparisons. These biases can be used to assign different weights to each member of an ensemble, and are ultimately removed from a "final" forecast. Although each final or "best guess" forecast is fundamentally obtained from physical principles as expressed in the NWP model, it is also adjusted to take into account what can be learnt from the statistics of previous performance.

The HARMONIE domain used for most forecasts covers a region slightly larger than Ireland and the UK (approx. 1,200 x 1,500 km^2), has a horizontal grid-resolution of 2.5 km, 65 vertical levels, and is run (operationally, by Met Éireann) 4 times daily at 00Z, 06Z, 12Z and 18Z. The first 30 hours of each forecast run were used for the wind-farm forecasting system. HARMONIE is "nested" in a larger but coarser-resolution global model. In other words, its boundary conditions are taken from the global model.

Output from operational HARMONIE runs were kindly provided by Met Éireann for use by this project. As long as such permission is granted, accessing the daily output files is straightforward, since the Met Éireann forecasts are run on the ICHEC "Fionn" supercomputer, and output remains on Fionn for several days before being rotated out to archive at Met Éireann.

Specifically for the purposes of this project, HARMONIE was also configured with a finer resolution (0.5 km) over a smaller domain centred on Kerry, and "nested" in turn inside the 2.5 km HARMONIE. In other words, the 0.5 km model takes its boundary condition updates from the 2.5 km model. This model was run twice daily (starting at 00Z and 12Z) to produce forecasts out to 30 hours, with shorter 6-hour forecasts starting at 06Z and 12Z to ensure the smooth "blending" of initial fields from one run to the next.

The wind-farm forecasting system reported on here is very similar to that described in [4]. In the present case it is applied to a different wind-farm, and is used to make real-time (operational) forecasts in a fully automated way. The system was also adapted to make historical "hind-casts" as well, using several different ensemble constructions from NWP model output. The main new contribution of this paper is to show some real-time "products", along with a simple evaluation of system performance. This shows the relatively large contribution to forecast skill made by BMA, and the relatively small contribution made by each incremental ensemble member.

2. Data

Observed wind-speeds at each individual turbine, along with the power generated, were provided from 1st Jan. 2014 until 8th March 2015. Data up to 31st Dec. 2014 was "historical" and only useful for verification of "hind-casts". Observational data provided after 1st Jan. 2015 lagged the forecasts, which were made in "real-time" (though of course those data can now also be used for "hind-casts").

While the turbine operator provided observational data every 10 minutes, only values at the start of each hour were used for forecast verification purposes, in order to correspond with forecast output which was only available at hourly intervals. Thus, 5/6 of the information contained in the observations was not used at all. This represents quite a large waste of data, and is an issue worth re-visiting in the future.

Courtesy of Met Éireann, archived forecasts from the 00Z and 12Z runs of the operational HARMONIE model were provided from 1st Jan. to 31st Oct. 2014, at "standard" pressure levels (mean sea-level, 850 hPa, 700 hPa, and higher). The sequence of forecasts made by those twice-daily runs formed the basis of a ***2-member "ensemble"***, for the purposes of BMA processing.

From 1st Nov. 2014 onwards, more complete output was saved from all 4 operational HARMONIE forecast runs each day, and from all 65 model levels. Those runs formed the basis of a ***4-member "ensemble"*** for BMA purposes.

Also, from 1st Nov. 2014 onwards, complete output was also available from the 00Z and 12Z runs of the high-resolution 0.5km HARMONIE forecasts nested inside the 2.5km operational runs. When combined with the 4 operational runs each day, these constituted a ***6-member "ensemble"*** for BMA purposes.