CUT-IN NOTE. Research in Progress

ViLab: a Virtual Laboratory for Collaborative Research on Wind Power Forecasting

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ABSTRACT

The consortium of the European Coordination Action 'Prediction of Waves, Wakes and Offshore Wind' (POW'WOW) has established a Virtual Laboratory (ViLab) for the development and operational use of wind power prediction systems. The objectives are to stimulate research in this field, to tighten the collaboration between forecasters and forecast users, and to follow and communicate the state of the art in short term prediction of wind generation. The present note clarifies the benefits for the participants to the ViLab. Also, it describes the methodology employed and some practical issues related to data and confidentiality.

1. INTRODUCTION

Increasingly, research organizations and companies seek to develop operational systems for short-term prediction of wind power production, commonly for horizons up to 48 or 72-hour ahead, as needed for the management and trading of electricity. A state of the art on wind power forecasting has been published by Giebel *et al* [1]. Such forecasting is recognized as a cost effective solution for an optimal integration of wind generation into power systems. Transmission System Operators (TSOs), wind farm operators, and traders usually rely on one or more forecasting systems for making optimal decisions.

We describe here an initiative developed by the European Coordination Action 'Prediction of Waves, Wakes and Offshore Wind' (POW'WOW), partly funded by the European Commission (Contract Number 019898). This initiative has established a collaborative action in the form of a 'Virtual Laboratory' (ViLab) for the evaluation of state-of-the-art prediction methods and systems, in addition to stimulating collaborative research in the field of wind power forecasting. This continues the benchmarking exercise of the European project ANEMOS, in which more than 10 prediction methods were evaluated on a variety of test cases with different terrain characteristics and wind climatologies [2]. We first describe the objectives of the ViLab initiative and the benefits for the participants. Then, we explain the

methodology behind ViLab, which encompasses aspects ranging from the definition of test cases to the method employed for the evaluation and communication of prediction results, via more practical aspects, e.g. databases and data formats. Finally, we consider the practical issues related to participation in ViLab, both for data providers and for forecasters, including confidentiality and commitments.

2. OBJECTIVES & BENEFITS FOR THE PARTICIPANTS

By setting up ViLab, the main scientific and technological objective is to promote the evaluation of operational methods and systems for the short term prediction of wind generation in order to follow and stimulate the advances in this area. Since wind predictions provided by meteorological offices are the principal input used by the various prediction methods, it is crucial to evaluate the quality of this input. Another objective is to disseminate results so the wind energy sector may know the state of the art in short term forecasting.

Through ViLab, forecasters may test their models on wind farms with representative environments and forecasting conditions, for which a large quantity of high quality data would be made available. They can also compare the performance of their prediction models against other participants. This will identify and underline advantages and drawbacks of rival methodologies and indicate the necessary scientific and technological developments in the field. Another advantage for these participants is to be included in the dissemination actions of the POW'WOW project e.g. web page, presentations, and workshops.

A main benefit for the organizations providing wind power data as an input to ViLab is their access to all evaluation results. Consequently, they may know the state of the art of wind power prediction models for their own wind generation portfolio. By collaborating in this initiative, they can review and comment on the evaluation results. As for forecasters, the organizations supporting the benchmarking and giving access to the wind farm data will be included in the dissemination activities of POW'WOW.

3. THE ViLab METHODOLOGY

The experience of the consortium members evaluating forecasting methods produced the clear structure of the ViLab benchmarking exercise, which enables the results generated by the various forecasting systems to be compared. In addition, it is important to analyse the advantages and handicaps of each forecasting method and of wind power forecasting methodology as a whole. The general structure of ViLab is depicted in Figure 1. It can be divided into two main parts: (i) the setup of test cases and handling of data, and (ii) the application and evaluation of the forecasting methods. Both parts are described in the following.

3.1 Test cases and data

The evaluation of state-of-the-art forecasting methods has to be carried out on a set of test cases whose characteristics span the range of different conditions affecting the performance of forecasting systems. This choice of test cases followed from the conclusions of the Anemos benchmarking exercise [2].

The test cases selected have various (i) terrain characteristics and (ii) wind climatologies. These two sets of characteristics are known to have an influence on both the average performance of forecasting methods and the variability of expected performance depending on the method chosen. In addition, the size of the wind farms (in terms of nominal power and area over which turbines are dispersed) considered as test cases may prove to be important,

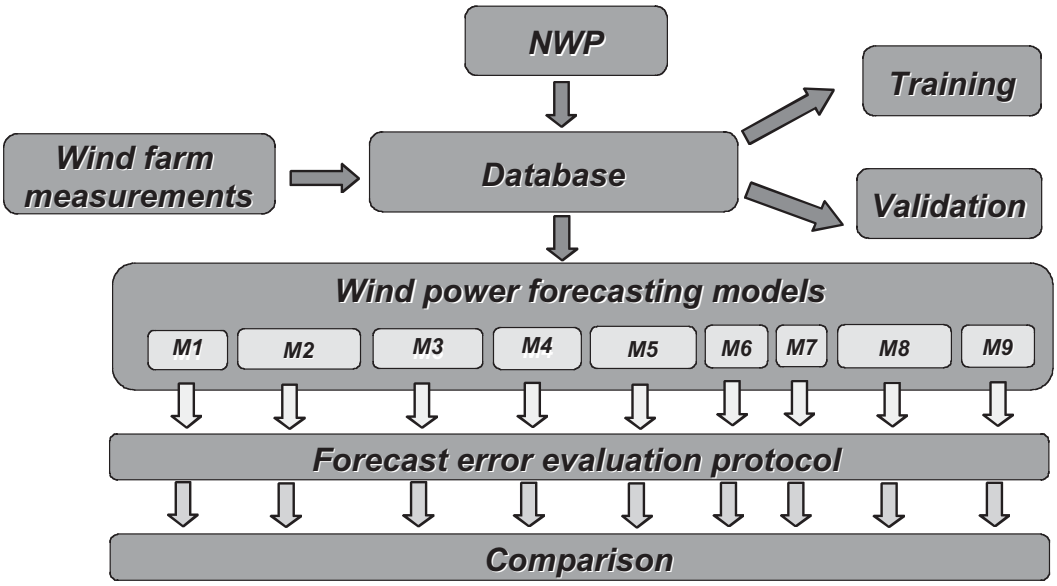

Figure 1. General structure of the ViLab.

since both factors affect the smoothness of the wind power output. For each of the test case, an extensive description of the wind farm characteristics, i.e. wind farm and turbines coordinates, turbine types, terrain and roughness maps, etc., are provided along with the available measurement data. Whenever wind measurements or of other meteorological variables are available, they will also be integrated in the test case definition.

It is clear that the same dataset cannot be used both for (i) developing and optimizing a forecasting method, and (ii) for carrying out its evaluation. Such an approach would lead to over-optimistic conclusions on the performance of the prediction method (see discussion in [3, ch. 3]). Since the aim of the ViLab initiative is to make a fair comparison between different state-of-the-art wind power forecasting methods regarding their operational application, the dataset for each test case is divided into (i) a training set and (ii) an evaluation set, which are independent. The former can be used for training prediction models and optimizing their parameters, while the latter is considered for assessing the performance of the forecasting method only. The bounds of these two periods must be clearly specified. The length and temporal resolution of wind power forecasts must also be defined. Commonly, wind power predictions have an hourly resolution up to 48- or 72-hour ahead.

A test case does not only consist of a wind farm, related measurements, and of the definition of the target forecast characteristics. Also needed are the Numerical Weather Predictions (NPWs) to be used as input to the prediction of wind generation. In the ViLab, one or several sets of NWPs will be made available for each of the test cases. These sets of NWPs come from operational models running in various European meteorological offices. A complete description of their characteristics will be provided in the test case description transmitted to the ViLab participants. In addition, participants can use their own set of NWPs, if they anticipate better forecast accuracy or improved operational arrangement. In such case, the NWPs would be provided to the POW'WOW consortium and integrated in the case study definition, so that other participants may evaluate their prediction methods with these additional NWPs as input.

With the number of test cases and related quantities of data involved, it has been necessary to build appropriate databases and to define standard formats for data storage and

communication. This has been done following the experience gained through the European project Anemos. In addition, all the data exchanges will be through a secured website. This guarantees an optimal flow of information while respecting the confidentiality.

3.2 Forecasting systems and their evaluation

The second part of the ViLab methodology relates to the forecasting systems and to their evaluation. When applying for participation in ViLab, each forecaster must provide the POW'WOW consortium with documentation on the methods embedded in his operational forecasting system, its input requirements, etc. The forecasters must also describe their operational experience and, if possible, clarify the accuracy of their forecasting system. The POW'WOW consortium will review applications and related documentation for relevance. The aim is certainly not to select a limited number of participants, but to guarantee the seriousness and commitment of the participants in the ViLab consortium. All participants must agree to maintain confidentiality and to keep the defined protocol for data storage and exchanges.

After applying their forecasting systems to the various test cases, the ViLab participants will communicate their forecast results in the agreed common format. Then the POW'WOW consortium will carry out a cross-evaluation of the forecasting results on the different test cases. The ViLab participants are obviously allowed to do their own evaluation of their forecast results, and to communicate them through reports and publications in conferences or scientific journals. For evaluation and comparison of the accuracy of the forecasting systems, a standard protocol will be applied as a basis. This protocol is described in Reference 4. It consists of a set of error measures (e.g. Normalized Bias, Normalized Mean Absolute Error, Normalized Root Mean Square Error), which provide complementary information on forecasting performance. More advanced approaches to forecast verification will be employed, such as the distribution-oriented approach described in [3], in order to highlight the influence of some specific variables on forecasting performance.

The dissemination of results is planned as follows. Within the ViLab consortium, each participant will have access to their individual performance and to the performance evaluation results of other participants, but without naming them. For broader and public publication of the ViLab benchmarking results, three options are made available to the participants. Each of these options defines how the results from the common evaluation will be available and publicly reported. These options are: (i) full confidentiality, i.e. only performance results without naming the participant or related forecasting system will be included in any public communication; (ii) limited confidentiality, i.e. the participation in the ViLab will be made public, though the results from the forecasting system will be disseminated without naming it; (iii) no confidentiality, i.e. both participation and results may appear in any public document. The communication of the ViLab results will include communications in conferences and scientific journals, as well as organization of specific workshops for stimulating discussion on the state-of-the-art in wind power prediction between forecasters and forecast users.

4. PRACTICAL ISSUES

Successful collaboration between those researching forecasting and those applying forecasting requires the mutual respect of both parties. Therefore practical rules have been set up to limit the present ViLab activity to research and development only.

Applicants and participants to the ViLab activity must provide documentation describing

the methods embedded in their forecasting systems, and demonstrate the operational nature of their forecasting service. All data made available through the ViLab must be used for this purpose only, and certainly not for commercial application. The participation of both forecasters and forecast users is at their own cost. Proper communication of the use of the ViLab data will be as agreed scientific publications in conferences or journals. Obviously, the POW'WOW project shall be cited in any use of the provided data. All practical issues related to availability and use of data will be settled through the signature of confidentiality agreements between the ViLab participants and data providers through the POW'WOW consortium.

The essential dates for the ViLab benchmarking exercise are the 1st June 2007 for its starting data, and the 30th April 2008 as the deadline for the forecasters participating in the ViLab to provide their final results. The POW'WOW consortium is committed to compile, analyse and communicate the final results, whilst defining directions for further research in wind power forecasting.

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