POW'WOW Virtual Laboratory for Wind Power Forecasting – ViLab.

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ABSTRACT

As development and operational use of forecasting solutions take more and more importance in the wind energy sector, the consortium of the European Coordination Action 'Prediction of Wakes, Waves and Offshore Wind' (POW'WOW) has taken the initiative of setting up a Virtual Laboratory (ViLab). The related objectives are to stimulate research efforts in this field, to tighten the collaboration between forecasters and forecast users, as well as 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 eg. data and confidentiality.

1. Introduction

More and more research organizations and companies invest efforts in the development of operational tools for the short-term prediction of wind power production. The relevant and common forecast length of these tools is up to 48- or 72-hour ahead, corresponding to the needs of forecast users for management or trading purposes. A state of the art on wind power forecasting has been published by Giebel *et al* [1]. On the other side, such forecasting systems are fully 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 among others, usually rely on a unique or on several forecasting systems for making optimal decisions.

We describe here an initiative developed in the frame of the European Coordination Action 'Prediction of Wakes, Waves and Offshore Wind' (POW'WOW) partly funded by the European Commission (Contract Number 019898). This initiative consists in setting up 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. It can be seen as a follow-up of the benchmarking exercise carried out in the frame of the European project ANEMOS, in which more than 10 prediction systems have been evaluated on a variety of test cases with different terrain characteristics and wind climatologies, see eg. [2]. The objectives of the ViLab initiative and the benefits for the participants are described in a first part. Then, the methodology behind the ViLab is developed. It 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 eg. databases and data formats. Finally, a last part deals with practical issues related to the participation to the ViLab, both for data providers and forecasters, including confidentiality matters and commitments.

2. Objectives & Benefits for the Participants

By setting up the 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 also crucial to evaluate the quality of the wind forecasts used as input. A second objective is to disseminate results that can help the wind energy sector to have a better appraisal of the state of the art in short term forecasting.

Through the ViLab, forecasters will have the opportunity to test their models on wind farms representing a set of 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 permit to identify advantages and drawbacks of rival methodologies and to point towards 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 eg. web page, presentations, workshops, etc.

In parallel, the main benefit for the organizations providing wind power data as an input to the ViLab is that they will have access to all evaluation results, and thus have the opportunity to know the state of the art of
wind power prediction models for their own wind generation portfolio. Also, their collaboration to this initiative will allow them to orientate the research efforts in the field by reviewing and commenting on the evaluation results. As it is the case 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.

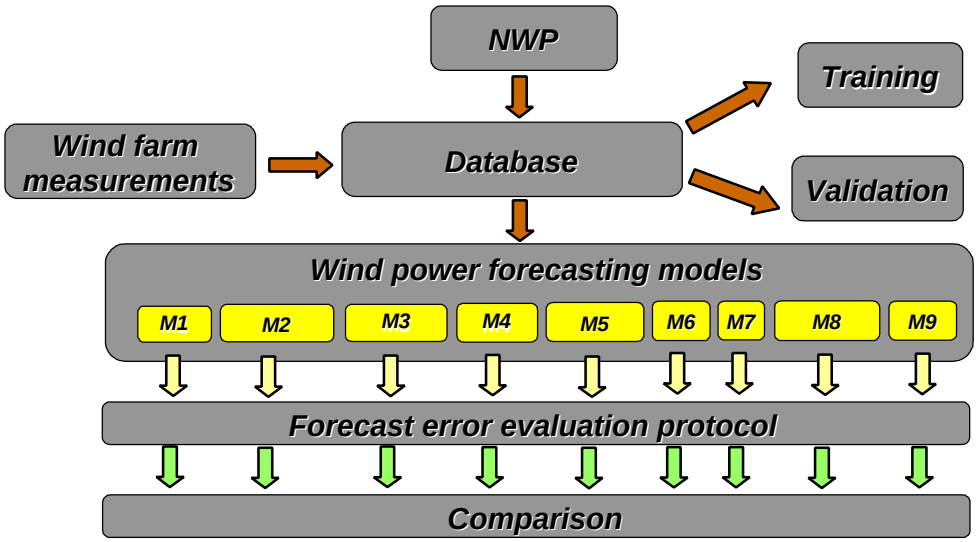

Figure 1: *General structure of the ViLab.*

3. The ViLab Methodology

The experience of the POW'WOW consortium members related to evaluation of forecasting methods has led to the clear definition of the structure of the ViLab benchmarking exercise. The aim of having such a clear structure is to guarantee that results generated by the various forecasting systems involved would be comparable. In addition, it is also important in order to be able to draw relevant conclusions on the advantages and bottlenecks of each of the various forecasting methods, or of the current wind power forecasting methodology as a whole. The general structure of the ViLab is depicted in Figure 1. It can be divided into two main parts, which correspond to the setup of test cases and handling of data on the one hand, and to the application and evaluation of the forecasting methods on the other hand. Both parts are described in the following.

Test cases and data

A first point concerns the selection of test cases. It has been decided that the evaluation of state-of-the-art forecasting methods should be carried out on a set of test cases that cover different types of conditions that are known to impact the performance of forecasting systems. This choice follows from the conclusions drawn after the ANEMOS benchmarking exercise [2]. First, the test cases selected have various terrain characteristics and wind climatologies. These two characteristics are known to have an influence on both the average performance level of forecasting methods, as well as on the variability of expected performance depending on the method chosen. In addition, the size (in terms of nominal power and area on which turbines are dispersed) of the wind farms considered as test cases may prove to be important since having an impact on the smoothness of the wind power output. For each of the test case, an extensive description of the wind farm characteristics, ie. wind farm and turbines coordinates, turbine types, terrain and roughness maps, etc., will be provided along with the available measurement data. In the case for which wind measurements are available (or of other meteorological variables), they will also be integrated in the test case definition.

It is clear that the same dataset cannot be used both for developing (and optimizing) a forecasting method and for carrying out its evaluation. Such an approach would lead to over-optimistic conclusions on the performance of the prediction method. Training error consistently decreases with model complexity, typically dropping to zero if complexity is large enough. The forecasting community often refers to that 'abnormal' level of performance as artificial skill: this same skill could never be reached in an operational context in which forecasts can only have a genuine nature. Since the aim of the ViLab initiative is to introduce a fair comparison between the state-of-the-art wind power forecasting methods, but with focus on their operational application, the dataset for each test case is divided into a training and 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 will be clearly specified. The length and temporal resolution of wind power forecasts to be produced will 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 in a wind farm and in the definition of how the power measurements or forecasts should be handled. Another important point concerns 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. Actually, each of these participants also has to right to use his own set of NWPs, if they think that it could lead to a better forecast accuracy or because of some 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 also have the possibility to evaluate their prediction methods with these additional NWPs as input.

One realizes that in regard to 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 carried out through a secured website. This guarantees an optimal flow of information while respecting the confidentiality issues involved in such exercise.

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 the ViLab, each forecaster is committed to provide the POW'WOW consortium with documentation on the methods embedded in his operational forecasting system, its input requirements, etc. The forecaster will also be asked to describe his operational experience and, if possible, give information on the witnessed accuracy of his forecasting system. The POW'WOW consortium will review applications and related documentation in order to decide on their relevance. The aim of such review is certainly not to select a limited number of participants, but more to guarantee the seriousness and commitment of the participants in the ViLab. An important point is that any participant will have to agree with the confidentiality framework and with 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, in order for the POW'WOW consortium to 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 3. It consists in a set of error measures eg. Normalized Bias, Normalized Mean Absolute Error, Normalized Root Mean Square Error, etc, which are known to provide complementary information on a forecasting method's performance. More advanced approaches to forecast verification will be employed, such as the distribution-oriented approach described in [4] for instance, in order to highlight the influence of some specific variables on the performance of the forecasting methods.

The dissemination of results is planned as following. Within the group of ViLab participants, each of them 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 to what extend the results from the common evaluation will be available and publically reported. These options are: (i) full confidentiality, ie. only performance results without naming the participant or related forecasting system will be included in any public communication; (ii) limited confidentiality, ie. the participation in the ViLab will be made public, though the results from the forecasting system will disseminated without naming it; (iii) no confidentiality, ie. 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

A crucial point for a sane collaboration between the community spending efforts in forecasting research and development on one side, and forecast users on the other side, is to ensure the respect of the interests of both parties. For that purpose, certain practical rules have been set up, with the aim of making sure that collaboration through the ViLab initiative stays at the research and development level.

As explained above, applicants and participants to the ViLab shall provide documentation describing the methods embedded in their forecasting systems, and demonstrate the operational nature of their forecasting service. In parallel, the data made available through the ViLab shall be used for this purpose only, and certainly not for commercial ones. The participation of both forecasters and forecast users is at their own cost. Proper communication through the use of the ViLab data shall take the form of 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. A commitment of the Pow'Wow consortium will finally be to compile, analyse and communicate these results, in parallel to defining directions for further research in wind power forecasting.

5. References

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