Master Thesis projects on Wind Energy

Who we are

Vattenfall is one of the largest wind power developers and operators in Europe with more than 1000 operating turbines in Sweden, Denmark, Germany, the Netherlands, and the UK. Our electricity generation from wind power exceeds 5 TWh annually – a volume that has approximately tripled over the past five years and will continue growing fast based on a solid pipeline of onshore and offshore construction projects.

What projects do we offer

We are looking for (master-level) students to carry out four different projects:

1. Wind Turbine ice detection based on blade image analysis
2. Forecasting the Risk of Lightning Strikes
3. Forecasting maximum wind speed at offshore sites
4. Combining multiple weather or power forecasts for trading activities

As a thesis worker, you will be part of a multi-disciplinary team of skilled R&D engineers with background in meteorology, physics, and applied mathematics. You will be located in one of our offices in Kolding, Copenhagen, or Edinburgh for the estimated project duration (4-6 months).

Who we are looking for

We are looking for students, who …

- have a proactive attitude and feel comfortable in an international working environment.
- are interested in renewable energy, atmospheric dynamics, and making sense of data.
- are well versed in scripting/programming languages such as Python, Matlab, R, or similar.
- have good oral and written communication skills, particularly in English.

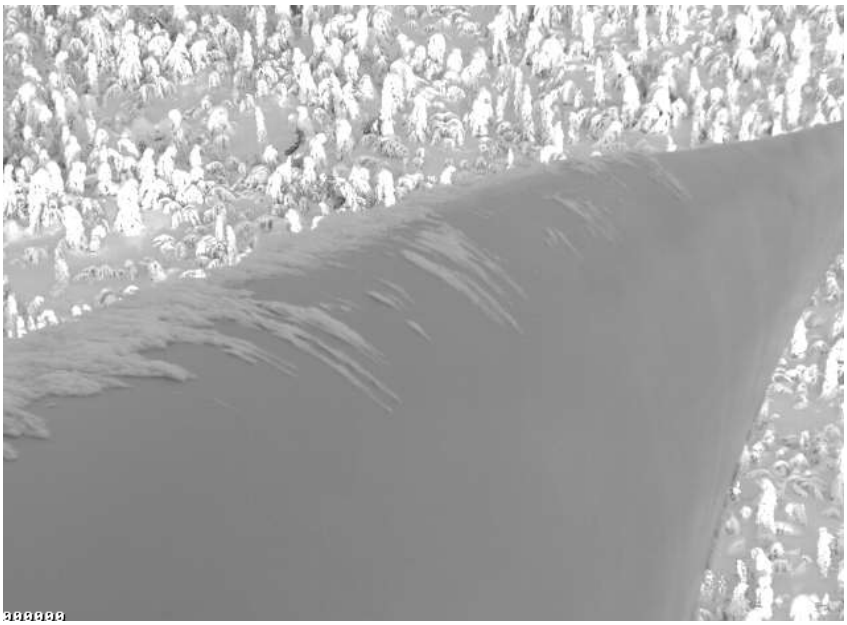
Contact us

Apply or ask questions by email to studentproject.wind@vattenfall.com. The application deadline is 04.01.2016, remember to indicate which project(s) you are interested in.

Project #1: Wind Turbine Ice Detection based on Blade Image Analysis

Background

Building wind farms in cold climate holds a unique set of operational challenges. During icing events, ice builds up on the wind turbine blades and reduces the aerodynamic performance and power production. To counteract this, turbines can be equipped with de-icing or anti-icing systems capable of removing the accreted ice by applying heat to parts of the blade. Such ancillary systems require extra power and are triggered by an ice detection system that provides a binary signal. If ice is detected early enough, the process of de/anti-icing can be properly optimized in terms of production, providing also the extra benefit of reducing safety hazards due to ice throws from the blades. For this purpose, Vattenfall has installed nacelle-mounted cameras that monitor wind turbine blades at cold climate sites, see example below.



Ice accreted on the blade of a wind turbine

The project

The present project aims at developing an automated ice detection system based on the images captured by a nacelle mounted camera. To this end, techniques from image analysis (e.g. texture analysis) and Computer Vision (e.g. shape recognition and image segmentation) are to be used. Another objective of the project will be to evaluate the potential of such a system for estimating power losses due to icing based on features (e.g. spread of the area covered by the ice) extracted from the images. The ideal student will have prior experience with image analysis and/or statistical methods. For this project, you will be located in our Kolding office.

Further reading

IEA Task 19 Cold Climate reports available at: https://www.ieawind.org/publications/19.html

Project #2: Forecasting the Risk of Lightning Strikes

Background

The scale of offshore wind operations continues to grow. Working offshore with construction or maintenance of offshore wind farms will at times leave personnel exposed to severe weather conditions. To mitigate health and safety concerns related to lightning strikes, there is a need to build reliable a prognostic capability to forecast the likelihood of such events at short-term time horizons up to 48 hours, in order to factor this in to the planning of transportation and work.

The current understanding of the cloud electrification processes that produce lightning is still incomplete and resolution of weather models is insufficient to explicitly forecast lightning events. Advanced Statistical methods are therefore used to predict the risk of lightning from various predictor variables taken from high-resolution weather models. In this project the student will work with a combination of good quality observations and output from a state of the art high-resolution weather model.

The project

Throughout this project, the student will be responsible for:

1. Coding up own version of the Analog Ensemble approach (Delle Monache, 2011)
2. Test a range of WRF predictor variables for probabilistic lightning forecasting such as wind shear, vertical wind speed, cape, graupel flux, and atmospheric stability.
3. Definition of relevant error metrics used to validate forecasting skill.
4. Presenting the results for a broad audience when the project is finished

The project is well suited for students with a solid background in either computer science, physics, geophysics, mathematics or statistics.

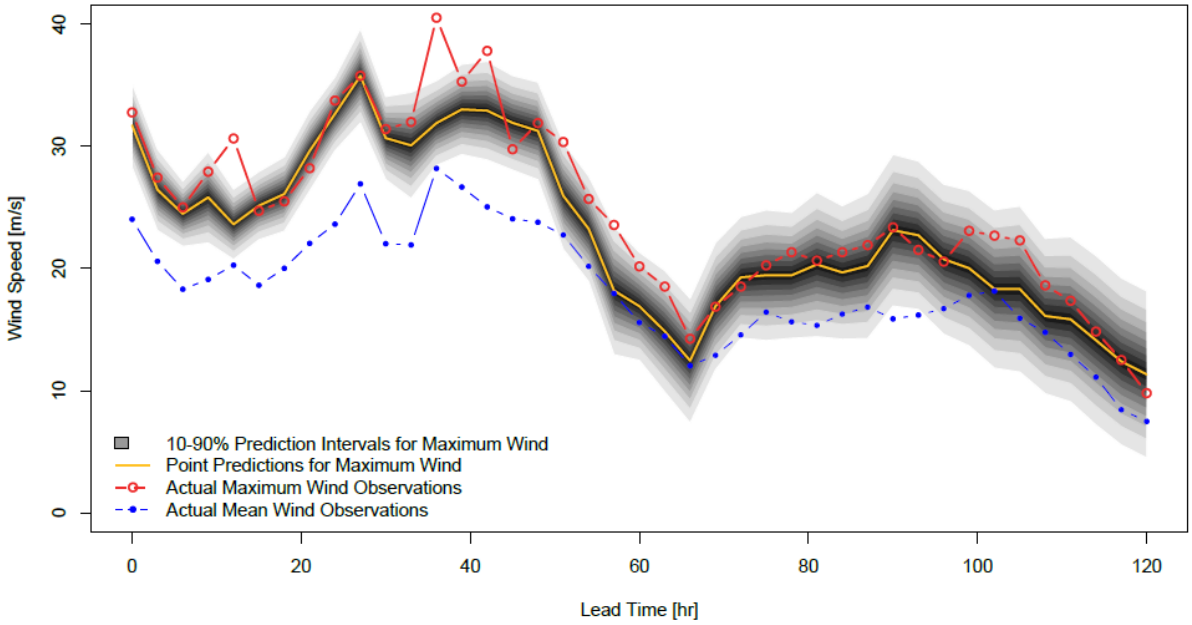
Project #3: Forecasting maximum wind speed at offshore sites

Background

Vattenfall is currently the second largest developer and operator of offshore wind farms in the world with more than 1.1 GW of installed capacity, and a solid pipeline of projects under construction or development. Our offshore activities sites are highly dependent on weather conditions. In particular, high wind speeds can pose a great risk to the work safety at site and may also trigger shut down of wind turbines leading to ramps in production that must be accounted for in the balancing of production schedules and power grids. For these reasons, accurate forecasting of wind and its associated uncertainty is essential for a wind power operator.

The project

The present project aims at developing a flexible forecasting system for maximum wind speeds. Statistical and machine learning techniques will be used to combine existing meteorological forecasts with a wide range of online measurements from offshore wind farms (i.e. data from wind turbines, meteorological masts, buoys, etc.) in order to deliver tailored forecasts of maximum wind speed to a number of internal customers. The results of this project are expected to be integrated into Vattenfall's in-house weather forecasting system.



An example of maximum wind speed forecasts (Source: Staid et al. (2014))

Further reading

Staid A, Pinson P, and Guikema SD (2014). Probabilistic maximum-value wind prediction for offshore environments. *Wind Energy*. Available at: http://pierrepinson.com/docs/Staid2013_maxwind_revised.pdf

Project 4: Combining multiple weather or power forecasts for trading activities

Background

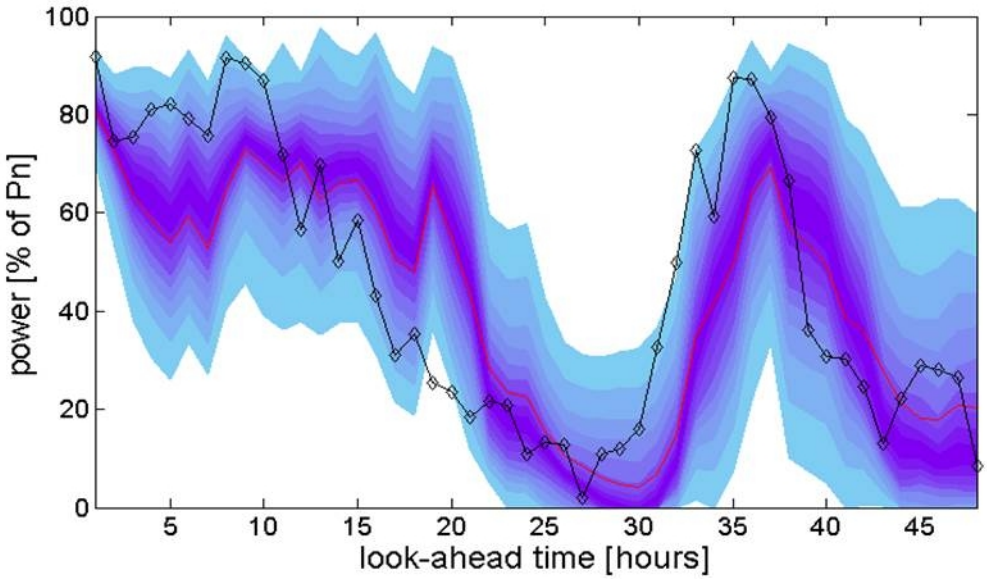
Vattenfall's wind energy business is highly exposed to the weather variability. In particular, the power produced by wind turbines is traded in day-ahead auctioned markets. For that purpose, power traders rely heavily on several sources of weather and power production forecasts. However, since weather forecast providers use different methods and draw from different sources of information, there are many situations where the resulting forecasts differ substantially. In this context, there are two possible strategies, either track and pick the single best forecast at any time (based on past performance), or consider that each forecast has something to contribute and use an intelligent combination method.

The project

The present project aims at developing a flexible method for generating improved weather and power forecasts based on multiple weather forecasts. To this end, statistical and machine learning techniques will be used in a number of tasks including:

- the identification and classification of weather regimes,
- the development of models for generating wind power production forecasts,
- development of methods for combining multiple weather or power production forecasts,

The results of this project are expected to be integrated into Vattenfall's in-house weather forecasting system and made available to a number of internal customers.



Further reading

Pinson P. (2013). Wind energy: Forecasting challenges for its operational management. *Statistical Science,* 28, 4: 564-585. Available online at: http://arxiv.org/pdf/1312.6471.pdf