Topics in High Dimensional Energy Forecasting

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Introduction

Energy forecasts are critical for the reliable and economic operation of modern power systems. They can be used as an informative tool for effective:

- Participation in electricity markets
- Scheduling of conventional generation
- Balancing of the power system
- Maintenance planning to minimise lost energy capture

An objective of many renewable power stakeholders is to manage and understand the risk introduced by the limited predictability of wind energy and other stochastic generators. This demands that forecast uncertainty be quantified through use of probabilistic forecasts in order to make the most well informed decisions. Additionally, operators and traders require accurate and reliable forecasts on a wide range of spatial and temporal scales to cover a portfolio of wind farms.

Aims & Objectives

The aims and objectives of this PhD include (but are not limited to):

- Literature review and implementation of simple and advanced probabilistic forecasting methods
- Identify and implement forecast methodologies that are scalable and therefore suitable for the required spatial scale
- Investigate the space-time structure and dependencies of forecast error covariance
- Produce and evaluate space-time trajectories on huge spatial scale
- Undertake 3-6 month research visit to Technical University of Denmark to work with Pierre Pinson and colleagues on one of the above topics

Methodology

A selection of the statistical tools planned for the forecasting include:

- Modern regression and estimation techniques (LASSO, elastic net, ridge regression)
- Boosting (gradient boosting machines, extreme gradient boosting, regularised boosting)

These methods will ultimately be included in a Big Data framework using R/H2O/Spark on local clusters or in the cloud.

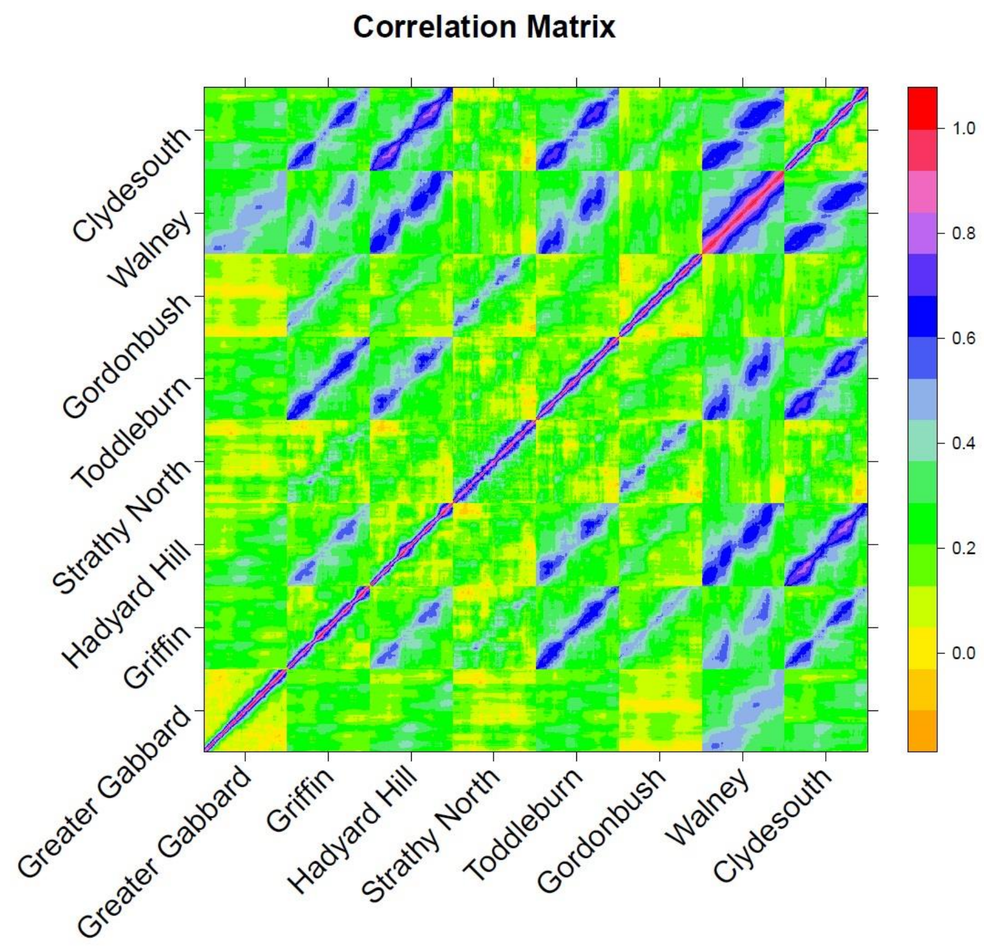
Discussion

Forecasts that quantify uncertainty for individual points in space and time are approaching technological maturity. However, their usefulness is limited since they do not capture:

- Temporal dependencies - required in multi-stage decision-making problems and for scheduling generation and reserve capacity.
- Spatial dependencies - required when considering portfolios of wind farms or managing transmission constraints.

Forecasts containing full spatio-temporal information require space-time covariance to be estimated. These covariance structures are both complex and dynamic, and difficult to estimate for large-scale problems for two main reasons: data volume and model complexity. These two issues remain open research questions that will be investigated in this project.

As an example, the following is a forecast error correlation matrix for some selected wind farms using a point forecasting methodology [1].



[1] Sofia Koukoura, Jethro Browell, and David McMillan, "Hierarchical Wind Power Forecasting", CDT Mini-project, 2016

Project Plan

Months 1-6
- Study of time series analysis, regression and machine learning techniques
- Implement standard techniques as learning exercise and to serve as benchmarks

Months 7-12
- Implement advanced techniques on modest spatial scale
- Explore Big Data platforms for extending methodology

Months 13-18
- Big Data implementation
- Exploration and model covariance structures
- Produce and evaluate scenario forecasts

Months 19-24
- Research visit to Technical University of Denmark

Months 25-30
- Further development of specific topics such as: dynamic covariance estimation, algorithm improvement, visualisation and communication of results

Months 31-36
- Write-up!

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