Engineering and Physical Sciences Research Council

Energy Forecasting Innovation Conference

Building capacity from modern Statistical Methodology

Bush House, King's College London and Online

PROGRAMME

Overview

The Energy Forecasting Innovation Conference is a dissemination and engagement event presenting outputs from three major EPSRC-funded projects related to forecasting in the energy sector. You will hear from the leaders of this research and their industrial partners and have the opportunity to shape the next generation of research in this area.

Tuesday 24 May	
Morning BH (S) 1.01 LT	9am for 9:30: Welcome and opening remarks from organisers followed by three presentations from industry of current and future challenges in energy forecasting.
Afternoon BH (S) 1.01 LT	Research presentations from academics on advances in energy forecasting and associated statistical methods.
Wednesday 25 May	
Morning BH (S) LT 2 (4.04)	9am: Research presentations continued, and innovation partners present their experience on translating research into practice.
Afternoon BH (S) LT 2 (4.04)	Research and innovation workshop facilitated by *Research in Focus*.
Thursday 26 May	
Morning BH (S) room 2.05 BH (S) room 2.06	9am: Parallel training courses in the use of research outputs and dedicated software: ProbCast and Statistical Inference with Max-Stable Processes. In-person only.

Sponsoring projects:

- Multivariate max-stable processes with application to the forecasting of multiple hazards, EPSRC Innovation Fellowship held by Dr Claudia Neves, King's College London (EP/S001263/1)
- System-wide probabilistic energy forecasting, EPSRC Innovation Fellowship held by Dr Jethro Browell, University of Glasgow (EP/R023484/2)
- Analytical Middleware for Informed Distribution Networks (AMIDiNe), EPSRC, Principal Investigator Dr Bruce Stephen, University of Strathclyde (EP/S030131/1)

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Tuesday 24 May 2022

09.00 Arrival, coffee, registration. Online stream open from 09.15.

09.30 Welcoming remarks, event overview, and case studies of collaboration and innovation

10.00 Daniel Drew, Senior Energy Modelling Specialist, NGESO
Title: *Operating the Power System in Great Britain: Forecast Development and Challenges*

10.45 Break

11.15 Maciej Fila, SSE Networks
Title: *Use of forecast to optimise battery flexible services on constrained distribution network and provide security of supply service to DNO" (jointly with E-On) - Provisional Title*

12.00 Matthew Allcock, EDF R&D UK Centre
Title: *Using statistics to ensure energy infrastructure safety from climate change and space weather impacts*

12.30 Lunch

13.30 Jethro Browell, University of Glasgow
Title: *System-wide probabilistic energy forecasting*
Abstract: Energy systems are evolving rapidly as they decarbonize, consequences of which include an increasing dependence on weather and new consumer and producer behaviours. As a result, all actors in the energy sector are increasingly reliant on short-term forecasts, from the National Grid to me and (maybe) you. Furthermore, in operate as economically as possible and maintain high standards of reliability, forecast uncertainty must be quantified and managed. This talk will give an overview of key findings from the EPSRC Innovation Fellowship *"System-wide probabilistic energy forecasting"*, including new statistical methods for high-dimensional forecasting, predicting extreme quantiles, and modelling time-varying covariance structures.

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14.15 Jennifer Wadsworth, Lancaster University

Title: *Modelling non-stationarity in asymptotically independent extremes*

Abstract: In many practical applications, evaluating the joint impact of combinations of environmental variables is important for risk management and structural design analysis. When such variables are considered simultaneously, non-stationarity can exist within both the marginal distributions and dependence structure, resulting in complex data structures. In the context of extremes, few methods have been proposed for modelling trends in extremal dependence, even though capturing this feature is important for quantifying joint impact. Motivated by the increasing dependence of data from the UK Climate Projections, we propose a novel semi-parametric modelling framework for bivariate extremal dependence structures. This framework allows us to capture a wide variety of dependence trends for data exhibiting asymptotic independence. When applied to the climate projection dataset, our model is able to capture observed dependence trends and, in combination with models for marginal non-stationarity, can be used to produce estimates of bivariate risk measures at future time points.

15.00 Refreshment Break

15.30 Claudia Neves, King's College London

Title: *Extreme value statistics born out of domains of attraction*

Abstract: Extreme value statistics is essentially concerned with the modelling of rare events which are hard to predict and occur with only little warning. In this talk, I will address a number of challenges highlighted in the literature and how these map on to the domain of attraction characterisation for extreme values. Such a characterisation stems from a suite of mildly restrictive conditions, qualitative in nature, which not only provide computational convenience but also furnish good approximations, a key aspect to statistical testing procedures as well as interval estimation methodology. This talk will consist of a light-touch presentation of the key findings the EPSRC Innovation Fellowship for the project "Multivariate Max-stable Processes with Application to the Forecasting of Multiple Hazards" has determined.

16.15 Marco Oesting, Universität Stuttgart – *Online Talk*
Title: *Statistical inference with max-stable processes*
Abstract: Max-stable processes have become popular models for spatial and spatiotemporal extremes, specifically in environmental applications. In statistical practice, they are used to approximate pointwise areal block maxima taken over sufficiently long time periods. This can help to answer practical questions about the distribution of (joint) areal maxima of a quantity of interest (e.g. temperature or wind) or the distribution of simultaneous threshold exceedances in specified areas. The training course, taking place on the 26th May, will guide through the main steps of statistical analysis using max-stable processes. While simulation plays an important role in the analysis, most of the available methods can at first sight seem practically prohibitive due to the high computational cost for each simulation. We will provide guidance how method choices can be adapted to practical needs.

17.00 *Close*

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9.00 Bruce Stephen, University of Strathclyde

Title: *Informing the behaviour of the last mile of distribution networks*

Abstract: Power distribution networks are in a state of transition, with the largely unmonitored low voltage feeders facing increased penetrations of low carbon technologies. Distribution Network Operators are presently aware of the potential effects of LV network loads but historic lack of observability means they are unable to quantify the impact these have on the voltage profiles, phase balance, losses and power flows on distribution feeders. Failure to contain these may result in regulatory limits being violated, quality of supply compromised or assets being aged prematurely. However, it does not translate directly into metrics quantifying operational threats to the network or the extent to which these may be seen in practice – this is where power systems modelling and machine learning would be required to work in conjunction: power network models estimate the parameters throughout the topology of the network while the machine learning models capture their uncertainty even in the event of missing data. This talk will provide an overview of the research undertaken as part of the EPSRC AMIDiNe project in predicting distribution load behaviours, identifying embedded generation and providing a unifying framework that utilises data driven and power system models to articulate operational consequence at distribution level.

9:45 Theo Moins, EDF France

Title: On the use of a local R-hat to improve MCMC convergence diagnostic

10:15 David Brayshaw, University of Reading

Title: Combining numerical and statistical methods for improved anticipation of weather and climate risk in energy systems

Abstract: The growing use of weather-dependent renewable power is changing the way electricity systems operate. The traditional paradigm where large power plants are managed to meet variations in electricity demand is being replaced by a situation in which both demand and supply are strongly influenced by weather. This has profound consequences for power systems where supply-demand balance must be maintained in real time, and the need for high-quality information for characterizing and anticipating future weather events has never been greater. This talk will discuss the use of 'numerical' meteorological models (so called 'NWP' and 'GCM' models) in assessing weather and climate risk in energy systems, reviewing both their construction and their advantages and disadvantages with respect to statistical methods. A key focus will be to demonstrate why combining numerical modelling

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with statistical techniques offers significant benefits over purely numerical- or statistical- methods alone. Recent examples of energy-system forecasting days-to-decades ahead will be highlighted as illustrations including: the use of sequential learning algorithms (combine multiple numerical and statistical forecast information); pattern-based methods to exploit conditional predictability; and the use of multi-decadal climate and climate-change datasets for assessing extreme weather-stress.

10.45 *Break*

11.15 Gordon McFadzean, TNEI Services & Owen Huxley, National Grid ESO
Title: Use-cases for probabilistic forecasting in electricity transmission system operation

11.45 Danica Greetham, Capgemini Engineering and Stephen Haben, Energy Systems Catapult
Title: Review of Low Voltage Load Forecasting: Methods, Applications, and Recommendations
Abstract: The increased digitalisation and monitoring of the energy system opens up numerous opportunities to decarbonise the energy system. Applications on low voltage, local networks, such as community energy markets and smart storage will facilitate decarbonisation, but they will require advanced control and management. Reliable forecasting will be a necessary component of many of these systems to anticipate key features and uncertainties. Despite this urgent need, there has not yet been an extensive investigation into the current state-of-the-art of low voltage level forecasts, other than at the smart meter level. This paper aims to provide a comprehensive overview of the landscape, current approaches, core applications, challenges and recommendations. Another aim of this paper is to facilitate the continued improvement and advancement in this area. To this end, the paper also surveys some of the most relevant and promising trends. It establishes an open, community-driven list of the known low voltage level open datasets to encourage further research and development.

12.30 *Lunch*

13.30 Research and Innovation Workshop
Facilitator: Becky Steliaros, Research in Focus Ltd
The primary focus of this workshop will be gathering ideas and initiating discussions about future research. We hope in the longer term that interactions initiated at the conference will lead to follow on collaborative projects focused on the needs identified.

15:00 *Break*

15:30 Research and Innovation Workshop continued

17:00 Close

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Thursday 26 May 2022

09.00 Arrival, parallel groups for training courses. In-person only, registration required. Please see details below.

12:00 Close

1. ProbCast: an R package for probabilistic forecasting

Instructor: Jethro Browell, University of Glasgow

Learning Objectives

Participants will leave this course with a working R script implementing state-of-the-art methods for electricity demand and wind power forecasting. After this training course, participants will be able to:

- Describe the principles of parametric probabilistic forecasting, and non-parametric (multiple quantile regression) probabilistic forecasting
- Use ProbCast to produce parametric probabilistic forecasts building on the framework of Generalised Additive Models for Location Scale and Shape (GAMLSS)
- Use ProbCast to produce multiple quantile forecasts based on gradient boosting machines (a best-in-class algorithm for renewable energy forecasting)
- Use ProbCast to visualise probabilistic forecasts
- Use ProbCast to evaluate probabilistic forecast in terms of reliability/calibration and Pinball Score

Requirements

Prior knowledge of basic probability and probability distractions, regression models, and programming (ideally but not necessarily R) are essential. Attendees should bring a laptop with R and ProbCast already installed (https://github.com/jbrowell/ProbCast/, instructions at this link). If you cannot bring your own, please contact us and we will make every effort to arrange sharing.

About ProbCast

ProbCast is an R package for producing and working with predictive distributions. It was developed with energy forecasting in mind, but its functionality is general and may be useful for any probabilistic prediction task. ProbCast defines two new data classes, one for parametric probabilistic forecasts, and another for non-paramedic predictions in the form of multiple quantiles. The latter may be augmented with parametric tail distributions.

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Functions are provided to rapidly visualise and evaluate such forecasts. Furthermore, ProbCast provides wrapper functions for a range of model types, including generic and tree boosting methods (gbm, lightGBM, mboost, rq) for quantile regression, and gamlss-type models for distributional regression (gamlss, gamboostLSS).
ProbCast was initially developed by Jethro Browell and Ciaran Gilbert as part of the EPSRC Fellowship "System-wide probabilistic energy forecasting" (EP/R023484/1). It is maintained on GitHub, where a full list of contributors and acknowledgements can be found: https://github.com/jbrowell/ProbCast/.

2. Statistical inference with max-stable processes (using R-software)

Instructor: Kirstin Strokorb, Cardiff University
This course will complement the talk by Dr Marco Oesting on 24 May

Learning Objectives

At the end of this course, it is expected that participants will be able to:

- Perform statistical inference with spatial data using max-stable processes
- Simulate max-stable processes using a range of available methods
- Make informed choices in terms of methods that can be adapted to practical needs

Requirements

Basic understanding of probability distributions required. In the training event, basic familiarity with the R language (including usage of data frames) is assumed. Participants are expected to bring their own laptop with R installed.

About Max-stable Processes

Max-stable processes have become popular models for spatial and spatiotemporal extremes, specifically in environmental applications. In statistical practice, they are used to approximate pointwise areal block maxima taken over sufficiently long time periods. This can help to answer practical questions about the distribution of (joint) areal maxima of a quantity of interest (e.g. temperature or wind) or the distribution of simultaneous threshold exceedances in specified areas. This course will guide through the main steps of statistical analysis using max-stable processes. While simulation plays an important role in the analysis, most of the available methods can at first sight seem practically prohibitive due to the high computational cost for each simulation. We will provide guidance how method choices can be adapted to practical needs.