Understanding forecast value in complex decision-making systems

Lead Supervisor: David Brayshaw, University of Reading, Department of Meteorology
Email: d.j.brayshaw@reading.ac.uk

Co-supervisors: John Methven, University of Reading, Department of Meteorology; Kjeld Jensen, BT research

A forecast is only useful to a decision-maker if it can be acted upon
and only valuable insofar as the resulting action leads to improved outcomes.

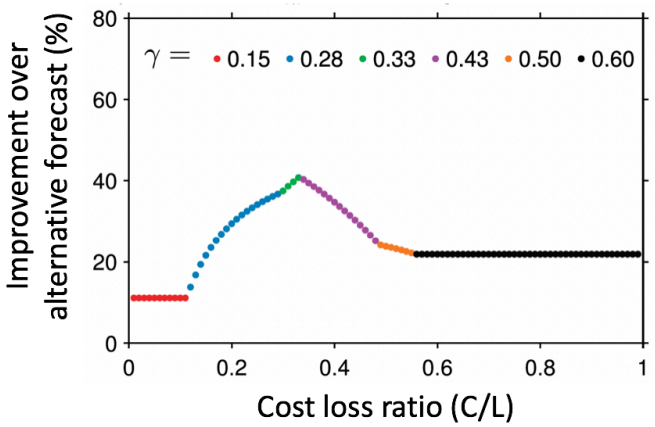
The application of forecasts to produce socio-economic *value* has long been a goal of weather and climate research. The Climate Services sector in particular – the provision of user-relevant predictions spanning weeks to decades ahead – has seen rapid growth in recent years. However, despite the apparent "end use" focus of these activities, scientific understanding of how meteorological forecasts interact with decisions in complex human- and environmental- systems is limited. This multi-disciplinary project seeks to address this important research gap and lead a step-change in how meteorological forecasts are assessed.

Examples of meteorology influencing decisions in complex systems are widespread, e.g., in national infrastructure such as telecommunications and energy. To date, however, the user-value of a forecast has been typically measured through a static "cost-loss" framework (i.e., a binary decision of act/do not act; Murphy 1985, Richardson 2000; see figure). Although this cost-loss approach has provided useful insights, it is severely limited for many real-world decisions. In particular, for complex impacted systems, weather states cannot always be uniquely mapped to impact states (Brayshaw 2018). Moreover, the decisions themselves may:

- depend on the preceding "trajectory" of forecasts over time,
- contain multiple actions across a range of lead-times,
- be updated as new forecasts become available.

Drawing upon a range of disciplines (atmospheric sciences, mathematics, statistics and engineering), this project will seek to extend the "cost-loss" framework. It will develop novel methods to maximize the *quality* of impact forecasts for infrastructure applications and, by linking meteorological forecasts to a suite of decision-models, it will develop an in-depth process understanding of how forecast *quality* transfers to forecast *value*. These decision models will be informed by "real world" examples, spanning a hierarchy of complexity and timescales (e.g., day-to-day operations to multi-year planning). A specific example concerning the management of the UK's fixed-line telecommunications network will be explored through a CASE partnership with BT Research. Alongside developing novel *scientific* insights, the project will also therefore contribute to informing improved weather-management techniques for critical aspect UK national infrastructure.

	Event occurs	
Action Taken	Yes	No
Yes	C	C
No	L	0



The cost-loss framework. Left – Contingency table: a loss, L, can be avoided by taking an action at cost C. The user may act or not, with the outcome depending on both their choice and whether the event occurs. Right – Cost-loss "valuation" of a probabilistic forecast system: the user maximizes the value of the forecast for their particular situation (i.e. fixed value of C/L) by acting when the event is forecast to occur. At higher cost-loss ratios, the user will wish to be more confident that the event will occur before incurring the cost C. Adapted from Lynch et al 2014.

Training opportunities:

The student will join the Energy Meteorology research group (research.reading.ac.uk/met-energy) in the Meteorology Department at Reading University and work with an experienced supervisory team. World-leading MSc-level training in meteorological science will be provided, and students encouraged to participate in relevant summer schools, seminars and workshops. Through a CASE studentship with BT Research (co-supervisor Jensen) and there will be opportunities to engage with and undertake a placement with the industry partner. On completion, it is expected that the student will have a good grounding in climate science and its applications with excellent career prospects, particularly within the growing Climate Services sector.

Student profile:

This project will suit an individual with a very strong quantitative background in mathematical/physical science, engineering, quantitative economics/statistics or similar. The student will undertake high-quality meteorological research with a focus on process-understanding. They must be enthusiastic about going beyond traditional subject boundaries and to work with an industry stakeholder.

Funding particulars:

CASE studentship (subject to confirmation of contract).

References:

Brayshaw, D.J. (2018) In: Weather & Climate Services for the Energy Industry. Palgrave Pivot, 151-160.
Murphy, A., (1985). Monthly Weather Review, 113, 362-369
Richardson, D.S. (2000). Q. J. R. Meteorol. Soc, 126, 649-667.
Lynch, K. J. et al. (2014). Monthly Weather Review, 142, 2978-2990.

http://www.reading.ac.uk/nercdtp