Bayesian deep learning for large scale environmental data modelling

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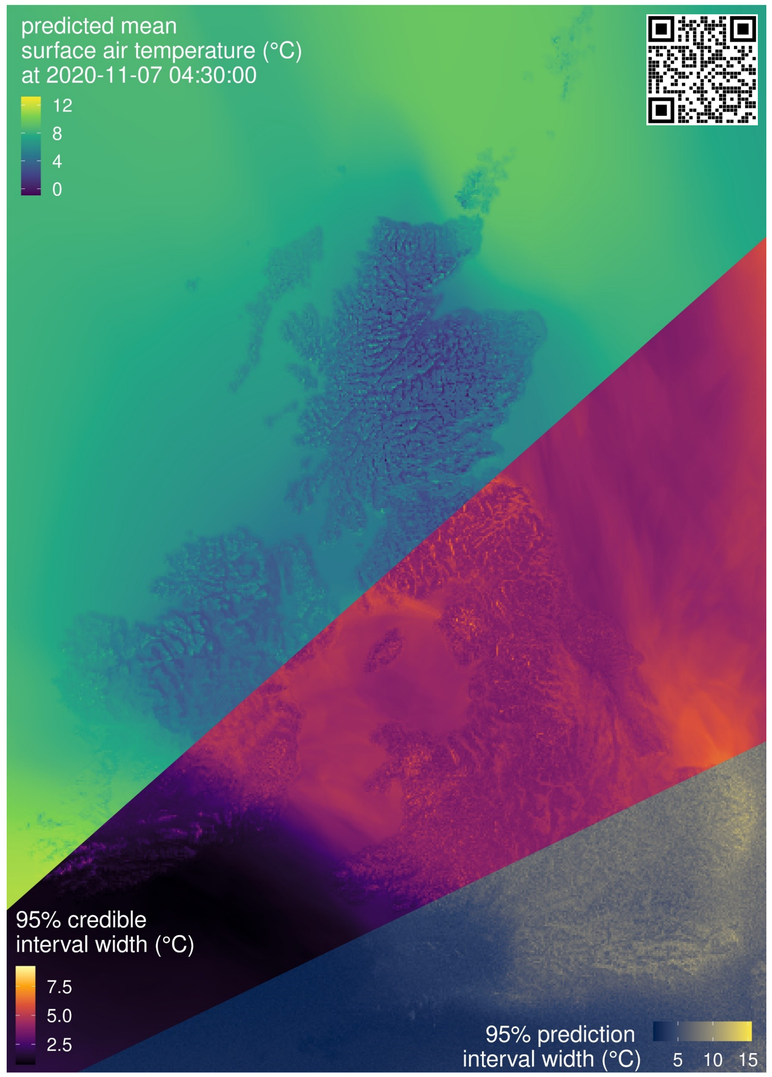
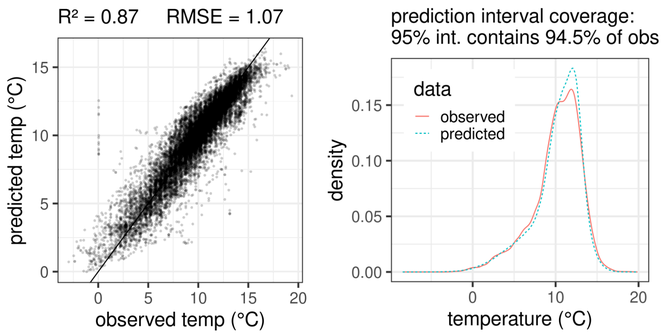
Outcomes

- Deep learning – machine learning using deep neural networks – is an efficient way to discover patterns in data that may be more complex than we could manually hypothesise.
- Here we learn spatio-temporal models that harness information from gridded auxiliary datasets, such as digital terrain models and satellite imagery, by learning task-relevant derivatives of these with no requirement for manual feature engineering.
- By operating within the Bayesian probabilistic framework, we can learn well-calibrated deep models that quantify epistemic and aleatoric uncertainties and avoid overfitting despite the capacity of deep models to do so.
- This allows us to simulate infinite 'ensemble members' from the posterior distribution, approximating the range of plausible hypotheses (data generating functions) that can explain the environmental phenomena we observe.
- In addition, we can make data collection more efficient by targeting regions for which the variability between plausible hypotheses – the epistemic uncertainty – is greatest.

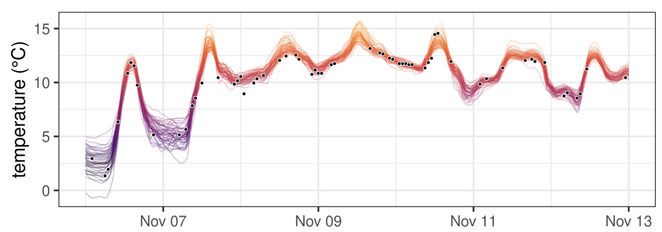
Example: modelling air temperature from Internet-of-Things sensors



Over 1500 unofficial weather stations across the UK provide over 8000 observations per hour. We interpolate these and assess against observations at held-out locations to reveal the predictive performance:



Above L: deterministic results **Above R:** probabilistic results
Below: 50 samples, or ensemble members, from the posterior



Wide applicability

Making the right decisions requires having good information – including modelled uncertainty.

We can use deep learning as an algorithmic interface to distill information from otherwise overwhelming sources, allowing us to manage the unmanageable.