Met Office

A Challenge for Wind Gust Forecasting with Convection-Permitting Models

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Challenge: How to get a consistent Gust diagnostic for both Shear-Driven Turbulent Gusts and resolved Convective Gusts?

Motivation

- Impacts of strong winds are typically caused by severe gusts rather than the mean wind speed, so gust diagnostics are important in model output to support impact-based warnings.
- Global models, and older regional models with grid lengths ~10km or more use a shear-driven turbulence parameterization to estimate wind gusts alongside the 10m windspeed output. This works well for strong-wind scenarios, although does not capture convective gusts.
- Convection-permitting models and ensembles with horizontal grid-lengths of order 1-2km resolve some convective overturning on the grid-scale, and therefore provide some representation of convective gusts in the mean windspeed outputs. Use of the shear-driven gust parameter over-estimates gusts in convective situations by adding a turbulent enhancement to the convective gust.
- It is difficult to separate the two effects in interpreting model outputs, especially in automated forecast production.
- The purpose of this poster is to set out a challenge with the aim of stimulating research into how best to derive a unified approach to gust estimation from convection-permitting NWP models. This may be either a model solution or a post-processing one.

2km UK model resolved wind field (right) shows resolved wind gust related to convection over the sea (A) and strong winds on the southern flank of a cyclone (B). The location and timing of convective gusts are usually wrong because individual showers have low predictability and therefore forecasts need to be probabilistic.

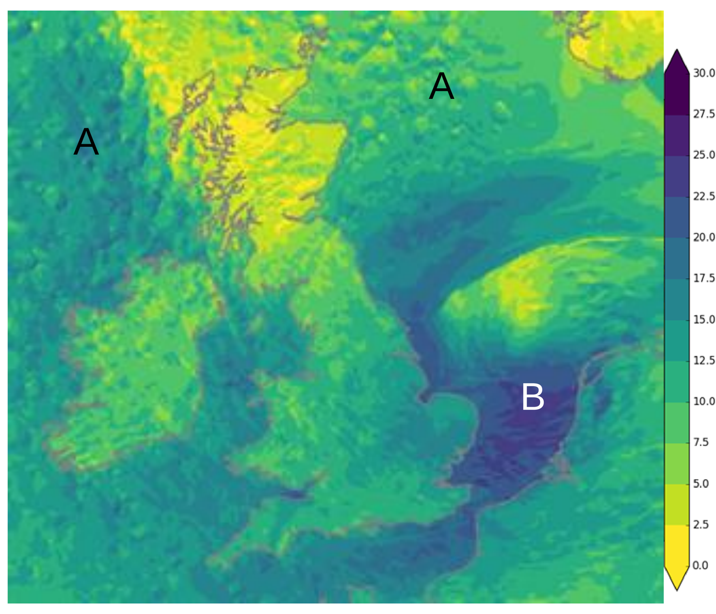
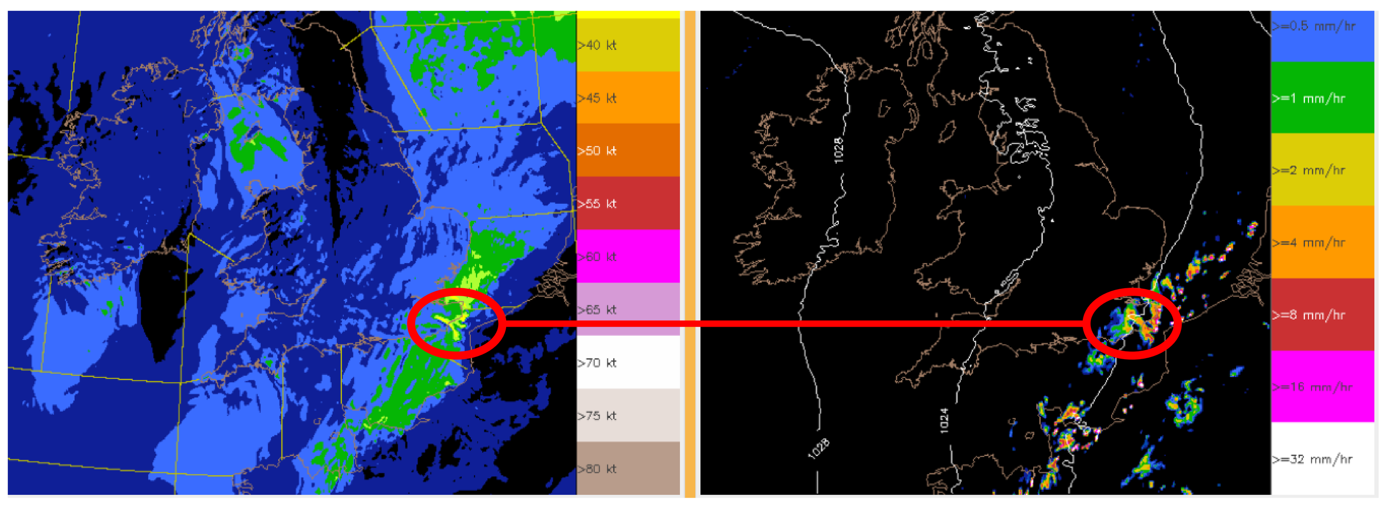
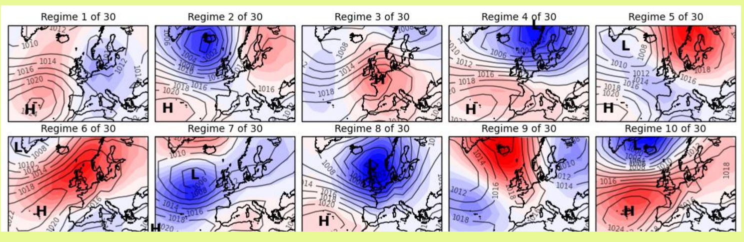


Illustration of wind (below left) and precipitation (below right) fields from UK model forecast shows gust outflow associated with convective shower.



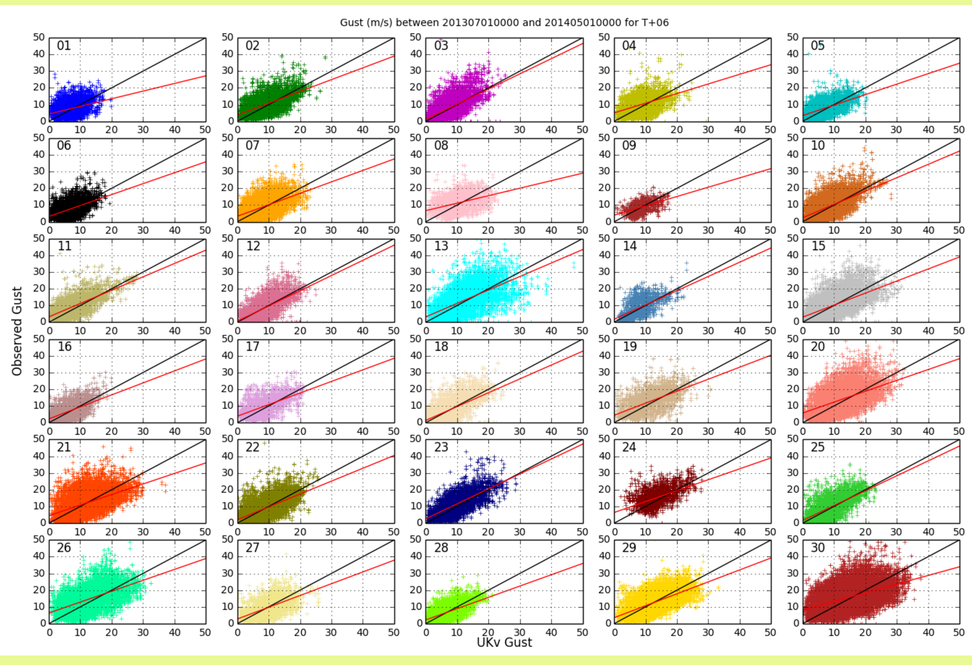
A Weather Regime Approach

Some synoptic flow regimes are more likely to produce significant convection than others, so it may be possible to calibrate gust forecasts according to weather regime. The Met Office uses a UK-centred regime categorization for its Decider ensemble downscaling system – the figure on the right illustrates 10 out of 30 regimes used.



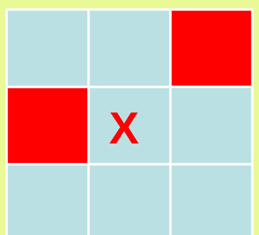
10 of the 30 flow regimes in the Met Office Decider weather regime system

By stratifying gust verification according to flow regime (right), calibration relationships between models gusts and observations may be derived. All regimes display a large degree of scatter, illustrating the difficulty in making accurate forecasts of gusts. A few regimes (e.g.23, 26) have a significant number of strong gusts which are under-forecast by a large factor. In general gust verification is difficult because of variations in gust reporting in observations, and some weather regimes will also have small samples of significant gusts, but there is some scope for a useful calibration. A regime diagnosis that incorporates atmospheric stability and dynamical forcing more locally may be beneficial.



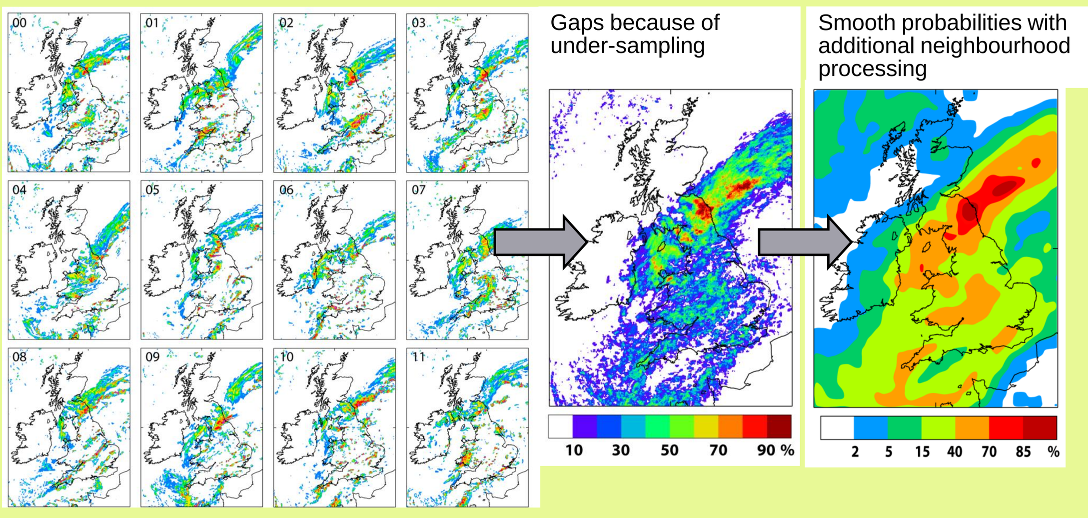
Observed vs. UK model gust for T+06 separated into weather regimes.

A Neighbourhoods Approach



Neighbourhood processing – looking at nearby pixels to address spatial predictability – is already used to give smooth probabilities from small ensembles:

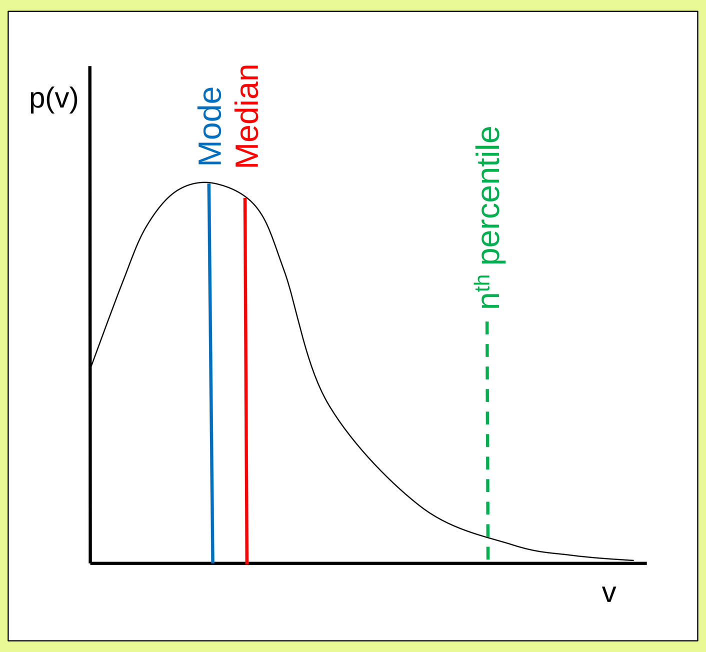
Exactly the same spatial uncertainty affects the wind gusts as the precipitation – so can we use the same approach to post-process gusts?



Neighbourhood processing (combined with an ensemble) provides a much larger ensemble sampling and a probability distribution for each grid-cell:

Proposal for a unified gust diagnostic:

Use neighbourhood processing to generate *pdfs* of 10m windspeed $p(v_{10})$ and shear-driven gust diagnostic *p(g)* from the model or ensemble:



Shear-driven gusts

In strong winds shear-driven turbulent gusts will typically be represented by the Mode or Median of *p(g)*: ***M(g)***

(Extreme gusts may be given by the n^{th} percentile of *p(g)*. e.g. g_{95})

Convective gusts

In convection the gusts are represented by the model 10m windspeed in those pixels where convection is resolved, so the typical gust is given by the n^{th} percentile of $p(v_{10})$: ***n^{th} percentile of v_{10}***, denoted v_n

Combined Diagnostic

At any grid-point, the highest typical gust will be either a shear-driven gust or a convective gust and may be considered to be the higher of the two:

Gust = max(***M(g)***, v_n)

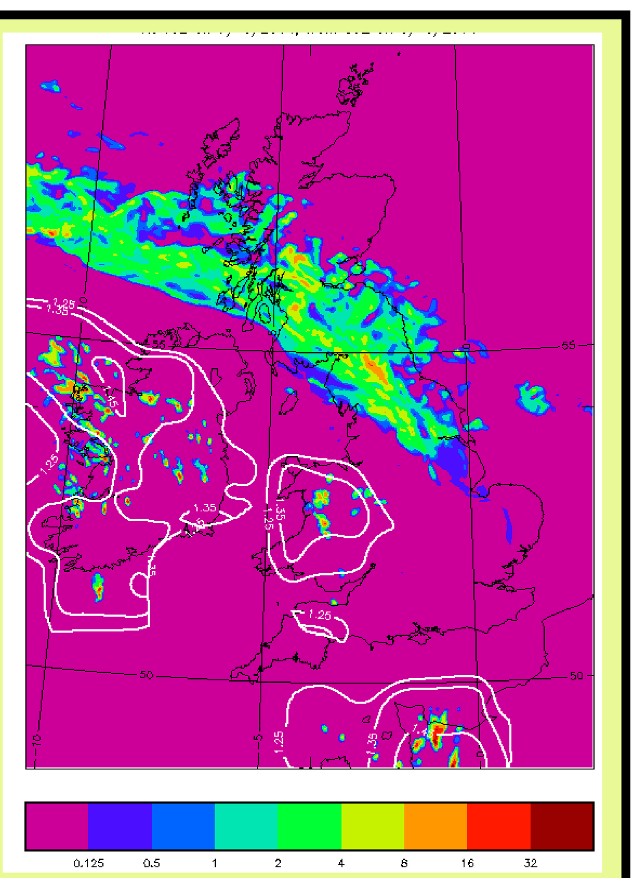
Care needs to be taken with neighbourhood processing not to incorporate inappropriate neighbouring grid-points e.g. using grid-points from mountain tops for a neighbouring valley location, or sea-points over land. Any use of a neighbourhood approach will need to be combined with effective masking in a practical application.

This idea has not yet been trialled in practice and is proposed to stimulate discussion and invite testing. There is scope for tuning in choice of Median or Mode as ***M(g)*** and the percentile **n** (eg 95^{th} or 99^{th}).

This idea also makes the assumption that the partially resolved convective gusts are quantitatively realistic – this assumption is probably false, but may be calibrated by appropriate choice of the percentile **n.**

Diagnosis of Active Convection

Identification of active convection within model fields could also offer the scope for using a specific gust diagnostic within a region. A simple algorithm based on rainfall intensity gradients may be used to differentiate between convective and stratiform rainfall. White lines in the plot (right) indicate regions of convective activity. Where convection is active the peak gusts could be estimated based on a neighbourhood approach using the 10m windspeed model fields. Where there is no convection diagnosed we could then revert to the standard gust diagnostic based on shear-driven turbulence.



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