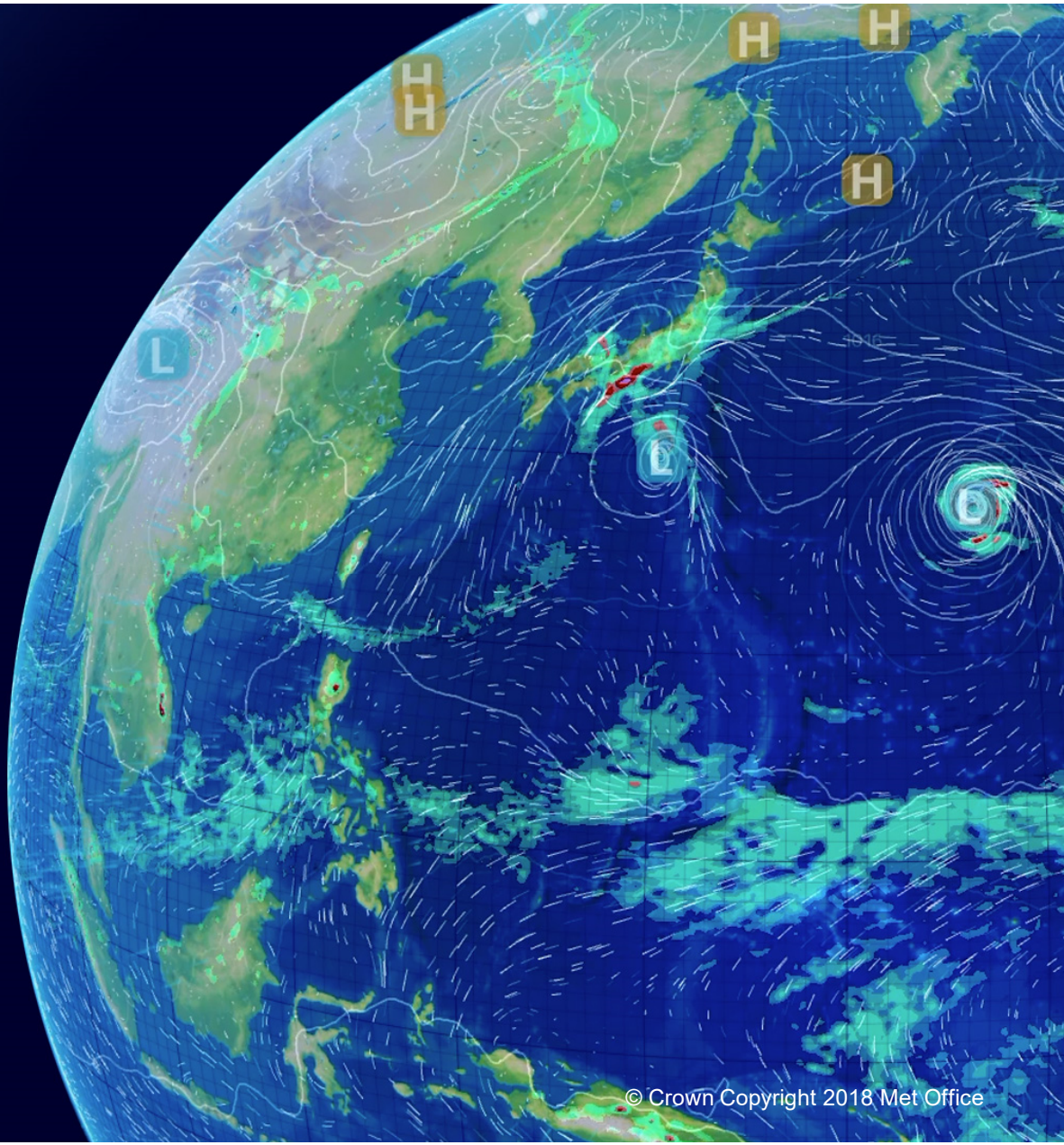
IMPROVER

Integrated Model post-PROcessing and VERification

EWGLAM 2019

Fiona Rust & Nigel Roberts

Paul Abernethy, Ben Ayliffe, Mark Baker, Laurence Beard, Anna Booton, Dan Brierley, Clare Bysouth, Rob Coulson, Ric Crocker, Neil Crosswaite, Gavin Evans, Ben Fitzpatrick, Jonathan Flowerdew, Tom Gale, Roger Harbord, Aaron Hopkinson, Kathryn Howard, Teresa Hughes, Simon Jackson, Caroline Jones, Stephen Moseley, Ken Mylne, Tim Pillinger, Fiona Rust, Caroline Sandford, Tomasz Trzeciak, Mark Worsfold, Bruce Wright.



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Introduction and strategy for IMPROVER

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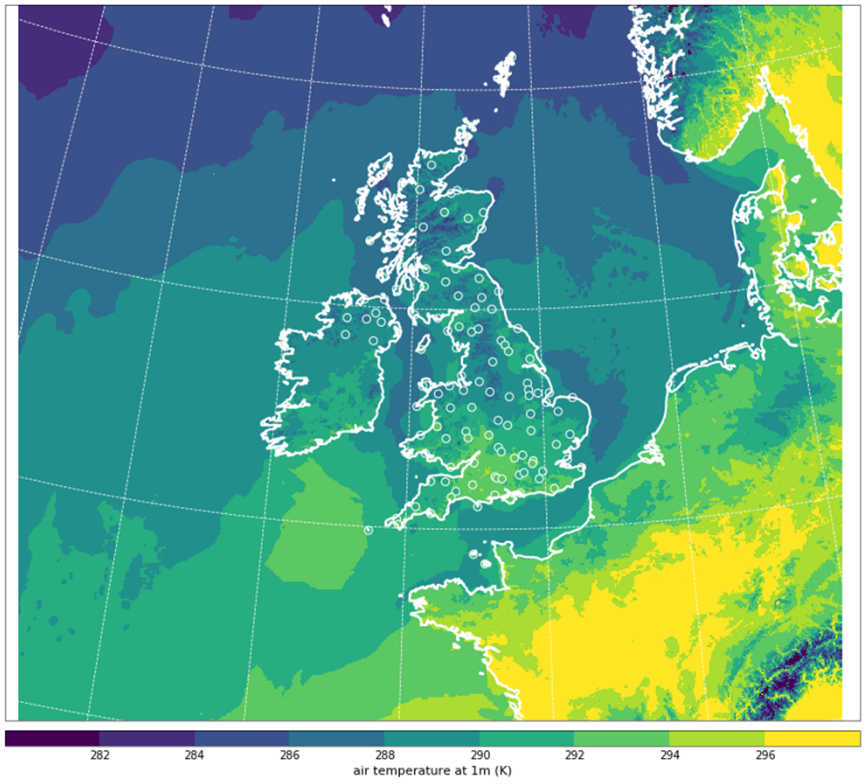
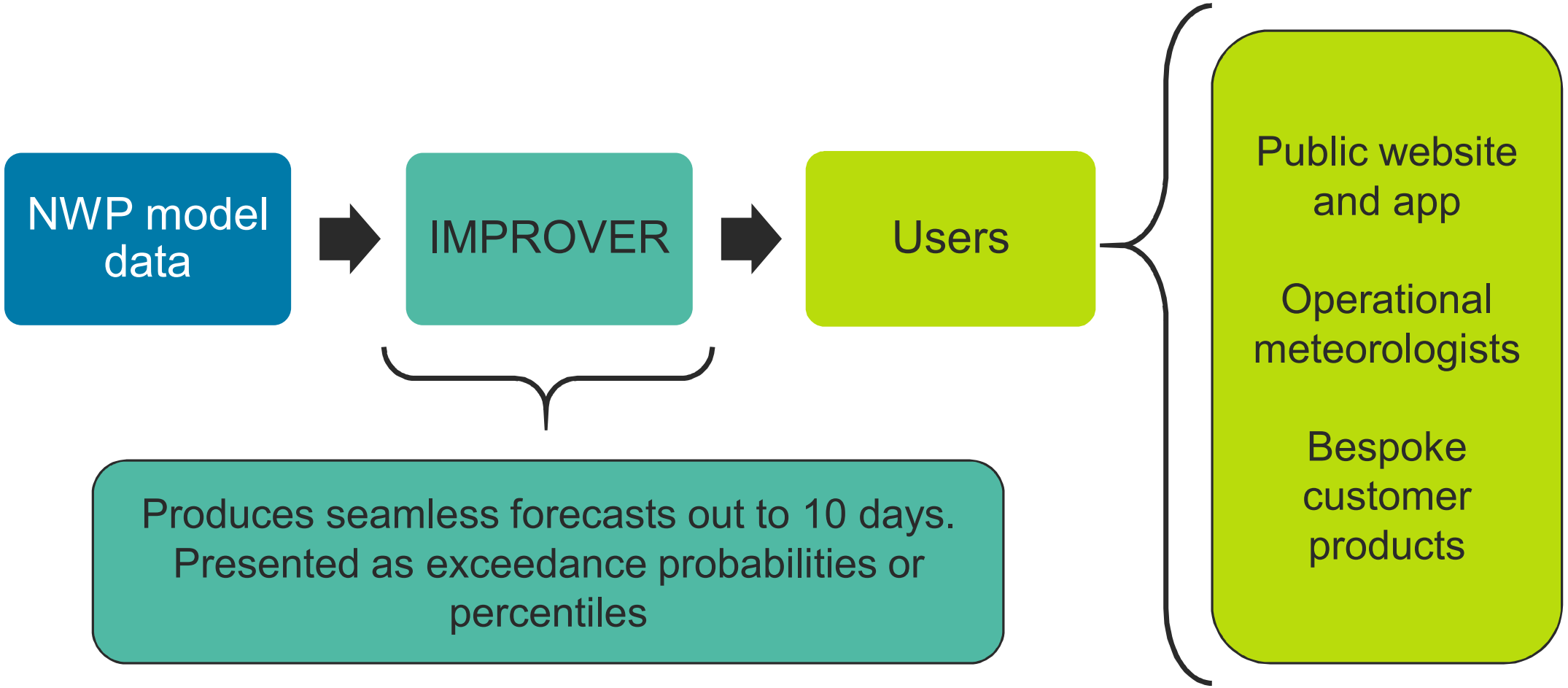
Key principles

- Process each variable separately on the grid.
- Extract site-specific forecasts at the end of the processing chain
- Allows for time-lagging and blending between models/ensembles.
- A modular software framework following modern professional software development practices.



Air temperature at 1m (K)


NWP model data
IMPROVER
Users
Public website and app
Operational meteorologists
Bespoke customer products
Produces seamless forecasts out to 10 days. Presented as exceedance probabilities or percentiles

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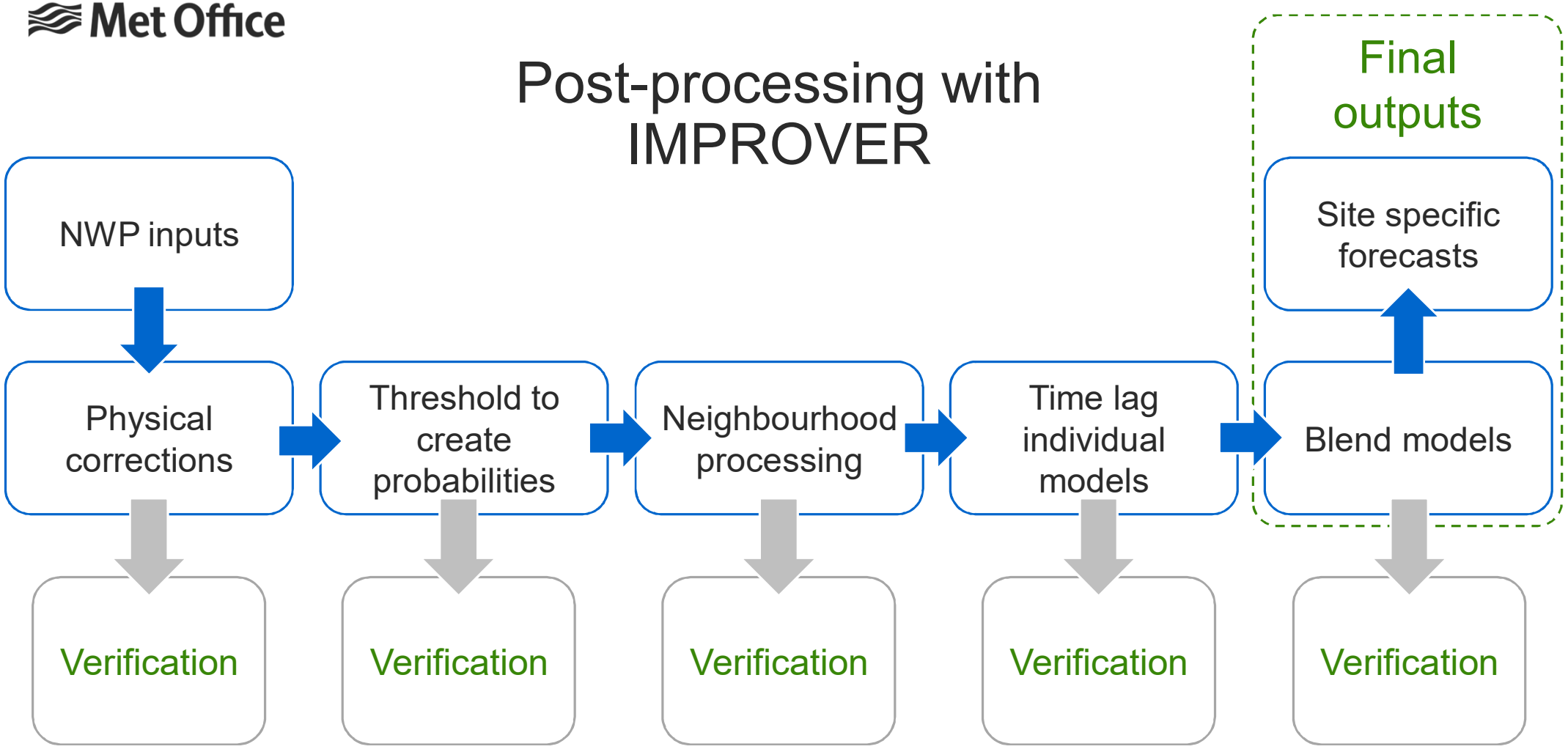
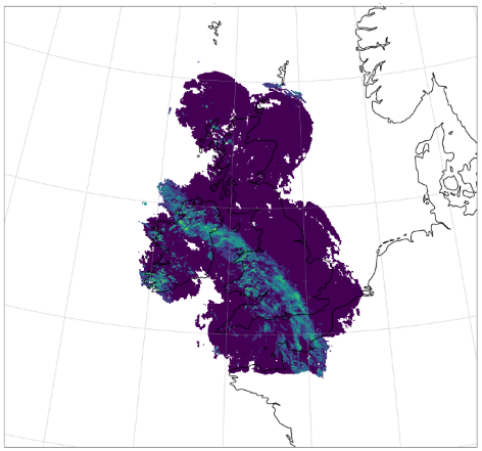
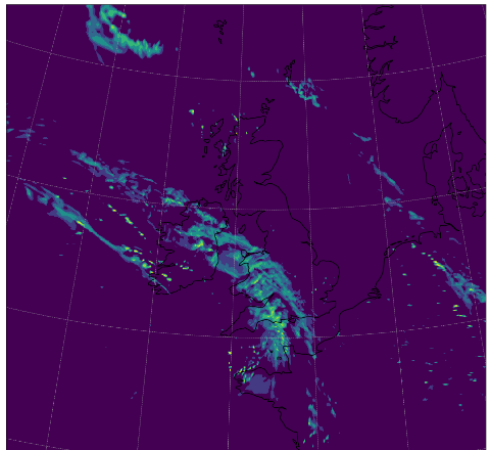
Post-processing with IMPROVER



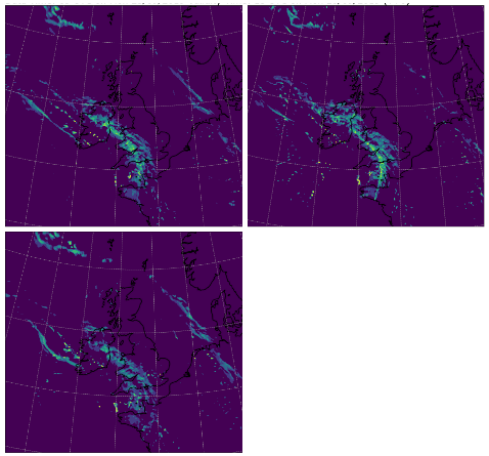
Input models



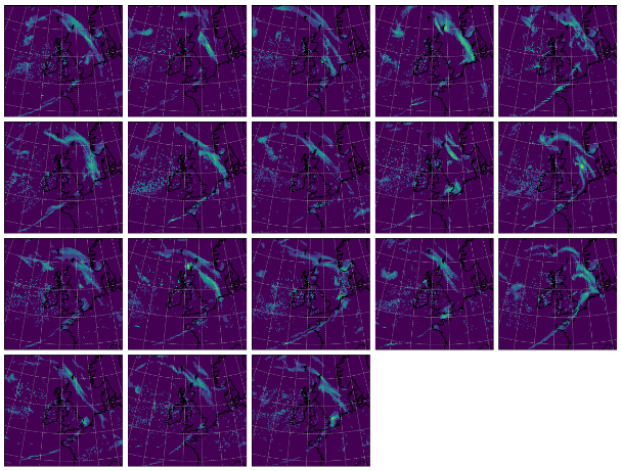
Nowcast
Out to 6 hours
Available every 15 minutes



UKV
Out to 12 hours
Available every hour



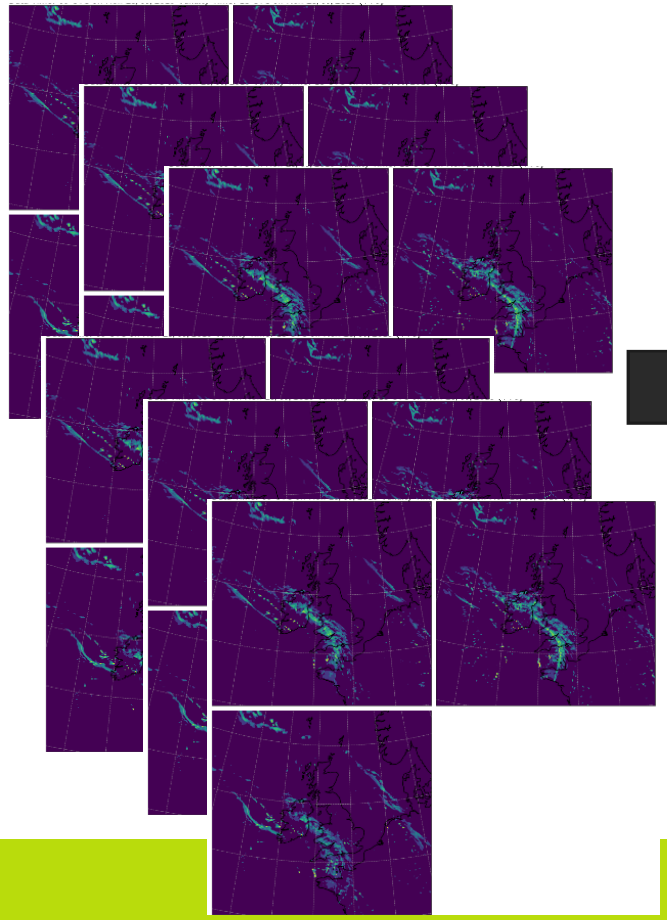
MOGREPS-UK
Out to 5 days
Available every hour
3 members



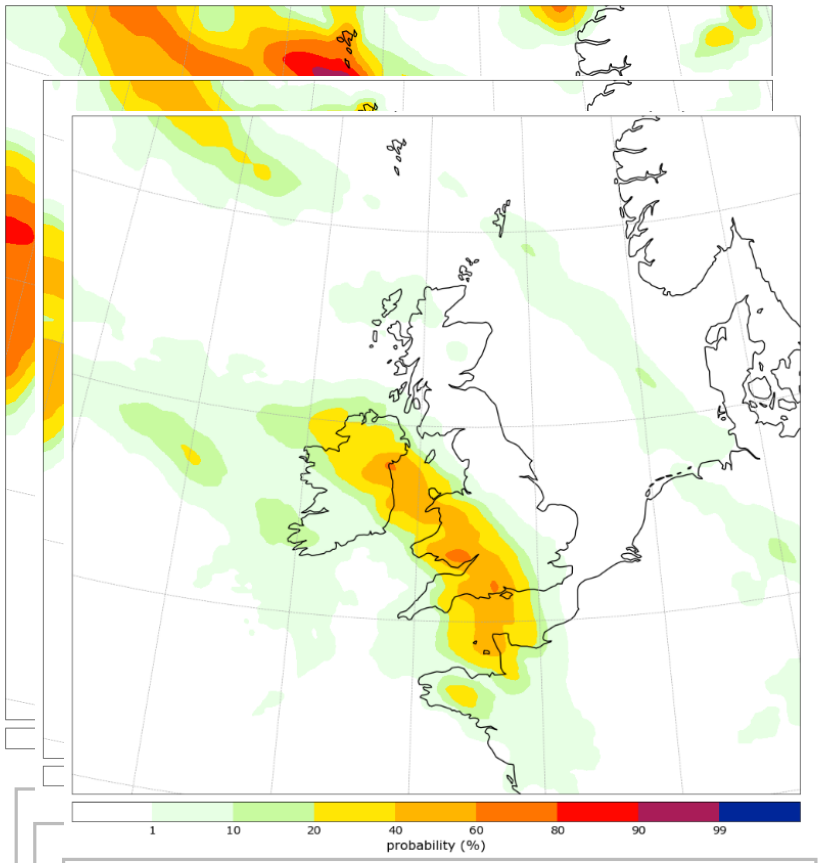
MOGREPS-G
Out to 7 days
Available every 6 hours
18 members

Process probabilities

6 cycles of MOGREPS-UK

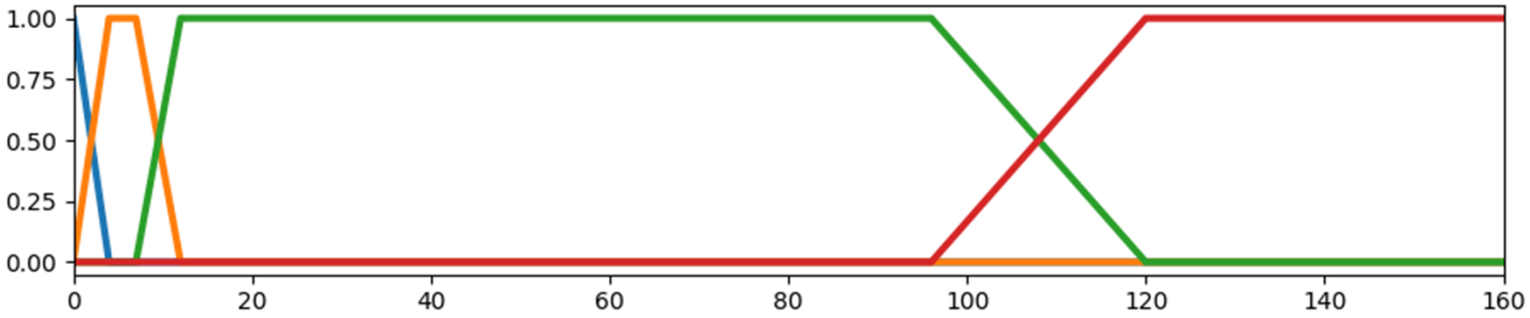


Processing probabilities:
Spatial uncertainty
Blend members



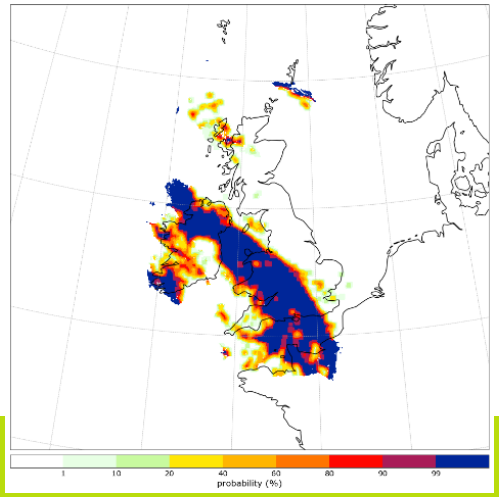
Probability precipitation rate is above 2 mm/hr

Blend models

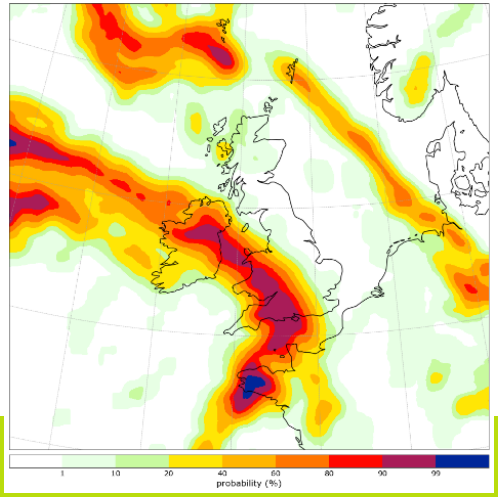


Nowcast
UKV
MOGREPS-UK
MOGREPS-G

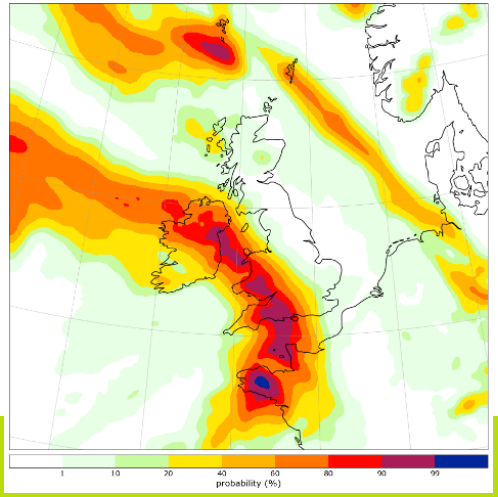
Nowcast



UKV



MOGREPS-UK

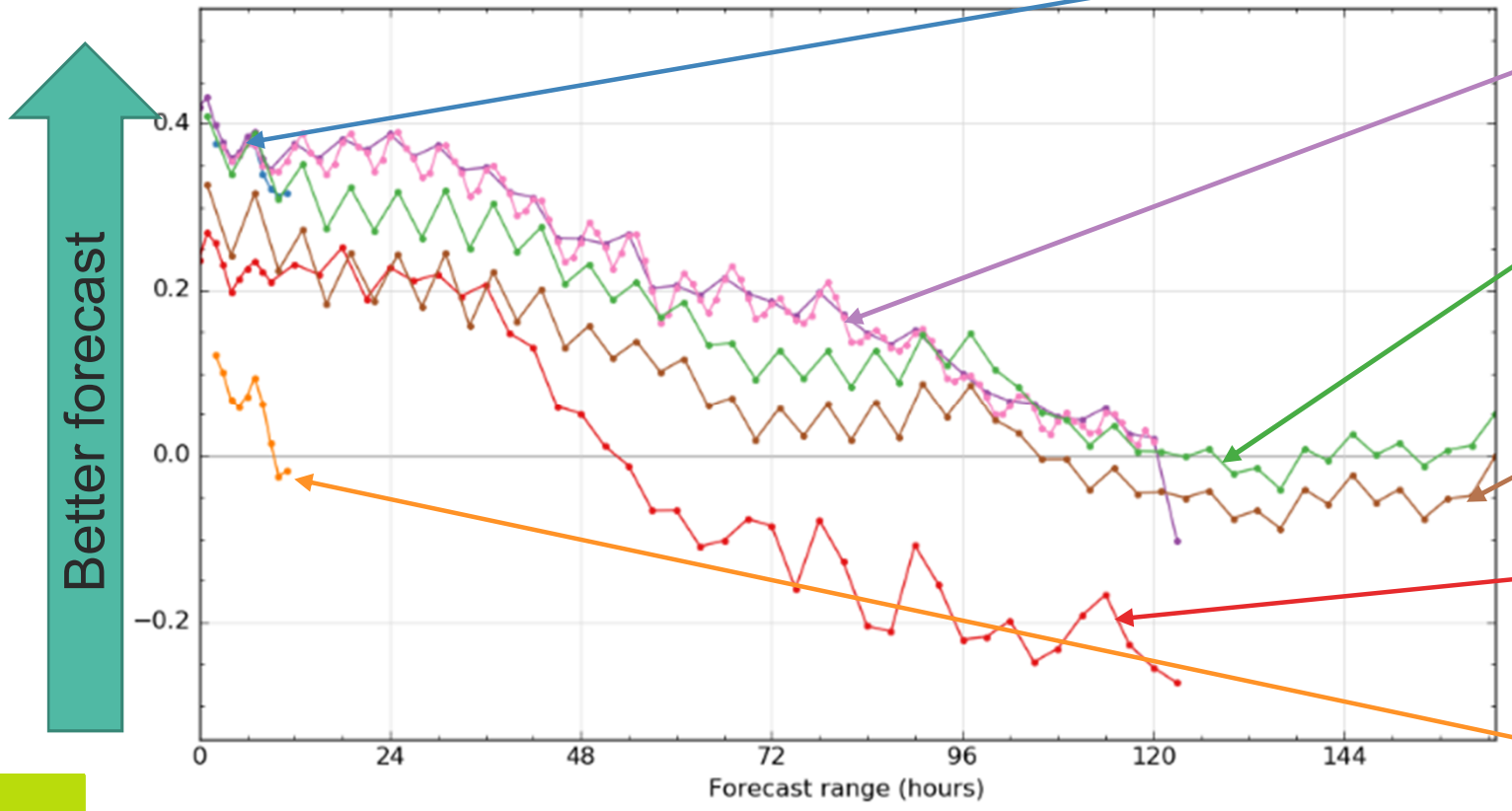


Blend each threshold of the distribution

Convert to percentiles or realizations if needed

Verification at every stage

Ranked Probability Skill Score for 3 hour precipitation accumulation, calculated for January 2019



Post-processed and cycle blended UKV

Post-processed and cycle blended MOGREPS-UK

Post-processed MOGREPS-G

MOGREPS-G raw forecast (18 members)

MOGREPS-UK raw forecast (3 members)

UKV raw forecast

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Precipitation types

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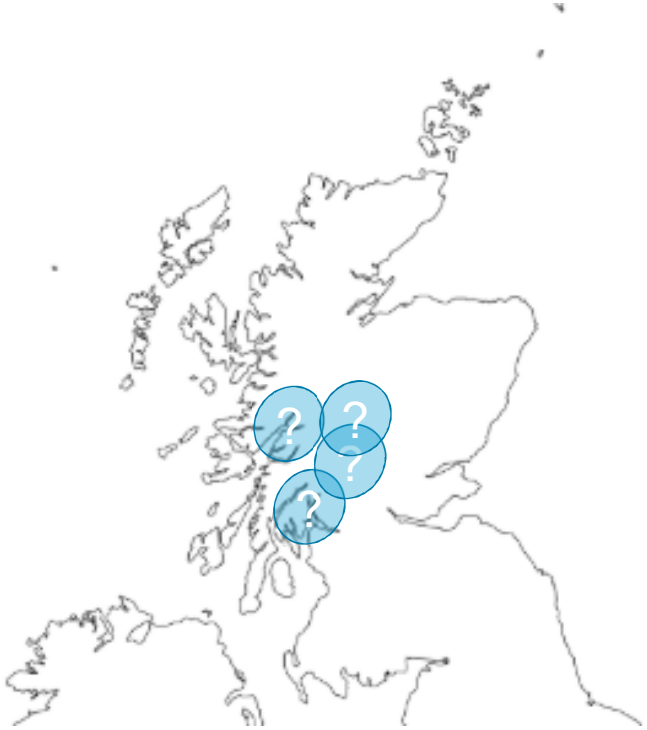
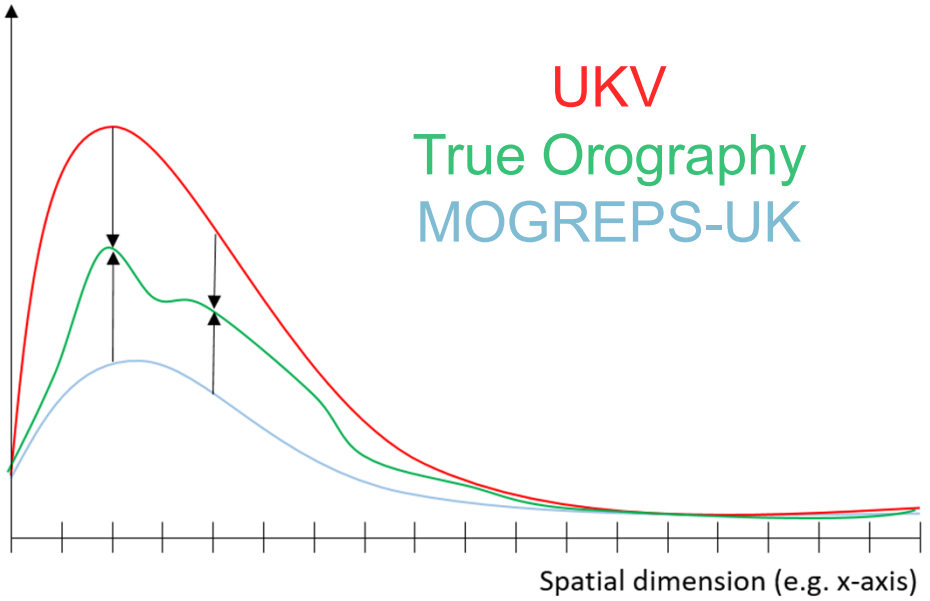
Justification





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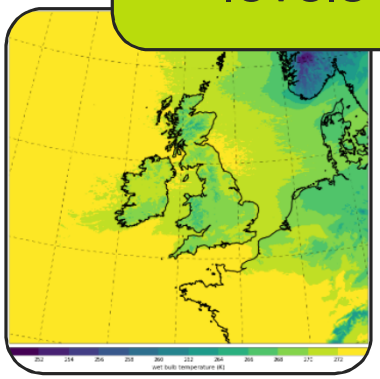
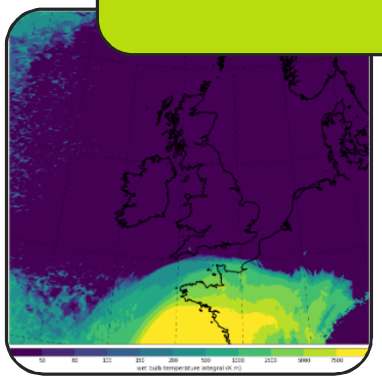
Snow falling level process

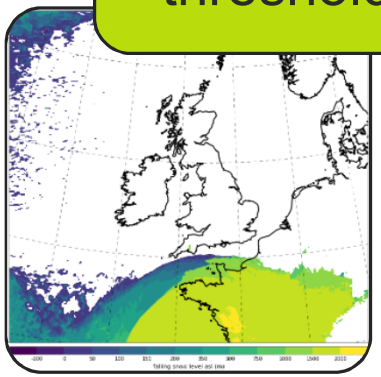
Calculate wet bulb temperature on height levels



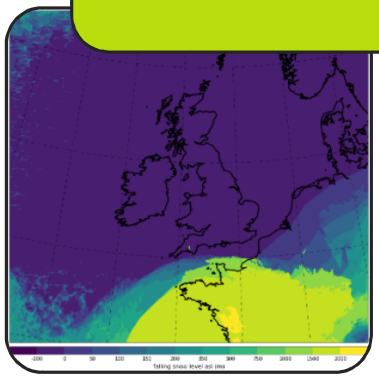
Integrate down to the surface



Find the height that the integral crosses a threshold



Fill in missing data



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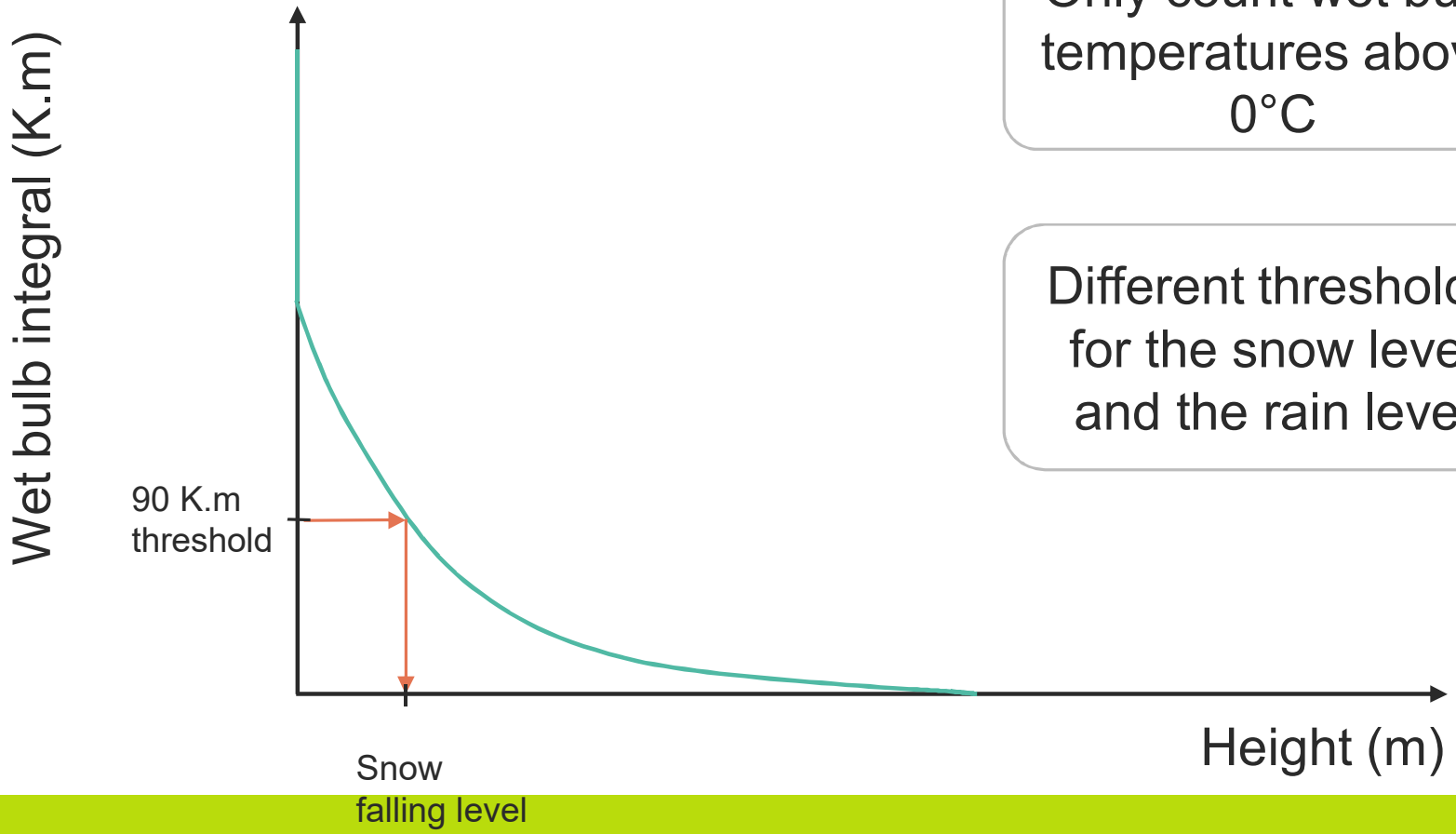
Snow falling level

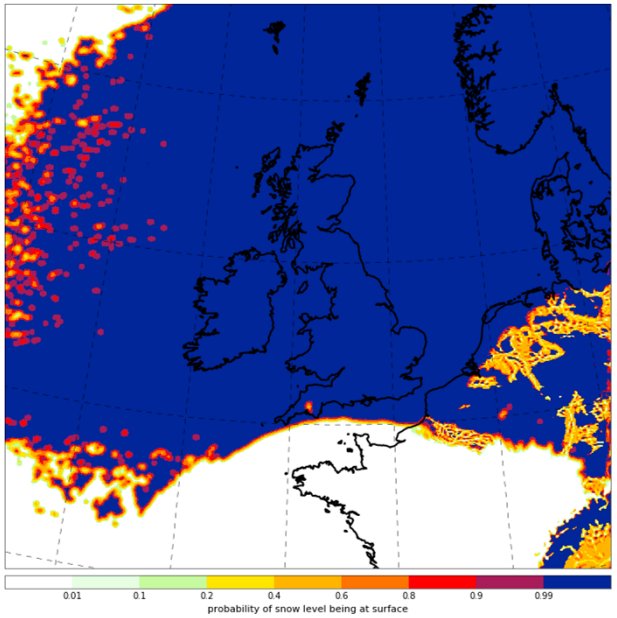


Only count wet bulb temperatures above 0°C

Different thresholds for the snow level and the rain level

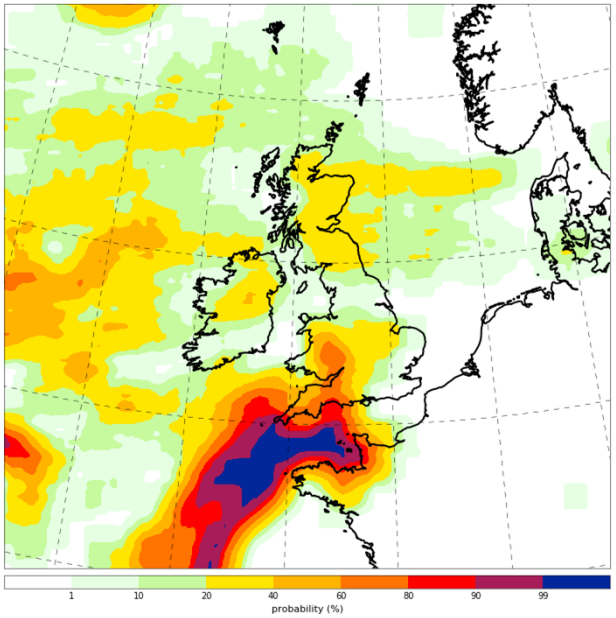
Multiply with probability of precipitation.

Probability of snow falling level being at the surface



x

Probability of precipitation rate (0.03mm threshold)



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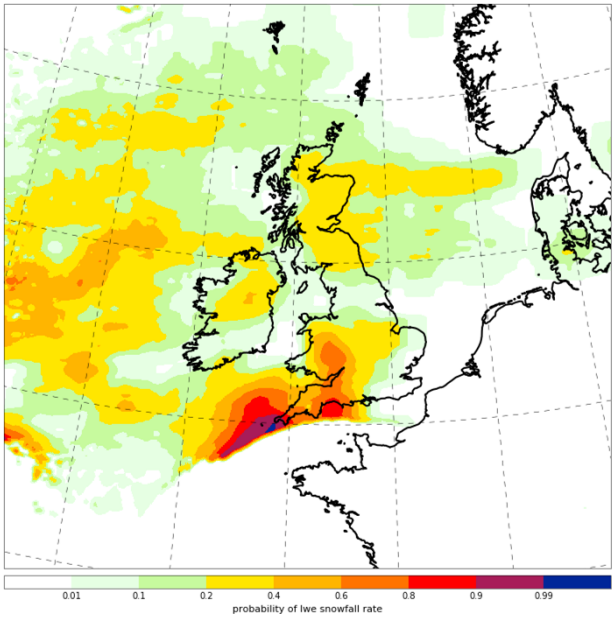
Final probability of snow rate at 0.03mm threshold



Current work

Freezing rain

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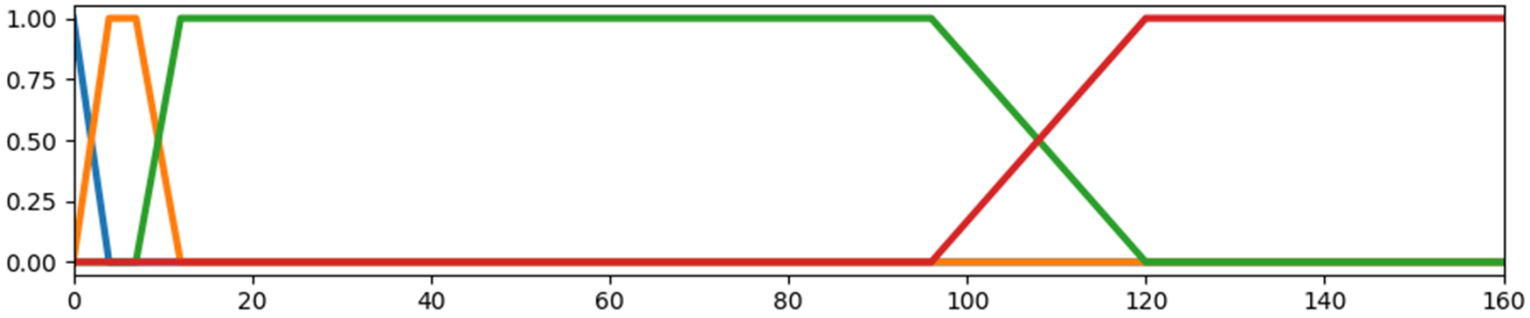
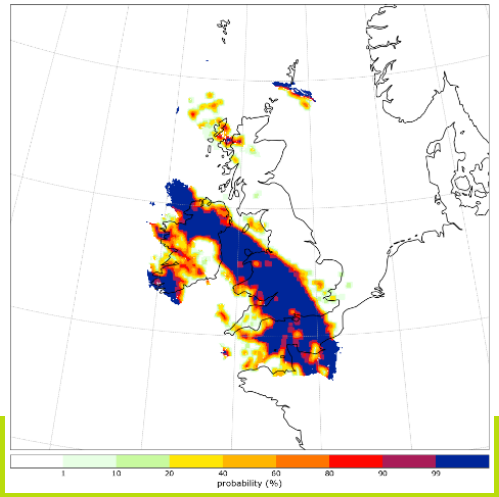
Current and future challenges

Blend models

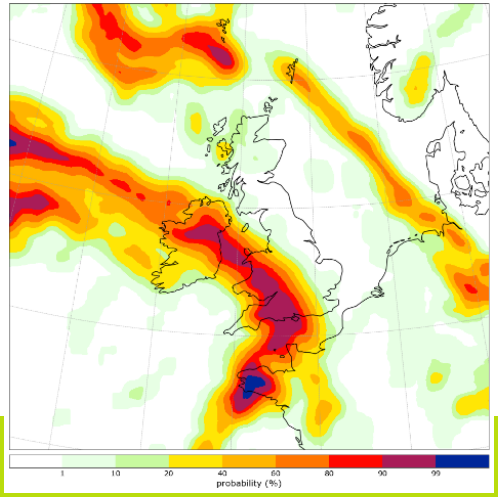


Nowcast
UKV
MOGREPS-UK
MOGREPS-G

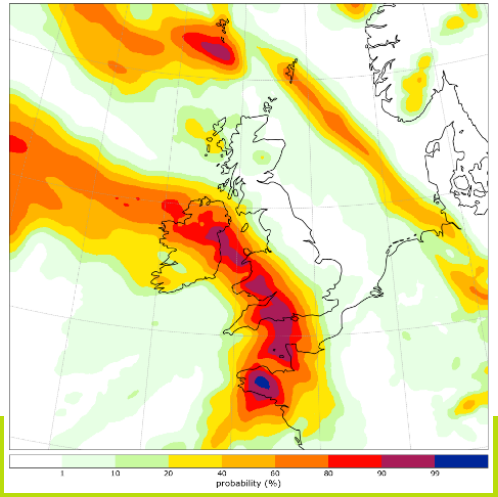
Nowcast



UKV



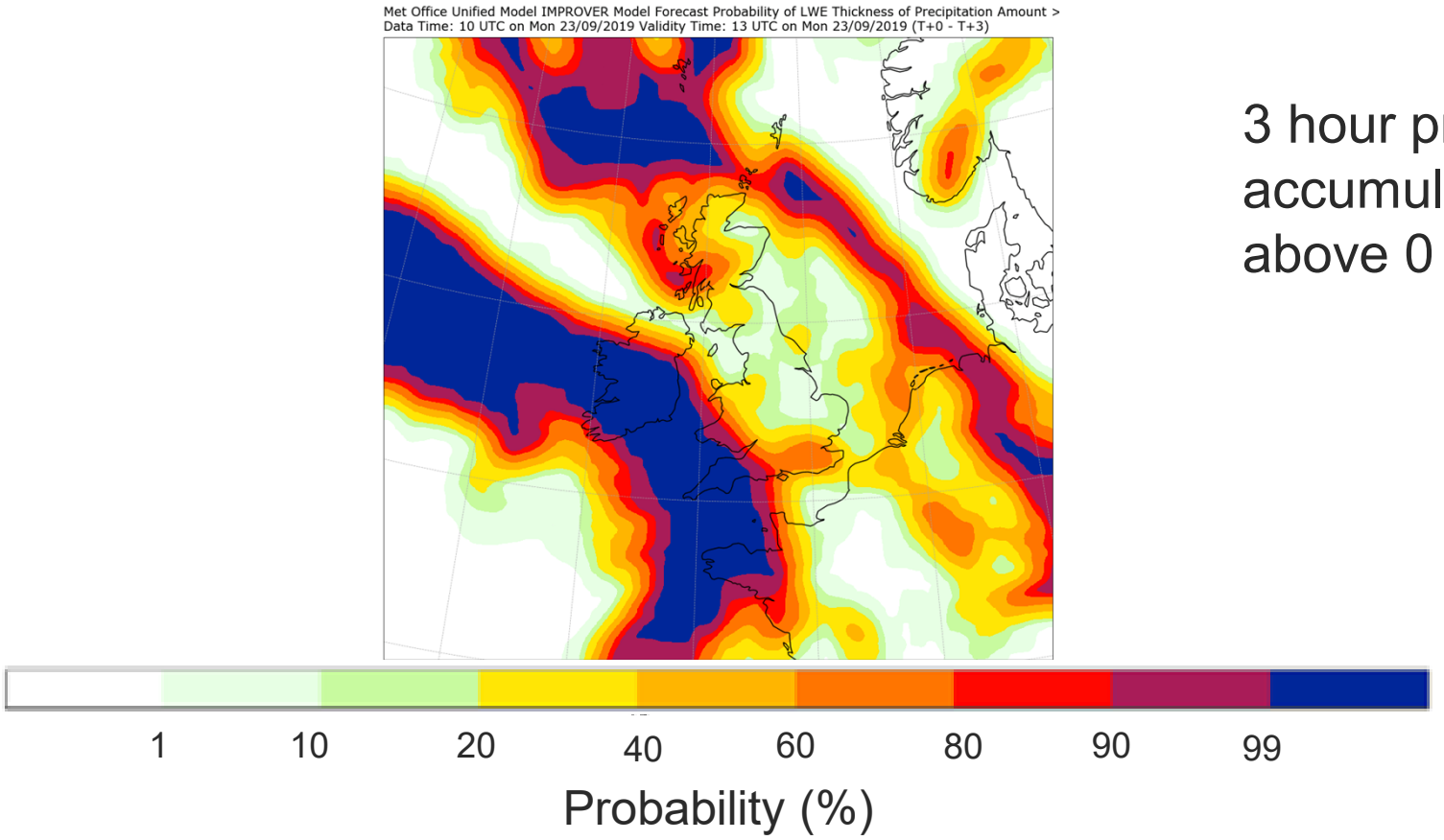
MOGREPS-UK



Blend each threshold of the distribution

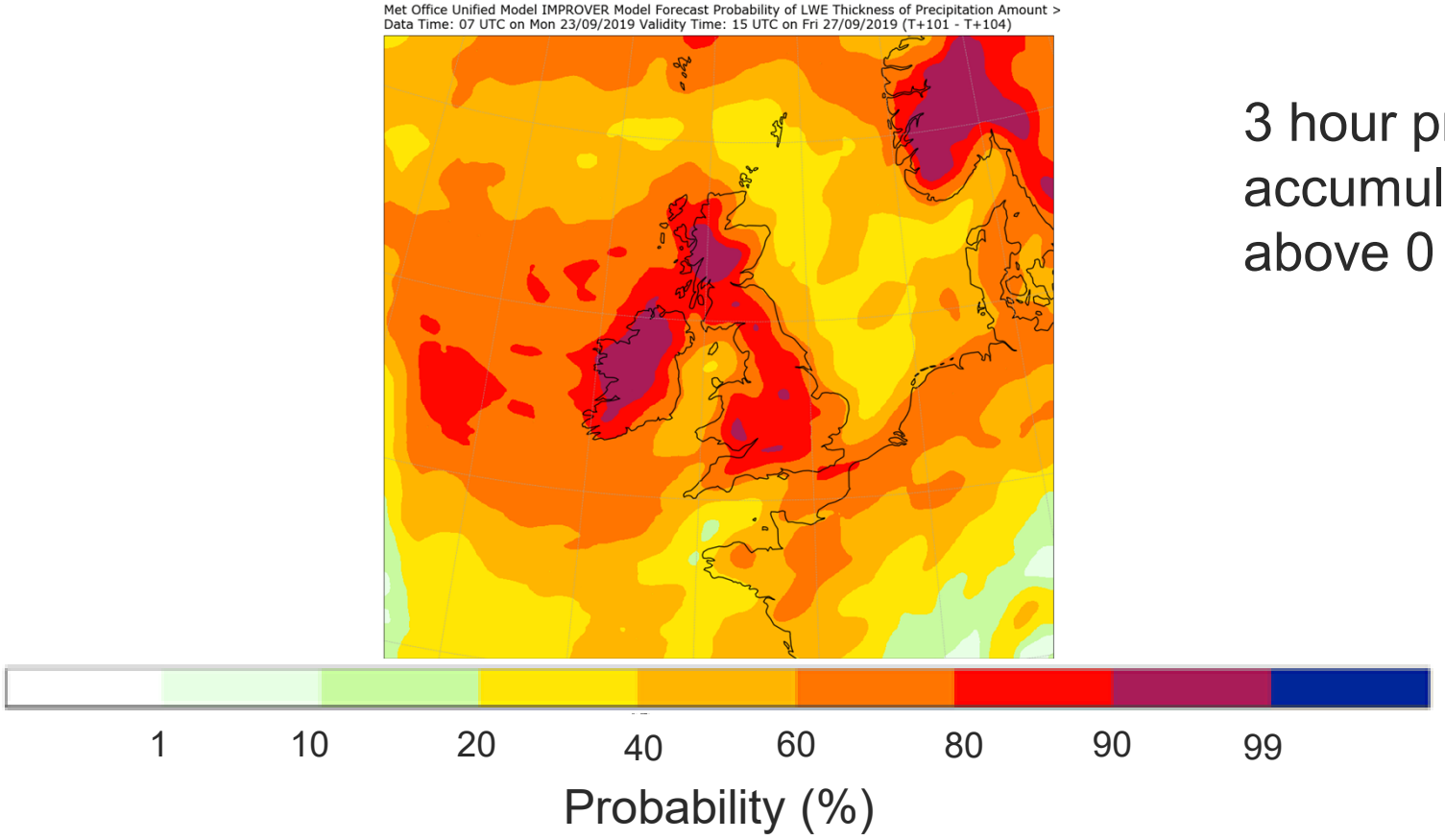
Convert to percentiles or realizations if needed

A blended forecast example



3 hour precipitation accumulation above 0 mm

A blended forecast example



3 hour precipitation accumulation above 0 mm

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How do we fix this?

Apply statistical post-processing methods.

- Calibrate each model against the same truth.
- Should improve reliability.
- Remove threshold dependent biases so blend should be smoother.
- Apply to many parameters (not just precipitation).

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Statistical post-processing methods

Ensemble model output statistics (EMOS) also known as Non-homogeneous Gaussian Regression (NGR)

Ready to test, but not suitable for all variables

Reliability calibration

Improves reliability and acts on each threshold

Quantile mapping

Corrects today's forecast based on historic forecast quantiles

Machine learning

Possible to investigate in the future

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Statistical post-processing methods

Challenges:

- Training periods – longer versus shorter, and impact of model upgrades.
- Offline (train once on a large dataset) versus online (continually retrain with new data).
- Technical infrastructure and data volumes.
- Extremes and rare events – we don’t want to artificially constrain them.
- Sources of truth to train against – start with UKV analysis to keep things simple.

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The Vision

Let’s really exploit our convection permitting forecasts – seamless probabilities

Let’s pull out the wealth of information in our models – structures / regimes / storylines

Tailored probabilistic outputs to aid warnings and novel automated outputs

Framework to allow new methods – physical/statistical correction, adaptive methods, ML

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Questions

https://improver.readthedocs.io

fiona.rust@metoffice.gov.uk or nigel.roberts@metoffice.gov.uk

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Products from IMPROVER

Two examples:

- Weather symbols
- Precipitation types

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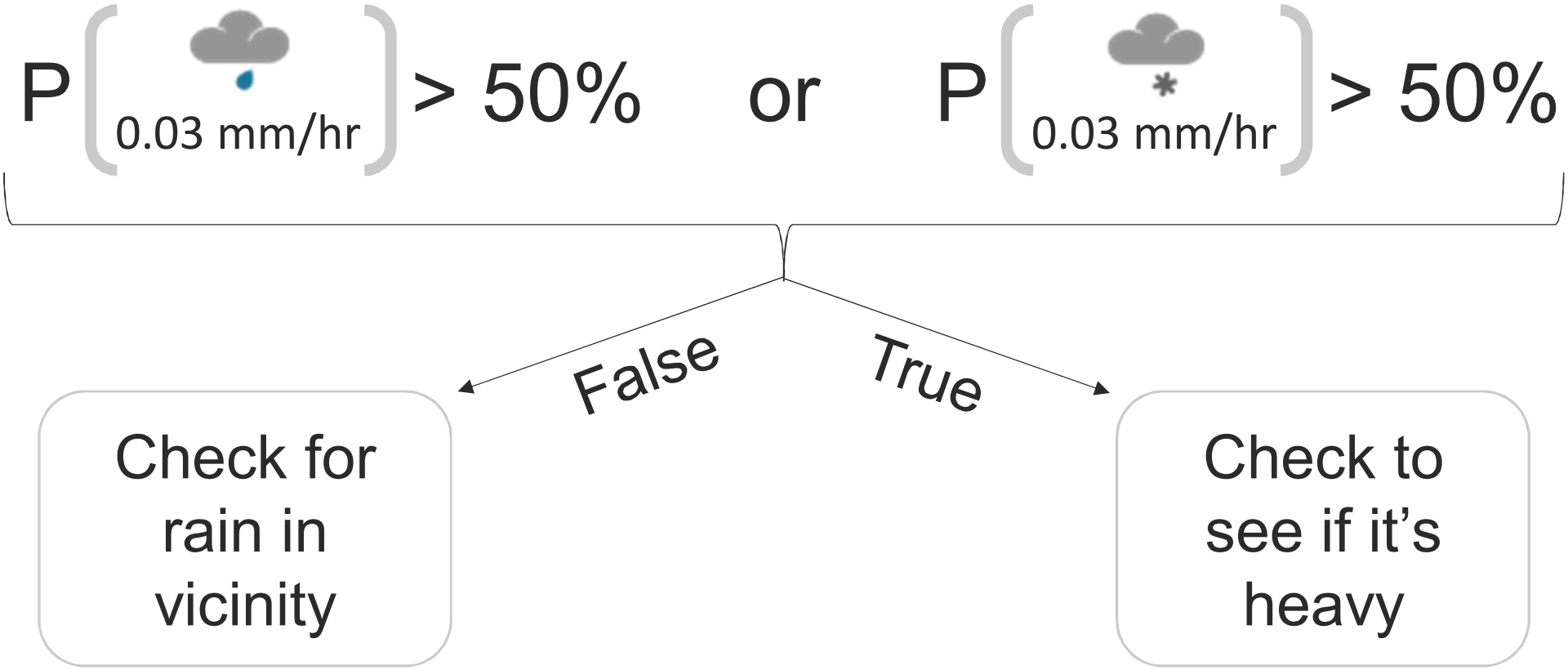
Weather symbols

Weather Symbols

- Widely used and recognised public weather service product
- Production simplified using probabilistic data

A decision tree…



A decision tree…