# Seamless Probabilistic Forecasts from IMPROVER

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StaGE

IMPROVER

IMPROVER is a new post-processing system under development by the Met Office to provide seamless probabilistic forecasts from 15 min to 2 weeks ahead blending different NWP inputs including nowcasts, convective-scale UK deterministic and ensemble forecasts and the ECMWF ENS. (For more details of IMPROVER see the complementary poster by Roberts and Mylne). Forecasts are updated up to every 15 mins to incorporate frequent model update cycles into the blend and present forecasters and users with a single blended forecast picture at all times, incorporating the latest data. IMPROVER also provides comprehensive verification at each stage of processing, both in real-time and trial forecast modes. IMPROVER software is open source and available for other centres to use and contribute to and data are managed on standard grid formats (Global and UK) stored in NetCDF format to facilitate model blending and to decouple end users from multiple model grids. IMPROVER forecast outputs are presented as probability distributions, as probabilities or percentiles depending on the variable, on standard grids or as site extractions. This poster describes the data standardization and presentation with a view to stimulating discussion about wider data sharing and interoperability. The Met Office is already collaborating on IMPROVER development with the Bureau of Meteorology in Australia, and is working closely with ECMWF to enable ECMWF data to be incorporated into IMPROVER - there is great potential for collaboration across Europe and beyond on harmonization of data formats to ease data sharing and facilitate greater use of multi-model ensemble blending which has been consistently shown to provide improved probabilistic forecasts.
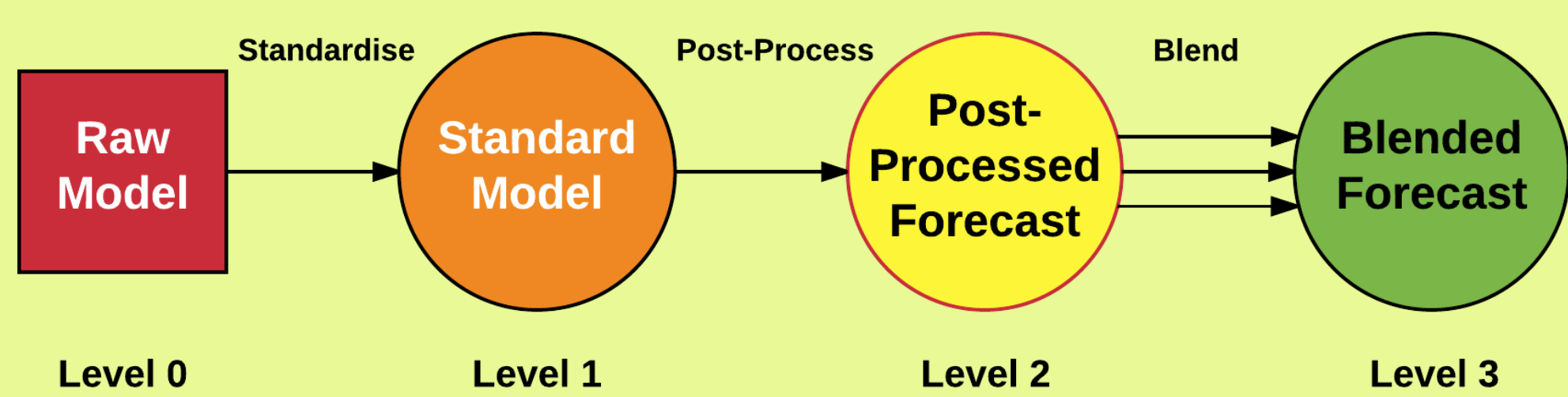


**Data Standardisation**: we define 4 levels of data processing, with increasing levels of separation from the model and of forecast refinement.
• Level 0 data is exactly as output from the model;
• Level 1 puts individual model forecasts and ensemble members into a standard format enabling users to access different models in exactly the same way;
• Level 2 applies post-processing to individual models or ensembles;
• Level 3 provides a final blended forecast.
Only Levels 1 and 3 are exposed to users (through the Service Hub).
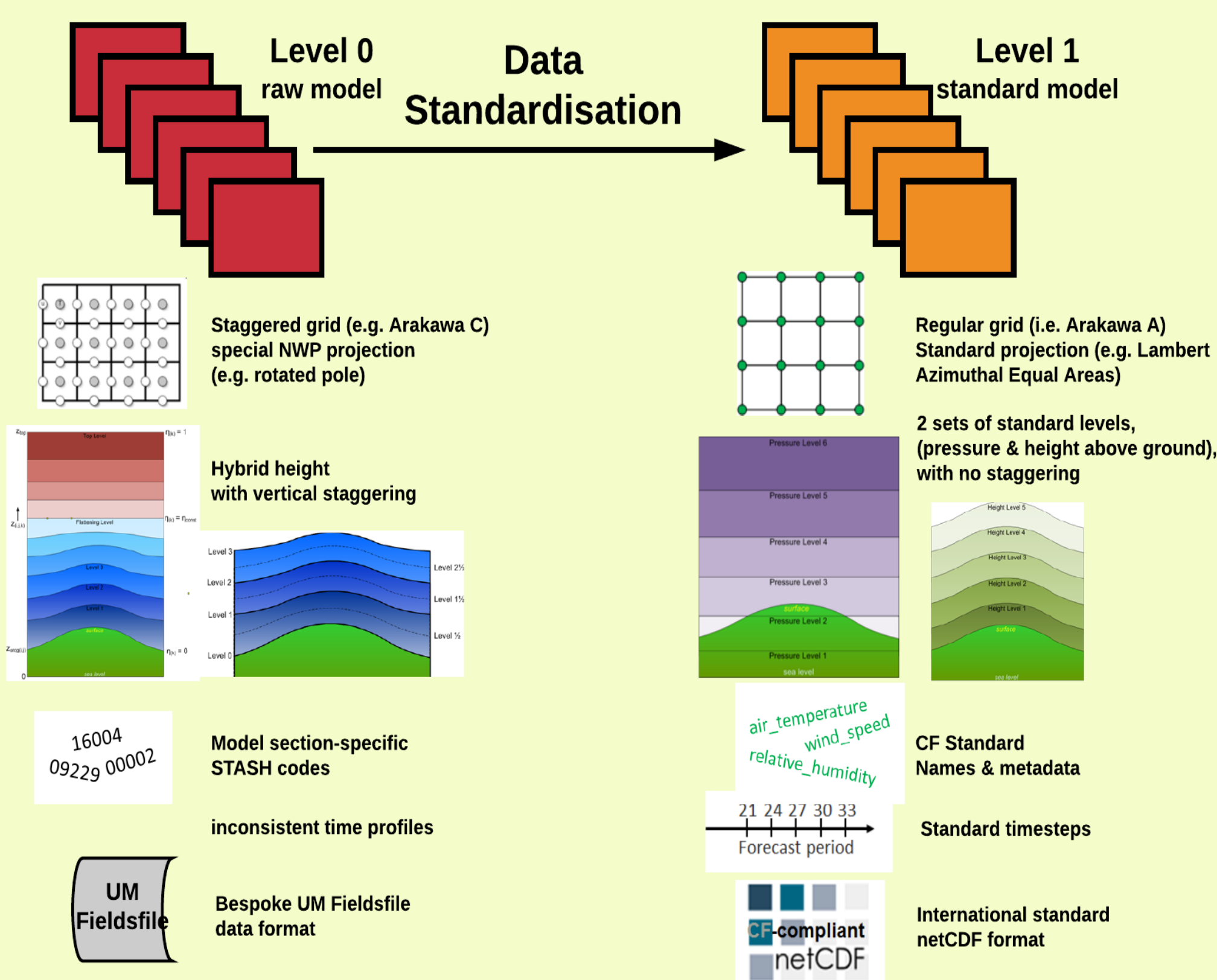Level 0 to Level 1 conversion is provided by StaGE;
Level 1 to Level 3 is provided by IMPROVER; Level 2 is an internal step within IMPROVER.
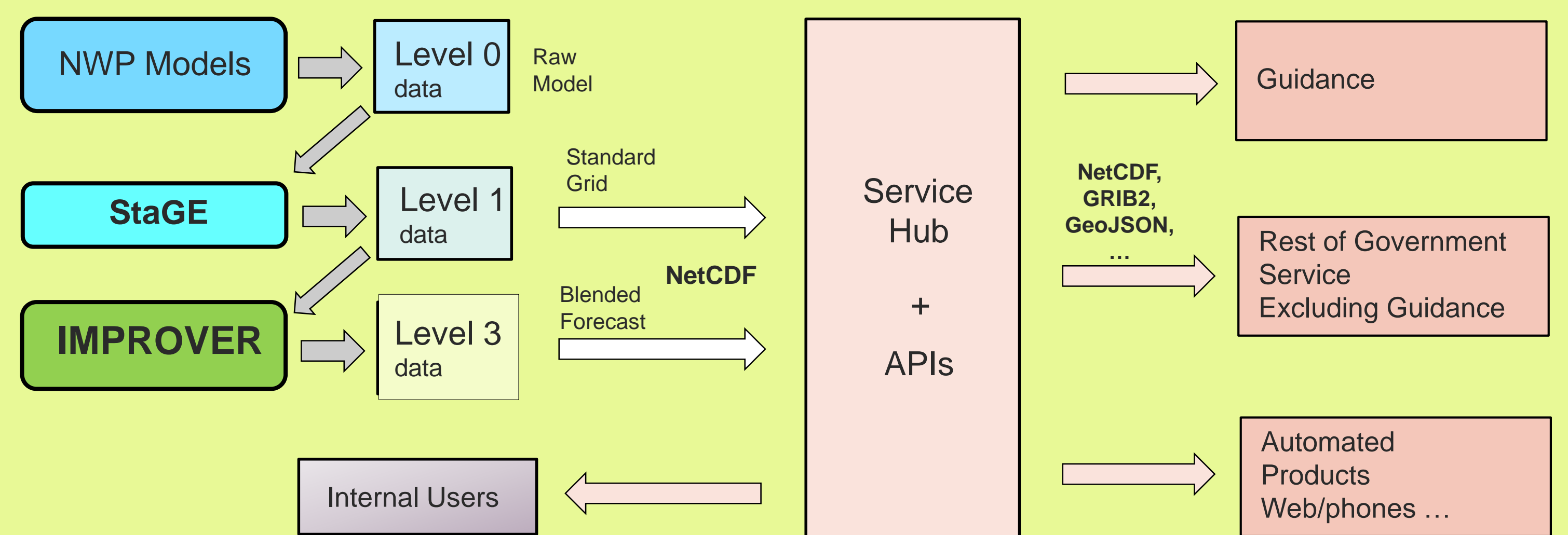
Service Hub is our Cloud-based data-store which serves up Level 1&3 data for all users via APIs.



## StaGE — Standard Gridding Engine

StaGE is built on the Python Iris library and runs operationally on the HPC to convert the primary Met Office NWP systems to Level 1 and route them to the cloud-based Service Hub:
• **10km Global deterministic model** – four forecasts per day to 7 days
• **20km MOGREPS-G global ensemble** – 18 Members four times per day to 8 days
• **1.5km convective-scale UK model** – 8 forecasts per day to 2 days; 16 forecasts per day to 12h
• **2.2km MOGREPS-UK ensemble** – 18-member time-lagged ensemble to 5 days, updated hourly with 3 new members.

StaGE was developed to read standard Met Office Unified Model output formats (UM Fieldsfile) but work is being adapted to ingest ECMWF ENS data in GRIB2 format to enable IMPROVER to extend to two weeks and provide multi-model ensemble blending in week 1. Iris software facilitates adaptation to other data formats.

The Met Office is currently using 3 standard grids:
• **10km Global** – used for Global deterministic model
• **20km global ensemble grid –** global ensembles
• **2km UK grid** – all UK models including nowcasts
StaGE is easily configured to produce other standard grids as required.

We are keen to explore the development of new global standards to facilitate the exchange of NWP data for multi-model ensemble creation and blending, as done by IMPROVER.

## Post-processing with IMPROVER
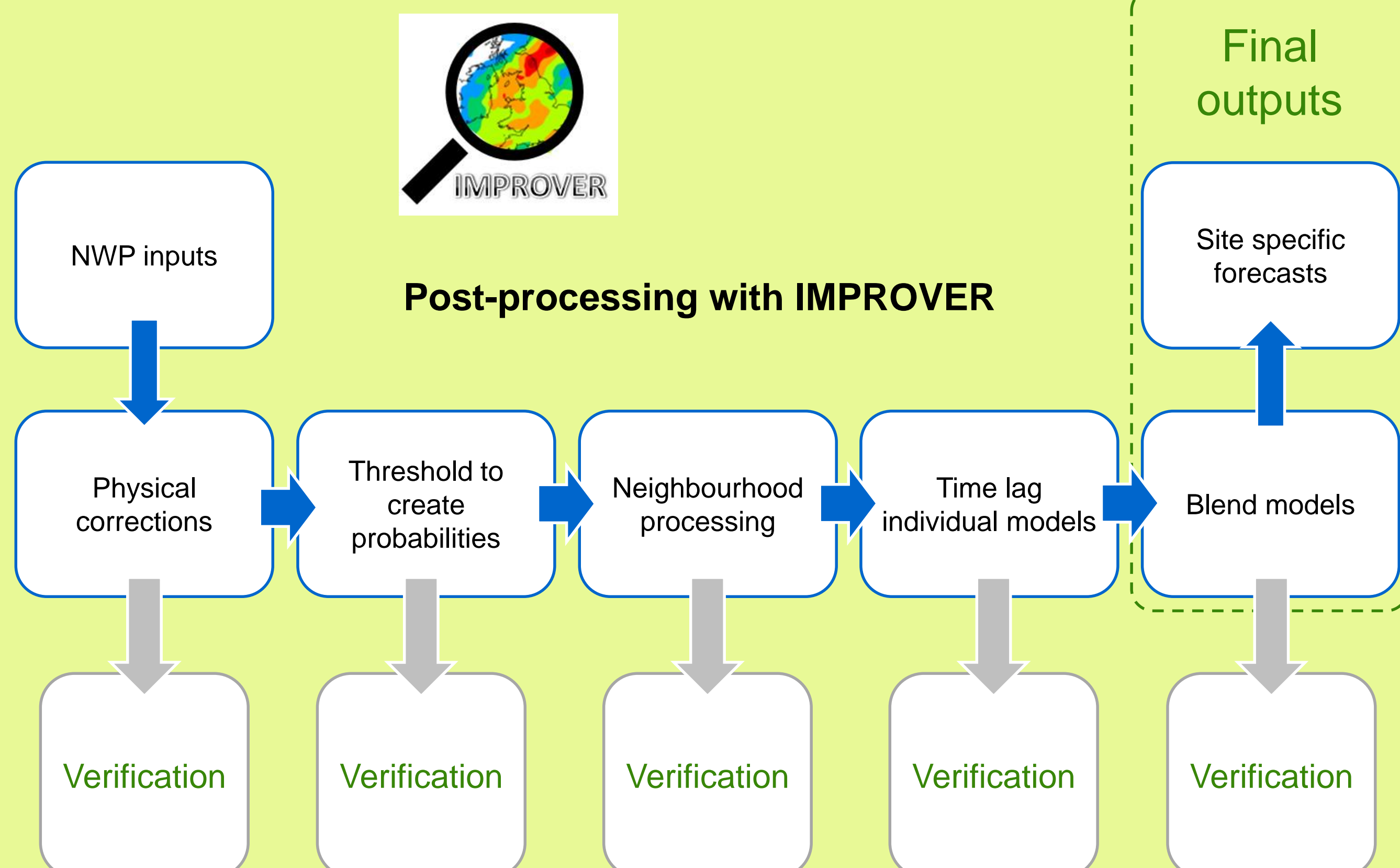


Like StaGE, IMPROVER is also built on Python Iris and runs within ROSE/Cylc suites to generate updated blended forecasts up to every 15 mins.

IMPROVER is designed to run in both real-time operational mode and in trials for testing science upgrades.

A key feature of IMPROVER is verification at every step, enabling the benefit of each step of processing to be measured. Verification is implemented using the Met Office VER and VerPy system. The plot on the right illustrates an example of verification of multiple stages of processing from the winter 2019 IMPROVER Alpha release trial, demonstrating the capability to compare performance of processing stages.

IMPROVER outputs are probability distributions, from which deterministic forecasts can also be extracted. Probabilities may be presented as:
• percentiles,
• probabilities of exceeding thresholds, or
• ensemble members.

All processing is done on the Standard Grids – both Global 20km and UK 2km IMPROVER Alpha-release suites are now running in real-time demonstration. Site forecasts are extracted from the grids at the end of the processing chain.

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IMPROVER code is open source and can be found at github.com/metoppv/improver with documentation at improver.readthedocs.io/en/latest.