Met Office

Processing ECMWF Ensemble Data for use in Met Office Systems

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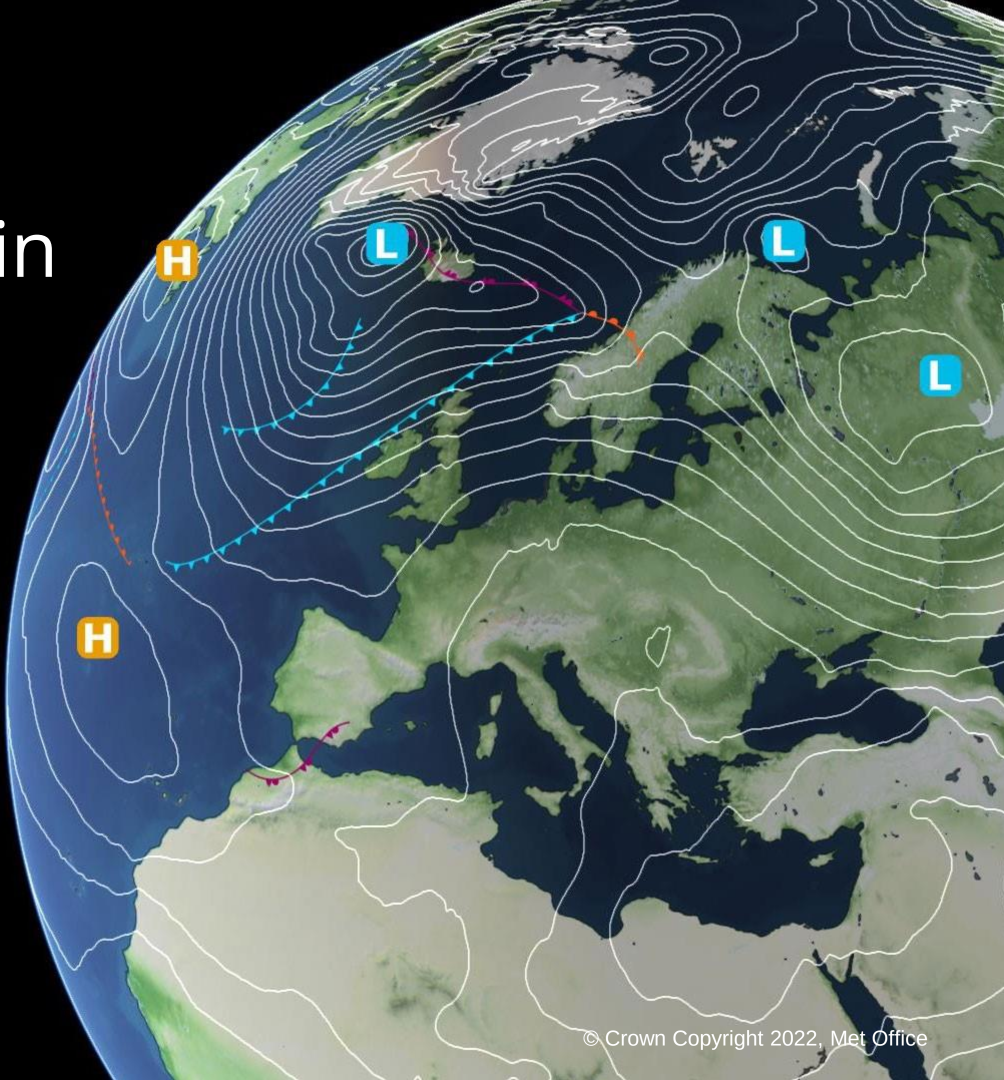
Verification, Impacts, and Post-Processing

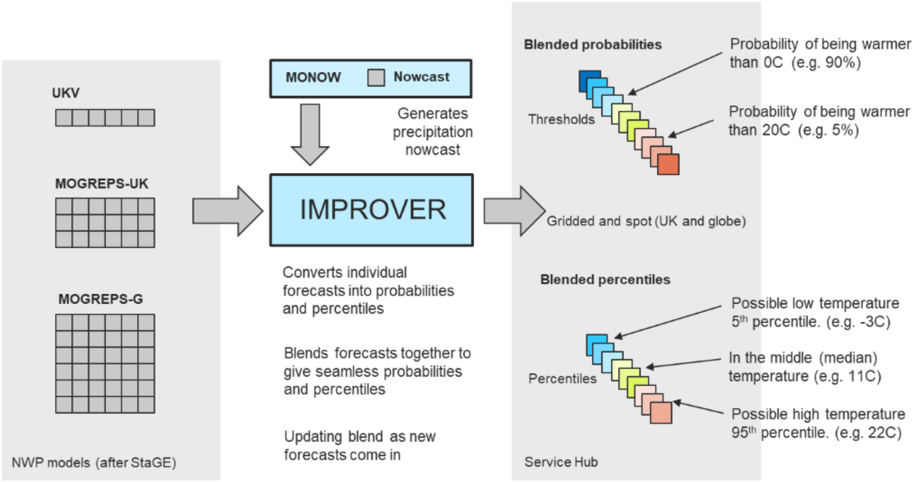


Outline

- Why do we want to utilise ECMWF ensemble data in the Met Office?
- Fitting ECMWF data into Met Office workflows; aims and issues.
- The software developed to solve these problems: StaGE.
- Next steps utilising ECMWF data in Met Office systems.

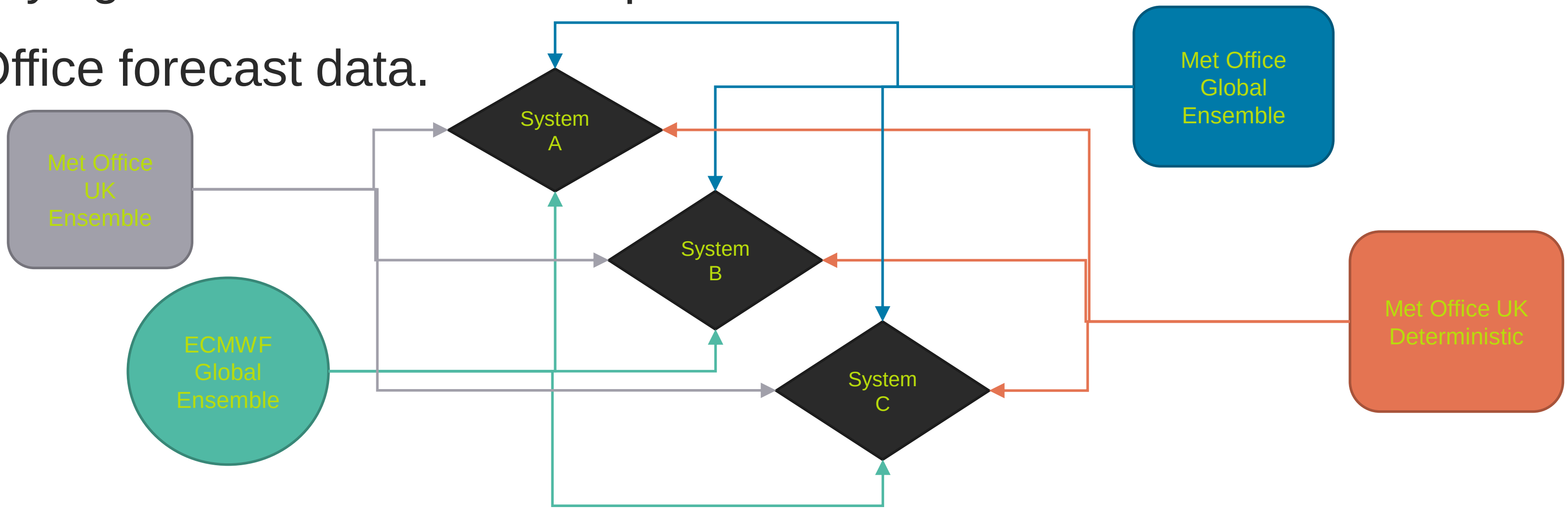
Why do we want to utilise ECMWF ensemble data in the Met Office?

- Improving blended probabilistic forecast offering; forecast skill and forecast period.



Why do we want to utilise ECMWF ensemble data in the Met Office?

- Simplifying combination and comparison of ECMWF forecast data with Met Office forecast data.



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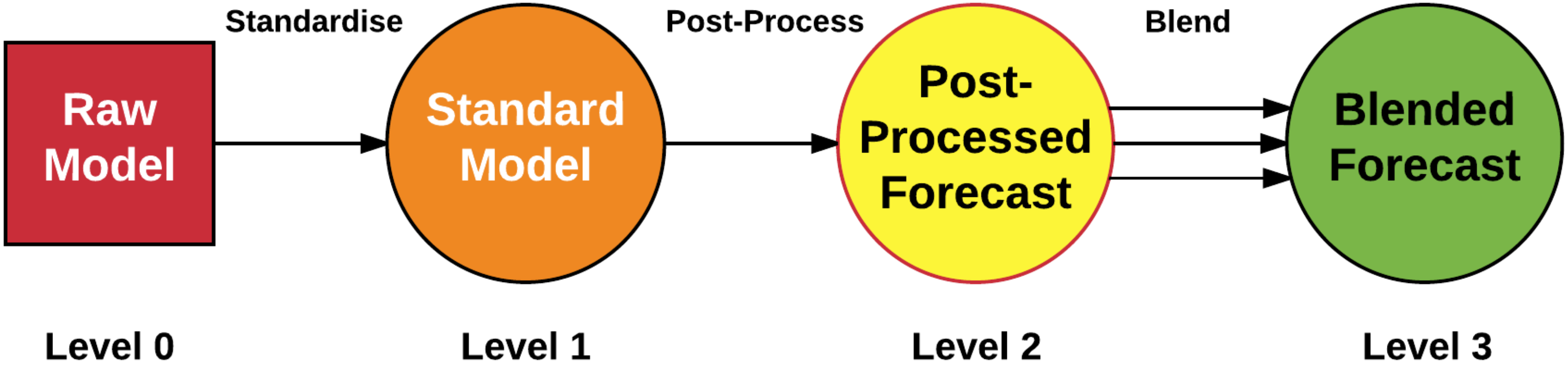
Met Office Data Processing Levels



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What standardisations are required to fit into Met Office workflows?

- File formats
- Metadata
- Time profiles
- Horizontal grids
- Vertical levels
- Non-functional benefits

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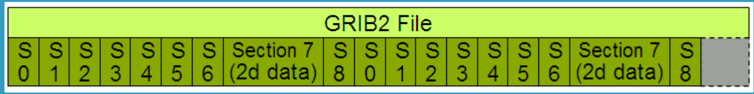
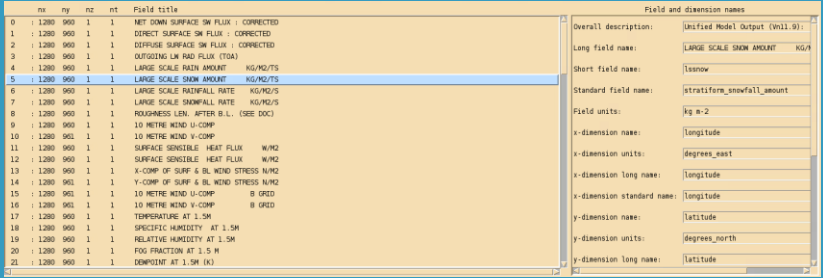
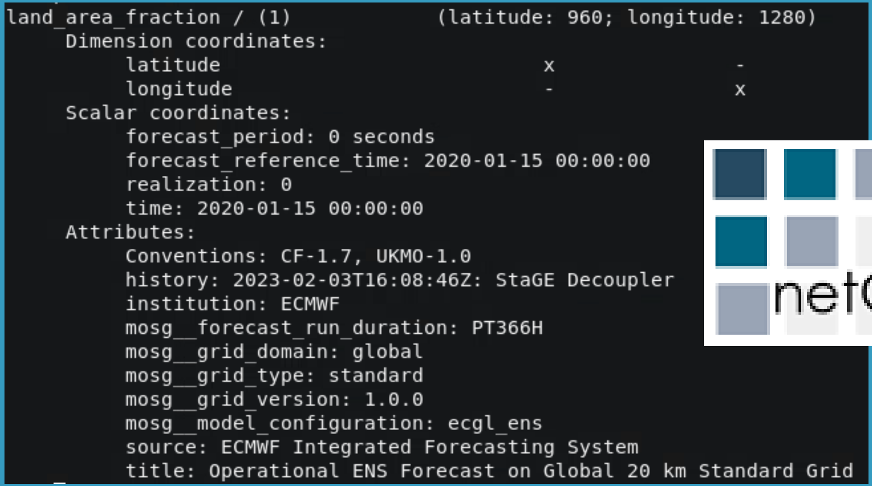
File Format

Raw Model / Level 0





Standardised Model / Level 1



netCDF

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Metadata

CF MetaData

Raw Model / Level 0

```
GRIB {
  editionNumber = 1;
  table2Version = 128;
  # European Centre for Medium-Range Weather Forecasts (common/c-1.table)
  centre = 98;
  generatingProcessIdentifier = 148;
  # 2 metre temperature  (K)  (grib1/2.98.128.table)
  indicatorOfParameter = 167;
  # Surface  (of the Earth, which includes sea surface)  (grib1/local/ecmf/3.table , grib1/3.table)
  indicatorOfTypeOfLevel = 1;
  level = 0;
  # Forecast product valid at reference time + P1  (P1>0)  (grib1/local/ecmf/5.table , grib1/5.table)
  timeRangeIndicator = 0;
  # Unknown code table entry (grib1/0.ecmf.table)
  subCentre = 0;
  paramId = 167;
  #-READ ONLY- cfNameECMF = unknown;
  #-READ ONLY- cfName = unknown;
  #-READ ONLY- cfVarNameECMF = t2m;
  #-READ ONLY- cfVarName = t2m;
  #-READ ONLY- units = K;
  #-READ ONLY- nameECMF = 2 metre temperature;
  #-READ ONLY- name = 2 metre temperature;
```

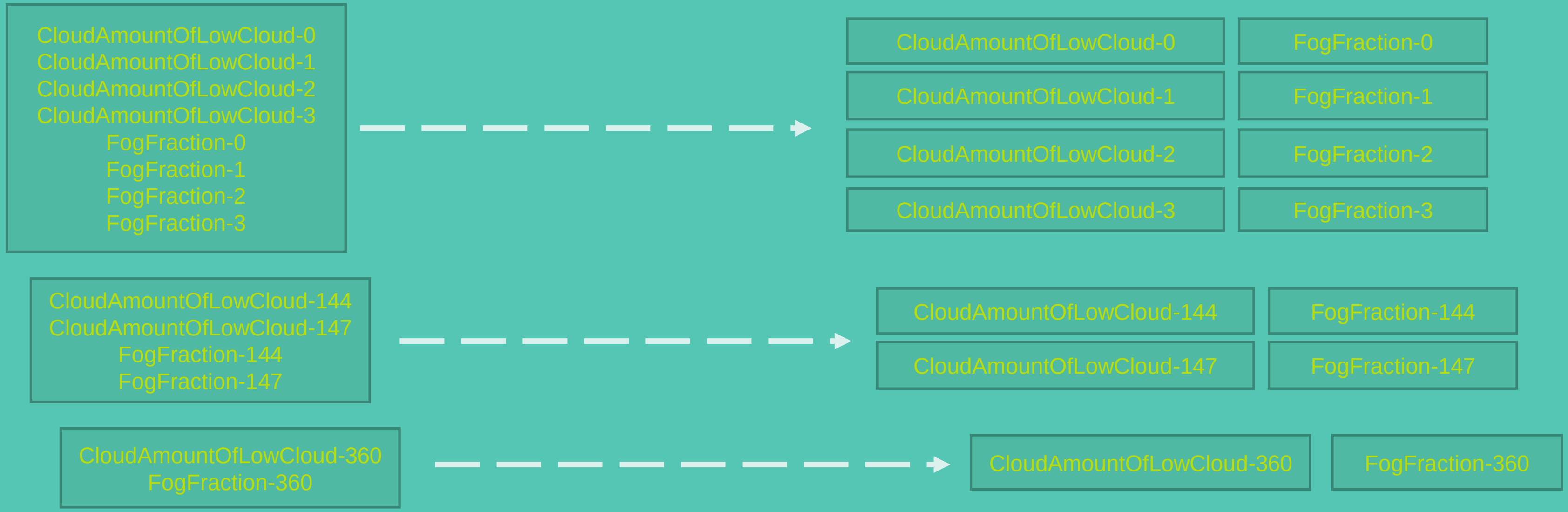
Standardised Model / Level 1

```
dimensions:
        latitude = 960 ;
        longitude = 1280 ;
        bnds = 2 ;
variables:
        float land_area_fraction(latitude, longitude) ;
                land_area_fraction:standard_name = "land_area_fraction" ;
                land_area_fraction:units = "1" ;
                land_area_fraction:grid_mapping = "latitude_longitude" ;
                land_area_fraction:coordinates = "forecast_period forecast_reference_time realization time" ;
        int latitude_longitude ;
                latitude_longitude:grid_mapping_name = "latitude_longitude" ;
                latitude_longitude:longitude_of_prime_meridian = 0. ;
                latitude_longitude:earth_radius = 6371229. ;
        float latitude(latitude) ;
                latitude:axis = "Y" ;
                latitude:bounds = "latitude_bnds" ;
                latitude:units = "degrees_north" ;
                latitude:standard_name = "latitude" ;
        float latitude_bnds(latitude, bnds) ;
        float longitude(longitude) ;
                longitude:axis = "X" ;
                longitude:bounds = "longitude_bnds" ;
                longitude:units = "degrees_east" ;
                longitude:standard_name = "longitude" ;
        float longitude_bnds(longitude, bnds) ;
        int forecast_period ;
                forecast_period:units = "seconds" ;
                forecast_period:standard_name = "forecast_period" ;
        int64 forecast_reference_time ;
                forecast_reference_time:units = "seconds since 1970-01-01 00:00:00" ;
                forecast_reference_time:standard_name = "forecast_reference_time" ;
                forecast_reference_time:calendar = "gregorian" ;
        int realization ;
                realization:standard_name = "realization" ;
        int64 time ;
                time:units = "seconds since 1970-01-01 00:00:00" ;
                time:standard_name = "time" ;
                time:calendar = "gregorian" ;
```

Time Profiles

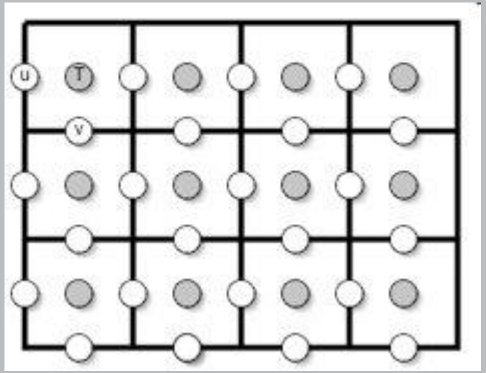
Raw Model / Level 0

Standardised Model / Level 1



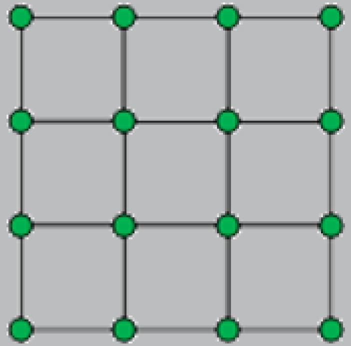
Horizontal Grids

Raw Model / Level 0



Staggered grid,
Model Coordinate Reference System

Standardised Model / Level 1



Regular grid,
Standard Projection

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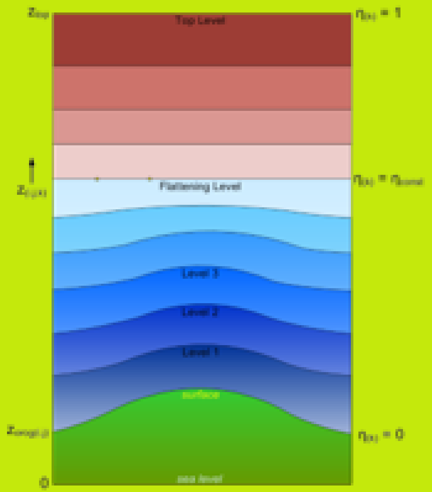
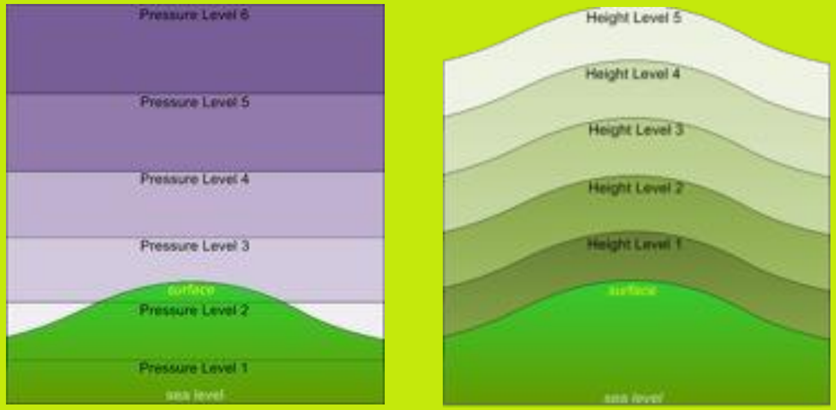
Vertical Levels

Raw Model / Level 0



Standardised Model / Level 1



Non-functional Benefits

- Maintain metadata and file structure for end users during model changes.
- Reduce the demands on model developers for change requests that can be undertaken by standardisation software.
- Increase update frequency compared to model update timelines.

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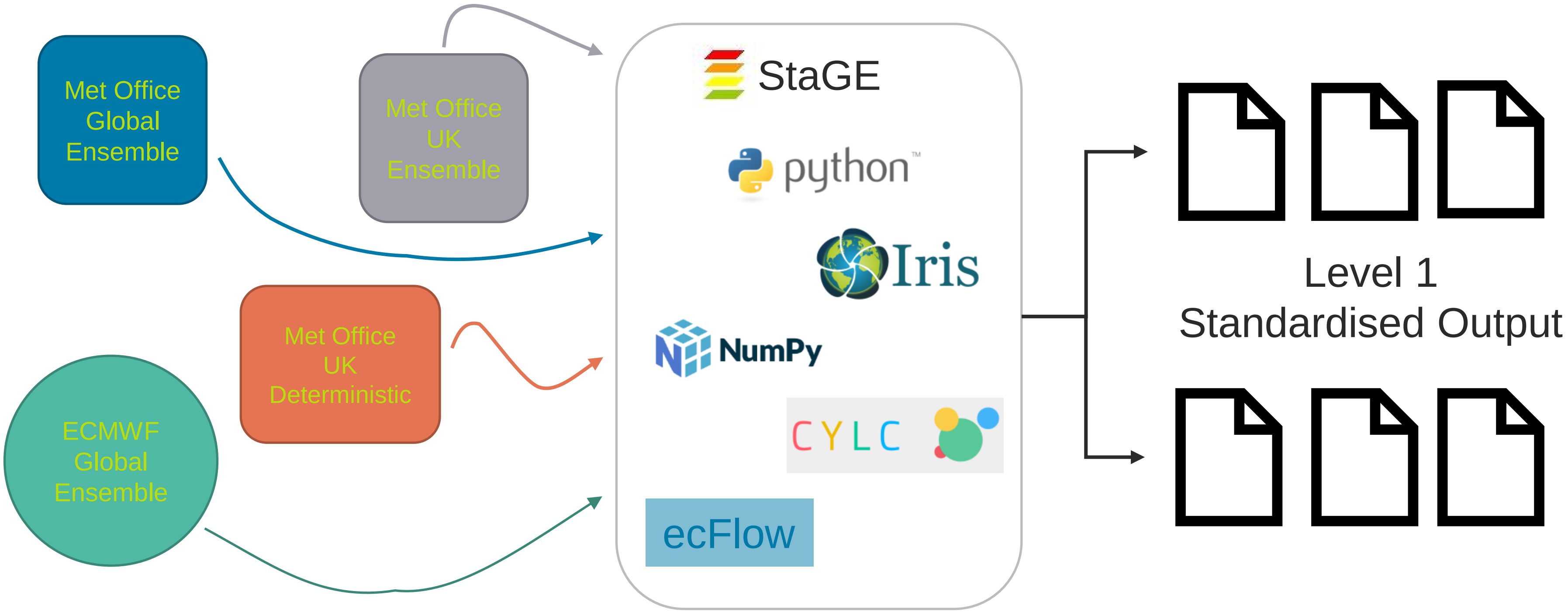
The Standard Gridding Engine - StaGE

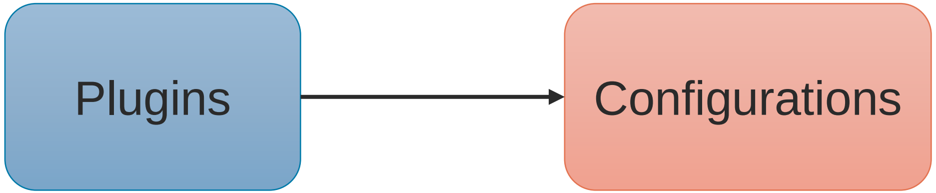


Structure of StaGE Application

Plugins

LoadGrib
RegridBilinear
Rename
StandardTimeSteps

Structure of StaGE Application



CloudAmountOfLowCloud
PressureAtSurface
TemperatureAtScreenLevel
WindSpeedAt10m

Structure of StaGE Application


```
$ python -m stage run ec_engl_standard CloudAmountOfLowCloud 000
```

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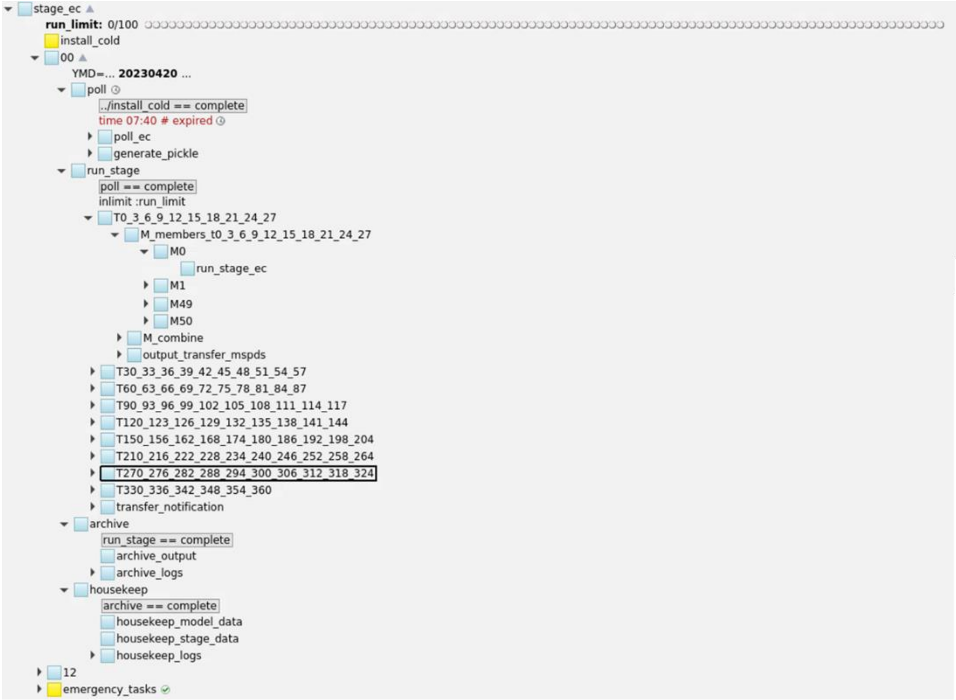
ecFlow StaGE workflow



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Next Steps Using ECMWF Data

- Providing level 3 global forecast data out to 14-days. EC will be our sole source model until the Met Office global ensemble has been extended (2024).
- Providing level 3 UK forecast data out to 14-days. Regrid global data to UK domain and blend with Met Office UK ensemble and deterministic models.
- We will look at calibrating the EC data for particular diagnostics to improve performance and alignment between different forecasts.

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Acknowledgements

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Bureau of Meteorology

- Daniel Mentiplay

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Summary

- Adding ECMWF data into existing and new Met Office systems will improve current products and create new ones.
- Combining data from multiple sources is complicated and technically challenging.
- Updating and deploying the Standard Gridding Engine (StaGE) at ECMWF has standardised ECMWF and Met Office forecast data for simplified downstream usage.
- This new capability will help extend the IMPROVER probabilistic forecast system to 14 day forecasts for both the global and UK domains.

Extra Slides

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Technical Challenges

- Acclimatise to a new compute estate – Atos HPC
- Learning a new workflow manager – ecFlow
- Developing grib loading capability in StaGE
- Developing grib parameter translation in StaGE and contributing to Iris-grib
- Configuring a conda environment for StaGE running at ECMWF
- Ensuring data are promptly and reliably transferred from the ECMWF Atos machine to the Met Office HPC estate

Derived Diagnostics

- Combining u & v wind to provide wind direction and speed
- Converting between humidity types
- Combining precipitation types