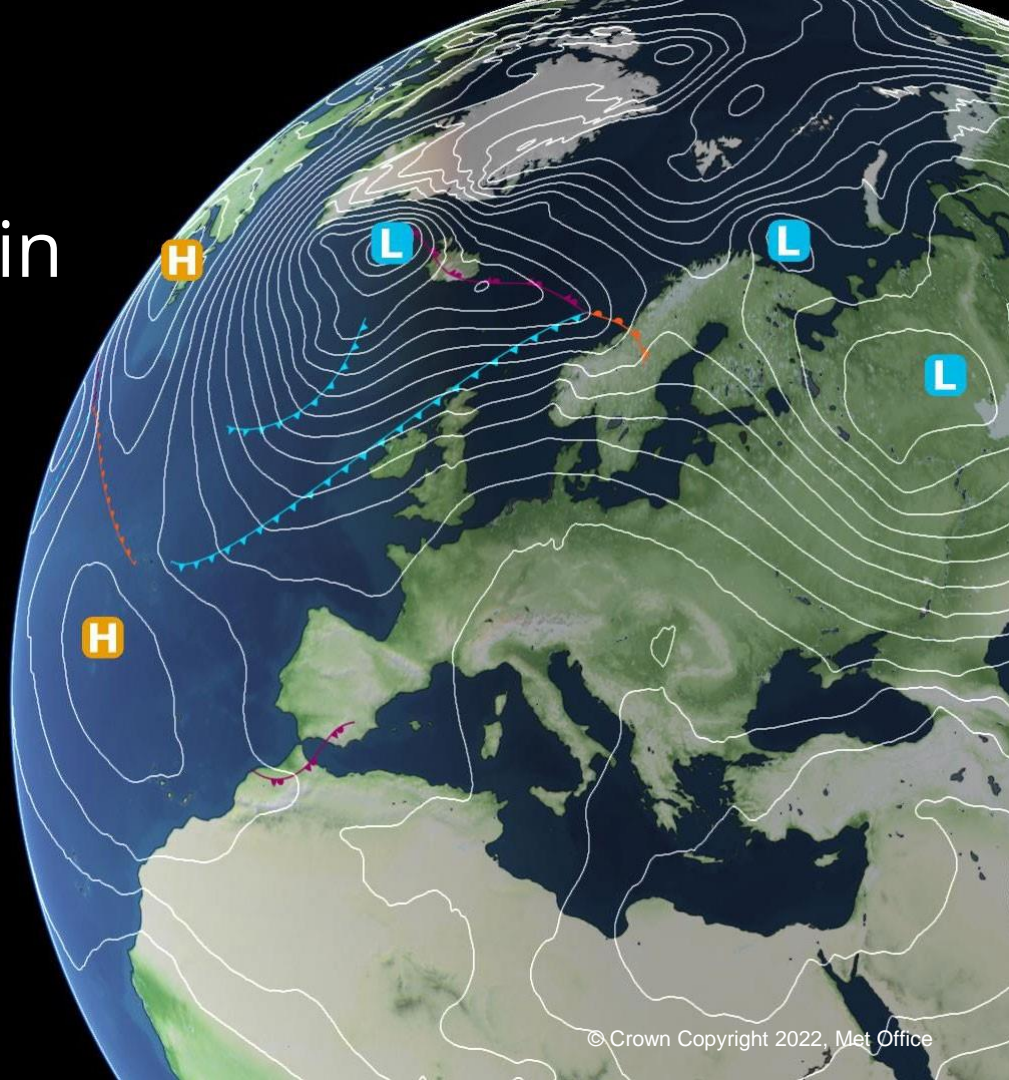


# Processing ECMWF Ensemble Data for use in Met Office Systems

Simon Boardman

Senior Scientific Software Engineer

Verification, Impacts, and Post-Processing

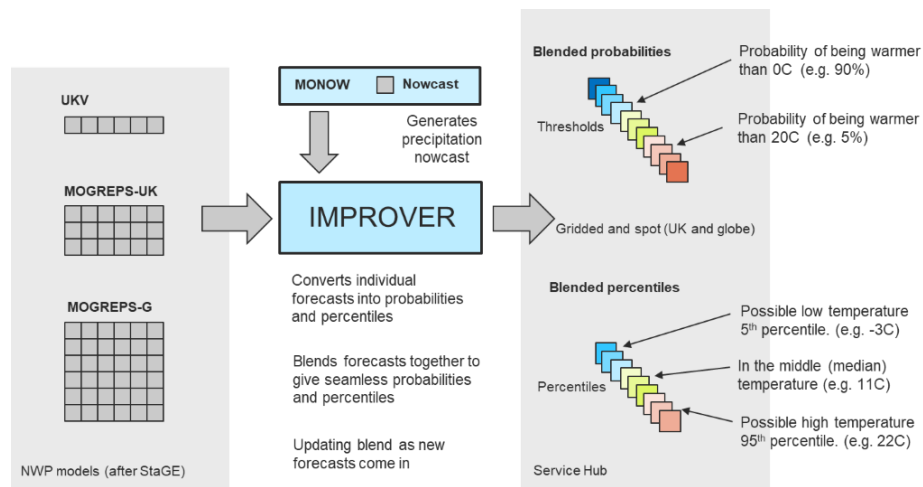


# Outline

- 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.

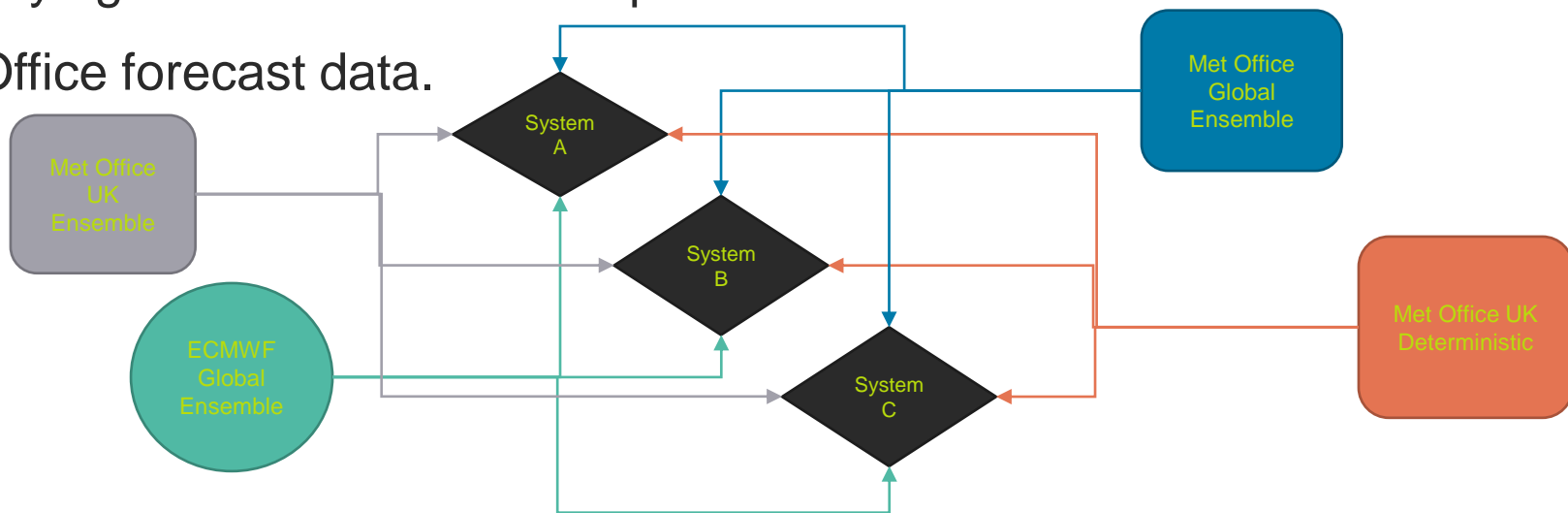
# Why do we want to utilise ECMWF ensemble data in the Met Office?

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

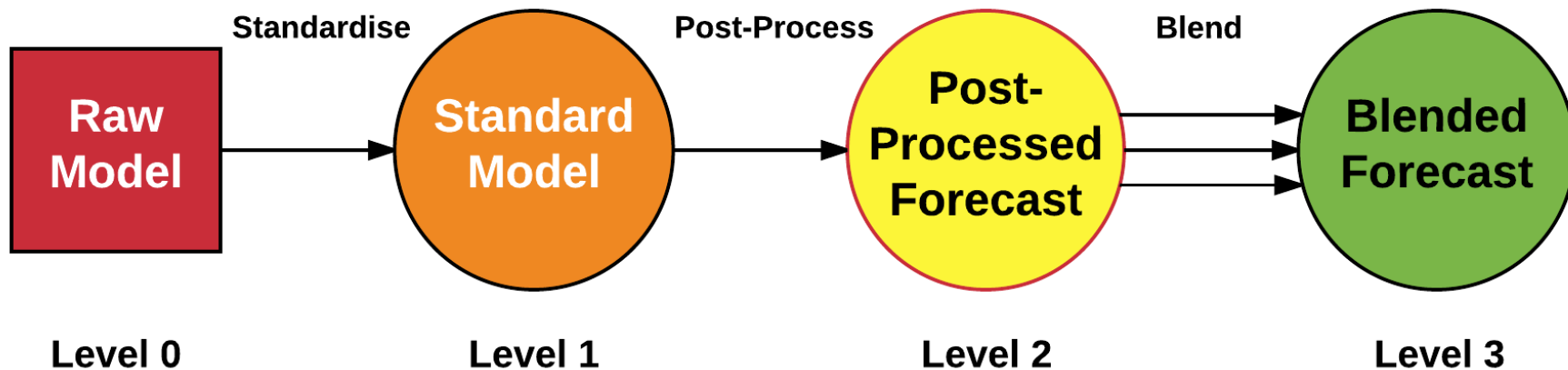


# Why do we want to utilise ECMWF ensemble data in the Met Office?

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



# Met Office Data Processing Levels



# What standardisations are required to fit into Met Office workflows?



File formats



Metadata



Time profiles



Horizontal  
grids



Vertical levels



Non-functional  
benefits

# File Format

## Raw Model / Level 0

GRIB2 File																	
S	S	S	S	S	S	S	Section 7	S	S	S	S	S	Section 7	S			
0	1	2	3	4	5	6	(2d data)	8	0	1	2	3	4	5	6	(2d data)	8

no	ny	nz	nt	Field title	Field and dimension names
0	1280	960	1	NET DOWN SURFACE SW FLUX / CONNECTED	Overall description: Unified Model Output (v011.9):
1	1280	960	1	DIRCT SURFACE SW FLUX / CONNECTED	Long field name: LARGE SCALE SNOW AMOUNT KG/M2
2	1280	960	1	DIFFUSE SURFACE SW FLUX / CONNECTED	Short field name: Isnow
3	1280	960	1	OUTGOING LW RAD FLUX (TOA)	Standard field name: stratiform_snowfall_amount
4	1280	960	1	LARGE SCALE RAIN AMOUNT KG/M2/S	Field units: kg m-2
5	1280	960	1	LARGE SCALE SNOW AMOUNT KG/M2/S	x-dimension name: Longitude
6	1280	960	1	LARGE SCALE RAINFALL RATE KG/M2/S	x-dimension units: Degree_east
7	1280	960	1	LARGE SCALE SNOWFALL RATE KG/M2/S	x-dimension long name: Longitude
8	1280	960	1	ROUGHNESS LEN. AFTER B.L. (SEE DOC)	x-dimension standard name: Longitude
9	1280	960	1	10 METRE WIND U-COMP	y-dimension name: Latitude
10	1280	960	1	10 METRE WIND V-COMP	y-dimension units: Degree_north
11	1280	960	1	SURFACE SENSIBLE HEAT FLUX W/M2	y-dimension long name: Latitude
12	1280	960	1	SURFACE SENSIBLE HEAT FLUX W/M2	
13	1280	960	1	X-COMP OF SURF & BL WIND STRESS N/M2	
14	1280	960	1	Y-COMP OF SURF & BL WIND STRESS N/M2	
15	1280	960	1	10 METRE WIND U-COMP B GRID	
16	1280	960	1	10 METRE WIND V-COMP B GRID	
17	1280	960	1	TEMPERATURE AT 1.5M	
18	1280	960	1	SPECIFIC HUMIDITY AT 1.5M	
19	1280	960	1	RELATIVE HUMIDITY AT 1.5M	
20	1280	960	1	FOG FRACTION AT 1.5 M	
21	1280	960	1	DEWPOINT AT 1.5M (K)	

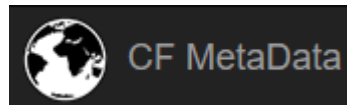
## Standardised Model / Level 1

```

land_area_fraction / (1) (latitude: 960; longitude: 1280)
Dimension coordinates:
  latitude X -
  longitude - X
Scalar coordinates:
  forecast_period: 0 seconds
  forecast_reference_time: 2020-01-15 00:00:00
  realization: 0
  time: 2020-01-15 00:00:00
Attributes:
  Conventions: CF-1.7, UKMO-1.0
  history: 2023-02-03T16:08:46Z: StaGE Decoupler
  institution: ECMWF
  mosg_forecast_run_duration: PT366H
  mosg_grid_domain: global
  mosg_grid_type: standard
  mosg_grid_version: 1.0.0
  mosg_model_configuration: ecgl_ens
  source: ECMWF Integrated Forecasting System
  title: Operational ENS Forecast on Global 20 km Standard Grid
  
```



# 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

CloudAmountOfLowCloud-0  
CloudAmountOfLowCloud-1  
CloudAmountOfLowCloud-2  
CloudAmountOfLowCloud-3  
FogFraction-0  
FogFraction-1  
FogFraction-2  
FogFraction-3



## Standardised Model / Level 1

CloudAmountOfLowCloud-0	FogFraction-0
CloudAmountOfLowCloud-1	FogFraction-1
CloudAmountOfLowCloud-2	FogFraction-2
CloudAmountOfLowCloud-3	FogFraction-3

CloudAmountOfLowCloud-144  
CloudAmountOfLowCloud-147  
FogFraction-144  
FogFraction-147



CloudAmountOfLowCloud-144	FogFraction-144
CloudAmountOfLowCloud-147	FogFraction-147

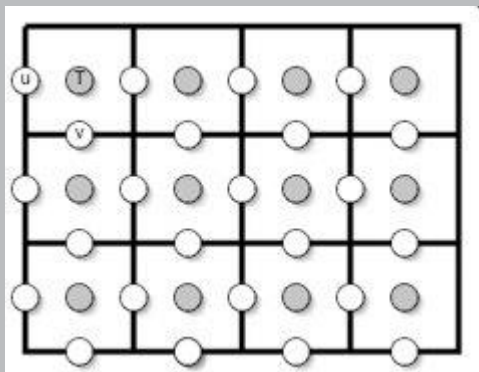
CloudAmountOfLowCloud-360  
FogFraction-360



CloudAmountOfLowCloud-360	FogFraction-360
---------------------------	-----------------

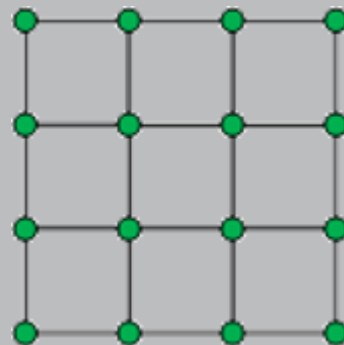
# Horizontal Grids

Raw Model / Level 0



Staggered grid,  
Model Coordinate Reference System

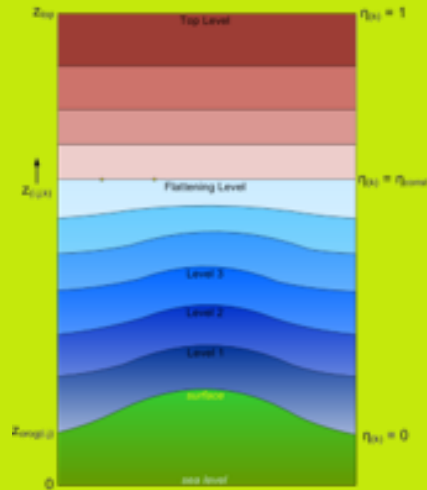
Standardised Model / Level 1



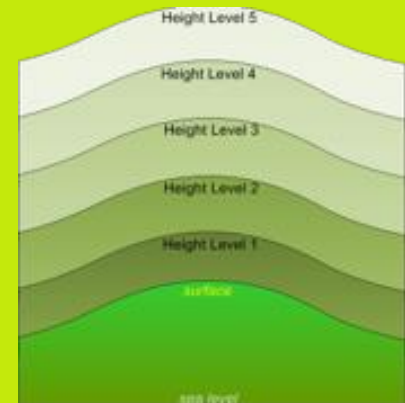
Regular grid,  
Standard Projection

# Vertical Levels

Raw Model / Level 0



Standardised Model / Level 1

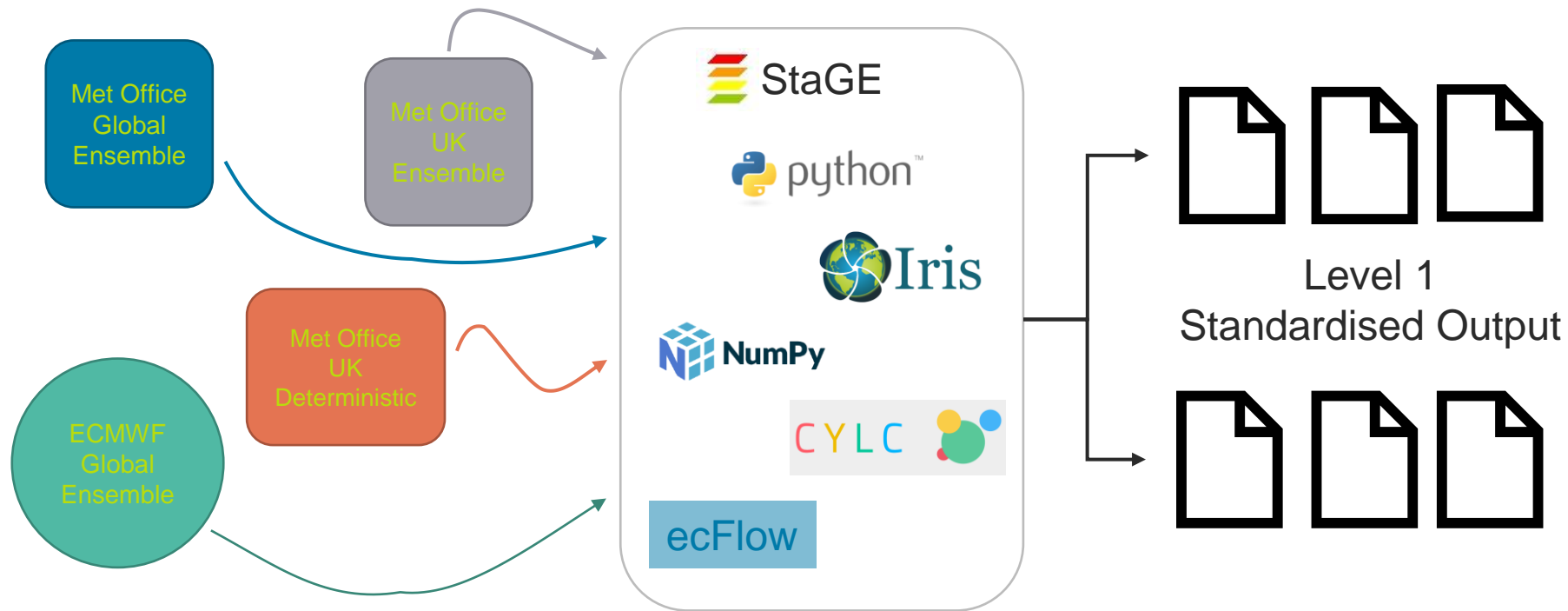


# Non-functional Benefits

- 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.



# The Standard Gridding Engine - StaGE



# Structure of StaGE Application



Plugins

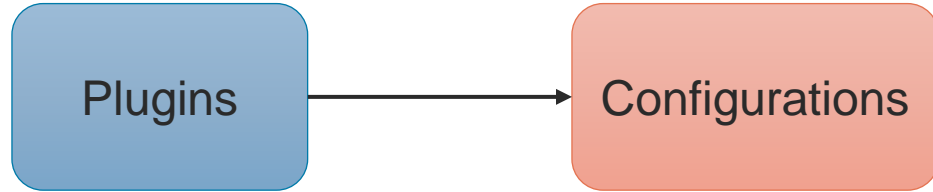
LoadGrib

RegridBilinear

Rename

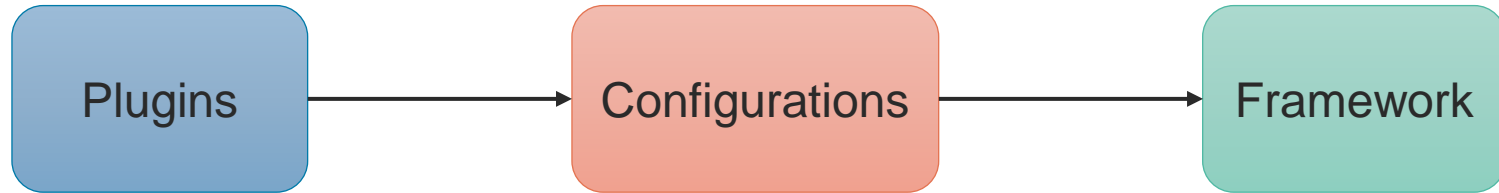
StandardTimeSteps

# Structure of StaGE Application



CloudAmountOfLowCloud  
PressureAtSurface  
TemperatureAtScreenLevel  
WindSpeedAt10m

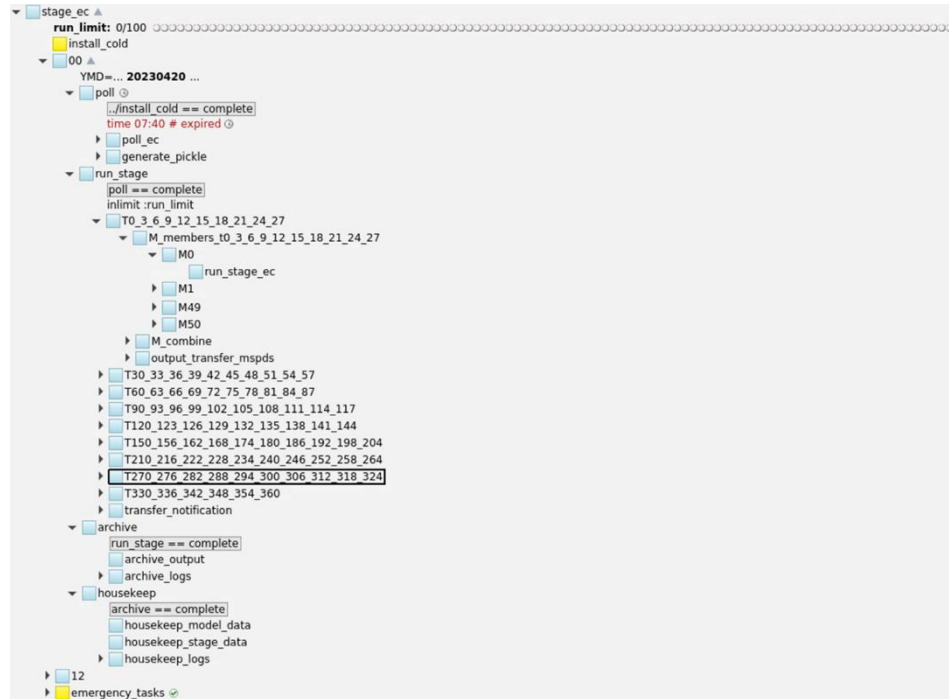
# Structure of StaGE Application



```
$ python -m stage run ec_eng1_standard CloudAmountOfLowCloud 000
```



# ecFlow StaGE workflow



# 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.

# Acknowledgements

- Aled Owen
- Neil Crosswaite
- Sam Griffiths
- David James
- Caroline Jones
- Ben Ayliffe
- Alex Ferguson
- Paul Abernethy
- Ben Fitzpatrick



- Paul Dando
- Andrew Bennett



**Australian Government**  
**Bureau of Meteorology**

- Daniel Mentiplay

# 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

# 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