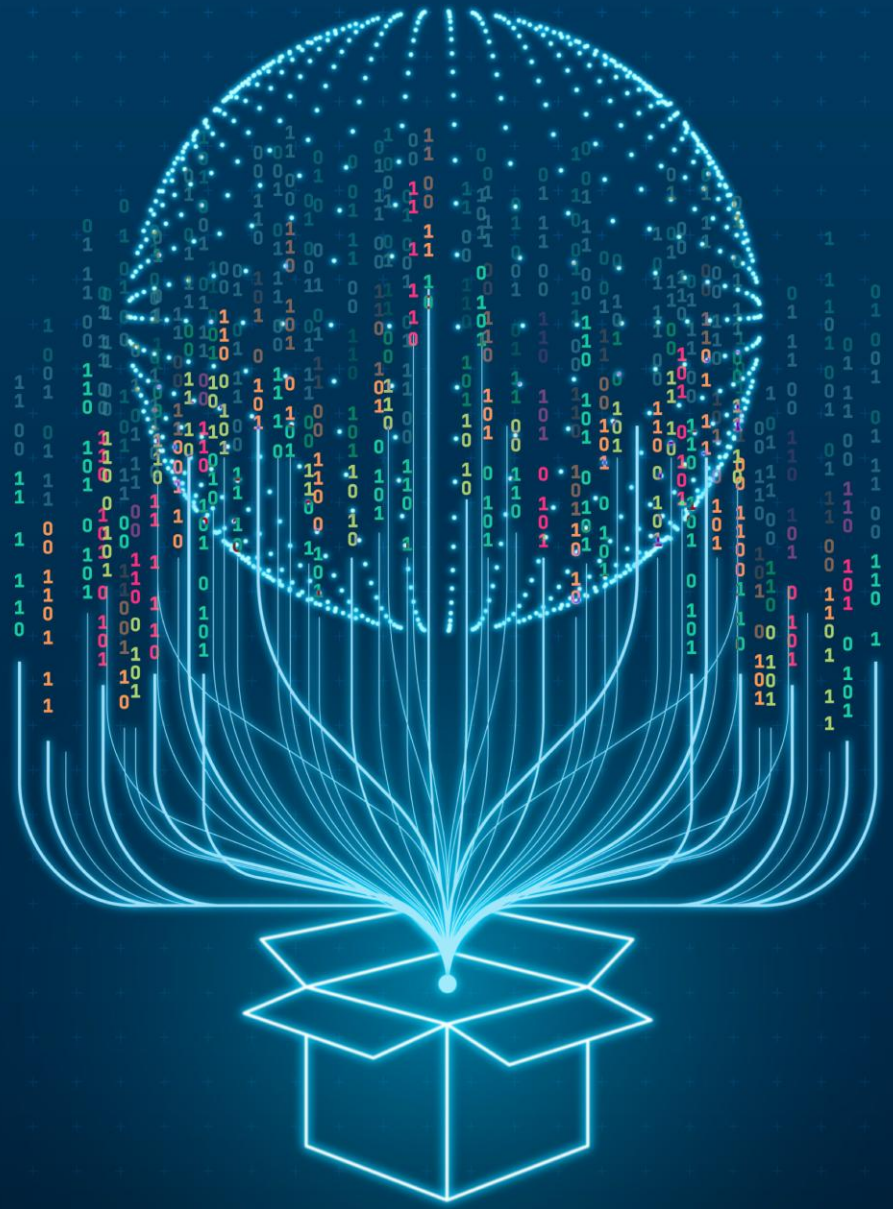
ECMWF – DESTINATION EARTH

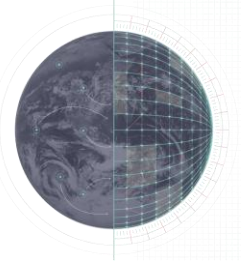
FORECAST-IN-A-BOX

Application of ML Forecast Models

Harrison Cook, Corentin Carton de Wiart, James Hawkes, Vojtech Tuma, Jenny Wong, Tiago Quintino

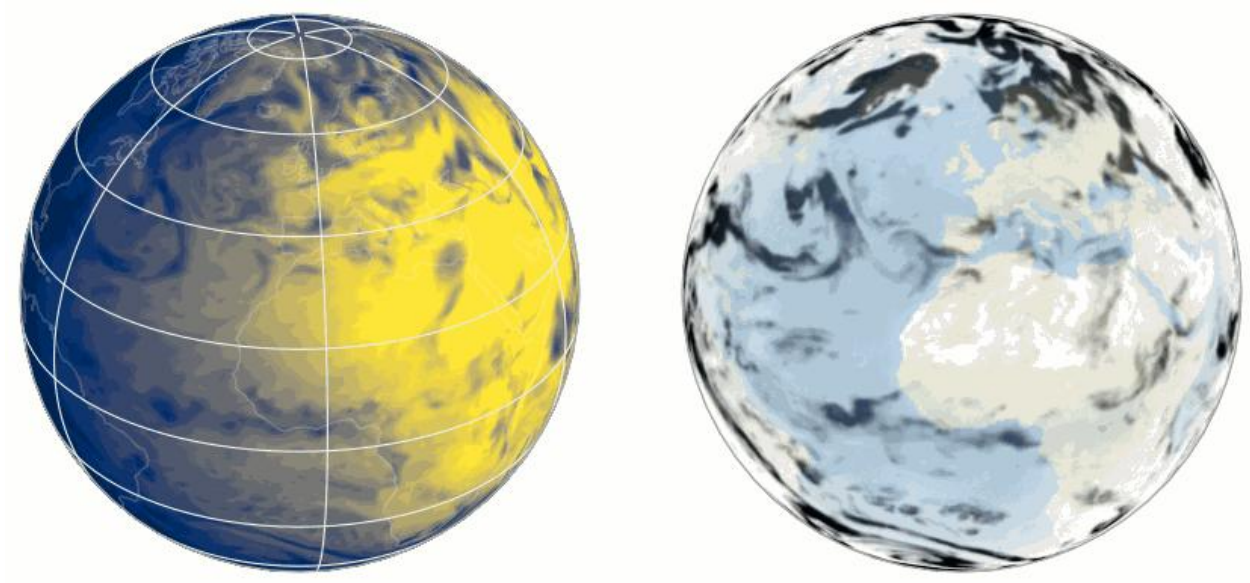


Funded by the European Union co funded by Destination Earth implemented by ECMWF esa EUMETSAT



Data-Driven ML Models

- Data-driven ML models run on a fraction of resources used to run physics-based models
- ML leads to an explosion of new models, and increase of resolution (spatial/ensemble)



AIFS-Single v1

Copernicus ERA5:
15 billion (one off)

Hersbach, H et al. (2020)

Training dataset
Based on a physical model

Physics-based Forecast:
180 000
per forecast

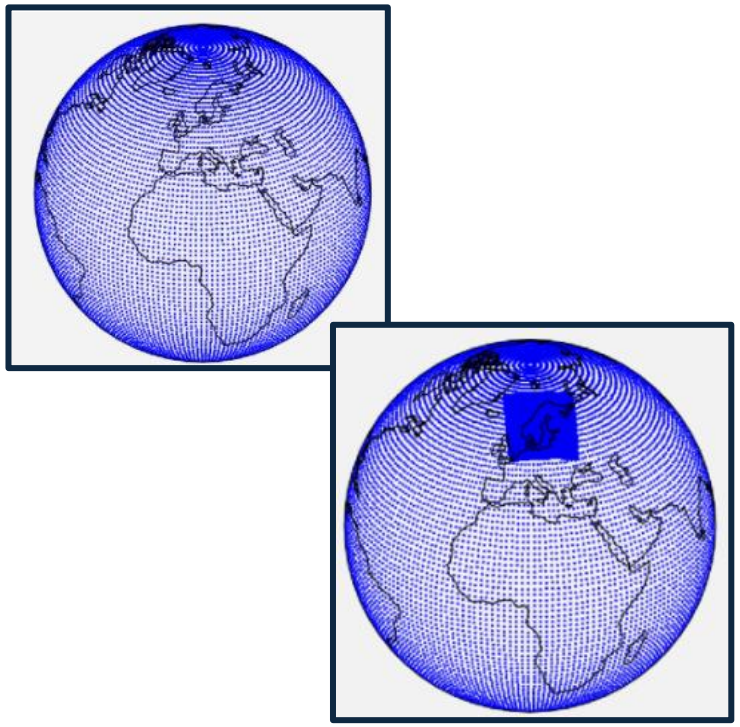
AI Model:
0.3
per forecast

~1000x
reduction in
energy
Forecast time
reduced from
~30minutes to
~3minutes

Unit: System Billing Units (SBU)

Norwegian Meteorological Institute

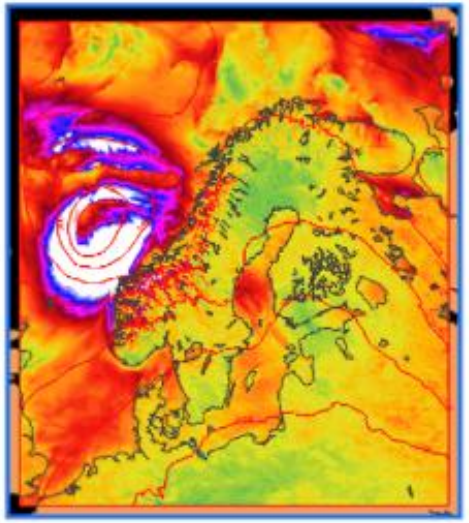
Bris Model – Local Area Model



Does a data-driven model trained on one domain generalize to another?

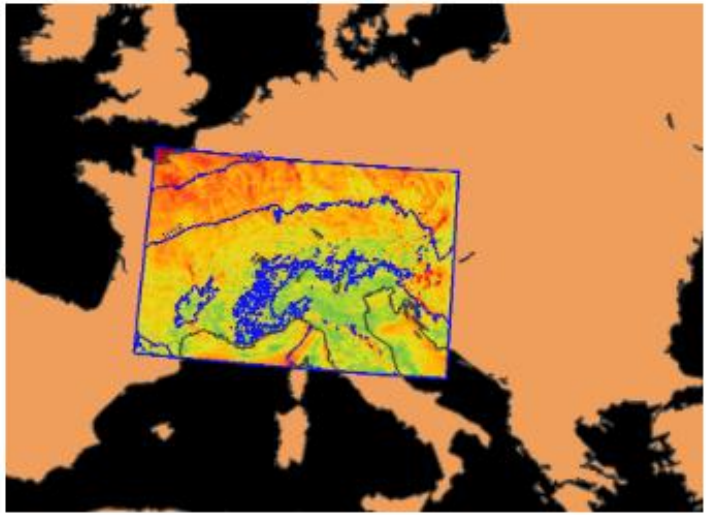
Trained on:

- MEPS 2.5 km analyses 2020-2023
- 1000 * 950 grid points
- Biggest mountain: 2019 m



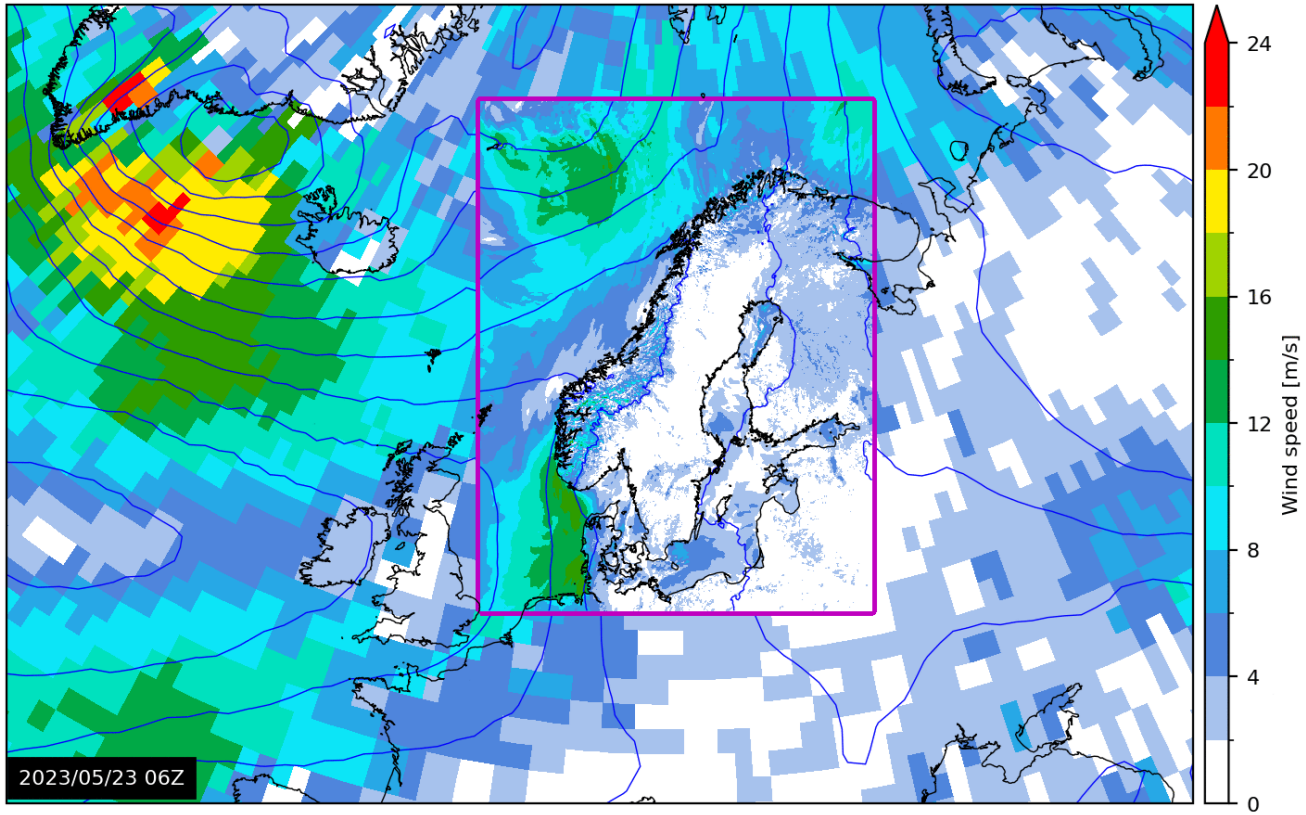
Inference on:

- COSMO 2 km analyses (Feb 2020)
- 290 * 582 gridpoints
- Biggest mountain: 3867 m



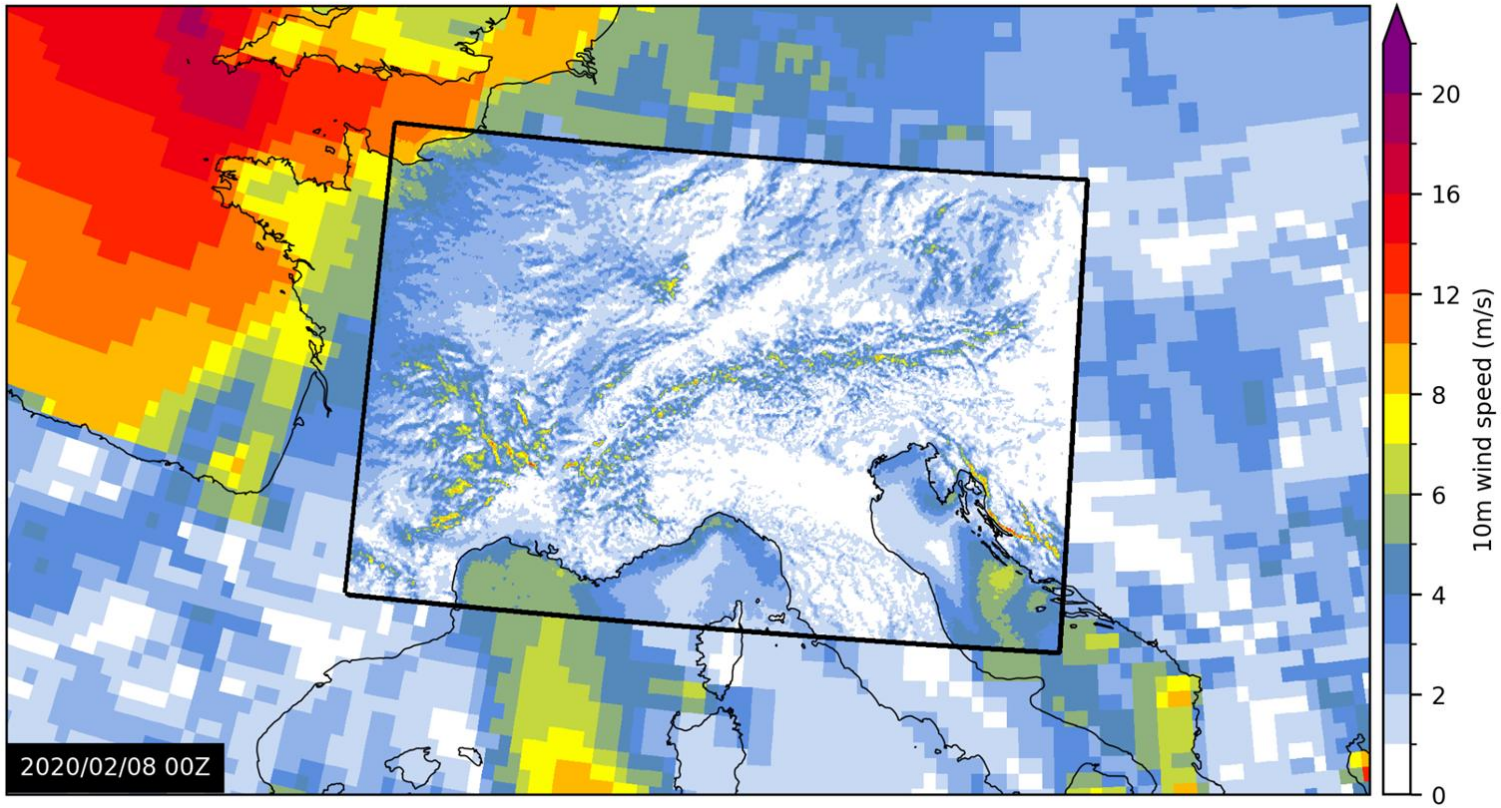
Norwegian Meteorological Institute

The Bris Model …



Norwegian Meteorological Institute

… Can Run Anywhere!

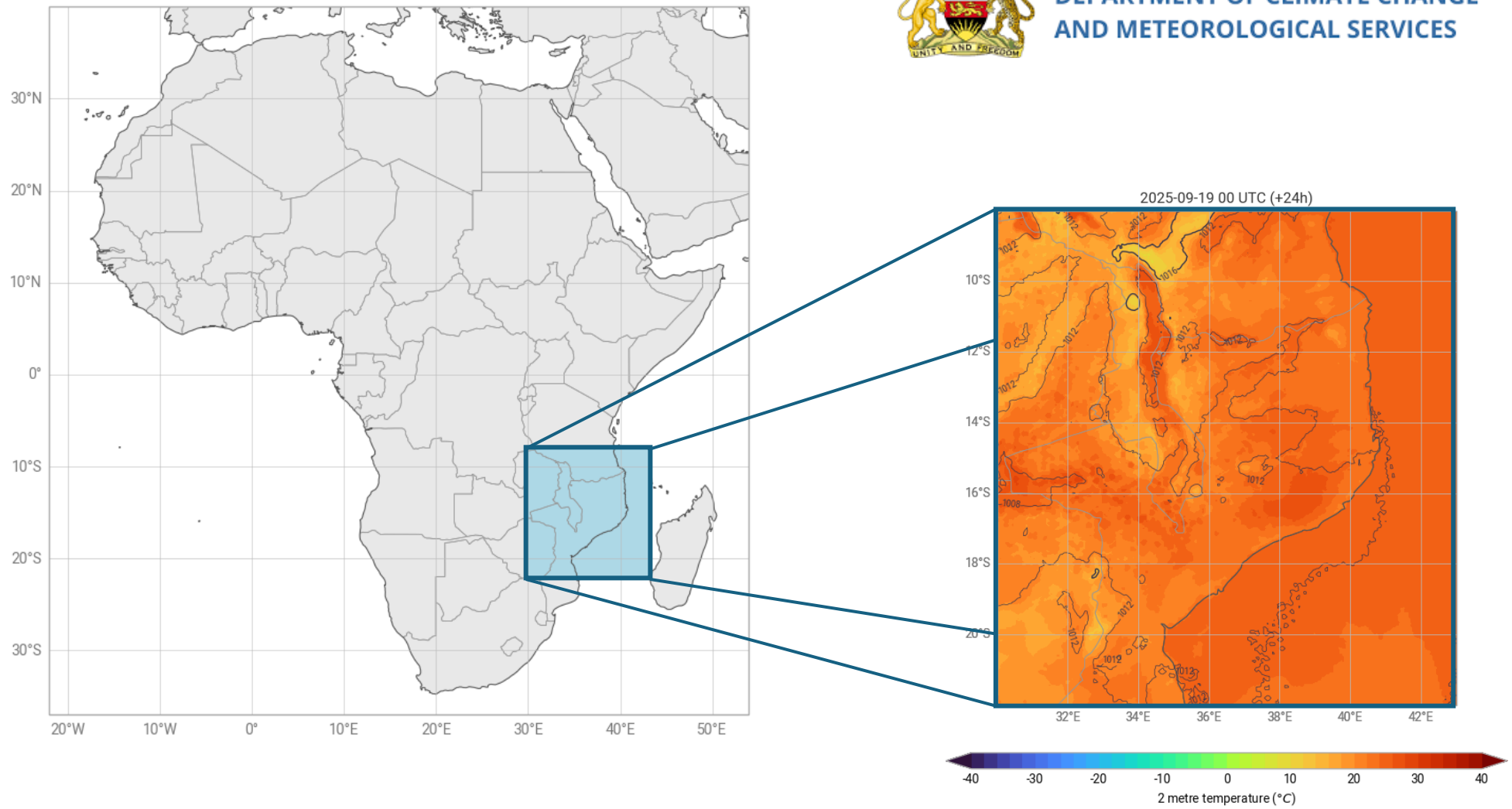


Norwegian Meteorological Institute

MINISTRY OF NATURAL RESOURCES AND CLIMATE CHANGE
DEPARTMENT OF CLIMATE CHANGE AND METEOROLOGICAL SERVICES

WMO

WMO/Malawi Pilot Project



Bringing it from Norway...

...to Malawi

Data-Driven ML Models

- Easy to run
- But the data is too large to ship to users
  - Send the model instead?
- (or) Give them the “box” that makes the data
- Drastic simplification of running a forecast

The goal

- Run the Bris Model Within Forecast-in-a-Box
- Deliver a fully packaged forecasting system
  - End to end
- Intuitive for forecasters
  - Get the data that they need, when they need it
- Accelerate the adoption of AI Weather models

Impact

- “Democratisation” of Weather forecasts
  - No longer limited to big meteorological organisations
- Faster / Higher Resolution / More accurate*?
- Early warnings for communities that need it most
- Training cost upon the larger organisations
  - Inference used by everyone else

* On certain metrics

What's in the box?

earthkit

anemoi

Earthkit and its components

earthkit data

earthkit geo

earthkit hydro

earthkit workflows

earthkit

earthkit.ecmwf.int

earthkit meteo

earthkit utils

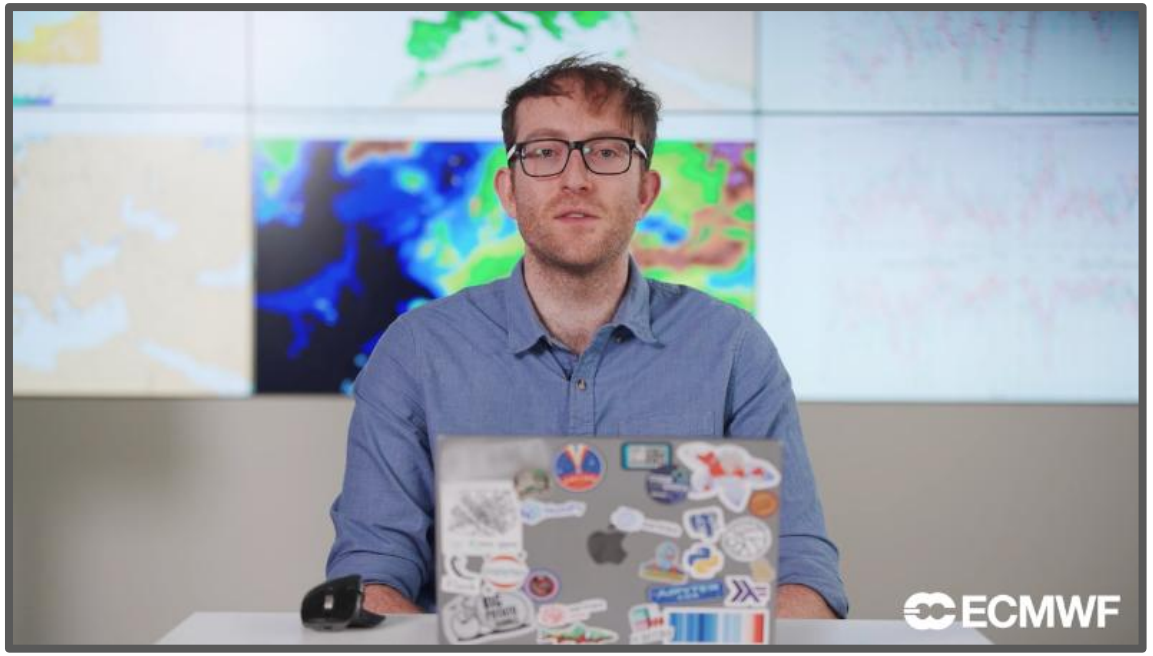
earthkit plots

earthkit regrid

earthkit time

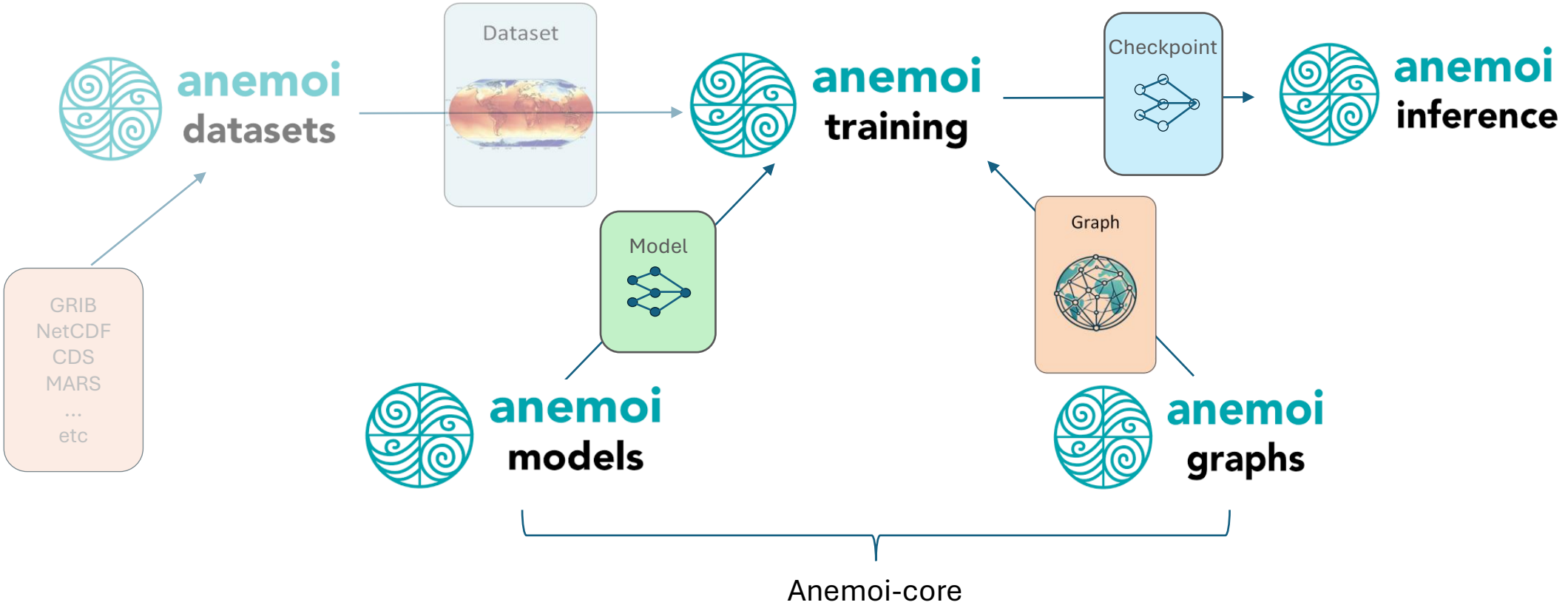
earthkit transforms

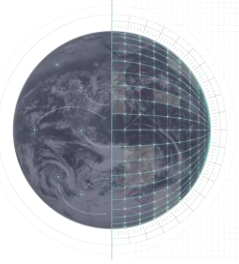
earthkit



Introductory videos

Anemoi in a Nutshell

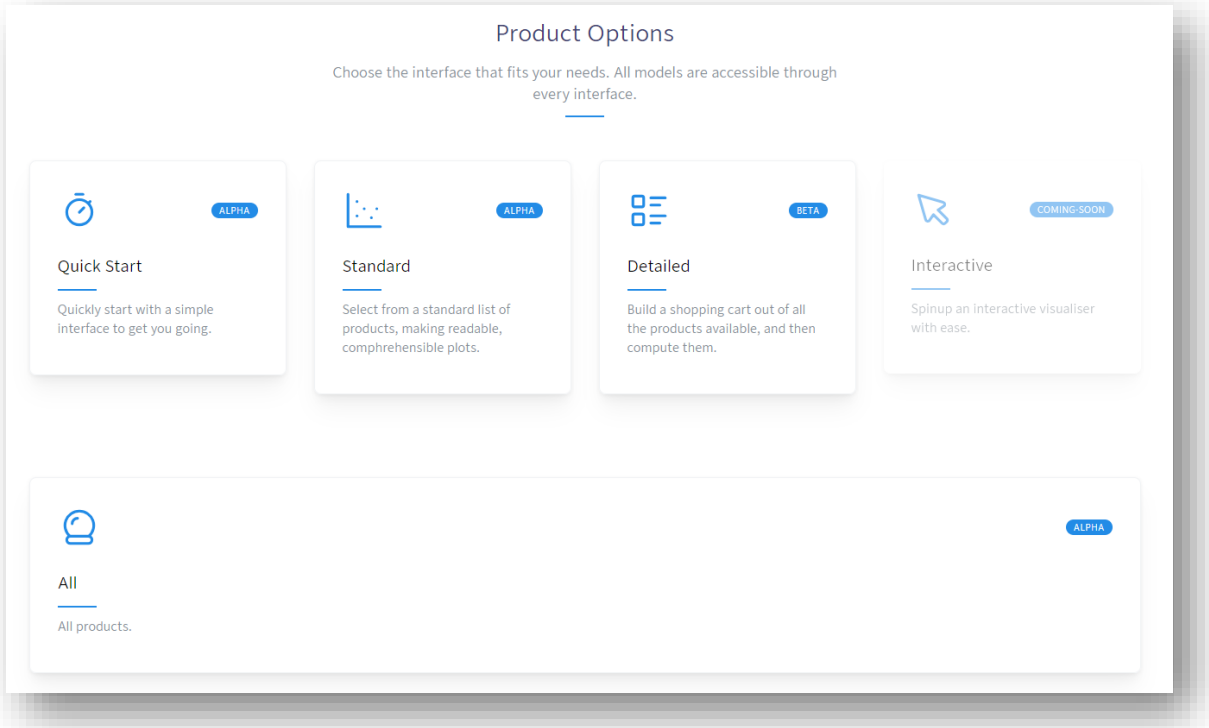




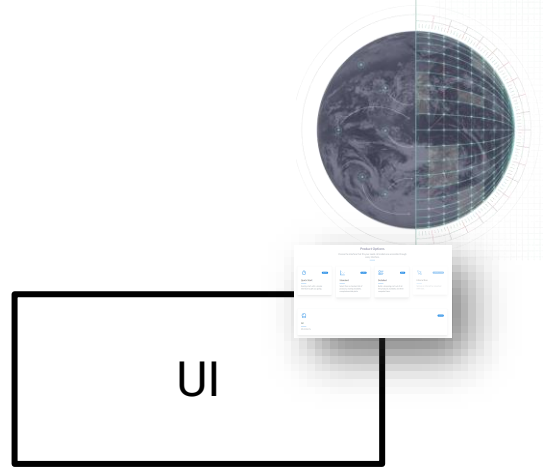
Showcase

Forecast-In-A-Box – “What’s in the box?”

- **UI + Catalogue**
  - Provides control to the user, whilst keeping it accessible



Forecast-In-A-Box – “What’s in the box?”



- **Task Definitions**
  - Constructed from Anemoi and Earthkit functions

Fetch Initial Conditions

Regrid and Interpolate

Execute ML model

anemoi

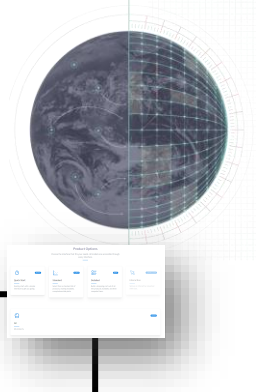
earthkit

Generate Products

Transform Outputs

Visualise

Forecast-In-A-Box – “What’s in the box?”

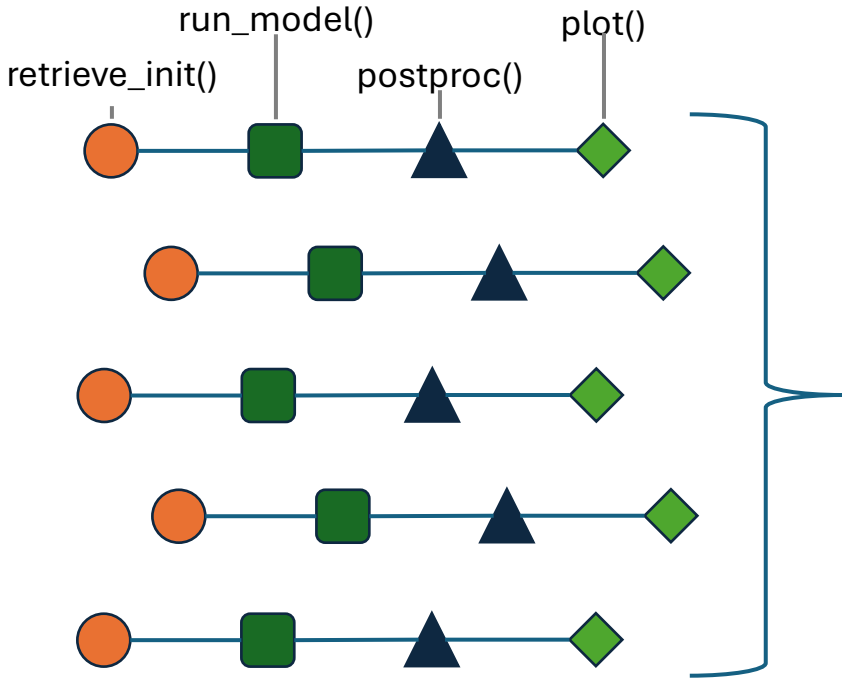


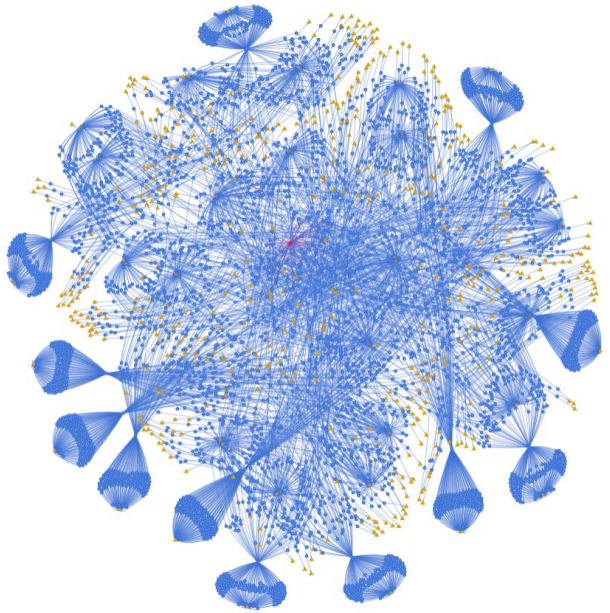
UI

Task Definitions

anemoi earthkit

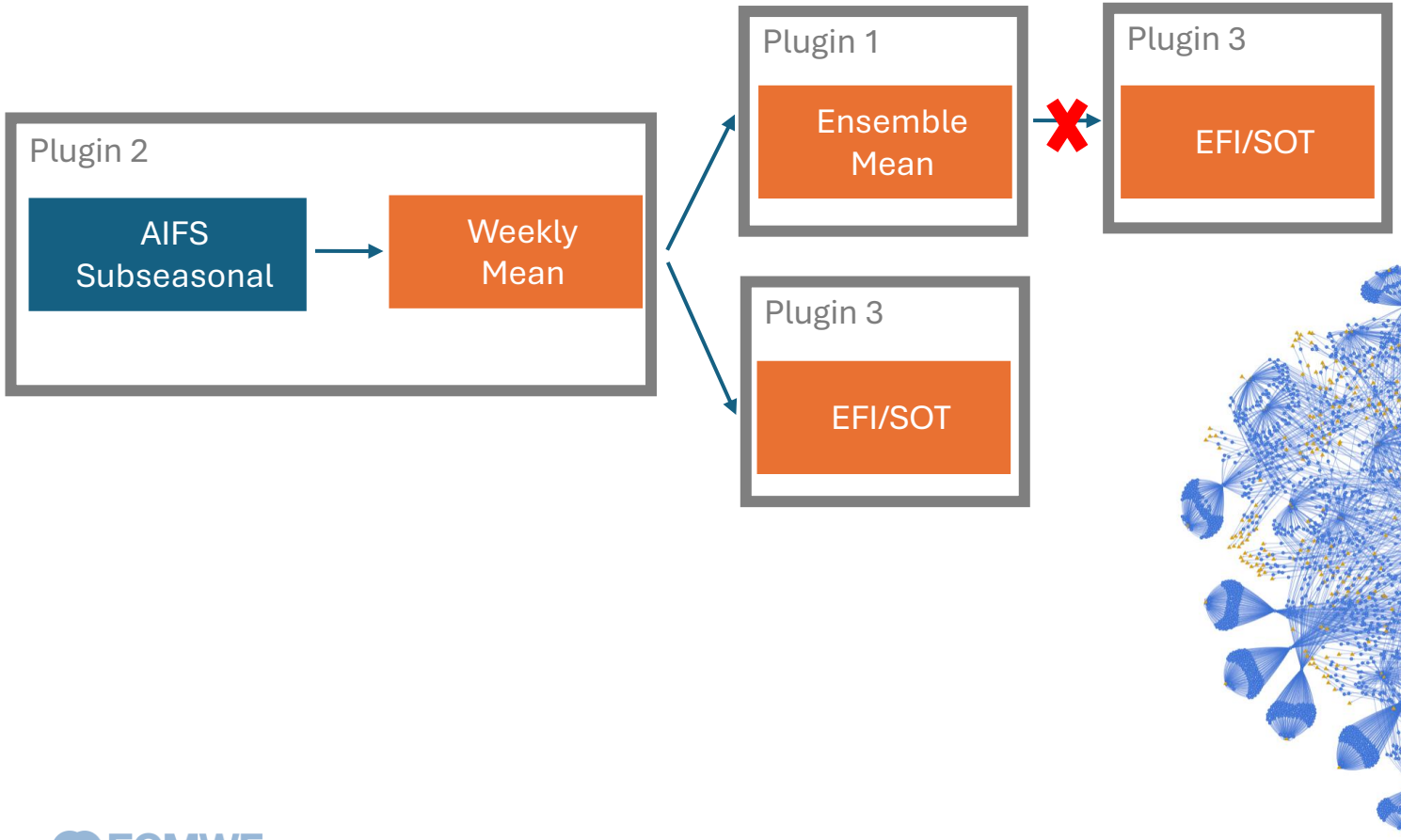
- **Orchestration**
  - Creation of a series of graphs from products specifications
  - Construction of meta computing graph and scheduling

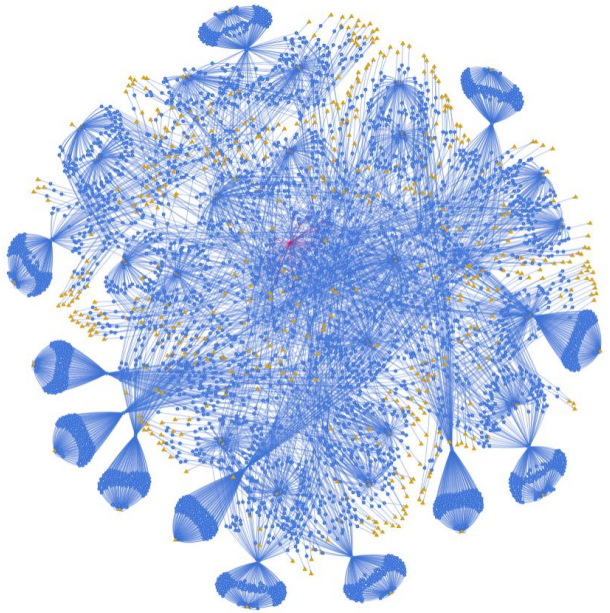


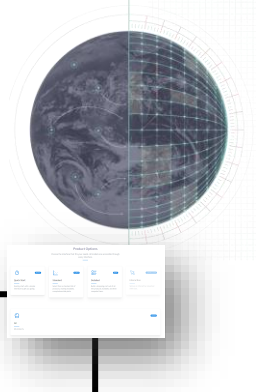


Forecast-In-A-Box – “What’s in the box?”

- **Combining Products**







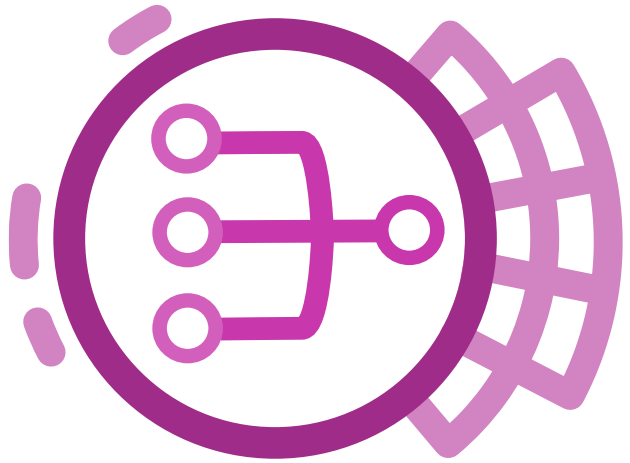
UI

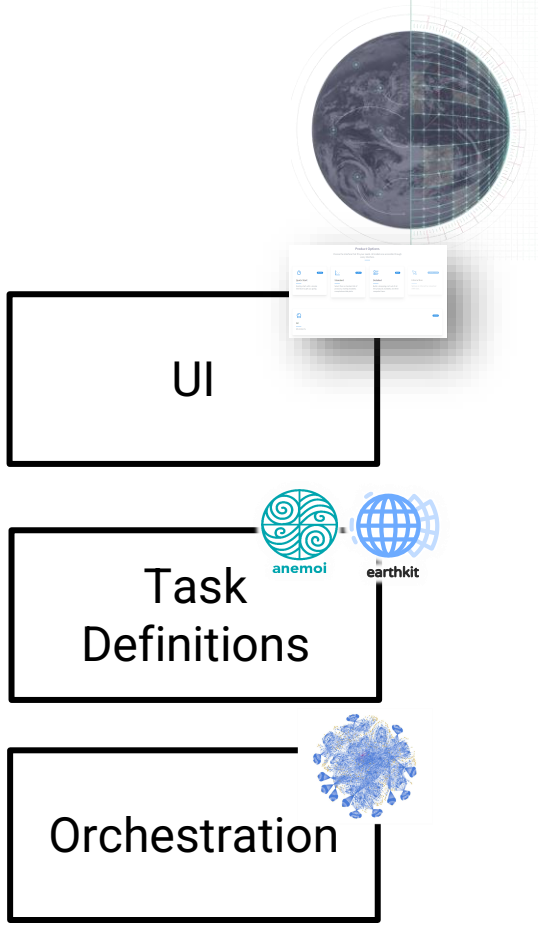
Task Definitions

earthkit

Forecast-In-A-Box – “What’s in the box?”

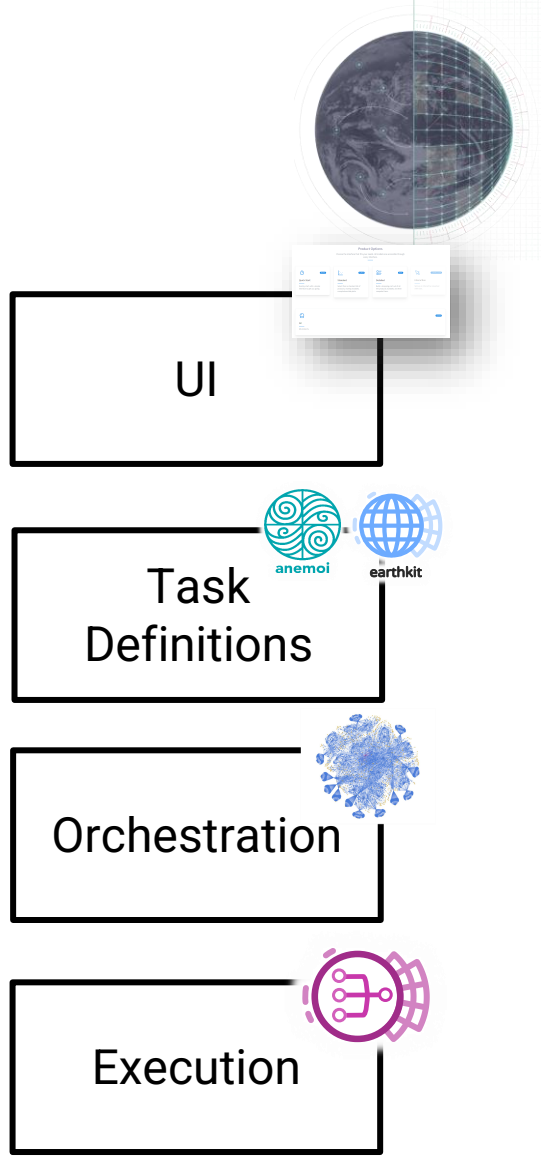
- **Execution Layer**
  - Executes the task graph
  - Data caching and persistence layer
  - Optimizing for data colocation and transfer
  - All in memory





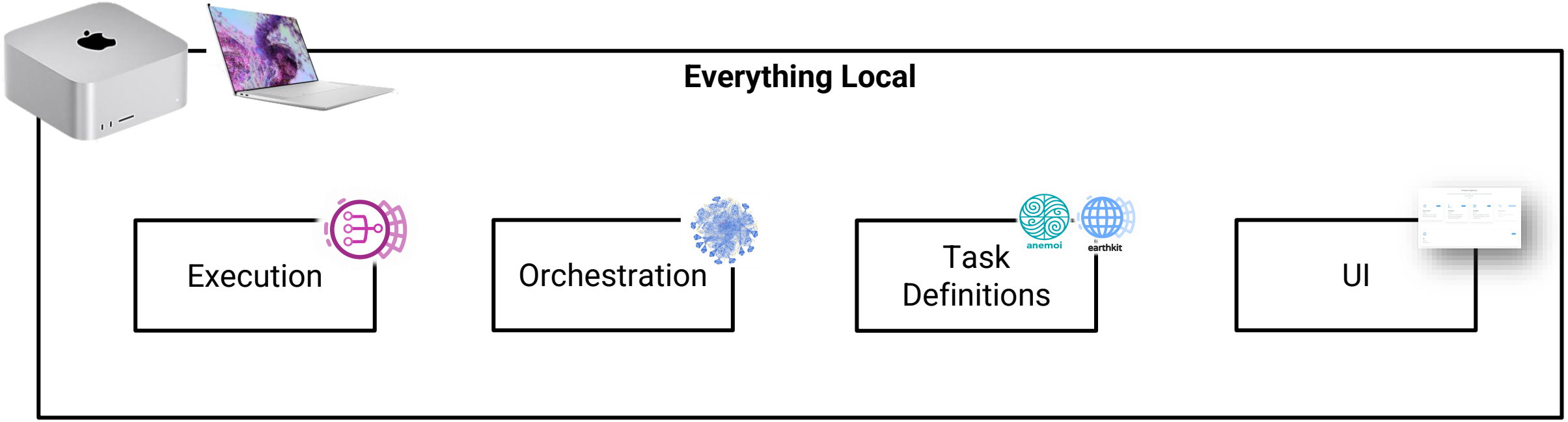
Forecast-In-A-Box – “What’s in the box?”

- **Putting it all together**
  - A complete forecasting system
  - Capable of running any Anemoi inference model
  - Runs ECMWF’s full operational product and post processing software
  - Provides ECMWF production quality graph and plotting software



Forecast-In-A-Box – “What’s in the box?”

- Can be deployed in many ways…



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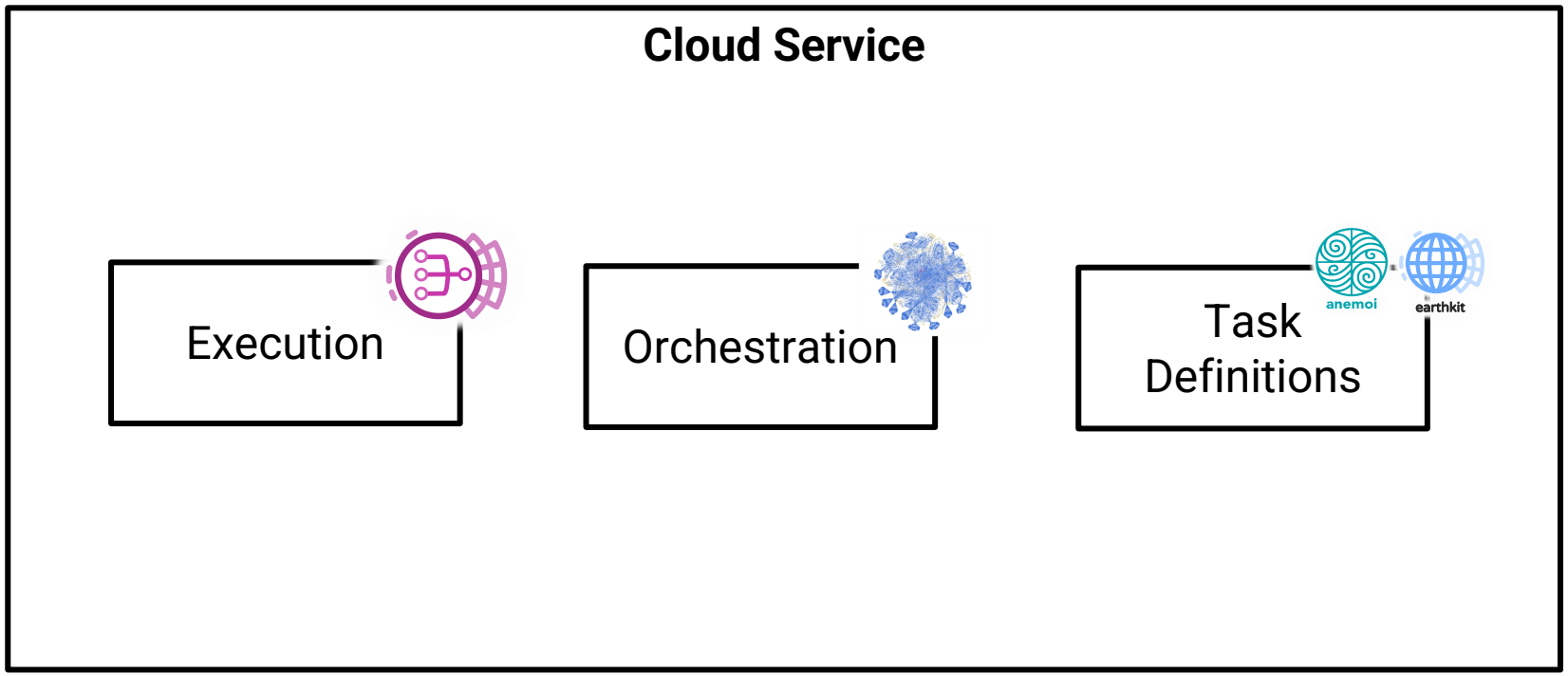

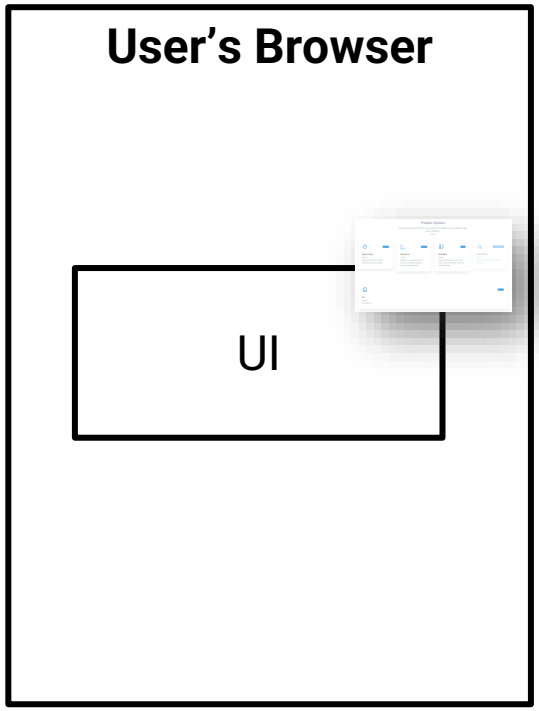

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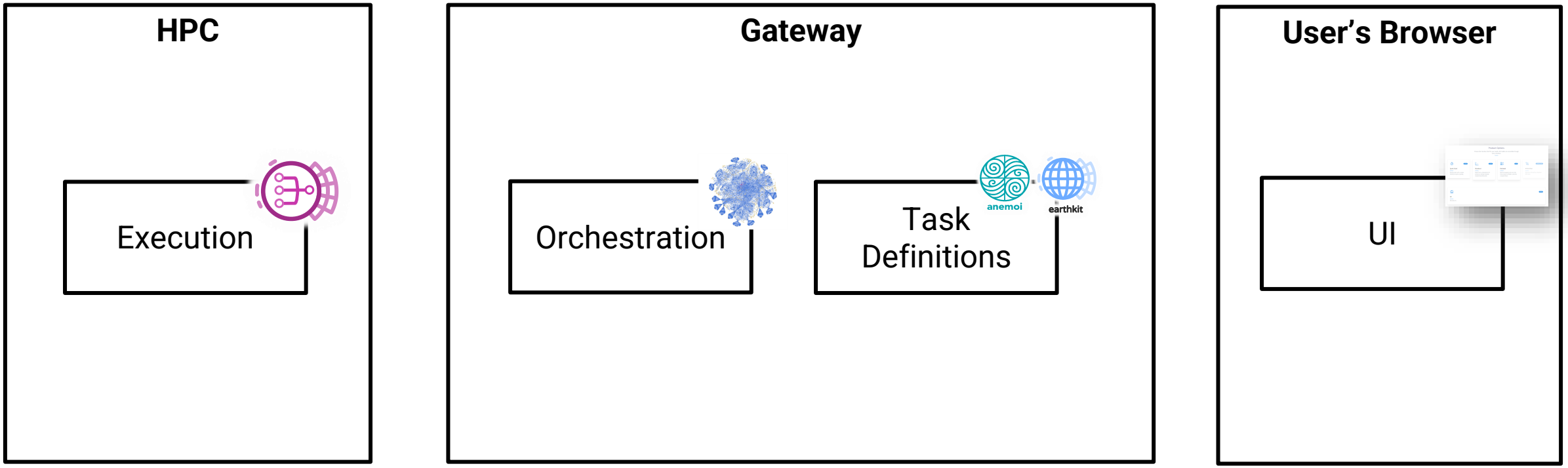
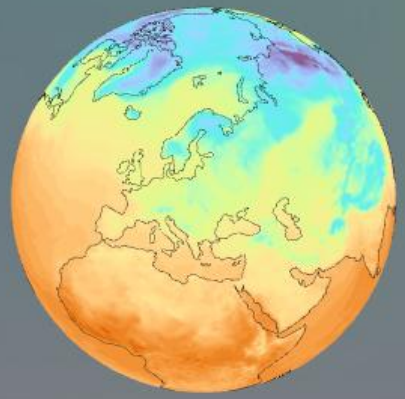


Product generation on the fly, for any Anemoi model

Forecast-in-a-Box reimagines how forecasts are produced and delivered. Rather than relying on remote, data-intensive numerical weather prediction pipelines, Forecast-in-a-Box distributes a self-contained forecasting environment that users can install and run anywhere.

Get Started



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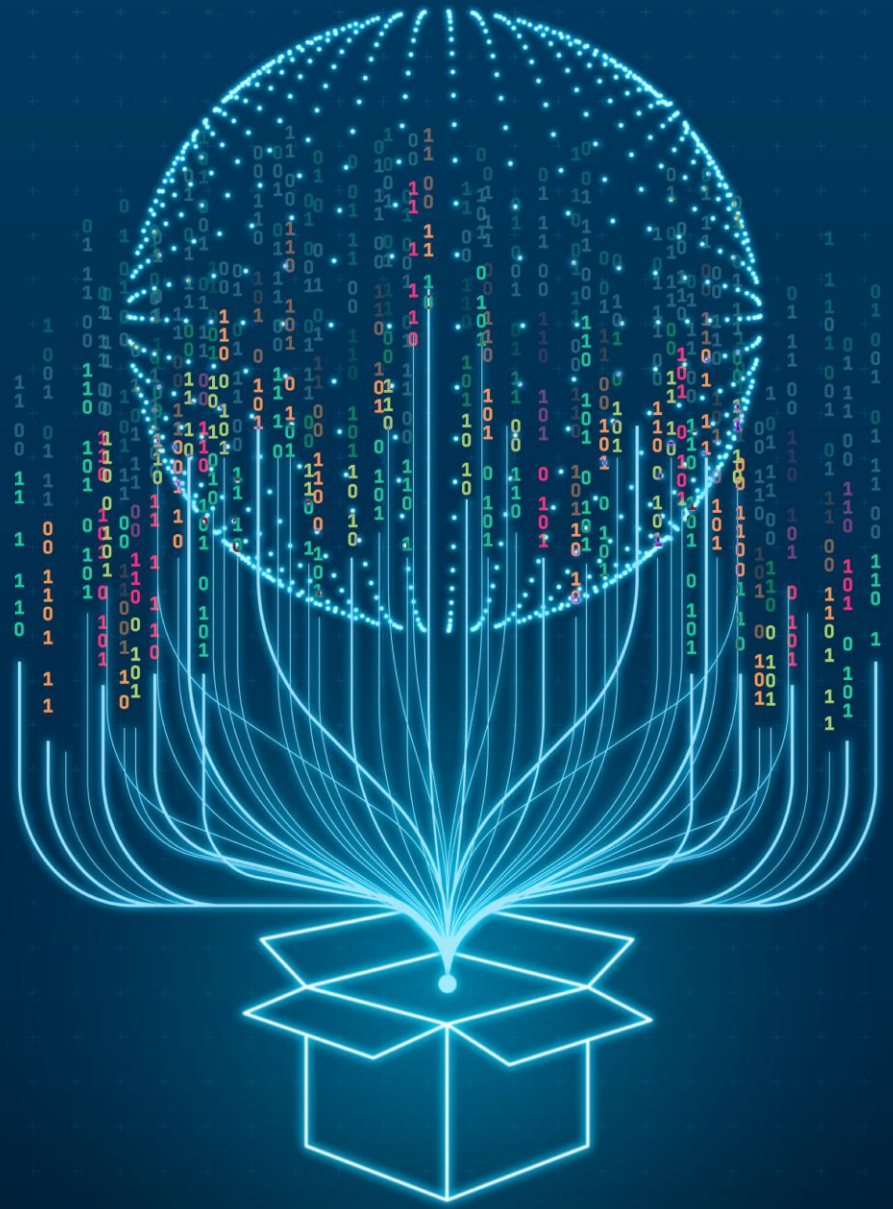

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2026 Timeline

Q1 2026

Prototype V2

- Prototype features reproduced
- New UI
- Plugin system

Q2 2026

Advanced visualisation

- Improved outputs system
- WMS server integrated
- Experiment tracking

Q3/Q4 2026

Refinement and Expansion

- Iterate on design
- Add new products
- Extend to other projects such as SEWA/ArcX