ML forecasting at the Met Office

Ben Fitzpatrick

Head, Science IT Data Management and Processing

AI4NWP, Met Office: Ryan Boult, Lewis Blunn, Hannah Brown, Mark Burgoyne, Helen Buttery, Maria Carvalho, Sebastian Cole, Nathan Creaser, Kirstine Dale, Tom Dodds, Laura Dreyer, Tom Dunstan, Anna-Louise Ellis, Ben Fitzpatrick, Stephen Haddad, Richard Hattersley, Roger Harbord, Aaron Hopkinson, Joel Lalu, Jon Lillis, Suzannah Knight, Richard Lawrence, Sam Madge, Theo McCaie, Nikita Ovcinnikovs, Aled Owen, Steven Ramsdale, Jose Rodriguez, Adam Scaife, Christine Sheldon, David Walters, James Warner, Karina Williams

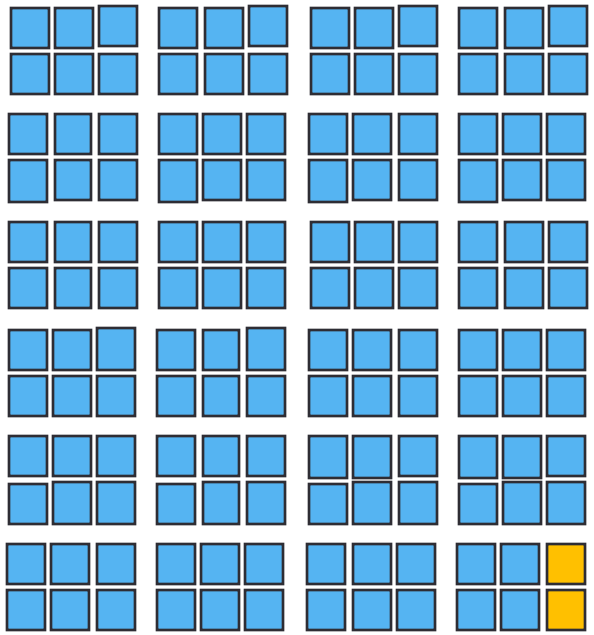
AI4NWP, Alan Turing Institute: Levan Bokeria, Eric Daub, Marc Deisenroth, Dan Delbarre, Mohamad Elmasri, Scott Hosking, David Salvador Jasin, Tomas Lazauskas, Ben MacArthur, Joseph Palmer, James Robinson, Nathan Simpson, Adam Stanton, Iain Stenson, Oliver Strickson, Monica Vakil-Dewar, Peter Yatsyshin, Louisa Van Zeeland

Organisation

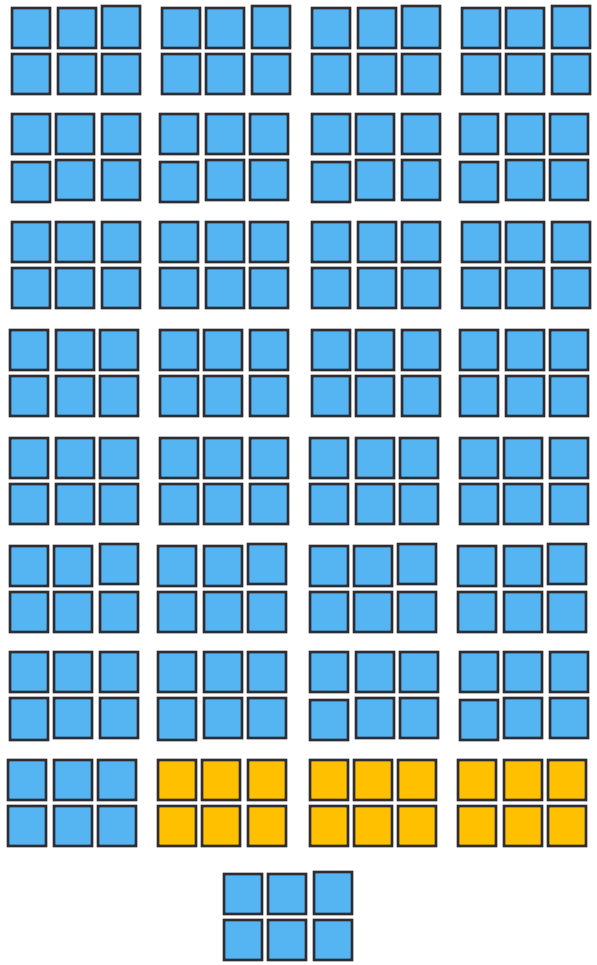
Met Office Science Directorate 2022

= Physical based = ML based

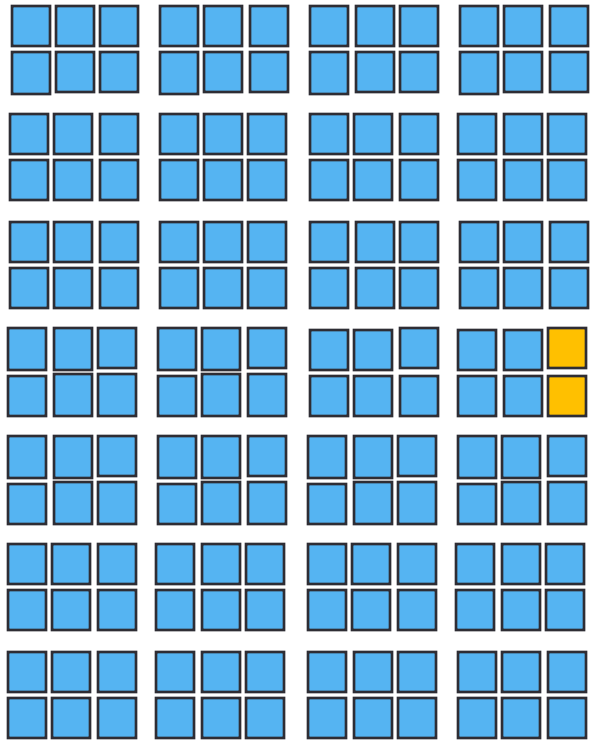
Climate Science



Foundation Science

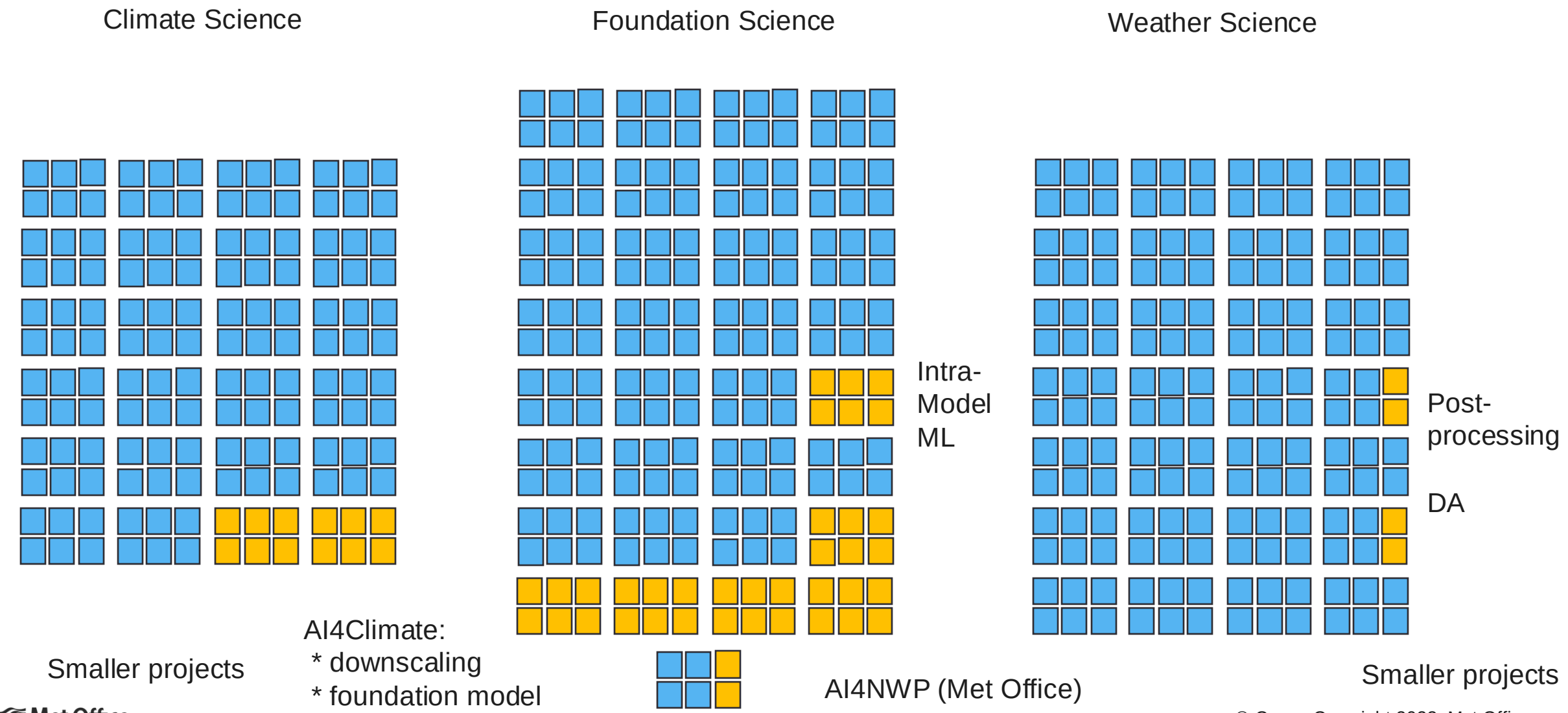


Weather Science



Met Office Science Directorate 2024

■ = Physical based FTE ■ = ML based FTE



AI4Climate (selected highlight)

Climate Science Flagship AI projects

Ambitious high reward AI-enabled projects to transform Climate projections

- **Downscaling (Lead: Ben Booth)**

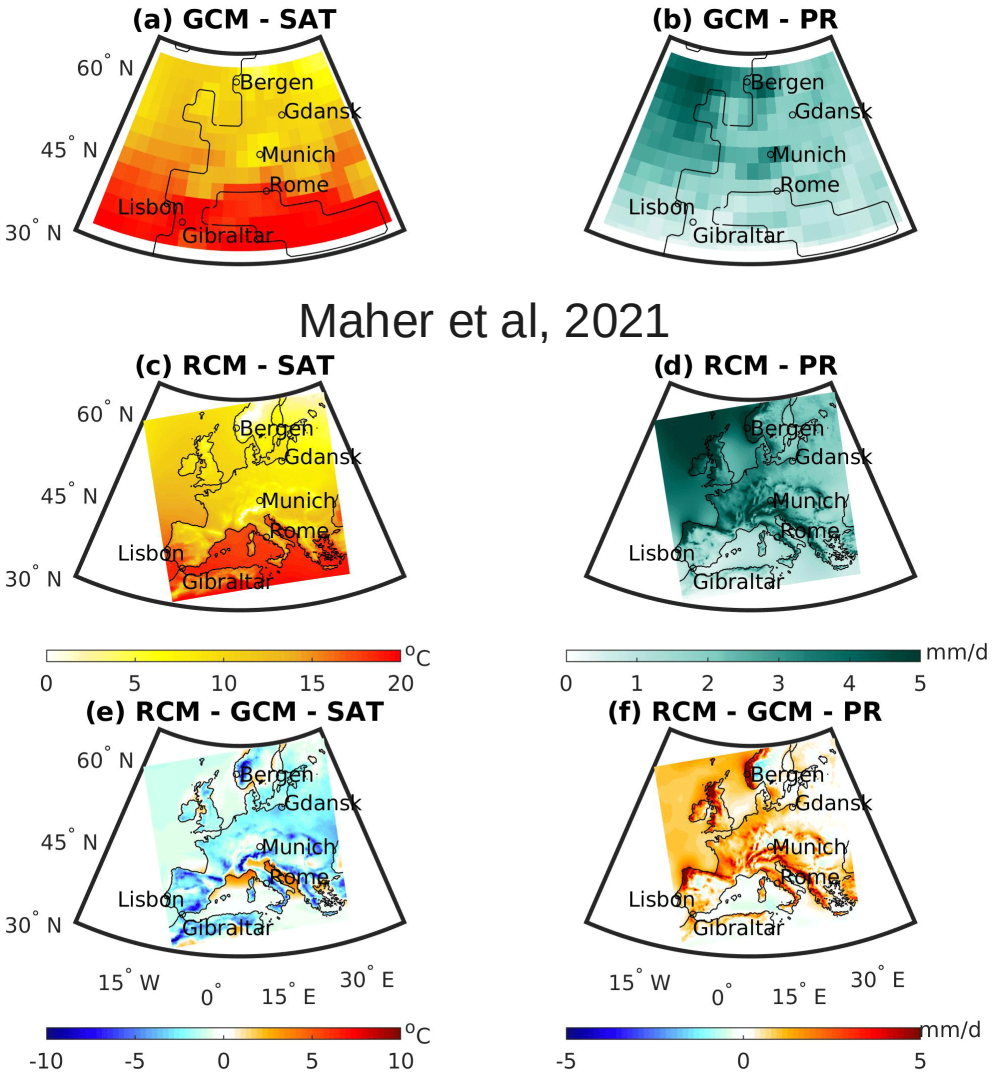
By training ML to emulate downscaling, we can better expose the wider range of climate changes to impact and adaptation

Dynamical Downscaling Strengths:

- Multi-variate, spatially and temporally coherent projections (needed for many impacts models)
- Expose how small-scale physics impacts projections.

Weakness:

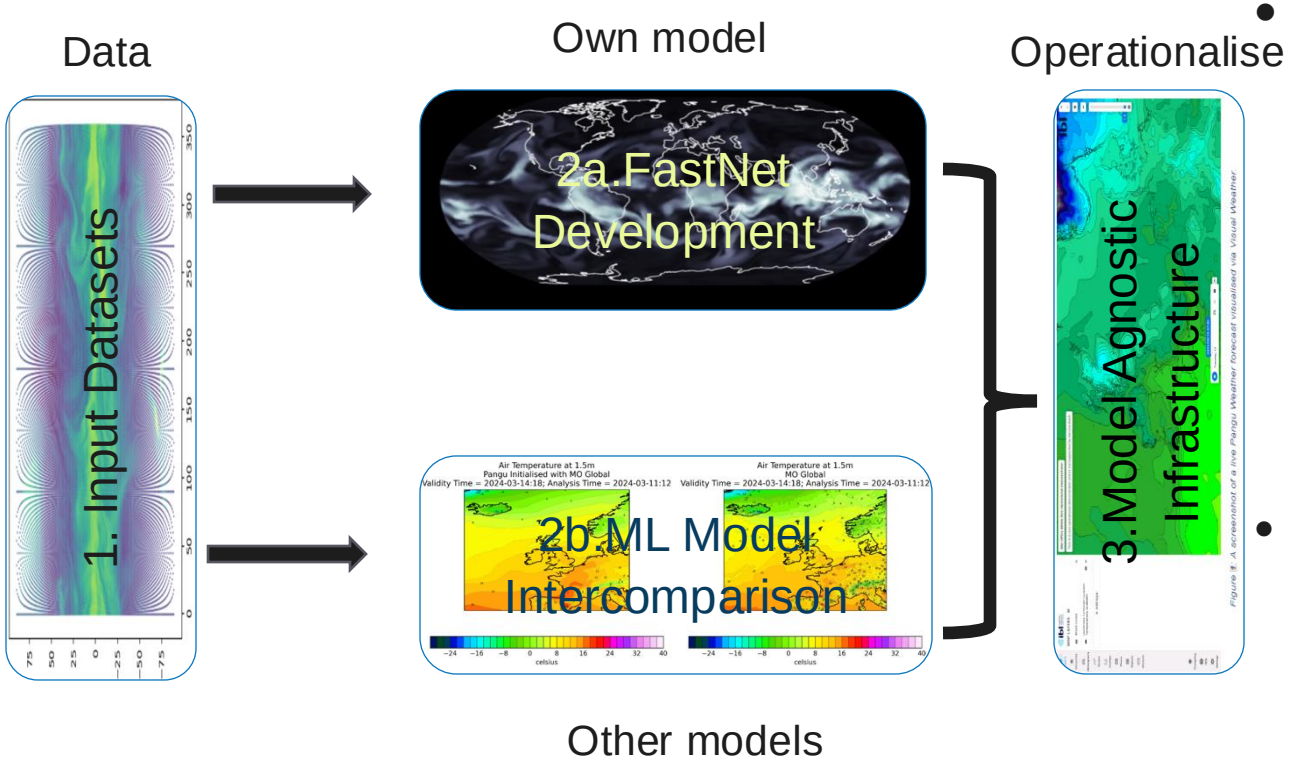
- Limited samples



Maher et al, 2021

AI4NWP

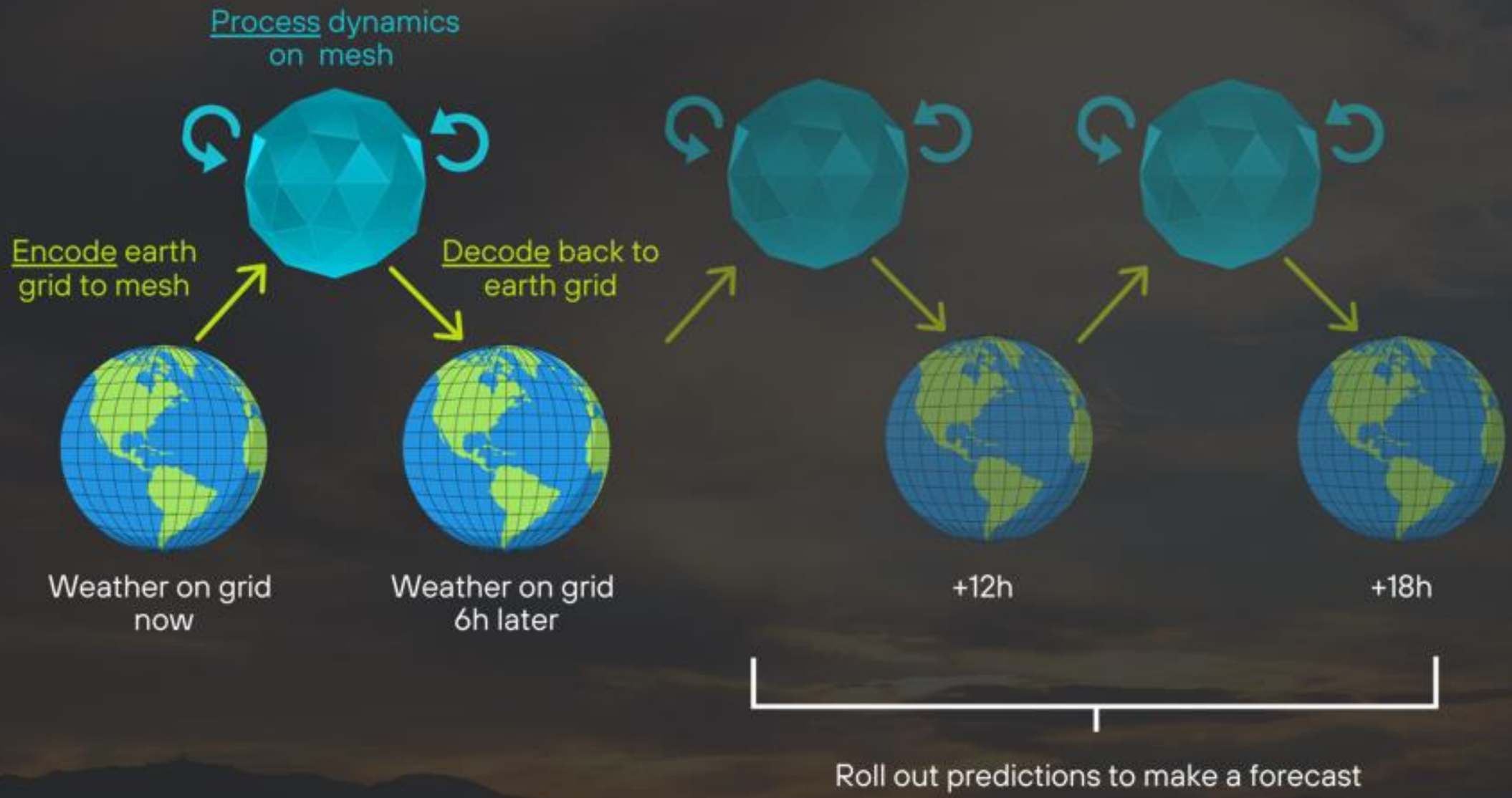
AI for Numerical Weather Prediction (AI4NWP)



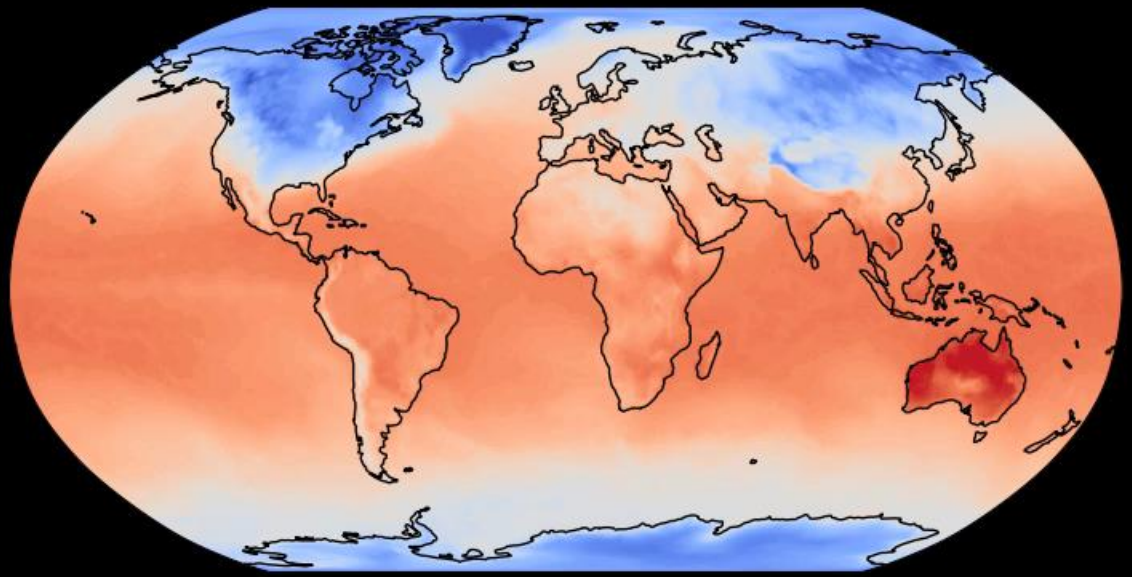
- **Input Datasets**. Provides appropriate, sustainable, datasets for training, testing, and verifying.
- **FastNet Development**: Explores the use of ML for Global and UK weather forecasting. Establishes the capability to exploit data from multiple sources (e.g. model data on different domains, resolutions, time periods, and configurations) and the direct use of observations. Through this project the Met Office and The Alan Turing Institute are developing the ML weather forecast model 'FastNet'.
- **ML Model Intercomparison**: Evaluation of ML weather forecast models for use within the Met Office. Enables comparison of ML models (including FastNet) and physics-based weather forecast models to make appropriate choices for different use cases.
- **Model Agnostic Infrastructure**: Provides greater organisational clarity and demonstrates how to integrate ML NWP models into operational data flows.

FastNet: How our model predicts the weather

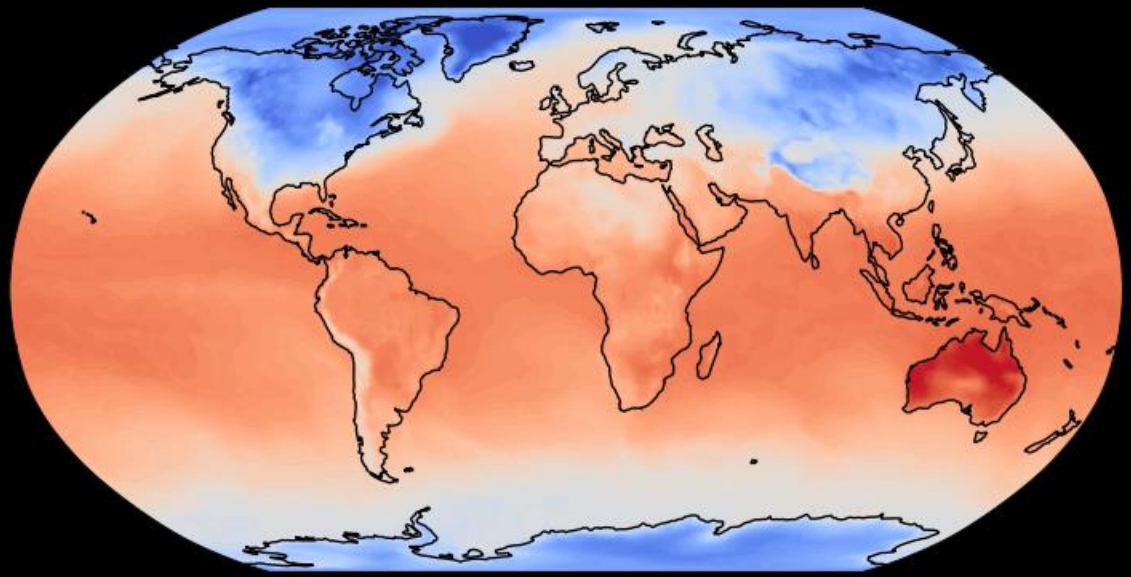
Met Office | The Alan Turing Institute



Ground truth (ERA5)



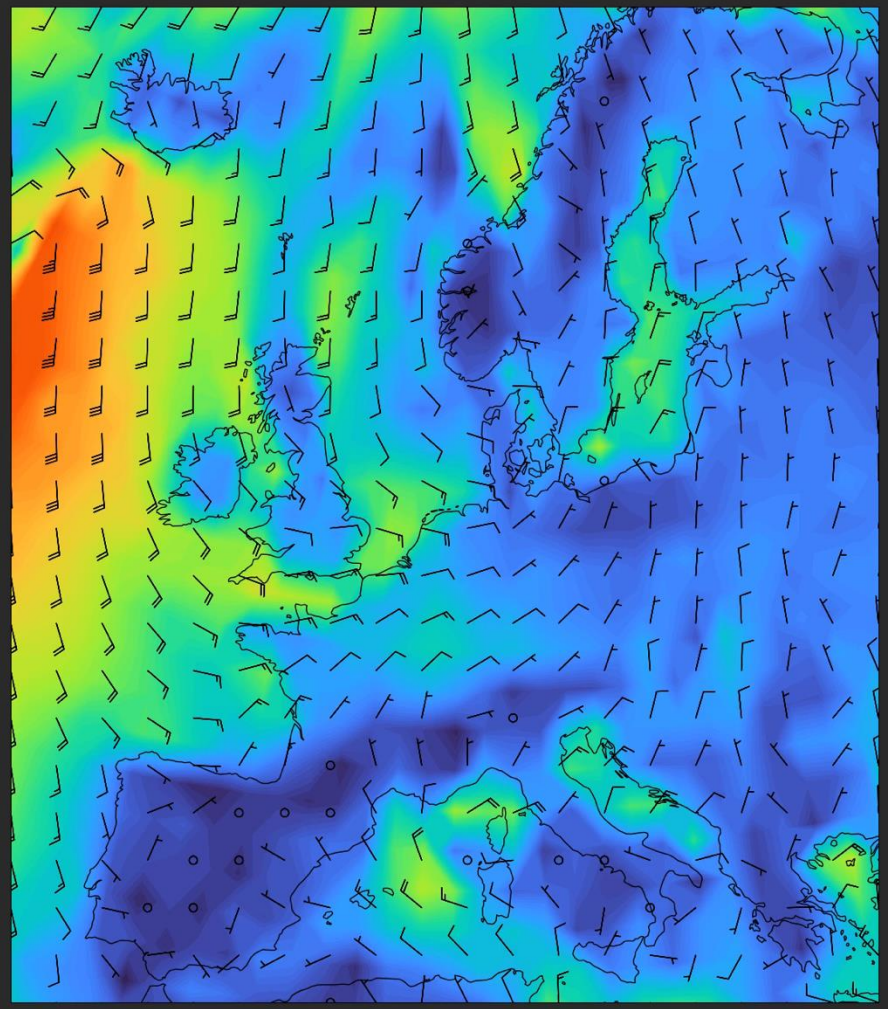
FastNet ML model prediction



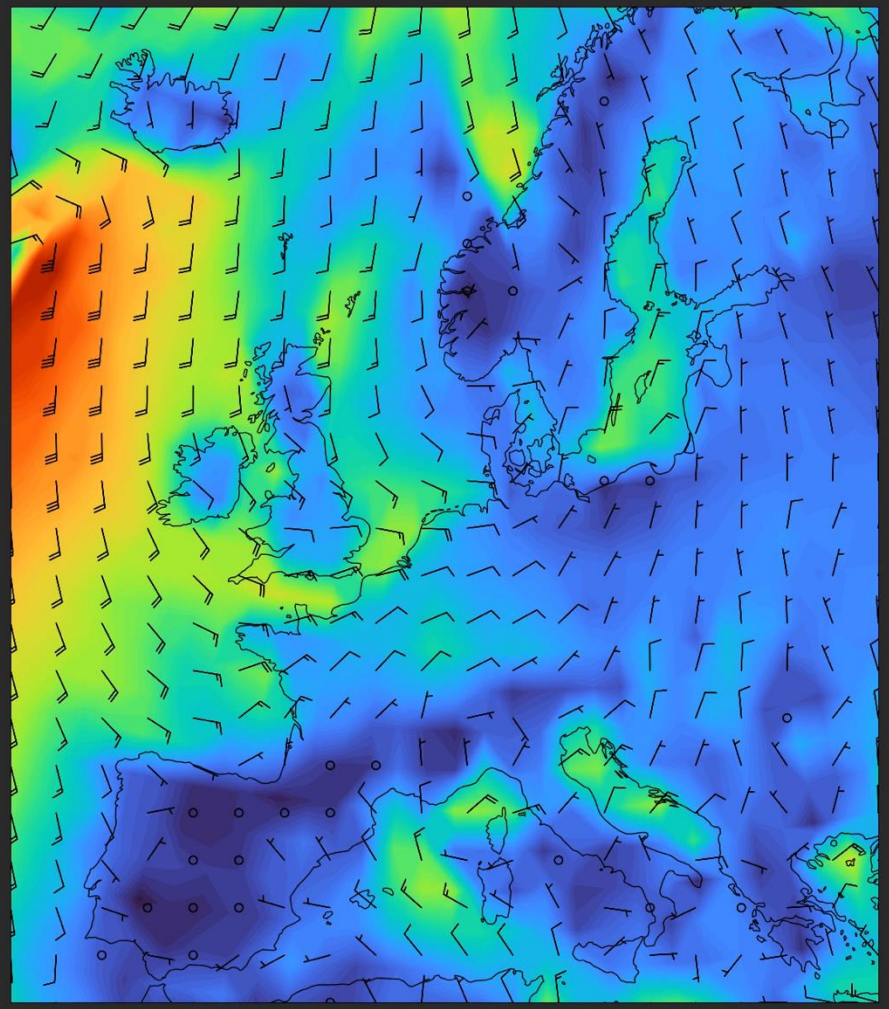
2018-01-01 0600 UTC

Temperature at 2 m above surface level

Ground truth (ERA5)



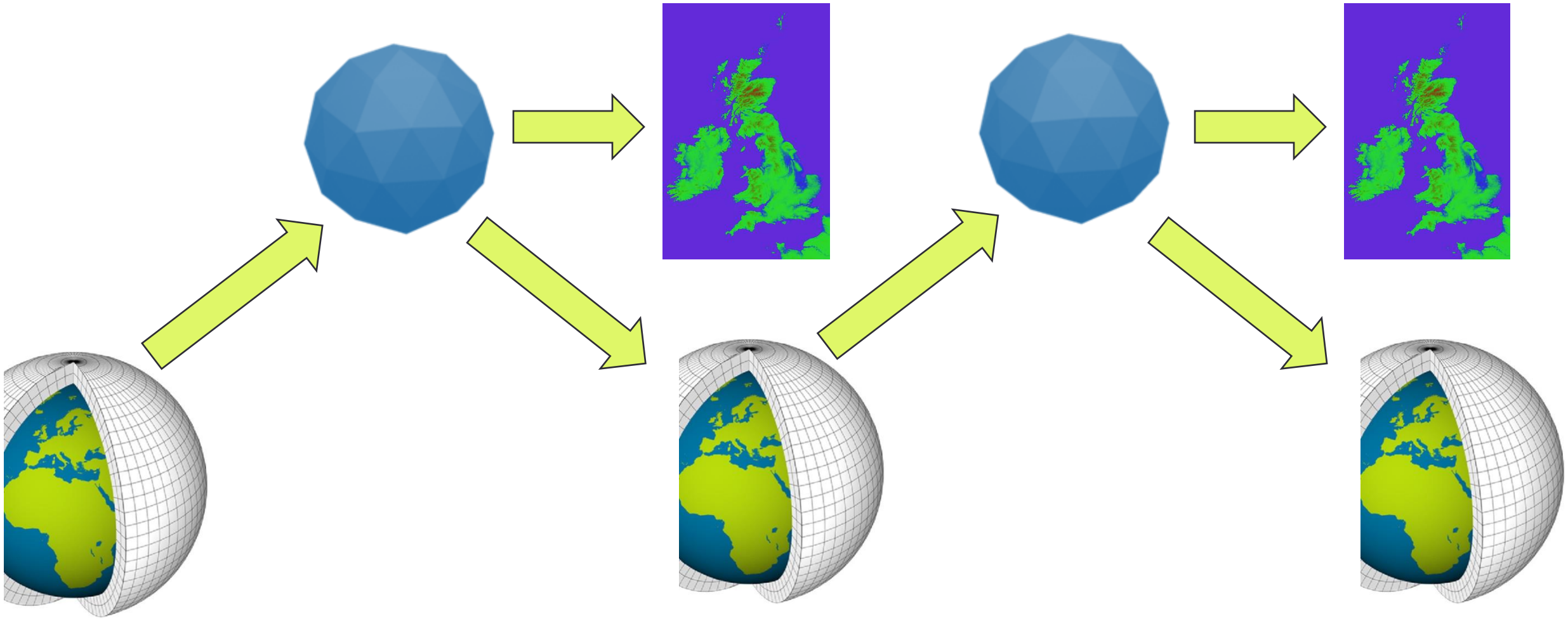
FastNet ML model prediction



2018-02-25 0600 UTC 6 hour forecast

Wind at 10 m above surface level

Exploring additional regional decoders



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Who's using what?

FourCastNet

ERA5

Keisler 2022

ERA5
GFS

Pangu

ERA5

ClimaX

ERA5
CMIP6

GraphCast

ERA5

FengWu

ERA5

FuXi

ERA5
IFS HRES+ENS

Aardvark

Station obs
Sondes
Satellite
IFS HRES

AIFS

ERA5
IFS HRES/ENS

FuXi ENS

ERA5

GenCast

ERA5
ERA5 EDA

Aurora

ERA5
CMIP6
GFS

IFS HRES
GFS
CAMS (Copernicus)

Who's using what?

FourCastNet

ERA5

Keisler 2022

ERA5
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ERA5

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ERA5
ERA5 EDA

Aurora

ERA5
CMIP6
GFS

IFS HRES
GFS
CAMS (Copernicus)

FastNet?

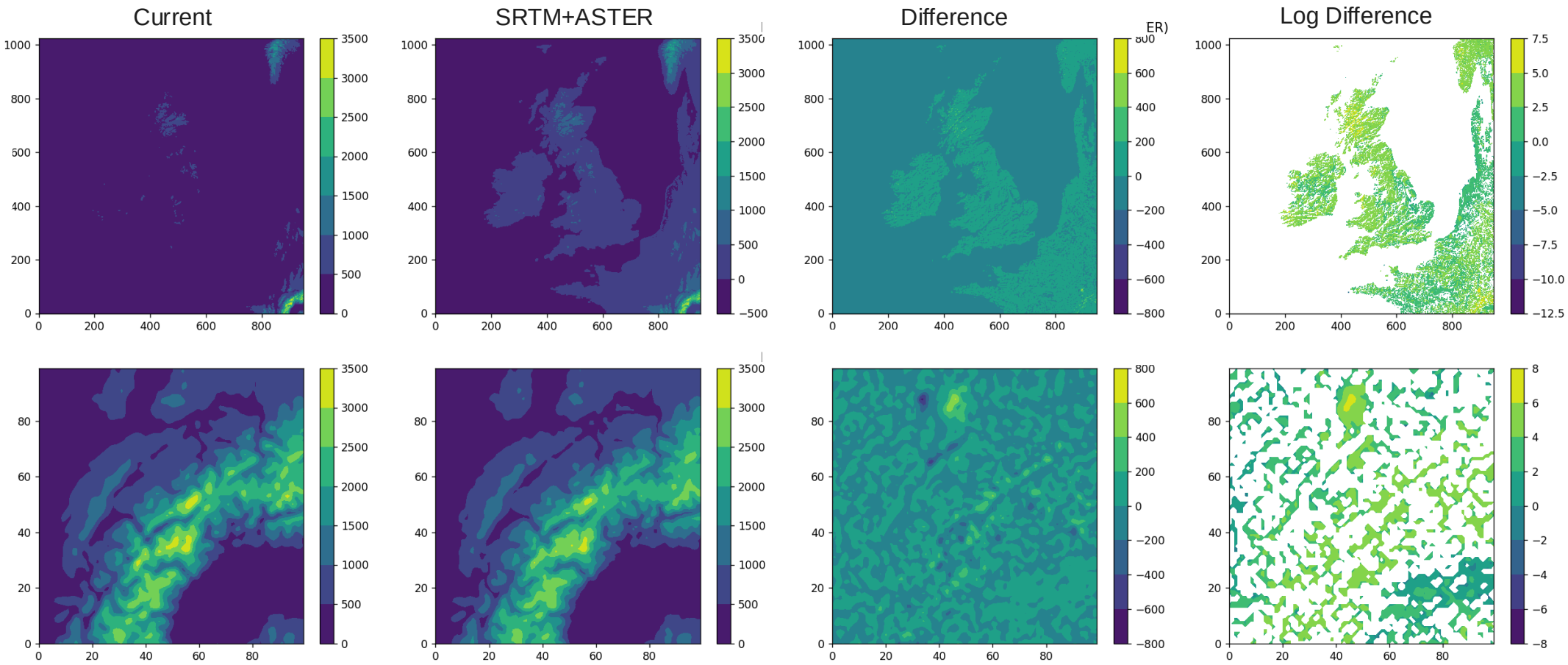
ERA5
Station obs
Sondes
Satellite

Global Model
UKV

UKV orography – current (DTED1-based?) vs smoothed SRTM+ASTER

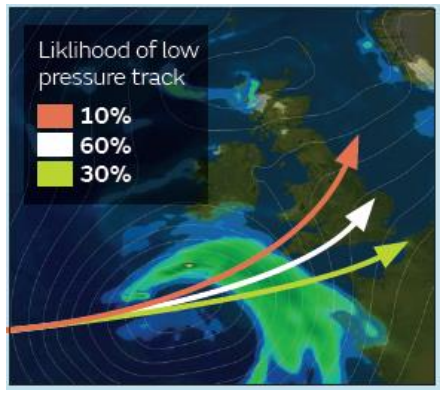
Full UKV domain

French Alps



New UKV data for training purposes (credit: Jon Lillis)

Training data next steps



Complete ~5 years of regional data from operational UKV

Satellite data and station obs

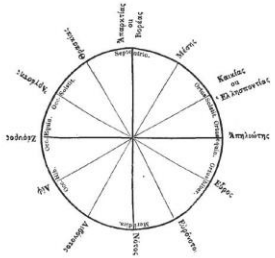
Metadata proposal and implementation

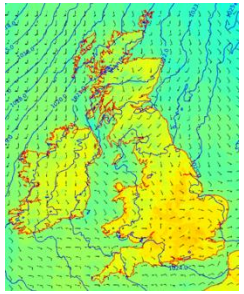
Refactor data preparation code using anemoi/EDIT/StaGE/CDDS functionalities

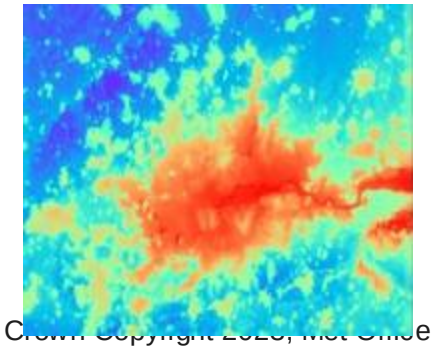
Met Office Global Model datasets

Ensemble datasets

Mesoanalyses, 300m model data







Some Big Gaps

Retention and recruitment of ML staff

Collaboration on data, model comparison, operationalising

Reanalyses

AI-DA

Direct use of obs

Less “likely” pathways

Image credit: Facebook/The Simpsons

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Image credit: simpsons.wiki / The Simpsons

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Image credit: ~~giphy~~/The Simpsons

What next?

- AI/ML as the third forecasting engine alongside UM and Momentum
- More ■, better performance, better use of public money
- Collaboration/cooperation/knowledge between Momentum Partners as a massive good