

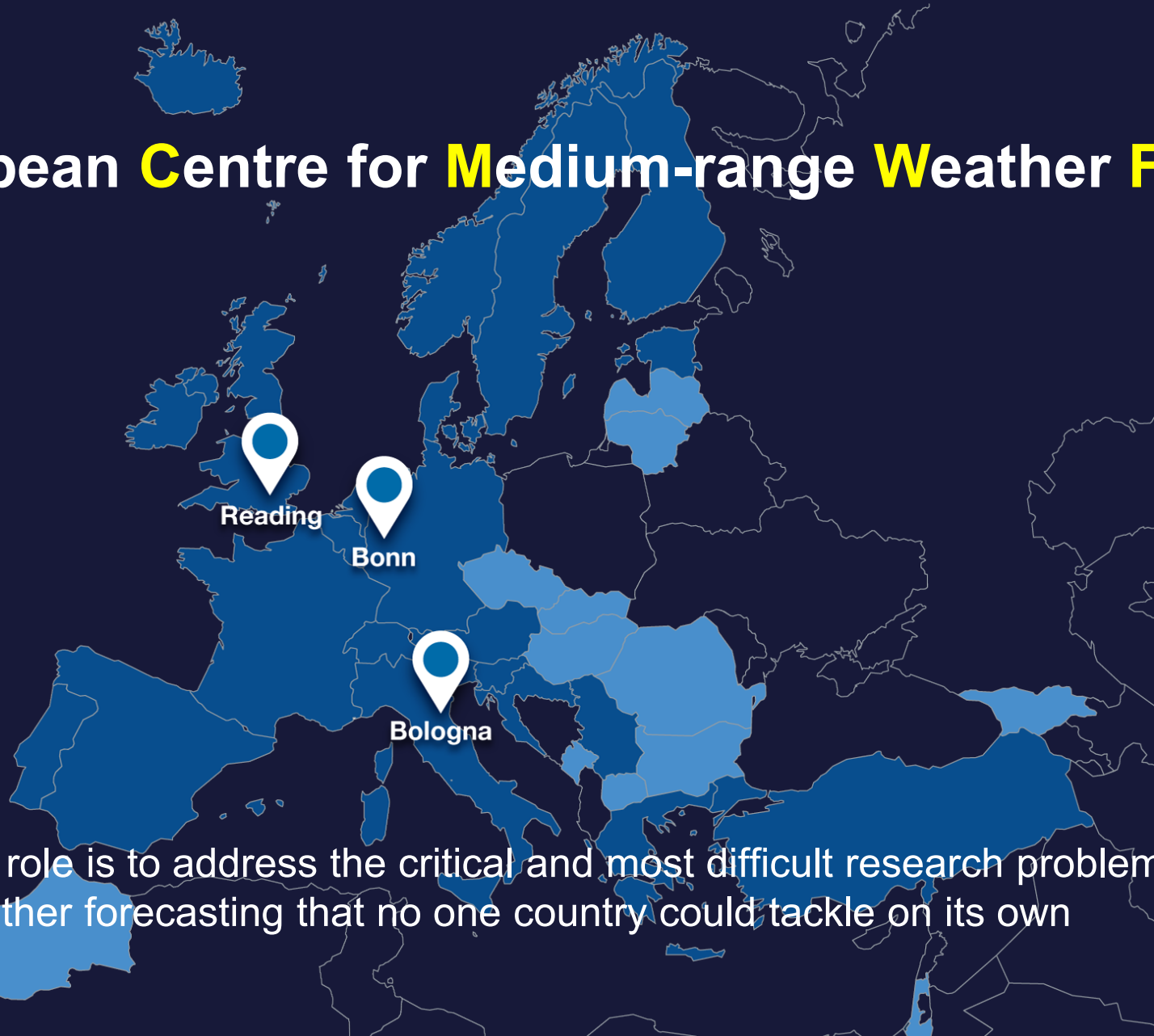
AI Developments at ECMWF: AIFS and beyond...

Mariana Clare

on behalf of many colleagues at ECMWF



European Centre for Medium-range Weather Forecasts

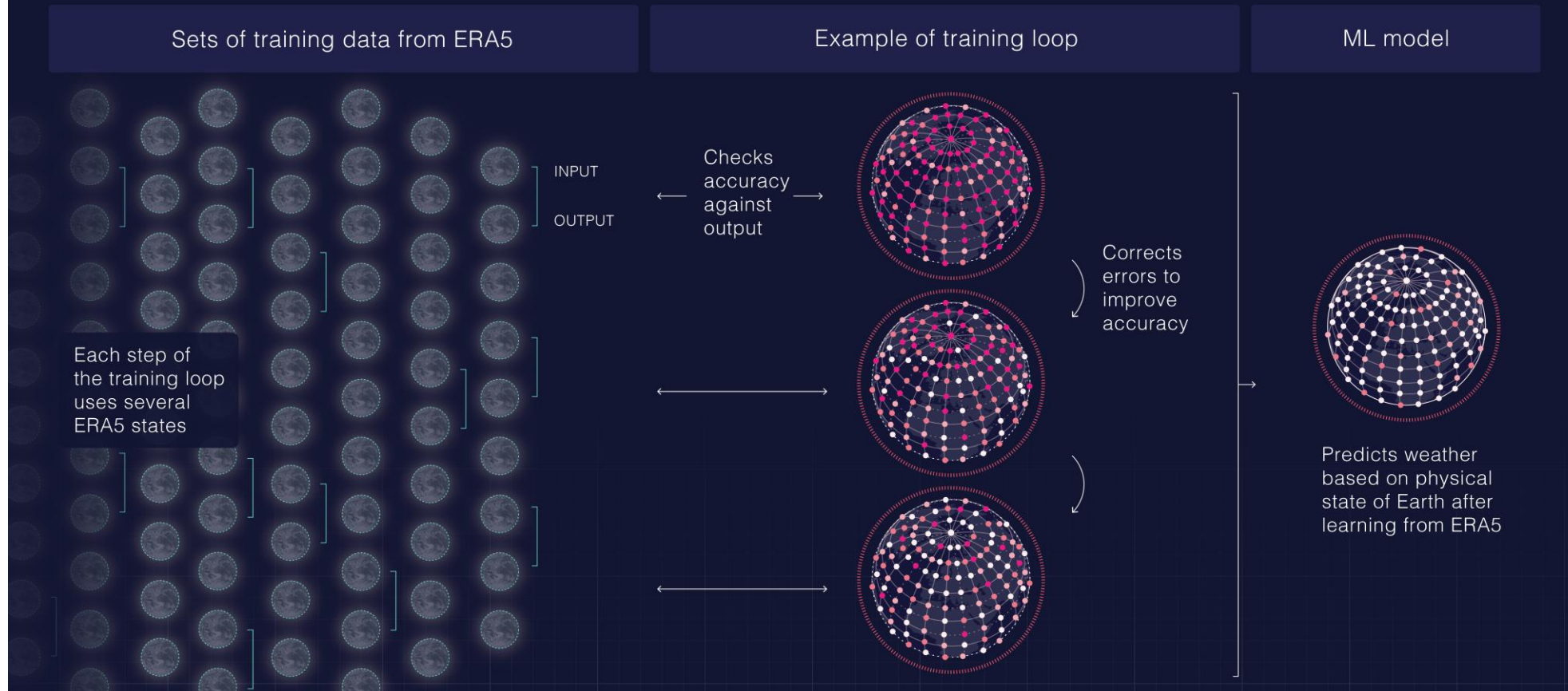


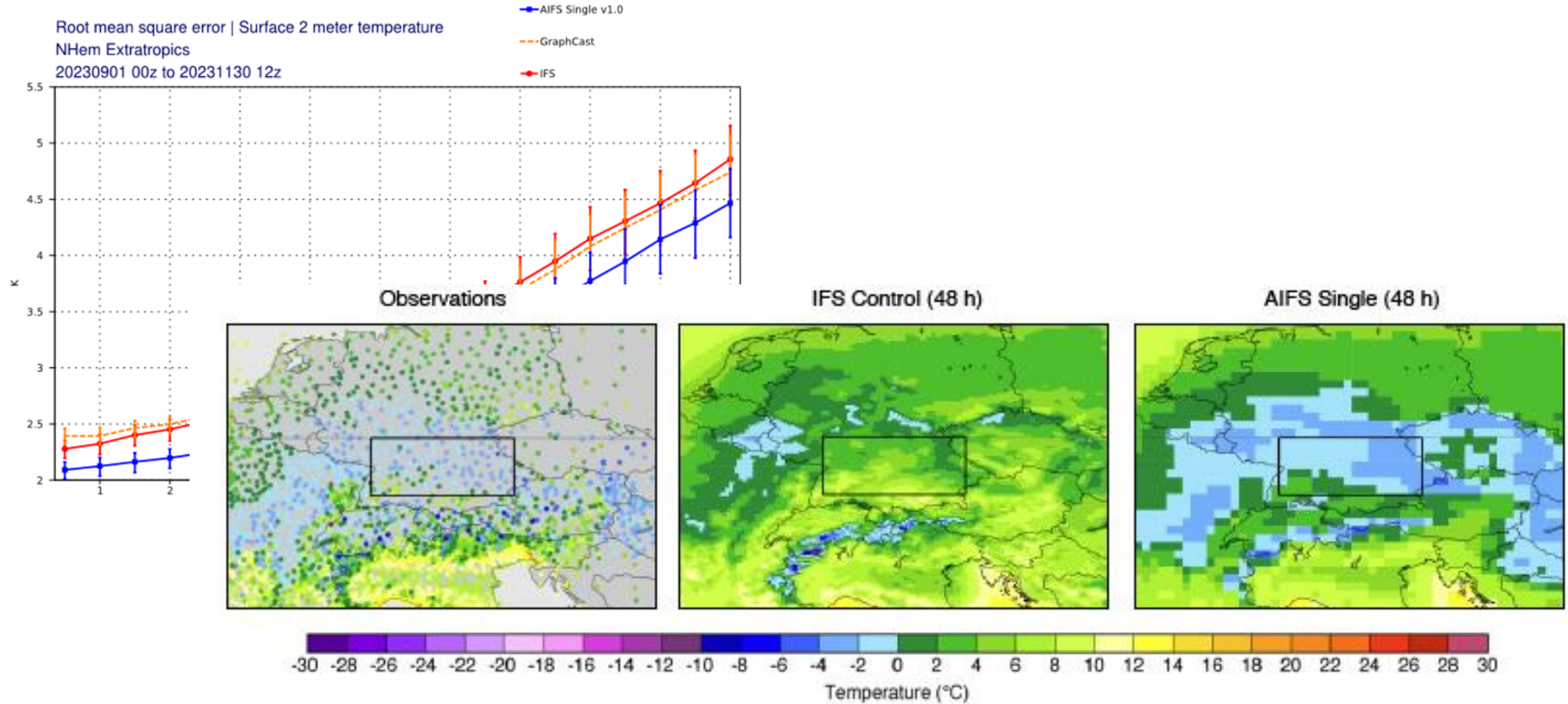
ECMWF's role is to address the critical and most difficult research problems in medium-range weather forecasting that no one country could tackle on its own

AIFS: a data-driven probabilistic weather forecasting system

TRAINING THE AIFS MACHINE LEARNING (ML) MODEL

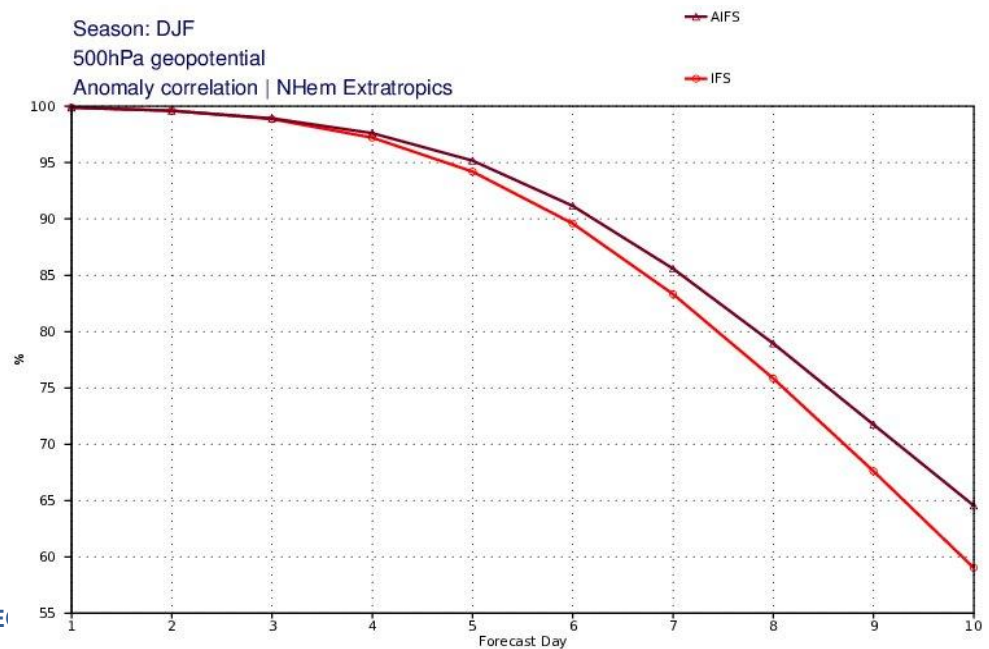
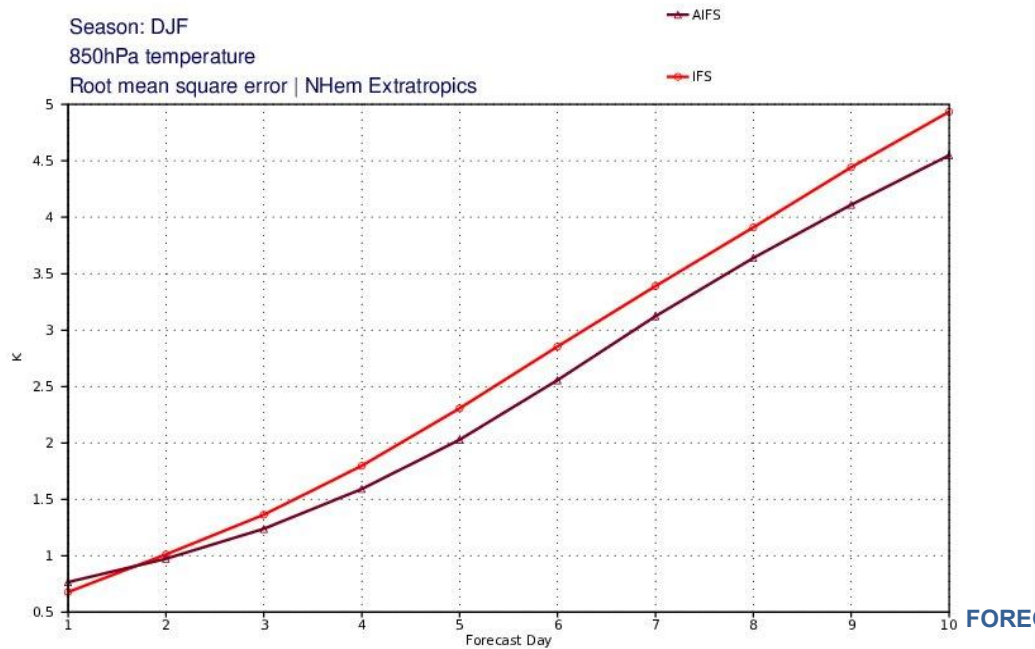
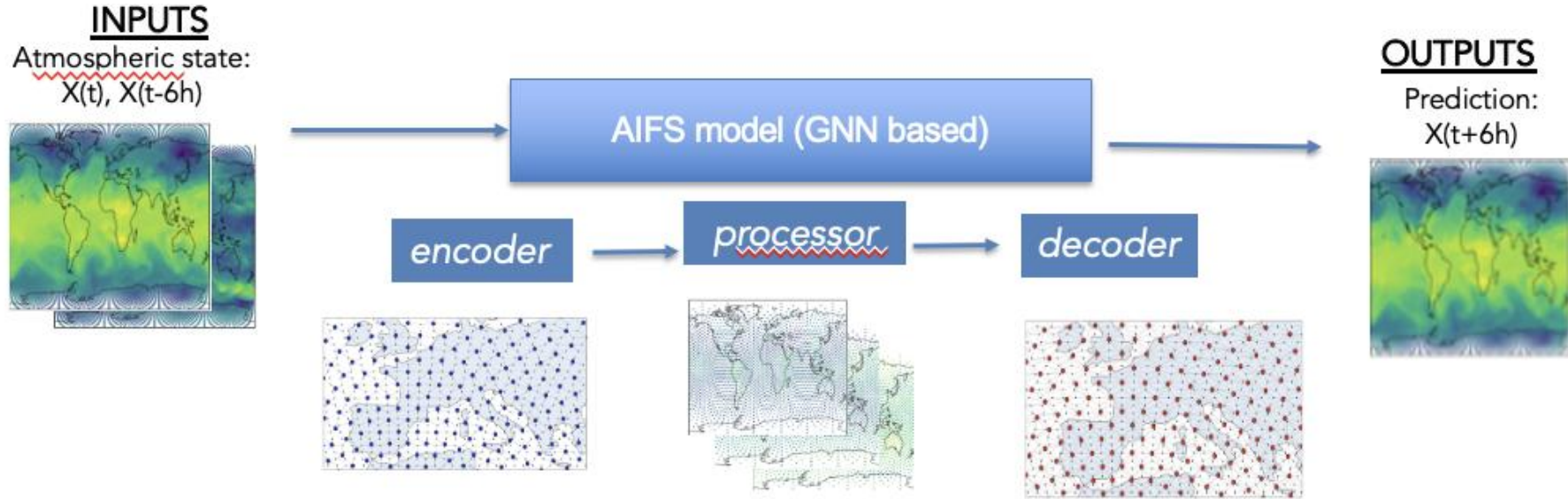
The model is highly accurate due to ERA5, a dataset of hourly physical states of Earth since 1940.





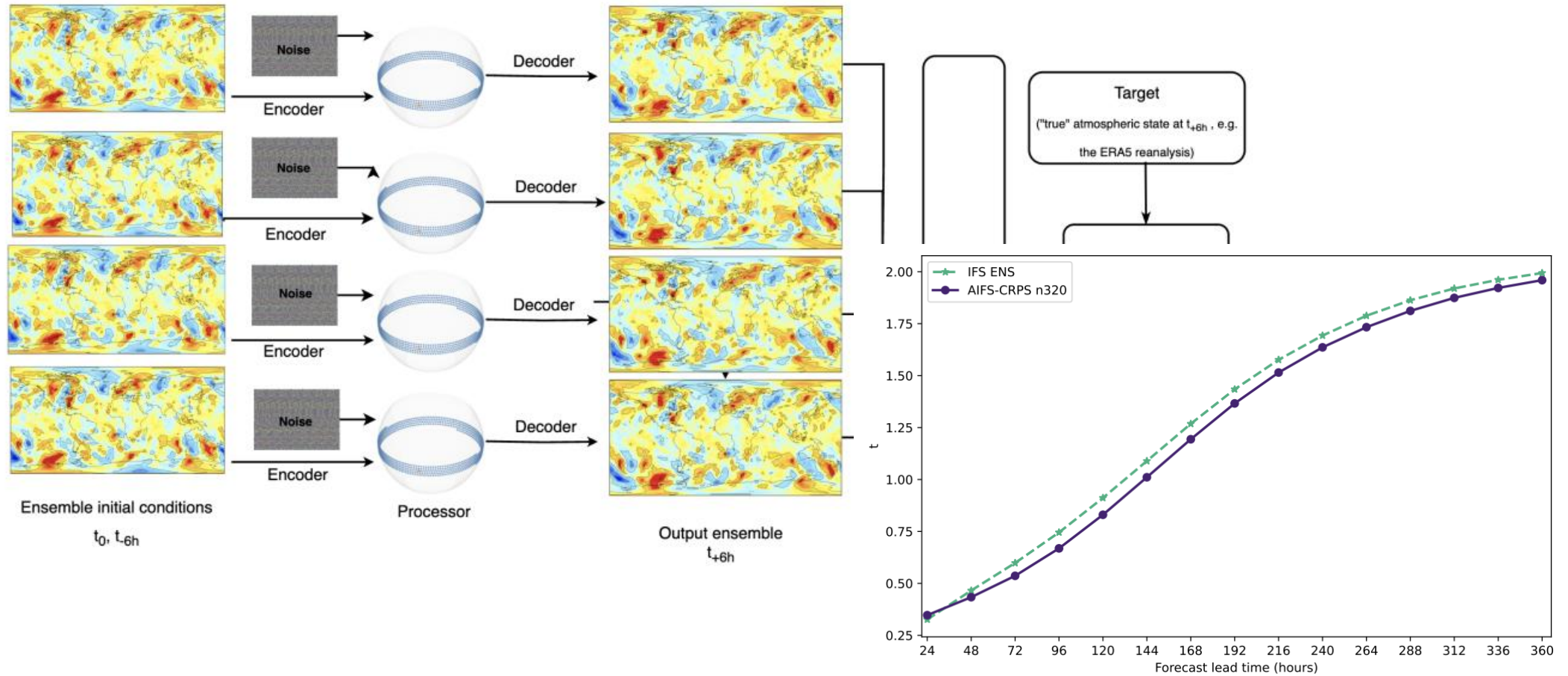
AIFS Single v1

Lang et al 2024a
Operational system
from 25/2/25



AIFS ENS CRPS

Lang et al 2024b
Operational system from 1/7/25



Running AIFS yourself interactively

The screenshot shows the Hugging Face interface for the model `ecmwf/aifs-single-1.0`. The page includes a search bar, navigation tabs (Models, Datasets, Spaces, Posts, Docs, Enterprise, Pricing), and a model card. The model card features a title, a description, and a list of features:

- Improved performance for upper-level atmospheric variables (AIFS Single still uses 13 pressure-levels, so this improvement mainly refers to 50 and 100 hPa)
- Improved skill for total precipitation.
- Additional output variables, including 100 meter winds, snow-fall, surface solar-radiation and land variables such as soil-moisture and soil-temperature.



AIFS Single v1.0



AIFS Ens v1.0

- AIFS Single v1.0 and AIFS Ens v1.0 on Hugging Face – an open platform for sharing the models.
- Includes interactive notebook on how to run from ECMWF open data, can be adapted for other sources.

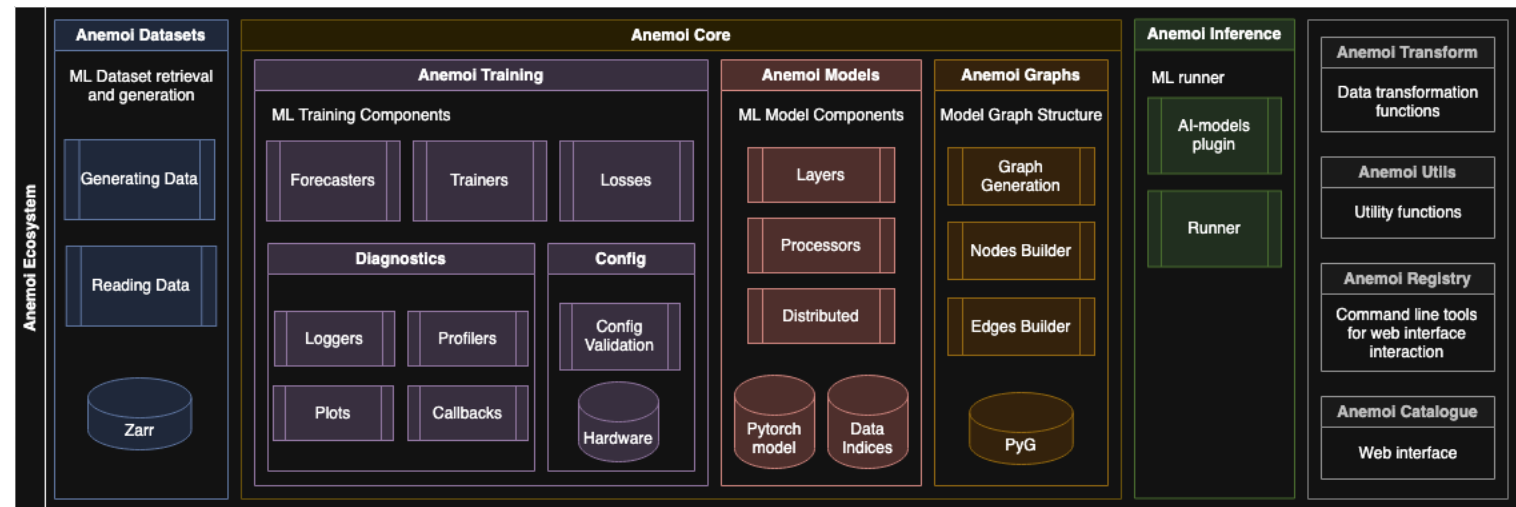
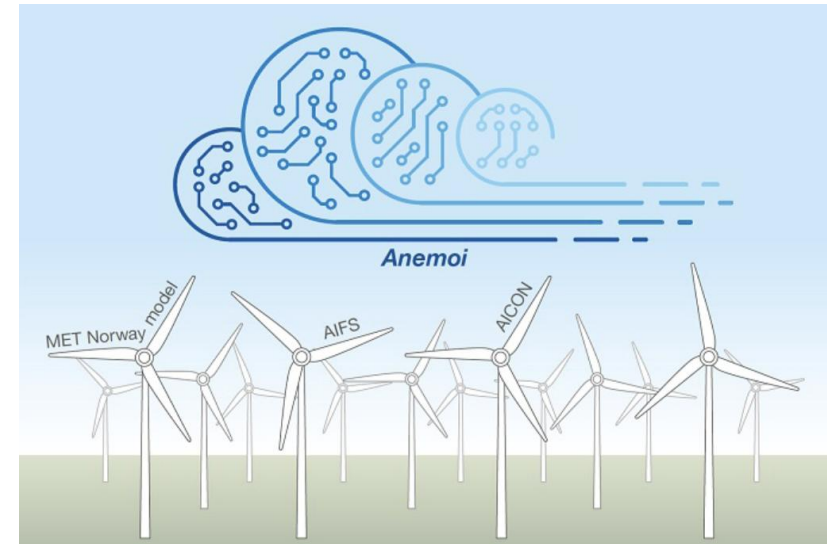
3. Load the Model and Run the Forecast

Download the Model's Checkpoint from Hugging Face & create a Runner

```
In [13]: checkpoint = {"huggingface": "ecmwf/aifs-single-1.0"}
```

Anemoi, the tool behind it all

- Anemoi is an open-source framework that provides a complete toolkit to develop data-driven weather models – from data preparation through to inference
- A highly modular framework organised into different Python packages
- Builds upon on established Python tool including PyTorch, Pytorch Lightning, Hydra, Pydantic, and earthkit.

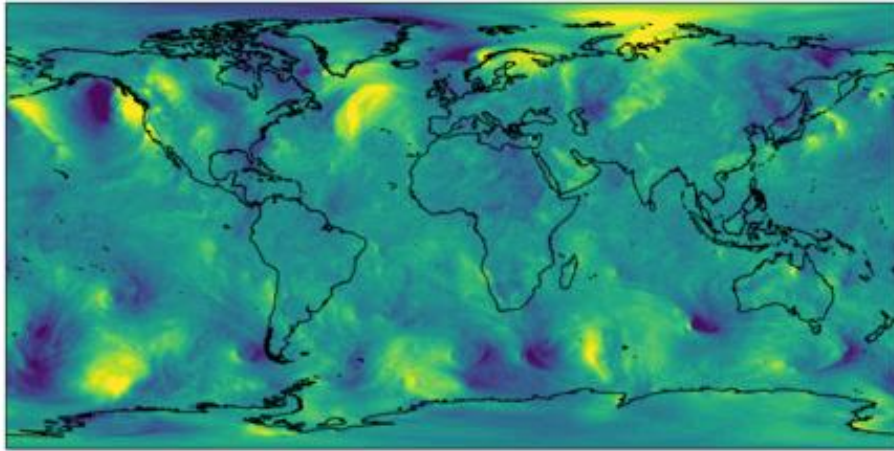


Who is Anemoi?

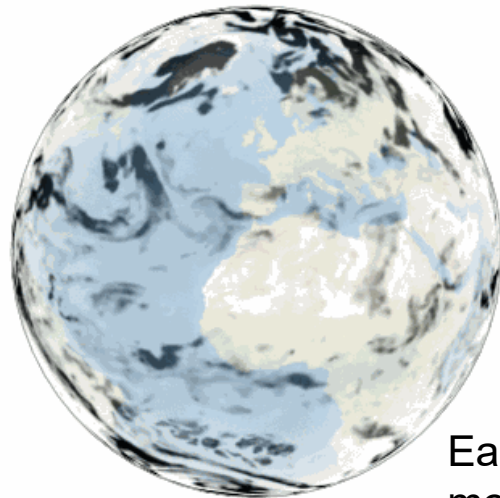


Open-source development driven by European Meteorological Centers and ECMWF

What Anemoui enables?



Training deterministic & ensemble models

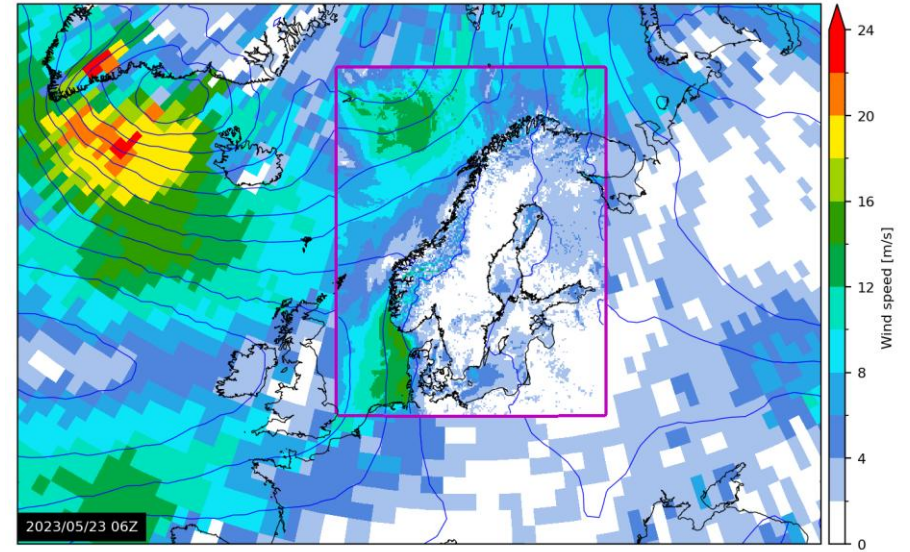


Easy exploration of more atmospheric fields



Regional high-resolution modelling:

Nipen et al. 2024



Real-time running at operation centres
Anemoui is powering ECMWF's operationalisation of AIFS in 2025.

Latest forecast

AIFS CRPS Control: Mean sea level pressure and 850 hPa wind speed

Wind speeds near the surface are roughly proportional to the distance between isobars so closely packed isobars mean strong surface winds...

Latest forecast

AIFS Single: Mean sea level pressure and 850 hPa wind speed

Wind speeds near the surface are roughly proportional to the distance between isobars so closely packed isobars mean strong surface winds...

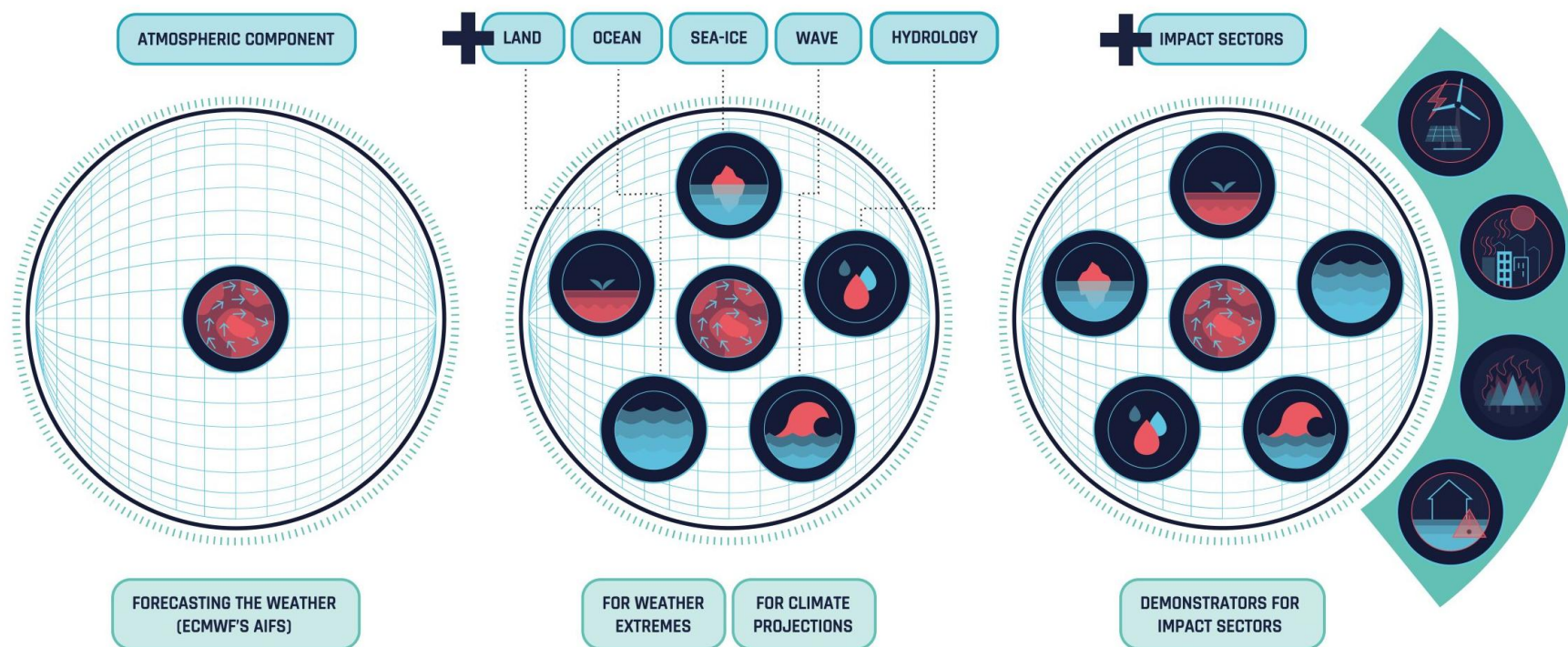
Latest forecast

AIFS CRPS Control: 500 hPa geopotential height and 850 hPa temperature

The 850 hPa level is usually just above the boundary layer and at this level the day-night variation in temperature is generally negligible...

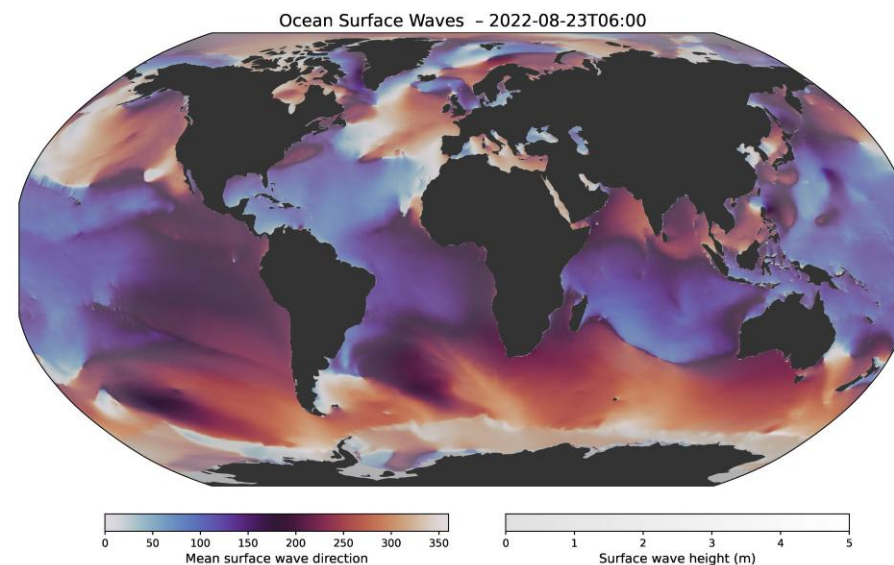
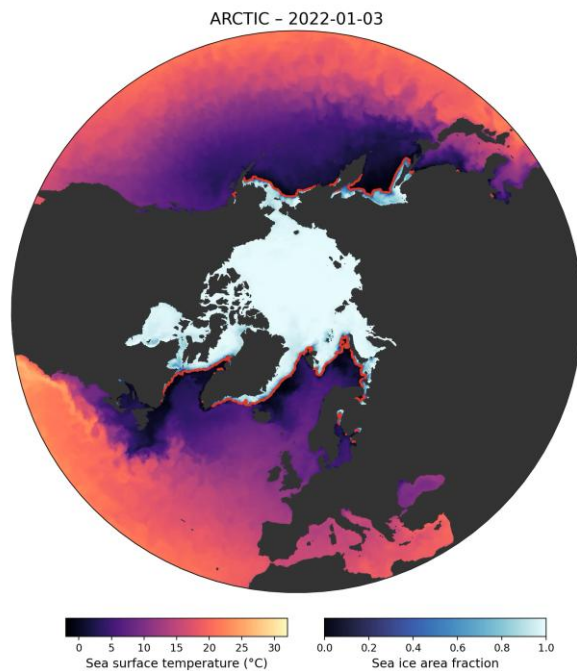
A Full Earth System Model

As part of **Destination Earth** – the ambitious initiative of the European Commission to create digital twins of our planet - ECMWF and its partners aim to expand AIFS to all components of the Earth System, including land, ocean, sea ice, waves and hydrology.



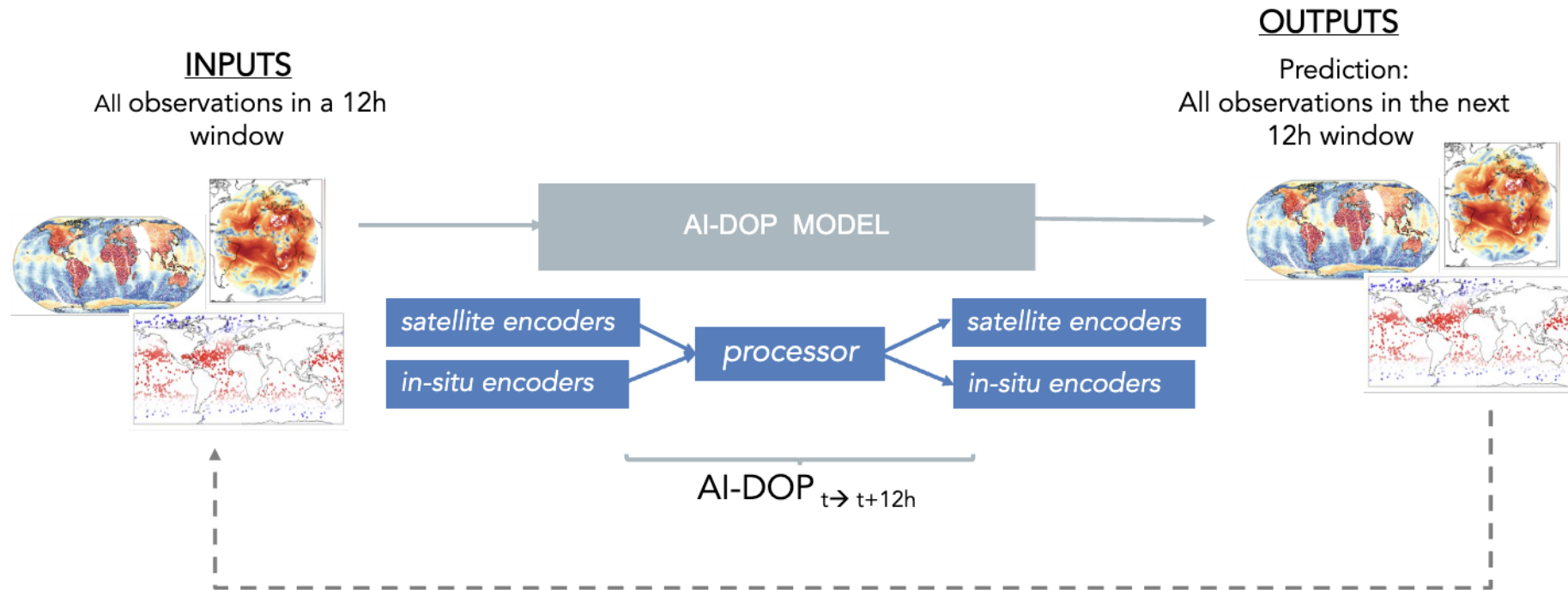
A Full Earth System Model

As part of **Destination Earth** – the ambitious initiative of the European Commission to create digital twins of our planet - ECMWF and its partners aim to expand AIFS to all components of the Earth System, including land, ocean, sea ice, waves and hydrology.



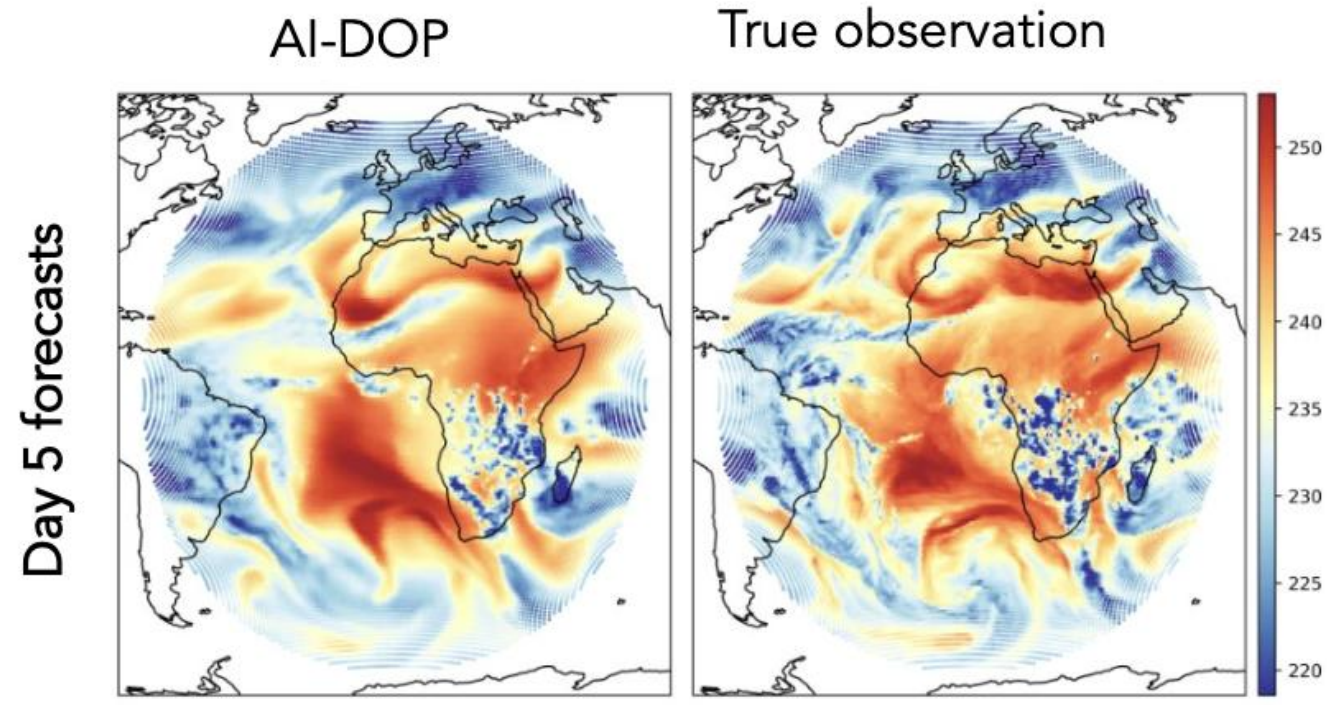
Graph-DOP: Emulating the entire chain using only observations

Alexe et al. 2024



AI-DOP: Emulating the entire chain using only observations

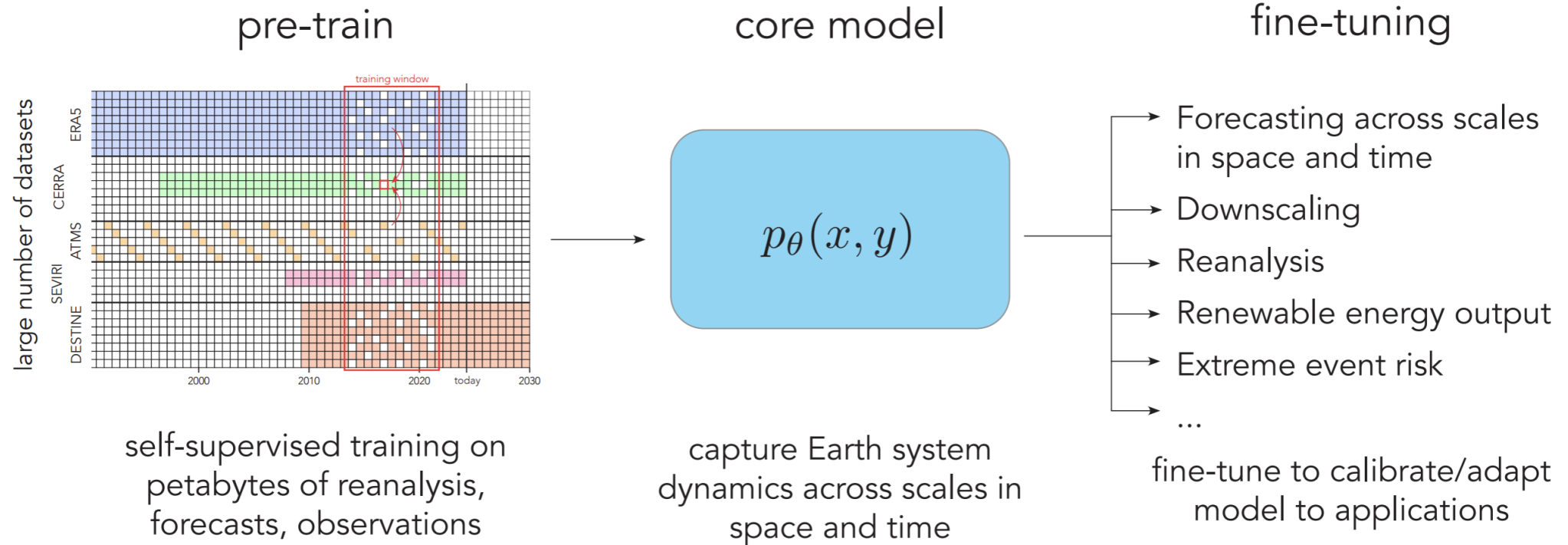
McNally, Alexe et al. 2024



WeatherGenerator



A pan-European initiative to build an open source foundational model for weather and climate



Summary

- ECMWF has launched the first operational data-driven weather forecasting system, AIFS
- Working with our member states, we have built Anemoi, an open-source framework that provides a complete toolkit to develop data-driven weather models
- And there's more to come:
 - Full Earth System model
 - AI-DOP
 - WeatherGenerator
 -

Model Checkpoints



AIFS Single v1.0



AIFS Ens v1.0

Code



Anemoi code tour



Anemoi GitHub Repo



WeatherGenerator
GitHub Repo

Papers



AIFS



AIFS Ens



Graph-DOP

Summary

- ECMWF has launched the first operational data-driven weather forecasting system, AIFS
- Working with our member states, we have built Anemoi, an open-source framework that provides a complete toolkit to develop data-driven weather models
- And there's more to come:
 - Full Earth System model
 - AI-DOP
 - WeatherGenerator
 -

Model Checkpoints



AIFS Single v1.0



AIFS Ens v1.0

Code



Anemoi code tour



Anemoi GitHub Repo



WeatherGenerator
GitHub Repo

Papers



AIFS



AIFS Ens



Graph-DOP

Summary

- ECMWF has launched the first operational data-driven weather forecasting system, AIFS
- Working with our member states, we have built Anemoi, an open-source framework that provides a complete toolkit to develop data-driven weather models
- And there's more to come:
 - Full Earth System model
 - AI-DOP
 - WeatherGenerator
 -

Model Checkpoints



AIFS Single v1.0



AIFS Ens v1.0

Code



Anemoi code tour



Anemoi GitHub Repo



WeatherGenerator
GitHub Repo

Papers



AIFS



AIFS Ens



Graph-DOP

Summary

- ECMWF has launched the first operational data-driven weather forecasting system, AIFS
- Working with our member states, we have built Anemoi, an open-source framework that provides a complete toolkit to develop data-driven weather models
- And there's more to come:
 - Full Earth System model
 - AI-DOP
 - WeatherGenerator
 -

Model Checkpoints



AIFS Single v1.0



AIFS Ens v1.0

Code



Anemoi code tour



Anemoi GitHub Repo



WeatherGenerator
GitHub Repo

Papers



AIFS



AIFS Ens



Graph-DOP

Summary

- ECMWF has launched the first operational data-driven weather forecasting system, AIFS
- Working with our member states, we have built Anemoi, an open-source framework that provides a complete toolkit to develop data-driven weather models
- And there's more to come:
 - Full Earth System model
 - AI-DOP
 - WeatherGenerator
 -

Model Checkpoints



AIFS Single v1.0



AIFS Ens v1.0

Code



Anemoi code tour



Anemoi GitHub Repo



WeatherGenerator
GitHub Repo

Papers



AIFS



AIFS Ens



Graph-DOP