

UEF 2026

Extreme Temperature Forecasts



ECMWF Updates

- Model Cycles
- Research
- Machine Learning
- Forecasting and Services

30 minutes for Q&A



Questions at any time via Slido

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UEF 2026

Extreme Temperature Forecasts



Model cycle updates

Mike Sleigh

Head of Integrated Forecast Systems

slido

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What this update covers

- The current IFS cycle roadmap
- The main dates users should plan around
- Where the larger user-facing impacts are likely to be

Cycle roadmap

- **Cy49r2** - ERA6, EAC5 and SEAS6
- **Cy50r1** - current operational IFS cycle
- **Cy50r2** - technical consolidation and GRIB2-only forecasts
- **Cy51r1** - next main scientific cycle, linked to the next HPC
- **AIFS** - operational and experimental ML forecast system updates alongside IFS

Cy49r2 / ERA6

- Dedicated cycle for systems that update less frequently than operational NWP
- Main users: ERA6, EAC5 and SEAS6
- *ERA6 production started on March 2026*
- EAC5 to follow after ERA6
- SEAS6 first forecast remains targeted for late Q3 2026
 - Operational declaration expected in Q4 2026
 - Parallel running with SEAS5 before final SEAS5 forecast in Jan 2027
 - See Tim Stockdale's talk

Cy50r1 / AIFS v2

- This is now the current operational IFS cycle
- Implemented operationally on 12 May 2026
- AIFS v2 was implemented operationally alongside IFS 50r1

Cy50r2 / GRIB2

- Meteorologically neutral technical consolidation cycle
- Consolidates the main development streams:
 - Cy49r2 for ERA6, EAC5 and SEAS6
 - Cy50r1 for NWP and COMPO
 - Cy49r3 for Destination Earth
 - Cy50r3 for GPU and HPC benchmarking work
- Completes the transition to GRIB2-only forecasts
- This is the largest near-term technical change for many downstream users

Cy50r2 timeline

- Release Candidate Phase expected to start in Q4 2026
 - 6-month Release Candidate Phase
- Implementation target Q2 2027
- Static sample data set (50r1 output in full-GRIB2) available soon for exploration / testing
 - (and give us feedback)
 - See Sebastien Villaume's talk

Cy51r1

- Requires a consolidated Cy50r2 baseline
- Various candidates for science improvements; no firm decisions yet
- Development likely to run into commissioning of the next HPC
- Implementation: as soon as practical after the next HPC is commissioned
- Small chance of opportunistic pre-HPC upgrade

AIFS

- AIFS v2 (Single and ENS) operational with IFS 50r1 from 12 May 2026
- AIFS sub-seasonal remains an experimental target for Q2 2026
- AIFS-Single v3 and AIFS-ENS v3 are pencilled in for Q4 2026
 - Exact configuration still to be confirmed
- Expect the physical and ML forecast systems to continue evolving together, but not always on identical release paths
 - AIFS upgrades can/may occur in-between IFS cycle upgrades
 - At IFS cycle upgrades it is highly probable that an AIFS upgrade is also necessary due to the impact of initial conditions

What this means for users

- Cy50r1 is now operational
- The next major planning item is Cy50r2 and the GRIB2-only transition
- Cy51r1 is the next major scientific cycle, but its operational implementation is tied to the HPC transition
- AIFS updates will continue to arrive alongside the physical-system roadmap
- Dates remain planning targets and may move as testing, user readiness and HPC delivery become clearer

Key messages

- GRIB2-only forecasts are the biggest expected technical impact
- Please initially use the release static data (when it becomes available) for early familiarisation, followed by the release candidate phase to test downstream workflows
- Please give feedback of issues as early as possible

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Extreme Temperature Forecasts



Research update

Tony McNally

Head of Earth System Assimilation

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ECMWF R+D landscape: 2 parallel streams

1) Physics / hybrid

2) End-to-end ML

1) Physics / hybrid

1) Physics / hybrid

Rationale:

- The 4D-Var analysis is currently critical to all physics-based forecasts **and** ML forecast systems via training and initialisation
- Currently the only system that can provide the wide range of required forecast products at the resolution they are required
- Independent (standalone) ML systems are not yet operationally proven

New operational cycle 50r1:

Summary – IFS Cycle 50r1

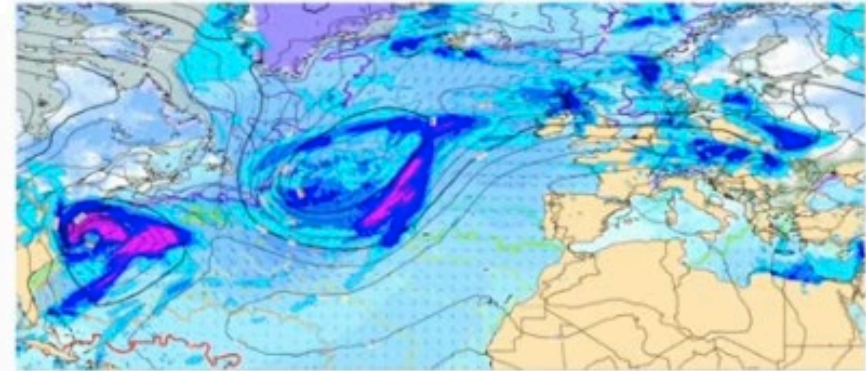
- New science: Earth System, coupling, more observations, responding to known issues
- Configuration changes and new products: IFS-ENS Control forecast, updates to 06/18UTC runs, new parameters
- Wave in sea ice, snow over sea ice, ocean current impact on waves, full ocean-atmosphere coupling...
- Improvements in convection, precipitation (still issues with light precipitation), surface parameters, reduced excessive wind spread, slightly improved tropical cyclone (intensity)... in medium-range IFS-ENS.
- Reduced SST biases, including Western Boundary Currents
- Improvements in ocean, stratosphere, and MJO in sub-seasonal IFS-SUBS.
- Improved scores for ozone and primary species in IFS-COMPO (CAMS); reduced bias in IFS-GHG (not shown).



NWP



CAMS



Successfully implemented earlier this month

1) Physics / hybrid

Key research themes :

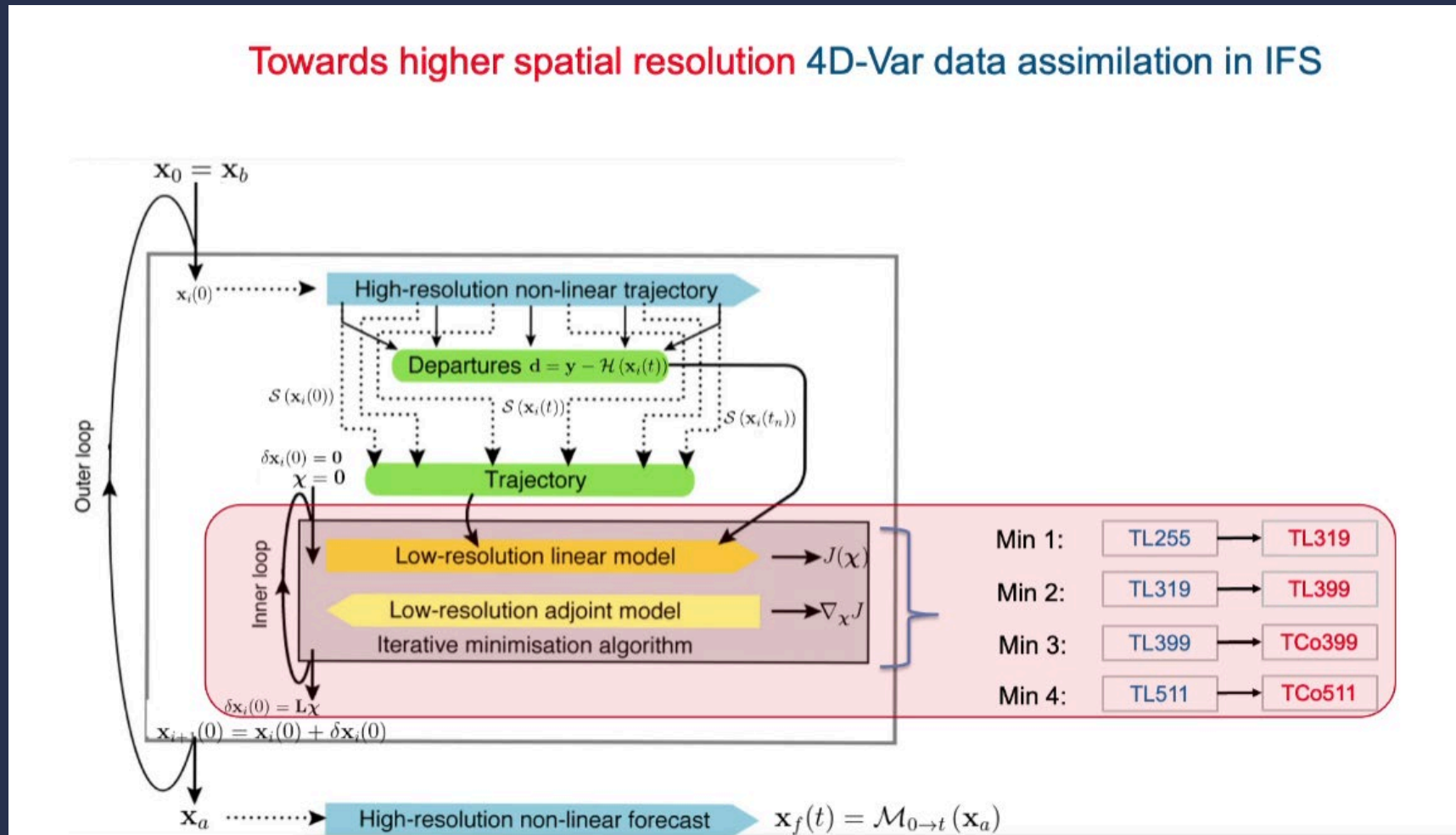
- Improving analysis (DA) accuracy, detail and delivery schedule
- Rapid onboarding and exploitation of new observations
- Improving IFS and AIFS forecast model accuracy and detail
- Applying ML corrections to physical (IFS) forecasts

1) Physics / hybrid

Key research themes :

- **Improving analysis (DA) accuracy, detail and delivery schedule**
- Rapid onboarding and exploitation of new observations
- Improving IFS and AIFS forecast model accuracy and detail
- Applying ML corrections to physical (IFS) forecasts

High spatial resolution 4D-Var: inner loop 40km > 20km



Still extremely computationally demanding...challenge to fit in real-time critical path

1) Physics / hybrid

Key research themes :

- **Improving analysis (DA) accuracy, detail and delivery schedule**
- Rapid onboarding and exploitation of new observations
- Improving IFS and AIFS forecast model accuracy and detail
- Applying ML corrections to physical (IFS) forecasts

4D-Var with Extending Windows (ExWin)

Rationale

- Simplify numerous operational suites to a single workflow
- Phase 1 aim – reproduce current operational analysis schedule (with a single suite)
- Future capability to provide Member States with more frequent analyses on demand

Goals

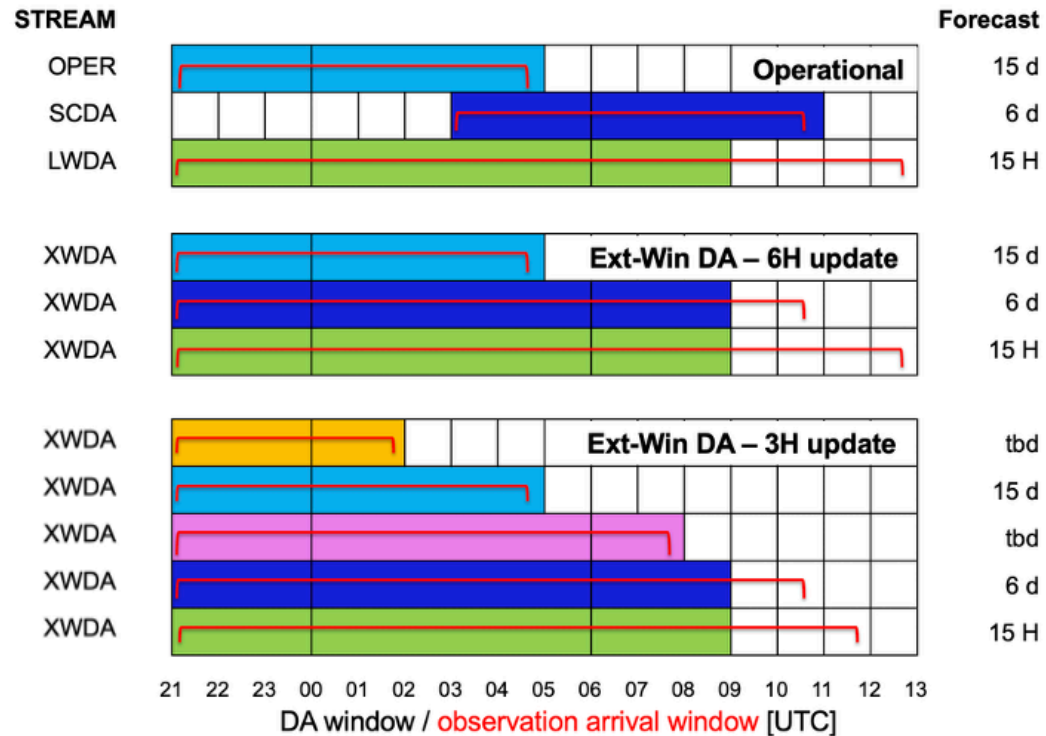
- Simplify DA system and *its upgrades*
- Improve forecast scores
- **Increase analysis update frequency**
- **Uniformly distribute HPC resources**

Status

- Scripts/code porting to CY50R1 near completion
- MARS+EcCode compatible backends promised by end of September 2025
- Proposed for CY51R1
 - 6H update version
 - Neutral to positive impact against operational setup

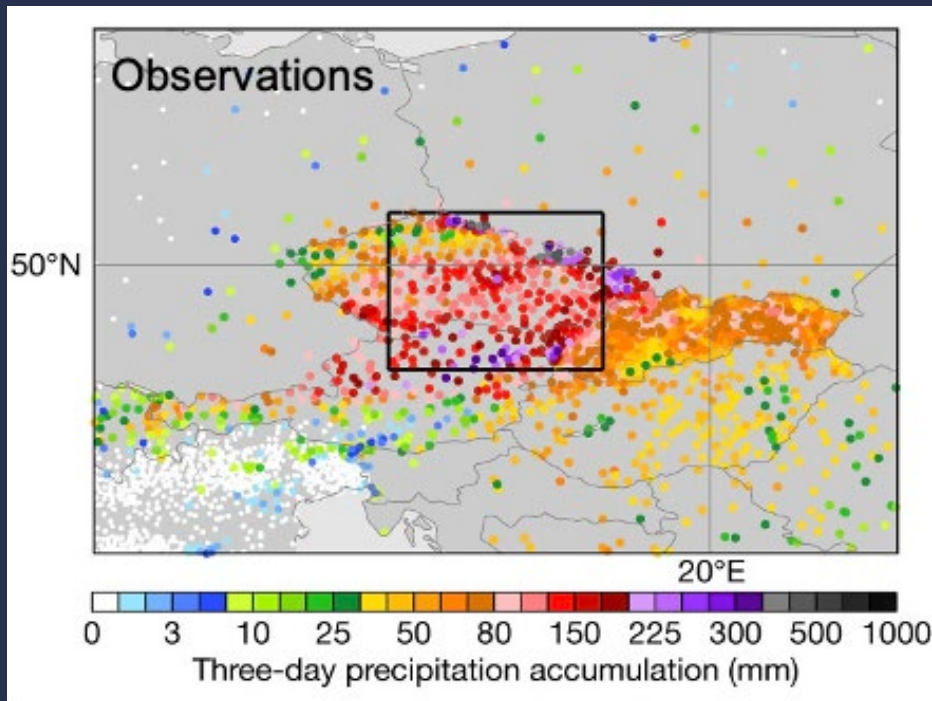
Upgradable to 3H update freq

- Case study @ TCo1279



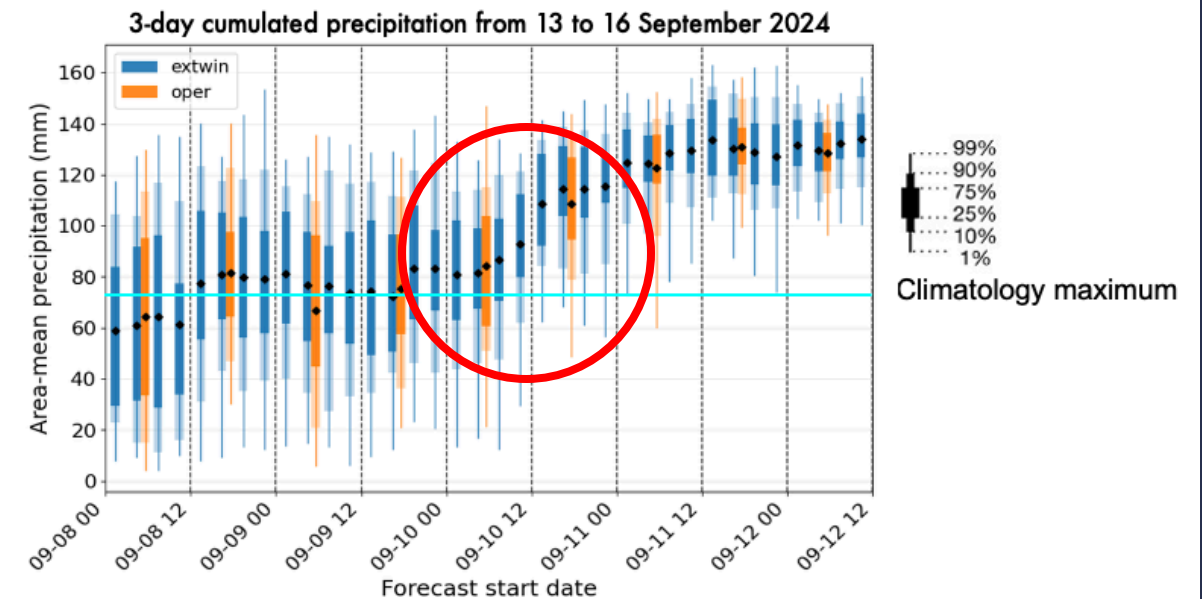
4D-Var with Extending Windows (ExWin)

More frequent analyses can be vital in severe weather



Storm Boris September 2024 @ TCo1279

- Extending window: 3 hourly analysis and forecast update frequency
- Continuously follow the evolution of the forecast
- Increase confidence in issuing alerts



2) End-to-end ML

2) End-to-end ML

Rationale:

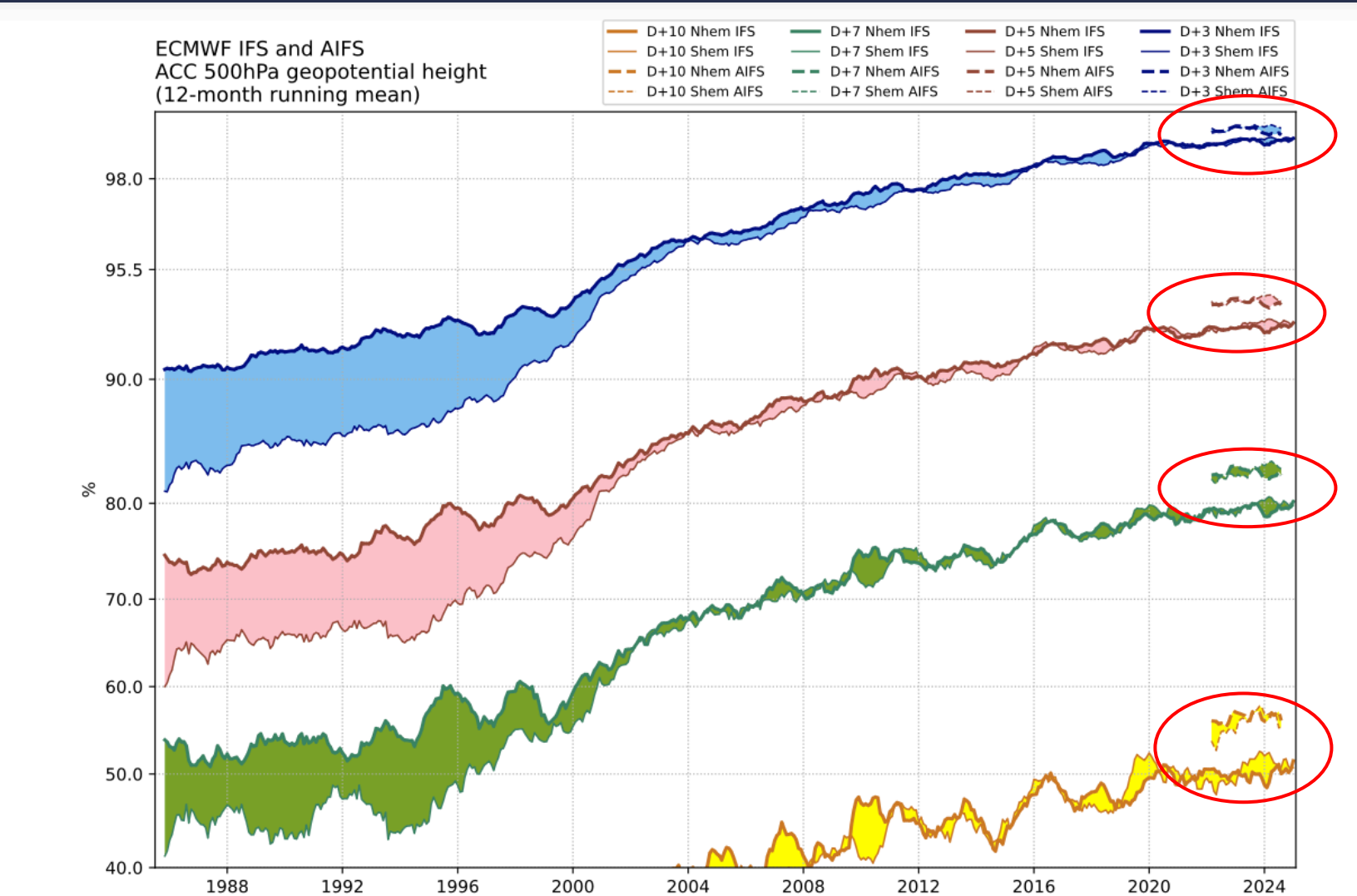
- Improving forecast accuracy, detail and speed of delivery
- Eliminate all hard inter-dependencies to simplify R2O for both physics-based and ML system
- Risk reduction / resilience against challenges of evolving HPC market

2) End-to-end ML

Rationale:

- **Improving forecast accuracy, detail and speed of delivery**
- Eliminate all hard inter-dependencies to simplify R2O for both physics-based and ML system
- Risk reduction / resilience against challenges of evolving HPC market

AIFS delivers skill gains over physics-based models similar to 10 years of R+D...but how do we improve from here ?



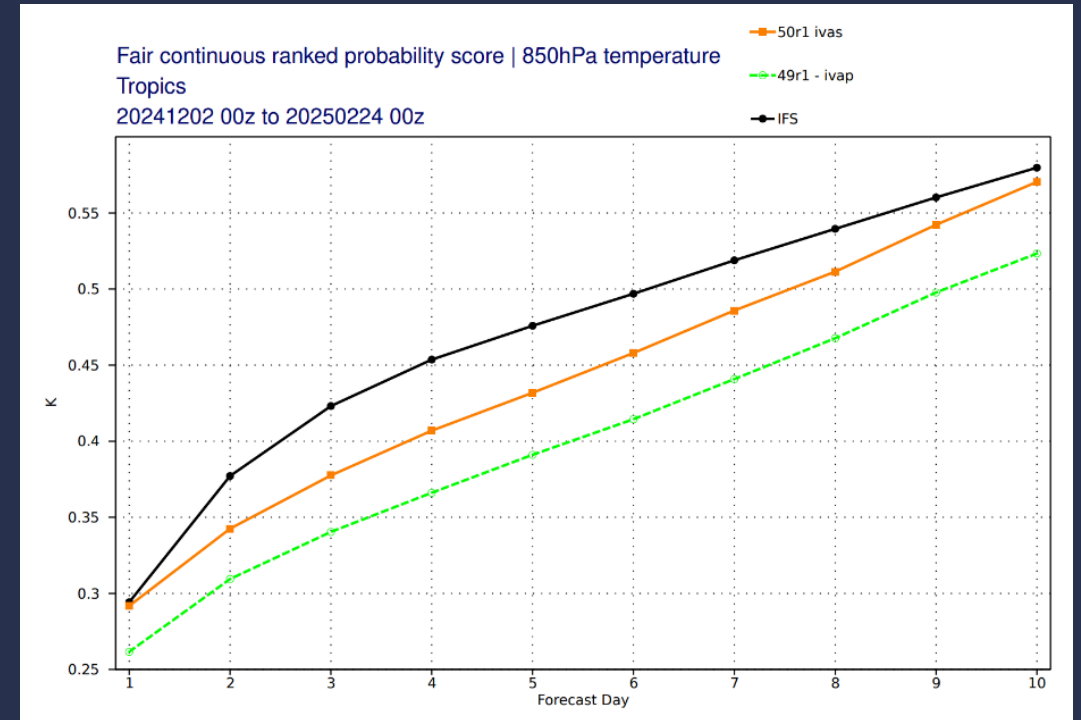
2) End-to-end ML

Rationale:

- Improving forecast accuracy, detail and speed of delivery
- **Eliminate all hard inter-dependencies to simplify R2O for both physics-based and ML system**
- Risk reduction / resilience against challenges of evolving HPC market

New AIFS operational cycle v2: unexpected adverse reaction to 50r1 initial conditions...complex R2O

- We know the 50r1 DA changes produced a more accurate 4D-Var analysis
- However, initializing AIFS forecasts with this analysis significantly degraded AIFS!
- AIFS skill was recovered only when retrained / fine-tuned against 50r1 analyses



2) End-to-end ML

Key research themes:

- Improving core model accuracy
-
- Enhancing observation curation and training
- Development for real-time operational resilience
- Developing reanalysis capability

Presented by Eulalie...

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Machine Learning update

Eulalie Boucher

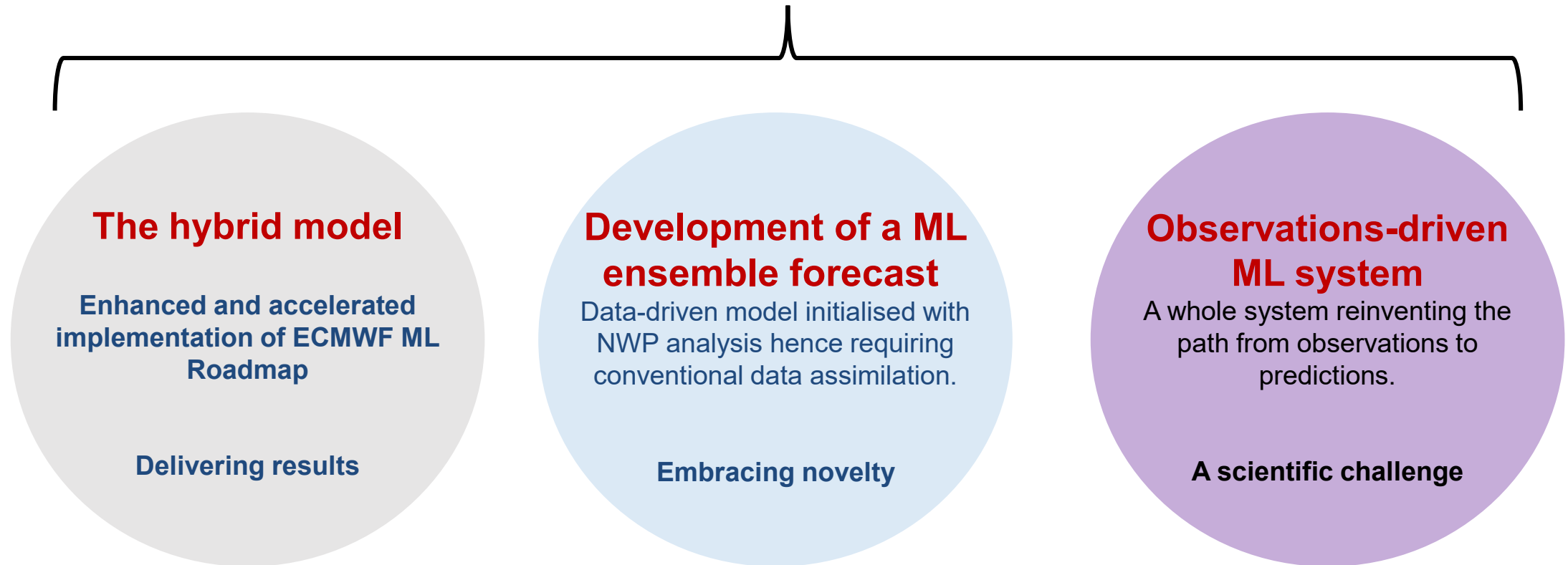
Scientist for Machine Learning

slido

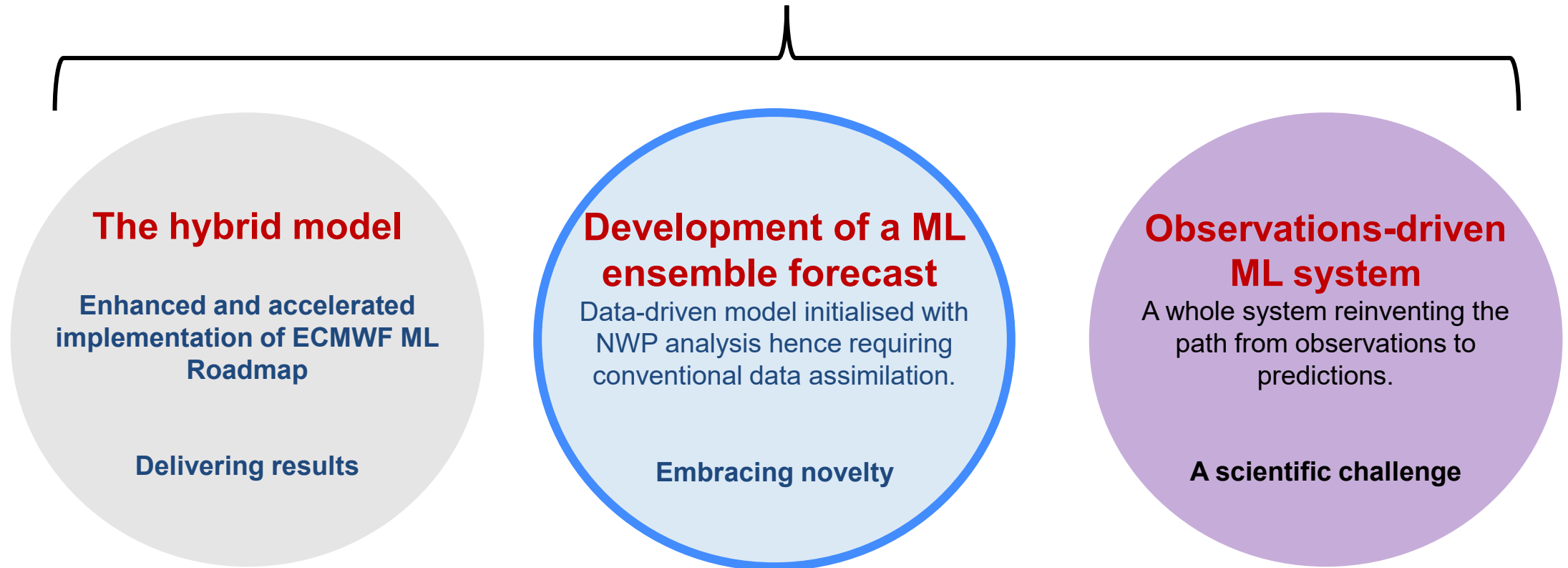
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Three strands of machine learning at ECMWF

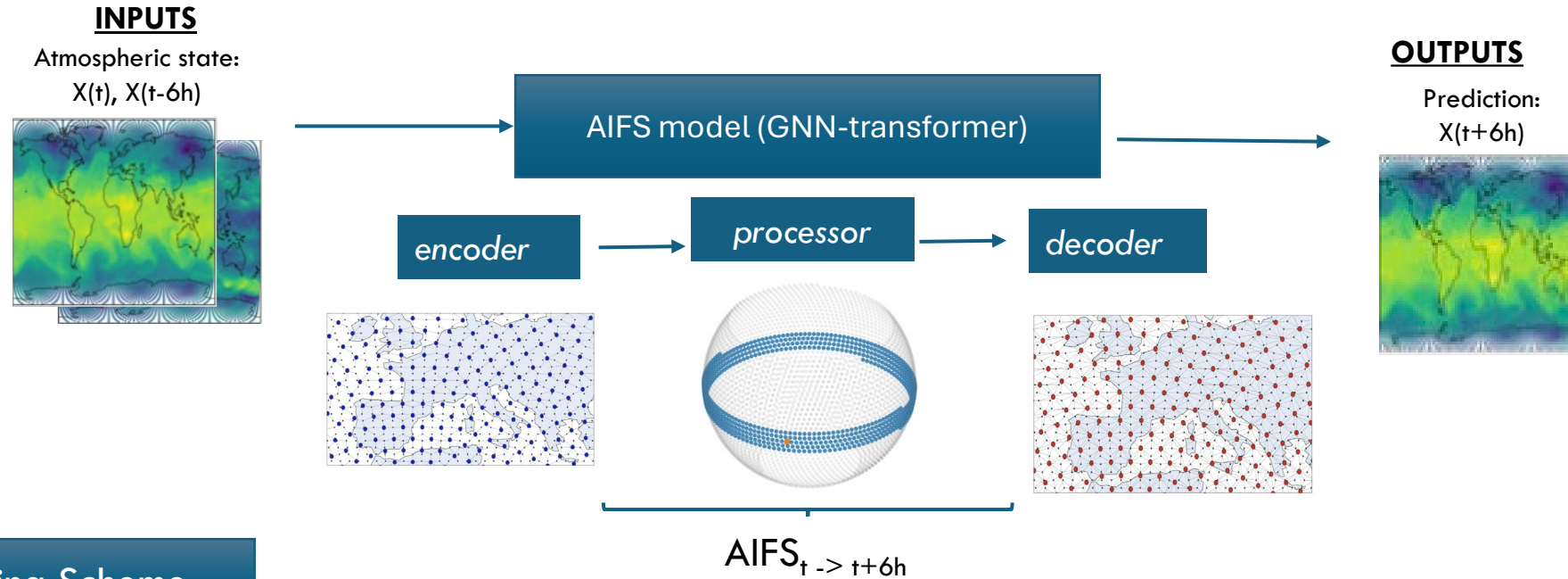


Three strands of machine learning at ECMWF



AIFS - Artificial Intelligence Forecasting System

<https://arxiv.org/abs/2406.01465>



Training Scheme

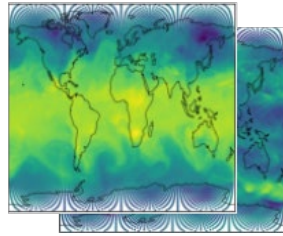
Step 1: pre-training phase, during which the model is given the task to forecast 6h ahead

Step 2: model is autoregressively trained to optimise forecasts between 6h and 72h ahead

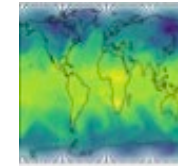
- General improvement in forecast accuracy and less smoothing in AIFS-single forecasts
- ECMWF will issue data-driven wave forecasts for the first time, leading to a substantial improvement in medium-range skill of wave forecasts
- New data-driven land surface variables
- Marked improvements in forecast accuracy at the top of the atmosphere
- Improved vertical velocities
- Finetuning on 50r1 data

AIFS - Single v2 new variables

OPERATIONAL SINCE
MAY 2026



AIFS MODEL



Forcings:

- Land-sea mask
- Orography
- Deviation of sub-grid orography
- Slope of sub-scale orography
- Insolation
- Latitude/longitude
- Time of day + day of year
- **Model bathymetry**

Prognostics:

Pressure levels at 10, 50, 100, 150, 200, 250, 300, 400, 500, 600, 700, 850, 925, 1000 hPa:

- Geopotential
- ~~Horizontal and vertical wind components~~
- Temperature

Pressure levels at 50, 100, 150, 200, 250, 300, 400, 500, 600, 700, 850, 925, 1000 hPa:

- Specific humidity

Surface fields:

- Surface pressure
- Mean sea-level pressure
- Sea-surface temperature
- Skin temperature
- 2m temperature
- 2m dewpoint temperature
- 10 m horizontal wind components (u,v)
- Total column water
- **Snow cover**
- **Significant wave height**
- **Significant wave height of all waves with periods**
- **Coefficient of drag with waves**
- **Mean wave period and direction**

Diagnostics:

Pressure levels at 10, 50, 100, 150, 200, 250, 300, 400, 500, 600, 700, 850, 925, 1000 hPa:

- **vertical wind components**

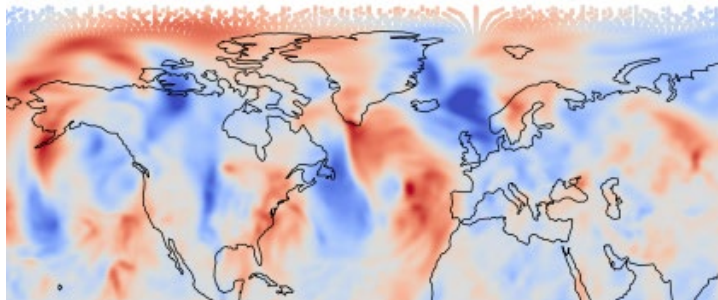
Surface fields:

- Total and convective precipitation
- **Snow depth**

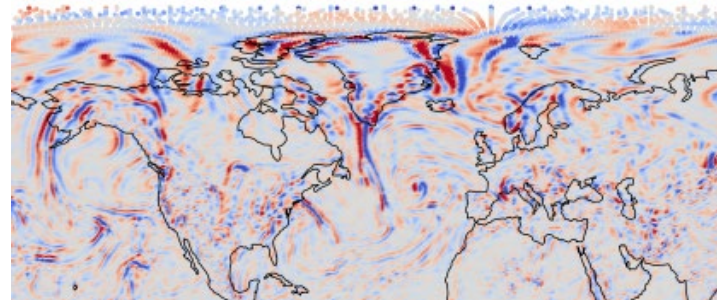
AIFS-ENS v2

OPERATIONAL SINCE
MAY 2026

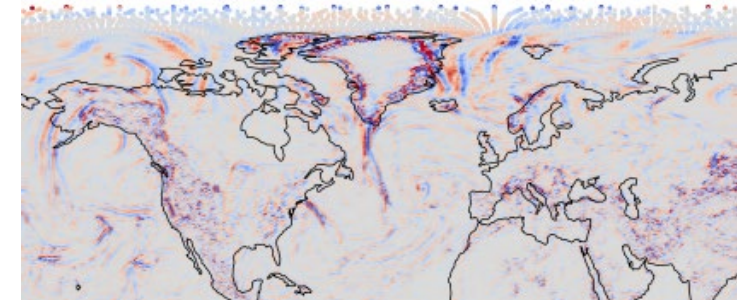
- New variables, waves, etc. (see AIFS v2 for full list of variables)
- Introduction of bounding of TP, CP, SF
- Multi-scale loss replaces reference state truncation
- Increase the number of edges in the decoder from 3 to 16, new edge features
- Fine-tuned on HRES analyses from 2016 to end of 2024 (including 50r1 data)



Scale 1



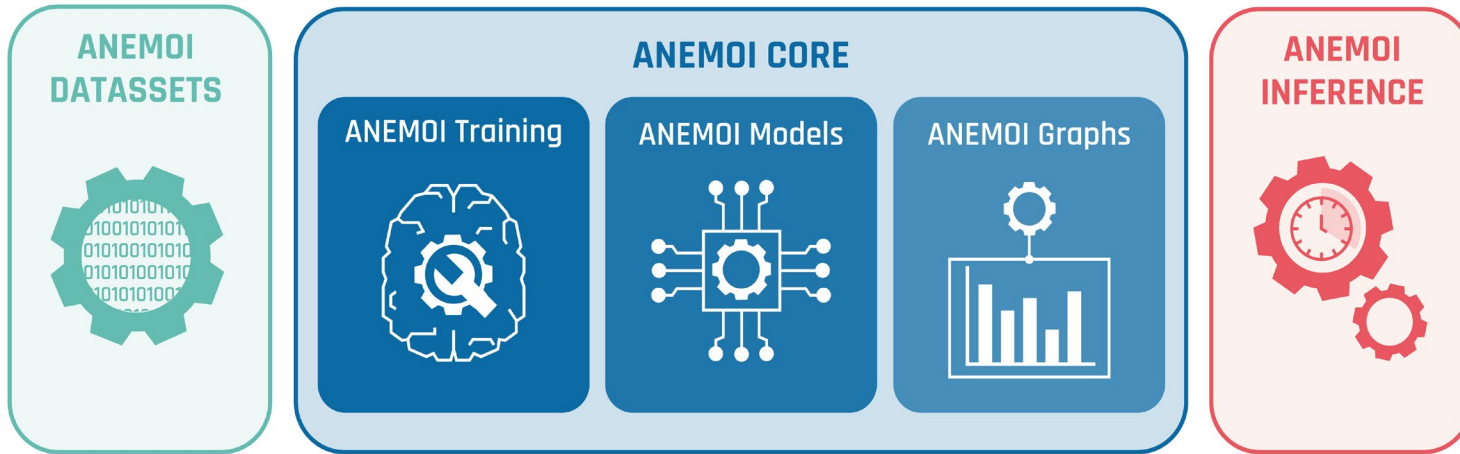
Scale 2



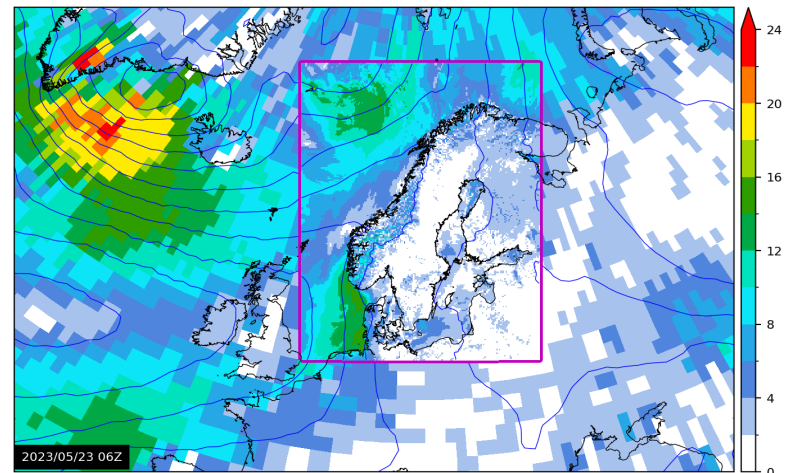
Scale 3

Anemoi: the tool behind it all

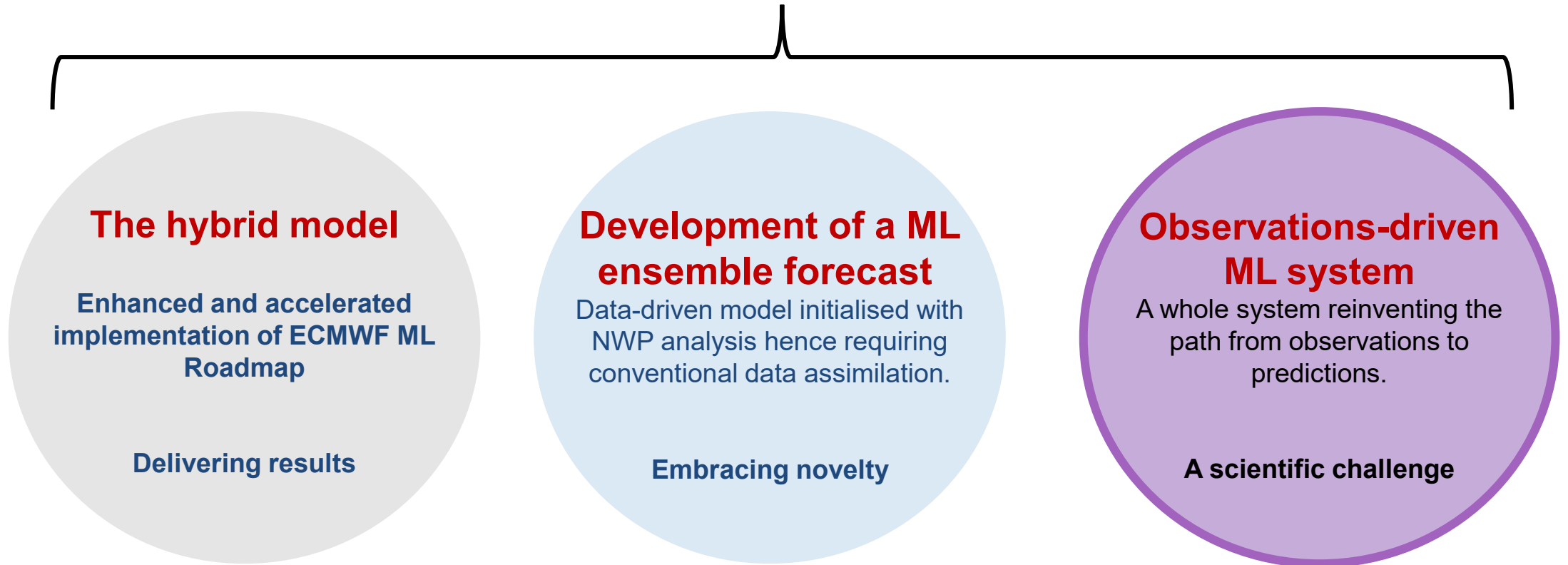
Open-source framework that provides a complete toolkit to develop data-driven weather models – from data preparation through to inference



Creating successful ML-weather models (Bris - MetNo)



Three strands of machine learning at ECMWF



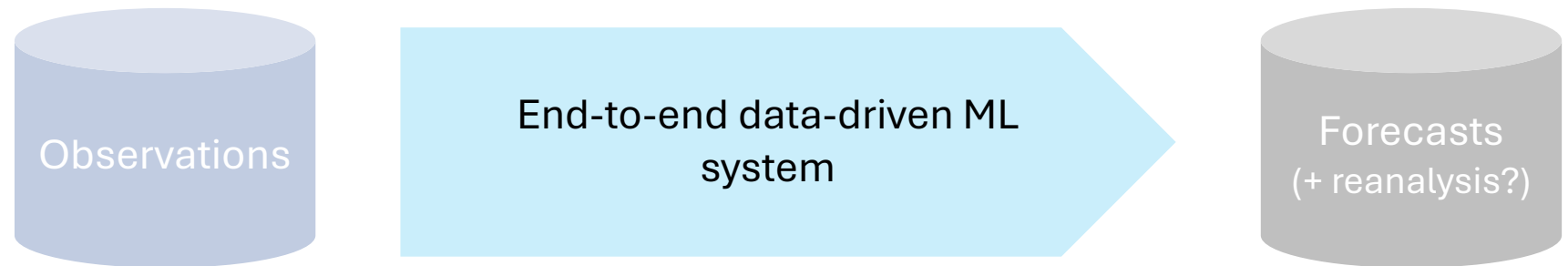
End-to-end ML system

1) Physics/Hybrid (analysis-based)



→ Operational AIFS still has a hard dependency on 4D-Var (NEMOVAR / LDAS)

2) Pure ML (observation-based)

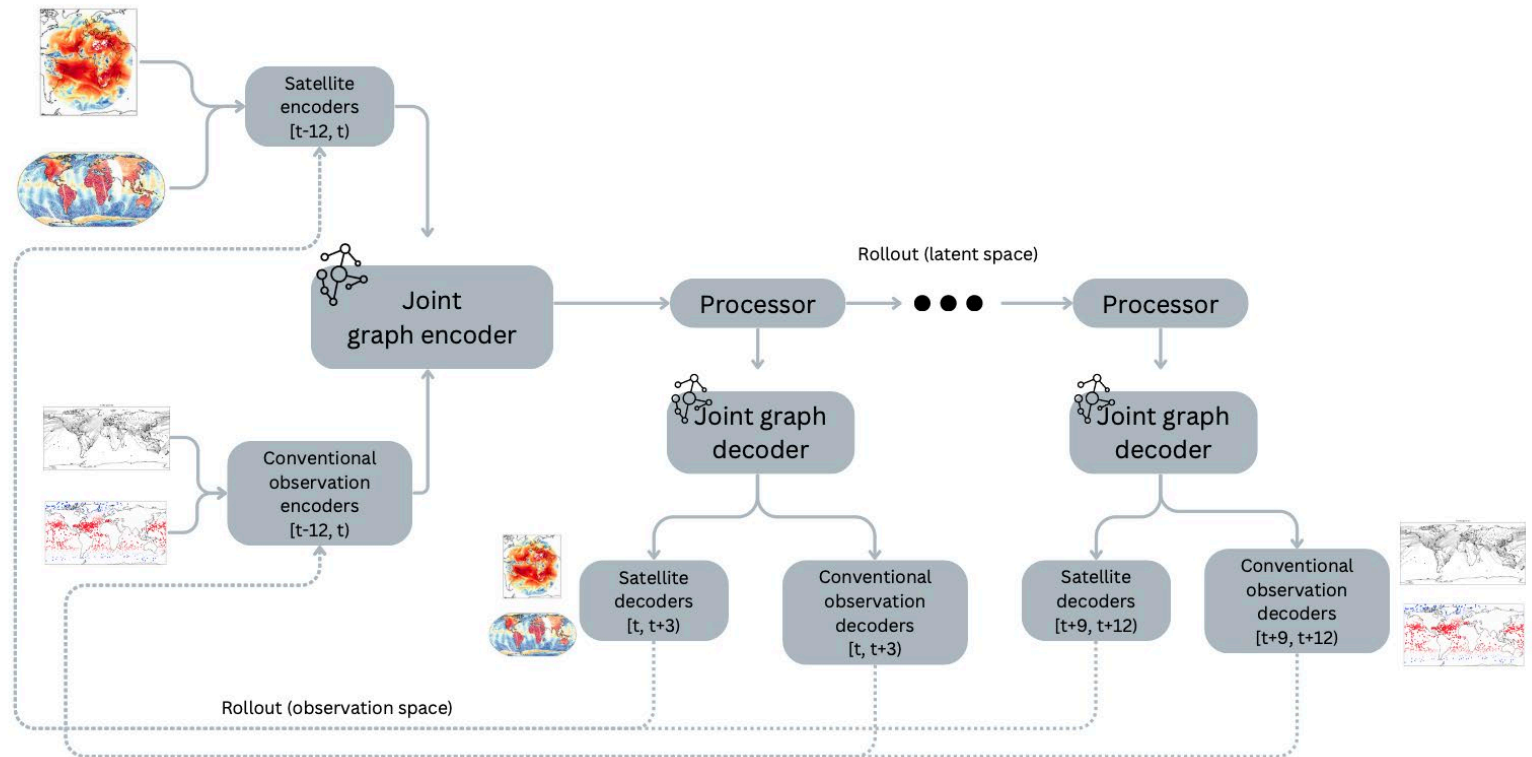


→ Ambition is to have a **pure ML observation-based end-to-end system**, what that system will look like is still to be determined – AI-DOP is one possibility, but research incoming from AIFS and WeatherGenerator as well

AI-Direct Observation Prediction (DOP)

How to learn a forecast from observations

- Use historical observations to train a Neural Network to forecast future observations (**don't need analysis or reanalysis**)
- Include all available observations of the full Earth system (atmosphere, ocean, land) simultaneously
- Once trained, initialize the model directly with the observations themselves
- The model can produce a forecast at unobserved locations (e.g., on a grid)

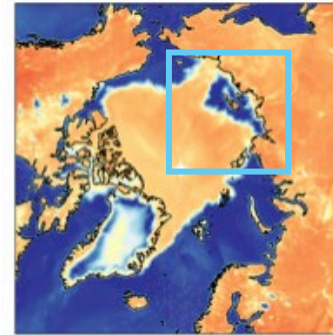


AI-Direct Observation Prediction (DOP) How to learn a forecast from observations

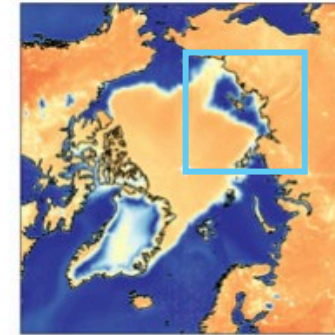
- DOP can forecast the satellite observations themselves
- AMSR-2 (5v) MW brightness temperature signal of the sea ice extent
 - **Captures a rapid freezing event**
 - Reproduces the signature of sea ice in the brightness temperatures
 - Underscores the capacity to learn representations of sea ice dynamics from indirect observations without access to explicit sea ice labels

T+24h

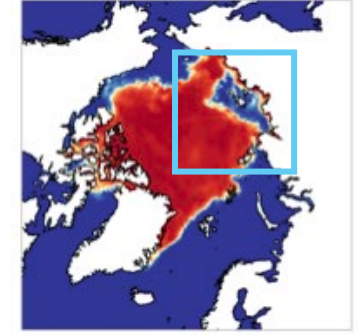
GraphDOP
(prediction)



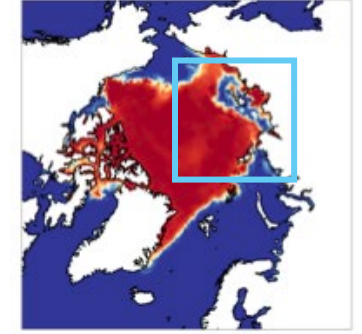
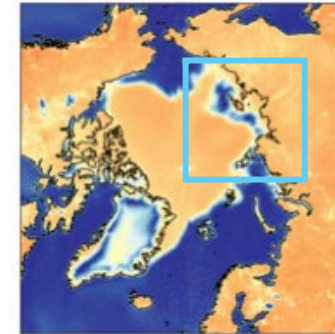
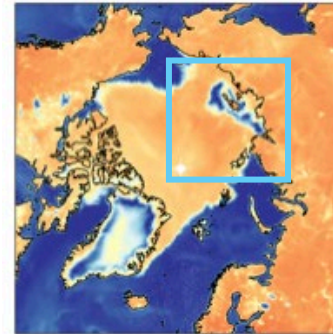
AMSR-2
(target)



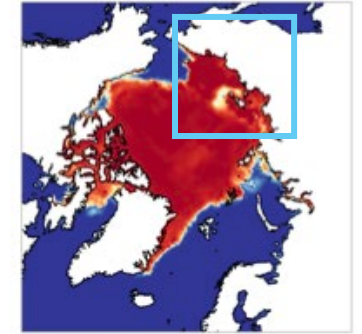
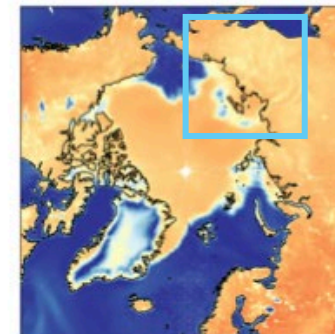
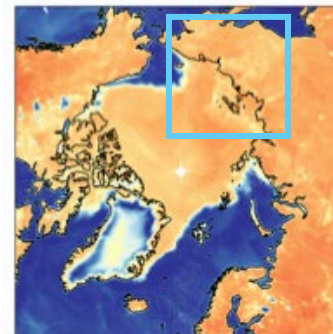
ORAS6 SIC



T+5 days



T+10 days

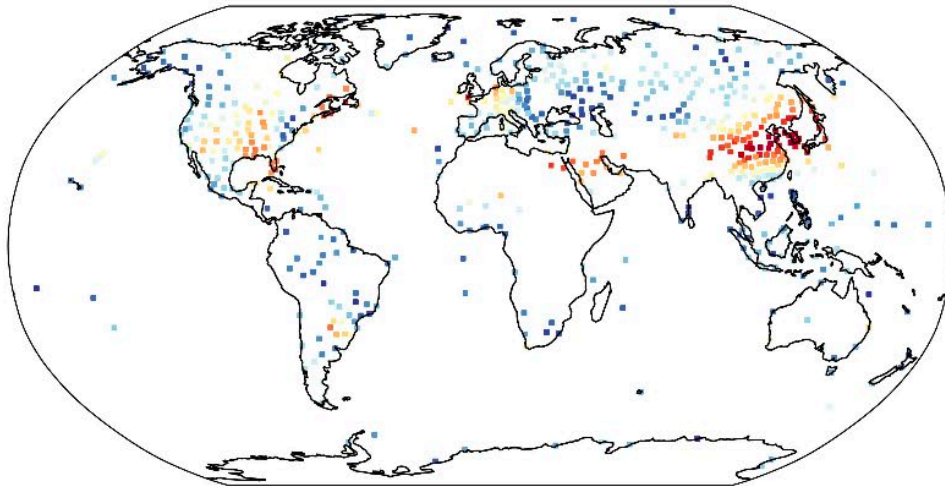


AI-Direct Observation Prediction (DOP)

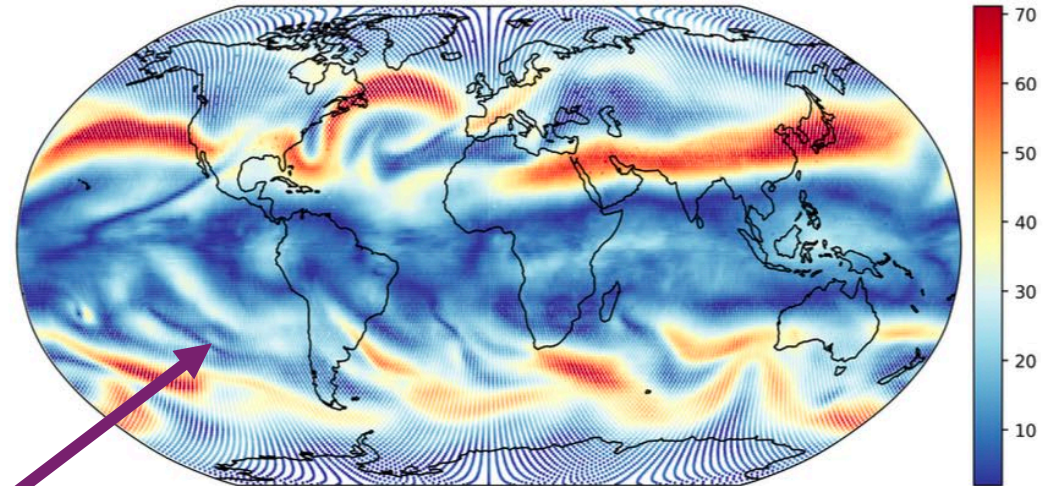
How to learn a forecast from observations

- At inference time, the graph decoders can be used to produce a forecast at any arbitrary point

Input 200hPa wind obs



Predicted 200hPa wind at t+24h on O96 grid

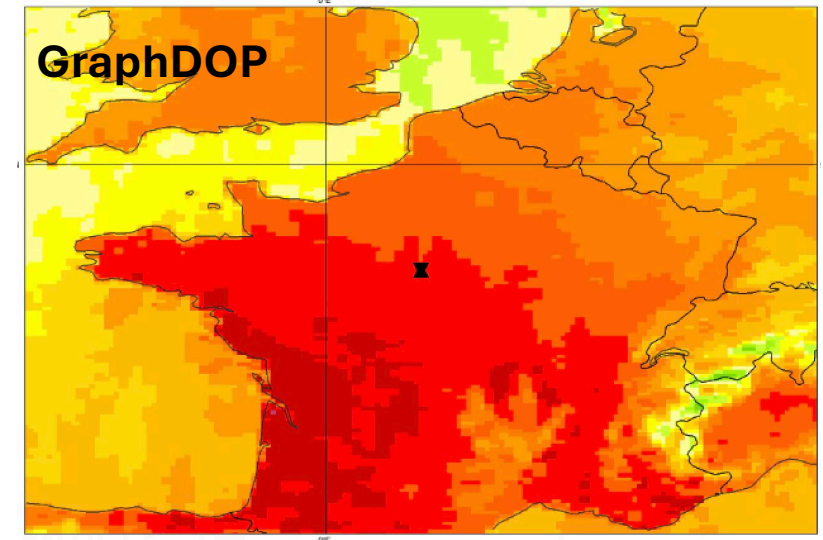
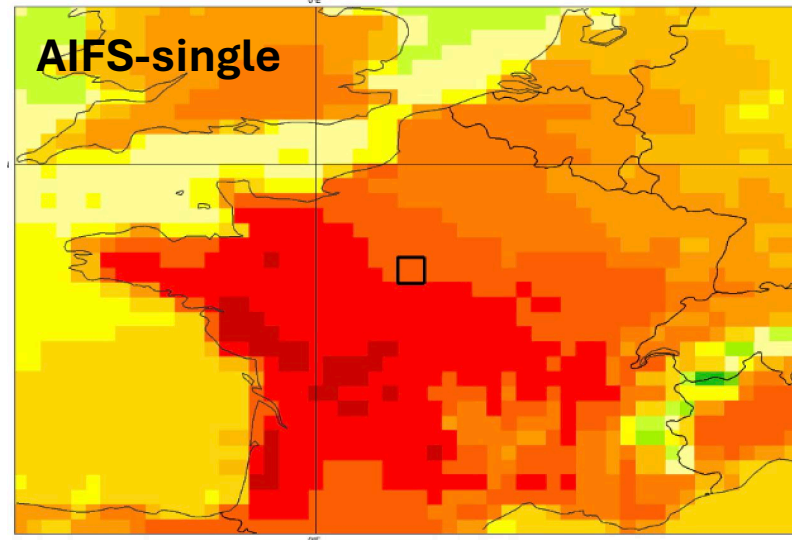
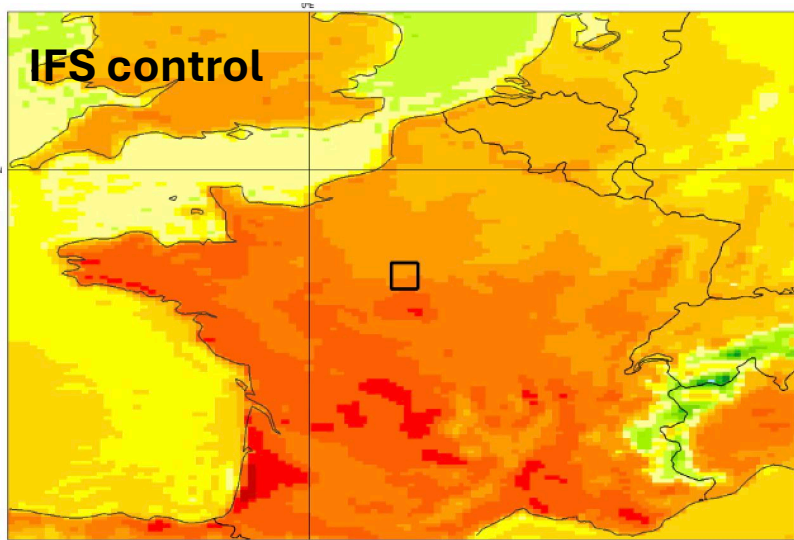
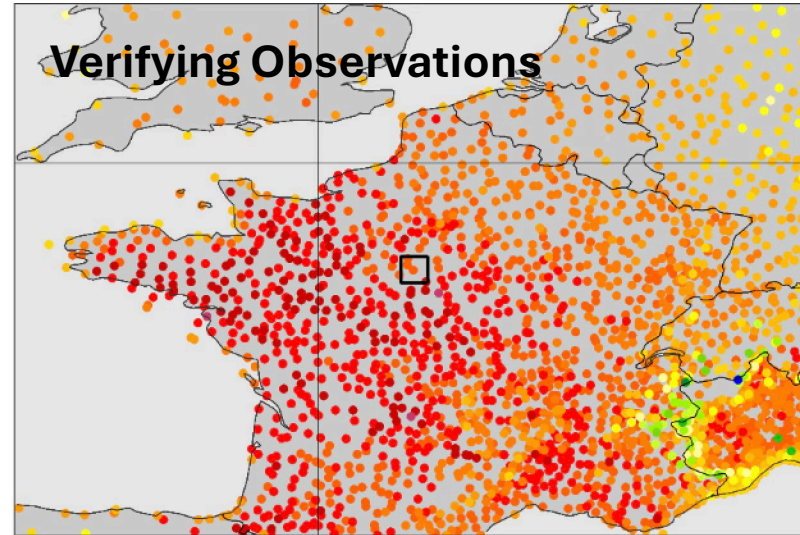
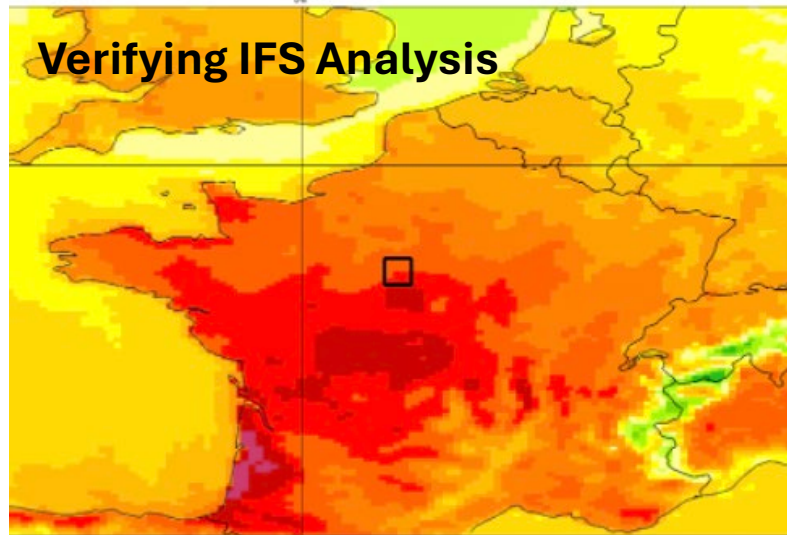


Even in areas where there are no direct observations for that variable
→ evidence that it **has developed a model** of the relationship
between different observed variables

Real-time system prototype

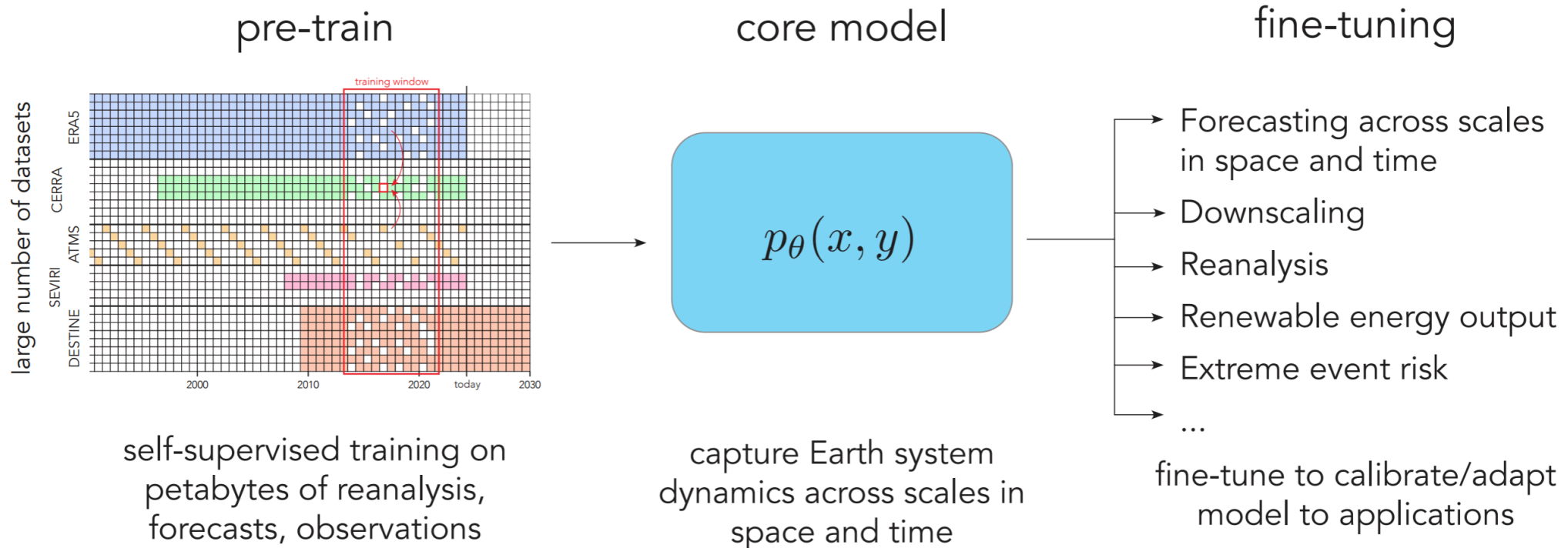
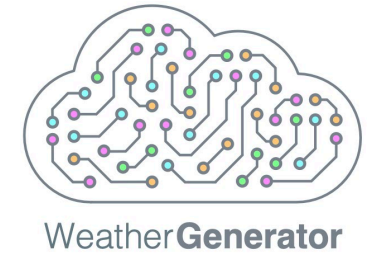
2-metre temperature in **84h forecasts** valid 8 April 12UTC

Linus Magnusson



WeatherGenerator

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



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Extreme Temperature Forecasts



Forecasting and Services update

Matthieu Chevallier

Head of Evaluation Section

slido

#2414240

Forecast performance – upper-air – IFS-ENS and AIFS-ENS

850hPa Temperature Northern Hemisphere Extratropics – CRPSS reaches 50%

— AIFS-ENS (estimate)

2m Temperature

IFS-ENS

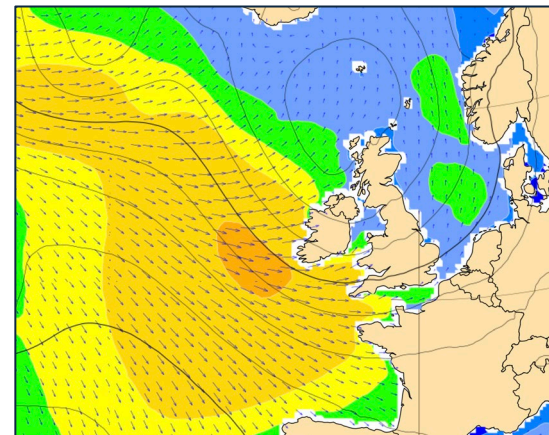
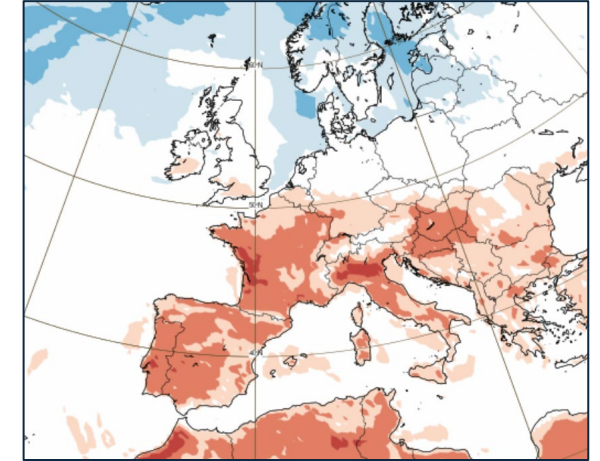
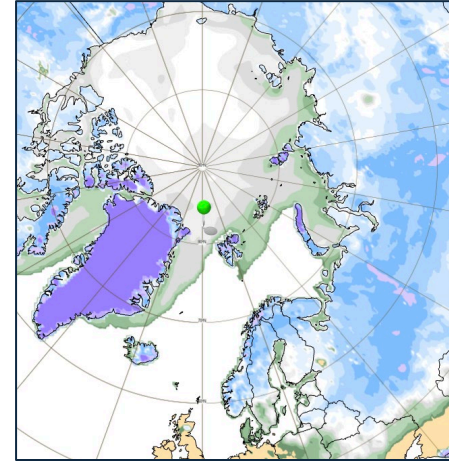
AIFS-ENS

Winter 2025-26

IFS Cycle 50r1 / AIFS v2 – new outputs and products – highlights

IFS Cycle 50r1

- New ocean parameters: 2D and 3D on 75 vertical levels
- New sea ice parameters
- Snow: new “fraction of snow cover”, snow over sea ice
- New parameters added to 06/18UTC runs
 - Heat and cold indices, simulated satellite images, EFI/SOT...
- Other new parameters (urban cover, wet bulb temperature)
- Hourly IFS-COMPO and (new) IFS-GHG output



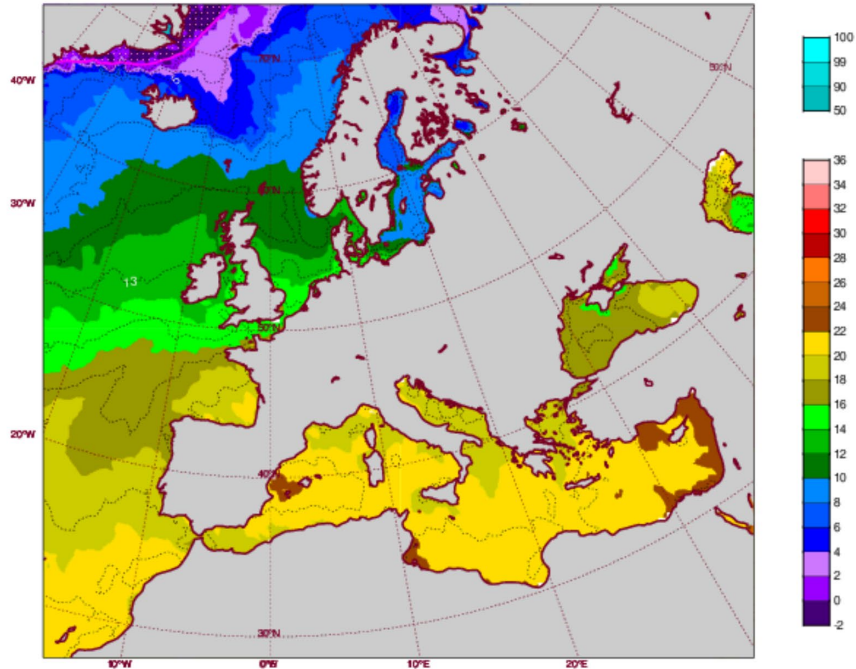
AIFS Single/ENS version 2

- Wave fields
- Snow cover

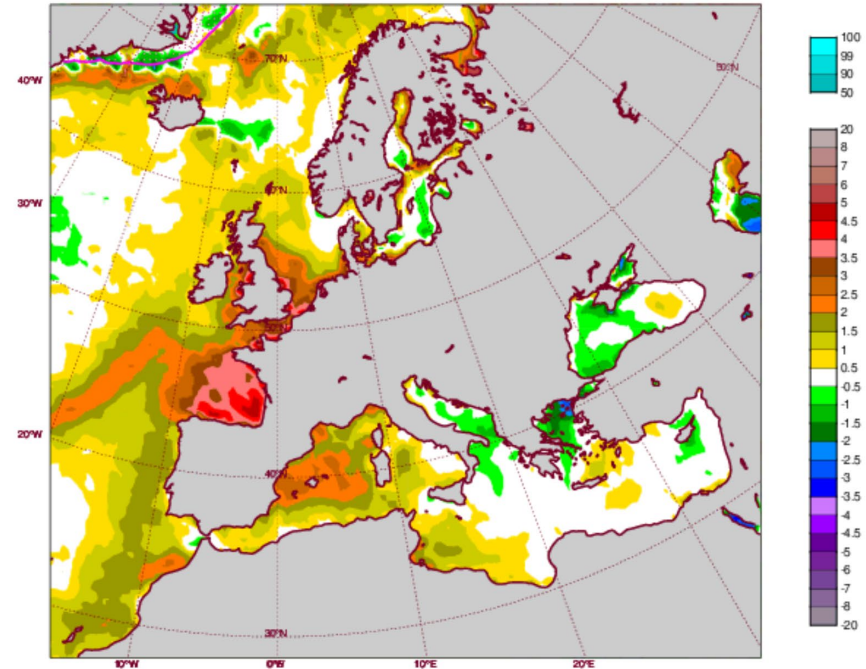
IFS Cycle 50r1 / AIFS v2 – new outputs and products – highlights

Revised graphical products – IFS-CF sea surface temperature (SST) / SST anomaly

Thursday 21 May 2026 0000 UTC ECMWF 1+240 VT-Sunday 31 May 2026 0000 UTC
SST and Sea Ice. Sea Surface Temperature (C) in control run (bottom legend).
Control Run Sea Ice cover (top legend >>- 50% only). Climatological Sea Ice cover in magenta (>- 50%).



Thursday 21 May 2026 0000 UTC ECMWF 1+240 VT-Sunday 31 May 2026 0000 UTC
SST anomaly and Sea Ice. Sea Surface Temperature anomaly (C) in control run (bottom legend, 2C contour interval near extrema).
Control Run Sea Ice cover (top legend >>- 50% only). Climatological Sea Ice cover in magenta (>- 50%).



Updated climatology (ERA5, 1991-2020) !

<https://charts.ecmwf.int>

EarthKit 1.0 upcoming release



- High-level API support for **xarray** across the ecosystem
- New-and-improved documentation



- New-and-improved high-level data abstraction



- Convenient regridding support
- Loads more plot types



- Greatly expanded regridding support (including for NumPy and xarray)



- Deaccumulations, improved climatology statistics



- Mode and percentile support



- Verification metrics support



```
pip install earthkit==1.0.0rc1
```

ECMWF Data Store

Established in 2026, powered by the same technology as Copernicus Data Stores

The screenshot shows the ECMWF Data Store interface. At the top left is the ECMWF logo. To the right, there is a 'Login - Register' link. Below the logo, a navigation bar contains 'ECMWF Data Store', 'Datasets', 'User guide', and 'Live status'. The main content area is titled 'Datasets' and features a search bar. Below the search bar, it states 'We found 3 results' and provides buttons for 'Search on CDS', 'Search on ADS', and 'Search on EWDS'. A 'Sort by Last updated' dropdown is also visible. On the left side, there is a 'Filter by' sidebar with categories: 'Product type', 'Spatial coverage', 'Temporal coverage', and 'Variable domain'. The search results list three datasets:

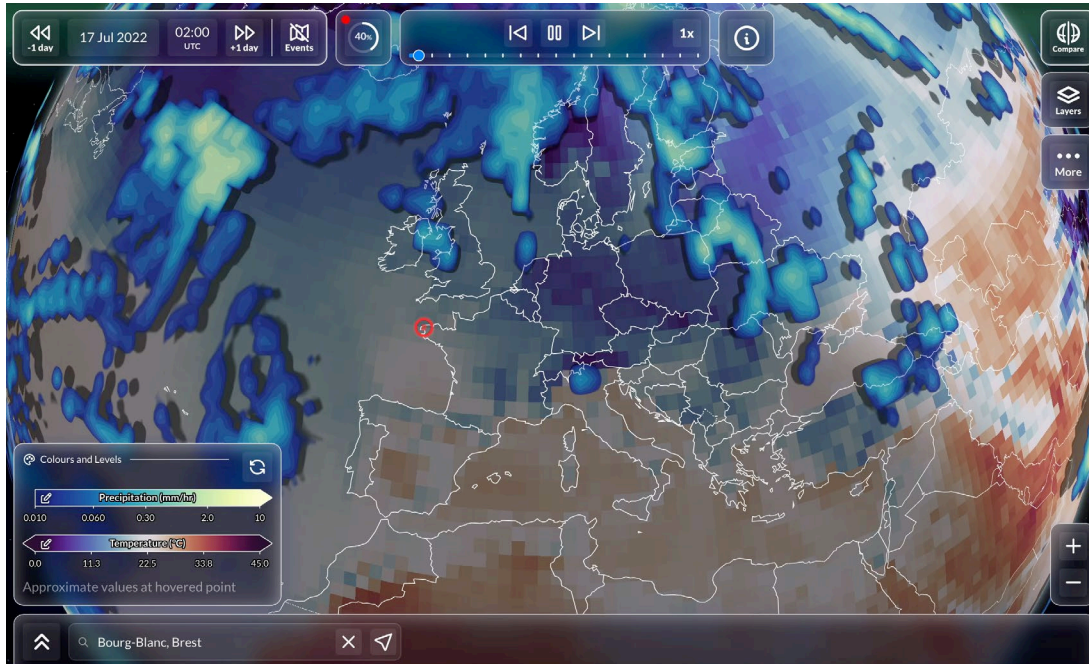
- TIGGE global medium-range ensemble forecasts from multiple NWP centres since 2006**
The International Grand Global Ensemble (TIGGE) dataset consists of global medium-range ensemble forecasts from thirteen numerical weather prediction (NWP) centres. The dataset has been available since October 2006. TIGGE was established as a key component of THORPEX: a World Weather Research Progr...
Tags: Medium range forecasts, Global, Future, Past, Present, Atmosphere (surface), Atmosphere (upper air)
- S2S global sub-seasonal to seasonal ensemble real-time forecasts from multiple NWP and research centres since 2015**
The Sub-seasonal To Seasonal dataset (S2S) consists of global ensemble real-time forecasts and reforecasts from thirteen numerical weather prediction (NWP) and research centres. S2S project behind the dataset started in 2013 as a joint initiative of the World Weather Research Programme (WWRP) and t...
Tags: Sub-seasonal forecasts, Global, Future, Past, Present, Atmosphere (surface), Atmosphere (upper air), Ocean (physics)
- S2S global sub-seasonal to seasonal ensemble reforecasts from multiple NWP and research centres since 2015**
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Access to WMO public datasets managed by ECMWF: TIGGE, S2S

<https://ecds.ecmwf.int>

Reanalysis

Global reanalysis – explore weather events in ERA5 with Weather Replay app!

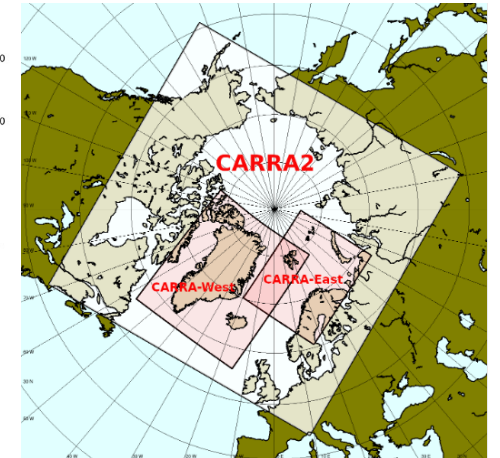
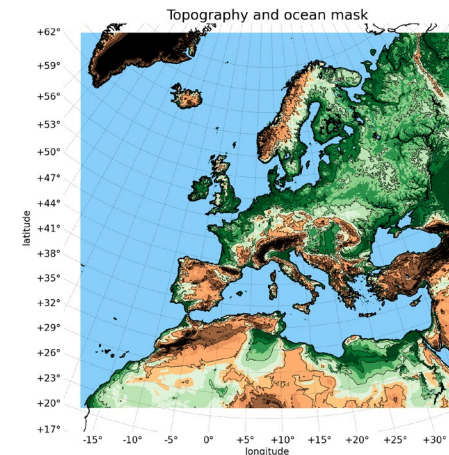


New – launched 11 May 2026 !

<https://weather-replay.climate.copernicus.eu>

Regional reanalysis Europe: CERRA

Arctic: CARRA

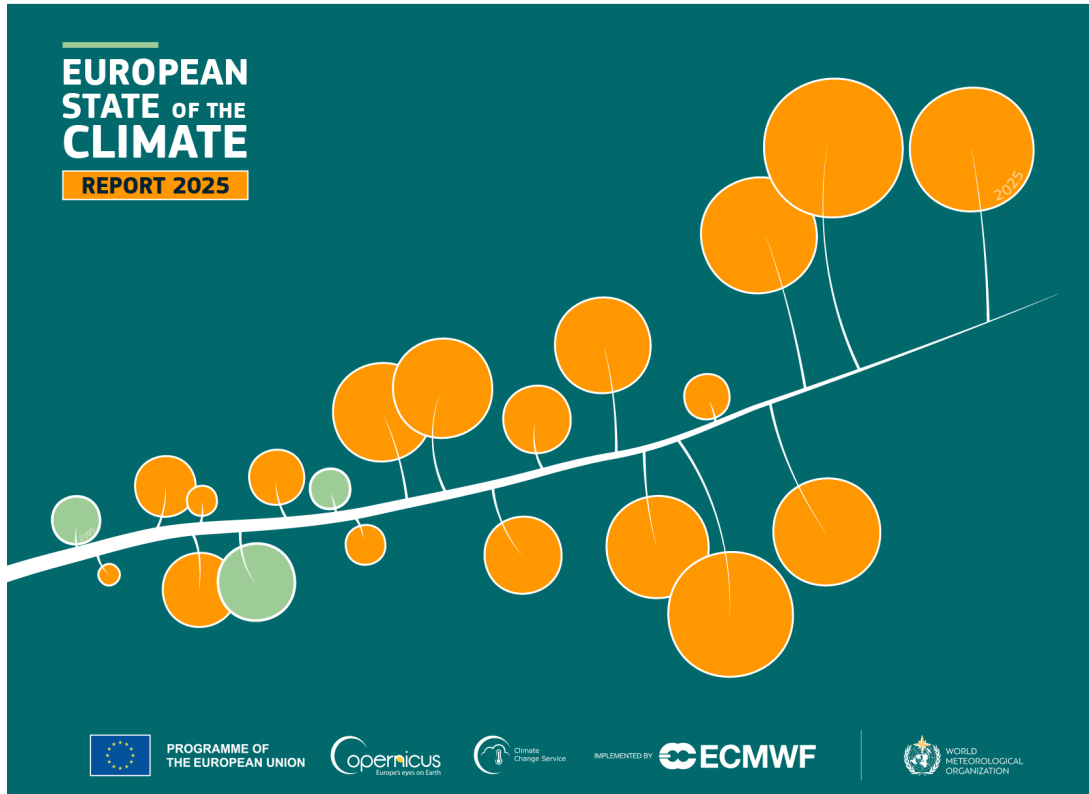


Full 40-year pan-Arctic CARRA2 datasets released in May 2026 !

<https://cds.climate.copernicus.eu>

Climate monitoring – European State of the Climate

Joint C3S-WMO report for 2025

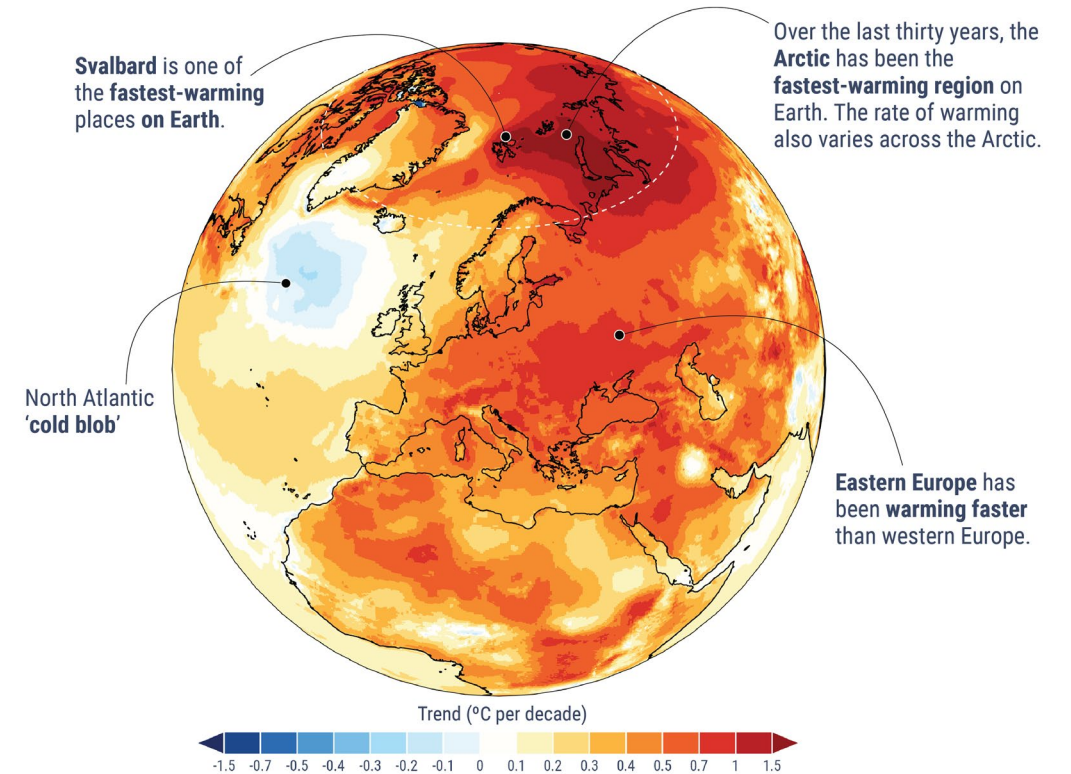


New – launched 29 April 2026

<https://climate.copernicus.eu/esotc/2025>

The rate of warming varies across Europe

Linear trend in annual surface air temperature for 1996–2025



Data: ERA5 • Credit: C3S/ECMWF

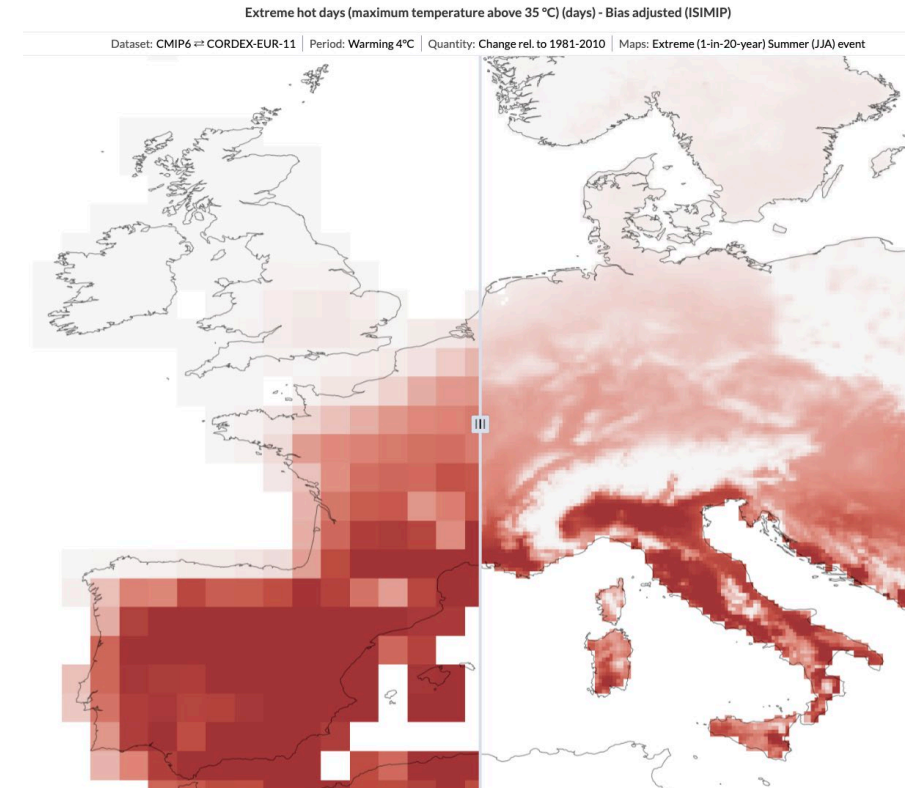
Climate projections

WCRP project outputs are utilised to create services for Copernicus users:

- **Global climate model output from CMIP (1850-2100)**
 - CMIP5 and CMIP6 data available
- **Regional climate model output from CORDEX (1950-2100)**
 - CORDEX-CMIP5 available and CORDEX-CMIP6(-ML) coming soon
- **Decadal predictions from DCPD (annual 10-year forecasts)**
 - Latest 2025-initialised forecasts (and hindcasts) from 5 systems coming to the CDS this year

This data feed into the **C3S Climate Atlas**

<https://atlas.climate.copernicus.eu>



New version released in May 2026 – new indices and side-by-side comparisons !



Funded by the European Union

Destination Earth

implemented by



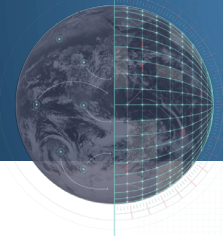
ECMWF



esa

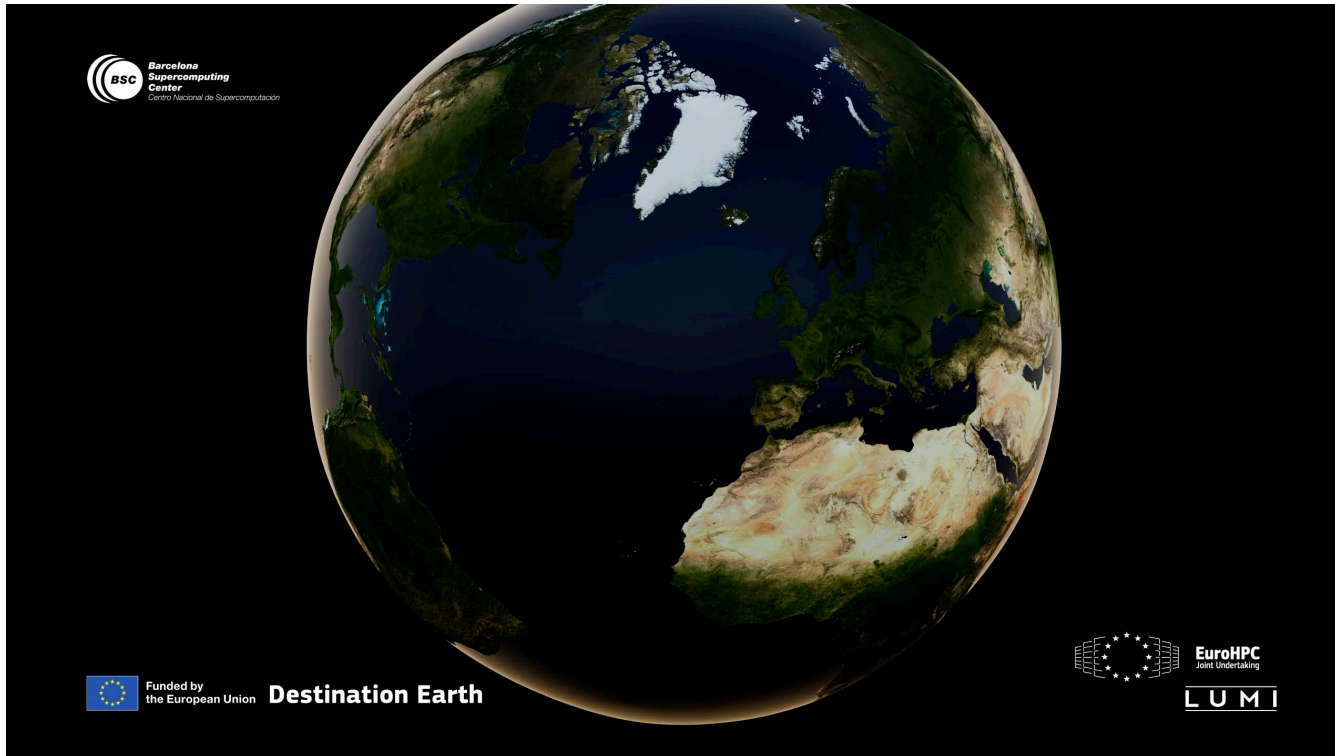


EUMETSAT

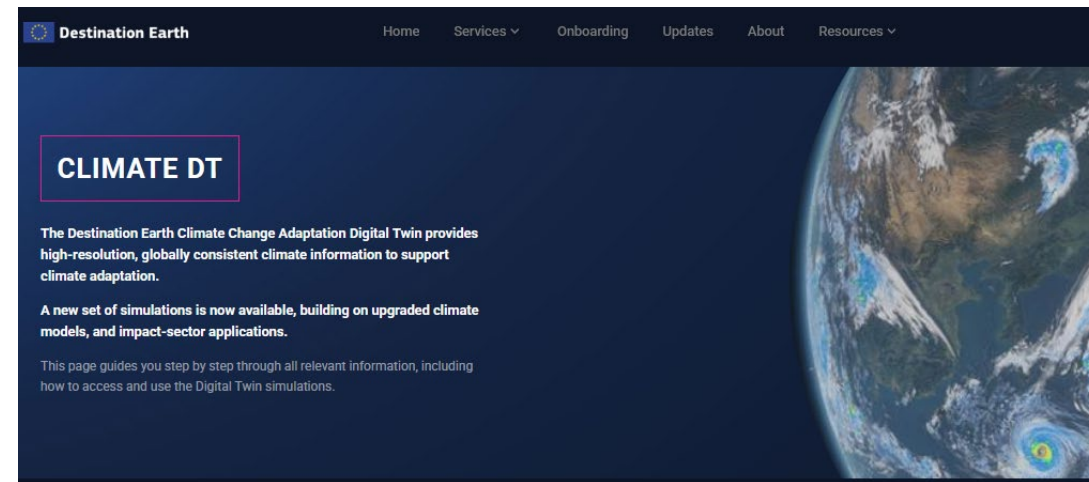


CLIMATE DIGITAL TWIN:

First simulations with operational workflows released



MORE INFORMATION & DATA ACCESS

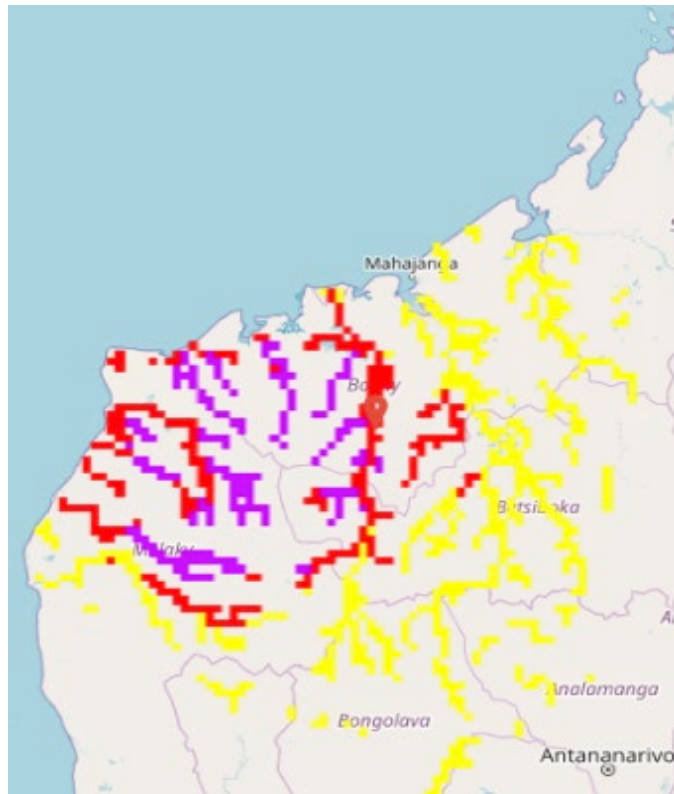


Copernicus Emergency Management Service

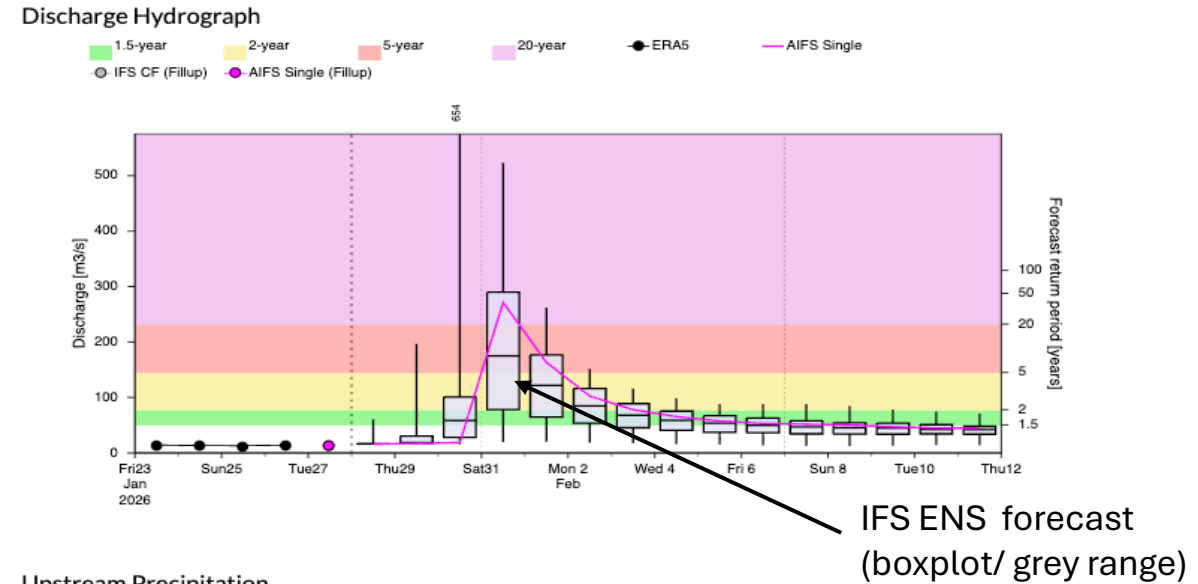
AIFS Single integrated in CEMS-Flood operational forecasts

EFAS and GloFAS

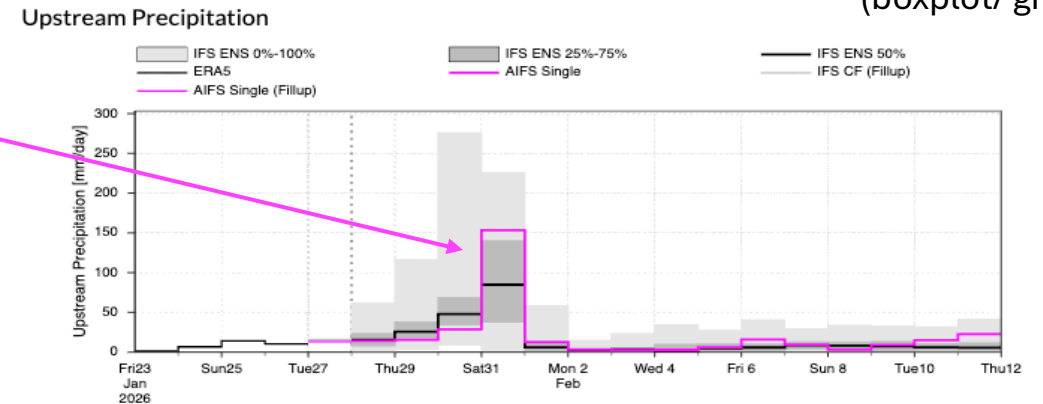
AIFS Single layer:



Return Period layer:



AIFS Single forecast (Magenta lines)



Questions for panel discussion

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