ECMWF Overview:

Recent Updates and Research Plans

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(on behalf of ECMWF Research Department)

22th September 2025, EWGLAM-SRNWP 2025, Norrköping

Overview

Part 1. *Recent and Upcoming Operational Upgrades*

Part 2. *Destination Earth Developments*

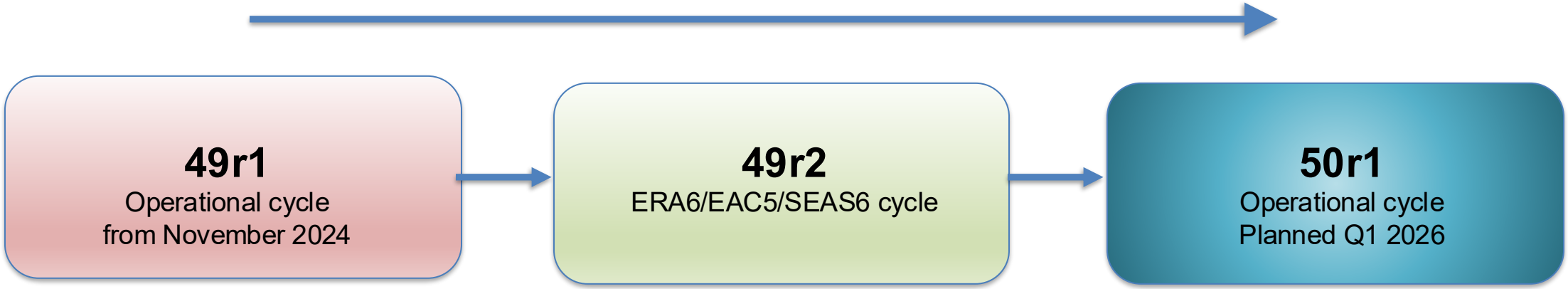
Part 3. *Data-Driven Forecasting*

Part 1

Recent and Upcoming Operational Upgrades

Science evolution: From 49r1 to 50r1

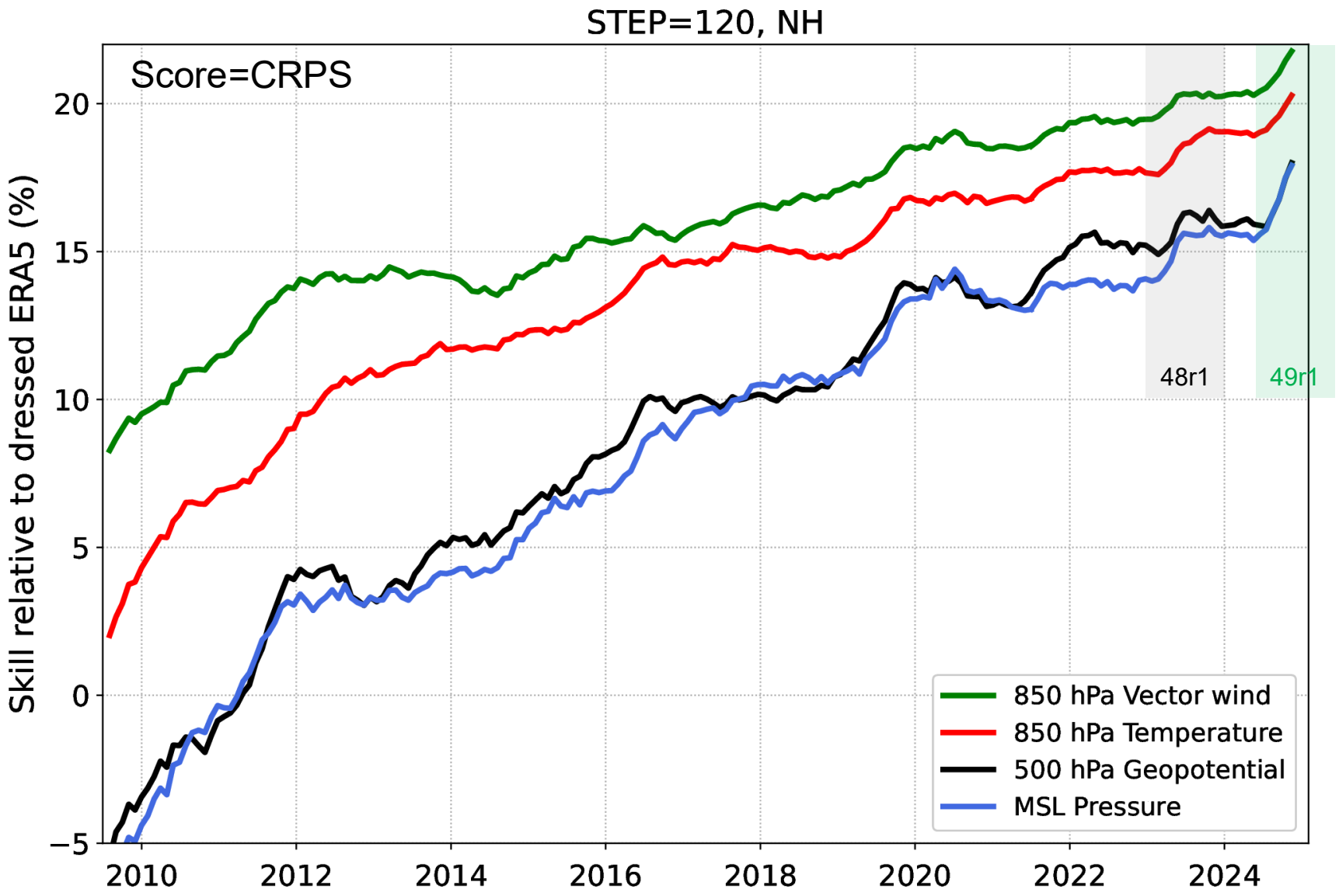
Numerous upgrades to observation usage between cycles
e.g. global MODE-S; Meteosat-12; Arctic Weather Satellite; more wave observations…..



- ERA6/EAC5 historical reanalyses
- SEAS6 seasonal forecast system
- Output in GRIB2

- All science from 49r2 + additional science upgrades
- Output in GRIB1

ENS skill relative to dressed ERA5 – Day 5



850 hPa Wind
850 hPa Temperature

500 hPa Geopotential
MSL pressure

Very clear improvement from 49r1!

Towards ERA6

- ✓ higher resolution
- ✓ additional 8 years R&D
- ✓ more observations
- ✓ ocean component

➔ **Better extremes**

Tons of rocks bury Assos village in Kefalonia hit by Medicane Ianos

https://www.keeptalkinggreece.com/2020/09/20/assos-kefalonia-buried-rocks-medicane-ianos/

FEATURED / SOCIAL / WEATHER

September 20, 2020 | 2 min. read

BAMS Article

Ianos—A Hurricane in the Mediterranean

K. Lagouvardos, A. Karagiannidis, S. Dafis, A. Kalimeris, and V. Kotroni

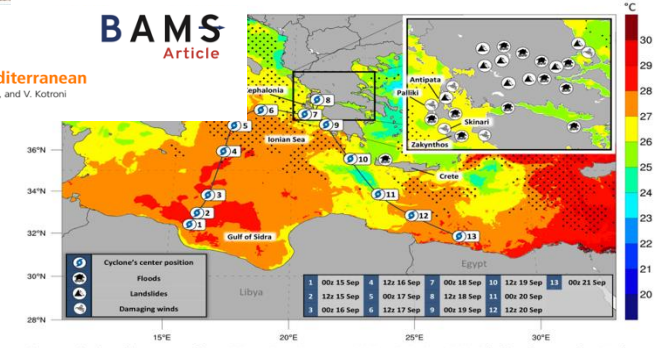


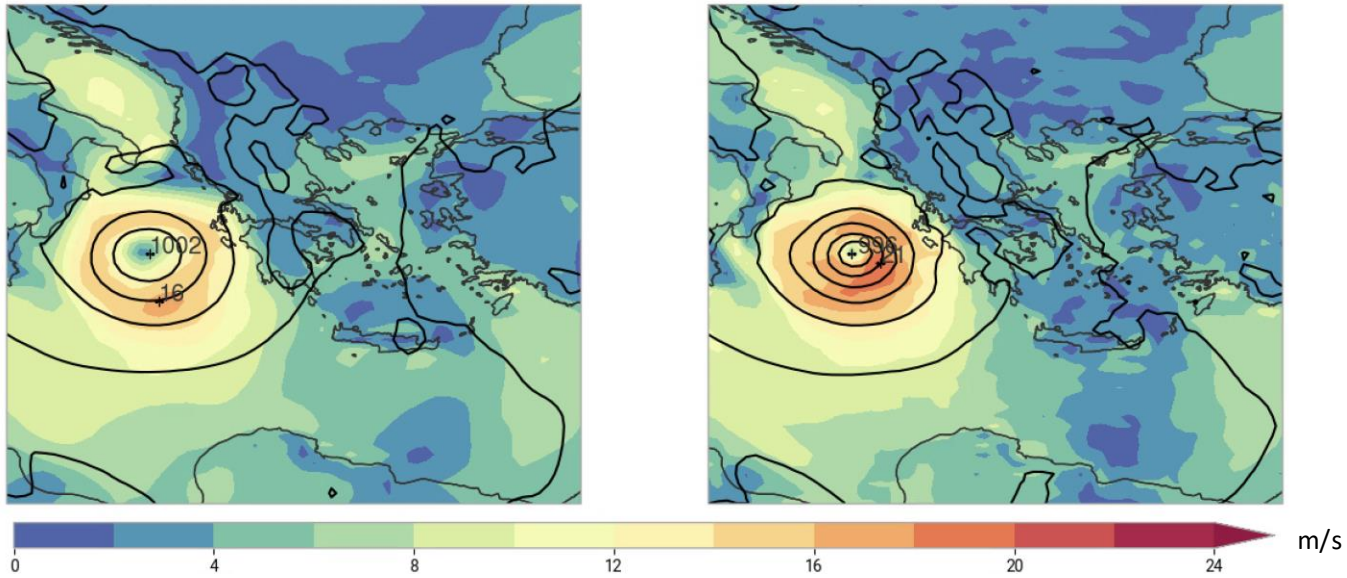
Fig. 1. Path of Medicane Ianos, from 0000 UTC 15 Sep up to 0000 UTC 21 Sep 2020. Shading denotes the SST (at 1-K intervals), and the black dots the daily SST anomaly higher than 2 K on 15 Sep 2020. Symbols for floods, landslides, and damaging winds are placed over the most affected areas.

Lagouvardos, et al, 2022: Ianos—A Hurricane in the Mediterranean. Bull. Amer. Meteor. Soc., 103, E1621–E1636, https://doi.org/10.1175/BAMS-D-20-0274.1.

Example: Medicane Ιανός (Ianos)

ERA5 Ten-meter wind speed, MSLP
valid on 2020-09-17 12 UTC

ERA6P2 Ten-meter wind speed, MSLP
valid on 2020-09-17 12 UTC

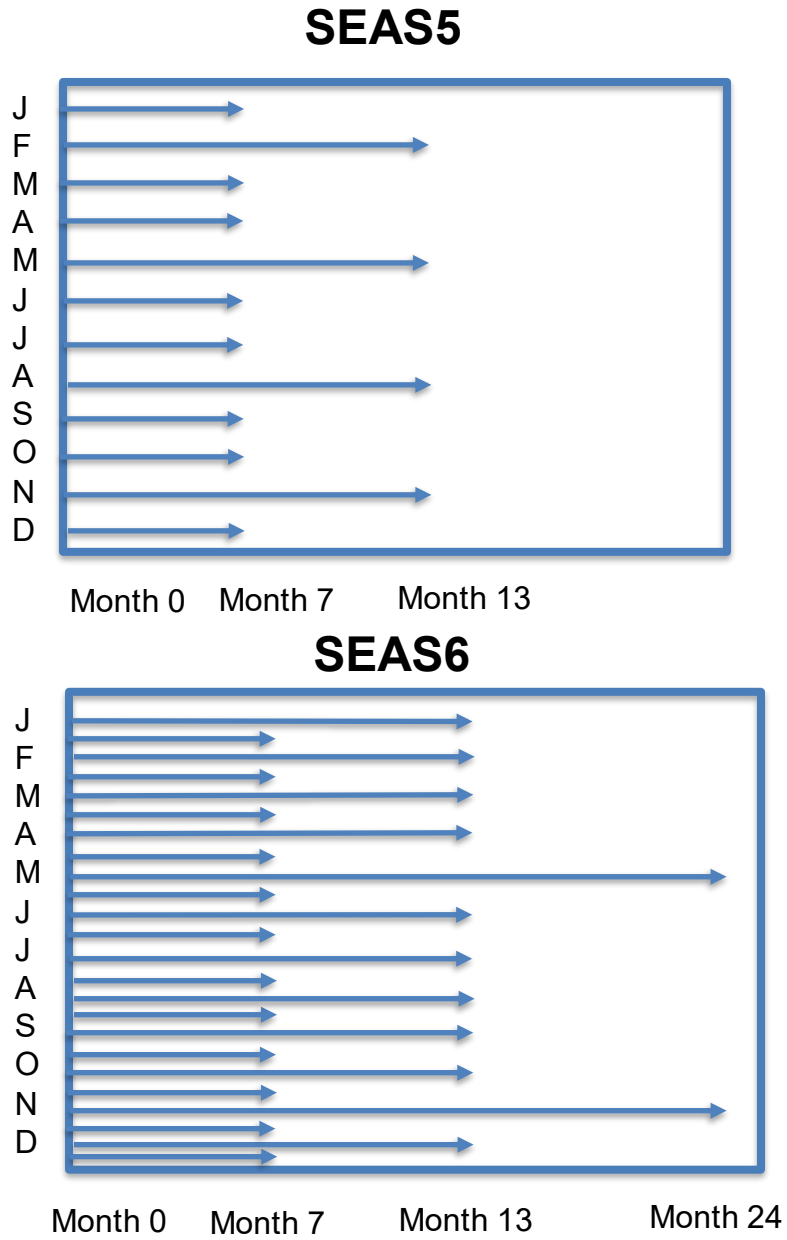


Lowest pressure: **1002** hPa in ERA5 ➔ **996** hPa in ERA6 prototype

Strongest wind: **16** m/s in ERA5 ➔ **21** m/s in ERA6 prototype

SEAS6 configuration – operational Q3 2026

- **Enhancement 1: Real-time 101 member ensemble**
  - Currently 51 members
- **Enhancement 2: Issue SEAS twice per month**
  - Initial date 1st and 16th of each month
- **Enhancement 3: Expand annual-range ENSO forecasts**
  - Issue forecast monthly not quarterly
  - Twice per year, increase range to 24 months
- **Enhancement 4: More comprehensive reforecasts**
  - Larger ensemble sizes and larger set of years
  - Some reforecasts will extend to the 1960s
  - Bias correction of products will continue use a recent period (e.g. 1993 onwards) for consistency with C3S and improved anomalies relative to a changing climate



49r1 → 50r1 “highlights of the highlights”

- Outer loop coupling (more exchange of information between atmosphere and ocean within the data assimilation cycle)
- Weak constraint 4D-Var in the boundary layer allowing assimilation of all 2 metre temperature observations
- Numerous enhancements to the use of upper-air observations

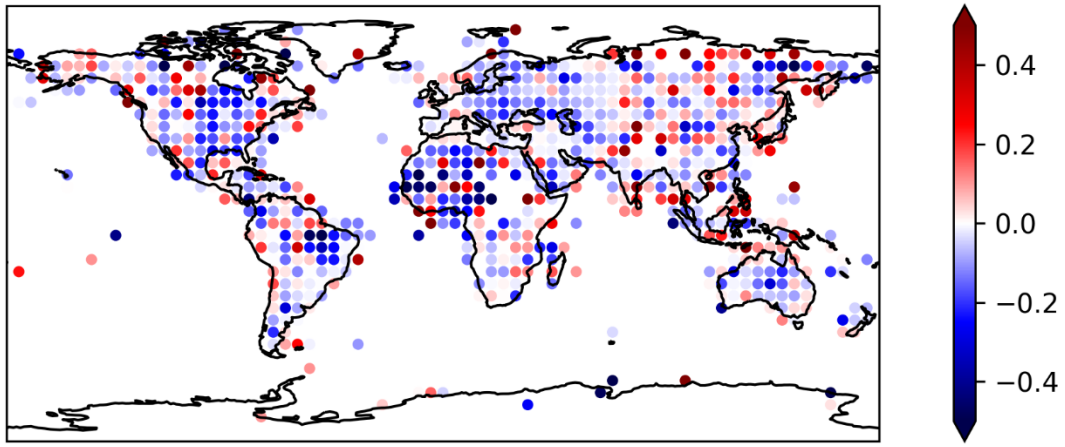
- New ocean and sea-ice model (NEMO4-SI^3)
- Waves and sea-ice interaction
- Reduced vertical diffusion in the stratosphere (better QBO) and convection and microphysics modifications

- Response to specific user-relevant issues
  - Inland convection penetration
  - Reduced 10m wind spread
  - Improved tropical cyclone initialization

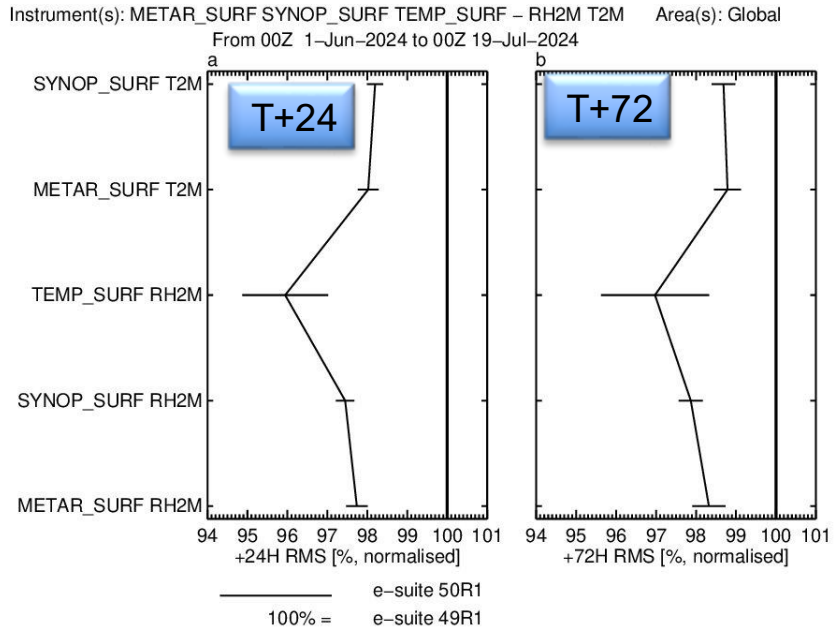
T2m assimilation: Weak constraint 4d-var in the boundary layer

- Weak constraint extended to the boundary layer (& top soil temperature level) including representation of the diurnal cycle of model error

RMS of first-guess departure for T2m



RMS of forecast departure against surface data



Overall a 3% reduction in the RMS compared to CY49R1

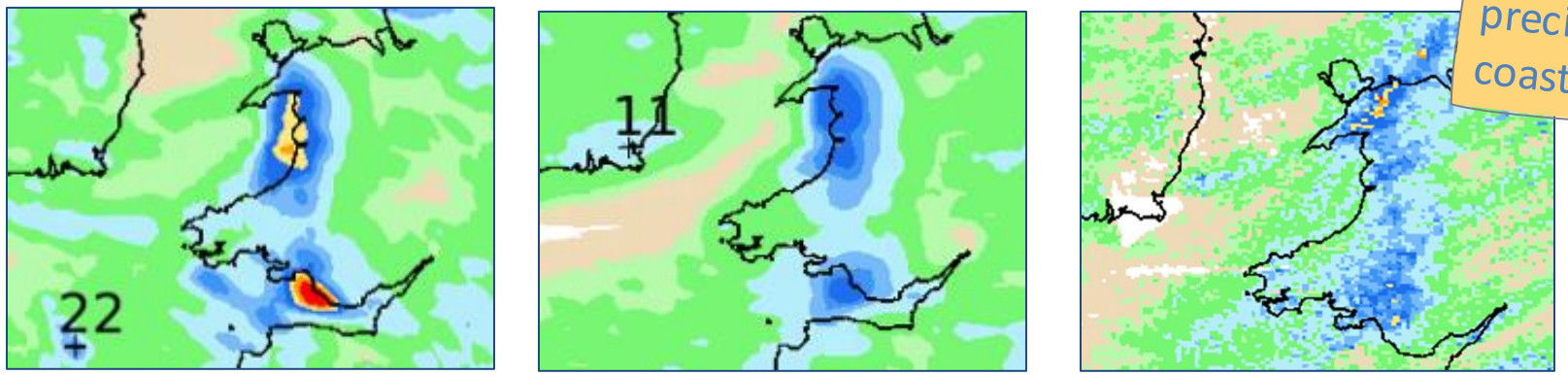
Impacts for summer 2024

Convection updates in 50r1

- Some of the convective precipitation now handled prognostically by the cloud scheme and advected
- Mitigates known bias of excessive offshore convective precipitation with onshore wind
- Inland penetration of precipitation improved in convective situations

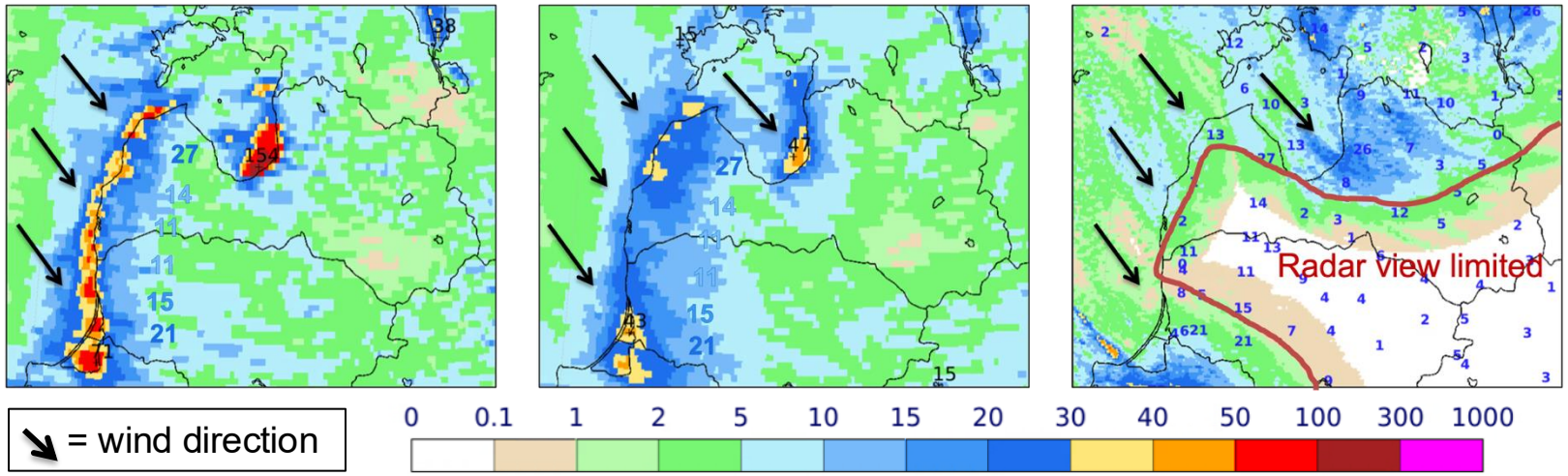
Improvement in precipitation near coasts

Example: 01 Sep 2025 Wales/UK



49r1 | 50r1 | Radar / SYNOP

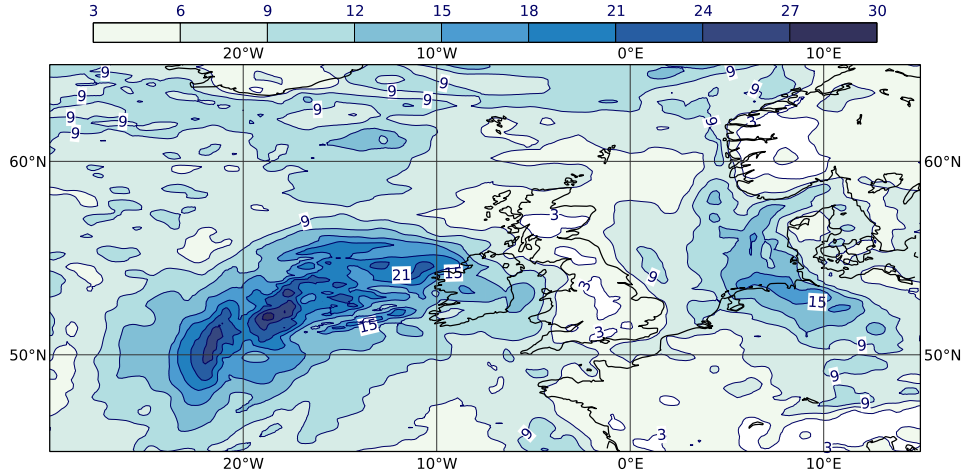
Example: 24 Aug 2025 Latvia & Lithuania



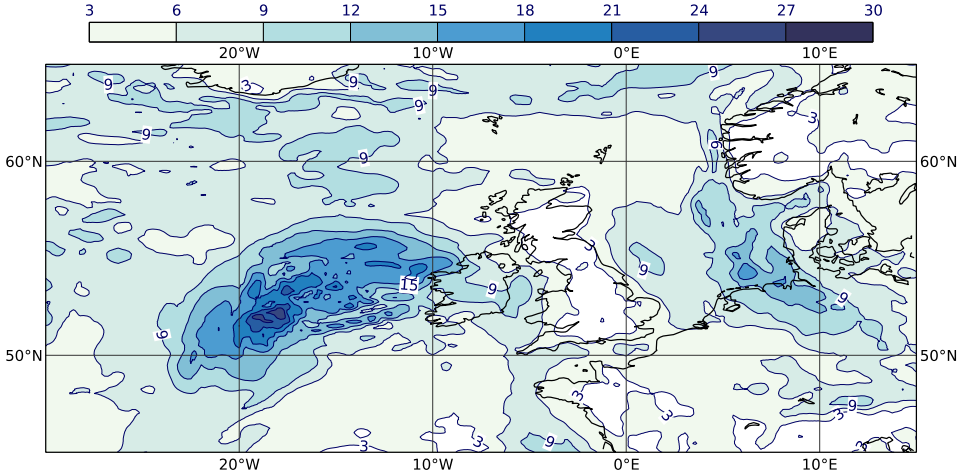
Responding to known issues

Ensemble range in 10m wind for Storm Daragh (m/s)

49r1

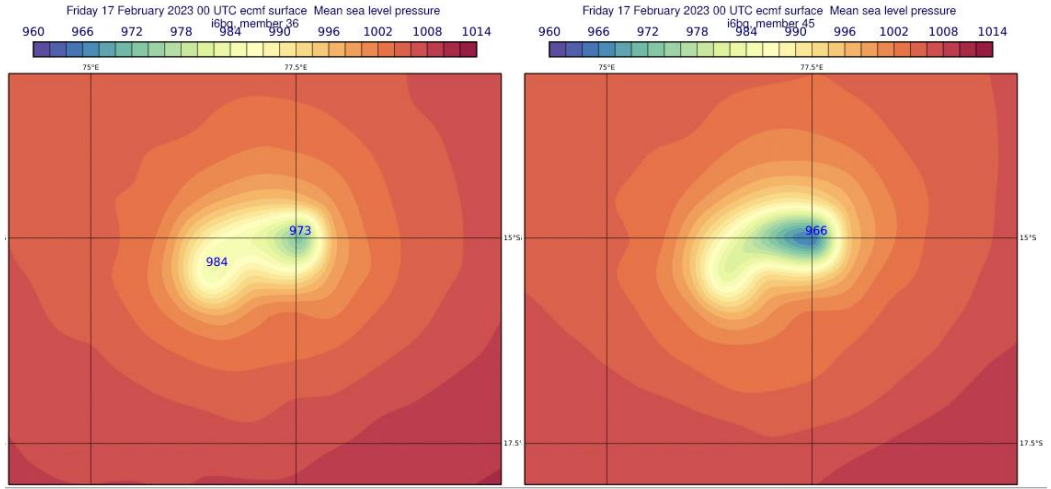


50r1

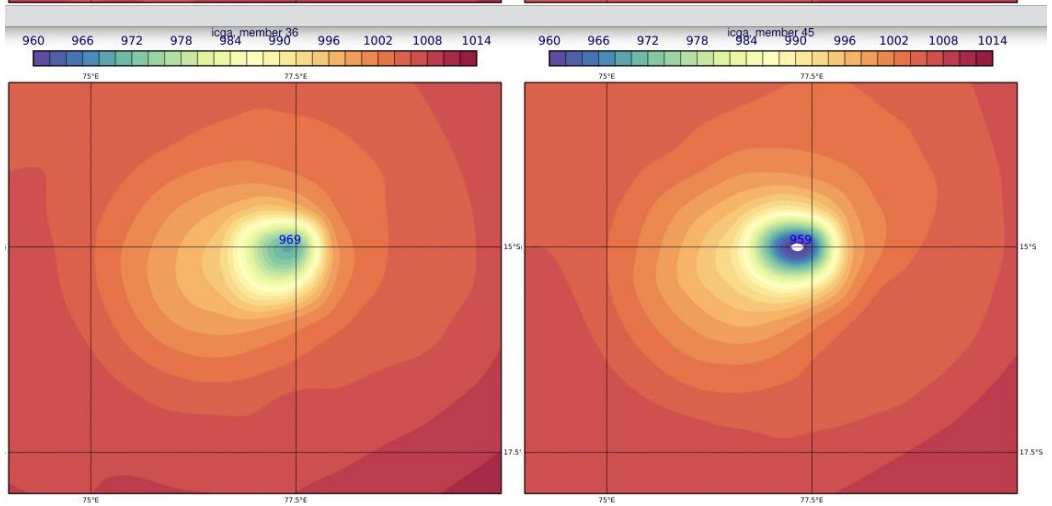


Mean sea level pressure initial conditions, TC Freddy, Two selected ensemble members

49r1

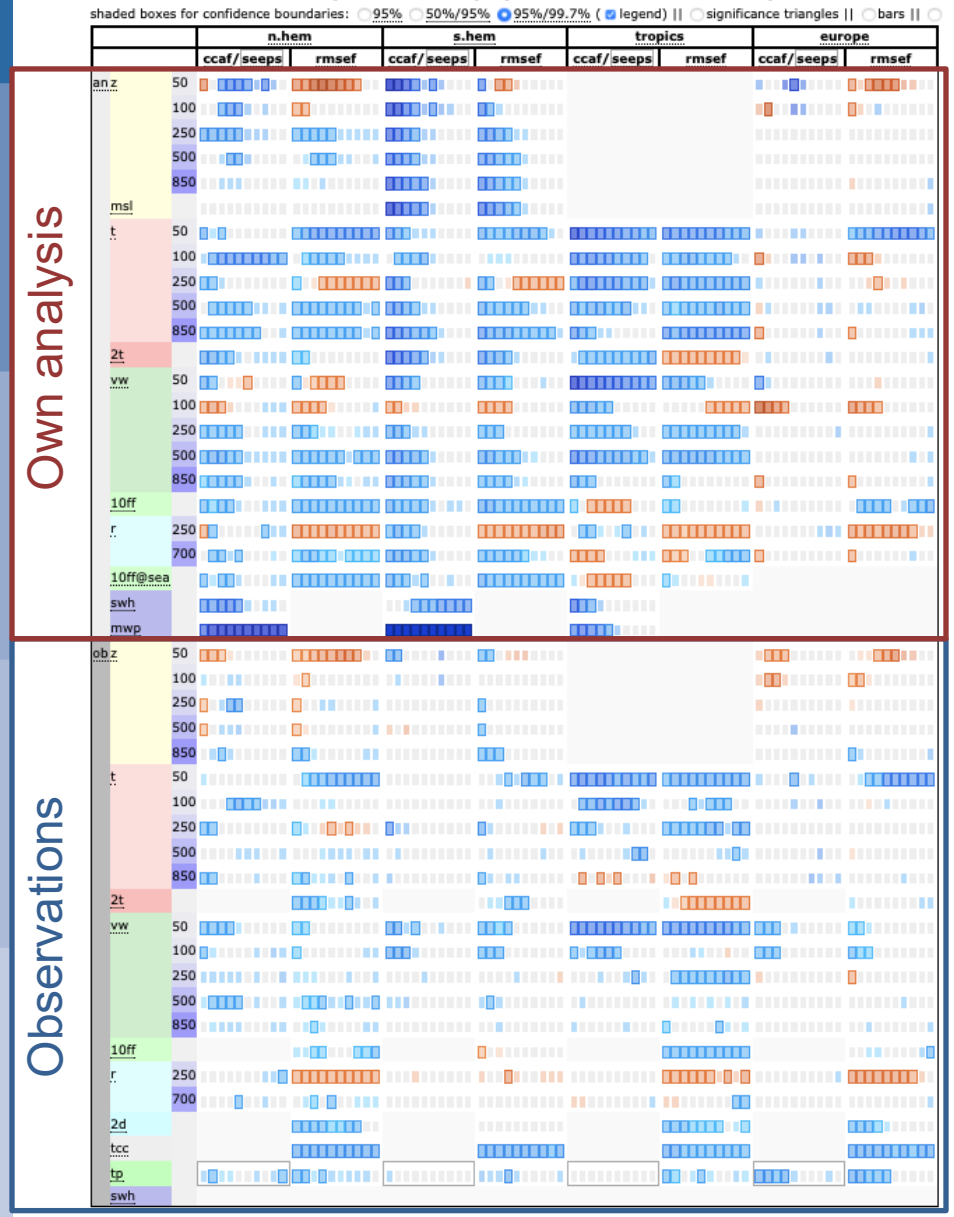


50r1



50r1 RD esuite: score cards (summer + winter combined)

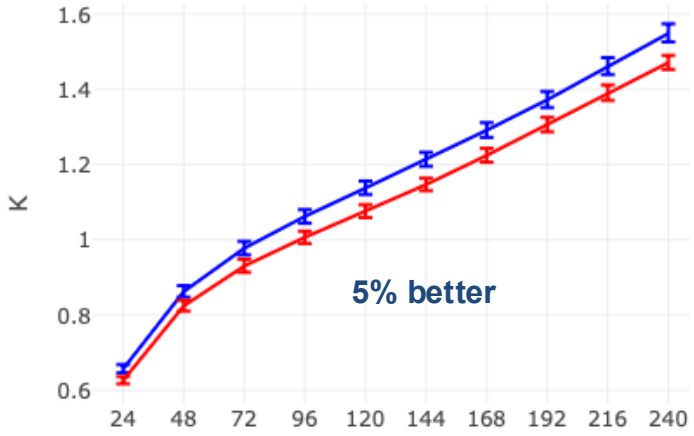
ENS Control (=HRES) (430 forecasts)



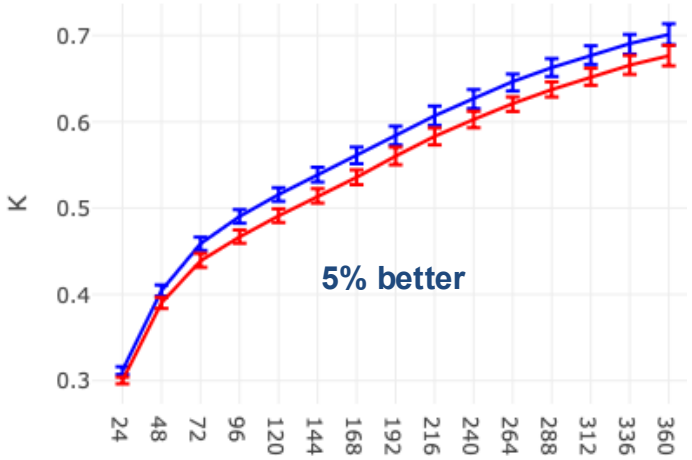
50-member ENS (142 forecasts)

Improvement to tropical upper air scores in 50r1 (summer+winter): ENS and CF

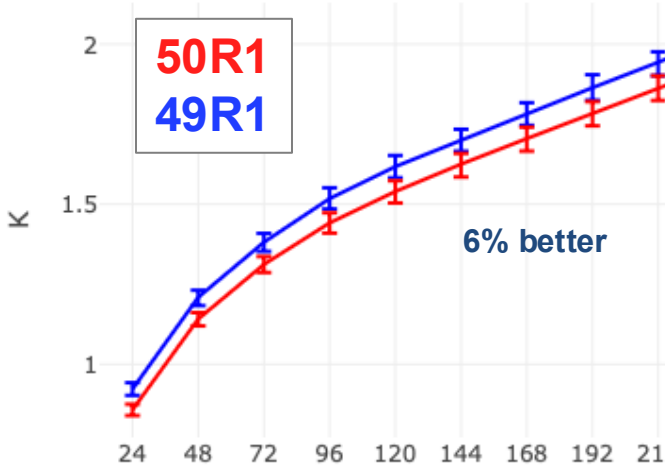
t850 | tropics | rmsef | an



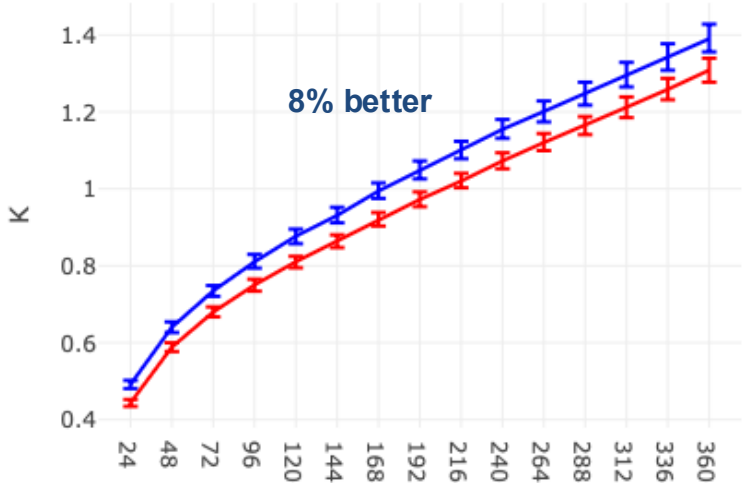
t850 | tropics | crps | an



t50 | tropics | rmsef | an



t50 | tropics | crps | an



Cycle 50r1 improves tropical troposphere and stratosphere forecasts — first notable gain in years

- Improvement mostly from physics contributions.

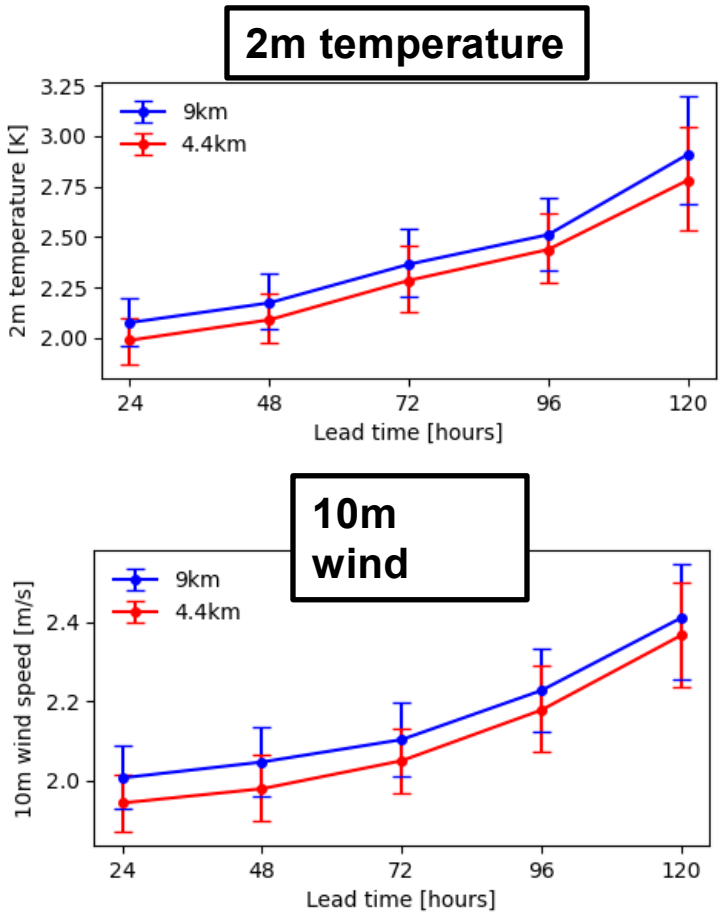
ECMWF

Part 2

Destination Earth Developments

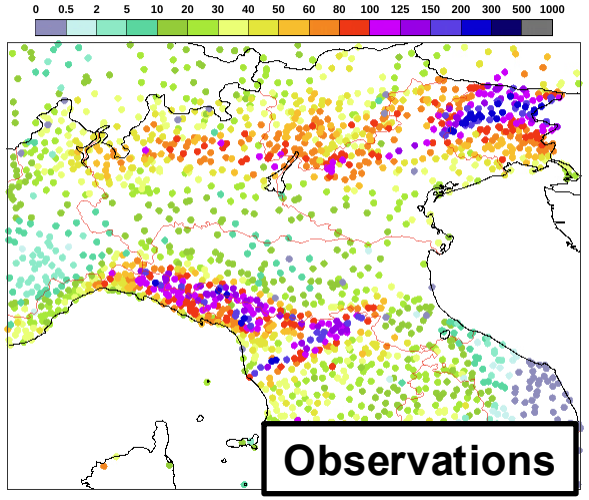
Longer term: Benefits from km-scale IFS (forecasts and training data)

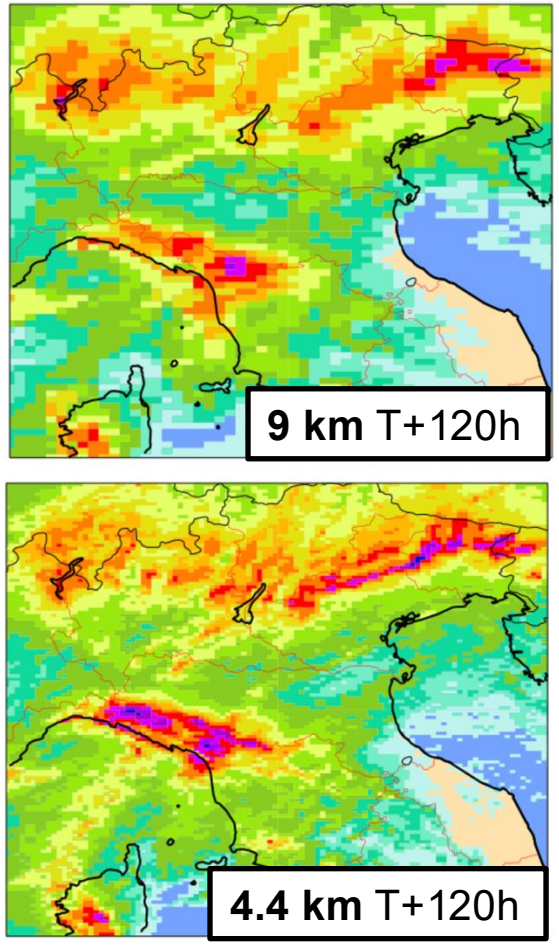
Improved statistics of European near-surface weather



Improved prediction of high-impact weather

Total precipitation
2 Nov 2023



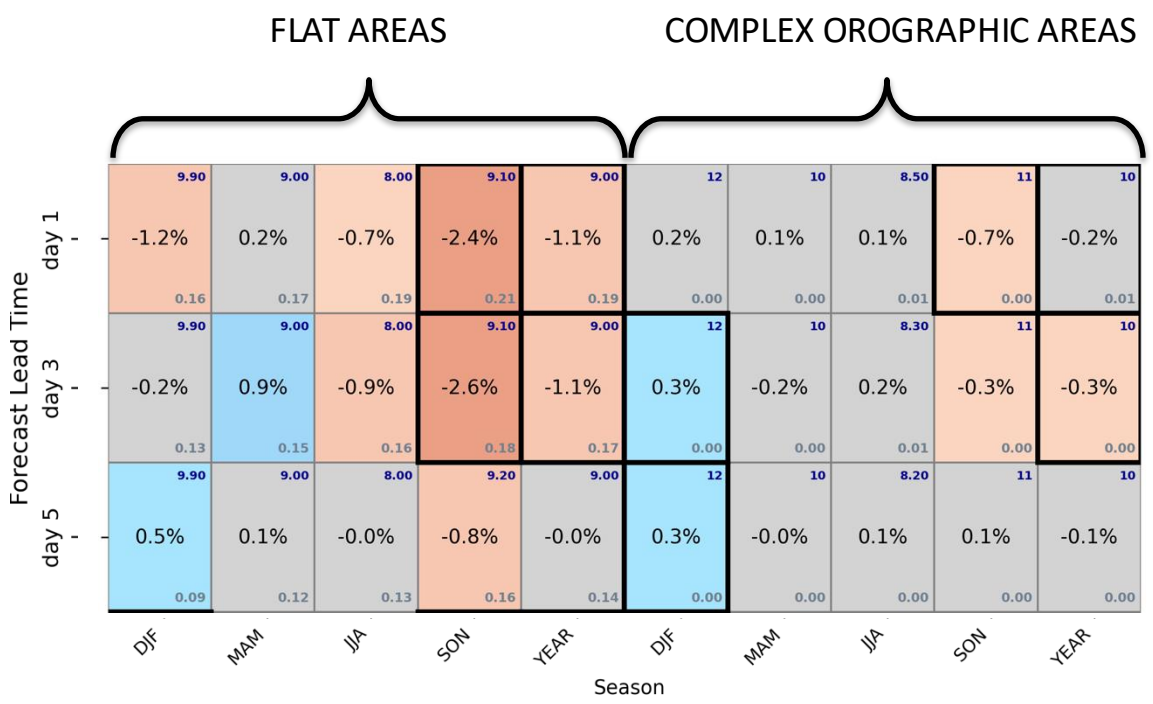


FORECASTING EXTREMES: PHYSICAL MODELS VS. AI — WHO DOES IT BETTER?

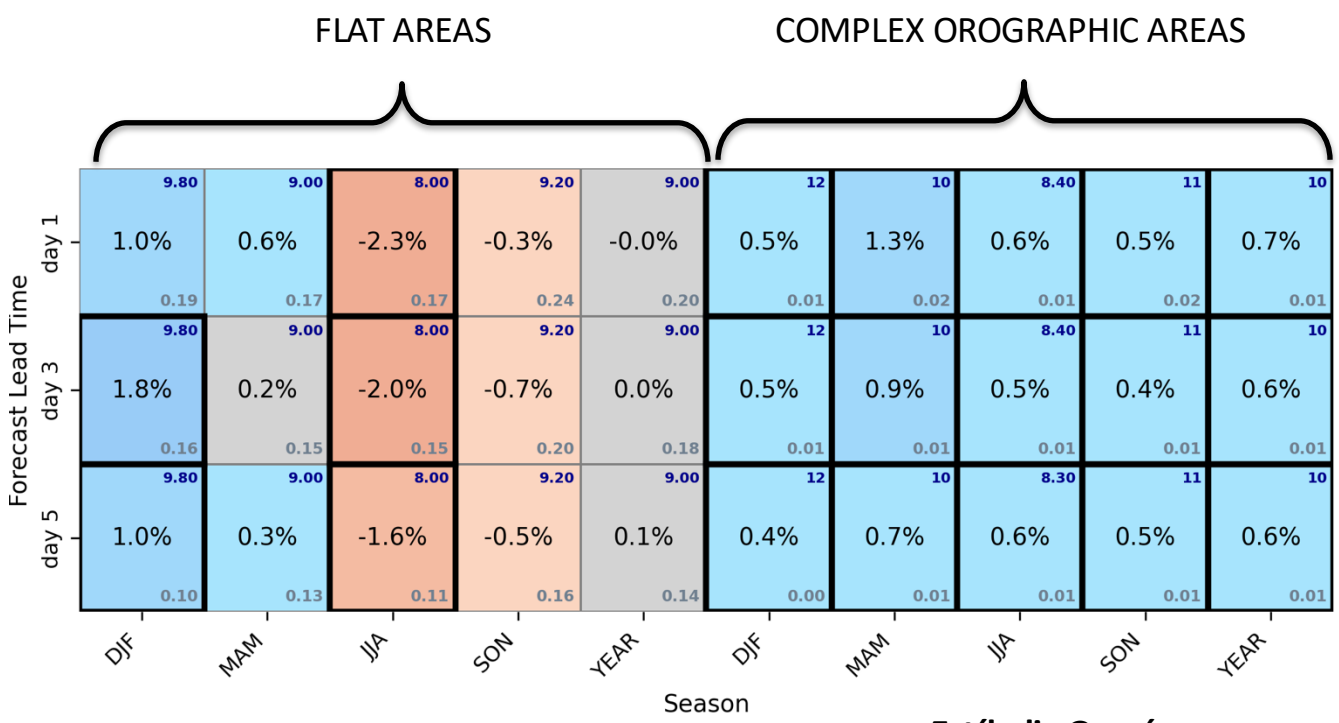
Equitable Threat Score > 99th percentile

10m wind speed

AIFS vs OPER



Global DT vs OPER

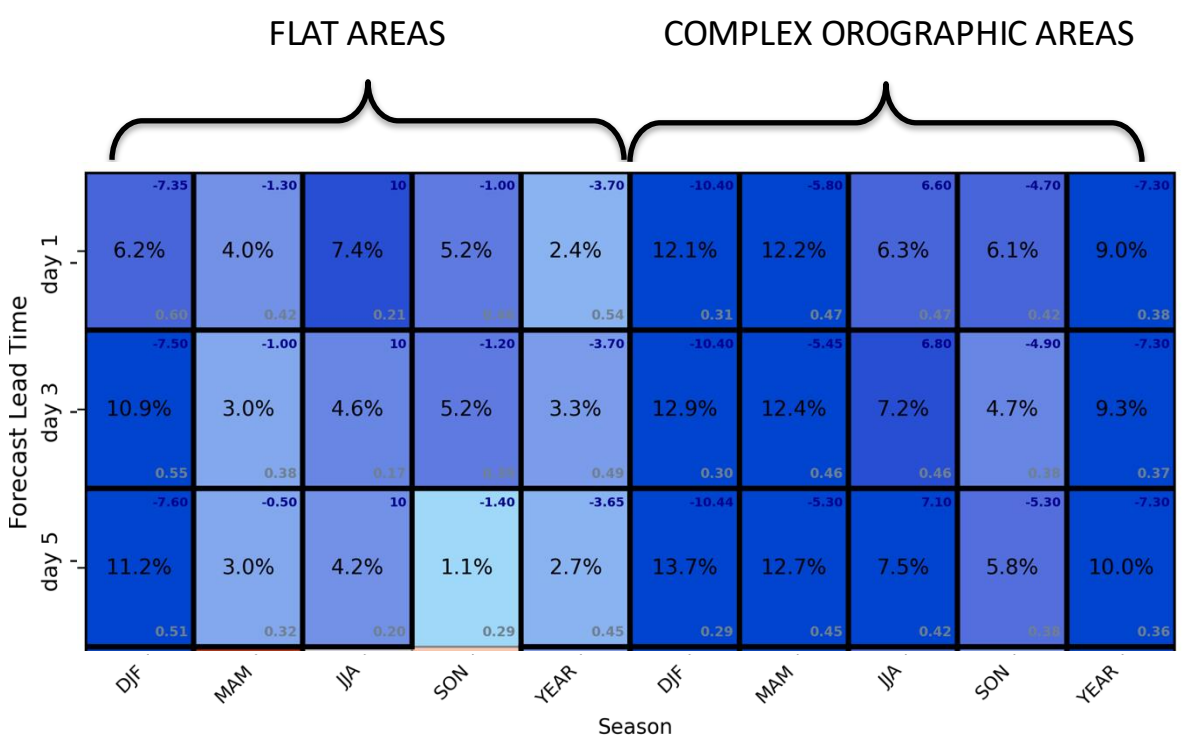


FORECASTING EXTREMES: PHYSICAL MODELS VS. AI — WHO DOES IT BETTER?

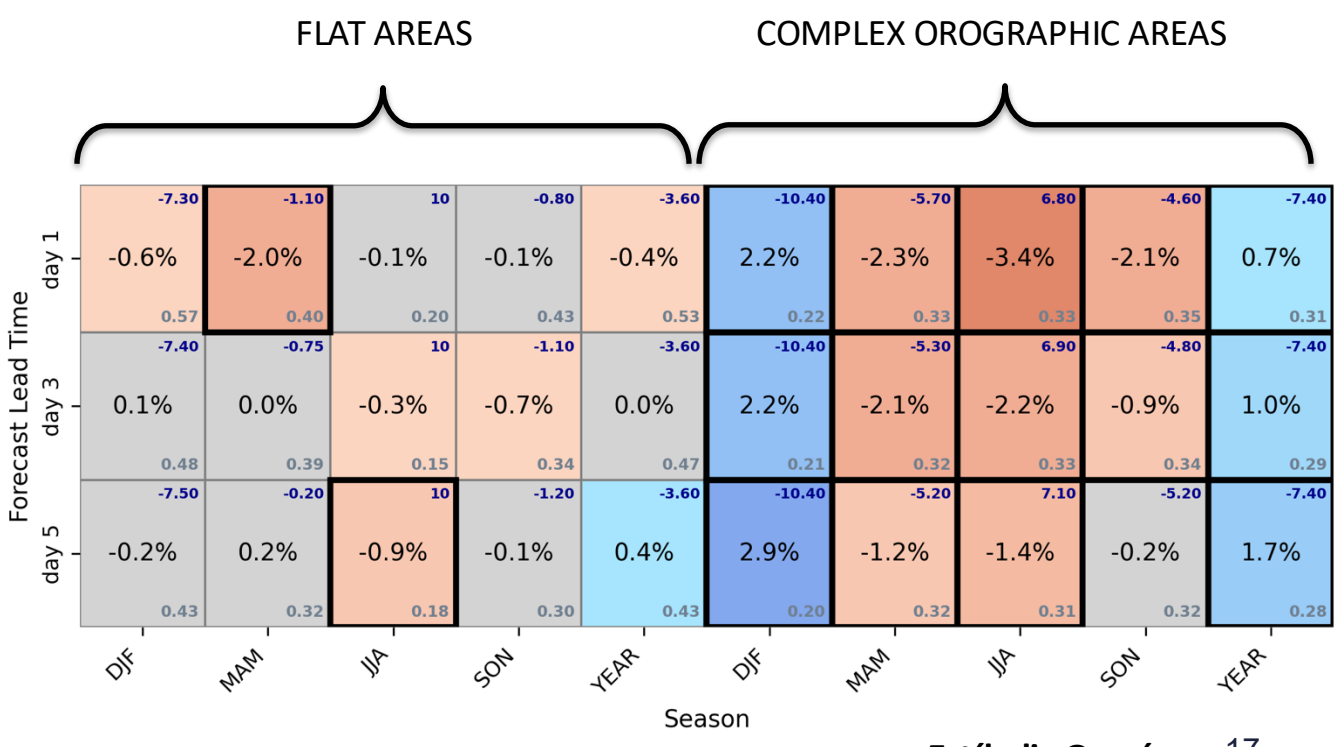
Equitable Threat Score > 99th percentile

Cold 2m-temperature

AIFS vs OPER



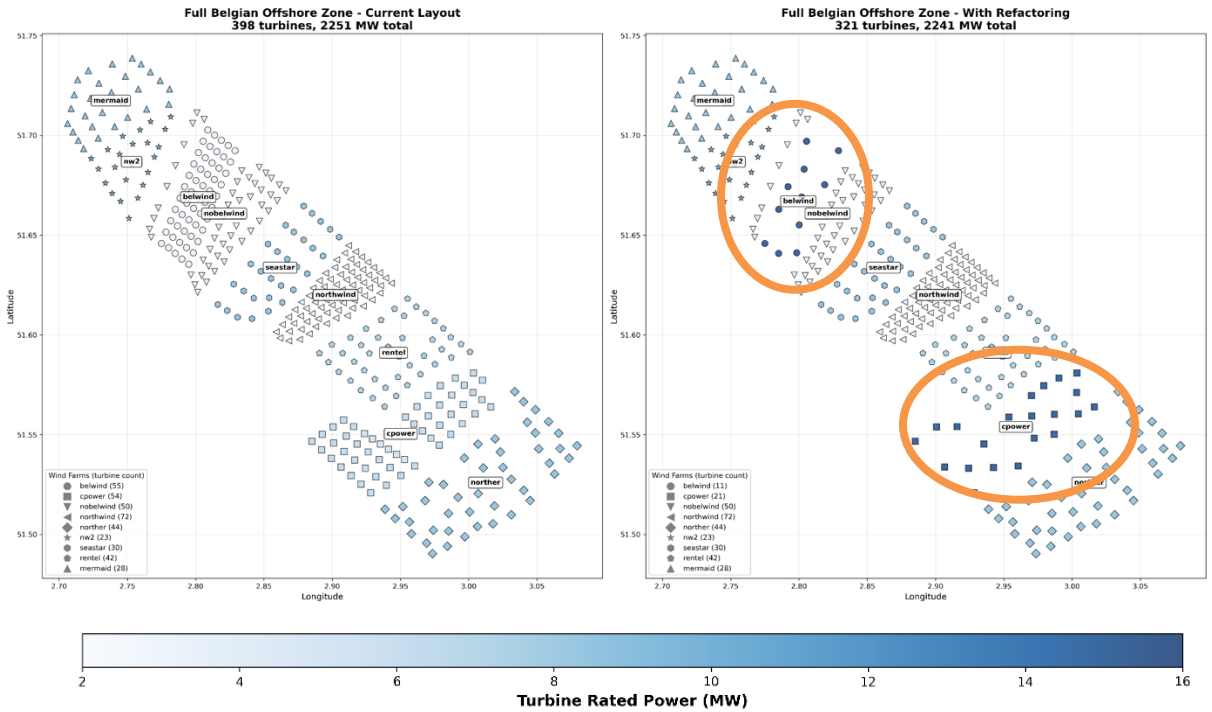
Global DT vs OPER



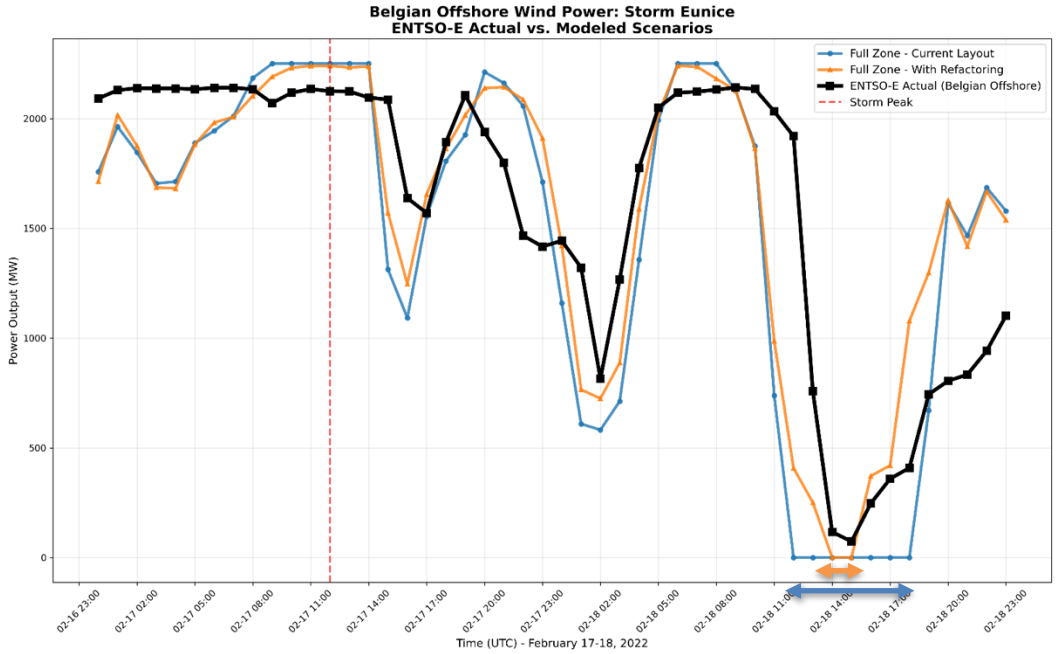
… NOW LET'S REPLAY THE STORY

What if Belgian offshore wind farms had been refactored with modern turbines before Storm Eunice?

Current farm (398 turbines) **Refactored farm (321 turbines)**



"Refactor" 2 out of 8 Belgian offshore wind farms with the "oldest" or "smallest" wind turbine types to new and modern turbines while keeping the overall BOZ installed capacity



Why is the cut-out with modern turbines reduced from 6 to 1h?

- Legacy turbines (3-6MW) cut-out at **20-25** m/s
- Modern turbines (15MW) cut-out at **25-28** m/s
- Storm Eunice winds: **25-27** m/s peak

… but also advanced control Systems, new structural design…

Credit : Irene Schicker

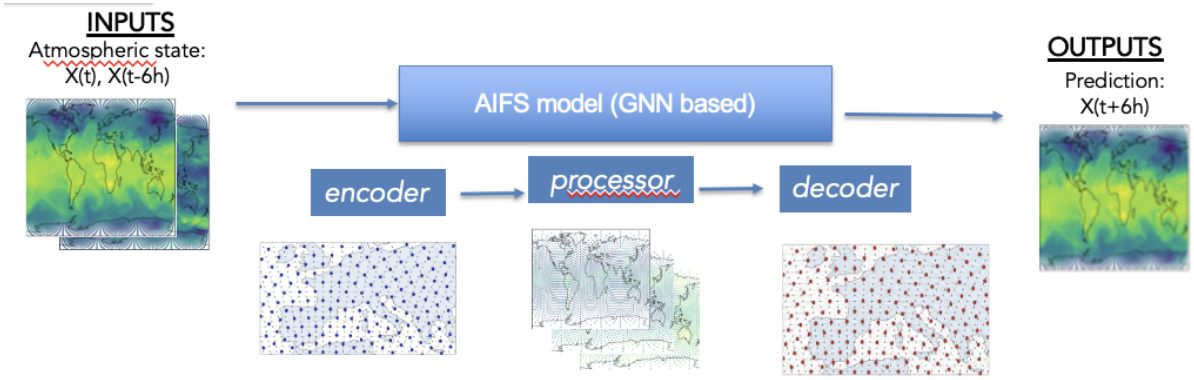
Part 3

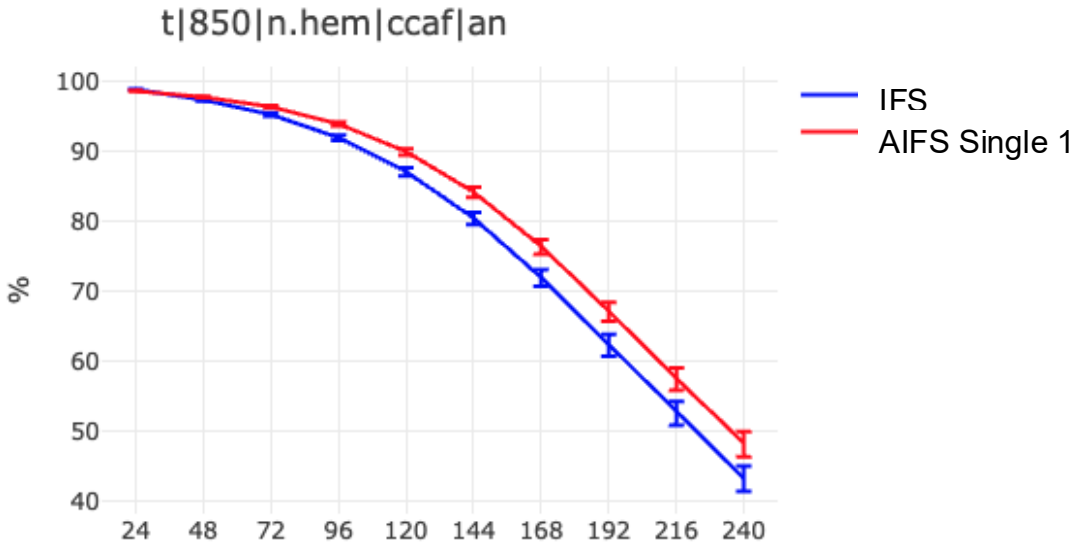
Data-Driven Forecasting

AIFS Single vs IFS

Lang et al 2024a

Operational system from 25/2/2025

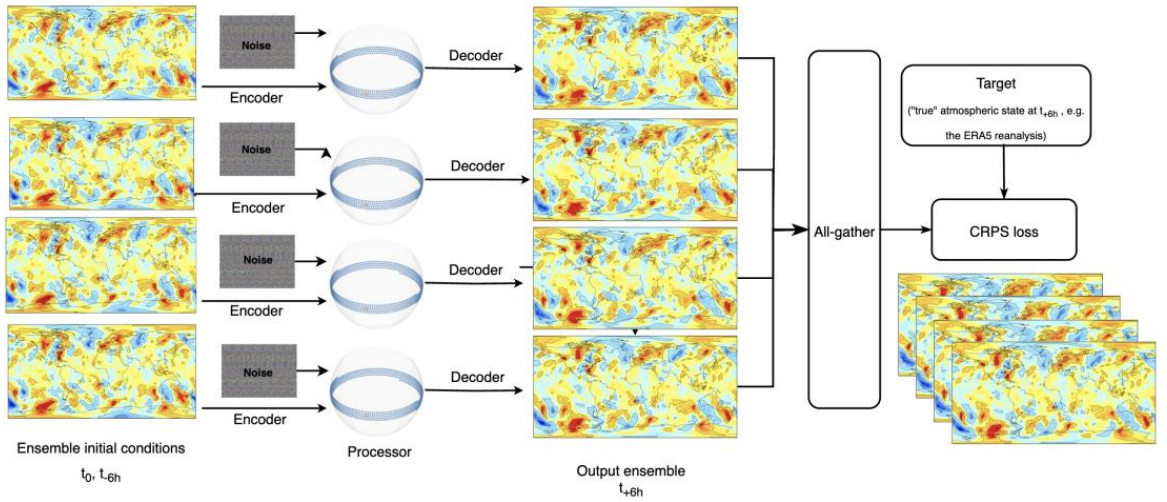


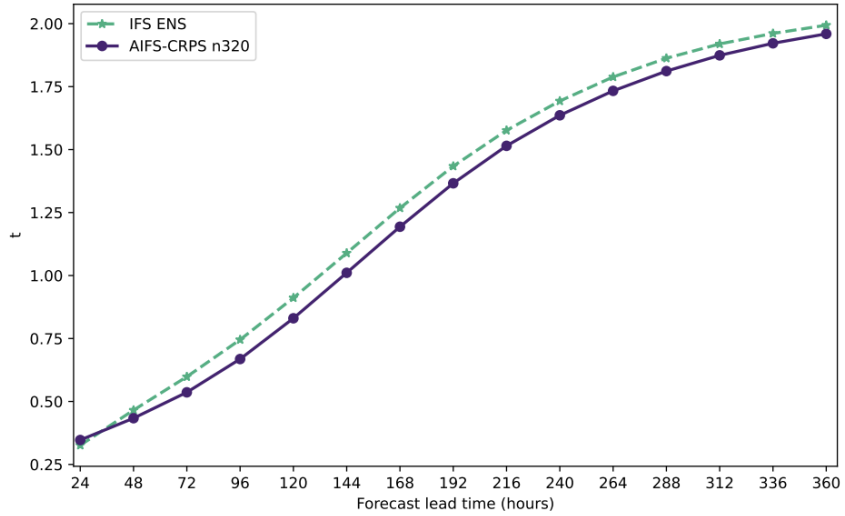


AIFS ENS CRPS vs IFS ENS

Lang et al 2024b

Operational system from 1/7/2025

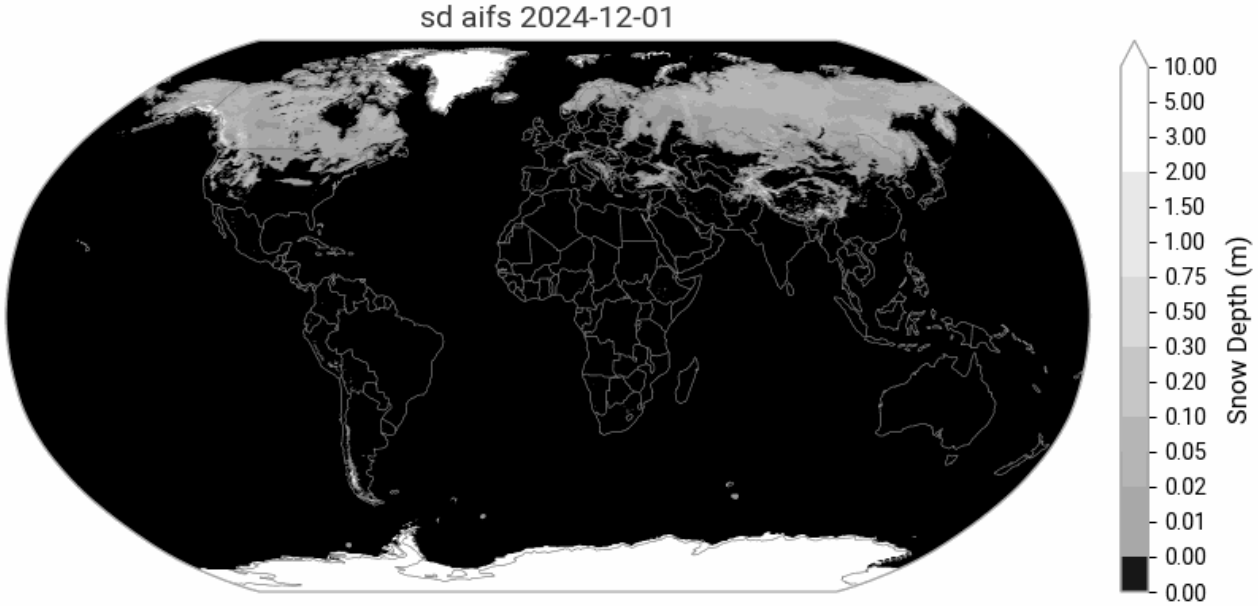




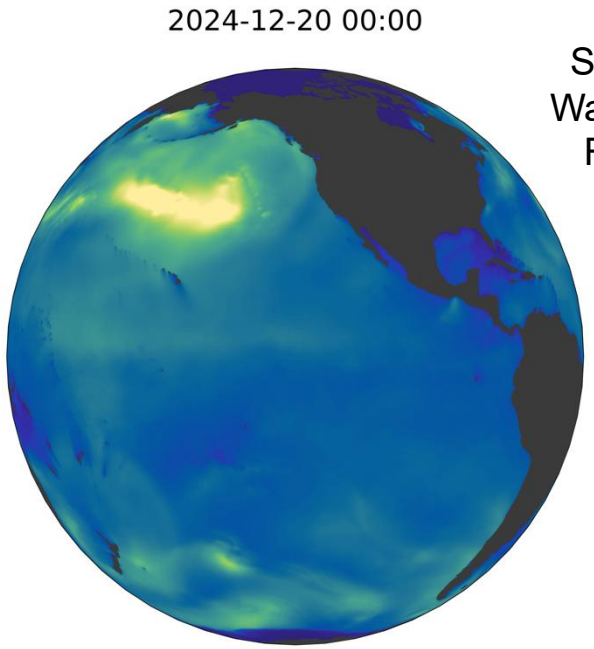
AIFS Single 2

Implementation in early 2026.

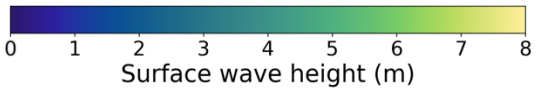
- Snow cover and depth
- Wave representation
- Improved and expanded stratosphere

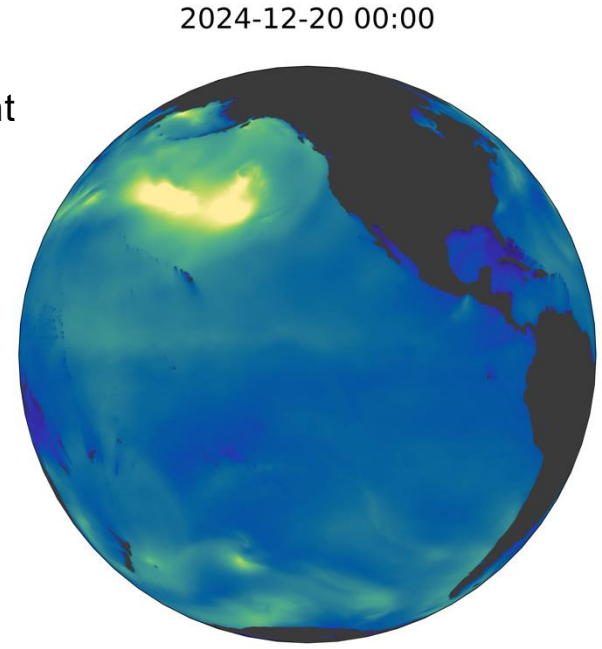


Significant Wave Height Forecast

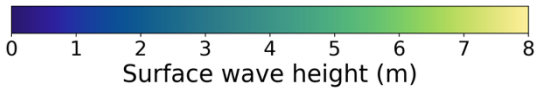


Data-driven forecast





Operational wave model ecWAM



What next for the AIFS?

- Expanded products – waves, snow depth, raised model top – in upcoming AIFS 2.

- Beyond in medium-range forecasting:
  - Further expansion to ocean in 2026.
  - EFI in 2026.
  - Higher temporal resolution – 1-hourly data – in 2026.
  - Higher spatial resolution also in development.
  - What products should we prioritise?

- Real-time sub-seasonal system with dissemination by 2026.
  - Including reforecasts.

- Real-time AIFS composition forecasts.

Thank you!