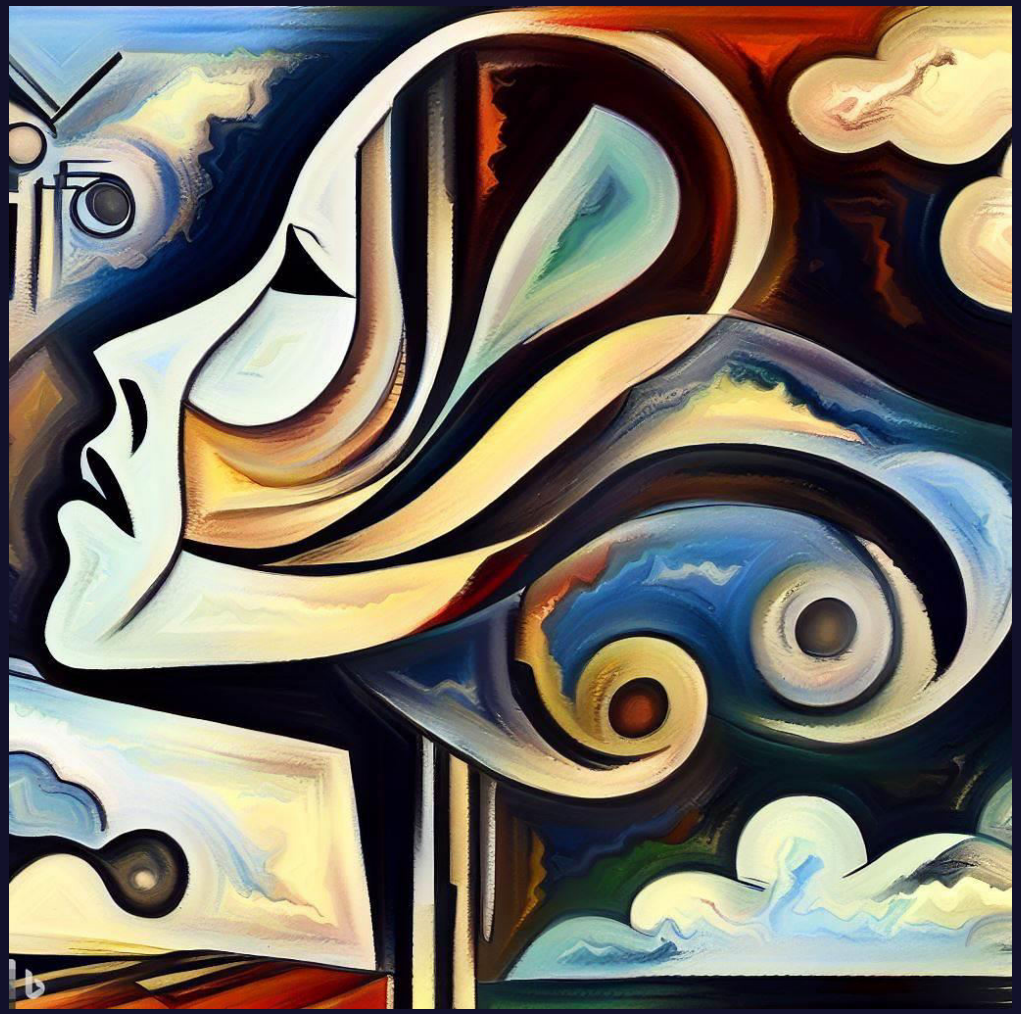
The rise of machine learning in forecasting – HEPEXAI?



Florian Pappenberger

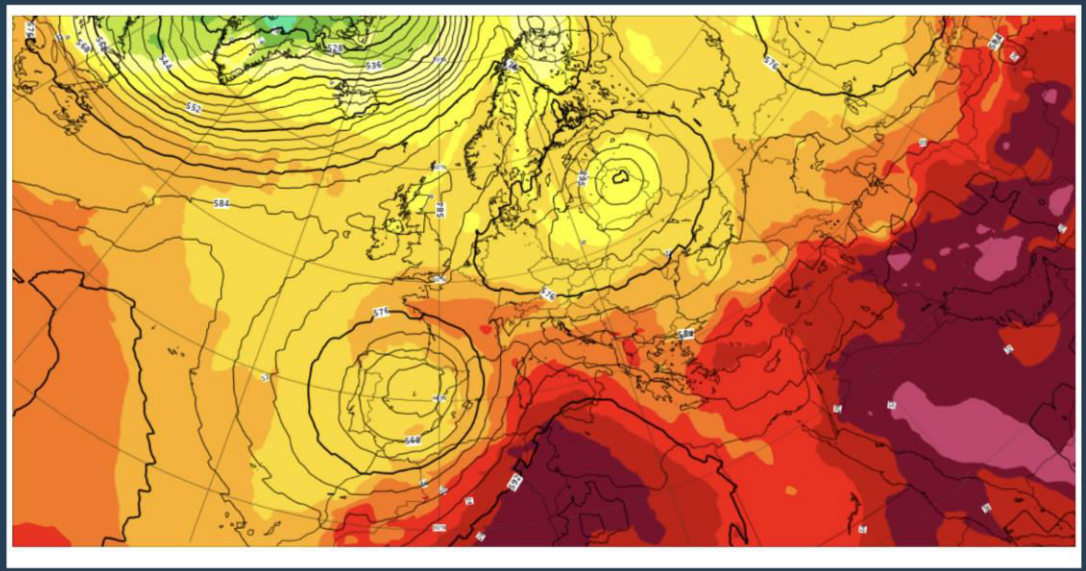
Matt Chantry & many ECMWF colleagues

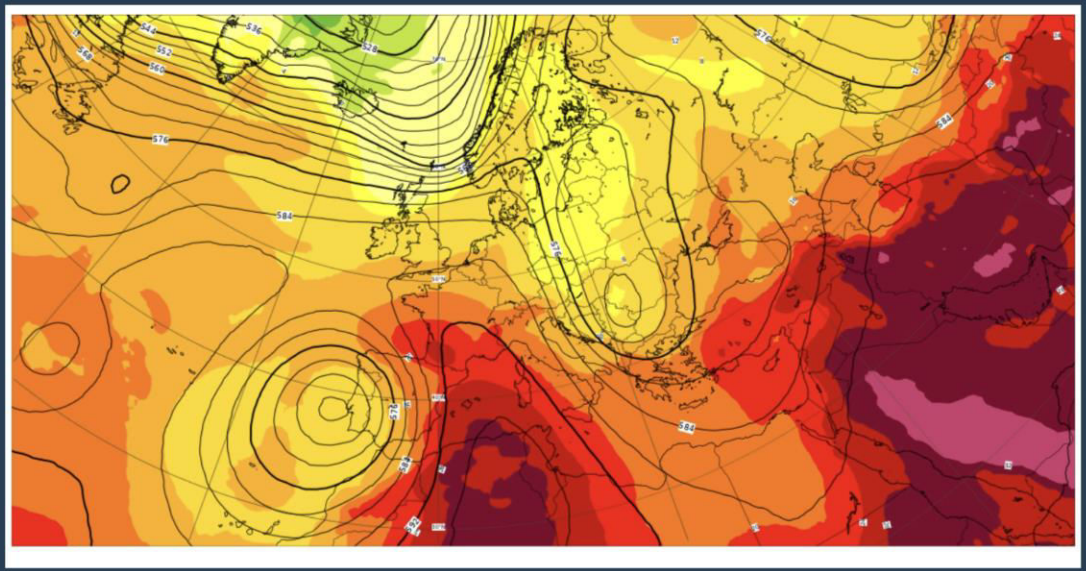
Deputy Director-General & Director of Forecasts

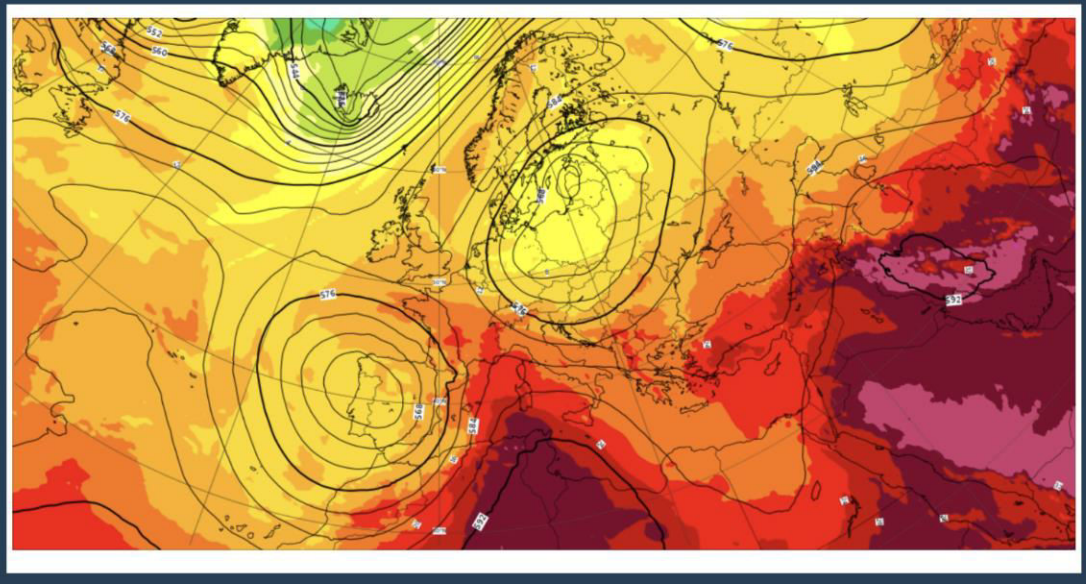
ECMWF

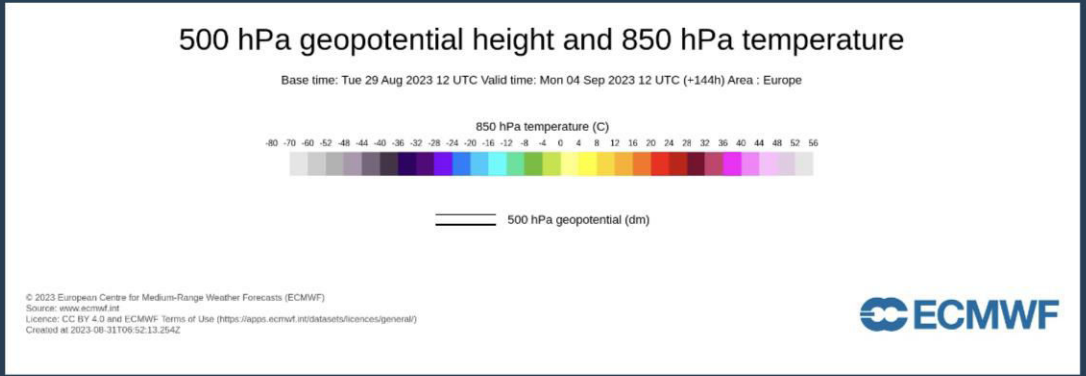
hepex.

Day 6 forecasts over Europe (valid today, 4 Sept 2023 12UTC)

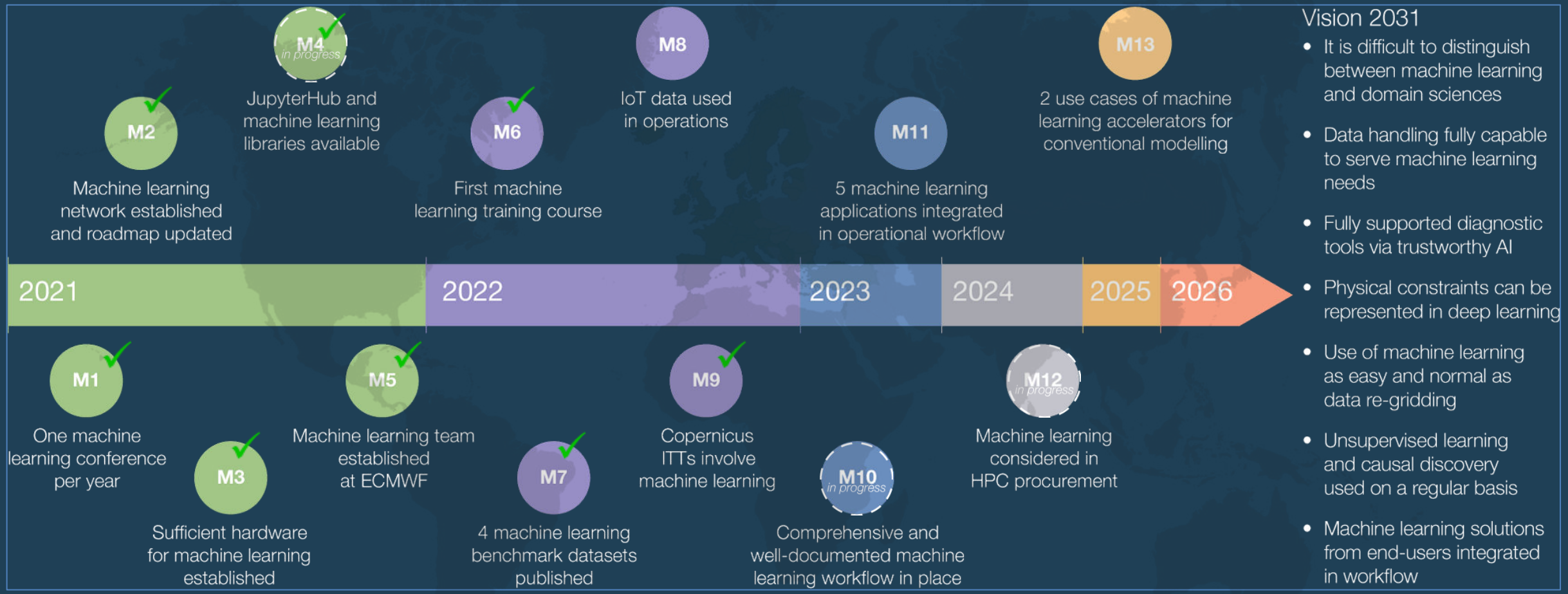






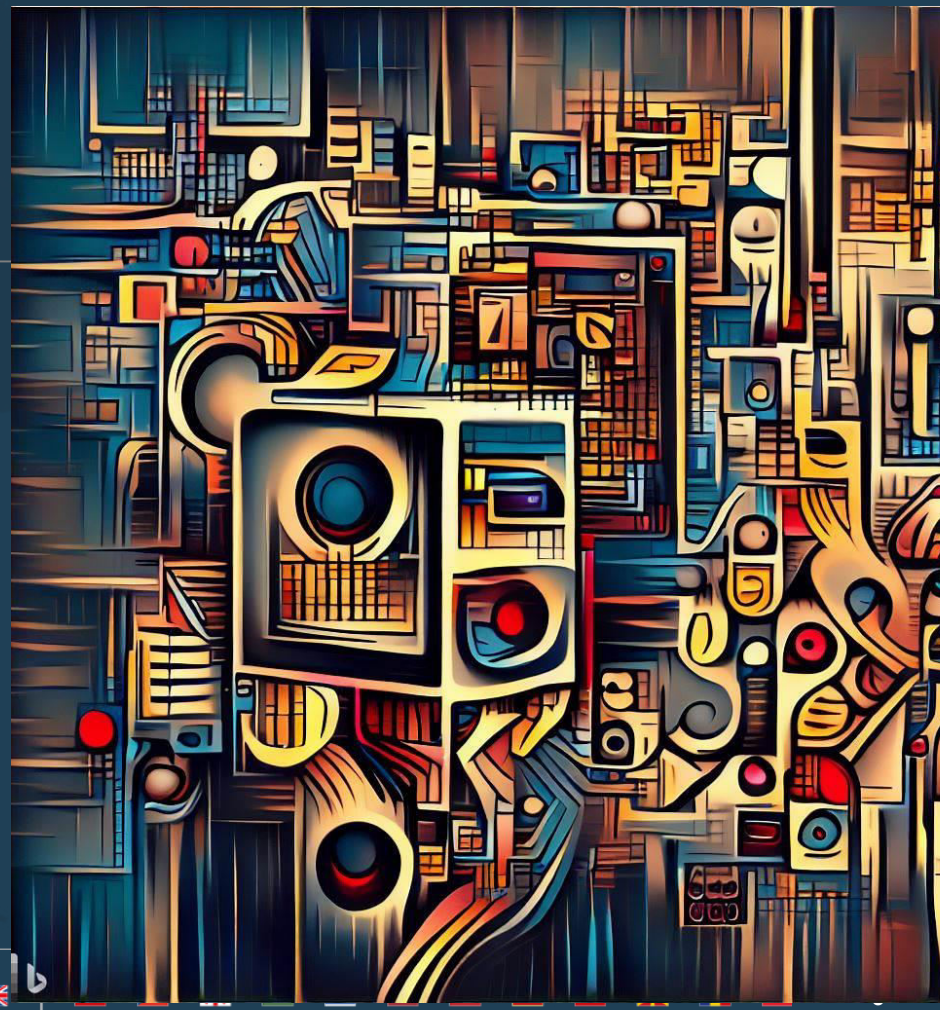


What the ML Roadmap has achieved so far

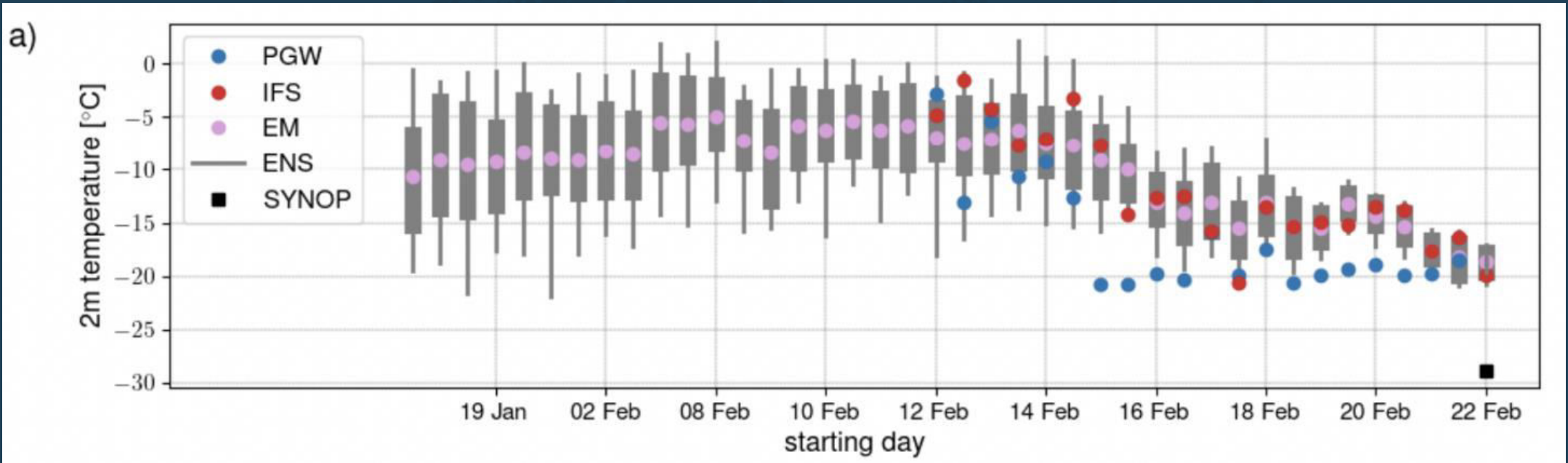


ECMWF's ML Strategy: with **a very busy and FAST evolving landscape**

What ML models are showing...

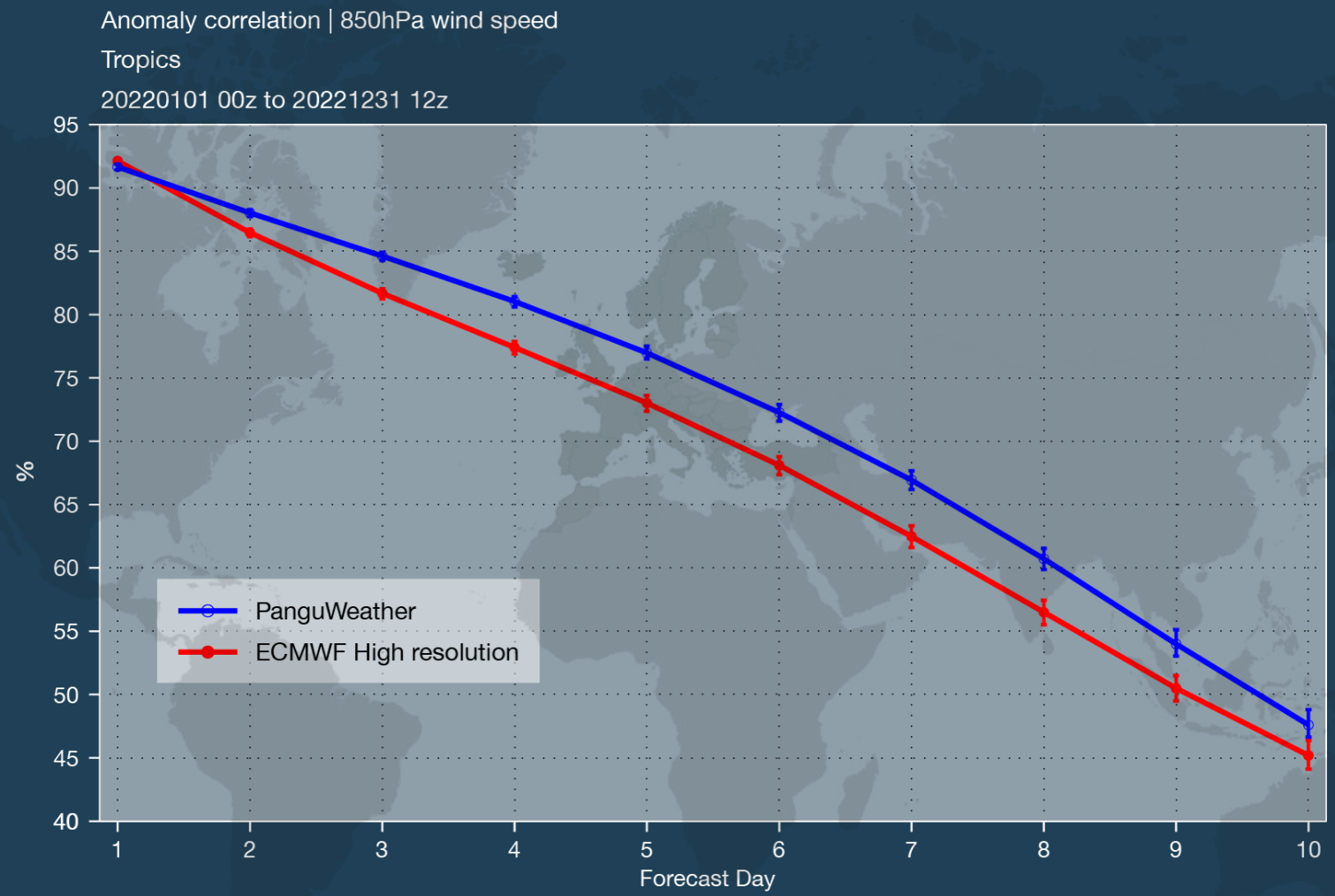


What the forecasts are showing: **Sodankylä, Finland, 22 Feb 00UTC**



To explore the ability of data-driven models to capture extreme events we examine a case study from Finland from earlier this year, when -29C was observed.
We find that Pangu recognised the severity of this event earlier, however both the IFS and Pangu underestimated the temperature significantly, to a similar degree.

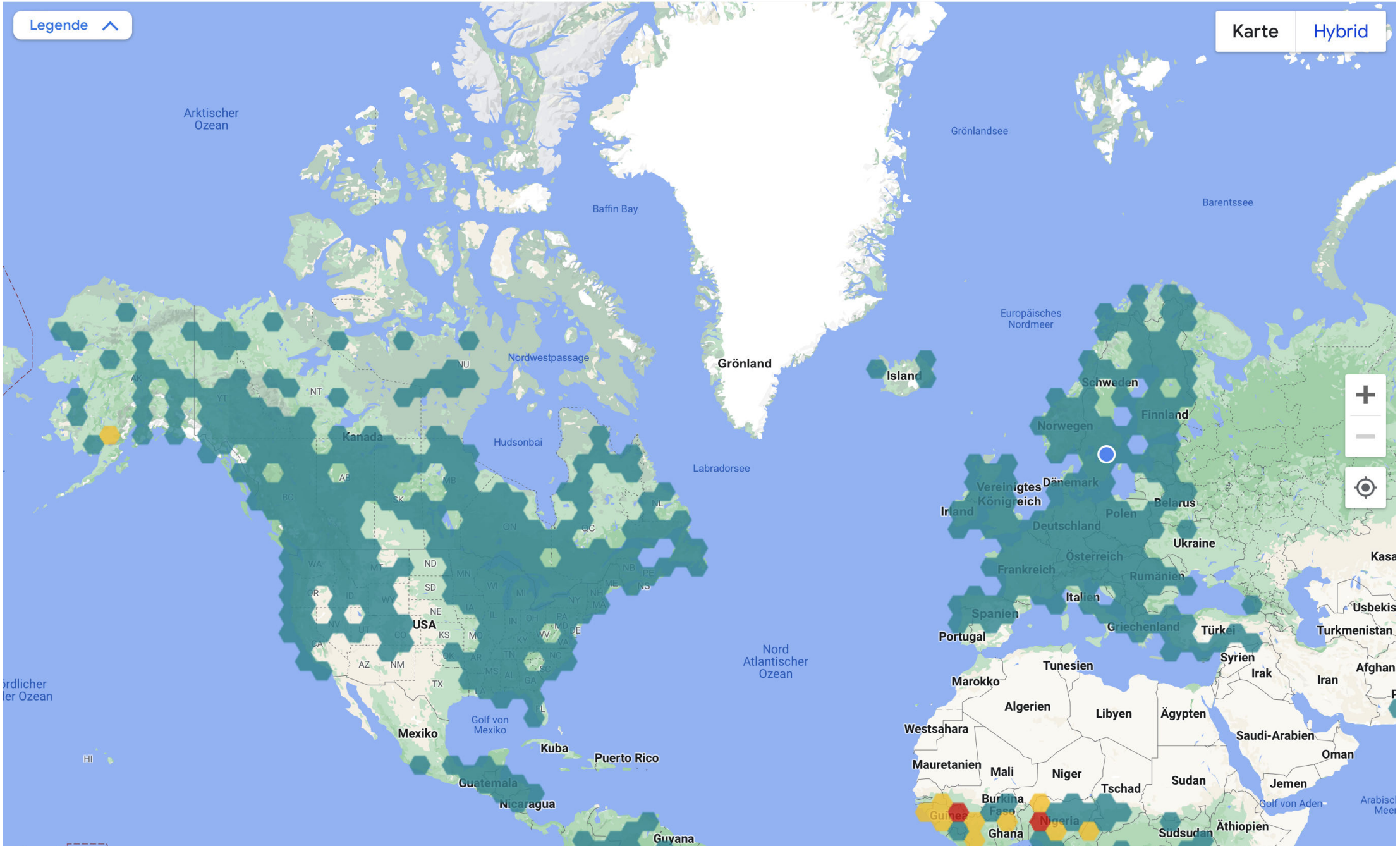
What the analysis is showing: **an undeniable skill**



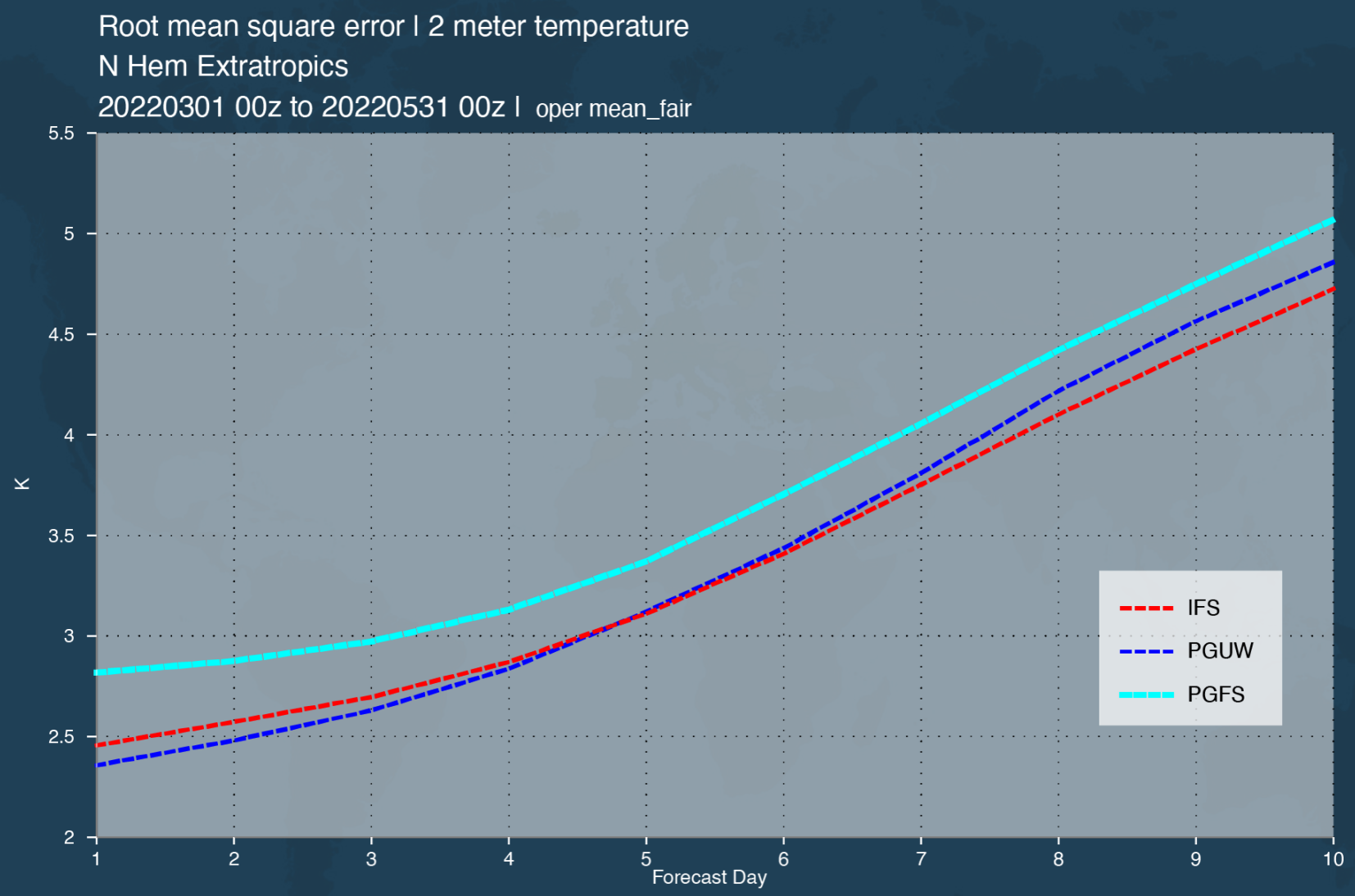
BUT Evaluation of surface parameters against observations demonstrates that the IFS is superior.

Google Flood Hub

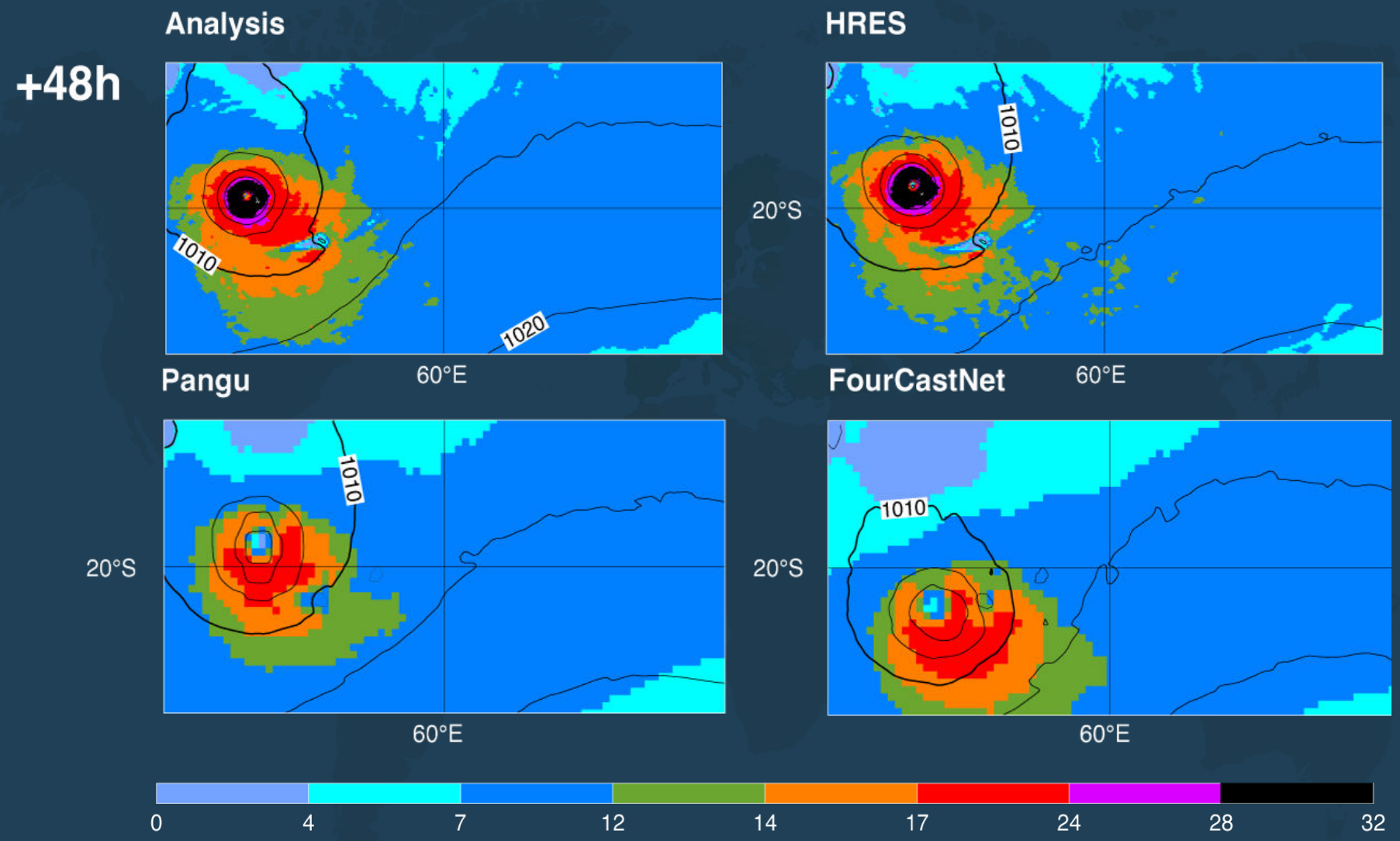
Nach Standort suchen



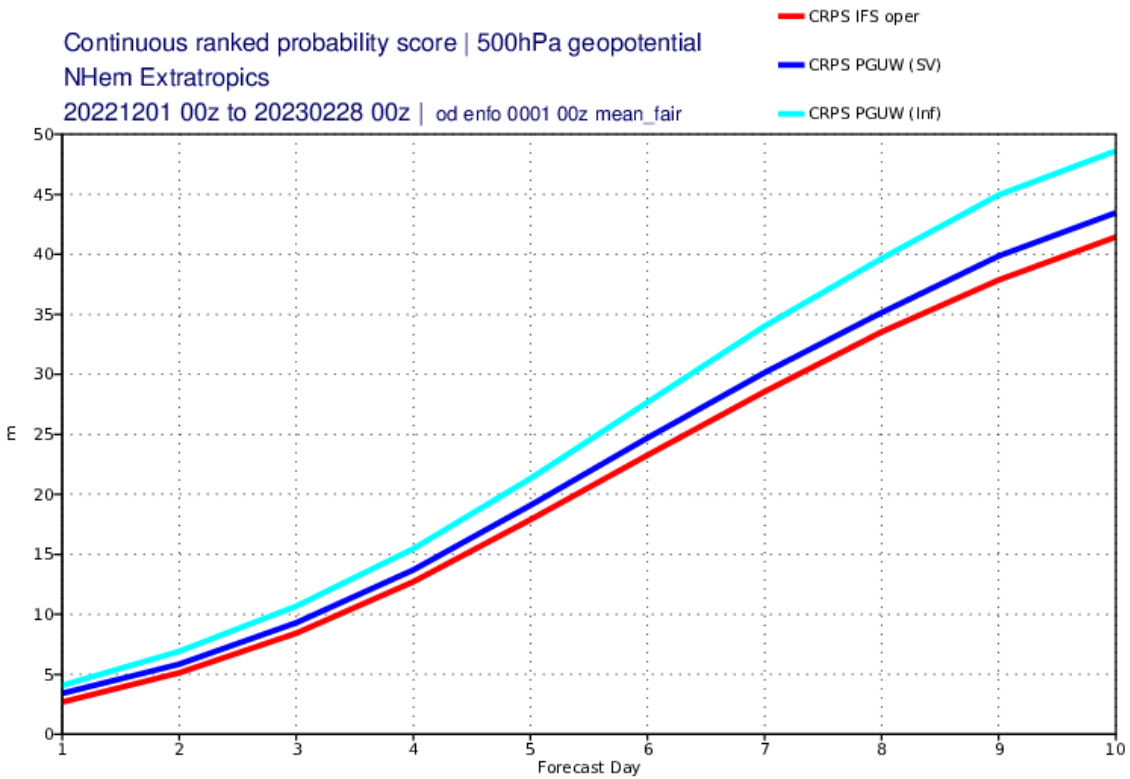
What the analysis is showing: **the importance of Initial Conditions**

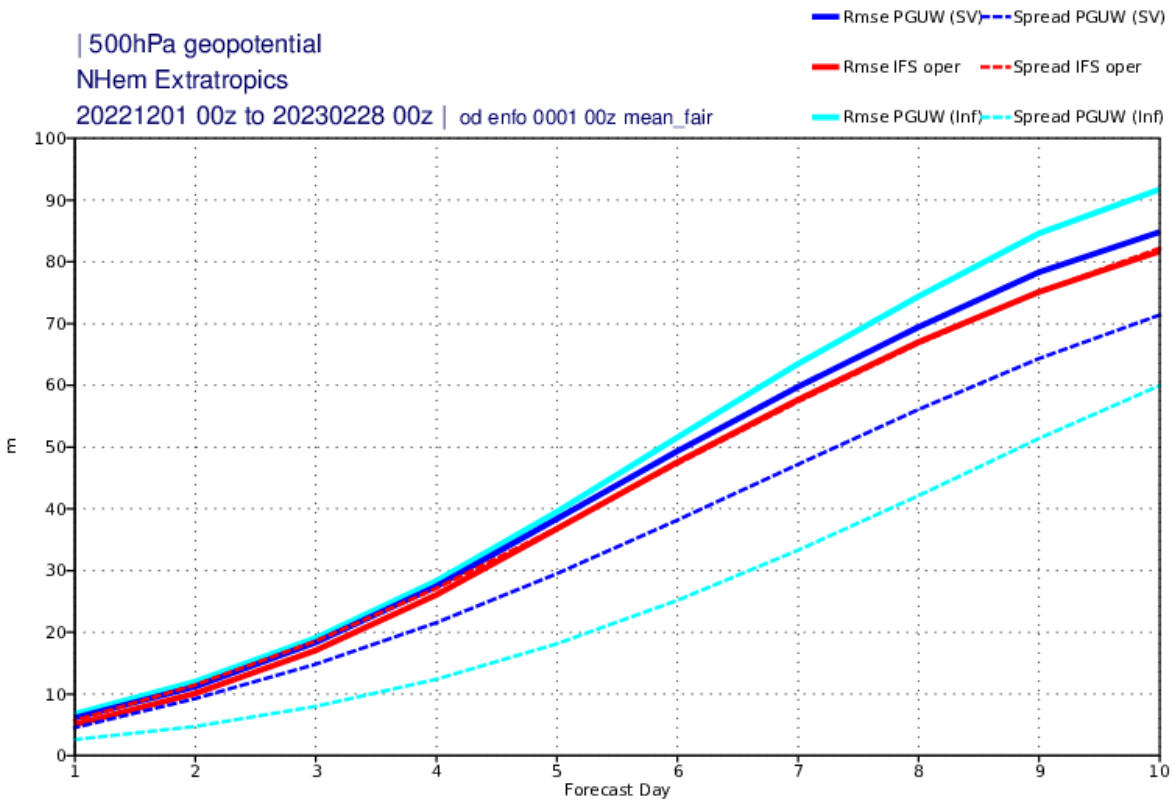


What the forecasts are showing: **Tropical cyclone Freddy (19 Feb 00UTC)**



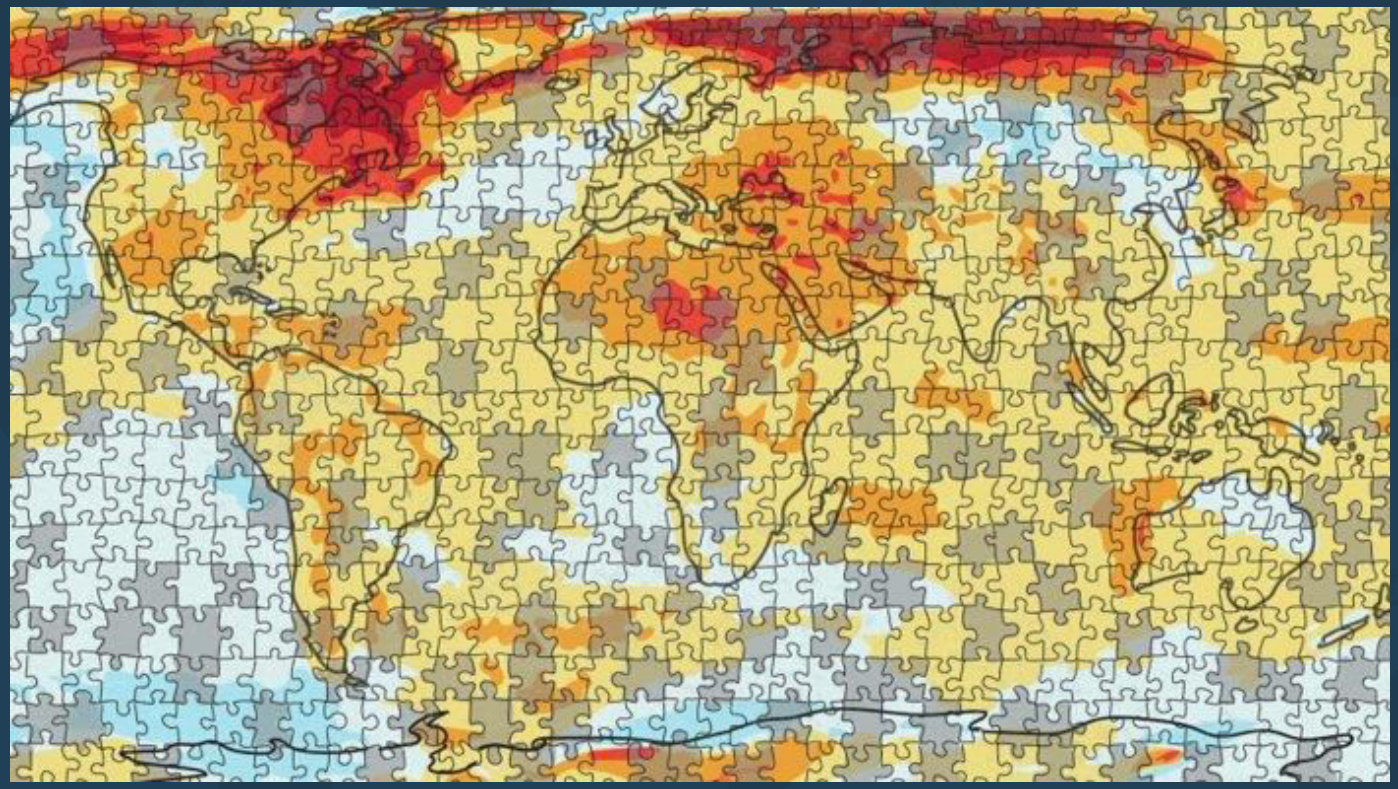
What about Uncertainties?





Why is Reanalysis used to train ML models?

Reanalysis combines observations with cutting-edge weather models, to provide maps without gaps.



ERA6 coming out in 2026...

What the ML forecasts are showing: **potential gain in time and energy**

ERA5:
15 billion (one off)
($7.4Mio (compute only))

opernicus
Europe's eyes on Earth

ECMWF HRES:
180 000 ($90)
per forecast

Pangu:
0.3 (<¢1)
per forecast

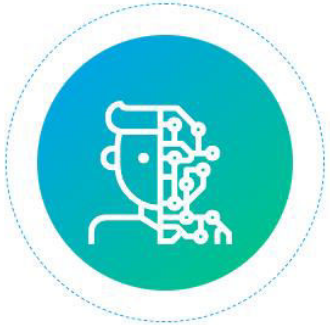
Impacts ……

Impact: Training & Staffing

MOOC Machine Learning in Weather & Climate

Tier 1 introduces you to Machine Learning in weather and climate

Tier 2 takes a deeper look at the concepts of Machine Learning



Tier 3 demonstrates practical Machine Learning applications in weather and climate

Impact: Software

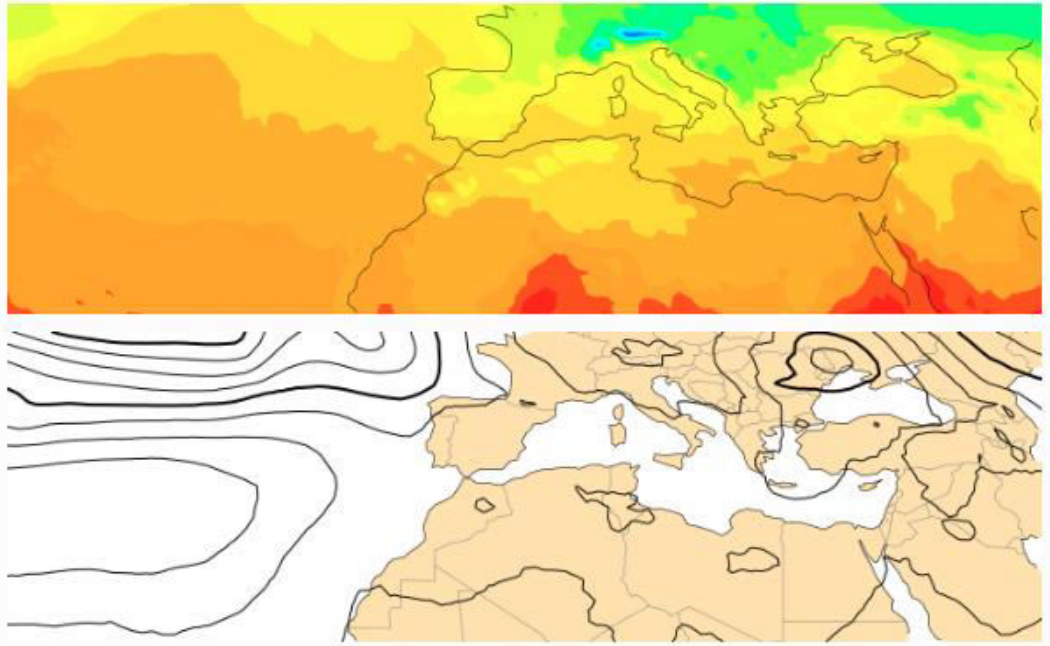
CliMetLab simplifies access to meteorological datasets.

Data downloading and loading is handled for the user.
After first download, data is cached locally.

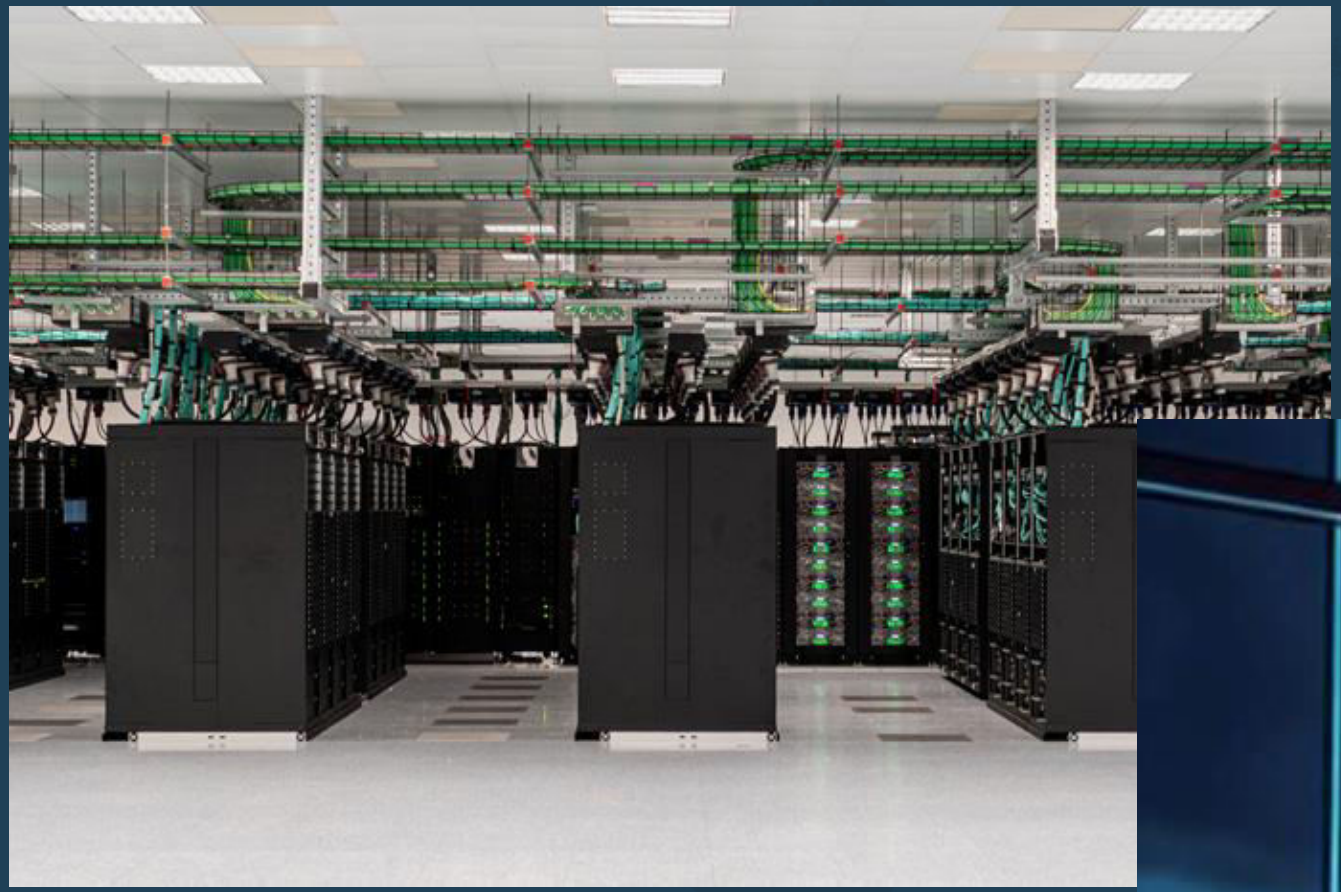
CliMetLab

```
[2]: import climetlab as cml

[6]: source = cml.load_source(
         "cds",
         "reanalysis-era5-single-levels",
         variable=["2t", "msl"],
         product_type="reanalysis",
         area=[50, -50, 20, 50],
         date="2012-12-12",
         time="12:00",
     )
     for s in source:
         cml.plot_map(s)
```



Impact: HPC & Anyone Can do it



ECMWF Experimental Chatbot

Chat.ECMWF.int

CODE FOR EARTH ECMWF

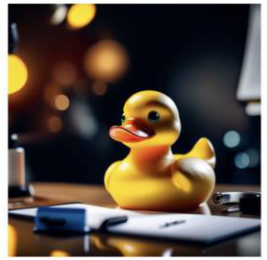
13:54 Dienstag 5. Sept. 63 %

chat.ecmwf.int

Welcome to ECMWF's experimental AI-based assistant.

Type a question in the box below and click "Submit question". Examples:

- Дайте ми метеограма за София.
- Adj nekem egy meteogramot Budapestre.
- Gib mir einen Meteogramm für Bonn.
- Donnez-moi un météogramme pour Paris.
- Anna minulle meteogrammi Helsingille.
- Wie verwendet man das GRIB-Format?
- Will it rain tomorrow in Bonn?
- Geben Sie mir ein Meteogramm für Wien.
- أعطني ميتيوجرام للرباط
- Dê-me um meteograma para Lisboa.



Model:

gpt-4

Temperature: 0.5

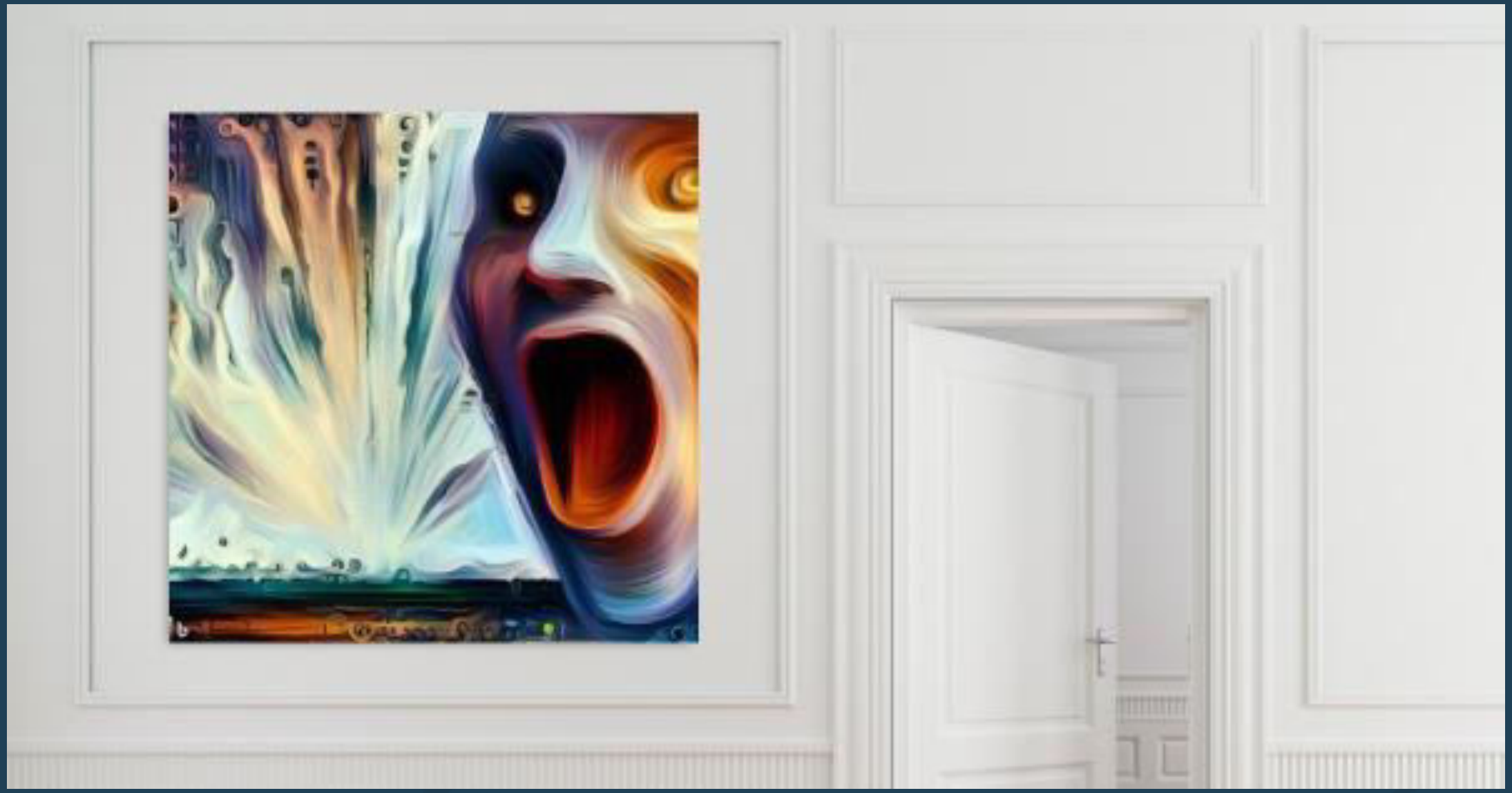
Make sure questions ends with a question mark. Be as precise a possible. For example, instead of asking "What is the weather in Reading?", ask "What is the temperature forecast in Reading?" You may also try to ask question in different languages. The same question may lead to different answers. If you get an error, simply try again.

Was ist dir Co2 Vorhersage für Bratislava

Submit question

Die CO2-Vorhersage für Bratislava am 5. September 2023 beträgt 447,98 ppmv.

Impact tbc




What's next?

Project overview: different paths **towards a ML ensemble prediction at ECMWF**

The hybrid model

Enhanced and accelerated implementation of ECMWF ML Roadmap

Delivering results

Development of a ML ensemble forecast

Data-driven model initialised with NWP analysis hence requiring conventional data assimilation.

Embracing novelty

Observations-driven ML system

A whole system reinventing the path from observations to predictions.

A scientific challenge

Check them out yourselves …..

ECMWF | Charts

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Search products...

Range

- [ ] Medium (15 days)
- [ ] Extended (42 days)
- [ ] Long (Months)

Type

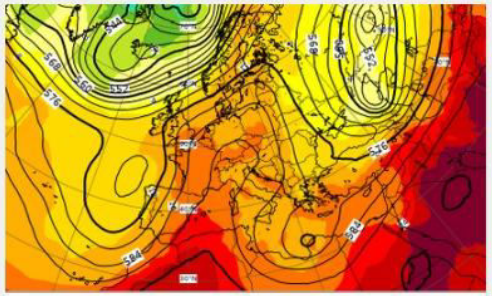
- [ ] Forecasts
- [ ] Verification

Component

- [ ] Surface
- [ ] Atmosphere

Product type

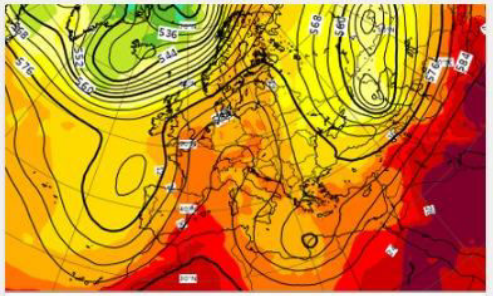
- [ ] High resolution forecast (HRES)
- [ ] Ensemble forecast (ENS)
- [ ] Combined (ENS + HRES)
- [ ] Extreme forecast index
- [ ] Point-based products
- [x] Experimental: Machine learning models
- [ ] Atmospheric composition



Latest forecast

(FourCastNet machine learning model: Experimental): 500 hPa geopotential height and 850 hPa temperature

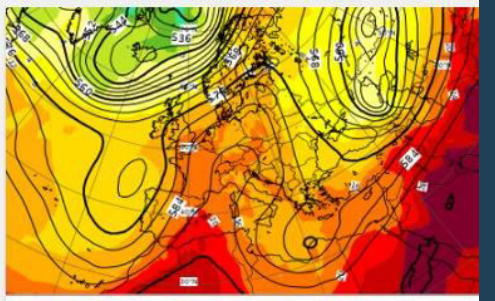
FourCastNet v2-small:a deep learning-based system developed by NVIDIA in collaboration with researchers at several US universities.It is initialised with ECMWF HRES analysis. FourCastNet operates at 0.25° resolution.



Latest forecast

(GraphCast machine learning model: Experimental): 500 hPa geopotential height and 850 hPa temperature

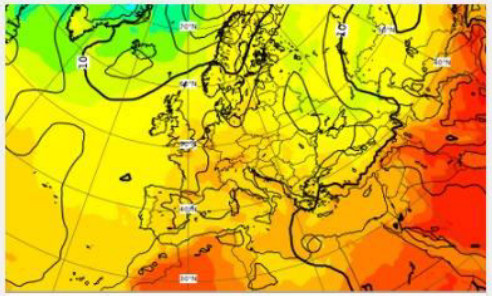
GraphCast (Google DeepMind): a deep learning-based system developed by Google DeepMind.It is initialised with ECMWF HRES analysis. GraphCast operates at 0.25° resolution.



Latest forecast

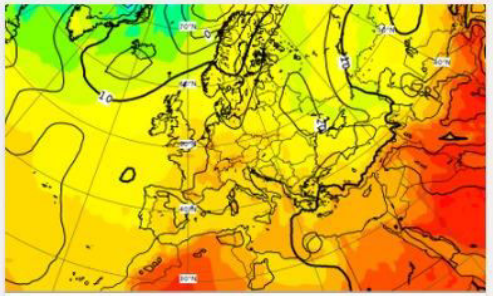
(Pangu-Weather machine learning model: Experimental): 500 hPa geopotential height and 850 hPa temperature

Pangu-Weather: a deep learning-based system developed by Huawei. It is initialised with ECMWF HRES analysis. Pangu-Weather operates at 0.25° resolution.



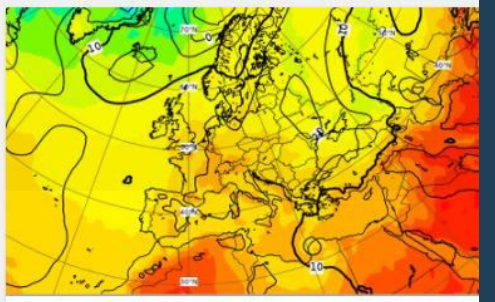
Latest forecast

(FourCastNet machine learning model:



Latest forecast

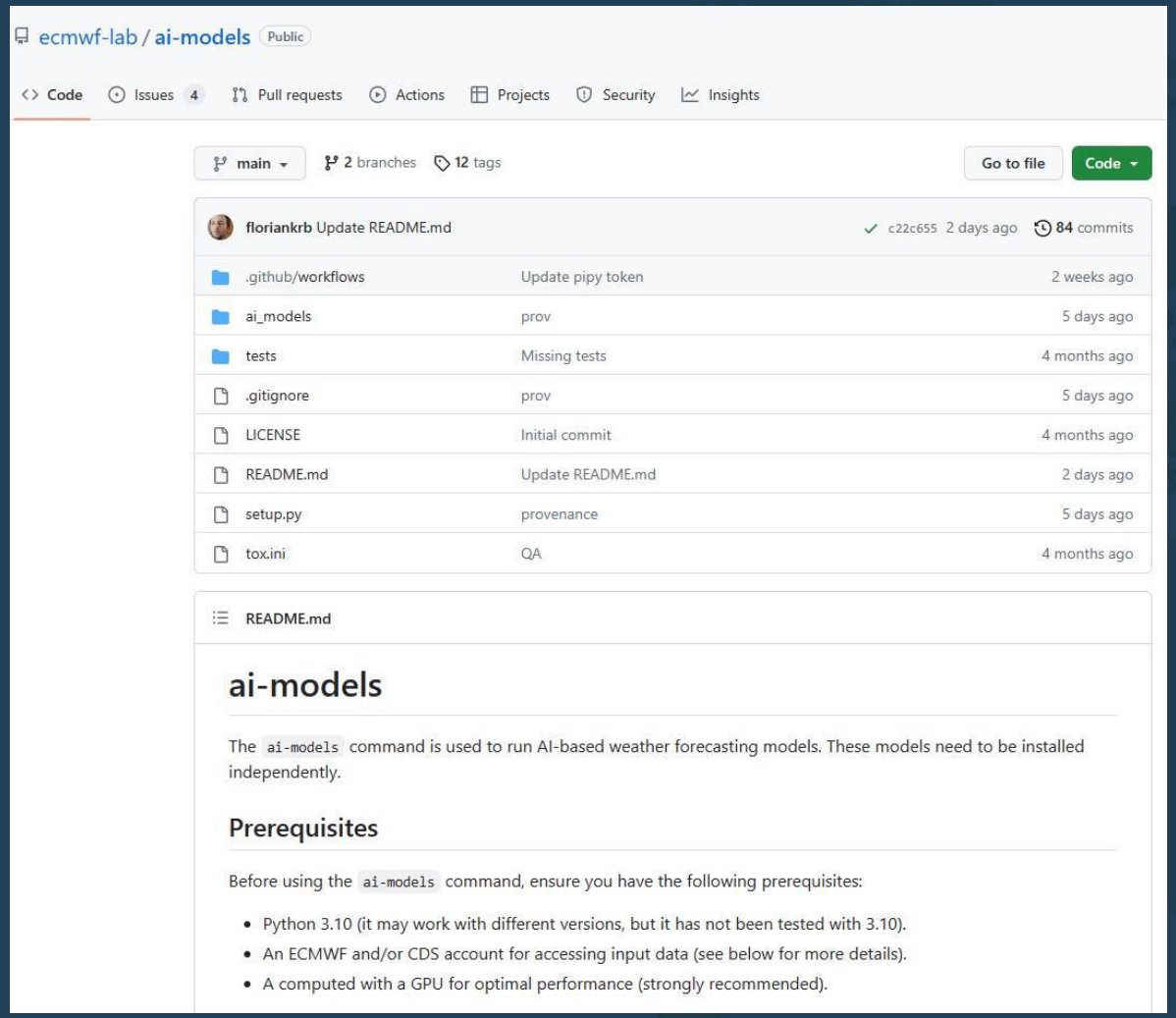
(GraphCast machine learning model:



Latest forecast

(Pangu-Weather machine learning model:

Run them yourselves …..



ecmwf-lab / ai-models Public

Code | Issues 4 | Pull requests | Actions | Projects | Security | Insights

main | 2 branches | 12 tags | Go to file | Code

floriankrb Update README.md — c22c655 2 days ago — 84 commits

.github/workflows	Update pipy token	2 weeks ago
ai_models	prov	5 days ago
tests	Missing tests	4 months ago
.gitignore	prov	5 days ago
LICENSE	Initial commit	4 months ago
README.md	Update README.md	2 days ago
setup.py	provenance	5 days ago
tox.ini	QA	4 months ago

README.md

ai-models

The `ai-models` command is used to run AI-based weather forecasting models. These models need to be installed independently.

Prerequisites

Before using the `ai-models` command, ensure you have the following prerequisites:

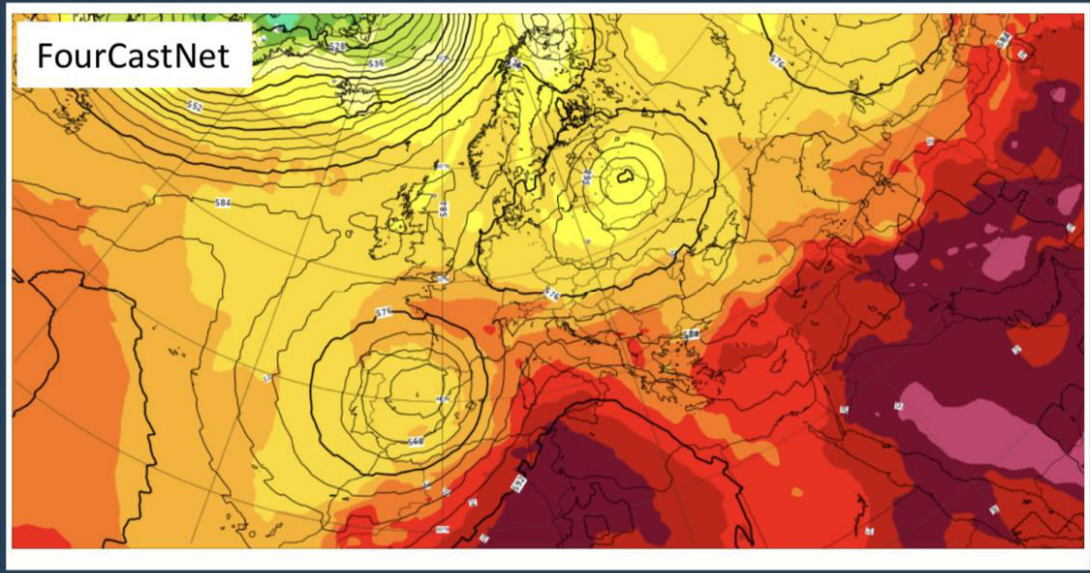
- Python 3.10 (it may work with different versions, but it has not been tested with 3.10).
- An ECMWF and/or CDS account for accessing input data (see below for more details).
- A computed with a GPU for optimal performance (strongly recommended).

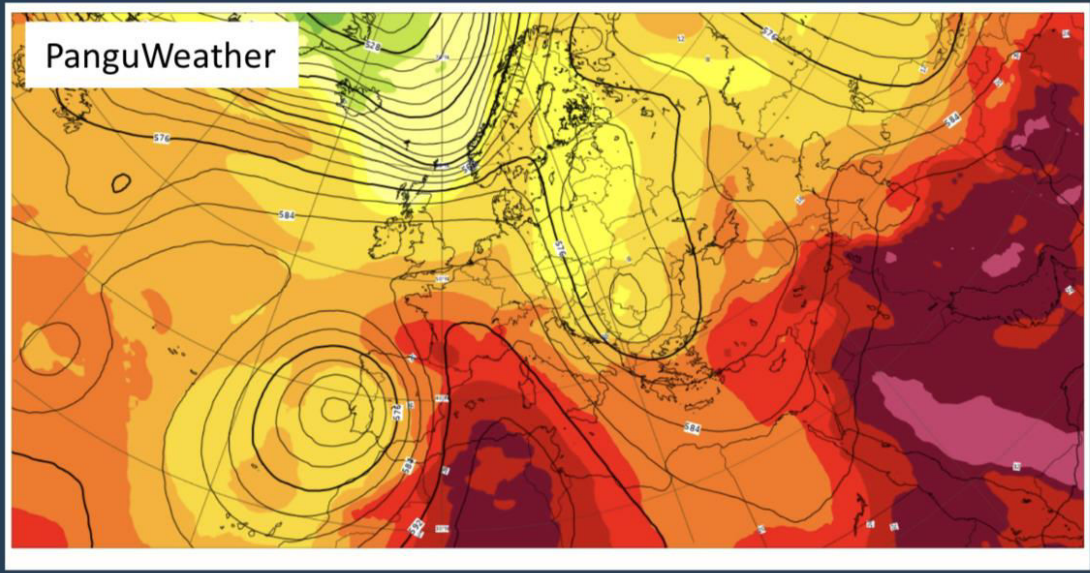
Available Models

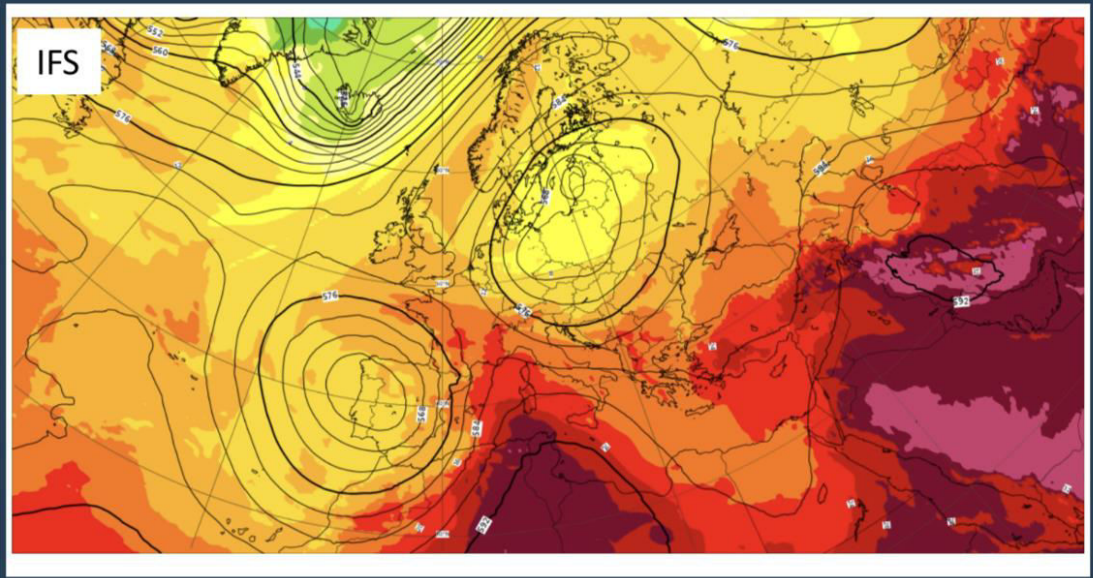
Currently, four models can be installed:

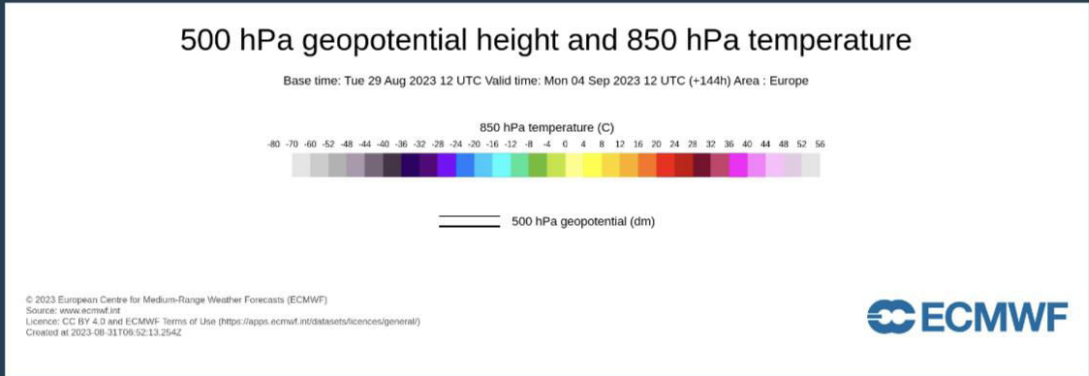
```
pip install ai-models-panguweather
pip install ai-models-fourcastnet
pip install ai-models-graphcast  # Install details at https://github.com/ecmwf-lab/ai-models-graphcast
pip install ai-models-fourcastnetv2
```

Day 6 forecasts over Europe (valid today, 4 Sept. 2023 12UTC)









Did you pass the test? Congratulations, you are invited to apply

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Postdoctoral position in surface hydrology, with focus on modeling human-water systems

Published: 2023-08-29

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Scientist/Engineer for Machine Learning (multiple vacancies)

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Job reference: VN23-41

Salary and Grade: Grade A2: EUR 83,888 (DE) or GBP 68,374 (GB);
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Deadline for applications: 17/09/2023

Department: Research or Forecast

Location: Reading, UK or Bonn, Germany


Working together
to improve
weather predictions