



SCREEN CAPTURE
WELCOME

EUMETNET's E-AI Programme:

Advancing Weather, Climate, and Environmental Applications through Artificial Intelligence (AI) and Machine Learning (ML)

Marek Jacob (DWD), Roland Potthast (DWD)

And the E-AI participants

47th EWGLAM and 32th SRNWP Meeting – 2025-09-22



EUMETNET E-AI initiative

“Artificial Intelligence and Machine Learning for Weather, Climate and Environmental Applications” (E-AI)

Optional Programme, est. Jan 2024

High level objectives:

- To enhance the collaboration of European NMHSs and external partners in the area of AI/ML in weather, climate and environment.
- To share the developments which take place under E-AI using a commonly-used permissive open-source licence.

Coordinating EUMETNET member: DWD (Germany)



Revolutionary Technology

Technology Introduction	Year
Radio	1895
Television	1927
Mobile Phones	1973
Internet	1974
World Wide Web	1989
Social Media	2004
Smartphones	2007
AI Chat Bots	2022



AI based Weather Forecasting

02/2022 FourCastNet (NVIDIA)

11/2022 Pangu-Weather (Huawei)

12/2022 GraphCast (Google)

10/2023 AIFS (ECMWF)

11/2023 NeuralLAM (Sweden)

Decision for E-AI 12/2023

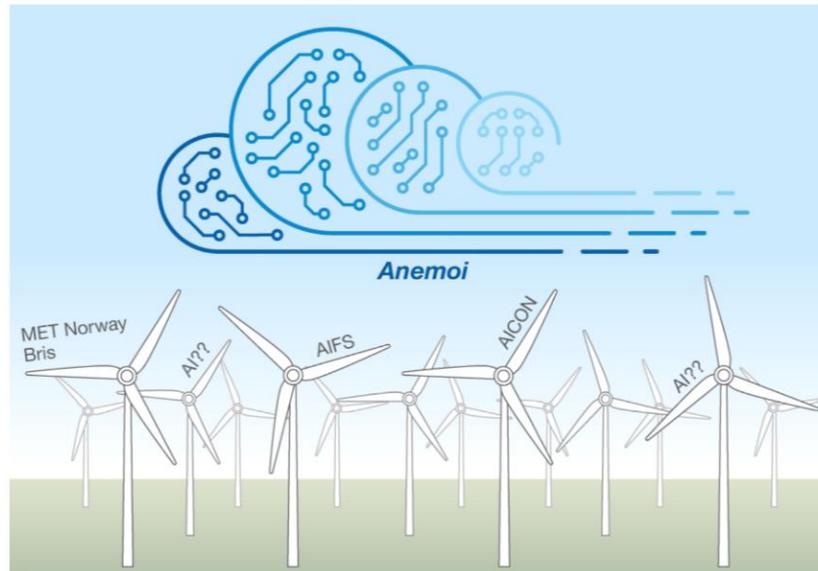
06/2024 Anemoi (ECMWF and European Meteorological Services)

FOURCASTNET: A GLOBAL DATA-DRIVEN HIGH-RESOLUTION WEATHER MODEL USING AN LSTM-EMBEDDED NEURAL NETWORK

Jaideep Pathak
NVIDIA Corporation
Santa Clara, CA 95051

Ashesh Choudhury
Rice University
Houston, TX 77005

GraphCast: Learning skillful medium-range global weather forecasting



AIFS B



Fortunato^{*,1},
Merose²,
Mohamed¹ and

on System
er Forecast

an[✉], Fellow, IEEE

ML model

to the Integrated Forecasting System (IFS), the forecasting System. It is one of three components

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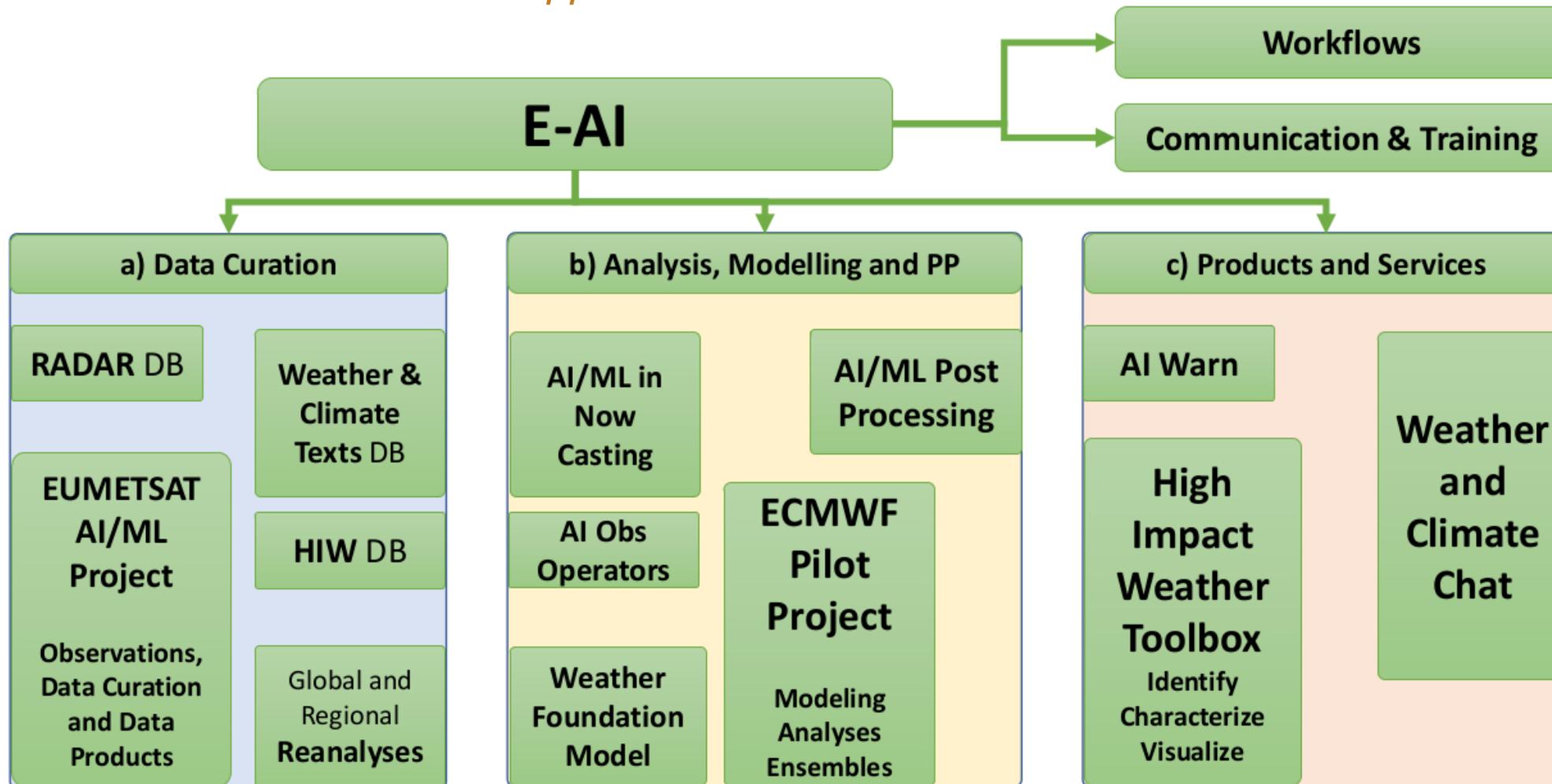
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„E-AI“

E-AI: Artificial Intelligence and Machine Learning in Weather, Climate and Environmental Applications



Roland Potthast 2024

EUMETNET E-AI Modules

Modules

1. **Data Curation**. Objective: Enhance the value of observations, gridded observational datasets, model fields and further datasets by making them AI ready.

This module is expected to receive substantial contributions from EUMETSAT project that is currently under development and aims for activities in data curation, management and exploitation as well as in training and capacity building and infrastructure support. EUMETSAT organizes annual workshops to advance this activity.

2. **Analysis, Modelling and Postprocessing**, including retrieval and estimation products, nowcasting, data assimilation and modelling, uncertainty estimation and postprocessing. Objective: Enhance our capabilities to use AI/ML approaches in modelling.

This module includes the ECMWF Machine Learning Pilot Project (MLPP) with Member States.

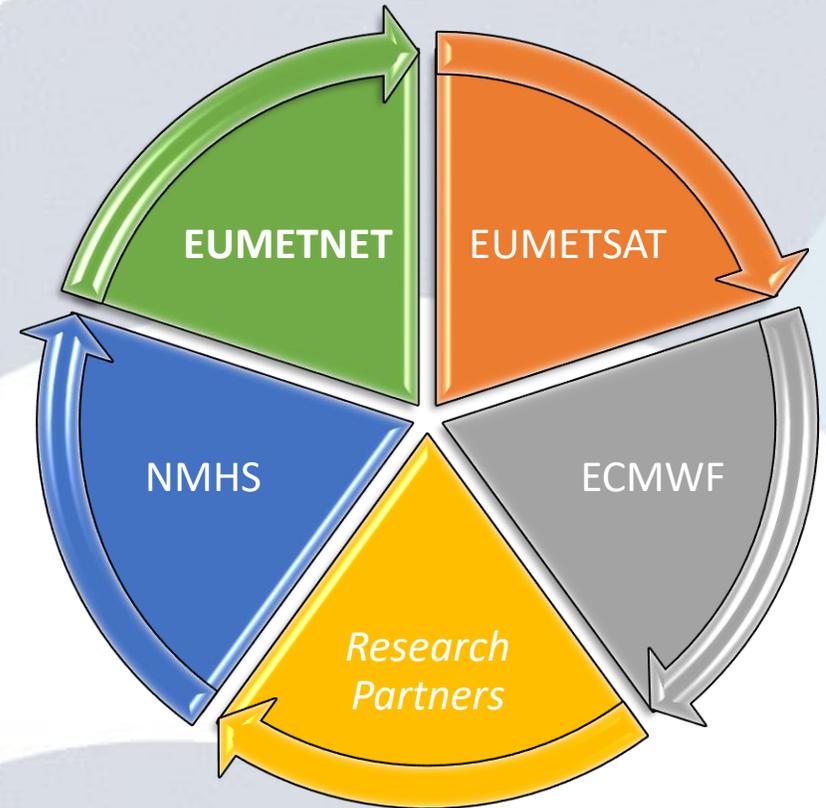
3. **Products and Services**. Objective: Enhance the use of AI/ML in the development of products and services



Shaping the AI/ML Revolution in Weather, Climate and Environment

Activity of Key Players

- **EUMETNET**: provide an active and agile collaboration framework
- **NMHS**: contribute and raise resources for AI/ML developments
- **EUMETSAT**: organise and contribute to joint AI/ML data curation
- **ECMWF**: organise and contribute to joint AI/ML model developments
- **Research Partners**: innovation and research contributions

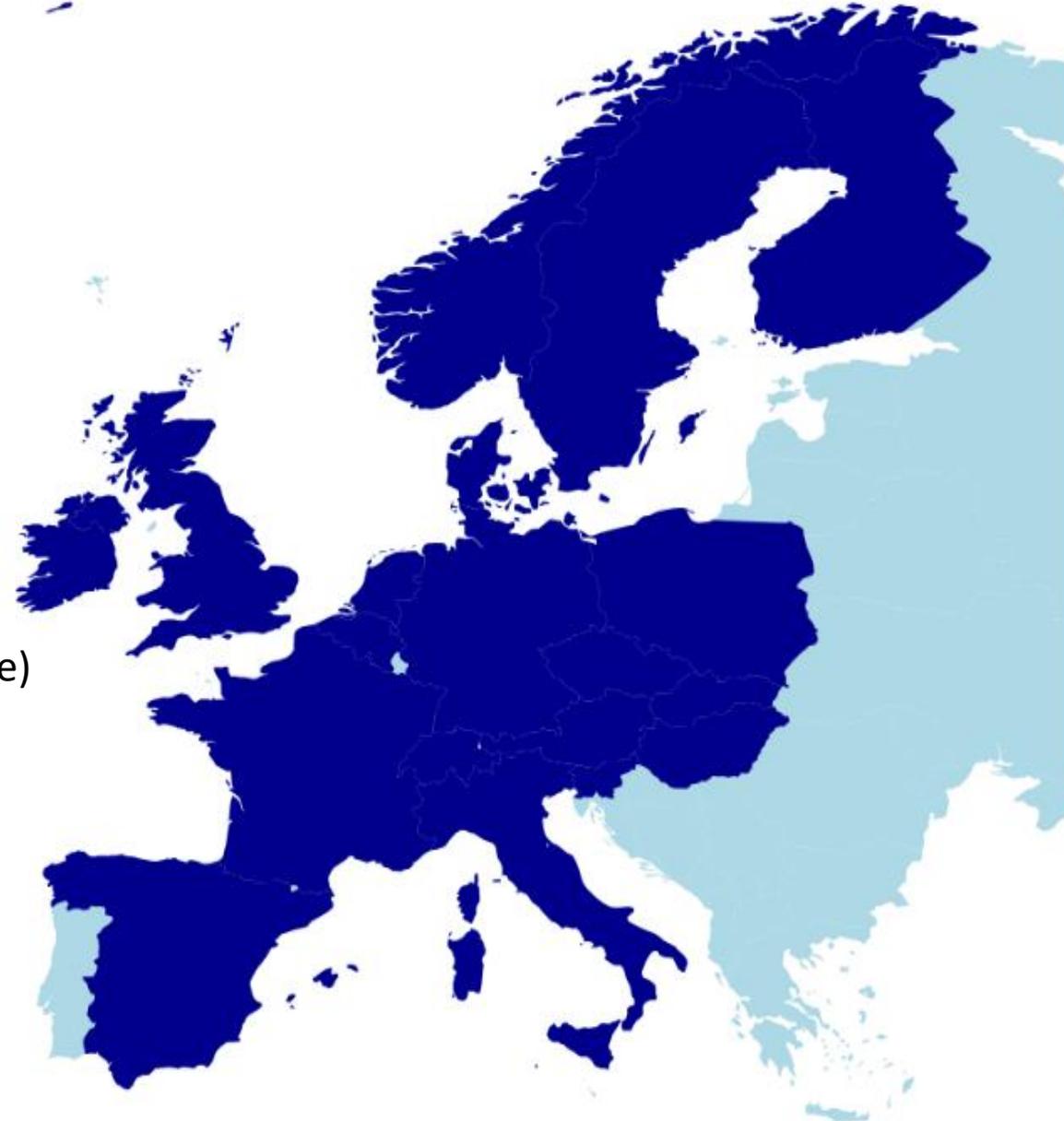


Participating Meteorological Agencies

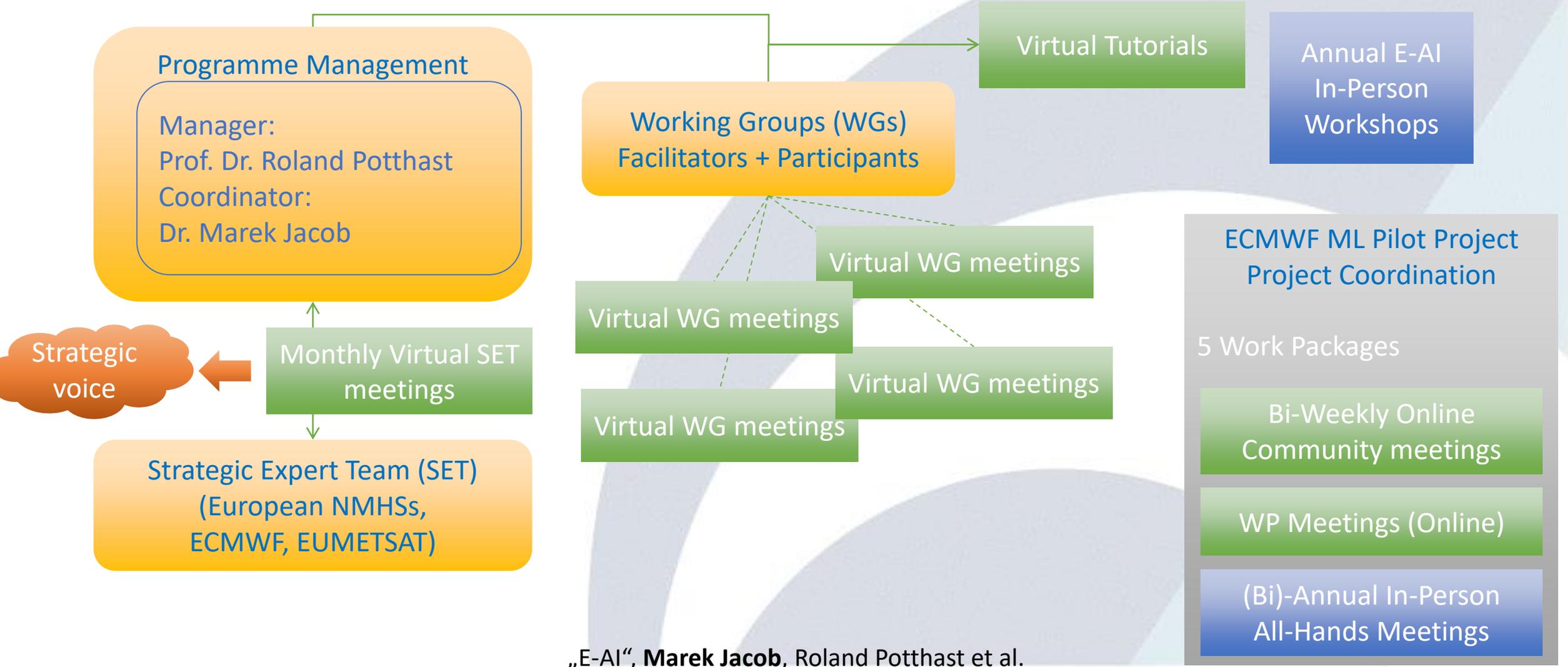
20 NMHS, EUMETSAT, ECMWF:

- Austria (GeoSphere)
- Belgium (RMI)
- Czech Republic (CHMI)
- Denmark (DMI)
- Finland (FMI)
- France (Météo France)
- Germany (DWD)
- Hungary (HungaroMet)
- Ireland (Met Éireann)
- Italy (ItAF-AVIAMM)
- Netherlands (KNMI)
- Norway (MET Norway)
- Poland (IMGW-BIP)
- Slovak Republic (SHMU)
- Slovenia (ARSO)
- Spain (AEMet)
- Sweden (SMHI)
- Switzerland (MeteoSwiss)
- United Kingdom (Met Office)
- Canada (CCCE)

About **400 participants**, dedicated experts or points of contact



EUMETNET E-AI Working Structure



„E-AI“, Marek Jacob, Roland Potthast et al.

WG 1	AI Data Readiness and Curation (e.g. Data Sets Preparation and Management, Standards, IPR, Labeling)		active
WG 2	Large Language Model (LLM) Implementation and Services LLMs for AI-based Information Condensation and Communication, AI-based High Impact Weather (HIW) Warnings, Personalisation (formerly WG5)		active
WG 3	AI Operationalisation, Maintenance With AI Frameworks and Libraries		active
WG 4	AI Sensing and Novel Observations (e.g. Webcams and Co.)	Exchange of best practices Joint software development Joint funding proposals	Being started
WG 6	MLCast Nowcasting – jointly with EUMETNET		active
WG 7	User Optimised Products and Information (e.g. AI in the EUMETNET Aviation Support)		Starting with ASP
WG 8	Ethics Questions		With SET
WG10	Data Rescue – jointly with EUMETNET Climate Programme		active
WG11	Regional Downscaling for Climate Impact Analysis – jointly with EUMETNET Climate Programme		active
WG12	Quality Control – jointly with EUMETNET Climate Programme		active
WG13	Data Fusion and PostProcessing (PP) Activities under discussion with postprocessing programme		Being started
ATS	Anemoi Technical Subgroup (formerly ATG) – Within ECMWF MLPP		active

Communication and Training

E-AI Basic Tutorials

<https://github.com/eumetnet-e-ai/tutorials/>

1. Intro, Environment, First Example
2. Dynamics, Downscaling, Data Assimilation Examples
3. LLM Use, Transformer Example, RAG
4. "MLOps" - Machine Learning Operations
5. MLflow - an open-source platform for managing the machine learning lifecycle
6. CI/CD - Continuous Integration and Continuous Deployment of ML codes

In-Person Training

- Tutorial day at **E-AI Products and Services Workshop at DWD July 7-11, 2025**

Communication & Training

ECMWF AI/ML Training Courses and Webinars

<https://events.ecmwf.int/category/1/>

- ML for weather prediction
- ML for operational forecasters
- Anemoi
-

6-Day Python and ML Tutorial

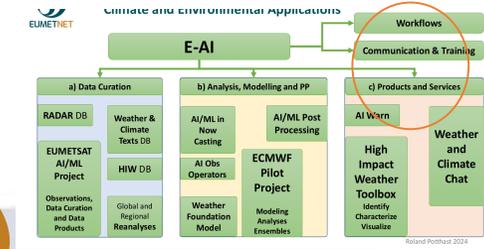
https://github.com/eumetnet-e-ai/e-ai_python_ml_tutorial

- Python as Workhorse
- AI/ML Basic Introduction
- LLM RAG, Python Packages, Multi-Modality
- Diffusion Networks, AI Agents, Feature Detection
- Towards Operations with MLFlow, MLOps, CI/CD
- Anemoi, AICON and AI Data Assimilation



E-AI Example Activities





Example activity 1: Workflows & Module C

MLOps: From Research to Operations (WG3)

Out-of-the-box ML Platform: Is it the right fit?

Vertex AI: Build, deploy, and manage ML models

Gen AI: Model Garden, Generative AI Studio, Foundation models, Pre-trained models, Prompt design, Tuning

ML Platform: ML Platform training, serving models with fully-managed infrastructure; Data science toolkit: Notebooks + integration with data services; Experiment, Train, Deploy, ML Ops

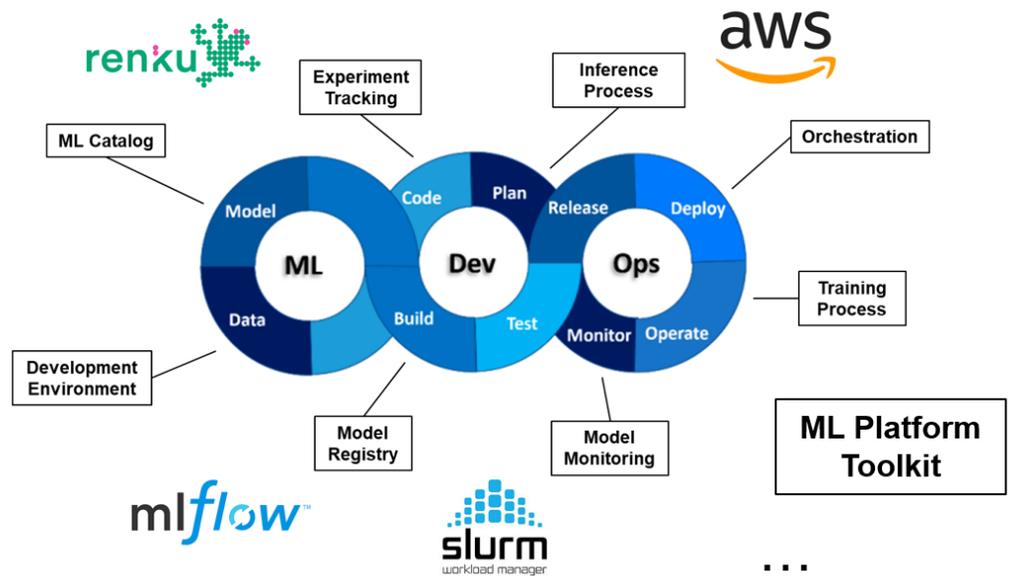
Feature Inspiration

Amazon SageMaker: Unified Studio, SQL Analytics, Data Processing, Model Development, Gen AI App Development, Streaming, Business Intelligence, Search Analytics, Data & AI Governance, Labhouse

Azure Machine Learning: Manage compute, Train and experiment, Build model (your favorite IDE), Models registration and management, Data Preparation, Models deployment

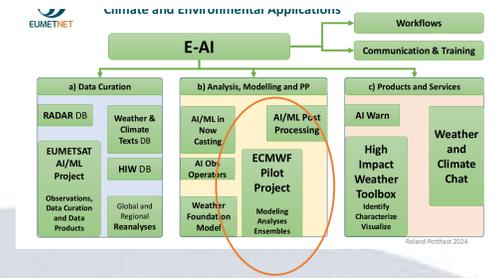
ML Platform Toolkit

The ML Platform Toolkit provides glue code, conventions, and scaffolding to integrate and standardize the platform's ML tools.



Courtesy of Gabriela Aznar Siguan (Meteo Swiss)





Example activity 2: Module B

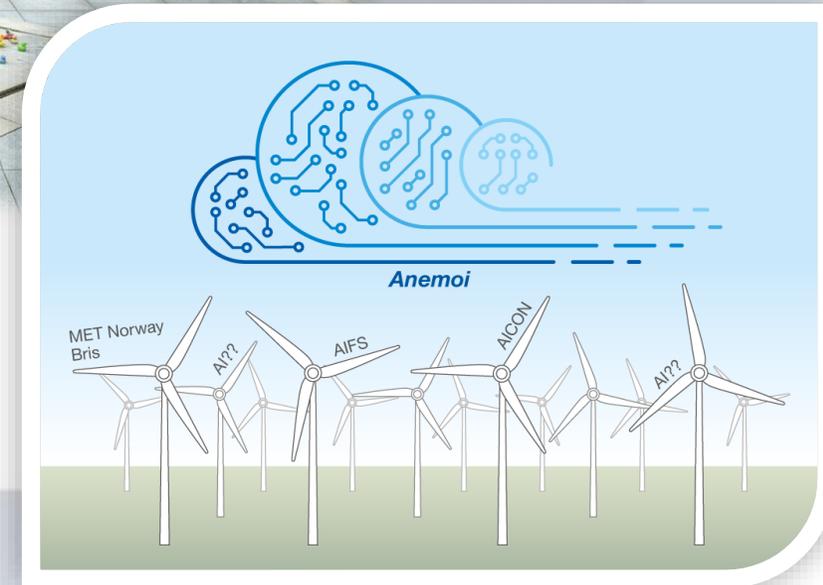
ECMWF Machine Learning Pilot Project

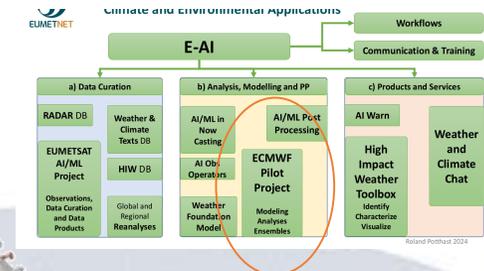
- ECMWF + 14 Member States
 - Forecasting
 - Ensembles
 - Data assimilation
 - Infrastructure and MLOps



EMS Technology Achievement Award 2025

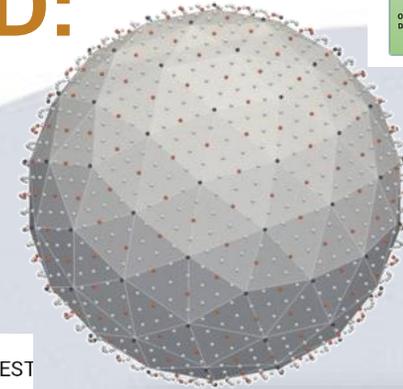
- Main code: **Anemoi**
- A European open-source software framework
 - To develop data-driven weather forecasting
- Flexible configuration
 - Deterministic & ensemble forecasting, nowcasting, global & LAM, temporal interpolation, post processing products, ...
 - Multiple data sources



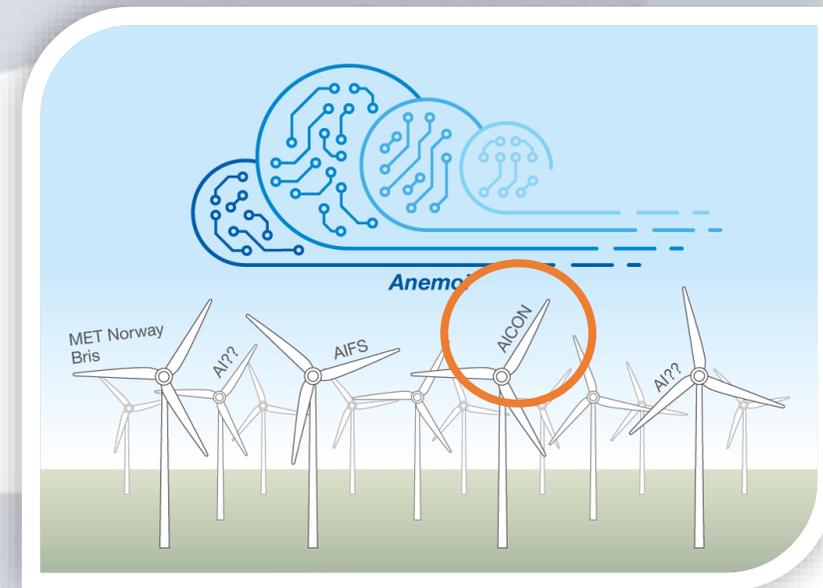
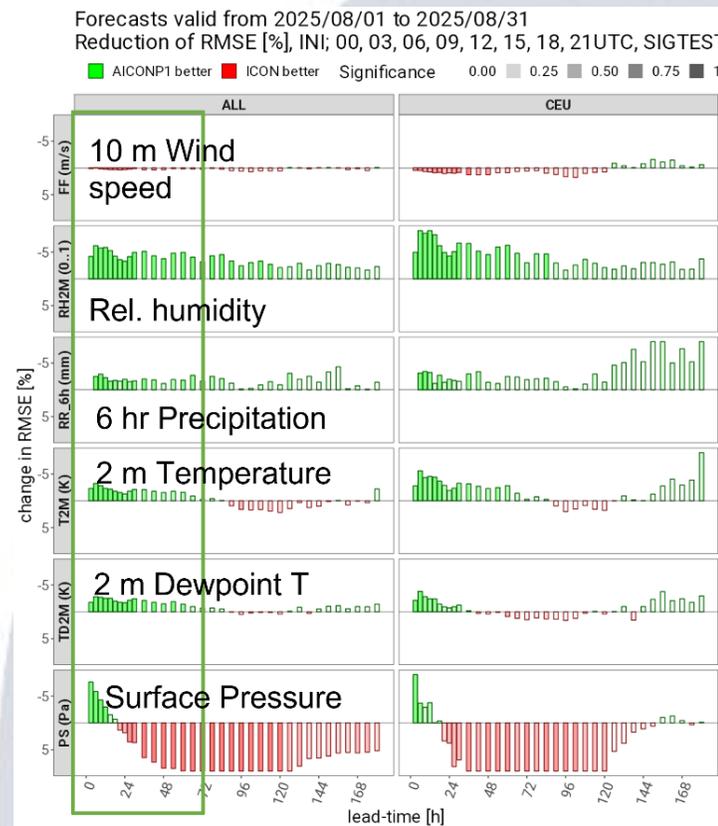


Example activity 2: Module B

Global Data-Driven forecasts at DWD: AICON Model

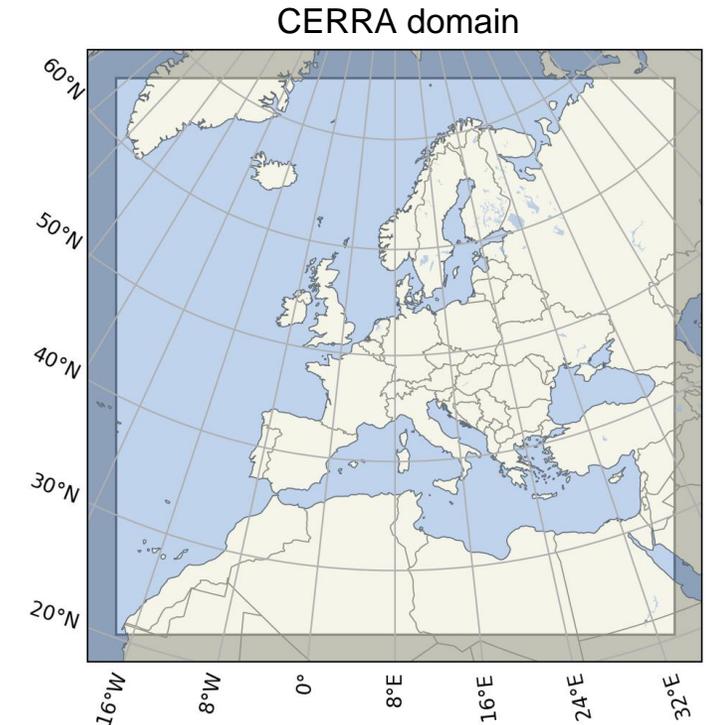


- Leverages Anemoi
- Extended Anemoi
 - to support 13 km icosahedral grid
 - Testing
- Trained on ICON-DREAM reanalysis data (15 years)
- In operational NWP production since September 3rd

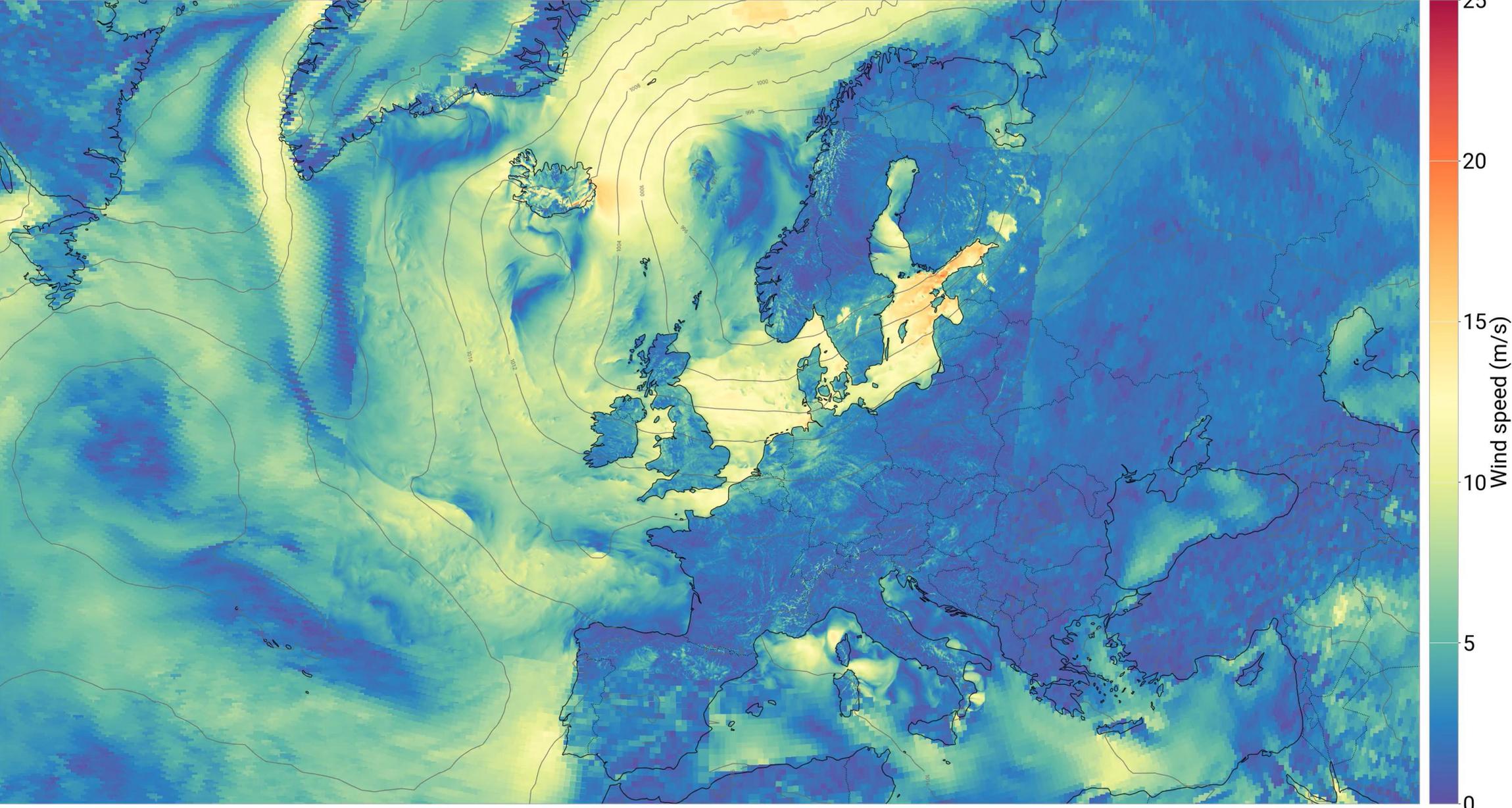


Regional models

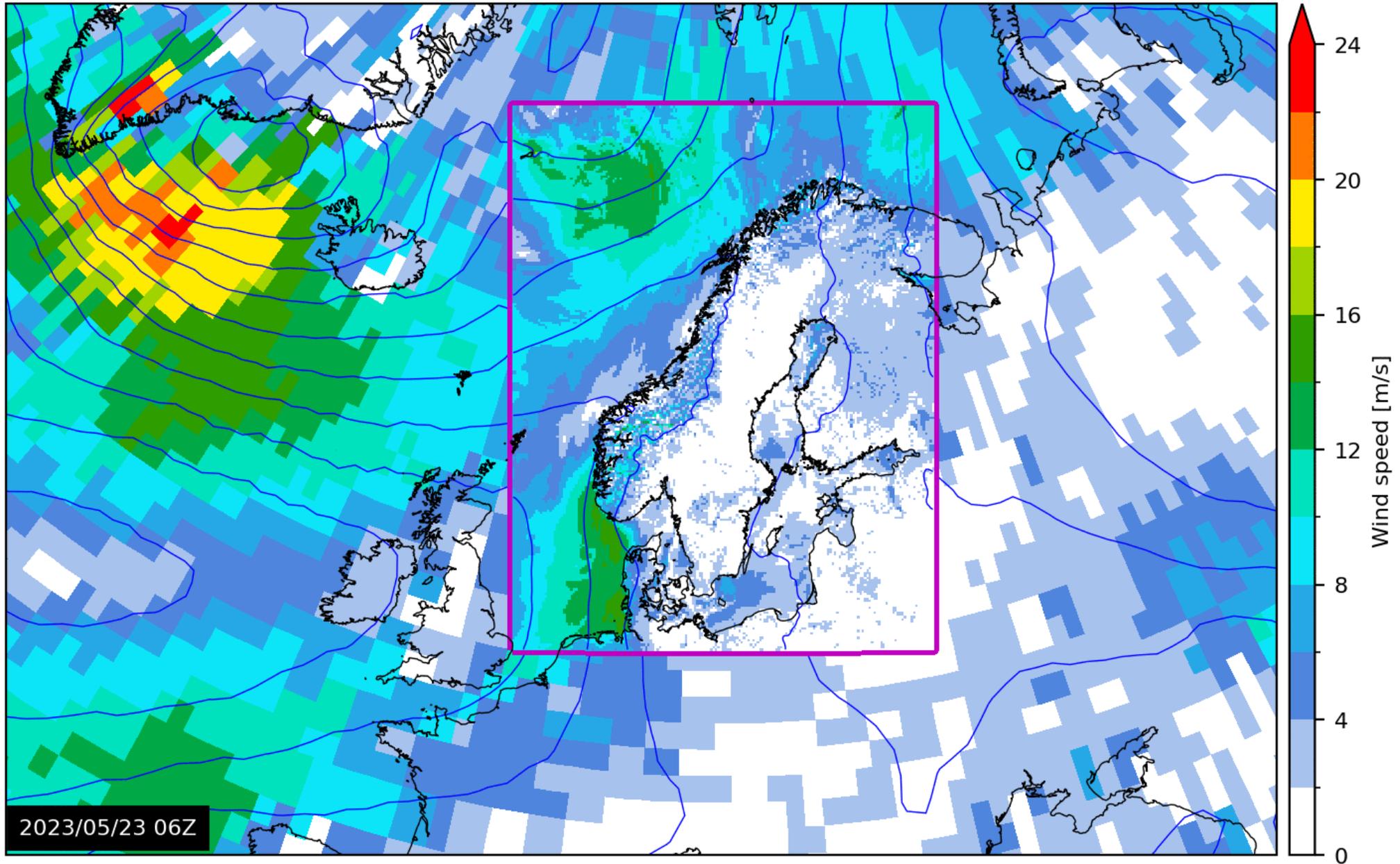
- Stretched-grid base models
 - Global domain uses ERA5 at 0.25° (~ 31 km)
 - Regional domain uses Copernicus European Regional Reanalysis (CERRA) at 5.5 km resolution
 - Datasets overlap for 1984–2020, meaning 36 years of training data
 - Common prognostic variables: pressure levels (q, t, u, v, z), surface (2t, 2d, skt, 10u/v, sp, msl, z, tp)
- Latest base model for European domain:
 - Graph transformer architecture with 1.1 billion parameters
 - Trained on 128 GPUs (NVIDIA A100) continuously for one month
- CERRA base models have been used for transfer learning by various institutes (e.g., MeteoSwiss, MET Norway, AEMET, KNMI)



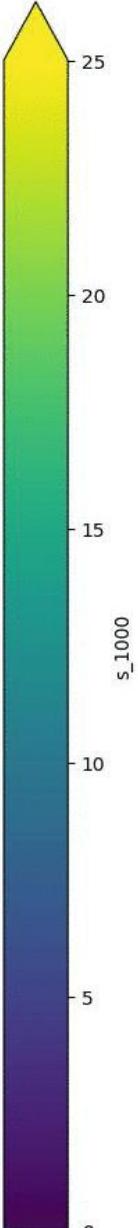
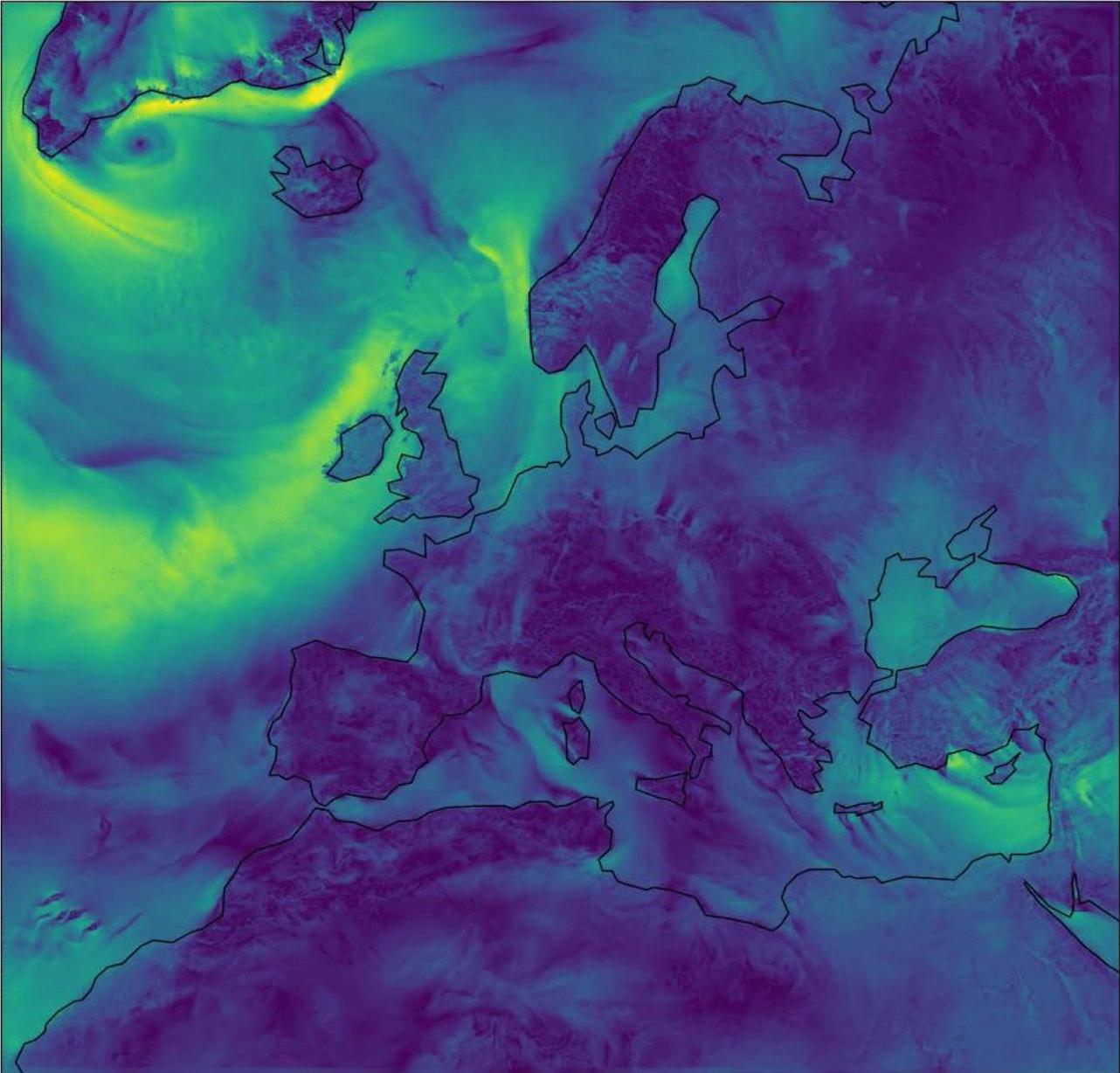
KNMI – Stretched grid over UWC-West domain



MET Norway – Enhancement of temporal resolution



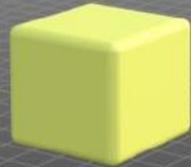
RMI – Limited Area Model



Duration/energy estimate of a deterministic ICON global run (13 km)

deterministic ICON global run
energy consumption: 60.24 kWh
~ 21.87 kg CO₂ emission¹

AICON inference
energy consumption: 0.13 kWh
~ 48.28 g CO₂ emission



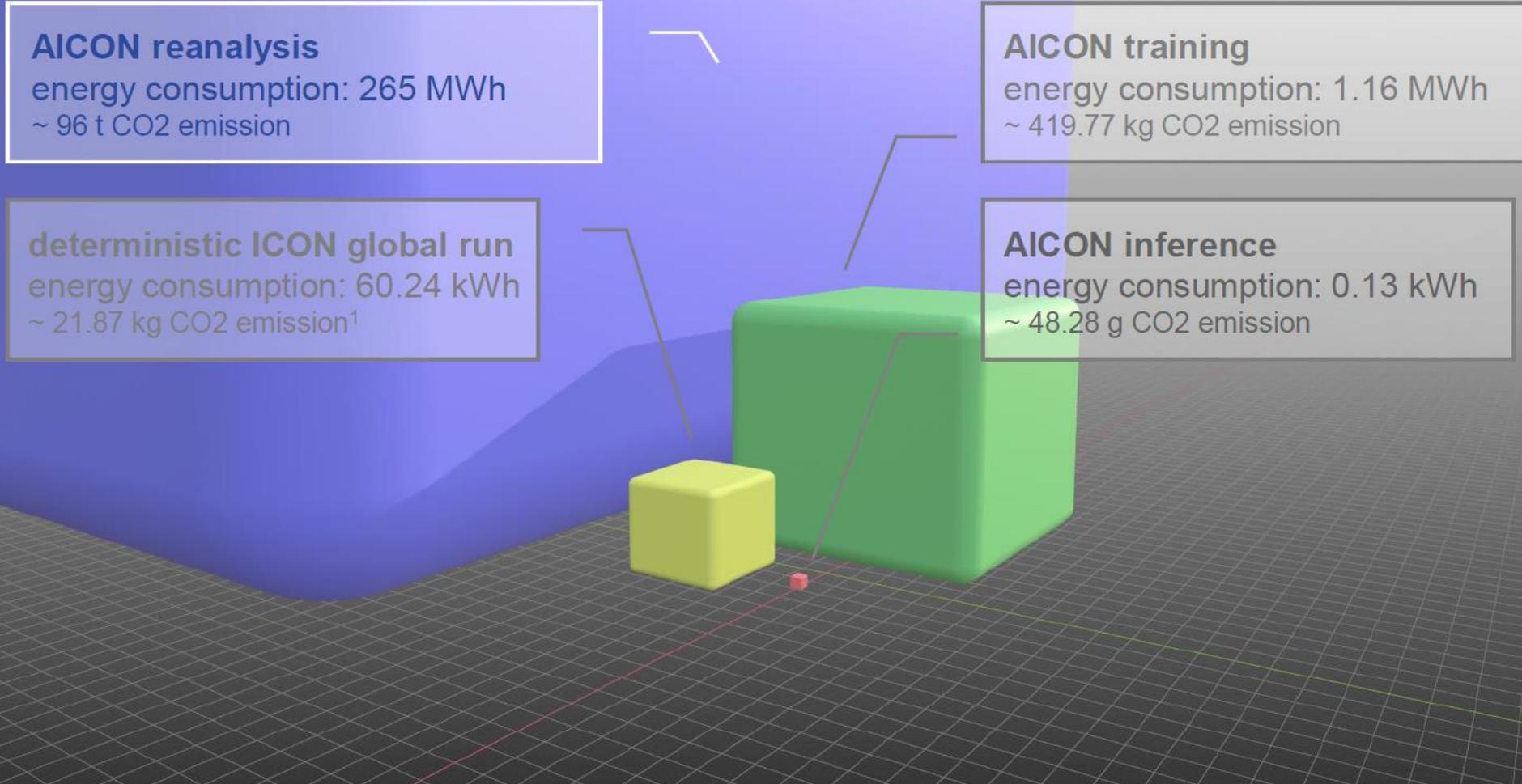
Writing Grib
is almost
the limiting
factor

Details

180h lead time
GPU: A100-80, 400W
SX Aurora 1: avg. 1480W

¹ CO₂ emissions based on German electricity mix (as of 2023/2024)

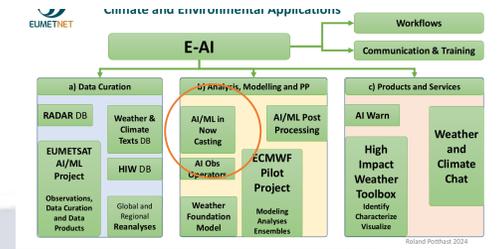
Energy Statistics



Details

Reanalysis
deterministic, global,
2010-01 until 2025-04

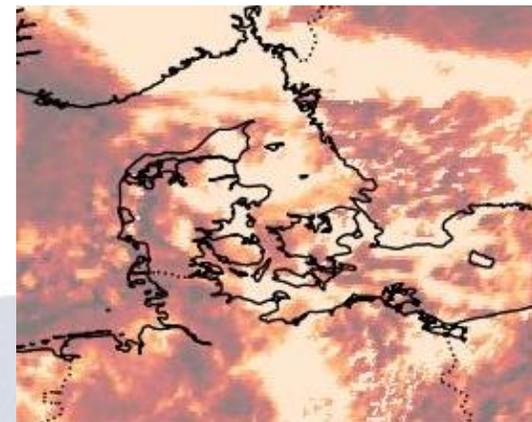
(currently on-going,
including back-extension)



Example activity 3: Module B

AI/ML for Now Casting: MLCast (WG6)

- AI-based nowcasting of precipitation and solar radiation
- Joint development of the MLCast Python Package
- Collect, prepare and provide ML ready datasets
 - Zarr format with metadata
 - Radar climatology over Germany, Netherlands, Italy, UK
- V 1.0 release end of 2025 (BSD 3 & Apache 2)
 - Precipitation
- Trained checkpoints will be available



Example activity 4: Module C

DWD AI Centre & E-AI

Use Logout New Session

Session ID: 957cc0c35c38ff0381bac1007e4d5f21

DAWID

You asked:

What is the EMS GA Conference?

DAWID:

... EMS GA is the General Assembly of the European Meteorological Society (EMS). This annual conference brings together meteorologists, climatologists, and other professionals to share their latest research and advancements in the field. It's a great opportunity for networking and staying updated on the latest developments.

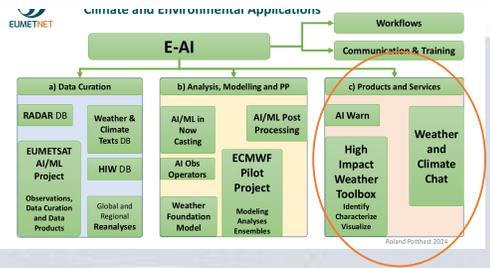
?  

Model: Local Mistral 24B Data Space: None

Enter your question...

Ask 

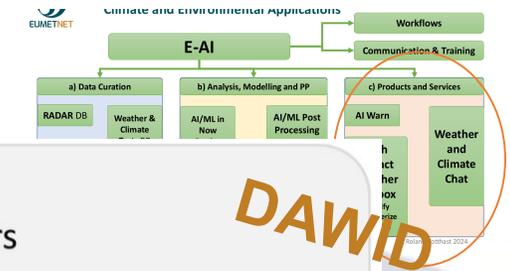
Editor



DAWID

- Framework for natural language services
- **Large Language Models**
- **Agent based Framework**
- Client Server Architecture
- **Full control over privacy**
- **Full functionality available on premises**

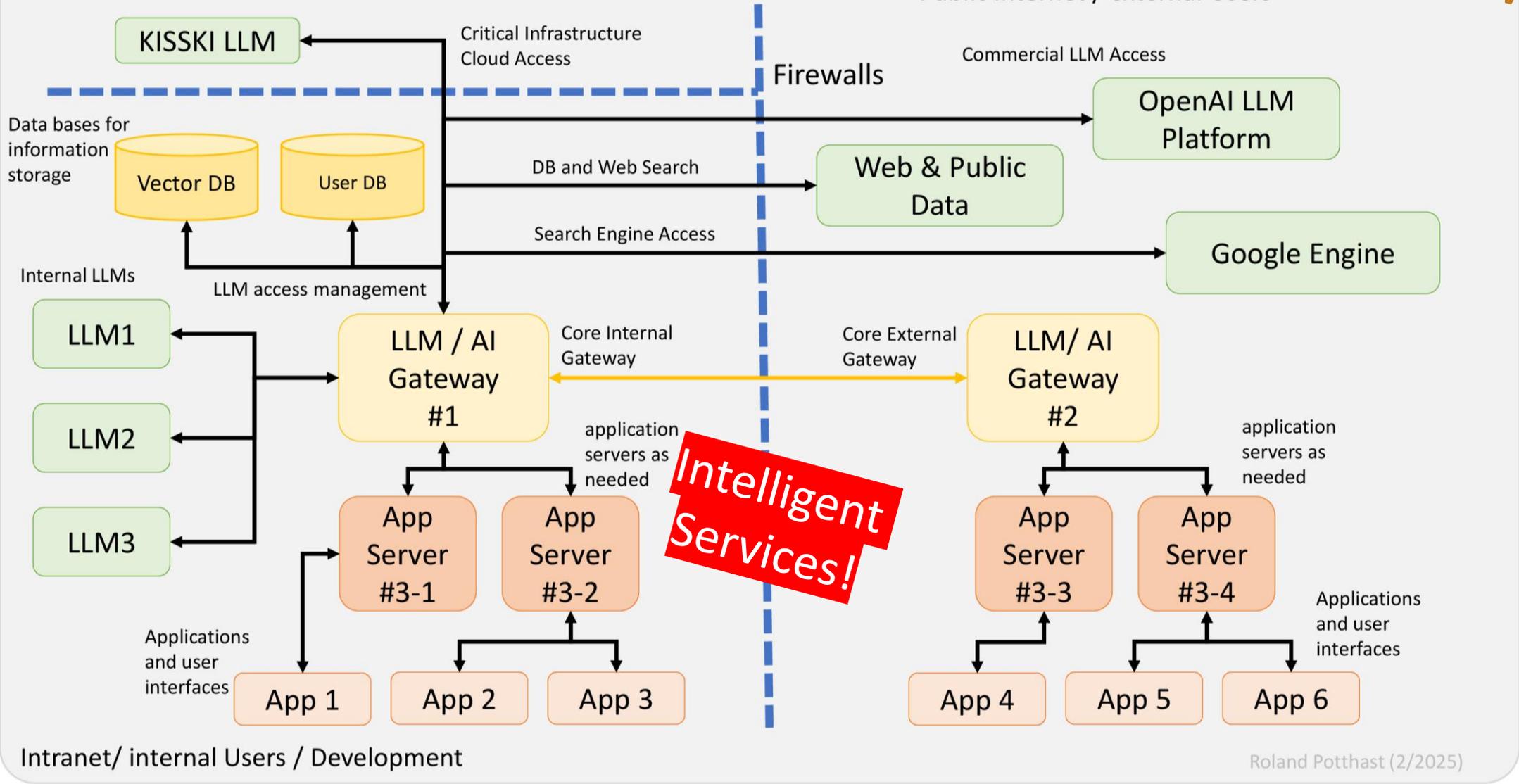




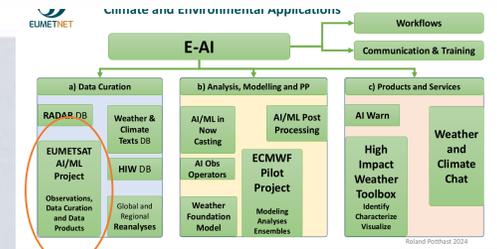
Example activity 4: Module C

DWD AI Center - Client Server Architecture

DAWID



ET



Example activity 5: Module A

E-AI WG Data Curation's primary intention is to lower barriers in E-AI activities data usage by analysing available and missing data holdings, obstacles in using them, and creating examples of using and converting the data into a suitable form for Machine Learning. The considered applications cover weather forecasting (from nowcasting to seasonal), climate applications, and downstream products and services

Key activities

- Gap analysis of used and missing data in AI/ML applications relevant to E-AI content
- Zarr usage best practices
- Feature detection

Considered / future ideas

- Catalogue of datasets used for E-AI applications, with link to use cases and associated tools
- Usage and conversion examples
- Create a mechanism for sharing data inside the community

Your contribution is needed!

- Tell us about your (or your colleagues') use case and datasets
- Contribute to the activities
- Participate meetings



https://github.com/eumetnet-e-ai/wg1_data_curation

E-AI in a Nut Shell

- Joins forces of NMHSs, ECMWF, and EUMETSAT
- Connects people and fosters exchange
- Explore AI/ML
- Develop AI/ML capabilities and application
- Under open-source licence
- Advance weather, climate and environment services



CONTACT DETAILS



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