



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

UEF2025 – 2025-09-18



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)

FOURCASTNET: A GLOBAL DATA-DRIVEN HIGH-RESOLUTION
WEATHER MODEL USING ADAPTIVE FOURIER NEURAL NETWORKS

Jaideep Pathak^{*},
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GraphCast: Learning skillful medium-range global weather forecasting

Remi Lam^{*,1}, Alvaro Sanchez-Gonzalez^{*,1}, Matthew Willson^{*,1}, Peter Wirnsberger^{*,1}, Meire Fortunato^{*,1}, Ferran Alet^{*,1}, Suman Ravuri^{*,1}, Timo Ewalds¹, Zach Eaton-Rosen¹, Weihua Hu¹, Alexander Merose², Stephan Hoyer², George Holland¹, Oriol Vinyals¹, Jacklynn Stott¹, Alexander Pritzel¹, Shakir Mohamed¹ and Peter Battaglia¹

^{*}equal contribution, ¹Google DeepMind, ²Google Research

Global medium-range weather forecasting is critical to decision-making across many social and economic domains. Traditional numerical weather prediction uses increased compute resources to improve forecast accuracy, but cannot directly use historical weather data to improve the underlying model. We introduce a machine learning-based method called “GraphCast”, which can be trained directly from reanalysis data. It predicts hundreds of weather variables, over 10 days at 0.25° resolution globally, in under one minute. We show that GraphCast significantly outperforms the most accurate operational deterministic systems on 90% of 1380 verification targets, and its forecasts support better severe event prediction, including tropical cyclones, atmospheric rivers, and extreme temperatures. GraphCast is a key advance in accurate and efficient weather forecasting, and helps realize the promise of machine learning for modeling complex dynamical systems.

Keywords: Weather forecasting, ECMWF, ERA5, HRES, learning simulation, graph neural networks

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an[✉], Fellow, IEEE

global weather forecast. For
data from the 5th generation of
total. The spatial resolution
nly, for the first time, an
accuracy (latitude-weighted
all time ranges (from one
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ports a wide range of
ge-member ensemble
conventional NWP methods,

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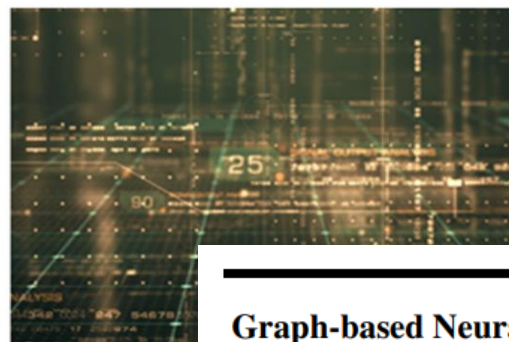
Remi Lam^{*,1}, Alvaro Sanchez-Gonzalez^{*,1}, Matthew Willson^{*,1}, Peter Wirsberger^{*,1}, Meire Fortunato^{*,1}, Ferran Alet^{*,1}, Suman Ravuri^{*,1}, Timo Ewalds¹, Zach Eaton-Rosen¹, Weihua Hu¹, Alexander Merose², Stephan Hoyer², George Holland¹, Oriol Vinyals¹, Jacklynn Stott¹, Alexander Pritzel¹, Shakir Mohamed¹ and Peter Battaglia¹

11/2022 Pangu-Weather (Huawei)

12/2022 GraphCast (Google)

10/2023 AIFS (ECMWF)

AIFS Blog



ECMWF unveils alpha version of new ML model

13 October 2023

This blog introduces an important companion to the Integrated Forecasting System (IFS), the AIFS, our Artificial Intelligence/Integrated Forecasting System. It is one of three components of our new machine learning project.

11/2023 NeuralLAM (Sweden)

Graph-based Neural Weather Prediction for Limited Area Modeling

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UEF2025, „AI in Weather Forecasting“, 10-11 October 2025, Stockholm, Sweden

AI based Weather Forecasting

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Decision for E-AI 12/2023

06/2024 Anemoui (ECMWF and European Meteorological Services)

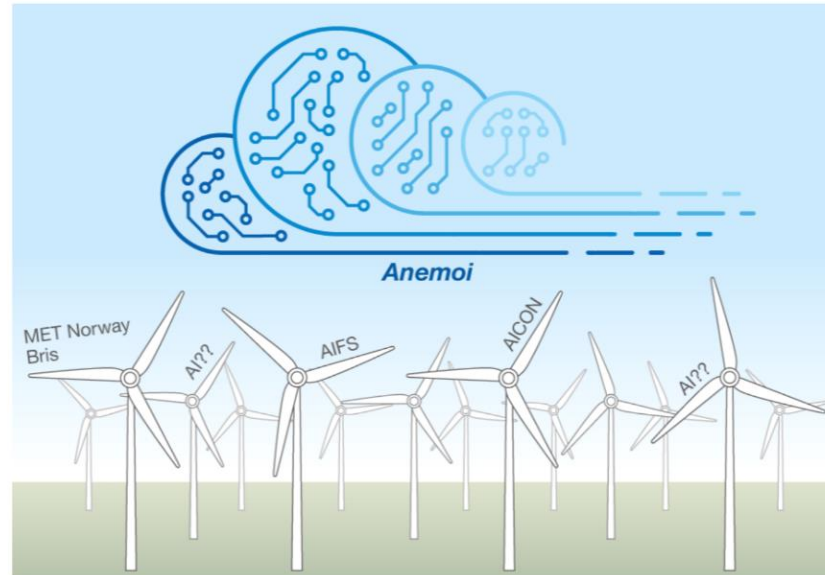
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AIFS B

GraphCast: Learning skillful medium-range global weather forecasting



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er Merosse²,
kir Mohamed¹ and

on System er Forecast

ML model

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

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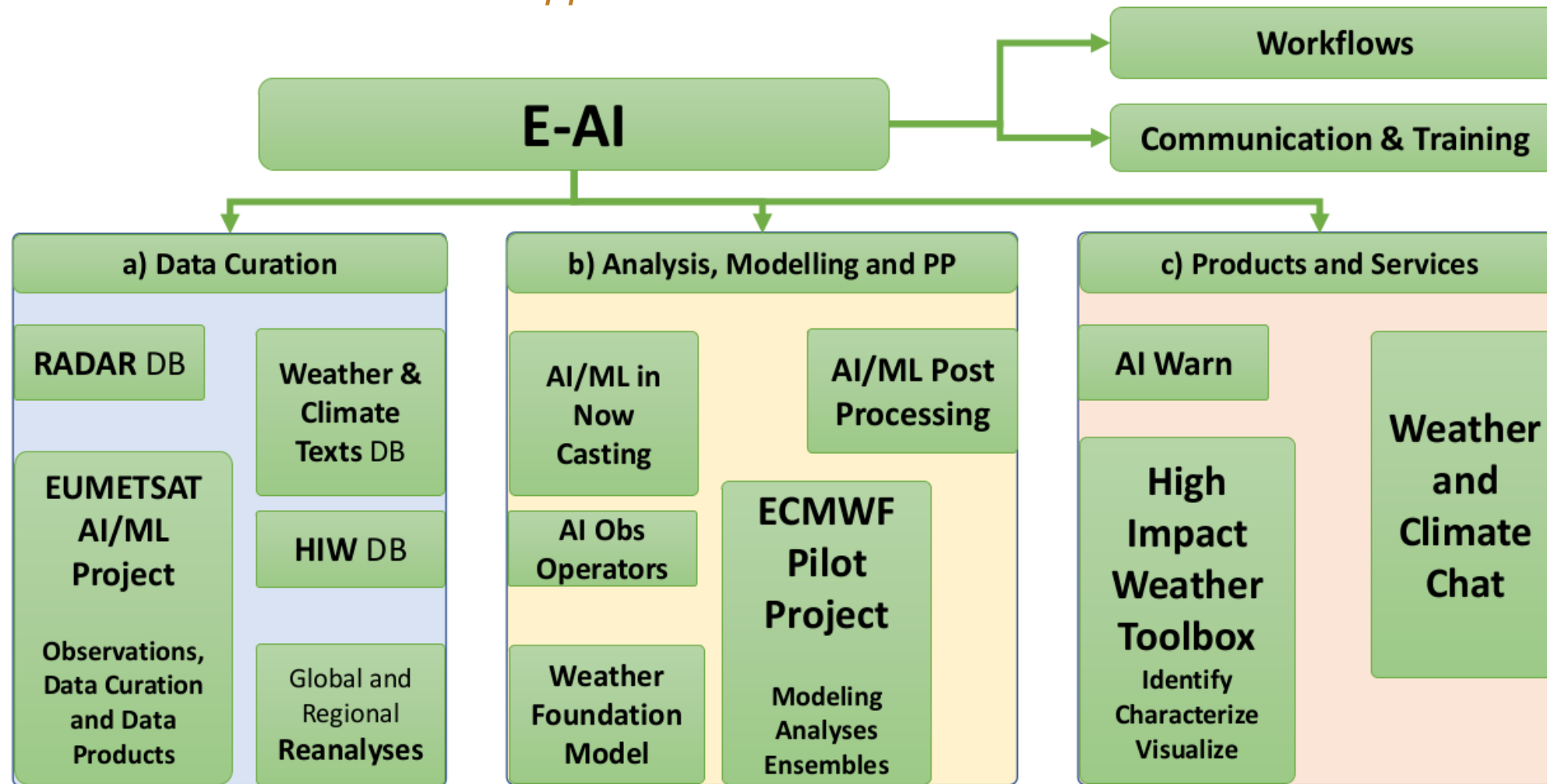
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E-AI: Artificial Intelligence and Machine Learning in Weather, Climate and Environmental Applications



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.

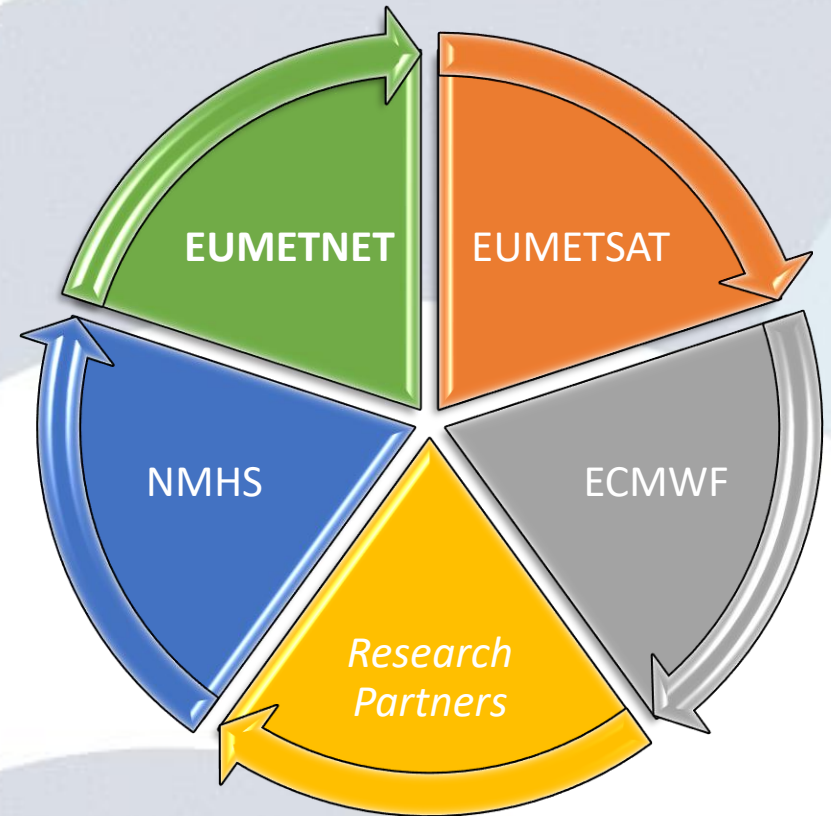
3. **Products and Services**. Objective: Enhance the use of AI/ML in the development of products and services



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 Weather Services

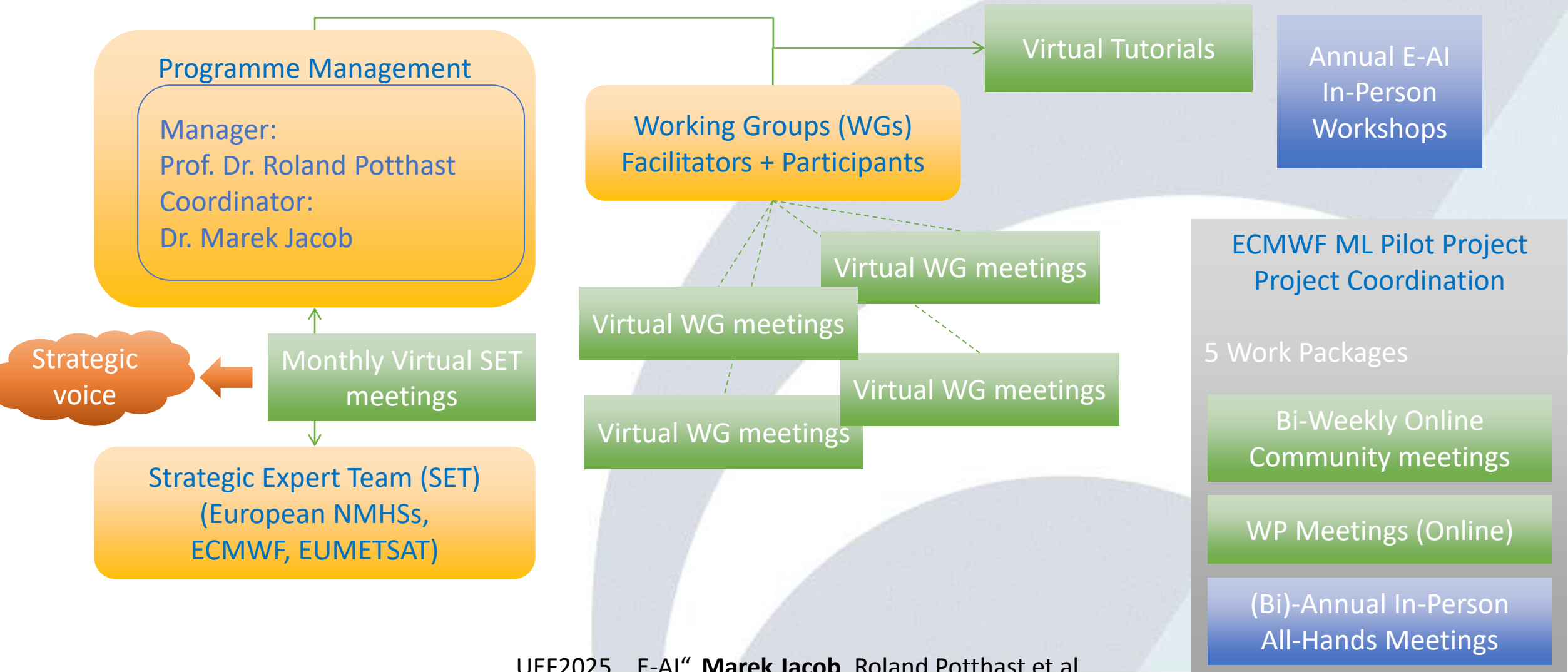
20 NMHS, EUMETSAT, ECMWF:

- 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 Working Groups

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 and QC, MLOps With AI Frameworks and Libraries (formerly WG 9)	active
WG 4	AI Sensing and Novel Observations (e.g., Phenomena and Identification, Webcams and Co.)	Being started
WG 6	MLCast Nowcasting – jointly with NWC of EUMETNET	active
WG 7	User Optimised Products and Impact (e.g. Cross Border Aviation Products) AI in the EUMETNET Aviation Support Programme	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

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Exchange of best practices
Joint software development
Joint funding proposals

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

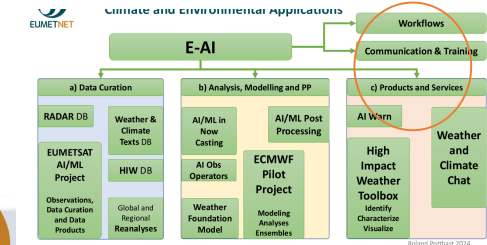
https://github.com/eumetnet-e-ai/e-ai_python_ml_tutorial

- 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

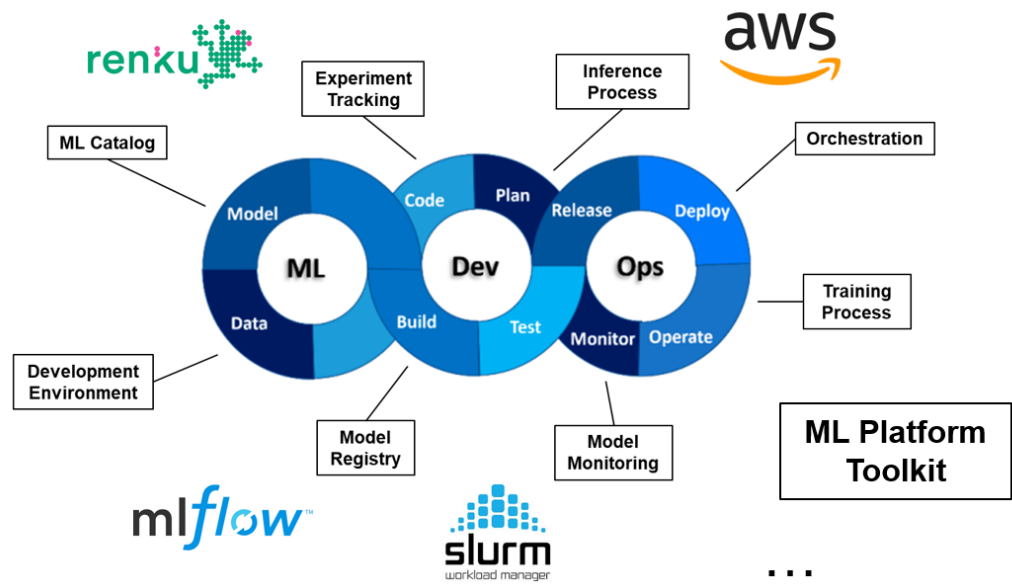
MLOps: From Research to Operations (WG3)

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

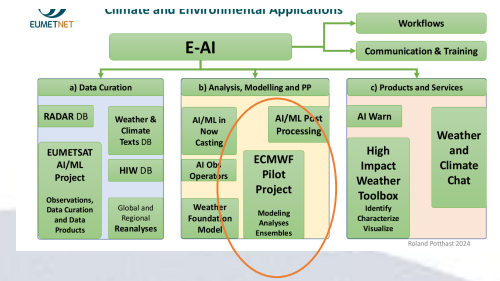
This block contains a collage of various ML platform interfaces. On the left, there's a 'Vertex AI' interface with sections for 'Gen AI' (Model Garden, Generative AI Studio) and 'ML Platform' (training, serving models). In the center, 'Azure Machine Learning' is shown with a 'Build model' workflow. To the right, 'Amazon SageMaker' is displayed with a 'Unified Studio' interface. Above the SageMaker interface, the text 'Feature Inspiration' is written in green. The collage also includes a 'Google Cloud Platform' interface at the top left.

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

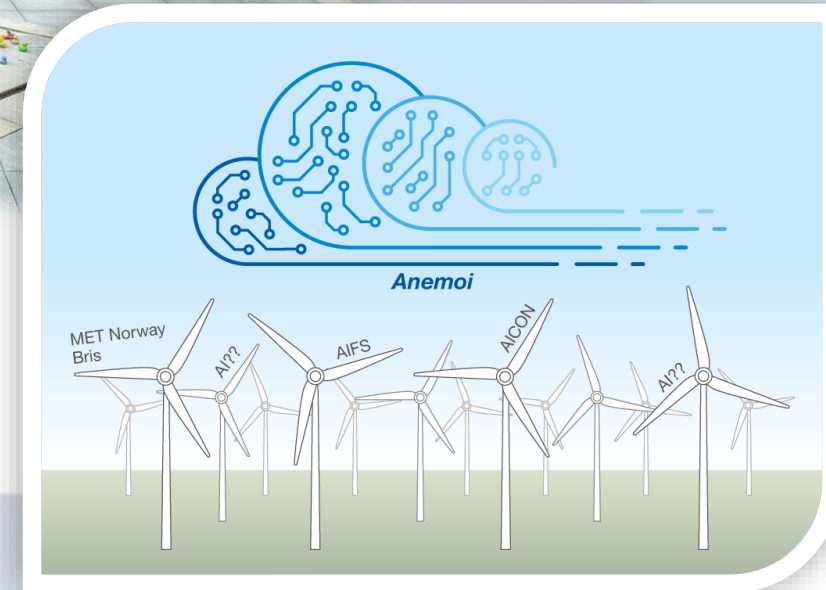
- ECMWF + 14 Member States

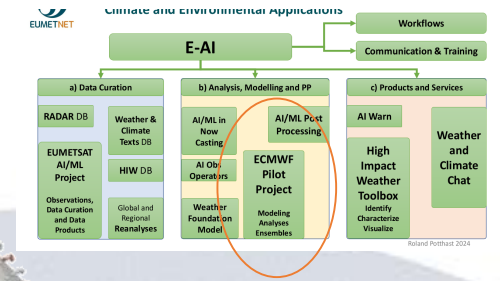
- Forecasting
- Ensembles
- Data assimilation
- Infrastructure and MLOps



EMS Technology Achievement Award 2025

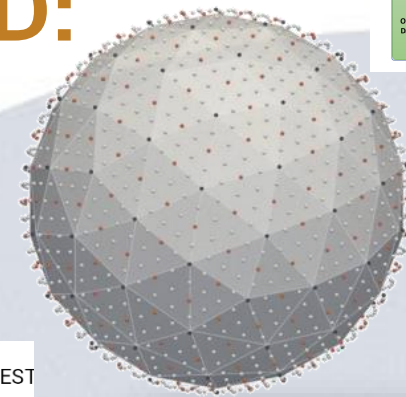
- Main code: **Anemoi**
- A European open-source software framework
 - To develop data-driven weather forecasting
- Flexible configuration
 - Deterministic & ensemble forecasting, nowcasting, global & LAM, temporal interpolation, post processing products, ...
 - Multiple data sources



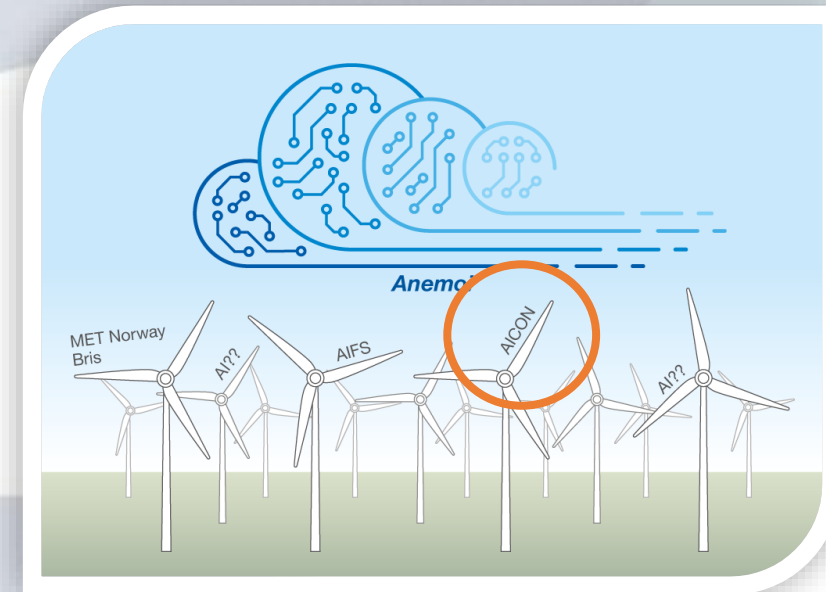
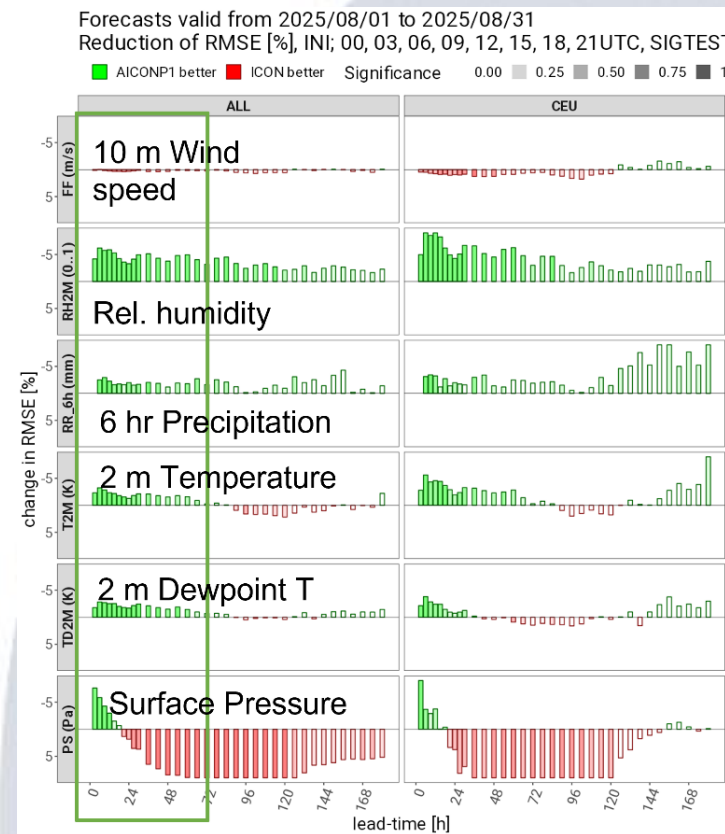


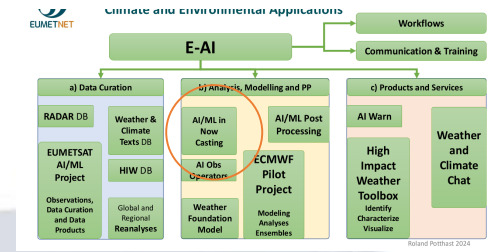
Example activity 2: Module B

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

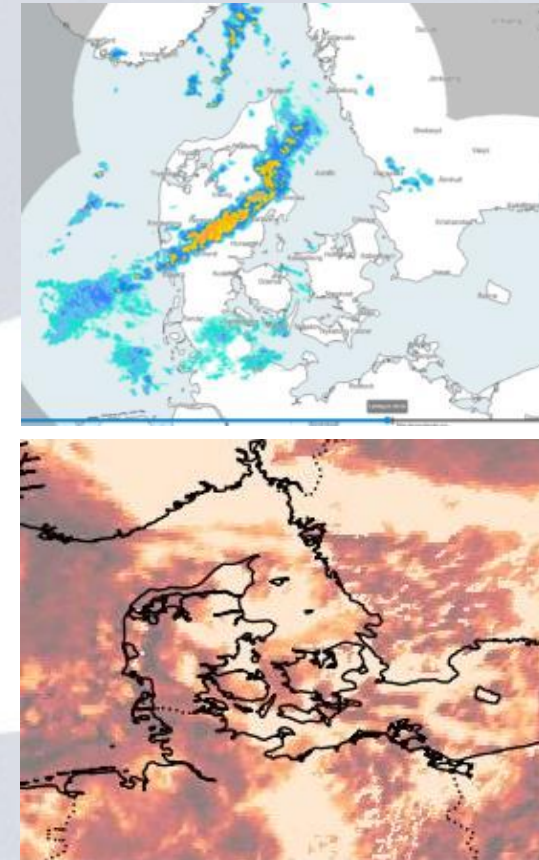




Example activity 3: Module B

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.

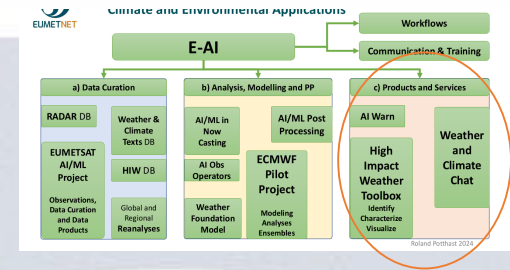
?  

Model: Local Mistral 24B Data Space: None

Enter your question...

[Ask](#) 

☐ Editor

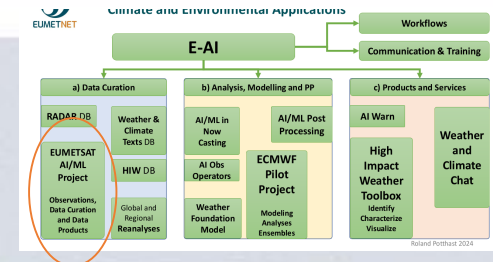


DAWID

- 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 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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