Machine Learning and Destination Earth

Introduction

William Becker

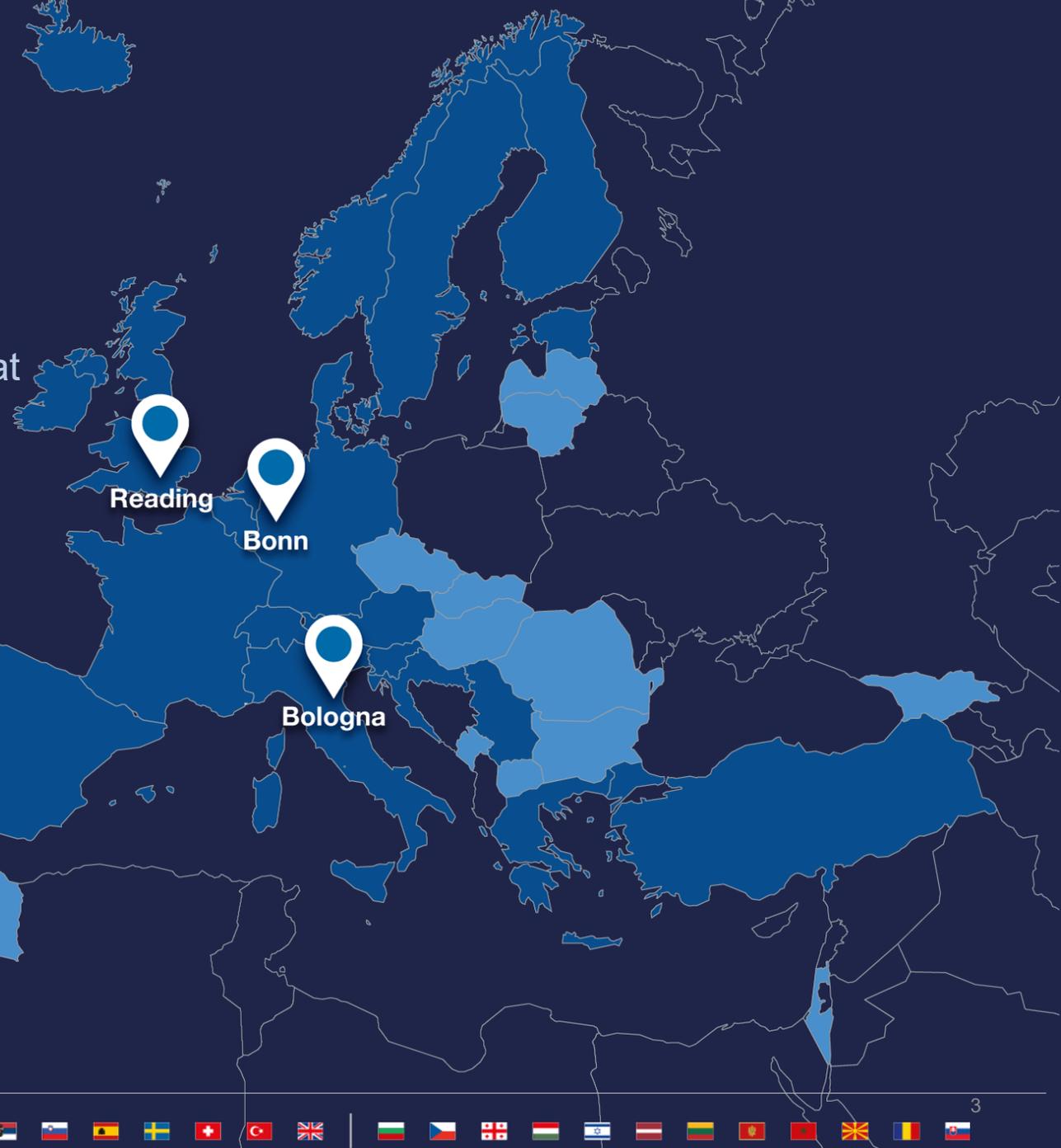Training coordinator in Machine Learning

william.becker@ecmwf.int

About ECMWF

European Centre for Medium-Range Weather Forecasts (ECMWF)

Three sites: one unique role

ECMWF's role is to address the critical and most difficult research problems in medium-range NWP that no one country could tackle on its own

European Centre for Medium-Range Weather Forecasts (ECMWF)

ECMWF is an international organisation with

- 23 Member States

- 12 Cooperating States

Three sites in UK, Italy and Germany

- Both research institute & 24/7 operational centre
- Established in 1975
- Advanced training = one of ECMWF's strategic activities
- Entrusted entity for Copernicus services (C3S, CAMS, support to CEMS)
- One of three Entrusted Entities delivering EU's Destination Earth
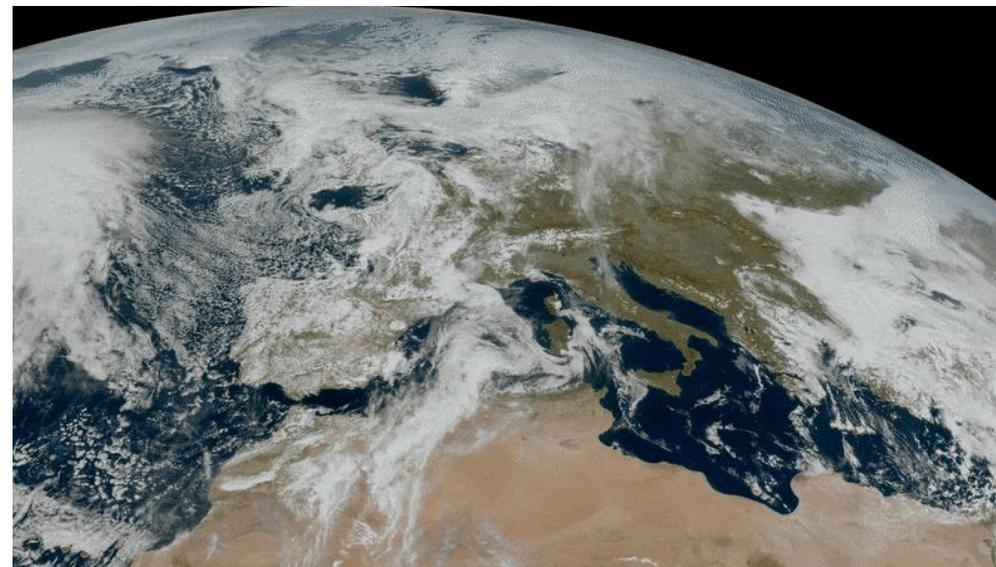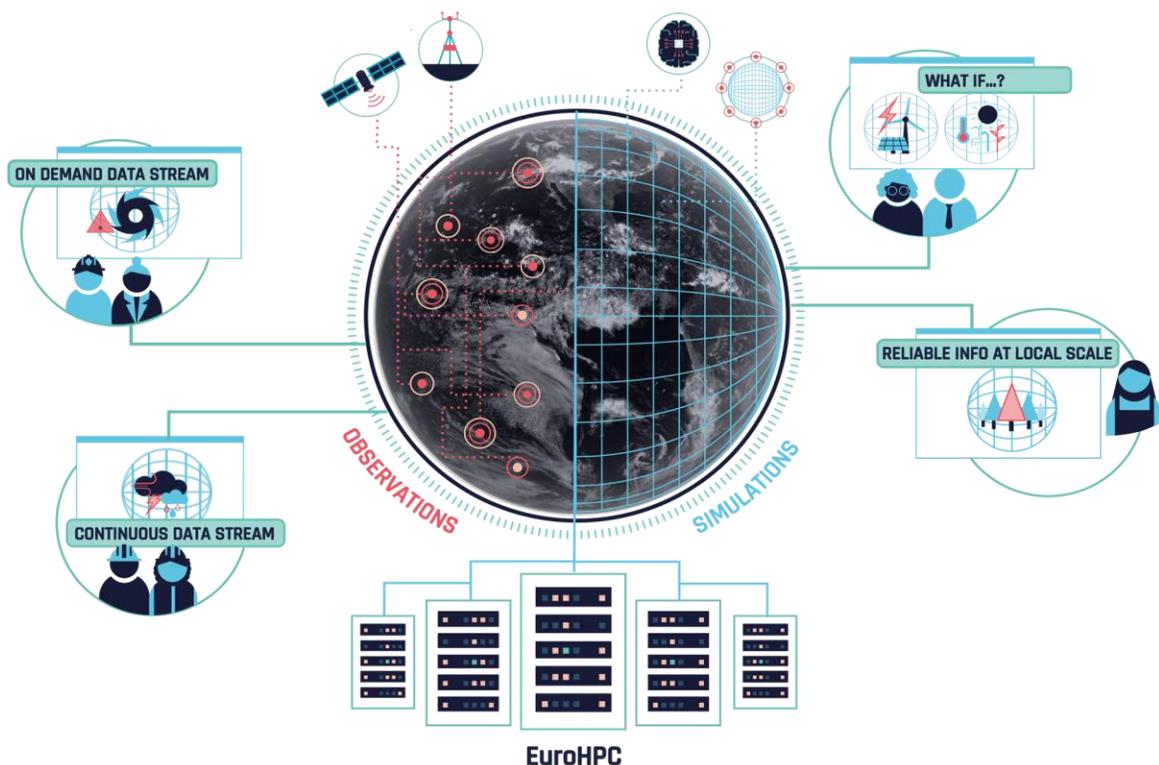
Reading

Bonn

Bologna
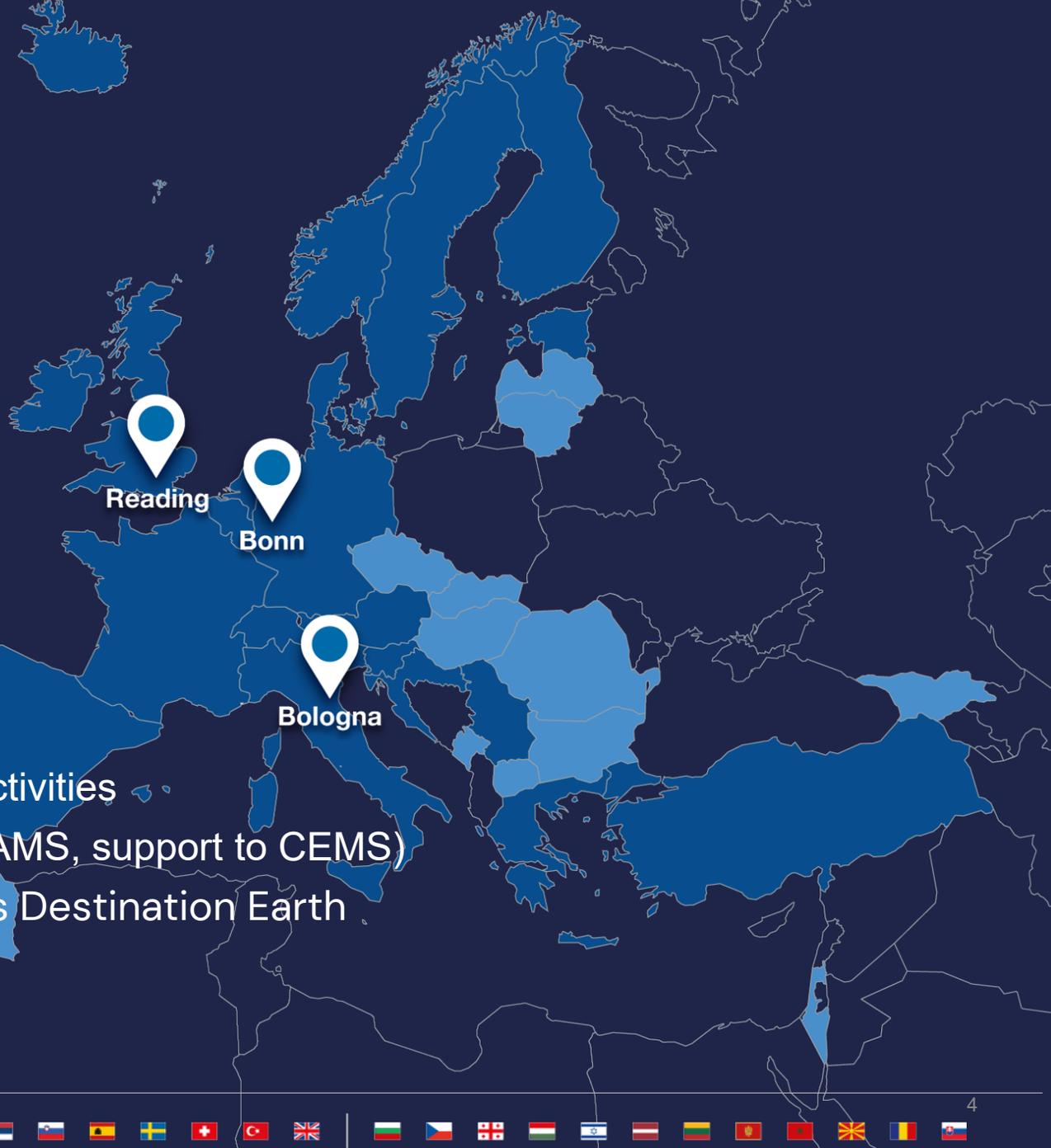
FULL, FREE AND OPEN
ACCESS TO DATA

ATMOSPHERE MONITORING

MARINE ENVIRONMENT MONITORING

LAND MONITORING

CLIMATE CHANGE

EMERGENCY MANAGEMENT

SECURITY

Copernicus
Europe's eyes on Earth

The Destination Earth System

Digital twins

- Climate change adaption

- Weather-induced extremes

- Machine learning components

https://destine.ecmwf.int/ai-in-destination-earth/

ARTIFICIAL INTELLIGENCE FORECASTING SYSTEM (AIFS)

ECMWF

| 1. Observe | 2. Absorb | 3. Model | 4. Predict |

Every day, we collect **800 million** observations of Earth's atmosphere, wind, temperature and beyond

60 million quality-controlled observations are absorbed by our physics-based Integrated Forecasting System

They feed the **AIFS'** new AI model, which predicts Earth's weather for the coming days

Now: AIFS Single one forecast at a time
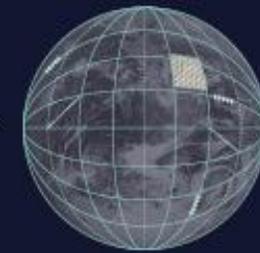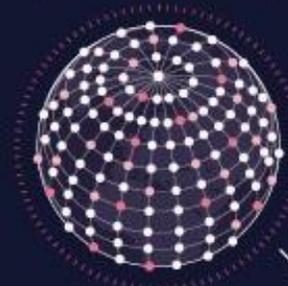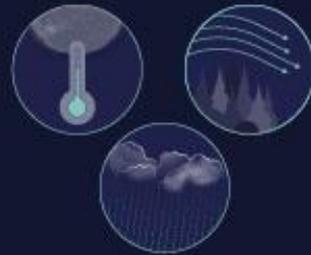
Next: AIFS ENS ensemble modelling for 50 forecast scenarios

How we train the AI model

Our **data archive** of the Earth's hourly weather creates a training loop that feeds the AI model using data from 1979 to present

1979   2025

The AI model repeatedly checks and corrects errors to improve accuracy

AIFS: launched 25th Feb 2025
AIFS-ENS: launched 1st July 2025

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Training at ECMWF

In-person events

✓ Approx. 8 multi-day courses per year in Reading

✓ Events also held in Member and Cooperating States, and in collaboration with EUMETSAT, WMO and others

https://www.ecmwf.int/en/learning

Online training and training catalogue

✓ Material available on demand

✓ Courses, videos and resources on ML, research, forecasting, C3S

✓ Search by keyword, topic, etc

Online courses incoming!

Machine Learning for Earth Systems Modelling – three online courses

Content
- Machine Learning Training
- Course information
- Objectives
- Target audience
- More to explore

Understanding and modelling our planet is rapidly evolving as machine learning becomes increasingly central to Earth system sciences. Under the Destination Earth (DestinE) initiative, three free online courses on Machine Learning (ML) for Earth systems modelling are being developed and offered in 2026. This series of three short online courses introduce participants to the fast-moving world of ML in Earth system modelling, from foundational concepts to advanced prediction and hands-on applications.

Whether you are a researcher, practitioner, or technical specialist from a meteorological service, climate centre, academic institute, or industry, this training series will help you build the skills and confidence to:

- understand the fundamentals of machine learning in Earth system science,
- apply ML concepts within the DestinE ecosystem, and
- engage with next-generation artificial intelligence (AI) modelling tools.

All three courses will be taught by ECMWF and European experts in AI and Machine Learning in Weather prediction and Climate science.

Register now for course 1 starting 16 March.

Interested? Show your interest by filling in this form: Machine Learning in Earth System Science – form. You will receive an update when new learning materials or courses become available.

Course information

Course 1 - Foundations, context and new frontiers	Course 2 - Architectures, data, and prediction	Course 3 - Applications and new directions
March 2026 | 10 hours	Mid 2026 | 19 hours	Late 2026 | 20 hours
This online course offers an introduction to machine learning and its growing role in weather and climate science.	This course examines how machine learning is transforming numerical weather prediction and how these methods are being operationalised within the DestinE initiative.	This course explores the frontier of AI in environmental modelling and its emerging applications.

ML in Earth Systems Modelling series – keep updated

https://destine.ecmwf.int/machine-learning-training/

Machine Learning for Earth Systems Modelling

Foundations and New Frontiers

Online training course 1
From foundations to hands-on applications!

📅 16 March 2026
✈ Online, self-paced

Funded by the European Union — Destination Earth

Enrol now!

Fundamentals	⚙ Certification available	10 hours	📖 Multi-lesson course
Level	Recognition	Estimated duration	Type of learning resource

Topics 🏷 Computing services and tools 🏷 Machine learning

Foundations and New Frontiers: March 16th

https://learning.ecmwf.int/enrol/index.php?id=96

Understanding Climate Data

From analysis of the past to future projections

Short online course
Because you don't have to be a climate scientist to make climate data work for you!

📅 February 2026
✈ Online, self-paced
⏱ 8 hours

Enrol now!
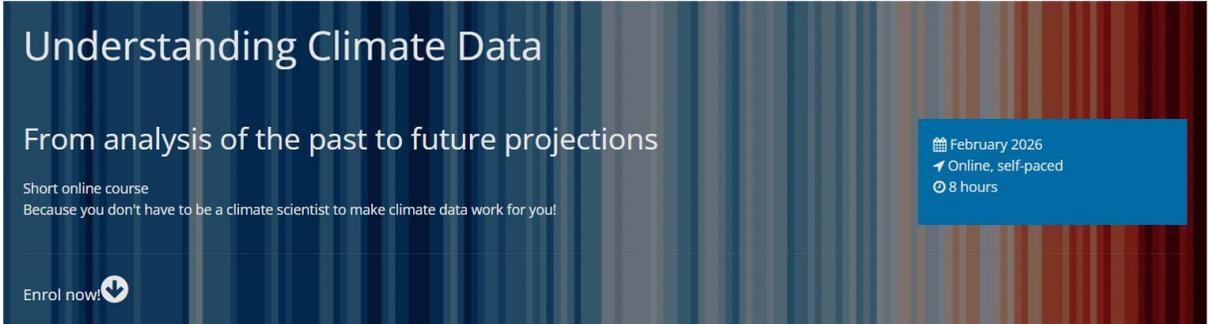
Fundamentals	⚙ Certification available	📖 Multi-lesson course
Level	Recognition	Type of learning resource

Topics 🏷 Climate

Understanding Climate Data
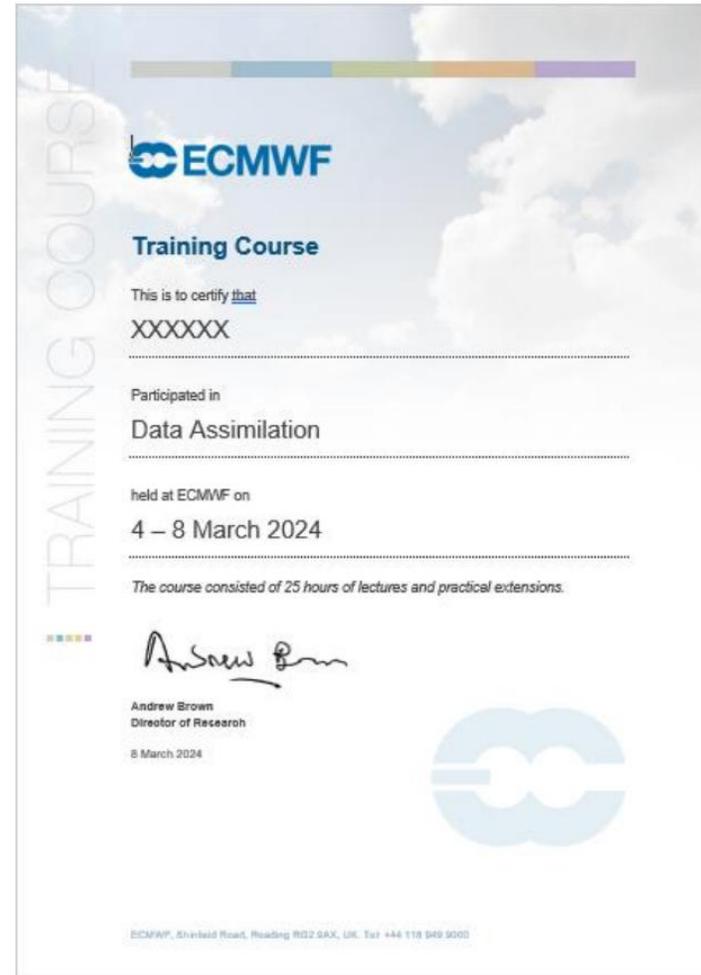
https://learning.ecmwf.int/enrol/index.php?id=89

ECMWF

On this course

Timetable

Monday 23 February	Tuesday 24 February	Wednesday 25 February	Thursday 26 February	Friday 27 February
No course	09:00 **Hands on: Neural Networks Basics** *Matthias Karlbauer, William Becker*	09:00 **Transformers** *Matthias Karlbauer*	09:00 **Hands on: Graph Neural Networks** *Mihai Alexe, Mario Santa Cruz Lopez*	09:00 **Hands on: Anemoi 2** *Jakob Schlör, Mario Santa Cruz Lopez, Matthew Chantry, Ana Prieto Nemesio*
		09:45 **Deep Generative Models** *Sophie Xhonneux*		10:00 **DestinE: Forecast in a Box** *Harrison Cook*
	10:30 – 11:00 Coffee break			
	11:00 **ML Evaluation and Data Leakage** *Ilaria Luise*	11:00 **DestinE: Hydrology** *Maria Luisa Taccari*	11:00 **Anemoi Datasets and Inference** *Harrison Cook*	11:00 **DestinE: Downscaling** *Joffrey Dumont Le Brazidec*
		11:45 **Self-supervised Learning** *Christian Lessig*		11:30 **DestinE: Earth System Modelling** *Rachel Furner*
	12:00 **Data Handling and Infrastructure** *Julien Lefaucheur*		12:00 **Hands-on: Running the AIFS** *Jakob Schlör, Mariana Clare, Mario Santa Cruz Lopez*	12:15 **Farewell** *William Becker*
12:30 **Registration**				
13:00 **Welcome and General Info** *William Becker*	**13:00 – 14:00 Lunch break**			
13:30 **Overview and Motivation** *Christian Lessig*				
14:15 **Machine Learning Foundations** *William Becker*	14:00 **Convolutional Neural Networks** *Maria Luisa Taccari*	14:00 **Graph Neural Networks** *Mihai Alexe*	14:00 **Anemoi Graphs** *Mario Santa Cruz Lopez*	
			14:30 **Anemoi Models** *Joffrey Dumont Le Brazidec*	
	15:00 – 15:30 Coffee break			**No course**
15:30 **Neural Networks and Deep Learning** *Mario Santa Cruz Lopez*	15:30 **Hands on: Debugging Machine Learning models** *Matthias Karlbauer, Maria Luisa Taccari*	15:30 **Data-driven Weather Forecasting** *Mariana Clare*	15:30 **Anemoi Training** *Ana Prieto Nemesio, Mario Santa Cruz*	
16:30 **Setup for Practicals** *William Becker*			16:00 **Hands on: Anemoi 1** *Mariana Clare, Mario Santa Cruz Lopez, Matthew Chantry, Ana Prieto Nemesio*	
Icebreaker drinks		**Course dinner**		

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Certificate of attendance & course material

- Course web page: https://events.ecmwf.int/event/495/

- Presentations: https://events.ecmwf.int/event/495/timetable/

- Certificate of attendance awarded at end of course

Housekeeping

General Housekeeping

Access to Centre

- Please sign in/out each day at reception, and on the sign in sheet

- Please stay within the "Nest" area unless accompanied (toilets at back of Nest)

Personal belongings

- Do not leave any personal belongings at ECMWF outside office hours.

- We recommend that you do not leave valuables unattended

- ECMWF will not take any responsibility for items lost at the premises.

Smoking

- Smoking is not allowed inside the building.

Fire escapes at the back of this room

Visitor WiFi

You should be able to log on without any registration.

WiFi network: ECMWF-Visitors

Coffee and lunch

- We'll have morning and afternoon coffee breaks here in the Nest
- Lunch will be in the canteen downstairs
  - Please wait for an ECMWF staff member to accompany you down and back up

- The restaurant accepts both card and cash.

General Housekeeping

Recording and photos

- Lectures are hybrid and streamed to some colleagues

- We may take some photos during the training – let us know if you want to opt out
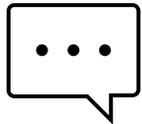
Make the most of the training!

- There are no stupid questions!

- Please feel free to talk to us and get to know each other ☺

Any questions so far?

Feedback

Survey at the end of the training

Talk to me any time or email contacts:

- william.becker@ecmwf.int for anything related to ML training and the present course

- training@ecmwf.int for general training enquiries.

Good luck with the training!