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Accessible air quality forecasts for Arctic communities: how AI can help citizens and policy-makers

The Real-World Impact of AI in the Polar Regions

2024 European Polar Science Week - Copenhagen

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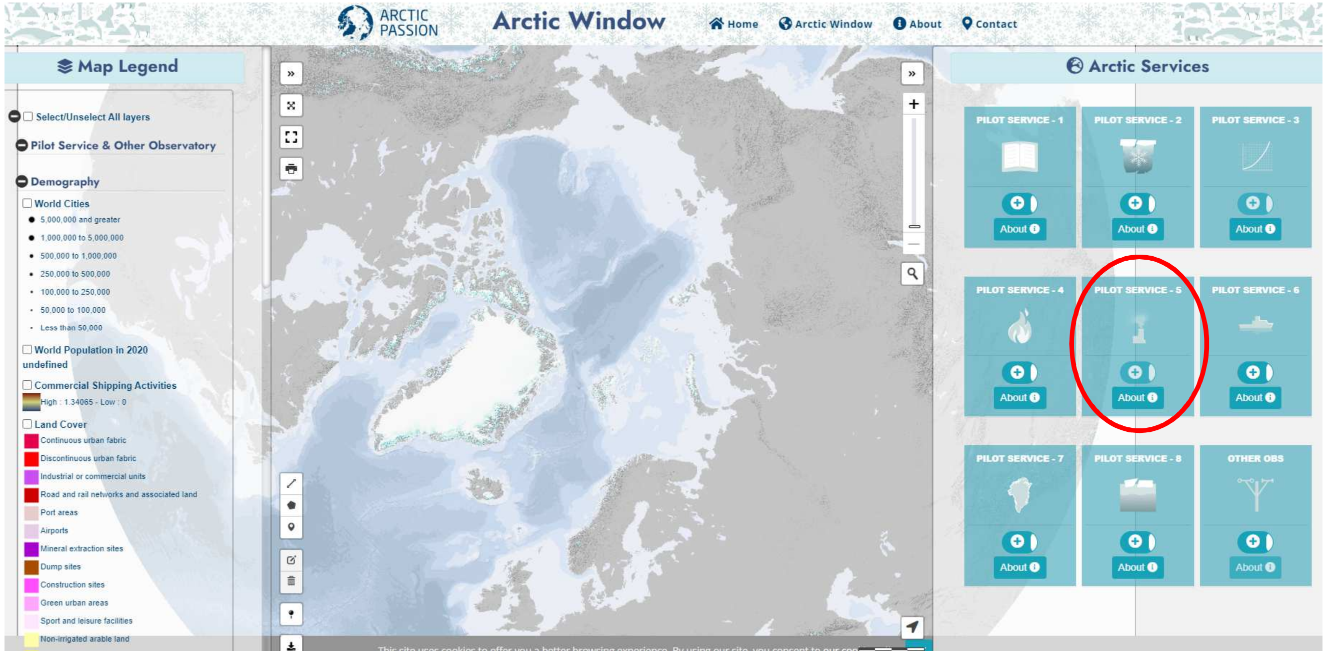
Arctic PASSION H2020 Project

Arctic PASSION
Pan-Arctic Observing System of Systems
Implementing Observations for Societal Needs



PARTNERS: 43 partners from 17 countries including Indigenous communities across the Arctic

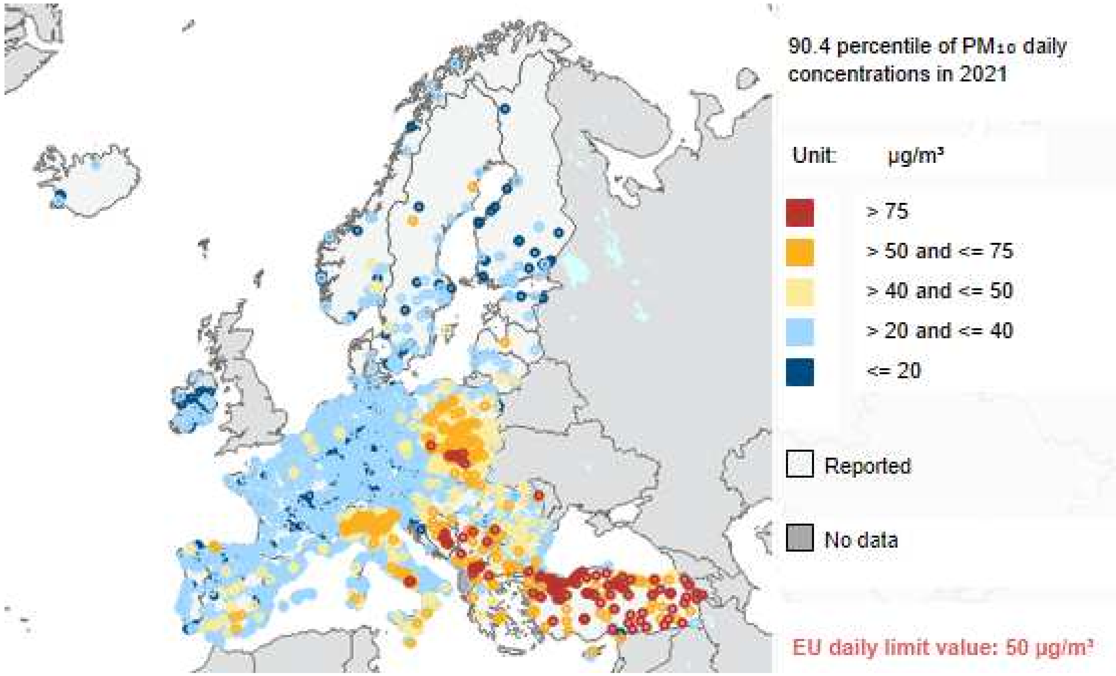
https://arcticpassion.eu/
linkedin.com/in/arctic-passion-875113221
arctic_passion

PM_{10} in North Europe

PM_{10} is a complex mixture of solids and aerosols with a diameter of 10 microns or less

It is inhalable into the lungs and can induce adverse health effects (respiratory, cardiovascular, etc.)

<u>WHO 2021 recommendations</u>
15 µg/m^3 mean annual concentration
45 µg/m^3 mean daily concentration



Source: European Environmental Agency (www.eea.europa.eu/)

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Limits of CAMS PM_{10} forecast

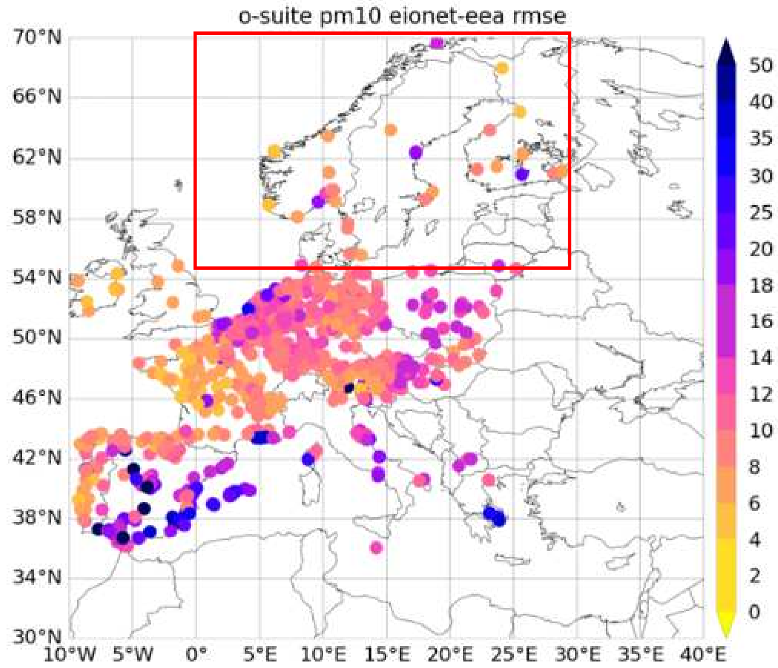
Forecast performances

- High error for CAMS forecast vs in-situ measurements
- Limited number of in-situ monitoring stations data used for assimilation (less than 20 for all North Europe)

Data accessibility

- Data available only in professional users' format
- Manual download needs some knowledge of modelling vocabulary and technical knowledge and/or programming skills
- Absence of a unique platform to access near-real time air pollution data (EEA) and forecast (CAMS)

Copernicus Europe's eyes on Earth — Atmosphere Monitoring Service



RMSE for 24-hour forecasts (at 3hourly basis) of CAMS for the 1 June – 31 August 2021 and 3 hourly PM_{10} from EIONET measurements (Ramonet et al. 2021)

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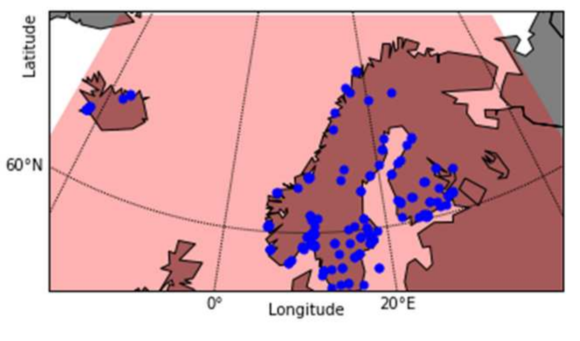
1. Improve forecast performances with AI

Input data

- PM_{10} data at hourly frequency from ~ 100 monitoring stations (June 2020-June 2023)
- CAMS PM_{10} forecast (48 hours) at each station
- Meteorological variables (temperature, boundary layer, wind components, precipitation, m.s.l. pressure) at each station (ECMWF)

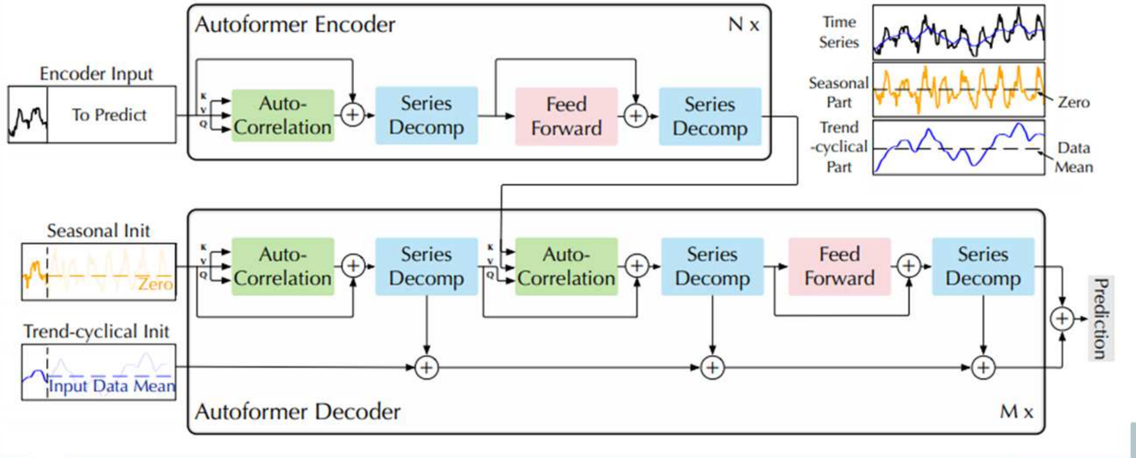
European Environment Agency

FINNISH METEOROLOGICAL INSTITUTE



Deep learning models

- LSTM-networks used as baseline for long series forecasting
- Transformer architectures better track long-term dependencies exploiting time series decompositions and correlations



Source: Wu et al. 2021

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Transformer Architecture

In recent developments, time series forecasting is turning away from RNNs as new models coming from Natural Language Processing are being adapted to time series analysis tasks as they:

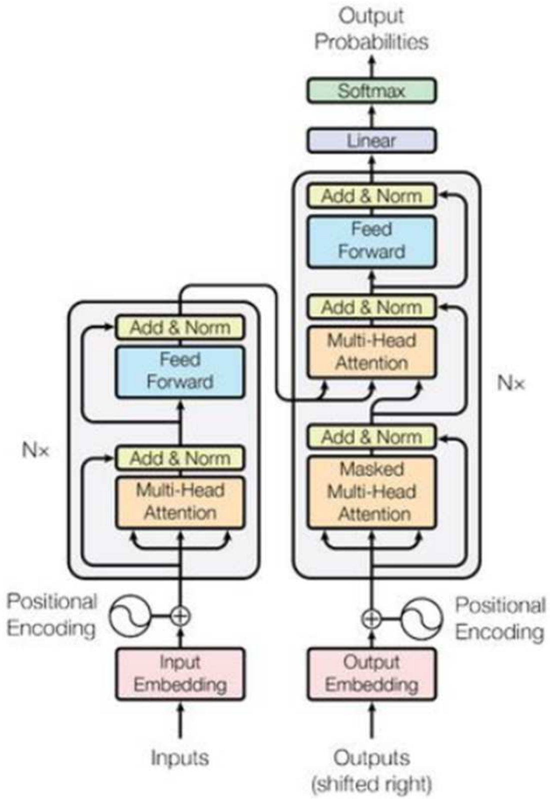
- better incorporate sequential data and thus historical information
- prove to be more suited for long sequence forecasting
- Better encode temporal and cross dimensional information

Encoder + Decoder structure

Spatial/Temporal embedding

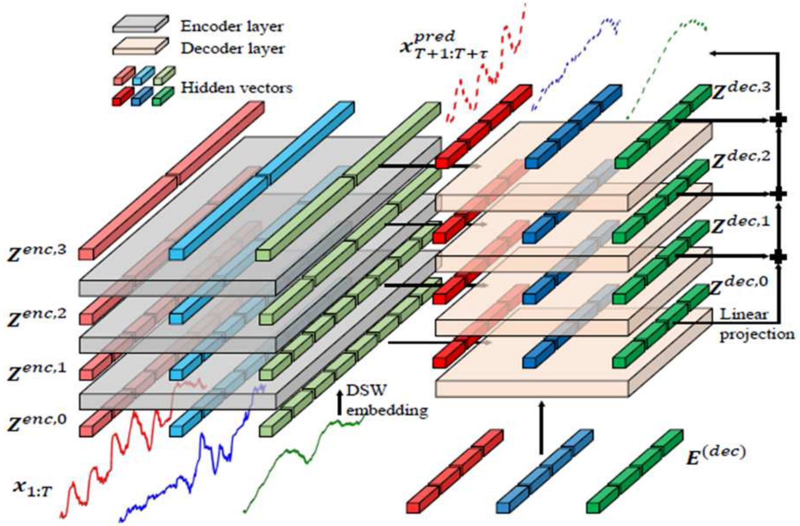
Attention mechanism

Feed-Forward Network

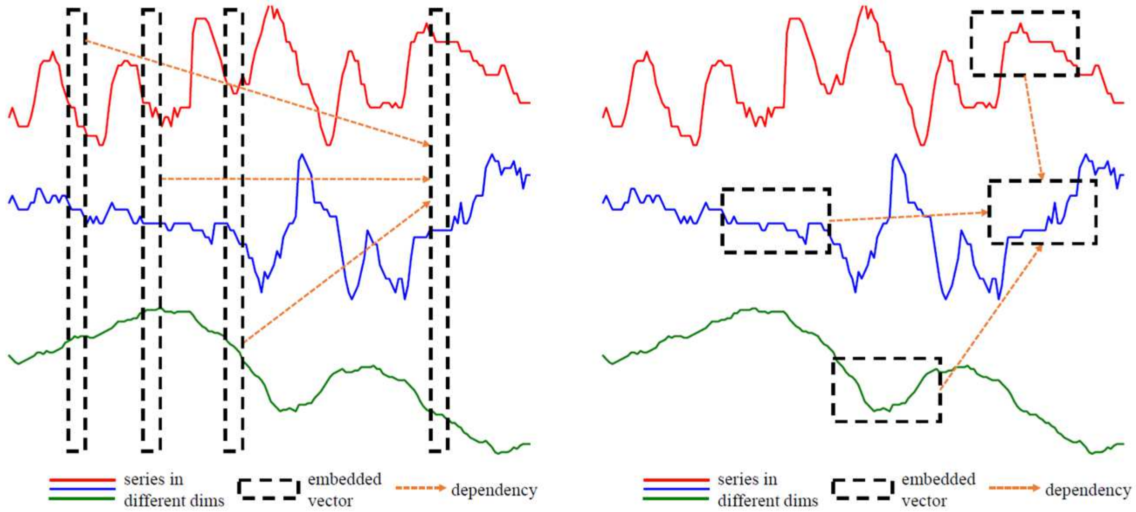


Original Transformer Architecture as defined in Vaswani, A., Shazeer, N., Parmar, N., Uszkoreit, J., Jones, L., Gomez, A. N., Kaiser, L., and Polosukhin, I. Attention is all you need. CoRR, abs/1706.03762, 2017

Variation: Incorporating Cross-Dependencies



Original Crossformer Architecture as represented in Zhang, Y. and Yan J., Crossformer: Transformer Utilizing Cross-Dimension Dependency for Multivariate Time Series Forecasting, International Conference on Learning Representations, 2023



- Most Transformer architectures try to capture cross dependencies amongst features within embedding and forward stages, while it is possible to incorporate a cross-dimension stage within an encoder layer as a two-step attention block
- The embedding also considers segment-wise decomposition in order to track correlations between subsequences

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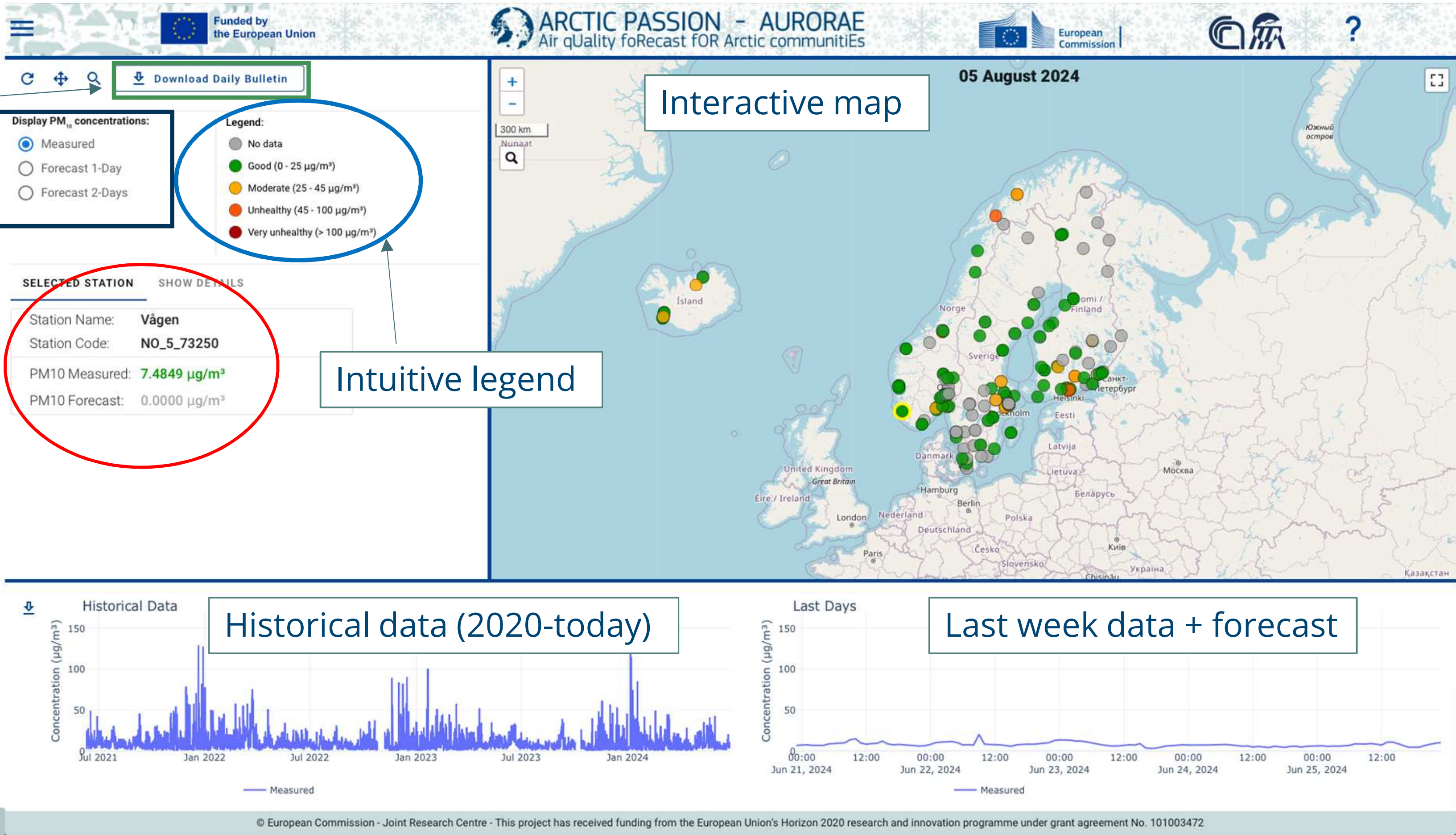
2. Improve data accessibility

The Air Quality Forecast for Arctic Communities (AURORAE) service website

Download .txt files

Choose between near-real time data and forecast

PM_{10} concentration + forecast + information on the station



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A tool for citizens and policymakers

- AURORAE improves the available 2 days PM_{10} forecast for municipalities in North Europe and in the European Arctic
- Non-scientific users can easily navigate the interactive map and access air pollution data
- The service empowers Nordic and Arctic communities on air quality topic and its effects on public health
- AURORAE helps to promptly take action in case of episodes of high level of air pollution

We'd love to hear you feedback!

To take part in our Slido survey scan the QR code!

THANK YOU!

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