

Introduction


- **Data-driven** weather prediction is rapidly advancing at **global** and **regional** scales.
- **Regional** data-driven forecasting is not yet widely adopted **operationally**, partly due to high computational demands and limited ML expertise in many weather services.
- Training high-resolution models requires substantial **computational resources**, posing challenges for smaller national weather services.
- **Transfer learning** provides a promising solution by **reducing training costs and environmental impact**, while leveraging knowledge from large-scale datasets.

What this poster is about:

- First regional **data-driven model** for the Eastern Alps and Northern Adriatic
- **Transfer learning**: Swiss LAM → Slovenian LAM
- Comparison: **fine-tuned vs direct inference**

Methodology

Model

- Developed within the Anemol framework [1] 
- **Graph Neural Network (GNN)** architecture – limited-area model configuration [2]

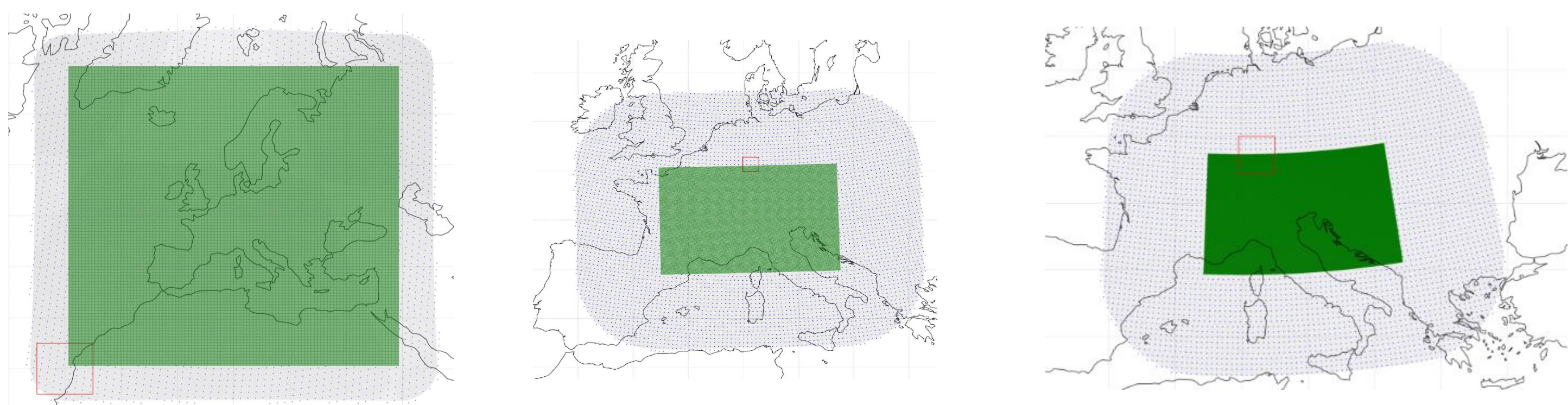
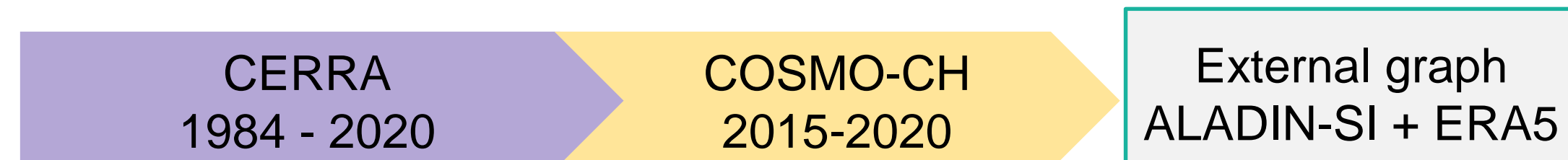
Transfer learning approach

- Start from **pretrained limited-area model** (Switzerland) trained on COSMO-CH (2 km)
- Fine-tune on Slovenian **high-resolution dataset** – ALADIN-SI (1 km) + ERA5 (N320)



External graph (inference on different graph)

- GNNs allow **training** and **inference** on different **graphs**
- Enables application of a model to a **new domain** without retraining
- Provides a tool to assess **model generalizability prior to fine-tuning**



Discussion

- Both approaches show **promising skill**, but more comprehensive **verification** is required: additional case studies, longer evaluation periods, quantitative skill scores.
- The fine-tuned model is **comparable** to the pretrained model for temperature and precipitation, and shows **improved performance for wind speed**.
- Results are encouraging, but further work is needed: **hyperparameter** tuning and validation, comparison with **fine-tuning** from the pretrained **CERRA** checkpoint.
- Future development: extension to an hourly forecasting model, use of observations...

Conclusions:

- Results demonstrate the **potential of data-driven limited-area forecasting** for an orographically complex region.
- **Transfer learning** is effective, enabling adaptation of pretrained models to a new region with reduced computational cost.
- Applying models on a **different graph/domain** without fine-tuning shows promise as a fast approach to assess generalizability, though with limitations.
- These findings support the feasibility of **operational** regional ML-based forecasting.

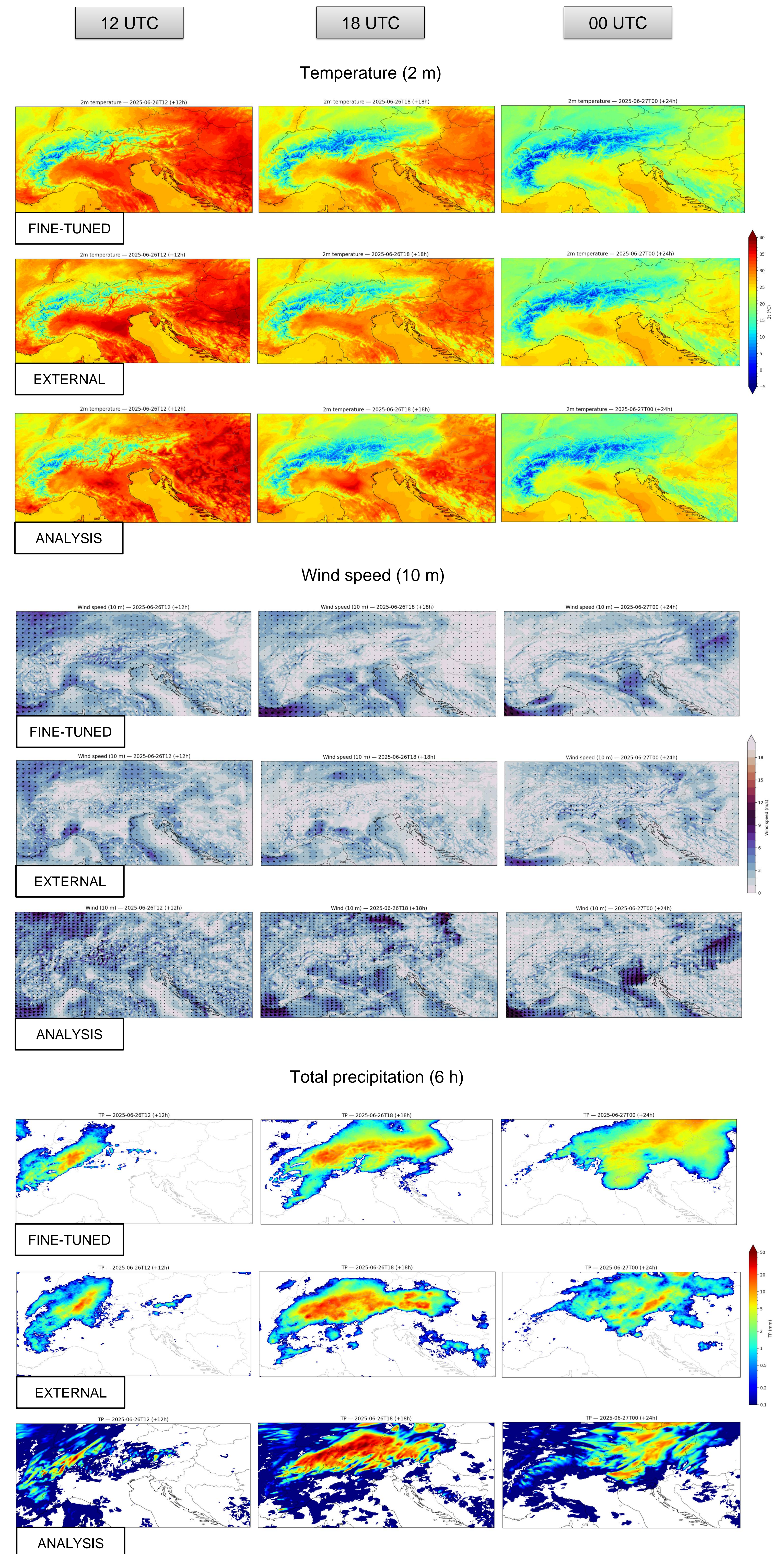
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2. Nipen, T. N., Haugen, H. H., Ingstad, M. S., Nordhagen, E. M., Salihi, A. F. S., Tedesco, P., Seierstad, I. A., Kristiansen, J., Lang, S., Alexe, M., et al., 2024: Regional data-driven weather modeling with a global stretched-grid. arXiv:2409.02891. <https://doi.org/10.48550/arXiv.2409.02891>

Results

Case study: 26 June 2025

- **Extreme heat**: several stations in Slovenia measured record values for June.
- In the evening, a **large convective system** developed over northeastern Italy and moved across Slovenia during the night, producing hail and strong wind gusts.



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