

Graph-based data-driven weather prediction over Austria: Assessing Temporal Resolution Trade-Offs

Çağlar Küçük, Pascal Gfäller, Irene Schicker, Alexander Kann

GeoSphere Austria – Federal Institute for Geology, Geophysics, Climatology and Meteorology



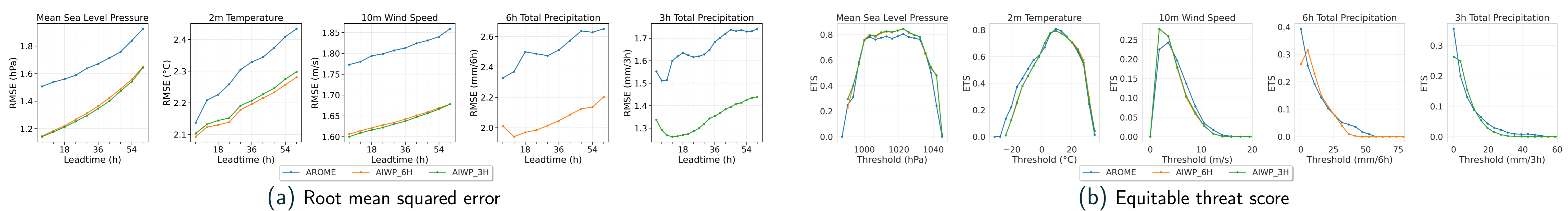
Summary & Outlook

Introduction

- Data-driven modelling leveraging global and regional reanalysis datasets
- Graph-neural networks with *anemoi*
- Stretched-grid model with 2.5km spatial resolution over Austria
- Temporal resolution: 6- or 3-hours?

- On a full year of test dataset, our models show consistently lower RMSE than AROME
- On extremes, our models smoothing out and missing spatial structure
- No performance degradation due to error growth moving from 6- to 3-hour temporal resolution
- Outlook: (i) Increase temporal resolution to 1hr (ii) Ensemble forecasting (iii) Add further variables from additional datasets

Model Performance



(a) Root mean squared error

(b) Equitable threat score

Figure 1: Performance scores for mean sea level pressure (*mslp*), 2m temperature (*t2m*), 10m wind speed (*ws*), and total precipitation (*tp*), computed over measurement stations across Austria, using test dataset (2021)

- Clear improvement over RMSE
- Low error growth at both temporal resolutions
- Extreme values remain challenging
- No performance degradation in 3-hour temporal resolution

Case Study

Storm Bernd (2021-07-17) with heavy precipitation over Austria and strong winds over Adriatic

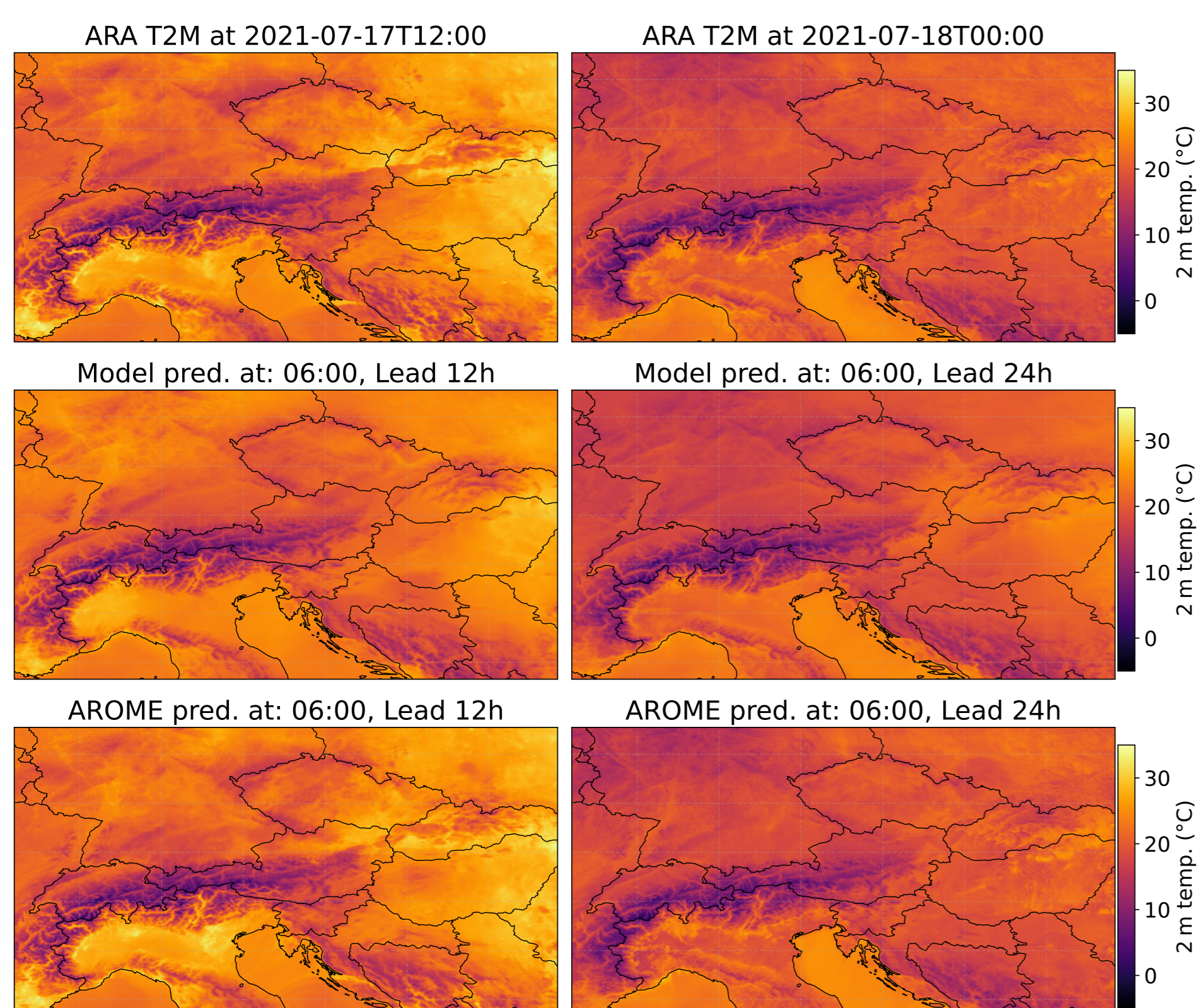


Figure 2: 2m Temperature (*t2m*)

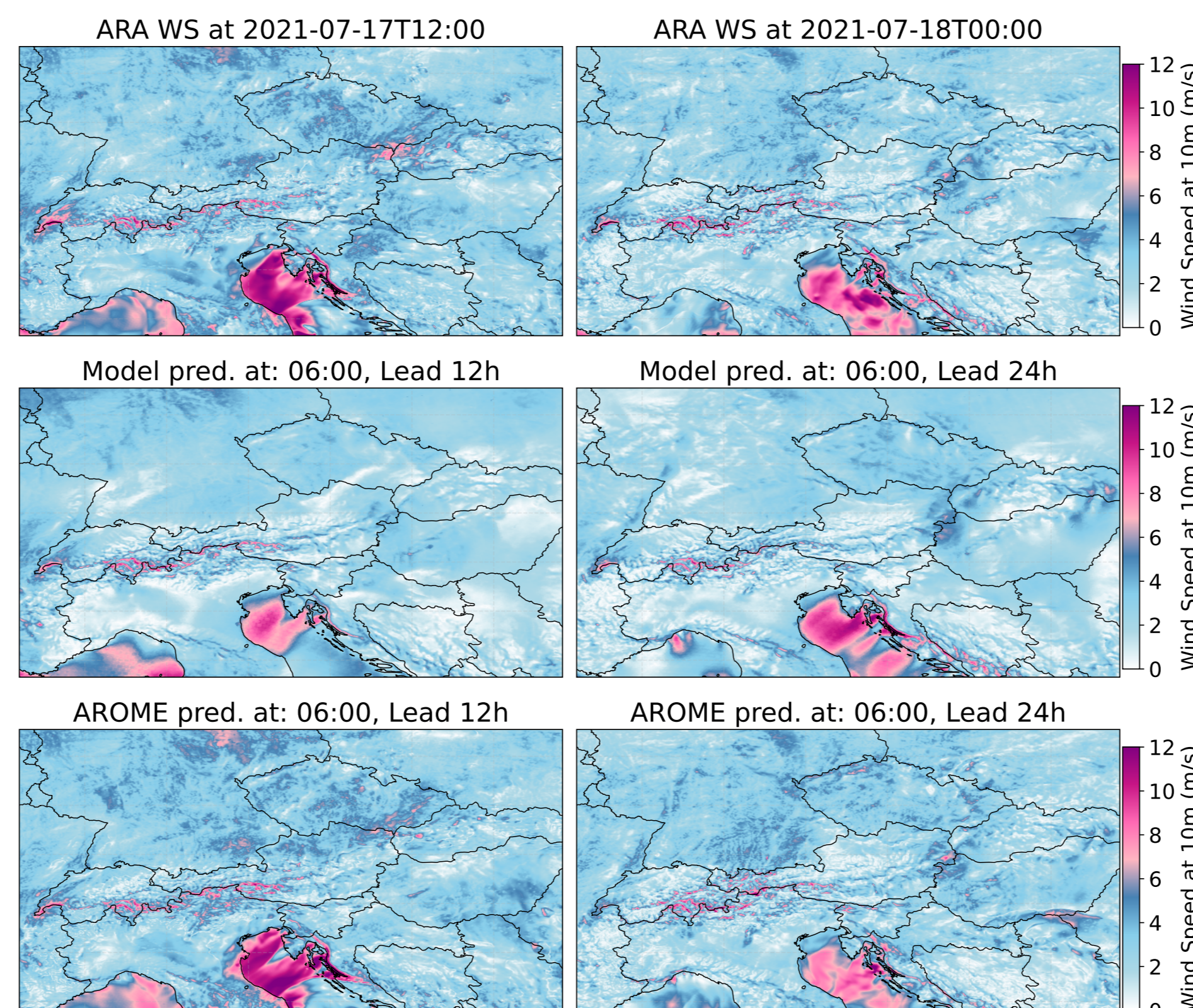


Figure 3: 10m Wind Speed (*ws*)

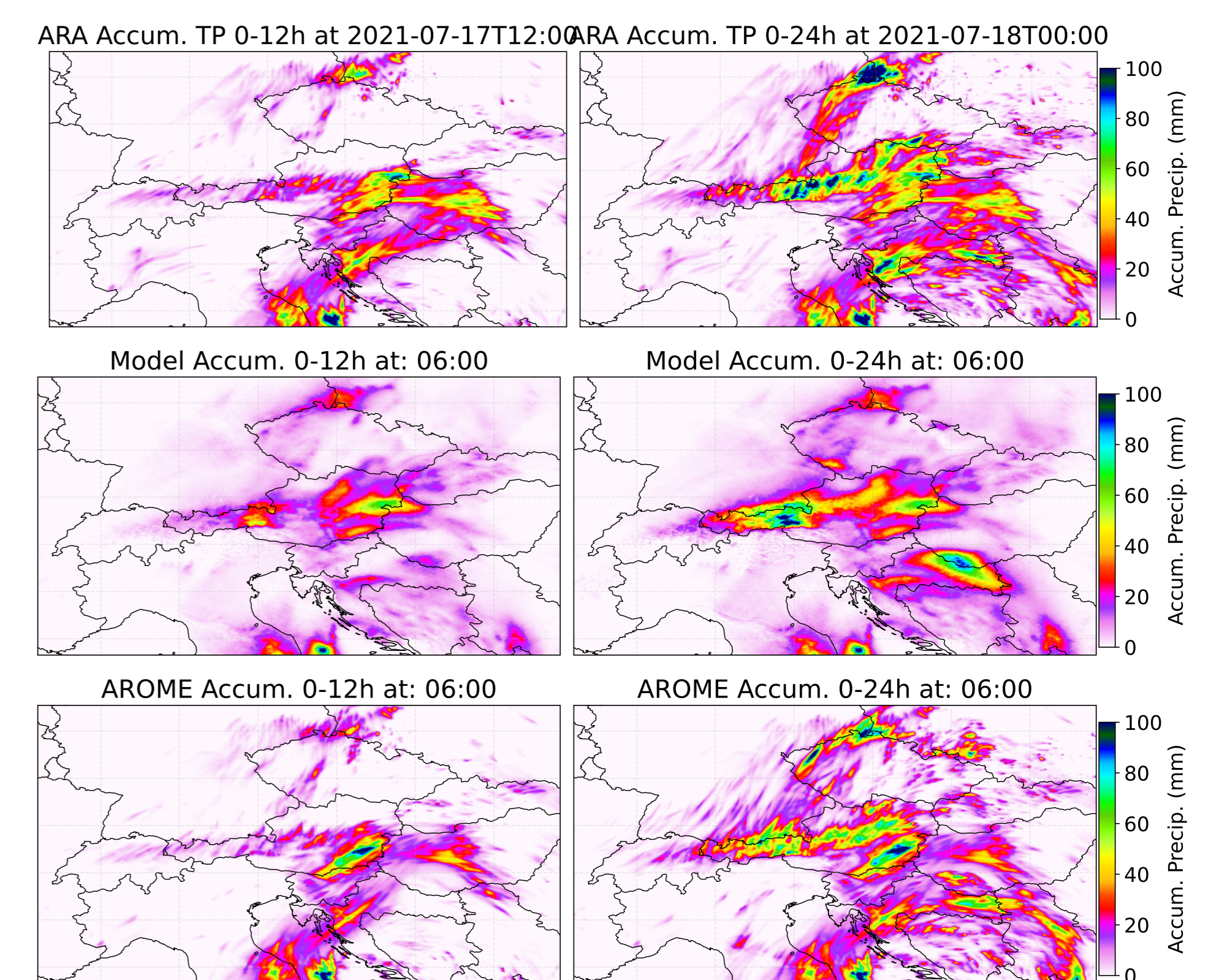
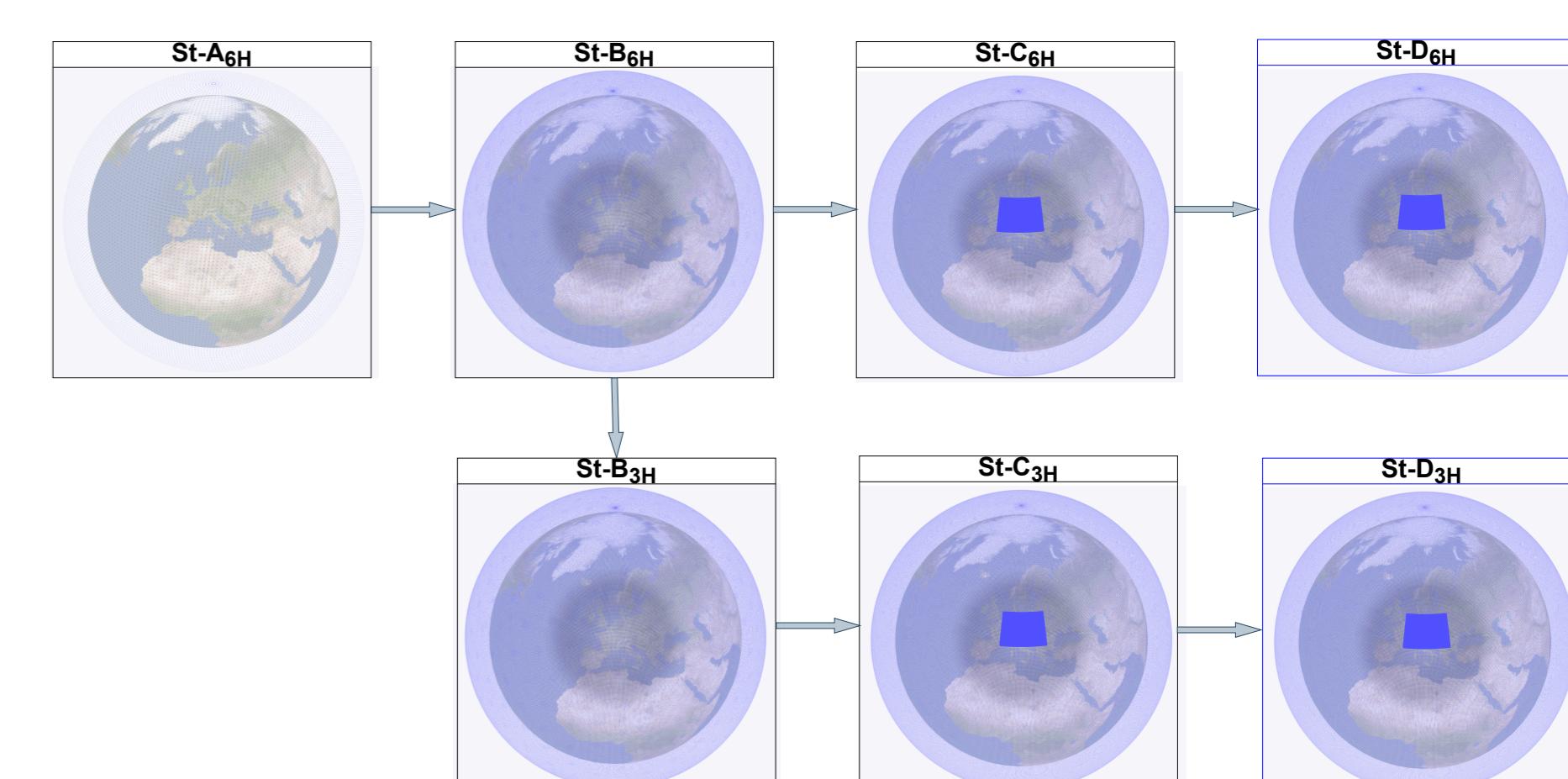


Figure 4: Total precipitation (*tp*)

- Amplitude and spatial structure reproduced in *t2m*
- 'Blurred' predictions in *ws* and *tp*
- Underestimation of large values in *ws* and *tp*

Data & Methods

- ERA5 & ARA
- ARA dataset:
 - Train: 2012-2019; Valid: 2020; Test: 2021
- Bris-style multi-stage training
- 6- and 3-hr temporal res.
- Pressure levels:
 - param: $[u, v, w, t, q, z]$
 - level: $[100, 150, 200, 300, 400, 500, 600, 700, 850, 925, 1000]$
- Surface:
 - $[10u, 10v, 100u, 100v, sp, msl, tp, 2t, skt, z, dpt, tcw, tp]$



This work is supported by ECMWF MLPP and DEODE WP14.

We are grateful for collaborations with ECMWF and other NHMS, particularly MetNorway, KNMI, RMI, and MeteoSwiss.