NWP activities at the Hungarian Meteorological Service

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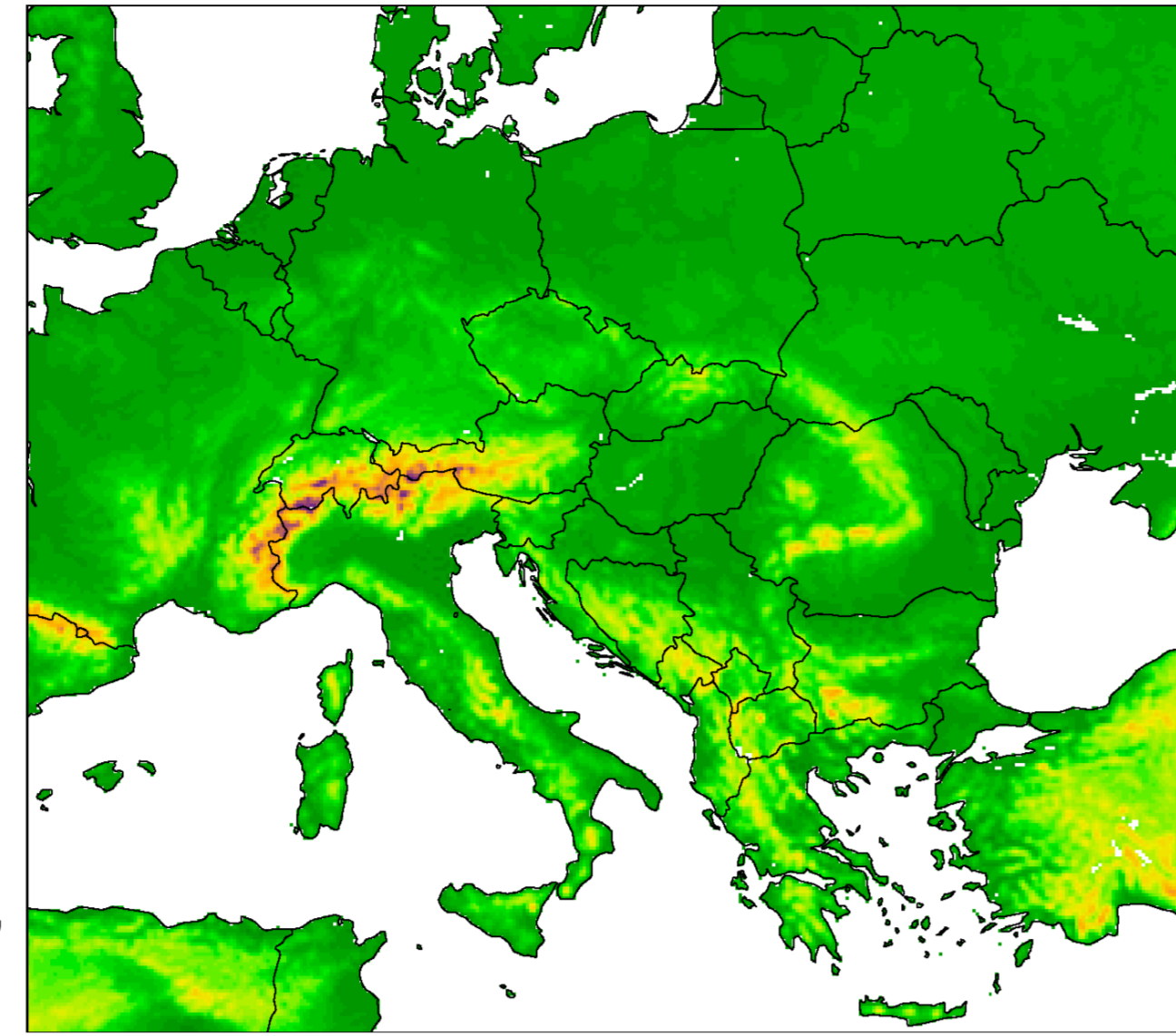Anikó Kardos-Várkonyi, Dávid Lancz, Balázs Szintai, Gabriella Tóth, Helga Tóth

Operational configurations

ALADIN/HU

- Model version: cy40t1 (ALARO-v1b physics)
- 8 km horizontal resolution, 49 vertical levels
- Local data assimilation:
  - 3D-Var in upper air, optimal interpolation at surface
  - 6-hour assimilation cycle
  - Short cut-off analysis for the production runs
  - Downscaled ensemble background error covariances
- Digital filter initialization
- 4 runs a day: at 00/06/12/18 UTC up to 60/48/60/36 h
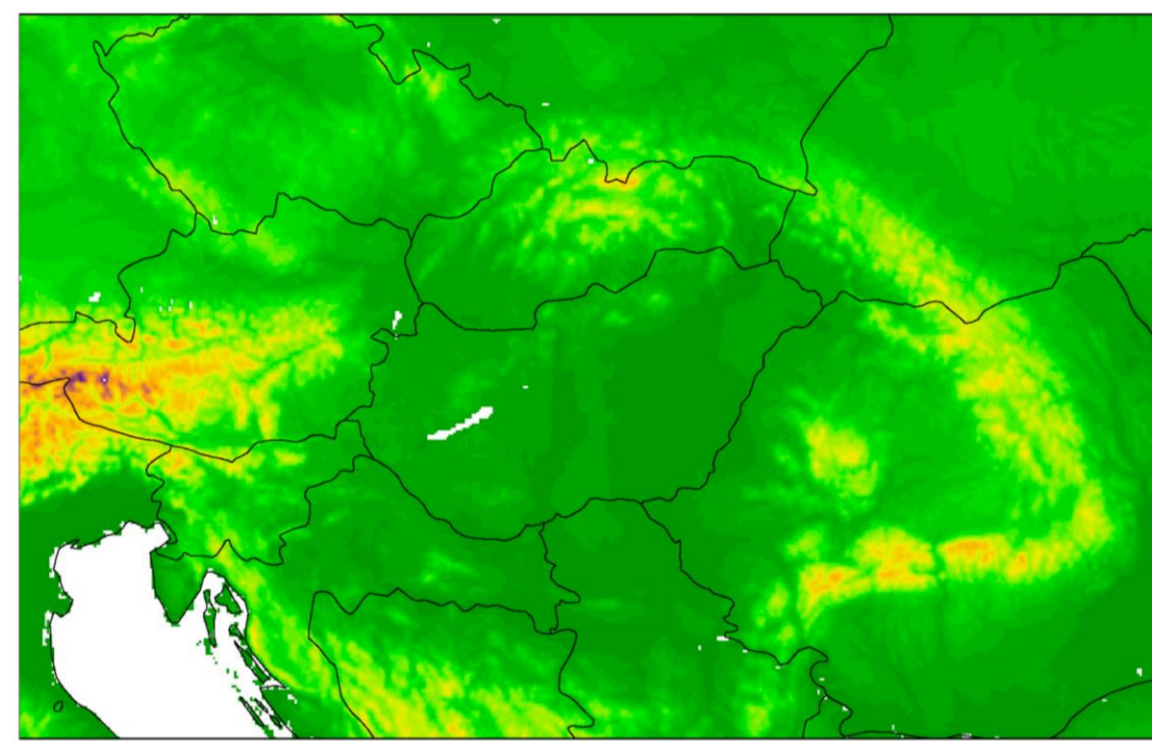- 3 hourly lateral boundary conditions from ECMWF-"HRES"
- Hourly outputs

ALADIN/HU model domain

Assimilated observations (via OPLACE)	
ALADIN/HU	AROME/HU
• SYNOP (u, v, T, RH, z)	• SYNOP (u, v, T, RH, z)
• SYNOP-SHIP (u, v, T, RH, z)	• TEMP (u, v, T, q)
• TEMP (u, v, T, q)	• AMDAR (u, v, T, q)
• AMDAR (u, v, T)	• Slovenian & Czech Mode-S
• ATOVS (AMSU, MHS radiances)	MRAR (u, v, T)
• MSG/GEOWIND (AMV)	• GNSS ZTD (IWV)
• MSG/SEVIRI (radiances)	• AMV, HRWIND (u, v)

AROME/HU

- Model version: cy43t2_bf11
- 2.5 km horizontal resolution, 60 vertical levels
- Local data assimilation:
  - 3D-Var in upper air, SEKF at surface
  - 3-hour assimilation cycle
  - Lake temperature initialized from measurements at Lake Balaton
  - Hydrometeors & snow cycled in assimilation
- Initialization: space-consistent coupling (no DFI)
- 8 runs a day: 00/06/12/18 UTC up to 48h;
  03/09/15/21 UTC up to 36h;
- LBCs from ECMWF-"HRES" with 1h coupling frequency
- SBL scheme over nature & sea to calculate the screen level variables
- Hourly outputs for forecasters, special outputs in every 15 minutes for commercial users & hail prevention system

AROME-EPS

- 11 ensemble members using AROME
- Local perturbations: 3 hourly ensemble data assimilation
- 2 forecast runs a day, at 0 and 12 UTC up to 48 hours
- Hourly LBCs from 18/6 UTC ECMWF-ENS
- Resolution, physics etc. as in AROME/HU

AROME/HU and AROME-EPS domain

Computer system

- HPE Apollo 6000 server
- 22 nodes x 2 CPU x 20 cores, 2.2 GHz Intel XeonE5-2698 processors
- 128 GB RAM/node
- IFS LBCs from ECMWF via Internet, backup ARPEGE LBCs from Météo-France

Testing assimilation of ASCAT soil moisture

The MetOp-B satellite carries the Advance SCATterometer (ASCAT) instrument passing over Europe twice a day, around 9 and 19 UTC. EUMETSAT produces near-real time soil moisture data based on it in the framework of the H-SAF collaboration. We used the H08 superficial soil moisture products available at 1 km horizontal resolution over Europe.

First we interpolated the raw data to the AROME/HU grid, then converted the percentage values to volumetric water content data. The satellite observations were calibrated using a CDF matching technique. In the test runs for May 2023 we used 3 hourly assimilation in the upper air, while several settings were tested on the surface with different values for observation and model errors.

| Experiments	REF	ECM	JFM	HYB
Surface observations	SYNOP T2M, HU2M	ASCAT SM	ASCAT SM	SYNOP T2M, HU2M ASCAT SM
Control variables	WG1, WG2, TG1, TG2	WG1, WG2	WG1, WG2	SYNOP: WG1, WG2, TG1, TG2 ASCAT: WG1, WG2
Observation errors	1 K, 7 %	0.05 m³/m³	0.06 m³/m³	SYNOP: 1K, 7 % ASCAT: 0.05 m³/m³
Model errors	0.1 m³/m³, 0.15 m³/m³, 2 K, 2 K	0.01 m³/m³, 0.01 m³/m³	0.06 m³/m³, 0.03 m³/m³	SYNOP: 0.1 m³/m³, 0.15 m³/m³, 2 K, 2 K ASCAT: 0.01 m³/m³
Surface analysis [UTC]	0, 3, 6, 9, 12, 15, 18, 21	9, 18, 21	9, 18, 21	SYNOP: 0, 3, 6, 12, 15 ASCAT: 9, 18, 21
Reference	-	de Rosnay et al., 2013 DOI:10.1002/qj.2023	Mahfouf, 2010 DOI:10.1002/qj.602	-

Large differences are detected in the soil moisture after 1 month between the runs containing SYNOP data and the ones assimilating only ASCAT data. There is a dry patch to the south of Hungary, especially in the **REF** and **HYB** experiments, while they produce much higher soil moisture values over East Hungary than the **ECM** and **JFM** runs using only ASCAT data.

Apart from the run with model errors adopted from **ECMWF**, 2m dewpoint is underestimated. Night temperature is overestimated by all runs.

WG2 soil moisture analysis [m³/m³] at 0 UTC on 31 May 2023
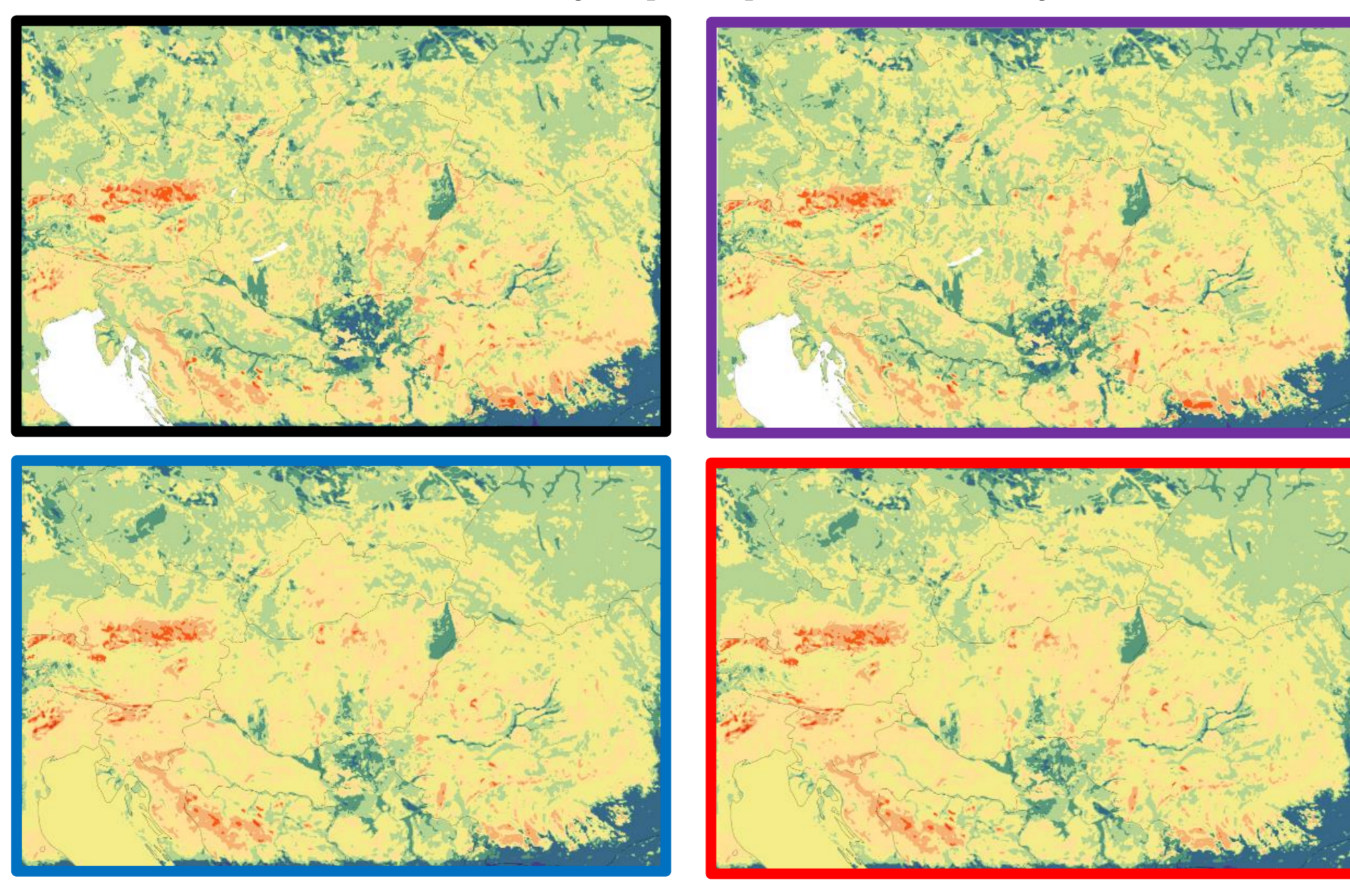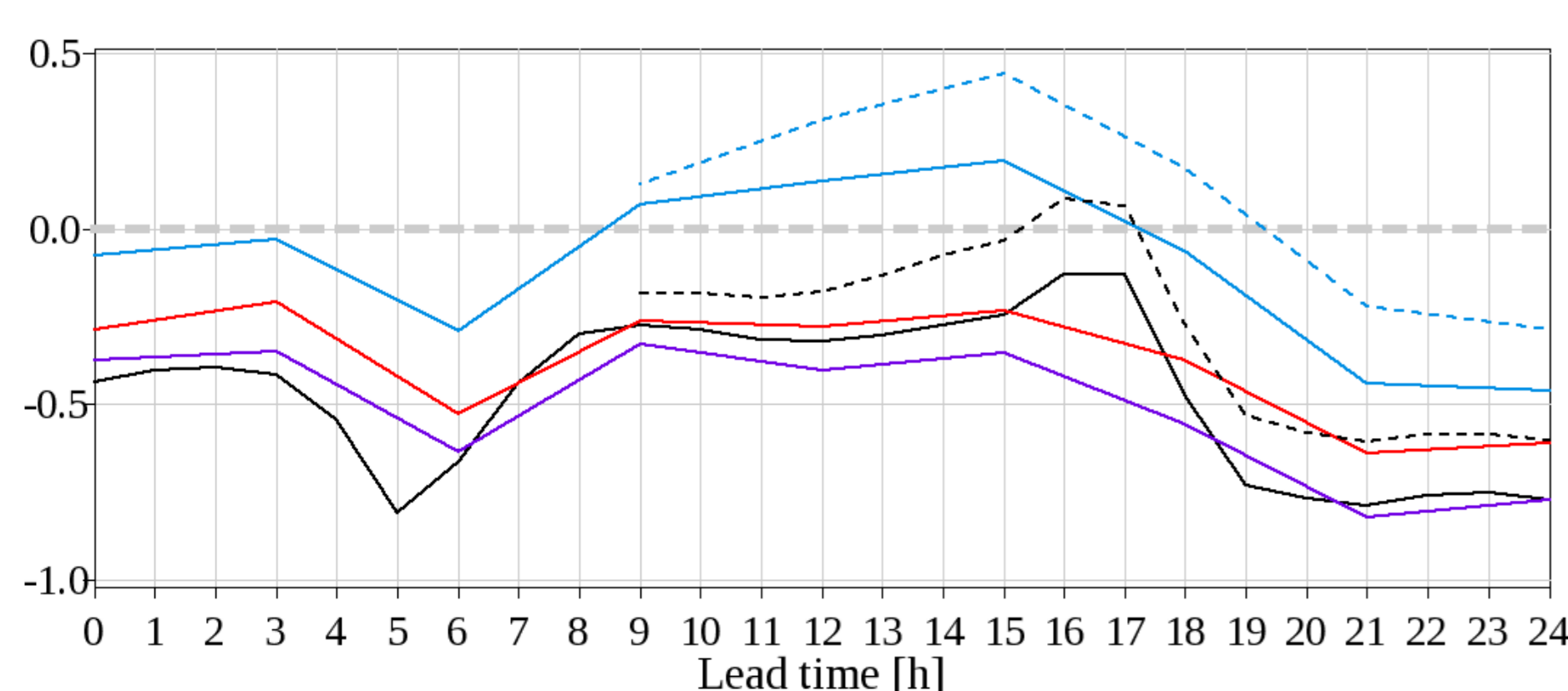
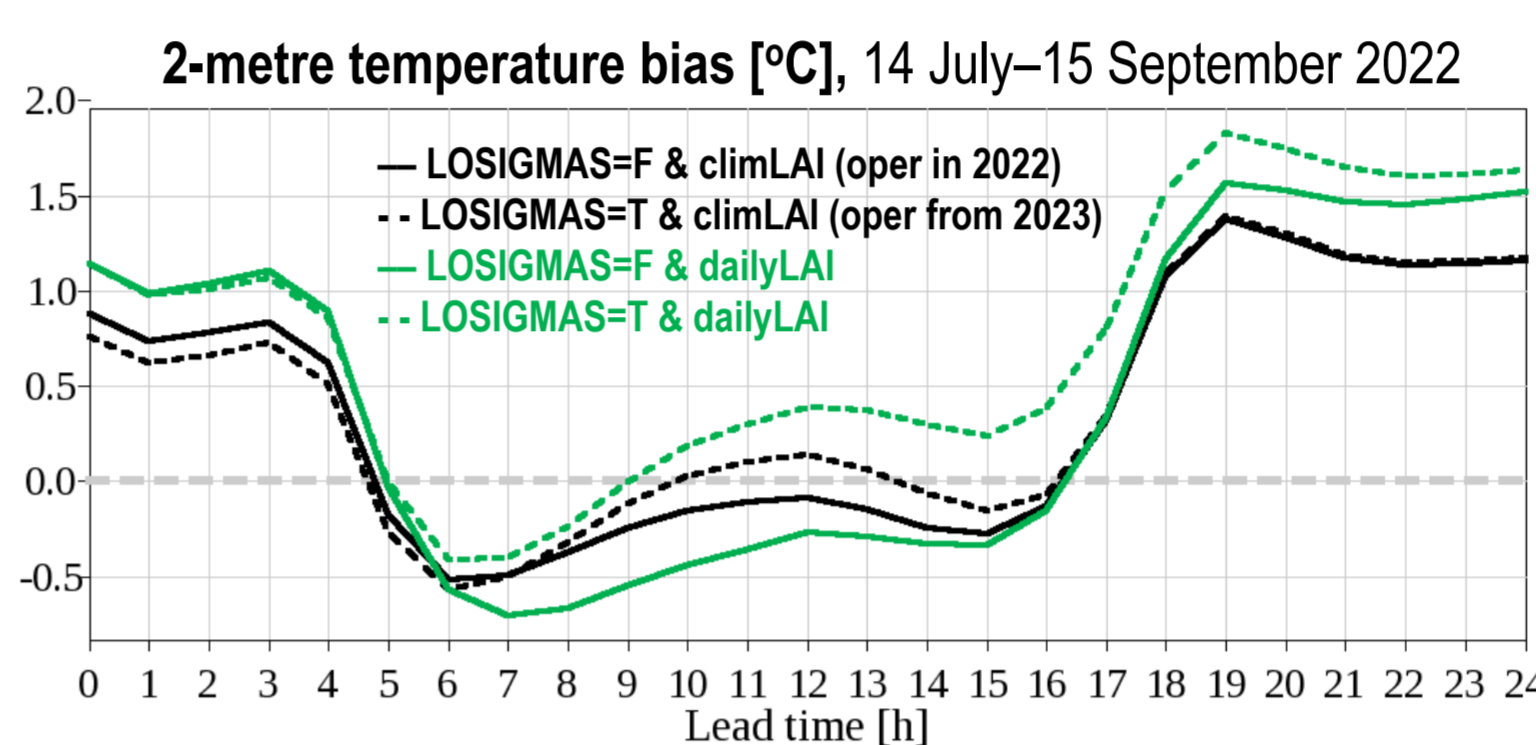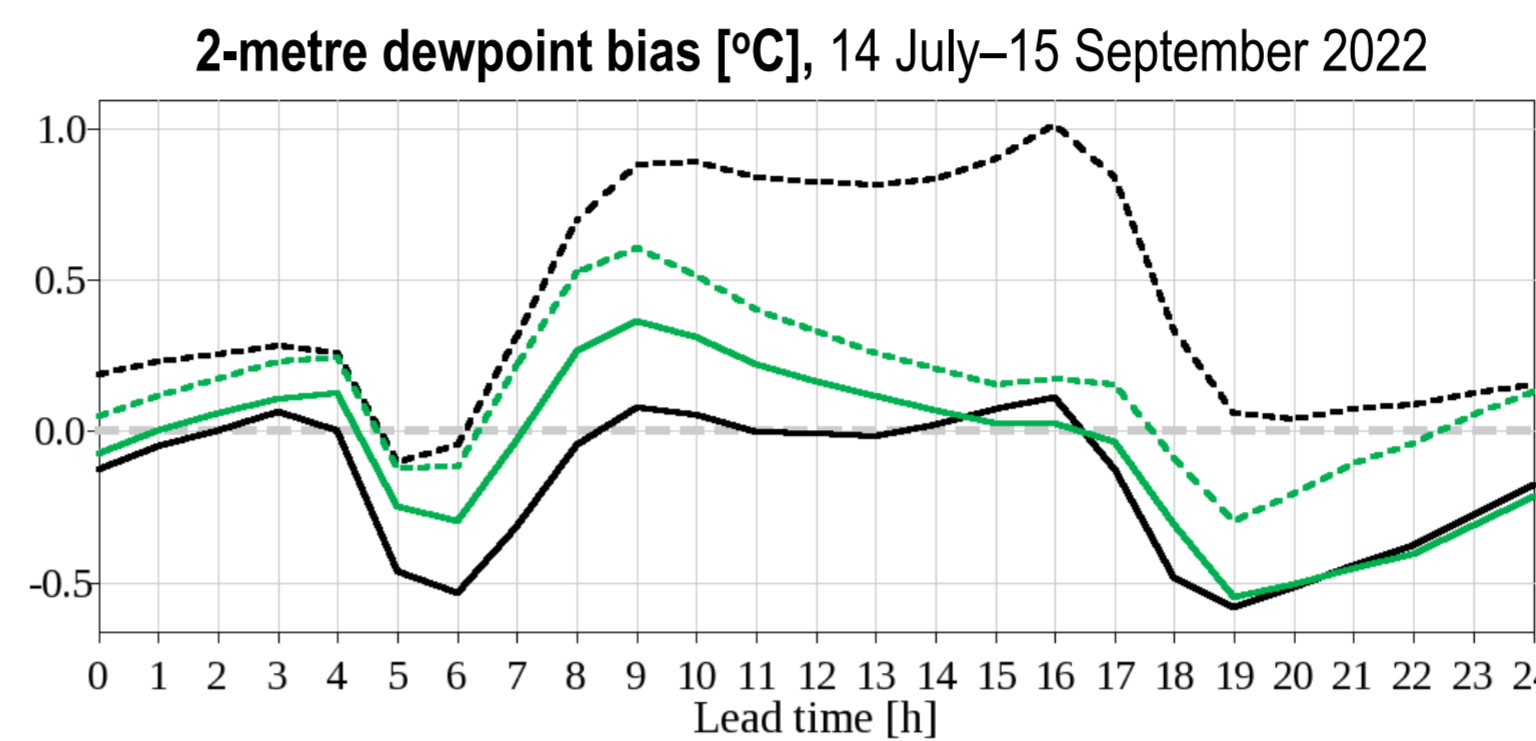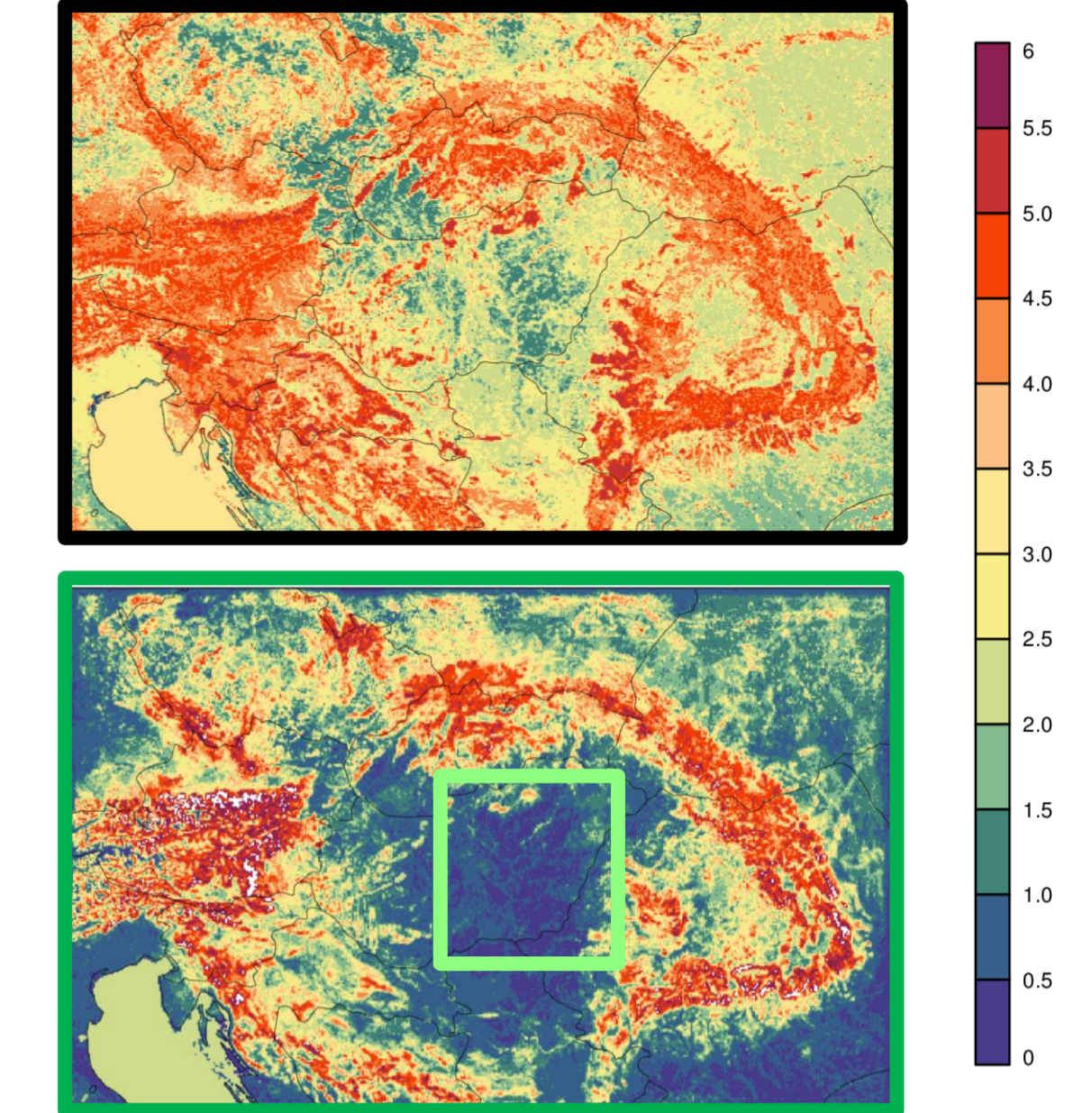**2-metre dewpoint bias [ºC]**
May 2023, 0 (–) and 9 (- -) UTC runs

The research continues with testing joint assimilation of SYNOP and ASCAT data (when both are available), tuning the model errors, moving to ASCAT H28 products.

Daily updated LAI using SURFEX ISBA-Ags

Daily update of leaf area index (LAI) is planned instead of the climatological LAI in AROME/HU. For this purpose, LAI values are computed by an offline SURFEX ISBA-Ags run applying the prognostic vegetation scheme and the LAI product of Copernicus Global Land Service (based on Sentinel-3 data) is assimilated with SEKF.

A severe drought occurred in summer 2022 leading to negative LAI anomalies in Hungary. Replacing the **climatological LAI** with **prognostic one** in 0 UTC AROME runs had an overall neutral impact, apart from 2 weeks and the eastern part of Hungary mostly affected by the drought.

Leaf area index [m²/m²] on 15 August 2022

2-metre dewpoint bias [ºC], 14 July–15 September 2022

2-metre temperature bias [ºC], 14 July–15 September 2022
- LOSIGMAS=F & climLAI (oper in 2022)
- LOSIGMAS=T & climLAI (oper from 2023)
- LOSIGMAS=T & dailyLAI
- LOSIGMAS=T & dailyLAI

In November 2023, the statistical cloud scheme was changed (from LOSIGMAS=F to T) in AROME/HU with considerable impact on cloud forecasts. The summer period in 2022 was recomputed with this set-up. A significant overestimation of the 2m dewpoint is seen for the **reference run**. This is explained by the increased surface radiation due to reduced cloud amount causing unrealistically high transpiration. **Daily LAI updates** (i.e. lower LAI values) improve the dewpoint error during daytime over East Hungary (**green** box). The impact is rather negative on 2m temperature.

Supervisor: Clemens Wastl

Implementation of SPP in AROME-EPS

To increase the ensemble spread further, we started to test the Stochastically Perturbed Parametrizations (SPP) scheme. SPP allows us to assess the model sensitivity on the individual physical parameters by perturbing them one-by-one. During the perturbation, a spatially and temporally varying 2-dimensional stochastic pattern field is used. In the local application, 100 km was chosen as spatial length scale, 0.5 as standard deviation of the random field, and 6 h as temporal scale in the pattern generator.

The first experiment was run from 1 to 14 December 2023 after 10 days of spin-up. 10 parameters were perturbed following the lognormal distribution. The operational value of the parameter was set to the mean or median of the perturbation. The unperturbed values of the parameters followed the suggestion of Météo-France (Wimmer et al., 2022), apart from the snow auto conversation threshold.

Parameter	CMPERT	Range
PSIGQSAT constant for subgrid condensation	0.4	[0, 0.1]
RSWINHF short-wave inhomogeneity factor	0.05	[0.6, 1]
RLWINHF long-wave inhomogeneity factor	0.04	[0.6, 1]
XCTP constant for temperature and vapour pressure correlations	0.3	[1.035, 22]
XCEP constant for wind-pressure correlations	0.2	[0.225, 4]
XCED constant for dissipation of TKE	0.2	[0.4, 2]
XCMF closure coefficient at the bottom level	0.1	[0, 0.1]
XFRACZ0 coefficient for the orographic drag	0.15	[2, 10]
RCRIAUTI (0.2*10⁻³ → 1*10⁻³) snow autoconversion threshold	0.2	[0.1* 10⁻³, 1.1* 10⁻³]
RCRIAUTC rain autoconversion threshold	0.02	[0.4* 10⁻³, 1*10⁻³]

SPP slightly increased the spread in all lead times, and it had neutral (10m wind) to positive (2m relative humidity, temperature) impact on CRPS and RMSE. No significant effect is detected in upper levels.
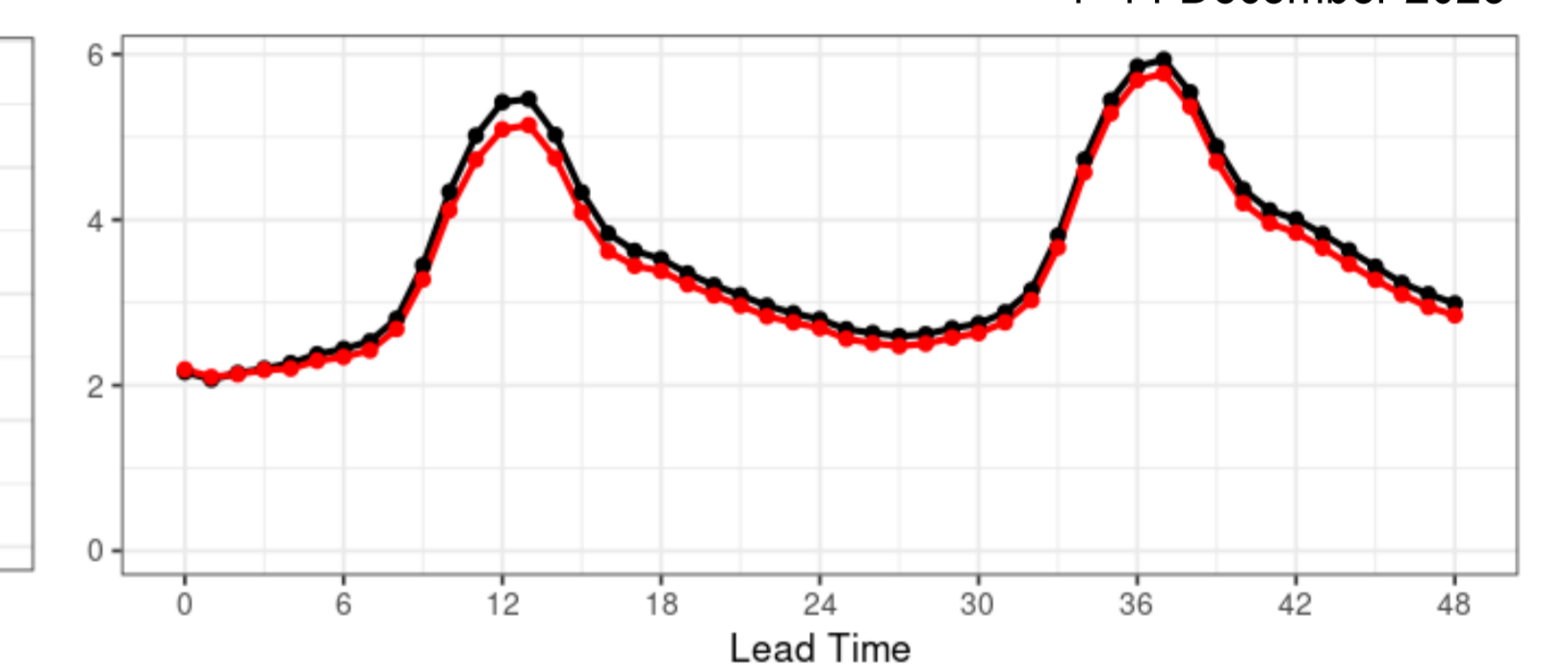
We will run experiments for 1-month summer period as well as add surface perturbations.

Spread & RMSE of 2-metre relative humidity forecasts [%]
0 UTC runs of AROME-EPS with/without SPP
1–14 December 2023
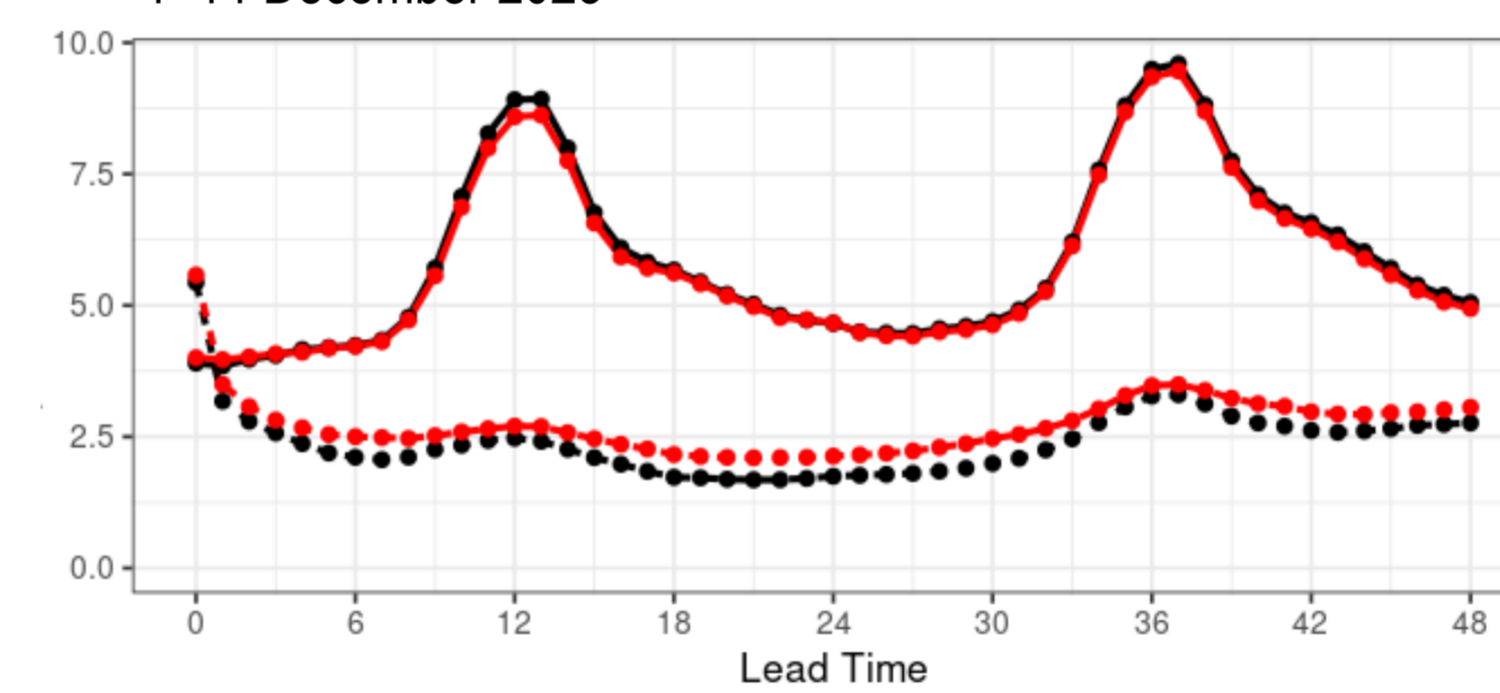
CRPS of 2-metre relative humidity forecasts [%]
0 UTC runs of AROME-EPS with/without SPP
1–14 December 2023

E-suite at 1.3kmL90 resolution and with hourly assimilation

In October 2023 we launched the first test-suite of AROME Rapid Update Cycle with hourly assimilation using 3D-Var and SEKF at 1.3 km horizontal resolution and 90 levels. 30 minutes after the nominal initial time we immediately start the assimilation procedure and then the forecast. The 12-hour forecasts run at 0, 3, 6, 9, 12, 15 and 18 UTC. After hour 1, the forecast can be delivered in real time. A long-cutoff assimilation cycle (providing first guess for the short-cutoff analysis in every 3 hours) is scheduled 2 hours after its nominal initial time.

Based on the first results, **hourly analysis updates together with high resolution** improve the overestimation of incoming surface solar radiation with respect to the 3 hourly cycled **operational AROME/HU**.
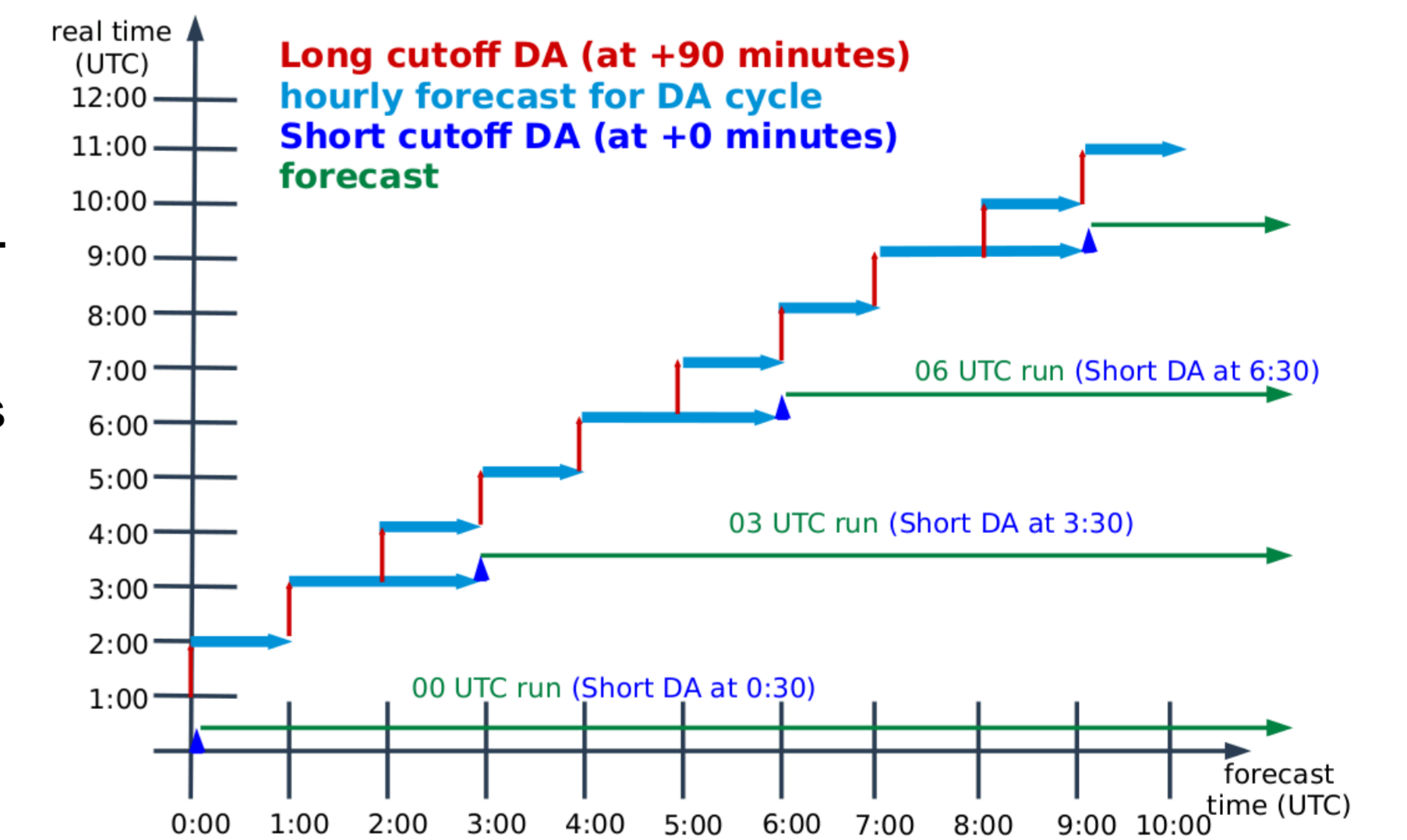
Due to its known overestimation, 10m wind gust is tuned based on FACRAF and HTKERAF parameters in the runs at **3, 9 and 15 UTC**. The tuning is overdamping the gust during daytime, so further adjustment is needed.

Radiation RMSE (–) and bias (- -) [W/m²]
From 13 December 2023 to 9 April 2024, 6 UTC runs
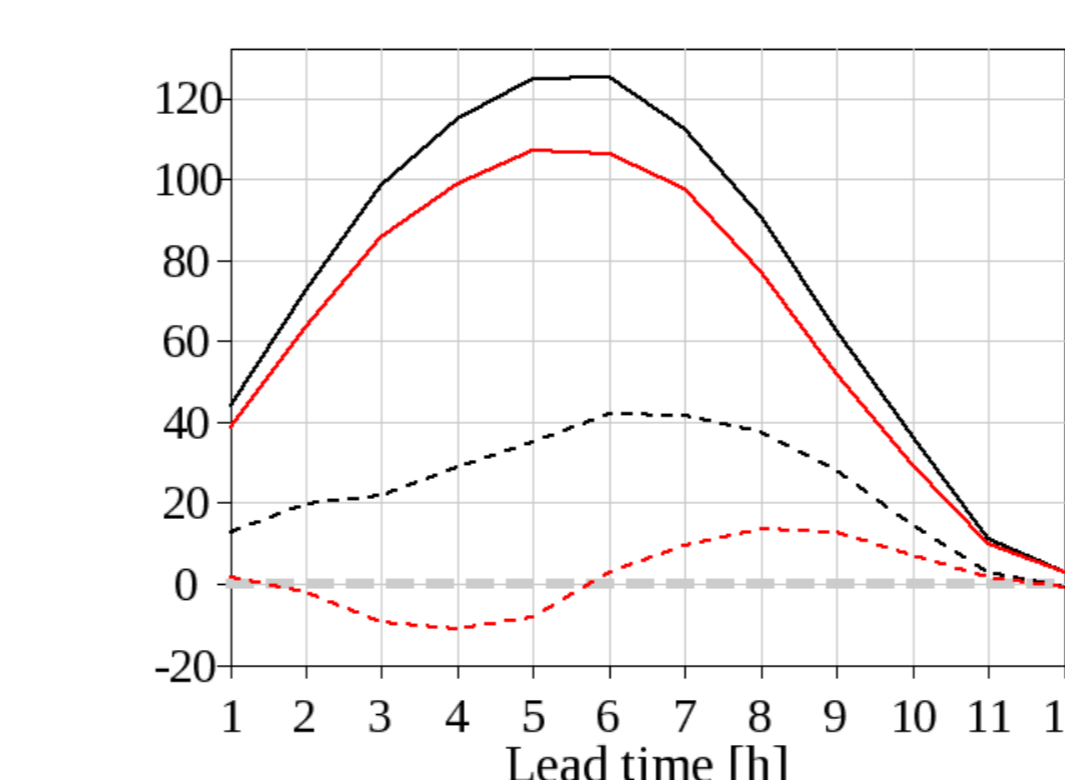
10-metre wind gust bias [m/s]
From 13 December 2023 to 9 April 2024; 0,0,3,6,9,12,15 UTC runs