

*Regional Cooperation for  
Limited Area Modeling in Central Europe*



# NWP developments in Hungary in 2024

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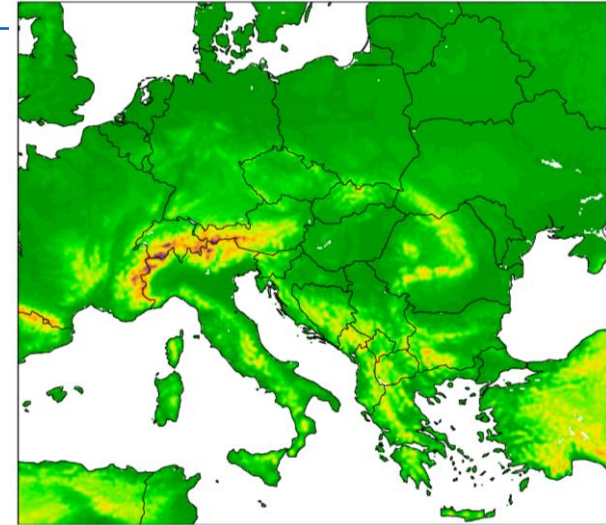
ARSO METEO  
Slovenia

- ▶ Status of operational DA systems
- ▶ AROME DA with additional national SYNOP observations
- ▶ GNSS ZTD assimilation in fine resolution AROME
- ▶ Testing assimilation of ASCAT soil moisture in AROME surface DA
- ▶ Mode-S EHS assimilation in AROME
- ▶ AROME EDA SPP
- ▶ HIRLAM obsmonitor
- ▶ Implementation of CY46T1
- ▶ Future plans

# Operational NWP and DA systems

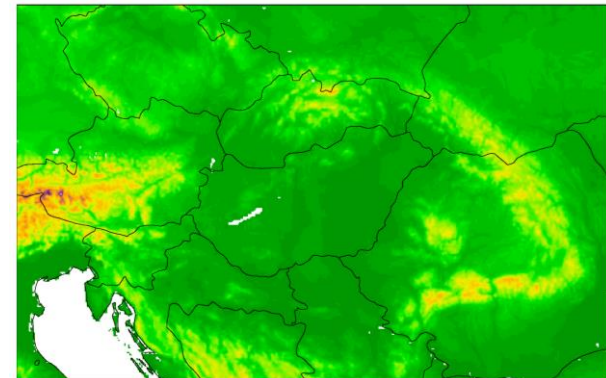
## ▶ ALARO

- ▶ 8 km horizontal resolution/49 vertical levels
- ▶ 300 s timestep
- ▶ cy40t1\_bf05
- ▶ ECFLOW environment
- ▶ 4 runs/day up to 60/48/60/36 hours
- ▶ Coupled to ECMWF HRES
  - ▶ 3-hourly frequency
  - ▶ Time-lagged coupling for forecast
  - ▶ Direct coupling for DA cycle



## ▶ AROME

- ▶ 2.5 km horizontal resolution/60 vertical levels
- ▶ 60 s timestep
- ▶ cy43t2\_bf11
- ▶ ECFLOW environment
- ▶ 8 runs/day up to 48/36 hours
- ▶ Coupled to ECMWF HRES
  - ▶ 1-hourly frequency
  - ▶ Time-lagged coupling for forecast
  - ▶ Mixed coupling in DA cycle



## ▶ **ALARO**

- ▶ With digital filter initialization
- ▶ 3DVAR + CANARI
- ▶ 6-hour DA cycle
- ▶ Observations: SYNOP, AMDAR, TEMP, SEVIRI, Geowind AMV, NOAA-18 AMSU-A, MHS
- ▶ Static ALADIN EDA B-matrix

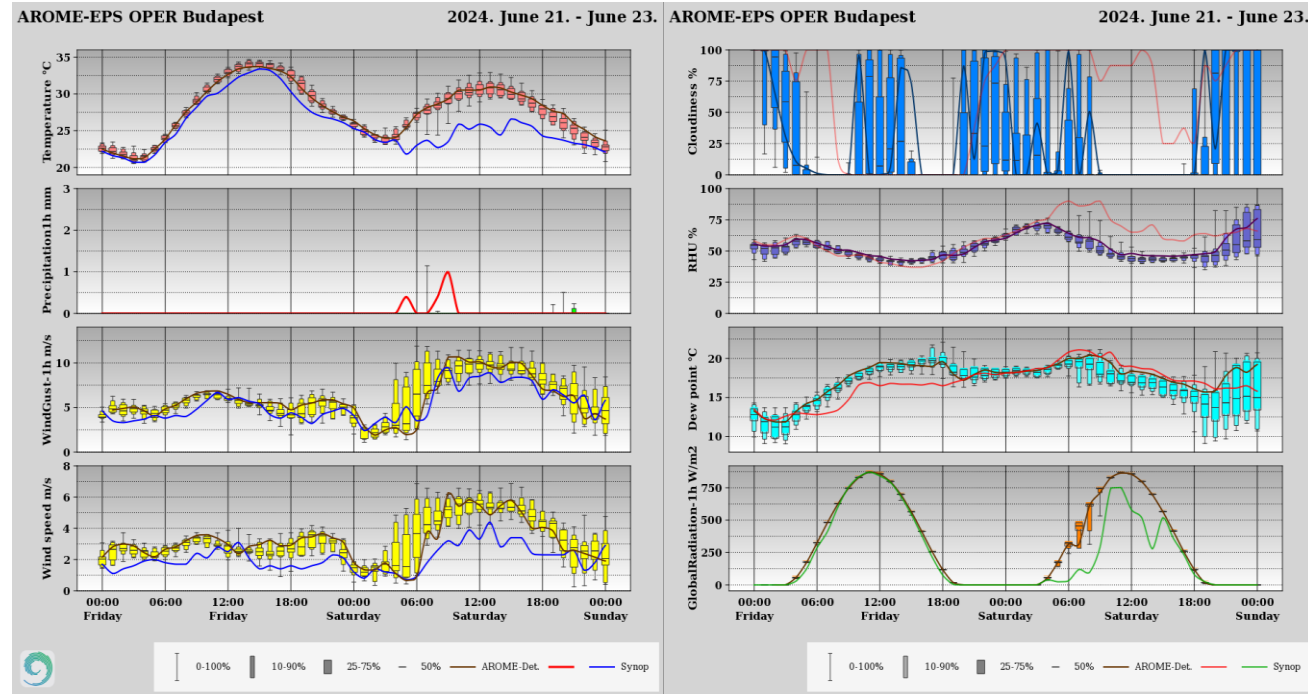
## ▶ **AROME**

- ▶ Without digital filter initialization
- ▶ 3DVAR + SEKF
- ▶ 3-hour DA cycle
- ▶ Observations: SYNOP, AMDAR, TEMP, GNSS-ZTD, Slovenian and Czech Mode-S MRAR, AMV and HRWind
- ▶ Static AROME EDA B-matrix

# Operational NWP and DA systems

## ▶ AROME-EPS EDA

- ▶ 11 members
- ▶ 2.5 km horizontal resolution
- ▶ 60 vertical levels
- ▶ cy43t2\_bf11
- ▶ 2 runs/day up to 48 hours (00 and 12 UTC)
- ▶ Coupled to ECMWF ENS (first 10 members + control member)
  - ▶ 1-hourly frequency
- ▶ Initial condition: 3DVAR + SEKF
- ▶ 3-hour DA cycle (same obs. as in AROME)



- ▶ 1.3 km horizontal resolution / 90 vertical levels
- ▶ 50 s timestep
- ▶ cy43t2\_bf11
- ▶ ~ same domain as oper. AROME
- ▶ 8 runs/day up to 12 hours (from 27/08/2024: 00 UTC + 30 h, 06 UTC + 24h)
- ▶ Coupled to ECMWF HRES
  - ▶ 1-hourly frequency
  - ▶ Time-lagged coupling for forecast
  - ▶ Mixed coupling in DA cycle
- ▶ 3DVAR + SEKF
- ▶ 1-hour DA cycle, 30 min cut-off
- ▶ Observations: SYNOP, AMDAR, TEMP, GNSS-ZTD, Slovenian and Czech Mode-S MRAR, AMV and HRWind
- ▶ Static AROME EDA B-matrix

# AROME DA with additional national SYNOP observation

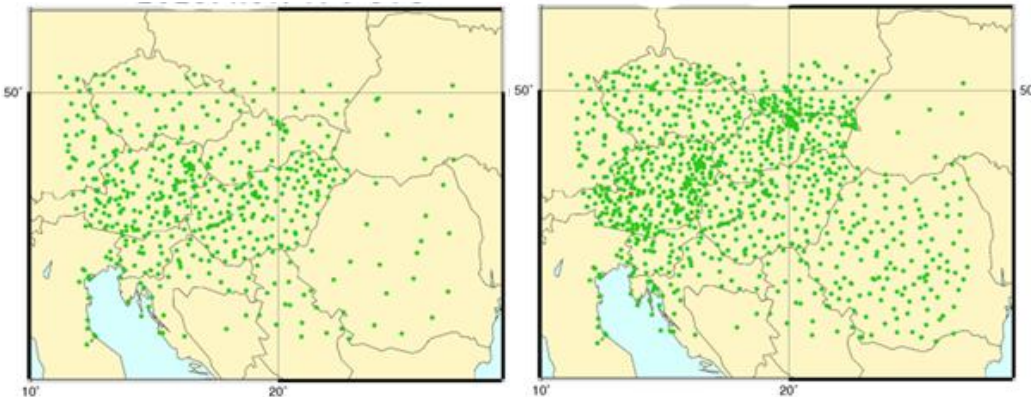
- ▶ OPLACE obsoul format, SYNOP neighbouring countries:
  - ▶ Romania, Slovakia, the Czech Republic, Austria, Croatia and Slovenia

- ▶ Experiments for May and November, 2023 (1-week spin-up)

- ▶ **REF**
- ▶ **EXP1** (add. SYNOP)
- ▶ **EXP2** (add. SYNOP + REF\_A\_H2= REF\_A\_T2 = 40000, *Bučánek, 2020*)

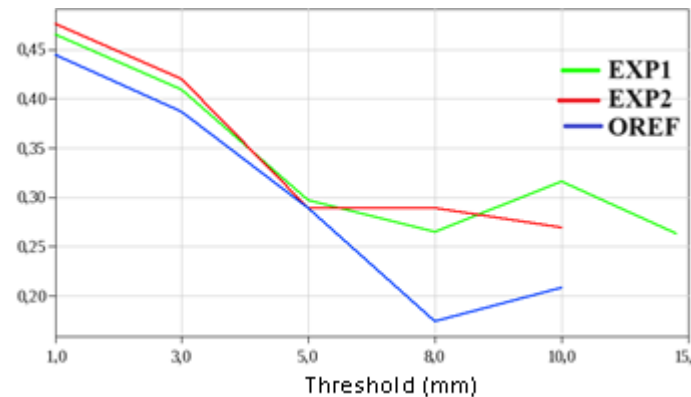
- ▶ Neutral scores, minor improvements

**EDS** of 3-hour precipitation for +15-18 forecast hours for May, 2023



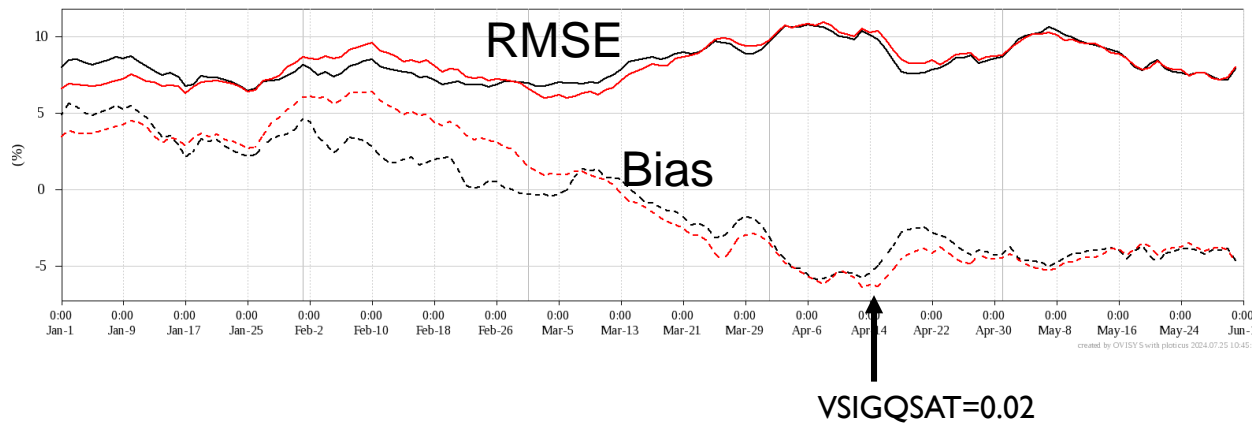
SYNOP reports used by Operational AROME

Additional SYNOP reports





- ▶ Bugfix in **PREGPSSOL**: 1-hourly cycling should be added
- ▶ Used in fine resolution e-suite from 16th of January, 2024 (same whitelist as in AROME-OPER)



Verification of 2 meter relative humidity analyses for the time period 01/01/2024 – 31/05/2024  
**AROME-OPER** 2.5 km,  
**AROME-RUC** 1.3 km run.

- ⇒ Both models overestimated Rh2m for winter.
- ⇒ The overestimation subsided in spring, and even turned into an underestimation.



▶ New whitelist for the e-suite (OLD + GOP1)

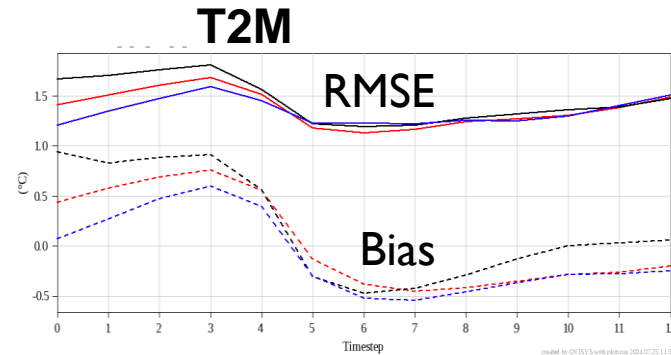
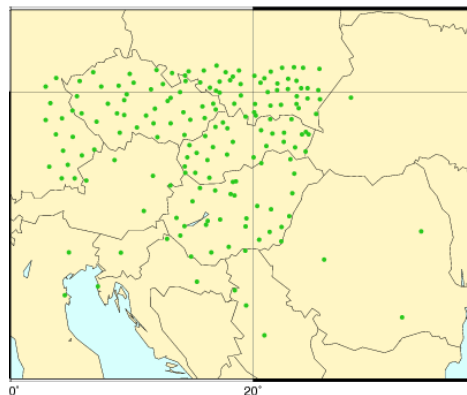
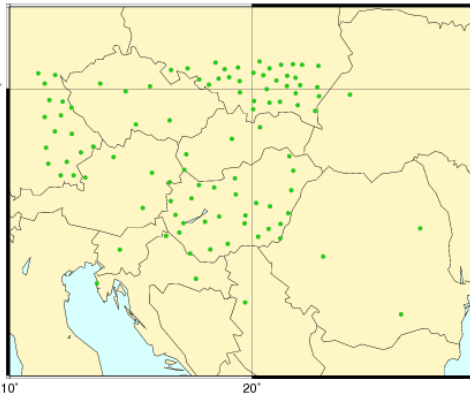
▶ Experiment: 1-15 May, 2024

**DA: ALD/3DVAR Exp: OPEG**  
 Date: 2024.05.01. HH: 09 UTC  
 Obs: Synop Var: ZTD (100) **OLD**

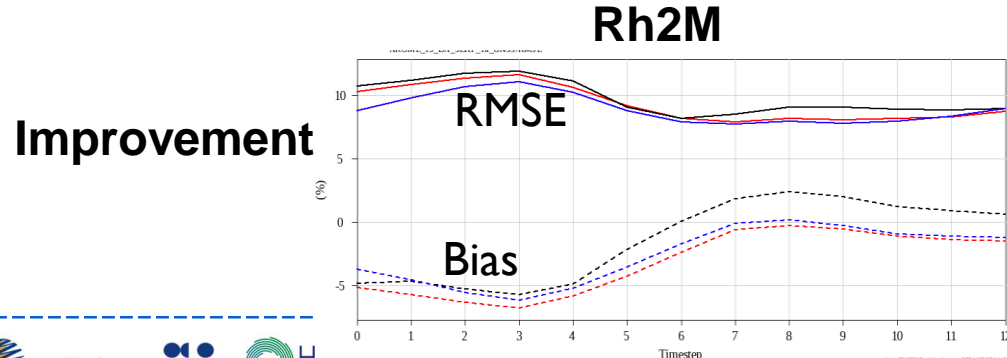
● Active (100) ● Passive(0) ● Rejected (0) ● Blacklisted (0)

**DA: ALD/3DVAR Exp: RUGN**  
 Date: 2024.05.01. HH: 09 UTC  
 Obs: Synop Var: ZTD (172) **NEW**

● Active (172) ● Passive(0) ● Rejected (0) ● Blacklisted (0)



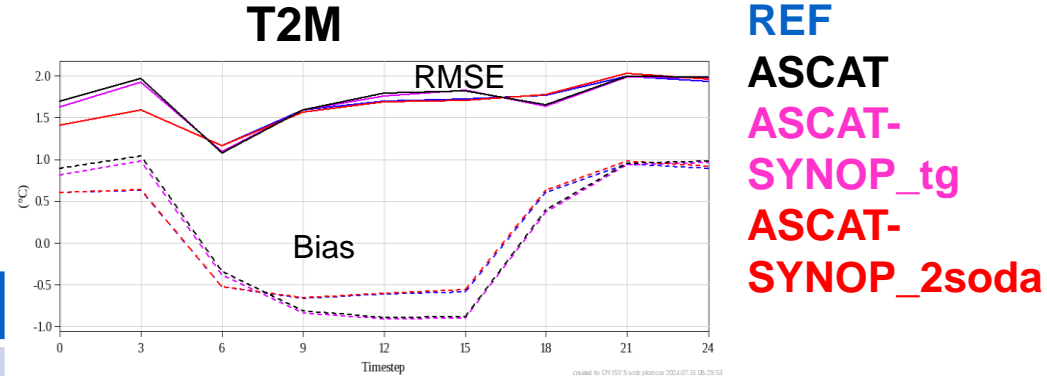
- AROME-OPER 2.5
- AROME-RUC 1.3
- AROME-RUC 1.3 km with using new whitelist.



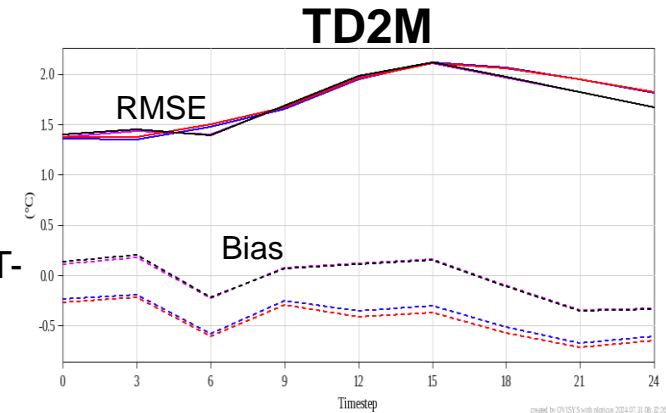
# ASCAT soil moisture in AROME surface DA

- ▶ ASCAT H08 Level-2 Soil Moisture, 1 km res.
- ▶ Exp: 1-31 May, 2023 with a 1-week spin-up

Experiments	REF ("OPER")	ASCAT	ASCAT-SYNOP_tg	ASCAT-SYNOP_2soda
Observations	SYNOPSIS T2M, HU2M	ASCAT SM	ASCAT SM + SYNOPSIS T2M HU2M	ASCAT SM + SYNOPSIS T2M HU2M
Control variables	WG1, WG2, TGI, TG2	WG1, WG2	WG1, WG2, TGI, TG2	WG1, WG2, TGI, TG2, SODA1: T2M: 1K, HU2M: 7% SODA2: ASCAT: 0.05 m <sup>3</sup> /m <sup>3</sup> ,
Observation errors	1K, 7%	0.05 m <sup>3</sup> /m <sup>3</sup>	ASCAT: 0.05 m <sup>3</sup> /m <sup>3</sup> , T2M: 1K, HU2M: 7%	
Model errors	0.1 m <sup>3</sup> /m <sup>3</sup> , 0.15 m <sup>3</sup> /m <sup>3</sup> , 2K, 2K	0.01 m <sup>3</sup> /m <sup>3</sup> , 0.01 m <sup>3</sup> /m <sup>3</sup>	0.01 m <sup>3</sup> /m <sup>3</sup> (WG1 & WG2), 0.2 K (TGI & TG2)	SODA1: 0.1 and 0.15 m <sup>3</sup> /m <sup>3</sup> (WG1 & WG2), 2 K (TGI & TG2) SODA2: 0.01 m <sup>3</sup> /m <sup>3</sup> (WG1 & WG2), 0.2 K (TGI & TG2)
Analyses (UTC)	00, 03, 06, 09, 12, 15, 18, 21	09, 18, 21	00, 03, 06, 09, 12, 15, 18, 21	00, 03, 06, 09, 12, 15, 18, 21
Forecast	00 UTC + 24h	00 UTC + 24h	00 UTC + 24h	00 UTC + 24h



- REF ~ ASCAT-SYNOP\_2soda (SODA2 has no impact?)  
 - ASCAT ~ ASCAT-SYNOP\_tg (SYNOPSIS has no added value?)



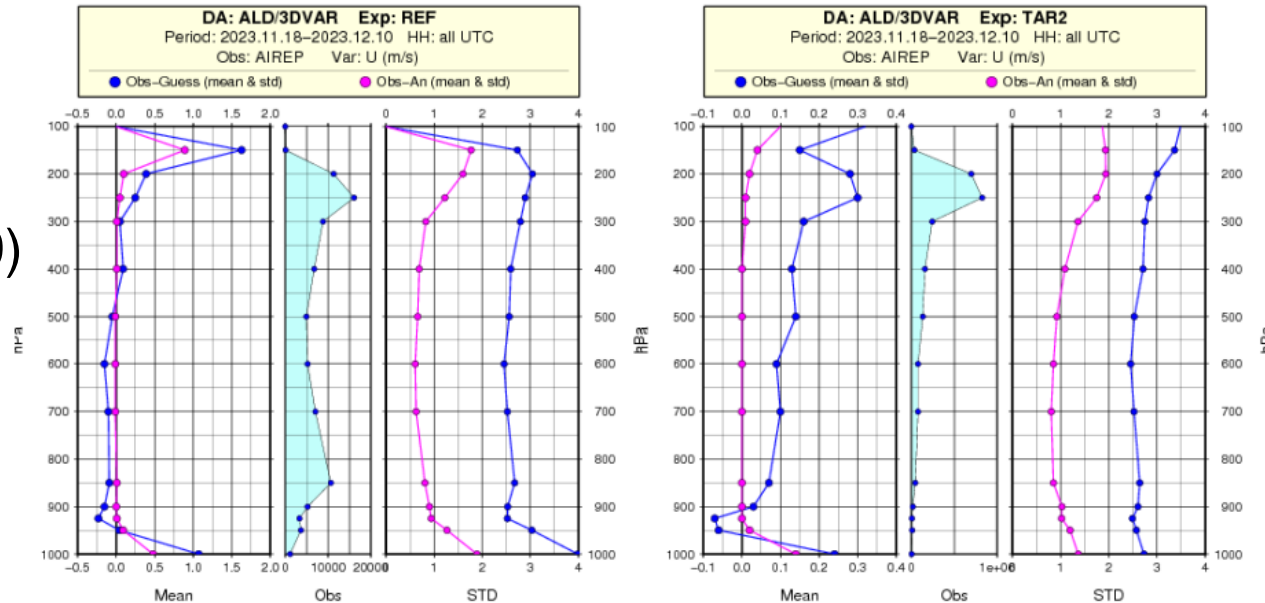
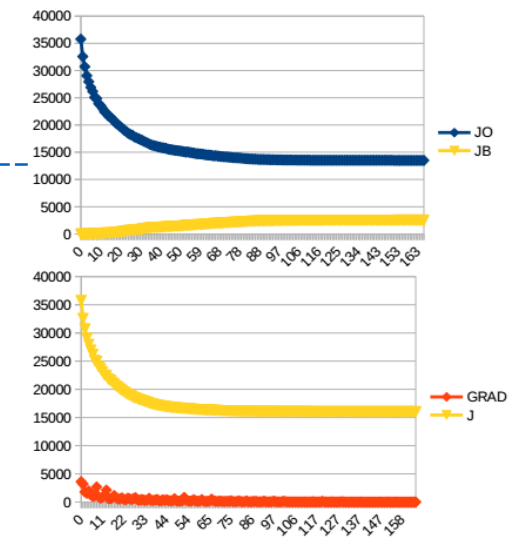
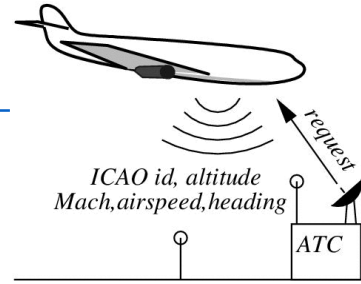
**No improvement 😞**

# Mode-S EHS (2.5 km)

- ▶ EMADDC v2.2 data from OPLACE in BUFR
- ▶ FAST observation data (5 min)
- ▶ experiments in winter and summer periods
- ▶ pre-thinning python script from Siebren de Haan

(boxthinning: --box\_heights 300,300,600,1000 --box\_width 40)

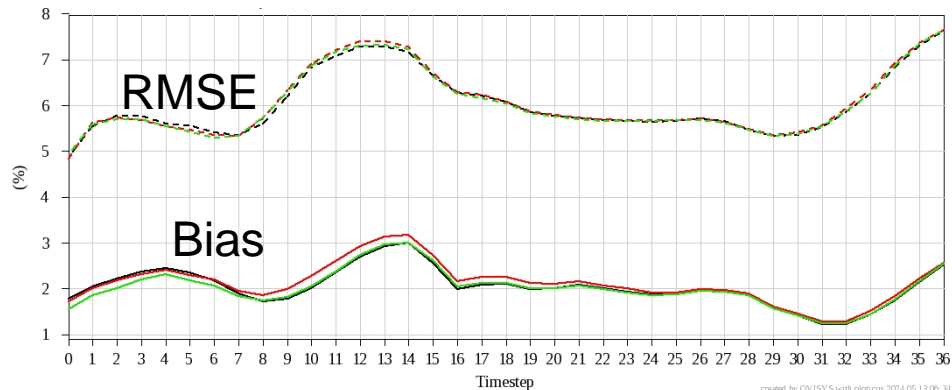
- ▶ SIGMAO\_COEF(2)=2.8 (0.9)
- ▶ NITER=200 (60)
- ▶ NSIMU=210 (70)



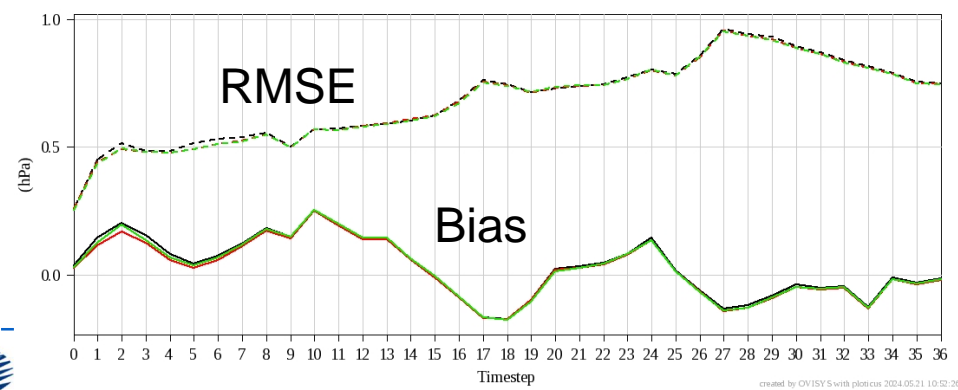
# Mode-S EHS (2.5 km)

- ▶ EMADDC v2.2 data from OPLACE in BUFR, FAST observations (5 min)
- ▶ winter period: 27/11/2023 – 10/12/2023
- ▶ pre-thinning python script from Siebren de Haan  
(boxthinning: --box\_heights 300,300,600,1000 --box\_width 40)
- ▶ **EXP1**: SIGMAO\_COEF(2)=0.9 (default)
- ▶ **EXP2**: SIGMAO\_COEF(2)=2.8

relative humidity(2m)



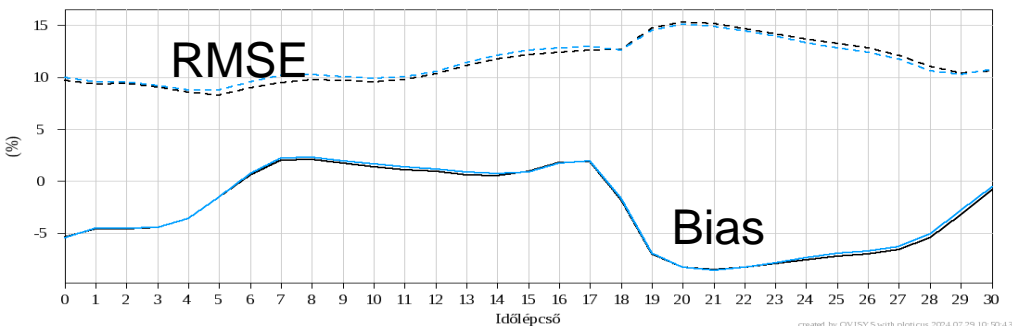
mean sea level pressure



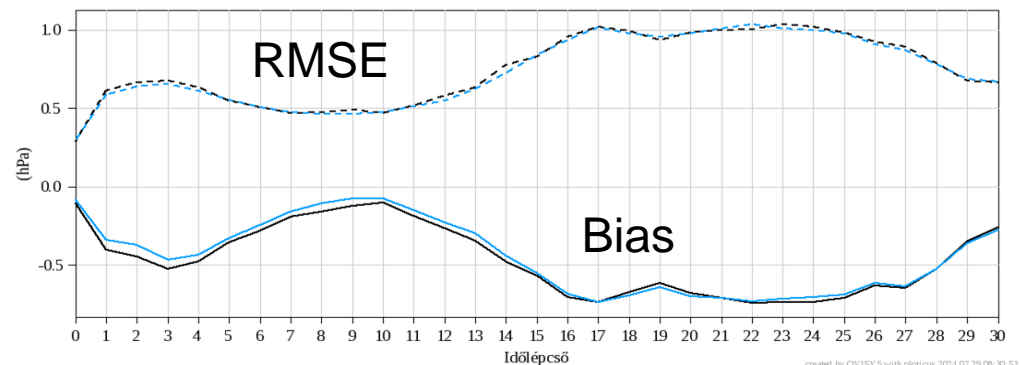
# Mode-S EHS (2.5 km)

- ▶ summer period: 01/06/2024 –30/06/2024
- ▶ **REF:** SIGMAO\_COEF(2)=0.9 (default)
- ▶ **EXP2:** SIGMAO\_COEF(2)=2.8

relative humidity(2m)

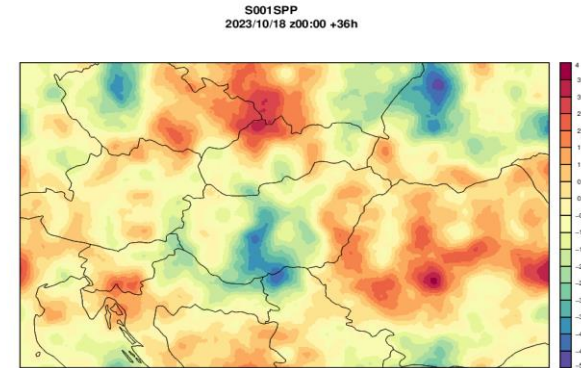


mean sea level pressure



# Stochastically Perturbed Parametrizations in AROME-EPS

- ▶ EDA: operational since 2023, improves the initial condition
- ▶ Goal: improving the spread in the later forecast hours
- ▶ 10 perturbed parameters:



Temporally- and spatially variable stochastic pattern

Radiance	Turbulence	Convection	Subgrid orography	Microphisycs
RSWINHF	XCTP	XCMF	XFRACZ0	PSIGQSAT
RLWINHF	XCEP			RCRIAUTI
	XCED			RCRIAUTC

# Stochastically Perturbed Parametrizations in AROME-EPS

## ▶ Winter-time experiment:

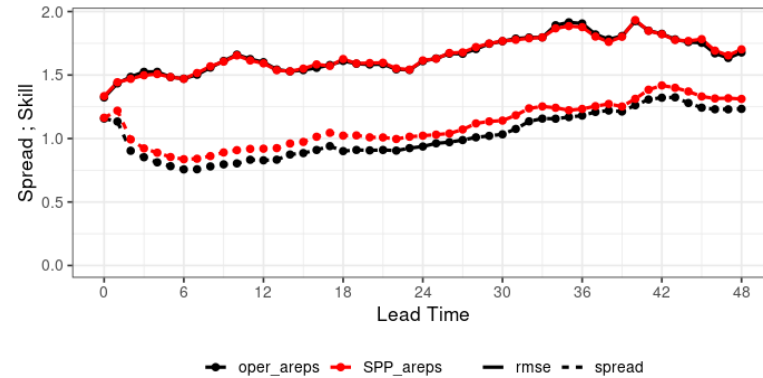
- ▶ **01-14.12.2023. (14 days)**
- ▶ Increase the spread in the surface and in the upper air variables

## ▶ Summer-time experiment

- ▶ **15.07.2023 – 15.08.2023. (30 days)**
- ▶ Less impact in the summer-time experiment, but improves the spread in general

Spread skill 01.12.2023 - 14.12.2023

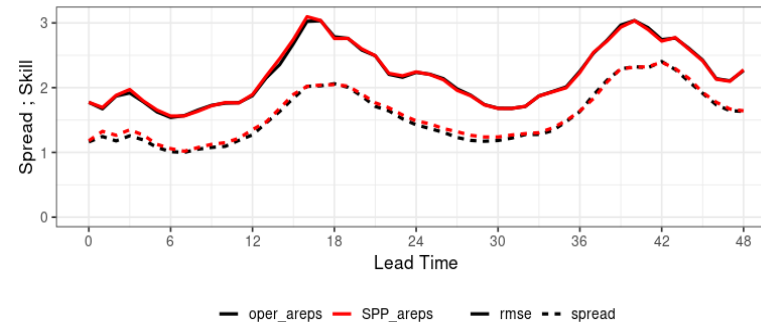
142 stations



Verification for windGust

Spread skill 15.07.2023 - 15.08.2023

142 stations

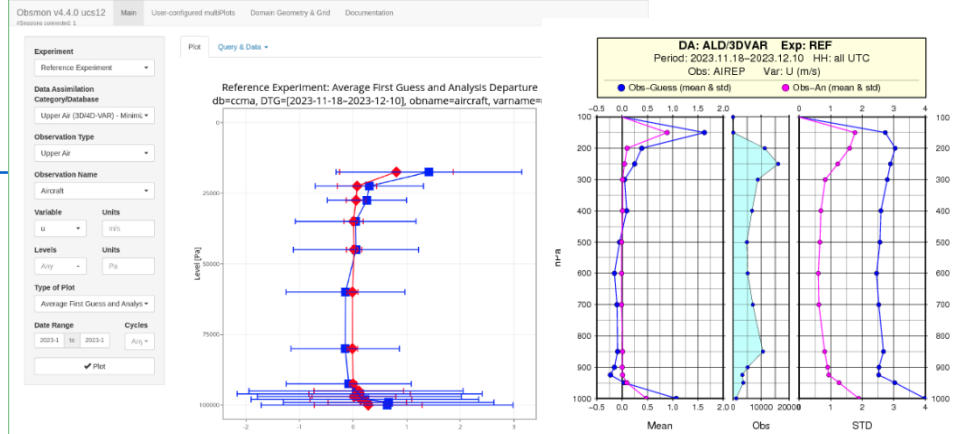


Verification for windGust



# HIRLAM obsmonitor

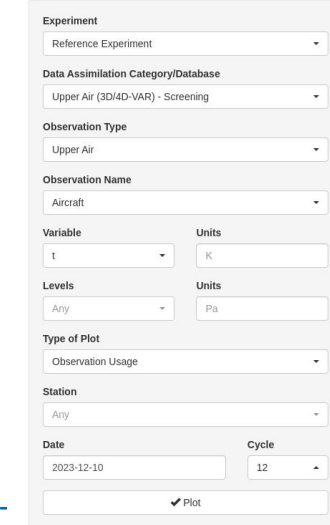
- ▶ installing the back-end and the front-end
- ▶ lots of interactive possibilities
- ▶ no statistical tables
- ▶ different appearance



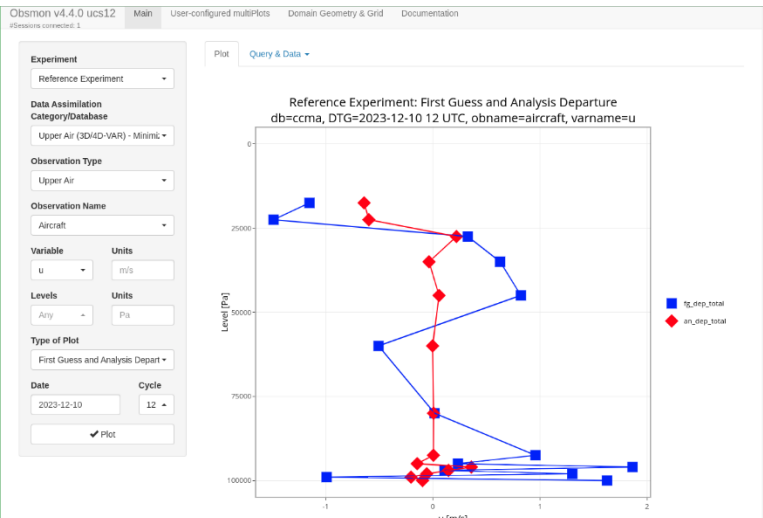
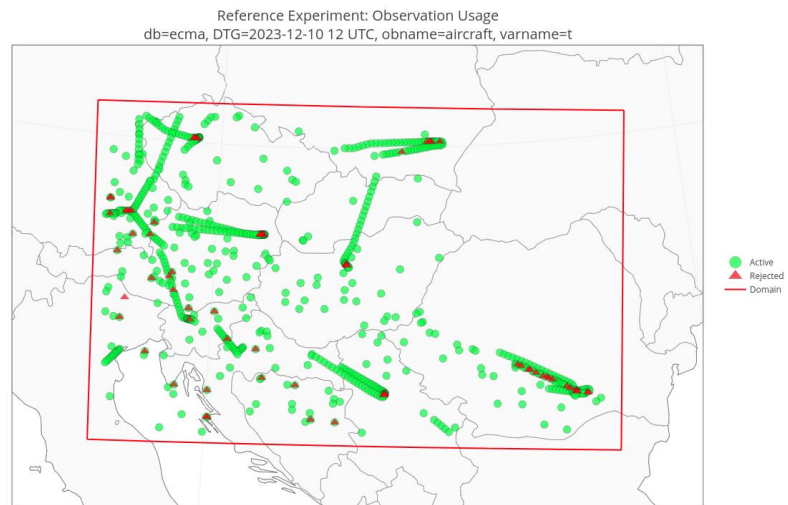
**AIREP**

Var	Total	Active	Pass	Reject	Black	O-G Mean	O-A Mean	O-G STD	O-A STD
Report	1311	1205	0	106	0	---	---	---	---
T	1311	1202	0	108	1	-0.09	-0.02	0.80	0.38
U	1311	1205	0	105	1	-0.10	-0.02	1.97	0.84
V	1311	1205	0	105	1	0.38	0.05	1.98	0.84

Obsmon v4.4.0 ucs12 Main User-configured multiPlots Domain Geometry & Grid Documentation #Sessions connected: 1



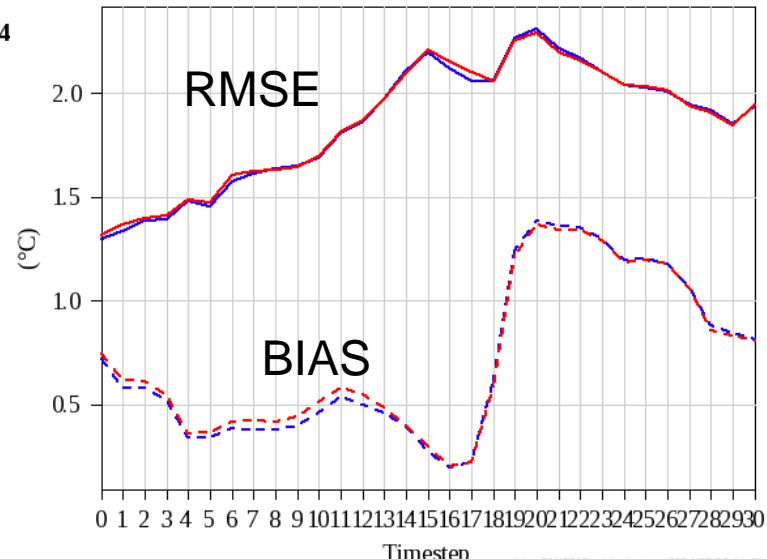
Plot Map Query & Data



# CY46 verification

Period: 06/01/2024 - 06/30/2024  
 Area: AROME\_max\_400m  
 Variable: Temperature (2m)  
 Runhour: 00

Legend (Model/S core)  
 — AROME\_CY46/RMSE  
 - - AROME\_CY46/BIAS  
 — AROME\_202406/RMSE  
 - - AROME\_202406/BIAS



**CY43**  
**CY46**

▶ The differences between **CY43** and **CY46** are **very small**

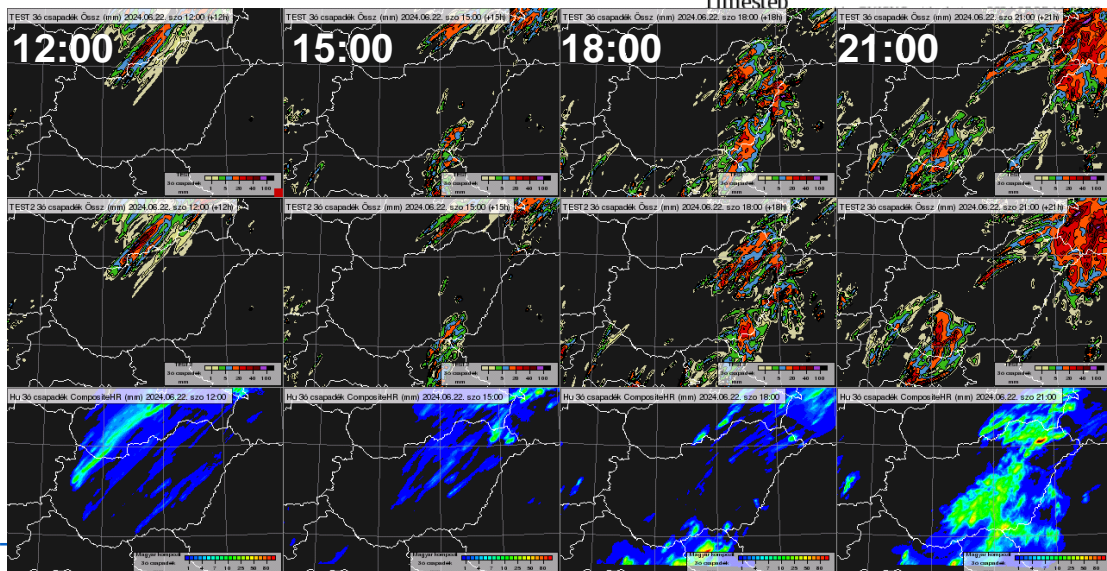
▶ Two time periods were examined: winter (06/01/2024 – 11/02/2024) and summer (june, 2024). In winter the diff. are even smaller

▶ In case studies the prec. fields are almost identical (e.g. 22/06/2024)

**CY46**  
 3h prec.

**CY43**  
 3h prec.

**RADAR**  
 3h prec.



- ▶ National SYNOP assimilation
  - ▶ Operational implementation after some tests (modification in 3DVAR settings besides CANARI?)
- ▶ GNSS assimilation
  - ▶ New center: BMEL (new whitelist)
  - ▶ Change to use BUFR instead of obsoul (ASCII)
- ▶ Mode-S assimilation
  - ▶ Tests with different thinning options
- ▶ ASCAT SM assimilation
  - ▶ CDF matching for longer period (2018-2023)
  - ▶ Further tuning of DA settings (observation errors, model errors)
  - ▶ ASCAT H28 instead of H08
- ▶ CY46 operational in February, 2025
- ▶ SPP
  - ▶ Single precision
  - ▶ Operational introduction in Q2-3, 2025

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Limited Area Modeling in Central Europe*



**Thank you for your attention.**

