NWP related activities in AUSTRIA

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GeoSphere Austria

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1. Operational NWP systems at GeoSphere

All NWP systems (AROME-Aut, C-LAEF, AROME-RUC) operated by GeoSphere Austria (formerly ZAMG) are currently based on AROME. Since 2019, C-LAEF has been running on the same resolution as AROME-Aut (2.5km/L90). The C-LAEF control run and AROME-Aut are running with an identical setup on two different HPC platforms, such that the C-LAEF control run can be used as a backup for AROME-Aut, if necessary.

	AROME-Aut/C-LAEF ctrl	C-LAEF	AROME-RUC
Model version	cy43t2bf11	cy43t2bf11	cy43t2bf11
Resolution	2.5km	2.5km	1.2km
Area / centered over	600x432 / Alpine region	600x432 / Alpine region	900x576 / Austria
Members	1	16 + 1	1
Levels (lowest/highest)	90 (5m / 35km)	90 (5m / 35km)	90 (5m / 35km)
Starting times	00, 03, … 21 UTC	00, 03, … 21 UTC	00, 01,…,22,23 UTC
Forecast range	60 hours	60 hours (00 and 12), 3 h	12 hours
Time step	60s	60s	30s
Output Frequency	1h 2D/3D	1h 2D/3D	15min 2D/1h 3D
Orography / physiography	GMTED2010 ECOCLIMAP 1	GMTED2010 ECOCLIMAP 1	SRTM 90m ECOCLIMAP 1
LBC model	IFS HRES	IFS ENS (first 16) + HRES (ctrl)	AROME-Aut / C-LAEF ctrl
LBC update	1h	1h	1h
Surface scheme	SURFEX 8.0	SURFEX 8.0	SURFEX 8.0
Initial conditions (3D / Surf.)	3DVAR / OI	Ens 3DVAR+Jk / Ens OI	3DVAR / OI +IAU+Nudging/LHN
Cycle interval	3 hours	3 hours	1 hour
Assimilation Window	-90min-+90min	-90min-+90min	-90min-+30min
B-Matrix	C-LAEF EDA climatologic	C-LAEF EDA climatologic	AROME-RUC EDA climatologic
Hardware	HPE CRAY-XD2000 (GeoSphere)	ATOS XH2000 (ECMWF)	HPE CRAY-XD2000 (GeoSphere)

Table 1: Setup of the operational NWP systems at GeoSphere Austria

2. Towards C-LAEF 1k

A continuous C-LAEF 1k suite is running for more than 1.5 years on ATOS. The system is developed and maintained in cooperation with Slovenia and Croatia. In the last year some major upgrades in the setup of the ensemble were implemented.

- Domain extension: To meet requirements of Croatia the domain has been extended to the south with additional computational costs of about 15%.

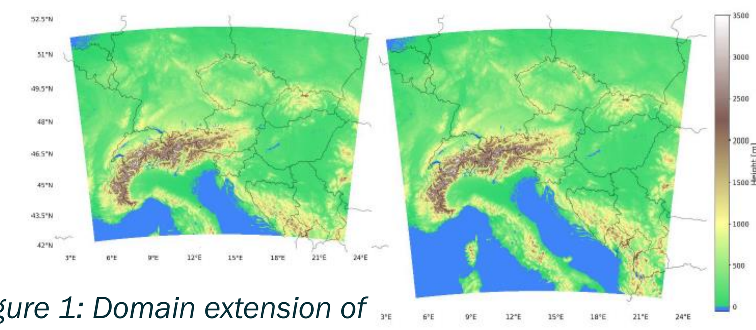

Figure 1: Domain extension of C-LAEF 1k. Left old, right new domain

- To save computational costs and provide more runs with long forecast range at the same time, the system was changed beginning of 2025 to run in lagged mode.

The current setup is as follows:
- 16+1 Member, 1km resolution, 3D-Var/CANARI, SPP
- Additional EnVar test member using perturbed member of last two runs as input
- CTRL run 8x per day up to +60h
- 4 alternating members with long forecast range (+69h)
- remaining members lead time +6h for assimilation cycle and input for EnVar
- In time-lagged mode full ensemble can be provided 8x per day with forecast range up to +60h and maximum time lagging of 9h

The lagged ensemble was running from mid of January until end of February 2025 and was evaluated against the operational 2.5km C-LAEF system

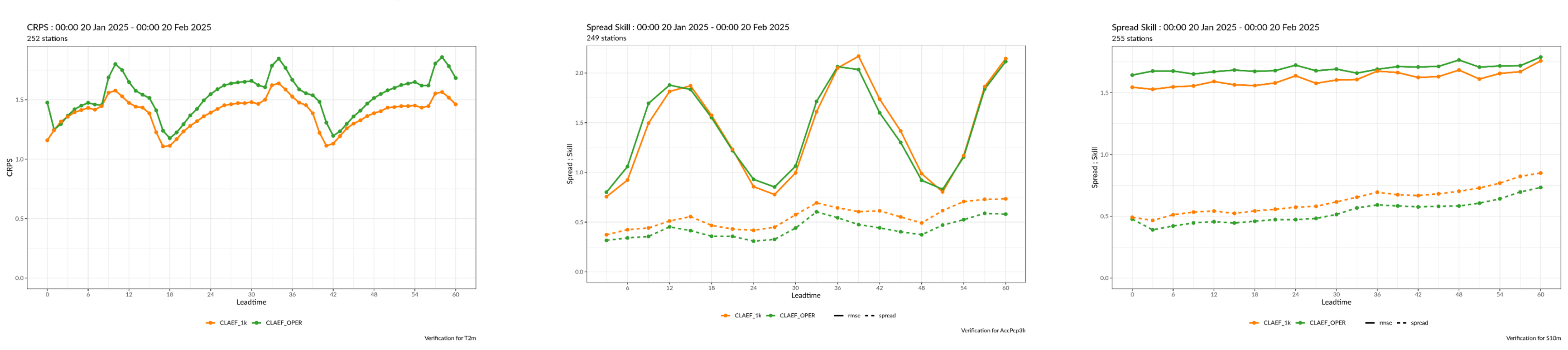

Figure 2: Verification of C-LAEF 1k ensemble (orange) vs. C-LAEF operational (green) for winter period 2025. CRPS of 2m temperature (left), Spread/Skill for 3h precipitation (middle), and 10m wind speed (right)

3. New HPC-system at GeoSphere

A new HPC was installed at GeoSphere in the second half of 2024. The new system is a **HPE CRAY-XD2000** cluster with:

- 100 nodes, including two fat nodes, 19200 cores AMD Genoa processors
- Interconnect: Slingshot 11
- Lustre file system with capacity of 200TB
- 100% water cooling
- Scheduling system: PBS Pro
- Additional GPU optional

All operational NWP-systems run operational at the new HPC since 15.01.2025.

Figure 3: HPE-CRAY system at GeoSphere

4. ARA – high resolution Austrian Re-analysis ensemble with AROME

Within the framework of FFG funded project "The high resolution Austrian Re-analysis ensemble with AROME (ARA)", we investigated ARA's re-analysis ensemble's performance for short duration convective events. This was done by comparing the ARA ensemble reanalysis with Wegener Net (WEGN) observations, which cover a relatively small region (20 km x 25 km). We found out that due to the small size of the WEGN region, a comparison only for the WEGN data set and event hours is too restrictive. Figure 4 shows the spatial and temporal drift seen for 30-06-2021 event. Despite poor hourly correlation the daily sums for the WEGN region fit reasonably well.

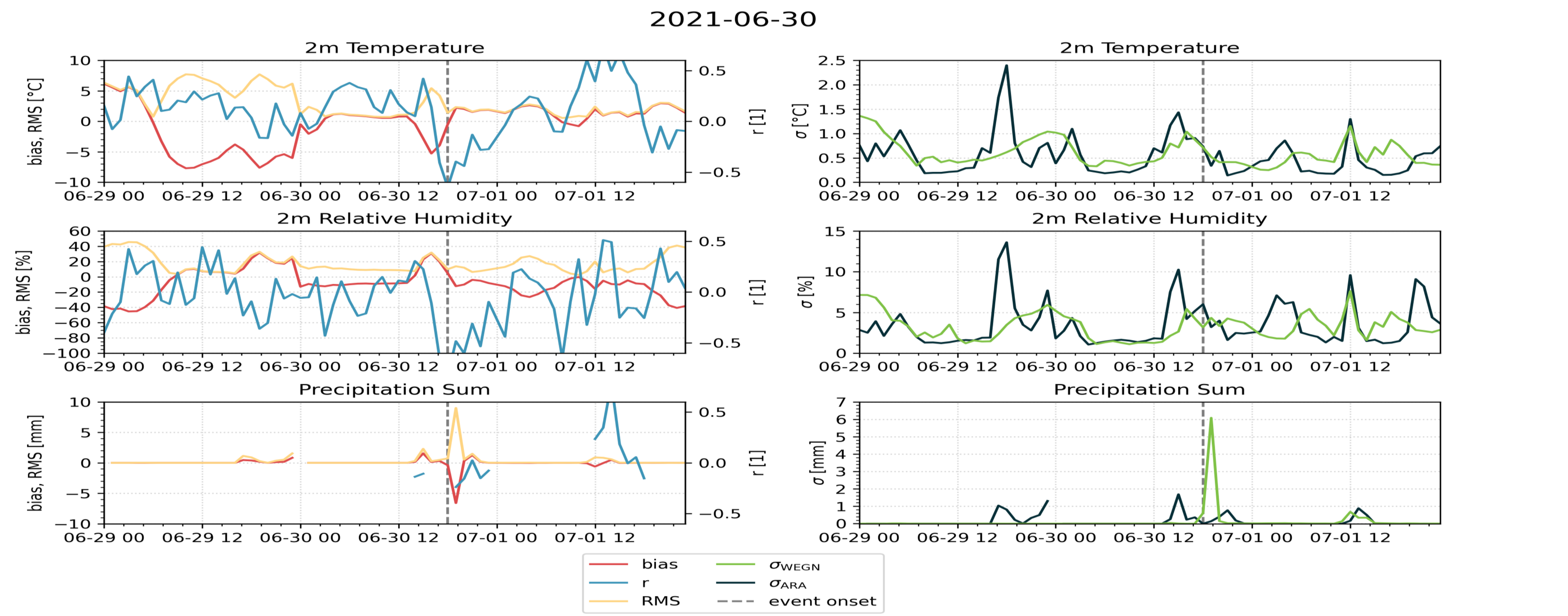

Figure 4: Standard metrics of the 2021-06-30 event (spatial mean over WEGN area). Each row corresponds to one atmospheric parameter: 2m temperature (top), relative humidity (middle), and precipitation sum (bottom). In the left column, the bias (red), correlation coefficient (light blue), and root mean square error (yellow) are shown. The standard deviation of both datasets (WEGN in green and ARA in dark blue) are depicted in the right column. The dashed grey line indicates the time, when the event started.

Figure 5 shows a comparison of precipitation from ARA and WEGN datasets, covering hourly precipitation from 5h before to 5h after the event. The green-blue colorbar represents ARA data, while the reddish colorbar shows WEGN data. Only cells with >0.29 mm/h precipitation are displayed. The area of interest is shown, with WEGN area in the center (black box). Black arrows indicate ARA 10 m wind speed for estimating rain cell movement. Statistical values (max 1h precipitation, 90th and 95th percentiles) are in the grey box. Black values represent the full region, while colored lines compare corresponding boxes, accounting for potential shifts in ARA data.

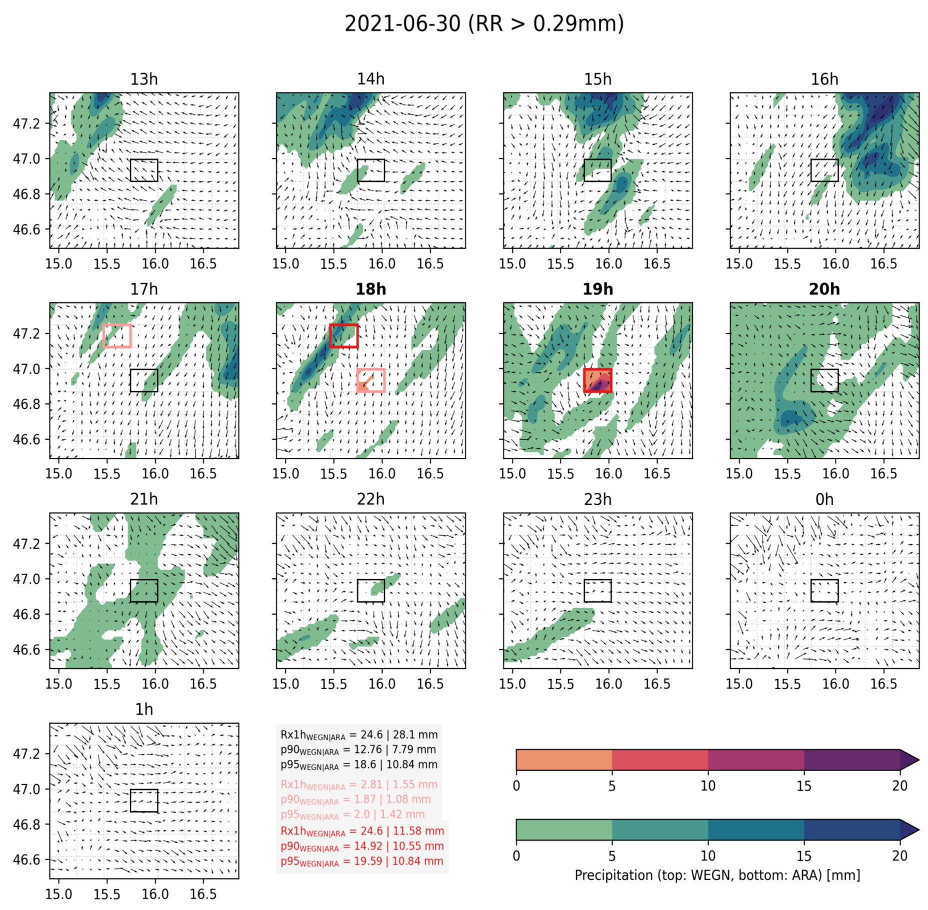

Figure 5: Comparison of precipitation amounts in both datasets, 2021-06-30 event.

5. Reducing warm bias in stable conditions in C-LAEF 1k

Several modifications have been investigated to reduce nocturnal warm bias in near-surface air temperature forecasts, particularly in Alpine valleys during winter.

1. Setting the maximum bulk Richardson number to zero (XRIMAX=0) to enhance the surface turbulent fluxes in stable conditions

2. Changes affecting soil freezing/melting
   a. Replaced sub-surface soil layer with total soil layer in soil freezing scheme
   b. Use soil freezing characteristic curve
   c. Enhance insulation effect of vegetation

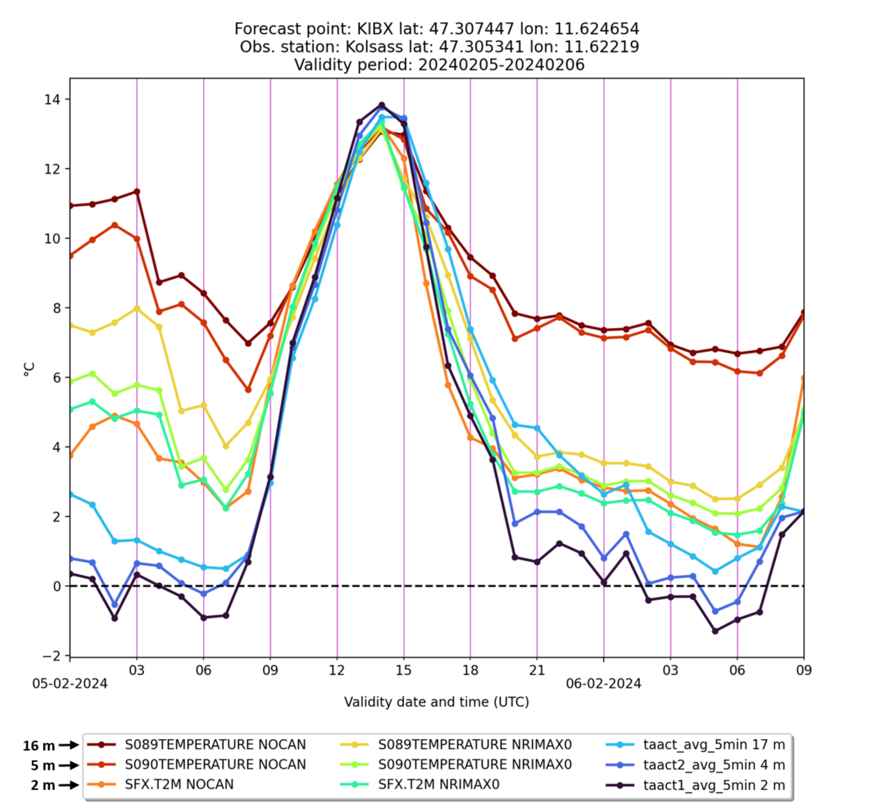

Figure 6: Hourly air temperatures observed at the i-Box Kolsass station (Inn Valley, Rotach et al. 2017) and simulated at the nearest grid point. The observation heights are 2, 4 and 17 m. The air temperature at 2 m, 5 m and 16 m was simulated in two experiments: NOCAN (reference, XRIMAX=0.2) and NRIMAX0 (XRIMAX=0).

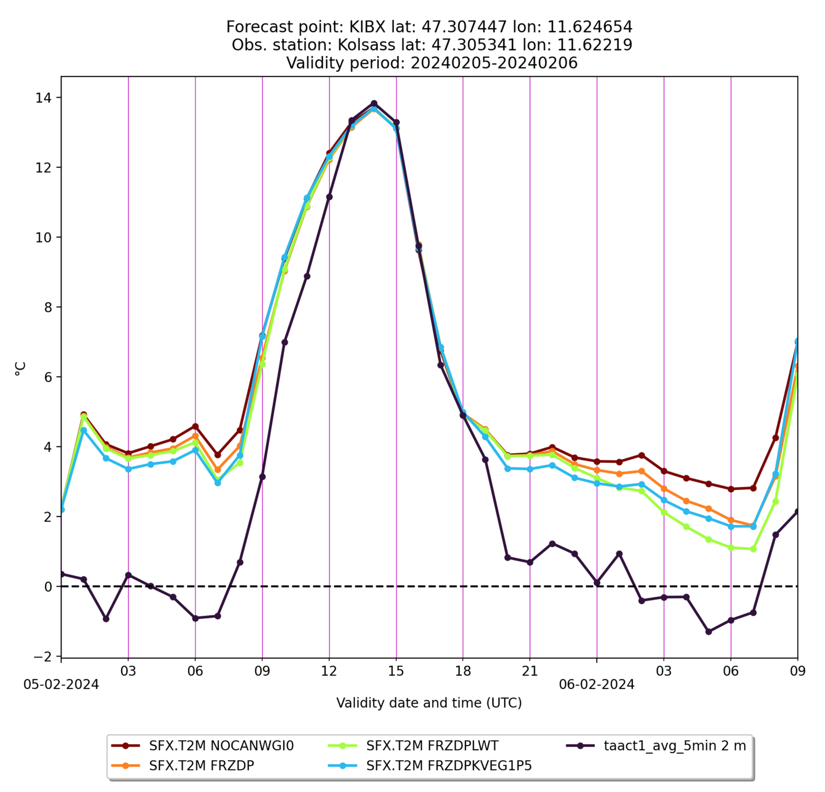

Figure 7: Hourly 2-m temperatures observed at the i-Box Kolsass station and simulated at the nearest grid point in experiments NOCANWGI0 (reference), FRZDP (change 2a), FRZDPLWT (changes 2a and 2b) and FRZDPKVEG1P5 (changes 2a and 2c).

References:
Deacu D., C. Wastl and C. Wittmann, 2024: Reducing the Nocturnal Warm Bias in C-LAEF 1k Simulations for Alpine Valleys, ACCORD Newsletter, 6, 81–87.
Rotach M., I. Stiperski, O. Fuhrer, B. Goger, A. Gohm, F. Obleitner, G. Rau, E. Sfyri and J. Vergeiner, 2017: Investigating Exchange Processes over Complex Topography: The Innsbruck Box (i-Box), Bull. Amer. Meteor. Soc., 98, 787–805.

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