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ZAMG
Zentralanstalt für Meteorologie und Geodynamik

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NWP related activities in AUSTRIA

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1. Operational systems

In December 2021, a major upgrade of the operational model systems at ZAMG (AROME-Aut, C-LAEF and AROME-RUC) has been implemented. Beside the change of the model cycle (cy40t1 -> cy43t2) several modifications were included into this upgrade. The main characteristics/setup of the current systems can be seen in table 1 below.

Table 1: Setup of operational model systems at ZAMG

	AROME-Aut	C-LAEF	AROME-RUC
Model version	cy43t2bf11	cy43t2bf11	cy43t2bf11
Resolution	2.5km	2.5km	1.2km
Area	Alpine area (600x432)	Alpine area (600x432)	Austrian area (900x576)
Members	1	16 + 1	1
Levels (lowest/highest)	90	90	90
	(5m / 35km)	(5m / 35km)	(5m / 35km)
Starting times	00, 03, … 21 UTC	00, 03, … 21 UTC	00, 01,…,22,23 UTC
Forecast range	60 hours	60 hours / 48 hours	12/25 hours
Time step	60s	60s	30s
Output Frequency	1h 2D/3D	1h 2D/3D	15min 2D/1h 3D
Orography / physiography	GMTED2010	GMTED2010	SRTM 90m
	ECOCLIMAP 1	ECOCLIMAP 1	ECOCLIMAP 1
LBC model	ECMWF HRES	ECMWF ENS	AROME-Aut
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 Apollo 8600 (ZAMG)	Cray XC40 (ECMWF)	HPE Apollo 8600 (ZAMG)

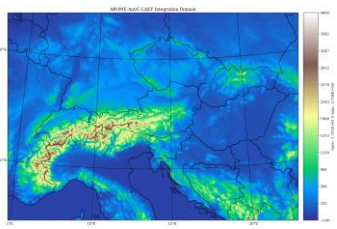

Figure 1: Integration domain of AROME-Aut/C-LAEF

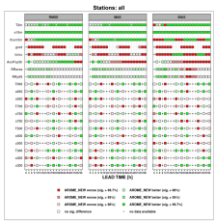

Figure 2: Scorecard for new AROME-Aut, 01/2019 – 03/2019

The 2.5km AROME-Aut is in operations at ZAMG for several years and serves as one major backbone for operational forecasts and warnings as well as for several downstream models and applications (e.g. INCA nowcasting system, WRF-Chem system). With the latest upgrade several modifications were introduced:

- Adapted screening level diagnostics (for LCANOPY=.T. case) to improve the T2m/RH2m performance in the Alpine region
- Modified 3DVAR setup (e.g. new Bmatrix, REDNMC tuning)
- Switch from GTOPO30 to GMTED as orography input data base
- Additional forecast parameters: Precipitation type, updraft helicity, weather symbol code

C-LAEF (2.5 km)

C-LAEF (Convection Permitting - Limited Area Ensemble Forecasting) has been developed at ZAMG and is an AROME-based EPS, running on the ECMWF HPC facility as TC2 application. The C-LAEF system is running on the same grid as AROME-Aut. With the latest upgrade, the setup of the C-LAEF control member now has the identical setup as AROME-Aut and thus serves as a full backup for the deterministic run. In addition to the modifications listed above for AROME-Aut (which were also introduced in C-LAEF), the latest upgrade also included:

- Switch from 6-hour to 3-hour assimilation cycle
- Implementation of a surface perturbation scheme to improve the skill/spread ratio for near surface parameters

AROME-RUC (1.2 km):

AROME-RUC is the nowcasting version of AROME running operationally at ZAMG since 2019. The AROME-RUC system runs with an hourly 3D-Var, Latent Heat Nudging of INCA precipitation analyses and forecasts, and FDDA nudging of surface stations (T2m, RH2m, u10m). Also, additional observations like MODE-S, GNSS-ZTD/-RO, WP, SODAR and 3D-RADAR are integrated into the system. Recent changes in AROME-RUC included:

- Modification of the screening level diagnostics (recently coded option N2M=3)
- Adapted/extended windfarm parametrization
- Additional Mode-S data, E-GVAP ZTD and bufrtemp data

Outlook:

At ZAMG first steps towards the development of a C-LAEF 1km system are currently undertaken. The long term plan is to merge the AROME-Aut and C-LAEF system while keeping AROME-RUC as a nowcasting version at resolutions < 1km. The use of additional observations and methods in the assimilation procedure are under evaluation.

2. DERECHO-event in Austria

On 18.8.2022 thunderstorms with severe wind gusts of more than 140 km/h hit the south/east part of Austria. The system originated near Corse (France), moved across Italy and Slovenia towards Austria, reinforced over the Alps and finally weakened on its way towards Czech Republic. The thunderstorms caused several fatalities and large damages on infrastructure in Austria.

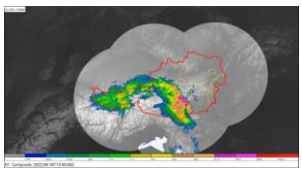

Figure 3: Radar composite from 18.8.2022 13:40 UTC, damaged power supply and forests.

The models indeed indicated the potential for heavy thunderstorms including high wind gusts on that day but clearly missed the right timing and location by shifting the systems approx. 100 km to the north-west. Fig. 4 shows the predicted wind gusts of AROME-Aut forecast from 18.8.22 00 UTC run. Wind gusts of more than 100km/h were predicted to the West/North of the area with highest observed wind speeds (red circle).
Most of the C-LAEF member confirmed the AROME-Aut forecasts with only a few member indicating high wind gusts on the right location (Fig 5).

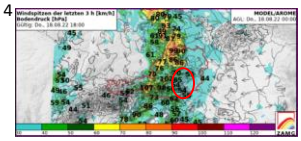

Figure 4: Wind gusts predicted by AROME-Aut. Red circle marks area with hightest observed wind speeds

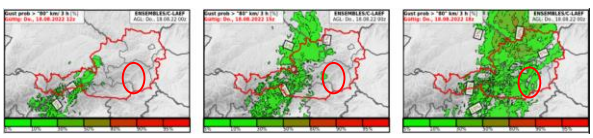

Figure 5: Probability of C-LAEF wind gusts > 80 km/h from 18.8.22 00 UTC run valid for 12 UTC (left), 15 UTC (middle), 18 UTC (right)

AROME-RUC forecasts indicated highest wind gusts in the right location but underestimated the wind speed at longer lead times. The latest AROME-RUC runs finally forecasted the event quite well (incl. gusts >> 100km/h) in the correct area, however theses runs were too late to be used in operational forecasts/warnings.

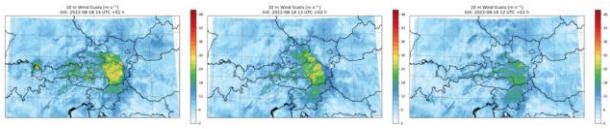

Figure 6: Wind gusts predicted by AROME-RUC in m/s. Forecasts from 18.8.22 14 UTC (left), 13 UTC (middle), and 12 UTC (right). All forecasts for valid time 15 UTC on 18.8.2022.

3 ENVAR

The OOPS-Version of the AROME Code (cy46t1 export) was successfully compiled on ZAMG's and new ECMWF's HPC. The new code not only allows to reproduce incremental 3D-Var but also Ensemble Var (Montmerle et al. 2018) and hybrid version. To use the ensemble of C-LAEF 3D-Var EDA within the EnVar all spectral fields had to be converted to gridpoint space. Technical tests of the different 3D assimilation schemes were successful. As small services can hardly afford huge EPS systems to mitigate sampling error, we also tested the use of lagged ensemble within 3D-EnVar. C-LAEF 3h and 6h forecast of 16+1 member ensemble was combined including slightly increased inflation from 0.5 (16) to 0.6 (34). Also different localization lengths were tested.

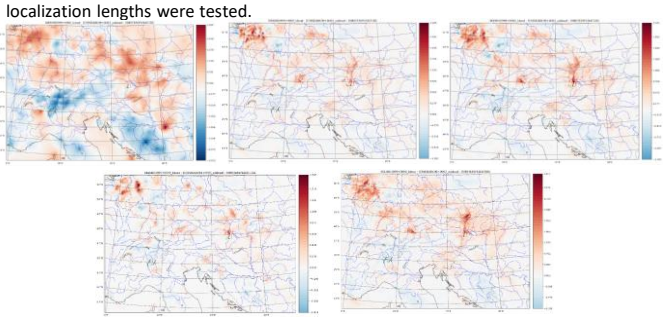

Figure 7: Increment of temperature 200m above ground level on 29th July 2022 06UTC: On top, 3D-Var (left), 3D-EnVar 16 member (middle) and 3D-Envar 34 lagged member (right) with localization of 100km. The inflation was slightly increased from 0.5 to 0.6 for lagged mode. Bottom: 34 lagged members, localization length 50km (left), and 200km (right).