NWP related activities in Austria

45th EWGLAM and 30th SRNWP Meeting, 25.-28.10.2023, Reykjavík / Iceland

Christoph Wittmann, Nauman Awan, Adhithiyan Neduncheran, Florian Meier, Phillip Scheffknecht, Clemens Wastl, Florian Weidle

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	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 (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	GMTED2010	SRTM 90m
	ECOCLIMAP 1	ECOCLIMAP 1	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 Apollo 8600 (GeoSphere)	Cray XC40 (ECMWF)	HPE Apollo 8600 (GeoSphere)

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

The last upgrade of C-LAEF took place just this September with the main changes being:

- Model physics perturbation scheme: The hybrid perturbation scheme (acting on tendencies and selected parameters) was replaced by a pure stochastic parameter perturbation scheme (SPP)
- Ceilometer observations: Cloud cover observations (converted to RH) were introduced into the ensemble 3DVar system. Tests have shown that these observations can improve low stratus forecasts during autumn and winter.

The rapid update system (AROME-RUC) is running on higher resolution (1.2km) and uses significantly more observations than AROME-Aut/C-LAEF. Table 2 lists all observations currently integrated into the assimilation system.

Observation Type	Parameter assimilated	Source	AROME/C-LAEF	AROME-RUC	research mode
SYNOP/TAWES	U10m, V10m, Z, T2m,RH2m	OPLACE/GeoSphere/GTS	x	x	
AMDAR, MODE-S	U,V,T,Q	OPLACE/EUMADDC/ACG	x	x	
MODE-S MRAR	U,V,T	EUMADDC/OPLACE		x	
GEOWINDMSG3	U,V	OPLACE/GTS	x	x	
GEOWIND-HR MSG3	U,V	OPLACE/NWC-SAF		x	
TEMP (radiosonde)	U,V,T,Q,Z	GTS/OPLACE/GeoSphere	x	x (bufr)	
PILOT	U,V	GTS/GeoSphere		x	
WINDPROFILER, SODAR	U,V	OPLACE/GTS/GeoSphere		x	
SCADA	U,V,T	Energie Burgenland		x	
MSG3-SEVIRI	WV-radiances	OPLACE	(x)	x	
NOAA18/19/20/SNPP/Met Op-B-C AMSU-A, MHS, ATMS	radiances	OPLACE	(x)	x	
MetOp-B-C IASI	radiances	OPLACE	(x)	x	
ASCAT wind	U10m,V10m	OPLACE/EUMETSAT	x (25km)	x (12,5km)	
RADAR	reflectivity / radial winds	various		x	
INCA-RR	RR 5min LHN	GeoSphere		x	
SNOWGRID snow analysis	snowheight/density	GeoSphere	x	x	
GNSS	ZTD (optional STD)	EPOSA/E-GVAP	(x)	x	
Radio Occultation	GPSRO bending angles	OPLACE/ROMSAF		x	
Ceilometer	N -> RH	GeoSphere	x	x	
Microwave Links	(estimated RR)	DREI Hutchison			x
Sentinel-1 InSAR	(STD)	ESA/Joanneum R./EOG			x
ZTD on trains	(ZTD)	ÖBB/TU-Vienna			x
T-LAKE	T Water	Hydrol. Service/ZAMG	x	x	

Table 2: Overview observation (types) used in operational NWP systems

2. Towards C-LAEF 1k

As one of the major upcoming upgrades, the new "C-LAEF 1k" system is being developed for operations starting in winter 2024/2025. The main components of the upgrade include:

- Increase of resolution from 2.5km to approximately 1 km
- Move from SPP to a flow dependent parameter perturbation scheme
- Change from a static to a flow-dependent assimilation system (using EnVar)
- Use of single precision code
- Increased number of observation types for DA

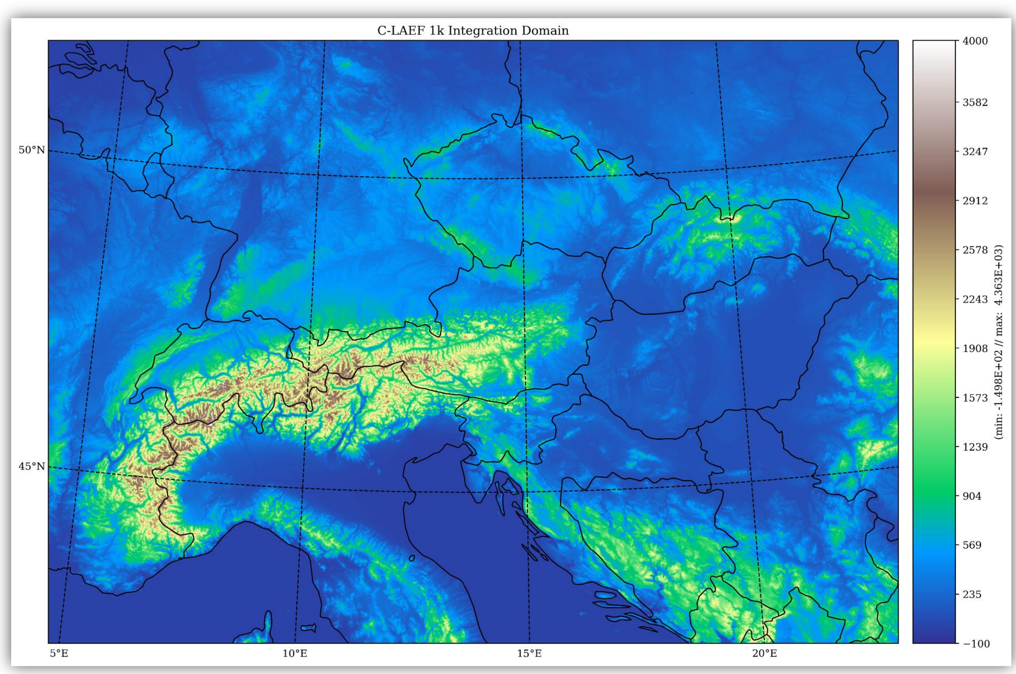

Fig.1: Integration domain of the new C-LAEF 1k system

A first prototype of C-LAEF 1k (16 + 1 member) has been running on ECMWF HPC since June 2023. The performance was continuously evaluated over the summer months, results indicate neutral to slightly positive results compared to the operational system.

3. Summer 2023 extreme events

Summer 2023 brought several challenging weather situations in the Alpine region. After several weeks of unstable weather conditions resulting in thunderstorms almost every day in July, the Southeast of Austria and parts of Slovenia were affected by a major precipitation event at the beginning of August. During the night from 3rd to 4th of August, 100 – 200 mm of precipitation was observed in less than 12 hours, resulting in flash floods and landslides. Precipitation continued, albeit less intense, in the days that followed this event.

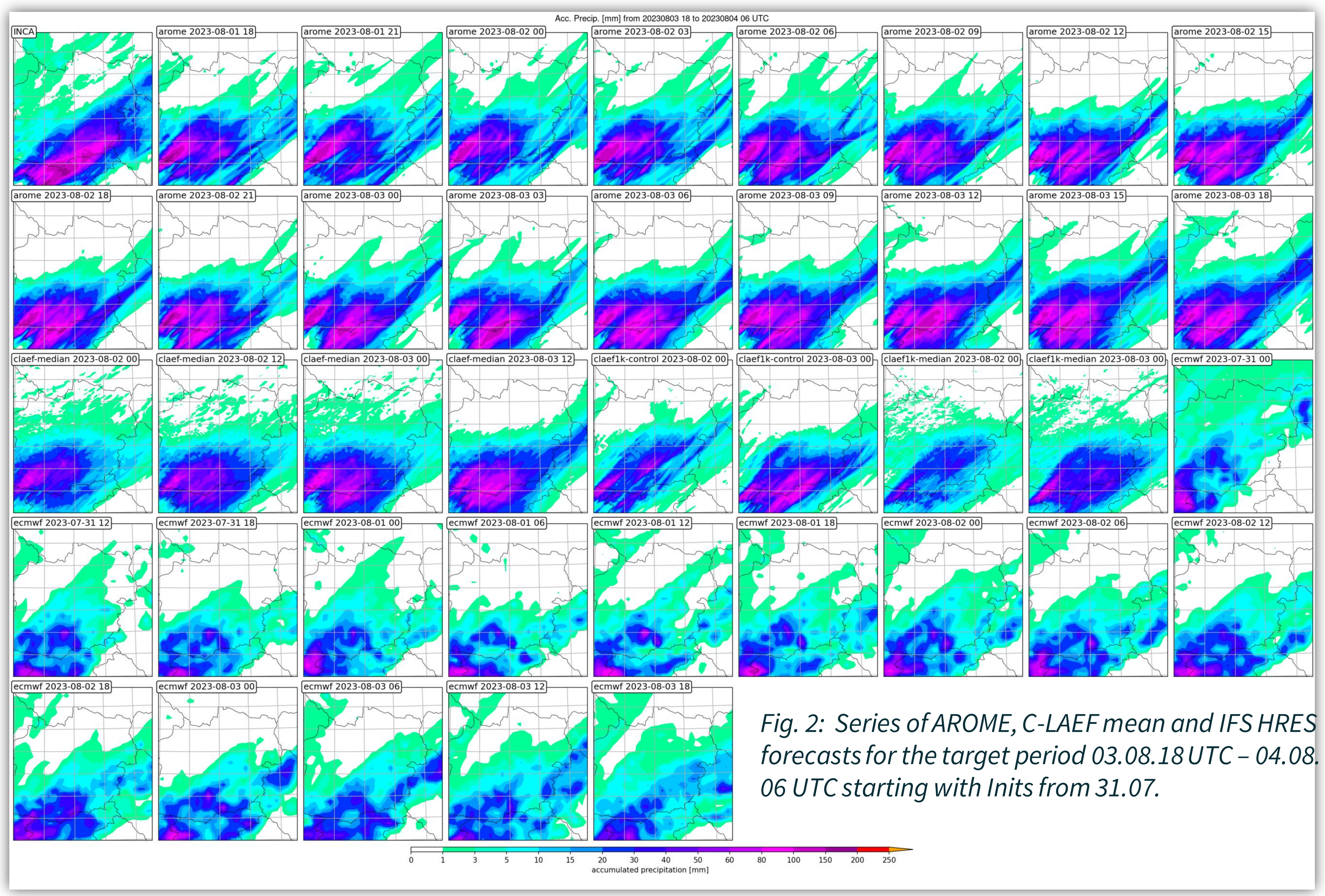

Fig. 2: Series of AROME, C-LAEF mean and IFS HRES forecasts for the target period 03.08.18 UTC – 04.08. 06 UTC starting with Inits from 31.07.

Fig. 2 shows the precipitation analysis (INCA, upper left) and a series of multiple runs with different starting times of AROME-Aut, C-LAEF, C-LAEF1k, and IFS HRES for the 12 hours from 3 Aug 18 UTC to 4 Aug 6 UTC. While the LAMs indicated a regional extreme event with rather low variability from run to run, IFS HRES was not able to predict the extreme precipitation and locality of the event.

4. Recent research activities

Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie — FFG Forschung wirkt. — Bundesministerium Finanzen

Several ongoing and recently finished research projects performed by GeoSphere Austria and financed through national research funding schemes, are focused on the use of new observation types: *SAME-AT* and *ACHILLES* explore high resolution INSAR delays from Sentinel-1; *TRain* deals with ZTD data derived from GNSS receivers on trains; *CloudyRadiances* uses cloud-affected satellite radiances.

The recently completed *LINK* project explored the potential of data from cell phone towers. Drei Hutchison Austria GmbH delivered raw data of emitted and received signal strength for about 5000 microwave links between cell phone towers with frequencies from 13 to 80 GHz along with metadata about the links (e.g., frequency, location, and length). FH St. Pölten quality-controlled the data and converted it into rain rates using machine learning. The method allowed the use of 80 GHz links, which where thus far not converted into rain.

To assimilate the rain rates, a 1DVar + 3DVar approach was chosen. It was based on the work of Lopez et al. (2007), who used it to assimilate rain observations from satellites into IFS. Despite not being designed for AROME, Salahoui et al. (2018) showed that assimilating radar and surface station observations with this method can improve AROME forecasts.

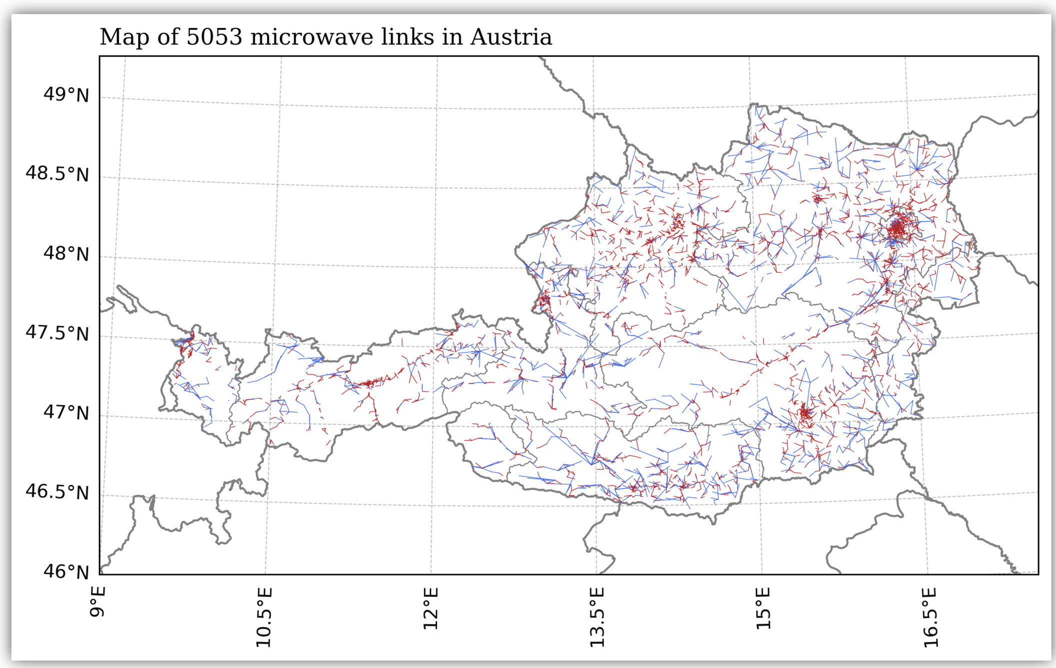

Fig. 3: Locations of microwave links for a single observation time, 80 GHz links are shown in red, all lower frequencies (13 – 38 GHz) are shown in blue.

The 1D-Var produces profiles of increments for q and T, which are converted into profiles of relative humidity and assimilated as pseudo-dropsondes. The observations were tested by running the deterministic 2.5 km AROME-Aut for June 2022 using 3-hourly cycling, with the 00 and 12 UTC runs running for 24 hours while the other runs only maintained cycling. While the impact was largely neutral, the observations lowered the bias of T, q, and the precipitation slightly during the first few hours.

P. Lopez und P. Bauer (2007). "1D+4DVAR" assimilation of NCEP Stage-IV radar and gauge hourly precipitation data at ECMWF. Mon. Wea. Rev. 135(7), 2506– 2524. doi:10.1175/MWR3409.1.

Z. Sahlaoui, S. Mordane, E. Wattrelot, J.-F. Mahfouf (2019). Improving heavy rainfall forecasts by assimilating surface precipitation in the convective scale model AROME: A case study of the Mediterranean event of November 4, 2017, Meteorological Applications, 10.1002/met.1860,27, 1.

Contact: Christoph Wittmann, Department Analysis and Model Development | christoph.wittmann@geosphere.at | www.geosphere.at