SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2024
Project Title:	A-LAEF upgrade and development
Computer Project Account:	spcralae
Principal Investigator(s):	Martina Tudor (HR), Martin Belluš (SK), Maria Derkova (SK), Jan Mašek (CZ)
Affiliation:	Croatian Meteorological and Hydrological Service
Name of ECMWF scientist(s) collaborating to the project (if applicable)	…… ……
Start date of the project:	19.1.2024
Expected end date:	31.12.2026

Computer resources allocated/used for the current year and the previous one

(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)				
Data storage capacity	(Gbytes)				

Summary of project objectives (10 lines max)

This special project is devoted to the upgrades and development of A-LAEF limited area ensemble running as TC2 application in ECMWF. Description and objectives of the research planned for 2024:
- upgrade of the model cycle to the CY46T1 (export version + the most recent ALARO development and A-LAEF specific routines like surface stochastic physics for ISBA prognostic fields)
- related to the above, new definitions of perturbed physics
- updates in the surface data assimilation
- re-runs of extreme weather case studies (with different tunings)
- testing new software upgrades by ECMWF before their operational deployment
- preparation of flow-dependent B-matrix using the A-LAEF 4.8 km operational outputs
- inline production of grib files (partially GRIB2)

Summary of problems encountered (10 lines max)

Some multi-physics options that were used in CY40T1 are not available in CY46T1, but there are new options available in physics.
Some new developments in physics parametrisations of ALARO had to be backphased to CY46T1 from more recent cycles.
Debugging FASGRA subroutine to avoid crashing the model during inline postprocessing and grib files production.
Occurrence of instability in one of the perturbed physics setups.
Irreproducible crash during validation possibly related to sporadic SW/HW issues on Atos HPC.

Summary of plans for the continuation of the project (10 lines max)

The project plans for 2024:
- testing of LBCs generated from CY49R1 parallel suite and operational implementation
- re-runs of extreme weather cases and longer period validations and scores
- Preparation of flow-dependent B-matrix using the A-LAEF 4.8 km operational outputs

Further plans:
- testing of new cycle release (probably CY49T1 or CY48T3, not yet known)
- testing single precision ALARO physics with possible implementation in operations
- testing SURFEX with ALARO physics
- testing prolongation of A-LAEF forecast to +78 h (to fulfil hydrologist and climatologist needs)
- exploring higher resolution (vertical, horizontal, spectral)

List of publications/reports from the project with complete references

Martin Belluš, Jan Mašek: Upgrade and validation of A-LAEF multiphysics based on the latest ALARO-1 code at CY46T1. 20 pp RC LACE report https://rclace.eu/predictability

Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

The ALARO-LAEF system (Belluš et al., 2022) runs operationally on the High Performance Computer Facility (HPCF) at the European Centre for Medium-Range Weather Forecasts (ECMWF) twice a day with the integration starting at 00 and 12 UTC producing 72 hour forecasts.

The ensemble consists of 1 unperturbed control run and 16 perturbed members involving initial condition uncertainty, model error simulation and coupled in lagged mode to perturbed lateral boundary conditions coming from the ECMWF EPS.
At the beginning of 2022, the system used CY40T1, which was very stable, but missed several recently introduced prognostic and diagnostic fields, such as prognostic graupel and 16 diagnostic precipitation types, lightning and wet snow accretion to high voltage wires. The suite used topography description from older input.
The climatological files that describe underlying topography parameters are prepared and updated.
The A-LAEF multiphysics is now based on CY46T1. There were many developments in the physics package of ALARO between those two cycles, but also some cleanings of options in the code that lead to mandatory changes in the way multiphysics is defined in the A-LAEF ensemble. Four different physics setups were defined, as summarized in Table 1.

Tab.1: New A-LAEF multiphysics configurations.

cluster	phys01	phys02	phys03	phys04
member	0,1,5,9,13	2,6,10,14	3,,7,11,15	4,8,12,16
namelist parameter				
RDHAIL1	2.8	2.4	2.8	2.4
RDHAIL2	7.5	6.5	7.5	6.5
CGMIXLEN	EL0	EL0	EL1	EL1
LPBLH_TKE	F	F	T	T
XMAXLM	0	0	5000	5000
ETKE_C0SHEAR	N/A	N/A	0.35	0.35
ETKE_DTHETA_S1	N/A	N/A	-2.5	-2.5
ETKE_DTHETA_S2	N/A	N/A	1.0	1.0
ETKE_R2SIM	N/A	N/A	0.1	0.1
LEVAPLOP	F	T	F	T
LZ0SNOWH	F	T	F	T
HUCREDRA	0.42	0.46	0.42	0.46
RAUTEFR	0.5E-3	0.8E-3	0.5E-3	0.8E-3
RAUTEFS	2.E-3	1.E-3	2.E-3	1.E-3
RCFLASH1	16.76	22.29	16.76	22.29
RDECRD1	10000	8000	10000	8000
RDECRD2	20000	215000	20000	215000
RDTFAC	1	0.75	1	0.75
REVASXR	0	7.E-7	0	7.E-7
RQLCR	3.E-4	4.E-4	3.E-4	4.E-4
WCRIN	4	10	4	10
RZ0_TO_HEIGHT	N/A	0.1	N/A	0.1
FACRAF	10	3.6	10	3.6
LRAFTKE	F	T	F	T

LRAFTUR	T	F	T	F

The new CY46T1 export version does not contain all the ALARO developments that are used here, therefore the developments were backphased from more recent cycles (CY48T3 and CY49T1 as well as some development branches) into the export version of CY46T1.
A-LAEF uses multi physics approach where different physics parameterizations and tunings are applied to the precipitation types, mixing length choice, PBL height computation and related tuning of the TOUCANS turbulence scheme, choice of evaporation scheme, roughness impact of snow via snow height, critical humidity profile tuning for radiation cloudiness, autoconversion to rain and snow, flash diagnostics, variation of exponential-random cloud overlap in radiation, liquid/ice partition for cloud condensate, max. evaporation rate for rain, critical liquid water content for liquid cloud water autoconversion, ratio of mechanical roughness length to obstacle height, choice of wind diagnostics (TKE vs friction velocity), etc.
It should be stressed that all setups originate in well tested and tuned configurations used (or meant to be used) in the NWP operations for the deterministic runs, which makes this kind of model physics uncertainty simulation different from the nowadays widely used stochastically perturbed parameterizations (SPP). Nevertheless, it can obviously produce reasonable spread in the EPS context.
The stochastic perturbation of ISBA surface prognostic fields was phased into CY46T1.

Summary

Four different physics clusters for the A-LAEF system based on the latest ALARO-1 development at model cycle CY46T1 were set up and tested. It must be noted that a substantial part of this code is generally not available in the CY46T1 export version (nor in the later bugfixes). It includes some add-ons back-phased from newer cycles CY48T3 and CY49T1. New physics clusters were also successfully combined with the stochastic perturbation of the physics tendencies for ISBA surface prognostic fields. This code was locally phased to the CY46T1 as well. Such configuration is capable of producing qualitatively comparable results to those of the operational version (for tested cases). Moreover, it provides new interesting diagnostic fields and should also offer better physics.

Future work

Apart from the case studies, we expect to carry out a more complex comparison of statistical scores for the new system vs the old one, for a reasonably long verification period (however, this might be difficult due to the computational costs and limited SBUs for research).
The new low spectral truncation clim files computed from the new database are yet to be tested with the upper air blending employed in the data assimilation cycle.
After the finalisation of the upgrade of all A-LAEF components (e.g. ESDA, post-processing), the new system should become operational in Q3/2024.

Belluš, M., M. Tudor, X. Abellan, 2022: The mesoscale ensemble prediction system A-LAEF. ECMWF Newsletter, 172, 27-34.