LATE REQUEST FOR A SPECIAL PROJECT 2025–2027

MEMBER STATE:	Austria
Principal Investigator[1]:	Kaushambi Jyoti
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Project Title:	Testing the Hybrid-3DEnVar method in a convective scale NWP model AROME over Austria

To make changes to an existing project please submit an amended version of the original form.)

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** …….	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2025	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for project year:		**2025**	**2026**	**2027**
High Performance Computing Facility	[SBU]	3.5M		
Accumulated data storage (total archive volume)[2]	[GB]	11500		

EWC resources required for project year:		**2025**	**2026**	**2027**
Number of vCPUs	[#]			
Total memory	[GB]			
Storage	[GB]			
Number of vGPUs[3]	[#]			

Continue overleaf.

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide annual progress reports of the project's activities, etc.
[2] These figures refer to data archived in ECFS and MARS. If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year etc.
[3] The number of vGPU is referred to the equivalent number of virtualized vGPUs with 8GB memory.

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Extended abstract

All Special Project requests should provide an abstract/project description including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The completed form should be submitted/uploaded at https://www.ecmwf.int/en/research/special-projects/special-project-application/special-project-request-submission.

Following submission by the relevant Member State the Special Project requests will be published on the ECMWF website and evaluated by ECMWF and its Scientific Advisory Committee. The requests are evaluated based on their scientific and technical quality, and the justification of the resources requested. Previous Special Project reports and the use of ECMWF software and data infrastructure will also be considered in the evaluation process.

Requests exceeding 10,000,000 SBU should be more detailed (3-5 pages).

Convective systems present a major challenge for data assimilation (DA) due to their rapid evolution and strong non-linearity in forecast error growth. Traditional DA systems, such as the operational 3DVar at GeoSphere Austria, rely on a static climatological background error covariance matrix (B_c), which struggles to capture these flow-dependent error structures. In contrast, the ensemble-based error covariance matrix (B_e) incorporates information about the current weather situation (flow-dependency).

We have tested the Hybrid 3-Dimensional Ensemble Variational (Hybrid-3DEnVar) technique within the convective-scale limited-area NWP model AROME, configured over Austria at a 2.5 km horizontal resolution with a 50-member ensemble of GeoSphere Austria's convection-permitting Limited-Area Ensemble Forecasting system (C-LAEF). We conducted experiments assimilating Aircraft Enhanced Surveillance (Mode-S) wind and temperature observations across several summertime convective precipitation cases. The analyses are validated against independent wind and temperature data from AMDAR, wind profilers, and radiosondes. Our results have shown that the Hybrid-3DEnVar outperforms 3DVar. However, the optimal weight given to B_e is weather-dependent.

To further understand the interactions between localization length scales and weight provided to B_e within the hybrid configurations, we plan additional sensitivity experiments combining different localization length scales with the existing ensemble weight configurations. Additionally, forecast runs will be conducted to compare the skills of the 3DVar and hybrid methods.

We tested Hybrid-3DEnVar using AROME cycle 46t1 on the ECMWF-ATOS system under the "atvinar" project, which has been ongoing since July 2022. This work will be completed in year 2025, hence resources are requested for 2025, and we have submitted another request for year 2026-28

Required resources

Sr. No.	Work plan	SBU estimate	Storage requirement

1	Hybrid-3DEnVar assimilation and a 3-hour forecast	3000	5 GB + 700 GB (for one 3-hourly 50-member forecast)
3	Miscellaneous test	500000	4000 GB

Total number of experiments = localization-settings (60, 100, 150, 300 km) x DA-configuration (11 DA experiments) x obs (T, UV) x exp-per-day (5 times) x time-period (2 days) = 4x11x2x5x2 = 880
SBU consumption = 880x3000 = 2640000
Total SBU consumption = 2640000 + 500000 (Miscellaneous test)

References

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[Courtier et al., 1998] Courtier, P., Andersson, E., Heckley, W., Vasiljevic, D., Hamrud, M., Hollingsworth, A., Rabier, F., Fisher, M., and Pailleux, J. (1998). The ecmwf implementation of three-dimensional variational assimilation (3d-var). i: Formulation. Quarterly Journal of the Royal Meteorological Society, 124(550):1783–1807.

[Lorenc, 2013] Lorenc, A. C. (2013). Recommended nomenclature for envar data assimilation methods.

[Michel and Brousseau, 2021] Michel, Y. and Brousseau, P. (2021). A square-root, dual-resolution 3denvar for the arome model: formulation and evaluation on a summertime convective period. Monthly Weather Review, 149(9):3135–3153.

[Montmerle et al., 2018] Montmerle, T., Michel, Y., Arbogast, E., M´en´etrier, B., and Brousseau, P. (2018). A 3d ensemble variational data assimilation scheme for the limited-area arome model: Formulation and preliminary results. Quarterly Journal of the Royal Meteorological Society, 144(716):2196–2215.

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