REQUEST FOR AN EMI R&D PROJECT 2027–2029

Country/Organisation: ……Italy……

Principal Investigator[1]: …Francesco Graziosi

Affiliation: …University of Urbino

Address: …Via Aurelio Saffi 2 , 61029 PU……

Other researchers: ……

Project Title: Machine Learning Approach for Emission Monitoring

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** ITGRAZ……..	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2027	
Would you accept support for 1 year only, if necessary?	YES X	NO ☐

Computer resources required for project year:		**2027**	**2028**	**2029**
High Performance Computing Facility	[SBU]	900.000	900.000	900.00
Graphics Processing Unit Cluster-A	[GBU]	1 M	1 M	1 M
Graphics Processing Unit Cluster-B	[GBU]	1 M	1 M	1 M
Accumulated data storage (total archive volume)[2]	[GB]	8000	8000	8000

[1] The Principal Investigator will act as contact person for this EMI R&D 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.

EWC resources required for project year:		**2027**	**2028**	**2029**
Number of vCPUs	[#]	4	4	4
Total memory	[GB]	18000	18000	18000
Storage	[GB]	18000	18000	18000
Number of vGPUs[3]	[#]			

Continue overleaf.

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……

Extended abstract

All EMI R&D 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 EMI R&D 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 EMI R&D Project reports and the use of ECMWF software and data infrastructure will also be considered in the evaluation process.

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

Abstract

Accurate quantification of greenhouse gas (GHG) and air pollutant emissions is fundamental for understanding the Earth system, improving air-quality forecasts, and assessing climate mitigation strategies. While atmospheric inverse modelling represents the state of the art for deriving emissions from atmospheric observations, its computational cost limits the exploitation of the rapidly growing volume of satellite data and the delivery of high-resolution, near-real-time emission estimates.

This project builds upon ECMWF's **Anemoi** machine-learning framework to develop a new generation of physics-informed AI methods for atmospheric emission inversion. By combining high-resolution atmospheric chemistry-transport modelling, Earth observations, and advanced machine learning, the project will create scalable, observation-driven systems capable of rapidly estimating greenhouse gas and air pollutant emissions from global to local scales.

Large ensembles of WRF-Chem simulations will be generated to describe atmospheric responses to controlled emission perturbations under diverse meteorological and environmental conditions. These datasets will be used to train forward and adjoint ML emulators within the Anemoi framework, enabling rapid emission inference while preserving the physical consistency of conventional atmospheric modelling. A second ML framework will integrate Earth observations and spatial proxies to produce high-resolution emission maps and quantify localized sources.

Beyond accelerating atmospheric inversion, the project will investigate how AI can uncover previously unresolved relationships between atmospheric composition, environmental drivers, and emission processes. Particular emphasis will be placed on monitoring natural carbon exchanges, industrial hotspots, as well as assessing the capability of current and future satellite missions to constrain emission fluxes. The project requires extensive high-resolution simulations for training and validation, making ECMWF's computational infrastructure, Anemoi ecosystem, and expertise in AI for Earth-system modelling essential to its successful implementation.