REQUEST FOR A SPECIAL PROJECT 2025–2027

MEMBER STATE: Italy………………………………………………………………………………………..

Principal Investigator[1]: Dr. Francesco Graziosi………………………………………………

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Other researchers: ………………………………………………………

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Project Title:

Inverse modelling as tool to support F-gases emission monitoring in Europe……………………………………………………………………………………

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.	-	
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 X	NO ☐

Computer resources required for project year:		**2025**	**2026**	**2027**
High Performance Computing Facility	[SBU]	10.000	10.000	10.000
Accumulated data storage (total archive volume)[2]	[GB]	1500	1500	1500

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).

The Fluorinated gases (F-gases) includes Hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride are synthetic, powerful greenhouse gases that are emitted from variety of anthropogenic applications and processes. The aim of this project is to provide a robust and independent F-gases emissions estimates at the scale of nation states trough F-gases atmospheric observations and atmospheric inversion approach. Atmospheric measurement of F-gases can be used to provide “top-down” emission estimates. The Inverse Modelling (IM) approach is a common top down method. The IM utilise observed temporal and spatial pattern in atmospheric species concentration to constrain initial (prior) estimates of emissions of respective species. These prior estimates can be based on reported national annual inventory estimates that are mapped out in time and space, or regional/global emissions datasets that have been independently compiled. By adjusting the *prior* emissions estimates and simulating the subsequent atmospheric transport (and potential chemical transformation), the modelling framework produces *posterior* emissions estimates with which the measured atmospheric concentrations can be reproduced by the model simulations. Through an optimisation process, the modelling framework iteratively adjusts the prior estimates until an *acceptable* agreement between the simulated and observed concentrations is reached with the final posterior emissions estimates. The difference between the prior and posterior emission fields can be used to identify potential quality issues within the national F-gases inventories, and thus form a relatively independent quality check of these inventories.

The atmospheric inversion framework requires four basic types of input :

1) atmospheric observations, 2) a model of atmospheric transport, 3) prior estimates of the fluxes, and 4) initial concentrations.

1) Atmospheric observations

   The atmospheric measurements are one of the key input of the inversion cascade.

   The inversion frameworks estimate the source affecting the measurement sites; for this reason the density of the measurement points determine the extension of the area that can be constraint by the inversions system.

   In principle, any type of atmospheric observation, from stations, aircrafts, ships and satellite, can be assimilate by an atmospheric inversions system. However, aircraft and ship campaign are mainly used to estimate the emission over a limited emitted area (i.e landfill, city), and have limited time representativeness. Meanwhile, the high frequency observations detecting the short term variability of the concentrations, are the most common observations used by the model inversion to determine the emission over regional and global domain.

   The in situ high frequency observations of F-gases from atmospheric networks are mainly distributed over central part of Europe (i.e. Advanced Global Atmospheric Gases Experiment (AGAGE). This implies that the central part of European domain will be well resolved by the model inversions.

2) The atmospheric transport model links the atmospheric fluxes and the atmospheric concentrations, describing the atmospheric transport of the species from the sources to the monitoring sites. For this project, we plan to use the FLEXPARTv10.4 (Pisso et al., 2019) model, driven by meteorological model (ECWMF ERA5), whose spatial and temporal resolution affects the quality of the model simulations. For out purpose, we will use a nested wind field over European domain, at 0.25° x 0.25° latitude longitude degree resolution, over a mother grid of 0.5° x 0.5° latitude longitude degree resolution, both with 1 hour temporal resolution.

3) The prior emissions will be based on bottom up official inventory, and emissions datasets that have been independently compiled (EDGARv8 [Crippa et al., 2023], E-PRTR-https://industry.eea.europa.eu/).

4) The baseline will be provided from statistical analysis of observations representing the well-mixed troposphere .

During the first year we will setup the model system, testing the impact of the input to the model results. For this purpose, we will evaluate the particles release altitude of mountain monitoring stations, the different a priori emission fields, and wind filed resolutions and station geometry in the inversion system. The uncertainty reduction obtained after the inversion iterations, and the statistical agreement between the observations and optimized model concentrations will indicate the model performance. The second and third years we will dedicated to extend the inversions during the all (from 10 to 20 years, depending of the F-gases). We will focus on perfluorocarbons and sulfur hexafluoride. The SBU's requested are needed for conduct run tests, and for post-processing the wind-field data driving the model simulations. Indeed, large part of the model inversions and model simulations will be conducted in an external cluster. The data storage quantity request are need to elaborate the high resolution wind-field data

Reference

Crippa, M., Guizzardi, D., Pagani, F., Banja, M., Muntean, M., Schaaf E., Becker, W., Monforti-Ferrario, F., Quadrelli, R., Risquez Martin, A., Taghavi-Moharamli, P., Köykkä, J., Grassi, G., Rossi, S., Brandao De Melo, J., Oom, D., Branco, A., San-Miguel, J., Vignati, E., GHG emissions of all world countries, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/953322, JRC134504.

Pisso, I., Sollum, E., Grythe, H., Kristiansen, N. I., Cassiani, M., Eckhardt, S., Arnold, D., Morton, D., Thompson, R. L., Groot Zwaaftink, C. D., Evangeliou, N., Sodemann, H., Haimberger, L., Henne, S., Brunner, D., Burkhart, J. F., Fouilloux, A., Brioude, J., Philipp, A., Seibert, P., and Stohl, A.: The Lagrangian particle dispersion model FLEXPART version 10.4, Geosci. Model Dev., 12, 4955–4997, https://doi.org/10.5194/gmd-12-4955-2019, 2019.