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
2026……..……

Project Title:
Inverse modelling as tool to support F-gases emission monitoring in Europe
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Computer Project Account:
… spitgraz
……..……

Principal Investigator(s):
Francesco Graziosi……..……

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Affiliation:
University of Urbino
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Name of ECMWF scientist(s) collaborating to the project
(if applicable)
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……..……

Start date of the project:
01/01/2025……
……..……

Expected end date:
…31/12/2028……
……..……

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)	10000	--	10000	
Data storage capacity	(Gbytes)	1500	--	1500	

Summary of project objectives (10 lines max)

The project aims to estimate national emissions of fluorinated gases (F-gases) like hydrofluorocarbons and sulphur hexafluoride, which are potent greenhouse gases. Using atmospheric observations and inverse modeling, the project provides "top-down" emission estimates by refining prior data from national inventories or independent datasets. Key inputs include high-frequency atmospheric observations, particularly from central Europe, and the FLEXPARTv10.4 transport model driven by ECWMF ERA5 data. The first year focuses on model setup and testing, while the following years extend the inversion process over 10 to 20 years, emphasizing perfluorocarbons and sulphur hexafluoride. This work aims to enhance the accuracy of national inventories and offer an independent quality assessment.

Summary of problems encountered (10 lines max)

No main problem encountered

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

The continuation of the project will focus on completing the inversion simulations and analysing F-gas (HFCs, CFCs, SF_6) emissions up to 2024 using the newly processed multi-resolution meteorological datasets for Europe and Asia. Additional sensitivity studies will be carried out to assess the impact of meteorological resolution and inversion settings on the emission estimates. The derived HFC-125 and HFC-134a emissions will be validated against national inventories and independent datasets, supporting the preparation of scientific publications and the development of a robust framework for independent verification of F-gas emissions.

List of publications/reports from the project with complete references

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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.

During the second year of the project, substantial progress was made in extending and consolidating the modelling framework for estimating national F-gas emissions. Building on the model chain established during the first year, new meteorological datasets were retrieved and processed for both

Europe and Asia, allowing the inversion system to be applied across different spatial domains and resolutions.
For the European domain, ERA5 meteorological fields were processed at both coarse resolution (1° × 1°) and higher resolution (0.25° × 0.25°), with an additional very-high-resolution setup over the Alpine region at 0.1° × 0.1°. These nested configurations were designed to improve the representation of atmospheric transport, especially for mountain stations and complex terrain, where transport errors can strongly affect the interpretation of observed concentrations. In parallel, meteorological fields were also downloaded and processed for the Asian domain to support the extension of the inversion framework beyond Europe.
Using these meteorological inputs, atmospheric transport simulations were performed up to 2023. The observations were obtained from four stations of the AGAGE network: Jungfraujoch, Monte Cimone, Tacolneston, and Mace Head. The resulting sensitivity fields were integrated into the inversion system and used to derive updated emission estimates for the main target compounds, HFC-125 and HFC-134a. The emissions obtained from the inversion system were analysed and compared with the values reported in the accompanying figures, providing an updated assessment of the temporal evolution of F-gas emissions.
Overall, the second-year activities significantly expanded the geographical and temporal coverage of the project. The availability of multi-resolution meteorological fields, together with simulations extending to 2024, provides a stronger basis for producing robust and policy-relevant emission estimates for HFC-125 and HFC-134a over Europe and Asia. The inversions were conducted in external machine.

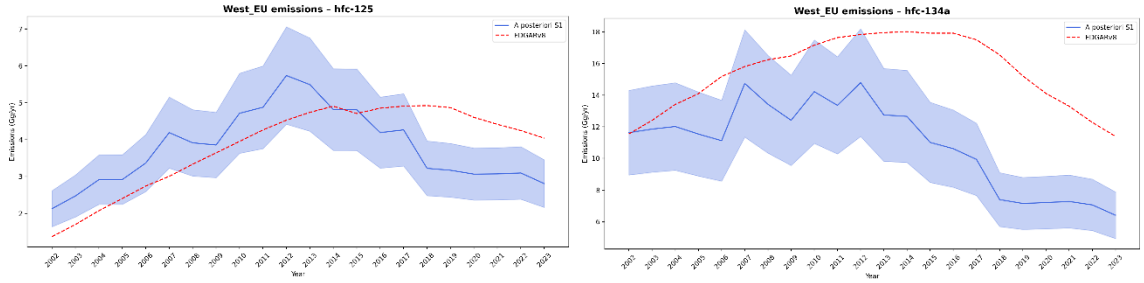

Fig 1 Preliminary annual HFC-125 (left) HFC-134a (right) emissions for Western Europe derived from the atmospheric inversion system for the period **2002–2023**. The estimates are based on atmospheric observations and the inversion framework developed within the project. Results are preliminary and are currently undergoing validation and scientific review.