



Attributing and Verifying European and National Greenhouse Gas and Aerosol Emissions and Reconciliation with Statistical Bottom-up Estimates

Deliverable 7.6

Avengers Dissemination and Exploitation Plan V2.1

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Date: 30/06/2024 (updated 06/12/2024)
Dissemination: Public
Work package: 7.4
Version: 2.1



**Funded by
the European Union**

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 101081322

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Attributing and Verifying European and National Greenhouse Gas and Aerosol Emissions and Reconciliation with Statistical Bottom-up Estimates (AVENGERS)

Call: HORIZON-CL5-2022-D1-02

Topic: HORIZON-CL5-2022-D1-02-01

Type of action: HORIZON Research and Innovation Actions

Granting authority: European Climate, Infrastructure and Environment Executive Agency

Project starting date: 01/01/2023

Project end date: 31/12/2026

Project duration: 48 months

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Document history:

Version	Author(s)	Date	Changes
0.1	M. Scholze & J-N Poussart (ULUND)	31/05/2023	First draft version
1.0	M. Scholze & J-N Poussart (ULUND)	30/06/2023	Final version after internal review
2.0	M. Scholze, J.-N. Poussart (ULUND) & C. Gallo (CMCC)	30/06/2024	Included dissemination / communication activities for first 18 month period and updated plan v1 accordingly
2.1	M. Scholze, J.-N. Poussart (ULUND) & C. Gallo (CMCC)	06/12/2024	Update table to map target groups to each of the identified key results together with the specific dissemination means. Added a more detailed timeline and specification of target groups and dissemination means.

Internal review: TNO, EMPA, iLab

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1 Executive Summary

Dissemination and exploitation activities play a major role in ensuring that the AVENGERS project remains visible within and results are taken up by the wider community.

D7.6 provides an update of the activities performed by the project partners within the first 18 months of the project, and reviews the dissemination and exploitation plans.

To-date, AVENGERS work has been presented 10 times at conferences and workshops; and contributed to a cross HORIZON-CL5-2022-D1-02-01 projects (i.e. AVENGERS, EYE-CLIMA and PARIS) newsletter. One webinar was organised by the project.

Exploitation activities remain focused on improving the various scientific elements produced within the AVENGERS project, with the ultimate aim being to a) reconcile reported major (CO₂, CH₄, N₂O) greenhouse gas (GHG) from national inventory agencies with estimates obtained from using atmospheric observations and b) improve estimates of selected aerosol emissions from atmospheric observations.

During the first 18 months of the project period, two relevant amendments have been approved by the European Commission. The first one is on the inclusion of the Cyprus Institute (Cyl) as an additional beneficiary through a successful Hop-On proposal. The second amendment is on a project extension of six months with the subsequent update of several milestone and deliverable due dates (see tables 5 and 6 in the Appendix). As part of this second amendment, it has been approved to submit the deliverable D6.2 'Guidelines for supporting national inventories' as a common deliverable with EYE-CLIMA (one of the other two additional projects funded under the topic HORIZON-CL5-2022-D1-02-01). This is essentially a result of an established and effective cross-project cooperation.

2 Introduction

The project's overall objective is to reconcile reported GHG emissions with independent information from atmospheric observations using top-down methods and process-based models, aiming at reducing the most important uncertainties of national emission inventories. For this, AVENGERS will develop methodologies for the use of high-quality atmospheric data in national GHG inventory reports, in close cooperation between atmospheric scientists and inventory compilers.

This Dissemination and Exploitation Plan is a Deliverable of WP 7: Coordination and Management (as part of Task 7.4), developed in two versions; version 1 by month 6 of the project and an updated version 2 by month 18 of the project. This report constitutes the updated version including first a short update of dissemination activities during the first 18 months followed by the general description of the Dissemination and Exploitation Plan.

3 Report on Dissemination and Exploitation Activities

AVENGERS has been active on various dissemination streams, including workshops, conferences, etc.

The dissemination activities since the start of the project are presented in Table 1 below. Most of these events are also listed on the project website that acts as AVENGERS's main dissemination tool. During the upcoming project period the project website will increasingly be used to also announce future events with AVENGERS participation.

Type of dissemination and communication activities	Description
Conferences	WMO International Greenhouse Gas Monitoring Symposium <ul style="list-style-type: none"> • Geneva, CH, 30 Jan-01 Feb, 2023 • Poster
	WMO Observations within the Global Greenhouse Gas Watch <ul style="list-style-type: none"> • Geneva, CH, 30 Jan-01 Feb, 2023 • Part of organization committee; Oral presentation
	UNFCCC Conference of Parties 28 <ul style="list-style-type: none"> • Dubai, UAE, 30 Nov-12 Dec, 2023 • Participation and discussions
	EGU General Assembly <ul style="list-style-type: none"> • Vienna, AT, 14-19 Apr, 2024 • 2 Oral presentations; 2 On-site posters; 1 Virtual poster; 1 Splinter meeting
	UNFCCC SB 60 <ul style="list-style-type: none"> • Bonn, DE, 3-13 Jun, 2024 • Participation and discussions
Workshops / meetings	WMO G3W (modelling) <ul style="list-style-type: none"> • Bonn, DE, 19-21 Sep, 2023 • Oral presentation
	Implications of Methane Remote Sensing for Control Policies <ul style="list-style-type: none"> • Los Angeles, US, 02-03 Oct, 2023 • Oral presentation
	3rd Annual Workshop: Climate and Atmosphere Research & Innovation in the Eastern Mediterranean & Middle East <ul style="list-style-type: none"> • Online, 7 Nov, 2023 • VPico presentation
	CoCO2/CORSO Annual Meeting / Stakeholder workshop <ul style="list-style-type: none"> • Wageningen, NL, 20-22 Nov, 2023 • 2 Oral presentations; 1 poster; Several people attending and participating in the discussions
	ESA-EC Earth System Science Initiative <ul style="list-style-type: none"> • Frascati, IT, 21-24 Nov, 2023 • Oral presentation
	ICCARUS ICON/COSMO User Seminar <ul style="list-style-type: none"> • Offenbach, DE, 04-07 Mar, 2024 • Oral presentation

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	Symposium 50 years Dutch emission inventory <ul style="list-style-type: none">• Wageningen, NL, 11 Jun, 2024• Oral presentations
Website	https://avengers-project.eu/
Webinar	A Primer on Atmospheric Inverse Modelling: Towards greenhouse gas emission monitoring using atmospheric measurements <ul style="list-style-type: none">• Online, 24 Oct, 2023• Presentation of inverse modelling for general public• General presentation of the project
Press release / Newsletter	Newsletter-GHG Emissions Projects

In order to facilitate the collaboration among the three projects funded under the same topic (HORIZON-CL5-2022-D1-02-01: AVENGERS, EYE-CLIMA and PARIS) various activities have either been established as a series of events, hold as single events or planned for the upcoming project period:

- Cross-project Webinars (two per year)
- Cross-project bi-annual Newsletter
- Cross-project Early Career Network with bi-monthly meetings
- Cross-project EGU General Assembly 2024/25 splinter meetings
- Guidelines deliverable with EYE-CLIMA
- Linked training events with EYE-CLIMA

In particular, the cross-project webinar series with the plan to have two webinars per year was organised following the success of the AVENGERS webinar 'A Primer on Atmospheric Inverse Modelling' which was held in October 2023 with more than 140 participant connections (some of them included larger groups of people following the webinar). AVENGERS also contributed and contributes to a cross-project (also including the CAMS CO2MVS) annual newsletter highlighting project news and results. The newsletter is widely distributed among the target audience (see below for a list of target groups). As also listed above, AVENGERS and EYE-CLIMA will closely collaborate on the development of guidelines using atmospheric derived emissions estimates for supporting national inventories. Through the amendment it has been agreed with the EC to submit the guidelines as common deliverable of both projects AVENGERS and EYE-CLIMA. For AVENEGERS this constitutes deliverable D6.2. In connection with the guidelines EYE-CLIMA is planning to hold a training event, whereas AVENEGRS is organising a training event on the Flexible Inversion Tool for Inventory Compilers (FIT-IC, deliverable D6.1). The current planning is to organise these two training events back-to-back at the end of the projects to facilitate participation in both events.

In addition to the collaboration with EYE-CLIMA and PARIS, project partners have reached out and established links to other ongoing projects such as the HEU projects CORSO, GREENFEEDBACK, the ESA projects MEDUSA, SMART-CH4 and World Emissions.

In terms of interaction with stakeholders beyond the national inventory agencies that are project partners, AVENGERS, together with EYE-CLIMA and PARIS, was in contact with EEA and prepared a short project overview for use by EEA.

Additional dissemination work has been done by project partners to improve the Community Inversion Framework (CIF; inclusion of ensemble square root filter method and diagnostic tools) that is publicly available and can be used by other research groups.

4 Scope of Dissemination and Exploitation Plan

The plan provides general guidance to how knowledge, tools, models, databases and country- and region-specific information can be made widely available, e.g. to peer scientists, environmental and inventory reporting agencies, policy-makers). It therefore details pertinent to:

- The AVENGERS visual identity
- Communication and dissemination target audiences
- Dissemination management and distribution of roles and responsibilities
- Dissemination and communication channels/instruments
- The timing of dissemination activities
- The integration of project outputs and expected outcomes
- The exploitation strategy to increase the probability that the new knowledge, understanding, methods and products generated during the project will be effectively exploited by partners as well as interested third parties in further research and innovation activities after the end of the project.

Relevant stakeholders (such as the partner inventory agencies) will actively participate in the co-design of dissemination and exploitation activities, to develop the exploitation strategy in a way that contributes to maximize the impact of the project beyond its own lifetime; in particular, national inventory experts, members of the advisory board and partners within the consortium that are involved within international frameworks (e.g. GEO, UNFCCC, IG3IS).

4.1 Project Results

The project aims to accomplish the following key results:

1. **Improved inversion systems** for GHG and aerosol emissions estimation based on multiple observations and methodologies.
2. **Good practice guidelines** on how top-down emission estimation systems can support GHG inventories and the Global Stocktake.
3. **A Flexible Inversion Tool** for Inventory Compiler for demonstrating the strengths and weaknesses in estimating GHG emissions, which will be made available to national inventory compilers.
4. **Observation-based estimates of GHG emissions** (CO₂, CH₄, N₂O) for European countries (with a specific focus on Germany, The Netherlands, Sweden and Switzerland such that they can be used as input in the respective GHG inventories).
5. **Observation-based estimates of aerosol emissions** and their uncertainties for European countries.
6. **Improved estimates of uncertain emission factors** used in the inventories, based on process modelling in ORCHIDEE and LPJ-GUESS of Sweden and Italy for the AFOLU sector.
7. **Estimates of the climate impact of national emissions** in terms of radiative forcing taking into account the radiative impact of aerosols and GHGs.
8. **An evaluation of future observing systems** (both satellite and in-situ) in terms of their potential to further reduce uncertainties in the estimated GHG emissions and corresponding guidelines on the design of the networks.
9. **An estimate of the impact of planned satellite missions** for quantifying aerosol emissions

10. **Scientific publications** on the contribution of top-down techniques to the verification of national GHG inventories and their reconciliation with relevant assessment and monitoring systems as well as on aerosol emissions estimations.
11. **Trained employees** (on a PhD as well as postdoc/researcher level) in the growing field of GHG and aerosol emissions estimations, inventory compilation and reporting.

The main target groups and stakeholders of the project as well as the envisaged dissemination means are listed below and summarized in the following table.

- **End-users**
 - *Representatives:* National inventory agencies and compilers from countries represented in the AVENGERS project (from Germany, The Netherlands, Sweden, Italy and Cyprus), as well as all from other countries in Europe (e.g. EPA Ireland, UBA Austria, CITEPA France) or world-wide who want to benefit from the emission estimation methodologies developed in the project.
 - *Means:* We will establish connections to the agencies outside of AVENGERS through the links and networks of the agencies represented in AVENGERS as well as through established connections from previous Horizon 2020 projects such as VERIFY and COCO2. We also have set up a list with contact details of potential stakeholders (incl. inventory agencies across Europe) together with Eye-Clima, PARIS and CAMS. We will invite these contacts to our webinars and distribute the newsletters and the guidelines to them.
- **Policy makers**
 - *Representatives:* United Nations Framework Convention on Climate Change (UNFCCC), United Nations Environment Programme (UNEP) and more specifically IMEO, European Environment Agency (EEA), European Commission (EC) through relevant DGs (Climate Action, Defense and Space, Environment, and Research and Innovation), national environment agencies and governmental ministries in charge of climate policy (both from countries who are represented as beneficiaries in AVENGERS).
 - *Means:* Dissemination to this target group will be either through direct contacts of AVENGERS beneficiaries to such policy makers (i.e. national inventory agencies to respective governmental officials) or through outreach activities such as bi-annual newsletters and webinars, and relevant symposia/town halls meetings.
- **Scientific community**
 - *Representatives:* Colleagues studying GHG and aerosol emissions (carbon cycle, climate, change and feedback processes in the field of Earth system science).
 - *Means:* Dissemination of project outcomes will take place in the form of peer-reviewed publications as well as presentations at scientific conferences such as EGU, AGU and ICOS Science conference.
- **International organisations**
 - *Representatives:* Global Carbon Project (GCP), Group on Earth Observation (GEO), WMO's Integrated Global GHG Information System (WMO-IG3IS) and the newly established Global Greenhouse Gas Watch (WMO-G3W).
 - *Means:* For all these international organisations we have established links either through direct participation in relevant activities of AVENGERS colleagues (IG3IS, G3W, GCP) or through members of the AVENGERS Scientific Advisory Board. We will invite these contacts to our webinars and distribute the newsletters and the guidelines to them. Additionally we will brief our advisory board members on project news and outcomes.
- **Society**

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- *Representatives:* Citizens/entities benefiting from improved open access information about emissions, and an improved quality control on reported emissions through the use of independent atmospheric measurements.
- *Means:* We will release press releases for any major (news worthy) project outcomes as well as highlight project news on the project website. In addition we will present the AVENGERS project and the general problematic around emissions estimation and verification at through e.g. presentations at Open University Days.

A table relating the main target groups to the key results along with the main dissemination measures is provided

4.2 Links between work packages and deliverables

Task 7.4 of AVENGERS: Communication and Dissemination is done in collaboration with WP6 that focuses on outreach, liaison with, and input to international programmes. WP6 brings the outcome of the project to the service of the global stocktake of the Paris Agreement and provides input and contributions to international programmes and assessments (such as IPCC and Global Carbon Project), through the provision of guidelines including identification of open data and metadata standards, facilitating the transfer of information and tools, and ensuring the replicability of methodologies and tools worldwide.

A Data Management Plan, as a separate project Deliverable will also be delivered in three successively more detailed versions (v1 at month 6, v2 at month 24 and v3 at month 42)

4.3 Intellectual property management

The consortium is aware that transparency and clarity in terms of results ownership is needed to strengthen the deployment and exploitation of innovative solutions. Knowledge generated will be managed in compliance with the Consortium Agreement (CA), signed at the beginning of the project. The CA will address background and foreground knowledge, ownership, protected third party components, and protection, use, and dissemination of results and access rights. The basic principles are that:

- Background information and knowledge of the participants will be provided royalty-free to other participants for the implementation of the project's tasks.
- Results shall be owned by the partner who generated them. Each participant will be responsible for ensuring fulfilment of their obligations under the CA regarding results by planning with any third parties that could claim rights to them.
- Whenever results have been produced jointly by two or more participants, the ownership of the results will be shared among the participants who carried out the work. The terms of joint ownership, protection, share of ownership, and costs for possible protection will be agreed upon in writing by a joint ownership agreement.
- Each participant will be responsible for examining possibilities to protect results that may be commercially or industrially exploited. When deciding on protection, the participant must consider its own legitimate interests and the interests of the other participants. Participants will ensure that adequate steps towards protection are taken prior to deployment,

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exploitation and commercialisation activities, preventing unapproved public disclosure of results, models, tools, and data.

- Access rights to results will be granted on a royalty-free basis for further research, and on fair and reasonable conditions if needed for commercial exploitation.

4.4 Impact indicators

AVENGERS' Key Performance Indicators (KPIs) are described in table 2 below.

KPI	Description	Target	Threshold	Achieved so far*
1.1	Produced number of datasets of emission factors, GHG and aerosol emissions for the EU, freely available upon request	6 datasets	2 datasets	3 datasets
1.2	Updated the gridded maps of the three main anthropogenic GHG and aerosol emission fields to recent years	4 maps	2 maps	None so far
1.3	Results of the bottom-up estimates (WP4) and of the inverse modelling approach (WP2) are tested by a KPI number of European national environmental agencies in the 5 selected areas/regions of case-study countries	3 agencies	1 agency	None so far
2.1	Use of the data created in WP2-3-4 by a KPI number of inventory agencies inside the consortium for national inventories' verification purposes	4 agencies	2 agencies	2 agencies
2.2	Presentation of the results at the final event to ≥10 European inventory agencies, with emphasis on key results: reconciled emission estimates (D1.4), comparison of GHG and aerosol radiative forcing (D1.5), Flexible Inversion Tool for Inventory Compiler (D6.2) and best-practice guidelines (D6.1)	10 agencies	5 agencies	Not yet applicable
2.3a	Number of attendees to the first webinar on project presentation	60 attendees	30 attendees	~140 attendees
2.3b	Number of attendees to the webinar on project results	60 attendees	30 attendees	Not yet applicable
3.1	Number of international programmes/initiatives directly involved in dissemination and outreach of project results.	5	3	1
3.2	Number of EU and non-EU programmes, initiatives, networks and knowledge platforms with which the project will collaborate.	10	6	4

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4.1	The Flexible Inversion Tool for Inventory Compiler is tested in KPI number of countries	4	2	Not yet applicable
4.2	The updated emissions factors of the three major GHGs are used by KPI number of EU member states.	5	3	Not yet applicable

* Explanation of Achievements

- 1.1: Deliverables D2.1, D2.2 and D3.1
- 2.1: RIVM and UBA have looked into datasets resulting from the project
- 2.3a: Webinar on 'A Primer on Atmospheric Inverse Modelling'
- 3.1: Copernicus Atmospheric Monitoring Service (CAMS)
- 3.2: EYE-CLIMA, PARIS, cross-project Early Career Researchers network, CAMS

5 Dissemination plan

Expected key project results are listed in section 2 above, framing the essence of dissemination activities. The main target groups are also listed in Table 3 below, including end-users, policy makers, the scientific community, international organisations and society as a whole.

Dissemination activities are designed around providing/disseminating information to the scientific communities and relevant stakeholders in three key areas:

1. Scientific and technical results through:
 - Scientific publications
 - Conference talks
 - Organised workshops, providing updates on the project results
 - Reports to, and feedback, from committees and boards

2. Products through dissemination of:
 - Datasets and accompanying material (e.g. descriptions, metadata) at the ICOS Carbon Portal
 - Good practice guidelines (published together with Eye-Clima either as a booklet or as a white-paper)
 - Tools / algorithms / specifications

3. Progress information through provision of:
 - Regular digital newsletters
 - Public project deliverables
 - Dissemination materials (posters)
 - Website and social media

One of the major project contribution to the dissemination is the deliverable report D6.2 'Guidelines for supporting national inventories'. This deliverable report has been approved to be a common deliverable with EYE-CLIMA (one of the other two additional projects funded under the topic HORIZON-CL5-2022-D1-02-01). It will be delivered towards the end of the project (M) summarising the knowledge gained and results achieved in both projects in a language that is understandable for non-atmospheric inversion experts. To avoid disseminating contradicting information/guidelines the report will be produced in coordination with WMO's Integrated Global Greenhouse Gas Information System (IG3IS) who is preparing a national scale emissions estimation report.

Table 3 below provides information on the AVENGERS Dissemination (and Communication) Targets.

Target group	Key Result (see 4.1)	Communication / Dissemination Means
End users	2, 3, 4, 6, 11	Dissemination: <ul style="list-style-type: none"> • Workshops and resulting reports • Good practice guidelines Communication: <ul style="list-style-type: none"> • Project and/or relevant news/newsletters (CINEA/AVEYPA*) • Tailored updates on the results • AVENGERS website
Policy makers	4, 5, 7	Dissemination:

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		<ul style="list-style-type: none"> • Workshops and resulting reports • Good practice guidelines Communication: <ul style="list-style-type: none"> • Project and/or relevant news/newsletters (CINEA/AVEYPA*) • Tailored updates on the results • AVENGERS website
Scientific community	1, 2, 3, 10, 11	Dissemination: <ul style="list-style-type: none"> • Peer-reviewed scientific papers • AVENGERS data portal • Workshops • Conferences Communication <ul style="list-style-type: none"> • Newsletters (CINEA/AVEYPA*)
International organisations	10, 11	Dissemination <ul style="list-style-type: none"> • AVENGERS data output at ICOS Carbon Portal Communication <ul style="list-style-type: none"> • Targeted publication material • Links with relevant projects and initiatives • Representation at relevant conferences and fairs • Newsletters (CINEA/AVEYPA*)
Society / General public	4, 7	Communication <ul style="list-style-type: none"> • General Information Material • AVENGERS website • Press releases • Public lectures

*: CINEA – Climate, Infrastructure and Environment Executive Agency; AVEYPA – Avengers, Eye-Clima and Paris

5.1 Dissemination timeline

Figure 1 below shows the general time plan for dissemination, the red vertical line indicates the time of this deliverable. A more detailed timeline focussing on the dissemination of the project’s key results as listed in Section 4.1 is provided in Figure 2. A first webinar was successfully given in Oct 2024 (M10) and more webinars (in collaboration with EYE-CLIMA and PARIS) and training events as indicated by the bars (blue bars aiming for policy makers and the general public incl. scientists) will follow. Presentations at conferences are ongoing and will continue during the project and beyond the project end. Brown bars indicate scientific conferences, showing exemplary the annual EGU/AGU and similar re-occurring meetings. UNFCCC events and JRC workshops (shown as blue bars) are important venues to interact with policy makers. The brown/blue striped bar was a WMO conference aimed at both scientists and policy-makers (inventory agencies). Dissemination in journal papers has already started during the fires reporting period and will continue during the next project phase with more upcoming project results and continues after the project ends. Contributions to IPCC (mainly

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through peer-reviewed publications) and GCP (through contributions to the Global Carbon Budget) will start during the next project phase.

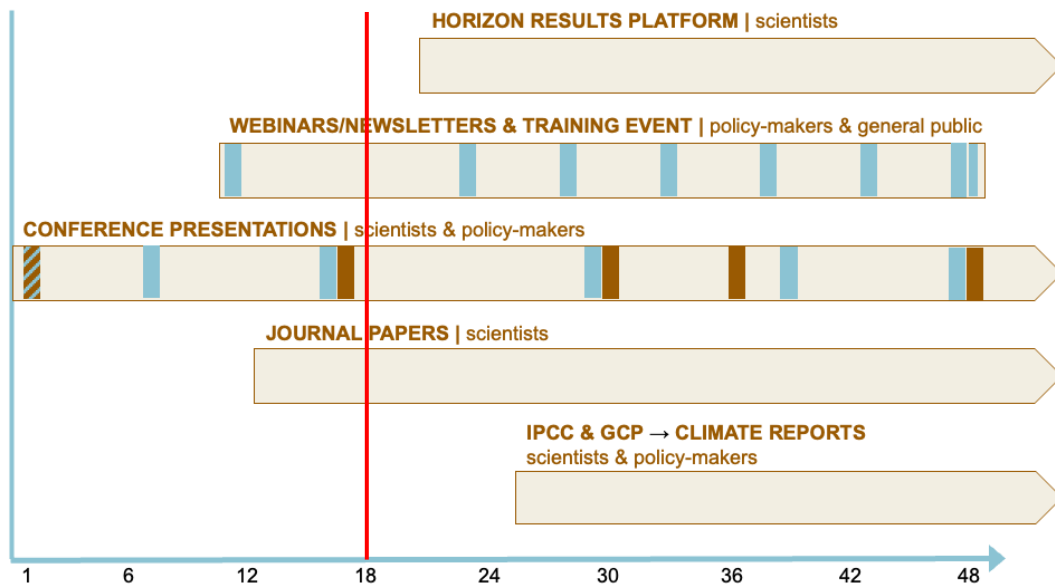


Figure 1: General time plan for project dissemination, the red bar indicates time time of the first review.

We envisage to participate (maybe even co-organise together with CAMS and/or ICOS and a member of the parties) in a side event at COP30 and COP31 to present project results around monitoring and verification of emissions based on atmospheric records. Of special interest for this will be the FIT-IC tool as well as the guidelines. In Figure 2 scientific publications are included exemplary. Also, only the main fixed scheduled conferences such as EGU's General Assembly (annually), ESA's Living Planet Symposium (every two years), the ICOS Science conference (every two years) are listed for future conference participation. In addition to these there will be 'conferences of opportunity', which do not occur on a regular, fixed schedule but where AVENGERS partners will also participate and disseminate project results. The timing of the planned webinars including their potential topics are listed under section 5.3.4.

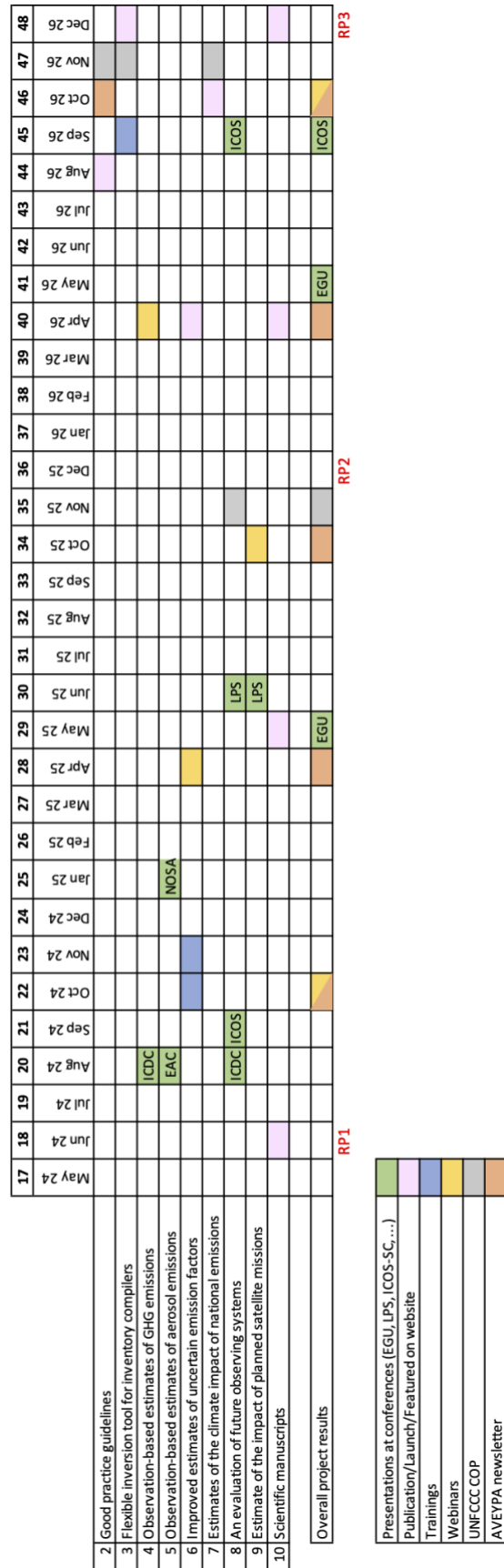


Figure 2: Timeline planning of dissemination events for the project's key results from M17 onwards (RP1-3 indicate the timing of the project reviews).

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5.2 AVENGERS visual identity

An AVENGERS project logo was agreed upon by the consortium in addition to the standard colour scheme.



AVENGERS green colour codes:

RGB: 67, 106, 86

CMYK: 73, 37, 67, 27

Hex: #436a56

5.3 Dissemination instruments

5.3.1 AVENGERS project website

The AVENGERS website (<https://avengers-project.eu/>) serves as the main dissemination instrument for the project.

Past and future events with AVENGERS participation (such as conference presentations, engagements in workshop/discussion meeting, webinars/newsletters) are announced on the website together with regular news updates. Also, any project results such as datasets and other resources (deliverable reports) are published on the project website.

The website also provides access to the data portal, as specified in the Data Management Plan (D7.3), building on existing tools and services of the Integrated Carbon Observation System (ICOS) Data Portal. The AVENGERS data portal provides an interface to the distributed data and products made available by the project and is therefore also a major dissemination instrument in itself.

5.3.2 Conferences

Strong engagement with the academic sector will promote the work performed AVENGERS and at the same time follow the scientific developments taking place outside the consortium. This exchange of information and knowledge will be realised through attendance of scientific conferences, organisation of sessions devoted to AVENGERS, and by the general process of AVENGERS scientists attending and presenting seminars and engaging in discussion at universities and research institutes.

AVENGERS will benefit from the contacts that the partners have with some international initiatives, programmes and networks. Conferences and events of interest for AVENGERS, where results and outcomes will be presented include:

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- The periodic AGU/EGU general assemblies
- ESA's Living Planet Symposiums
- ICOS Science Conferences
- GEO (Group on Earth Observation) Week
- International Workshop on GHG Measurements from Space (IWGGMS)
- UNFCCC COP/SB (2024, 2025, 2026)
- The annual LULUCF workshops organised by the EC's Joint Research Centre
- Annual forums on research and systematic observation (RSO) organized by UNFCCC
- Research dialogue and Earth information days through ICOS
- IG3IS science meeting and stakeholder consultations
- FAO's World Forestry Congress 2026
- UNECE TFEIP (Task Force on Emission Inventories and Projections) meetings
- IUFRO (International Union of Forest Research Organizations) World Congress

5.3.3 Open access scientific publications

Publication in open-access scientific journals will play a major role as this allows a rigorous peer-review to take place, ensuring that AVENGERS results are relevant to the community. Among the relevant Journals are for example:

- Atmospheric Chemistry and Physics (ACP) <https://www.atmospheric-chemistry-and-physics.net/>
- Geoscientific Model Development (GMD) <https://www.geoscientific-model-development.net/index.html>
- Earth System Science Data (ESSD) <https://www.earth-system-science-data.net/>
- Biogeosciences (BG) <https://www.biogeosciences.net/>
- Earth System Dynamics (ESD) <https://www.earth-system-dynamics.net/>
- Journal of Advances in Modeling Earth Systems (JAMES) <https://agupubs.onlinelibrary.wiley.com/journal/19422466>

5.3.4 Webinars, workshops, seminars

Events are and will continue to be organized covering the core topic of the project and involving the major experts and institutions in the field of atmospheric inverse modelling and data assimilation, remote sensing, environmental monitoring and observation, terrestrial ecosystem modelling. Special attention will be paid to national inventory compilers. At the initial stage of the project, an introductory webinar on the status and potentials of top-down monitoring systems was organised. Due to its large success AVENGERS, EYE-CLIMA and PARIS agreed to organise now a cross-project webinar series (as outlined above) instead of the originally planned one other AVENGERS webinar.

Topics and timing for the upcoming webinars have already been discussed and agreed upon with EYE-CLIMA and PARIS:

- Autumn 2024: The process of collaboration between atmospheric scientists and national inventory agencies using the example of UK and C
- Spring 2025: Process-based modelling of land surface greenhouse gas fluxes emissions (LPJ-GUESS/ORCHIDEE as an example)
- Autumn 2025: Satellite remote sensing of CO₂ and CH₄, mapping of point sources

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- Spring 2026: Satellite remote sensing of land biosphere and mapping terrestrial biomass
- Autumn 2026: Atmospheric inverse modelling and using the results to support NGHGs

The webinars will be organised in turn by CMCC and ICOS.

5.3.5 Collaboration with research projects, programmes and networks

AVENGERS has established strong collaboration with its two “sister projects”, both running throughout the full project period (from January 2023 for 48 months).

- EYE-CLIMA: Verifying Emissions of Climate Forcers
- PARIS: Process Attribution of Regional Emissions

Regular Coordinator meetings are held between the three projects, and a common stakeholder group is set-up. An Early Career Researchers (ECRs) network from the 3 EU-funded projects (EYE-CLIMA, AVENGERS and PARIS) has been set-up (coordinated by PARIS), for PhD students and post-doctoral researchers in their first five years post-PhD.

As part of this collaboration, the above mentioned webinar series is organised to disseminate project cross-project results. In addition, bi-annual cross-project newsletters (together with the Copernicus Atmospheric Monitoring Service, CAMS, who is in charge of implementing a CO2 MVS capacity) will be sent out to the common-stakeholder group. These newsletters report on individual project results but also on common activities such as the webinars, EGU splinter meetings etc.

The project will make full use of the Community Research and Development Information Service (CORDIS), as the EC’s primary source of results from projects funded by the EU’s framework programmes for research and innovation. The monthly newsletter sent out internally within EC divisions by EU/CINEA may serve as a good communication channel to increase awareness on AVENGERS activities and results.

Other key research projects, programmes and networks of interest to AVENGERS include (for some of which established collaborations or working connections exist already) :

- CORSO
- ICOS-Cities
- GreenFeedback
- TRANSCOM
- Relevant JPI Climate projects

5.3.6 Scientific Committees

Members of the AVENGERS consortium are actively engaged in European and international science networks and programmes, enabling the promotion of the project and its outputs to a broad range of scientific and inventory communities, key international programmes and policy-makers. AVENGERS partners are represented, among others, in the following international programmes:

- EC CO2 Monitoring Task Force

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- WMO GAW Scientific Advisory Group
- WMO IG3IS steering committee
- UNFCCC Roster of Experts and Delegate Experts
- EU Climate Change Committee, Working Group 5 (LULUCF)
- Lead Author in the IPCC 2019 Refinement
- Co-Chair of the Climate Change Working group at GEO
- GEIA (IGAC- Global Emission Inventory Activity) steering committee

5.3.7 AVENGERS Advisory Board

The consortium is accompanied by an Advisory Board (AB) of three high-profile experts representing international organisations, policy-makers, and carbon cycle scientists:

- Pierre Friedlingstein (University of Exeter, UK),
- Mark Dowell (EC Joint Research Centre, Ispra, IT) and
- Sara Mikaloff-Fletcher (National Institute of Water & Atmospheric Research – NIWA, NZ).

The members of the AB will support the AVENGERS research activities through expert advice, outreach to international programmes, provision of feedback and critical review of the results and products generated throughout the project.

5.3.8 Skilling/training events

To boost the uptake of methods and products, training activities for knowledge exchange and capacity building will involve inventory compilers, scientific and technical expert in relevant fields (e.g. atmospheric inverse modelling and data assimilation, remote sensing, environmental monitoring and observation, terrestrial ecosystem modelling, GHG inventory, climate policies), national and EU policy-makers. In particular, the project will organise an open training event for the FIT-IC targeting inventory compilers which, as mentioned above, will most likely be organised back-to-back with an EYE-CLIMA training event on the use of atmospheric based emissions estimates by inventory agencies. This training event will be organized towards the end of the project in late autumn 2026.

5.3.9 Lectures

University partners will include in their lessons the recent results from AVENGERS into the curriculum and train the next generation of researchers in top-down approaches and emissions quantification. Communication and dissemination activities will be aligned and coordinated with exploitation activities, which will aim at generating favourable circumstances for the exploitation of the following three main results:

1. The Flexible Inversion Tool for Inventory Compiler (D6.2), which will be a prototype demonstrator. We will co-design and co-develop the FIT-IC with inventory agencies, which

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will have the opportunity to use the prototype during the project and provide feedbacks that will help the developers to fine-tune it for GHG inventory purposes. The system will be introduced to other European agencies at the final project event.

2. The good practice guidelines (D6.1) are conceived to promote top-down methods in the inventory community, and in particular they are addressed to inventory compilers. The guidelines will condense and enhance the knowledge gained in the AVENGERS case studies.
3. Estimates of European GHG (CO₂, CH₄ & N₂O) and aerosol emissions and their trends using top-down approach (D.2.5; D.2.6; D.2.7). This data will be especially useful for National and EU policy-makers, scientific community, national inventory compilers, who can use the data to verify their estimates and assess more accurately the impact of emission reduction efforts.

5.3.10 Final project event

AVENGERS will organise a final event (potentially together with EYE-CLIMA and PARIS) in the form of a larger workshop / mini-conference with scheduled presentations on project results by project partners, selected invited presentations from colleagues outside of the project (potentially members of the SAB) but relevant to the project's objectives and free discussion time. The event will be organized at the end of the project and we will invite representatives from

- European inventory national inventory agencies,
- international initiatives (e.g. GCOS, GEO, ICOS etc.),
- decision-makers / policy-makers,
- scientists.

The event will put special focus on the FIT-IC, and the guidelines to maximize the exploitation of top-down approaches.

6 Exploitation plan

An exploitation strategy will increase the probability that the new knowledge, understanding, methods and products generated during the project will be effectively exploited by partners as well as interested third parties in further research and innovation activities after the end of the project. Relevant stakeholders will actively participate in the co-design of dissemination and exploitation activities, to develop the exploitation strategy in a way that contributes to maximize the impact of the project beyond its own lifetime; in particular, national inventory experts, members of the advisory board and partners within the consortium that are involved within international frameworks (e.g. GEO, UNFCCC, IG3IS).

6.1 Exploitation targets

Project results should contribute to achieve the following expected outcomes (EO):

- EO1 - Enhancing the ability to ascertain whether and to what extent emission reduction efforts are producing the desired atmospheric signals for key greenhouse gases on relevant spatial and temporal scales.
- EO2 - Better understanding of apparent discrepancies between reported greenhouse gas (GHG) emissions and removals (in national inventories and other schemes), measured atmospheric signals and modelled levels, with the aim of reducing and/or reconciling them on the long run.
- EO3 - Reduced uncertainty of national GHG inventories through improved comparability with models and observations and piloting top-down approaches recognised in the 2019 refinement of the IPCC 2006 Guidelines for National Greenhouse Gas Inventories.
- EO4 - Contribution to improving the attribution of GHG fluxes (anthropogenic vs natural) as well as non-GHG atmospheric climate forcers (such as aerosols), including feed-backs.
- EO5- Support the Paris Agreement, in particular the Global Stocktake, and the implementation and monitoring of EU climate policy instruments.
- EO6 - Provide input (such as open data, models, methods and protocols) and contributions to international programmes and assessments (such as IPCC, Global Carbon Project).

6.2 Exploitation activities and pathways

The following table 4 summarises exploitation activities and pathways envisioned.

Exploitable products	<ul style="list-style-type: none"> • Good practice guidelines on how top-down emission estimation systems can support GHG inventories and the Global Stocktake. • A Flexible Inversion Tool for Inventory Compiler • Observation-based estimates of GHG emissions (CO₂, CH₄, N₂O) for European countries • Observation-based estimates of aerosol emissions and their uncertainties for European countries. • Improved estimates of uncertain emission factors used in the inventories • Estimates of the climate impact of national emissions in terms of
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	<p>radiative forcing taking into account the radiative impact of aerosols and GHGs</p> <ul style="list-style-type: none"> • An evaluation of future observing systems (both satellite and in-situ) • An estimate of the impact of planned satellite missions for quantifying aerosol emissions
<p>Exploitation activities during the project</p>	<ul style="list-style-type: none"> • Links with the CO2MVS (exploiting generated datasets & acquired knowledge for uptake in the CO2MVS, common stakeholder database) • Integration of the resulting emission datasets into the national emission inventory reports for selected countries (e.g. Switzerland) • Webinars/Workshops with stakeholders
<p>Exploitation activities after the end of the project</p>	<ul style="list-style-type: none"> • Exploitation activities post-AVENGERS will depend on the results of the research conducted in AVENGERS • Further development/exploitation of the inverse modelling systems (both for GhGs as well as aerosols) on various scales in future research projects post-AVENGERS • Further development/exploitation of emission estimation algorithms (spatialisation) as well as uncertainty characterization on various scales in future research projects post-AVENGERS. • Uptake and exploitation of AVENGERS results in university courses on data assimilation methods, GhG cycling, atmospheric physics and chemistry, terrestrial ecology/forestry • Uptake and exploitation of the FIT-IC by inventory compilers and also as a demonstrator for future training purposes • Something on the guidelines • Future usage and exploitation of emissions datasets (priors) for both GhG and aerosols (Improved land surface conditions in atmospheric models, i.e. numerical weather prediction models, air quality models, and climate models) • Uptake and exploitation of the results from the Network design experiments guiding upcoming satellite mission design as well as in-situ measurement networks • Uptake and exploitation of improved emission factors by agriculture/forestry actors • Exploitation of the established stakeholder network in future research projects post-AVENGERS

7 Appendices

Table 5: List of deliverables

Deliverable (number)	Deliverable name	WP number	Short name of lead participant	Type	Dissemination level	Delivery date (month)
D7.1	Risk and quality management plan	7	VUA	R	PU	2
D7.2	Project website	7	VUA	DEC	PU	3
D3.1	Input data for aerosol inversions	3	TNO	DATA	PU	5
D7.3, D7.5 & D7.7	Data management plan	7	ICOS	R	PU	6, 18, 48
D7.4 & D7.6	Dissemination Plan	7	ULUND	R	PU	6, 18
D2.1	Data set on observations	2	ULUND	DATA	SEN	12
D1.1	User stories (case-studies) and user needs	1	UBA	R	PU	18
D2.2	Prior emissions for for European inversions and national case studies	2	TNO	DATA	SEN	18
D1.2	Target quantities for future observing capabilities in WP5	1	UBA	R	PU	22
D5.1	Preliminary scenarios and assessments in WP5	5	iLab	R	PU	22
D8.1	National Reporting Status Assessment	8	Cyl	R	SEN	25
D1.3	TOPAS_CH ₄ service	1	TNO	DEC	PU	28
D3.2	Posterior aerosol emissions inventory	3	VUA	DATA	PU	34
D2.3	European CO ₂ inversions	2	iLab	R	PU	35
D2.4	European CH ₄ inversions	2	VUA	R	PU	35
D2.5	European N ₂ O inversions	2	EMPA	R	PU	35

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D3.3	Aerosol forcing estimates and uncertainties	3	VUA	DATA	PU	36
D4.1	Modelled C and N ₂ O fluxes and emission factors	4	ULUND	R	PU	36
D4.2	Attribution of European methane emissions	4	VUA	R	PU	36
D2.6	National case-studies GHG inversion	2	ULUND	R	PU	41
D8.2	Report on Regional Forcings (RF) and Regional MVS	8	Cyl	R	PU	41
D4.3	Method for spatially explicit LULUCF GHG emissions	4	ISPRA	R	PU	42
D3.4	Intercomparison of emissions and forcings	3	ULUND	R	PU	43
D2.7	Synthesis and recommendations on GHG inversions	2	EMPA	R	PU	43
D6.1	Guidelines for supporting national inventories	6	VUA	R	PU	44
D1.4	Reconciliation of top-down and bottom-up estimates	1	VUA	R	PU	46
D1.5	GHG and aerosol national contributions to radiative forcing	1	VUA	R	PU	46
D3.5	Impact of observations from future missions	3	VUA	R	PU	46
D5.2	Final scenarios and assessments in WP5	5	iLab	R	PU	46
D8.1	Improved Access to R&I excellence	8	Cyl	R	Sen	47
D6.2	Flexible Inversion Tool for Inventory Compilers	6	iLab	Other	PU	48
D6.3	Project contribution to international initiatives	6	CMCC	R	PU	48

Table 6: List of milestones

Milestone number	Milestone name	Related WP(s)	Due date (in month)	Means of verification
M1	Project initiated	7	2	Minutes of KO meeting
M2	Test sets for aerosol emissions data	3	3	data provided to model teams
M3	Model input data for DGVM	4	6	Data quality validated
M4	First set of case-studies	1	7	Requirements made available
M5	TOPAS_CH4 demonstrator	1	12	Website running
M6	First set of prior emissions	2	12	Data made available to project partners
M7	Initial observation scenarios	5	12	list of scenario specification
M8, M13 & M15	General assemblies	7	15, 29, 42	Minutes of meetings
M9	Inverse models setup	2	23	Model runs demonstrated for test periods
M10	Estimates of aerosol forcings	3	34	Data made available to project partners
M11	DGVM runs completed	4	30	Model output available
M12	Progress on contribution to international initiatives	6	27	Report published
M14	Python inventory verification software tool	1	30	Software tested
M16	Cyprus Case-Study successfully achieved	8	23	D8.1
M17	Cyl-CARE-C engaged in R&I excellence	8	29	Project website