



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

Deliverable 7.4

Avengers Dissemination and Exploitation Plan

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

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1 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.

The project aims to accomplish the following key results:

- **Improved inversion systems** for GHG and aerosol emissions estimation based on multiple observations and methodologies.
- **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 for demonstrating the strengths and weaknesses in estimating GHG emissions, which will be made available to national inventory compilers.
- **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).
- **Observation-based estimates of aerosol emissions** and their uncertainties for European countries.
- **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.
- **Estimates of the climate impact of national emissions** in terms of radiative forcing taking into account the radiative impact of aerosols and GHGs.
- **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.
- **An estimate of the impact of planned satellite missions** for quantifying aerosol emissions
- **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.
- **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 of the project are:

- **End-users:** National inventory agencies and compilers from countries represented in the project (from Germany, The Netherlands, Sweden and Italy), as well as all other countries world-wide who want to benefit from the emission estimation methodologies developed in the project.
- **Policy makers:** United Nations Framework Convention on Climate Change (UNFCCC), United Nations Environment Programme (UNEP), European Commission (EC), European Environment Agency (EEA) and national environment agencies and governmental ministries in charge of climate policy.
- **Scientific community** studying GHG and aerosol emissions (carbon cycle, climate, change and feedback processes in the field of Earth system science).

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- **International organisations:** the Global Carbon Project (GCP), the Group on Earth Observation (GEO), the Integrated Global GHG Information System (WMO-IG3IS)
- **Society** benefiting from improved open access information about emissions, and an improved quality control on reported emissions through the use of independent atmospheric measurements

1.1 Scope of this deliverable

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 24 of the project.

The plan aims to provide 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 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).

1.2 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)

1.3 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, 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.

1.4 Impact indicators

AVENGERS’ Key Performance Indicators (KPIs) are described in table 1 below.

KPI	Description	Target	Threshold
1.1	Produced number of datasets of emission factors, GHG and aerosol emissions for the EU, freely available upon request	6 datasets	2 datasets
1.2	Updated the gridded maps of the three main anthropogenic GHG and aerosol emission fields to recent years	4 maps	2 maps
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
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

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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
2.3	Number of attendees to the webinar on project results	60 attendees	30 attendees
3.1	Number of international programmes/ initiatives directly involved in dissemination and outreach of project results.	5	3
3.2	Number of EU and non-EU programmes, initiatives, networks and knowledge platforms with which the project will collaborate.	10	6
4.1	The Flexible Inversion Tool for Inventory Compiler is tested in KPI number of countries	4	2
4.2	The updated emissions factors of the three major GHGs are used by KPI number of EU member states.	5	3

2 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 section, 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)
 - Good practice guidelines
 - Tools / algorithms / specifications
3. Progress information through provision of:
 - Regular digital newsletters
 - Public project deliverables
 - Dissemination materials (brochures, posters, flyers)
 - Website and social media

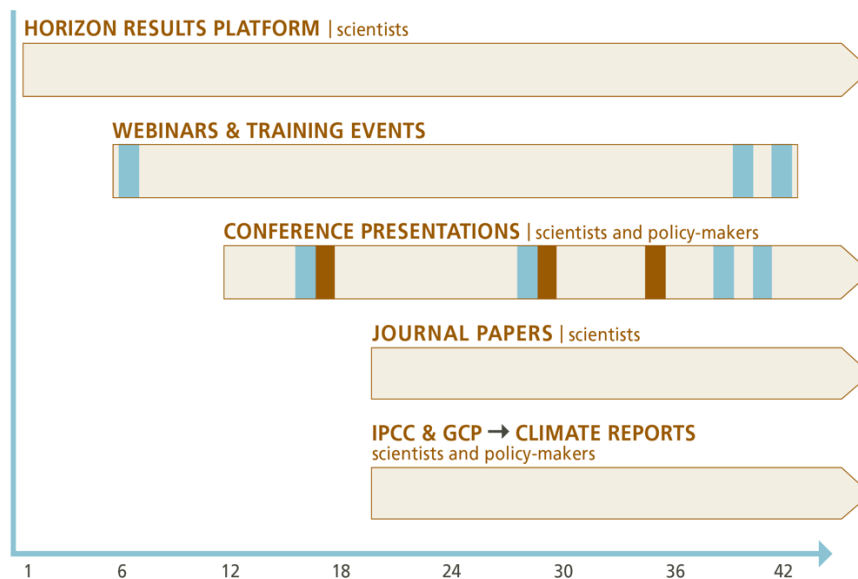
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Table 2 below provides information on the AVENGERS Dissemination (and Communication) Targets.

Target audience	Communication / Dissemination Means
End users (incl. policy makers)	Dissemination: <ul style="list-style-type: none"> • Workshops and resulting reports • Good practice guidelines Communication: <ul style="list-style-type: none"> • Project news/newsletters • Tailored updates on the results • AVENGERS website
Scientific community	Dissemination: <ul style="list-style-type: none"> • Peer-reviewed scientific papers • AVENGERS data portal • Workshops • Conferences Communication <ul style="list-style-type: none"> • Newsletters
International organisations	Dissemination <ul style="list-style-type: none"> • AVENGERS data portal Communication <ul style="list-style-type: none"> • Targeted publication material • Links with relevant projects and initiatives (• Representation at relevant conferences and fairs • Newsletters
Society / General public	Communication <ul style="list-style-type: none"> • General Information Material • AVENGERS website • Project news/ Newsletters • Dissemination Material • Press releases

2.1 Dissemination timeline

Figure 1 below shows the general time plan for dissemination. Webinars and training events are indicated by the bars. Presentations at conferences will take place during the project, but continue after the project has ended. Brown bars indicate scientific conferences, showing exemplary the annual EGU meetings. UNFCCC events and JRC workshops (shown as blue bars) are important venues to interact with policy makers. Dissemination in journal papers as well as in ICPP and GCP reports continues after the project ends.



2.2 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

2.3 Dissemination instruments

2.3.1 AVENGERS project website

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

Events as well as resources will be published on the website together with regular news updates.

The website will also provide 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 will provide an interface to the distributed data and products made available by the project and is therefore also a major dissemination instrument in itself.

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2.3.2 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:

- The periodic AGU/EGU general assemblies
- ESA's Living Planet Symposiums
- GEO (Group on Earth Observation) Week
- International Workshop on GHG Measurements from Space (IWGGMS)
- UNFCCC COP/SB (2024, 2025)
- 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

2.3.3 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>

2.3.4 Webinars, workshops, seminars

Events will 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

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the status and potentials of top-down monitoring systems will be organised, while another webinar covering project results, and in particular the FIT-IC and the guidelines (D6.1 and D.6.2) will be organized towards the end of the project.

2.3.5 Collaboration with research projects, programmes and networks

AVENGERS will first and foremost ensure 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 planned between the three projects, and a common stakeholder group will be set-up. An Early Career Researchers (ECRs) network from the 3 EU-funded projects (EYE-CLIMA, AVENGERS and PARIS) will be set-up (coordinated by PARIS), for PhD students and post-doctoral researchers in their first five years post-PhD. 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.

Other key research projects, programmes and networks of interest to AVENGERS include:

- CoCO2 / CORSO
- ICOS-Cities
- GreenFeedback
- TRANSCOM
- Relevant JPI Climate projects

2.3.6 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
- 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

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2.3.7 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.

2.3.8 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.

2.3.9 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 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.

2.3.10 Final project event

AVENGERS will organise a final event at the end of the project especially addressed to European inventory national inventory agencies, international initiatives (e.g. GCOS, GEO, ICOS etc.), but also to scientists and decision-makers to disseminate final results, with special focus FIT-IC, and the guidelines to maximize the exploitation of top-down approaches.

3 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).

3.1 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).

3.2 Exploitation activities and pathways

The following table summarises exploitation activities and pathways envisioned.

<p>Exploitable products</p>	<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 radiative forcing taking into account the radiative impact of aerosols and GHGs • 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

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	<p>experiments guiding upcoming satellite mission design as well as in-situ measurement networks</p> <ul style="list-style-type: none">• Uptake and exploitation of improved emission factors by agriculture/forestry actors• Exploitation of the established stakeholder network in future research projects post-AVENGERS
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Appendices

Table 1: List of deliverables

Deliverable (number)	Deliverable name	WP number	Short name of lead participant	Type	Dissemination level	Delivery date (month)
D7.1	Consortium Agreement	7	ULUND	R	SEN	1
D7.2	Risk and quality management plan	7	VUA	R	PU	2
D7.3	Project website	7	VUA	DEC	PU	3
D7.4	Data management plan	7	ICOS	R	PU	6, 24, 42
D7.5	Dissemination Plan	7	ULUND	R	PU	6, 24
D3.1	Input data for aerosol inversions	3	TNO	DATA	PU	5
D2.2	Data set on observations	2	ULUND	DATA	SEN	12
D1.1	User stories (case-studies) and user needs	1	UBA	R	PU	16
D1.3	Target quantities for future observing capabilities in WP5	1	UBA	R	PU	18
D3.2	Posterior aerosol emissions inventory	3	VUA	DATA	PU	24
D5.1	Preliminary scenarios and assessments in WP5	5	iLab	R	PU	20
D2.1	Prior emissions for for European inversions and national case studies	2	TNO	DATA	SEN	24
D3.3	Aerosol forcing estimates and uncertainties	3	VUA	DATA	PU	26
D1.2	TOPAS_CH ₄ service	1	TNO	DEC	PU	28
D2.3	European CO ₂ inversions	2	iLab	R	PU	30
D2.4	European CH ₄ inversions	2	VUA	R	PU	30
D2.5	European N ₂ O inversions	2	EMPA	R	PU	30

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D2.6	National case-studies GHG inversion	2	ULUND	R	PU	30
D4.1	Modelled C and N ₂ O fluxes and emission factors	4	ULUND	R	PU	30
D4.2	Attribution of European methane emissions	4	VUA	R	PU	30
D3.4	Intercomparison of emissions and forcings	3	ULUND	R	PU	33
D2.7	Synthesis and recommendations on GHG inversions	2	EMPA	R	PU	36
D3.5	Impact of observations from future missions	3	VUA	R	PU	36
D4.3	Method for spatially explicit LULUCF GHG emissions	4	ISPRA	R	PU	36
D6.2	Guidelines for supporting national inventories	6	CMCC	R	PU	40
D1.4	Reconciliation of top- down and bottom-up estimates	1	VUA	R	PU	42
D1.5	GHG and aerosol national contributions to radiative forcing	1	VUA	R	PU	42
D5.2	Final scenarios and assessments in WP5	5	iLab	R	PU	42
D6.1	Flexible Inversion Tool for Inventory Compilers	6	iLab	Other	PU	42
D6.3	Project contribution to international initiatives	6	CMCC	R	PU	42
D7.6	Technical and financial reports	7	ULUND	R	SEN	42

Table 2: List of milestones

Milestone number	Milestone name	Related WP(s)	Due date (in month)	Means of verification
M7.1	Project initiated	7	2	Minutes of KO meeting
M3.1	Test sets for aerosol emissions data	3	3	data provided to model teams
M4.1	Model input data for DGVM	4	6	Data quality validated
M1.1	First set of case-studies	1	7	Requirements made available
M1.2	TOPAS_CH4 demonstrator	1	12	Website running
M2.1	First set of prior emissions	2	12	Data made available to project partners
M5.1	Initial observation scenarios	5	12	list of scenario specification
M7.2	General assemblies	7	15, 29, 42	Minutes of meetings
M2.2	Inverse models setup	2	18	Model runs demonstrated for test periods
M3.2	Estimates of aerosol forcings	3	24	Data made available to project partners
M4.2	DGVM runs completed	4	24	Model output available
M6.1	Progress on contribution to international initiatives	6	24	Report published
M1.3	Python inventory verification software tool	1	30	Software tested