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

AVENGERS Overview

A project funded by European Union's Horizon Europe research and innovation programme

Marko Scholze, Lund University

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Funded by
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LUND
UNIVERSITY

Some AVENGERS facts

- Horizon Europe project funded under the call on "Verification and reconciliation of estimates of climate forcers" (Cluster 5, Destination 1: Climate sciences and responses for the transformation towards climate neutrality).

- 42 months (01/2023 to 06/2026) and involves 15 partners (including 5 national UNFCCC reporting agencies) from 7 countries, total budget 5.9M Euro.

- 2 other projects funded under this call: EYE-CLIMA and PARIS

Part. No.	Participant organisation name	Country
1 Coordinator	LUNDS UNIVERSITET (ULUND)	Sweden
2	THE INVERSION LAB (iLab)	Germany
3	ISPRA	Italy
4	RIVM	The Netherlands
5	UNIVERSITAET HEIDELBERG (UHEI)	Germany
6	CMCC	Italy
7	TNO	The Netherlands

| Part. No.	Participant organisation name	Country
8	ICOS ERIC	Finland
9	UMWELTBUNDESAMT (UBA)	Germany
10	SVERIGES LANTBRUKS-UNIVERSITET (SLU)	Sweden
11	EMPA	Switzerland
12	SRON	The Netherlands
13 Co-Coordinator	STICHTING VU (VUA)	The Netherlands
14	Chalmers University of Technology (Chalmer)	Sweden
15	The Cyprus Institute (CyI)	Cyprus

Scientific Advisory Board: M. Dowell (JRC), P. Friedlingstein (U Exeter) & S. Mikaloff-Fletcher (NIWA)

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
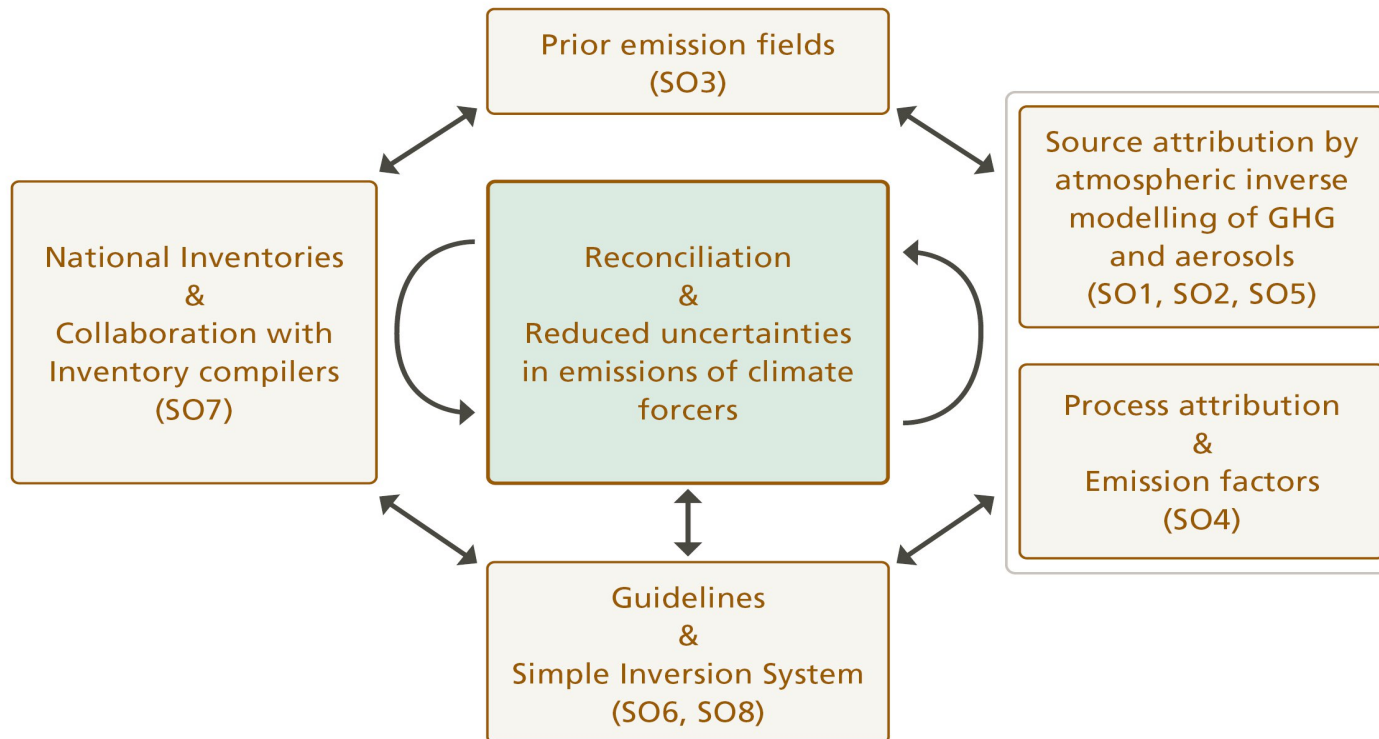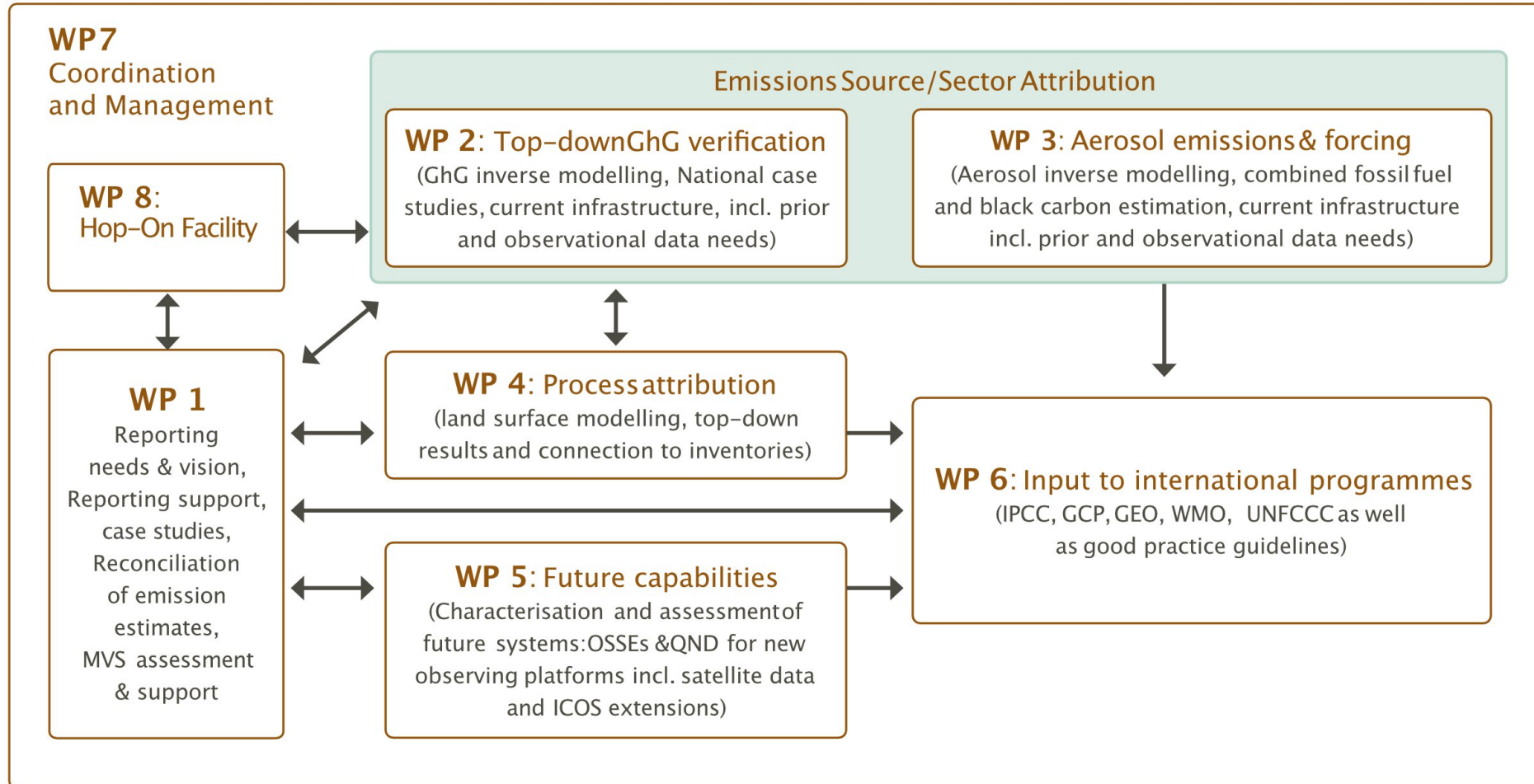
Variety of observation and model-based methods employed
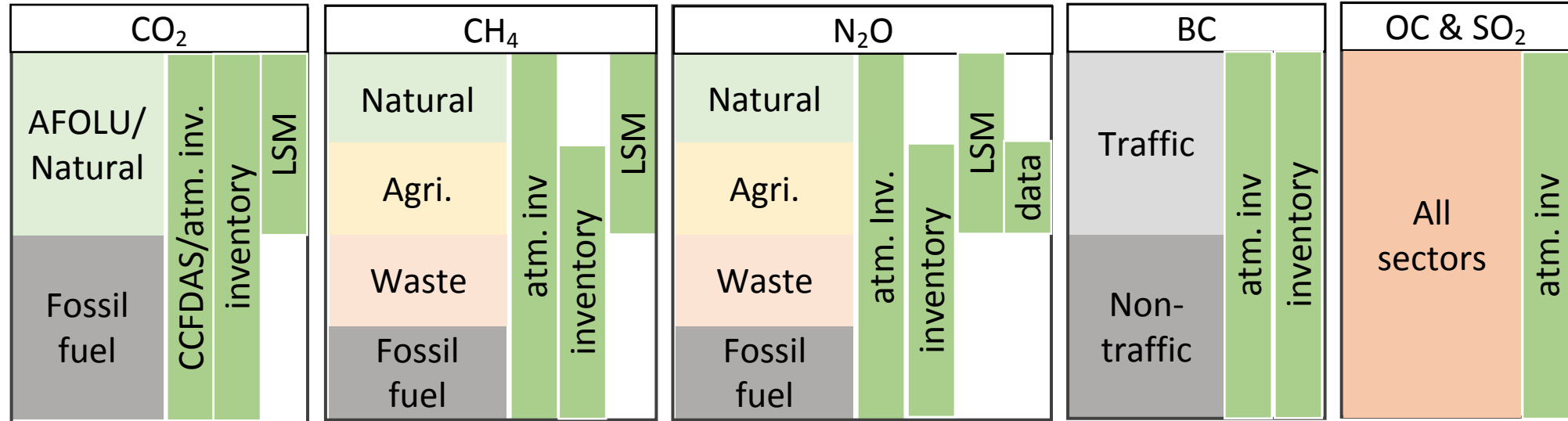
Legend	
atm. inv.	Inversions of atmospheric observations
CCFFDAS	Carbon Cycle Fossil Fuel DA system
LSM	Land Surface Models
data	Data driven model
inventory	EFs and activity data

WP8 for Hop-On partner The Cyprus Institute to extend the methodology to Eastern Mediterranean countries

AVENGERS

- AFOLU sector
  - Forestry: Sweden
  - Agricultural land use: Italy & The Netherlands
- Germany: largest economy in EU, UBA partner
- Switzerland: front-runner of top-down aided emission reporting
- Cyprus & MEME region: Hop-on objective
- EU+UK: GhG and aerosol (pre-cursor) emissions of SO_2, OC (organic carbon), and BC (black carbon) and their uncertainy

- Multi-tracer atmospheric inversion systems for GHG and aerosol emissions estimation
  - Co-emitted species (NO$_2$, ^{14}CO$_2$, δ13C, δD, alkanes)
  - Joint Black Carbon-CO$_2$ inversions

Name	Model	DA method	Application	Reference
CCFFDAS	TM3/CMAQ	4D-VAR	CO$_2$	Kaminski et al. (2022)
ICON-ART-CTDAS*	ICON	EnKF	CO$_2$, CH$_4$, N$_2$O	Schröter et al. (2018)
LOTOS-Euros	LOTOS-Euros	4D-VAR, EnKF	CH$_4$, N$_2$O[#], aerosols	Jin et al. (2017)
LUMIA	TM5/Flexpart	4D-VAR	CO$_2$, CH$_4$, aerosols & BC[#]	Monteil and Scholze, (2021)
WRF-CTDAS*	WRF-Chem	EnKF	CO$_2$, CH$_4$, N$_2$O[#]	Dekker et al. (2019)
TRACE	WRF-Chem	EnKF	CO$_2$	Chen et al. (2019)

- Coupled fossil fuel carbon cycle data assimilation
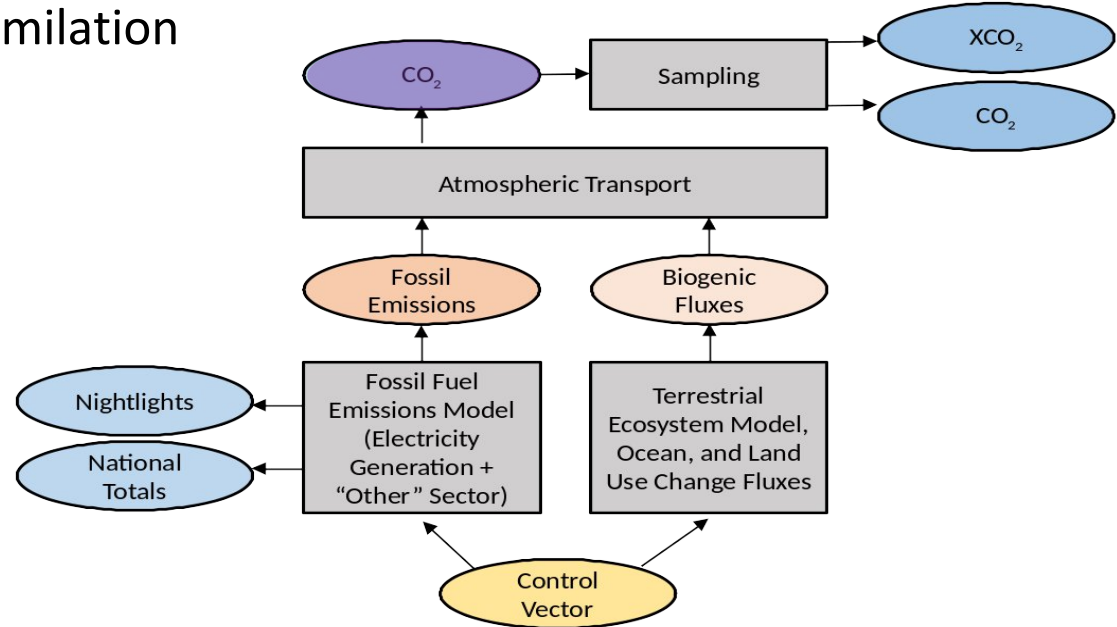
- Evaluation of future infrastructures: OSSEs and QND studies for all three GhGs (CO_2, CH_4 & N_2O)
  - e.g. PRISMA, EnMAP, CO2Imager, CO2M, ICOS extension
  - Good coverage of neighbouring countries for national totals of a country
  - How does an in-situ network need to look like for estimating Italian GhG budget
 - What is the added value of CH4 isotopes

- Emission factor quantification for GHG flux estimation in the AFOLU sector using process-based DGVMs (ORCHIDEE, LPJ-GUESS) and forest management model (HEUREKA)
  - How can we better estimate CO2 emissions from the forestry sector with process-based bottom up models
  - Can we quantify Dutch CH4 emissions from organic and mineral soils using process-based bottom up models
  - What is the contribution of the agricultural sector to the Italian GhG budget from process-based bottom up models

- Comparison of GHG and aerosol radiative forcing
  - Using EC-Earth to calculate radiative forcing of aerosol emissions for a given year and country

- Development of a Flexible Inversion Tool for Inventory Compilers (FIT-IC) to use and in a way that non-atmospheric scientists can apply it

TOPAS-CH₄: A methane source attribution tool
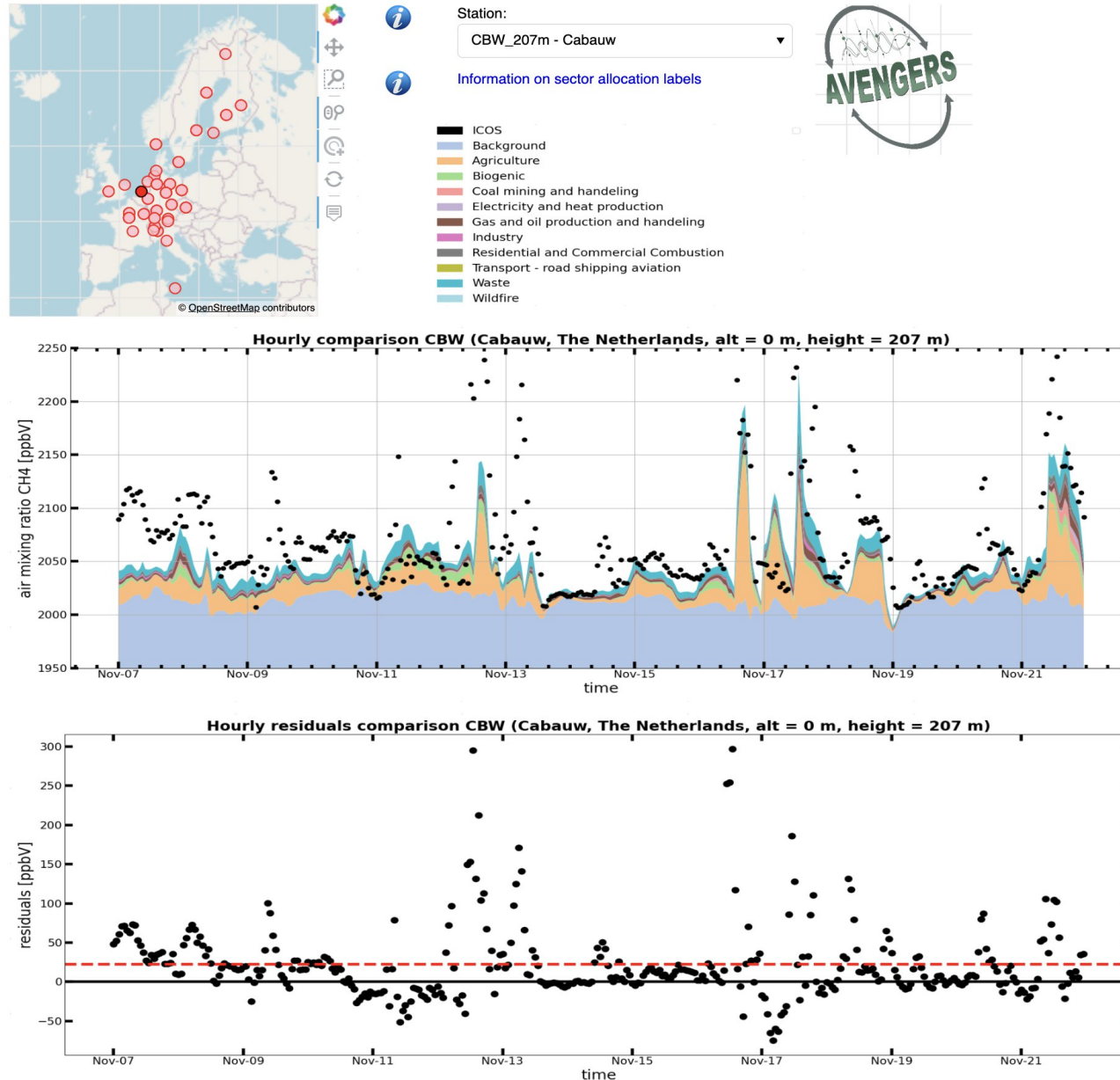
- TOPAS services: **T**NO **O**perational **P**ollution **A**pportionment **S**ervices

- CH$_4$ service: daily updated simulations by LOTOS model of CH$_4$ and C$_2$H$_6$ concentrations over Europe

- Visualized on website: https://topas-ch4.tno.nl

- **Good practice guidelines** on how top-down emission estimation systems can support GHG inventories and the Global Stocktake (in collaboration with EYE-CLIMA).

- **A Flexible Inversion Tool for Inventory Compiler** for demonstrating the strengths and weaknesses in estimating GHG emissions, made available to national inventory compilers incl training events.

- **Observation-based estimates of GHG (CO_2, CH_4, N_2O) and aerosol emissions and their uncertainties** 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)**.

- **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.

- An **evaluation of future observing systems (both satellite and in-situ)** in terms of their **potential to further reduce uncertainties** in the estimated GHG and aerosol emissions and corresponding guidelines on the design of the networks.

Most importantly:

A better understanding of how the different communities work and what is needed to effectively work together among atmospheric scientists, process-based land surface modellers and inventory compilers!

THANK YOU!

https://avengers-project.eu

marko.scholze@nateko.lu.se