VERBE - Towards a greenhouse gas emission monitoring and Verification system for Belgium

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VERBE project and objectives

VERBE is a BRAIN-be 2.0 project, funded by BELSPO, that aims to establish a sustainable Belgian observation- and model-based Emission Monitoring and Verification System (MVS) for emissions of greenhouse gases (GHGs) anchored in a structural collaboration between BIRA-IASB and UAntwerp, The target GHGs are CO_2, CH_4 and N_2O. The **long-term objectives of VERBE** are:

- Quantifying the GHG concentrations above Belgium at a subregional scale ($\sim$ 25 km^2),
- Identifying and quantifying major sources and sinks,
- Distinguishing between anthropogenic and biogenic sources and sinks
- Monitoring the evolution of the atmospheric burden of GHGs above Belgium and evaluating the impact of mitigation strategies, e.g., the impacts of the energy transition and future negative emission technologies, traffic control measures, changes in agricultural practices, etc...
- Providing indications for sectors or point-sources with a high potential for GHG emission reduction.

The MVS research will also enable the assessment of feedbacks between the GHG (semi-) natural balance and climate change, which is useful to improve the mitigation and adaptation strategies.
This poster gives an overview of how the VERBE project will work towards these long term objectives.

Observation infrastructure

Design of an appropriate observation infrastructure and strategy for building an MVS capacity for GHG emissions in Belgium. The design will be based on an ensemble of existing observations, including the Integrated Carbon Observing System (ICOS) atmospheric and ecosystem observations and existing satellite data and analyses from the Copernicus Atmosphere Monitoring Service (CAMS) and Climate Change Service (C3S), to be complemented with new local observations.

Atmospheric observations

Campaign-based initialisation of the proposed infrastructure for ground- and tall-tower based in-situ and remote sensing observations of the target GHGs in Belgium.

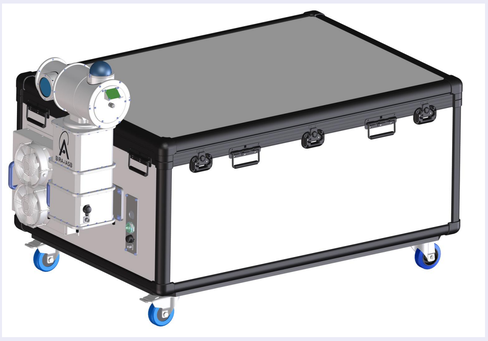


Figure: Compact mobile FTIR spectrometer enclosure for ground-based total-column GHG concentration measurements using direct solar light, developed as part of the ESA FRM4GHG 2.0 project.

The first VERBE campaign is being planned for spring 2024. The campaign will focus on the city and port of Antwerp. Mobile FTIR remote sensing instruments will be placed up- and downwind of the Antwerp area to monitor the city and port emissions. The FTIR observations will be complemented with an in-situ GHG analyzer.

Ecosystem observations

UAntwerp and the ULiège operate 6 ICOS ecosystem stations in Belgium. These partners bring the knowledge of their ecosystem sites and associated datasets, and their experience in the modelling of biogenic GHG exchanges, ensuring an appropriate use of the ICOS flux data. Their expertise will help to optimize the Vegetation Photosynthesis and Respiration Model parameters for Belgian ecosystems and their implementation in WRF-GHG and to validate the results.

Related projects and partners

Related projects

- BELSPO FEDtWIN project (10 year duration for 1 FTE): A Belgian greenhouse gas emissions Monitoring and Verification System (BIRA-IASB and UAntwerp)
- ESA World Emission project (`https://www.world-emission.com`)

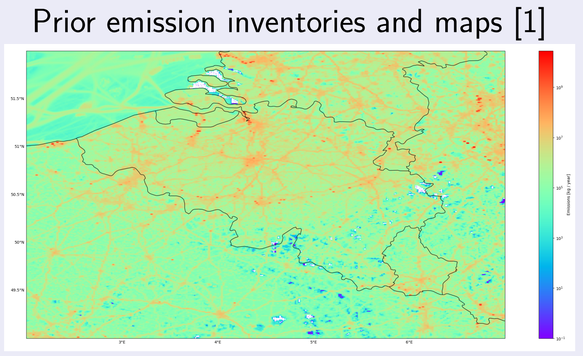
National and international partners

International partners from Germany, France and the Netherlands are involved in the VERBE project or are member of the project's follow-up committee. DWD and DLR are part of the ITMS project, that aims to establish an integrated greenhouse gas monitoring system for Germany (`https://www.itms-germany.de`).

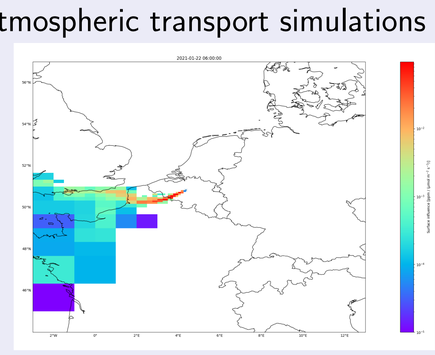
VERBE Concept

VERBE will develop a system that combines ground- and space-based observations of atmospheric GHG concentrations with atmospheric transport models in a Bayesian inversion framework. The observations are used to constrain prior emission inventories and to yield top-down emission estimates for the target GHGs.

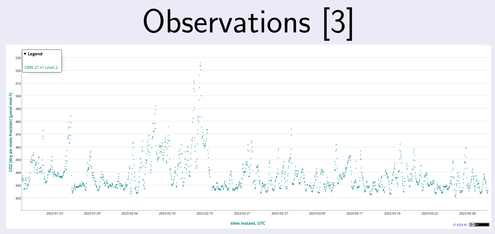
Prior emission inventories and maps [1]



Atmospheric transport simulations [2]



Observations [3]



Bayesian inversion

CIF

A posteriori emission estimates and maps constrained by the observations

VERBE aims to

- Demonstrate the added-value of the developed system (local observations + inverse modelling framework + complementary existing data) for deriving top-down spatially and temporally explicit GHG emission estimates.
- Assess the future needs for enhancing and maintaining the MVS capacity in Belgium.

Inverse modelling based on WRF-GHG

Development and application of inverse modelling tools based on WRF-GHG [4], using the Community Inversion Framework (CIF) [5], to enable the creation of 4D (space and time) concentration maps and source/sink maps of GHGs in Belgium. These efforts will provide Belgium with a "GHG inversion framework" and associated expertise in support of the Belgian and European GHG reduction policies and the Belgian NIR.

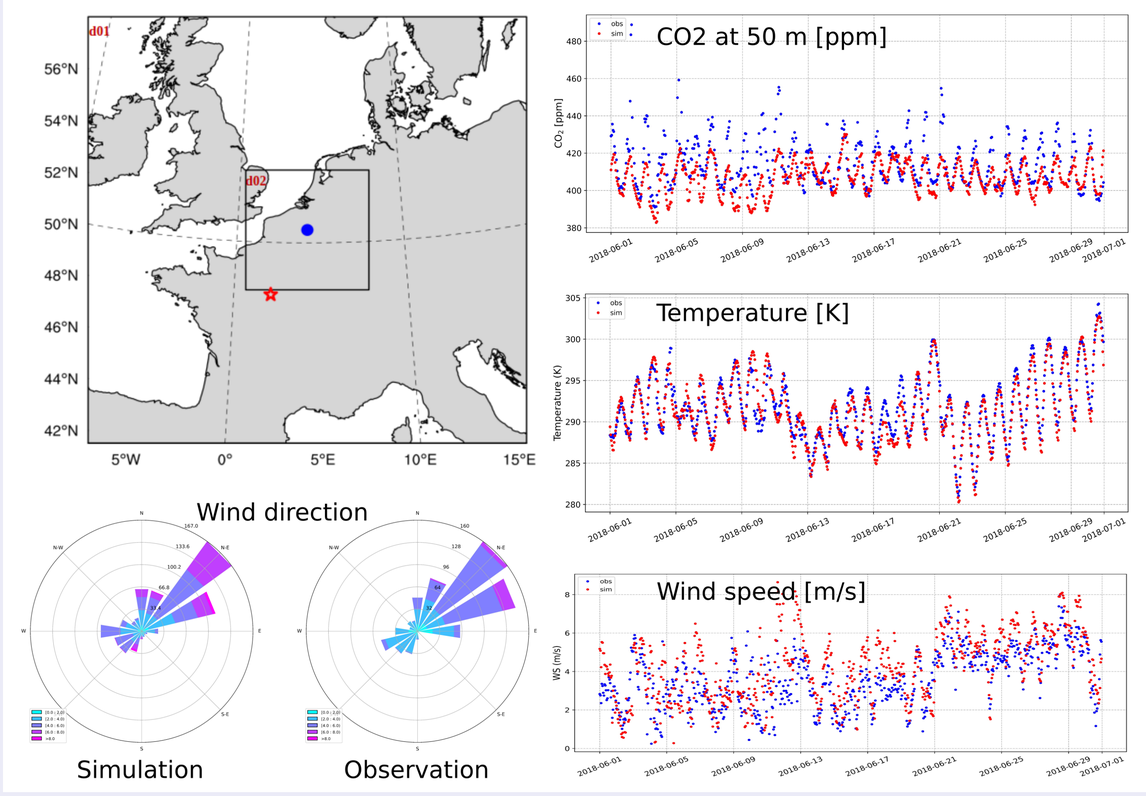


Figure: Results of an initial test run of WRF-GHG using nested domains, with a 7 km resolution in d02 over Belgium and 21 km in d01. Comparison of the model output and the observations at the ICOS atmospheric station at Trainou for June 2018.

References

1. Ingrid Super, Hugo Denier van der Gon, Jeroen Kuenen, TNO, Utrecht, The Netherlands
2. Ute Karstens, ICOS ERIC - Carbon Portal, STILT transport model results (footprints) for station BRS200 from 2021-01-01 to 2021-12-31, `https://www.icos-cp.eu/data-services/tools/stilt-footprint`
3. Frumau, A., Hensen, A. (2023). ICOS ATC CO2 Release, Cabauw (27.0 m), 2022-09-09 – 2023-03-31, ICOS RI, `https://hdl.handle.net/11676/TAe-jU3yfj8gvkScZ7E_hoNQ`
4. Beck et al., (2011): The WRF Greenhouse Gas Model (WRF-GHG) Technical Report No. 25, Max Planck Institute for Biogeochemistry, Jena, Germany
5. Berchet et al., Geosci. Model Dev., 14, 5331â5354, 2021 `https://doi.org/10.5194/gmd-14-5331-2021`