The European observation-based system for monitoring and verification of greenhouse gas fluxes (the VERIFY and CoCO2 projects)

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The two Horizon 2020 projects VERIFY and CoCO2 support the development of a European regional monitoring and verification support (MVS) system. They integrate in situ and satellite observations, inventories and modelling in inform and support climate policy.

Method: Observation-based system

➤ USE of atmospheric & ecosystem measurements (in situ & satellite) with modeling systems


ESTIMATING GREENHOUSE GAS FLOWS
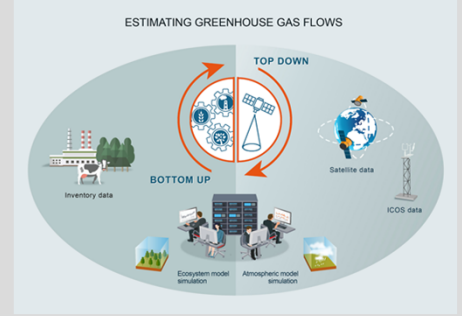
➤ Combine complementary approaches including process-based, data-driven, bookkeeping, atmospheric inversions models.
➤ Application with high resolution data over Europe (land cover, meteorology, management, transport)
➤ Apply Data Assimilation to merge information from model and observations
➤ Develop a Community Inversion Framework (CIF)

Objectives: A pre-operational system to support national GHG inventories

➤ INTEGRATE EFFORTS between the research community, national inventory compilers, operational centers, international organizations.

➤ PRODUCE annual synthesis of national GHG balance in Europe.

RECONCILING STATE REPORTING AND SCIENTIFIC CLIMATE DATA
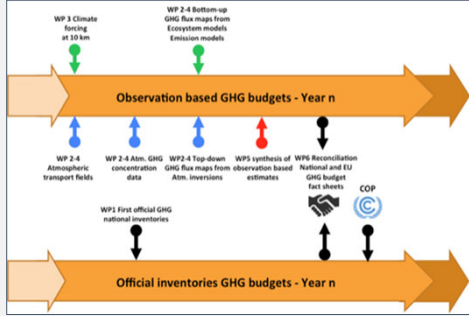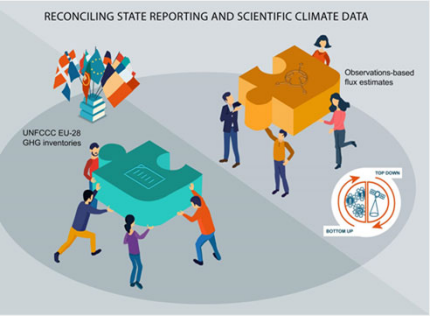
➤ ENHANCE current observation & modeling abilities.
➤ DEVELOP NEW research approaches to monitor anthropogenic GHG fluxes.

# Snapshots of main results (VERIFY) and key messages

CO$_2$ fossil

➤ Annual maps of CO$_2$ fossil fuel emissions at high resolution.
➤ Inversion estimates of fossil fuel emissions from atmospheric observations including satellites data for Nox and CO.

Total (2015)
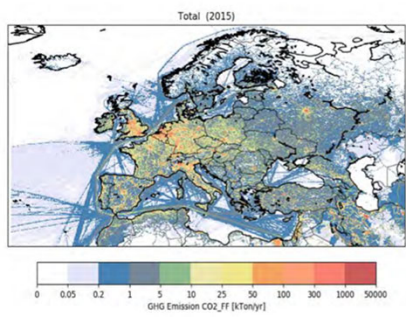
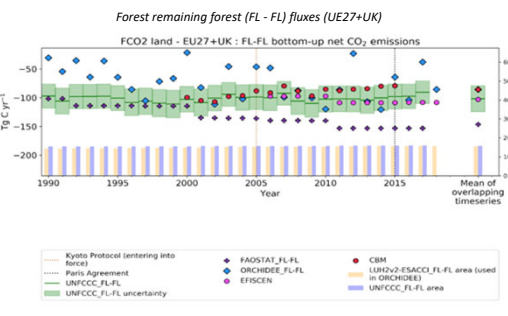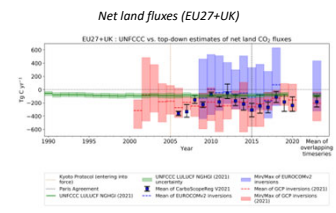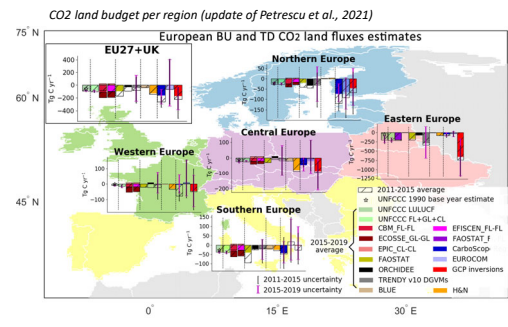Fossil fuel map at ~6x6 km resolution (also for co-emitted species CO, NOx)

Using emission modelling to complete the timeseries up to the present year as input for inversions
(Note: 2016 and 2017 used for testing)

CO2
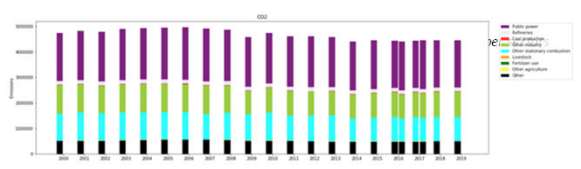
- Fossil CO$_2$ emissions from 9 sources, including *UNFCCC NGHGI, and a first inversion estimate (CIF-Chimere).*
- Differences mostly due to different accounting systems
- Understanding is critical for analysis and communication; inversions are still very uncertain and at their infancy.

Land biosphere CO$_2$ fluxes (EU27 + UK GHG synthesis)

➤ Derive annual land-biosphere CO$_2$ fluxes: Process-based model at 10 km resolution, statistical bookkeeping and regional inversion ensembles.

CO2 land budget per region (update of Petrescu et al., 2021)
European BU and TD CO2 land fluxes estimates

Net land fluxes (EU27+UK)
EU27+UK : UNFCCC vs. top-down estimates of net land CO2 fluxes

Forest remaining forest (FL - FL) fluxes (UE27+UK)
FCO2 land - EU27+UK : FL-FL bottom-up net CO2 emissions

- Geographical eastern Europe has a stronger sink !
- Bottom-up models (sector-specific and all ecosystems) vary in terms of interannual variation but agree with the mean National GHG Inventories (NGHGIs) reported to UNFCCC
- Top-down inversions indicate stronger sinks compared to NGHGIs, with large variation between individual members of each ensemble. CarboScope inversion is « robust » against a priori fluxes
- Care must be taken to not apply inversions to too small regions!

CH$_4$ and N$_2$O

Regional inversion (mg CH$_4$ m^{-2} d^{-1})
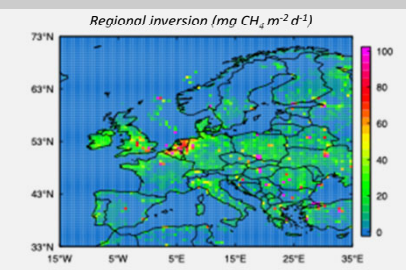
➤ Monthly estimates of anthropogenic & natural sources of CH$_4$ and N$_2$O using regional inverse modelling and process- and statistics- based models

- CH$_4$ total regional inversions larger than total NGHGI emissions, differences due to natural fluxes or underestimation of the anthropogenic fluxes
- N$_2$O total estimates from inversions are slightly larger then NGHGI fluxes but within the (very large) uncertainty range.

Regional inversion (g N m^{-2} y^{-1})