Sentinel EO-Based Emission and Deposition Service

Reporting

Project Information

SEEDS

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Project website

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Project closed

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€ 1 498 875,00

Coordinated by
STIFTELSEN NILU
Norway

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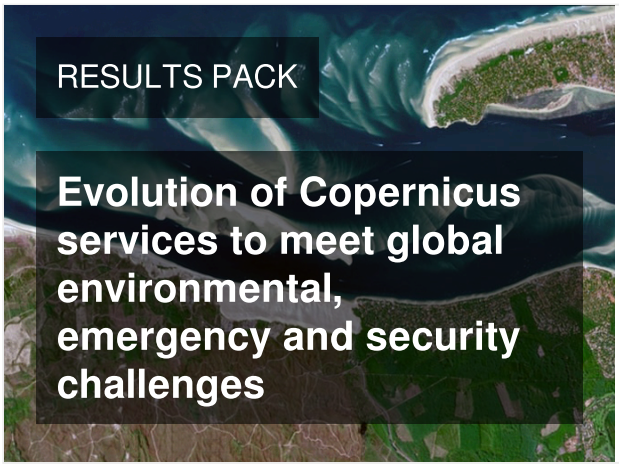


4 December 2024

Periodic Reporting for period 2 - SEEDS (Sentinel EO-Based Emission and Deposition Service)

Reporting period: 2022-01-01 to 2023-12-31

Summary of the context and overall objectives of the project

A central objective of the H2020 SEEDS project has been to inform and support the evolution of the Copernicus Atmospheric Monitoring Service (CAMS) by providing a proof-of-concept for a new service using satellite data to provide improved emissions and deposition estimates. The project has produced an impressive amount of new information based on satellite data, showing among other, the capabilities of TROPOMI foe emission validation services. The project has provided novel top-down estimates of anthropogenic (NOx, NH3 and biomass burning) and biogenic (BVOCs)emissions; novel approaches to land surface modelling in combination with chemical transport models to describe the impacts of drought, heatwaves and vegetation on surface pollution deposition; and novel data assimilation methods to prepare for new satellite geostationary air quality observations such as Sentinel-4.

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

Satellite-based anthropogenic emissions

SEEDS has produced top-down anthropogenic emissions of nitrogen dioxide (NO2), ammonia (NH3) and biomass burning emissions based on satellite data from TROPOMI and CrIS instruments, delivering hourly, daily, and monthly anthropogenic emission estimates.
The results show comparison between top-down and bottom-up emission estimates can improved current emission data estimates. Most interestingly, it shows how satellite data allows to appreciate variations over time, verifying yearly variations and estimating monthly and weekly variations. This enables a more detailed analysis of biases linked to seasonal variations. SEEDS has demonstrated the added-value of top-down emissions to provide independent emission estimates with valuable

temporal information allowing the identification of inconsistencies and gaps in current inventories.

Biogenic emission estimates

SEEDS has produced new up-to-date emissions of biogenic organic compounds (BVOC) both bottom -up (using land-surface and chemical transport models) and top-down estimates (using TROPOMI HCHO data with the MAGRITTEv1.1 inversion system). In addition, the DECSO inversion system has been applied in SEEDS to identify soil emissions of nitrogen oxides (NOx) for the first time, where comparison with bottom-up inventories revealed gaps in the current bottom-up inventories. SEEDS shows that the comparison between bottom-up and top-down emissions helps improve the quality of current emission estimates. Two concepts used in SEEDS are retained for integration in CAMS: the potential of using a simplified chemistry scheme for the oxidation of isoprene (CAMEO project), and the coupling of land surface and vegetation data for biogenic emissions estimates (MEGAN model).

SEEDS Land surface data and deposition estimates

SEEDS proposed to add an off-line land surface data assimilation modelling system to the CAMS production chain, linking a land surface-vegetation model to atmospheric composition models allowing vegetation-meteorology feedback that impact atmospheric composition. The land surface model at the core of this approach (SURFEX) has been proven to have a high level of skill at simulating vegetation and soil dynamics. The comparison with TROPOMI SIF shows that the assimilation of CGLS LAI improves the consistency of model simulations with SIF. This comparison establishes SURFEX as an excellent basis for simulating dry deposition over vegetation. Furthermore, the earth system approach here allows representation of complex interactions and dynamics due to drought and heatwaves.

SEEDS data assimilation algorithm

SEEDS has developed an advanced data assimilation algorithm (4DEnVar) to improve air quality forecasts in the CAMS operational system. This is an open-source code that helps prepare the way for better exploitation of the hourly data from Sentinel 4. It is available for download from the SEEDS data portal.

Pathways to operationalization in CAMS

The following SEEDS methods are already in the path towards operationalization with CAMS: a) DECSO and top-down emission products are already incorporated in CAMEO, a new HE project to support CAMS evolution and b) CAMS has indicated an interest to adopt the SEEDS land-surface vegetation approach by incorporating it to the production chain. The added value of the SEEDS products when used as input in the CAMS forecasting chain has been difficult to prove. This is because the CAMS analyses scores are driven by assimilated data so that changes in input data does not change significantly scores. In retrospect, the design of experiments to demonstrate better scores in the CAMS operational results due to SEEDS products should have focus on forecast data and take

stock of the added value of the temporal variability in SEEDS.

Stakeholder engagement

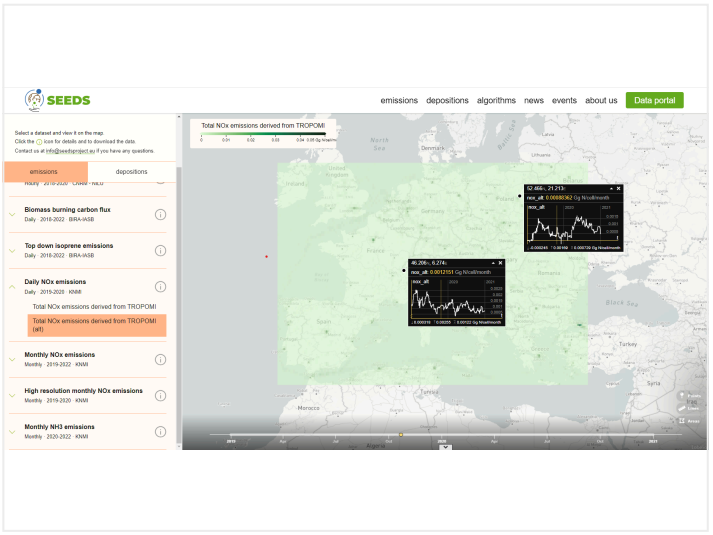
SEEDS has hold 3 conferences and 3 co-creation workshops to engage stakeholder knowledge from industrial, agricultural, and urban environmental management sectors, in addition to publicizing and presenting the results for the scientific community in multiple fora. There is a clear interest on SEEDS top-down emission results from any type of stakeholder involved in the development of bottom-up inventories. However, it was difficult to engage with agriculture stakeholders regarding both emission and depositions. Most of the interests of private agriculture stakeholders is focused on fertilization and yield maximization, the use of the SEEDS products requires additional value-creating activities to secure its uptake. Private industrial emitters were equally difficult to engage with at conference level but are more interested in bilateral exchanges.

Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider societal implications of the project so far)

The SEEDS project datasets constitute its legacy, as a first proof-of-concept of the capabilities of TROPOMI data for the improvement of satellite-based emissions. The SEEDS portal has adopted a FAIR approach and proposes the use of visualization tools that can be introduced further in WEKEO and CAMS ADS. There are 8 unique emission data sets and 10 unique land surface and deposition data sets in the SEEDS Portal. The project has already produced 4 publications and we have 5 more on the pipeline.

- SEEDS has demonstrated that it is possible to derive valuable emission information from TROPOMI and CrIS through the use of inverse modelling. It had shown how these products can be used by urban, regional and national groups interested in validating bottom-up emissions, in particular with respect to trends, monthly variations and identification of gaps. SEEDS anthropogenic emission products can be used by industry (metallurgy, cement, energy, oil and gas production sectors) as independent and scientifically sound data to validate monthly emissions from space, but such work requires bilateral approaches.

- SEEDS ammonia emission information and SEEDS products on soil moisture and leaf area index are expected to support environmental management practices in precision agriculture while the SEEDS deposition products for ozone and nitrogen can inform control options for eutrophication and crop yield damage. For the exploitation of these data for agriculture stakeholders' impact and use, an approach through value creating activities is necessary, such as linking the data to the socio-economic evaluation of the food chain or to nature restauration indicators.



SEEDS data portal

SEEDS

Sentinel EO-based Emission and Deposition Service

Seeds Logo

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