Sentinel EO-Based Emission and Deposition Service

WP2
Up-to-date Natural Top-down Emissions

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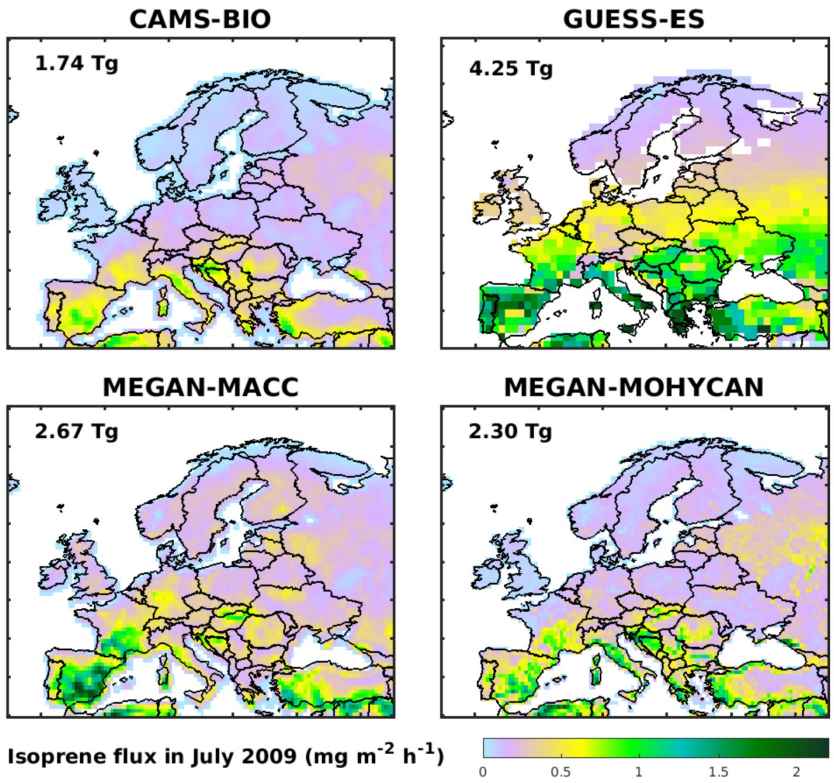
Outline

- What this WP is about?
- Identifying links between work packages
- Planning for the next 6 months
- Discussion

Rationale

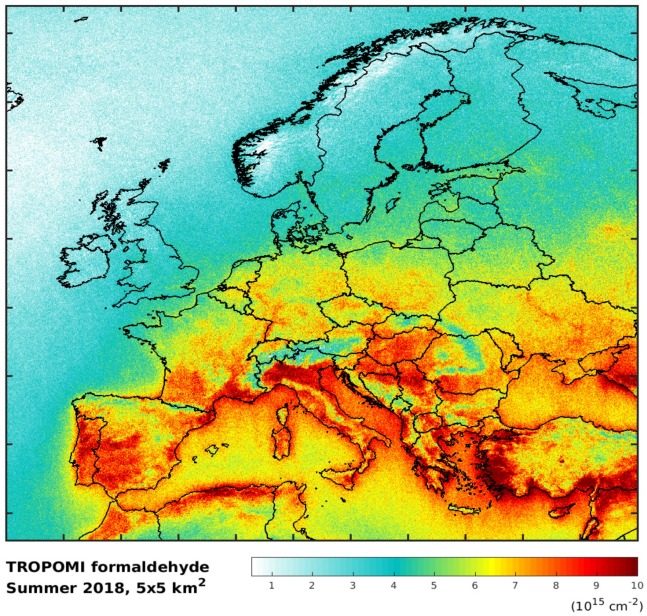
- ✓ Natural emissions due to vegetation are a **large source of uncertainty** for air quality forecast and chemistry climate models.
- ✓ In Europe, **large differences** are found even among inventories built on the same (MEGAN) emission model..



- ✓ Soil NOx is an important part of the total NOx emissions (20%), but their uncertainties are high. This reflects our **incomplete knowledge** of the factors driving these emissions. Top-down estimates based on OMI NO_2 are 2x higher than estimated in bottom-up inventories.

Objectives

- ✓ Develop top-down biogenic VOC emissions based on S5p HCHO observations over 2018-2022



- ✓ Develop soil NO fluxes constrained by S5p NO_2 observations over 2019-2022
- ✓ Evaluate the uncertainties on those estimations
- ✓ Make the products available for use by CAMS

Innovative aspects: HCHO

- ✓ Due to faint biogenic HCHO imprint and coarse resolution of previous instruments, there was little success of past attempts to derive top-down isoprene over Europe → In SEEDS: exploitation of **TROPOMI advantages** with respect to previous missions (higher signal-to-noise, higher number of measurements, lower uncertainties) to provide effective top-down isoprene emissions over Europe at a resolution unmatched by previous sensors

  - ✓ Wealth of space data (15x than with OMI, more cloud-free scenes)
  - ✓ Use of the advanced adjoint model technique (MAGRITTE CTM)
  - ✓ High spatiotemporal resolution of the inferred emissions
  - ✓ Validation of the top-down emissions using independent data
  - ✓ Estimation of uncertainties in the top-down fluxes
  - ✓ Estimation of the impact of NOx levels on top-down estimates

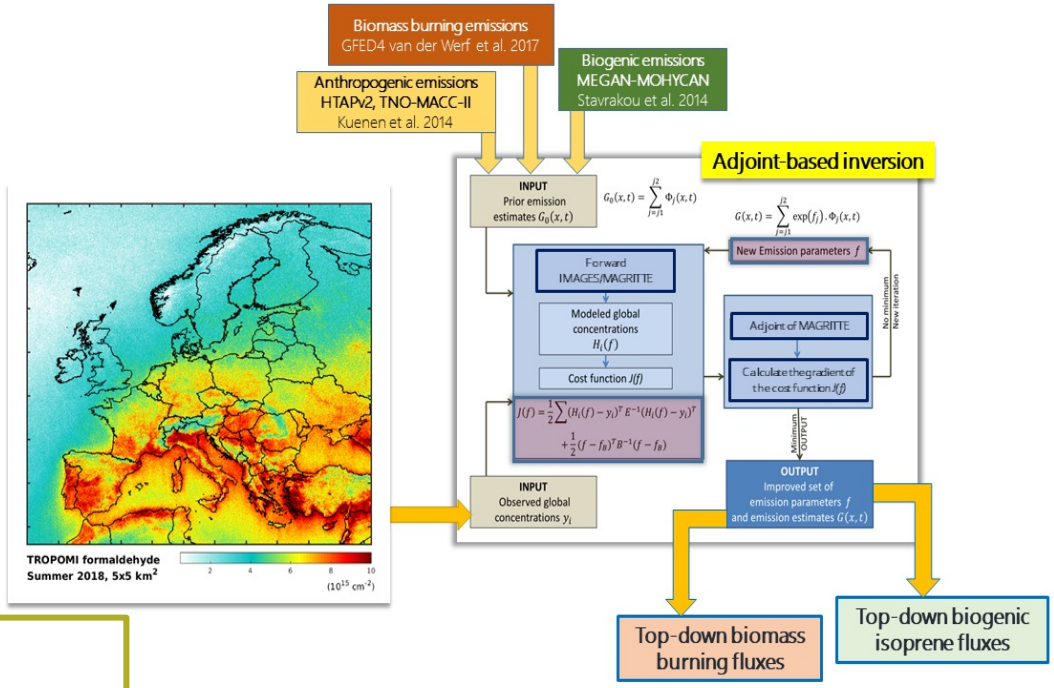
Innovative aspects: NO_2

- ✓ First time DECSO is used to infer soil NOx fluxes in Europe
  - ✓ Develop a new DECSO algorithm for ingesting TROPOMI data on a fine resolution grid
  - ✓ Simultaneous derivation of top-down biogenic (soil) and anthropogenic NOx emissions

Main tasks

T2.1: Design optimal methodology (BIRA-IASB)

Optimal methodology for top-down estimation of biogenic (+biomass burning, see T1.4) emissions using the **adjoint** of MAGRITTE CTM and TROPOMI HCHO



T2.2: Bottom-up biogenic emissions (NILU)

- Bottom-up biogenic VOC emissions for 2018-2022 using **MEGANv3.1** (SURFEX+IFS) + SURFEX LDAS-MONDE (from T3.1) at 0.1°
- Deliver to MF-CNRM at M18 in order to be used in WP5 (T5.2, T5.4)
- Link to T2.3: Use MEGANv3.1 instead of MEGAN-MOHYCAN emissions in MAGRITTE model

T2.3: Derivation of S5p-based biogenic VOC emissions (BIRA-IASB)

- Use T2.1 to update the MEGAN-MOHYCAN emissions over Europe
- Period: **2018-2022**
- Use alternative biogenic emissions from T2.2
- Deliver 2020 data to MF-CNRM at M24 (T5.2, T5.4)

T2.4: Assessment of top-down biogenic VOC fluxes (BIRA-IASB)

- Evaluation against isoprene flux measurements and ground-based FTIR HCHO column data

T2.5: Uncertainties in biogenic VOC fluxes (BIRA-IASB)

- Use TROPOMI clear-sky instead of the standard TROPOMI HCHO product
- Uncertainties related to the chemistry of isoprene
- Uncertainties in the soil NOx emissions, carry out experiments adopting the top-down inventory from T2.6
- Uncertainties will be derived and used as input for WP4

T2.6: Delivery of S5p-based biogenic NOx soil emissions (KNMI)

- Use method developed in T1.1 constrained by TROPOMI NO_2
- Emissions+uncertainty estimates to be made available for 2019-2022

Deliverables of WP2

Deliverable	Title	Who?	What?	When?
D2.1	**Optimal methodology for the estimation of S5p-based BVOC fluxes over Europe**	**BIRA-IASB**	***Report***	**12**
D2.2 **D2.3**	**Bottom-up emission estimates of biogenic VOCs based on coupling MEGAN v3.1 and SURFEX LDAS MONDE (2018-2020), (2021-2022)**	**NILU**	**Dataset**	**18** **30**
D2.4	**Top-down S5p-based biogenic VOC emissions in Europe 2018-2020**	**BIRA-IASB**	**Dataset**	**24**
D2.5	Idem, 2021-2022	BIRA-IASB	Dataset	30
D2.6	Assessment of top-down biogenic VOC fluxes and uncertainties	BIRA-IASB	*Report*	30
D2.7	Biogenic NOx emissions based on S5p data (2019-2022)	KNMI	Dataset	30

MS3 @ 24m: Biogenic VOC emissions+errors for 2020 → WP4

MS4 @ 24m: Biogenic NO emissions+errors for 2020 → WP4

Participation per partner

Partner	WP2 effort	Total effort
BIRA-IASB	21	29
NILU	5	32
KNMI	5	42

Risks and actions

Risks related to WP2	Actions
Low quality of TROPOMI HCHO data in specific regions (e.g. high latitudes), need for bias-correction	More efforts in correcting the satellite data; provide quality flag top-down emission data to inform on the estimated reliability level
Low ability to distinguish between the biomass burning and biogenic emissions when they co-occur (in summertime)	Perform additional inversion experiments, e.g. by varying the emission distributions, and the a priori error covariance matrices.
Any delays in delivering of one or more of the SEEDS anthropogenic and biogenic emissions for use in MOCAGE experiments	The order for running MOCAGE will be changed to fit with the availability of SEEDS emission products

Identifying links with other WPs

WP2		Other WPs
T2.1 Simultaneous inversion of biogenic and biomass burning fluxes using TROPOMI HCHO (BIRA- IASB)		**T1.4** Derivation of S5p-based biomass burning emissions (BIRA-IASB)
T2.2 Development of bottom-up biogenic VOCs (NILU)		**T3.1** Delivery of SURFEX LDAS MONDE of LAI and soil moisture (MF-CNRM)
T2.2 Bottom-up biogenic inventories (NILU)		**T2.3** Use these inventories as alternative a priori in MAGRITTE (BIRA-IASB)
T2.3, T2.6 Deliver top-down biogenic VOC and soil NO emissions for 2020 to MF-CNRM at M24		**T5.3, T5.4, WP4** Run MOCAGE in 2020 using the biogenic and anthropogenic emissions from WP2 (and WP1); Impact of combining SEEDS emission and deposition products (MF-CNRM)
T2.5 Adopt KNMI emissions in MAGRITTE (BIRA-IASB)		**T2.6** Delivery of top-down anthropogenic NO2 emissions (KNMI)
T2.6 Use methodology to derive top-down soil NO fluxes		**T1.1** Methodology for splitting biogenic and anthropogenic NOx emissions (KNMI)

Planning for the next 6 months BIRA-IASB

- Derive bottom-up biogenic emissions for 2018-2019 using MEGAN-MOHYAN and ERA5 reanalysis at 0.1°; Use these emissions as a priori in MAGRITTE

- Explore differences between anthropogenic inventories (EDGARv5, EMEP, CAMS-ANT) over Europe

- Perform global model simulations with ERA5 meteorology for 2018-2019 to generate lateral conditions for MAGRITTE over Europe (34–70°N, 25°W–50°E)

- Conduct forward MAGRITTE simulations and comparisons with the standard TROPOMI HCHO product; Is the standard TROPOMI product satisfactory? Account for adjustments of the TROPOMI data based on published studies

Planning for the next 6 months
NILU

- Various test datasets of SURFEX LAI and soil moisture of varying domain and resolution will be made available by Meteo-France/CNRM

- Planned delivery of one year (2018) SURFEX open-loop, forecast, analysis LAI and soil moisture on the HRES domain before summer 2021 by Meteo-France/CNRM.

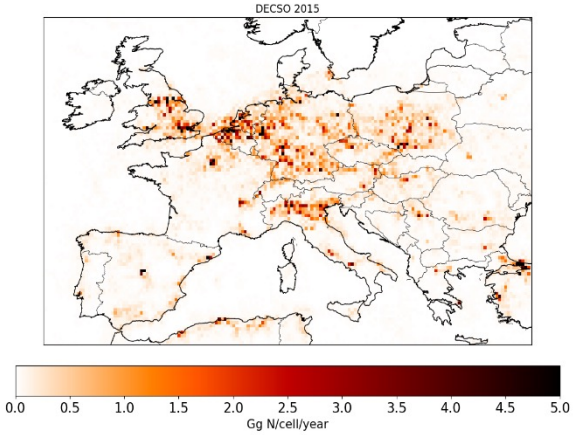
Planning for the next 6 months KNMI

- Soil NOx emissions are estimated to be 300-500 Gg/year for Europe, but large uncertainties exist

- DECSO will be applied to TROPOMI observations. Collection of meteo data started and TROPOMI data will be preprocessed for use in DECSO

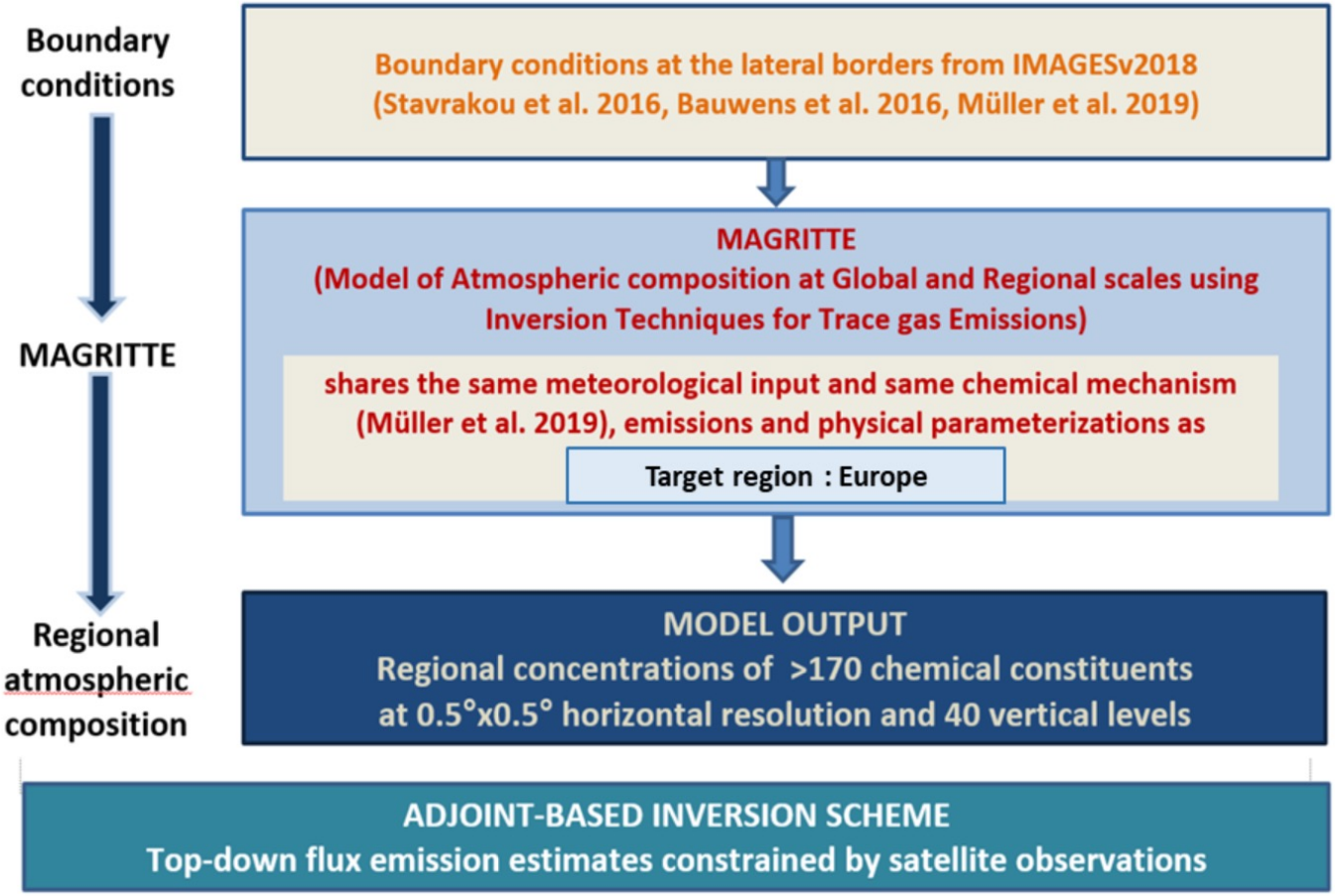
- Start of inversion experiments with split between soil NOx emissions and anthropogenic NOx emissions

- Collection of land-use data for verification of soil emissions

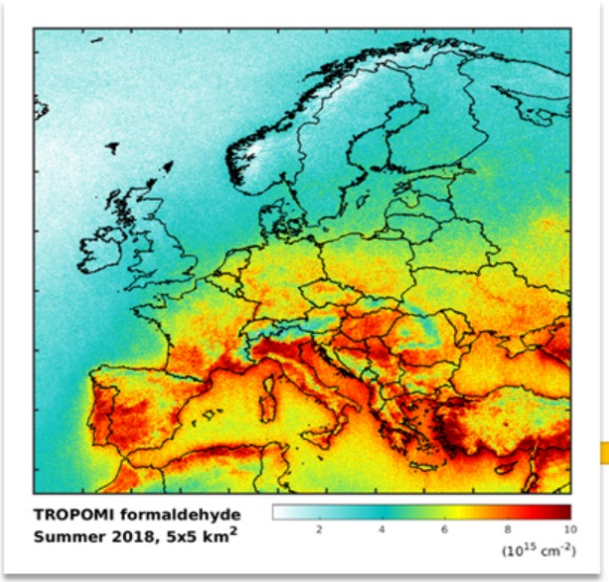


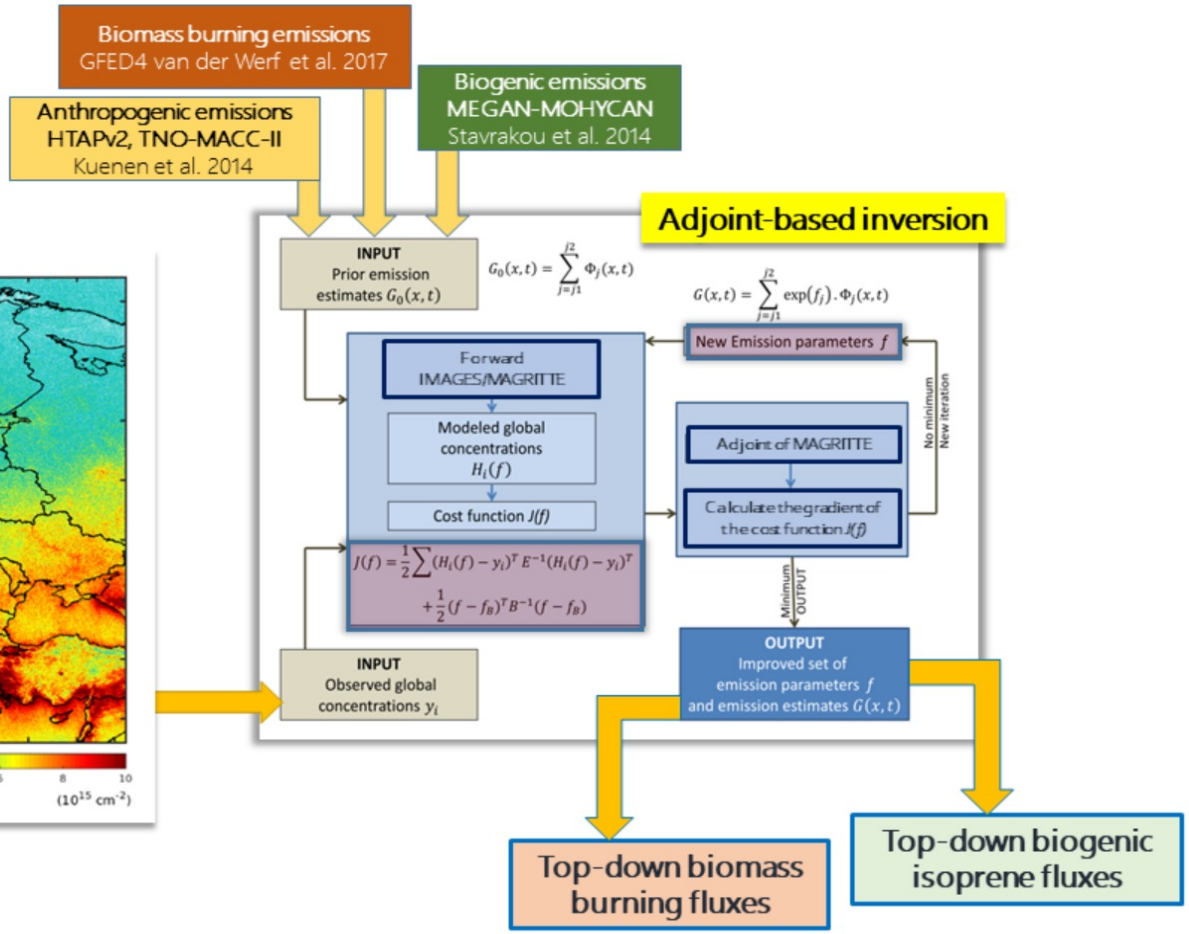
Preliminary result of total NOx emissions

The MAGRITTE CTM…



…and its adjoint





- Adjoint-based optimizations can address non-linearities and handle large numbers of control variables without increasing the computational cost → method has been applied to global or regional scale (South America, China)
- Satellite-based fires and biogenic emissions are derived either separately or simultaneously from the same inversion experiment
- Significant developments of MAGRITTE+adjoint required to exploit the measurement capabilities of TROPOMI

Discussion