EQUATOR

Emission QUantification of Atmospheric tracers in the Tropics using ObseRvations from satellites

DURATION
15/12/2020 - 15/03/2025

BUDGET
271 832 €

PROJECT DESCRIPTION

The biogenic volatile organic compounds (BVOCs) affect the tropospheric chemistry, air quality and the climate. They are ubiquitous in tropical ecosystems, and isoprene (C5H8) is by far the dominant compound. However large uncertainties in BVOC emission estimates exist, mostly due to the large biological diversity, the complex mechanisms driving the emissions, and the paucity of direct observations. While direct satellite observations of isoprene are still in the early stages of development, spaceborne formaldehyde (HCHO) data have been used in combination with models to constrain the emissions of isoprene and other reactive non-methane VOCs (NMVOCs). There are, however, major hurdles in the derivation of NMVOC emissions from HCHO columns: (i) contribution from several compounds (C5H8, methanol (CH3OH), biomass burning VOCs), (ii) significant biases in the satellite HCHO data, and (iii) the chemical uncertainties (isoprene oxidation mechanisms and the influence of NOx levels, of which atmospheric abundances are uncertain).

The EQUATOR project aims to provide an improved appraisal of the budget and role of emissions of key compounds (NOx, HCHO, CH3OH, C5H8) in the Tropics. The specific objectives are:

- To account for land cover changes in BVOC emission estimates over the last two decades.
- To quantify the magnitude of lightning and soil NOx emissions in the Tropics. These two sources are recognized to bear large uncertainties, which can strongly affect the HCHO model abundances.
- To determine the contribution of CH3OH oxidation to the HCHO budget, as CH3OH is an important biogenic precursor of HCHO.
- To develop novel methodologies for quantifying the BVOC emissions based on the simultaneous inversion of spaceborne HCHO and C5H8 column data.

To achieve our objectives, the following models and techniques will be used: the MEGAN-MOHYCAN biogenic emission model at a global resolution of 0.5°x0.5°; the MAGRITTEv1.1 regional chemistry-transport model (CTM) at 0.5°x0.5° over the Tropics and the adjoint of the MAGRITTEv1.1 to derive space-based emission datasets. All models have been developed within the Tropospheric Chemistry Unit of BIRA-IASB, and have been used in many published studies. Satellite observations from different sensors will be used as top-down constraints in an inversion scheme based on the adjoint of the MAGRITTEv1.1 model.

Several model updates will be carried out in MAGRITTEv1.1, e.g. the vertical distribution of lightning NO emissions will be revised and recent high-resolution soil NO emission inventories will be implemented. The natural sources of NO_x will be optimized using OMI (Aura) and TROPOMI (Sentinel 5-p) NO_2 columns corrected for biases using independent observations. We will derive lightning and soil NO emissions simultaneously; the distinction between the two sources will be based on their a priori geographical and temporal patterns, through the a priori emission covariance matrix.

The continental sources of CH_3OH will be optimized using the IASI (MetOp) columns corrected for biases against aircraft campaigns. The biogenic and biomass burning source of CH_3OH will be derived simultaneously. The optimized emissions will replace the current bottom-up CH_3OH emissions in MAGRITTEv1.1.

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To consider the effects of land cover changes on biogenic emissions, the static plant functional type distributions of the stand-alone MEGAN model will be replaced by annually updated spaceborne land cover products from MODIS and Landsat's instruments. We will conduct MEGAN-MOHYCAN simulations over 2001-2020 to calculate bottom-up BVOC emissions that will be used as a priori emissions in MAGRITTEv1.1. The emissions of NMVOCs will be optimized based on OMI and TROPOMI HCHO data corrected for biases against aircraft campaigns and further evaluated against FTIR data. Pyrogenic and biogenic VOC emissions will be inferred simultaneously, and the optimized HCHO concentration fields will be validated against aircraft campaign and ground-based data. An optimal inversion methodology will be designed for conducting simultaneous inversion of emissions of TROPOMI/OMI HCHO and C_5H_8 from CrIS (Suomi-NPP/JPSS) for the emissions of isoprene and other NMVOCs at a global scale. Several trials might be needed for this step as the assimilation of isoprene and HCHO will likely require adjustment of OH fields.

The derived space-based emission datasets and updated modelled concentrations will be evaluated through comparison with available bottom-up inventories, as well as ground-based and airborne observations. Finally, a tentative assessment of uncertainties of the top-down emissions will be realized, based on a set of sensitivity inversions conducted to investigate the impact of errors in the model simulations and in the satellite retrievals.

Overall, the expected outcome of the project will be a better understanding of natural emissions and their impact in tropical regions, as well as to an improved assessment of the respective roles of natural and human-induced emissions in these environments. EQUATOR will lead to openly accessible space-based emission datasets, which will be distributed via well-established networks (like IGAC), in order to enhance their visibility, strengthen existing collaborations, and create new opportunities for future research.

CONTACT INFORMATION

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LINKS

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