SATELLITE-BASED ISOPRENE EMISSION ESTIMATES 2007-2012 : FIRST RESULTS OF GlobEmission PROJECT.

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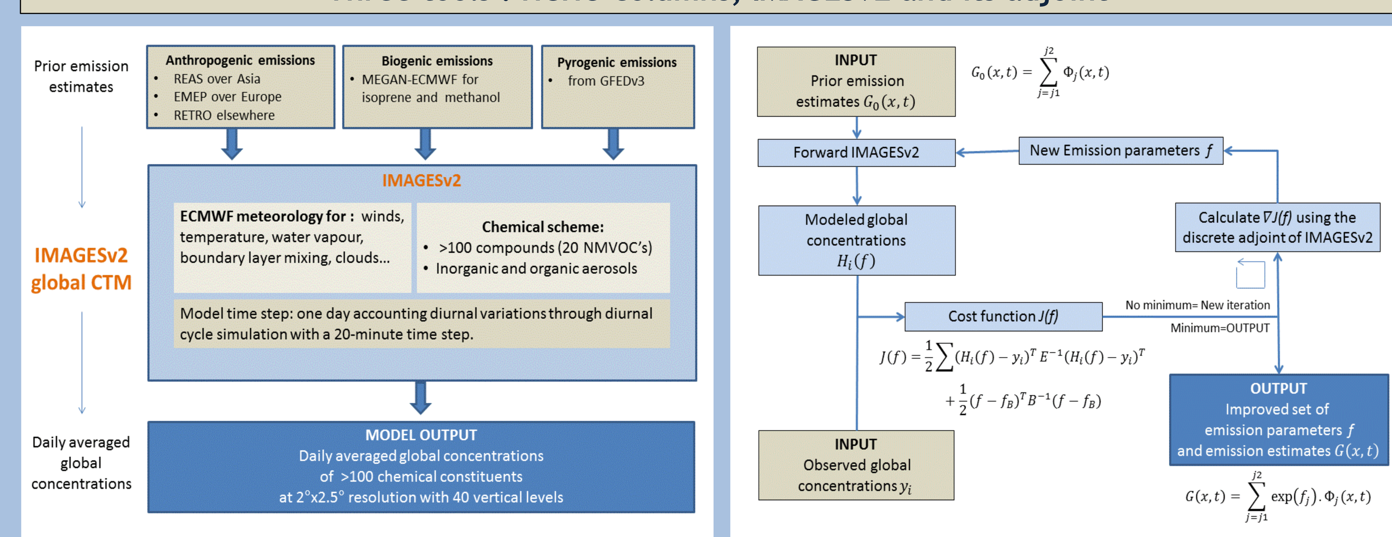
Introduction

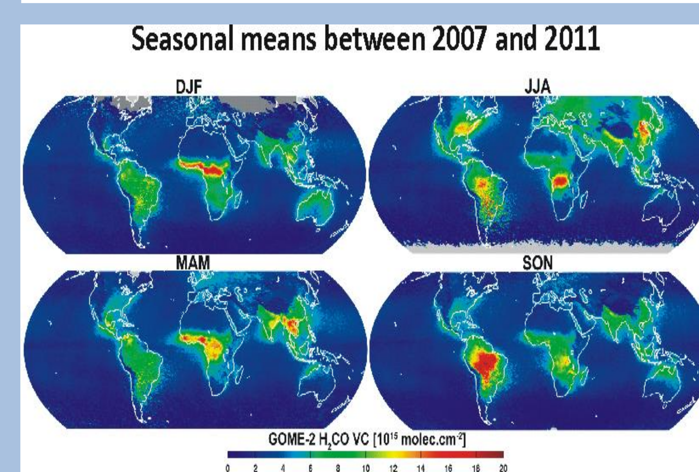
Isoprene is the most largely emitted biogenic NMVOC. It is believed to enhance tropospheric ozone formation in polluted areas, leading to smog formation, to decrease the oxidizing capacity of the troposphere, and to contribute to the production of secondary organic aerosols. Therefore it is important to have accurate emission estimates for isoprene. The Model of Emissions of Gases and Aerosols from Nature version 2 (MEGANv2) is the most commonly used bottom-up isoprene inventory. However, substantial uncertainties remain, owing to the large spatiotemporal variability of the emitting source and to the limited representativity of field studies.

Inversion methods provide an independent estimation of isoprene emission strengths and are used to complement the bottom-up approach. Here we use an inverse modeling scheme based on top-down constraints of formaldehyde (HCHO) columns retrieved from the Global Ozone Monitoring Experiment-2 (GOME-2). The discrepancy between formaldehyde columns calculated by the IMAGESv2 global CTM and those observed from GOME-2 is minimized using the adjoint modeling technique. This technique allows for the optimization of the emission strengths at the model resolution and provides a differentiation among the emission sources.

On the global scale, the updated biogenic emissions are found to be relatively close to MEGANv2. In particular, the interannual variability of MEGANv2 is preserved. The inversion suggests emission decreases above Australia, Europe and North America, whereas over Equatorial Africa a strong increase of biogenic emissions is inferred. The updated biogenic emission estimates are validated through comparison with independent regional bottom-up and top-down inventories reported in literature. Furthermore, an additional inversion constrained by HCHO columns retrieved from the Scanning Imaging Absorption Spectrometer for Atmospheric Chartography (SCIAMACHY) is conducted for evaluation of the emission estimates.

Three tools : HCHO columns, IMAGESv2 and its adjoint



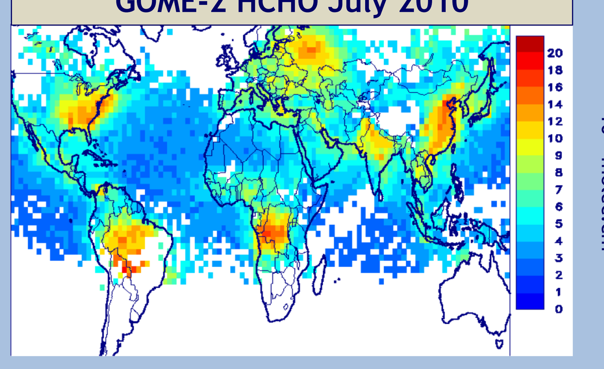


Inversion is run at 2x2.5 deg. resolution,
Runtime = 20 days on 16 processors,
40 iterations needed to reach convergence

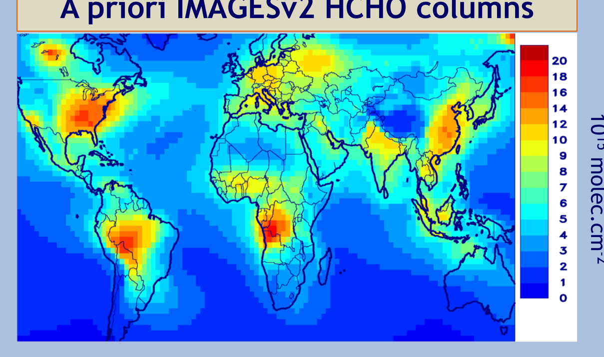
- HCHO-column data are available at: http://www.temis.nl , http://h2co.aeronomie.be
- Up to 40% noise reduction, due to improved spatial sampling
- More info: De Smedt et al. (2012)

The inverse modeling scheme uses HCHO columns retrieved from the GOME-2 as top-down constraints and minimizes the discrepancy between the observed columns and those simulated by the IMAGESv2 global CTM.

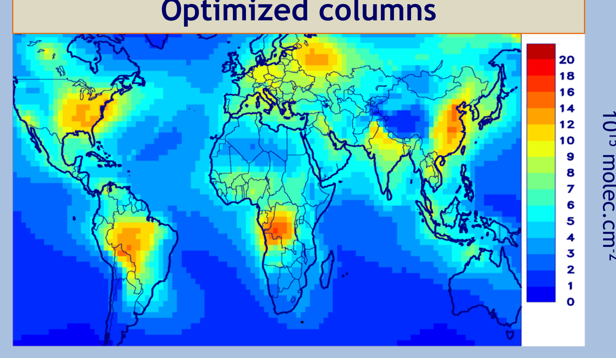
GOME-2 HCHO July 2010



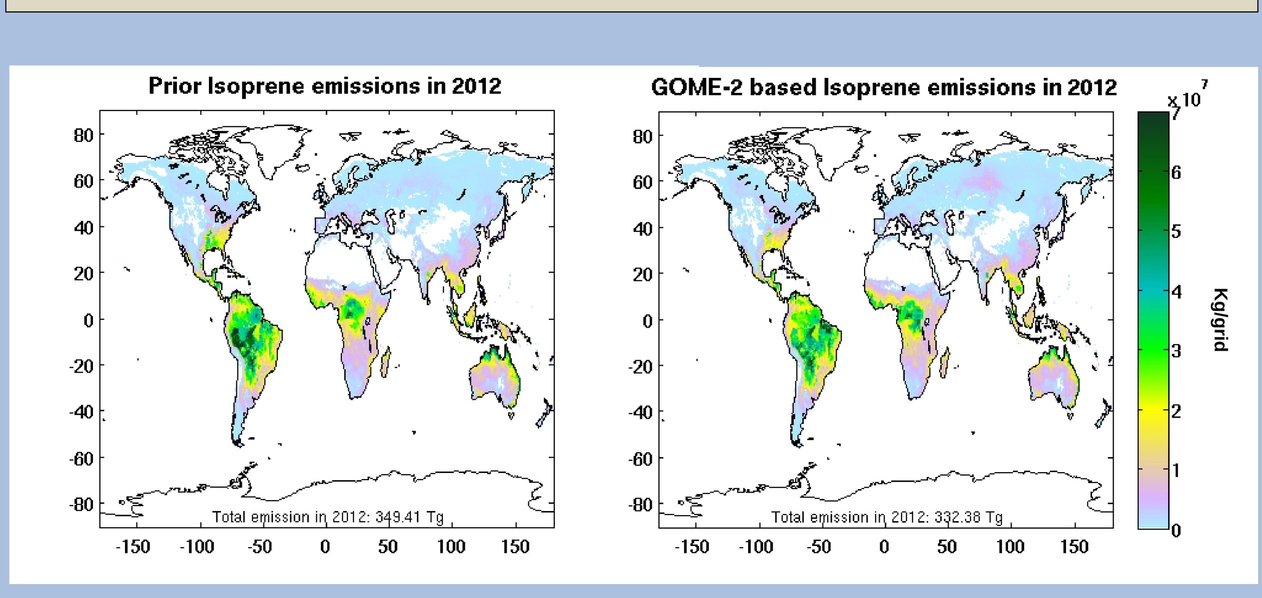
A priori IMAGESv2 HCHO columns

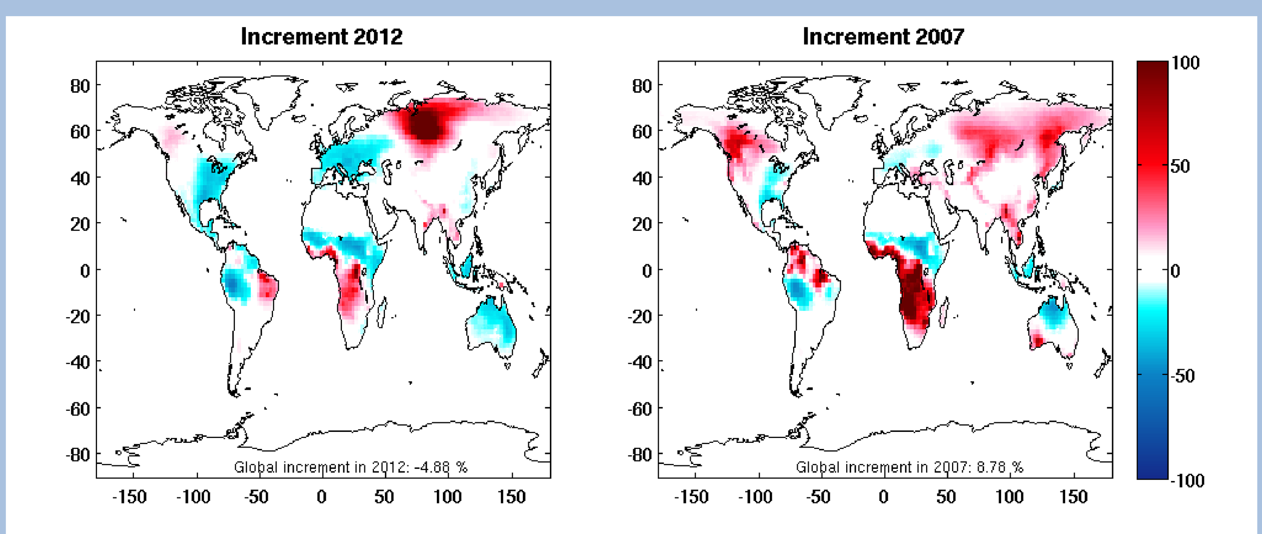


Optimized columns



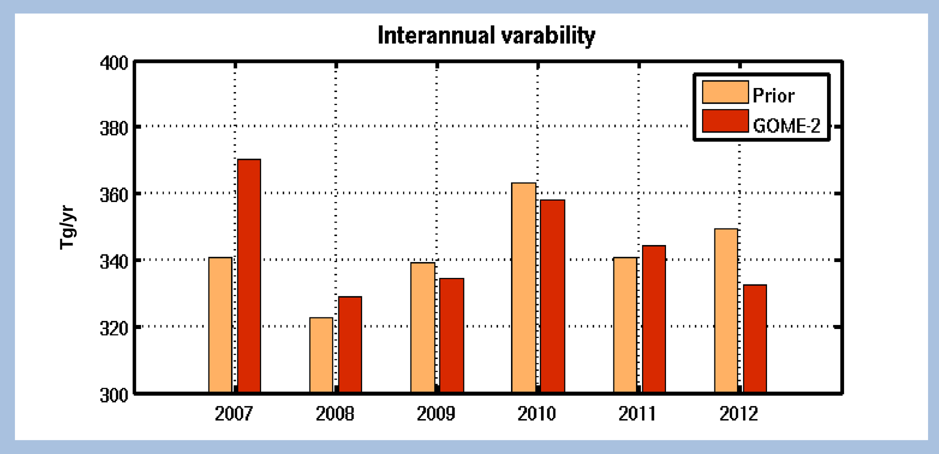
Results of inversion

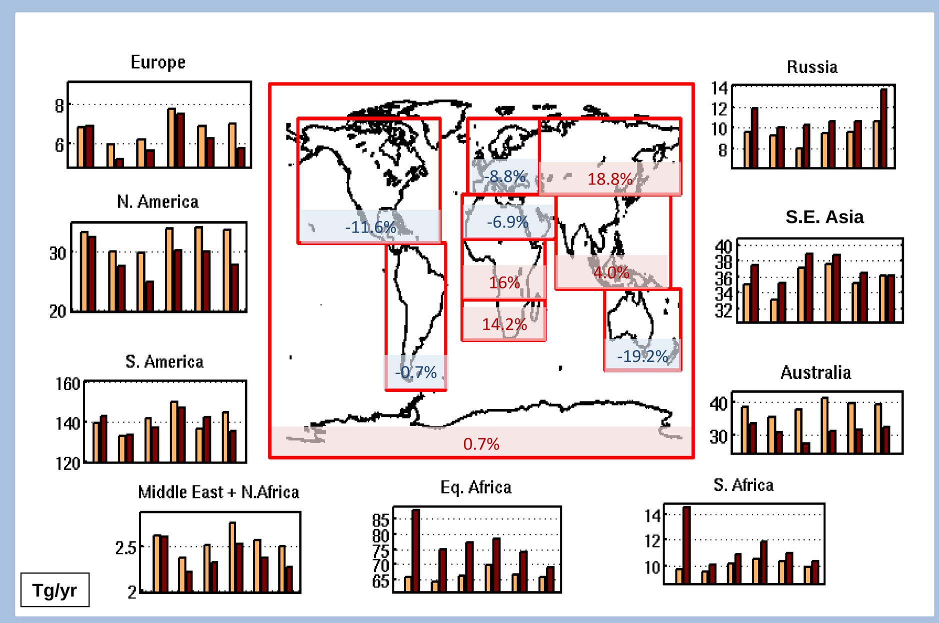




The updated global biogenic emissions are found to be close to the prior: between 5% lower and 10 % higher. However, large increments are derived on the regional scale : emission increases above southern and equatorial Africa and Russia, emission decreases above Australia, Europe and eastern US.

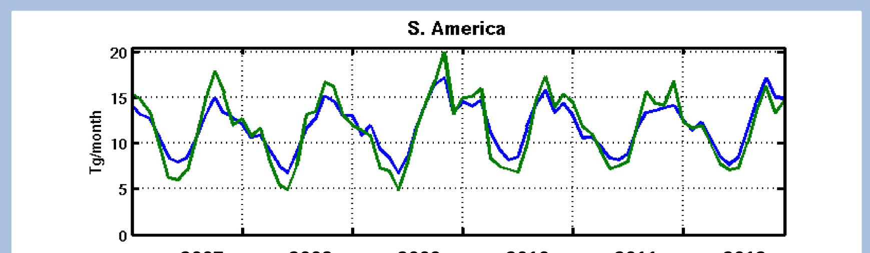
Average increment and interannual variability





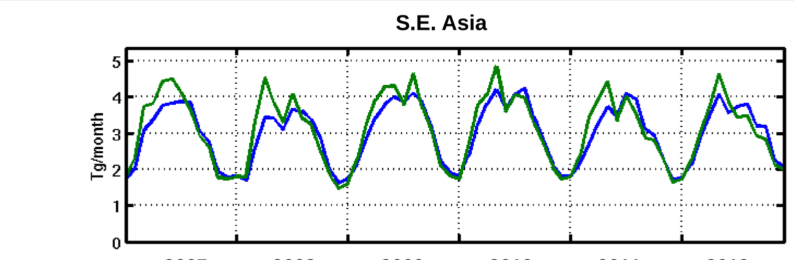
In most regions the interannual variability obtained by the inversion is similar to the prior. In Equatorial and South Africa GOME-2 measurements suggest a higher increase in 2007 than for the other years, by about 30-40%.

Seasonal variations



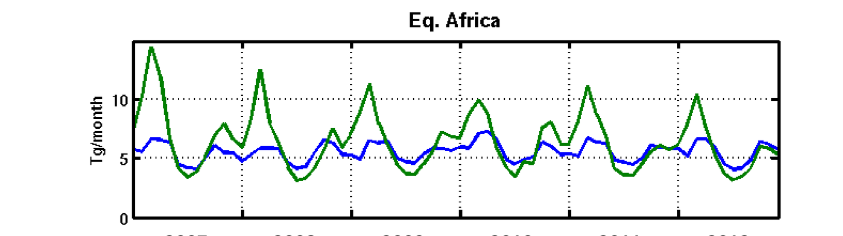
	2007	2008	2009	2010	2011	2012
Prior	139.5	133.2	141.8	150.2	136.1	144.5
GOME-2	143.0	133.6	137.1	147.1	142.4	135.5

- Generally decreased emissions, especially in the late rainy season (March), due to low HCHO columns during the wet-to-dry transition period, this is in agreement with the suggested annual shutdown of Amazonia isoprene fluxes when isoprene emitters experience new leaf growth prior to the dry season (Barkley et al. 2009).
- High emissions in 2010 related with to major drought in Amazonia (Lewis et al. 2011)



	2007	2008	2009	2010	2011	2012
Prior	35.0	33.1	37.1	37.6	35.1	36.1
GOME-2	37.4	35.1	38.8	38.6	36.4	36.1

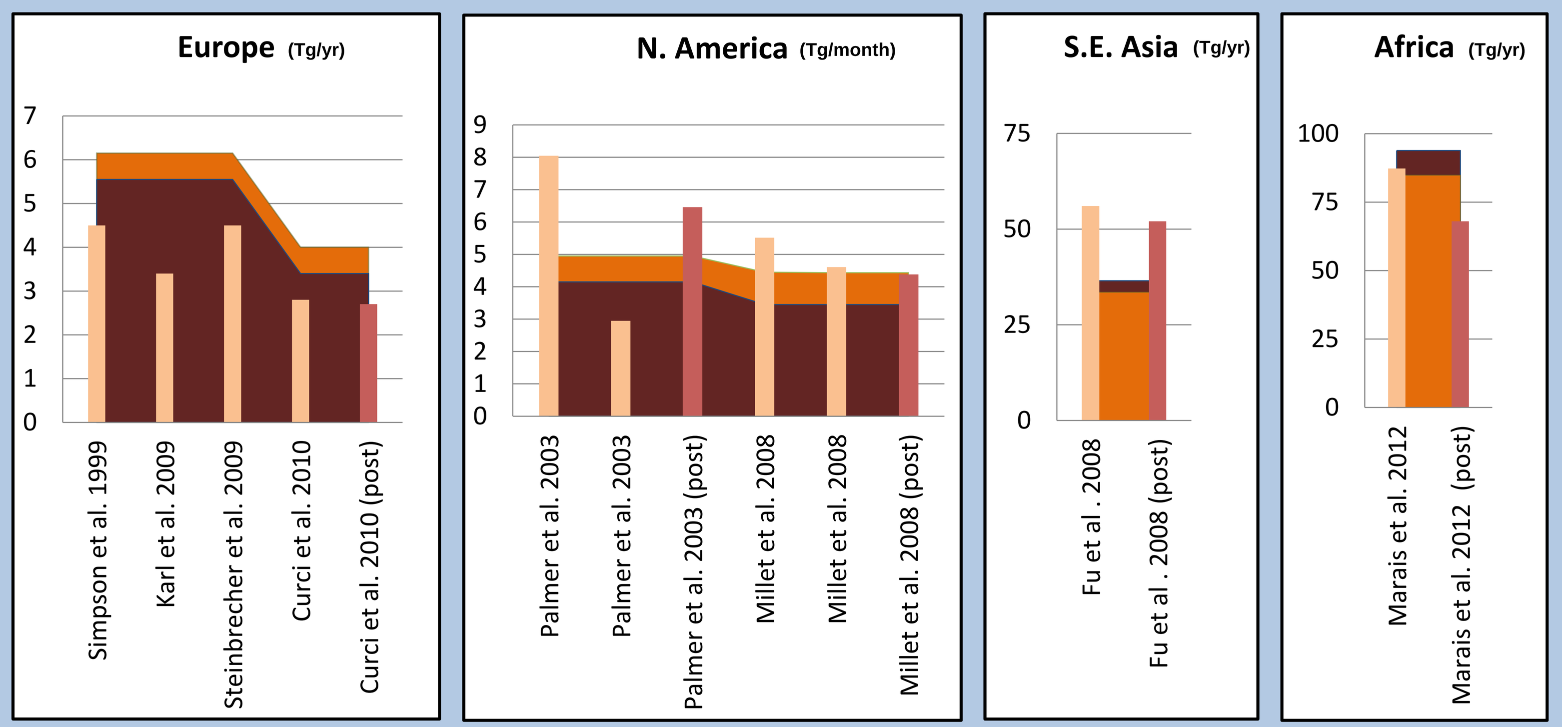
- Good agreement between the prior and GOME-2.-derived estimates. Note that MEGANv2 has been updated in this region to account for the findings of Langford et al. (2010), pointing to a significant reduction of the isoprene emission rate from Southeast Asian tropical rainforests based on field measurements (OP3 campaign).



	2007	2008	2009	2010	2011	2012
Prior-	65.5	64.1	66.1	69.6	66.3	65.8
GOME-2	88.1	74.6	77.0	78.4	73.9	68.8

- The increase inferred in isoprene emissions is in line with the inversion results of Stavrakou et al. (2009), which were based on SCIAMACHY observations, with Shim et al. (2005) based on GOME HCHO data, as well as with the detailed bottom-up inventory of Otter et al. (2003).
- However, the derived increase does not seem to be supported by the OMI-based inversion of Marais et al. (2012) that suggests a 22% decrease of MEGANv2 isoprene emissions over central Africa (cf. comparison to literature data).

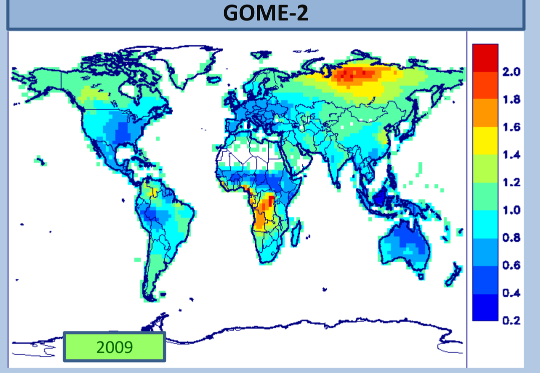
Comparison to literature

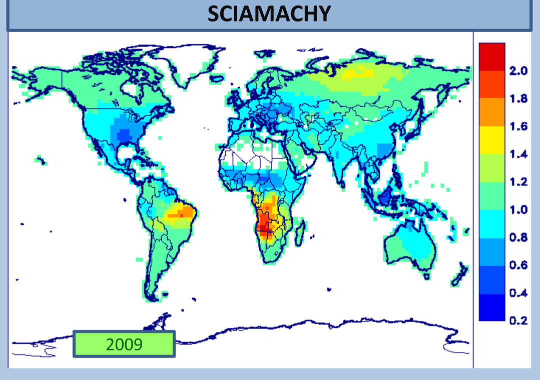


- Prior
- Posterior
- Bottom-up literature
- Top-down literature

The updated biogenic emission estimates are validated through comparison with independent estimates reported in literature (bottom-up inventories and top-down estimates). Regional top-down studies (marked in red) support our results, i.e. the decrease of the emission estimates over Europe, and North America. Over Southeast Asia, the posterior emission is closer to the value by Fu et al. (2007) derived after optimization using GOME data. Over Africa however, the increase suggested by our inversion contrasts with the OMI-based result by Marais et al. (2012) for 2005-2009, which suggests an decrease by 22% with respect to the a priori.

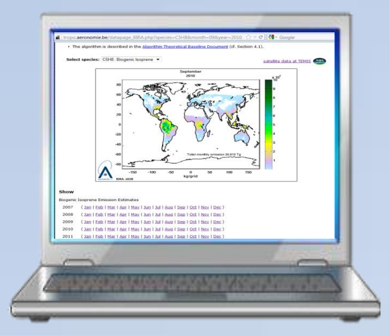
Isoprene updates : GOME-2 vs. SCIAMACHY





An additional inversion constrained by HCHO columns retrieved from the Scanning Imaging Absorption Spectrometer for Atmospheric Chartography (SCIAMACHY) is conducted to investigate the robustness of the inversion results to the choice of the satellite sensor.

http://www.globemission.eu



This study has been carried out as part of the GlobEmission project of ESA, aiming at the development of emission estimates from satellite observations of air constituents.
Monthly updated biogenic isoprene emission estimates are available for use in NetCdf format, at a resolution of 0.5x0.5° for 2007-2012 at the GlobEmission website.

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