Geophysical Research Abstracts
Vol. 21, EGU2019-5499, 2019
EGU General Assembly 2019

Thirteen years of top-down VOC emission estimates over South America inferred by inversion of OMI formaldehyde observations

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South America is home to the largest rainforest in the world and its significant role on the global climate is widely recognized. This region contributes to about 35% to the global isoprene emissions (Guenther et al. 2012), and is prone to intense wildfires, especially under El Niño conditions. In the last two decades, South America has been affected by various man- and climate-induced changes, e.g. deforestation (Chen et al. 2018), increasingly frequent droughts and severe floods (Brown 2016, Esquivel-Muelbert et al. 2018). However, little is known about the impact of these changes on the hydrocarbon emissions, partly due to the inaccessibility of the Amazon forest resulting in the current scarcity of ground-based measurements, and to the South Atlantic anomaly in the Earth's magnetic field reducing the number and quality of satellite observations.

Here we use the long record of formaldehyde (HCHO) column retrievals obtained from the OMI spectrometer (2005-2017, De Smedt et al. 2018) as top-down constraint in the regional MAGRITTE chemistry-transport model (Müller et al. Geosci. Mod. Dev. 2018 a, b) to infer monthly VOC fluxes over South America using the adjoint model method. The estimation relies on the formation of HCHO at high yields in the photo-oxidation of most organic compounds released by vegetation and biomass burning. Satellite observations of HCHO can therefore inform us on the magnitude and spatiotemporal variability of the biogenic and pyrogenic organic compounds. The MAGRITTE model is run at a resolution of 0.5 degree using boundary conditions from the IMAGESv2 global model (Bauwens et al. 2016, Stavrakou et al. 2018). The regional and global models share the same chemical mechanism, emissions and physical parameterizations. Anthropogenic VOC emissions and their speciation are obtained from EDGARv4.3.2 (Huang et al. 2017), wildfire emissions from GFED4 (van der Werf et al. 2017), and biogenic emissions from the MEGAN-MOHYCAN model (Bauwens et al. 2018, Stavrakou et al. 2018). Individual inversions are performed for every year.

Detailed comparisons between observed and modeled HCHO columns over climate zones defined by Köppen's classification system are analyzed. Overall, the inferred top-down isoprene emissions are about 40% lower on average than the a priori (88 vs 144Tg/yr). Significant changes are predicted regarding the interannual variability, and pronounced negative trends are inferred. The inversion suggests a moderate decrease of fire VOC fluxes compared to the a priori (12 vs 15Tg/yr), while the interannual variability remains unchanged. The top-down fluxes are evaluated through model comparisons with independent observations: ground-based remote sensing data (FTIR) at Porto Velho and Paramaribo, and aircraft data (GABRIEL). Both show a quite satisfactory agreement between the optimized model and these datasets. As long-term VOC flux measurements are inexistent in this region, the 13-year long top-down dataset of this study provides a unique insight in the link between the VOC emissions, climate and human-induced drivers.