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Climate variability and trends in biogenic emissions imprinted on satellite observations of formaldehyde from SCIAMACHY and OMI sounders

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Biogenic hydrocarbon emissions (BVOC) respond to temperature, photosynthetically active radiation, leaf area index, as well as to factors like leaf age, soil moisture, and ambient CO_2 concentrations. Isoprene is the principal contributor to BVOC emissions and accounts for about half of the estimated total emissions on the global scale, whereas monoterpenes are also significant over boreal ecosystems. Due to their large emissions, their major role in the tropospheric ozone formation and contribution to secondary organic aerosols, BVOCs are highly relevant to both air quality and climate. Their oxidation in the atmosphere leads to the formation of formaldehyde (HCHO) at high yields. Satellite observations of HCHO abundances can therefore inform us on the spatial and temporal variability of the underlying sources and on their emission trends.

The main objective of this study is to investigate the interannual variability and trends of observed HCHO columns during the growing season, when BVOC emissions are dominant, and interpret them in terms of BVOC emission flux variability. To this aim, we use the MEGAN-MOHYCAN model driven by the ECMWF ERA-interim meteorology to calculate bottom-up BVOC fluxes on the global scale (Müller et al. 2008, Stavrakou et al. 2014) over 2003-2015, and satellite HCHO observations from SCIAMACHY (2003-2011) and OMI (2005-2015) instruments (De Smedt et al. 2008, 2015). We focus on mid- and high-latitude regions of the Northern Hemisphere in summertime, as well as tropical regions taking care to exclude biomass burning events which also lead to HCHO column enhancements. We find generally a very strong temporal correlation (>0.7) between the simulated BVOC emissions and the observed HCHO columns over temperate and boreal ecosystems. Positive BVOC emission trends associated to warming climate are found in almost all regions and are well corroborated by the observations.

Furthermore, using OMI HCHO observations over 2005-2015 as constraints in an inversion based on the adjoint of the IMAGESv2 chemistry-transport model (Bauwens et al. 2016), we derive top-down biogenic emissions, which exhibit stronger emission trends than the bottom-up inventory at high-latitude regions of the Northern Hemisphere, suggesting that the response of biogenic emissions to warming temperature might be stronger than currently assumed in models.