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Investigation of rain-induced NO_x and HCHO emissions from soils as viewed by the GOME-2 and SCIAMACHY satellite sensors

Jan Zörner, Marloes Penning de Vries, Steffen Beirle, Patrick Veres, Jonathan Williams, and Thomas Wagner
Max Planck Institute for Chemistry, Mainz, Germany

Outside industrial areas, soil emissions of NO_x (stemming from bacterial emissions of NO) represent a considerable fraction of total NO_x emissions and may even dominate in remote tropical and agricultural areas. NO_x fluxes from soils are controlled by abiotic and microbiological processes which depend on ambient environmental conditions, but are also strongly affected by agricultural management practices. Rain-induced spikes in NO_x have been observed by in-situ measurements and also satellite observations, i.e. by Jaegle et al. (2004), Bertram et al. (2005), Ghude et al. (2010) and Hudman et al. (2010). The latter studies present the first estimation of soil NO_x emissions derived from satellite observations of tropospheric NO_2 columns. However, since soil emissions over broad geographic regions remain difficult to measure or even estimate using bottom-up approaches, their representation in chemical models can still be improved by accurate satellite constraints.
This study extends the previous research by investigating peaks in tropospheric NO_2 concentrations after rain fall events following dry spells. Additionally, we examine the possibility for detection of HCHO emissions from wetted soils which has not been previously attempted by using satellite observations. A limited number of laboratory experiments on soil fluxes suggest that significant HCHO emissions from soil can occur. Vertical NO_2 and HCHO columns retrieved from GOME-2 aboard METOP and SCIAMACHY aboard ENVISAT were used. An in-depth analysis of rain-induced soil emissions was conducted for not only broad seasonal and annual averages but also investigate the soil-temperature dependencies using TRMM precipitation data and model data from the ECMWF Interim Reanalysis project. Moreover, a thorough validity check and the crucial source partitioning of the measured NO_2 and HCHO signals are conducted to evaluate whether the observed signals originate from fire, other anthropogenic and biogenic influences, lightning or are strongly affected by measurement errors in the satellite retrieval caused by manifold reasons such as an increased cloud fraction. For many seasons and regions we see significant responses to rain events in NO_2 columns and to a lower extent also in HCHO columns with both satellite instruments. However, some seasons and regions show no responses which is not yet understood. Hence, rain-induced soil emissions remain elusive and further investigations are necessary.