Geophysical Research Abstracts
Vol. 16, EGU2014-6666-2, 2014
EGU General Assembly 2014
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Rain-induced emission pulses of NO_x and HCHO from soils in African regions after dry spells as viewed by satellite sensors

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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. Rain-induced spikes in NO_x have been observed by in-situ measurements and also satellite observations. However, the estimation of soil emissions over broad geographic regions remains uncertain using bottom-up approaches. Independent, global satellite measurements can help constrain emissions used in chemical models. Laboratory experiments on soil fluxes suggest that significant HCHO emissions from soil can occur. However, it has not been previously attempted to detect HCHO emissions from wetted soils by using satellite observations.

This study investigates the evolution of tropospheric NO_2 (as a proxy for NO_x) and HCHO column densities before and after the first rain fall event following a prolonged dry period in semi-arid regions, deserts as well as tropical regions in Africa. Tropospheric NO_2 and HCHO columns retrieved from OMI aboard the AURA satellite, GOME-2 aboard METOP and SCIAMACHY aboard ENVISAT are used to study and inter-compare the observed responses of the trace gases with multiple space-based instruments. The observed responses are prone to be affected by other sources like lightning, fire, influx from polluted air masses, as well measurement errors in the satellite retrieval caused by manifold reasons such as an increased cloud contamination. Thus, much care is taken verify that the observed spikes reflect enhancements in soil emissions. Total column measurements of H_2O from GOME-2 give further insight into the atmospheric state and help to explain the increase in humidity before the first precipitation event. The analysis is not only conducted for averages of distinct geographic regions, i.e. the Sahel, but also for higher resolution grid boxes to map the spatial pattern of absolute and relative enhancements after the wetting of dry soils.

At the beginning of the wet season in the Sahel in April/May/June strong NO_2 VCD enhancements compared to the background levels are observed by all three satellite sensors. A significant enhancement in HCHO VCD is also detected with GOME-2. Further analysis shows that spatial patterns and the magnitude of such enhancements over Africa are highly dependent on the season, prevailing temperatures and land cover types.