Satellite evidence of substantial rain-induced soil emissions of ammonia across the Sahel.

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Abstract:
In regions with distinct dry and wet seasons such as the Sahel, the start of the rainy season triggers a pulse of biogeochemical activity in surface soils known as the Birch effect. Field and lab studies have sometimes, but not always, observed pulses of NH$_3$ after the wetting of dry soils, but the potential regional importance of these emissions remains poorly constrained. Here we use satellite retrievals of atmospheric NH$_3$ using the Infrared Atmospheric Sounding Interferometer (IASI) in combination with satellite-based observations of precipitation, surface soil moisture, and nitric dioxide (NO$_2$) concentrations, to present evidence of substantial precipitation-induced pulses of NH$_3$ across the Sahel at the onset of the rainy season in 2008. In the Sahel, the highest concentrations of NH$_3$ occur in pulses during March and April, when biomass burning emissions estimated for the region by the GFED4s database are low. Changes in NH$_3$ concentrations are significantly correlated with changes in soil moisture during the period from mid-March through April, when the peak NH$_3$ concentrations occur ($r=0.28$, $p=0.02$). The correlation is also present when evaluated on an individual pixel-basis during April ($r=0.16$, $p<0.001$). Using a simple box model, average emissions for the entire Sahel are between 2 and 6 mg NH$_3$ m$^{-2}$ day$^{-1}$ during peaks of the observed pulses, depending on the assumed effective lifetime. These early season pulses are consistent with surface observations from the INDAAF network, which show an uptick in NH$_3$ deposition at the start of the rainy season for sites in the Sahel. The NH$_3$ peaks also broadly correspond to peaks in tropospheric NO$_2$ concentrations, which have previously been attributed to the Birch effect. Box model results suggest that pulses occurring over a 35-day period in March and April are responsible for roughly one fifth of annual NH$_3$ emissions from the Sahel.