Airborne measurements of ammonia emissions: A case study over a livestock farm in Grosseto, Italy

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ABSTRACT

Ammonia (NH_3) is excessively emitted into the atmosphere by anthropogenic activities, particularly agriculture. For example, in northern Italy, agricultural activities, primarily manure management and fertilizer use, account for more than 90% of the total NH_3 emissions. These emissions significantly harm the environment and degrade air quality. Unfortunately, despite ongoing efforts to regulate NH_3 emissions, they remain high across vast regions worldwide. To develop more targeted and effective mitigation strategies, we need improved measurement means capable of identifying and quantifying the diversity of NH_3 emissions sources.

Currently, NH_3 is measured globally from space using hyperspectral infrared sounders, such as the Infrared Atmospheric Sounding Interferometer (IASI). Over a decade of observations have enabled the identification and quantification of the world's most significant NH_3 hotspots, most of which are associated with intensive farming or fertilizer production. However, the instrument's spatial resolution (coarser than 10 km) and non-contiguous coverage make it challenging to survey small-scale sources. Even with IASI-NG offering considerable improvements, high spatial resolution measurements will be missing.

We report here on a case study of a large livestock farm in Grosseto, Italy, whose NH_3 emissions are not observable from space. The analysis is based on aerial survey data collected as part of a joint ESA-NASA campaign in Italy between May and July 2023. The measurements, at high spatial and spectral resolution, were performed by the NASA-JPL's Hyperspectral Thermal Emission Spectrometer (HyTES) onboard the Kenn Borek Air (KBA) aircraft. The livestock farm and its immediate surroundings were surveyed 12 times during several weeks, and at different times of the day. From the raw HyTES radiance data, we derived NH_3 distributions using a look-up table approach. In turn, these distributions were used to estimate the NH_3 fluxes emitted from the farm at the time of each overflight. The entire time series of emission fluxes reveals a surprisingly high degree of temporal variability. We present a detailed analysis of the emissions in relation to meteorological parameters to pinpoint the driving factors for these variations.