AIRBORNE MEASUREMENTS OF AMMONIA EMISSIONS: A CASE STUDY OVER A LIVESTOCK FARM IN GROSSETO, ITALY

Lara Noppen[1], Lieven Clarisse[1], Frederik Tack[2], Martin Van Damme[1,2], Mary Langsdale[3], Martin Wooster[3], Seyedhamed Shariatmadar[3], Mark Grosvenor[3], Gerardo Rivera[4], Simon Hook[4], Michel Van Roozendael[2], Dirk Schuettemeyer[5] and Pierre Coheur[1]

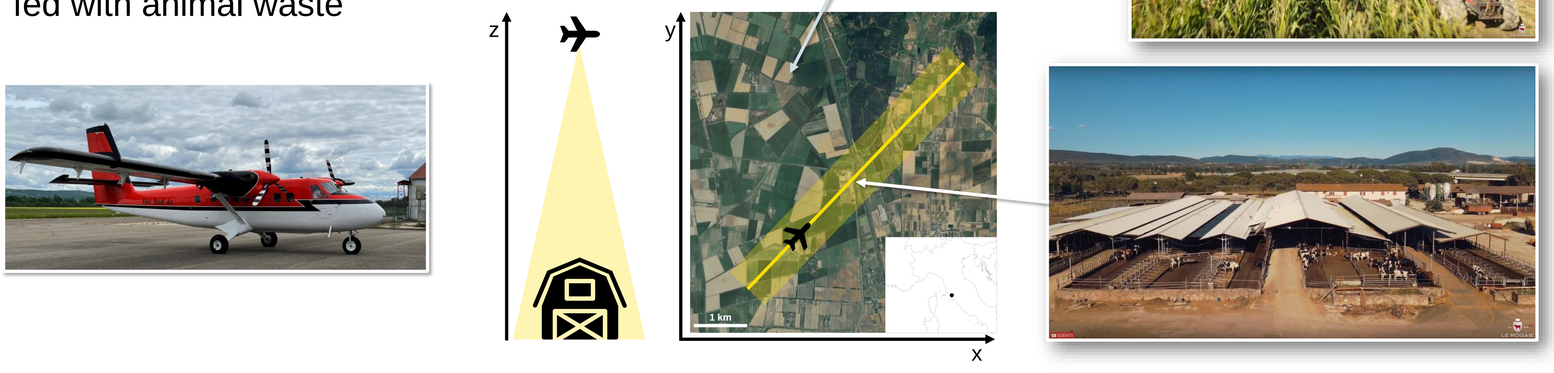
[1] Université libre de Bruxelles (ULB), Brussels, Belgium
[2] Royal Belgian Institute for Space Aeronomy (BIRA-IASB), Brussels, Belgium
[3] King's College London (KCL), London, United Kingdom
[4] Jet Propulsion Laboratory (JPL), Pasadena, United States
[5] European Space Agency (ESA-ESTEC), Noordwijk, Netherlands

INTRODUCTION

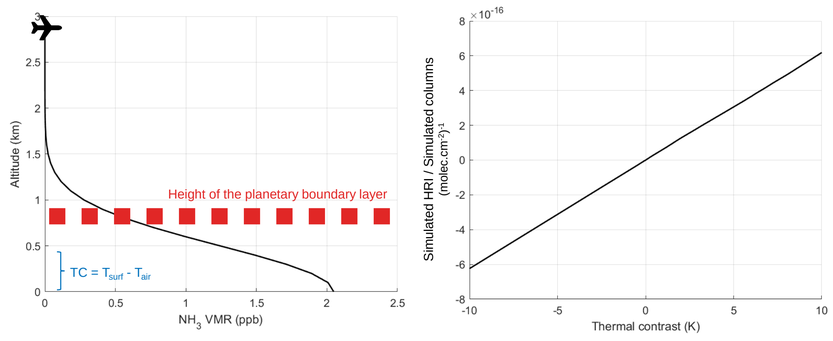
- Ammonia (NH_3) is excessively emitted into the atmosphere by anthropogenic activities, particularly agriculture. These emissions significantly harm the environment and degrade air quality.
- NH_3 is currently measured globally from space using infrared sounders such as the Infrared Atmospheric Sounding Interferometer (IASI).
- The instrument's spatial resolution is coarser than 10 km. Only the strongest and most isolated point sources have been identified and quantified. High spatial resolution measurements are missing.
- Here, we report the preliminary analysis of NH_3 observations made during aerial surveys of a small livestock farm in Grosseto (Italy) whose NH_3 emissions are not observable from space.

MEASUREMENTS

- The measurements were performed by NASA-JPL's Hyperspectral Thermal Emission Spectrometer (HyTES) onboard the Kenn Borek Air aircraft on July 2, 2023
- HyTES is a compact image spectrometer that acquires data in 256 spectral bands between 860 and 1300 cm^{-1} at a spatial resolution of about 4 m
- The livestock farm and its immediate surroundings were overflown almost 100 times over ten days between May and July 2023 at different times of the day
- Le Rogaie is a small family farm, with about 600 cows and 200 hectares for forages. The farm produces 25,000 hectoliters of milk and generates 1,800,000 kWh of electricity through a biogas tank fed with animal waste



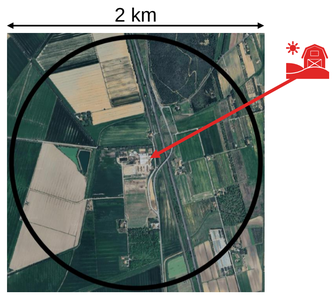
METHODOLOGY & RESULTS

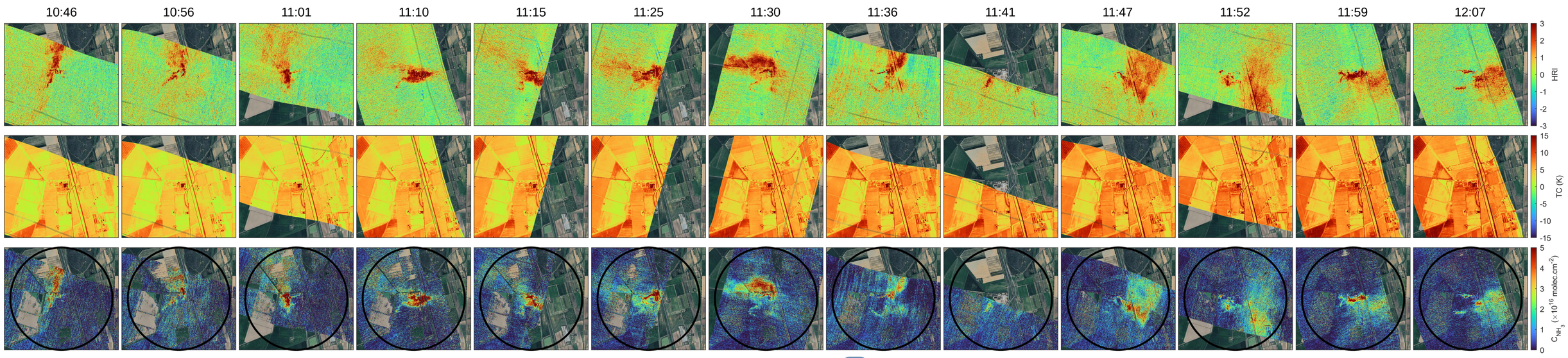


- The detection of NH_3 is based on the hyperspectral range index (HRI), which quantifies the spectral contribution of NH_3 in a given spectral range
- HRIs are converted to NH_3 total columns using theoretical lookup tables (LUT) set up by radiative transfer simulations

$$Col = LUT . HRI + B$$

Col: NH_3 retrieved columns; LUT: HRI calculated over the scene; B: Background columns of NH_3 → neglected as we are interested in excess NH_3 emitted by the farm



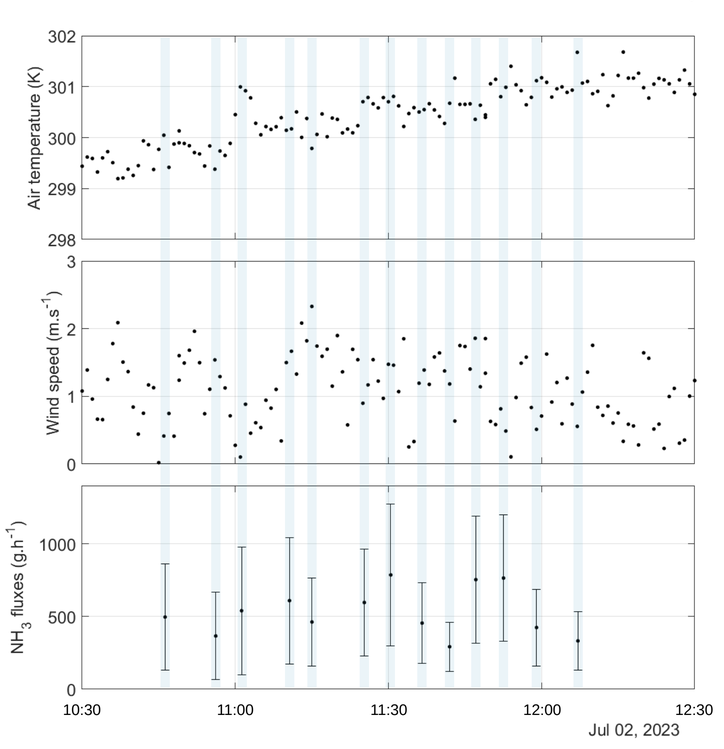


- The NH_3 fluxes are estimated with a simple box model

$$F = \frac{M}{\tau}$$

F: NH_3 emission fluxes; M: NH_3 mass inside the considered box; τ: NH_3 lifetime → 2 hours

- Uncertainties are estimated through propagation of uncertainty on the input variables
- Averaged NH_3 fluxes, considering constant emissions and the number of animals : [0.3 – 1.5] $g.h^{-1}.hd^{-1}$
  → Slightly below the NH_3 emission factors of 2.5 $g.h^{-1}.hd^{-1}$ for dairy operations reported in Hristov et al. (2011)
- The next step is to perform the same analysis for all monitored days, studying the variability of the emissions as a function of time of the day, wind and temperature



REFERENCES

1. Van Damme, M. et al. (2018). Industrial and agricultural ammonia point sources exposed. *Nature*, 564(7734) :99-103.
2. Clarisse, L. et al. (2019). Tracking down global NH_3 point sources with wind-adjusted superresolution. *Atmos. Meas. Tech.*, 12: 5457-5473.
3. Hook, S. et al. (2013). NASA's Hyperspectral Thermal Emission Spectrometer (HyTES), in: Thermal Infrared Remote Sensing – Sensors, Methods, Applications, Springer, Dordrecht, the Netherlands.
4. Walker, J. et al. (2011). An effective method for the detection of trace species demonstrated using the MetOp Infrared Atmospheric Sounding Interferometer. *Atmos. Meas. Tech.*, 4: 1567-1580.
5. M. Van Damme et al. (2014). Global distributions, time series and error characterization of atmospheric ammonia (NH_3) from IASI satellite observations. *Atmos. Chem. Phys.*, 14(6) :2905-2922.
6. Clarisse, L. et al. (2023). The IASI NH_3 version 4 product: Averaging kernels and improved consistency. *Atmos. Meas. Tech.*, 16: 5009-5028.
7. Hristov, A. N. et al, (2011). Review: Ammonia emissions from dairy farms and beef feedlots. *Can. J. Anim. Sci.*, 91: 1-35.