Aircraft observations of NH_3 from agricultural sources

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1. Aircraft & satellite observations

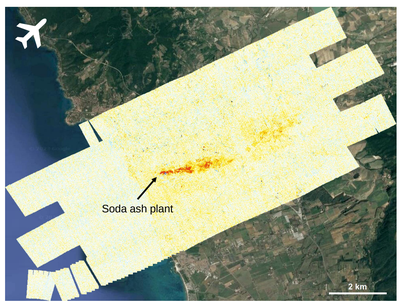
- The nitrogen cycle is heavily perturbed by excess anthropogenic emissions of reactive nitrogen components (Nr)
  → Detrimental consequences on air quality, environment and climate
  → Effective monitoring of Nr is essential
- Main Nr species (ammonia (NH_3) and nitrogen dioxide (NO_2)) are currently monitored from space at a spatial resolution of ~ 10 × 10 km² → Only the strongest and most isolated point sources have been identified and quantified
- The satellite Nitrosat was selected to enter phase 0 of ESA's 11th Earth Explorer call to map NH_3 and NO_2 globally at a spatial resolution of ~ 500 × 500 m²
  → Dozens of aircraft demonstration flights in Europe since 2020 to measure:
  - NH_3 in the infrared (800-1350 cm^{-1}) with the Telops HyperCam LW spectrometer at 4 m spatial and 1.2-1.6 cm^{-1} spectral resolution
  - NO_2 in the visible (280-550 nm) with the SWING+ instrument from BIRA at 170 m spatial and 0.7 nm spectral resolution

2. Soda ash plant

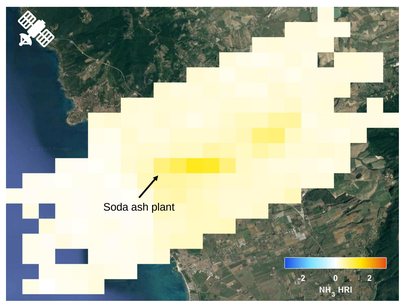
See L. Noppen et al. (2023) for more airborne observations of NH_3 industrial emissions and fluxes retrievals

- Detection of NH_3 in the spectra measured with HyperCam LW based on a hyperspectral range index (HRI) that quantifies the spectral signature of NH_3 in a given spectral range → Ex: NH_3 HRI distribution over Rosignano (Italy)

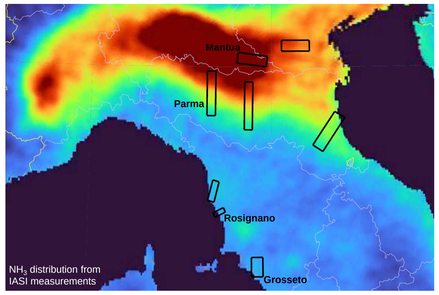
→ At native spatial resolution (~ 4 × 4 m²)



→ At hypothetical satellite resolution (~ 500 × 500 m²)

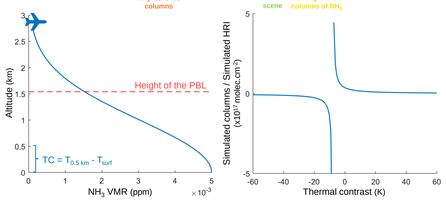


3. Agricultural point sources

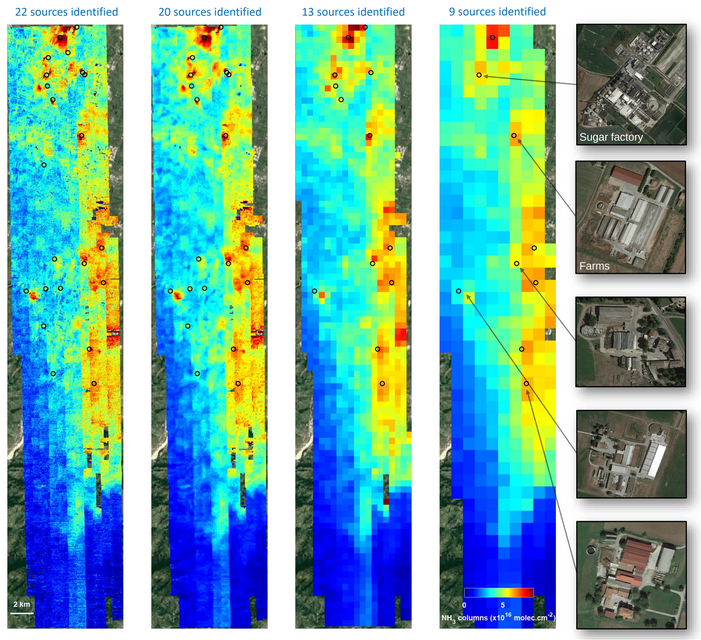


- Main target of airborne campaigns in 2022: the Po Valley in Italy → Largest (agricultural) hotspot of NH_3 in Europe
- Conversion of HRIs to NH_3 total columns using theoretical lookup tables (LUT) set up by radiative transfer simulations:

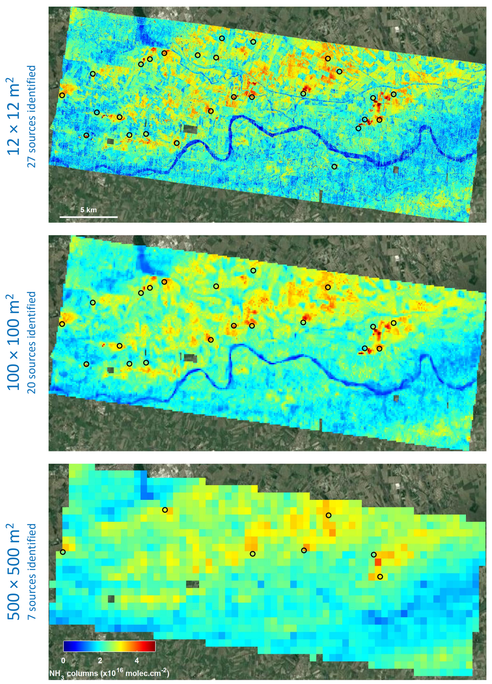
$$\underset{\text{NH}_3\text{ retrieved columns}}{\text{Col}} = \underset{}{\text{LUT}} \cdot \underset{\text{HRI of the scene}}{\text{HRI}} + \underset{\text{Background columns of NH}_3}{\text{B}}$$



→ Ex: NH_3 column distributions from measurements performed over Parma computed at various hypothetical satellite footprints



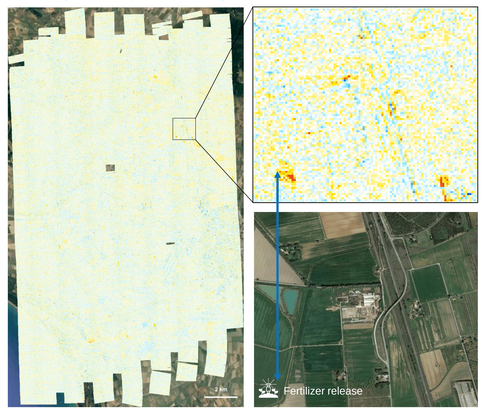
→ Ex: NH_3 column distributions over Mantua



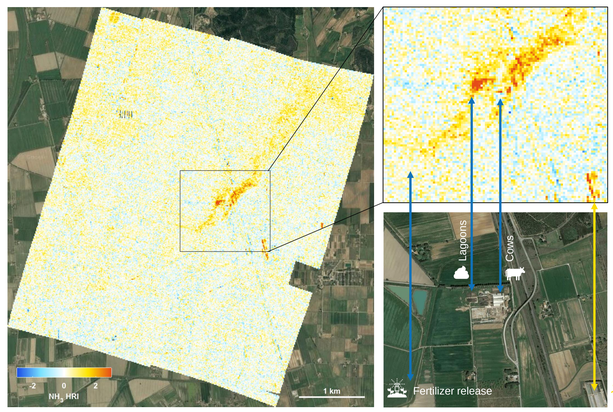
4. Nitrogen fertilizer release experiment

- Nitrogen fertilizer release experiment organized in Grosseto in collaboration with a farmer using a sprinkler

→ Day of the release experiment



→ Day after the release experiment



- The day after the spreading, NH_3 had time to dry up and volatilize → plume
- Different contributions:
  - The fertilizer release
  - The farm in the downwind direction, through the animals and the lagoons where their manure is stored

→ Greenhouses → false signal, no NH_3 in the spectra

References

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