The development of a mechanistic ammonia volatilization model, based on IASI data retrieved from the Metop-A & Metop-B missions

Rosiers Mauri [1,2], Romain A.C. [2], Viatte C.[3], Clerbaux C.[1,3], Van Damme M. [1], Clarisse L. [1], Coheur P. [1]

*[1] **Université libre de Bruxelles – ULB-BLU Space Research Center - Spectroscopy, Quantum Chemistry and Atmospheric Remote Sensing service (SQUARES)***
Av. Franklin Roosevelt 50, 1050, Brussels, Belgium

*[2] **SAM Laboratory, Université de Liège – Campus Environnement***
Av. de Longwy 185, 6700, Arlon, Belgium

*[3] **LATMOS/IPSL – Sorbonne Université - UVSQ***
Boulevard D'Alembert 5, 78280, Guyancourt, France

ABSTRACT

A mechanistic model for ammonia (NH_3) volatilization is developed, based on 15 years of NH_3 total column IASI data, retrieved from EUMETSAT's Metop-A & Metop-B satellite missions. The mechanistic model is based on the relationship between the total atmospheric NH_3 columns and the soil temperature, at specifically chosen agricultural regions. The 15 years of total atmospheric NH_3 column data is averaged per degree of Kelvin for each region, ensuring the precision and accuracy of the results. The regions are selected based on multiple factors, such as the agricultural intensity, the soil composition, the temperature range, etc.

The preliminary results portray a direct proportionality between the total atmospheric NH_3 columns and the soil temperature, certainly at soil temperatures up to 310K for all regions, as several regions portray a severe decrease in atmospheric NH_3 concentrations once a certain optimal temperature is surpassed, which cannot be explained by previous models. For these regions there seems to be a variation in optimum temperature as well, varying between 310 and 329K (or possibly even higher). The different observations once a certain optimal soil temperature value is exceeded are likely to be linked to the use of different fertilizer types, as regions that extensively apply urea portray a severe decrease in atmospheric NH_3 concentrations once the optimal temperature is surpassed, whereas regions that mainly consume non-urea fertilizers do not.

For urea-fertilized regions, the differences in optimal temperature can be attributed to several factors, with soil composition and soil moisture content emerging as the primary contributors. Interestingly, these factors, alongside soil pH and soil temperature, are known to significantly influence the activity of soil urease, a soil enzyme known to convert large amounts of urea into ammonia. Previous research indicates that urease activity is strongly influenced by temperature, increasing up to an optimal temperature, before sharply declining due to protein denaturation. In soil, two types of urease exist; "free" urease and "immobilized" urease, each with a distinct optimal temperature. Free urease exists in its natural form, without the binding of any soil component and has an optimal activity at a temperature around 313K, whereas immobilized urease is formed through the binding of urease with soil components (e.g. clay minerals & organic matter), resulting in the formation of urease-complexes, increasing its optimal temperature up to 343K, through thermal stabilization.

To analyze the influence and magnitude of different fertilizers and ultimately of soil urease activity on atmospheric NH_3 concentrations, both urea-fertilized & non urea-fertilized agricultural regions were selected, representing three main soil types: sandy (loam) regions, silt-rich regions (high organic matter content), and clay-rich regions (high abundance in clay minerals and organic matter). Sandy (loam) regions tend to portray little to no urease complexation, whereas silt-rich and - to a greater extent - clay-rich soils tend to be perfect for soil urease complexation. The selected agricultural regions include central India (clay-rich), northeast India & parts of Pakistan (sandy soil), northern central USA (silt-rich), the Nile Delta (silt-rich), a sandy agricultural region in Spain and many others.