Improving Ammonia Retrievals from IASI

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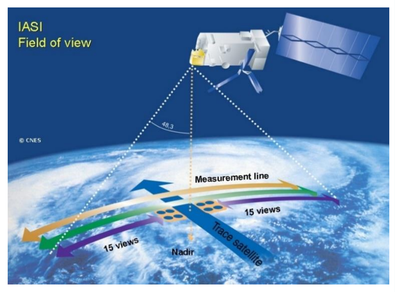
Introduction

Ammonia (NH_3) is a highly reactive and soluble alkaline gas, whose atmospheric emissions have a negative impact upon the ecosystem, through nitrogen deposition and soil enrichment, as well as air quality and human health. NH_3 reacts to produce ammonium aerosol, which has a long lifetime allowing transport over great distances.
Emission sources, such as agriculture and biomass burning, can be monitored using satellite observations. However, these data are still under-used. Here we show NH_3 results obtained using the MORSE retrieval algorithm, which has been adapted for use with IASI, and the improvement it gives over more simplistic methods.

IASI (Infrared Atmospheric Sounding Interferometer)

- Nadir viewing Fourier transform spectrometer
- Onboard MetOp-A and MetOp-B
- Spectral Range: 645 to 2760 cm^{-1} (3.62–15.5µm)
- Spectral Resolution: 0.25 cm^{-1} (unapodised)
- FOV: 2x2 matrix of 12 km (diameter) circles
- Each IASI instrument provides near global coverage every 12 hours



Linear Retrieval Algorithm

- Fast detection methods based upon the work of Walker *et al.*[1] have been developed that look for departures of IASI spectra from an expected background, which is created from a training set of IASI data containing the natural spectral variability caused by interfering trace species and clouds as well as the IASI instrument noise.
- An optimal unconstrained least-squares estimate (linear retrieval) of the state parameter is calculated.
- The gain is pre-computed to make the method computationally inexpensive.
- The algorithm has been run over all available days in the IASI lifetime for over 20 species. These anomaly flags are available in NRT(< 3hours) for SO_2 and Ash at **www.nrt-atmos.cems.rl.ac.uk**. NH_3 will be available soon.

Example: European NH_3 Plumes 2010

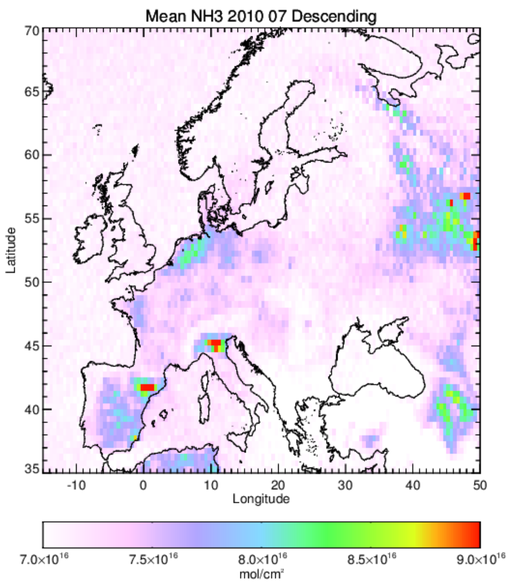


Figure 1. NH_3 enhancements observed by IASI in the July 2010 monthly mean caused by agricultural hotspots.

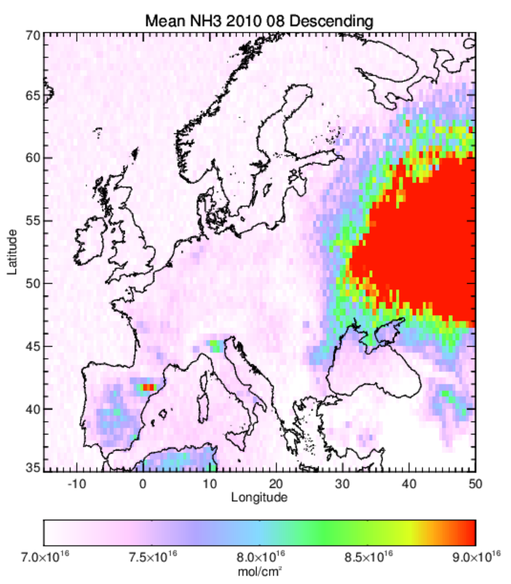
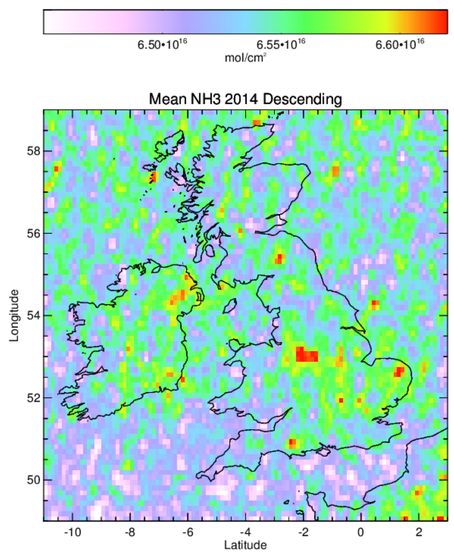
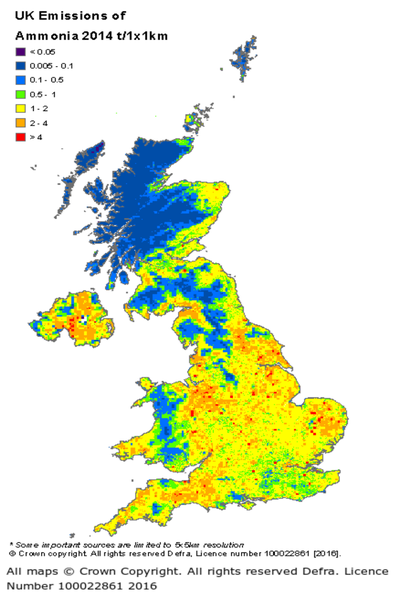


Figure 2. NH_3 enhancements observed by IASI in the August 2010 monthly mean caused by a large Russian fire event.

Example: UK Emission Hotspots

Figure 3. Comparing the 2014 UK surface emission inventory to the 2014 yearly mean atmospheric concentration (linear retrieval).





MORSE Retrieval Algorithm

- **M**ultispectral **O**rbital **R**etrievals using **S**equential **E**stimation
- MORSE is a constrained iterative optimal estimation retrieval algorithm that was originally designed for MIPAS (limb-viewing) but has now been adapted for IASI (nadir-viewing).
- The Reference Forward Model (RFM) is utilised for radiative transfer calculations using either HITRAN line data or pre-computed look-up tables.
- The atmospheric profile data used as input to the retrieval can be either a climatology or the RAL IMS L2 products (e.g. T, Ts, H2O, O3 etc.)
- In this preliminary work several assumptions have been made. These include; considering only the IASI instrument noise in the error covariance matrix, assuming a fixed NH_3 profile shape, and carrying out a joint retrieval of column NH_3, T_s, and H_20.

Example: Indonesian Fire Plumes 2015

The Indonesian fire season was significantly enhanced in 2015 by the strong El Niño event; drier conditions than usual lead to increased biomass burning.

- All retrievals show good spatial agreement.
- MORSE using standard atmospheres introduces more noise (potentially due to cloud or inaccurate climatology) but an improved variability in the NH_3 concentration.
- MORSE using the RAL IMS L2 products reduces the noise but eliminates part of the plume due to only running for 'clear-sky' pixels.

Although the initial results are promising, further work is needed to improve the results from the MORSE algorithm. This includes; modelling surface emissivity and improving the use of cloudy scenes by implementing AVHRR radiances to retrieve partially-cloudy scenes.

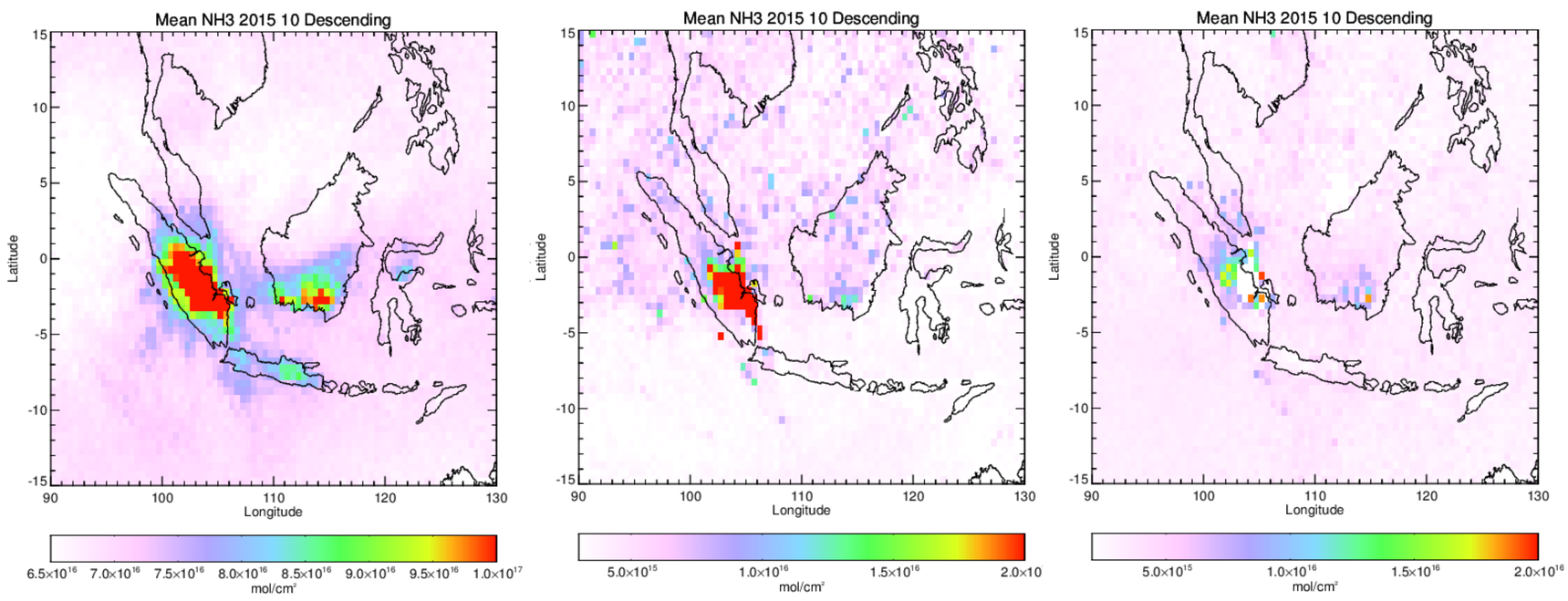


Figure 4. NH_3 enhancements caused by the Indonesian fire plumes observed by IASI in the October 2015 monthly means calculated by a.) the linear retrieval, b.) MORSE using standard atmospheres, and c.) MORSE using RAL IMS L2 products (only clear-sky pixels).

References
1. Walker, J., Dudhia, A., Carboni, E., An effective method for the detection of trace species demonstrated using the MetOp Infrared Atmospheric Sounding Interferometer, 2011. DOI: 10.5194/amt-4-1567-2011