Aerosol extinction and classification using MIPAS

Andrew Smith, Anu Dudhia, Don Grainger

Atmospheric, Oceanic and Planetary Physics, University of Oxford.

smith@atm.ox.ac.uk

Abstract

Research analysing the MIPAS data set has largely concentrated on retrievals of molecular species. However, there is a significant amount of information to be obtained from the continuum, avoiding molecular lines. MIPAS is an instrument well adapted to detection of aerosols. The limb view gives good vertical resolution and a deep space background that does not interfere with continuum signals. The IR spectra contains information about aerosol "type" that is not available from measurements in the visible and so is good for the classification of aerosol signals.

A preliminary spectral aerosol extinction product is which takes advantage of these properties is currently being developed at Oxford using the MORSE retrieval scheme (see Anu Dudhia's poster). Singular value decomposition of the extinction profiles will be used to disentangle various aerosol types. This is demonstrated for the case of volcanic eruptions where several species of aerosol are observed.

Background

Volcanic aerosols make excellent case studies for testing a new extinction algorithm. They are discrete events, with spectrally distinct IR signatures.

Using singualr value decompositon [Press et al., 1992], standard atmospheric variability taken from measurements before an eruption can be removed, leaving suspected volcanic signatures. This follows a cloud flagging method developed by Hurley et al. [2009].

Figures 1 & 2 demonstrates this process for the June 2011 eruption of Nabro in Eritrea. This eruption was extremely rich in SO_2 emissions, but with very little ash. As a consequence, the volcanic singular vector is close to a sulphate aerosol, with the SO_2 ν_3 band at 1362 cm^{-1} clearly evident. Comparisons with an IASI sulphate aerosol flag also show good agreement.

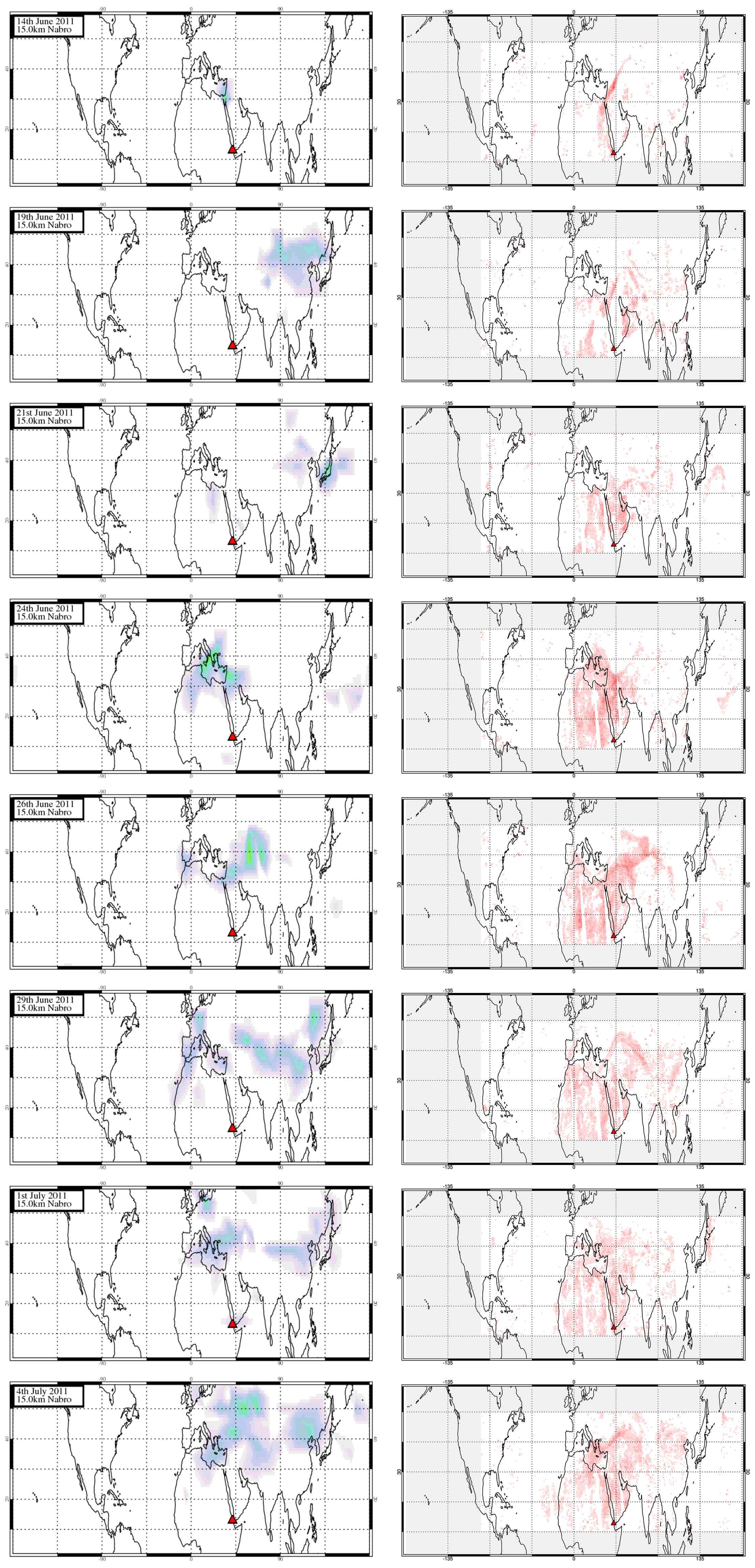

Figure 2: Snapshots showing time evolution of the plume from the Nabro eruption from MIPAS at an altitude of 15 ± 1.5 km, and from IASI. Since IASI is a nadir instrument, it samples the atmospheric column and so sees the initial plume before it reaches 15 km and is more sensitive to signatures from lower in the atmosphere.

Observed spectral variation

Comparisons of plumes from different eruptions show great variability, indicating the different sizes and compositions of the ejecta. Additionally, within the same eruption, the aerosols at different times can have different signatures.

This is shown in Fig. 3, where the evolution with time of the aerosols from Puyehue-Cordón Caulle, Chile and Nabro (both in June 2011) are shown. The strong ash signture from Puyehue is relatively constant throughout time suggesting an invariant aerosol, while the Nabro signal begins with very little ash signature but gradually aquires a stronger H_2SO_4 signature over the space of two months as the SO_2 is oxidised.

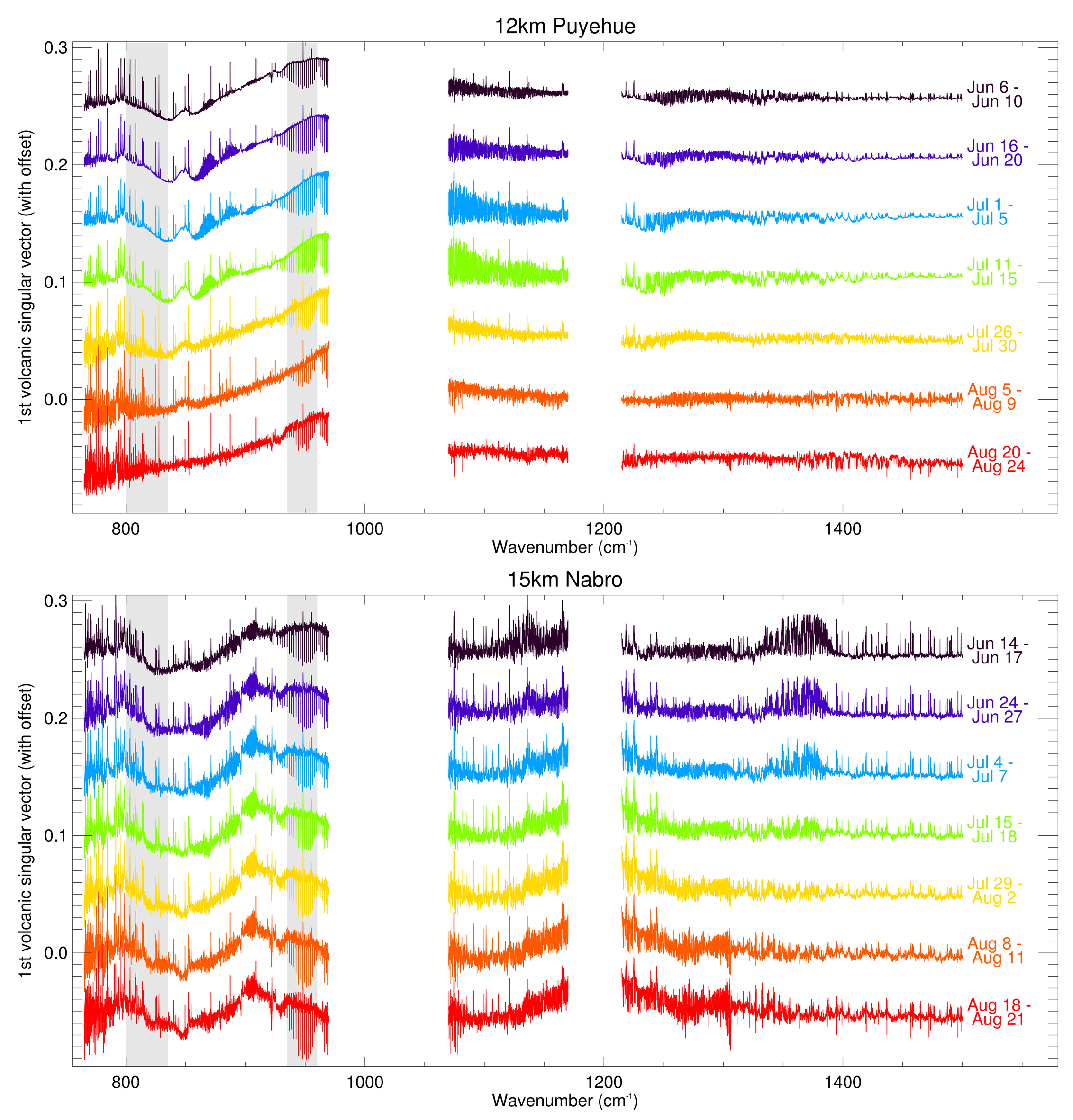

Figure 3: Showing the time evolution of recalculated 1st volcanic singular vectors at various times after the Nabro and Puyehue eruptions. The Puyehue eruption has a constant signal over time, whereas the Nabro eruption begins with a clear signal showing in the SO_2 ν_1 and ν_2 bands (at 1152 and 1362 cm^{-1}). As time progresses, this signal decreases as the SO_2 changes to sulphate aerosol.

Singular value decomposition

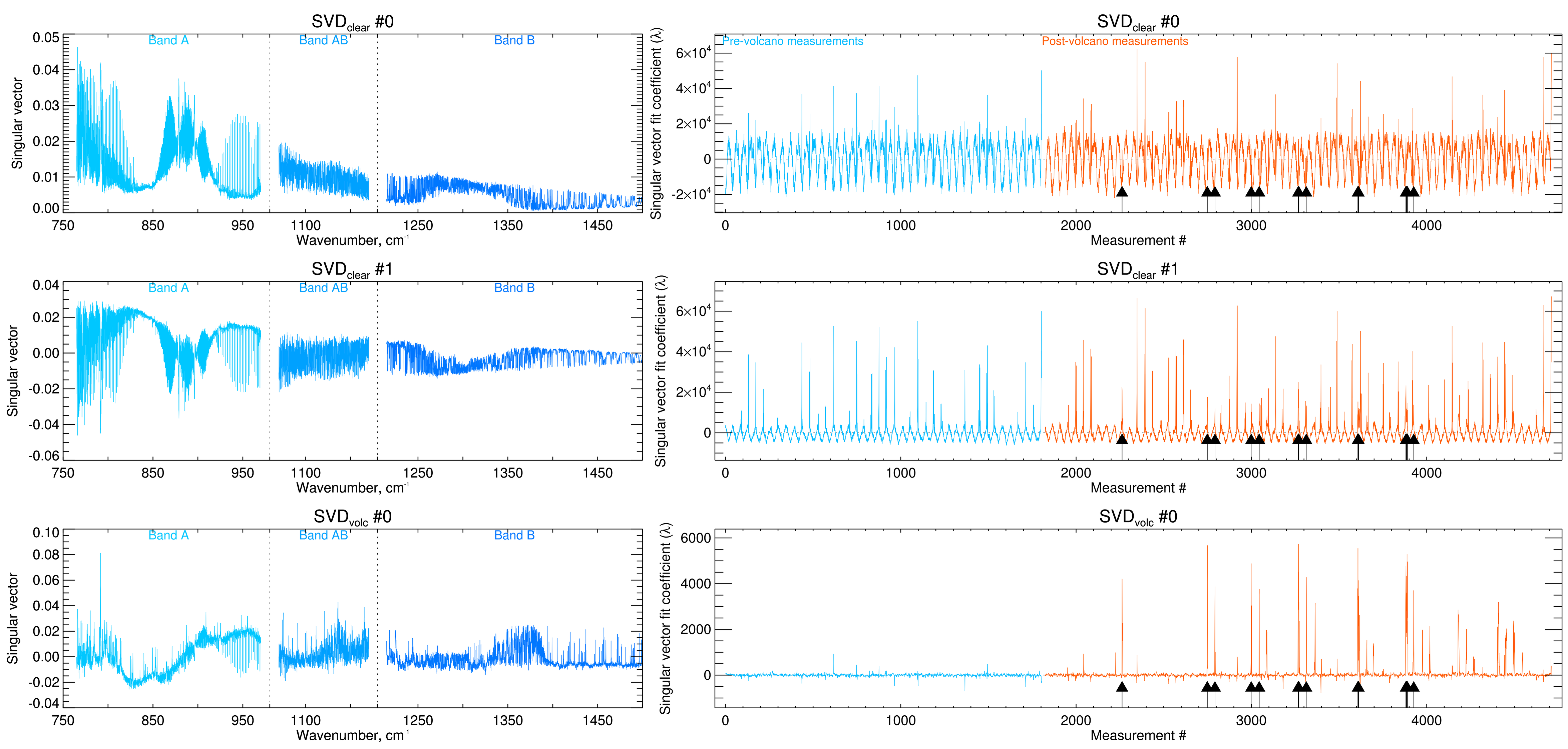

Figure 1: Showing the first two 'clean sky' SV (which capture 70 % of all variability), and the first 'volcanic' SV for the Nabro eruption at an altitude of 15 ± 1.5 km. The left-hand figures show the SV, while the right-hand figures show the fitting coefficient for MIPAS measurements before (blue) and after (orange) the eruption. Volcanic profiles flagged using a simple brightness temperature flag are marked by arrows. The diurnal cycle can clearly be seen in the first two vectors. The large peaks in the second clear vector's coefficents are due to the presence of thick cloud. Peaks in the first volcanic vector only begin to appear after the eruption.

Future work

The MORSE retrieval is currently being adapted to retrieve aerosol extinction in ten microwindows selected to optimise the distinction of different aerosol and cloud types. Singular value decomposition will likely be used to suggest plausible aerosol species such as desert dust, volcanic ash and sulphate which are spectrally distinct.

Early, qualitative results from SVD analysis of volcanic eruptions provide confidence that this is possible. A speciated MIPAS aerosol extinction product is expected soon.

References

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