High spectral resolution infrared sounders (IASI, TANSO-FTS, IASI-NG, IRS) capabilities to measure aerosols and trace gases emitted by volcanic eruptions.

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Introduction

Volcanic activity is an important source of aerosols (Ash, H₂SO₄) and trace gases (SO₂, H₂S) which have a significant impact on climate, and affect the regional air quality or air traffic. In this context, spatial remote sensing represents an efficient tool for the spatio-temporal monitoring of volcanic emission. In particular, some recent works have demonstrated the potential of high spectral resolution infrared sounders to study the volcanic ash plumes distributions and to measure the SO₂ concentrations from local to continental scale. However, this kind of studies remains quite challenging. The applications are particularly sparse and concern often only the very large eruptions.

Here, we present a study conducted as part of the Stratoclim European project, which aims to determine the capabilities of present and future infrared hyperspectral sounders (IASI, TANSO-FTS, IASI-NG, MTG-IRS) to measure concentration and altitude of SO₂, H₂S and OCS, but also the volcanic ash and sulphate aerosols parameters (Height, thickness, size distribution).

Instrumental specifications

Each instrument is a Fourier transform spectrometer; some specifications of the 4 sounders are summarized in this Table:

<table>
<thead>
<tr>
<th>Spectral coverage (cm⁻¹)</th>
<th>IASI</th>
<th>IASI-NG</th>
<th>TANSO-FTS</th>
<th>IRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>645-2760</td>
<td>645-2760</td>
<td>700-1800</td>
<td>500-4800</td>
<td>700-2175</td>
</tr>
<tr>
<td>Spectral resolution (cm⁻¹)</td>
<td>0.25</td>
<td>0.20</td>
<td>0.20</td>
<td>0.625</td>
</tr>
<tr>
<td>Signal to noise ratio</td>
<td>500</td>
<td>1000</td>
<td>300</td>
<td>500</td>
</tr>
<tr>
<td>Spatial resolution at Nadir</td>
<td>12.5</td>
<td>12.5</td>
<td>12.5</td>
<td>4</td>
</tr>
<tr>
<td>Spatial coverage</td>
<td>Global : 2 times/day</td>
<td>Global : 2 times/day</td>
<td>Global : 1 time/3 days</td>
<td>Lat. 30-65° N and long. 30° W to 45° E: 1 time/hour</td>
</tr>
</tbody>
</table>

- IASI and IASI-NG have a coarser spectral resolution as compared to TANSO-FTS, but they have a very high signal to noise ratio. IASI and IASI-NG have further advantages over TANSO-FTS like spatial coverage and temporal sampling.
- The main advantage of TANSO-FTS is its ability to measure the SWIR polarized bands, especially in the case of scattering atmosphere.
- IRS despite its weaker spectral resolution, has all the advantages of a geostationary instrument.

Forward Model & Information content

- The ARAHMS (Atmospheric Radiation Algorithm for High-spectral resolution Measurements from Infrared Spectrometers) line-by-line radiative transfer model developed at LOA is used to perform information content analysis.
- Retrieval of quantitative informations for H₂S and OCS is restrained to important and elevated eruptions.
- We have established a parametrization for radius and acid weight based on thermodynamical equilibrium.

Conclusion

- We have developed an algorithm which is able to simulate IRS, IASI, IASI-NG and TANSO-FTS radiances in clear sky and scattering atmospheres.
- We performed a sensitivity study and information content analysis of volcanic species (gas/aerosols) for each instrument.
- We have compared the capabilities of the four instruments to retrieve gas and aerosol parameters.

Work in progress

- An algorithm based on channels selection is currently being developed. It allows detecting these volcanic species in near real time conditions.
- Fig. 3 shows spatio-temporal distribution of SO₂ concentrations during the eruption of Kasocho volcano (07/08/2008), using IASI spectra.