Contribution to tropospheric studies using IASI data

Belgian Institute for Space Aeronomy (BIRA-IASB)

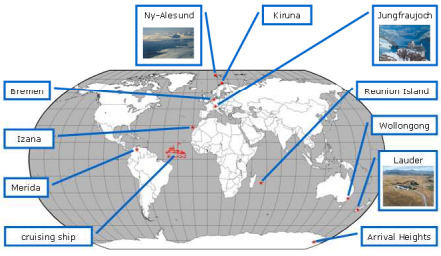
M. Kruglanski, A.-C. Vandaele, C. Vigouroux, B. Dils, N. Kumps, M. De Mazière

aeronomie.be

The Belgian Institute for Space Aeronomy (BIRA-IASB) is involved in two EPS/MetOp Research Announcements of Opportunity (ID2904 and ID2913) for the exploitation of IASI observations. It has committed itself to validate IASI level-2 products for tropospheric species and to evaluate the load of tropospheric aerosols from IASI level-1c spectra. The validation part makes use of ground-based remote Fourier transform infrared measurements from 11 stations of the Network for the Detection of Atmospheric Composition Change (NDACC, formerly NDSC). The validation relates to total columns and/or vertical profiles of CO, O_3, N_2O, CH_4 and HNO_3.

In order to achieve these goals, we have been developing the ASIMUT line-by-line spectral simulation and inversion code. The code includes an analytical calculation of the Jacobians for use in the inversion part of the algorithm, based on the Optimal Estimation Method. A second inversion is used to evaluate the load of tropospheric aerosols, mainly sea-salt aerosols and transported Saharan dust above the Atlantic Ocean.

Validation of IASI atmospheric chemistry products with FTIR ground-based network data



The validation project includes 11 mobile and fixed stations worldwide with NDSC-qualified Fourier transform infrared (FTIR) spectrometers for remote sensing of the atmospheric composition. All stations are operated on a quasi continuous basis and have long time series of data; most time series span at least a decade. At Reunion, the site is operated on a campaign basis. The ship cruises travel over the Atlantic Ocean from Bremerhaven to Cape Town. They mostly happen every year, since more than 10 years now.

The stations are operated by six partners having a long-lasting expertise in FTIR remote sensing: observations, algorithm developments, data analysis, and exploitation of the data for the satellite validation. They also collaborate at the validation of Envisat atmospheric data products and participate in the European project UFTIR to improve the quality of tropospheric data products from ground-based FTIR observations.

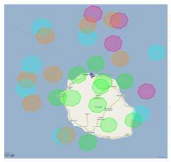
ULg Université de Liège · BIRA-IASB · iup · University of Wollongong · Forschungszentrum Karlsruhe · NIWA Taihoro Nukurangi

Preliminary retrieval of CH_4 columns above Saint-Denis using ASIMUT

The ASIMUT program performs simulation and retrieval of atmospheric transmittances and radiances in cases where scattering can be neglected and under conditions when local thermodynamic equilibrium is verified. The model assumes that all parameters are varying only with altitude. ASIMUT can be used to simulate/retrieve measurements recorded under various geometries (nadir, off-axis nadir, down and up looking, limb looking) with the instrument located at ground level, inside the atmosphere, or in space.

ASIMUT has been used to retrieve methane from both IASI level 1C and ground-based FTIR spectra. The illustrated data are related to August 15, 2007. Both retrievals are done in two passes, the first pass of which is mainly used to fit the water content. Temperature and pressure profiles are extracted from ECMWF analysis.

IASI Level-1C orbit 4255 5:20 UT



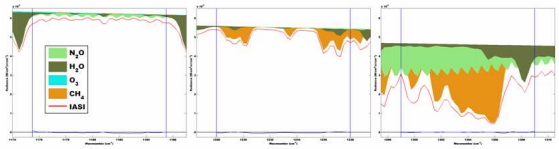
IASI pixels above Reunion island located at less than 60km from St-Denis. Only seven pixels located above sea are used: green pixels are above land; red pixels have been rejected; orange pixels are from orbit 4262 (17:48UT) but have been also rejected.

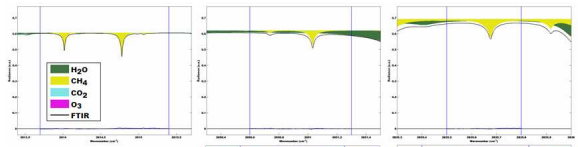
The cyan pixels satisfy the conditions:
Pass 1: $\chi^2_y < m$, RMS < 5 10^{-8} W/cm²/Sr/cm^{-1},
Pass 2: $\chi^2_y < m$, RMS < 3 10^{-8} W/cm²/Sr/cm^{-1}

Ground-based FTIR @ St-Denis 7:00 UT

The current campaign operated by BIRA-IASB extends from May to December 2007 using a BRUKER 120M coupled to a sun tracker.

The illustrated data are based on a spectrum recorded at a solar zenithal angle of 40° with a resolution of 5.13 mk, using an iris diameter of 650µm, a NDSC filter number 3 and a InSb detector.

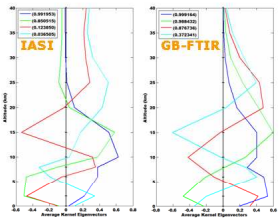




To retrieve CH_4 from IASI spectra, we use 3 large windows (1175.5-1185.5, 1228.0-1238.0 and 1299.0-1309.0 cm^{-1}). It results to a RMS about 0.24 10^{-7} W/cm²/Sr/cm^{-1} and about 2.0 degrees of freedom for CH_4.

To retrieve CH4 from the ground-based FTIR, we use the 5 µ-windows defined by UFTIR. It results to a RMS of 2.6 10^{-7} (a.u.) and 3.2 degrees of freedom for CH_4.

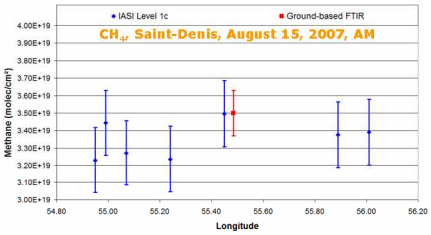
In order to facilitate the comparison, both cases use the same discretization and a priori data. The a priori vertical profiles are obtained from the IG2 climatologies (Remedios et al., 2007). Our CH_4 a priori covariance matrix has diagonal values corresponding to a standard deviation of 10% and a Gaussian off-diagonal correlation with a scale height of 5km.



Comparison of collocated data should take into account their averaging kernels since they characterize the retrievals. Only the four first eigenvectors are illustrated.

In this case, the retrieval from the IASI spectra contains mainly information between 4.0 and 6.0km with no sensitivity at the surface, while the retrieval from the ground-based FTIR contains mainly information between 0.1 and 17.5km. Both retrievals have a coarse vertical resolution allowing only comparison of partial columns.

The comparison of the total columns of methane from both retrievals shows a good agreement. Note that in both cases the retrieved profiles exhibit an oscillation which probably causes an underestimation of the total column.



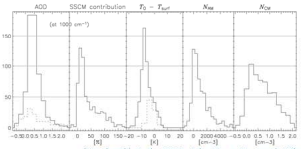
Atmospheric Aerosol Retrieval from Thermal Infrared Nadir Sounding

We have developed an algorithm to retrieve tropospheric aerosol optical depth (AOD) over the ocean from nadir high-resolution radiance spectra in the thermal infrared that includes the effects of scattering within the aerosol layer. It consists of an optimal estimation method where the forward part implements the radiative interaction between the surface and the atmospheric layers, assuming a thin horizontal layer of a mixture of two aerosol types located at an arbitrary height. A simple doubling method is applied to evaluate the effects of scattering within the aerosol layer. The Jacobians associated to the surface temperature and the aerosol contents are derived analytically.

We plan to apply our algorithm on IASI spectra. ASIMUT will be used to generate the molecular vertical optical depths from the IASI level 2 products. The retrievals will be focussed on both sea-salt aerosols and transported Sahara dust above the Atlantic Ocean.

Distribution of sea-salt aerosol in the boundary layer over the ocean obtained from IMG radiances with a simplified version of our algorithm where the effects of scattering is not taken into account. It assumes a mixture of both a coarse mode (SSCM) and an accumulated mode (SSAM) located just above the sea surface. The molecular vertical optical depths are generated from the ERA-40 daily fields.

The results show:
- sea-salt AOD at 1000 cm^{-1} between 0.21 and 0.65 for 50% of the pixels,
- contribution of SSCM aerosols to the AOD only between 0 and 25%, in 50% of the cases,
- difference between surface and aerosol temperatures from 4.7 to 9.5 K.



(Kruglanski et al., 2006, Adv. Space Research 37)

This work is supported by the Belgian PRODEX programme and the Belgian Science Policy

Dr Michel Kruglanski
Belgian Institute for Space Aeronomy
Ringlaan 3, 1180 Brussels, Belgium
michel.kruglanski@oma.be

Belgian Federal Science Policy

.be