VALIDATION OF IASI ATMOSPHERIC CHEMISTRY PRODUCTS FOR CO, O₃, HNO₃, N₂O AND CH₄ WITH FTIR GROUND-BASED NETWORK DATA


1) Belgian Institute for Space Aeronomy (BIRA-IASB), Brussels, Belgium, martine@oma.be
(2) Institute of Meteorology and Climate Research, Karlsruhe, Germany, thomas.blumenstock@imk.fzk.de
(3) Institute of Astrophysics, University of Liège, Belgium, emmanuel.mahieu@ulg.ac.be
(4) Institute of Environmental Physics, University of Bremen, Germany, jnotholt@iup.physik.uni-bremen.de
(5) National Institute of Water and Atmospheric Research, New Zealand, s.wood@niwa.co.nz
(6) Atmospheric Chemistry Research Group, University of Wollongong, Australia, njones@uow.edu.au

RESUME
For every satellite experiment, it is extremely important to perform a thorough validation of the geophysical data products to guarantee a correct assessment of the capabilities and performances of the satellite experiment. IASI on METOP-1 will be the first Fourier transform infrared (FTIR) spectrometer of the METOP series to be launched. With METOP the emphasis is on the meteorological data products. However, this project will support the expectations of the atmospheric chemistry community who is very interested in the exploitation of the IASI spectra for deriving additional geophysical data products. Expected IASI data products are total columns and information as to the vertical distribution of the following gaseous species: CO, O₃, HNO₃, N₂O and CH₄. These gases play key roles in tropospheric chemistry and climate. This project will use independent correlative data at 11 stations worldwide to validate the before mentioned IASI products, while covering all major latitude bands. Recently developed inversion strategies for the ground-based FTIR data will be applied to provide correlative data of the highest possible quality for the present validation purposes.

1. SCIENTIFIC ISSUES
With IASI onboard, METOP has the capability of filling the gap in the availability of satellite data for tropospheric chemistry and climate researches that is expected in the post-Envisat era. But, to achieve this goal, the IASI performances for delivering appropriate geophysical data must be verified.

Also measured by MOPITT and TES, CO is an important O₃ precursor in the troposphere. While O₃ is measured by many satellite instruments (Envisat, Aura, ...), IASI should reach a better sensitivity to the troposphere region. The variability of HNO₃ in the troposphere is known to be large, mainly from aircraft and balloon measurements. But it has not been measured yet on a global scale, except for some IMG measurements. N₂O and CH₄ are important greenhouse gases. N₂O is also a major component of the nitrogen budget.

2. ANALYSIS METHOD
Ground-based data will be collected from 11 mobile or fixed stations worldwide with NDSC-qualified FTIR spectrometers for remote sensing of the atmospheric composition. Fig. 1 and Table 1 identify the locations of the contributing stations. The stations cover all major latitude bands. Except for the site at Reunion Island and for the ship cruises, all the stations operate on a quasi continuous basis and have long time series of data, spanning at least a decade. The operation of an FTIR experiment at Merida is not guaranteed yet. At Reunion Island, the site is operated on a campaign basis. The ship cruises travel over the Atlantic Ocean from Bremerhaven to Cape Town. These cruises mostly happen every year, since more than 10 years now. Both stations of Jungfraujoch and Izaña are located at high altitudes (3580 and 2367 m, resp.) and provide observations above the boundary layer.

The project is split in three phases. During the first phase, an optimum common data retrieval strategy to

Table 1. Spatial coordinates of the ground-based FTIR stations depicted in Fig. 1.

<table>
<thead>
<tr>
<th>Station</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ny.Alesund</td>
<td>79°N</td>
<td>12°E</td>
</tr>
<tr>
<td>Kiruna</td>
<td>68°N</td>
<td>20°E</td>
</tr>
<tr>
<td>Bremen</td>
<td>53°N</td>
<td>9°E</td>
</tr>
<tr>
<td>Jungfraujoch</td>
<td>46°N</td>
<td>8°E</td>
</tr>
<tr>
<td>Izaña</td>
<td>28°N</td>
<td>16°E</td>
</tr>
<tr>
<td>Merida</td>
<td>8°N</td>
<td>70°W</td>
</tr>
<tr>
<td>Reunion Island</td>
<td>21°S</td>
<td>55°E</td>
</tr>
<tr>
<td>Wollongong</td>
<td>34°S</td>
<td>151°E</td>
</tr>
<tr>
<td>Lauder</td>
<td>45°S</td>
<td>170°E</td>
</tr>
<tr>
<td>Arrival Heights</td>
<td>78°S</td>
<td>167°E</td>
</tr>
<tr>
<td>cruising ship</td>
<td>50°N–30°S</td>
<td>—</td>
</tr>
</tbody>
</table>
invert the spectral FTIR data to vertical profiles of the
target species will be established. This implies the
choice of retrieval microwindows and ancillary
parameters, the choice of spectroscopic data, etc.
During the second phase comparisons between IASI
Level 2 data and the early correlative ground-based
data will be made using all network data. These
comparisons will be supported by ancillary
meteorological data and additional METOP data
products from AVHRR (clouds and surface images)
and GOME-2 (O_3 products) for a better interpretation
of the results. The comparisons should provide
insights in possible latitudinal, seasonal, and/or surface
dependencies of the results. Finally in the last phase,
the comparisons will be refined by including more data
and reprocessing updated data.

The validation of IASI by ground-based FTIR is not
straightforward due to the inherent different properties
of both measurements. Several issues have to be
addressed in order to perform a proper comparison.
The first issue is related to the differences in altitude
sensitivity between satellite-based and ground-based
observations, which directly affects the evaluation of
the total column and requires a specific normalisation
of the total columns. This normalisation should take
into account the averaging kernels associated to the
total column inversions. A second issue concerns the
availability of ground-based FTIR data because the
observations can be made in clear-sky conditions only.
To overcome the poor number of real coincidences and
to ensure a statistically significant correlative data set,
temporal interpolation techniques through the FTIR
ground-based data will be considered. A third issue
involves the difference in observed air masses that
might create apparent biases between FTIR and IASI
measurements. It is particularly the case with
mountainous ground-based stations for which the
Corresponding IASI pixel could include part of the
surrounding valleys that often harbour significantly
higher concentrations of pollutants.

3. CONSORTIUM EXPERTISE
The six partners have a long-lasting expertise in FTIR
remote sensing: observations, algorithm developments,
data analysis, and exploitation of the data for satellite
validation. They have been working together since
many years as members of the Infrared Working Group
of NDACC (Network for the Detection of Atmospheric
Composition Change, formerly NDSC, http://www.ndacc.org),
and more recently in the European EC-funded project UFTIR
(http://www.nilu.no/uftir).

In these collaborations, the capabilities of ground-
based FTIR for the determination of tropospheric
abundances have been demonstrated, and the
homogenization of the tropospheric retrieval products
across the network has been improved. For example
for O_3, it has been established that the FTIR profiles
are in excellent agreement with O_3 sonde
measurements and that the total column values agree to
better than 1% with Dobson/Brewer data [1, 2]. CO
profile measurements have been shown to agree very
well with in-situ measurements; they have also been
characterized in comparison with MOPITT [3].
Comparisons between SCIAMACHY and FTIR
ground-based data for CO, CH_4, CO_2 and N_2O total

Figure 1. Distribution of stations contributing to the delivery of correlative ground-based FTIR data for comparisons
with IASI products. The ship cruises travel over the Atlantic Ocean.
columns [4], and between MIPAS and FTIR ground-based data for N₂O and HNO₃ profiles [5] have proved the robustness of the FTIR data retrievals from the network. FTIR ground-based data for O₃, N₂O and CH₄ data have also been compared successfully to independent model results [6]. In addition to the comparisons with independent data, side-by-side intercomparisons between FTIR instruments have been carried out, demonstrating good mutual agreements between the measurement results (among others for N₂O, CH₄ and HNO₃) in similar operating conditions (e.g., [7], [8], and references therein).

Some members of the consortium have also a long-standing expertise in laboratory spectroscopy for atmospheric applications that can provide uncertainty estimates as to the spectroscopic data used on the one hand in the ground-based FTIR and on the other hand in the satellite (IASI) retrievals.

4. REFERENCES