High resolution solar infrared Fourier transform spectrometry: application to the study and long-term monitoring of the Earth’s atmosphere

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1. Project description

The Liège team has a long tradition in the monitoring of the Earth’s atmosphere. Indeed, the first observations and investigations were carried out by Pr Marcel Migeotte and collaborators in the late 1940s, using a grating infrared spectrometer. This instrument was then installed at the Jungfraujoch station and infrared spectra were systematically recorded in 1950-1951 such as to cover the 2.8 to 23.7 micrometer (μm) spectral range (Migeotte et al., 1956). The next period was dedicated to the study of the sun and to the production of photometric solar atlases, using a 7 m grating spectrometer, in single then double pass mode. In the mid-1970s, the team resumed its atmospheric monitoring activities which are still ongoing nowadays. Since the mid-1980s, Fourier Transform InfraRed (FTIR) instruments are used, allowing to record very high resolution and signal-to-noise wide-band solar infrared spectra. This sustained effort has led to an unrivalled collection of infrared spectra which is unique worldwide in terms of length, measurement density and quality. At the end of 2020, we reached 37 years of continuous FTIR measurements at the Jungfraujoch station!

The main objectives of the team are essentially twofold: (i) maintain the instrumentation operational while also improving its performance, (ii) analyse the spectra in order to produce high-level geophysical parameters and valorise them.

In 2020 and given the travel restrictions, it was only possible to collect remote observations. Altogether and before any averaging, about 2600 high resolution infrared solar spectra have been collected on 84 days. The failure of a KVM adapter prevented the recording of spectra in August. Thanks to the invaluable support of the custodians, the problem was fixed and normal operations resumed in early September.

The analysis of our spectra allows us to determine the abundance of an increasing number of key constituents of the Earth atmosphere (currently more than 30, see Table 1), playing a role in ozone depletion, climate change, or affecting air quality. Numerous target species are therefore relevant to the Montreal Protocol on substances that deplete stratospheric ozone (e.g. CFCs, HCFCs, HCl) and/or to the Paris Agreement (COP21) to mitigate climate change (e.g. CO2, CH4, N2O).

Table 1. List of atmospheric species (>30) currently retrieved from the Jungfraujoch observational database

<table>
<thead>
<tr>
<th>Category</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse gases; support to the Paris Agreement</td>
<td>H2O, CO2, CH4, N2O, CF4, SF6</td>
</tr>
<tr>
<td>Ozone-related; support to the Montreal Protocol</td>
<td>O3, NO, NO2, HNO3, ClONO2, HCl, HF, COF2, CFC-11, CFC-12, HCFC-22, HCFC-142b, CCl4, CH3Cl</td>
</tr>
<tr>
<td>Air quality; support to the EU-Copernicus programme</td>
<td>CO, CH3OH, C2H6, C2H2, C2H4, C2H6, HCN, HCHO, HCOOH, NH3, PAN</td>
</tr>
<tr>
<td>Other</td>
<td>OCS, N2, various isotopologues2</td>
</tr>
</tbody>
</table>

1) Figure 1 displays the multi-decadal time series of four of these strong greenhouse gases.
2) An isotopologue is a molecular twin that differs from the reference molecule in the isotopic composition.

References

Internet data bases


Collaborating partners / networks

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Figure 1. Multi-decadal evolution of the monthly averages of the total vertical columns, expressed in molecules per square centimeter, of four of the greenhouse gases monitored at the Jungfraujoch station, and comparison with their abundance in the middle of the last century (see Mahieu et al., 2019).

Magazine and Newspaper articles

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