

Name of research institute or organization:

Institut d'Astrophysique et de Géophysique, Université de Liège

Title of project:

High resolution, solar infrared Fourier Transform Spectrometry. Application to the study of the Earth atmosphere

Project leader and team

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Project description:

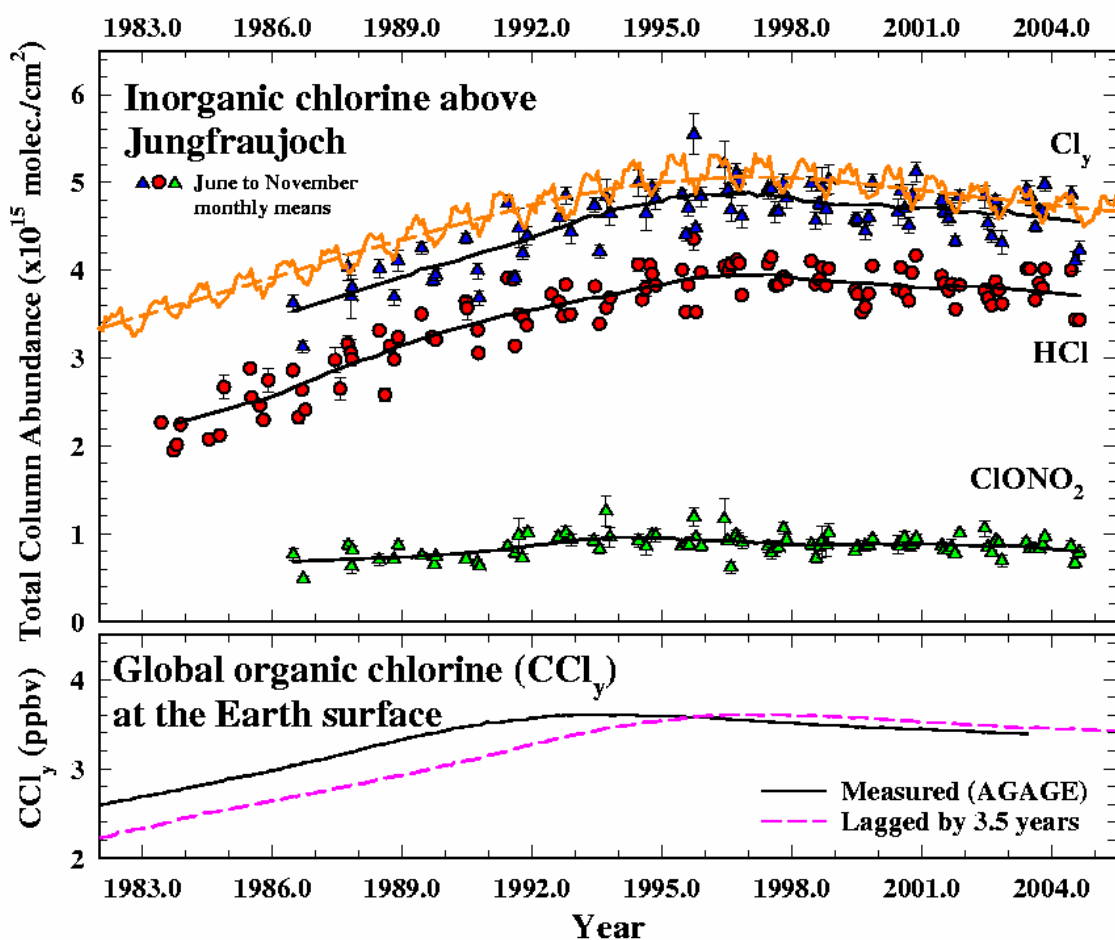
The main activity of the Liège group at the Jungfraujoch was the continuation of the long-term monitoring of the Earth atmosphere. The observations achieved by the two high-performance infrared spectrometers allow to routinely derive abundances of more than 20 constituents related to the erosion of the ozone layer in the stratosphere (HCl, ClONO₂, HNO₃, NO, NO₂, HF, COF₂, O₃, ...), monitored in the frame of the Kyoto protocol (N₂O, CH₄, CO₂, SF₆, CCl₂F₂, CHClF₂, ...) or affecting the oxidization processes in the troposphere (CO, C₂H₂, C₂H₆, OCS, HCN, H₂CO, ...). The resulting databases allow the determination of the short-term variability, seasonal modulations, as well as long-term changes affecting most of these species.

During 2004, Liège observers spent 238 days at the Jungfraujoch. Unfortunately, weather conditions enabled observations on 93 days only, which is proportionally less than for the previous years.

For a number of the species listed above, a complete re-analysis of the archived spectra is currently under way with SFIT-2, a recent retrieval algorithm that provides in most cases information on the distribution of the molecules versus altitude. This algorithm allows to determine partial columns (e.g. to distinguish between tropospheric and stratospheric contents) as well as more accurate total columns.

Within the frame of the NDSC (Network for the Detection of Stratospheric Change), the total vertical column abundances of HCl and ClONO₂, by far the two most important inorganic chlorine (Cl_y) reservoirs at northern mid-latitudes, have been further monitored above the Jungfraujoch station. Their temporal evolution indicates that, after a steady increase at a mean rate of 3.8 %/yr during the 1986-1993 period, the total stratospheric inorganic chlorine loading has begun a progressive stabilization, with a maximum observed during the second half of 1996. Since then, a slight Cl_y decrease has been observed, at a mean yearly rate close to -0.7% over the 1997-2003 period (see Figure 1) [Mahieu et al., 2004].

Overall, these findings are in very good agreement with the 2D-model calculations at University of Leeds that, after smoothing of the seasonal variations (see upper dashed curve in the top frame of Figure 1), also indicate a Cl_y peak during the second half of 1996.



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ULg-GIRPAS / 10-Sep-2004

Figure 1: Top panel: total column abundances of HCl and ClONO₂ above the Jungfraujoch. Their sum (blue triangles) is a good estimate for the total inorganic chlorine Cl_y. The upper trace (in orange) corresponds to the sum of the HCl and ClONO₂ columns calculated by a 2D-model at University of Leeds. The lower panel displays the evolution of total organic chlorine based on in situ surface measurements performed by the AGAGE network.

The Cl_y long-term evolution is also consistent with the temporal development of the organic chlorine (CCl_y) loading measured at the surface, when accounting for a time delay of about 3.5 years for tropospheric air to propagate and mix into the mid-latitude stratosphere (Figure 1, lower frame). After a peak occurrence in 1993, CCl_y also exhibits a slow decrease of about 0.7%/yr, in excellent agreement with the Cl_y observations and model calculations.

These results demonstrate the appropriateness and proper implementation of the phase out scenarios adopted by the Montreal Protocols and its subsequent enforcements.

To evaluate the worldwide evolution of the inorganic chlorine and fluorine in the Earth's middle atmosphere, our group coordinates the Cl_y-F_y project, involving 23 NDSC FTIR stations. Data from the *in situ* surface networks as well as measurements from the satellite experiments HALOE, ENVISAT, ACE and AURA will also be included in the analysis.

In the frame of the SOGE (System for Observation of halogenated Greenhouse gases in Europe) project, sulphur hexafluoride (SF₆) concentrations have been deduced from the infrared spectra recorded at the Jungfraujoch. Mainly produced by man-made activities, SF₆, with its long lifetime of about 3200 years, is one of the most efficient greenhouse gases present in the atmosphere, with a global warming potential of 22 200 relative to CO₂ over a 100-year time horizon.

Our analysis shows a linear SF₆ increase of 0.24 ± 0.01 pptv per year between 1986 and 2002. Extrapolation of the Jungfraujoch data predicts tropospheric SF₆ concentrations of about 15 pptv in 2050 (compared this to the 2.0 pptv concentration measured in 1988) [Krieg et al., 2005]

Measurements of carbon monoxide total column amounts above the Jungfraujoch reveal increased CO abundance during summer and autumn periods of 2002 and 2003 in comparison with the previous two years. Similar increases in the northern hemisphere were observed from other ground-based stations in the Arctic and Europe, as well as from the space-based MOPITT experiment onboard the Terra satellite. Moreover, the CMDL and GAW networks also observed increased CO concentrations near the surface. It is most likely that strong boreal forest fires are responsible for this hemispheric CO build up [Yurganov et al., 2004b].

During 2004, we also continued to provide data for the calibration/validation of 3 instruments (MIPAS, SCIAMACHY and GOMOS) aboard the European satellite Envisat. On the whole, we supplied to the calibration team 8376 total column abundances of O₃, N₂O, CO, CH₄, NO, NO₂, HNO₃ and CO₂, deduced from Jungfraujoch observations between July 2002 and October 2003. Vertical distributions of HNO₃ and N₂O for 199 days between July 2002 and March 2004 were also produced for specific validation of MIPAS profiles.

Key words:

Earth atmosphere, ozone layer, greenhouse gases, long-term monitoring, infrared spectroscopy

Internet data bases:

<http://www.nilu.no/nadir/>, <ftp://ndsc.ncep.noaa.gov/pub/ndsc/jungfrau/ftir/>

Collaborating partners/networks:

Main collaborations: IASB (Institut d'Aéronomie Spatiale de Belgique) / NDSC (Network for the Detection of Stratospheric Change) / SOGE partners (e.g. EMPA) [<http://www.nilu.no/soge/>] / NASA Langley Research Center / NASA JPL / University of Oslo / University of Leeds / IMK (Forschungszentrum Karlsruhe) / satellite experiments: MOPPIT, ENVISAT and ACE validation / ...

Scientific publications and public outreach 2004:

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