Activity report of the Solar and Atmospheric Laboratory of the University of Liège at the Jungfraujoch 1999

Scientists and co-workers from the University of Liège, helped by colleagues of the "Observatoire Royal de Belgique" (ORB) and of the "Institut d'Aéronomie spatiale de Belgique"(IASB), spent a total of 334 nights at the Jungfraujoch during 1999. One to three co-workers have thus been in the laboratory for a total of 267 different days, observing the sun during 120 days.

We would like to mention that the annual meeting of the NDSC (Network for the Detection of Stratospheric Change) infrared group took place in Wengen, June 14 to 17, 1999.

The most important topics on its agenda were:

- review of the activities in the five primary sites and most of the complementary ones;
- discussion of the results of four instrument intercomparison campaigns organized over the last two years;
- reports and discussions of three internal subgroups (Bruker users group, CRISTA validation group, Error analysis working group).

One full day was devoted to a visit of the Jungfraujoch laboratories with presentations of the major long term experiments. We thank the colleagues who came at the Jungfraujoch to give these presentations.

The program of observations is primarily connected with the NDSC, with also specific efforts within other collaborations. Validation of space research data is still part of our interest. We can mention the projects CRISTA (an experiment onboard the shuttle), UARS (NASA satellite) and GOME (on the European platform ERS-2).

The laboratory is cooperating to the joint Europe-USA Arctic Campaign THESEO-2000/SOLVE (November 1st 1999 to April 30, 2000).
The monitoring of the abundances of 22 molecular species in the atmosphere has continued. The observational end products used for that purpose are the vertical column abundances (VCAs, expressed in number of molecules per cm^2) derived, as usual, from spectra taken by our two high resolution Fourier spectrometers. All the deduced values are archived in two international data banks, at NILU (Norvegian Institut for Air Research) and NOAA (Washington DC).

Our main objective being the determination and discussion of trends, it would not be very instructive to give, in this report, only one year’s results. That is why, in the given examples, the 1999 values are appended at the end of a multiple year period.

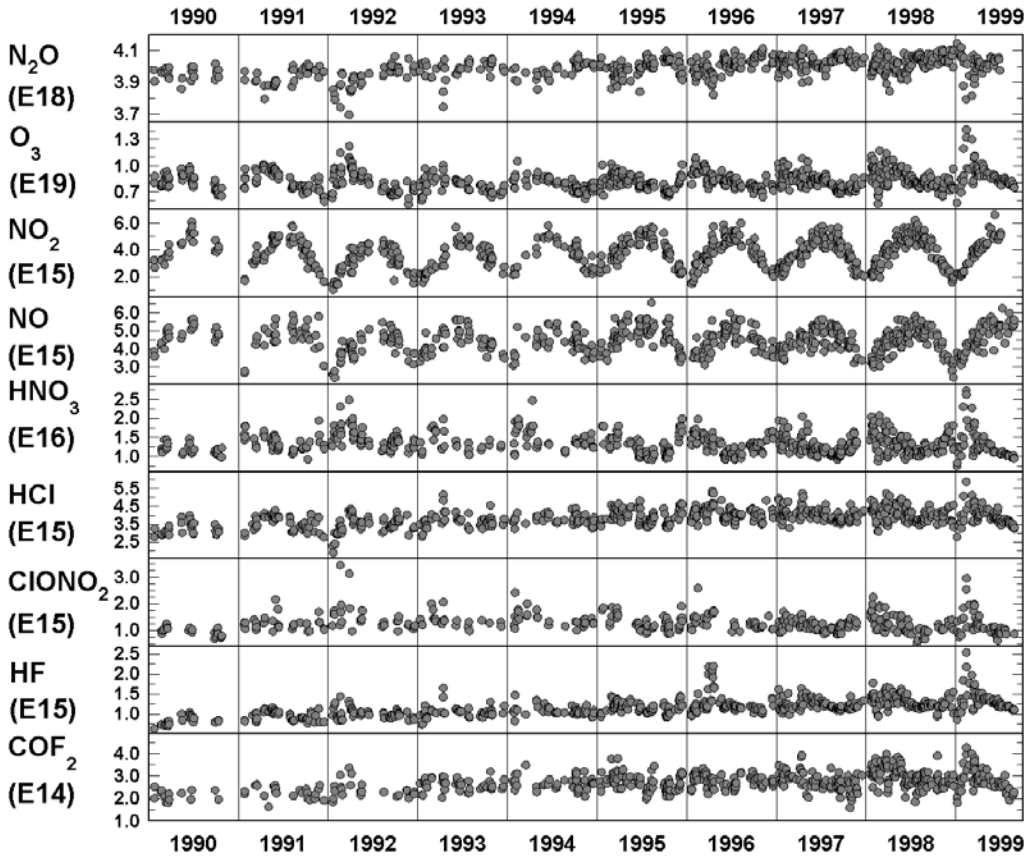

Fig. 1 : Variations of the vertical columns abundances of a series of atmospheric constituents, from 1990 to present. The numbers between parentheses are the multiplicative base ten exponents associated to each group of values.
Note the exponent, different for each molecule.

An excerpt of the Liège total data sets is reproduced in figure 1. It shows daily mean VCAs during the last decade for eight key stratospheric constituents, as well as for the long-lived source gas N_2O used as tracer of atmospheric circulation and dynamics. Within that context, it can be noticed that the low N_2O columns observed during the first months of 1999 anti-correlate with high columns of $ClONO_2$ and with record high values of O_3, HNO_3, HCl, HF and COF_2, thus clearly indicating significant intrusions of Arctic polar air over Europe during that period; this was confirmed upon inspection of back-trajectory maps produced by the ECMWF (European Centre for Medium-Range Weather Forecasts) and accessed via NILU (a similar situation had been encountered during the first months of 1992).

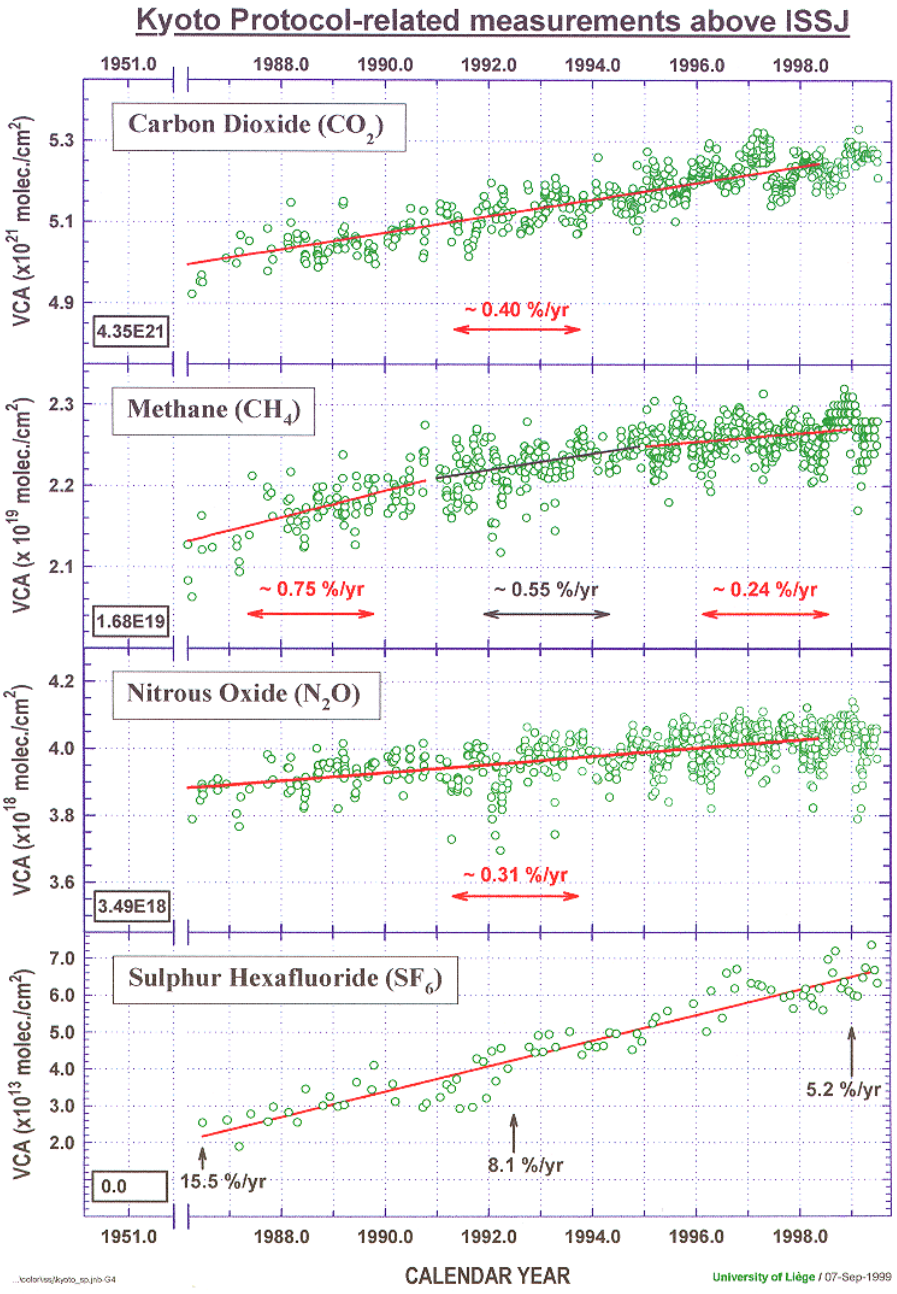

Fig. 2 : The vertical column abundances of five molecular species playing a role in the greenhouse effect. No change can be detected in their rates of increase.

As generally accepted, one important concern connected to the chemical composition of the atmosphere is the general Earth's surface warming due to the "greenhouse" effect.
The international conferences held in Kyoto and Buenos-Aires have attempted, with a very limited success, to achieve a reduction in the abundances of atmospheric constituents absorbing in the infrared, implying corresponding control observations in which we are involved.
Figure 2 shows that, as expected, no evident effect of any such attempt can yet be detected.

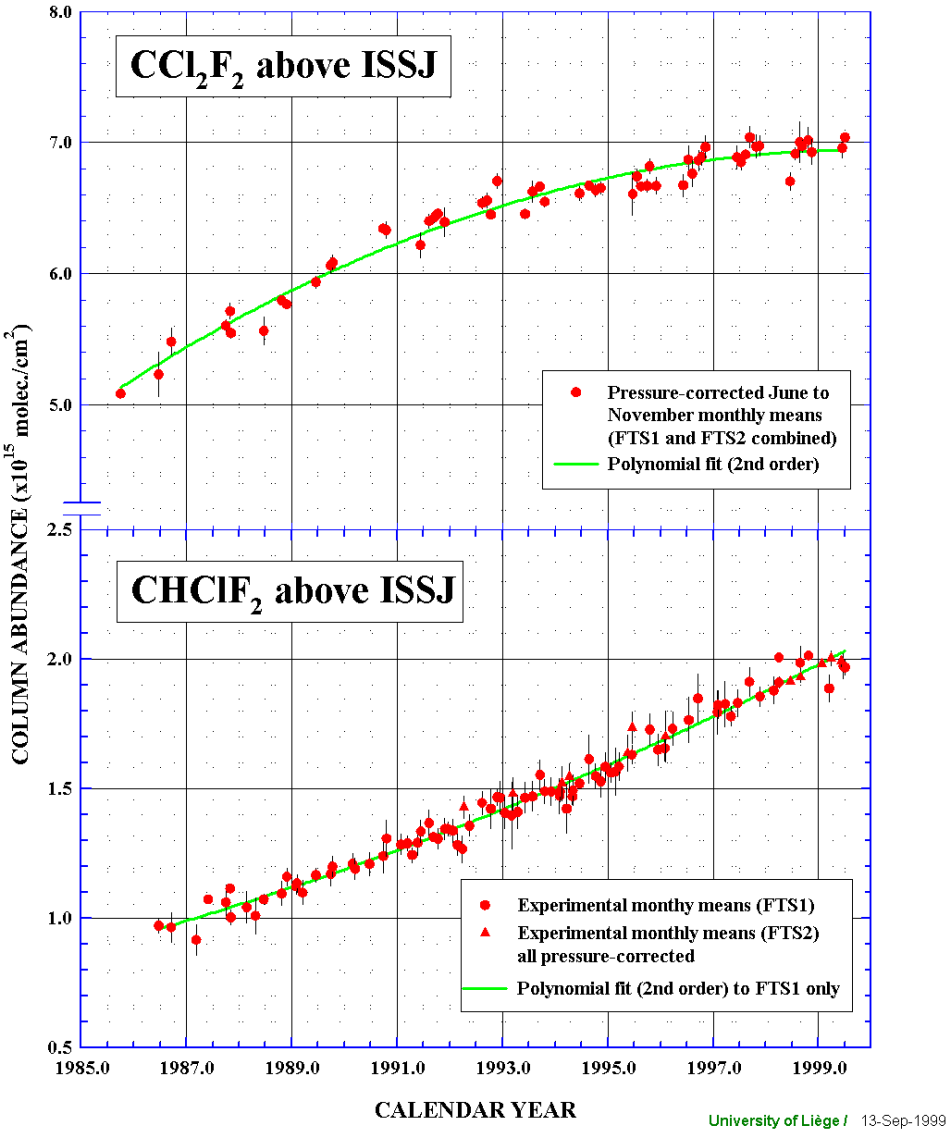

Fig. 3 Top : The "freon 12" abundance is now practically constant.
Bottom : The abundance of the not regulated "freon 22" continues to increase.

The news is clearly better concerning another important topic in atmospheric physics: the destruction of ozone at all latitudes due to chemical reactions involving various chlorinated molecules.

As shown in figure 3 (upper curve) the quantity of "freon 12" (CCl_2F_2, the most active species in the processes of destruction of ozone) is now stable after many years of rapid increase.

The lower curve of that same figure shows that the abundance of the less active "freon 22" ($CHClF_2$), not banned by the international agreements, continues to grow.

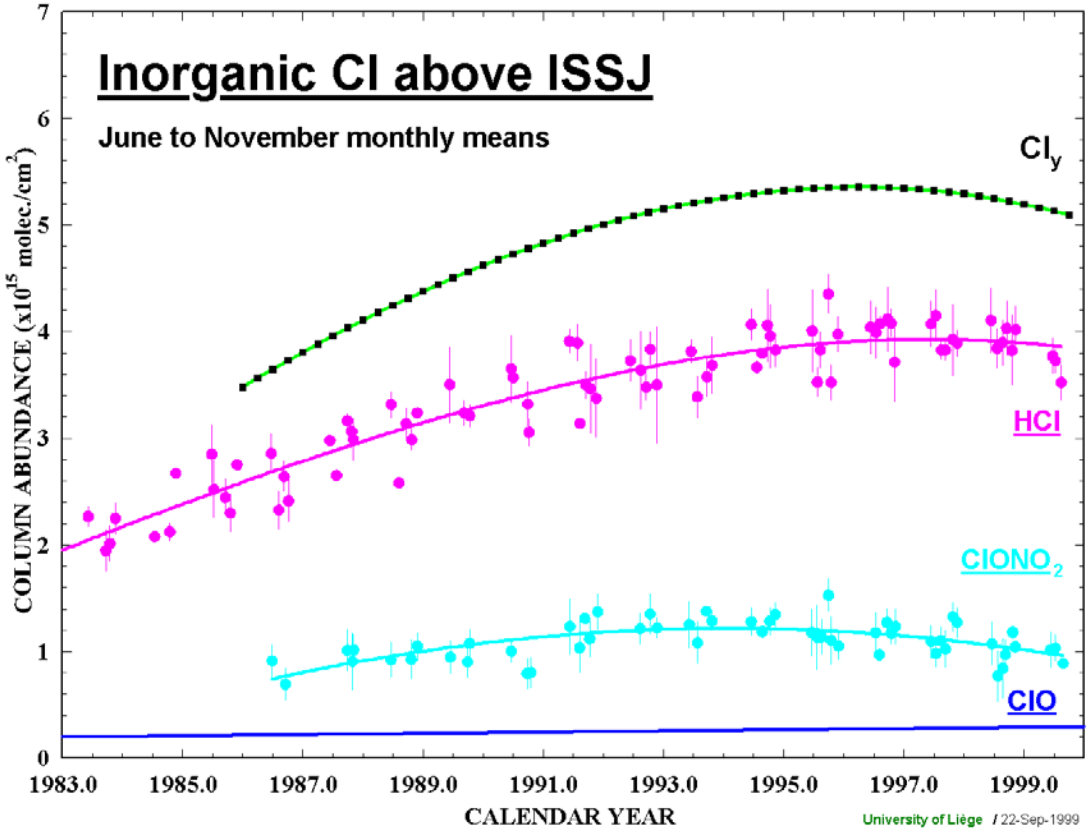

Fig. 4 : The evolution of the abundances of HCl (in red) and $ClONO_2$ (in blue).
These two molecules contain 98% of the atmospheric chlorine.
The top curve (in black) is the sum of these abundances, plus a ClO background (dark blue) derived from model calculations. The total amount of chlorine is recessing since a few years.

The data displayed in figure 1 have been normalized for a mean local pressure of 654 hPa. They allow to produce budget estimates of inorganic chlorine, Cl_y and inorganic fluorine, F_y.

The Cl_y atom rate of change resulting from the summation of our HCl and $ClONO_2$ measurements, complemented by a ClO model background for northern mid-latitudes is shown in the figure 4. The observed stabilization and initial slowing down of its loading is an unambiguous proof that the Montreal Protocol and its Amendments have been properly implemented and applied; the peak load of Cl_y identified around 1995-1997 is consistent with the maximum concentration of organic chlorine (CCl_y) observed between 1992-1993 by in-situ ground level measurements networks.

Fluorine does not contribute to ozone depletion, because F atoms released from the photodissociation of fluor-bearing sources are quickly sequestred into carbonyl compounds (COF_2 and COClF) and subsequently into the ultimate HF, which is very stable in the stratosphere. The primary interest in monitoring the inorganic fluorine (F_y) is as a surrogate of the amounts of its precursors (mainly the long-lived CFCs and HCFCs) having been photodissociated.

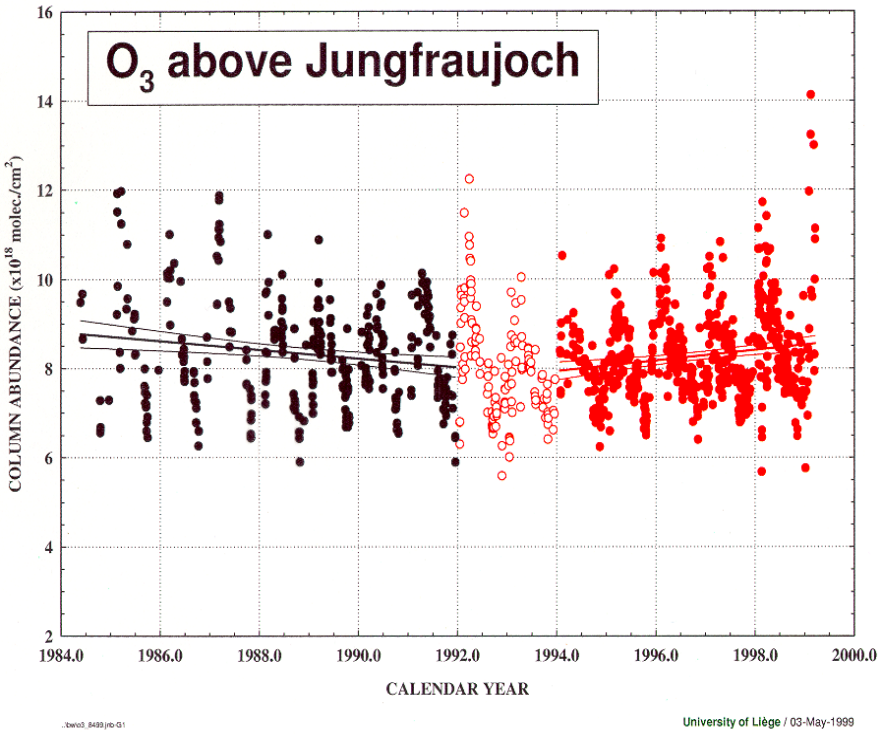

Fig. 5 : Evolution of the quantity of ozone above the Jungfraujoch. The solid lines indicate the fitted average, in between estimated error bar limits. An increase since 1993 seems evident, but the effect is still to be confirmed, and then explained, before to be accepted as showing an ozone layer recovery.

The evolution of the total amount of ozone above the Jungfraujoch is, if confirmed, perhaps the most instructive recent result.

The total O_3 column was stable, of the order of 9.4E18, between 1950 and 1975, and then started to slowly decrease. For the period 1980-1992, our results showed a decrease of, on the average, (0.75 ± 0.15)% per year. Careful examination of the more recent measurements seems to indicate that this decrease stopped around 1993, and that, having then reached a minimum of 8.0E18, the O_3 column started to increase, by (1.0 ± 0.3)% per year, over the last five years.

It is much too early to conclude that the ozone layer, thinned under the effect of the chlorofluorocarbons, is starting to recover. As clearly evident in figure 5, erratic and seasonal fluctuations are very large, complicating the determination of a smooth average. A non negligeable part of the increase can be due to specific atmospheric circulation characteristics that affected meridianal transport in the northern hemisphere during the recent past years.

Only future observations will tell us what really happens...

Publications

1998

1- Northern and southern hemisphere ground-based infrared spectroscopic measurements of tropospheric carbon monoxide and ethane,

C.P. RINSLAND, N.B. JONES, B.J. CONNOR, J.A. LOGAN, N.S. POUGATCHEV, A. GOLDMAN, F.J. MURCRAY, T.M. STEPHEN, A.S. PINE, R. ZANDER, E. MAHIEU and Ph. DEMOULIN,

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1- Investigation of pole-to-pole performances of space-borne atmospheric chemistry sensors with the NDSC,

J.C. LAMBERT, M. Van ROOZENDAEL, M. De MAZIERE, P.C. SIMON, J-P. POMMEREAU, F. GOUTAIL, A. SARKISSIAN and J.F. GLEASON,

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2- Slant column measurements of O_3 and NO_2 during the NDSC intercomparison of zenith-sky UV-Visible spectrometers in June 1996,

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Geophys.Res. Lett., 26, (1999), 1169-1172.

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R.G. PRINN, R. ZANDER, J.W. ELKINS, P.J. FRASER, M.K.W. KO, D. CUNNOLD, A. ENGEL, M.R. GUNSON, E. MAHIEU, P.M. MIDGLEY, J.M. RUSSELL III and R.F. WEISS,

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5- Column abundance measurements of formaldehyde above the Jungfraujoch,
Ph. DEMOULIN, R. ZANDER, F. MELEN, E. MAHIEU and Ch. SERVAIS,
Proc. "Atmospheric Spectroscopy Application 1999", Reims, Sept.1-3, (1999),

59-62.

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F. MELEN, E. MAHIEU, Ph. DEMOULIN, Ch. SERVAIS and R. ZANDER,
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M. Van ROOZENDAEL, and H.K. ROSCOE,
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8- Atmospheric observations :synergy between groud, air-borne and space-based atmospheric measurements,
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1- Daily ozone vertical profile model built on geophysical grounds, for column retrieval from atmospheric high-resolution IR spectra,
M. De MAZIERE, O. HENNEN, M. Van ROOZENDAEL, Ph. DEMOULIN, H. De BACKER,
accepted for publication J. Geophys. Res., Nov. 1999.

2- Long-term evolution of the loading of CH_4, N_2O, CO, CCl_2F_2, $CHClF_2$ and SF_6 above Central Europe during the last 15 years,
R. ZANDER, E. MAHIEU, Ph. DEMOULIN and F. MELEN,
to appear in 1999.

3- The NDSC in support of satellite data validation and calibration,
R. ZANDER, P.M. MIDGLEY and M.J. KURYLO,
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