

LE LABORATOIRE DE PHYSIQUE SOLAIRE ET ATMOSPHERIQUE DU JUNGFRAUJOCH

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The International Scientific Station of the Jungfrauoch is situated in the Swiss Alps (latitude: N 46°33', longitude: E 7°59', altitude: 3580 meters).

After his discovery of the CH<sub>4</sub> lines in a high resolution infrared solar spectrum recorded from Columbus (Ohio) in 1949, M. Migeotte (1) decided to install an improved spectrometer at that station, far from any industrial pollution. With that instrument, he first confirmed that methane is an everywhere present permanent constituent of our atmosphere, and then recorded, with two collaborators, an atlas of the infrared solar spectrum (2) which has been, for more than 25 years, the accepted "reference" book. He also discovered how exceptionally dry the atmosphere above the Jungfrauoch can be, in the cold winter days.

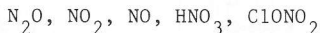
The decision was then taken to build a maximum resolution vacuum-grating spectrometer, and to install it at the Jungfrauoch for a long period. This instrument was put into operation in 1958, and produced an atlas of the near infrared solar spectrum published in 1963 (3). Its performances were greatly improved in 1963, by double-passing the grating with an intermediate slit, and in 1966, by installing a computer to control a rapid-scanning system with numerical filtering of the data (4). Between 1966 and 1976, the main activity of the "Solar Physics Laboratory", operated with the collaboration of colleagues from the Royal Observatory of Belgium, was the study of the solar photospheric spectrum, mainly to obtain better values of the abundance of many elements in the Sun. A two-volume atlas of the solar spectrum from 300 to 1,000 nanometers was also patiently recorded, on the driest days (5).

The interest then shifted progressively towards atmospheric spectrometry: very high resolution solar spectrometers are ideal tools to isolate lines in molecular vibration-rotation bands, with absolute specificity. The efficiency of the laboratory was greatly improved by the installation, in 1984, besides the grating instrument, of a high performance Fourier Transform spectrometer. Developed at the Institute of Astrophysics of the University of Liège, this instrument reaches a resolution limit of 0.0025 cm<sup>-1</sup>, is equipped with beam splitters and detectors to cover the domain between 1 and 14 micrometers and produces photon noise limited spectra up to 5 micrometers.

Last year, the Belgian National Scientific Research Fund provided the necessary budget to replace the grating spectrometer by a second very high performance Fourier Transform spectrometer: a BRUKER-Model 120, with large optics, able to reach a resolution limit of 0.001 cm<sup>-1</sup>. This new instrument is now in operation.

Most of the investigations conducted so far have been devoted to the determination of column abundances of various atmospheric constituents in order to evaluate their changes on various time scales.

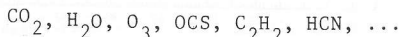
\* Monitoring programs for HF, HCL



\* Trends evaluation over 40 years for N<sub>2</sub>O, CH<sub>4</sub>, CO, C<sub>2</sub>H<sub>6</sub>

\* Determination of upper abundance limits for ClO, HOCl, HBr

\* Data are also collected about various other molecules such as :



The most striking column abundance monitoring examples are those related to HF (figure 1) and to HCl (figure 2), derived from near-infrared solar observations between 1976 and today. Details about the analytical procedure applied to retrieve these columns can be found in Zander et al. (6, 7). An intensification of the measurements after 1982 has revealed a seasonal variation in the columns of both species, likely to be related to the tropopause height. While the HF trend is well established ( $9 \pm 1\%$  / year) and in agreement with model predictions, the HCl evolution has remained more obscure: between 1977 and 1983, the increase appeared negligible, while its trend on the subsequent years has become better established, reaching a value of  $7 \pm 2\%$  / year, which is higher than the model predictions.

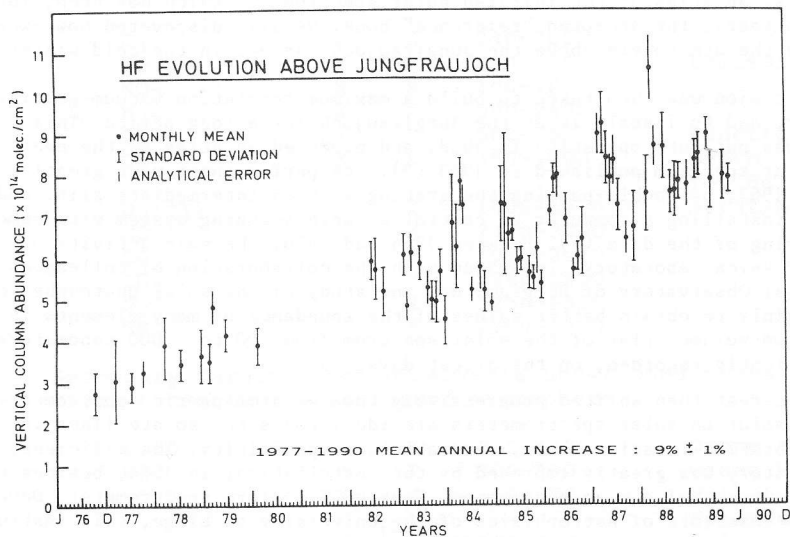


figure 1.

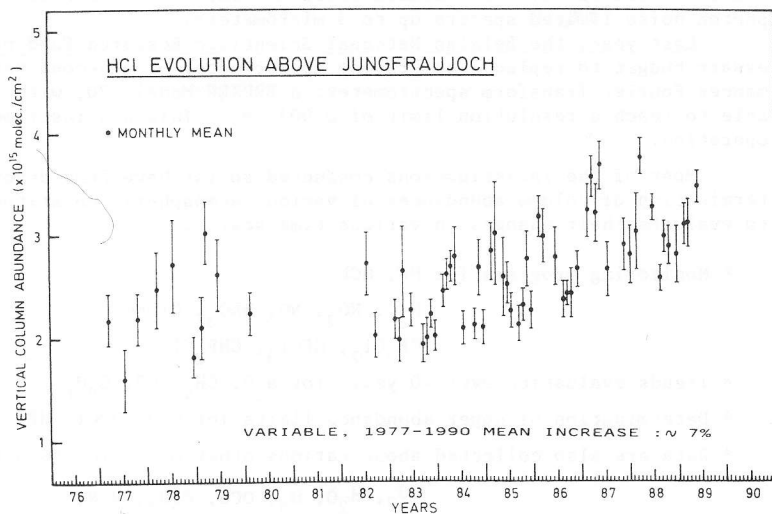


figure 2.

Another approach for column abundance monitorings above the Jungfraujoch has been based on the comparison between original 1950-1951 old solar spectra recorded by Migeotte et al. (2) and similar ones taken more recently at the same site. After the seasonal variation and the shorter term variability of a gas under investigation has been established on the basis of dense series of recent observations, one then can degrade such modern recordings to the spectral resolution of the older ones and evaluate the differences in terms of column abundance changes. This approach has been applied to  $\text{CH}_4$  (8),  $\text{CO}$  (9) and  $\text{C}_2\text{H}_6$  (10), the respective secular trends over the last 35 years being equal to :  $0.7 \pm 0.1$ ,  $0.85 \pm 0.2$ , and  $0.85 \pm 0.3 \%$  / year.

As a final example, figure 4 reproduces two spectra recorded under similar geometric conditions in 1951 (trace C) and in 1986 (trace A), over the 1155 to 1167  $\text{cm}^{-1}$  interval. Trace B corresponds to trace A after degradation from its original spectral resolution of  $0.005 \text{ cm}^{-1}$  to the  $0.25 \text{ cm}^{-1}$  resolution achieved in 1951. While the  $\text{CF}_2\text{Cl}_2$   $\nu_8$ -Q branch at 1161 is clearly visible on both traces A and B, it is definitely absent on the 1951 observation; such obvious differences corroborate the drastic increase of that "Freon" F-12 in our environment during the last decades.

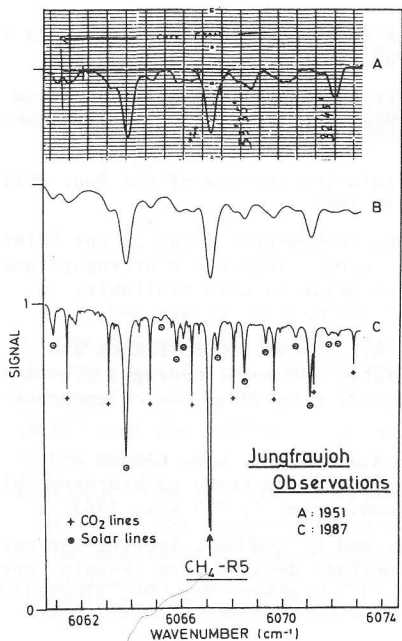


figure 4.

- TRACE C : M. MIGEOTTE, 1951
- TRACE A : RECENT RECORD
- TRACE B CORRESPONDS TO TRACE A DEGRADED TO A RESOLUTION OF  $0.25 \text{ cm}^{-1}$

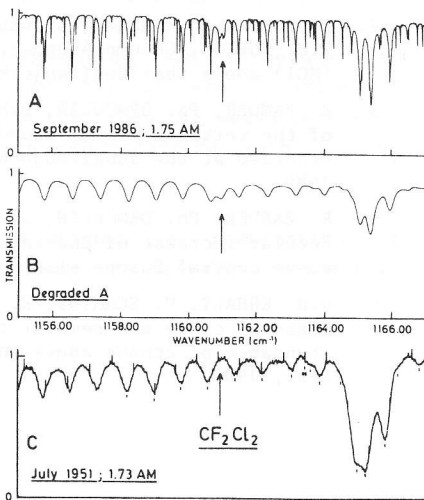
NO TRACE OF ABSORPTION BY  $\text{CF}_2\text{Cl}_2$  CAN BE SEEN ON THE 1951 RECORD

figure 3.

SECTION OF SOLAR SPECTRA RECORDED AT A SOLAR ZENITH ANGLE OF  $61^\circ$

- TRACE A : M. MIGEOTTE, 1951 (notice pencil tracings of the R5 line wings and of the local continuum)
- TRACE C : RECENT RECORD
- TRACE B CORRESPONDS TO TRACE C DEGRADED TO A RESOLUTION OF  $0.25 \text{ cm}^{-1}$

SUCH COMPARISONS REVEALS THE INCREASE OF  $\text{CH}_4$  COLUMN DENSITY (ACTUALLY  $\approx .7 \%$  PER YEAR)



A Network for the Detection of Stratospheric Changes (NDSC) is under development. Its scientific steering committee has recognized, as the first site, the so called "ALPINE STATION", already existing, supposed to fulfil the needs for observations at the 45° N latitude. That station combines laboratories installed in different places, in central western Europe, using different techniques; amongst them, the Jungfrauoch Laboratory will produce the high resolution spectroscopic data base through infrared solar observations.

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# POLAR STRATOSPHERIC OZONE

PROCEEDINGS

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FIRST EUROPEAN WORKSHOP

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$\text{HCHO}$   $\text{HCOOH}$   $(\text{CH}_3)_2\text{S}_2$   $\text{H}_2\text{SCH}_3$   $\text{S}$

$\text{CH}_3\text{C}(\text{O})\text{OONO}_2$   $\text{CH}_3\text{OOH}$   $\text{CMF}_5$   $\text{C}$

$\text{CH}_3\text{Cl}$   $\text{CH}_3\text{CCl}_3$   $\text{CH}_3\text{Br}$   $\text{CH}_3\text{I}$   $\text{CCl}_4$   $\text{SCl}$

AEROSOLS COMBUSTION SOI

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