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Ground-Based Infrared Solar Observations for Early Detection of Stratospheric Changes

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Over the last decades, spectroscopic ground-based observations in the infrared, using the sun as the source of radiation, have provided a large amount of information about the composition and structure of the Earth's atmosphere. Recognition of many advantages of that infrared absorption spectroscopy technique for remote sensing of specific layers in the atmosphere led to subsequent investigations from on-board flying aircraft, balloons, satellites and more recently from the shuttle platform. These various "sites" of observation show obvious relative advantages, also constraints and limitations; within the context of telluric researches encompassing wide time and space spans, none of these "sites" has proven obsolete yet. Worth recalling here is the fact that the absorption spectroscopy technique for remote sensing is as good as the tools involved in both the observation and the analysis phases: grating - and Fourier transform spectrometers, heterodyne systems,..., associated to cryogenically cooled detectors have reached some state-of-the-art operation (providing high resolution and signal-to-noise ratios) and line parameters compilations have been supplemented significantly over the last years (major improvements are anticipated for OH, HO_2, H_2O_2 and some HNO_3 bands).

Ground-based stations located favorably on high mountains and equipped with high performance instruments offer routine possibilities to:

(1) measure integrated column densities for a large number of atmospheric constituents (e.g. N_2, H_2O, CO_2, N_2O, CH_4, CO, O_3, NO, NO_2, HNO_3, HF, HCl, HCN, OCS, H_2CO, HCOOH, C_2H_2, C_2H_6, $CFCl_3$, CF_2Cl_2, CHF_2Cl,...), among which are all those gases playing an important role in the radiation budget of the Earth's atmosphere and therefore of key importance in climatology related studies.

(2) provide information on diurnal variations (e.g. NO, NO_2...), establish seasonal changes and secular trends (e.g. HCl, HF, CH_4, CO_2,...)

For most of the measurements related to points (1) and (2) above, the precision is very important. Using high quality solar spectra recorded at the Jungfraujoch station (Switzerland, 3580m altitude, 46.5°N, 8°E) with an FTS (resolution 0.005 cm^{-1}; S/N > 1000), we have established that moderately strong absorption lines with central depths between 10 and 50% can be measured to better than $\pm$ 2%; for this, use was made of solar lines as well as temperature-independent lines of N_2, CO_2 and N_2O.

Further to the determination of integrated column densities, ground observations carried out with spectral resolutions of 0.005 cm^{-1} or better and S/N ratios in excess of 1000 allow to extract information about the concentration versus altitude, by fitting precisely the contours of series of lines having various strengths and temperature dependences, recorded over large zenith angle changes; such retrievals are relatively time consuming and not always unambiguous (they require a good knowledge of the temperature profile prevailing during the observations).

Investigations are being carried out at the Jungfraujoch station to assess the detectability limits of $ClONO_2$, HO_2NO_2 and ClO.

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