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# $H_2O$, $CO_2$, and $CH_4$ Monitoring at Astronomical Telescope Sites

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Astronomical observatories that offer near-IR spectrographs can, in principle, be used as sites for monitoring greenhouse gases. In particular, observations for calibration purposes of so-called telluric standard stars are suitable. These are usually white dwarfs or hot stars, which show nearly no intrinsic spectral features in the required wavelength range. Therefore, absorption features in their spectrum arise mainly from the influence of the Earth's atmosphere and indicate its state and composition during the observation. Since calibration observations are taken several times per night, the temporal coverage is high.

The European Southern Observatory (ESO) provides one of the world-wide largest telescope sites in the Atacama Desert of Chile. The Very Large Telescope located on Cerro Paranal (2635m) consists of four 8m class telescopes and a number of smaller ones incorporating a wide range of instruments. One of the most versatile instruments is X-Shooter, which has gone in operation in October 2009. It is a medium resolution spectrograph ($R = 3000 - 18000$) covering the entire wavelength range from $0.3 - 2.5\mu$m simultaneously. Therefore, spectral features of water, oxygen, methane, and carbon dioxide are visible.

We have taken all publically available X-Shooter spectra in the ESO data archive starting from October 2009 to establish a set of telluric standard star observations ($\sim 1400$ per year). We have developed an algorithm which is able to determine molecular column densities by fitting spectral absorption features with the help of the LBLRTM radiative transfer code package and the HITRAN line database. By scaling molecular abundance profiles iteratively, a best fit is achieved incorporating a Levenberg-Marquard $\chi^2$-minimisation algorithm. A similar method based on spectroscopy and profile scaling is used by the TCCON network.

This algorithm is applied to the X-Shooter spectra in order to determine a time-dependent evolution of the $H_2O$, $CH_4$, and $CO_2$ content of the Earth's atmosphere over Cerro Paranal. Currently, a pilot study to estimate the accuracy is conducted. The results will be compared to measurements achieved by ground-based and satellite data for similar sites and latitudes. In principle, the same method can be applied to all data of appropriate spectrographs also on other telescope sites, leading to a coarse world-wide coverage of measurements.