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How accurately can we measure the water vapour content with astronomical spectra?

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Light from astronomical objects unavoidably has to pass through the Earth's atmosphere when being observed by ground-based telescopes. Thus, the fingerprint of the atmospheric state at the time of the observation is present in any spectrum taken by astronomical spectrographs due to absorption and emission arising in the atmosphere.

The Very Large Telescope (VLT), operated by the European Southern Observatory, is one of the world's largest telescope facilities located at Cerro Paranal in the Chilean Atacama Desert offering a wide selection of various instruments. One of the most versatile instruments is X-Shooter. This medium resolution Echelle spectrograph covers the entire wavelength regime from 0.3 to 2.5 μm and is mounted on one of the 8m-class telescopes of the VLT. Due to its versatility, it is widely used, which leads to a good temporal coverage.

We have recently developed the software package `molecfit`, a tool used to model and correct for atmospheric absorption lines visible in astronomical spectra. It is based on the radiative transfer code LBLRTM, the HITRAN line parameter database, the GDAS atmospheric profiles, and local meteorological data. A by-product is the determination of the amount of precipitable water vapour (PWV) above the observatory, as well as several other molecules, including CO_2.

In this poster, we investigate the accuracy of this method. We have used a set of X-Shooter spectra of so-called telluric standard stars, which are hot and bright stars showing nearly no intrinsic spectral features in the near infrared regime. Thus, most absorption features present in these spectra are related to the absorption arising in the Earth's atmosphere. For each spectrum, we have determined the PWV with our `molecfit` code and compared it with direct measurements achieved by the LHATPRO radiometer recently installed at Cerro Paranal. Therefore we have extended the results obtained by Kerber et al. (2012, Proc. SPIE, 8446) on a long time scale.

Due to the wide wavelength coverage of X-Shooter, the atmospheric content of CO_2 can also successfully be determined. The good accuracy obtained by this method confirms that regular monitoring for a number of other molecules by the various spectrographs installed on the Very Large Telescope is possible.