Automatic model-based telluric correction for the ESPRESSO data reduction software

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Extremely precise radial velocities (RV) require high-fidelity unbiased spectra. One of the main biases is caused by the Earth's atmosphere and its large molecular absorption bands. Even if different techniques (forward radiative transfer models, principle component analysis (PCA), or other empirical methods) exist to correct telluric contamination, telluric lines with an absorption depth of >2% are generally masked for RV studies. This poses a problem for faint targets and M dwarfs as most of their RV content is present where telluric contamination is important. This led us to develop a simple telluric model to be embedded in the ESPRESSO data reduction software (DRS) to deliver telluric-free spectra and enable RV measurements through the cross-correlation function technique for all ESPRESSO users. The model is a line-by-line radiative transfer code that assumes a single atmospheric layer. When applied to stellar spectra, the residuals of the strongest water lines are below the 2% peak-to-valley amplitude or within the pseudo-continuum. We identified that micro-telluric lines introduce systematics up to an amplitude of 58 cm/s and with a period of one year if not corrected on the RVs of Tau Ceti. For late-type stars, the gain in spectral content at redder wavelengths is equivalent to a gain of 25% in photon noise, which leads to better constraints on the semi-amplitude and eccentricity of Proxima d for example. This simple model is performant enough to deliver higher fidelity unbiased spectra for ESPRESSO and can be extended to other high-resolution spectrographs as its DRS is shared with HARPS, HARPS-N and NIRPS.