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Variability of various nightglow emissions from about 100,000 VLT/X-shooter spectra

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Chemiluminescent emission from the mesopause region between 75 and 105 km dominates the Earth's low-to-mid-latitude nocturnal radiation in the wavelength domain from the near-UV to the near-IR. This nightglow consists of various roto-vibrational bands of molecules such as hydroxyl and molecular oxygen as well as individual lines from atoms such as oxygen and sodium. In principle, each line shows an individual vertical emission profile with a characteristic mean peak height and a typical full width at half maximum of less than 10 km. The total emission rate, peak height, and shape of the different profiles depend on the temperature, density, and the concentrations of different chemical species, especially of atomic oxygen. As the state of the mesopause region is strongly affected by the solar activity (especially via the rate of hard UV photons that produce highly reactive radicals) and different kinds of passing waves such as tides and gravity waves that mainly originate in the lower atmosphere, nightglow is also highly variable and can, thus, be used to trace the different processes. Various ground- and space-based observing strategies have already been applied. However, recording the variations of many different (and especially weak) emission lines in parallel with good temporal coverage for perturbations with time scales from minutes to years is challenging.

In this context, we have now achieved to process about 100,000 medium-resolution spectra with a wavelength coverage from 0.3 to 2.5 µm that were taken with the astronomical X-shooter spectrograph at the Very Large Telescope of the European Southern Observatory at Cerro Paranal in Chile between 2009 and 2019. This promising data set allows us to study the variability of hundreds of nightglow lines and mutual correlations on time scales from those related to gravity waves to those related to the solar activity cycle. We will show first results. The goal of the project will be a better understanding of the nightglow layering and the sensitivity of the different emissions to different kinds of changes in the atmospheric conditions.