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Vertical layering of OH line emission from X-shooter and SABER observations of a passing quasi-2-day wave

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The nighttime near-infrared radiation of the Earth's atmosphere is mainly produced in the mesopause region between 80 and 100 km by chemiluminescent emission of the OH radical. The line radiation of various vibrational and rotational states is therefore a valuable indicator of the chemistry and dynamics in the upper atmosphere. The vertical emission distribution can significantly change with time. It is also expected that the time-averaged effective emission height depends on the studied OH line due to differences in the radiative lifetimes, the collision-related transition probabilities, and the initial level population after the production of the radical. Although the knowledge of the OH emission layering is important for the interpretation of passing perturbations, the line-specific details are still uncertain.

We have studied the effective emission heights of about 300 OH lines based on near-infrared spectroscopic data from the X-shooter spectrograph at the Very Large Telescope at Cerro Paranal in Chile. The line intensities showed very strong variations due to a rising quasi-two day wave during eight nights at the beginning of 2017. With complementary vertically resolved broad-band observations of OH emission from the limb-sounder SABER on the TIMED satellite, we could link the line-dependent wave phases from the fitting of the X-shooter data with emission altitudes. With a period of about 44 h and a vertical wavelength of about 32 km, the observed wave turned out to be an excellent indicator of line-dependent altitude differences, which reached up to 8 km for the investigated lines. In general, the effective emission altitude increases with increasing vibrational and rotational level. Moreover, the derived wave amplitudes imply the presence of a cold thermalised and a hot non-thermalised population for each vibrational level. As the wave amplitudes also showed a strong dependence on local time, significant interactions between the quasi-two-day wave and other perturbations such as tides are likely.