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Investigating metals in the MLT using astronomical facilities

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Metals in the mesopause region, such as Na, Fe or Ni, originate from meteoric ablation in the upper atmosphere. Through reactions with ozone they emit airglow and in the case of Fe and Ni form metal oxides. Unlike Na, their emission does not result in line emission but in a (pseudo-) continuum. However, (pseudo-) continuum emission is difficult to observe since it is a broad but weak spectral feature compared to the line emissions arising from Na. The pseudo-continuum of FeO is located in the wavelength range of 0.55 to 0.72 μm, while NiO covers 0.45 to 0.72 μm. So far FeO has been studied with the Odin satellite and with ground-based astronomical facilities (ESI/Keck and Kitt Peak). The observed spectral data were compared to laboratory spectra. The diurnal behaviour of FeO was studied in comparison to OH, Na, and O(5577) during nine nights. For NiO even fewer observations are available. NiO has been detected via night airglow tangent limb spectroscopy with the GLO-1 instrument onboard a space shuttle.

For this study on metals in the mesopause region we use astronomical data taken with the Very Large Telescope (VLT) operated by the European Southern Observatory (ESO) in Chile (24° 37′ S, 70° 24′) and the Apache Point Observatory (APO) in New Mexico/USA (32° 46′ N, 105° 49′ W). The ESO spectrograph X-shooter (0.30 - 2.48 μm, resolving power R = 3000 - 18000) as well as the APO MaNGA survey instrument (0.36 - 1.03 μm, R $\sim$ 2000) were utilized. The X-shooter sample consists of 3662 spectra taken between October 2009 to March 2013. The MaNGA sample consists of $\sim$1500 spectra taken between February 2014 and June 2015.

Using X-shooter data the diurnal and seasonal behaviour of FeO and Na was studied for the southern hemisphere. We found a semi-annual amplitude of 27% and 30% with respect to the annual mean for FeO and Na respectively. This compares to 17% and 25% in the amplitude of the annual oscillation for FeO and Na, respectively. In addition simulations with WACCM allowed us to quantify the reaction rates in the MLT and compare them to laboratory results. We find a quantum yield of 13% for FeO and 11% for Na which is in reasonable agreement with laboratory results. Also first estimates of the ratio of FeO/NiO within a small subsample were obtained. The MaNGA data allow us to further study the behaviour of FeO and Na at the northern hemisphere and compare it to the one at the VLT. Furthermore, the instrumental setup allows for a more detailed study of the contribution of NiO to the night-sky emission.