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Statistical variability of orthohelium airglow brightness based on ground-based observations at the KHO, Longyearbyen

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This study presents the temporal variability of metastable orthohelium, He(2^3S), across multiple scales in the polar region. Orthohelium produces 1083 nm emission through resonance scattering, which was first reported more than 65 years ago during a strong aurora over Moscow. Model studies predict that the orthohelium layer forms at altitudes between ~250 km and 800 km or higher, making it a promising candidate for remote sensing of upper thermospheric and lower exospheric dynamics. However, variations of orthohelium associated with geomagnetic disturbances remain poorly investigated. Continuous He(2^3S) airglow measurements can improve our understanding of orthohelium variability within the magnetosphere – thermosphere – ionosphere coupling system and extend the capability of space weather forecasting up to the exobase.

We obtained a dataset of continuous He(2^3S) airglow brightness from late September 2024 to early April 2025 using the short-wavelength infrared imaging spectrograph NIRAS-2 at the Kjell Henriksen Observatory (KHO), Svalbard (78.1° N, 16.0° E). NIRAS-2 is a newly developed 2-D imaging spectrograph sensitive to radiation from 1.05 to 1.35 μ m (Nishiyama et al., 2024). It provides a 1-D field of view (FOV) aligned with the geomagnetic meridional direction, with an angular coverage of 55° and a resolution of 0.11° per pixel. He(2^3S) spectra with a spectral resolution of 0.44 nm/pixel were obtained by subtracting OH(5,2) Q-lines, as described in Nishiyama et al. (2025).

The observed He(2^3S) airglow brightness time series exhibited clear seasonal variations, including the well-known helium winter bulge, as well as a dependence on solar zenith angle (SZA). Semiannual variations of He(2^3S) airglow brightness were consistent with He density at 500 km altitude calculated by MSIS 2.1. We will further investigate He(2^3S) variability as a function of SZA, magnetic local time, geomagnetic activity, solar activity, and season. In addition, sudden increases in He(2^3S) airglow, likely associated with solar proton events, were observed several times. These enhancements appear to result from particle precipitation (He^{++}/He^{+} and electrons), typically when KHO was located within the cusp region. We plan to compare the observed He(2^3S) variability with in situ particle measurements and far-ultraviolet (FUV) spectral imaging from DMSP satellites.