Atmospheric wave variability in the upper mesosphere based on ground-based observations of OH airglows (1.20-1.35 µm) in Longyearbyen (78.1°N, 16.0°E)

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The energy and momentum of the atmospheric waves, such as atmospheric gravity waves, tides, and planetary waves, can be a driving force for the dynamics in the mesosphere and lower thermosphere (MLT) region, which is considered to be closely related to the general circulation in the whole atmosphere. Thus, it is important to observe the activities of such atmospheric waves in the MLT region, for more precise understanding of the whole atmosphere. Many observations of such atmospheric waves have been done for many years. In particular, recent polar-orbit satellites have been providing near-global observations. In addition to such satellites, ground-based observations with higher temporal and spatial resolutions are important to resolve smaller-scale waves. For example, such high-resolution observations can be effective to obtain information on tides with higher frequencies (8- and 6-hours periods), in which there are relatively less observations especially in polar regions.

As for the temperature observations from the ground, the rotational temperature estimated from OH airglow has been extensively investigated in the past over 60 years. Recently, short-wavelength infrared (SWIR) OH airglow observations using InGaAs FPA (Focal Plane Array) have been reported. The OH airglow intensity in this region is stronger than that in the visible subrange, and thus more advanced airglow observations (e.g, with higher time resolution) can be expected. However, observations using the SWIR OH bands are still limited so far, especially in the polar region. In addition, auroral contamination is one of the difficulties in airglow observations in the polar region. For example, there is a report that temperature measurements using the OH (3,1) band (~1.5 um) can be underestimated possibly by ~40 K due to auroral contamination [Nishiyama et al., 2021]. Therefore, a more robust method is needed for OH temperature observations in the polar region.

In this research, we propose spectroscopic observations of the OH airglow in 1.1~1.3 µm, which would be expected to be more robust to such auroral contamination, We have developed a brand new Near-InfraRed Aurora and airglow Spectrograph-2 (NIRAS-2). It is an imaging spectrograph with InGaAs 2D FPA, which has a wide FOV of 55 degrees with a resolution of 0.11 degrees, and its wavelength resolution is variable with combinations of three slits, 30-, 60-, and 90-µm, and two volume phase holographic gratings, 950- and 1500-lpmm. OH airglow observations are mainly performed using the low-dispersion 950-Ipmm grating with 60-µm slits. The wavelength range is from 1195 to 1350 nm, targeting the OH (7,4) and (8,5) bands and O_2 IR band with a spectral resolution better than 1.1 nm. NIRAS-2 was installed at The Kjell Henriksen Observatory (KHO), Longyearbyen (78.1°N, 16.0°E) in late November 2022. Continuous 24-hour observations of the OH bands were made with 30-second exposures from November 23 to December 26, 2022, and then the OH observations were also routinely done for continuous two weeks in every month from January to March 2023. OH rotational temperatures derived from the 30-minute integrations are in a good agreement with the OH (6,2) rotational temperatures obtained from the spectrometer of the University Centre in Svalbard and the temperature obtained from Aura/Microwave Limb Sounder. Moreover, we are working on data analysis to investigate the activities of atmospheric waves, mainly atmospheric tides and gravity waves. In the preliminary analysis, we found clear 6- and 8-hour wave activities in both the OH (7,4) and OH (8,5) bands data with 5-min resolutions (figure 1). A composite analysis was performed to remove the incoherent signal with respect to local time. Then, least squares fitting was applied to the composite data and found to be dominated by the 8-hour tide (figure 2). These results would be similar to the previous results obtained at Eureka (80°N) [Oznovich et al., 1997]. For further investigation, the results from the temperature observations will be then compared with wind observations from the co-located Nippon/Norway Svalbard Meteor Radar (NSMR) [Hall et al., 2002]. In the presentation, we will show these results and give a more detailed discussion.

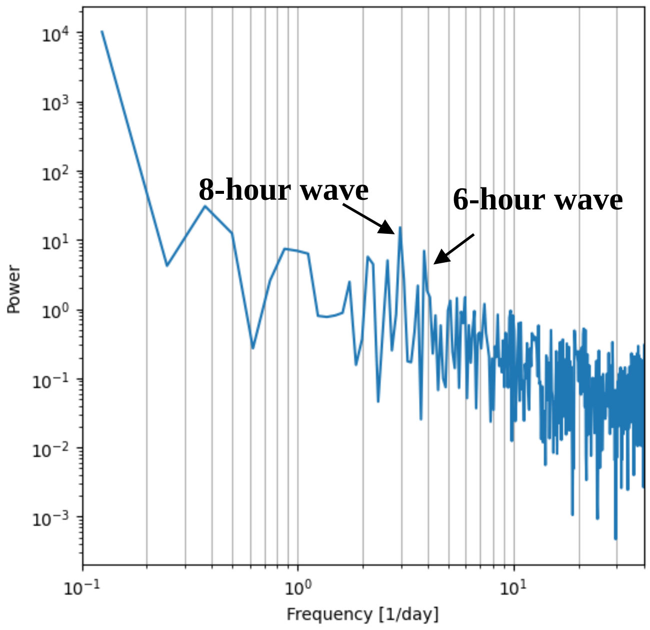

Figure 1. The power spectrum of OH (8,5) rotational temperatures from November 23, 2022 to December 1, 2022.

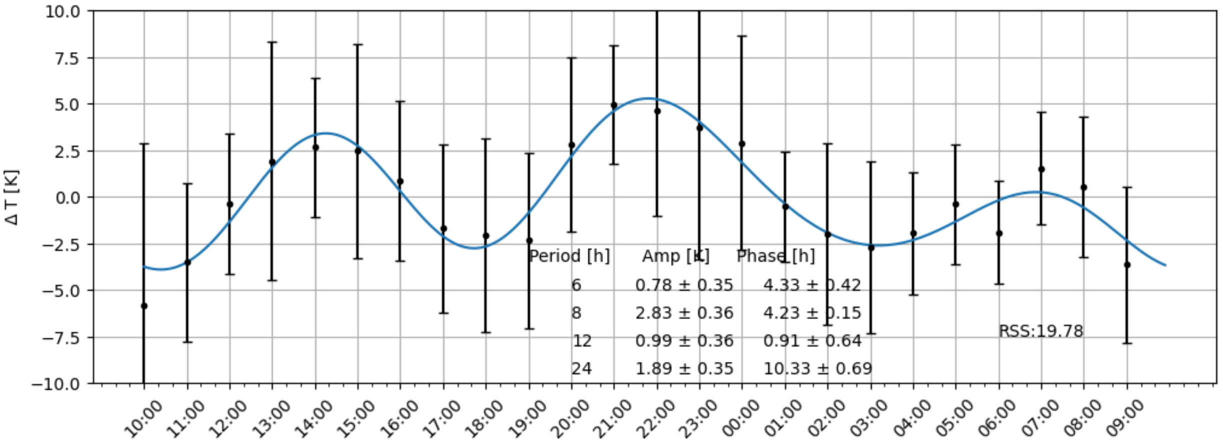

Figure 2. The composite analysis from November 23, 2022 to December 1, 2022 (black). Error bars are one standard deviation of the mean. The solidline is a least sqares fit to the composited data (blue).

References

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