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大気光イメージング観測による大気重力波構造を利用した新たな風速決定

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A New Approach to Measuring Wind Speed with Airglow Imaging of Atmospheric Gravity Waves

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In this study, we estimated wind speed near the mesopause by observing atmospheric gravity waves using airglow imaging. According to the linear dispersion relation for gravity waves, the vertical wavelength can be derived from the intrinsic velocity (the difference between the horizontal phase velocity and the background wind) and the horizontal wavelength. In airglow imaging, the horizontal phase velocity and horizontal wavelength of the waves can be directly obtained from the images. Assuming that the same wave structure is observed in airglow emissions at different altitudes, the ratio of horizontal to vertical wavelength can be calculated from the phase difference between the wavefronts observed in two airglow images and the altitude difference of the airglow layers. This allows for the determination of the background wind solely from airglow observations.

On May 2, 2010, clear gravity wave structures were observed with the Shigaraki airglow camera (OMTI: Optical Mesosphere Thermosphere Imager) in OI airglow (altitude: 95 km) and OH airglow (altitude: 85 km). The gravity waves had a horizontal wavelength of 28.6 km and a horizontal phase velocity of 33.9 m/s, propagating northeastward (about 52.4° from north). The calculated tilt of the vertical wavefront, based on the phase difference of the gravity waves observed between the OI and OH airglow images, was about 20.4° , corresponding to an estimated background wind speed of 1.3 m/s in the direction of gravity wave propagation. Simultaneous wind measurements at the OI airglow altitude using a Fabry-Perot interferometer (FPI) indicated a wind speed of 75.5 m/s towards the southeast. When projected along the direction of gravity wave propagation, the FPI wind speed was 1.5 m/s, consistent with the estimated wind speed of 1.3 m/s obtained in this study, thus validating both the results and the estimation algorithm. These findings suggest that airglow imaging is a viable method for estimating winds in the mesopause region, offering a cost-effective alternative to significantly more expensive FPI or meteor radar systems.