

Development and accuracy evaluation of the image processing system for Stabilized High-sensitive Imager on Shirase

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Ionospheric phenomena such as aurora and airglow are mainly observed by ground-based all-sky imagers, so there are observational gaps over the ocean, especially in the southern hemisphere, where the ocean occupies a large proportion. If these gaps are solved, it will be possible to compare phenomena between the northern and southern hemispheres to evaluate differences, and to observe phenomena with a structure too large to be observed only on the ground. In addition, it will be possible to compare phenomena over the ocean and over the ground, and to evaluate the effect of the ocean-ground distribution on the variability of the upper atmosphere. In order to conduct these observations and evaluations, it is necessary to enable optical observations over the ocean and to solve the gaps. In the case of optical observations from the ocean, the vibration of the ship must be taken account of, unlike on the ground. The imager posture changes during the exposure time due to the vibration of the ship, and the position and orientation of the imager change for each observation data as the ship moves. The purpose of this study is to solve these ship-specific problems and to grasp the structure of airglow and aurora. We installed an all-sky imager on the Antarctic research vessel "Shirase" and conducted optical observations during the 61st Japanese Antarctic Research Expedition from November 2019 to March 2020. Shirase's route is suitable for observing aurora because it sails under the southern auroral zone for a long time. It is also suitable for observing airglow, as it passes through the equatorial anomaly zone. The imager was mounted on a 3-axis attitude stabilized gimbal, which cancels out the vessel's vibration, and was equipped with the bandpass interference filter, whose center wavelength is 630.0nm, and the fisheye lens. The observation system was constructed to capture the light emission at an altitude of 250 km without being affected by vessel motion. The imager's exposure time was set to 20s, and the images were automatically taken every day between sunset and the rising of the moon. For the analysis, I used the position and attitude data of the Shirase, such as latitude, longitude, and ship speed data every second, and azimuth angle data every quarter second. In addition to these data, during the 62nd Japanese Antarctic Research Expedition from 2020 to 2021, we do not only capture the new 670nm wavelength emission with two imagers, but we also installed a GNSS receiver to obtain ionospheric total electron content data. The shooting direction of the imager changes with each shot due to the vibration and movement of the vessel. Therefore, the relative azimuth angle of the shooting direction to the vessel was obtained by automatically detecting the structure of the vessel in the image, and then combined with the position and attitude data of the Shirase, the shooting direction was automatically detected. The accuracy of this direction estimation was evaluated by comparing it with the shooting direction obtained from the position of the stars in the image, and the maximum error was 2 degrees. This error corresponds to a few tens of kilometers on the horizontal scale at an altitude of 250 km, and it is small enough to be compared with the horizontal scale of aurorae and airglow. Other corrections for optical sensitivity were also made. We successfully observed the equatorial anomaly zone with 630.0 nm airglow at low latitudes on November 22 and 23, 2019, and the aurora at high latitudes on several nights from late February to early March 2020. I evaluate the accuracy of the observation system by comparing these phenomena with

other observation data from OMTI. The results of this study will be used to develop and improve the observation system for the 63rd Japanese Antarctic Research Expedition, which will be conducted this year, and will also be used to develop observation systems for other ships in the future.

Keywords: aurora, airglow, ionosphere observation