

Aurora and airglow observations with the multi-wavelength all-sky attitude-stabilized imagers and GNSS receiver on Shirase

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We report the results on the all-sky imaging observation on Shirase at 630 nm during the period of 2019-2020, and the status for improved imaging system for the operation in 2020-2021. To cover the auroral and airglow observation gap in the Southern Ocean, we developed an all-sky imaging system (Shirase ASI) with a 3-axis attitude stabilized gimbal installed on the icebreaker Shirase. The route of Shirase from February to March is preferable to observe aurora in the aurora region at the south of Australia. This region is also important to understand the height and zonal variations of mesospheric atmospheric gravity waves (AGWs). This all-sky image data on Shirase is useful in collaboration with ground-based imager networks, such as ANGWINS, UAO and AGO. In addition to auroral observation, Shirase ASI can observe airglow variations caused by plasma bubbles and MSTID when Shirase is located at the mid- and low-latitudes between Japan and Antarctica.

We developed a monochromatic all-sky imager at 630 nm in 2019, and carried out continuous observation on Shirase from November 2019 to March 2020 as a part of 61th Japanese Antarctic Research Expedition (JARE) conducted by NIPR. In 2020, we are additionally developing an all-sky imager for the measurement of auroral and airglow emissions at N2 1PG/OH at 650-690 nm, and going to perform similar operation in the JARE 62 period. A compact and high-sensitivity all-sky imager consists of the low-noise CMOS camera (ZWO ASI183MM Pro), the fisheye lens (Fujinon FE185C086HA, $f=2.7$ mm, F/1.8), and the bandpass interference filter (Andover, center wavelength 630nm, FWHM 4.4nm). The sensitivity at a wavelength of 630nm was calibrated by the integrated sphere in NIPR on June 26 and 27, 2019, and confirmed dynamic range is 80 - 20000 R with a resolution of ~ 5 R with an exposure time of 19s. This optical system was mounted on a 3-axis attitude stabilized gimbal (DJI Ronin-S), and installed in the water-proof observation box on the 06 deck of Shirase. The controlling laptop PC obtained the current location from GPS signal, and calculated the appropriate start and end timings of observation every day. The exposure time and interval were changeable, and set to be 19 s and 20 s, respectively. All data were stored in NAS via PC, and analyzed after April 2020 when Shirase returned to Japan. Thumbnail images and housekeeping data were sent to Japan via e-mail everyday to monitor the operation status. The temperature of observation box on the Shirase deck worked sufficiently using heater, and cooler throughout the operation period. We confirmed the performance of attitude stabilization by the gimbal of which vibration was attenuated by 1/14, and the resolution of obtained image is sufficient for auroral and airglow measurements.

Since the departure of Shirase on Nov. 12, 2019, we succeeded to carry out automatic and continuous observations for 4 months. On several nights from February to March in 2020, we observed 630nm auroral emission with intensity of several kR in the northward direction when Shirase existed in the polar cap region. We also observed the enhancement of 630nm airglow emission with intensity of a few hundreds R at equatorial ionospheric anomaly (EIA) on November 22 and 23, 2019. On the other hand, the gimbal stopped on March 21 due to the DC-DC regulator of power supply was broken. In addition, the controlling PC had been stopped on the return route from Australia to Japan.

In 2020-2021 (JARE 62), we adopt more reliable power supply and controlling PC, and develop the two-imager system to observe auroral and airglow emissions at OI 630 nm and N2 1PG/OH at 650-690 nm. We also use a GNSS receiver to monitor ionospheric total electron content. Installation of two all-sky imagers and GNSS monitoring system was completed in this August, and test observation was carried out in this September and October. This system is scheduled to be operated after the departure of Shirase in this November, and will perform continuous observation between Japan and Syowa station except for the EEZ areas.