Development of new multi-wavelength all-sky imagers for observation of polar cap aurora

Hiroyasu Kondo[1], *Takeshi Sakanoi[1], Masato Kagitani[1], Ryuho Kataoka[2], Yoshimasa Tanaka[2], Yasunobu Ogawa[2], Takanori Nishiyama[2], Kiyoka Murase[2], Keisuke Hosokawa[3], Yoshizumi Miyoshi[4], Yusuke Ebihara[4] Saki Yamashina[5], Yuta Hozumi[6]

[1]Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University
[2]National Institute of Polar Research, [3]The University of Electro-Communications, [4]Nagoya University
[5]Kyoto University, [6]National Institute of Information and Communications Technology

We are developing a camera system to observe the polar cap aurora as a part of the phase X Priority Research program of the NIPR. The period of phase-X (FY2022-2027) involves the solar maximum, and we expect to obtain sufficient data at high-latitude Antarctic region. The main purpose of this program is to understand how the Earth's environment is an open system to space. There have been few observations in the polar cap region because of limited observational places, and only a limited number of large space weather events such as solar proton events (SEP) have been reported. The polar cap region is particularly important since the direct interaction between the solar wind and atmosphere happened in by precipitating electrons and ions in a wide energy range from hundreds eV (typical solar wind) to MeV (SEP). SEP causes the ionization in the middle atmosphere and induce chemical processes including O3, HOx, and NOx, and may change temperature structure.

To estimate the energy of precipitating particles, it is essential to observe auroras at multiple wavelengths. Our auroral camera systems will be installed in automated stations over Antarctic polar region during the phase X, and there are a variety of development items such as isolated long-term monitoring system, power-saving multi-wavelength cameras, power, insulation box, etc.

To check the functions of our camera system, this year we plan to install four all-sky monochromatic imagers in the Syowa station as a part of the JARE 64, and also install two camera system at Longyearbyen, Svalbard. The wavelengths of the Syowa station system are N2+ 391.4 nm, O 557.7 nm, O 630.0 nm, N2 670.0 nm. The exposure time for the cameras of 391.4 nm and 630.0 nm is 18 sec with a cadence of 20 sec, and that for the cameras of 557.7 nm, 670.0 nm is sampled with up to ~10 Hz. The wavelengths of the Longyearbyen system are N2+ 391.4 nm and O 630.0 nm, and the exposure is 18 sec with a cadence of 20 sec.

The camera system consists of CMOS sensor (ZWO ASI183MM Pro), fisheye lens (Fujinon FE185C086HA, f=2.7 mm, F/1.8) and bandpass optical filter made of Andover. The filter is equipped between the lens and sensor to minimize the whole optical system. The cameras are controlled by small PCs (ESC LIVA-Q2 and LIVA-Z2, OS: Linux Ubuntu). Each PC is designed to control one camera, and all of the cameras are operated at simultaneous PC timings. The imaging schedule is based on a software whose start and end times are automatically generated every day. The imaging program uses a ZWO's library as a module, and automatic operation is performed based on the imaging schedule. The data are stored on a NAS (Synology) with a mode of RAID-1 (mirroring) via network. The LIVA PCs, NAS and router are powered by an internet switch (Watchboot). Watchboot is capable of ping monitoring via the internet, and when there is no response from the PC and so on, power turns off and on to recover. To check the camera system remotely, we make thumbnail images for the quick-look plot. The system will also be rebooted automatically when problem happens in the camera system. If the PC freezes, the ping monitoring will detect the problem and temporarily cut off the power supply, allowing the system to reboot.

Currently, all of the development was done, and we are ready to ship them. The Syowa system will depart Japan in this November and install at the Syowa station by the members of JARE64. Automatic four-wavelength auroral all-sky imaging will start in the next winter season, and these data will be brought back to Japan by JARE65. For the Longyearbyen cameras, we will install them at the observatory (KHO) in this November, and we expect to transfer most data via internet and bring the data back in next spring or summer. In addition, next year we plan to install similar camera system at the South Pole, and develop isolated inland system with a power-saving camera electronics, power, insulation box for unmanned observatories which is the key of phase X program.