Imaging Observation of Ionospheric Field Aligned Irregularities by the PANSY Radar at Antarctic Syowa Station

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Program of Antarctic Syowa MST/IS radar (PANSY radar) is the large atmospheric and VHF-band radar located at the Antarctic Syowa Station. This radar has the capability of observing plasma quantities at altitudes of 100-500km using the ionospheric incoherent scatter (IS). In 2015, the PANSY radar performed the first ionospheric IS observation in the Antarctica. This has a frequency of 47MHz, so it is capable of observing the echoes of field aligned irregularities (FAI) in E-region. If FAI has a space scale of half wavelength of radio waves, they are coherently backscattered, so the PANSY radar observes the coherent echoes from 3-meter-scale FAI in E-region. In order to suppress contamination from the FAI echoes during the IS observation by the PASNY radar, Hashimoto et al. (2019) developed a signal processing using adaptive beamforming. The PANSY radar has the FAI array in addition to the main array, and it can separate the signal from various angles using the method based on directionally-constrained minimization of power (DCMP) algorithm. In fact, using this method we can observe E-region FAI and its motion.

In December 2017, FAI imaging observation was performed, and periodic-like echoes were detected with global Pc5 pulsations. Studies and observations of Pc5 and FAI are performed before. For example, Wang et al. (2019) provided measurements of 2-dimensional structures of dayside Pc5 waves utilizing coordinated observations by the THEMIS satellites and the all-sky imager at South Pole, and F-region FAI observation by the SuperDARN also detected periodic echoes for the same period as one by the PANSY radar. The former, however, reported the events only at nighttime and the latter cannot measure detailed spatial structures because of its HF frequency. Therefore, utilizing the PANSY radar, it is expected that we can provide observations also at daytime and measurements of spatial structures of the FAI occurring with Pc5 pulsations.

However, it is found that FAI imaging using the Capon method cannot measure the spatial structures accurately. FAI echoes are generally observed if the conditions that radio waves are perpendicular to FAI are satisfied, but the imaging also shows the "ghosts" which were mistakenly observed as FAI in the non-echoing region. This problem occurs probably because objects in the grating lobes which are in the FAI array radiation pattern are not identified. So, we should develop the new imaging method which removes the effects of them and provides accurate spatial structures. The new method is based on the CLEAN algorithm, and in the iteration the responses of the non-mainlobe region in the radiation pattern of the FAI array, such as grating lobes and sidelobes, are suppressed, which gives the imaging of FAI detected by the mainlobe without contamination of noises.

In the presentation, we will show the new FAI imaging method which removes the effects of antenna radiation pattern, and gives accurate and high-resolution spatial structures of FAI. Moreover, performing the imaging using this method we try to find out physical processes of FAI generation.