



E region irregularities observed by dual band beacon from the sounding rocket S-520-32

Toru Takahashi⁽¹⁾, Susumu Saito⁽¹⁾, Mamoru Yamamoto⁽²⁾ and Manabu Shinohara⁽³⁾

(1) Electronic Navigation Research Institute, National Institute of Maritime, Port and Aviation Technology, Tokyo, Japan; e-mail: toru.takahashi@mpat.go.jp

(2) Research Institute for Sustainable Humanosphere, Kyoto University, Kyoto, Japan

(3) Liberal Arts and Science, National Institute of Technology, Kagoshima College, Kagoshima, Japan

The ionosphere plays an important role as a communication path between a ground-ground and satellite-ground. The irregularity of the plasma density in the ionosphere is often generated with spatial scales from a few tens of kilometers to a few meters. Notably, irregularities on the scale of hundreds of meters to a few kilometers cause fluctuation in the radio wave transmitted from the Global Navigation Satellite System (GNSS) satellites. Previous studies presented small-scale ionospheric irregularities were generated by cascading of the large-scale irregularities. Therefore, it is important to observe large (few km) scale irregularities simultaneous with small (100 m-few km) scale irregularities.

We receive the VHF (150 MHz) and UHF (400 MHz) beacon signals transmitted from Low Earth Orbit satellites by receivers based on the software-defined radio (SDR) [1]. The total electron content (TEC) and the amplitude scintillation were derived from the phase difference between 150 and 400 MHz signals and the amplitude fluctuations, respectively. We installed the receiver to National Institute of Technology, Kagoshima Collage, Kirishima (KRS) (31.73 deg. N 130.73 deg. E), Kagoshima, Japan on 27 July 2022.

The sounding rocket S-520-32, which aimed to observe irregularities associated with the sporadic E (Es) layer and medium-scale traveling ionospheric disturbances (MSTIDs), was launched from Uchinoura Space Center (USC), JAXA (31.25 deg. N, 131.08 deg. E) at 23:20:00 JST (UT+9) on 11 August 2022. It transmitted the dual band beacon signals (150 and 400 MHz) during the flight. The rocket flew between the E and F layer and reached the apogee of 270 km. It splashed into the sea around 23:28:43. Kyoto University temporally installed the beacon receivers to USC, Tarumizu (TRM) (31.49 deg. N, 130.70 deg. E), KRS, and Satsumasendai (SND) (31.83 deg. N, 130.34 deg. E), Kagoshima to receive the signal from the rocket. These four sites almost aligned with the backward extension of the line of rocket trajectory. Thus, the tomography technique could be attempted in the line to estimate the spatial distribution of the Es layer [2].

During the rocket flight, the MSTIDs were seen in the TEC map derived from the GNSS receiver network around the rocket trajectory. The ionosonde in Yamagawa, Kagoshima 44 km away from USC detected the Es layer and its critical frequency was approximately 8 MHz. The dual band beacon signals transmitted from the rocket were successfully received in all sites.

The TEC values were derived from the phase difference of 150 and 400 MHz signals after removing the phase shift due to the rocket spin. The TEC observed at four sites showed a similar trend and drastically increased when the rocket reached 115 km. This indicated that the path between the receiver and rocket crossed the Es layer. After that, the TEC values increased moderately until the rocket reached 200 km in the descending interval. During the rocket went down below 200 km, the TEC values decreased and widely fluctuated implying the horizontal structure of the Es layer.

In this presentation, we will show the calculation process as well as the observation results. Furthermore, we are currently trying to estimate the horizontal structure of the Es layer by the tomography. Thus, we will compare it with the MSTID to investigate the contribution of E-F coupling process to the Es layer generation, and also show those results in the presentation.

References

- [1] M. Yamamoto, "Digital beacon receiver for ionospheric TEC measurement developed with GNU Radio," *Earth Planets Space*, **60**, e21-e24, November 2008, <https://doi.org/10.1186/BF03353137>.
- [2] P. A. Bernhardt, C. A. Selcher, C. Siefing, M. Wilkens, C. Compton, G. Bust, M. Yamamoto, S. Fukao, O. Takayuki, M. Wakabayashi, and H. Mori, "Radio tomographic imaging of sporadic-E layers during SEEK-2," *Annales Geophysicae*, **23**, 2357-2368, October 2005, doi: 10.5194/angeo-23-2357-2005.