

Observation of sporadic E using aeronautical navigation radio for instrument landing system

S. Tabuchi^{1)†}, K. Hosokawa¹⁾, S. Saito²⁾, J. Sakai¹⁾, I. Tomizawa¹⁾, T. Takahashi²⁾ and H. Nakata³⁾

¹⁾ *University of Electro-Communications, Japan*

²⁾ *Electronic Navigation Research Institute (ENRI),*

National Institute of Maritime, Port and Aviation Technology (MPAT), Japan

³⁾ *Chiba University, Japan*

† *email: shumpei.tabuchi@uec.ac.jp*

Sporadic E (Es) observations were conducted in Kure, Japan, by using a software receiver and an Instrument Landing System receiver for aircraft. We confirmed that the source of the anomalous propagation at 110.30 MHz observed in Kure was the Localizer Type Directional Aid at Hualien Airport in Taiwan. We also observed a systematic change in the angle-of-arrival of the received signal, which may be used for observing the spatial structure of Es.

Key Words: Sporadic E, VOR, ILS

1. Introduction

The sporadic E (Es) layer is a phenomenon in which the electron density increases locally at an altitude of about 100 km in the ionosphere. The extremely high electron density in Es can sometimes reflect HF to VHF radio waves and cause anomalous propagation of such waves for a long distance. Recently, Sakai et al. [2020] reported a case of anomalous propagation on May 15, 2014, during which radio wave in the frequency range of Instrument Landing System Localizer (ILS LOC) at 110.3 MHz was observed in Kure, Hiroshima, Japan. They suggested that the source of the wave was the Localizer Type Directional Aid (LDA) at Hualien Airport, Taiwan. However, this speculation has not been confirmed by actual measurements because it was difficult to observe detailed information of the signal (i.e., Morse code/angle-of-arrival) with the spectrum analyzer used in their study. The purpose of this study is to clarify the transmitting station of the 110.3 MHz radio waves observed in Kure by a newly installed ILS LOC receiver for aircraft and to evaluate the effects of Es on such onboard aircraft equipment.

2. Methods

In addition to the spectrum analyzer used in the previous study [Sakai et al., 2020], an airborne ILS LOC/VOR receiver for general aviation (KN35 LOC/VOR), was installed in Kure to observe the radio waves. We recorded the Morse and the angle of arrival of the 110.30 MHz radio in the summer seasons of 2021 from May to August.

3. Results and Conclusion

During an anomalous propagation event on May 17, 2021, the ILS receiver detected the 110.3 MHz radio signal. The needle of the meter on the receiver was ob-

served to swing during the anomalous propagation due to Es. From the analysis of the received Morse code, it was confirmed that the signal surely arrived from the Hualien airport. The difference between the direction of Kure as viewed from Hualien and the beam direction of the Hualien LDA is -0.68° . During the anomalous propagation of Es on May 17, 2021, the angle derived from DDM (Difference in depth of modulation), which we call DDM angle, was around -0.68° . However, the most frequent DDM angle obtained during four months from May to August 2021 was slightly different (The mode of DDM was -0.48°) from the direction of Hualien (-0.68°). It was also found that the DDM angle was not always constant during the anomalous propagation, and there was sometimes a systematic decreasing trend. In particular, on June 30, 2021, there was a characteristic change in the angle, which continuously decreased by ~ 1.5 degrees in 30 minutes. Based on the direction of horizontal motion of Es layer inferred from the deviation index of total electron content (ROTI) from GPS receivers and the change in the DDM angle on June 30, 2021, we suggest that the Es layer had a wedge-like shape in its bottom part, which may explain the difference in the angle-of-arrival between the predicted and observed cases.

Acknowledgments

We are grateful to Professor Atsushi Yamamoto at Japan Coast Guard Academy for operating the receivers in Kure.

References

- 1) Sakai, J., Saito, S., Hosokawa, K., and Tomizawa, I., Anomalous propagation of radio waves from distant ILS localizers due to ionospheric sporadic-E, *Space Weather*, 18, e2020SW002517, 2020