R005-P31
ポスター 3 ：11/25　PM1/PM2 （13:15-18:15）

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Observations of sporadic E using marine traffic radio waves

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The sporadic E layer (Es) is recognized as one of the most outstanding phenomena in the E region. During Es events, the electron density at an altitude of around 100 km is significantly enhanced, often exceeding the maximum electron density in the F region. At mid-latitudes, Es typically occurs during the summer months, with two distinct peaks in occurrence: one during the day and another at night. The increase in critical frequency due to Es can reflect obliquely incident radio waves at frequencies up to 150 MHz. The impact of Es on analog television and FM radio signals within this frequency range has been well documented over the years. Our studies have shown that VHF radio waves used for aeronautical navigation (known as NAV signals in the 108 – 118 MHz range) are also affected by the presence of Es. In particular, it has been statistically confirmed that Es-related anomalous propagation of the NAV signals frequently occurs in Japan during the summer months. Following these findings, routine monitoring of anomalous propagation of NAV signals has been conducted at nine stations across Japan since 2019.

In this study, we propose utilizing another VHF radio wave used for maritime navigation, known as the Automatic Identification System (AIS), for wide-area observations of Es. The AIS operates at a frequency of 162 MHz, which is higher than that of aeronautical radio waves; therefore, only intense Es, with a critical frequency of around 30 MHz, would be detected. Our AIS signal monitoring has been carried out in Kure, Hiroshima. To assess the feasibility of using AIS for Es monitoring, we present two case studies of Es events detected simultaneously by the monitoring observations of NAV and AIS radio waves: one on May 30, 2023, and the other on June 5, 2023. Additionally, we leverage data from multi-constellation GNSS receivers across Japan, particularly the electron density disturbance index ROTI, to further infer the 2D structure and dynamic characteristics of Es over a wide area. In both intervals, the spatial structure of several Es traces, extending from east to west, was clearly visualized, and their speed and direction were estimated. Based on these findings, we discuss the factors that control the motion of Es, through comparison with recent numerical simulations.