



Long-term trend in sporadic E layer observed in Japan during 1948-2021

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Ionospheric Sporadic E layer (Es) is a thin but dense plasma layer occurring mostly between 95-125 km altitudes. Due to its high plasma density, which can sometimes exceed the F region peak density NmF2, Es can severely disrupt long-distance radio communications. Increasing greenhouse gases CO₂ is known to cause global cooling and shrinking of the thermosphere, and consequently affect the ionosphere (Lastovich et al, 2013). In this study we investigate the long-term trend in the Es occurrence frequency, intensity, and height using observations made at four stations (Okinawa, Yamagawa, Tokyo, Wakkanai) in Japan spanning between 1948-2021.

By using multi-variant regression, we remove known variations with periods of half year, one year, QBO and solar cycle in the Es observations and examined the trend in the residual signals. The results shows a significant decreasing trend in the magnitude of the Es layer as shown in Table 1 below, with the largest trend being -0.568 MHz/decade. Furthermore, the negative trend shows a clear local time dependence, with larger trend at day than at night. On the other hand, no significant trend was revealed in the occurrence rate of the Es layer.

Sites			Trend (MHz) /decade	1 σ /10year
OK			-0.568	$\pm 3.77 \times 10^{-2}$
TO			-0.250	$\pm 1.85 \times 10^{-2}$
WK			-0.240	$\pm 1.63 \times 10^{-2}$
YG			-0.312	$\pm 2.71 \times 10^{-2}$

Table 1. Long-term trend observed in the Es intensity at four locations in Japan between 1948-2021. A significant negative trend is found at all locations.

References

- [1] Laštovička, J. (2013). Trends in the upper atmosphere and ionosphere: Recent progress. *Journal of Geophysical Research: Space Physics*, 118(6), 3924–3935. <https://doi.org/10.1002/jgra.50341>