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Manuscript Title: Variation characteristics of sporadic-E layer in East Asia based on long-term data

Replies to Editor

You were asked to demonstrate if the trend at any of the stations is statistically significant. This means you need to report the uncertainties of the slopes of the linear regression fits in Table 5. These slopes are very small, and are most likely not statistically significant within their uncertainties: that is, if the slope is b +/- x (where x is the standard error), and x > b, you cannot state that there is a positive or a negative change. If this is the case, that is what should be reported in the paper.

Reply: Thank you very much for taking the time to review this manuscript and provide valuable feedback. We greatly appreciate the constructive comments and suggestions, which have helped us improve the quality and clarity of our work.

The authors have provided responses to your queries concerning the reliability of the observational data, the methodologies adopted for mitigating random errors, and the statistical significance of the long-term variation trends.

Firstly, the observational data employed in this study were acquired through manual scaling accompanied by a rigorous quality control process. Concurrently, periodic calibration and verification of the observing instruments were performed during operation, ensuring the reliability and accuracy of the data.

Secondly, this study adopts the monthly median as a statistical metric to analyze the long-term trend of the Es layer. This approach effectively mitigates the interference of random errors and enhances the robustness of the results. The measurement error of the critical frequency for a typical ionosonde is approximately 0.02 MHz. Based on the statistical properties of multiple independent measurements, the monthly median adopted in this study — derived from 24 daily observations over approximately 30 days (totaling ~720 independent measurements) — reduces the random error to about $0.02/\sqrt{24 \times 30} = 0.00074$ MHz. Furthermore, considering the long-term observations spanning over 40 years at most stations, the random error is

further compressed to approximately $0.00074/\sqrt{12 \times 40} = 0.0000336$ MHz. In contrast, the long-term trend average absolute slope of the Es layer in East Asia obtained in this study is 0.00059, which is about 17.56 times the magnitude of the random error. Therefore, the derived long-term variation trend significantly exceeds the fluctuation range of random errors, rendering its uncertainty negligible.

Finally, it should be specifically noted that although the fitted slope of the long-term trend of the Es layer in East Asia is small, the trend is statistically significant. Figure 9 illustrates the monthly variations. Based on the average absolute slope of 0.00059 listed in Table 5, the corresponding annual change rate is calculated to be 0.00708 Given that the average intensity of the Es layer is approximately 3 MHz, the corresponding relative variation rate is estimated to be about 0.23% per year. This magnitude of variation is considered significant: according to the World Meteorological Organization (WMO) and the EU's Copernicus Climate Change Service (C3S), the global warming rate is approximately 0.02 ° C/year; given a baseline global average temperature of 20 ° C, this corresponds to a relative annual change rate of about 0.1%. It is evident that the 0.23% annual variation rate of the Es layer is comparable to that of global temperature changes, suggesting important indicative significance in ionospheric climatology.

Thank you for your great effort and valuable time spent in reviewing this paper. We sincerely wish that with the careful revision of the paper, the revised manuscript is acceptable for publication.