Long-term variations in tweek reflection height in the D- and lower E-region ionosphere

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We investigated, for the first time, long-term (1976-2010) variations in reflection heights of tweek atmospherics based on very low frequency (VLF) observations at Kagoshima, Japan. The tweek reflection heights on geomagnetically quiet days were analyzed every month over three solar cycles using an automated procedure of spectral fitting to estimate the cut-off frequency. The average and standard deviation of the reflection height were 95.9 km and +/-3.1 km, respectively. Typical periods of the time variation for the reflection height were identified as 13.3, 3.2, 1.3, 1.0, 0.6, and 0.5 years. The variations in the tweek reflection heights did not show simple anti-correlation with solar activity. The correlation coefficient between the tweek reflection height and the sunspot number was 0.03 throughout the three solar cycles. The Hilbert-Huang transform analysis identifies the 0.5-1.5 year and ˜10 year variations as intrinsic mode functions (IMF). The decomposed IMF with the ˜10 year variation has positive correlation with sunspot numbers and negative correlation with galactic cosmic rays (GCRs). We hypothesize that these variations in the tweek reflection heights are caused by the coupling of several ionization effects at the D- and lower E-regions: geocorona, GCRs, particle precipitation, and variations in neutral density in the lower thermosphere. In these processes, the geocorona, the GCRs, and particle precipitation could have negative correlation with the tweek reflection height, while the neutral density could have positive correlation. In the presentation, we discuss possible causes of several variations in the tweek reflection height embedded in the long-time data.