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Wave behaviour of sporadic *E*-layer variations at the latitudes 30–70°N

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Abstract

Wave behaviour of ionospheric sporadic *E*-layer variations is investigated by analysing Northern hemisphere ionosonde data for a continuous interval of 20 years. Wavelet analysis is used to derive time-frequency amplitude spectra of f_oEs oscillations. Dominant periodicities of 4–6 and 14–16 days in *Es* variations were detected. A spatio-temporal picture of quasi-16-day *Es*-layer oscillations during 1970–1989 is created by interpolation of wavelet amplitude values, calculated for each of more than one hundred stations. Several typical movement directions of quasi-16-day waves are determined using an original pattern recognition algorithm. A zonal component of 16-day wave direction is found to be dominant practically everywhere in the latitudes 45–75°N. Zonal distributions of quasi-16-day oscillation amplitude at 30–70°N are derived; their seasonal and longitudinal features are significant.

Keywords: Sporadic *E*-layer variations; Ionospheric dynamics; Quasi-16-day wave; Seasonal *Es*-layer variations

1. Introduction

Sporadic *E*-layer temporal variations have a complex structure which is determined by many solar and terrestrial factors. The Earth's atmosphere greatly affects the *Es*-layer variations by tidal, gravity and planetary waves (Akchurin et al., 1997; Fahrutdinova et al., 2001). One of the possible mechanisms of this influence is explained by classic wind shear theory (Whitehead, 1989). Taking into account the wave features of the wind velocity field on a planetary scale, one can expect typical 2–20-day planetary wave periodicities (Forbes et al., 1995; Forbes and Zhang, 1997; Mitchell et al., 1999) in *Es*-layer parameters. The existence of these periods in *Es* oscillations is a well-known fact indicating significant influence of planetary waves on this layer (Danilov et al., 1987; Haldoupis and Pancheva, 2002; Pancheva et al., 2003; Voiculescu et al., 2000).

A detailed study of *Es* oscillations with periods in the range 2–32 days was conducted by the authors in a previous paper (Sherstyukov and Ryabchenko, 2004). Several dominant periods and seasonal morphology, typical for the mid-latitude *Es*-layer, were discovered by analysing the *Es* highest frequency (f_oEs) series using the wavelet transform for a continuous period of 20–40 years. The dominant periodicities of 4–6 and 14–16 days in *Es* variations were detected by averaging the amplitude of each considered oscillation over the 20–40 year interval. These periodicities are highly expressed in the summer and the fall, while winter and spring spectra are more uniform and have no significant maximum at any scale. The other feature of these periodicities is their prevalence in middle latitudes from 40 to 70°N. Typical summer spectra of six mid-latitude stations, calculated by averaging annual values during 1957–2003 of summer medians (from June 1 to August 31) of f_oEs oscillation amplitude, are shown in Fig. 1, where the confidence intervals of yearly mean estimates, corresponding to 95% confidence level, are also shown.

The 16-day oscillation seems to be the most dominant scale in the planetary wave periodicities. Actually, a 16-day oscillation implies a certain range of periods, up to 10–20 days; all these periodicities are observed in the MLT region and correspond to expected resonant frequencies of atmospheric disturbances associated with westward propagating free Rossby modes of zonal wavenumber 1

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