

# Long-term variations in relationships of ionospheric F2-layer parameters based on different solar activity indices

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Studies of long-term changes in the middle and upper atmosphere, including ionosphere, are significant for the detection of changes in the Earth climate system, including diagnostics of relative role of natural and anthropogenic factors [1-8]. Significant ionospheric characteristics are critical frequency of the F2 layer on its height  $h_mF2$ . The change in the dependence of the critical frequency of the F2 layer on its height  $h_mF2$  was considered in [6] on the basis of two sources of initial data. It was found that the slope  $k$  of the dependence of  $foF2$  on  $h_mF2$  systematically decreases from the earlier period (1958–1980) to the later periods (1988–2010, 1998–2010, 1998–2014). According to obtained results the detected decrease in  $k$  confirms the concept of the decrease in the concentration of atomic oxygen in the thermosphere since the value of  $foF2$  depends much more on the concentration of atomic oxygen in the F region than  $h_mF2$ . Here, the relationships of different ionospheric parameters and their variations are studied with the use of cross-wavelet analysis of global-scale data for the period 1948-2009 [4,5]. In particular, similar to [5] two data sets for  $foF2$  and  $h_mF2$  (derived from M(3000)F2) based on solar 10.7 cm radio flux F10.7 (data set I) and based on the solar sunspot number R (data set II) have been used.

Figure 1 shows local coherence between  $h_mF2$  and  $foF2$  (data set I) for 1948-2009 with an intervals of significant positive correlation of  $h_mF2$  and  $foF2$  interannual and interdecadal variations. There is a significant coherence for quasi-decadal variations of  $h_mF2$  and  $foF2$  with a decrease in significance since the end of 1990s. Significant coherence was noted for intra-decadal variations in the 1970s (till the early 1980s). It should be noted that no long-term coherence was revealed.

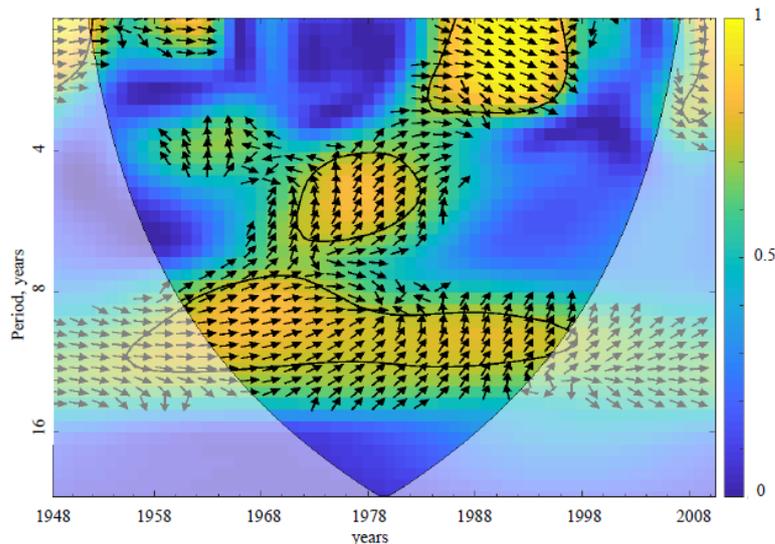


Fig. 1. Local coherence between  $h_mF2$  and  $foF2$  (data set I) during the period 1948-2009.

Figure 2 shows local coherence between different data series (I and II) for  $h_mF2$  for the period 1948-2009. There is a significant coherence of long-term (inter-decadal) variations for two data series of  $h_mF2$ . The time intervals with significant positive correlation for decadal and intra-decadal variations alternate with intervals of its lack. The only regime with significant negative

correlation was noted for intra-decadal variations in the time interval from the second half of 1970s till the beginning of 1980s.

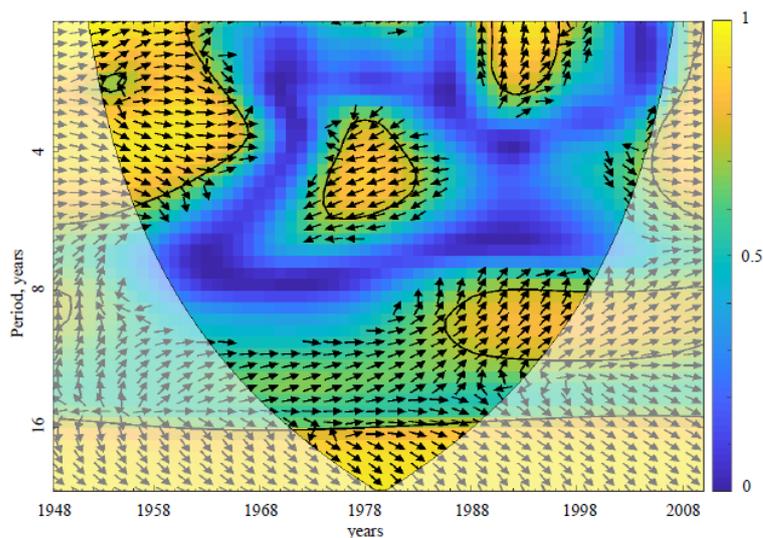


Fig. 2. Local coherence between different data series (I and II) for  $h_mF2$  for the period 1948-2009.

The local coherence between different data series (I and II) for  $f_oF2$  during 1948-2009 was obtained substantially weaker than for  $h_mF2$ . For the second data set (II), the coherence between  $h_mF2$  and  $f_oF2$  during 1948-2009 was also estimated as a whole substantially weaker than for the first data set (I).

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