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Long-distance HF propagation due to scattering on the plasma irregularities in the auroral ovals

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Continuous Doppler monitoring of the propagation of HF signals from Europe and North America to the Antarctic Peninsula region has been performed at the Ukrainian Antarctic Station *Akademik Vernadsky* (UAS) since May 2010. Data analysis of long-term measurements shows that long-distance propagation in these directions is provided by four different mechanisms that are realized at different times or simultaneously. These are multi-hops or waveguide propagation along either the straight great-circle arc or the reverse great-circle arc, propagation due to focusing along the solar terminator, and due to scattering on plasma irregularities in the auroral oval into the interlayer waveguide toward the UAS. This paper describes the latter mechanism supported by measurements of the propagation time of radio signals from the RWM time service station near Moscow, Russia during radio pulse transmissions at a 10 Hz repetition rate. Signals scattered in the northern polar oval arrive at the UAS for all RWM carrier frequencies, 4996, 9996, and 14996 kHz. Signals scattered in the southern polar oval are detected less frequently (most probably due to the geometry of experiment and geomagnetic field). Figure 1 shows an example of such cases observed at UAS on 18:24-18:26 UT on April 9, 2013. Daily Doppler spectrogram of a RWM 9996 kHz signal registered at UAS (frame a) consists of different spatial modes. At 0-5 and 18-24 UT the spectral mode with DFS near 0 Hz propagates along the straight great-circle arc. The mode observed near 0 HZ between 10 and 18 UT propagates along the reverse great-circle arc. The spectral satellite located at DFS bigger than 2 Hz at 3-6 UT is due to scattering on plasma irregularities in the northern auroral oval. A similar spectral mode between 18 and 20 UT shifted to -1…-4 Hz arrived from the southern auroral oval. The arrow in Fig.1a points to the moment shown at the group path-frequency diagram (Fig. 1b) that allows separation of two spatial modes registered at 18:24-18:26 UT. The first spectral mode propagates along the straight great-circle arc of the length ~16000 km. The second mode propagates along the path of ~20000 km. The red line in the Fig. 1c demonstrates the straight great-circle arc. The magenta line shows the locus of single scattering points corresponding to the length of the second spatial mode. Black lines show the position of the solar terminator. The position of the particle precipitation area in the southern auroral oval at the same time is obtained using the OVATION resource (http://sd-www.jhuapl.edu/Aurora/). Thus, spectral and time selection of HF signals on long-distance radio paths allows determining the location of the equatorial boundaries of the auroral ovals and estimating the drift velocities of the ionospheric irregularities in the scattering region. For example, in the case under consideration, the measured projection of the speed of plasma irregularities is ~50 m/s and opposite to the receiving site.

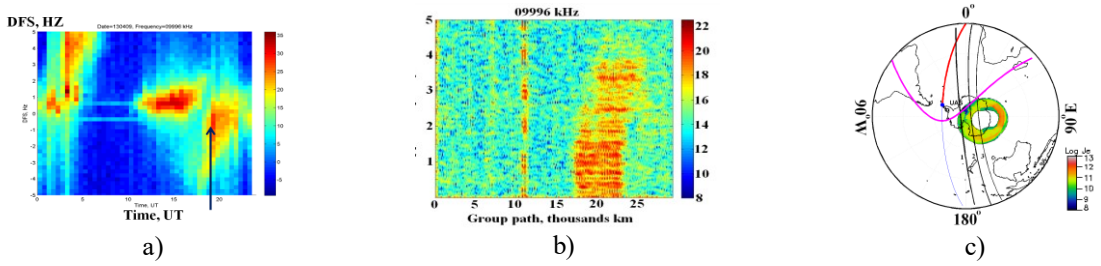

Figure 1. a) Daily Doppler spectrogram of RWM 9996 kHz signals recorded at UAS *Akademik Vernadsky* on 9 April 2013; b) group path-frequency diagram for the time interval 18:24-18:26 UTC April 9, 2013 (indicated by the arrow in frame a); and c) a schematic of scattering on the border of the Southern polar oval for the considered case