Phase effects in subionospheric VLF/LF signals observed at middle and low latitudes during the August 21, 2017 total solar eclipse

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Abstract

Experimental study of the phase and amplitude observations of sub-ionospheric very low and low frequency signals is performed to analyze the response of the lower ionosphere during the August 21, 2017 total solar eclipse in the United States of America. Three subionospheric wave paths have been investigated. The length of the paths varied from 2200 to 6500 km, signal frequencies were 21.4 kHz, 25.2 kHz and 40.8 kHz. Two paths crossed the region of total eclipse and the third path was in the region of 40-60% of obscuration. None of the signals revealed any noticeable amplitude changes during the eclipse while negative phase anomalies (from -35° to -95°) were detected for all three paths. It was shown that the effective reflection height of the ionosphere in low and middle latitudes has been increased by 3.5-5 km during the eclipse.







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3/7/09 3/11/09 3/11/09 3/11/09 3/11/09 3/11/09 3/11/09 3/21/09 3/21/09 3/21/09 4/2/09 4/100 4/11/09 4/11/09 4/11/09 4/11/09 The upper panel indicates the magnitude of the main earthquakes from 26 March to 17 April 2009. The next panel shows the amplitude of NRK signal recorded in Bari in the period 7 March–22 April, 2009. The signal propagated just over seismic area. In the last panel the nighttime residual amplitude (dA) for the paths NRK-Bari. NRK-MOS and NRK-GRZ are shown. The last two paths were far away from seismic area. The color fill zone indicates values exceeding the 2 sigma level, represented by a horizontal dotted line, for the NRK-Bari path (Rozhnoi et al., NHESS, 2009, 9,



1727-1732).



21401 (near Japan) and 51407 (near the Hawaiian Islands). (Rozhnoi et al., Geomatics, Natural Hazards and Risk, 2014, 5, Issue 4, 285-292).

Our VLF/LF network was developed during last years due to joint cooperation of scientists from different countries. At present the network consists from 11 receiving stations deployed in Europe (Moscow, Sheffield, Graz), the Far East (Kamchatka, Sakhalin, Kuril Islands), Asia (Bishkek, Varanasi) and the USA (Chapman University, Orange, CA). All the stations are equipment with the UltraMSK receivers (http://ultramsk.com/). The receivers measure the amplitude and phase of the signals from the transmitters which are situated in Europe, Asia, America and Australia. So, our network covers the all high seismic active regions in the North Hemisphere, including Pacific and Mediterranean-Asian seismic belts. Using data from our network we can investigate influences of different natural hazards events, such as earthquakes, magnetic storms, tsunami propagations, typhoons, Cosmic Weather and others. Some examples of the effects observed during natural hazards events we give here. Besides, our network gives us possibility to study the changes in the D region of ionosphere during solar eclipses when the solar radiation changes abruptly.





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VLF/LF network

2012, 55, 1, 181-186).

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Effect from the total solar eclipse on March 20, 2015



On the left: The VLF/LF network in Europe and the areas of obscurations during eclipse on March 20, 2015 (from timeanddate.com). The positions of receivers are shown by green circles.. The triangles are transmitters. Four long paths which crossed the area of 90-100 of obscuration are show by lines. The vertical double line shows the position of morning terminator in 07:40 UT. On the right: the amplitude and phase variations of the NRK (37.5 kHz) signal, measured in Sheffield (SHF) on March 20, 2015. The solid lines show the current amplitude and phase of signal, dotted lines are the monthly average of signal. The eclipse period are shown by the grey rectangles on X axis. The ellipses highlight the anomalies in signal connected with the eclipse. T max indicates the time of the greatest eclipse in the transmitter place (97%). (Solovieva et al., J. Geomagnetism and Aeronomy, 2016, 56(3), 323-330).

Effect from the total solar eclipse on August 21, 2017



are shown by red triangles. (Present work).



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The recent development of observation systems can provide useful information on the properties and position of the perturbation region in connection with natural hazards events. The use of a network of observation makes it possible to separate the local VLF/LF perturbations connected with earthquakes, volcanic eruptions, tsunamis, typhoons, cyclones from large-scale or global anomalies related to planetary waves, magnetic storms and substorms, solar flares or energetic particle precipitation

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