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Comparative statistical and spectral studies of seismic and non-seismic sub-ionospheric VLF anomalies

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We present a comparative study of seismic and non-seismic sub-ionospheric VLF anomalies. Our method is based on parameter variations of the sub-ionospheric VLF waveguide formed by the surface and the lower ionosphere. The used radio links working in the frequency range between 10 and 50 kHz, the receivers are part of the European and Russian networks.
Various authors investigated the lithopsheric-atmospheric-ionospheric coupling and predicted the lowering of the ionosphere over earthquake preparation zones [1]. The received nighttime signal of a sub-ionospheric waveguide depends strongly on the height of the ionospheric E-layer, typically 80 to 85 km. This height is characterized by a typical gradient of the electron density near the atmospheric-ionospheric boundary [2].
In the last years it has been turned out that one of the major issues of sub-ionospheric seismo-electromagnetic VLF studies are the non-seismic influences on the links, which have to be carefully characterized. Among others this could be traveling ionospheric disturbances, geomagnetic storms as well as electron precipitation.
Our emphasis is on the analysis of daily, monthly and annual variations of the VLF amplitude. To improve the statistics we investigate the behavior and typical variations of the VLF amplitude and phase over a period of more than 2 years.
One important parameter considered is the rate how often the fluctuations are falling below a significant level derived from a mean value. The temporal variations and the amplitudes of these depressions are studied for several years for sub-ionospheric VLF radio links with the receivers in Graz and Kamchatka. In order to study the difference between seismic and non-seismic turbulences in the lower ionosphere a power spectrum analysis of the received signal is performed too. We are especially interested in variations T>6 min which are typical for atmospheric gravity waves causing the lithospheric-atmospheric-ionospheric coupling [3].
All measured and derived VLF parameters are compared with VLF observations several weeks before an earthquake (e.g. L'Aquila, Italy, April 6, 2009) and with co- and post-seismic phenomena. It is shown that this comparative study will improve the one parameter seismo-electromagnetic VLF methods.

References:
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