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## On the characterization of VLF radio signal propagation in atmosphere in quite solar conditions

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In this work we use Very Low Frequency (VLF) radio signals, having a frequency in the bands 20-80 kHz, to study the VLF signal propagation in the atmosphere quite undisturbed conditions by selecting the signals recorded during night. As a good approximation, we can model the propagation of VLF radio signals as characterized by a ground-wave and a sky-wave propagation mode. The first one generates a radio signal that propagates in the channel ground-troposphere, while the second one generates a signal which propagates using the lower ionosphere as a reflector. The VLF receivers of the INFREP (European Network of Electromagnetic Radiation) network are used. These receivers have been installed since 2009 mainly in southern and central Europe and currently the INFREP network consists of 9 receivers. A 1-minute sampling interval is used to record the amplitude of VLF signals. Long time-series of VLF signals propagating during night are extracted from recorded signals to study possible seasonal effects due to temporal variations in the physical properties of troposphere. A graph theory approach is used to investigate the spatial correlation of the aforementioned effects at different receivers. A multivariate analysis is also applied to identify common temporal changes observed at VLF receivers.

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