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Automatic detection of whistler waves in the top-side ionosphere: a physical based method

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Very-low frequency (VLF) electromagnetic waves observed in the ionosphere by Low Earth orbit (LEO) satellites show different characteristics (in terms of frequency, duration, polarization etc.) and may have different origins (magnetospheric, atmospheric, seismic or volcanic activity etc.).

Among those, the electromagnetic waves caused by lightning activity, i.e. the whistlers, are particularly difficult to detect, since they endure for a short period of time (from fractions of seconds to few seconds). A spectrogram or dynamic spectra of this kind of signal reveals the peculiar shape as a chirped falling tone structure. For this reason, in the last years, some techniques based on image recognition were proposed for the automatic detection of whistlers. However, these methods are based on machine learning techniques that often obscure the physical interpretability of the results.

Here, we propose a new approach which is totally based on physical observables. In particular, we based our detection algorithm on the observation of the Search-Coil-Magnetometer (SCM) on board the China Seismo-Electromagnetic Satellite (CSES-01), in the Extreme-Low frequency (ELF) band, with a sampling frequency of 10240 Hz.

Here we present the results of the automatic detection over a period of more than 3 years (from 2019 to 2022). In addition, we propose a method for the joint analysis of the whistler wave both as observed by the SMC and the Electric Field Detector (EFD) on board the same satellite. The simultaneous analysis of the three components of the electric and magnetic field allow to determine all the characteristics of the electromagnetic wave.

Finally, we present the preliminary results of the study of the correlation between these electromagnetic phenomena and the particles fluxes, measured by the High-Energy Particle Package (HEPP), which is on board the same satellite.