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Neural network-based recognition of whistlers on spectrograms detected by satellite

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We present a system to automatically recognize and classify the occurrence of whistler waves on spectrograms of electric field measurements performed by satellite. Whistlers - VLF waves generated by lightning, with a specific spectral dispersion relation - can induce precipitation of trapped Van Allen particles and have a role in the chemistry of some atmospheric components (mainly NO_x). Moreover, it has also been suggested that the increase of the number of anomalous whistlers (i.e. whistlers with high value of dispersion constant) could be induced by disturbances in the Earth-ionosphere wave-guide, generated by seismo-electromagnetic emissions. On satellite, the recognition of whistlers asks for analyzing high-resolution spectrograms that cannot be downloaded to Earth, due to the limits of data transmission. For this reason, a real time identification and classification must be performed on satellite, by avoiding downloading all the unprocessed data. The procedure that we have developed is based on a Time Delay Neural Network (TDNN). The TDNN, proposed some years ago for speech recognition, can be fruitfully also applied in real-time analysis of electromagnetic spectrograms in order to detect phenomena characterized by a specific shape/signature such as those of the whistler waves. Some studies have been performed by the RNF experiment on board of the DEMETER satellite and our algorithm could be adopted on board of the satellite CSES (China Seismo-Electromagnetic Satellite), launch scheduled by the end of 2016. Moreover, the procedure can be also adopted to automatic analysis of whistlers detected on ground.