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Statistics of Small-Scale Ionospheric Waves in European Mid-Latitudes Observed Using LOFAR

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The LOw Frequency ARray (LOFAR) is a radio telescope centred in the Netherlands, consisting of over 50 individual stations. The observed impact of the ionosphere on signals from astronomical radio sources can be used to derive differential Total Electron Content (dTEC) between the lines of sight from different LOFAR stations. The dTEC derived in calibration has extremely high precision ($\sim$ 1 mTECu) and is available at high temporal ($\sim$ 4 s) and spatial (baselines from $\sim$ 100 m to $\sim$ 100 km) resolutions. This is routinely calculated for astronomical observations as part of the calibration process required to mitigate instrumental and ionospheric distortions to the images, however this data is not currently widely available or used within the ionospheric community. These measurements provide a new means of studying ionospheric disturbances in the mid-latitudes.

A method for identifying wave signatures in the dTEC data has been developed and shown to be capable of identifying waves with amplitudes as low as a few mTECu [1]. This method has been used to analyse over 2,500 hours of observations made as part of an astronomical survey. The statistical characteristics of the identified waves and their dependence on time of day, season, and geomagnetic activity are discussed, such as variations in dominant propagation direction. Potential source mechanisms, both terrestrial (e.g. convective systems, solar terminator) and space weather (e.g. auroral activity) are considered to explain the observed characteristics. These observations extend the range of ionospheric waves that can be identified to shorter wavelengths and lower amplitudes beyond what is currently detectable using GNSS derived TEC. This method complements established techniques for detecting ionospheric waves.

References

[1] B. Boyde, A. G. Wood, G. Dorrian, F. Sweijen, F. de Gasperin, M. Mevius, K. Beser, D. Themens, "Wavelet Analysis of Differential TEC Measurements Obtained Using LOFAR," *Radio Science (Under Review)*, 2023, doi: 10.22541/essoar.169754969.93126117/v1