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Long-duration Structure in LOFAR Dynamic Spectrum Observations of mid-Latitude Ionospheric Scintillation

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Observations of strong natural radio sources such as Cassiopeia A and Cygnus A taken using the Low Frequency Array (LOFAR – a radio astronomy array consisting of 38 stations across the north-east of the Netherlands and a further thirteen stations internationally) over the frequency range 10-250 MHz show almost continual ionospheric scintillation. Dynamic spectra of these observations show scintillation progressing through the weak and strong scattering regimes and sometimes the effects of refraction due to large-scale structure in the ionosphere. Data taken routinely over the past two years illustrate in the dynamic spectra a wide range of scintillation conditions, some of which are seen only rarely, or even only once, or above only one or two single LOFAR stations.

Among these cases are several showing long-duration structure in the dynamic spectrum with time-scales of tens of minutes, sometimes superposed on regular short-duration (seconds) scintillation structure. This structure predominantly appears only in data taken by the Onsala station near Gothenburg in Sweden, but has also been seen by the entire Dutch array in one or two instances. A working hypothesis is that this structure may be associated with the mid-latitude trough: These are daytime observations where the lines of sight to the radio source observed pass through ionospheric pierce points, calculated using an assumed altitude of 200km, which cover latitudes of southern Sweden and southern Norway. The structure seen in the dynamic spectra may then be due to refraction through the steep density gradients of the trough walls, or by low-incidence-angle reflection off of the trough walls. In this paper, we will present these observations and the latest analysis and modelling results.

The presence of such long-duration structure in the dynamic spectrum further illustrates the value of broadband observations of scintillation to fully model both the scintillation and the conditions giving rise to it. These observations significantly expand upon those based on single-station single-frequency and offer the opportunity to appreciate large-to-small plasma scales in the presence of different scattering regimes.