Geophysical Research Abstracts
Vol. 21, EGU2019-5446, 2019
EGU General Assembly 2019

Ionosphere Focusing Effect Manifestations in Solar Radio Observations over Europe

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Being a highly dynamical medium strongly coupled with neutral atmosphere the ionosphere contains variable electron density irregularities of different scales (from tens of meters up to thousands of kilometers). The electron density variations could affect incident radiation that leads to interesting effects. Thus, electromagnetic waves within meter and decameter wavelengths ranges passing through the ionosphere could be subject to refraction which may cause their sporadic focusing. In particular, this phenomenon shows itself in observations of solar radio emission.

The solar radiation focusing effect relates to the specific phenomenon of propagation of the Sun-emitted high frequency (decameter) and very high frequency (meter) waves through terrestrial ionosphere with irregularities. This natural effect is occasionally observed with ground-based radio instruments running within 10-200 MHz range. Its manifestations are distinctive-in-morphology patterns – Spectral Caustics (SCs) – on the dynamic spectrum.

Keen interest was demonstrated to the SC topic in the 1970s–1980s, when the number of papers on the issue was published (e.g., see [1]). In the following years, there has been a lull in the research of focusing effect of solar radio emission. We have revived the SC problem by our recent works [2,3]. Evidently, the SC topic has not been fully explored yet. So, we continue the SC research.

Until now, it has been suggested that SCs are caused by ionospheric plasma density irregularities, namely, medium-scale traveling ionospheric disturbances (MSTIDs). In the present study, we demonstrate the first direct observations of the solar radiation focusing induced by MSTIDs. We have considered the solar dynamic spectra with multiple SCs obtained by different European radio telescopes on December 12, 2013 and January 8, 2014. The well-pronounced distinctions in the respective spectrograms can be explained only due to propagation effects of the radio emission in the ionosphere. At the same time, using the high resolution two-dimensional de-trended total electron content (TEC) maps over Europe, we have revealed numerous daytime TIDs in those two days. Spatial analysis of de-trended TEC maps, as well as precise timing of the maps and the dynamic spectra have been performed. In this way, for the first time we have found several pairs of one-to-one (TID-SC) correspondences. The study provides strong observation evidence which can unambiguously confirm the theory of the SCs origin.

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