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Benefits for space science and applications from innovative tools based on LOFAR measurements and other radio diagnostics

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The Low-Frequency Interferometer Array LOFAR is one of the world's most-flexible radio instruments with capabilities that enable studies of several aspects radio astronomy and space weather to be progressed beyond today's state-of-the-art. LOFAR has emerged as a powerful tool for studying space weather phenomena by means of observation, monitoring, analysis, and modelling of the solar wind-magnetosphere-ionosphere-thermosphere system. In order to give a more detailed and complete understanding of physical plasma processes that govern the solar-terrestrial space, and to develop qualitative and quantitative models of the magnetosphere-ionosphere thermosphere coupling, it is necessary to design and build the next generation of constructing new types of space plasma multi-point and multi-type sensors and analysis techniques for space diagnostics and monitoring. Novel ground-based wide-area sensor networks, such as the LOFAR radar facility, comprising wideband, and vector sensing radio receivers and multi-spacecraft plasma diagnostics should help solve outstanding problems of space physics and describe long-term environmental changes.

What is significant, LOFAR, with its unique capabilities, offers significant advantages for investigating ionospheric disturbances and their effects. By employing an array of low-frequency antennas, operating in the frequency range of 30-210 MHz, LOFAR can accurately measure and analyse the propagation of radio waves through the ionosphere. This capability enables researchers to study phenomena such as ionospheric scintillation, plasma irregularities, and the coupling between the ionosphere and the magnetosphere.

Additionally, integrating observing facilities, data processing tools and prediction models dedicated to ionosphere, thermosphere and plasmasphere research, as it is aimed in the Horizon 2020 INRF project PITHIA-NRF is a key approach which can provide easy access to all European research infrastructures.

The aim of this presentation is to report the current status of space weather activities with highlights of the contribution from the Polish station. We also aim to include some of the longer-term goals envisaged for LOFAR to become one of Europe's most comprehensive space-weather observatories, shedding new light on several aspects of the space-weather system, from the Sun to the solar wind to the ionosphere.