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Ground-Based Radio Observations for Space-Weather Science and Monitoring

Mario M. Bisi[(1)], Richard A. Fallows[(2)], Jasmina Magdalenic[(3)], Caterina Tiburzi[(4)], Bernard V. Jackson[(5)] , Oyuki Chang[(6)], Biagio Forte[(7)], and Hsiu-Shan Yu[(5)]
(1) RAL Space, Science & Technology Facilities Council – Rutherford Appleton Laboratory, Harwell Campus, Oxfordshire, OX11 0QX, UK; e-mail: Mario.Bisi@stfc.ac.uk
(2) ASTRON – the Netherlands Institute for Radio Astronomy, Postbus 2, 7990 AA Dwingeloo, the Netherlands; e-mail: fallows@astron.nl
(3) Royal Observatory of Belgium, Ringlaan 3, BE-1180, Brussels, Belgium; e-mail: jasmina.magdalenic@oma.be
(4) Fakultät für Physik, Universitaat Bielefeld, Postfach 100131, D-33501 Bielefeld, Germany; e-mail: ctiburzi@physik.uni-bielefeld.de
(5) Center for Astrophysics and Space Sciences, University of California, San Diego, 9500 Gilman Drive #0434, La Jolla, CA 92093-0424, USA; e-mail: bvjackson@ucsd.edu; hsyu@ucsd.edu
(6) Laboratorio Nacional de Clima Espacial, UNAM, Morelia, México; e-mail: tania.oyuki@gmail.com
(7) Department of Electronic and Electrical Engineering, University of Bath, Claverton Down, Bath, Somerset, BA2 7AY, UK; e-mail: B.Forte@bath.ac.uk

Ground-based radio observations are of great importance for space-weather science and are also becoming increasingly important for monitoring purposes. In addition, some aspects of space-weather radio observations are being used formally and informally to aid in space-weather forecasting as well as in space-weather situational awareness.

On the scientific research side, several of the most-cutting-edge radio arrays such as the Low Frequency Array (LOFAR) in Europe and the Murchison Widefield Array (MWA) in Western Australia are actively being used to explore many aspects of Heliophysics, including space weather. These range from detailed solar observations to observations of the inner heliosphere and of Earth's ionosphere. In addition, there is currently a Horizon-2020 (H2020) INFRADEV (Infrastructures) project underway to investigate and develop an upgrade path and system design for LOFAR to enable simultaneous space-weather observations alongside normal telescope radio-astronomy observations (see Fallows *et al*., this session).

Coronal mass ejections (CMEs) and their associated shocks are the biggest drivers of disturbed geomagnetic conditions (typically driving substorms and subsequent geomagnetic storms), but high-speed streams (HSSs) and stream interaction regions (SIRs) are also important drivers of space weather at Earth. Thus, tracking of CMEs, CME-driven shocks, and solar-wind structures (HSSs, SIRs, *etc*…) from near the Sun all the way through the inner heliosphere to the Earth has become one of the most-often addressed topics in space-weather research and forecasting.

Observations also range from direct (these can include solar imaging, solar radio-burst detections, solar dynamic spectra) to indirect (these are usually undertaken by measuring distant natural radio sources such as quasars and pulsars or by observing spacecraft radio beacons during their passage near to and/or behind the Sun on the sky plane). Three particularly-important indirect observations are those of interplanetary scintillation (IPS), ionospheric scintillation, and Faraday rotation (FR); the latter still being very much in the experimental stage for Heliophysics space-weather purposes.

In this invited presentation, we will highlight several aspects of the use of radio observations for space weather, including detections of radio bursts, CME and solar-wind structures throughout the inner heliosphere (including the potential for using Faraday rotation to detect the magnetic field in the outer corona and inner heliosphere), and of local ionospheric observations.