4th URSI AT-RASC, Gran Canaria, 19-24 May 2024

Recent developments for solar radio observations and Space Weather applications

Carine Briand[(1)]
[(1)] *Observatoire de Paris-PSL, CNRS, Sorbonne Université, Université Paris Cité, carine.briand@obspm.fr*

Solar eruptive events produce enhanced emissions of energetic particles and electromagnetic fluxes. Protons and electrons accelerated during CME propagation in the interplanetary medium hurl to Earth, where they can damage in-orbit spacecraft, penetrate the Earth's magnetosphere, and lead to an increase of the irradiation dose at civil aviation flight altitude or to disturbances of the magnetospheric currents that generate Ground induced currents. On their side, increases in the X radiation during flares modify the electron contents of the ionosphere with considerable consequences on the HF and VHF absorption. The Sun also emits enhanced radiation levels at GHz, a range of frequencies for GPS information transfer or cell phone communications. Thus, understanding the solar conditions that lead to eruptive events is crucial and part of space weather activities.

Modeling solar active regions to forecast eruptions requires knowledge of many parameters at the coronal level, including the magnetic field vector, the plasma temperature, and the velocity field. Once the eruption has begun, other parameters are necessary to forecast its impacts on the Earth's environment: energy and spectral density of the particles, location of the eruption on the Sun and its connectivity to Earth, time duration of the event, etc.

Many observations of the space environment rely on spacecraft measurements. However, those missions have a long but finite lifetime, and the launch of new instruments is uncertain. Ground-based infrastructures then provide more long-term access to observations. They also present the advantage of quick access to data to alert services. Finally, their size is much less limited than space-based instruments, enabling high spatial resolution. Of course, they also have their limits, like the range of accessible frequencies (above 10MHz for radio observations) and the alternance of night and day that restricts the solar observing time to six to eight hours from a single instrument.

Among the ground-based infrastructures, radio telescopes play an essential role in providing access to parameters of the low solar corona. Also, when energetic particles hurl toward the Earth, the CDD cameras of space missions become blind, but this is when radio instruments perform best.
The frequency range 400 - 10MHz covers the low corona heights (typically 1.1 to 1.2 Solar Radii). The decameter range (80-10MHz) covers the lower frequency range accessible from Earth and links with spacecraft radio observations that explore the interplanetary medium. Bremsstrahlung, cyclotron emission, or plasma emission are the most common generation mechanisms from which coronal magnetic field strength, electron beam velocity, or turbulence level, among others, can be deduced.

Due to the long emission wavelength, providing a spatial resolution at least the size of the Sun requires a long-bases interferometer. That's particularly true in the decameter range. Recently, two large radio interferometers have been put in activity in Europe: LOFAR (*LOw-Frequency ARray*) and NenuFAR (*New extension in Nançay ugrading LOFAR*). These two instruments will be presented during this seminar through recent results obtained from their data to illustrate their pertinence for solar studies.