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Radio Observations and Space Weather

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1. Introduction

The solar corona is a dynamic plasma system in which the most energetic transient processes in the solar system, flares and coronal mass ejections (CMEs) occur. CMEs are large amounts of plasma and magnetic flux expelled from the Sun into the interplanetary medium and they are, together with CME-driven shock waves, the most important drivers of disturbed geomagnetic conditions. Eruptive events can be associated with radio emission which brings a plentiful information about the particle acceleration processes, shock waves and ambient plasma conditions. Studies of radio emission associated with CME-driven shocks, so-called type II radio bursts, are of particular interest because radio observations cover a broad frequency domain which enables tracking of the shocks all the way from the low corona to the Earth, and also forecasting shock arrival at the Earth (see e.g. [1]).

The importance of the radio science for space weather, and the use of the radio observations in the operational space weather forecasting will be addressed. To demonstrate the significance of the added value which radio observations bring to the operational space weather forecasting, we will consider the example of two homologous radio events. The events were observed starting at about 03:25 and 12:00 UT on November 04, 2015. They both showed well defined metric type II radio emission, signature of the coronal shock wave, and no significant components of radio emission continuing to the interplanetary space. The type II bursts had no associated type III emission (radio signatures of fast electrons accelerated along the open or quasi-open filed lines) or type IV burst (possibly CME-associated), but only weak and patchy emission at the beginning of the radio event. The intense metric type II bursts both started at rather high frequency (about 330 and 400 MHz for the fundamental bands), and they showed fundamental, 2nd harmonic and 3rd harmonic emission band.
What can be deduced from the observed radio emission, for both events? Since the type II emission is present, the eruptive events were associated with the coronal shock wave. Further, metric type II bursts were both intense and they had high starting frequency which indicates that the associated flare was impulsive and possibly strong (e.g. [2] and references therein). The information that both type II bursts show not only fundamental and 2nd harmonic, but also 3rd harmonic component indicates that the source regions of the associated eruptive events were situated close to the solar limb [3]. And since type II bursts had no associated strong type III and/or type IV emission, the CMEs associated with this events were neither fast nor wide. To summarize, using only radio observations, one can conclude, that these two CMEs will not arrive to the Earth and induce disturbed geomagnetic conditions since they were narrow and had the source region close to the solar limb. The EUV and coronagraph observations confirm the conclusions based on radio observations. The flares associated with radio events were both very impulsive (the flare rise time of only several minutes) and rather strong (M2.1 and M2.5 flares). The source region of both flares was the NOAA AR 2445, situated at the moment of eruptions close to the west solar limb and the CMEs associated with the radio events were both narrow (angular width of 50 and 30 degrees), and slow (speeds of 400 and 300 km/s), and as such not expected to arrive at the Earth.
As demonstrated with this example, radio emission can allow us to deduce important information relevant for the space weather forecasting, and has therefore a very important place in space weather studies.

2. References

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