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TSRS diagnostics for Space Weather effects analysis

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Abstract. The Trieste Solar Radio System (TSRS) was recently upgraded to provide additional radio diagnostics relevant to the analysis of Space Weather effects. In particular coronal radio indexes and high resolution radio data are made available in near-real-time on the dedicated web site and the indexes are also published on a web site reachable via mobile phones. The relevance of such new features in the framework of Space Weather monitoring is briefly discussed.

Key words. solar radio astronomy – radio flare – solar flare – space weather

1. Introduction

The Sun is a non-directional, broad band radio source and the generated radio noise is the signature of thermal and non-thermal plasma processes occurring at different levels in the atmosphere. The level of the solar radio noise can increase by several orders of magnitude during outbursts associated with transient solar activity like flares (see e.g. Nita et al. 2002) and can persist from minutes to hours. Hence the solar radio emission is a potential source of perturbation for High Frequency (HF) communications, which have a broad range of users for civil and military purposes, as well as for mobile communications, such as GSM, GPRS and UMTS systems. In this framework the routinary surveillance of the radio emissions from the solar corona is the only way to monitor the status of representative radio bands and issue alerts at the onset of noise increase and persistence.

2. Diagnostics via solar radio events

Solar radio events are historically grouped into five main types according to their spectral characteristics, but the progress in observing techniques allowed a fine to hyperfine sub-classification, which makes the observational scenario quite difficult to interpret. Notwithstanding consistent theories exist for most radio events (see e.g. Benz 1993, Bastian et al. 1998) and the future multiband observations will improve our knowledge of the radio timings with respect to non-radio phenomena. This will in turn consolidate the radio diagnostics of plasma processes and allow a consis-

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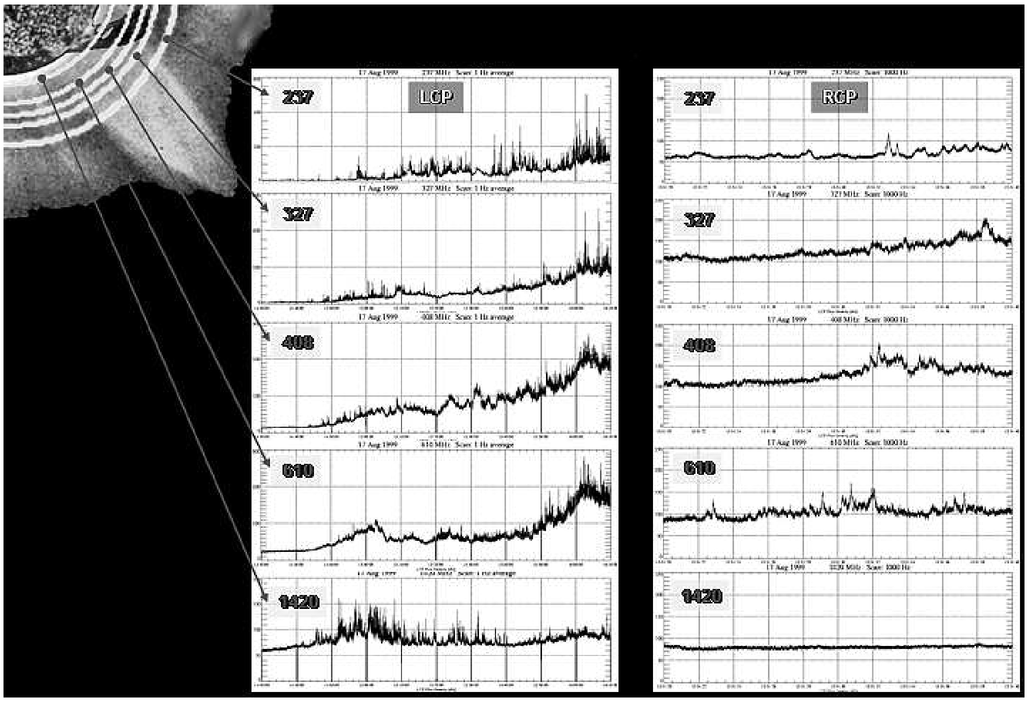

Fig. 1. A radio flare (type IV burst) detected by TSRS at 5 frequencies is the signature of plasma perturbations occurring at different coronal altitudes. Left (LCP) and Right Circular Polarization (RCP) channels are shown in left and right panels respectively.

tent reverse modelling from the radio signatures to the originating plasma perturbations and physical state. In fact, various radio events are associated with flares and most of them with magnetic rearrangements, so that they act as proxies of solar drivers: a) magnetic topology changes (Type I bursts); b) propagating shocks and particle beams (Type II bursts); c) particle acceleration and particle beams (Type III bursts); e) magnetic reconnection and acceleration processes (Type IV bursts); f) energy release fragmentation and acceleration (spikes); g) pre-flare state (microwave radio precursors); h) EUV enhancements (10 cm radio emission). Intense, broad band type IV bursts associated with X and/or Hα flares are also known as "radio flares" and flare-associated 10-cm radio bursts as "tenflare" in the Space Weather terminology. When an energetic perturbing phenomenon occurs in the corona, plasma layers at increasing altitudes are excited and emit radio waves at decreasing frequencies according to the local plasma frequency which decrease with the electron density (Fig. 1). Independently of secondary phenomena, which can be originated and propagate at low speed to the Earth, such as Coronal Mass Ejections (CMEs), radio signatures carry physical information quasi-instantaneously and are therefore precious proxies of coronal activity phenomena (Messerotti 2001; Messerotti et al. 2003). In particular, solar radio indexes at different frequencies are used in nowcasting and forecasting models of terrestrial perturbations, such as the 10 cm (2800 MHz) one.

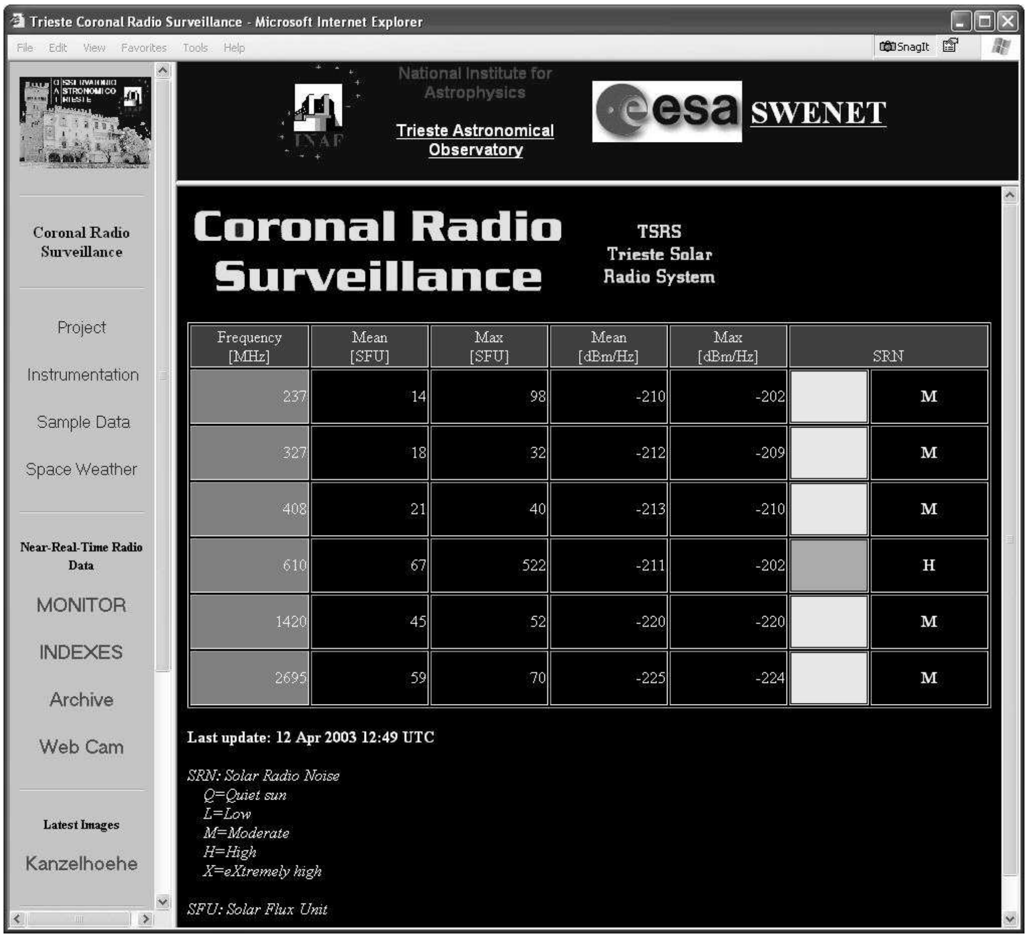

Fig. 2. Homepage of the TSRS web site (http://radiosun.ts.astro.it) with the most recent radio indexes displayed in numerical, in color-coded and in text format.

3. Relevant new features of TSRS

TSRS is a set of two radiopolarimeters automatically operated, which acquire the solar radio emissions (flux density and circular polarization) at a routinary sampling rate of 1000 Hz at all receiving frequencies (237, 327, 408, 610, 1420, 2695 MHz) by means of a common digital acquisition system. This allows the near-real-time (NRT) processing of the digital data, the derivation of solar radio indexes as average flux density values over subsequent 1-minute time intervals, and their publication on the Internet (Fig. 2). The data flow for the real-time processing is the following: a) Low-Level (LL) drivers manage the analogic data flow from the antennas through the receivers to the digital acquisition system; b) a C program controls the Analog-to-Digital (A/D) conversion and storage onto disk files; c) an IDL package running on the real-time processor machine performs a series of tasks such as 1) transfer raw data via network share, 2) calibrate data on-the-fly, 3) compute radio indexes, 4) graph synoptic data and radio indexes, 5) transfer Space Weather data to web server, 6) convert calibrated data to FITS format via an Object

Library, 7) manage data ingestion into the SQL archive server via an IDL COM (Component Object Model) by means of an ADO (ActiveX Data Object). This set of procedures provides in NRT a series of products relevant to Space Weather such as: a) a multichannel radio synoptic chart descriptive of the activity status of the coronal layers (1 Hz sampling rate); b) the peak flux at 1 Hz sampling in numerical format file; c) the related high resolution data in FITS format (10 mins data blocks at 1000 Hz sampling); d) the 1-min average radio indexes and the 1-min maximum flux for each frequency and polarization mode in graphical, text and FITS format files. All these data products are published on the web site (http://radiosun.ts.astro.it) by automatic updating. The major new features which were added to better exploit the potentialities of TSRS for Space Weather are: a) a table in the homepage (Fig. 2) which reports the 1-min average and max flux at each channel, expressed in solar flux units (SFUs) and in dBm/Hz, as well as color- and text-coded indications of the activity levels; b) the activation of a WAP (Wireless Application Protocol) site, which reports in compact form the above information and is reachable via a mobile phone connection, allowing any user wherever located to get the level of solar radio noise (Fig. 3). Off-line data analysis is based on an IDL package which provides a Graphical User Interface to perform archive access, data retrieval, data calibration, data visualization and printing.

4. Conclusions

New data products published in near-real-time extend the diagnostic capabilities of the Trieste Solar Radio System for Space Weather applications. The availability of 1-min average and 1-min peak radio indexes both on a web site and WAP site allows the tracing of coronal transients in nowcasting and forecasting associated phenomena.

Fig. 3. The screen of a mobile phone, connected with the TSRS WAP server via a GPRS link, displays the radio indexes.

Furthermore the radio indexes expressed in dBm/Hz are more suitable for evaluating the solar radio noise level in monitoring radio bands used in telecommunications.

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