CATALOGS OF SOLAR ENERGETIC ELECTRONS AND THEIR RADIO EMISSIONS IN SOLAR CYCLES 23 AND 24

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Abstract: *We present the status of two comprehensive catalogs of in situ observed energetic electrons (from ACE/EPAM DE instrument, with energy coverage 103–315 keV) and their related radio emissions. The focus is on the developed dual web-based interface and their planned capabilities. For the first time solar energetic electrons are identified over the period of two solar cycles, from 1997 to 2017. In addition, we present the solar radio emission signatures observed remotely (both from satellites and ground-based observatories). Thus, for the first time the radio signatures of electrons (radio burst types, single frequency records, dynamic radio spectra) can be directly compared with the in situ observed electron events.*

КАТАЛОЗИ ОТ СЛЪНЧЕВИ ЕНЕРГЕТИЧНИ ЕЛЕКТРОНИ И ТЕХНИТЕ РАДИО ЕМИСИИ ПО ВРЕМЕ НА СЛЪНЧЕВИТЕ ЦИКЛИ 23 И 24

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Ключови думи: *Слънчеви енергетични електрони, радио емисионни сигнатури, слънчев цикъл*

Резюме: *Представяме два подробни каталога от наблюдавани in situ енергетични електрони (от инструмента ACE/EPAM DE с енергии в диапазона 103–315 keV) и техните радио емисии. Фокусът е върху разработваната двойка от уеб-структури и техните планувани възможности. За първи път слънчеви енергетични електрони се определят за период от два слънчеви цикъла, от 1997 до 2017. В допълнение, представяме слънчевите радио емисионни сигнатури наблюдавани дистанционно (както от спътници, така и от наземни обсерватории). Така за първи път радио сигнатурите на електрони (тип радио избухване, едночестотни записи, динамичен радио спектър) може да бъде директно сравнен с in situ наблюдаваните електронни събития.*

Introduction

The objective of this report is to outline the setting of a web-interface for a dual catalogs: one listing the in situ observed solar energetic electrons (SEEs) and another, showing the remotely detected radio emission signatures of these electrons. The basis of this project is the catalog of electrons as detected by the ACE/EPAM DE [1] instrument. Furthermore, to each electron event, we performed – to the best of our abilities – a solar origin association. Namely, each in situ electron is allocated to a pair, where possible, of a solar flare (SF) and coronal mass ejection (CME). We used a standard procedure utilized in this research field by selecting the strongest flare and the fastest and widest CME, giving a preference to a western eruption in case of several competing candidate pairs.

There is a lack of a comprehensive list of solar electrons detected near Earth. Several partial listings exist [2–5], however none of them covers continuously two solar cycles (SCs), which is the aim of our current efforts. Moreover, the radio emissions considered as the signatures of in situ observed

particles are always compared to the occurrences and peak intensities of protons and not to electrons, see, e.g., [6–9]. Our project aims to finally bridge his gap.

Catalogs

Solar energetic electrons: http://www.nriag.sci.eg/aceepam-electron-event-catalog-2/

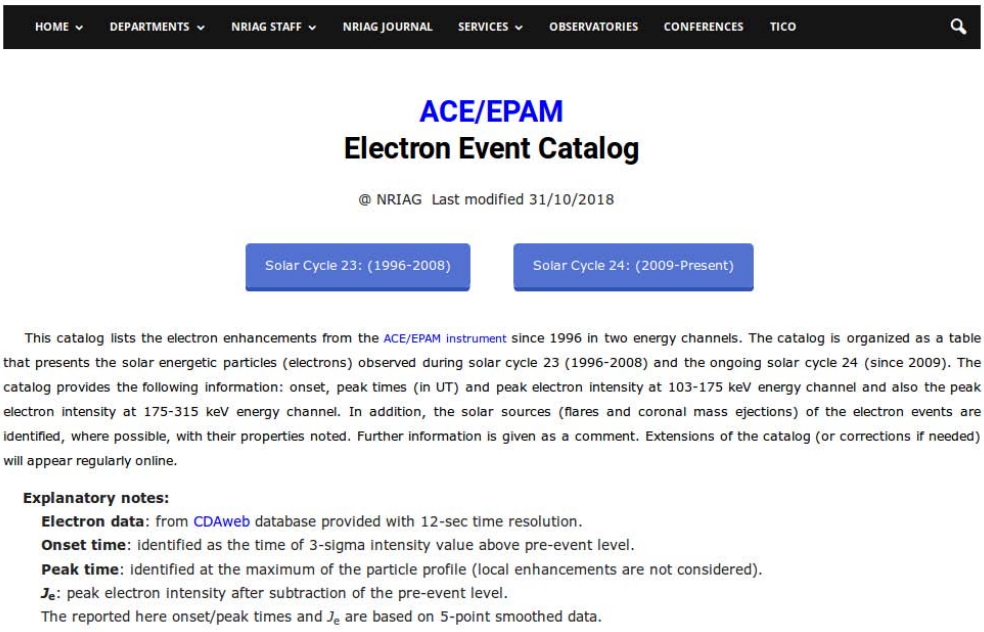


Fig. 1. Screen-view of the home page of the electron catalog web-site

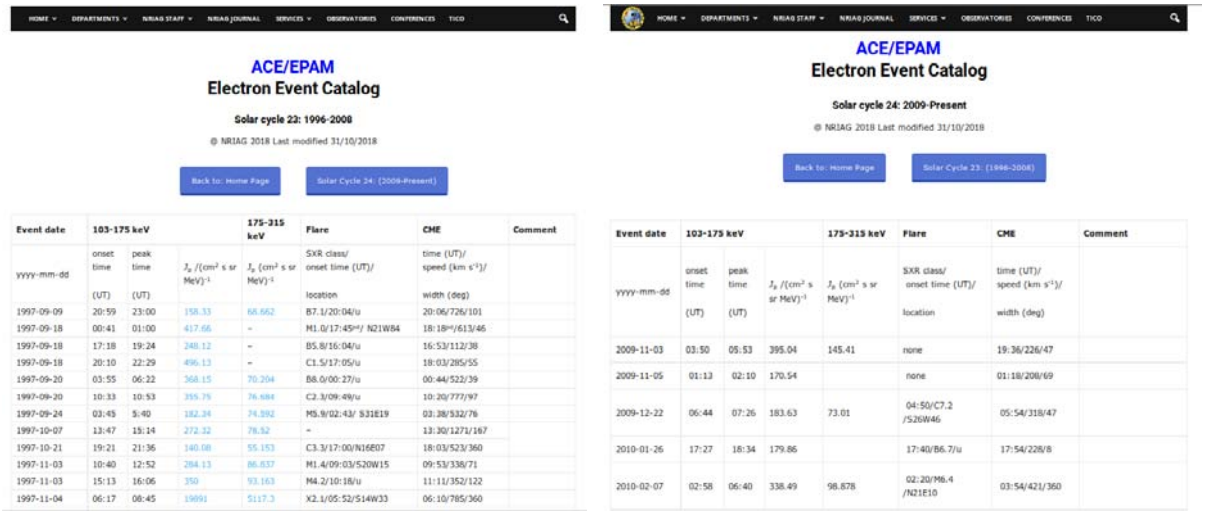


Fig. 2. Screen-views of the tables with electron events in solar cycles 23 (on the left) and 24 (on the right)

The electron data is collected from CDAW omni database**:** http://cdaweb.gsfc.nasa.gov/ with 12-sec time resolution in the two highest energy channels, 103–175 and 175–315 keV. The electron enhancements are first visually identified by an observer and then a semi-automatic routine is used to calculate the pre-event background level (using observer defined start and end times), the value of the peak electron intensity and the background subtracted peak intensity at each energy channel under consideration. The latter values (with their corresponding links to overview plots), the lower energy SEE date, onset and peak times and the properties of the SEE-related SF and CME are finally reported in the online catalog. The onset time is defined as the time when the electron flux surpasses three standard deviations above the background flux level.

The access point to the electron catalog is via: http://www.nriag.sci.eg/aceepam-electron-event-catalog-2/ A screen-view of the home page for the electron events is given in Fig. 1, whereas Fig. 2 presents screen-views of two separate tables with the events is each SC.

Radio emission signatures: http://newserver.stil.bas.bg/SEPcatalog

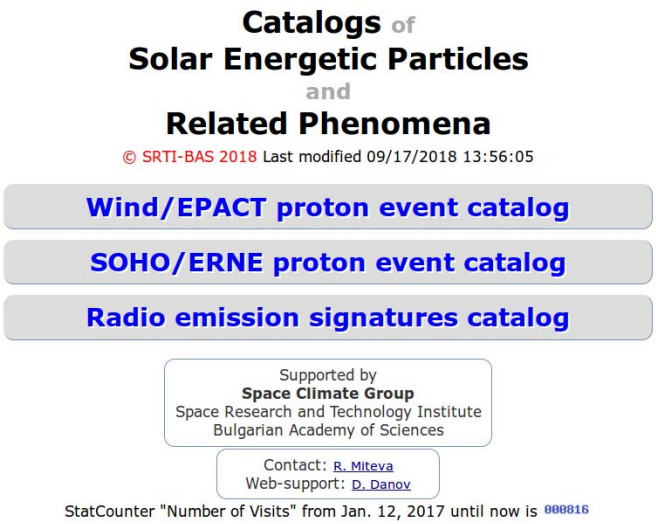
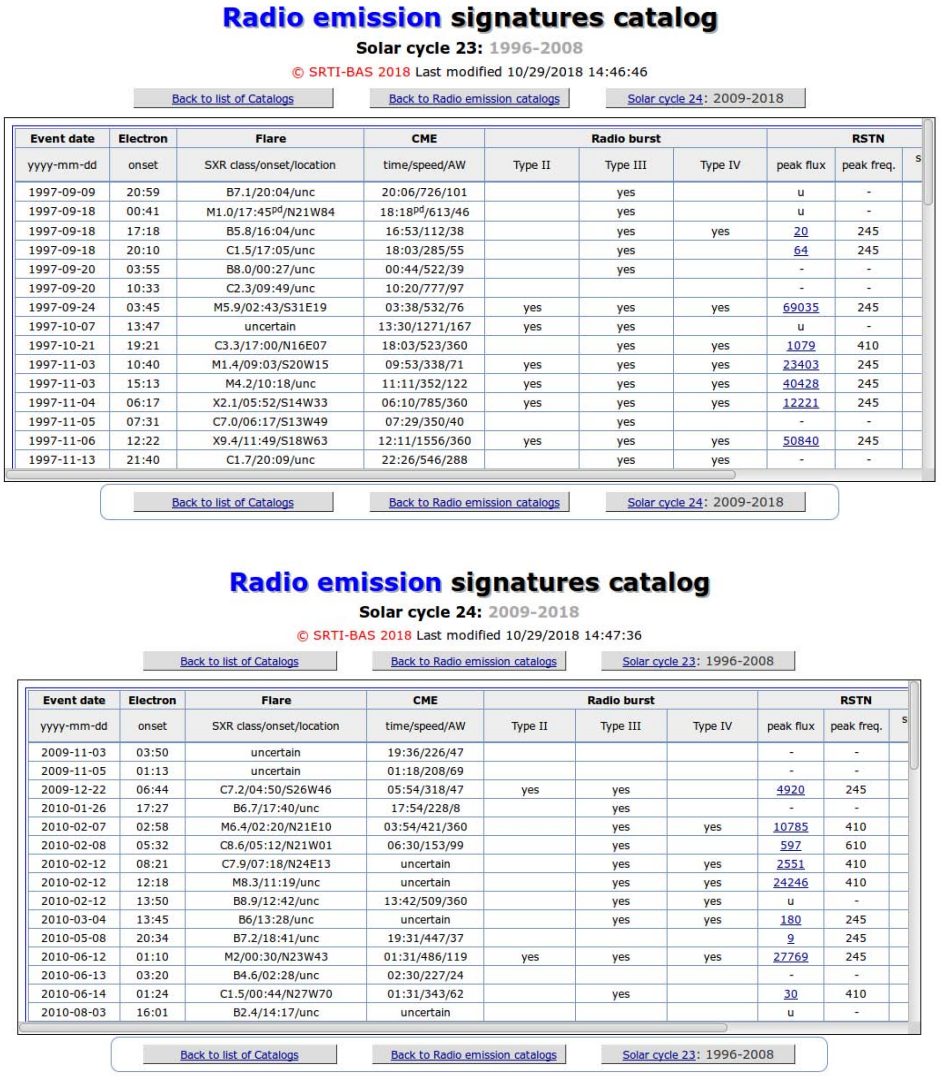


Fig. 3. Overview of the website hosting also the radio emission signatures catalog

Fig. 4. Overview of the home page of the radio catalog



Radio emission signatures catalog

Solar cycle 23: 1996-2008

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Event date	Electron	Flare	CME	Radio burst			RSTN		
yyyy-mm-dd	onset	SXR class/onset/location	time/speed/AW	Type II	Type III	Type IV	peak flux	peak freq.	s
1997-09-09	20:59	B7.1/20:04/unc	20:06/726/101		yes		u	-	
1997-09-18	00:41	M1.0/17:45pd/N21W84	18:18pd/613/46		yes		u	-	
1997-09-18	17:18	B5.8/16:04/unc	16:53/112/38		yes	yes	20	245	
1997-09-18	20:10	C1.5/17:05/unc	18:03/285/55		yes		64	245	
1997-09-20	03:55	B8.0/00:27/unc	00:44/522/39		yes		-	-	
1997-09-20	10:33	C2.3/09:49/unc	10:20/777/97				-	-	
1997-09-24	03:45	M5.9/02:43/S31E19	03:38/532/76	yes	yes	yes	69035	245	
1997-10-07	13:47	uncertain	13:30/1271/167	yes	yes		u	-	
1997-10-21	19:21	C3.3/17:00/N16E07	18:03/523/360		yes	yes	1079	410	
1997-11-03	10:40	M1.4/09:03/S20W15	09:53/338/71	yes	yes	yes	23403	245	
1997-11-03	15:13	M4.2/10:18/unc	11:11/352/122	yes	yes	yes	40428	245	
1997-11-04	06:17	X2.1/05:52/S14W33	06:10/785/360	yes	yes	yes	12221	245	
1997-11-05	07:31	C7.0/06:17/S13W49	07:29/350/40		yes		-	-	
1997-11-06	12:22	X9.4/11:49/S18W63	12:11/1556/360	yes	yes	yes	50840	245	
1997-11-13	21:40	C1.7/20:09/unc	22:26/546/288		yes	yes	-	-	

Back to list of Catalogs | Back to Radio emission catalogs | Solar cycle 24: 2009-2018

Radio emission signatures catalog

Solar cycle 24: 2009-2018

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Event date	Electron	Flare	CME	Radio burst			RSTN		
yyyy-mm-dd	onset	SXR class/onset/location	time/speed/AW	Type II	Type III	Type IV	peak flux	peak freq.	s
2009-11-03	03:50	uncertain	19:36/226/47				-	-	
2009-11-05	01:13	uncertain	01:18/208/69				-	-	
2009-12-22	06:44	C7.2/04:50/S26W46	05:54/318/47	yes	yes		4920	245	
2010-01-26	17:27	B6.7/17:40/unc	17:54/228/8		yes		-	-	
2010-02-07	02:58	M6.4/02:20/N21E10	03:54/421/360		yes	yes	10785	410	
2010-02-08	05:32	C8.6/05:12/N21W01	06:30/153/99		yes		597	610	
2010-02-12	08:21	C7.9/07:18/N24E13	uncertain		yes	yes	2551	410	
2010-02-12	12:18	M8.3/11:19/unc	uncertain		yes	yes	24246	410	
2010-02-12	13:50	B8.9/12:42/unc	13:42/509/360		yes	yes	u	-	
2010-03-04	13:45	B6/13:28/unc	uncertain		yes	yes	180	245	
2010-05-08	20:34	B7.2/18:41/unc	19:31/447/37				9	245	
2010-06-12	01:10	M2/00:30/N23W43	01:31/486/119	yes	yes	yes	27769	245	
2010-06-13	03:20	B4.6/02:28/unc	02:30/227/24				-	-	
2010-06-14	01:24	C1.5/00:44/N27W70	01:31/343/62		yes		30	410	
2010-08-03	16:01	B2.4/14:17/unc	uncertain				u	-	

Back to list of Catalogs | Back to Radio emission catalogs | Solar cycle 23: 1996-2008

Fig. 5. Screen-views of the tables with radio signatures in solar cycles 23 (upper part) and 24 (lower part)

The radio data is collected from various radio observatories, both in space and on ground, providing dynamic radio spectra and single frequency radio records (the latter adopted primarily from the four RSTN network stations: ftp://ftp.ngdc.noaa.gov/STP/space-weather/solar-data/solar-features/solar-radio/rstn-1-second/). We used only those electron events for which at least one of the solar origin has been identified. In such a way, the list of radio signatures is not the complete set of in situ observed electrons, but only those of them with identified SF or/and CME.

The radio catalog can be accessed via the portal: http://newserver.stil.bas.bg/SEPcatalog which contains three catalogs (Fig. 3). After selecting the lowest box, a new sub-page is opened providing a description of the radio catalog (Fig. 4). Finally, the listings with radio signatures can be inspected after selecting one of the two boxes, depending on the SC, organized at the top of the page. Either time period contains the relevant information organized in a similar online table, see Fig. 5 for the preliminary version of the tables. Namely, the individual columns list the following: date of the ACE/EPAM electron event; onset time of the same SEE; SEE-related flare class, onset time and location; time of first occurrence, linear speed and angular width (AW) of the SEE-related CME; radio burst occurrences of types II, III and IV; peak RSTN flux (in solar flux units with a link to an overview plot at all eight RSTN single frequencies), peak frequency (in MHz); spectral index of the higher frequency branch; comment. All times are in UT. In the finalized stage of the catalog, the frequency coverage of the given radio burst type will be specified in terms of decimetric, metric, Decametric, Hectometric and/or kilometric range.

Outlook

Both catalogs are currently under completion and will include also events during 2018 if any. The catalogs contents will be freely available after the publication of the scientific results.

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