STEREO/PLASTIC Suprathermal Proton Event List

Version	Date	Modifications
1	Sep. 10, 2010	Original Version
2	Jan. 13, 2011	Update list to 12/31/2010
3	Nov. 09, 2011	Update list to 08/31/2011 Used the version of SIR times created on 06/09/2011.
4	Jan. 30, 2012	Update list to 09/30/2011 Matrix rate 0 and 1 are summed yielding the full proton rate and allowing for the definition of faint events. For each spacecraft a single trigger value is used to trigger events instead of a trigger value times a background, resulting in a more accurate automated definition of events. A more accurate method is used to determine the bulk solar wind speed at the spacecraft. Included columns that indicate whether an event overlaps an ICME, ±1 day of an ICME, ±1 hour of a shock, ±1 day of a shock, a SEP, and ±1 day of a SEP.
5	Apr. 11, 2012	Update list to 01/31/2012. The most recent SIR, ICME, Shock and SEP (updated on 4/4/12) list were called when updating the suprathermal lists.
6	Mar. 10, 2020	Update list to 12/05/2019. Event List criteria have changed; beyond 2011, lists include new criteria used by Lan Jian for ICME, SEP, SIR, and Shock definitions.

Created by: Josh Barry at the University of New Hampshire
Funded by: NASA contract NAS5-00132

Updated by: Nick Lubinsky at the University of New Hampshire
Contact: nkx22@unh.edu

Intro

This data product contains a list of automatically identified suprathermal proton events measured on the Wide Angle Partition without a Solid State Detector (WAP non-SSD) portion of the STEREO/PLASTIC instrument. This list in conjunction with the IMPACT magnetic field information and PLASTIC solar wind data can aid a user in identifying energetic proton events related to Stream Interaction Regions (SIRs), shocks, upstream events, magnetospheric events, etc. For information on the WAP non-SSD portion of PLASTIC see below. A thorough explanation of both PLASTIC and IMPACT can be found in [*Galvin* et al., 2008] and [*Luhmann et al.*, 2007], respectively.

Events are triggered if the rate-averaged flux of high energy protons accumulated over 10 min exceeds a threshold to match manual definitions. The program then compiles Event Lists for ICME, SEP, SIR, and Shock data to compute overlap with the suprathermal event and within +/- 1 day of these Event Lists.

Instrument

The WAP non-SSD portion of the PLASTIC instrument is utilized in creating these event lists. This non-sunward facing section has an 180º in-ecliptic view and covers an energy range from 0.2 keV/q to 80keV/q, Electro Static Analyzer (ESA) step 128 to 0. Early in the mission the WAP non-SSD portion of both spacecraft, STEREO-Ahead (STA) and STEREO-Behind (STB), are ideal for detecting bow shock/magnetospheric ion events.

Suprathermal Event Definition

The energy spectrogram produced by summing the 10 min resolution Supra_no_E_Non-SSD_class_0 and Supra_no_E_Non-SSD_class_1 matrix rate data[1] (there are two classes allocated for protons on the WAP non-SSD so we sum them together) allows for quick manual identification of suprathermal proton events. The top panel in Figure 1 is an example of an energy spectrogram showing suprathermal proton signatures (the sum of Supra_no_E_Non-SSD_class_0 and Supra_no_E_Non-SSD_class_1 matrix rate data), while the lower panel shows |B|. Plots similar to those shown in Figure 1 can be created using the PLASTIC public domain routine SPLAT (IDL). The SPLAT software can be downloaded at http://stereo.sr.unh.edu/data/PLASTIC_Resources/index.htm. Daily plots

[1] For a more detailed explanation of the PLASTIC matrix rate data, see 'Level1Data.doc' located at http://stereo.sr.unh.edu/data/PLASTIC_Resources/index.htm.

similar to those in Figure 1 can be found at http://fiji.sr.unh.edu/wap_bfield_public.html.

In the automated process to define events, we first define 3 bands in Energy/Charge (E/Q) covering the same number of ESA steps (8 ESA Steps). The red horizontal bands in the top panel of Figure 1 depict these energy bands. The upper, middle, and lower energy bands cover the E/Q range 59.0-42.2keV/q, 19.7-14.1keV/q, and 5.95-4.26keV/Q, respectively.

If the average of the number of events in a 10 min increment in any one of the three energy bands exceeds a trigger value, the program identifies the start of an event period. The end of an event occurs when none of the three E/Q bands are triggered. The triggering of events was adjusted as to match those defined by eye.

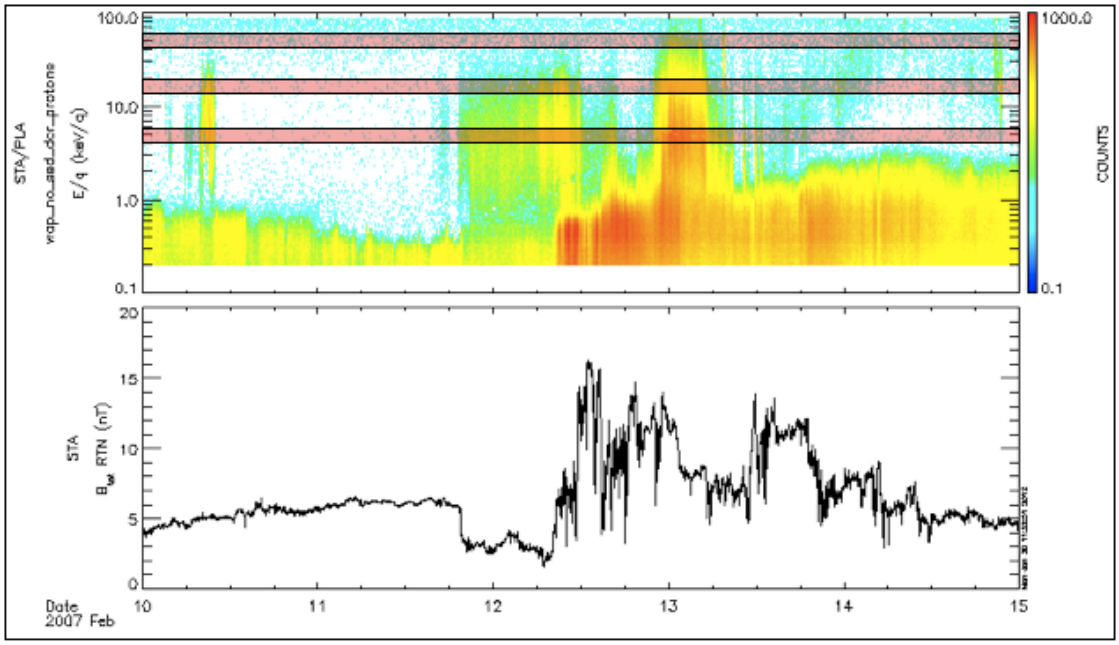

Figure 1 The top panel shows an energy spectrogram of suprathermal protons detected on the WAP Non-SSD while the bottom panel shows the magnitude of the magnetic field on STA. The red horizontal bands indicate the energy bands used to define suprathermal proton events.

Event List Criteria

Event criteria for ICMEs, SEPs, SIRs, and Shocks have changed for the start of the 2012 year. Most noticeable impact this has is on the SEP events. Event List Criteria used by Lan Jian:

ICME: The criteria of event classification are published in the following papers:

L.K. Jian, C.T. Russell, J.G. Luhmann, and A.B. Galvin, STEREO Observations of Interplanetary Coronal Mass Ejections in 2007 - 2016, The Astrophys. J., 885, 114, doi: 10.3847/1538-4357/aab189, 2018.

L.K. Jian, C.T. Russell, J.G. Luhmann, A.B. Galvin, K.D.C. Simunac, Solar Wind Observations at STEREO: 2007 – 2011, Amer. Inst. Phys. Proceedings of Solar Wind 13, 1539, 191-194, doi: 10.1063/1.4811020, 2013.

L. Jian, C.T. Russell, J.G. Luhmann, and R.M. Skoug, Properties of Interplanetary Coronal Mass Ejections at One AU during 1995 – 2004, Solar Phys., 239, 393-436, 2006.

SIR: The criteria of event classification are published in the following papers:

L.K. Jian, J.G. Luhmann, C.T. Russell, A.B. Galvin, Solar-Terrestrial Relations Observatory (STEREO) Observations of Stream Interaction Regions in 2007 - 2016: Relationship with Heliospheric Current Sheets, Solar Cycle Variations, and Dual Observations, Solar Phys., 294, 31, doi: 10.1007/s11207-019-1416-8, 2019.

L.K. Jian, C.T. Russell, J.G. Luhmann, A.B. Galvin, K.D.C. Simunac, Solar Wind Observations at STEREO: 2007 - 2011, Amer. Inst. Phys. Proceedings of Solar Wind 13, 1539, 191-194, doi: 10.1063/1.4811020, 2013. L. Jian, C.T. Russell, J.G. Luhmann, and R.M. Skoug, Properties of Stream Interactions at One AU during 1995 â€“ 2004, Solar Phys., 239, 337-392, 2006.

SEP: Prior to 2012, SEP definitions are defined by the UCLA team: where the 3-hour time-averaged flux of $1.8 - 3.6\ MeV$ protons exceed $5 \times 10^{-4}\ {}^{pfu}/_{MeV}$ (where 1 pfu = 1 $p\ cm^{-2}sr^{-1}s^{-1}$) as measured by the LET onboard STEREO A(B).

Beyond 2011: The list is compiled by Dr. Lan Jian (lan.jian@nasa.gov) using the criterion that the flux of $13 - 100\ MeV$ protons from hourly High Energy Telescope (HET) measurements > 10 pfu, to mimic the list of Solar Proton Events provided by NOAA Space Weather Prediction Center using the GOES spacecraft data (http://www.swpc.noaa.gov/ftpdir/indices/SPE.txt).

Shock: The criteria of event classification are published in the following paper:
L.K. Jian, C.T. Russell, J.G. Luhmann, A.B. Galvin, K.D.C. Simunac, Solar Wind Observations at STEREO: 2007 - 2011, Amer. Inst. Phys. Proceedings of Solar Wind 13, 1539, 191-194, doi: 10.1063/1.4811020, 2013.

Explanation of Columns in the STEREO Suprathermal Proton Lists

Column 1 - Event Number
This is the number of the event in the time period investigated. The investigation period of each list can be found in the 1st row of the suprathermal event lists header.

Column 2 & 3 - Start Date/Time & Stop Date/Time
These two columns indicate the start and stop of each event. The date/time format is YYYY:MM:DD/HH:MM:SS.

Column 4 – Duration (min)
This column gives the duration of the event in minutes. Equivalent to Stop Date minus Start Date.

Column 5 & 6 – Event Averaged SW @ STA(B) (km/s) & Event STDEV of SW @ STA(B) (km/s)
The first of these columns is the average solar wind speed measured by PLASTIC-A(B) over the duration of an event. The second column is the STandard DEViation (STDEV) of the solar wind speed measured by PLASTIC-A(B) over the duration of an event. If no solar wind velocity data is available then the average and STDEV solar wind velocity are filled with NAN.

Column 7 – STA(B)-Earth Separation (Re)

This column gives the event average separation distance between the center of the Earth and the spacecraft in Earth radii.

Column 8 & 9 – Event Averaged Linear Miss (Re) & Event STDEV Linear Miss (Re)

We define the linear miss-distance as the distance that a straight line extrapolated along the locally measured interplanetary magnetic field vector misses an intersection with the planet.

$$Linear\ Miss \equiv \frac{r}{R_E} sin\left(\cos^{-1}\left(\frac{-(\vec{s} \cdot \vec{b})}{b_t r}\right)\right)$$

with r = GSE radial distance from STEREO A to Earth (km)
R_E Earth radius (km)
b_t= magnitude of b field in GSE (nT)
$\vec{s}$ = STEREO position in GSE
$\vec{a}$ = Magnetometer data in GSE
$\vec{b} = \vec{a} - \vec{s}$

The result gives the average Linear Miss to the Earth's center (a term introduced in [Desai et al., 2000]) of an event.

To produce the Linear Miss, the 1 min magnetic field data is analyzed to determine the direction of the field during an event. A straight line is then extended from the spacecraft in the direction of the measured magnetic field. The shortest distance between the extension of the magnetic field and the Earth is then the Linear Miss. The Linear Miss of all 1 min magnetic field vectors within an event are averaged to give the value in column 8. The next column is the STDEV of the Linear Miss of events in an event time period. If no magnetic field data is available, then the average and STDEV Linear Miss are filled with NAN.

Column 10 & 11 – Overlap SIR & Overlap +/- 1 Day of SIR

Prior to 2012, the SIR event list provided at http://www-ssc.igpp.ucla.edu/forms/stereo/stereo_level_3.html is used. Otherwise, the list provided at https://stereo-ssc.nascom.nasa.gov/data/ins_data/impact/level3/ by Lan Jian is used.

Using the criteria outlined in [Jian et al., 2006], we place the number of SIR time periods the event overlaps in column 10. In column 11, we place the number of SIR time periods with a day added to the end time and a day

subtracted from the start time an event overlaps. If the suprathermal proton event time occurred outside the time range inspected for SIRs then N/A is inserted in these two columns. The time range inspected for SIRs is located in the 4th row of the suprathermal event lists header. This row also contains the date the SIR list, used in the program, was last updated.

Column 12 & 13 – Overlap ICME & Overlap +/- 1 Day of ICME
Prior to 2012, the ICME event list provided at http://www-ssc.igpp.ucla.edu/forms/stereo/stereo_level_3.html is used. Otherwise, the list provided at https://stereo-ssc.nascom.nasa.gov/data/ins_data/impact/level3/ by Lan Jian is used.

We place the number of ICME time periods the event overlaps in column 12. In column 13, we place the number of ICME time periods with a day added to the end time and a day subtracted from the start time an event overlaps. If the suprathermal proton event time occurred outside the time range inspected for ICMEs then N/A is inserted in these two columns. The time range inspected for ICMEs is located in the 6th row of the suprathermal event lists header. Row 7 contains the date the ICME list, used in the program, was last updated.

Column 14 & 15 – Overlap +/- 1 Day of Shock & Overlap +/- 1 Day of Shock
Prior to 2012, the Shock list provided at http://www-ssc.igpp.ucla.edu/forms/stereo/stereo_level_3.html is used. Otherwise, the list provided at https://stereo-ssc.nascom.nasa.gov/data/ins_data/impact/level3/ by Lan Jian is used.

We place the number of shocks time's ± 1 hour an event overlaps in column 14. In column 15, we place the number of shock times ±1 day an event overlaps. If the suprathermal proton event time occurred outside the time range inspected for shocks then N/A is inserted in these two columns. The time range inspected for shocks is located in the 6th row of the suprathermal event lists header. Row 7 contains the date the shock list, used in the program, was last updated.

Column 16 & 17 – Overlap SEP & Overlap +/- 1 Day of SEP
Prior to 2012, the SEP event list provided at http://www-ssc.igpp.ucla.edu/forms/stereo/stereo_level_3.html is used. Otherwise, the list provided at https://stereo-ssc.nascom.nasa.gov/data/ins_data/impact/level3/ by Lan Jian is used.

We place the number of SEP time periods the event overlaps in column 12. In column 13, we place the number of SEP time periods with a day added to the end time and a day subtracted from the start time an event overlaps. If the suprathermal proton event time occurred outside the time range inspected for SEPs then N/A is inserted in these two columns. The time range inspected for SEPs is located in the 6th row of the suprathermal event lists header. Row 7 contains the date the SEP list, used in the program, was last updated.

Column 18, 19, & 20 – Hi Bin Triggered, Med Bin Triggered & Low Bin Triggered

These columns represent how many times each of the three E/Q bands is triggered within an event. The 'Hi Bin Triggered' column indicates how many times the 59.0-42.2keV/q band is triggered, 'Med Bin Triggered' column indicates how many times the 19.7-14.1 keV/q band is triggered, and 'Low Bin Triggered' column indicates how many times the 5.95-4.26keV/q band is triggered within an event. The 59.0-42.2keV/q band is excluded as a possible event trigger on STB before 10-21-2007 due to high background.

References

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