ECLAT In Situ data products: Cluster event identification (D210.1)

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1. Introduction

The European Cluster Assimilation Technology (ECLAT) project is funded by the Seventh Framework Programme of the European Union to provide contextual datasets for inclusion in the Cluster Active Archive (CAA) [*Laakso, et al.*, 2010] ,the repository of data from the 4-spacecraft Cluster mission [*Escoubet et al.*, 2001]. This document describes the data product provided by the Institut für Weltraumforschung der Österreichischen Akademie der Wissenschaften (IWF/OEAW) under work-package WP210 of ECLAT, "*In Situ data products: Cluster event identification*".

Three types of 'event' are identified, separate event catalogues for each type of event are provided as the final data product containing event start and end epochs, as well as representative parameters. The input data for each event search algorithm is CAA Cluster data from tail season (July-October) periods 2001-2009. The events identified are tail magnetic field dipolarization, large gradient (current) events in the magnetotail (e.g. reconnection, strong field-aligned currents), and wavy current sheets. The event catalogues have been delivered to various public access ECLAT data portals (including the OEAW ECLAT website) and will be incorporated into the CAA by the European Space Agency. Visualization of the events will be provided through the existing CAA graphical products, and quicklooks are also available on the OEAW ECLAT webpage.

Please acknowledge the European Union Framework 7 Programme, the ECLAT project FP7 grant number 263325, and the ESA Cluster Active Archive in any publications based upon the use of these data.

2. Cluster

The Cluster mission [*Escoubet et al.,* 2001] is a four spacecraft mission launched in the summer of 2000 (data provided from early 2001) to investigate the three-dimensional structure in key plasma regions of the Earth's magnetosphere. The four identical spacecraft are flown in a constellation configuration with initial perigee of 4 R_E (26,000 km) and apogee of 19.6 R_E (125,000 km), and a tetrahedron separation of ~200-10,000 km in the magnetotail region. The Cluster mission is designed to observe a complete 360 degree sweep of the Earth's magnetosphere every year, and therefore spends four months a year, July through October, in the tail plasma regions.

Each Cluster spacecraft (from here on referred to as C1, C2, C3, and C4) carries on-board a suite of instruments to investigate electric and magnetic fields, as well as ion and electron distributions, of which the Fluxgate Magnetometer (FGM), Cluster Ion Spectrometry experiment (CIS), and The Plasma Electron and Current Experiment (PEACE) are important in the identification of plasma regimes. FGM measures the magnetic field vectors, CIS measures the composition, mass and distribution of ions in the energy range ~0-40 keV/q, and PEACE measures the electron distribution between 0.59 eV and 26.4 keV. CIS consists of two separate instruments measuring the ion population, the Hot Ion Analyser (HIA) and the Composition and Distribution Function

Analyser (CODIF). While CODIF gives the mass per charge composition with medium angular resolution, allowing different ion species to be analyzed separately, HIA offers a better angular resolution but no mass separation of ion species. Of the CODIF ion species measured, measurements of H^+, the major ion population in the tail, only are used in the identification of different plasma regions and referred to in this report as CODIF H1. In identifying events we make use of CAA provided spin resolution (~4 second) moments data. This data consists of magnetic field and plasma moments (e.g. ion/electron density, temperature, velocity and magnetic field components) averaged over 1 spacecraft spin from the full 3-D particle distributions/high resolution magnetic field datasets. A full CAA description is given by *Laakso, et al.,* 2010.

3. Dipolarization Front (*DF*) Event List

3.1 Introduction

Magnetotail dipolarizations are usually associated with substorms [e.g. *Baumjohann et al.*, 1999]. After reconnection has taken place on stretched open magnetic field lines, newly connected field lines move towards the Earth releasing magnetic tension. The magnetic energy is converted to plasma kinetic energy. This creates fast flows [e.g. *Angelopoulos et al.*, 1992] and a turning of the magnetic field from the x-direction along the tail axis into the z-direction perpendicular to the current sheet in the tail, making it look like a more dipole-like field, hence the name dipolarization. However, it is not just a simple turning of the field from x into z-direction, for example, it has been observed in experimental data that the increase of the z-component is preceded by a decrease and often there is an overshoot of the z-component.

Although the term "dipolarization" may be inappropriate describing the configuration of the magnetotail, it has been expanded in meaning to include processes accompanied by transient enhancements in the z component of the Earths' magnetic field (*Bz*) that occur in the near-Earth magnetotail. In order to keep nomenclature consistent with the many magnetotail papers that have been published over the last years, we use terms and dipolarization front (*DF*) for the flow-associated transient magnetic field turnings.

The important characteristics obtained from *Ohtani et al.*, 2004, by using the observations from the Geotail spacecraft, and *Sigsbee et al.*, 2005, from the Wind spacecraft, are:

1. The magnetic field becomes more dipolar-like in the course of the fast earthward flow;
2. Sharp dipolarization tends to be preceded by a transient decrease in *Bz*, which starts along with the fast flow and is accompanied by an increase in the plasma density;
3. The plasma and total pressures decrease in the course of the fast flow.

The four spacecraft tetrahedron configuration of Cluster makes it possible to measure gradients in the magnetic field and in other parameters of the magnetotail plasma. For this reason not only the time of the *DF* onset of one spacecraft (the reference spacecraft) is given but also the time of the *DF* onset at the other spacecraft, provided that the other spacecraft observe a *DF* within the event interval of the reference spacecraft (see below). If the same event is observed by more than one spacecraft the event is only recorded once.

3.2 DF-event Search Algorithm

The starting datasets for the event search are the CAA Cluster 4-sec averaged magnetic field data obtained by FGM and plasma data from CIS-HIA, as described above. C1 and C3 only are used as reference spacecraft, due to the poorer resolution and quality of plasma data on other spacecraft (PEACE on C2 and CIS-CODIF on C4 are the only working plasma instruments on those spacecraft). To find the *DF* events between July and October for the years 2001-2009, similar selection criteria as in *Schmid et al*. [2003] are used. At the beginning, a 3 minute long sliding window with an increment of 30 seconds has been used, where the following requirements on the FGM dataset had to be accomplished:

- The spacecraft is located between -8 $Re \geq X_{GSM} \geq 19$ Re and 15 $Re \geq |Y_{GSM}|$.
- The difference in elevation angle ($\theta = tan^{-1}(Bz/Bxy)$) between minimum and maximum *Bz* during the window exceeds $\Delta\theta \geq 10°$ and ΔBz also exceeds 4 *nT*.
- The time at the maximum *Bz* is greater than the time at the minimum *Bz*.
- The elevation angle is at least in one data point (out of 45 data points in the 3-min window) greater than $\theta \geq 45°$.

A reference time corresponding to the onset of the dipolarization front has been established. This time is the start time of the sharpest increase in *Bz* within the 3 minute long sliding window and therefore called t_Bzmin. This reference time is centred at t=0-sec in a 3 minute long window (exactly plus 88 seconds and minus 88 seconds around t_Bzmin due to the 4-sec resolution of the dataset) and the following requirements within this window had to be satisfied:

- *Bz* at the reference time (t_Bzmin) is the global minimum of *Bz* within the window (Bzmin).
- The minimum of *Bz* is not the first or last data point of the window.
- The maximum of *Bz* is not the first or last data point of the window.
- The median of *Bz* before the reference time is greater than the median after the reference time.
- Data gaps within the window are not allowed.

Tail plasma region files resulting from WP220 '*In Situ data products: Cluster region and boundary identification*' of the ECLAT project have been used to maintain that the reference spacecraft remains in the plasma sheet (outer or inner). Subsequently the following requirements on the CIS-HIA plasma dataset of the reference spacecraft had to be satisfied:

- The absolute value of the x-component of the plasma flow velocity (*Vx*) is at least in one data point (out of 45 data points in the 3-min window) greater than 100 *km/s*.
- Data gaps within the window are not allowed.

This selection criterion therefore limits *DF*'s with a timescale of *Bz* enhancement (monotonic increase) up to 3 minute scale. For each event found by the reference spacecraft, C1 or C3, the magnetic field conditions above only (no plasma condition) are used to check if the same event can be found in each other spacecraft within the event interval of the reference spacecraft, and the time of *Bz* minimum and maximum recorded by the other spacecraft is recorded in the reference spacecraft event record. If the same event is found by both reference spacecraft's C1 and C3, the spacecraft in which the *Bz* minimum occurs first is taken as the reference spacecraft in the event list. That is, events seen by both C1 and C3 are only recorded once in the event list.

Notice that some of the Events found in the paper of *Schmid et al.* [2011] (S 2011-List) are not listed in the ECLAT Dipolarization Event List. This is caused by slightly different and additional selection criteria in the tail region identification process of the ECLAT project.

- In the ECLAT Dipolarization Event list (*S 2011-List*):

1. *Bz* at the reference time (t_Bzmin of the sharpest increase in *Bz* within the 3-min long sliding window) is centered in the 3-min (*2min*) window and has to be the global minimum within this window;
2. The minimum and maximum of *Bz* is not the first or last data point of the 3 minute (*2min*) window;
3. The median of *Bz* before the reference time has to be smaller than the median after the reference time; (*no such condition*)
4. The events were required to be in the plasma sheet (IPS or OPS) during the entire 3-min window in the ECLAT Tail Region Identification List (*β>0.5 during the entire 2-min window*).

Requirement 1 above was slightly different, and requirements 2 and 3 were not considered, in the *Schmid et al.* [2011] paper.

3.3 DF-event File Format

The final file format consists of one list containing all *DF* events encountered by the reference spacecraft between July and October for the years 2001 to 2009. Each record represents the event interval (always 88 seconds before and after the dipolarization front onset) and the averaged characteristic plasma and magnetic field parameters observed by the reference spacecraft, described in the section below. The parameters and their representation have been chosen in such a way, that they are expected to describe the dipolarization front characteristics.

The data files will be written in the CAA standard CEF format, containing two headers, one indicating the providence of the data and the second describing the format of the data, and the data records themselves. The CEF header is shown in Appendix 1.

Each record in a file has the following format:

2001-07-03T16:14:11Z/2001-07-03T16:17:07Z,1,18.22,5.35,1.04,7.87,2001-07-03T16:15:39Z,9999-12-31-T23:59:59Z,9999-12-31-T23:59:59Z,9999-12-31-T23:59:59Z,2001-07-03-T16:16:19Z,9999-12-31-T23:59:59Z,9999-12-31-T23:59:59Z,9999-12-31-T23:59:59Z,6.57,5.27,-69.64,0.310,0,-10.22,-14.45,-2.06

, where each parameter is separated by the ',' marker and described below.

3.3.1 event_interval__CL_CP_AUX_ECLAT_DIPOLE

ISO time range, 88 seconds before and after dipolarization front onset observed by the reference spacecraft, i.e.

2001-07-03T16:14:11Z/2001-07-03T16:17:07Z,

corresponding to a start time of the event interval of year 2001, month 07, day 03, hour 16, minute 14, second 11, and an end time of the event interval of year 2001, month 07, day 03, hour 16, minute 17, second 07.

Merged CAA Cluster moments (spin resolution, 4 seconds) are used in dipolarization front identification such that time tags of each event interval are the time tag of the first Cluster plasma moment of the reference spacecraft.

3.3.2 ref_sc__CL_CP_AUX_ECLAT_DIPOLE

The reference spacecraft, which is used to find the event. All characteristic plasma and magnetic field parameters in the following are observed by this spacecraft

3.3.3 median_Bxy___CL_CP_AUX_ECLAT_DIPOLE

Median value FGM *Bxy* (magnetic field) during event interval, observed by the reference spacecraft.

3.3.4 median_Bz__CL_CP_AUX_ECLAT_DIPOLE

Median value FGM *Bz* (magnetic field) during event interval, observed by the reference spacecraft.

3.3.5 min_max_Bz__CL_CP_AUX_ECLAT_DIPOLE

Minimum and maximum value of FGM *Bz* component of magnetic field, observed by the reference spacecraft. The minimum value is the *Bz* at the dipolarization front onset (Bzmin) and at the same moment the global minimum in the event interval. The maximum value corresponds to the *Bz* maximum observed within the 88 seconds after the onset, which is not necessarily the global maximum during the entire event interval (e.g. ±88 secs).

3.3.6 t_Bz_min__CL_CP_AUX_ECLAT_DIPOLE

Four element array consisting of the ISO time of the dipolarization front onset for each SC, corresponding to the sharpest increase in *Bz* in the event interval and at the same moment the time where *Bz* is minimum (t_Bzmin), i.e.

2001-07-03T16:15:39Z,9999-12-31-T23:59:59Z,9999-12-31-T23:59:59Z,9999-12-31-T23:59:59Z

The first time refers to the time of the dipolarization front onset observed by Cluster 1 and the others to Cluster 2, 3 and 4 respectively. The time of dipolarization front onset of other spacecraft than the reference spacecraft is only given when this time is in the event interval of the reference spacecraft. In this example Cluster 1 is the reference spacecraft and the other three spacecraft do not observe a dipolarization front in the event interval around year 2001, month 07, day 03, hour 16, minute 15 and second 39 and hence are flagged (9999-12-31-T23:59:59Z). In case that a spacecraft observes two dipolarization front onsets within the event interval of the reference spacecraft, the closer one is chosen.

3.3.7 t_Bz_max__CL_CP_AUX_ECLAT_DIPOLE

Four element array consisting of the ISO time where *Bz* is maximum within 88 seconds after the onset of the dipolarization front (*t_Bz_min*), i.e.

2001-07-03-T16:16:19Z,9999-12-31-T23:59:59Z,9999-12-31-T23:59:59Z,9999-12-31-T23:59:59Z

The first time refers to the time of Cluster 1 where *Bz* is maximum after the onset of the dipolarization front and the others to Cluster 2, 3 and 4 respectively. Only when spacecraft other than the reference spacecraft observes an event in the event interval of the reference spacecraft the time is given. In this example Cluster 1 is the reference spacecraft and the other three spacecraft do not observe a dipolarization front onset in the event interval (*t_Bz_min* is flagged) and hence also *t_Bz_max* is flagged (9999-12-31-T23:59:59Z).

3.3.8 median_Bz_plus_minus90__CL_CP_AUX_ECLAT_DIPOLE

Two element array containing the median value of the z component of the magnetic field 84 seconds after dipolarization front onset, and the median value of *Bz* 84 seconds before the dipolarization front onset, observed by the reference spacecraft. The value of *Bz* at the dipolarization front onset is excluded for both estimations.

3.3.9 median_Vx__CL_CP_AUX_ECLAT_DIPOLE

Median value of the x component of the plasma flow in the event interval measured by CIS-HIA on the reference spacecraft.

3.3.10 median_plasma_beta__CL_CP_AUX_ECLAT_DIPOLE

Median value of plasma beta (from CIS-HIA) in the event interval, observed by the reference spacecraft.

3.3.11 flag__CL_CP_AUX_ECLAT_DIPOLE

Quality flag describing if it is a multiple dipolarization or a clean dipolarization front.

Values:

0- no flag

1- Single dipolarization front.

2- Multiple dipolarization: The next Bz minimum is within 3 minutes.

3.3.12 sc_pos__CL_CP_AUX_ECLAT_DIPOLE

The x,y,z location of the reference spacecraft at the time of the dipolarization front onset in units of Earth radii and GSM coordinates.

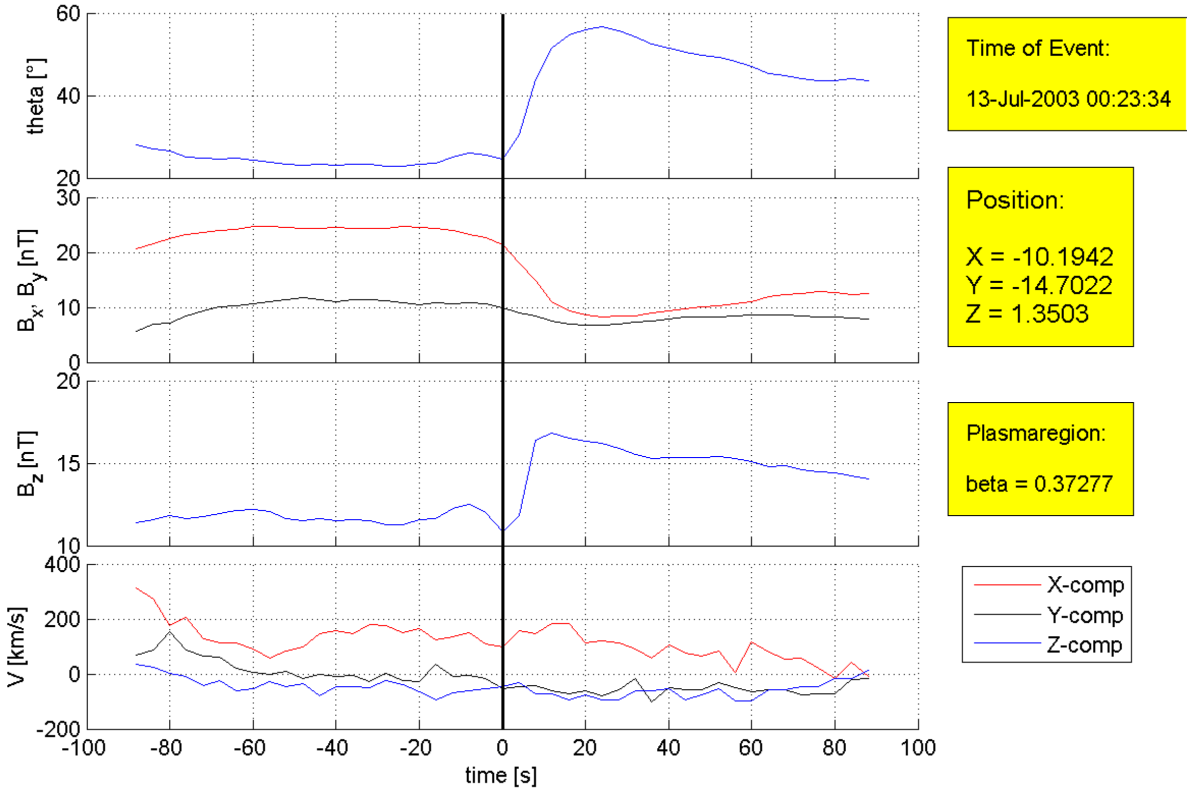

Figure 3.1. Example of a dipolarization event. Top to bottom panel, the magnetic field angle theta, *Bx* (black) and *By* (red) components of the magnetic field, *Bz*, and CIS HIA plasma velocity. The dipolarization front onset is at 00:23:34 on the 13th of July 2003 (recorded by *t_Bz_min* parameter) such that the event is recorded in the event list with the interval 2003-07-13T00:22:05Z/2003-07-13T00:25:03Z with the following entry in the event list:

2003-07-13T00:22:05Z/2003-07-13T00:25:03Z,1,21.44,12.26,10.86,16.82,2003-07-13T00:23:34Z,2003-07-13T00:23:31Z,2003-07-13T00:23:33Z,2003-07-13T00:23:34Z,2003-07-13T00:23:46Z,2003-07-13T00:23:43Z,2003-07-13T00:23:41Z,2003-07-13T00:23:42Z,15.30,11.63,112.86,0.373,1,-10.19,-14.70,1.35

4. Wavy Current Sheet (*WCS*) Event List

4.1 Introduction

The magnetotail current sheet has been shown to often exhibit a wavy or flapping motion. This motion, its causes and dynamics are not yet fully understood (see e.g. *Speiser and Ness*, 1967, *Nakagawa and Nishida*, 1989, *Zhang et al.,* 2002, 2005, *Sergeev et al.,* 2003, 2004, 2006, *Runov et al.,* 2003, 2006). The ECLAT dataset of wavy current sheet events will facilitate further investigation of this dynamical feature, increasing our knowledge and understanding of the current sheet, its internal structure and interaction with external regions and events, as well as our understanding of the magnetotail environment as a whole.

4.2 WCS-event Search Algorithm

FGM data from C1 is used to search for waves in the Pi2 period range (40-150s/25-0.66 mHz) in the central plasma sheet. The central plasma sheet is defined as $B_{XY} = (B_x^2 + B_y^2)^{1/2} < 15\ nT$, such that all waves must be completely within this range. GSM co-ordinates are used. The spacecraft must also be within the magnetotail beyond X_{GSM}=-10 *Re* and inside of $|Y_{GSM}|$=15 *Re*. Firstly, current sheet crossing intervals are selected by searching for B_x=0 crossings, and an interval of ±30 minutes taken from the crossing point. If the time between one B_x=0 crossing and the next is less than 30 minutes then those crossings are counted as one current sheet crossing interval. That is, the crossing interval will last up to 30 minutes after the final *Bx=0* crossing. Waves in the range 40-150 seconds in the band pass filtered magnetic field components (*Bx, By, Bz)* are searched for, and an interval considered a *WCS* event if waves of magnitude (peak minus trough) greater than 5 *nT* are found, and there are at least three waves of significant magnitude. That is, at least two other waves must have magnitude of at least a third of the magnitude of the largest wave in the original non-filtered magnetic field data. The last criterion is applied manually.

4.3 WCS-event File Format

The final file format consists of one list containing all *WCS* events. Each record represents the event interval and averaged characteristic plasma and magnetic field parameters observed by the reference spacecraft, and described in the section below. The parameters and their representation have been chosen in such a way, that they are expected to describe the characteristics of the wavy current sheet events.

The data files are written in the CAA standard CEF format, containing two headers, one indicating the providence of the data and the second describing the format of the data, and the data records themselves. The CEF header is shown in Appendix 1.

Each record in a file has the format:

2001-07-10T17:00:00.000Z/2001-07-10T17:15:00.000Z, 6.49,2001-07-10T17:10:00.000Z, 12,10.26, 7.63,1,2,2,2,-11.99,-14.07, -0.83

where each parameter is separated by the ‘,’ marker and described below.

All parameters are determined from C1 FGM.

4.3.1 event_interval__CL_CP_AUX_ECLAT_WAVE

ISO time range of event interval, e.g.

2001-07-10T17:00:00.000Z/2001-07-10T17:15:00.000Z,

corresponding to a start time of the event interval of year 2001, month 07, day 10, hour 17, minute 00, second 00, and an end time of the event interval of year 2001, month 07, day 10, hour 17, minute 15, second 00.

4.3.2 max_amplitude __CL_CP_AUX_ECLAT_WAVE

The maximum amplitude of the wave in filtered data.

4.3.3 max_amp_time __CL_CP_AUX_ECLAT_WAVE

The time of maximum amplitude, in ISO time format.

4.3.4 peak_frequency __CL_CP_AUX_ECLAT_WAVE

The peak frequency from the FFT in mHz.

4.3.5 mean_Bx __CL_CP_AUX_ECLAT_WAVE

Mean value of absolute *Bx* in nT.

4.3.6 mean_Bz __CL_CP_AUX_ECLAT_WAVE

Mean Value of *Bz* in nT.

4.3.7 quality __CL_CP_AUX_ECLAT_WAVE

Flag describing the quality/goodness of event determined manually by visual inspection.

1- good

2- very good (clear/regular/many waves)

4.3.8 sc_info __CL_CP_AUX_ECLAT_WAVE

Three element array containing flag which describe whether the event was seen by other spacecraft, C2, C3 and C4 respectively, 0-no FGM data for SC, 1-not seen, 2-seen.

4.3.9 sc_pos __CL_CP_AUX_ECLAT_WAVE

Three element array containing the x, y, and z location of C1 in GSM Re at the time of event maximum amplitude.

5. Large Gradient (LG) Event List

Two event lists are provided for the large magnetic field gradient events in the magnetotail. The first covers large *dBx/dz*, where *dBx* is the difference in the magnetic field *Bx* component measured by two spacecraft and *dz* the spacecraft separation in the Z direction (GSM co-ordinates), e.g. strong field-aligned current events. The second covers large *dBy/dz* events, e.g. thin current sheets.

The input datasets for the *LG* event search algorithm are the four spacecraft CAA spin resolution FGM magnetic field data in the magnetotail (X<-8 *Re*, |Y|<15 *Re*). The time tags of the four spacecraft data are then nearest-neighbour matched to produce time matched FGM datasets for each spacecraft pair (e.g. C1-C2, C1-C3 etc.).

During the years 2001-2004 all spacecraft separations in the tail are small such that it is desirable to select large gradient events over the largest spatial scale of the tetrahedron. Firstly, *dBx/dz* and *dBy/dz* are determined between all Cluster spacecraft pairs. An interval is considered to be large gradient event if the gradient (*dBx/dz* or *dBy/dz*), averaged over 1 minute, is larger than a statistically determined threshold. For 2001-2004 this threshold value is 50 nT/*Re* (corresponding to a current of approximately 6.2 nA/m^2). The search algorithm compiles a list of events for one year of tail data (July-October) for each spacecraft pair. In a one minute sliding window, shifted by ten seconds, the average magnetic field gradient is compared to the threshold. The start time (taken from the matched FGM time stamps) is the start time of the first minute to have an average greater than the threshold, and the finish time is the end of the last minute. However, if the next event interval found is within 5 minutes of the previous, then the previous event interval is extended to cover both. That is, the event interval now becomes the start of the first event until the end of the last event. As discussed below, this can result in longer event intervals containing several data points below the threshold such that the averaged parameters within the interval are now taken over a longer time interval than if the two events were considered separately. However, this does not make a significant difference to the final event lists. In each record the number of events separated by 1 minute or more which have been combined in the record interval are indicated by a flag.

Large gradients can be caused by *dz* going to zero, and two criteria are used to remove these anomalous gradients. Any events in which *dz* crosses zero are removed, they are also removed if the gradient measured is larger than 4000 *nT/Re* (which effectively removes large gradient events which are caused by spacecraft separation in the z direction going close to zero but not crossing it). As a further check, using the tail plasma region identification dataset of ECLAT WP220 (also provided by OEAW) all events in which either of the two spacecraft are in the lobe and/or undefined regions for the entire event interval, or an unidentified region is encountered in the event interval by either spacecraft, are removed (these intervals often correspond to magnetopause current observations).

All events recorded by all spacecraft pairs are then combined in a working list, sorted by the mean of *dBx* or *dBy* in the event interval. Starting at the top of the working list (largest *dBx* or *dBy*), if an event is the only event recorded in the working list for that interval (i.e. event is only seen by one spacecraft pair) then it is moved to the final list of events. If the event is seen by more than one spacecraft pair in the working list the event observed by the spacecraft pair with the largest separation will be recorded in the final event list. This procedure is continued until 30 events are selected for the final event list.

From 2005 onwards the spacecraft separations increase significantly, with usually one spacecraft pair having much smaller separation than others. Because of the different scales involved, only events from the spacecraft pair which has the smallest average separation in xy (that is, $\sqrt{x^2+y^2}$) and z are selected. The threshold gradient value used for the selection of large gradient intervals from this spacecraft pair is then selected as the three sigma value of all gradients (dBx/dz or dBy/dz) in that tail season for that spacecraft pair after data spikes are removed using criteria determined statistically (when spacecraft separation in z is less than 0.01 *Re* and gradient is less than 1000 data points are removed). The spacecraft pairs and gradient threshold values used are given in table 1. The final events given for years 2005-2009 are thus the top 30 (*dbx* or *dby* sorted) large dBx/dz and dBy/dz events for the spacecraft pair chosen. If there are less than 30 events then all are recorded.

YEAR	SC PAIR	3SIGMA dBx/dz (nT/Re)	3SIGMA dBy/dz (nT/Re)
2005	C3C4	33 (4.1 nA/m^2)	21 (2.6 nA/m^2)
2006	C1C2	71 (8.9 nA/m^2)	61 (7.6 nA/m^2)
2007	C3C4	122 (15.3 nA/m^2)	97 (12.1 nA/m^2)
2008	C3C4	37 (4.6 nA/m^2)	19 (2.4 nA/m^2)
2009	C3C4	45 (5.6 nA/m^2)	31 (3.9 nA/m^2)

Table 1. Year, spacecraft pair and gradient threshold values use in determination of large gradient events for year 2005-2009.

All events from all years (2001-2009) are then collected into one file for dBx/dz events, and one file for dBy/dz events in epoch order (their ranking in dBx/dz or dBy/dz for their year is given in the event record).

5.3 Large Gradient Event File Format

The final file format consists of two lists containing all top 30 *dBx or dBy* sorted *LG* events for large dBx/dz and large dBy/dz respectively for all years (2001-2009). Each record in a file represents the event interval and the averaged characteristic parameters.

The data files are to be written in the CAA standard CEF format, containing two headers, one indicating the providence of the data and the second describing the format of the data, and the data records themselves. The CEF header is shown in Appendix 1.

Each record in a file is of the format:

2001-07-31T22:27:50:621/2001-07-31T22:30:06:884Z,2.27,c3c4,60.73,7.29,89.75,18.16,0.220,13.36,1.60,19.75,3.99,0,26

, where each parameter is separated by the ',' marker and described below.

5.3.1 event_interval__CL_CP_AUX_ECLAT_GRADIENT

ISO time range of event interval, e.g.

2001-07-10T17:00:00.000Z/2001-07-10T17:15:00.000Z,

corresponding to a start time of the event interval of year 2001, month 07, day 31, hour 22, minute 27, second 50, millisecond 621, and an end time of the event interval of year 2001, month 07, day 31, hour 22, minute 30, second 06, millisecond 884.

5.3.2 ref_sc__CL_CP_AUX_ECLAT_GRADIENT

The spacecraft pair used to determine gradient. e.g. C1C2. The most southern spacecraft is recorded first, C1 in the example.

5.3.3 mean_dbxdz_dbydz__CL_CP_AUX_ECLAT_GRADIENT

Mean value of *dBxdz* and *dBydz* in interval between reference spacecraft pair, in nA/m^2.

5.3.4 max_dBxdz_dBydz__CL_CP_AUX_ECLAT_GRADIENT

Maximum value of *dBxdz* and *dBydz* in interval between reference spacecraft pair, in nA/m^2.

5.3.5 mean_dz__CL_CP_AUX_ECLAT_GRADIENT

Mean value of reference spacecraft separation in z (in *Re*)

5.3.6 mean_dbx_dby__CL_CP_AUX_ECLAT_GRADIENT

Mean value of *dBx* and *dBy* in interval between reference spacecraft pair.

5.3.7 max_dBx_dBy__CL_CP_AUX_ECLAT_GRADIENT

Maximum value of *dBx* and *dBy* in interval between reference spacecraft pair.

5.3.8 sc_pos__CL_CP_AUX_ECLAT_GRADIENT

x,y,z location of the most southern spacecraft in *Re* (the most southern spacecraft is placed first in the *ref_sc* parameter.

5.3.9 multiflag__CL_CP_AUX_ECLAT_GRADIENT

The number of events separated by 1-5 minutes which have been combined in the event interval.

5.3.10 region__CL_CP_AUX_ECLAT_GRADIENT

Flag of which plasma regions where encountered by the spacecraft. Regions determined by WP220. Five value integer, e.g. 01220, where the first position represents the lobe, 2nd the boundary region (BR, as defined by WP220), 3rd the outer plasma sheet (OPS), and 4th the inner plasma sheet (IPS), and fifth the neutral sheet region (NSR). Values: 0-region not seen by either spacecraft in interval, 1-region seen by one of the spacecraft pair, 2-both spacecraft encounter this region. In the example, 01220, no spacecraft encounter the lobe, one spacecraft encounters the boundary region, both spacecraft encounter the OPS and IPS, and no spacecraft encounter the NSR.

5.3.11 ranking__CL_CP_AUX_ECLAT_GRADIENT

Order of event in *dBx* or *dBy* value for that year's top 30. i.e. 1=event with largest dBx/dBy in the relevant year.

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