

ECLAT In Situ data products: Event finding and Visualization tool (D230.1)

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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., 2009], the repository of data from the 4-spacecraft Cluster mission [Escoubet et al., 2001]. This document describes the work carried out by the Institut für Weltraumforschung der Österreichischen Akademie der Wissenschaften (IWF/OEAW) under work-package (WP) 230 of ECLAT, “*In Situ data products: Event finding and Visualization tool*”.

The work carried out under this work package consists of the development, testing and refining of the search algorithms used to produce the ECLAT Cluster spacecraft in-situ data products. A full description of these data products can be found within the reports for work-packages 210 (In Situ data products: Cluster event identification) and 220 (In Situ data products: Cluster region and boundary identification). The original search code is available to download by the public. Also falling under WP230 is the development, testing and delivery of a visualization tool for the in-situ Cluster data products, which is also available to download. The first part of this report describes the search algorithm code for WP210 and WP220 data products, while the second describes the visualization tool.

2. Search Algorithm Development

2.1 WP220 In Situ data products: Cluster region and boundary identification.

This data product consists of a comprehensive list of plasma regions encountered in the nightside magnetosphere (a tail box region of $X < -8 Re$, $|Y| < 15 Re$ GSM was selected) using CAA Cluster data from periods 2001-2009. The final delivery format consists of epoch ordered lists of plasma region encountered for each of the four Cluster spacecraft, with region entry and exit times, plus averaged characteristic parameters and data flags. Due to the large input dataset, covering 9 years, four spacecraft, and at an average data resolution of four seconds, it is necessary to develop an automated region identification method. The first step in such a method is to identify the search criteria needed for accurate region identification. From a basis of previous works, extensive statistical studies of plasma and magnetic field moments for each tail season of the Cluster dataset (2001-2009), as well as analysis of individual plasma region crossings by the spacecraft, were constructed to find the best search criteria/threshold to identify different plasma regions. Different thresholds were also tested against one another and with region identifications from an external source [Grigorenko et al., 2012]. For the outer (tenuous) plasma regions of the tail magnetosphere, thresholds in plasma beta were identified as the best search criteria, while for the most inner regions a threshold in the magnetic field was selected. Five plasma regions are identified. The magnetospheric lobe, the boundary region (BR), outer plasma sheet (OPS), inner plasma sheet (IPS) and neutral sheet region (NSR). In addition to these regions, an undefined region record is used to

identify periods in which, for example, Cluster data caveats are found and therefore no plasma region can be identified. Flags in each region record also record statistically unusual regions. The details of the regions identified and threshold criteria are given in the report of WP220. Delivered publically is the set of routines and files needed to recreate the database within a zip file containing the directory /ECLAT_OEAW/. The directory /region/ contains the IDL programs, and the steps below must be taken to reproduce the dataset.

1. Download starting datasets:

1a. CAA Cluster moments: The files needed to be downloaded from the CAA (http://caa.estec.esa.int/caa_search/search.xml) for full dataset reproduction are

- a. CIS ion spectrometer: Science: Ion moments, H+ moments. Ancillary: instrument modes, CODIF caveats, HIA caveats.
- b. FGM fluxgate magnetometer: Science: Magnetic field spin resolution. Ancillary: FGM caveats.
- c. Auxiliary and support data: Auxiliary Data

For the routines provided the files must be downloaded in the cdf format.

1b. 5 Hz Neutral Sheet crossings: For each NSR region the number of multiple neutral sheet crossing found in the higher resolution (5Hz) FGM data set are recorded. The files containing every 5 Hz identified neutral sheet crossing in the tail box region used are provided in the zip file directory '/ECLAT_OEAW/region/ECLAT_5Hz_crossings/'. The code used to identify 5Hz crossings is also provided, for which the user would need to download from the CAA the FGM Magnetic field, 5 vector/second resolution dataset (~66 GB when compressed) in cef format, as well as the cef_read IDL program provided on the CAA software page.

1c. Criteria files: In addition to the plasma region boundaries, several other criteria/thresholds in various parameters are used to create the region characteristic parameters. The criteria files are provided in the zip directory '/ECLAT_OEAW/region/', can be edited by the user to create a user defined region database, and are as follows:

plasma_boundaries_CODIF_bxy.dat,
plasma_boundaries_HIA_bxy.dat,
plasma_boundaries_PEACE_bxy.dat: Contain the beta and magnetic field thresholds for different plasma region boundaries.

high_PEACE_values.dat: PEACE plasma beta value used for high beta IPS flag.

velocity_boundaries_3sigma: Contains the value of 3sigma parallel and perpendicular velocities for each year and plasma instrument, used for percentage of high speed flow region flags.

SEP_events.dat: list of Solar Proton Events compiled by the U.S. Dept. of Commerce, NOAA, Space Weather Prediction Center.

For full details of region parameters and how each threshold was determined, please see the documentation of WP220.

2. Co-ordinate conversion: CAA provides Cluster data in the GSE co-ordinate system. Since GSM is the co-ordinate system required for the ECLAT database, a conversion must take place. The conversion of co-ordinate system is made by in-house software at IWF, the code will not be provided by ECLAT. However, the conversion is relatively straightforward and many codes exist online for such conversions. Parallel and perpendicular (to the magnetic field) components of the plasma velocities must also be calculated by the user, such that the following variables must be converted to GSM and the new converted variables added and saved to the cdf files (the IDL code for doing so is provided below) for all spacecraft (here the parameters are for the C1 spacecraft, variable names will change accordingly with spacecraft):

- a. FGM cdfs:

B_vec_xyz_gse__C1_CP_FGM_SPIN to B_vec_xyz_gsm__C1_CP_FGM_SPIN.

sc_pos_xyz_gse__C1_CP_FGM_SPIN to sc_pos_xyz_gsm__C1_CP_FGM_SPIN.

IDL:

```

;add gsm to cdf files
result = size(B_vector_gsm) ;find size of B vector array
id = cdf_open(filename) ;open the cdf file
result=execute('varid =
CDF_VARCREATE(id,"B_vec_xyz_gsm__'+sc+'_CP_FGM_SPIN",/zvariable,/cdf
_double,dim=[result[1],[1]]') ;create new variable in cdf file, e.g. sc = string
variable 'C1', 'C2', 'C3', or 'C4'
result=execute('CDF_VARPUT, id, "B_vec_xyz_gsm__'+sc+'_CP_FGM_SPIN",
B_vector_gsm,/zvariable') ;read the values of the GSM vector into the
cdf variable
result = size(sc_pos_gsm) ;read size of position vector
result=execute('varid =
CDF_VARCREATE(id,"sc_pos_xyz_gsm__'+sc+'_CP_FGM_SPIN",/zvariable,/cdf
_double,dim=[result[1],[1]]') ;create new GSM position vector variable in
cdf file
result=execute('CDF_VARPUT, id, "sc_pos_xyz_gsm__'+sc+'_CP_FGM_SPIN",
sc_pos_gsm,/zvariable') ;read GSM spacecraft position into new variable
cdf_close,id ;close the cdf file

```

- b. CIS-HIA

velocity_gse__C1_CP_CIS-HIA_ONBOARD_MOMENTS to velocity_gsm__C1_CP_CIS-HIA_ONBOARD_MOMENTS.

Vperp: Perpendicular component of velocity_gsm__C1_CP_CIS-HIA_ONBOARD_MOMENTS, using B_vec_xyz_gsm__C1_CP_FGM_SPIN.

Vpar: Parallel component of velocity_gsm__C1_CP_CIS-HIA_ONBOARD_MOMENTS, using B_vec_xyz_gsm__C1_CP_FGM_SPIN.

IDL:

```
result = size(vel_gsm)
id = cdf_open(filename) ;open the cdf file
result=execute('varid = CDF_VARCREATE(id,"velocity_gsm__'+sc+'_CP_CIS-
HIA_ONBOARD_MOMENTS",/zvariable,/cdf_double,dim=[result[1]],[1])')
;create new cdf variable
result=execute('CDF_VARPUT, id, "velocity_gsm__'+sc+'_CP_CIS-
HIA_ONBOARD_MOMENTS", vel_gsm,/zvariable') ;add values to cdf
variable
result=execute('varid =
CDF_VARCREATE(id,"Vperp",/zvariable,/cdf_double,dim=[[3]],[1])') ;create
Vperp variable
result=execute('CDF_VARPUT, id,"Vperp",Vperp,/zvariable') ;add values
of vperp to vperp cdf variable
result=execute('varid =
CDF_VARCREATE(id,"Vpar",/zvariable,/cdf_double,dim=[[3]],[1])') ;create
Vpar variable in cdf file
result=execute('CDF_VARPUT, id,"Vpar",Vpar,/zvariable') ;add values Vpar to
Vpar cdf variable
cdf_close,id ;close the cdf file
```

c. CIS-CODIF_H1

velocity__C1_CP_CIS-CODIF_HS_H1_MOMENTS to velocity__C1_CP_CIS-CODIF_HS_H1_MOMENTS_GSM.

Vperp: Perpendicular component of velocity__C1_CP_CIS-CODIF_HS_H1_MOMENTS_GSM, using B_vec_xyz_gsm__C1_CP_FGM_SPIN.

Vpar: Parallel component of velocity__C1_CP_CIS-CODIF_HS_H1_MOMENTS_GSM, using B_vec_xyz_gsm__C1_CP_FGM_SPIN.

IDL:

```
id=cdf_open(filename) ;open the cdf file
result = size(vel_gsm) ;get array size
result=execute('varid = CDF_VARCREATE(id,"velocity__'+sc+'_CP_CIS-
CODIF_HS_H1_MOMENTS_GSM",/zvariable,/cdf_double,dim=[result[1]],[1])'
) ;create gsm velocity variable in cdf file
result=execute('CDF_VARPUT, id, "velocity__'+sc+'_CP_CIS-
CODIF_HS_H1_MOMENTS_GSM", vel_gsm,/zvariable') ;add values to
variable
```

```

result=execute('varid =
CDF_VARCREATE(id,"Vperp",/zvariable,/cdf_double,dim=[[3]],[1])') ;create
Vperp variable
result=execute('CDF_VARPUT, id,"Vperp",Vperp,/zvariable') ;add values
of vperp to vperp cdf variable
result=execute('varid =
CDF_VARCREATE(id,"Vpar",/zvariable,/cdf_double,dim=[[3]],[1])') ;create
Vpar variable in cdf file
result=execute('CDF_VARPUT, id,"Vpar",Vpar,/zvariable') ;add values Vpar to
Vpar cdf variable
cdf_close,id ;close the cdf file

```

d. PEACE

Data_Velocity_GSE__C1_CP_PEA_MOMENTS to
Data_Velocity_GSM__C1_CP_PEA_MOMENTS

Data_Velocity_Perp__C1_CP_PEA_MOMENTS_GSE to
Data_Velocity_Perp__C1_CP_PEA_MOMENTS_GSM

Data_Velocity_Parr__C1_CP_PEA_MOMENTS_GSE to
Data_Velocity_Parr__C1_CP_PEA_MOMENTS_GSM

IDL:

```

result = size(vel_gsm) ;get array size
result=execute('varid =
CDF_VARCREATE(id,"Data_Velocity_GSM__'+sc+'_CP_PEA_MOMENTS",/zvar
iable,/cdf_double,dim=[result[1]],[1])') ;create cdf variable
result=execute('CDF_VARPUT, id,
"Data_Velocity_GSM__'+sc+'_CP_PEA_MOMENTS", vel_gsm,/zvariable') ;add
values
result = size(vel_B_perp_gsm)
result=execute('varid =
CDF_VARCREATE(id,"Data_Velocity_Perp__'+sc+'_CP_PEA_MOMENTS_GSM"
,/zvariable,/cdf_double,dim=[result[1]],[1])')
result=execute('CDF_VARPUT, id,
"Data_Velocity_Perp__'+sc+'_CP_PEA_MOMENTS_GSM",
vel_B_perp_gsm,/zvariable')
result = size(vel_B_par_gsm)
result=execute('varid =
CDF_VARCREATE(id,"Data_Velocity_Parr__'+sc+'_CP_PEA_MOMENTS_GSM"
,/zvariable,/cdf_double,dim=[result[1]],[1])')
result=execute('CDF_VARPUT, id,
"Data_Velocity_Parr__'+sc+'_CP_PEA_MOMENTS_GSM",
vel_B_par_gsm,/zvariable')

```

3. Merge data part1: The input data for the search algorithm is time matched FGM and plasma data. The program 'match_instruments_to_FGM_v1.pro' will produce files containing the array indexes for the matched FGM and plasma instrument (CIS-HIA, CIS_CODIF, and

CIS_PEACE) data (e.g. c1_FGM_CODIF_H1_200107.dat). The original files are also provided in the directory “/ECLAT_OEAW/region/matched_locations/”.

4. Merge Data Part2: The next step is to create IDL .sav files containing the input data for the search algorithm of matched FGM and plasma data. This can be achieved through the ‘create’ procedure within ‘mainpart1.pro’, for which the IDL routines contained within ‘routines.pro’ must be first compiled. The IDL save files will be produced and deposited in the main directory, e.g. c2_200709_data_PEACE.sav. Only one plasma instrument is used to identify plasma regions per spacecraft and year, and therefore only one sav file for the required instrument is needed.
5. Search Regions: The main search algorithm code and region file creation is achieved through the ‘year_run_files’ procedure within mainpart2.pro, for which the routines within routines2.pro must be compiled. This creates yearly region files, e.g. 2001ECLAT_C4_REGION_V1.dat, for the given year, spacecraft and plasma instrument (as discussed in report WP220, one plasma instrument is used for one tail season). The plasma instrument used is recorded within each region record.
6. Fine Tuning: The procedures within ‘remove_sheath_intervals_C2_v1.pro’ remove possible magnetosheath entry regions from the C2 region files by removing sheath intervals found in other spacecraft (identified by plasma flow velocity, which is unreliable on C2 PEACE) for the years 2001-2004, when the spacecraft are in close proximity. This can only be run after all yearly region files have been created.

The contents of the zip file is given in the appendix.

2.2 WP210 In Situ data products: Cluster Event Identification.

Three types of event have been identified under WP210, tail magnetic field dipolarization, large gradient (current) events in the magnetotail (e.g. reconnection, strong field-aligned currents), and wavy current sheets.

2.2.1 Dipolarization Event List

The starting datasets for the event search are the CAA Cluster 4-sec averaged magnetic field data (FGM spin resolution) and plasma data from CIS-HIA (CIS Ion moments). Spacecrafts 1 and 3 only are used as reference spacecraft, due to the poorer resolution and quality of plasma data on other spacecraft. To find the *DF* events between July and October for the years 2001-2009, similar selection criteria as *Schmid et al., 2011* 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 $-8Re \geq XGSM \geq 19 Re$ and $15Re \geq |YGSM|$.
- The difference in elevation angle (θ) between minimum and maximum B_z during the window exceeds $\Delta\theta \geq 10^\circ$ and ΔB_z also exceeds 4 nT.
- The minimum of B_z is not the first or last data point of the window.
- The maximum of B_z is not the first or last data point of the window.

- The time at the maximum B_z is greater than the time at the minimum B_z .
- The elevation angle is at least in one data point (out of 45 data points in the 3-min window) greater than $\theta \geq 45^\circ$.

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 B_z within the 3 minute long sliding window and therefore called t_{Bzmin} . This reference time is centered at $t=0s$ in a 3 minute long window (actually 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:

- B_z at the reference time (t_{Bzmin}) is the global minimum of B_z within the window (B_{zmin}).
- The median of B_z 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 sufficed:

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

This selection criterion therefore limits DF 's with a timescale of B_z enhancement (monotonic increase) less than 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 the other spacecraft within the event interval of the reference spacecraft, and the time of B_z 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 B_z minimum occurs first is taken in the event list. That is, the C1 and C3 events are only recorded once in the event list.

The search algorithm was developed in the Matlab programming language, and is provided in a zip file for download from the CAA. A further description of the event list, and full description of output files, is given in the report of WP210.

2.2.2 Large gradient event list

The four spacecraft of the Cluster mission allow gradients in the Earth's magnetic field to be measured. Two event lists are provided per year, one for large (statistically) dB_x/dz (where dB_x is the difference in the x component of the magnetic field between two spacecraft, and z is the spacecraft separation in the z direction) and one for large dB_y/dz .

The input data set for the search algorithm (written in the IDL programming language) is CAA provided Cluster spin resolution FGM magnetic field data. To reproduce the dataset, the users must download the 4 second average spin resolution data from the CAA for each of the 4 Cluster

spacecraft. Since the time tags of the spin resolution FGM data differs between spacecraft, time matching must be performed. Monthly cdfs have been used (e.g. C1_CP_FGM_SPIN__20010701_000000_20010801_000000_V051214.cdf). CAA provided data only in the GSE co-ordinate system, such that conversion to the GSM co-ordinate system used by ECLAT must be carried out. This is done in-house at IWF and the code will not be provided (such conversion codes are available online). The following parameters must be converted to GSM and new variables saved to the cdf files, as described in 2a of section 2.1 of this report:

B_vec_xyz_gse__C1_CP_FGM_SPIN to B_vec_xyz_gsm__C1_CP_FGM_SPIN.

sc_pos_xyz_gse__C1_CP_FGM_SPIN to sc_pos_xyz_gsm__C1_CP_FGM_SPIN.

The following steps must then be taken to reproduce the dataset, using the provided IDL routines which have been made publically available and will be made available on the CAA. The routines discussed below can be found in the zip file directory '/ECLAT_OEAW/events/'.

1. A dataset of time matched FGM data is created (create_matched_data.pro). That is, from a pre-determined dataset of the array indices of matched FGM data for each spacecraft pair (e.g. C1-C2 etc.), IDL .sav files are created for each pair (e.g. c1c22001_gradient_data.sav), containing the FGM magnetic field vector and spacecraft position in GSM co-ordinates.
2. Large gradient intervals are selected by searching for intervals in which the gradients are larger than a statistically determined threshold. The intervals and data are saved in IDL .sav files (e.g. allgt50grad_c1c22001dbxdz.sav, and allgt50grad_c1c22001dbydz.sav, where 50 is the threshold value used for large gradient). In the years 2001-2004 separate files for each spacecraft pair (e.g. C1-C2, C1-C3 etc.), year and gradient (dBx/dz or dBy/dz) are needed, and can be produced using the code found in search_gradient_v1.pro. As discussed above and in the data product report for WP210, in the years 2005-2009 only the spacecraft pair with the most steady, smallest separation in xy and z are needed. A threshold value for large gradient of 50 (nT/Re) has been used in the years 2001-2004, while the threshold values and spacecraft pairs used in the years 2005-2009 are given in table 1 of ECLAT report WP210.
3. Two separate codes are then used to select the top 30 large gradients events, separate lists for dBx/dz and dBy/dz, for years 2001-2004 and 2005-2009. In the years 2001-2004 the search algorithm (find_top30_gradient_multisc_ECLATV1.pro) sorts all large gradient events from all spacecraft pairs into one array, sorted by the magnitude of dBx or dBy. The list is searched beginning with the largest current event until 30 events are selected. For each event selected in the initial list, it is checked whether any other spacecraft pairs have recorded an event within this interval further down the dBx or dBz sorted list. If matches are found and the spacecraft separation in z is not largest for the first event found then the first event is not recorded in the final top 30 list (the interval may still appear in the final list if the event recorded by the spacecraft pair with largest separation in z falls within the final top 30 dBx/dBy sorted events) such that larger spatial scale events are recorded. In the years 2005-2009 the spacecraft separation is

much increased, with one spacecraft pair, in general, having much smaller and more steady separation than others. The spatial scales are now such that we wish to only select events from those spacecraft pairs with smallest separation. Therefore, the search algorithm in the years 2005-2009 (find_top30_gradient_singlepair_ECLATV1.pro, for both search algorithms routines_gradientV1.pro file must also be compiled) identifies the top 30 events as above using only one spacecraft pair where the spacecraft pair used has been chosen to be the spacecraft with least and most steady separation in the xy ($\sqrt{X^2 + Y^2}$) and z directions for each year. Table 1 of the WP210 report lists the spacecraft pairs used. More comments and instruction are found in the code itself.

2.2.3 Wavy Current Sheet Events

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 $B_{XY} = (B_x^2 + B_y^2)^{1/2} < 15 \text{ nT}$, such that all waves must be completely within this range. GSM co-ordinates are used. The spacecraft must also be within the magnetotail beyond $X_{\text{GSM}} = -10 \text{ Re}$ and inside of $|Y_{\text{GSM}}| = 15 \text{ Re}$. 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 $B_x=0$ crossing. Waves in the range 40-150 seconds in the band pass filtered magnetic field components (B_x , B_y , B_z) 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.

3. Visualization Tool

Early in the project it was realized that to best facilitate the use of ECLAT region and event datasets by the user, visualization of the datasets should be incorporated with the excellent graphical products already existing within the CAA. After discussion with the CAA it was decided that a plotting option for ECLAT region and event datasets will be added to the existing CAA graphical products interface. This will be a task completed by the CAA. It has been discussed that this may take the form of a plotting panel of time on the x-axis and four horizontal lines whose colour represents the ECLAT plasma region for each of the four Cluster spacecraft. In addition, vertical lines will show the time of ECLAT identified events.

In addition to the visualization of plasma region and event datasets on the CAA as above, a region plotting tool written in the IDL programming language is made available to download by the public. The program header, describing its use, is shown below, and example output in the appendix. The plotting tool and search algorithm code of WP220 can be combined and edited by the user to produce user defined region files and plots.

```

,*****
,*****
; PROJECT:   ECLAT
; MODULE:   IDL Cluster Region Plotting Tool
; LANGUAGE: IDL 8.1
; AUTHOR:   peter.boakes@oeaw.ac.at
; DATE:    2013-07-10
;
; Description: This tool plots time-series of CAA Cluster spin resolution data
; with ECLAT plasma region identifications (http://www.iwf.oeaw.ac.at/eclat/).
; Three plot windows are produced, the first plots the Cluster spin resolution
; data, the second the averaged plasma region parameters provided by ECLAT,
; and the third the plasma region dataset flags and caveats.
; The plasma region is represented by the background colour.
; The key is shown in a separate window.
; The user can choose to plot to screen or file.
; Each plot is for the specified Cluster spacecraft.
; The program asks the user for the Cluster spacecraft number,
; year and month of interval (once one year and months worth of
; data has been loaded by the program the user is able to plot any
; interval for that spacecraft in that month), starting day, hour, and
; minute of the plot interval, and plot interval duration in minutes.
;
; In order to produce the plots several files need to be downloaded by the user.
; The Spin resolution Cluster data must be downloaded in monthly cdf files from
; the CAA. For each year and month and Cluster spacecraft the relevant magnetic
; field data from FGM, and plasma data for instruments CIS-CODIF_H1, CIS-HIA,
; & PEACE must be downloaded (e.g.
C1_CP_FGM_SPIN__20010701_000000_20010801_000000_V051214.cdf).
; Examples of the format and directory tree are found within the download package.
; Since the ECLAT plasma regions are calculated in the GSM co-ordinate system
; and the original Cluster data is in GSE co-ordinates, conversion to GSM must
; be carried out by the user. That is, the following parameters
; must be converted to GSM and new GSM variables saved to the cdf files (thus the time consuming
; process of conversion is only required once, see documentation for IDL help in adding variables to
; cdfs):
; e.g.
; FGM data (e.g file C1_CP_FGM_SPIN__20010701_000000_20010801_000000_V051214.cdf):
; B_vec_xyz_gse__C1_CP_FGM_SPIN to B_vec_xyz_gsm__C1_CP_FGM_SPIN.
; sc_pos_xyz_gse__C1_CP_FGM_SPIN to sc_pos_xyz_gsm__C1_CP_FGM_SPIN
; CODIF_H1 (e.g. file
C1_CP_FGM_SPIN__20010701_000000_20010801_000000_V051214.cdf):
; velocity__C1_CP_CIS-CODIF_HS_H1_MOMENTS to velocity__C1_CP_CIS-
CODIF_HS_H1_MOMENTS_GSM

```



```

; HIA (e.g. file C1_CP_CIS-
HIA_ONBOARD_MOMENTS__20010701_000000_20010801_000000_V100213.cdf):
; velocity_gse__C1_CP_CIS-HIA_ONBOARD_MOMENTS to velocity_gsm__C1_CP_CIS-
HIA_ONBOARD_MOMENTS
;
; In order to plot the xy component the perpendicular and parallel plasma velocities, the users
must
; also calculate and add the parameters 'Vperp' and 'Vpar' to the HIA and CODIF_H1 cdfs. That
is,
; Vperp and Vpar is a three elements array containing the perpendicular and parallel to the
magnetic field
; components in the x,y, and z directions respectively, calculated from, e.g.,
; velocity__C1_CP_CIS-CODIF_HS_H1_MOMENTS_GSM and
B_vec_xyz_gsm__C1_CP_FGM_SPIN.
;
; PEACE data (e.g.
C1_CP_PEA_MOMENTS__20010701_000000_20010801_000000_V101014.cdf):
; Data_Velocity_GSE__C1_CP_PEA_MOMENTS to
Data_Velocity_GSM__C1_CP_PEA_MOMENTS
; Data_Velocity_ComponentParallelToMagField__C1_CP_PEA_MOMENTS to
; Data_Velocity_Parr__C1_CP_PEA_MOMENTS_GSM
; Data_Velocity_ComponentPerpendicularToMagField__C1_CP_PEA_MOMENTS
; Data_Velocity_Perp__C1_CP_PEA_MOMENTS_GSM
;
; If the conversion to GSM is not carried out no data will be plotted unless the gse keywords are
; are supplied. A warning is printed if GSE co-ordinates are selected, and is not recommended to
choose
; such a plot, as the ECLAT plasma regions where determined used thresholds in GSM magnetic field,
and
; plotted region parameters and background region colours are in the GSM co-ordinate system.

;
; The ECLAT daily region files must also be downloaded from http://www.iwf.oeaw.ac.at/eclat/ (see
example files).
;
;
; The European Cluster Assimilation Technology (ECLAT) project
(http://www2.le.ac.uk/departments/physics/research/rspp/missions/eclat/eclat-european-cluster-
assimilation-technology/) is funded by the
; Seventh Framework Programme of the European Union to provide contextual datasets
; for inclusion in the Cluster Active Archive. As part of the ECLAT project
; Institut für Weltraumforschung der Österreichischen Akademie der Wissenschaften comprehensive
have developed a list of plasma regions encountered in the nightside magnetosphere using CAA
Cluster data from periods 2001-2009.

```

```

; Before using this plotting tool it is strongly recommended that the user read
; the ECLAT documentation describing this dataset, available online from
; http://www.iwf.oeaw.ac.at/eclat/. Please acknowledge the European Union
; Framework 7 Programme, the ECLAT project FP7 grant number 263325, and the ESA
; Cluster Archive in any publications based upon the use of these data.
;
;
;
; Usage:
;

```

```

        plot_regions,year=year,month=month,Clusterpath=Clusterpath,regionpath=regionpath,outp
ath=outpath,gse=gse,gse_vel=gse_vel,gse_FGM=gse_FGM
;

```

```

; year = year 2001-2009
; month = tail season month (07-10)
; Clusterpath = location of the Cluster spin resolution data cdfs,
;     if not specified=user homedir, e.g. /home/user/, +cdf_files/'
; regionpath = location of the daily plasma region files,
;     if not specified = user homedir, e.g. /home/user/, +'region_files/'
; outpath = location to write plots,
;     if not specified = user homedir, e.g. /home/user/, +plots/'
; gseplot = gseplot. Set to value to plot magnetic field and plasma velocity in GSE.
; gse_vel = gse_vel. Set to value to plot plasma velocity in GSE.
; gse_FGM = gse_FGM. Set to value to plot magnetic field in GSE.
;
;
;
;Version 1.1
;*****
;*****
;*****
;*****

```

Appendix

Contents of zip file: 'ECLAT_OEAW'

/region/ ;directory for region identification

produce_NS_crossing_files_v1.pro: used to create list of 5HZ neutral sheet crossings in the specified tail box.

match_instruments_to_FGM_v1.pro: creates files containing array indices of matched FGM and plasma instrument data from monthly CAA cdf data files.

routines.pro & mainpart1.pro: contains routines for created IDL .sav files of matched FGM and instrument data for search algorithm input.



routines2.pro &mainpart2.pro: contains procedures for creating the yearly region files.

high_PEACE_values.dat: PEACE plasma beta value used for high beta IPS flag.

plasma_boundaries_CODIF_bxy, plasma_boundaries_HIA_bxy,
plasma_boundaries_PEACE_bxy: Contains the beta and magnetic field thresholds for different plasma region boundaries. Can be edited by the user if so wished.

velocity_boundaries_3sigma: Contains the value of 3sigma parallel and perpendicular velocities for each year and plasma instrument, used for percentage of high speed flow region flags.

SEP_events.dat: list of Solar Proton Events compiled by the U.S. Dept. of Commerce, NOAA, Space Weather Prediction Center.

/5_Hz_FGM/

If the user wished to use the program provided to recalculate high resolution neutral sheet crossings the CAA 5Hz FGM cdfs should be downloaded here.

/cdfs/

The original monthly CAA cdf files must be downloaded here (as described above). Example files and directory tree is given.

/ECLAT_5Hz_crossings/ (year/month/)

Contains the high resolution (5Hz) FGM neutral sheet crossing identifications using for multi neutral sheet crossing flag of NSR regions.

/matched_locations/

Contains the files of matched FGM and plasma data array indices from the monthly cdf files.

/events/ ;directory for event identification code

Code_dip_list.txt: algorithms for dipolarization list creation.

create_matched_data_v1.pro: IDL code for creation of nearest neighbor matched FGM data.

search_gradient_v1.pro: search magnetic field gradients between spacecraft pairs to find intervals of above the given threshold value.

find_top30_gradient_multisc_ECLATV1.pro: create list of top 30 large gradient events selected from all spacecraft pairs.

find_top30_gradient_singlepair_ECLATV1.pro: create list of top 30 large gradient events selected from given spacecraft pair.



Routines_gradientv1.pro: routines must be compiled in IDL for find_top30_gradient programs.

/tool/ ;directory of visualization tool

ECLAT_region_plotting_toolv1.pro: the IDL plotting tool program

/072001/

Example of required Cluster data input files and directory tree needed for plotting tool to plot data/regions from July 2001.

/regions/

Plotting tool input ECLAT region files needed to plot July 2001.



Example plotting tool output.

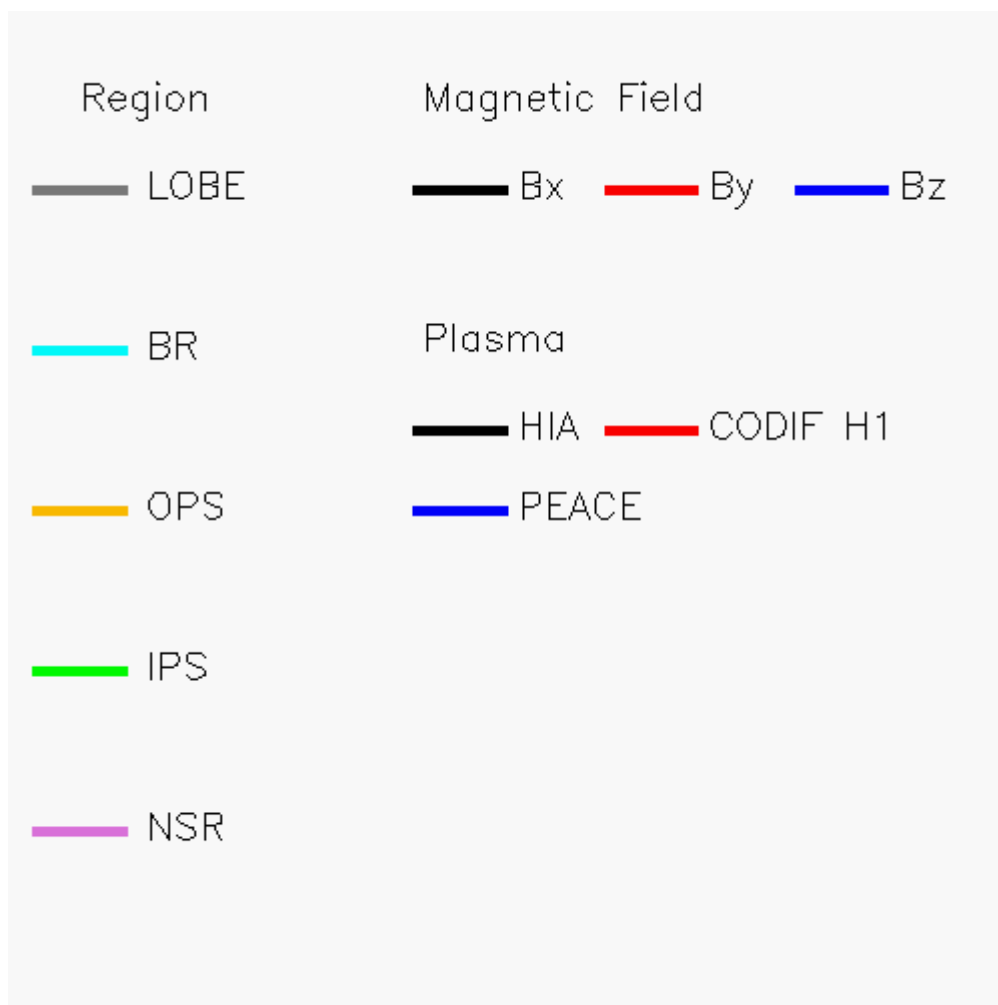


Figure 1.1. Region plotting tool key.

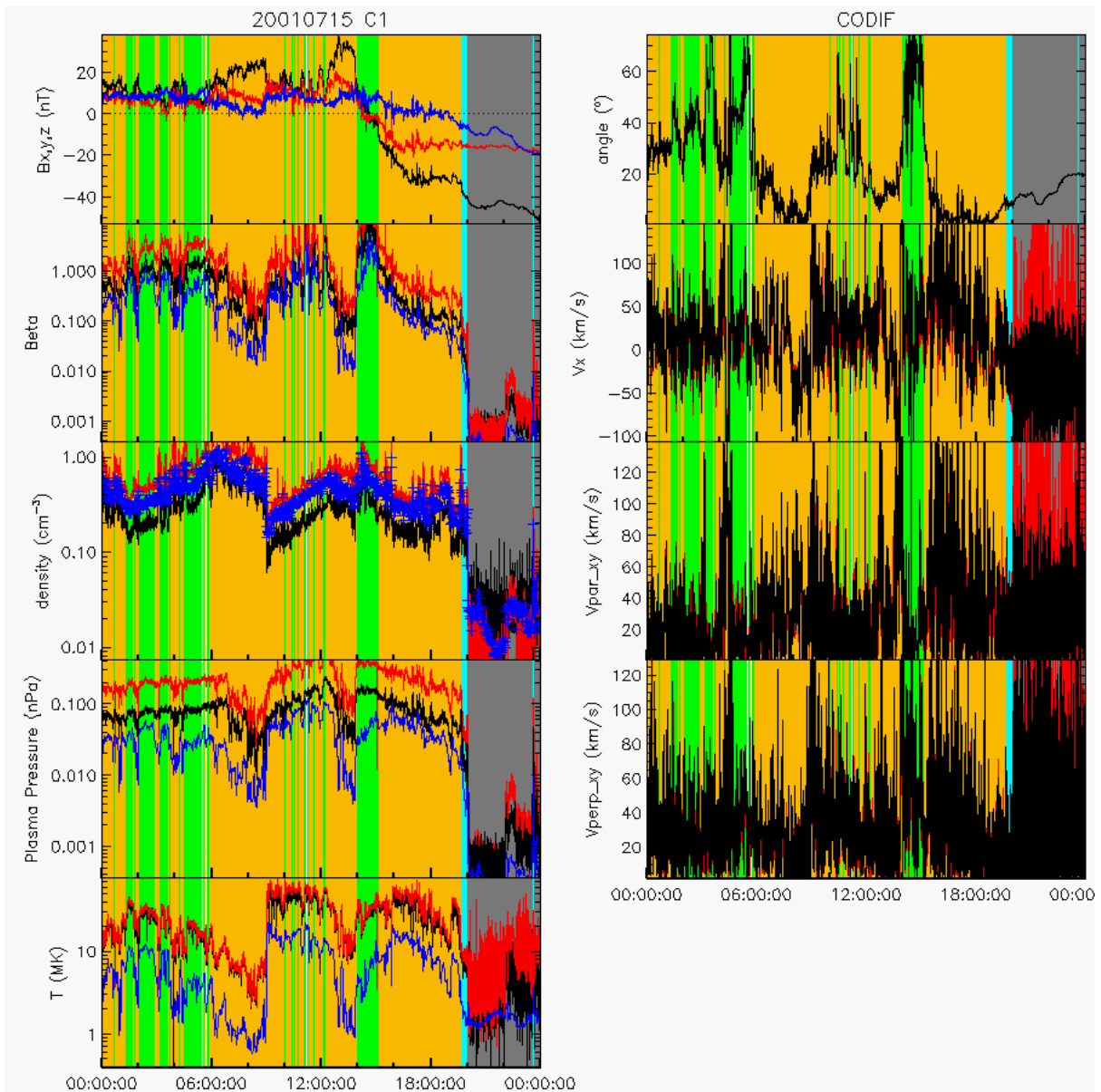


Figure 1.2: Region plotting tool output 1, Cluster spin resolution data. Background colour represents plasma region.

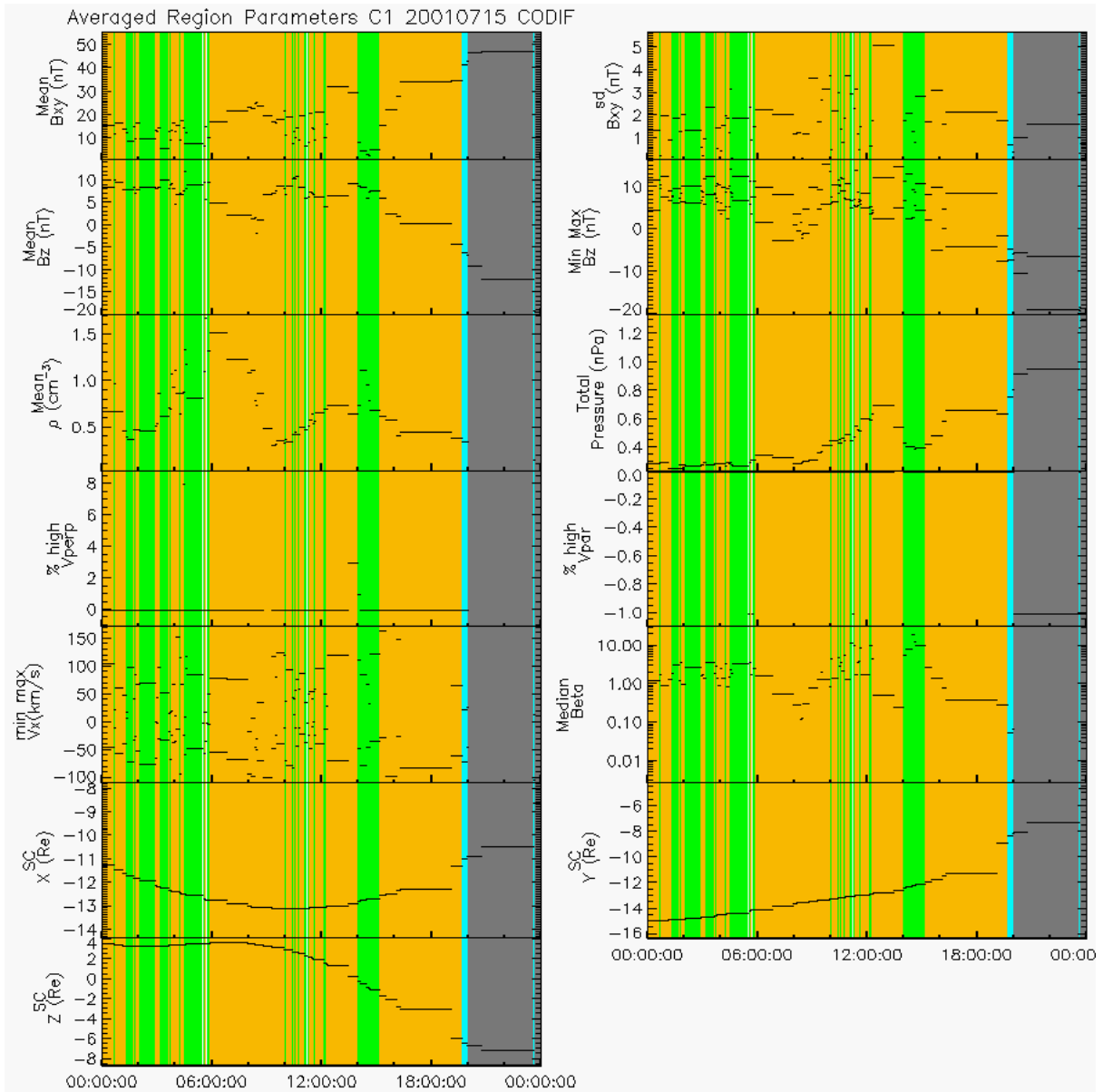


Figure 1.3: Cluster region plotting tool output 2, averaged ECLAT plasma region parameters.

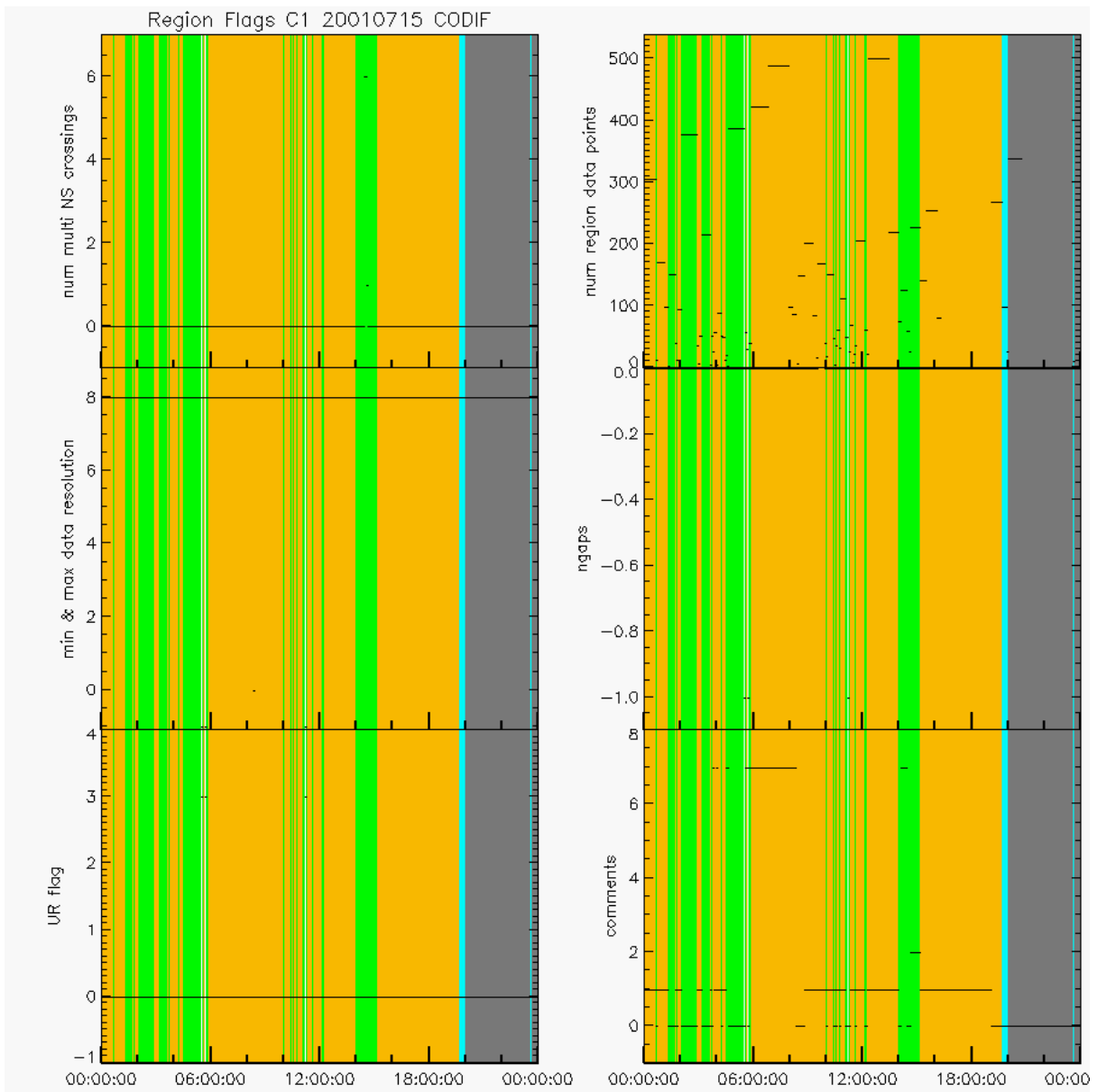


Figure 1.4: Region plotting tool output 3, ECLAT plasma region data flags.

References

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