CLUSTER WBD DATA AND THE CLUSTER ACTIVE ARCHIVE

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ABSTRACT

The Cluster Wideband (WBD) Plasma Wave Receiver obtains high resolution waveform measurements over approximately 4% of the Cluster orbit. The frequency range covered by WBD is 100 Hz to 577 kHz with time between samples ranging from 5-36 microseconds. Both electric field and magnetic field antennas can be used as the sensor. The data are telemetered directly to the ground in real time to the Deep Space Network ground stations. Cluster WBD contributions to the Cluster Active Archive (CAA) currently consist of the following: overview calibrated spectrograms (multi-spacecraft if available) of ~ 1-4 hours in duration; 30-second uncalibrated full-time resolution spectrograms (one spacecraft only per spectrogram); listings of the time periods during which WBD data were taken; and documentation on the WBD instrument, its various modes and interpretation issues. Digital WBD waveform data are available through the Iowa WBD website, and through the Cluster PEACE High Resolution Data System at Southwest Research Institute in San Antonio, Texas. In order to provide WBD digital waveform data through the CAA, we are assessing the possibility of the CAA mirroring the SwRI website.

1. THE WBD PLASMA WAVE INVESTIGATION

The Cluster Wideband (WBD) Plasma Wave Receiver is a digital wide-band receiver that provides very high-resolution waveforms over a wide range of frequencies from 100 Hz to 577 kHz with a time resolution of 5-36 microseconds between samples depending on the mode. WBD makes measurements along one axis only and uses only one electric or magnetic field sensor at any given time. WBD receivers are mounted on each of the four Cluster spacecraft. A description of the WBD instrumentation and investigation is available in [1]. The first results obtained from the Cluster WBD investigation can be found in [2]. The WBD publication list is provided on the WBD website (see Section 4).

With one exception in March 2001, all WBD data obtained during the Cluster Mission Operations Phase have been obtained by directly downlinking the data to a Deep Space Network ground station at about 220 kbits/second in real time, rather than recording the data onboard at 73 kbits/second. Because WBD data are not routinely recorded onboard, WBD receives only about 4% orbit coverage (2 hours per spacecraft per 57-hour orbit). Thus, all of WBD's operations have been targeted to specific regions of Earth for which high time resolution waveform measurements will be crucial in understanding the physics of that region or of the region from which Cluster observes wave emissions remotely.

A 4 ms sample of the calibrated WBD time series data obtained in the magnetosheath using the 77 kHz bandpass filter with a base frequency of 0 kHz is shown in Fig. 1. This example shows a series of solitary waves in the form of very short time duration pulses, which are typical for this region. The calibrated electric field scale is given on the left-hand vertical axis for the WBD data plotted as a solid black line with time provided on the horizontal axis. The angle of the electric field antenna used by WBD to the magnetic field, using the Cluster FGM data, is plotted as a dashed red line with the scale given on the right-hand vertical axis.

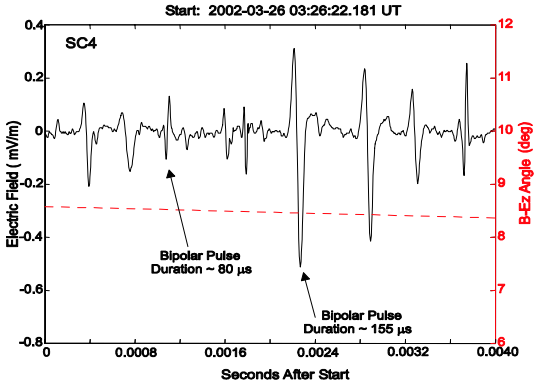

Fig. 1. Four ms sample of WBD waveform data obtained in the magnetosheath on 26 March 2002. (From [3])

2. WBD ARCHIVING PLANS

The WBD archiving team at The University of Iowa will archive data graphics for the first four years of the Cluster mission, documentation, and software at the Cluster Active Archive (CAA). Below we describe these in more detail.

2.1 Graphics

Two types of graphical plots will be archived at the CAA. The first is the overview plot and the second is the browse plot, both containing WBD data in spectral form. The overviews are intended for locating wave features for study. The browse plots are intended for investigating wave features in minute detail. These two plot types are described below.

Overview Plots

WBD data are typically obtained for data periods on the order of one to four hours, sometimes more or less, and from just one spacecraft or from up to four spacecraft simultaneously. These data are obtained from targeted points in the orbit where WBD wave data are expected to provide insight into the physics of the targeted region or into the region from which WBD is observing wave emissions remotely. WBD overview plots, in postscript format, contain one panel for each spacecraft from which there are WBD data for each data period, as well as ephemeris data in tabular form beneath the last panel (see Fig. 2). These ephemeris data apply only to the spacecraft for which data are plotted in the panel immediately above. The spacecraft panels contain the WBD data in spectral form, with time plotted on the horizontal axis, frequency on the vertical and power spectral density represented by color according to the color bars on the right-hand side of the figure.

Because WBD has the capability of using either the electric or magnetic field antennas as its sensor, and has the added capability of converting its base frequency from 0 kHz up to 125, 250 or 500 kHz, WBD often cycles between the two antennas and the various conversion modes during any one data period. Thus, we have generated overview spectrograms where the data obtained in any one mode are dilated across the data gaps created when the receiver is in a different mode. The reason for doing this is to provide continuity of the data across the mode changes so that one can more easily find data features of interest not interrupted by the white blocks created by the data gaps. These plots have been labelled "Not for Publication" on the left-hand side of the plot, with a description of the specifics of the data dilation contained on that plot. If WBD is not cycling between modes, this note will not be applied to the plot. Figs. 2 and 3 are examples where cycling is taking place. Fig. 2 shows the electric field power spectral density for a perigee crossing on 17 November 2003 where the electric field data are sampled 42 seconds out of every 52 with the remaining 10 seconds consisting of magnetic field sampling with the electric field data being dilated across the gaps created when the magnetic field data are being sampled; Fig. 3 shows the corresponding magnetic field power spectral density for the same time period with dilation across the electric field sampling periods. The ephemeris data shown at the bottom applies only to spacecraft 4, which is the bottom panel in both figures. The provided ephemeris data are, top row to bottom, distance from Earth in R_E, geomagnetic latitude in degrees, geomagnetic local time in hours, and L value.

Browse Plots

The WBD browse plots are 30-second, full resolution spectrograms, in gif format, from one spacecraft only containing instrument status and ephemeris data (see Fig. 4). These plots are used to investigate the fine features of the wave emissions since no averaging takes place in these plots.

WBD status data are contained in the top part of the plot. The top panel contains the value of the automatic gain control (AGC) level in dB, with the scale shown on the left-hand side of the panel. Following this are color coded lines showing the source of the data (whether through DSN, or through recording onboard in one of two modes, filtering or duty cycling), the antenna being used (one of four options), the resolution of the data (1, 4 or 8 bit), and the translation or base frequency of the data (0, 125, 250 or 500 kHz) with the color key on the right-hand side. This is followed by the time-frequency spectrogram with color representing the power spectral density, in dB above noise level, according to the color bar on the right-hand side. The date and start time of the plot, as well as the Cluster spacecraft number, are given to the right of the color bar, with the seconds of the start minute given on the horizontal scale of the plot. Finally, the ephemeris data (same parameters as on the overview plots) applicable to the start of the plot are provided in the box in the lower-right hand corner of the plot. An example of a typical browse data plot taken from a 30-second time period contained in Figs. 2 and 3 is provided in Fig. 4.

2.2 Documentation

WBD will be archiving several documents that provide information and guidance for using WBD data. These are as follows:

- Instrument description
- Table of data availability, showing instrument modes and whether ASPOC and EDI are operating
- Digital listing of data availability containing start and stop times, spacecraft, conversion frequency, bandwidth, antenna and resolution (see Fig. 5 for a short sample of this listing)
- Special event tables showing time periods when special operations were carried out for certain science targets or with other missions and ground-based facilities

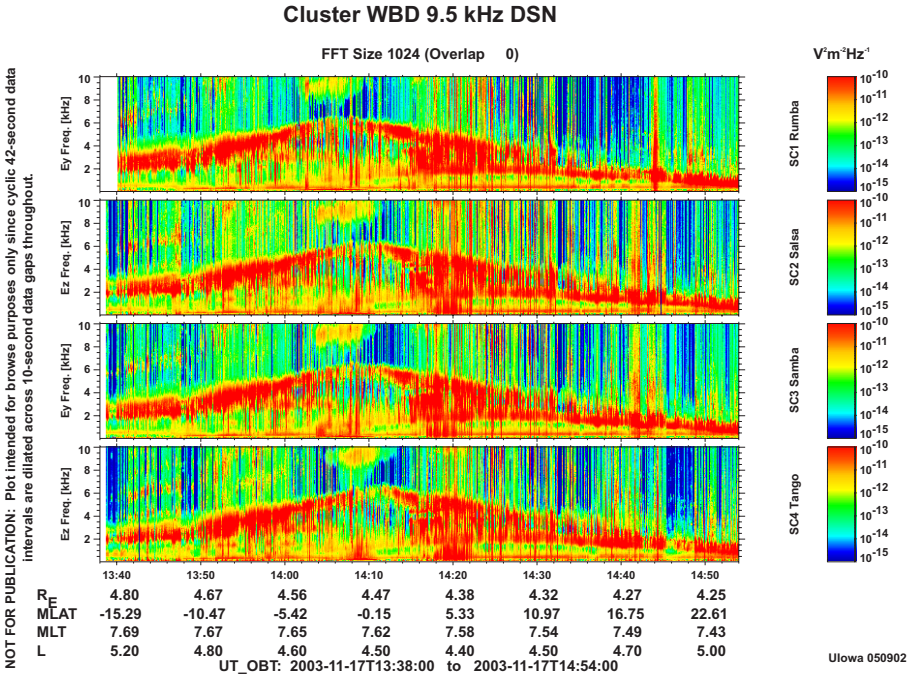

Fig. 2. Sample WBD overview spectrogram covering 1.3 hours in time obtained at perigee showing intense chorus emissions using the electric field sensor.

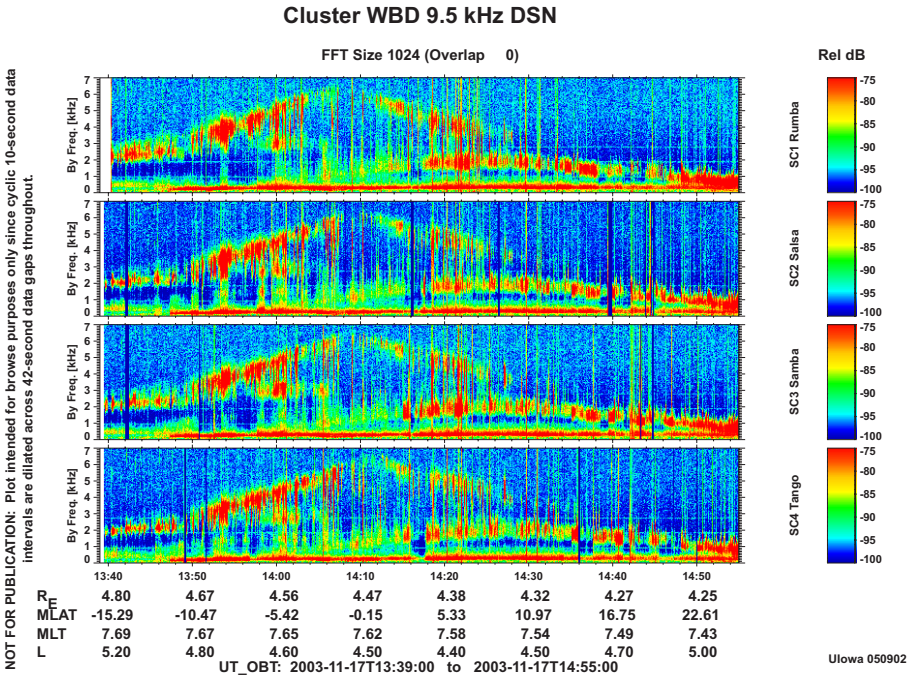

Fig. 3. Sample WBD overview spectrogram covering the same time period as Fig. 2 but using the magnetic field sensor.

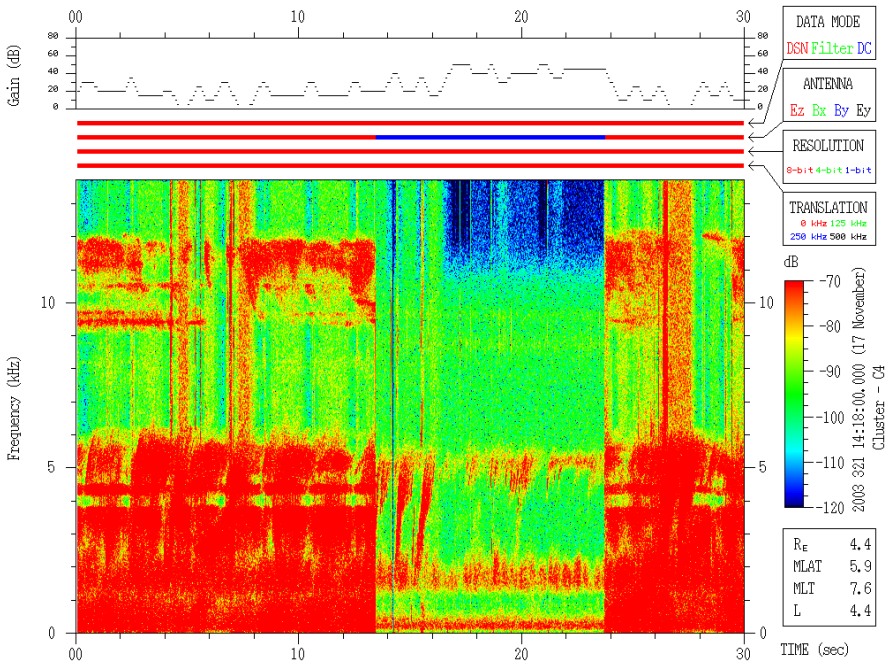

Fig. 4. Sample WBD browse plot covering a 30-second time period included in Figs. 2 and 3, showing the switching from electric to magnetic field sensors.

- Interpretation issues, which discuss various known problems with the data and caveats with regard to known interferences, etc.
- Format of WBD Level 1 validated data DVDs
- Format of WBD Level 1 data files
- Description of various WBD data time tags
- Calibration function/table

2002-03-25T14:29:37.024Z	2002-03-25T14:30:07.766Z	C4	0 kHz 9.5 kH Ez 8 bits
2002-03-25T14:29:37.045Z	2002-03-25T14:30:16.367Z	C2	0 kHz 9.5 kH Ez 8 bits
2002-03-25T14:30:16.217Z	2002-03-25T14:30:25.829Z	C1	0 kHz 9.5 kH By 8 bits
2002-03-26T01:06:00.264Z	2002-03-26T03:05:25.111Z	C2	0 kHz 77 kHz Ez 8 bits
2002-03-26T01:29:06.104Z	2002-03-26T03:50:57.412Z	C4	0 kHz 77 kHz Ez 8 bits
2002-03-26T01:30:20.778Z	2002-03-26T03:50:54.714Z	C3	0 kHz 77 kHz Ez 8 bits
2002-03-26T17:04:08.656Z	2002-03-26T19:05:05.651Z	C4	0 kHz 77 kHz Ez 8 bits
2002-03-26T17:04:16.287Z	2002-03-26T19:05:31.234Z	C3	0 kHz 77 kHz Ez 8 bits
2002-03-26T17:04:42.613Z	2002-03-26T19:05:00.842Z	C1	0 kHz 77 kHz Ey 8 bits
2002-03-29T18:59:13.699Z	2002-03-29T19:00:51.407Z	C1	0 kHz 77 kHz Ey 8 bits
2002-03-29T18:59:18.349Z	2002-03-29T19:00:50.814Z	C3	0 kHz 77 kHz Ez 8 bits
2002-03-29T18:59:26.147Z	2002-03-29T19:00:48.444Z	C2	0 kHz 77 kHz Ez 8 bits
2002-03-29T18:59:46.613Z	2002-03-29T19:00:48.415Z	C4	0 kHz 77 kHz Ez 8 bits

Fig. 5. Sample digital listing of WBD data availability

2.3 Software

Although the WBD digital data set is not being archived at this time, we are archiving various software routines that would allow a user to process the WBD data using the Level 1 data DVDs, which are archived at the Cluster French, Swedish and U.K. Data Centres and at Southwest Research Institute in the United States. The software routines being archived are:

- Generic programs to read WBD Level 1 data files contained on the DVDs
- Generic programs to apply calibration
- Generic program to interpolate across known problems in Cluster 2 data field

3. WBD DATA NOT BEING ARCHIVED

Due to a lack of funding in the U.S. at this time, the time tagged, fully calibrated WBD time series data will not be archived at the CAA. These data would allow users the flexibility of creating and running their own analysis software, including looking at the time series data (example in Fig. 1) from which the spectrograms are created, and creating wavelet periodograms or spectrograms with various windowing techniques, variable FFT sizes and overlapping FFTs.

NASA is exploring the possibility of designating Southwest Research Institute (SwRI) as the official

archiving site for WBD data in the U.S. since SwRI is the official distribution site for Cluster PEACE data in the U.S. Further, NASA and Iowa are exploring the possibility of SwRI acting as a mirror site to the CAA, thus providing a means of obtaining calibrated WBD time series data through the CAA. WBD data DVDs are already being archived at SwRI and the WBD data are being made available through their web site:

http://cluster2.space.swri.edu/

either as downloadable plots or as digital files, containing the calibrated time series data.

4. ADDITIONAL INFORMATION

Archiving of the WBD data for the first four years of the mission (1 Feb. 2001 through 31 Jan. 2005) and documentation outlined in Sections 2.1 and 2.2 above are expected to be completed by August 2006. Until that time, all WBD plots described above, plus additional analysis tools, such as spectrogram, wavelet and time series plotters, and a digital data download tool will be available from the WBD website:

http://www-pw.physics.uiowa.edu/cluster/

5. CONTACTS

The primary contacts for the WBD data archiving efforts at the CAA are:

- Jolene S. Pickett: Cluster WBD Archiving Technical Manager and PI Representative (pickett@uiowa.edu)
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- Melvyn L. Goldstein: Cluster Project Scientist at NASA Goddard Space Flight Center (melvyn.l.goldstein@nasa.gov)

6. REFERENCES

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3. Pickett J. S., Chen L.-J., Kahler S. W., et al., On the Generation of Solitary Waves Observed by Cluster in the Near-Earth Magnetosheath, *Nonlinear Processes in Geophysics*, Vol. 12, 181-193, 2005.

7. ACKNOWLEDGMETS

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