Binary 3D Data Cube Format for E-fields Version 4

Version 1: Adam B. Birchfield, Texas A&M University, 3/24/2017

- Original version

Version 2: Thomas J. Overbye, Texas A&M University, January 2020

- Supports specifying location points individually, rather than as a regular grid

Version 3: Thomas J. Overbye, Texas A&M University, April 2021

- Supports starting at a time other than the beginning of a second

Version 4: Thomas J. Overbye, Texas A&M University, May 2021

- Supports indicating units of time for offset and time step:

Adam B. Birchfield, Texas A&M University, 10/27/2021 (documentation changes, version remains at 4).

- Updates TIME_UNITS to use signed integers
- Updates field names of TIME_UNITS and TIME_OFFSET
- Clarifies variable time points do include TIME_OFFSET
- All new code should use version 4; previous versions are depreciated

Thomas J. Overbye, 1/7/2022, documentation update

This document describes the Version 2, 3 and 4 data format for *.b3d files which hold two-dimensional, time-varying data such as electric fields. It is a binary format which uses little-endian order. The types allowed are: unsigned 32-bit integers (UINT), bytes, single-precision 32-bit floating-point numbers (FLOAT), and double-precision 64-bit floating-point numbers (DOUBLE). In addition, the metadata is specified with single-byte ASCII null-terminated strings. All new code should use version 2 as its default. The version 1 format is given below, but as of January 2020 version 1 is deprecated.

Name	Bytes	Type	Description	Example
KEY	4	UINT	Use decimal code 34280 to confirm the file type.	Hex: E8 85 00 00
VERSION	4	UINT	Use decimal code 4 for this current version	Hex: 04 00
META_STRINGS	4	UINT	Number of strings in the metadata section	6
(Metadata)	variable	ASCII Strings	META_STRINGS number of ASCII strings terminated with 1-byte null characters.	“test_meta\0”
FLOAT_CHANNELS	4	UINT	Number of floating point number channels at each point. For data with X and Y directional E-fields, this value will be 2. Convention will be to put X first and then Y.	Hex: 02 00
BYTE_CHANNELS	4	UNIT	Number of byte channels at each point. Usually this value is either zero or one to indicate a quality flag byte	Hex: 01 00
LOC_FORMAT	4	UNIT	**(New in Version 2)** Used to indicate the location format. Valid values are either 0 or 1. If zero the point	

			locations are specified by a grid with the next six FLOAT fields. If the LOC_FORMAT is 1 then the points are specified by UNIT number of points and then three location fields for each point.	
LON_0	4	FLOAT	Longitude of first point in degrees (only if LOCATION FORMAT = 0)	-112.0
LON_STEP	4	FLOAT	Longitude step in degrees (only if LOCATION FORMAT = 0)	0.5
LON_POINTS	4	UINT	Number of longitude points (only if LOCATION FORMAT = 0)	30
LAT_0	4	FLOAT	Latitude of first point in degrees (only if LOCATION FORMAT = 0)	40.0
LAT_STEP	4	FLOAT	Latitude step in degrees (only if LOCATION FORMAT = 0)	0.5
LAT_POINTS	4	UINT	Number of latitude points (only if LOCATION FORMAT = 0)	25
NUM_ POINTS	4	UNIT	Number of point locations. Each point location is specified by three FLOATs with details in the next row. (only if LOCATION FORMAT = 1)	125
(Location Data Section)	variable	DOUBLEs	If the LOC_ FORMAT = 1 this section contains the point locations, with each point specified by three DOUBLEs. The first DOUBLE gives the point's longitude in degrees, the second DOUBLE gives the point's latitude in degrees, and the third DOUBLE gives the distance to the nearest measurement station in km. Hence the third float is used to indicate if a point has been interpolated. If the point corresponds to a measurement station then this field should be 0. If the measurement station location is unknown, then the value should be less than zero.	
TIME_0	4	UINT	Seconds of first time point, using midnight 1/1/1970 as epoch, not counting leap seconds. (Same as IEEE Std. C37.118.2-2011)	5/7/2016 00:00:00 = 1,462,665,600
TIME_UNITS	4	INT	**(New in Version 4)** Indicates the scaling used for subsequent time values. Valid entries are 0 indicating milliseconds, 1 indicating seconds, -1 for microseconds,-2 for nanoseconds, -3 for picoseconds	0 indicates units of milliseconds, -2 indicates nanoseconds
TIME_OFFSET	4	UINT	**(New in Version 3)** Offset in first time point in units indicated by TIME_UNITS.	If TIME_UNITS=0, 400 is an offset of 0.4 seconds
TIME_STEP	4	UINT	Constant time step in units indicated by TIME_UNITS. If set to zero, indicates variable time step (see below).	10,000 with TIME_UNITS of 0 would be 10 seconds.
TIME_POINTS	4	UINT	Number of time points	25,920
(Variable time points)	variable	UINTs	If TIME_STEP > 0, this section will be skipped. Otherwise, the section consists of TIME_POINTS number of 4-byte UINTs, giving the time in TIME_UNITS of each point since TIME_0 + TIME_OFFSET	

(Data Section)	variable	FLOATs	This section contains the actual data. The section contains (FLOAT_CHANNEL*4 + BYTE_CHANNEL) * NUM_POINTS * TIME_POINTS bytes. If LOC_FORMAT = 0 then NUM_POINTS is automatically set from the grid values. The first element is at TIME_0, LAT_0, LON_0, and the first FLOAT channel. Then the rest of the FLOAT_CHANNELs are given for this location and time followed by the BYTE_CHANNELS. Then the data for the next point is given. If LOC_FORMAT is zero then the grid points are given by latitude rows so the next point would be LAT_0, LON_1, continuing for all the longitude points in the row; then the next row of latitude will be given, still at the same time point. Once all the data for the first time point is given, the second time point will be given in the same way, continuing to the end of the time series. Note that for electric fields the convention is to record the data in units of V/km.