EISCAT Level 3 data storage: the HDF5 files

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Contents

1 Introduction

The standard data products from the EISCAT incoherent scatter radars are the ionospheric parameter data (Level 3 data) obtained through analysis and parameter fitting to the time-integrated power spectral data (Level 2 data). The Level 3 data are physical parameters describing the ionospheric plasma, which is what most users of EISCAT data are using and interested in. Currently, EISCAT uses the Madrigal system to distribute Level 3 data (`https://portal.eiscat.se/madrigal`). An upgrade to the current release, Madrigal 3, is planned.

The next generation multistatic radar system EISCAT_3D will replace the current mainland radars and is planned to start operating in 2021, and it will produce orders of magnitude more data than the current radars. It is therefore important to create Level 3 data storage routines that are structured, storage effective and user-friendly, and compatible with both Madrigal and future EISCAT_3D portal(s).

Consequently, the work of storing and organizing data produced by the current radar systems is also a pre-study for the data handling issues that EISCAT will face in the near future. We have introduced the use of HDF5 files to achieve these goals. HDF (Hierarchical Data Format) and is a container format specifically designed to store and organize large data volumes. The HDF5 library is available for several common programming languages and presents a directory-like structure, hiding the detail of file storage while still allowing many parameters to be tuned for storage optimisation.

A new HDF-based file format for analysed EISCAT data has been developed. Madrigal 3 uses its own HDF5-based format as well, and care has been taken to ensure backward compatibility between the format described here and Madrigal 3 by designing a converter routine.

The purpose of this document is to give an overview of the structure and content of the new EISCAT generated HDF5 files from the current radar system at EISCAT. Analysed EISCAT_3D data will be stored in a similar manner but in higher dimensionality.

2 The HDF5-file

For a given experiment analysis an HDF5-file will be generated, containing all the parameter data obtained from the analysis (parameter fitting) of Level 2 data. There are two types of HDF5-files generated, one for 'older' experiments (data from the pre-2000 Norsk Data mainland systems) and one for 'newer' experiments (data from the present digital receivers), and the differences will be highlighted below. The newer experiments are analysed using the GUISDAP software (Grand Unified Incoherent Scatter Data Analysis Package), whereas the older experiments were analysed by a variety of programmes/softwares collected under the common name On-An.

There are also routines to calculate 3D ion velocity vectors using measurements from several receivers when possible. These results are stored in separate HDF5 files, which differ somewhat depending on if they are from 'old' or 'new' experiments. These structures will also be described in this document, section 3. In this section focus is on the standard products and the corresponding

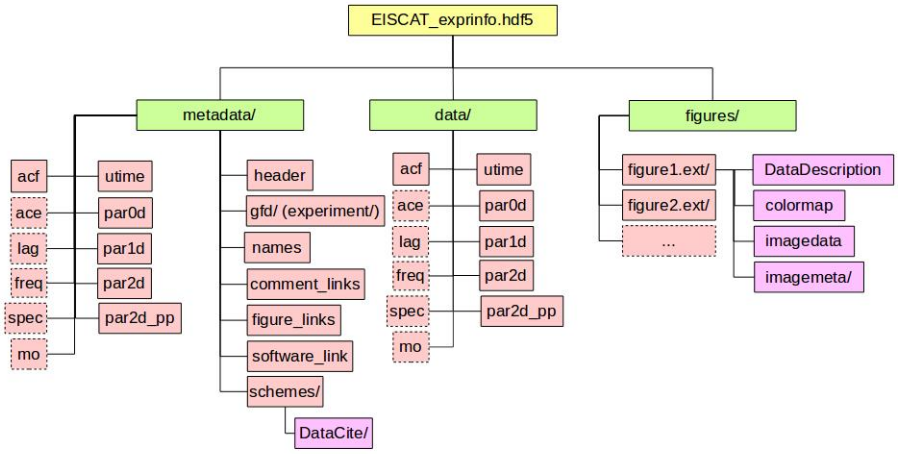

Figure 1: The structures and possible contents of the HDF5-files. The boxes with dashed lines are data that can only be obtained from GUISDAP analyses.

HDF5-files.

2.1 Filename

The name of a generated HDF5-file is unique and of the form `EISCAT_exprinfo.hdf5`, where 'exprinfo' specifies the details about the experiment in the following order: date, experiment name, record integration time [s] and receiving antenna. For example, `EISCAT_2015-02-06_beata_60@uhf.hdf5`, where the antenna is always preceded by an @. The date is the date of the first record in the analysis. The record integration time is the mean between the 1st and 3rd quartile. The antenna name may be followed by a letter (`a,b,c`) for experiments with multiple channels. It may also be followed by a number (`1,2,...`) if an analysis generates an otherwise already existing filename.

2.2 The HDF5-file structures

The structure of an HDF5-file is hierarchical, and the generated EISCAT HDF5 files consist of the groups `/data`, `/metadata`, and `/figures` under which the numerical data, corresponding metadata and figures are sorted. The structure of the HDF5-files is illustrated in Fig. 1, which shows which data, metadata and figure data that may be stored. The structure is slightly different depending on which analysis program has been used (GUISDAP or On-An), and the data that can be obtained and stored from GUISDAP analyses but not from On-An are specified in the figure by dashed box lines.

2.3 Data

0d

The data are mainly divided into different datasets depending on their dimensions. An exception are the record start and stop times. These are collected separately in `data/utime` for practical purposes. Parameters that are constant over the whole analysis of the experiment are referred to as 0d-parameters and stored in `/data/par0d`. A few examples of 0d-parameters are the transmitter and receiver location, different analysis settings etc.

1d

Parameters that are constant during each single integration record, but not constant from record to record, are 1d-parameters and stored in `/data/par1d`. 1d-parameters are for example the system temperature and the peak power of the transmitter.

2d

Most experiments measure over a range interval for each integration time, such that altitude dependent parameters are obtained. These parameters are refered to as 2d-parameters and stored in `/data/par2d`. The 2d-parameter data for one time record is an $h \times p$–matrix, where h is the number of range intervals of that specific time record, and p is the number of 2d-parameters. The matrices for all records are stacked below each other such that a $H \times p$–matrix is constructed, where H depends on the number of records in the analysis and the number of range intervals in the records.

2d_pp

There is also a dataset `/data/par2d_pp`, which is data retrieved from the power profiles. It contains the range and uncorrected electron densities and usually the error of the uncorrected densities and the width of the range gate and their dependencies on range. It is also a matrix, compiled in the same way as `/data/par2d`, but of a different size. Note that several power profiles can be generated for a single integration period, such as un-decoded long pulse resolution and one or more decoded resolutions, sometimes also at different frequencies. These are listed after each other. When converting the files for inclusion in Madrigal these profiles are separated, and profiles with the same resolution are averaged.

utime_pp, 1d_pp

Sometimes (rarely) the number of records corresponding to common data and power profile data differ for a given analysis. In these cases both additional time and 1d-data are created: `utime_pp` and `par1d_pp`.

Other data

In addition there may be other datasets of individual parameters that are presented with their own matrices for each time record. Therefore they have each been appointed an individual dataset named as the parameter itself. Examples of such parameters are auto correlation functions (`/data/acf`) and the measured spectrum (`/data/spec`). For old experiments (On-An) only ACF might be obtained and stored, whereas for Guisdap-analysed experiments there are several in addition (see Fig. 1).

/metadata/header	
1.	Parameter
2.	Description
3.	Unit
4.	(Guisdap parameter name)
5.	Madrigal mnemonic
6.	Madrigal Id
7.	Identifier

Table 1: Listing the parameter metadata content as described by the header. Number 4 (GUISDAP parameter name) is only present for GUISDAP analysed experiments.

2.4 Metadata

The metadata for the data described above are named the same but ordered under `/metadata`. For example, for the dataset `/data/par1d` the corresponding metadata is `/metadata/par1d`.

These metadata give all the relevant information for each parameter, as defined by `/metadata/header` listed in Table 1. The only difference between the headers for the two HDF5-file types is that the GUISDAP parameter name is not included in the On-An analysed experiments. The data and the corresponding metadata for a given parameter are organized in the same way: If the metadata for a certain parameter are listed in column c in `/metadata/par1d`, the corresponding data are in column c in `/data/par1d`.

names

There is a metadataset called `/metadata/names`, where the experiment name (`name_expr`), receiving site (`name_site`), receiving antenna (`name_ant`), and the location/computer and time of the analysis (`name_sig`) are specified. For On-An analysed experiments only `name_expr` and `name_ant` are stored. They are given in Table 2.

Parameter	**Description**
/metadata/names	
name_expr	Name of experiment.
name_site	Code of receiving site.
name_ant	Name of receiving antenna, (or alternative code name for multistatic analyses.)
name_sig	Location/computer and time of the analysis.
name_exps	Name of the experiments used for velocity-vector calculations.
name_ants	Name of receiving antennas used for velocity-vector calculations.

Table 2: The content with descriptions included in `metadata/names`

software

Software related information is collected under `/metadata/software`. The used analyis software is given by an URL defined in `/metadata/software_link`. For GUISDAP analysed experiments the version of the GUISDAP software is given `GUISDAP_ver`. Also the version of the HDF5-file genetating routine is specified: `EISCAThdf5_ver`. Also the `strategy`, defined as the mean integration period between the the first and third quartiles.

Experiment setup:
Specific experiment metadata (setups) are stored. For GUISDAP analysed experiments these metadata are `/metadata/software/gfd`, and for On-An analysed experiments the corresponding group is `/metadata/software/experiment`. They contain somewhat different information and are listed in Table 3 with descriptions.

Parameter	**Description**
GUISDAP: `/metadata/gfd/`	
`name_expr`	Name of the experiment.
`expver`	Version of the experiment.
`siteid`	ID for the site of the receiving antenna.
`data_path`	Path to the data used for the analysis.
`result_path`	Path to the stored analysis results.
`intper`	Record integration time.
`t1`	Start time of the analysis.
`t2`	End time of the analysis.
`rt`	Real time analysis (0/1).
`figs`	Figures displayed.
`path_exps`	Path to the GUISDAP experiment folder.
`extra`	List of extra GUISDAP analysis commands.
On-An: `/metadata/experiment/`	
`instrument`	Name of the antenna.
`kindat`	Kind of data, specified by the *kindat* number
`start_time`	Start time of the analysis.
`end_time`	End time of the analysis.
`Cedar_file_name`	Path and name of the Cedar file.
`kind_of_data_file`	Describes the type of data.
`status_description`	Status of the data.
`instrument_latitude`	Latitude of the receiving antenna.
`instrument_longitude`	Longitude of the receiving antenna.
`instrument_altitude`	Altitude of the receiving antenna.
`name_expr`	Name of the experiment.

Table 3: Contents of the experiment setup metadata for GUISDAP and On-An analysed experiments, respectively.

schemes

A dataset needs to be uniquely identified in order to be accurately referenced and cited. There are several standardizations for this purpose. We use DataCite as scheme, consisting of a few mandatory (and non-mandatory but recommended) pieces of information to be provided in order for users to access published EISCAT data.

DataCite:
This DataCite information is provided at `/metadata/schemes/DataCite/` and listed in Table 4, with explanations. `GeoLocation` is typically the rectangle with minimum area enclosing the datapoints of the dataset. The longitudes and latitudes of the corners of the rectangle are given in `GeoLocation/PolygonLon` and `GeoLocation/PolygonLat`, respectively. Figure 2 shows a typical example of such a case. If the longitudinal extent of the rectangle exceeds 180 degrees the centre of the rectangle is set as well at `GeoLocation/PointInPolygonLon` and `GeoLocation/PointInPolygonLat`. However, if the rectangle area is smaller than 10^{-4} km^2, the spatial region of the data is considered as a single point: the centre point of the rectangle.

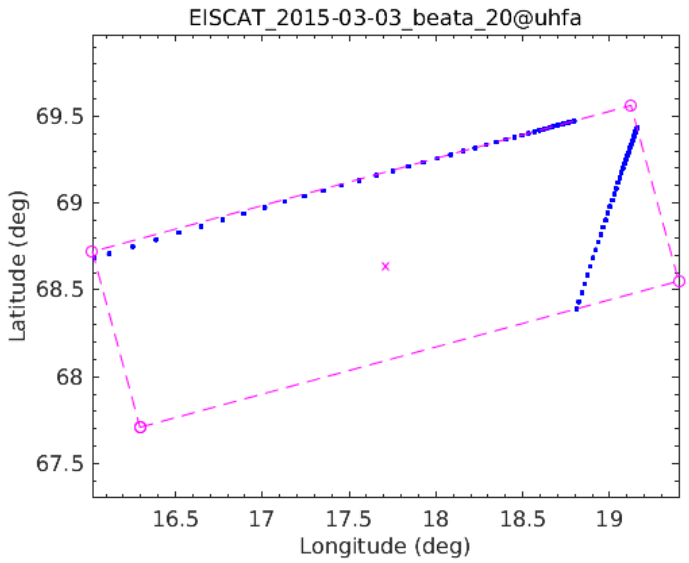

Figure 2: An axample of a rectangle with minimum area (purple) enclosing a dataset (blue). The purple x marks the centre of the rectangle.

notes and log-files

When calibration of data is done there are often needs to comment any certain circumstances, and these notes are put in `/metadata/comments`. More over, for experiments analysed with On-An there are often log-files which are compressed into a TAR file. This file is stored separetely together with the HDF5 file, but with a pointer to the log file in `/metadata/logs_links`.

Parameter	Description
/metadata/schemes/DataCite/	
Identifier	DOI (a random string at the moment).
Creator	Name of the creator (site).
Title	Name of the dataset.
Publisher	The publisher (EISCAT Scientific Associaton).
ResourceType/Dataset	A description of the resource.
Date	Start and stop time of the experiment analysis.
PublicationYear	Year when the dataset was defined.
GeoLocation	Spatial region bounding the dataset.

Table 4: List of DataCite parameters and the descriptions.

2.5 Figures

The image data of figures generated from the analysis are saved as matrices. Each figure is a specific group under `/figures`, such that the image data and the corresponding metadata for "figurename.ext" is under `/figures/figurename.ext`. The image data is stored as an `m`-by-`n`-by-3 matrix in `imagedata`, and the data is described in `DataDescription`. Generally, metadata of an image is stored in `imagemeta/`, and they are listed and describedin 5.

Each image that is stored has also been stored separately as a PDF together with the HDF5 file, pointers to which are embedded in `/metadata/figures/figure_links`.

Parameter	Description
/figures/figurename.ext/imagemeta/	
Figurename	Name of the image.
Radar	The receiving antenna.
Computer	Computer and date of the image generation.
Experiment	Information about the experiment.
Copyright	The copyright of the image.
Source	Location of data used for plotting.
Results	List of variables plotted in the image.

Table 5: Metadata of a stored image with name `figurename` and extension `ext`.

3 Velocity vectors HDF5-files

The EISCAT HDF5 files generated for ion velocity vectors are named similar as the standard data, but with a `V` in front of the integration time. E.g. `EISCAT_1993-02-16_cp1k_V150@kst.hdf5`

The HFD5 structure is very similar to the files for the standard products as described above (and shown in Fig. 1), but with data only present in `utime`, `par0d`, `par1d`, and `par2d`. The metadata content is also very similar, but with the addition of setup data `/metadata/Vinputs/` for newer experiments (Guisdap). The contents and descriptions of `/metadata/Vinputs/` are listed in Table 6.

A couple of addional parameters (`name_exps` and `name_ants`) are present in `/metadata/names` for multistatic GUISDAP analyses, as described in Table 2.

Parameter	Description
`/metadata/Vinputs/`	
`AltitudeRange`	Handled altitude ranges.
`DynasondeVelocity`	Used Tromsö dynasonde vectors, bitpattern for F,E values.
`InputData`	Directories containing data that were used.
`LatitudeRange`	Handled latitude ranges.
`MinDir`	Minimum no of directories and angel difference.
`TimeSpan`	Maximum time span, time step, and first time.
`UpConstraint`	Constraint on the vertical (from 160 km parallel) component.

Table 6: Setup metadata for velocity vectors calculations.

4 Parameter list and metadata

Below follows a list of all possible Level 3 data parameters (including parameters from velocity vector calculations) that are obtained in the analysis and their metadata content of the HDF5-files.

Parameter	Description	Unit	Original parameter	Madrigal Mnemonic	Madrigal Id	Identifier
time1	start time of the integration period, unix time	s	r_time	ut1_unix	11	1
time2	end time of the integration period, unix time	s	r_time	ut2_unix	12	1
ver	Guisdap version	N/A	r_ver	N/A		2
Magic_const	scale factor for rx power	N/A	r_Magic_const	N/A		3
az	antenna mean azimuth angle, 0 to north	deg	r_az	azm	130	4
el	antenna mean elevation angle, 90 to zenith	deg	r_el	elm	140	5
Pt	peak power of transmitter	W	r_Pt	power	486	6
SCangle	half scattering angle	rad	r_SCangle	hsa	190	7
XMITloc1	transmitter location, latitude	deg	r_XMITloc	N/A		8
XMITloc2	transmitter location, longitude	deg	r_XMITloc	N/A		8
XMITloc3	transmitter location, altitude	km	r_XMITloc	N/A		8
RECloc1	receiver location, latitude	deg	r_RECloc	N/A		9
RECloc2	receiver location, longitude	deg	r_RECloc	N/A		9
RECloc3	receiver location, altitude	km	r_RECloc	N/A		9
Tsys	system temperatures, one for each calibrated code set used in analysis	K	r_Tsys	systmp	482	10

Parameter	Description	Unit	Original parameter	Madrigal Mnemonic	Madrigal Id	Identifier
code	code sets used (from initialisation)	N/A	r_code	N/A		11
om0	scale factor for om frequency	s^{-1}	r_om0	N/A		12
om	frequency scale for inverted spectra	N/A	r_om	N/A		13
m0	ion masses in the fit	amu	r_m0	N/A		14
phasepush	phase error in transmitter	s^{-1}	r_phasepush	N/A		15
Offsetppd	pulse propagation delay offset	μs	r_Offsetppd	N/A		16
lag	ACF lag values	s	r_lag	N/A		17
h	weighted mean of the scattering volume altitude	m	r_h	gdalt	110	18
range	weighted mean range to the scattering volume	m	r_range	range	120	19
Ne	electron density	m^{-3}	r_param	ne	510	20
Ti	ion temperature	K	r_param	ti	550	21
Tr	electron to ion temperature ratio	1	r_param	tr	570	22
Collf	ion collision frequency	s^{-1}	r_param	col	709	23
Vi	ion drift velocity, positive towards antenna	m/s	r_param	vo	580	24
Dp	ion species content: ion mix [O2+,NO+]/Ne, oxygen ions [O+]/Ne	1	r_param	N/A		25
wn	broad band noise	K	r_param	N/A		26
dc	DC spike	K	r_param	N/A		27
dNe	error electron density	m^{-3}	r_error	dne	-510	28
dTi	error ion temperature	K	r_error	dti	-550	29
dTr	error electron to ion temperature ratio	1	r_error	dtr	-570	30
dCollf	error ion collision frequency	s^{-1}	r_error	dcol	-709	31
dVi	error ion drift velocity	m/s	r_error	dvo	-580	32
dDp	error ion species content: ion mix [O2+,NO+]/Ne, oxygen ions [O+]/Ne	1	r_error	N/A		33
dwn	error broad band noise	K	r_error	N/A		34
ddc	error DC spike	K	r_error	N/A		35
crossvar	parameter cross variance, order p1p2, p2p3, p3p4, ... , p1pn	N/A	r_error	N/A		36
aprNe	a priori electron density	m^{-3}	r_apriori	N/A		37
aprTi	a priori ion temperature	K	r_apriori	N/A		38
aprTr	a priori electron to ion temperature ratio	1	r_apriori	N/A		39
aprCollf	a priori ion collision frequency	s^{-1}	r_apriori	N/A		40
aprVi	a priori ion drift velocity, positive towards antenna	m/s	r_apriori	N/A		41

Parameter	Description	Unit	Original parameter	Madrigal Mnemonic	Madrigal Id	Identifier
aprDp	a priori ion species content: ion mix [O2+,NO+]/Ne, oxygen ions [O+]/Ne	1	r_apriori	N/A		42
aprwn	a priori broad band noise	K	r_apriori	N/A		43
aprdc	a priori DC spike	K	r_apriori	N/A		44
aprNe_error	a priori error electron density	m^{-3}	r_apriorierror	N/A		45
aprTi_error	a priori error ion temperature	K	r_apriorierror	N/A		46
aprTr_error	a priori error electron to ion temperature ratio	1	r_apriorierror	N/A		47
aprCollf_error	a priori error ion collision frequency	s^{-1}	r_apriorierror	N/A		48
aprVi_error	a priori error ion drift velocity	m/s	r_apriorierror	N/A		49
aprDp_error	a priori error ion species content: ion mix [O2+,NO+]/Ne, oxygen ions [O+]/Ne	1	r_apriorierror	N/A		50
aprwn_error	a priori error broad band noise	K	r_apriorierror	N/A		51
aprdc_error	a priori error DC spike	K	r_apriorierror	N/A		52
status	status of the fit (0=fit ok, 1=max number of iterations exceeded, 2=No fit done, 3=fit fail (outside limits))	N/A	r_status	gfit	430	53
po+	composition [O+]/Ne	1	r_dp	po+	620	54
res1	residual of the fit with standard deviation	N/A	r_res	chisq	420	55
res2	sqrt(2/#measurements)	N/A	r_res	N/A		55
w1	range resolution (90% level)	m	r_w	N/A	122	56
w2	range resolution (2nd moment)	m	r_w	N/A	122	56
w3	width of range gate (total)	m	r_w	N/A	125	56
spec	measured spectrum	Ks	r_spec	N/A		57
freq	frequency scale for forward spectrum	s^{-1}	r_freq	N/A		58
ace	error bars for gated ACFs	K	r_ace	N/A		59
acf	gated unbiased ACFs	K	r_acf	acf		60
pprange	power profile range to scattering volume	m	r_pprange	range	120	61
pp	uncorrected electron densities (Te/Ti=1)	m^{-3}	r_pp	pop	500	62
pperr	error of uncorrected electron densities	m^{-3}	r_pperror	dpop	-500	63
ppw	width of the range gate for uncorrected densities	m	r_ppw	rgate	125	64
name_expr	name of experiment	N/A	name_expr	N/A		65
name_site	code of receiving site	N/A	name_site	N/A		66
name_ant	name of receiving antenna	N/A	name_ant	N/A		67
name_sig	location/computer and time of the analysis	N/A	name_sig	N/A		69
name_strategy	strategy of integration	N/A	name_strateg	N/A§		70

Parameter	Description	Unit	Original parameter	Madrigal Mnemonic	Madrigal Id	Identifier
name_exps	name of the experiments used for the velocity-vector calculations	N/A	name_exps	N/A		70
name_sites	code of receiving sites in the velocity-vector calculations	N/A	name_sites	N/A		71
name_ants	name of receiving antennas used for the velocity-vector calculations	N/A	name_ants	N/A		72
name_sigs	location/computer and time of the analyses of the experiments used for the velocity-vector calculations	N/A	name_sigs	N/A		73
name_strategies	strategies of integration for the experiments analyses used for the velocity-vector calculations	N/A	name_strategies	N/A		74
gfd	analysis setup	N/A	r_gfd	N/A		75
nrec	number of altitude intervals for integration	N/A	N/A	N/A		76
ppnrec	number of range intervals for each integration	N/A	N/A	N/A		77
Nsamp	# samples used in time average	N/A	N/A	nsamp	414	78
Nsampi	# samples used in time average; or increment to Nsamp	N/A	N/A	nsampi	415	79
fradar	transmitted frequency	s^{-1}	N/A	tfreq	490	80
lat	geographic latitude of measurement	deg	N/A	gdlat	160	81
lon	geographic longitude of measurement	deg	N/A	glon	170	82
snr	signal to noise ratio	1	N/A	sn	410	83
snrl	log10 (signal to noise ratio)	1	N/A	snl	412	84
status	EISCAT data quality code 1	N/A	N/A	eisqc1	476	85
status2	EISCAT data quality code 2	N/A	N/A	eisqc2	477	86
status3	EISCAT data quality code 3	N/A	N/A	eisqc3	478	87
status4	EISCAT data quality code 4	N/A	N/A	eisqc4	479	88
status5	EISCAT data quality code 5	N/A	N/A	eisqc5	480	89
Recdfo	received doppler frequency offset	s^{-1}	N/A	rcdfo	492	90
ppl	log10(uncorrected electron density)	$lg(m^{-3})$	N/A	popl	505	91
Nel	log10(Ne in m-3)	$lg(m^{-3})$	N/A	nel	520	92
dNel	error log10(Ne in m-3)	$lg(m^{-3})$	N/A	dnel	-520	93
Te	electron temperature (Te)	K	N/A	te	560	94
dTe	error electron temperature (Te)	K	N/A	dte	-560	95
Vobi	bisector ion vel (bistatic sys; pos = up)	m/s	N/A	vobi	590	96
dVobi	error bisector ion vel (bistatic sys; pos = up)	m/s	N/A	dvobi	-590	97

Parameter	Description	Unit	Original parameter	Madrigal Mnemonic	Madrigal Id	Identifier
Collfl	log10 (ion-neutral collision frequency)	lg(s-1)	N/A	col	720	98
dCollfl	error log10 (ion-neutral collision frequency)	lg(s-1)	N/A	dcol	-720	99
dpo+	error composition – [O+]/Ne	1	r_param	dpo+	-620	100
pm	composition – ion mix [O2+,NO+]/Ne	1	r_param	pm	690	101
dpm	error composition – ion mix [O2+,NO+]/Ne	1	r_param	dpm	-690	102
ph+	composition – [H+]/Ne	1	r_param	ph+	660	103
dph+	error composition – [H+]/Ne	1	r_param	dph+	-660	104
Ne_lag0+	electron density estimate from lag 0+	m^{-3}	N/A	ne_lagO+	511	105
Ne_tp	electron density estimate from true power	m^{-3}	N/A	ne_tp	513	106
hw_lor	spectral half-width from Lorentzian fit	s^{-1}	N/A	hw_lor	536	107
hw_expfit	spectral half-width from exponential fit	s^{-1}	N/A	hw_expfit	537	108
ampl	amplitude estimate from Lorentzian fit	N/A	N/A	ampl	506	109
blev	base level of Lorentzian fit	N/A	N/A	blev	507	110
dNe_lag0+	error electron density estimate from lag 0+	m^{-3}	N/A	dne_lagO+	-511	111
dNe_tp	error electron density estimate from true power	m^{-3}	N/A	dne_tp	-513	112
dhw_lor	error spectral half-width from Lorentzian fit	s^{-1}	N/A	dhw_lor	-536	113
dhw_expfit	error spectral half-width from exponential fit	s^{-1}	N/A	dhw_expfit	-537	114
dampl	error amplitude estimate from Lorentzian fit	N/A	N/A	dampl	-506	115
dblev	error base level of Lorentzian fit	N/A	N/A	dblev	-507	116
var_Ne_lag0+	variance of electron density estimate from lag 0+	m^{-3}	N/A	var_ne_lagO+	2351	117
var_Ne_tp	variance of electron density estimate from true power	m^{-3}	N/A	var_ne_tp	2352	118
var_hw_lor	variance of spectral half-width from Lorentzian fit	s^{-1}	N/A	var_hw_lor	2364	119
var_hw_expfit	variance of spectral half-width from exponential fit	s^{-1}	N/A	var_hw_expfit	2365	120
var_ampl	variance of amplitude estimate from Lorentzian fit	N/A	N/A	var_ampl	2363	121
var_blev	variance of base level of Lorentzian fit	N/A	N/A	var_blev	2366	122
gain	antenna gain	N/A	r_gain	N/A		123

Parameter	Description	Unit	Original parameter	Madrigal Mnemonic	Madrigal Id	Identifier
ppfradar	transmitted frequency (for power profile)	s^{-1}	r_fradar	tfreqpp	493	124
vi_east	ion velocity in eastward direction	m/s	Vg	vi1	1210	125
vi_north	ion velocity in northward direction	m/s	Vg	vi2	1220	126
vi_up	ion velocity in upward direction	m/s	Vg	vi3	1230	127
dvi_east	error ion velocity in eastward direction	m/s	Vgv	dvi1	-1210	128
dvi_north	error ion velocity in northward direction	m/s	Vgv	dvi2	-1220	129
dvi_up	error ion velocity in upward direction	m/s	Vgv	dvi3	-1230	130
var_vi_east	variance of ion velocity in eastward direction	m^2/s^2	Vgv	var_vi1	2373	131
var_vi_north	variance of ion velocity in northward direction	m^2/s^2	Vgv	var_vi2	2374	132
var_vi_up	variance of ion velocity in upward direction	m^2/s^2	Vgv	var_vi3	2375	133
vi_crossvar_12	ion velocity cross variation, vi1-vi2 (east-north)	m^2/s^2	Vgv	N/A		134
vi_crossvar_23	ion velocity cross variation, vi2-vi3 (north-up)	m^2/s^2	Vgv	N/A		135
vi_crossvar_13	ion velocity cross variation, vi1-vi3 (east-up)	m^2/s^2	Vgv	N/A		136
vi_east_perp	ion velocity in perpendicular (to B) eastward direction	m/s	N/A	vipe	1240	137
vi_north_perp	ion velocity in perpendicular (to B) northward direction	m/s	N/A	vipn	1250	138
vi_antipar	ion velocity in antiparallel (to B) direction	m/s	N/A	vi6	1260	139
dvi_east_perp	error ion velocity in perpendicular (to B) eastward direction	m/s	N/A	dvipe	-1240	140
dvi_north_perp	error ion velocity in perpendicular (to B) northward direction	m/s	N/A	dvipn	-1250	141
dvi_antipar	error ion velocity in antiparallel (to B) direction	m/s	N/A	dvi6	-1260	142
vi_solidangle	solid angle of measurements	sr	V_area	N/A		143
E_east	eastward component of the electric field	V/m	N/A	ee	1610	144
E_north	northward component of the electric field	V/m	N/A	en	1620	145
E_up	upward component of the electric field	V/m	N/A	eu	1630	146
E_east_perp	electric field perpendicular (to B) eastward direction	V/m	N/A	epe	1640	147

Parameter	Description	Unit	Original parameter	Madrigal Mnemonic	Madrigal Id	Identifier
E_north_perp	electric field in perpendicular (to B) northward direction	V/m	N/A	epn	1650	148
E_antipar	electric field in antiparallel (to B) direction	V/m	N/A	eap	1660	149
B_north	northward component of the geomagnetic field	T	N/A	bn	204	150
B_east	eastward component of the geomagnetic field	T	N/A	be	206	151
B_down	downward component of the geomagnetic field	T	N/A	bd	208	152
leaps	leapseconds between UNX and TAI (constant over the whole analysis)	s	N/A	N/A		153
leaps1	leapseconds between UNX and TAI (start time of integration period)	s	N/A	N/A		153
leaps2	leapseconds between UNX and TAI (end time of integration period)	s	N/A	N/A		153
EISCAThdf5_ver	EISCAT HDF5 file structure version	N/A	N/A	N/A		154
var_Ne	variance of electron density	m^{-6}	r_error	var_ne	2350	155
var_Ti	variance of ion temperature	K^2	r_error	var_ti	2355	156
var_Tr	variance of electron to ion temperature ratio	1	r_error	var_tr	2359	157
var_Collf	variance of ion collision frequency	s^{-2}	r_error	var_col	2360	158
var_Vi	variance of ion drift velocity	m^2/s^2	r_error	var_vo	2370	159
var_Dp	variance of ion species content: ion mix [O2+,NO+]/Ne, oxygen ions [O+]/Ne	1	r_error	N/A		160
var_wn	variance of broad band noise	K^2	r_error	N/A		161
var_dc	variance of DC spike	K^2	r_error	N/A		162
phe+	composition – [He+]/Ne	1	r_param	phe+	650	163
dphe+	error composition – [He+]/Ne	1	r_param	dphe+	-650	164
var_Te	variance of electron temperature	K^2	N/A	var_te	2358	165
var_pm	variance of ion mix content: [O2+,NO+]/Ne	1	N/A	var_pm	2395	166
var_po+	variance of O+ content: [O+]/Ne	1	N/A	var_po+	2390	167
var_phe+	variance of He+ content: [He+]/Ne	1	N/A	var_phe+	2393	168
var_ph+	variance of H+ content: [H+]/Ne	1	N/A	var_ph+	2394	169
time_sd	dump end time of space debris detection, unix time	s	r_sd	N/A		170

Parameter	**Description**	**Unit**	**Original parameter**	**Madrigal Mnemonic**	**Madrigal Id**	**Identifier**
lpg_sd	lag profile group index	N/A	r_sd	N/A		171
range_sd	range to space debris	m	r_sd	N/A		172
power_sd	power expressed in unit of estimated standard deviation	1	r_sd	N/A		173
aprpm	a priori ion mix content: [O2+,NO+]/Ne	1	N/A	N/A		174
aprpo+	a priori O+ content: [O+]/Ne	1	N/A	N/A		175
aprphe+	a priori He+ content: [He+]/Ne	1	N/A	N/A		176
aprph+	a priori H+ content: [H+]/Ne	1	N/A	N/A		177
aprpm_error	a priori error ion mix content: [O2+,NO+]/Ne	1	N/A	N/A		178
aprpo+_error	a priori error O+ content: [O+]/Ne	1	N/A	N/A		179
aprphe+_error	a priori error He+ content: [He+]/Ne	1	N/A	N/A		180
aprph+_error	a priori error H+ content: [H+]/Ne	1	N/A	N/A		181
dppl	log10(error uncorrected electron density)	$\lg(m^{-3})$	N/A	dpopl	-505	182