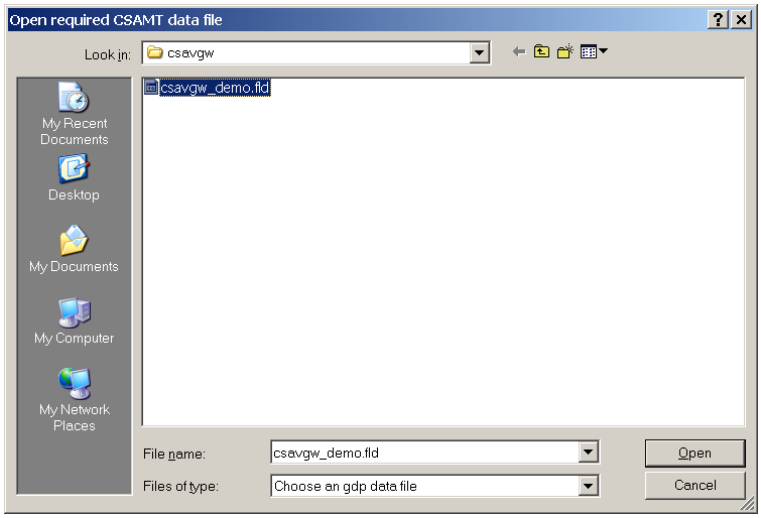
CSAVGW Documentation

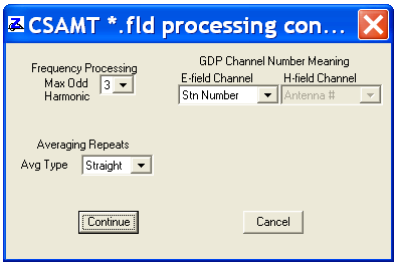
updated 28Jan/08 by Scott MacInnes

Csavgw is a CSAMT/NSAMT data averaging and quality-control utility program that reads controlled- or natural-source magnetotellurics data binary-format ***cac*** or ASCII ***fld*** files, displays the data in pseudosection, sounding curve or data point graphs to allow skipping of outlier data, and then saves the data in Zonge-format ***zdb*** and ***avg*** files. {Zonge ***zdb*** and ***avg*** files have the same format, but use a different file-name extension to distinguish between unaveraged data (***zdb*** files) and files with repeat data averaged (***avg*** files).} ***Csavgw*** reads and writes survey configuration and processing control parameters from ***mde*** files.

Start ***Csavgw*** by running it from the command line, the windows start menu or with a short-cut icon. ***Csavgw*** will open a full size window and show a file selection dialog. Select an appropriate ***cac*** or ***fld*** file holding CSAMT or NSAMT data and click on the **Open** button to start processing. Click on the **Cancel** button to abort ***Csavgw***.

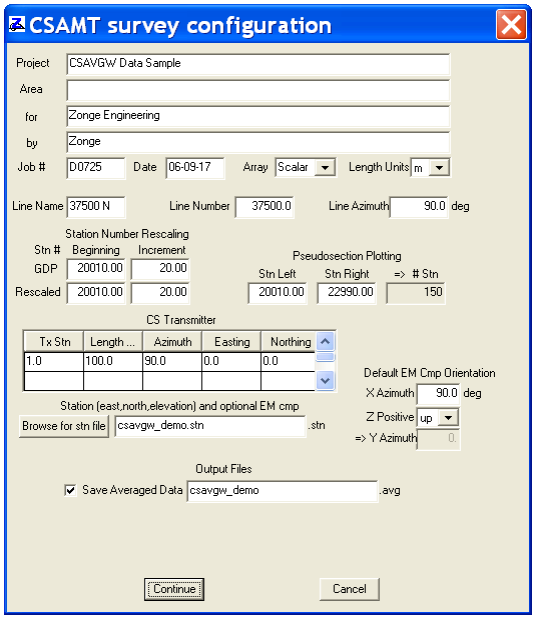


Metadata with survey configuration, data acquisition and processing control information are read from ***ini*** and ***mde*** files using the ***cac*** metada record ascii `keyword=value(s)` format. ***Csavgw*** first searches for the optional file ***csavgw.ini*** to get default processing-control values. It then shows a processing-control dialog to allow interactive verification of control parameters.



The first five odd harmonics are measured with harmonic CSAMT data acquisition, but the first and third harmonics generally provide sufficiently dense spectral coverage. Higher-order harmonics have less signal strength and tend to be noisier. Repeat data can be averaged either using a “straight” or un-weighted average, or with “robust” averaging which automatically deweights outlier data. Robust averaging usually generates better results, but it requires three or more repeats per data point.

After verifying processing control parameters, ***Csavgw*** looks for a ***mde*** file with the same file-name stem as the input CSAMT ***cac*** or ***fld*** data file. ***Csavgw*** shows a survey-configuration and processing-control dialog every time it encounters a new line name or number, although input data are usually split up by line before ***Csavgw*** processing.



Fields in the upper left section of the dialog store descriptive survey annotation information. **Project** name, **Area**, **for**, **by** and **Job #** fields store arbitrary text strings that are stored in ***zdb*** and ***avg*** files for descriptive documentation. **Line Name** is a string line label that can be used to hold descriptive "line" labels like "Drill Hole 001". CSAMT **Array** types can be Scalar for data with pairs of electric- and magnetic-field components (Ex/Hy), Vector for data acquired using one transmitter orientation and both horizontal EM component pairs (Ex/Hy & Ey/Hx). Tensor data acquisition provides the most complete description of field behavior, but requires two or more controlled-source transmitter antenna orientations (or natural-source) and all four horizontal EM component pairs (Ex/Hx, Ex/Hy, Ey/Hx, Ey/Hy).

Length units can be in meters or feet. **Line Number** is a floating-point line number, suitable for use as a coordinate value in a curvilinear (line,station) coordinate system. **Line Azimuth** is a line bearing indicating the direction of increasing station numbers in degrees east of north.

The **Station Number Rescaling** dialog fields allow linear rescaling of the GDP station numbers used during data acquisition. It is not uncommon to need a linear scaling change from GDP station numbers to a different station number system for deliverable data files and plots. **GDP Station Numbers** indicate the station number system used during data acquisition, while **Rescaled Station Numbers** are the possibly different station numbers needed for final data files and plots. The default values don't rescale GDP station numbers, but entering different station number start and increment values can be used to define a rescaling. Negative increment values can be entered if it is desirable to reverse station number ordering. Two Pseudosection Plotting fields **Stn Left** and **Stn Right** are set after reading the input data and indicate the line's extent. Stn Left and Stn Right values can be changed to limit the length of ***Csavgw*** pseudosection plots.

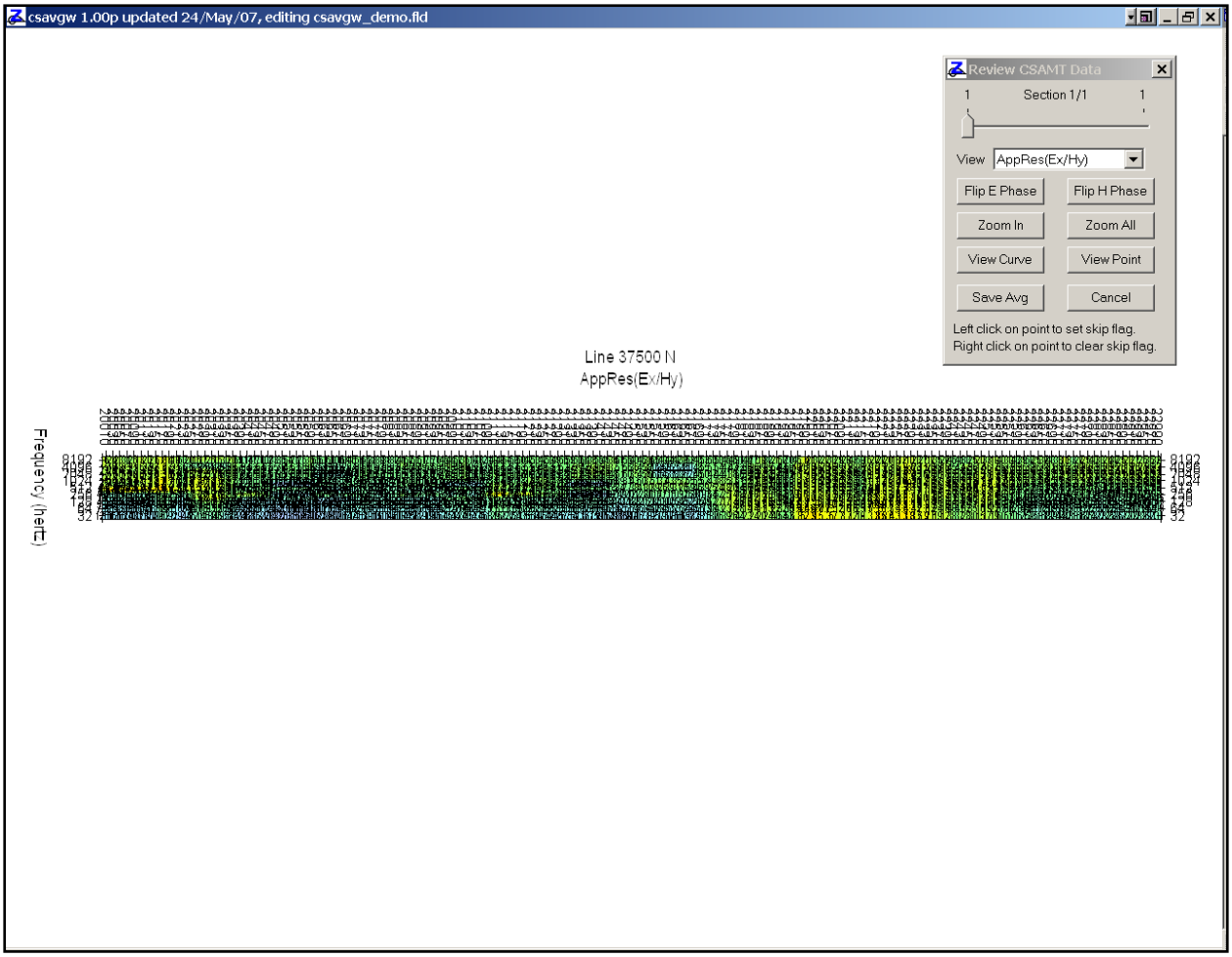
CS Transmitter fields are included in the survey configuration dialog to prompt for controlled-source transmitter length, orientation and bipole center location. Scalar or Vector CSAMT surveys use one transmitter bipole or loop. Additional rows are included in the CS Transmitter field to hold parameters for tensor CSAMT surveys.

Csavgw uses the input data file name to construct a default ***stn*** file name, but the **Browse for stn file** button can be used to select a different ***stn*** file. ***Stn*** files hold tables of station, east, north and elevation to link CSAMT soundings to geographic locations.

Ex and Hx are usually used to label along-line EM components (and lines are nominally perpendicular to strike). The default **X Azimuth** value is Line Azimuth. Given an X azimuth and specifying **Z Positive** up or down controls the Y azimuth required for a right handed coordinate system.

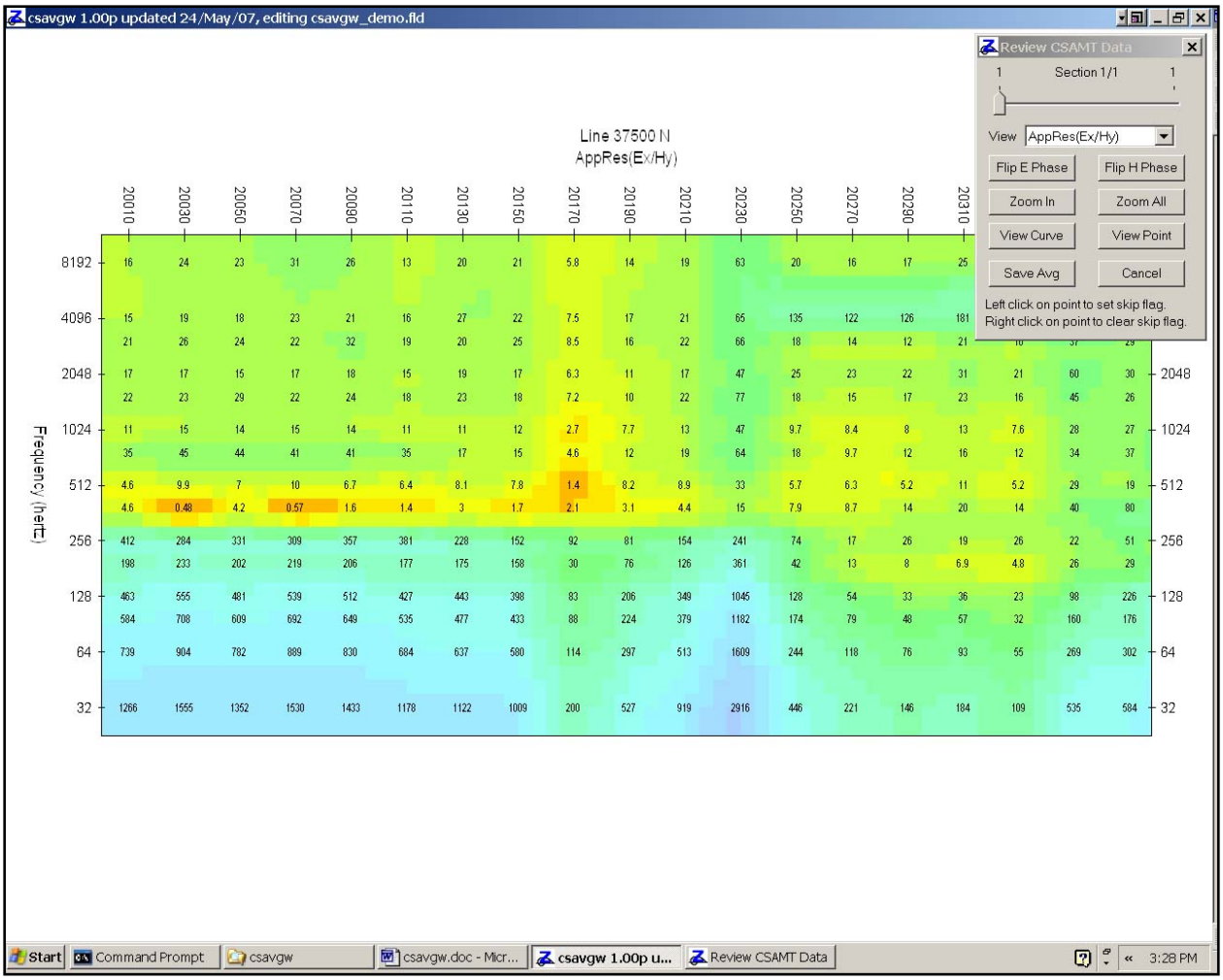
After survey configuration values have been verified, click on the **Continue** button to go to the next processing step or select **Cancel** to abort data input. If you continue with processing, ***Csavgw*** will read station location coordinates from the ***stn*** file, if one is present. To verify ***stn*** file values, ***Csavgw*** shows a three-panel plot with a topographic profile, station-to-station azimuth and station-to-station separation. Any large errors from mistakes in the ***stn*** file will be visible as large excursions in the profile plots. Smooth profiles are indicative of valid ***stn*** file data.

For data quality review, ***Csavgw*** can show data for the entire line as a pseudosection, data for one sounding as a curve, or a complex plane plot for an individual data point. ***Csavgw*** starts by showing an apparent resistivity pseudosection view of the entire line.



To see details in long lines, as for this sample data set, **Zoom In** allows magnification of pseudosection details. ***Csavgw*** will show a magnifying glass cursor when **Zoom In** has been clicked. Position the curser on one corner of the area of interest and "left click" (depress the left mouse button) to anchor a corner of the **Zoom In** selection rectangle. ***Csavgw*** will then show a + shaped cursor and a green rubber-band box indicating the extent of the

selection rectangle. Move the mouse cursor to adjust the selection box to include the area of interest and left click again to see a magnified pseudosection plot.

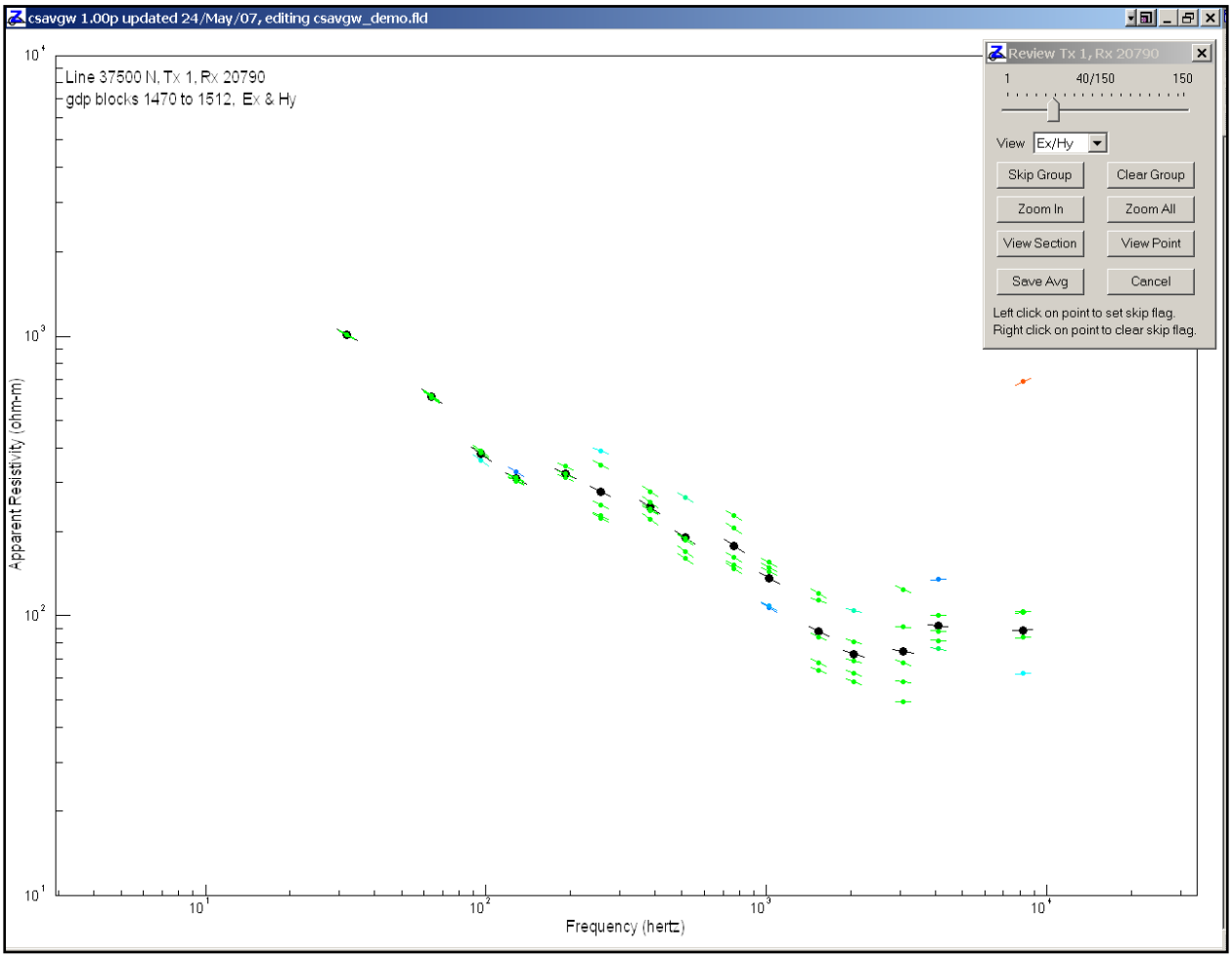


The **View** field in the **Review CSAMT Data** dialog can be used to review magnitude or phase of individual field components, apparent resistivity from magnitude of (E/H), or phase(E/H). The **Flip E Phase** or **Flip H Phase** buttons can be used to select rectangular areas within which ***Csavgw*** reverses the polarity of the E- or H-field component respectively. **Zoom All** is complimentary to **Zoom In**, as it can be used to return to a plot of the entire pseudosection.

Toggling between **Zoom In** detail and **Zoom All** overview plots facilitates review of different areas along the pseudosection. **Save Avg** saves the data to ***zdb*** and ***avg*** files, while **Cancel** aborts data review and stops ***Csavgw***.

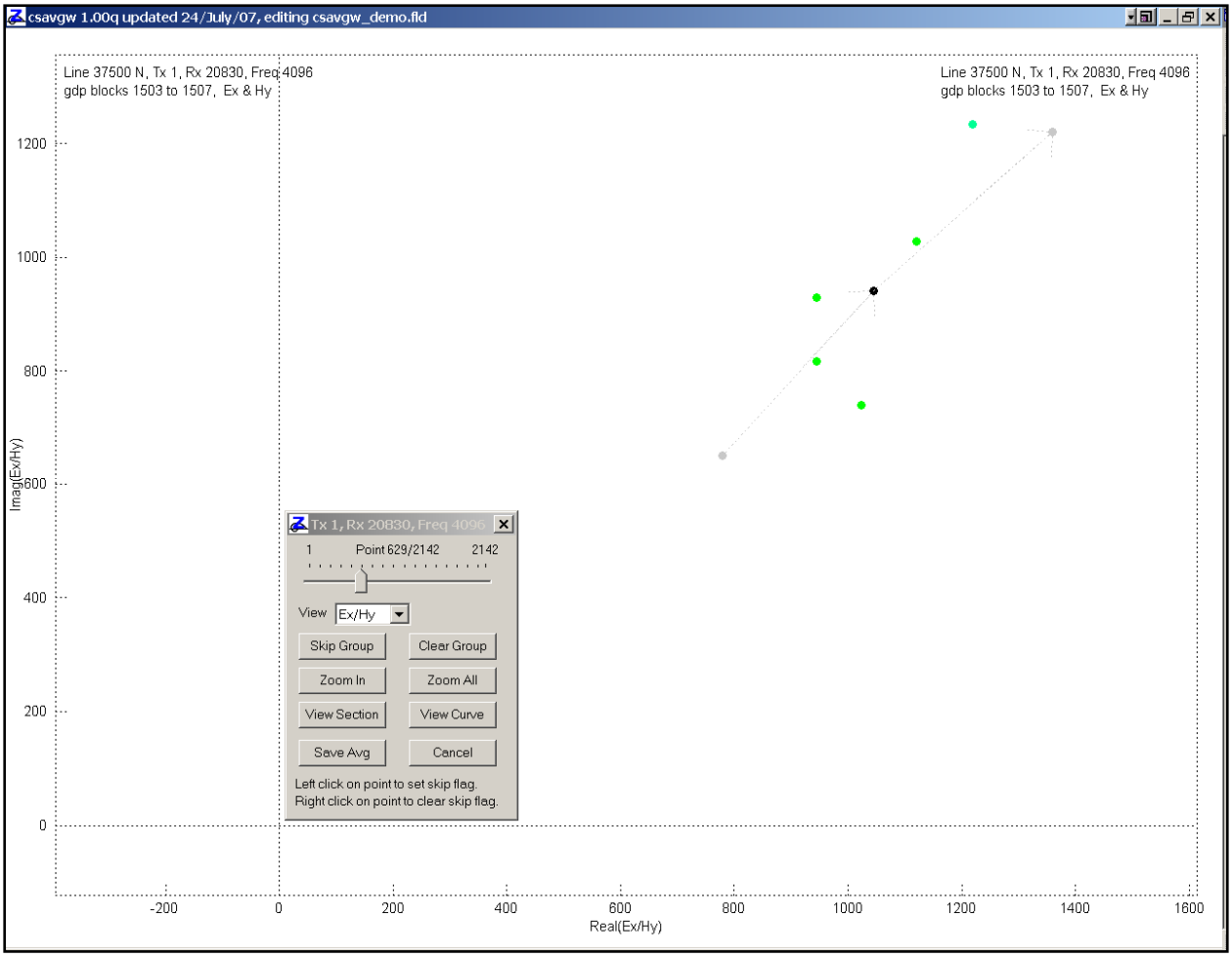
To look at the data in even more detail, **View Curve** or **View Point** can be used to select an individual sounding curve or point. Clicking on the View Curve button brings up a mouse cursor in the shape of a green square and center dot. Move the square over the sounding curve that you wish to view and left click with the mouse button.

After **View Curve**, ***Csavgw*** will then show a sounding curve plot with log(frequency) along the horizontal axis and log(apparent resistivity) on the vertical axis. In apparent resistivity curve plots, the sloping bars indicate a curve slope based on each data point's E/H impedance phase. Slope from phase values should be consistent with the point-to-point trend of the sounding curve plot. Unskipped repeat-data values are plotted in green while skipped repeat-data values are plotted in red. Averaged data values are shown in black.



The Review Data dialog box will now show a slider field which can be use to move between sounding curves. Putting the mouse button on the slider control and then pressing the left or right arrow keys allows movement one sounding curve at a time without demanding precise control of mouse cursor movement. The sounding curve **View** field allows selection of magnitude(E) versus frequency, magnitude(H) versus frequency or apparent resistivity versus frequency curves. Bad repeat data points can be removed from the average or "skipped" by putting the mouse cursor on the offending point and left-clicking. A right click on a data point will clear the point's skip flag. Averaged data values are updated whenever a skip flag is set or cleared, so the effects of making changes are visible immediately. Data values can be skipped or unskipped within rectangular regions by using the **Skip Group** or **Clear Group** dialog buttons. ***Csavgw*** shows a red cross cursor after the **Skip Group** button is clicked, indicating that a left mouse-button click should be used to anchor the upper-left corner of a rectangular selection box. ***Csavgw*** then shows a green rubber band box which will follow the mouse cursor until a second left click is used to anchor the box's lower left corner. Then all data points within the selection box will be skipped. Clear Group works the same way, except that ***Csavgw*** starts with a green cross cursor shape to prompt you to anchor one corner of a rectangular selection box.

Zoom In can be used to magnify a section of the sounding curve plot, while **Zoom All** returns to a view of the entire sounding curve. **Save Avg** saves the data to ***zdb*** and ***avg*** files, while **Cancel** aborts data review and stops ***Csavgw***. **View Section** and **View Point** buttons can be used to switch from the sounding curve display to either the more general pseudosection plot or the more specific individual data point complex plane plot. **View Point** shows a complex plane plot for an individual data point.



Point plots show a complex plane view of repeat data for an individual data point. For E/H impedance values, the horizontal axis is Real(E/H) and the vertical axis is Imag(E/H). To look at individual EM components, the dialog **View** field can be used to select plots of E or H in addition to the default view of E/H. Unskipped repeat values are shown with green points, indicated that they represent good data. Skipped values are shown as red points and the average value is indicated with a black point. To put the data in context, light gray arrows are used show the position of the previous and next averaged data in the sounding curve. Data skipping and clearing in point plots is analogous to the curve plot methods. Left click on a point to skip it. Right click on a point to clear the skip flag and include the value in the data average. The slider bar at the top of the point plot control dialog allows movement from point to point. The slider bar can be dragged back and forth by putting the mouse cursor on top of the bar, holding down the left mouse button and then moving the mouse cursor sideways. Pressing the left or right arrow keys while the mouse cursor is on the slider bar will move between points one at a time without requiring precise mouse movement. The **Skip Group** and **Clear Group** dialog buttons can be used to skip or clear points within a rectangular selection box. **Zoom In** can be used to magnify part of the plot, while **Zoom All** returns to a view of the entire set of point repeats. **View Section** and **View Curve** can be used to return to pseudosection of sounding curve displays. Clicking on the dialog **Save Avg** button will save data and exit ***Csavgw***, while clicking on **Cancel** will exit ***Csavgw*** without saving the data set.

When ***Csavgw*** saves data, it writes averaged data into an ***avg*** file. It saves un-averaged data with the current skip flag pattern into a file with the extension ***zdb***. Survey configuration and processing control parameters in the ***mde*** file are updated. Quality control decisions can be revisited by re-running ***Csavgw*** and selecting a ***zdb*** file for input. ***Csavgw*** will then start with the skip flag pattern that was saved at the end of the previous ***Csavgw*** session.

File Formats

Csavgw.ini File: default processing control parameters

Csavgw.ini is an ascii file that can be edited with a generic text editor.
Each line uses a `group.keyword=values(s)` format. For ***Csavgw***, the group name is CSAVGW. There may be one or more comma-separated values to the right of the "=" character, depending upon the variable. Most variables only have a single value, but some like `CSAVGW.Ch.NumberType` are followed by a list of values. Blank lines or lines beginning with the character `"`, `!`, `/` or `\` are skipped while ***Csavgw*** is reading ***ini*** files.

Listing of sample ***csavgw.ini***

```
------------------------------------------------------------------------------
CSAVGW.Process.FDCS=Yes
CSAVGW.Process.TS=No
CSAVGW.Process.STACK=No
CSAVGW.Stack.Type=Straight
CSAVGW.Stack.Taper=5
CSAVGW.Stack.Trim=20
CSAVGW.FD.MHAFreq=1
CSAVGW.Avg.Type=Robust
CSAVGW.Ch.NumberType=Stn Number,Antenna #
------------------------------------------------------------------------------
```

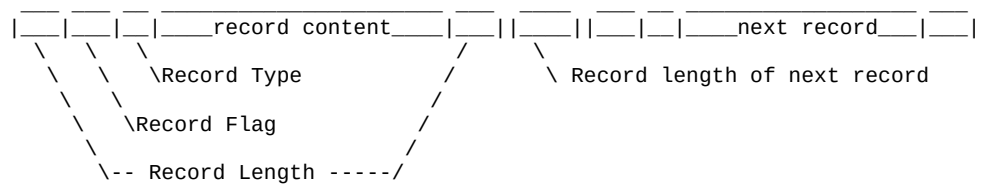
Keyword definitions:

`Process.FDCS` = `yes =>` process frequency-domain CSAMT data
`Process.TS` = `yes =>` process ***cac*** file time-series data
`Process.Stack` = `yes =>` process ***cac*** file stack data
`Stack.Type` = ***cac*** file time-series stacking method {straight, taper or robust}
`Stack.Taper` = stacking taper {0=straight stack to 5=Gaussian taper }
`Stack.Trim` = robust stack alpha-trim clipping (%)
`FD.MHAFreq` = # odd harmonics to save in ***avg*** files (1 to 5)
`Avg.Type` = straight or robust averaging of repeat data
`Ch.NumberType` = E & H GDP channel # meaning {Stn Number, Stn # Offset, N-Spacing, Antenna #}
Stn Number: most common for CSAMT/NSAMT data, GDP Chn number = Station Number
Stn # Offset: GDP Chn Number represents offset from GDP Rx value.
N-Spacing: GDP Chn Number represents offset in dipole lengths from GDP Rx value.
Antenna #: Used for H-field GDP channels to select correct antenna calibrate values.

cac Files: binary time-series ***cac*** data

The GDP-32 saves time-series data in a binary cache file with a block-record format. Each record has a consistent external structure, so that programs can search through ***cac*** files and skip records that are not of immediate interest or are of an unknown type. The format anticipates the addition of new record types in the future, and new record types using the consistent external record structure will not break existing software.

Each ***cac*** record (of any type) in the binary cache is stored in the following manner.



The first and last element in every stored record is the length of the core data record in bytes (stored as a 4 byte integer). The second element in every record is a 4 byte code with all four bytes equal to FFFF hex. This in conjunction with the bracketing record length field allows processing of a damaged cache. Software can skip through the file without reading entire records. Record length values are used to adjust the file position pointer directly, without the overhead of reading the record's data content.

The first 2 byte element in every core data record tells which type of data record has been stored. The 16-bit record-type is a bit-packed field, containing three subfields. The main field defines a record "class" such as header or data. The second sub-field determines record format. Currently records can be either in an ASCII meta-data format or binary numeric data (see below). The final sub-field indicates the file-format version and is currently not used.

cac file metadata records

The internal body of metadata records, as indicated by the record type's format subfield, is ASCII text holding comma separated value `keyword,value` sub-records. Sub-record endpoints are delineated by a carriage-return character (`\n`). Keywords are case insensitive and may include the letters `a` to `z`, numbers `0` to `9` and the underscore character. Keywords must be spelled exactly, no matching is done on substrings or aliases. Array parameter values are saved as a string of comma-separated fields.

Programs should skip sub-records with novel or unknown keywords, allowing future extension without breaking existing software.

Parameters are organized into groups, distinguished by a "`GroupName.`" prefix on the keyword. Each header type has a distinct collection of group.keyword sub-records.

Each metadata record starts with `Header.Type`, enumeration, {`Survey,Calibrate,Data` }
Group names associated with `Header.Type=Survey` are `Job, Survey, GDP, TX, RX, TS, CH`
Group names associated with `Header.Type=Calibrate` are `Cal`
Group names associated with `Header.Type=Data are Data, Weight, Column, Row`

Cac file Navigate records (record type = 4)

```
--------------------------------------------------------------------------------
used for direct file access
binary record pointer and record size
--------------------------------------------------------------------------------
```

Cac file Survey Metadata records (record type = 514)

`Header.Type` = enumeration, `Survey`

`Survey.Type` = enumeration, {`LOTEM,TEM,CSAMT,NSAMT,CR,RPIP,TDIP`}
`Survey.AcqMethod` = enumeration, {`TimeSeries,Stack,Decay,Binned,Frequency`}
`Stack` = represents a stacked and rectified half-waveform with NWaveform/2 floats
`Decay` = represents a segment of A/D points from a stack, made a distinct type because the GDP-32 can be gained up if on-time or turn-off waveform can be saturated.
`Transients` = binned time-window decays: binned time-domain "Transients" for both TEM and TDIP
`Frequency` = frequency domain (real,imag) data extracted from an FFT, usually 1,3,5,7,9th harmonics
`Survey.Array` = enumeration, array type, CSAMT: {`Scalar,Vector,Tensor`}
`Survey.Name` = string, project name, added post acquisition
`Survey.Area` = string, project name, added post acquisition
`Survey.By` = string, client name, added post acquisition
`Survey.For` = string, contractor name, added post acquisition
`Survey.Spread` = string, spread label, not always interpretable as a number
`Survey.sLine` = string, line label, not always interpretable as a number although that can cause problems later (as in Oasis montaj)
`Survey.fLine` = float, line number, incremented by 1 when **Continue** pressed during DNT survey
`LengthUnits` = enumeration, {`m,ft`} used to specify dipole lengths and loop size.
`DATE0` = string, data acquisition date (mm/dd/yyyy)
`TIME0` = string, data acquisition time of day (hh:mm:ss.sss)
`GDP.SN` = string, GDP serial number
`GDP.TCardSN` = string, timing card serial number
`GDP.ADCardSN` = string array, a/d card serial numbers
`GDP.Oper` = string, GDP-32 operator's name or initials
`GDP.NumCh` = integer, number of active channels in GDP-32
`GDP.Ch` = integer list, card slots of active channels
`GDP.Bat` = float, GDP-32 battery voltage (volts)
`GDP.Temp` = float, GDP-32 temperature (deg C)
`GDP.Humid` = float, GDP-32 relative humidity (%)

`Tx.Stn` = float, for CSAMT: Tx dipole ID
`Tx.Freq` = float, Tx repetition rate (hertz)
`Tx.Duty` = float, Tx waveform duty cycle, usually 50 or 100 (%)
`Tx.Amp` = float, Tx peak current in time domain
`Tx.Shunt` = float, current monitoring shunt resistance (ohms)
`Tx.Delay` = float, transmitter turn-off ramp duration (μsec)

`TS.ADFreq` = float, a/d sampling frequency (hertz)
`TS.DecFac` = integer, decimation factor
`TS.NCycle` = number cycles/stack
`TS.NWaveForm` = integer, number samples/waveform = TS.ADFreq/(TS.DecFac*Tx.Freq)
`TS.NPnt` = integer, # points stored in subsequent data record

(*cac* file Survey Metadata records, continued)

```
Rx.Stn          = float, CSAMT: GDP-32 or H-field coils location
Rx.Length       = float, default dipole length (LengthUnits)
Rx.AntDelay     = float, antenna preamp delay (µsec)
Rx.AliasDelay   = float, anti-alias filter delay (µsec)

Ch.Factor       = float list, scale a/d counts to volts excluding gain or attenuator settings (volts/ad_count)
Ch.PreAmp       = float list, pre-amplifier gain as a scaling multiplier
Ch.Gain         = string list, gain stage settings as binary exponents
Ch.Number       = float list, component-specific meaning
    E-field chn, dipole center location
    H-field chn, antenna number used to index AntCal table
Ch.Cmp          = enumeration list, chn component label {Off,Ex,Ey,Ez,Hx,Hy,Hz,Ref}
Ch.Status       = packed byte list, information about channel status
Ch.SP           = float list, self-potential offset (volts)
Ch.Res          = float list, contact resistance of each channel (ohms)

Stack.Type      = enumeration, {Straight,Tapered,Robust}
Stack.Taper     = float, Kaiser taper: 0=straight stack, 5=Gaussian, (0 to 6)
Stack.Trim      = float, % trimmed from robust stack (0 to 49)
-------------------------------------------------------------------------------
```

***cac* file Calibrate Metadata records (record type = 768)**

```
-------------------------------------------------------------------------------
Header.Type     = enumeration, Calibrate
Cal.Sys         = list, ADCardSN,frequency,cal_amplitude,cal_phase_mrad
Cal.Ant         = list, Antenna_#,frequency,cal_amplitude,cal_phase_mrad
-------------------------------------------------------------------------------
```

***Cac* file Calibrate Metadata records (record type = 528):**

```
-------------------------------------------------------------------------------
Header.Type     = enumeration, Data

Weight          = float, data weight: 0=skip data block, 1=use data block
Date0           = string, date when acquisition started (YY/MM/DD)
Time0           = string, time when acquisition started (HH:MM:SS.SSSS)
Data.Kind       = enumeration {long,float,double,ASCII }
Row.Num         = integer, number of rows in subsequent data block(s)
Row.Freq        = float, frequency for data in row (hertz).
Col.Num         = integer, number of columns in data block
Col.Chn         = integer list, list of active GDP-32 channels = GDP.ch list
Col.Label       = string list,  column label
Col.Units       = enumeration list, data value units
    ADcounts a/d counts after FFT, without scaling by Ch.Factor, Ch.Gain or any calibrate values
Data.Blocks     = integers, first and last data block in the following data record, allows for continuous
                  mode acquisition
-------------------------------------------------------------------------------
```

Cac file Binary Data records (record_type = 16):

Survey.AcqMethod=TimeSeries

Time-series data are held in rectangular blocks of 4-byte binary integer values representing A/D levels which must be scaled to volts using the ChFactor and ChGain information from the proceeding metadata record. The time-series data block is equivalent to a NChn by NPnt array with the channel index varying the fastest.

Survey.AcqMethod=Stack

Stacked data are held in rectangular blocks of 4-byte floats representing stacked A/D levels. Values must be scaled to volts using the ChFactor and ChGain information from the proceeding metadata record. The time-series data block is equivalent to a NChn by NWaveform array with the channel index varying the fastest.

Survey.AcqMethod=Decay

"Decay" data are held in rectangular blocks of 4-byte floats representing stacked and rectified A/D levels over length of the off-time transient. Values must be scaled to volts using the ChFactor and ChGain information from the proceeding metadata record. The time-series data block is equivalent to a NChn by NPnt array with the channel index varying the fastest. Each segment is offset beyond the end of the Tx turn-off ramp based on AntDelay + AliasDelay + Tx.Delay.

Survey.AcqMethod=Transient

"Transient" data are held in rectangular blocks of 4-byte floats representing stacked, rectified and binned A/D levels. Values must be scaled to volts using the ChFactor and ChGain information from the proceeding metadata record. The time-series data block is equivalent to a NChn by NPnt array with the channel index varying the fastest. Each segment is offset beyond the end of the Tx turn-off ramp based on AntDelay + AliasDelay + Tx.Delay and time-window values indicate averages of groups of A/D samples.

Cac file GDP Status (record_type = 640):

`QCGdpTemp` = float, GDP-32 temperature (deg C)
`QCGdpTemp` = float, GDP-32 relative humidity (%)

---

zdb and ***avg*** Files: NSAMT/CSAMT data

zdb and ***avg*** files have the same format, but ***zdb*** files are used to store data with unaveraged repeats, while the file name extension ***avg*** implies that repeat measurements have been averaged.

zdb files use the ***avg*** file format to store unaveraged data with the detailed skip-flag pattern set during interactive QC. ***Csavgw*** can re-read data from ***zdb*** files to revisit QC decisions without starting over from the beginning. All harmonic data (cs harmonics 1 to 9) can be saved on a first pass, and then limited (i.e. cs harmonics 1 and 3) when a zdb file is re-loaded.

avg files may have comment lines preceded by a "\", "/", "!" or "″" in column 1 anywhere within the file, although they are normally grouped at the top of the file.

Metadata records with a leading "$" character are also present and play a large role in recording information that does not fit into a tabular spreadsheet format. Metadata records have a `$program:group.variable=value(s)` format. The program name is optional, but if present the metadata record is ignored if the program name is not ***Csavgw***. Version 2 metadata keywords generally have a `group.variable` structure with the group name unifying keywords with a common theme. An equals "="sign separates the keyword from one or more comma-separated values. String values which may include commas as part of the value, instead of as a separator, should be enclosed in quotes.

Records with a leading letter are interpreted to contain column labels. A line holding column labels must precede numerical data. Column label matching is not case sensitive, but does not allow substring matching. Column order is not fixed and all possible columns may not be present in a particular file. If an essential column is missing, the program will show a warning message and abort input.

Numeric data records begin with a leading number. Numerical values are free format with columns separated by either spaces or commas, although comma separated values are preferred. Missing numeric values are flagged by a "*" symbol or a missing value bracketed by commas.

Csavgw *.avg-file keywords:

Survey annotation

$Job.Name	project name	(128 character string)
$Job.Area	project area	(128 character string)
$Job.For	customer company name	(128 character string)
$Job.By	contractor company name	(128 character string)
$Job.Number	job label or number	(16 character string)
$Job.Date	data acquisition date	(16 character string)

Survey configuration

$Survey.Type	survey type	(CSAMT, TEM, CR, TDIP)
$Survey.Array	array type	(for CSAMT: Scalar, Vector, Tensor)
$Line.Name	line label	(16 character string) (alias = JobLine)
$Line.Number	line number	(float)
$Line.Azimuth	line azimuth	(float, deg E of N) (alias = BrgLine)
$Stn.GdpBeg	first GDP station number	(float) (alias = StnBeg)
$Stn.GdpInc	GDP station number increment	(non-zero float) (alias = StnDelt)
$Stn.Beg	possibly rescaled first station number	(float) (alias = LblFrst)
$Stn.Inc	possibly rescaled station number increment	(float) (alias = LblDelt)
$Stn.Left	rescaled station number on left edge of pseudosection plot	(float) (alias=LblFrst)
$Stn.Right	rescaled station number on right edge of pseudosection plot	(float)
$Unit.Length	length units	(m,ft) (alias = Units)
$Unit.E	electric field units	(nV/m,nV/Am)
$Unit.B	magnetic field units	(pT,pT/A
$Unit.Phase	phase units	(mrad,deg)

Transmitter properties

$Tx.Type	source type (for NSAMT /CSAMT: Natural, Bipole,Loop)
$Tx.GdpStn	transmitter ID from GDP Tx field (GDP stn #) (alias = XMTR)
$Tx.Stn	rescaled Tx ID (rescaled client stn #)
$Tx.Center`	transmitter center-point easting, northing, elevation (float, length units) (aliases = TxCX, TxCY)
$Tx.HPR	transmitter orientation heading, pitch, roll (Tx heading alias = TxBrg) (heading = bipole azimuth, pitch=0, roll=0 for z+up or 180 for z positive down)
$Tx.Length	transmitter bipole length or square loop width (positive float, length units)

Receiver properties

$Rx.GdpStn	receiver GDP station number (alias = Station)
$Rx.Stn	receiver client station number
$Rx.HPR	EM component heading, pitch, roll (floats, Rx heading alias = RxBrg, ExAzm) (heading = x component azimuth in degrees east of north, pitch = x component orientation in degrees. up from horizontal, pitch = z cmp rotation about x cmp, 0=z+up, 180 = z+ down)
$Rx.Length	E-field dipole length or loop widths (positive float(s), length units) (alias = aspace)
$Rx.Cmp	EM component/impedance label (ExHx, ExHy, EyHx, EyHy, Zxx, Zxy, Zyx, Zyy, Zvec, Zdet)

Csavgw *.avg-file columns:

skp	skip flag (0=drop data, 1=skip data, 2=good data)
Freq	frequency (hertz)
Tx.Amp	Tx current (square-wave peak amps)
E.mag	electric field magnitude (Unit.E)
E.phz	electric field phase (mrad)
B.mag	magnetic field magnitude (Unit.B)
B.phz	magnetic field phase (mrad)
Z.mag	impedance magnitude (km/sec)
Z.phz	impedance phase (mrad)
Ares.mag	Cagniard apparent resistivity magnitude (ohm-m)
SRes	static-corrected apparent resistivity added by Astatic (ohm-m)
E.wgt	electric field weight, -1 indicates polarity flip
H.wgt	magnetic field weight, -1 indicates polarity flip
E.%err	relative |E| error (%)
E.perr	phase(E) error (mrad)
B.%err	relative |H| error (%)
B.perr	phase(H) error (mrad)
Z.%err	relative |Z| error (%)
Z.perr	phase(Z) error (mrad)
ARes.%err	relative apparent resistivity error (%)
Gdp.Blk	first GDP block number in average
Gdp.Chn	GDP chn1.chn2 analog channel #s
Gdp.Time	data acquisition time (hh:mm:ss)

STN Files = station locations and EM component orientations

****.Stn*** files are most often used to import geographic easting, northing and elevation coordinates for each station, but may also include information about EM component orientation. A ****.stn*** file should have at least two entries, corresponding to the first and last stations. Additional entries may be necessary to trace out topographic changes or curved lines. Programs assume that station numbers represent distance along line and use station numbers to interpolate between coordinate records, if necessary. **If station numbers have been rescaled, **.stn* station numbers should be in rescaled values, not the original GDP numbers.** Station number rescaling is controlled by the keywords Stn.GdpBeg, Stn.GdpInc, Stn.Beg, Stn.Inc equal to the legacy keywords StnBeg, StnDelt, LblFrst, LblDelt.

****.Stn*** files use a comma- or space-separated-value spreadsheet format. Comment lines with a leading !, “, \, or / character may occur anywhere in the file and are ignored. Column-label records begin with a letter and are applied to subsequent numeric data. ****.Stn*** files must always have the four columns station, easting, northing and elevation. A Line column may be included if the ****.stn*** file includes data for multiple survey lines. The optional columns heading, pitch and roll may also be included to specify EM component orientations for individual stations. Programs look for the case-insensitive sub-strings, line, station, east, north, elev, heading, pitch, roll, when parsing a column label line. Lines that do not begin with a comment line flag or a letter should hold numeric data.

Partial *.stn file listing:

```
! Sample *.stn file for astatic v3.30 using an extended format
! with column labels, comma-separated values and extra columns
! for EM cmp (x,y,z) heading, pitch and roll.
! Heading = x cmp azimuth in deg east of north.
! Pitch   = x cmp angle relative to horizontal (deg up from horizontal)
! Roll    = z cmp rotation around x axis
!           roll=  0 = z positive up
!           roll=180 = z positive down
station,easting,northing,elevation,heading,pitch,roll
-200,1472490,11773343,2475,100,0,180
0,   1472687,11773311,2490,100,0,180
200, 1472885,11773279,2495,100,0,180
400, 1473082,11773246,2505,100,0,180
600, 1473280,11773214,2505,100,0,180
800, 1473477,11773182,2510,100,0,180
1000,1473674,11773149,2520,100,0,180
.           .           .
.           .           .
.           .           .
7200,1479792,11772147,2718,100,0,180
7400,1479990,11772115,2730,100,0,180
7600,1480187,11772083,2760,100,0,180
```