

TEMTRIM v3.30

Updated June 4, 2009

TEM Data Review

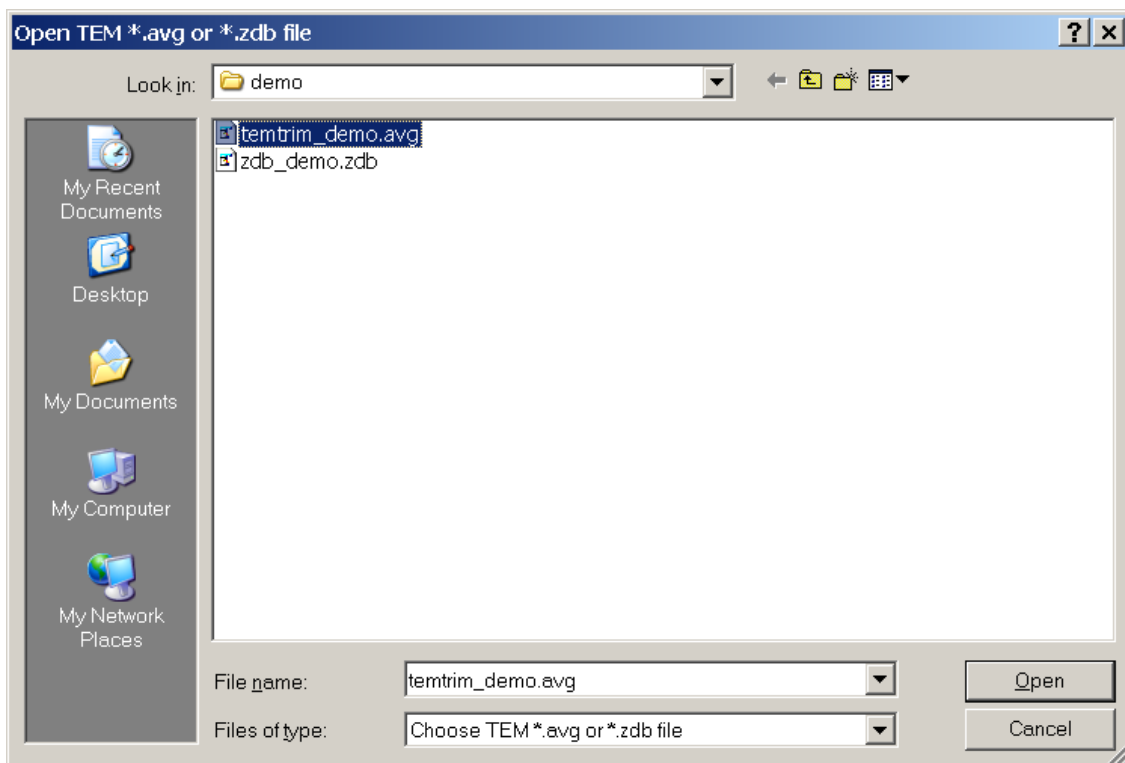
TEMTRIM is a utility program for TEM data review. It's main purpose is to allow interactive review of TEM transients with methods for setting skip flags to drop noisy data. In addition to interactive data review, TEMTRIM provides options for reading station coordinates and TEM component orientation, automatic noisy data skipping and filtering TEM transient curves to reduce noise. TEMTRIM also includes auxiliary functions for the merging of data with the same station number integer and averaging of repeat data.

TEMTRIM reads TEM data from avg (or zdb) files and writes updated avg, amira, z and/or usf files. A backup copy of the original avg file is saved with the extension \$avg, so the original data file can always be recovered if necessary. TEMTRIM can be re-run for multiple quality control sessions. Decisions about which data points are "noisy" is reversible, as skip flags can be set or cleared. Some operations do change the original data values, namely using moving-average filters to smooth data, merging data or averaging repeats.

TEMTRIM will also optionally create or update mde files to save TEM survey configuration parameters. Mde files save parameters in a \$keyword=value(s) format and provide a mechanism for storing data processing control and survey configuration information.

TEMTRIM v3.30 is a MS Windows program using "high-color", "16-bit" or "32-bit" color graphics. To install TEMTRIM, copy temtrim.exe to a directory on your computer's operating system path.

TEMTRIM can be run from the start menu, a short cut or from a Command Prompt window. When running from a Command Prompt window, TEMTRIM checks for an input file name on the command line (i.e. typing "temtrim temtrim_demo.avg" to start temtrim). If no command-line file name is entered, TEMTRIM shows an open file dialog to prompt for an input avg or zdb file.



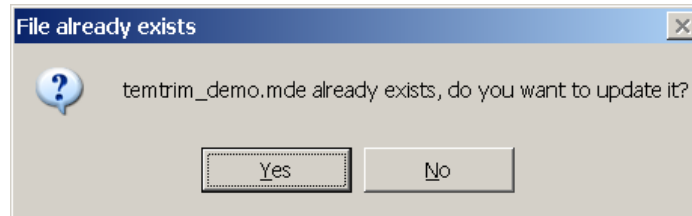
Zonge format avg files hold data in which repeat measurements have been averaged together. Zonge format zdb (Zonge Data Base) files have the same format as avg files, but store data in which repeats have not been averaged. Once an input data file has been selected, TEMTRIM shows a survey configuration dialog to verify TEM survey configuration parameters.

| Stn # | Beginning | Increment |
|----------|-----------|-----------|
| GDP | 84.0 | 2.00 |
| Rescaled | 84.0 | 2.00 |

| | Area (m ²) |
|---|------------------------|
| X | 1.0000E+4 |
| Y | 1.0000E+4 |
| Z | 1.0000E+4 |

Job Name, **Job Area**, **Job For**, **Job By**, **Job Number** and **Job Date** are descriptive text strings that may be used to record descriptive survey annotation. **Line Name** can be an arbitrary alphanumeric label, but it is preferred that it be restricted to a meaningful across-line grid coordinate label like 2400E. A common exception is the use of drill-hole labels as line names for down-hole TEM survey. **Line Number** is a floating point number that is usually equal to the numeric part of Line Name. Station and line numbers are used to interpolate from tabular stn file data to geographic (east,north,elevation) locations and optional (heading,pitch,roll) orientation values for each transient record. **Line Azimuth** is the orientation of the line in the direction of increasing station numbers. Azimuths are specified as degrees east of north. The station numbers used during data acquisition sometimes need to be rescaled to suit customer preferences. Dialog fields for GDP and rescaled station number beginning and increment provide a method for offsetting and/or rescaling station numbers. Station interval values must be non-zero, but a negative station interval value can be used to flip station number sign. Possible Zonge **TEM Arrays** are FXL = fixed loop, MVL = moving loop with arbitrary relative placement of the Tx and Rx loops, INL = moving loop with the receiver coil centered in the transmitter loop, COL = coincident loop, CNT = continuous recording TEM (with the loop array generally described in a detailed cfg file), LOT = LOTEM. For most surveys **Tx Loop** size is constant and a rectangular loop can be described by it's size along line and across line. The **Tx Loop** center values are used as transmitter loop center east, north for fixed-loop surveys. For moving-loop surveys, the Tx center values are used to specify the offset between transmitter and receiver loop centers. The **Rx Loop/Coil** grid field allows specification of an effective area (including pre-amp gain) for each TEM component. Normally TEM x components are oriented along

line in the direction of increasing station number, while y components are across line and z components are positive upward. The **Default EM Component Orientation** fields allow verification of TEM component orientation. "Default orientation" is a reminder that dialog field orientation values can be reset by reading a stn file with columns of (station, east, north, elevation, heading, pitch, roll). Multi-component down-hole or DNT cart surveys usually have a different TEM component orientation for each station, requiring that orientation data be imported from a stn file. Selecting the **Cancel** button will abort data input, while selecting **Continue** implies that the survey configuration values are satisfactory. After the Continue button is selected by left-button mouse click, TEMTRIM prompts for an optional mde file update.



Selecting Yes will create or update a mde file with the same file-name stem as the input data file. Selecting No skips over the mde file update option. TEMTRIM then sorts transients low-to-high on TEM component, transmitter frequency, transmitter station and receiver station. It finishes its data input by calculating B(t) curves from the dB/dt input data. dB/dt data are integrated from late-to-early time to calculate B(t). The integration starts with a zero value at the last time window, an implicit assumption that the measured transient is sufficiently long to reach negligible dB/dt levels.

After finishing data input, TEMTRIM displays a menu of processing options:

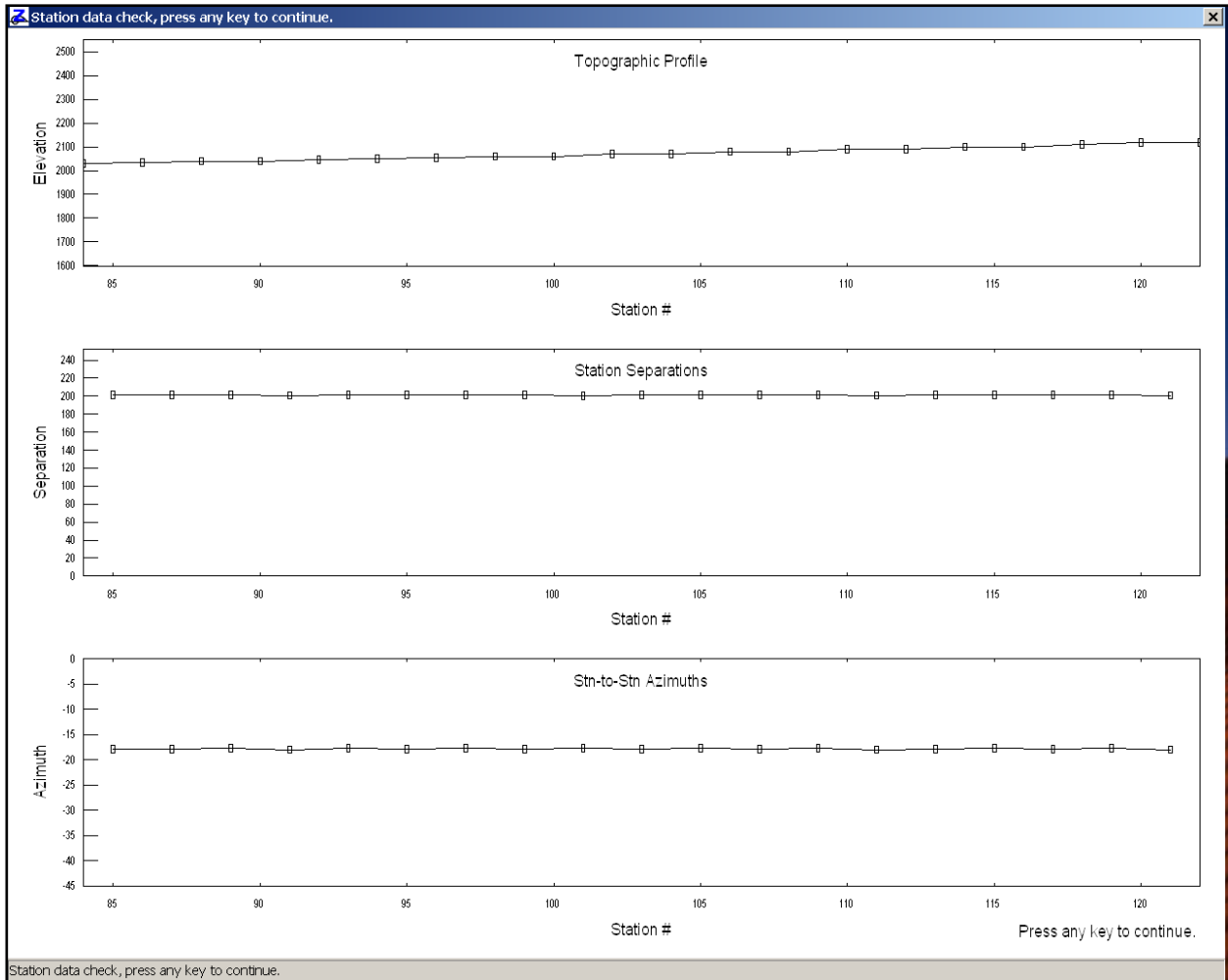


File|Open brings up the open file dialog prompting for a new input avg or zdb file name. **File|Save** saves the current avg file data to avg, amira, z and/or usf file formats. **File|Save As** allows you to change the file name before saving the current data set. **File|Exit** stops TEMTRIM.

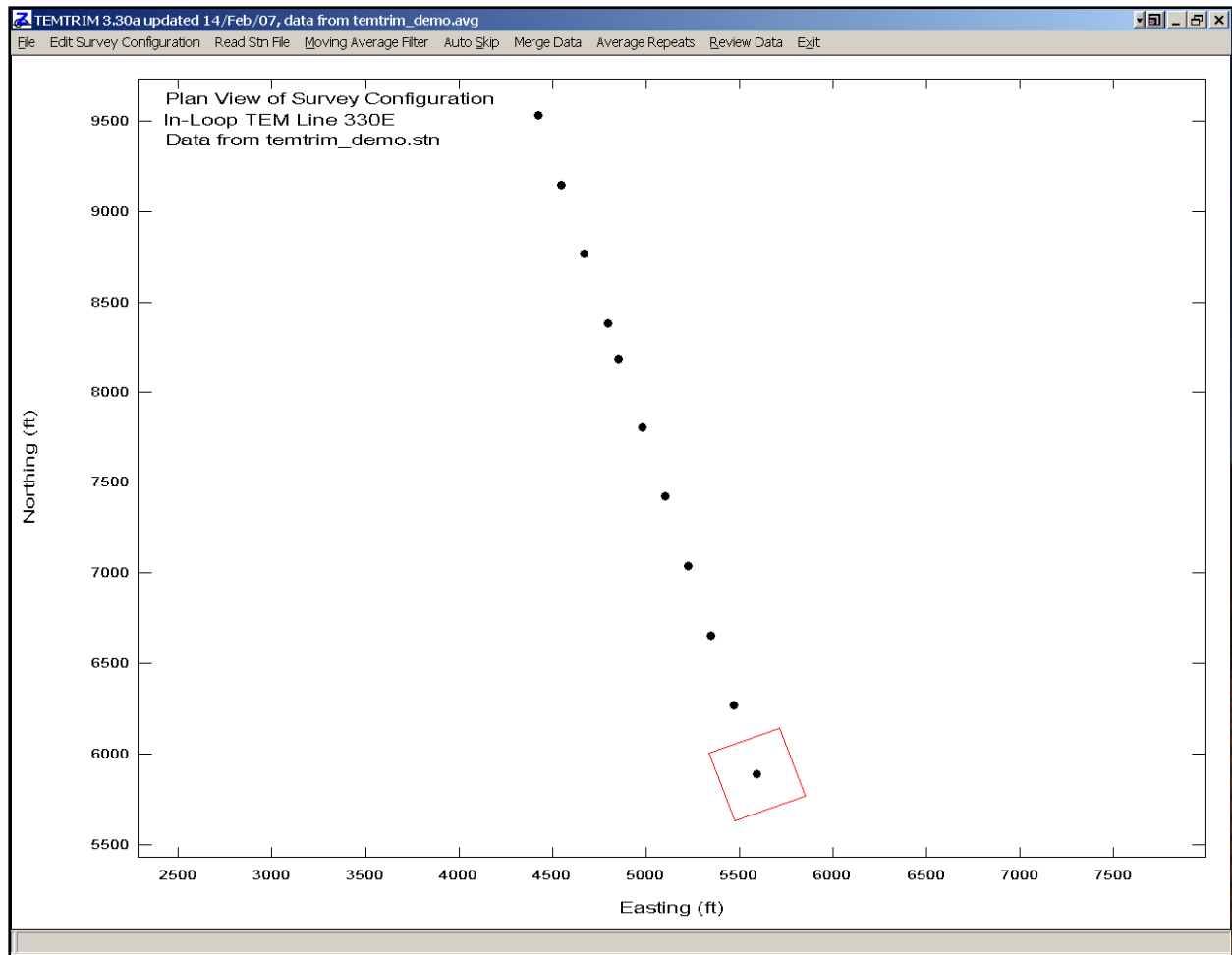
Edit Survey Configuration brings up the same Verify TEM survey configuration dialog that TEMTRIM shows when importing data from and input file.

Read Stn File interpolates values from a tabular stn file with required columns of station, east, north, elevation and optional columns of heading, pitch, roll, line. Station files may include values for multiple lines. If the optional line column is present, TEMTRIM will limit stn file data input to values with a matching line number. TEMTRIM interpolates on station number to estimate station locations and TEM component orientation. TEMTRIM stores component orientation values for each transient since receiver coils may be oriented differently at each station for down-hole or CNT cart surveys. Read Stn File shows two plots to verify stn file data correctness. First is a multi-panel profile plot with topography, station interval and station-to-station azimuth profiles.

Any typo or character transposition errors in stn file tables should show up as large excursions in the profile plot.

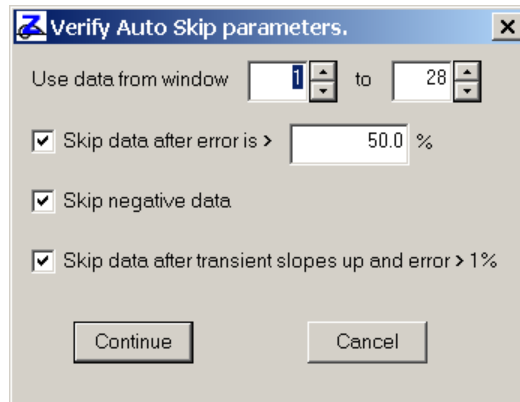


TEMTRIM then shows station locations in map view for further verification of correct station location data. The transmitter loop associated with the first receiver position is outlined on the map-view plot to provide a check on transmitter loop size and offset parameters.



Moving Average Filter applies a Gaussian moving average filter to each sounding curve. It smooths both dB/dt and apparent resistivity curves. Smoothing sounding curves reduces the effects of noise, but as it modifies sounding curve shape and changes inversion results, so it should only be used as a last resort. Per a suggestion from Neville Brown, the smoothing filter skips the first two early-time points, which are often displaced by the trailing edge of transmitter turn-off pulse. After smoothing the dB/dt transient data, TEMTRIM recalculates $B(t)$.

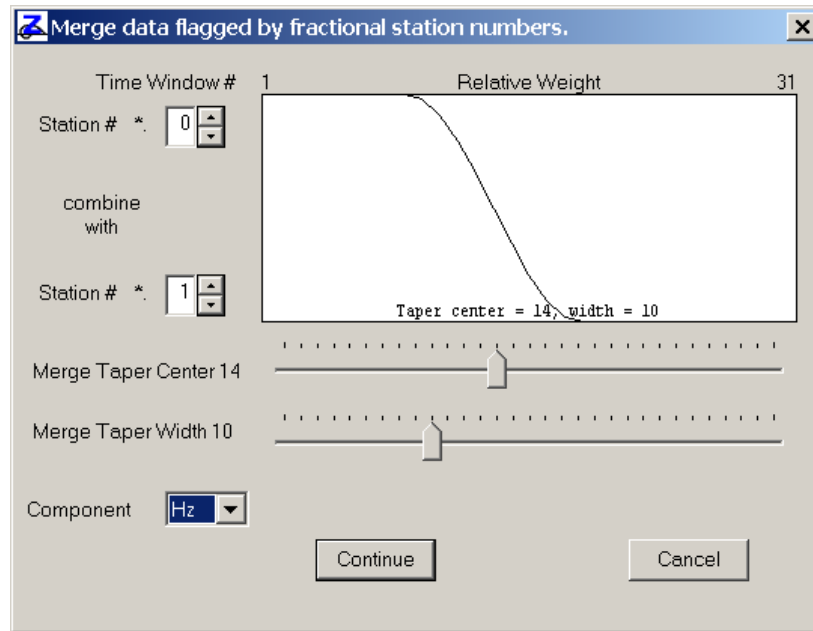
Noisy data can be skipped automatically with the **Auto Skip** menu option. **Auto Skip** first shows a dialog with auto skip control and filter settings.



The **Use data from window** ?? to ?? fields are useful if a fixed range of time windows should be skipped. For example, if transmitter turn-off has saturated the first 2 windows, set the lower index to 3 and time windows 1 and 2 will be skipped on all transients. If the **Skip data after error is > ??%** check box is checked, then all transient values after the first point with an error level greater than the error-level floor will be skipped. Checking **Skip negative data** will skip all data with transient values less than or equal to 0. It is useful for dropping negative early-time out-of-loop data before inversion with steminv. **Skip data after transient slopes up and error > 1%** is a combination filter that skips all data after the first upsloping transient segment. It also checks for data error > 1%, so that upsloping early-time data (as when the Rx is outside the Tx loop) will not set skip flags over the entire transient. Click on the **Continue** button to apply the Auto Skip filters or click on **Cancel** to return to the main menu without modifying the data. Note that using Auto Skip clears all previous skip flag settings, including any that may have been set manually.

Merge Data is an option intended to facilitate processing of TEM data components collected with two GDP channels, one channel with normal gains and a second gained up to improve late-time data quality. Since TEMAVG drops information about the GDP channels used during data acquisition, TEMTRIM depends upon a specialized station number convention to distinguish between transients from the channel with normal gains and transients from the gained up GDP channel. When merging data, TEMTRIM matches up transients with the same component label (Hx, Hy or Hz) and integer station number value. It uses the fractional part of the station number (*.0, *.1, ..., or *.9) to distinguish between transients from the channel with normal gains and transients from the gained up GDP channel. Station numbers with fractional values can be entered directly into the GDP channel station number fields, or the channel station number fields can be used as offsets relative to the GDP Rx field followed by station number recalculation using the shred /rs processing option.

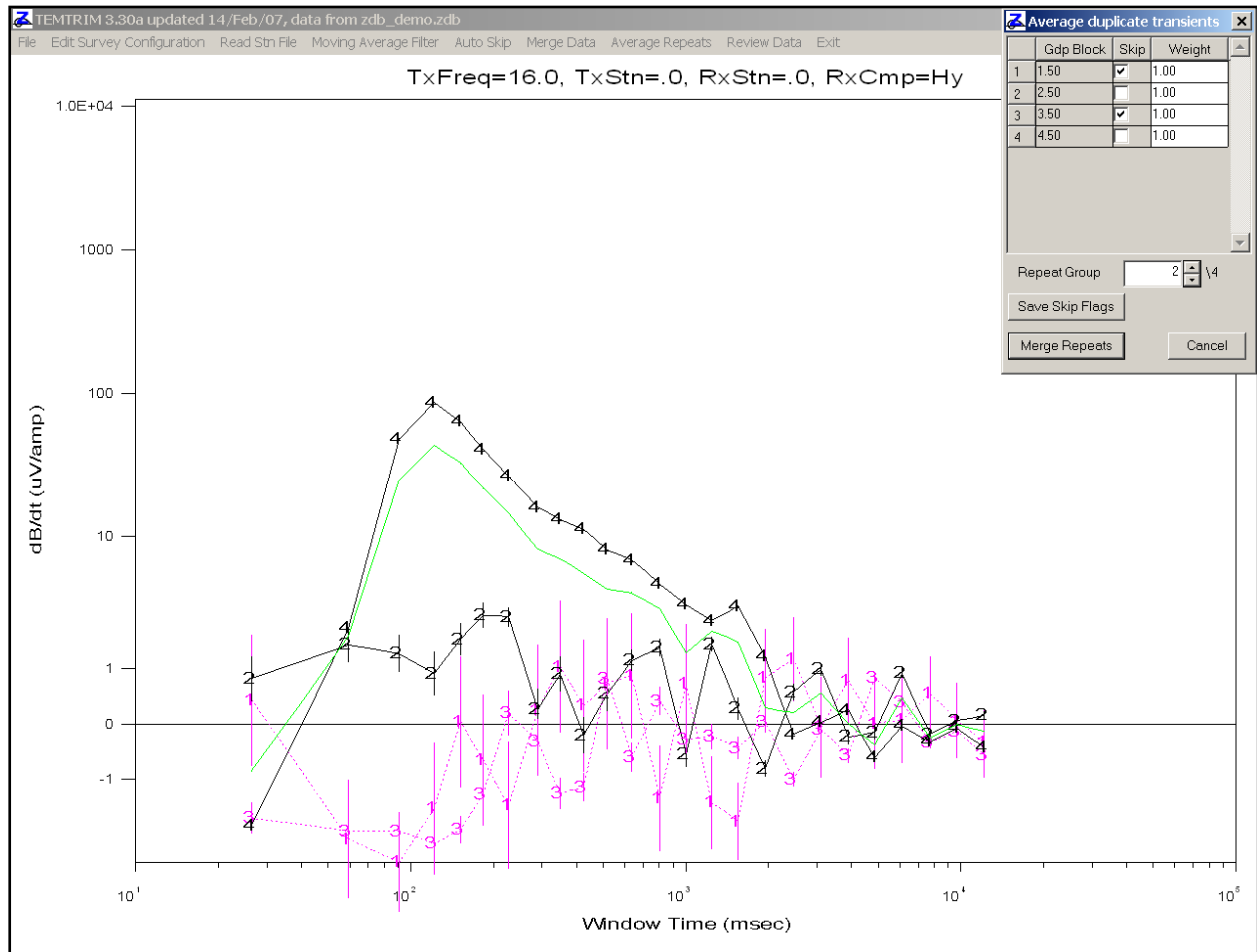
When selected, **Merge Data** shows a dialog with fields for processing control parameters.



The upper **Station # *** field allows input of the fractional value to use for selecting transients for early-time data. Using the default value of 0 will select transients with integer valued station numbers (100.0, 200.0, etc) for early-time data. The lower **Station # *** field controls the fractional value to use for finding transients with late-time data. Using the default value of 1 will select transients with station numbers like (100.1, 200.1, etc) for late-time data. Moving the control on the **Merge Taper Center** and **Merge Taper Width** track bars controls the taper weighting used to blend early- and late-time transients together. The **Component** field selects which component to merge. If the merge component is Hz, Hx and Hy data will be ignored. Click on the **Continue** button to merge data or **Cancel** to abort transient merging.

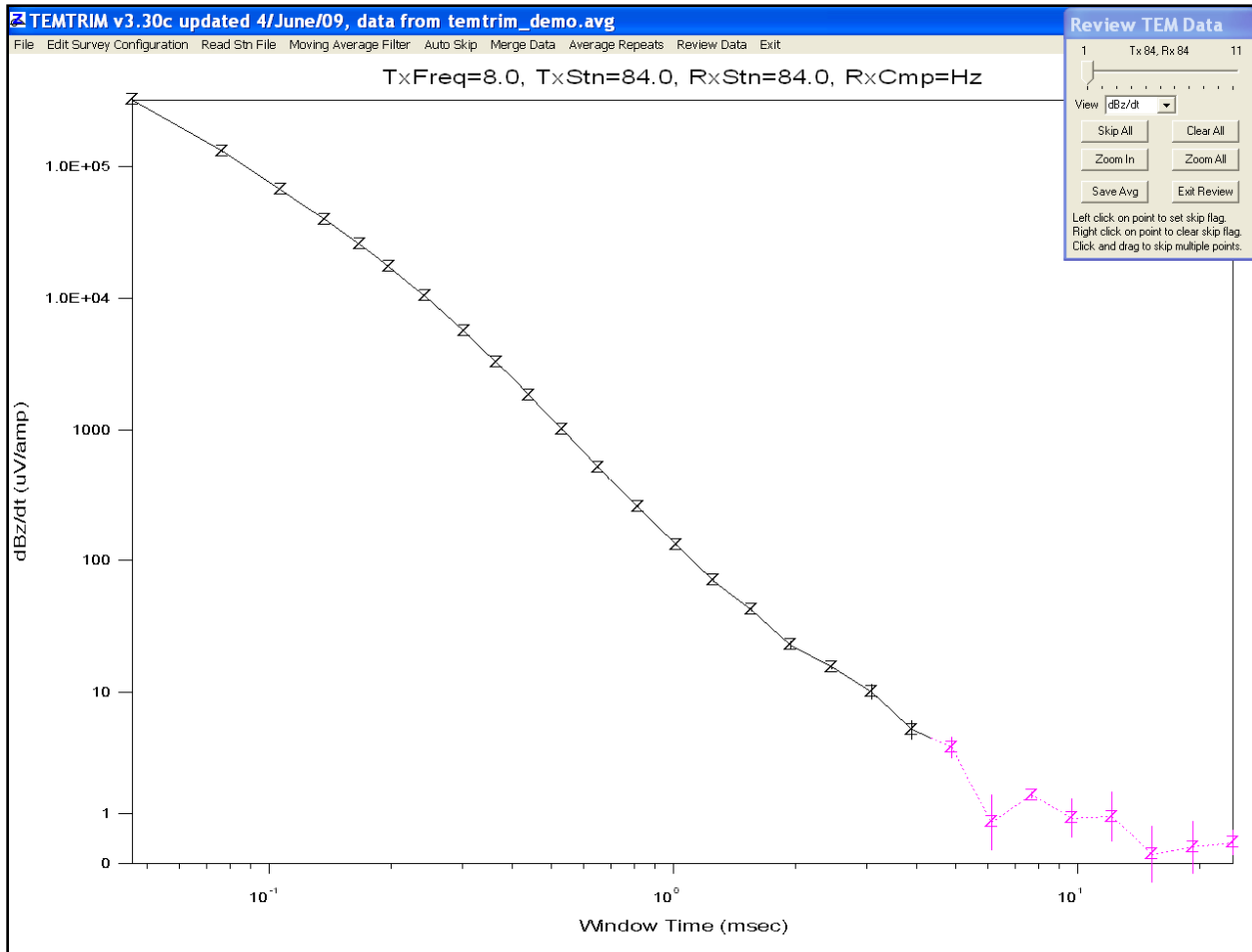
Choosing **Review Data** allows you to look at individual transient curves and to set or clear skip flags. Skipping noisy TEM transient data is the principal use of TEMTRIM and is essential in preparing data for inversion. It saves time to apply Auto Skip before selecting Review Data for interactive quality control. TEMTRIM's **Data Review** option individual transient curves. It defaults to a display of dB/dt (uV/amp) versus time (msec), but can also show B(t) curves or, if available, apparent resistivity versus time.

TEMTRIM includes the menu choice **Average Repeats** to combine duplicate transients. If no repeat data groups are found, Average Repeats will show a message box and return to the main menu. Otherwise it shows a plot displaying the duplicate transient curves.



Transient curves can be skipped by via the **Skip** check boxes in the plot control dialog. Skipped transients are shown in magenta, unskipped transients are plotted in black and the current average is indicated with a green curve. You can move between transient groups via the **Repeat Group** dialog field.

Clicking on the **Save Skip Flags** button saves transient skip flags and exits Avg Repeats without averaging repeat data together. You can re-enter the Avg Repeat procedure and TEMTRIM will recover the existing transient skip flag pattern. Clicking the **Merge Repeats** button averages repeat data together, reducing the total number of transient curves.

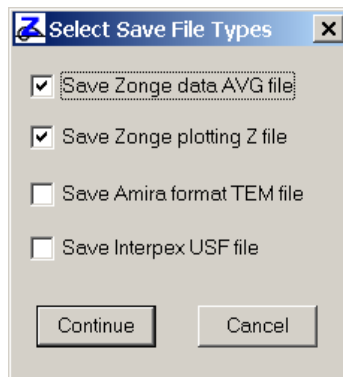


The **Data Review** dialog control allows you to move between transients by dragging the track bar cursor, with the left and right arrow keys, or with the mouse scroll wheel. Skipped data points are plotted in magenta. Individual data points can be skipped by left-clicking on a data point, while groups of points can be skipped with a left-click and drag to surround the noisy points with a rubber band selection box. Individual skip flags can be cleared with right click, or groups of points clear with a right click and drag. The **Skip All** button allows skipping of the entire transient. **Clear All** clears the entire transient and recovers the previous skip flag pattern. To examine part of the plot in more detail, click on the **Zoom In** button. It changes the mouse cursor shape to a spy glass, indicating that Zoom In has been invoked and that you should anchor the first corner of a selection box. After you anchor the two corners of a selection box, TEMTRIM expands the selected plot segment. The default transient plot view can be recovered with **Zoom All**.

Transient data can be reviewed efficiently by using one hand on the keyboard to press short-cut keys while moving the mouse around the data plot with the other hand. Movement between transients can be controlled by the short-cut keys **F = First Stn**, **P = Previous Stn**, **N key = Next Stn** and **L = Last Stn**. It is even easier to move through the transients with the mouse scroll wheel, while using mouse button left- or right-click or click-and-drag to set or clear skip flags on groups of points. Pressing the **ESC** or **X** keys will **Exit** Data Review.

Clicking on the Data Review **Save Avg** button will invoke an immediate Save data and then leave data review, while **Exit Review** returns control to the main menu without an immediate data file save.

You can use the menu options **File|Save** or **File|Save As** to write current data values to output data files before opening a new file or exiting TEMTRIM. With either save action TEMTRIM will show a dialog with a selection of output file types before writing output data files.



“Average” files with the file-name extension .avg are Zonge’s main format for storing processed TEM data. The name “average” comes from the practice of recording two or more stacks of TEM data at each field setup to demonstrate data repeatability. These data repeats are averaged together in post-acquisition data processing and are stored in “average” format files. Zonge format “Z” files have a block oriented format specialized for use by the Zonge plotting program ZPlot. Australians prefer to store TEM data in an “AMIRA” format data file, which TEMTRIM writes with the extension *.tem. The AMIRA format stores time-window information in an auxiliary file with the file-name extension .chn. Interpex layered-model programs read “universal sounding format” or USF files. TEMTRIM can save dBz/dt transient data in the USF format with the file-name extension .usf for use with Interpex modeling software.

File Format Documentation

AVG file - averaged TEM data and measurement error estimates

Partial listing of temtrim_demo.avg file, a "version 1" TEM average file.:

```
\ TEMAVG 7.20: "STEMDEMO.FLD", Dated 92-01-03, Processed 08 Sep 93
$ TEM: Array=In Loop (Central Loop)
$ TEM: TxRamp= 72.0 us
$ TEM: TxDX= 400. ft
$ TEM: TxDY= 400. ft
$ TEM: TxArea= 14884 m^2
$ TEM: RxArea= 10000 m^2
skp Station Freq Cmp Amps Win Time Magnitude RampAppRes Depth %Mag
2 84.00 8 Hz 3.30 1 0.046 3.2343e+5 1.6668e+1 8.0440e+1 0.5
2 84.00 8 Hz 3.30 2 0.0764 1.3097e+5 2.1763e+1 1.1845e+2 0.4
2 84.00 8 Hz 3.30 3 0.1068 6.6870e+4 2.4185e+1 1.4764e+2 0.4
2 84.00 8 Hz 3.30 4 0.1372 3.9800e+4 2.5457e+1 1.7168e+2 0.3
2 84.00 8 Hz 3.30 5 0.1676 2.5615e+4 2.6564e+1 1.9383e+2 0.3
2 84.00 8 Hz 3.30 6 0.198 1.7297e+4 2.7756e+1 2.1535e+2 0.3
2 84.00 8 Hz 3.30 7 0.243 1.0403e+4 2.9498e+1 2.4596e+2 0.3
2 84.00 8 Hz 3.30 8 0.304 5.6044e+3 3.2553e+1 2.8896e+2 0.4
2 84.00 8 Hz 3.30 9 0.3648 3.2564e+3 3.5902e+1 3.3247e+2 0.2
2 84.00 8 Hz 3.30 10 0.44 1.8347e+3 3.9854e+1 3.8470e+2 0.1
2 84.00 8 Hz 3.30 11 0.5314 1.0040e+3 4.4749e+1 4.4799e+2 0.7
2 84.00 8 Hz 3.30 12 0.651 5.1652e+2 5.0964e+1 5.2912e+2 0.7
2 84.00 8 Hz 3.30 13 0.8175 2.5543e+2 5.6969e+1 6.2690e+2 2.7
2 84.00 8 Hz 3.30 14 1.0145 1.3129e+2 6.2953e+1 7.3414e+2 0.6
2 84.00 8 Hz 3.30 15 1.2559 7.0447e+1 6.7643e+1 8.4670e+2 3.6
2 84.00 8 Hz 3.30 16 1.5584 4.2245e+1 6.7033e+1 9.3891e+2 5.3
2 84.00 8 Hz 3.30 17 1.9493 2.2802e+1 7.0219e+1 1.0748e+3 18.5
2 84.00 8 Hz 3.30 18 2.4626 1.5583e+1 6.1692e+1 1.1323e+3 6.8
2 84.00 8 Hz 3.30 19 3.0981 1.0010e+1 5.6809e+1 1.2187e+3 34.6
2 84.00 8 Hz 3.30 20 3.8833 5.1514e+0 6.0988e+1 1.4137e+3 44.1
2 84.00 8 Hz 3.30 21 4.8655 3.7640e+0 5.1783e+1 1.4582e+3 52.6
2 84.00 8 Hz 3.30 22 6.1163 7.9410e-1 1.0019e+2 2.2741e+3 199.1
2 84.00 8 Hz 3.30 23 7.7035 1.5104e+0 4.4472e+1 1.7003e+3 13.5
2 84.00 8 Hz 3.30 24 9.6681 8.8540e-1 4.3562e+1 1.8852e+3 113.2
2 84.00 8 Hz 3.30 25 12.142 9.1543e-1 2.9166e+1 1.7288e+3 167.0
2 84.00 8 Hz 3.30 26 15.283 1.6923e-1 6.1388e+1 2.8138e+3 205.0
2 84.00 8 Hz 3.30 27 19.226 2.9407e-1 2.8980e+1 2.1683e+3 183.6
2 84.00 8 Hz 3.30 28 24.191 3.7493e-1 1.6808e+1 1.8524e+3 63.8
2 88.00 8 Hz 3.50 1 0.043 3.5985e+5 1.5033e+1 7.3859e+1 0.5
2 88.00 8 Hz 3.50 2 0.0734 1.3595e+5 2.1816e+1 1.1625e+2 0.5
2 88.00 8 Hz 3.50 3 0.1038 6.2277e+4 2.6365e+1 1.5197e+2 0.4
. . . . .
. . . . .
. . . . .
```

A TEM avg file contains averaged TEM data for discrete times. TEM version 1 avg files are produced by the Zonge data processing program TEMAVG, which reads files with repeat readings, averages them and calculates measurement error from variation between repeats. Avg files are usually archived together with GDP-format files (raw) and station location files (stn). Avg files are used by Zonge programs that provide plots, options for further data processing, or modeling.

Comment lines preceded by a "\", "/", "!" or "" in column 1 may be placed anywhere within avg files. Data processing mode lines preceded by a "\$" in column 1 may also be present. A line holding column labels must precede the numerical data. Column order is not fixed and all columns may not be present in a particular file. Missing values are flagged by a "*". Numerical values are free format with columns separated by spaces or commas.

TEM version 1 AVG file column definitions:

| | |
|------------|--|
| Skp | - skip flag, 2 = good data, 1= bad data, 0 = very bad data. |
| Station | - receiver station number in unscaled and unshifted units. |
| Freq. | - repetition rate frequency (hertz). |
| Cmp | - measured field component (Hx, Hy or Hz). |
| Amps | - peak-to-peak square-wave current (amps). |
| Window | - time window index. |
| Time | - time window center (msec). |
| Magnitude | - dB/dt magnitude (uV/amp). |
| RampAppRes | - ramp-corrected apparent resistivity (ohm-m) (only calculated for in-loop data). |
| Depth | - diffusion depth = $28 \cdot \sqrt{\text{resistivity} \cdot \text{time}}$ (m) (only calculated for in-loop data). |
| %Mag | - relative dB/dt magnitude error (percent). |

TEM version 2 AVG file format

As of March 2005, TEM data may also be stored in a "version 2" TEM avg file, which has the same fundamental format as version 1 files, but holds many more survey configuration parameters and uses a different set of data column labels. TEMINV v3.20 reads both version 1 and 2 avg files, but it writes data to the version 2 format.

As with version 1 avg files, version 2 format 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 temtrim or tem. 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 column label lines. 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 (Twin.Center or dBdt.mag), temtrim 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.

Partial listing of MVLsample2.avg file, a "version 2" TEM average file.:

```

\ TEMAVG 7.20: "STEMDEMO.FLD", Dated 92-01-03, Processed 08 Sep 93
\ TEM data reviewed with TEMTRIM v3.20a on 12/04/05
$ Job.Name = "In-Loop TEM"
$ Job.Area = "Zonge Tucson"
$ Job.For = "TEMTRIM Documentation"
$ Job.By = "Zonge"
$ Job.Number = "9200"
$ Job.Date = April 2005
$ Survey.Type = LITEM
$ Survey.Array = INL
$ Line.Name = "0"
$ Line.Number = 0
$ Line.Azimuth = N20W
$ Stn.GdpBeg = 84
$ Stn.GdpInc = 2
$ Stn.Beg = 84
$ Stn.Inc = 2
$ Unit.Length = ft
$ Unit.Time = msec
$ Unit.dBdt = uV/A
$ Unit.B = pT/A
$ Tx.Length = 400,400 ft
$ Tx.Area = 1.4864E+04 m^2

$ Gdp.TxStn = 84
$ Gdp.RxStn = 84
$ Tx.Stn = 84
$ Tx.Center = 0,0 ft
$ Tx.Freq = 8
$ Tx.Amp = 3.7
$ Tx.Ramp = 72 usec
$ Rx.Stn = 84
$ Rx.Center = 5595,5887 ft
$ Rx.HPR = 240,0
$ Rx.Area = 1.0000E+04 m^2
$ Rx.Cmp = Hz
Twin.Index,Twin.Center,Twin.Beg,Twin.End,dBdt.Mag,dBdt.Err,dBdt.%Err,dBdt.Wgt,ARes.Mag,Depth.Image
1, 4.6000E-2, 3.5694E-2, 5.9282E-2, 3.23430E+05, 1.62E+03, 0.5, 1.0, 1.667E+01, 8.044E+1
2, 7.6400E-2, 5.9282E-2, 9.0330E-2, 1.30970E+05, 5.24E+02, 0.4, 1.0, 2.176E+01, 1.184E+2
3, 1.0680E-1, 9.0330E-2, 1.2105E-1, 6.68700E+04, 2.67E+02, 0.4, 1.0, 2.418E+01, 1.476E+2
4, 1.3720E-1, 1.2105E-1, 1.5164E-1, 3.98000E+04, 1.19E+02, 0.3, 1.0, 2.546E+01, 1.717E+2
5, 1.6760E-1, 1.5164E-1, 1.8217E-1, 2.56150E+04, 7.68E+01, 0.3, 1.0, 2.656E+01, 1.938E+2
6, 1.9800E-1, 1.8217E-1, 2.1935E-1, 1.72970E+04, 5.19E+01, 0.3, 1.0, 2.776E+01, 2.154E+2
7, 2.4300E-1, 2.1935E-1, 2.7179E-1, 1.04030E+04, 3.12E+01, 0.3, 1.0, 2.950E+01, 2.460E+2
8, 3.0400E-1, 2.7179E-1, 3.3302E-1, 5.60440E+03, 2.24E+01, 0.4, 1.0, 3.255E+01, 2.890E+2
9, 3.6480E-1, 3.3302E-1, 4.0064E-1, 3.25640E+03, 6.51E+00, 0.2, 1.0, 3.590E+01, 3.325E+2
10, 4.4000E-1, 4.0064E-1, 4.8355E-1, 1.83470E+03, 1.83E+00, 0.1, 1.0, 3.985E+01, 3.847E+2
11, 5.3140E-1, 4.8355E-1, 5.8817E-1, 1.00400E+03, 7.03E+00, 0.7, 1.0, 4.475E+01, 4.480E+2
12, 6.5100E-1, 5.8817E-1, 7.2952E-1, 5.16520E+02, 3.62E+00, 0.7, 1.0, 5.096E+01, 5.291E+2
13, 8.1750E-1, 7.2952E-1, 9.1069E-1, 2.55430E+02, 6.90E+00, 2.7, 1.0, 5.697E+01, 6.269E+2
14, 1.0145E+0, 9.1069E-1, 1.1288E+0, 1.31290E+02, 7.88E-01, 0.6, 1.0, 6.295E+01, 7.341E+2
15, 1.2559E+0, 1.1288E+0, 1.3990E+0, 7.04470E+01, 2.54E+00, 3.6, 1.0, 6.764E+01, 8.467E+2
16, 1.5584E+0, 1.3990E+0, 1.7429E+0, 4.22450E+01, 2.24E+00, 5.3, 1.0, 6.703E+01, 9.389E+2
17, 1.9493E+0, 1.7429E+0, 2.1910E+0, 2.28020E+01, 4.22E+00, 18.5, 1.0, 7.022E+01, 1.075E+3
18, 2.4626E+0, 2.1910E+0, 2.7621E+0, 1.55830E+01, 1.06E+00, 6.8, 1.0, 6.169E+01, 1.132E+3
19, 3.0981E+0, 2.7621E+0, 3.4686E+0, 1.00100E+01, 3.46E+00, 34.6, 1.0, 5.681E+01, 1.219E+3
20, 3.8833E+0, 3.4686E+0, 4.3467E+0, 5.15140E+00, 2.27E+00, 44.1, 1.0, 6.099E+01, 1.414E+3
21, 4.8655E+0, 4.3467E+0, 5.4552E+0, 3.76400E+00, 1.98E+00, 52.6, 1.0, 5.178E+01, 1.458E+3
22, 6.1163E+0, 5.4552E+0, 6.8642E+0, 7.94100E-01, 1.58E+00, 199.1, 0.0, 1.002E+02, 2.274E+3
23, 7.7035E+0, 6.8642E+0, 8.6301E+0, 1.51040E+00, 2.04E-01, 13.5, 1.0, 4.447E+01, 1.700E+3
24, 9.6681E+0, 8.6301E+0, 1.0835E+1, 8.85400E-01, 1.00E+00, 113.2, 1.0, 4.356E+01, 1.885E+3
25, 1.2142E+1, 1.0835E+1, 1.3622E+1, 9.15430E-01, 1.53E+00, 167.0, 0.0, 2.917E+01, 1.729E+3
26, 1.5283E+1, 1.3622E+1, 1.7141E+1, 1.69230E-01, 3.47E-01, 205.0, 0.0, 6.139E+01, 2.814E+3
27, 1.9226E+1, 1.7141E+1, 2.1566E+1, 2.94070E-01, 5.40E-01, 183.6, 1.0, 2.898E+01, 2.168E+3
28, 2.4191E+1, 2.1566E+1, 2.7135E+1, 3.74930E-01, 2.39E-01, 63.8, 0.0, 1.681E+01, 1.852E+3

```

TEM version 2 avg file metadata keywords:

Job.Name = string, project name (< 128 char)
Job.Area = string, project area (< 128 char)
Job.For = string, client name (< 128 char)
Job.By = string, contractor name (< 128 char)
Job.Number = string, identifying job label (< 16 char)
Job.Date = string, data acquisition date (< 16 char)
Survey.Type = enumeration, {LOTEM,TEM,CSAMT,NSAMT,CR,RPIP,TDIP}
Survey.Array = enumeration, TEM array {FXL,MVL,INL,COL,LOT,CNT}
Line.Name = string, arbitrary line "number" (<16 char)
Line.Number = float, line number, used for coordinate interpolation
Line.Azimuth = float, azimuth (deg E of N) or string = NnnE bearing format
Stn.GdpBeg = float, minimum gdp stn number, used for gdp to final stn #
scaling
Stn.GdpInc = float, gdp stn number increment
Stn.Beg = float, final stn number
Stn.Inc = float, final stn number increment
Unit.Length = enumeration, length units {m,ft}
Unit.Time = enumeration, transient-delay time units {usec,msec,sec}
Unit.dBdt = enumeration, dB/dt unit {uV/A,nV/Am2}
Unit.B = enumeration, B unit {pT/A,uT/A,nT}
Tx.Length = float, Tx loop side length (length units)
Tx.Area = float, Tx loop area (m²)
Gdp.Blk = float, gdp data block number for traceback
Gdp.Time = string, gdp data acquisition time (hh:mm:ss.sss) (<16 char)
Gdp.TxStn = float, original gdp Tx.Stn value
Gdp.RxStn = float, original gdp Rx.Stn value
Tx.Stn = float, Tx center stn #
Tx.Center = floats, Tx center east,north,elevation (length units)
Tx.Freq = float, Tx repetition rate (hertz)
Tx.Amp = float, Tx peak current (amps)
Tx.Ramp = float, Tx turn-off ramp extent (usec)
Rx.Stn = float, Rx coil stn number
Rx.Center = floats, Rx coil east,north,elevation
Rx.HPR = floats, Rx cmp orientation (heading,pitch,roll deg)
Rx.Area = float, Rx coil effective area (m²)
Rx.Cmp = enumeration, Rx component {Hx,Hy,Hz}

TEM version 2 avg file column labels:

TWin.Index = time window index
TWin.Center = time window geometric center (msec)
TWin.Beg = time window beginning (msec)
TWin.End = time window end (msec)
dBdt.Mag = dB/dt magnitude (uV/A)
dBdt.Err = dB/dt error (uV/A)
dBdt.%Err = dB/dt relative error (percent)
dBdt.Wgt = dB/dt data skip-flag weight (0=skip,1=use)
ARes.Mag = apparent resistivity (ohm-m)
Depth.Image = image section plot-point depth (length units)

STN file - station location and optional orientation

Partial Listing of temtrim_demo.stn:

| Station, | Easting, | Northing, | Elevation, | Heading, | Pitch, | Line |
|----------|----------|-----------|------------|----------|--------|------|
| 84.0, | 5595, | 5887, | 2030, | 340, | 0, | 330 |
| 86.0, | 5533, | 6079, | 2035, | 340, | 0, | 330 |
| 88.0, | 5471, | 6271, | 2040, | 340, | 0, | 330 |
| 90.0, | 5410, | 6463, | 2040, | 340, | 0, | 330 |
| 92.0, | 5348, | 6654, | 2045, | 340, | 0, | 330 |
| 94.0, | 5287, | 6846, | 2050, | 340, | 0, | 330 |
| 96.0, | 5225, | 7038, | 2055, | 340, | 0, | 330 |
| 98.0, | 5164, | 7230, | 2060, | 340, | 0, | 330 |
| 100.0, | 5102, | 7422, | 2060, | 340, | 0, | 330 |
| 102.0, | 5041, | 7613, | 2070, | 340, | 0, | 330 |
| 104.0, | 4979, | 7805, | 2070, | 340, | 0, | 330 |
| 106.0, | 4918, | 7997, | 2080, | 340, | 0, | 330 |
| 108.0, | 4856, | 8189, | 2080, | 340, | 0, | 330 |
| 110.0, | 4795, | 8381, | 2090, | 340, | 0, | 330 |
| 112.0, | 4733, | 8572, | 2090, | 340, | 0, | 330 |
| 114.0, | 4671, | 8764, | 2100, | 340, | 0, | 330 |
| 116.0, | 4610, | 8956, | 2100, | 340, | 0, | 330 |

Stn files hold information about station locations in a tabular format with space or comma separated values. TEMTRIM will interpolate between tabulated values, so stn file rows don't have to correspond exactly with TEM data stations. However, 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. Heading, pitch and roll columns are optional and are used when there is variation in the orientation of EM components along along line (or down hole). Down-hole measurements or continuously recording cart or marine TEM systems generally have variable x,y,z component orientation along the length of the survey line (or hole).

TEMTRIM assumes that station numbers are related to distance along line, but that precise scaling may vary due to survey error or topography. Station number values are used to linearly interpolate (easting, northing, elevation, [heading, pitch, roll], [line]) coordinates of stations without a matching entry in the STN file. If station numbers are scaled by entries in the MDE file, STN-file station numbers should be in the scaled and shifted final station numbers defined by Rx.Stn and Tx.Stn in version 2 avg files, not the unscaled and unshifted GDP station numbers saved in Gdp.RxStn and Gdp.TxStn.

Some grid coordinate systems, such as UTM coordinates, can generate very large coordinate values. TEMINV stores station locations as floating-point numbers with about seven significant figures. It may be necessary to subtract a constant from large coordinate values in order to allow accurate representation with seven significant figures.

Records beginning with a leading !, ", / or \ character are interpreted as comment lines and are skipped. Records beginning with a letter are interpreted to be column labels lines, and lines beginning with a number are input as tabular numeric data. Stn files should have a column label record before any numeric data. Columns may be in any order and label matching is done by searching for the case-insensitive substrings station, east, north, elev, heading, pitch, roll and line. Columns station, east, north, elevation must be present. Heading, pitch and roll columns are optional and are used for down-hole or continuous recording surveys. Stn files generally hold data for one line, but to if it is more convenient to combine location data for multiple lines into a single station file, a "line" column can be used to segregate data by line number. If a line column is present, temtrim drops all stn file data that do not have a value matching the floating point Line.Number (the numeric part of Line.Name).

STN file column definitions:

Station = client station numbers, scaled from gdp stn numbers by
$$Rx.Stn = (Gdp.RxStn - Stn.GdpBeg) * Stn.Inc / Stn.GdpInc + Stn.Beg.$$

Easting = grid east (m or ft, length units specified by Unit.Length)
Northing = grid north (m or ft)
Elevation = elevation (m or ft)
Heading = x component heading (deg east of north)
Pitch = x component pitch (deg up from horizontal)
Roll = y component rotation about x axis (0=z positive up, 180=z positive down)
Line = line number (specified as Line.Number in version 2 avg file metadata)

AMIRA TEM and CHN files – an Australian TEM data file format

Partial listing of MVLsample2.tem:

```
TEM data reviewed with TEMTRIM v3.20a on 12/04/05
DATATYPE:TEM INSTRUMENT:ZONGE UNITS:(uV/A) CHANNELFILE:MVLsample2.chn INITDELAY:.0720 F:U
\ Project:In-Loop TEM
\ for TEMTRIM Documentation
\ Job by Zonge", on April 2005
\ Window Times:
LOOP      LINE      STN      EAST      NORTH     RL      TxArea    CUR    RMP    G    C NCH
84        0        84       5595     5887     2030    1.486E+4  3.3   0.072  8    Z 28
88        0        88       5471     6271     2040    1.486E+4  3.5   0.072  8    Z 28
92        0        92       5348     6654     2045    1.486E+4  3.5   0.072  8    Z 28
96        0        96       5225     7038     2055    1.486E+4  3.2   0.072  8    Z 28
100       0        100      5102     7422     2060    1.486E+4  3.5   0.072  8    Z 28
```

AMIRA-format TEM and CHN files are in a standard format widely used in Australia. AMIRA .tem files hold survey configuration metadata, optional station locations and TEM transient data in a column-oriented profile format. AMIRA.tem files generally have an associated .chn file with TEM transient delay times. Comment lines starting with a \ may appear anywhere in AMIRA-format files. Other than comment lines, AMIRA TEM file records fall into three categories. First, TEM files must start with a single unflagged comment line which may contain any text and is ignored by programs reading the file. Second is a line of keywords and keyword values, each with a keyword=value or keyword:value format separated by spaces. Keywords can contain letters and numbers, but no other special characters or spaces. Third is a list of column labels which are space separated keywords indicating the content of columns in subsequent numerical records. The remainder of a .tem file is a block of numeric records in space separated columns. Missing values are indicated by a * symbol.

Most keywords can be either in the keyword line or used as column labels. If a parameter has a constant value for all stations, then it is best specified as a constant in the keyword record. If it varies, then it must be included as a column of values. The minimum required columns include STATION and CH1, CH2, ..., all other columns are optional.

AMIRA Keywords recognized by STEMINV

UNITS = uV/A, nV/Am² or nT/sec (default = uV/A)
CONFIGURATION or CONFIG = Moving_Loop, Slingram, InLoop, In_Loop, InOut, Fixed, FixedLoop, Fixed_Loop (default = moving-loop)
If CONFIG type doesn't start with Fixed, STEMINV assumes a moving loop survey
CHANNELFILE = channel file name (default = same file name stem as *.tem file)
PROFILE = line number
NCH or NUMTIMES = # transient delay time windows, also read from *.chn file
FREQUENCY, FREQ or F = transmitter repetition rate (hertz)
CURRENT, CURR or CUR = transmitter current (amps)
TURNOFF, RAMP or RMP = transmitter turn-off ramp time (msec)
INIT_DELAY, INITDELAY or INIT = offset between beginning of Tx ramp and transient time = 0 (msec) (default = 0)
TXAREA or LOOPAREA = Tx loop area (m²)
RXAREA = Rx effective loop area (m²)

Custom comment lines with Tx loop center coordinates

/TXX = Tx loop easting
/TXY = Tx loop northing

AMIRA Column Labels recognized by STEMINV

STATION or STN = station numbers (required column)
LINE or PROFILE = line number (optional column)
LSIDE = Tx loop width (m) (optional column)
CURRENT or CUR = Tx current (optional column)
COMPONENT or C = Rx component (X,Y,Z,A,U,V,C,I)
NUMTIMES or NCH = number of dB/dt values, also in channel file
CH1, CH2, CH3, ... or CH01, CH02, CH03, ... = dB/dt values (required columns)

Listing of MVLsample2.chn:

Zonge GDP delay times w.r.t. end of Tx ramp (msec).

NUMTIMES:28

DELAY

4.6000E-2
7.6400E-2
0.1068
0.1372
0.1676
0.1980
0.2430
0.3040
0.3648
0.4400
0.5314
0.6510
0.8175
1.015
1.256
1.558
1.949
2.463
3.098
3.883
4.865
6.116
7.703
9.668
12.14
15.28
19.23
24.19

Interpex USF files – an Interpex “Universal Sounding Format”

Usf files are used by Interpex modeling programs to import sounding data from a variety of electrical and electromagnetic methods. Complete documentation may be found at <http://www.interpex.com>.

Partial listing of MVLsample2.usf:

```
! TEM data reviewed with TEMTRIM v3.20a on 12/04/05
! Job.Area: Zonge Tucson
! Job.For: TEMTRIM Documentation
! Job.By: Zonge
! Job.Date: April 2005
```

```
//USF: Universal Sounding Format
//SOUNDINGS: 11
//END
```

```
/ARRAY: CENTRAL LOOP TEM
/SOUNDING_NAME: 122
/DATE: 20050412
/PROFILE: 0
/AZIMUTH: 340
/Z_DIRECTION: UP
/LENGTH_UNITS: ft
/VOLTAGE_UNITS: V/AM2
/DUMMY: *
/INSTRUMENT: "Zonge TEM"
/SWEEPS: 1
/LOOP_SIZE: 400,400
/LOOP_TURNS:1
/LOCATION: 5595,5887,2030
/FREQUENCY: 8
/CURRENT: 3.3
/RAMP_TIME: 7.2000E-05
/COIL_SIZE: 1.0000E+4
/POINTS: 24
/END
```

```
INDEX, TIME, WIDTH, VOLTAGE
1, 1.1800E-4, 2.3589E-5, 3.23430E-05
2, 1.4840E-4, 3.1048E-5, 1.30970E-05
3, 1.7880E-4, 3.0719E-5, 6.68700E-06
4, 2.0920E-4, 3.0591E-5, 3.98000E-06
5, 2.3960E-4, 3.0527E-5, 2.56150E-06
6, 2.7276E-4, 3.7182E-5, 1.72970E-06
7, 3.1757E-4, 5.2445E-5, 1.04030E-06
8, 3.7600E-4, 6.1221E-5, 5.60440E-07
9, 4.3883E-4, 6.7624E-5, 3.25640E-07
10, 5.1409E-4, 8.2906E-5, 1.83470E-07
11, 6.0786E-4, 1.0462E-4, 1.00400E-07
12, 7.3084E-4, 1.4135E-4, 5.16520E-08
13, 8.9210E-4, 1.8117E-4, 2.55430E-08
14, 1.0917E-3, 2.1808E-4, 1.31290E-08
15, 1.3359E-3, 2.7023E-4, 7.04470E-09
16, 1.6430E-3, 3.4393E-4, 4.22450E-09
17, 2.0389E-3, 4.4804E-4, 2.28020E-09
18, 2.5486E-3, 5.7116E-4, 1.55830E-09
19, 3.1873E-3, 7.0642E-4, 1.00100E-09
20, 3.9796E-3, 8.7819E-4, 5.15140E-10
21, 4.9730E-3, 1.1084E-3, 3.76400E-10
23, 7.8191E-3, 1.7659E-3, 1.51040E-10
24, 9.8044E-3, 2.2046E-3, 8.85400E-11
27, 1.9426E-2, 4.4246E-3, 2.94070E-11
/END
```

Comment lines with a leading ! may appear anywhere in a usf file. TEMTRIM puts a block of comment lines with descriptive information at the beginning of its usf files. TEMTRIM writes only vertical component data to usf files, dropping all horizontal component data, since TEM "soundings" generally rely on dBz/dt.

A main header block is required and specifies the number of soundings saved in the usf file.

```
//USF: Universal Sounding Format
//SOUNDINGS: 11
//END
```

USF – Zonge keyword synonyms.

Each sounding is preceded by a data header block with /keyword: value records specifying the survey configuration.

```
/ARRAY:           = Survey.Array       = TEM array type enumeration
/SOUNDING_NAME:   = Rx.Stn              = stn number
/DATE:           = Job.Date             = data acquisition date
/PROFILE:        = Line.Name            = line "number" string
/AZIMUTH:        = Line.Azimuth         = line azimuth (deg E of north)
/Z_DIRECTION:    = Rx.HPR               = roll=0=z+ up, roll=180=z+down
/LENGTH_UNITS:   = Unit.Length         = m or ft length units
/VOLTAGE_UNITS:  = Unit.dBdt           = dB/dt units (usf= V/AM2, Zonge=uV/A)
/DUMMY: *        =                     = represents missing or invalid data
/INSTRUMENT:     = "Zonge TEM"         = always set to Zonge TEM by TEMTRIM
/SWEEPS: 1       =                     = always set to 1 by TEMTRIM v3.20
/LOOP_SIZE:     = Tx.Length            = rectangular Tx loop size (length units)
/LOOP_TURNS:1   = Tx.Turns             = number of Tx loop turns
/LOCATION:        = Rx.Center            = Rx coil location (east,north,elevation)
/FREQUENCY:     = Tx.Freq              = Tx repetition rate (hertz)
/CURRENT:       = Tx.Amp               = Tx current (amps)
/RAMP_TIME:     = Tx.Ramp               = Tx ramp time (usf=sec,zonge=usec)
/COIL_SIZE:     = Rx.Area              = Rx coil/loop effective area (m^2)
/POINTS:        =                     = number of points in transient
```

USF file column labels

```
INDEX           = time window index
TIME            = time-window arithmetic centers = (TW_begin + TW_end)/2 in
                 seconds with respect to the beginning of the Tx turn-off ramp.
                 (Note that Zonge formats use geometric centers = sqrt(TW_begin*TW_end)
                 in msec with respect to the end of the Tx turn-off ramp.)
WIDTH           = time-window width (sec)
                 (Note that Zonge and AMIRA formats use msec.)
VOLTAGE         = dB/dt magnitude (V/Am2)
                 (Note that Zonge avg and z files use uV/A.)
```

Z file - TEM data format for ZPLOT plotting

The .Z file is a format specialized for use by the Zonge profile plot program ZPLOT. For general use, the avg file format is preferred because it retains much more information about the survey configuration and includes measurement error estimates.

```
$ ZPLOT: Project = In-Loop TEM
$ ZPLOT: Client = TEMTRIM Documentation
$ ZPLOT: JobNumb = 9200
$ ZPLOT: JobDate = April 2005
$ ZPLOT: JobLine = 330E
$ ZPLOT: BrgLine= N20W
$ ZPLOT: BrgBack= 160
$ ZPLOT: STNLOW = 84
$ ZPLOT: STNDELT = 2
$ ZPLOT: LBLFRST = 84
$ ZPLOT: LBLDELT = 2
$ ZPLOT: DATA= TIME
  TEMAVG Contour File
  Cl Cn Ce Ns Nd Yl Plot file 1
    0 1 0 3 1 0
  TEM SURVEY DATA
  dBz/dt uV/amp
    Tx 122
$ CONTOUR= NONE
$ PROFILE= 0d
$ POST = NONE
IIxxxxxxxxxYYYYYYYzzzzzzzzzzzz
2      84. 0.04600 3.2343E+05
2      84. 0.07640 1.3097E+05
2      84. 0.1068 6.6870E+04
2      84. 0.1372 3.9800E+04
2      84. 0.1676 2.5615E+04
2      84. 0.1980 1.7297E+04
2      84. 0.2430 1.0403E+04
:      :      :      :      :      :
:      :      :      :      :      :
9999.0
```

Z files are used for storing plot file data in multiple (skp,x,y,z) data blocks. Numerical values are stored in a fixed format, so column position is important. Numerical field widths are indicated by the "lXyZ" record preceding numerical data. A "lXyZ" record flags the beginning of a block of numerical (skp,x,y,z) data and a 9999.0 value flags the end of the block.

Description of lines in sample Z file:

\$ ZPLOT: Project = Job.Name = project name
\$ ZPLOT: Client = Job.By = customer name
\$ ZPLOT: JobNumb = Job.Number = job ID number
\$ ZPLOT: JobLine = Line.Name = alphanumeric line label
\$ ZPLOT: BrgLine = BrgRight = bearing annotation posted on right edge of plot
\$ ZPLOT: BrgBack = BrgLeft = bearing annotation posted on left edge of plot
\$ ZPLOT: StnLow = Stn.GdpBeg = first GDP station number in plot
\$ ZPLOT: StnDelt = Stn.GdpInc = GDP station number interval
\$ ZPLOT: LblFrst = Stn.Beg = first rescaled station number in plot
\$ ZPLOT: LblDelt = Stn.Inc = rescaled station number interval
TEMAVG Contour File = descriptive file label
CI Cn Ce Ns Nd YI - labels for integer contour control flags.
 CI - label for contour type: 0 = linear
 1 = logarithmic
 2 = pseudo-log: Pseudo-log contours = positive and negative values are contoured separately, using $\log_{10}(\text{abs}(\text{value}))$, plus a zero contour.
 Cn - label for number of contours per interval.
 Ce - label for exponent of the contour interval, $\text{interval}=10^{\text{Ce}}$.
 Ns - label for number of significant digits when posting values.
 Values: -1, 3, 4, 5. (-1 = free format for small values)
 Nd - label for the number of digits after the decimal.
 YI - label for vertical axis: 0 = none
 1 = log frequency axis
 2 = linear frequency axis
 3 = linear depth
1 5 0 3 1 1 - integer values for contour control flags.
 1 - value of CI => logarithmic contours
 5 - value of Cn => 5 contours per "interval"
 0 - value of Ce => $\text{interval}=10^{\text{Ce}}$
 3 - value of Ns => use 3 significant digits for contouring
 1 - value of Nd => plot 1 digit after the decimal
 1 - value of YI => log frequency axis
TEM SURVEY DATA - Data description for this plot file. Two to six lines are available.
values in microV/ampere ZPLOT plots these lines as title annotation.
Component: Hz, Rxna: 10000.0
\$ CONTOUR= NONE - ZPLOT plot control keywords, no contours.
\$ PROFILE= AUTO - plot magnitude profiles.
\$ POST = NONE - do not post data values.
llxxxxxxxYYYYYYYzzzzzzzzzzz - Header line for the data that follows.
ll - skip flag field:
 0 = Skip this line of data.
 1 = Omit for contouring, but post the bracketed value.
 2 = Use for contouring and post the value (most common).
 3 = Label a point or station by plotting a symbol under the X-axis at the X-coordinate.
 4 = Use for contouring, post the symbol and not the value. Used for depth plots where interpolated values are used at the bottom of the plot to improve gridding.
 5 = Use to set plot limits, do not contour or post. Used for depth plots to set zero depth. Also used to provide a margin around the data, as for plan maps.
xxxxxxx - x value field, usually unscaled and unshifted station numbers.
YYYYYYY - y value field, for TEM, time window center (msec).
zzzzzzzzzzz - z value field, to be plotted at (x,y) when skip flag=1, 2, or 4.
9999.0 - marks end of (stn,x,y,z) data block.