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Levelling Utilities

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Abstract

A series of GX utilities for Geosoft's Oasis Montaj software have been developed to facilitate the levelling of magnetic airborne survey data. The utilities and method described in this document are based on the principle of minimizing the tie line and traverse line intersection differences. A Geosoft intersection database is used as the input source to TIELEV.GX which applies a low-pass filter to the mis-tied values along the tie lines. The GX, LOADLEV.GX, then loads the levelling corrections to the tie lines and traverse lines into the main database.

Table of Contents

List of Figures

Minimum System Requirements

As a minimum, a dual core processor running Windows XP Service Pack 3 (32-bit) or higher with at least 1GB memory is required. The levelling utilities are Geosoft Executables (GX) and requires Geosoft Oasis montaj software, v7.5.1 or higher.

Installation

Installing the software is a three-step process:

Step 1 - Copy tielev.gx, loadlev.gx, btwcor.gx, editlev.gx, edit_cd.gx, prev.gx, next.gx, reinterp.gx, transpose.gx, xjump.gx, dist_int.gx and xjumphome.gx to Geosoft's Oasis montaj's "resourcefiles\gx" directory. Typically, this is "C:\Program Files\Geosoft\Oasis montaj\resourcefiles\gx" on a 32-bit system and "C:\Program Files (x86)\Geosoft\Oasis montaj\resourcefiles\gx" on 64-bit systems.

Step 2 – Copy xjump.omn to Geosoft Oasis montaj's "resourcefiles\omn" directory. Typically, this is "C:\Program Files\Geosoft\Oasis montaj\resourcefiles\omn" on a 32-bit system and "C:\Program Files (x86)\Geosoft\Oasis montaj\resourcefiles\gx" on 64-bit systems.

Step 3 – Copy xjump.geobar to Geosoft Oasis montaj's "resourcefiles\bar" directory. Typically, this is "C:\Program Files\Geosoft\Oasis montaj\resourcefiles\bar" on a 32-bit system and "C:\Program Files (x86)\Geosoft\Oasis montaj\resourcefiles\gx" on 64-bit systems.

Usage

Load the Levelling Utilities toolbar by clicking on the "GX" -> "Load Menu…" menu option in Oasis Montaj. Look for "xjump.omn" in the file browser window that opens. Due to a bug is Oasis Montaj, you may need to move one or more of the existing toolbars in order for the Levelling Utilities toolbar to show up.

Since these GXs are not signed by Geosoft, an authorization window is displayed the first time the GX is run. Clicking the "Run Always" button will permanently eliminate the display of this window.

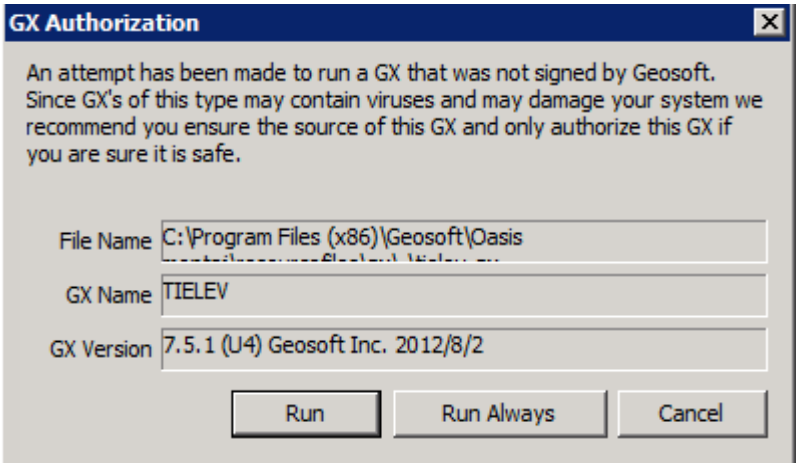


Figure 1 - GX first-run authorization popup

Levelling Procedure

Summary:

1. Clean up the flight path.
2. Apply dc and first order adjustment on the intersection database.
3. Apply a low-pass filter to the mis-tied values (Run TIELEV.GX).
4. Review the low-pass filter results on the tie lines.
5. Load the levelling corrections into the main database (Run LOADLEV.GX).
6. Review the levelling corrections for the traverse lines.
7. Apply the levelling corrections.

STEP 1 – Clean up the flight path

Before starting the levelling process, it is necessary to trim the flight lines so that when a line is flown in multiple segments, consecutive segments should overlap on one control line only as shown on Figure 2, see (a) L4330 and L4331. The same rule applies for tie line segments in Figure 2, see (b) at T8111 and T8114, which overlap only on one traverse line L4290.

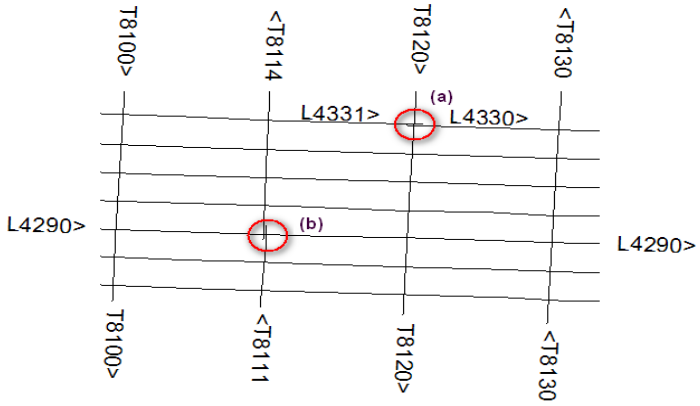


Figure 2 - Trimming of line segments. The red circles indicate the two intersection types discussed in the text. Prefix T = tie line; prefix L = traverse line.

STEP 2 – Apply DC and first order adjustments on the intersection database

A DC and first order levelling adjustments must be applied to the CROSS DIFFERENCES in the intersection database file. This first step is a standard procedure in levelling using the Geosoft Iterative Levelling software. Recalculate a new intersection file from the levelled channel after the first order levelling has been done.

STEP 3 – Apply a low-pass filter to the mis-tied values

Under the Run GX menu, select the TIELEV.gx GX

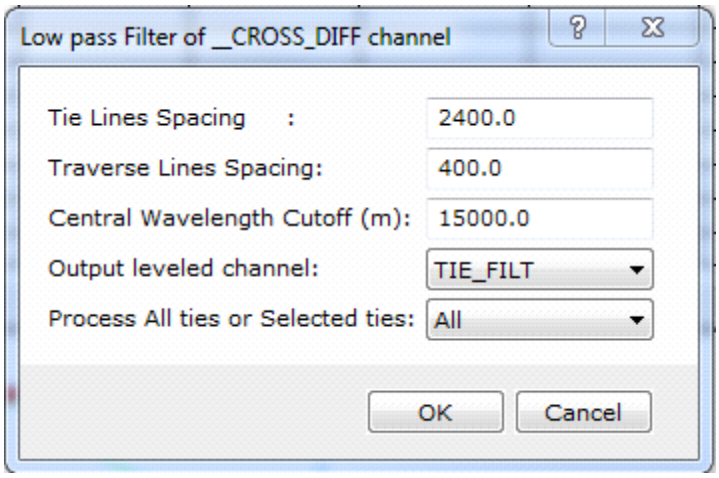
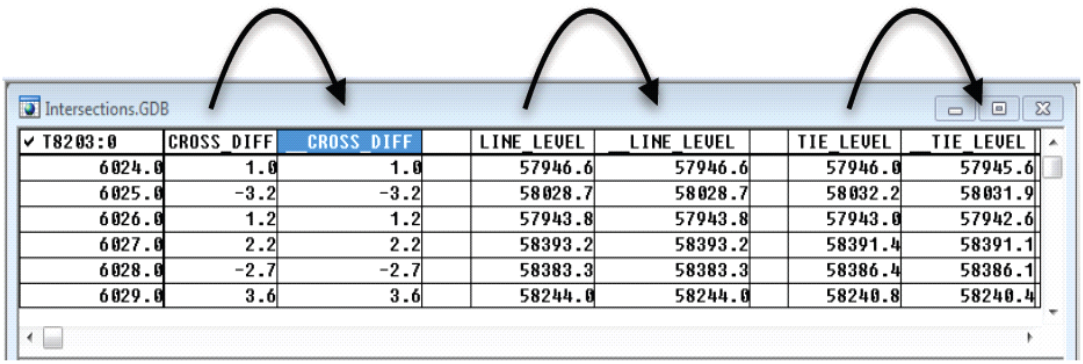


Figure 3 - Sample input to TIELEV.gx

INPUT PARAMETERS:

Tie Line spacing (m)	Distance between tie lines (m)
Line spacing (m)	Distance between traverse lines (m)
Central Wavelength Cut-off (m)	For standard GSC survey with traverse line spacing of 400m, a value of 5 000 – 15 000 m is commonly used.
Output filtered channel	TIE_FILT
Process All ties or Selected ties	Tie line selection option: “All” or “Selected”

Low-pass filtering of tie line intersection mis-ties is done after a DC and first order levelling adjustments have been applied to the intersection database file. The first time the TIELEV GX is executed on a database, it produces a backup copy of the original traverse and tie line levels and their mis-tied values (CROSS_DIFF) (see Figure 4). This is done in order to preserve the original mis-tied values, which can then be reapplied if the GX is re-run on the same database.



T8203:0	CROSS_DIFF	__CROSS_DIFF	LINE_LEVEL	__LINE_LEVEL	TIE_LEVEL	__TIE_LEVEL
6024.0	1.0	1.0	57946.6	57946.6	57946.0	57945.6
6025.0	-3.2	-3.2	58028.7	58028.7	58032.2	58031.9
6026.0	1.2	1.2	57943.8	57943.8	57943.0	57942.6
6027.0	2.2	2.2	58393.2	58393.2	58391.4	58391.1
6028.0	-2.7	-2.7	58383.3	58383.3	58386.4	58386.1
6029.0	3.6	3.6	58244.0	58244.0	58240.8	58240.4

Figure 4 - Backup copy of original channels

The TIELEV GX applies a Butterworth low-pass filter to the "__CROSS_DIFF" channel. The low-pass filtered result is stored in the intersection database in the channel "TIE_FILT" and is added to the "TIE_LEVEL" channel as the levelling correction to the tie lines. This correction should approximate the effect of the diurnal variation (see Figure 5).

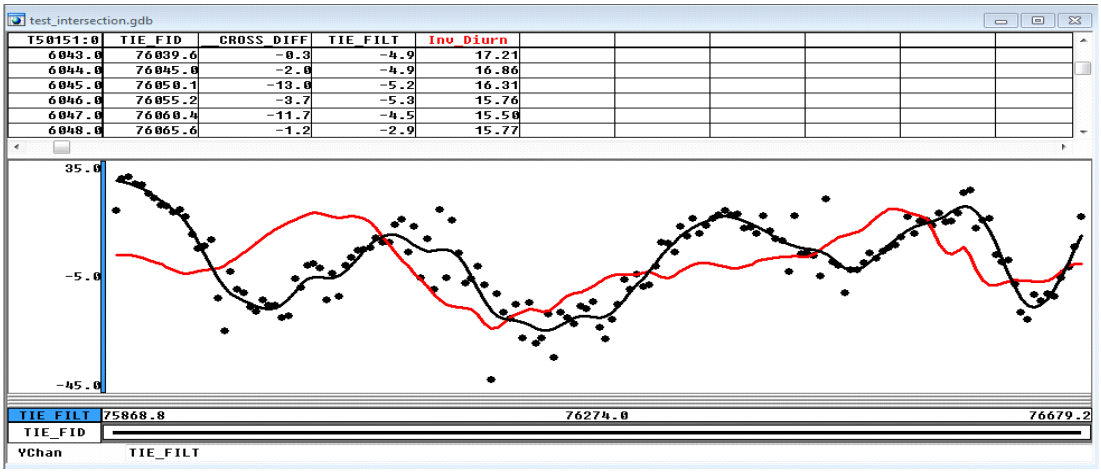


Figure 5 - Comparison of inverse of the diurnal (red profile) and low-pass filtered profile (black)

The comparison of the inverse of the diurnal variation and the low-pass filtered results is helpful in estimating the appropriate filter length. It is not uncommon to have magnetic base stations a few hundred kilometres away from the survey aircraft. With such distances, one should keep in mind that lag and amplitude differences can exist between the two locations. The visual best fit between the low-pass filtered results and the intersection mis-ties (Figure 5) and to some extent the resemblance of this profile to the inverse of the diurnal are concluded to be the main criteria in the determination of the filter length.

On the first pass, the TIELEV GX should be run with the option "All" ties selected, however subsequent runs can be executed on "Selected" tie lines only. Different filter lengths can then be tested with this option.

STEP 4 – Review the low-pass filter results on the tie lines

Once the TIELEV GX has been executed, compare the low-pass filtered profile "TIE_FILT" channel to the original mis-tie values ("__CROSS_DIFF" channel). At this point the user can eliminate "outlier" intersections by dummying the corresponding intersection in the "MASK" channel or by editing the value of the __CROSS_DIFF channel. Intersections with dummy values in the "MASK" channel are ignored by TIELEV GX. Special attention should be paid to outliers located at

the extremities of profiles, since a single point can badly modify the shape of the low-pass filter results at these locations. Figure 6 shows the original low-pass filtered results, red profile, with the beginning of the profile being pulled down by a single very low mis-tied value (see boxed point). The profile in blue shows the improved result after dummying this intersection in the MASK channel.

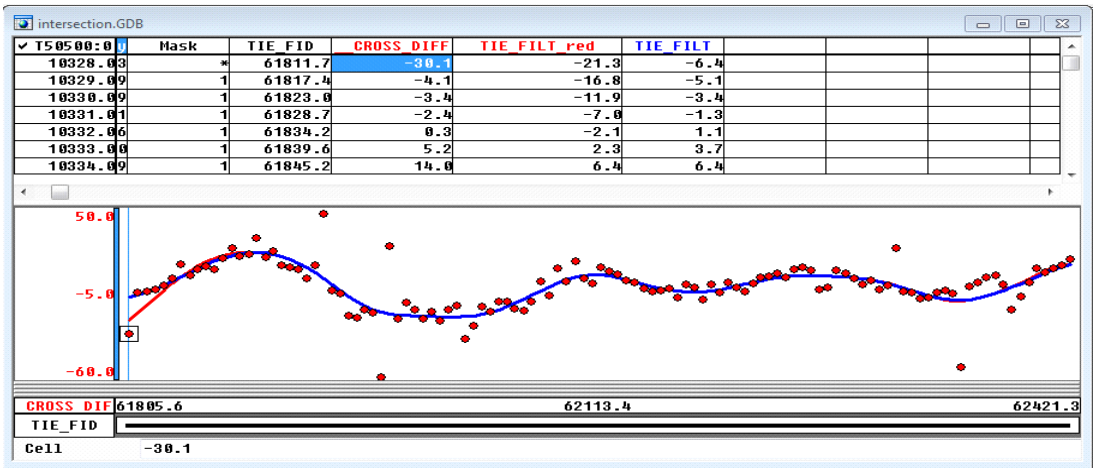


Figure 6 - End points effect on low-pass filtered profile shape

Once a good match of the low-pass filter results to the intersection differences is achieved (Figure 7), the filtered values can then be loaded into the main database, with the LOADLEV GX. These values will be added to the unlevelled values of the magnetic field along the tie lines. The levelling adjustments of the traverse lines will be achieved by tying them to the levelled tie lines. If the user wants to close all intersections of the traverse lines, reset the "Mask" channel to the value of 1.

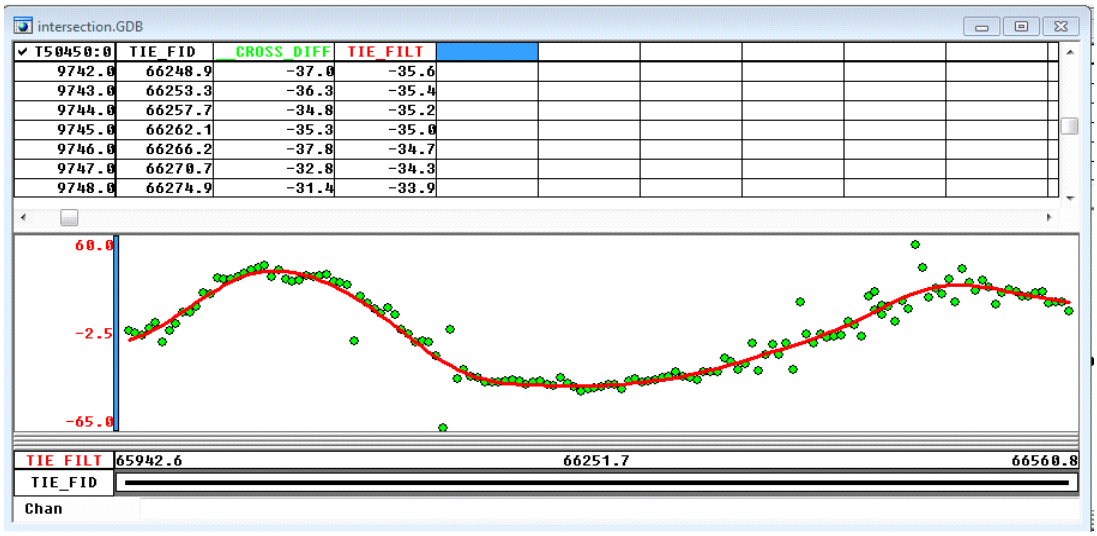


Figure 7 - Butterworth low-pass filter results of the intersection differences are used to set the tie line level adjustment

STEP 5 – Load the levelling corrections in the main database

Under the Run GX menu, select the LOADLEV.GX GX

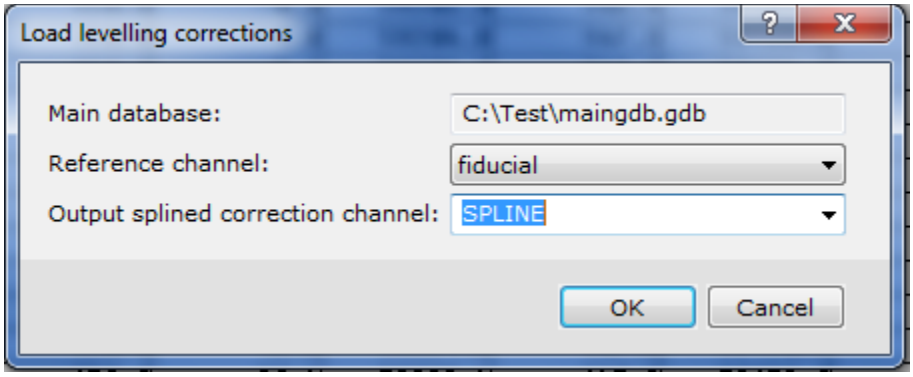


Figure 8 - Sample input to LOADLEV.gx

INPUT PARAMETERS:

Main database	Destination database
Reference channel	fiducial (Reference channel name in the main database. This channel must correspond to the left most column in the database)
Output correction channel	Output corrections (SPLINED) interpolated channel name

The LOADLEV GX loads the levelling corrections into the main database and interpolates the corrections using splines. Only the "selected" lines in the main database are updated. The LOADLEV GX adds 7 new channels to the main database.

X_DIFF	Levelling correction (used)
X_DF_UNUSED	Levelling correction (unused)
X_LEVEL	Magnetic level of the crossing line
X_DOUBLE	Double intersection Flag
X_LINE	Line number of the crossing line
X_FID	Fiducial number of the crossing line
SPLINE	Spline interpolated values of the X_DIFF channel

The levelling adjustments are stored in the X_DIFF channel for all used intersections (those which are not dummied in the MASK channel). The levelling adjustments of the unused intersections are stored in the X_DF_UNUSED channel. A review of the traverse line levelling corrections is always necessary to verify their validity. To facilitate this process, a series of special GX's have been developed to enable visual inspection and to provide easy navigation to individual X_DIFF values. The controls are accessed by icons which are illustrated at the bottom left corner of the window shown in Figure 9.

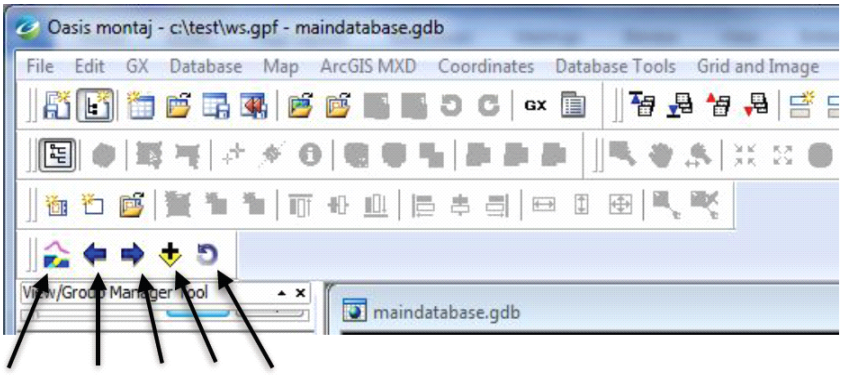


Figure 9 - Icons added to facilitate review of levelling adjustments for traverse lines

Selecting the left-most icon "Display" in the bottom row toolbar shown in Figure 9 prompts the user for input parameters (Figure 10). It initiates the creation of a new working view that displays the crucial channels in two panels (Figure 11). The left and right arrows (Previous/Next) are used for quick cursor displacement to the previous or next mis-tied value in the X_DIFF channel. The cross icon (Jump) switches the display of the actual intersection from the traverse line to the tie line or vice versa. The right-most icon (Home) will bring back the previous display prior to the Jump selection (the cross icon).

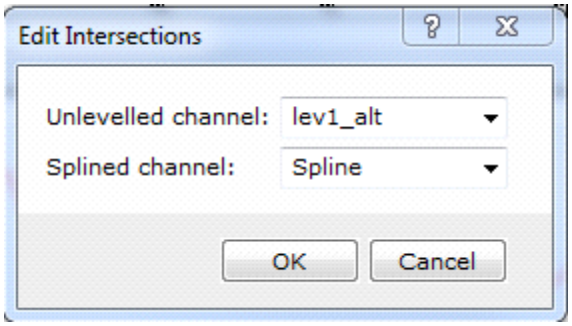


Figure 10 - Input parameters to display crucial diagnostic channels

INPUT PARAMETERS:

Unlevelled channel	Channel to level (Output channel created by Geosoft Iterative Levelling).
Spline Channel	Splined channel name (output from LOADLEV GX).

Once the desired channel names are entered, the desired diagnostic channels are displayed as shown in Figure 11. The top panel shows the unlevelled traverse line with the levelled tie line intersections. The bottom panel shows the splined correction profile and the cross difference (X_DIFF) symbol for each used intersection. The mis-tie values of an unused intersection (X_DF_UNUSED) that is masked out in the Tie line levelling process, is shown as a large filled black circle. The triangle symbol flags juxtaposed intersections for cases like (a) or (b) shown in Figure 2. In this case the triangle symbol indicates a double intersection of two tie lines on the traverse line. The GX does the levelling adjustment of the traverse line using only that tie line of the two which minimizes the levelling adjustment. When the triangle symbol appears as the first or last intersection on a traverse line, it is an indication of a case where two traverse line segments are joining on a tie line, see Figure 2, case (a).

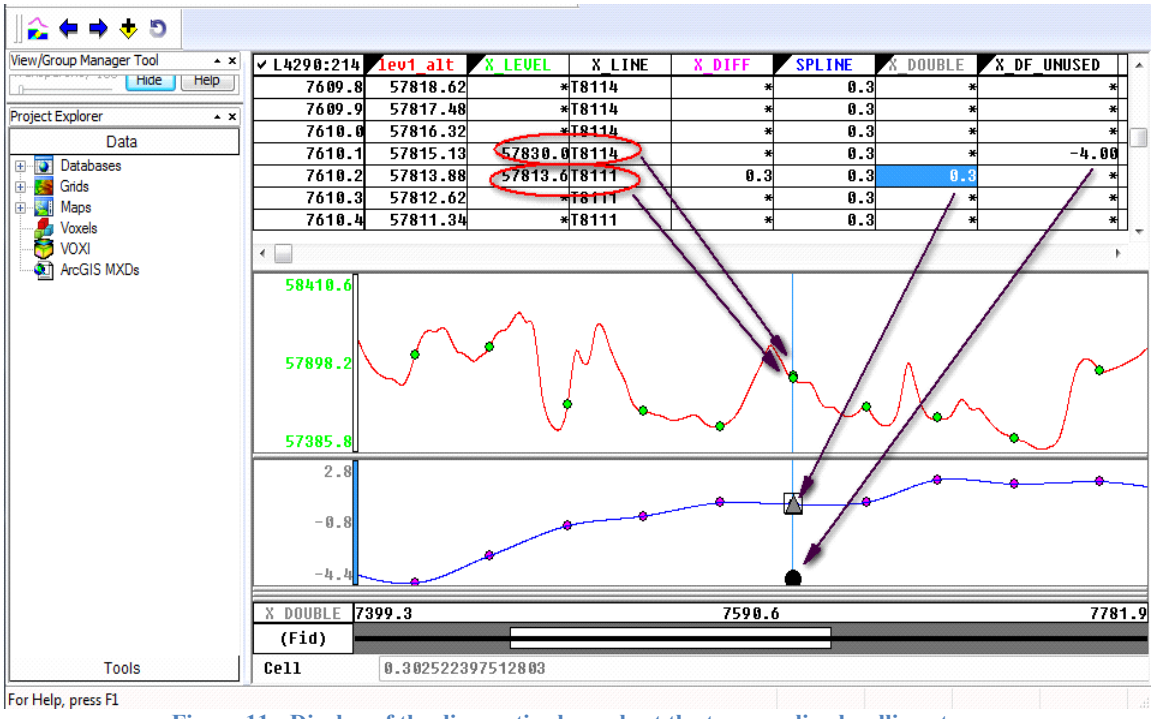


Figure 11 - Display of the diagnostic channels at the traverse line levelling stage

STEP 6 – Review the levelling corrections for the traverse lines

The main objective of reviewing/editing the correction profile is either to delete or to bring back unused intersections, if warranted. Figure 12 shows an example of an intersection located in a steep horizontal gradient section. This unreliable intersection can be deleted from the X_DIFF channel and at the end of the review, the SPLINE channel will be regenerated using the Geosoft LevTieLine/Spline correction software.

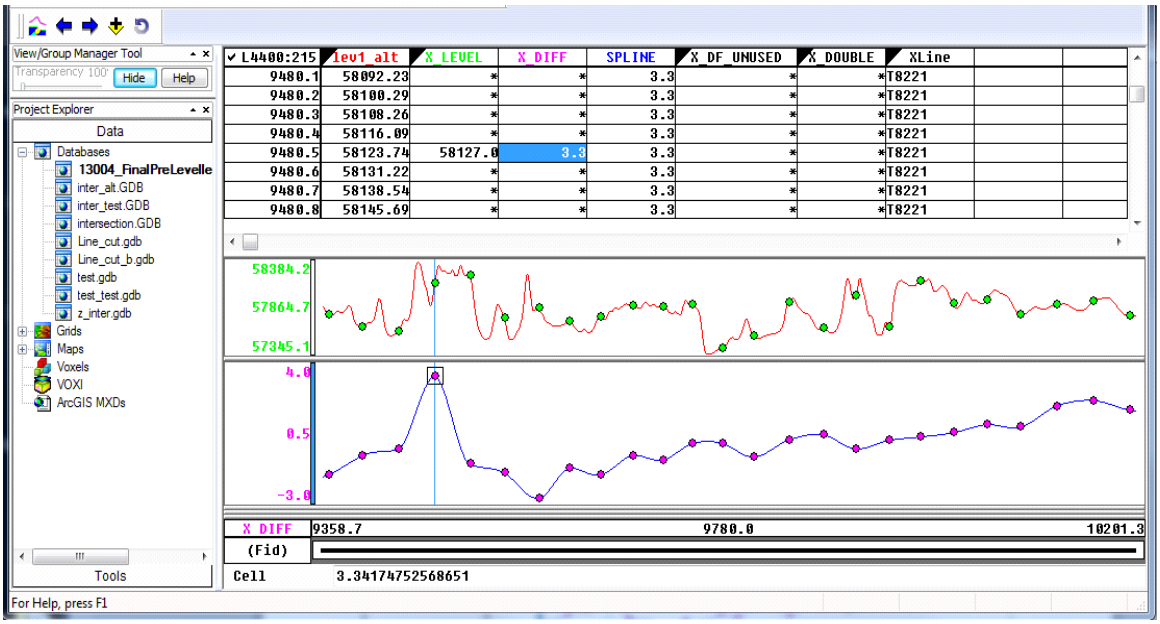


Figure 12 - An example showing detection and optional removal of an unreliable intersection

STEP 7 – Apply the levelling corrections

If there were any modifications done to the X_DIFF channel, the SPLINE channel needs to be regenerated. This can be done using the Spline Correction option in the Geosoft Careful Levelling

software. The final step consists of applying the levelling corrections. This function is also available in the Geosoft Careful Levelling.