Levelling—removing the GRF component (G12)

After correcting our data for the diurnal time variation, we can now proceed to further processing of our airborne magnetic survey data.

In this tutorial we use the INTREPID Levelling tool to perform the next step in our processing sequence. This step requires the removal of the magnetic component caused by the Earth's regional field, the **G**eomagnetic **R**eference **F**ield (GRF).

Context of this guided tour

In the context of your data processing cycle, the GRF removal follows the magnetic diurnal correction. This Guided Tour assumes you have already completed the Introduction to the Spreadsheet Editor (G04), and have a diurnally corrected field in your database, ready for further processing.

Overview

Standard GRF models provide estimates of the Earth's regional magnetic field as a function of (X,Y,Z), and time. They are based on satellite and ground observations. Our aim in processing aeromagnetic data is to produce a time-independent map of local anomalies, with the Earth's regional magnetic field removed, and with artefacts caused by errors in the acquisition process removed.

The INTREPID Levelling tool allows you to perform several standard corrections on magnetic, radiometric, full tensor gravity gradiometry, airborne gravity and digital elevation data:

- Aircraft heading effects
- Parallax corrections
- Time synchronisation and subtraction of diurnal
- GRF removal
- Network adjustment (tie-line levelling) using either polynomial or loop closure methods
- The Pro version of the tool:
    - Supports gradient and tensor levelling functions. these include Heading and Loop closure methods
    - Has altitude adjustment corrections for FTG/Falcon data
    - We are thinking on a full rotational levelling correction for gradient tensors as well.

This Guided Tour covers the process of GRF calculation and removal. This correction is only relevent to TMI or vector components of the magnetic field. It has little relevance to magnetic tensor gradients, as the base distance seperation of most instruments is so small.

Location of sample data for Guided Tours

We provide two complete sets of sample datasets, one in INTREPID format and one in *Geosoft* format. INTREPID works equally well with both formats. When you want to open a dataset, navigate to the directory containing the required data format.

Where **`install_path`** is the path of your INTREPID installation, the project directories for the *Guided Tours* sample data are

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install_path\sample_data\guided_tours\intrepid_datasets and
install_path\sample_data\guided_tours\geosoft_datasets.

For example, if INTREPID is installed in
C:\Program Files\Intrepid\Intrepid4.5.nnn,
then you can find the INTREPID format sample data at
C:\Program Files\Intrepid\Intrepid4.5.nnn\sample_data
guided_tours\intrepid_datasets

This is the default location for the sample data. If you have installed INTREPID normally, the data resides there. If you have installed INTREPID elsewhere, the exercises will work just as well. Just use the appropriate pathnames.

For more information about installing the sample data, see "Sample datasets—installing, locating, naming" in INTREPID Guided Tours Introduction (G01)

For a more detailed description of INTREPID datasets, see Introduction to the INTREPID database (G20). For even more detail, see INTREPID database, file and data structures (R05).

Location of sample data for CookBooks

Right next to the Guided tours data, is a rich set of more exotic geophysics datasets and grids, already prepared for the cookbook training sessions. A casual user might also gain some trial and error insights into the capbilities of the software, just by testing the Project Manger's ability to preview and describe the attributes of each of the cookbook datasets.

Steps to follow

Note: In this tour we assume that you have completed the exercise in Introduction to the Spreadsheet Editor (G04) and created the field **magd** in the **albury** dataset. If you have not completed the exercise, then use the field **rawmag** instead. You will not get exactly the same result, but you will still successfully learn how to remove the GRF component.

Calculate the GRF correction

1   *Launch the Levelling tool*

Start the Project Manager. Navigate to the directory
install_path\sample_data\guided_tours\intrepid_datasets. From
the **Levelling** menu, launch **Tie Line Levelling**. The INTREPID Levelling tool
window appears.
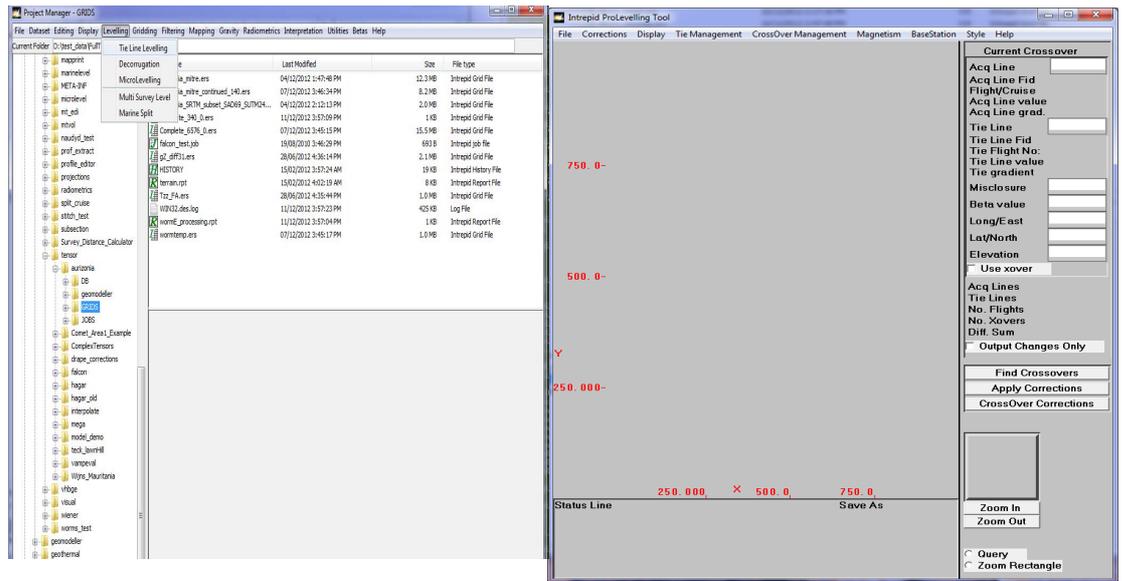
2   *Open the input dataset and field*

From the **File** menu, choose **Specify Input.** The **Select Database** dialog box appears. Select the dataset **albury..DIR** and choose **Open**. The **Select Signal Field** dialog box appears. Select **magd** from the list of dataset fields and choose **OK**. You are then prompted for an optional Elevation and drape Elevation Field, choose **Skip**.
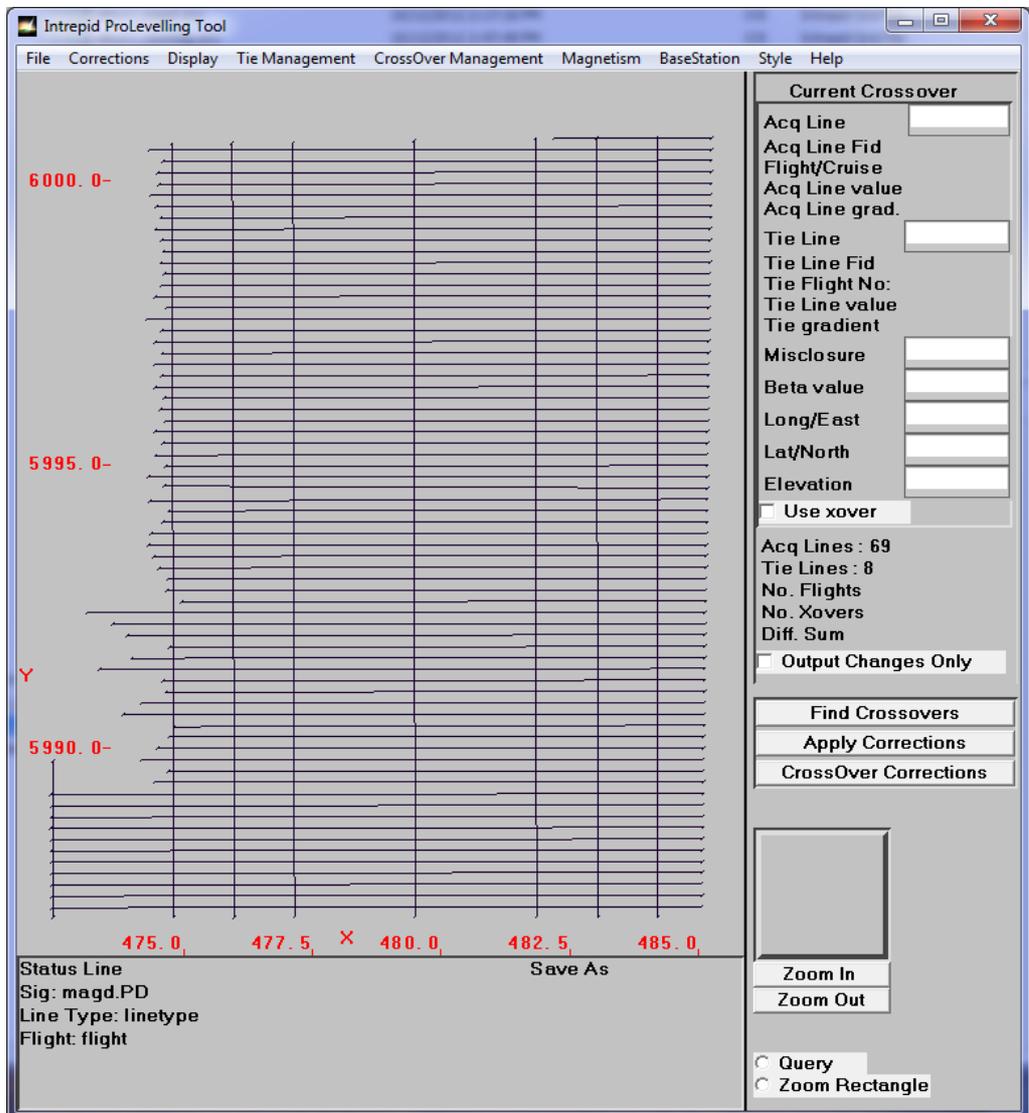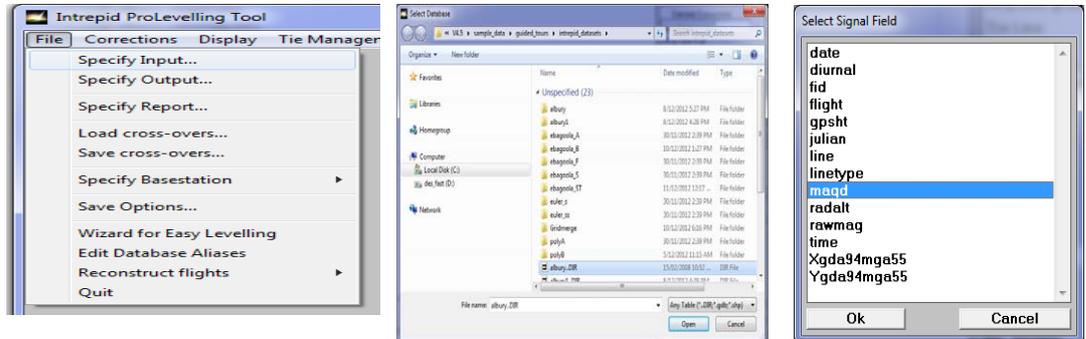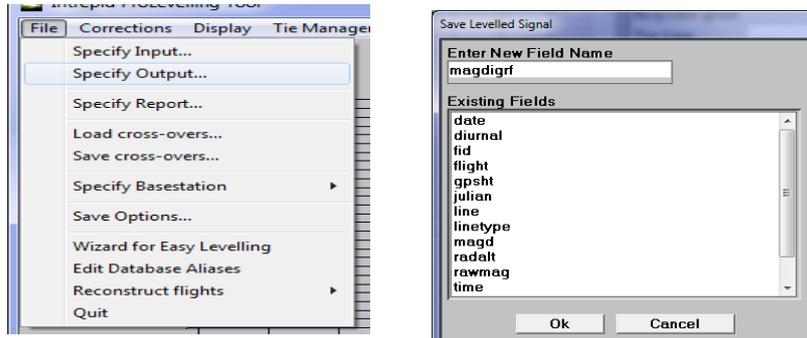

3   *Specify the output field name*

From the **File** menu, choose **Specify Output**.

If a **Select Database** dialog box appears, select the same dataset, **albury..DIR**,

and open it.

The **Save Levelled Signal** dialog box appears. Click in the **Enter New Field Name** text box and delete `Zout`. Now type **`magdigrf`** for the new field name. Choose **OK**.

4 *Reconstruct the flights*

The process of reconstructing the flights sorts the data into chronological order. This is a necessary step if the Levelling tool is to do any time-based processing. The sort is only temporary, and it does not affect your dataset.

Quick review: Standard GRF models provide estimates of the Earth's regional magnetic field as a function of (X,Y,Z), and time.

- If GPS height data is available it can be used as the **Z** value to calculate the GRF. If GPS height data is not available as a field in the dataset, it is common practice to replace the Z value with the mean height of the sensor above sea level. The error introduced by this approximation is small.

- If the survey date field is available it can be used as the **time** value to calculate the GRF. If the survey date is not available as a field in the dataset, it is common practice to replace the time with the mean survey date. The error introduced by this approximation is insignificant because the time variation of the GRF is very slow.

For this tutorial we compute the GRF using the **GPS height** field we have in our dataset, and the **survey date** field we also have in our dataset. Because we are using the survey date field INTREPID is required to perform time-based processing, which is why we must first sort the data in time by using the flight reconstruction option.

To reconstruct the flights, from the **File** menu, choose **Reconstruct Flights**, and then **Date/time Fids**. The **Load Date** dialog box appears. Select **date** from the list of fields and choose **OK**.

The **Optional Time** dialog box appears. Select **time** from the list of fields and choose **OK**.

The **FID Factor and date style** dialog box appears. The FID factor is the number of seconds per fiducial. Leave it as 0.1 (default). The date style for this dataset is **YYMonthDay**, so select it in the **date style** list. You can verify this yourself by using the Project Manager to obtain statistics for the date field if you wish.
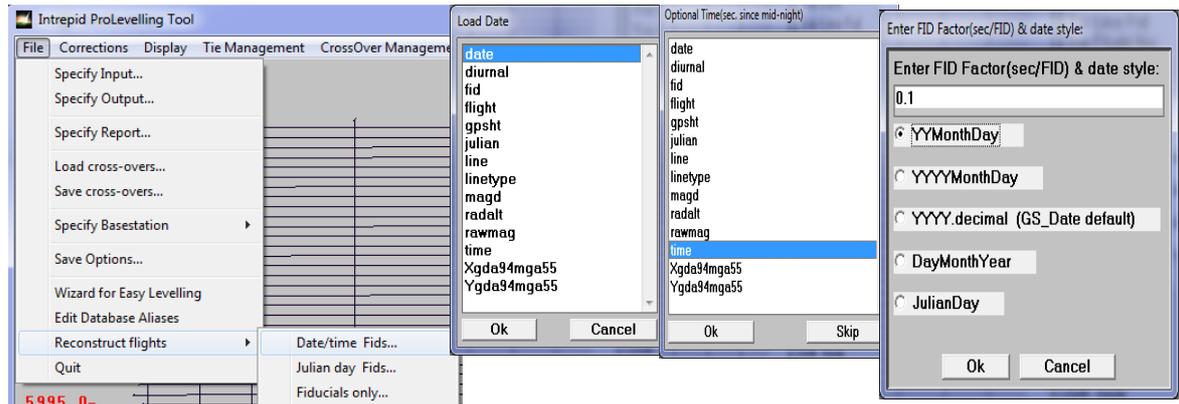

Quick review: The survey aircraft takes a measurement at a typical rate of 10 samples per second. Every sample has a unique identifying number and time associated with it. The unique identifying number is called a fiducial. Think of it as a 'data sample counter'. It is an incrementing integer or real number.

When you are finished choose **OK** on the **FID Factor and date style** dialog box. INTREPID sorts the dataset according to date and time. This operation takes a few seconds. When it is completed a report appears on the right hand side of the Levelling tool window, showing the number of acquisition lines, tie lines and flights that make up the dataset. Also, the file "prolevelloing.rpt" can be examined for a detailed report on the flight reconstruction process, including the time each flight/line was flown and the fiducials.
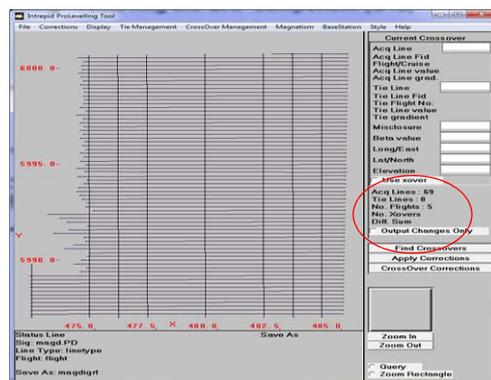
5   *Specify the levelling correction type*

From the **Corrections** menu, choose **GRF**. The GRF parameter box appears.
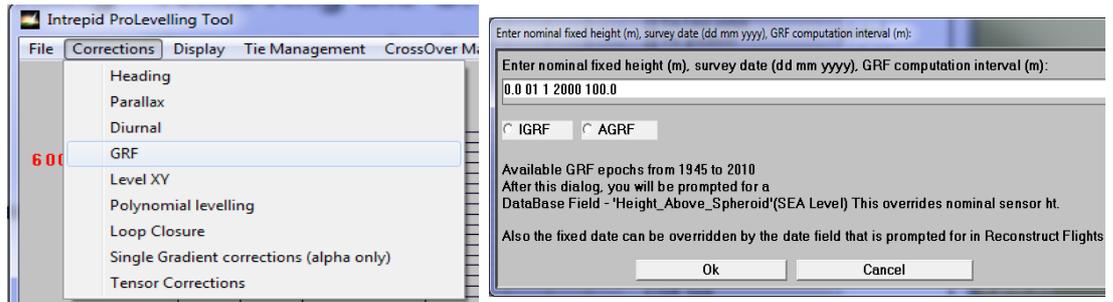
6   *Enter parameters for the GRF correction*

If we were going to approximate our GRF correction by using a mean survey height and a mean survey date, we would need to enter the nominal sensor height (metres) and survey date (DDMMYYYY) in the GRF parameter box.

However because we are computing the GRF accurately using the GPS height field and the survey date field we have in our dataset, INTREPID **ignores** the nominal fixed height and fixed survey date parameters. Leave them as they are (defaults).

Since the GRF varies slowly with position, the GRF can be computed every 100 metres rather than for every data sample. This is controlled by the **GRF computation interval**. This approximation speeds up the GRF calculation, and the error introduced by this is insignificant. Therefore leave the **GRF computation interval** as 100 (default).

Select the IGRF model (default), and choose **OK**.

Note: For Australia there is a choice of two GRF models, the International Geomagnetic Reference Field (IGRF) and the Australian Geomagnetic Reference Field (AGRF). For a typical survey extent of 100-200 km, the models are very similar.

The **Load Height Above Spheroid** box appears. This is where we select the GPS Height—the field name is **gpsht**. Choose **OK**.

7   *Apply the GRF corrections*

Choose **Apply Corrections**. (The button is located at the bottom of the Levelling tool window). The **Apply Save** dialog box appears. Under **Choose Corrections to Apply**, check **Grf**. Now choose **Apply**.
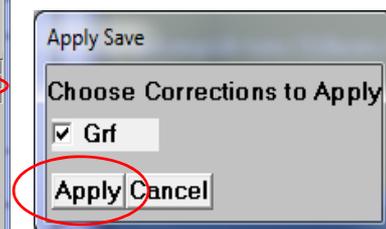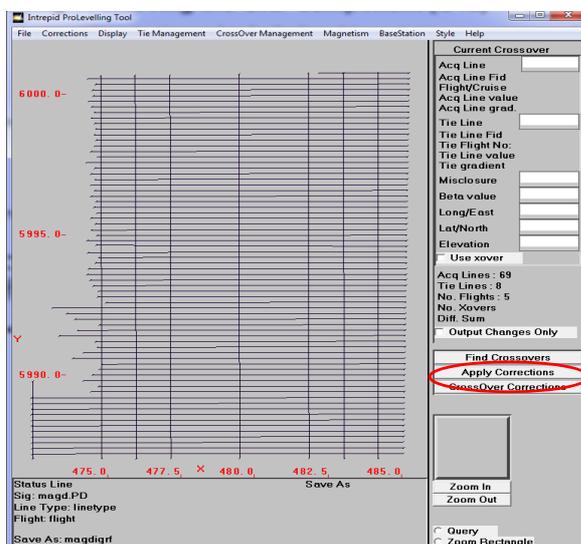
INTREPID computes the GRF correction. When completed an information box will appear telling you that the process is finished. INTREPID produces a report file called **`levelling.rpt`**. Choose **OK** on the information box.

You have now completed the GRF correction. At this point you should have a new GRF corrected field in your dataset called **`magdigrf`**.

Leave the Levelling tool window open and move to the next exercise.

Calculate the GRF field

The GRF field itself can be easily calculated and saved in the dataset by using the Levelling tool. The following exercise describes how to do this.

1 *Change the GRF mode of calculation*

On the right hand side of the tool window, note the **Output Changes Only** box. Check this box. This changes the output mode from **GRF corrected** to **GRF**.
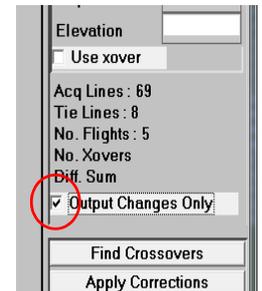
2 *Specify the output field name*

From the **File** menu, choose **Specify Output**. The **Save Levelled Signal** dialog box appears. Click in the **Enter New Field Name** text box and delete `Zout`. Now type `igrf` for the new field name. Choose **OK**.

3 *Specify the levelling correction type*

From the **Corrections** menu, choose **GRF** to deselect it and then choose it again. The GRF parameter box appears. Choose **OK**. The **Load Height Above Spheroid** box appears. Select the GPS Height field—the field name is `gpsht`. Choose **OK**.

4 *Apply the GRF corrections*

Choose **Apply Corrections**. The **Apply Save** dialog box appears. Under **Choose Corrections to Apply**, check `Grf`. Now choose **Apply**.

INTREPID computes the GRF. When completed an information box appears telling you that the process is finished. INTREPID produces a report file called **levelling.rpt**. Choose **OK** on the information box.

At this point you should have a new GRF field in your dataset called `igrf`.

5 *Exit from the tool.*

To exit from the Levelling tool, choose **Quit** from the **File** menu. The **levelling.rpt** file opens in *Notepad*. You can examine this report file if you wish, and exit from it when you are finished.

Further things to consider

The GRF is a slowly varying field. If you grid it, you don't see much detail. However if you look closely at a grid of the GRF you can see the GPS Height character in the gridded GRF field. Of course you would not see this if you used a mean survey height approximation.

Inspect the histogram of the GRF. The histogram shows a low dynamic range. This means there is not much variation between the highest and the lowest data values.

It is common practise to add the mean value of the GRF to the GRF-corrected data. This keeps the processed magnetic data values close to the values of the observed field readings. This is easily done using the Project Manager and the Spreadsheet Editor. You can do this if you have time.

Key points for this guided tour

In this guided tour you have:

- Used the Levelling tool to calculate and save the IGRF field
- Used the Levelling tool to calculate and save the IGRF-corrected magnetic field

Frequently Asked Questions

Q : Where are the INTREPID GRF models derived from?

A : Geoscience Australia (GA) publish models for epochs that run for groups of 5 years starting from 1940. Both AGRF and IGRF models are available.

Q : What sort of Earth model does the GRF correction assume?

A : A spheroid model is used and it has a mean radius of 6371.2 metres. The survey coordinates are converted to geodetic coordinates prior to calculating the GRF.

Q : I want to calculate the GRF for a single XYZ coordinate. Can I do that using the Levelling Tool?

A : Yes. In the Tool under Mag Field there is a GRF calculator. Enter the XYZ and Time parameters and it calculates the Total Field, Magnetic Inclination and Declination.

Q : How do I level tensor data?

A : This opens up a whole new area of issues for geophysicists, as each component of the field is linked to the others both spatially and by such conditions as the Trace of the tensor being required to sum to zero, as adjustments are made. INTREPID has special tensor and vector algebra designed to overload some of the traditional levelling methods such as Loop Levelling, to transform them into whole of tensor methods. Suggest you watch out for a tensor training course and attend.