

# Line filtering (G15)

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Line filtering is the process of applying a filtering operation to the geophysical **line or profile** data, as opposed to filtering the gridded data. Some experience with line filtering and a familiarity with the more common filters is essential for understanding how geophysical data is manipulated.

The INTREPID Line Filter tool can be used to apply either spectral (Fourier) or convolution (Spatial) filters.

## Context of this guided tour

**In the context of your data processing cycle**, Line filtering may be carried out at any stage of the processing sequence. Your signal maybe be as simple as a set of samples, a time series, or fully geolocated samples that are more or less in a straight line. Signal is defined in the generic INTREPID sense and can mean scalar measures of magnetics, gravity, elevations, or gradients, vectors and tensors that have purpose built algebra behind them. For magnetic data it is often applied to the final processed data for the purposes of producing an enhanced product for interpretation.

This Guided Tour can be followed at any stage of the processing sequence. If you have a final levelled and fully processed magnetic data field in your dataset, use that. Otherwise you can use any magnetic data field created at any stage of the processing.

## 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 *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:\Intrepid\Intrepid5.nnn,  
then you can find the INTREPID format sample data at  
C:\Intrepid\Intrepid5.nnn\sample\_data\  
guided\_tours\intrepid\_datasets

For more information about installing 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

In the adjacent folder to Guided Tours data is a collection of more exotic geophysics datasets and grids already prepared for the cookbook training sessions. You may also gain some insights into the capabilities of the software by testing the Project Manager’s ability to preview and describe the attributes of each of the cookbook datasets.

For an introduction to the Cookbooks, see [Using INTREPID Cookbooks \(R19\)](#).

For a list of available Cookbooks, see [INTREPID Cookbook](#).

### Sample data for batch processing

Yet more sample datasets are available in `install_path\sample_data\datasets`. We have provided these for users to learn about batch processing with `.task` and `.job` files. For more information, see:

- [INTREPID batch processing \(G19\)](#) (Guided Tour)
- [INTREPID task, HISTORY, report and log files \(R06\)](#) (Reference)

## Overview



Line filtering is a basic and fundamental data processing operation which is used in numerous data processing applications. Line filtering is routinely used to remove noise from radar altimeter and cosmic data during the processing of radiometrics. It is used implicitly in procedures such as tie line levelling, decorrugation and microlevelling. It is used to separate different frequencies for interpretation analysis.

### Filters available

The INTREPID Line Filter tool supports spectral (Fourier) and convolution (Spatial) filters as well as some special depth estimation filters. The more commonly used filters include:

- Moving average and median
- Non-linear Naudy
- High pass, low pass and band pass
- Vertical derivative
- Phillips depth estimation
- Gravity section basement modelling ( Murty & Rao)
- Full tensor gradient support for high pass, low pass and band pass
- Quaternian filtering for roll, pitch and yaw rotation data.
- Full vector component or gradient filtering support.
- Murthy and Rao (see [“Murthy and Rao method” in Other depth estimation methods \(C04\)](#))

### Sampling modes

The Line Filter tool operates in one of three different **sampling** modes.

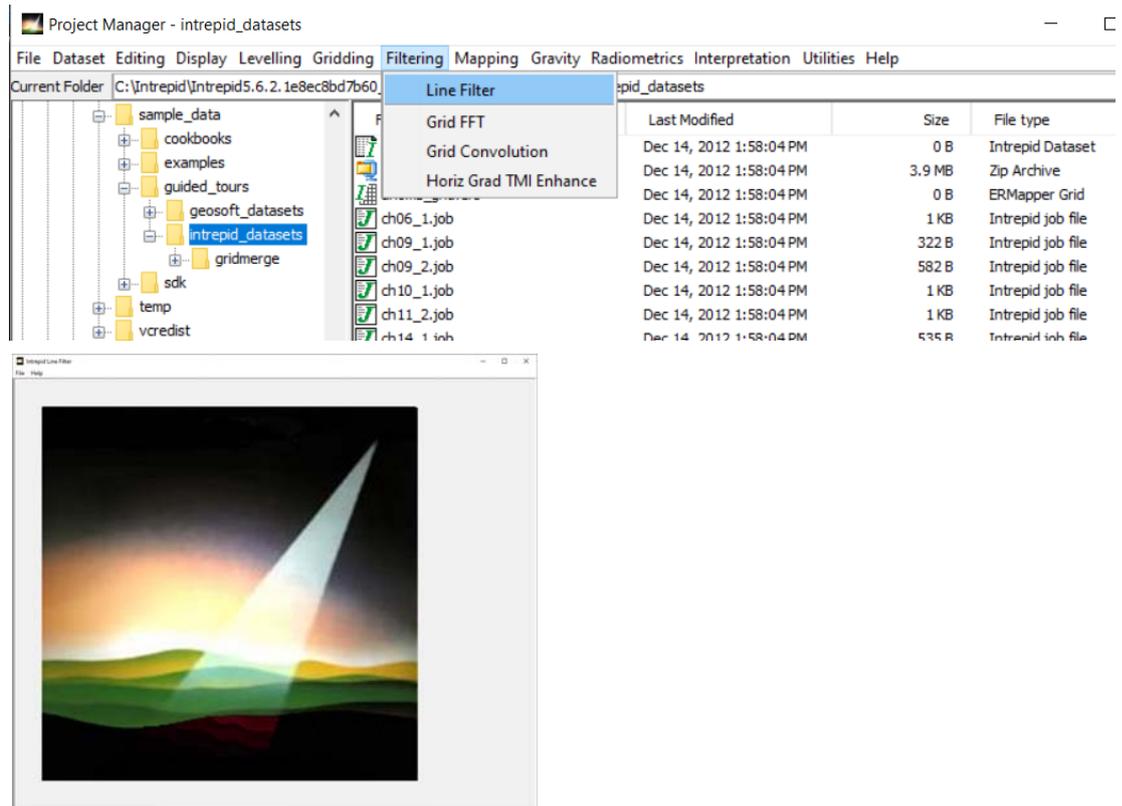
- 1 **Spatial mode.** Every data point has an associated X and Y value.
- 2 **Time-based mode.** Every data point has an associated time value or fiducial.
- 3 **Fixed sample mode.** The data is just regularly sampled data with no time or spatial associations.

## Steps to follow

### Filter input and create output field

#### 1 *Launch the Line Filter tool*

Start Project Manager. Navigate to the directory `install_path\sample_data\guided_tours\intrepid_datasets`. From the **Filtering** menu, launch **Line Filter**. The INTREPID Line Filter tool window appears.

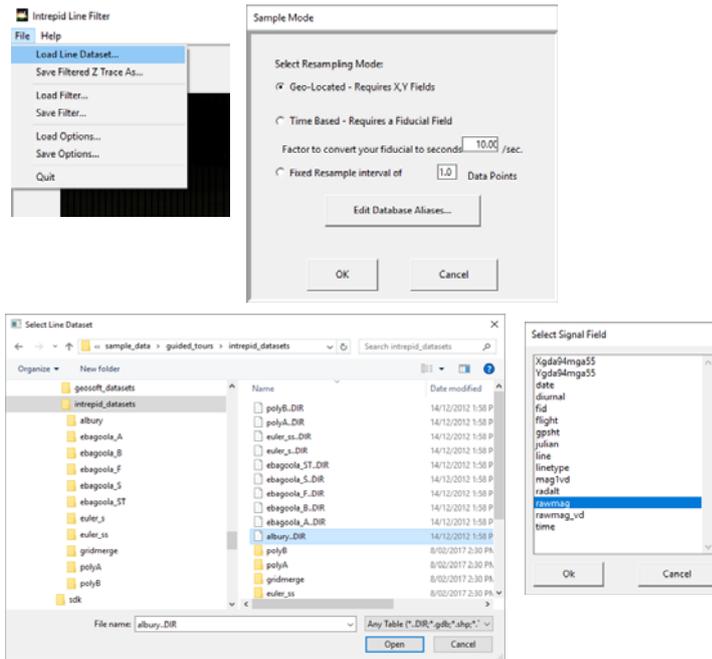


## 2 Open the input dataset and field

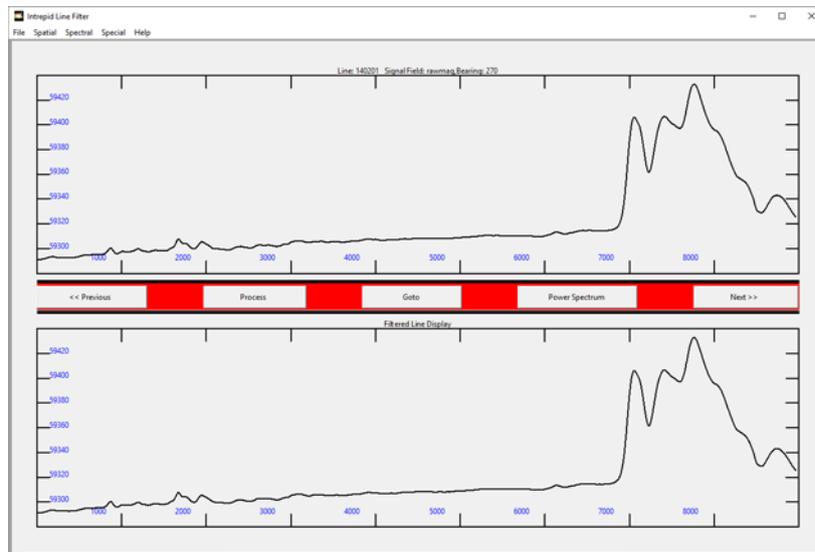
From the **File** menu, choose **Load Line Dataset**. The **Sample Mode** dialog box appears. Under **Select Resampling Mode**, select **Geo-Located**. Choose **OK**. This is the vital decision regarding what context you are wanting to operate in.

The **Select Line Dataset** dialog box appears. Select the dataset **albury..DIR** and choose **Open**.

The **Select Signal Field** dialog box appears. Select **magfinal** from the list of dataset fields. If you do not have **magfinal** in your dataset you may select any other magnetic data field, for example, **rawmag**. Choose **OK**.

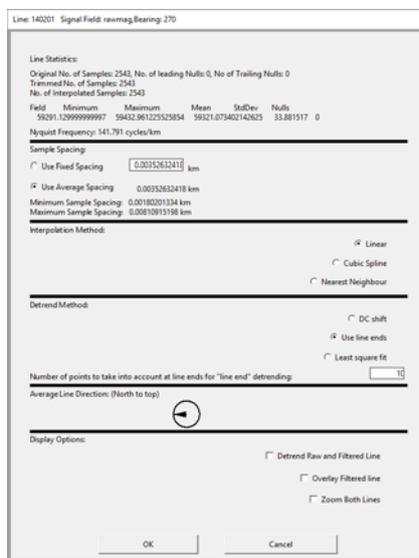


The main filtering user interface appears in the **Line Filter** window. The top panel displays the input (**unfiltered**) signal, and the bottom panel displays the output (**filtered**) signal. Since there is currently no filter chosen, the input and output signal are the same.



### 3 Examine the display options

Right click the input signal area (top panel). A properties dialog box appears. It contains useful statistical information about the current line, including the number of samples, statistics, sample spacing, line direction, and some display options.



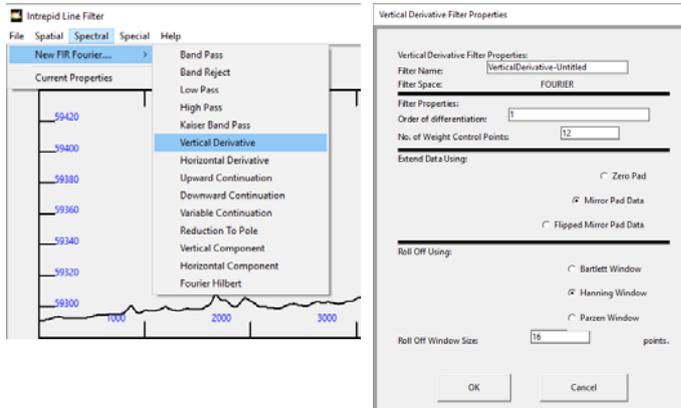
Under **Display Options**, observe that the **Detrend Displayed Line** box is not checked. This means that the default setting is not to remove the trend from the input data before displaying the data.

Check the **Detrend Displayed Line** check box and then choose **OK**. The input data will appear with detrending applied.

Open the properties dialog box again and clear the **Detrend Displayed Line** check box. Observe how the shape of the input signal changes depending on whether detrending is enabled or disabled.

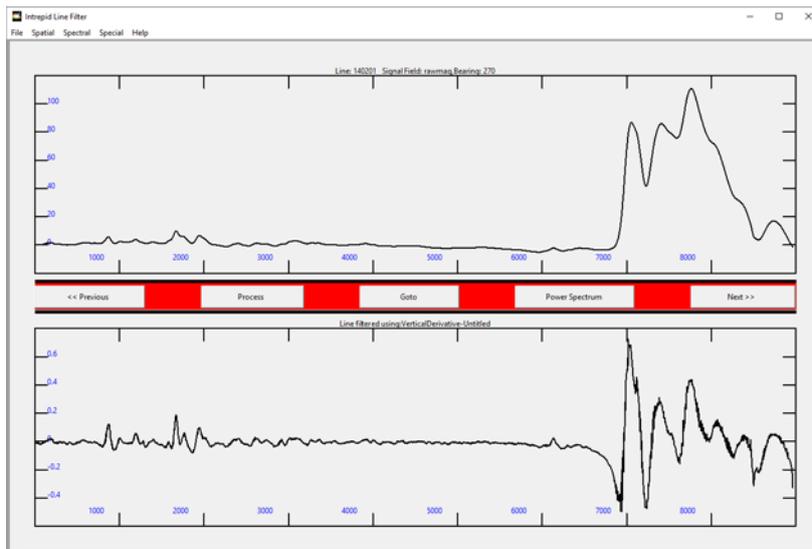
4 Apply a filter to the input signal

From the **Spectral** menu, choose **New FIR Fourier > Vertical Derivative**. The **Vertical Derivative Filter Properties** dialog box appears.



Under **Filter Properties**, you can specify order of the vertical derivative. The default is 1.

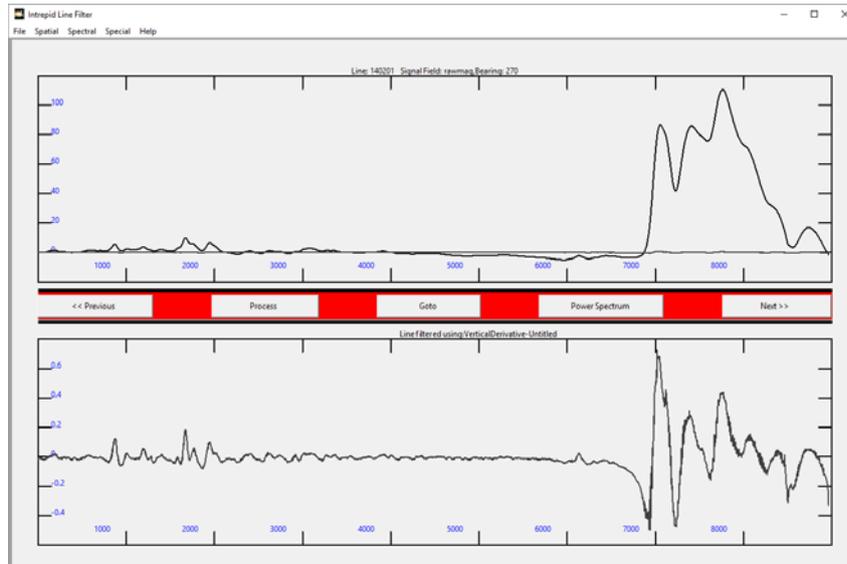
Select **OK** to dismiss the dialog box. The panel under **Filtered Line Display** displays the filtered output signal. At this point you are simply previewing the effect of the filter. No output has been saved in the dataset yet.



5 Use the control buttons to navigate

Use **Previous** and **Next** to preview the effect of the filter on different lines. Choose **Goto** to select and preview any line in the dataset.

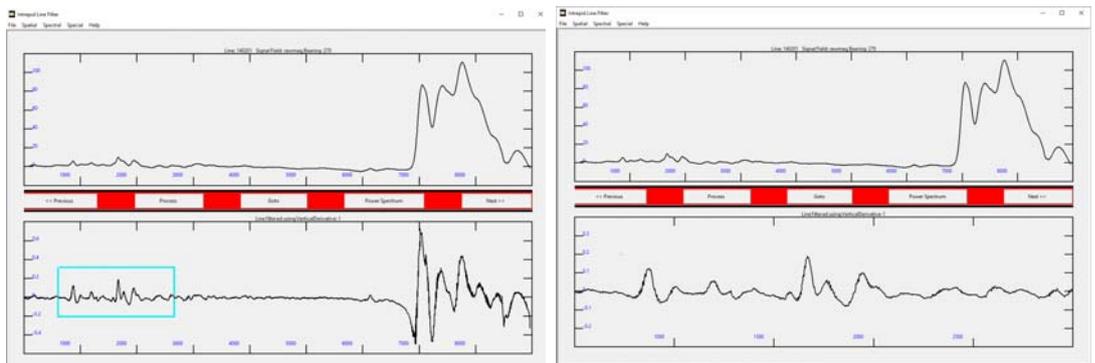
Right click the input signal area. In the properties dialog box under **Display Options**, check **Overlay Filtered line**. Select **OK**. The Line Filter tool displays the input and output signal together using the same scale in the input panel. Since the dynamic ranges are very different, the vertical derivative signal appears mainly as a straight line.



Turn the **Overlay Filtered line** option off.

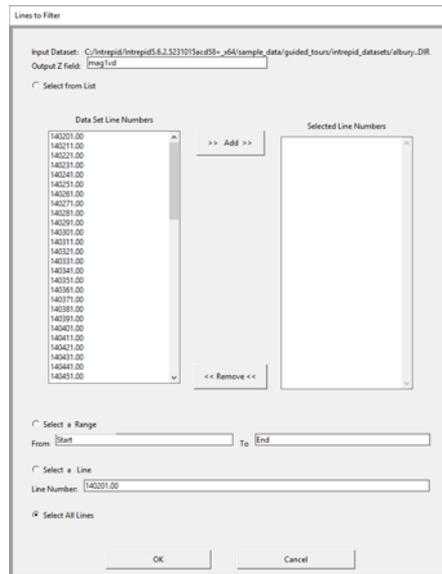
6 Use the zoom feature

Now try zooming in on either the input or output signal. To do this, using the left mouse button, drag to define the rectangular area you want to zoom to. Zoom in to the filtered signal and observe how the vertical derivative filter enhances noise in the data. To zoom back out and view the whole line, double click the zoomed section of signal.



### 7 Apply the filter to the dataset

Now we are ready to process the lines using the vertical derivative filter and create a new output field in the dataset. Choose **Process**. The **Lines to Filter** dialog box appears.



The following options are available for selecting the lines that you want to process:

- Select lines from a list
- Select a range of lines
- Select a single line
- Select all lines

For this exercise select the default option **Select All Lines**, which processes all the lines.

In the **Output Z Field** text box, delete the default field name and enter the new field name **mag1vd**. Choose **OK**. A progress bar appears and INTREPID begins processing the lines in the dataset. When the progress box disappears, the processing is complete.

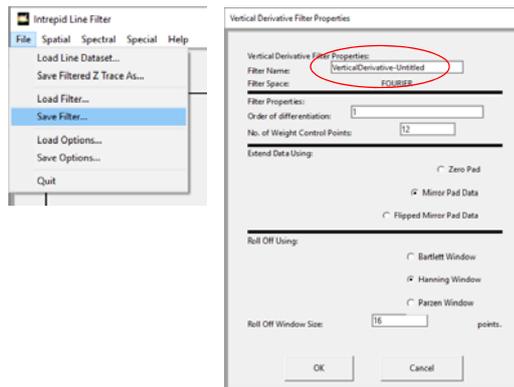
Leave the **Line Filter** tool window open and move to the next exercise.

## Save the filter description file and the power spectrum

INTREPID allows you to save and load your filter parameters using special files called filter description files (**.fdf**). If you want to run the same filter at a later date, it is useful to be able to save the current filter description. In fact, this is a necessary step if you want to run the filtering as a batch process. The following section describes how you can save and load filters as filter description files, and also how to view and export power spectra.

### 1 *Save the current filter description*

From the **File** menu, choose **Save Filter**. The **Vertical Derivative Filter Properties** dialog box appears. In the **Filter Name** text box, change **VerticalDerivative-Untitled** to **VerticalDerivative-1**. Choose **OK**.



The filter specification has now been saved into a filter description file called **VerticalDerivative-1.fdf**. All of the **.fdf** files are stored in the **filters** folder in your INTREPID installation. You can embed a filter description directly in a line filter task specification file instead of referencing the separate **.fdf** file.

### 2 *Load a new filter description*

From the **File** menu, choose **Load Filter**. The **Available Filters** dialog appears. This displays a list of pre-defined filters that are provided with INTREPID and you'll be able to see the one you just created. Select any one of the filters and choose **OK**. INTREPID loads the filter and displays a preview for the current line.

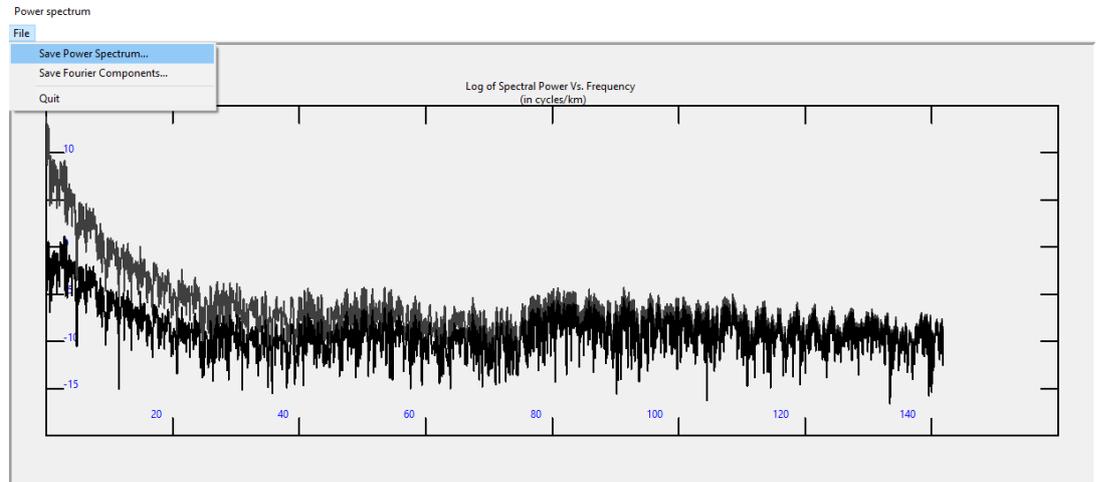
To check which filter is currently loaded, choose **Current Properties** from either the **Spatial**, **Spectral** or **Special** menus. The filter properties box will appear. Another way to do this is to right click the output signal area.

### 3 *Compute and save the power spectrum*

The INTREPID Line Filter tool provides access to the power spectrum for any line. Choose **Power Spectrum**. The **Power Spectrum** window appears. The window displays graphs of power spectra computed for the current line. Spectra are displayed for the input data in grey and the output data in black.

In the **Power Spectrum** window, from the **File** menu, choose **Save Power Spectrum**. The **Save Power Spectrum** dialog box appears. Navigate to the folder you would like to use. Enter (for example) **power1** for the filename and choose **Save**. INTREPID will create a file called **power1.spec** (in your working directory or location you selected). This file contains the power spectrum calculated for the **output data only**. If you load the file into an editor (for example, *Excel*), you can do depth estimates.

We have made the process automatable for large profile databases. You may, for example, want to create your own procedures for estimating either depths or properties of rocks using a moving window along each profile. The numbers in the file have the units of wavenumber (X) and log of power (Y).



When you have finished inspecting the \*.spec file, dismiss the **Power Spectrum** box by choosing **Quit** from the **File** menu.

----- Power Spectrum -----

Filter Name: VerticalDerivative-Untitled

Filter Size: 4096

Line Name : Line: 140201 Signal Field: magfinal,Bearing: 270

Units : Cycles / kilometer

Wave Number	Power
0.000000,	Null
0.069234,	-1.051153e+001
0.138467,	-1.051363e+001
0.207701,	-1.274858e+001
0.276935,	-8.913523e+000

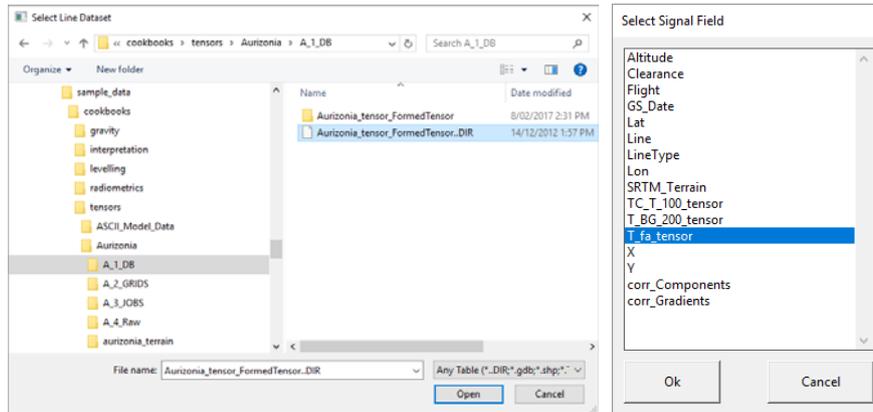
4 *Exit from the Line Filter tool.*

To exit from the **Line Filter** tool, choose **Quit** from the **File** menu.

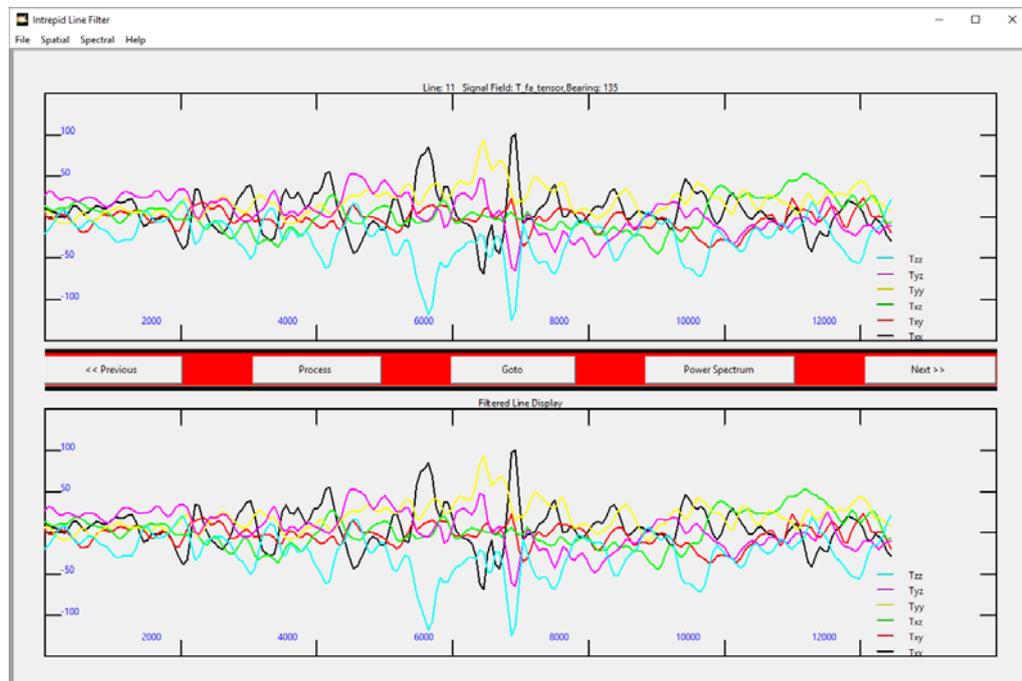
## Gradient Data Example from Cookbook

If you wish to see how we handle FTG data, start again, but this time navigate to `sample_data\cookbooks\tensors\Aurizonia\A_1_DB`.

Start Line Filter, choose Open Line Dataset, choose Geo-located dataset, then select `Aurizonia_tensor_FormedTensor.DIR`. Choose the field `T_fa_tensor`. This represents FreeAir measured gravity tensor gradients. Skip the **Optional FID** and **Optional Clearance** fields.

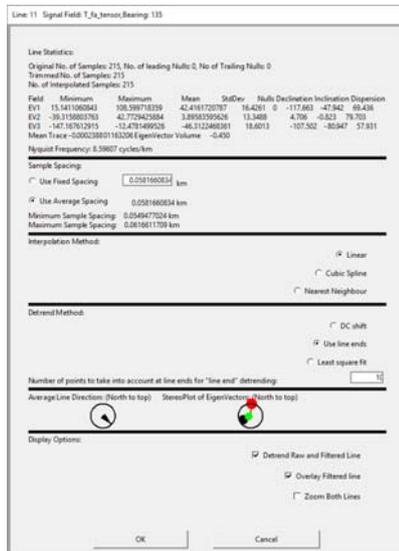


This is the initial tensor profile screen, without any filters being applied. The characteristic for a profile of tensor data is the lack of any long wavelength trends, with all the components around zero. The before and after colours are changed slightly in the superimpose view so you can make out which is which.



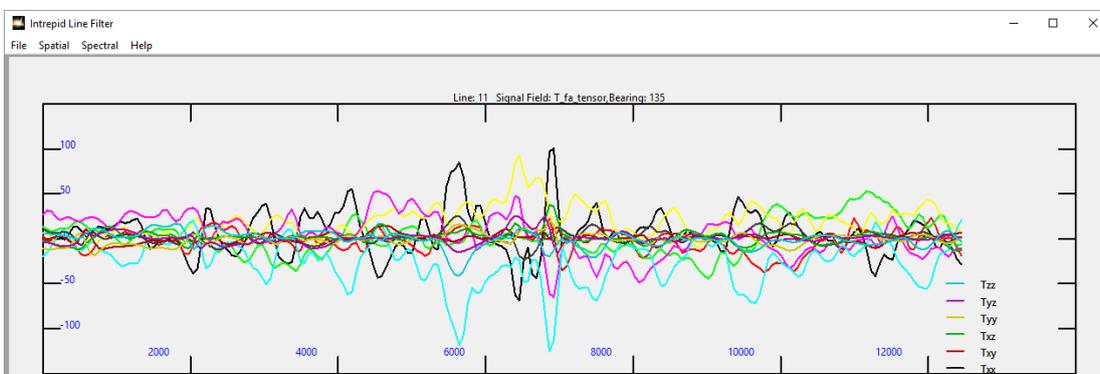
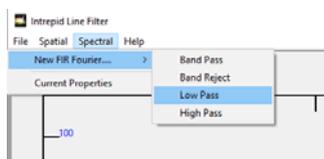
### Tensor Statistical Report

As with scalar data, a right mouse button in the top window displays a dialog that summarises the current line's statistical properties. These have been extended to include characteristics of the tensor, such as the average eigenvector direction and angular spread for each eigenvector. We then represent these in a stereonet-style plot mimic. The sizes of the Black, Green and Red circles reflect the angular dispersion of the eigenvector.



### Tensor Low Pass Filter

Some standard convolution filters have been implemented for tensors. From the **Spectra** menu choose **FIR Fourier > Low Pass**. Then left click in the top panel and choose **Superimpose**.



## Key points for this guided tour

In this guided tour you have:

- Used the Line Filter tool to filter some data and save the filtered data as a new field in the dataset
- Learned how INTREPID manages filter description files
- Used the tool to save power spectra to a file
- Had a glimpse of the Full Tensor support offered in this tool

## Frequently Asked Questions



**Q : Can I write out power spectra for all the lines without having to do it one by one?**

*A : Yes this can be done easily as a batch operation. There are example batch files in `install_path/sample_data/Examples/jobs`.*

**Q : The gravity inversion filter looks interesting. What is it?**

*A : This is an implementation of a paper by Murthy and Rao, from Computers and Geosciences, Vol 15 No 7. A profile of gravity data is inverted to yield either 1) depths to the top of the basement surface below each point of gravity anomalies, or 2) anomaly of structure.*

**Q : Can I chain two filters together and apply them in the same operation?**

*A : Yes, there is a composite option that allows you to do this.*

**Q : Does the filter use FIR and IIR methods?**

*A : Yes, most standard digital operations are supported together with several quite specialist geophysical ones.*

**Q : Is there a limit to the number of samples in a profile?**

*A : Over 8 million observations of a full tensor gradient signal have successfully been filtered using this tool for one profile. This is close to a current limit.*