

Line filtering (G15)

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:\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 capabilities of the software, just by testing the Project Manger's ability to preview and describe the attributes of each of the cookbook datasets.

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
- Highpass, lowpass and bandpass
- Vertical derivative
- Phillips depth estimation
- Gravity section basement modelling (Murty & Rao)
- Full tensor gradient support for high pass, low pass and band pass
- Quaternion filtering for roll, pitch and yaw rotation data.
- Full vector component or gradient filtering support.

Sampling modes

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

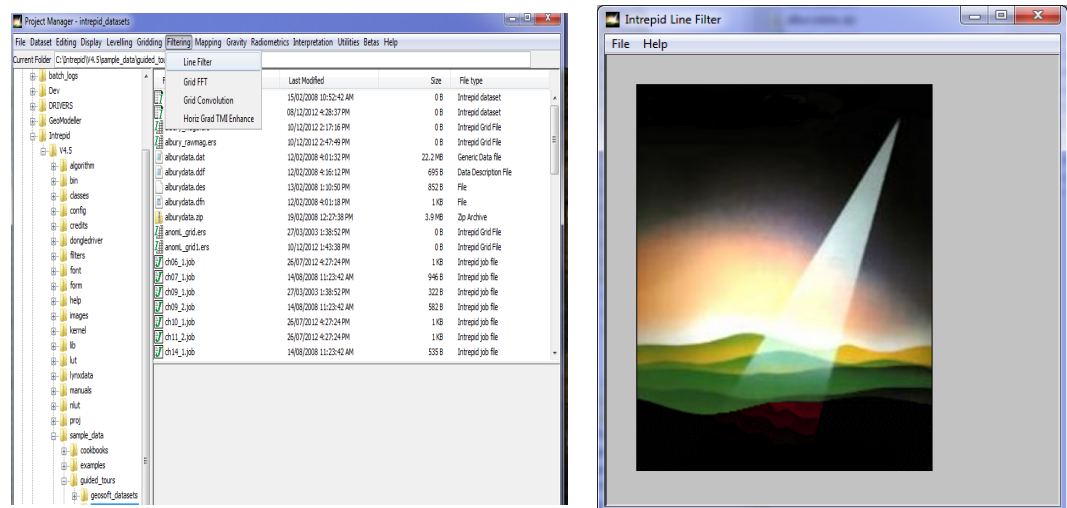
- 1 Spatial mode.** Every data point has an associated X and Y value.
- 2 Time-based mode.** Every data point has an associated time value or fiducial.
- 3 Fixed sample mode.** The data is just regularly sampled data with no time or spatial associations.

Steps to follow

Filter input and create output field

1 *Launch the Line Filter tool*

Start the 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*

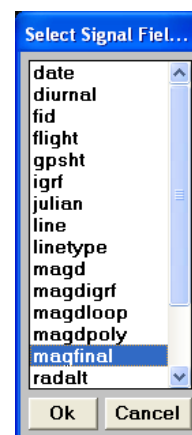
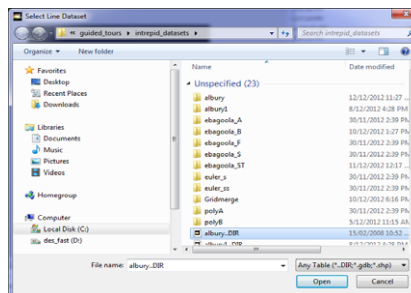
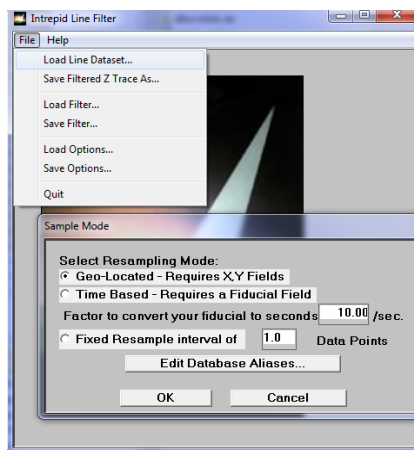
From the **File** menu, choose **Load Line Dataset**. The **Sample Mode** dialog box appears. Under **Select Resampling Mode**, select **Geo-Located**. Choose **OK**. This is the vital decision regarding what context you are wanting to operate in.

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

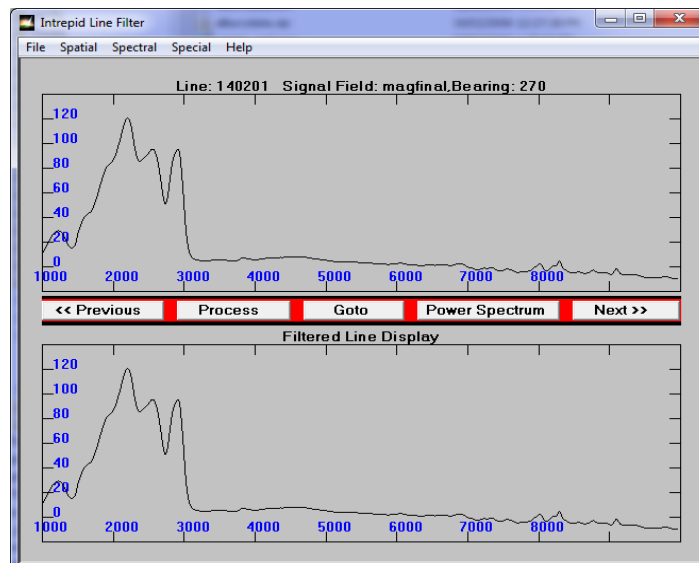
The **Select Signal Field** dialog box appears. Select **magfinal** from the list of dataset fields. If you do not have **magfinal** in your dataset you may select any other magnetic data field, for example, **rawmag**. Choose **OK**.

The **Select Sensor Altitude(m) & Select Optional Drap Altitude(m)** dialog boxes appear. Choose **SKIP**. These are when you want to do an altitude adjustment of your signal.

This can also be a vector, tensor or quaternion field.

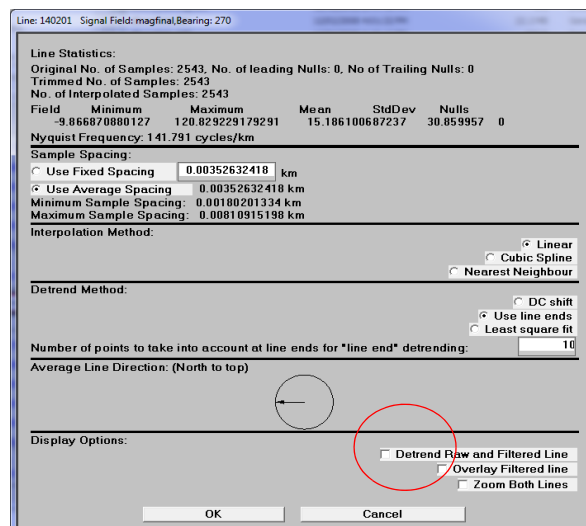


The main filtering user interface appears in the **Line Filter** window. The top panel displays the input (**unfiltered**) signal, and the bottom panel displays the output (**filtered**) signal. Since there is currently no filter chosen, the input and output signal are the same.



3 Examine the display options

Right mouse 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.



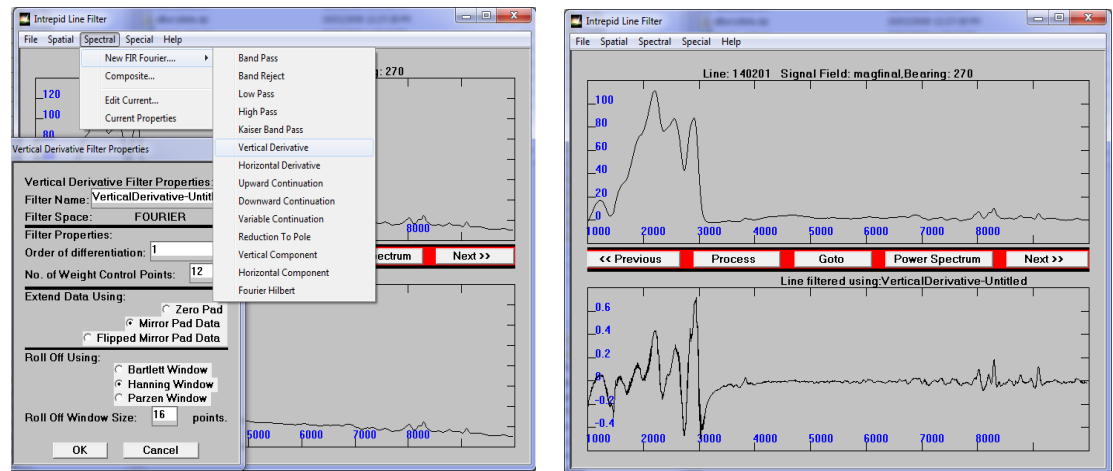
Under **Display Options**, observe that the **Detrend Displayed Line** box is checked. This means that the default behavior is to remove the trend from the input data before the signal is displayed.

Clear the **Detrend Displayed Line** check box and then choose **OK**. The input signal will appear as it really is—with no detrending applied.

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

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

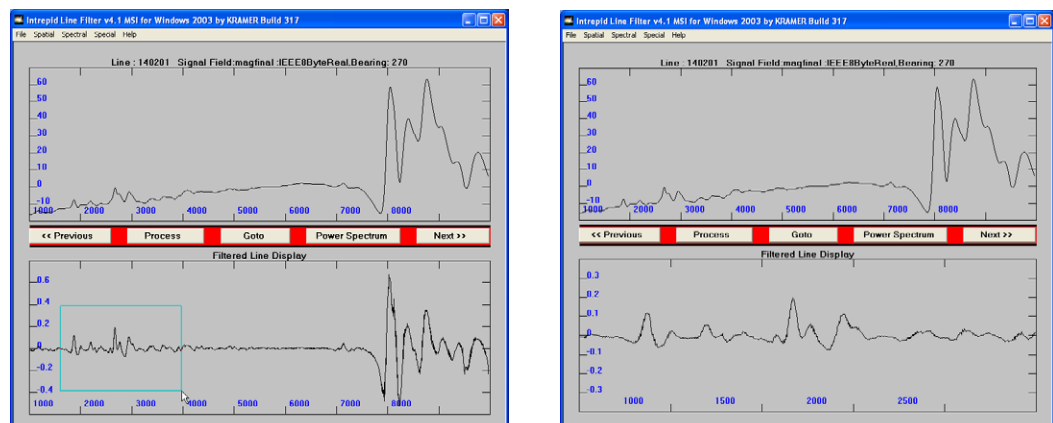
Use **Previous** and **Next** to preview the effect of the filter on different lines. Choose **Goto** to select and preview any line in the dataset.

Right click the input signal area. In the properties dialog box under **Display Options**, check the box next **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 will appear 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, using the left mouse button, 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

In this exercise we use the default option **Select All Lines**, which processes all the lines. Choose **OK**. The **Save Filtered Signal Field** dialog box appears. In the **Enter New Field Name** text box, delete **newZ**. Enter the new output 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.

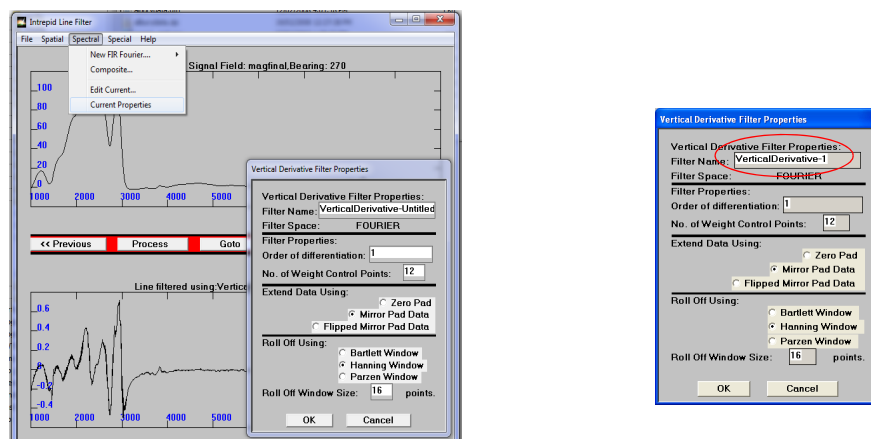
Leave the **Line Filter** tool window open and move to the next exercise.

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 get access to power spectra.

1 Save the current filter description

From the **Spectral** menu, choose **Save Filter**. The **Vertical Derivative Filter Properties** dialog box appears. In the **Filter Name** text box, change **VerticalDerivative-Untitled** to **VerticalDerivative-1** for the new field name. 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 a directory called **filters** within your INTREPID installation. As of this version of INTREPID, it is possible to embed a filter description into a line filter job file, rather than call out to a separate *.fdf file. At V5.0, this also generalises to using GOOGLE protobuf syntax for all filter descriptions and tasks.

2 Load a new filter description

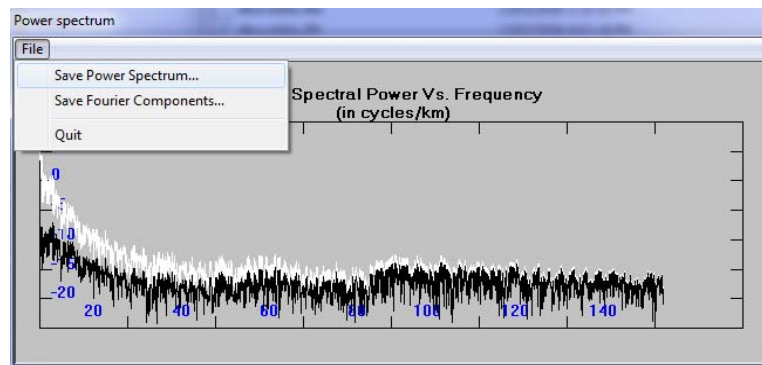
From the **Spectral** menu, choose **Load Filter**. The **Available Filters** parameter box appears. This displays a list of pre-defined filters that are provided with INTREPID. Choose any one of the filters and choose **OK**. INTREPID will load the filter and preview it for the current line.

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** box appears. The box displays graphs of power spectra computed for the current line. Spectra are displayed for the input data in black and the output data in white.

From the **File** menu, choose **Save Power Spectrum**. The **Save Power Spectrum** dialog box appears. Enter **power** for the filename and choose **Save**. INTREPID will create a file called "**Your_Name**".**spec** in your working directory. This file contains the power spectrum calculated for the **output data only**. Load the file into an editor (for example, *Excel*), and you can do depth estimates etc. we have made this something that can be automated as well, when you have large profile databases, and wish 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

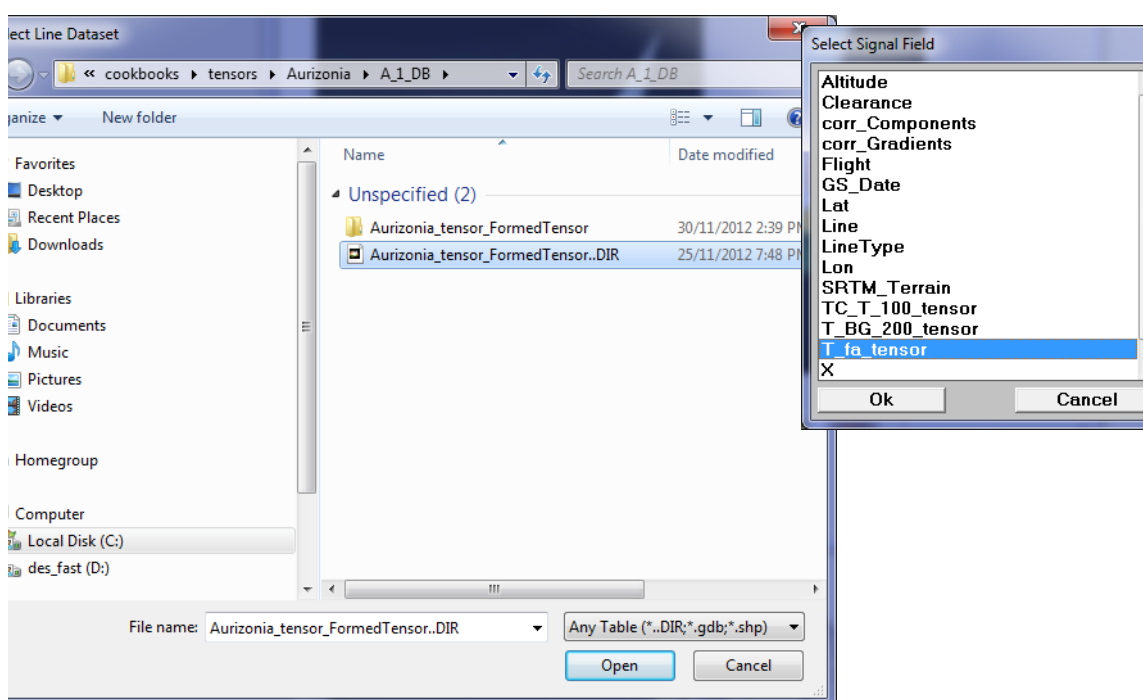
4 Exit from the Line Filter tool.

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

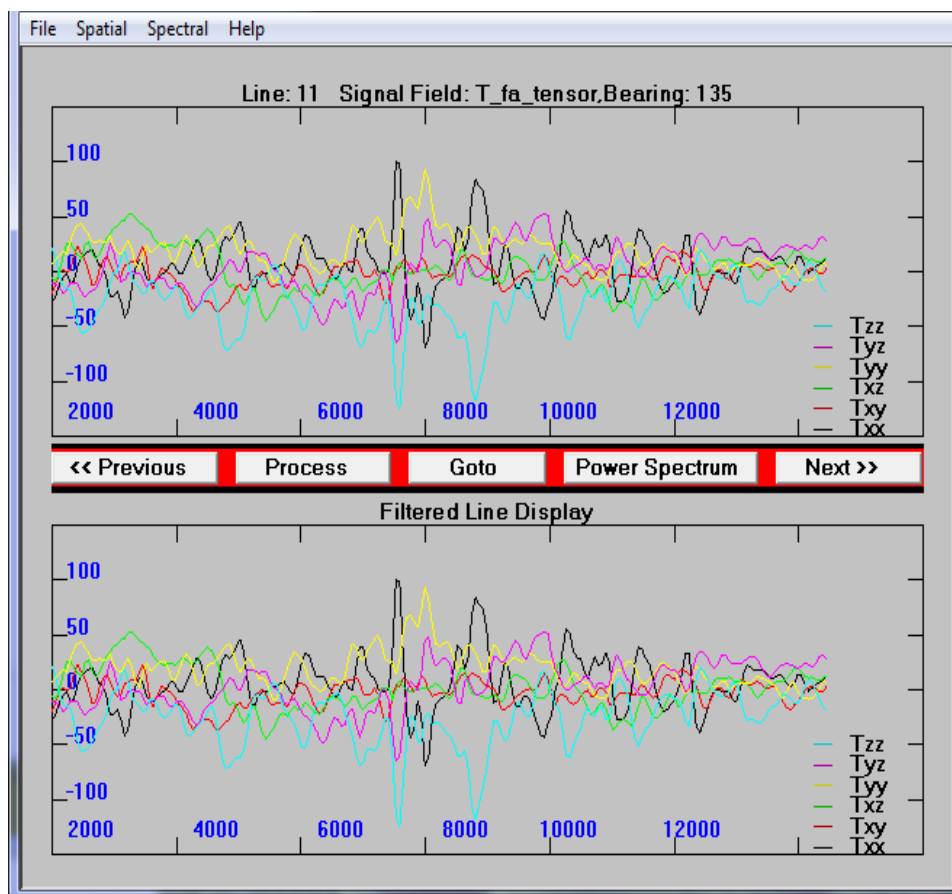
Gradient Data Example from Cookbook

If you wish to see how we handle FTG data, start again, but this time navigate to the **Intrepid\V4.5\sample_data\cookbooks\tensors\Aurizonia\A_1_DB** directory.

Start the line filtering tool, choose Open Line Dataset, choose Geo-located dataset, then select **Aurizonia_tensor_FormedTensor..DIR**. Choose the Field **T_fa_tensor**. This represents a FreeAir measured gravity tensor gradients.



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 $\pm$ 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, brings up a dialog that summarises the current lines statistical properties. These have been extended beyond normal stats 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 size of the Black, Green and Red circle reflects the angular dispersion of the eigenvector.

Line: 11 Signal Field: T_fa_tensor, Bearing: 135

Line Statistics:
Original No. of Samples: 215, No. of leading Nulls: 0, No of Trailing Nulls: 0
Trimmed No. of Samples: 215
No. of Interpolated Samples: 215

Field	Minimum	Maximum	Mean	StdDev	Nulls	Declination	Inclination	Dispersion
EV1	15.1411060843	108.599718359	42.1589849192	16.3906	0	-6.129	9.322	59.283
EV2	-39.3158803763	47.9752282877	4.03561773815	13.8906	0	93.751	-5.168	55.091
EV3	-147.167612915	-12.4781499526	-46.1948414585	18.6711	0	-142.742	81.703	45.080

Mean Trace -0.000238801163206 EigenVector Volume 0.969
Nyquist Frequency: 8.59607 cycles/km

Sample Spacing:
☐ Use Fixed Spacing 0.0581660834 km
☒ Use Average Spacing 0.0581660834 km
 Minimum Sample Spacing: 0.0478173609 km
 Maximum Sample Spacing: 0.0616611709 km

Interpolation Method:
☒ Linear
☐ Cubic Spline
☐ Nearest Neighbour

Detrend Method:
☐ DC shift
☒ Use line ends
☐ Least square fit

Number of points to take into account at line ends for "line end" detrending: 10

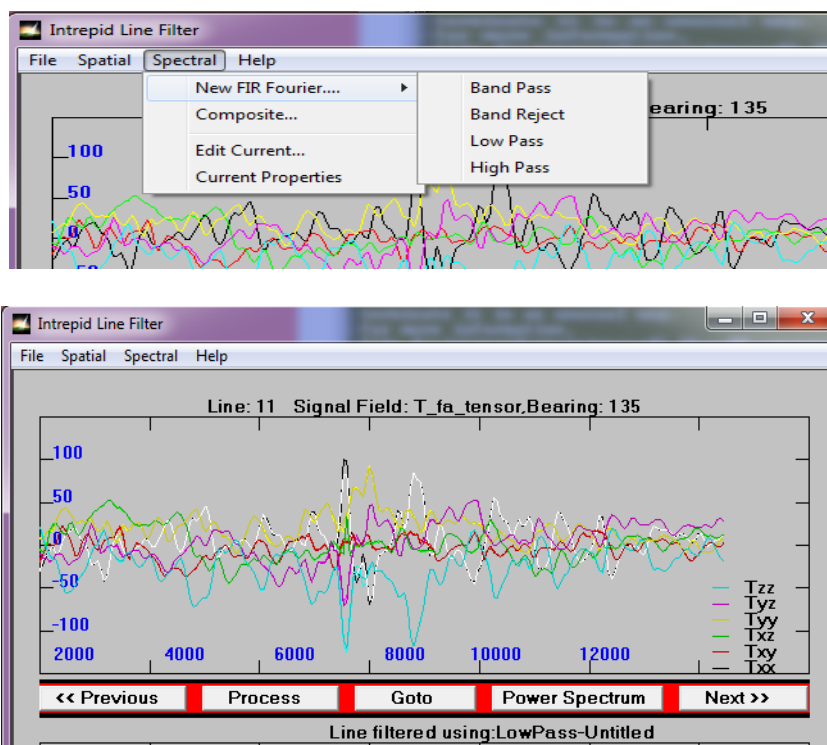
Average Line Direction: (North to top) StereoPlot of EigenVectors: (North to top)

Display Options:
☐ Detrend Raw and Filtered Line
☐ Overlay Filtered line
☐ Zoom Both Lines

OK Cancel

Tensor Low Pass Filter

A few standard convolution filters have been implimented for tensors. Choose the Low Pass from the Pull right menu. Then left click in top, 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.