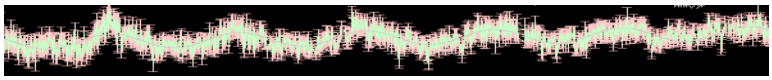
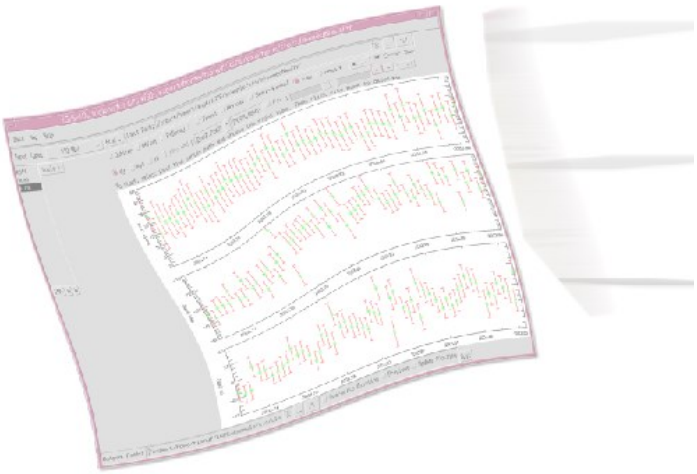


iGPS Step-by-step Tutorial

Yunfeng Tian



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1 Anningzhuang Road, Haidian District
Beijing, China 100085, May 2015

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***iGPS** Panel*

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1 Introduction

1.1 Objectives

The idea of developing ***iGPS*** origins from the attempt to rewrite Thomas Herring's GGMatlab programs with IDL (Interactive Data Language). However, many things changed when the work started. I finally discarded the framework of GGMatlab, and construct a new GUI (Graphic User Interface) according to the characteristics of IDL languages. Thus, ***iGPS*** is completely different from Thomas Herrin's GGMatlab program, with many features that I had used in the analysis of GPS (Global Positioning System) position time series.

Currently, ***iGPS*** is supposed to provide the following functions.

- ✓ View and plot time series;
- ✓ Time series editing: site selection, observation statistics, time span removal, delete outliers;
- ✓ Detect abnormal position variations: identify offsets (co-seismic or non-tectonic) and post-seismic decay events;
- ✓ Time series modeling (linear trend, jumps, and seasonal variations);
- ✓ Spatial filtering of the common-mode components in continuous GPS positions.

1.2 Supported Platforms

iGPS has been developed in IDL v7. Some tests were also carried out under previous version IDL v6.4. The modeling utility in ***iGPS*** will use the *IDL Advanced Math and Stats (IMSL Numerical Library)* module if it is available on the running platform; otherwise, ***iGPS*** will use IDL built-in *LA_LEAST_SQUARES* routine to solve the linear regression problem.

Because IDL is a cross-platform product (Microsoft Windows, Linux, Mac OS X, Solaris, *etc.*), it is OK to run ***iGPS*** in these systems if the above conditions are met. For Linux/Unix users, the X-Window packages should be installed on systems to run ***iGPS***, since it is a GUI-based program.

Note: *iGPS* is not a command-line program.

To view ***iGPS*** document, PDF reader software (e.g. Foxit Reader) is required.

1.3 Installation & Startup

It is simple to install ***iGPS***. The source code of ***iGPS*** with examples can be downloaded from http://igps.sourceforge.net/. First, download the ***iGPS*** source file (iGPS.tar.gz) to a local directory, *e.g.* your home directory (~). Extract the compressed file with

```
tar zxvf iGPS.tar.gz
```

This will create an iGPS directory in current path. In Solaris X86, you may use gtar instead of tar. For Solaris SPARC users, you may use:

```
zcat iGPS.tar.gz | tar xvf –
```

Second, set IDL to include ***iGPS*** paths. For IDL v7.0, select "Window-Preferences" from the IDLDE main menu. In the Preferences window, select "IDL-Paths". Insert the ***iGPS*** home path (say, ~/iGPS) to the path list. It is also required to select the checkbox ahead the ***iGPS*** path.

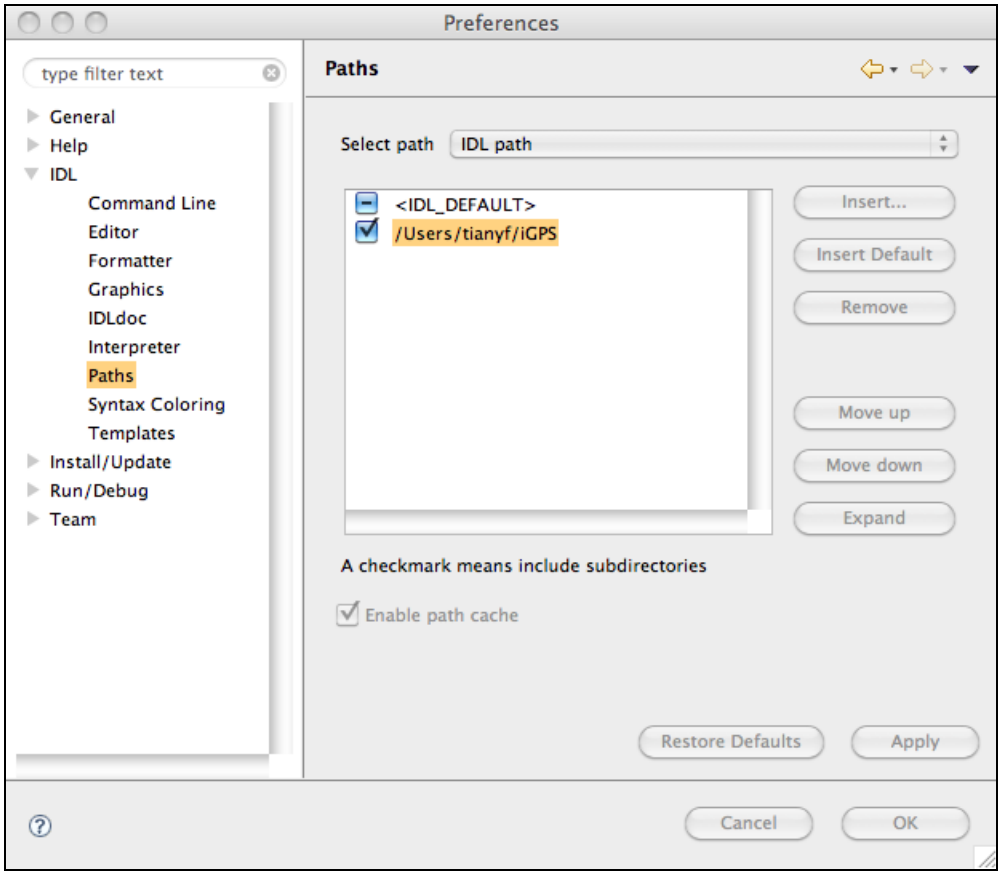


Figure 1. Set ***iGPS*** path in IDL v7.

It is now ready to start ***iGPS*** by just typing igps in the IDL Command Line. Or, you can open the main source code file ($iGPS_ROOT/main/igps.pro), compile and run it in IDLDE.

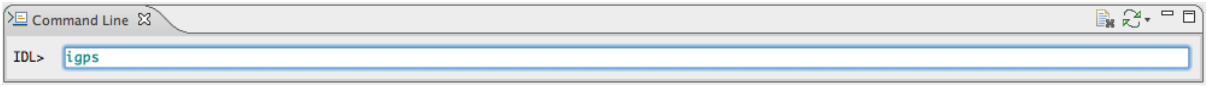


Figure 2. Start ***iGPS*** from IDLDE Command Line by **igps.** The ***iGPS*** path should be already set.

If you do not want to set the IDL path variable manually, you can use start_igps script to run ***iGPS*** (which will set the IDL searching path variable (!PATH) automatically and call the igps program). The start_igps.pro program is in the same directory as ***iGPS*** GUI source (igps.pro).

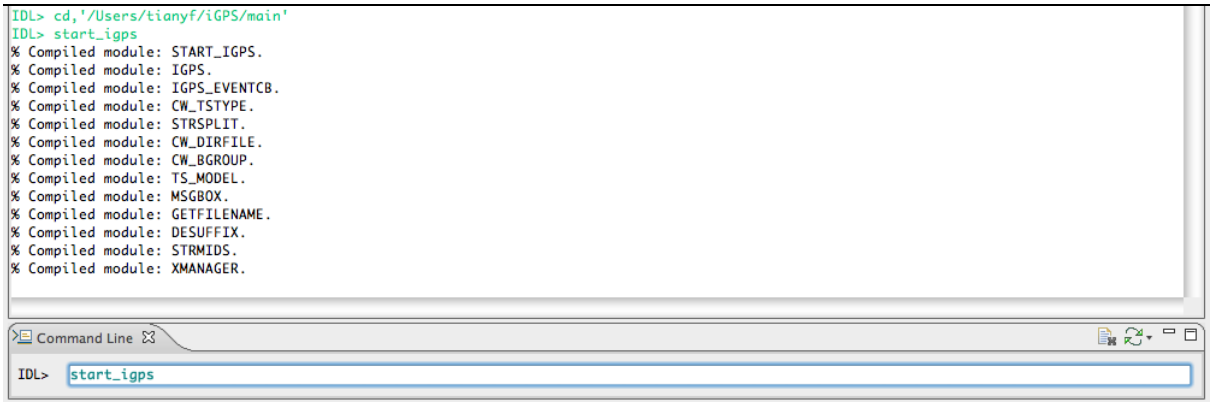


Figure 3. Start ***iGPS*** from IDLDE Command Line by start_igps. No modifications to IDL !PATH variable needed; but you need to go to the current directory ($IGPS_ROOT/main) first.

In Linux, the command-line IDL can be started by typing idl at terminals like xterm or konsole.

```
IDL> start_igps
% Compiled module: START_IGPS.
% Compiled module: IGPS.
% Compiled module: IGPS_EVENTCB.
% Compiled module: GET_PATHS.
% Compiled module: CW_TSTYPE.
% Compiled module: STRSPLIT.
% Compiled module: CW_DIRFILE.
% Compiled module: CW_BGROUP.
% Compiled module: TS_MODEL.
% Compiled module: MSGBOX.
% Compiled module: PATH_SEP.
% Compiled module: GETFILENAME.
% Compiled module: DESUFFIX.
% Compiled module: STRMIDS.
% Compiled module: XMANAGER.
IDL>
```

Figure 4. Start ***iGPS*** from command-line IDL by start_igps under xterm of Linux.

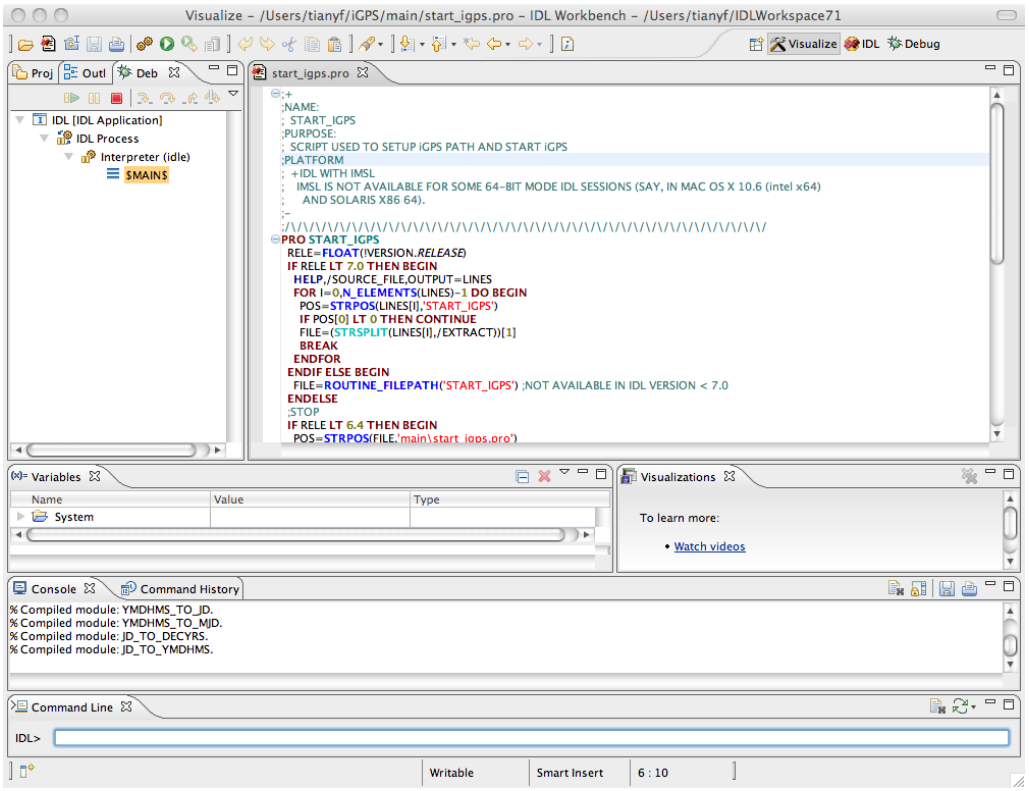


Figure 5. Start ***iGPS*** in Linux from IDLDE (idlde; idlde -32)—open, compile and run start_igps.pro file.

IDL IMSL module is not available in some systems (*e.g.*, 64-bit IDL in 64-bit operating systems; IDL v7 in Solaris X86_64). In this case, ***iGPS*** will stop with an error when estimating rates and other parameters.

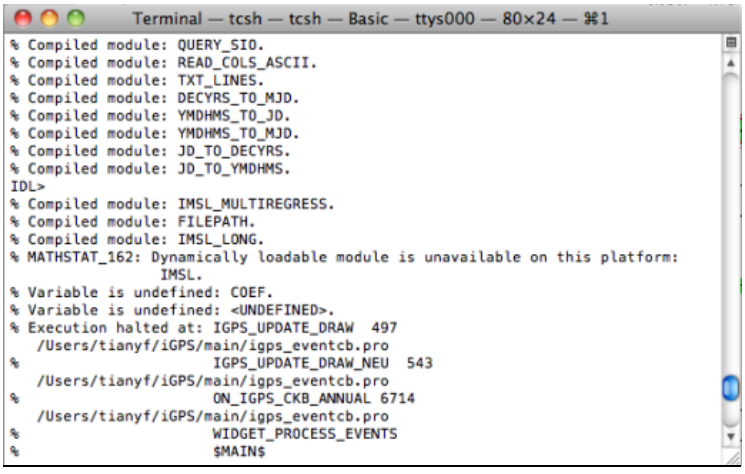


Figure 6. Error message when running ***iGPS*** in systems without IMSL support.

In some 64-bit system, you may be lucky to find that the 32-bit IDL has IMSL support. To start IDL in 32-bit mode, use "idl -32" or "idlde -32" commands.

```
[tianyf:~] tianyf% cd /Users/tianyf/iGPS/main/
[tianyf:~/iGPS/main] tianyf% idl -32
IDL Version 7.1.1, Mac OS X (darwin i386 m32). (c) 2009, ITT Visual Information
Solutions
```

Figure 7. Start IDL in 32-bit mode when using a 64-bit system.

1.4 Functionality of *iGPS*

iGPS is supposed to perform such tasks as:

a). Display various GPS time series;
b). Time series plotting;
c). Clean time series (get rid of outliers);
d). Find offsets and strong seismic events;
e). Time series modeling (rate, seasonal terms);
f). Statistics (starting and ending time, number of epochs);
g). Extract and remove the common-mode component (CMC).

1.5 *iGPS* GUI & Menu

iGPS graphic interface contains several panels:

(a). *Main Menu*: provides access to some utilities.
(b). *Input Panel*: for select input data path and type.
(c). *Site Panel*: list sites found in input path. Single click to load the time series. You can select multiple sites by clicking when pressing CTRL or SHIFT. However, the last selected one will be always plotted in the drawing areas.
(d). *Popup Menu* (

at the top right side of *Site Panel*): main tasks of ***iGPS***.
(e). *Control Panel*: includes some overplotting options, X-axis (time) format, plot styles, and zoom buttons, *etc.*
(f). *Draw Panel*: 3 sub-panels for plotting north, east and up (vertical) time series from top to bottom, respectively.
(g). *Output Panel*: output directory, output options.
(h). *Parameter Panel*: set parameters for individual task.

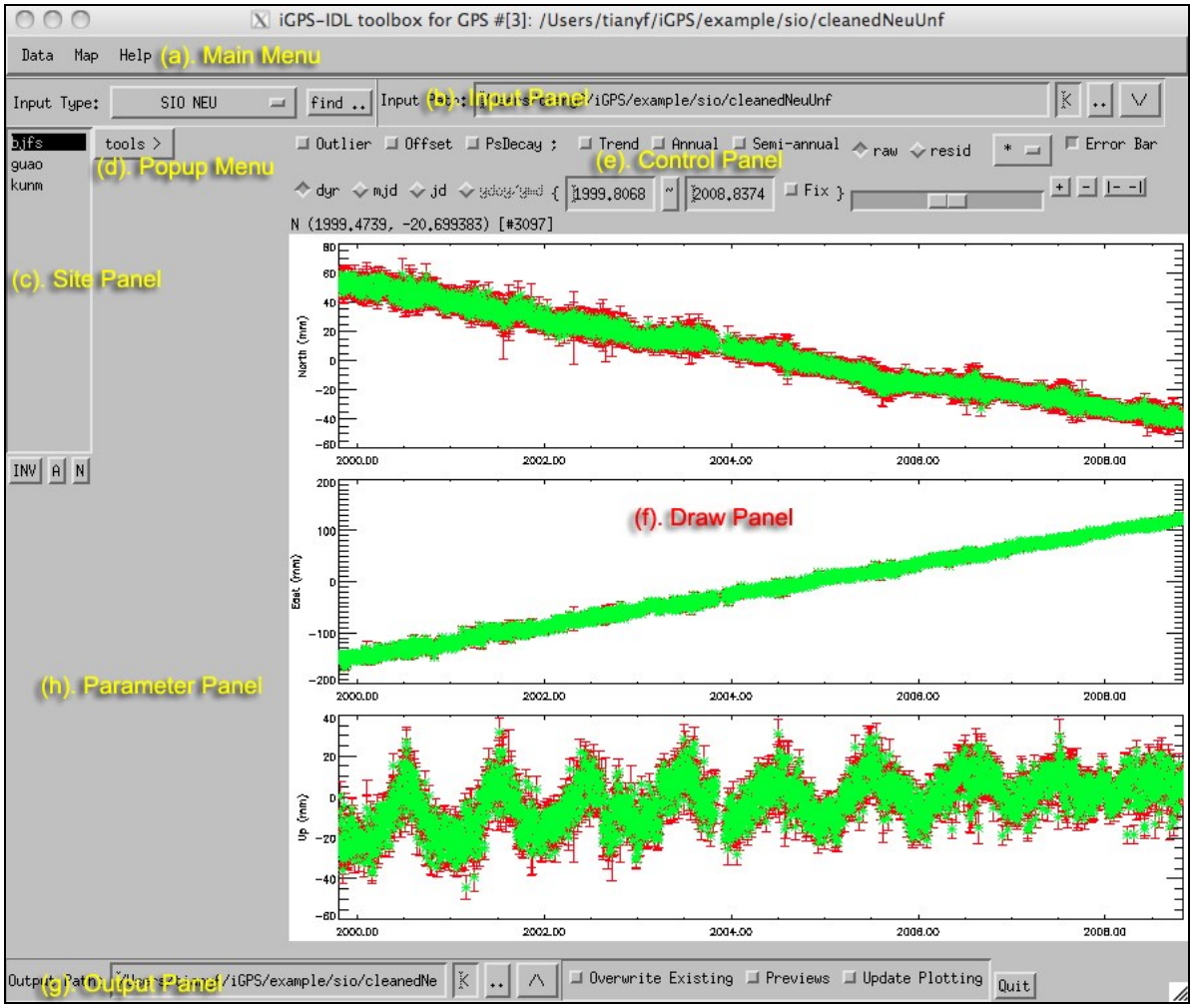


Figure 8. ***iGPS*** graphic user interface (major panels)**.**

To exit ***iGPS***, use menu Data – Quit or the Quit button in the lower right corner.

Now, let's get familiar with ***iGPS*** with a few examples.

2 Task 1: Annual Terms Analysis

Supposing we are going to study the annual signals in GPS positions time series, then

- we need to use sites with long observation history (say, 5 years);
- we should exclude abnormal sites which are obviously affected by nontectonic noises—sites with large non-linear movements (*e.g.*, AB12).

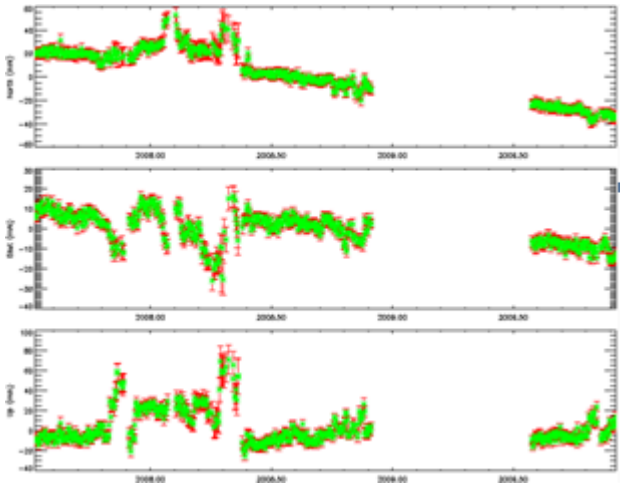


Figure 9. Positions time series of AB12 contain many non-tectonic variations.

2.1 Get the Data

We use the SIO (Scripps Institution of Oceanography) NEU files as input data.

First, download the time series files from SIO FTP/HTTP site.

- ftp://garner.ucsd.edu/pub/timeseries/
- http://garner.ucsd.edu/pub/timeseries/

Use anonymous and your email address to login into the sites.

Here, we use the cleanedNeuUnfTimeSeries20100126.tar file as the input data. Let's save it in ${HOME}/sopac/

Then, extract the files into ${HOME}/sopac/cleanedNeuUnfTimeSeries20100126/.

```
tar xvf cleanedNeuUnfTimeSeries20100126.tar --wildcards "????CleanUnf.neu.Z"
uncompress *.neu.Z
mv *.neu cleanedNeuUnfTimeSeries20100126
```

Now, the files are in ${HOME}/sopac/cleanedNeuUnfTimeSeries20100126. There are 1857 files in this directory.

Tip

Accepted Time Series Formats

iGPS recognizes several kinds of time series, including:

a). SIO (*.neu; *.xyz; ftp://garner.ucsd.edu/pub/timeseries/; see http://garner.ucsd.edu/pub/timeseries/measures/ats/ATS_TarFile_README.txt for format description);

b). PBO (*.pos; ftp://data-out.unavco.org/pub/products/position/; http://pboweb.unavco.org/dmsdocs/Root%20Folder/Data%20Management/Data%20Product%20Documentation/gps_timeseries_format.pdf);

c). JPL (*.lat, *.lon, and *.rad; ftp://sideshow.jpl.nasa.gov/pub/usrs/mbh/);

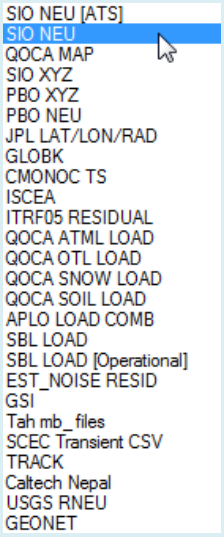
d). GLOBK (mb_*.dat?; http://www-gpsg.mit.edu/~simon/gtgk/);

e).Output files by mload in QOCA (*.?load; http://gipsy.jpl.nasa.gov/qoca/extclass/ext_mload.html);

f).SCEC Transient CSV format (*.csv; http://groups.google.com/group/SCECtransient);

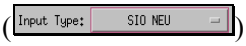
g).Output of track program in GAMIT (renamed to *.trk; http://www-gpsg.mit.edu/~simon/gtgk/). But note: TRACK outputs are highrate time series; and timing problems will arise if converted to conventional daily SIO NEU format. Thus, currently, ***iGPS*** does not allow highrate GPS time series analysis.

All ***iGPS*** operations only accept SIO NEU formats. You can convert other formats into SIO NEU ones using Format Converter tool.



2.2 View Time Series

One of the main objectives of ***iGPS*** is to facilitate the viewing of time series to get a clue on the quality of time series. To view time series,

a). In Input Path, select the directory (${HOME}/sopac/cleanedNeuUnfTimeSeries20100126/) where you saved the time series files. ***iGPS*** use the Input Type droplist (

) to recognize time series types.

- Time series types are distinguished by the file extension;
- Filenames begin with unique 4-character site names.

The *Site Panel* will be updated automatically if at least one time series file is found.

b). Click a site name (*e.g.*, AB07) in *Site Panel* will load the time series data and display them in *Draw Panel*. The number of found sites and input pathname will be shown in the ***iGPS*** window title.

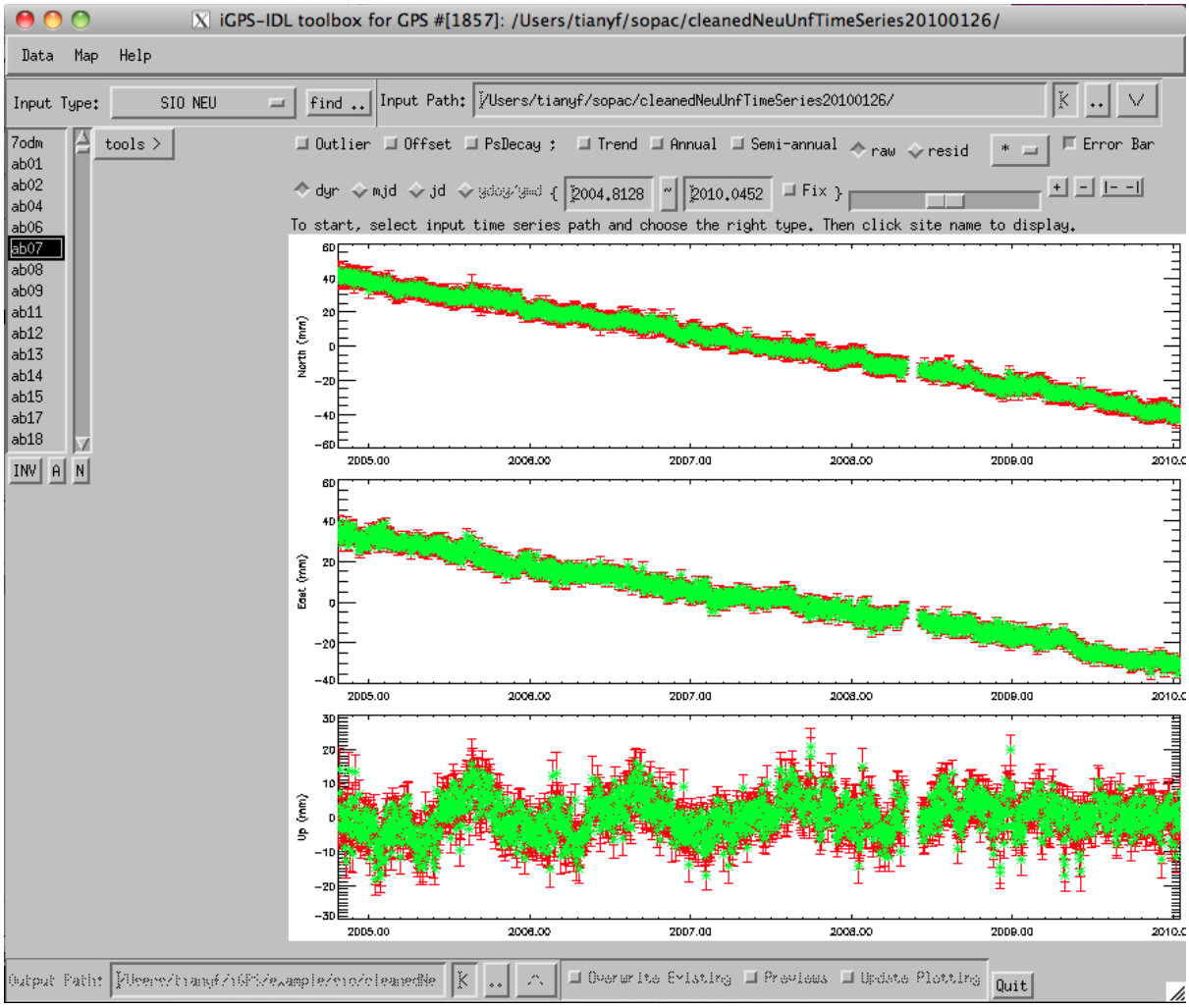
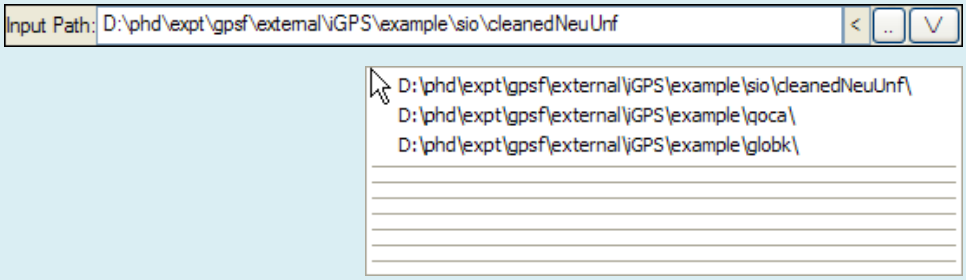


Figure 10. Using ***iGPS*** to view time series of AB07**.**

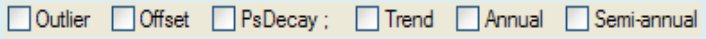
Tip

Right click the field which is left to select button will bring up the popup menu of recently visited list. ***iGPS*** can remember the last ten selections. Click the right-side button will copy the input pathname to Output Path text field; and *vice versa*.

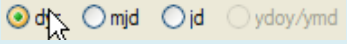
When the content of Input Path textfield changed or focused, the site list in *Site Panel* will be updated automatically.



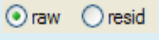
The checkboxes are used for plotting the fitted time series: turn options on to estimate them.



Currently, ***iGPS*** support three types of time (decimal year—dyr, MJD, and JD) for X-axis.



iGPS also provides a quick switch between the raw and residual (resid) time series.

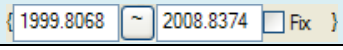


iGPS supports eight styles of plotting.

iGPS has three zoom options: zoom in (+), zoom out (-)and zoom to the whole time series (|- -|).

You can use either the slider  or middle mouse button to move the time series plots.

iGPS provides text fields to show the starting and ending epochs of current view of displayed time series. You can modify the epochs and then click the middle tilde button () to zoom in. There is also a checkbox button (Fix) to fix the time axis of plotting when necessary.



2.3 Select Sites with Long History

iGPS provides a module to do this task—Selector. In the parameter setting panel for Selector, input 5 as the minimum length of observations and leave all other fields as blanks. Then choose an output path and select all sites by click the A button below the list of available sites (*Site Panel*).

Note: Most *iGPS* operations are only applied to sites highlighted.

Also note: Selector only use the starting and ending epoch to calculate the length of observation; no statistics of number of available days. To exclude sites with long time span but large data gaps, specify the minimum days of Gap.

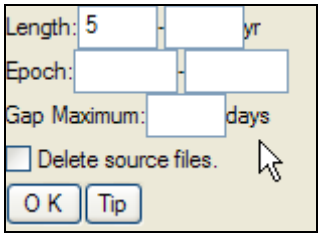


Figure 11. Input parameters for site Selector (according to observation length).

Tip:

You can use the \/ button in input path selector to send the pathname to output path field; or use /\ as an inverse.

In Linux/Unix, you cannot create a new directory in the file or directory selection dialogs. The path or file you plan to select must exist beforehand.

Here, we created the output path ${HOME}/sopac/cleanedNeuUnfTimeSeries20100126.5yr/ manually.

Time series selectors (Selector, Selector [Net], and Selector [Geographic]) are used to selected sites by different standards.

- By time series statistics: length, maximum data gap, starting and ending epochs;
- By network: PBO/…(the site names in a site list file .sit will be used);
- By geographic corners.

After selecting sites, click the OK button to start the search. If there are already output files and you want to overwrite them, please check the Overwrite Existing checkbox in the *Output Panel*.

When Selector working, it will loop through all the sites to be processed in the sites listbox. Information will also be given in the status bar (at the top of drawing areas). After Selector finished, use the /\ button to send the output pathname to Input Path textfield. The site list will be updated accordingly. Click on a site name to display its time series.

Now, we got 858 sites with 5-year observations.

2.4 Manually Delete Abnormal Sites

In the above selected 858 sites, there are some sites (*e.g.*, ARM1) endured non-linear movements and should be excluded from further analysis.

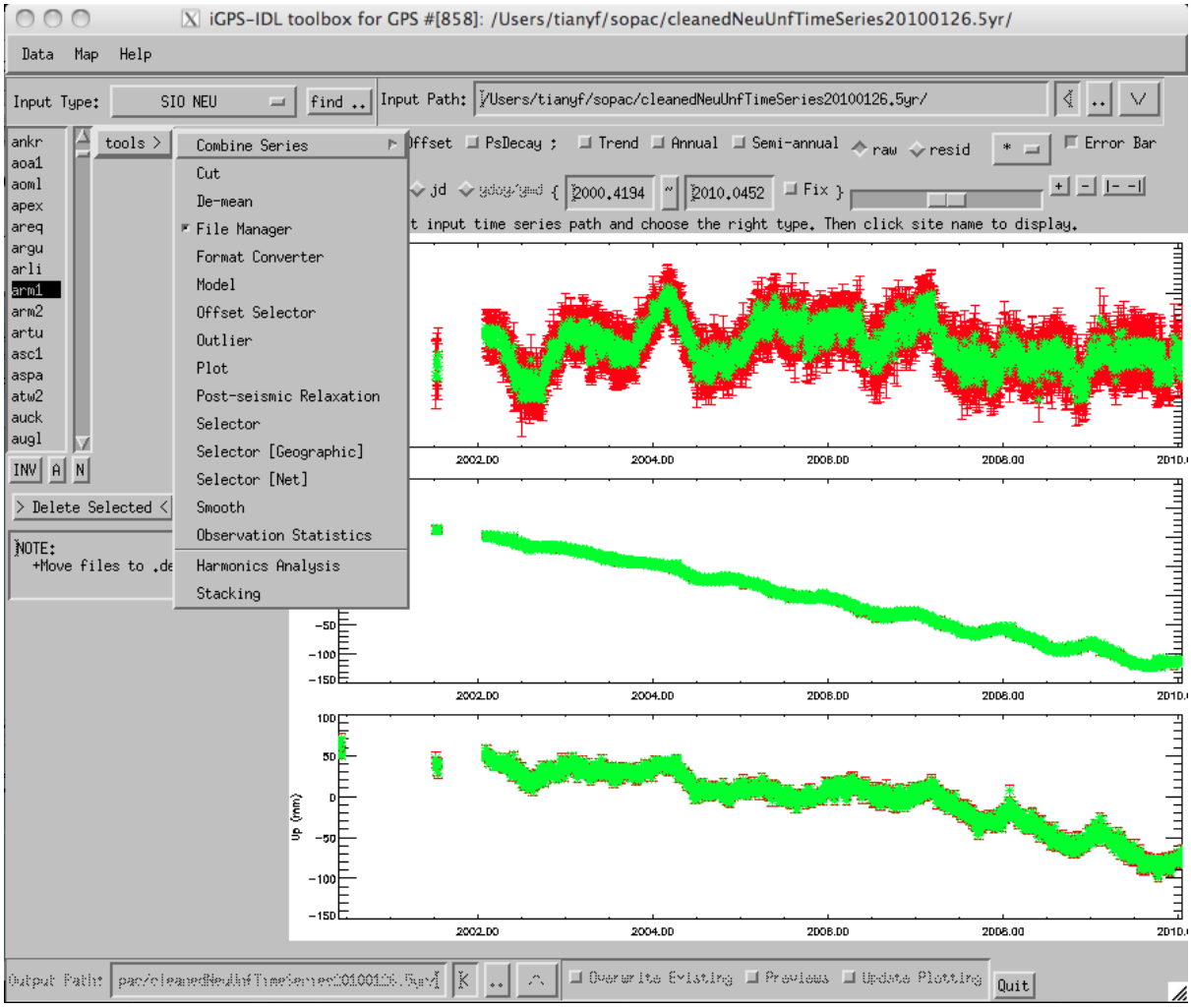


Figure 12. Deleting anomalous sites (*e.g.*, ARM1).

This is done by using the File Manager utility. Use Delete Selected button to delete selected sites from current directory. In fact, ***iGPS*** just moves the deleted files into a ".deleted" directory in current path.

```
[tianyf:~] tianyf% ls /Users/tianyf/sopac/cleanedNeuUnfTimeSeries20100126.5yr/.d
eleted/
arm1CleanUnf.neu        deleted.list
arm2CleanUnf.neu        ykroCleanUnf.neu
[tianyf:~] tianyf%
```

Figure 13. Deleted files by File Manager utility.

To check whether a site is stable, one can try to do a fast fit to the time series. To only fit a line trend, please check the Trend (

) checkbox. If you also want annual or semiannual terms, please select Annual and Semi-annual checkboxes (a linear trend is implied in this case). A fitted curve will be shown over the raw time series.

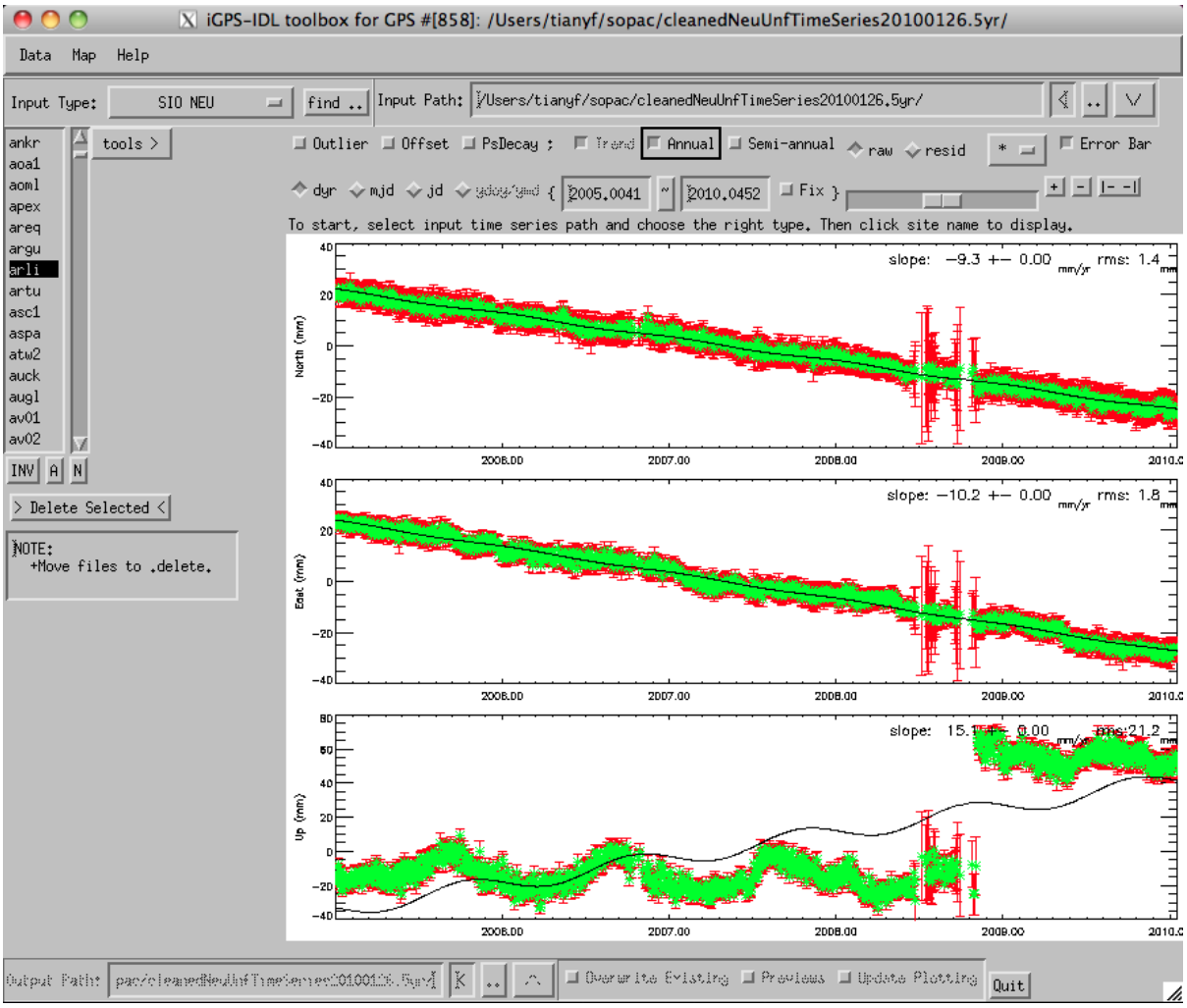


Figure 14. Time series for ARLI (with a large jump in the vertical component).

If there are any offsets or post-seismic decays in the time series. Use the Offset and PsDecay utilities to define the time of occurrence. With SOPAC NEU files, you are lucky to find some offsets/psdecay events were already embedded in the time series files. In this case, turn on the +SIO/NEU Offset or +SIO/NEU Psdecay checkboxes in the *Control Panel* to load the jump or psdecay events list automatically when these sites are displayed. The plots will be updated and a new modeled curve will be shown, with offset and post-seismic decay parameters estimated, if you set to show the modeled lines.

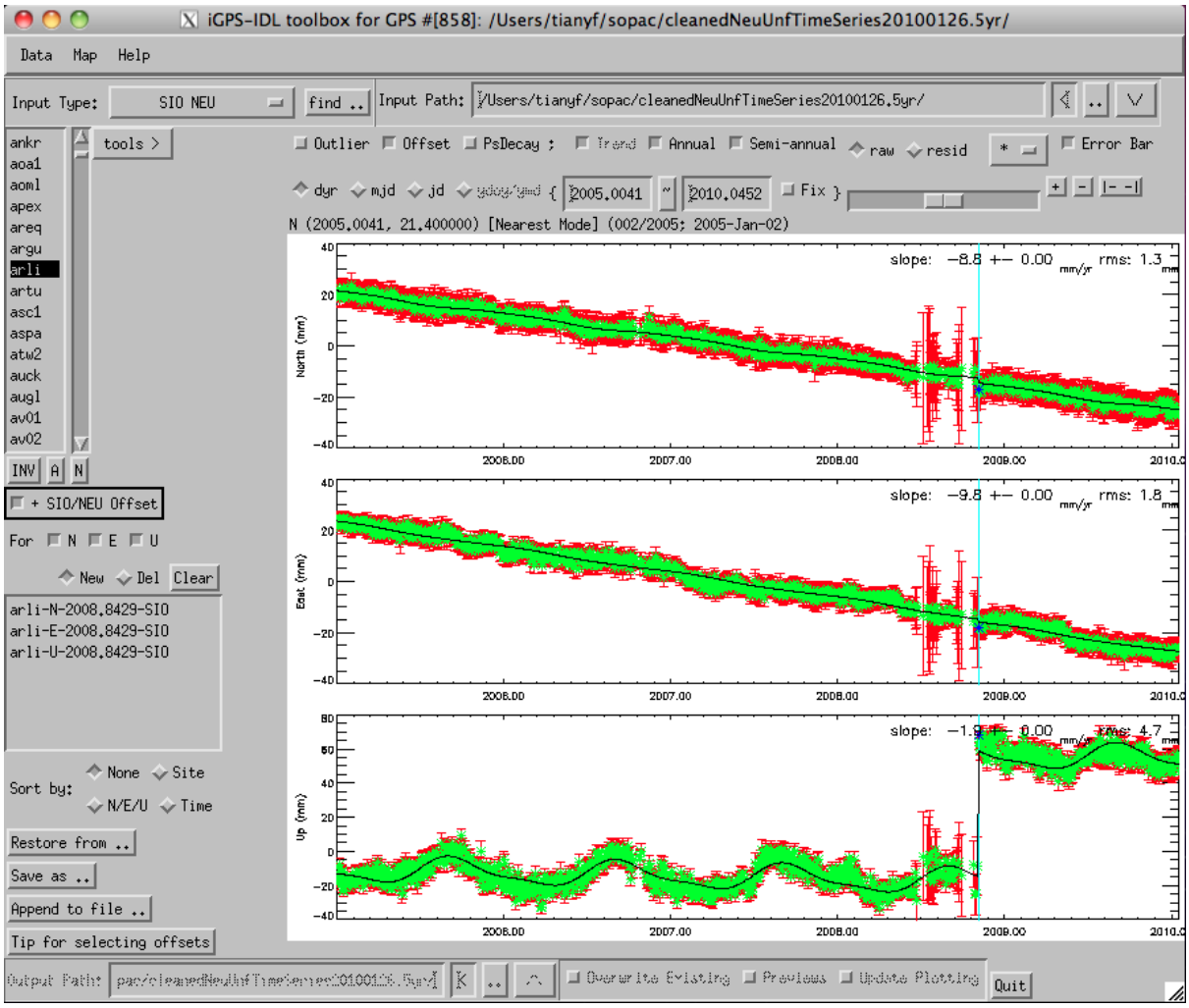


Figure 15. Time series for ARLI with offsets. (Pay attention to changes in the fitted vertical line)

Tip:

You can use +,"- buttons to zoom in or zoom out the time series. Or use |- -| to show the whole time series.

Use the slider to move the time series. Or hold down the middle button when moving the mouse, and release it.

Change the display pattern among several symbols: -, +, *, *etc.*

Turn Error Bar on or off.

2.5 Delete Abnormal Time Spans

Sometimes, parts of the positions time series are contaminated by abnormal effects. For example, the time series at ZIMM before 1996 is not stable.

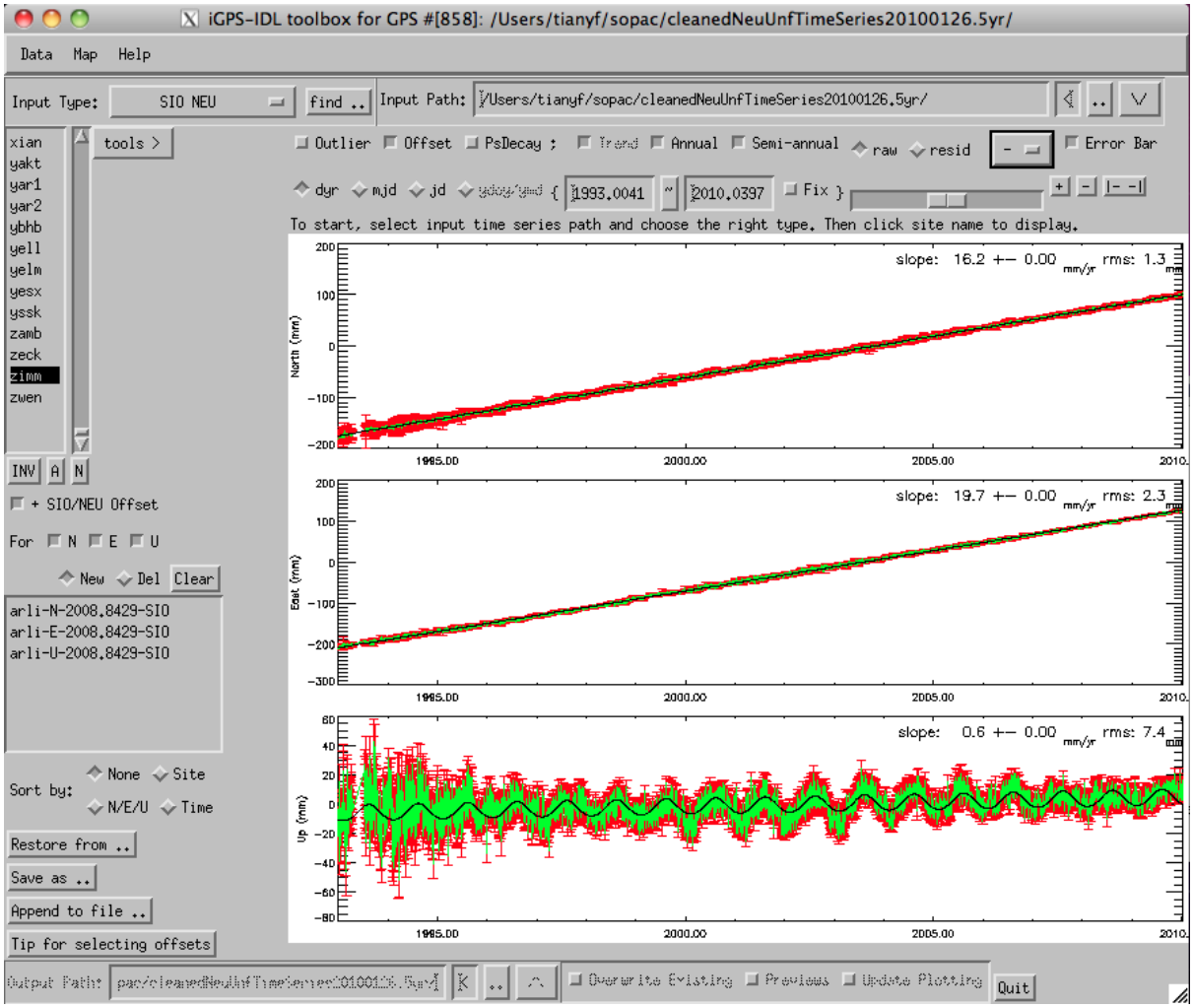


Figure 16. Time series for ZIMM before year 1960 is not stable.

iGPS provides a tool-Cut-to remove abnormal spans in time series. Two clicks (starting and ending points) are needed to define a time span: click the left button in the plotting area to define the starting time; click again to define a ending time. Several spans can be defined.

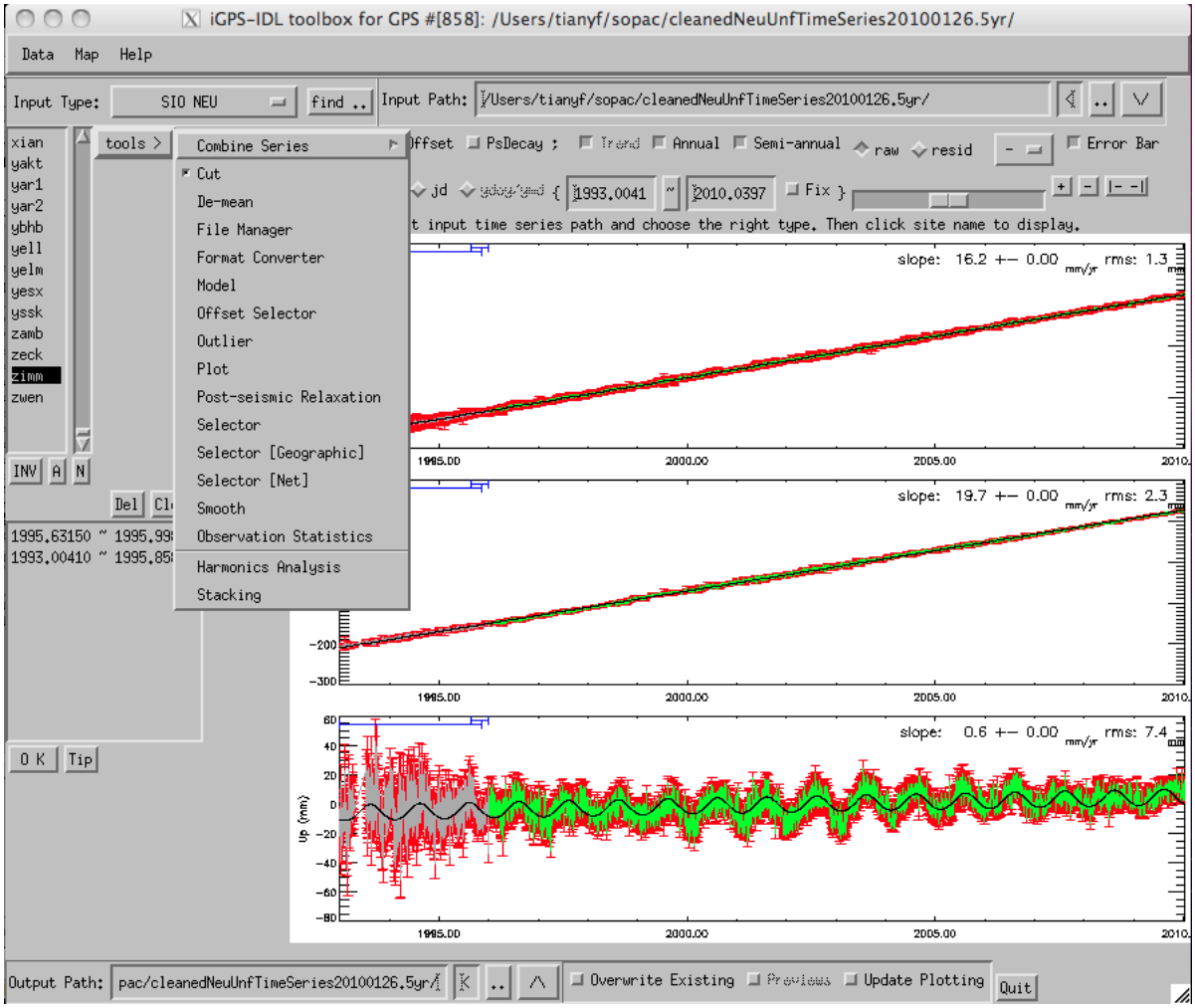


Figure 17. Time series for ZIMM with data priori to 1996 will be deleted.

Set the output path to the same value as Input Path field, check the Overwrite Existing option, and click OK button in *Parameter Panel* of Cut to do the cleaning. Click the site name to refresh the time series plots.

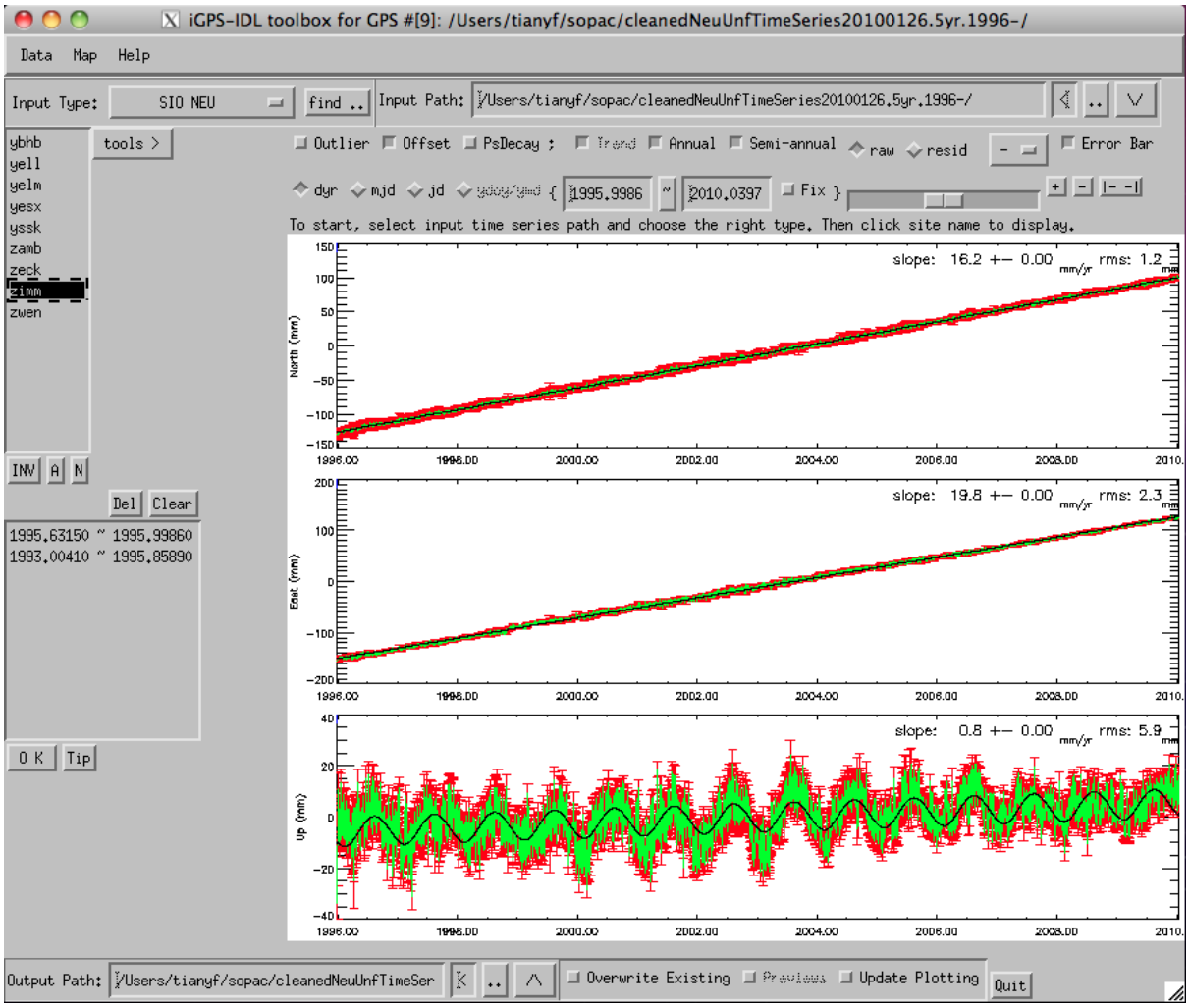


Figure 18. Time series for ZIMM after deleting abnormal time spans.

> **Tip**:
>
> Use "Clear" button to clear all definitions of time spans to-be-deleted.
>
> Use "Del" to delete selected spans.

In the following examples, we only choose the last several sites to analyze.

2.6 Parameters Estimation

We will estimate linear rate, annual and semiannual terms, together with offsets and post-seismic relaxation simultaneously. This is done by using Model (Model) utility.

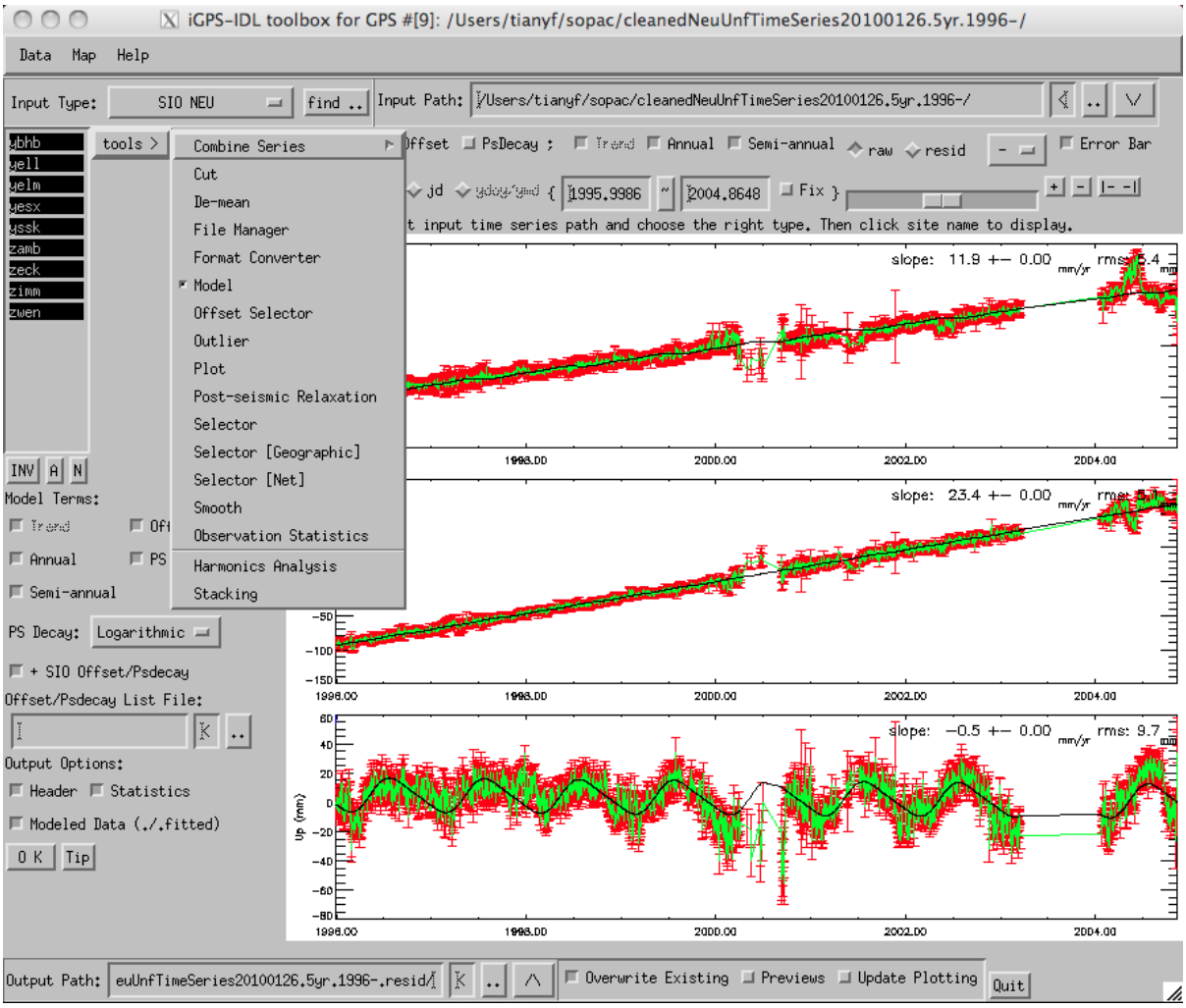


Figure 19. Model utility.

Turn on all the checkboxes, and choose Logarithmic from the PS Decay droplist. Pick an output path, and select all sites by click A button, click OK button to run the program to get residual positions time series.

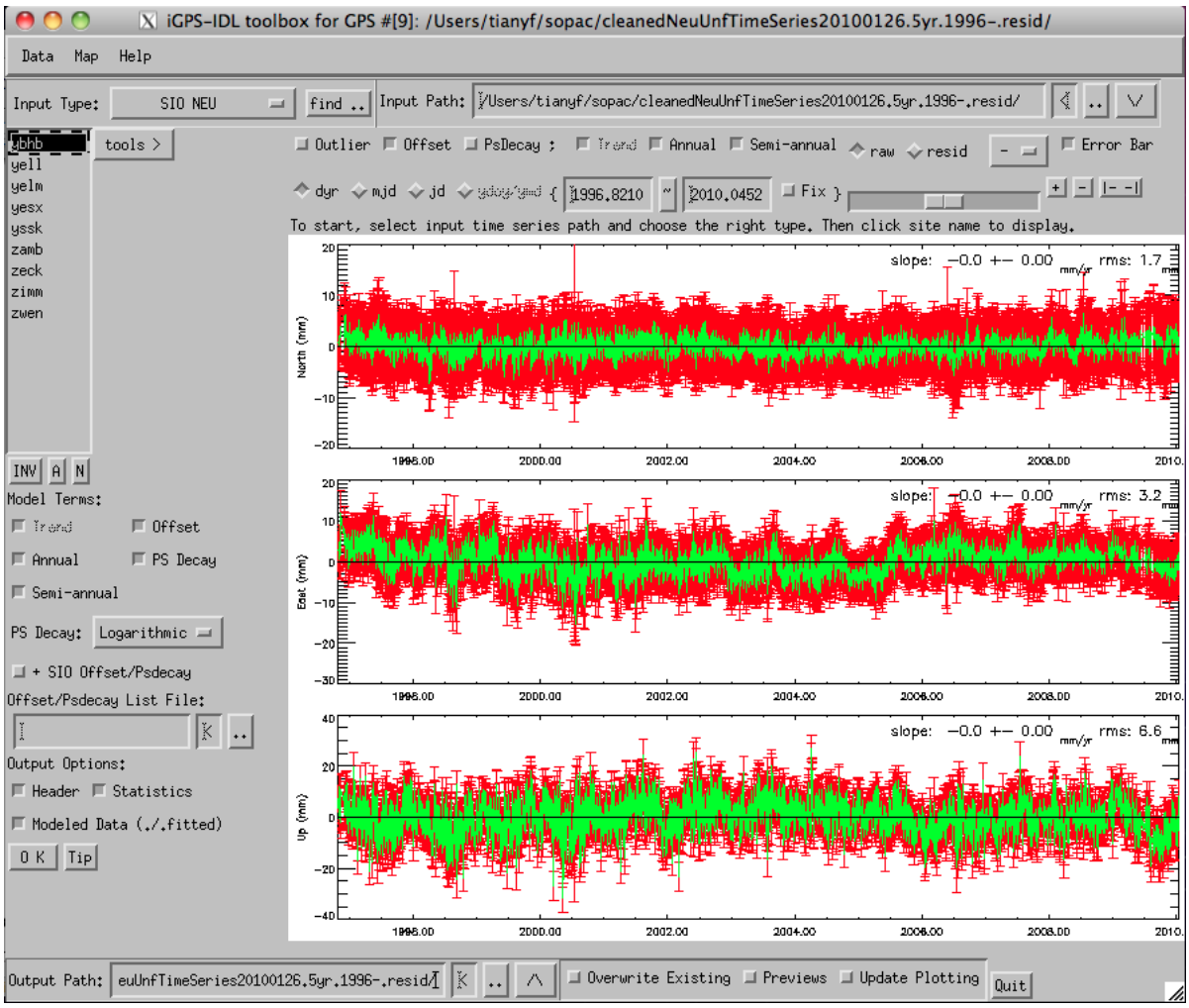


Figure 20. Residual positions time series of YBHB.

If there are undetected offsets, we can easily find it by looking the residual time series plots. For example, at site YELL, there is a jump in the vertical residual positions near August 23 1996.

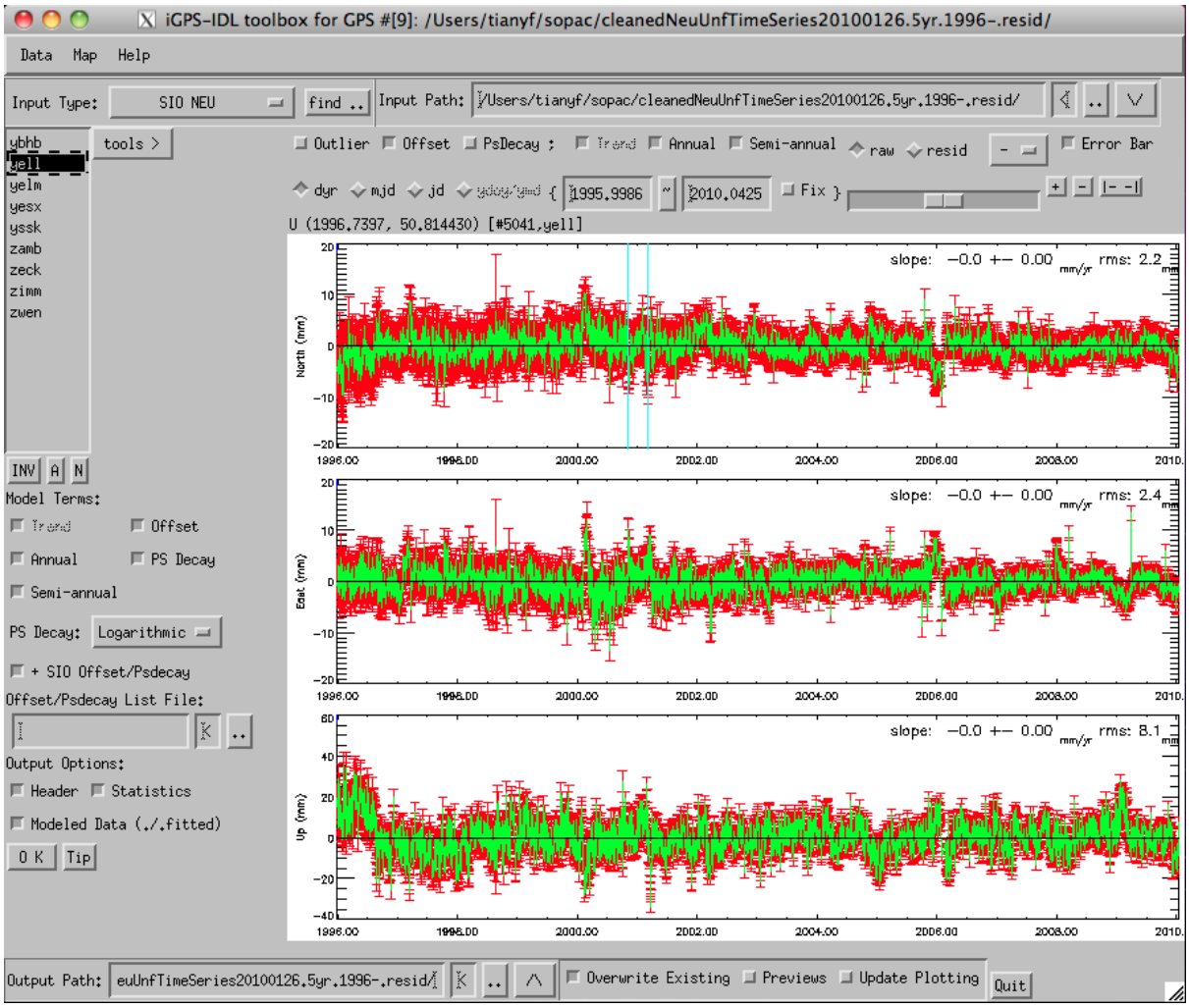


Figure 21. Undetected offset in the vertical component of YELL.

There are similar cases for other sites.

2.7 Find Offsets Visually

Offset is the most common kind of non-linear movements in GPS positions time series. ***iGPS*** provides an interface to define the offset epochs manually. Select Offset Selector (Offset Selector) menu item under the *Popup Menu* button tools> to show offset *Parameter Panel*. In this case, more information will be shown in the status bar area; the current epoch will be highlighted; the data values in time series files will be shown, instead of the current positions of the mouse cursor.

To create a new offset, make sure that New (New) radio button is selected. The current focused point will be highlighted as blue. A single click of the left mouse button will add a new offset and append it to existing offsets list. By default, ***iGPS*** will add offsets for all components. To add jumps for specific components, turn the N, E, U checkboxes (N E U) on or off.

To delete an offset, select Del (Del) radio button, and then move the mouse cursor to time series plotting area. The nearest offset to be selected will be highlighted in black (line); click the left mouse button to delete it. You can also use Clear (Clear) button to delete all offsets.

Warning: the deletion operation is ***irreversible***!

Note: *iGPS* does not make a copy of the old offsets list. You CANNOT undo the deletion operation.

You can sort the offset list by switching among "None", "Site", "N/E/U", and "Time" radio buttons.

You can then save or append the selected offsets to a text file (*.def). The format of output offset definition file (*.def) is as follows.

a). Lines with non-blank first character are comments.

b). The first field is data type: offset or psdecay. offset is for discontinuities in time series; psdecay refers to post-seismic relaxation decay events. Co-seismic displacements are classified as one kind of offsets.

c). The second field is 4-char site name. If this field is all then, the event is for all sites.

d). The third field is decimal year.

e). The fourth field indicates the component; if missing, the event is for all three components.

f). The other fields are ignored currently.

g). The offset/psdcay definition file is case **in**sensitive.

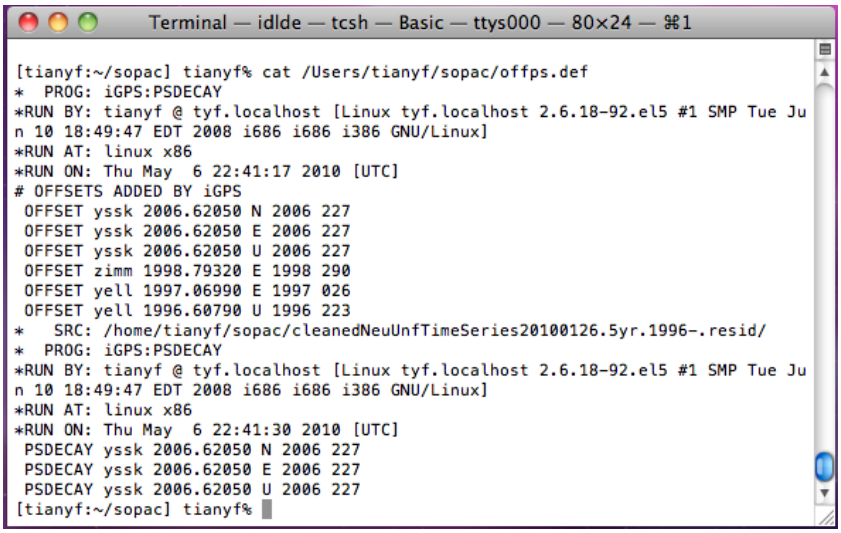


Figure 22. View the sample of offset/psdecay list file (*.def).

To save your offsets to a text file, click the Save as ... button. Use Append to file .. to append the offsets to an existing file. If you want to reload previous files, use the Restore from ... button; ***iGPS*** will discard duplicate records when importing.

If the input series is SOPAC NEU files, then available offsets list time series files can be extracted by turning on the checkbox +SIO/NEU Offset (

). ***iGPS*** will automatically load the offset list when the time series is displayed. A suffix -SIO will be appended to those SIO offset items.

Let's take the vertical component of YELL for an example.

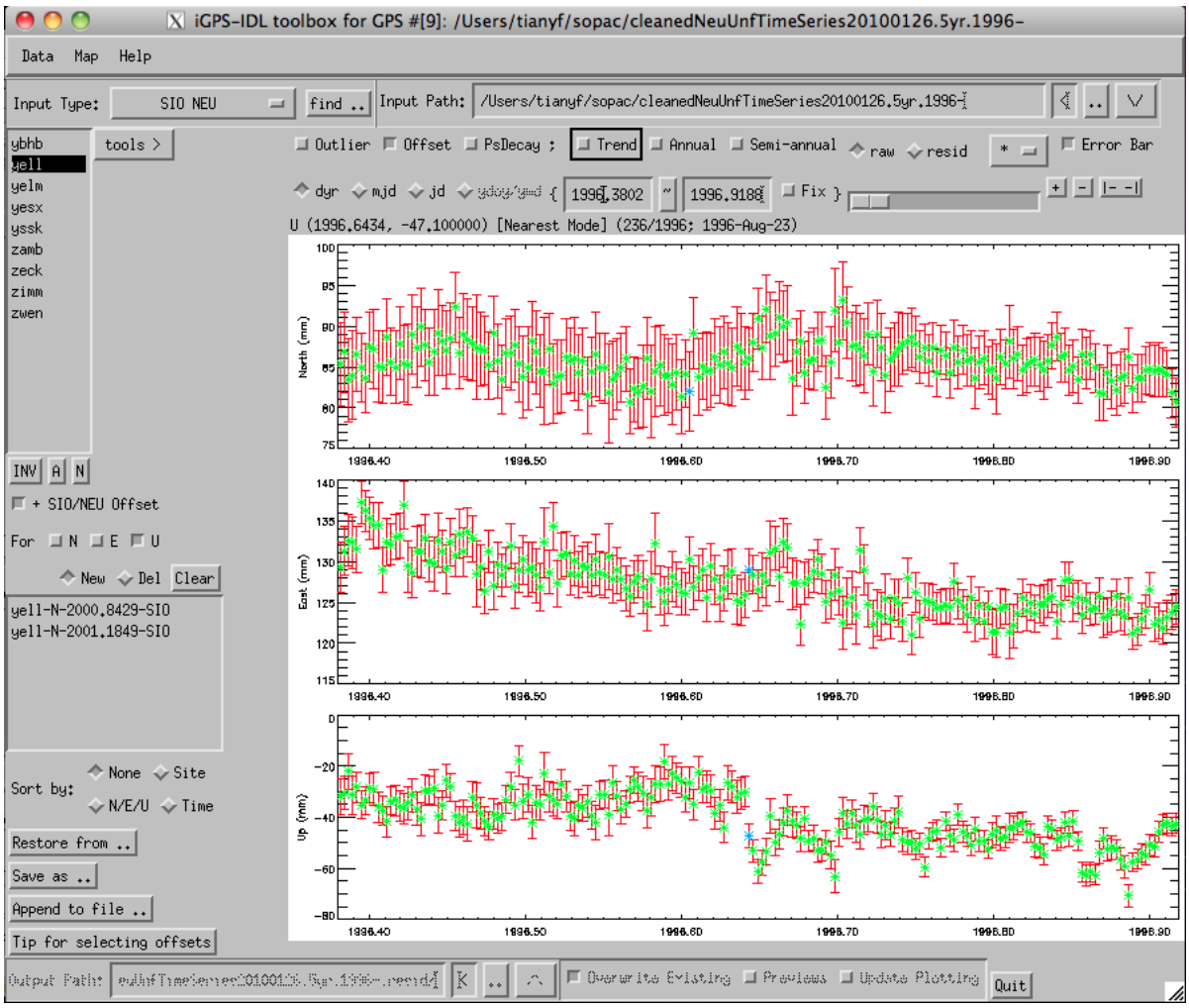


Figure 23. Time series of YELL around 1996.7 (possible jump near August 23 1996).

We found that there is a neglected discontinuity in the vertical component of YELL near August 23 1996. First, we can use zooming and sliding tools to narrow to time span near the jump. Then turn on the Offset checkbox to bring up the offset *Parameter Panel*. This panel can also be activated by choosing the Offset Selector menu item from the popup menu (tools > button).

Then, uncheck the N and E checkboxes in the offset Parameter Panel, because we only want to add an offset for the vertical component. Move the mouse to the day of August 23 1999, and then click the mouse button to add an offset event. Information will be shown in the status bar over the top of drawing areas when moving the mouse, *e.g.*,

```
U (1996.6434, -47.100000) [Nearest Mode] (236/1996; 1996-Aug-23)
```

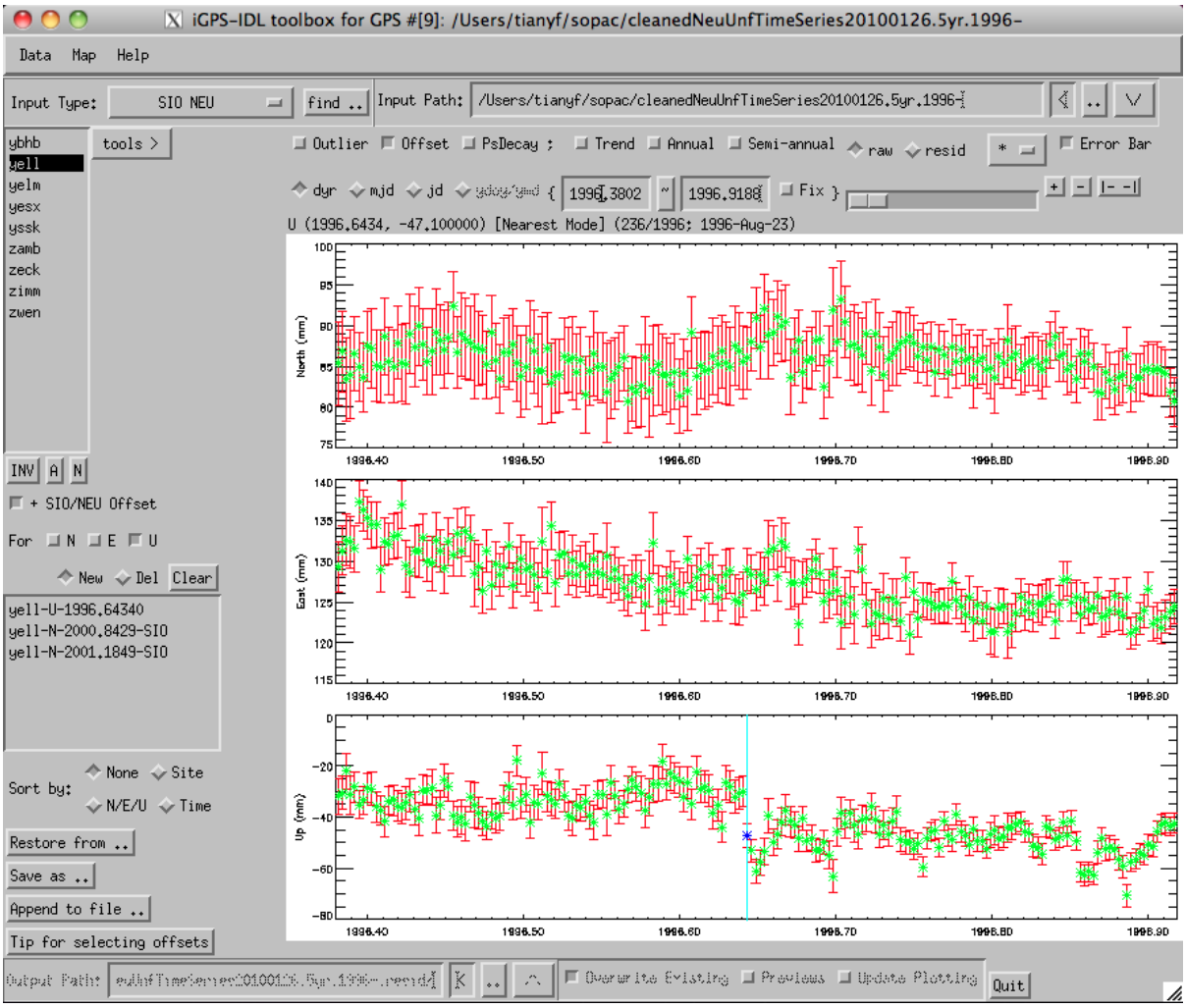


Figure 24. Define a new offset for the vertical time series of YELL.

Sometimes, you might have misplaced an offset, *e.g.*, the offset in the vertical component of YELL near September 13 1996. To delete it, select Del radio button in the offset *Parameter Panel*, move the mouse cursor to position near the data point (the focused offset line will be highlighted in *black* instead of in *blue*), and click the left mouse button to remove it.

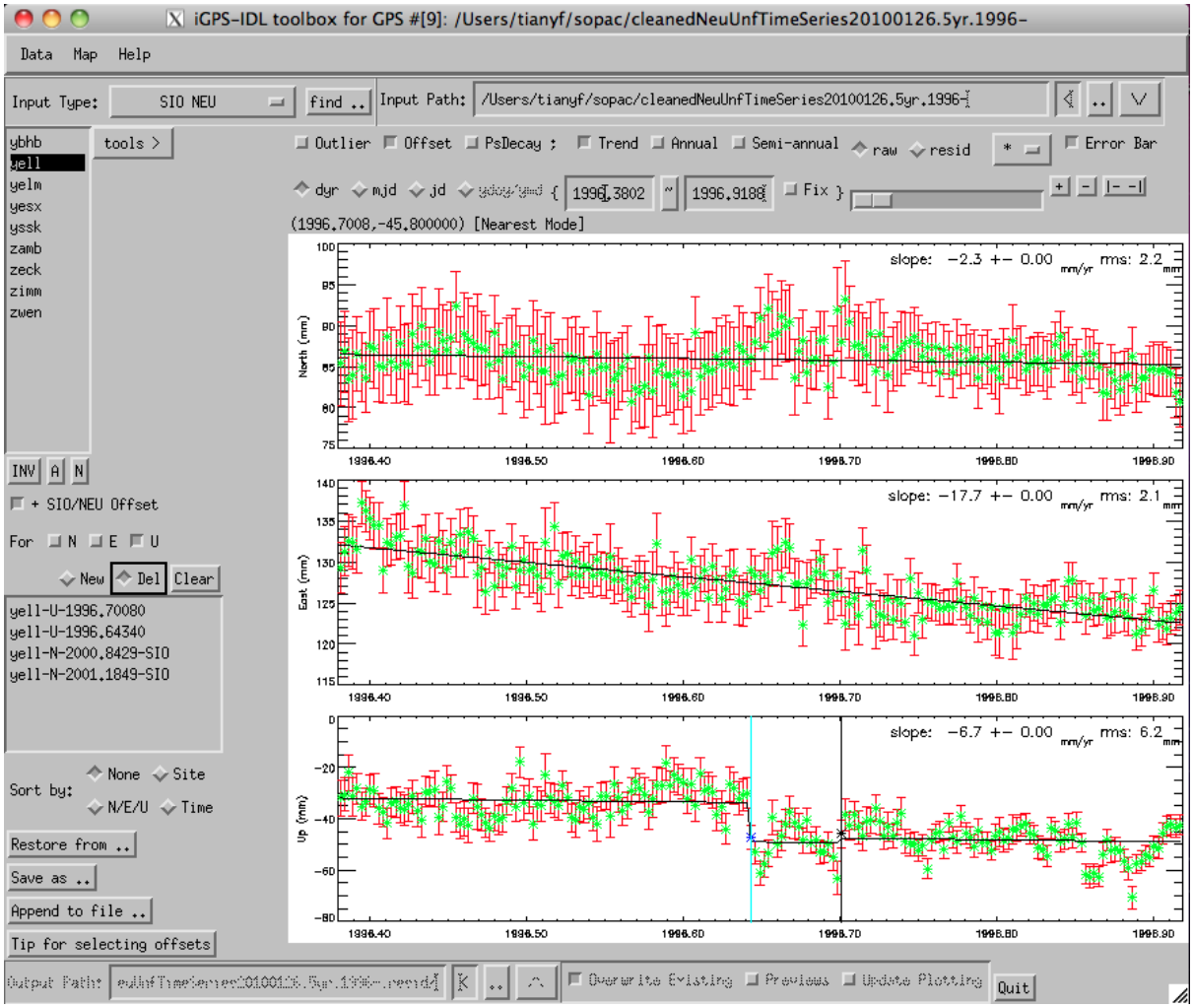


Figure 25. Delete an erroneous offset in the vertical time series of YELL near September 13 1996.

Finally, we created our offsets and psdecays list file—offps.def.

2.8 Run Model Utility Again with Manual Offsets

Similar to the modeling in section 2.6 Parameters Estimation, we run the Model utility again to estimate parameters. The only difference is that we use a new offset list file (*.def) created in the above step. Chose the above offps.def file in the Offset/Psdecay List File field, and then hit OK button to run the Model again. The resulting residual time series for YELL should look more flat.

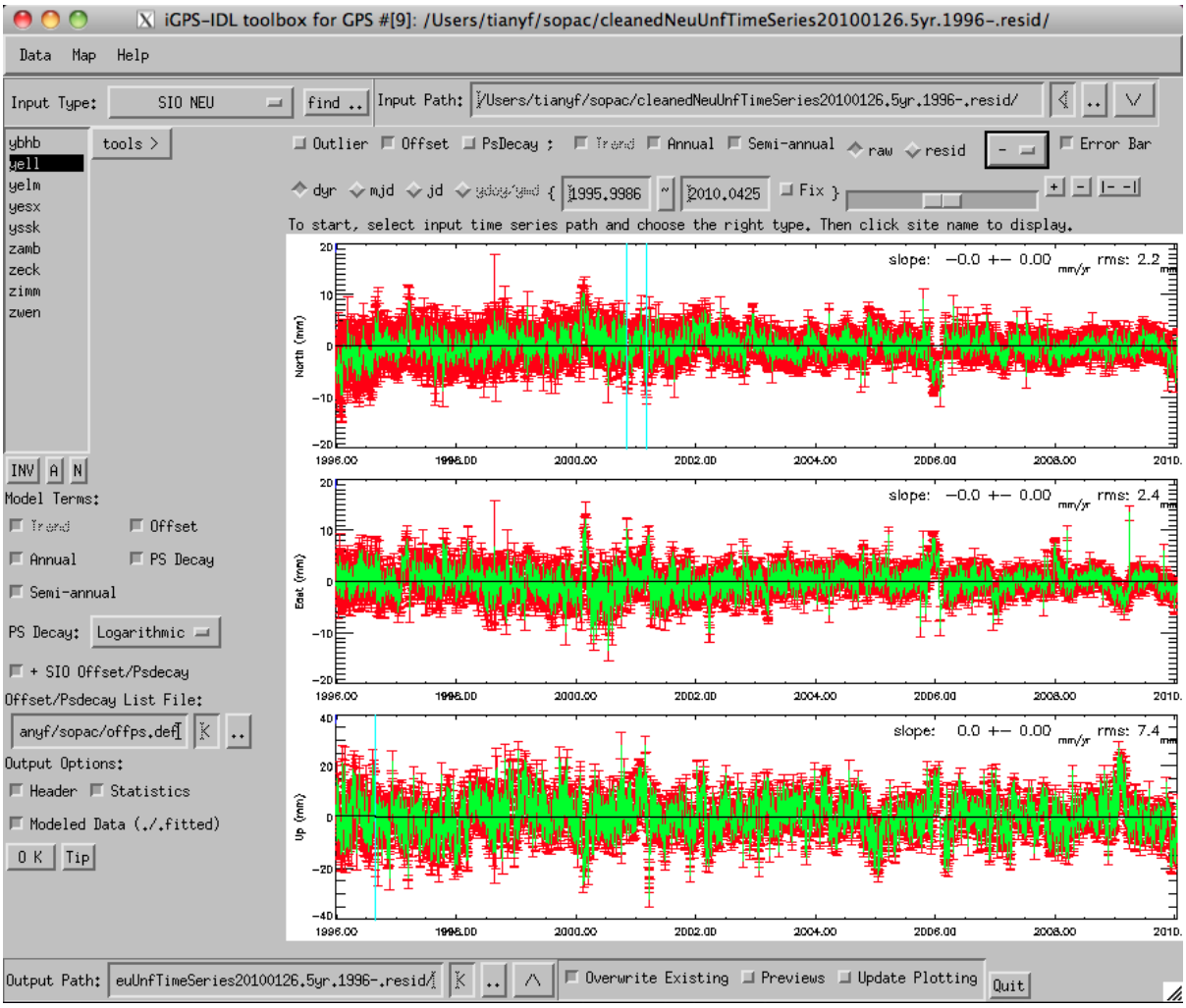


Figure 26. Residual positions time series of YELL after estimating an undetected jump in the vertical component.

The estimated parameters will appear in the resulting time series files as headers (comments).

yellCleanUnf.neu

```
#*   SRC: /Users/tianyf/sopac/cleanedNeuUnfTimeSeries20100126.5yr.1996-/yellCleanUnf.neu
#*  PROG: iGPS:MODEL+WRITE_SIO
#*RUN BY: tianyf @ tianyf.local [Darwin tianyf.local 10.2.0 Darwin Kernel Version 10.2.0:
#*RUN AT: Mac OS X x86_64
#*RUN ON: Fri May 21 00:29:02 2010 [UTC]
# N COMPONENT
#     slope 1:  -0.01131 +-    0.00000 (1995.99860-2010.04250)
#    offset 1:  -0.00561 +-    0.00000 (2000.84290)
#    offset 2:   0.00733 +-    0.00000 (2001.18490)
#      annual:   0.00026 +-    0.00000 ; phase:    3.04669
# semi-annual:   0.00052 +-    0.00000 ; phase:   -1.99407
# E COMPONENT
#     slope 1:  -0.01663 +-    0.00000 (1995.99860-2010.04250)
#    offset 1:   0.00025 +-    0.00000 (1997.06990)
#      annual:   0.00100 +-    0.00000 ; phase:    1.40228
# semi-annual:   0.00037 +-    0.00000 ; phase:   -2.54213
# U COMPONENT
#     slope 1:   0.00622 +-    0.00000 (1995.99860-2010.04250)
#    offset 1:  -0.01710 +-    0.00000 (1996.60790)
#      annual:   0.00425 +-    0.00000 ; phase:    3.02977
# semi-annual:   0.00344 +-    0.00000 ; phase:    0.24622
#<<
```

Figure 27. Sample output file header.

iGPS also provides a summary file STAT.MODEL to store seasonal terms and rate estimations for all sites in the output directory when the Statistics checkbox is selected.

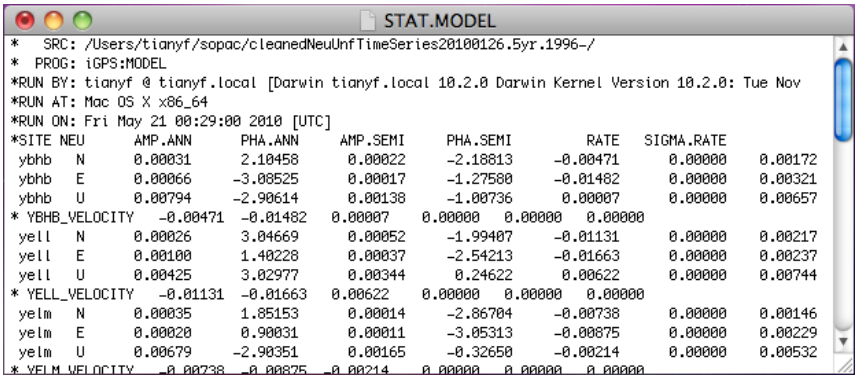


Figure 28. Sample output STAT.MODEL file by Model.

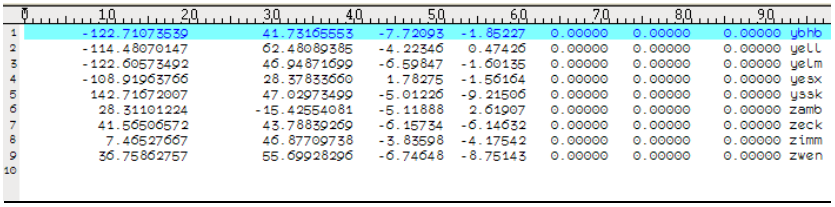
Note: *iGPS* neglects the existence of colored law noises (random walk noise, flicker noise) in estimations.

Tip

Users may use Langbein's est_noise program (ftp://ehzftp.wr.usgs.gov/langbein) or Williams' CATS software (http://www.ngs.noaa.gov/gps-toolbox/cats.htm) to carry out colored noise analysis.

2.9 Create Annual Terms Plots using GMT

First, convert the above STAT.MODEL file into file format which can be accepted by GMT. This is done using menu Data - Convert STAT.MODEL Annual Terms to GMT (psvelo). An input STAT.MODEL (created by Model utility) and an output file basename will be asked. You may specify your own a priori coordinate file (*.llhxyz) (for more information about *.llhxyz files, please refer to section 6.6 Create iGPS A Priori Coordinate File (*.llhxyz)) if your sites are not included in the default one (Cancel to use the default one).



1	-122.71073539	41.73165553	-7.72093	-1.85227	0.00000	0.00000	0.00000	ybhb
2	-114.48070147	62.48089385	-4.22346	0.47426	0.00000	0.00000	0.00000	yell
3	-122.60573492	46.94871699	-6.59847	-1.60135	0.00000	0.00000	0.00000	yelm
4	-108.91963766	28.37833660	1.78275	-1.56164	0.00000	0.00000	0.00000	yesx
5	142.71672007	47.02973499	-5.01226	-9.21506	0.00000	0.00000	0.00000	yssk
6	28.31101224	-15.42554081	-5.11888	2.61907	0.00000	0.00000	0.00000	zamb
7	41.56506572	43.78839269	-6.15734	-6.14632	0.00000	0.00000	0.00000	zeck
8	7.46527667	46.87709738	-3.83598	-4.17542	0.00000	0.00000	0.00000	zimm
9	36.75862757	55.69928296	-6.74648	-8.75143	0.00000	0.00000	0.00000	zwen
10								

Figure 29. Annual terms for input of psvelo in GMT.

Then use psvelo in GMT to create plots.

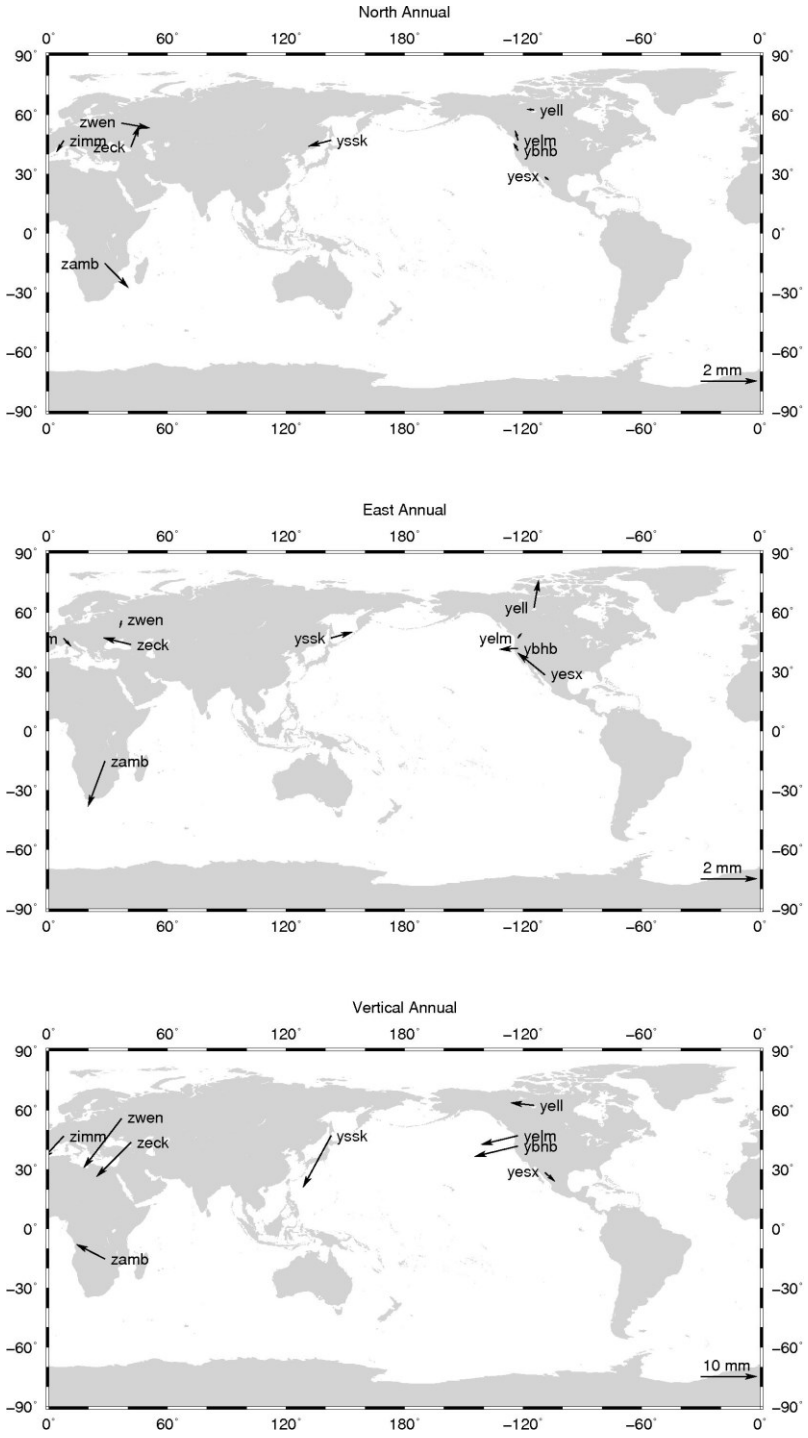


Figure 30. Annual terms plots. The arrow directions indicate phase lags in degrees which are count-clockwise from the east. For vector version of plot, please refer to the end of this tutorial.

An input file for psxy will be also created at the same time.

1	-122.71073539	41.73165553	-166.50956	0.00794	ybhb
2	-114.48070147	62.48089385	173.59303	0.00425	yell
3	-122.60573492	46.94871699	-166.35887	0.00679	yelm
4	-108.91963766	28.37833660	-41.21744	0.00237	yesx
5	142.71672007	47.02973499	-118.54268	0.01049	yssk
6	28.31101224	-15.42554081	152.90353	0.00575	zamb
7	41.56506572	43.78839269	-135.05131	0.00870	zeck
8	7.46527667	46.87709738	-132.57384	0.00567	zimm
9	36.75862757	55.69928296	-127.62864	0.01105	zwen
10					

Figure 31. Annual terms input file for psxy in GMT.

3 Task 2: Derive GPS Velocity for East Asia

In this section, we will learn how to use ***iGPS*** to derive velocities for GPS sites in East Asia.

3.1 Select Time Series for Sites in a Geographic Range

First, we need to know how many continuous GPS sites there are in East Asia. ***iGPS*** provides a utility (tools> - Selector [Geographic], Selector [Geographic]) to select sites falling within a geographic range. ***iGPS*** needs a priori coordinates file (*.llhxyz) (A Priori Coordinates field) to get the location information for each sites. (For more information on *.llhxyz file, please refer to the 6.5 Create iGPS A Priori Coordinate File (*.llhxyz) section.)

The geographic range is input as decimal degrees.

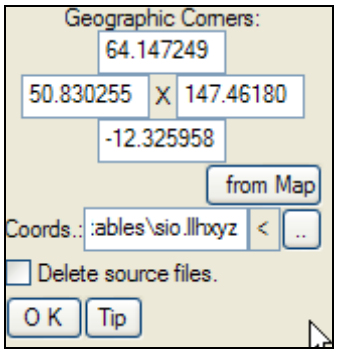


Figure 32. Parameters for selecting sites within a certain geographic rectangle.

The range values can also be obtained from a map by drawing a rectangle (in red)—click from Map button to show the map window; hit OK button in map window to quit and return choice; click Cancel or just close the map window to abort.

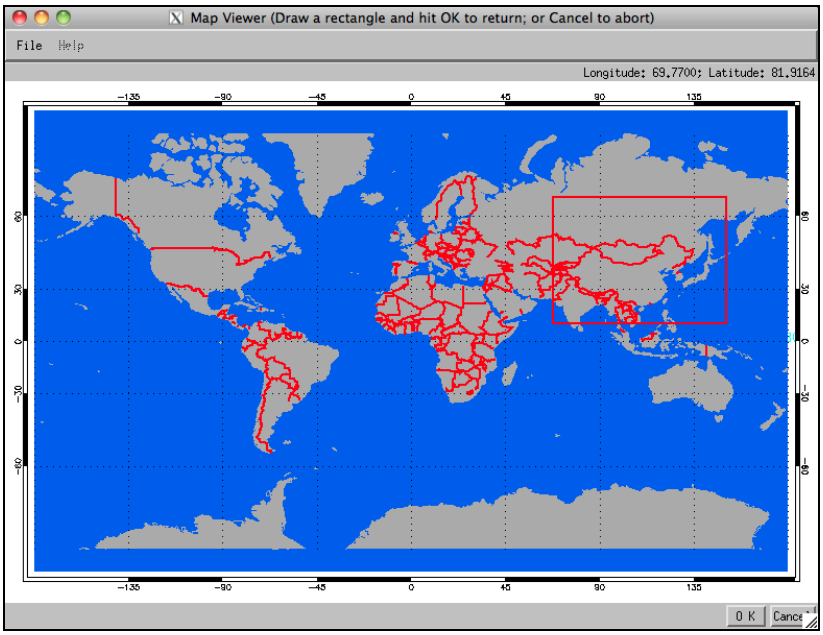


Figure 33. Set geographic corners from a map.

Then select the default a priori coordinates file (${iGPS}/tables/sio.llhxyz) in the A Priori Coordinates field. Select all sites in the site list by clicking the A button below the sites list; choose an output path; and then click OK button to start the search.

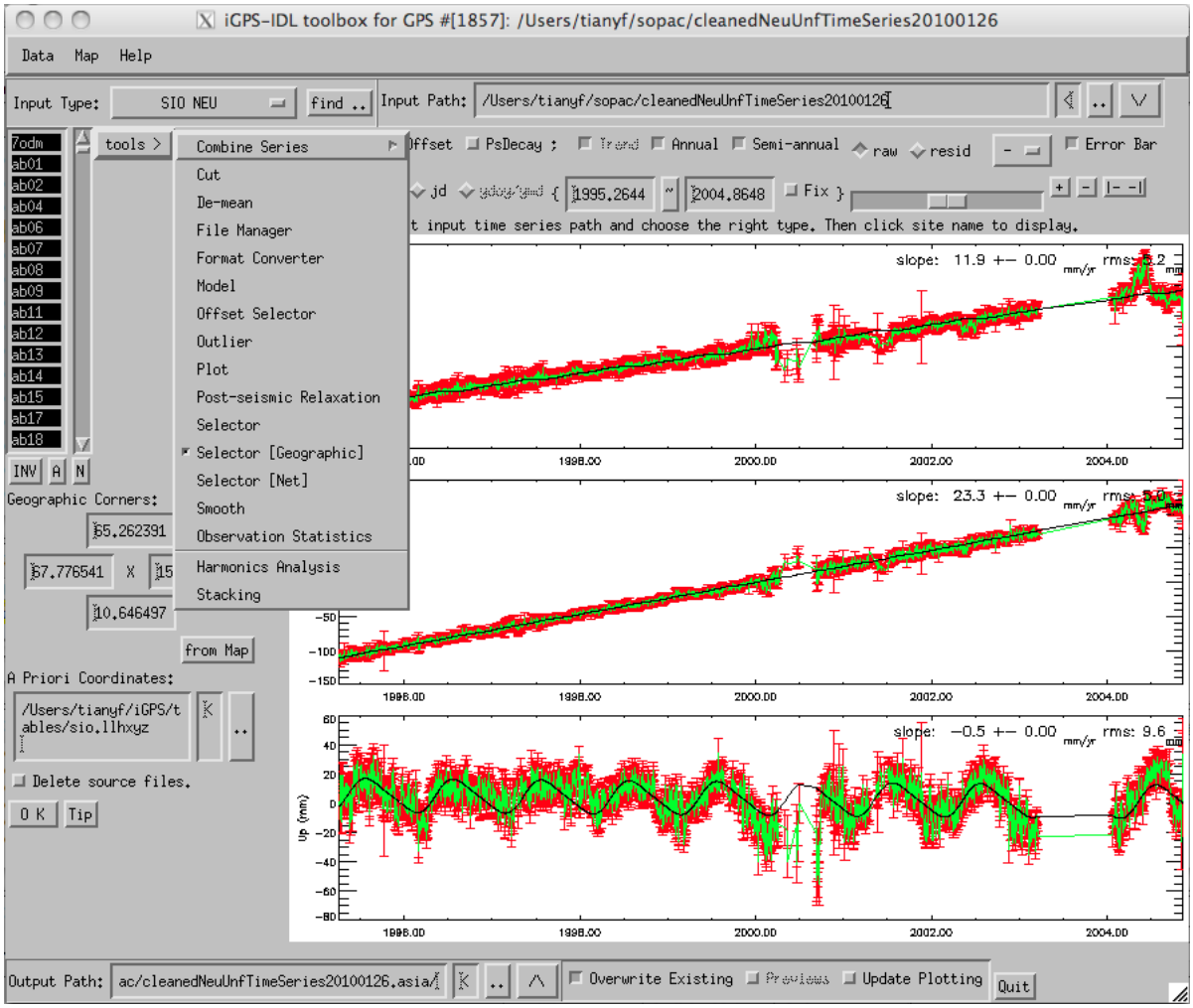
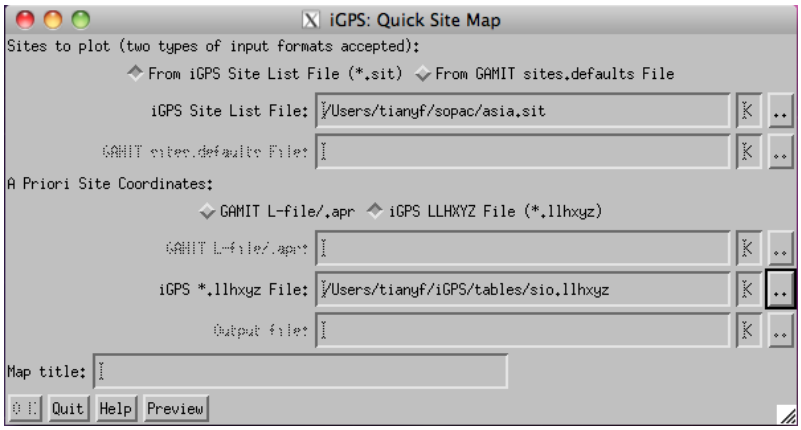


Figure 34. Select sites within East Asia.

We got 35 files by this search; and four sites were then deleted because of too few observations.

Now, let's get a quick look at the sites locations using ***iGPS*** Site Map utility (Map – Site Map menu).



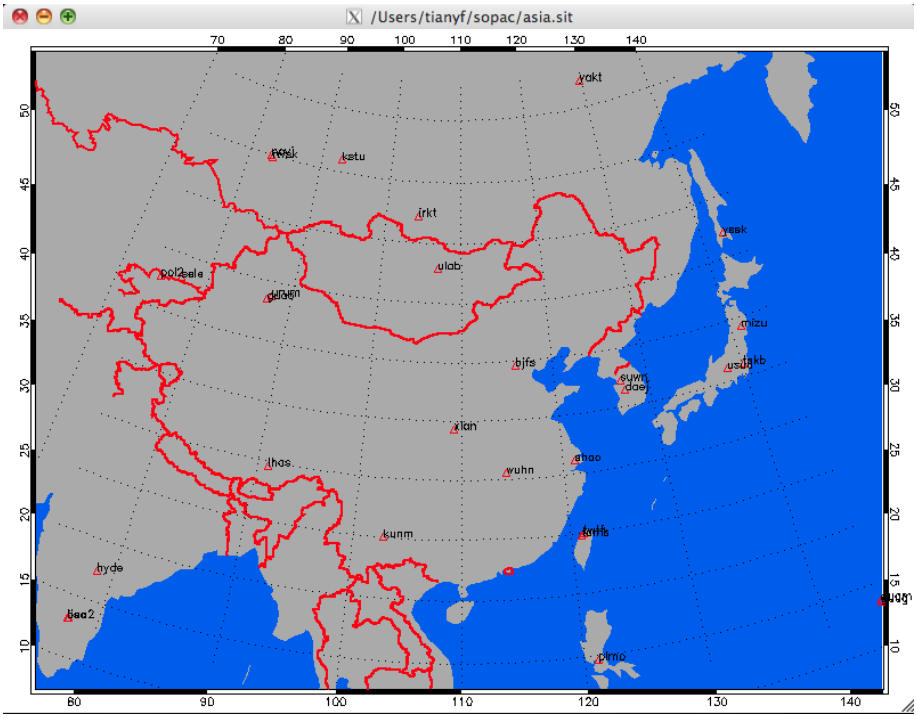


Figure 35. Site map for studying velocity in East Asia.

3.2 Find Post-seismic Relaxation Visually

The finding of post-seismic relaxation events is almost the same as selecting offsets. The post-seismic decay epoch definition *Parameter Panel* will show by choosing Post-seismic Relaxation from the *Popup Menu* button (tools>). The control parameters are near the same as that of Offset Selector, except that the adding of a new Psdecay event will also add corresponding offsets (co-seismic displacements). Moreover, the Del button is used to delete selected items in the listbox, rather than delete them in the drawing areas by using mouse.

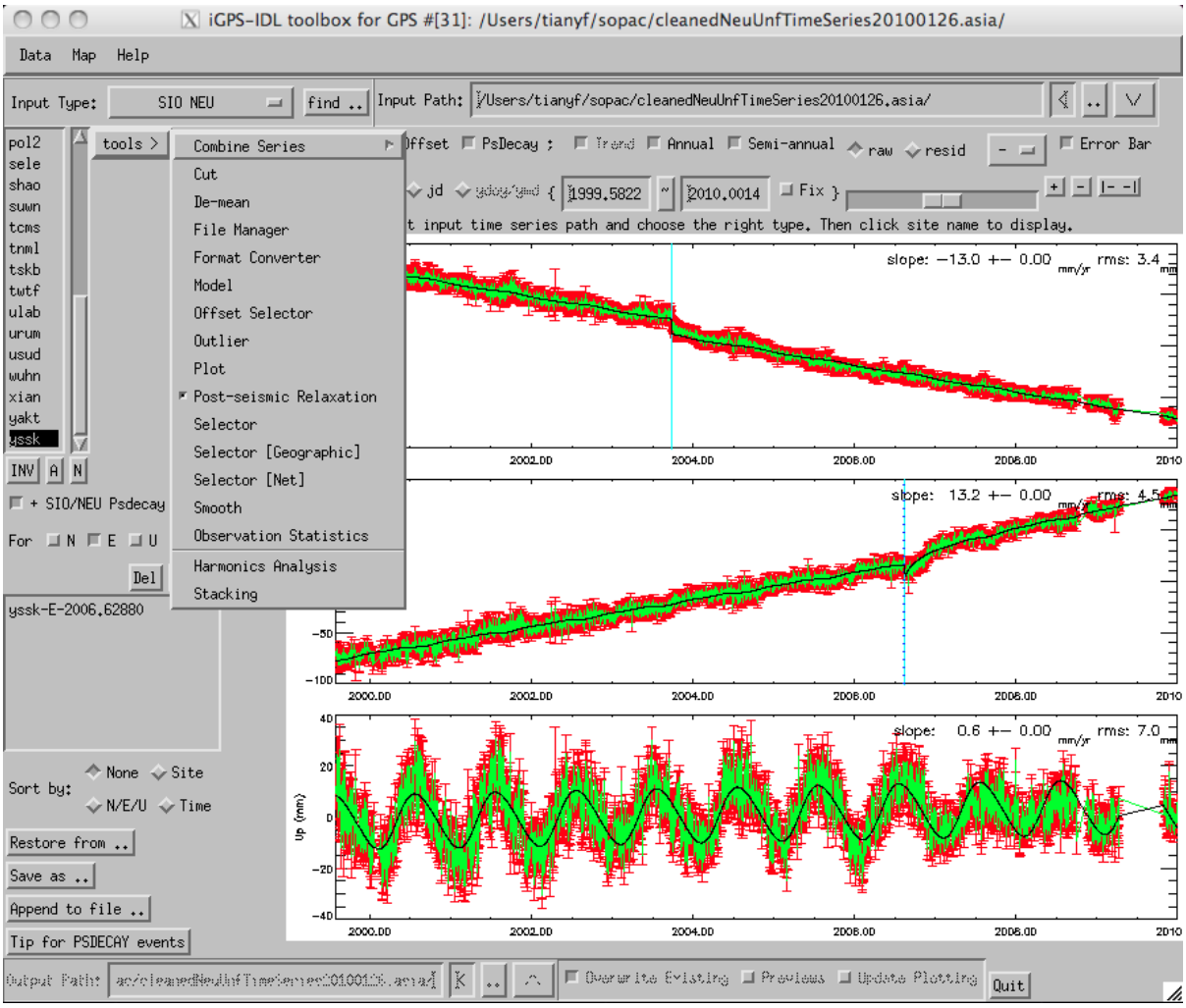


Figure 36. Find post-seismic relaxation events.

There is one psdecay-like motion in the east component of YSSK starting from 2006.6205. However, a search in Harvard Global CMT catalog didn't return any significant earthquakes in the surrounding areas during that period. Here, we assume that the non-linear motion is caused by earthquake, because a logarithmic model fits the data quite well. Turn on only the east component check box (E) , move the cursor to the east time series plot, position to the day of August 15 2006, and click the left mouse button. A psdecay will be added, together with a concurring offset.

3.3 Velocity Estimation

Then estimate the rates by running Model as described in section 2.8 Run Model Utility Again with Manual Offsets. To assess the accuracy of estimation, use ***iGPS*** to view the residual time series which should be flat in general. The estimated results are included in output file headers (as comments). A summary will also be stored in the STAT.MODEL file in the output directory as (if output option Statistics is checked):

* BJFS_VELOCITY -0.01041 0.03070 0.00205 0.00002 0.00003 0.00004

3.4 Create Velocity Plots using GMT

Use Data - Convert STAT.MODEL Terms to GMT (psvelo) to convert estimated rates to inputs of psvelo in GMT. The new rate files are ended with .VEL_HORIZONTAL_PSVELO and . VEL_VERTICAL_PSVELO.

```
0        10        20        30        40        50        60        70        80        90        100       110
1 *   SRC: E:\tmp\sopac\cleanedNeuUnfTimeSeries20100126.asia.resid\STAT.MODEL
2 *  PROG: STAT_MODEL_VEL_2_PSVELO
3 *RUN BY: tianyf @ TYF [x86 Family 6 Model 15 Stepping 2, GenuineIntel]
4 *RUN AT: Microsoft Windows x86
5 *RUN ON: Sun May 16 13:35:49 2010 [UTC]
6       115.8924851633920000      39.6086013260860030      30.7000000000000030     -10.4100000000000000      0.03
7       127.3744791839250000      36.3994287833760030      26.7700000000000000     -12.4400000000000000      0.03
8       144.8683610976299900      13.5893292915640010      -9.6799999999999997      5.2100000000000000      0.03
9        87.1773069440860030      43.4711077087720080      31.5700000000000000      5.0300000000000006      0.04
```

Figure 37. Sample output of rates files for input of psvelo of GMT (converted from STAT.MODEL).

Use grep and awk to extract data from these files and use psvelo to plot them on a GMT map.

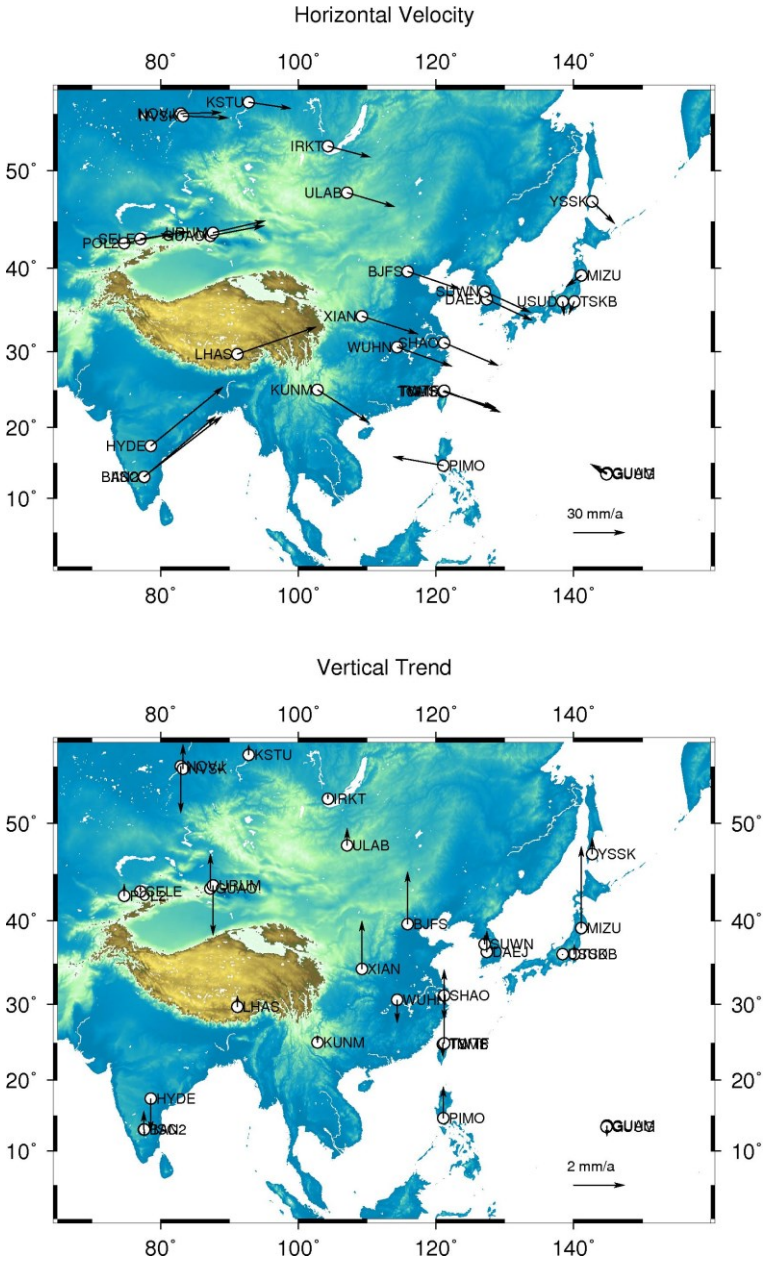


Figure 38. Horizontal and vertical rates for GPS stations in East Asia. For vector version of plot, please refer to the end of this tutorial.

4 Task 3: Analyze the Common-mode Errors

It has been confirmed that there are large common-mode errors (CME) in the global GPS positions time series. The sources of these noises are still not confirmed and cannot be eliminated at the observation level at present. Fortunately, it was found that these noises are common to GPS sites in a small area and can be removed by certain spatial filtering methods. For introduction on CME noise in continuous GPS positions time series, please refer to some published journal papers (*Wdowinski et al.*, 1997; *Dong et al.*, 2002). ***iGPS*** use the weighted regional stacking filtering method proposed in *Nikolaidis* [2002] to derive the CME correction series for a small regional GPS network. In this section, we will learn how to correct CME bias for PBO Nucleus subset GPS sites group.

4.1 Select Time Series for Sites for a Specific Network

To select files for a specific network (*e.g.*, PBO Nucleus subset), use the Selector [Net] utility. ***iGPS*** provides build-in site list files (*.sit) for several GPS networks: BJGPS (Beijing GPS Network), CMONOC (Crustal Motion Observation Network of China), PBO (Plate Boundary Observatory GPS Network), and old SCIGN (Southern California Integrated GPS Network). These can be chosen from GPS Network droplist. To use your own site list file, choose Other item from the network droplist, and select your file in the below file selector (Site List File (*.sit)).

If you want to move the file rather make a copy one, check the Delete source files checkbox in *Parameter Panel*.

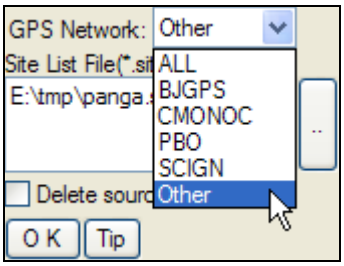


Figure 39. Parameters for site Selector [Net].

First, create a ***iGPS*** site list file (*.sit) named pbo.nucleus.of.scign.sit which contains the sites we chose.

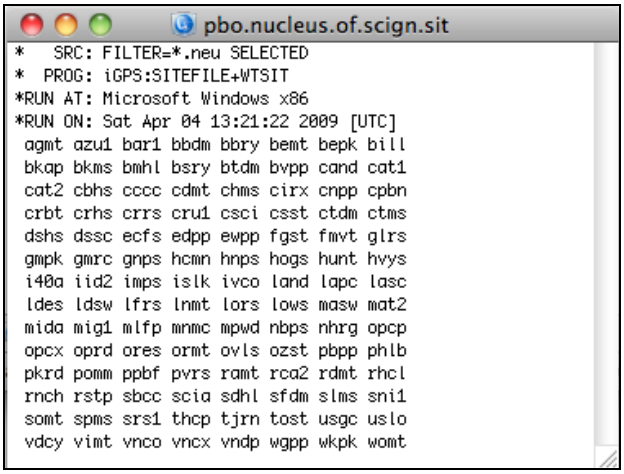


Figure 40. Input ***iGPS*** site list file (*.sit) for PBO Nucleus.

Then set GPS Network droplist to Other, and selected pbo.nucleus.of.scign.sit as the value of Site List File (*.sit) field; choose the SIO time series with more than 5-year observation history as the input data. Hit OK button to start the searching. ***iGPS*** will copy the files to the new place. In this example, we got 111 sites.

4.2 Derive Residual Time Series

After select out the sites, we can then run Model utility to get the residual time series. Here, only the *offset* and *psdecay* lists in SIO NEU time series files are used, without additional examining the series to find undetected ones. Set the Model parameters as the below figure, than press OK button to derive the residuals.

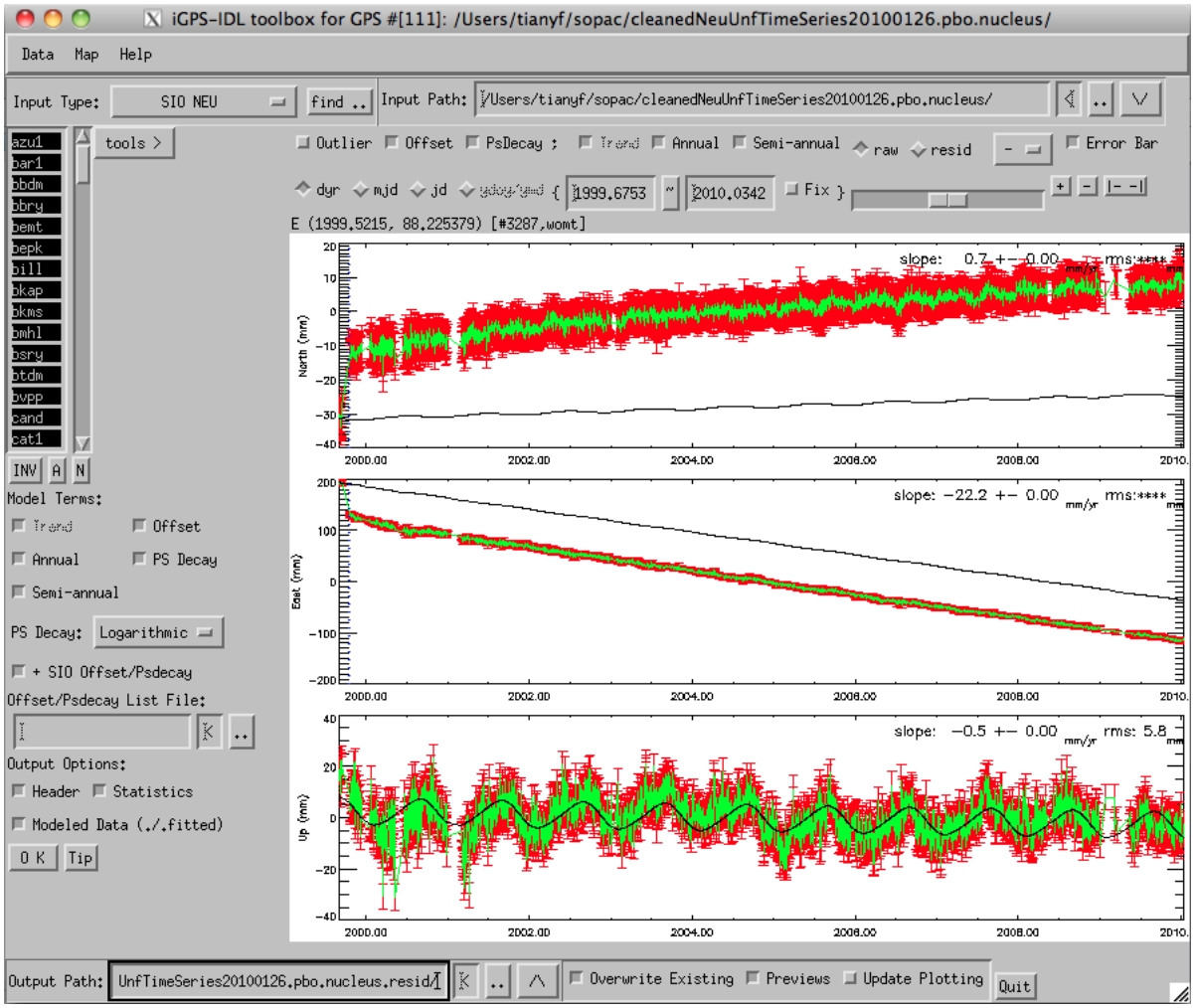


Figure 41. Parameters settings for Model estimation.

4.3 Smoothing the Residual Time Series

To get more familiar with CME, one can compare the residual positions of adjacent GPS sites. To compare the residual, it is better to smooth out the high-frequency noises. This is done by using Smooth module.

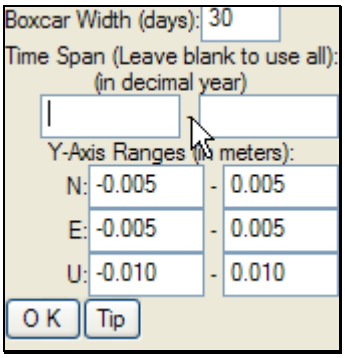


Figure 42. Parameters for smoothing time series.

The Time Span and Y-Axis Ranges fields are for plotting the time series. A JPEG file will be saved in the output path if the output option Previews in *Output Panel* is checked. One can use picture viewing software to loop through the plots and investigate the difference of time series.

4.4 Create Time Series Animation

iGPS provides a tool to create GIF animation from some JPEG files: Data - Create GIF Animation from JPEG Files.

4.5 Calculate CME from Residual Time Series

Use ***iGPS*** Stacking tool to derive CME series for PBO Nucleus network. In this test, only 10 sites are used for calculating CME: usgc, uslo, vdcy, vimt, vnco, vncx, vndp, wgpp, wkpk, and womt. Save them in an ***iGPS*** site list file (pbo.nucleus.of.scign.cme.sit), and select it in the CME Sites field of stacking *Parameter Panel*. Then choose an output file (Output CME Series). If you want to correct the time series after calculating CME, check the Output filtered time series checkbox, and choose an output path. Hit OK button to go.

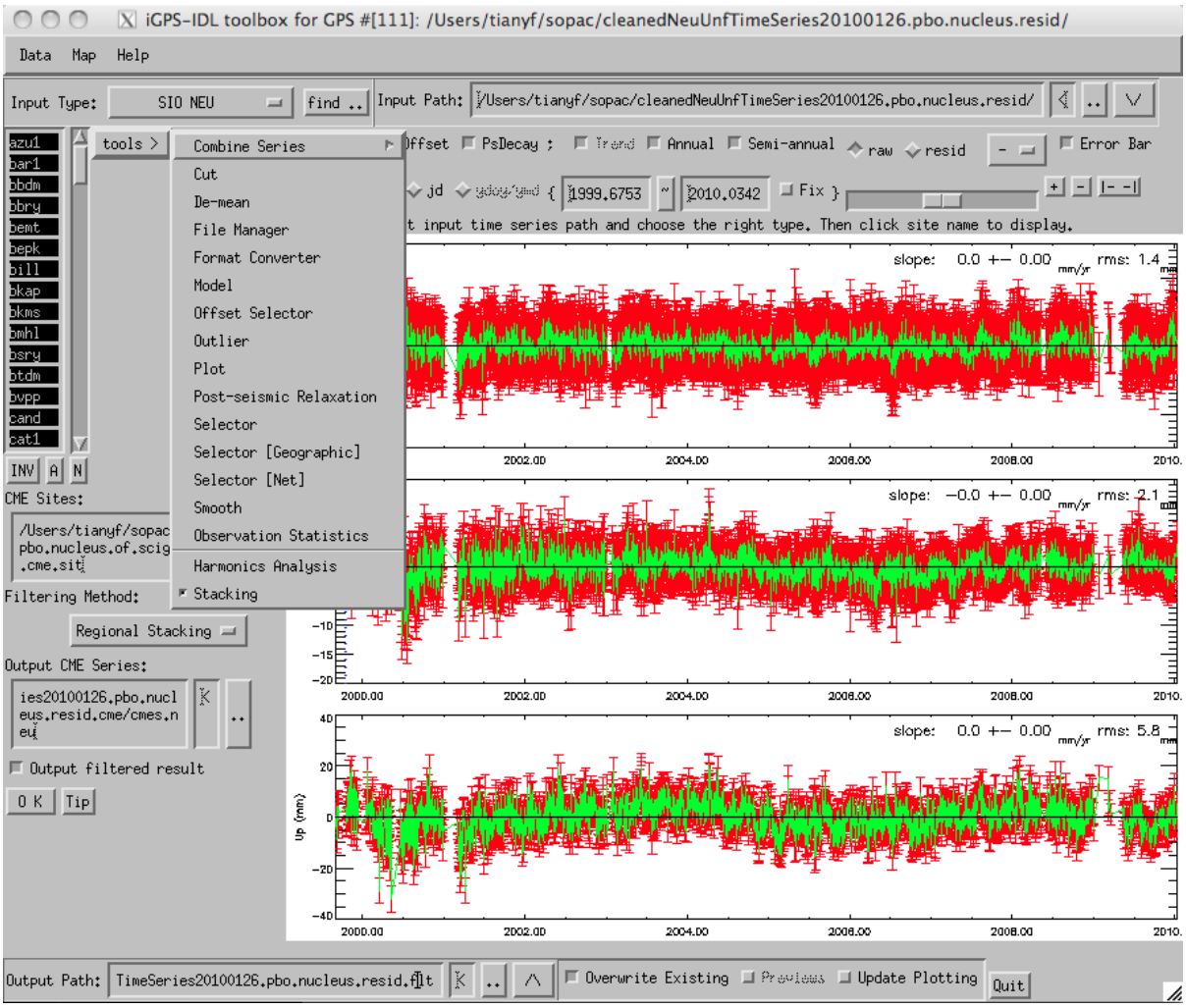


Figure 43. Parameters for calculating CME by Stacking.

4.6 Assess the Effect of CME Filtering

Smooth the filtered time series, and compare it with unfiltered ones. A large sum of high frequency variations disappeared in the filtering time series (*e.g.*, at BILL).

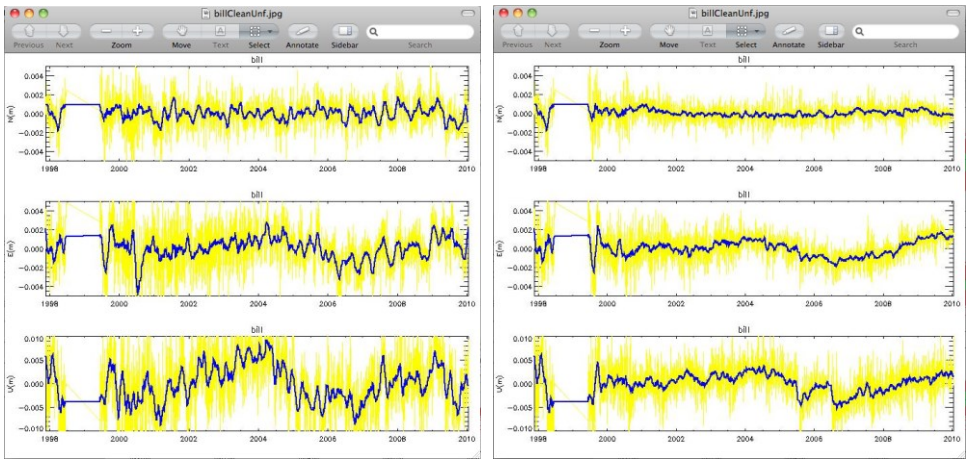


Figure 44. Time series for BILL: before (left) and after (right) CME corrections.

5 Task 4: Extract Common-mode Signals from a Dense cGPS Network

5.1 Introduction

With more and more continuous GNSS station observing the movement of the Earth's crust, it is now impossible to search for the transient signals visually by examining the whole time series dataset. With the help of spatial filtering methods, we can now identify the existence of regional transients in an automated way. The main algorithm of the spatial filtering method can be found in Tian and Shen [2015, manuscript]. Different from the regional stacking [e.g. Nikolaidis, 2002] and PCA [Dong et al., 2006] methods, the new spatial filtering utilizes the inter-station correlation and a grid-search scheme when calculating the common-mode component (CMC), and hierarchical clustering to display the level of similarity of cGPS positions.

5.2 Prepare the Time Series

The derivation of CMC of position time series is usually based upon the residual position time series in which an initial position, linear rates, annual and semiannual terms, jumps, and post-seismic relaxation are removed. However, it depends on the goal of your analysis.

The iGPS tutorial contains an example for the co-seismic displacements caused by 25 April 2015 Mw 7.8 Nepal earthquake. The position time series can be found in ${iGPS_HOME}/example/eq.nepal20150425.

The raw data were collected by TO (Tectonic Observatory) of Caltech and other agencies, and are available at UNAVCO website (http://www.unavco.org/data/gps-gnss/data-access-methods/dai2/app/dai2.html). More information about data can be found at UNAVCO event response coordination web page for 2015.04.25-M7.8 Gorkha, Nepal Earthquake (http://www.unavco.org/voce/viewforum.php?f=59).

The daily observation data were processed with GAMIT/GLOBK V10.5 software. The final positions are in ITRF2008 reference frame. The demeaned time series for TO and nearby IGS cGPS stations can be found in pos.neu directory, which covers the time span from one month before the event (26 March 2015) to half a month after the event (11 May 2015). Since the time span is too short, the linear trend and seasonal variations are not removed before perform the following spatial filtering. There are outliers on 1 May 2015 for the reason of missing global H-files, which can be removed using the Outlier utility.

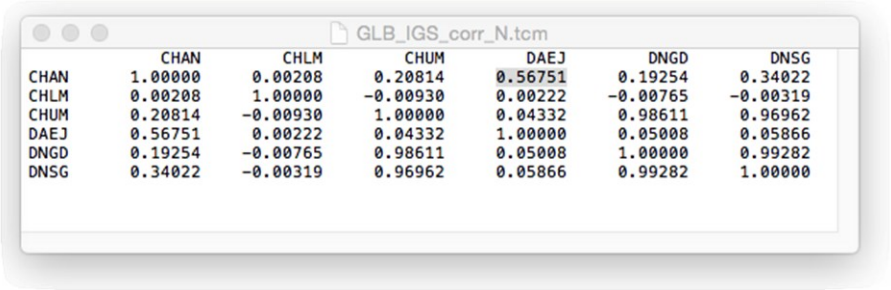
5.3 Calculate Inter-station Correlation

The first step of extract CMC is calculating the inter-station correlations, which is done using the "Inter-station Correlation" tool. First, select "`/Users/tianyf/iGPS/example/eq.nepal20150425/pos.neu/`" in the Input Path field and 37 sites will show in the sites list. Click the "A" button below the site list to select all sites. Choose the "`/Users/tianyf/iGPS/example/eq.nepal20150425/lfile.nepl.net`" as the a priori coordinate file. Modify the correlation type or identifiers when necessary. Finally, select an output path, e.g. `/Users/tianyf/iGPS/example/eq.nepal20150425/pos.neu.corr/` in the "Output Path" field. Now, click the "OK" button to calculate correlations.

iGPS will generate five output files for inter-station correlations:

- Two distance files (one in angular degrees and on in km);
- Three correlation matrix files (one for each of the three components);
- One summary file containing a priori coordinates and all the above information (similar to the SINEX format).

To perform correlation analysis for a subset of the network, select the site names in the site list (hold down the SHIFT or CTRL key when selecting multiple sites). For example, if use the first 6 sites, the correlation matrix for the north component is shown in Figure 45.


GLB_IGS_corr_N.tcm

	CHAN	CHLM	CHUM	DAEJ	DNGD	DNSG
CHAN	1.00000	0.00208	0.20814	0.56751	0.19254	0.34022
CHLM	0.00208	1.00000	-0.00930	0.00222	-0.00765	-0.00319
CHUM	0.20814	-0.00930	1.00000	0.04332	0.98611	0.96962
DAEJ	0.56751	0.00222	0.04332	1.00000	0.05008	0.05866
DNGD	0.19254	-0.00765	0.98611	0.05008	1.00000	0.99282
DNSG	0.34022	-0.00319	0.96962	0.05866	0.99282	1.00000

Figure 45. Inter-station correlation matrix.

5.4 Calculate CMC

Choose the "Extract CMC (CWSF)" utility from the "tools" pull-down menu to invoke the CMC parameter panel. Select sites, the a priori coordinate file, correlation type, network identifier, and agency identifier. Leave the number of minimum stations used to computer CMC ("#Minimum CMC Sites:") as the default value (5). Set the "Out Distances" to be zero (0). Choose an output directory, e.g. `/Users/tianyf/iGPS/example/eq.nepal20150425/pos.neu.cmc/`. Now click the "OK" button to start calculating CMC and perform filtering.

iGPS will generate several output directories:

- corr directory which contains the inter-station correlation coefficient matrix;
- cmc directory which contains CMC time series for each station;
- flt directory which contains the filtered position time series.

iGPS will create plot previews (in JPEG format) for the CMC and filtered position time series (stored in *.smoothed directories).

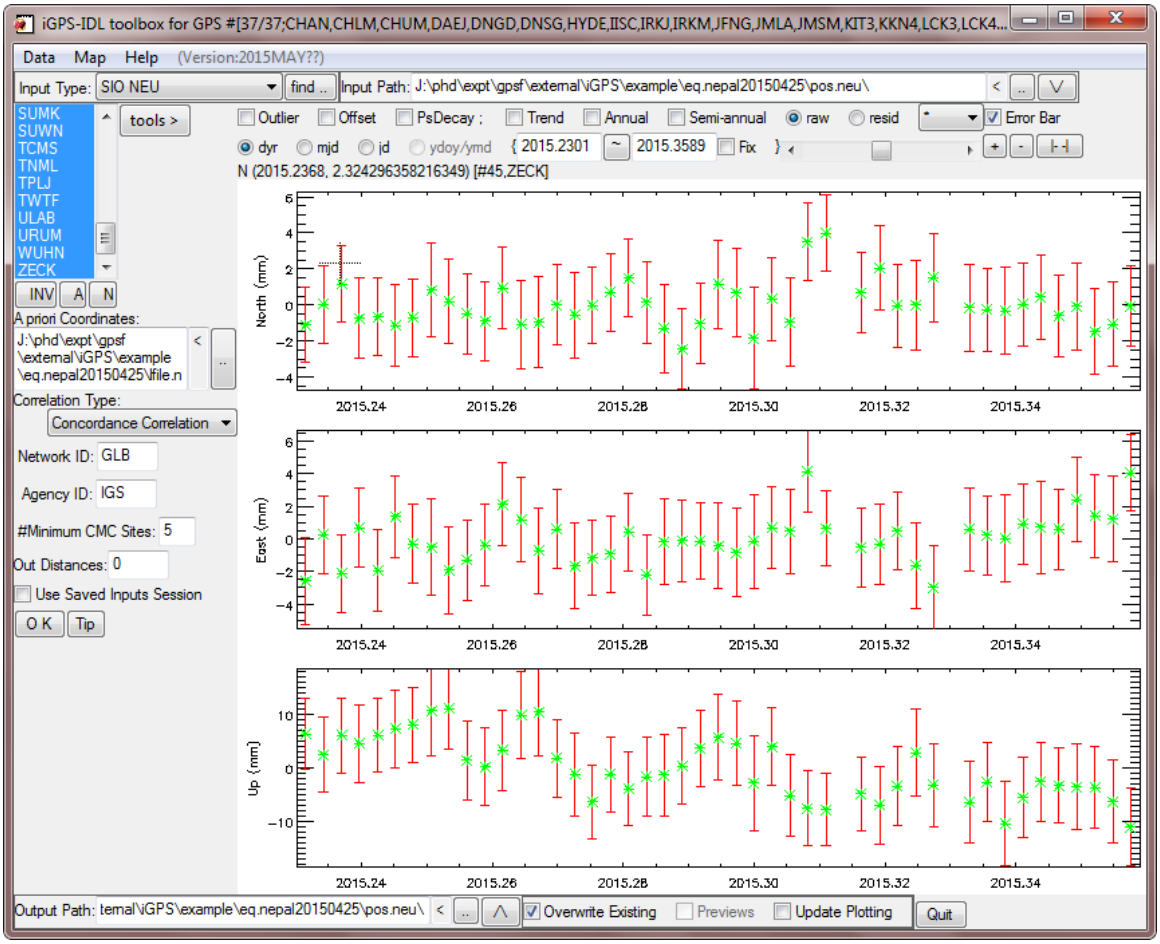


Figure 46. Parameters for extracting CMC.

6 Task 5: Processing Time Series from GLOBK

6.1 Demean the Time Series

The raw NEU time series from GLOBK (*.org) files are need to de-meaned, because we are only concerned about the rates and other relative motions in time series. Thus, it is more visually clear when the positions are centered around zero.

To subtract mean value from time series, use the tools> - De-mean menu in ***iGPS***. Choose the sites which you want to operate on, select an output path, and then click OK button to run.

6.2 Remove Outliers

The outliers in time series can be removed using the Outlier utility in ***iGPS***.

Outliers will be overplotted in blue if the 

button is checked.

To find outliers, we adopted three standards:

a). Formal errors greater than 10, 10, and 20 mm for north, east and vertical components, respectively;

b). Residual deviates from the mean by more than 3 times the RMS (Root Mean Square);

c). IQR standard [*Nikolaidis*, 2002].

The resulting cleaned time series will be saved in Output Path directory. So, attention must be paid when the outputting option Overwrite Existing is checked.

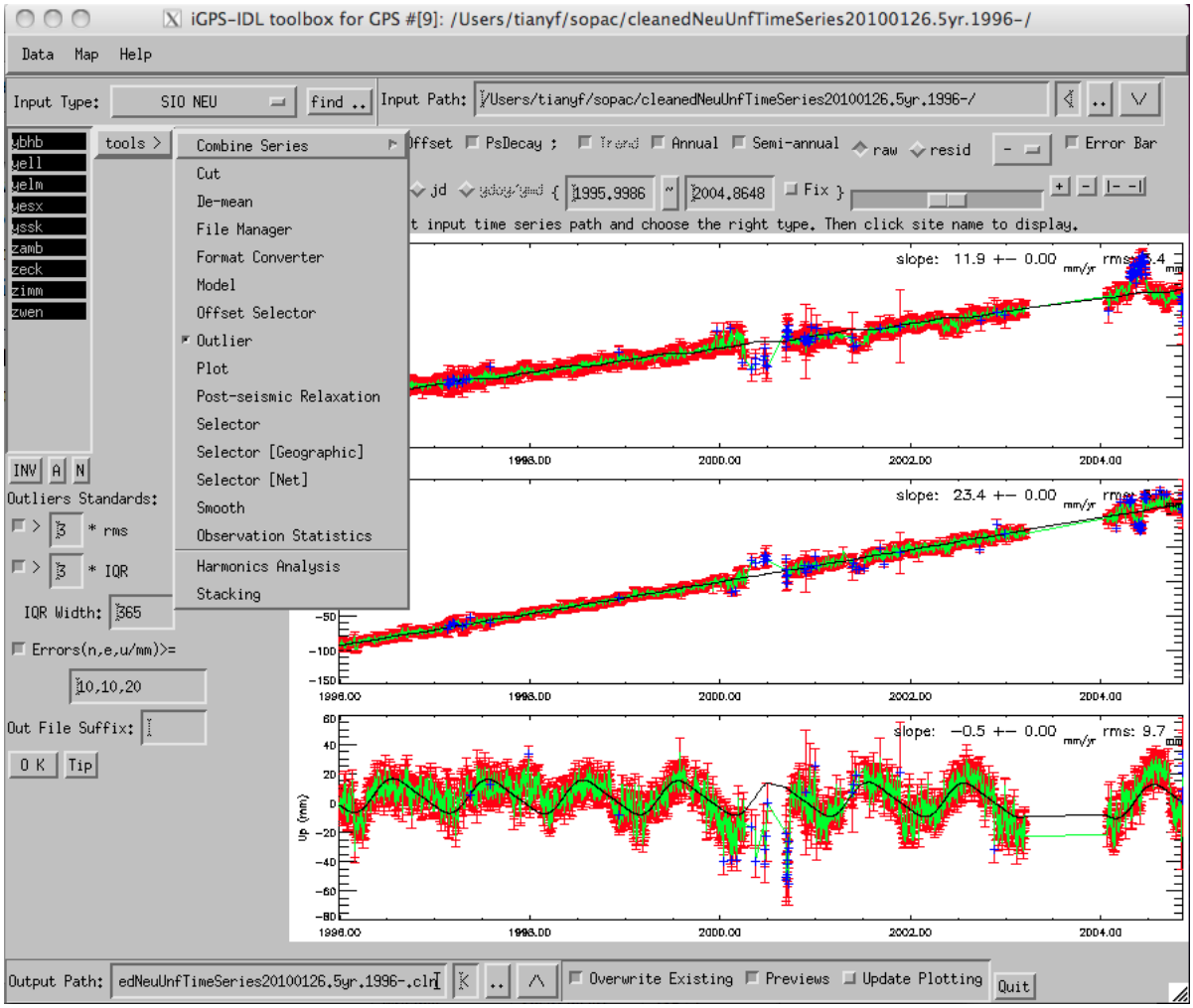


Figure 47. Detect outliers in time series.

6.3 Get Statistics of Available Epochs for Time Series

Do you want to know how many days of data are available for your GPS sites? ***iGPS*** can create the following statistics from time series files.

```
[tianyf@gpsac ~]$ cat /home/tianyf/sopac/site101.spa | awk '{print substr($0,1,7
0)}'
   50082
SITE |
-----|----------------------------------------------------------------------
     1111111111111111111111111111111111111111111111111111111111111111111111
     9999999999999999999999999999999999999999999999999999999999999999999999
     9999999999999999999999999999999999999999999999999999999999999999999999
     5666666666666666666666666666666666666666666666666666666666666666666666
     ----------------------------------------------------------------------
     3000000000000000000000000000000000000000000000000000000000000000000000
     6000000000111111111122222222223333333334444444445555555556666666
     5123456789012345678901234567890123456789012345678901234567890123456789012345678901234
-----|----------------------------------------------------------------------
ybhb
yell **********************************************************************
yelm
yesx
yssk
zamb
zeck
zimm * ****************************************** ********************
zwen ***** *********** ******************************   **** ********
[tianyf@gpsac ~]$
```

Figure 48. Sample output of epochs statistics.

This is done by clicking the OK: site 1 0 1 … button in Observation Statistics utility.

The OK: site dyrs dyre nepoch button will return the starting and ending time, number of days for sites.

```
[tianyf@gpsac ~]$ cat /home/tianyf/sopac/site-span.spa
ybhb        1996.8210        2010.0452        4611
yell        1995.9986        2010.0425        5041
yelm        2003.7164        2010.0452        1518
yesx        2004.4549        2009.8068        1197
yssk        1999.5822        2010.0014        3442
zamb        2002.4233        2008.4057        1674
zeck        1997.5274        2010.0452        3871
zimm        1995.9986        2010.0397        4974
zwen        1995.9986        2004.8648        2529
[tianyf@gpsac ~]$
```

Figure 49. Sample output of time span statistics.

7 *iGPS* Utilities

7.1 Plot Time Series

Select Plot from *Popup Menu* (tools>), a parameter panel will appear.

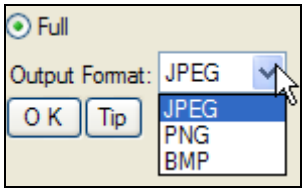


Figure 50. Parameters for plotting time series.

The default output image format is JPEG. ***iGPS*** can also create output files in BMP or PNG formats.

Select an output directory and click O K button in the *Parameter Panel* section. ***iGPS*** will create a time series plot for each site selected in *Site Panel*.

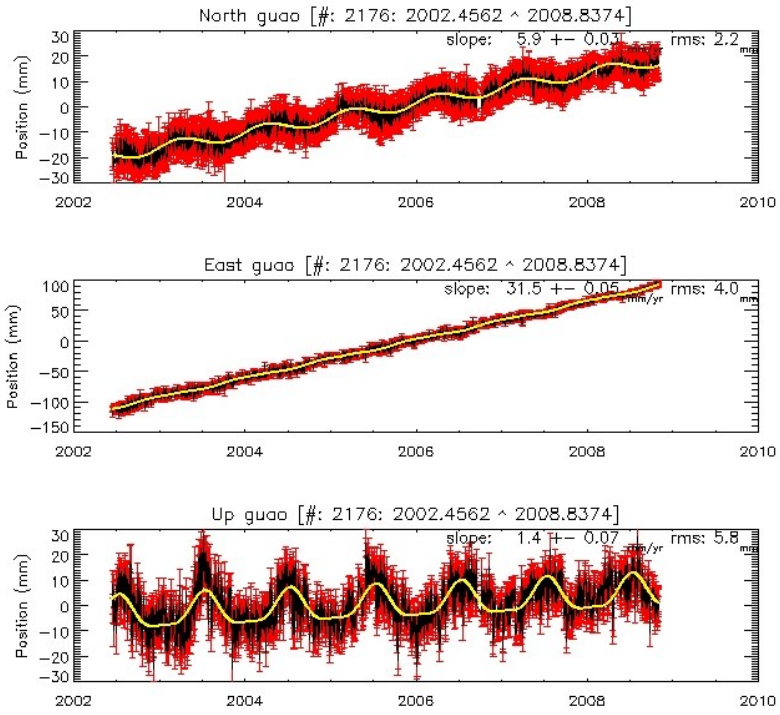


Figure 51. Sample of time series plot.

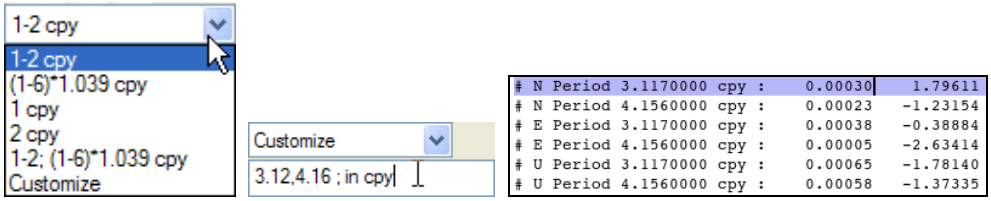
7.2 Harmonics Analysis

iGPS provides a tool (Harmonics Analysis)to analyze the anomalous periodicities of the fundamental frequency about 1.039 *cpy* (*cycles per year*) [*Ray et al.*, 2008].

iGPS already has several pre-defined periodicities (in *cpy*).

You can also customize your own combination in the below textfield: each periodicity is separated by a comma; the content after the semicolon is comment.

The estimated parameters will be saved in the output files as comment: the first field is amplitudes in meters; the second one is phase in radians.



(a) Predeifned periodocities (b) Customize periodocities (c) Sample output headers

Figure 52. Parameters for Harmonic Analysis utility.

7.3 Coordinates Converter (WGS84 vs. XYZ)

iGPS provides a tool to convert coordinates between WGS84 and XYZ (ECEF) systems: Data - WGS 1984 <-> XYZ [ECEF] menu item. The WGS84 coordinates can be input in decimal degrees (DD) or in degree-minute-second (DMS) formats.

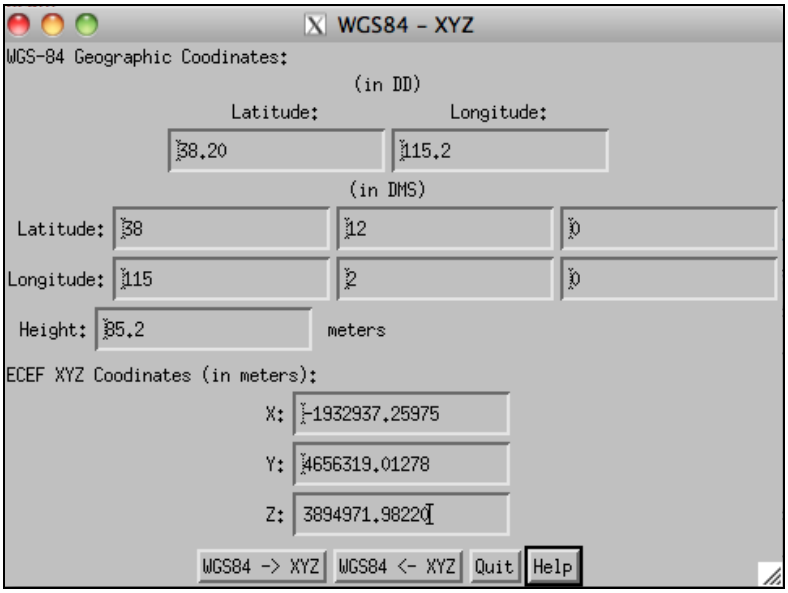


Figure 53. Coordinates converter.

Note: no warranty of the conversion accuracy. Use this program at your own risk.

7.4 Create *iGPS* Site List File (*.sit)

iGPS uses a site list file (*.sit) to store sites names.

Several rules about ***iGPS*** site list file (*.sit):

a). Lines starting with non-blank characters are comments;

b). Unique four-character site name separated by at least one blank (space; NOT tab);

c). The file is case-insensitive.

To create a site list file for currently selected sites in *Site Panel*, choose menu Data –Sites List File - Save Selected Sites as iGPS Sites List File (*.sit), and then specify an output file and save it.

7.5 Create Input Site List File for QOCA

iGPS can create two types of QOCA site list file (*.list): one contains only site names, and another with geographic coordinates.

```
[tianyf@gpsac templates]$ cat /usr/local/qoca/templates/rm_sit.list
  4                    ! for strc89
KINO_GPS
PENA_GPS
BDLA_GPS
SFBC_GPS
```

Figure 54. QOCA site list file without geographic information.

gps.sites.pbo.pbo.list

```
  211
AB07_GPS 55.3492765098 199.5232430085 89.57287
AB37_GPS 62.9673230754 214.5481232731 1136.57684
AB50_GPS 58.4167757993 225.4546996217 51.50713
AB51_GPS 56.7976234438 227.0864399534 75.81564
AC15_GPS 60.4813330382 210.2759940457 151.41586
AC20_GPS 60.9292078155 210.6474973066 43.65113
AC27_GPS 59.2525075232 205.8371196179 417.48307
AC38_GPS 57.7536854746 206.6581284547 43.78849
AC59_GPS 59.5671985890 206.4147997239 308.55755
AC62_GPS 63.0836067456 213.6873053713 1347.10236
AC63_GPS 63.5024266368 214.1527550819 815.02969
```

Figure 55. QOCA site list file for mload program.

To create the first type site list file, use Data - Sites List File - Create QOCA Sites List File (*.list); to create the latter, use Data - Sites List File - Create QOCA Sites List File [+LLH]. For the latter, an input a priori coordinate file (iGPS LLHXYZ file; *.llhxyz) will be need.

One can also combine/subtract QOCA site list files using Combine QOCA Sites List Files and Minus QOCA Sites List Files [+LLH] menu items under Data - Sites List File.

7.6 Create *iGPS* A Priori Coordinate File (*.llhxyz)

iGPS uses a priori coordinate file (*.llhxyz) to store the approximate positions of sites. This information is used to plot site map, coarse positioning; but not for millimeter-level positioning and crustal deformation studies.

sio.llhxyz

```
*SOURCE: E:\data\garner.ucsd.edu\pub\timeseries\sio.llhxyz
*CREATED BY: CREATE_LLHXYZ_FROM_SIONUE
*RUN BY: tianyf
*RUN AT: Microsoft Windows x86
*RUN ON: Sun Jun 22 03:13:37 2008 [UTC]
 7odm    -117.093193194321     34.116407160246     762.079685452394     -2407750.97328     -4706536.66375     3557571.42108
 ab01    -174.204756375065     52.209504611022      25.464633463882     -3896562.93546      -395471.62381     5017141.80791
 ab02    -168.854670310157     52.970605496857     192.788910199888     -3776808.15266      -744083.82658     5068728.08664
 ab06    -163.423453870975     54.885322595630     500.414482121356     -3524499.51409     -1049128.16762     5194460.02747
 ab07    -160.476757063319     55.349276332364      89.572362215258     -3425750.05056     -1214685.92161     5223662.81435
 ab09    -168.062125135162     65.614981418284     162.087747732177     -2583614.63632      -546236.96724     5786501.79050
 ab11    -165.373458492841     64.564496316246     349.457131477073     -2658010.28328      -693674.80883     5737338.57455
 ab12    -161.746261468301     58.950795308691     587.111196093261     -3132127.64070     -1033047.40076     5441614.18301
 ab13    -158.503793914474     56.307326201778     487.822750187479     -3299991.51688     -1299648.81559     5283907.02947
 ab14    -159.091531310436     59.108166382534     657.643635686487     -3066909.46184     -1171658.28095     5450696.65331
 ab15    -159.878361267076     61.039752892705     560.337324324064     -2907528.09768     -1065249.49127     5557979.06734
 ab18    -162.613507251283     66.858363553763      37.140613511205     -2398929.03765      -751157.75824     5842257.77153
```

Figure 56. Sample a priori site coordinates file (*.llhxyz) used by ***iGPS***.

Some rules for a ***iGPS*** a priori coordinate file (*.llhxyz):

a). Lines begin with a non-blank character are comments;

b). The fields in each line are 4-character site name, longitude, latitude, X, Y, and Z values, respectively;

c). The LLHXYZ file is case insensitive.

To create ***iGPS*** a priori coordinate file, use menu items Create LLHXYZ from SIO NEU, Create LLHXYZ from PBO/POS, Create LLHXYZ from APR (ITRF/lfile.) under Data - iGPS A Priori Coordnate File (*.llhxyz) menu to extract information from existing data sources.

7.7 Show GPS Sites in Google Earth

Use the menu item Data - Sites List File - Create Sites File in KML (Google Earth) to create a site KML

file for display site positions in Google Earth. An input a priori coordinate file (iGPS *.llhxyz file) will be need.

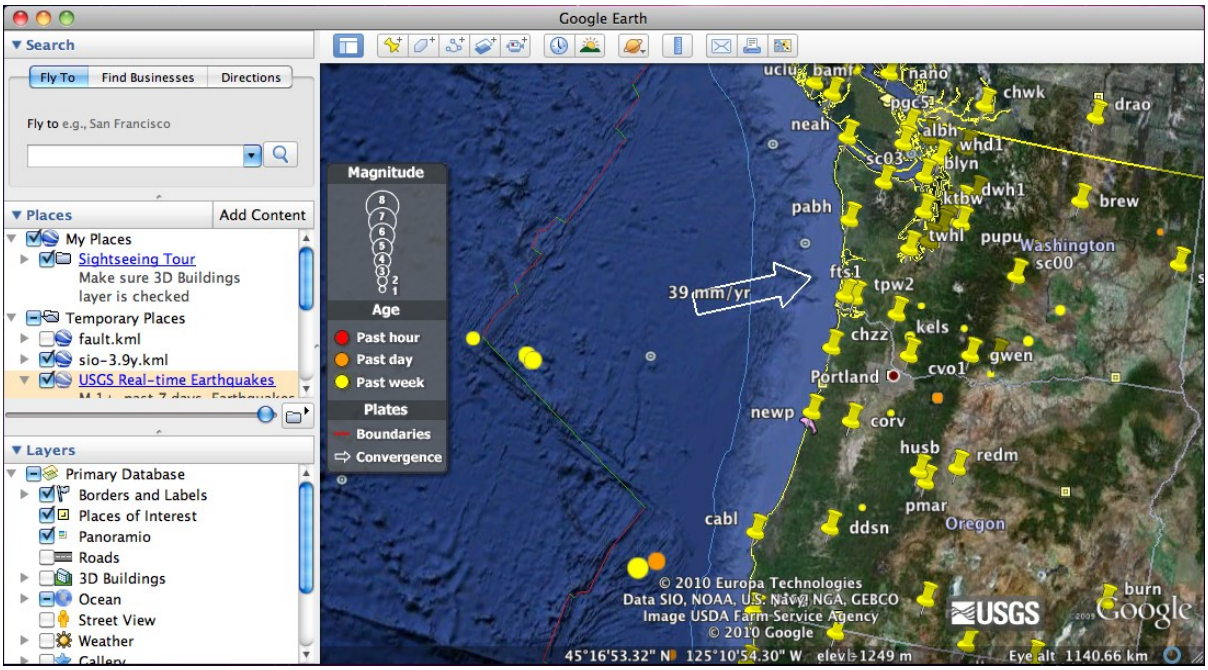


Figure 57. Display site locations in Google Earth

Note: The positioning accuracy depends upon the precision of input a priori coordinate file and Google Earth.

7.8 Download Public GPS Time Series

Under Data - Download Time Series menu, ***iGPS*** presents links for downloading time series from the internet. A click on this menu item will open the URL in web browser.

- Go to SOPAC Time Series (FTP): SIO time series product;
  http://garner.ucsd.edu/pub/timeseries/
  ftp://garner.ucsd.edu/pub/timeseries/
- Go to PBO Time Series (FTP): PBO time series;
  ftp://data-out.unavco.org/pub/products/position/
- Go to JPL Time Series (FTP/MBH): JPL time series (outdated).
  ftp://sideshow.jpl.nasa.gov/pub/mbh/

7.9 Create Paths in Linux *iGPS*

The pick file dialog in unix-like systems may do not have the function of making a new directory which is usually created on the fly in Microsoft Windows version of ***iGPS*** to store output files. ***iGPS*** provides a way to create a new path without doing it in a terminal (*e.g.*, xterm) or a file manager (*e.g.*, konqueror in KDE): Data - Make Directory [for Linux/Unix users]. If the parent directory does not exist, ***iGPS*** will create it as well.

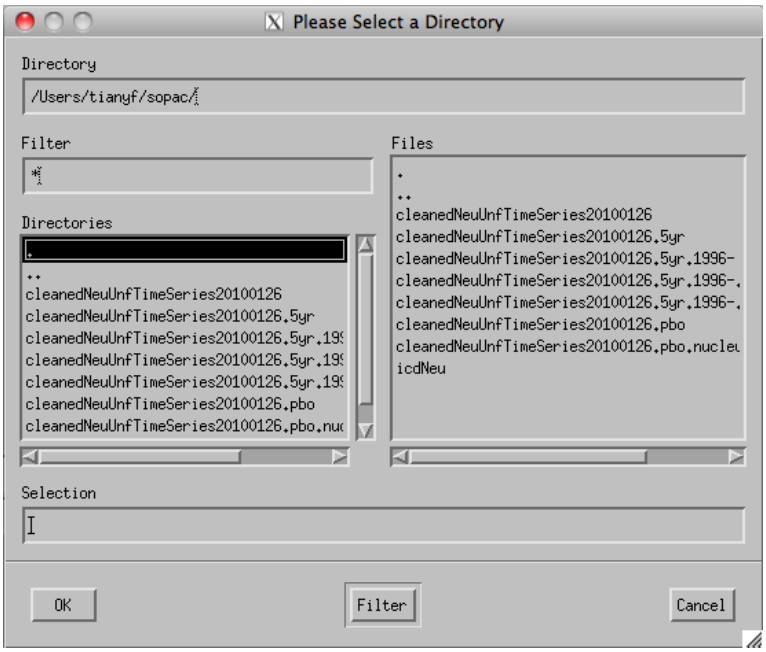


Figure 58. There is no creating new directory option in file selection dialog in Linux/Unix/Mac IDL.

7.10 Invoke Terminal in *iGPS*

Sometimes one needs to invoke the Windows Command Prompt (cmd.exe) or Linux Terminal (xterm) to do some things. The terminals can be invoked by the Data - System Console (cmd.exe/xterm) menu item. The keyboard shortcut is CTRL+K.

7.11 Create Input Site Map File for GMT (psxy/pstext)

iGPS can create a input file for plotting site map in GMT (using psxy/pstext command): Map - Prepare Site Map Files for GMT (psxy). A priori coordinate file (*.llhxyz) may be needed if the sites are not included in ***iGPS*** default file ${IGPS_ROOT}/tables/sio.llhxyz.

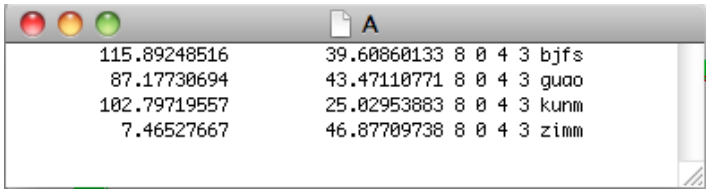


Figure 59. Site map information for pstext in GMT.

Use psxy/pstext in GMT to plot the sites map.

7.12 Create a Quick Preview of Site Locations

Want to get a quick view of sites location? Try ***iGPS*** map tool: Map – Site Map menu.

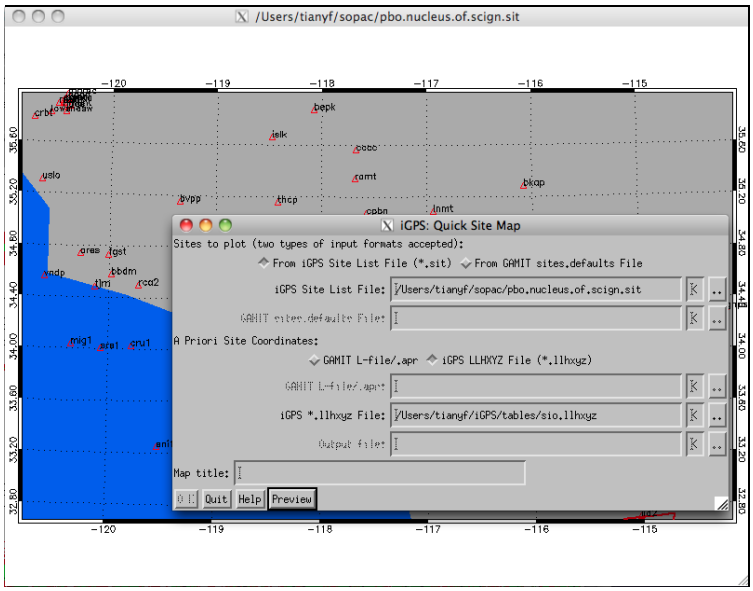


Figure 60. Get a quick look of sites locations by using Site Map utility.

The Site Map utility needs two input files:

- Site list file: either from an ***iGPS*** site list file (*.sit), or a GAMIT sites.default file;
- A priori coordinate file: either from a GAMIT L-file, or an ***iGPS*** a priori coordinate file (*.llhxyz).

7.13 Convert Shapefile Fault Line File to GMT

Map - Polylines: Shapefile -> GMT psxy (Polylines: Shapefile -> GMT psxy): convert GIS vector files in Shapefile to GMT `psxy` input format.

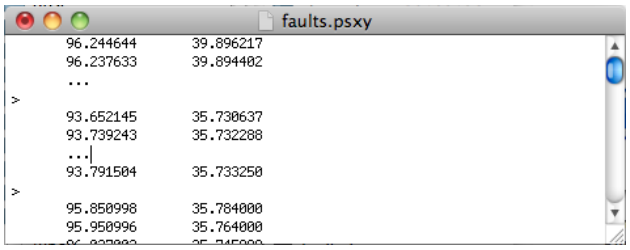


Figure 61. Sample output of fault lines for `psxy` in GMT.

7.14 Convert Shapefile Fault Line File to Google Earth (KML)

Map - Polylines: Shapefile -> Google Earth (KML) (Polylines: Shapefile -> Google Earth (KML)): a tool to convert GIS vector files in Shapefile format to Google Earth KML format.

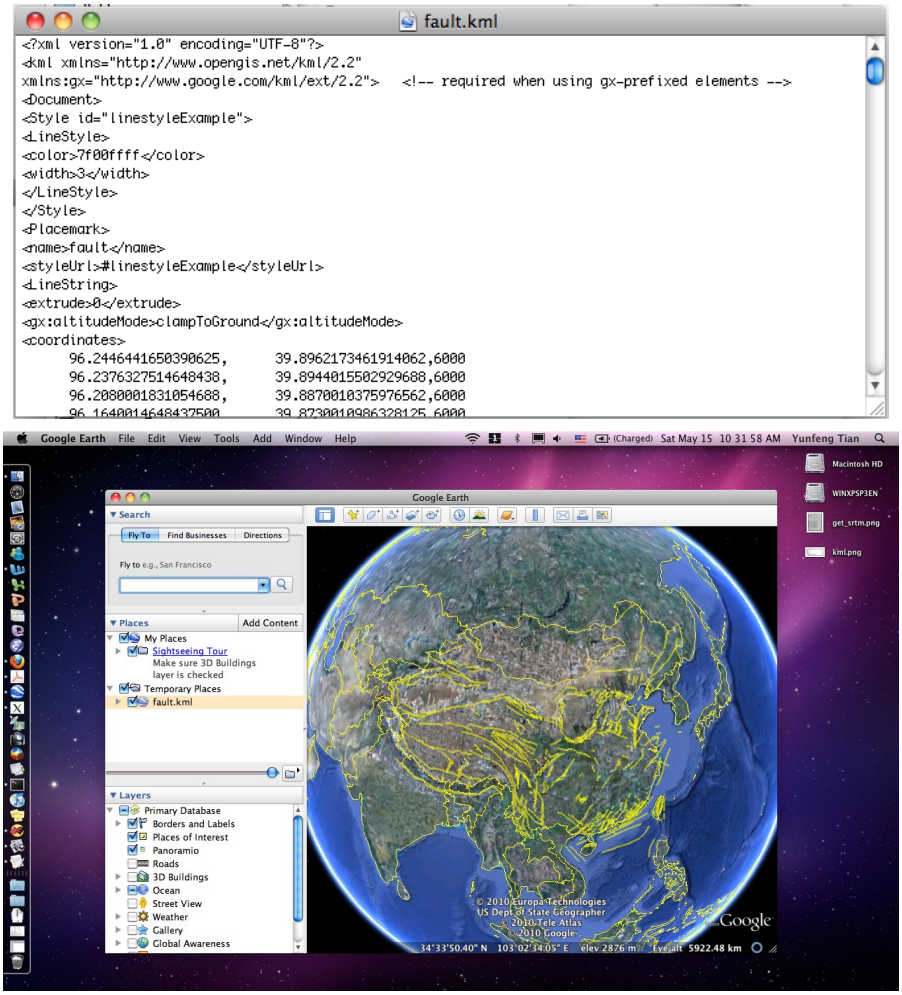


Figure 62. Converted KML file (top) and view fault lines in Google Earth (bottom).

7.15 Download SRTM DEM Data

iGPS provides a tool to download SRTM DEM data from remote FTP server. Please click the menu item Map - Download SRTM [-> GMT .grd] (Download SRTM [-> GMT .grd]) to active it. The utility is only available in Linux with ncftp (FTP client) package installed. ***iGPS*** does not start the downloading process itself, because we encourage users to run the shell script manually for more verbose messages.

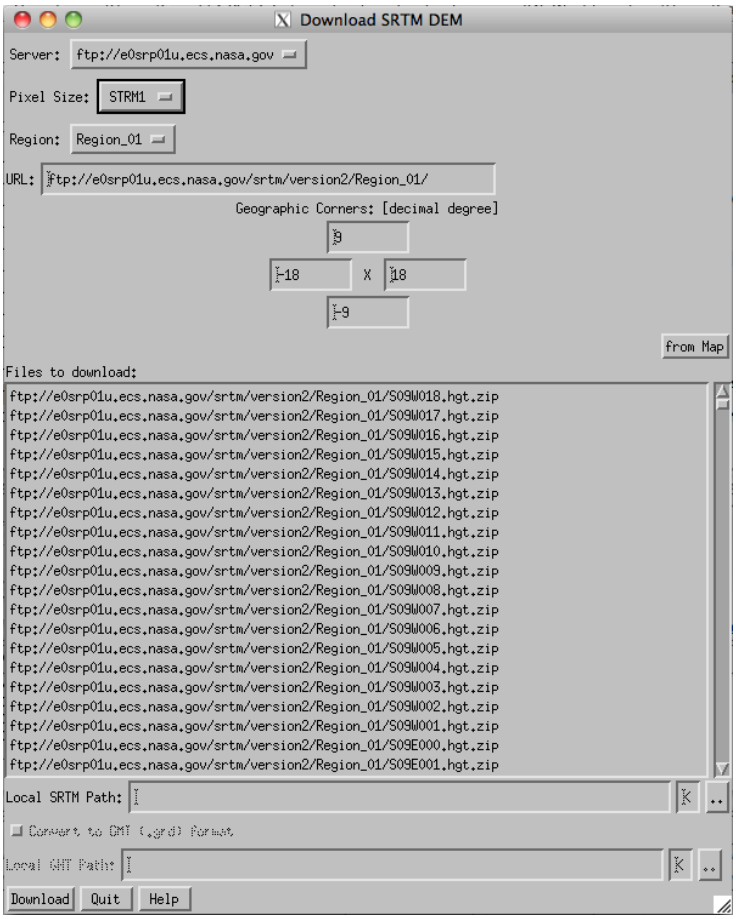


Figure 63. Download SRTM data.

7.16 Get PDF Help

A PDF version of tutorial (this one) is available for ***iGPS*** as ${iGPS_ROOT}/doc/iGPS_tutorial.pdf. To open it, click the menu Help – Online Help.

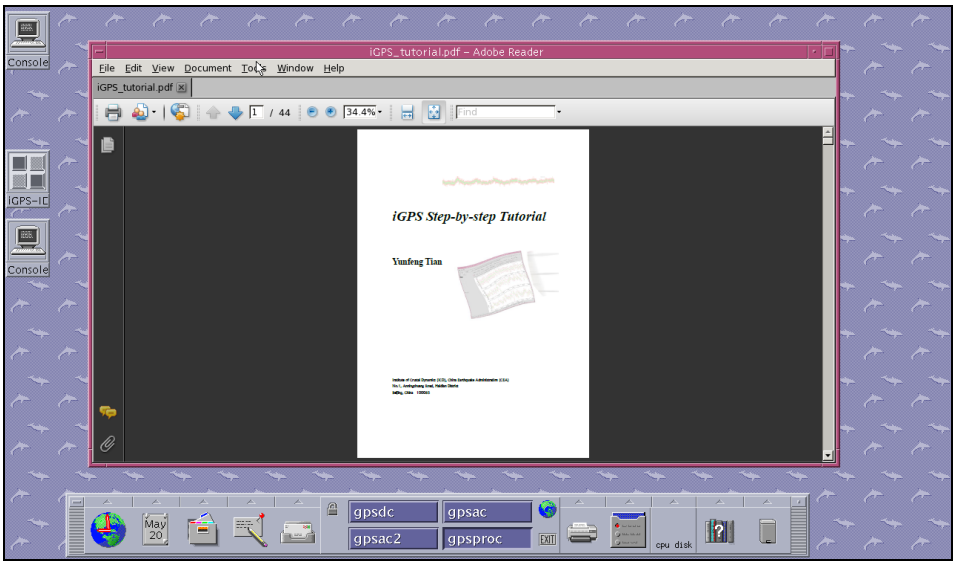


Figure 64. View ***iGPS*** tutorial (PDF) with Adobe Reader.

8 Edit *iGPS* Source Code

iGPS is provided as a bundle of IDL source code files, which enables users to modify the codes to meet their own needs or add new features.

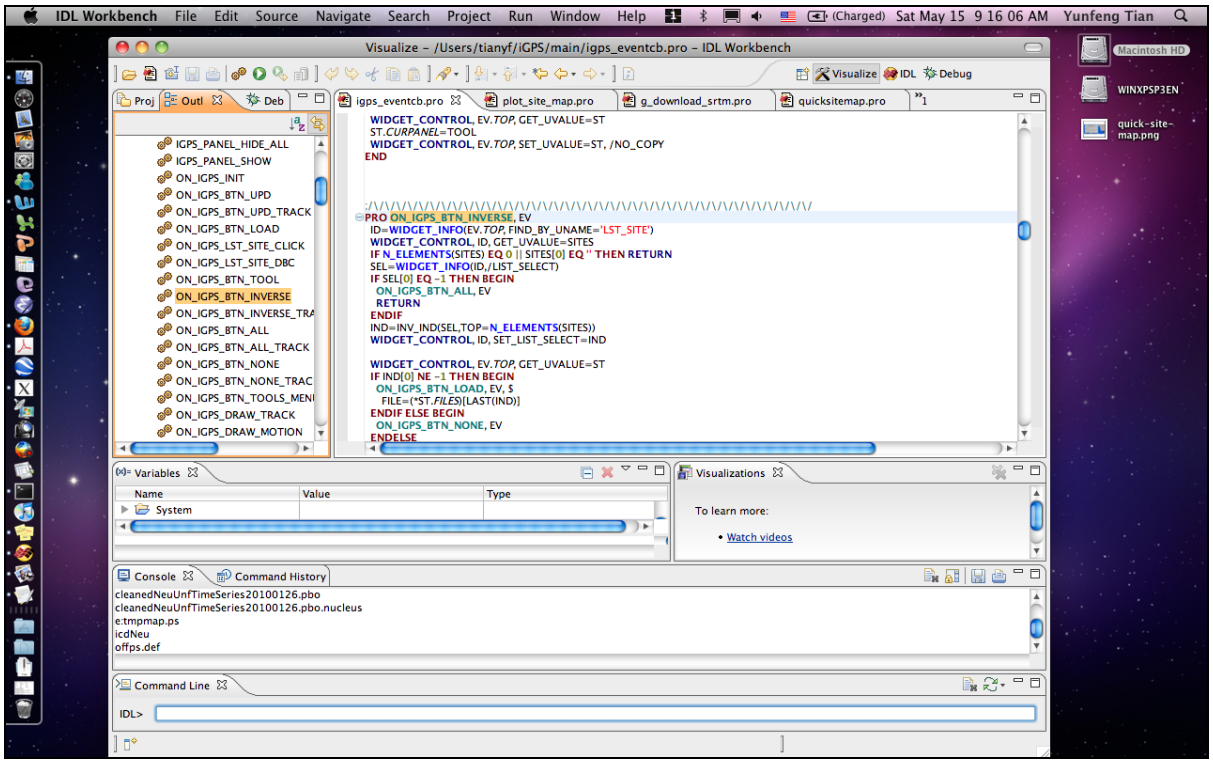


Figure 65. Edit ***iGPS*** source code with IDLDE.

If errors occur, the program will stop at the line which caused the error. This is useful for investigating the causes of errors. If you use the command-line IDL to run ***iGPS***, use retall command to escape the debug mode. If you start ***iGPS*** from IDLDE, then the source code file will be open and the error line will be highlighted. To continue the session, compile the source code in IDLDE.

One can use print or help commands to show the values of variables.

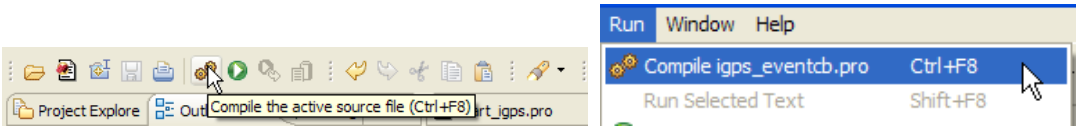


Figure 66. Compile IDL source code using toolbox (left) button or menu item (right). The keyboard shortcut for source code compilation is CTRL+F8.

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Known Bugs

There are some known bugs for ***iGPS***. However, I didn't have time to get solutions.

1. Offset, psdecay and cutting lines will not show if the x-axis is in MJD or JD.
2. The highlighted points will plot over the fitted line when in "Nearest Point Mode".
3. In Linux/Unix, the first selected path or file will not show in the recent list.

Please direct any suggestions or bug reports to tianyf@gmail.com. Attaching an error log or screen snapshot is greatly recommended when submitting bugs. Thank you.

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Some date conversion routines are rewritten from FORTRAN 77 source files in GAMIT/GLOBK software. Permissions had been obtained from MIT/Harvard/Scripps to use them in ***iGPS***.

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