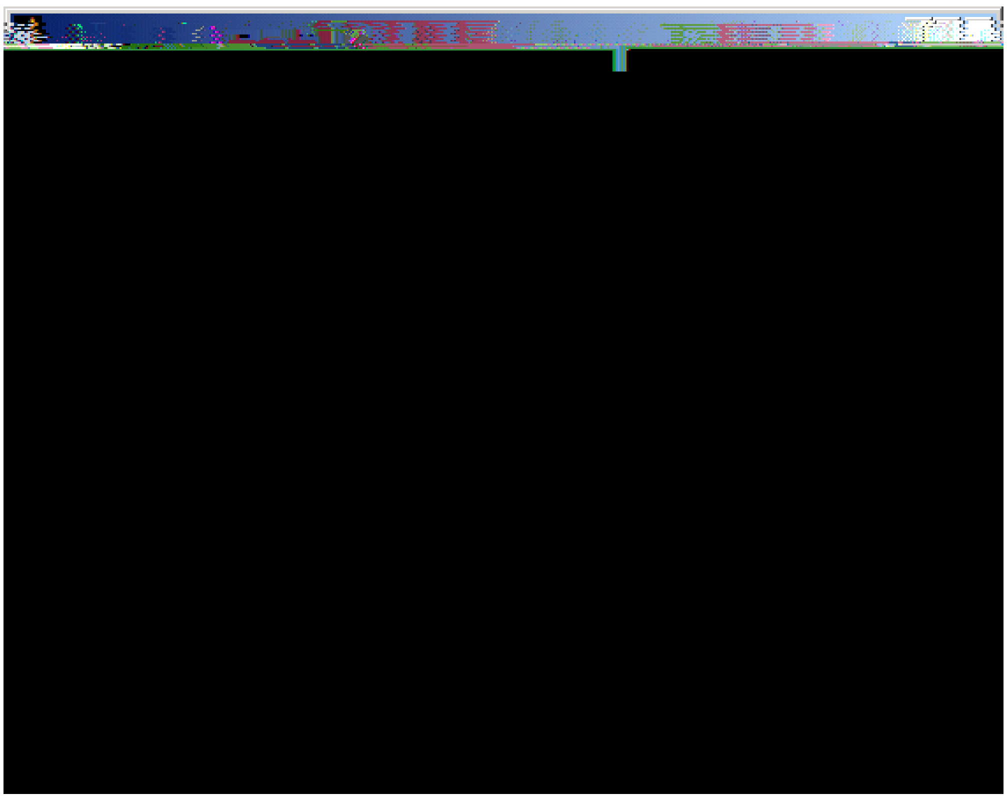
12/4/2001

ZMAP
A TOOL FOR ANALYSES OF SEISMICITY PATTERNS



TYPICAL APPLICATIONS AND USES:
A COOKBOOK

MAX WYSS, STEFAN WIEMER & RAMÓN ZÚÑIGA

Table of Content

INTRODUCTION *3*
CHAPTER I *4*
What's going on with this earthquake catalog? Which parts are useful? What scientific problems can be tackled? **4**

INTRODUCTION

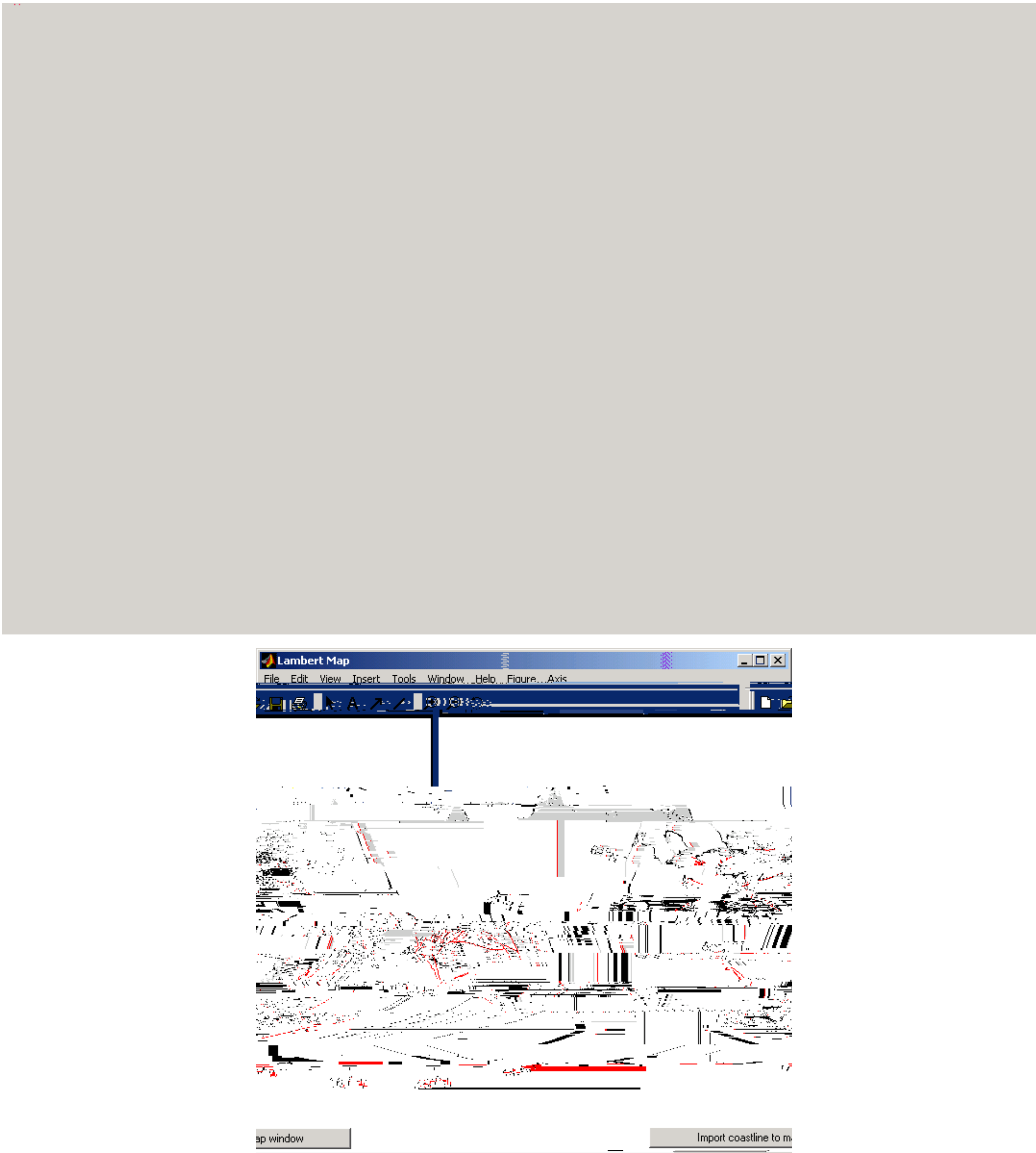
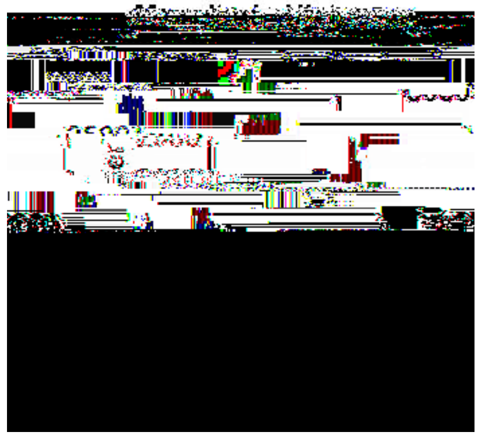

Lambert Map
File Edit View Insert Tools Window Help Figure Axis

Figure 2

Rough selection of the period of interest: It is evident from Figure 1.3a that only very large events are reported before the mid 1960se subjlecd ofyour

b (Figure 1.b) efos periodduring



Narrowing the target of investigation: At this point one might decide to study just the shallow seismicity. Because of the minimum of the numbers at 35 km depth (Figure 5), this offers itself as the natural cut. The bulk Mc for the shallow events can be estimated

this quality control, we open the select menu in the seismicity map, click on set m circle and place the cross hairs8into the red zone offshore, where we click, to learn if really the resolution is a bad as the algorithm
process, only this time we Set m Circle Overlay existing plot, such that

Figure 12: Histogram of radii in Figure 11.

35 km is the most common radius.

A further of quality control is offered by the standard error map for the b-value estimates (Figure 13). This map allows the investigator to select saipi

CHAPTER II

Are there serious problems with heterogeneous reporting in a catalog? What is the starting time of the high-quality data?

Work done already: We assume that you have acquainted yourself with the general properties of the catalog. You deleted the hypocenters outside the priphery of the network and those of erroneously large depth, as well as the M0, if they are maningless,

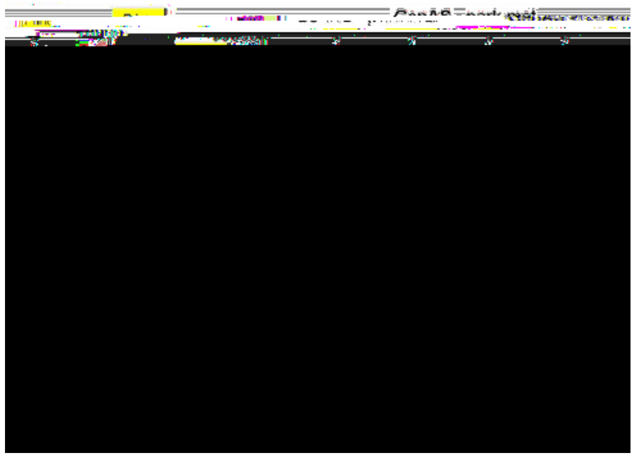


Figure 2.2: Genas1 window. The cumulative numbers of earthquakes with M>Mi and with M<Mi are

chosen on the basis of the linearity of the observed curves. Once this selection has been performed, the routine attempts to fit the background to the foreground by assuming two possibilities:

(1) The background is first adjusted to fit the foreground by assuming a simple magnitude

this case, the routine found that a simple shift of +0.1 units applied to the background, would best fit the foreground, while if a stretch is chosen, one needs to apply a shift of +0.3 and a multiplicative factor of 0.82. Notice that in the selection panels, a simple magnitude shift of +0.1 is input, which resulted in the plot shown in Figure 2.7A.

(A)

(B)

.

Another date of interest is 1980, because at this time approximately, improvements in analysis techniques took place cumulative number curve for M>1. events is

CHAPTER III

Measuring Changes of Seismicity Rate

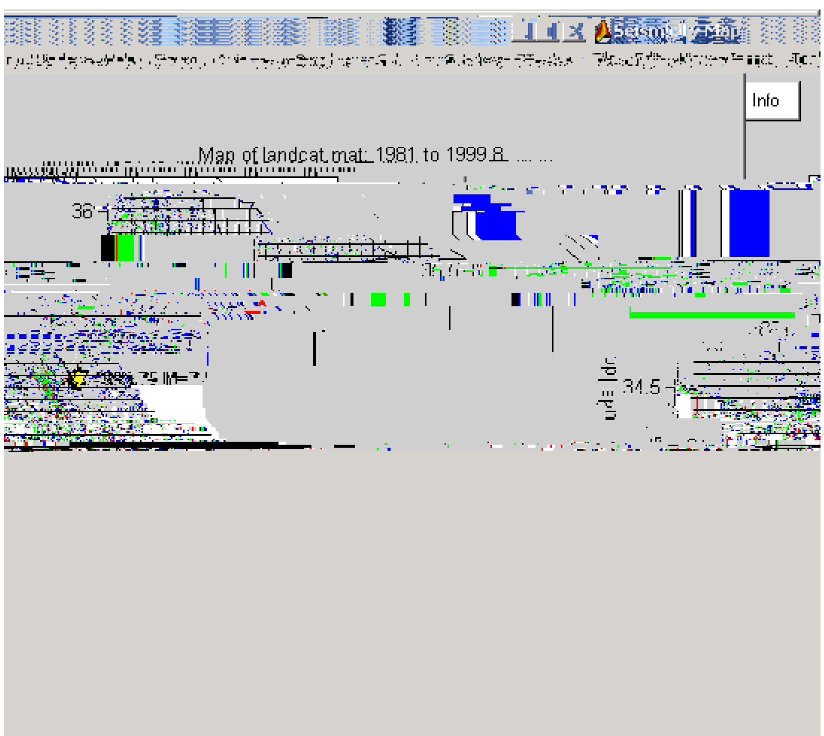
Precondition: You have already selected the part of an earthquake

In the example shown in Figure 3.3, the rate change evenly affects all magnitude bands. This favors of the interpretation that the rate change is real. In addition, this change took

Figure 3. 5: Z-menu window. Choosing LTA opens a window that asks for the definition of the time

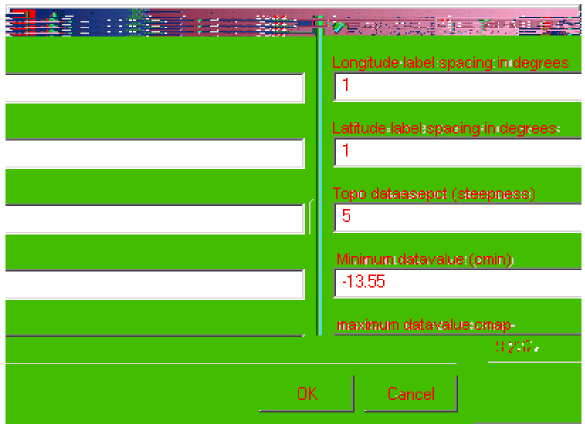
Figure 3.7: Z-map of the rate change at the time of the Landers earthquake. (a) Automatic scales, (b) Lambert projection. Stars mark the epicenters of the La5(La1(epm7vTn)5.1(d B4.47jec)8.1g)5.1(B4.47jea5(La1)3.8(ars)7-33(

each node and calculates for every position the Z-value comparing the rate in the window


Seismicity Map
Info
Map of landcat mat: 1981 to 1999.8
36°
34.5

Again the grid is chosen by using the left mouse button to define the perimeter, trying to exclude low seismicity areas, and clicking the right mouse button for the final point. The result of the computation will be displayed in a map.

The map can be limited in range, plotted in lambert projection, or on top of topography (if you have the mapping toolbox). To plot on top of topography, use the option Display -> Plot on topo map. You will need to define several input parameters:



The data-aspect refers to the steepness of the topography. You may need to experiment a little, since it depends on the specific region. You can again limit the range of the map. Values above the selected range will be set to the maximum value. It is often sensible to use a range symmetric around zero. If you have not yet imported a topography and plotted it, you will be reminded to do so. Th

Articles in which tools discussed in this chapter were used:

Wiemer, S., and M. Wyss, Seismic quiescence

CHAPTER IV

Measuring Variations in b-value

Precondi2 0n: You have already selected the part of an earthquake catalog that is reasonably homogeneous in space, time and magnitude band. All inadequate parts of the catalog and explosions have been removed. Also, you have culled the events with magnitudes significantly below the Mc, such that the algorithm that finds Mc for the local samples cannot mistakenly fit a straight line to a wide magnitude band below Mc.

Assumption: The b-value is relatively stable as a function of time. The first order variations are expected as a function of space.

Mapping b-values: In the **seismicity map** window, open the **ZTools** menu and point to **Mapping b-values**. From the sub-menu select **Calculate a Mc and b-value map.** The window for **Grid Input Parameters** I(Figure 4.1) will open. After defining the)-5.9( )]TJ-16.20

Figure 4.2: b-value maps of southern California for the period 1981-1992.42. (a) Maximum likelihood method, (b) weighted least squares method.

The default scale for the b-values, with which the maps are presented, includes the minimum and the maximum values that are found. However, it is usually better to select limits that result in a map in which the blue

Figure 4.3: Frequency-magnitude distributions for quality control, comparing distributions which were judged as different in the maps. (a) Comparison of data sets with a high and a low b-value. (b) Comparison of datasets with a high and a low Mc.

For all of the maps (Figures 4.2 and later) a ***histogram showing the distribution of the values*** can be plotted by selecting **Histogram** in the menu of **Maps** of the **b-value map** window. Figure 4.4, for example, shows the

Figure 4.4:

and offering several buttons at the top as

b and Mc grid

nd position of cross sections.

Table 1: Fault plane solution input data format

dip-direction	dip	rake	misfit
230.0000	75.0000	137.3870	0.03
325.0000	90.0000	55.0000	0.04
145.0000	80.0000	-55.0000	0.12
140.0000	75.0000	50.0000	0.01
50.0000	50.0000	140.0000	0.10
45.0000	50.0000	-135.0000	0.03

Data import is only supported through the ASCII option. Select the EQ Datafile (+focal) option when importing your data into ZMAP. Several precompiled datasets are available through the online dataset web page (use the ‘online data’ button in the ZMAP menu).

Inverting for the best fitting stress tensor.

Stress tensor inversions can either be performed for individual samples, or on a grid. The inversion for individual samples is initiated form the cumulative number window. Select a subset from the seismicity window (generally 10 < N < 300). Select the ZTOOLS -> Stress Tensor Inversion -> Invert using Michael's Method option. The inversion is started and will take several seconds, depending on the sample size and speed of your machine. The inversion is performed by first saving the necessary data into a file, then calling Michael's inversion program unix(' slfast data2 ') to find the best solution. To estimate the confidence regions of the solution, a bootstrap approach is used by Michael (unix([' bootslickw data2 2000 0.5']);). In the defaults setup, fault planes and auxiliary planes are assumed equally likely to be the rupture plane (expressed by the 0.5 in the bootslickw

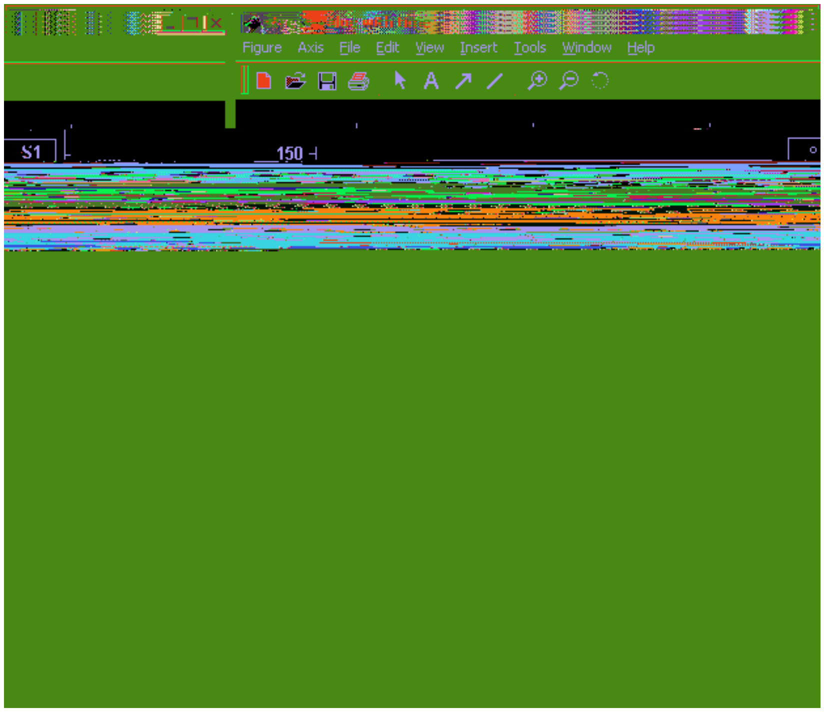


Figure 5.4: Stress tensor inversion results

Using Gephart's code

An alternative code to compute stress tensor was given by Gephart [*Gephart*, 1990a; *Gephart*, 1990b; *Gephart and Forsyth*, 1984]. His code performs a complete grid search of the parameter space. The ZMAP6 version of the code is essentially unchanged from the ZMAP5 version, with the exception that now a precompiled PC version is also available. The data input format is identical to the one for Michael's inversion. Note that significant differences between the two methods have been observed in special cases.

For UNIX or LINUX version, you need to precompiled a few files, that are located in the external/src_unix directory. Check the INFO file in this directory for information on compiling.

To initiate a stress tensor inversion, select the "Invert for stress tensor" option from the

```
#define VARIANCE_30 30
```

change to:

```
#define VARIANCE_30 90
```

and re-compile (cc -o msiWindow_1 msiWindow_1.c)

The cumulative misfit method

Stress tensor inversions are time consuming, and the resulting tensor is not easily visualized. To identify crustal volumes that satisfy one homogeneous stress tensor Lu and uced the cumulative misfit method. The misfit, *f*, for each individual earthquake can be summed up in a number of different ways, for example along the strike of a fault or

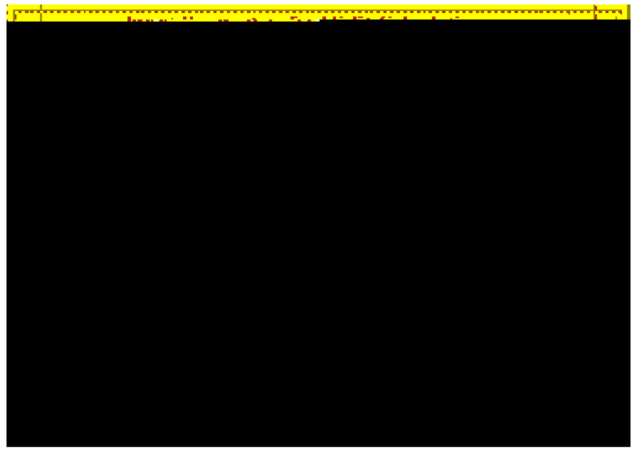


Figure 5.10. Input parameters for te misfit calculation

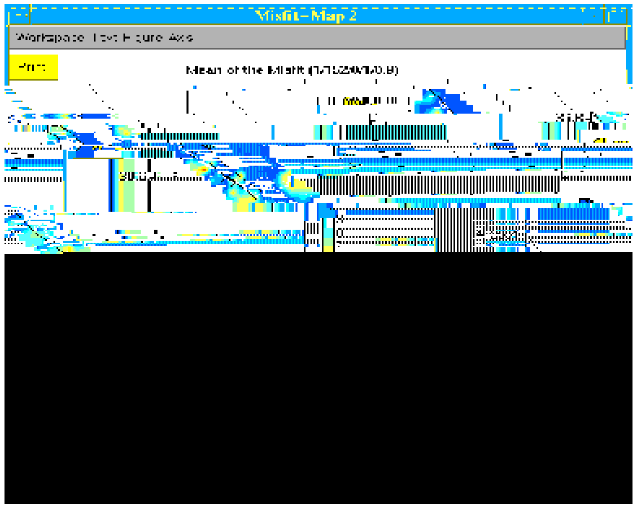


Figure 5.14. Image showing the distribution of average misfit values F in map view. Red colors indicate a low average misfit and thus good compliance with the assumed theoretical stress field. This map shows the

Lu, Z., M. Wyss, and H. Pulpan, Details of stress directions in the Alaska subduction zone from fault plane solutions, *Journal of Geophysical Research*, *102*, 5385-5402, 1997.

Michael, A.J., Determination of Stress From Slip Data: Faults and Folds, *Journal of Geophysical Research*, *89*, 11517-11526, 1984.

Michael, A.J., Stress rotation during the Coalinga aftershock sequence, *Journal of Geophysical Research*, *92*, 7963-7979, 1987a.

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Michael, A.J., Spatial variations of stress within the 1987 Whittier Narrows, California, aftershock sequence: new techniques and results, *Journal of Geophysical Research*, *96*, 6303-6319, 1991.

Michael, A.J., W.L. Ellsworth, and D. Oppenheimer, Co-seismic stress changes induced by the 1989 Loma Prieta, California earthquake, *Geophysical Research Letters*, *17*, 1441-1444, 1990.

Wiemer, S., M.C. Gerstenberger, and E. Hauksson, Properties of the 1999, Mw7.1, Hector Mine earthquake: Implications for aftershock hazard, *Bulletin of the Seismological Society of America*, in press, 2001.

CHAPTER VI

Importing data into ZMT3-CiP

[redacted]

- First rename mydata into a: a = mydata; then start zmap and type: startwitha
- Use the 'Import Filter' option from the ZMAP menu, and select the ASCII import filter.

To get your data into ASCII column format, you can use various tools. On a PC, I often use textpad (http://www.textpad.com/

CHAPTER VII

Tips an tricks for making nice figures

Figure 7.4. Final edited figures

Alternatively, you can print from the command prompt in Matlab, using, for example:

print –dps –noui myplot.ps

The figure you want to print must be the active one. The –noui option avoid printing the menus. See help print for details on drivers etc. The same PageSize setup applies.

In addition, you could keep a copy as a Matlab *.fig(e)me. These Figures can be reloaded into any Matlab session, and edited within Matlab. See hgsave and hgload for details.

Postscripts f ed into PDF, but they cannot always be edited. On Unix workstations, IslandDraw does a good job opening simple postscript figures from Matlab – but fa inter polated color See he61eTro.ning3.4.1etc.


Insert Format Tools Slide Show Window Help
File Edit