Making maps and profiles in SEISAN

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Contents

Introduction

SEISAN has several programs for making epicenter maps and one program that in addition can also make a depth profile. The map contours can be the SEISAN included world contours, map data from GMT or using Google map or Google Earth. The details of the different programs are given in Chapter 10 of the Manual. Plotting of epicenters can be initiated from EEV or SeisanExplorer (SE). From EEV only one event can be plotted while from SE a selection of events can plotted. Alternatively many events can be plotted from a CAT file like a collect.out or select.out. Some of the programs can also plot fault plane solutions, seismic rays and error ellipses. Only the basic global contour file, WORLD.MAP (and low resolution version WORLD_LO.MAP) is included in the distribution). If using GMT, a GMT topography file must be installed.

Programs

EPIMAP: makes a basic map with built in contours, make one or several profiles interactively, select an area to make an output file of that area, fault plane solutions, error ellipses and more. The program asks several questions to give all the options.

MAP: a wrapper for EPIMAP where most common options are selected automatically so simple to use. This program makes simple plots and has the largest number of options. It is intended for a quick view of the data or preparing data for other programs.

MAPG: makes a GMT map, most parameters are automatically selected, options for e.g. fault plane solutions, station names and ray plotting. Many options are similar to MAP, but the plots are of much better quality. It is very easy to make an initial plot and then the output commented GMT script can be modified for the users different needs.

GMAP: prepares a KML file for e.g. GoogleEarth. Has many options for colors, stations, animation, rays etc. Beta version also prepare a GeoJSON file to be used by e.g. QGIS and web applications.

SEIS2VIEVER: plots the data in the SeismicityViewer. 3D data can be visualized.

SEIGMT: converts CAT file parameters to format used by GMT for a general GMT script. It is automatically used with the MAPG program.

Programs setup

MAP and EPIMAP do not require any setup but some default parameters can be changed, see examples below and later. To use the GMT program MAPG, GMT must be installed and if color contours are to be used, a grid file must be installed. The default global grid file gmt.grd used with SEISAN is located in DAT so it must be uploaded from the SEISAN web site. Any other file of the user's choice can be used, and the name and location of the file is specified in SEISAN.DEF:

```
GMT_GRIDFILE                            \seismo\DAT\gmt.grd
```

The GMT script makes a PostScript output file mapg.ps which automatically is displayed on the screen with a command defined in SEISAN.DEF

```
PLOT_PS_COMMAND         for windows     gswin64
```

Here the well-known program GhostScript is used. So, the user must install a ps viewing command (if not already there) and update SEISAN.DEF.

For MAP/EPIMAP several elements can have different colors, see setup file COLOR.DEF in DAT. Some examples:

```
1: blue   2: green   3: red   4: yellow   5: white   6: black

color_frame             1   ! frames like epimap map frames, mulplt
color_title             6   ! titles on top of plots
color_spec              1   ! spectras
color_axis_not          3   ! axis notations
color_epi               3   ! epicenters
color_station           3   ! seismic stations
color_map_contour       1   ! epimap contours
```

If plotting with GoogleEarth, it must also be installed. SeismicityViewer needs Java.

Test data for the tutorial

The test data comes from the SEISAN test data set found at the SEISAN web site. The following files are used:

wn-grid.cat:	local data from Western Norway
fps.inp:	local data from Western Norway used for fps tutorial
2002.isc:	global data from ISC for the year 2002, shallow events, compact file
2002-2004.isc:	global data from ISC, m>5, contains headers
TEST:	events in TEST data base for 199606 and 199607
santo.fps	ISC events with moment tensor solutions from Dominican Republic

All files are in WOR/catalogs

The simple MAP and MAPG commands with no options

Many events can be plotted with MAP and MAPG. MAP is a driver program for EPIMAP.

Plotting local seismicty

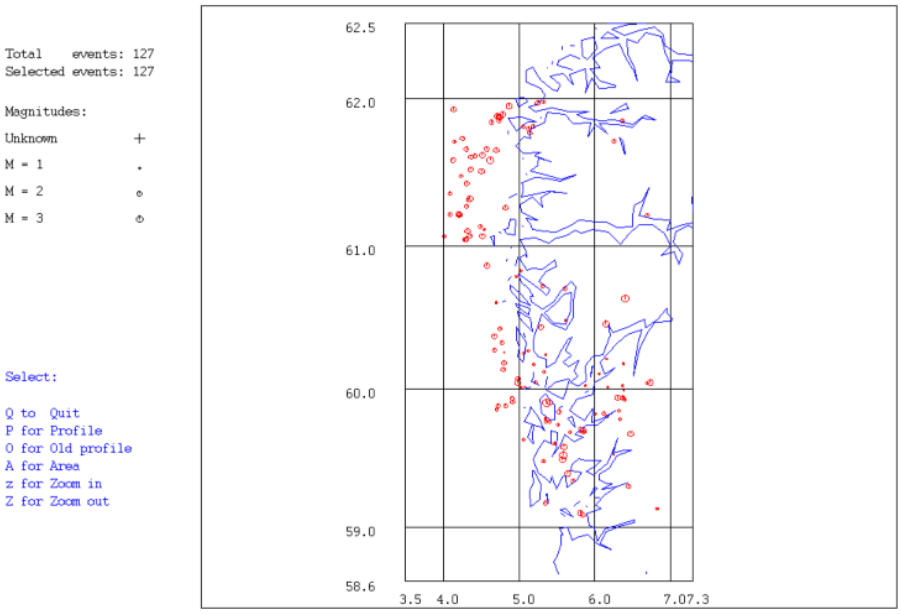
The simplest and fastest is to use the map command. Example:

```
map wn-grid.cat

  Options, by interactive input or as arguments
  The first argument is filename so e.g. map select.out f s

  s: plot stations as triangles
  S: --------- with stations code above
  a: plot all stations as triangles
  A: --------- with stations code above
  f: plot fault plane solutions
  e: plot error ellipse
.
.
.
```

Output from MAP and EPIMAP

.

```
==== Loading Epicentres...
```



The default projection chosen here is Mercator. Another projection can be set in SEISAN.DEF:

```
EPIMAP_PROJECTION  number       3.0
```

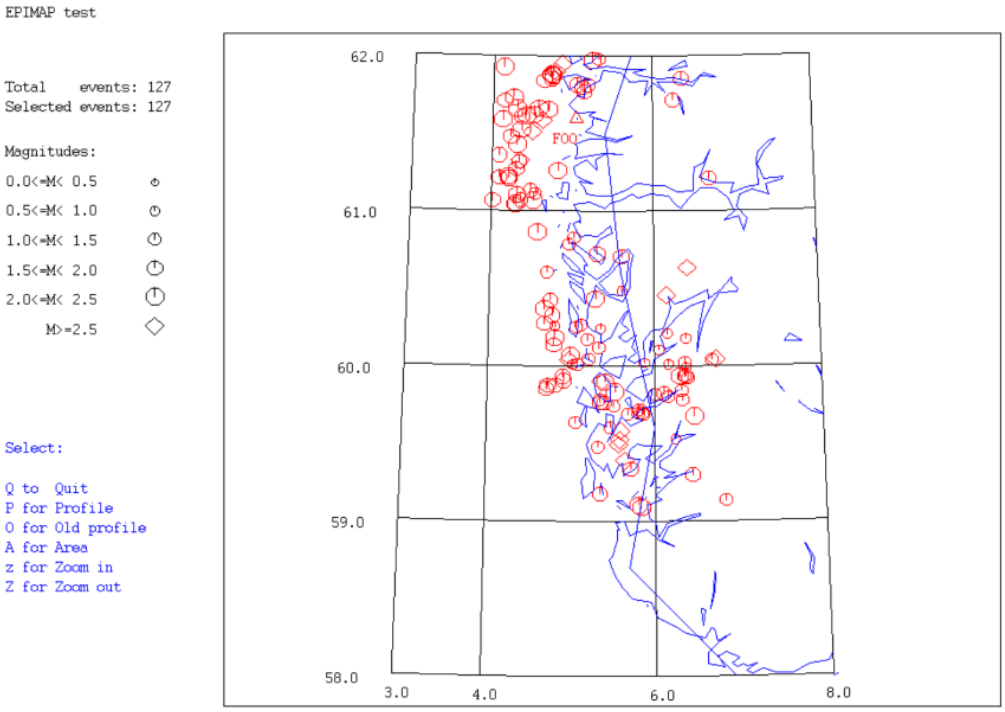
Using EPIMAP directly

The same map can be made directly with EPIMAP. This gives more choices but takes more time. The example below is the same as the map above and uses a different projection (stereographic), plot both the low and high resolution contours, uses different magnitude symbol and plot the location of station FOO (triangle):

```
epimap

 Projection menu
 ===============

    1: POLAR STEREOGRAPHIC     conformal, azimuthal
    2: ORTHOGRAPHIC            view from infinity, azimuthal
    3: MERCATOR                cylindrical, conformal
    4: LAMBERT EQUAL AREA      azimuthal
    5: GNOMONIC                Great Circles are straight lines
    6: AZIMUTHAL EQUIDISTANT   distance from origin is to SCALE$
```

```
    7: STEREOGRAPHIC           conformal, azimuthal
    8: EQUIDISTANT CYLINDRICAL
    9: OBLIQUE MERCATOR        cylindrical, conformal
   10: MOLLWEIDE ELLIPTICAL    pseudocylindrical, equal area
   11: SANSON'S SINUSOIDAL     pseudocylindrical, equal Area

 Please enter projection number   : 7

 Enter latitude  range of the map : 58 62

 Enter longitude range of the map : 3 8

 Centre latitude-longitude is ( 60.0,   5.5) degrees.
 Press <return> to accept this as the reference point of the projection

  Enter latitude of ANY grid line and also the grid spacing
 : 1 1
  Enter longitude of ANY grid line and also the grid spacing
 : 2 2

 DO YOU WANT THE EVENTS NUMERATED? (Y/N=RETURN)
 c:\seismo

  Searching for available map files...

 dirf c:\seismo\DAT\*.MAP
 #  1  c:\seismo\DAT\WORLD.MAP
 #  2  c:\seismo\DAT\WORLD_DR.MAP
Select number or return for no more selection
1
 c:\seismo\DAT\WORLD.MAP
 Select number or return for no more selection
2
 c:\seismo\DAT\WORLD_LOW.MAP
 Select number or return for no more selection

 Plot title (max 60 chars), or press <return> for none: EPIMAP test
 Plot error ellipses: e or fps: f (n=return)?:
 File name for contour levels, or press <return> for none:

  Plot place names (P) or
  Plot all (a) or some (s) stations with a label,
```

```
  or some (z) stations without a label,
  all stations without a label (x), or none <return>?
  ...Enter in uppercase if you wish the symbols to be filled
  and this facility is available...
 : s
  Enter stations (one per line) & end list with <return>
FOO


 Available colour index values are:
             1 ) Blue
             2 ) Green
             3 ) Red
             4 ) Yellow
             5 ) White
             6 ) Black


  Enter epicentre filename and colour index,
  separated by a blank, otherwise press <return>
wn-grid.cat

 .... opened "wn-grid.cat" for plotting...
 .... default colour (COLOR.DEF)

  Input file is Nordic

  Enter epicentre filename and colour index,
  separated by a blank, otherwise press <return>


 Enter the following in uppercase if you wish the symbols
 to be filled and this facility is available...
 By default, symbols will be plotted according to
 magnitude, do you wish them to be plotted according
 to magnitude range?: y

 ==== Loading Epicentres...
```



Replotting with different parameters, MAP

Every time MAP operates, it creates an output file map.inp. For the first example above, it is shown below:

```
3
  58.6    62.5
    3.5     7.3

  1   1
  1   1

c:\seismo\DAT\WORLD.MAP
$$$$$$end of contour list$$$$$$



wn-grid.cat  3
$$$$$$end of epicentre file list$$$$$$
```

The file lists the choices given to EPIMAP when stated from MAP, for details, see manual for EPIMAP. This file can be edited to add more files to plot, change projection etc. and then a new plot with the new options can be made with command:

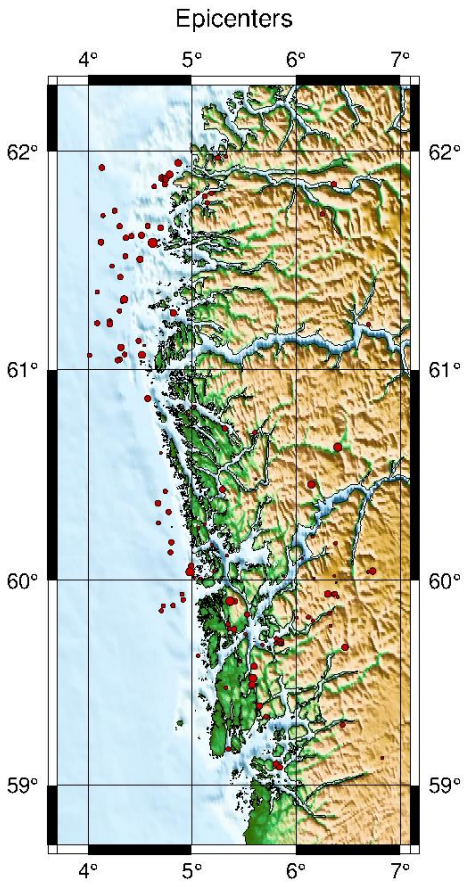
```
epimap map.inp
```

The same plot as above with MAPG:

```
mapg wn-grid.cat

  Options, some by interactive input or as arguments
  The first argument is filename so e.g. mapg select.out f l
  s: plot stations as triangles
  S: --------- with station code above
.
.
```

Output from MAPG and SEIGMT

```
.
.
 Number of events in input file         127
 Number of events with location         127
Latitude range to use     58.7   62.3
Longitude range to use     3.7    7.1
Grid size in lat and lon:   1.00  1.00
gswin64 mapg.ps
```



The last command is to plot the PostScript file. Plotting with MAPG takes more time than with MAP. The title 'Epicenters' is hardwired but can be changed in the script file, see below.

Replotting with different parameters, MAPG

Like MAP, MAPG also makes an output file with commands used for the plotting. This is a GMT script that can be reused. The file is mapg.gmt:

```
REM
REM   Set font, size and color of title
REM
gmt gmtset  FONT_TITLE = 14p,Helvetica,black
REM
REM   Cut out desired area from grid file, area is 3.700/7.100/58.70/62.300
REM
gmt grdcut \seismo\DAT\gmt.grd -R3.700/7.100/58.70/62.300             -Gmapg.grid
REM
REM   Make color table, global colors
REM
```

```
gmt makecpt -Cglobe -T-8500/8500/50 -Z > mapg.cpt
REM
REM   Plot base map, midpoint is 5.40/60.50/         horizontal size in cm is 07
REM   Longitude and latitude grids are:    1.00   1.00
REM
gmt psbasemap -Bxa001.00g001.00 -Bya001.00g001.00 -B+t"Epicenters" -JM5.40/60.50/07c -
R3.700/7.100/58.70/62.300             -K -P >mapg.ps
REM
REM    Compute directional gradients from a grid
REM
gmt grdgradient mapg.grid -Nt1 -A225 -Gmapg.gradient
REM
REM   Make the map
REM
gmt grdimage -JM5.40/60.50/07c -R3.700/7.100/58.70/62.300             mapg.grid  -
Imapg.gradient  -O -K  -Cmapg.cpt >> mapg.ps
REM
REM   Plot coast line
REM
gmt pscoast -JM5.40/60.50/07c -B -R3.700/7.100/58.70/62.300             -Dh -
N1/1.00p,- -K -O -W >> mapg.ps
REM
REM   Plot epicenters, size proportinal to magnitude
REM
gmt psxy gmtxy.out -R -J -Sc -G200/0/0 -W0.3 -O -K >> mapg.ps
REM
REM
REM   Plot map on screen
REM
gswin64 mapg.ps
REM
```

This script can now be used to make a tailor-made script for the plot. With the comments it is simple to find relevant sections. To execute the script, in Linux write

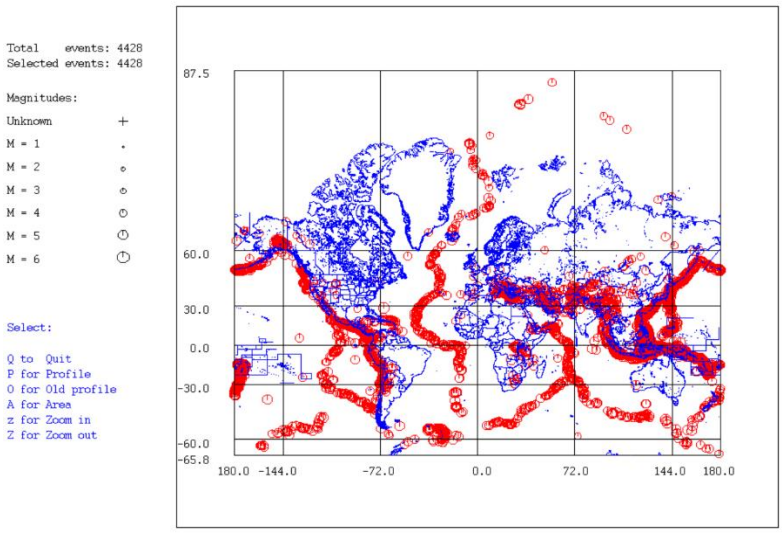
```
source mapg.gmt
```

while in Windows the file must be renamed to a BAT or CMD file with a name different from mapg (which would start the MAP program), e.g. mymap.bat and then execute the script by writing

```
mymap
```

Plotting global seismicity:

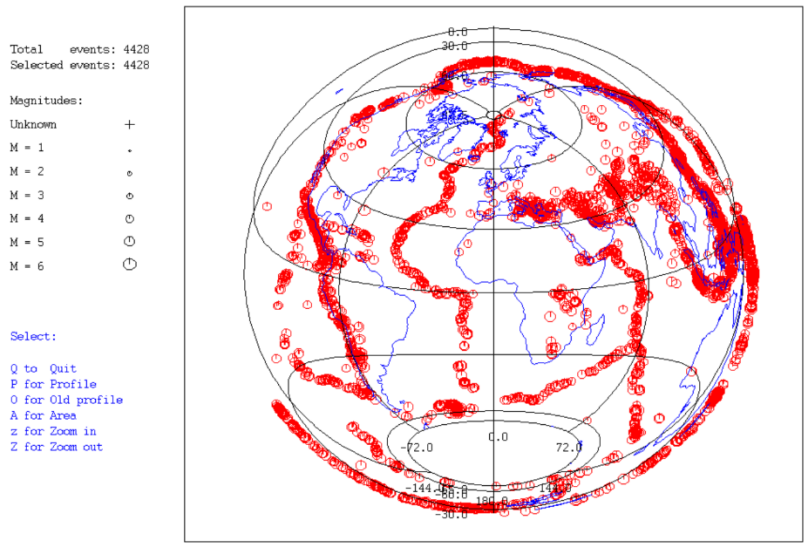
```
map 2002.isc
```



This map uses the default map resolution and Mercator projection. The defaults can be changed in SEISAN.DEF.

```
EPIMAP_MAP_FILE     name of map          WORLD
EPIMAP_PROJECTION   number                  3.
```

Changing the map resolution to WORLD_LOW and projection to 4 (Lambert equal area) gives:

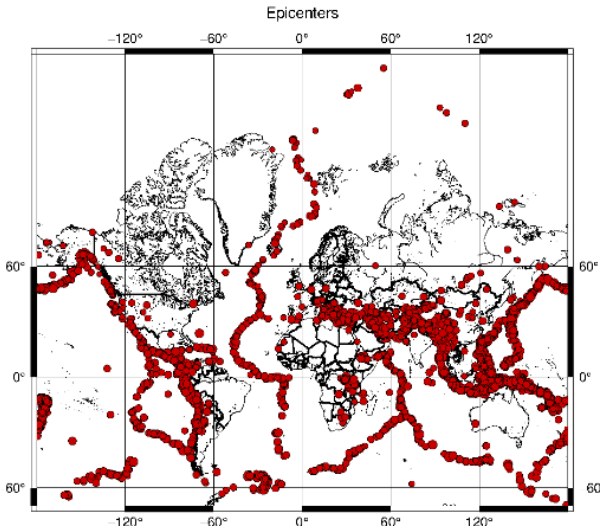


For plotting the whole world or large part of the world, the low-resolution map is the most suitable but for smaller areas, the normal resolution is used. Higher resolution maps are available on the SEISAN web site, see EPIMAP manual.

NOTE: Not all projections work in all map areal selections.

Plotting the whole world with GMT is VERY time consuming with the default topography grid file, but it is possible to plot only the coastlines etc. like with MAP. The coastlines are built into GMT and not the same as used by MAP:

```
mapg 2002.isc t
```



where the option 't' indicates that no topography should be used.

Plot user generated MAP or other files with contours

When using EPIMAP, the user can enter several map files located in DAT. In order for EPIMAP to find the files, they must end with .MAP. Let's add a supposed fault at the locations (lat lon)

```
60.5    5.0
61.0    4.5
62.0    4.5
```

in a file called fault.inp

```
 3
   60.5     5.0      61.0      4.5     62.0      4.5
```

The first line gives number of points (format I4 so the number must end in column 4) and the second line (format 10f8.3, so each real number occupies 8 columns).

In the script file generated by MAP we have the lines

```
c:\seismo\DAT\WORLD.MAP
$$$$$$end of contour list$$$$$$
```

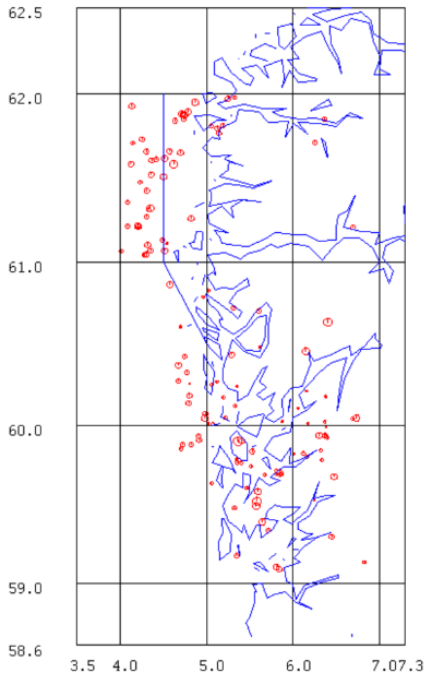
and the file fault is now added assuming it is in working directory. The name can be anything if added directly in script file:

```
c:\seismo\DAT\WORLD.MAP
fault.inp
$$$$$$end of contour list$$$$$$
```

Now giving command

```
epimap map.inp
```

and we get



An alternative to having a separate file is to add the contours to WORLD.MAP.

Running MAP and MAPG interactively

Both MAP and MAPG can be operated interactively where the user is asked one question at a time. MAP can only use a file for input, but MAPG can also take input directly from a SEISAN data base:

```
mapg

  Options, some by interactive input or as arguments
  The first argument is filename so e.g. mapg select.out f l

  s: plot stations as triangles
  S: --------- with station code above
  -s or -S: as above with station file following
  f: plot fault plane solutions, size proportional with magnitude
  F  -------------------------, size constant
  mt: plot moment tensor solutions, size proportional with magnitude
  MT: -------------------------, size constant
  -m: plot epicenter symbol with constant size,
      default is proportional to magnitude
      optionally add size in cm
  E: plot error ellipse
  l: plot localities names
  L: plot localities with names and symbols
  r: plot rays
  t: no topography
  u: user gives area, question asked later
  e: do not plot epicenter
  rf, rh, rl or rc: high to low resolution
  c: do not plot coast line
  -c: fill landmas with color from next argument
      e.g. -c blue

  Event data input - select one:

     SEISAN default data base or                    :Enter
     Alternative data base, give 1-5 letter code or  :
     Local index file, name must start with index or :
```

```
    Local data base, write ,, or                    :
    Filename for one file, min. 6 chars or with a . :



 Start Time           (YYYYMMDDHHMMSS): 199606
 End Time, enter is to end of month:

  Some single letter command can be entered here
  Plot stations(s), stations with code(S), fixed size for magnitude symbols(m),
  fault plane solutions(f) and rays(r) e.g. sf, enter for none

Plot now follows….
```

Note that not all single letter options are available when running interactively.

Options in MAP and MAPG

Both programs have many options, and they are slightly different for the two programs. Some of the options will be illustrated.

Typing map, you get

```
Options, by interactive input or as arguments
  The first argument is filename so e.g. map select.out f s

  s: plot stations in S-file as triangles
  S: --------- with stations code above
  a: plot all stations as triangles
  A: --------- with stations code above
  f: plot fault plane solutions
  e: plot error ellipse
  m: plot epicenter symbol according to magnitude range
  l: plot localities names
  r: plot rays
  n: do not plo text to the left
  N: number events

  Input files, optional color like eev.out 1, default is red
  Colors are 1:blue 2:green 3:red 4:yellow 5: white 6: black
  End with enter
```

Typing mapg, you get the options:

```
Options, some by interactive input or as arguments
 The first argument is filename so e.g. mapg select.out f l

 s: plot stations as triangles
 S: --------- with station code above
 -s or -S: as above with station file following
 f: plot fault plane solutions, size proportional with magnitude
 F  -------------------------, size constant
 mt: plot moment tensor solutions, size proportional with magnitude
 MT: -------------------------, size constant
 -m: plot epicenter symbol with constant size,
     default is proportional to magnitude
     optionally add size in cm
 E: plot error ellipse
 l: plot localities names
 L: plot localities with names and symbols
 r: plot rays
 t: no topography
 u: user gives area, question asked later
 e: do not plot epicenter
 rf, rh, rl or rc: high to low resolution
 c: do not plot coast line
 -c: fill landmass with color from next argument
     e.g. -c blue
```

Plot stations

Both programs use options s (station) and S (station and code) to plot stations. All stations found in the input file are used. The station coordinates are found in STATION0.HYP. Option a (station) and A (station and code) for MAP plots all stations in STATION0.HYP that are within the map boundary. To use option s or S, the input file must contain phase lines. If using a compact file with only header lines, option a or A can be used. Sometimes only specific stations are plotted. Option -s station.file for MAPG can then be used. The format of the station.file (longitude, latitude and code) is the one used by GMT and generated automatically by SEIGMT:

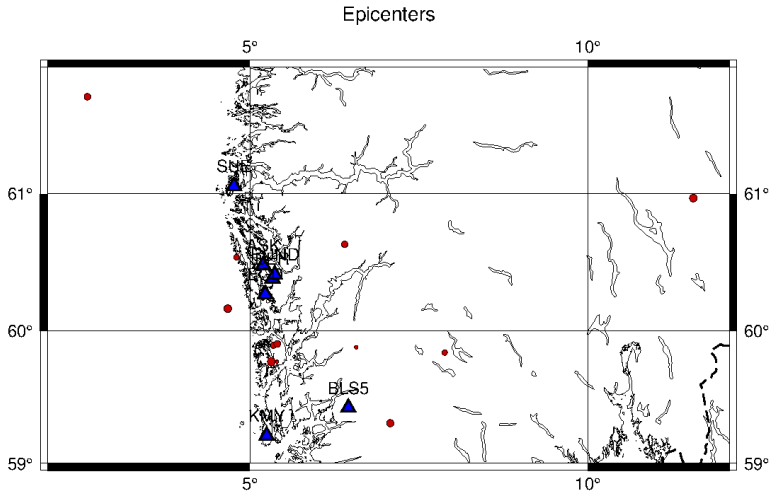
```
 5.226   60.271 EGD
 5.247   59.212 KMY
 5.334   60.384 BER
 5.367   60.414 RUND
 6.456   59.423 BLS5
 5.195   60.483 ASK
 4.761   61.057 SUE
```

For MAP, plotting all stations with flag ‘a’ can also be done without giving the option by setting a flag in SEISAN.DEF:

```
EPIMAP_STATIONS    plot stations        a
```

Examples:

```
Mapg fps.inp t -S station.file
```

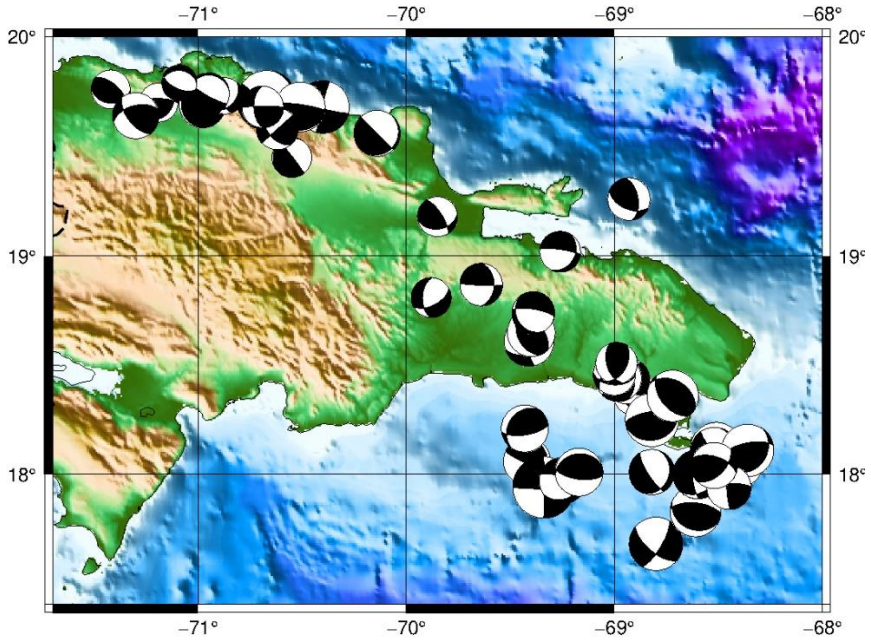


Plotting only some stations can be done directly with EPIMAP, but then all questions for the plotting must be entered manually, see EPIMAP manual.

Plot fault plane and moment tensor solutions

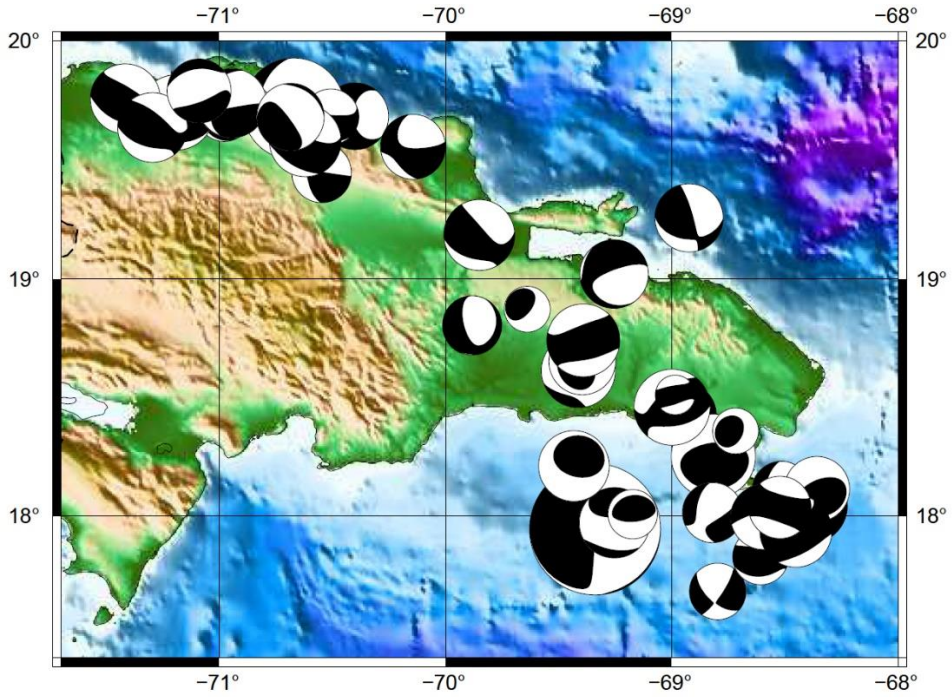
Both MAPG and MAP can plot fault plane solutions but only MAP can plot moment tensor solutions. Plot fault plane solutions with command:

```
mapg santo.fps  f
```



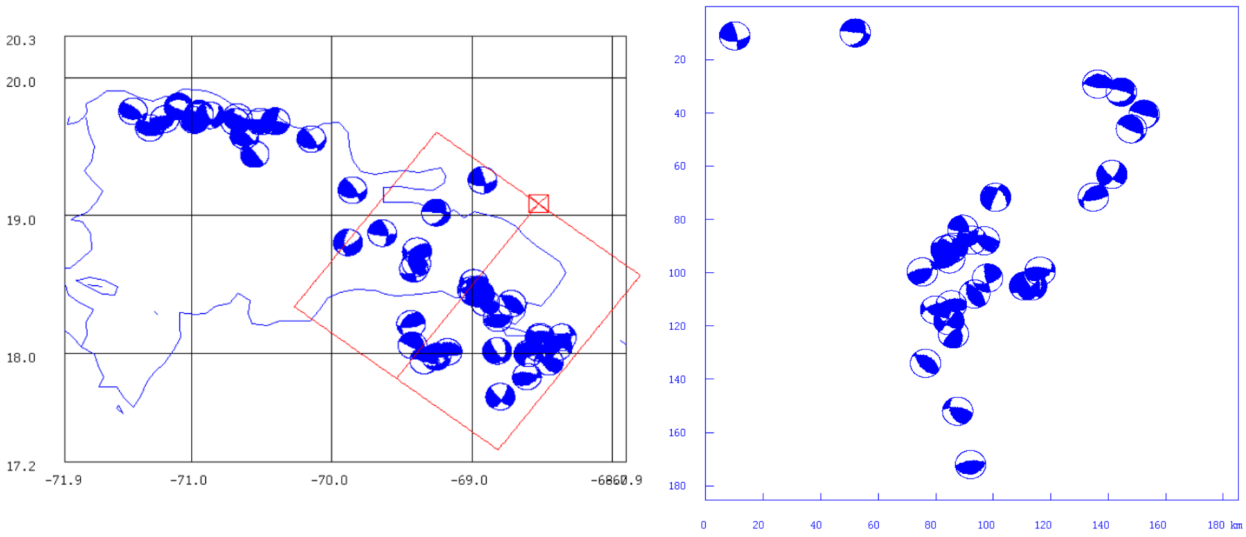
Here the plot is made with size dependent on magnitude, but fixed size can also be used with options ‘F’. The corresponding moment tensor plot is

```
map santo.fps mt
```



The corresponding plot with MAP is

```
map santo.fps f
```



The profile with the fault plane solutions is seen to the right. The solutions are oriented in the same way as on the surface. The size of the fault plane solutions with MAP is set in SEISAN.DEF:

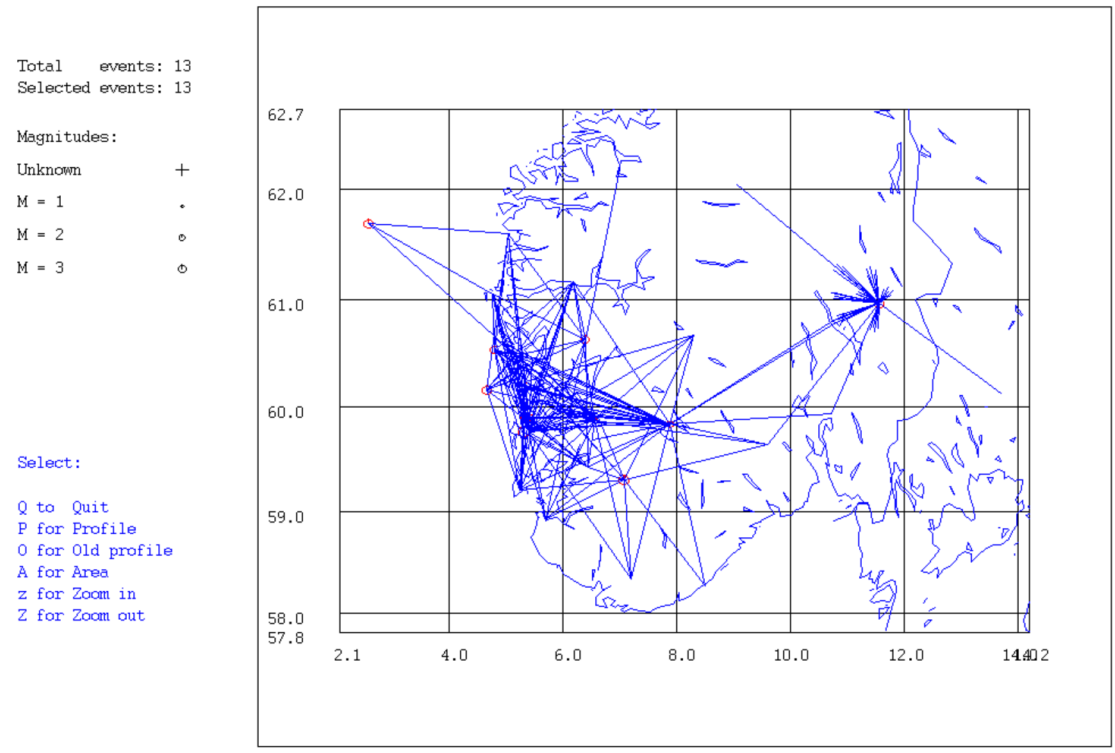
```
EPIMAP_FPS_SIZE  25.0 is def            15.0
```

Plot rays

Rays between stations and events can be plotted. Rays are plotted for stations with particular phases. When using MAP the rays are plotted as straight lines while with MAPG, great circle are used so MAP is only useful for a local area. Example with MAP:

```
map fps.inp r

  Options, by interactive input or as arguments
.
.
.

 Enter phases to use for ray paths, one per line, terminate with enter
 Only the chars given will be used so entering e.g. P, all P-type phases will be used
P
```

```
 Minimum output weight for phase-stat to be used, enter for non zero weight phases

 Max distance (km) for rays, enter for all
200
```

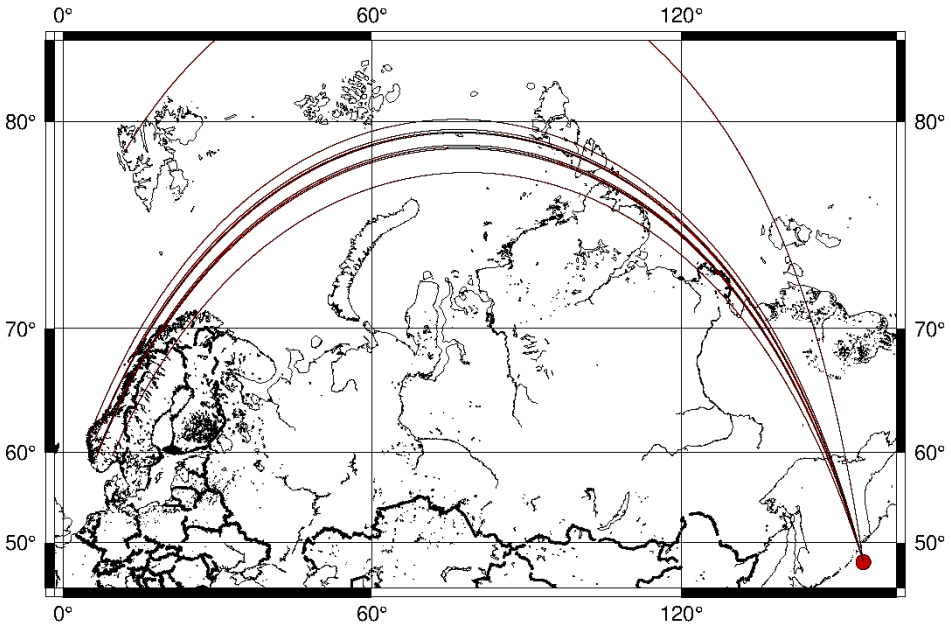


Example of a teleseismic event from the default data base. Copy out the first test event to create file eev.out:

```
eev 199606

 Give operator code, max 3 characters
jh
 1996  6 Reading events from base TEST_  9
#    1 03 Jun 1996 19:55 32  D  47.470 155.326  7.2    1.1  5.1sIPL  10  ? c

  Copy event: Other data base, give 1-5 letter name
              Local data base, type ,,
              Working directory in file eev.out: return
```

```
#     1 03 Jun 1996 19:55 32  D  47.470 155.326  7.2    1.1  5.1sIPL  10  ? q
```

```
mapg eev.out r t
```

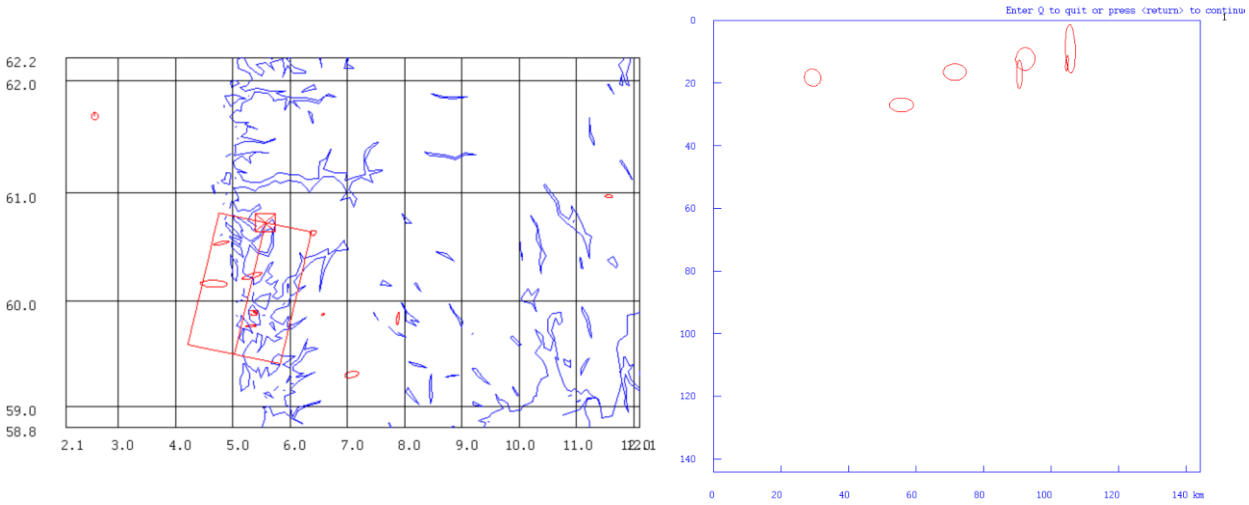


Option ‘t’ has been used to avoid using the detailed topography.

Plot error ellipses

When locating with SEISAN the error ellipse parameters are output in the S-file on the error line (E). Error ellipses can be plotted with MAP and MAPG. With MAP it is also possible to plot the vertical projection of the error ellipse. Example with MAP:

```
map fps.inp e
```

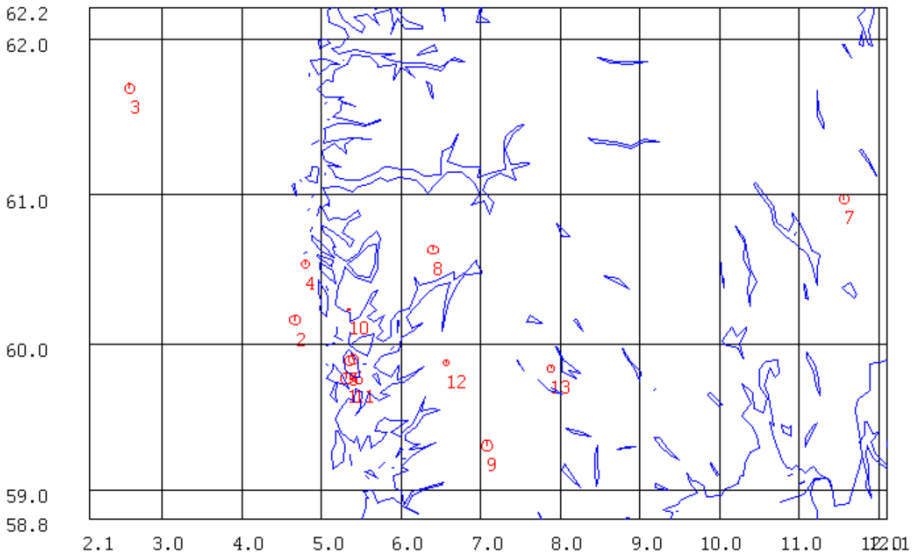


Notice that vertical errors often are larger than horizontal errors.

Plot epicenters with numbers

It can be useful to number events on the plot to identify certain events. The numbers can also be shown on a profile:

```
map fps.inp N
```



An output file epimap.num is given with the numbered events:

```
1   2000 0812 1427 26.2 L   59.769    5.316   9.1   BER 53 .30 3.9CBER 3.9WBER
2   2000 1208 0048 06.2 L*  60.163    4.671  16.5F BER 33 .90 3.3CBER 3.6WBER
3   2003 1215 0428 23.9 L*  61.691    2.595  22.9   BER 47 .10 3.3LBER 2.4CBER
```

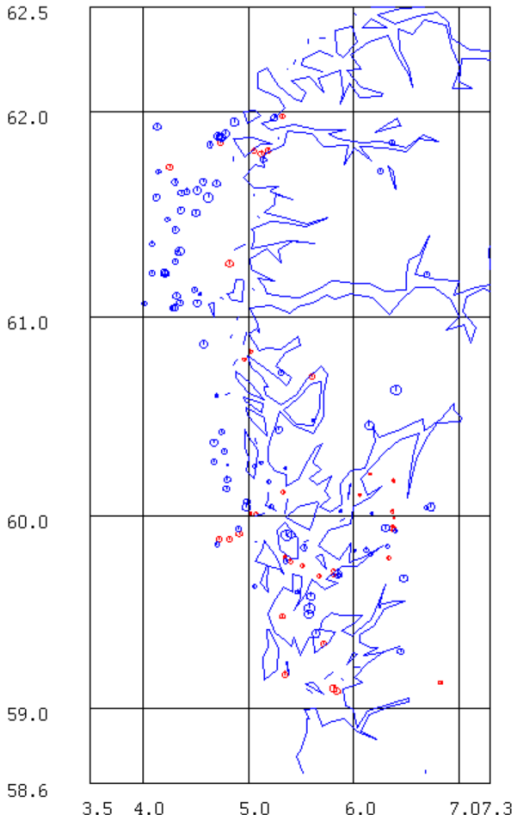
```
   4  2004 1101 2226 58.4 L* 60.541   4.799 18.3  BER 21 .50 2.6LBER 2.0CBER
   5  2010 1220 0043 23.9 LQ 59.892   5.347 12.4  BER 39 .80 3.0LBER 2.5CBER
   6  2010 1220 1230 12.7 LQ 59.902   5.403 17.2  BER 41 .10 3.3LBER 2.6CBER
   7  2011 0721 0059 16.9 LQ 60.969  11.561 19.6  BER 68 .70 3.3LBER 3.2WBER
   8  2012 0324 1106 30.5 L  60.635   6.401 15.5  BER 51 .70 3.0LBER
   9  2015 0429 2246 20.7 LQ 59.306   7.076 12.5F BER 62 .90 3.6LBER
  10  2018 0331 0405 12.1 LQ 60.237   5.342 27.0F BER 19 .60 0.8LBER
  11  2019 0517 0122 59.0 LQ 59.769   5.400 13.7  BER 38 .10 1.6LBER
  12  2019 0607 1217 46.9 L  59.877   6.572  1.5  BER 47 .30 1.7LBER
  13  2021 0524 1802 26.8 LQ 59.837   7.881 12.1F BER 83 .90 2.4LBER 2.7WBER
```

Plot two or more data sets with different color

It is sometime useful to plot different data sets with different colors like comparting locations with different models or different colors for different depths. Use file wn-grid.cat to select out events deeper than 5 km in file epi-deep and shallower than 5 km in epi-shallow. Now plot the 2 data sets:

```
map

  Options, by interactive input or as arguments
  The first argument is filename so e.g. map select.out f s

  s: plot stations in S-file as triangles
  S: --------- with stations code above
  a: plot all stations as triangles
  A: --------- with stations code above
  f: plot fault plane solutions
  e: plot error ellipse
  m: plot epicenter symbol according to magnitude range
  l: plot localities names
  r: plot rays
  n: do not plot text to the left
  N: number events

  Input files, optional color like eev.out 1, default is red
  Colors are 1:blue 2:green 3:red 4:yellow 5: white 6: black
  End with enter
epi-shallow 3
epi-deep 1

  Plot stations(s), stations  with code(S), fixed size for magnitude symbols(m),
```

```
  Plot all stations(a), all stations with code(A)
  fault plane solutions(f), locality(l), rays(r), number events(N)
  error ellipses(e) e.g. sf, enter for none

End of s-file
End of s-file
```



Another way of plotting 2 or more data sets is to edit the map.inp file and add the name of the files (see above).

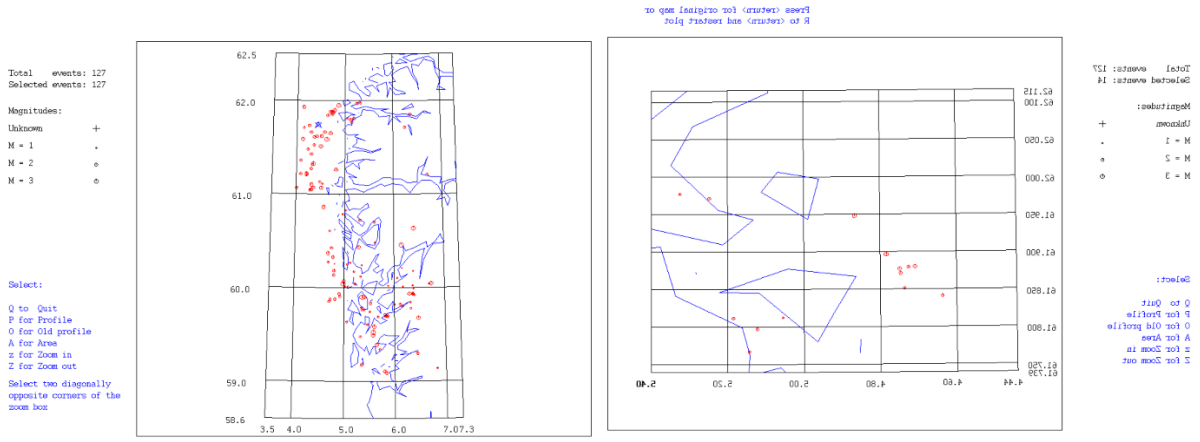
Interactive use of MAP

Once the plot is on the screen there are several interactive options:

Zooming

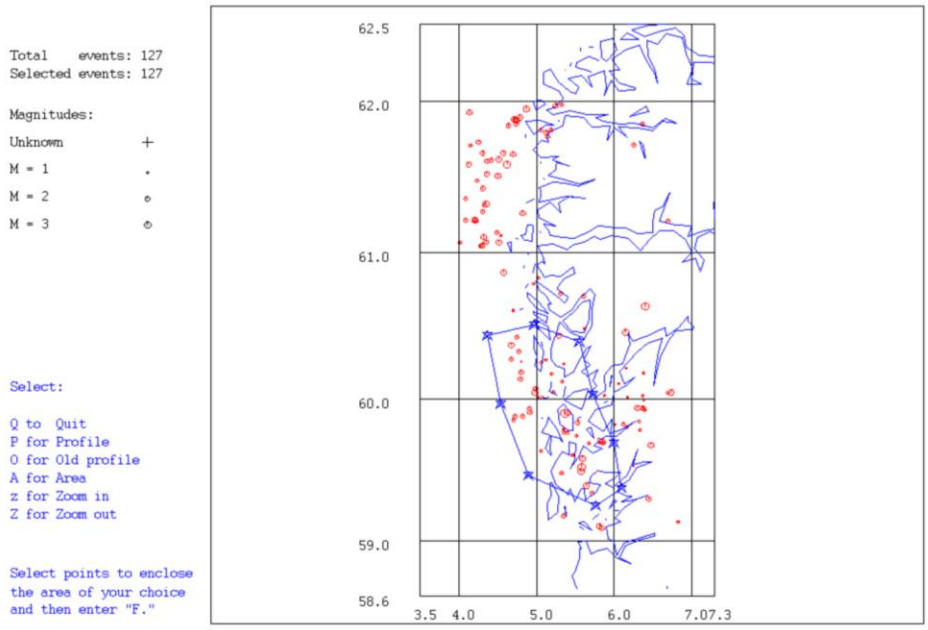
Options z is to zoom in. Press z and click the cursor at the corners of the area to be selected and the new plot comes up. Zoom in zoom can be done. To zoom out just press Z and a fixed zoom out is done. To get back to the original plot, press any key.

```
map wn-grid.cat
```

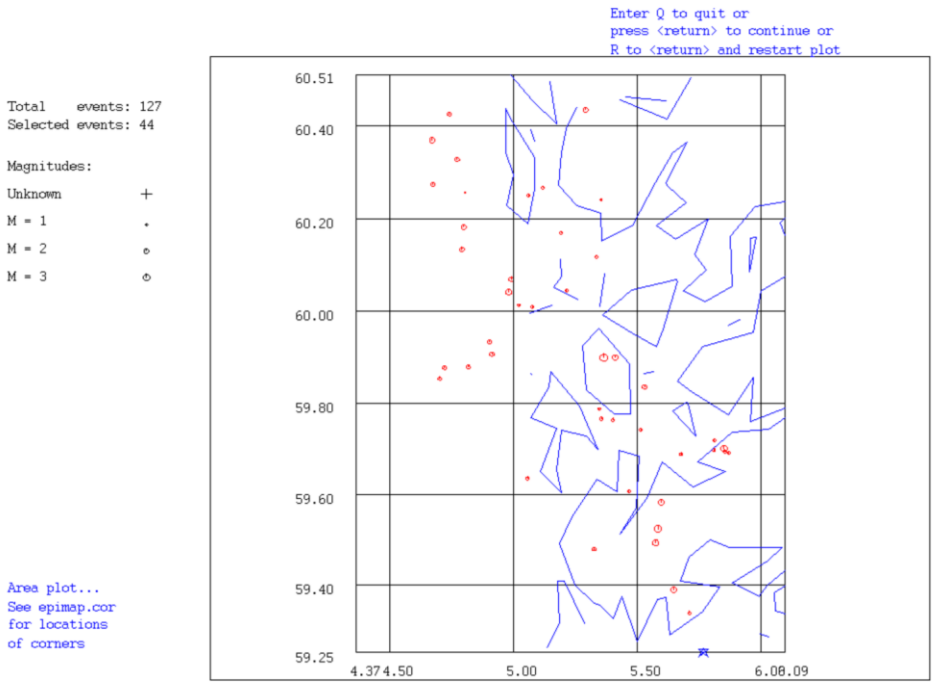


Selecting a subset of events interactively

Searching events inside a polygon or a square can be done with SELECT, but it is often more practical to select events interactively using an epicenter map. This can be done with MAP. Use command map wn-grid.cat and when the plot comes up, press ‘a’ and click on the map to select a polygon:



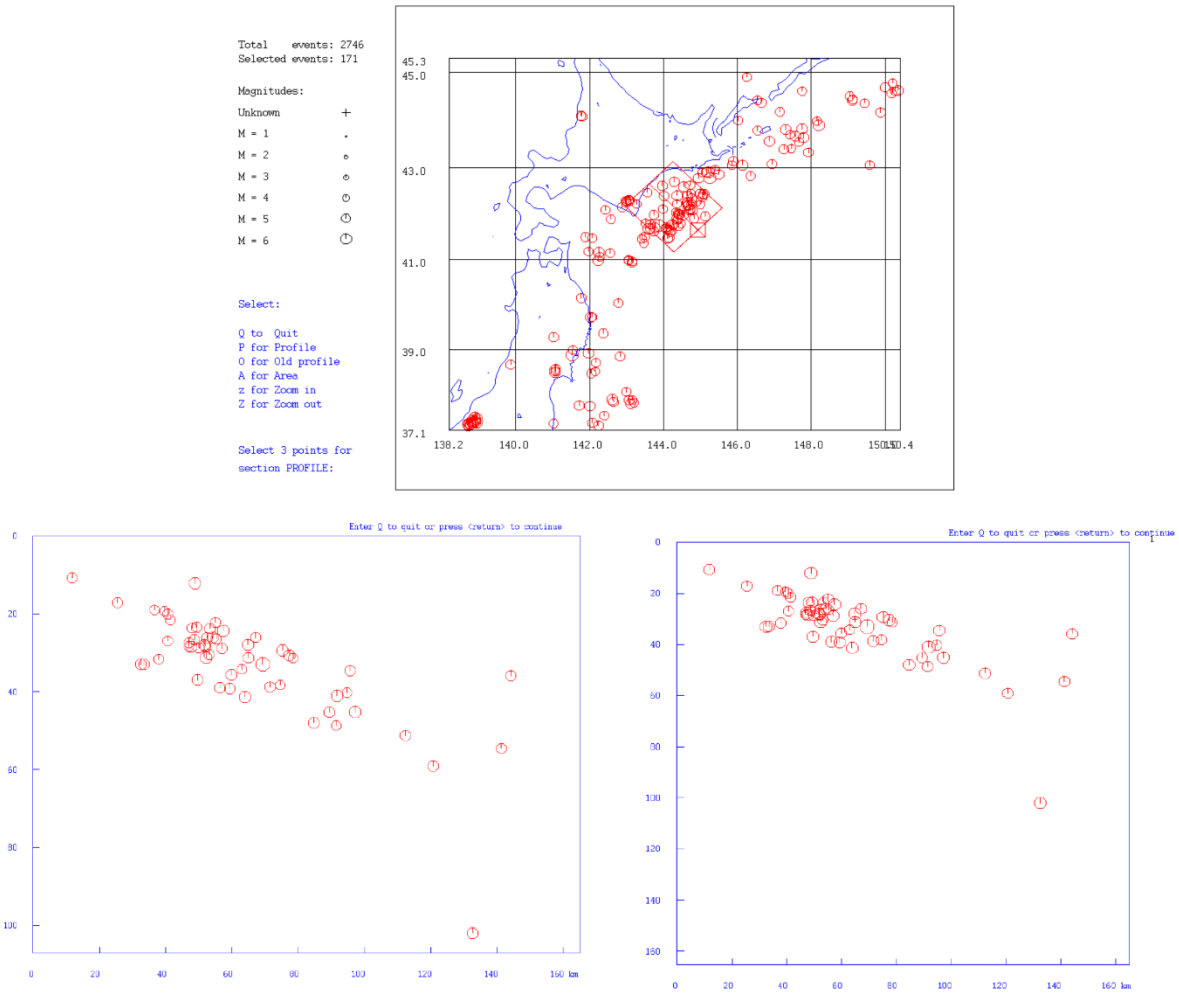
Now press ‘f’ and the selected area comes up



Press ‘q’ for quit and the data in the selected area is stored in file epimap.are. The corners of the polygon selected are in file epimap.cor.

Depth profile

The MAP program is the only one that can make depth profiles. The location of the depth profile is selected by pressing first ‘p’, the selecting the start point, end point and width with a mouse click. Another mouse click and the profile comes up. By default, the plot scale so maximum space is used for the depth, but if ‘f’ is pressed instead of the 4’th click, the two axis have the same scale. Below is an example from the Japanese subductions zone. The data first zoomed and then the profile was selected. Below left is automatic scaling and right is fixed scaling. The hypocenter file to use is 2002-2004.isc.



The specifics for the profile is stored in profile.out:

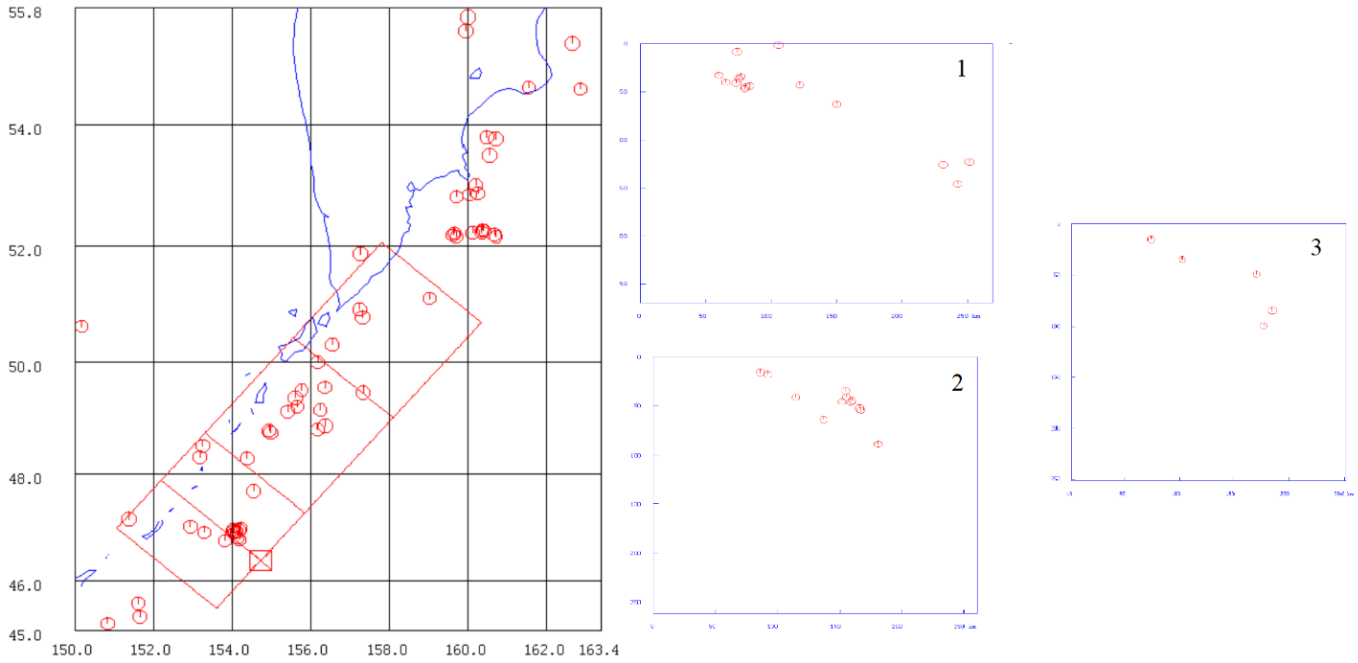
```
41.65381 144.93161   42.65375 143.60347   42.68427 144.84859
   107.1
       1
 42.1323891        145.584549
 41.1716499        144.278671
 42.1791153        142.950531
 43.1247902        144.256409
```

The first line gives latitude and longitude of the 3 points used for selecting profile, next line is the azimuth calculated for the profile. The third line gives the number of profiles (see below). The following 4 lines are the coordinates of the corners (lat, lon) of the area for the profile. The file can be used to repeat the same profile as in an earlier run or to prepare a more exact profile than

can be selected with the cursor. When the map is shown, the profile from profile.out can be selected by pressing ‘o’.
The numbers (length and depth in km) used for profile are listed in profile.num which can be used for making nicer plots in other software:

```
59.3160400       39.2000008
132.566437       102.000000
52.2672462       31.2999992
49.9655228       28.7999992
69.3206177       33.0000000
77.3613052       30.7000008
71.4965134       38.7999992
144.190857       35.9000015
37.8892822       31.7000008
47.0087051       27.5000000
…
…
```

Up to 9 profiles can be made at the same time. When selecting the profile, the 3. click will be the number of profiles. The profiles are shown one at a time, use ‘f’ to go to the next one. Example with 3 profiles:



Note that the size of the depth profile is determined from the first profile, so if events in later profiles are deeper than events in the first profile, they will not be shown. Fault plane solutions can also be shown on the profiles, see above.

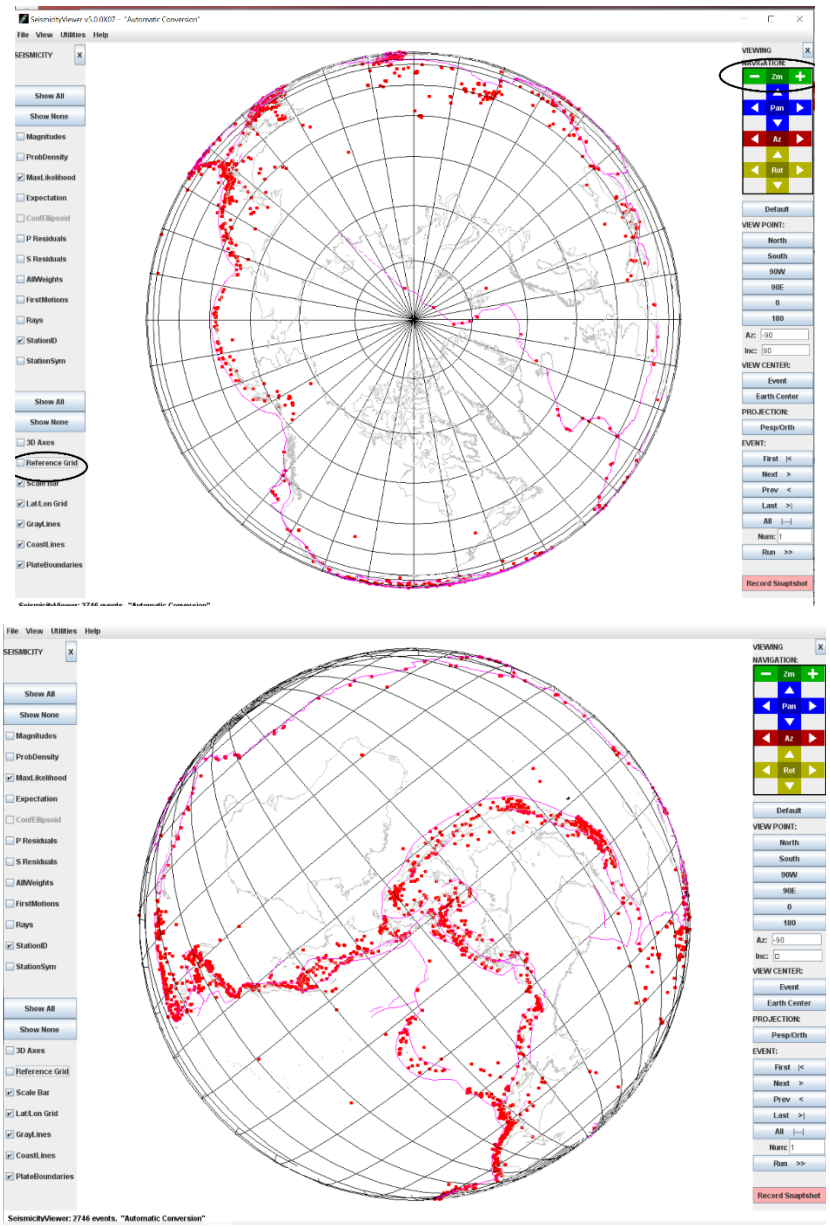
SeismicityViewer, interactive 3D plot, command smap

The program is an implementation of the SeismicityViewer50 program by Anthony Lomax (http://alomax.free.fr/seismicity/).

The program can only use S-files, not compact files (optionally it is possible, see manual) and all options have not been implemented. The command

```
smap 2002-2004.isc
```

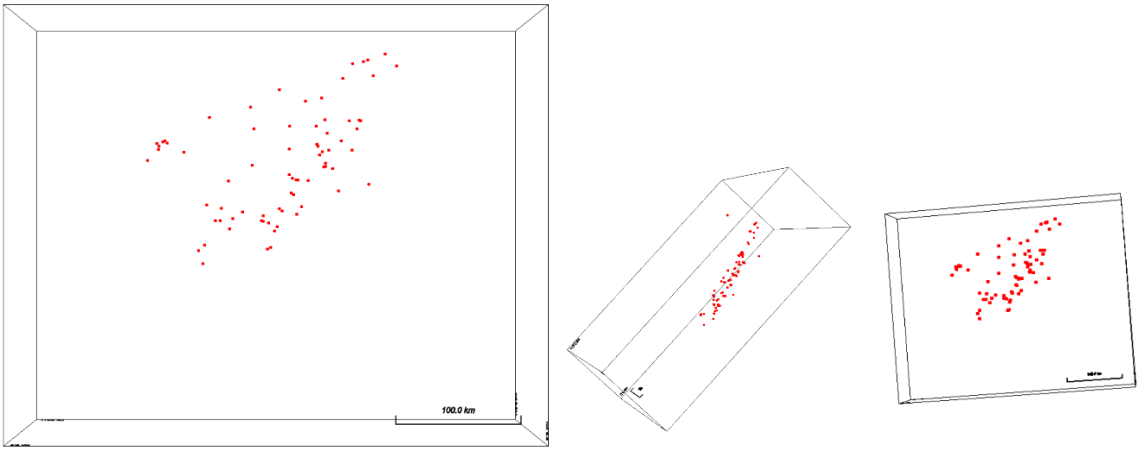
is used to make the plot below. The figure may come up very big so use Zoom (upper right corner) to make it fit on the screen and click Reference grid (lower left corner) to take grid lines away. The plot can now interactively be rotated (right figure). It shows coastlines and tectonic boundaries in global mode which is when the distance between epicenters is more than 8 degrees. For local mode, no boundaries are shown.



The program can be useful to visualize seismicity in 3D for local earthquakes. Make a file with the events used for the Japanese depth profile with the MAP area option to get a file epimap.are. Then write

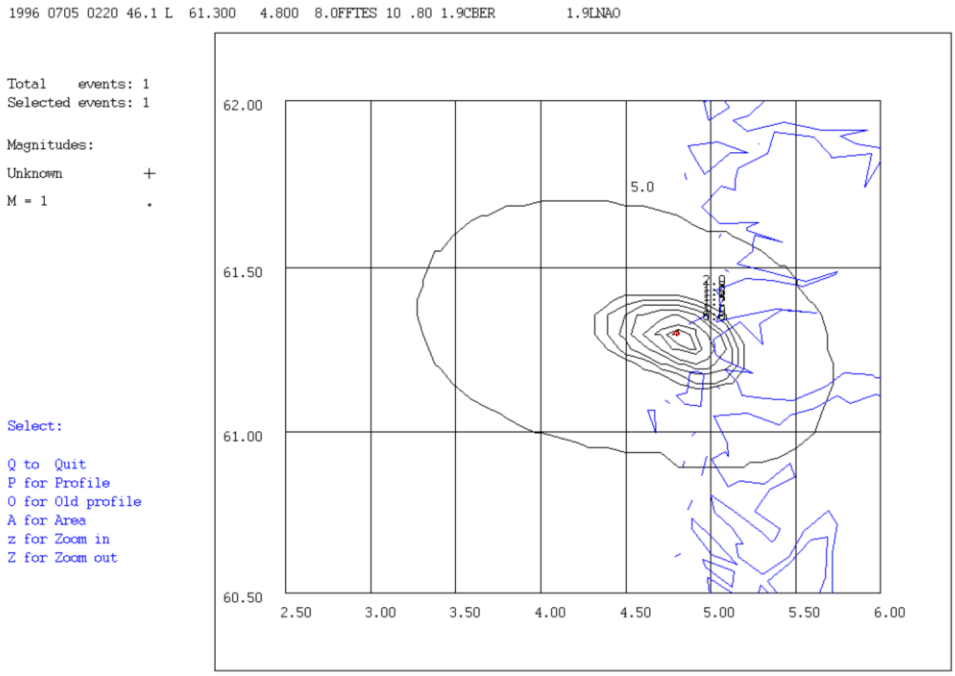
```
smap epimap.are
```

The plot to the left is a horizontal view and the two others are rotated in 3D.



Plotting contours with EPIMAP

EPIMAP has a routine for making contours. In SEISAN it is only used in EEV for plotting contours when doing a grid search for epicenter location, command grid.



The red dot shows the normal location, and it is seen that the grid search shows its minimum rms at almost the same location. The input file with the contour specification has this format (see EPIMAP for more details):

```
Fields to use
```

```
 Latitude range and number of values        60.500    62.000        31
 Longitude range and number of values        2.500     6.000        36
 Contour level to plot and color          90.0
 Contour level to plot and color          50.0
 Contour level to plot and color          20.0
 Contour level to plot and color           5.0
 Contour level to plot and color           2.0
 Contour level to plot and color           1.8
 Contour level to plot and color           1.6
 Contour level to plot and color           1.4
 Contour level to plot and color           1.2
 Contour level to plot and color           1.0
 Contour level to plot and color           0.9
 Contour level to plot and color           0.8
 Contour level to plot and color           0.7
 Contour level to plot and color           0.6
 Contour level to plot and color           0.5
 Contour level to plot and color           0.4
 Contour level to plot and color           0.3
 Contour level to plot and color           0.2
 Contour level to plot and color           0.1
   2.50000000       60.5000000       10.9673882
   2.59999990       60.5000000       10.8201189
   2.70000005       60.5000000       10.6776829
   2.79999995       60.5000000       10.5454350
   2.90000010       60.5000000       10.4444952
   3.00000000       60.5000000       10.3622761
   3.09999990       60.5000000       10.2919874
-- More (2%) --
```

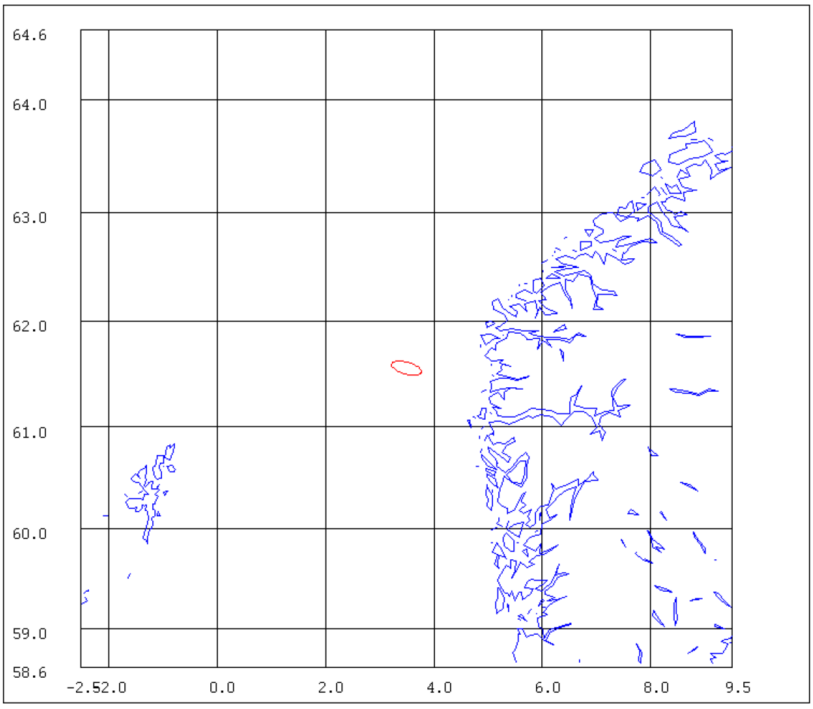
Map options in EEV and SE

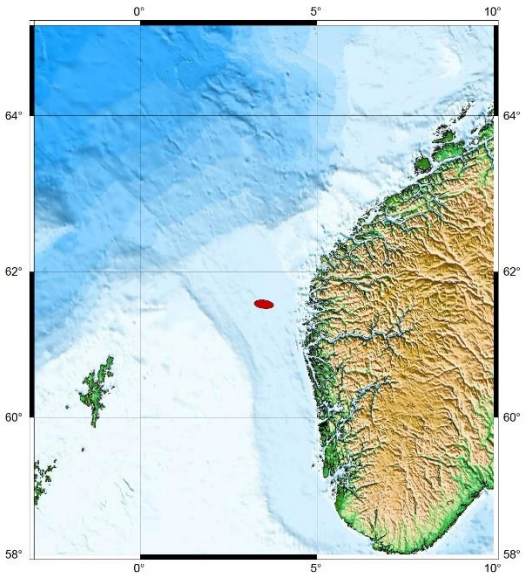
Some of the programs can also be used from EEV and SE to show single events (EEV and SE) or a selection of events (SE). In addition, GoogleMap can be used from EEV. Commands in EEV are

```
 gmap:      Make epicenter map with Google Map
 map:       Make a map of current location with EPIMAP
 mapf:      Makes a map like the MAP command showing fps if there
 mape:      Makes a map like the MAP command showing  error ellipse
 mapg:      Makes a GMT map like the MAP command
 mapgf:     Makes a GMT map like the MAP command showing fps if there
 mapge:     Makes a GMT map like the MAP command showing error ellipse
```

```
mapgm:     Makes a GMT map like the MAP command showing moment tensor
```

The majority of plots look like the maps shown above for MAP and MAPG so not all will be shown. Examples for MAPE for event June 23, 03:37 1996 in the TEST data base and MAPG for the same event:



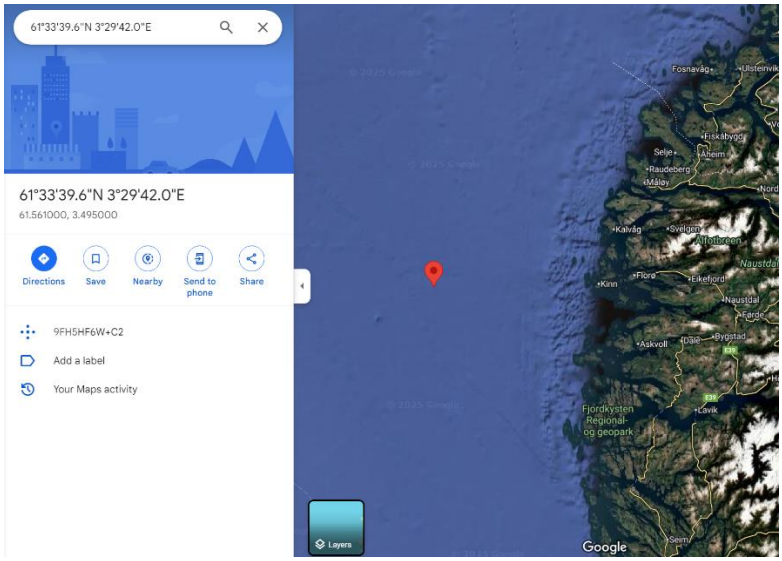


Since there is only one event, the size of the map must be predefined and this is done in SEISAN.DEF:

```
MAP_LAT_BORDER      dist from center        3.0
MAP_LON_BORDER           "                  6.0
MAP_LAT_LON_DIV     lat-long divisions      1.0       2.0
```

These limits for the size of the map are also used for MAPG but not the divisions.

Using the command gmap for the same event gives:



From SE, the MAP program can be used with the only difference that several events can be selected and plotted. Open SE with events from July 1996:

```
se 199607
```

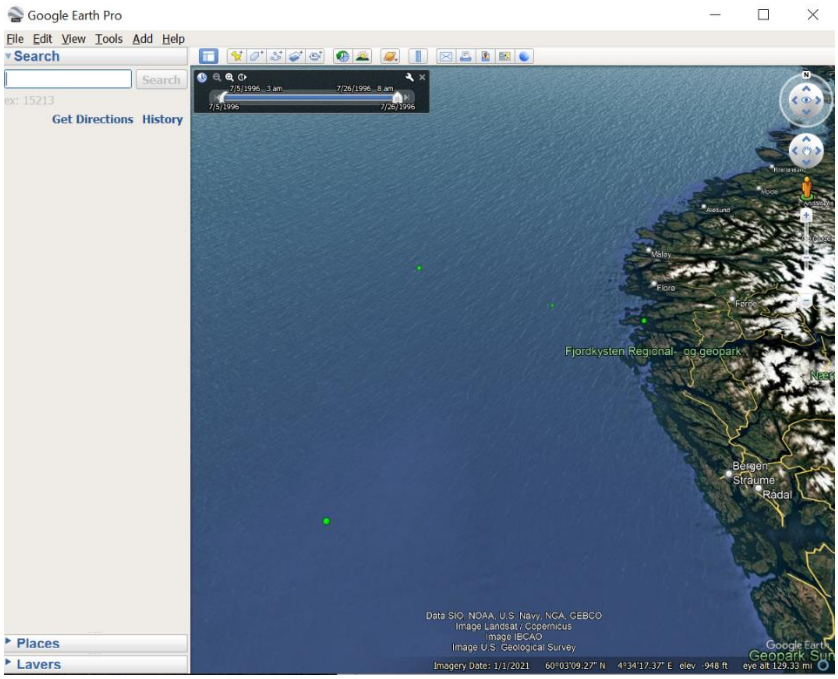
Seisan Explorer 2.7.4 [TEST_ (c:\seismo\REA\TEST_) 5 events] [C:\seismo\WOR\MAP]

File Event List Statistics Help

Log TEST_

Row	Ac	Date and Time	Lat	Lon	Dep	Mod	Ag	RMS	Gap	ELat	ELon	EDep	DI	EI	MInt	NSt	M	MW	ML	Mw
1	SPL	1996-07-05 02:20:46.50	61.2870	4.8290	8.0		TES	0.40	190	4.5	12.0	7.5	L			10	2.0		2.0	
2	SPL	1996-07-13 05:56:46.00	61.4190	3.8720	12.2		TES	0.50	265	3.3	20.8	12.8	L			9	1.5	1.6	1.5	
3	SPL	1996-07-18 09:46:51.40	60.1580	2.0700	15.0		TES	1.10	285	8.5	39.7	25.0	L			9	1.8	2.1	1.8	
4	LOC	1996-07-18 22:55:08.10	51.6880	157.5710	31.2		BER	0.50	347	92.1	144.7	5.3	D			17	5.4			
5	SPL	1996-07-26 07:42:12.00	61.7560	2.3160	20.8		TES	0.40	280	13.1	59.8	45.6	L			9	1.8	2.0	1.8	

The local events have been highlighted and can now be plotted with command ‘M’ for MAP or ‘G’ for GoogleEarth. For GoogleEarth, the program must be installed and started and when pressing ‘G’, a file gmap.cur.kml is generated in working directory and must be opened in GoogleEarth (File).

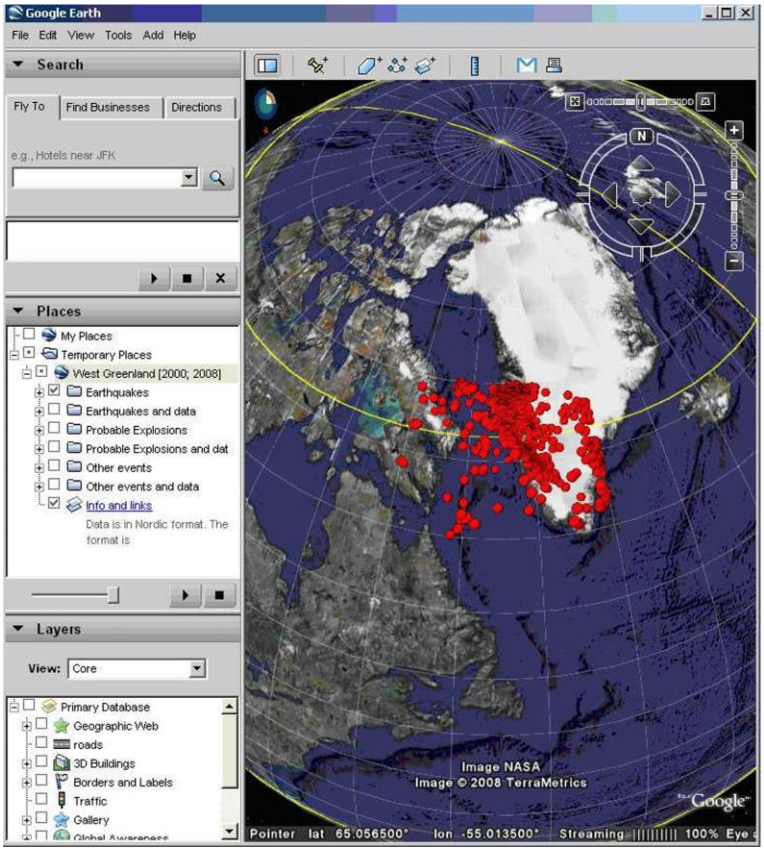


With SE, there is also option ‘V’ to map the data with SeismicityViewer, see above.

Epicenter mapping with Google Earth

The command line program GMAP can be used to generate a KML file with information on multiple events. KML is readable by GIS programs such as QGIS and Google Earth. GMAP has several options on event; icon, coloring, style and size etc. GMAP reads output from COLLECT, SELECT or single event files in the Nordic format.

The events are separated into KML layers with regard to event type. The parameters used for changing the default GMAP parameters is described in the SEISAN manual (e.g. v13) under section "GMAP, Plotting epicenters with Google maps or Google Earth". Below is shown a plot of epicenters in Google Earth using a GMAP generated KML file.



When events are located in SEISAN, a KML file can be generated automatically, if selected in SEISAN.DEF. The KML file named 'gmap.cur.kml' is readable by GIS programs such as QGIS

and Google Earth. The KML file contains information on the recent location of the epicenter, its error ellipse, the magnitude, the stations used for the location, station residuals and if present the prior location of the epicenter. The figure below shows a KML file plotted in Google Earth.

By using the NetworkLink feature one can use Google Earth to reload the KML file at short intervals e.g. every 3 seconds, and thereby automatically plot a map of the recently located event as seen in the figure below. The feature is useful during analysis since epicenters can be displayed on satellite photos, visualizing critical infrastructure, and the error ellipse and station used, and coloring provide information on location quality. Below is shown SEISAN KML file plotted in Google Earth, epicenter, error ellipse, stations and station paths are seen. The stations used stations are colored with respect to the travel time residual.