GMT examples:

Plotting *SKS-SKKS* pierce point areas in D”

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General information

If you make use of the content described in this manual please give reference to my disseration in which a slightly modified version of the presented map is included:

> Grund, M. (2019), *Exploring geodynamics at different depths with shear wave splitting*, Karlsruhe Institute of Technology (KIT), doi:10.5445/IR/1000091425.

1 Plotting the map

All content shown in the following is based on the bash-script `Scan_SKS_SKKS.gmt` that can be downloaded together with all required files (station locations, event-station paths, colormaps etc.) from https://github.com/michaelgrund/GMT-plotting. If GMT 5.2.1 (or higher, Wessel et al., 2013) is installed on your (Linux) system you can directly reproduce the whole content shown in this manual by running `Scan_SKS_SKKS.gmt` via command line. In the following the individual steps to get the final figure are lined out.

1.1 Basic settings

```
#!/bin/bash

gmtset   MAP_GRID_PEN_PRIMARY  0.3p,dimgrey        \
         PROJ_LENGTH_UNIT          c          \
         MAP_ANNOT_OBLIQUE         30         \
         MAP_ANNOT_OFFSET          5p         \
         MAP_ANNOT_OFFSET_PRIMARY  5p      \
         MAP_ANNOT_OFFSET_SECONDARY  5p    \
         COLOR_MODEL       rgb        \
         FONT_ANNOT_PRIMARY  8p,Helvetica  \
         FONT_LABEL  8  \
         MAP_FRAME_TYPE  plain  \
         MAP_FRAME_WIDTH  2p  \
         FORMAT_GEO_MAP  F  \
         MAP_TICK_LENGTH_PRIMARY  12p  \
         MAP_FRAME_PEN   1.2p,black  \
         MAP_LABEL_OFFSET  5.5p

################################################################################################
```

```
# GMT (5.2.1) script to plot pierce point areas of SKS-SKKS in D"
################################################################################################

# 2019, Michael Grund (KIT Karlsruhe, Geophysical Institute)

################################################################################################
# If you use the content of this script or the accompanying files please acknowledge GMT,
# as well as my PhD thesis (DOI: 10.5445/IR/1000091425) in which a modified version of the
# generated map is included.
################################################################################################

# output file
psMAP=MapScandi

################################################################################################
```

1.2 Plot raw map with landmasses and plate boundaries

```
##########
# Fig. 1 # plot geographic content first
##########

# squared map mercator
projJ="ml:55000000"
projR=0/40/53/72
mapframes=SWnE
coloral1=197.6/197.6/197.6

pscoast -Rg -JG20/63.5/4.5i -B15g15 -Dc -G$coloral1 -A500000 -C$coloral -Wblack -K -P > $psMAP
pscoast -Rg -JG20/63.5/4.5i -B15g15 -Dc -G$coloral1 -C$coloral -Wblack \
    -K -O -P >> $psMAP

# plot plate boundaries
psxy -J -R PB2002_boundaries_GMTready.txt -Wlp,245.7600/204.8000/204.8000 -O -K >> $psMAP
pscoast -Rg -JG20/63.5/4.5i -B15g15 -Dc -G$coloral1 -A500000 -Wblack -C$coloral1 \
    -K -O -P >> $psMAP

################################################################################################
```

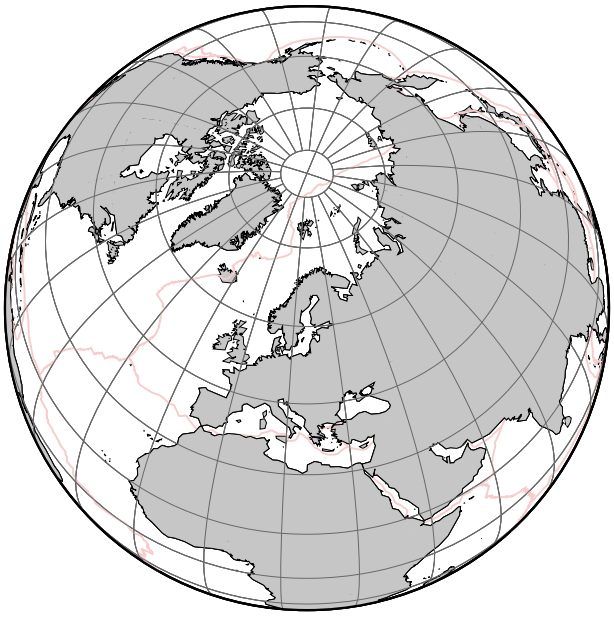

Figure 1: Plot a map centered on Fennoscandia and plate boundaries (red lines) after Bird (2003).

1.3 Plot raypaths from earthquake sources to station locations

```
##########
# Fig. 2 # plot raypaths from earthquake source locations to station locations in Fennoscandia
##########

psxy SKS_SKKS_paths_Ddprime.geo -: -R -J -O -K -W1 -Wblack -Gblack -t99  >> $psMAP

#################################################################################################
```

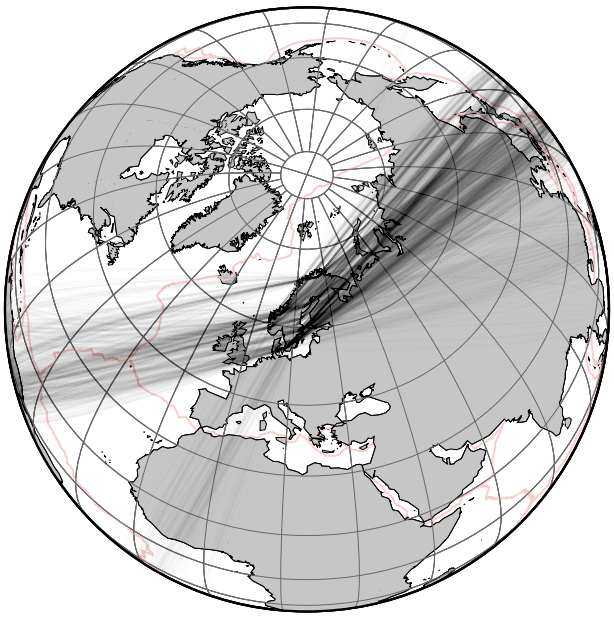

Figure 2: Plot raypaths (thin black lines) from earthquake source locations to station locations in Fennoscandia (stations are not shown here). Transparency of the raypaths allows to generate a kind of ray-density look.

1.4 Plot thick circles in red and orange that cover the D" pierce point areas

```
##########
# Fig. 3 # plot thick circles in red and orange that cover the D" pierce point areas of
########## SKS and SKKS

# !!! note: the circles are manually adjusted to fit the reuqired areas!!!

SA_centerN=63.5
SA_centerE=20

psxy -R -J -Wdarkorange -Sc122p -t45 -O -K -W30.5p << EOF >> $psMAP
$SA_centerE $SA_centerN
EOF

psxy -R -J -Wred3  -Sc60p -t45 -O -K -W30.5p << EOF >> $psMAP
$SA_centerE $SA_centerN
EOF

#################################################################################################
```

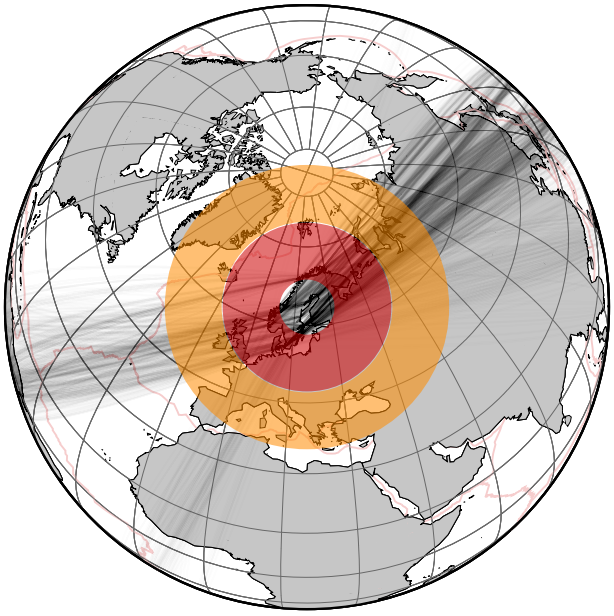

Figure 3: Plot thick circles in red and orange that cover the D" pierce point areas of *SKS* and *SKKS* (for the true locations of the pierce points see e.g. Grund & Ritter, 2019). The circles are centered approximately in the center of the seismic recording network ScanArray (Thybo et al., 2012; Grund et al., 2017). Please note: the circles are manually adjusted (size and linewidth) to fit the required areas.

1.5 Plot thinner black circles to overlay edges of red and orange circles

```
##########
# Fig. 4 # plot thinner black circles to overlay edges of red and orange circles
##########

psxy -R -J -Sc152p -O -K -t10 -Wblack -W0.8p  << EOF >> $psMAP
$SA_centerE $SA_centerN
EOF
psxy -R -J -Sc91p -O -K -t10 -Wblack  -W0.8p  << EOF >> $psMAP
$SA_centerE $SA_centerN
EOF
psxy -R -J -Sc30p -O -K -t10 -Wblack -W0.8p  << EOF >> $psMAP
$SA_centerE $SA_centerN
EOF

#############################################################################################
```

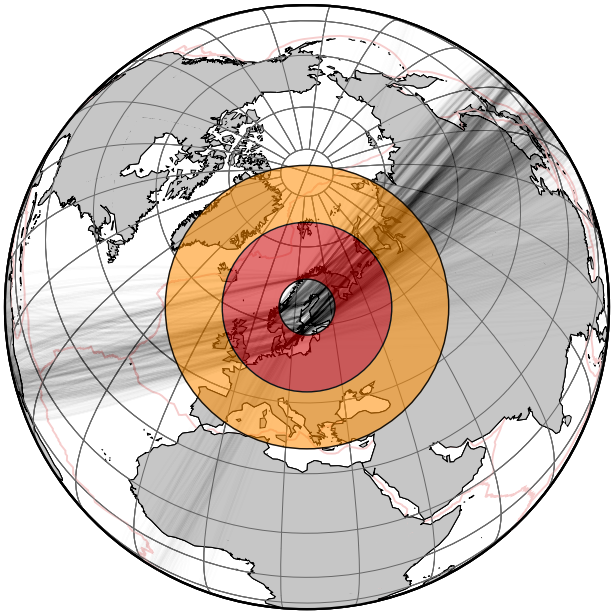

Figure 4: Plot thinner black circles to overlay edges of red and orange circles.

1.6 Plot zoom-in and dashed lines connecting the inset to the main map

```
##########
# Fig. 5 # plot area of zoom-in as well as dashed lines connecting the inset to the main map
##########

SA_insN=54.5
SA_insE=5

gmtset MAP_LINE_STEP 0.75p

psxy -R -J -Gblack -SV0c+e+n5.0c+a0 -W2.4,black,6_3:0p -K -N -O -t30 << EOF >> $psMAP
$SA_insE $SA_insN 131.17 6.4
EOF

psxy -R -J -Gblack -SV0c+e+n5.0c+a0 -W2.1,black,6_3:0p -K -N -O -t30 << EOF >> $psMAP
46 72 125.57 7.2
EOF

psxy -R -J -W1.2,white,6_3:0p -K -N -O -t30 << EOF >> $psMAP
5 54.5
-6 72
46 72
35 54.5
5 54.5
EOF

#############################################################################################
```

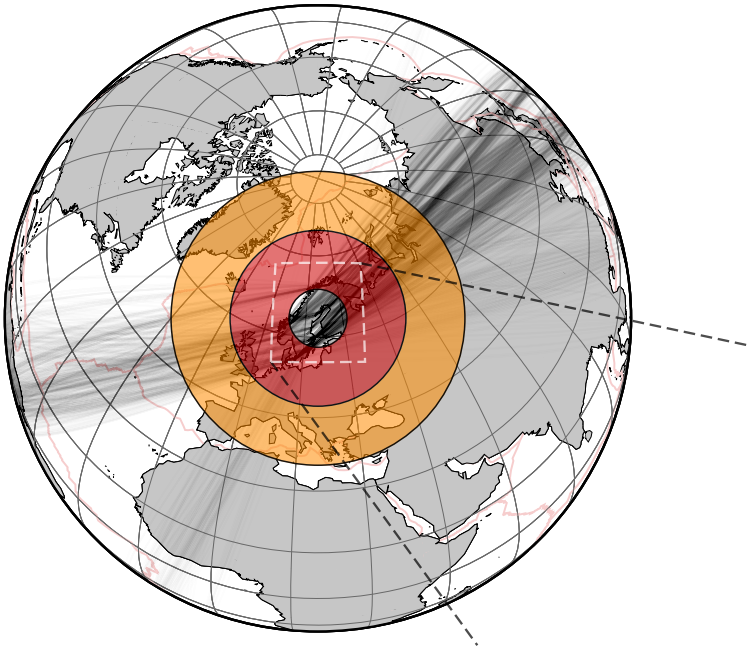

Figure 5: Plot zoom-in (white dashed) and black dashed lines connecting the inset (shown in Fig. 7) to the main map.

1.7 Add annotations, station marker and an exemplary raypath

```
##########
# Fig. 6 # add annotations, station marker and an exemplary raypath as white line
##########

# annotation SKS in red
pstext -R -J -F+f10p,darkred -Gwhite@30 -TO -O -K <<EOF >> $psMAP
$SA_centerE 53 SKS
EOF

# annotation SKKS in orange
pstext -R -J -F+f10p,darkorange -Gwhite@30  -TO -O -K <<EOF >> $psMAP
$SA_centerE 41 SKKS
EOF

# single raypath
psxy SKS_SKKS_paths_Ddprime_single.geo -: -R -J -O -K -W1 -Wwhite,-- -Wthicker \
    -Gblack    >> $psMAP

# station marker
psxy -R -J -St20.5p   -O -K -t5 -Wwhite -Gblue -W1.3p  << EOF >> $psMAP  # path connection
$SA_centerE $SA_centerN
EOF

# contients
pstext -R -J -F+f10p -N -O -K <<EOF >>$psMAP
21.00 18.38 Africa
-114.553  53.099 North America
175 80 North Pole
#-13.708 47.388 Europe
EOF

# Asia
pstext -R -J -F+f10p,Helvetica,black -Gwhite@30 -N -O -K -t30 <<EOF >>$psMAP
98.255 37.704 Asia
EOF
```

```
# north pole annotation
pstext -R -J -F+f10p,Helvetica,black -Gwhite@30 -N -O -K <<EOF >>$psMAP
175 80 North Pole
EOF

# arrow to north pole
psxy -R -J -Gblack  -SV1.2c+e+n2.0c+a60 -W10.4,black -K -N -O  << EOF >> $psMAP
175 82.5 -0.7 .65
EOF

# epidistance annotation
pstext -R -J -F+a14+f8p,Helvetica,black -Gwhite@30 -N -O -K <<EOF >>$psMAP
-40 33 epicentral distance
EOF

#################################################################################################
```

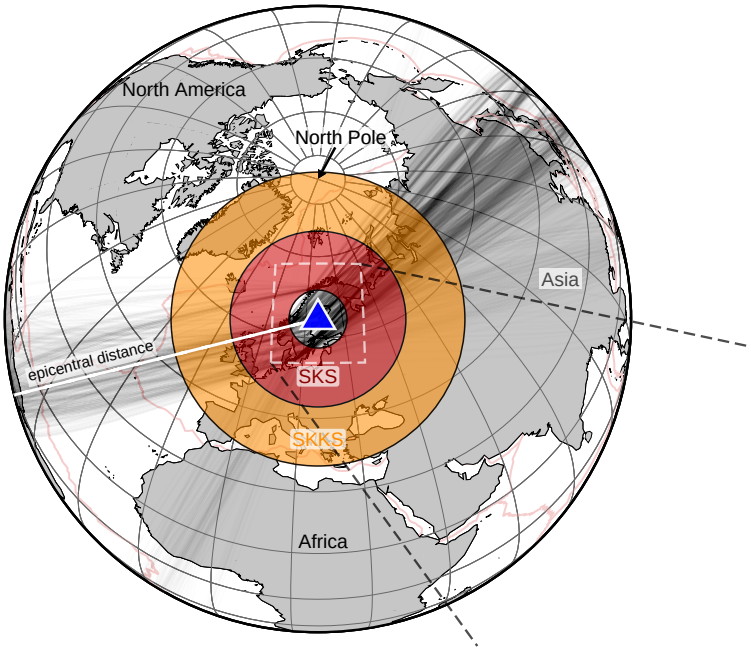

Figure 6: Add annotations, station marker (blue triangle) and an exemplary raypath as white line.

1.8 Plot inset with zoom-in map in lower right corner

```
##########
# Fig. 7 # plot inset with zoom-in map in lower right corner
##########

# map settings
projJ="l20/60/16/80/1:20000000"
projR=3.5/36.5/54/71.5r

# gridfile
grd=etopo1_bedrock.grd

mycpt=topo_mod.cpt

gmtset MAP_TICK_LENGTH_PRIMARY 3.5p
gmtset MAP_ANNOT_OFFSET_PRIMARY 3p
gmtset MAP_ANNOT_OFFSET_SECONDARY 3p
```

```
makecpt -C$mycpt -T-4000/1500/10 -Z > topo_scandi_mod.cpt
grdimage $grd -JE20/60/5c -R4.5/53.5/45/71.4r -Ctopo_scandi_mod.cpt -I$grd.grad \
    -Bx10g5 -By5g5 -BSE -X3.4i -Y-0.12i -O -K >> $psMAP

# add scale
pscoast -R -J -B0NW -Dh -A100 -N1 -N3/1.5p,red -Lf3.1/70/70/400+lkm+jt -F+gwhite+r -O -K -t30
>> $psMAP
pscoast -R -J -B0NW  -Dh -A100 -N1 -N3/1.5p,red -Lf3.1/70/70/400+lkm+jt -O -K >> $psMAP

#############################################################################################
```

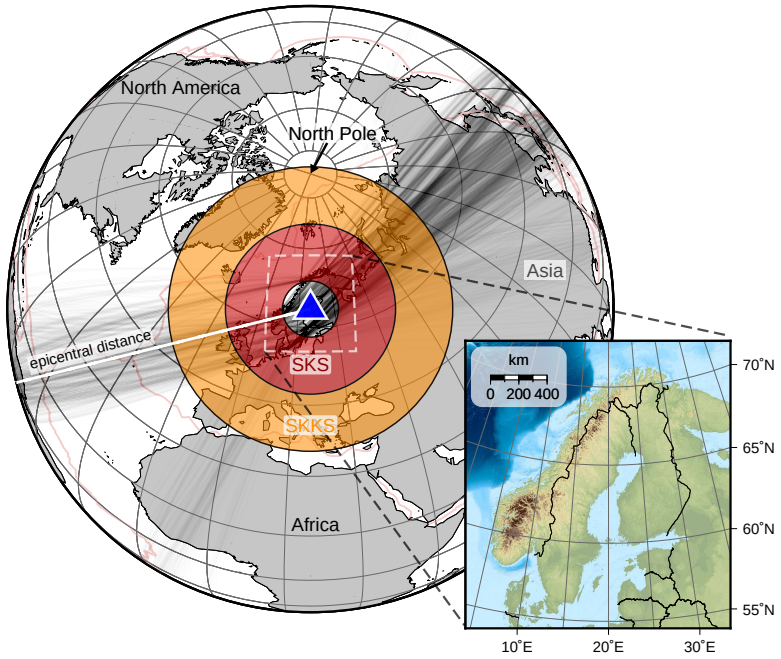

Figure 7: Plot inset with zoom-in map focused on Fennoscandia. Furthermore, add a scale.

1.9 Plot station network and add final annotations

```
##########
# Fig. 8 # plot station network and add annotations
##########

# all stations
awk '{print $2, $3}' sta_coordinates_all.txt | psxy -R -J -K -St0.2c -Wthinner,white \
    -Gblue -O >> $psMAP

add annotations
pstext -: -R -J -F+f8p,Helvetica,black -D0.25/-0.25 -Gwhite@30 -O -K << EOF >> $psMAP
61.38   5.0 Norway
59.7  14.0 Sweden
63.1  24.3 Finland
EOF

#########################

ps2pdf $psMAP $psMAP.pdf
pdfcrop $psMAP.pdf $psMAP.pdf

#########################
```

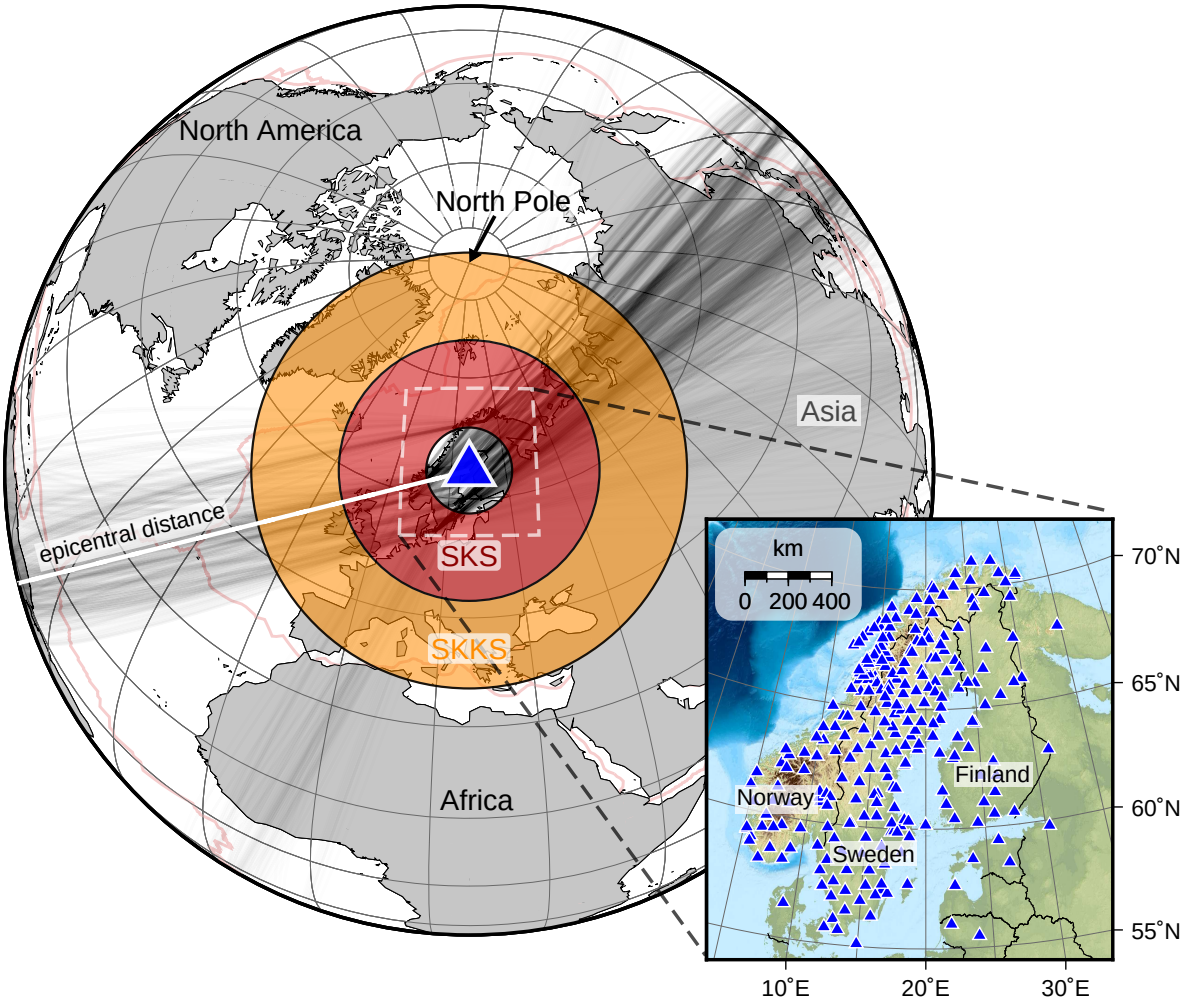

Figure 8: Finally plot station network (blue triangles) and add further annotations.

References

Bird, P., 2003. An updated digital model of plate boundaries, *Geochem. Geophys. Geosyst.*, **4**, 1027.

Grund, M. & Ritter, J. R. R., 2019. Widespread seismic anisotropy in Earth's lowermost mantle beneath the Atlantic and Siberia, *Geology*, **47(2)**, 123–126.

Grund, M., Mauerberger, A., Ritter, J. R. R., & Tilmann, F., 2017. Broadband Recordings for LITHOS-CAPP: LITHOspheric Structure of Caledonian, Archaean and Proterozoic Provinces Sep. 2014 - Oct. 2016, Sweden and Finland, Scientific Technical Report STR-Data 17/02, GIPP Experiment and Data Archive, Potsdam: GFZ German Research Centre for Geosciences.

Thybo, H., Balling, N., Maupin, V., Ritter, J., & Tilmann, F., 2012. ScanArray Core (1G 2012-2017), Seismic Network, The ScanArray consortium.

Wessel, P., Smith, W. H. F., Scharroo, R., Luis, J., & Wobbe, F., 2013. Generic Mapping Tools: Improved version released, *Eos Trans. AGU*, **94(45)**, 409–420.