

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 dissertation 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](https://doi.org/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="m1:55000000"
projR=0/40/53/72
mapframes=SWnE
colorall=197.6/197.6/197.6

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

```

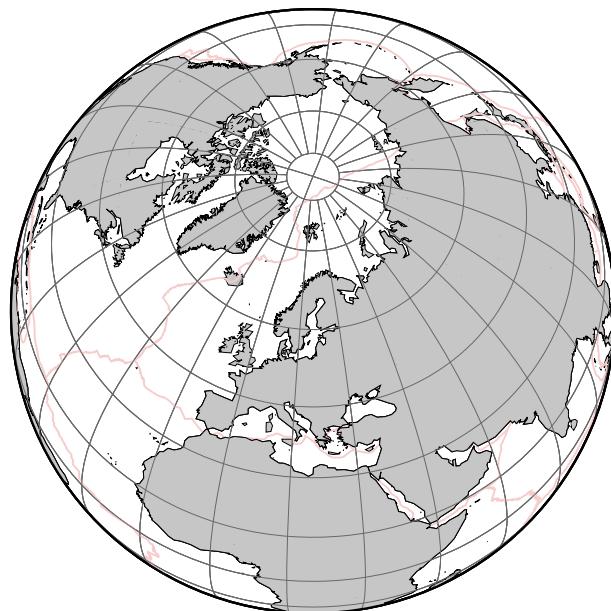


Figure 1: Plot a map centered on Fennoscandia and plate boundaries (red lines) after [Bird \(2003\)](#).

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

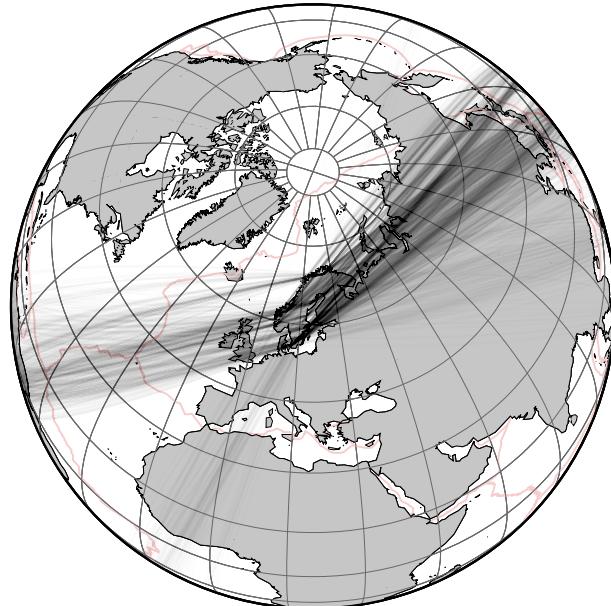


Figure 2: Plot raypaths (thin black lines) from earthquake source locations to station locations in Fennoscandia (stations are not shown here). Transparency of the raypaths allows to generate a kind of ray-density look.

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 required 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
#####
#####
```

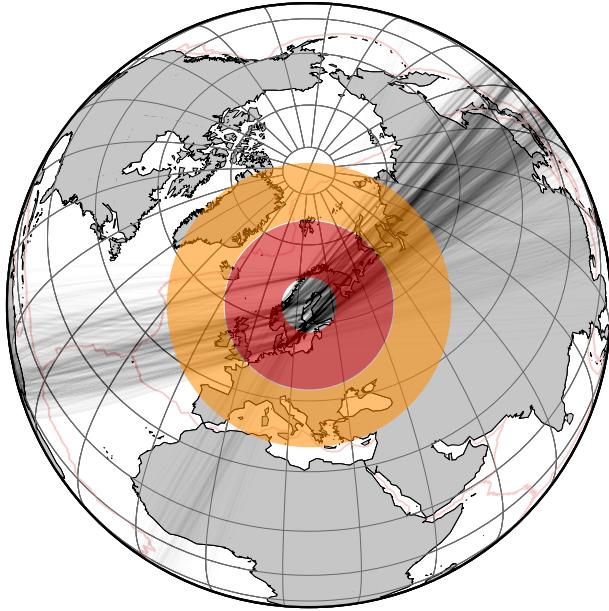


Figure 3: Plot thick circles in red and orange that cover the D'' pierce point areas of SKS and SKKS (for the true locations of the pierce points see e.g. [Grund & Ritter, 2019](#)). The circles are centered approximately in the center of the seismic recording network ScanArray ([Thybo et al., 2012](#); [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
#####
#####
```

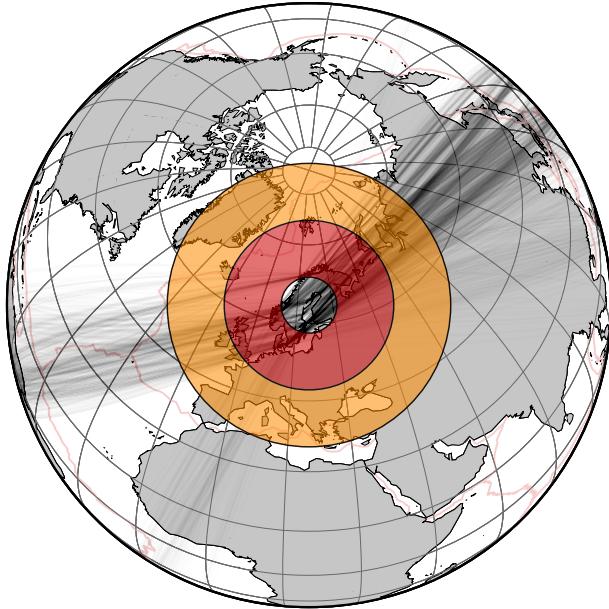


Figure 4: Plot thinner black circles to overlay edges of red and orange circles.

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

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

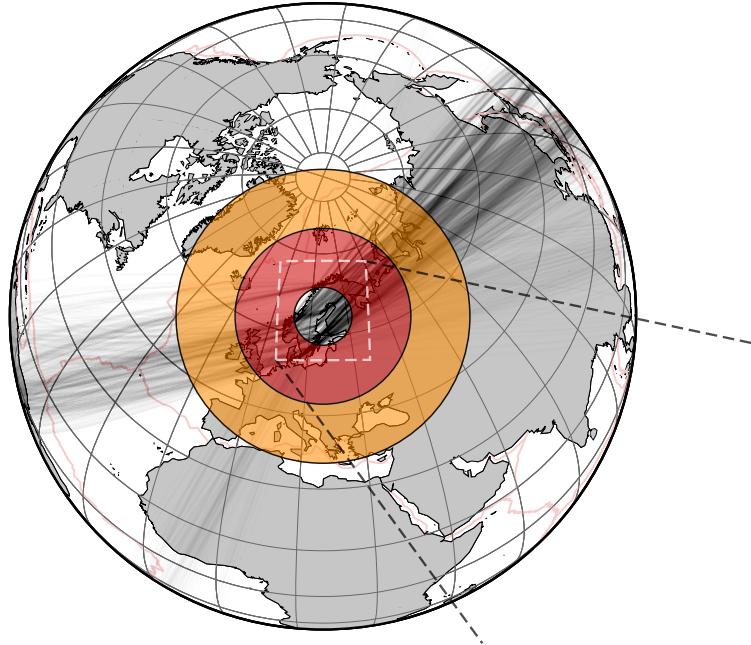


Figure 5: Plot zoom-in (white dashed) and black dashed lines connecting the inset (shown in Fig. 7) to the main map.

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

# continents
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

#####

```

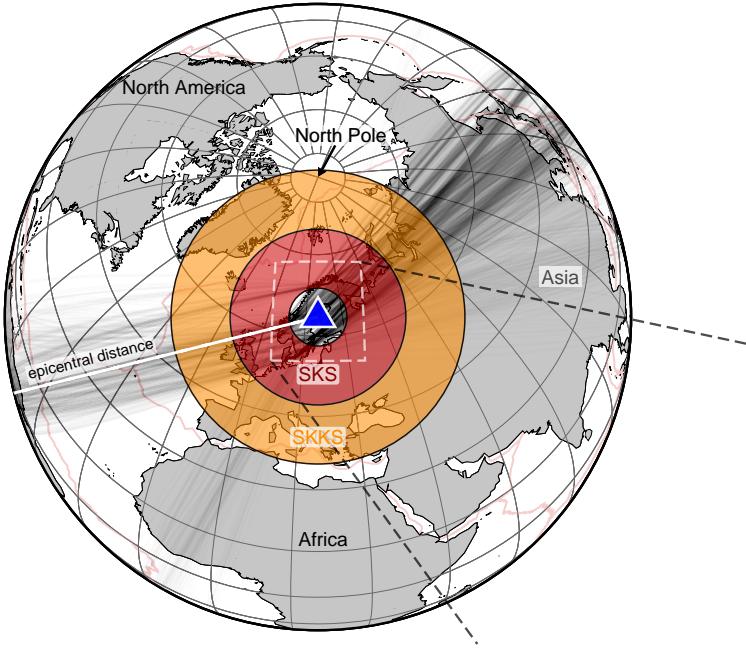


Figure 6: Add annotations, station marker (blue triangle) and an exemplary raypath as white line.

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="120/60/16/80/1:20000000"
projR=3.5/36.5/54/71.5 r

# 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

#####

```

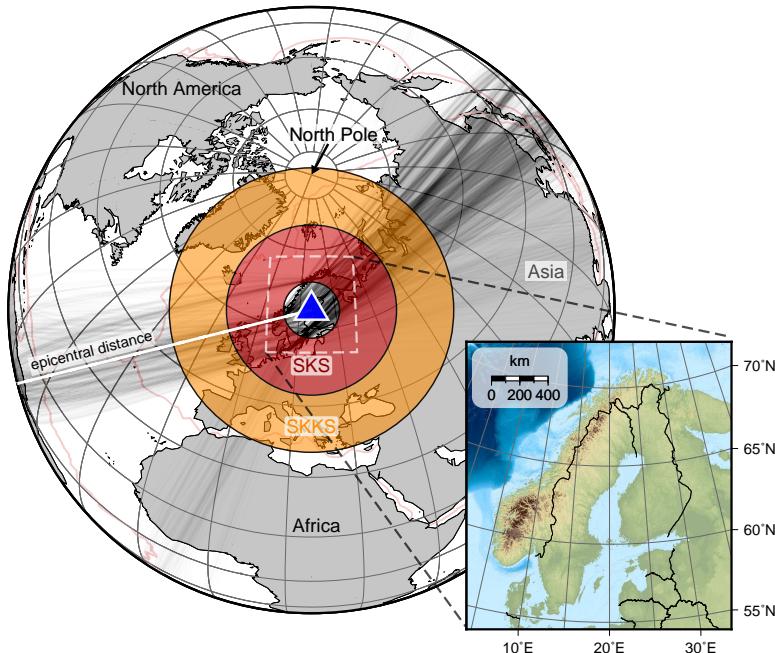


Figure 7: Plot inset with zoom-in map focused on Fennoscandia. Furthermore, add a scale.

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

#####

```

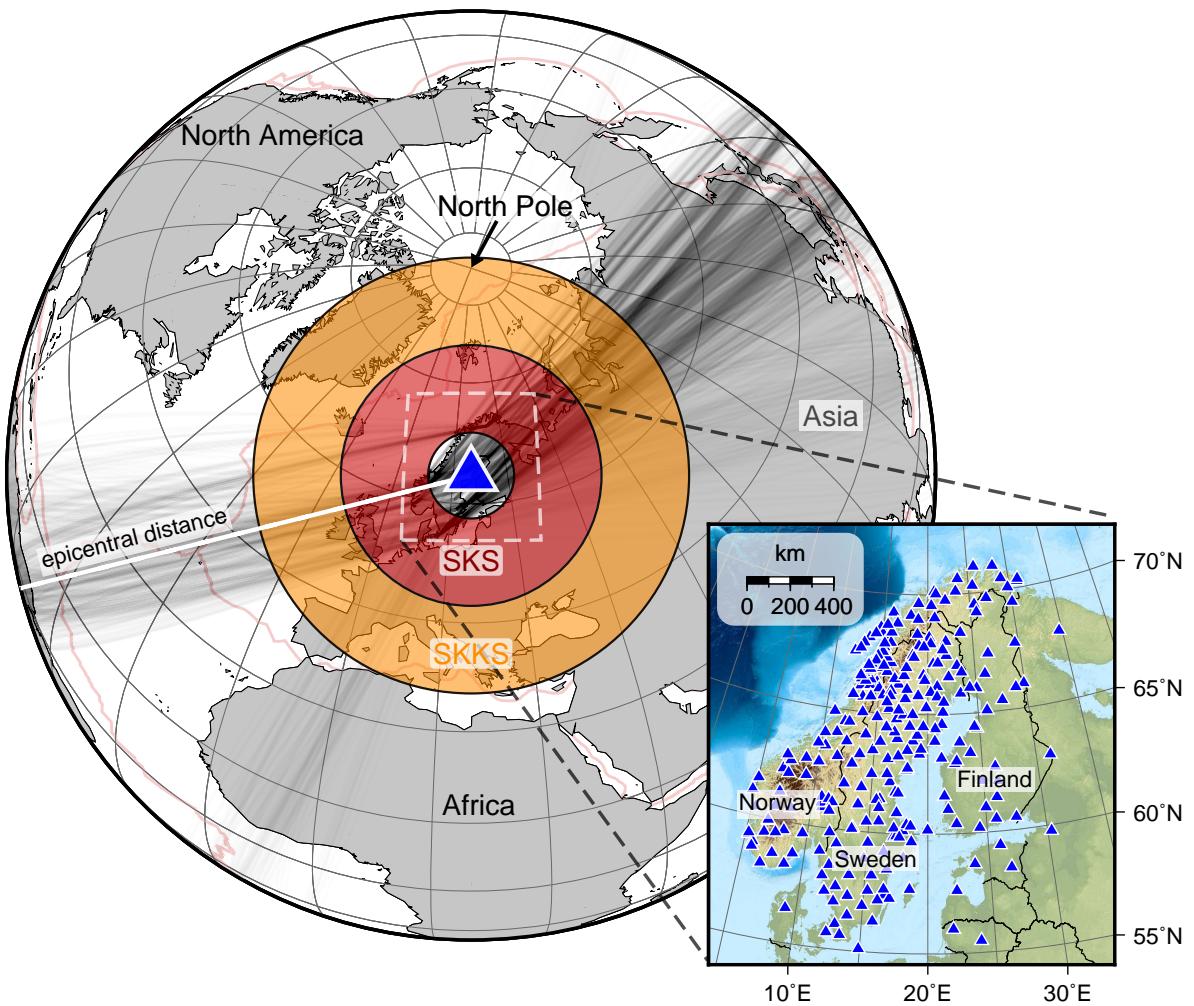


Figure 8: Finally plot station network (blue triangles) and add further annotations.

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.