Manual for Shear-wave splitting (SWS) analysis codes

Note: This version is for using on r42sgao.managed.mst.edu. It should also work on other 64-bit Linux servers such as gao.nic

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Programs in this directory (/home/sgao/progs/B_XKS) perform the following tasks:

1). Requesting and processing teleseismic XKS (including PKS,SKKS, and SKS) data from the IRIS Data Management Center(DMC).

2). Automatically measuring SWS parameters

3). Automatically ranking SWS parameters

4). Manually screening the results

** Please report confusions/errors to sgao@mst.edu

The technique is described in a number of papers (the PDF file of the papers can be downloaded from http://www.mst.edu/~sgao/publications).

You may want to read Paper 1 below to learn about the ranking procedure, and Paper 2 below for the general procedure.

1). Liu, K. H., S. S. Gao, Y. Gao, and J. Wu (2008), Shear wave splitting and mantle flow associated with the deflected Pacific slab beneath northeast Asia, Journal of Geophysical Research, Vol. 113, B01305, doi:10.1029/2007JB005178.

2). Liu, K.H. (2009), NA-SWS-1.1: A uniform database of teleseismic shear-wave splitting measurements for North America, Geochemistry, Geophysics, Geosystems, 10, Q05011, doi:10.1029/2009GC002440.

3). Gao, S. S., and K. H. Liu (2009), Significant seismic anisotropy beneath the southern Lhasa Terrane, Tibetan Plateau, Geochemistry Geophysics Geosystems, 10, Q02008, doi:10.1029/2008GC002227.

4). Gao, S.S., K.H. Liu, R.J. Stern, G.R. Keller, J.P. Hogan, J. Pulliam, and E. Y. Anthony (2008), Characteristics of mantle fabrics beneath the south-central United States: Constraints from shear-wave splitting measurements, Geosphere, Vol. 4, doi: 10.1130/GES00159.1, p. 411-417.

***** Part 1: Copying the useful files to your directory

**Step1.1). Make sure that you have sufficient amount of disk space. Of course, what is "sufficient" is dependent on the scope of your project. As a rule, if the disk is more than 80% full, you should ask Drs. Gao or Liu before proceeding. The capacity of a disk can be found using the df command, and the disk you are currently using can be found using the pwd command.

**Step1.2). Choose a sensible name for your project and make a directory for your new project (e.g., mkdir YS_SWS for YellowStone), and cd to that directory (e.g., cd YS_SWS)

For NA-SWS project only: type nasws, then mkdir Block_name (e.g., mkdir J180W) and cd to this directory name before you move on.

**Step1.3). type the following command in your project directory will copy over all the useful files from sgao's progs directory to your new project directory:

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copysws
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Here is the structure of your directory tree that created by the command above.
(If you get lost in the future steps, please refer to this roadmap):

Level 1:    Project_directory (e.g., YS_SWS)

Level 2:    seismic phase directory: 1_PKS, 2_SKK, 3_SKS

Level 3:   main work directories under each of the 3 level 2 dirs above

       ++ Under 0_get_IRIS_data, you have the following 5 directories:
       00_breq_fast/  01_Do_234/  02_Iris2dtm/  03_dtm2ucla/  04_phase_search/
       They are used to request and process IRIS DMC Data

       ++ Files under 1_measu are for automatically measuring SWS parameters

       ++ Files under 4_ranking are for automatically ranking SWS parameters

       ++ Files under 4c_rescreen_AB are for manually checking SWS parameters

       .... (there are several other dirs)


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****Part 2: requesting and processing the data

Note that data for all the 3 phases (PKS, SKKS, SKS) are requested under the 3_SKS
directory, meaning that there is no need to separately request PKS and SKKS data.

**Step2.1). cd 3_SKS/0_get_IRIS_data/00_breq_fast

**Step2.2). find the coordinates of your study area from a map. For MST Seismology users,
the big tectonics map on the wall of B40 is a good one.

If you only do one station, typing
stloc station_name
can give you the coordinates of the station.
(where station_name is the name of the seismic station.
E.g., stloc TAM. The last digit is the longitude, and the second last is the latitude).

Then type
evselect.exe
in the directory 3_SKS/0_get_IRIS_data/00_breq_fast

You will be asked to input the 4 coordinates values for your study area. Pay attention
to the fact that for the western hemisphere, -120 is smaller than -100 etc. You also will
be asked to enter your name and your email address.

For NA-SWS project: Please do NOT use your own name, but instead, put the name of the
block that you are working on (e.g., J180W).

**Step2.3). This step is only used for MST users!!
For other users, you need to work with your computer people to figure out a way of
automatically sending out emails from your Linux/Unix computer.

If you are a MST user, you need to set up your minermail account by creating a new rule
so that emails sent from r42sgao can be automatically forwarded to the IRIS data
management center. Here are the steps:

a). Open Internet Explorer
b). go to minermail.mst.edu and logon into your email account
c). Click on "Rules" in the lower-left panel of minermail
d). click on "New"
e). In "Rule Name", enter breq_fast
f). In "Subject contains", enter "breq_fast request" (note: quotes are needed)
g). In "Then", highlight "Forward it to" and enter breq_fast@iris.washington.edu
f). Click on "Save and Close"


You may also want to establish another rule which deletes all the emails from
dmsque@iris.washington.edu to avoid thousands of emails from IRIS to mess up your email
account. Here are the steps:

a). Open Internet Explorer
b). go to minermail.mst.edu and logon into your MST email account
c). Click on "Rules" in the lower-left panel of minermail
d). click on "New"
e). In "Rule Name", enter IRIS_DMC
f). In "From field contains", enter dmsque@iris.washington.edu
g). In "Then", highlight "Delete it"
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f). Click on "Save and Close"

The steps ensure that the emails are in the Deleted Items folder which can be easily cleaned by right-click and "Empty Deleted Items". You need to frequently empty this folder, otherwise your mailbox will be full and no emails can be sent or received. In addition, emailbox will be filled by regular emails in the Inbox directory. It is a good practice to periodically (e.g., every 3 months) save your emails to your local computer.

**Step2.4). For MST users only!

When the program evselect.exe is finished,
cd mailfiles
and type
email_iris.cmd

This should produce a file called "zz_send_requests.cmd". Do not worry about the "... not found" warning message.

**Step2.5). For MST users only!

more zz_send_requests.cmd
and make sure that it is what you want, and type
zz_send_requests.cmd
to make the request. This might take some time. Do not logoff until all the emails were sent.

**Step2.6). After some minutes (5-30?), check your MST email. You should have many emails from dmc.iris.edu in the "Deleted Items" folder

**Step2.7). Check http://www.iris.edu/data and click on "request status", you should be able to see your name and the status of your requests. You may also want to try "recent shipments" to see whether your requests are done or not.

**Step2.8). Check to make sure that all of your requests are finished (this can be verified using several ways, e.g., you no longer receiving emails from iris, you cannot find your name in the "request status" entry in Step 2.7, or you find your last request is under "recent shipments").

**Step2.9). Get the files from IRIS.
When you are sure that all of your requests are finished,
cd 3_SKS/0_get_IRIS_data/02_Iris2dtm/iris, and type
irisftp.
After Name, put ftp, and put your email address as the password.
cd pub, cd userdata, cd Your_Name (e.g., Barack_Obama) or your block_name.

For NA-SWS project: cd Block_name (e.g., cd J180W)

mget * (note: mget * gets all the files. "*" is a "wildcard")
This step takes some time (hours?).
When it is done, type "quit"
You should see your SEED files under 02_Iris2dtm/iris

**Step2.10). Start the processing:
Under your project directory (e.g. YS_SWS), type yy_Do_0_1_4.cmd. This will takes a lot of time (hours to days, depending on the amount of data). Do not logoff your computer until it is done.

**Step2.11). Checking the progress:
You have several ways to check the progress and to see if the jobs are finished.
a). type "top" and see if your jobs (rdseed, dtm2ucla.exe, or 1_SKS.exe etc.) are still running;
b). go to 3_SKS/4_ranking/Out_all to see if there are *.out files in the dir.

When everything is finished, you will also find the processed seismograms in 04_phase_search/Outp. The seismograms are organized into events (that is, an event directory holds all the seismograms from all the stations for this event).

For instance, directory EQ070480002 holds all the data for the event occurred in 2007, Julian day 048, at 00 hour and 02 minute. Under this directory, the file N12Axx_TA0r070480002.sac is a seismogram in SAC format from station N12A which is a station in the TA network. 0r indicates that it is the radial component. The rest of the name indicates the event time.

After the steps above, all of your PKS, SKKS, and SKS splitting measurements are done, and are ranked. The resulting parameters and the associated waveforms can be found under the 1_measu/Data directory under each of the 1_PKS, 2_SKK, and 3_SKS directories.

The ranked results can be found under the 4_ranking/Out_all directory.
The good measurements (A, B, S, and N) are under 4_ranking/Out_good.

Part 3: Manually checking the splitting parameters. This is the most time-consuming and most critical step. It requires experience and a deep understanding of seismic wave propagation and shear-wave splitting. Your results could be publishable or trashy, all depending on how careful and knowledgeable you are when you are doing this step.

You need to do this in each of the 1_PKS, 2_SKK, and 3_SKS directories:

**Step3.1). Checking 1_PKS results.

cd 1_PKS

cd 4c_rescreen_AB

type 4c_screen_ABS.exe

and follow the instructions. You will be asked to enter the full name (9-letter) of the station to be checked. The stations can be found under the 4_ranking/Out_all directory

**Step3.2). Checking 2_SKK results.

cd 2_SKK

cd 4c_rescreen_AB

type 4c_screen_ABS.exe and follow the instructions.

**Step3.3). Checking 3_SKS results.

cd 3_SKS

cd 4c_rescreen_AB

type 4c_screen_ABS.exe and follow the instructions.

Part 4: Displaying the checked results in various waves

This can be done by typing a single command under your project dir:
zzz_Do_5c_6c_7c_cc_dd.cmd

The final splitting parameters for all the 3 phases plotted at the ray piercing points can be found at 3_SKS/7d_plot_at_piercing_points_3phases/tmp.ps

The GMT program that produced tmp.ps is:
3_SKS/7d_plot_at_piercing_points_3phases/plot_pie.gmt
You may want to modify this program to make a prettier plot for your manuscript.

Part 5: Setup a website for your project on your MST homepage.

**Step5.1). Open a brand new PUTTY window and logon to r42sgao.managed.mst.edu if you have been working on r42sgao, or to gao.nic.mst.edu if you have been working on gao.nic (Note: for NA-SWS project, all work is done on gao.nic)

**Step5.2). If you are working on gao.nic, type
cd /tmp/.userweb/your_user_name/your_username (or simply www)

If you are working on r42sgao, cd /mnt/dfs/your_user_name/userweb/your_user_name

For NA-SWS project only: cd NASWS after the cd command above

**Step5.3). mkdir project_name (e.g., YS_SWS)

For NA-SWS project: use block name as project_name (e.g., J180W)

**Step5.4). cd project_name (note: For NASWS project, the following command must be typed under the Block_name (e.g., J180W)

**Step5.5). type /home/sgao/progs/B_XKS/3_SKS/9_web_setup/*.exe or copyswsweb
Note that the required input is your project directory
(for instance, for my Tibet project, it is /home/sgao/Proj/09N_Tibet_Perm_SWS.
For NA-SWS project, an example is /share/gao/data07/har5gd/NASWS2/J180W)

**Step5.6). View the results: on your PC, open IE, and go to

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            http://www.mst.edu/~your_user_name/project_name
            Click on a station name to view the splitting parameters, and
            click on "plot" at the end of each line to see the waveform



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Part 6: Fine tuning results. You can modify your results (e.g., the *.out
files in 4c*/Out) using one of the two ways:

1). If you are sure that a measurement should not be included, pico or vi
the *.out file in the directory 4c_*/Out/ for this station, and change the ranking
from A or B to N or C.

2). Even better, you can run the program *exe in 4d to re-measure this single
event. The program makes changes to your output file in 4c/Out.

Some general rules about a good measurement:

a). The STD of Phi (the 8th column of your meas.html in Step5.6) should be less than 20.0
    If larger than 20.0, you need to run *exe in 4d to change the a and f values, and/or
    to filter the waveform, or to change the ranking to N or C for this station in 4c_*/Out

b). The DT value cannot be larger than 3.0. It is extremely rare for it to be larger than
    3.0. Take the same actions if DT is greater than 3.0. As a general rule, caution is
    needed if DT is larger than 2.5 s.

c). The STD of DT cannot be greater than 2 seconds.

d). Be very careful for 'outliers' in the parameter-versus-BAZ plots (which can be found
    by clicking the station name under "Station").


After you are done with the checking, you can finalize the results by re-running
zzz_Do_5c_6c_7c_cc_dd.cmd in your project directory.

The revised results must be copied again to your web page by using step 5.5 above. You
can then view and re-refine the results using steps 5.6 and 6 until the results are
satisfactory.

For NA-SWS project: Stop here

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Part 7: Fitting the results using a two-layer model

**Step 7.1). cd 3_SKS/8a* and run the *exe program

**Step 7.2). cd 3_SKS/8b*, vi or pico 2do.stlist, and add the 9-letter station
name (e.g., TAMxxx_IU) to the list. Do not leave blank lines in the file.
Save the file and quit the editor.

**Step 7.3). Type *exe to run the program. This takes a lot of time (hours or days).
The results are under Out/station_name. Type plot.gmt and gv tmp.ps to view the
original data and fitted curves. The optimal parameters are in data.par

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Part 8: For Drs. Gao or Liu to merge the NA-SWS2 results together:

**Step 8.1). cd to /share/gao/data08/sgao/NASWS2 by typing nasksfinal

**Step 8.2). copyfinal (this is /share/gao/data08/sgao/NASWS2/z_merge/01_copy_final/*exe)
             You need to enter the username and block name. The copied results are
             under user_name/block_name under NASWS2
             This program will also execute z_finalcopy.cmd under the block dir. This is
             the same as zzz_Do* but the JPEG files under 6d_ will not be produced to save
             space and CPU time.

**Step 8.3). cd /tmp/.userweb/sgao/sgao/XKS/NA-SKS2/final  and run copyswswebfinal
             (this is /share/gao/data08/sgao/NASWS2/z_merge/02_web_setup_for_final/*exe)




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Summary -- the Fortran programs were executed in the following order
(note: there is one and only one Fortran program in each directory):
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1). 3_SKS/0_get_IRIS_data/00_breq_fast
2). 3_SKS/0_get_IRIS_data/02_Iris2dtm
3). 3_SKS/0_get_IRIS_data/03_dtm2ucla
4). 3_SKS/0_get_IRIS_data/04_phase_search
5). 1_PKS/0_get_IRIS_data/04_phase_search
6). 2_SKK/0_get_IRIS_data/04_phase_search
7). 1_PKS/1_measu
8). 1_PKS/4_ranking
9). 2_SKK/1_measu
10). 2_SKK/4_ranking
11). 3_SKS/1_measu
12). 3_SKS/4_ranking
13). 1_PKS/4c_rescreen_AB
14). 2_SKK/4c_rescreen_AB
15). 3_SKS/4c_rescreen_AB
16). 1_PKS/5c_plot_summary_rescreened/
17). 1_PKS/6c_plot_ind_JPEGs_rescreened
18). 1_PKS/6d_plot_ind_JPEGs_rescreened_all_events
19). 1_PKS/7c_plot_at_piercing_points_rescreened
20). 1_PKS/cc_make_webpage_rescreened
21). 2_SKK/5c_plot_summary_rescreened/
22). 2_SKK/6c_plot_ind_JPEGs_rescreened
23). 2_SKK/6d_plot_ind_JPEGs_rescreened_all_events
24). 2_SKK/7c_plot_at_piercing_points_rescreened
25). 2_SKK/cc_make_webpage_rescreened
26). 3_SKS/5c_plot_summary_rescreened/
27). 3_SKS/6c_plot_ind_JPEGs_rescreened
28). 3_SKS/6d_plot_ind_JPEGs_rescreened_all_events
28). 3_SKS/7c_plot_at_piercing_points_rescreened
29). 3_SKS/7d_plot_at_piercing_points_3phases
30). 3_SKS/cc_make_webpage_rescreened
31). 3_SKS/dd_make_webpage_pks_skks_sks
32). 3_SKS/ee_make_webpage_pks_skks_sks_all_events
33). 3_SKS/9_web_setup
34). 3_SKS/8a_freq_dependent
35). 3_SKS/8b_two_layer_fits
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