InSAR Processing Guide with GMTSAR

December 14, 2020

1 *Instructions*

By: Elizabeth A. Menezes

1.1 Set-up

```
[ ]: mkdir Project
     cd ../project
     cp /gpfs/summit/scratch/elme7187/scripts/gmt.conf .
     cp /gpfs/summit/scratch/elme7187/scripts/data.csh .
     cp /gpfs/summit/scratch/elme7187/scripts/config.s1a.txt . (batch.config)
     cp /gpfs/summit/scratch/elme7187/scripts/run.csh .
     cp /gpfs/summit/scratch/elme7187/scripts/select_pairs.csh . #for Sentinel
     cp /gpfs/summit/scratch/elme7187/scripts/intf_tops.csh .
     cp /gpfs/summit/scratch/elme7187/scripts/inputfile . #not for Sentinel
     cp /gpfs/summit/scratch/elme7187/scripts/plot.csh .
     cp /gpfs/summit/scratch/elme7187/scripts/plot.zip .
     #or
     cp /gpfs/summit/scratch/elme7187/scripts/plot_corr_ll.csh .
     cp /gpfs/summit/scratch/elme7187/scripts/plot_los_ll.csh .
     cp /gpfs/summit/scratch/elme7187/scripts/plot_unwrap_ll.csh .
```

1.2 Script Run Order

0. Download ASF raw files to raw in parent dir
1. File structure and Organization - data.csh to generate data.in (copy scripts.zip to parent folder, unzip, move to raw subdir, ./data.csh)
2. Initiate Processing - run.csh (copy .csh to parent swath then ./run.csh)
3. Selecting Pairs - select_pairs.csh to generate intf.in
4. Processing - ./intf_tops.csh intf.in batch.config

1.2.1 *Things to CHANGE*

- run.csh:
- ln -s ../../raw/data_iw2.in #CHANGE
- ln -s ../../raw/*iw2*.xml . #CHANGE
- ln -s ../../raw/*iw2*.tiff . #CHANGE

- ln -s /gpfs/summit/scratch/elme7187/project/project/F2/raw/intf.in . #CHANGE
- batch.config:
- master_image = S1A20200908_ALL_F2 #CHANGE
- intf_tops.csh
- cp /gpfs/summit/scratch/elme7187/project/project/F2/gmt.conf . #CHANGE

1.3 1. File structure and Organization - data.csh

Run the command: chmod +x data.csh #to make script exe run in terminal

```csh
!/bin/csh -f
#KEEP in raw directory
#Unzip files
# echo 'Unzipping files'
# foreach i (*.zip)
# echo $i
# unzip $i
# end
# echo 'Unziped files'

#Link all files from the SAFE measurement subdirectories into raw
# ln -s *.SAFE/measurement/* .

#Then link the xml files for each
# ln -s *.SAFE/annotation/*.xml .

#REMOVE VH POLAR (go back and process it later)
# rm *vh* #CHANGE
# rm *vv*

rm *.in #rm old data.in files

#Make data.in
swath1=( $(ls *iw1*))
swath2=( $(ls *iw2*))
swath3=( $(ls *iw3*))

for i in  ${swath1[@]}
do
    ls *iw1*.xml > xml1.txt
    cut -c 1-64 xml1.txt > cut1.txt #droping the extention, (can also drop every
 thing but last 4 chz)
#     rm -f S1A*.EOF
    ls *.EOF > eof.txt
    paste -d ':' cut1.txt eof.txt > data_iw1.in
done

for i in  ${swath2[@]}
```

```
do
    ls *iw2*.xml > xml2.txt
    cut -c 1-64 xml2.txt > cut2.txt #droping the extention
    ls *.EOF > eof.txt
    paste -d ':' cut2.txt eof.txt > data_iw2.in
done

for i in  ${swath3[@]}
do
    ls *iw3*.xml > xml3.txt
    cut -c 1-64 xml3.txt > cut3.txt #droping the extention
    ls *.EOF > eof.txt
    paste -d ':' cut3.txt eof.txt > data_iw3.in
done

rm xml*.txt
rm cut*.txt
rm eof.txt

echo 'Made data.in files'

# chmod +x data.csh #to make script exe run in terminal
```

1.4 2. Initiate Processing - run.csh

```
[ ]: #!/bin/csh -f
     #        $Id$
     # KEEP in parent swath directory
     # alias rm 'rm -f' # tcsh shell allows you to embed command line arguments in an␣
      ↪alias
     # unset noclobber # unset noclobber so overwriting can take place

     # Aquire and organize your data into the four subdirectories
     # Copy this program to, and run it from, the top level directory of your␣
      ↪project#
     # Comment out or modify the commands below as necessary
     #
     # Elizabeth A. Menezes, Nov 17 2020
     #

     # File strtucture and organize within a swath
     # cp ../gmt.conf .
     mkdir raw
     mkdir SLC
     mkdir topo
     cd topo
```

```
ln -s ../../topo/dem.grd .


# Make and edit data.in outside of this program

# Link raw files
cd ..
cd raw
ln -s ../../raw/data_iw2.in #CHANGE
mv data*.in data.in
ln -s ../../raw/*iw2*.xml . #CHANGE
ln -s ../../raw/*iw2*.tiff . #CHANGE
ln -s ../../raw/*.EOF .
ln -s ../topo/dem.grd .
echo 'Linked RAW files'

# Converts raw files into a format understood by GMT5SAR
echo 'Preprocessing'
preproc_batch_tops.csh data.in dem.grd 1 # mode 1 preprocess and align a set of␣
 ↪tops images
# Select the super-master and move it to the top of the input file?
preproc_batch_tops.csh data.in dem.grd 2 # mode 2 generate PRM, LED, SLC files
# preproc batch tops esd.csh #for ESD
echo 'Preprocessed'

# Link SLCs
cd ../SLC
# Link files to SLC directory (linking saves space on drive)
ln -s ../raw/*.PRM .
ln -s ../raw/*.SLC .
ln -s ../raw/*.LED .
echo 'Linked SLCs'

# Run select_pairs.csh
cd ../raw
cp ../select_pairs.csh .

./select_pairs.csh baseline_table.dat 50 100 #threshold_time threshold_baseline
# 50 is the temporal baseline (days) and 100 is the perpendicular baseline␣
 ↪(meters).
echo 'Selected pairs'

# Link intf.in to parent swath dir
#ln -s intf.in ../ #or
cd ..
ln -s /gpfs/summit/scratch/elme7187/project/projectall/F3/raw/intf.in . #CHANGE
```

```
cp ../batch_tops.config .  #CHANGE super master

echo 'CHANGE super master in batch_tops.config'
# Make interferogram
#echo 'Running intf_tops.csh'
# cp ../intf_tops.csh .

#./intf_tops.csh intf.in batch_tops.config

# echo 'Ran intf_tops.csh'
```

1.5   3. Selecting Pairs - select_pairs.csh to generate intf.in

```
[ ]:  #!/bin/csh -f
      #       $Id$
      #KEEP in parent swath directory

      #An input file listing all the interferometric pairs
      #
      #The format is as follows: reference_image_stem:secondary_image_stem
      #Example: S1A20150628_ALL_F1:S1A20150720_ALL_F1 S1A20150720_ALL_F1:
       →S1A20150809_ALL_F1

      # Select pairs according to the given threshold in time and baseline
      # used for time series analysis

      # Xiaohua(Eric) Xu, Jan 21 2016


        if ( $#argv != 3) then
          echo ""
          echo "Usage: select_pairs.csh baseline_table.dat threshold_time␣
       →threshold_baseline"
          echo "  generate the input file for intf_tops.csh with given threshold of␣
       →time and baseline"
          echo ""
          echo "  outputs:"
          echo "    intf.in"
          echo ""
          exit 1
        endif

        set file =  $1
        set dt =  `echo  $2 | awk '{print $0}' `
        set db =  `echo  $3 | awk '{printf $0}' `
```

```csh
# loop over possible pairs
  rm intf.in

  awk '{print 2014+$3/365.25, $5, $1}' <  $1 > text
  set region =  `gmt gmtinfo text -C | awk '{print $1-0.5, $2+0.5, $3-50,
↪$4+50}' `
  gmt pstext text -JX8.8i/6.8i -R $region[1]/ $region[2]/ $region[3]/ $region[4]
↪-D0.2/0.2 -X1.5i -Y1i -K -N -F+f8,Helvetica+j5 > baseline.ps

  foreach line1 ( `awk '{print $1":"$2":"$3":"$4":"$5}' <  $file `)
    foreach line2 ( `awk '{print $1":"$2":"$3":"$4":"$5}' <  $file `)
      set t1 =  `echo  $line1 | awk -F: '{print $3}' `
      set t2 =  `echo  $line2 | awk -F: '{print $3}' `
      set b1 =  `echo  $line1 | awk -F: '{print $5}' `
      set b2 =  `echo  $line2 | awk -F: '{print $5}' `
      set n1 =  `echo  $line1 | awk -F: '{print $1}' `
      set n2 =  `echo  $line2 | awk -F: '{print $1}' `
      #if ($t1 < $t2 && $t2 - $t1 < $dt && $db0 < $db) then
      if ( $t1 <  $t2 &  $t2 -  $t1 <  $dt) then
        set db0 =  `echo  $b1  $b2 | awk '{printf "%d", sqrt(($1-$2)*($1-$2))}' `
        if ( $db0 <  $db) then
          echo  $n1  $n2 | awk '{print $1":"$2}' >> intf.in
          echo  $t1  $b1 | awk '{print $1/365.25+2014, $2}' >> tmp
          echo  $t2  $b2 | awk '{print $1/365.25+2014, $2}' >> tmp
          gmt psxy tmp -R -J -K -O >> baseline.ps
          rm tmp
        endif
      endif
    end
  end

awk '{print $1,$2}' < text > text2
gmt psxy text2 -Sp0.2c -G0 -R -JX -Ba0.5:"year":/a50g00f25:"baseline (m)":WSen
↪-O >> baseline.ps
```

1.6   4. Processing - ./intf_tops.csh intf.in batch.config

```csh
[ ]: #!/bin/csh -f
     #       $Id$

     # generate interferograms for tops stacks
     # used for time series analysis

     # Xiaohua(Eric) Xu - Jan 20 2016, Edited by Elizabeth A. Menezes - Nov.23, 2020
```

```csh
  if ( $#argv != 2) then
    echo ""
    echo "Usage: intf_tops.csh intf.in batch_tops.config"
    echo "  generate interferograms for a set of tops images in intf.in, dem␣
→required in ./topo"
    echo "  supermaster's name required in batch_tops.config"
    echo ""
    echo "  format of data.in:"
    echo "    master_image_stem:aligned_image_stem"
    echo ""
    echo "  example of data.in"
    echo "    S1_20150628_ALL_F1:S1_20150720_ALL_F1"
    echo "    S1_20150720_ALL_F1:S1_20150809_ALL_F1"
    echo ""
    echo "  outputs:"
    echo "    to ./intf_all"
    echo ""
    exit 1
  endif

# read parameters from config file

  set master =  `grep master_image  $2 | awk '{print $3}' `

# if filter wavelength is not set then use a default of 200m

  set filter =  `grep filter_wavelength  $2 | awk '{print $3}' `
  if ( "x$filter" == "x" ) then
  set filter = 200
  echo " "
  echo "WARNING filter wavelength was not set in config.txt file"
  echo "        please specify wavelength (e.g., filter_wavelength = 200)"
  echo "        remove filter1 = gauss_alos_200m"
  endif
  set dec =  `grep dec_factor  $2 | awk '{print $3}' `
  set topo_phase =  `grep topo_phase  $2 | awk '{print $3}' `
  set shift_topo =  `grep shift_topo  $2 | awk '{print $3}' `
  set threshold_snaphu =  `grep threshold_snaphu  $2 | awk '{print $3}' `
  set threshold_geocode =  `grep threshold_geocode  $2 | awk '{print $3}' `
  set region_cut =  `grep region_cut  $2 | awk '{print $3}' `
  set switch_land =  `grep switch_land  $2 | awk '{print $3}' `
  set defomax =  `grep defomax  $2 | awk '{print $3}' `
  set range_dec =  `grep range_dec  $2 | awk '{print $3}' `
  set azimuth_dec =  `grep azimuth_dec  $2 | awk '{print $3}' `
  set near_interp =  `grep near_interp  $2 | awk '{print $3}' `

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

```
# 3 - start from make topo_ra    #
################################

# make topo_ra

    echo " "
    echo "DEM2TOPO_RA.CSH - START"
    echo "USER SHOULD PROVIDE DEM FILE"
    cd topo
    cp ../raw/ $master.PRM ./master.PRM
    ln -s ../raw/ $master.LED .
        dem2topo_ra.csh master.PRM dem.grd
    cd ..
    echo "DEM2TOPO_RA.CSH - END"


###################################################
# 4 - start from make and filter interferograms  #
#                                                 #
###################################################

# make working directories

  echo ""
  echo "START FORM A STACK OF INTERFEROGRAMS"
  echo ""
  mkdir -p intf/
  mkdir -p intf_all/

# loop over intf.in

  foreach line ( `awk '{print $0}'  $1 `)
    set ref = `echo  $line | awk -F: '{print $1}' `
    set rep = `echo  $line | awk -F: '{print $2}' `
    set ref_id  = `grep SC_clock_start ./raw/ $ref.PRM | awk␣
↪'{printf("%d",int($3))}'  `
    set rep_id  = `grep SC_clock_start ./raw/ $rep.PRM | awk␣
↪'{printf("%d",int($3))}'  `

    echo ""
    echo "INTF.CSH, FILTER.CSH - START"
    cd intf
    mkdir  $ref_id"_" $rep_id
    cd  $ref_id"_" $rep_id
    ln -s ../../raw/ $ref.LED .
    ln -s ../../raw/ $rep.LED .
    ln -s ../../raw/ $ref.SLC .
    ln -s ../../raw/ $rep.SLC .
```

```
    cp ../../raw/ $ref.PRM .
    cp ../../raw/ $rep.PRM .

        ln -s ../../topo/topo_ra.grd .
        intf.csh  $ref.PRM  $rep.PRM -topo topo_ra.grd
    filter.csh  $ref.PRM  $rep.PRM 200 2 #$filter $dec #$range_dec $azimuth_dec
    echo "INTF.CSH, FILTER.CSH - END"
#
####################################
# 5 - unwrap phase                 #
#     snaphu.csh                    #
####################################

cp /gpfs/summit/scratch/elme7187/project/projectall/F2/gmt.conf . #CHANGE

    echo ""
    echo "SNAPHU.CSH - START"
    echo "threshold_snaphu: $threshold_snaphu"
      snaphu.csh  $threshold_snaphu  $defomax #$region_cut
    echo "SNAPHU.CSH - END"


###############################
# 6 - geocode                 #
###############################

    echo ""
    echo "GEOCODE.CSH - START"

      ln -s  ../../topo/trans.dat .
    geocode.csh 0.1 #$threshold_geocode


###############################
#       Plotting              #
###############################

rm -r plot*.csh
cp ../../../plot.zip .
unzip plot.zip
./plot_corr_ll.csh
./plot_los_ll.csh
./plot_unwrap_ll.csh

  cd ../..
  if(-f intf_all/ $ref_id"_" $rep_id) rm -rf intf_all/ $ref_id"_" $rep_id
  mv intf/ $ref_id"_" $rep_id intf_all/ $ref_id"_" $rep_id

  end
```

```
echo ""
echo "END STACK OF TOPS INTERFEROGRAMS"
echo ""
```

1.7 batch_tops.config (config.s1a.txt) edited for project

```
[ ]: # This is an example configuration file for p2p_S1A_TOPS.csh (or intf_tops.csh)

     # all the comments or explanations are marked by "#"
     # The parameters in this configuration file is distinguished by their first word
      ↪so
     # user should follow the naming of each parameter.
     # the parameter name, "=" sign, parameter value should be separated by space " ".
      ↪
     # leave the parameter value blank if using default value.


     ####################
     # processing stage  #
     ####################
     # 1 - start from preprocess
     # 2 - start from align SLC images
     # 3 - start from make topo_ra
     # 4 - start from make and filter interferograms
     # 5 - start from unwrap phase
     # 6 - start from geocode
     #proc_stage = 1

     # the namestem of the master image - REQUIRED
     master_image = S1A20200908_ALL_F3 #CHANGE
     #set to an acquisition somewhere in the center (spatially and temporally) of the
      ↪baseline plot.

     ################################
     #   parameters for preprocess    #
     #   - pre_proc.csh               #
     ################################
     # num of patches
     num_patches =

     # earth radius
     earth_radius =

     # near_range
     near_range =
```

```
# Doppler centroid
fd1 =


###############################################
#    parameters for focus and align SLC images   #
#    - align.csh                                  #
###############################################
#
###################################
#    parameters for make topo_ra        #
#    - dem2topo_ra.csh                   #
###################################
# subtract topo_ra from the phase
#   (1 -- yes; 0 -- no)
topo_phase = 1
# if above parameter = 1 then one should have put dem.grd in topo/

# topo_ra shift (1 -- yes; 0 -- no)
shift_topo = 1


####################################################
#    parameters for make and filter interferograms   #
#    - intf.csh                                       #
#    - filter.csh                                     #
####################################################
# switch the master and slave when doing intf.
# put "1" if assume master as repeat and slave as reference
# put "0" if assume master as reference and slave as repeat [Default]
# phase = repeat phase - reference phase
#switch_master = 0

# filters
# look at the filter/ folder to choose other filters
# for tops processing, to force the decimation factor
# recommended range decimation to be 8, azimuth decimation to be 2
filter_wavelength = 200
range_dec = 8
azimuth_dec = 2

# decimation of images
# decimation control the size of the amplitude and phase images. It is either 1␣
  ↪or 2.
# Set the decimation to be 1 if you want higher resolution images.
# Set the decimation to be 2 if you want images with smaller file size.
#
dec_factor = 2
```

```
#
#
####################################
#    parameters for unwrap phase      #
#    - snaphu.csh                      #
####################################
# correlation threshold for snaphu.csh (0~1)
# set it to be 0 to skip unwrapping.
threshold_snaphu = 0.1

# region to unwrap in radar coordinates (leave it blank if unwrap the whole␣
 ↪region)
# example 300/5900/0/25000
region_cut =

# mask the wet region (Lakes/Oceans) before unwrapping (1 -- yes; else -- no)
switch_land = 1

#
# Allow phase discontinuity in unrapped phase. This is needed for interferograms␣
 ↪having sharp phase jumps.
# defo_max = 0 - used for smooth unwrapped phase such as interseismic deformation
# defo_max = 65 - will allow a phase jump of 65 cycles or 1.82 m of deformation␣
 ↪at C-band
#
defomax = 0


####################################
#    parameters for geocode           #
#    - geocode.csh                     #
####################################
# correlation threshold for geocode.csh (0~1)
threshold_geocode = .10
```