



Sentinel-1 Interferometry and Unwrapping with GMT5SAR - Cloud

Credit: ASF Staff

This recipe creates an interferogram from two Sentinel-1 IW SLCs with VV polarization, and can optionally unwrap it.

In this document you will find:

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- B. Materials List
- C. Software version numbers
- D. Steps
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A) Background:

In order to perform differential interferometry on Sentinel-1 data using the GMT5SAR software package, ASF provides the python script `procS1GMTSAR.py`. This script takes two Sentinel-1 IW SLC files and creates a differential interferogram of the data in both geotiff and KMZ format. The user may specify an input DEM file (which must be in GMT `grd` format) or a DEM file will automatically be downloaded for the user via the `opentopo` service. The script creates an interferogram for the main polarization, VV, only.

The Sentinel-1 granules must be in the directory where the script is run, i.e. the `.zip` files must be in the directory where you run the script. In addition, the ASF provided GMT5SAR configuration file, `config.s1a.txt`, must be in the same location as your executable file `procS1GMT5SAR.py`.

B) Materials

- AMI (AWS East, ASF-INSAR-GMT5SAR)
- ASF config file: config.s1a.txt (home/Ubuntu)
- Python 2.7 (2.7.12-1ubuntu0~16.04.1)
- .netrc file (home/Ubuntu)
- GDAL (gdal-bin (2.1.3+dfsg-1~xenial2)
- Instructions
- Sample Granules (Two Sentinel-1 SLCs, IW, VV only)
 - Sample granules located at /home/Ubuntu/SLC
- ASF script: procS1GMT5SAR.py

C) AMI Software Version Numbers

python2.7 (2.7.12-1ubuntu0~16.04.1)
python-lxml (3.5.0-1build1)
python-requests (2.9.1-3)
gdal-bin (2.1.3+dfsg-1~xenial2)
libgdal-dev (2.1.3+dfsg-1~xenial2)
python-gdal (2.1.3+dfsg-1~xenial2)
csh (20110502-2.1ubuntu1)
subversion (1.9.3-2ubuntu1.1)
autoconf (2.69-9)
ghostscript (9.18~dfsg~0-0ubuntu2.7)
libfftw3-dev:amd64 (3.3.4-2ubuntu1)
libgmt-dev (5.2.1+dfsg-4ubuntu2~xenial2)
gmt (5.2.1+dfsg-4ubuntu2~xenial2)

D) Steps

Configure the script – from your EC2 window

- 1) Phase unwrapping on/off
 - a. Default is unwrapping off (interferogram only): **threshold_snaphu=0.0**
 - b. For unwrapping on, edit the config file in a text editor, set **threshold_snaphu=0.2**
- 2) Edit the .netrc file
To get the precision state vectors from ASF, you must edit the provided .netrc file.

Add your URS?Earthdata username and password (same as Vertex login):

```
cd /home/Ubuntu
```

```
vi .netrc
```

Add these lines:

```
machine urs.earthdata.nasa.gov
```

```
login <username>
```

```
password <password>
```

You are ready to create an interferogram!

Run the Script – Create an Interferogram

1. Issue the following command to run the GMT5SAR process:

\$ python procS1GMT5SAR.py <master granule name> <paired granule name>

Notes:

- a) Use two Sentinel-1 SLCs, VV polarization only
- b) The master (older) granule must be first
- c) Use .zip or SAFE files
- d) Script options:
 - a. -h, --help shows help message and exits
 - b. -d DEM, --dem <yourDEMfilename> User specified DEM file (in GMT format). If not used, the script will pull a DEM for you.
- e) Prior to running the script a second time, delete or move unnecessary files.

Example:

\$ python procS1GMT5SAR.py

S1A_IW_SLC 1SSV_20150526T014935_20150526T015002_006086_007E23_679A.zip

S1A_IW_SLC 1SDV_20150607T014936_20150607T015003_006261_00832E_3626.zip

The script will take about an hour. The three commands prefaced with “Running Interferogram:” takes the bulk of processing time. Expect to wait a significant amount of time for each of the calls to p2p_S1A_TOPS.csh to finish (as much as an hour per call).

E) Sample Granules

S1A_IW_SLC_1SSV_20150526T014935_20150526T015002_006086_007E23_679A.zip

S1A_IW_SLC_1SDV_20150607T014936_20150607T015003_006261_00832E_3626.zip

F) Sample Images

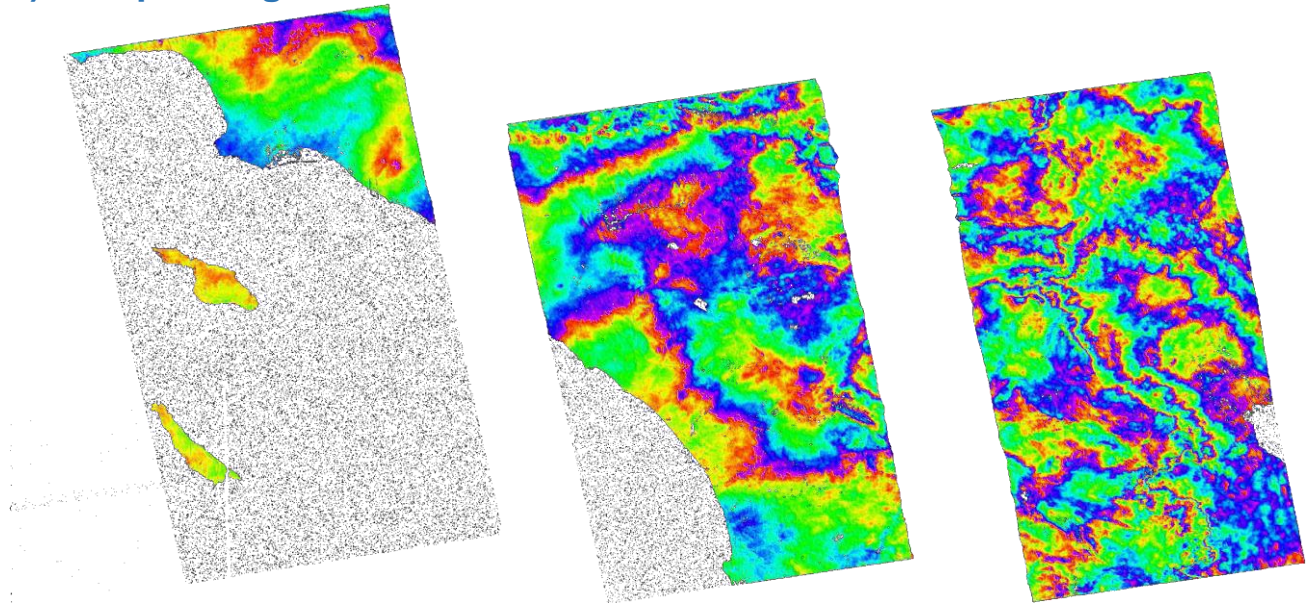


Figure 1. Script output images: color phase products for each swath F1, F2, F3. Contains modified Copernicus Sentinel data (2015) processed by ESA

G) Appendix 1: Steps the Script Completes

How it works:

- 1 Unzip the input Sentinel-1 input granules
- 2 Download appropriate restituted state vectors
- 3 Download DEM covering the area of master image (OpenTopo or user specified)
- 4 Align the two images using the GMT5SAR script align_tops.csh
- 5 Create the interferograms, optionally unwrap, using the GMT5SAR script p2p_S1A_TOPS.csh
- 6 Create and populate the PRODUCT directory

H) Appendix 2: Script Output Files – Unwrapping on

The outputs of the run will be placed in a directory called PRODUCT, e.g. the output from the above run will produce a PRODUCT directory with the following files:

20150526_20150607_F1_amp.tif
20150526_20150607_F1_color_phase.kmz
20150526_20150607_F1_color_phase.png
20150526_20150607_F1_corr.tif
20150526_20150607_F1_unw_phase.kmz
20150526_20150607_F1_unw_phase.png
20150526_20150607_F1_unw_phase.tif
20150526_20150607_F2_amp.tif
20150526_20150607_F2_color_phase.kmz
20150526_20150607_F2_color_phase.png
20150526_20150607_F2_corr.tif
20150526_20150607_F2_unw_phase.kmz
20150526_20150607_F2_unw_phase.png
20150526_20150607_F2_unw_phase.tif
20150526_20150607_F3_amp.tif
20150526_20150607_F3_color_phase.kmz
20150526_20150607_F3_color_phase.png
20150526_20150607_F3_corr.tif
20150526_20150607_F3_unw_phase.kmz
20150526_20150607_F3_unw_phase.png
20150526_20150607_F3_unw_phase.tif

The files are as follows:

F?	- swath designator, F1, F2, or F3
amp	- amplitude image
corr	- coherence map
color_phase	- wrapped phase file
unw_phase	- unwrapped phase file*

With extensions:

.kmz	- Google earth KMZ format
.tif	- Geotiff format
.png	- Portable Network Graphic (browse image)

I) Appendix 3: Sample Script Run

Example Output:

The output from an example run, using the same LA data used in the GMTSAR example found at <http://topex.ucsd.edu/gmtsar/downloads/>, is as follows:

```
➤ python procS1GMT5SAR.py
   S1A_IW_SLC    1SSV_20150526T014935_20150526T015002_006086_007E23_679A.zip
   S1A_IW_SLC    1SDV_20150607T014936_20150607T015003_006261_00832E_3626.zip
```

Found master file S1A_IW_SLC__1SSV_20150526T014935_20150526T015002_006086_007E23_679A.zip

Found slave file S1A_IW_SLC 1SDV_20150607T014936_20150607T015003_006261_00832E_3626.zip

Unzipping master file

Unzipping slave file

Getting orbit files

--2017-08-09 19:22:32--

https://s1qc.asf.alaska.edu/aux_poeorb/S1A_OPER_AUX_POEORB_OPOD_20150615T155109_V20150525T225944_20150527T005944.EOF

Resolving s1qc.asf.alaska.edu (s1qc.asf.alaska.edu)... 137.229.86.187

Connecting to s1qc.asf.alaska.edu (s1qc.asf.alaska.edu)|137.229.86.187|:443... connected.

HTTP request sent, awaiting response... 302 Found

Location:

https://urs.earthdata.nasa.gov/oauth/authorize?client_id=BO_n7nTlIMljdvU6kRRB3g&redirect_uri=https://vertex.daac.asf.alaska.edu/services/urs4_token_request&response_type=code&state=redirect%3Ahttps%3A%2F%2Fs1qc.asf.alaska.edu%3A443%2Faux_poeorb%2FS1A_OPER_AUX_POEORB_OPOD_20150615T155109_V20150525T225944_20150527T005944.EOF&app_type=401 [following]

--2017-08-09 19:22:32--

https://urs.earthdata.nasa.gov/oauth/authorize?client_id=BO_n7nTlIMljdvU6kRRB3g&redirect_uri=https://vertex.daac.asf.alaska.edu/services/urs4_token_request&response_type=code&state=redirect%3Ahttps%3A%2F%2Fs1qc.asf.alaska.edu%3A443%2Faux_poeorb%2FS1A_OPER_AUX_POEORB_OPOD_20150615T155109_V20150525T225944_20150527T005944.EOF&app_type=401

Resolving urs.earthdata.nasa.gov (urs.earthdata.nasa.gov)... 198.118.243.33, 2001:4d0:241a:4081::89

Connecting to urs.earthdata.nasa.gov (urs.earthdata.nasa.gov)|198.118.243.33|:443... connected.

HTTP request sent, awaiting response... 401 Unauthorized

Reusing existing connection to urs.earthdata.nasa.gov:443.

HTTP request sent, awaiting response... 302 Found

Location:

https://vertex.daac.asf.alaska.edu/services/urs4_token_request?code=2f2aa790b79b3c012b8a61acaf5877cff4f996fadbbcb4832e28e524802c99cb6&state=redirect%3Ahttps%3A%2F%2Fs1qc.asf.alaska.edu%3A443%2Faux_poeorb%2FS1A_OPER_AUX_POEORB_OPOD_20150615T155109_V20150525T225944_20150527T005944%2EEOF [following]

--2017-08-09 19:22:33--

https://vertex.daac.asf.alaska.edu/services/urs4_token_request?code=2f2aa790b79b3c012b8a61acaf5877cff4f996fadbbcb4832e28e524802c99cb6&state=redirect%3Ahttps%3A%2F%2Fs1qc.asf.alaska.edu%3A443%2Faux_poeorb%2FS1A_OPER_AUX_POEORB_OPOD_20150615T155109_V20150525T225944_20150527T005944%2EEOF

Resolving vertex.daac.asf.alaska.edu (vertex.daac.asf.alaska.edu)... 137.229.86.197

Connecting to vertex.daac.asf.alaska.edu (vertex.daac.asf.alaska.edu)|137.229.86.197|:443... connected.
HTTP request sent, awaiting response... 302 Found
Location:
https://s1qc.asf.alaska.edu:443/aux_poeorb/S1A_OPER_AUX_POEORB_OPOD_20150615T155109_V20150525T225944_20150527T005944.EOF [following]
--2017-08-09 19:22:34--
https://s1qc.asf.alaska.edu/aux_poeorb/S1A_OPER_AUX_POEORB_OPOD_20150615T155109_V20150525T225944_20150527T005944.EOF
Connecting to s1qc.asf.alaska.edu (s1qc.asf.alaska.edu)|137.229.86.187|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 4409878 (4.2M) [text/xml]
Saving to: 'S1A_OPER_AUX_POEORB_OPOD_20150615T155109_V20150525T225944_20150527T005944.EOF'

100%[=====]
=====>] 4,409,878 23.5MB/s in 0.2s

2017-08-09 19:22:35 (23.5 MB/s) -
'S1A_OPER_AUX_POEORB_OPOD_20150615T155109_V20150525T225944_20150527T005944.EOF' saved
[4409878/4409878]

--2017-08-09 19:22:35--
https://s1qc.asf.alaska.edu/aux_poeorb/S1A_OPER_AUX_POEORB_OPOD_20150627T155155_V20150606T225944_20150608T005944.EOF
Resolving s1qc.asf.alaska.edu (s1qc.asf.alaska.edu)... 137.229.86.187
Connecting to s1qc.asf.alaska.edu (s1qc.asf.alaska.edu)|137.229.86.187|:443... connected.
HTTP request sent, awaiting response... 302 Found
Location:
https://urs.earthdata.nasa.gov/oauth/authorize?client_id=BO_n7nTIIMljdvU6kRRB3g&redirect_uri=https://vertex.daac.asf.alaska.edu/services/urs4_token_request&response_type=code&state=redirect%3Ahttps%3A%2F%2Fs1qc.asf.alaska.edu%3A443%2Faux_poeorb%2FS1A_OPER_AUX_POEORB_OPOD_20150627T155155_V20150606T225944_20150608T005944.EOF&app_type=401 [following]

--2017-08-09 19:22:35--
https://urs.earthdata.nasa.gov/oauth/authorize?client_id=BO_n7nTIIMljdvU6kRRB3g&redirect_uri=https://vertex.daac.asf.alaska.edu/services/urs4_token_request&response_type=code&state=redirect%3Ahttps%3A%2F%2Fs1qc.asf.alaska.edu%3A443%2Faux_poeorb%2FS1A_OPER_AUX_POEORB_OPOD_20150627T155155_V20150606T225944_20150608T005944.EOF&app_type=401
Resolving urs.earthdata.nasa.gov (urs.earthdata.nasa.gov)... 198.118.243.33, 2001:4d0:241a:4081::89
Connecting to urs.earthdata.nasa.gov (urs.earthdata.nasa.gov)|198.118.243.33|:443... connected.
HTTP request sent, awaiting response... 401 Unauthorized
Reusing existing connection to urs.earthdata.nasa.gov:443.
HTTP request sent, awaiting response... 302 Found

Location:
https://vertex.daac.asf.alaska.edu/services/urs4_token_request?code=a425247b9ca1ea75bebbb622ba3fcd0fa9fe950f5aacfa3b6d57e7def61b0760&state=redirect%3Ahttps%3A%2F%2Fs1qc.asf.alaska.edu%3A443%2Faux_poeorb%2FS1A_OPER_AUX_POEORB_OPOD_20150627T155155_V20150606T225944_20150608T005944%2EEOF [following]
--2017-08-09 19:22:36--
https://vertex.daac.asf.alaska.edu/services/urs4_token_request?code=a425247b9ca1ea75bebbb622ba3fcd0fa9fe950f5aacfa3b6d57e7def61b0760&state=redirect%3Ahttps%3A%2F%2Fs1qc.asf.alaska.edu%3A443%2Faux_poeorb%2FS1A_OPER_AUX_POEORB_OPOD_20150627T155155_V20150606T225944_20150608T005944%2EEOF

9fe950f5aacfa3b6d57e7def61b0760&state=redirect%3Ahttps%3A%2F%2Fs1qc%2Easf%2Ealaska%2Eedu%3A443%2Faux_poeorb%2FS1A_OPER_AUX_POEORB_OPOD_20150627T155155_V20150606T225944_20150608T05944%2EEOF

Resolving vertex.daac.asf.alaska.edu (vertex.daac.asf.alaska.edu)... 137.229.86.197

Connecting to vertex.daac.asf.alaska.edu (vertex.daac.asf.alaska.edu)|137.229.86.197|:443... connected.

HTTP request sent, awaiting response... 302 Found

Location:

https://s1qc.asf.alaska.edu:443/aux_poeorb/S1A_OPER_AUX_POEORB_OPOD_20150627T155155_V20150606T225944_20150608T005944.EOF [following]

--2017-08-09 19:22:37--

https://s1qc.asf.alaska.edu/aux_poeorb/S1A_OPER_AUX_POEORB_OPOD_20150627T155155_V20150606T225944_20150608T005944.EOF

Connecting to s1qc.asf.alaska.edu (s1qc.asf.alaska.edu)|137.229.86.187|:443... connected.

HTTP request sent, awaiting response... 200 OK

Length: 4420094 (4.2M) [text/xml]

Saving to: 'S1A_OPER_AUX_POEORB_OPOD_20150627T155155_V20150606T225944_20150608T005944.EOF'

100%[=====]
=====>] 4,420,094 --K/s in 0.1s

2017-08-09 19:22:37 (34.8 MB/s) -

'S1A_OPER_AUX_POEORB_OPOD_20150627T155155_V20150606T225944_20150608T005944.EOF' saved
[4420094/4420094]

Getting DEM file

wget -Odem.tif "http://opentopo.sdsc.edu/otr/getdem?demtype=SRTMGL1&west=-

119.008456807&south=32.3644581974&east=-115.701091959&north=34.6778684913&outputFormat=GTiff"

--2017-08-09 19:22:37-- http://opentopo.sdsc.edu/otr/getdem?demtype=SRTMGL1&west=-

119.008456807&south=32.3644581974&east=-115.701091959&north=34.6778684913&outputFormat=GTiff

Resolving opentopo.sdsc.edu (opentopo.sdsc.edu)... 198.202.90.222

Connecting to opentopo.sdsc.edu (opentopo.sdsc.edu)|198.202.90.222|:80... connected.

HTTP request sent, awaiting response... 302 Found

Location: http://ot-data1.sdsc.edu:9090/otr/getdem?demtype=SRTMGL1&west=-

119.008456807&south=32.3644581974&east=-115.701091959&north=34.6778684913&outputFormat=GTiff
[following]

--2017-08-09 19:22:38-- http://ot-data1.sdsc.edu:9090/otr/getdem?demtype=SRTMGL1&west=-

119.008456807&south=32.3644581974&east=-115.701091959&north=34.6778684913&outputFormat=GTiff

Resolving ot-data1.sdsc.edu (ot-data1.sdsc.edu)... 198.202.90.171

Connecting to ot-data1.sdsc.edu (ot-data1.sdsc.edu)|198.202.90.171|:9090... connected.

HTTP request sent, awaiting response... 200 OK

Length: unspecified [application/octet-stream]

Saving to: 'dem.tif'

[<=>] 198,390,002 38.8MB/s in
6.3s

2017-08-09 19:22:54 (30.1 MB/s) - 'dem.tif' saved [198390002]

S1A20150526_014935_F1
 S1A20150607_014936_F1
 Writing 31 lines for orbit...
 Writing 31 lines for orbit...
 Writing 52 lines of precise orbit for the LED file...
 Writing 52 lines of precise orbit for the LED file...
 Successfully opened S1A20150526_014935_F1.PRM
 Successfully opened S1A20150607_014936_F1.PRM
 Elapsed time 00:00:19.036 | (grdfilter) |
 [1] 1551
 [2] 1552
 [2] + Done SAT_ilt2rat S1A20150607_014936_F1.PRM 1 < topo.ilt > slave.ratl
 [1] + Done SAT_ilt2rat S1A20150526_014935_F1.PRM 1 < topo.ilt > master.ratl
 [1] 1591
 [2] 1592
 [2] + Done gmt surface atmp.xyz -bi3d -R0/20664/0/12196 -l16/8 -T0.3 -Gatmp.grd -N1000 -r
 [1] + Done gmt surface rtmp.xyz -bi3d -R0/20664/0/12196 -l16/8 -T0.3 -Grtmp.grd -N1000 -r
 Writing 31 lines for orbit...
 Writing SLC..Image Size: 21928 X 12196...
 Working on burst #1 #2 #3 #4 #5 #6 #7 #8 #9
 number of points clipped to short int 14
 Writing 31 lines for orbit...
 Reading in range and azimuth shifts table...
 Writing SLC..Image Size: 20664 X 12196...
 Working on burst #1 #2 #3 #4 #5 #6 #7 #8 #9
 number of points clipped to short int 47
 Writing 52 lines of precise orbit for the LED file...
 Writing 52 lines of precise orbit for the LED file...
 Successfully opened S1A20150526_014935_F1.PRM
 Successfully opened S1A20150607_014936_F1.PRM
 S1A20150526_014936_F2
 S1A20150607_014936_F2
 Writing 31 lines for orbit...
 Writing 31 lines for orbit...
 Writing 52 lines of precise orbit for the LED file...
 Writing 52 lines of precise orbit for the LED file...
 Successfully opened S1A20150526_014936_F2.PRM
 Successfully opened S1A20150607_014936_F2.PRM
 Elapsed time 00:00:17.434 | (grdfilter) |
 [1] 2221
 [2] 2222
 [2] Done SAT_ilt2rat S1A20150607_014936_F2.PRM 1 < topo.ilt > slave.ratl
 [1] + Done SAT_ilt2rat S1A20150526_014936_F2.PRM 1 < topo.ilt > master.ratl
 [1] 2235
 [2] 2236
 [2] Done gmt surface atmp.xyz -bi3d -R0/24640/0/12196 -l16/8 -T0.3 -Gatmp.grd -N1000 -r
 [1] + Done gmt surface rtmp.xyz -bi3d -R0/24640/0/12196 -l16/8 -T0.3 -Grtmp.grd -N1000 -r
 Writing 31 lines for orbit...

Writing SLC..Image Size: 25788 X 12192...
 Working on burst #1 #2 #3 #4 #5 #6 #7 #8 #9
 number of points clipped to short int 6
 Writing 31 lines for orbit...
 Reading in range and azimuth shifts table...
 Writing SLC..Image Size: 24640 X 12196...
 Working on burst #1 #2 #3 #4 #5 #6 #7 #8 #9
 number of points clipped to short int 9
 Writing 52 lines of precise orbit for the LED file...
 Writing 52 lines of precise orbit for the LED file...
 Successfully opened S1A20150526_014936_F2.PRM
 Successfully opened S1A20150607_014936_F2.PRM
 S1A20150526_014937_F3
 S1A20150607_014937_F3
 Writing 31 lines for orbit...
 Writing 31 lines for orbit...
 Writing 52 lines of precise orbit for the LED file...
 Writing 52 lines of precise orbit for the LED file...
 Successfully opened S1A20150526_014937_F3.PRM
 Successfully opened S1A20150607_014937_F3.PRM
 Elapsed time 00:00:17.434 | (grdfilter) |
 [1] 3446
 [2] 3447
 [2] Done SAT_ilt2rat S1A20150607_014937_F3.PRM 1 < topo.ilt > slave.ratl
 [1] + Done SAT_ilt2rat S1A20150526_014937_F3.PRM 1 < topo.ilt > master.ratl
 [1] 3727
 [2] 3728
 [2] Done gmt surface atmp.xyz -bi3d -R0/23848/0/12196 -l16/8 -T0.3 -Gatmp.grd -N1000 -r
 [1] + Done gmt surface rtmp.xyz -bi3d -R0/23848/0/12196 -l16/8 -T0.3 -Grtmp.grd -N1000 -r
 Writing 31 lines for orbit...
 Writing SLC..Image Size: 24864 X 12196...
 Working on burst #1 #2 #3 #4 #5 #6 #7 #8 #9
 number of points clipped to short int 0
 Writing 31 lines for orbit...
 Reading in range and azimuth shifts table...
 Writing SLC..Image Size: 23848 X 12196...
 Working on burst #1 #2 #3 #4 #5 #6 #7 #8 #9
 number of points clipped to short int 1
 Writing 52 lines of precise orbit for the LED file...
 Writing 52 lines of precise orbit for the LED file...
 Successfully opened S1A20150526_014937_F3.PRM
 Successfully opened S1A20150607_014937_F3.PRM
 Running Interferogram: p2p_S1A_TOPS.csh S1A20150526_014935_F1 S1A20150607_014936_F1 config.s1a.txt
 > log 2>&1
 Running Interferogram: p2p_S1A_TOPS.csh S1A20150526_014936_F2 S1A20150607_014936_F2 config.s1a.txt
 > log 2>&1
 Running Interferogram: p2p_S1A_TOPS.csh S1A20150526_014937_F3 S1A20150607_014937_F3 config.s1a.txt
 > log 2>&1

Changing name field in KML file (phasefilt_mask_ll.kml)
Writing output file (20150526_20150607_F1_vv_phase.kml)
Changing name field in KML file (unwrap_mask_ll.kml) Writing
output file (20150526_20150607_F1_vv_unwrap.kml)
Changing name field in KML file (phasefilt_mask_ll.kml)
Writing output file (20150526_20150607_F2_vv_phase.kml)
Changing name field in KML file (unwrap_mask_ll.kml) Writing
output file (20150526_20150607_F2_vv_unwrap.kml)
Changing name field in KML file (phasefilt_mask_ll.kml)
Writing output file (20150526_20150607_F3_vv_phase.kml)
Changing name field in KML file (unwrap_mask_ll.kml) Writing
output file (20150526_20150607_F3_vv_unwrap.kml)