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:

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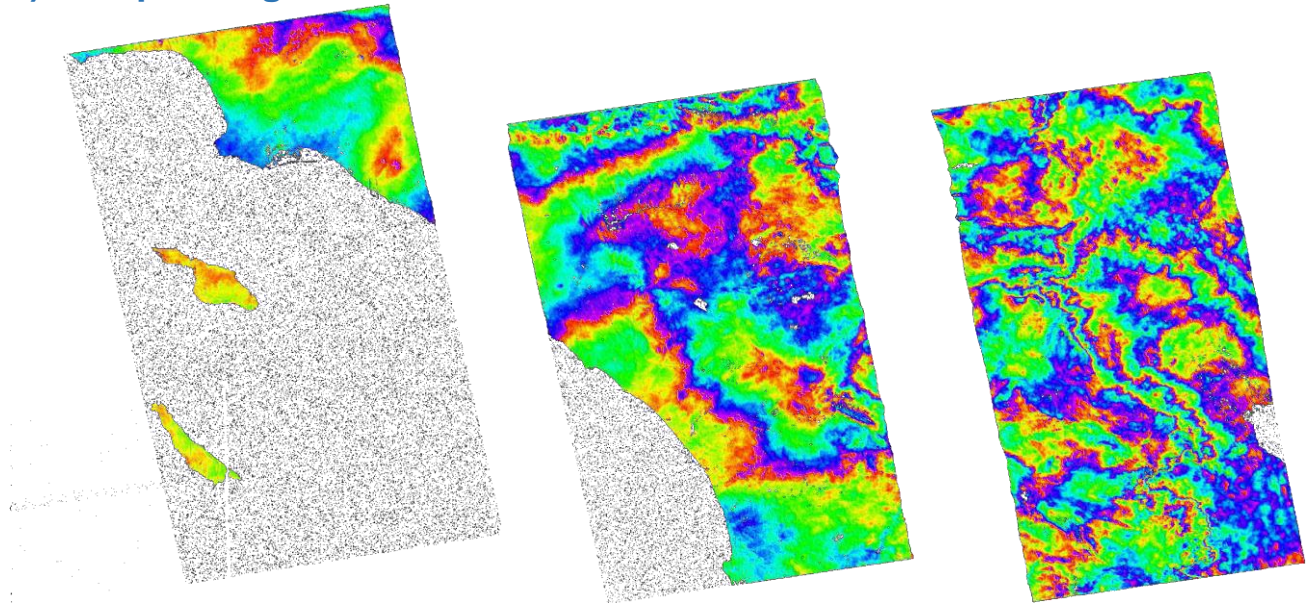
Figure 1. Script output images: color phase products for each swath F1, F2, F3. Contains modified Copernicus Sentinel data (2015) processed by ESA

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_n7nTIlMljdvU6kRRB3g&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_n7nTIlMljdvU6kRRB3g&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=2f2aa790b79b3c012b8a61acaf5877cff4f996fadbbc4832e28e524802c99cb6&state=redirect%3Ahttps%3A%2F%2Fs1qc%2Easf%2Ealaska%2Eedu%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=2f2aa790b79b3c012b8a61acaf5877cff4f996fadbbc4832e28e524802c99cb6&state=redirect%3Ahttps%3A%2F%2Fs1qc%2Easf%2Ealaska%2Eedu%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_n7nTIlMljdvU6kRRB3g&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_n7nTIlMljdvU6kRRB3g&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%2Easf%2Ealaska%2Eedu%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=a425247b9ca1ea75bebbb622ba3fcd0fa

9fe950f5aacfa3b6d57e7def61b0760&state=redirect%3Ahttps%3A%2F%2Fs1qc%2Easf%2Ealaska%2Eedu%3A4
43%2Faux_poeorb%2FS1A_OPER_AUX_POEORB_OPOD_20150627T155155_V20150606T225944_20150608T0
05944%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_V20150606
T225944_20150608T005944.EOF [following]
--2017-08-09 19:22:37--
https://s1qc.asf.alaska.edu/aux_poeorb/S1A_OPER_AUX_POEORB_OPOD_20150627T155155_V20150606T22
5944_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_llt2rat S1A20150607_014936_F1.PRM 1 < topo.llt > slave.ratll
[1]  + Done            SAT_llt2rat S1A20150526_014935_F1.PRM 1 < topo.llt > master.ratll
[1] 1591
[2] 1592
[2]  + Done            gmt surface atmp.xyz -bi3d -R0/20664/0/12196 -I16/8 -T0.3 -Gatmp.grd -N1000 -r
[1]  + Done            gmt surface rtmp.xyz -bi3d -R0/20664/0/12196 -I16/8 -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_llt2rat S1A20150607_014936_F2.PRM 1 < topo.llt > slave.ratll
[1]  + Done             SAT_llt2rat S1A20150526_014936_F2.PRM 1 < topo.llt > master.ratll
[1] 2235
[2] 2236
[2]    Done            gmt surface atmp.xyz -bi3d -R0/24640/0/12196 -I16/8 -T0.3 -Gatmp.grd -N1000 -r
[1]  + Done            gmt surface rtmp.xyz -bi3d -R0/24640/0/12196 -I16/8 -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_llt2rat S1A20150607_014937_F3.PRM 1 < topo.llt > slave.ratll
[1] + Done   SAT_llt2rat S1A20150526_014937_F3.PRM 1 < topo.llt > master.ratll
[1] 3727
[2] 3728
[2]   Done   gmt surface atmp.xyz -bi3d -R0/23848/0/12196 -I16/8 -T0.3 -Gatmp.grd -N1000 -r
[1] + Done   gmt surface rtmp.xyz -bi3d -R0/23848/0/12196 -I16/8 -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)