Batch processing and stacking in GMTSAR

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• Introduction
• Overview
• Batch processing with an example
• Stacking with an example
• Summary

InSAR workshop 2013, Boulder, CO
stacking for time series
\[ V_{\text{InSAR}}(x) = (\phi(x) - M(x)) \ast F_{\text{high}}(x) + M(x) \]

combined high-resolution velocity

http://topex.ucsd.edu/pub/saf_models/insar/ALOS_ASC_masked.kmz

standard deviation

[Tong et al., 2013]
Parkfield SAF
red  10 mm/yr
blue  -10 mm/yr
Parkfield SAF
red  10 mm/yr
blue -10mm/yr
Creeping SAF
red  10 mm/yr
blue -10mm/yr
Creeping SAF
red  10 mm/yr
blue -10 mm/yr
Introduction

• Automatic processing of a stack of SAR data to generate interferograms
• Average multiple interferograms to estimate velocity due to inter-seismic, post-seismic, volcano sources
• Can be integrated into time-series analysis tools, such as SBAS, PSInSAR
Introduction - continued

• Automatic data processing has advantages:
  – Objective
  – Reproducible
  – Less prone to errors

• Written in shell and is easy to modify

• Advanced user can explore customized features
Overview

• Batch processing:
  – Preprocessing without a master image
    `pre_proc_init.csh`
  – Preprocessing with a master image
    `pre_proc_batch.csh`
  – Align a stack of SAR data
    `align_batch.csh`
  – Form a stack of interferograms
    `intf_batch.csh`

• Stacking:
  – Average the phase
    `stack_phase.bash`
  – Average the correlation
    `stack_corr.bash`
  – Compute standard deviations
    `std.bash`
  – GPS/InSAR integration
    `stack.csh`
Batch processing: `pre_proc_init.csh`

- Function:
  - preprocess a stack of SAR data using default parameters (earth radius, Doppler centroid, near range)
  - Generate baseline-time plot to choose master images, alignment strategy, interferometric pairs
Batch processing: \textit{pre\_proc\_init.csh}

For example:

\begin{verbatim}
[speedychef:/spd2/tong/raw] xtong% ls IMG*A > data.in
[speedychef:/spd2/tong/raw] xtong% ls
IMG-HH-ALPSRP022200660-H1.0__A  LED-ALPSRP022200660-H1.0__A
IMG-HH-ALPSRP028910660-H1.0__A  LED-ALPSRP028910660-H1.0__A
IMG-HH-ALPSRP035620660-H1.0__A  LED-ALPSRP035620660-H1.0__A

[speedychef:/spd2/tong/raw] xtong% pre_proc_init.csh ALOS data.in
\end{verbatim}
Batch processing: *pre_proc_init.csh*

For example:

```
[speedychef:/spd2/tong/raw] xtong% ls
IMG-HH-ALPSRP022200660-H1.0___A
IMG-HH-ALPSRP022200660-H1.0___A.PRMA
IMG-HH-ALPSRP022200660-H1.0___A.raw
IMG-HH-ALPSRP035620660-H1.0___A
IMG-HH-ALPSRP035620660-H1.0___A.PRMA
IMG-HH-ALPSRP035620660-H1.0___A.raw
IMG-HH-ALPSRP055750660-H1.0___A
IMG-HH-ALPSRP055750660-H1.0___A.PRMA
IMG-HH-ALPSRP055750660-H1.0___A.raw
IMG-HH-ALPSRP129560660-H1.0___A
IMG-HH-ALPSRP129560660-H1.0___A.PRMA
IMG-HH-ALPSRP129560660-H1.0___A.raw
LED-ALPSRP022200660-H1.0___A
LED-ALPSRP035620660-H1.0___A
LED-ALPSRP055750660-H1.0___A
LED-ALPSRP129560660-H1.0___A
baseline_table.dat
data.in
stacktable_all.ps
table.gmt
[speedychef:/spd2/tong/raw] xtong%
```
Batch processing: `pre_proc_batch.csh`

• Function:
  – preprocess a stack of SAR data using uniform parameters (earth radius, Doppler centroid, near range) to make them geometrically consistent with one single image (super master)
Batch processing: `pre_proc_batch.csh`

1. Modify data.in file

   [speedychef:/spd2/tong/raw] xtong% more data.in
   IMG-HH-ALPSRP055750660-H1.0__A
   IMG-HH-ALPSRP022200660-H1.0__A
   IMG-HH-ALPSRP028910660-H1.0__A
   IMG-HH-ALPSRP035620660-H1.0__A
   IMG-HH-ALPSRP042330660-H1.0__A
   IMG-HH-ALPSRP049040660-H1.0__A
   IMG-HH-ALPSRP062460660-H1.0__A
   IMG-HH-ALPSRP075880660-H1.0__A
   IMG-HH-ALPSRP082590660-H1.0__A
   IMG-HH-ALPSRP089300660-H1.0__A
   IMG-HH-ALPSRP096010660-H1.0__A
   IMG-HH-ALPSRP109430660-H1.0__A

2. Delete old PRM and raw files
Batch processing: pre_proc_batch.csh

3. Modify batch.config file and run pre_proc_batch.csh

Stop here to look at the batch.config file
Batch processing: *align_batch.csh*

- **Function:**
  - Focus SAR images to form Single Look Complex (SLC) data
  - Align (image registration) a stack of SLC data using 2D cross-correlation within sub-pixel (<10m) accuracy
"Leap frog" method to align SAR images
“Leap frog” method to align SAR images
"Leap frog" method to align SAR images
Batch processing: *align_batch.csh*

1. Edit align.in file

```
IMG-HH-ALPSRP055750660-H1.0__A:IMG-HH-ALPSRP028910660-H1.0__A:IMG-HH-ALPSRP055750660-H1.0__A
IMG-HH-ALPSRP055750660-H1.0__A:IMG-HH-ALPSRP035620660-H1.0__A:IMG-HH-ALPSRP055750660-H1.0__A
IMG-HH-ALPSRP055750660-H1.0__A:IMG-HH-ALPSRP042330660-H1.0__A:IMG-HH-ALPSRP055750660-H1.0__A
IMG-HH-ALPSRP055750660-H1.0__A:IMG-HH-ALPSRP049040660-H1.0__A:IMG-HH-ALPSRP055750660-H1.0__A
```

Master or Surrogate master  Slave  Super master

2. Then run `align_batch.csh`

`align_batch.csh` ALOS `align.in`

*Time-consuming part of the processing .. take a break here ..*
Batch processing: *intf_batch.csh*

- **Function:**
  - Convert Digital Elevation Model into radar coordinates
  - Form interferograms using two SLC data
  - Remove phase due to earth curvature and topography
  - Plot amplitude, correlation, phase using GMT
  - Unwrap using SNAPHU
  - Geocode and make Google Earth KML files
Choose interferograms pairs

- primary match
- secondary match
- tertiary match

Choose interferograms pairs

primary match
secondary match
tertiary match
Batch processing: *intf_batch.csh*

1. Edit `intf.in` file to choose interferogram pairs
Batch processing: `intf_batch.csh`

2. Make dem.grd file and put it inside topo/ directory
Batch processing: `intf_batch.csh`

2. Make `dem.grd` file and put it inside `topo/` directory
Batch processing: *intf_batch.csh*

3. Check/modify batch.config file

```
[ speedychef:/spd2/tong ] xttong% ls
SLC       batch.config  raw  topo
align.in   intf.in      tong.tar
[ speedychef:/spd2/tong ] xttong% intf_batch.csh ALOS intf.in batch.config
```

clean up topo/ folder

```
DEM2TOPOPHASE.CSH - START
USER SHOULD PROVIDE DEM FILE
processing ALOS FBS data
blockmedian: W: 0 E: 11304 S: 0 N: 27648 nx: 5653 ny: 6913
blockmedian: Working on file trans.dat
```

*Time-consuming part of the processing .. take a break here ..*
Batch processing: results

- All interferograms are in different folders in intf/
- The folder can be named after either date or orbital number
  - Modify batch.config to choose among date or orbital number
- Each interferogram folder contains the following files:
  1. Amplitude, phase, correlation, unwrapped phase, filtered phase image files in GMT/NetCDF format “.grd”
  2. Corresponding files after geocoding with suffix “_ll.grd”
  3. Postscripts plots: “.ps”
  4. Google Earth “.kml” and “.png”
Batch processing: results

Phase of the 3 interferograms
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Stacking: *stack_phase.bash*

- **Function:**
  - Average unwrapped phase
  - Convert the phase (radius) to velocity (mm/yr)

- **Note:** it’s necessary to check the unwrapped phase before stacking or time-series analysis because unwrapping from SNAPHU may give errors, which will corrupt results

- **Complex processing techniques** (e.g. filtering, detrending, GPS/InSAR integration) can be incorporated along with stacking
complete data set
complete data set

Land subsidence near Coachella Valley, California
Summary

• Batch processing shell scripts provide automatic InSAR data processing (preprocess, alignment, form interferogram)
• Stacking shell scripts (under-development) provide methods to estimate mean velocity and its standard deviations.
• Advanced user can develop custom scripts using tools inside GMT and GMTSAR.
• InSAR time-series analysis can be developed in the next step of processing.
• Any questions?