A Combined Multi-Temporal InSAR Method: Incorporating Persistent Scatterer and Small Baseline Approaches

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Multi-Temporal InSAR

- Same area imaged each time
Multi-Temporal (Time Series) InSAR

- Persistent Scatterer Methods
- Small Baseline Methods

TS-InSAR
Persistent Scatterer (PS) Methods: optimized for pixels dominated by a single scatterer
Multi-Temporal (Time Series) InSAR

Persistent Scatterer (PS) Methods: optimized for pixels dominated by a single scatterer

Small Baseline (SB) Methods: optimized for pixels with a Gaussian distribution of scatterers
Conclusions

- PS and Small Baseline methods select different but overlapping sets of pixels.

- The noise characteristics of a pixel varies, depending on the method used (filtering or no filtering).

- The methods can be combined to extract signal from more pixels, and with higher SNR, than either method can achieve alone.
“Traditional” Small Baseline Approach

[e.g. Berardino et al., 2002, Schmidt and Bürgmann, 2003]

1. Interfere image pairs that are close in time and have a small separation between satellite positions

- Filtering is used to discard non-overlapping bandwidth
“Traditional” Small Baseline Approach

[e.g. Berardino et al., 2002, Schmidt and Bürgmann, 2003]

1. Interfer image pairs that are close in time and have a small separation between satellite positions

2. “Multilook” each interferogram to increase signal to noise ratio
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3. “Phase-Unwrap” each interferogram in 2-D
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4. Find pixels which are coherent in every interferogram and invert in some way for the temporal displacement
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- Essentially conventional InSAR with an inversion step
New Small Baseline Approach

1. Interfere image pairs that are close in time and have a small separation between satellite positions

2. Process “single look” images (similar to Stanford PS method)

3. “Phase-Unwrap” each interferogram in “3-D”

4. Find pixels which are coherent in every interferogram and invert in some way for the temporal displacement
## PS vs. Small Baseline Pixel Selection

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PS vs. Small Baseline Pixel Selection

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1. Form single-master interferograms at highest possible resolution  
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Eyjafjallajökull Volcano, Iceland

Einarsson and Saemundsson [1987]
Comparison of PS and Small Baseline Pixels

Single time period (Jun 1997 to Oct 1999)

PS pixels: 177,000
SB pixels: 659,000
Both: 133,000
Noise Statistics for Selected Pixels

- Pixels common to both analyses only

• PS Method has higher SNR
  • SB Method has higher SNR

SNR difference (PS Method – SB Method)

Number of pixels (thousands)
The Difference Filtering Makes
Multi-Temporal (Time Series) InSAR

- TS-InSAR
  - Persistent Scatterer Methods
  - Small Baseline Methods
  - Combined Method
Wrapped phase of pixels from both methods combined in Small Baseline Interferograms.

For pixels selected by both methods, the weighted mean phase is calculated, with the weighting being an estimate of SNR.
Phase- Unwrapping in Space-Time

Phase between 2 neighbouring pixels

Interferogram (order of master date)

Wrapped phase
Unwrapped smoothly

UW Phase

Time
Unwrapped phase difference between neighbouring pixels

2D (Space) Probability Density Functions

- Peak probability at phase from unwrapping smoothly in space-time
- Distribution width from variation of wrapped phase from phase determined by unwrapping smoothly in space-time.
Combined Time Series InSAR

- Combined before phase-unwrapping
- Duplicates weighted according to signal-to-noise ratio
Deformation For Each Time Step

- After unwrapping, phase is inverted to give phase relative to single master.
- In this plot, each image includes only the deformation since the previous image.
Variation in Deformation and Seismicity
(Catalogue Earthquake locations from Iceland Meteorological Office)

To May 1999

First days

May 1999 to Aug 1999

70 days

Aug 1999 to Oct 1999

70 days

Oct 1999 to Aug 2000

Last days

-4 LOS disp (cm) 14
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