ERTH 455 / GEOP 555
Geodetic Methods

– Lecture 15: InSAR - Unwrapping the Phase –

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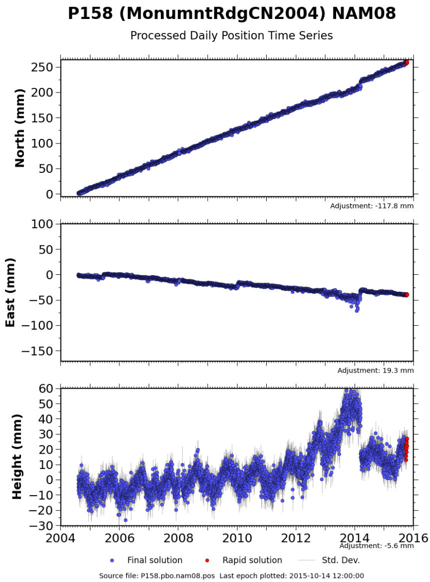
"Guess the Process"



UNAVCO, `https://plus.google.com/112042426109504523574/posts/62kUxwSWCiB`

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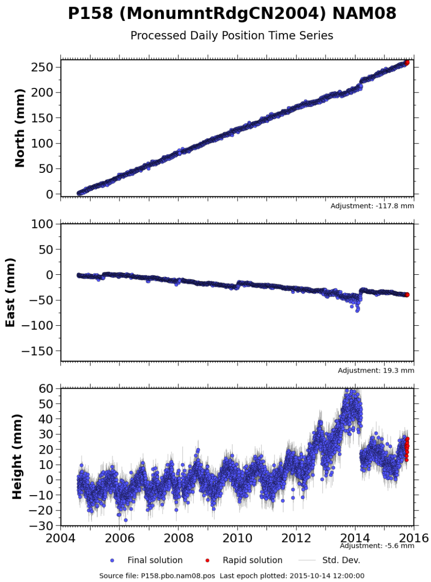

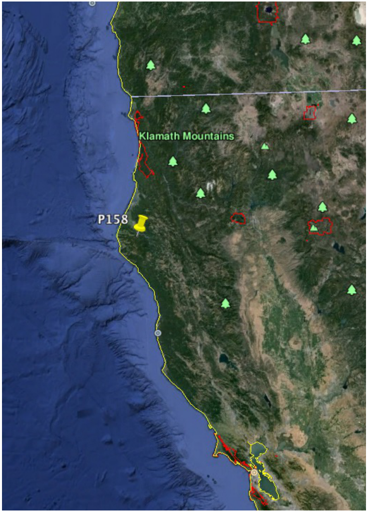

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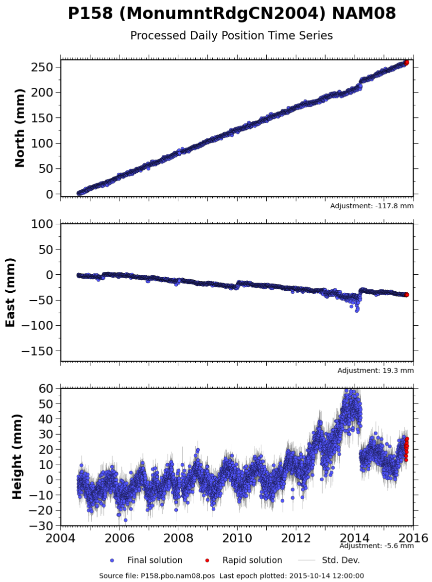

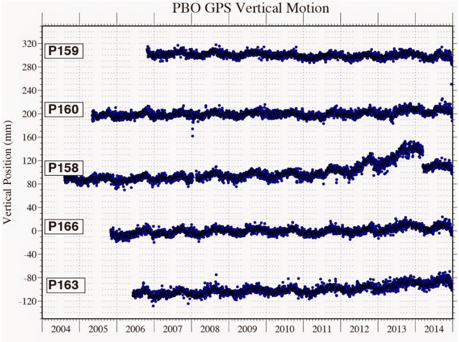

Figure 2. Comparison of vertical motion at P158 and nearby (<30 km) stations.

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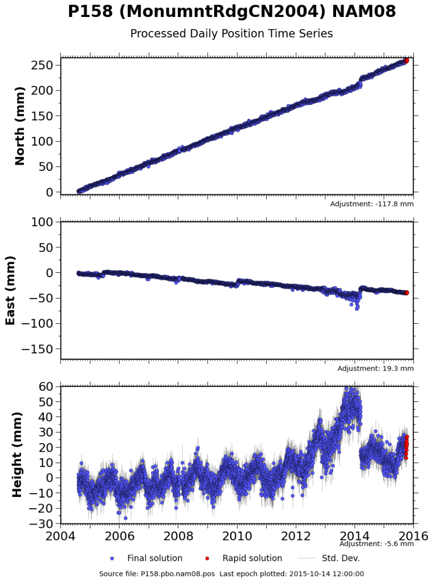

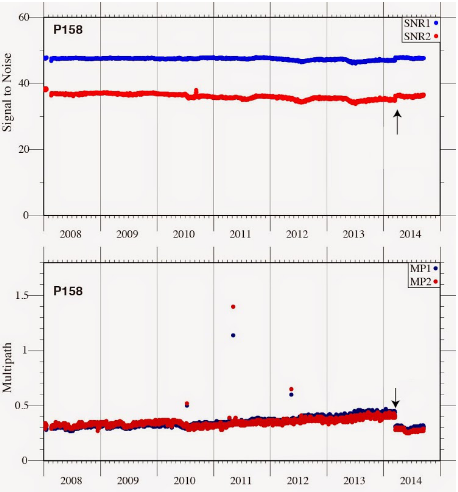

Figure 3. Signal to noise ration (top) and multipath (bottom) for P158.

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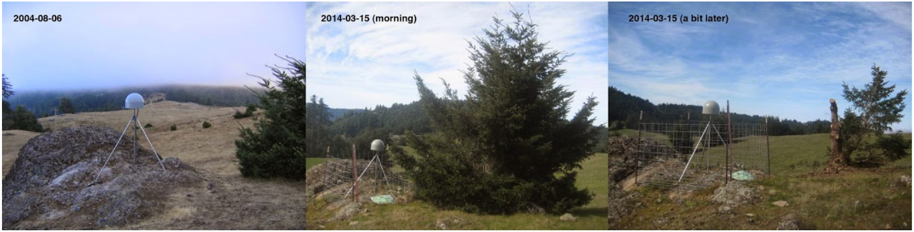

Figure 4. P158 at installation (left), ~10 years later (middle), ~10 years+2 hours later (right). The small tree north of the station grew into a larger tree and was removed on March 3, 2014.

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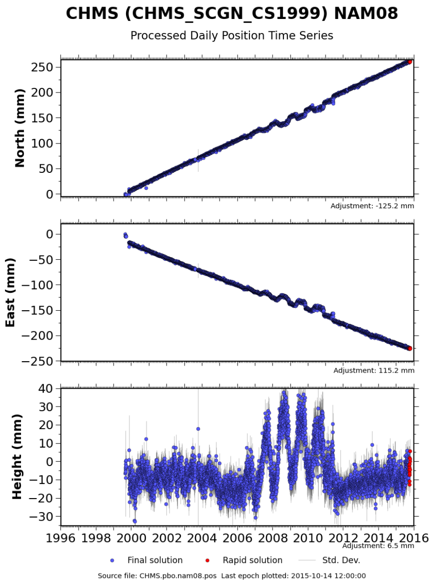

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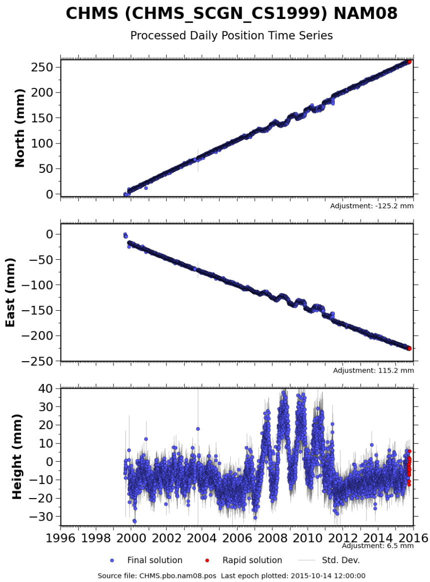


2009 vs 2015

UNAVCO, `https://plus.google.com/112042426109504523574/posts/62kUxwSWCiB`

InSAR - Processing Flow

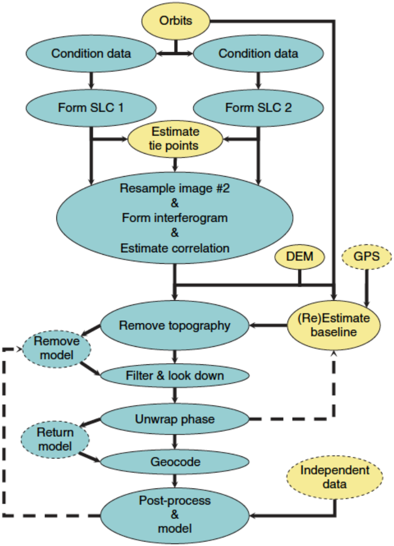
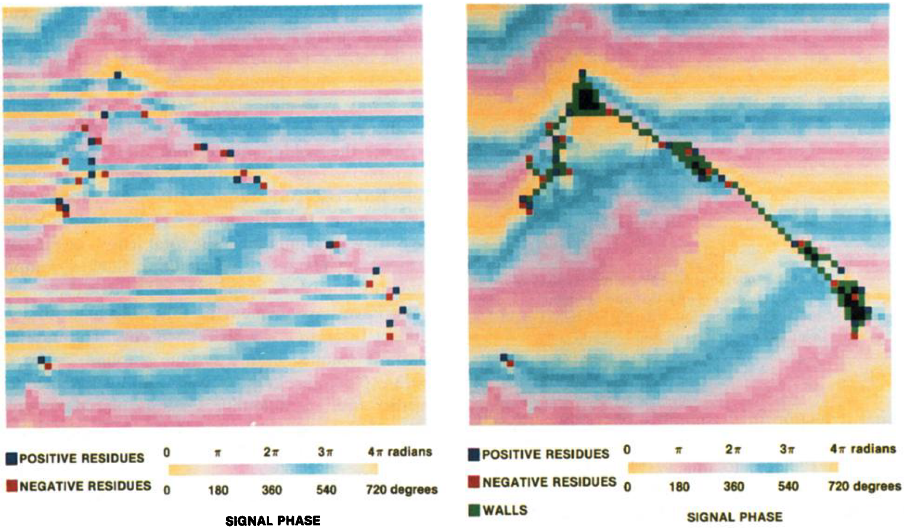


Figure 6 Representative differential InSAR processing flow diagram. Blue bubbles represent image output, yellow ellipses represent nonimage data. Flow is generally down the solid paths, with optional dashed paths indicating potential iteration steps. DEM, digital elevation model; SLC, single look complex image.

Simons and Rosen, 2007

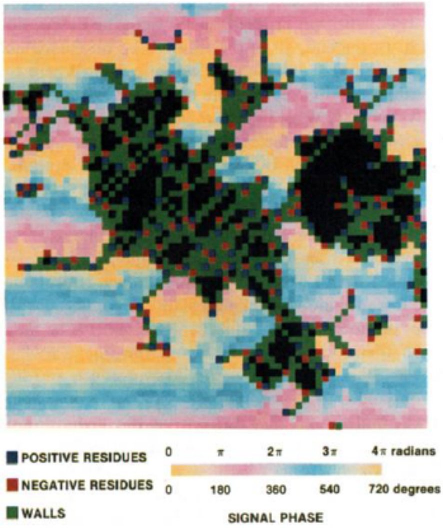
InSAR - Phase Unwrapping: Branch Cut



Goldstein et al., JGR, 1988

Cuts in place, not yet integrated

InSAR - Phase Unwrapping: Branch Cut



Goldstein et al., JGR, 1988

Dense area of residues: no reliable phase estimation possible, isolated from integration

InSAR - Phase Unwrapping: L-norm minimization

Minimize (2D-range-azimuth coordinate system):

$$\sum_i \sum_j g_{ij}^{(r)}(\Delta\phi_{ij}^{(r)}, \Delta\psi_{ij}^{(r)}) + \sum_i \sum_j g_{ij}^{(a)}(\Delta\phi_{ij}^{(a)}, \Delta\psi_{ij}^{(a)})$$

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- $\Delta\phi^{(r)}$, $\Delta\psi^{(r)}$: **range** component of wrapped, unwrapped (and rewrapped) phase gradients
- $\Delta\phi^{(a)}$, $\Delta\psi^{(a)}$: **azimuth** component of wrapped, unwrapped phase gradients
- e.g, $\Delta\phi_{ij}^{(r)} = \phi_{i,j} - \phi_{i-1,j}$, analog for azimuth, unwrapped components

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Cost-function often restricted in form:

$$g_{ij}(\Delta\phi, \Delta\psi) = w_{ij}|\Delta\phi_{ij} - \Delta\psi_{ij}|^P$$

- all cost functions have same shape determined by constant P ($P = 2$: Least squares problem)
- indep. weights w determine each cost function's contribution

InSAR - Phase Unwrapping: L-norm minimization

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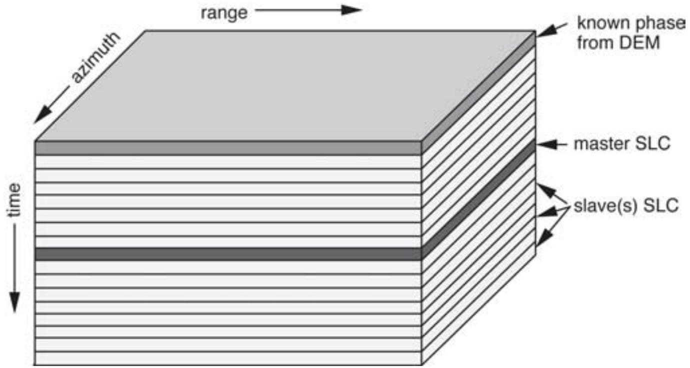
InSAR - Phase Unwrapping: L-norm & Probabilistic

- no physical reasons that optimal L^P solution must be correct
- *Chen & Zebker, JOSA, 2001* introduce objective from generalized, statistical cost functions
- allow any form for cost function g
- allow g shape to vary for different parts of interferogram
- choose cost function that maximizes conditional probably of solution based on wrapped phase, image intensity, coherence
- **application-specific** cost functions
- solution **approximation** based on non-linear network optimization

InSAR - Timeseries

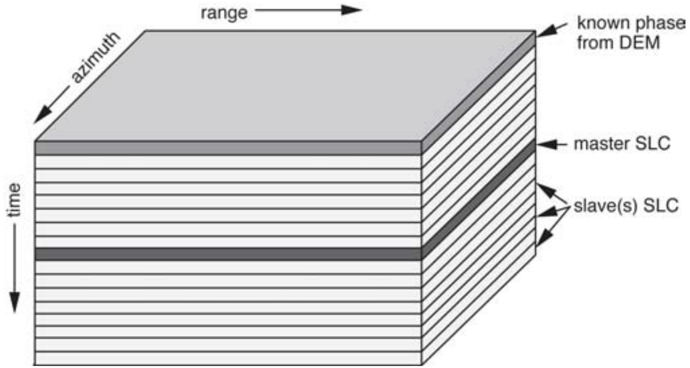
Improve signal to noise ratio by creating multiple interferograms.

InSAR - Timeseries: Stacking



Sandwell et al., 2011

InSAR - Timeseries: Stacking



Sandwell et al., 2011

What could be difficult about this?

InSAR - Timeseries: Stacking

- often most challenging: geometrical alignment of large stack of images, align with topographic phase
- alignment problematic: temporal and geometric decorrelation
- subpixel alignment can fail due to lack of correlated areas

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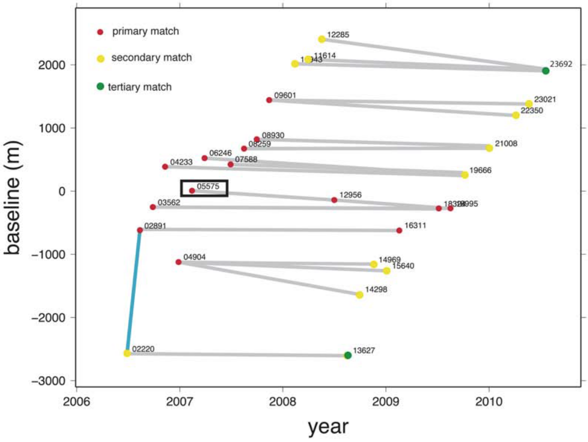

Sandwell et al., 2011

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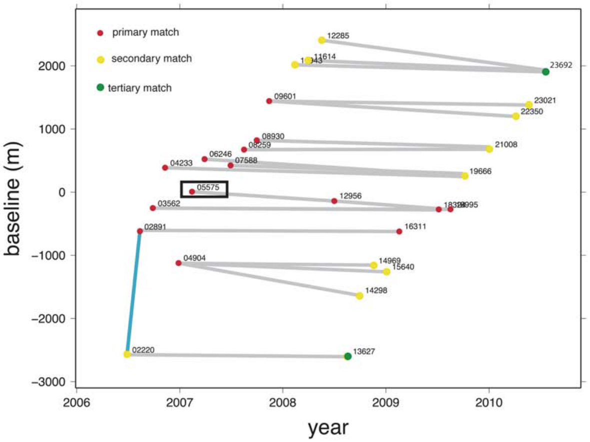

Sandwell et al., 2011

- ALOS stack, track 213, frame 0660, Coachella Valley, California
- temporal decorrelation not as problematic: desert
- geometry: 5 km perpendicular baseline change over 2 years

InSAR - Timeseries: Stacking

gmtSAR processing:

1. preprocess all images independently
2. use `pre_proc_batch.csh` – creates the baseline plot above
3. select master image in middle of baseline vs. time plot
   - alignment to overall $<$ 2-pixel precision
   - multi-step approach
   - *primary match* – images near master in baseline vs time plot aligned directly to master
   - *secondary match* – each primary match slave is surrogate master to its neighbors
   - *tertiary match* – possible to define for images very far from master
4. use `align_batch.csh` – to run alignment (time consuming!)
5. generate/retrieve a DEM
6. use `intf_batch.csh` – to make set of interferograms