Preliminary study on

新潟県中越地震・中越沖地震震源域でのEnvisat画像を用いたInSAR時系列解析

InSAR time-series analysis using Envisat images: application on the region of two earthquakes in Niigata, central Japan

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Motivation

- I work for RCEP of DPRI; we have been measuring crustal deformation for decades, trying to detect subtle precursors of EQs
- Can InSAR contribute also?
- Fully exploit C-band data
- Solution: Persistent scatterer (PS) and small-baseline (SB) approaches

L and C; difference in the quality of single interferograms is evident.

Niigata Chuetsuoki EQ,
Mw 6.6, Jul. 2007

ALOS (L-band)
(from JAXA website)

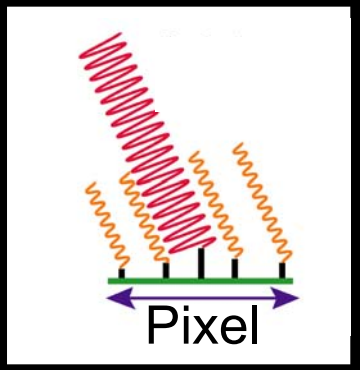
Envisat (C-band)

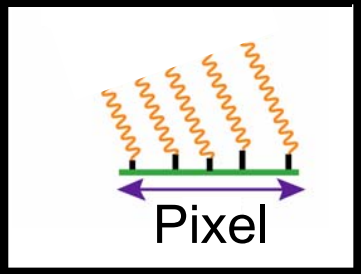
C-band still has advantages.

- Data in a long period
- Regularly acquired with shorter time intervals than that of PALSAR
- Less ionospheric effects than L-band

PS and SB = High precision (mm level) InSAR time-series analysis

- Both use tens of multi-temporal images and estimate time-series of LOS displacements
- PS methods: use pixels of point scatterers
- SB methods: use pixels that are stable with time





StaMPS/MTI (by Andy Hooper)

- Available from http://www.hi.is/~ahooper for non-commercial use
- Extract ground displacements for persistent scatterer pixels from multi-temporal acquisitions
- Uses Doris software to compute interferograms, can start from SLCs or from raw data (by using ROI_PAC)
- StaMPS/MTI (beta): PS + SB (only for collaborative purposes at the moment)

StaMPS characteristics

- Phase analysis for PS identification (same with other PS algorithms)

$$\psi_{x,i} = W\{\phi_{D,x,i} + \phi_{A,x,i} + \Delta\phi_{S,x,i} + \Delta\phi_{\theta,x,i} + \phi_{N,x,i}\}$$

Phase = Wrap (defo + DEM (look ang.) + atmos + orbit + other)

- No requirement for prior knowledge of deformation
- Sophisticated 3D unwrapping algorithm

StaMPS algorithm

1. Computation of interferograms

↓

2. Selection of PS pixels

↓

3. Estimation of displacements

StaMPS algorithm

1. Computation of interferograms

↓

2. Selection of PS pixels

↓

3. Estimation of displacements

- Selection of master

$$\sum_{all\ interfero} |total\ correlation|$$

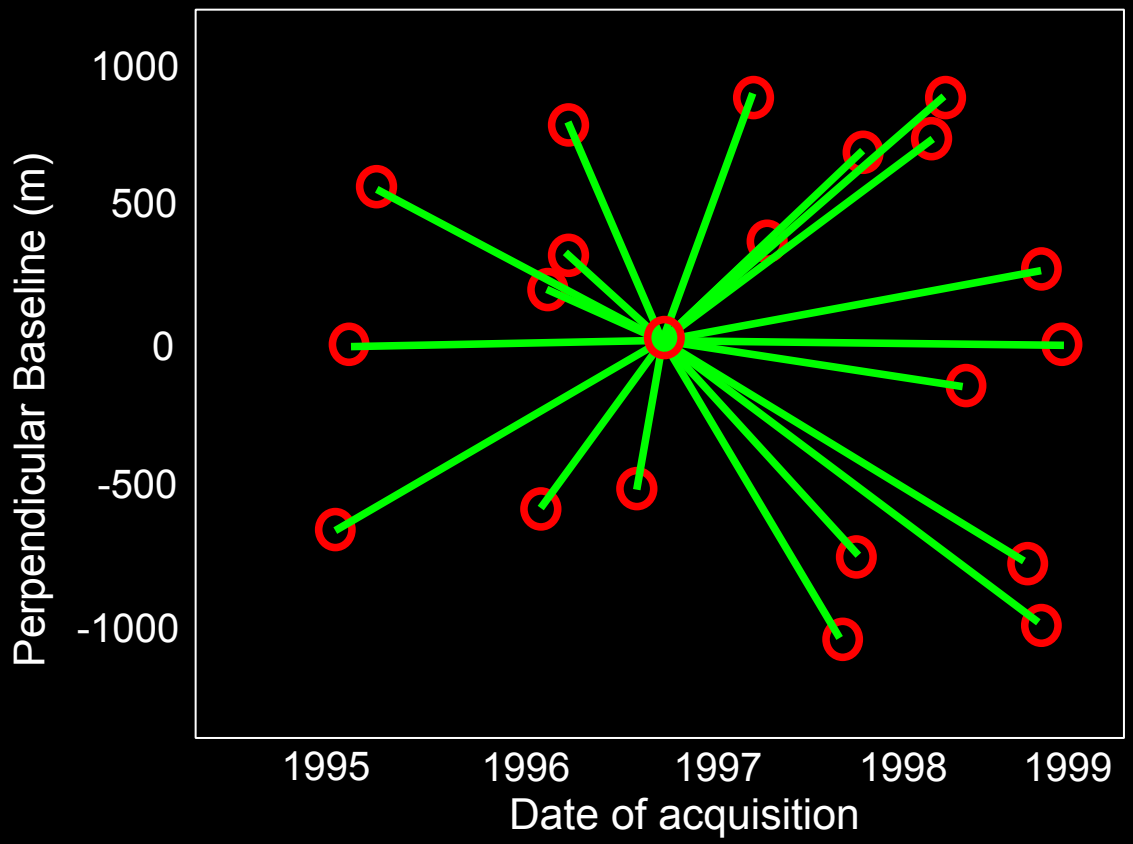
is maximized

- Coregistration to the master image

"Network" coregistration, use good estimation of slave-slave offsets to derive the final master-slave offsets

- Flattening

$$\begin{aligned}\rho_{total} &= \rho_{temporal} \cdot \rho_{spatial} \cdot \rho_{doppler} \cdot \rho_{thermal} \\ &\approx \left(1 - f\left(\frac{T}{T^c}\right)\right) \cdot \left(1 - f\left(\frac{B_\perp}{B_\perp^c}\right)\right) \\ &\quad \cdot \left(1 - f \cdot \left(\frac{F_{DC}}{F_{DC}^c}\right)\right) \cdot \rho_{thermal},\end{aligned}$$



StaMPS algorithm

1. Computation of interferograms

↓

2. Selection of PS pixels

↓

3. Estimation of displacements

- Initial selection based on amplitude dispersion

- Phase modeling

$$\psi_{x,i} = W\{\phi_{D,x,i} + \phi_{A,x,i} + \Delta\phi_{S,x,i} + \Delta\phi_{\theta,x,i} + \phi_{N,x,i}\}$$

Defo DEM atmos orbit other

Pixel with small noise term (last term) can be PS candidate

- Selection of PS based on the two

StaMPS algorithm

1. Computation of interferograms

↓

2. Selection of PS pixels

↓

3. Estimation of displacements

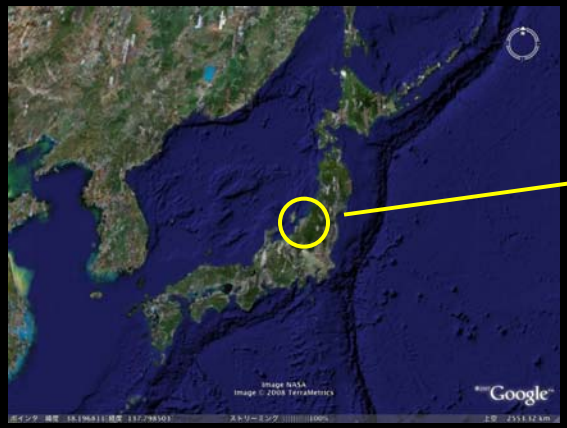
- Spatio-temporal unwrapping on PS pixels
- Eliminate nuisance terms by filtering

Atmos. and orbit effects of the master are extracted by low-pass filtering

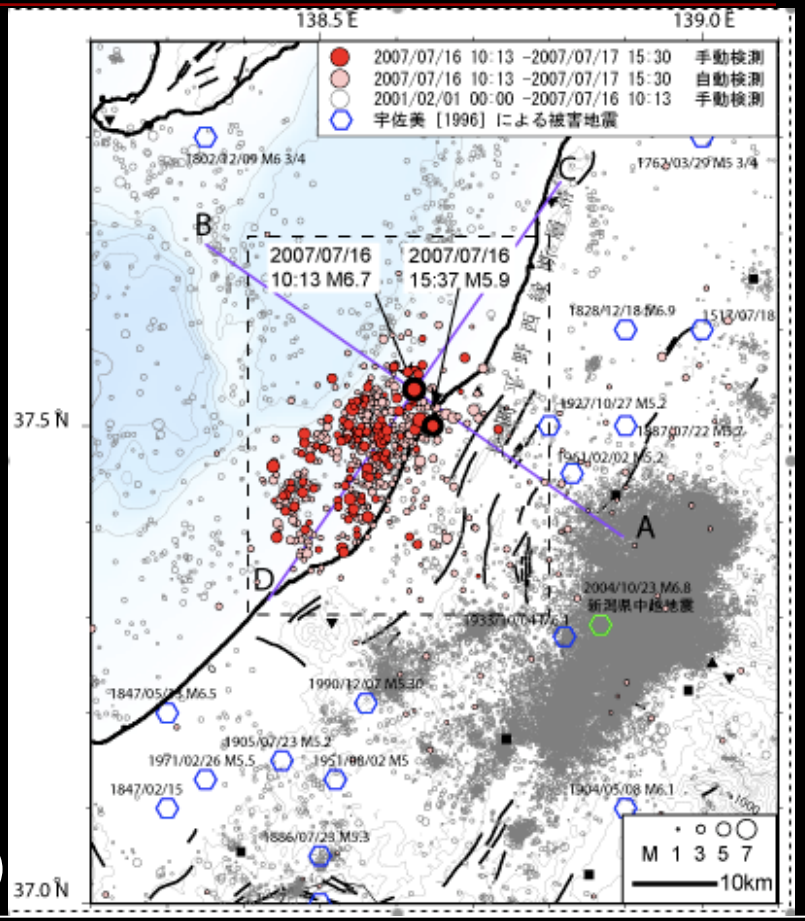
Atmos. effects of the slave are extracted by low-pass spatial filtering and high-pass temporal filtering

Target area: Niigata prefecture, central Japan

- Chuetsu: Mw 6.5 in Oct 2004, Chuetsu-oki: Mw 6.6 in July 2007
- High strain rate
- Focus on the interseismic interval for now

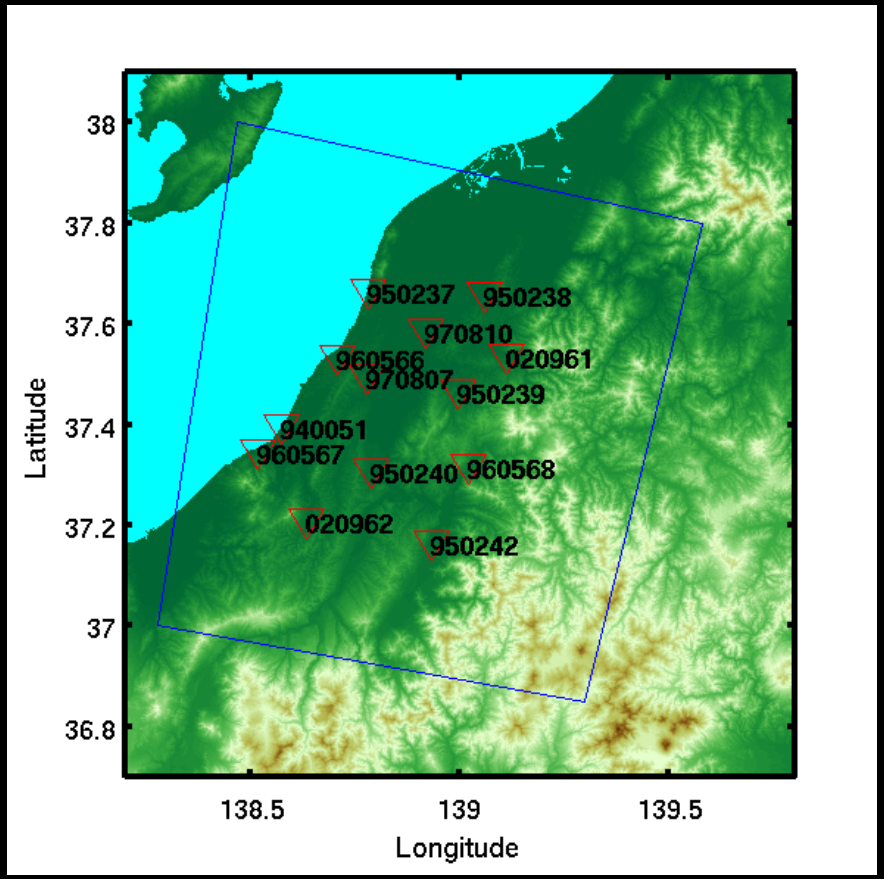


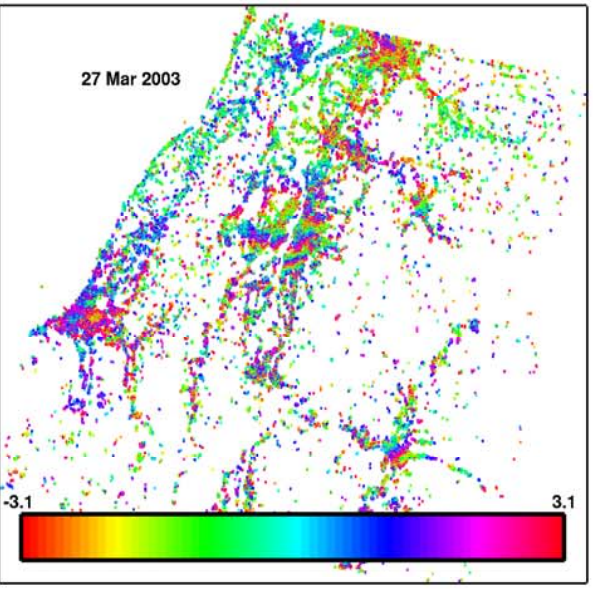
(NIED webpage)

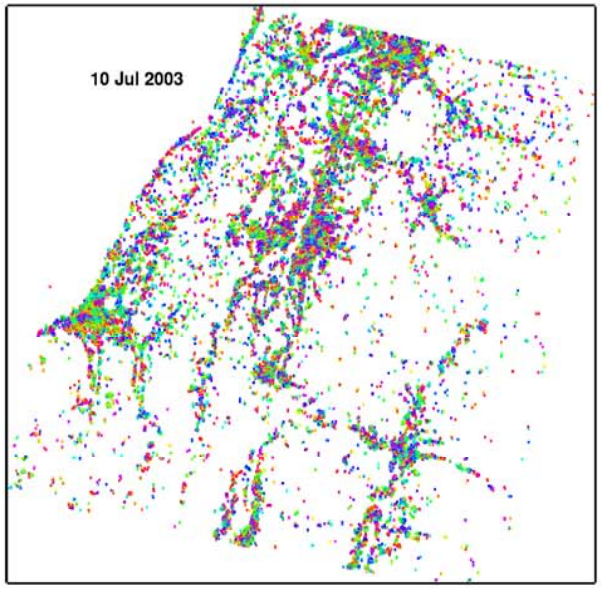


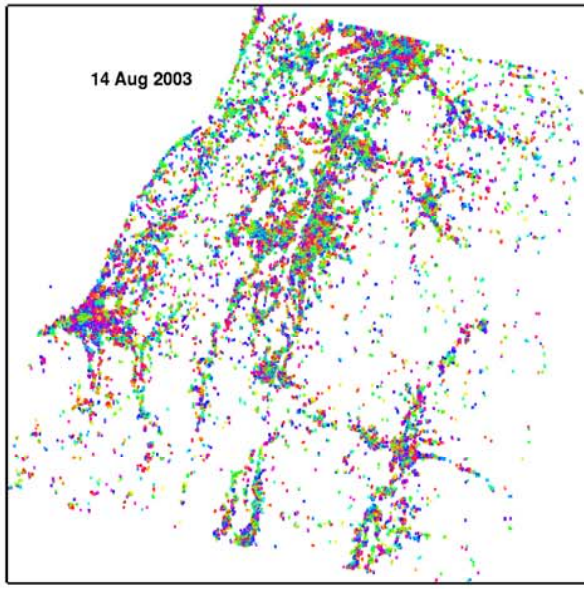
SAR scene location and GEONET GPS stations used for comparison

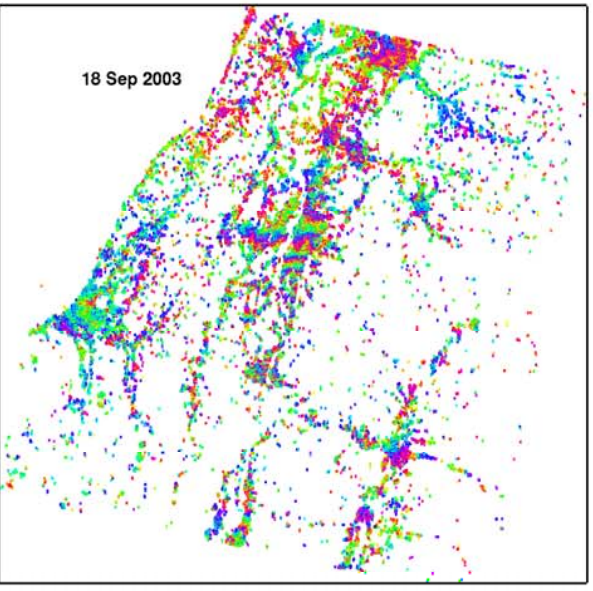
- 13 stations in the epicentral areas

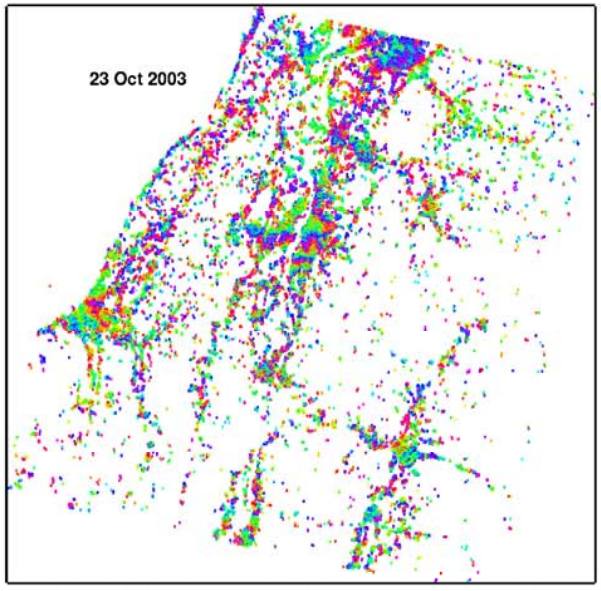


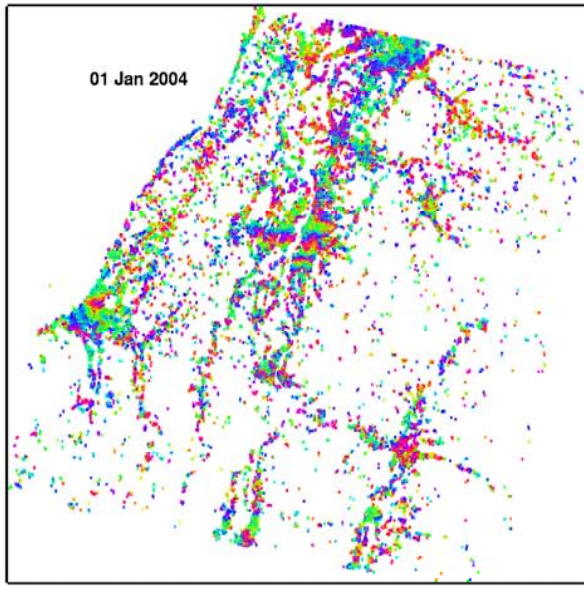




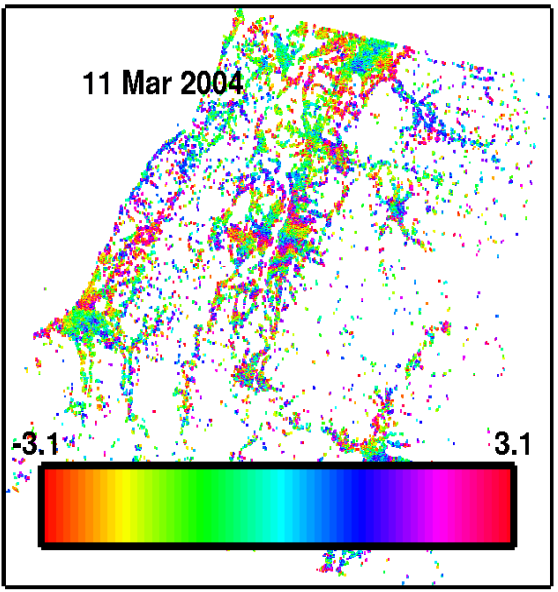


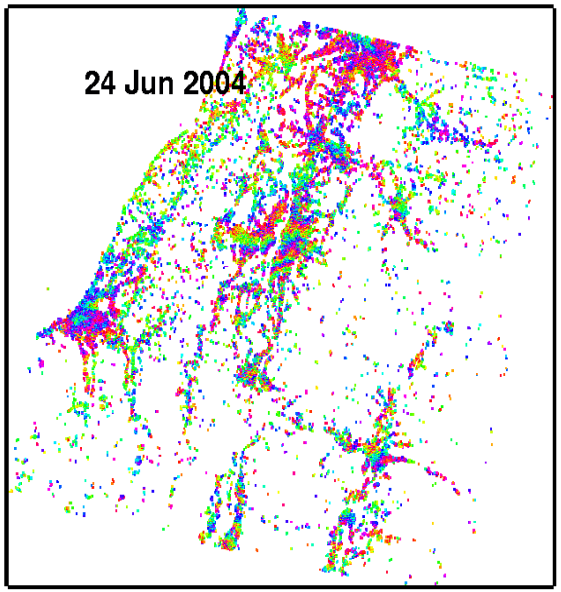


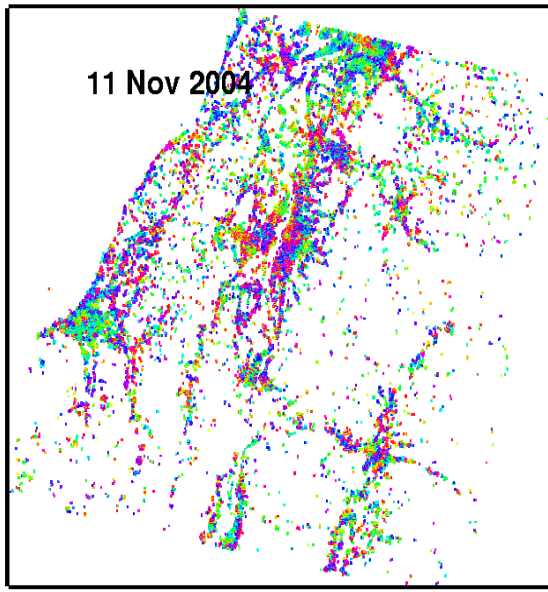


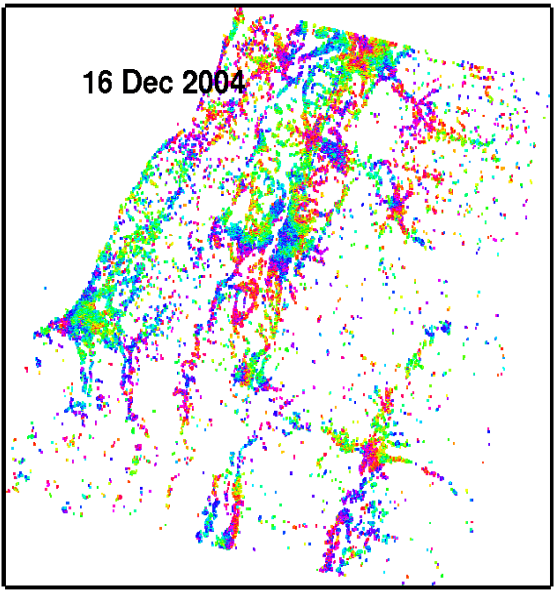


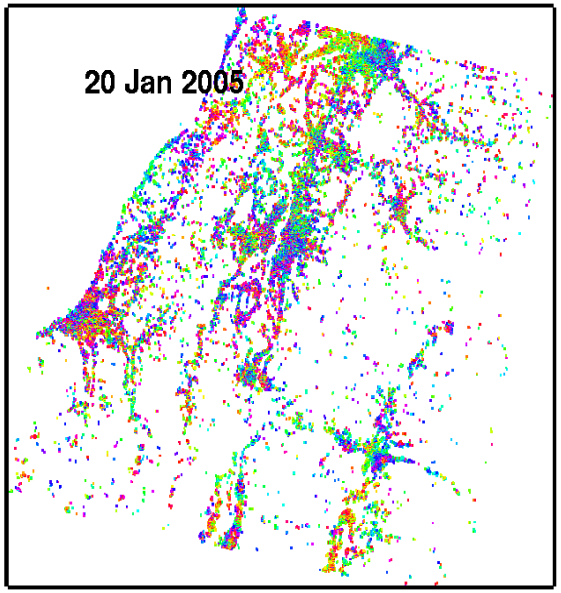
PS interferograms, master = 18 Aug. 2005.
77,521 PS pixels (~30 points/km^2)

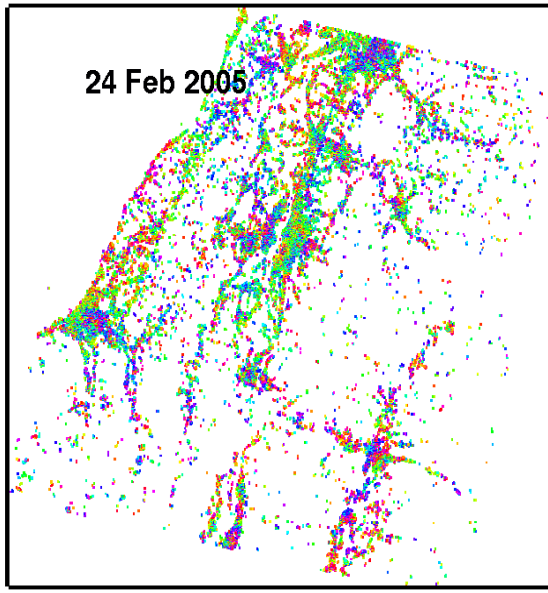

11 Mar 2004
-3.1
3.1

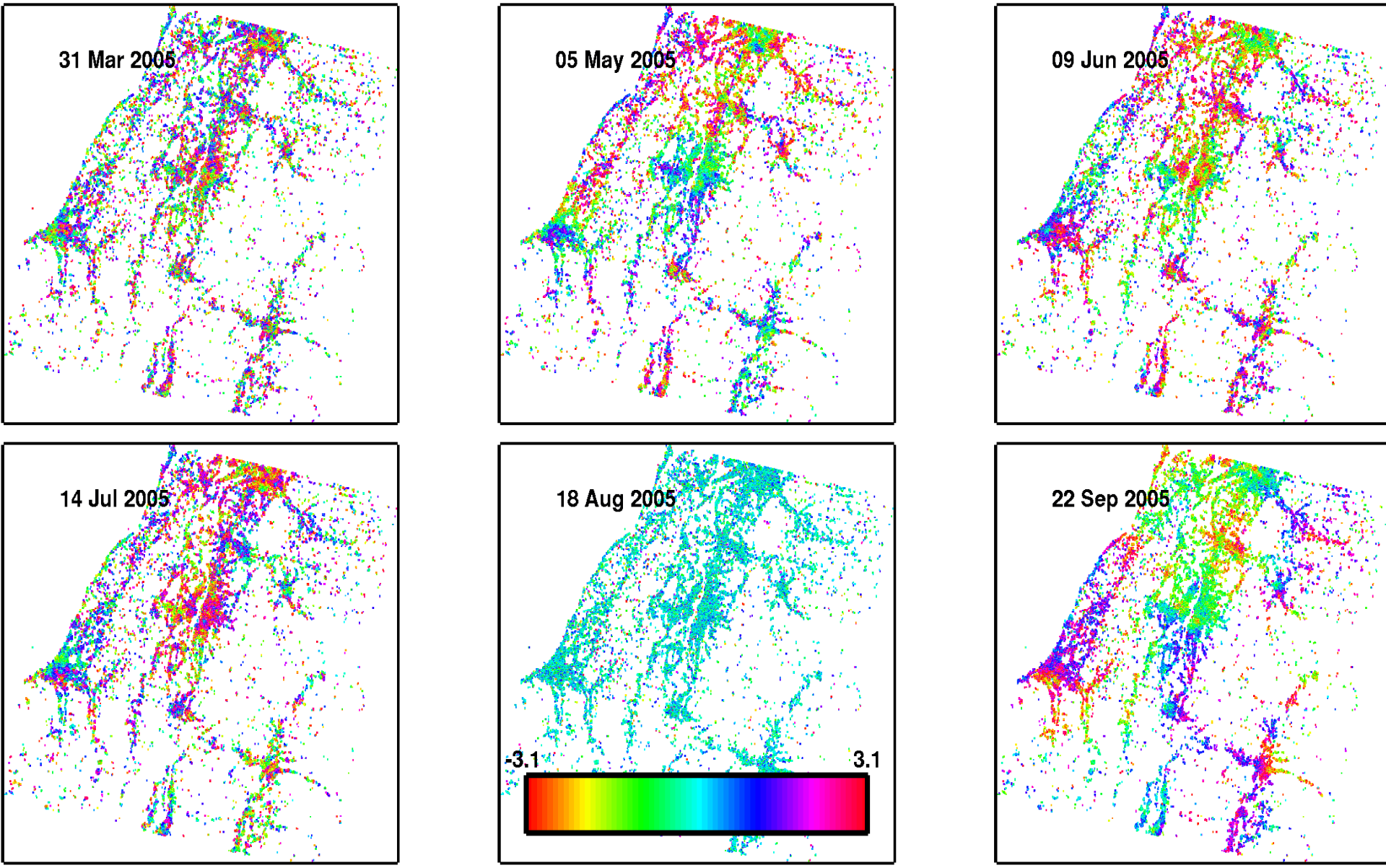

24 Jun 2004


11 Nov 2004

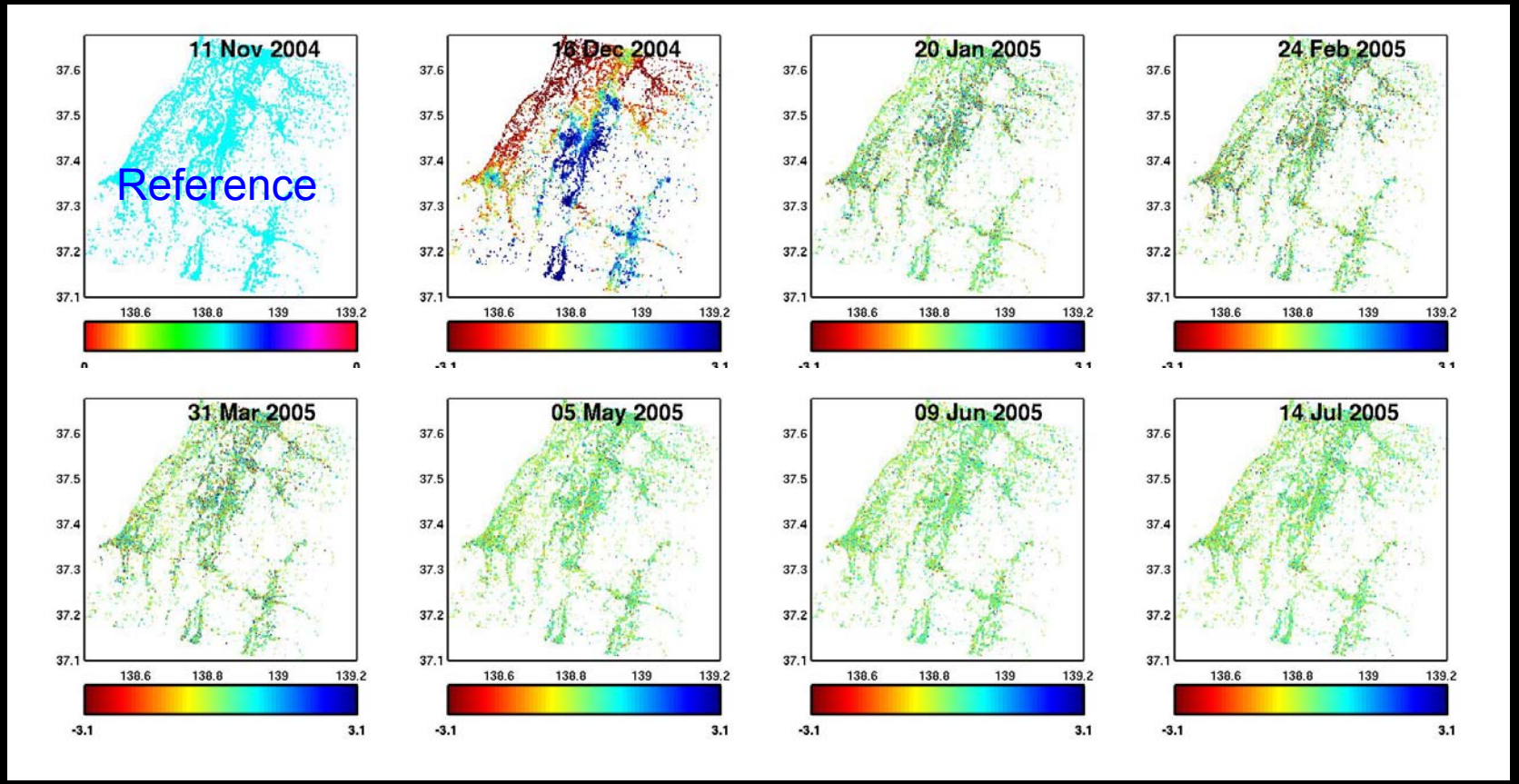

16 Dec 2004


20 Jan 2005

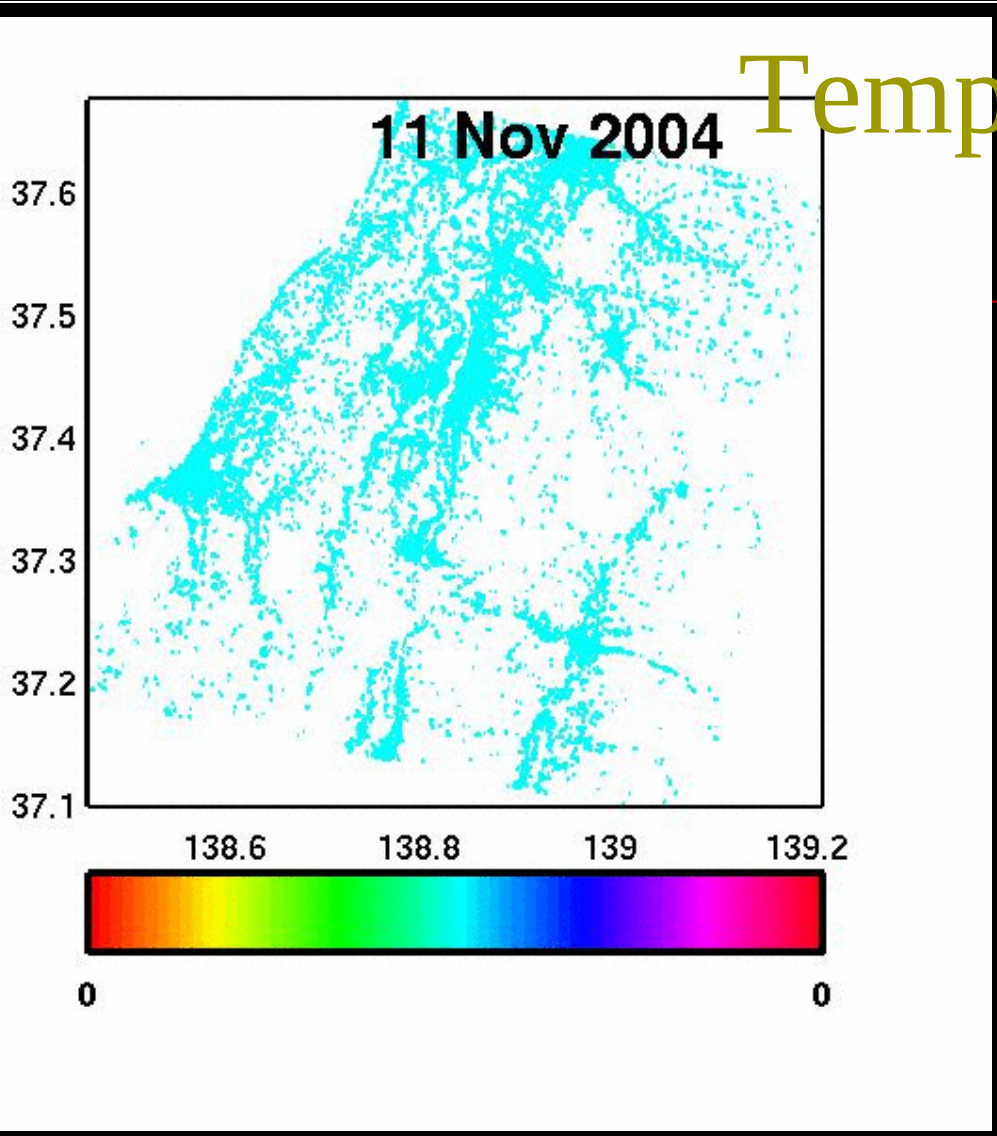

24 Feb 2005


31 Mar 2005
05 May 2005
09 Jun 2005
14 Jul 2005
18 Aug 2005
-3.1
3.1
22 Sep 2005

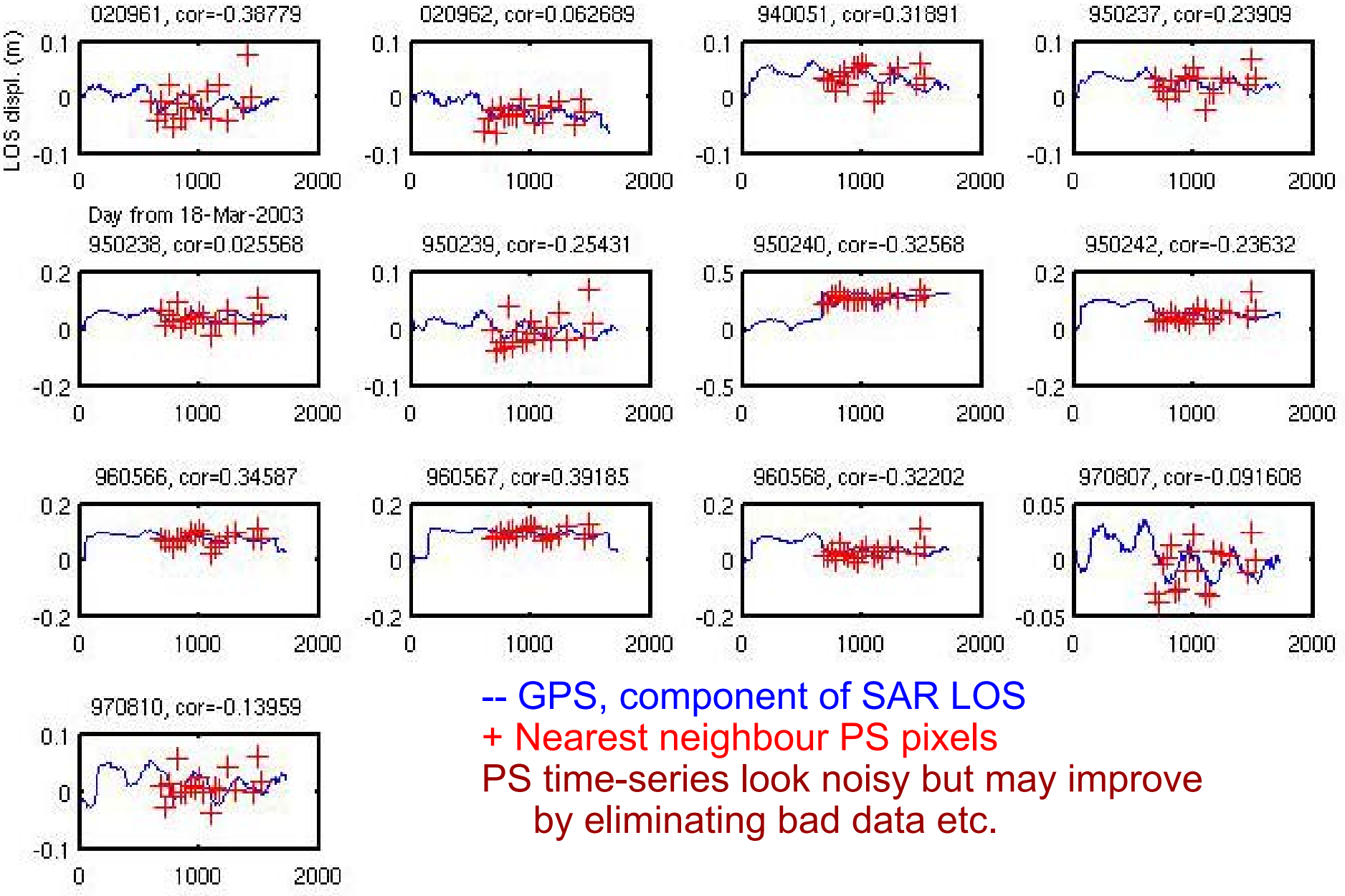
StaMPS unwrapped interferograms



Temporal change Animation



- Winter: noisy (snow)
- Summer: broad-scale signal (bogus?)



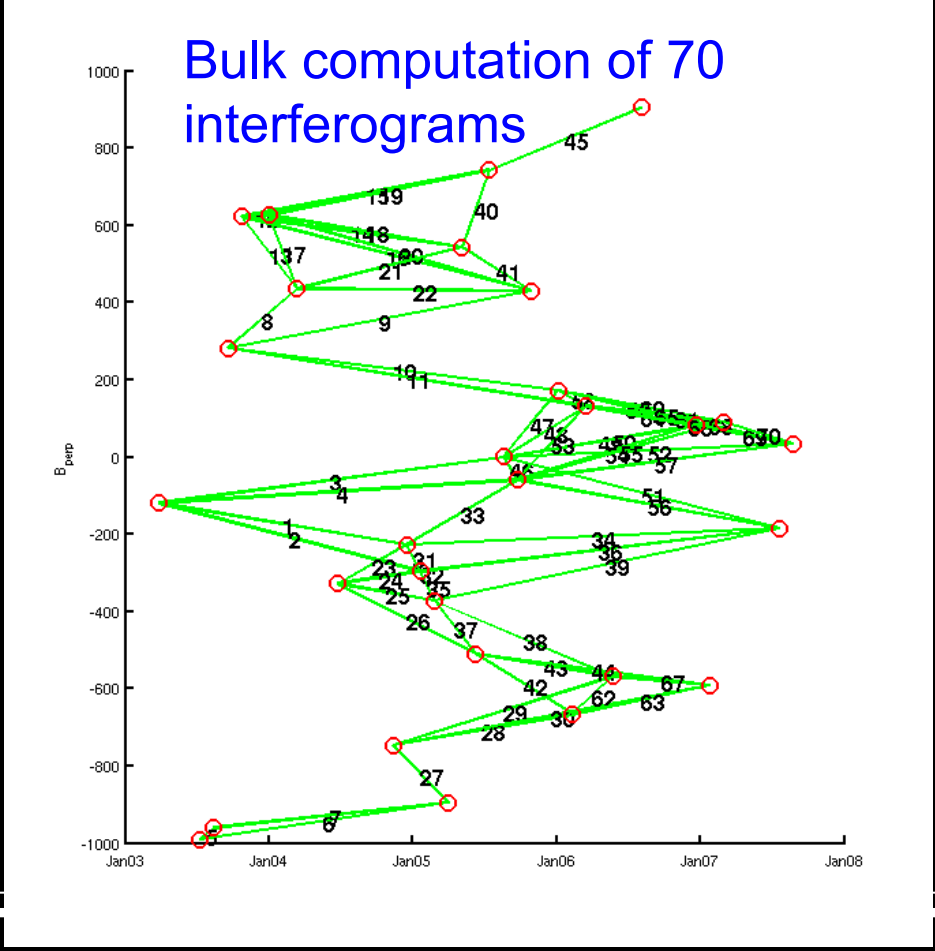
-- GPS, component of SAR LOS

+ Nearest neighbour PS pixels

PS time-series look noisy but may improve by eliminating bad data etc.

StaMPS SB analysis: algorithm

- Compute small-base-line interferograms
- Invert for time-series
- Single-look with range and azimuth filtering
- Select stable pixels based on amplitude difference variance
- 3D unwrapping
- Can be merged with PS result



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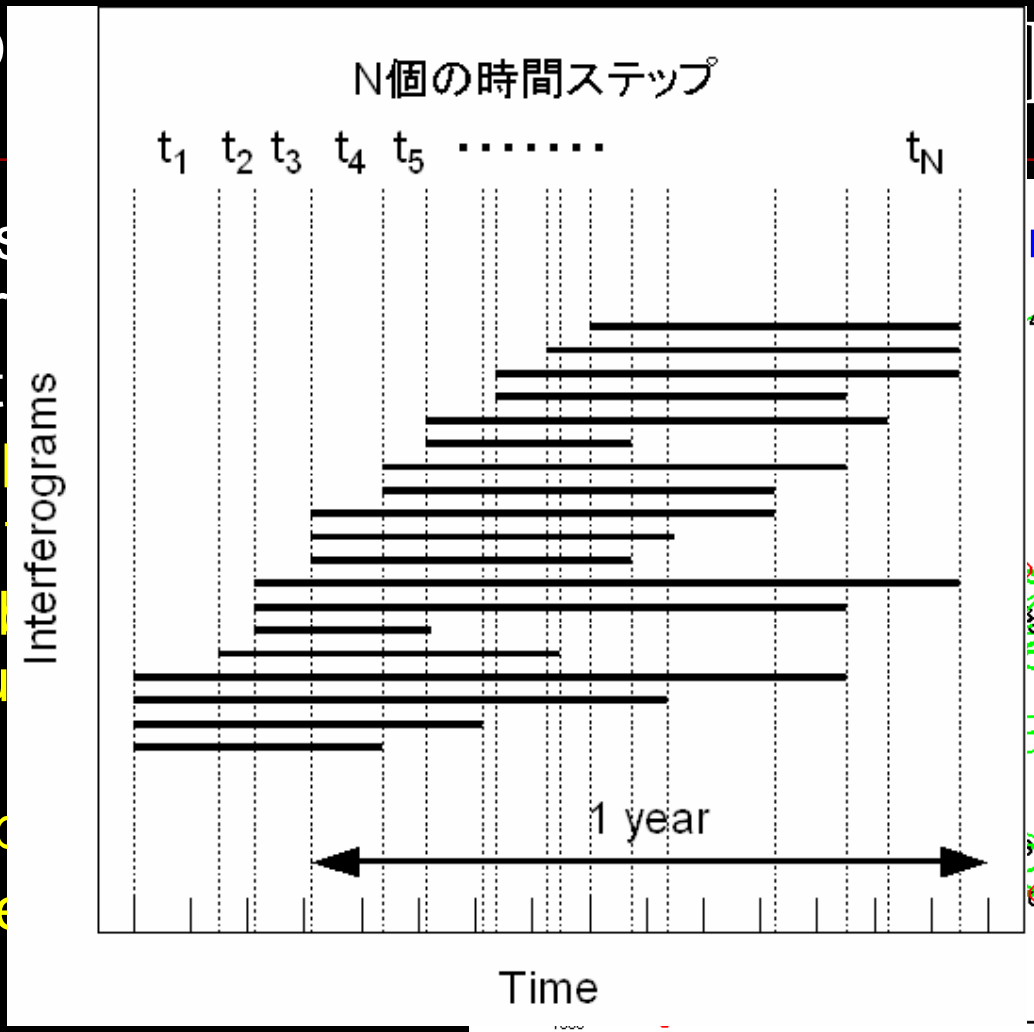

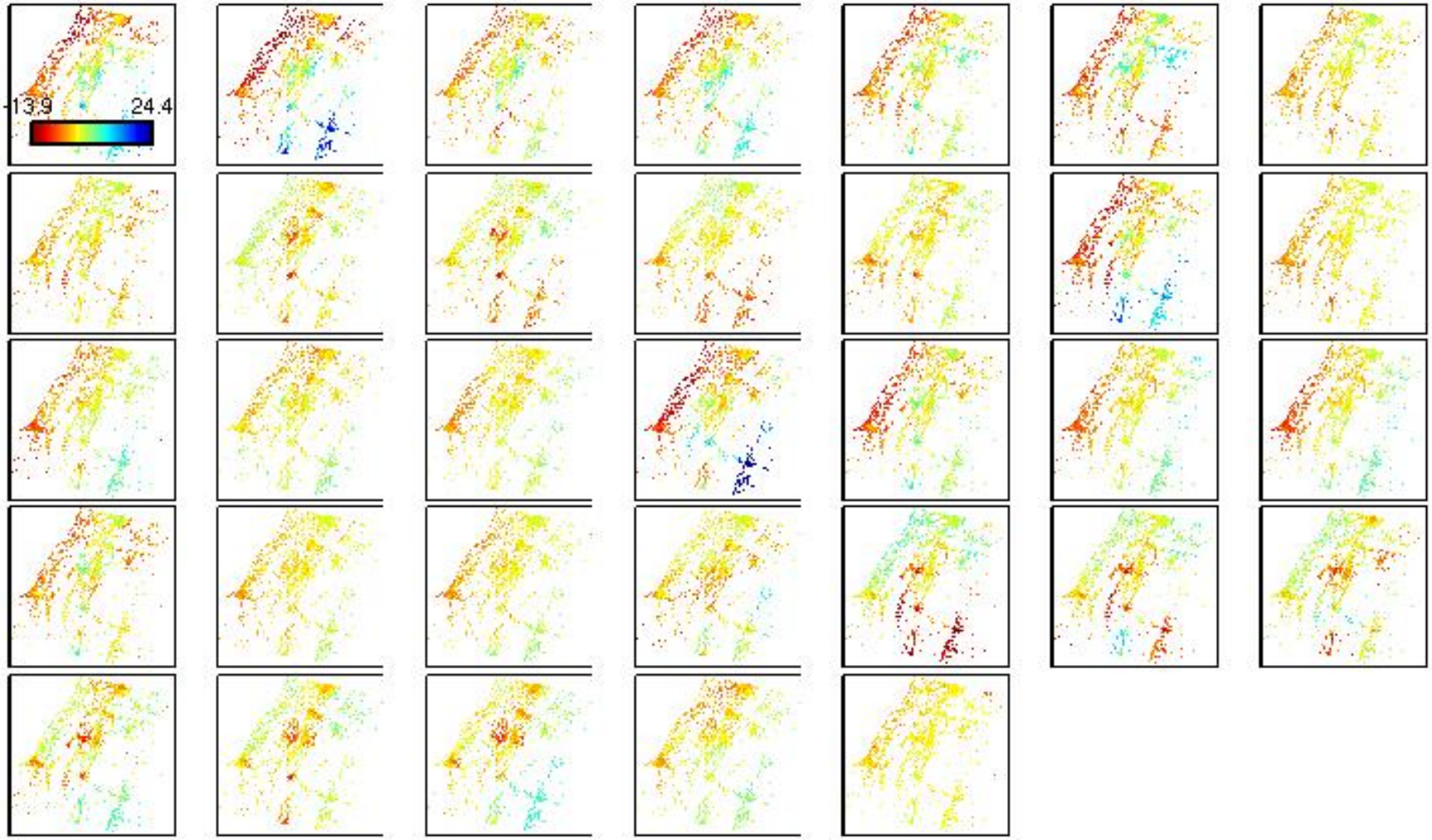

Example of unwrapped interferograms
(contain orbital errors)

Residuals after optimization (permits evaluation of likelihood of the solution)

To conclude

- Performed persistent scatterer and small-baseline analyses using StaMPS package.
- The postseismic deformation of the Chuetsu EQ seems to be consistent with GPS but noisier.
- Improvements in the analysis and more thorough evaluation of the results are to come.
- More data as well; images 1992 - 2007 are waiting for being analyzed (total ~60 images).