CERES Symposium, Chiba, 1st March 2012

Synthetic Aperture Radar Interferometry: techniques and applications

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Foreword

The Speaker

2002 Master in Telecommunication Engineering, Politecnico di Milano, Italy
2006 PhD degree in Information Technology, Politecnico di Milano, Italy
Till 2009 Assistant researcher in Politecnico di Milano, Italy

Since 2nd October 2009, Research Assistant Prof., ISEIS, CUHK

Techniques (1)

Synthetic Aperture Radar Interferometry

InSAR

Vertical gorund displacement with centimeter precision

Interferogram

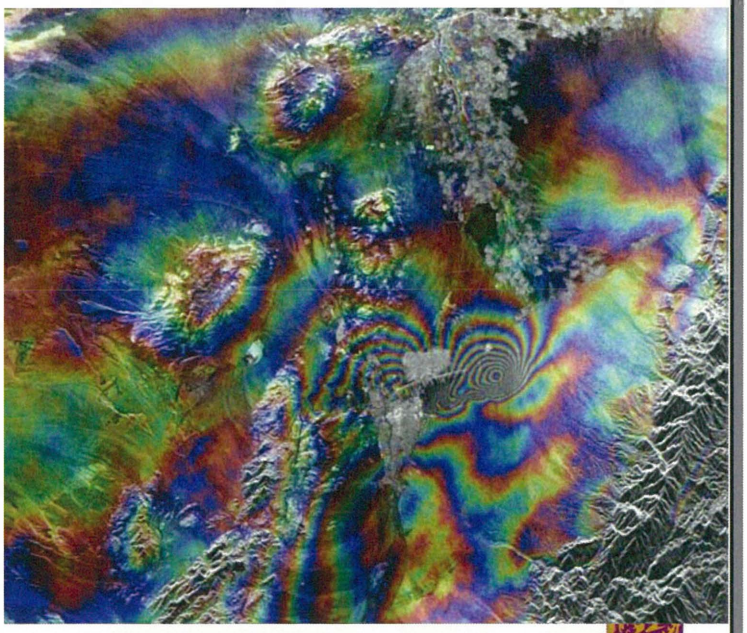
Colour map of the variation of the sensor-target distance as fractions of the wavelength

$$\frac{2\Delta r}{\lambda}$$

Each fringe indicates

$$\Delta r = \frac{\lambda}{2} \approx 2.8cm$$

of displacement



Bam (IRAN) Earthquake, Dec. '03

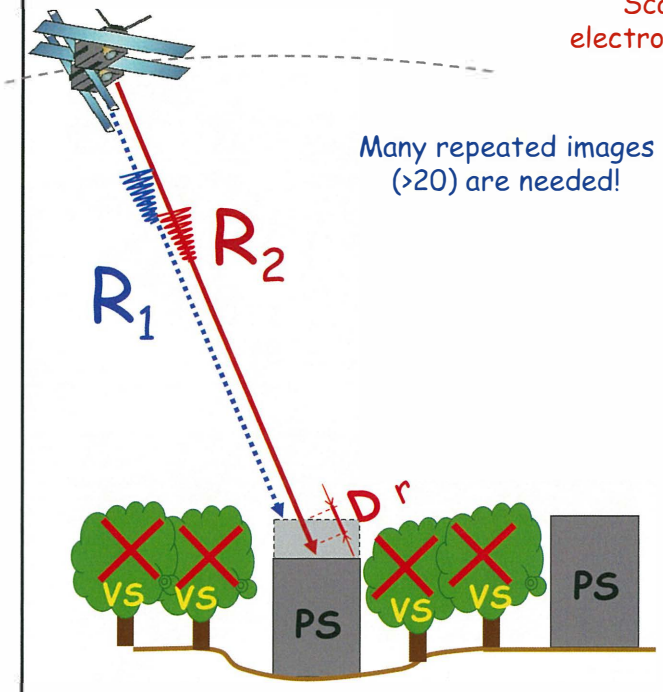
Techniques (2)

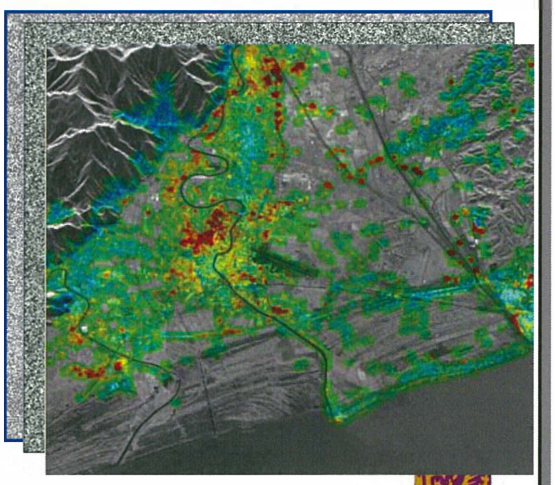
The Permanent Scatterers (PS) Technique

InSAR Permanent Scatterers (PS)

Scatterers that do not change their electromagnetic behavior (Houses, manmade constructions, exposed rocks)

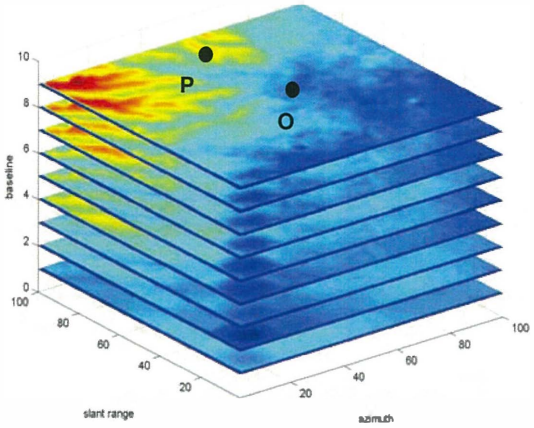
Many repeated images (>20) are needed!





PSInSAR

The Permanent Scatterers (PS) technique

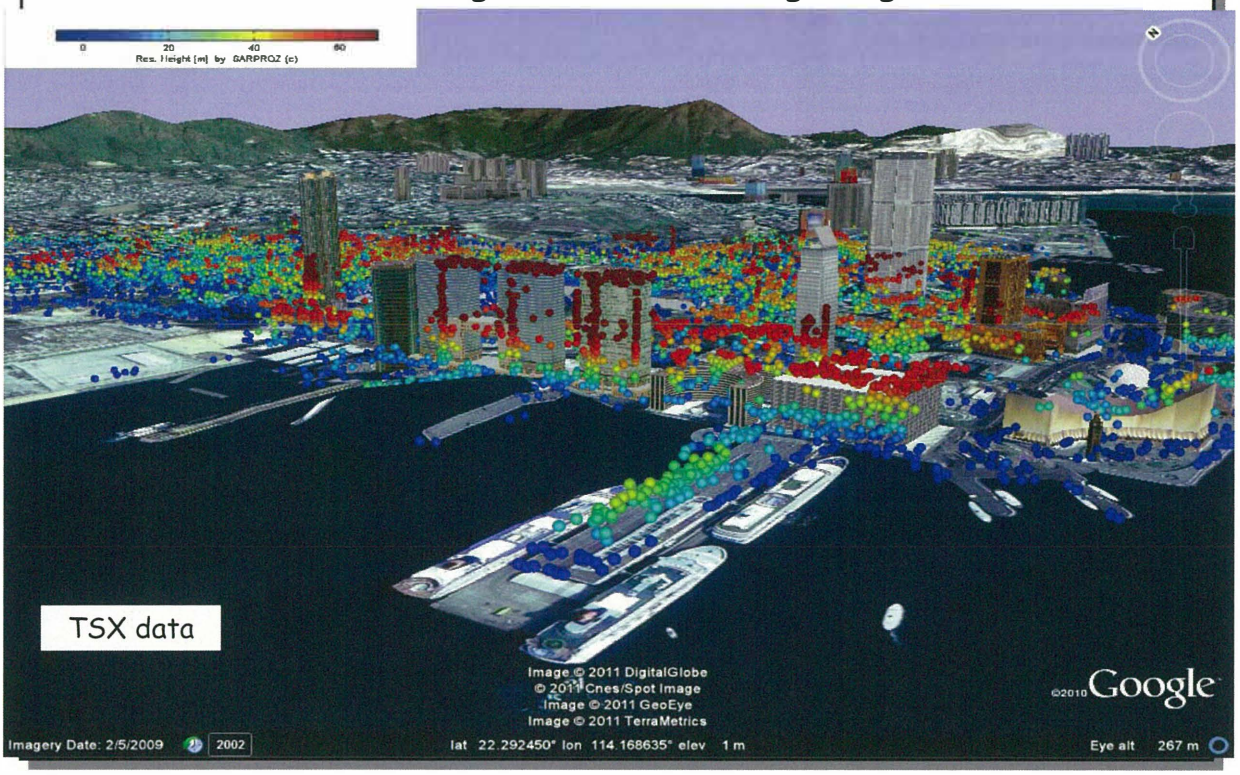


We can estimate the height between P and O only if P and O are *permanent* targets

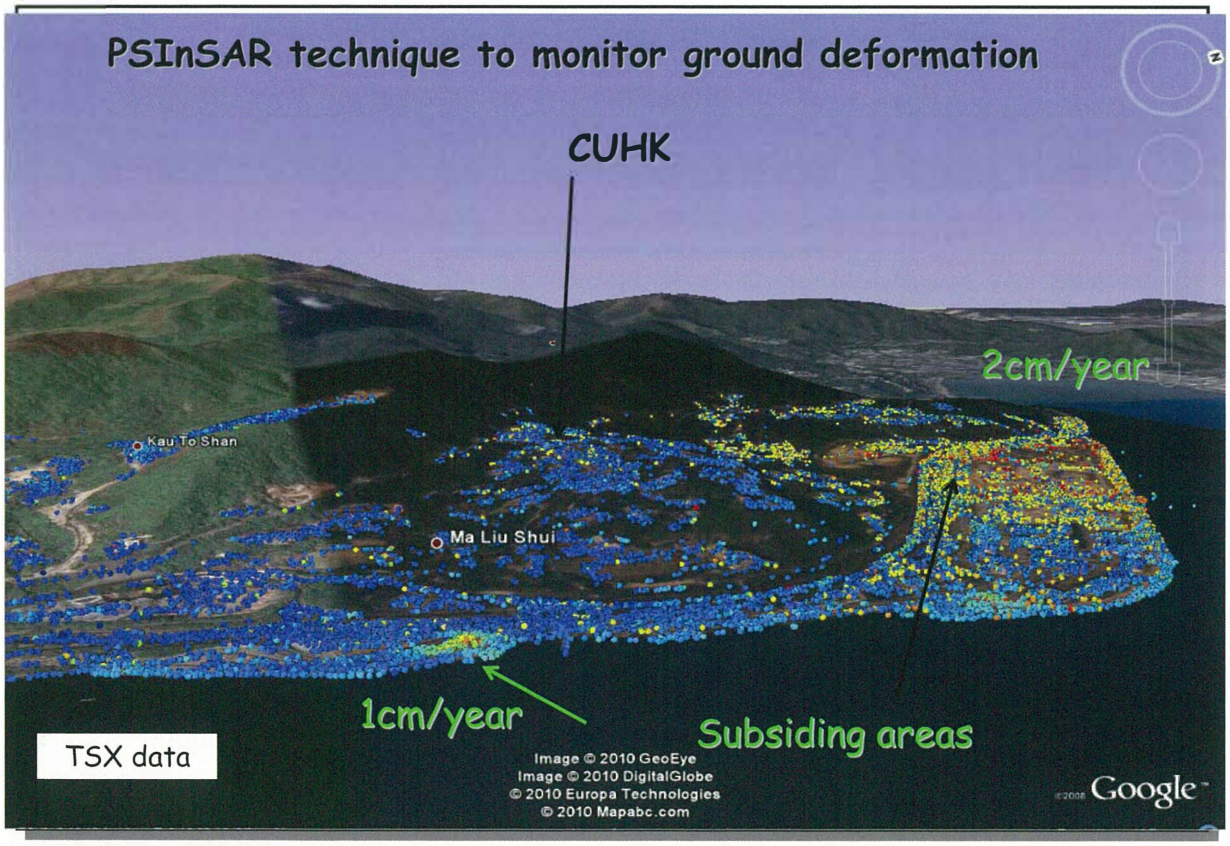
$$\Delta h_{PO} = \arg\max\left\{\left|\frac{1}{N}\sum_{i=1}^{N} e^{j\phi_i}\cdot e^{-jK_h\Delta h_{PO}B_{n,i}}\right|\right\}$$

Non-linear problem, can be solved through a periodogram

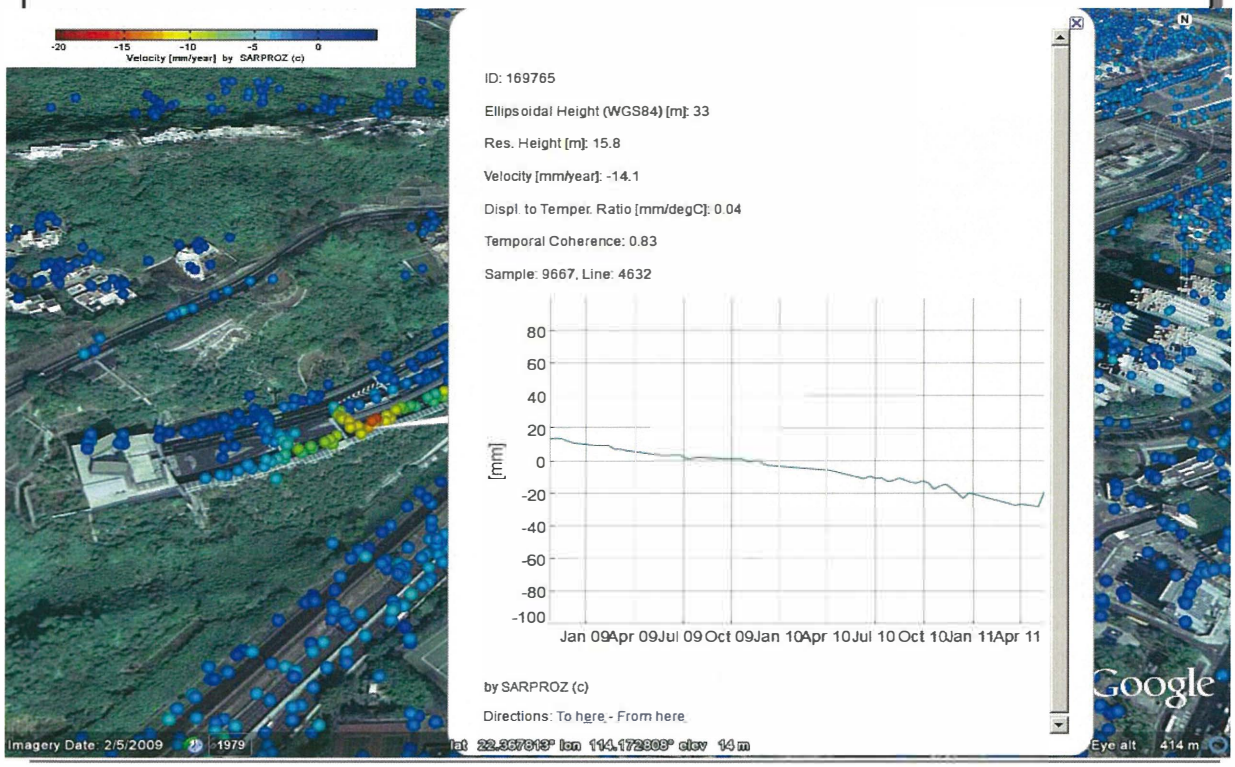
The Height of PS's in Hong Kong



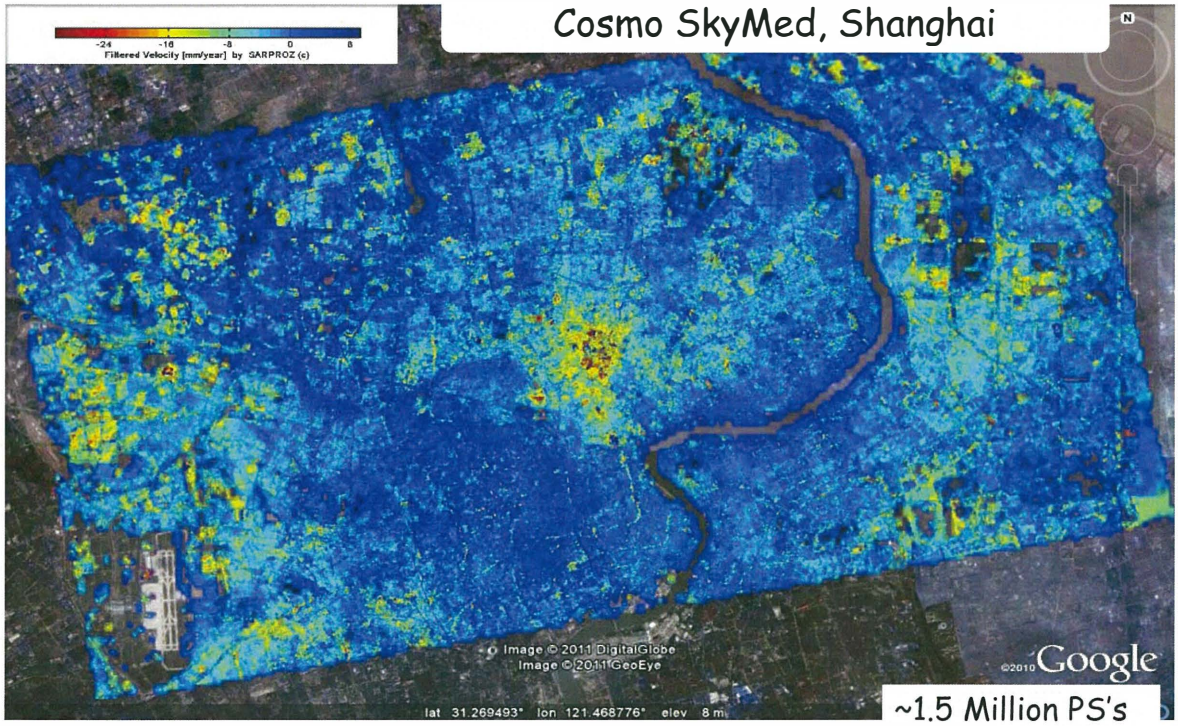
PSInSAR technique to monitor ground deformation



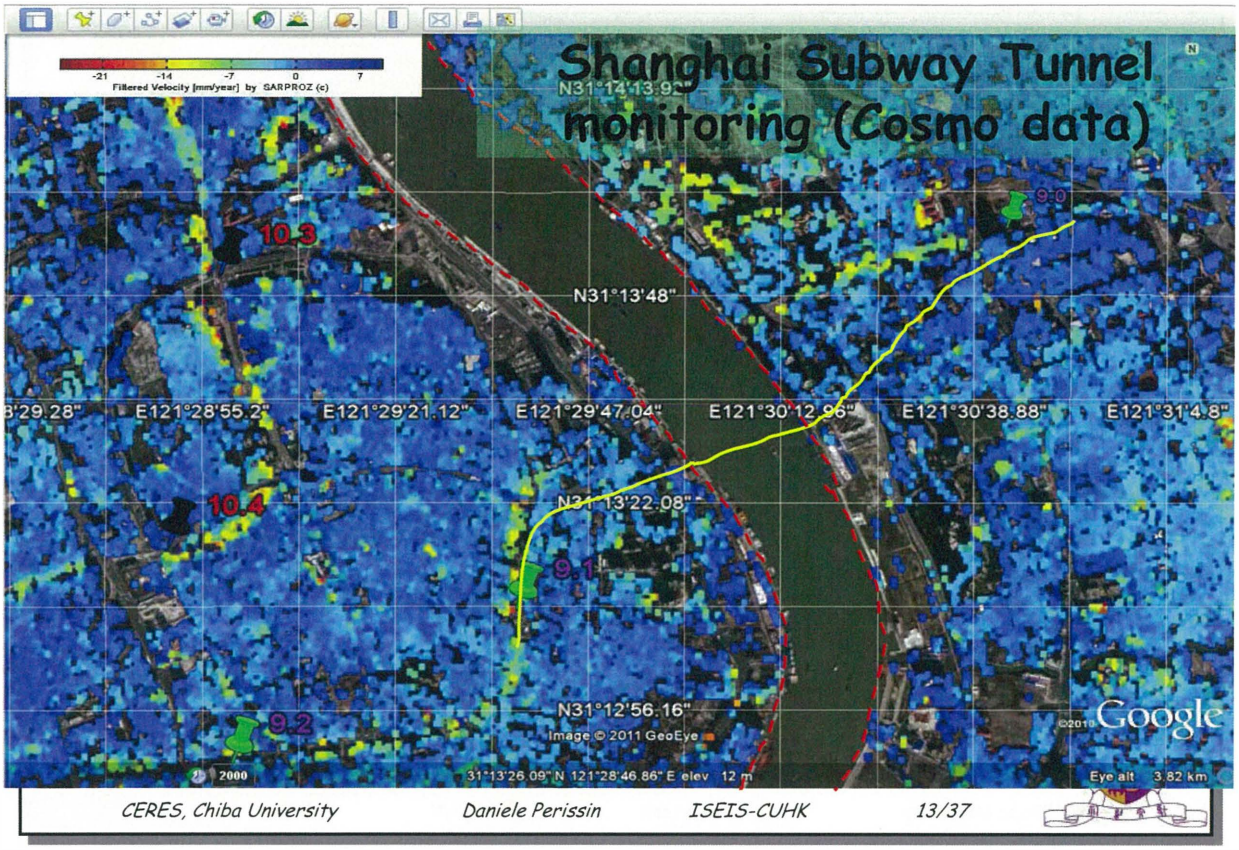
Hong Kong with TerraSAR-X data



Cosmo SkyMed, Shanghai



~1.5 Million PS's

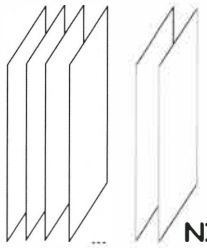


Techniques (3)

The ADVANCED Permanent Scatterers analysis

What are PS's?

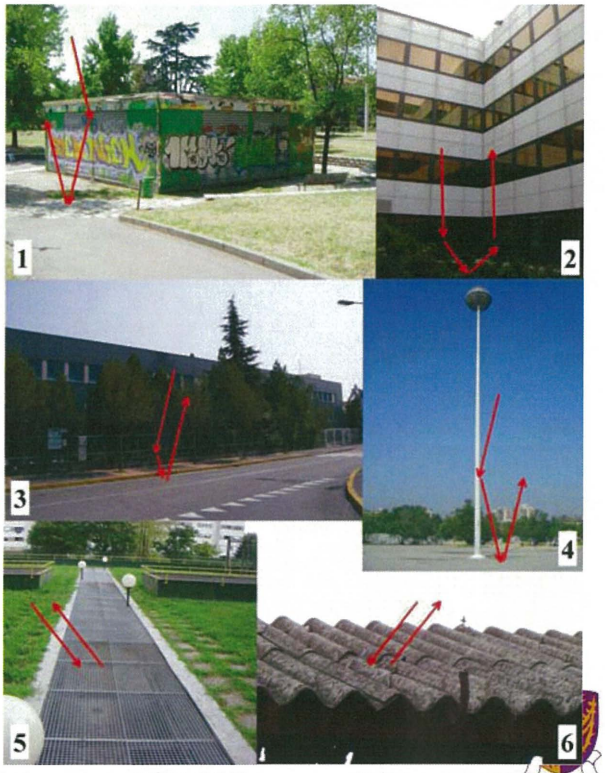
Many repeated acquisitions taken at different times, with different geometries, polarizations, …



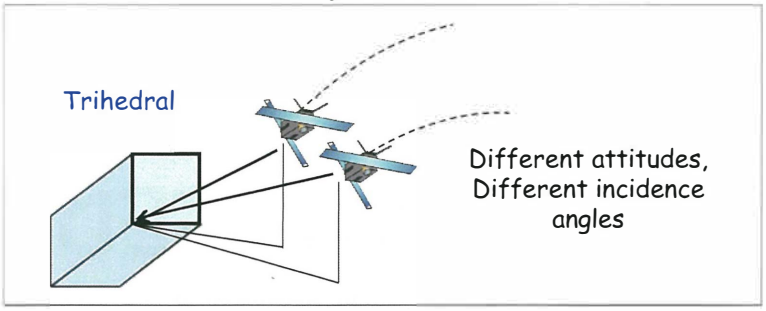
Point targets extraction

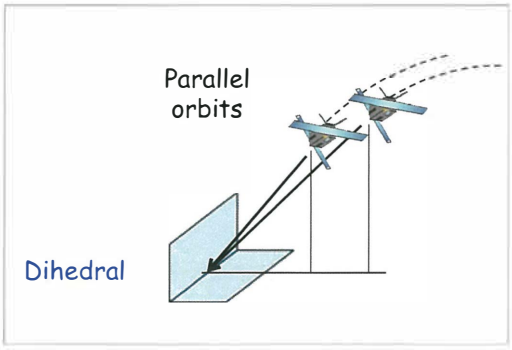
Estimation of RCS, size, resonance, height, …

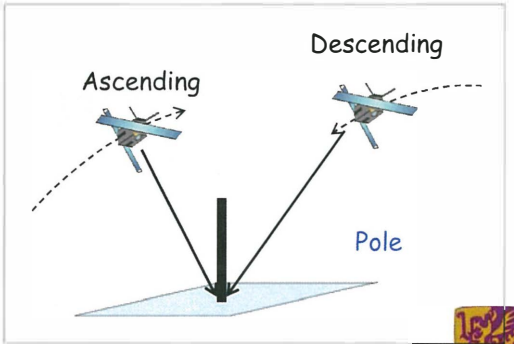
Characterization and classification



Multi-platform PS's

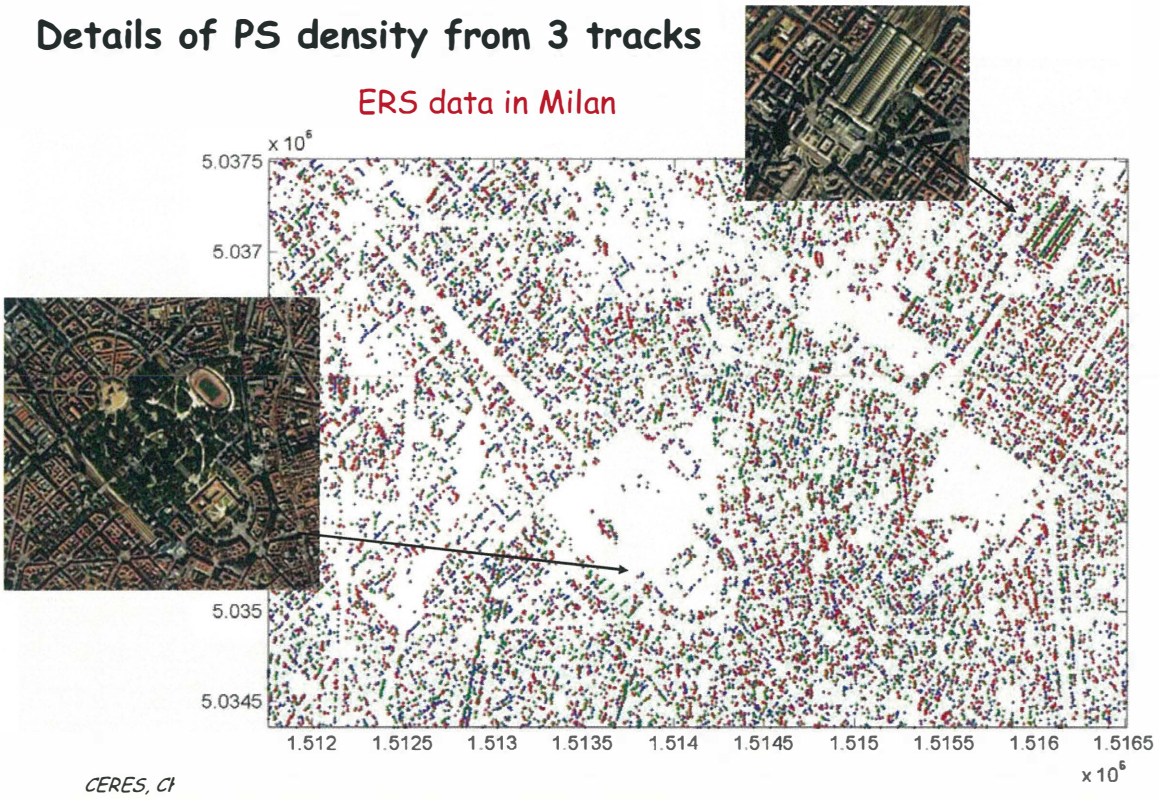






Details of PS density from 3 tracks

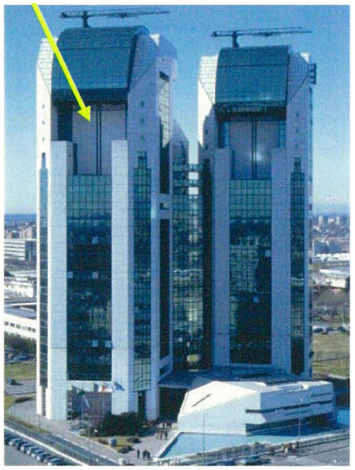
ERS data in Milan

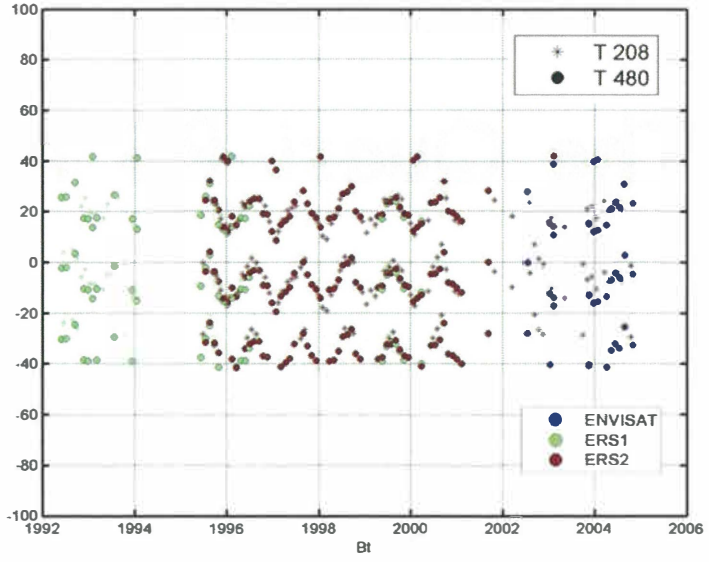


CERES, Ch

Parallel tracks combination, ERS + Envisat

Seasonal displacement time series of a DIHEDRAL PS in Milan





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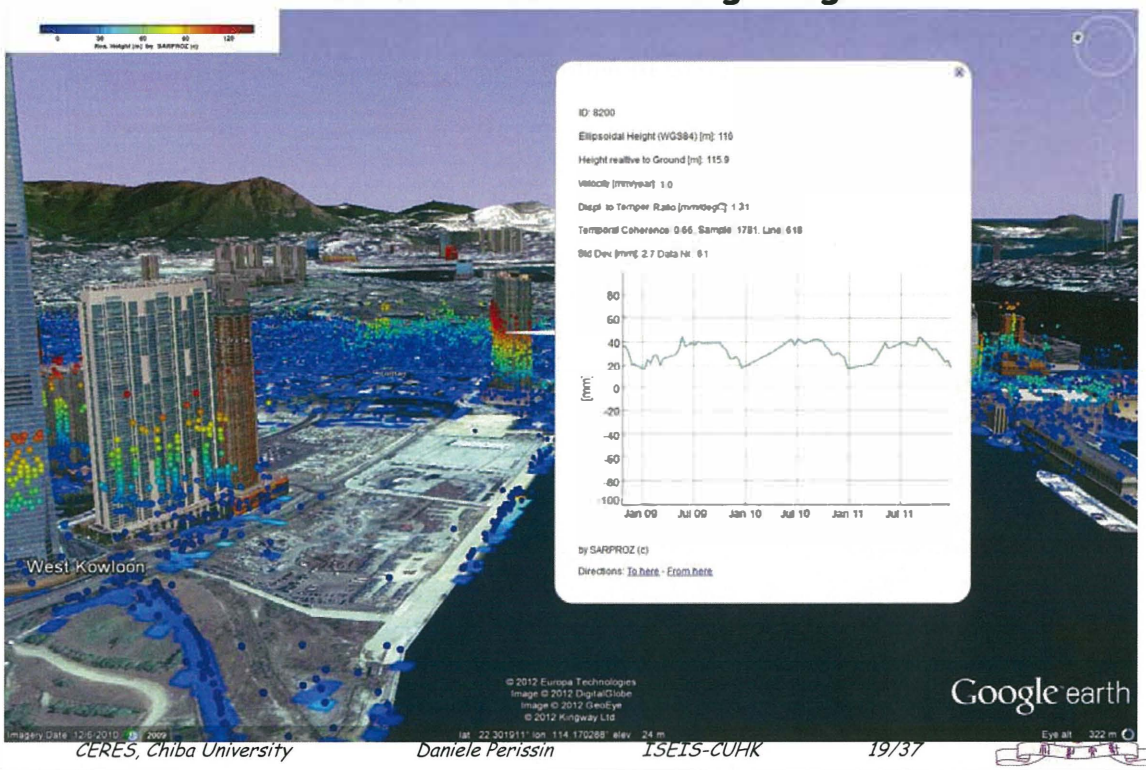
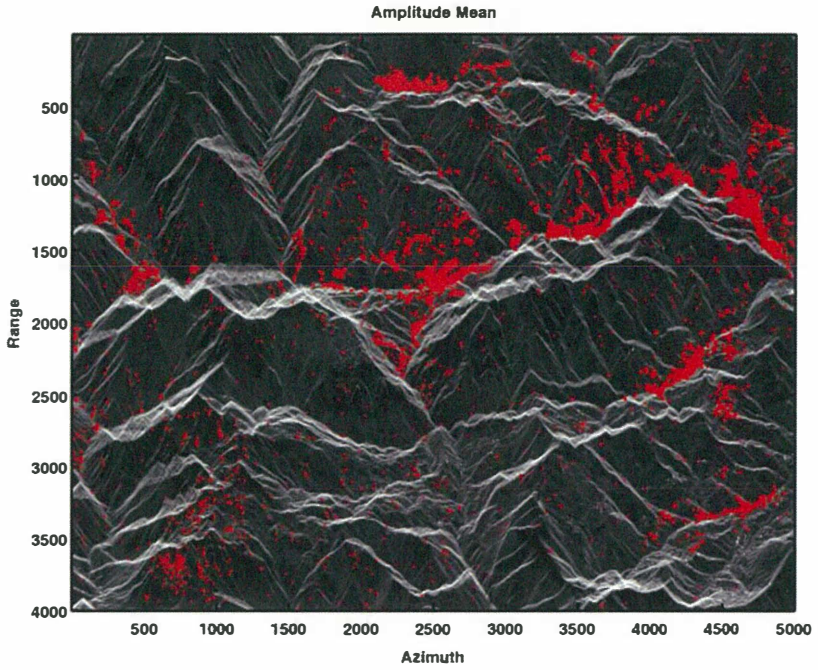
Thermal dilation in Hong Kong



Techniques (4)

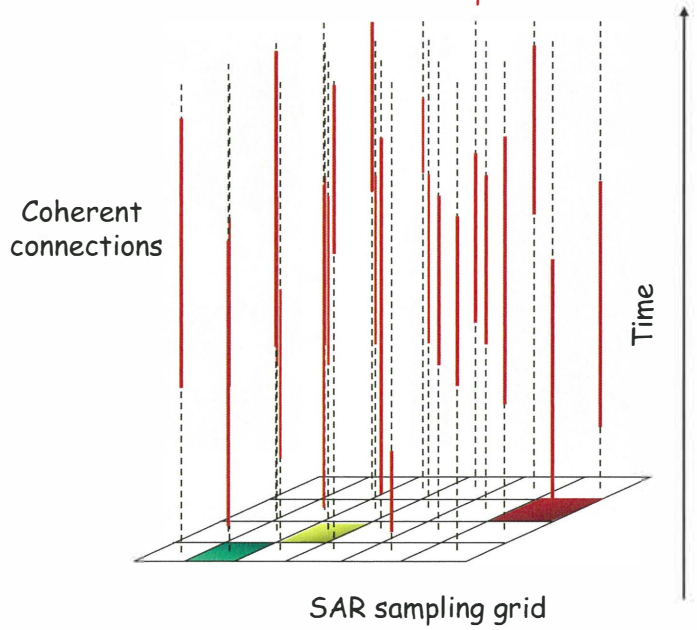
The Quasi-PS technique

On mountains or in vegetated areas, there are no PS's



The Quasi-PS analysis

The core concept



The Quasi-PS analysis

The basic idea

Model used in the PS analysis for estimating PS height and velocity

Modifications w.r.t the classic technique

$$\sum_{(i,k)} \left| \gamma_p^{i,k} \right| e^{j\left(\Delta\phi_{pq}^{i,k} - \Delta\phi_{Model}^{i,k} \right)}$$

Processing weights

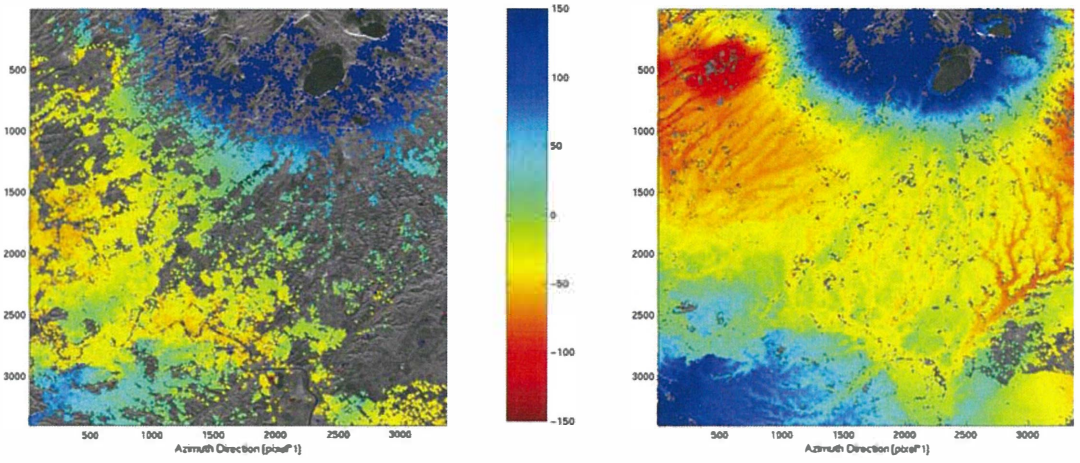
ik Images Graph

pq PSC Graph

D. Perissin and T. Wang, "Repeat-pass SAR Interferometry with Partially Coherent Targets", IEEE TGARS, in press, 2011.

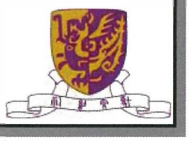
Quasi-PS: an example

Estimating the height of the terrain with ERS data in Rome, Italy

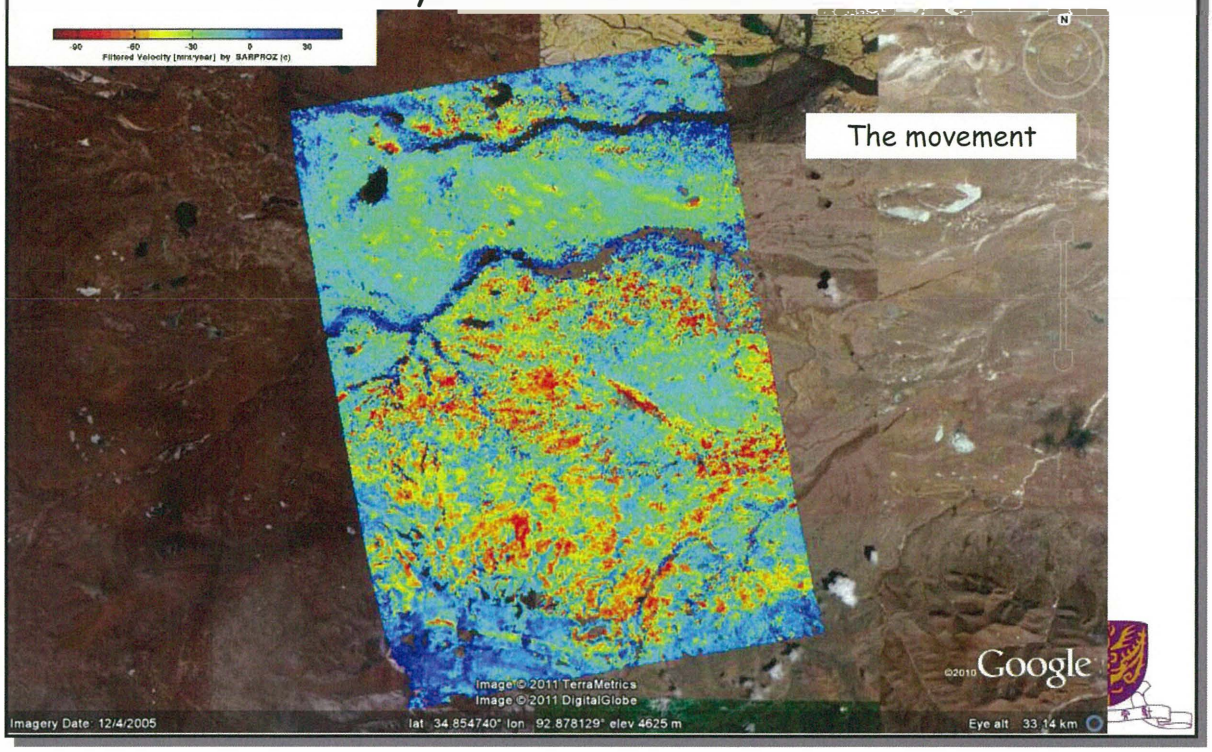


Permanent Scatterers

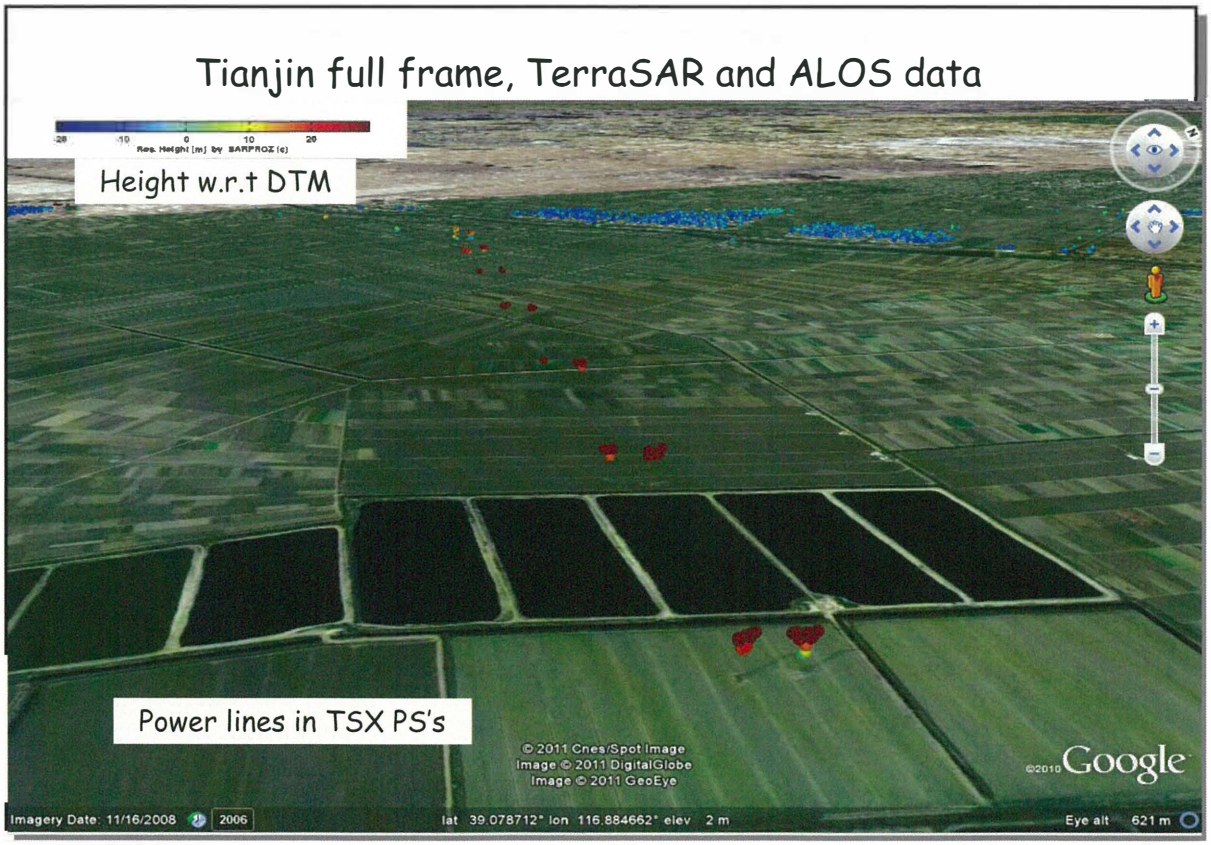
Quasi-Permanent Scatterers



Case study: Tibet with ALOS data



Tianjin full frame, TerraSAR and ALOS data

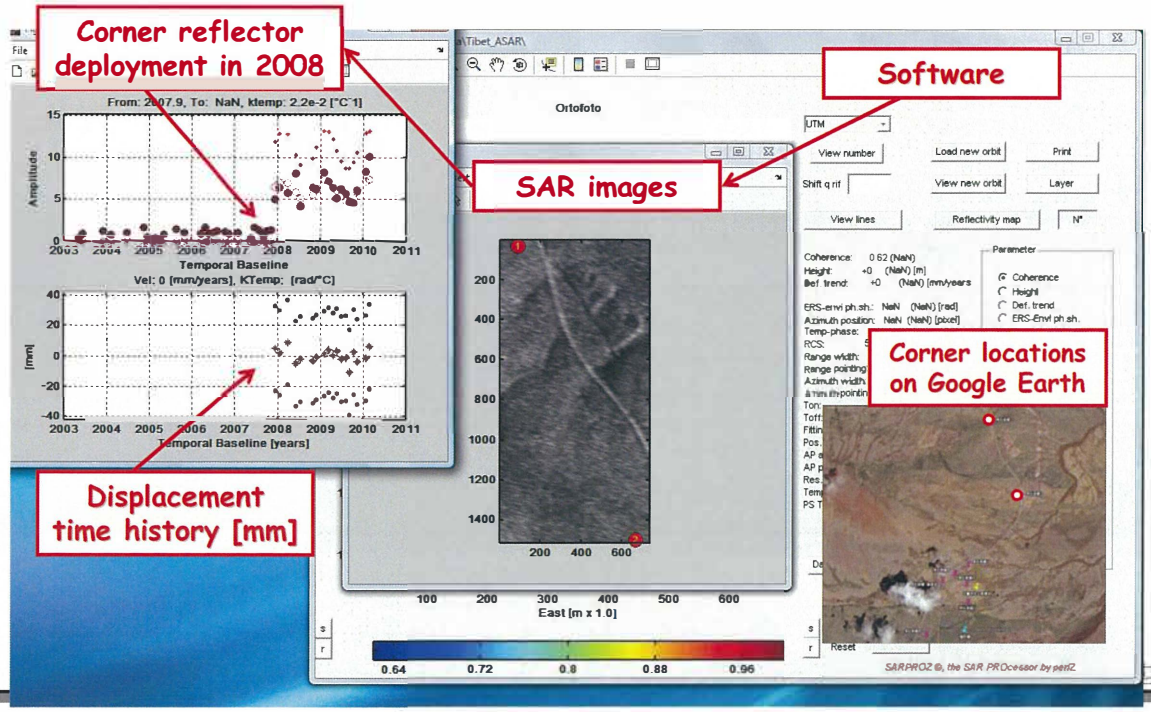


Techniques (5)

Change Detection and "Temporary" PS analysis

Tibet Railway stability monitoring

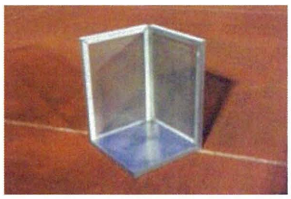
Monitoring the displacement of corner reflectors with Envisat

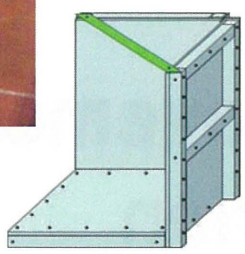


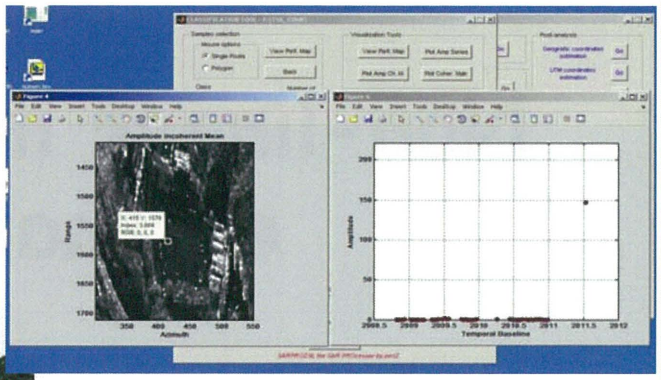
Case study: Hong Kong Government project

Hy(S)Q/007/2011 – Research on SPRST in Ground Settlement Monitoring

Hong Kong with TerraSAR data: study and test of CR's







Cheap, light, easy to carry, easy to mount, resistant to HK weather, …
…and: temporary.

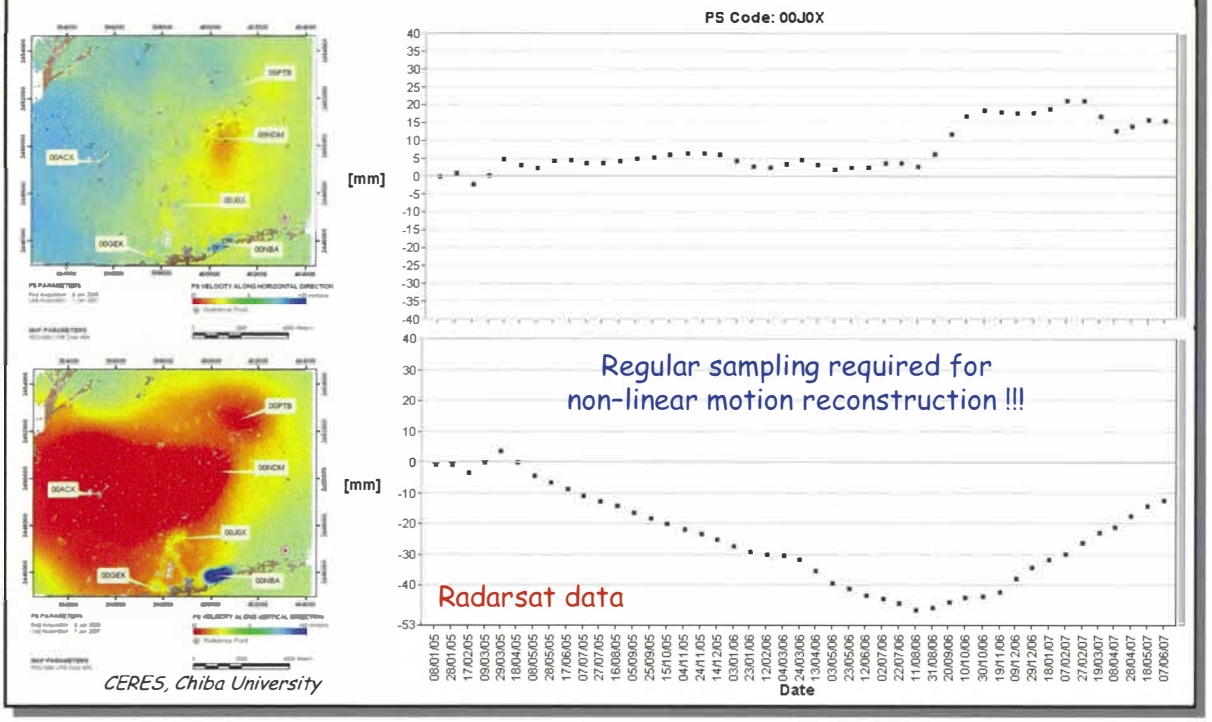
Hong Kong with TerraSAR data: deployment of CR's

Techniques (5)

Non-linear movements estimation

PSInSAR applications

Vertical-horizontal motion decomposition



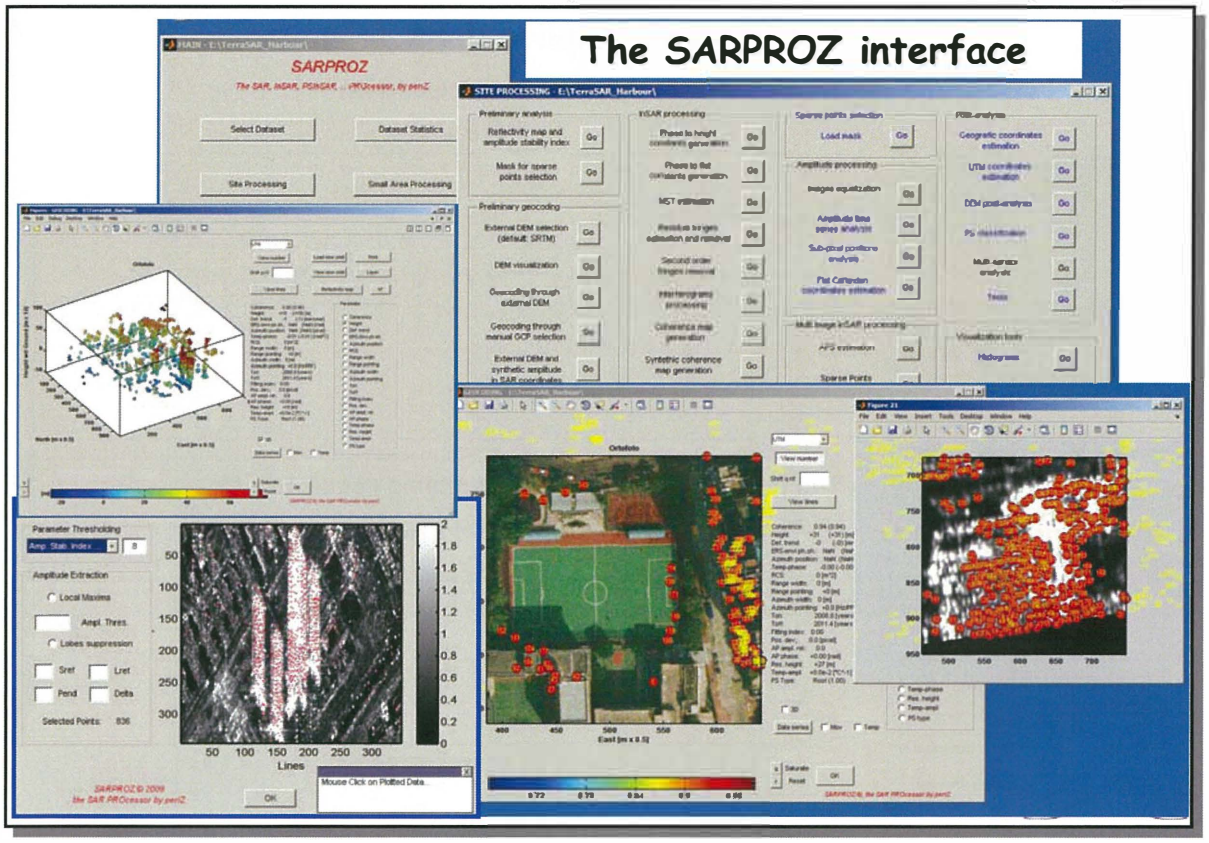
All these techniques (PS, A-PS, Q-PS, T-PS, …) are implemented in a sw:

SARPROZ

The SAR processing tool by PeriZ

http://ihome.cuhk.edu.hk/~b122066/index_files/download.htm

The SARPROZ interface



Main characteristics of SARPROZ:

- User friendly Graphical **Interface**: no other language knowledge is required for standard uses
- Based on **Matlab**: advanced users can very easily develop their own software extensions. Data and parameters are very easily imported/exported using Matlab.
- It can be compiled and it runs independently from Matlab on **any platform** (Unix, PC, Mac).
- Completely **parallelized**: SARPROZ can run on multiple CPU cores or computer clusters automatically.

http://ihome.cuhk.edu.hk/~b122066/index_files/download.htm

Multi-temporal InSAR processing: techniques and applications

Conclusions

Multi-temporal InSAR processing is a complex task involving different techniques depending on available data and aim of the analysis.

To be able to solve all cases, high expertise and powerful software tools are needed.

Multi-temporal InSAR has a wide range of applications, here we saw monitoring urban and extra/urban phenomena, like subsidence and settlement due to excavations/land reclamation

Collaborations are very welcome: daniele.perissin@cuhk.edu.hk