PSIC-4 validation activities

Background:

Persistent Scatterer Interferometry Codes Cross-Comparison And Certification (PSIC4)
- response to a recommendation of the Fringe 2003 Workshop,
- to produce reliable information about the accuracy and dependability of these methodologies.

Two phases:
- parallel processing of identical stacks of data by the participating teams.
- independent validation of the results.

Objective:

→ to test the ability of the participant teams to provide an accurate/precise description of the deformation field.

• validation of Persistent Scatterers (comparison PS/ground data) on the period 1992-2004

• intercomparison (PS Team A/Team B)

• « Blind test » - PS results provided to validation team anonymously

• 8 teams worked on the same test site

Test site: mining area of Gardanne
The test site
Gardanne site

Exploitation characteristics (on the period of interest):

- long wall (coal) mining technique.
- depth: 600m -1100m
- width about 250m.
- thickness: between 2 and 3 m.
- production (stopped in 2003): about 1,15.106 t/yr.

(ortho_image source IGN 1997)
Characteristics of the deformation (theoretical point of view)

Spatial characteristics (Arcamone et al., 1980):

The typical temporal evolution:
- during the first in 2 months 50-60% of the total deformation
- 90% in the next 18 months
- residual deformation can last up to 2-3 years after the extraction
Ground based data
Levelling network

- Since 1990.
- Objective: to monitor the deformation effects on the surface associated with the coal mining exploitation (initially required precision 1cm)
- Levelling instrument -> Wild NA3003, which is an automatic electronic level with bar code.

*Standard deviation of DH, measured point-to-point = ± 0.7 mm*

*Standard deviation of 1 km one way levelling = ± 1.5 mm*

(DH is the point-to-point height difference).

- 17 traverses covering the mining area, which is 6.5 km in the East-West direction and 5 km in the North-South direction.

- About 1000 monumented points, which have an average point-to-point distance which ranges between 40-80 m.
- Global precision = ± 3-5 mm
- Planimetric position of the points: ± 10 m
coverage
Location and evolution of the deformation
Total displacement in 1992
Coordinates in "Lambert III Sud" projection

Total displacement in 1997
Coordinates in "Lambert III Sud" projection

Distance from point sncl-312 (meter)

Cumulated displacement along the central part of SCNF line in december 1998

7cm !
Temporal evolution

- 2 steps subsidence
- ~3-4 y
Temporal variograms

Interpolation error at 35 days ~ 5mm
-> temporal interpolation to radar dates of levelling TS is relevant
Main aspects of the validation tasks
Data resampling

• Difference of locations PS/levelling and PS TeamA/PS Team B
• PS/levelling temporal sampling differences
• Resampling needed to carry out the comparison at given location/dates

- Basic idea: avoid or minimize the use of interpolated data

- Spatial interpolation: Due to the variability observed in the deformation area, we have to avoid spatial interpolation. We propose to assess the deformation TS and deformation rates at the levelling location from the PS in distances compatible with the geo-statistical analysis for a selected set of levelling points (availability – f.e. at least 4 teams - of PS in the neighbourhood, relevancy in terms of deformation field characterisation, …)

- Temporal interpolation: interpolation of levelling dates at PS times is possible, considering the temporal variability of the deformation and the number of PS acquisitions
Validation:

Time series validation

→ Comparison levelling points/PSI derived times series on the temporally interpolated dates

- Compute the mean and standard deviation of the PS vs. levelling differences ➔ see performance figures.
- Plot for all the dates the PS profiles along a levelling line vs. the levelling data ➔ see performance figures.
- Assess the differential (point-to-point) behaviour of PS ($\Delta_{\text{defo}_{\text{PSI}}} - \Delta_{\text{defo}_{\text{refere}}}$ function of distance)

Deformation rates

- Compute the mean and standard deviation of the differences PS vs. levelling ➔ see performance figures.
- Assess the differential (point-to-point) behaviour of PS ($\Delta_{v_{\text{PSI}}} - \Delta_{v_{\text{refere}}}$ function of distance)

Valid only on levelling points having 1992-2004 temporal coverage
Intercomparison

to estimate the relative coherence of the different products
→ test only based on velocity intercomparison (linear deformation assessment)

1) Classify PS data of the team in a grid,
2) Identify cells with at least 1 PS for each of the teams,
3) compute average velocity in each cell (if more than 1 PS)
4) compute variances of the differences between pairs of teams
5) compute the correlation matrix of the results
First observations

Density / distribution of PS
Example T2/T3

• T2 globally denser than T3 but mostly distributed in urban areas
• \(\rightarrow\) difference in PS selection
• For intercomparison: which are the corresponding PS?
Comments on geocoding

Changes in the procedure:

- Initial procedure: Provision of GCP both in geographic coordinates (among levelling points) and radar and identified on orthophoto small excerpt
- Provision of a small excerpt of the orthophoto projected in WGS 84
- additional shift needed

A correct geocoding is absolutely needed for the validation
(but also for any application of the technique)
Data geocoded with the orthophoto provided by teams

After final correction
Some teams used different stable areas and/or reference dates for TS (difference in used data set)

Additional modifications:

“Put to zero”:

- same stable area reference
  * estimation of the averaged velocities on the same small stable area
  * correction of the velocities using this velocity value
  * removal of a linear trend using this velocity value

- common reference date (15/07/1992) for the TS
Stable reference area
- Far from the mine
- around 5 stable levelling points

Example of modified TS for Team 4
Test on deformation rates values

<table>
<thead>
<tr>
<th>Stable area</th>
<th>CDF</th>
<th>Difference (mm/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>-0.619</td>
<td>-0.756</td>
</tr>
<tr>
<td>T2</td>
<td>-0.837</td>
<td>-1.102</td>
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<tr>
<td>T3</td>
<td>0.783</td>
<td>0.629</td>
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<tr>
<td>T4</td>
<td>0.754</td>
<td>0.609</td>
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<td>T5</td>
<td>-1.2</td>
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<td>T6</td>
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</tr>
<tr>
<td>T7</td>
<td>-0.751</td>
<td>-1.562</td>
</tr>
<tr>
<td>T8</td>
<td>-0.455</td>
<td>-1.969</td>
</tr>
</tbody>
</table>
Characterisation of the field
Characterisation of the field: Semi – variograms on deformation

Team 1

Team 2

Team 6
Conclusions

- Presentation of the site and data
- Procedure defined
- First observations
  - PS density differences
  - Differences in geocoding
  - Differences in deformation rates

- Validation end: March 2006