



# GMES Terrafirma: validation of PSI for users

## Results of the Provence inter-comparison

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**Michele Crosetto, Marta Agudo**

(Institute of Geomatics)

**Ren Capes**

(Nigel Press Associates)

**Stuart Marsh**

(British Geological Survey)



**British  
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL



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# Content

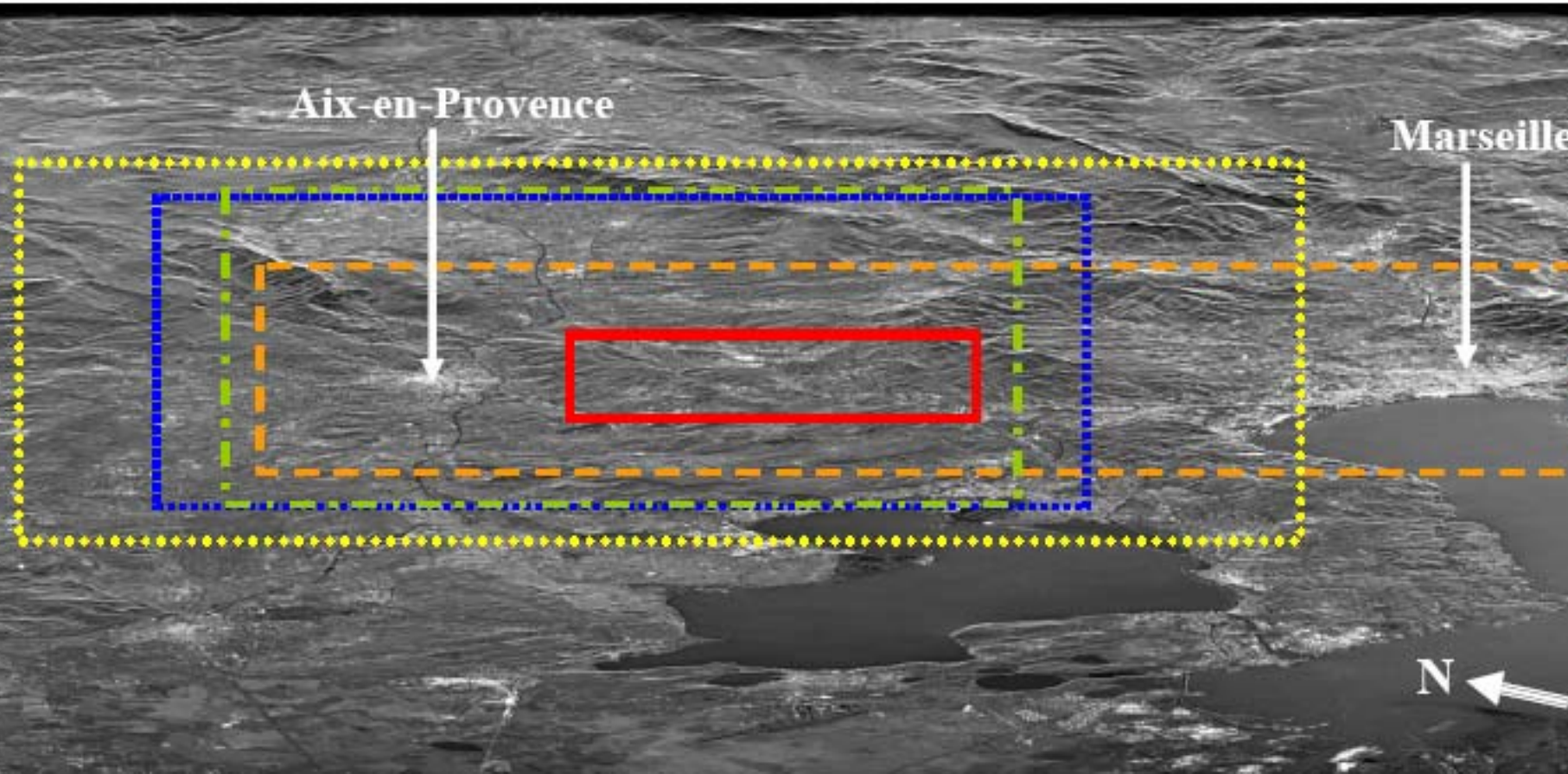
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  - PSIC4 vs. Provence inter-comparison
2. Analysis of deformation velocity
3. Analysis of time series
  - information content of time series
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- ❑ Complementary study based on the PSIC4 dataset:
  - Extend the analysis of PSIC4 → new insights
  - Collect inputs for a new validation experiment within Terrafirma
  
- ❑ PSIC4 vs. Provence inter-comparison:
  - 1) PSIC4: validation and inter-comparison of geocoded results  
Prov.: inter-comparison on the original PS data (radar image space)
  - 2) PSIC4: Gardanne mining area, about 100 km<sup>2</sup>  
Prov.: about 925 km<sup>2</sup> (include stable and moderate deforming areas)
  - 3) PSIC4: results of eight PSI teams  
Prov.: four of the five Terrafirma Operational Service Providers:  
Altamira, DLR, Gamma and TeleRilevamento Europa (TRE).
  
- ❑ The inter-comparison results are anonymous

# Introduction: test area



# Pre-processing

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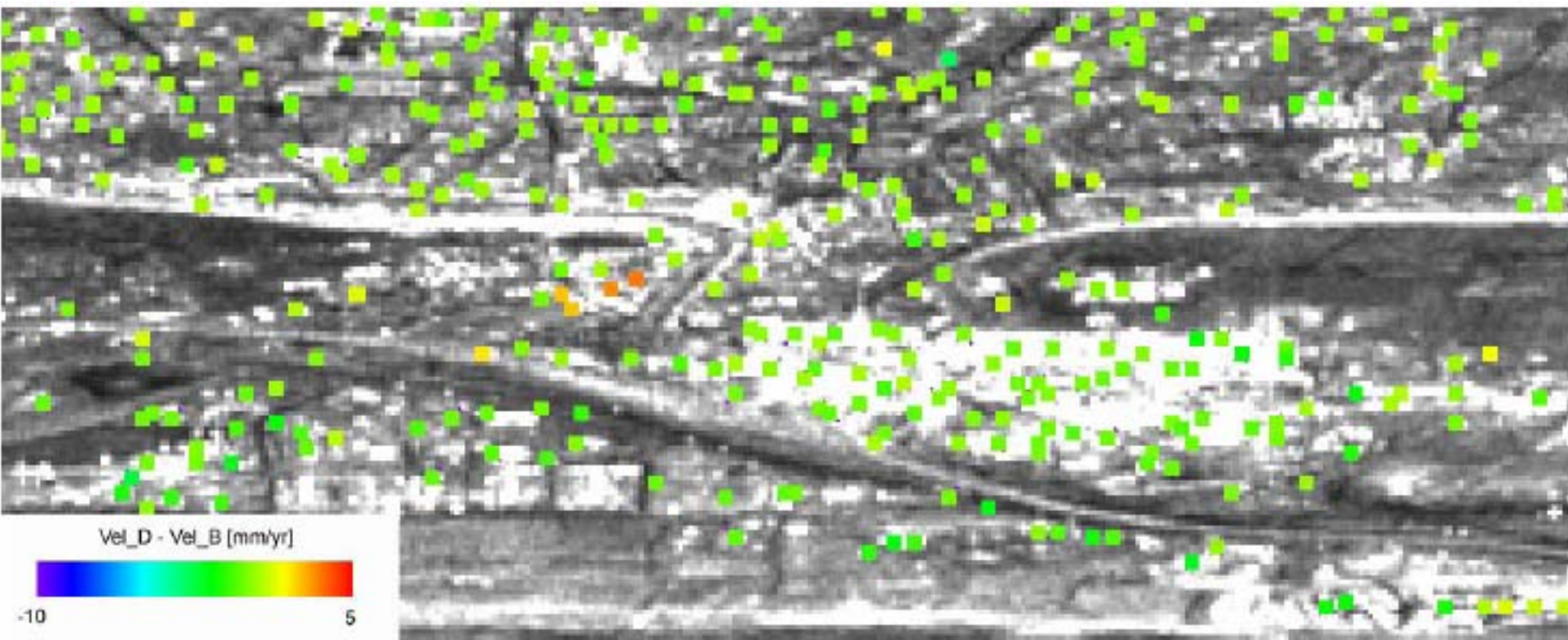


- ❑ Each of the four datasets includes a number of PS between 75000 to 95000  
The original PSIC4 datasets are not co-registered
  
- ❑ Two pre-processing steps:
  - Homogenizing the datasets:
    - transformation of the input PS data in the original SLC geometry
    - co-registration of the different PS datasets
  
  - Referring the four PS datasets to the same stable area

# Velocity inter-comparison



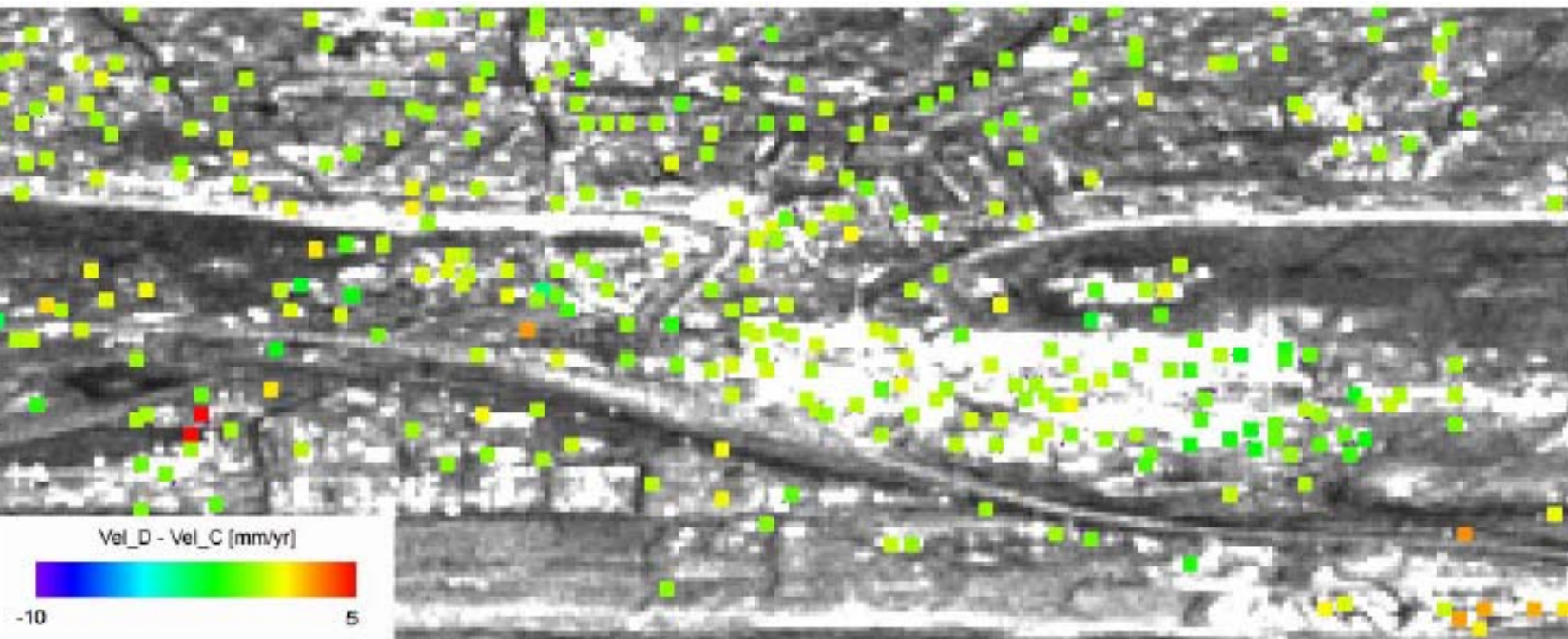
- ❑ Six possible differences between the four teams. Velocity differences computed on the common PS



# Velocity inter-comparison



- ❑ Six possible differences between the four teams. Velocity differences computed on the common PS



# Velocity inter-comparison



- The statistics global → global inter-comparison behaviour of the teams

[mm/yr]	Max.	Min.	Mean	Stdev	# PS
<b>TD-TB</b>	17.46	-13.71	0.18	0.70	12348
<b>TD-TA</b>	7.92	-11.46	-0.09	0.63	9579
<b>TD-TC</b>	11.24	-17.04	-0.02	0.77	8909
<b>TB-TA</b>	13.26	-14.98	-0.32	0.58	27445
<b>TB-TC</b>	10.13	-14.42	-0.37	0.80	23418
<b>TA-TC</b>	6.63	-11.47	-0.08	0.79	12471

# Velocity inter-comparison



- Mean differences between – 0.37 and 0.18 mm/yr.

Single sample T-test: five of six team pairs have means of the differences significantly different from zero (confidence interval of 99%):

- small errors when referring the PS datasets to the same stable area
- residual systematic errors in the velocities maps

- Standard deviations between 0.58 to 0.80 mm/yr. Distribution of the differences:

[mm/yr]	$ \Delta v  < 1$	$ \Delta v  < 2$	$ \Delta v  < 3$	$ \Delta v  < 4$	$ \Delta v  < 5$
	%	%	%	%	%
<b>TD-TB</b>	94.24	98.74	99.44	99.70	99.81
<b>TD-TA</b>	94.12	98.80	99.49	99.70	99.85
<b>TD-TC</b>	89.64	98.63	99.46	99.63	99.75
<b>TB-TA</b>	93.59	99.17	99.72	99.89	99.93
<b>TB-TC</b>	76.98	98.54	99.72	99.87	99.90
<b>TA-TC</b>	84.64	98.40	99.49	99.76	99.87

# Velocity inter-comparison



- Minimum and maximum differences:
  - In some locations big discrepancies occur
  - They are rather rare, e.g.:
    - absolute differences  $> 5$  mm/yr are 0.07% (TB - TA)

[mm/yr]	Max.	Min.	Mean	Stdev	# PS
<b>TD-TB</b>	17.46	-13.71	0.18	0.70	12348
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# Velocity inter-comparison

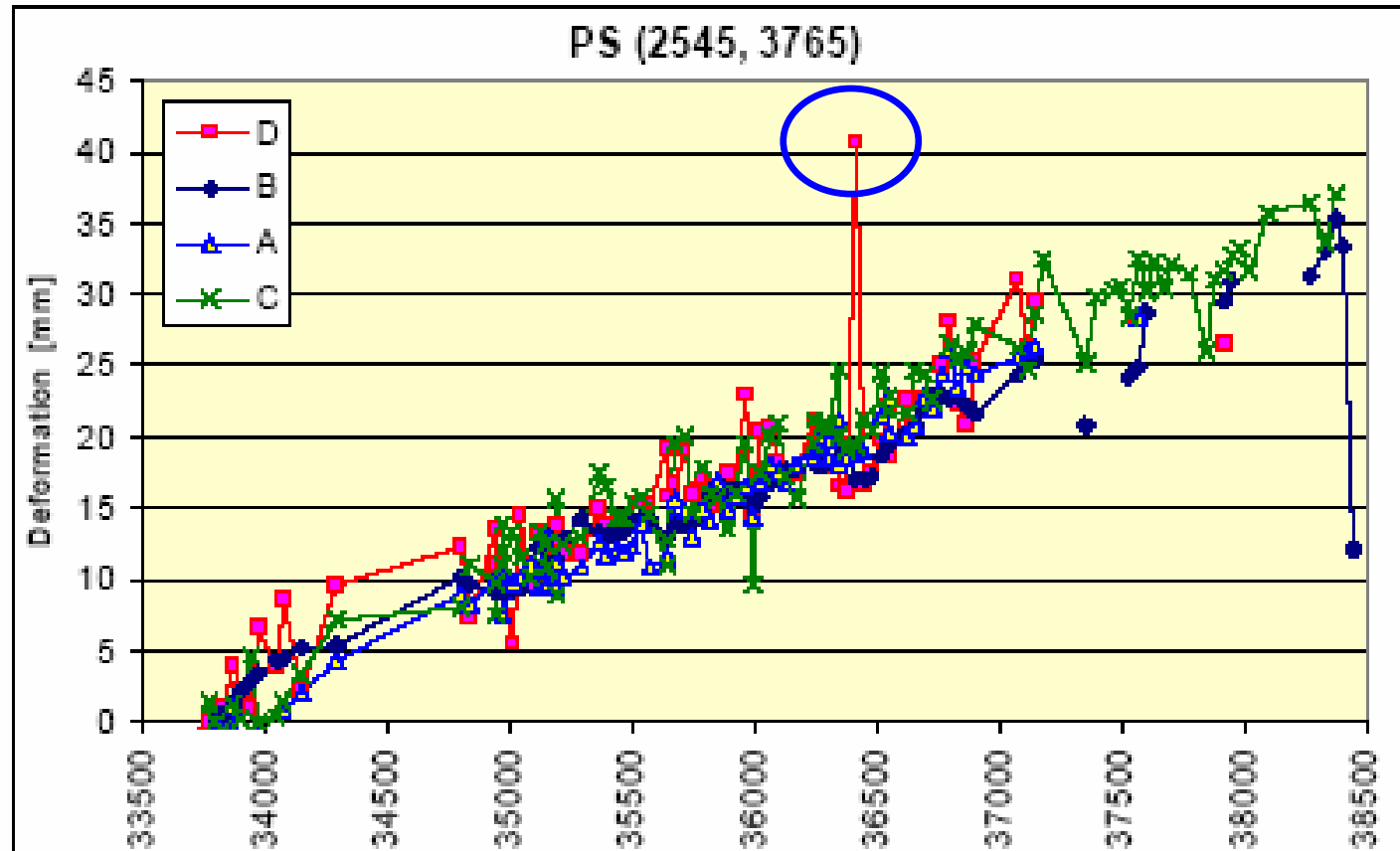


- Velocity differences as a function of velocity magnitude:  
Dispersion of differences increases when velocity module increases

[mm/yr]	TD-TB		
	Mean $\Delta v$	Stdev $\Delta v$	# PS
$-\infty \leq v \leq -4$	-0.25	1.85	247
$-4 \leq v \leq -3$	-0.14	1.07	179
$-3 \leq v \leq -2$	-0.02	0.78	417
$-2 \leq v \leq -1$	0.00	0.63	1547
$-1 \leq v \leq 0$	0.13	0.52	6183
$0 \leq v \leq 1$	0.36	0.55	3389
$1 \leq v \leq 2$	0.71	1.07	323
$2 \leq v \leq 3$	1.23	1.64	41
$3 \leq v \leq 4$	2.10	3.07	11
$4 \leq v \leq \infty$	3.04	5.31	11

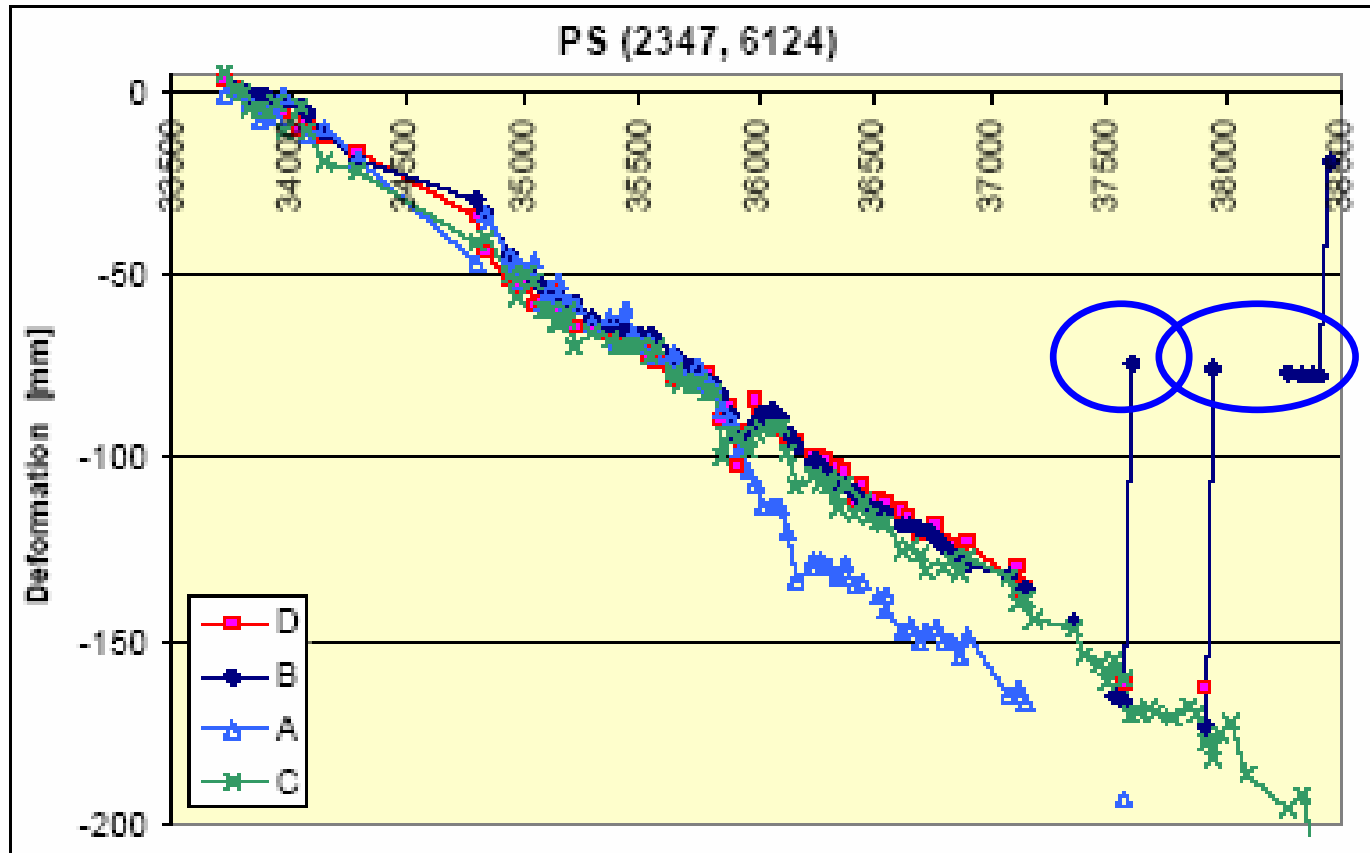
# Time series inter-comparison

□ Example:



# Time series inter-comparison

□ Example:



# Time series inter-comparison



## □ Global statistics:

<b>[mm]</b>	<b>mean of the mean differences</b>	<b>mean of the standard deviation of the differences</b>
<b>TD-TB</b>	- 0.78	3.87
<b>TD-TA</b>	- 0.11	4.34
<b>TD-TC</b>	0.88	3.94
<b>TB-TA</b>	0.86	3.57
<b>TB-TC</b>	0.71	4.18
<b>TA-TC</b>	0.13	3.86

## ❑ Correlation coefficient:

- 14.3% of 94170 pairs of time series have correlation coefficient above 0.7

However: most of the contribution comes from the linear velocity  
e.g. more than 99% of the time series with velocities below -2 mm/yr  
have a correlation coefficient above 0.7.

## ❑ Analysis of de-trended time series:

- 1.31 % of the pairs have a correlation coefficient above 0.7,
- 0.004% of the pairs have a correlation coefficient above 0.9

These low percentages show that, apart from the linear component,  
**time series have little in common.**

## ❑ Possible interpretation:

- We are not comparing exactly the same PS (co-registration, etc),
- Some PS really do not have non-linear deformation,
- Deformation is masked by the SAR measurement noise,
- Part of the non-linear deformation lost during the PSI processing.

# Conclusions

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- ❑ Inter-comparison: Important pre-processing aspects:
  - Accurate co-registration of datasets
  - Refer the PS datasets to the same stable area
  - Process the same SAR data stack
  
- ❑ Inter-comparison results:
  - PSI involves an estimation process: there are discrepancies between the results achieved by different PSI processings

- ❑ Deformation velocity – Global statistics:
  - Mean of the velocity differences ranges from -0.37 to 0.18 mm/yr  
These are significantly different from zero: there are (small) residual systematic errors in the velocities maps
  - Standard deviations of differences between 0.58 to 0.80 mm/yr  
Dispersion of differences increases when velocity module increases
  
- ❑ Deformation time series
  - Average of the means of the differences: -0.78 to 0.88 mm.
  - Analysis of de-trended time series:  
1.31 % of the pairs have a correlation coefficient above 0.7.  
Apart from the linear component, **time series have little in common.**  
➔ **Information content** of time series to be analysed in detail

- ❑ Results of the PSIC4 project (this afternoon)
  - Paper (proceedings of this Symposium):  
Crosetto et al.:  
Validation of PSI over a mining test site: Results of the PSIC4 project
  
- ❑ Ongoing Validation Project within GMES TerraFirma (Amsterdam/Alkmaar)
  - IG (project lead), TNO, TUDelft, DLR, BGS
  - PSI processing: Altamira, DLR, Gamma, NPA, TRE
  - Project results in November 2007