Comparison between Remote Sensing and GPS measurements for earthquake ground deformation monitoring

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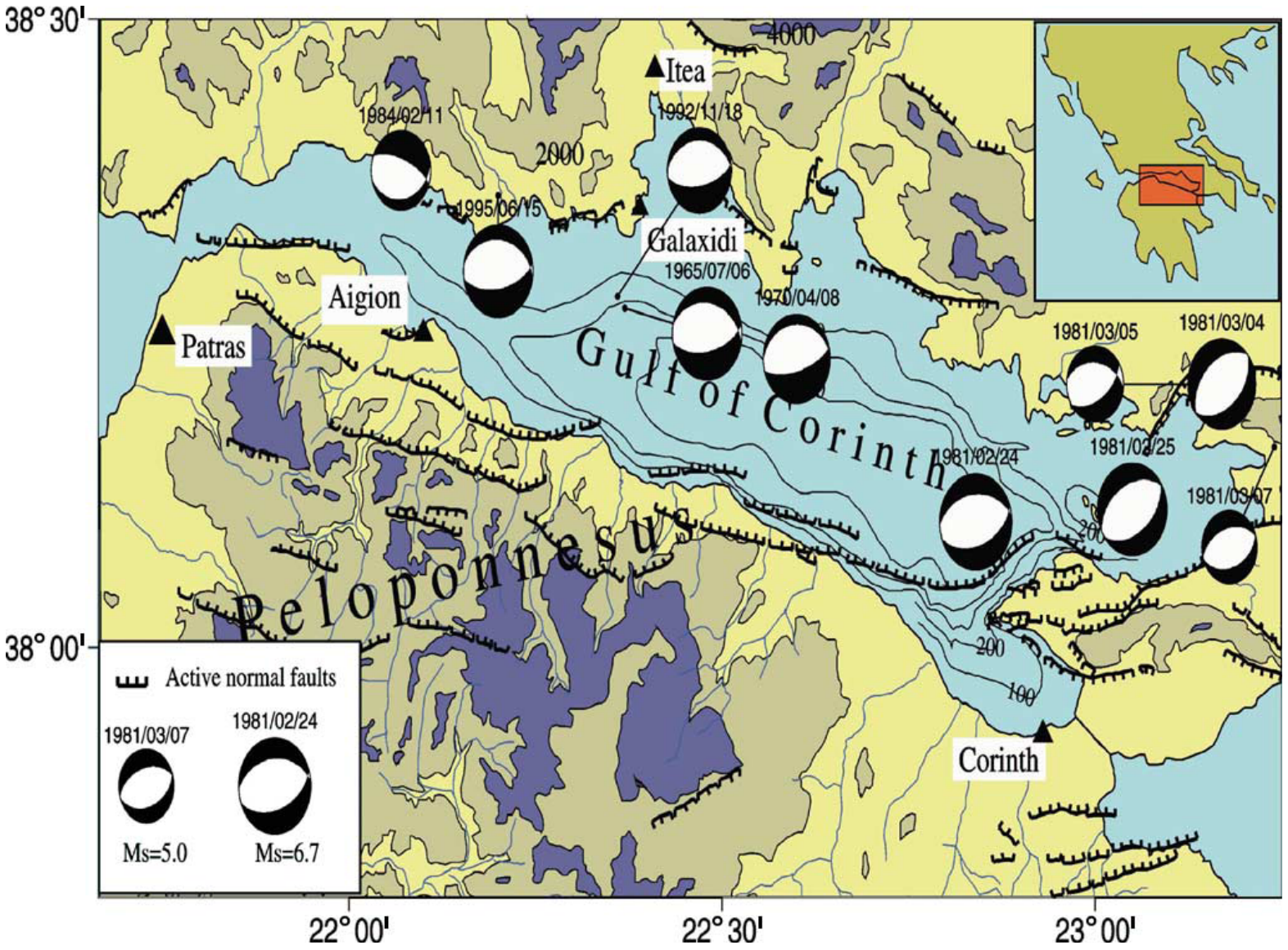
UN/UAE/USA Workshop on the Applications of GNSS, Dubai, United Arab Emirates, 16 - 20 January 2011

Context of this study



Golf of Corinth seismically map

Data

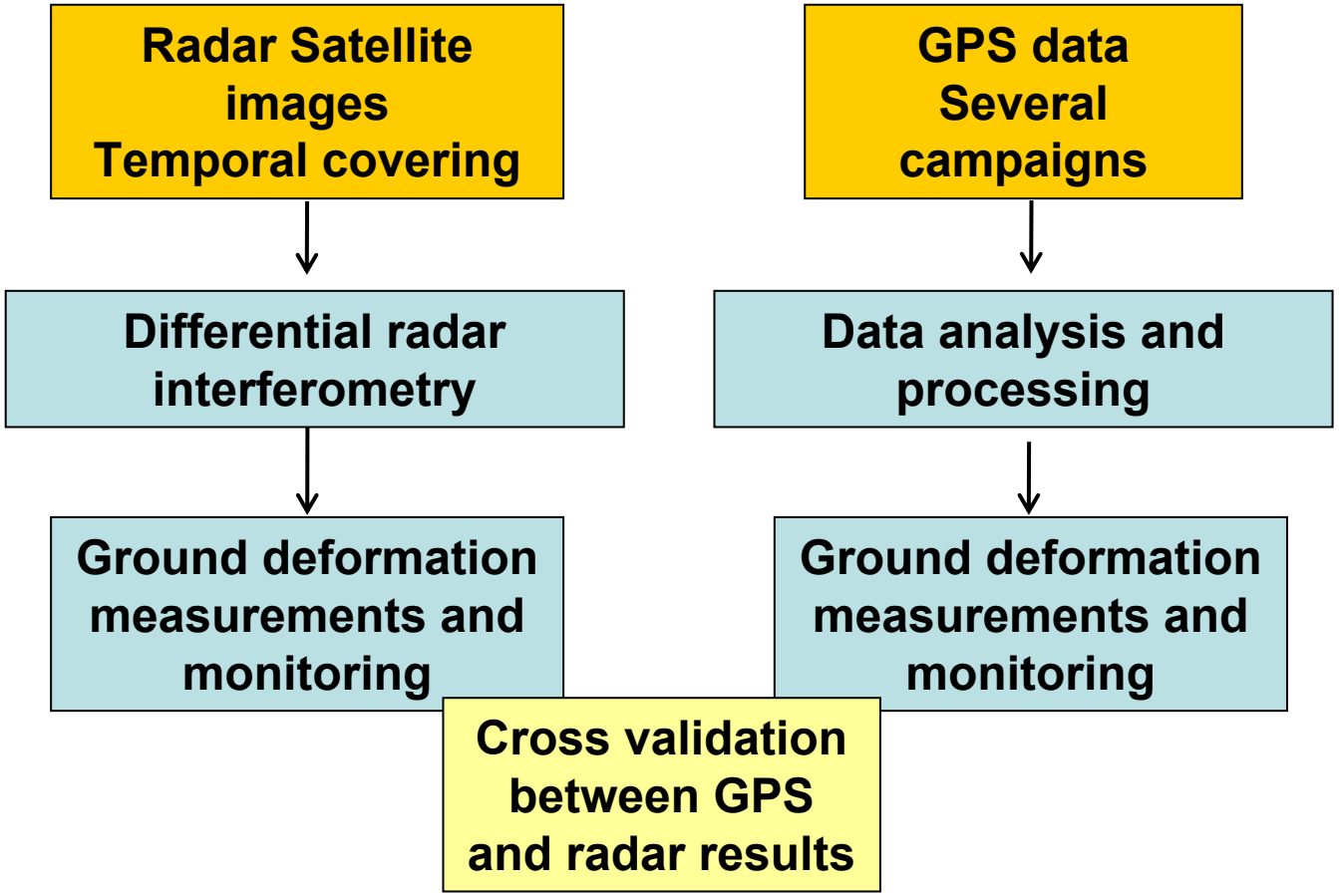
Satellite images

Geodesic data: GPS data

Tectonic and seismological data

Etc.

Objectives of this study



☞Confront both results

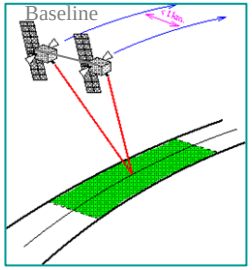
☞Measure with great accuracy earthquake ground deformation by combining GPS and satellite data results.

Overview of the presentation

1. **Radar interferometry for ground deformation**
   1. Principle
   2. Data
   3. Results
2. **GPS data analysis and processing**
   1. Data
   2. Data analysis
   3. Results
3. **Comparison results**
4. **Conclusion**

Radar interferometry for ground deformation

Radar and differential radar interferometry (1/2)



Radar image1

Radar Image2

DTM ou Radar Image3

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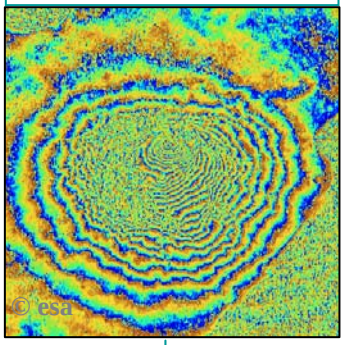
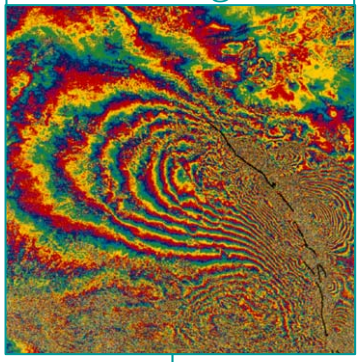
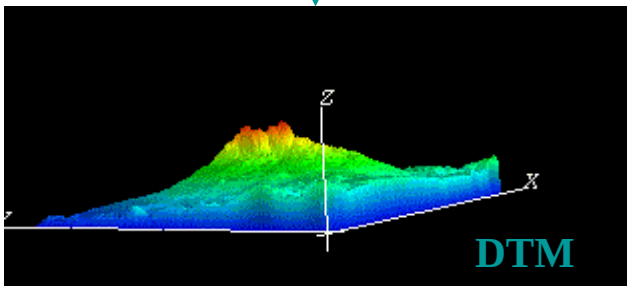
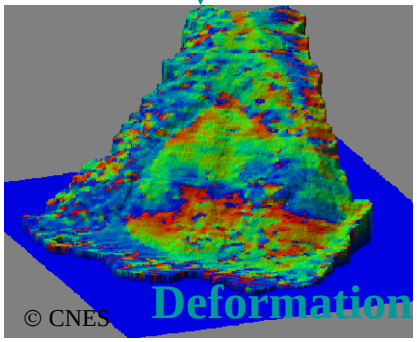
interferogram



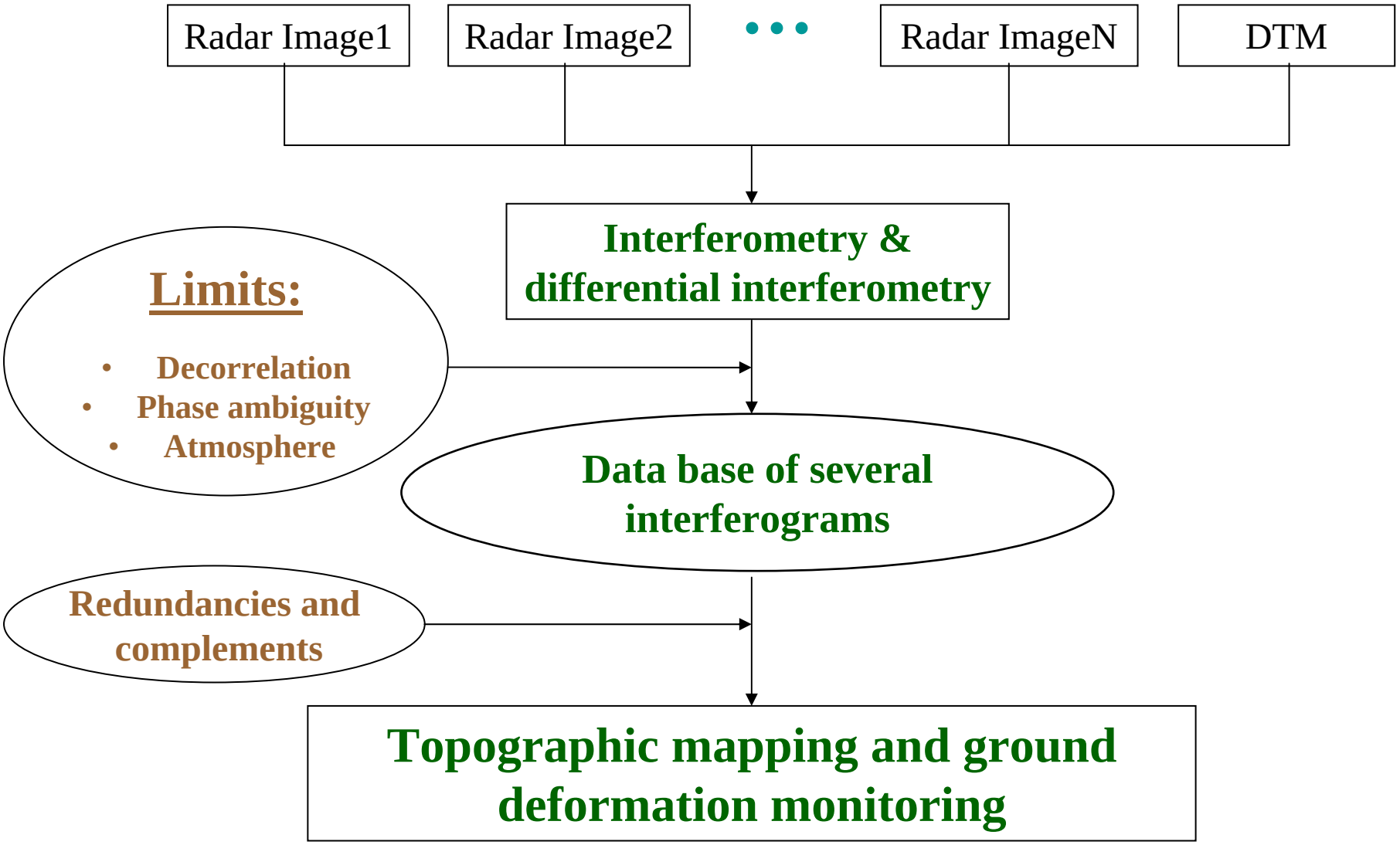
differential interferogram







Radar and differential radar interferometry (2/2)



Dataset

38 radar images

From 1992 to 2001

Three tracks 2 descending and one ascending

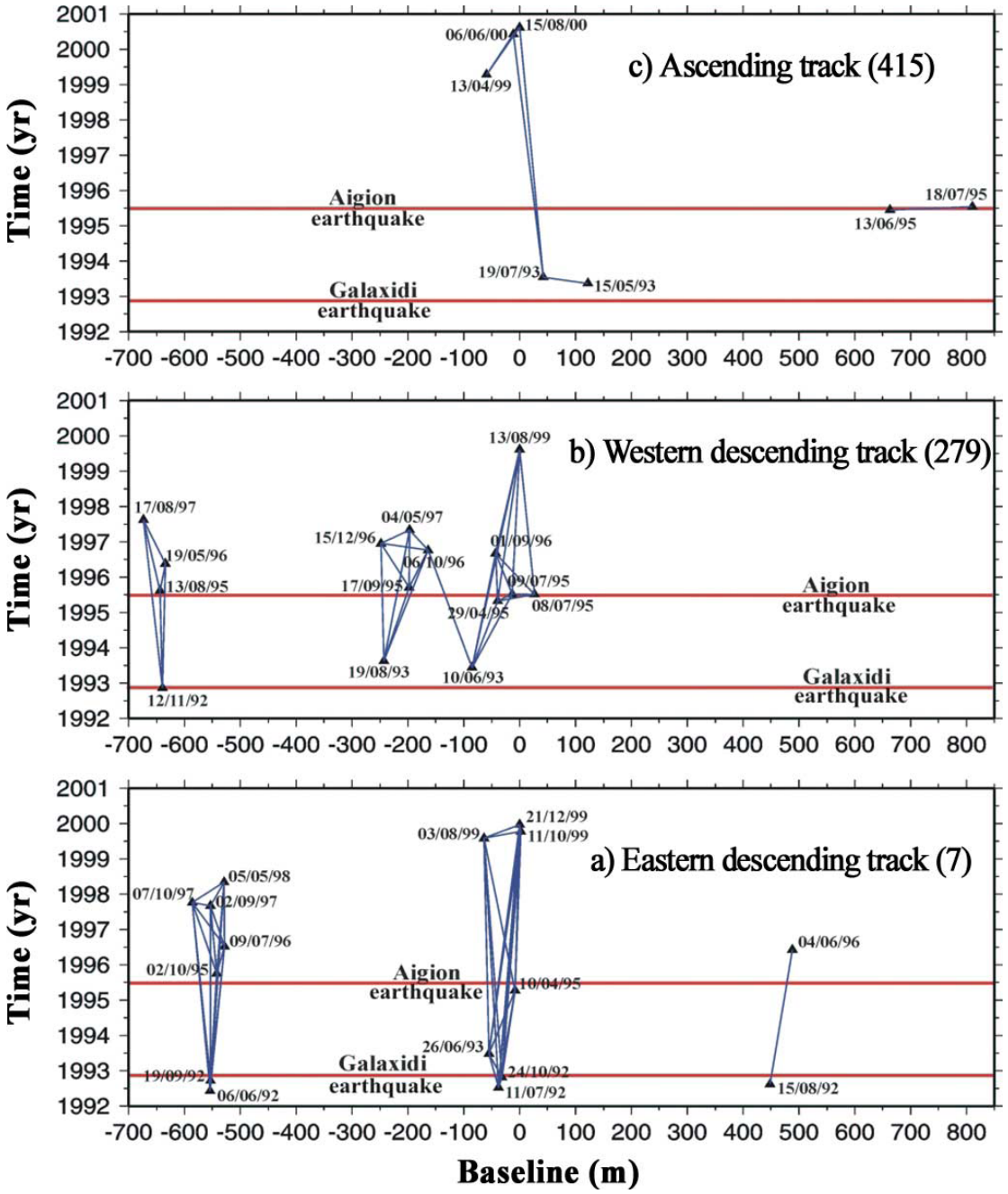
Satellite	N.orbite	Date	Time	Sense	Track	Frame
ERS1	4661	06/06/92	9h13 TU	D	7	2835
ERS1	5162	11/07/92	9h13 TU	D	7	2835
ERS1	5663	15/08/92	9h13 TU	D	7	2835
ERS1	6164	19/09/92	9h13 TU	D	7	2835
ERS1	6665	24/10/92	9h13 TU	D	7	2835
ERS1	10172	26/06/93	9h13 TU	D	7	2835
ERS1	19534	10/04/	9h13 TU	D	7	2835
ERS1	22039	02/10/95	9h13 TU	D	7	2835
ERS1	43081	11/10/99	9h13 TU	D	7	2835
ERS2	5873	04/06/96	9h13 TU	D	7	2835
ERS2	6374	09/07/96	9h13 TU	D	7	2835
ERS2	12386	02/09/97	9h13 TU	D	7	2835
ERS2	12887	07/10/97	9h13 TU	D	7	2835
ERS2	15893	05/05/	9h13 TU	D	7	2835
ERS2	22406	03/08/99	9h13 TU	D	7	2835
ERS2	24410	21/12/	9h13 TU	D	7	2835
ERS1	6937	12/11/92	9h15 TU	D	279	2835
ERS1	9943	10/06/93	9h15 TU	D	279	2835
ERS1	10945	19/08/93	9h15 TU	D	279	2835
ERS1	19806	29/04/95	9h15 TU	D	279	2835
ERS1	20808	08/07/95	9h15 TU	D	279	2835
ERS2	1135	09/07/95	9h15 TU	D	279	2835
ERS2	1636	13/08/95	9h15 TU	D	279	2835
ERS2	2137	17/09/95	9h15 TU	D	279	2835
ERS2	5644	19/05/96	9h15 TU	D	279	2835
ERS2	7147	01/09/	9h15 TU	D	279	2835
ERS2	7648	06/10/96	9h15 TU	D	279	2835
ERS2	8650	15/12/96	9h15 TU	D	279	2835
ERS2	10654	04/05/97	9h15 TU	D	279	2835
ERS2	12157	17/08/97	9h15 TU	D	279	2835
ERS2	21676	13/08/99	9h15 TU	D	279	2835
ERS1	9578	15/05/93	20h48 TU	A	415	765
ERS1	10079	19/07/93	20h48 TU	A	415	765
ERS2	770	13/06/95	20h48 TU	A	415	765
ERS2	1271	18/07/95	20h48 TU	A	415	765
ERS2	20810	13/04/99	20h48 TU	A	415	765
ERS2	26822	06/06/00	20h48 TU	A	415	765
ERS2	27824	15/08/00	20h48 TU	A	415	765

Data Temporal distribution

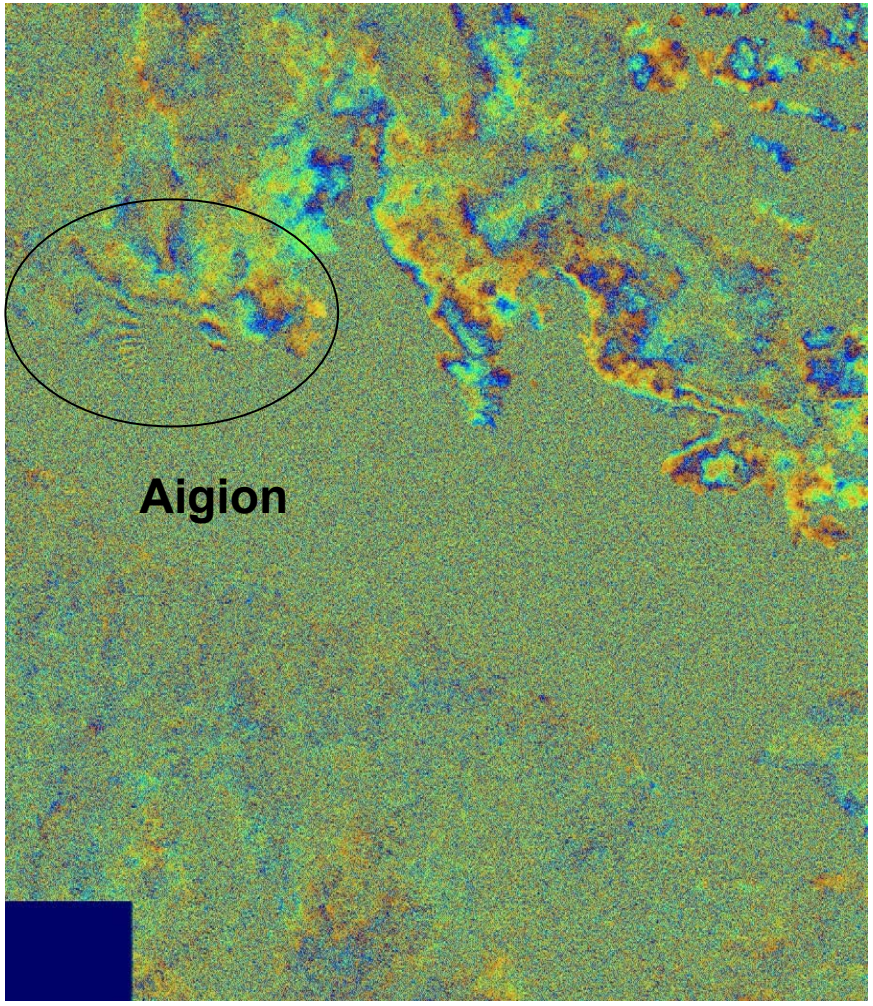
38 radar images

81 interferograms (7 for track a, 31 for track b, and 43 for track c) (blue lines).

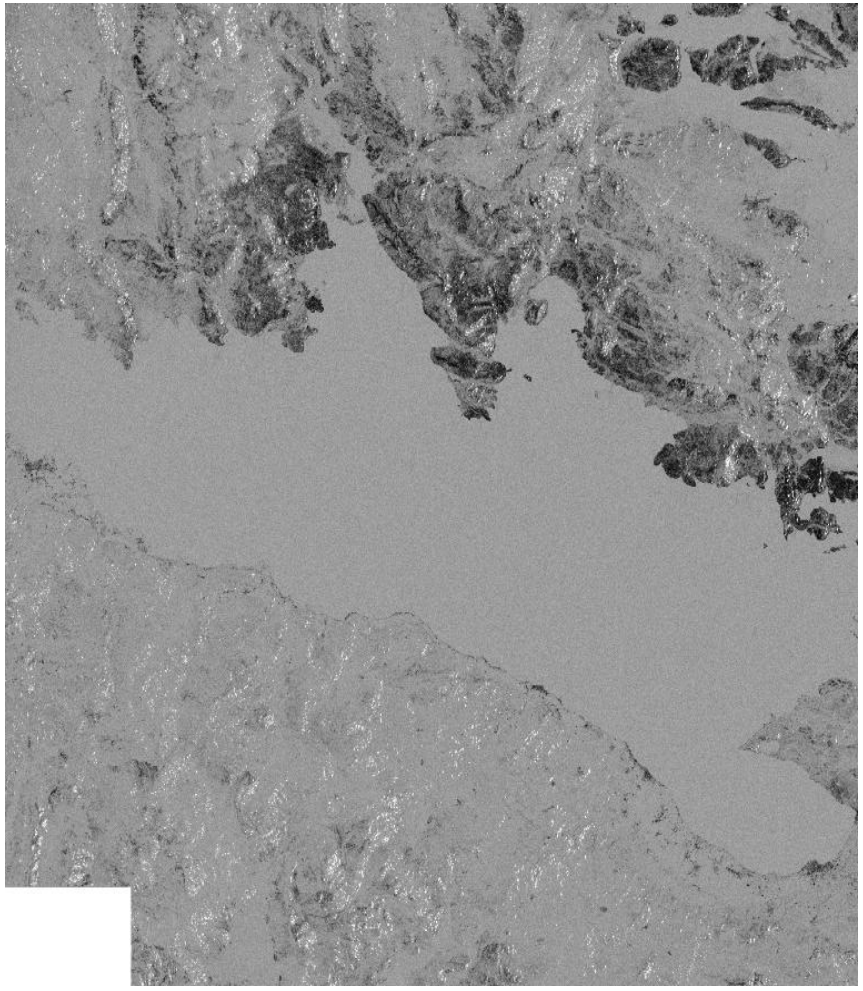
The 1992 Ms = 5.9 Galaxidi earthquake and the 1995 Ms = 6.2 Aigion event (red lines).



Interferometric data

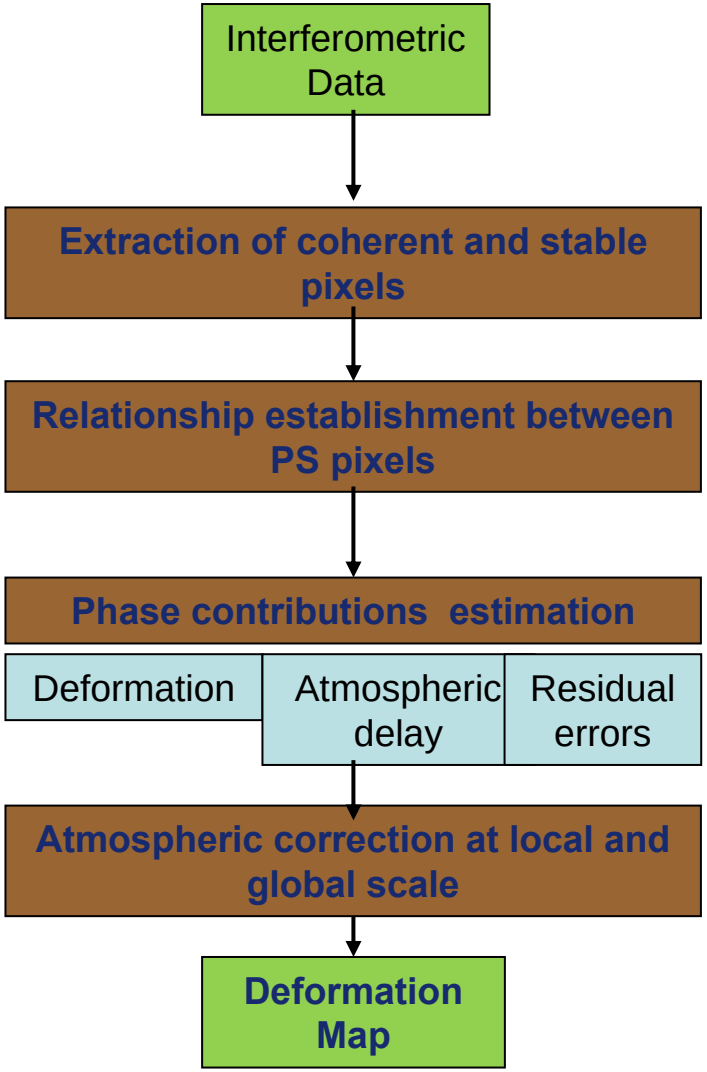


Differential interferogram

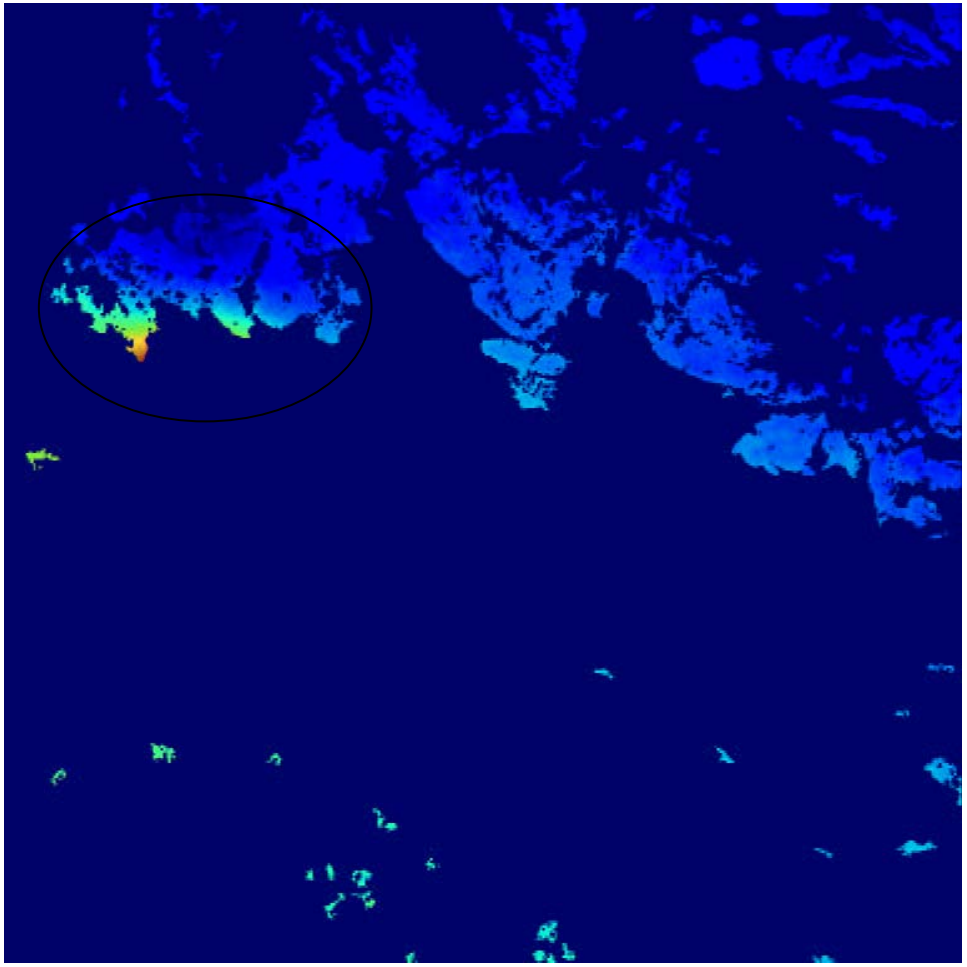


Temporal coherency map

Differential radar interferometry processing



Differential radar interferometry results

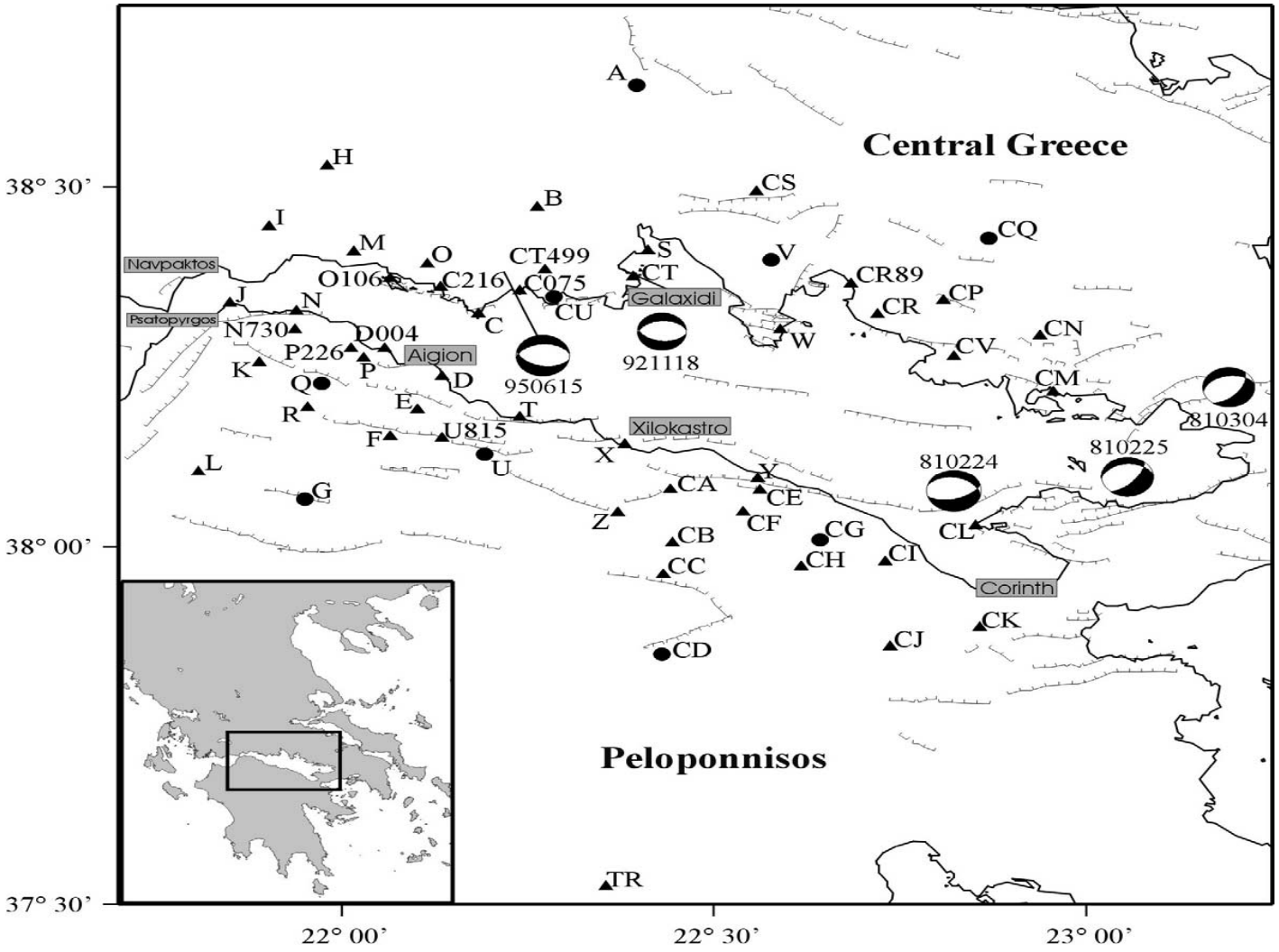


+30 mm 0 -235mm

Deformation map

GPS data analysis and processing

GPS data



Golf of Corinth seismically map

Eleven GPS campaigns from 1990 to 2001.

Dense GPS network: 57 fisrt order points measured at least 3 times in a given compaign.

1 point per 5 km^2: good simpling of the main active fault

GPS analysis and processing

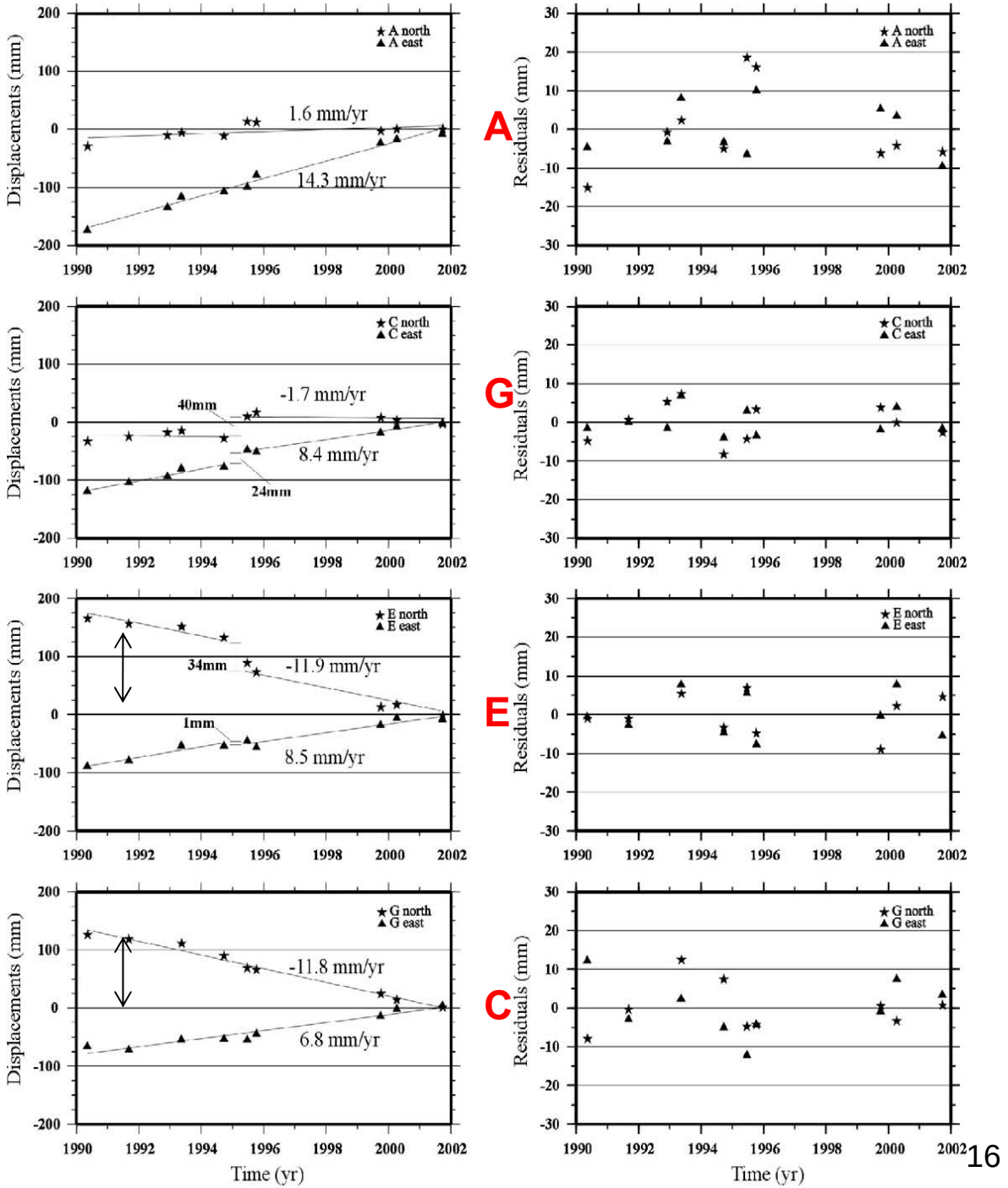
- **All data were processed using the GAMIT software and the same processing strategies.**
- **IGS precise orbits and GPS data are used to tie the network to ITRF2000 (International Terrestrial Reference Frame).**
- **The coordinates for each single campaign were obtained by combining the daily solutions using the GLOBK software.**
- **A 7-parameter Helmert transformation was applied and its parameters were estimated using the subset of IGS stations included in the computations.**

GPS results

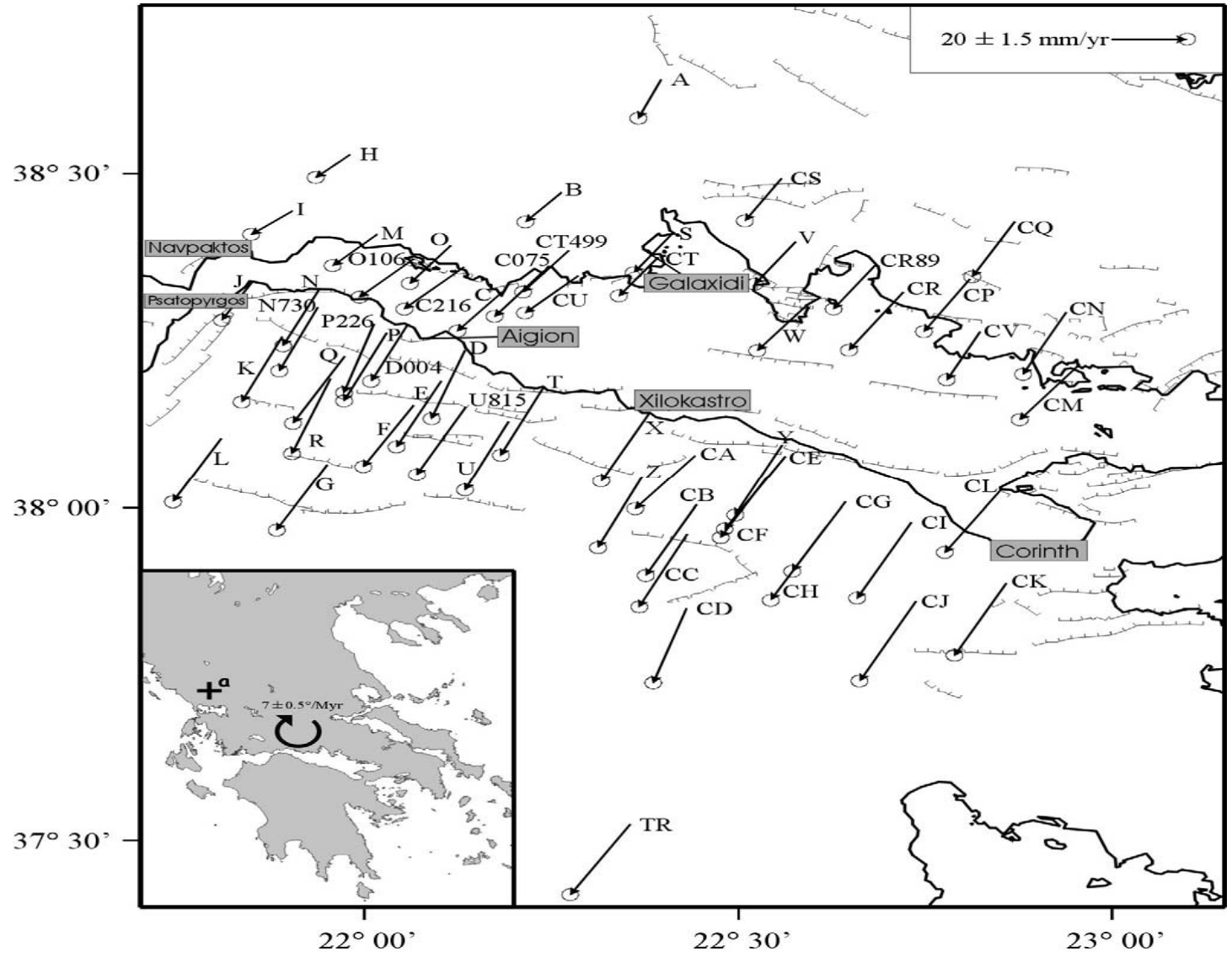
(Left) Temporal change of the ITRF2000 coordinates: points A, C, E, and G.

For C and E, a co-seismic offset has been estimated.

(Right) Residuals after velocities and co-seismic offsets.



GPS results



Velocities and Co-seismic displacements map

Velocities and Co-seismic displacements deduced from the 11 GPS surveys carried out between 1990 and 2001

The pole of rotation of the Central Greece block is shown in inset.

Fixed-Europe reference frame.

GPS conclusions

- **The GPS velocities show that the extension is almost entirely accommodated offshore in the internal part of the rift in a band as narrow as 10 km near Aigion.**
- **The extension rate measured over eleven years is ~11 mmyr^{-1} to the N185◦ E in the central part of the rift (Xilokastro) and ~16 mmyr^{-1} to the N185◦ E in its western part (Aigion).**
- **Peloponnesos moves at 30 mmy^{r-1} towards N215◦ E, a value in good agreement with that obtained from larger-scale surveys.**
- **The slow rate of deformation across the major faults of the southern part of the Gulf implies long recurrence periods for large earthquakes (Ms = 6.5 to 7) on these faults, 500–1000 years or more.**
- **The smaller structures located in the inner part of the rift (like the 1995 fault) accommodate most of the rift extension probably with relatively frequent earthquakes of lower magnitude (Ms = 5.5 to 6.5).**

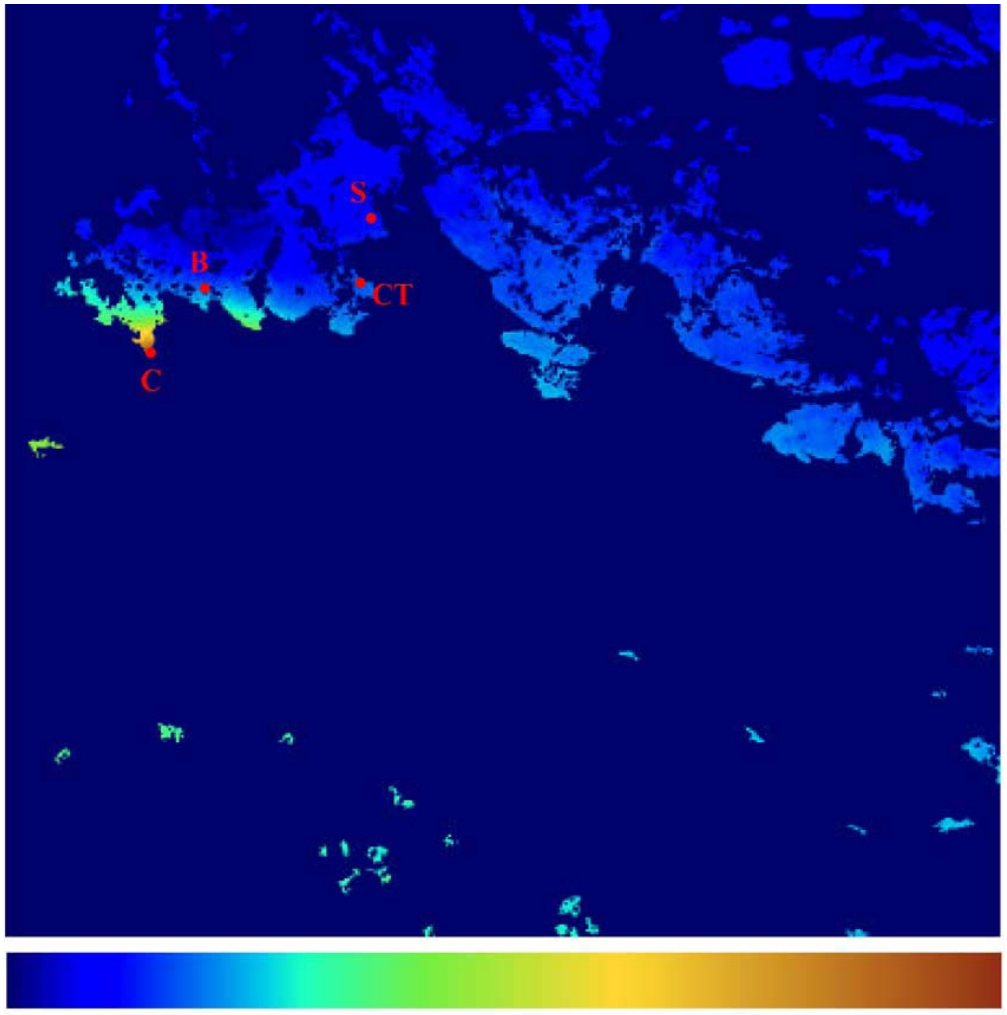
GPS and Satellite images comparison

Limitations: The incidence of two main aspects:

1) the time spanning of the GPS measurements of the Gulf of Corinth network does not cover always the time spanning of the Differential radar interferometry analysis.

2) The distribution of the coherence in the Gulf of Corinth area is not homogeneous.

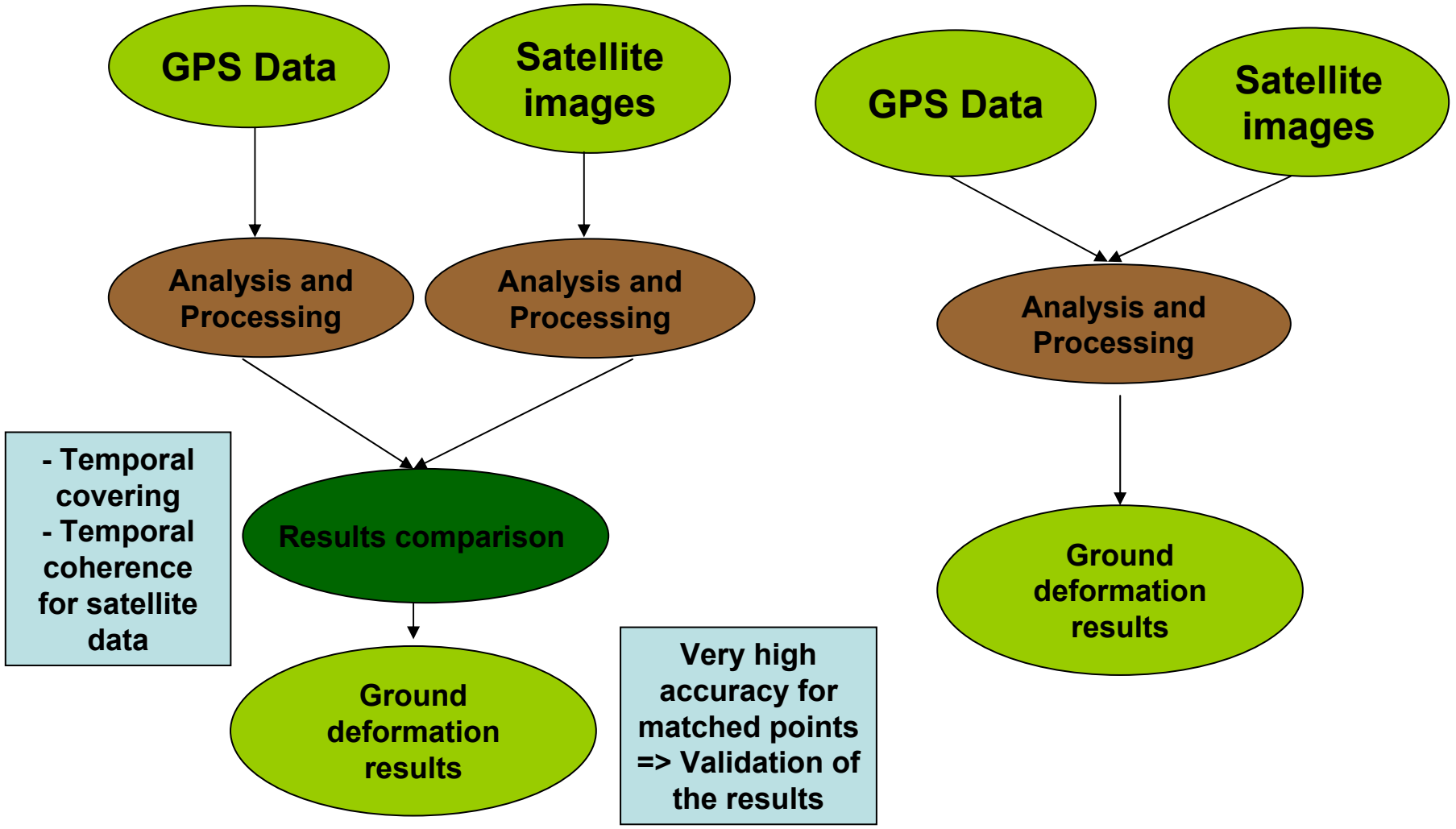
GPS and Satellite images cross validation



Deformation map

	GPS mesurements (mm)	DinSAR measurements (mm)
B	7±16	4 ± 19
C	-202 ± 17	-204 ± 23
CT	-1 ± 13	3 ± 10
S	-18 ± 20	-20 ± 7

Conclusion


GPS Data
Satellite images
Analysis and Processing
Analysis and Processing
Results comparison
Ground deformation results
- Temporal covering
- Temporal coherence for satellite data
GPS Data
Satellite images
Analysis and Processing
Ground deformation results
Very high accuracy for matched points => Validation of the results

Thanks for your attention