

Advanced interpretation of land subsidence by validating multi-interferometric SAR data: the case study of Anthemountas basin (Northern Greece)

By Raspini et al.

General comments

This paper shows a good application of standard Permanent Scatterer SAR Interferometry to the study of ground subsidence in Northern Greece.

It uses standard PSI techniques and a limited set of ground data to address the issue of subsidence hazard near Thessaloniki. It shows a with a valid scientific method, and is within the scope of NHESS.

It is well organized and fairly well written, but in many parts it does need a grammar revision by a native English speaker.

My main problem with this paper concerns an over-interpretation of the results (see below), but with appropriate revision I think it will maintain good scientific quality and it will deserve publication on NHESS.

Specific comments

- 1) I believe that part of the interpretation (and conclusion) is not supported by the results.

In particular the authors interpret a pattern of negative ground deformation following the NW-SE Thermi fault as a sign of the fault's activity and possibly of the activity of three E-W intersecting faults.

I do not see a clear correspondence between the ground deformation and the faults. In figure 14 only one of the intersecting fault shows a negative peak, the other two look like noise, while two other peaks to the East do not correspond to any crossing fault. Moreover the spatial wavelength of these signals is similar to the subsidence ones.

From figure 13 it is instead clear that the high subsidence rates cross the fault trace (which would exclude surface creeping), yet they are confined to only few km on both sides of the fault (which excludes deep creep below the brittle layer). 5-10 mm/yr of differential deformation rates along a fault plane means near surface fault creeping, which has never been observed along normal faults in Greece or elsewhere.

Finally, if near surface creeping would occur, there should be some microseismicity at some depth along the fault.

In fact the negative velocities closely correspond to the Quaternary formation, and it seems far more reasonable that the subsidence be due to sediment compaction, possibly driven by the fault plane, as observed in other cases (e.g. Colesanti et al., 2003, SAR monitoring of progressive and seasonal ground deformation using the permanent scatterers technique, IEEE Trans. Geosci. Remote Sens., 41, 1685–1701).

Unless other evidences and a more convincing reasoning support this interpretation, I would not consider it acceptable.

- 2) On a more technical perspective, I think that the authors should describe (without going into detail) the method used in PS InSAR for filtering the turbulent atmosphere and the amount and possible patterns of the remaining error sources in the PS velocity maps (orbital residuals, topography-correlated atmosphere, unwrapping), since they might affect their results.
- 3) In this work the advantages of the Wide Area Processing technique (WAP) are mentioned but in fact they have not been exploited, since the area is rather small. In my opinion this is only an application of a PSI algorithm, and the reader cannot understand, by this test case, the utility of the WAP technique. Please rewrite.

Technical corrections

The following list is non exhaustive and should be complemented by a revision of the English grammar.

Line	Comment or original	Suggested change
39	Quantify “large areas”	
41	Change “structures”	“ building structures”
46	“complicates the interpretation of the phenomenon”	“may complicate the interpretation of the phenomena”
46	“terrain drop is”	“the surface lowering patterns are”
53	“constrained”	“limited”
55	Delete “purely”	
58	“manifesting at”	“occurring “
59	“at the east”	“located East”
63	“manifested”	“occurred”
65	“reviled that beside the Perea village big parts of the coastal zone subside”	“revealed that along the coast other large areas besides the Perea village are affected by subsidence”
70	“validate”	“assess”
78	“is”	“has been”
81	Delete “they”	
83	“formations constituting”	“units occurring in the area of “
83	“can be distinguished on”	“are”
90	“successively”	“in sequence”
91	“with an increasing”	“with increasing”
100	“distinguished”	“divided”
105	“quaternary formations extends the Neogene sand and gravel Sequence”	“Quaternary formations, the Neogene sand and gravel sequence occurs.”
114 & 115	“Anthemounta”	“Anthemountas”
125	“an extra”	“a”
128	“At the”	“Along the”
133	“profiles”	“logs”
148	Delete “mineral”	
149-150	please rewrite to clear the origin of this aquifer	
164	“presented at the isopiezometric curves maps referring”	“shown by the isopiezometric curves referring”
166	“reduced for more”	“lowered by more”
167-168	“was intensified the following years leading, besides the 167 downgrading of the ground water quality, to the manifestation”	“intensified during the following years, leading to a degradation of the ground water quality and to the occurrence”
169	“If groundwater overexploitation keeps on going, land subsidence is going to affect rapidly”	The continuation of groundwater overexploitation is expected to spread land subsidence over “
175	“subsidence-affected areas maps”	“subsidence maps”
181	“update.”	“updates.”
184-188	I would delete this sentence, since it is trivial and not scientifically relevant. “Their suitability is particularly relevant for wide area studies: when dealing with basin-scale phenomena, the potential of conventional investigation for the analysis of ground deformation is not comparable to the	

	effectiveness of remote sensing in terms of systematic coverage, timely updating, cost-efficiency and density of measures	
190	"became even more deeply accepted"	"widened their range of applications"
192	"relied"	"relying"
195	Delete "by the same satellite", it is not true.	
199	"satellite conventional"	"conventional satellite"
203-206	"many multi- interferometric approaches (under the "family name" Persistent Scatterer Interferometry) have been implemented, processing multi-temporal stacks of satellite SAR images of the same target area."	"different approaches, relying on the processing of multi-temporal stacks of satellite SAR images of the same target area, have been developed."
206	Here a brief description of multi-temporal InSAR approaches should be given, mentioning the PS, Small Baseline, and mixed approaches. Only then the authors can detail the PS technique.	
208	"contribution"	"contributions"
209	"trough"	"through"
210	Delete "So,"	
211	"reflecting elements"	"elementary reflectors"
212	Here the authors should describe (without going into detail) the method used for filtering the turbulent atmosphere and the amount and possible patterns of the remaining error sources in the PS velocity maps (orbital residuals, topography-correlated atmosphere, unwrapping), since they might affect their results.	
215	"phase coherent"	"with temporally coherent phase"
215	"Sigh"	"Sight"
216	"with accuracy even better"	"with an accuracy theoretically better"
216	"Unlike DInSAR"	"Unlike the DInSAR"
217	"analyses"	"analysis"
219	"on"	"of the"
222	Delete "respectively"	
223-226	Move this part at the beginning of this section	
231	"may"	"could"
236	"challenging priority"	"main priorities"
236	Delete "concerning EO data and technology,"	
238	"includes"	"consists in"
240	Delete "Used"	
241	Delete "Bearing these objectives in mind,"	
241	"in framework"	"In the framework"
241	Describe the scope of Terrafirma and cite the website	
244-251	Present and past tenses are mixed, rewrite. Tracks have only one number (7_3 ?). ERS had only one acquisition mode (stripmap?).	
258	Delete "(fluctuation of the ground water level)"	
262	Please explain in more detail which is the advantage of the centrally located reference	

	date.	
265	Delete "wide area processing"	
276	"located."	"assessed"
287	Delete "enough"	
299-301	The graph in fig. 5 is much more useful to verify that elevation and def. rates are not correlated than to show where the subsidence is (this is visible in the maps). Please rewrite.	
306	"increasing deformation rates"	"increasing subsidence rates"
309	Delete" results and discussions"	
310	Delete "High PS points density over the urban fabric (Fig.6) reveals that"	
315	Delete "Nevertheless,"	
317-321 and elsewhere in the paper	Put the appropriate signs on deformation rates. Subsidence is negative !	
327	"at the hydrogeological setting paragraph"	"previously"
335	"outfall"	"outlet"
355	Delete "point-wise"	
359	"to less-density areas"	"to areas with lower PS density"
360	"To result a spatially continuous surface,"	"The"
360-362	This is unclear, please rewrite "To result a spatially continuous surface, IDW method uses a weighted average of the available known points, taking into higher account given values at nearby locations."	
364	"radar sensors mounted on satellite platforms,"	"satellite radar instruments, the"
366	Delete VLOS	
369 & 370	VLOS	LOS
377	Delete "the manifestation of"	
380	Delete "constituting the site"	
385	"it's other."	"each other"
408	"takes place for"	"took place over"
426	"intensiveness"	"intensity"
431	"water terrain"	"terrain"
440	"at the geological background paragraph"	"before"
446-447	This statement: " are mainly observed at the intersections of the main fault with the three E-W oriented active faults." is not true. Only one of the intersections shows a negative peak, the other two look like noise, and two other peaks to the right do not show any crossing fault.	
449-451	This statement is not supported by the data. Why should the subsidence not be due to sediment compaction driven by the fault plane? 5-10 mm/yr of differential deformation rates along a fault plane means near surface fault creeping, which has never been observed along	

	<p>normal faults in Greece or elsewhere.</p> <p>Moreover, from figure 13 it is clear that the high subsidence rates cross the fault trace (which excludes surface creeping), but are confined to few km on both sides of the fault (which excludes deep creep below the brittle layer).</p> <p>Finally, if near surface creeping would occur, there should be some microseismicity at some depth along the fault.</p> <p>Unless other evidences support this interpretation, I would not consider it reasonable.</p>	
455-458	See above	
473	"proved"	"confirms"
512-513	<p>Do not use commas for decimal points.</p> <p>How did you calculate these numbers? Cite or explain.</p>	
521-529	<p>These statements may hold true, but are not supported by the findings of this work, see above.</p>	
536-537	<p>In this work the advantages of WAP have not been exploited, since the area is rather small.</p> <p>This is merely an application of a PSI algorithm, and the reader cannot understand, by this test case, the utility of the WAP technique. Please rewrite.</p>	
543-544	See above comments	

Corrections for the Figures and legends

Figure 1 legend should include explanation of fault codes (F-Th, ...)

Figure 6-7-9-13 Correct Janury in January. Indicate the LoS direction with an arrow.

Figure 7 Indicate the actual PS values projected on the curves in the upper part, the reader needs to appreciate the effects of interpolation on gradient calculations