Application of PSI technique to slope stability monitoring in the Daunia mountains, Italy

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Two main problems arise:

- the objective scarcity of PS targets
- the difficulty of detecting the existing PS.

Application of Multitemporal InSAR on scarcely urbanised areas affected by landslides typically showing:

- Strong topographic variations
- Complex backscattering characteristics of the surface
- Variable atmospheric conditions
- Deformations are slope-specific and typically of limited spatial extent
SPINUA Processing Chain

- SAR data
- Ancillary data (orbits, Doppler...)
- AOI cropping
- Best Path Selection
- Coregistration
- Resampling
- Differential Interferogram Generation
- Differential Phase Stack
- Amplitude Equalization
- Amplitude Stability Map Evaluation
- Atmospheric Phase Filtering
- DEM Error & Movement Estimation
- DEM corrected at PS
- PS Map (SAR Coord.)
- PS Map (WGS84)
- Time series of LOS heights
- APS Maps
- Multi-image SAR reflectivity Map
- Geocoding
Stepwise approach for co-registration of multi-temporal data-sets: improves the precision of the pre-processing steps and consequently also the PS detection.

\[ D(i, j) = 1 - \Xi(i, j) = 1 - \max[\tilde{\Xi}_g, \tilde{\Xi}_s, \tilde{\Xi}_d, c] \]
Patch-wise processing: it consists in processing small areas confined around the site under investigation. SPINUA provides less accurate (fewer parameters to be estimated) but more robust algorithms that can overcome the scarcity of PS.
Urban Classification Based PSC Selection: an external classification procedure was employed to select the initial fiducial pixels used to start the subsequent iterative phase processing. It provides also a tool for a preliminary (low cost) evaluation of PSI applicability.
The sites are located in south-central Italy in unfavourable settings: Vegetated slopes, Limited size, Hilly / Mountainous areas, Clayey materials.
Area of 28 x 27 km² with several isolated small hill-top towns located in an hilly region characterised by the widespread presence of vegetation cover (mainly agricultural land and forests).
A dataset of both descending (84) and ascending (51) ERS-1/2 acquisitions was processed, for monitoring slopes with different facing directions.

Differential interferograms were obtained by using an external SRTM DEM.

The SPINUA patch-wise approach was adopted: the analysis was limited to 10 small image windows which enclose urban areas.

The value of $\gamma_{\text{temp}}$ which guarantees an acceptable $P_{\text{FD}}$ was evaluated by simulations given:

- the configuration of spatial and temporal baselines,
- the average PS density
- allowed 1 false detection every 100 PS $\rightarrow P_{\text{FD}} = 1/100 \times 10^4 = 10^{-5}$

$\gamma_{\text{temp}} = 0.8$ was selected as suitable for PS identification.
PS density resulted suitable for 8 out of the 10 investigated town areas. 2 towns show a very few PSC / PS making unreliable (−) the displacement measurement.

PS in ascending and descending data show complementary spatial distributions with densities always predominant in one of the two sets:

- Variable local facing direction (variable impact of geometrical deformations)?
- Different dominant orientations of the scattering structures?
The majority of detected PS are stable and lay on the historical centres of the towns.

The moving points are grouped in clusters showing the same average displacement and located along the borders of the towns.

Displacements related to landslide events occur mainly in the periphery of the towns where:
- the urban expansion occurred on steeper slopes in recent years
- the man-made structures (potential PS) are located close to the potential unstable slopes.

The only exception is the town of Pietramontecorvino where presence of instability problems affecting many buildings within the urban centre has been known for many years.

We focus here on the town of Volturino where previous knowledge has already been acquired in the framework of the LEWIS project.
|V| < 2mm/y

V ≤ -3mm/y

Landslide prone area

Point: (Row,Col)=(114,288) , (Lat,Long)=(41.4762 , 15.1214)

|V|_{lat} = 0.88 , Vel = -4 [mm/yr]
Concluding Remarks

- PSI approach was applied to slope instability monitoring in a hilly region including several isolated small hill-top towns.

- The vegetation cover and the scarcity of man-made structures hinder the application of large area approach while encouraging results were provided through ad hoc solutions adopted by SPINUA.

- In several cases the PS show clear evidence of moving objects located on urban and peri-urban areas.

- However some remarks are in order:

  - In geologically and topographically complex settings good local knowledge of the investigated area appears essential while attempting to interpret the exact significance of PS motion data.

  - In the absence of ground monitoring data and detailed records of landslide movements, it is not possible to identify the main mechanism of the detected deformations (subsidence, settlement of engineering structures, shrink and swell of some geological materials, structural deformation of buildings).
Future Activities & Acknowledges

- Refine the PSC selection where processing was unreliable
- More investigations on the scattering mechanism

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Thank you!