BEACH & DUNES VOLUME CHANGES WITH VHR SAR DATA

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Research theme aims

This research activity is focused on the exploitation of imaging radar systems for the detection and monitoring of changes interesting the volumes of beach and dunes in the coastal area south of Oristano (Sardinia). The activity has been oriented to the evaluation of the real applicability of satellite remote sensing techniques with data acquired by the COSMO-SkyMed in the standard mode (spatial resolution of 3 m), by means of classical multi-temporal interferometric analysis. The choice of performing this analysis will allow also carrying out further investigations of the variation over the time of the interferometric coherence.

Materials and Methods

The research activity concerning the beach and dunes volume changes was carried out in the test site of Piscinas, in correspondence of the most important Italian dune system. The analysis is concentrated on the use of the multitemporal amplitude and phase response, which allows characterizing the coherence properties as well as the presence or absence of deformation. More specifically, the activity on the investigation of the use of Tandem pairs has been extended to the application of multitemporal interferometric coherence analysis to identifying areas exhibiting conditions of stable electromagnetic response, i.e. under less influence of environmental factors (above all, the effects of strong and persistent wind) or of the effects of human activities, although of small entity. A stack of 62 COSMO-SkyMed images acquired in 3 years from 16/06/2015 to 24/06/2018 has been collected. The choice of the dataset, depending on the area orientation (toward W-NW for the case study), has been made to avoid possible resolution/coherence losses associated with the foreshortening. In particular, we focused on the area from the coastal zone of the Gulf of Oristano to the dune system of Piscinas. Data have been processed with a two-step interferometric processing chain implemented at small (low) and large (high) scale (resolution) [1]. A low resolution analysis has been firstly carried out by selecting a constraint on the interferometric network generation corresponding to a maximum spatial baseline of 750 m and a maximum temporal separation of 120 days. This step allows retrieving the small scale (low resolution) deformation pattern, as well as the atmospheric phase propagation delay (APD) that acts as a spatially correlated noise disturbance. The low resolution processing, has been carried out via a Small Baseline Subset (SBAS) DInSAR processing algorithm [2] with a multilook factor leading to pixels of 60x60 m^2. The high resolution analysis, carried out after the APD removal aimed at calibrating the multitemporal phase signal, is based on a tomographic method exploiting the amplitude and phase information. In particular, to account for the scattering characteristics of the analysed area, the CAESAR (Component extrAction and selEction SAR) method has been considered [3,4].

Results and Discussion

The deformation analysis is considered at this stage because it provides the information about the localization of areas that shows stable characteristics over the time and that are therefore less affected by the erosion factors (particularly the action of the wind). The deformation analysis indicates that the entire coastal area in the south of Oristano is not affected by any significant deformation phenomena in the considered temporal interval. Specifically, both deformation maps (high and low resolution) provide a clear evidence of the areas that are not affected by significant changes in the scattering properties over the observation period (Fig.1).

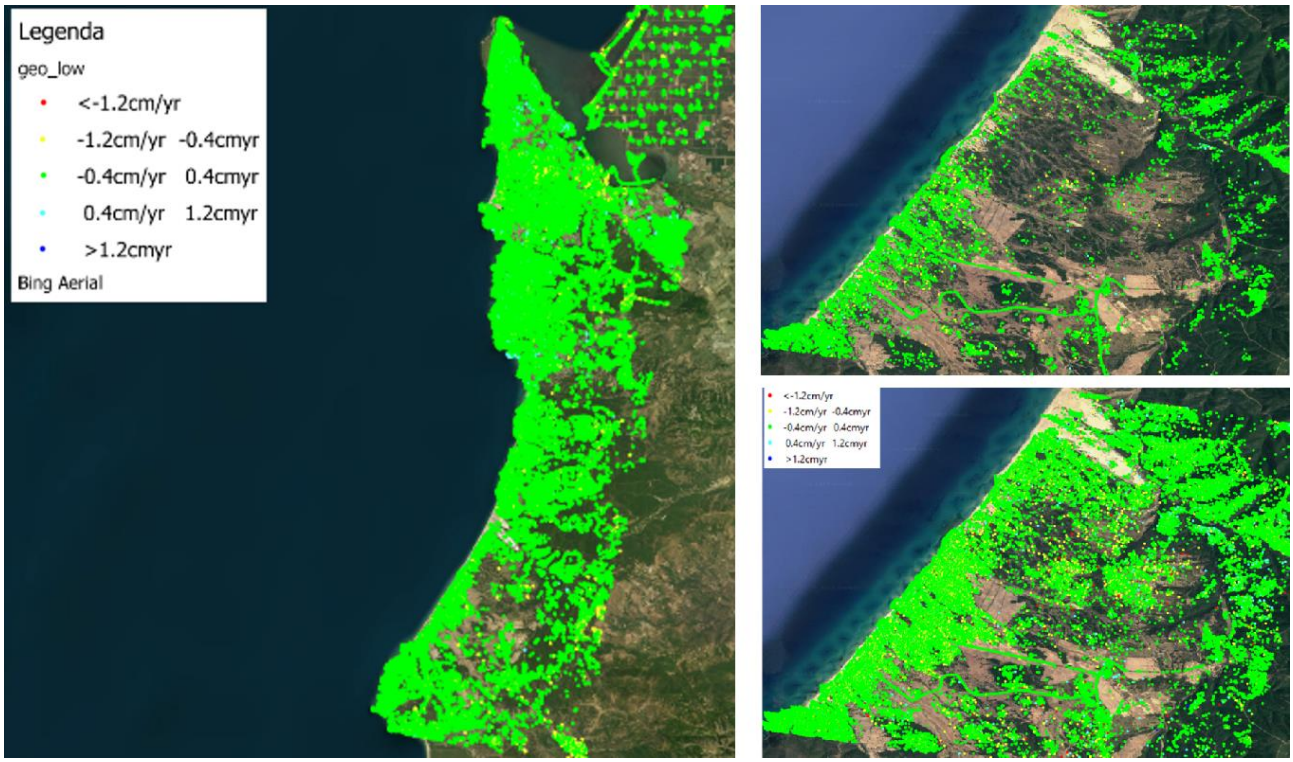

Figure 1: On the left the low resolution deformation map showing the mean deformation velocity of the entire study area. On the right the full resolution analysis of the Piscinas area: the top image shows the results at the highest resolution; the bottom image shows the results obtained by 3x3 multilook with the CAESAR method

In figure 2 it is shown the map of the scattering coherency indicating the temporal stability of the complex (amplitude and phase) response of the scatterer, more specifically the temporal correlation coefficient corresponding to the testing statistic of used for the detection of persistent scatterers [5]. The coherence map shows the presence of an area in the northernmost part of the coast, developing along a torrent bed like path aligned along the NW-SE direction, characterized by low level of coherence. The coherence on the coastal area is generally higher than in the inner regions. Moreover, the coherence in the southern part of the coast reaches values generally higher with respect to the northern part. The measurements seem to provide indications about an overall stability of the coastal area.

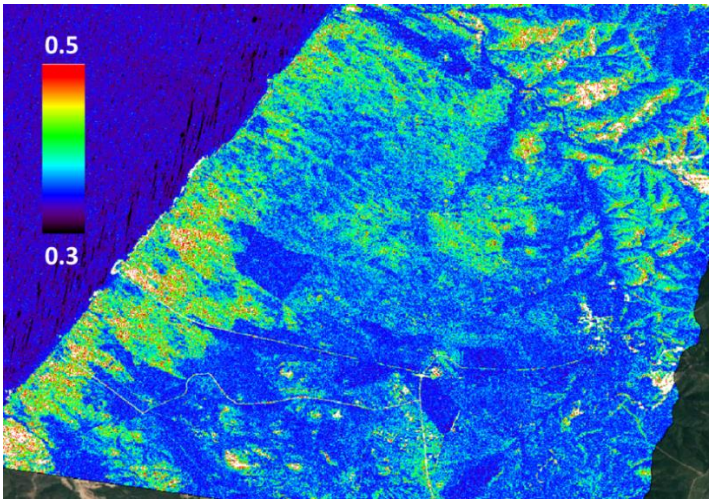

Figure 2: Temporal correlation coefficient used for the detection of the persistent scatterers

In order to further analyse the behaviour of the coherence on the multitemporal stack in figure 2, the coherence observed on all the possible interferometric pairings, has been modelled as a triangular function with respect to the (spatial) baseline shaped by the critical baseline and, with respect to the time, as an

exponentially decreasing function shaped by a temporal decorrelation constant [6,7]. This model shows that the temporal variations, not shown here, explain most of the spatial variability over the scene of the overall coherence reported in figure 2.

Future perspectives

The analysis reported in this research activity can be complemented by investigations carried out on the characterization of the multitemporal amplitude response of the scene. A simple analysis involving the first and second order statistics of the intensity can alone provide interesting information about the observed scene. Comparing a map provided by Corine Land cover [8] with a map showing the ratio between the squared mean intensity value and the intensity variance, it is interesting to note that a simple indicator derived by the analysis of the multitemporal radar response provide a rather accurate spatial mapping of the lines of land cover variation (Fig.3). This comparison provides evidence of the potential applicability of this index to infer the temporal variability of the ground scattering associated with the changes occurring on the scene in areas with different land cover.

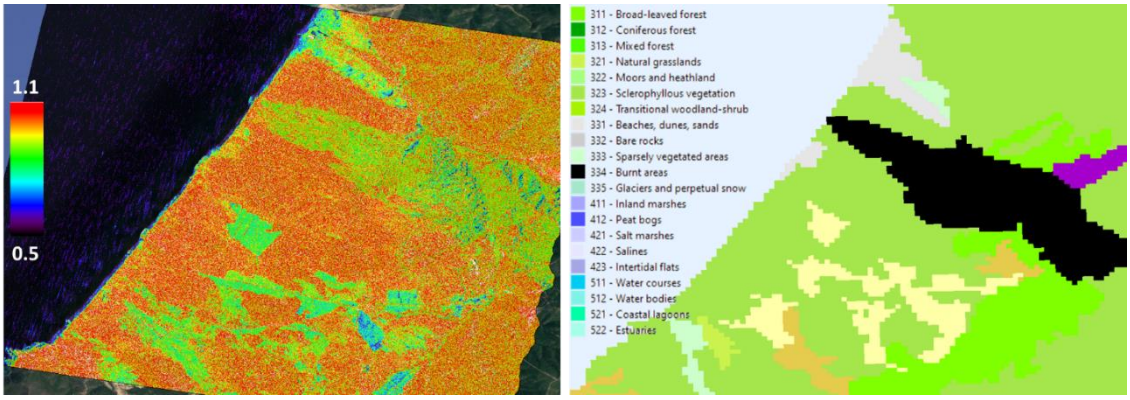

***Figure 3**:* Results of the intensity analysis. Left image: ratio between the squared average intensity and the variance of the intensity; Right image: Corine land cover 2018.

Publications and Presentations

- N. Ghirardi, M.Bresciani, G. Luciani, G. Fornaro, V. Zamparelli, F. De Santi, G. De Carolis, C. Giardino, "Mapping of the risk of coastal erosion for two case studies: Pianosa island (Tuscany) and Piscinas (Sardinia)" In book Eighth International Symposium "Monitoring of Mediterranean Coastal Areas. Problems and Measurement Techniques", Vol.126, pag. 713-722, Editore Firenze, 2020.
- M. Bresciani, N. Ghirardi, G. Fornaro, V. Zamparelli, F. De Santi, G. De Carolis, D. Tapete, M. Palandri, C. Giardino, "Mapping Of The Risk Of Coastal Erosion For The Case Study Of Piscinas (Sardinia)", In Proc. IGARSS 2021

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