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Monitoring land subsidence within the Venice Lagoon with SAR interferometry on trihedral corner reflectors

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The Venice lagoon in Italy is a unique worldwide environment vulnerable to loss in surface elevation because of land subsidence and sea level rise [1,2]. Land displacement in the Venice coastland has been determined over time by spirit leveling and GPS. Recently, SAR interferometry has been used to complement the ground-based methods [3]. In particular, interferometric analysis on persistent point targets has been proved to be very effective in detecting land displacement in this coastal environment [4,5]. ERS and ENVISAT SAR images of the time periods 1992-2005 and 2003-2007, respectively, have been analyzed at regional and local scale. At regional scale, the central lagoon, including the city of Venice, shows a general stability, while the northern and southern lagoon extremities and their related catchment sectors sink with rates averaging 3 to 10 mm/year. The observed land displacements have been associated to the geological features of the study region and to anthropogenic activities, such as land reclamation and groundwater withdrawal [4]. A detailed analysis of the SAR-based time series shows that the vertical component of the measured displacements are the superposition of a short timescale, generally seasonal, movement on the order of 1 cm that is likely related to the fluctuation of environmental variables (temperature, piezometric head in the aquifer system underlying the lagoon, sea/lagoon water level) and a long-term ground deformation associated with building construction, the geomorphology of the area, and the human development of natural resources [5].

Because in the inner lagoon anthropogenic structures completely lack or few constructions are scattered at a distance from one to each other too large to resolve the radar phase ambiguity, 58 square trihedral corner reflectors (TCR) were installed before the summer 2007. An optimal TCR network has been planned taking into account the location of "natural" point targets in ERS and ENVISAT SAR interferometric analyses and keeping to a value of about 1 km the maximum distance between them or between an “artificial” and the adjacent “natural” reflector. The TCR are characterized by 60 cm long edge, made of aluminium to reduce their weight and installed with foundations ranging different depths and at the same height above ground in order to study possible differences in their relative settlement. Although primary set up to be used with ENVISAT IS2 acquitions from a descending orbit, the TCR are also well visible in TerraSAR-X stripmap images, which were regularly acquired every 11 days since March 5, 2008 on descending orbits with an incidence angle of ~30º.

The normalized backscattering intensities extracted for ENVISAT ASAR and TerraSAR-X acquisitions as a function of range and azimuth show signal-to-clutter ratios better than 10 and 20 dB, respectively, for TCRs installed on regions lacking of strong natural scatterers. The backscettering intensity of the TCRs is remarkably stable for the TerraSAR-X acquisitions and noisier for the ENVISAT ASAR scenes. The relative phase difference of pairs of TCRs was computed in several cases and in a few examples a clear subsidence trend was observed. In our contribution we will discuss the set-up of the TCRs, their backscattering intensity response on ENVISAT ASAR and TerraSAR-X images and the approach we follow to employ the TCRs for the detection of displacement information in areas of particular interest within the Venice lagoon.

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