

EGU2020-6652

<https://doi.org/10.5194/egusphere-egu2020-6652>

EGU General Assembly 2020

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## DInSAR analysis for geohazard assessment at the Roman city of Carsulae (Central Italy)

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The Roman city of Carsulae was founded in a strategic position along the Via Flaminia and it reached the maximum expansion during Roman Empire age, as attested by the presence of important monuments: *Forum*, *Basilica*, temples, theater, amphitheater, *Thermae*, arches. The settlement is located on a travertine plateau that overlay recent marine clay, both Lower Pleistocene aged, at the foothill of Monti Martani Mesozoic carbonatic range. The site is characterized by karst morphologies due to the dissolution of travertine because of the large amount of groundwater. Historical sources attributed the progressive decline and abandoning of Carsulae, during the 4<sup>th</sup> century AD, to the construction of a new branch of the Via Flaminia as well as to karst phenomena and to earthquakes.

A DInSAR analysis has been conducted in the Carsulae Archaeological Park using free input SAR data from Sentinel-1 to run the SBAS technique. This good combination of wavelength band, data resolution and revisit time optimizes the results in rural areas. To obtain meaningful data particular attention was paid to the selection of the Ground Reference Area as a geologically stable site. The resulting map of ground displacements during the period August 2018 – July 2019, analyzing both Ascendent and Descendent datasets, highlights a general small movement downward and westward, by 5-10 mm during the fall period (November 2018 – January 2019), followed by a substantially stable period until the end of the analysis. A field survey has been carried out on the archaeological remains to validate EO analysis, highlighting the absence of important damages, according with the overall ground stability of the site. Although some useful results were obtained, it is worth noting that the lack of coherence due to the rare natural or manmade reflectors and the availability of images limited to last year did not allow the complete exploitation of the technique.

The availability from Copernicus Programme of open data, frequently acquired and of good resolution allows EO monitoring to support traditional in situ monitoring (topographic surveys, inclinometer, extensometer, crack gauge, etc.). SBAS technique applied on Sentinel-1 data allows the detection of millimetric vertical ground displacements every 2 weeks, by a spatial resolution of about 10 meters. Moreover, this remote sensing survey covers at a same time a wide area without

the installation and the maintenance on the walls of reflecting devices that could limit the function or the fruition of monuments. Finally, the automation of DInSAR analysis enables the site managers to monitor natural threats through an efficient and sustainable system, selecting proper alert and mitigation measures when critical displacements are reached.