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Sar polarimetric application for archaeology a multi-frequency Alos Palsar and Radarsat-2 analysis over the Unesco site of Gebel Barkal (Sudan)

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On the basis of increasing exploitation of new non-invasive techniques applied to the archaeological investigation, the aim of this work is to analyse potentials of SAR Polarimetry by means of RADARSAT-2 satellite (with a central frequency of 5.405 GHz) and ALOS PALSAR sensors (with a central frequency of 1.270 GHz) for the identification of surface and subsurface archaeological features in the archaeological area of Gebel Barkal, Sudan.

The choice to analyse satellite radar sensors capabilities is based on their 24-hour observations, as they are independent from Sun illumination and meteorological conditions. Moreover, the choice of SAR polarimetric sensors is due to their capability of providing additional information concerning electromagnetic properties of the target, qualities not derivable from optical images.

Gebel Barkal site, inscribed in the UNESCO World Heritage List since 2003, constitutes one of five sites belonging to the Napatan and Meroitic periods, stretching over more than 60 km in the Nile valley, in an arid area considered part of Nubia (Northern State, province of Meroe, Sudan). It is located between the west cultivable bank of the Nile river and the east sand-stone desert of Sudan. Archaeological excavations at Djebel Barkal have not reached yet the earliest strata. Its palaces, temples and pyramids, the last ones constituting the Royal cemetery of the necropolis, are of special interest because of their dimensions, appreciable from satellite.

The selected dataset was composed of two archived ALOS PALSAR polarimetric images and four RADARSAT-2 polarimetric data specifically acquired (2012-2013) with a compatible incidence angle configuration with ALOS PALSAR data. All the products have been then processed and integrated with the available optical data and the cartographic documentation. A multitemporal analysis was also performed thanks to the notable difference in time acquisition (six years) between ALOS PALSAR and RADARSAT-2 data, and a ground truth in situ was carried out as validation of the noticed anomalies.
The great potential of the two polarimetric instruments with different frequency for the detection of archaeological remains has been demonstrated thanks to the sand penetration capability of both C-band and L-band sensors.

The possibility of monitoring and observing ancient sites by means of remotely acquired SAR data could be an added value to the archaeological research, not only where detected anomalies can address archaeological excavations or ground truth verification, but mostly for those areas in which instable political situations do not allow surveys in situ.