Multi frequency polarimetric SAR sensors analysis

The archaeological UNESCO site of Djebel Barkal (Sudan)

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A non-invasive technique

Archaeology

Remote Sensing

SAR sensors

Polarimetry

HH + HV + VH + VV
The idea behind

STRUCTURES INTERACTION WITH SOIL

VEGETATION MARKS
Grass, weed, crop, marks

Underground structures affect regular growth of vegetation roots
The idea behind

STRUCTURES INTERACTION WITH SOIL

MOISTURE MARKS
Damp-marks

Soil moisture content underlines underground structures (different ground colours)
Goal of the research

- ALOS PALSAR L-band (1.27 GHz)
- RADARSAT-2 C-band (5.405 GHz)
- Polarimetric multi-frequency analysis

Detection of surface and subsurface archaeological structures
Study area: Gebel Barkal, Sudan
One of the five Napatan (900-270 BC) Meroitic (270 BC-350 AD) archaeological sites stretching over more than 60 km in the Nile valley, in an arid area part of Nubia, Sudan
Data set presentation

**ALOS PALSAR**
14th August 2006
5th November 2009

**INCIDENCE ANGLE**
26.20°
23°

**RADARSAT - 2**
28th April 2012
6th November 2012

27.06°

**KOMPSAT - 2**
16th May 2008

Semi desert area on the west bank of the Nile river

Continental climate with rare precipitations

Absence of rain phenomena in the days of the acquisitions

40°C

20°C
UNESCO World Heritage List since 2003
Part of the site still unexcavated

Aerial photograph (1950)

Treath Intensity Coefficient (2009 until today)

Archaeological map (1995)
Archaeological evidences

I Group of Royal Pyramids, Tombs

II Group of Royal Pyramids, Central Necropolis

Temple and Palaces Remains

KOMPSAT-2
16th May 2008
Qualitative analysis

ALOS PALSAR → KOMPSAT-2

L-BAND PENETRATION IN THE SAND

TARGET PERSISTENCE OVER YEARS
ALOS PALSAR analysis

[T3] elements

H/a/Alpha Decomposition

Elliptical Basis Change

Polarimetric functionalities

Polarimetric Decomposition

Prevalence Single bounce scattering mechanism

18 32 15 N 31 49 13 E WGS 84

Freeman_Odd

Freeman_Dbl

Freeman_Vol
Qualitative analysis

RADARSAT-2 → KOMPSAT-2

C-BAND FAVOURABLE INCIDENCE ANGLE

TARGET PERSISTENCE OVER SEASON
RADARSAT-2 analysis

- [T3] elements
- WGS 84

18 32 15 N 31 49 13 E WGS 84

- H/a/Alpha Decomposition
- Elliptical Basis Change
- Polarimetric functionalities
- Polarimetric Decomposition
RADARSAT-2 analysis

Yamaguchi 4 Components Decomposition

Target identification

Prevalence
Single bounce
scattering
mechanism

Yamaguchi4_G4UI_Odd

Yamaguchi4_G4UI_Db1

Yamaguchi4_G4UI_Vol

18 32 15 N  31 49 13 E
UTM WGS 84

* MODEL BASED - 4 COMPONENTS DECOMPOSITION Y. Yamaguchi et al. (2005 - 2013)
Persistence of the target (2006 -2012)

Lower frequency L-Band (deep penetration)

Low observation incidence angle (26°)

Higher frequency C-Band (lower penetration)
Summary

Scientific potential of radar applications for archaeology

Usefulness of radar remote sensing for areas lacking in optical remotely acquired data (both aerial and satellite)

Impossibility of ground truth or survey in situ (instable political conditions)

Possibility to detect underground targets
Meeting with Prof. Sist, Member of Gebel Barkal Archaeological Mission, Sapienza University of Rome

Analysis of the new RADARSAT-2 data (January 2013)

Time-series analysis: different seasons (RADARSAT-2) and different years (ALOS PALSAR)

Deepen the analysis of polarimetric descriptors, over the detected anomalies and the surroundings
Thank you for your attention