→ POLINSAR 2013
The 6th International Workshop on Science and Applications of SAR Polarimetry and Polarimetric Interferometry

Multi frequency polarimetric SAR sensors analysis

The archaeological UNESCO site of Djebel Barkal (Sudan)

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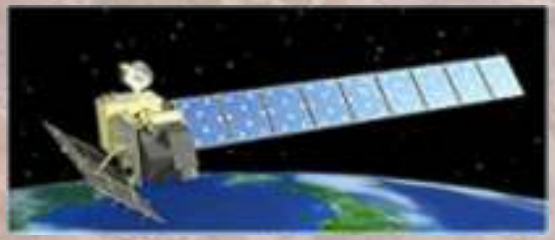
European Space Agency

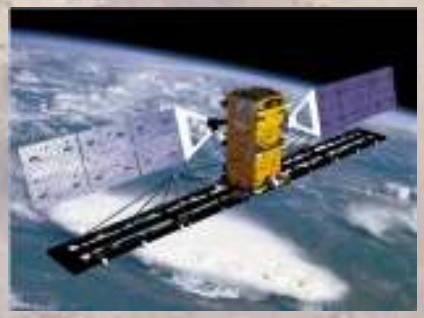
A non-invasive technique

Archaeology

Remote Sensing

SAR sensors





Polarimetry

HH + HV +VH +VV

The idea behind

STRUCTURES INTERACTION WITH SOIL

VEGETATION MARKS

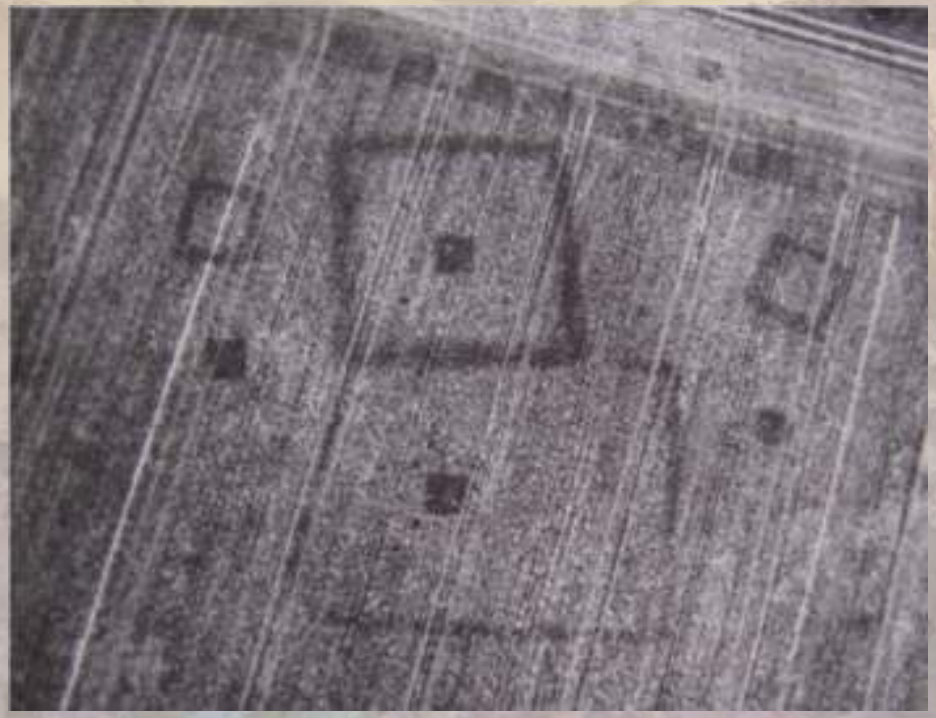
Grass, weed, crop, marks

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

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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

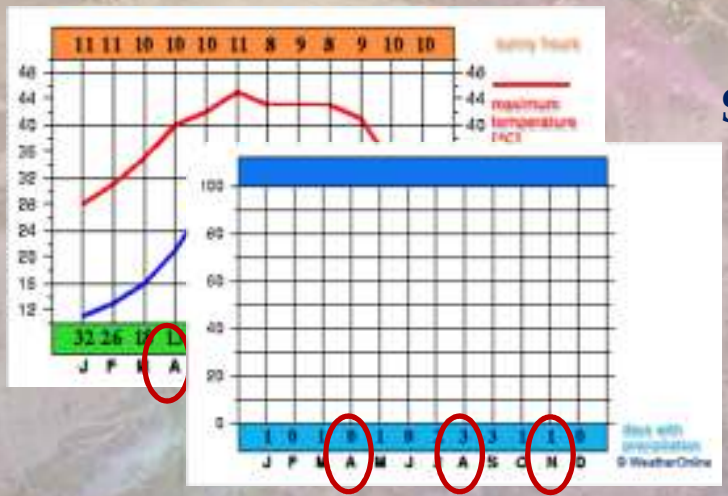
ALOS PALSAR	INCIDENCE ANGLE
14th August 2006	26.20°
5th November 2009	23°
RADARSAT - 2	
28th April 2012	27.06°
6th November 2012	

KOMPSAT - 2

16th May 2008

40° C

20° C



Semi desert area on the west bank of the Nile river

Continental climate with rare precipitations

Absebce of rain phenomena in the days of the acquisitions

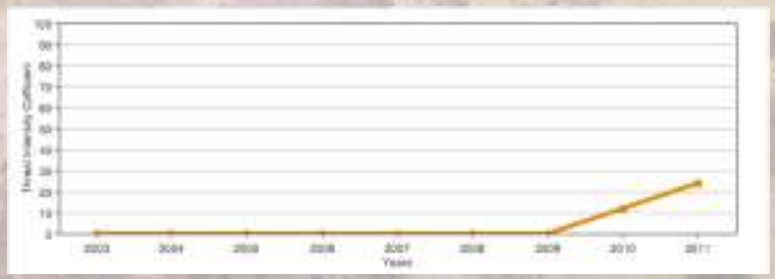
Cartographic documentation

UNESCO World Heritage List since 2003

Part of the site still unexcavated

United Nations Educational, Scientific and Cultural Organization

Aerial photograph (1950)



Treath Intensity Coefficient (2009 until today)

Archaeological map (1995)

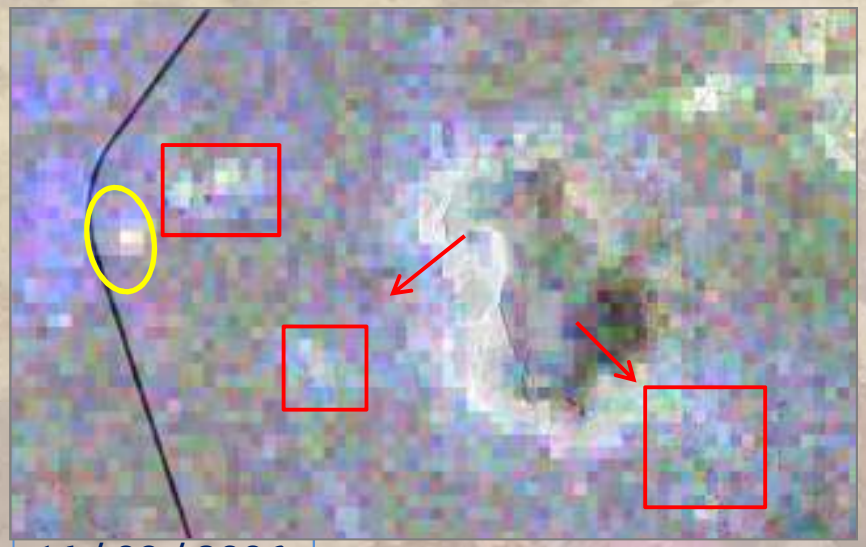
Archaeological evidences

KOMPSAT-2
16th May 2008

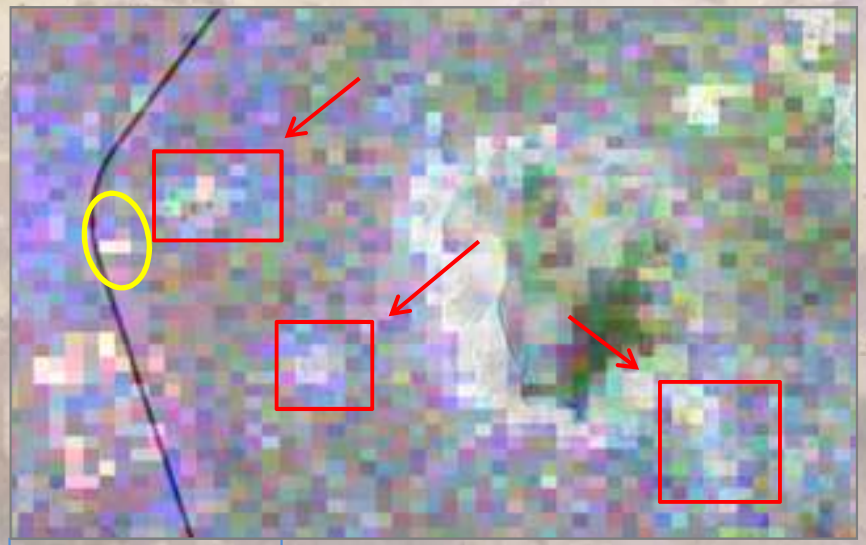
- ✓ I Group of Royal Pyramids, Tombs
- ✓ II Group of Royal Pyramids, Central Necropolis
- ✓ Temples and Palaces Remains

Qualitative analysis

ALOS PALSAR → *KOMPSAT-2*



14 / 08 / 2006



5 / 11 / 2009

L-BAND PENETRATION IN THE SAND

TARGET PERSISTENCE OVER YEARS

ALOS PALSAR analysis

[T3] elements

H/a/Alpha Decomposition

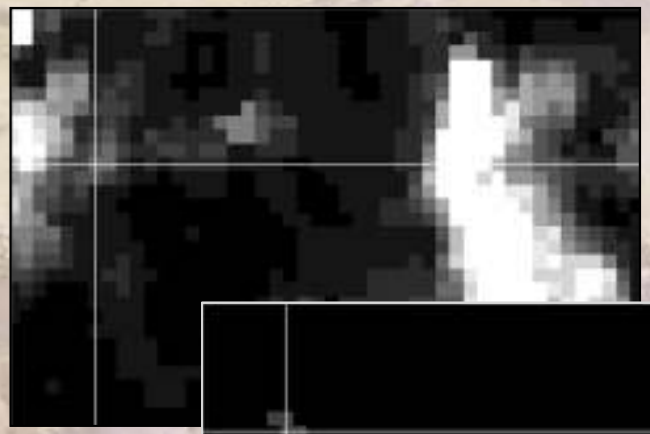
Elliptical Basis Change

Polarimetric functionalities

Polarimetric Decomposition

18 32 15 N
31 49 13 E
WGS 84

Prevalence Single bounce scattering mechanism



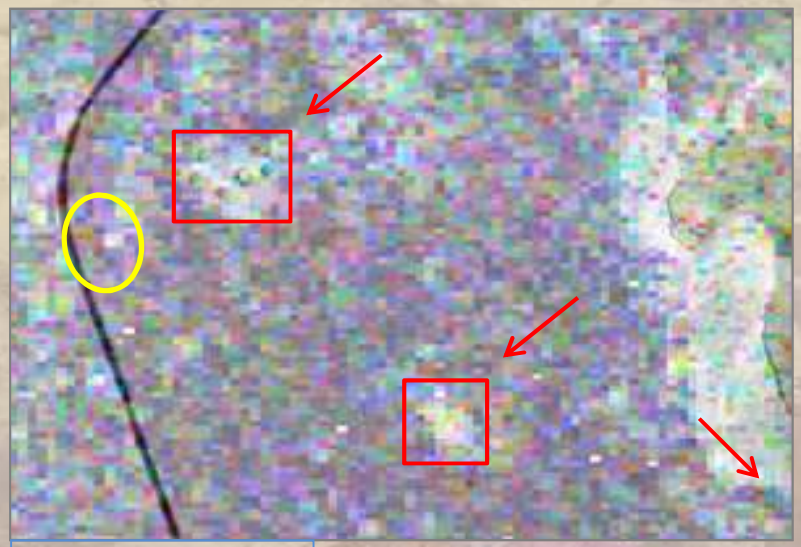
Freeman_Odd

Freeman_Dbl

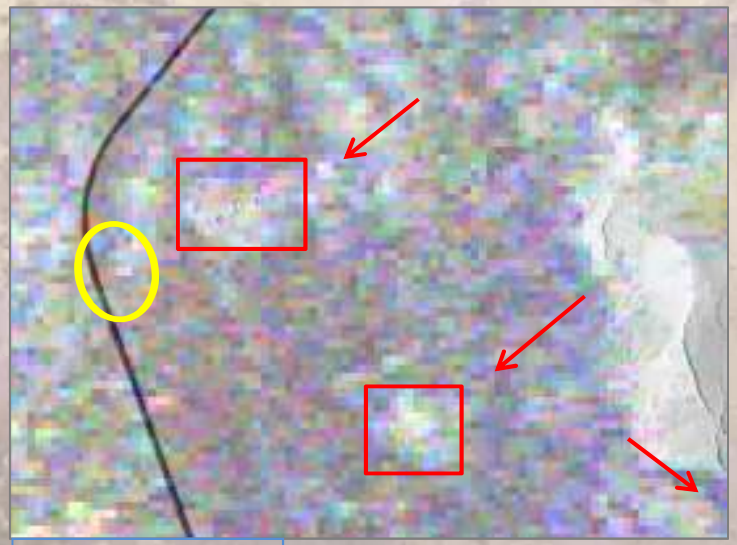
Freeman_Vol

Qualitative analysis

RADARSAT-2 → *KOMPSAT-2*



28 / 04 / 2012



6 / 11/ 2012

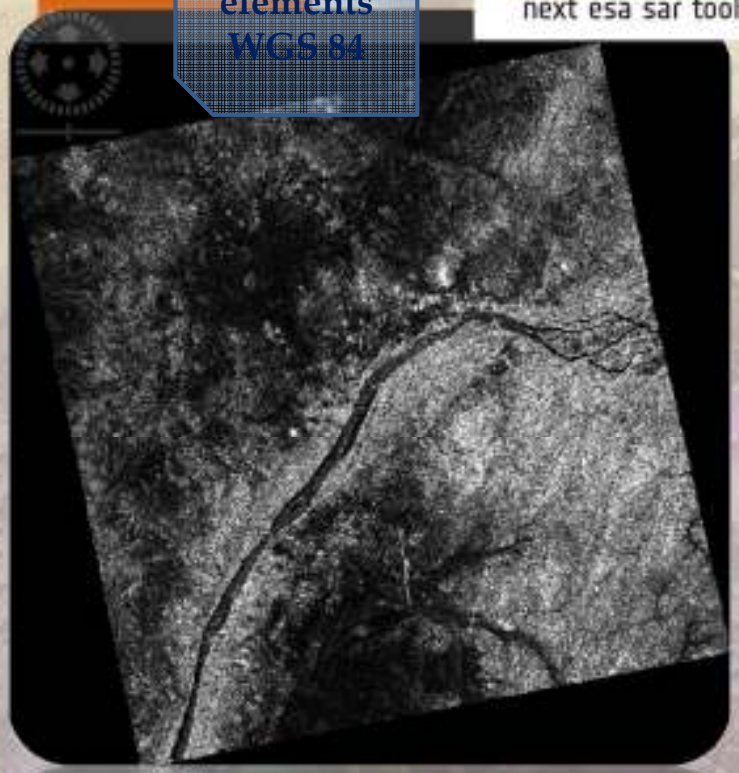
C-BAND FAVOURABLE INCIDENCE ANGLE

TARGET PERSISTENCE OVER SEASON

RADARSAT-2 analysis

[T3] elements WGS 84

nest
next esa sar toolbox



18 32 15 N 31 49 13 E
WGS 84

H/a/Alpha Decomposition

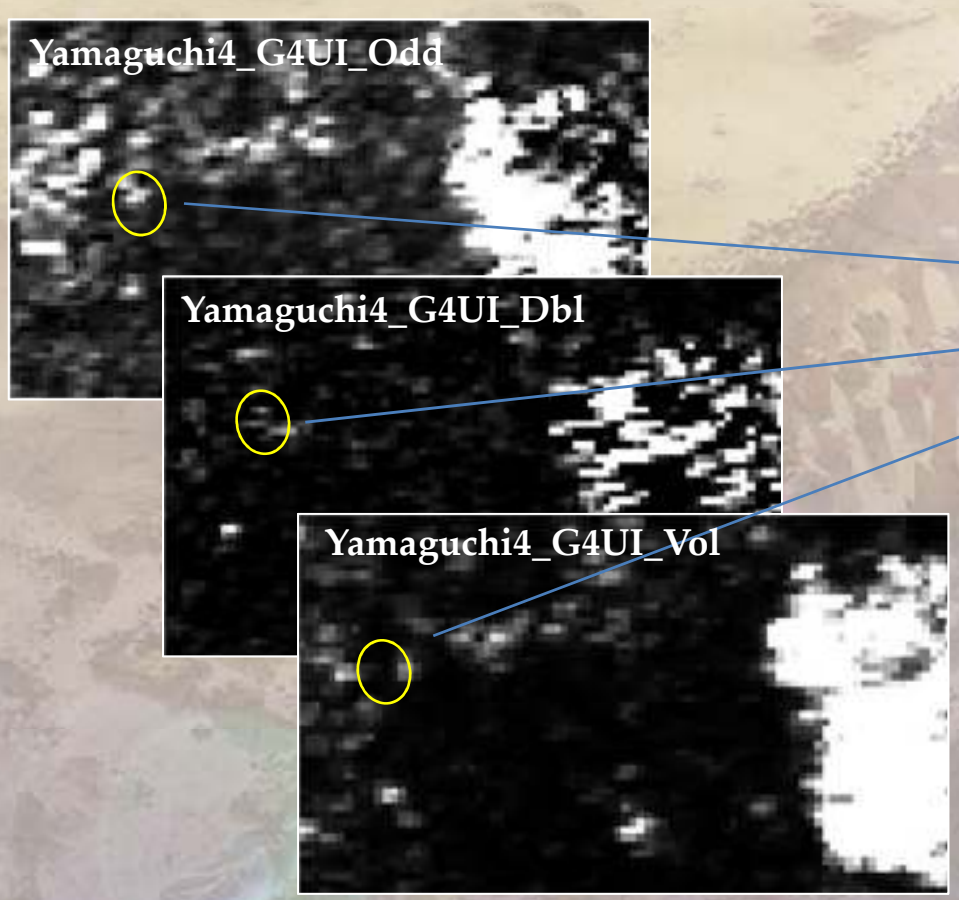
Elliptical Basis Change

Polarimetric functionalities

Polarimetric Decomposition

RADARSAT-2 analysis

Yamaguchi 4 Components Decomposition*



Target identification

18 32 15 N 31 49 13 E
UTM WGS 84

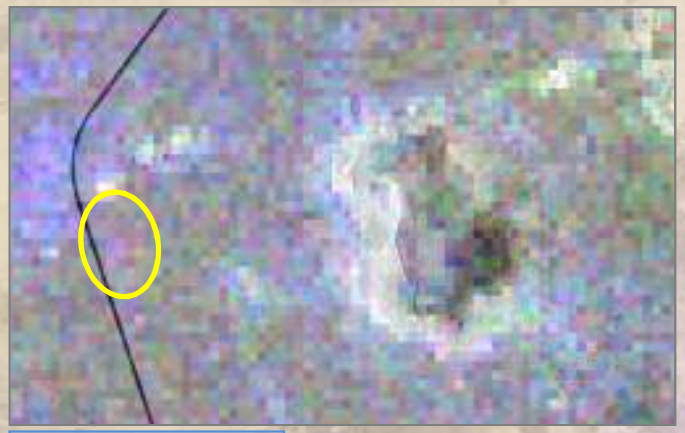
Prevalence
Single bounce
scattering
mechanism

* MODEL BASED - 4 COMPONENTS DECOMPOSITION Y. Yamaguchi et al. (2005 - 2013)

Summary

ALOS PALSAR

26° inc. a



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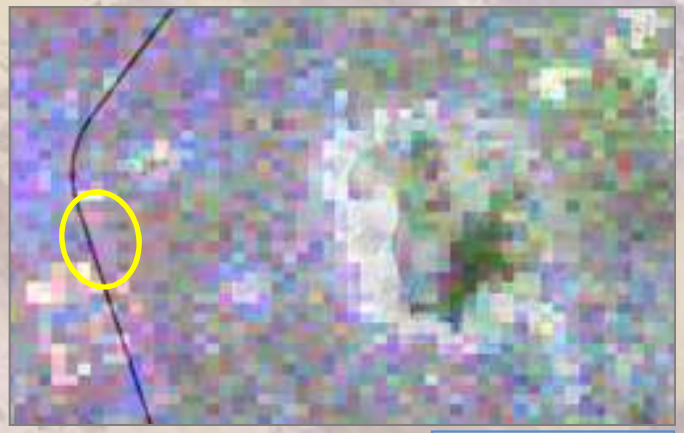
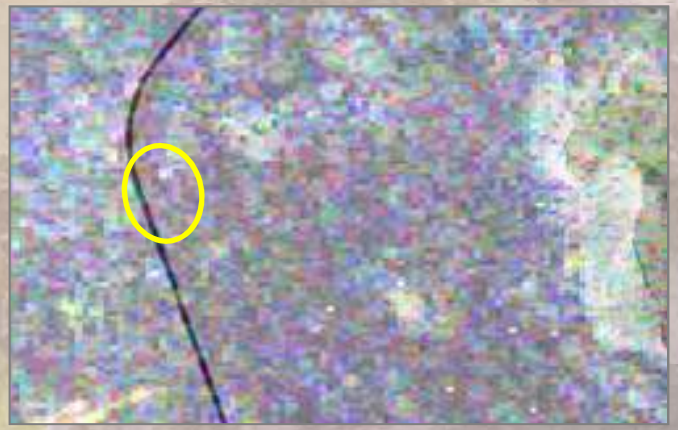


5 / 11 / 2009

RADARSAT-2

26° inc. a



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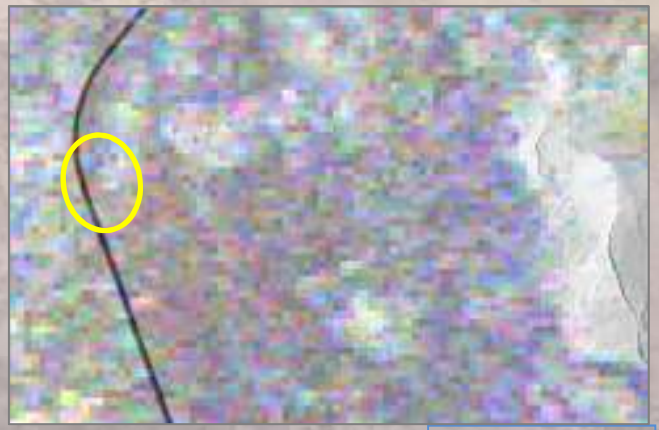
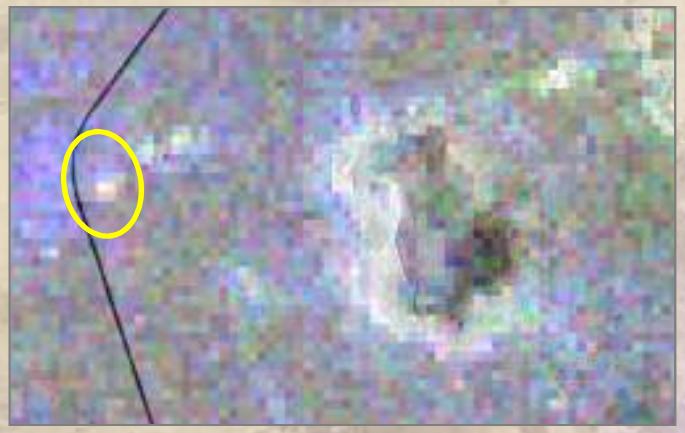


6 / 11/ 2012

Summary

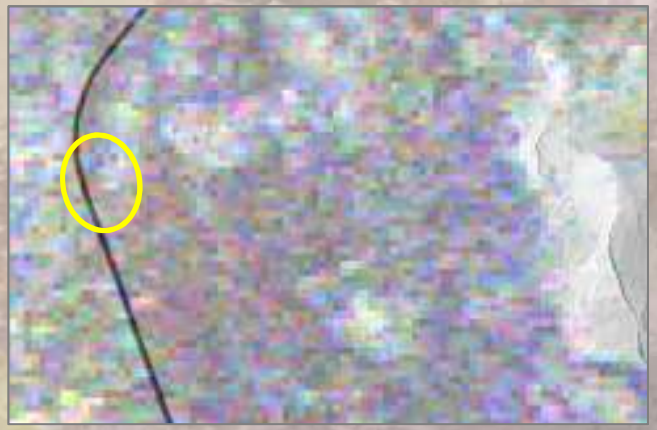
ALOS PALSAR

26° inc. a



RADARSAT-2

26° inc. a



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

Future steps

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