

→ POLINSAR 2013

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

# A RADARSAT-2 POLARIMETRIC MULTI INCIDENCE ANGLE ANALYSIS OVER ARCHAEOLOGICAL SITE

## THE UNESCO ANCIENT CITY OF SAMARRA (IRAQ)

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# WHAT ARCHAEOLOGY IS AND WHAT IT COULD BE

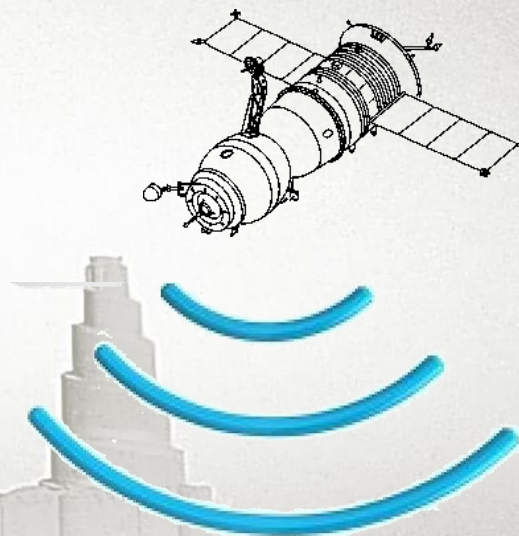
## WHO PEOPLE THINK WE ARE...



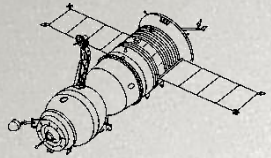
## WHO WE ARE...



# WHY ARCHAEOLOGY IS INVASIVE?



# AIM OF THE RESEARCH



We need **SATELLITES**



Non-invasive technique of investigation

Detection of archaeological structures affecting the soil



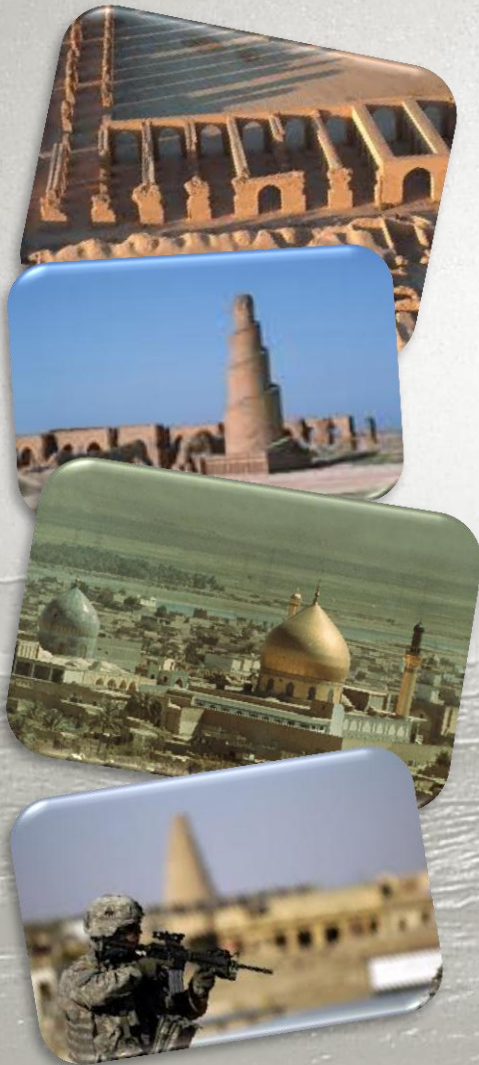
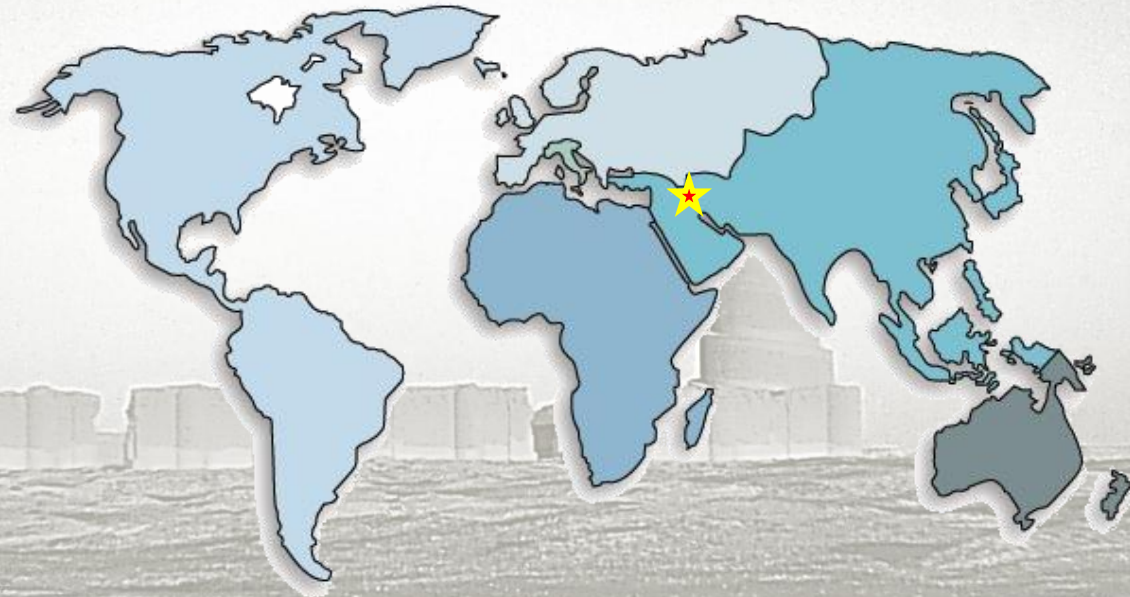
Detection and monitoring of structures already detected



Detection of structures still underground and unknown



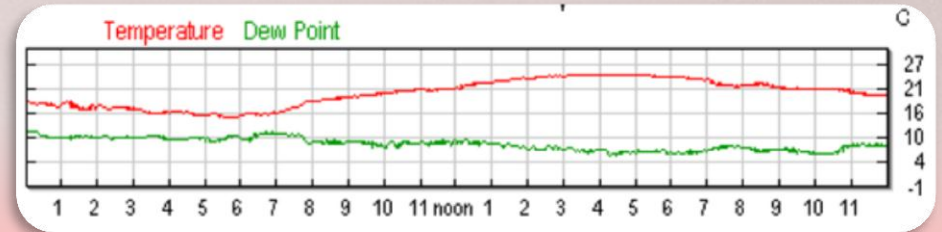
## SAMARRA



- Capital of Iraq only for 58 years (836 – 892 A.D.)
- Suddenly and mysteriously abandoned
- Very well preservation of its topography

# WHY SAMARRA ?

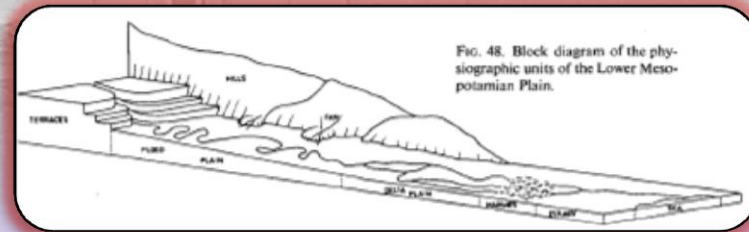
- Appropriate meteorological conditions



- Structures big enough for SAR spatial resolution



- Semi desert area characterized by fluvial terraces, never flooded



- 2007 inscribed in the UNESCO Cultural Heritage List in Danger

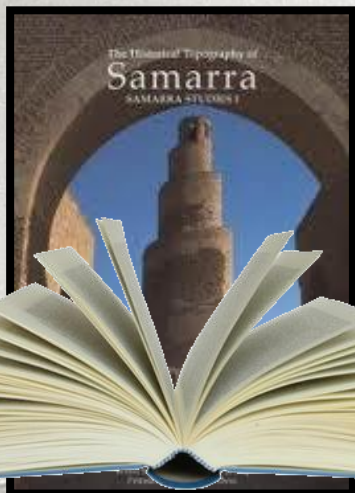
## List of World Heritage in Danger

The 38 properties which the World Heritage Committee has decided to include on the List of World Heritage in danger in accordance with Article 11 (4) of the Convention.



# STARTING POINT: *The empiric case study*

## *Books*



## *Archaeological maps*

## *Historical photographs*



**Professor**  
**Alastair Northedge**  
*Professor of Islamic Art and  
Archaeology  
Sorbonne (Paris, France)*



## *Photographs*

# SAR DATASET

## RADARSAT-2



### TIME ACQUISITION

### INC. ANGLE

16\04\2012

43.43°

07\05\2012

26.63°

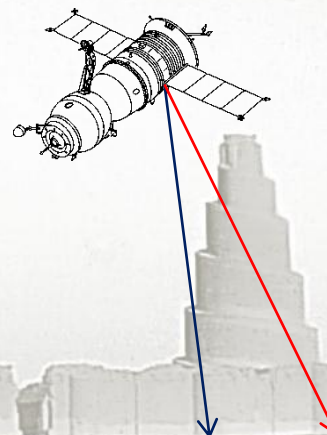
22\10\2012

43.43°

25\10\2012

26.63°

### Different Incidence Angle



26.62°

Better detection of  
**Single bounce**

43.43°

Better detection of  
**Double bounce**



# METEO DATASET

## RADARSAT-2



### TIME ACQUISITION

### INC. ANGLE

16\04\2012

43.43°

07\05\2012

26.63°

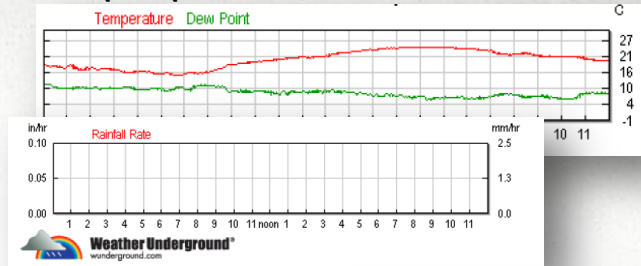
22\10\2012

43.43°

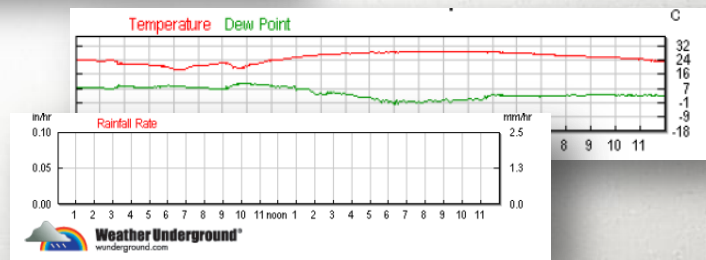
25\10\2012

26.63°

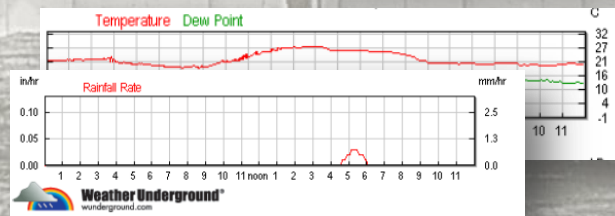
16\04\2012



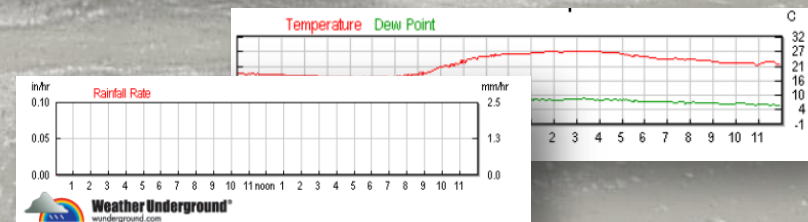
07\05\2012



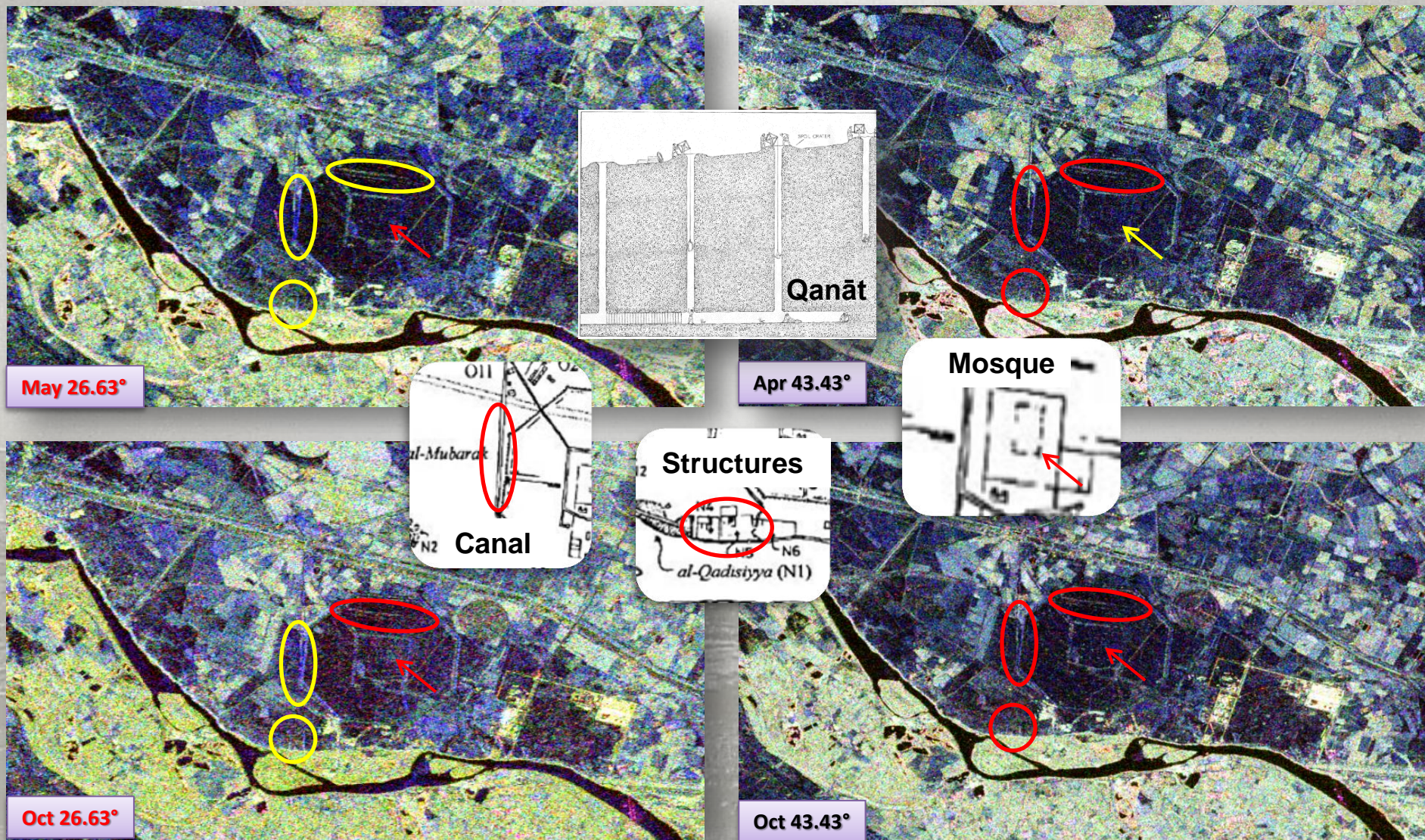
21\10\2012



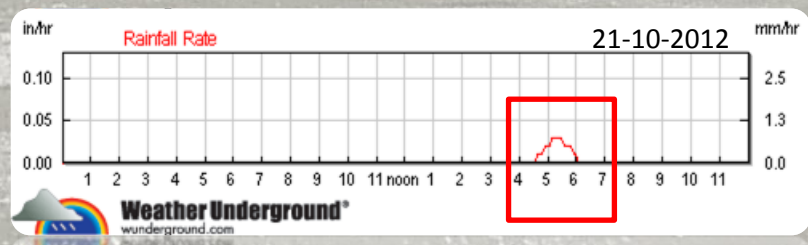
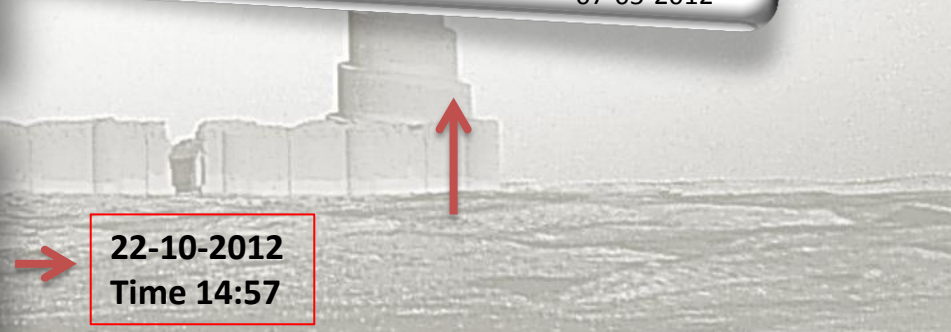
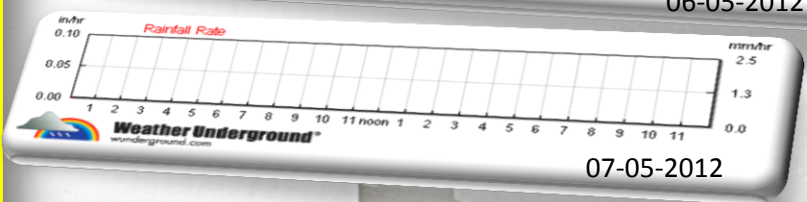
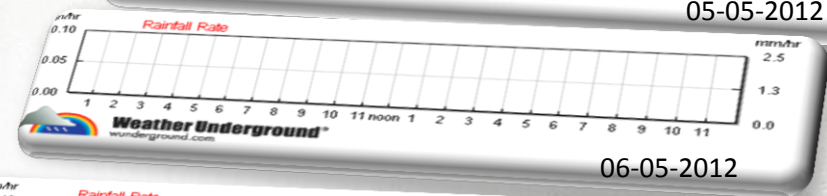
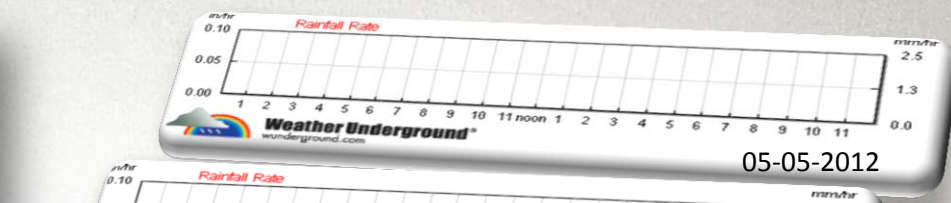
25\10\2012



# FIRST STEP: A QUALITATIVE ANALYSIS

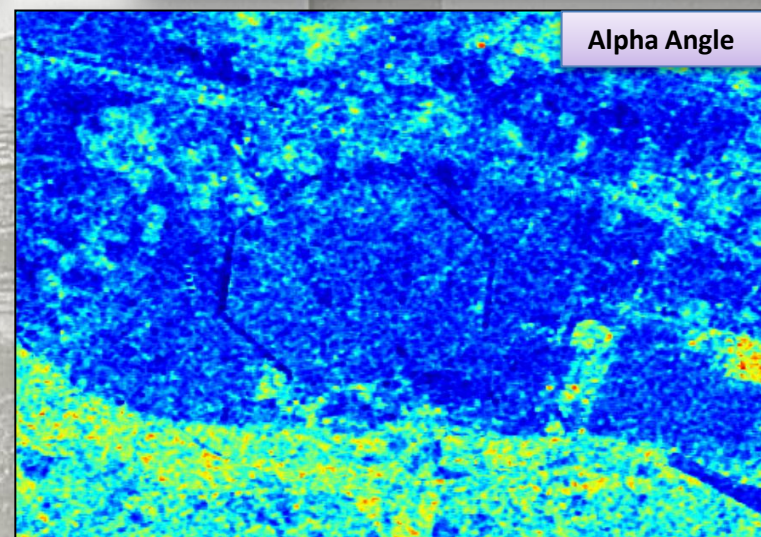
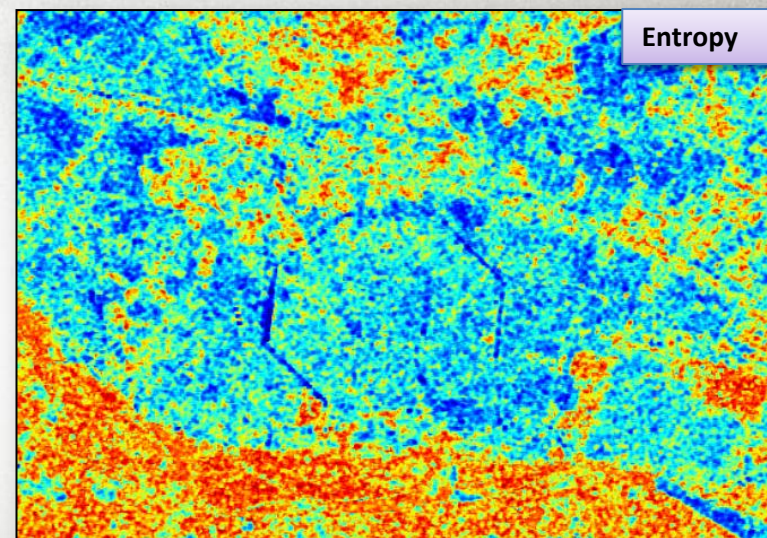


# 26° INCIDENCE ANGLE IMAGES

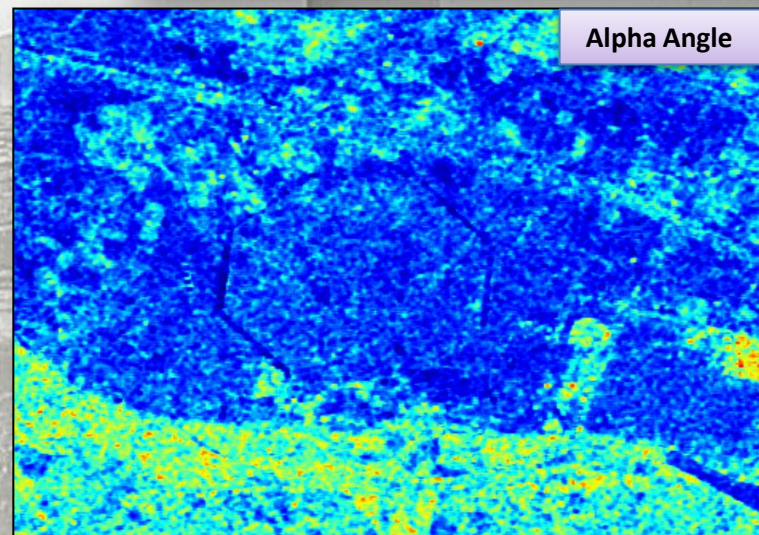
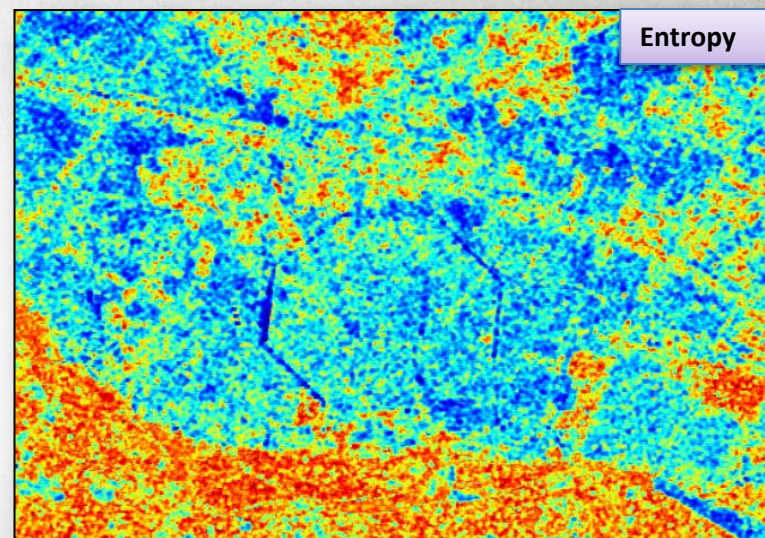
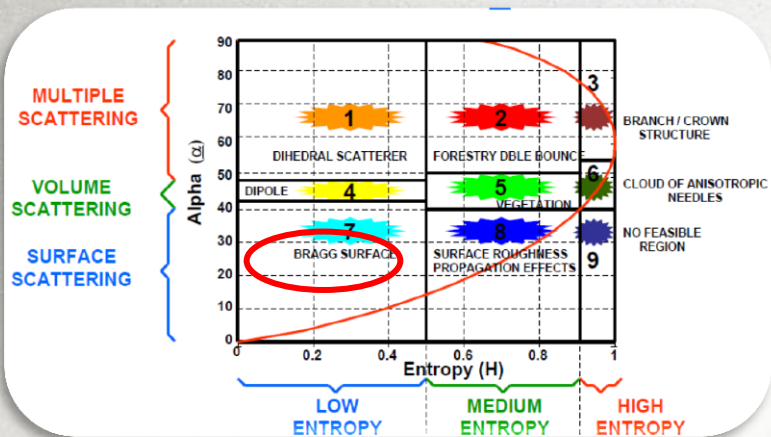


(meteo station: Tuz Khormato)

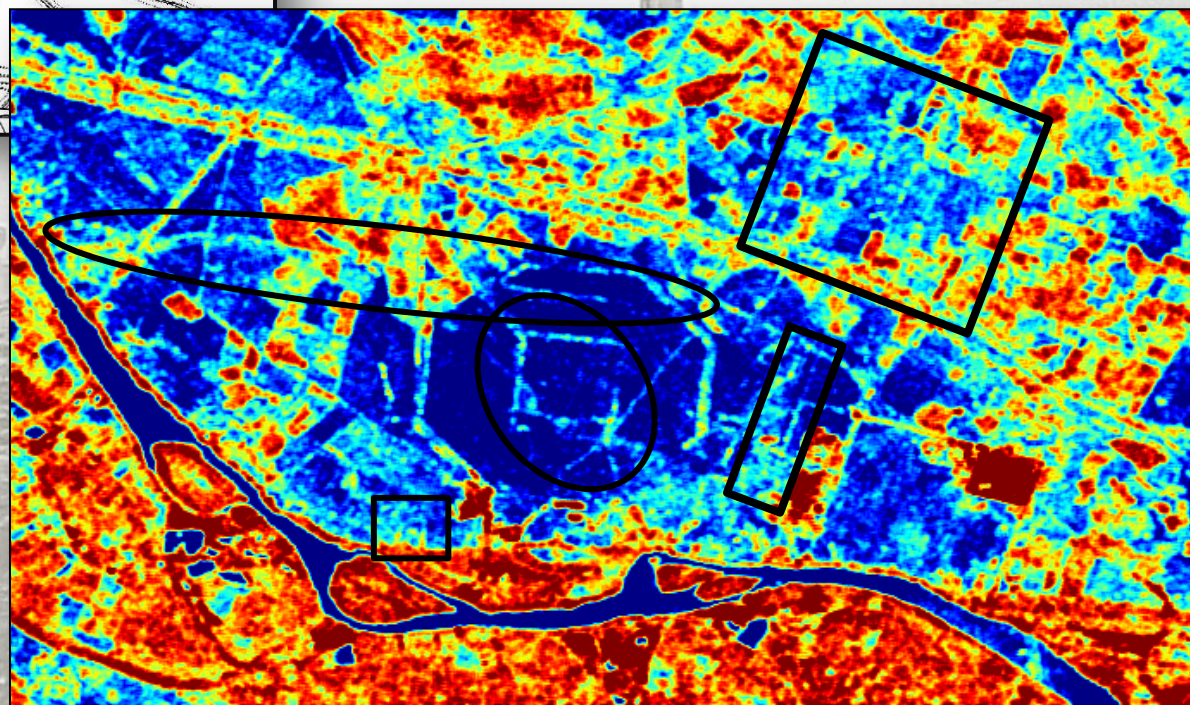
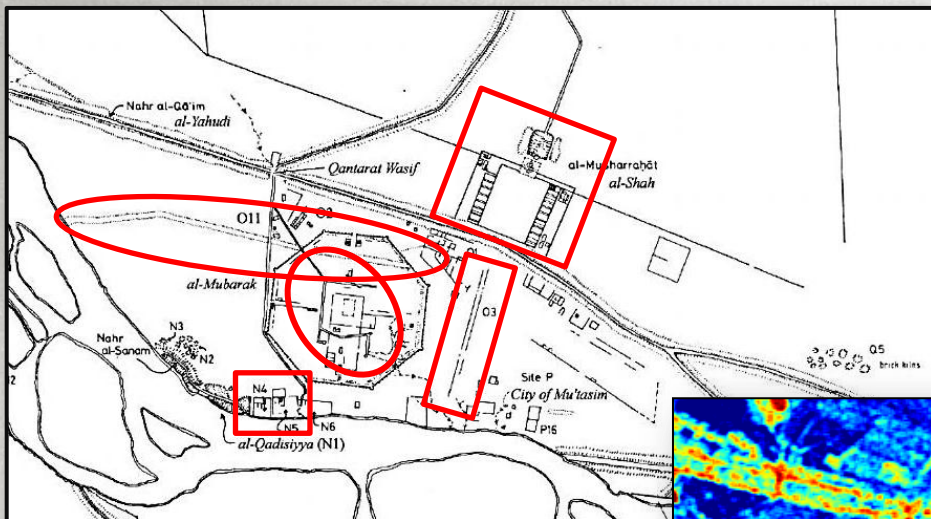
# PRODUCTS EVALUATION



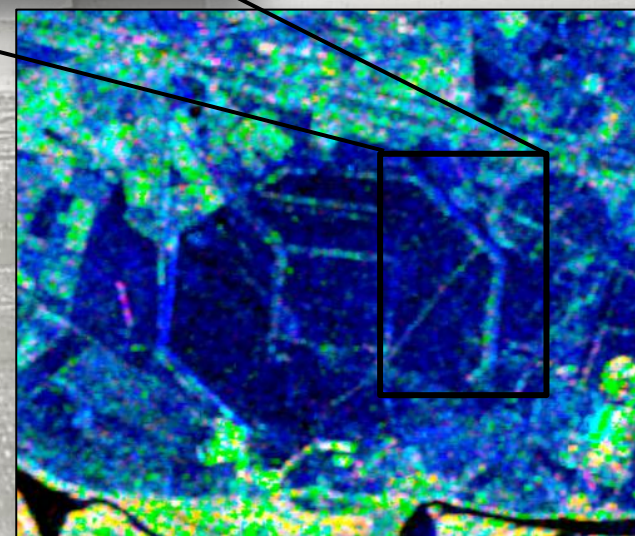
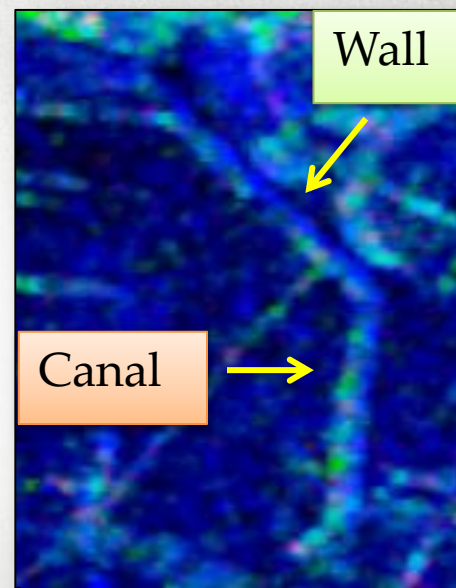
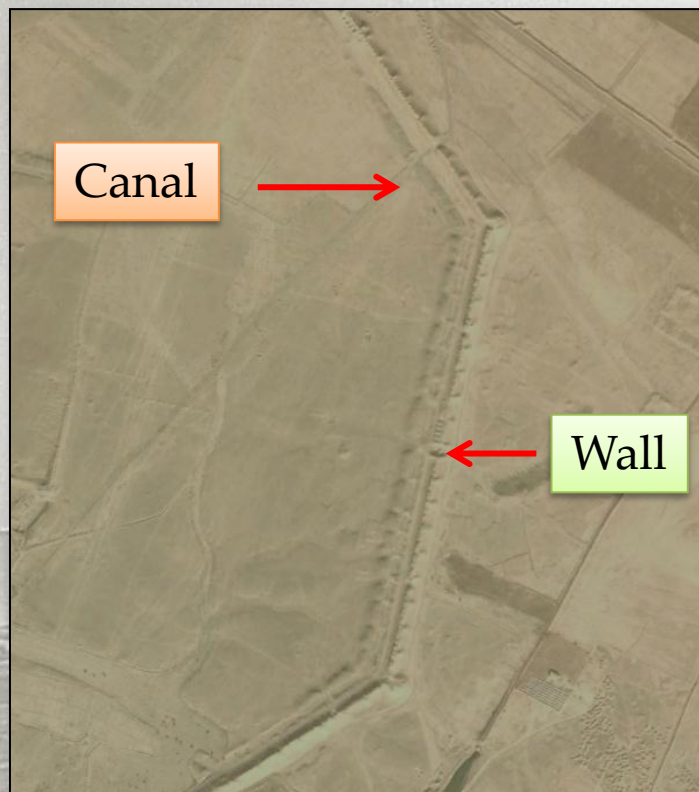
# PRODUCTS EVALUATION



# PRODUCTS ANALYSIS: Shannon Entropy

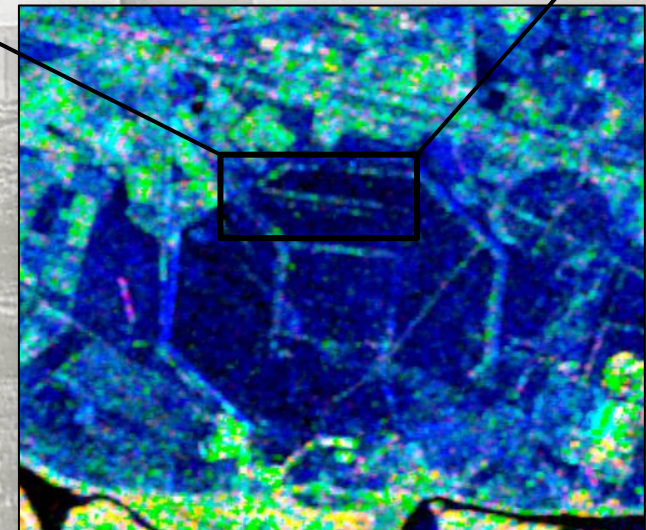
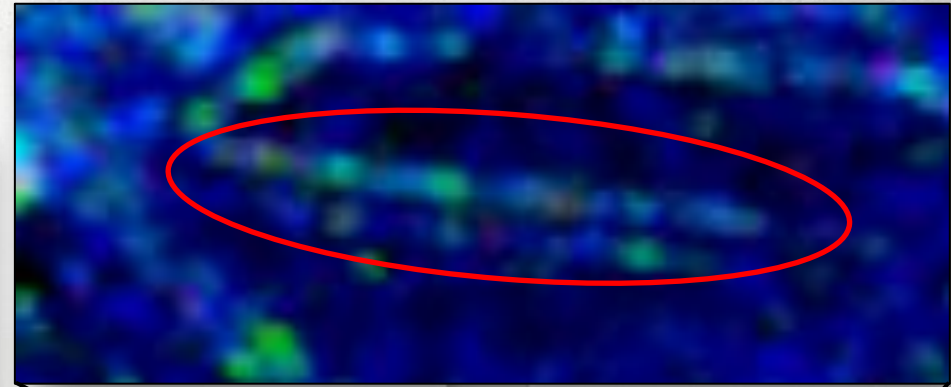


# YAMAGUCHI DECOMPOSITION AND PHOTO "TRUTH"



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

# YAMAGUCHI DECOMPOSITION AND PHOTO "TRUTH"



*\*Photographs courtesy of Prof. Alastair Northedge*

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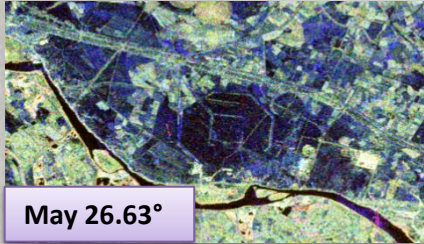
28 January - 1 February 2013 | ESA-ESRIN | Frascati (Rome), Italy



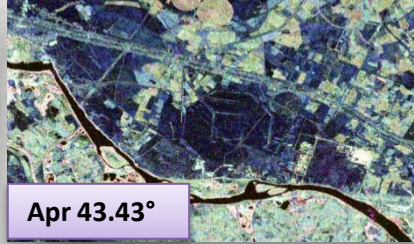
European Space Agency



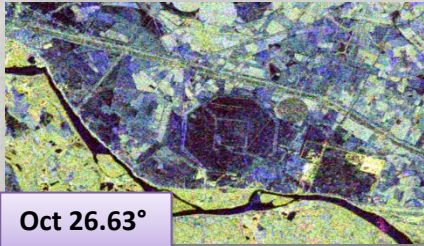
# SUMMARISING...



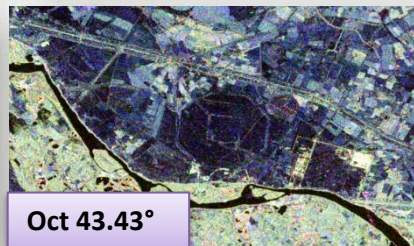
May 26.63°



Apr 43.43°



Oct 26.63°



Oct 43.43°

## I step

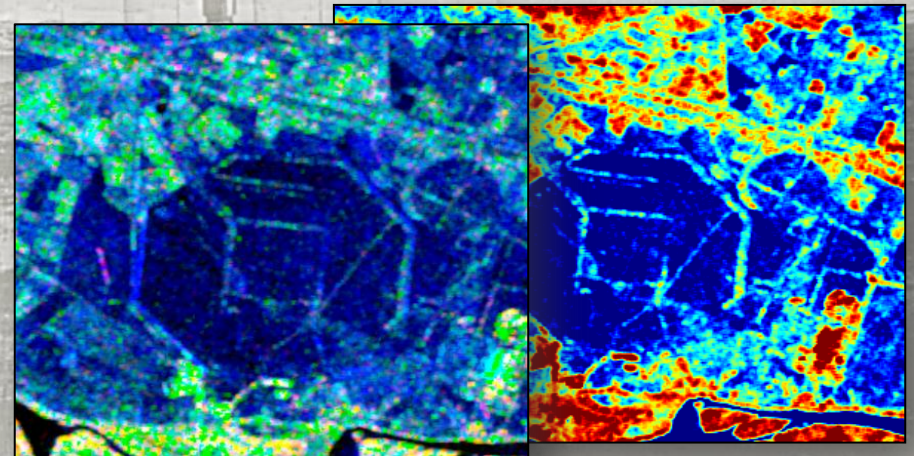
Qualitative analysis of the images

- Pauli RGB 26 °

## II step

Analysis of polarimetric products in order to find the most useful

- Yamaguchi decomposition
- Shannon Entropy



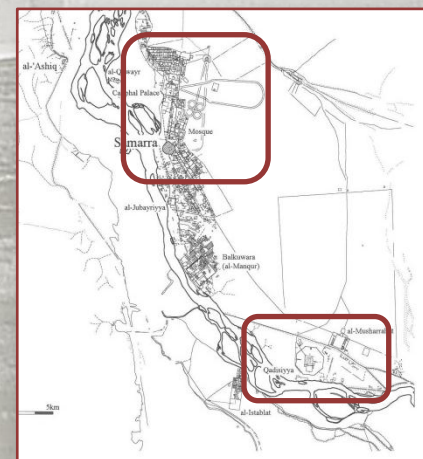
# FOR THE FUTURE

Evaluate if we have terrain deformation or presence of vegetation



Analysis of two more RADARSAT-2 images acquired on **02-01-2013** and **05-01-2013**

Analysis of the northern part of the archaeological area



# CONCLUDING AND REFLECTING...

*Before...*



*...After*



# CONCLUDING AND REFLECTING...

*Before...*



3D

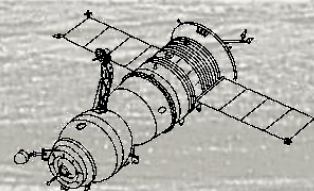


# CONCLUDING AND REFLECTING...

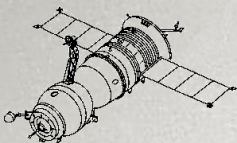
*Before...*



3D



**ALSO ARCHAEOLOGISTS  
NEED SATELLITES!**



**THANK YOU  
FOR YOUR  
ATTENTION**

