# From Detection of Underground Archaeological Relics to Monitoring of World Heritage Sites in Danger: Ongoing Research Activities in the Frame of the ATHENA Twinning Project

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# Remote Sensing Science Center for Cultural Heritage

Training

Staff exchange

workshops

Summer schools

What is ATHENA?

# Cooperative Research: DLR & CUT - Highlights

- Cooperation between DLR and CUT in the frame of ATHENA:
  - Staff Exchange
  - Virtual Seminars
  - Summer Schools
  - **Joint Research**
- Image Analysts at DLR and archaeologists and image analysts at CUT worked together on several topics
- Highlights reported here are from two applications:
  - Hyperspectral indices for the detection of crop marks
  - Monitorin of sensitive cultural heritage sites

# Hyperspectral

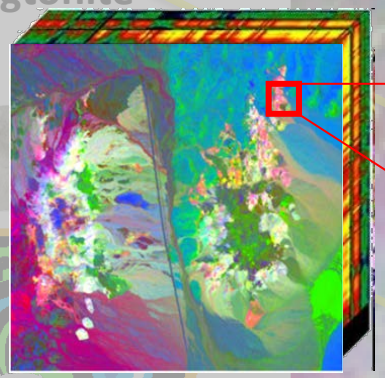
Buddingtonite

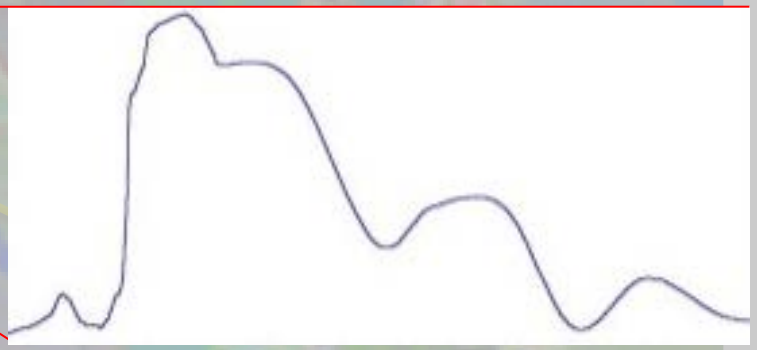
Alunite

Chalcedony

# Hyperspectral

Buddingtonite

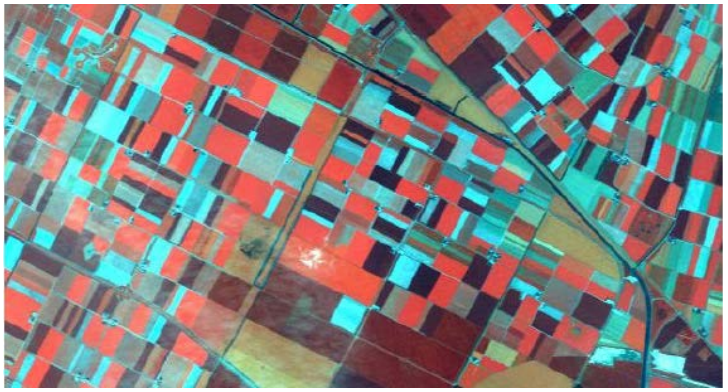




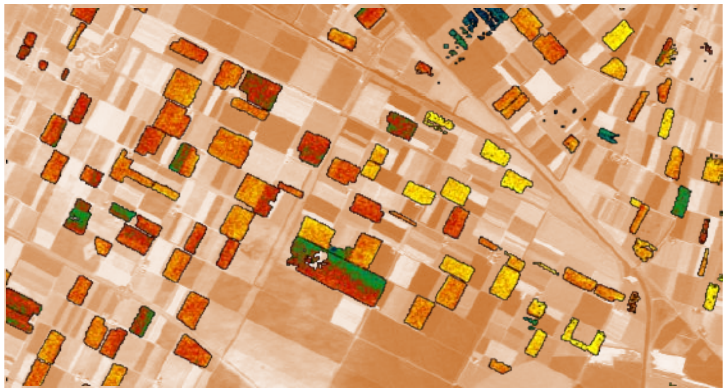
Alunite

Chalcedony

# Vegetation Health Analysis

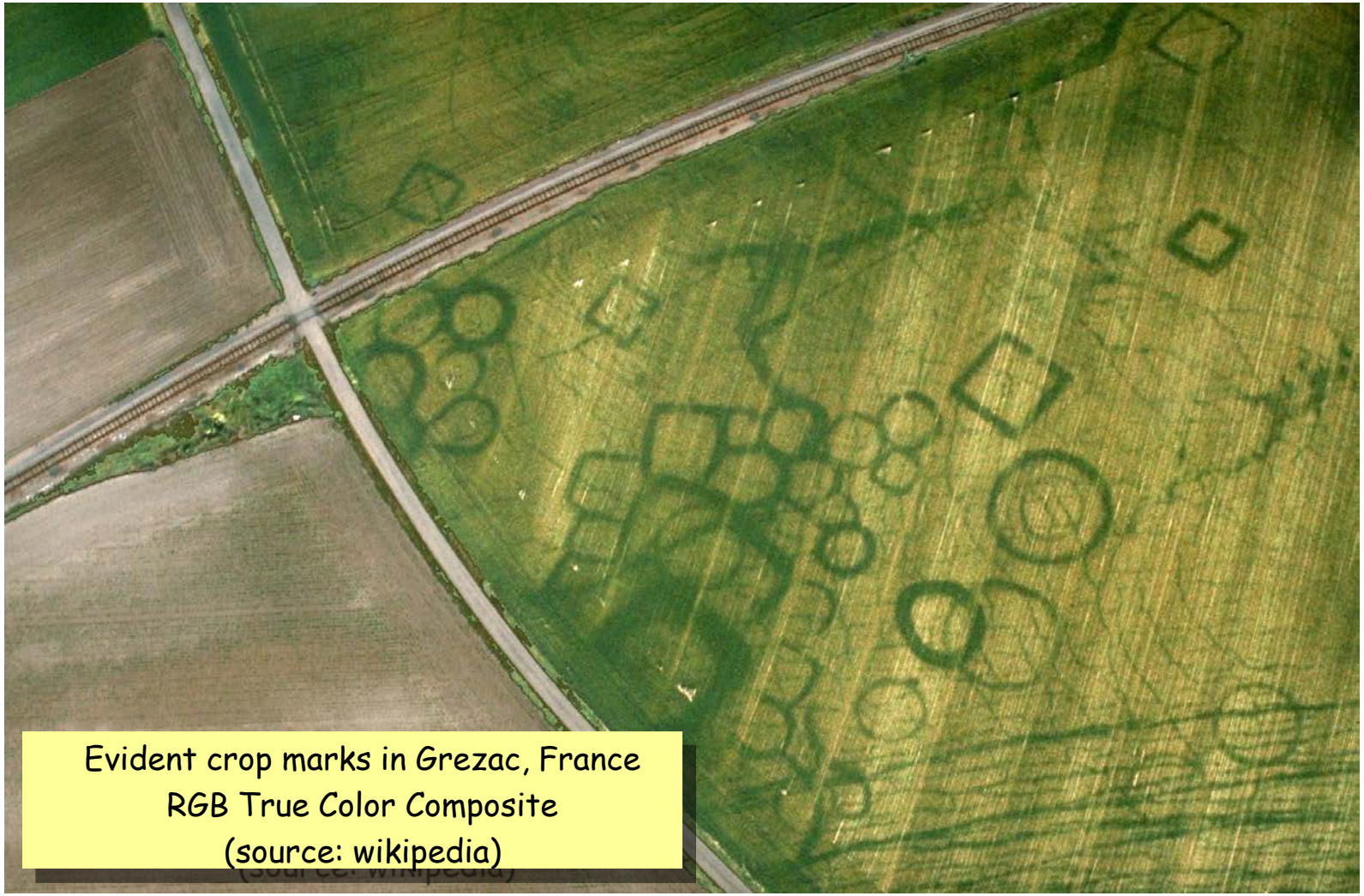


Crops (False Color Composite)




Health Status of Potato Fields

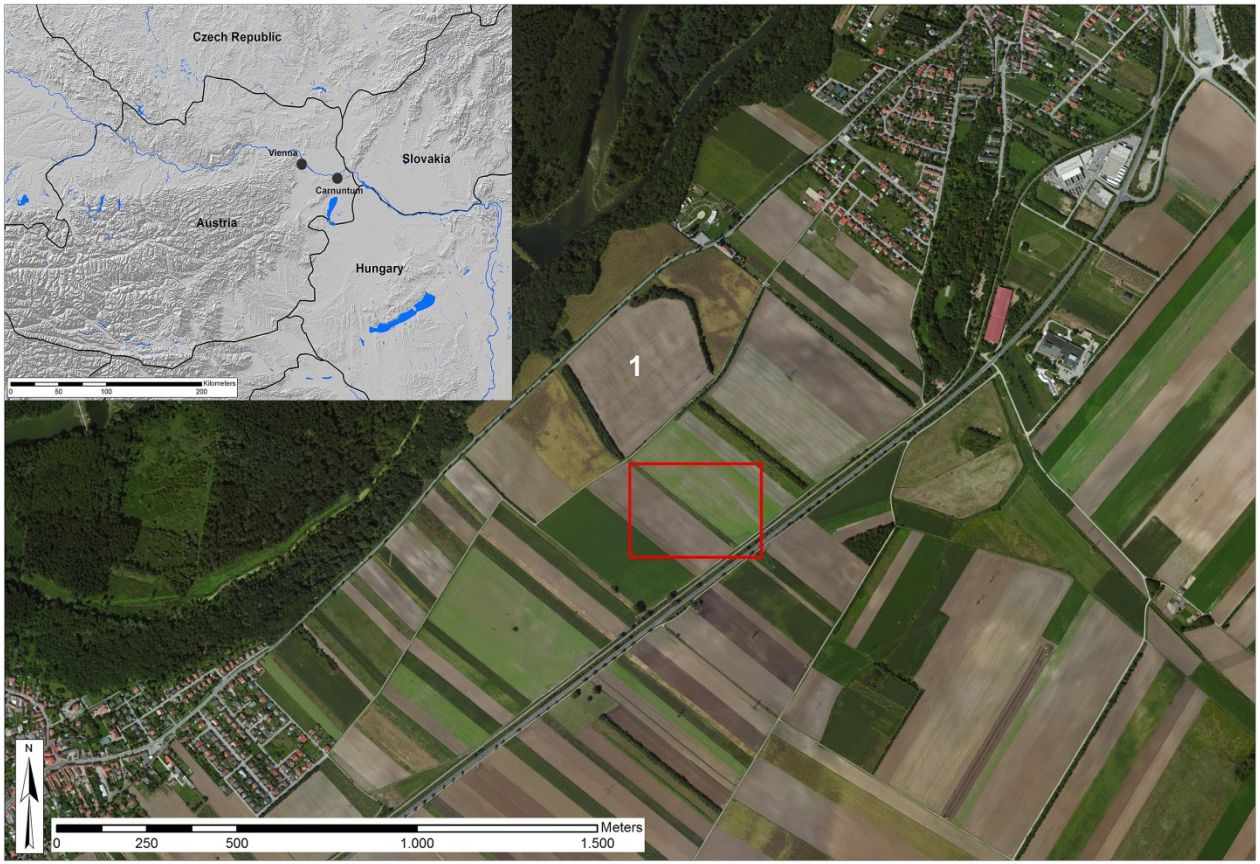
# About Vegetation Health: Crop Marks



Evident crop marks in Grezac, France
RGB True Color Composite
(source: wikipedia)

# An interesting application

- Dataset: Carnuntum
  - Capital of the former Roman province *Pannonia superior*
  - *Centuries IV BC – I AD*
- Airborne HS campaign
  - AisaEAGLE
  - 65 bands
  - 400-1000 nm
  - 0.4 m GSD
  - Courtesy of prof. Michael Donus




Michael Doneus et al., „New ways to extract archaeological information from hyperspectral pixels“, Journal of Archaeological Science, Volume 52, December 2014

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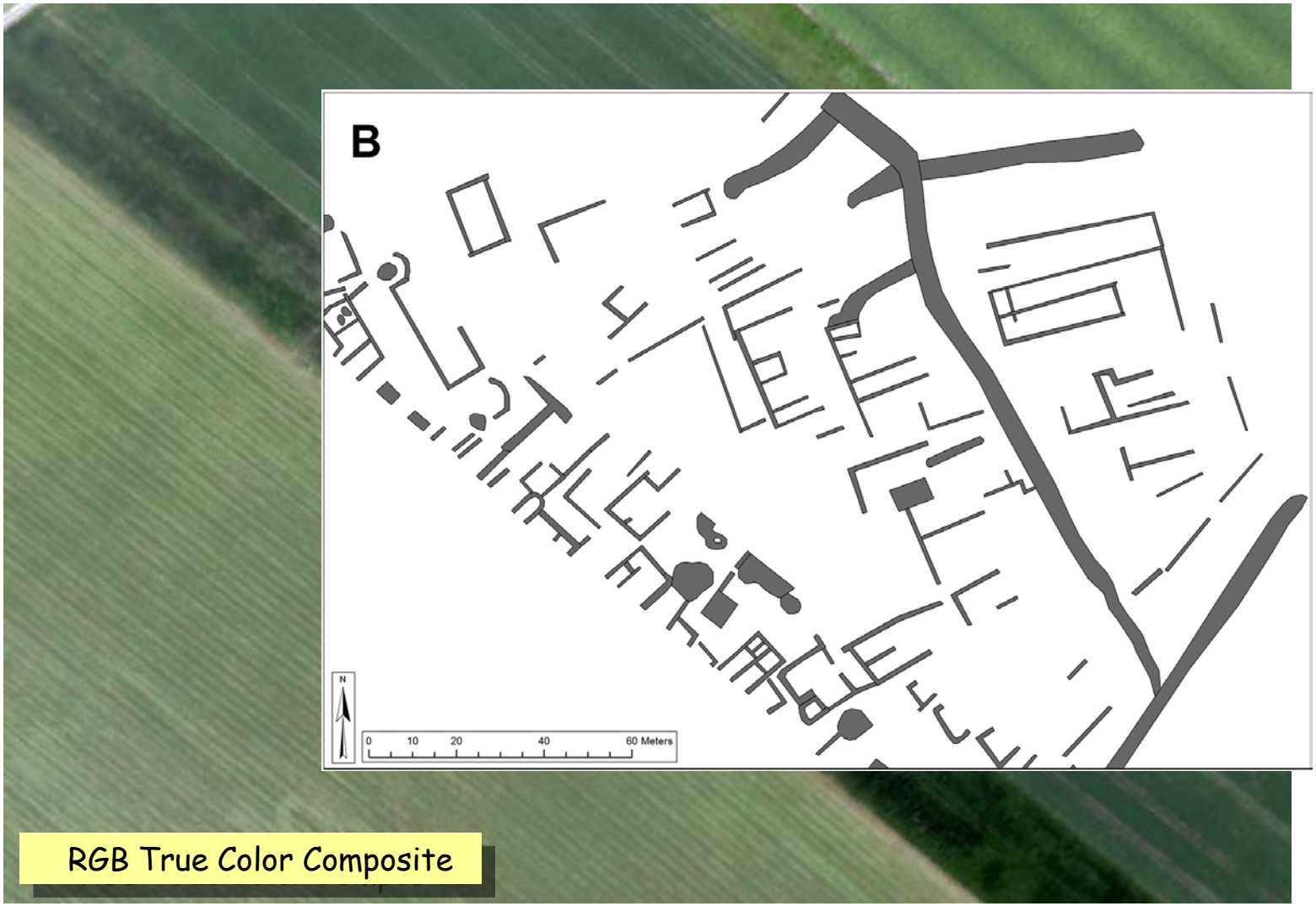
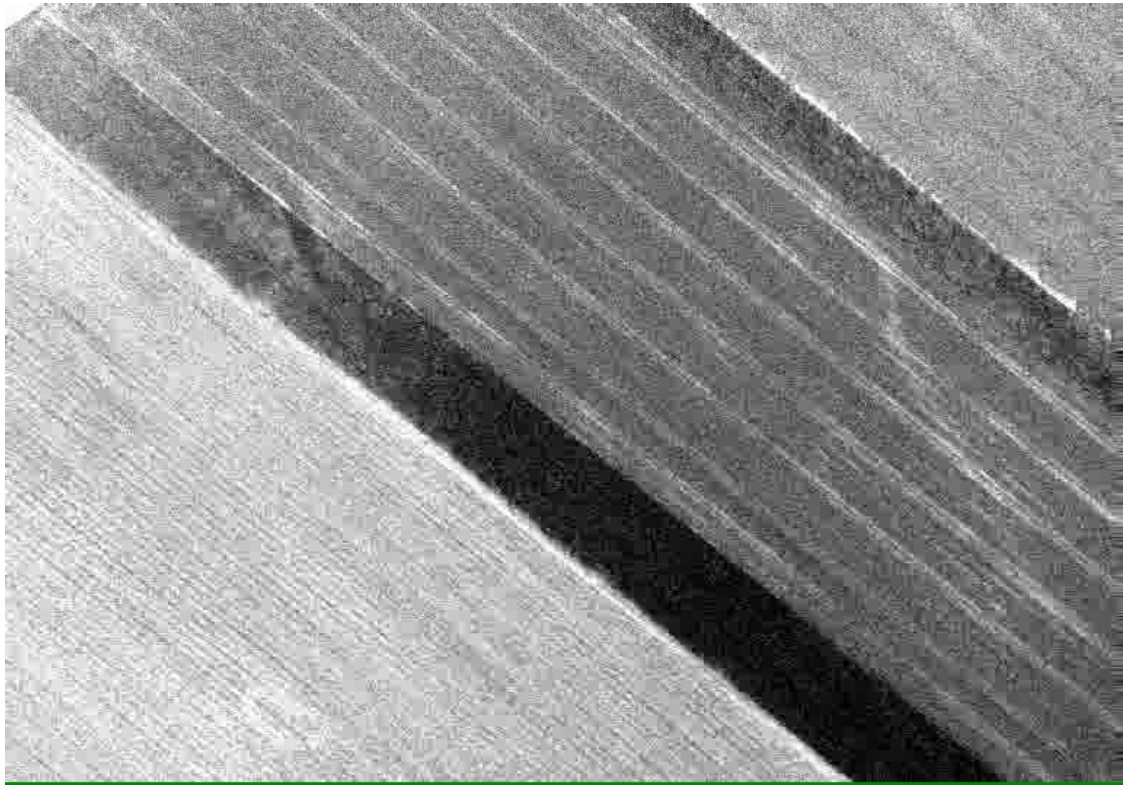
# Not always that easy…




# Which band is better?

- Let‘s have a look at all available bands…



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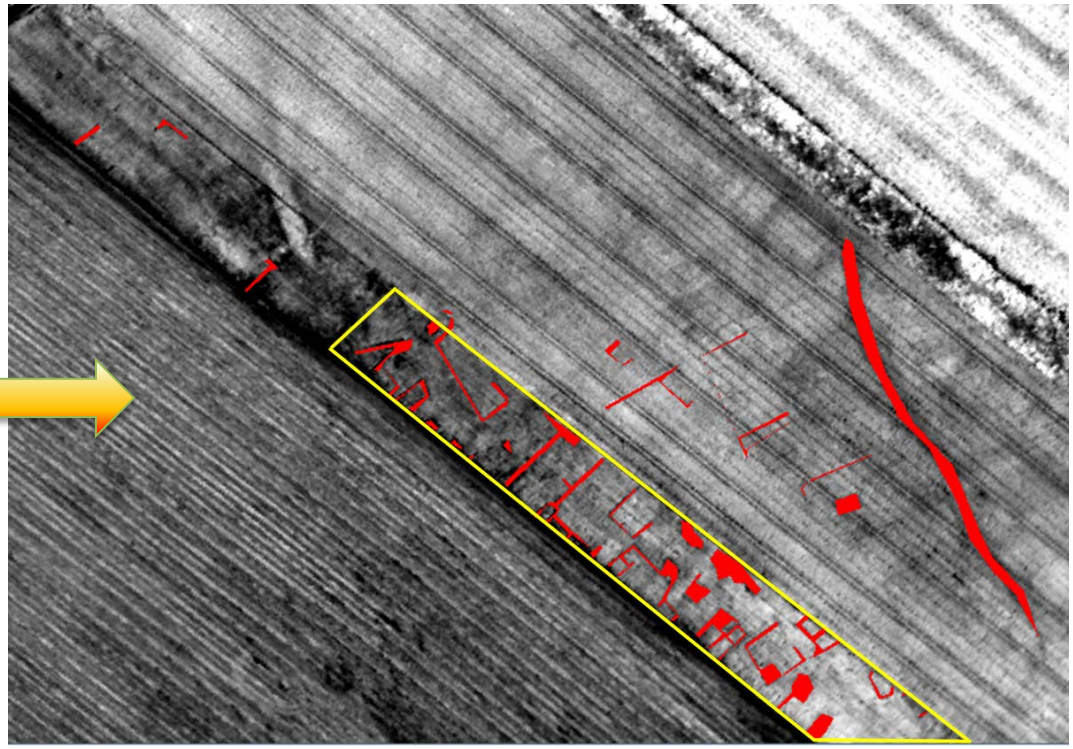
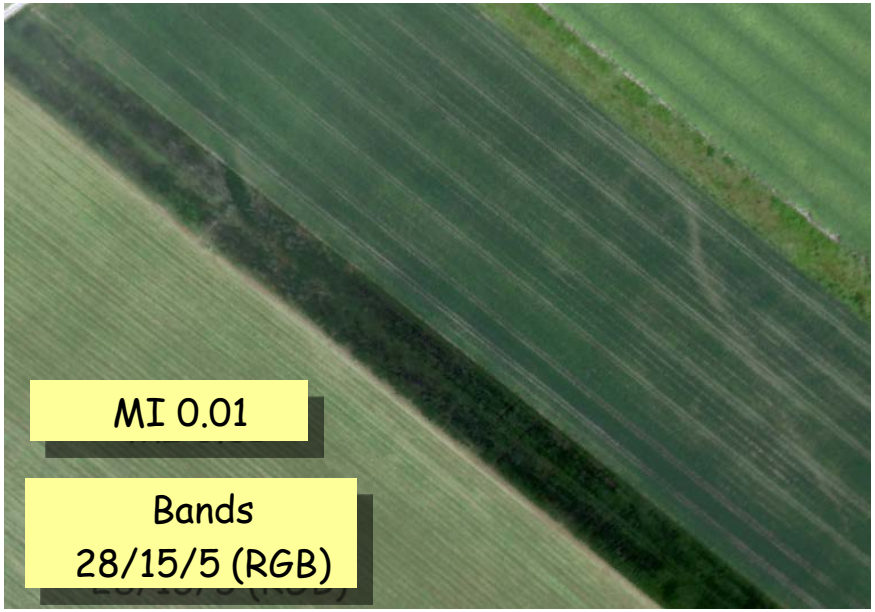
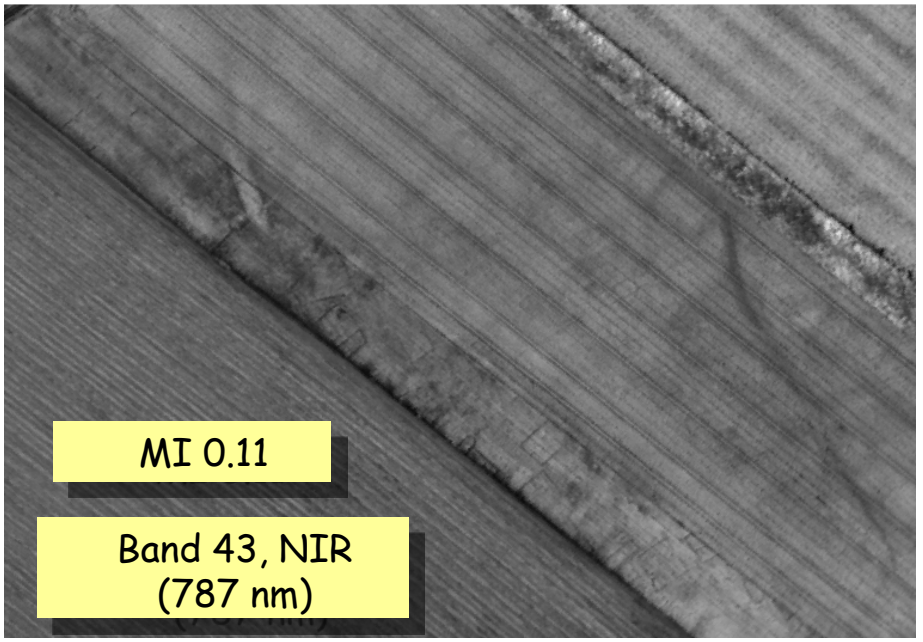
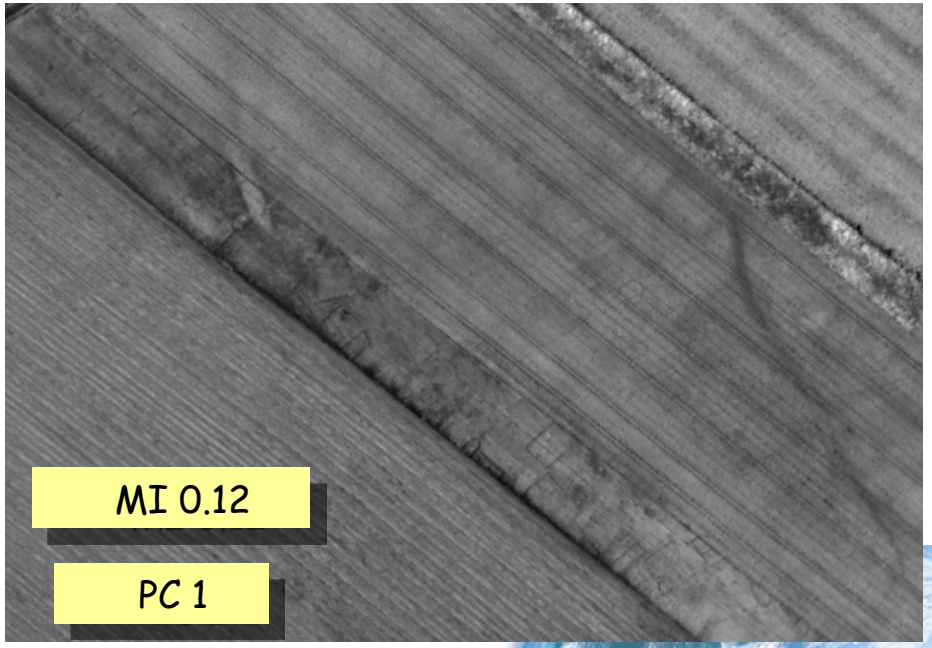
# Mutual Information

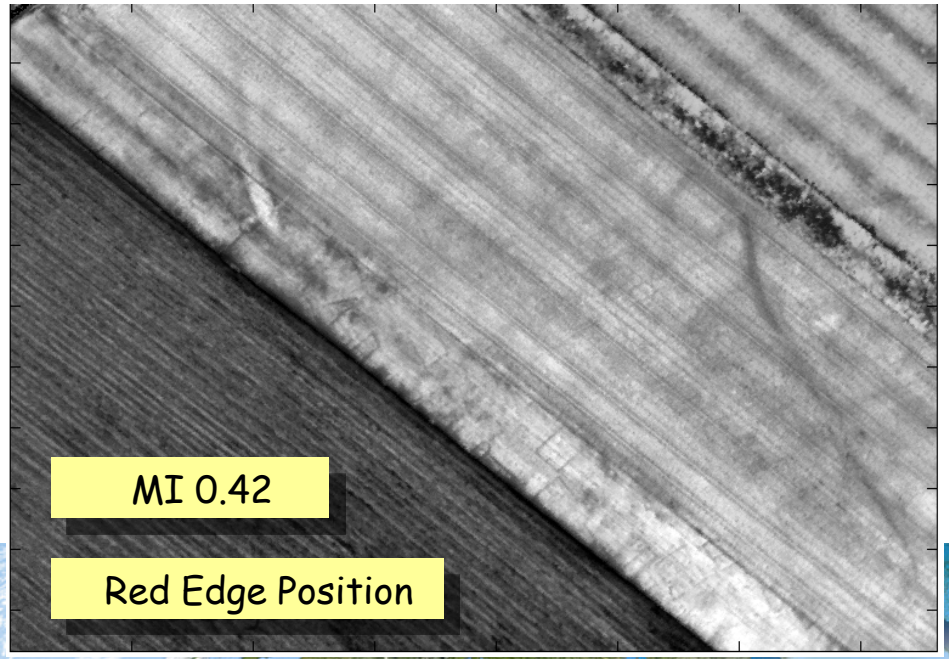
- Derivation of a reference image (manual)
- Analysis restricted to yellow rectangle

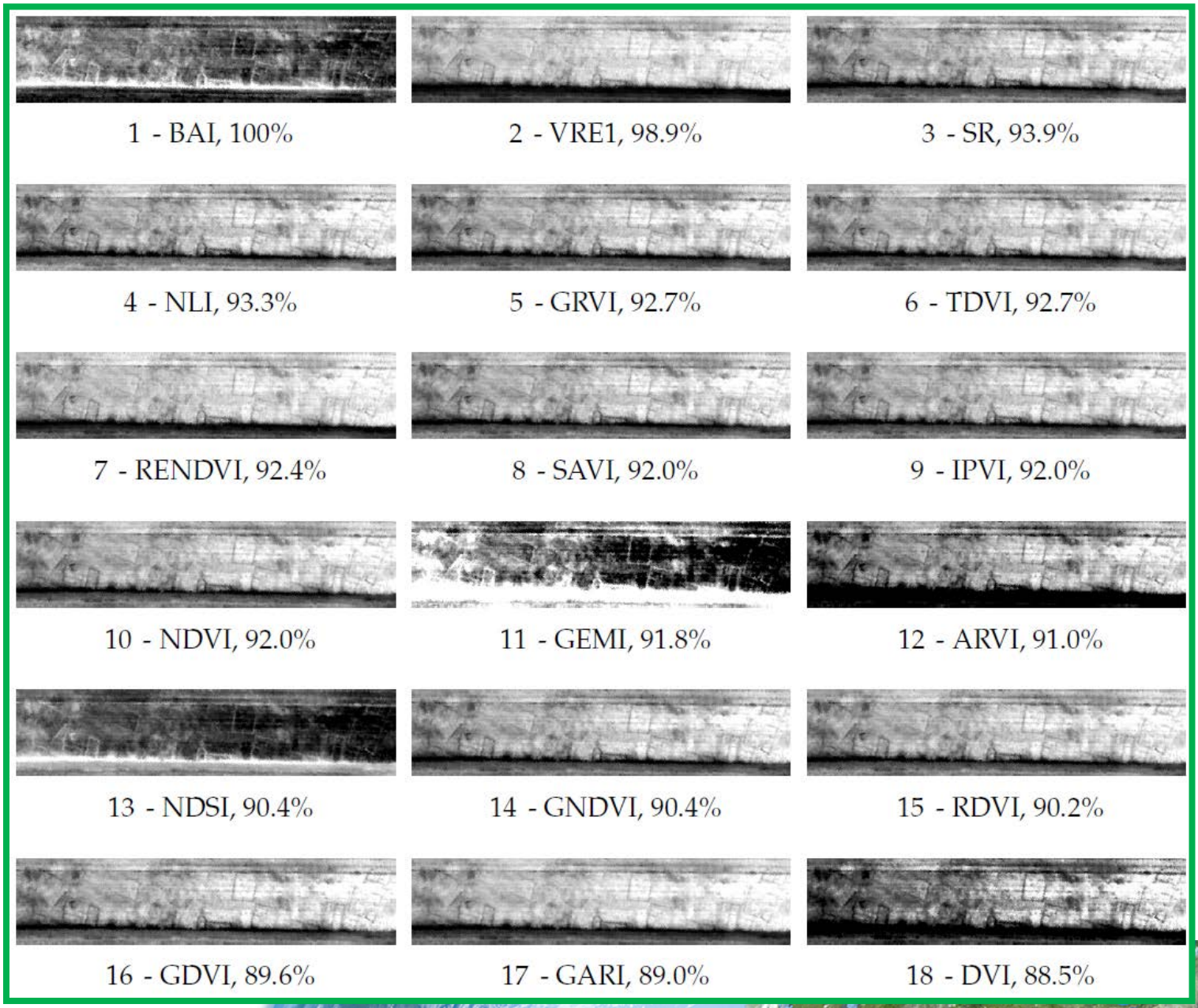

MI 0.01
Bands
28/15/5 (RGB)


MI 0.11
Band 43, NIR
(787 nm)


MI 0.12
PC 1


MI 0.42
Red Edge Position

# Ranking of several spectral indices for archaeological research purposes

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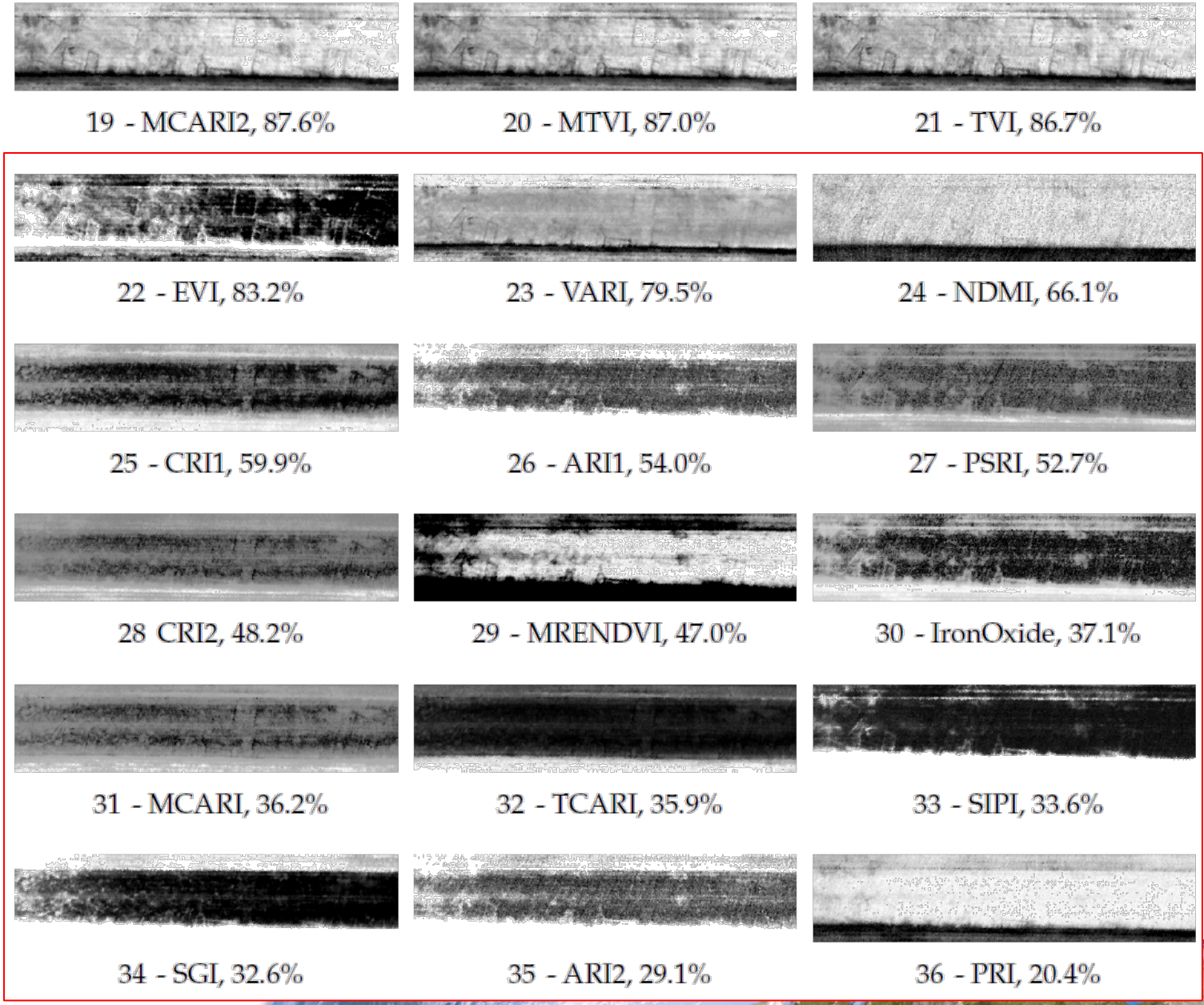


# Towards Automatic Monitoring of Endangered Cultural Heritage Sites

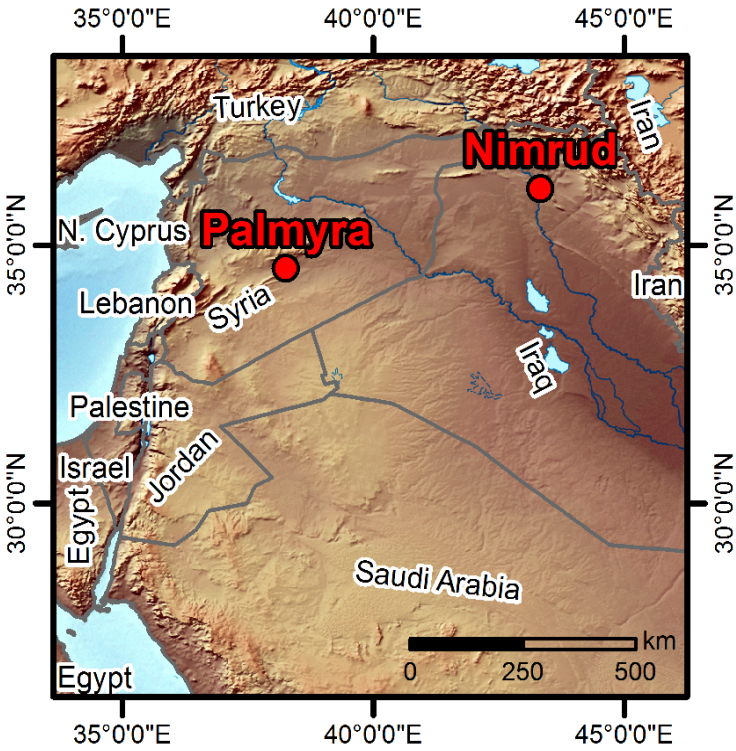
- Since spring 2015: Islamic State (IS) proclaims the destruction of cultural heritage sites, including Palmyra (Syria) and Nimrud (Iraq)

- Difficulties in confirming these damages at first

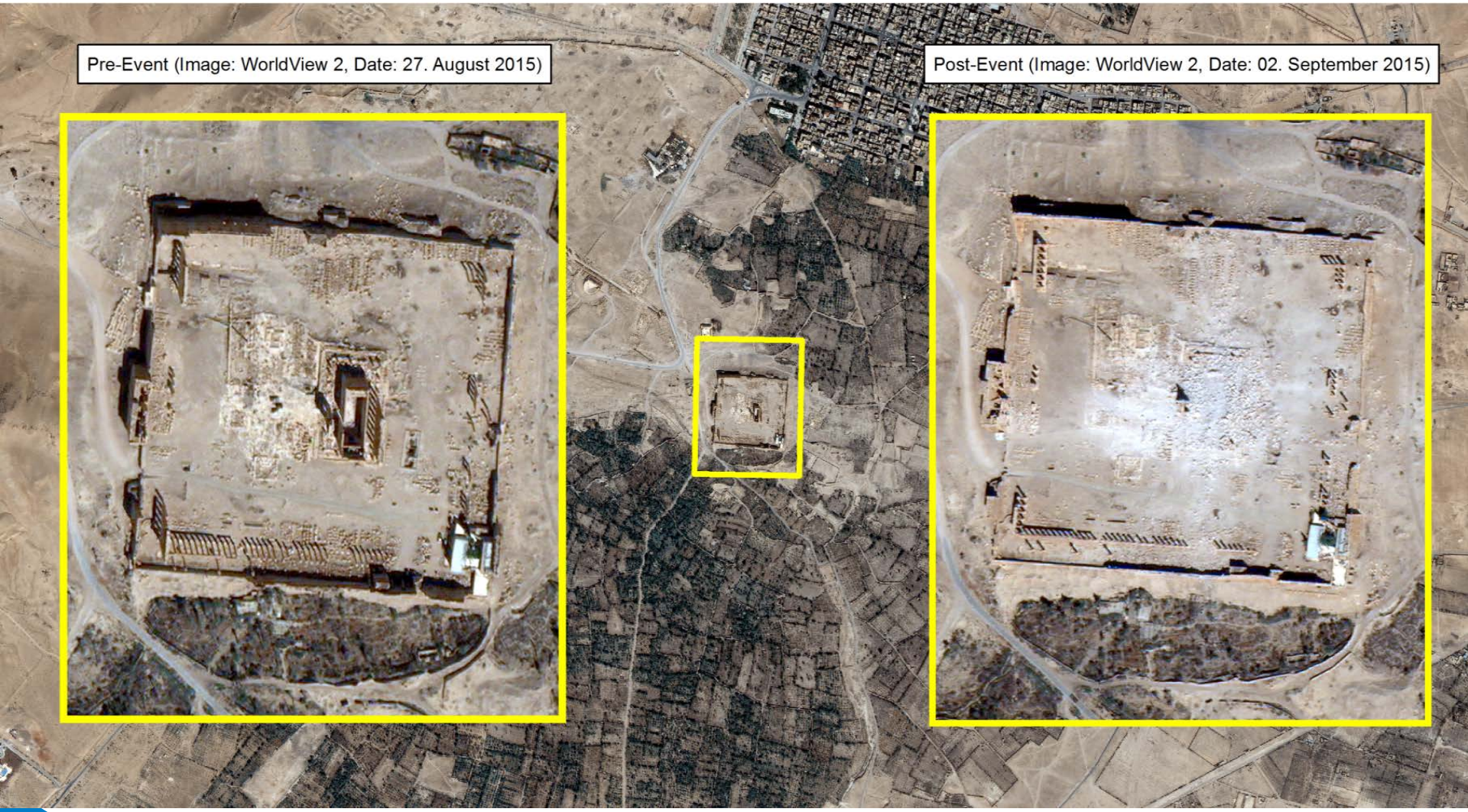
?

  - Non-accessible areas
  - Sources: Reports in social media (e.g., Facebook, Twitter): unreliable or sometimes contradictory

- Remote Sensing as independent & objective information source




# Example: Palmyra – Temple of Bel: destroyed by IS (30.08.2015)



# Motivation

Similar tasks are usually carried out through **visual analysis**

Would it be possible to help experts by providing automatic maps in which damages are likely to have occurred?

Could several images be automatically combined to estimate the evolution in time of damages?

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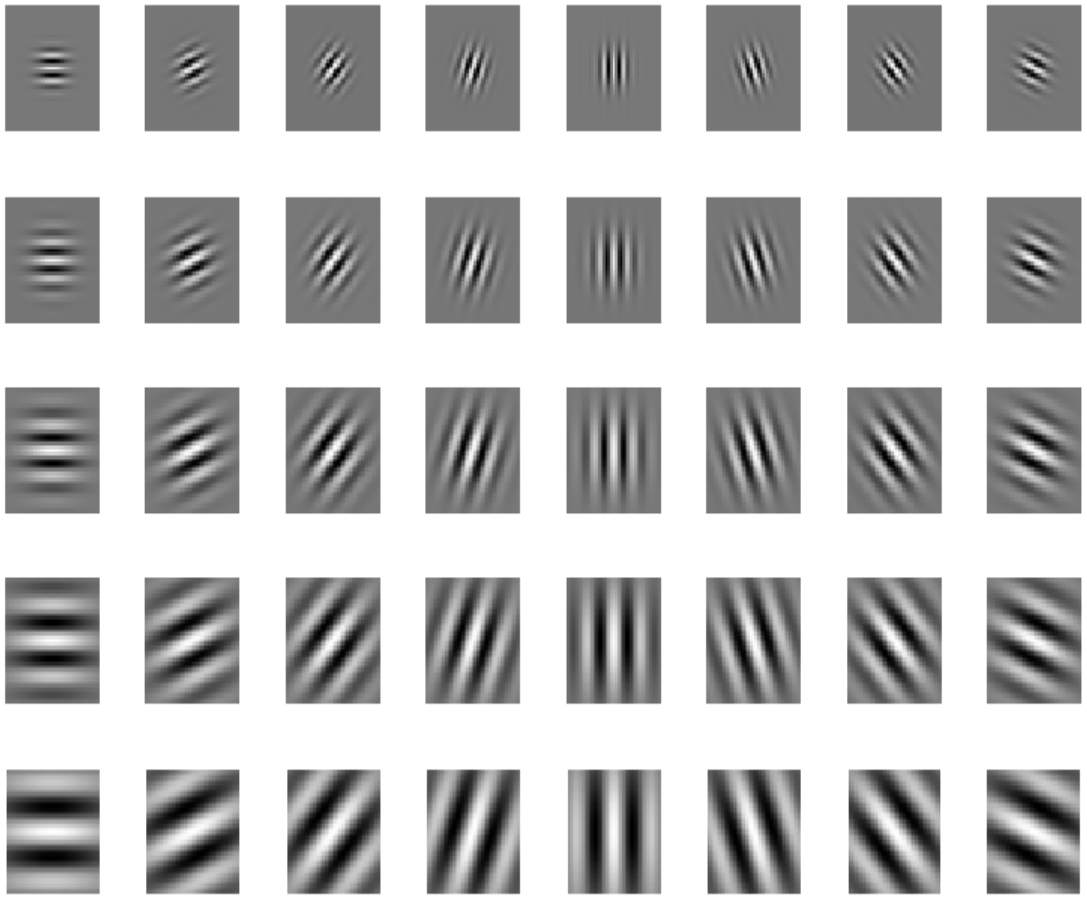
# Gabor Texture Features

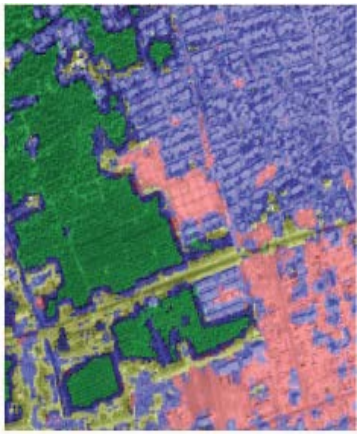


Selected filter bank

# Texture Classification: Example

Bam, Iran, suffered an earthquake in 2003

IKONOS image acquired in the aftermath of the earthquake




Classification obtained on the basis of the texture parameters only

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# Palmyra, Syria

Temple of Bel

Tower Tombs

# WorldView-2 Pre-Desaster Image


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# WorldView-2 Post-Desaster Image


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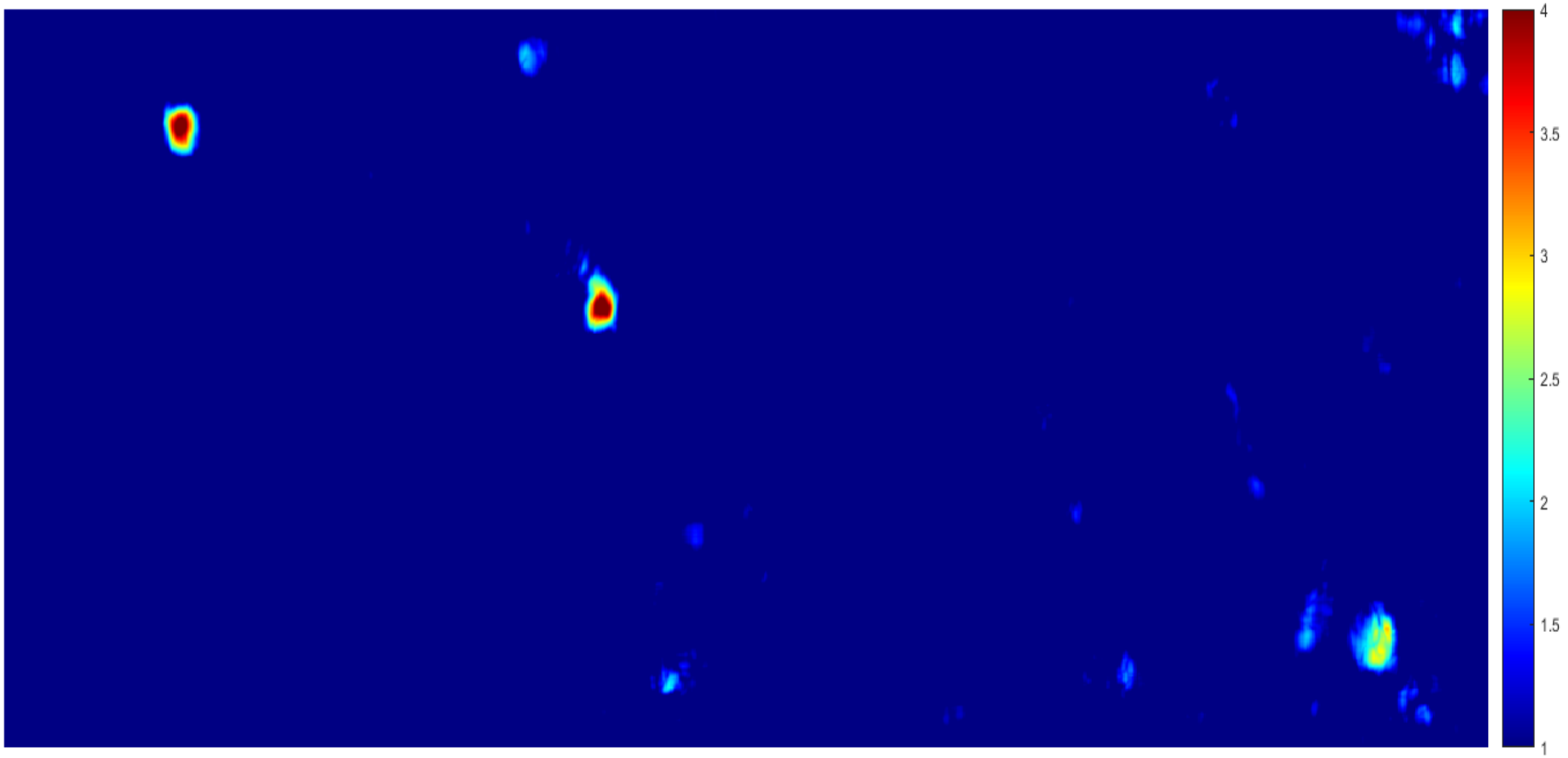
# Palmyra: Difference of Gabor Features

**(based on texture values)**

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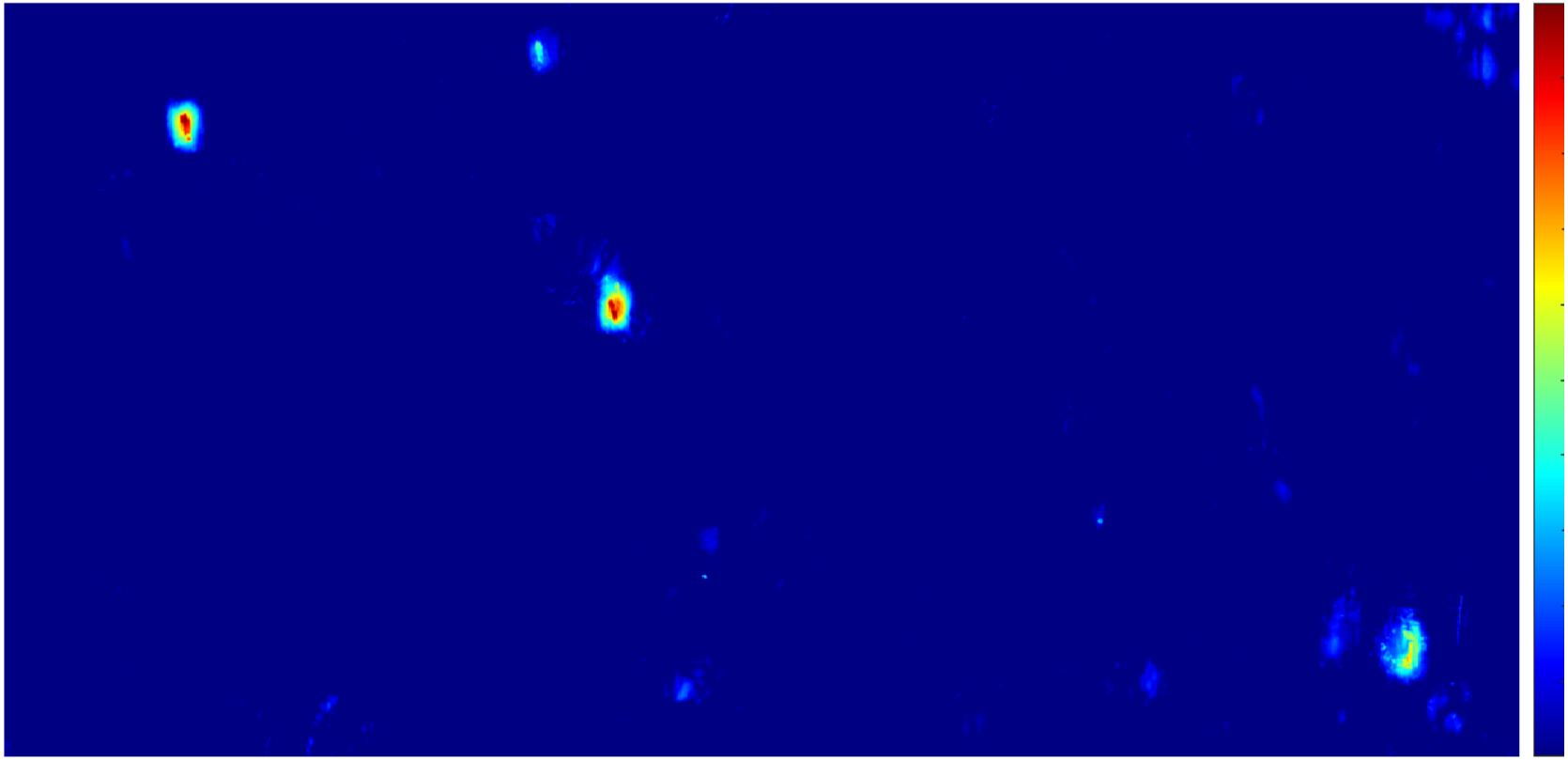
# Palmyra: Enhanced Gabor Features (using robust brightness differences)



# Detected Damages

# Detection of Damaged Areas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# What about previous damages? Google Earth image 20 02 2014

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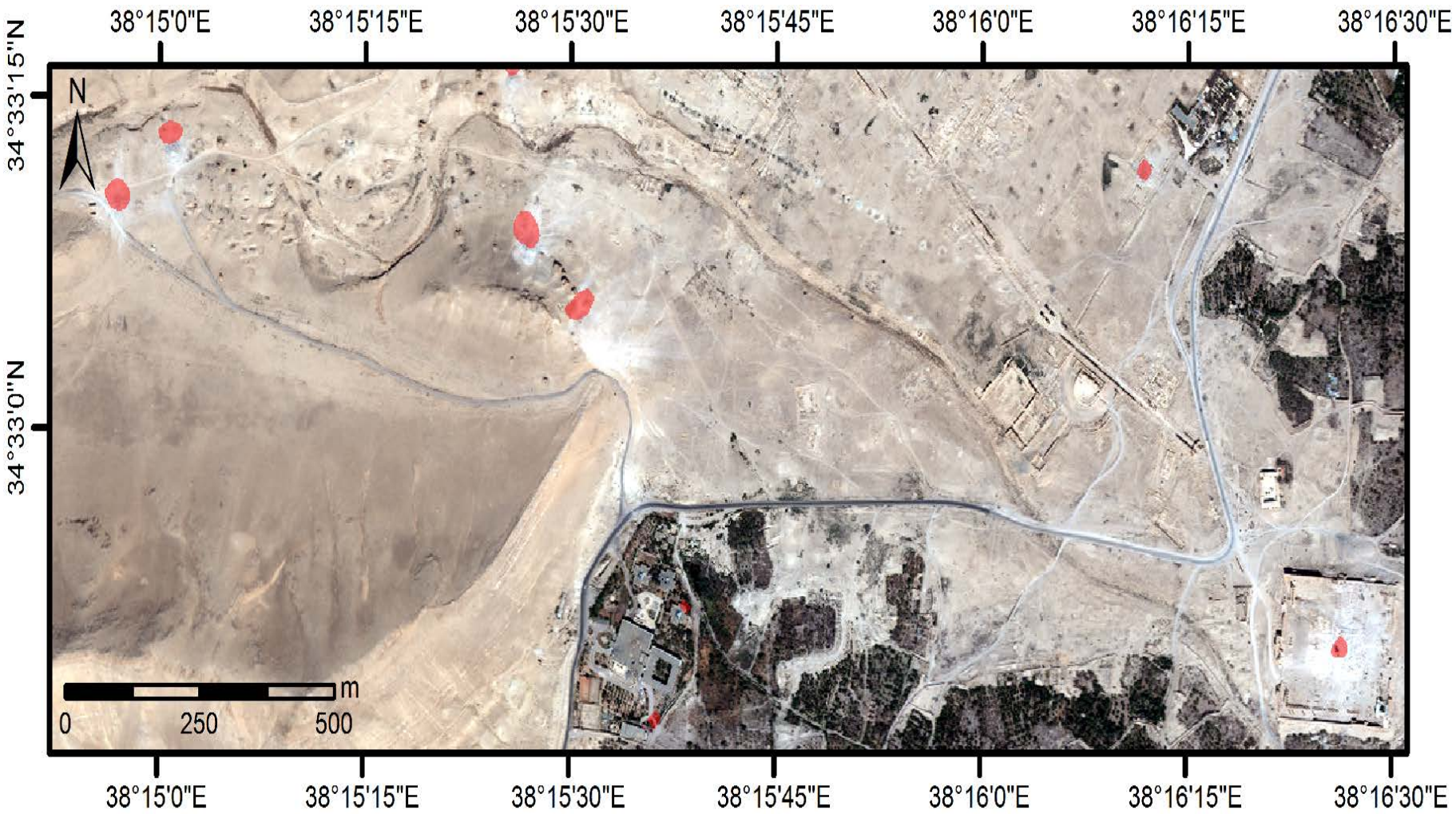
# Palmyra – Baalshamin Temple: destroyed by IS (24.08.2015)

Image: Google Earth
Date: 20th February 2014



Image: WorldView-2
Date: 2nd September 2015

# Detected Damages (from 02-2014 to 09-2015)




# Validation (ASOR*, 3.09.2015)

*American School of Oriental Research

http://www.asor-syrianheritage.org/special-report-update-on-the-situation-in-palmyra

# Multitemporal Damages

# **ATHENA:** a funded project under the H2020-TWINN-2015

**Thank you!**

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