

# 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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Knowledge for Tomorrow





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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



CHALCHICOMULA!



Alunite



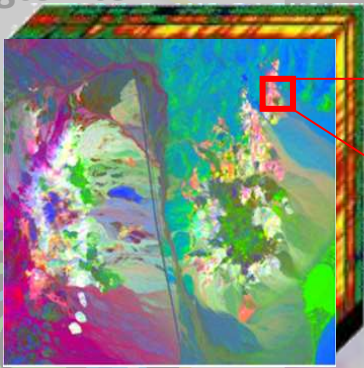
Chalcedony



# Hyperspectral



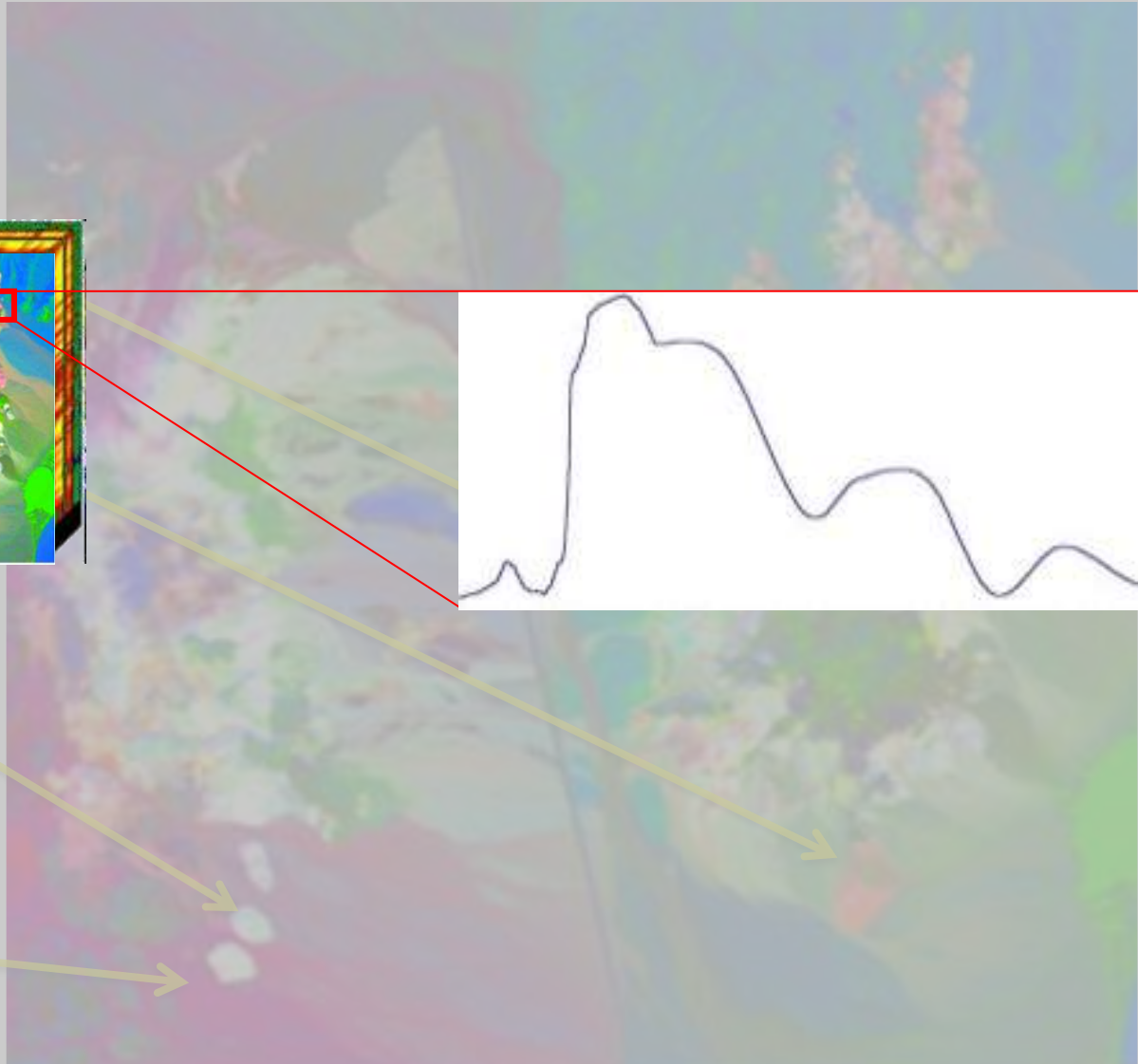
Buddingtonite



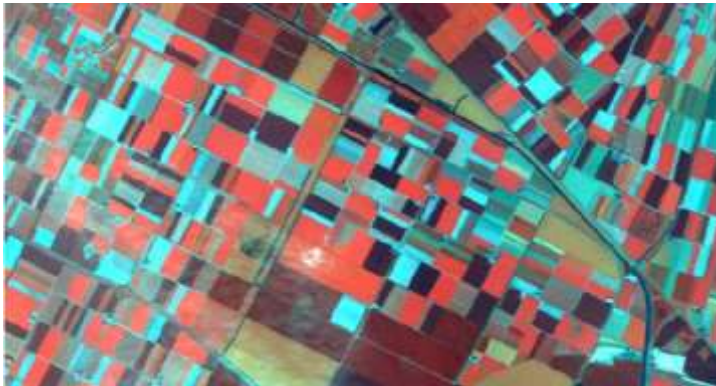
Alunite



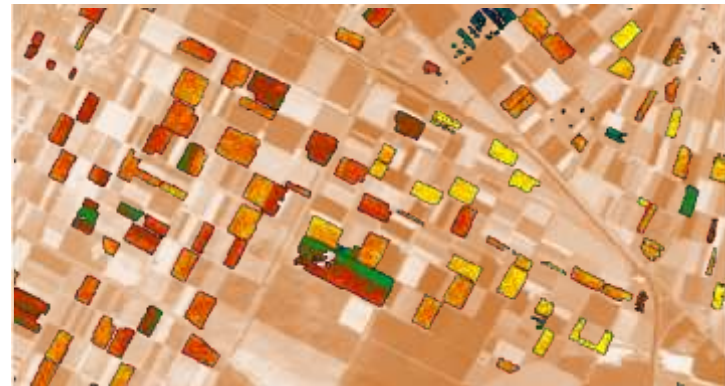
Chalcedony



# Vegetation Health Analysis



Crops (False Color Composite)



Health Status of Potato Fields



# About Vegetation Health: Crop Marks

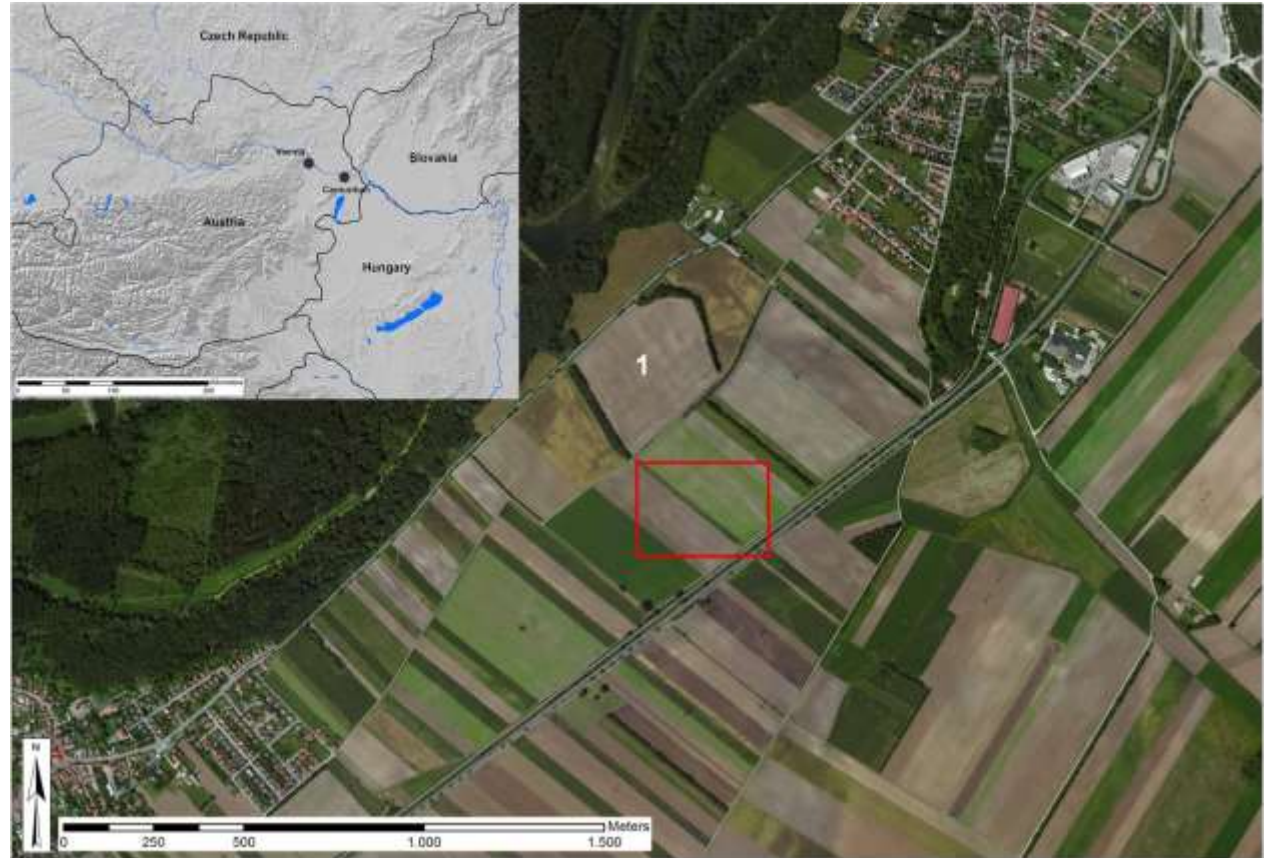


Evident crop marks in Grezac, France  
RGB True Color Composite  
(source: wikipedia)



# 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

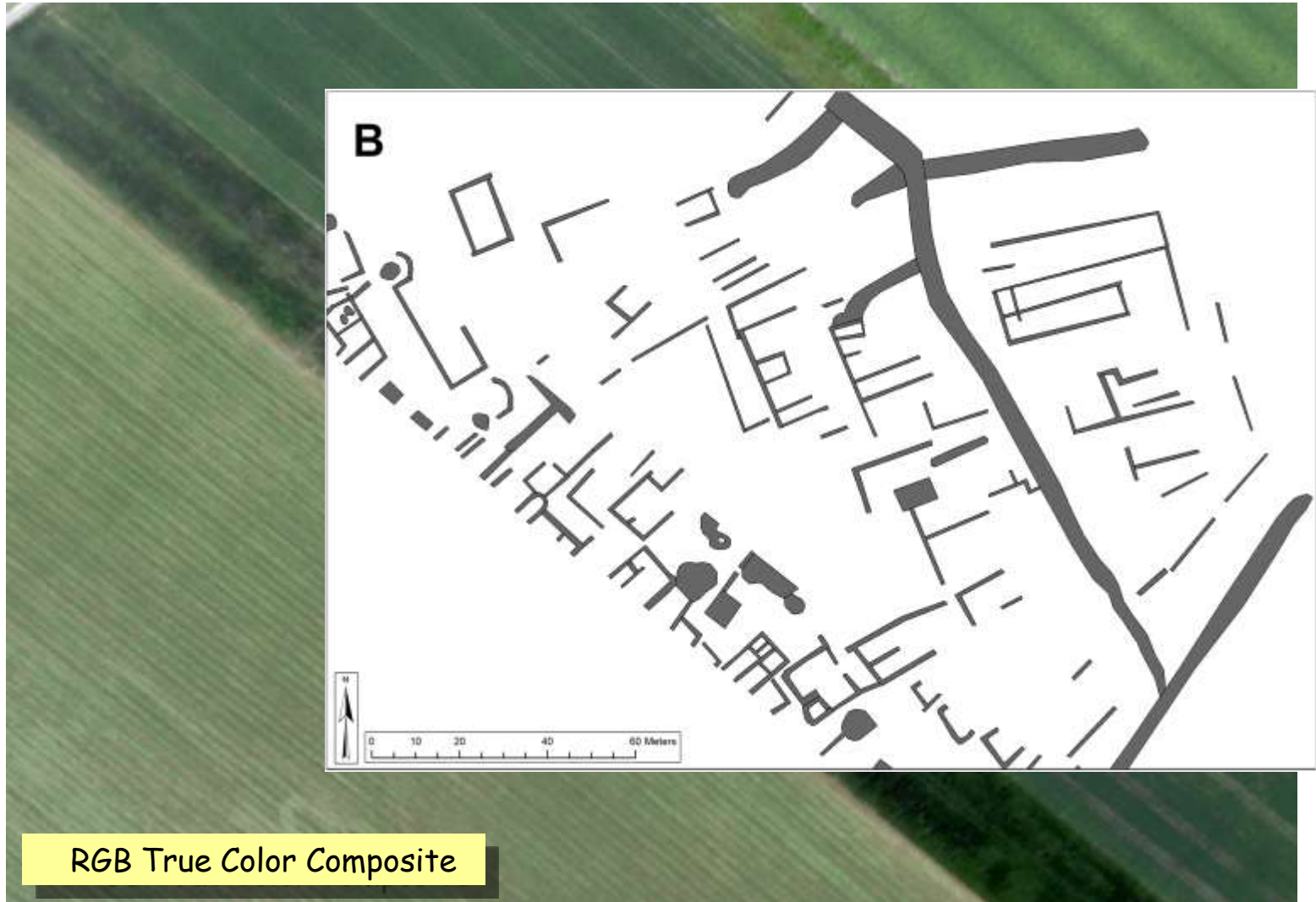


Michael Doneus et al., „New ways to extract archaeological information from hyperspectral pixels“, Journal of Archaeological Science, Volume 52, December 2014



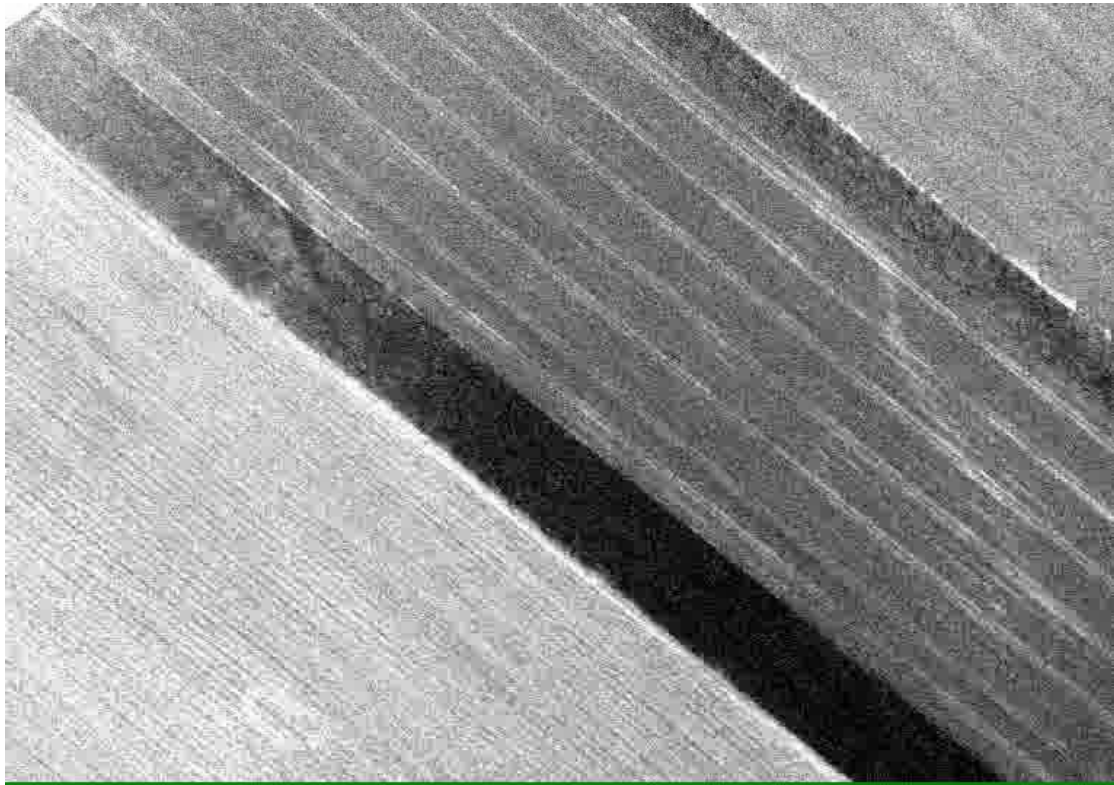


# Not always that easy...



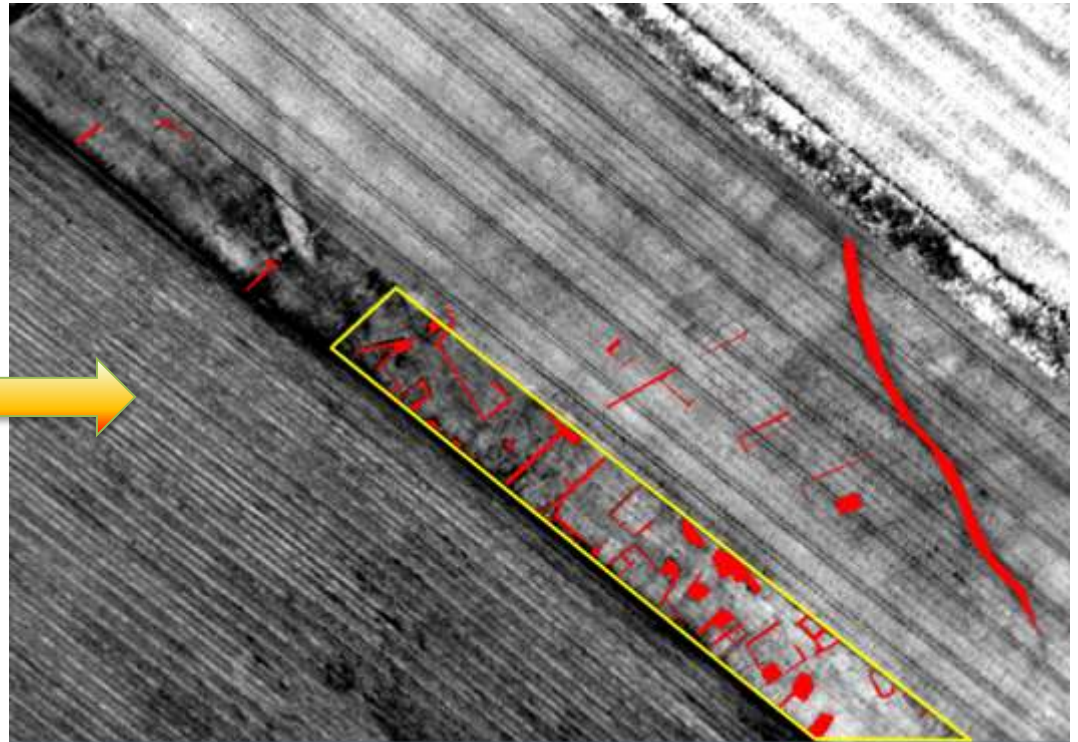
# Which band is better?

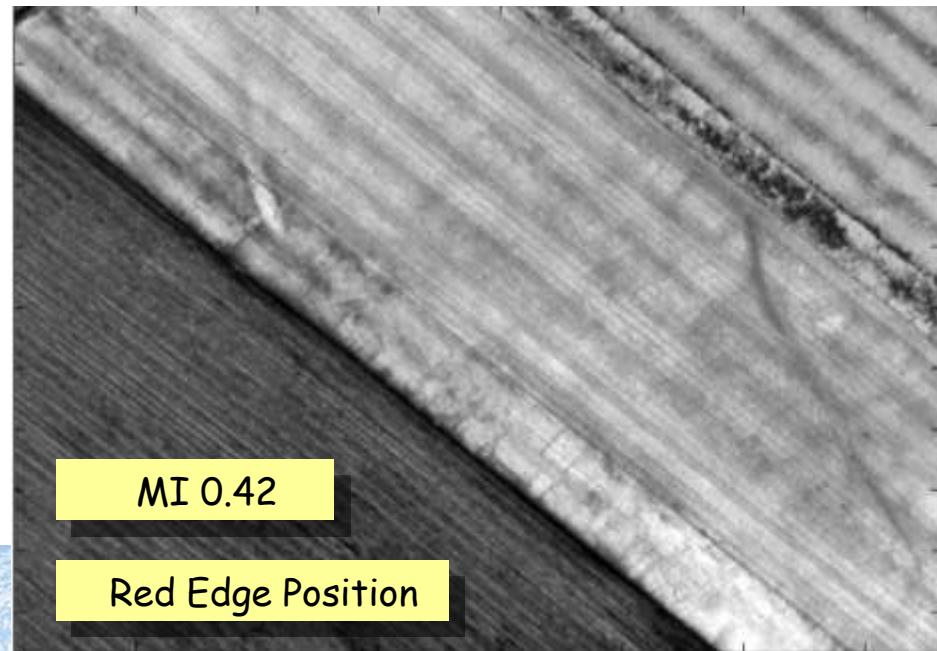
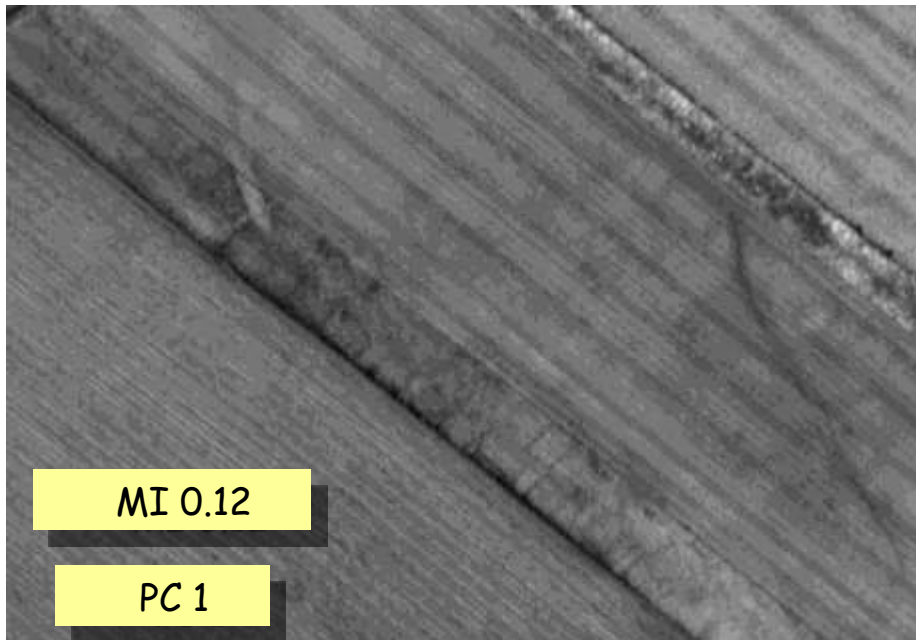
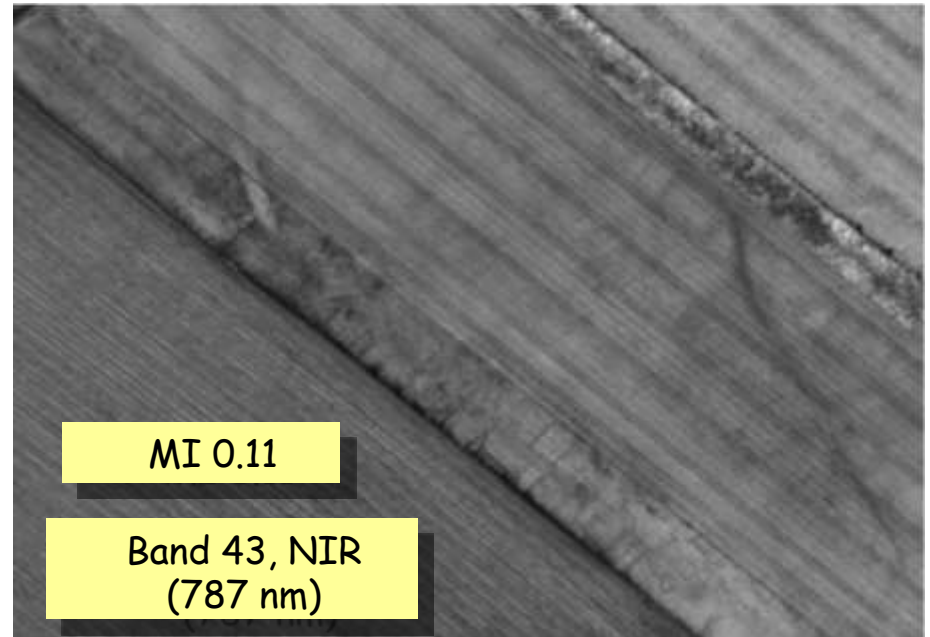
- Let's have a look at all available bands...



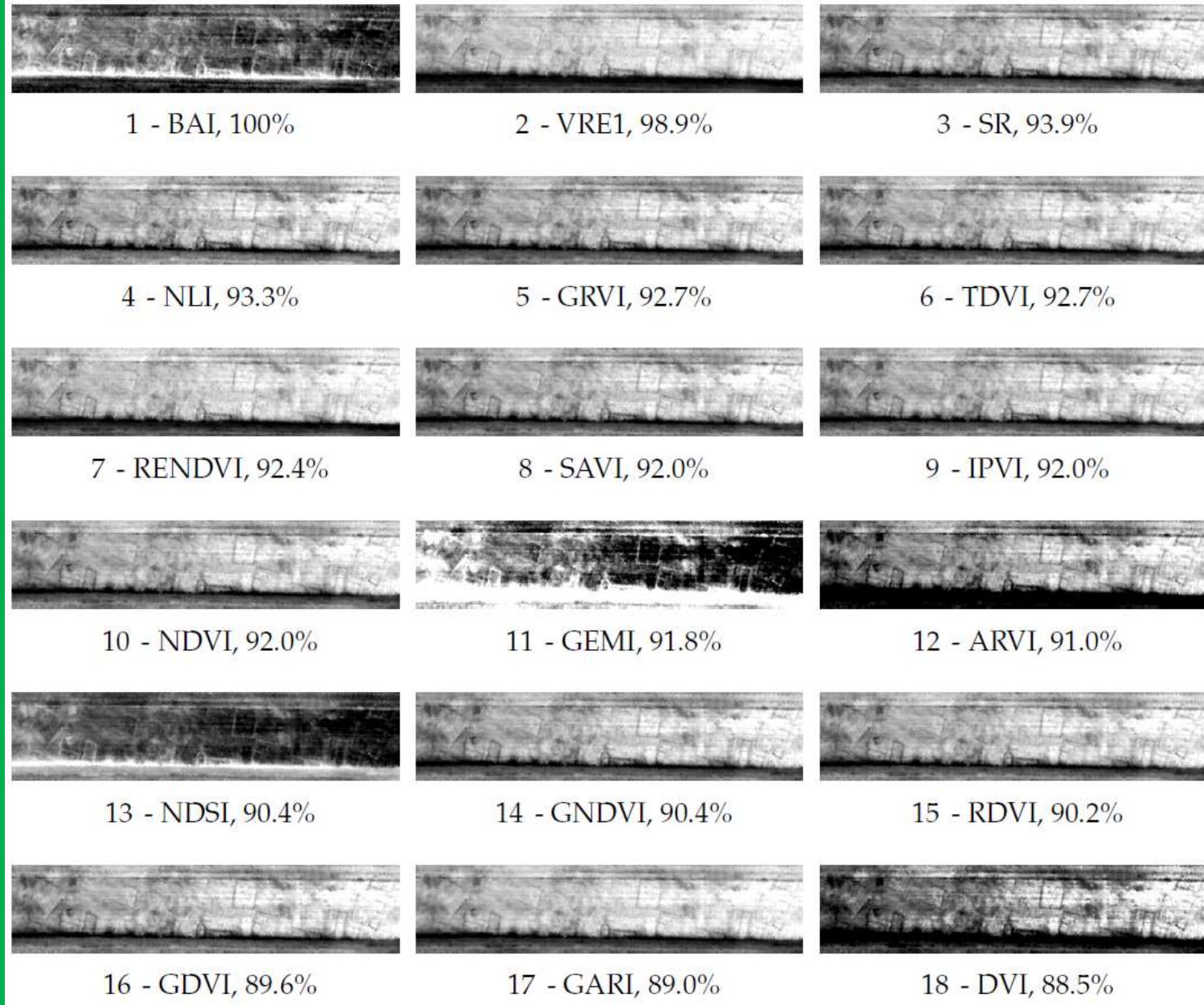
# Mutual Information

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

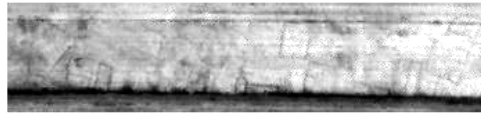




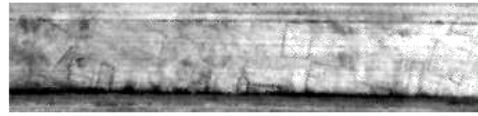
# Ranking of several spectral indices for archaeological research purposes



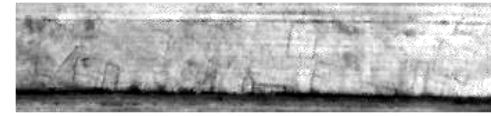
# Ranking of several spectral indices for archaeological research purposes



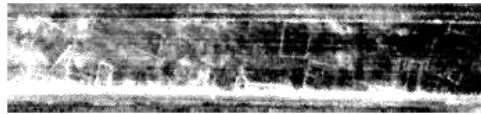
19 - MCARI2, 87.6%



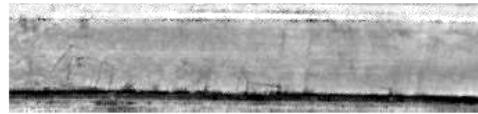
20 - MTVI, 87.0%



21 - TVI, 86.7%



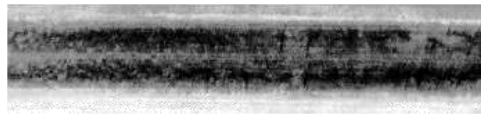
22 - EVI, 83.2%



23 - VARI, 79.5%



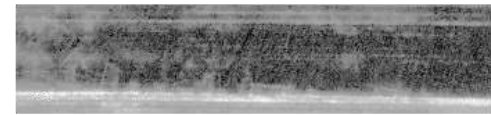
24 - NDMI, 66.1%



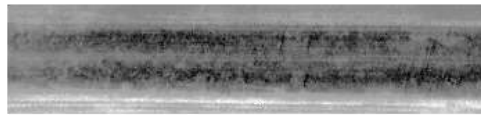
25 - CRI1, 59.9%



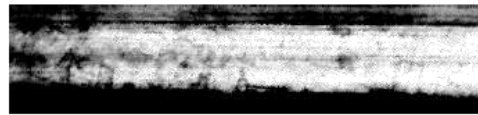
26 - ARI1, 54.0%



27 - PSRI, 52.7%



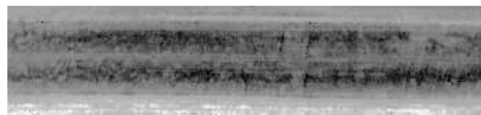
28 CRI2, 48.2%



29 - MRENDVI, 47.0%



30 - IronOxide, 37.1%



31 - MCARI, 36.2%



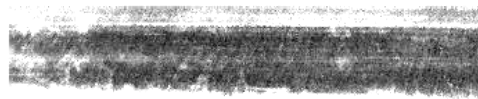
32 - TCARI, 35.9%



33 - SIPI, 33.6%



34 - SGI, 32.6%



35 - ARI2, 29.1%



36 - PRI, 20.4%

# Towards Automatic Monitoring of Endangered Cultural Heritage Sites

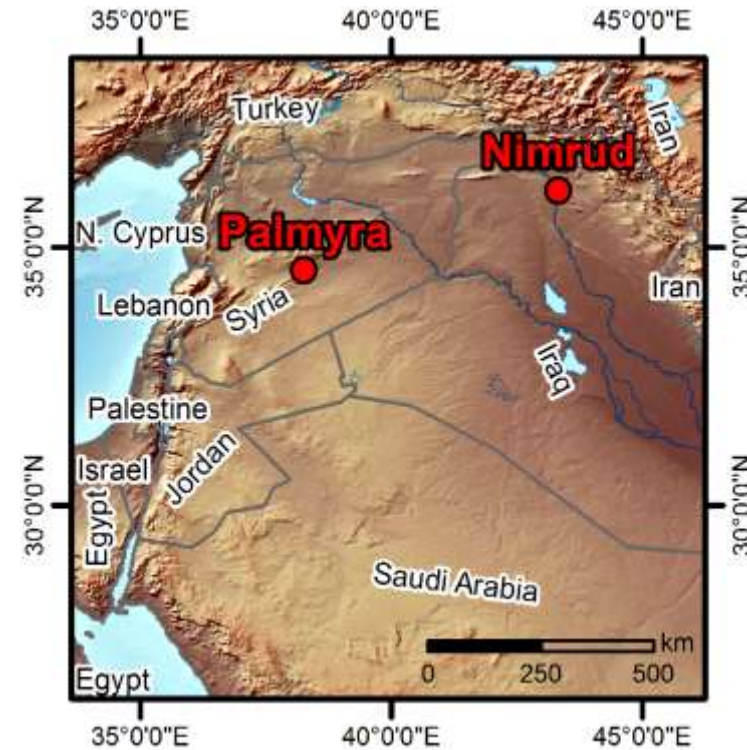
- Since spring 2015: Islamic State (IS) proclaims the destruction of cultural heritage sites, including Palmyra (Syria) and Nimrud (Iraq)

- 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)

Pre-Event (Image: WorldView 2, Date: 27. August 2015)



Post-Event (Image: WorldView 2, Date: 02. September 2015)





# Motivation



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



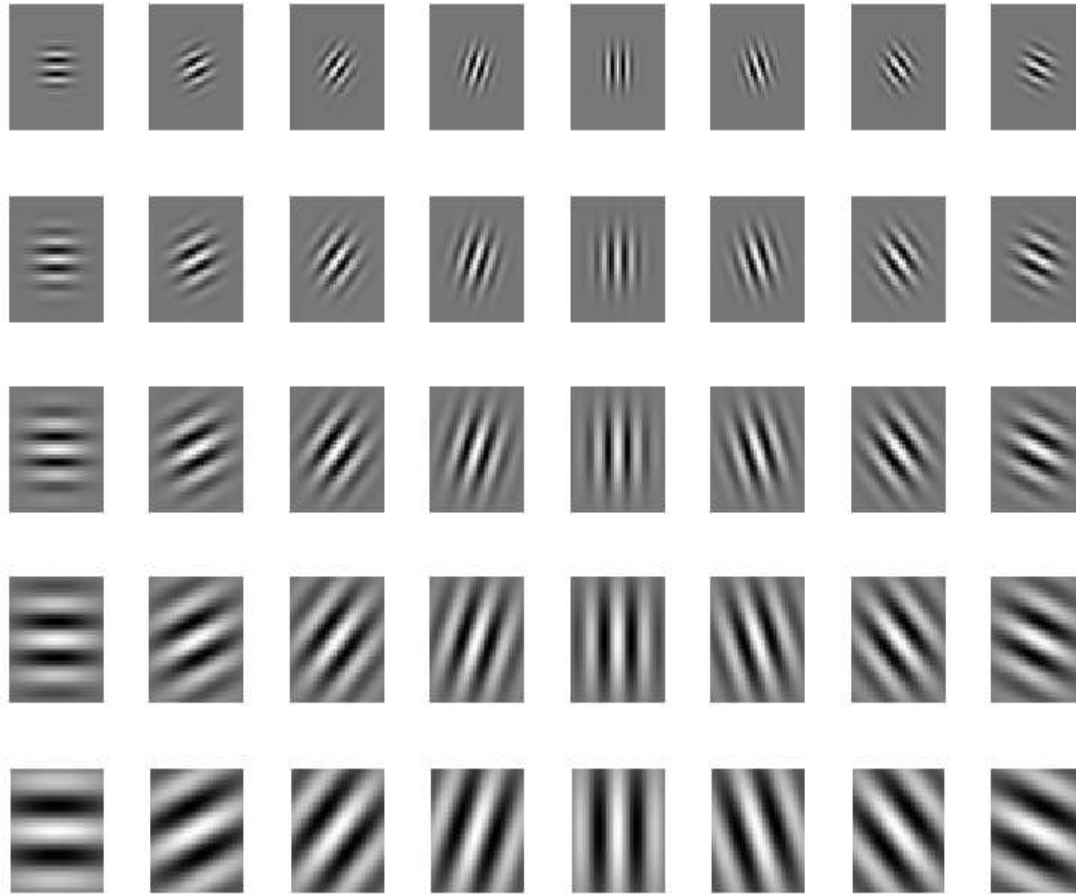
Would it be possible to help experts by providing automatic maps in which damages are likely to have occurred?



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



# Gabor Texture Features



Selected filter bank



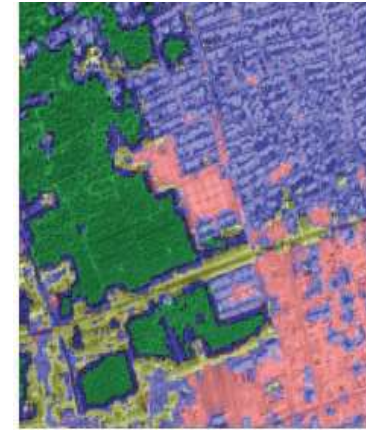
# Texture Classification: Example



Bam, Iran,  
suffered an  
earthquake in  
2003



IKONOS image  
acquired in the  
aftermath of the  
earthquake



Vegetation  
Destroyed Buildings & Open Areas  
Roads & Very Small Buildings  
Intact Buildings

Classification obtained on  
the basis of the texture  
parameters only



# Palmyra, Syria



Temple of Bel



Tower Tombs



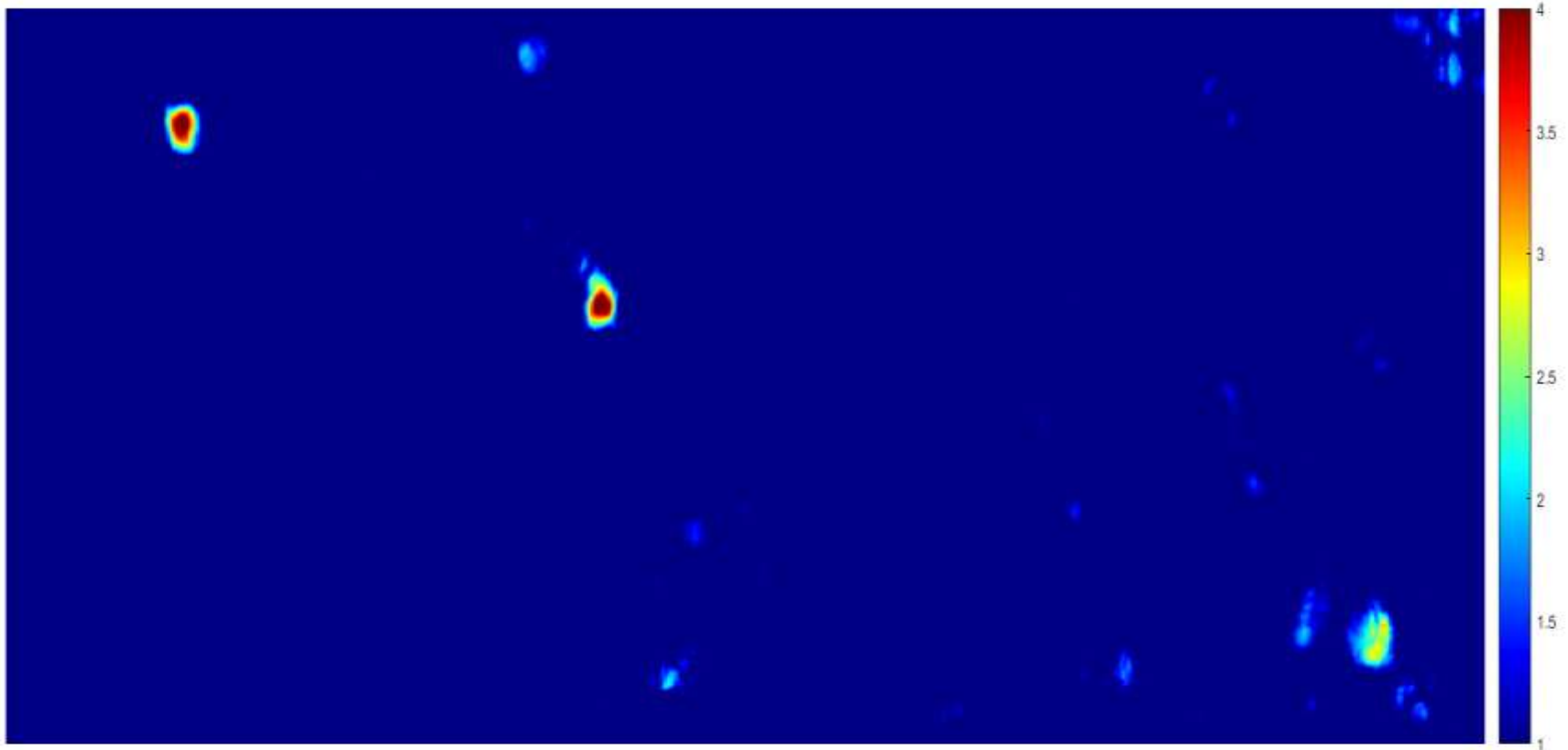
# WorldView-2 Pre-Desaster Image



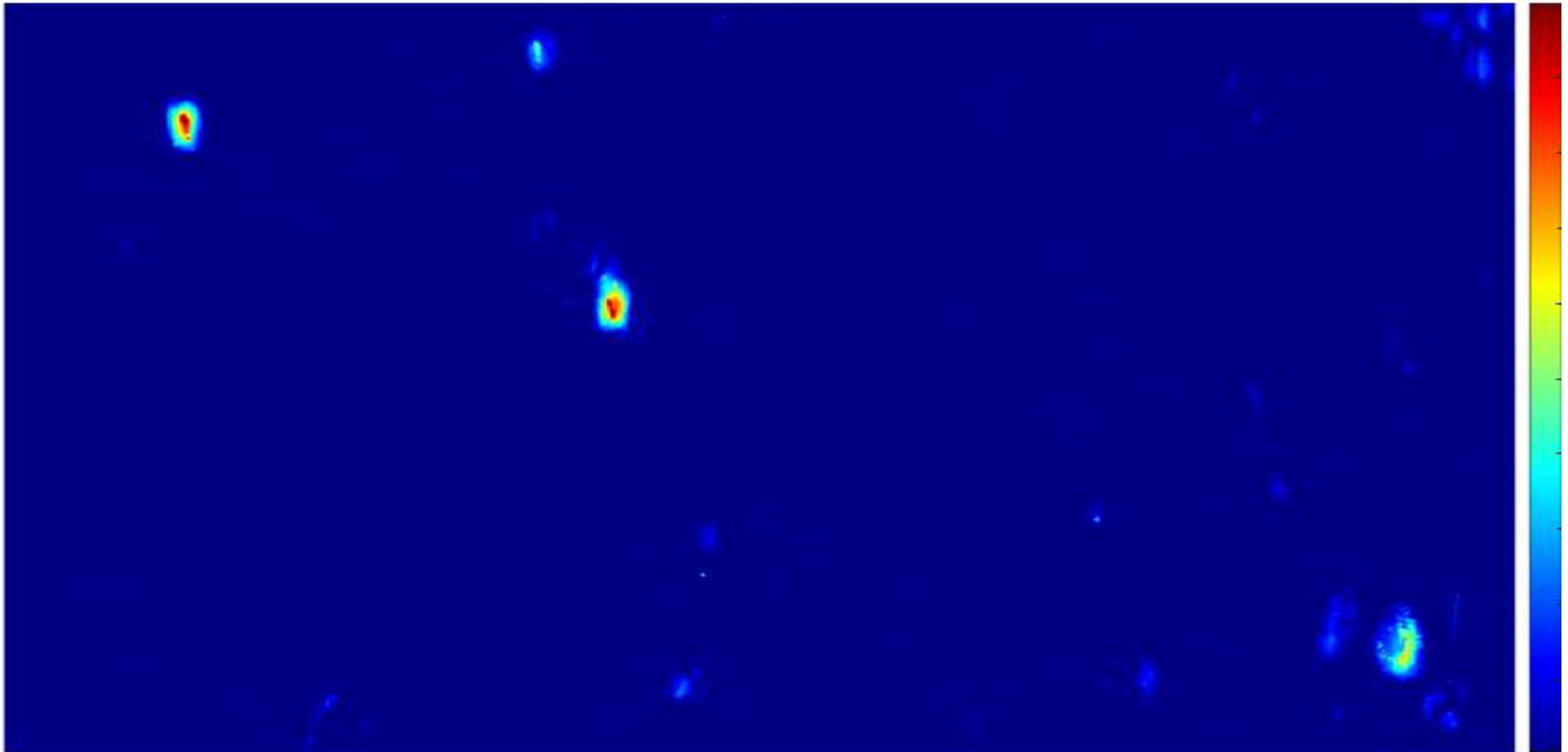
# WorldView-2 Post-Desaster Image



# Palmyra: Difference of Gabor Features (based on texture values)



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





# Detected Damages



# Detection of Damaged Areas



# What about previous damages? Google Earth image 20 02 2014



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



Image: Google Earth  
Date: 20<sup>th</sup> February  
2014

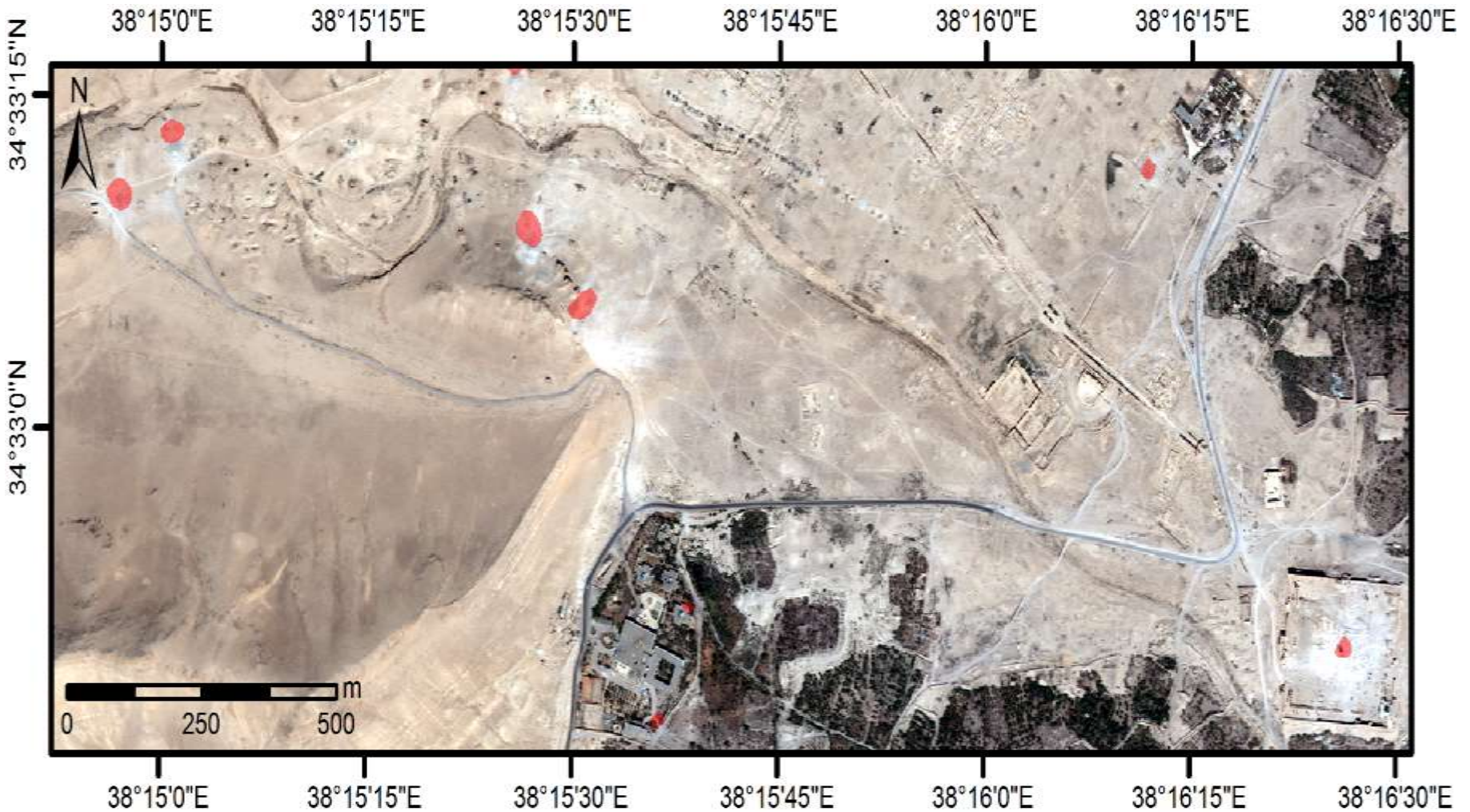


©European Space Imaging / DigitalGlobe

Image: WorldView-2  
Date: 2nd September  
2015



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



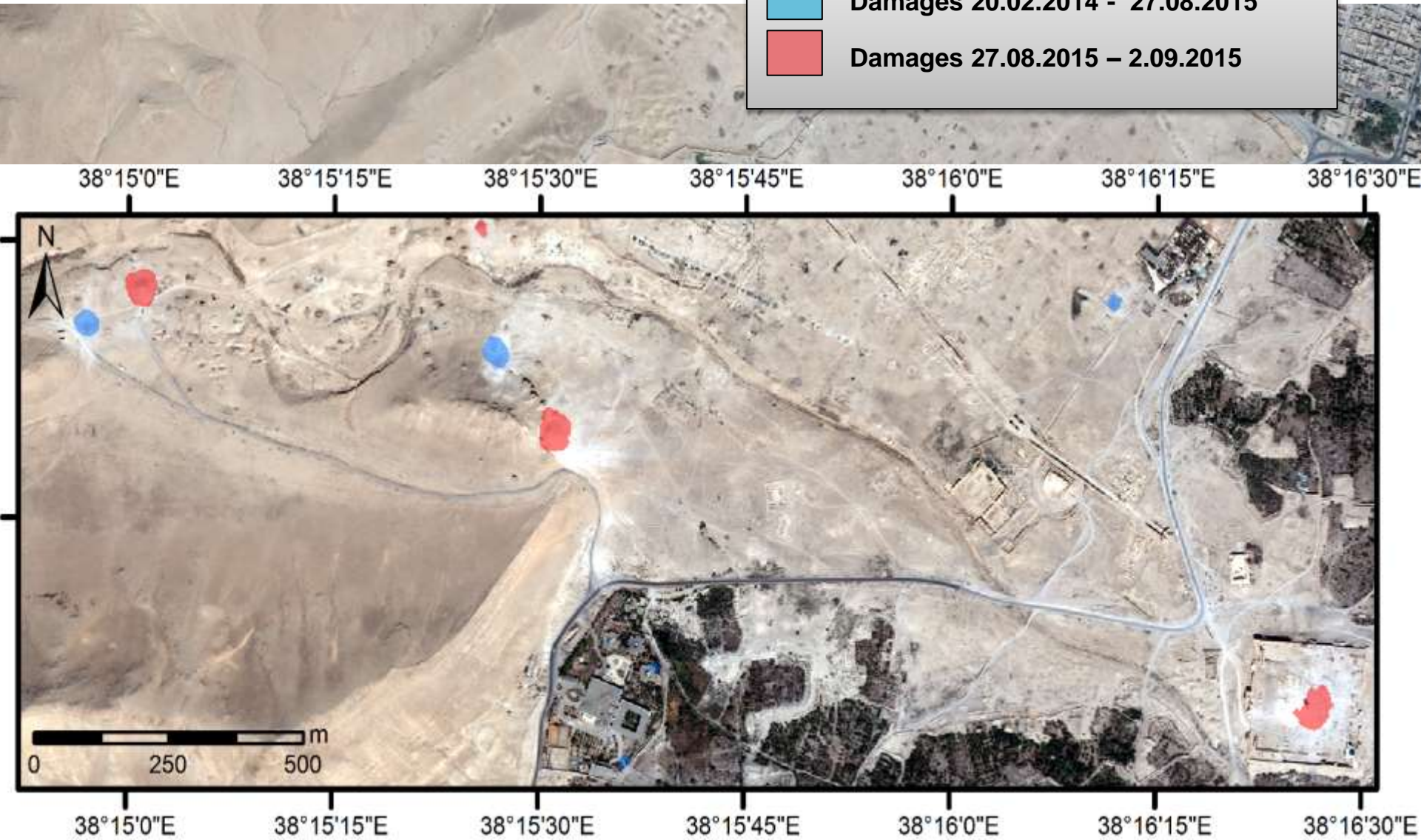
# Validation (ASOR\*, 3.09.2015)

\*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!

