COPERNICUS FOR CULTURAL HERITAGE

CASES OF STUDY AND PERSPECTIVES FROM GERMANY

Copernicus for Cultural Heritage Summer School Workshop, Rome, 13.06.2023

Daniele Cerra, Gunter Schreier, Thomas Krauss, Benjamin Ducke

Wildfires

Understanding the Impacts of the October 2017 Portugal Wildfires on Cultural Heritage

by Rui Figueiredo [1,*], Esmeralda Paupério [2] and Xavier Romão [1]

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Heritage **2021**, *4*(4), 2580-2598; https://doi.org/10.3390/heritage4040146

Figure 1. Map of the estimated burnt areas relative to the October 2017 wildfire, locations of protected and archaeological assets within the Copernicus Area of Interest (with larger icons indicating assets overlapping burnt areas), and names of the municipalities with potentially affected cultural heritage assets.

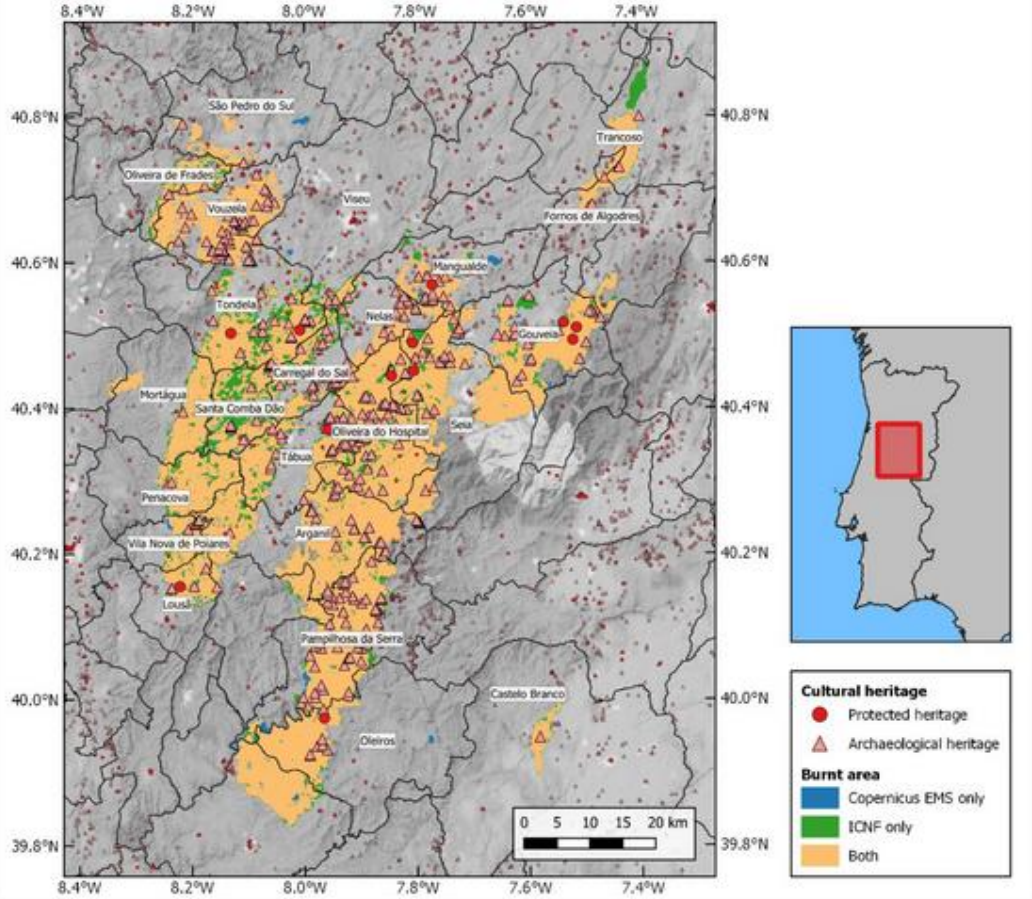
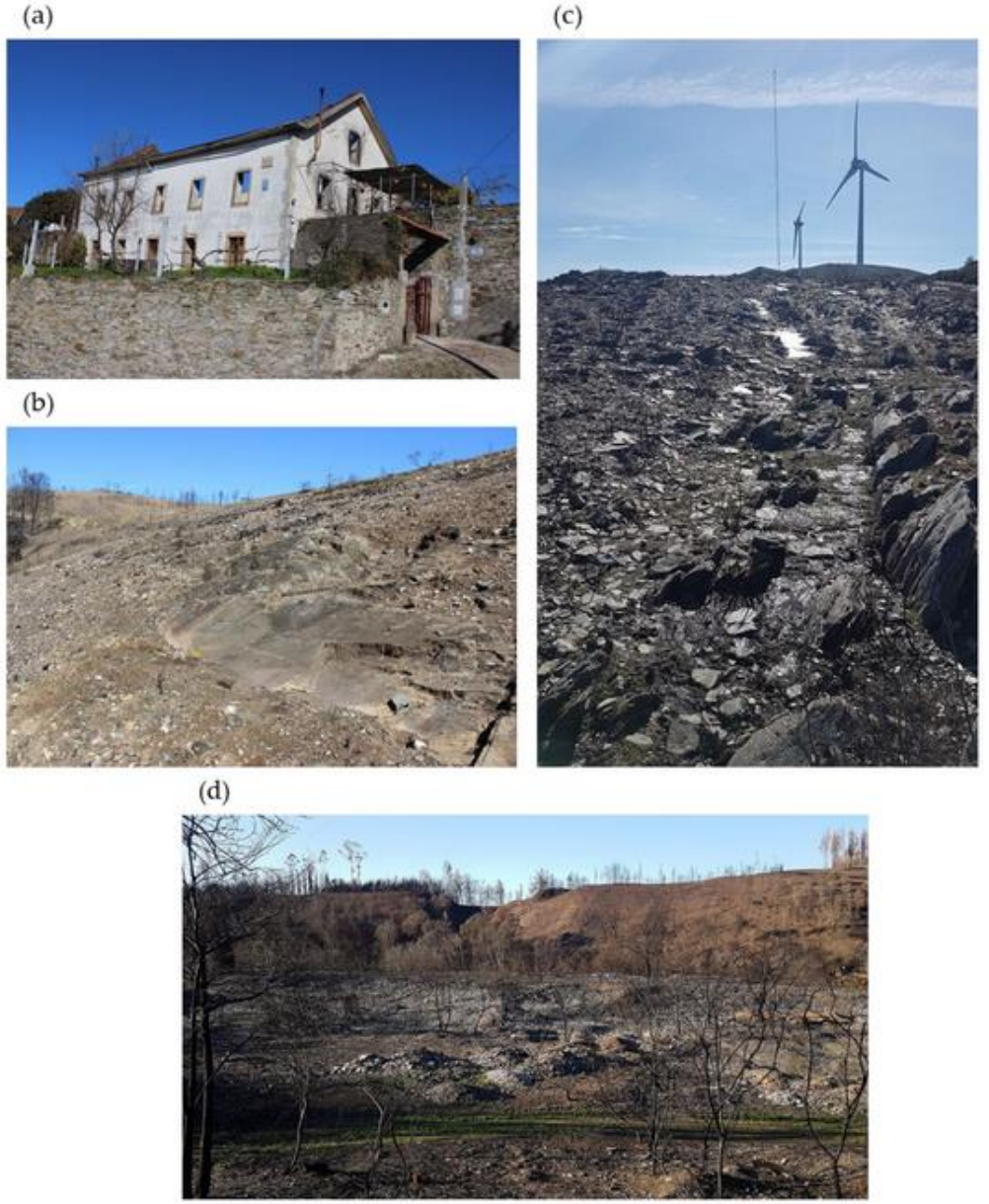


Figure 3. Photographs of some of the cultural heritage assets affected by the October 2017 fire in the municipality of Arganil: (**a**) House with coat of arms in the parish of Cerdeira e Moura da Serra, which was heavily damaged by the fire; (**b**) Rock art in the parish of Benfeita; (**c**) *Estrada Real* medieval road; (**d**) *Conheira* (heaps of pebbles related to alluvial gold mining).

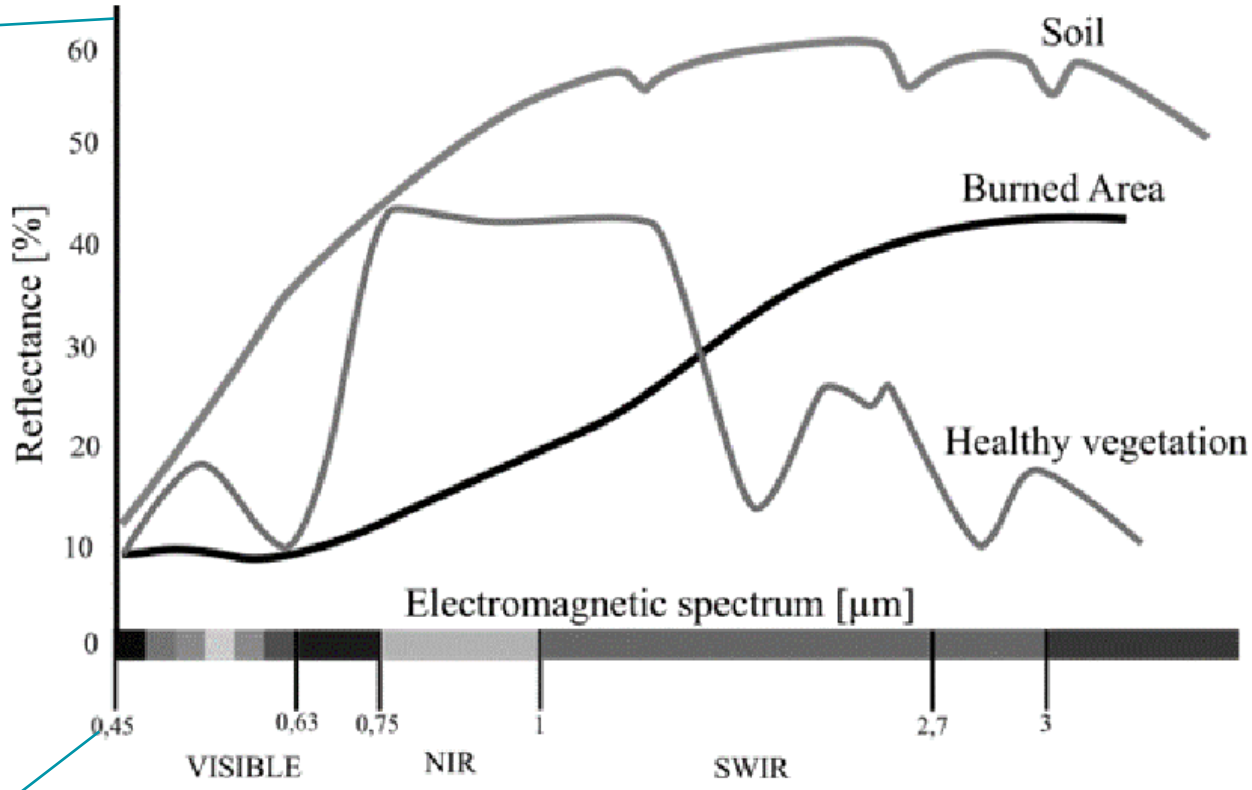


Case of study – the Arapakas Fire, Cyprus

- 3.07.21
- The total burnt area estimated (local authorities) ~45 Km2
- 10 Evacuated villages
- 13 Endangered CH sites
- 4 dead

TRTworld.com

Burned Areas Spectral Features

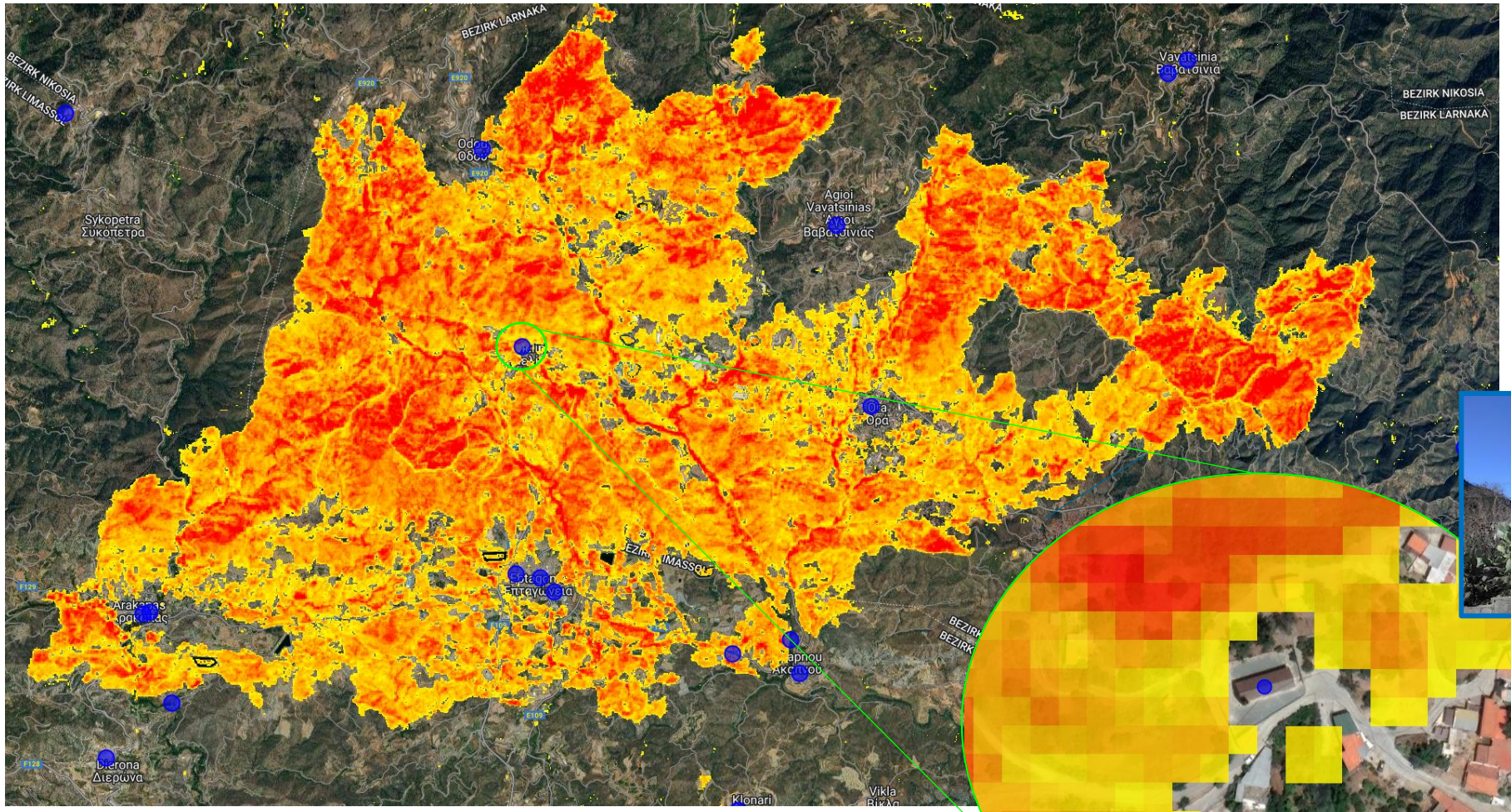


Adapted from Anna Szajewska & Miguel Castillo Soto

According to the Department of Antiquities, 13 cultural heritage sites in the extended region of the fire

Agios Georgios
Profitis Elias
Profitis Elias
Agia Marina
Agios Georgios
Church of Panayia
Agie Anargiri
Panayia Chryseleoussa
Agia Marina
Panayis tis Agapis
Timiou Stavrou
Agios Georgios
Agia Marina
Agios Fotios & Anikitos
Monasteri of Panayias Iamatikis
Panayia Iamatikis
Panayia tou Kampou
Akapnou Bridge
Kimiseos tis Theodokou
Dierona water mill
Dieronas Ancient Bridge
Agios Georgios
Churchiof Archangelou Michael
Agios Nicolaos
Panagia Parsata
Panayia Eleoussa

Cyprus: Sentinel-2 detection of burned areas in proximity of CH sites



Differential Normalized Burn Ratio

Παναγία Χρυσελεούσα, Μελίνη

No CH sites damaged

Detection of Damaged CH

unesco

Newsroom Explore UNESCO

Our Expertise Our Impact Ideas & Data Get I

Article ›

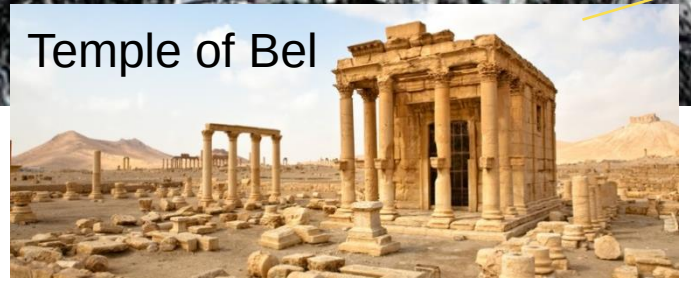
Damaged cultural sites in Ukraine verified by UNESCO

As of 17 March 2023, UNESCO has verified damage to 247 sites since 24 February 2022 – 107 religious sites, 20 museums, 89 buildings of historical and/or artistic interest, 19 monuments, 12 libraries.

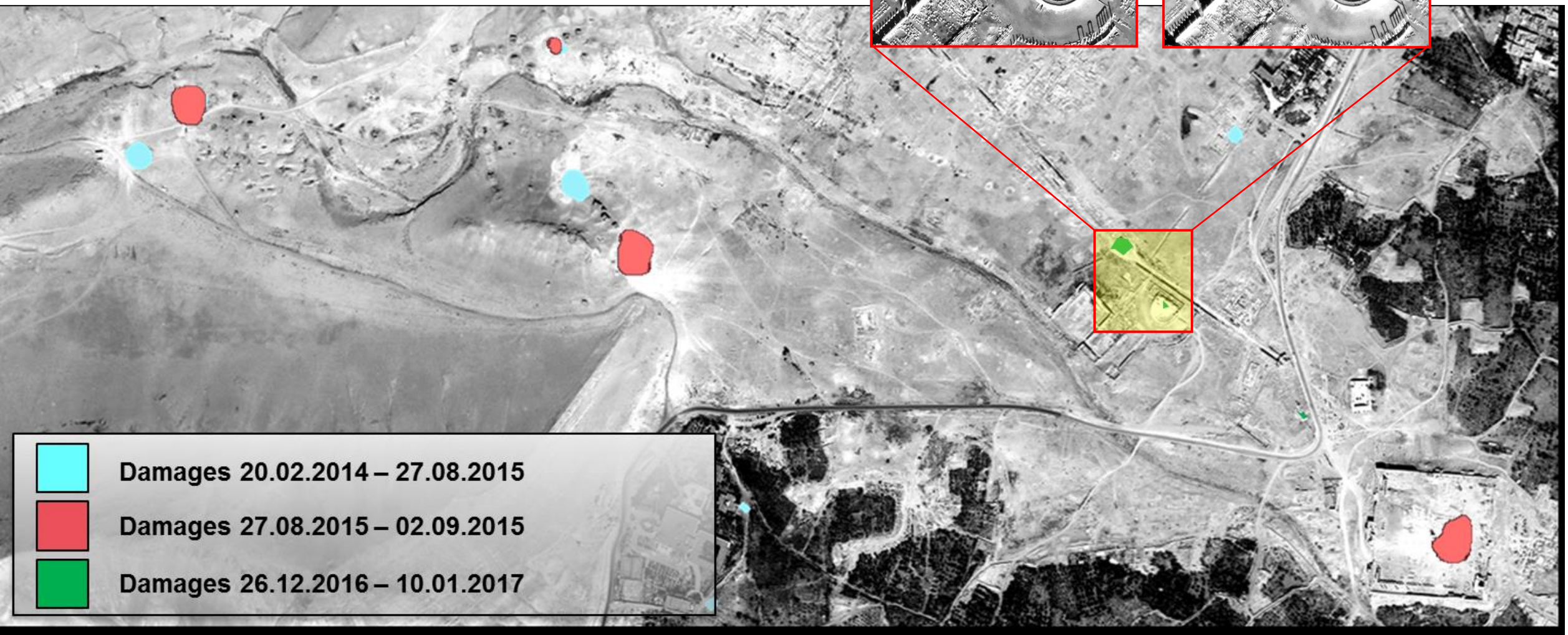
DLR

Palmyra:Detection of Damaged Areas

Cooperation with German Archaeological Institute (DAI)



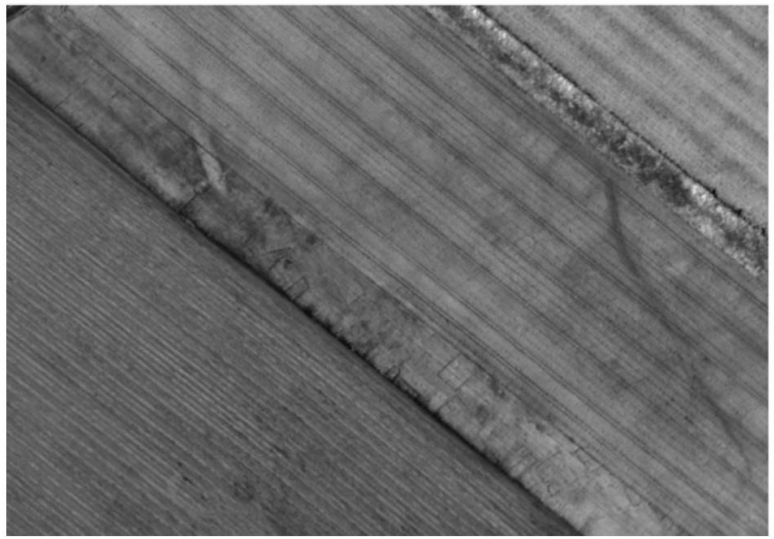
Palmyra: Multitemporal Study



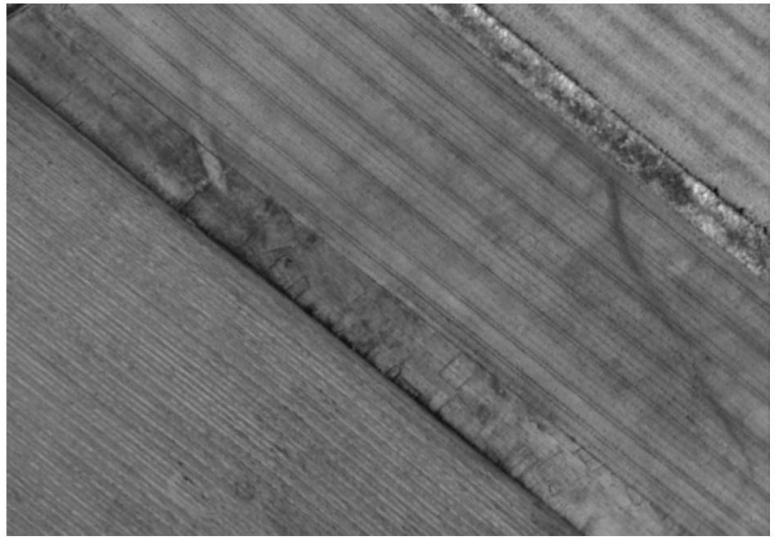
Crop Marks (hyperspectral analysis)

Buried roman houses and streets, Carnuntum (I century BC), Austria

1 - True Color Combination



2 - NIR band at 787 nm

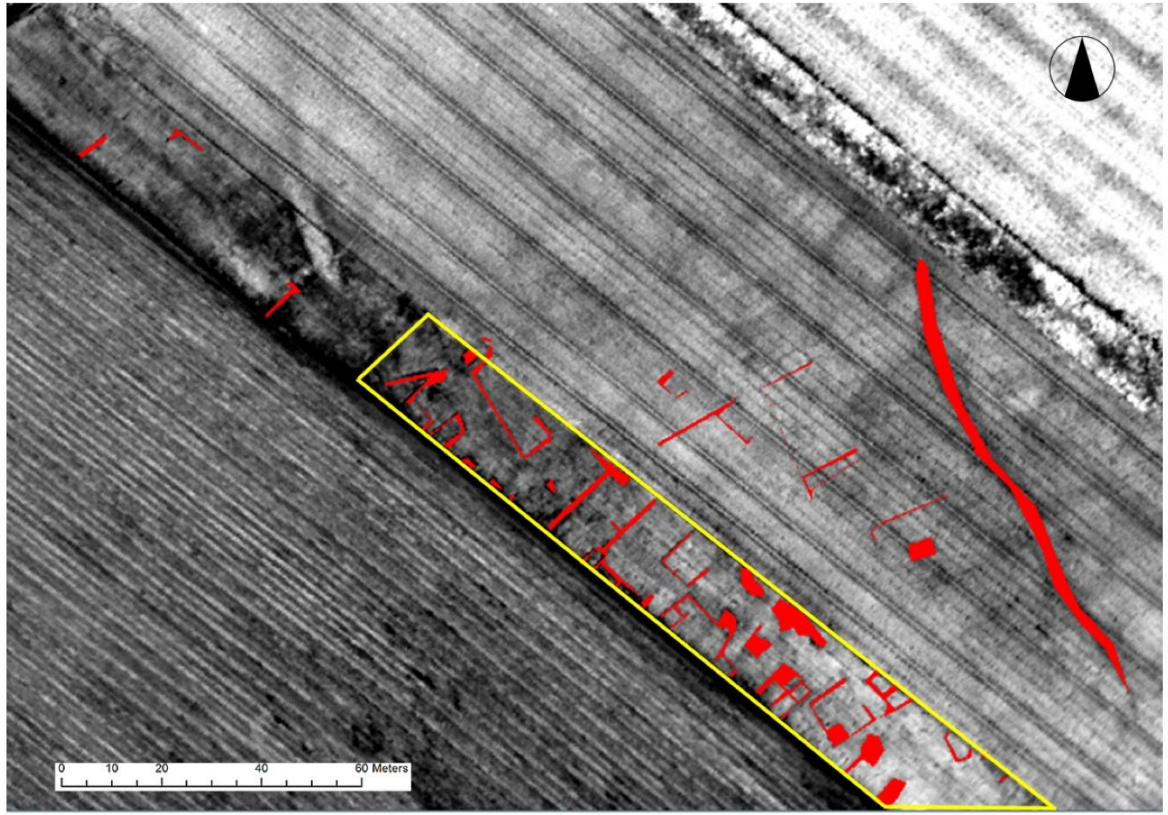


3 - PC 1

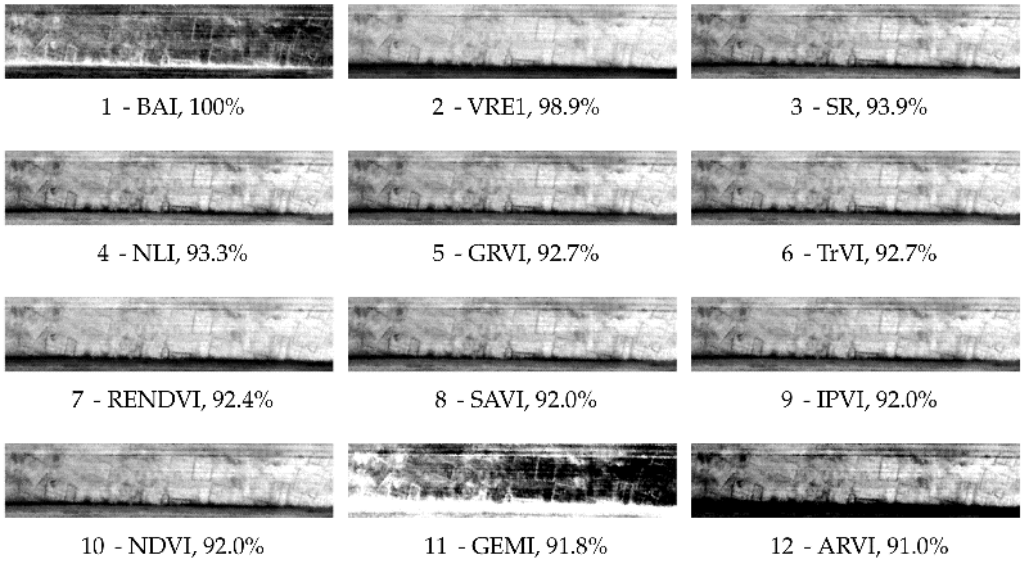
Cerra, D.; Agapiou, A.; Cavalli, R.M.; Sarris, A. An Objective Assessment of Hyperspectral Indicators for the Detection of Buried Archaeological Relics. *Remote Sens.* **2018**, *10*, 500. https://doi.org/10.3390/rs10040500

Crop Marks, best indices

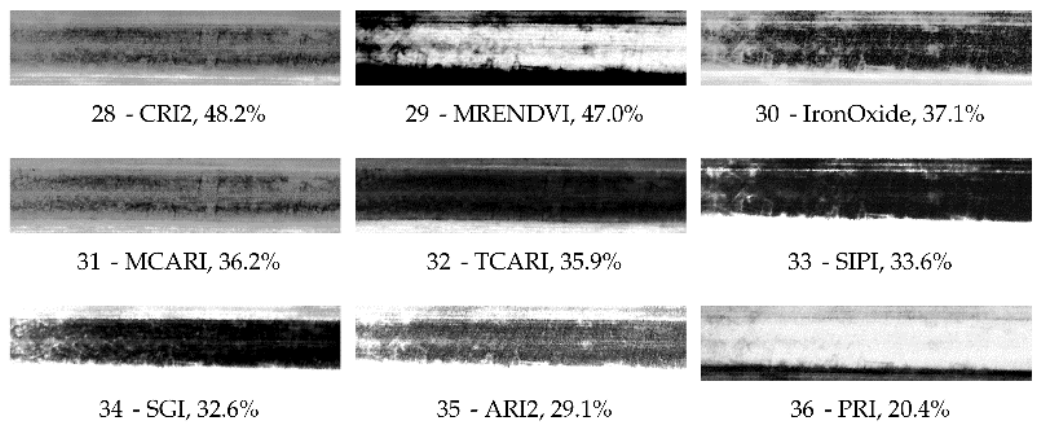
Spectral indices ranked according to mutual information

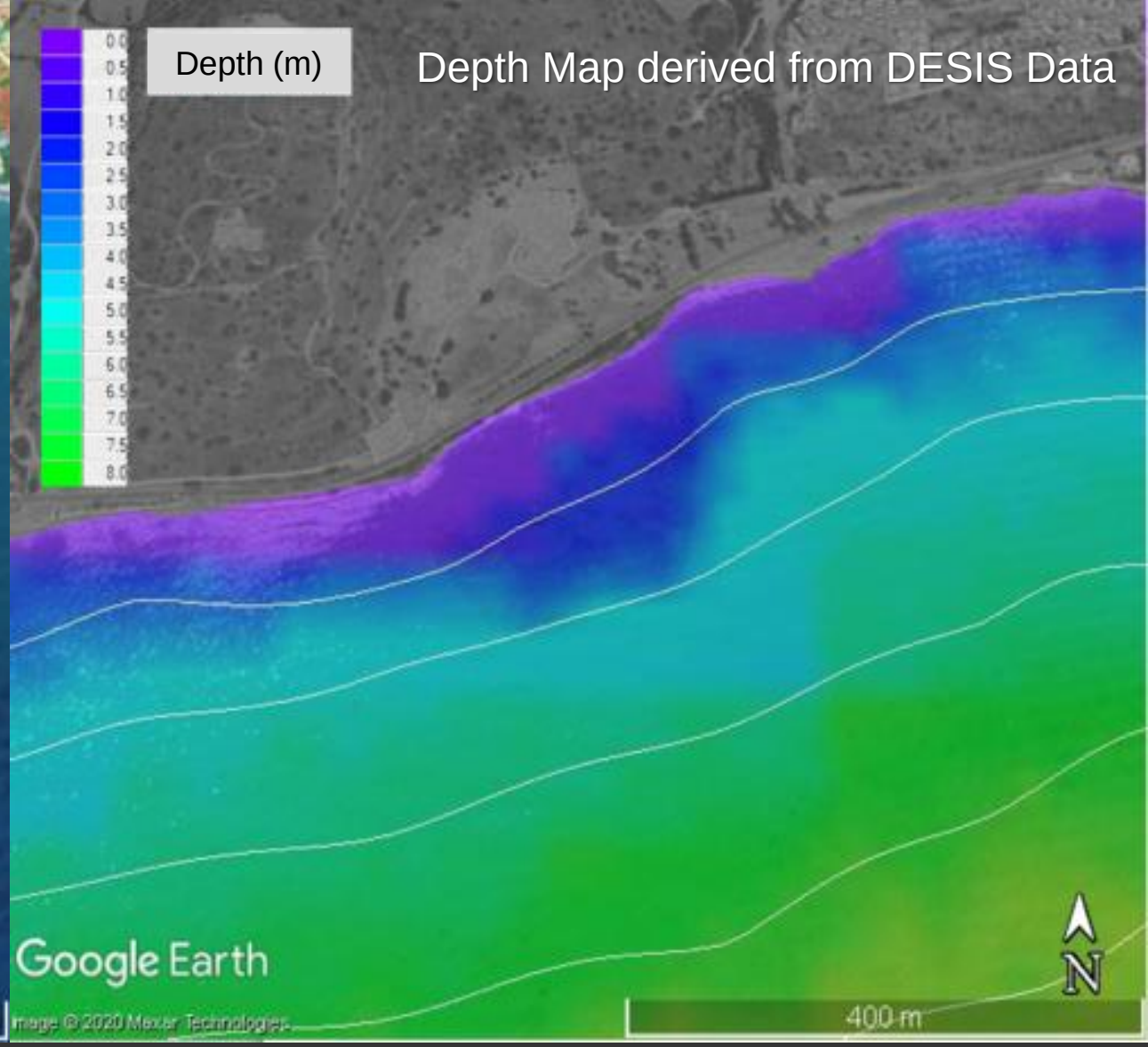


Best



Worst





The Submerged Amathus Harbor, Cyprus (1st century BC)

Risks of coastal erosion / water eutrophication

Hipponion Submerged Harbour

Renovated in 300 BC

Hosted half of Caesar's fleet during the Roman Civil War against Pompey

In use until 500 years ago

50 years ago (aerial photograph)

This bulwark disappeared

Vibo Marina, Italy

Google Earth

300 m

N

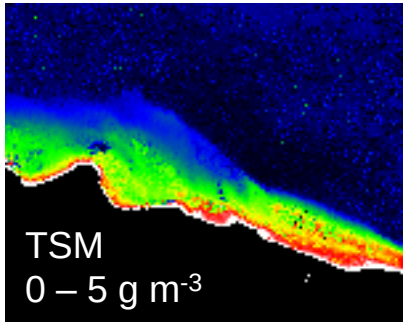
Hipponion Submerged Harbour

Renovated in 300 BC

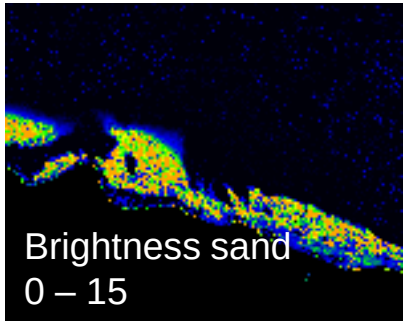
Hosted half of Caesar's fleet during the Roman Civil War against Pompey

In use until 500 years ago

Bathymetry
Estimated depth: 7m
Measured depth: 8m



Total Suspended Matter in Water



Risks: Coastal Erosion / Eutrophication

Google Earth

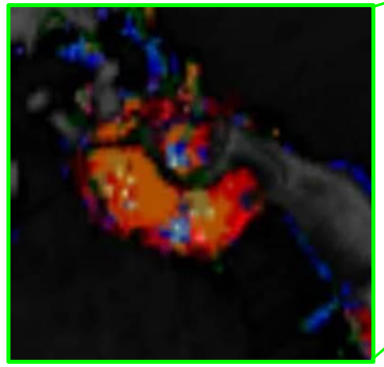
N

300 m

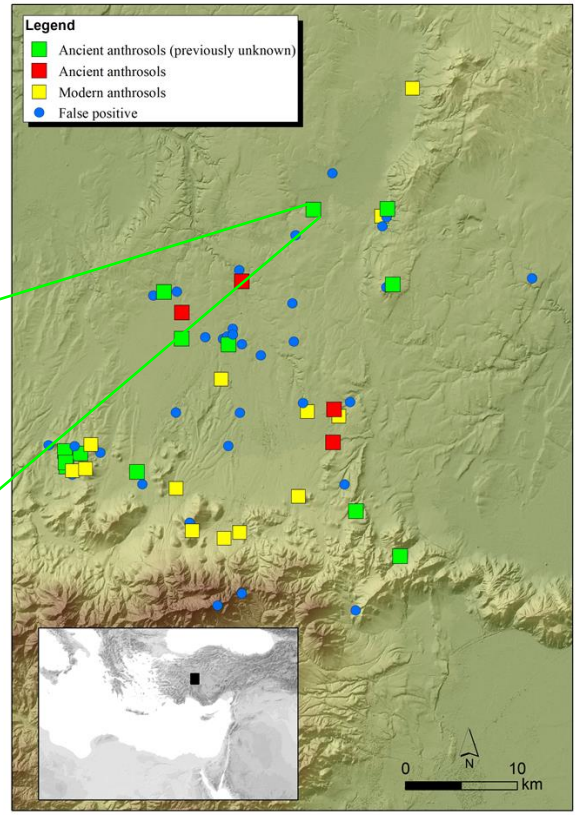
Landscape Archaeology: Mounds and archaeological areas around Konya, Turkey

Landscape Archaeology with DESIS (Konya, Turkey)

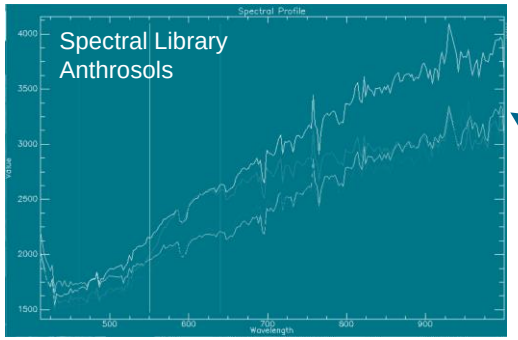
- **Anthrosols**: Anthropogenic soils characterized by a high level of organic content
- Result of dwelling for hundreds of years
- Several sites still unknown

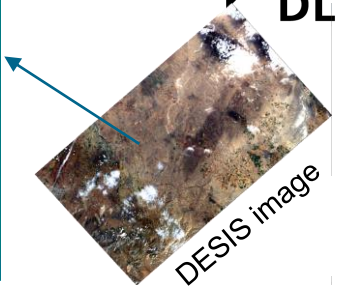


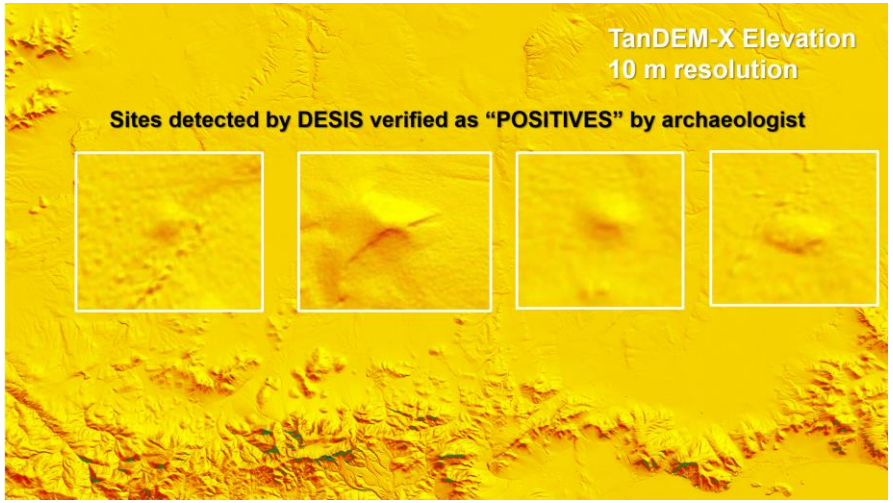
Probability of anthrosols



14 new discovered sites, Konya, Turkey
Verified by archaeologists (Univ. Chicago)





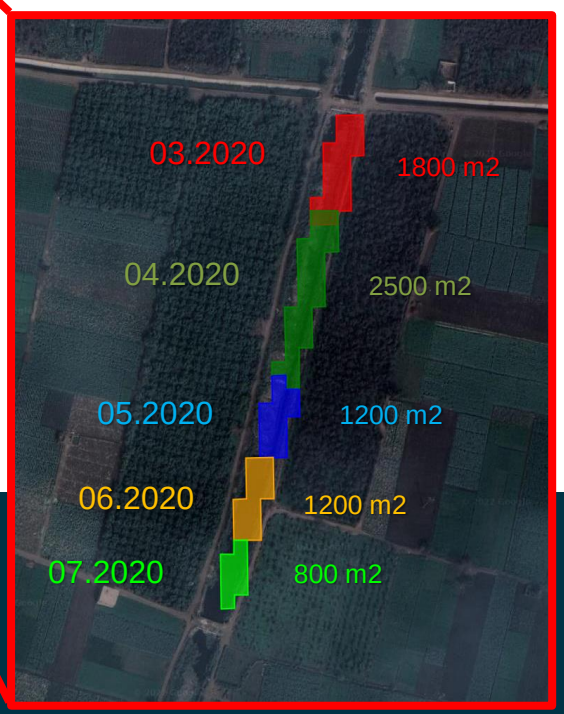


Additional Assessment using TanDEM-X

DESIS can provide an assessment of large areas for landscape archaeology by analyzing spectral signatures of soils

The produced maps can aid archaeologists in discovering previously unknown sites

Monitoring of Floating Plastic Debris Accumulation with Copernicus Data



Critical area automatically identified by spectro-temporal features

Consider proximity to CH sites

Example: dynamics of floating plastic debris

≈ 1 ha accumulated debris over 5 months, then released in July 2020

The TRIQUETRA Project

TRIQUETRA

TRIQUETRA proposes a technological toolbox and methodological framework for tackling CC risks and natural hazards threatening CH

- Cases of study include:
  - the island of Ventotene, Italy

  - Submerged sites of Roseninsel (Germany) and Argilliez (Switzerland)
    - Next slides

Remote sensing

- Sea level rise & water level mapping (AUTH & DLR)
- Coastal erosion (DLR)
- Land deformation & subsidence (ECOE& GSH)
- Tsunami risk mapping (NTUA)
- Flooding & storm surges risk mapping (DLR)
- Coastal algal blooming & eutrophication (GSH & DLR)
- Water quality hazards (DLR, ECOE)
- Snow & Ice coverage maps (DLR)

In-situ sensing

- Aerial, close-range & underwater photogrammetry (AUTH)
- Flash LiDAR bathymetry/altimetry (CSEM)
- Echo-sound bathymetry (DLR)
- Thermography (SUR)
- Passive seismic monitoring (SUR)
- Nitrates and Phosphates monitoring for algae blooming & eutrophication monitoring (UULM, ALPES)
- pH, temperature, turbidity, ions & O2 monitoring (CSEM)

Digital Twin, models & forecasts

- AR app based on 3D models (ECOE, GSH)
- Digital twin of CH sites (AUTH, NTUA)
- Downscaled climate models (AUTH)
- Geohazard & geophysical models (SUR)
- Risk modelling (damage functions) (NTUA)

Underwater invasive species

Lake Neuchatel, Switzerland

Roseninsel, Germany

- Several of 111 sites of the UNESCO World Heritage Site “Prehistoric Pile Dwellings around the Alps”

- Example: Les Argillez (CH)
  - Fully submerged pile dwelling (2 to 3 meters depth)
  - Covered by a layer of pebbles of anthropic and natural origin.
  - Dating suggests the construction of successive villages in the 4th millennium BC.
- Example: Roseninsel (DE), next slide

Les Argillez

TRIQUETRA

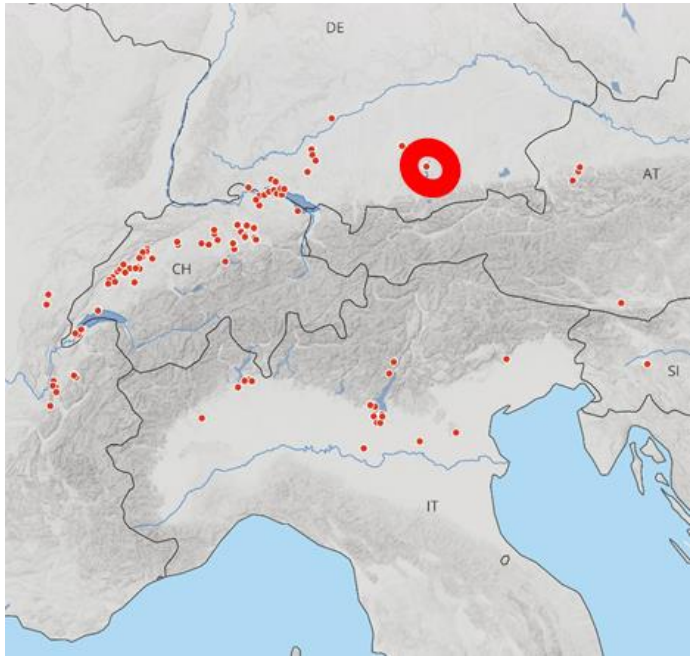
Toolbox for assessing and mitigating Climate Change risks and natural hazards threatening cultural heritage

BAYERISCHES LANDESAMT FÜR DENKMALPFLEGE

DLR

CL2-2022-HERITAGE-01-08 - Effects of climate change and natural hazards on cultural heritage and remediation

Roseninsel (Rose Island), Lake Starnberg, Bavaria, Germany



European Commission

Additional threat caused by climate change: drought
Causing wooden structures to be exposed - deteriorated

Quagga Mussels in lake Neuchatel
(underwater observations 2017-2022)

TRIQUETRA

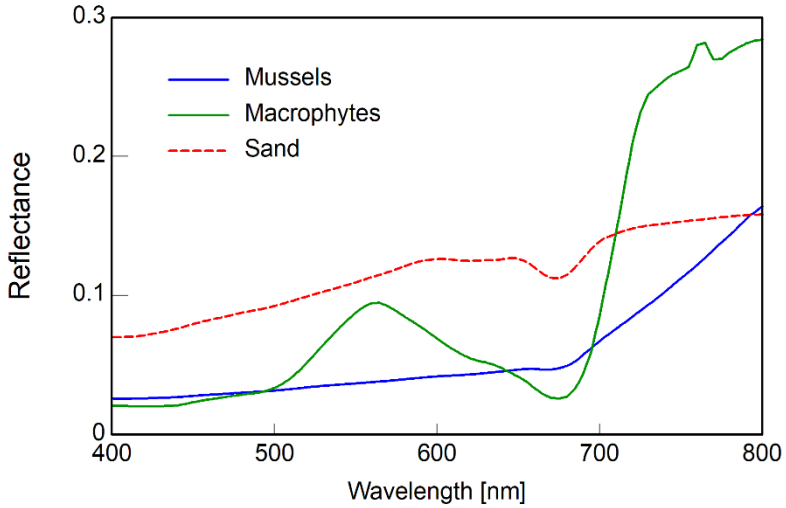
Lake Neuchâtel : Concise : 46.845022°, 6.716080°
Photos : © Fabien Langenegger (OPAN)

March 2017

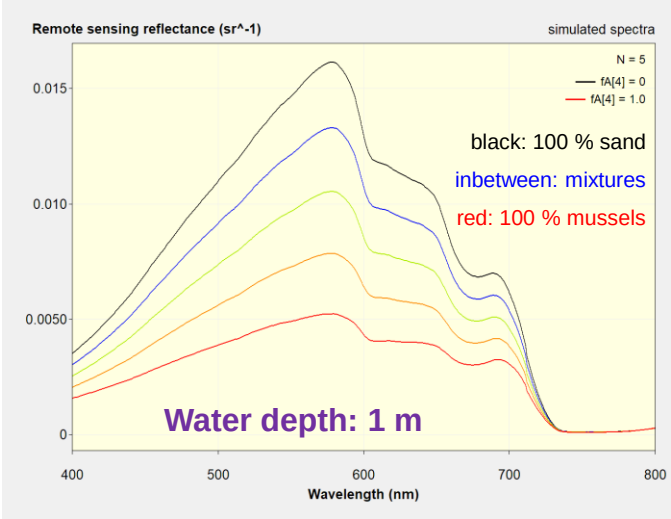
March 2022

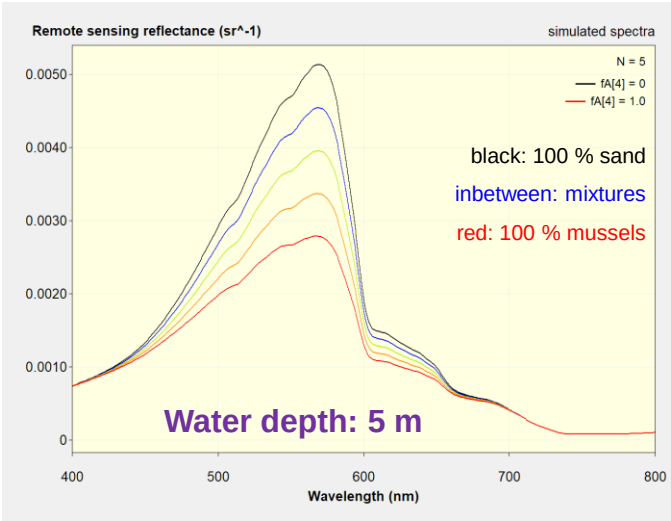
Spectral Signatures of Mussels vs. Sand and Macrophytes

- Very shallow water (~1 m): spectral differences are large enough to separate mussels and macrophytes
- Deeper water: spectral differences decrease with water depth, separation becomes increasingly difficult

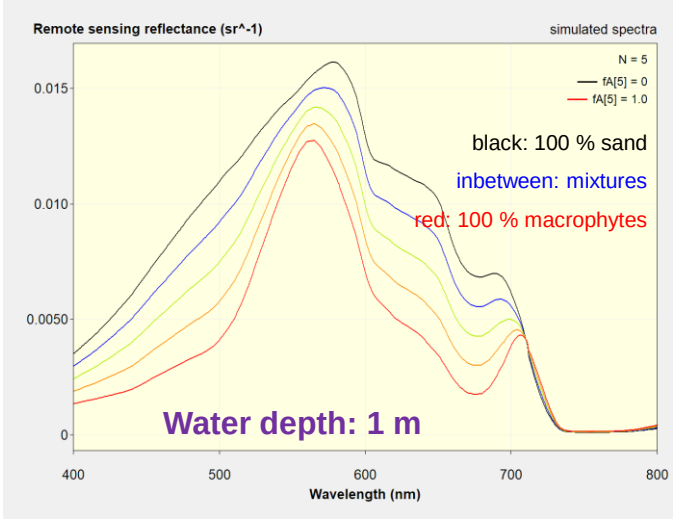


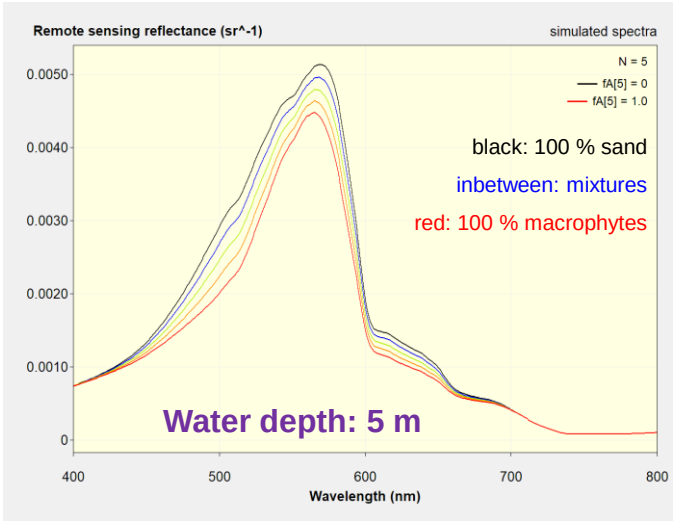
Mussels + Sand



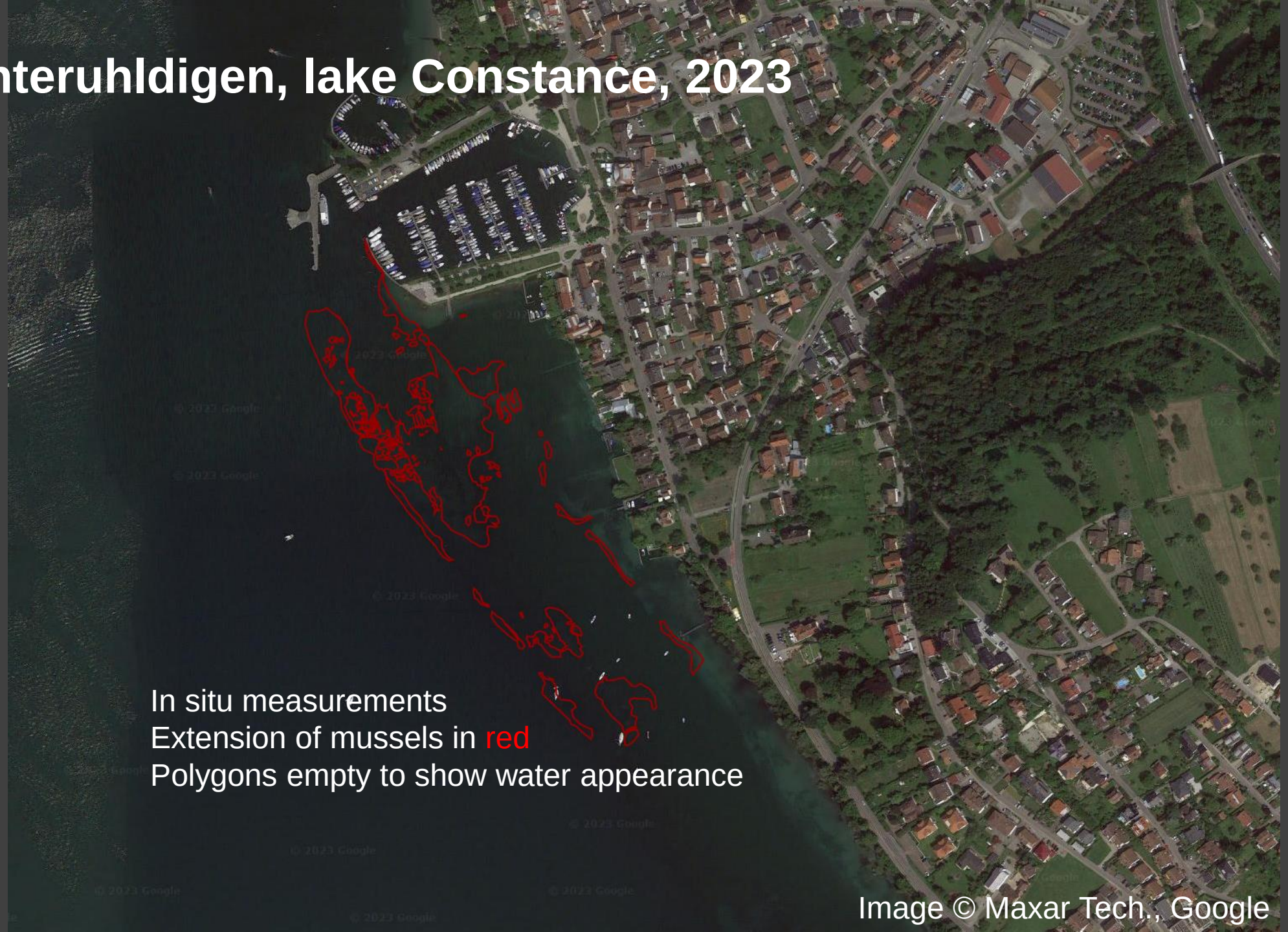


Macrophytes + Sand

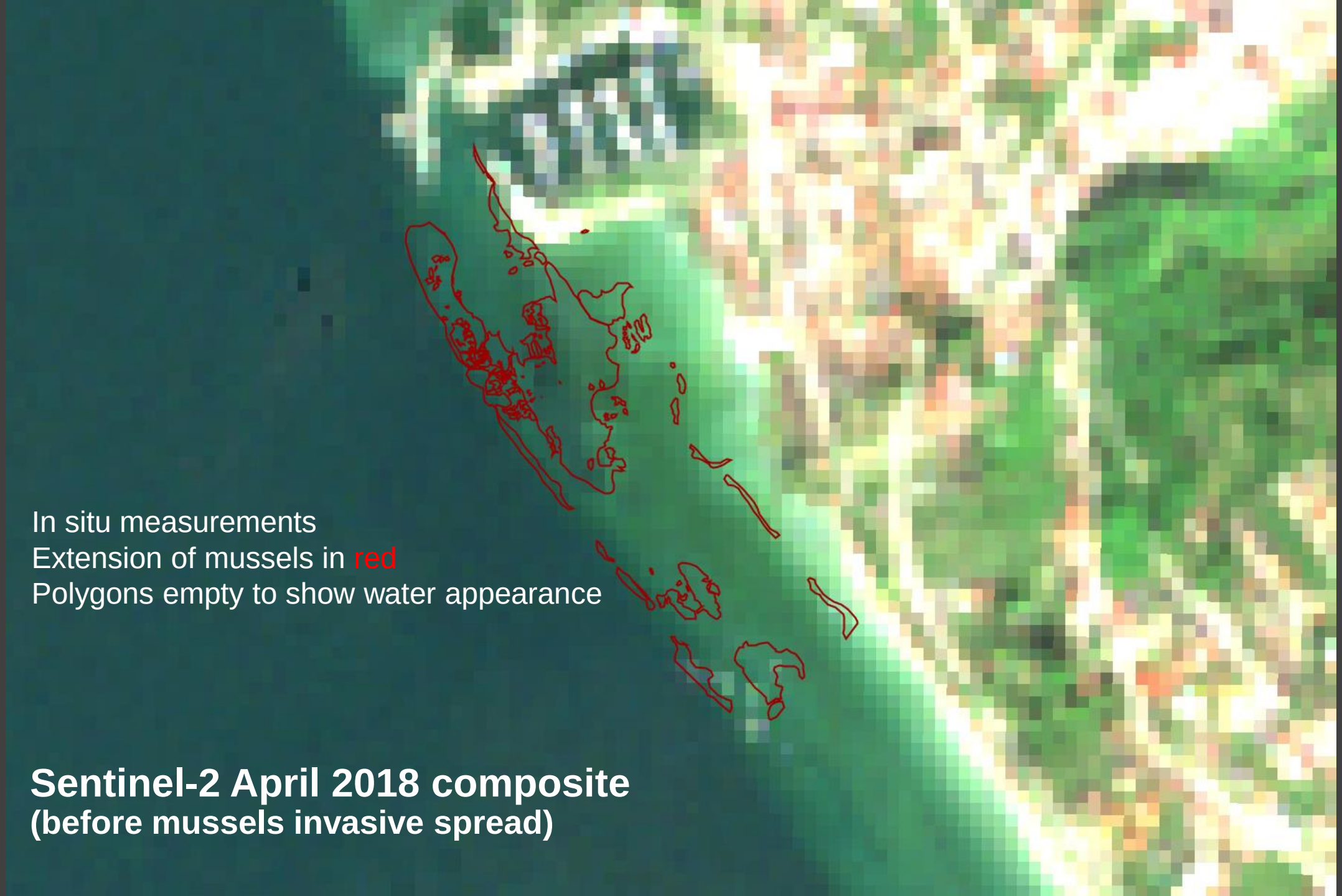


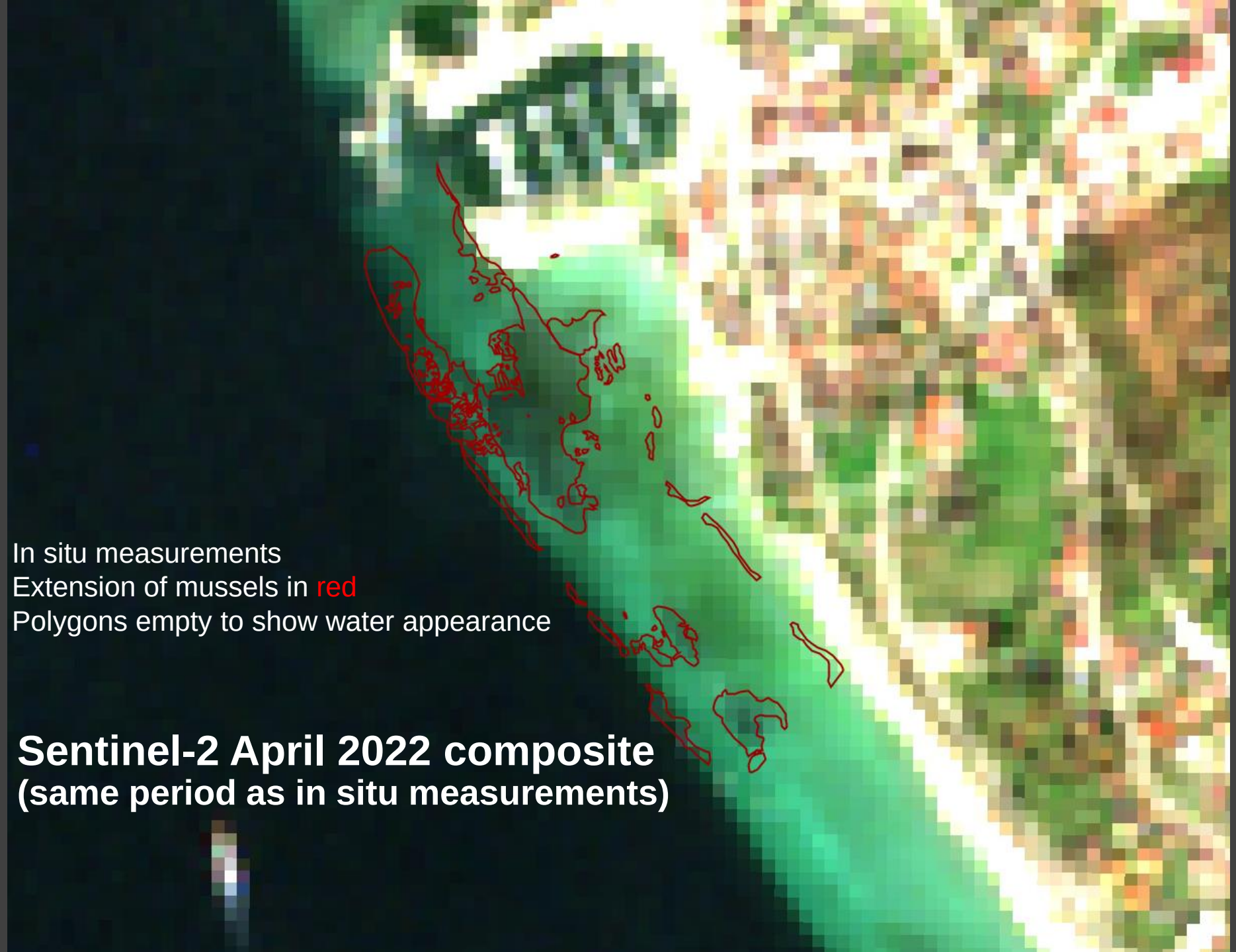


Unteruhldigen, lake Constance, 2023



In situ measurements
Extension of mussels in red
Polygons empty to show water appearance

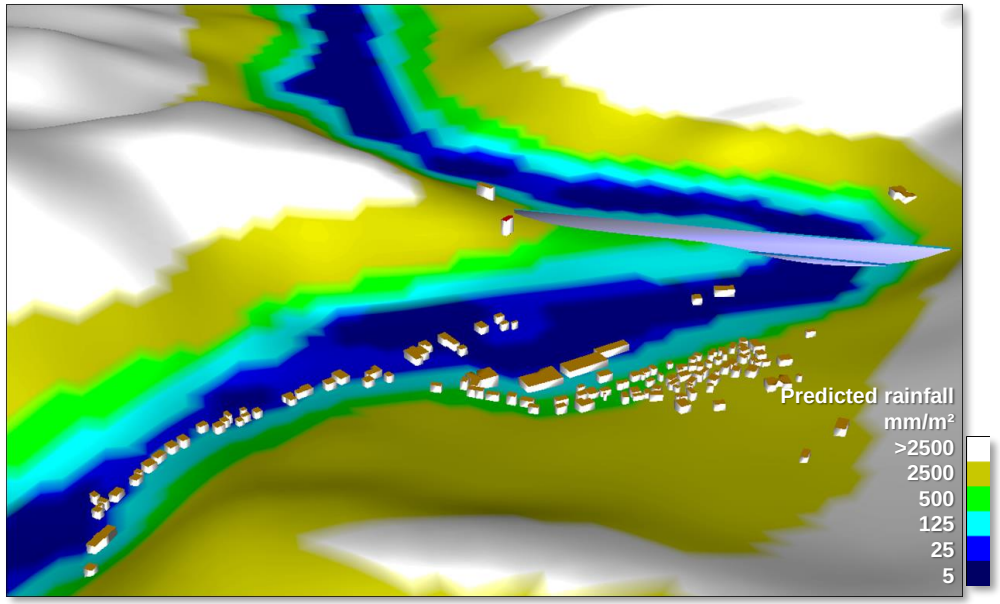

In situ measurements
Extension of mussels in red
Polygons empty to show water appearance
Sentinel-2 April 2018 composite
(before mussels invasive spread)


In situ measurements
Extension of mussels in red
Polygons empty to show water appearance
Sentinel-2 April 2022 composite
(same period as in situ measurements)

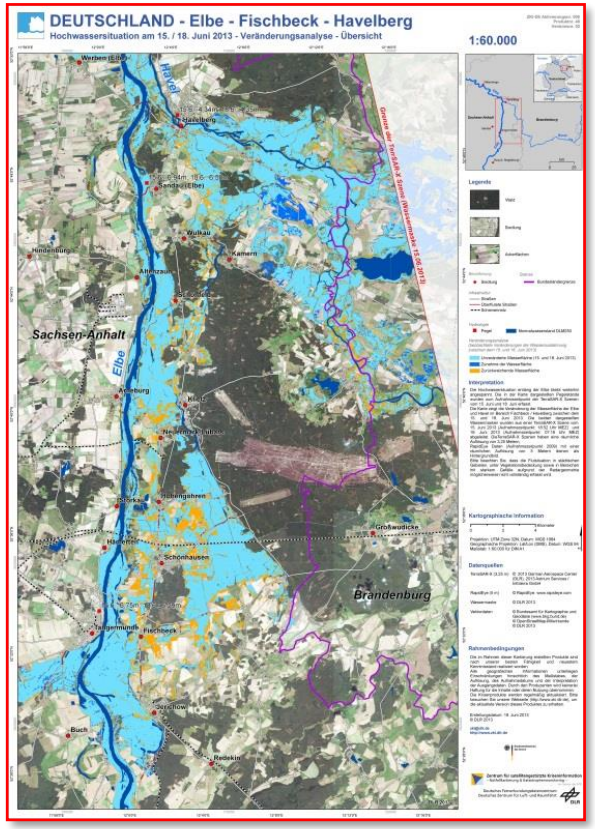
TRIQUETRA

Toolbox for assessing and mitigating Climate Change risks and natural hazards threatening cultural heritage

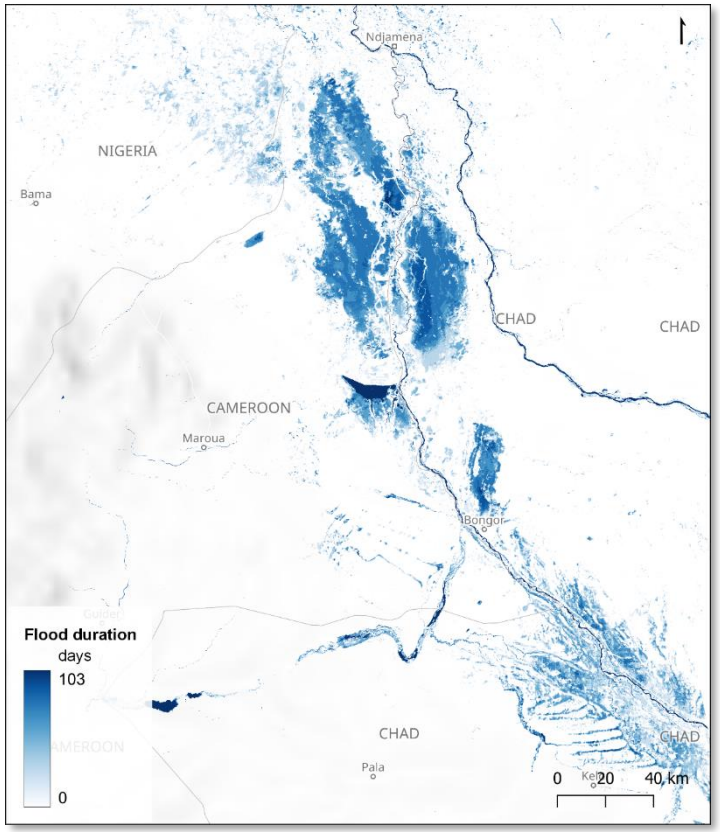
CL2-2022-HERITAGE-01-08 - Effects of climate change and natural hazards on cultural heritage and remediation



Risk Analysis: Heavy Rainfall



Flood Rapid Mapping



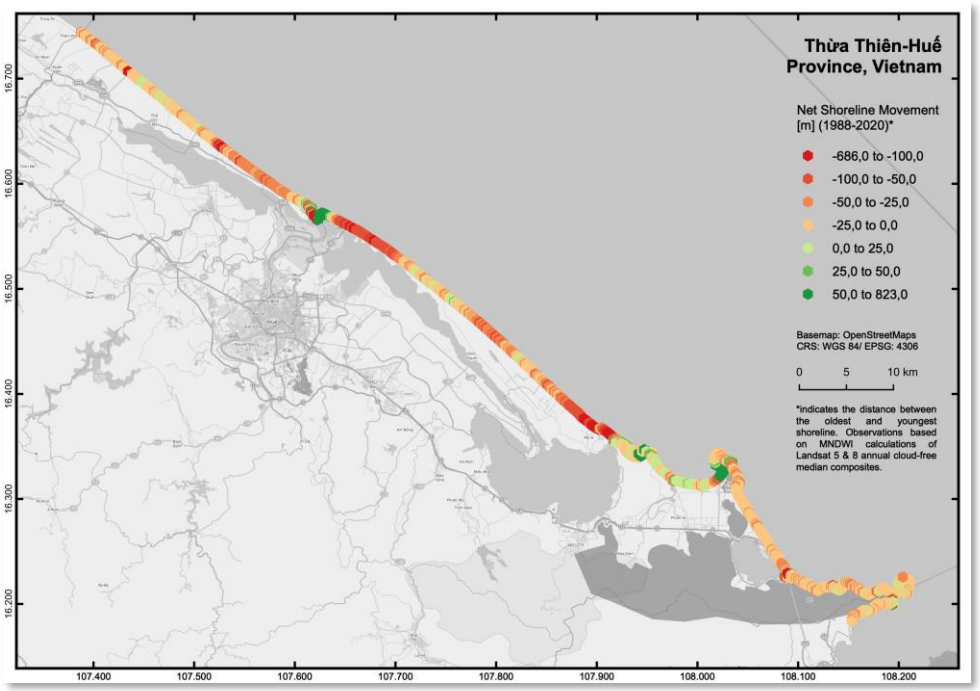
Flood Duration Estimation

Project funded from the EU HE research and innovation programme under GA No. 101094818.

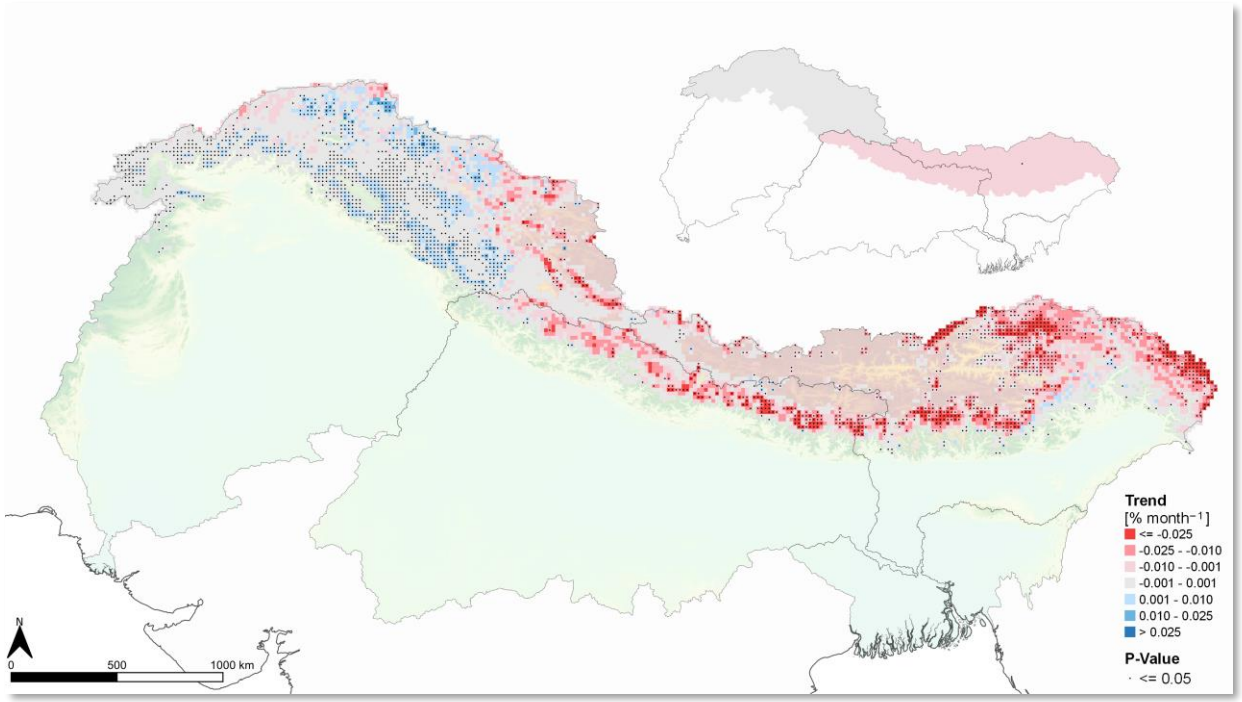
TRIQUETRA

Toolbox for assessing and mitigating Climate Change risks and natural hazards threatening cultural heritage

CL2-2022-HERITAGE-01-08 - Effects of climate change and natural hazards on cultural heritage and remediation



Shoreline Change
Thiên-Huê, Vietnam

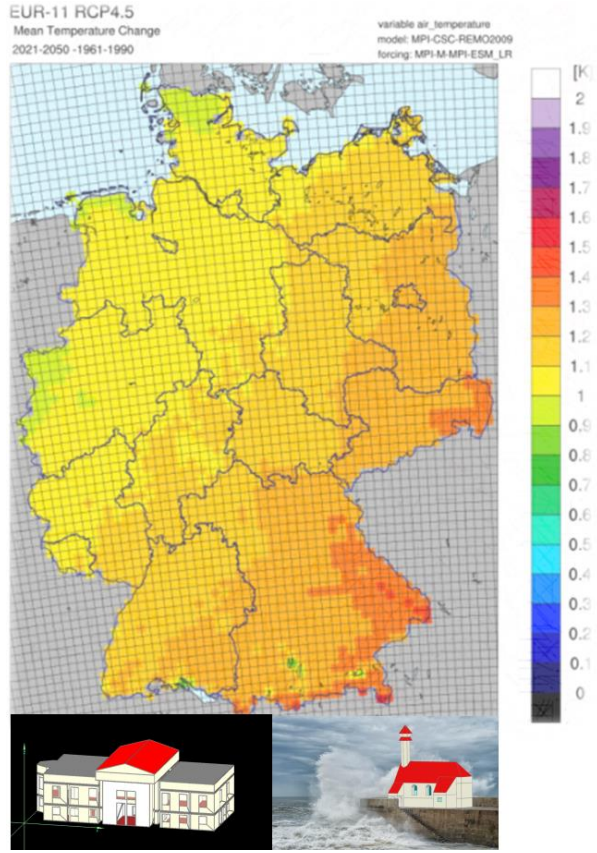


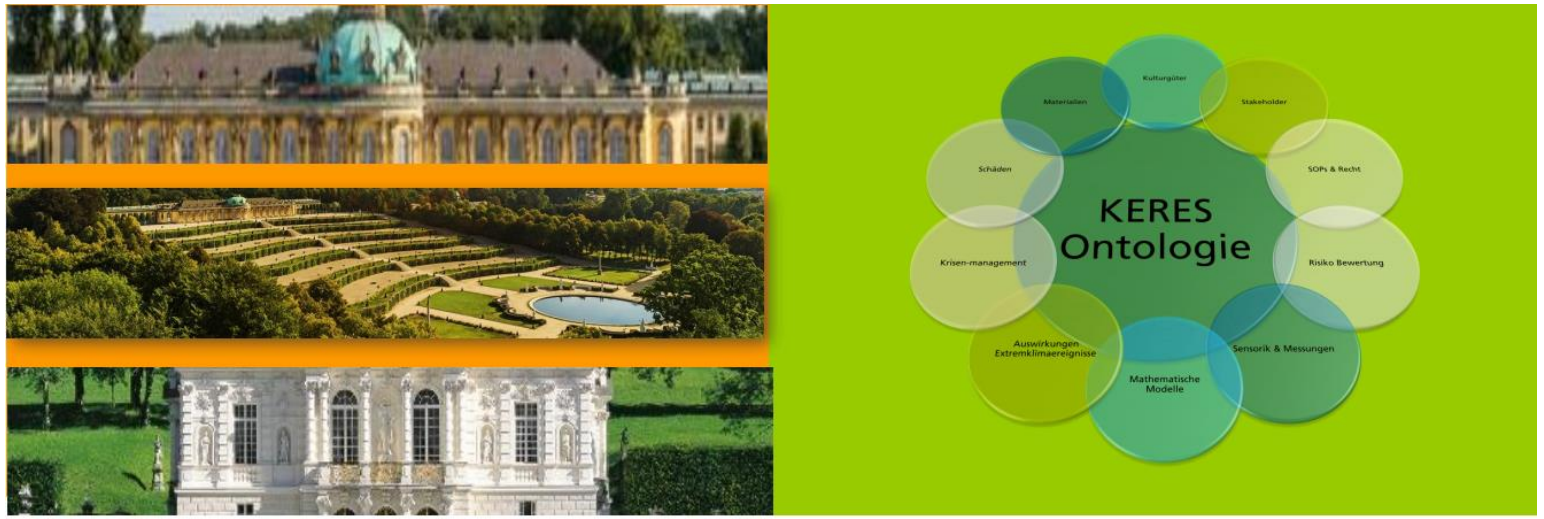
Trends and Causal Analytics of Snow Cover
Indus Ganges Brahmaputra Basins

Project funded from the EU HE research and innovation programme under GA No. 101094818.

KERES Project

- Climate projections for selected CH sites in different climate zones of Germany
- Analyses of the criticality and the adaptation and resilience options of CH sites in relation to extreme weather events
- Establishment of a cultural heritage expert panel - associated partners from CH and security/disaster sector and international experts





Perspectives of DAI (member of CHTF*) on „Copernicus Services for CH“

* Benjamin Ducke, IT Director; Deutsches Archäologisches Institut, DAI

- The Copernicus CH component should (re-)focus on the monitoring, management and protection of cultural heritage sites. This is the most urgent and the most well-defined task area.
- The Copernicus CHTF was never officially disbanded. It can and should continue to serve in an advisory function.
- There should be transparent deliberation about the question of which EU entity (or entities) will implement the Copernicus cultural heritage component. Ideally, the CHTF should participate in the decision-making process.
- It is very important that real progress on the Copernicus cultural heritage component is made now. The EU Commission and the member states' institutions have a responsibility to act.

Perspectives of DLR on „Copernicus Services for CH“

- Immediate threat to CH through natural desasters and man made crisis to some extent covered by Copernicus Rapid Mapping Service & Charter of Space and Major Disasters
- Need to introduce CH-domain knowledge in EO based CH-analysis
- Consider fight against looting and trafficking
- Consider long-term threats & challenges (e.g. air pollution, sea-level rise, soil movement, tourism)
- Should the Copernicus Service cover only „European CH Sites“ or „Global CH Sites“?
- Do we have a „priority“ list, at least for Europe?


thank
you