ATHENA

Remote Sensing Science Center for Cultural Heritage

H2020-TWINN-2015. Grant Agreement no 691936	
Project full title:	Remote Sensing Science Center for Cultural Heritage
Project acronym:	ATHENA
Work Package	WP4
Deliverable	D4.5 Material from 2nd workshop

	H2020-TWINN-2015 **Grant Agreement no 691936** This project is funded under the **EUROPEAN COMMISSION** in the Framework Programme for Research and Innovation (2014-2020).	
Call:	Work programme **H2020** under **"Spreading Excellence and Widening Participation", call: H2020-TWINN-2015: Twinning** (Coordination and Support Action).	
Project full title:	**Remote Sensing Science Center for Cultural Heritage**	
Project acronym:	**ATHENA**	
Work Package (WP):	**WP4**	
Deliverable (D):	**D4.5 (Material from 2nd workshop)**	
Due date of deliverable:	**April 2017** **(Month 17 of the project)**	**Version: 1**
Author(s):	**Diofantos G. Hadjimitsis, Vasiliki Lysandrou, Athos Agapiou**	
Contributor(s):	**Rosa Lasaponara, Nicola Masini**	
Start date of project:	**1/12/2015**	Duration: **36 months**

Dissemination Level		
PU	Public	√
CO	Confidential, only for members of the consortium (including the Agency Services)	I

Document Sign-off				
Nature	**Name**	**Role**	**Partner**	**Date**
DRAFT	Diofantos G. Hadjimitsis Athos Agapiou Vasiliki Lysandrou	Project Leader	CUT	29/03/2017
REVIEWED	Rosa Lasaponara, Nicola Masini	Partner 1	CNR	28/04/2017
REVIEWED	Gunter Schreier	Partner 2 (WP Leader)	DLR	28/04/2017
APPROVED	All partners	WP Leader / Partner 2	CUT, CNR, DLR	02/05/2017

Work Package: 4 – Training and knowledge transfer Deliverable: D4.5 – Material from 2nd workshop				
Sections to be protected	Description	Owner	Access Rights	
			Period	Type*
none				

Summary

The present deliverable summarizes the outcomes of the second ATHENA workshop and provides all related material, both prior its accomplishment (e.g. agenda) and material such as presentations and list of participants.

The second workshop was entitled: “Remote Sensing for Cultural Heritage beyond Europe” and was organised by Prof. R. Lasaponara and Prof. N. Masini from the CNR in Cyprus.

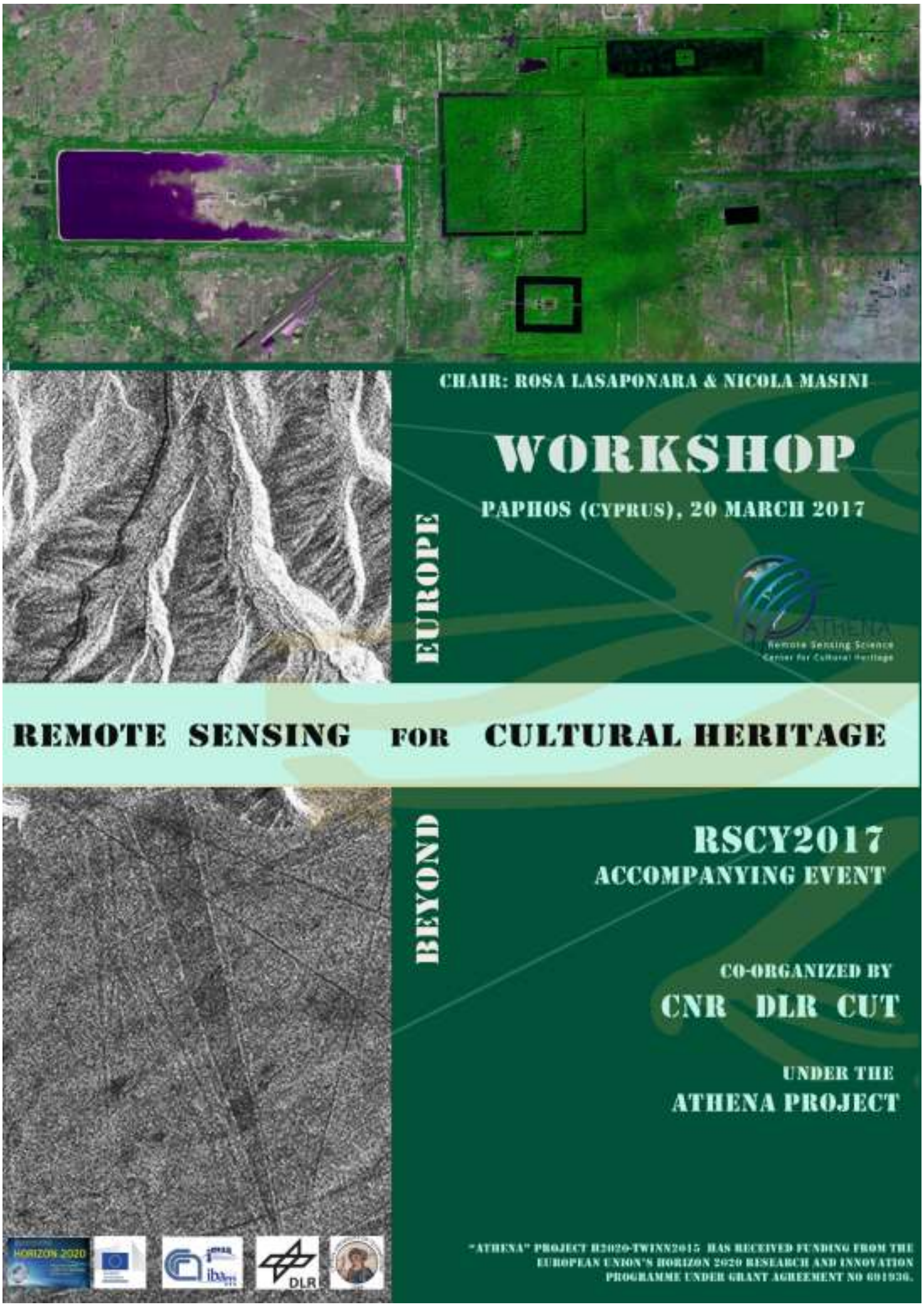
Table of Contents

Summary 5
1. Introduction 7
2. Agenda of the workshop 8
3. List of Participants 11
4. Presentations during the workshop .... **Error! Bookmark not defined.**
5. Minutes of the workshop 15
6. Photos from the Workshop 18
ANNEX 22

1. Introduction

The 2nd Workshop of ATHENA has been succesfully accomplished in line to the timeline of the project. The Workshop was leaded by CNR consortium member and hosted by CUT (Project coordinator) during the 'Fifth International Conference on Remote Sensing and Geoinformation of Environment' - RSCy2017 held on the 20 March 2017 in Paphos (Cyprus).
The topics of the conference and workshop are correlated, thus the partners of ATHENA project decided to combine the two events, in order to attract more scientists interested in the subject. This was an added value for the workshop, as well as for dissemination of the ATHENA project to the internaitonal scientific community and to local stakeholders. This was agreed by all ATHENA consortium members, after the last year's succesfull first workshop again combined with the RSCy2016 conference.
The workshop entitled "Remote Sensing for Cultural Heritage beyond Europe", was a half day (refer to the agenda below - section 2 of the present document) that concluded with interesting discussions and future expectations (refer to minutes of the workshop below - section 5 of the present document).

2. Agenda of the workshop



Workshop

Remote Sensing for Cultural Heritage Beyond Europe

In the last decades, the use of Earth Observation (EO) technologies for Cultural heritage has been strongly increased. This is due to the improvement of the performance of sensors that are capable to reveal ever more geometrically and thematically detailed information for the study of the human past and ancient landscapes, the identification of unknown sites and the detection of buried remains. The increased interest of archaeological community to exploit EO technologies has been raised due to the current availability of user-friendly and open source software tools for data processing and the increased interest for the study of the dynamics of ancient civilizations in relation to environmental changes, the latter traditionally being investigated by remote sensing techniques.

The ATHENA PROJECT (www.athena2020.eu) calls for a look outside of Europe to discuss the use, potential and specificities of remote sensing techniques for the study of human past and management of cultural heritage in the various regions of the world.

Remote sensing is currently positioned in a turning point for both the increased availability of spatial data and the increased awareness of the importance to study and protect cultural heritage increasingly threatened by natural and anthropogenic hazards and damaged by negligence and armed conflicts.

The Workshop is co-organized by IBAM and IMAA of the National Research Council of Italy (CNR), the German Aerospace Center (DLR) and the Cyprus University of Technology (CUT) in the framework of the ATHENA Project, which aims at establishing a Center of Excellence in the field of Remote Sensing for Cultural Heritage, as accompanying event of the 5th International Conference on Remote Sensing and Geo-information of Environment - RSCy2017: http://www.cyprusremotesensing.com/rscy2017/

The following topics are encouraged:

- ✓ Space-based applications: form site discovery to Cultural heritage management
- ✓ Satellite for risk monitoring and damage mapping
- ✓ LiDAR for the site detection and archaeological landscape
- ✓ Ancient landscapes from historical archive including aerial photos and declassified satellite images
- ✓ Vandalism and deliberate devastations: the contribution of RS for documentation
- ✓ Inteferometric techniques for monitoring cultural heritage
- ✓ Data integration and interpretation for an operational use of Earth Observation and Geophysics in Archaeology
- ✓ International archaeological missions and projects
- ✓ International programmes and organisations supporting EO use for monitoring and protection of cultural heritage
- ✓ Big data mining for remote sensing cultural heritage applications

Date: 20 March 2017

Venue: Annabelle Hotel in Paphos, Cyprus

Workshops:
Remote Sensing for Cultural Heritage Beyond Europe
Enjoyment of Cultural Heritage By Means of New and Old Media

Chair: Rosa Lasaponara (CNR-IMAA), Nicola Masini (CNR-IBAM / CAS-RADI)

14:20-4:30	Introduction To The Workshops	
14:30-14:45	Remote sensing for a smart management of cultural heritage from site detection to monitoring and documentation: the case studies of Silk Road Project	R. Lasaponara
14:45-15:00	Sensing beyond frontiers: remote sensing applications for archaeological heritage detection and management	A. Traviglia
15:00-15:15	On the use of remote sensing in areas selected in Georgia , Pakistan and Jordan (Petra)	D. Spizzichino
15:15-15:30	GIS and satellite data for urban sprawl close to archaeological areas in Iran	B. Murgante
15:30-15:45	An Overview of remote sensing in Altai archaeological area	J. Bourgeois
15:45-16:00	SAR applications in Egypt	C. Stewart
16:00-16:30	Coffee break	
16:30-16:45	The Christian reuse of the Egyptian temples and keeping methods using remote sensing and GIS techniques in Luxor city, Egypt	O. Wafa Abdel
16:45-17:00	Remote Sensing for Indian archaeological areas	Modella et al.
17:00-17:15	Remote sensing based archaeological research in Nasca and in Pachacamac (Peru)	N. Masini
17:15-17:30	Exploitation of big data cloud infrastructures for earth observation cultural heritage applications: mapping the land use changes patterns in the vicinity of "the great pyramid at Giza"	A. Agapiou
17:30-17:45	Automatic damage detection for sensitive Cultural Heritage Sites in Syria and Iraq	D. Cerra, J. Tian, V. Lysandrou, S. Plank & T. Krauß
17:45-18:00	Qualitative assessment of the medieval fortification conditions with the use of Remote Sensing data (Republic of Tatarstan)	I. Gainullin, B. Usmanov & A. Sitdikov
18:00-18:15	The Copernicus Programme and World Cultural Heritage preservation	G. Schreier
18:15-19:00	Round Table Discussion	

The workshop is open to all conference participants, stakeholders, interested parties and the public. There will be no fees for attending the workshop. Please reserve your participation by sending an email using the RSCy 2017 contact form.

3. List of Participants

Forty participants attended the Workshop coming from various European and international institutions, representing both the academia, industry and research centers. The percentage of the participants from each institutions presented during the workshop is indicatively shown below.

(4)

Cyprus University of Technology

Consiglio Nazionale Ricerche

H2020-TWINN-2015 - Remote Sensing Science Center for Cultural Heritage - A T H E N A
2nd Workshop
Topic: Remote Sensing archaeology applications beyond Europe -
Trainers: Rosa Lasaponara & Nicola Masini (CNR)
Monday, 20th March, 2017
Paphos - Cyprus

List of participants

A/A	NAME	INSTITUTION	CONTACT DETAILS	SIGNATURE
1	Argyro Nisantzi	CUT	argyro.nisantzi@cut.ac.cy	
2	Athos Agapiou	CUT	athos.agapiou@cut.ac.cy	
3	Demetris Demetriou	Public Works Dept	[illegible]	
4	AHMED ALBORAHNALLAH	PLYMOUTH Uni	[illegible]@students.plymouth.ac.uk	
5	Mohamed Bhaltammam	UAE University	[illegible]@uaeu.ac.ae	

1

A/A	NAME	INSTITUTION	CONTACT DETAILS	SIGNATURE
6	Vasiliki Nikolakopoulou	CUT	[illegible]@cut.ac.cy	
7	Danae Kalliabasou	University of Aegean	[illegible]@gmail.com	
8	Georgios Leventis	CUT	georgios.leventis@cut.ac.cy	
9	Pavlos Chatzigrigoriou	CUT Digital Heritage LAB	p.chatzigrigoriou@cut.ac.cy	
10	Maria Andreou	Research Promotion Foundation	mandreou@research.org.cy	
11	KAROL BARTOŠ	TECHNICAL UNIVERSITY IN KOŠICE, SLOVAKIA	KAROL.BARTOS@TUKE.SK	
12	KATARINA PUKANSKA	〃	katarina.pukanska@tuke.sk	
13	Betty Charalampopoulou	Geosystems Hellas	b.charalampopoulou@geosystems-hellas.gr	
14	Konstantina Liperi	Department of Electronic Communications	kliperi@mcw.gov.cy	
15	Michael Fraser	AP KYPROS SATELLITES	mfraser@[illegible]	
16	Christiana Papoutsa	CUT	christiana.papoutsa@cut.ac.cy	

2

17	DANIELE SPIZZICHINO	ISPRA	daniele.spizzichino@isprambiente.it	[signature]
18	LOUPASAKIS Constantinos	NTUA-[illegible]	cloupasakis@metal.ntua.gr	[signature]
19	ZOMENIA ZOMENI	Department of Antiquities	[illegible] zomenia.zomeni@ [illegible]	[signature]
20	Thomas Krauß	DLR	thomas.krauss@dlr.de	[signature]

(B)

Cyprus University of Technology

Consiglio Nazionale Ricerche

H2020-TWINN-2015 - Remote Sensing Science Center for Cultural Heritage - A T H E N A
2nd Workshop
Topic: Remote Sensing archaeology applications beyond Europe - Trainers: Rosa Lasaponara & Nicola Masini (CNR)
Monday, 20th March, 2017
Paphos - Cyprus

List of participants

A/A	NAME	INSTITUTION	CONTACT DETAILS	SIGNATURE
1	MARIOS TZOUVARAS	CYPRUS UNIV. OF TECHNOLOGY	marios.tzouvaras@cut.ac.cy	[signature]
2	GIORGOS MALLINIS	AUTH / DUTH	giorgos.mallinis@gmail.com	[signature]
3	MARIA SILEO	CNR IBAM (ITALY)	m.sileo@ibam.cnr.it	[signature]
4	VERONIKA KOPACKOVÁ	Czech Geological survey	veronika.kopackova@geology.cz	[signature]
5	EMANUELE MANDANICI	UNIVERSITY OF BOLOGNA	EMANUELE.MANDANICI@UNIBO.IT	[signature]

1

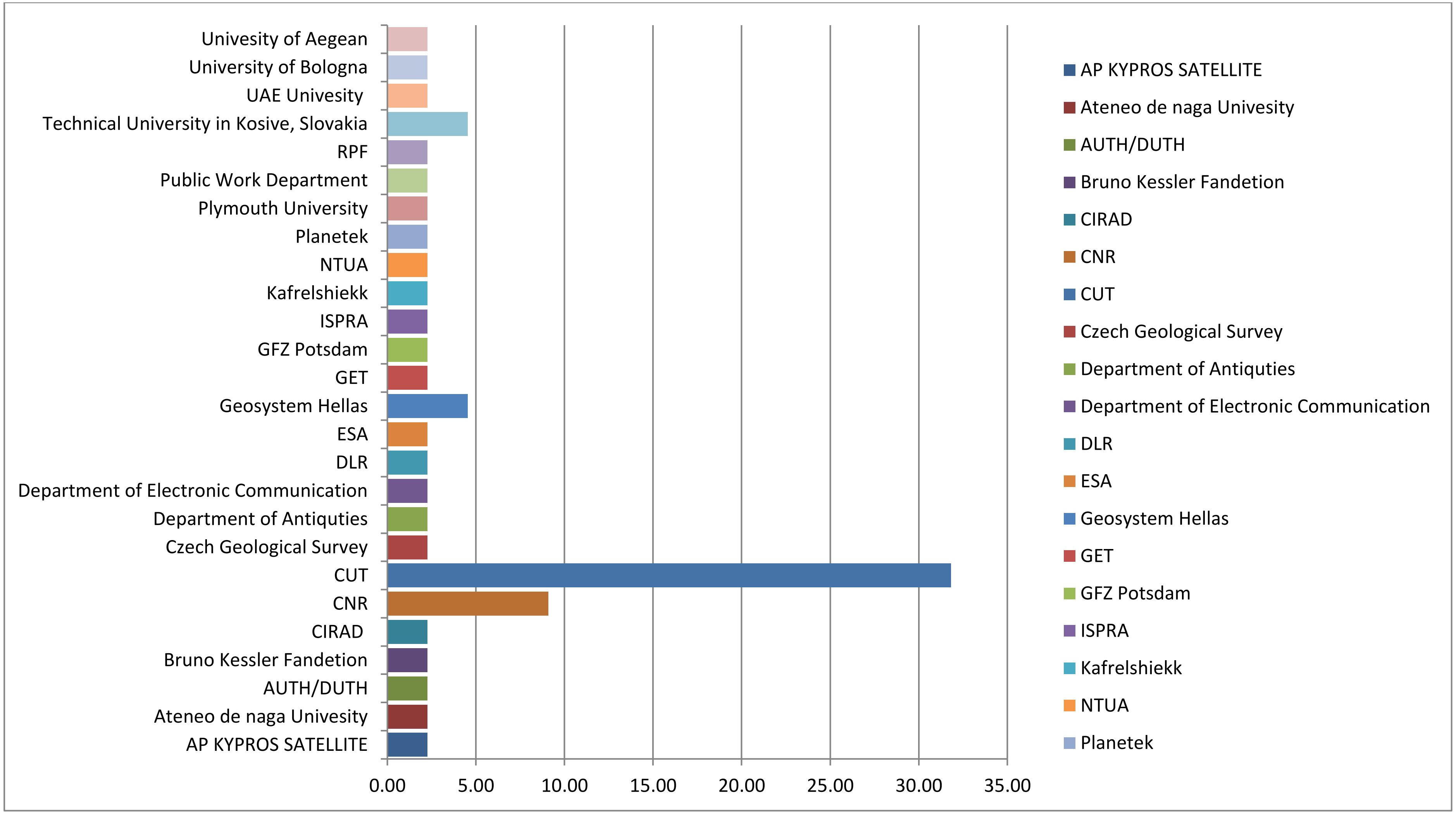
ATHENA

6	Christian Rogass	GFZ Potsdam	rogass@gfz-potsdam.de	[signature]
7	Jérôme Béquignon	European Space Agency	jerome.bequignon@esa.int	[signature]
8	FERDINANDO E BIEN	[illegible] UNIVERSITY	freddie.bien@gmail.com	[signature]
9	Αργέρικος-Σάββας Ευάγγελος-[illegible]	Cyprus University of Technology	a.argerikos@gmail.com	[signature]
10	Phaedon Kyriakidis	CUT	phaedon.kyriakidis@cut.ac.cy	[signature]
11	ISABELLA TOSCHI	Bruno Kessler Foundation	toschi@fbk.eu	ISABELLA TOSCHI
12	Eleanor Stella	PLANETEK	stella@planetek.it	[signature]
13	OSAMA WAF	Kafrelsheikh	osama.wafa@yahoo.com	Osama
14	ELFADALY ABDELAZIZ	CNR	abdelaziz.elfadaly@unibas.it	[signature]
15	Panagiotis Symeonidis	GET	psymeonidis@getmap.gr	[signature]
16	Paraskevi Chatzigrigoriou	CUT Digital Heritage Research Lab	p.chatzigrigoriou@edu.cut.ac.cy	[signature]

2

ATHENA

17	Marinos Ioannides	CUT / DHRLab	marinos.ioannides@cut.ac.cy	[signature]
18	Robert Davies	CUT / DHRLab	robert.davies@cut.ac.cy	[signature]
19	Silas Michaelides	CUT	silas.michaelides@cut.ac.cy	[signature]
20	Beatriz Bellón	CIRAD	beatriz.bellon@cirad.fr	[signature]


Univesity of Aegean
University of Bologna
UAE Univesity
Technical University in Kosive, Slovakia
RPF
Public Work Department
Plymouth University
Planetek
NTUA
Kafrelshiekk
ISPRA
GFZ Potsdam
GET
Geosystem Hellas
ESA
DLR
Department of Electronic Communication
Department of Antiquties
Czech Geological Survey
CUT
CNR
CIRAD
Bruno Kessler Fandetion
AUTH/DUTH
Ateneo de naga Univesity
AP KYPROS SATELLITE
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
AP KYPROS SATELLITE
Ateneo de naga Univesity
AUTH/DUTH
Bruno Kessler Fandetion
CIRAD
CNR
CUT
Czech Geological Survey
Department of Antiquties
Department of Electronic Communication
DLR
ESA
Geosystem Hellas
GET
GFZ Potsdam
ISPRA
Kafrelshiekk
NTUA
Planetek

4. Minutes of the workshop: "Remote Sensing for Cultural heritage. Beyond Europe", Paphos, Cyprus, March 20th 2017

Main Issues and results from the discussion with the Participants

Minutes: Compiled by Rosa Lasaponara and Nicola Masini CNR as part of the ATHENA project

Background

We are at a turning point in remote sensing for both the increased availability and resolution of spatial data and the awareness of the importance to study and protect cultural heritage threatened by natural hazards and damaged by war conflicts.
ATHENA PROJECT calls for a look outside of Europe to discuss the use, potential and specificities of remote sensing techniques for the study of human past and management of cultural heritage in the various regions of the world.

Major Points of Discussion and Results

The presentations provided the state-of-Art of Remote Sensing in the area of Cultural heritage: from the preventive archaeology to site risk monitoring and monument conservation beyond Europe. They have been focused on remote sensing based applications in remarkable archaeological sites and monuments including Angkor, Petra, Nasca, Luxor, Macchu Picchu, Silk Road.

In particular, Lasaponara discussed about the use of optical and radar satellite data for the site detection along the Silk Road with particular reference to oasis states in Xinjiang and Yumen Pass Frontier. The presentation also focused on the capability of diverse SAR bands for different tasks including the discovery, documentation and monitoring of Cultural Heritage
Traviglia presented and discussed the state-of-art of Satellite and LiDAR Remote sensing for the study of Cambodian ancient landscapes with particular reference to Angkor, the capital city of the Khmer Empire, which flourished from approximately the 9th to 15th centuries. The research focus was the identification of palaeo-channels and palaeoriverbeds and the detection of features connected to the water flow system in the forested areas, by the integration of multispectral satellite images and airborne LiDAR.

Spizzichino on the basis of several investigations conducted in Jordan and Bolivia, discussed the integrated use of satellite DinSAR and ground-based geodetic techniques for landslide monitoring to contribute to diagnosis and conservation policies

Murgante focused on GIS and satellite data for the analysis of urban sprawl impact to archaeological areas in Iran. Some methodological approaches based on Remote Sensing and Geostatistics have discussed for the evaluation of the effects of Urban Policies in presence of cultural heritage.

Bourgeois presented the results of long research activity conducted by Ghent University in the Altai Mountains that posed some challenges considered the difficult accessibility of the investigate areas and the lack of maps. In particular, for management purposes as well as for landscape analysis, a combination of GPS, aerial imagery acquired by UAV and balloon, and satellite data, including Corona, proved to be a time-efficient and precise way to map the archaeological sites.

Wafa and Elfadaly talked about the Christian re-use of holy Egyptian temples. They mainly focus on Luxor city and decay and weathering phenomena accelerated by the land use change including urban sprawl and agricultural activity. A risk mitigation strategy based on the use of Satellite data has been proposed, to define recommendations and actions to be implemented for the safeguard of the temples.

Masini presented ten years of investigations of CNR conducted in Peru and Bolivia, including Nasca, Pachacamac and Tiwanaku archaeological sites, by using in operational way different remote sensing approaches including satellite data and geophysics for site detection and archaeological heritage monitoring.

Agapiou discussed about the exploitation of big data cloud infrastructures for earth observation cultural heritage applications, including the mapping of land use changes patterns around Giza pyramids.

Automatic damage detection for sensitive cultural heritage sites such as Palmira has been the focus of Thomas Krauß. Damage evaluations is usually carried out through visual analysis. The presentations focused on the possibility to automatically map and monitor changes and damages by using very high resolution satellite imagery.

Finally, Copernicus initiative has been discussed as a mean to provide inputs for further research and operational applications in support of Cultural Heritage preservation and management. The following discussion higlighted some issues to address in the perspective of the workshop organized by EC in Bruxelles on the 24 April 2017 (http://workshop.copernicus.eu/cultural-heritage)

The presentations aroused the interest of the participants who posed several questions and commments.

After the presentations, a lively debate concluded the workshop involving all the participants. The main issue posed has been the operational state of earth observation for the protection of cultural heritage in danger and for supporting the sustainable exploitation of cultural property as economic asset.

Furthermore highlighted the following needs to further contribute to RS development for CH:

1) application of RS for the coastal and underwater property still today less investigated compare to land archaeological heritage;
2) major efforts to involve end users and stake holders and, consequently, to use RS as a tool for supporting decision maker
3) to set up specific data processing including automatic procedures for site discovery, documentation and monitoring
4) to facilitate the exploitation of Big data for applications addressed to cultural property
5) to improve the integration data coming from diverse sources including archaeological record, geoscience and RS.
6) to make more effort for improving RS data interpretation by means of a strategy oriented to create a multidisciplinary network of experts including archaeologists, conservators and managers.

5. Photos from the Workshop

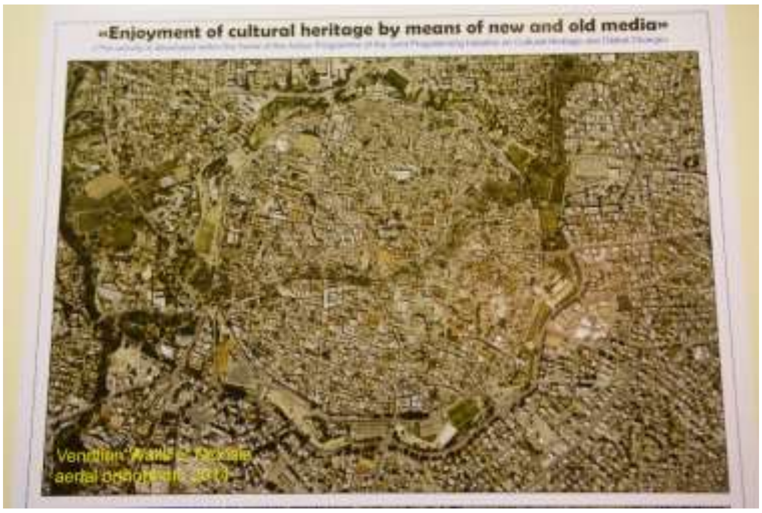

RSCy2017


RSCy2017
Remote sensing Laboratory


eratosthenes research center


RSCy2017


ATHENA
RSCy2017


«Enjoyment of cultural heritage by means of new and old media»

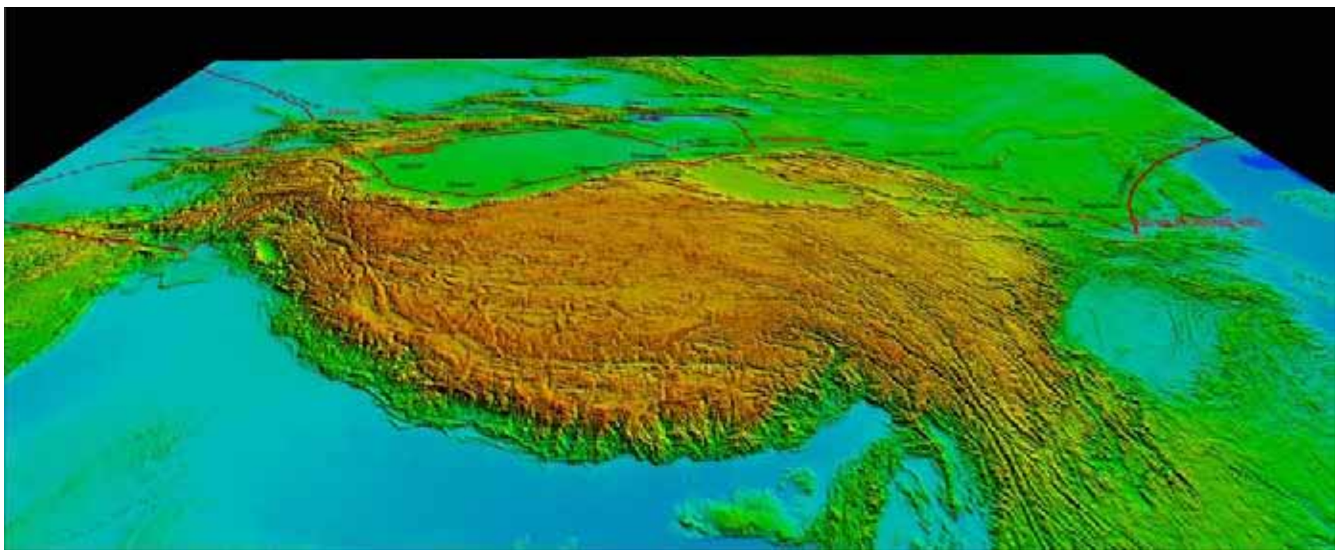
ANNEX

PRESENTATIONS OF THE WORKSHOP

Workshop. “ Remote Sensing for Cultural Heritage Beyond Europe”
Paphos, March 20th, 2017

Remote sensing for a smart management of cultural heritage from site detection to monitoring and documentation:the case studies of Silk Road Project

Rosa Lasaponara CNR-IMAA, Italy



Acknowledgements: The present communication is under the “ATHENA” project H2020-TWINN2015 of European Commission. This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 691936.

Outline

- Research and geographical context
- Space Archaelogy based on satellite : crop, soil marks etc
- Satellite SAR in Archaeology : Data processing issues
- Satellite in Archaeology: case studies along the Silk Road

Earth Observation (EO) technologies and ICT in **Archaeology**

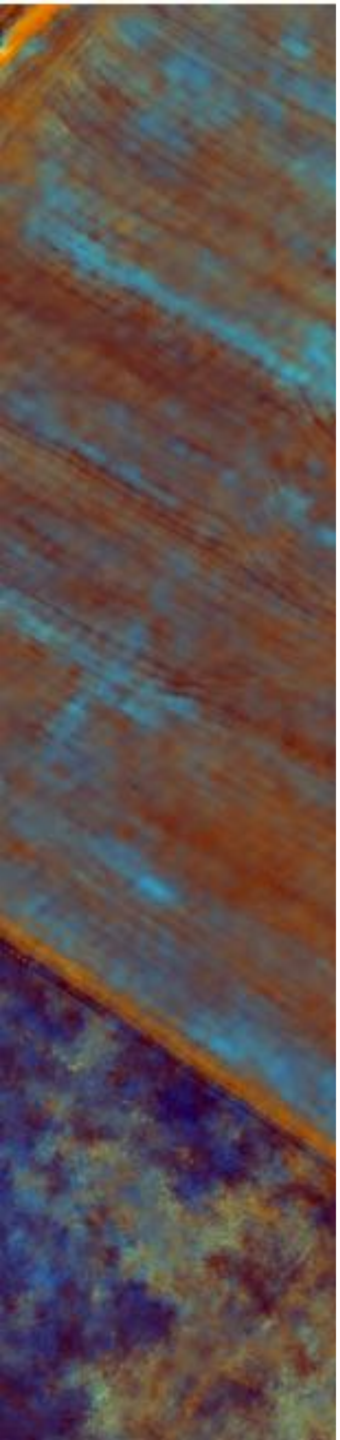
The use of **Earth Observation** (EO) technologies and ICT in **Archaeology** has been strongly **increasing** during the last twenty years.

Technological reasons

- ❑ improvement of spectral and spatial resolution of (airborne/satellite) sensors;
- ❑ availability of user-friendly and low cost softwares/tools for data acquisition, analysis and processing

Cultural reasons

- ❑ awareness of archaeologists of the benefits of EO
  - reduction of costs, time and risk associated with archeological excavations;
  - creation of site strategies addressed to conservation and preservation)
- ❑ the interests of archaeologists to study the dynamics of human frequentation in relation to environmental changes;
- ❑ Multipurpose needs (including monitoring)



rosa.lasaponara@imaa.cnr.it

Scientific interest of Satellite RS in Archaeology

- Non invasive technologies instead of destructive excavations

- <u>World coverage and Data availability</u>
  - free of charge and low cost of medium and HR satellite data
  - historical archives
  - Satellite imagery could be the unique data source in remote areas or under military control

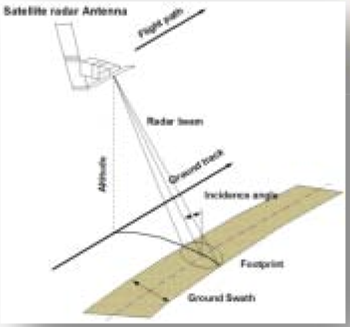
- <u>Reduction of costs, time and risk associated</u> with archeological excavations; availability of open free of Charge data (Sentinel missions) and software

- Useful data to study the dynamics of human frequentation in relation to environmental changes: intra-site and inter-site analyses

- <u>creation of site strategies addressed to conservation and preservation</u>

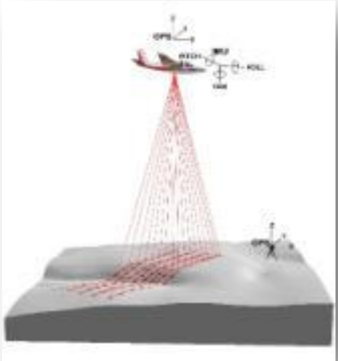
- <u>Multiscale data and synoptic view for large areas</u>

Remote ensing technologies used for the risk assessment and monitoring



Satellite remote Sensing

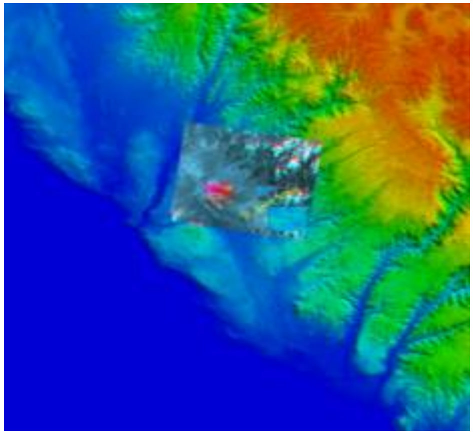
SAR/Multispectral/hyperspectral

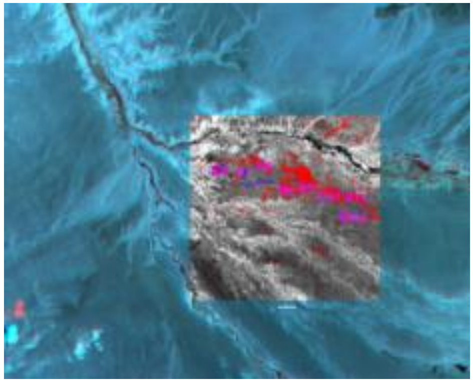


Airborne Remote sensing

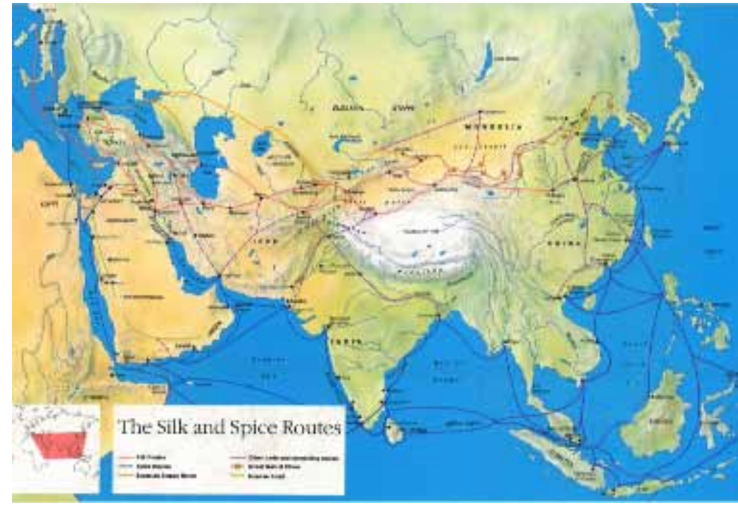
LiDAR/traditional/multi/hyper/SAR

UAV





From regional perspective to site /monumental view

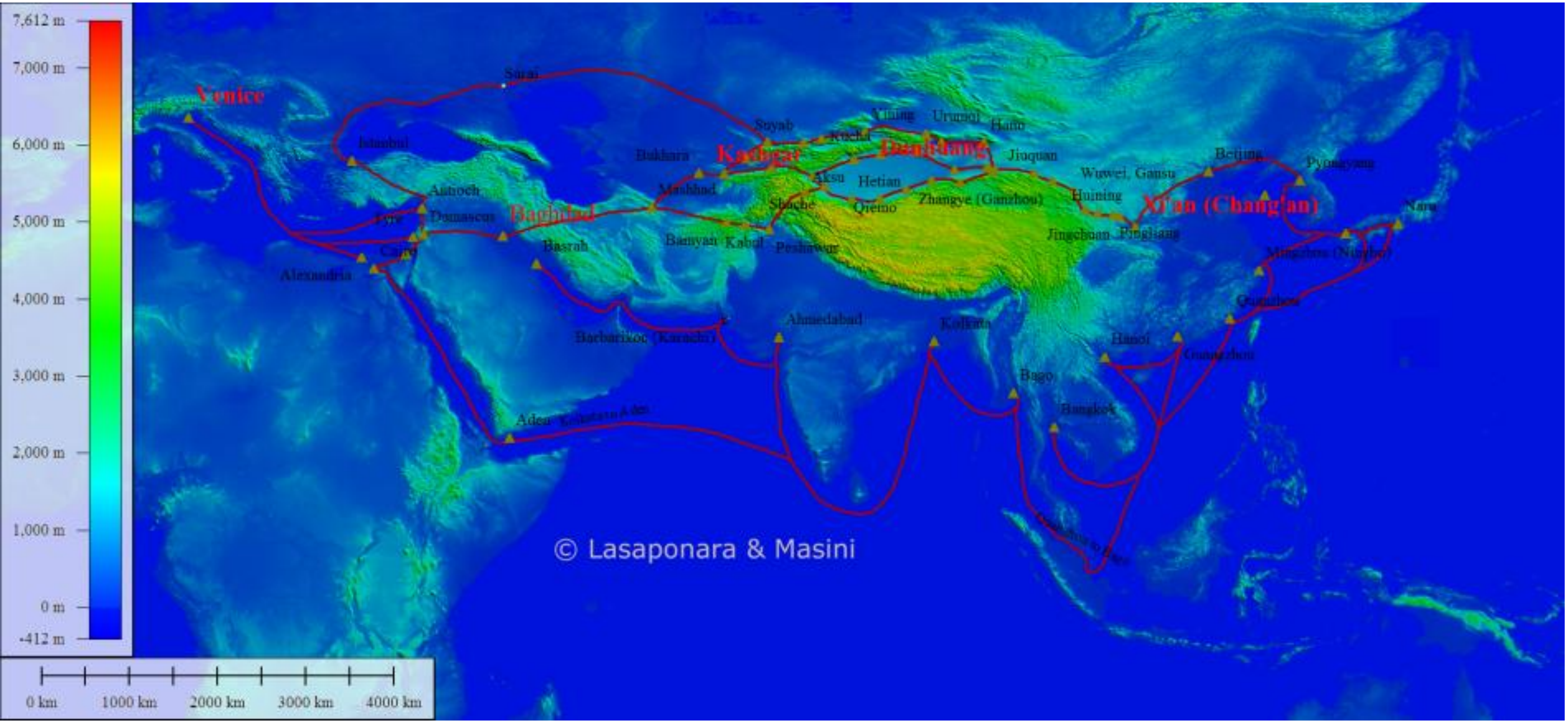


<u>On 22 June 2014, the World Heritage Committee inscribed a section of the Silk Roads network submitted by Kyrgyzstan, China and Kazakhstan on the World Heritage List.</u>

The Chang'an-Tianshan Corridor stretches 5,000 kilometres from Chang'an/Luoyang, the central capital of China in the Han and Tang Dynasties, to the Zhetysu Region of Central Asia.

It took shape between the 2nd century BC and 1st century AD and remained in use until the 16th century, linking multiple civilizations, and facilitating far-reaching exchanges of activities in trade, religious beliefs, scientific knowledge, technological innovation, cultural practices and the arts.

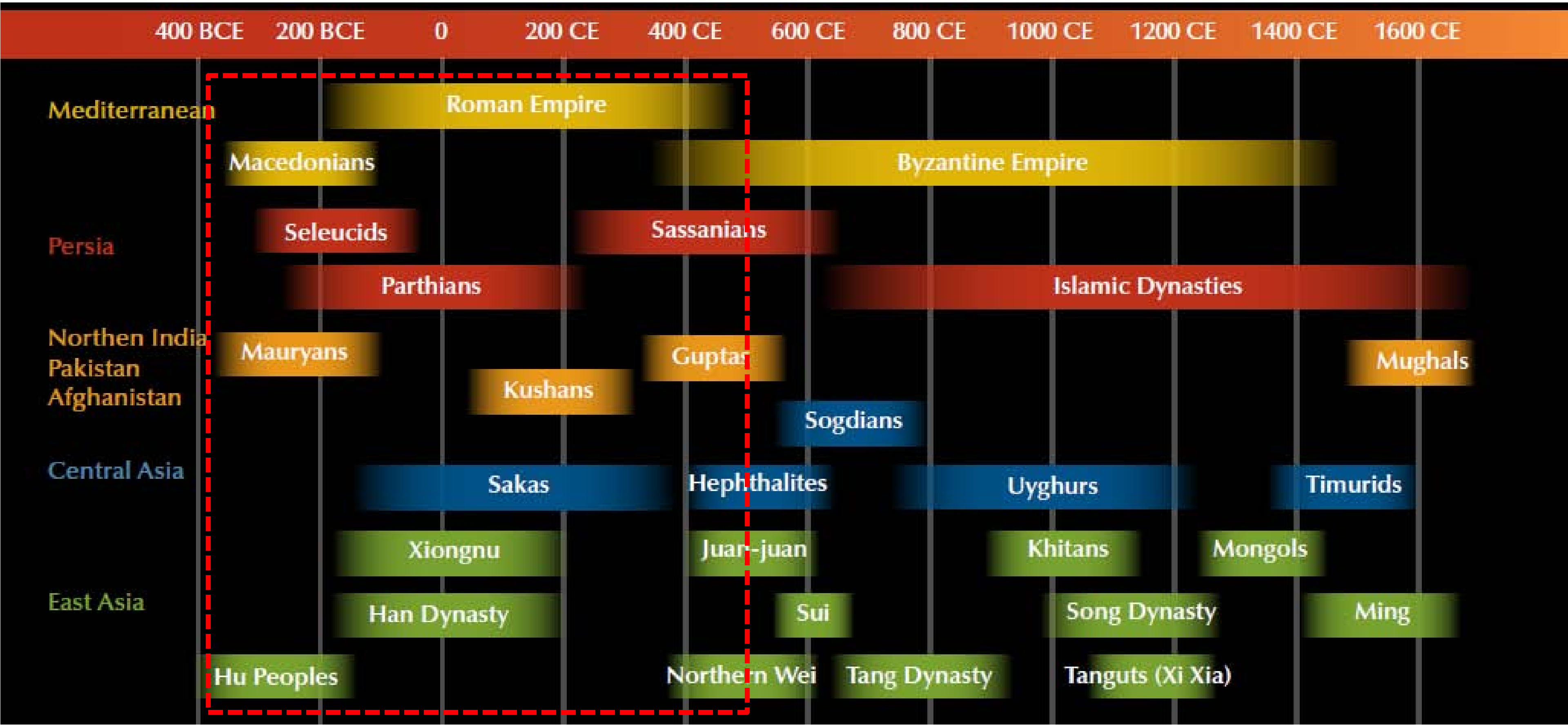
To support this, the ‘Roadmap for Development’ was developed to a achieve mutual goals for sustainable growth, community development, heritage management and conservation on the Silk Road Heritage Corridors.



Terrestrial and maritime Silk Road system from SRTM

Trade and cultural exchanges over time between civilizations and countries of Central Asia, Middle East, Europe and Northern Africa made also use of a system of **<u>land and maritime routes</u>**, based on a dense network of harbours, docks and anchorages, that formed the extreme western part of the 'Global' Silk Road.

SILK ROAD TIME LINE



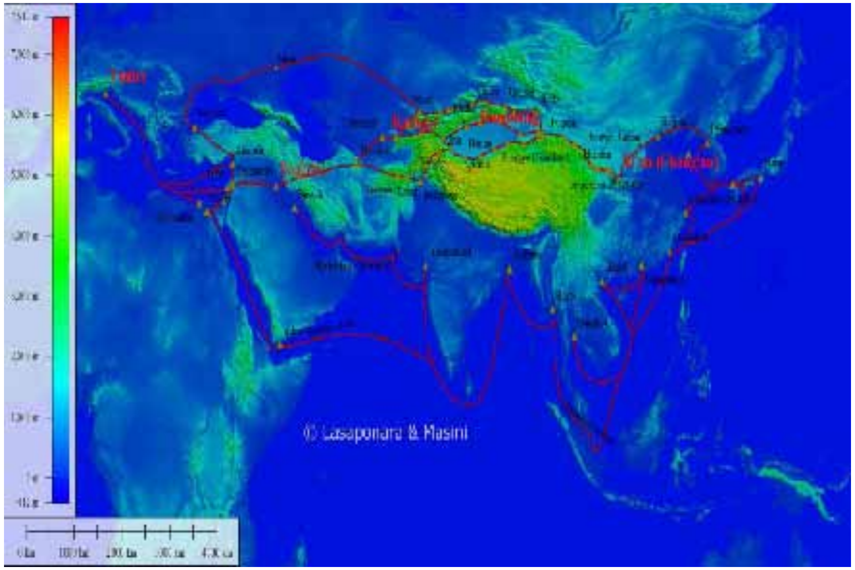
Anne Marie Kane, after Daniel C. Waugh

Conventional histories of the Silk Roads stop with the European Age of Discovery and the opening of maritime routes to the East in the late 15th century. Of course, there had already long been extensive maritime trade [**since ancient times]** between the Middle East, South Asia, Southwest Asia, and East Asia. (Waugh 2007)

One Belt, One Road” new “Silk Road”

- The Silk Road indicates a series of trade and cultural transmission routes connecting China to Europe, (UNESCO in 2014). The Chinese government launched the “One Belt, One Road” as new “Silk Road” aimed at accelerate the Asian financial integration, trade liberalization, and people-to-people connectivity.

- “Belt” indicates **a planned network of road and rail routes, oil and natural gas pipelines**, and other **infrastructures from Xi’an in central China**, through Central Asia, to Moscow, Rotterdam **and Venice.**



- As the artery for the implementation of the Silk Road Economic Belt (SREB) initiative in China, archaeological heritages on the Silk Road have become a public concern and its conservation was achieved significantly through multi-disciplinary investigation.

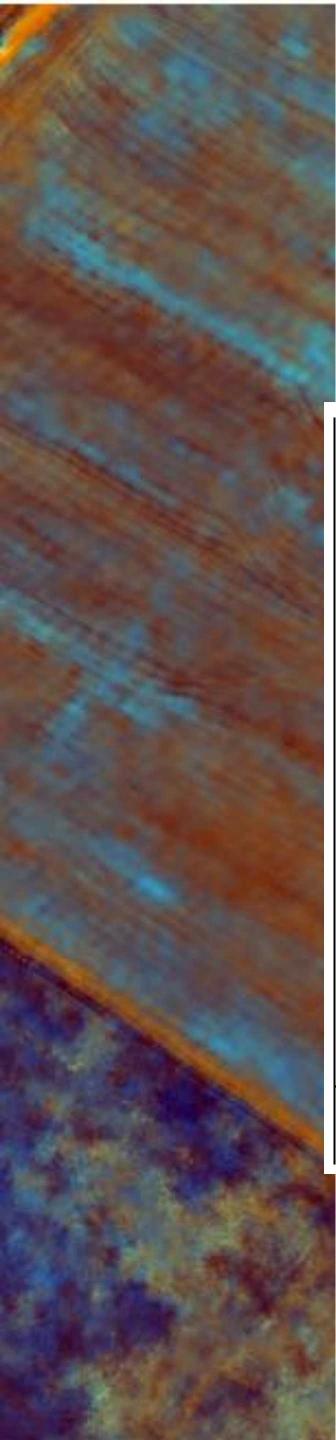
List of World Heritage in Danger

http://whc.unesco.org/en/danger/

Earth Observation and ICT for Archaeology : Debate issues ant topics

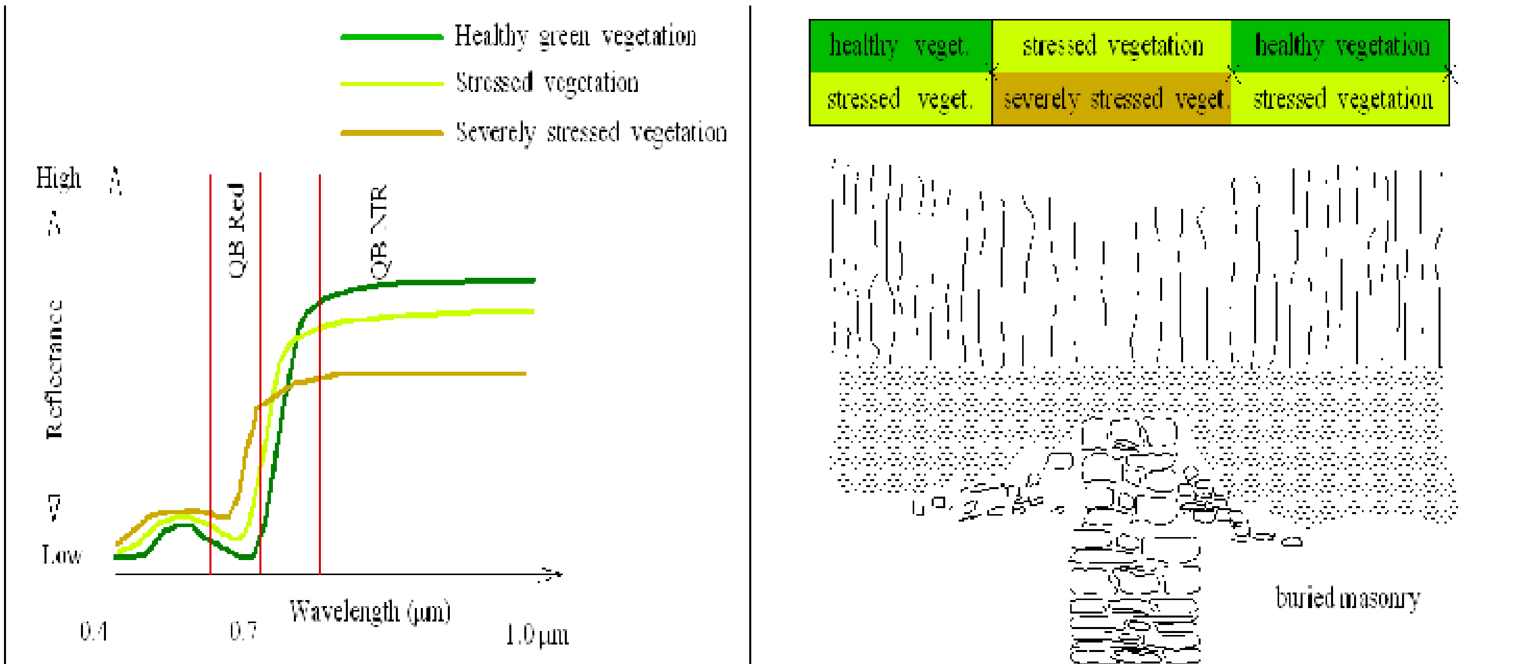
- How select the most appropriate technology and methodology?
- Is the technological potential of EO exploited for CH and Archaeology?
- Which are the physical parameters more significant for the identification of archaeological buried remains
- Are there models set to identify and analyze archaeological buried remains?
- How manage costs, time, information content?
- What is the added value of active data (LiDAR and SAR)
- Do user friendly and/or low cost affect the quality of information content for Cultural Heritage application ?

Project of Great Relevance Italy-China on Earth Observation (EO) and ICT for Cultural Heritage (CH) management



Information Extraction: physical basis for the detection of buried remains using optical data

Archaeological marks detection based on optical multispectral data



QuickBird (QB) band widths	blue = 0.45 - 0.52 μm	green = 0.52 - 0.60 μm	red = 0.63 - 0.69 μm	NIR 0.76 - 0.90 μm

Lasaponara and Masini, 2007,
Detection of archaeological crop marks by using satellite QuickBird multispectral imagery
Journal of archaeological science 34 (2), 214-221

Features related to buried structures of archaeological interest

Crop-marks

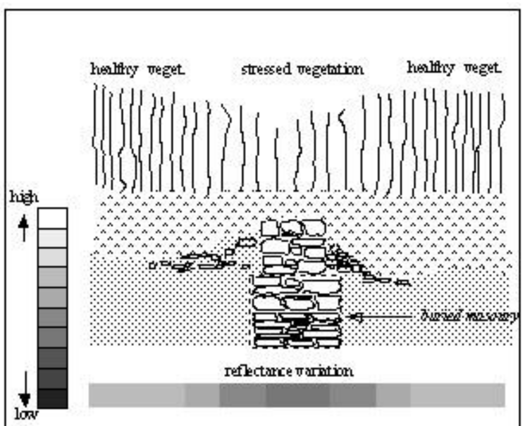
Soil-marks

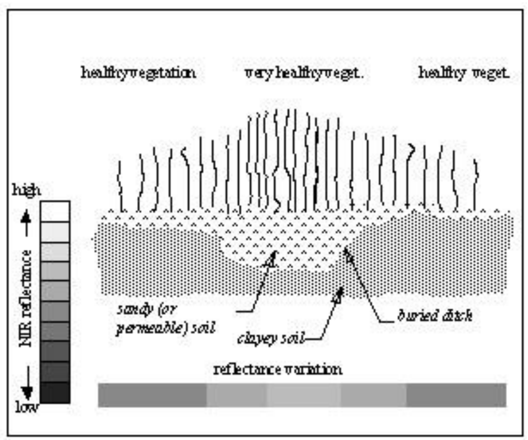
Shadow-marks

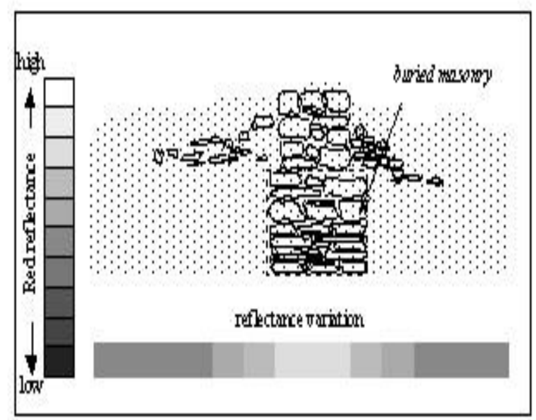
- Changes of soil constituents
- Variations of moisture content
- Nutrient deficiencies
- Differences in the plant growth

Archaeological deposit (negative/positive) cause

These variations induce changes in spectral response of surfaces







Lasaponara and Masini, 2005,
[QuickBird-based analysis for the spatial characterization of archaeological sites: Case study of the Monte Serico medieval village] Geophysical research letters 32 (12)

SAR technology
an underexploited source of information for Archaeology

- ❑Even if today a huge amount of SAR data are available, they are still underexploited in the archaeological operative practice.

- ❑ WHY?

  - ❑ the difficulty in interpreting the data, even though they are finely processed, and thus generating skepticism among archaeologists
  - ❑ and the belief that the complexity of this technology is not proportional to its real usefulness in archaeology.

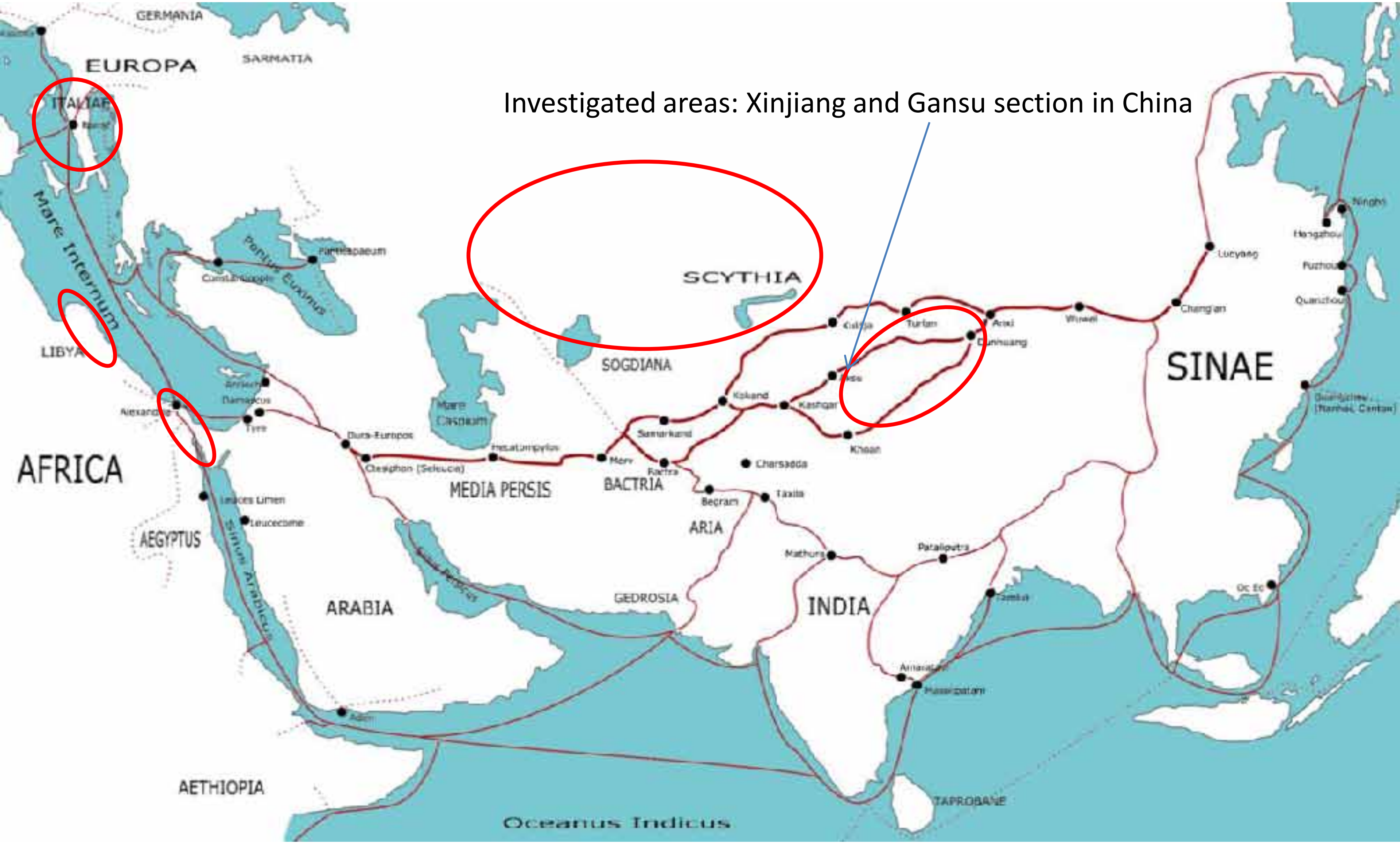
Efforts are needed for improving the ability to interpret the radar data, with the support of archaeological data source and additional information obtainable by other remote sensing methods (optical/geophysical)

Integrated approach along selected silk road sites

Hierapolis case study herein presented

- **What is the added value of active data as SAR?**

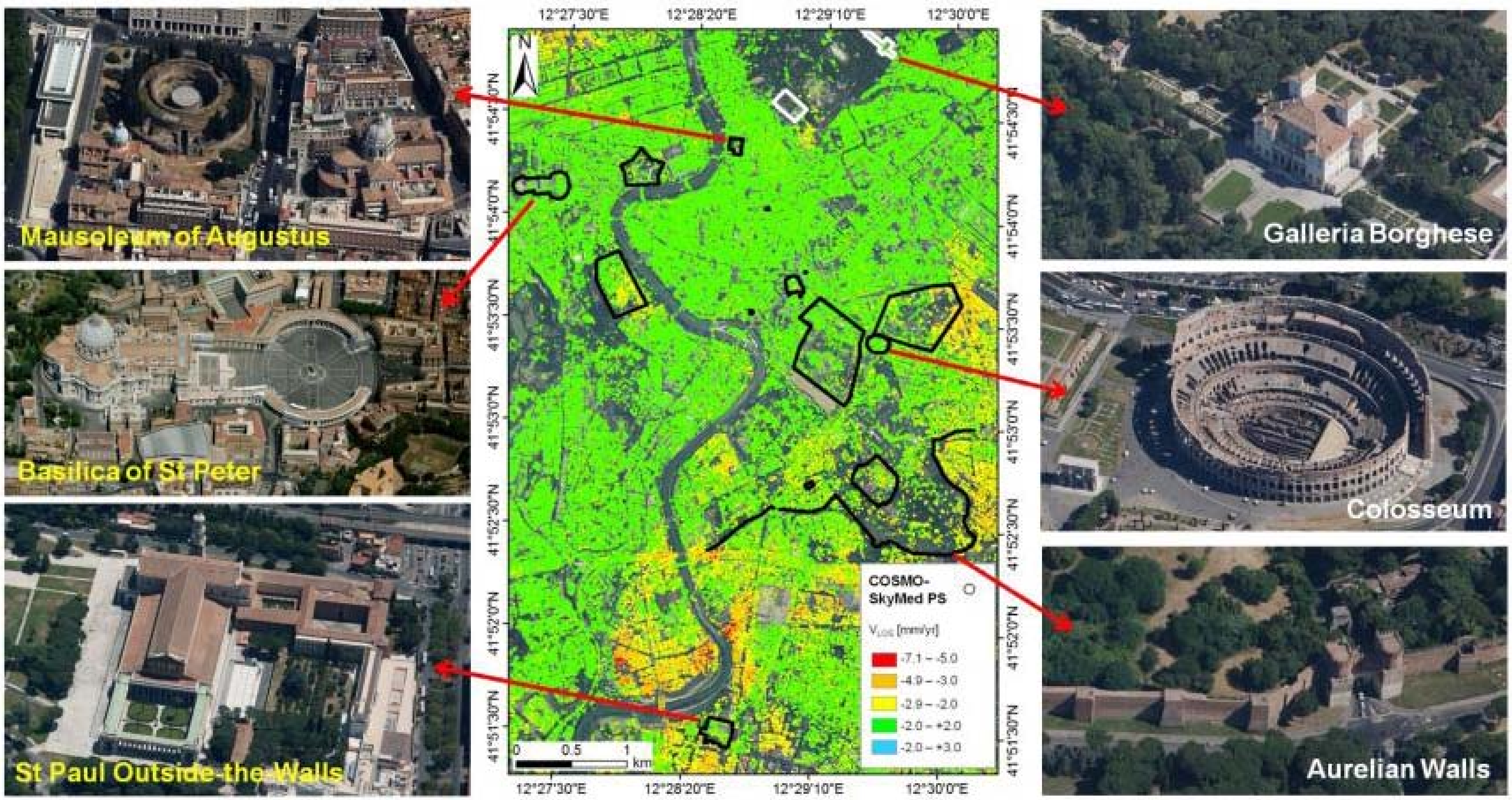
Project of Great Relevance Italy-China on Earth Observation (EO) and ICT for Cultural Heritage (CH) management


Investigated areas: Xinjiang and Gansu section in China
GERMANIA
EUROPA
SARMATIA
Mare Internum
Pontus Euxinus
LIBYA
AFRICA
AEGYPTUS
Sinus Arabicus
ARABIA
AETHIOPIA
Mare Caspium
MEDIA PERSIS
SOGDIANA
SCYTHIA
BACTRIA
ARIA
GEDROSIA
INDIA
SINAE
TAPROBANE
Oceanus Indicus
Dura-Europos
Ctesiphon (Seleucia)
Hecatompylos
Merv
Samarkand
Kokand
Kashgar
Khotan
Charsadda
Taxila
Begram
Turfan
Anxi
Dunhuang
Changan
Luoyang
Ningbo
Fuzhou
Quanzhou
Leucecome
Aden

- **What is the added value of active data as SAR?**

Project of Great Relevance Italy-China on Earth Observation (EO) and ICT for Cultural Heritage (CH) management

SUBSIDENCE MONITORING BY SAR INTERFEROMETRY



Francesca Cigna, Rosa Lasaponara, Nicola Masini, Pietro Milillo and Deodato Tapete **Persistent Scatterer Interferometry Processing of COSMO-SkyMed StripMap HIMAGE Time Series to Depict Deformation of the Historic Centre of Rome, Italy.** *Remote Sens.* **2014**, *6*(12), 12593-12618; doi:10.3390/rs61212593

Rome Site

- EO data

Image acquisition dates (yyyy/mm/dd)
2008/05/07
2008/05/31
2008/06/24
2008/07/18
2008/08/11
2008/09/04
2008/09/28
2008/10/22
2008/11/15
2008/12/09

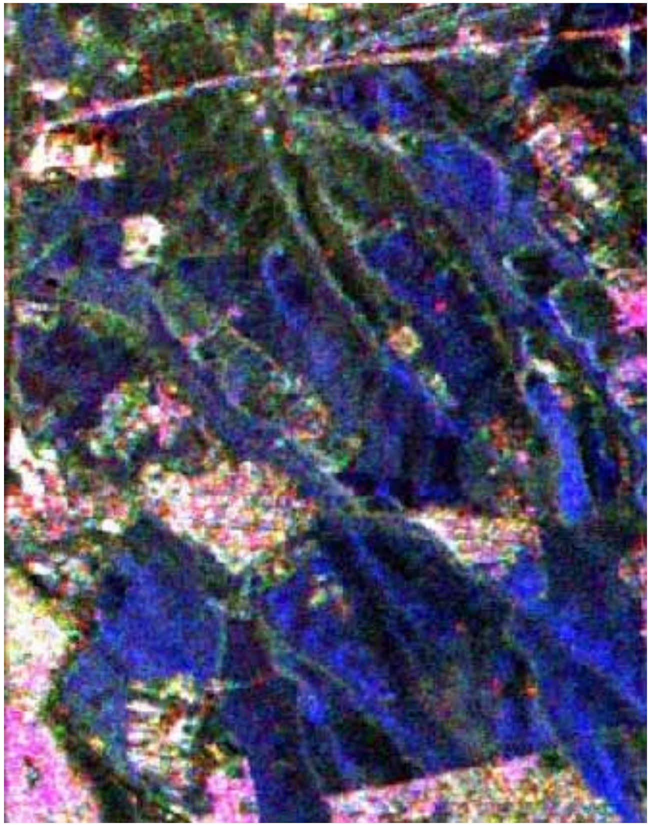
The dataset for the Rome site consists of 10 Radarsat-2 Fine Quad images.

Obtained through the University of Tor Vergata via the Science and Operational Application Research (SOAR) project 1488 and SOAR-EU Project 6795 of the RADARSAT-2 program.

The data is in Single Look Complex (SLC) format.

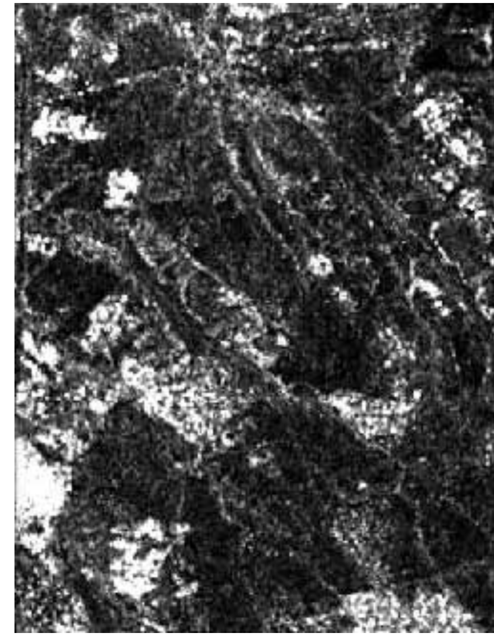
Google Earth acquisitions of **2007/07/29** and **2009/03/10** used for comparison.

Beam	Near Incidence Angle	Far Incidence Angle	Nominal Near Resolution	Nominal Far Resolution
FQ2	20.0 degrees	21.8 degrees	15.2 meters	14.0 meters



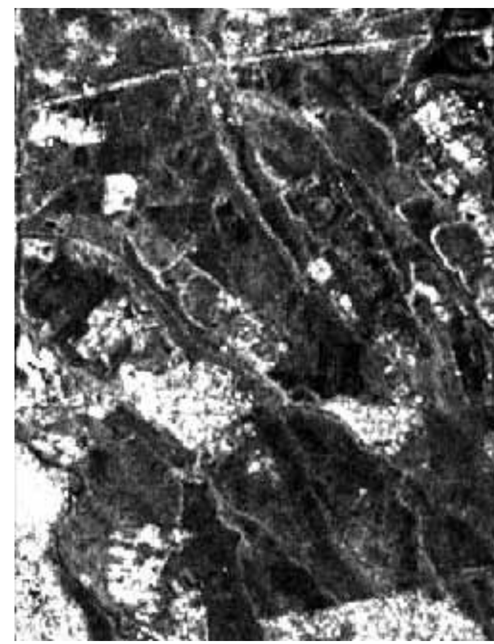
Krogager decomposition elements:
Red=Diplane, Green=Helix, Blue=Sphere.

Yamaguchi 4: Double bounce



Yamaguchi 4: Helix scattering

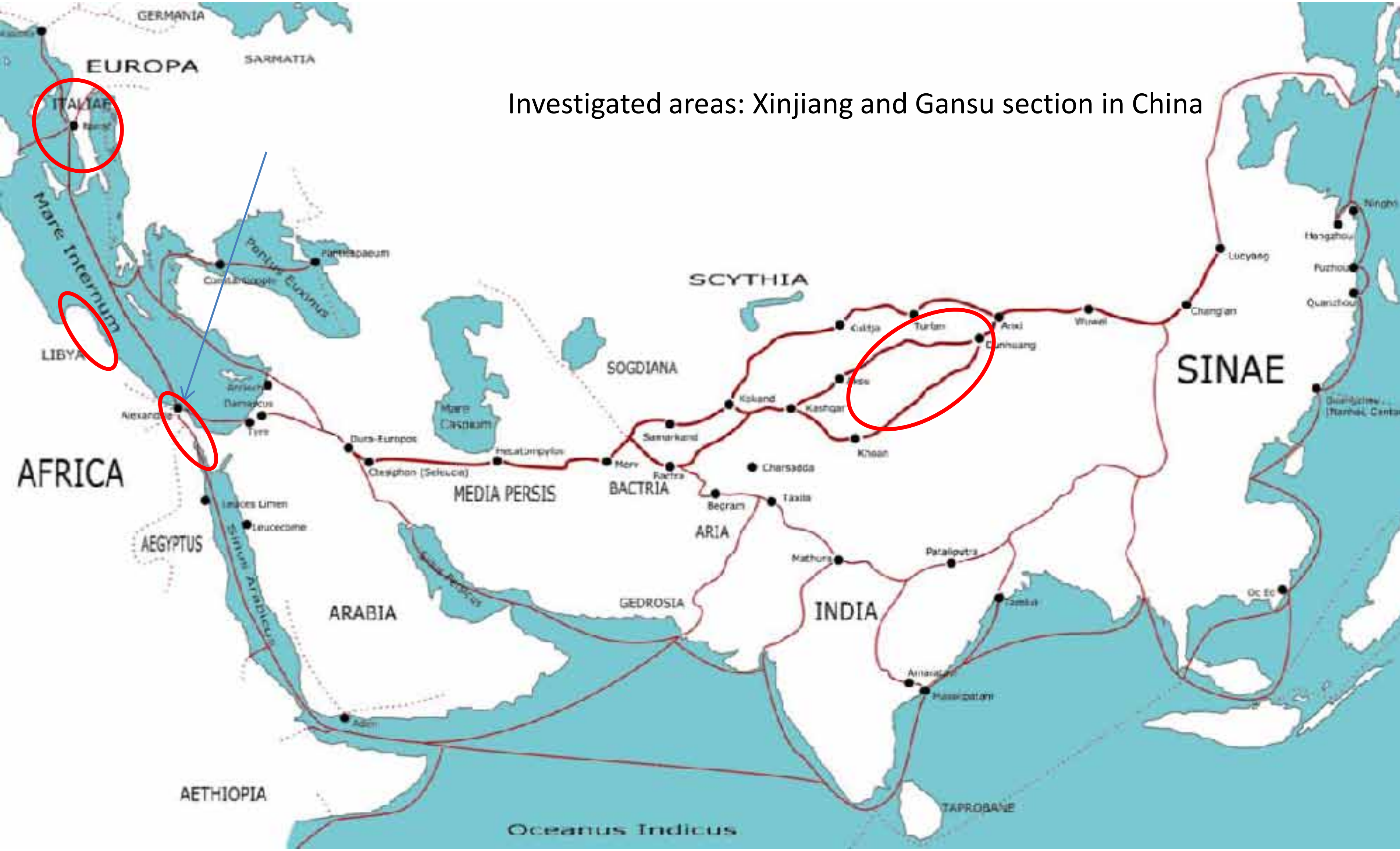
Yamaguchi 4: Odd bounce



Yamaguchi 4: Volume scattering

C Stewart, **R Lasaponara,** G Schiavon 2015 Multi-frequency, polarimetric SAR analysis for archaeological prospection International Journal of Applied Earth Observation and Geoinformation 28, 211-219 (http://dx.doi.org/10.1016/j.jag.2013.11.007)..

Investigated areas: Xinjiang and Gansu section in China



Archaeological Site of Pelusium

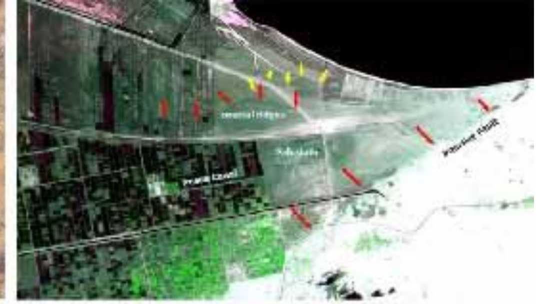
Sum of 2 PALSAR dual pol images. Band HH. Images acquired on 28 Jul 2008 and 15 Sep 2009.

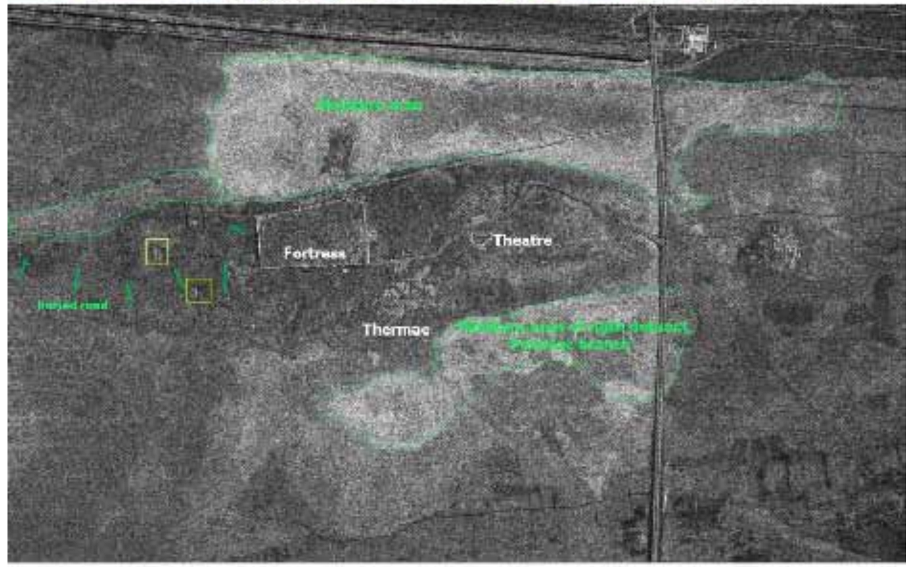
Optical image acquired on 1 August 2009.

Other imagery available on Google Earth include acquisitions on 17 Aug 2003 and 7 Feb 2007.

Additional details in Stewart et al. 2013; Lasaponara & Masini 2015

Visual comparison of Very high resolution optical and SAR data. The case of Pelusium (Egypt)

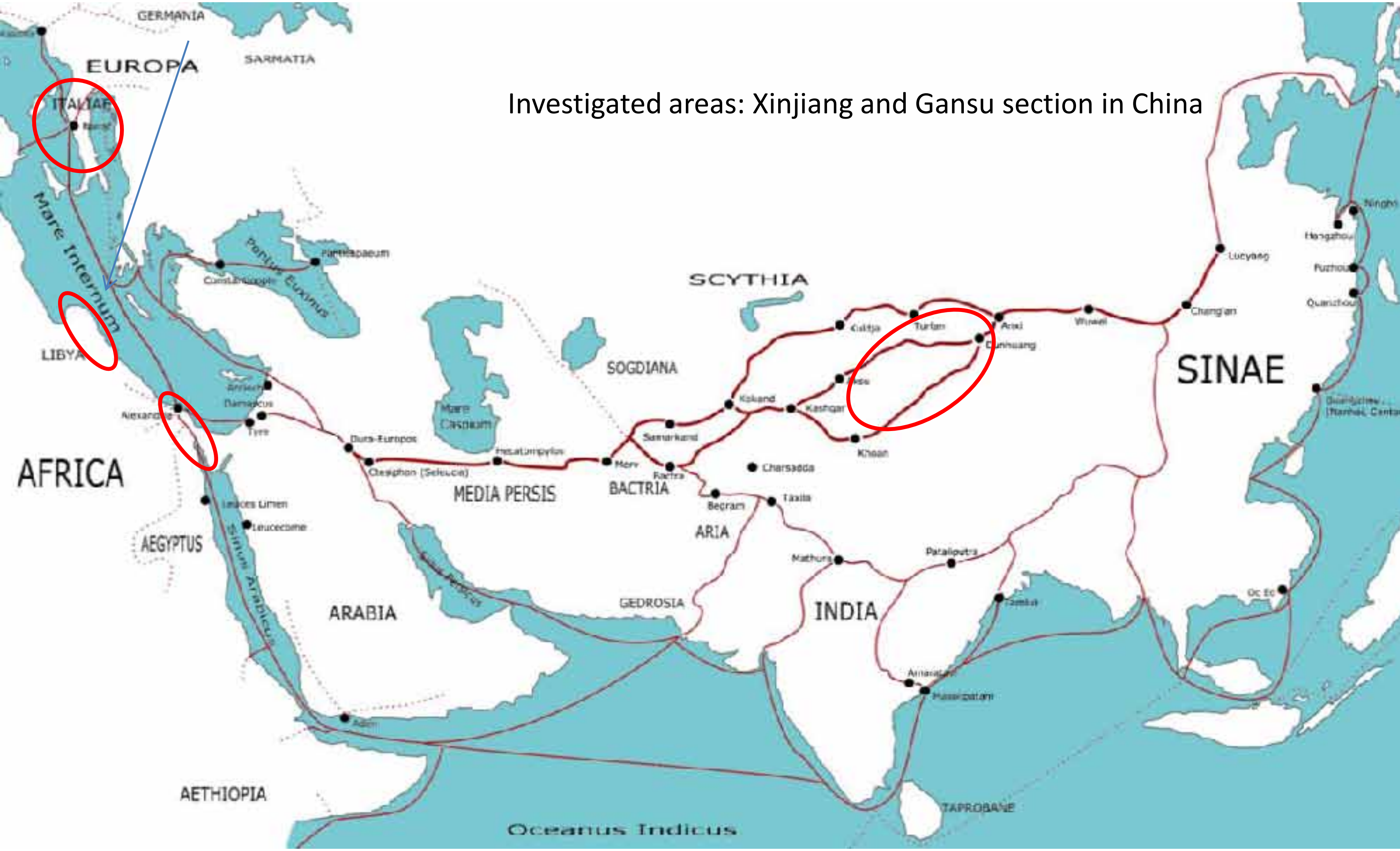




Additional details in

C Stewart, R Lasaponara, G Schiavon 2013 ALOS PALSAR analysis of the archaeological site of Pelusium Archaeological Prospection 20 (2), 109-116

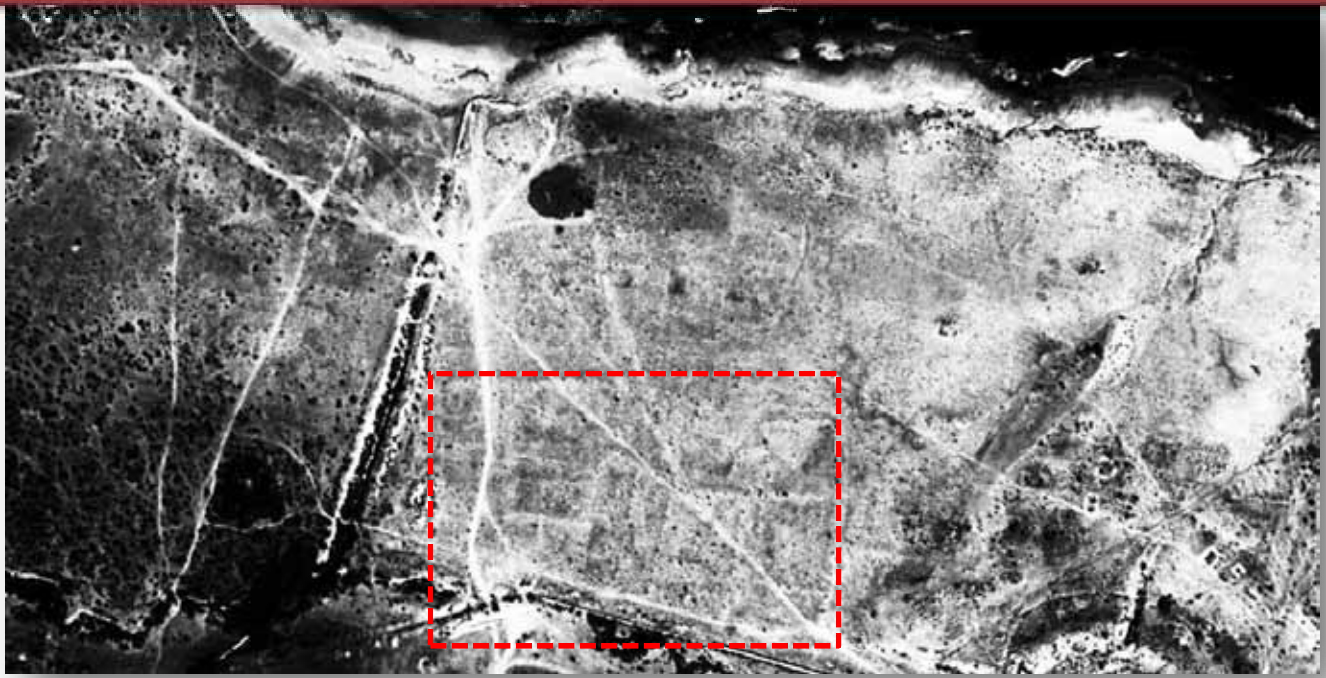
Rosa Lasaponara, Nicola Masini (2015). Reconnaissance of archaeology marks through satellite Synthetic Aperture Radar. In A. Chavarría, A. Reynolds (Eds) Detecting and understanding historic landscapes. SAP Società Archeologica s.r.l., Mantova, pp. 93-108



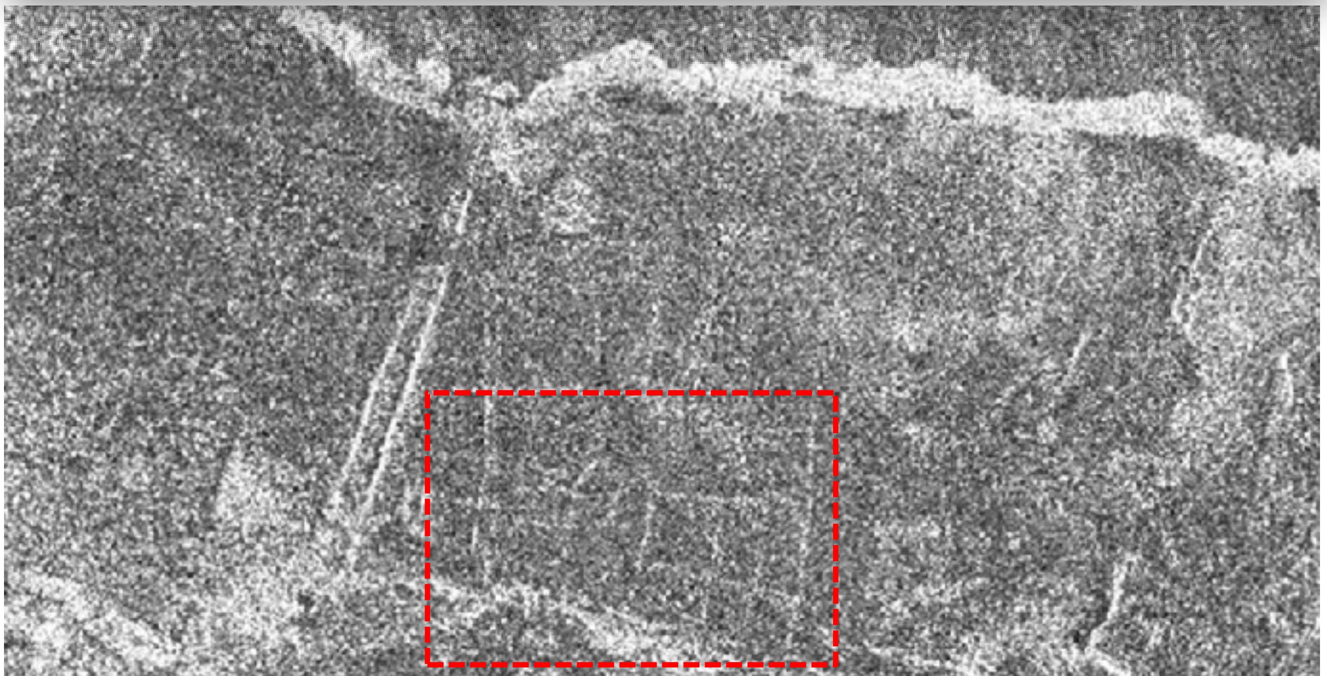
Investigated areas: Xinjiang and Gansu section in China

Integration : Very high resolution optical and SAR data. The case of Sabratha in Lybia

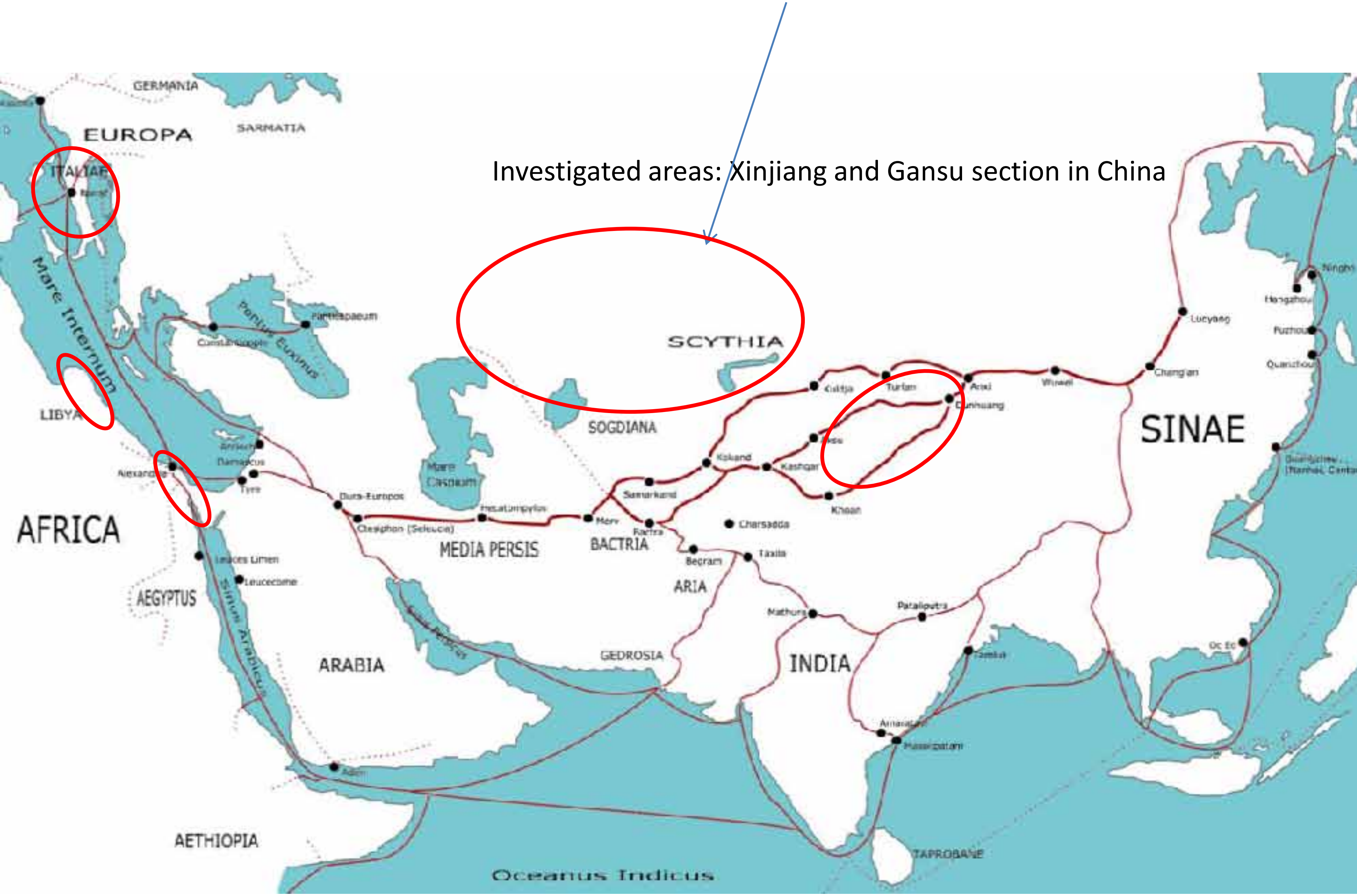
Pleiades 1A
(2013-03-02)



Cosmo SkyMed
Spotlight



Chen F., Masini N., Yang R., Milillo P., Feng D., Lasaponara R., 2015 A Space View of Radar Archaeological Marks: First Applications of COSMO-SkyMed X-Band Data. *Remote Sens.* **2015**, *7*, 24-50; doi:10.3390/rs70100024



Investigated areas: Xinjiang and Gansu section in China
GERMANIA
EUROPA
SARMATIA
Mare Internum
LIBYA
AFRICA
AEGYPTUS
ARABIA
AETHIOPIA
Sinus Arabicus
Mare Caspium
SCYTHIA
SOGDIANA
MEDIA PERSIS
BACTRIA
ARIA
GEDROSIA
INDIA
SINAE
TAPROBANE
Oceanus Indicus
Dura-Europos
Ctesiphon (Seleucia)
Samarkand
Kashgar
Khotan
Turfan
Dunhuang
Charsadda
Taxila
Begram
Pataliputra
Luoyang
Changan

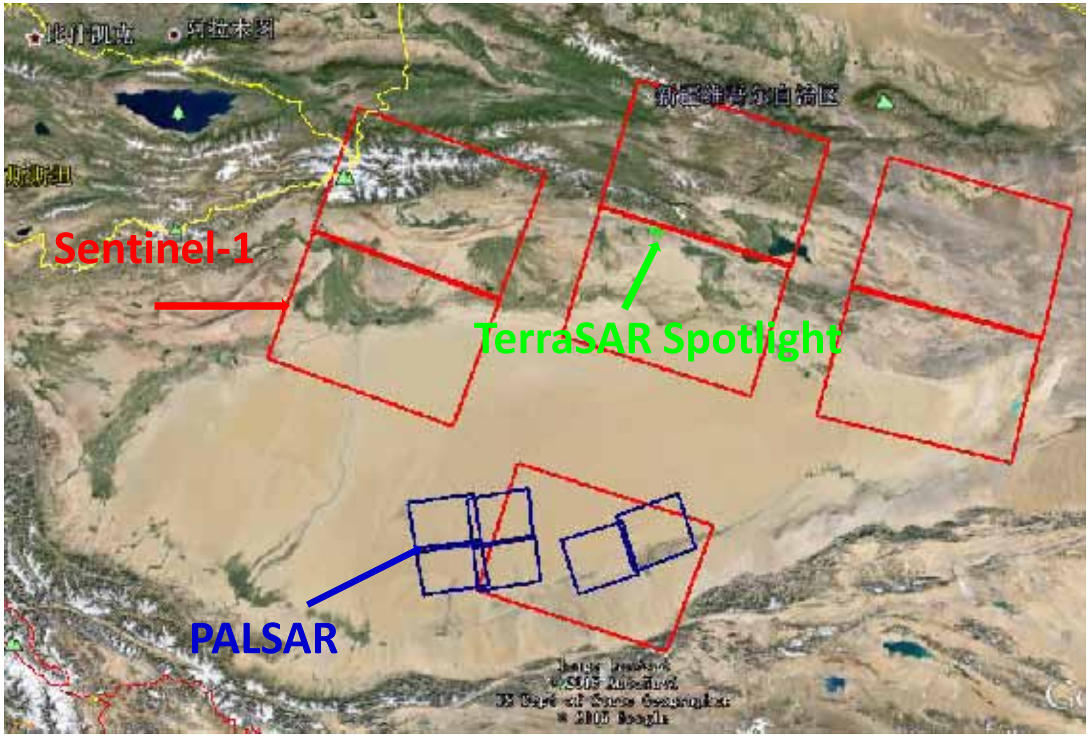
Satellite data

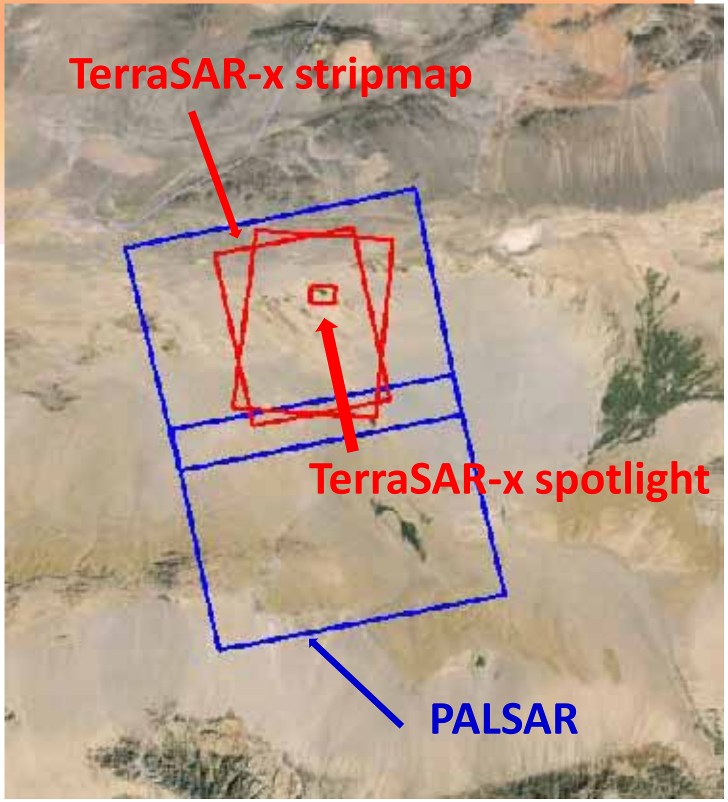
Gansu section

- 12 scenes of L-band PALSAR data in Yumen Frontier Pass and Yang Frontier Pass
- 3 scenes of X-band TerraSAR data (2 stripmap and 1 spotlight) in Yumen Frontier Pass
- 8 scenes of Sentinel-1 IW (7 dual polar and 1 single polar)
- 45 scenes of Chinese Gaofen-1 Optical remote sensing images (2 m Pan with 8 m multi-spectral)

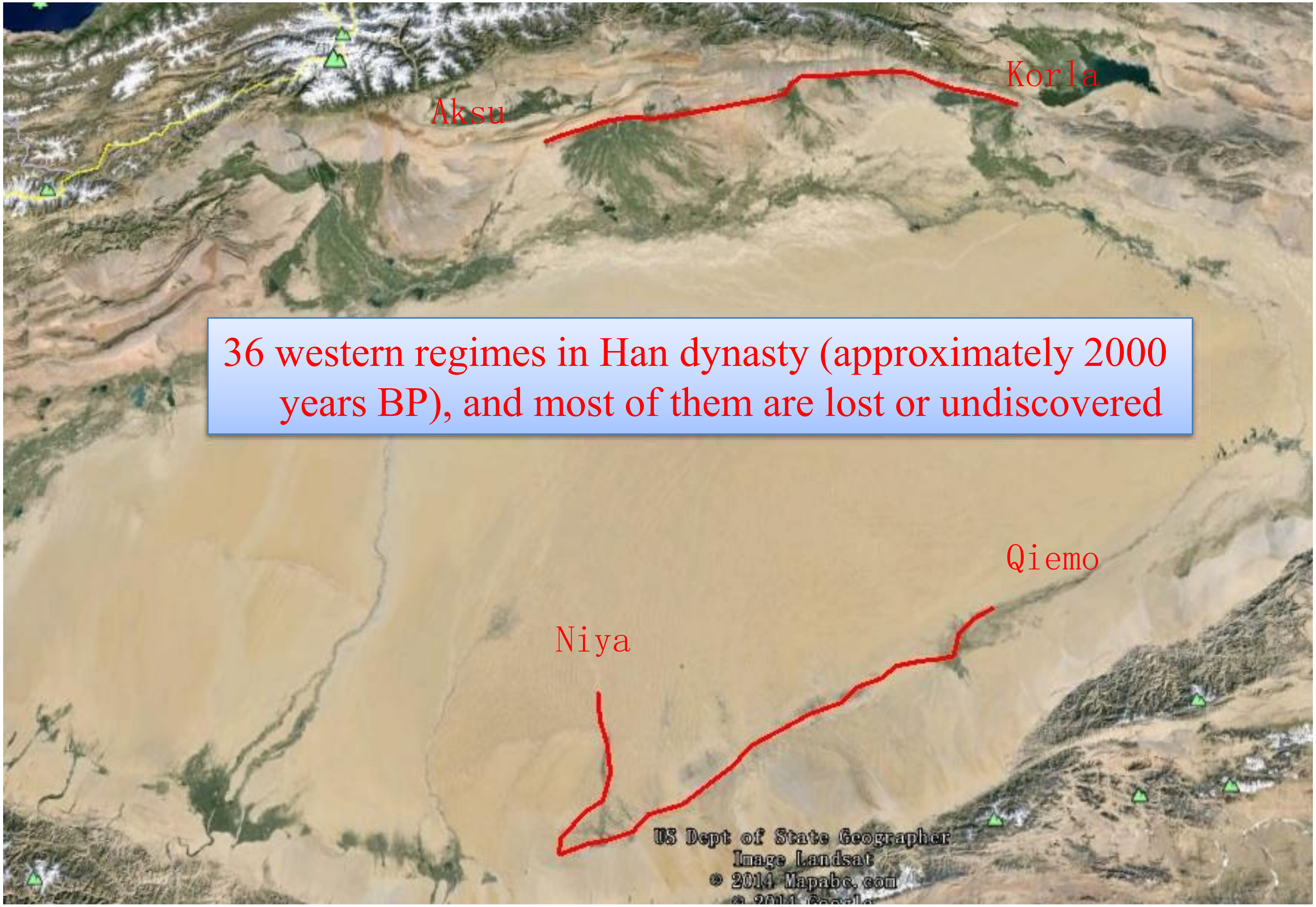
Xinjiang section

- 12 scenes of L-band PALSAR data
- 1 scene of X-band spotlight TerraSAR data



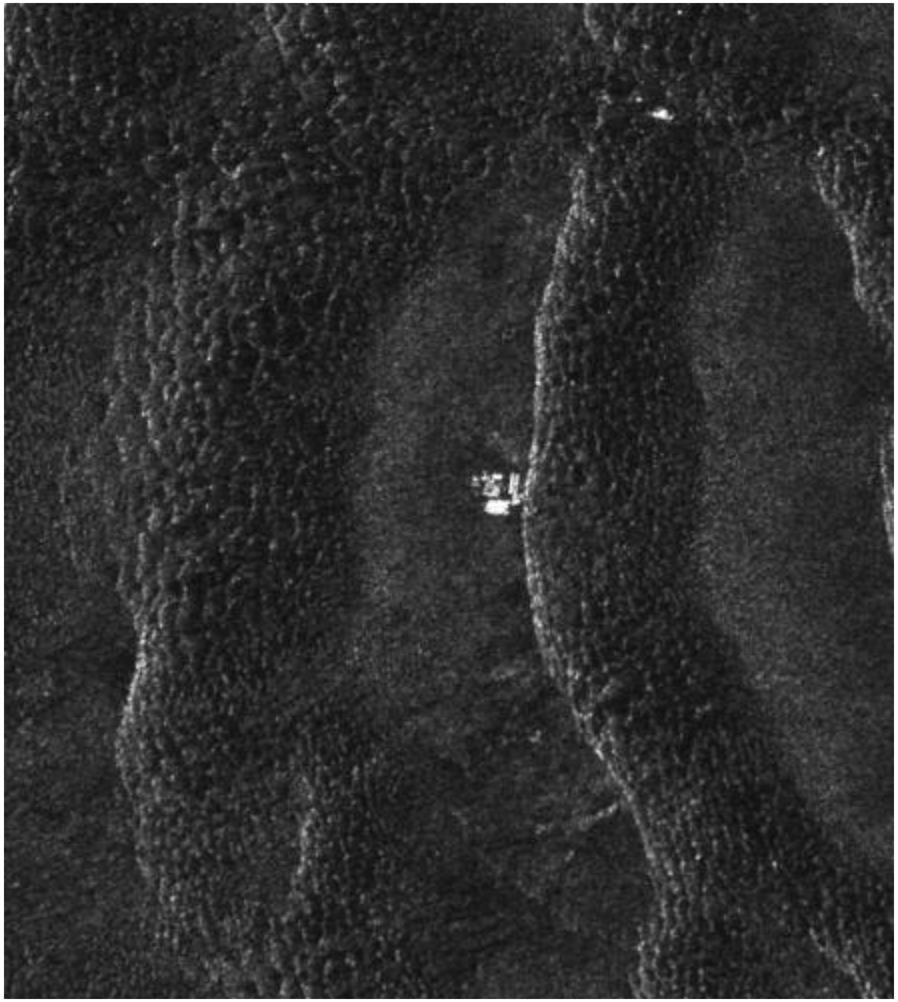


Xinjiang (Uygur Autonomous Region) Section of Silk Road



Suspected features were detected by SAR backscattering for searching the lost city of Qiemo country (one of 36 regimes)

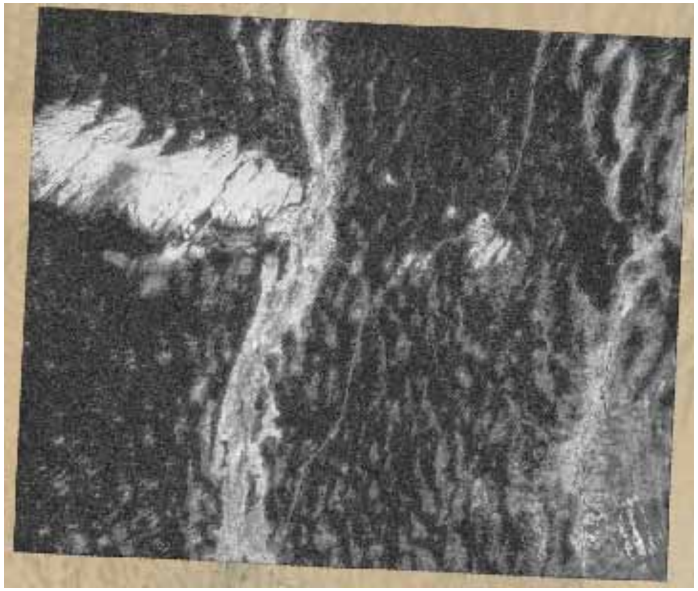
L-band PALSAR (acquired in 2009)

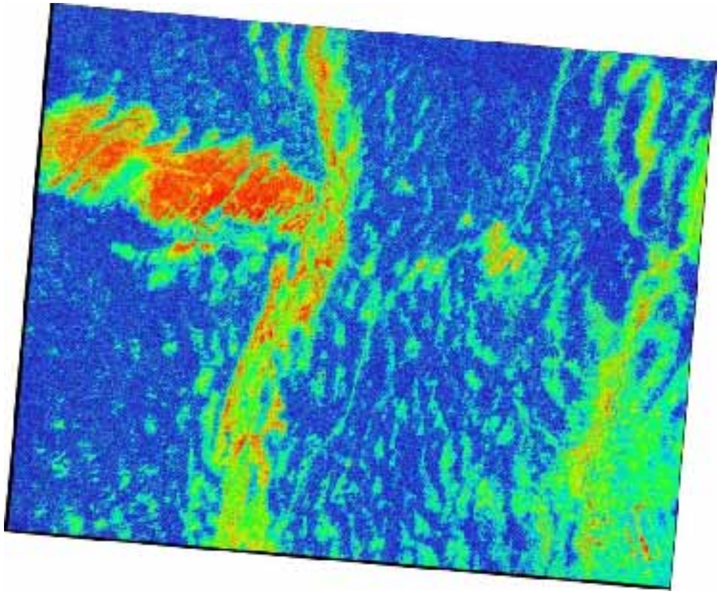


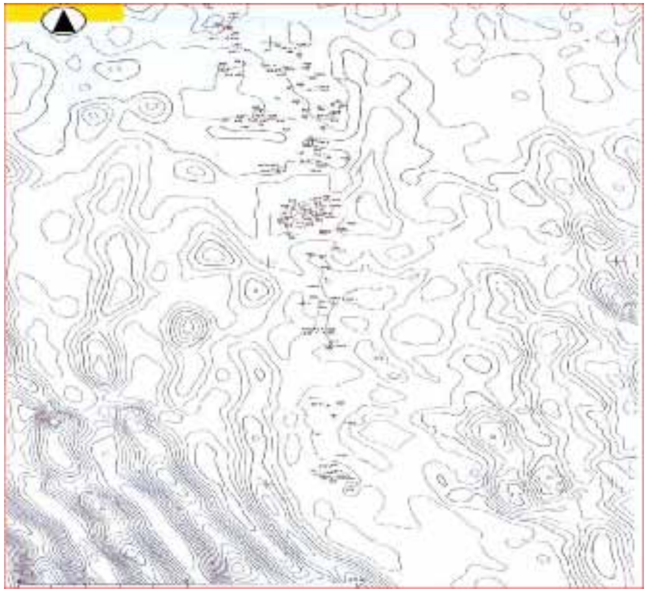
C-band Sentinel-1 (acquired in 2015)

F. Chen, N. Masini, Jie Liu, Jiangbin You & R. Lasaponara (2016): Multi-frequency satellite radar imaging of cultural heritage: the case studies of the Yumen Frontier Pass and Niya ruins in the Western Regions of the Silk Road Corridor, International Journal of Digital Earth, DOI: 10.1080/17538947.2016.1181213

The comparison of Amplitude and coherence image of PALSAR data in Niya ruin



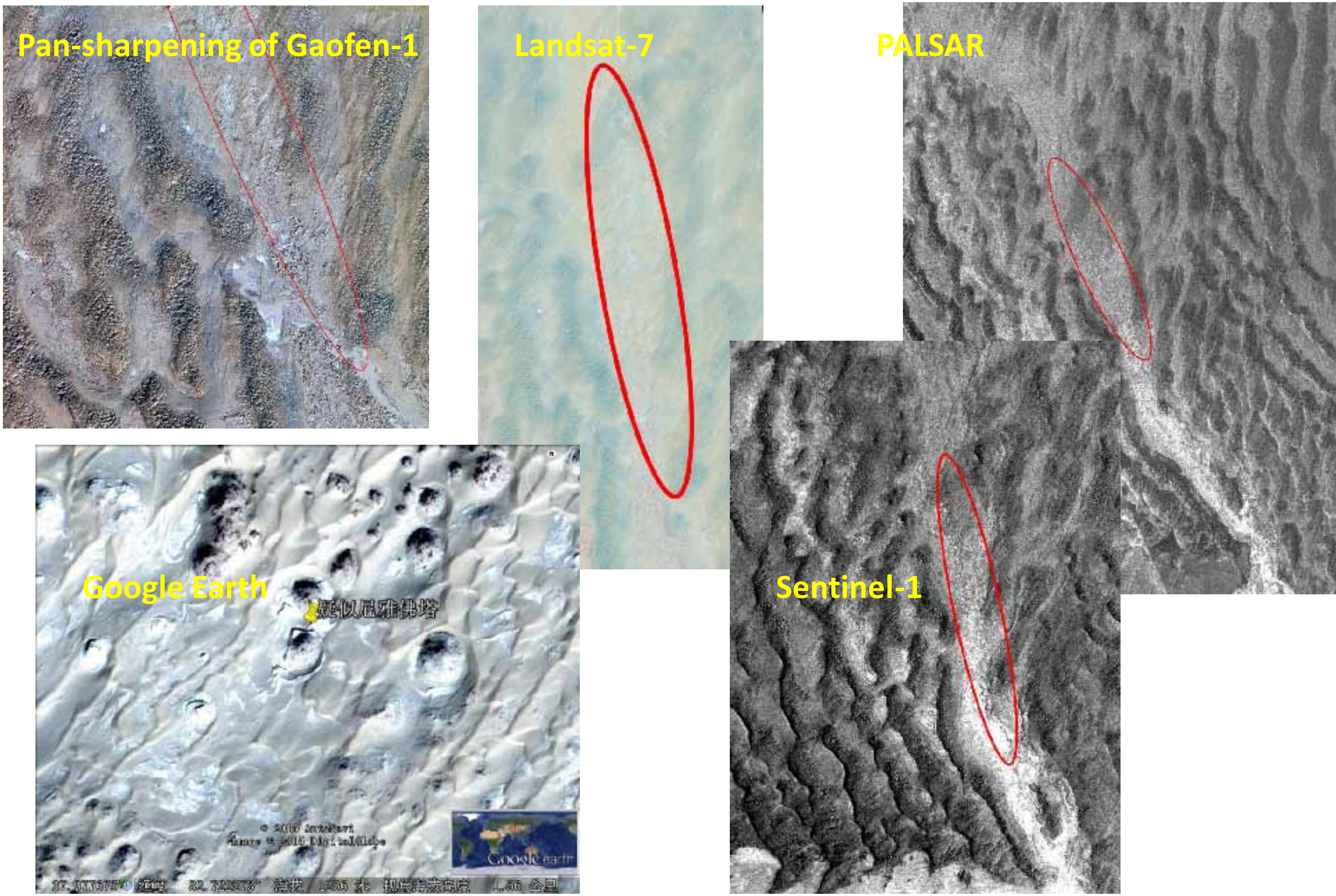




The variation of coherence is closely related to the physical parameters of observed surface, e.g. soil moisture, mild-relief as well as materials; and consequently it is useful for the relic feature enhancement and identification

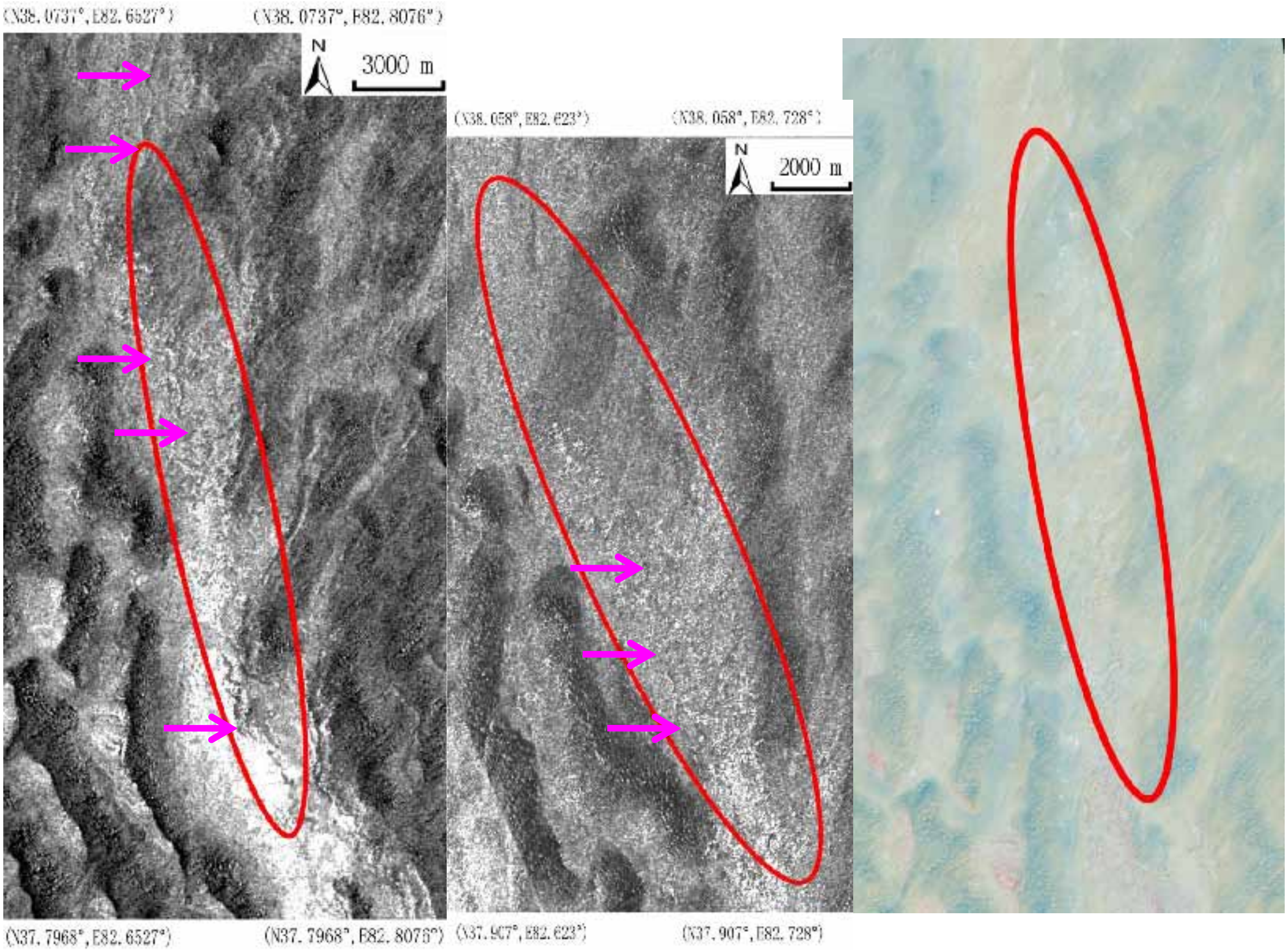
F. Chen, N. Masini, Jie Liu, Jiangbin You & R. Lasaponara (2016): Multi-frequency satellite radar imaging of cultural heritage: the case studies of the Yumen Frontier Pass and Niya ruins in the Western Regions of the Silk Road Corridor, International Journal of Digital Earth, DOI: 10.1080/17538947.2016.1181213

Archaeology investigation in Niya ruin using multi-source remote sensing data



F. Chen, N. Masini, Jie Liu, Jiangbin You & R. Lasaponara (2016): Multi-frequency satellite radar imaging of cultural heritage: the case studies of the Yumen Frontier Pass and Niya ruins in the Western Regions of the Silk Road Corridor, International Journal of Digital Earth, DOI: 10.1080/17538947.2016.1181213

Ancient Riverbank detection using SAR and optical remote sensing data

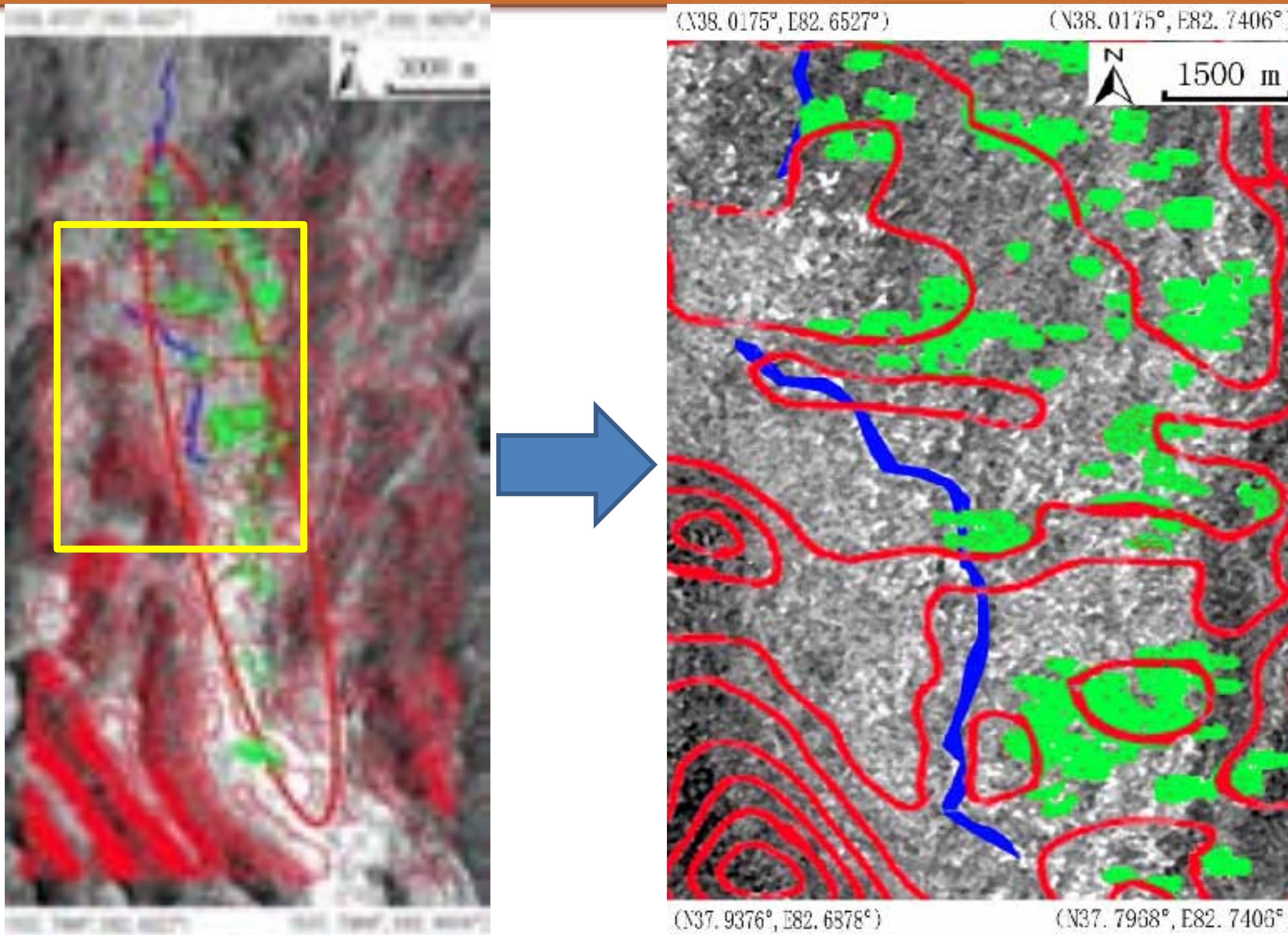


Sentinel-1 VV PALSAR HH Landsat-7

Compared with optical TM data, ancient bank of Niya river was detected by SAR images marked by the pink arrows. (higher performance of Sentinel vs. PALSAR)

F. Chen, N. Masini, Jie Liu, Jiangbin You & R. Lasaponara (2016): Multi-frequency satellite radar imaging of cultural heritage: the case studies of the Yumen Frontier Pass and Niya ruins in the Western Regions of the Silk Road Corridor, International Journal of Digital Earth, DOI: 10.1080/17538947.2016.1181213

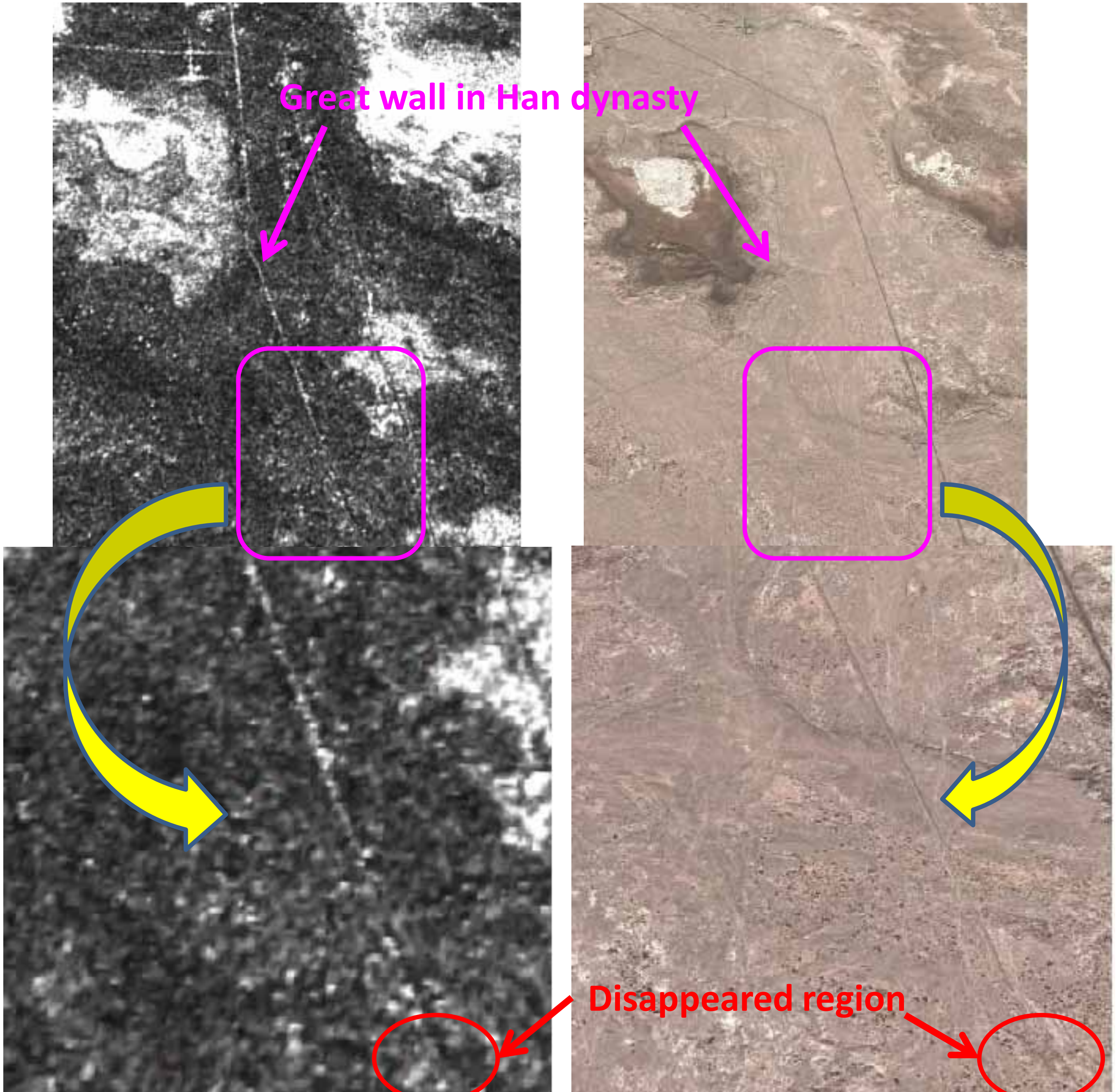
Spatial distribution relationship between archaeological features and suspected bank



Archaeological features locate on the right side of the suspected bank, highly probably corresponding to the river terrace. Suspected Riverbank marked by blue lines. Terrain and archaeological features are marked by red contour lines and green patches.

F. Chen, N. Masini, Jie Liu, Jiangbin You & R. Lasaponara (2016): Multi-frequency satellite radar imaging of cultural heritage: the case studies of the Yumen Frontier Pass and Niya ruins in the Western Regions of the Silk Road Corridor, International Journal of Digital Earth, DOI: 10.1080/17538947.2016.1181213

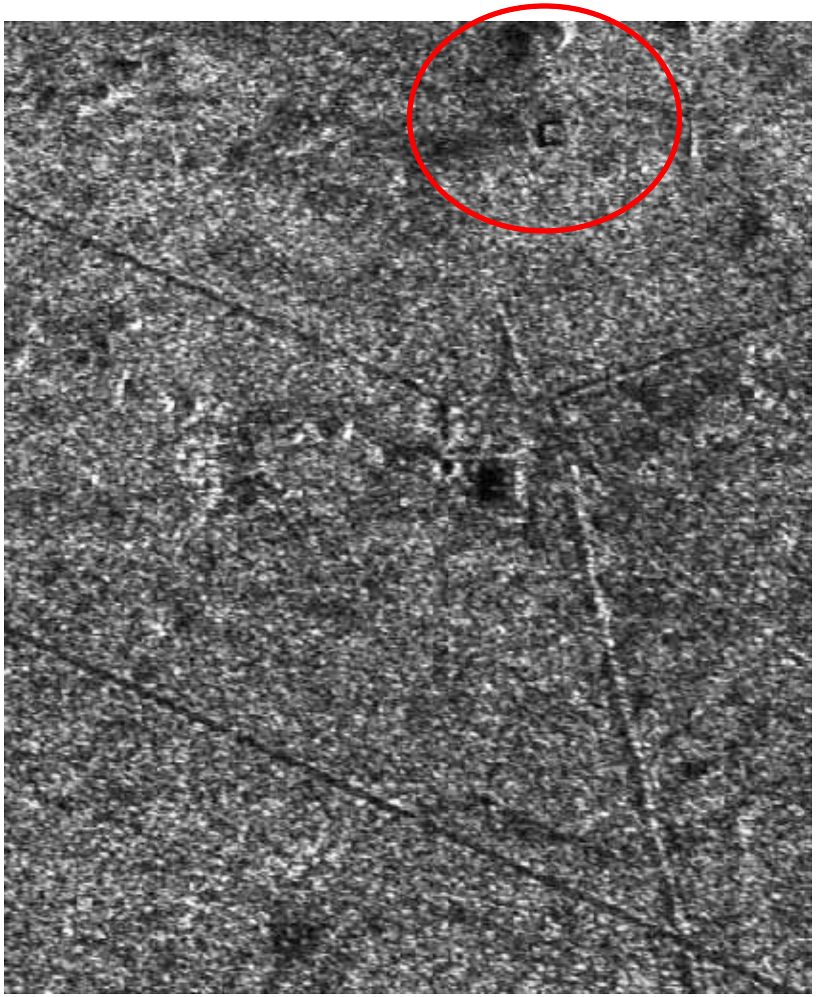
Penetration performance of PALSAR data in Yumen Frontier Pass



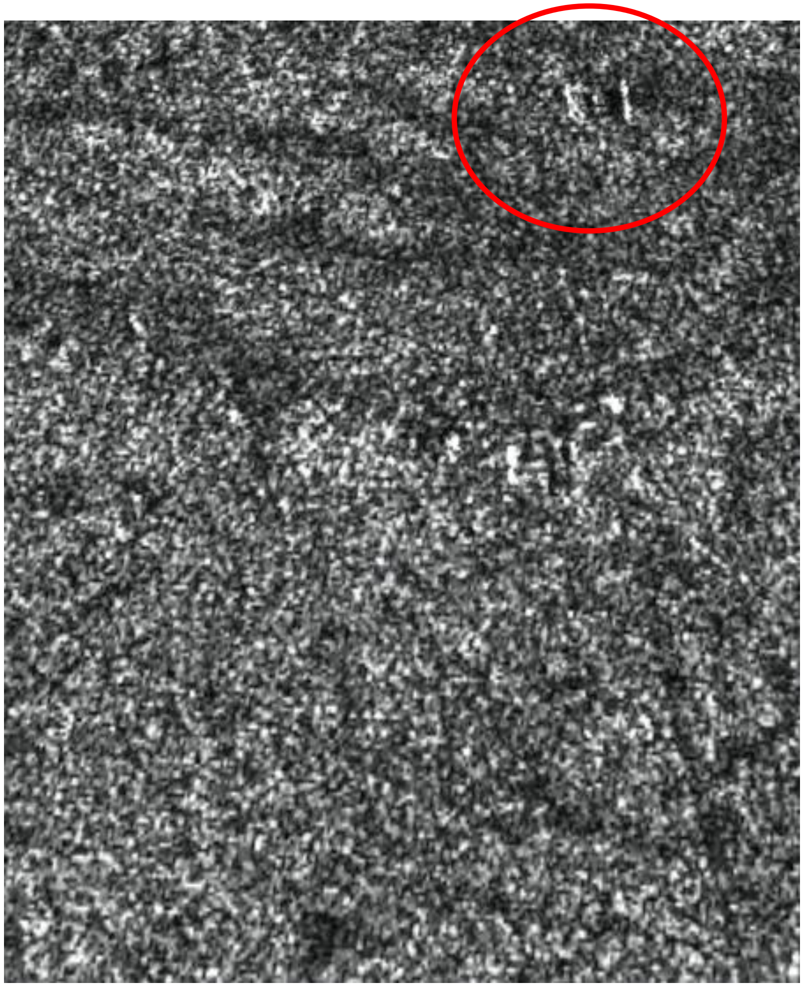
Great Wall in Han dynasty disappear in both images, demonstrating the penetration capability of PALSAR is limited in this arid region with Yardang geological condition (compacted deposit surface layer with low porosity). However, more experiments are required for a comprehensive quantitative evaluation

F. Chen, N. Masini, Jie Liu, Jiangbin You & R. Lasaponara (2016): Multi-frequency satellite radar imaging of cultural heritage: the case studies of the Yumen Frontier Pass and Niya ruins in the Western Regions of the Silk Road Corridor, International Journal of Digital Earth,

TerraSAR Spotlight (1m) VS. Stripmap (3m)



(a)



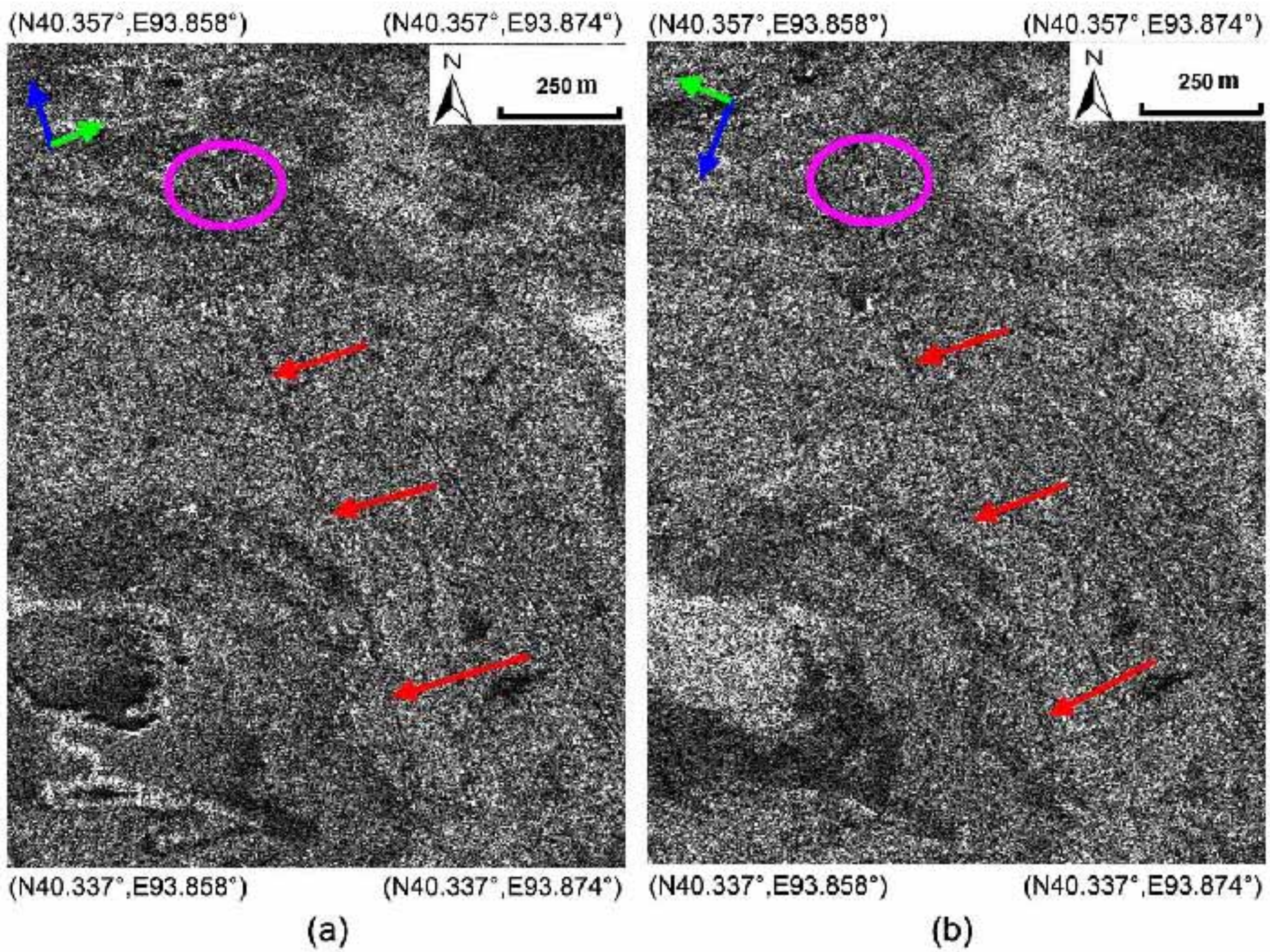
(b)

(a) Spotlight; (b) Stripmap. Archaeological features of Yumen Frontier Pass was highlighted by the red ellipse.

F. Chen, N. Masini, Jie Liu, Jiangbin You & R. Lasaponara (2016): Multi-frequency satellite radar imaging of cultural heritage: the case studies of the Yumen Frontier Pass and Niya ruins in the Western Regions of the Silk Road Corridor, International Journal of Digital Earth, DOI: 10.1080/17538947.2016.1181213

TerraSAR Ascending VS. Descending path

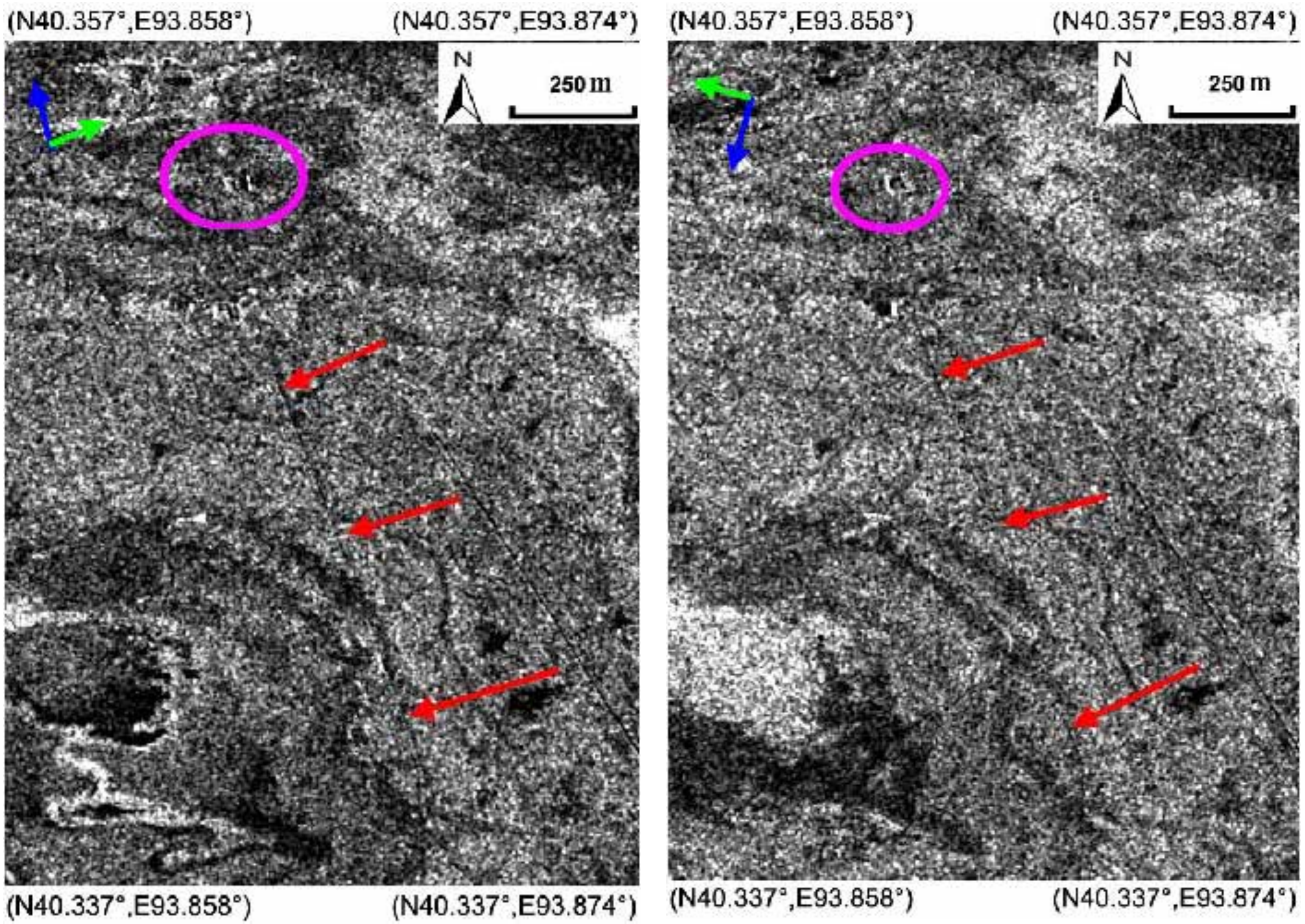
F. Chen, N. Masini, Jie Liu, Jiangbin You & R. Lasaponara (2016): Multi-frequency satellite radar imaging of cultural heritage: the case studies of the Yumen Frontier Pass and Niya ruins in the Western Regions of the Silk Road Corridor, International Journal of Digital Earth, DOI: 10.1080/17538947.2016.1181213



Two TerraSAR-X Stripmaps images (a) and (b) related to the same scene including the Great Wall in Han dynasty (marked by red arrows) and Yumen Frontier Pass (marked by the purple ellipse), and acquired in ascending and descending mode, respectively. The two data have been acquired on 28.04.2013 with 41° incidence angle and 23.09.2012 with 39° incidence angle, respectively.

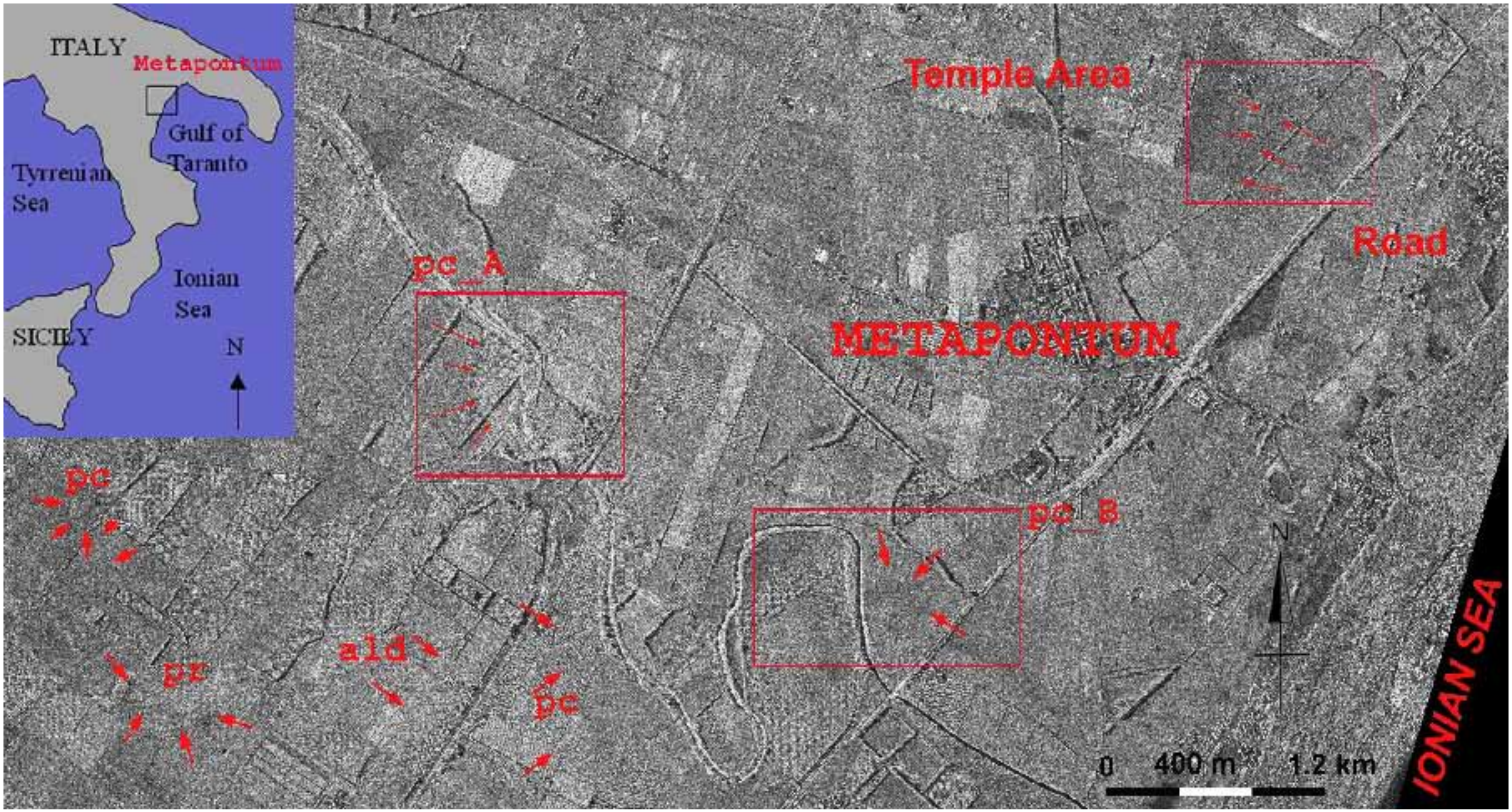
Speckle filtering

F. Chen, N. Masini, Jie Liu, Jiangbin You & R. Lasaponara (2016): Multi-frequency satellite radar imaging of cultural heritage: the case studies of the Yumen Frontier Pass and Niya ruins in the Western Regions of the Silk Road Corridor, International Journal of Digital Earth, DOI: 10.1080/17538947.2016.1181213

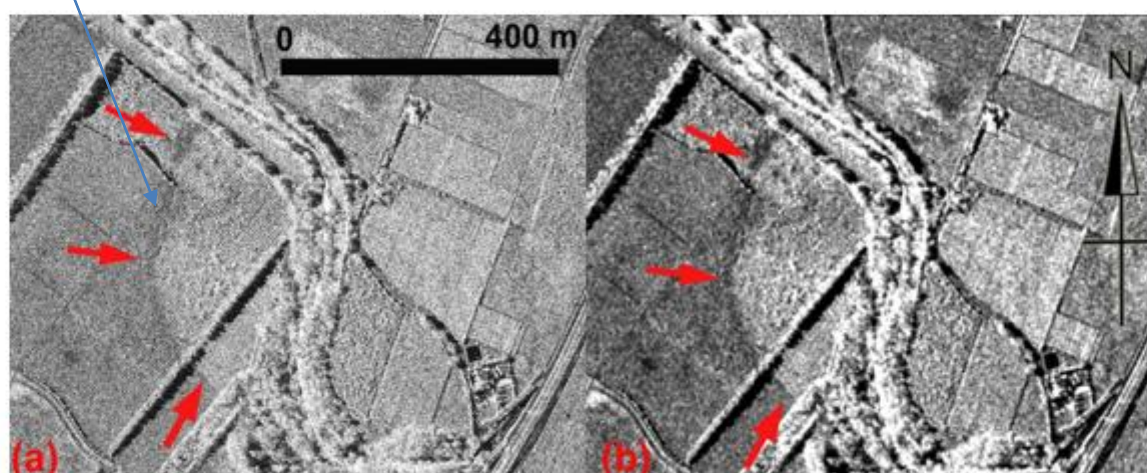


(a) (b)

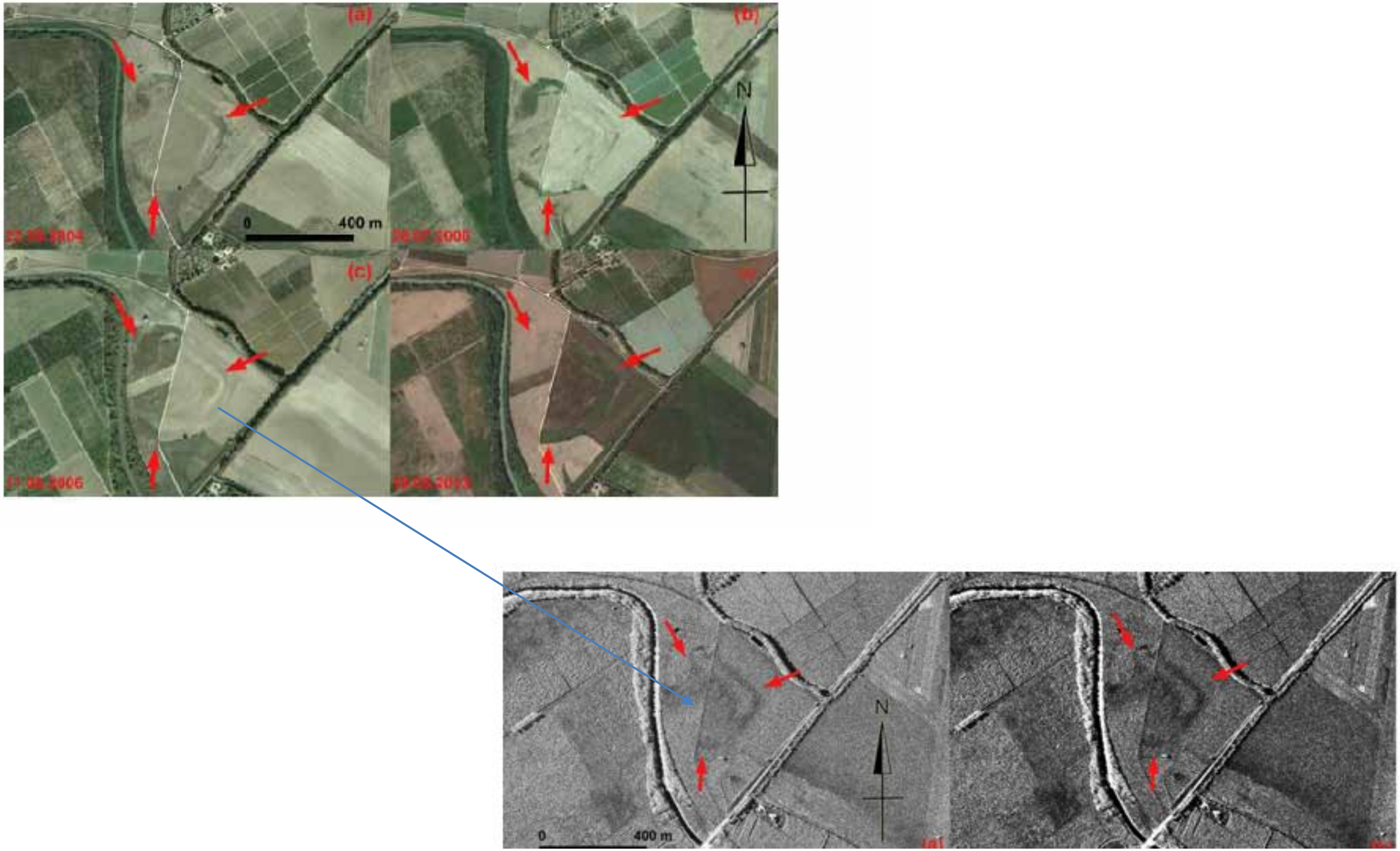
(a) Ascending of 20130428 <u>with enhanced Lee filter </u>; (b) Descending of 20120923 with enhanced Lee filter. The linear as well as rectangle archaeological features were more remarkable after speckle suppression using the 3*3 enhance Lee filter.



Chen F., Masini N., Yang R., Milillo P., Feng D., Lasaponara R., 2015 A Space View of Radar Archaeological Marks: First Applications of COSMO-SkyMed X-Band Data. *Remote Sens.* **2015**, *7*, 24-50; doi:10.3390/rs70100024

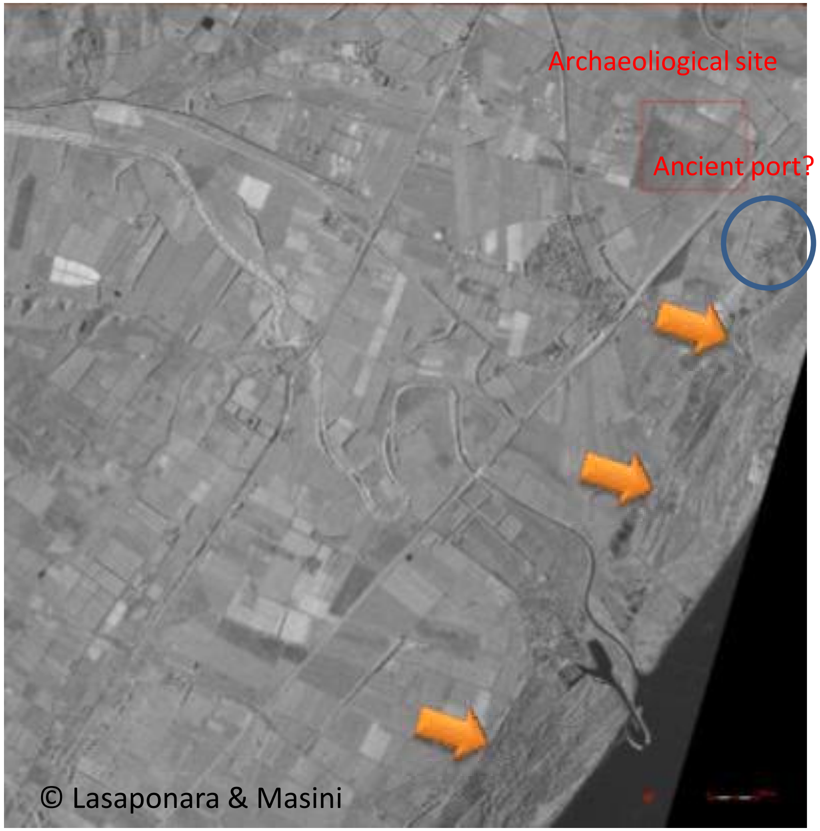


Chen F., Masini N., Yang R., Milillo P., Feng D., Lasaponara R., 2015 A Space View of Radar Archaeological Marks: First Applications of COSMO-SkyMed X-Band Data. *Remote Sens.* **2015**, *7*, 24-50; doi:10.3390/rs70100024



Chen F., Masini N., Yang R., Milillo P., Feng D., Lasaponara R., 2015 A Space View of Radar Archaeological Marks: First Applications of COSMO-SkyMed X-Band Data. *Remote Sens.* **2015**, *7*, 24-50; doi:10.3390/rs70100024

Metapontum Case Study



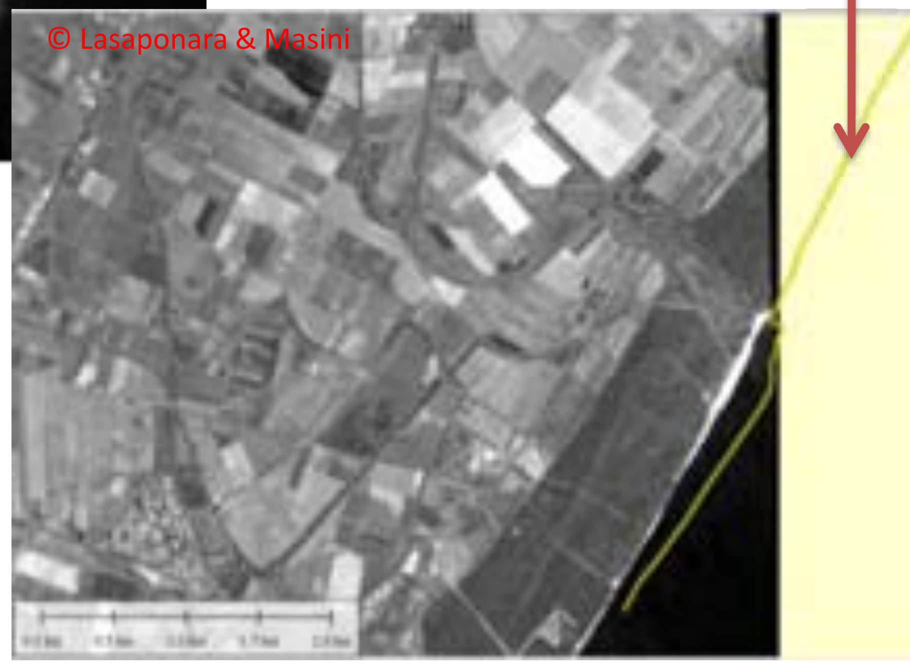
Cosmo SkyMed Spotlight : orange arrows denote the coastline in Metaponto was a greek and then roman site. At the age there was a port which si dated up to Middle Ages

Some historical data on the movements of the coastline come from archeology. In particular, the inner dune belt, near the ancient Metaponto could be dated between the 7th and 3rd centuries BC. Just in this last century the dune was cut artificially, probably to facilitate the drainage of inland wetlands to the sea. This hypothesis supported by the presence of archaeological remains, possibly belonging to the old port, would lead us to suggest the presence of a nearby coast. Two other bands of dune ridges, which are located further inland, would be formed between the Roman period and the Middle Ages. As for the medieval coastline, some indications of its position may be derived from the remains in the mouth of Basento rivers, near a medieval village, named Torre Mare, that, around the twelfth or thirteenth century, had served as a port.

Metapontum Case Study

1961 Satellite declassified Corona

1961 coastline



2004 Satellite QuickBird

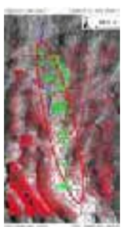
(a)

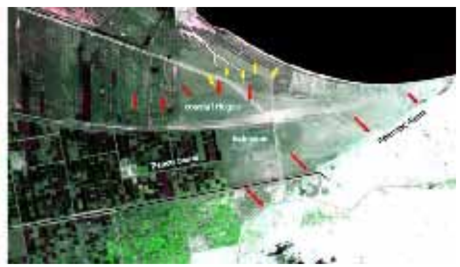
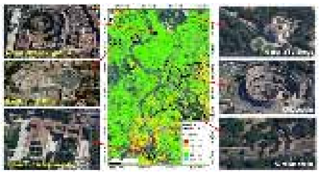
The multi-temporal analysis (1950, 1961, 2004, 2013) enabled to follow the changes of the Ionian coast that from the middle of the twentieth century was characterized by alternating phases of growth and regression. The latter prevails since the early 60s and continues today with varying rates of erosion

Conclusion

- **Satellite SAR enabled us to identify new sites along the Silk Road**

- **Multitask use of satellite data from the identification of buried structures, to palaeoenvironmental reconstruction, (past , present shorelines for example) risk estimation**




- **Satellite SAR in Archaeology : Data processing issues**
  - **Different approches based on Multidate and single date analysis**
  - **Early Characterization of the impact of different parameters (penetration, resolution, geometric conditions-asceding versus descending) <u>on the buried structured "visibility"</u>**

Thank you

The Copernicus Programme
and World Cultural Heritage preservation

Workshop
Remote Sensing for Cultural Heritage Beyond Europe
Paphos, March 20th, 2017

Gunter Schreier (Gunter.Schreier@dlr.de)
Deutsches Fernerkundungsdatenzentrum

Earth Observation Center
DLR-DFD, Oberpfaffenhofen
Germany

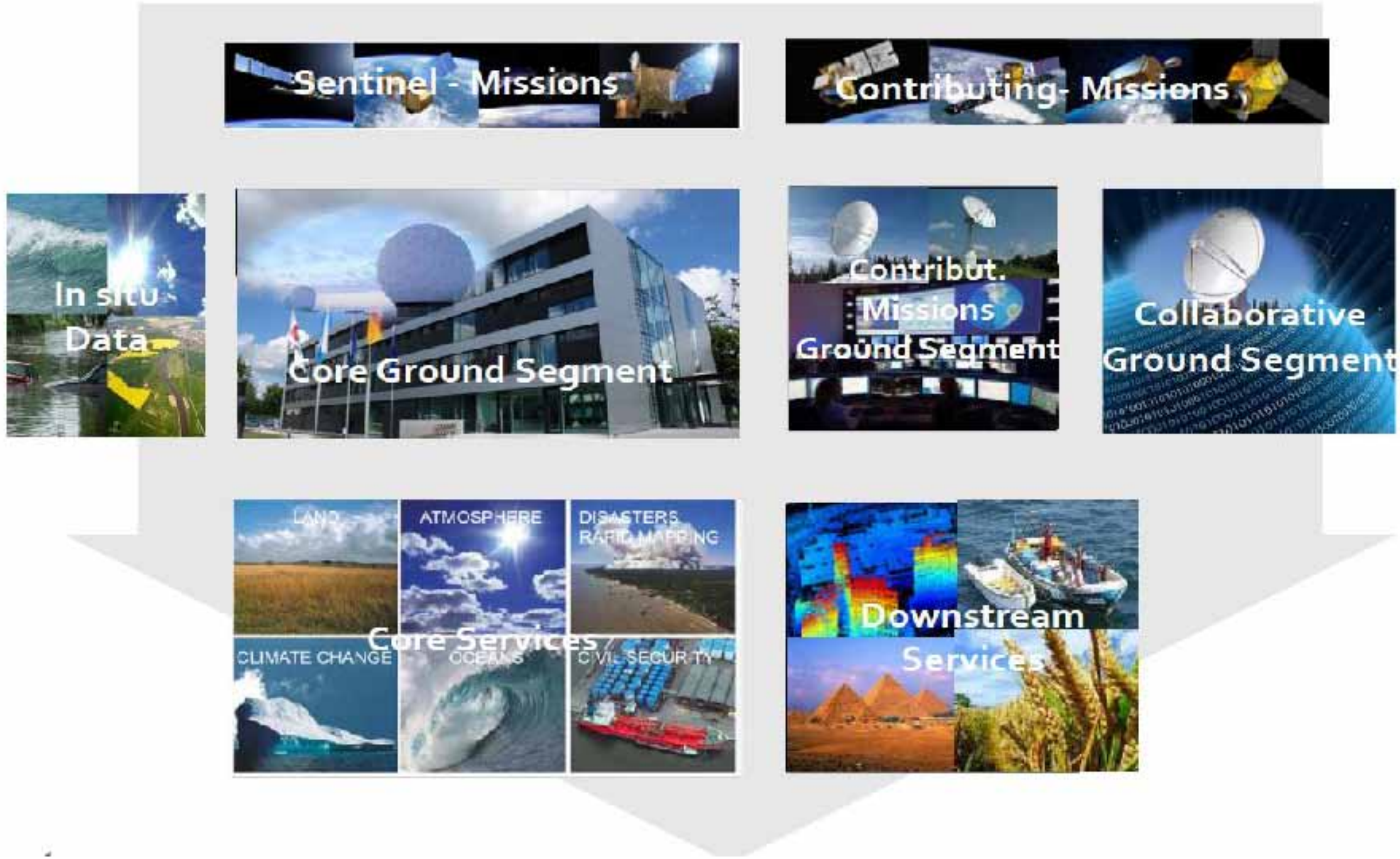
Acknowledgements: The present communication is under the "ATHENA" project H2020-TWINN2015 of European Commission. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691936.

Global Monitoring of Environment and Security

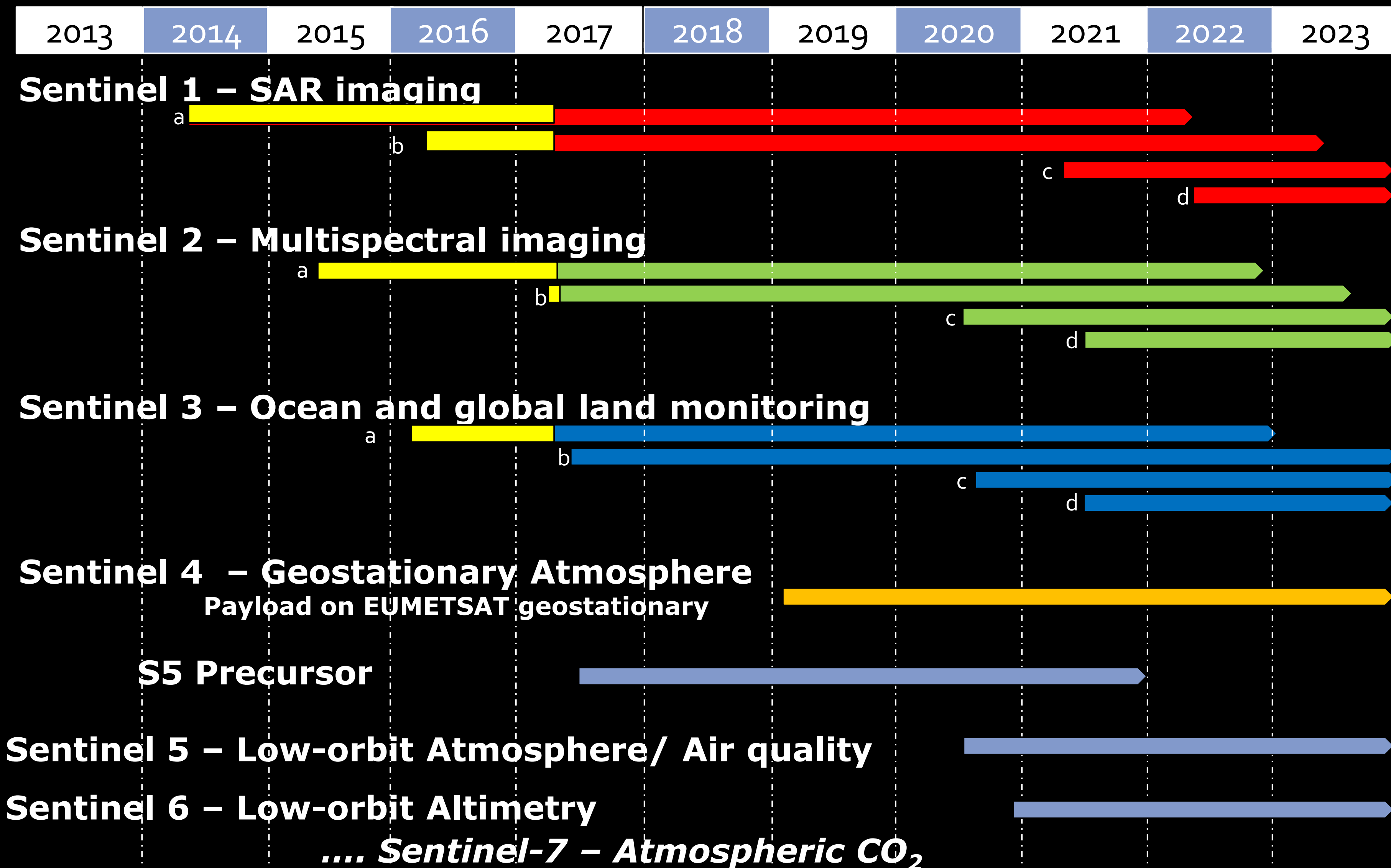
Copernicus
The European Earth Observation Programme

copernicus
The European Earth Observation Programme

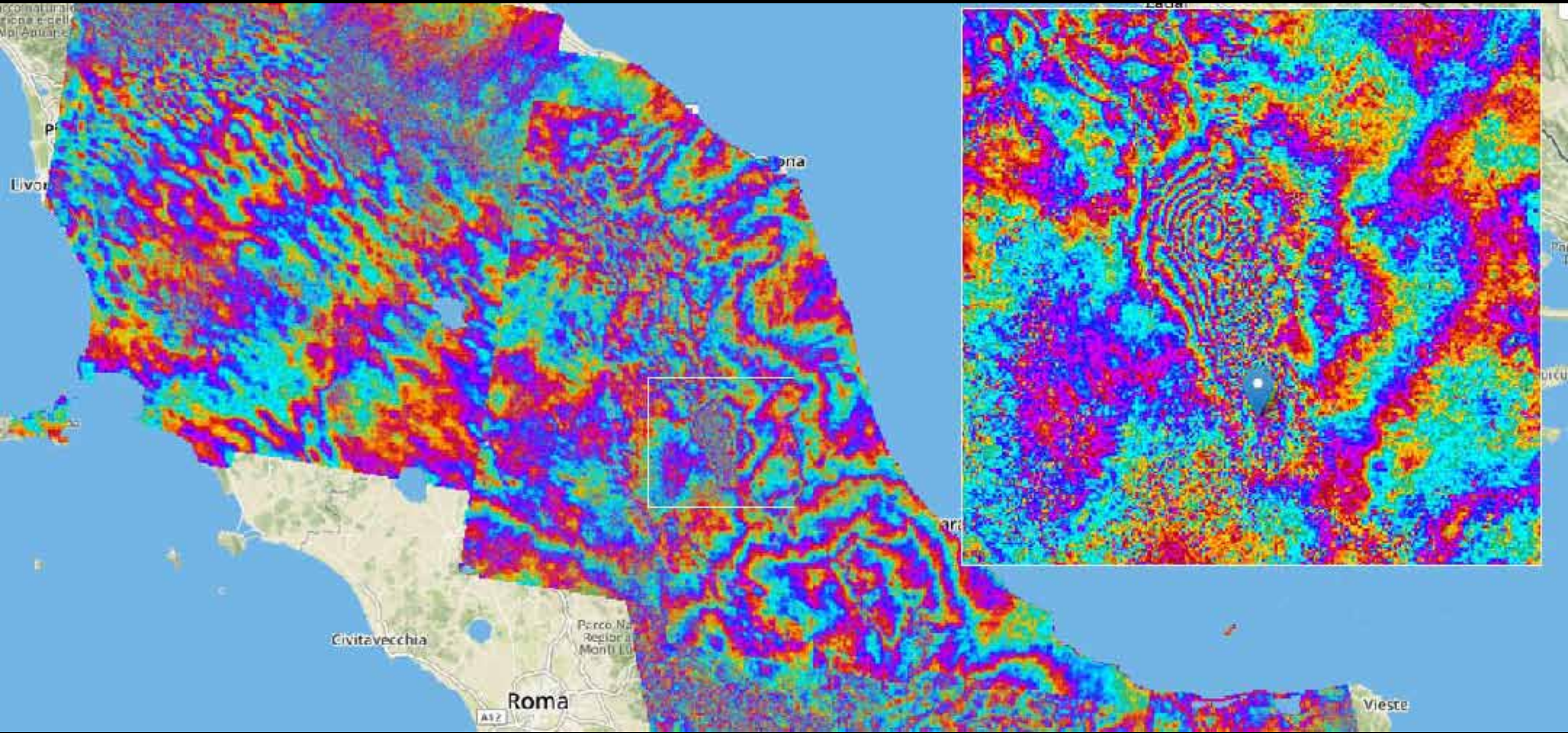
DLR


Sentinel - Missions
Contributing- Missions
In situ Data
Core Ground Segment
Contribut. Missions Ground Segment
Collaborative Ground Segment
LAND
ATMOSPHERE
DISASTERS RAPID MAPPING
Core Services
CLIMATE CHANGE
OCEANS
CIVIL SECURITY
Downstream Services

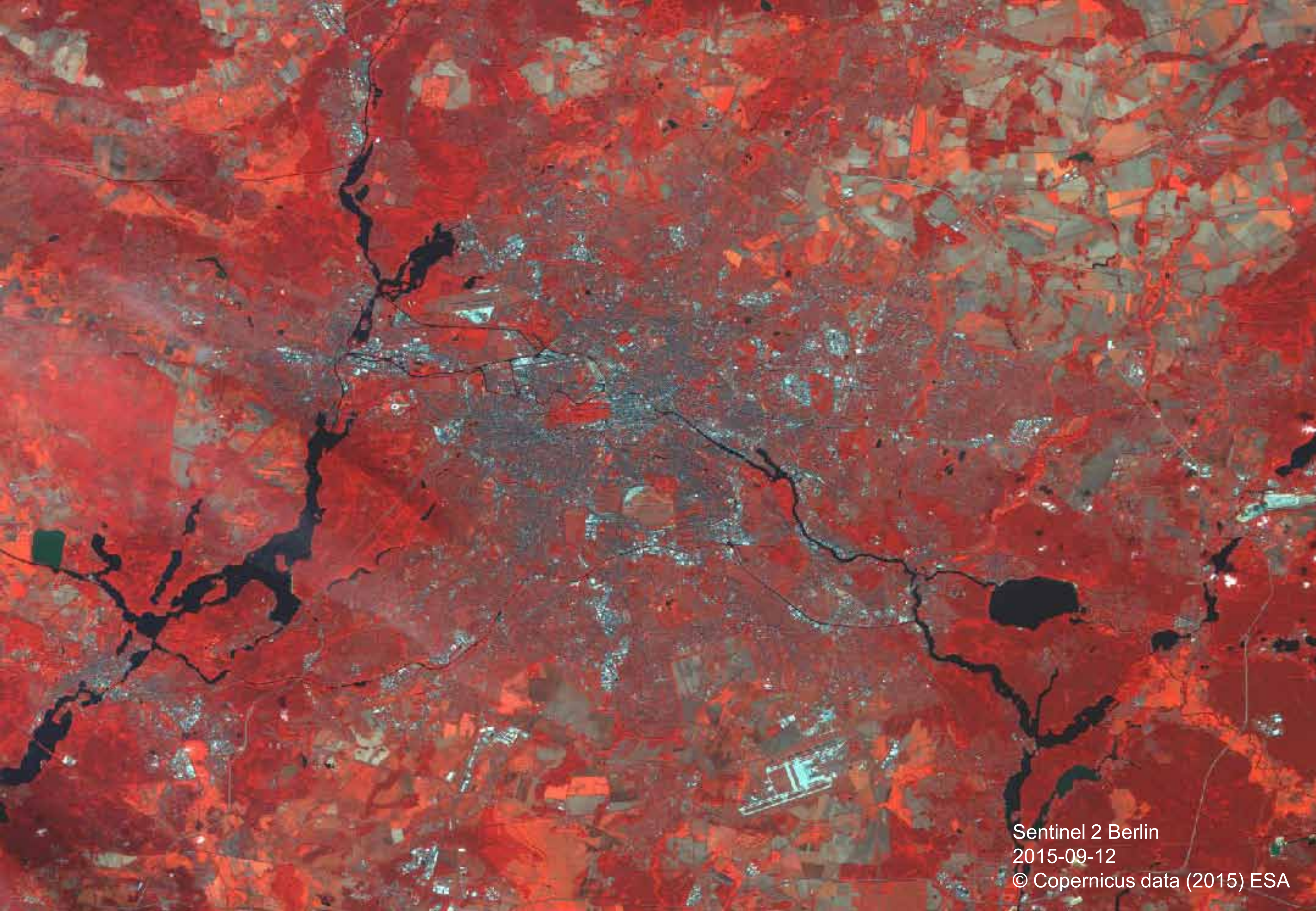
The Copernicus Sentinel Missions




Cyprus
Sentinel-1 : 14.02.2015 © Coperncius
Processed at DLR-Copernicus PAC

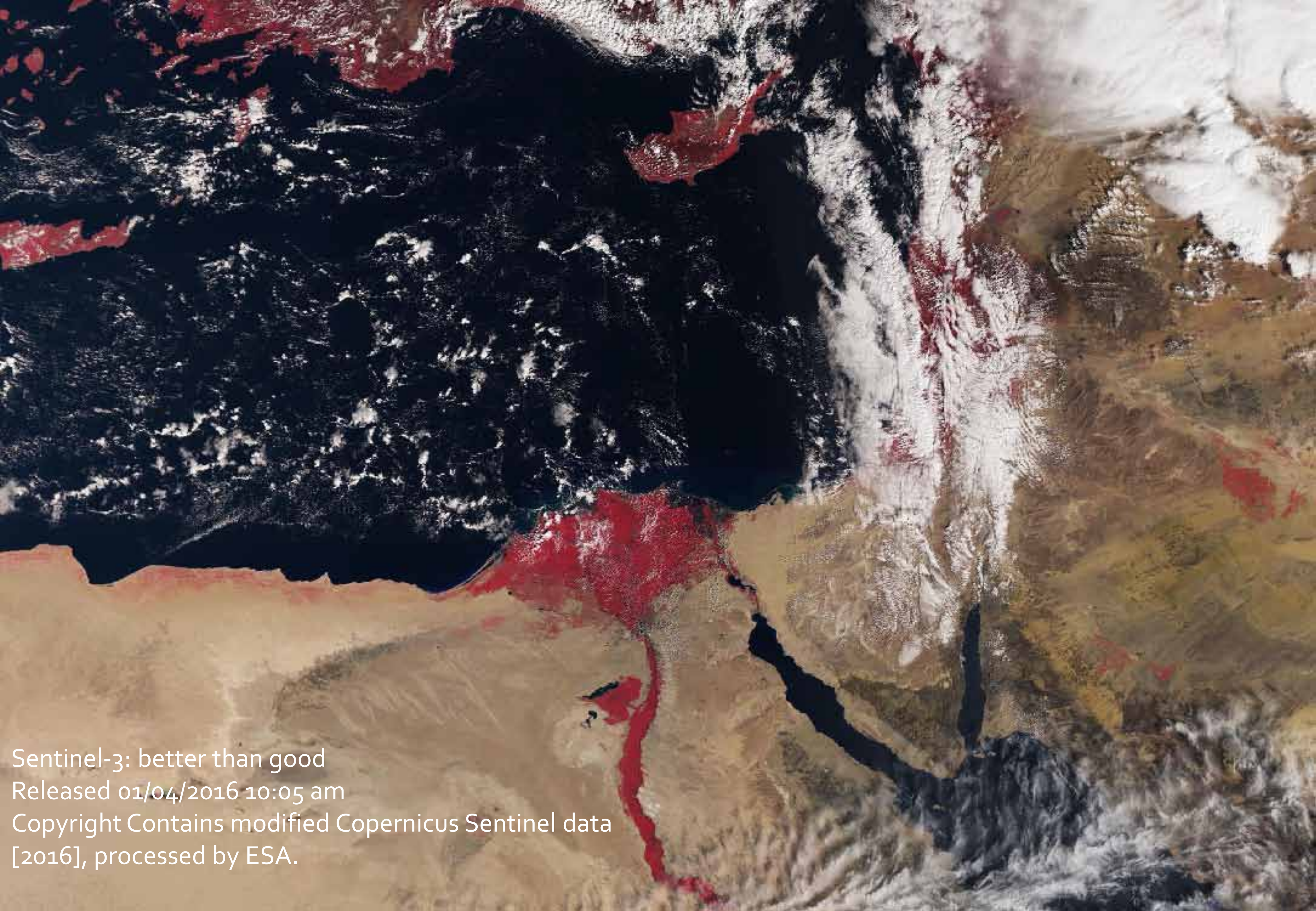


Earthquake area in Italy
Released 28/10/2016 10:54 am
Copyright contains modified Copernicus Sentinel data (2016), processed by DLR/ESA/Terradue
This interferogram shows how the ground moved as a result of the earthquakes that struck Amatrice in Italy on 24 August 2016.


Sentinel 2 Berlin
2015-09-12
© Copernicus data (2015) ESA


Cyprus/ Sentinel 2
Released 11/03/2016 10:05 am
Copyright Copernicus Sentinel data (2015)/ESA

Sentinel-3A satellite
Released 24/06/2016 10:00 am

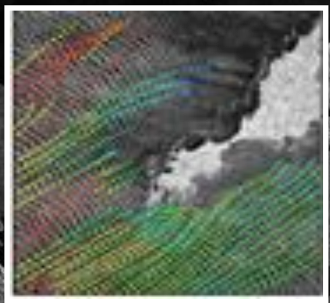


Sentinel-3: better than good
Released 01/04/2016 10:05 am

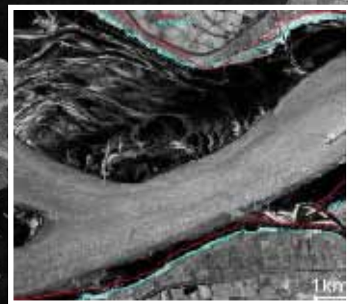
Copernicus Core Services


DEUTSCHLAND - Dessau (Elbe)
Hochwassersituation am 05. Juni 2013 - Betroffene Fläche
1:40.000
Elbe
Mulde
Steckby
Steutz
Aken (Elbe)
Großkühnau
Kleinkühnau
Dessau
Roßlau
Rodleben
Tornau
Mühlstedt
Waldersee
Vockerode
Mildensee
Alten
Mosigkau
Kochstedt
Törten
Reppichau
Osternienburg
Elsnigk
Quellendorf
Legende
Interpretation
Kartographische Information
Datenquellen
Rahmenbedingung
Emergency Response
Zentrum für satellitengestützte Kriseninformation
DLR

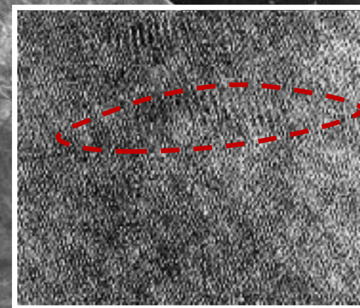
Research and Application Development for the Maritime Situational Awareness



Bathymetry

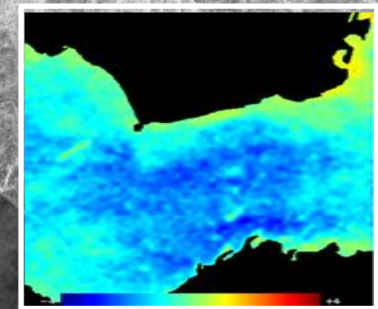


Land-Water Line

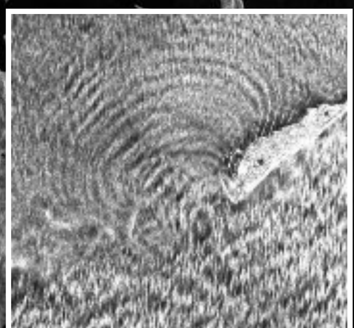


Wave groups & Forecast

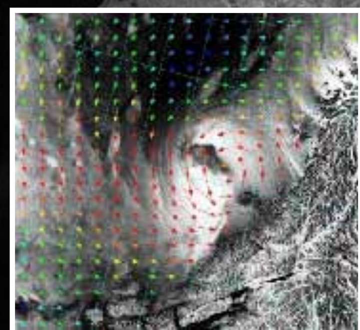
Wave breaking



Surface Currents

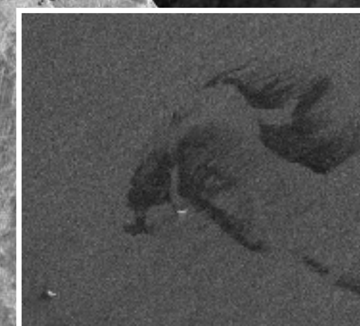


Sea State



Wind

Ship- detection

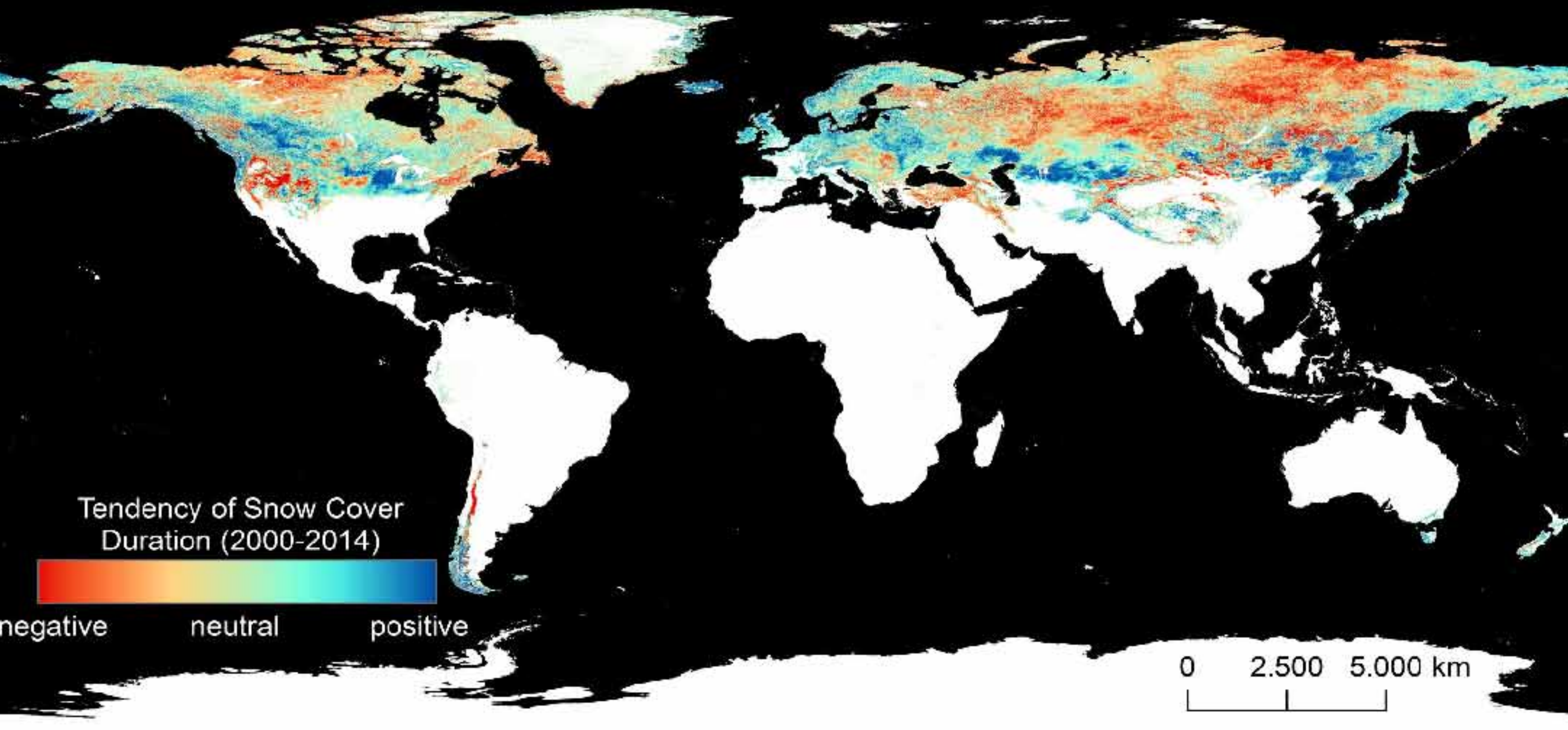


Oil Spills

Iceberg-detection, Ice classification

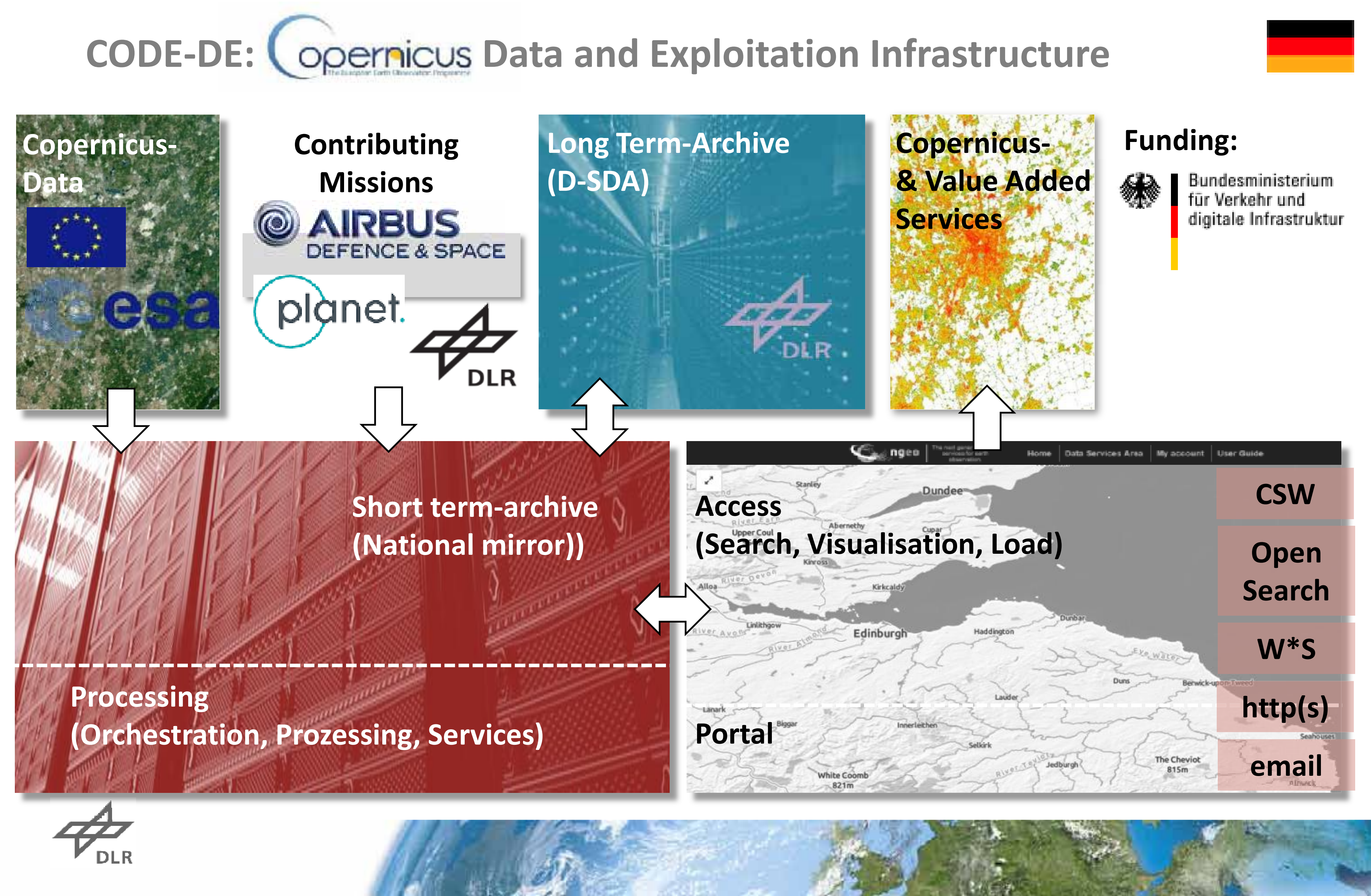
Maritime Security

Trends in Global Snow Cover (Goal: 30 Years)

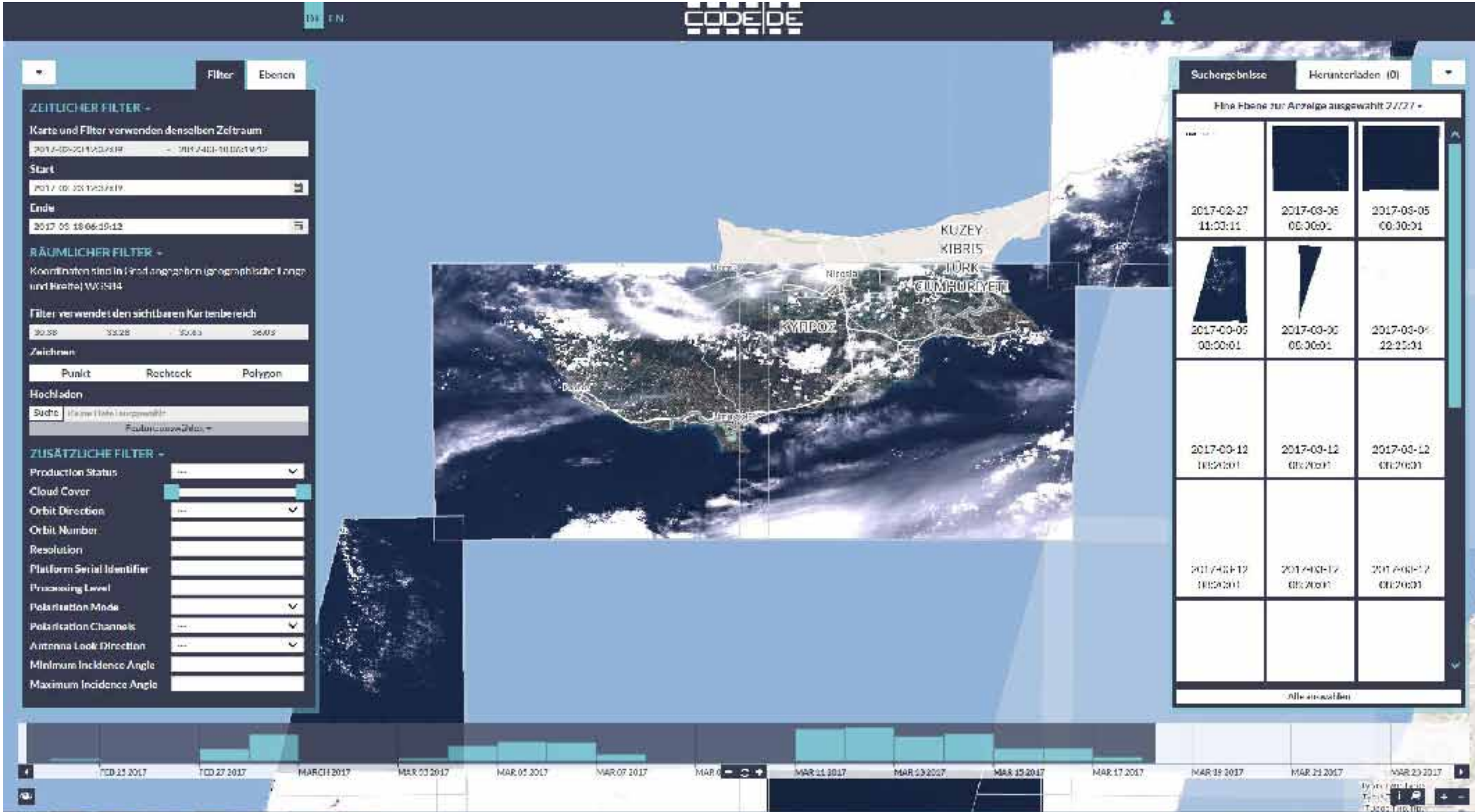


Global Change


Big Data
Sentinels
8 Terabytes/day
>> 20 Petabytes by 2020


CODE-DE: Copernicus Data and Exploitation Infrastructure
Copernicus-Data
esa
Contributing Missions
AIRBUS DEFENCE & SPACE
planet.
DLR
Long Term-Archive (D-SDA)
DLR
Copernicus- & Value Added Services
Funding:
Bundesministerium für Verkehr und digitale Infrastruktur
Short term-archive (National mirror))
Processing (Orchestration, Prozessing, Services)
Access (Search, Visualisation, Load)
Portal
CSW
Open Search
W*S
http(s)
email
DLR

CODE-DE – The German Copernicus Portal (www.code-de.org)



Copernicus
The European Earth Observation Programme

PATRIMONIO MUNDIAL • WORLD HERITAGE • PATRIMOINE MONDIAL

Palmyra, Syria
TerraSAR-X data with superimposed archaeologic linements
Andreas Schmidt-Colinet, Roland Link et al.

Between 10 October 2009 (top) and 8 March 2014 (bottom), Palmyra's North Roman Necropolis has been disrupted by road construction and numerous earthen berms (pink arrows) to provide cover for military vehicles (yellow arrows).

Credit: Images ©2014, DigitalGlobe, NextView License | Analysis AAAS. Coordinates 34.55N, 38.26E

DLR-ZKI: Palmyra – Temple of Bel: destroyed by IS (30.08.2015)

DLR

EUROPEAN COMMISSION

HIGH REPRESENTATIVE OF THE UNION FOR FOREIGN AFFAIRS AND SECURITY POLICY

Brussels, 8.6.2016
JOIN(2016) 29 final

JOINT COMMUNICATION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL

Towards an EU strategy for international cultural relations

- **Protect heritage:** The Commission will contribute to international efforts, led by UNESCO, to set up a rapid reaction mechanism for the protection of cultural heritage sites. The Commission will also share with UNESCO, *inter alia* through the Copernicus Emergency Management Service, satellite imagery of cultural heritage sites at risk in order to evaluate damage and plan possible reconstruction. The EU will include expertise to assess damages to cultural heritage as part of post-disaster and post-conflict recovery measures. The EU Regional Fund in Response to the Syrian Crisis will also contribute to protecting cultural heritage and promoting cultural diversity.

DLR

- identify intermediate and end-users' needs in the Cultural Heritage domain, and assess and characterise space-based applications in support of Cultural Heritage at EU and global level
- assess capabilities and outline requirements for Copernicus-based products/services in support of Cultural Heritage
- propose and assess implementation scenarios for a structured Copernicus-based approach for Cultural Heritage support
- identifying the main user requirements for space-based applications associated to the preservation and management of cultural heritage assets in Europe and Worldwide
- Analysing opportunities for standardisation taking into account what is already done in some European Countries, with risk assessments associated to each Cultural asset subject to environmental risks.

Different scenarios for Implementation in Copernicus:

1) A new Cultural Heritage Copernicus Service

2) Cultural heritage as part of an existing Copernicus Service

3) The structured use of a Combination of Copernicus Services for cultural heritage

4) A follow-up of Copernicus Products tailored for cultural heritage. Out of those, a preferred option will later be identified.


LAND
ATMOSPHERE
DISASTERS
RAPID MAPPING
World Heritage
CLIMATE CHANG
VIL SECURITY

Gunter Schreier

Earth Observation Center • EOC

DLR
Oberpfaffenhofen, Germany

Arianna Traviglia

SENSING BEYOND FRONTIERS: REMOTE SENSING APPLICATIONS FOR ARCHAEOLOGICAL HERITAGE DETECTION AND MANAGEMENT.

Università Ca' Foscari Venezia

RSCy

'Fifth International Conference on Remote Sensing and Geoinformation of Environment'
20-23 March, 2017 - Cyprus

Remote Sensing in SE Asia

- Limited use of RS due to:
  - Vegetation coverage
  - Seasonal and environmental factors (floods, monsoons)
    - Detection of features in wet or flooded soil
    - High water content in wet season effects vegetation marks
  - Logistic problems for airborne survey (e.g. hyperspectral or Lidar)
- Study of Cambodian landscapes need major support by RS

Archaeological landscape of Angkor

Pattern of topographic variations designed:

- to control the flow of water
- to mediate between wetter and dryer spaces of the landscape

↓

- Massive topographic variation (baray)
- Subtle topographic variations

Archaeological landscape of Angkor

Topographic variations

Topographic variations

- Extremely subtle

Shallow linear excavations designed to channel water across the landscape

- Covered by vegetation

Slightly elevated areas used for occupation

Research challenges

Research goal

To define the original hydrological system before the transformation created by the ancient Khmer civilization.

Crucial to understand the development of the pre-industrial water management system.

Research strategy

Detection and mapping: environmental and man-made features related to the hydrological and hydraulic system

Research state

Exploitation of spectral content of satellite images at disposal

Evaluation of outcomes of applied processes

New processing in progress

Focus

Identification of palaeo-channels and palaeo-riverbeds

Detection of features connected to the water flow system in the forested areas.

Goals

<u>Crucial aspect to be addressed</u>

- to augment the chronological resolution of the current map of Angkor
- to disentangle the layers of the palimpsest of features within

Reach an understanding of the original hydrological layout of the Angkor basin

- Palaeo-hydrological arrangement
- Archaeological evidence for occupation

- Insight into human modifications to natural hydrology and topography
- Understanding of choices at the base and the logic behind the palimpsest

Understand at a deeper level the Khmer water management system

RS and palaeorivers detection

Methodology: **remote sensing data**

- multispectral satellite images (Quickbird, Ikonos, Aster)
- DEM generated by radar data and stereoscopic pairs (SRTM and ASTER)
- Radar data (SIR-C image)

Data used

- to locate drainage networks
- to identify anthropogenic features connected to original fluvial system (relationship disposition of reservoirs/rivers).

Challenges

- Detection by RS of the traces of the primal fluvial arrangement in this complex environment: predictable difficulties.
- Features indicating ancient rivers are often difficult to discern.
- Challenges occur in different types of environment encountered in this area:
  - vegetated areas: forest forms a camouflage that inhibits the identification of features
  - open floodplain: difficulties
  - topographic variations that define dried riverbeds absent or too subtle
  - topographic variations washed out by floods and precipitation
  - contemporary water flow obscured surface wetness related to ancient water flow.

Traces identification factors

Range of factors allowing identification of the relevant traces :

- shadows projected by subtle topographic variations;
- variation in the growth or type of vegetation;
- broad damp marks on bare soils
- the disposition of topographic elements or spatial logic of archaeological features.

- Requires large dataset and processing:
  - MULTISPECTRAL IMAGES
  - DEM
  - Radar data

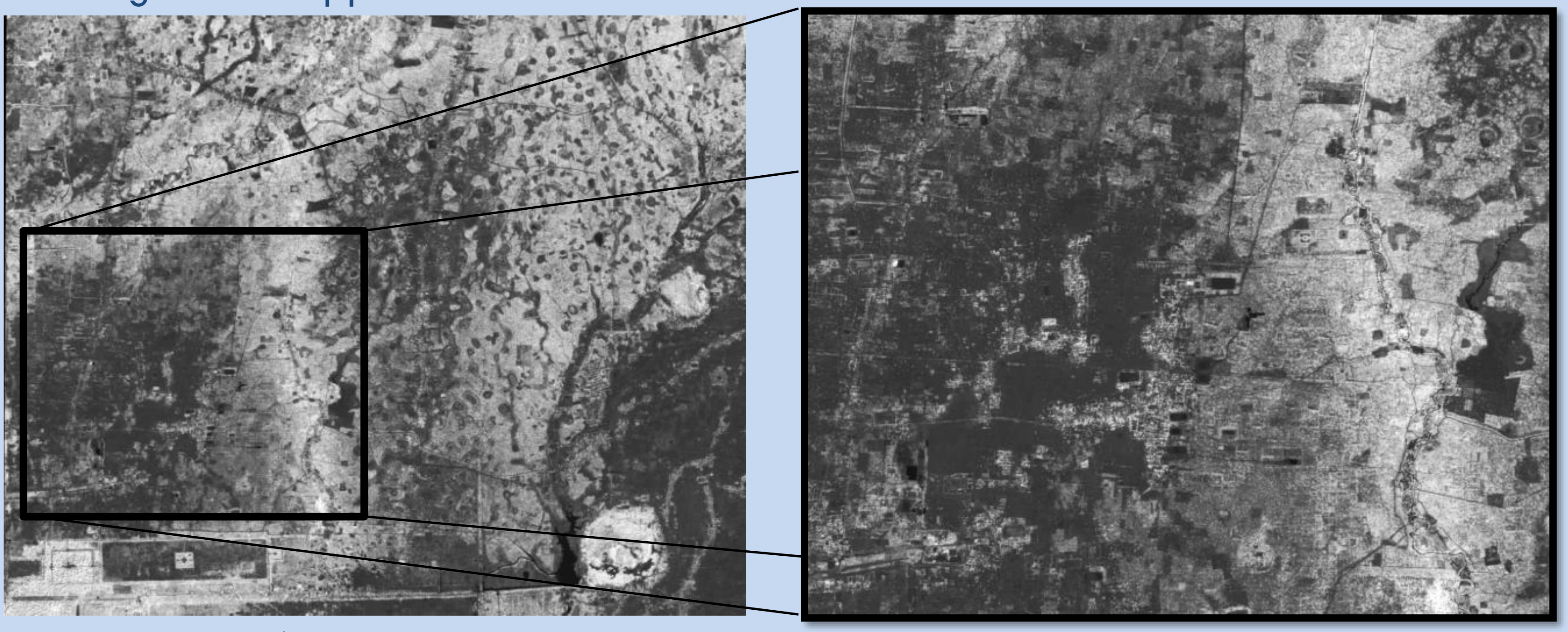
MULTISPECTRAL IMAGES: Quickbird, Ikonos, Aster

Image processing:

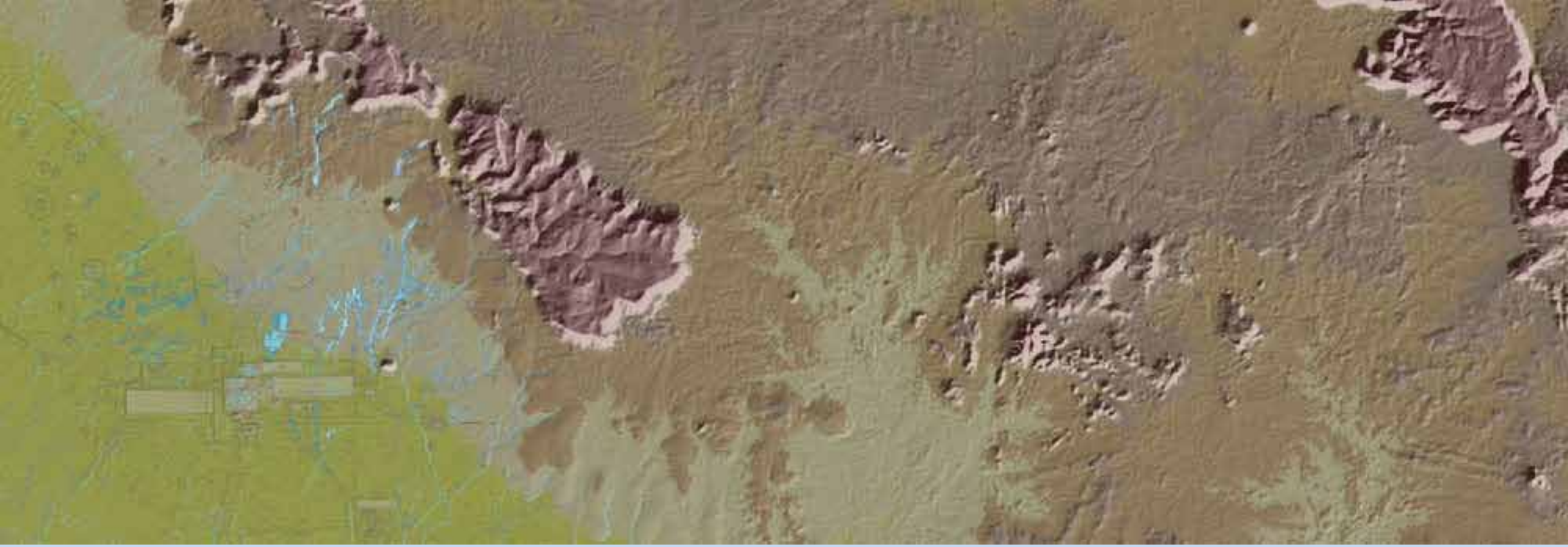
Ratio

Vegetation Indices

Vegetation Suppression



Quickbird. Ratio NIR/R



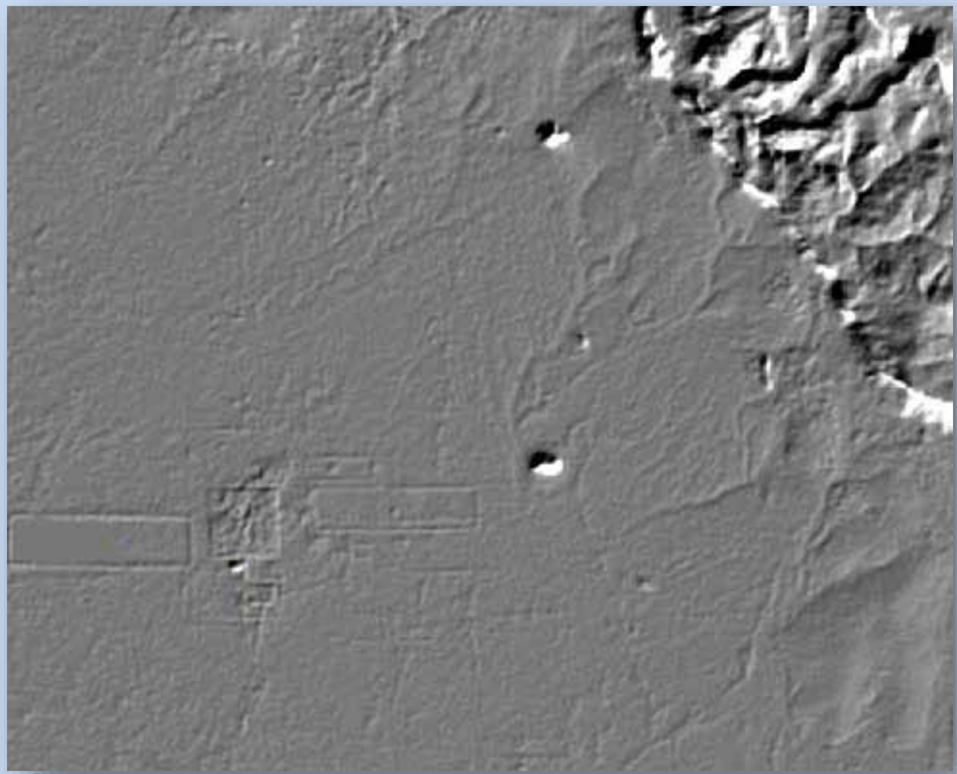
- DEM: generated by radar data and stereoscopic pairs (SRTM/ASTER)
  - SRTM DEM: digital elevation model based on the Shuttle Radar Topography Mission (Feb.2000); important source of elevation data (ground resolution 90 m)

    Reference dataset: systematically compared to the remotely sensed data
  - ASTER DEM: better resolution but still quite a number of problems

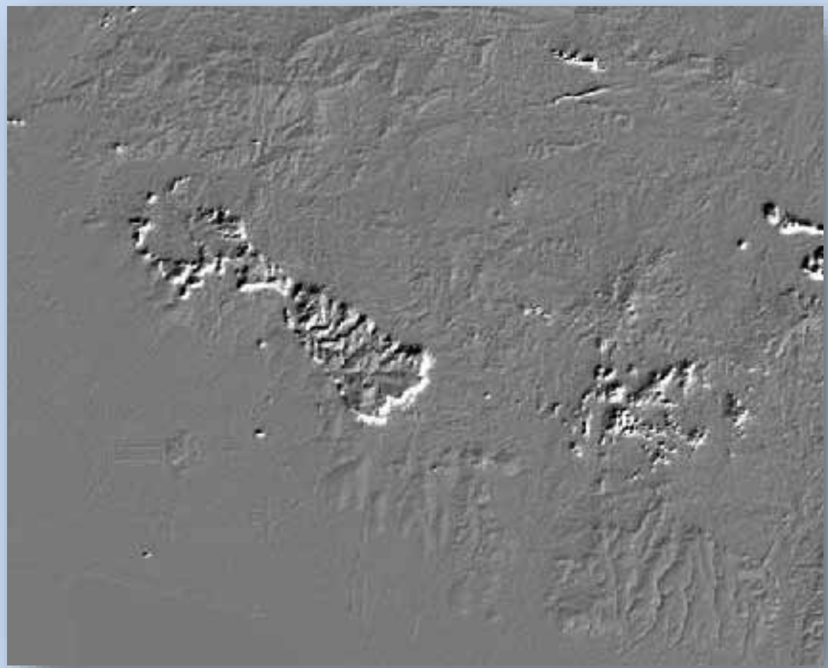
Hillshade

Hillshade:

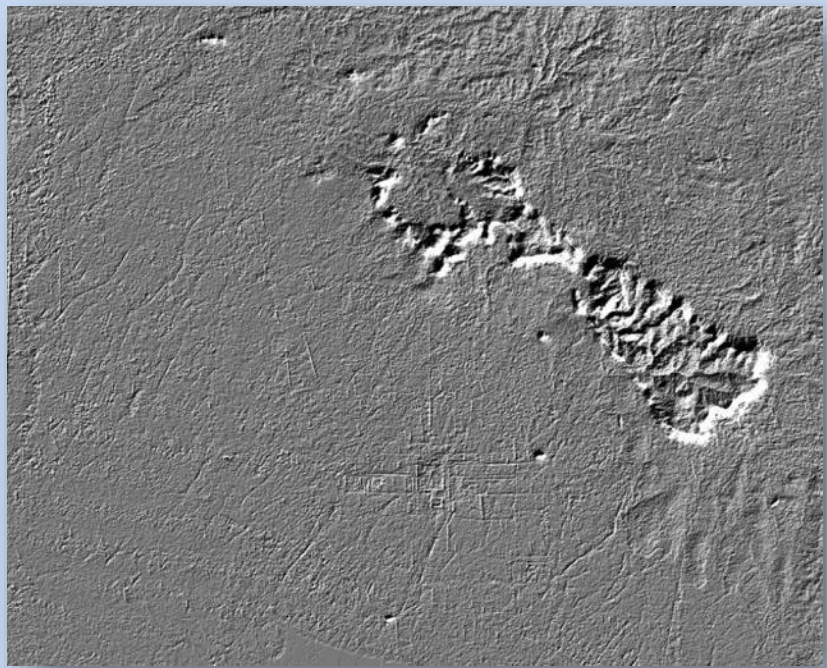
- shows the hypothetical illumination of a surface on the landscape by setting a position for a hypothetical light source and calculating the illumination values
- enhances the visualization of a surface for analysis



SRTM Hillshade

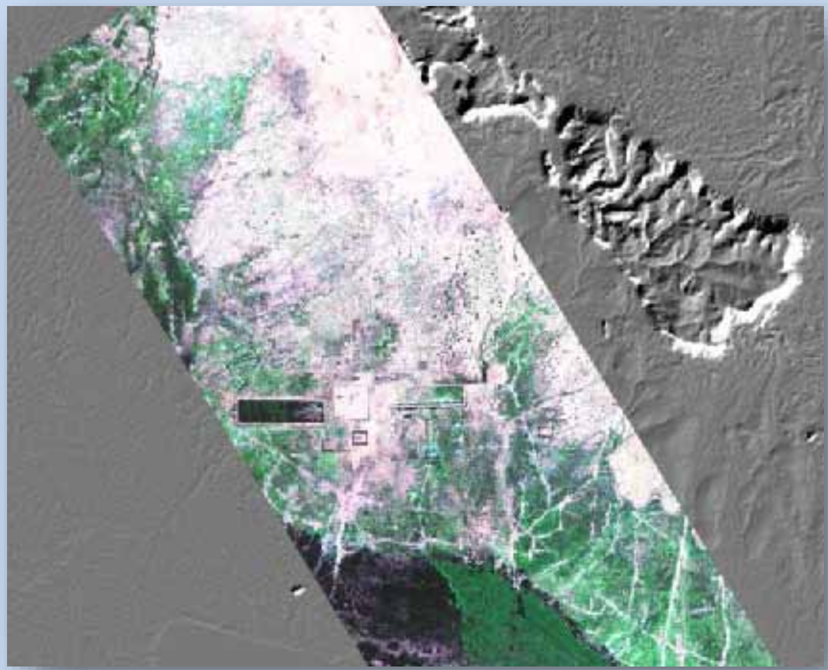


ASTER Hillshade



- RADAR DATA:

  SIR-C image1994



Data evaluation

- Evaluation of RS/DEM/Radar data performed in a GIS environment
- Mapping

  Anthropogenic features and topographical anomalies mapped (scale 1:2000) and given a series of attributes to encapsulate relevant information.

  Metadata retained in this process included:

  - the image process(es) that facilitated identification
  - possible interpretation of the feature
  - degree of visibility
  - factors in the recognition of the trace
  - archaeological reliability, i.e. an evaluation of the quality of the observed features.

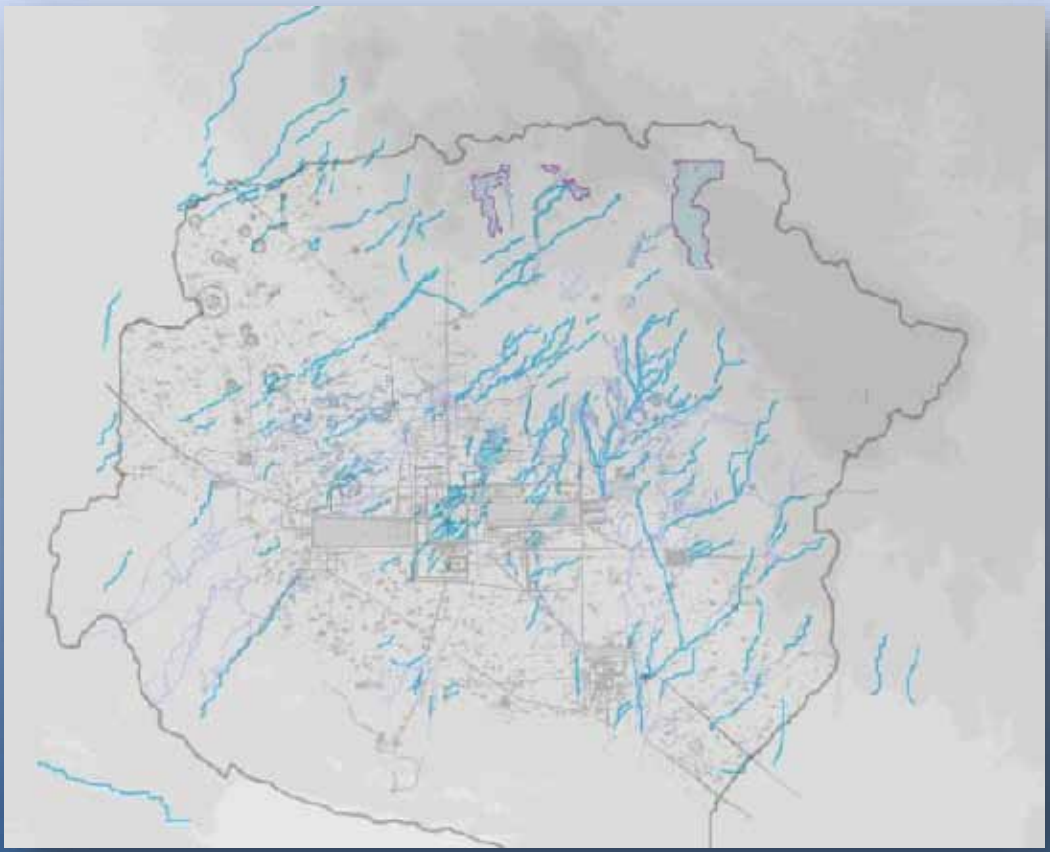
The new features and their metadata

- allow further analysis and interpretation by way of comparison with pre-existing topographical and cultural datasets and
- provide the basis for a prioritised strategy of ground verification.

Case study areas

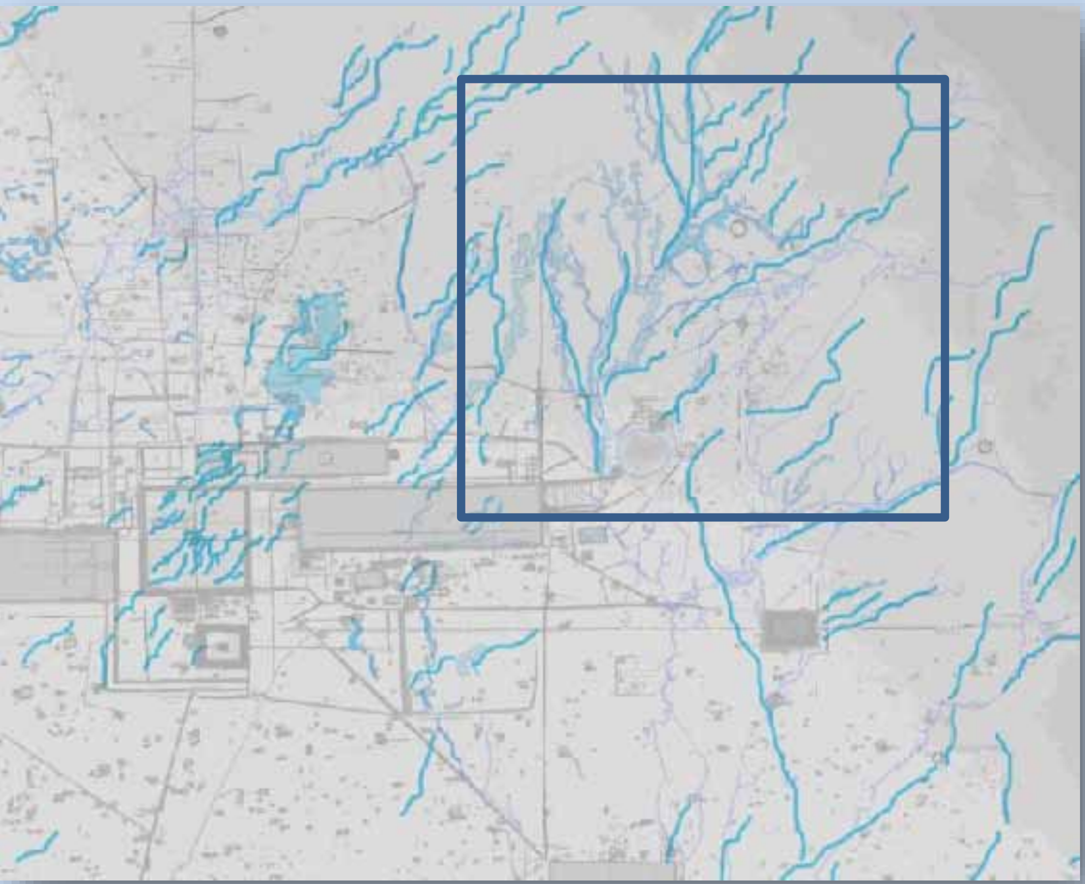
Greater Angkor basin MAP including existing and newly detected rivers:

2 noticeable trends



Background map courtesy of Pottier and Evans

- General trend of rivers orientation with a direction NE-SW
- Run parallel [NE area of the basin starting from the Puok]



Background map courtesy of Pottier and Evans

Fan disposition: NE of the temples area (just North of the East Baray), probably in connection with the presence of the Kulen hills.

Background map courtesy of Pottier and Evans

Further on, toward SE the usual inclination reappears.

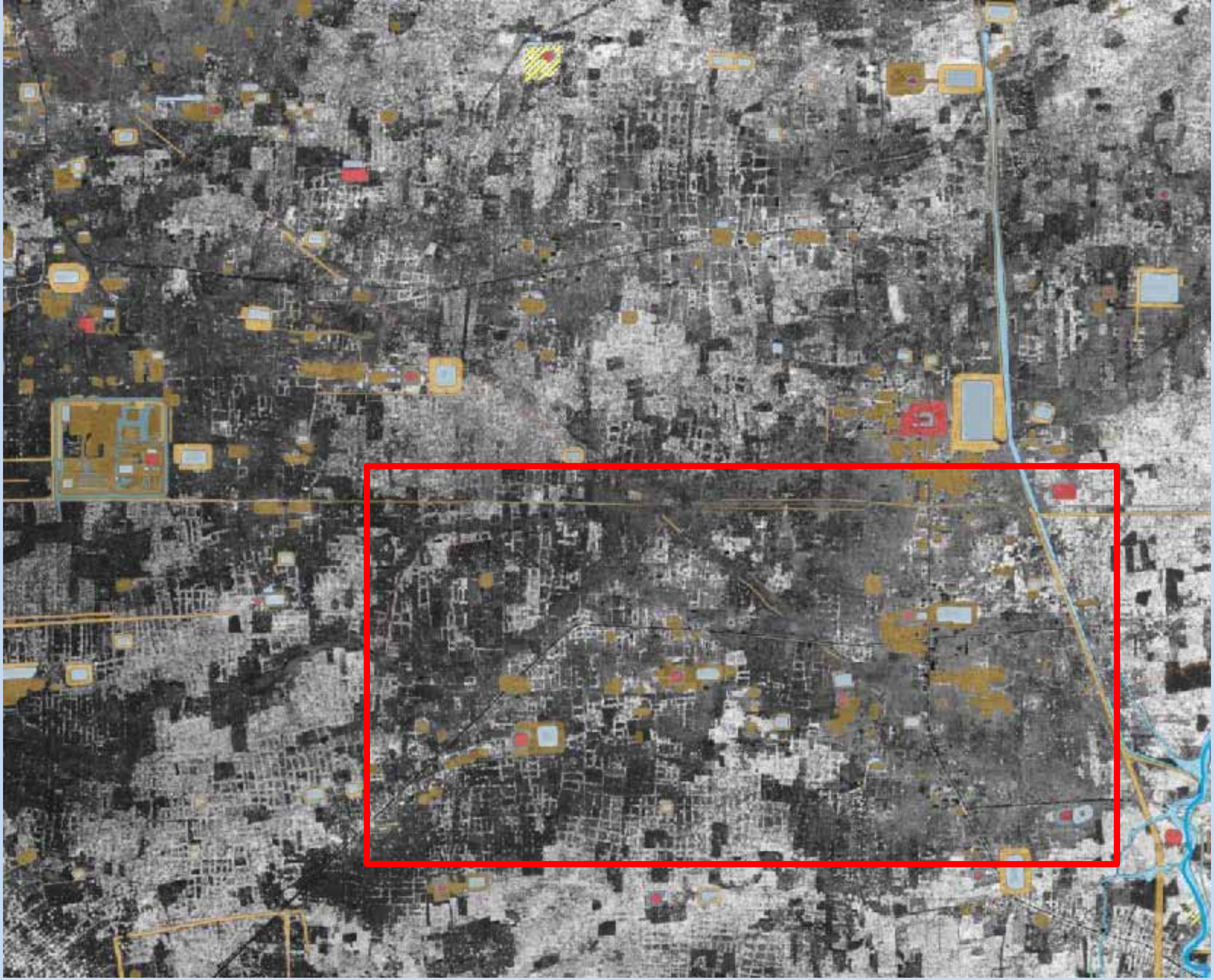
Case study areas: hold a very important meaning for the comprehension of the development of the hydraulic system.

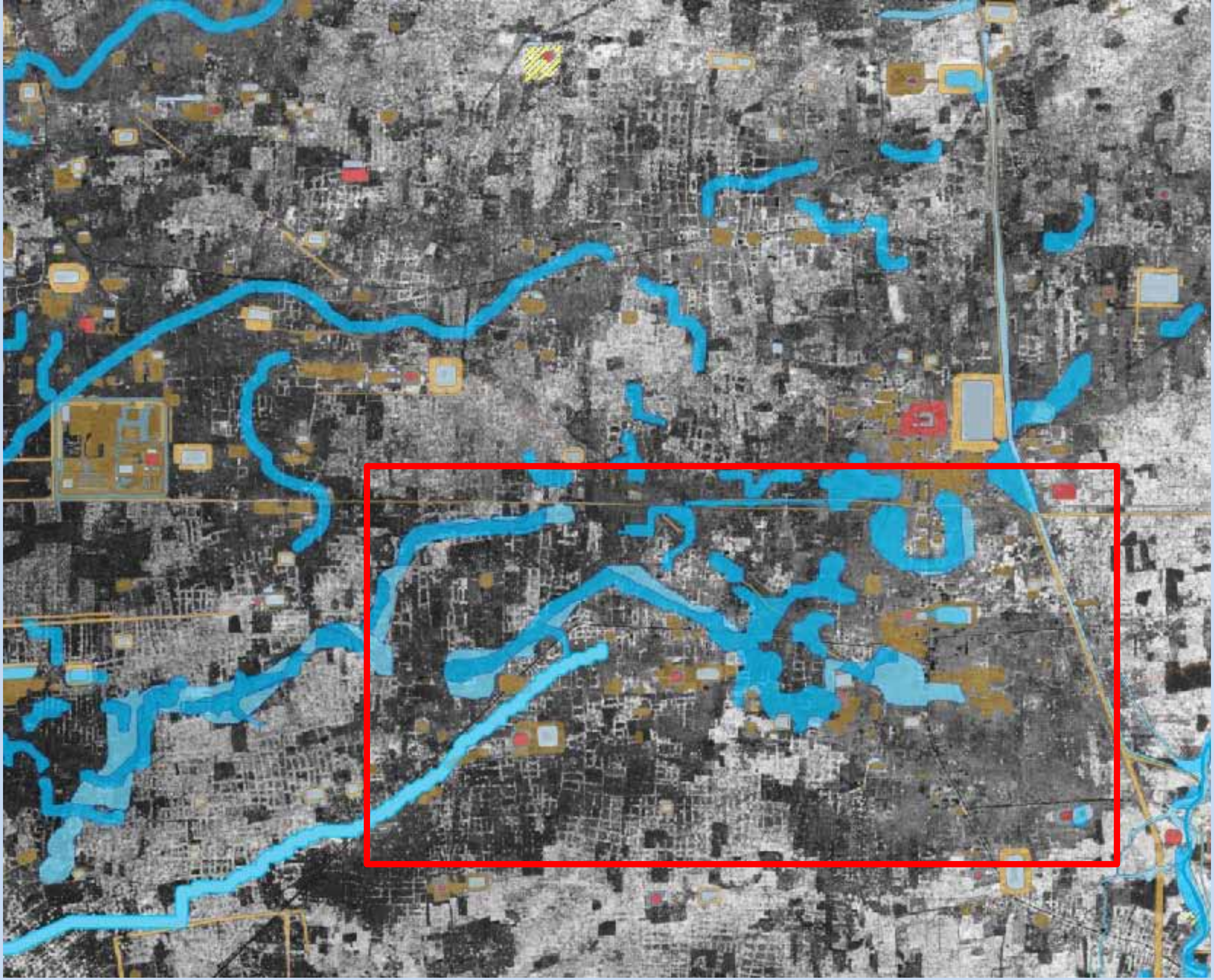
Background map courtesy of Pottier and Evans

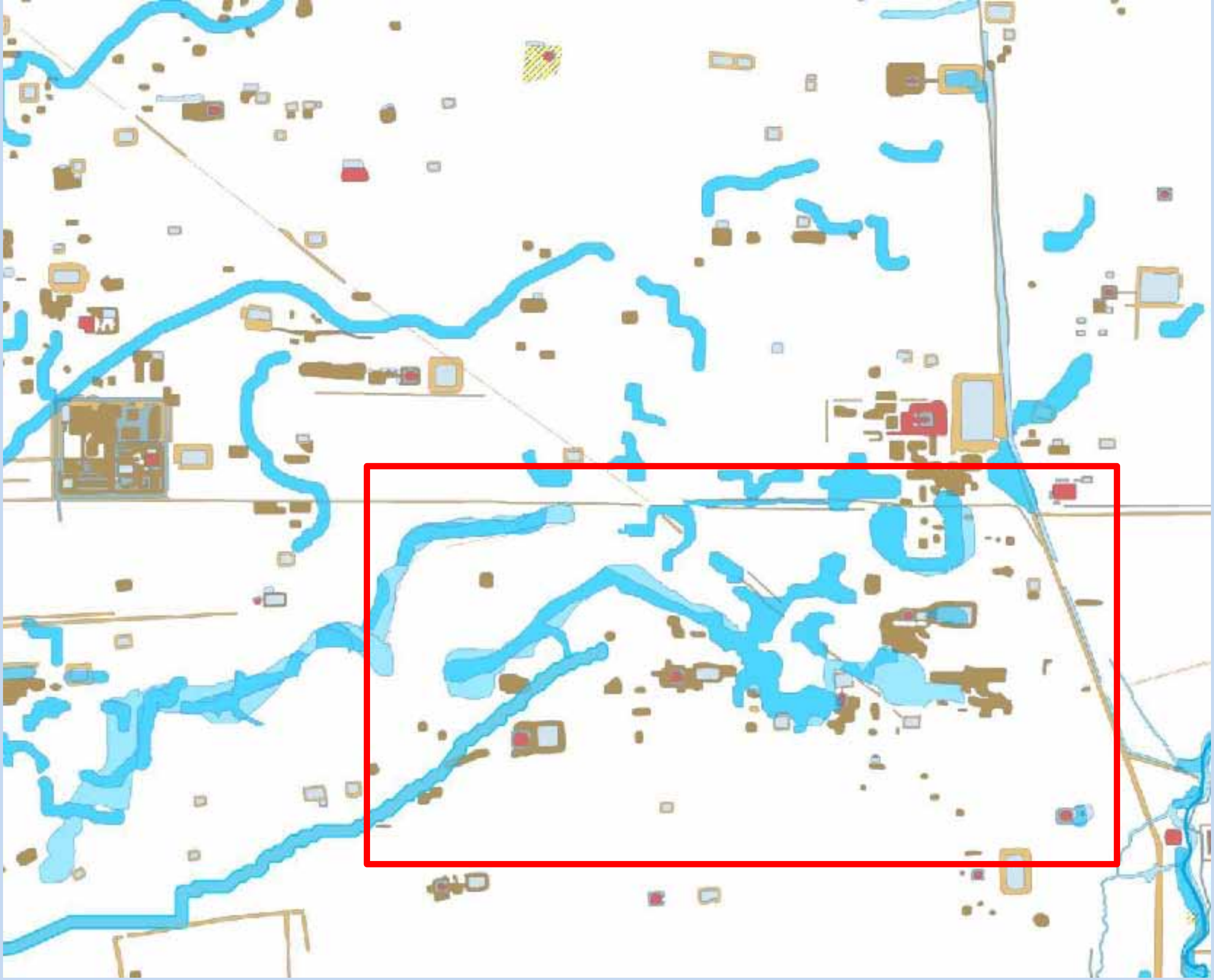
- Puok river flowing areas (N and S the river)
- diversions from Puok, (Great north canal /diversion of the Siem Reap)
- Area between the NE corner of the East Baray and the Phnom Bok
- sparse areas

- Trace of a palaeo-watercourse flowing with an orientation of E-NE/W-SW about 3km N of an intermittent side-stream of the present Puok River, oriented in similar way and almost parallel to the detected palaeo-feature.

- Flow seems to start diverting from Puok (gap) and follows a direction that goes more north
- High level of certainty:
  - clearly visible on QB data, SRTM data and SIRC
  - supported by an analysis of the distribution of reservoirs and other human occupation features .Their positioning implies the presence of a curved entity, like the flow of a river, which they border precisely.



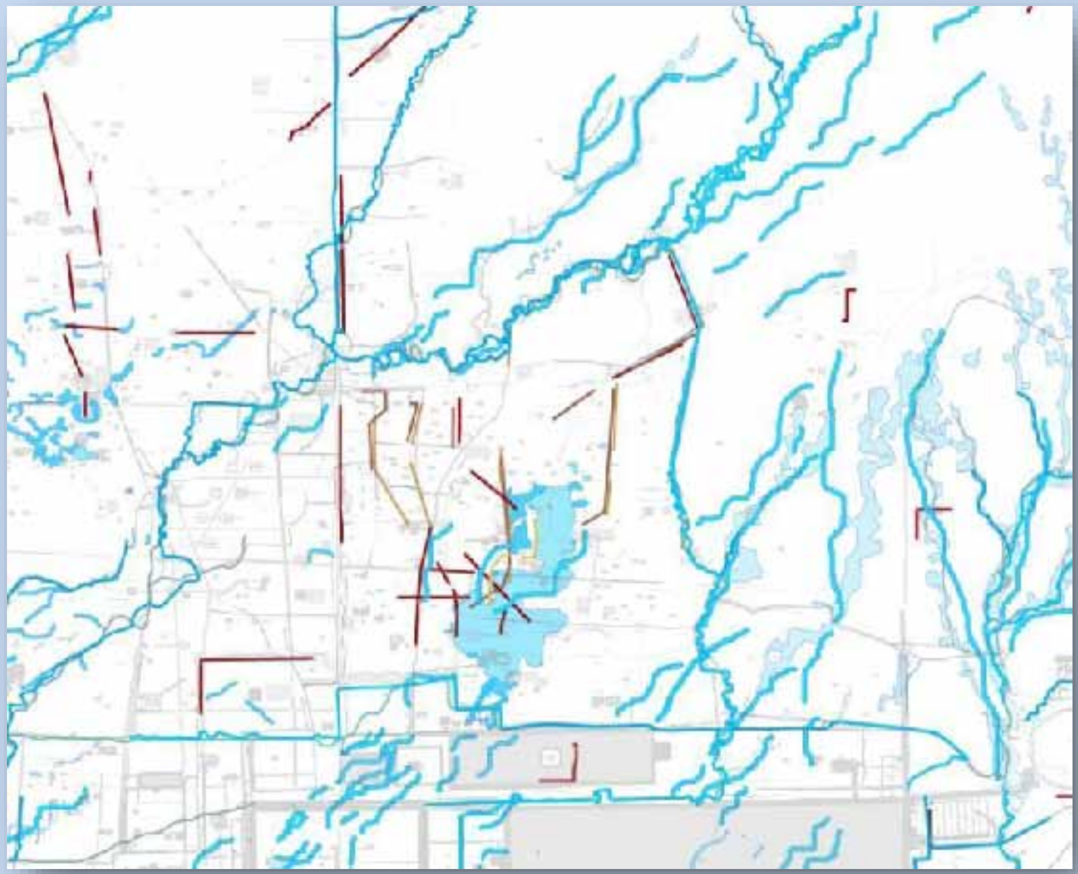




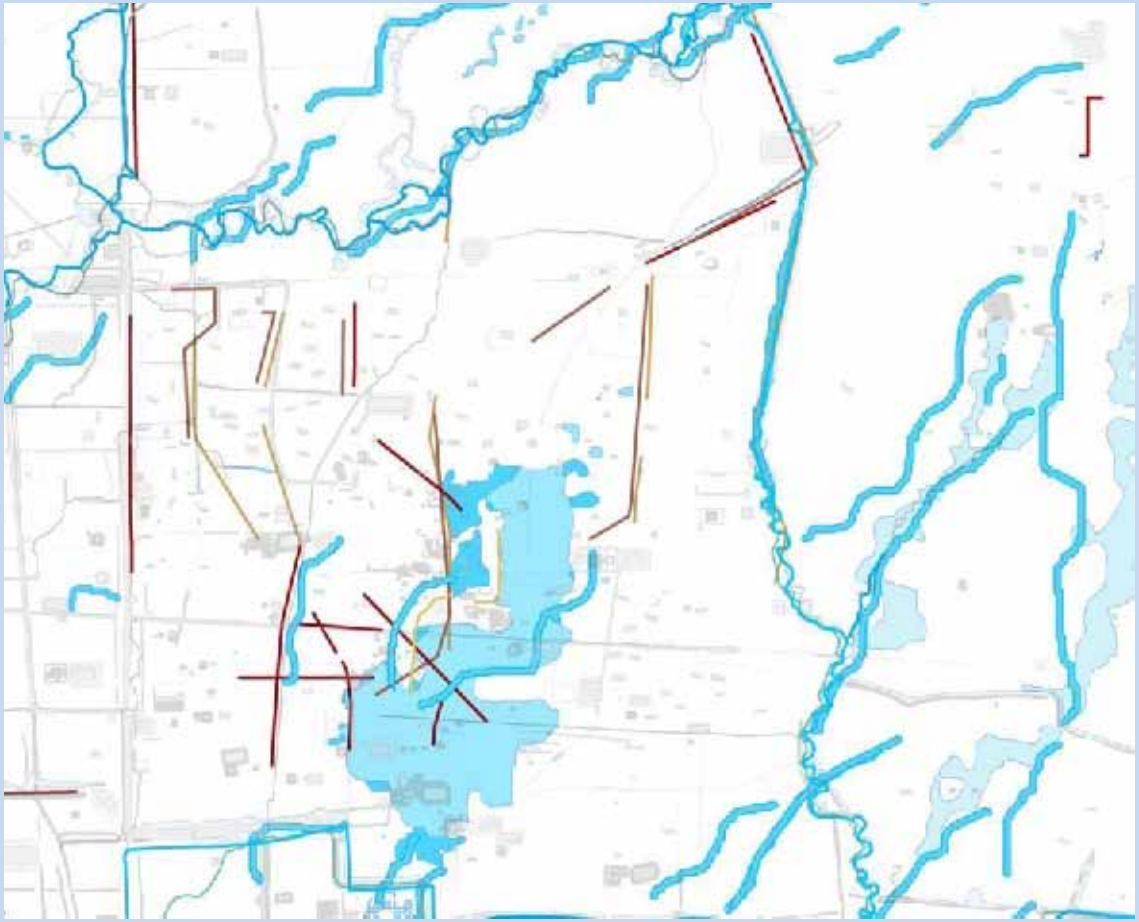
Background map courtesy of Pottier and Evans

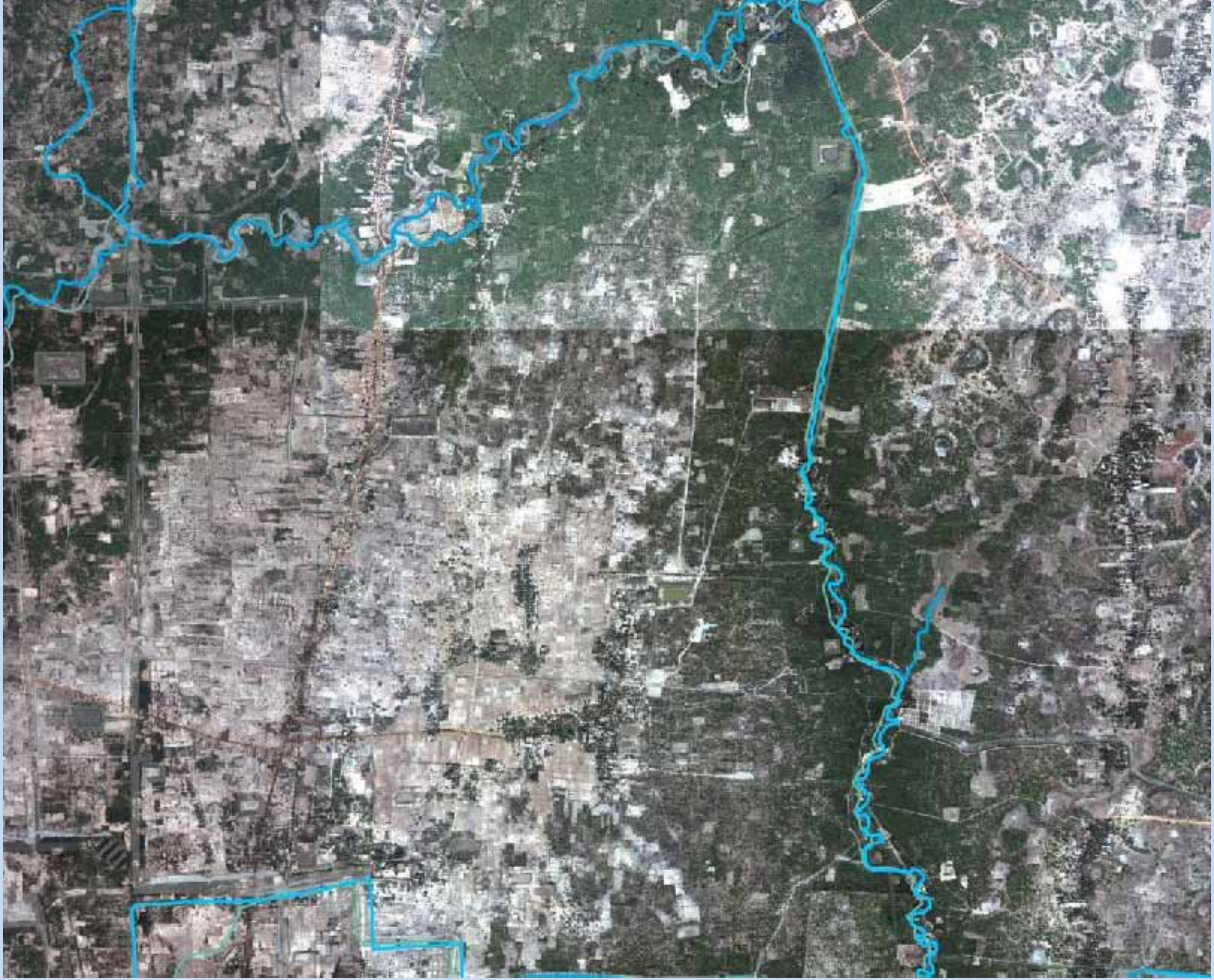
- Puok watershed: area west of the diversion that originated the Siem Reap:

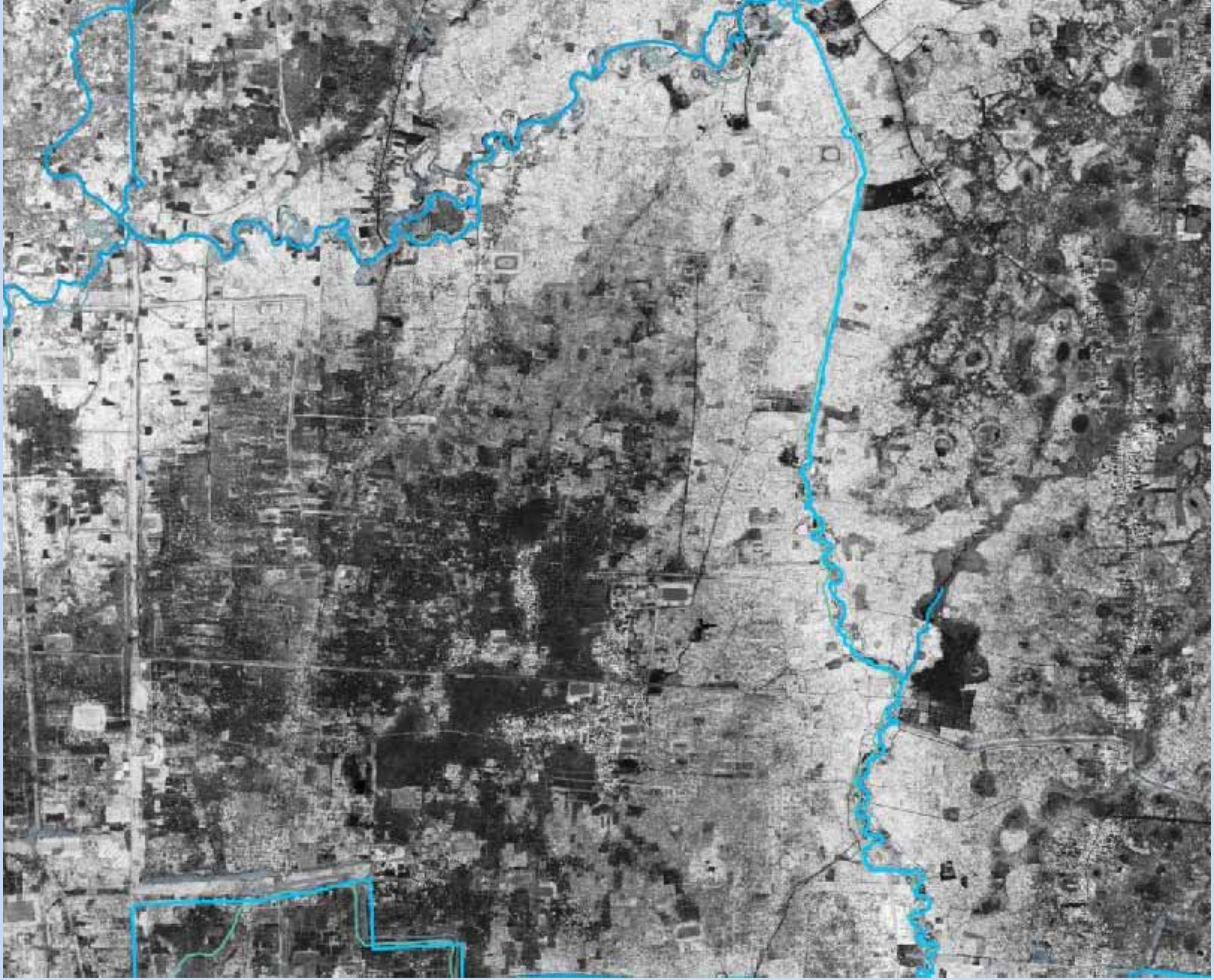
  Number of traces (possible embankments)

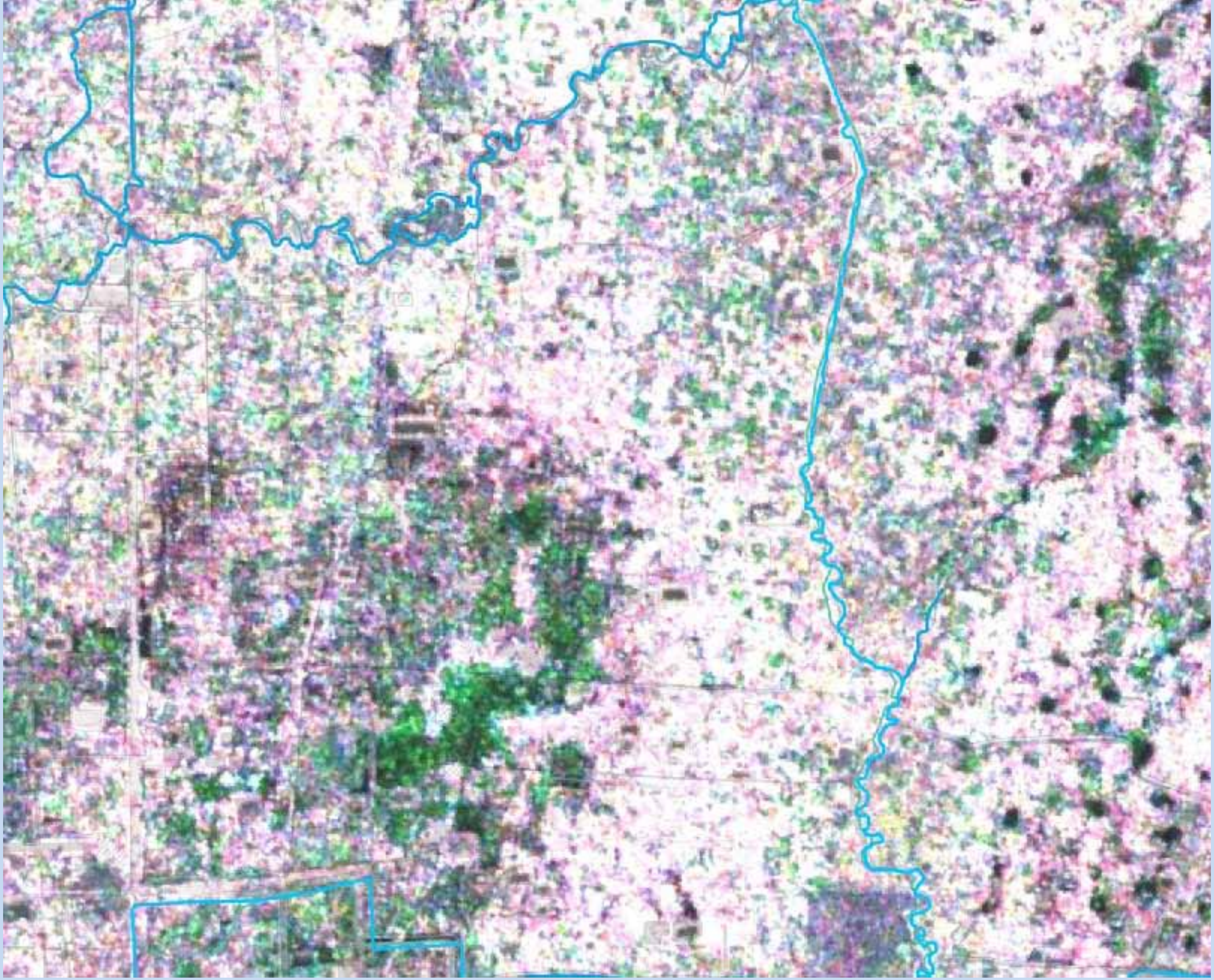


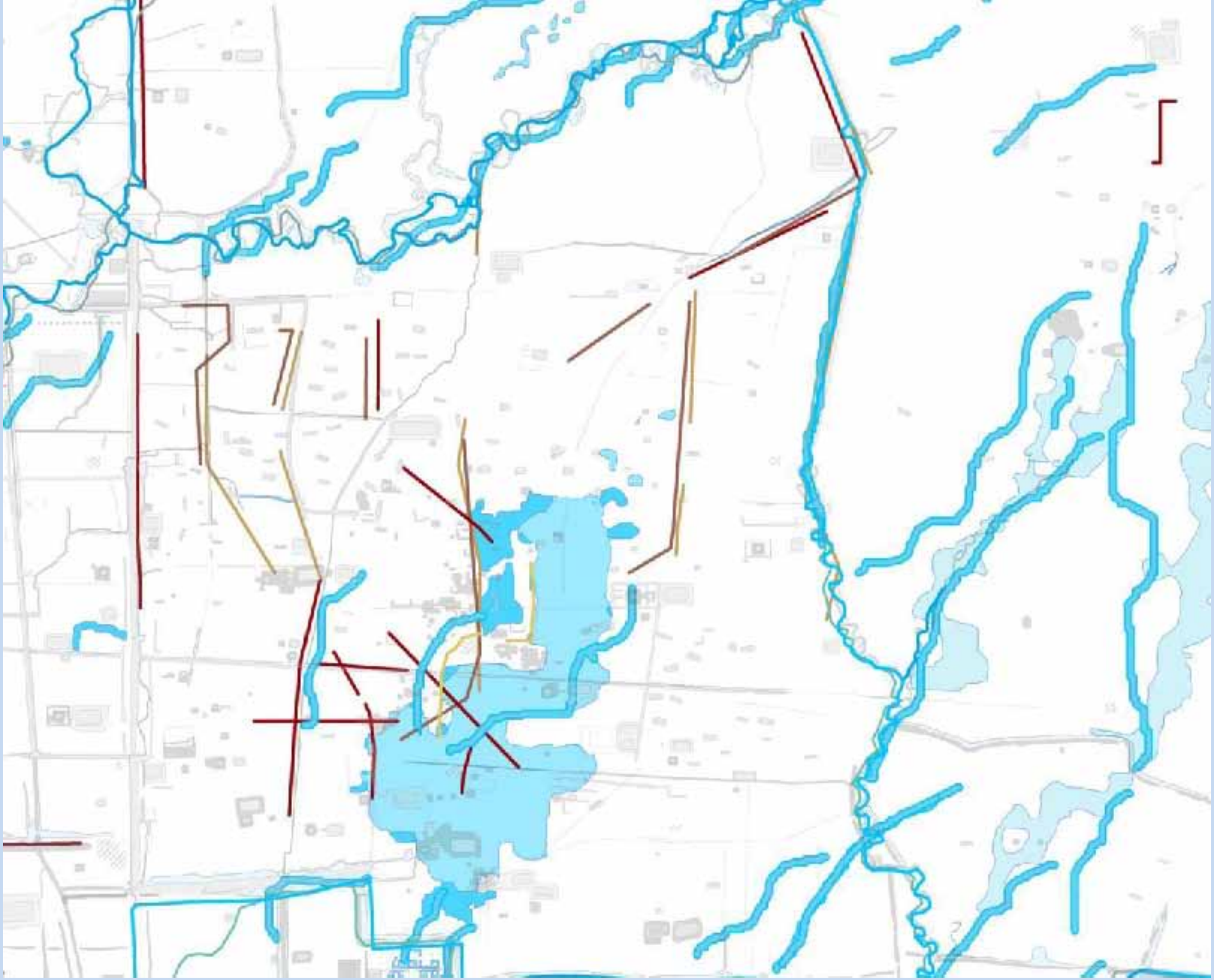
- Large trace of dampness [NW of Jayatataka]:
  - suggests a river flow
  - appears quite clearly in QB and SIR-C, almost with same shape and overlapping quite perfectly











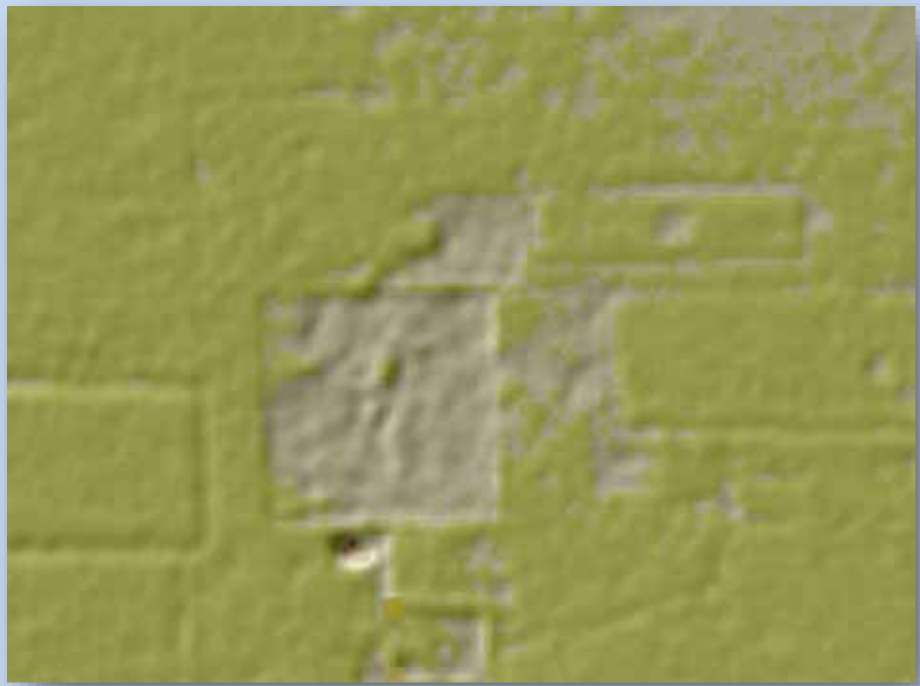
SIR-C: small precise tracts

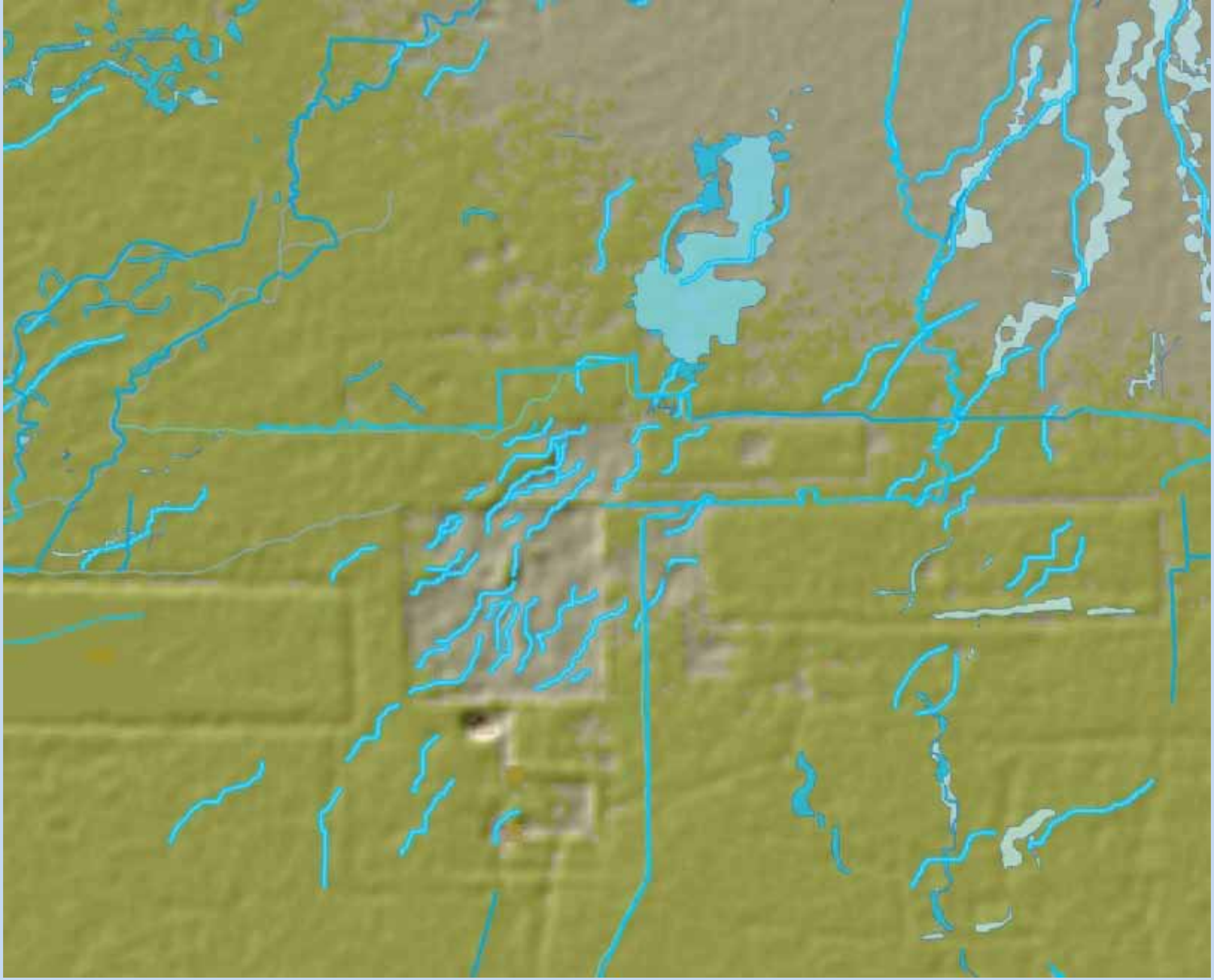
- Group of traces spread all over the inside of the Angkor Thom precinct
  - orientation varying from 35 to 45 degrees
  - appear spread in a fan fashion.

Background map courtesy of Pottier and Evans

Issues:

- Features mainly detected through topographical variation (DEM derived by ASTER and SRTM)
- 2 datasets provided slightly different results; both show linear topographic variations in the area (beds of past rivers?).





Detection of features in forested areas

Goal
- Detection of features in forested areas related to riverbeds or water management system

Strategy
- on surface features
- underground features

Data
Quickbird
Aster
Other data

- VEGETATION SUPPRESSION

- Vegetation suppression to better detect features in the forest

- VEGETATION INDICES (VI)

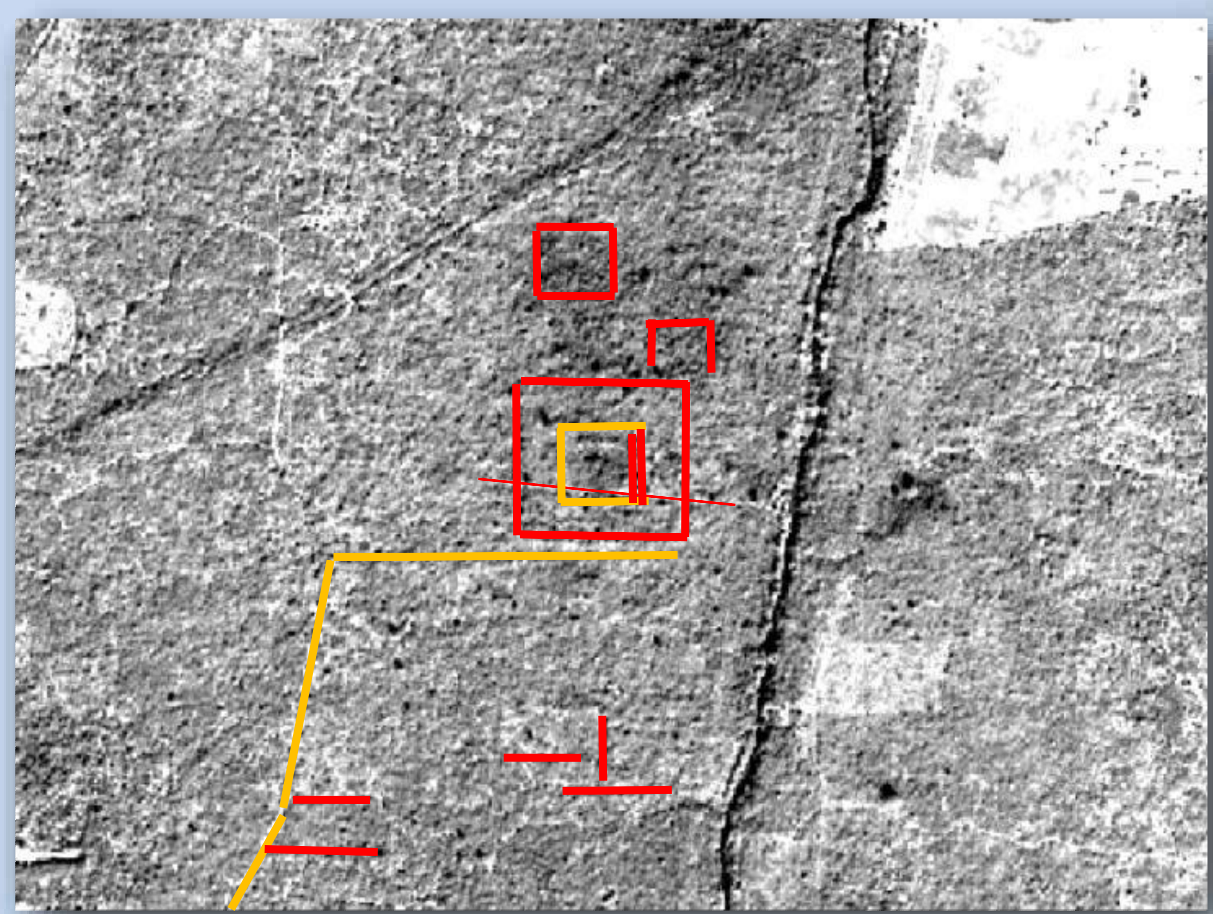
- Vegetation indices to create a map showing the overall health and vigour of a forested region

Vegetation suppression

Vegetation suppression:

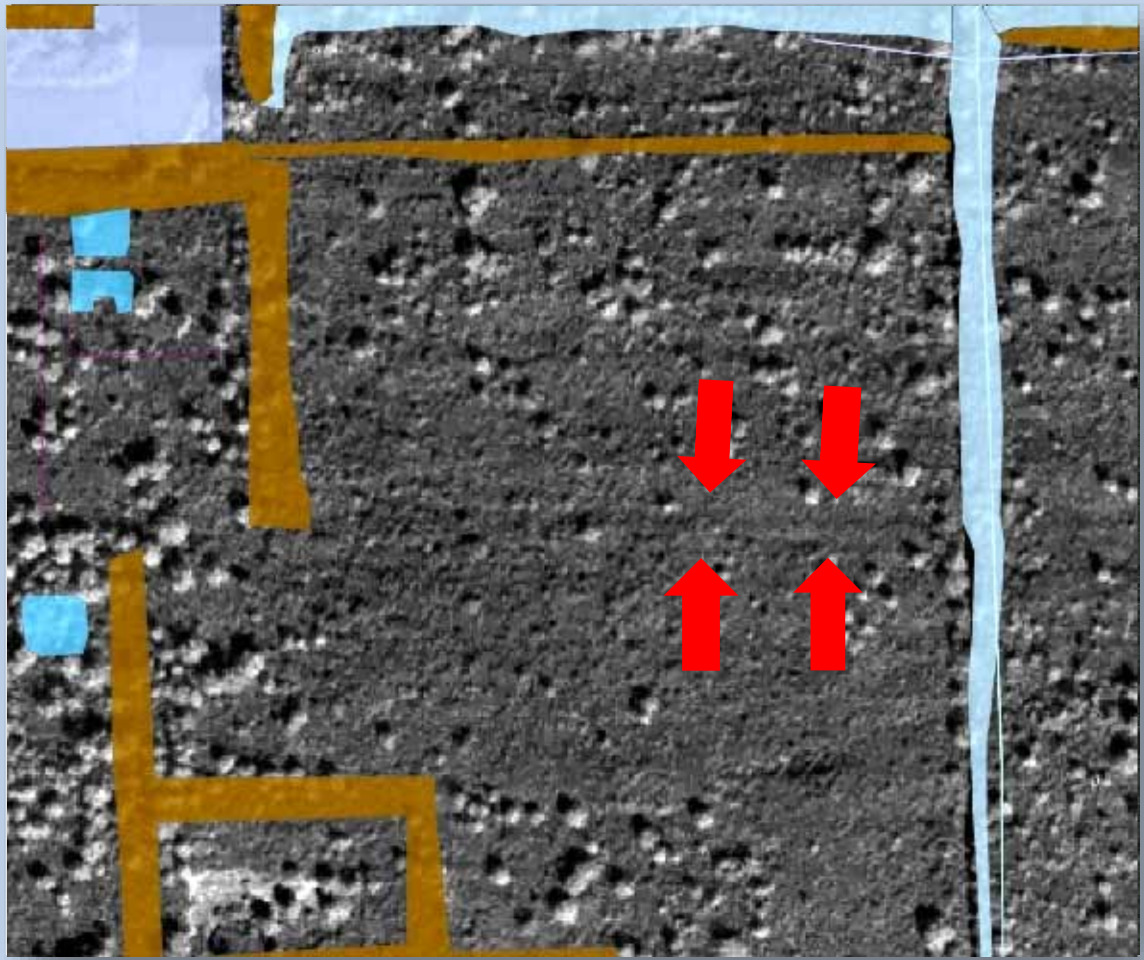
- Removes the vegetation spectral signature from imagery in order to better interpret features
- Allows to perform linear feature enhancement underneath vegetation
- Can identify items hidden under open and closed vegetation canopies, like embankments and ditches.

Central temple has already been detected previously but not the features hidden by vegetation around it.

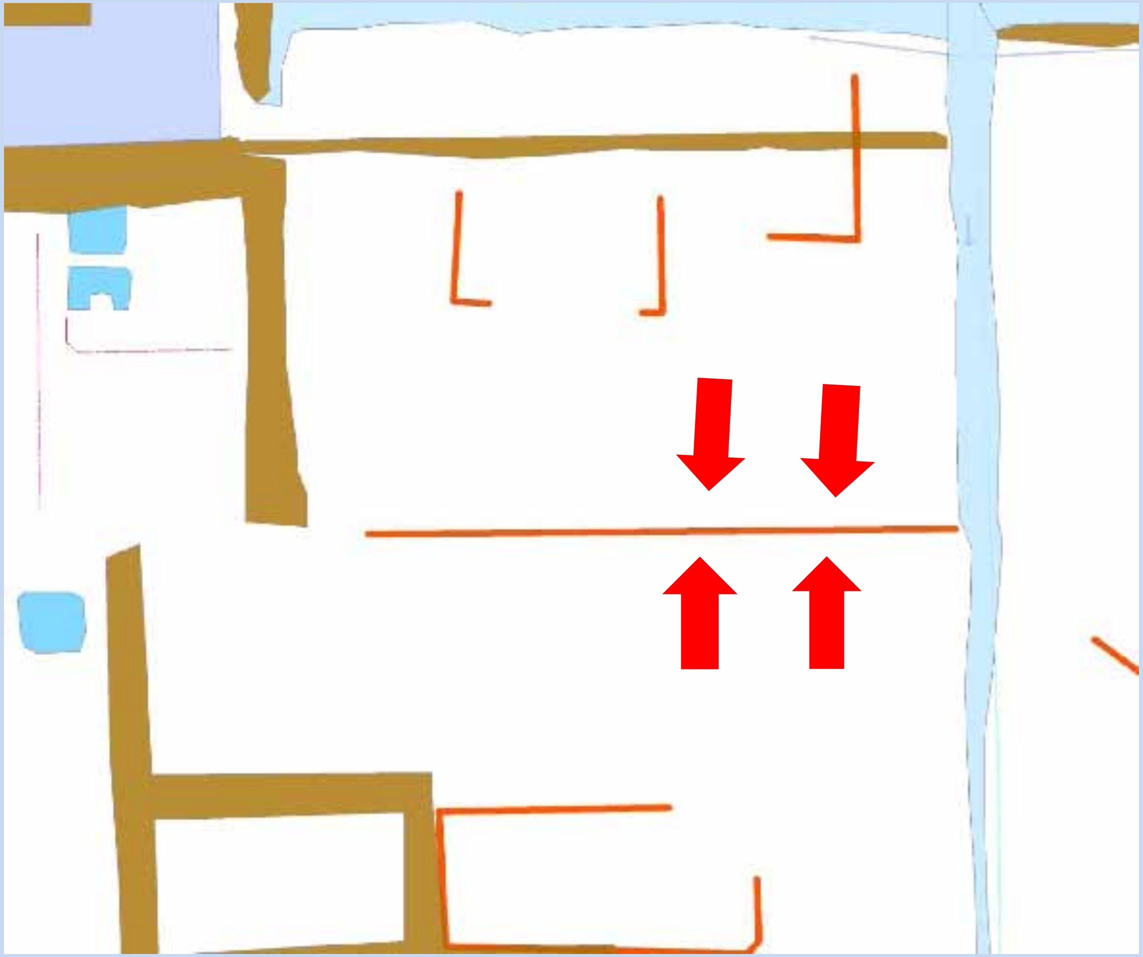


Vegetation suppression

Vegetation suppression



Vegetation suppression



Background map courtesy of Pottier and Evans

Thanks to

- The University of Sydney
- USYD Robert Christie Research Centre (RCRC)
- APSARA
- EFEO (Damian Evans and CALI project; C. Pottier)
- Kasper Hanus

- Arianna Traviglia’s work has received funding from the European Union’s Horizon 2020 Research and Innovation Programme under the Marie Skłodowska-Curie grant agreement No 656337

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

Fifth International Conference on Remote Sensing and Geo-information of the Environment 2017, 20-23 March, 2017, Cyprus

Workshops:
Remote Sensing for Cultural Heritage Beyond Europe Enjoyment of Cultural Heritage By Means of New and Old Media

The monitoring systems for World Cultural Heritage, from satellite techniques to in situ approach: The PROTHEGO methodology and some case study

Daniele Spizzichino e Claudio Margottini
ISPRA – Dipartimento per il Servizio geologico di Italia

JOINT PROGRAMMING INITIATIVE ON CULTURAL HERITAGE WORKSHOP:

FUNDED RESEARCH PROJECTS PARADE

PROTHEGO

Protection of European Cultural Heritage from Geo - Hazards

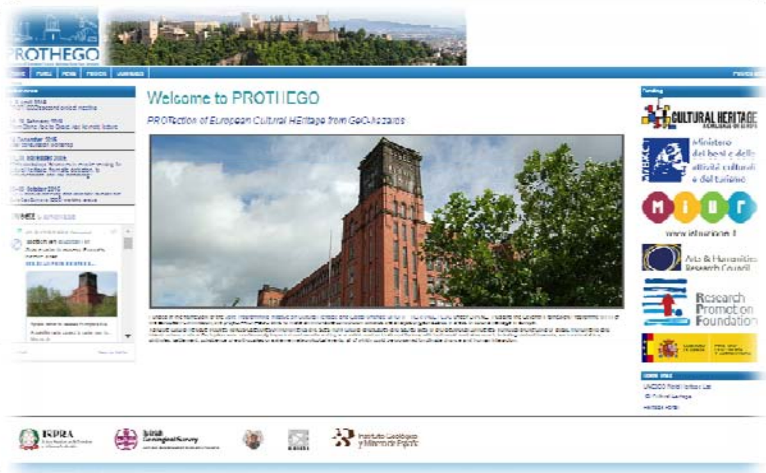
ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

NERC SCIENCE OF THE ENVIRONMENT

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

UNIVERSITÀ DEGLI STUDI DI MILANO BICOCCA

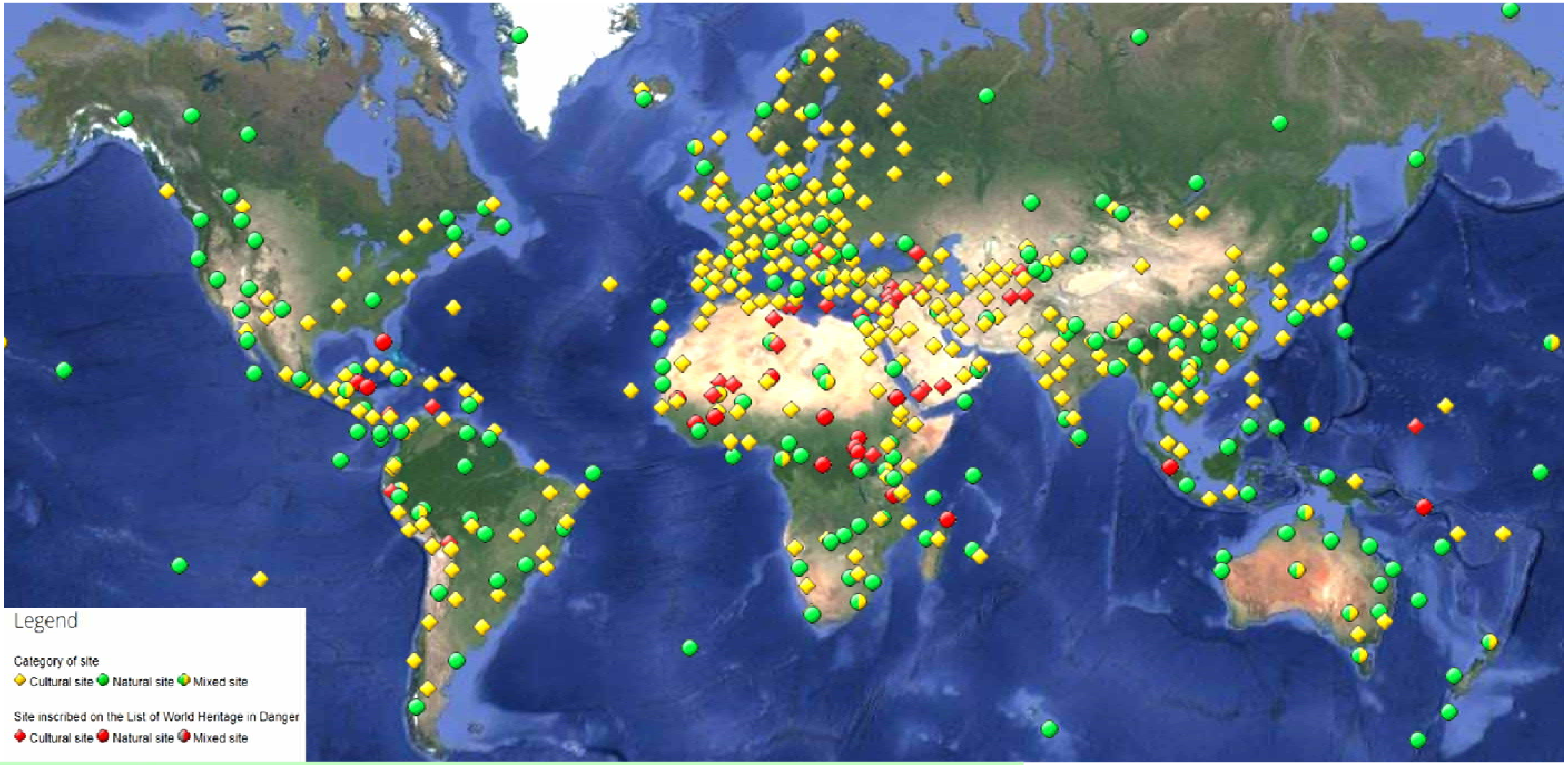
Instituto Geológico y Minero de España



other organization involved

No.	Support letter	AP - typology	Role in the project
1	ESA – European Space Agency [Pier Giorgio Marchetti]	European Agency	Steering Committee
2	EGS – Eurogeosurveys [Luca Demicheli]	Association of the European Geological Surveys	Steering Committee
3	Petra Archaeological Park - Jordan [Emad Hjazeen]	World Heritage Site	Steering Committee
4	ICL International Consortium on Landslides [Kyoji Sassa]	International Research consortium	Stakeholders
5	ISCR Istituto Superiore per la Conservazione ed il Restauro [DG Arch. Gisella Capponi]	Public Agency	Stakeholders
6	CRSS Cyprus Remote Sensing Society [Dr. Giorgos Papadavid]	SME	Stakeholders
7	Politecnica Madrid - Alert geo-materials Royal Academy of Sciences Seville [Manuel Pastor]	Public University	Stakeholders
8	CSPfea [CEO Eng. Paolo Segala]	SME	Stakeholders
9	Association of Cypriot Archaeologists [D. Pilides & V. Lysandrou]	Non-profit Scientific Association	Stakeholders
10	Patronato de la Alhambra y generalife	Public Authority	Demonstration Site Stakeholders: Alhambra, Spain
11	Sovrintendenza Capitolina – Roma Capitale [Claudio Parisi Presicce]	Technical body of the municipality of Rome	Demonstration Site Stakeholders: Historic Centre of Rome, Italy
12	Landscape Research & Management [Dr. Andy Howard]	Geo-archaeological landscape consultancy	Demonstration Site Stakeholders: Derwent Valley Mills, UK [via the project "*Managing Climate Change in the Derwent Valley*", commissioned by English Heritage]
13	Derwent Valley Mills - World Heritage Site [Mark Suggitt]	World Heritage Site Board	
14	Trent & Peak Archaeology and the York Archaeological Trust [Dr. David Knight]	Archaeological heritage Services provider	

RATIONALE:
WH Sites “in danger”



1052	34	2	55	814	203	35	165
Properties	Transboundary	Delisted	In Danger	Cultural	Natural	Mixed	States Parties

UNESCO World Heritage List March. 2017

PROTECTION FROM WHAT?

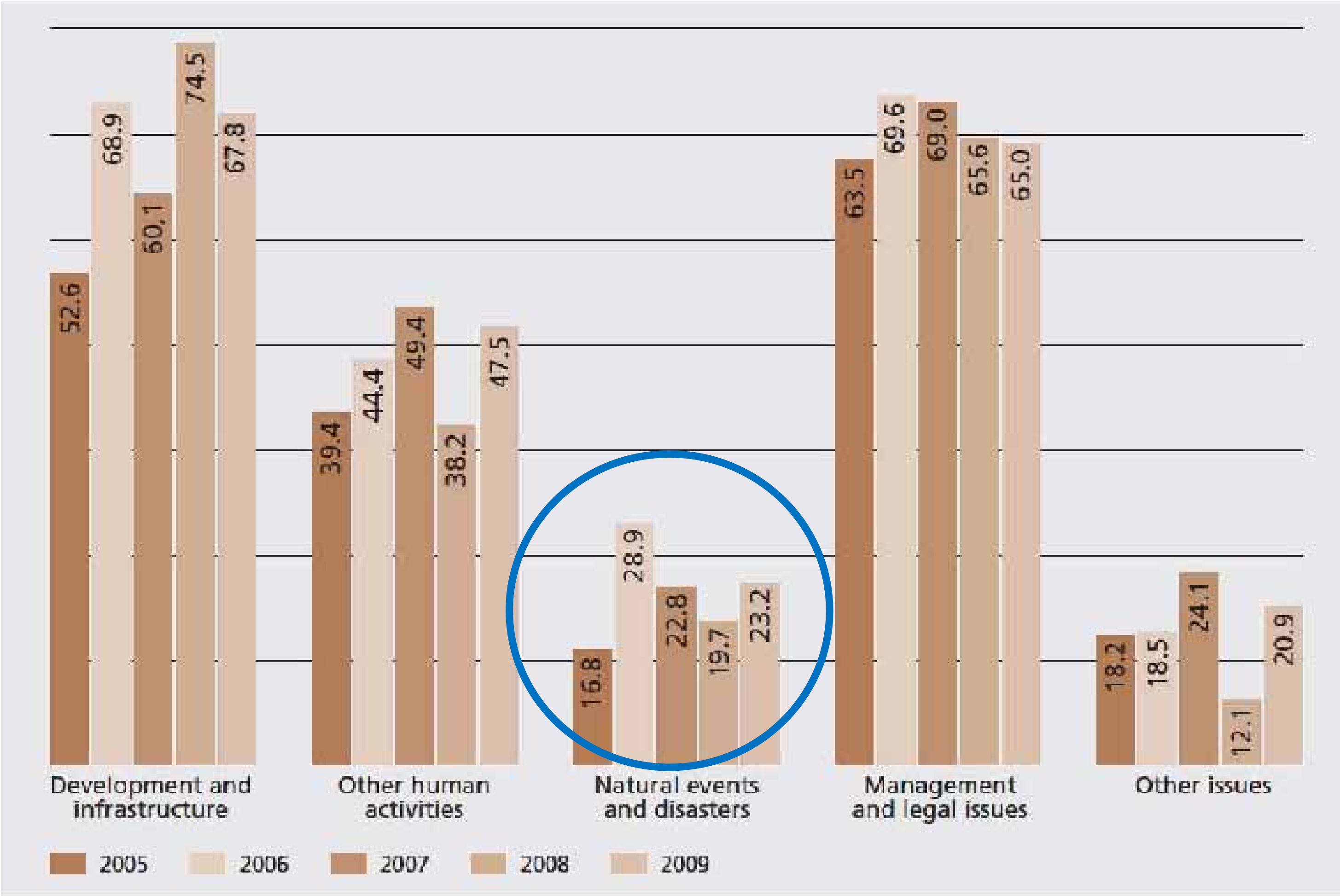
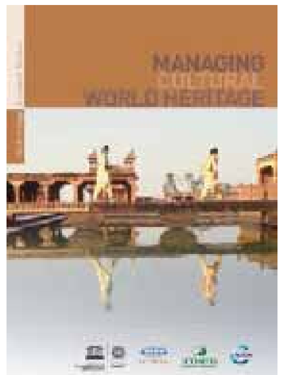


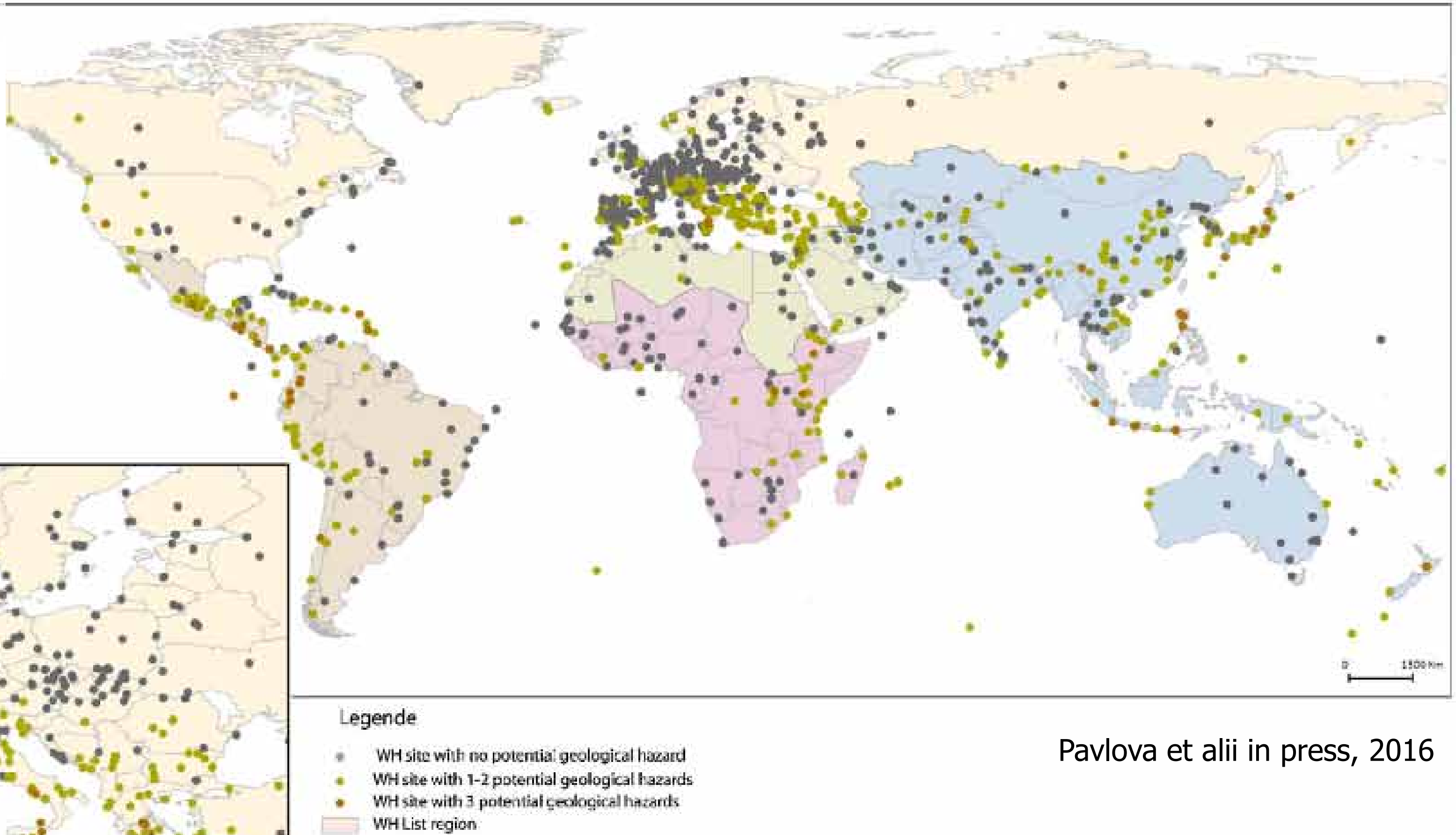
Diagram 4: Percentage of World Heritage properties affected by each primary group of threats (years progressing from 2005 to 2009, from left to right)[30]

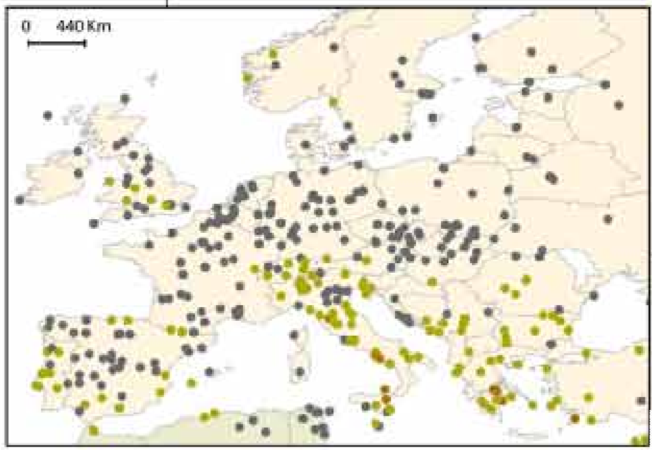


Source: UNESCO (2013)

Known Exposure of WH to Geo-Hazards

Article 11 of the Convention (Protection of WH) includes sites threatened also by armed conflicts, accelerated deterioration, calamities and cataclysms, and rapid urban or tourist development.





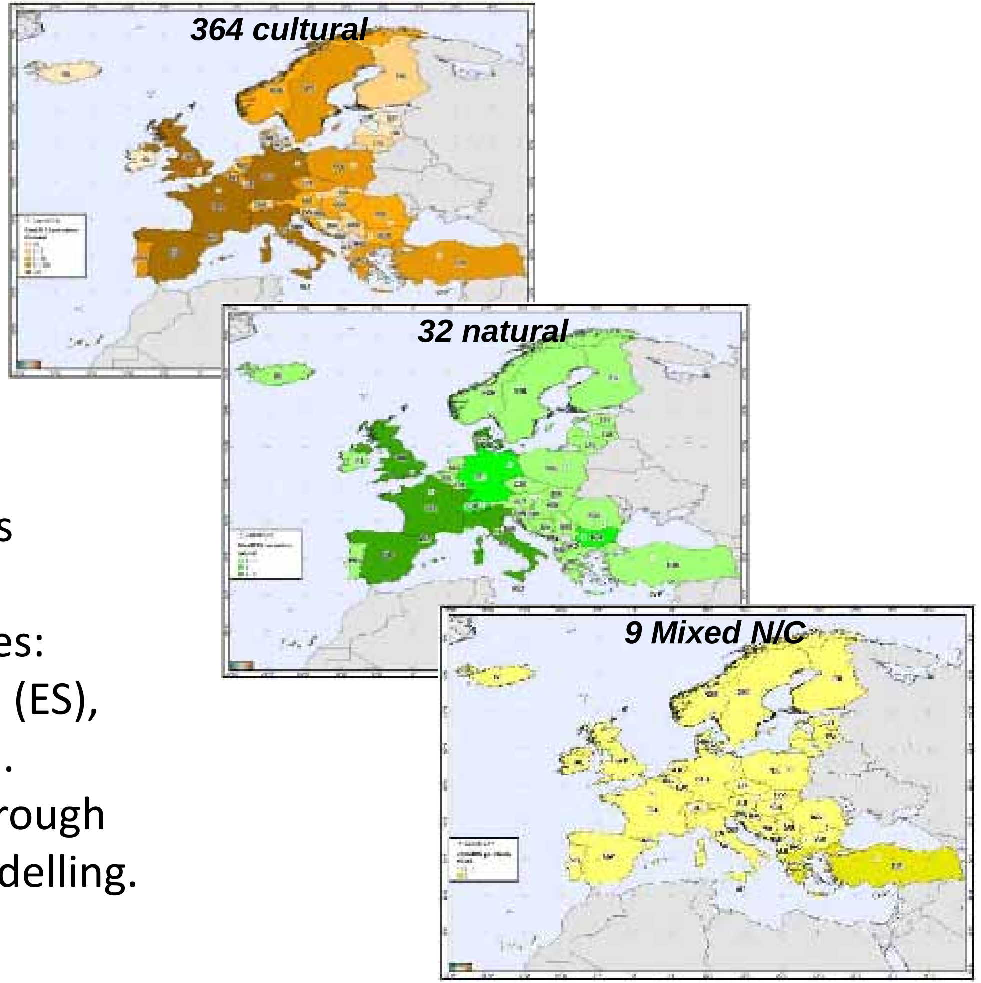
Pavlova et alii in press, 2016

WH properties exposed to geo-hazrads according to Global Risk Data Platform (GRDP) and Global Volcanism Programme (GVP) datasets.

Main goals of the project

Methodology
SAR (PS) techniques applied to
UNESCO World Heritage
Sites potentially affected by Geo-Hazards
(e.g. landslide, seismic, subsidence).

Target and main Goals
Calibrate and verifying limits and constrains
of SAR techniques applied to WH through
downscaling the analysis in specific test sites:
Mura Aureliane (IT), Pompei (IT), Alhambra (ES),
Derwent valley Mills (UK), Choirokoitia (CY).
The methodology will be calibrated also through
monitoring and advanced geotechnical modelling.



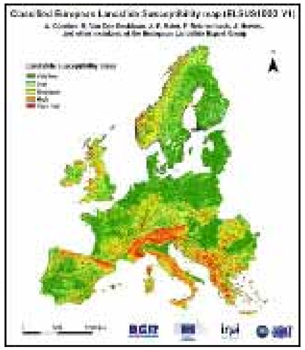
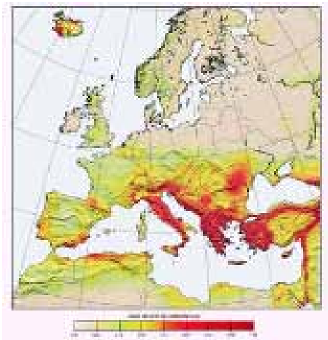
PROTHEGO Workplan

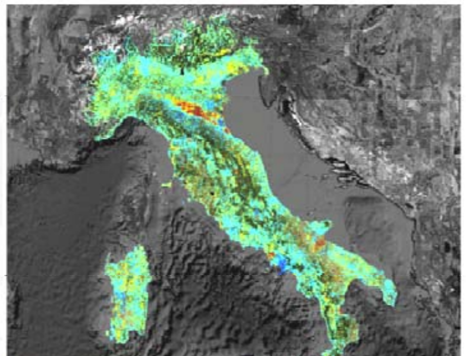
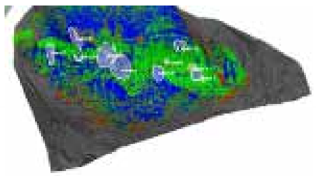
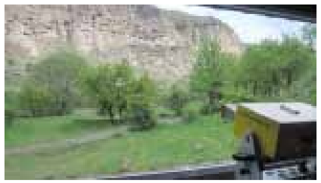
CULTURAL HERITAGE
A CHALLENGE FOR EUROPE

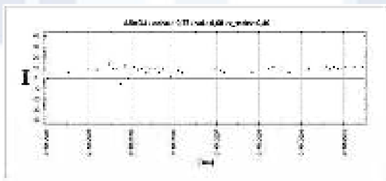
WP7 - Dissemination and communication

WP1 - UNESCO Cultural heritage Vs. Natural Hazard at European scale → WP2 - Harmonisation of PS data and creation of digital factsheets → WP3 - Integration of PS and geo-hazard products and implementation of multi-criteria methodology → WP4 - Identification of most endangered sites → WP5 - Local scale monitoring → WP6 - Local scale investigation and advanced modelling

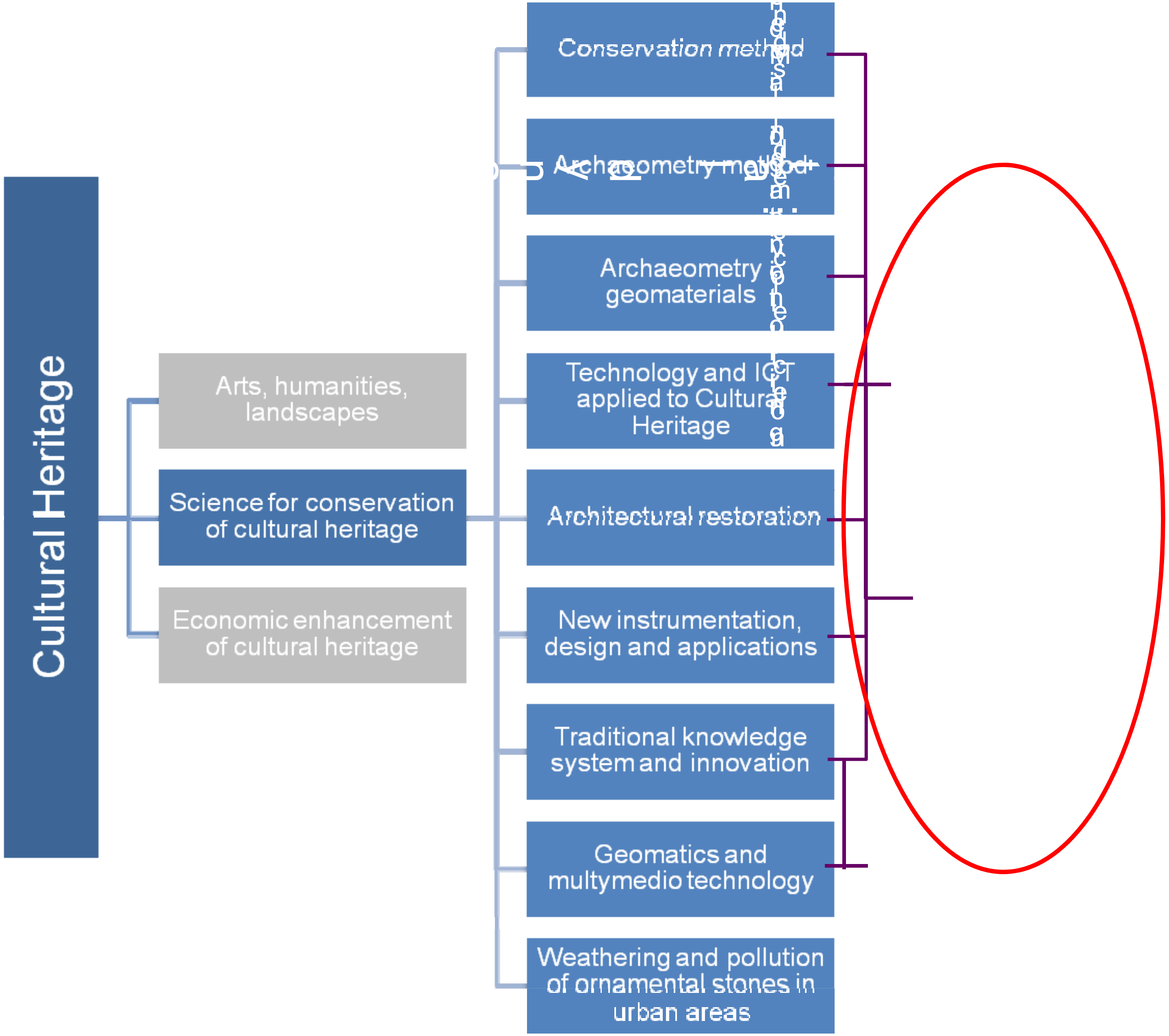
WP8 - Project Management




ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale



ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

METHODOLOGY SIMILARITY AND DIFFERENCES IN THE VARIOUS MONUMENTS AND SITES

BACKGROUND → DIAGNOSIS OF CURRENT CONDITIONS → MONITORING PROCESSES → CONSERVATION POLICIES AND MANAGEMENT

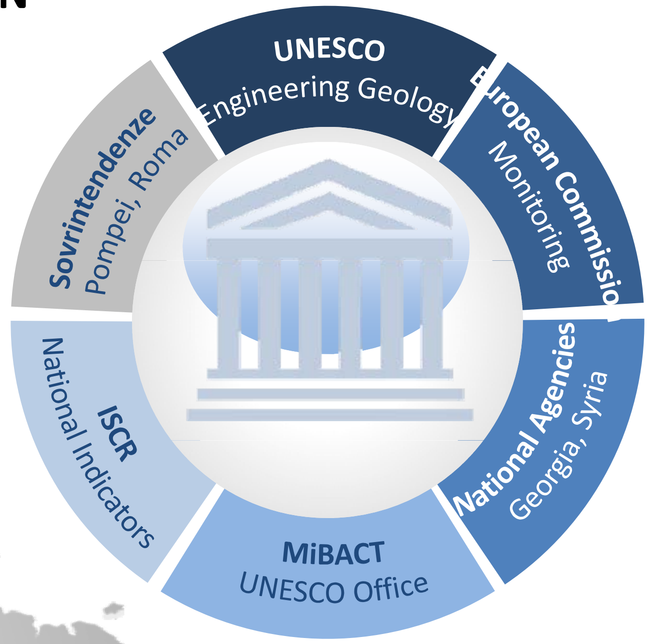
<u>Background</u>:
investigating the origin, typology, construction techniques, restoration history, evolution in time, etc.

<u>Diagnosis of current conditions</u>:
site conditions, materials and properties, threats (hazard and risk), state of deterioration, etc.

<u>Monitoring processes</u>:

<u>Conservation policies and management</u>:
An Eco-friendly strategy to enhance sustainability and local conservation practices

ISPRA ACTIVITIES TO SUPPORT WORLD WIDE CULTURAL HERITAGE CONSERVATION AND PROTECTION

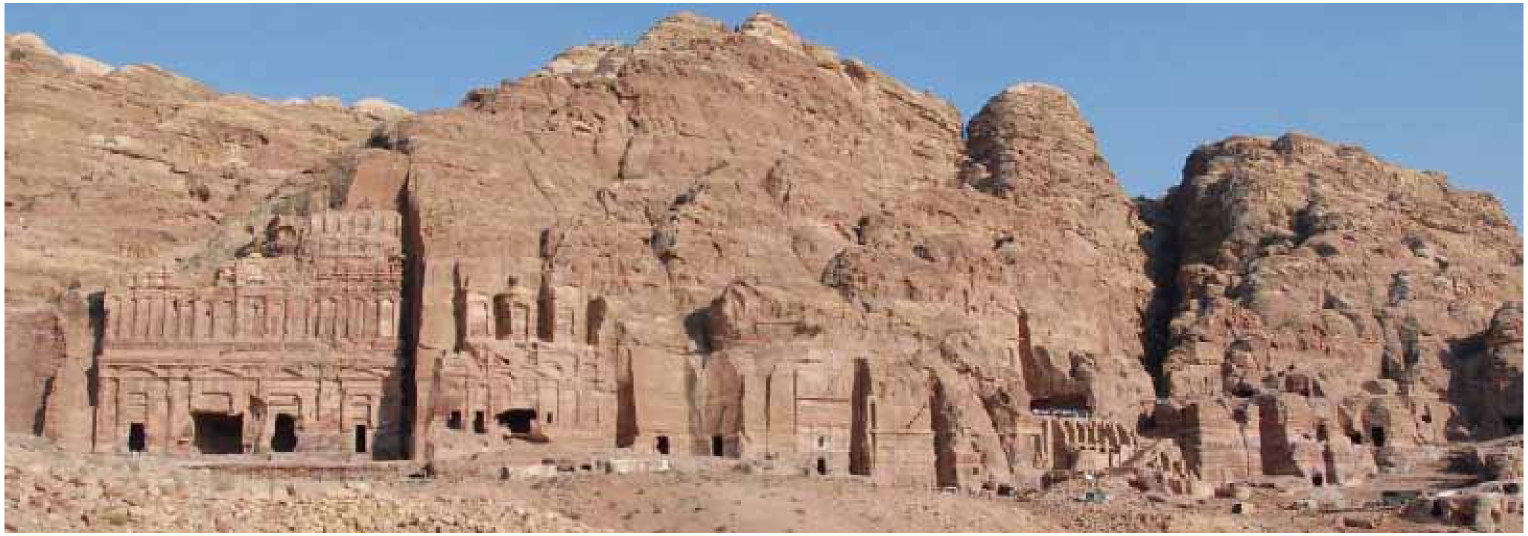


LAST 15 YEARS CASE STUDY DISTRIBUTON

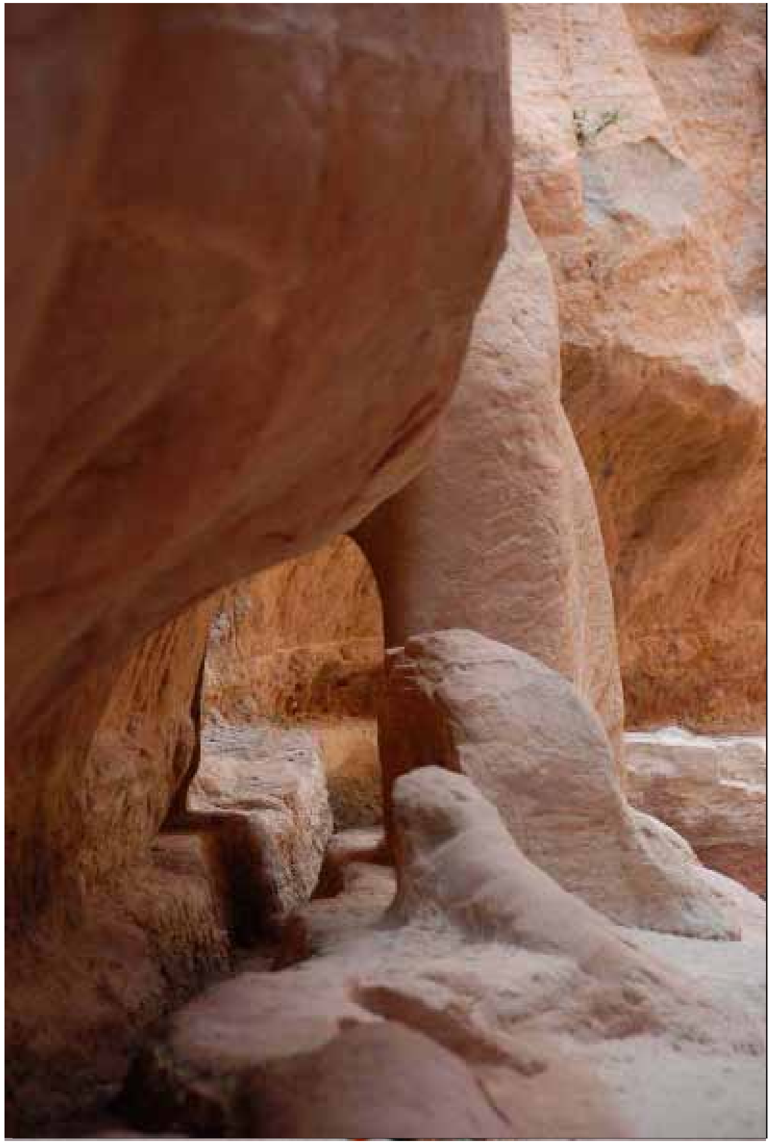
Legenda

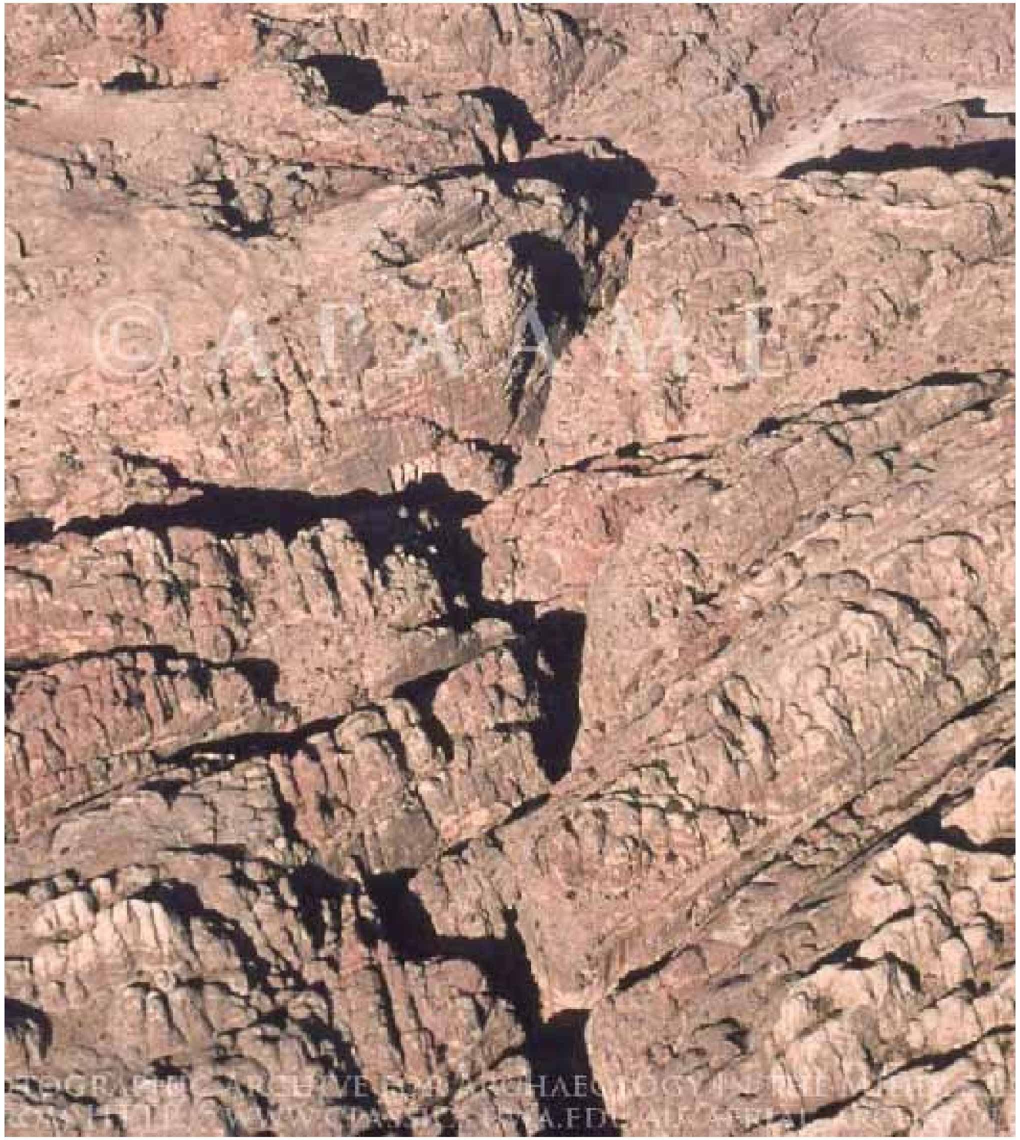
- Bearing capacity
- Enviromental issues (EIA, etc.)
- Landslides
- Hydrogeology
- Underground stability
- Geo-structural
- Archaeoseismicity

NABATEAN CITY OF PETRA (JORDAN)
Monument – rock cut site
Treats – rockfall



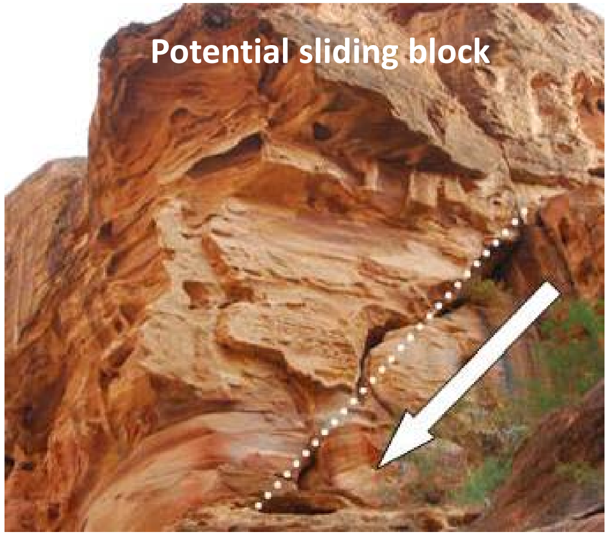
General description of the area and research background

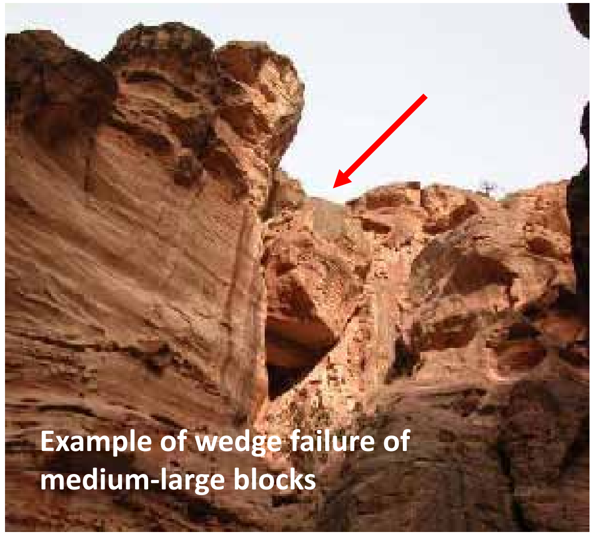


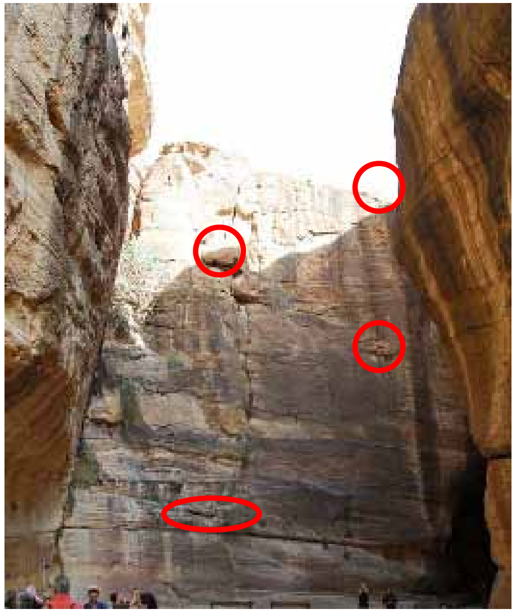


ISPRA Istituto Superiore per la Protezione e la Ricerca Ambientale

LANSLIDE TYPES AND SLOPE EVOLUTION







Small blocks volumes (volumes < 5m^3)

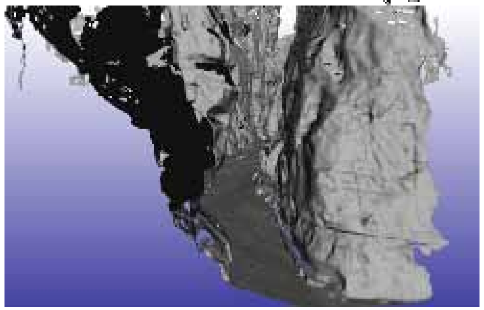
Large blocks volumes (volumes > 15m^3)

Medium blocks volumes (volumes 5m^3÷15m^3)

LOOSE BLOCKS IN THE UPPER SIQ OF PETRA

RECENT AND HISTORICAL EVENTS

TOPOGRAPHY LASER SCANNING THE SIQ

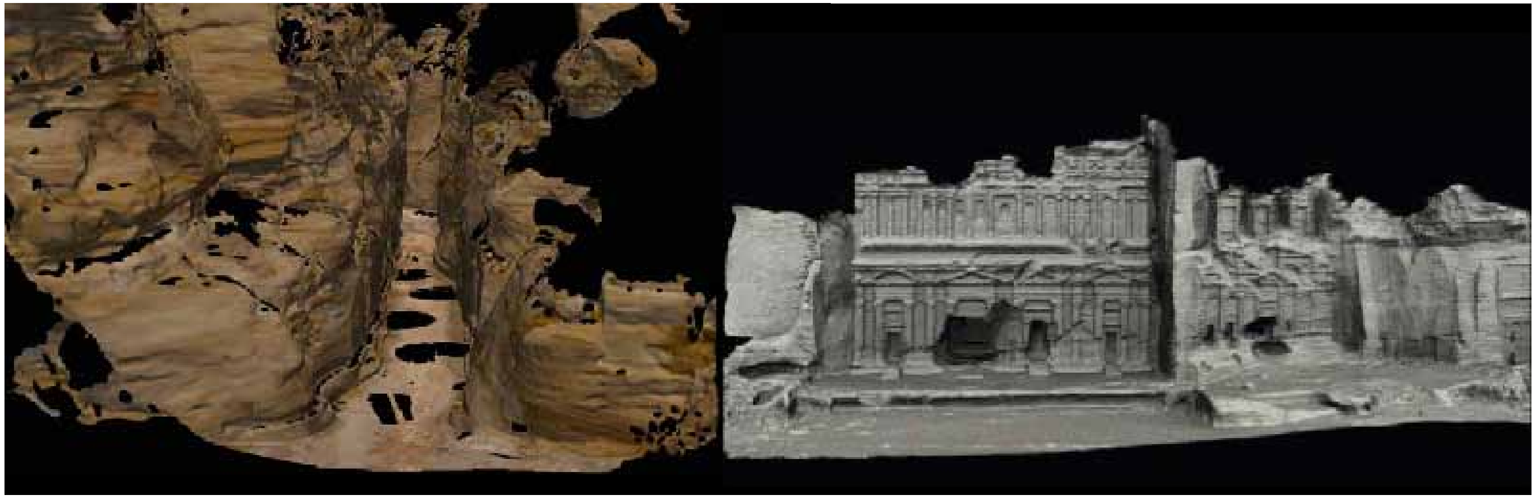


220 total scans;

average point interval of approximately 3 cm.

Given this a point cloud of **five billion** points was generated.

the Siq was divided in 15 sectors (left and right)



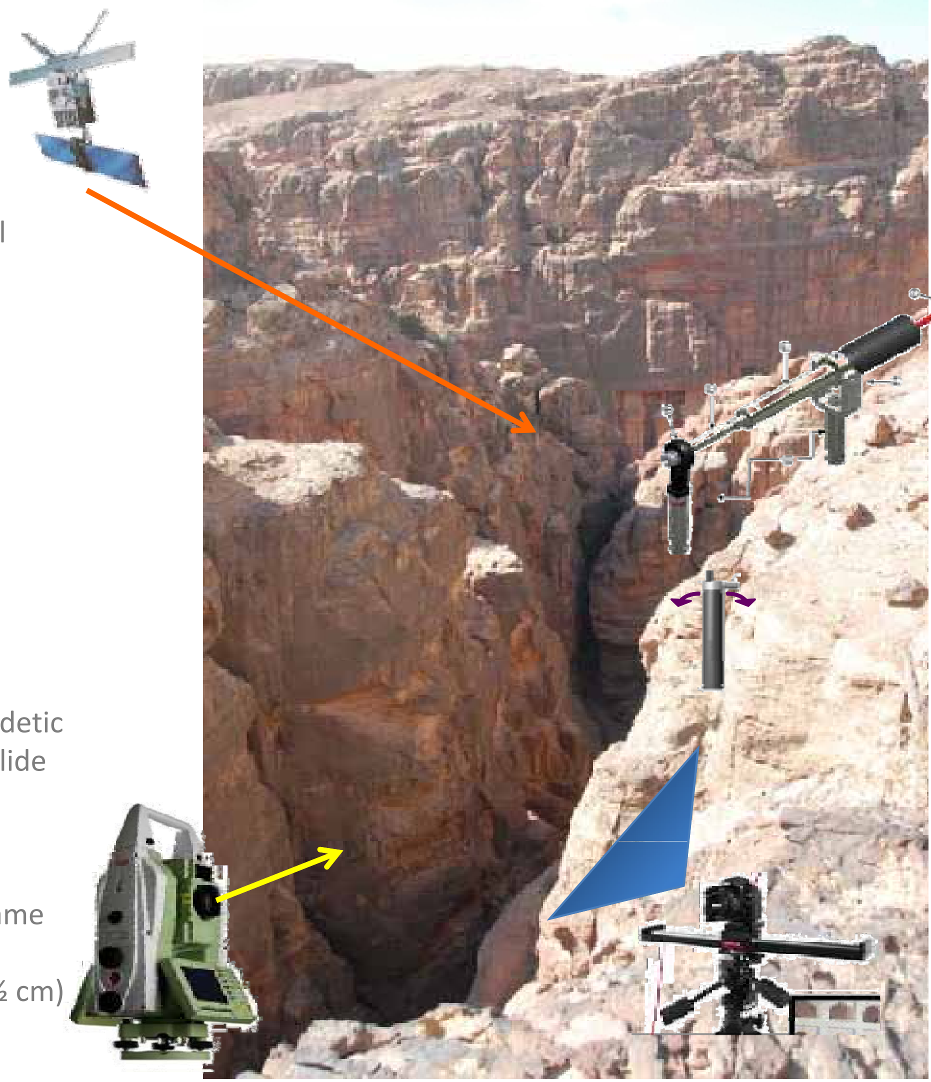
ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

INTEGRATED MONITORING SYSTEM WITH LOW ENVIRONMENTAL IMPACT

(MULTITECHNOLOGY)

TRE

1. Satellite DinSAR analysis with the technique of permanent scatter. Such technique will allow the understanding of last decade evolution of cliff and surface ; (resolution: mm)



3.Geotechnical techniques for landslide monitoring
•Automatic and wire extensometers, tilt meter and meteo data in a wi-fi environment;
manual crack meter .

Minteos

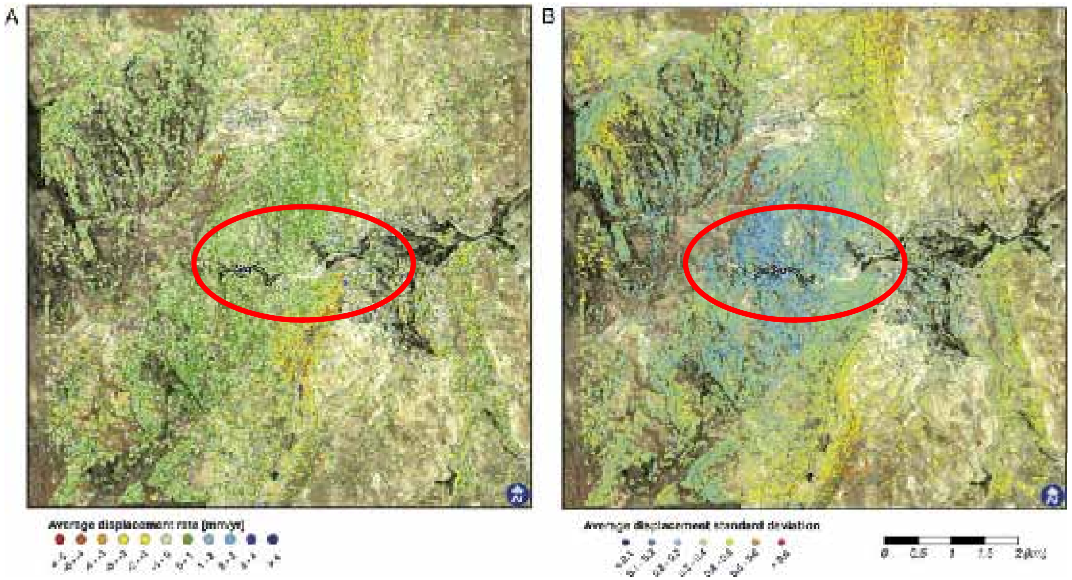
Leica Geosystems

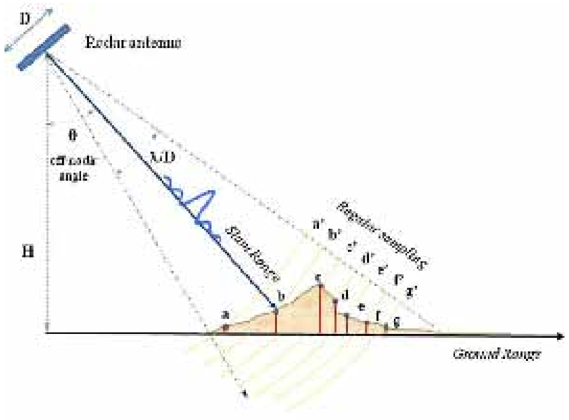
2.Ground-based geodetic techniques for landslide monitoring
•reflector-less total station, to be placed periodically in the same place;
(resolution: mm to ½ cm)

4.Digital Photogrammetric techniques for landslide monitoring
•terrestrial digital photogrammetry. (expected resolution: mm to cm)

MONITORING SATELLITE DINSAR ANALYSIS WITH THE TECHNIQUE OF PERMANENT SCATTERS (PS)

- **51 sq.km,**
- **38 images ENVISAT2-V**
- **from January 2003 to June 2010,**
- **61,983 measure points (ca. 1,215 points/sq.km)**

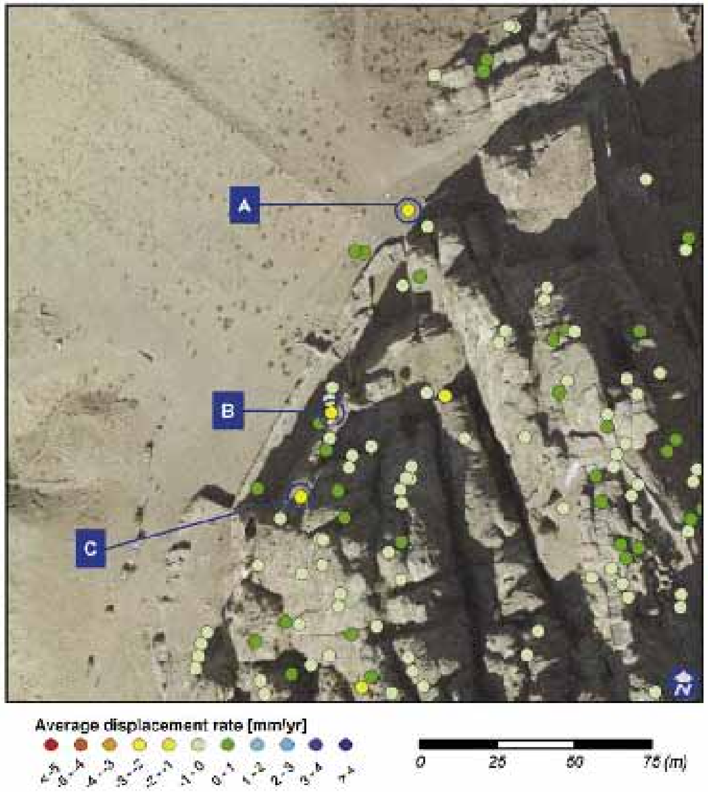


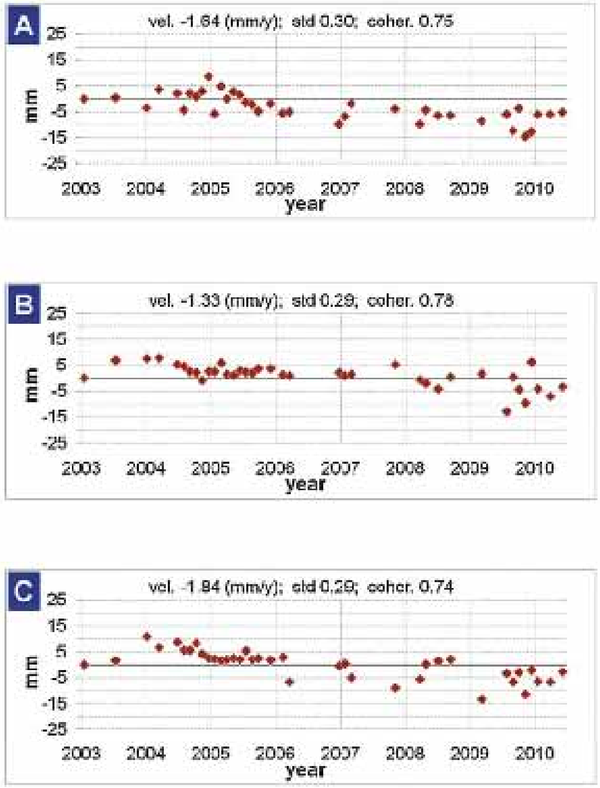


The dataset used in this study is composed of 38 radar images acquired by the ASAR C-Band radar sensor mounted on board the ENVISAT satellite operated by the European Space Agency from 2002 to 2012. Thirty-eight radar images over Petra were acquired along a descending orbit (Track 78-Frame 2997), from January 19th,2003 to June 6th, 2010, with satellite swath S2 and polarization VV. The incidence angle was approximately 23

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

The analysis highlighted that no major surface deformation phenomena were affecting Petra valley neither on the monuments nor on the cliffs during the monitored period (2003–2010), for the adopted methodology.

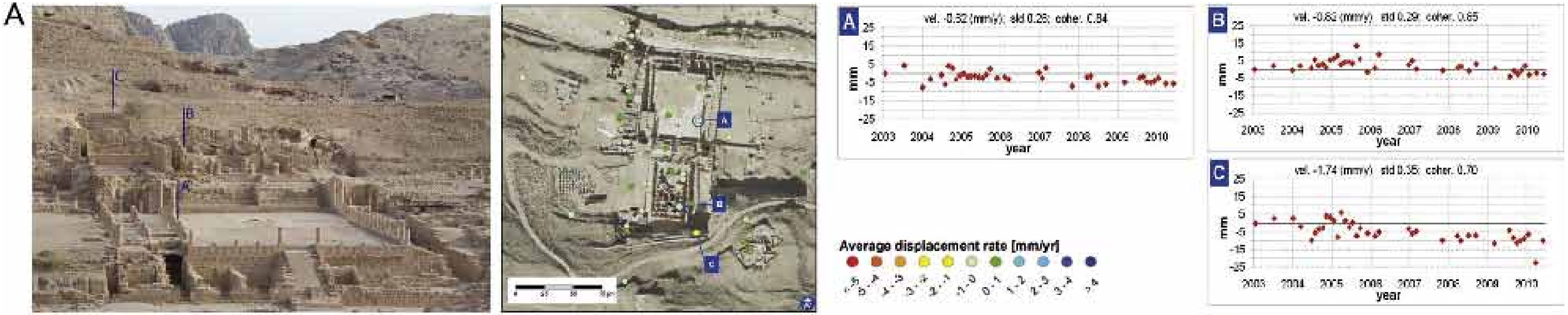




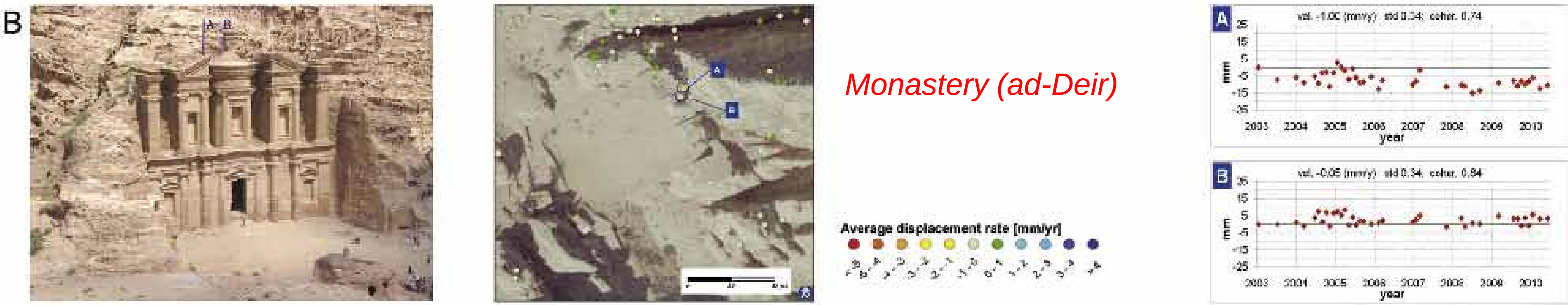
The performed investigation revealed a large number of MPs almost stable but also seven PSs showing a lowering trend, with a velocity of about 1,5 mm/y (Fig. 5). Considering that some of these MPs are positioned on top of the facades, close to the vertical cliff, a periodical verification is required and, may be, the installation of a proper ground-based geotechnical monitoring system would be necessary.

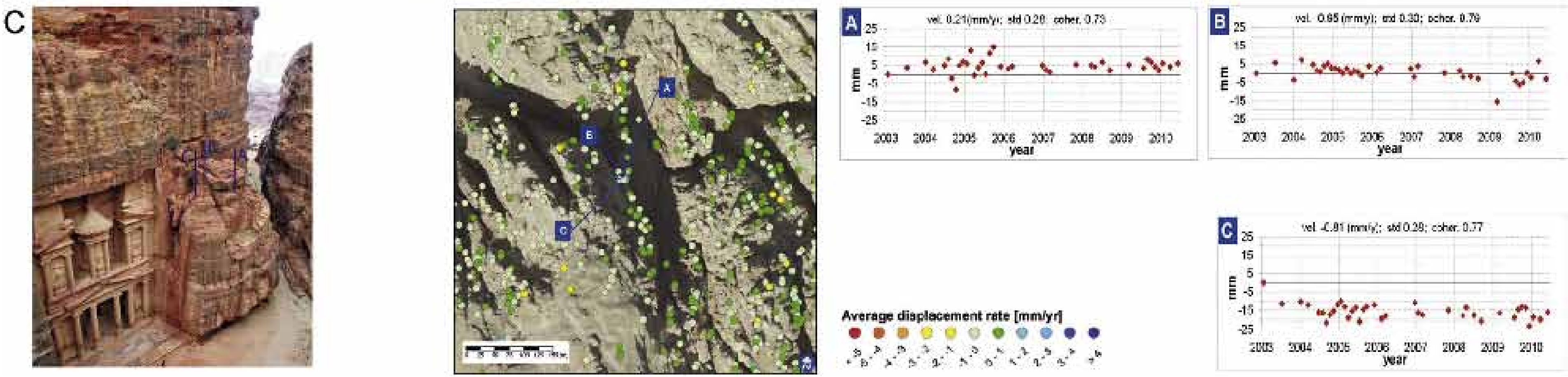
The ROYAL TOMBS FACADE

The Great Temple



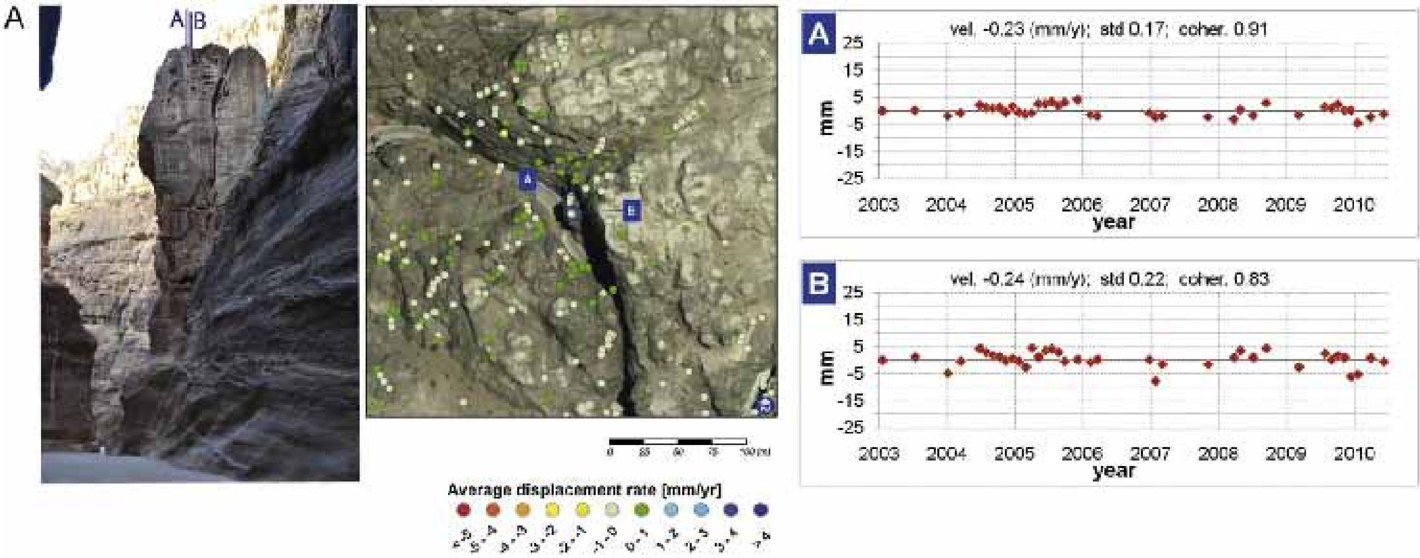
Monastery (ad-Deir)



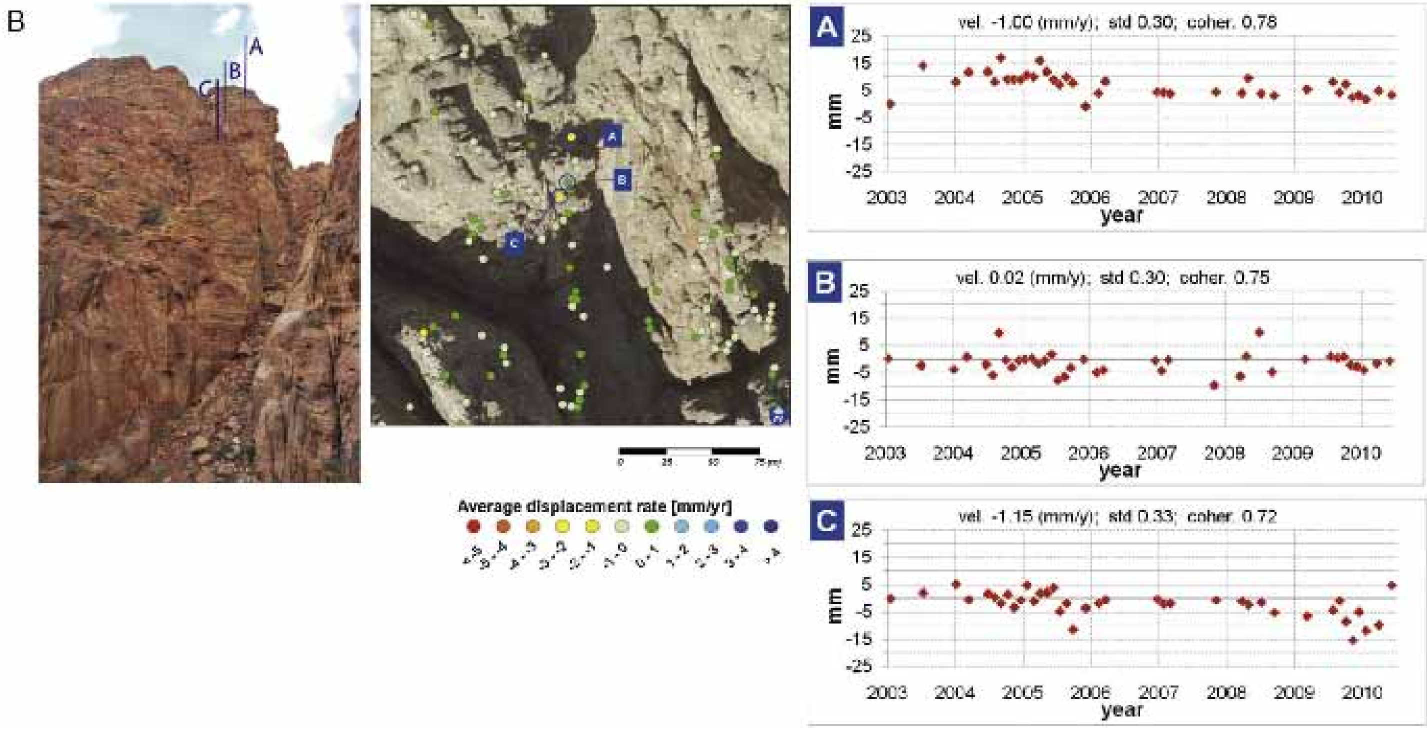


Treasury (al-Khazneh)

Coerence with the two different mnitoring techniques



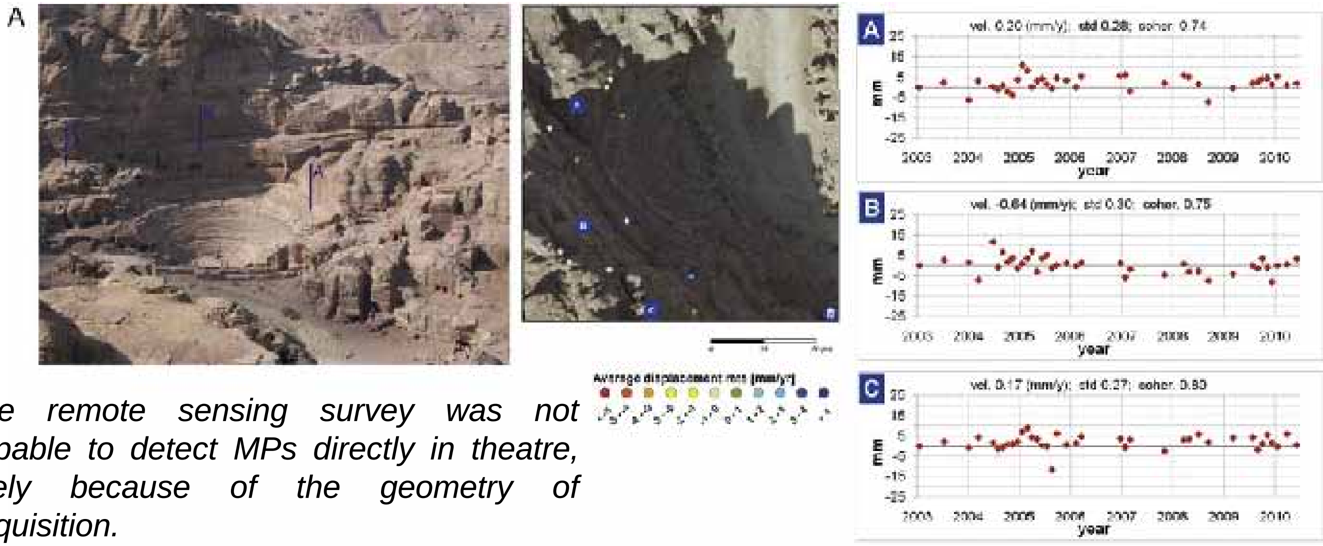
PSs data with ground-based ones, is in agreement with a model of a stable block, with a limited horizontal deformation



The MPs surveyed on the site are showing either stable surface displacement and lowering of about 1–1,2 mm/y, with a constant trend for the whole period. Considering the geomorphological conditions of the block a continuous ground-based monitoring is required, even if it is not affecting historical monuments but potential run out of displaced boulders may impact on visitors

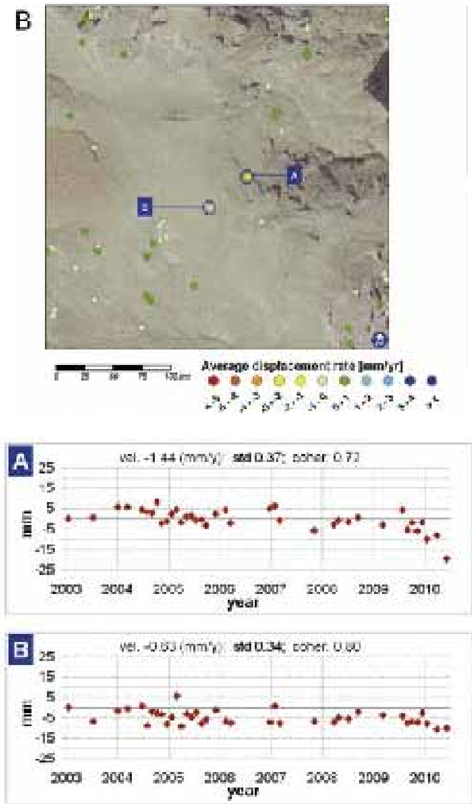
ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

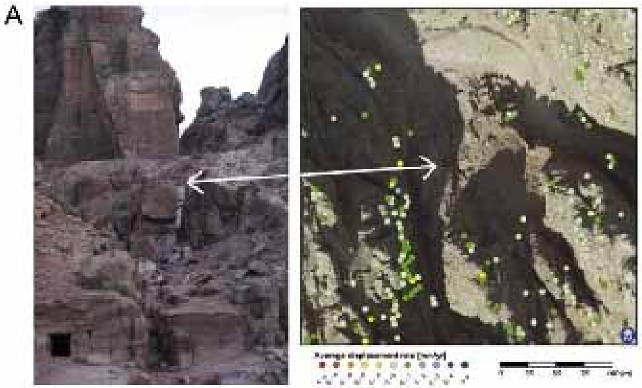
The "Theatre"

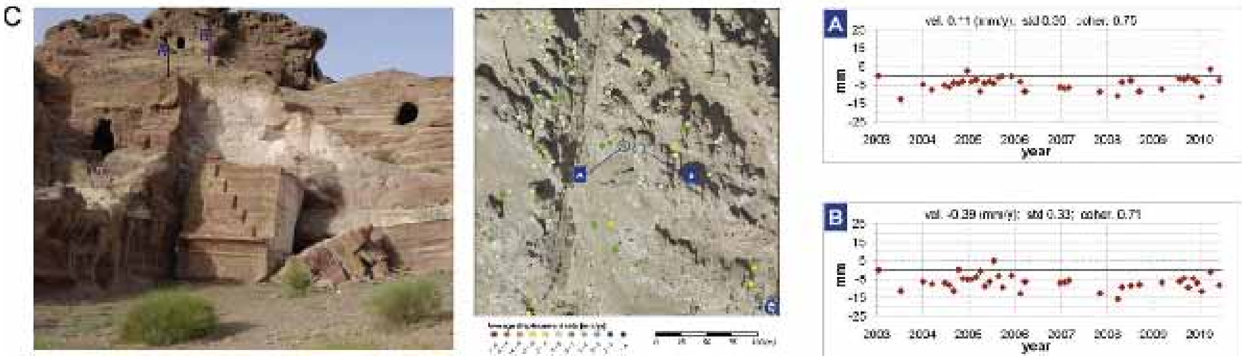


The remote sensing survey was not capable to detect MPs directly in theatre, likely because of the geometry of acquisition.

Newly discovered archaeological site in 2016







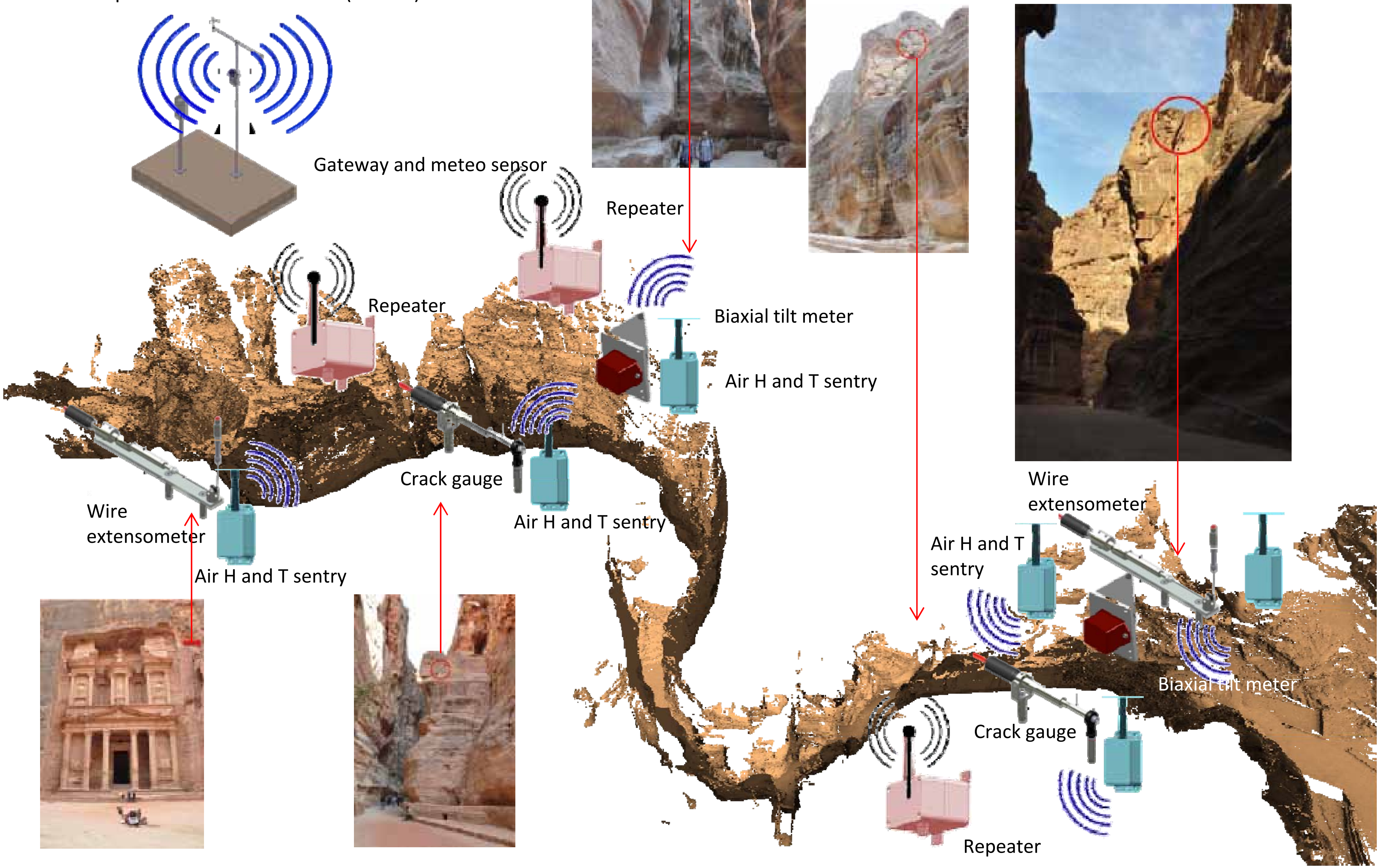
Cross check with dated collapse

remote sensing investigation was not revealing any deformation in the available time-window suggesting that the collapse was not exhibiting remarkable precursory phenomena with a brittle rupture and sudden fall

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

MONITORING WIRELESS NETWORK (DEVICES DISTRIBUTION)

Low impact installation in Petra (Jordan)



Wireless network installation in the Siq of Petra May – June 2013

REPEATER 1

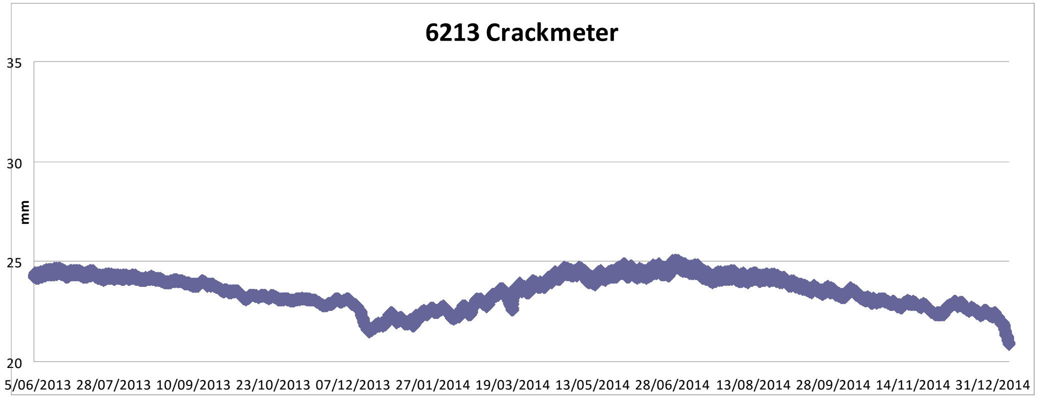
REPEATER 2

Gateway and meteo station

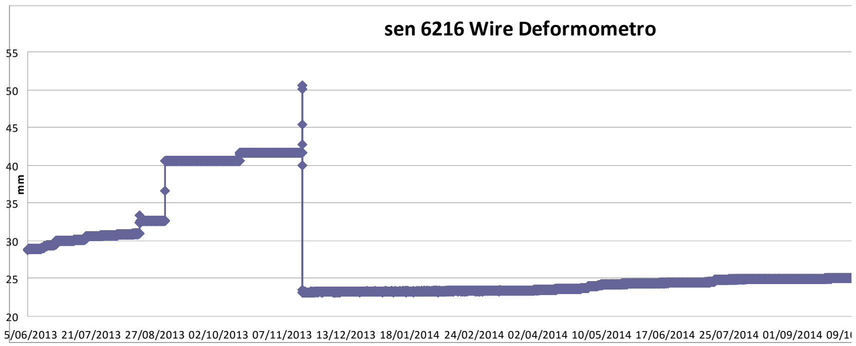
REPEATER 3

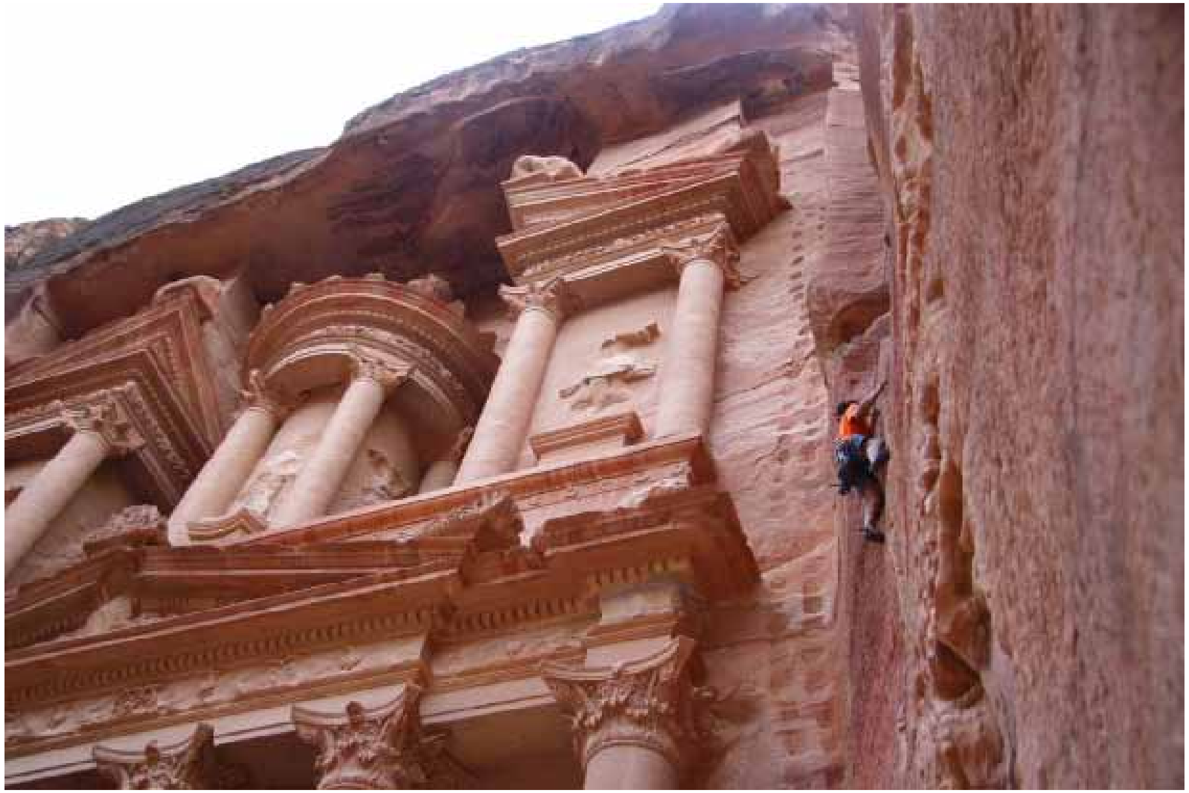
ISPRA Istituto Superiore per la Protezione e la Ricerca Ambientale

Crack meter



Wire deformometer

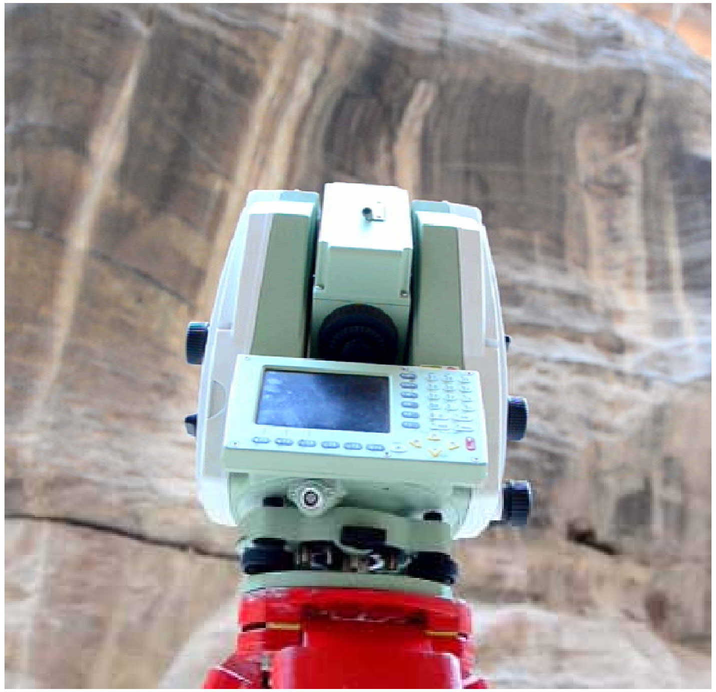


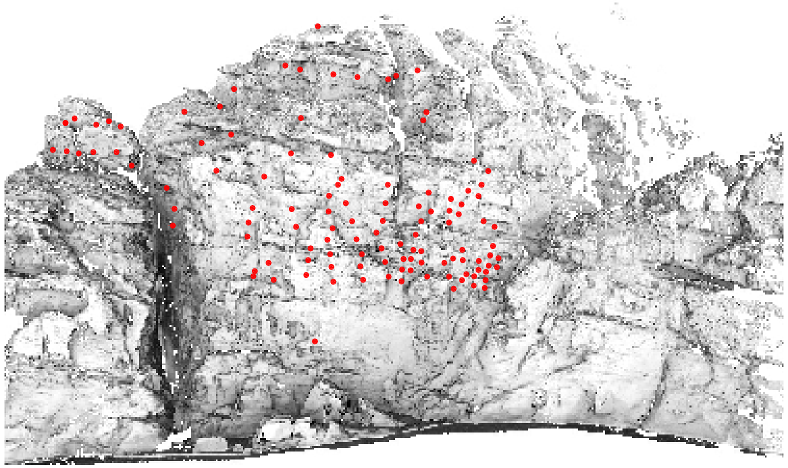


ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

MONITORING INNOVATIVE GEODETIC MONITORING WITH REFLECTORLESS ROBOTIC TOTAL STATION (PETRA, JORDAN)





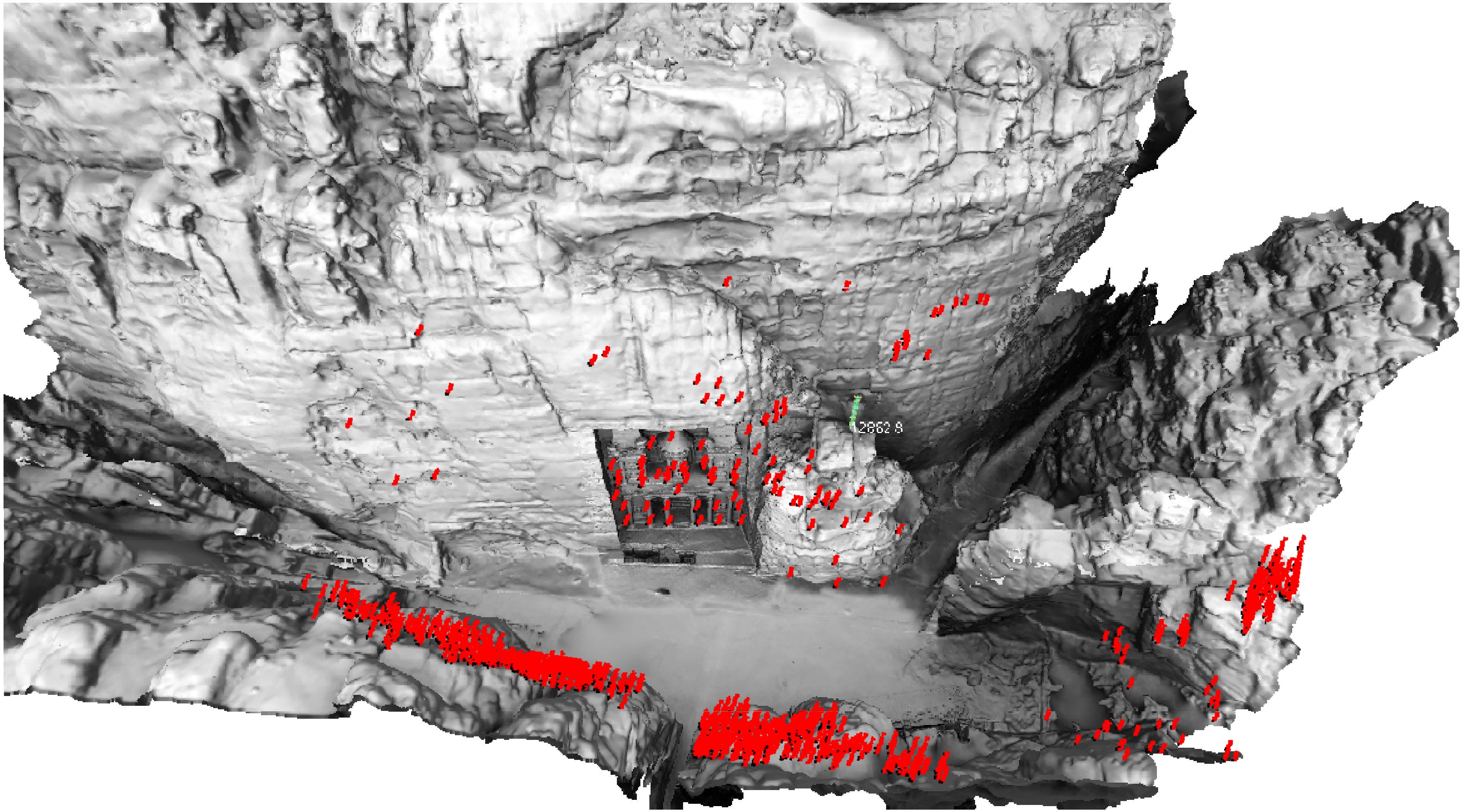
Reflector-less TS monitoring

Their presences is useful to materialized the network and improve the reflector less monitoring accuracy and precision. This system can be used both in continuous and discontinuous monitoring application. The last generation total station can generate 3D point cloud model (through laser scanner acquisition) in which is possible to visualize directly the monitored points.

MONITORING INNOVATIVE GEODETIC MONITORING WITH REFLECTORLESS ROBOTIC TOTAL STATION (PETRA, JORDAN)

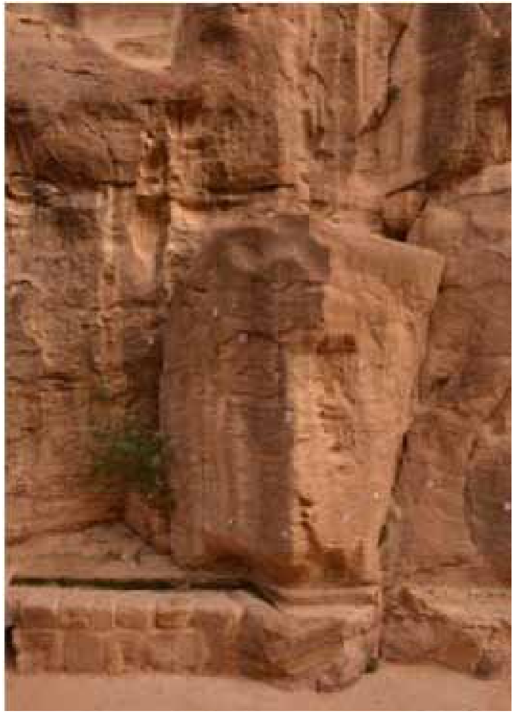
ACCURACY 2 MM

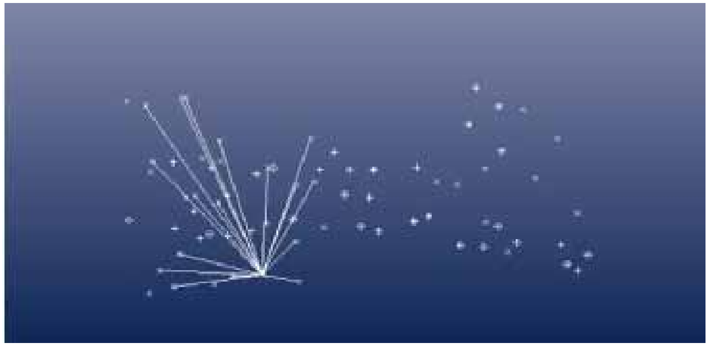
IN REFLECTORELESS MODALITY

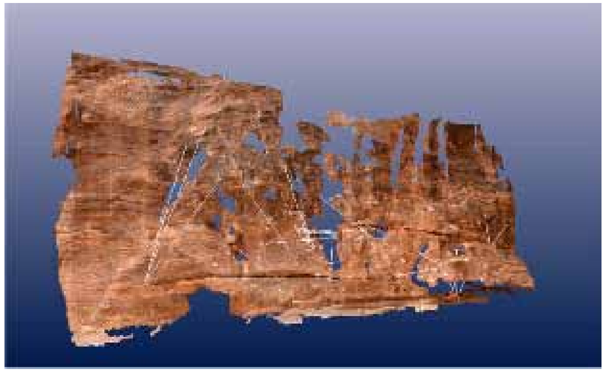


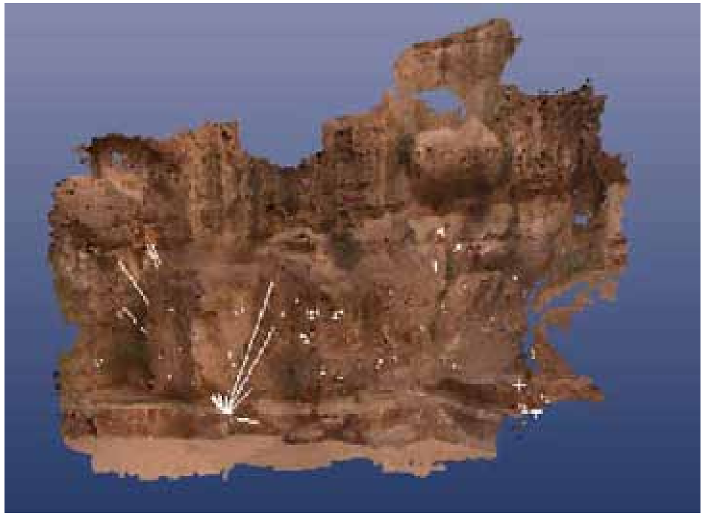
ISPRA
Istituto Superiore per la Protezione
e la Ricerca Ambientale

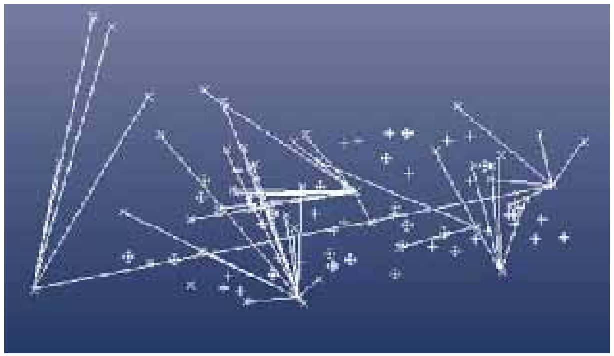
Digital photogrammetry : survey tools or monitoring systems?



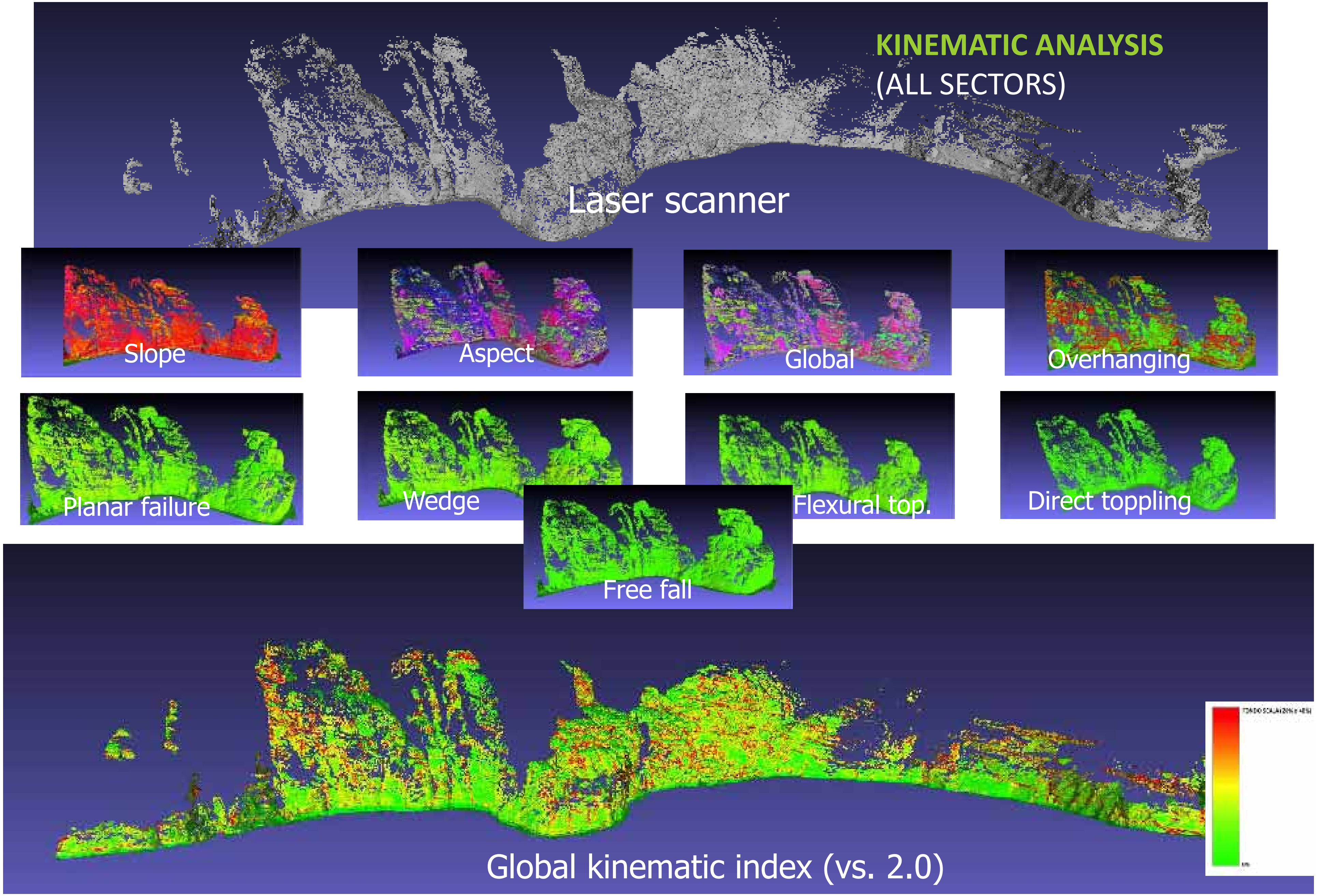








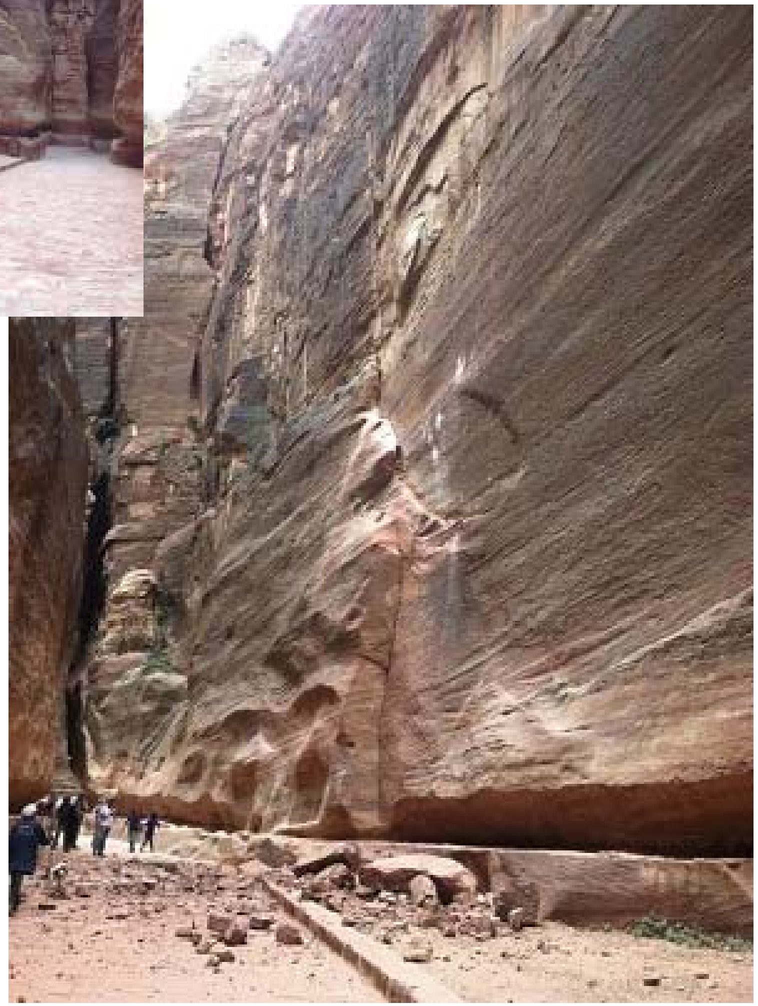
ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale



ISPRA
Istituto Superiore per la Protezione
e la Ricerca Ambientale

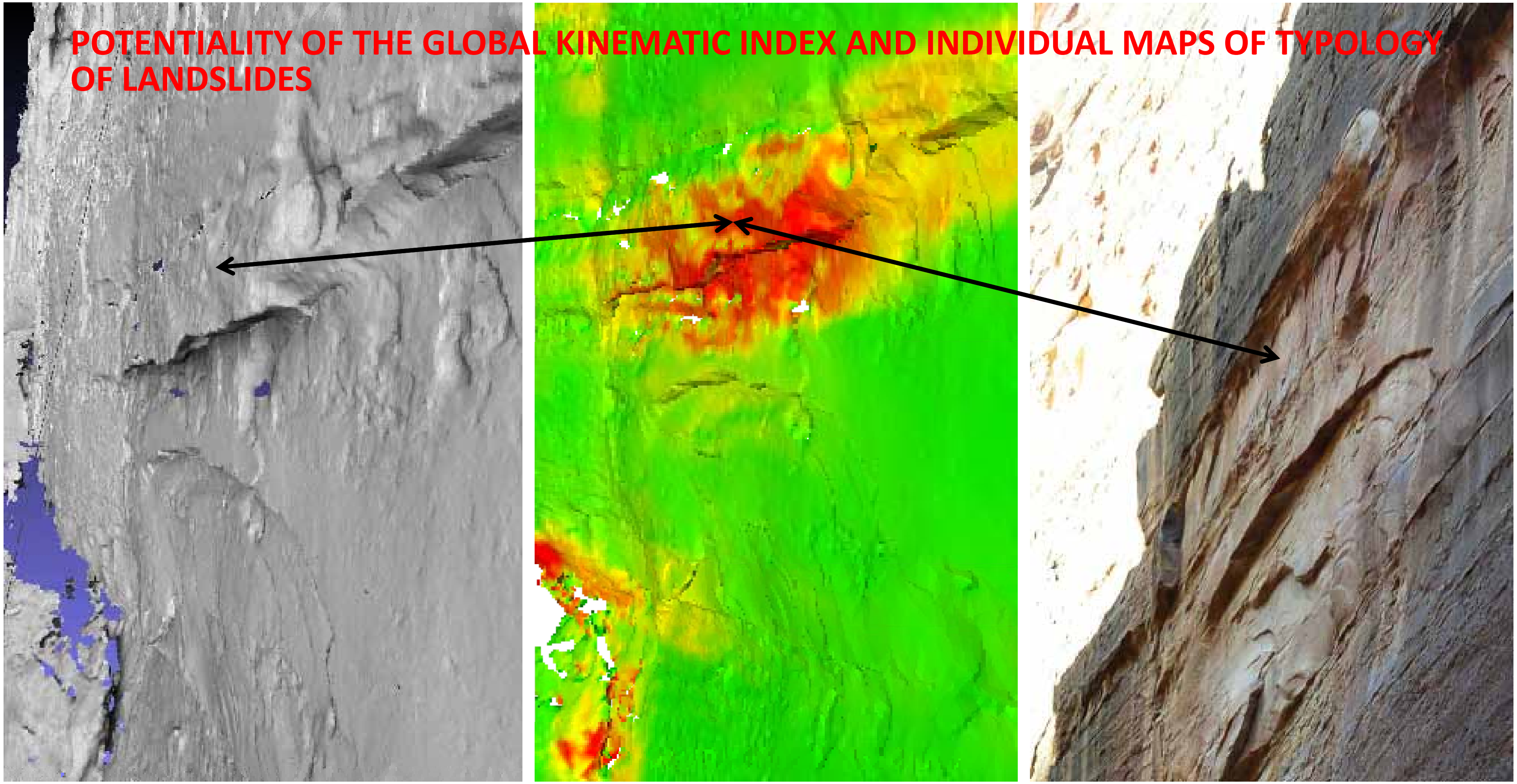
The rockfall of 28th May 2015, in the morning (11,30)

Durante il crollo



Pochi attimi dopo il collasso

POTENTIALITY OF THE GLOBAL KINEMATIC INDEX AND INDIVIDUAL MAPS OF TYPOLOGY OF LANDSLIDES



CONSERVATION SCALING UNSTABLE BLOCKS IN THE SIQ

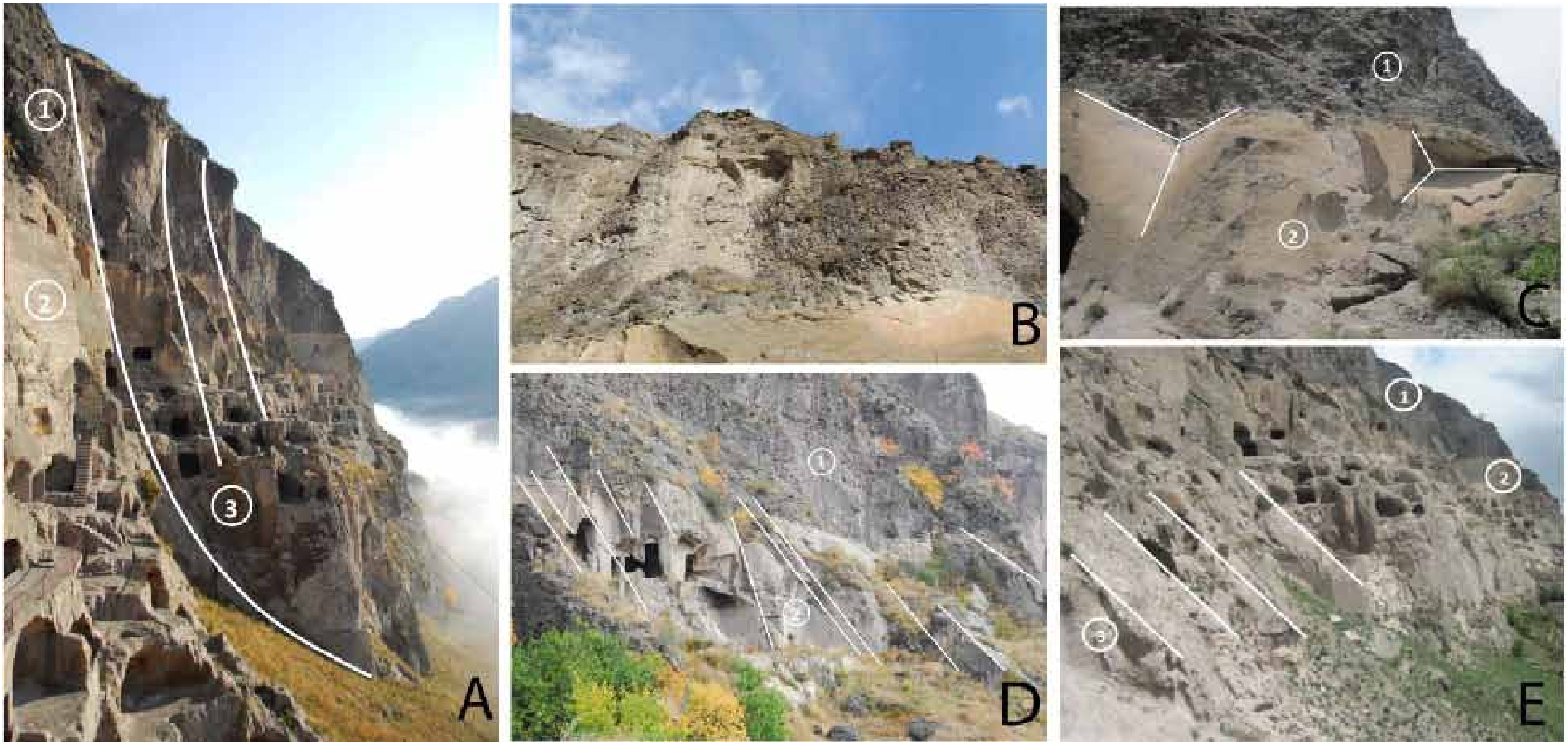
THE VARDZIA MONASTRY (GEORGIA)

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

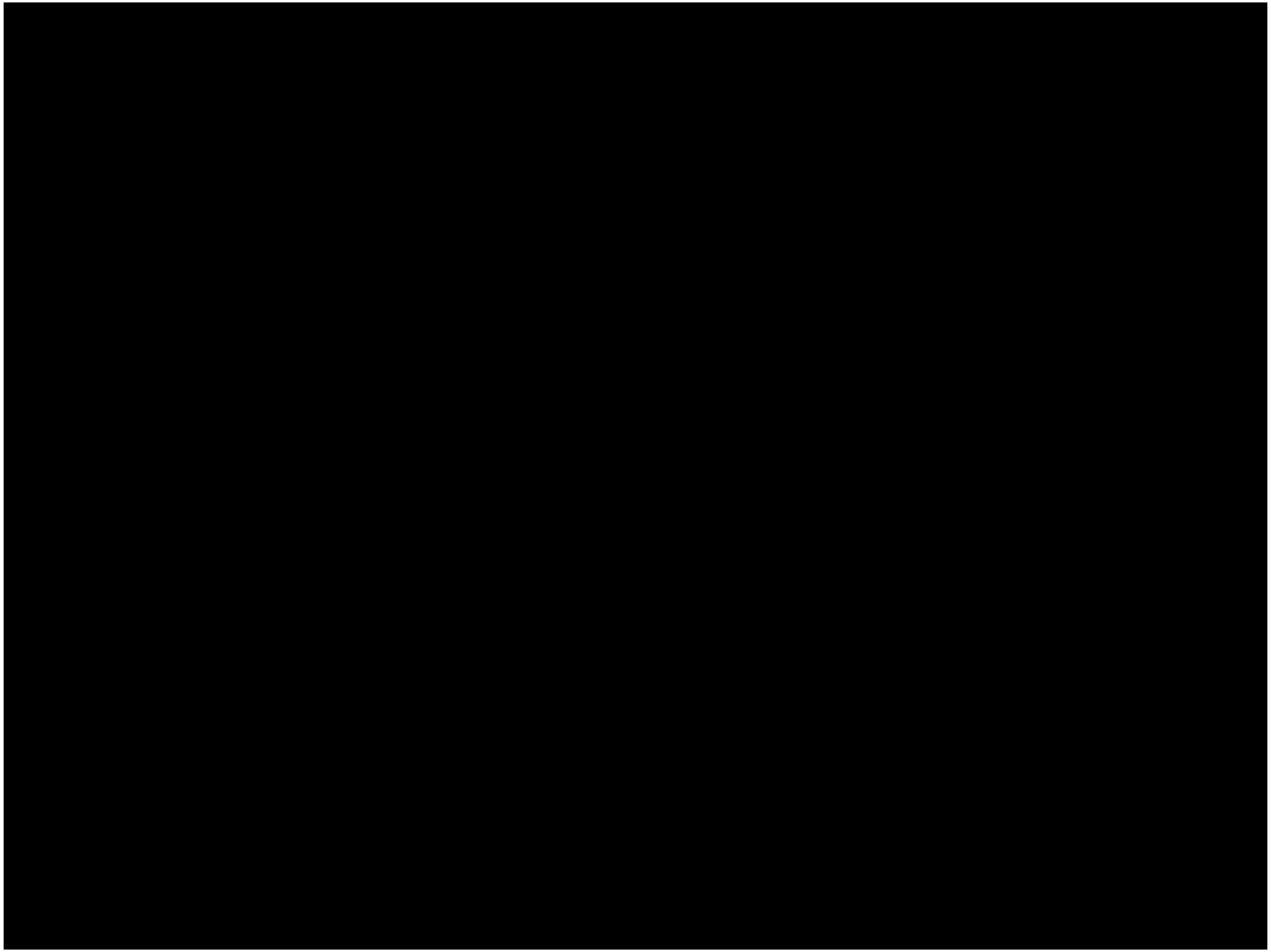
A BRIEF HISTORY

- THE ROCK-CUT CITY OF VARDZIA IS A CAVE MONASTERY SITE IN SOUTH WESTERN GEORGIA, EXCAVATED FROM THE SLOPES OF THE ERUSHETI MOUNTAIN ON THE LEFT BANK OF THE MTKHVARI RIVER. THE MAIN PERIOD OF CONSTRUCTION WAS THE SECOND HALF OF THE TWELFTH CENTURY.
- THE CAVES STRETCH ALONG THE CLIFF FOR SOME 800 M AND UP TO 50 M WITHIN THE ROCKY WALL . THE MONASTERY CONSISTS OF MORE THAN 600 HIDDEN ROOMS SPREAD OVER 13 FLOORS.

VARDZIA MAJOR PROBLEMS



VARDZIA MAJOR PROBLEMS



Sistemi di monitoraggio GBR (Ground Base Radar):

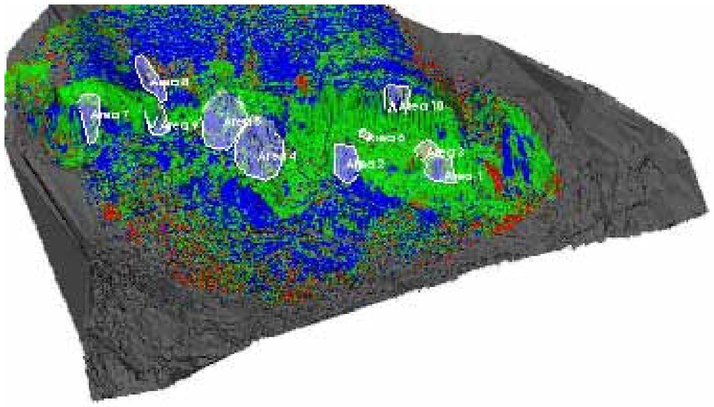
GBR (Ground Base Radar) monitoring system :

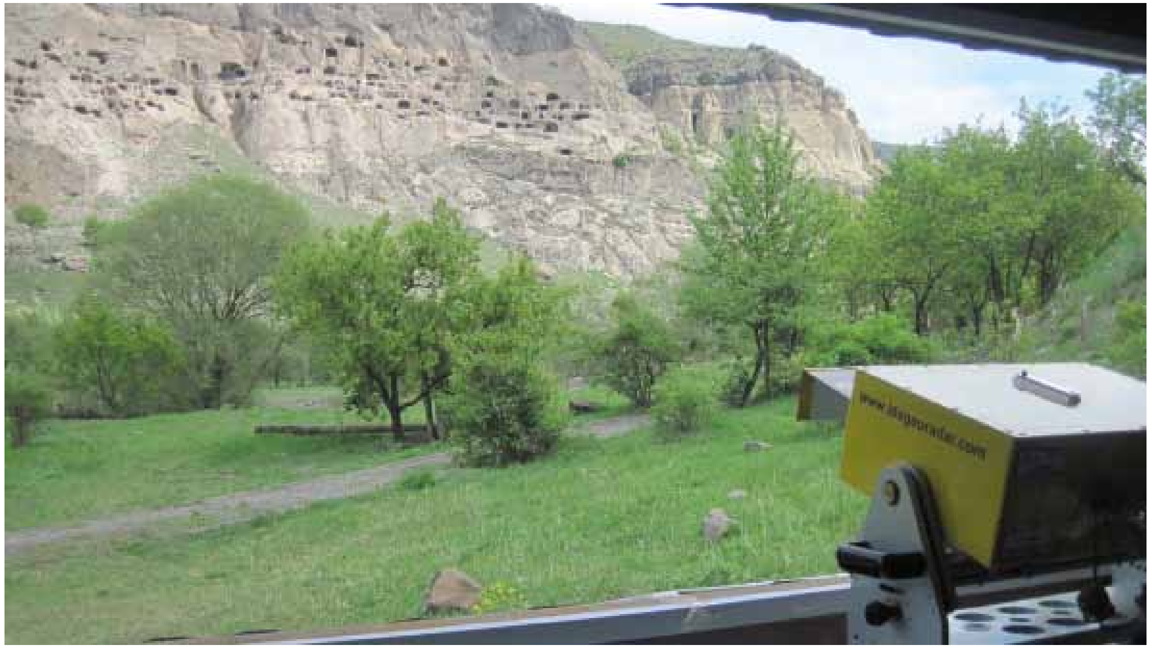
SAR interferometry techniques in real time Displacements control along structures and slope.

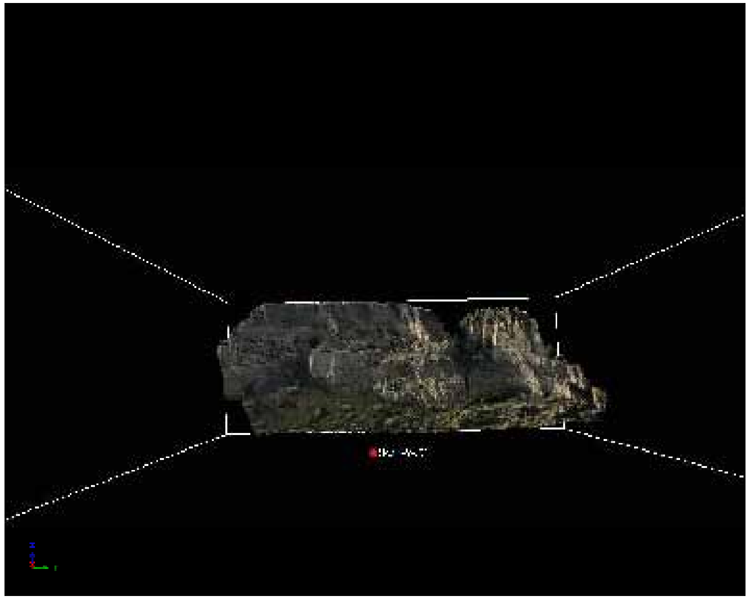
Fields of application:

Long distance measurements (≈ 1000 m) safety condition, several thousands of points every five minute. Map of velocity and displacements.

The initial costs are high but is perfect for big area and different types of phenomena (intensity, velocity, magnitude, severity). The equipments could be transported and reused in different sites.

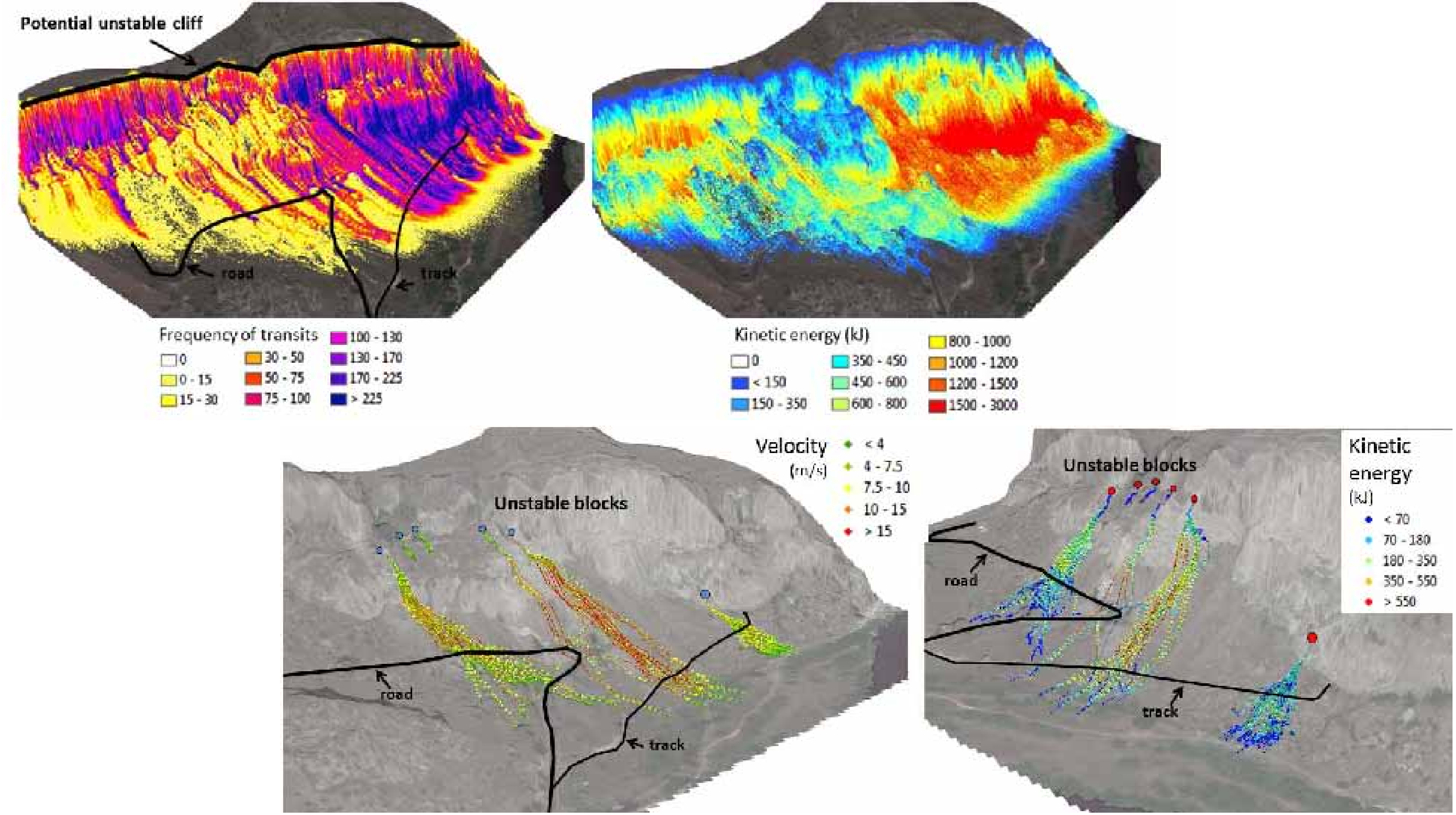






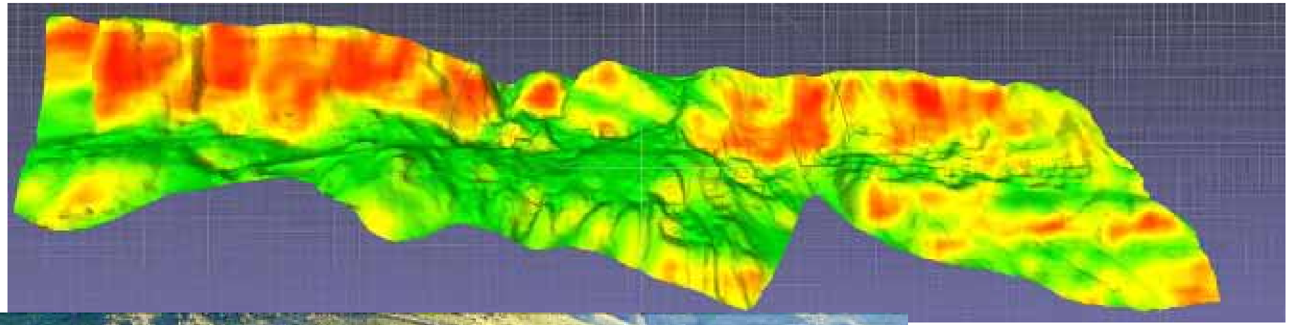
SAFETY OF TOURISTS

- TO INVESTIGATE THE PROPAGATION OF BLOCKS FALLING ALONG THE SLOPE, AND THE POTENTIAL VISITORS IMPACT, A SET OF ROCKFALL SIMULATIONS WAS PERFORMED BY MEANS OF THE 3D NUMERICAL MODEL **HY-STONE**. THE CODE ALLOWS TO SIMULATE THE MOTION OF NON-INTERACTING ROCKY BLOCKS IN A THREE-DIMENSIONAL FRAMEWORK. IT IS BASED ON A HYBRID (MIXED KINEMATIC–DYNAMIC) ALGORITHM WITH DIFFERENT DAMPING RELATIONSHIPS AVAILABLE TO SIMULATE ENERGY LOSS AT IMPACT OR BY ROLLING.

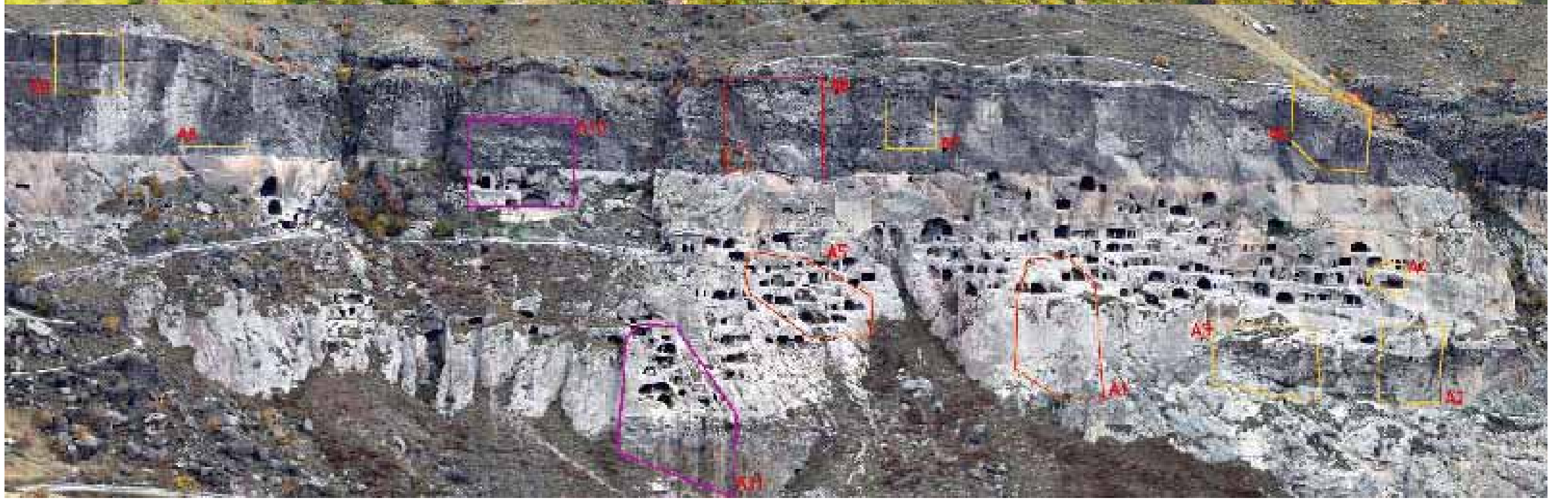


Results of potential future scenarios showing a) the number of blocks passing through each grid cell and b) the maximum kinetic energy of blocks passing for each cell: (s1) - rockfalls from rocky cliffs with slope gradient steeper than 50°.

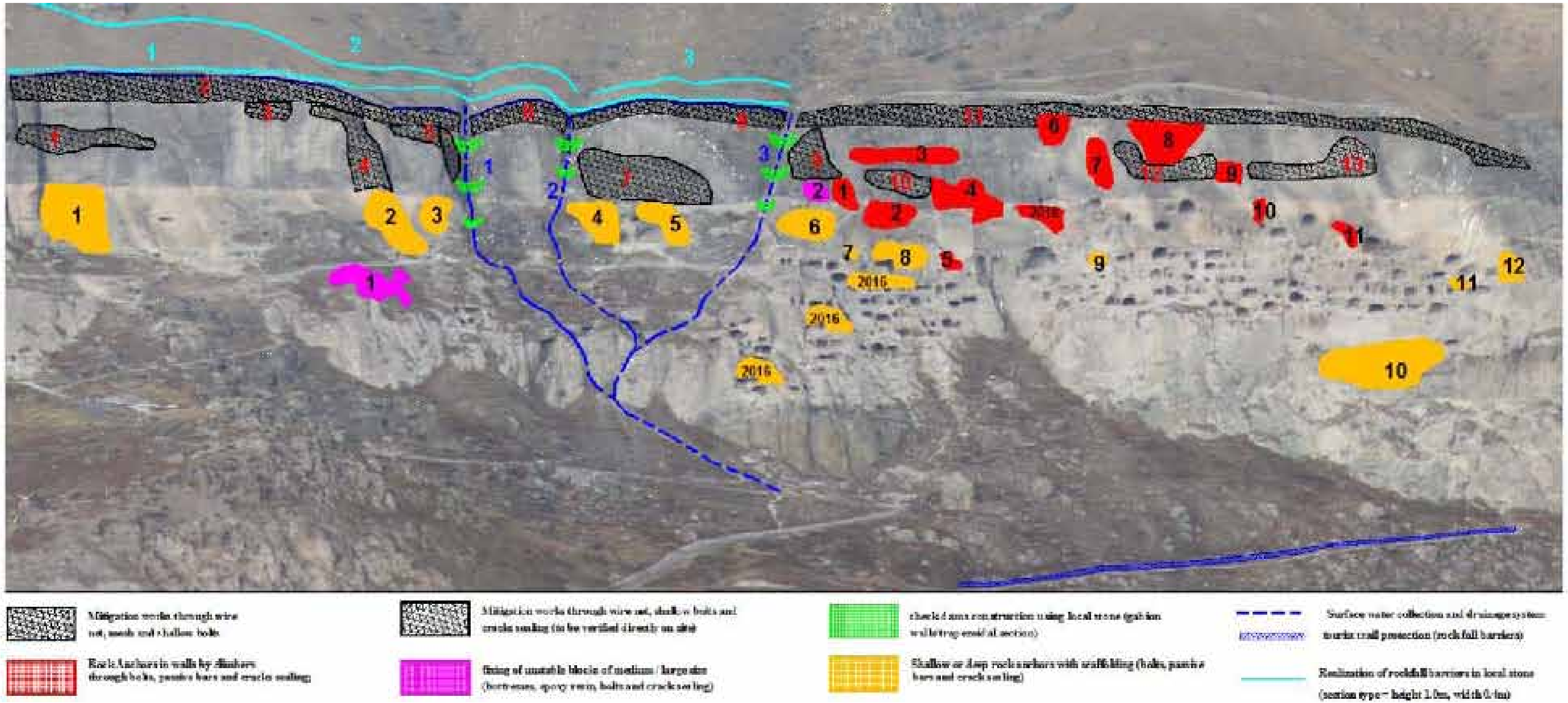
Global Kinematic Index



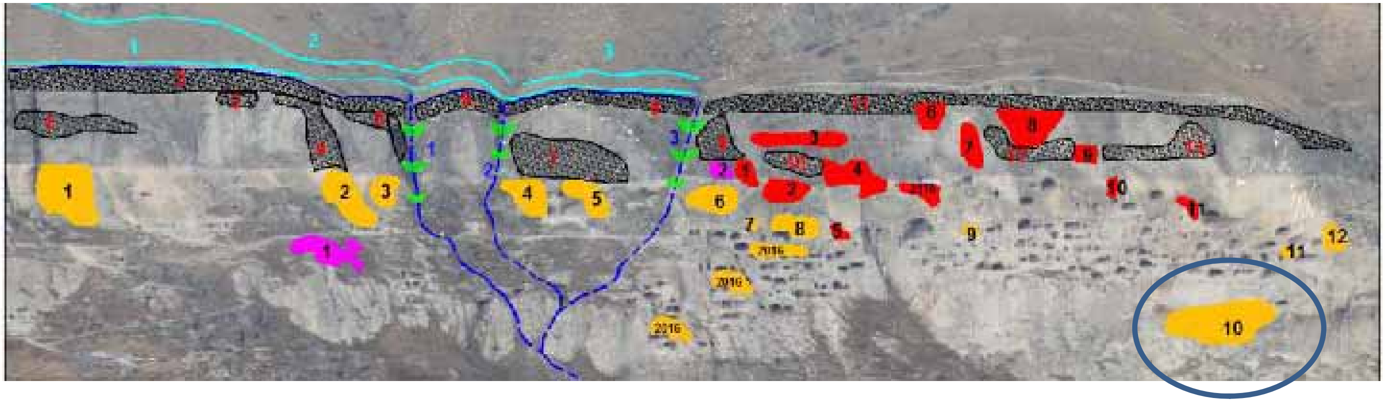
Unstable areas and fractures condition detailed maps



Unstable maps from the displacements maps obtained after two years of GBR monitoring

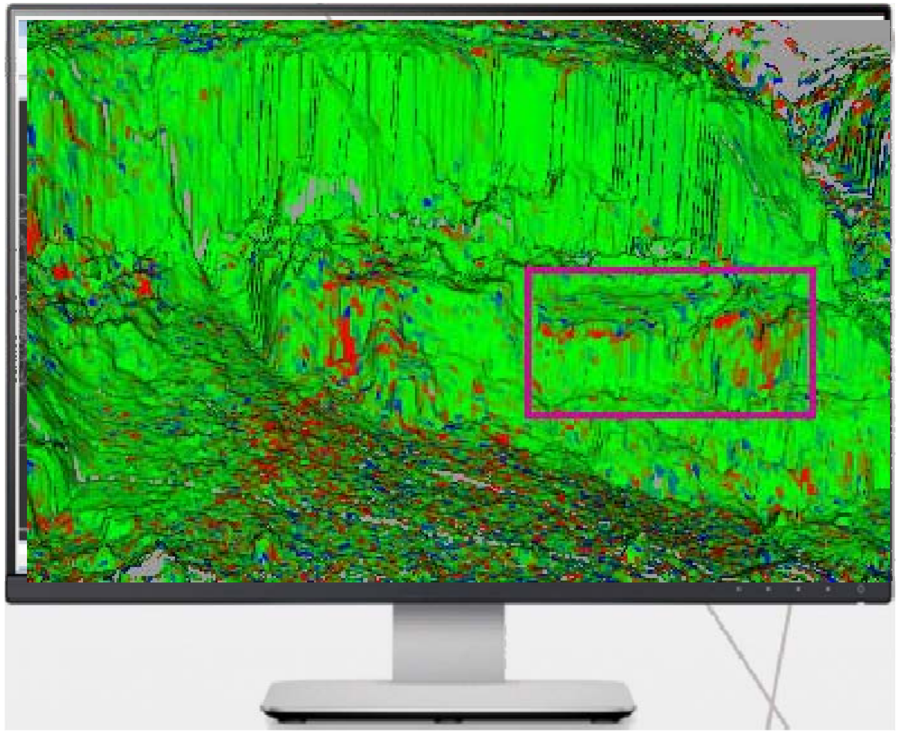

2016
Mitigation works through wire net, mesh and shallow bolts
Mitigation works through wire net, shallow bolts and cracks sealing (to be verified directly on site)
check dams construction using local stone (gabion wall trapezoidal section)
Surface water collection and drainage system
tourist trail protection (rock fall barriers)
Rock Anchors in walls by climbers through bolts, passive bars and cracks sealing
fixing of unstable blocks of medium / large size (buttresses, epoxy resin, bolts and crack sealing)
Shallow or deep rock anchors with scaffolding (bolts, passive bars and crack sealing)
Realization of rockfall barriers in local stone (section type – height 1.0m, width 0.4m)

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

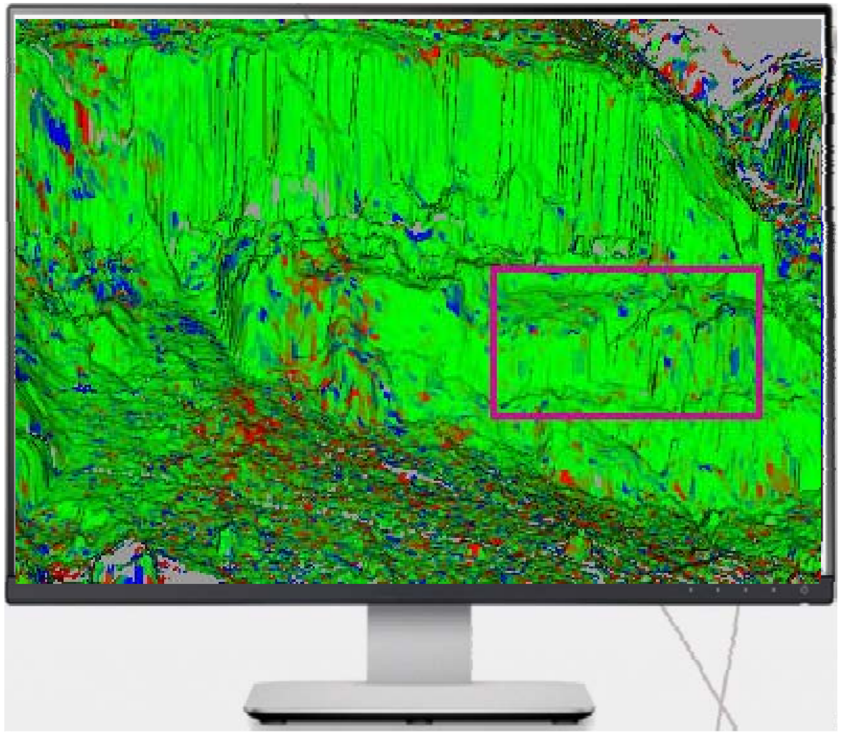


MONITORING OF ONGOING ACTIVITIES

BEFORE CONSOLIDATION



AFTER CONSOLIDATION



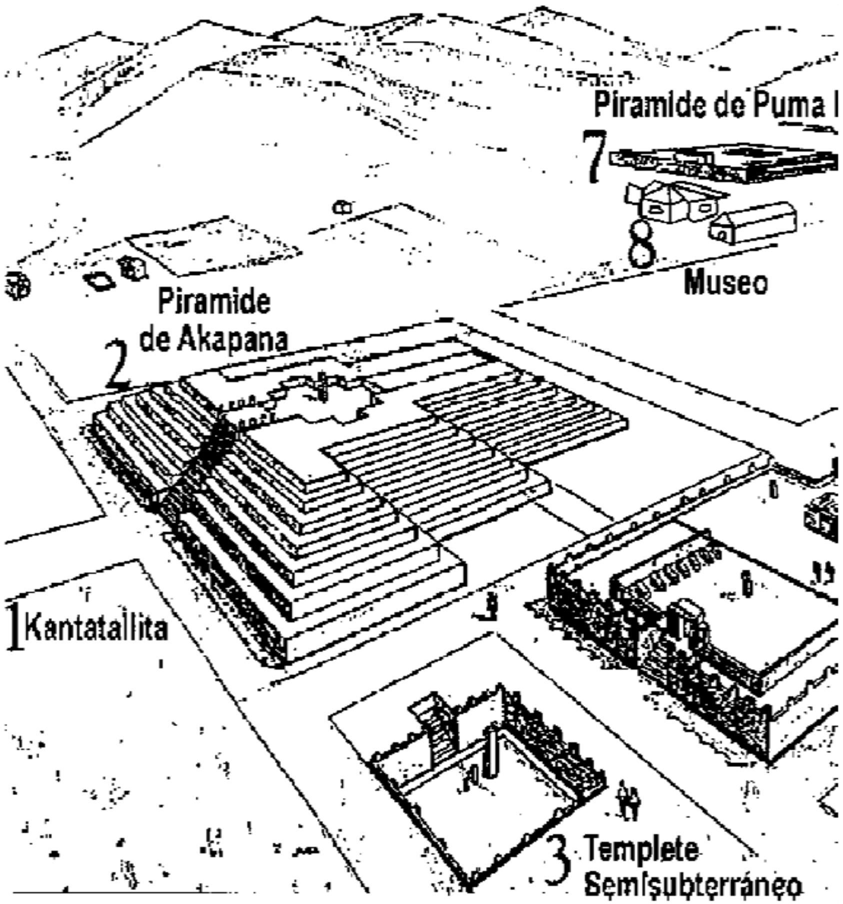
ISPRA
Istituto Superiore per la Protezione
e la Ricerca Ambientale

LOCALITY: AKAPANA (BOLIVIA)

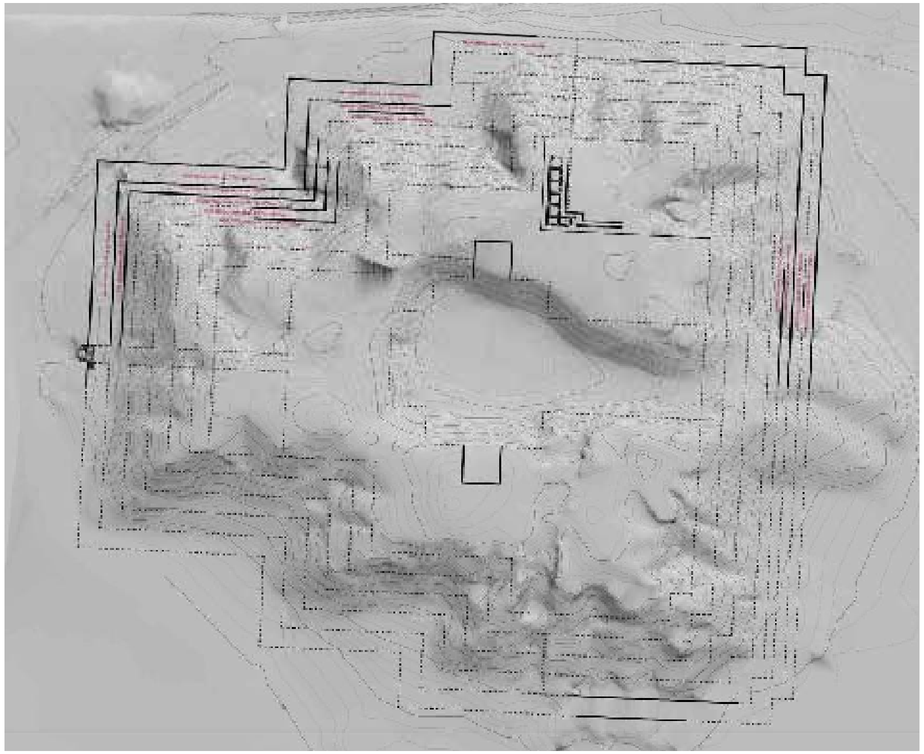
MONUMENT: EARTH PYRAMID

THREATS: SOIL EROSION

THE AKAPANA PYRAMID IN TIWANAKU. THE LARGEST PRE - INCA CEREMONIAL AREA



IV sec - XI sec. A.D.



ISPRA
Istituto Superiore per la Protezione
e la Ricerca Ambientale

BACKGROUND AKAPANA PYRAMID, THE THREATS



BACKGROUND AKAPANA PYRAMID, THE THREATS



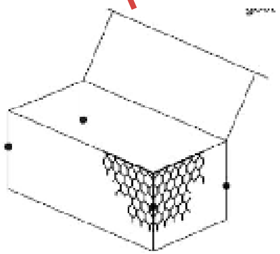


PRELIMINARY CONSERVATION THREE ACTIONS

GULLY and RILL EROSION IN AKAPANA PIRAMID (TIWANAKU, BOLIVIA)

① .

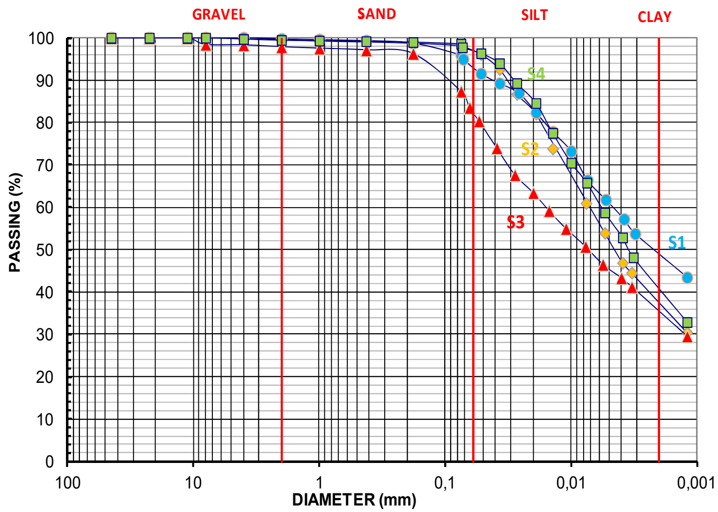
② .



POSSIBLE ALTERNATIVE TO THE USE OF GABIONS WITH THE SAME STATIC/CONSOLIDATION FUNCTION

SURFACE EROSION (PUMA PUNKO IN 2010 AND 2016)

PENKA


GRAVEL
SAND
SILT
CLAY
PASSING (%)
DIAMETER (mm)
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0,1
0,01
0,001
S1
S2
S3
S4

CONCLUSION FROM KNOWLEDGE TO SITE IMPLEMENTATION

(enhance traditional knowledge and sustainable practices)

- Space segment (satellite and remote sensing techniques) as well as on site monitoring applied to CH conservation and mitigation policies are the most advanced, sustainable, low impact techniques for the environmental risk reduction affecting WH properties;
- Calibrate and verifying limits and constrains of SAR techniques through downscaling approach for single WH properties, from static to dynamic assessment will promote the correct use of this advanced techniques;
- The final Target is to support CH site manager to integrate satellite techniques into the management plan and long terms conservation policy in the fields of geo hazards;
- Monitoring system implementation is always a multi disciplinary task and different skills must be involved in order to understand complex dynamics in complex cultural and environmental settlements;

Copernicus
Europe's eyes on Earth

Copernicus for Cultural Heritage Workshop

Contact: daniele.spizzichino@isprambiente.it

Remote Sensing for Cultural Heritage Beyond Europe in Fifth International Conference on Remote Sensing and Geoinformation of Environment, 20-23 March, 2017 - Cyprus

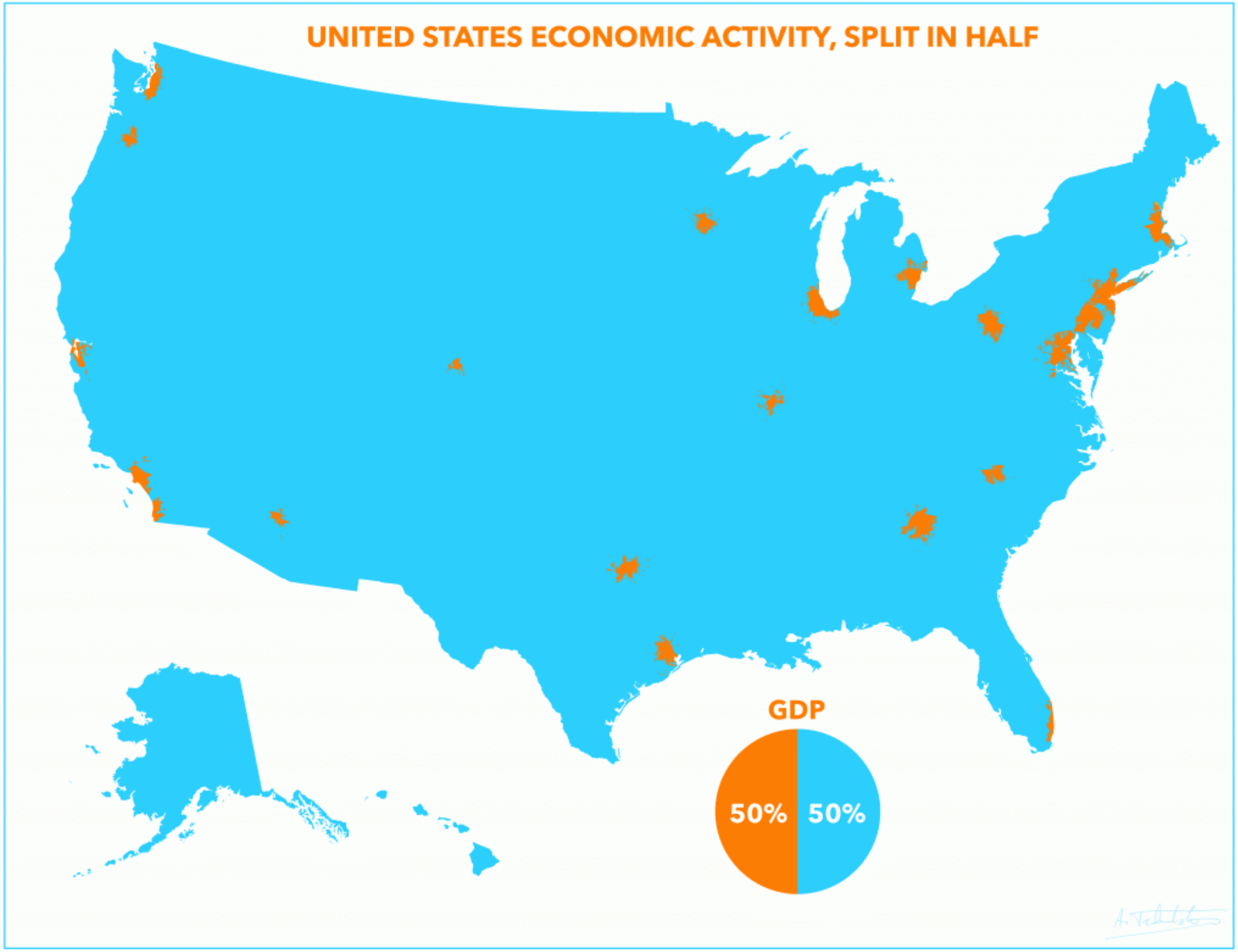
GIS and satellite data for urban sprawl close to archaeological areas in Iran

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

School of Engineering, University of Basilicata
beniamino.murgante@unibas.it
http://oldwww.unibas.it/utenti/murgante/Benny.html
https://unibas-it.academia.edu/BeniaminoMurgante
https://www.researchgate.net/profile/Beniamino_Murgante

SCUOLA DI INGEGNERIA

UNIVERSITÀ DEGLI STUDI DELLA BASILICATA



Cities are the economic heart of America

http://www.washingtonpost.com/blogs/the-fix/wp/2014/02/19/you-might-not-like-big-cities-but-you-need-them/?tid=sm_fb

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

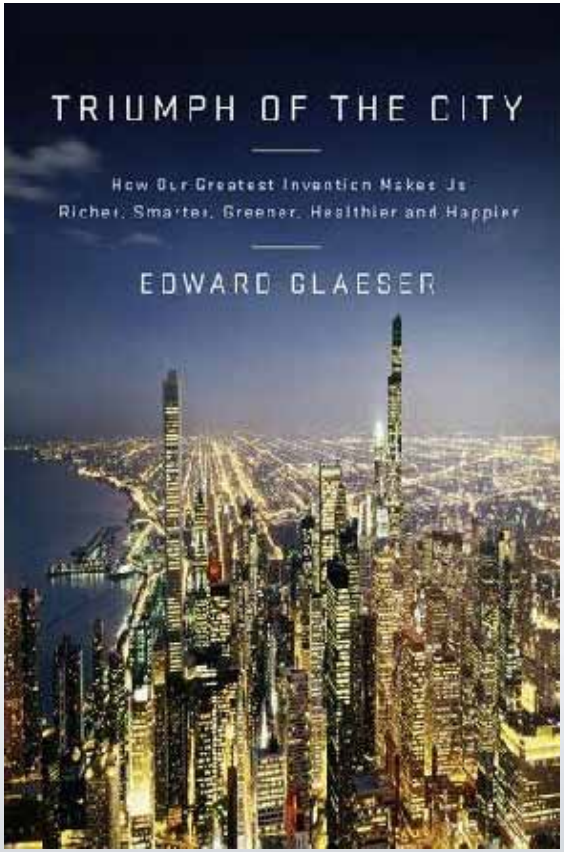
The following table ranks the gross domestic products of nations across the world alongside the gross metro product of the 50 biggest U.S. cities.

Rank	Country or Metro Area	2011 GDP or GMP (In billions)
1	United States	$15,094.0
2	China	$7,298.9
3	Japan	$5,869.1
4	Germany	$3,569.5
5	France	$2,774.4
6	Brazil	$2,476.7
7	United Kingdom	$2,416.4
8	Italy	$2,198.0
9	India	$1,897.9
10	Russia	$1,857.9
11	Canada	$1,739.4
12	Spain	$1,492.5
13	Australia	$1,483.8
14	***New York-Northern New Jersey-Long Island, NY-NJ-PA***	$1,287.7
15	Mexico	$1,154.1
16	South Korea	$1,116.4
17	Indonesia	$846.8
18	Netherlands	$837.8
19	Turkey	$773.1
20	***Los Angeles-Long Beach-Santa Ana, CA***	$755.0
21	Switzerland	$637.7
22	Saudi Arabia	$576.8
23	***Chicago-Joliet-Naperville, IL-IN-WI***	$546.8
24	Sweden	$537.7
25	Poland	$514.3
26	Belgium	$512.6
27	Iran	$499.7
28	Norway	$485.2

http://blogs.wsj.com/economics/2012/07/20/u-s-cities-with-bigger-economies-than-entire-countries/tab/interactive/

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

Cities play a central role for humanity, offering the opportunity to learn from each other face to face.

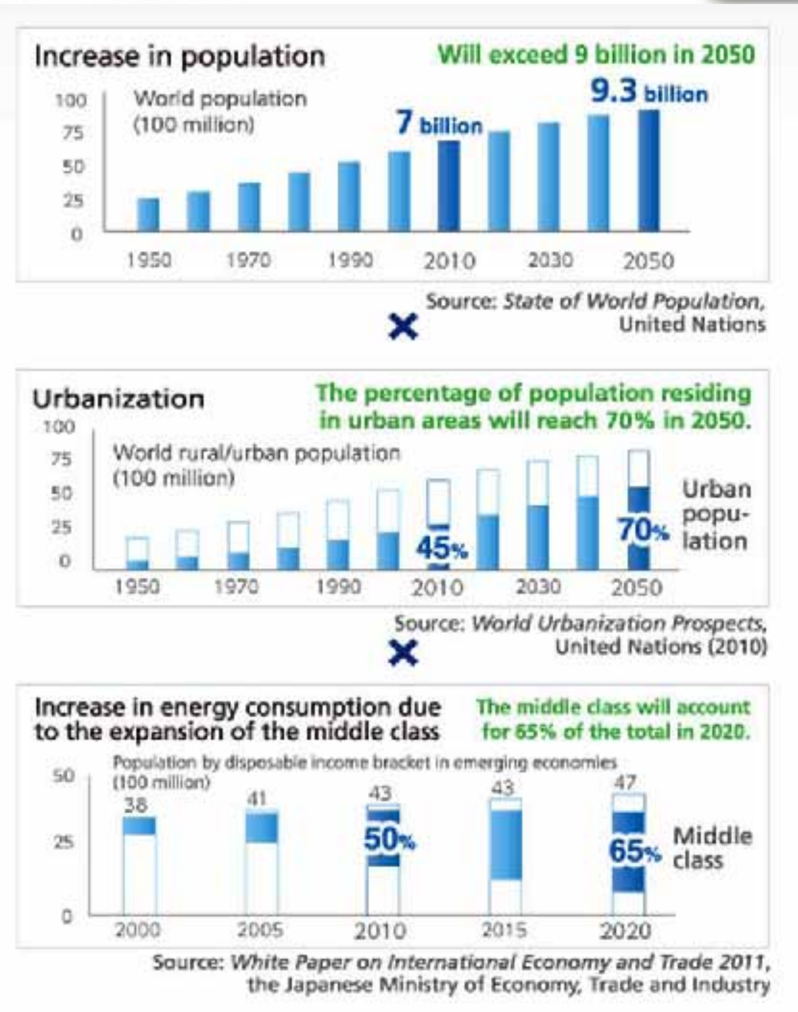


Cities have the capability of providing something for everybody, only because, and only when, they are created by everybody.
(Jane Jacobs)

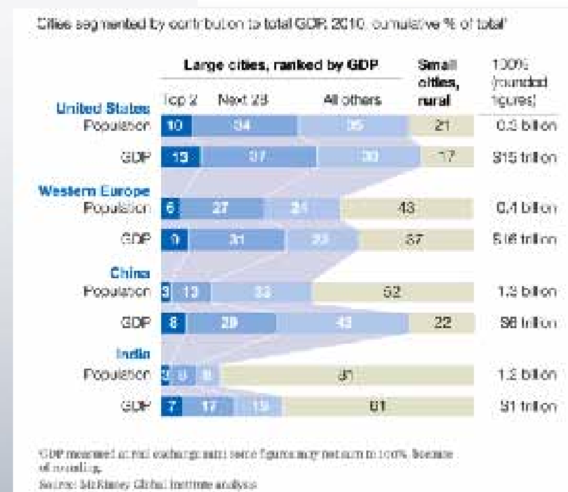
All of us articulate our understanding of the city in different ways, thus implying that cities are kaleidoscopes of plurality, a multiplicity of ideas, perceptions, theories, models.
(Batty, 2013)

GIS and satellite data for urban sprawl close to archaeological areas in Iran

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

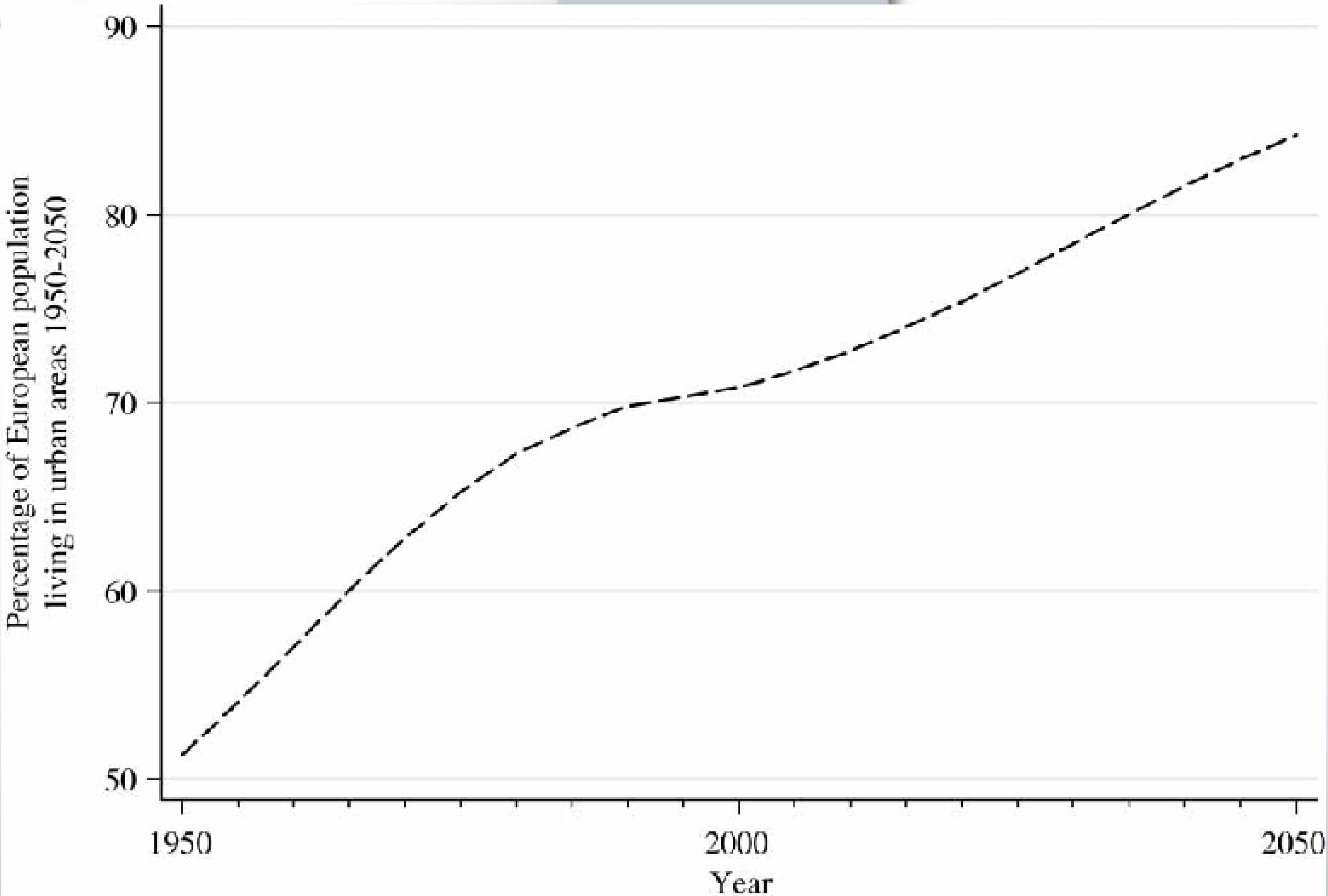


http://www.smartcity-planning.co.jp/en/outline/index.html



Remote Sensing for Cultural Heritage Beyond Europe in Fifth International Conference on Remote Sensing and Geoinformation of Environment, 20-23 March, 2017 - Cyprus

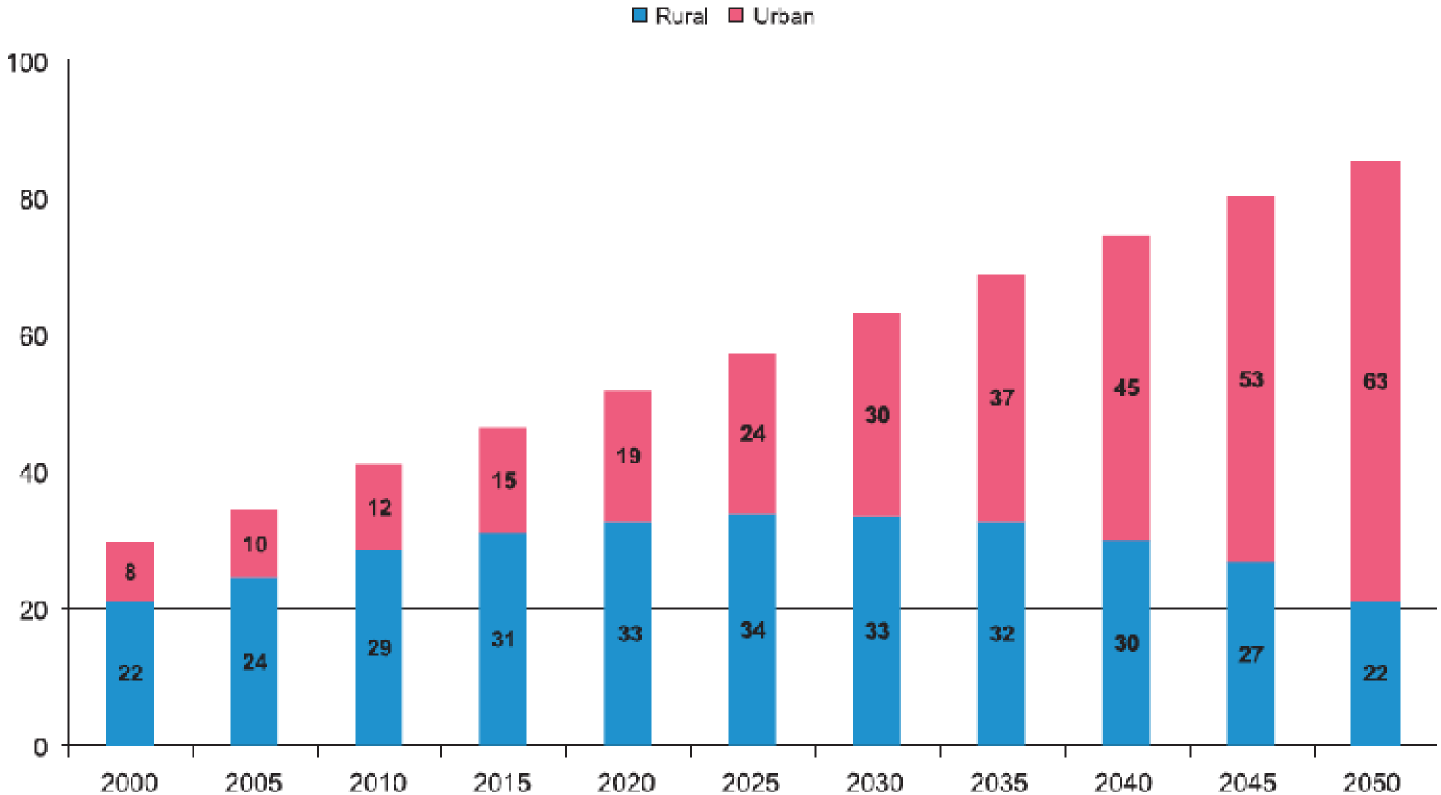
Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei



Percentage of EU population living in urban areas, 1950-2050 (forecast)
Source: UN (2009)

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

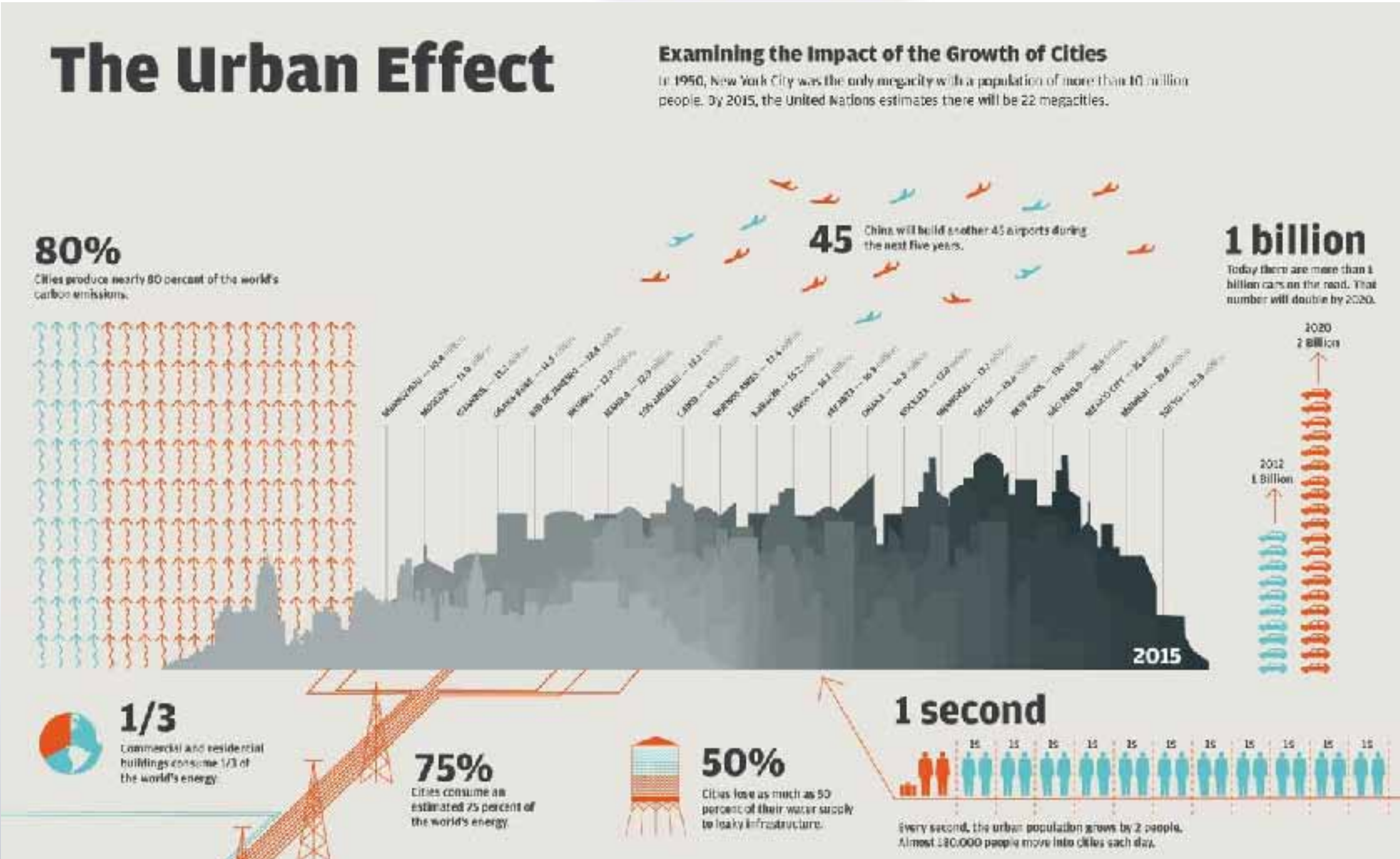
An urban future: Kenya's population growth



*Includes core- and peri-urban residents.
Note: Population growth projections are World Bank computations based on data from KNBS and UN, DESA (Source: World Bank)

GIS and satellite data for urban sprawl close to archaeological areas in Iran

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei



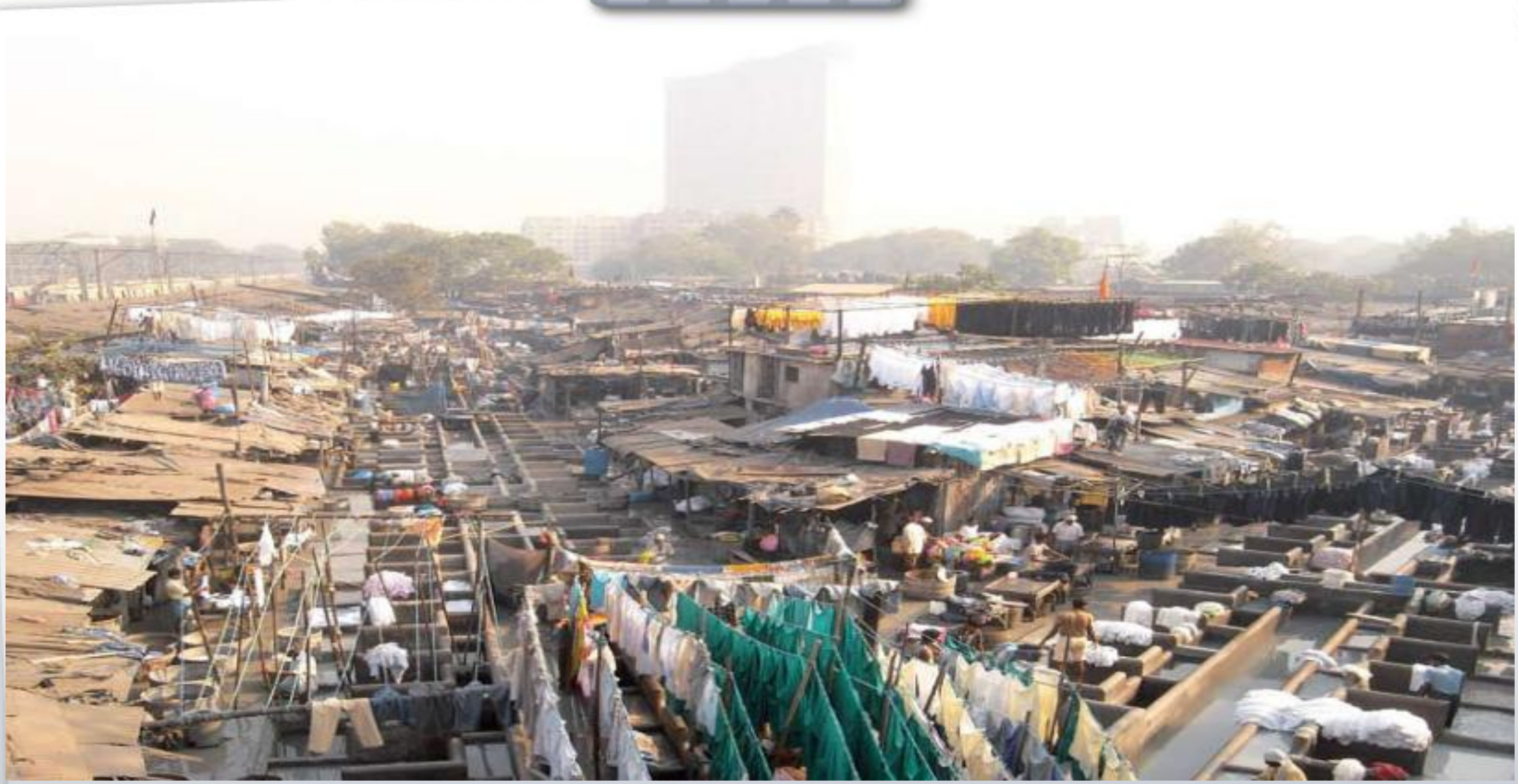
Remote Sensing for Cultural Heritage Beyond Europe in Fifth International Conference on Remote Sensing and Geoinformation of Environment, 20-23 March, 2017 - Cyprus

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

Dharavi: 240-hectare slum in central Mumbai

http://archive.indianexpress.com/news/dharavi-development-project-inches-ahead/1153592/

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei



Informal settlements (South East Asia)

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

Informal settlements: Nairobi

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

Techniques of spatial statistic

Bailey and Gatrell classification (1995)

- Point Pattern Analysis
- Spatially Continuous Analysis
- Area Data Analysis

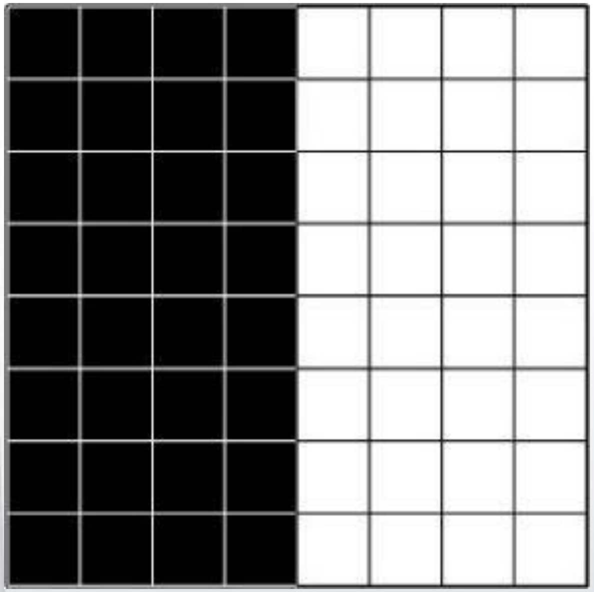
Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

Point Pattern Analysis

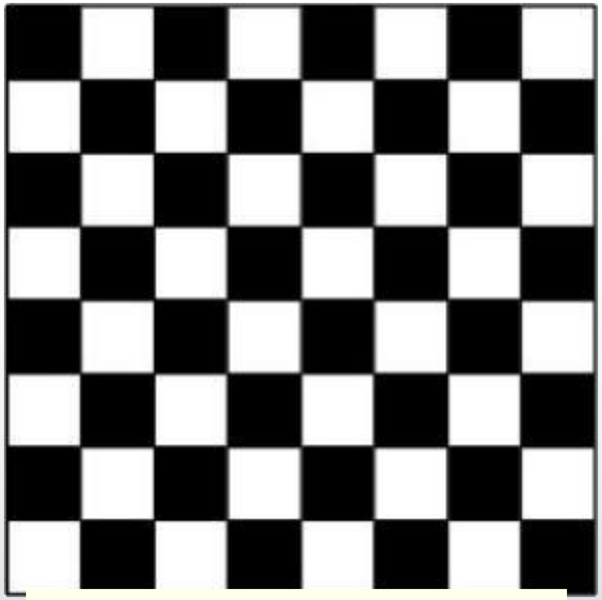
First order effects (Absolute location)

Second order effects (Relative location)

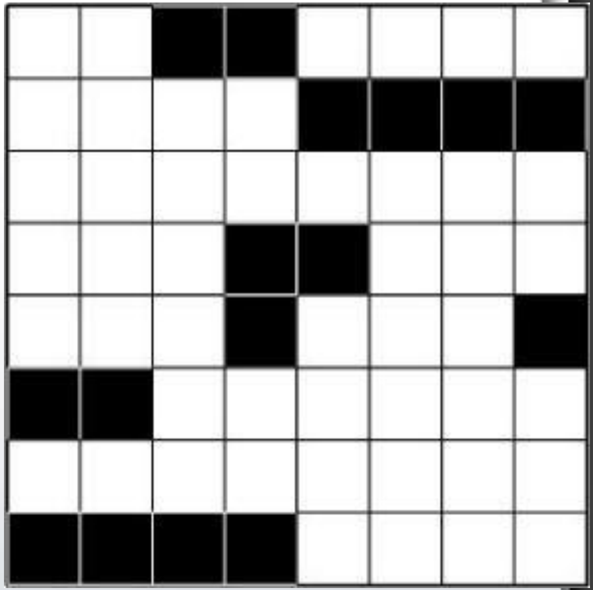
Tobler's First Law of Geography “All things are related, but nearby things are more related than distant things” (1970)



Positive Autocorrelation



Negative Autocorrelation



No Autocorrelation

(O’Sullivan and Unwin, 2002)

Tobler's First Law of Geography "All things are related, but nearby things are more related than distant things" (1970)

$$SAC = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} c_{ij} w_{ij}}{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}}$$

(Goodchild, 1986; Lee and Wong, 2001)

Where:

- n is the number of objects;
- i and j are two objects;
- x_i is the value of object i attribute;
- c_{ij} is a degree of similarity of attributes i and j;
- w_{ij} is a degree of similarity of location i and j;

Geary C Ratio (1954)

if $c_{ij}=(x_i-x_j)^2$

$$c=\frac{(N-1)(\Sigma_i\Sigma_j w_{ij}(x_i-x_j)^2)}{2(\Sigma_i\Sigma_j w_{ij})\Sigma_i(x_i-\overline{x})^2}$$

Moran index (1948)

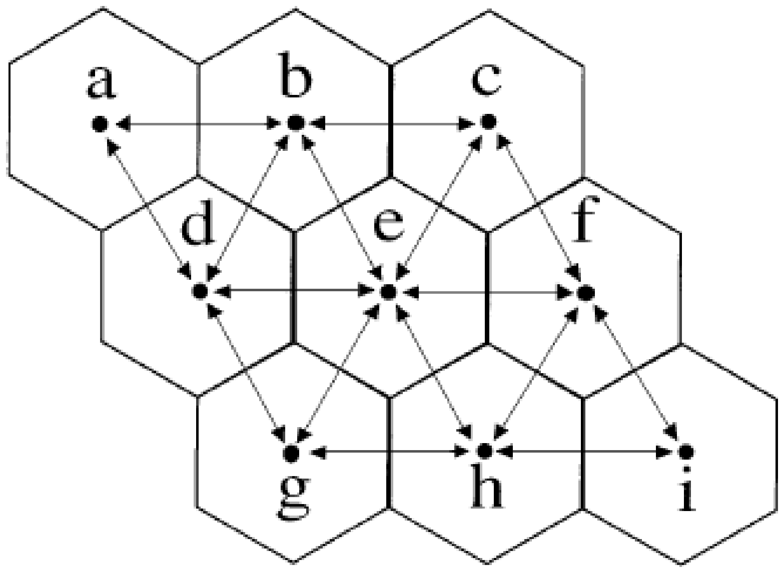
if $c_{ij}=(x_i-\overline{x})(x_j-\overline{x})$

$$I=\frac{N\Sigma_i\Sigma_j w_{ij}(x_i-\overline{x})(x_j-\overline{x})}{(\Sigma_i\Sigma_j w_{ij})\Sigma_i(x_i-\overline{x})^2}$$

$$w_{ij} = \begin{cases} 1 & i, j \text{ adjacent} \\ 0 & \end{cases}$$

$$w_{ij} = 1/d_{ij}$$

$$w_{ij} = 1/d_{ij}$$



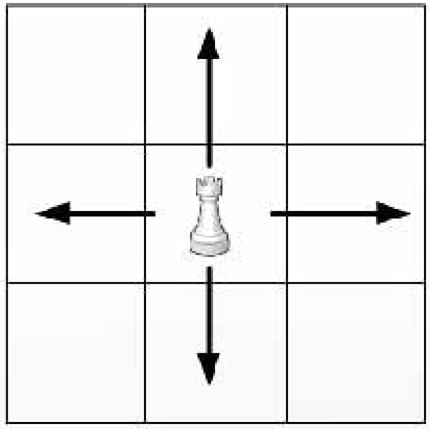
⇔

	a	b	c	d	e	f	g	h	i
a	0	1	0	1	0	0	0	0	0
b	1	0	1	1	1	0	0	0	0
c	0	1	0	0	1	1	0	0	0
d	1	1	0	0	1	0	0	0	0
e	0	1	1	1	0	1	1	1	0
f	0	0	1	0	1	0	0	1	1
g	0	0	0	0	1	0	0	1	0
h	0	0	0	0	1	1	1	0	1
i	0	0	0	0	0	1	0	1	0

Fixed Distance Band

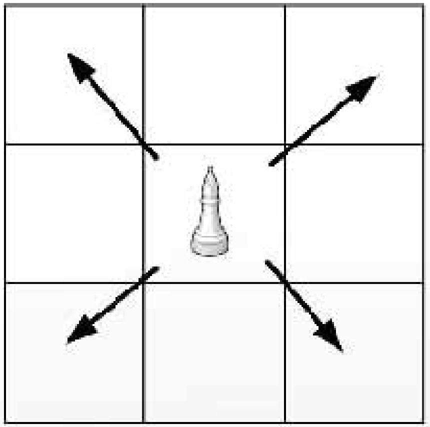
$$w_{ij} = \begin{cases} d_{ij} & d_{ij} < d \\ 0 & d_{ij} > d \end{cases}$$

Spatial weights matrix and the metaphor chess game



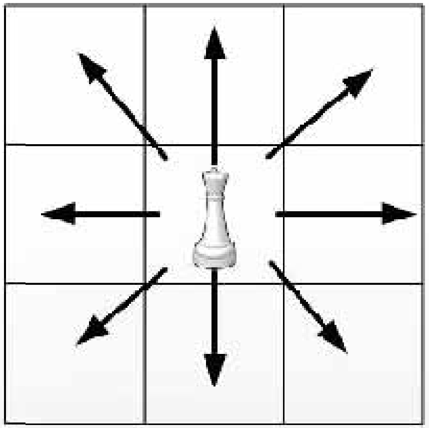
$$\begin{bmatrix} 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \end{bmatrix}$$

Rook



$$\begin{bmatrix} 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Bishop



$$\begin{bmatrix} 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 & 0 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 0 \end{bmatrix}$$

Queen

Local version of Geary Ratio C

$$c_i = \sum_{j=1}^{N} w_{ij} (z_i - z_j)^2$$

G function by Getis and Ord (1992)

$$G_i(d) = \frac{\sum_{i=1}^{n} w_i(d)\, x_i - \bar{x}_i \sum_{i=1}^{n} w_i(d)}{S(i)\sqrt{\left[(N-1)\sum_{i=1}^{n} w_i(d) - \left(\sum_{i=1}^{n} w_i(d)\right)^2\right] \Big/ N-2}}$$

Local Indicator of Spatial Association (Anselin, 1995)

$$I_i = z_i \sum_{j=1}^{N} w_{ij} \cdot z_j$$

$$I_i = \frac{\left(X_i - \bar{X}\right)}{S_X^{\ 2}} \sum_{j=1}^{N} \left(w_{ij}\left(X_j - \bar{X}\right)\right)$$

$$Z_i = \frac{\left(X_i - \bar{X}\right)}{S_X}$$

LISA allows for each statistical unit to assess the similarity of each observation with that of its surroundings.

Five scenarios emerge:

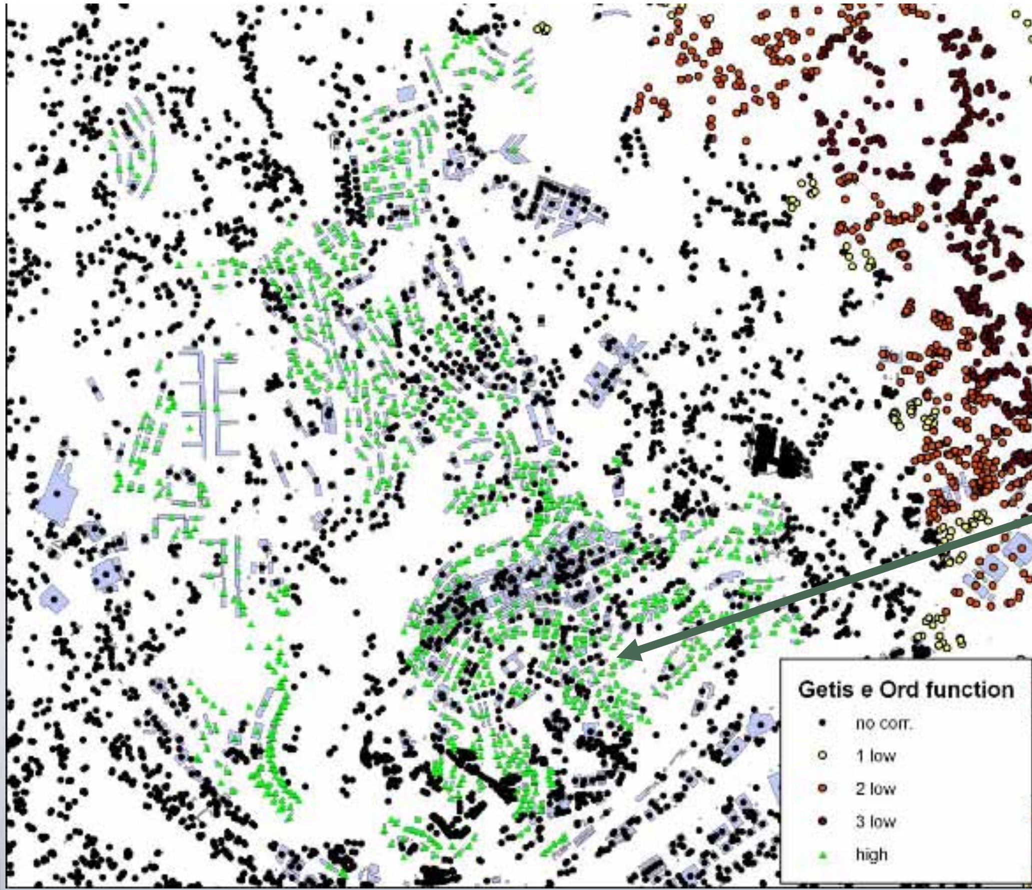
- Locations with high values of the phenomenon and high level of similarity with its surroundings (**high - high**), defined as HOT SPOTS;
- Locations with low values of the phenomenon and high level of similarity with its surroundings (low - low), defined as COLD SPOTS;
- Locations with high values of the phenomenon and low level of similarity with its surroundings (high - low), defined as Potential "Spatial outliers";
- Locations with low values of the phenomenon and low level of similarity with its surroundings (low - high), defined as Potential "Spatial Outliers";
- Location devoid of significant autocorrelations.

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

Murgante B. Danese M. (2011) "**Urban versus Rural: the decrease of agricultural areas and the development of urban zones analyzed with spatial statistics**" International Journal of Agricultural and Environmental Information Systems vol. 2, p. 16-28, IGI Global, doi:10.4018/jaeis.2011070102

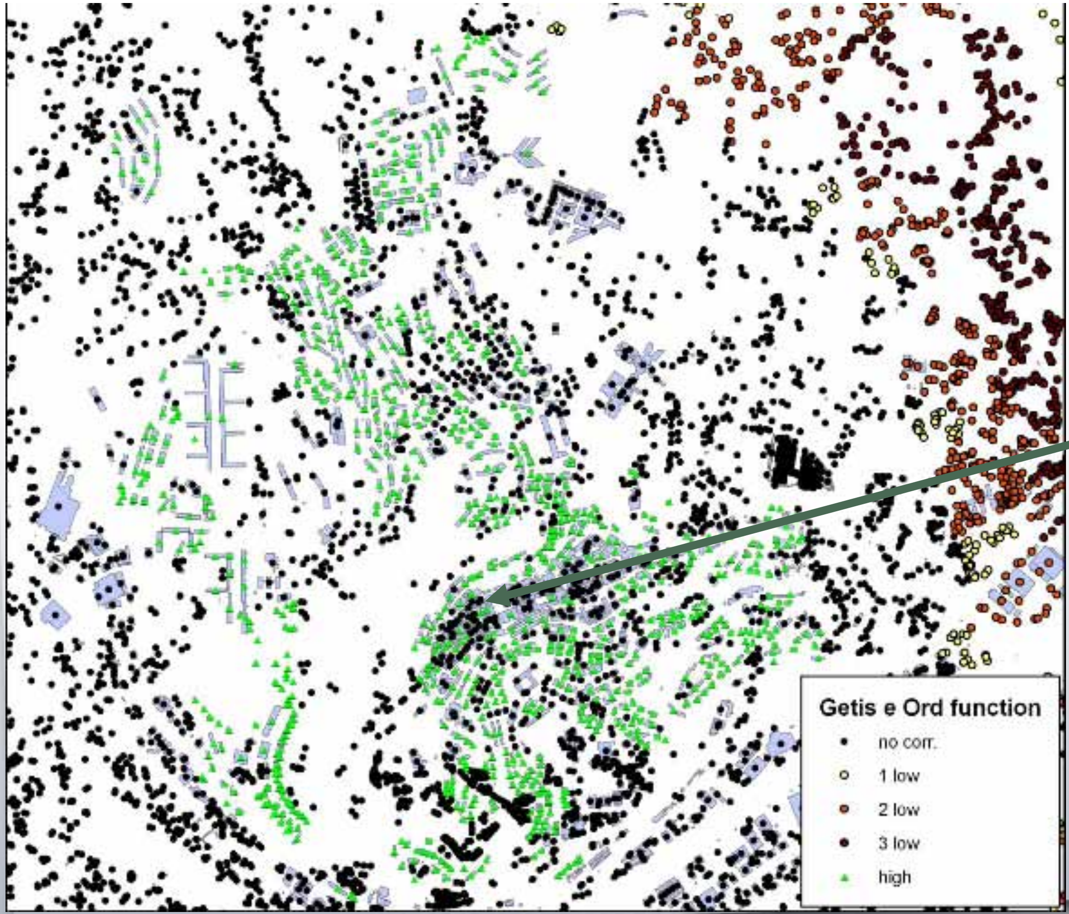
Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

Murgante B. Danese M. (2011) "**Urban versus Rural: the decrease of agricultural areas and the development of urban zones analyzed with spatial statistics**" International Journal of Agricultural and Environmental Information Systems vol. 2, p. 16-28, IGI Global, doi:10.4018/jaeis.2011070102



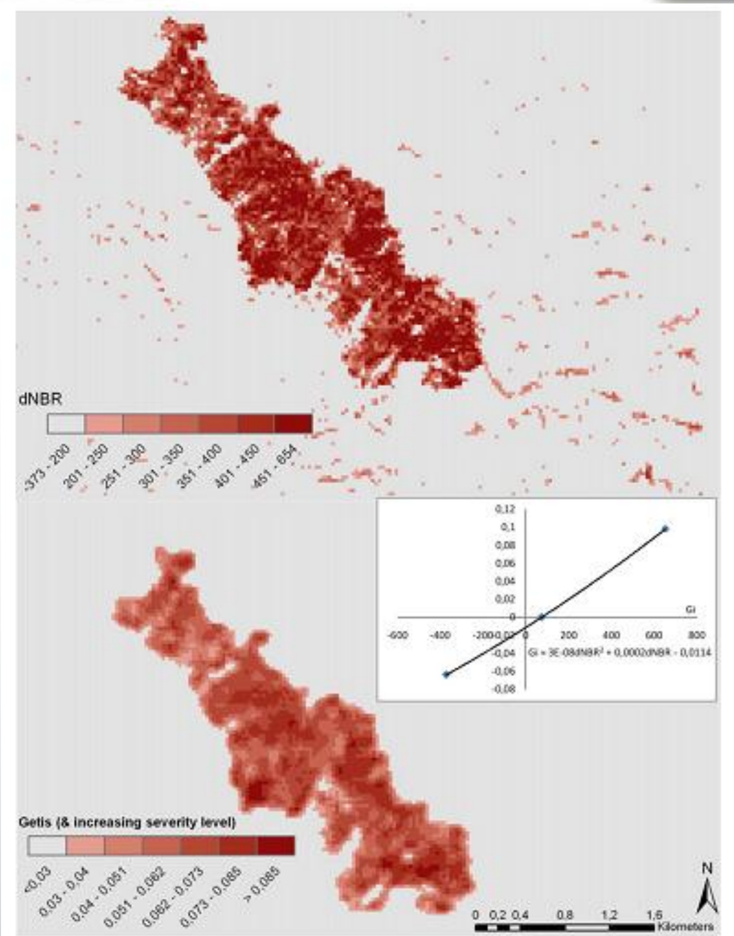
Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

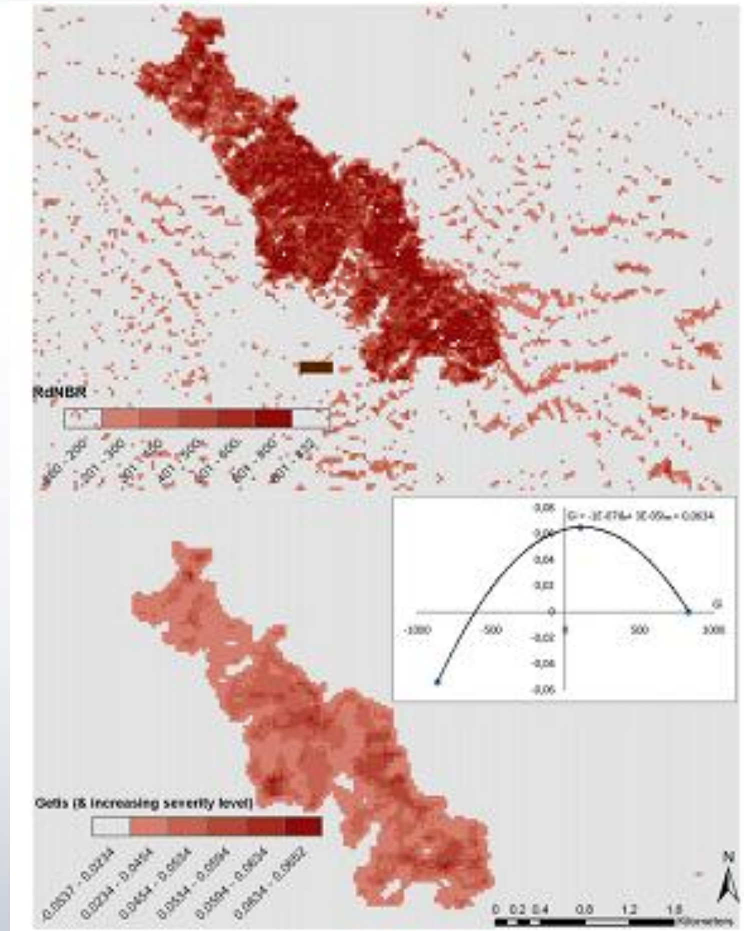
Murgante B. Danese M. (2011) "**Urban versus Rural: the decrease of agricultural areas and the development of urban zones analyzed with spatial statistics**" International Journal of Agricultural and Environmental Information Systems vol. 2, p. 16-28, IGI Global, doi:10.4018/jaeis.2011070102



GIS and satellite data for urban sprawl close to archaeological areas in Iran

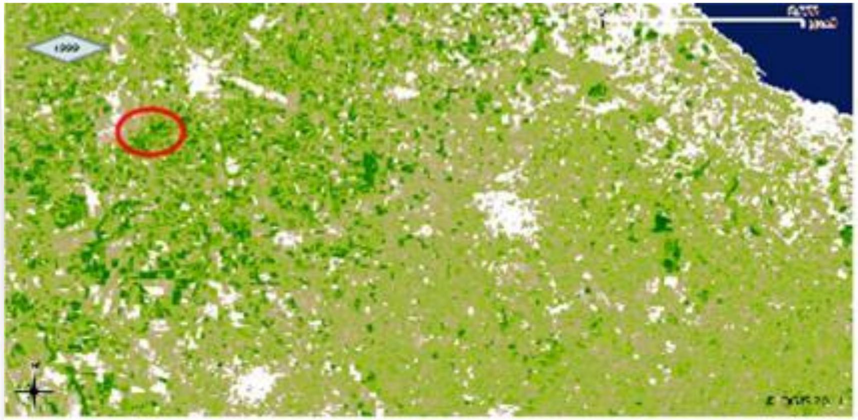
Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

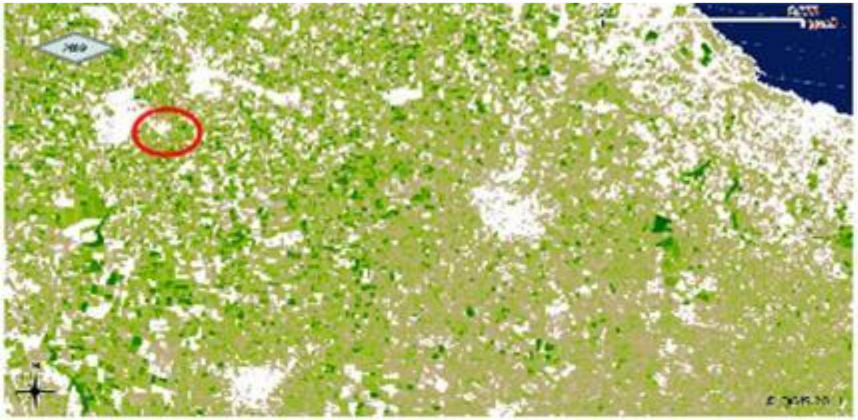


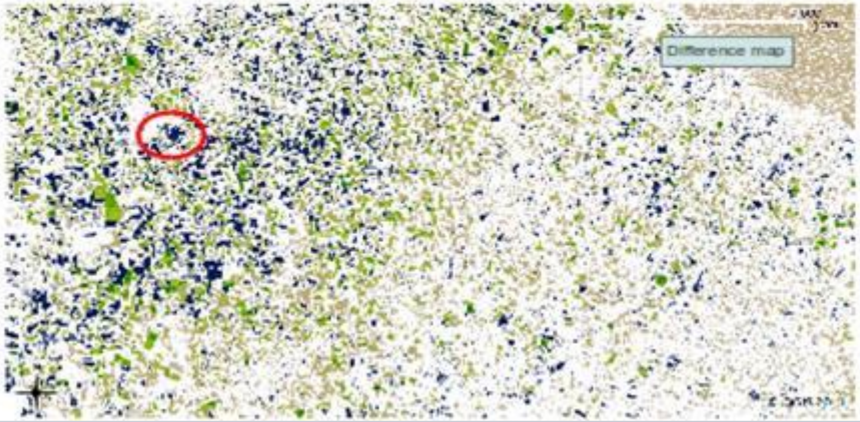


Lanorte, A., Danese M., Lasaponara R., Murgante B. (2011) "**Multiscale mapping of burn area and severity using multisensor satellite data and spatial autocorrelation analysis**" International Journal of Applied Earth Observation and Geoinformation

Change Detection 1999 – 2009 NDVI





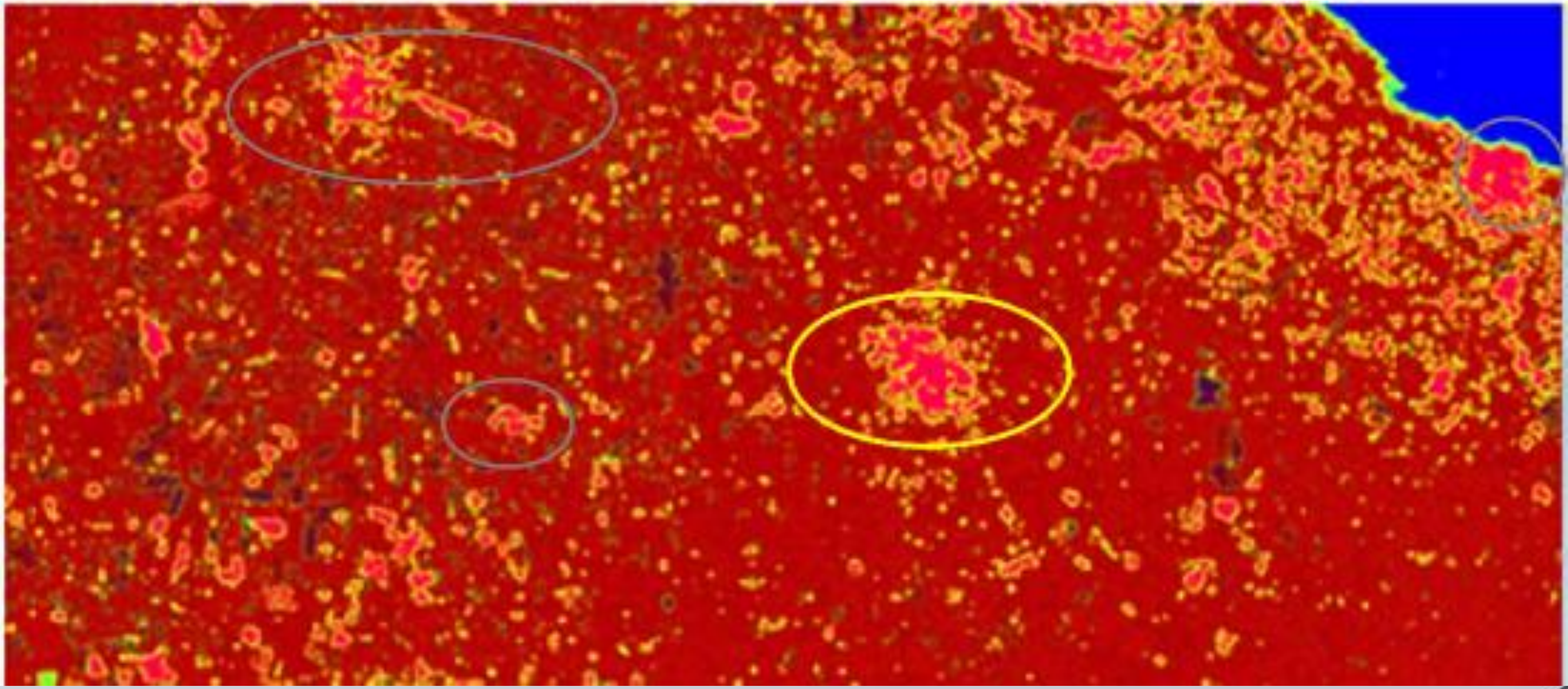


$$\mathrm{NDVI} = \frac{R_{NIR} - R_{RED}}{R_{NIR} + R_{RED}}$$

Nolè, G., Lasaponara, R., Lanorte A., Murgante, B., (2014) " **Quantifying Urban Sprawl with Spatial Autocorrelation Techniques using Multi-Temporal Satellite Data"** International Journal of Agricultural and Environmental Information Systems, 5(2), 20-38, April-June 2014 IGI Global 10.4018/IJAEIS.2014040102

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

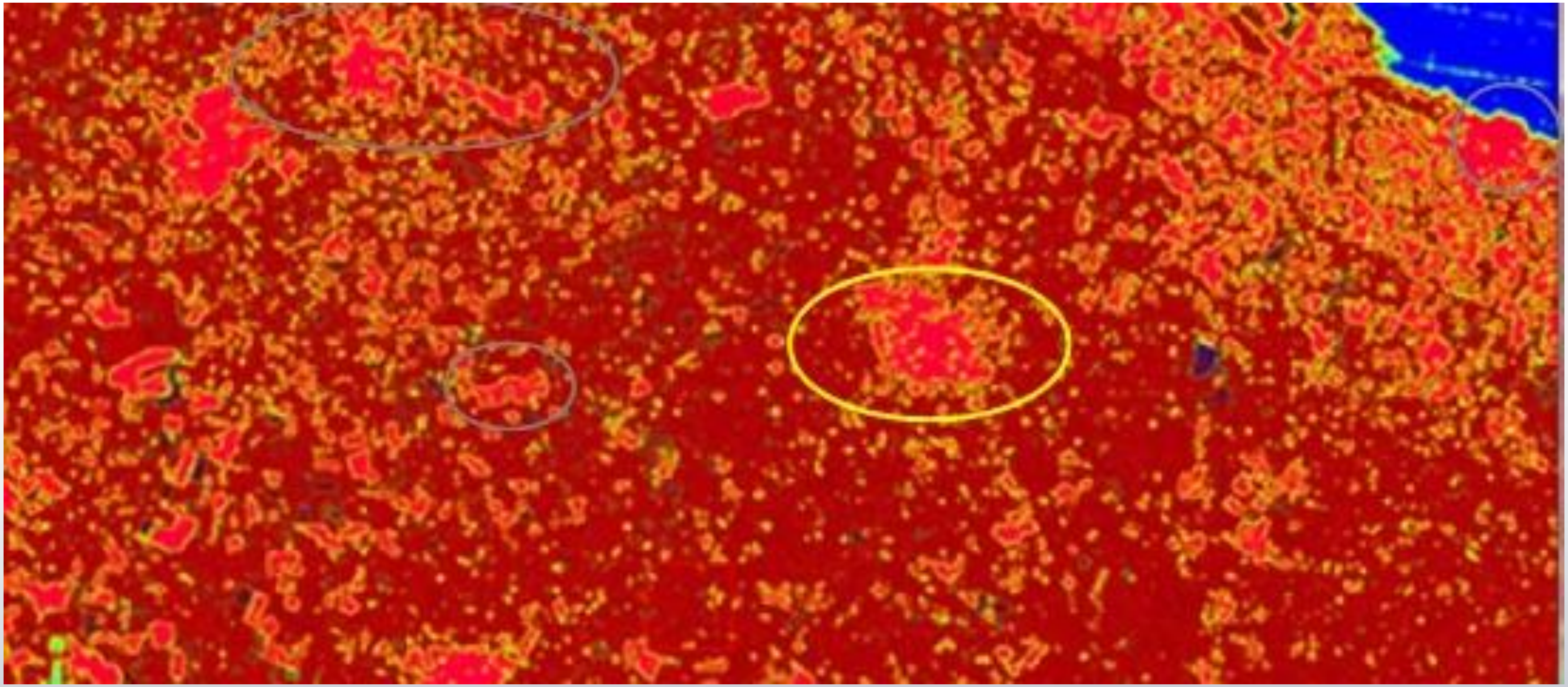
G function by Getis and Ord



Nolè, G., Lasaponara, R., Lanorte A., Murgante, B., (2014) " **Quantifying Urban Sprawl with Spatial Autocorrelation Techniques using Multi-Temporal Satellite Data"** International Journal of Agricultural and Environmental Information Systems, 5(2), 20-38, April-June 2014 IGI Global 10.4018/IJAEIS.2014040102

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

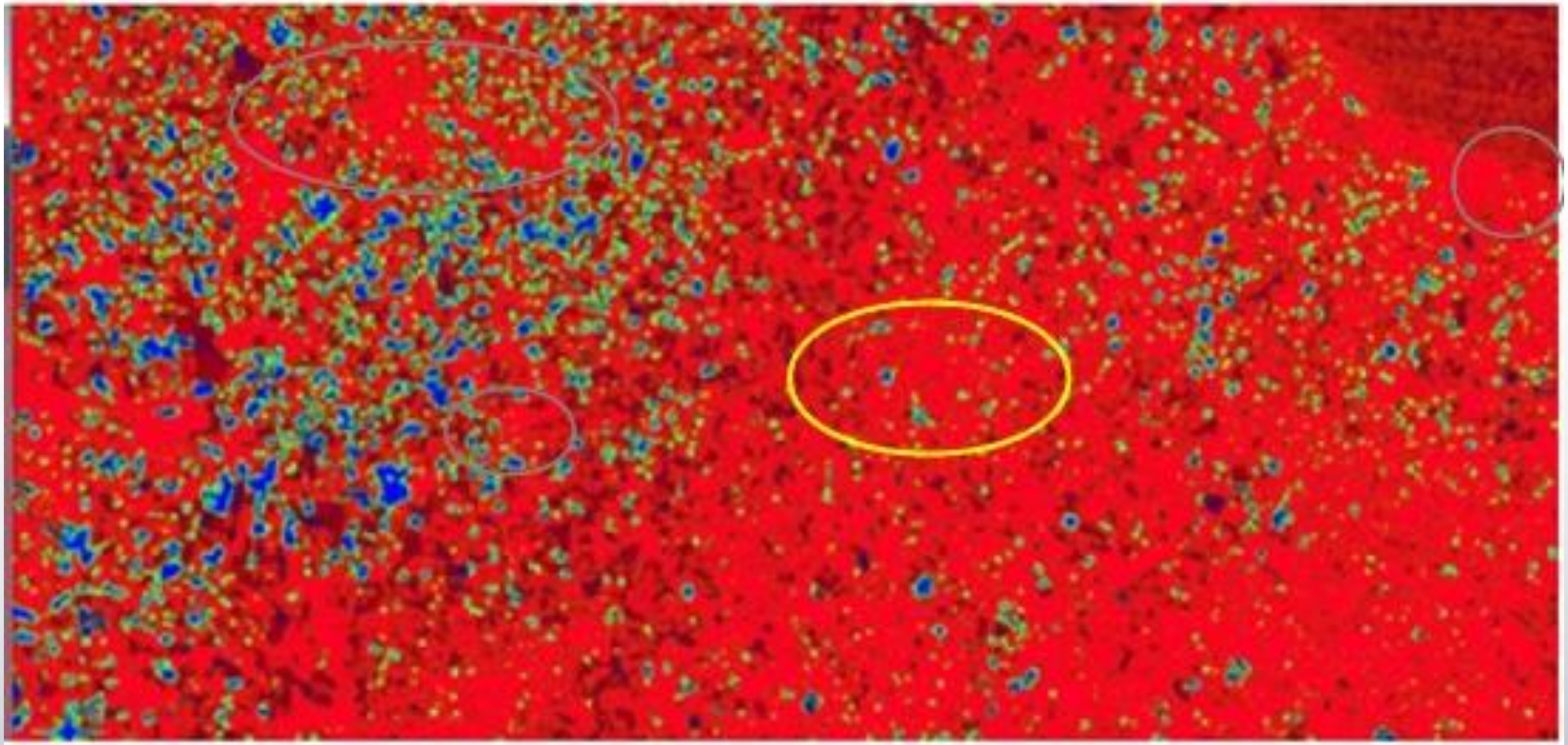
Local Geary



Nolè, G., Lasaponara, R., Lanorte A., Murgante, B., (2014) " **Quantifying Urban Sprawl with Spatial Autocorrelation Techniques using Multi-Temporal Satellite Data"** International Journal of Agricultural and Environmental Information Systems, 5(2), 20-38, April-June 2014 IGI Global DOI: 10.4018/IJAEIS.2014040102

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

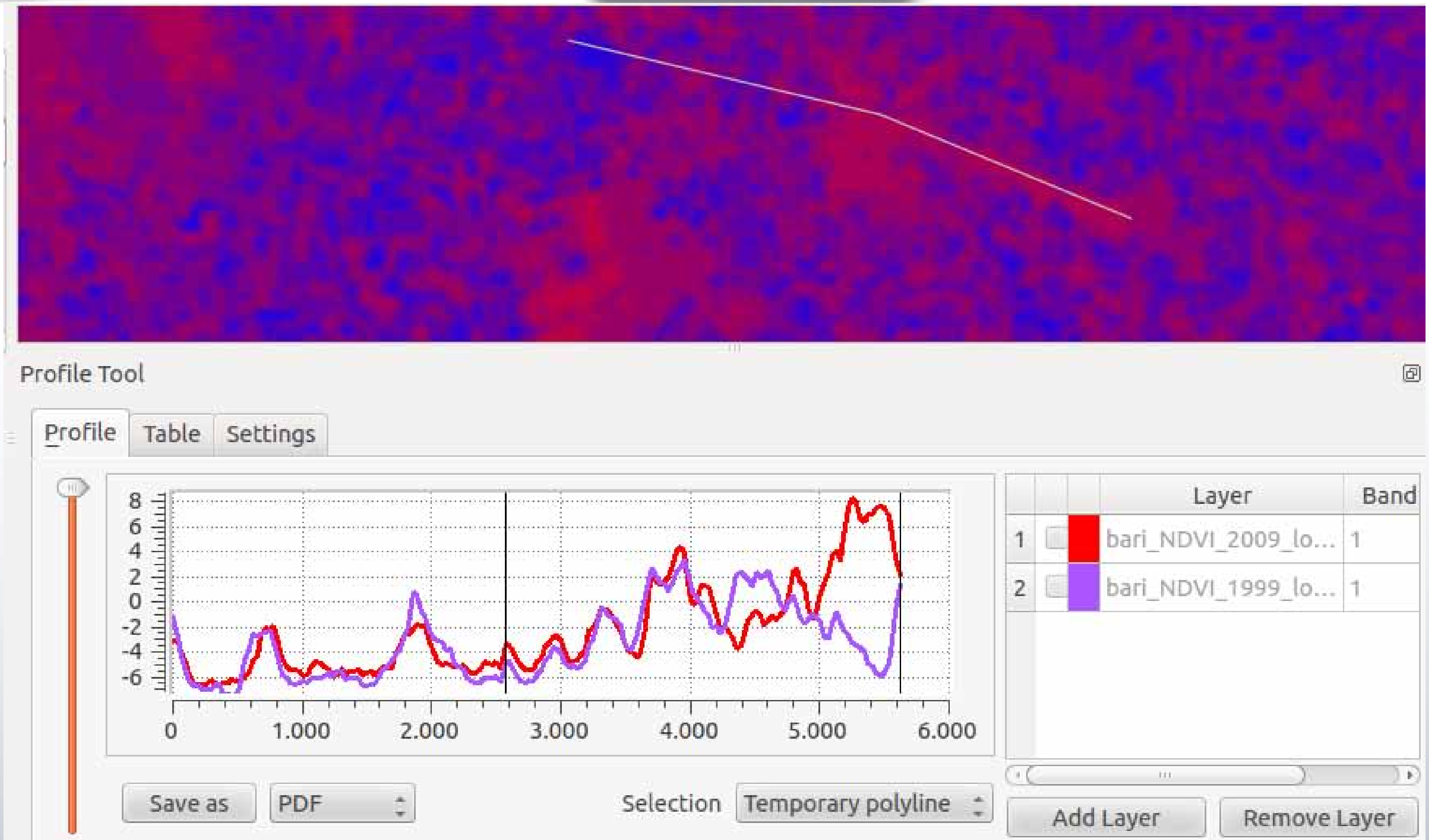
Local Indicator of Spatial Association



Nolè, G., Lasaponara, R., Lanorte A., Murgante, B., (2014) " **Quantifying Urban Sprawl with Spatial Autocorrelation Techniques using Multi-Temporal Satellite Data"** International Journal of Agricultural and Environmental Information Systems, 5(2), 20-38, April-June 2014 IGI Global 10.4018/IJAEIS.2014040102

GIS and satellite data for urban sprawl close to archaeological areas in Iran

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

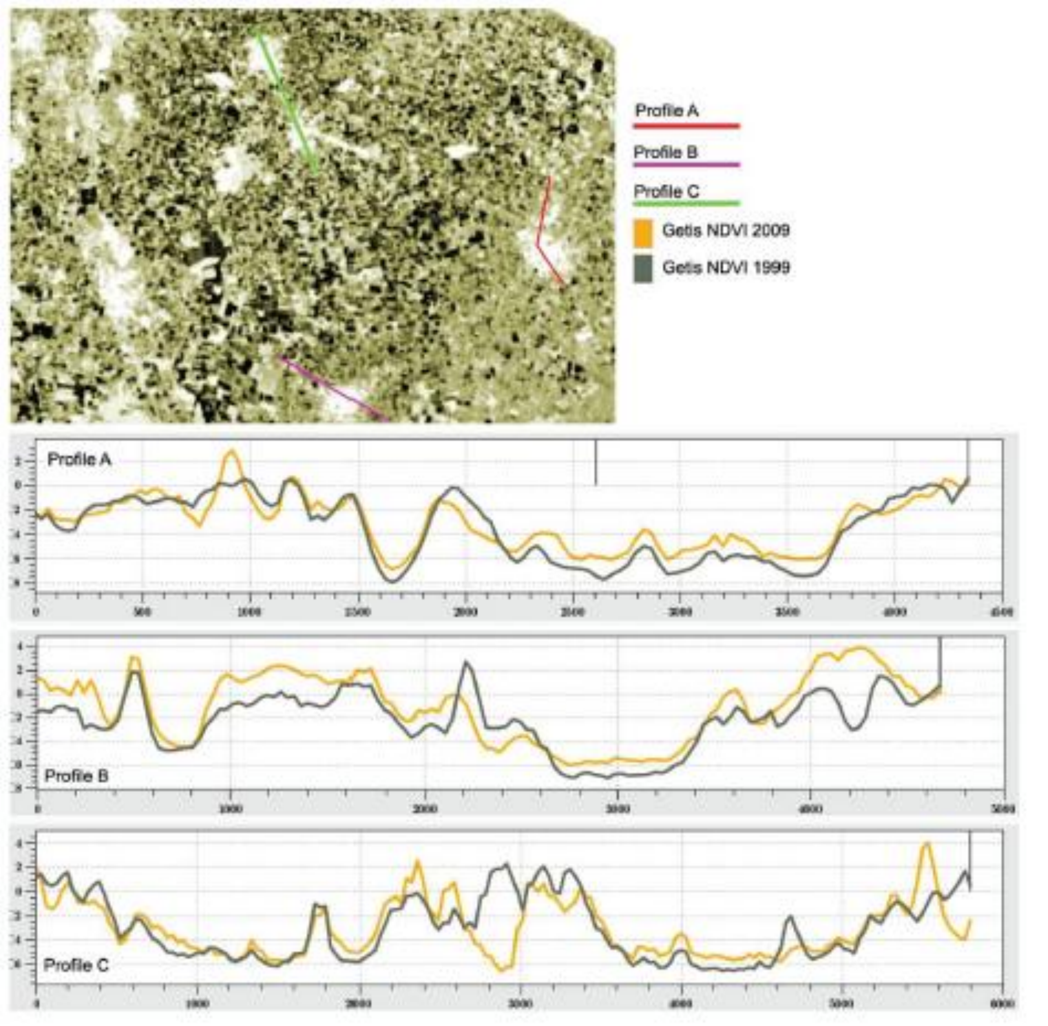


Nolè, G., Lasaponara, R., Lanorte A., Murgante, B., (2014) " **Quantifying Urban Sprawl with Spatial Autocorrelation Techniques using Multi-Temporal Satellite Data"** International Journal of Agricultural and Environmental Information Systems, 5(2), 20-38, April-June 2014 IGI Global 10.4018/IJAEIS.2014040102

Remote Sensing for Cultural Heritage Beyond Europe in Fifth International Conference on Remote Sensing and Geoinformation of Environment, 20-23 March, 2017 - Cyprus

GIS and satellite data for urban sprawl close to archaeological areas in Iran

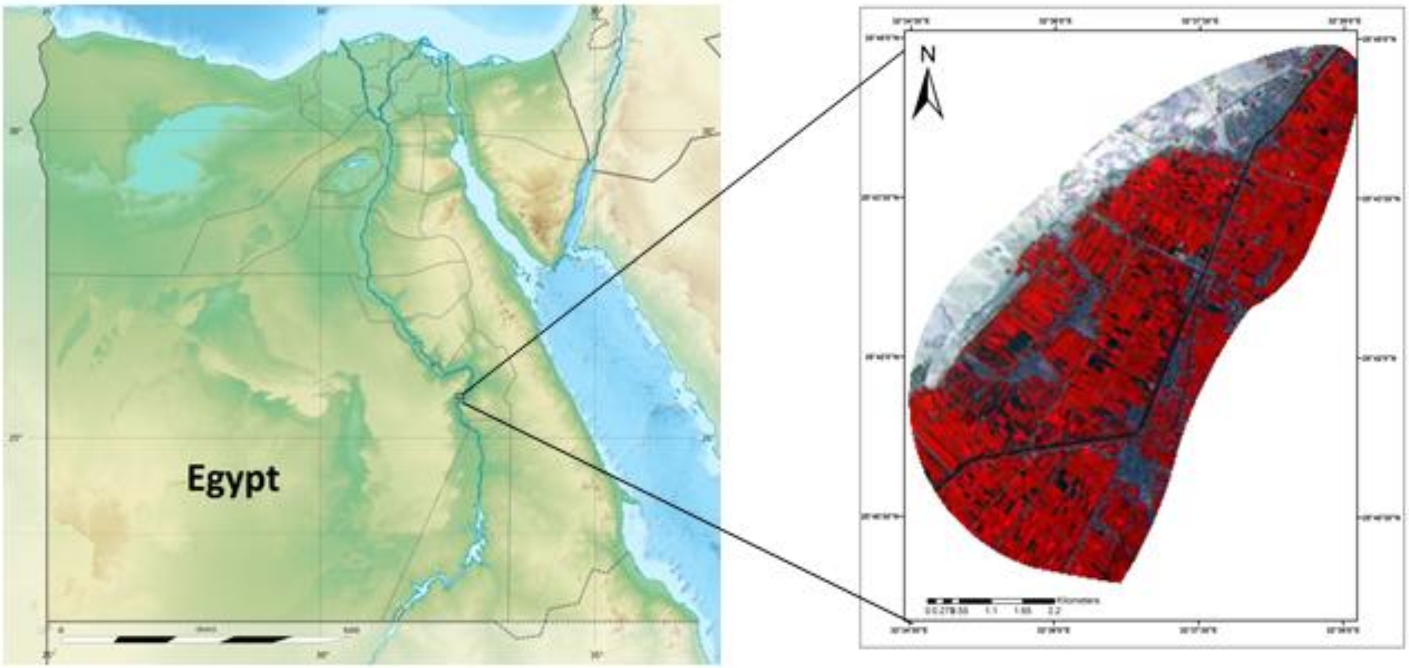
Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei



Nolè, G., Lasaponara, R., Lanorte A., Murgante, B., (2014) " **Quantifying Urban Sprawl with Spatial Autocorrelation Techniques using Multi-Temporal Satellite Data"** International Journal of Agricultural and Environmental Information Systems, 5(2), 20-38, April-June 2014 IGI Global
DOI: 10.4018/IJAEIS.2014040102

GIS and satellite data for urban sprawl close to archaeological areas in Iran

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

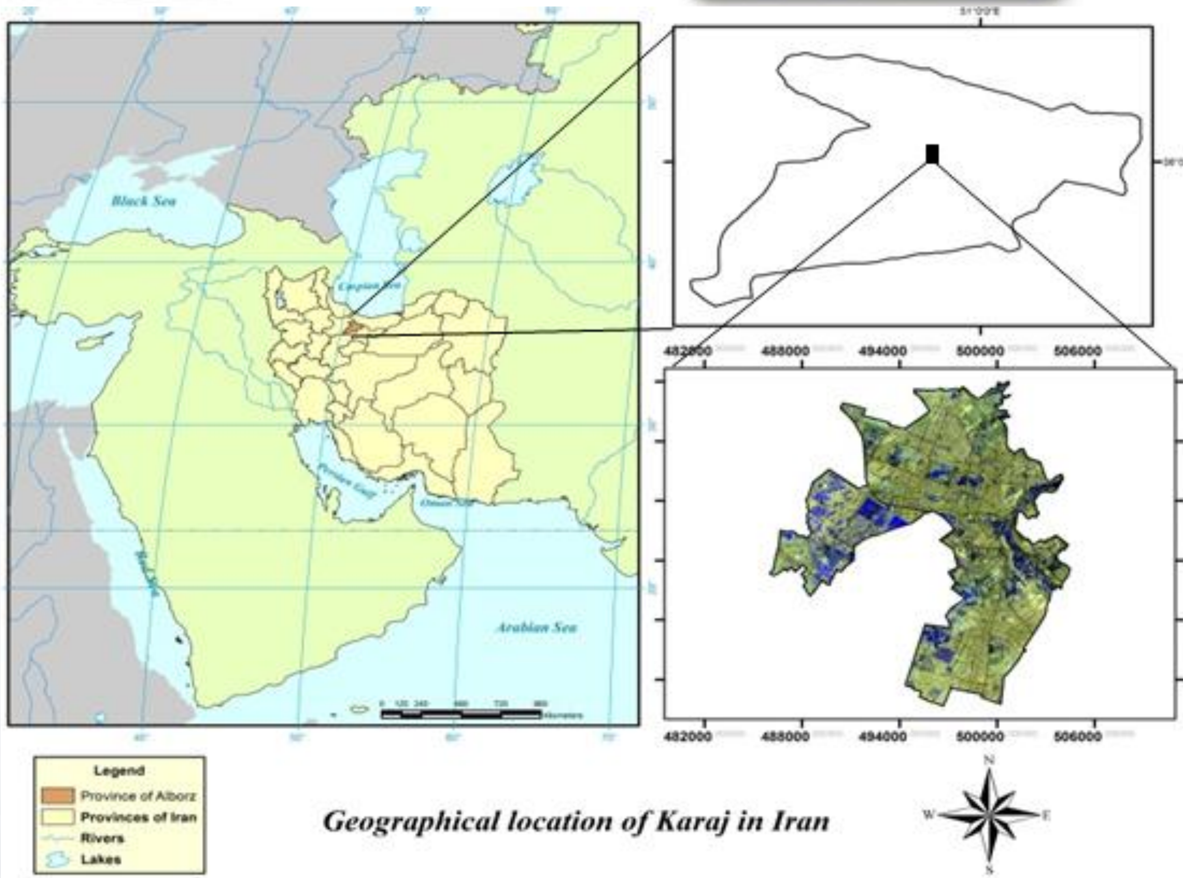


Luxor city 416 km^2
Population 506,588

Remote Sensing for Cultural Heritage Beyond Europe in Fifth International Conference on Remote Sensing and Geoinformation of Environment, 20-23 March, 2017 - Cyprus

GIS and satellite data for urban sprawl close to archaeological areas in Iran

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei



Karaj 858 km^2
Population 1,967

Remote Sensing for Cultural Heritage Beyond Europe in Fifth International Conference on Remote Sensing and Geoinformation of Environment, 20-23 March, 2017 - Cyprus

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

satellite	Sensor	Resolution (M)	Acquisition date
Landsat	TM	30 m	Sep 1984
Landsat	TM	30 m	Oct 1998
Landsat	L8	30 m	Sep 2016

- **Unsupervised classification of Images**
- **Supervised classification of Images**
- **Post classification of Images**
- **Getis-Ord and Hot Spot for Analysing spatial distribution**
- **NDVI index**

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

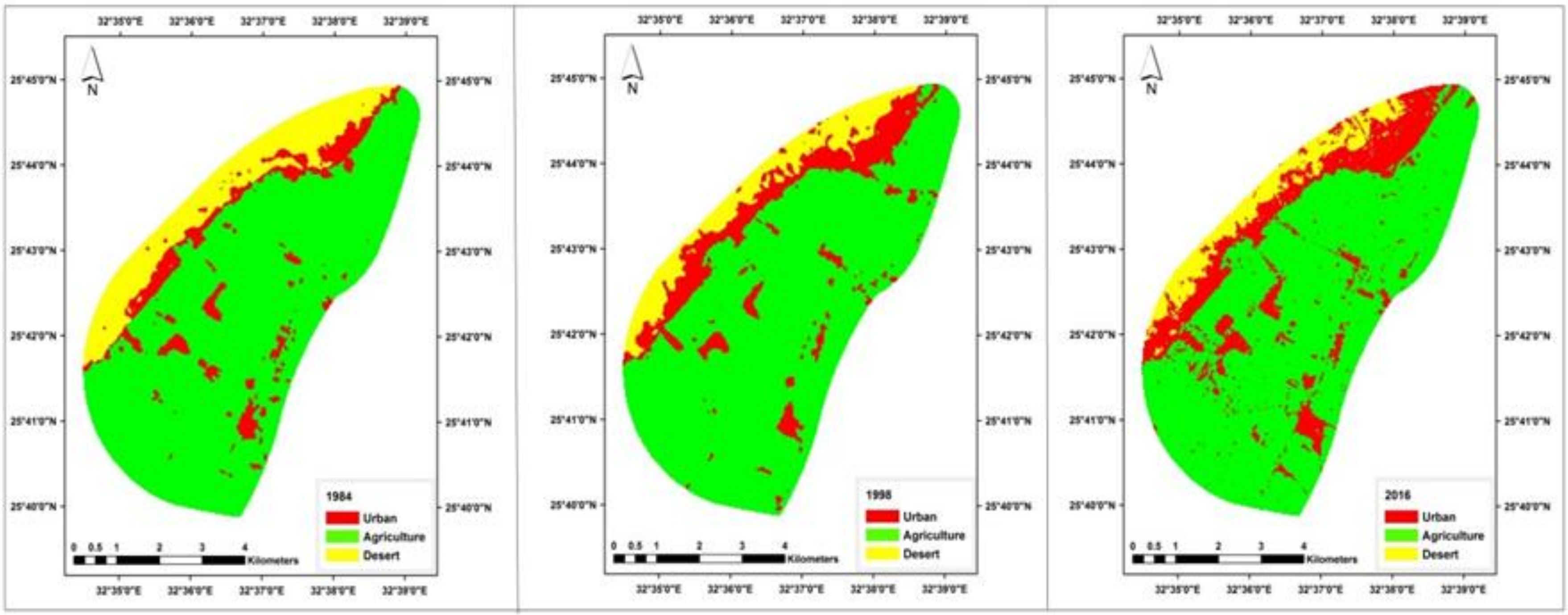
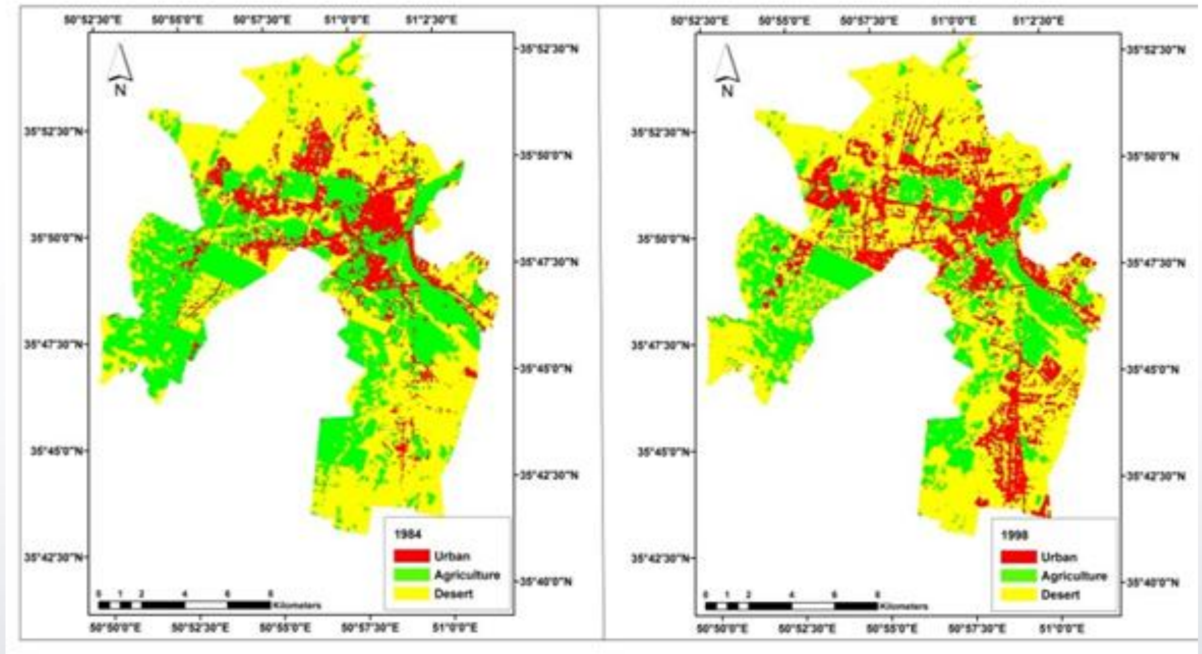


Fig. 3. Supervised classification in study area of Luxor between (1984 to 2016)

GIS and satellite data for urban sprawl close to archaeological areas in Iran

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei



GIS and satellite data for urban sprawl close to archaeological areas in Iran

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

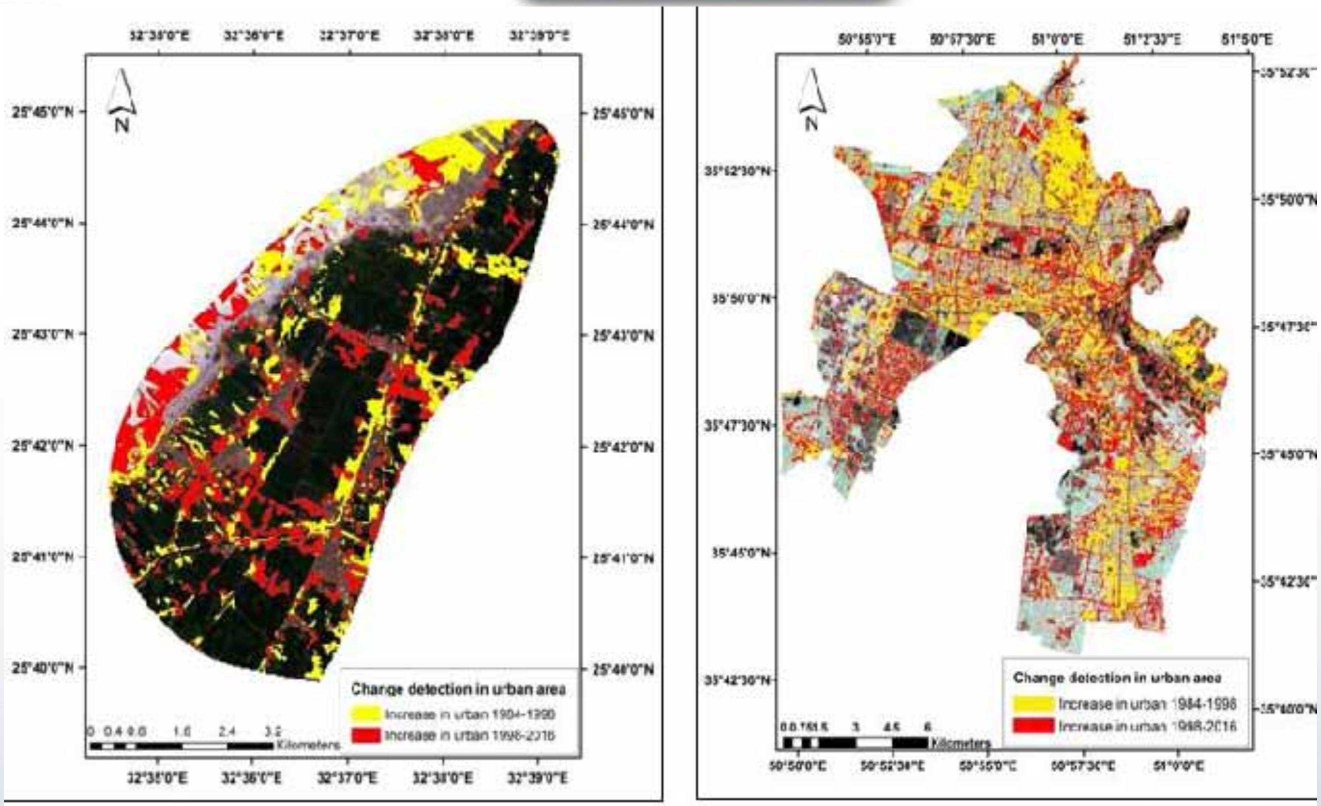
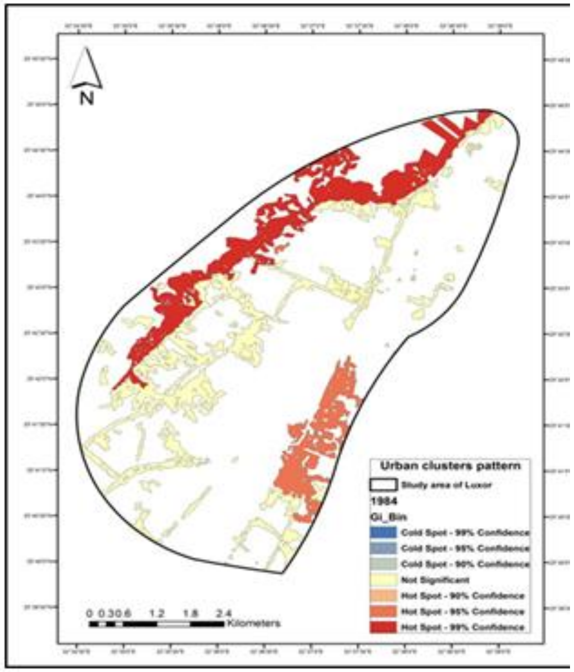


Fig. 6. Total changes in the urban Layers in study area of Luxor and Karaj between (1984 to 2016)

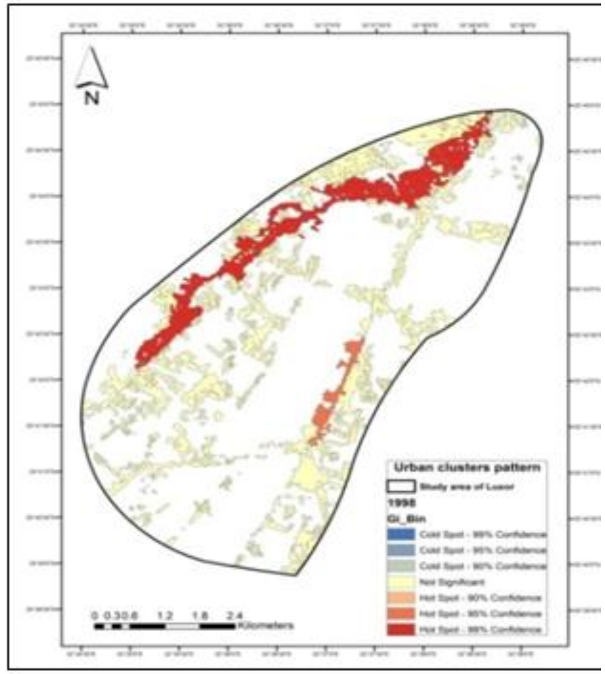
Study area	1984-9	change detection ± Km²	1998-10	change detection ± Km2	2016-9
Luxor	10.873 km²	.955 km²	11.828 km²	2.739 km²	14.567 km²
Karaj	43.420 km²	13.695 km²	57.115 km²	5.56 km²	62.675 km²

GIS and satellite data for urban sprawl close to archaeological areas in Iran

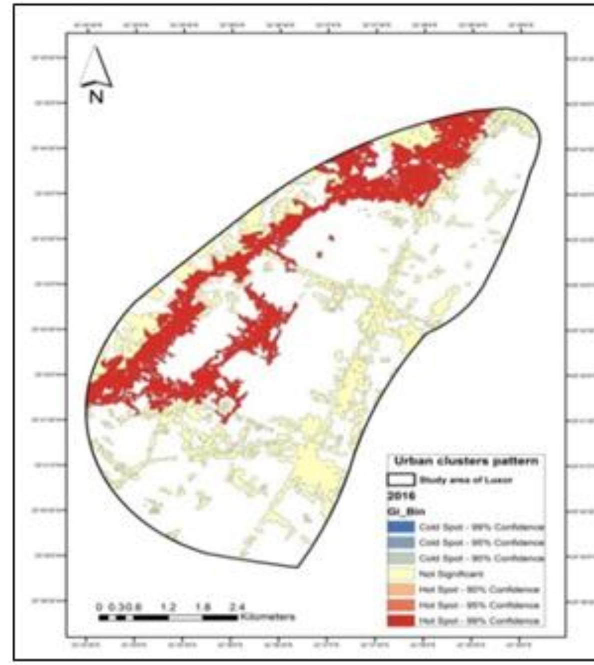
Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei



1984



1998

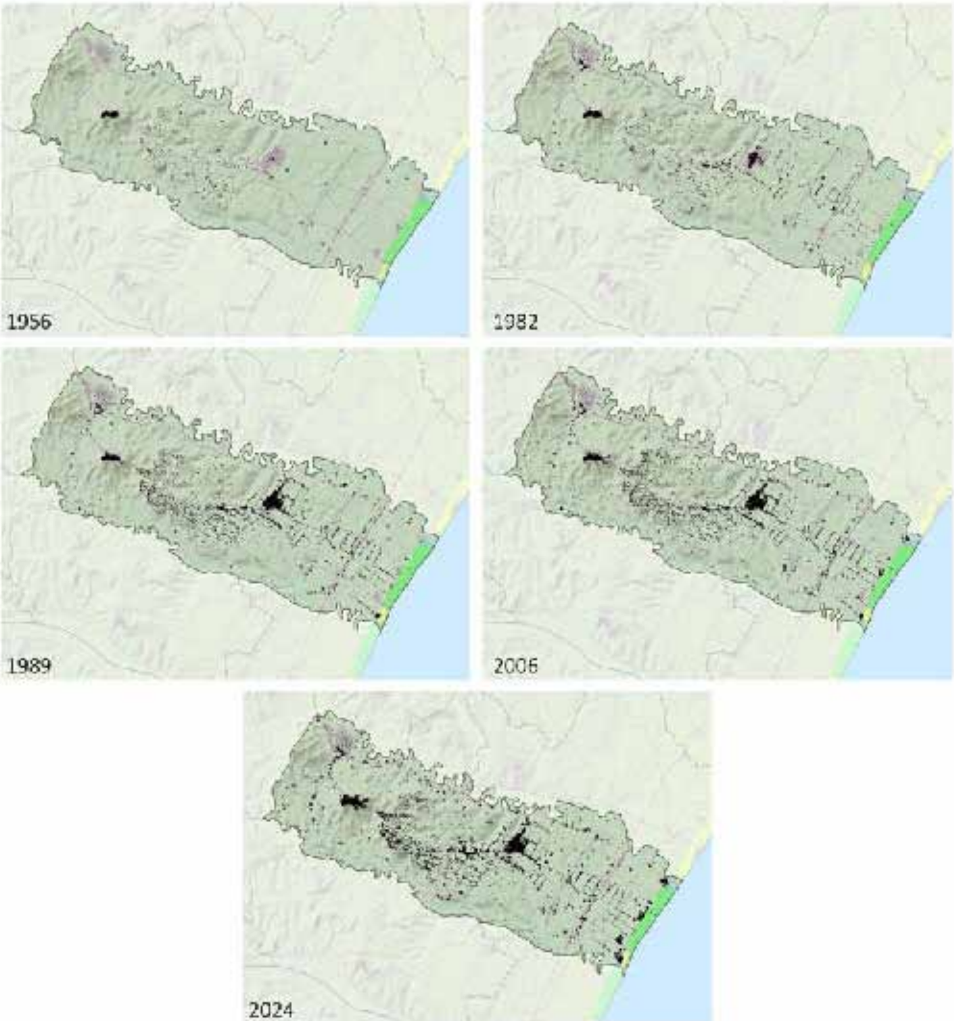


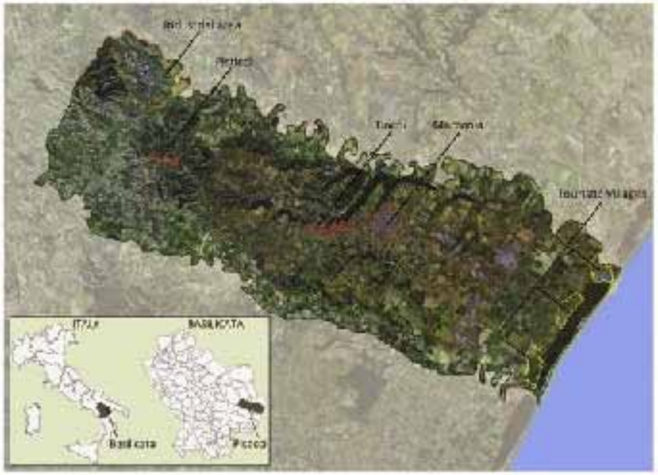
2016

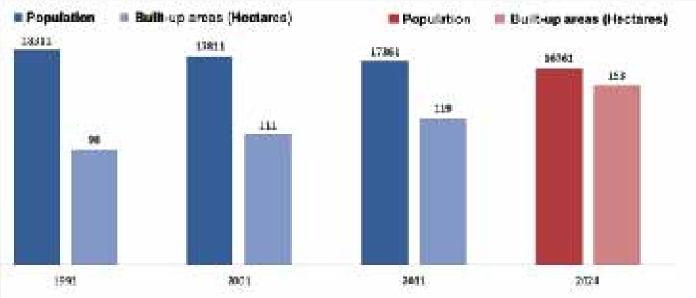
Remote Sensing for Cultural Heritage Beyond Europe in Fifth International Conference on Remote Sensing and Geoinformation of Environment, 20-23 March, 2017 - Cyprus

GIS and satellite data for urban sprawl close to archaeological areas in Iran

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei







Amato, F., Pontrandolfi, P., Murgante, B., 2015, Supporting planning activities with the assessment and the prediction of urban sprawl using spatio-temporal analysis, Ecological Informatics, Volume 30, November 2015, Pages 365–378 doi:10.1016/j.ecoinf.2015.07.004

Remote Sensing for Cultural Heritage Beyond Europe in Fifth International Conference on Remote Sensing and Geoinformation of Environment, 20-23 March, 2017 - Cyprus

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

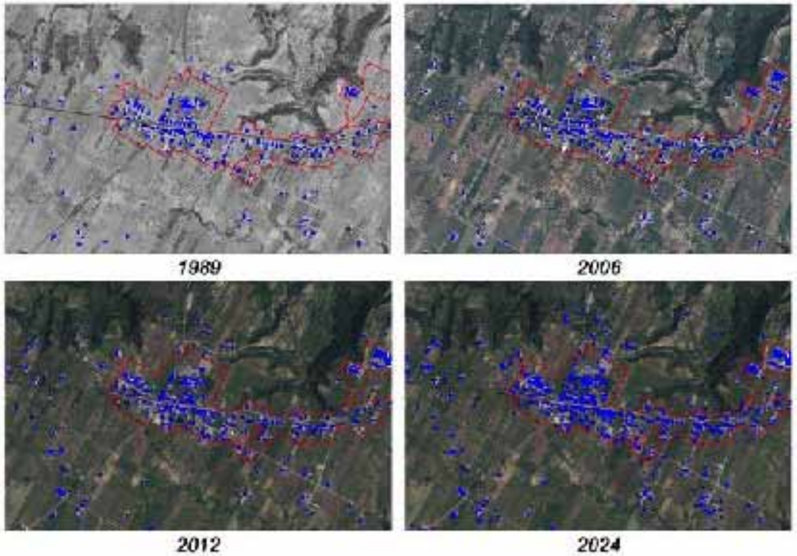


Fig. 8. The hamlet of Tinchi, highlighted by the red dashed line; blue pixels identify buildings at different dates.

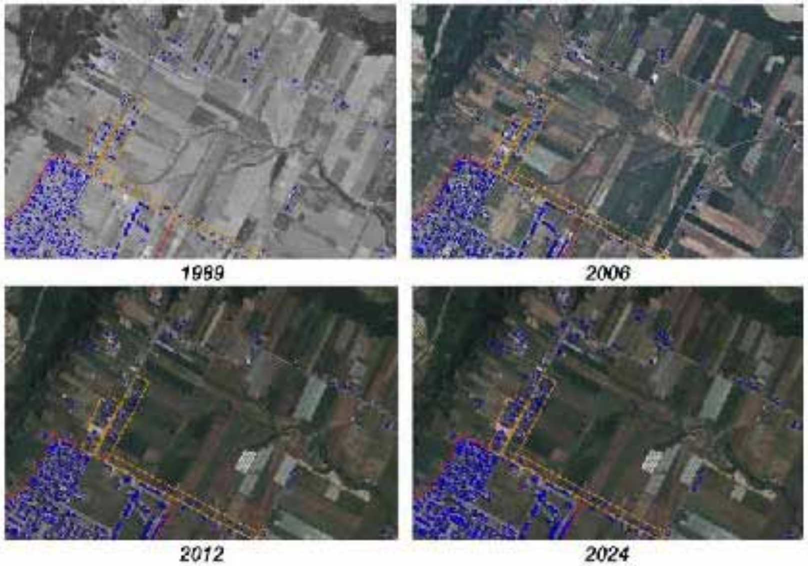
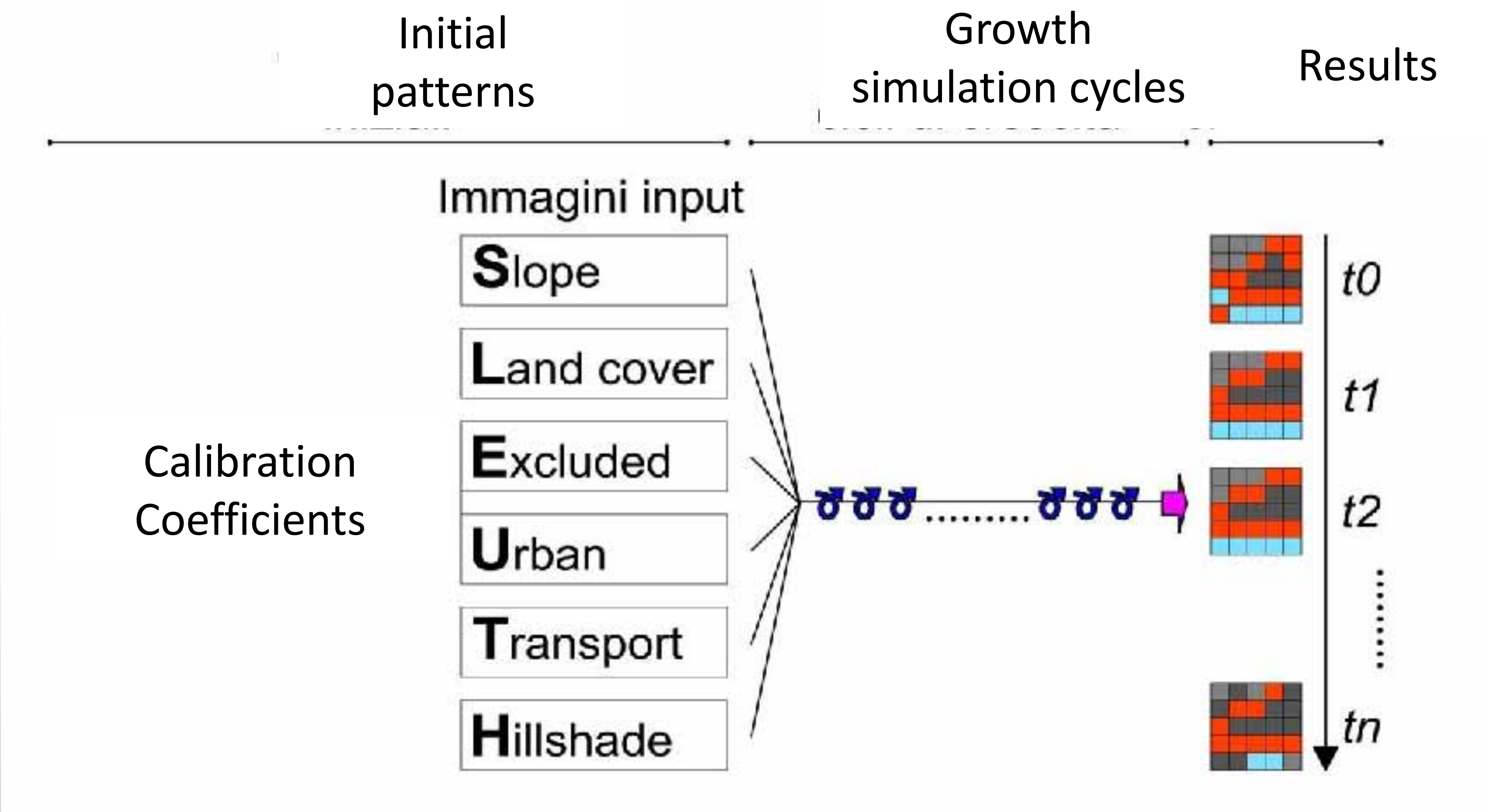


Fig. 9. The hamlet of Marconia, highlighted by the red dashed line; blue pixels identify buildings at different dates.

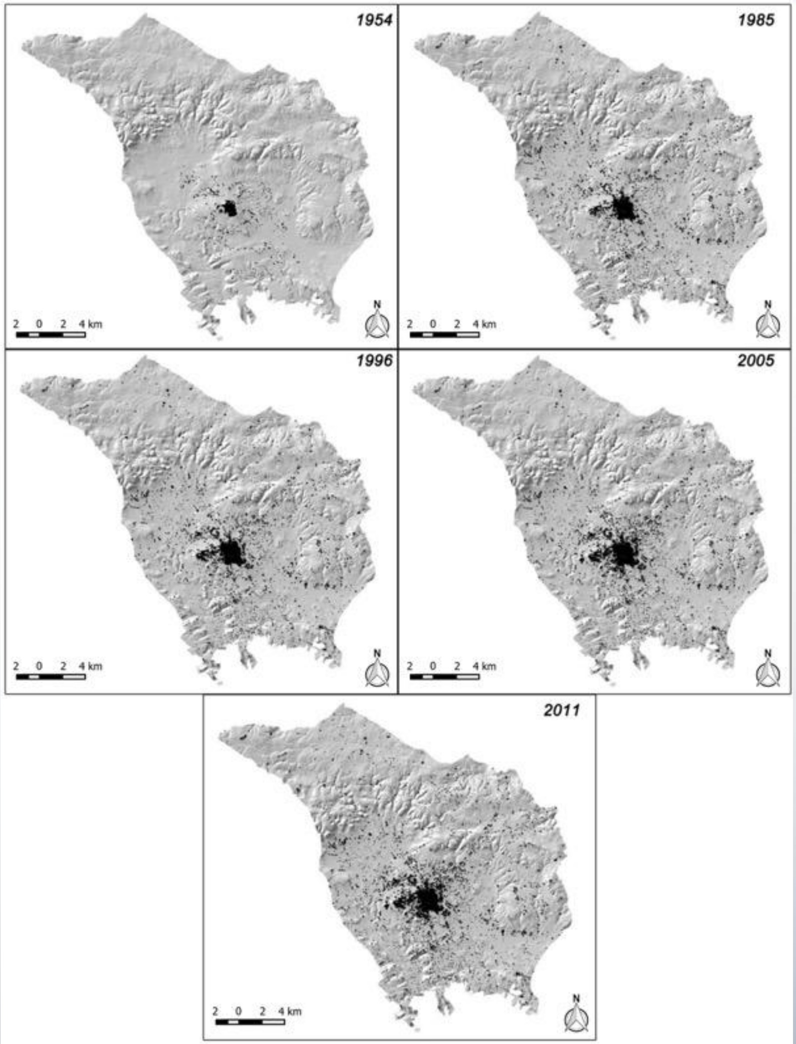
	1956	1982	1989	2006	2012	Δ 56-12	Δ 12-24	2024
Pisticci Municipality	28	58	98	111	125	97	28	153
Tinchi	1.62	6.05	9.06	9.73	10.43	8.81	5.72	16.15
Marconia	1.19	8.91	26.39	28.10	30.59	29.4	7.10	37.69
F. Terrupo	0.95	1.03	2.04	3.06	3.27	2.32	0.40	3.67
S. Leonardo	1.32	1.39	3.48	4.38	4.82	3.50	1.24	6.06
Coastal area	0.14	0.85	3.95	7.94	15.68	15.54	7.01	22.69

Amato, F., Pontrandolfi, P., Murgante, B., 2015, Supporting planning activities with the assessment and the prediction of urban sprawl using spatio-temporal analysis, Ecological Informatics, Volume 30, November 2015, Pages 365–378 doi:10.1016/j.ecoinf.2015.07.004

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei



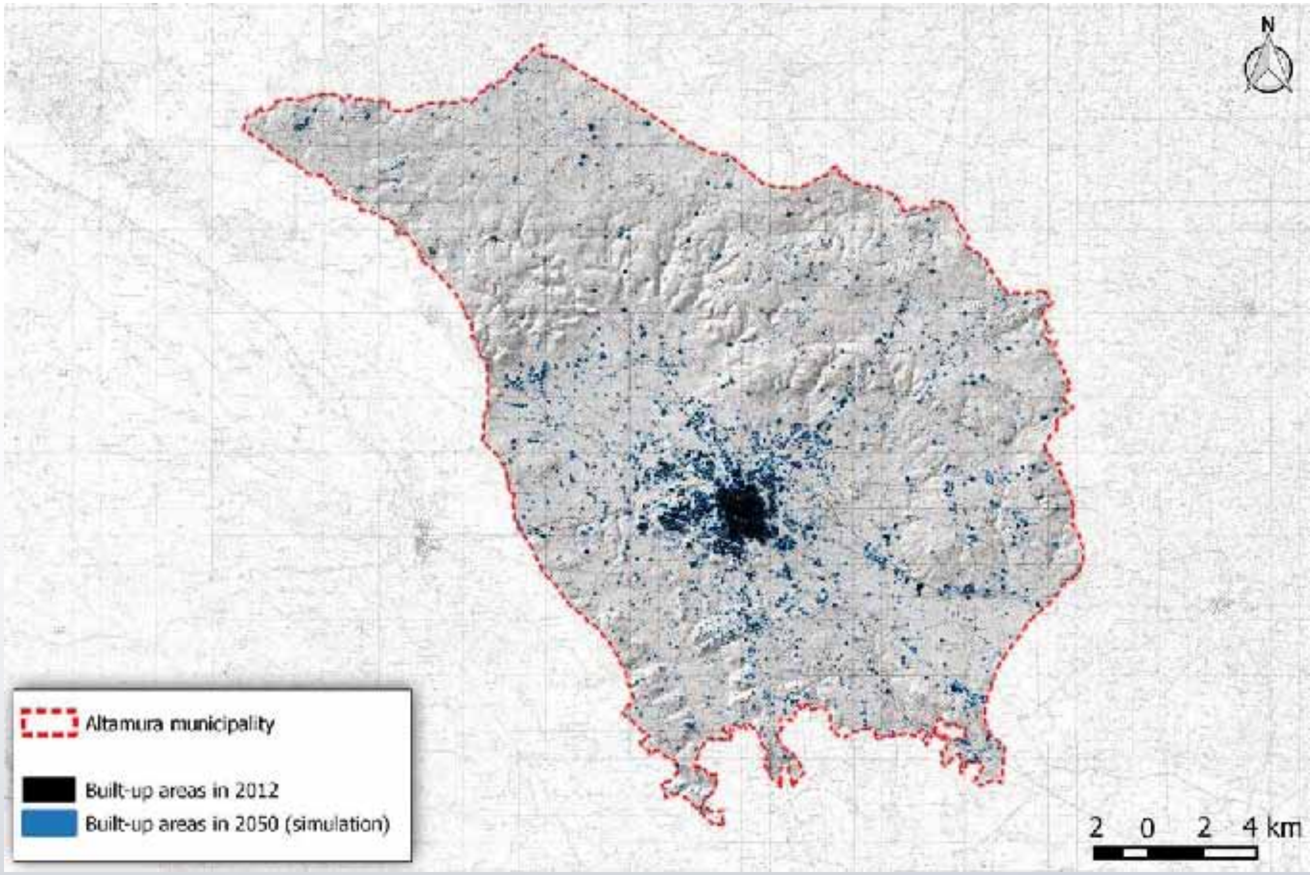
Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei



Amato F., Martellozzo F., Nolè G., Murgante B. (2016) "**Preserving cultural heritage by supporting landscape planning with quantitative predictions of soil consumption**" Journal of Cultural Heritage Elsevier doi:10.1016/j.culher.2015.12.009.

GIS and satellite data for urban sprawl close to archaeological areas in Iran

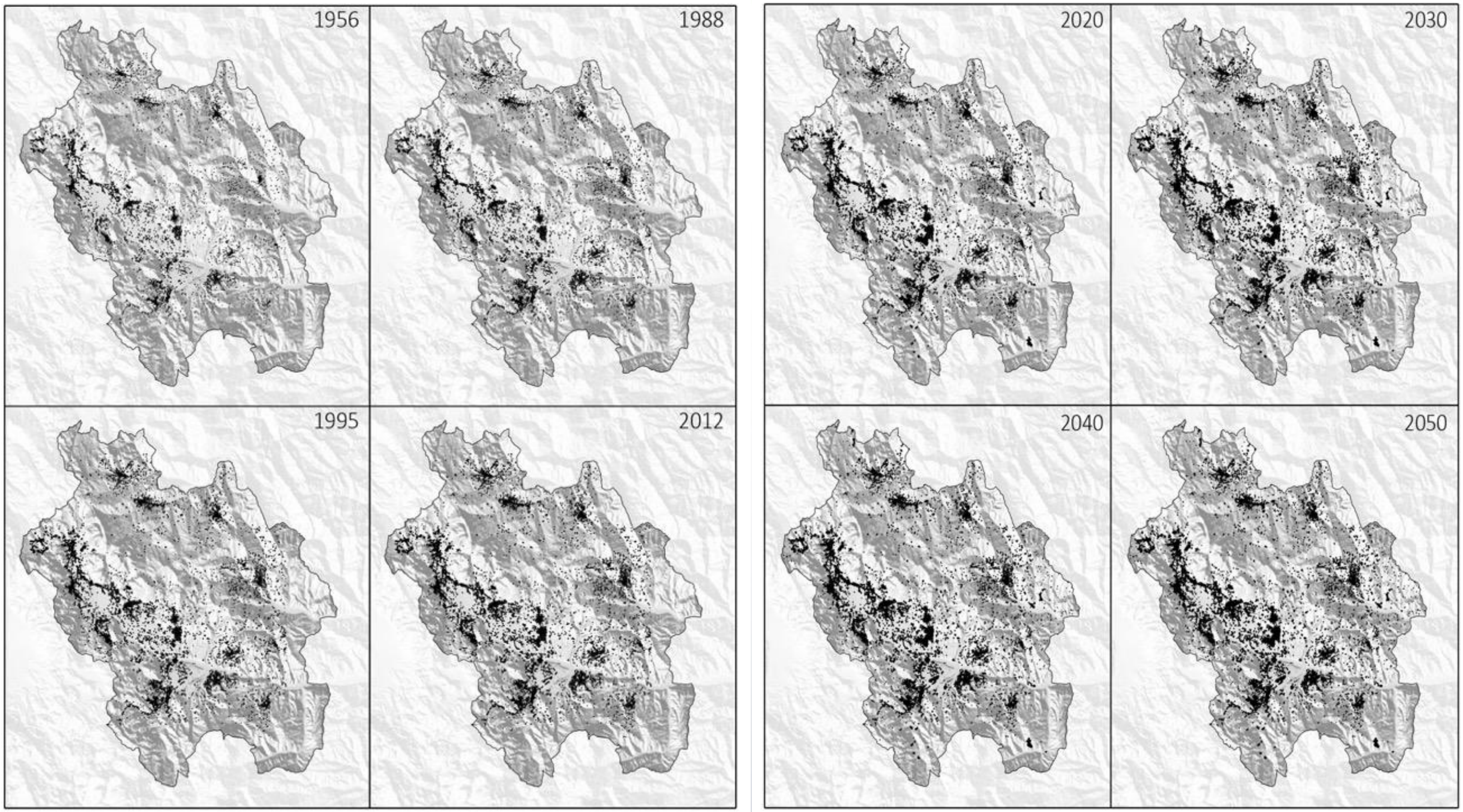
Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei



Amato F., Martellozzo F., Nolè G., Murgante B. (2016) "**Preserving cultural heritage by supporting landscape planning with quantitative predictions of soil consumption**" Journal of Cultural Heritage Elsevier doi:10.1016/j.culher.2015.12.009.

GIS and satellite data for urban sprawl close to archaeological areas in Iran

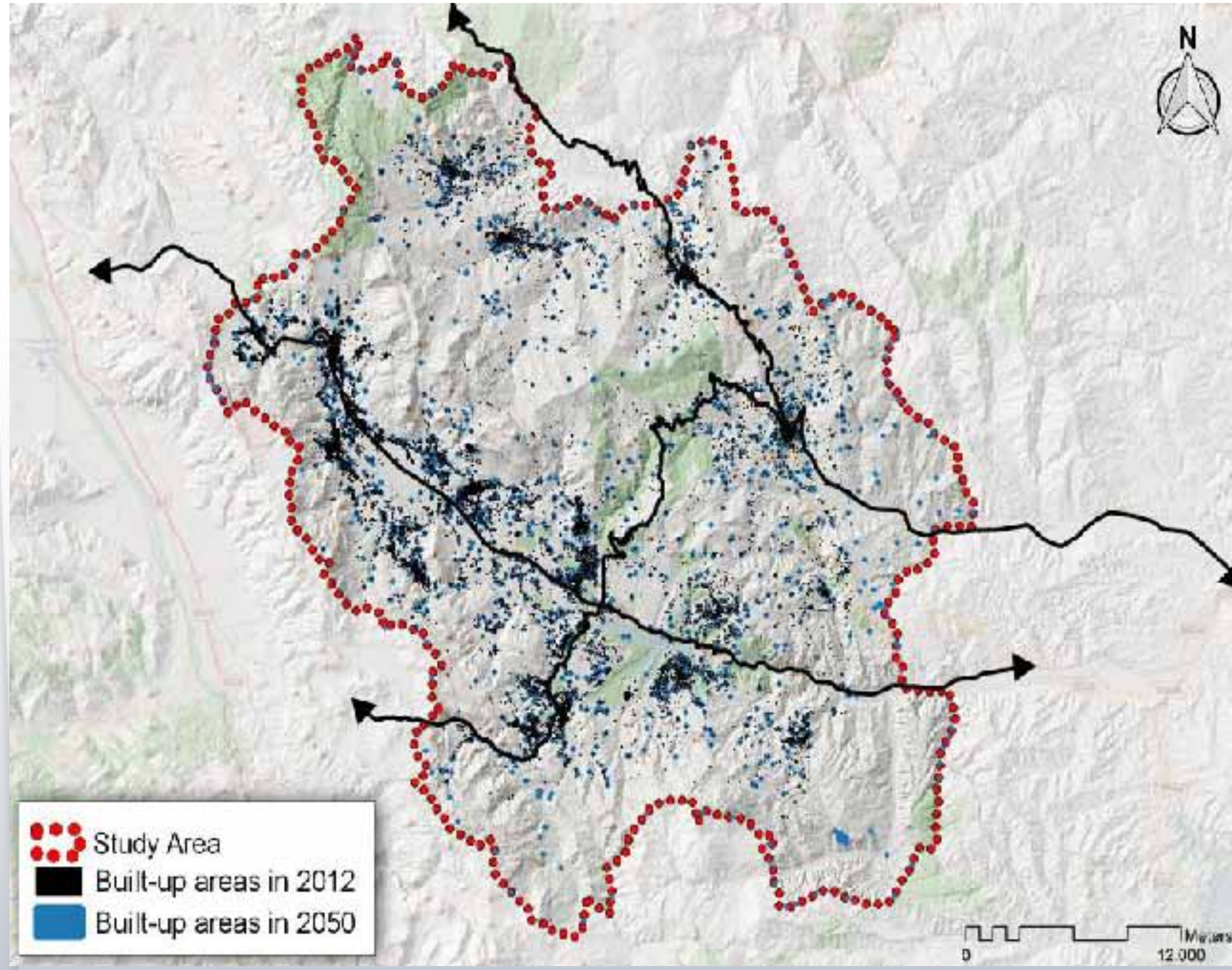
Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei



Amato, F.; Maimone, B.A.; Martellozzo, F.; Nolè, G.; Murgante, B. (2016) **The Effects of Urban Policies on the Development of Urban Areas.** Sustainability 2016, 8, 297. doi:10.3390/su8040297

GIS and satellite data for urban sprawl close to archaeological areas in Iran

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

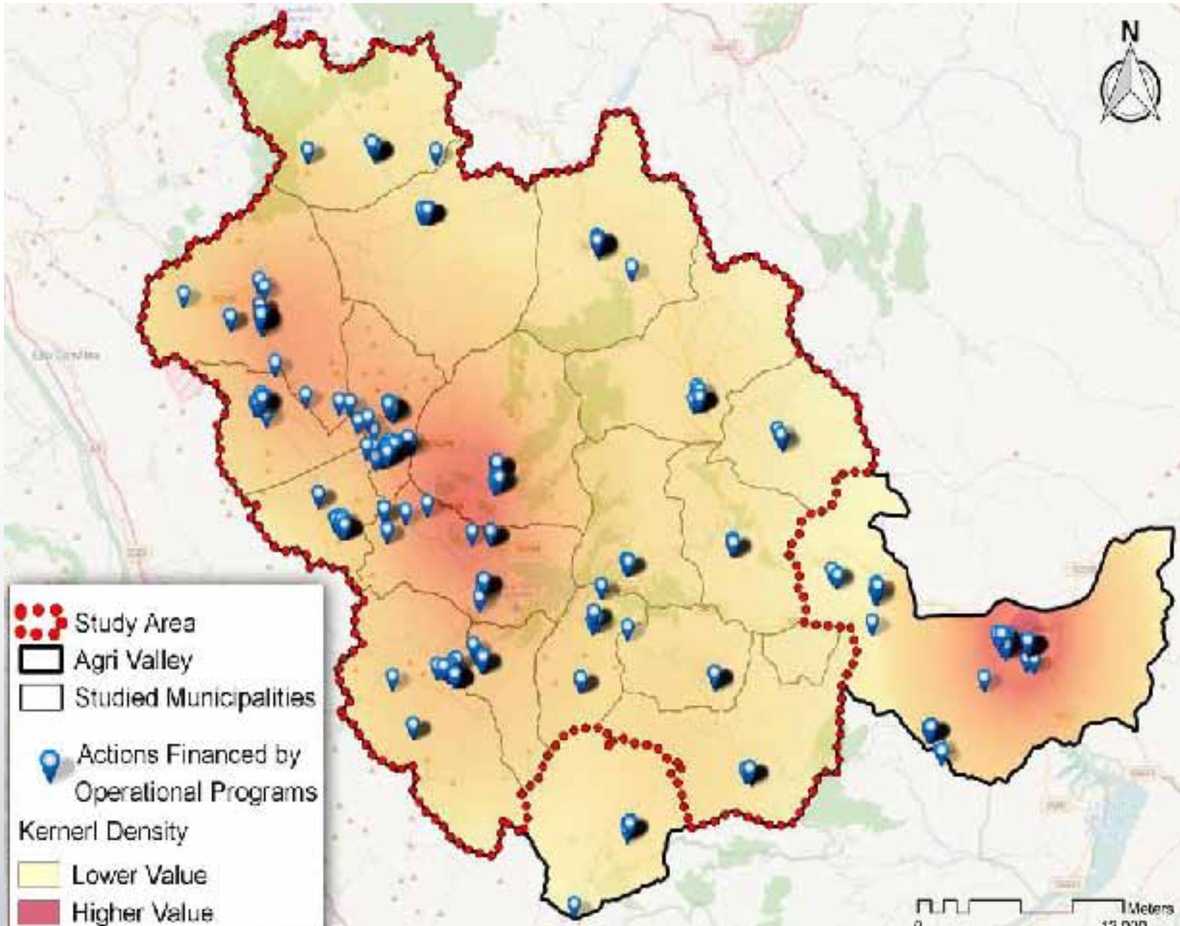


Amato, F.; Maimone, B.A.; Martellozzo, F.; Nolè, G.; Murgante, B. (2016) **The Effects of Urban Policies on the Development of Urban Areas.** Sustainability 2016, 8, 297. doi:10.3390/su8040297

Remote Sensing for Cultural Heritage Beyond Europe in Fifth International Conference on Remote Sensing and Geoinformation of Environment, 20-23 March, 2017 - Cyprus

GIS and satellite data for urban sprawl close to archaeological areas in Iran

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei

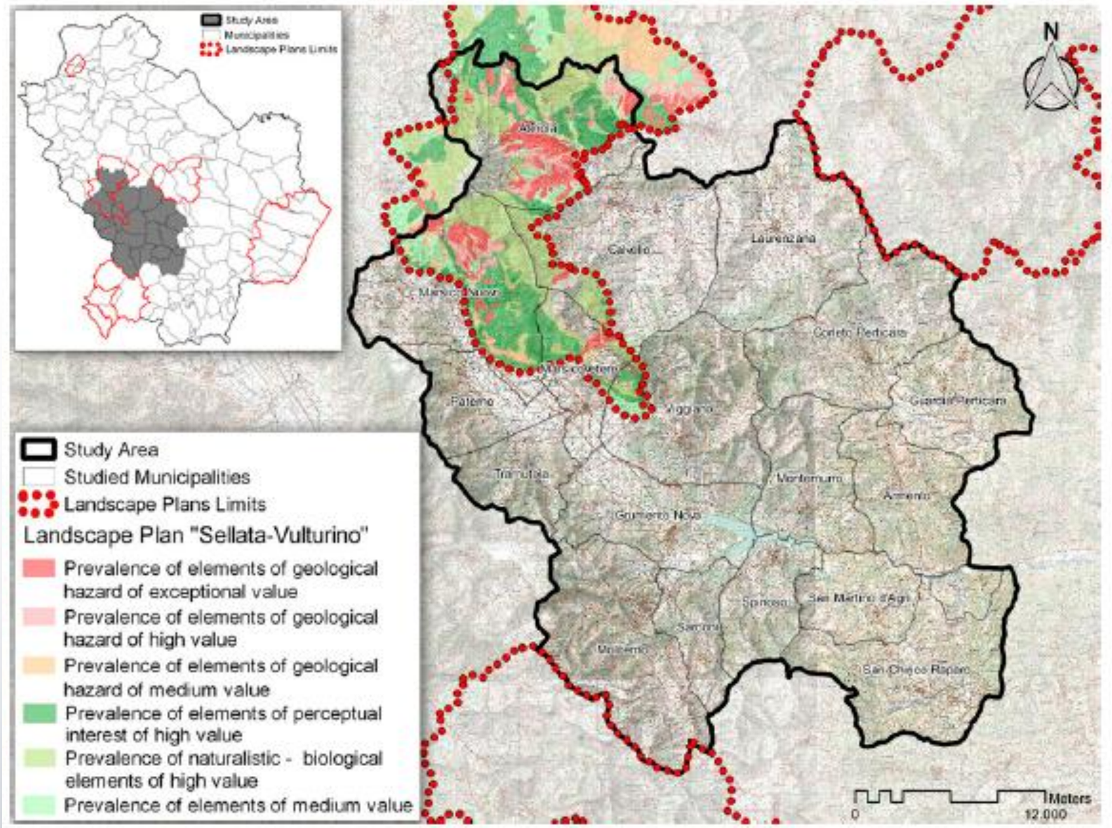


Amato, F.; Maimone, B.A.; Martellozzo, F.; Nolè, G.; Murgante, B. (2016) **The Effects of Urban Policies on the Development of Urban Areas.** Sustainability 2016, 8, 297. doi:10.3390/su8040297

Remote Sensing for Cultural Heritage Beyond Europe in Fifth International Conference on Remote Sensing and Geoinformation of Environment, 20-23 March, 2017 - Cyprus

GIS and satellite data for urban sprawl close to archaeological areas in Iran

Beniamino Murgante, Rosa Lasaponara, Abdelaziz Elfadaly, Mohammad Molaei



Amato, F.; Maimone, B.A.; Martellozzo, F.; Nolè, G.; Murgante, B. (2016) **The Effects of Urban Policies on the Development of Urban Areas**. Sustainability 2016, 8, 297. doi:10.3390/su8040297

GHENT
UNIVERSITY

FACULTY OF ARTS
AND PHILOSOPHY

DEPARTMENT OF ARCHAEOLOGY
PRE- AND PROTOHISTORY

REMOTE SENSING FOR ARCHAEOLOGICAL CULTURAL HERITAGE IN THE ALTAI MOUNTAINS: THE EXAMPLE OF TURU ALTY AND YUSTYD (GORNO-ALTAI, RUSSIA)

Jean Bourgeois
Gilles De Vuyst
Rudi Goossens
Nikita Konstantinov
Wouter Gheyle

Workshop
Remote Sensing for Cultural heritage. Beyond Europe
Paphos (Cyprus), 20 March 2017

GHENT UNIVERSITY

geography department Ghent University

Archaeology Ghent University

GAGU

Outline

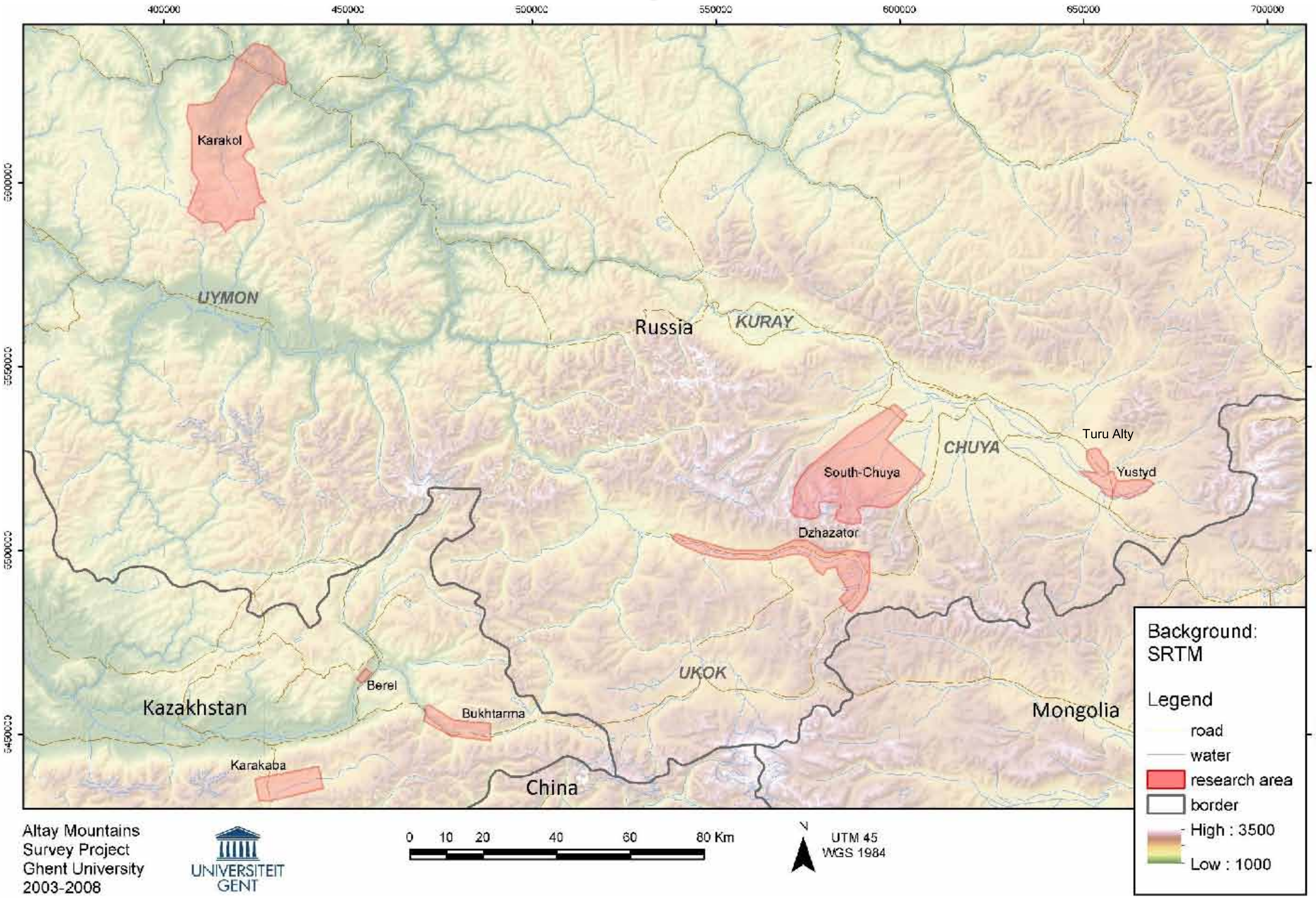
•History of the research and short presentation of the research area

• Methodology : Mapping archaeological sites in remote areas

• Results: Yustid and Turu Alty

GHENT
UNIVERSITY

Research history – Research area



GHENT UNIVERSITY

Karakol (1100 m)

GHENT UNIVERSITY

Dzahazator (1300-2000 m)

GHENT UNIVERSITY

GHENT UNIVERSITY


Yustyd (1800-2200 m)

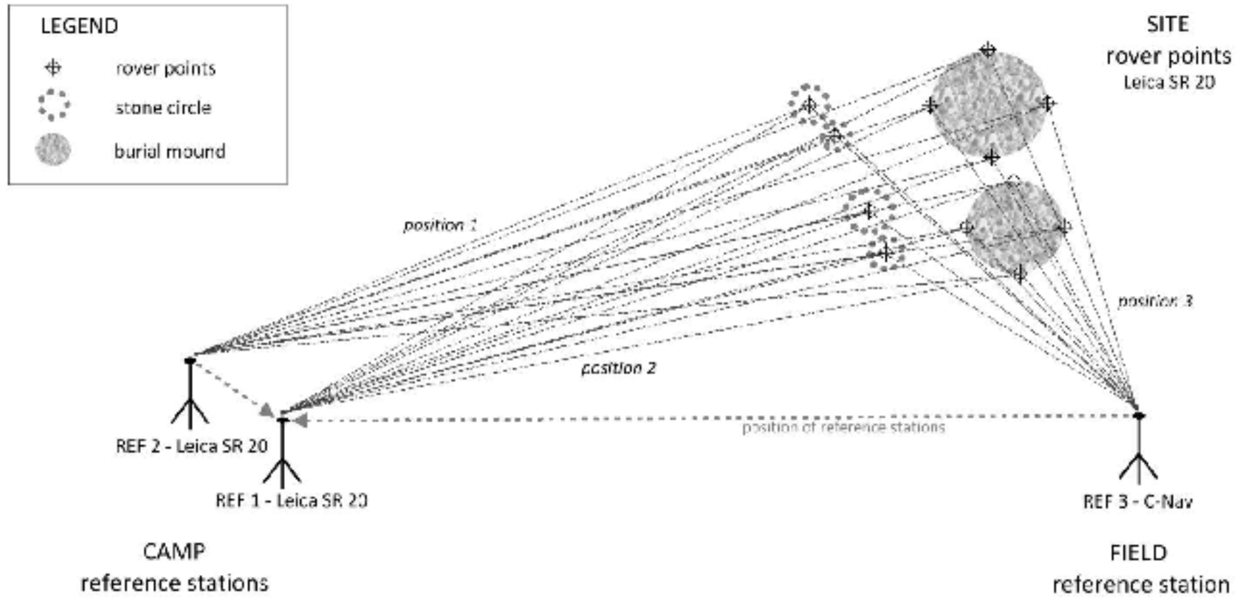
GHENT UNIVERSITY

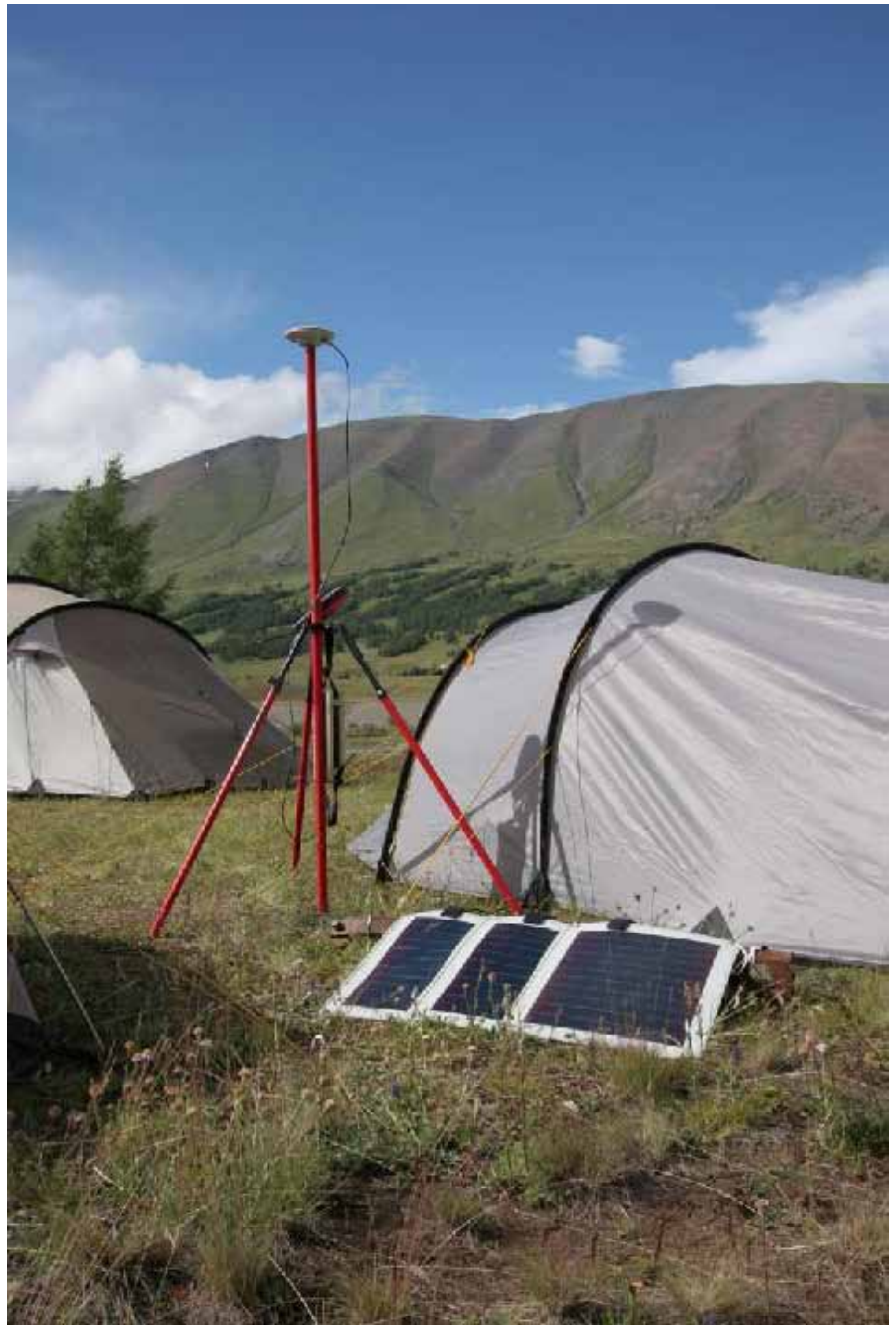
GHENT UNIVERSITY

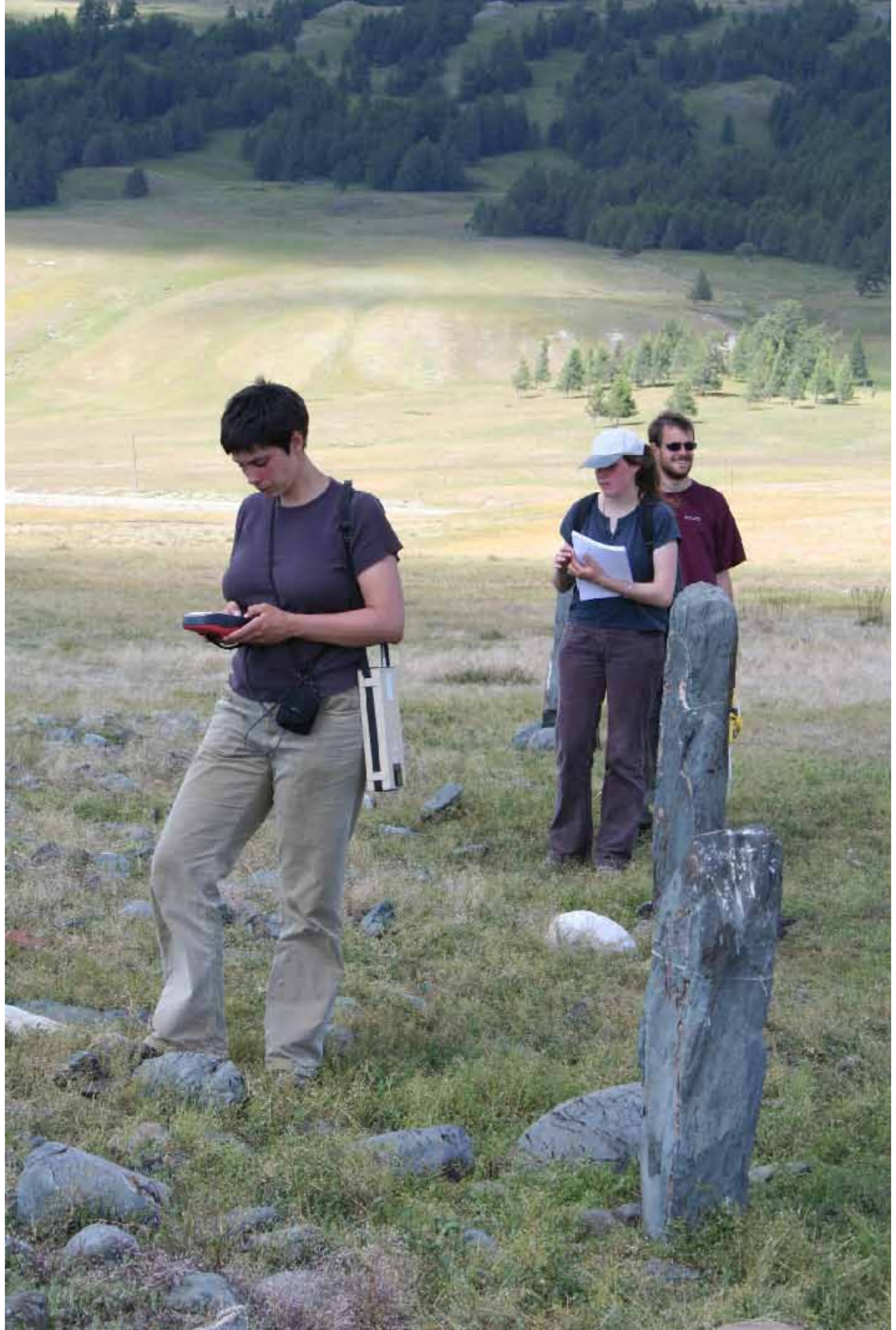
Methodology: Mapping archaeological sites in remote areas

- How to produce reliable topographical maps, in far remote areas, without reference points
  - Use of space technology (Corona, cheap, 0.9m resolution max; modern satellite images, 0.5m, expensive)
- How to produce reliable site plans
  - Use of GPS C-Nav
  - And differential GPS Leica SR20

GHENT UNIVERSITY

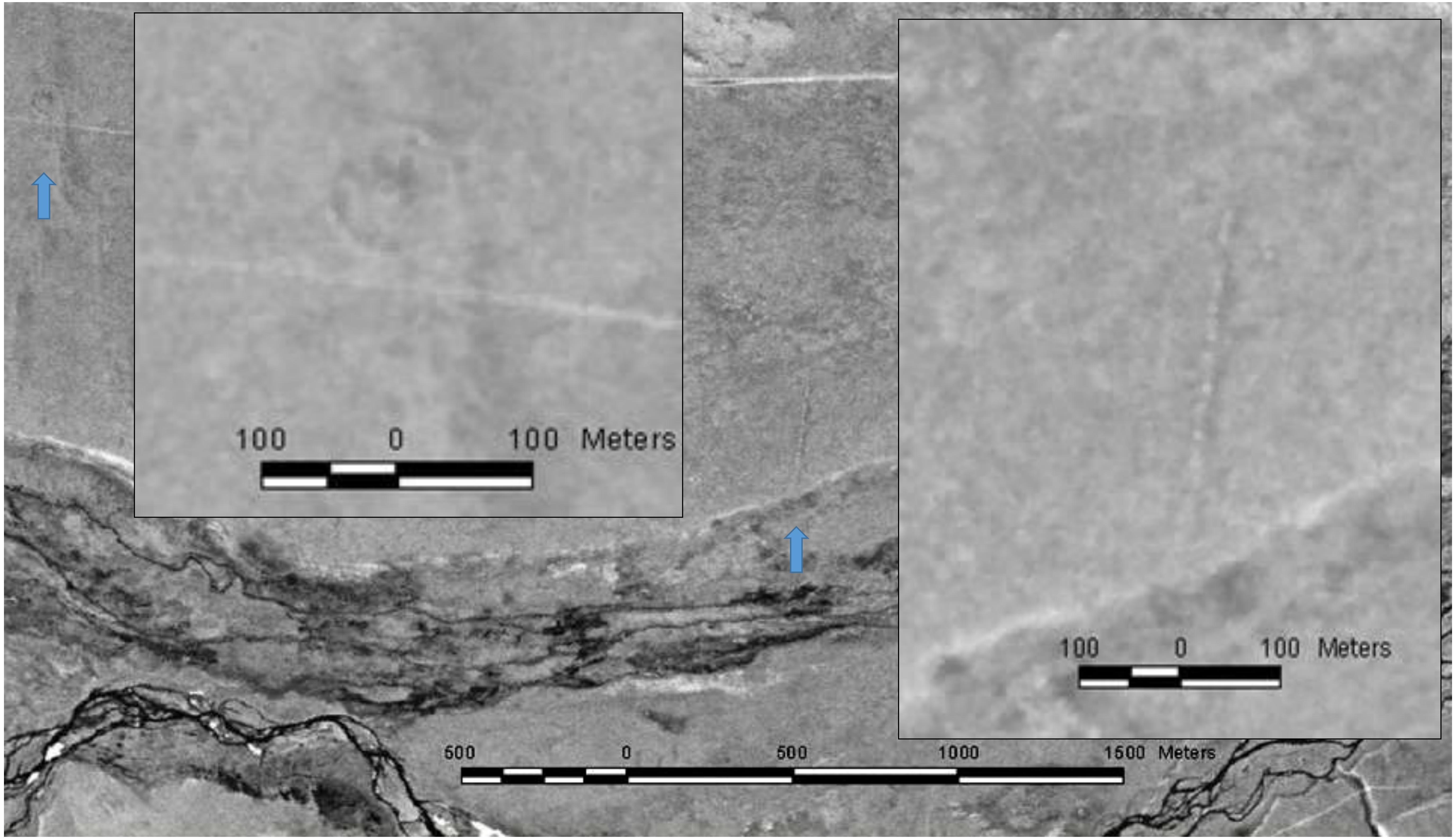

LEGEND
rover points
stone circle
burial mound
SITE
rover points
Leica SR 20
position 1
position 2
position 3
position of reference stations
REF 2 - Leica SR 20
REF 1 - Leica SR 20
REF 3 - C-Nav
CAMP
reference stations
FIELD
reference station



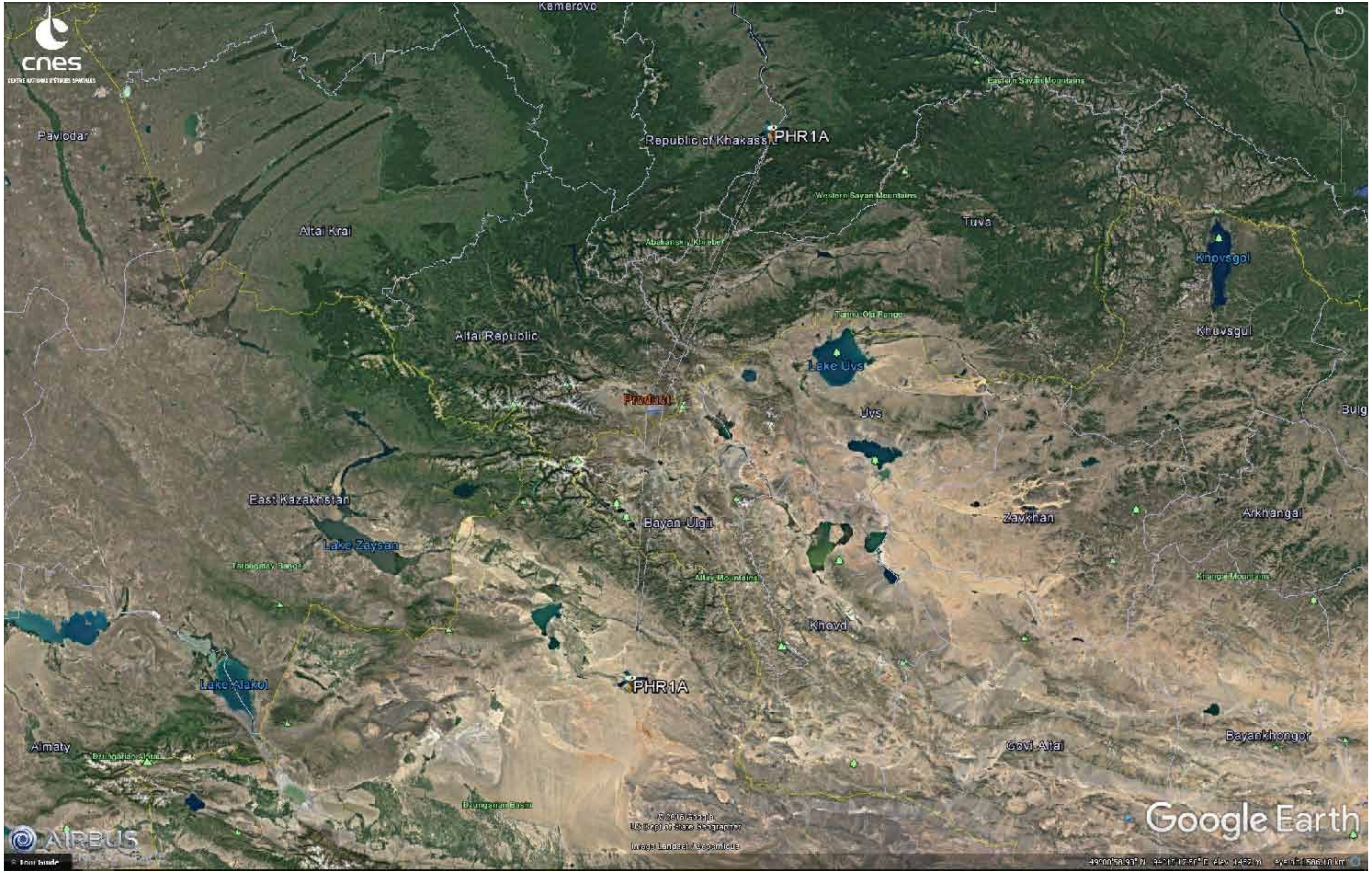


GHENT UNIVERSITY

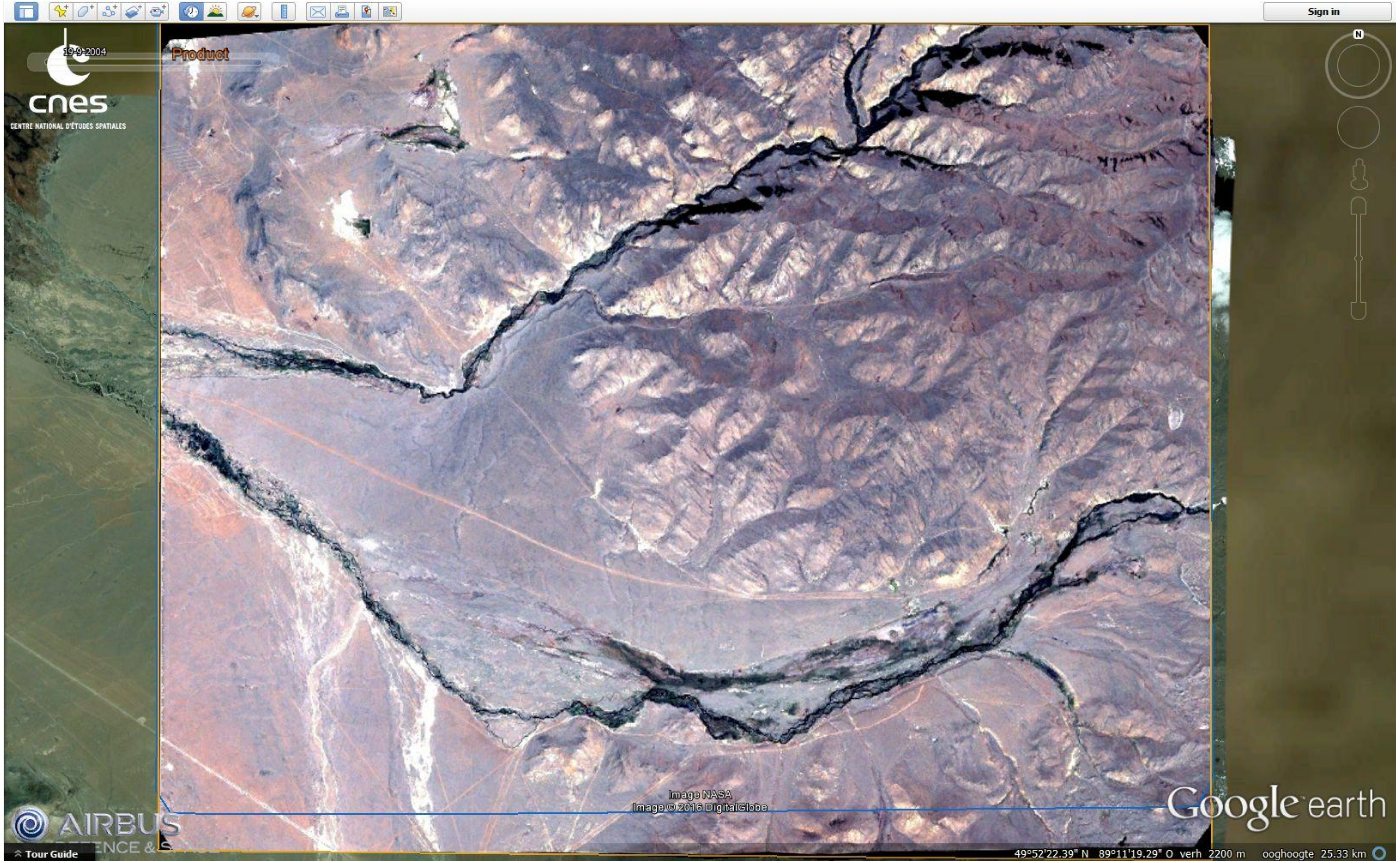
KH-4B



GHENT UNIVERSITY



GHENT UNIVERSITY



GHENT UNIVERSITY

ALTAI campaign – UGent – GASU

SITE FICHE NR. A53

SITE NR: KA-777 001-002 Name (Init.): WG
Definitive site name: Date: 13/07/2006

District: KA Land use: steppe

Valley / toponym: YUSTYD Topography: 1e terrace, close to hills

Structure	001 garmin		
North	49° 47' 25,4"		
East	89° 19' 16,3"		
Height	~~1,9 m + der~~ 2155m		
RMS	5 m		

GPS

Type of site: RITUAL General description: Big kereksur with high round and quadrangular, double stone setting. No side structures.

Kereksur: very high, on a platform: mixture of small stones (both broken stones and river stones). Rays on 3 sides, starting from the centre of the sides: N, E, S

General date: Late Bronze Age

Amount of structures (approx.): 1

Organisation: /

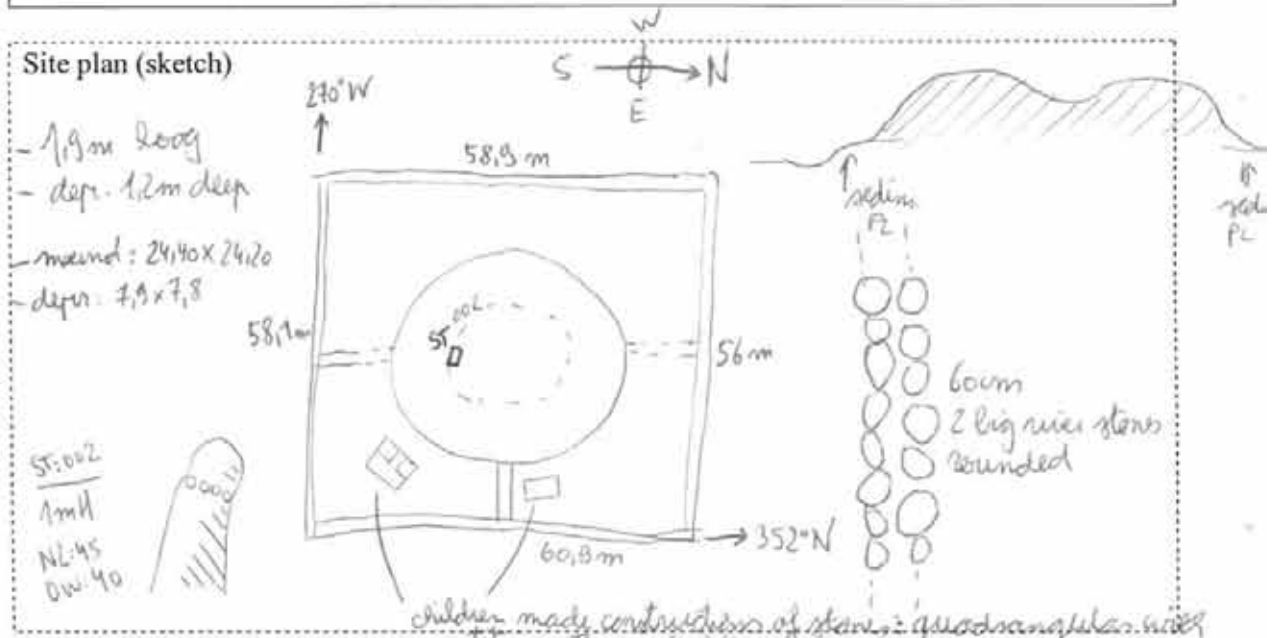
REMARKS: stele in the depression, to the E: carvings around the top (ring of round "pits")

NO STRUCTURE FICHE

Permafrost occurrence:

no information

Site plan (sketch)



children made constructions of stones: quadrangular with partitions. The people of the yurt tell us they made a plan of a house, with part for animals etc.

GHENT UNIVERSITY

site and localisation

site id - номер группы	ON-062
rayon - район	Ongudai
toponym - топоним	**Karakol**
town/village - город/деревня	
inputdate - дата	11/07/2008
input - автор	Bourgeois, J.
changes - корректировка	
by - корректировщик	

type site - тип группы	graveyard - погребение
land use - тип землепользования	grassland
topographical setting - размещение	valley
details - особенности размещения	slightly sloping valley, from east to west, on the right bank of the Karakol River: Nizhniy Sooru

site organization
объекты группы

petroglyph
петроглифы

remarks - замечания

Very complex site, composed of several lines of Scythian kurgans surrounded by a large amount of Turkic kurgans with a lot of small balbals to the north of them.
Site is in the Nizhniy Sooru valley and has already been excavated for parts by Mogilnikov, Ilyushin and Kubarev.

image - изображение: c:\Altari\images\CD_23\ON-062-000_2008-07

image
изображение

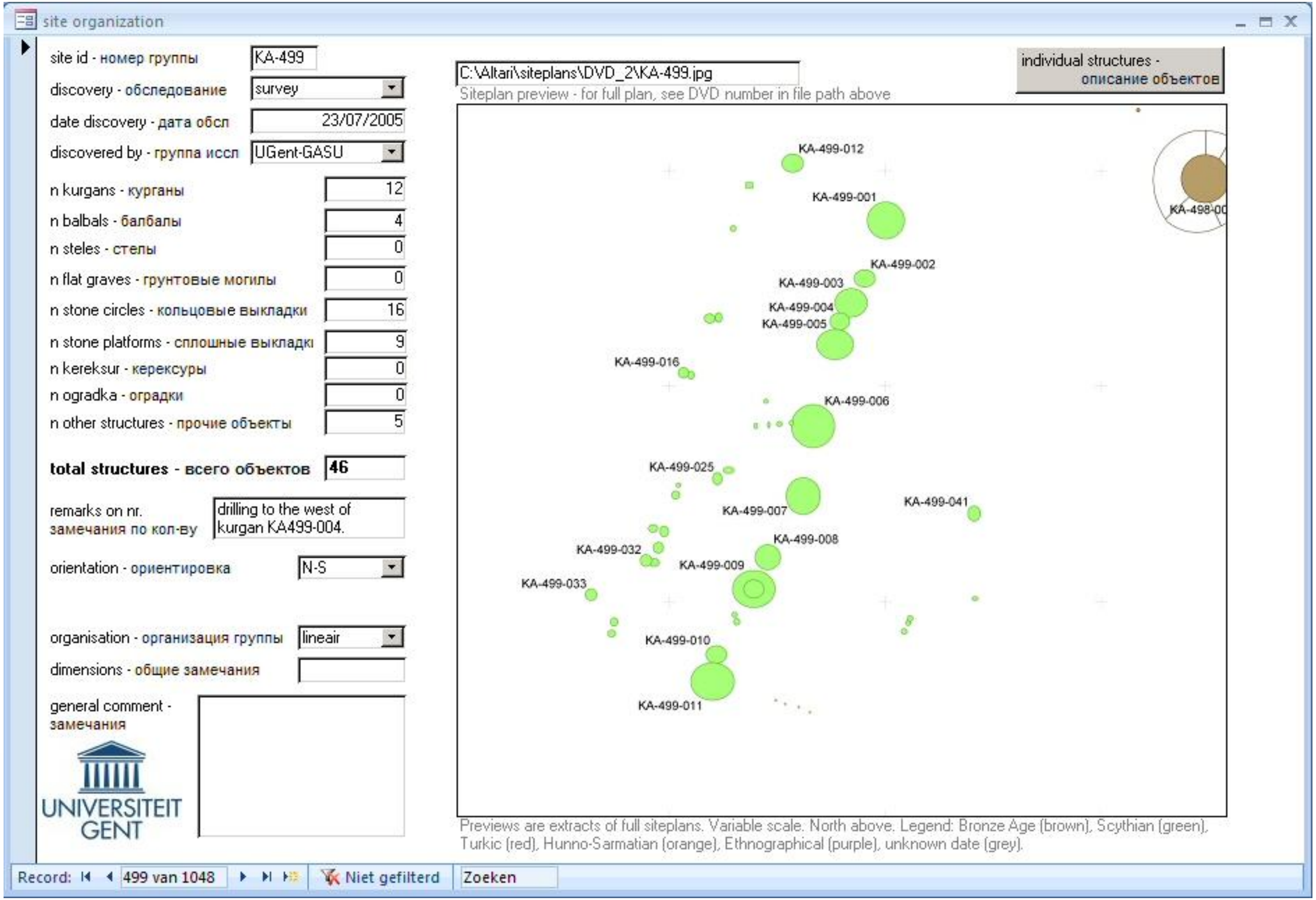
period - период	7 Iron Age - железный ве
culture - культура	Scythian - скифская куль
subperiod - подпериод	

device:	GarminVISTA
structure nr 1	ON-062-001
N1-coordinate	
E1-coordinate	
Height 1	0
structure nr 2	
N2-coordinate	
E2-coordinate	
Height 2	0

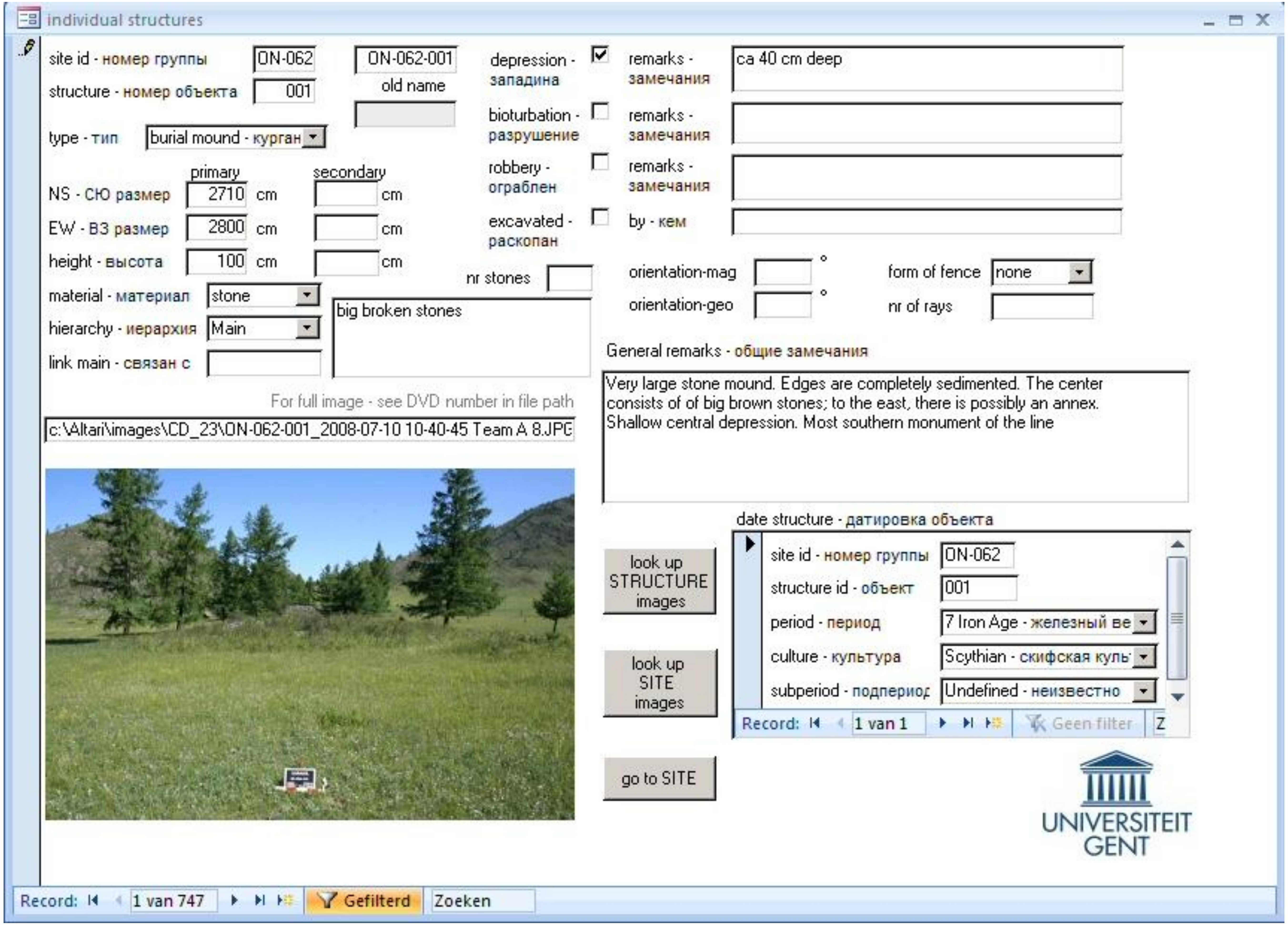
UNIVERSITEIT GENT

Record: 1 van 1 Gefilterd Zoeken

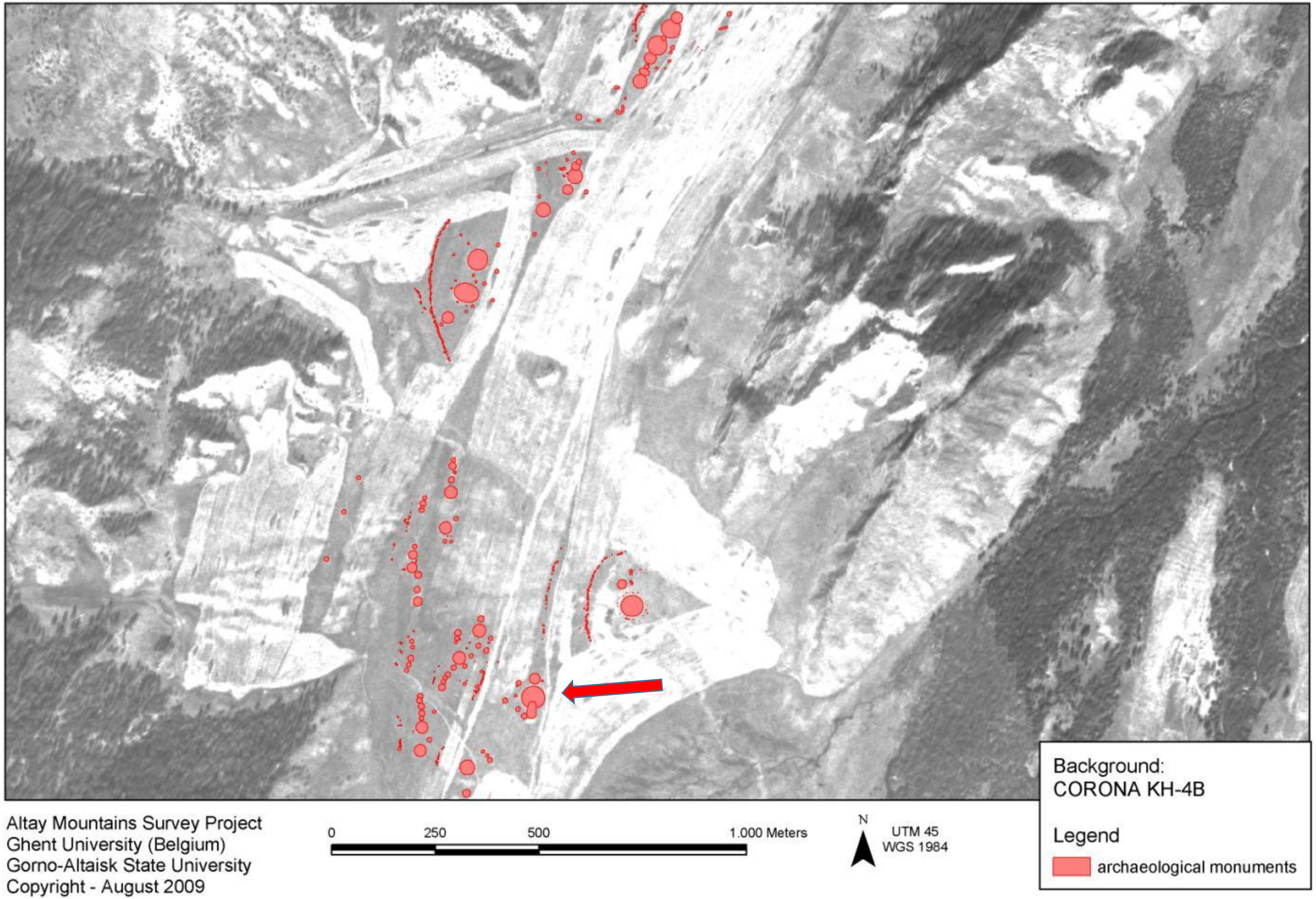
GHENT UNIVERSITY



GHENT UNIVERSITY

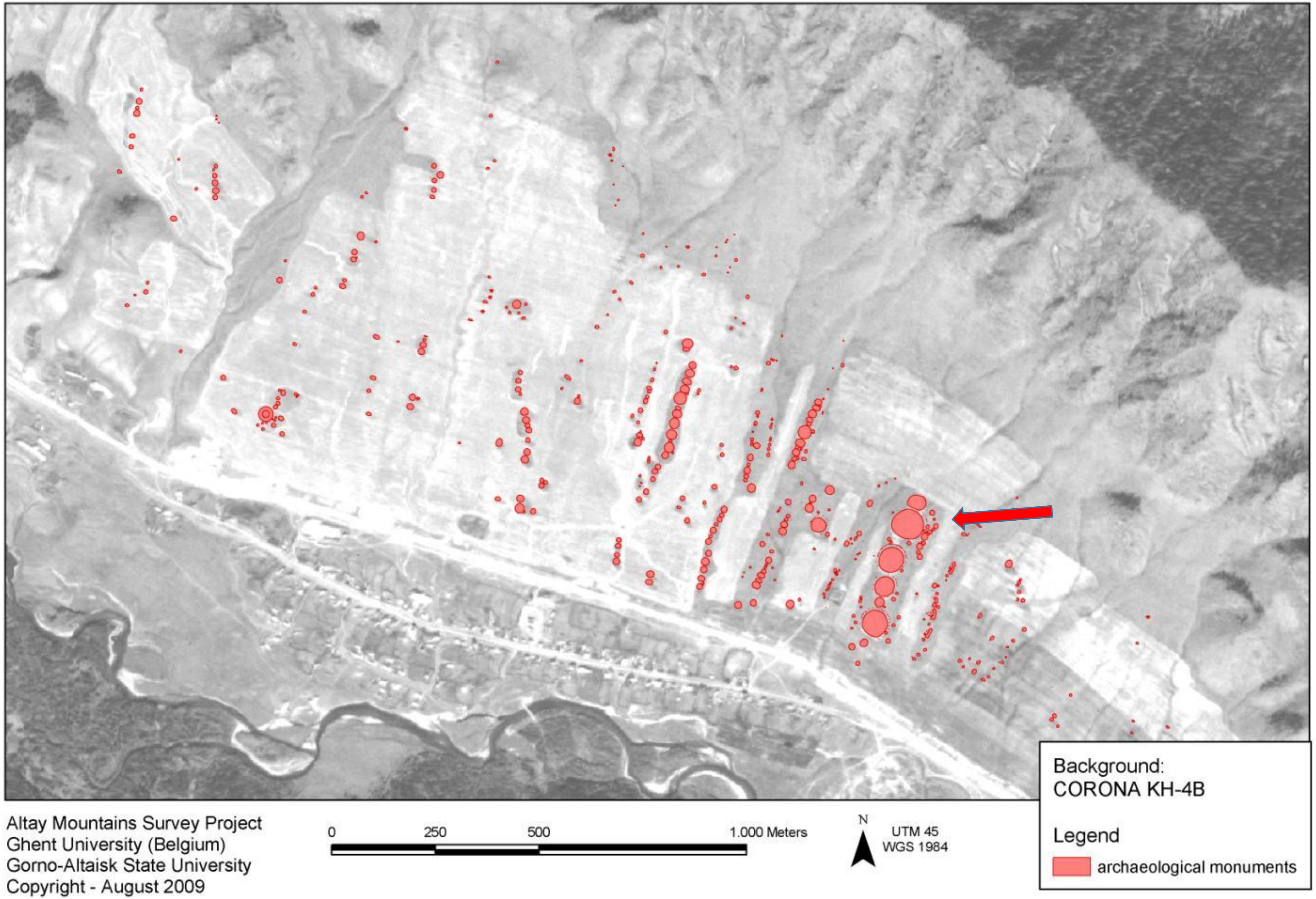

individual structures
site id - номер группы
ON-062
ON-062-001
old name
structure - номер объекта
001
type - тип
burial mound - курган
primary
secondary
NS - СЮ размер
2710 cm
cm
EW - ВЗ размер
2800 cm
cm
height - высота
100 cm
cm
material - материал
stone
hierarchy - иерархия
Main
link main - связан с
big broken stones
depression - западина
bioturbation - разрушение
robbery - ограблен
excavated - раскопан
nr stones
remarks - замечания
ca 40 cm deep
remarks - замечания
remarks - замечания
by - кем
orientation-mag
orientation-geo
form of fence
none
nr of rays
General remarks - общие замечания
Very large stone mound. Edges are completely sedimented. The center consists of of big brown stones; to the east, there is possibly an annex. Shallow central depression. Most southern monument of the line
For full image - see DVD number in file path
c:\Altari\images\CD_23\ON-062-001_2008-07-10 10-40-45 Team A 8.JPG
look up STRUCTURE images
look up SITE images
go to SITE
date structure - датировка объекта
site id - номер группы
ON-062
structure id - объект
001
period - период
7 Iron Age - железный ве
culture - культура
Scythian - скифская куль
subperiod - подпериод
Undefined - неизвестно
Record: 1 van 1
Geen filter
UNIVERSITEIT GENT
Record: 1 van 747
Gefilterd
Zoeken

Bashadar (Onguday Region, Karakol River)



GHENT UNIVERSITY

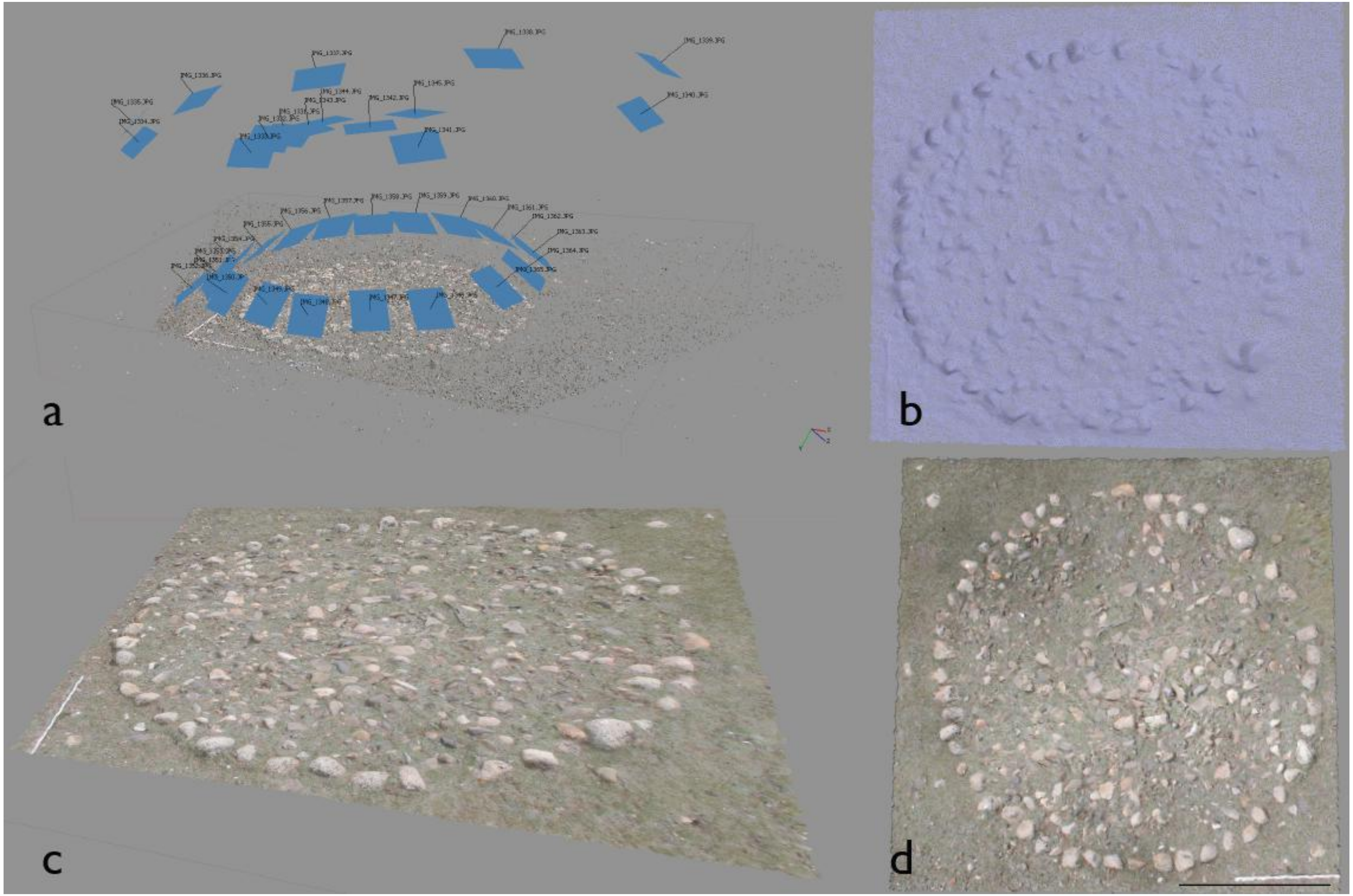
Tuekta (Onguday Region, Ursul River)



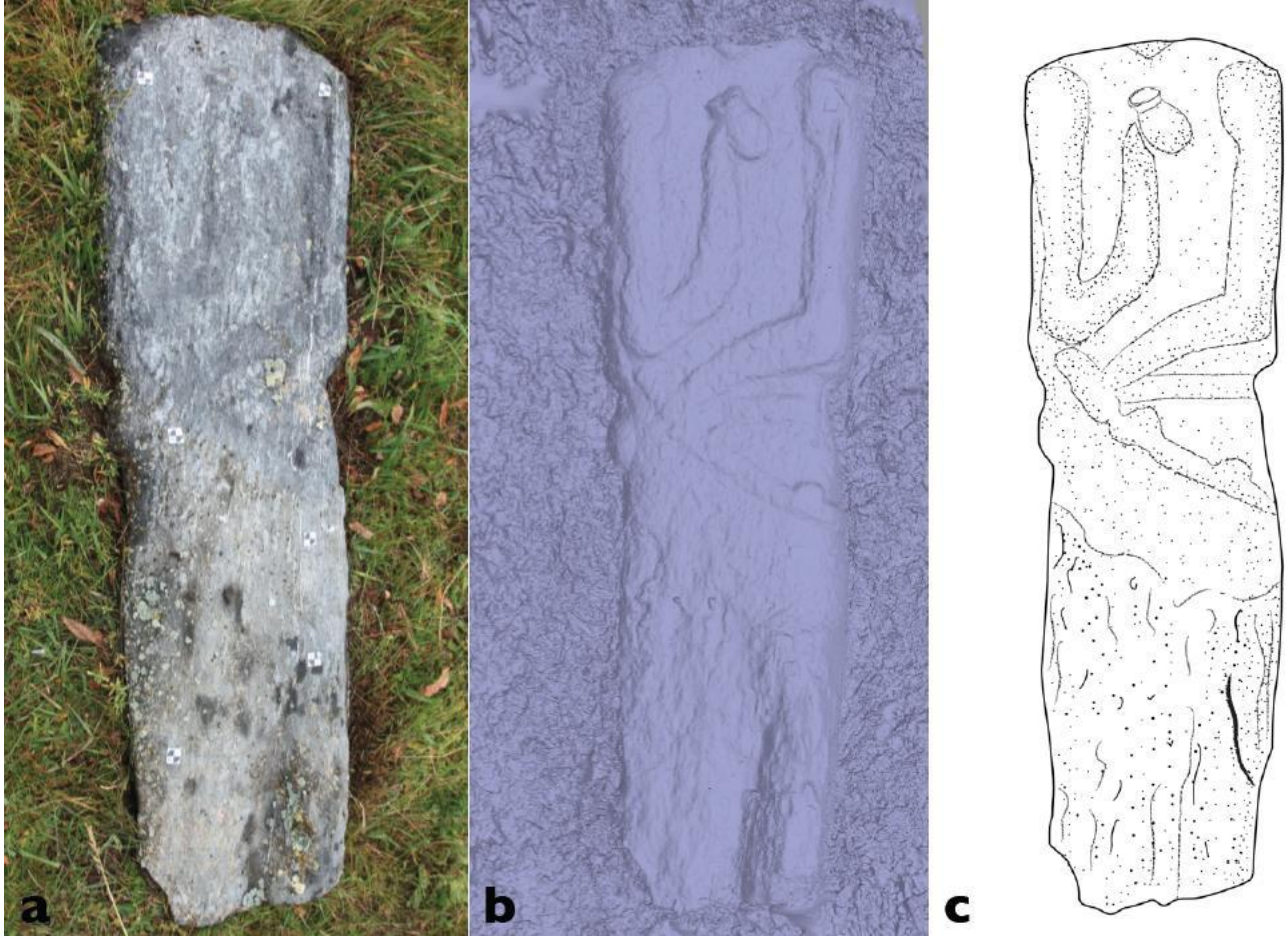
GHENT UNIVERSITY

GHENT
UNIVERSITY

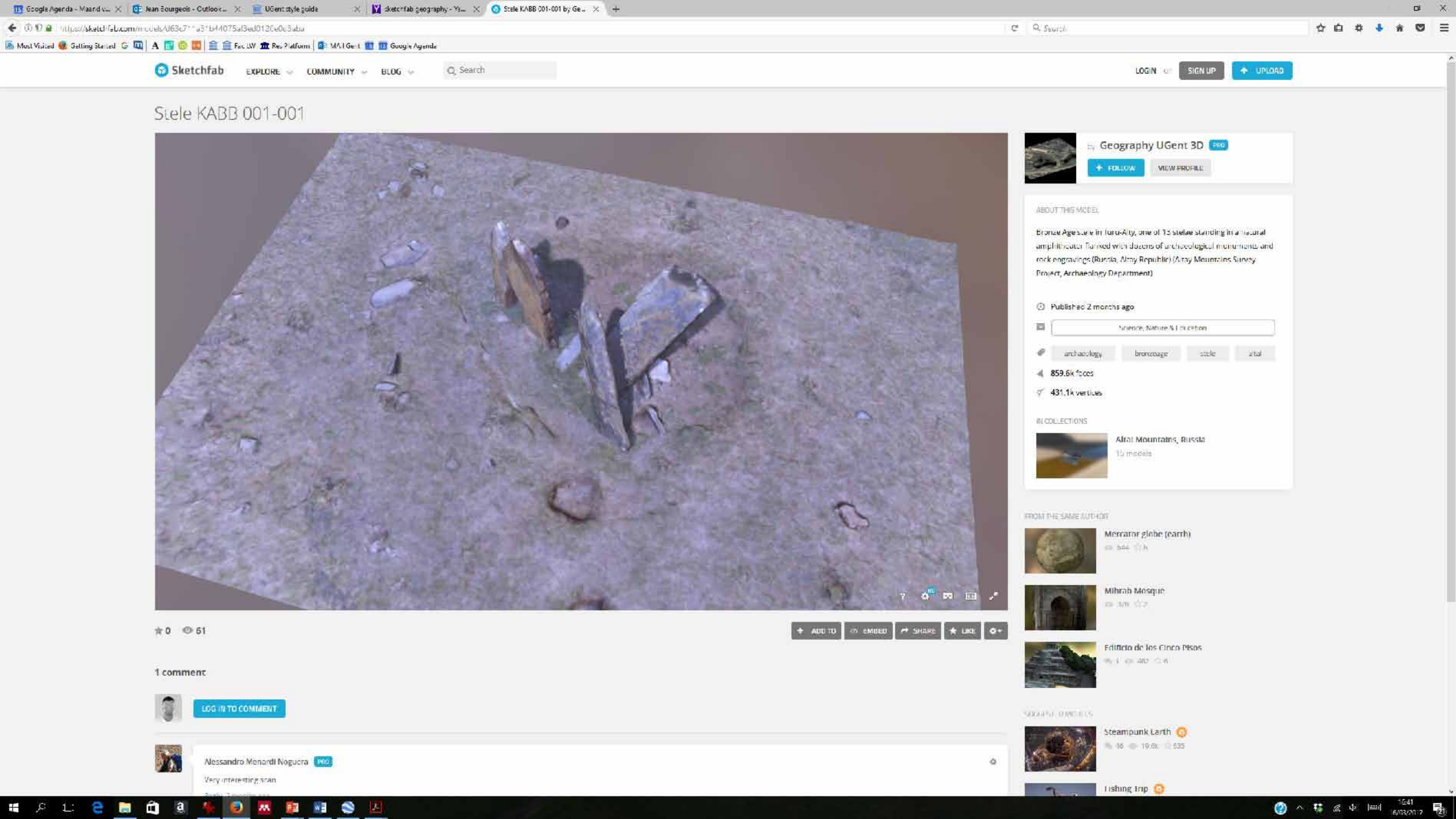
GHENT UNIVERSITY

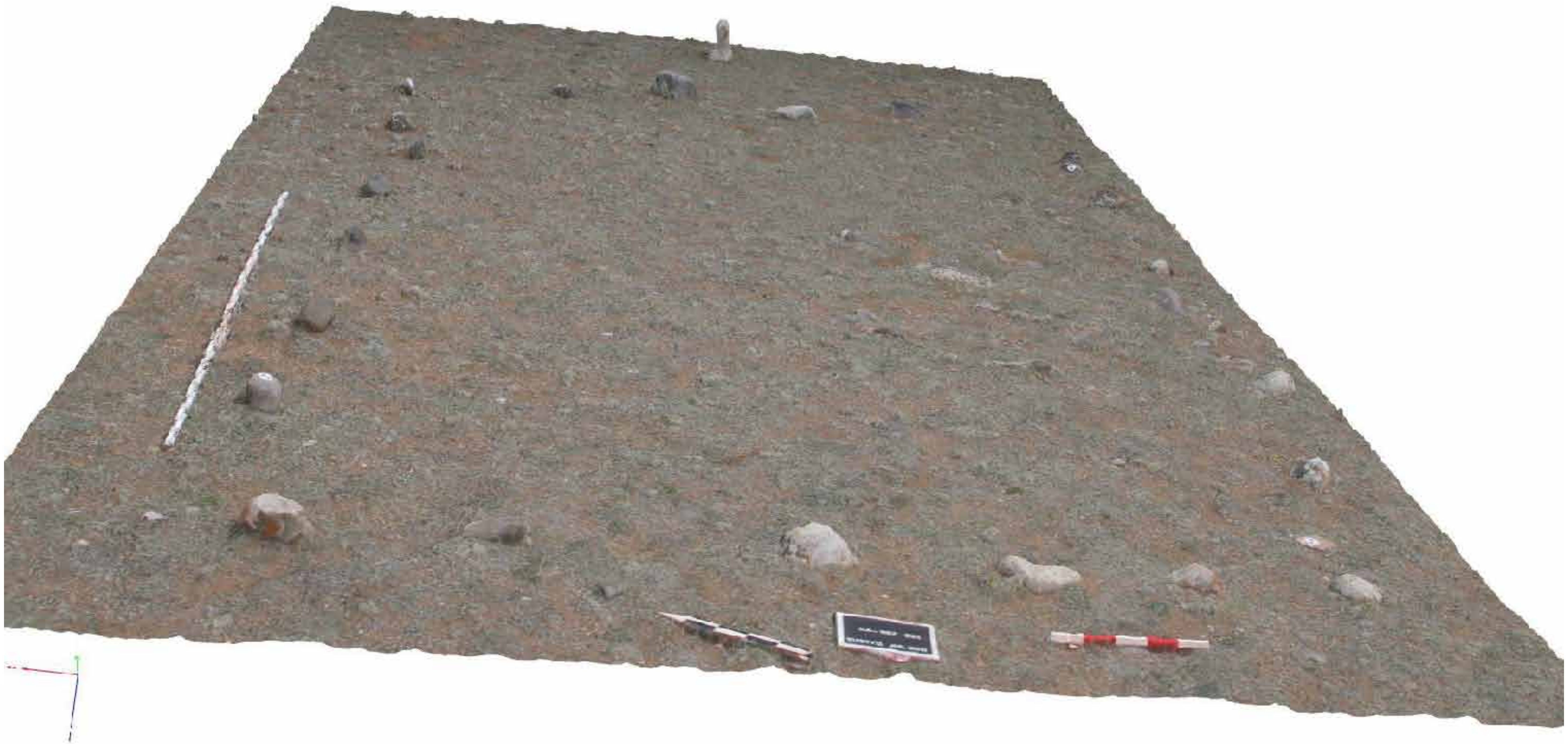


GHENT UNIVERSITY



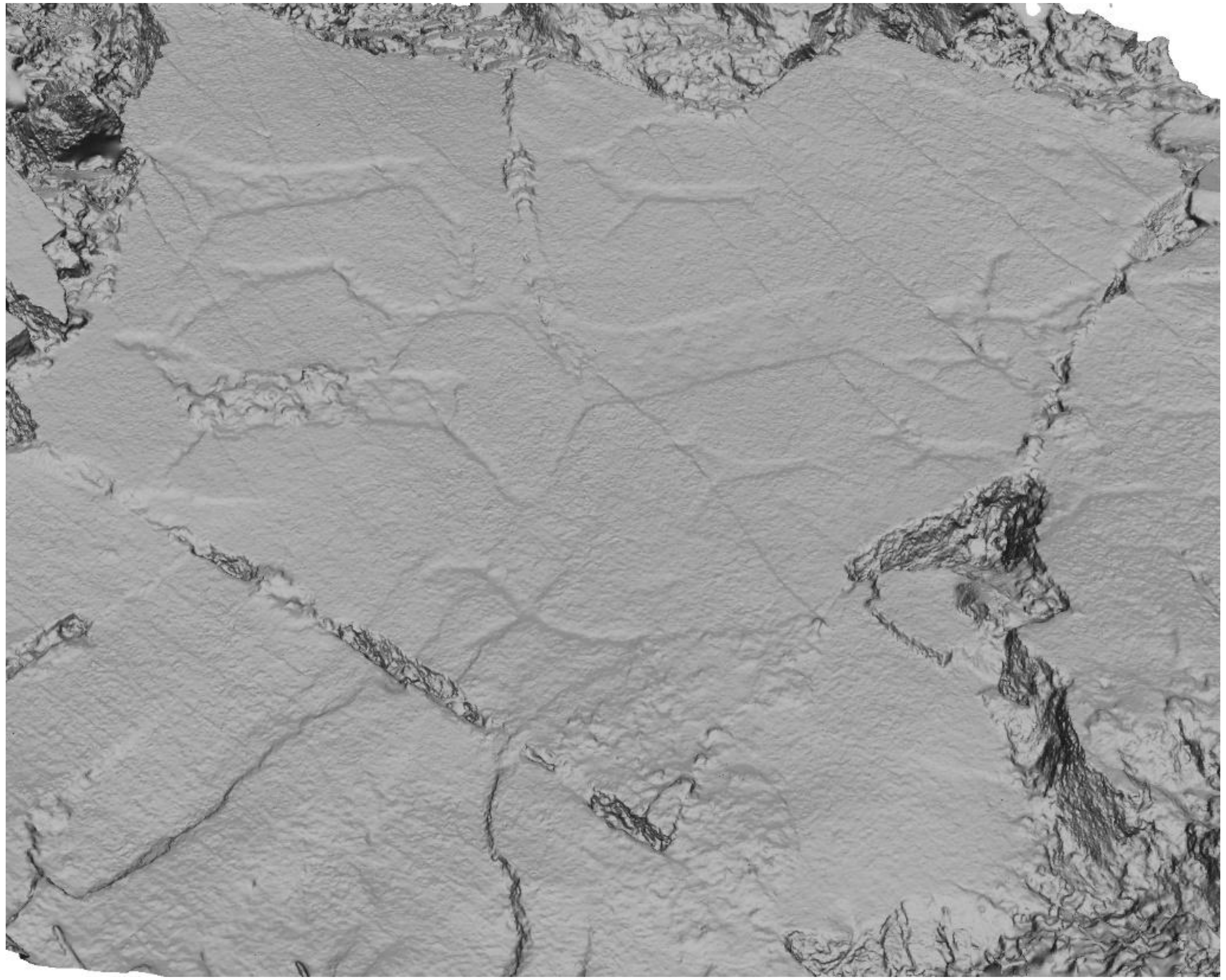
GHENT UNIVERSITY


Sketchfab
EXPLORE
COMMUNITY
BLOG
Search
LOGIN
SIGN UP
UPLOAD
Stele KABB 001-001
Geography UGent 3D
PRO
FOLLOW
VIEW PROFILE
ABOUT THIS MODEL
Bronze Age stele in Turu-Alty, one of 13 stelae standing in a natural amphitheater flanked with dozens of archaeological monuments and rock engravings (Russia, Altay Republic) (Altay Mountains Survey Project, Archaeology Department)
Published 2 months ago
Science, Nature & Education
archaeology
bronzeage
stele
altai
859.6k faces
431.1k vertices
IN COLLECTIONS
Altai Mountains, Russia
FROM THE SAME AUTHOR
Mercator globe (earth)
Mihrab Mosque
Edificio de los Cinco Pisos
Steampunk Earth
Fishing Trip
0
61
ADD TO
EMBED
SHARE
LIKE
1 comment
LOG IN TO COMMENT
Alessandro Menardi Noguera
PRO
Very interesting scan



Ghent University - Altai Mountains Survey Project - KA-967-061

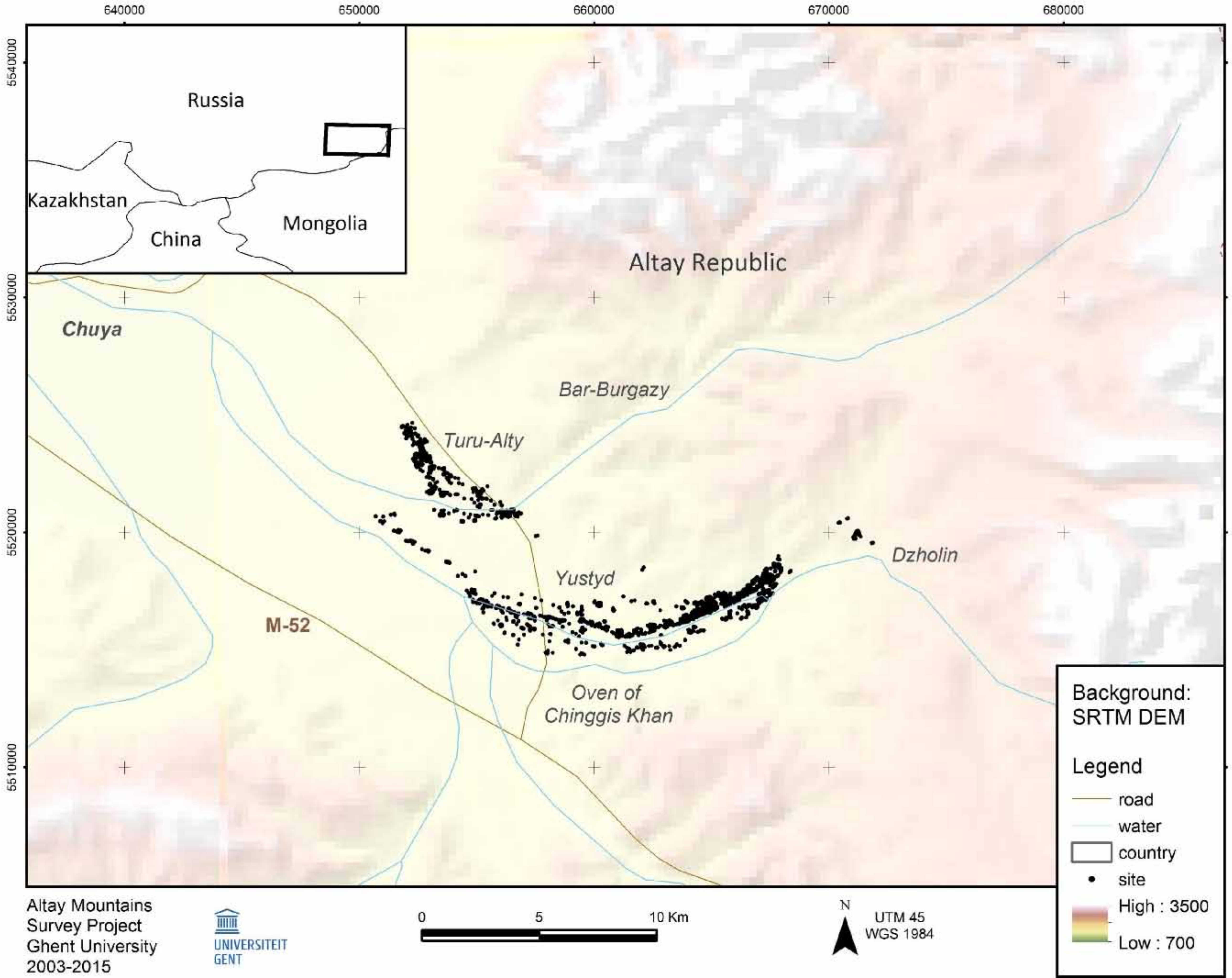
GHENT UNIVERSITY



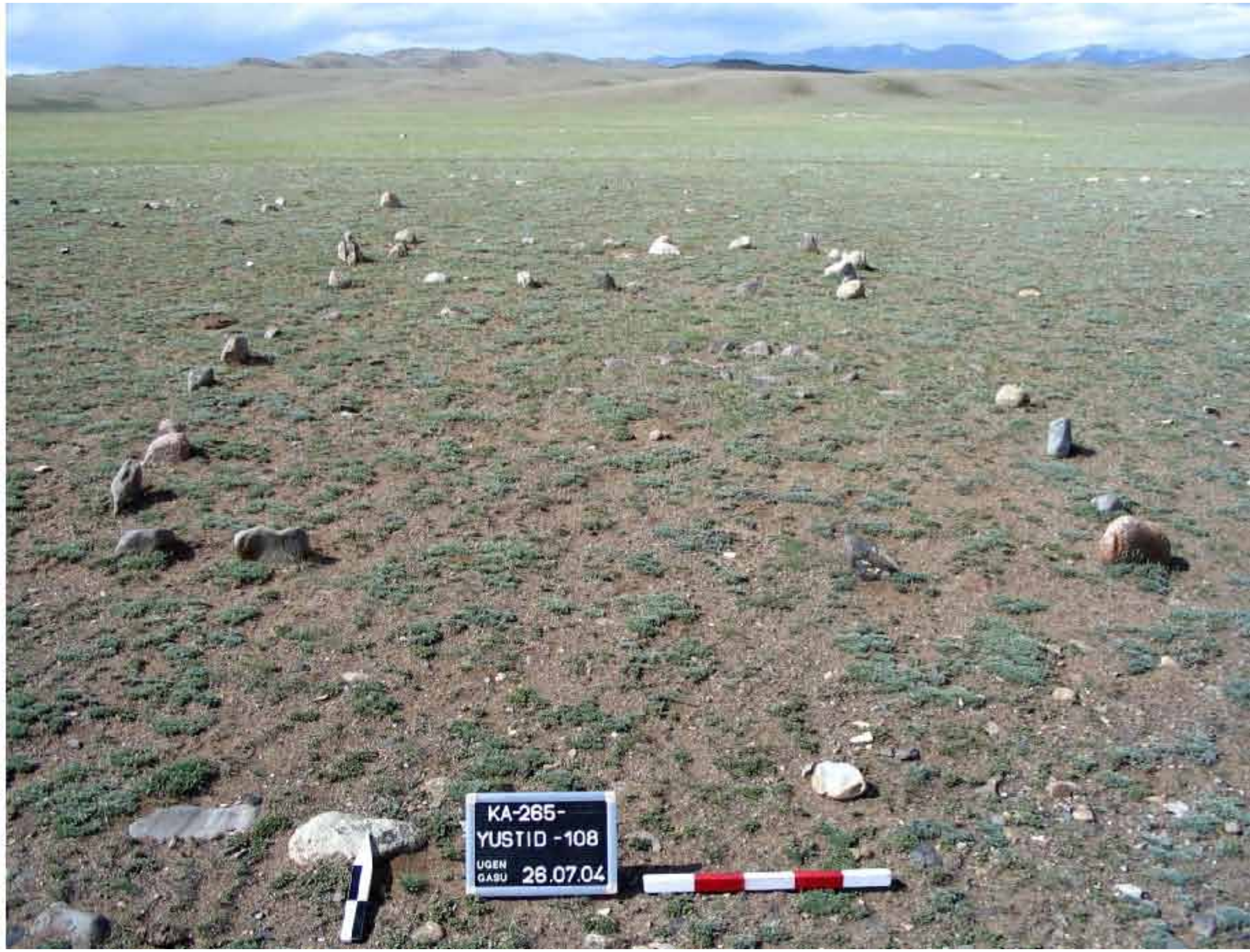
GHENT UNIVERSITY

	Hertenpaneel
Aantal foto's	49
Aantal punten ***sparse point cloud***	819977
Aantal punten ***dense point cloud***	8336780
Aantal ***faces*** **(*****mesh*****)**	797076
Aantal ***vertices***	400564

GHENT UNIVERSITY



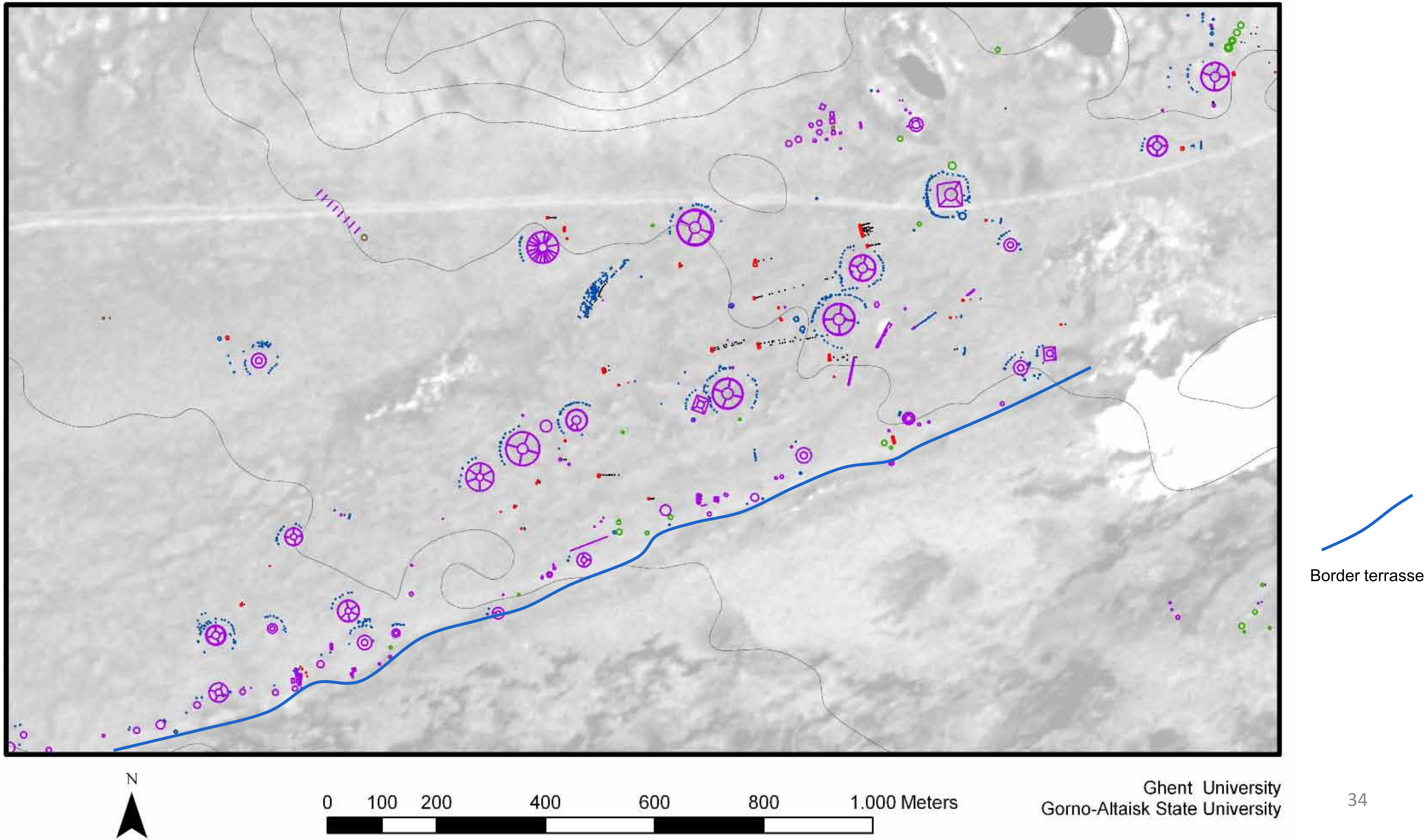
GHENT
UNIVERSITY



GHENT UNIVERSITY

GHENT
UNIVERSITY

Yustyd Survey Bronze Age kereksur and Turkic ogradki



GHENT UNIVER

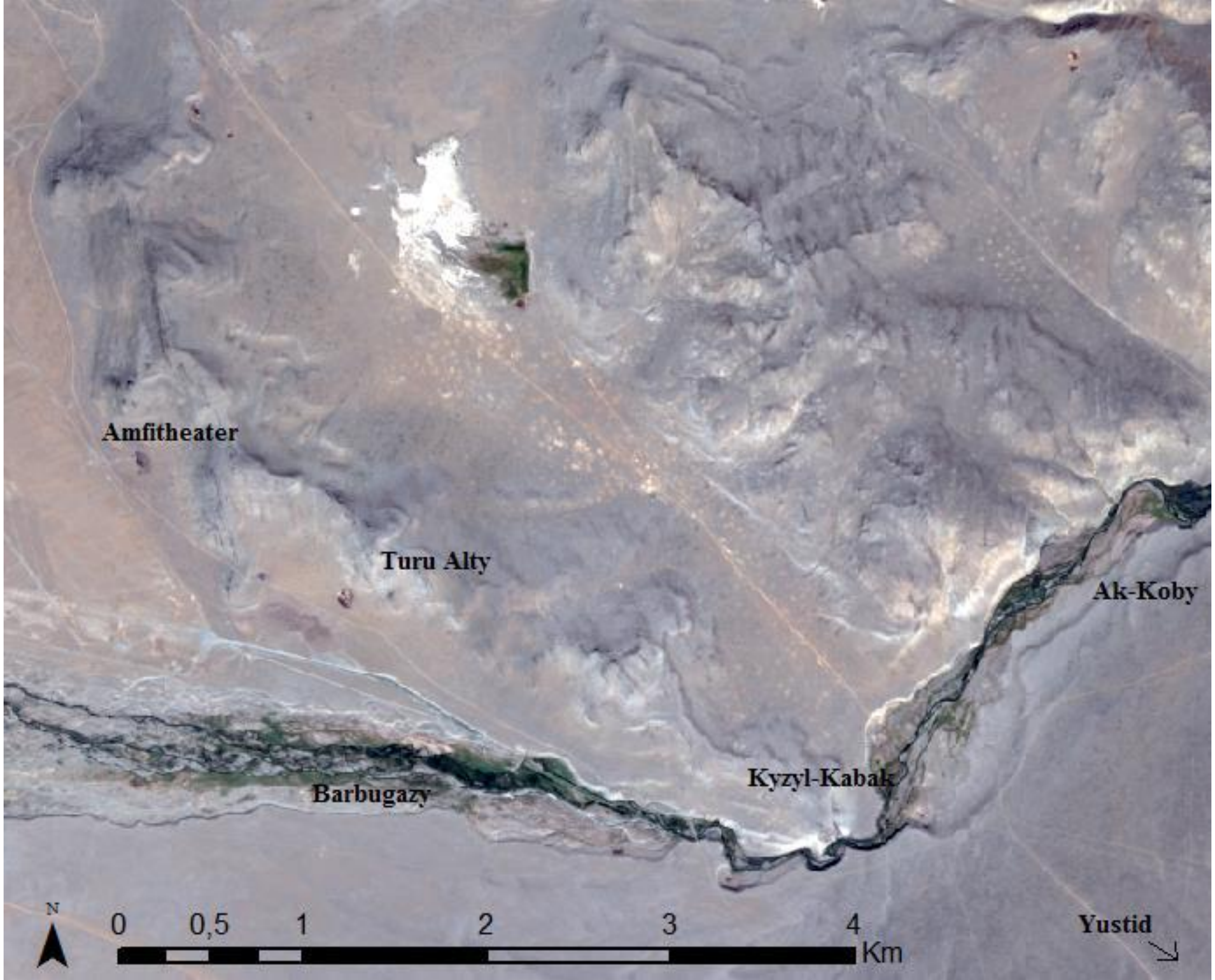
Ghent University
Gorno-Altaisk State University

GHENT
UNIVERSITY

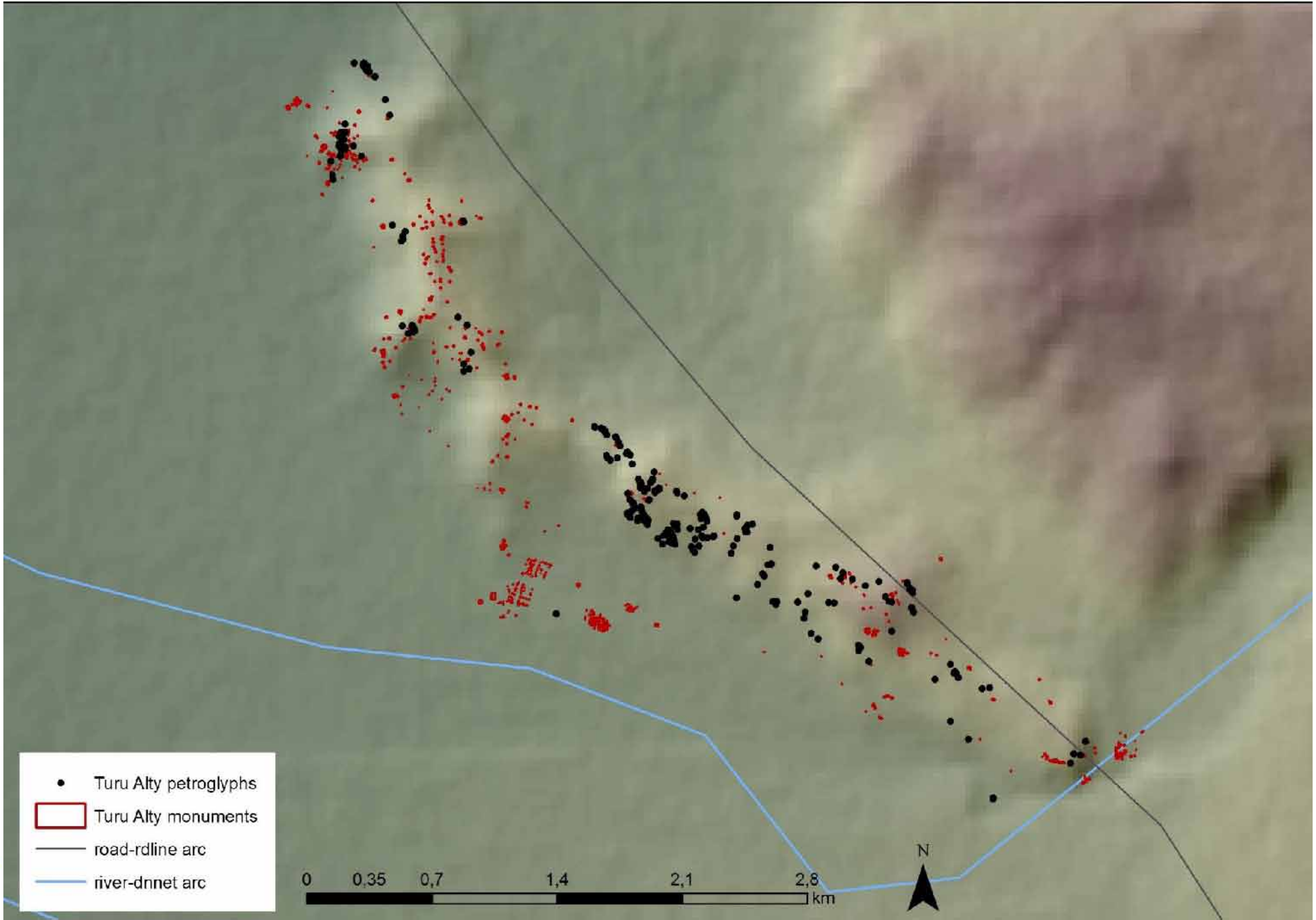
GHENT UNIVERSITY

The Turu Alty survey 2014-2015

GHENT UNIVERSITY



Amfitheater
Turu Alty
Ak-Koby
Kyzyl-Kabak
Barbugazy
Yustid
N
0
0,5
1
2
3
4
Km



GHENT UNIVERSITY

GHENT UNIVERSITY


KA BB 001
STR 005
UGENT GADU
11 07 2014

GHENT UNIVERSITY

GHENT UNIVERSITY

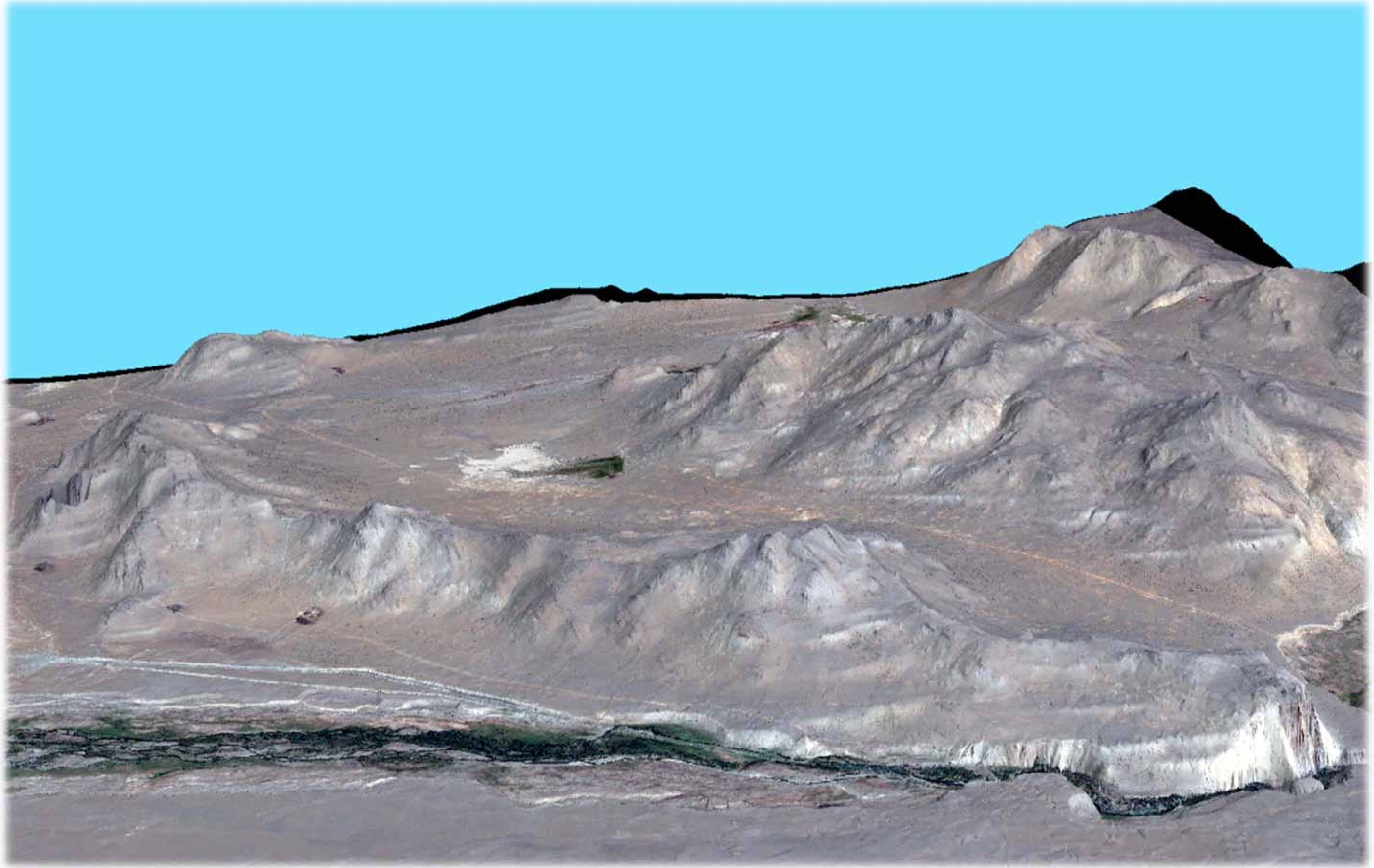
GHENT UNIVERSITY

GHENT UNIVERSITY

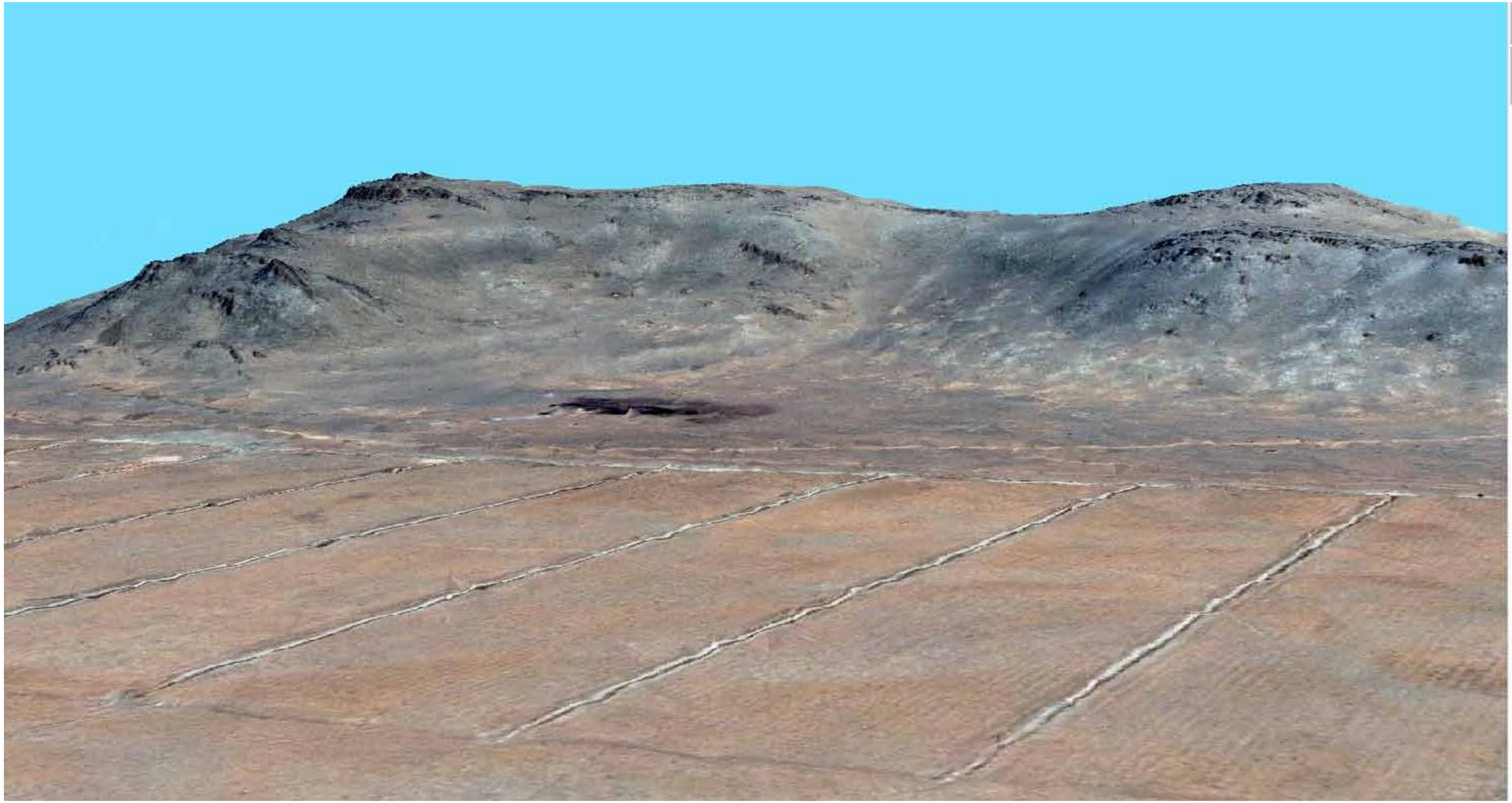
GHENT UNIVERSITY

Orthofoto Turu Alty

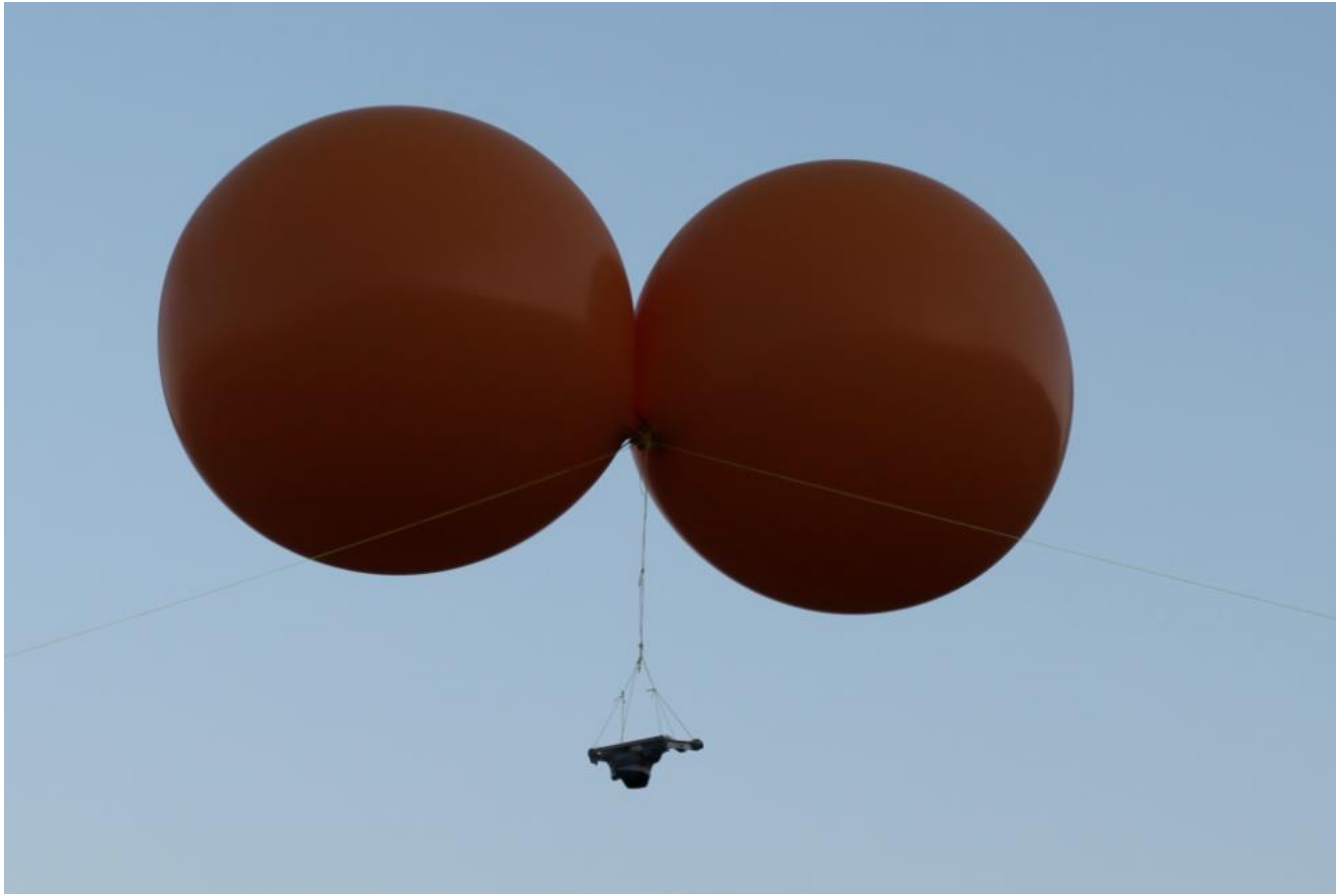
GHENT UNIVERSITY



GHENT UNIVERSITY

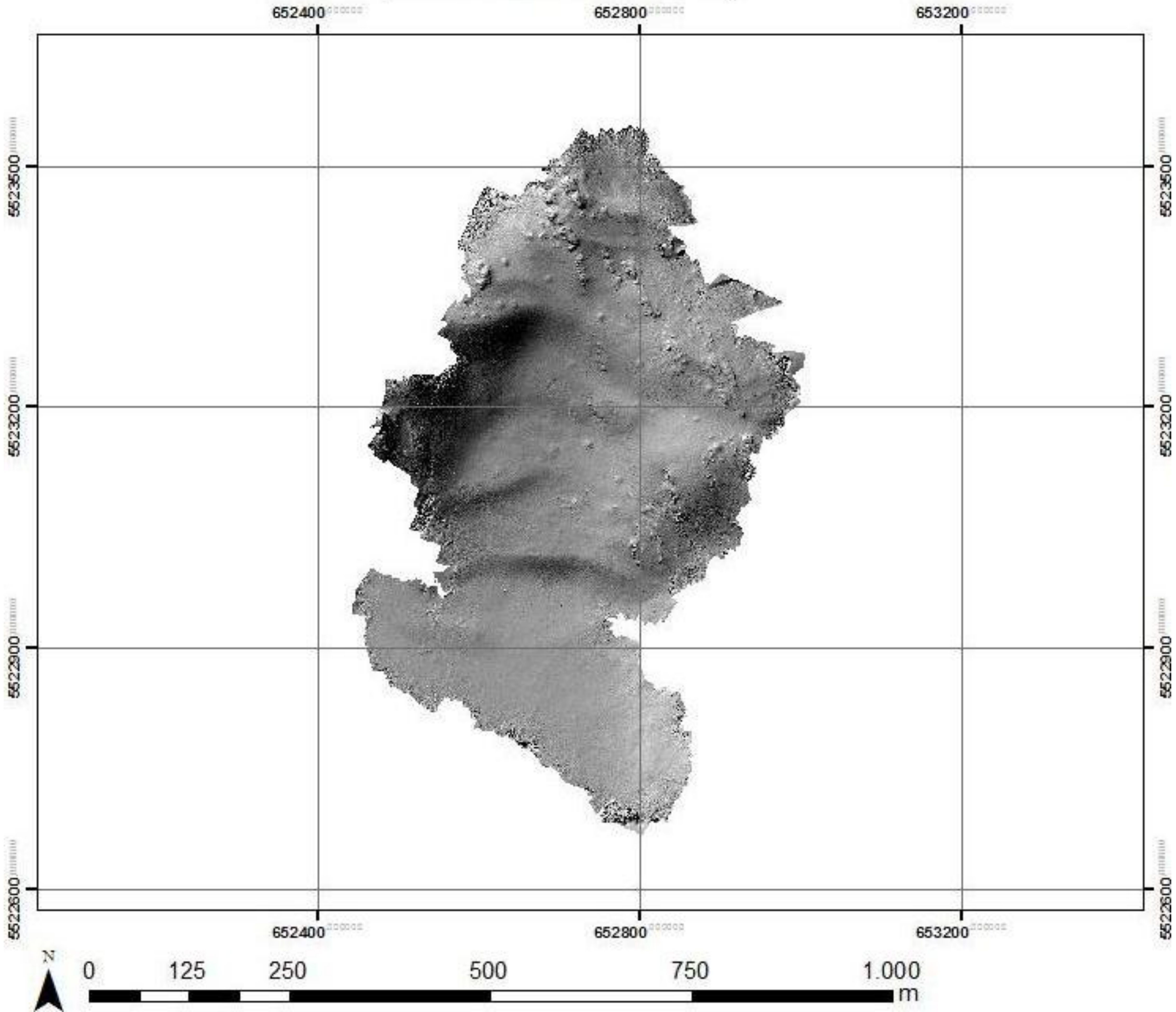


GHENT UNIVERSITY

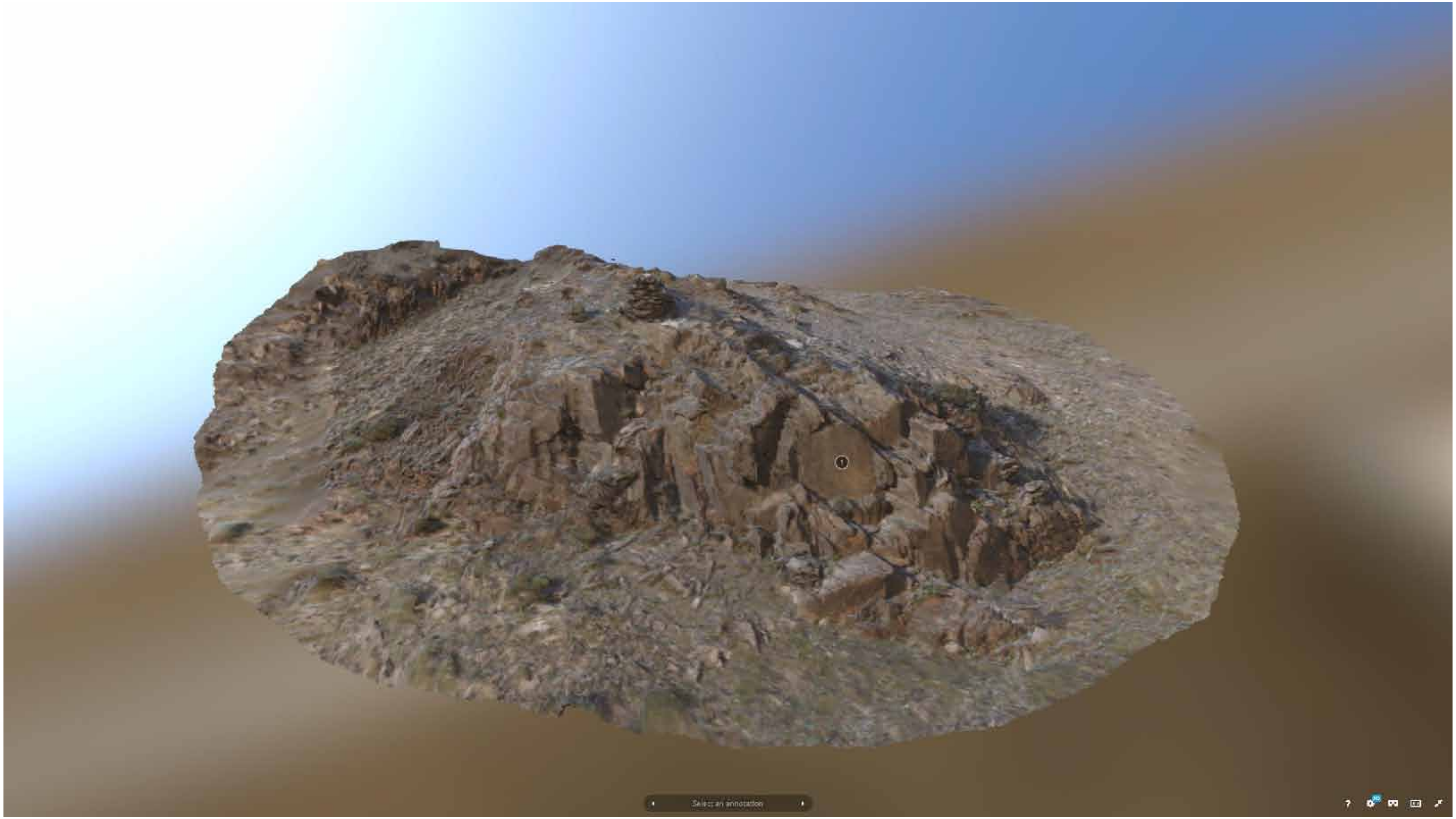


GHENT UNIVERSITY

Hillshade theater

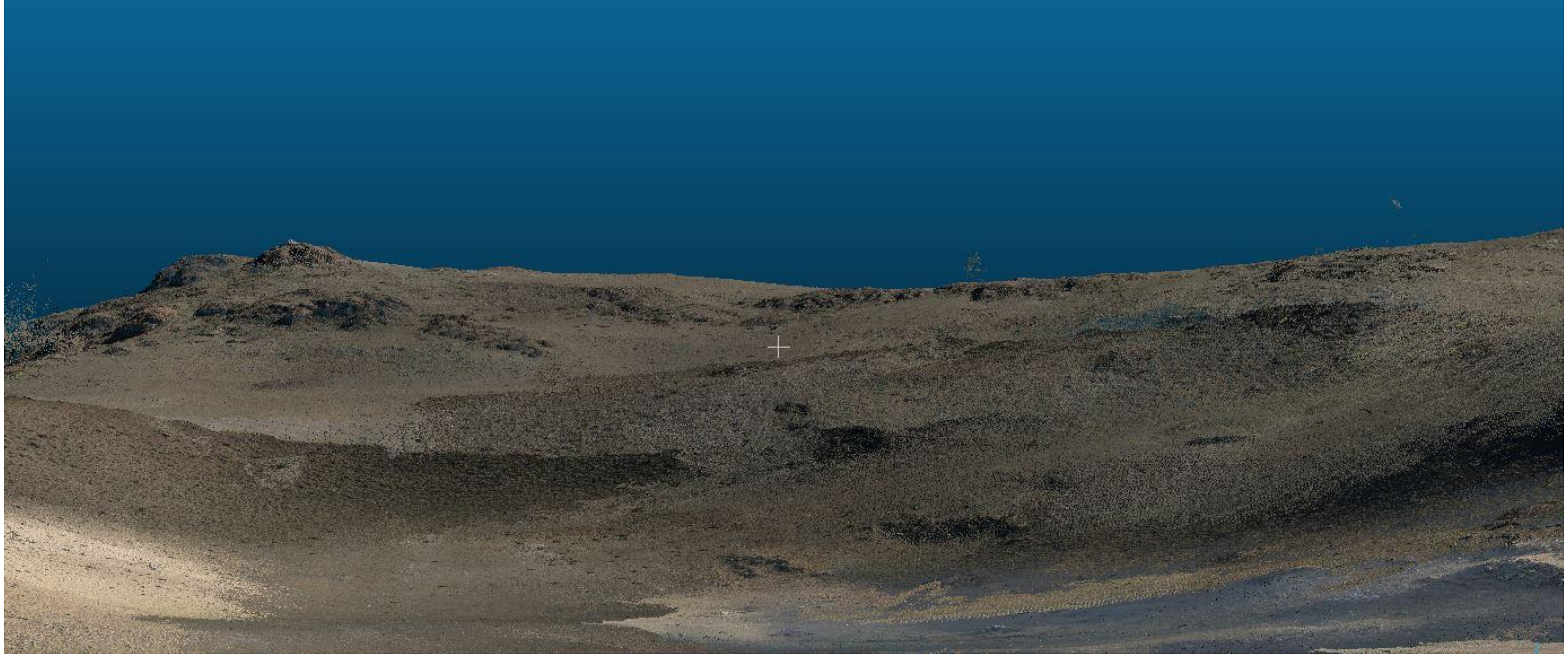


GHENT UNIVERSITY



GHENT UNIVERSITY

GHENT
UNIVERSITY



GHENT UNIVERSITY


Thank you
!

GHENT
UNIVERSITY

"The Christian Reuse of the Egyptian Temples and keeping Methods Using Remote Sensing and GIS Techniques In Luxor City, Egypt"

Osama Wafa, Abdelaziz Elfadaly,Antonella Guida, Pier Giorgio Spanu, Mohamed Abouarab, Rosa Lasaponara.

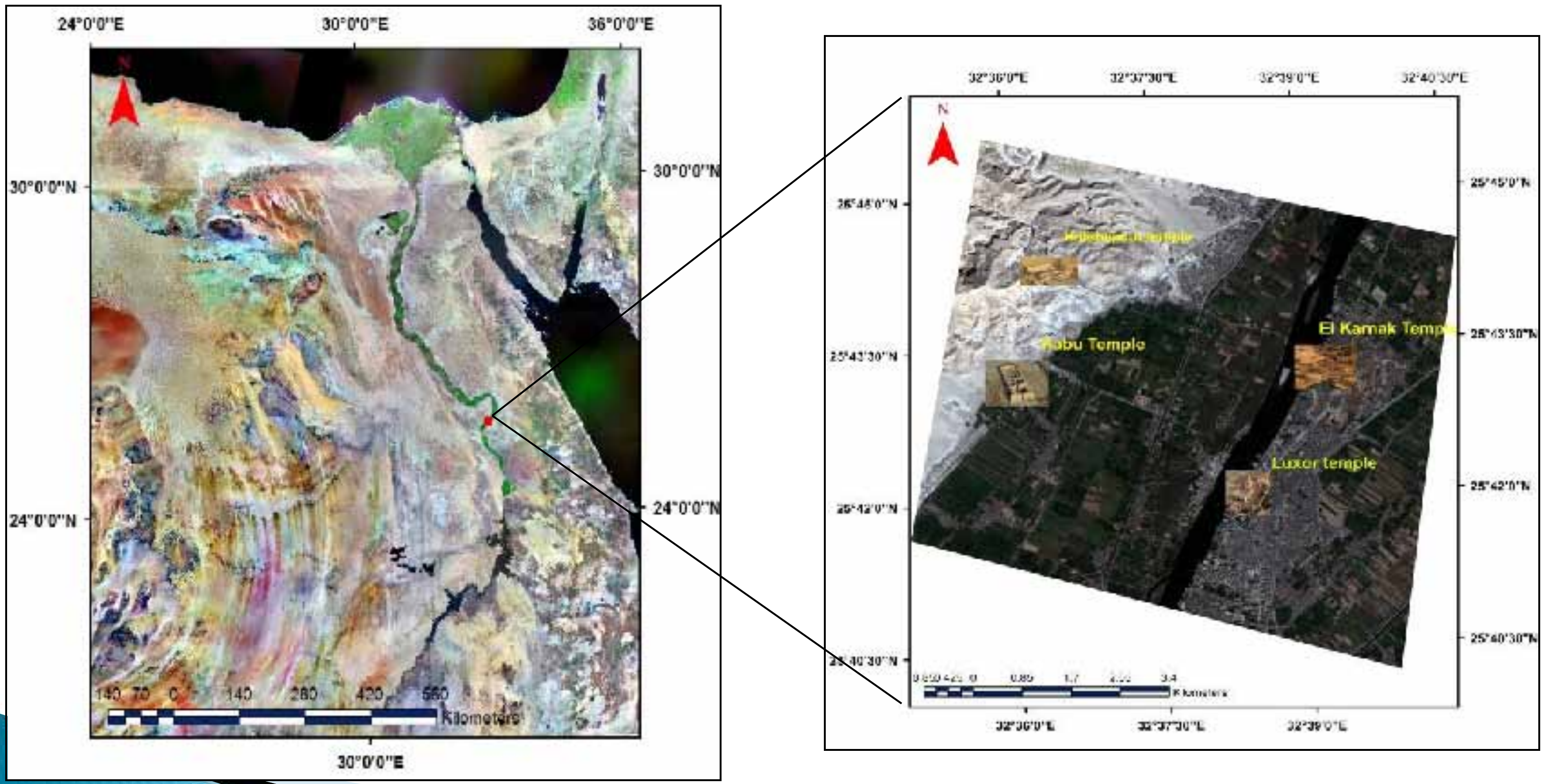
Speakers: Wafa and Elfadaly

Workshop
Remote Sensing for Cultural heritage. Beyond Europe
Paphos (Cyprus), 20 March 2017

Introduction

Study Area

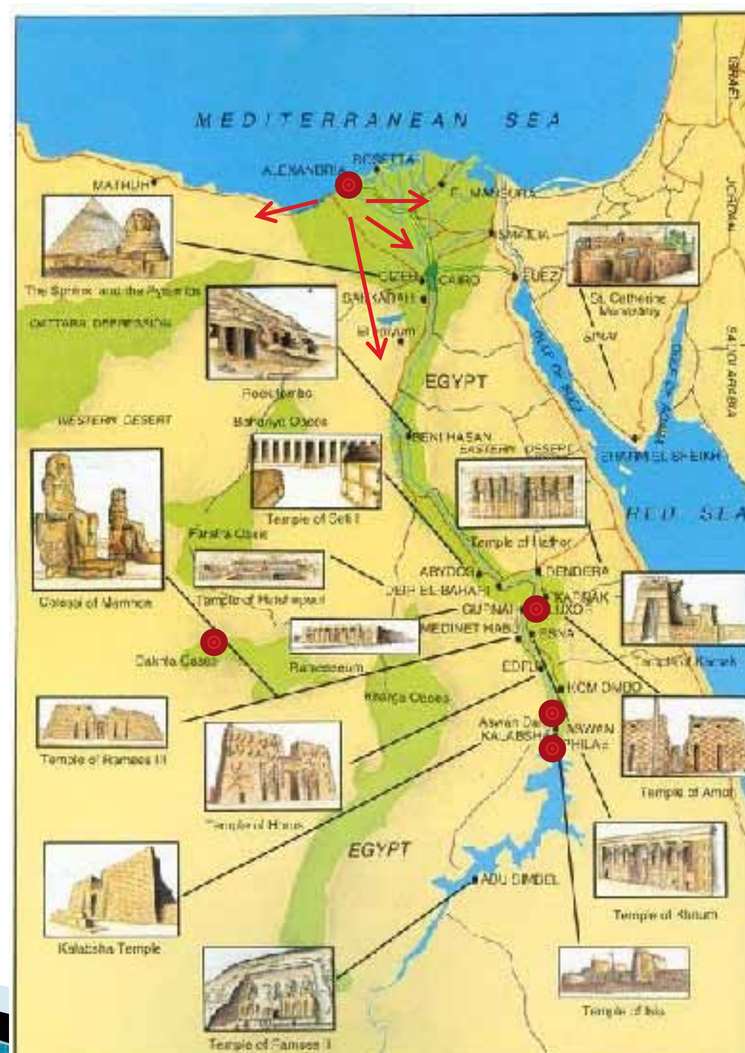
Luxor city is located 600 kilometres (DMS Long 32° 38' 22.6932'' E, DMS Lat 25° 41' 14.0748'' N) south of Cairo on the west and east banks of the River Nile



RSCy
'Fifth International Conference on Remote Sensing and Geoinformation of Environment' 20-23 March, 2017 - Cyprus

Introduction

During the fourth century paganism and Christianity coexisted in Egypt and especially in Alexandria with the balance shifting from one side to the other through the century as reflected in the major places of worship.



Introduction

There aren't previous studies talked about "The Christian re-use of holy Egyptian temples", in detail Luxor city, which give this study an important role.

- Reusing temples as churches were such a phenomenon which started to appear strongly from the fourth century.

- In Egypt, The era of the Emperor Diocletian had witnessed the roughest persecution of Christianity and Christians.

- In AD 303 Diocletian tried to clear the whole empire from Christians, so he ordered to collect all the copies of the Bible in order to burn them all, he destroyed churches and prevented Christians from meeting or practicing their worship.

Introduction

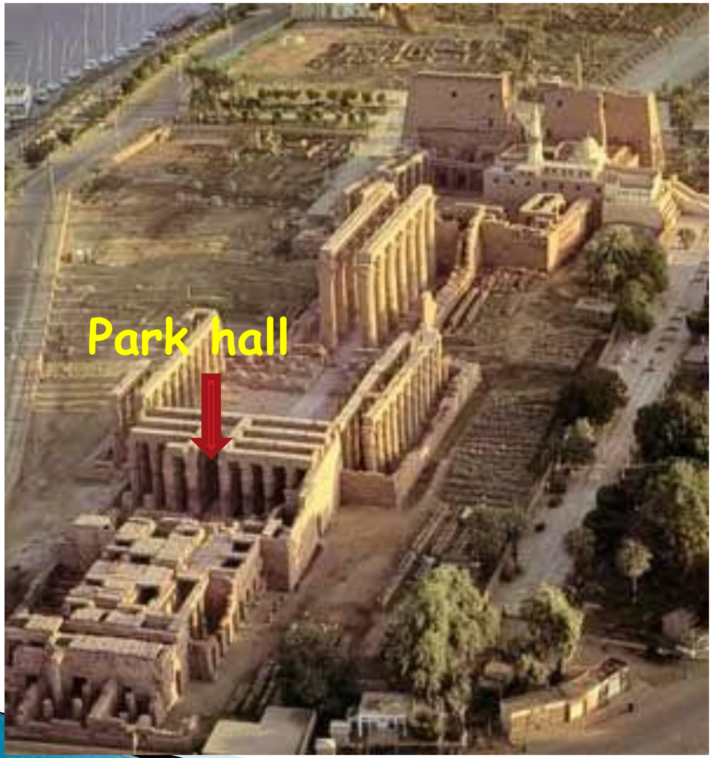
- After that under the Emperor Constantius, it was a golden era to the Christians, as in AD 312 the new emperor issued a new decree (Milan's famous decree).

- One of the most famous examples of the reusing of the temple as a church was that decision of Emperor Constantius II to rebuild the temple of Caesareum in Alexandria AD 346-AD 356 and turn it into church to use as the Cathedral, because the other churches were too small to hold the large number of Christians in that time.

- About Upper Egypt, temples distractions were still in full swing in the fifth century, at Luxor remains of churches have been found, whereas at Karnak temple

The Christian Reuse of LUXOR temple

Egyptian temples were considered to be a house for the god. Many types of evidence can tell us more about what the situation inside temples was at this time, they usually suggest that the choice to reuse temples was pragmatic rather than ideological, and show that many temples have turned either abandoned or were reused for purposes other than churches.

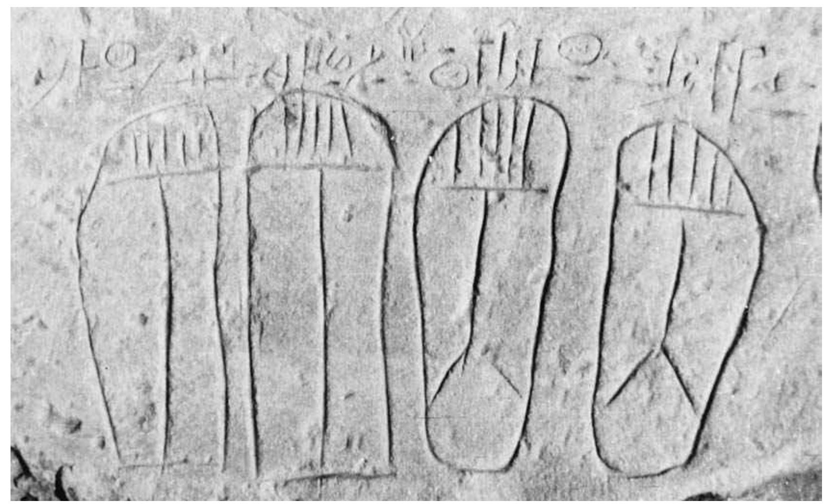


The using part in the temple

The Christian's symbols and paintings in Luxor temple

The Christian Reuse of KARNAK temple

Like many Egyptian temples, there aren't only official inscriptions, but also unofficial graffiti leaved by ancient priests. The majority of the 334 graffiti are founded on the surface blocks that cover the colonnade surrounding the court of Khonsu's temple at Karnak.



Christian cross and graffiti drawing over the East Colonnade of the Court, Rows A and B. Looking North, El Karnak temple

The Christian Reuse of MEDINET HABU temple

The graffiti within Medinet Habu temple, appear especially in the Treasury and the slaughter house. The dated texts range from 2 of Nektanebo II (359 B.C.). There are also numerous Coptic period texts and designs.

The Christian's symbols and paintings at the north part of Luxor temple

The Christian Reuse of the HATSHEPSUT temple

Papyri provided different methods of the reusing temples, including some rare cases of secular reuse. Hatshepsut temple one of the examples which show also the reuse of temples as churches or Christian shrines.

Depicts Coptic symbols, including early Coptic crosses with olive branches (Temple of Hatshepsut at El Deir elBahri).

So

- Reusing temples in the fourth century were such as a Christian triumph over paganism.
- The reusing temple as a church were almost a formal decision which taken always from the emperor himself, because such as these temples are considered secured places.

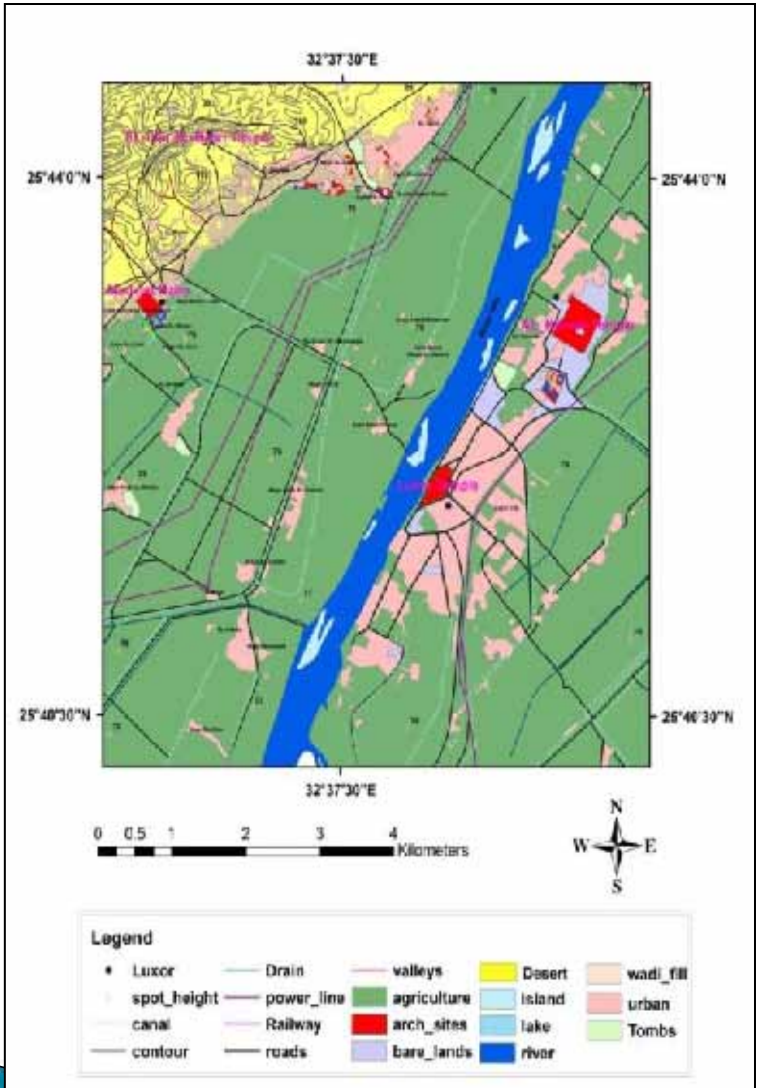
- These individual acts from those people who were thinking that they are protecting their religion by destroying and damaging the pagan temples, they were indeed far away from Christianity and its manors.

- Old buildings like temples had been reused for other purpose; not only reused as churches, For example a series of churches were built in the pharaohs of Egyptian temples so that their columns could be used to divide the church into three or more aisles, as happened with the Khonsu temple at Karnak (north of Thebes or Luxor).

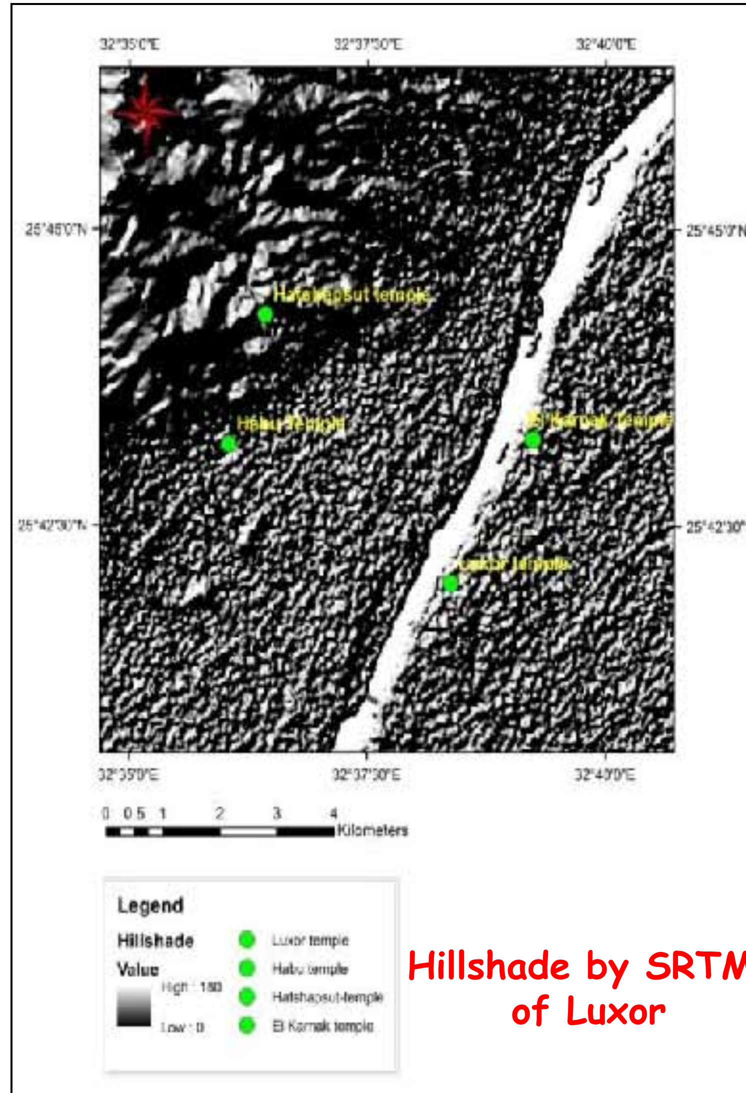
- Concerning the topic of the reusing temples as churches in Egypt, in my opinion three reasons must added;

I. Temples were too much bigger than any place in the city and once the new religion needed a bigger place
II. A lot of towns in the city in that period could not find the place to expand and built more religious building so they tried to build small chapels or reuse the space of the temple to reconstruct another religious building on its closure.
III. Bad economic situation of the Christians in this period.

Problem definition

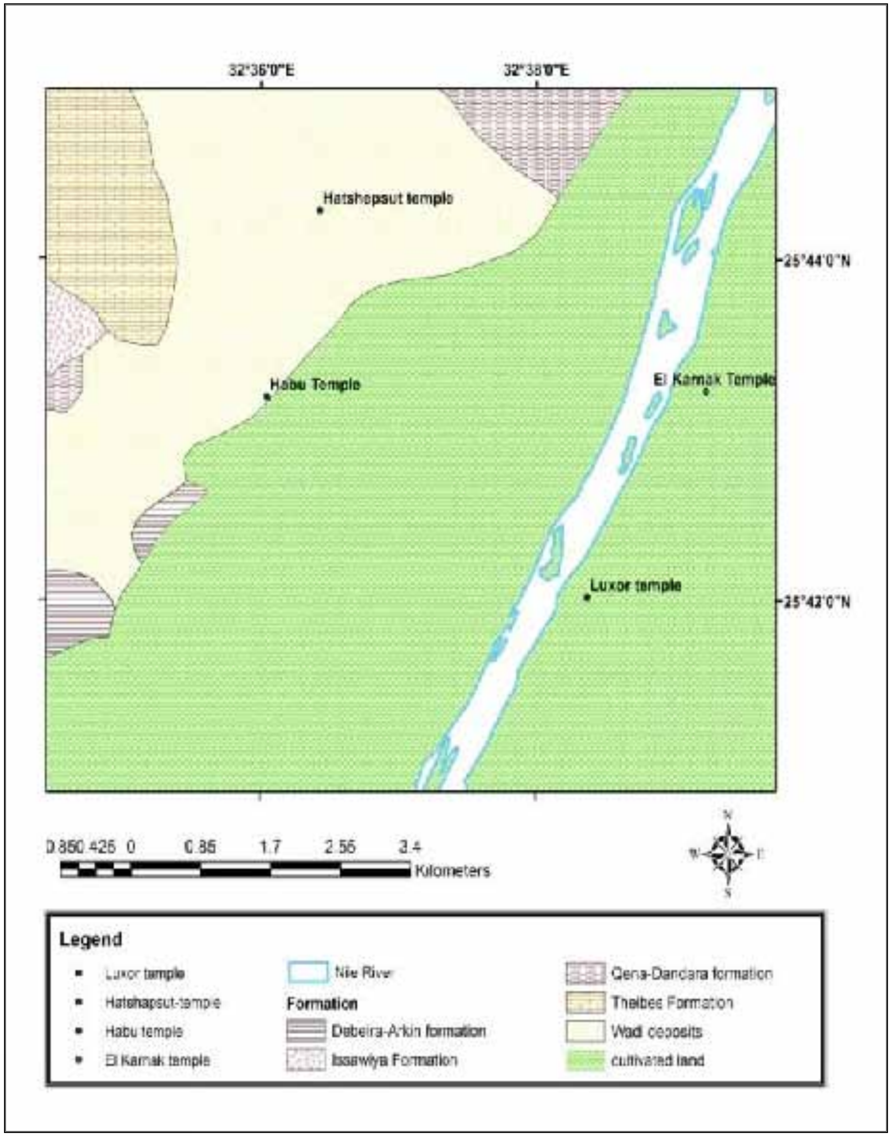


Topographic map of Luxor



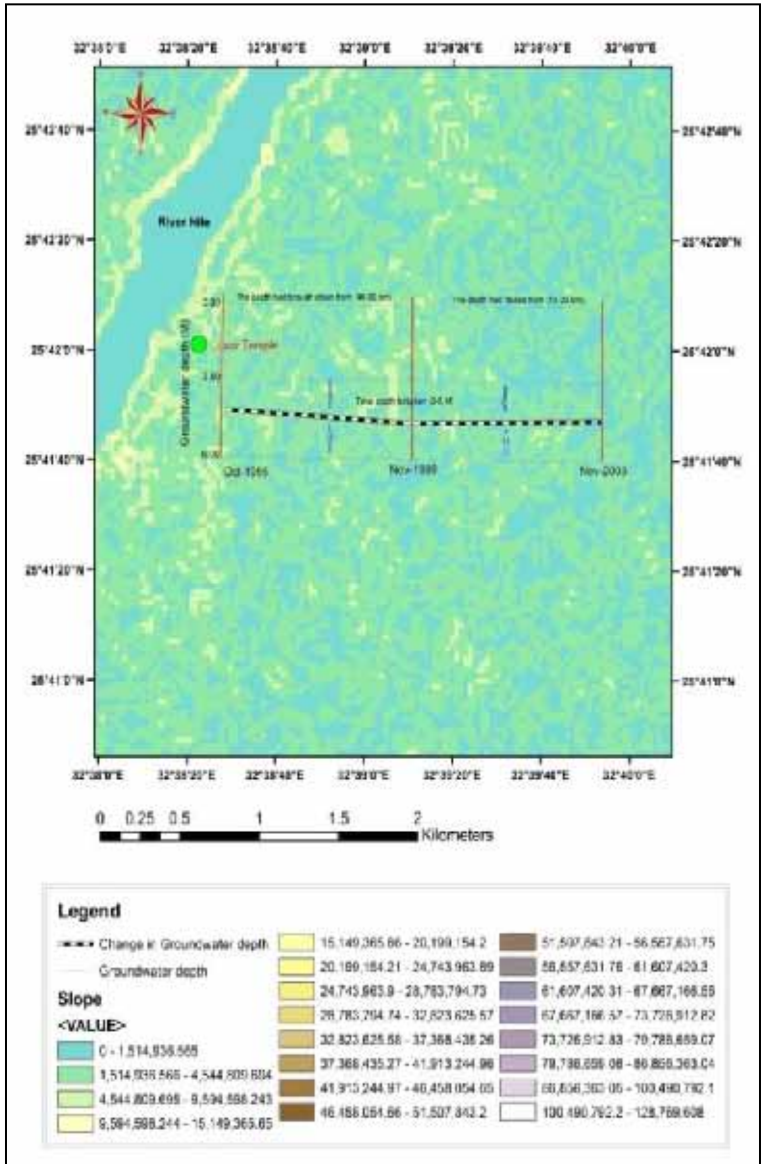
Hillshade by SRTM of Luxor

Problem definition



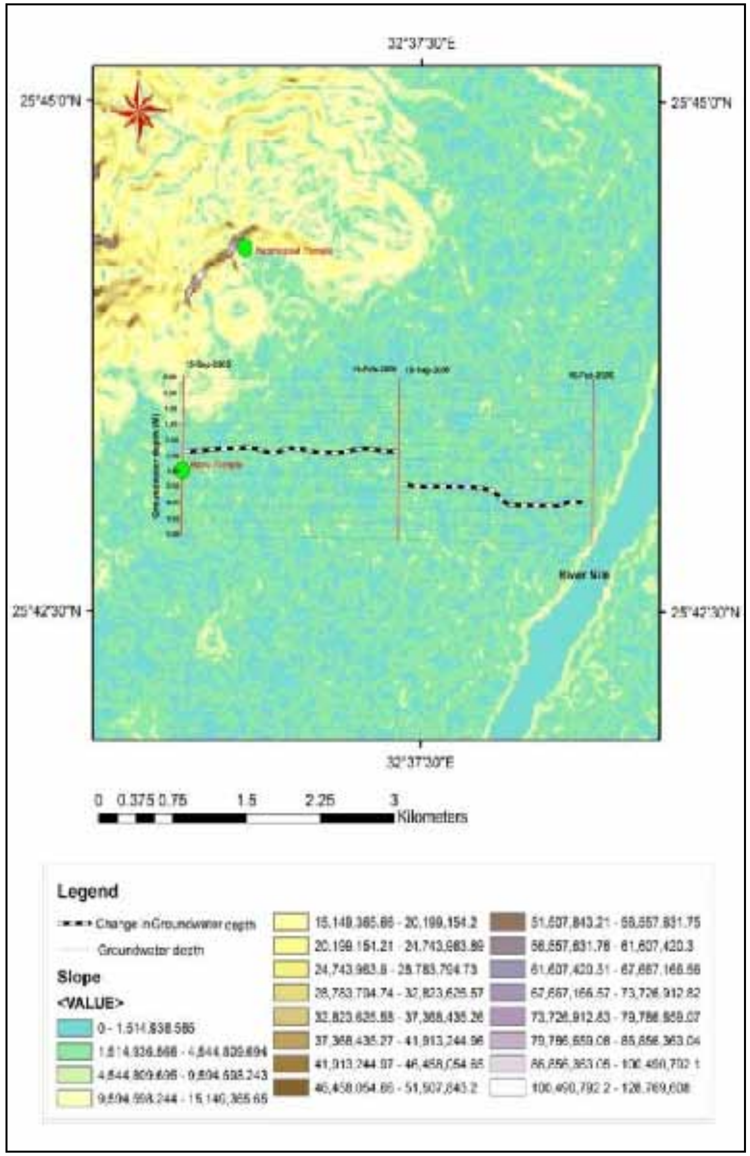
Geological map of Luxor

Problem definition



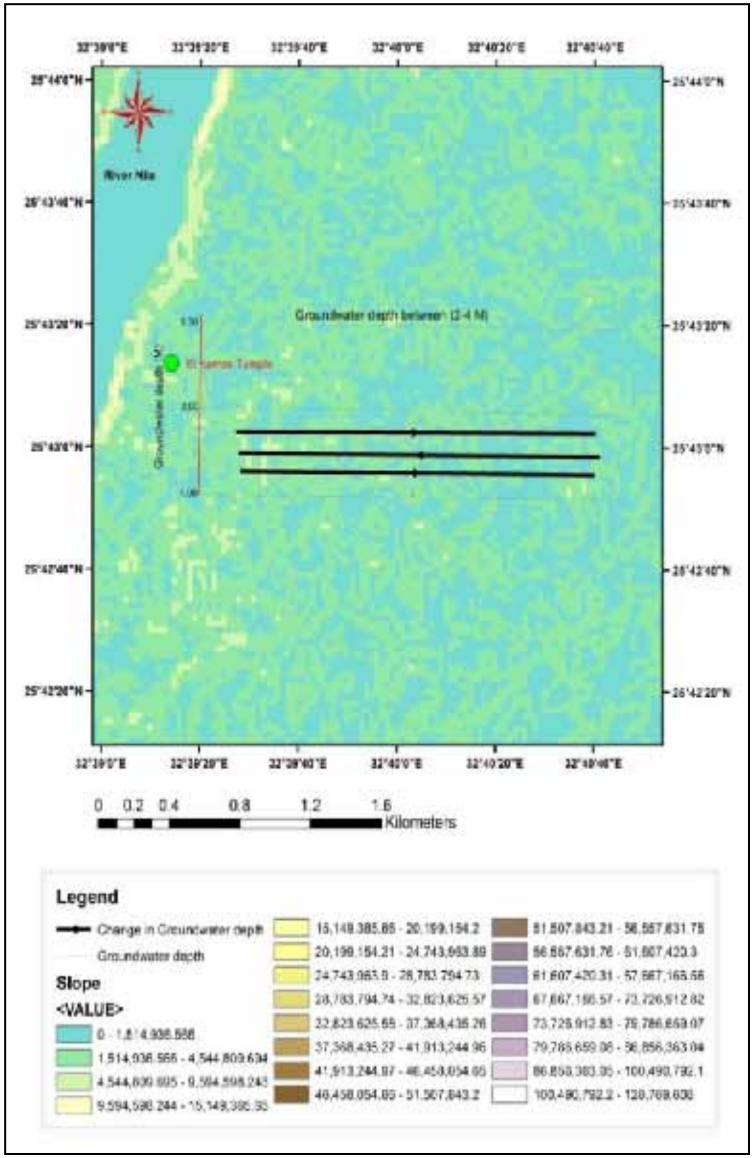
Groundwater depth around Luxor temple

Problem definition



Groundwater depth around Habu temple

Problem definition



Groundwater depth around Karnak temple

Problem definition

El Karnak temple

Medinet Habu temple

Urban sprawling around Luxor city temples

Hatshepsut temple (El Deir el-Bahari)

Luxor temple

Problem definition

Deterioration in the walls of El Karnak temple
(*http://www.touregypt.net/featurestories/waterdamage.htm*)

Deterioration in the walls of Medinet Habu temple
(*http://www.touregypt.net/featurestories/waterdamage.htm*)

Problem definition

Deterioration in the walls of Luxor temple

(*http://www2.uned.es/geo-1-historia-antigua-universal/egipto%20religion/templo_luxor.htm*)

Deterioration in the walls of Hatshepsut temple

(*https://fessell810.blogspot.it/2011_12_01_archive.html*)

Data collection

The current study included

1- Collection of *topographic sheets 1:50,000 from Survey of Egypt. National authority for Remote sensing and space science is the source of *geological and *hydrogeological sheets.

2- The required satellite imagery for the study area (*SRTM, * Landsat TM 1984) is to be downloaded from the USGS Earth Explorer

3- High resolution data (*Coronaj-3 1964 and *Sentinel2 2016)

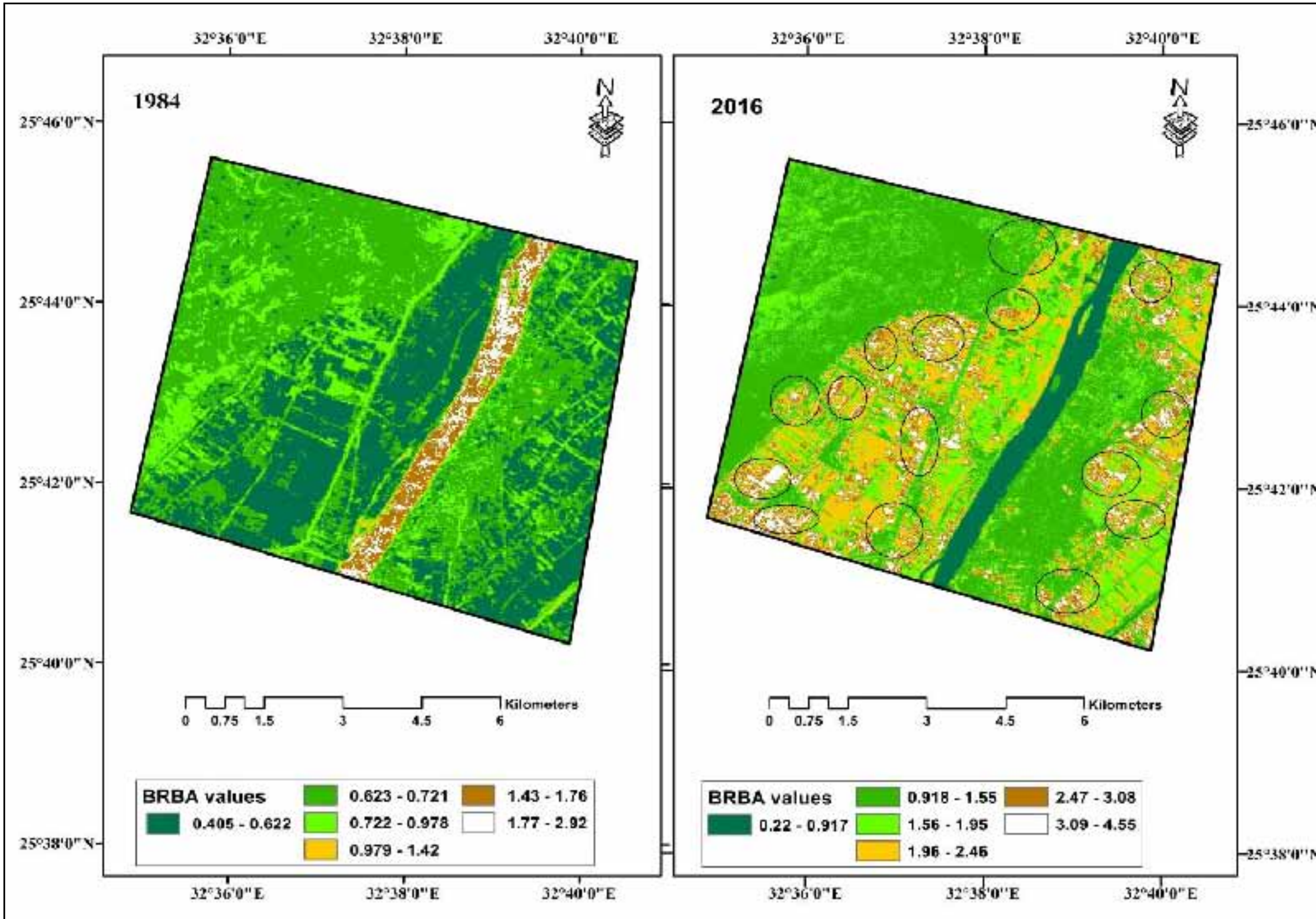
4- High resolution data by National authority for remote sensing and space science (*Quickbird 2005). The ground truth data were in the form of reference data points collected using randomly points by Quickbird image. Processing the maps and images interpretation is done in Arc GIS 10,4,1 , Snap (Sentinel application), and Envi 5,1 *software. The obtained Images are studied and analysed to detect the changes in the urban layers based on past and present data. Environmental modelling is based on Topographic map layers by Arc GIS software .

Methodology

(I) geometric correction, to co-register all the images investigated. (II) unsupervised classification for the identification of the prevailing classes and their statistical distribution. (III) supervised classification to improve the categorization of the images which will be further analyzed to identify changes. Supervised change detection methods are based on supervised classification methods applied to multi temporal data, and, therefore, require the suitable training availability set for the learning process of the classifiers. (IV) Post classification; The accuracy of the classification process has been out using the most popular metric based on the Kappa statistic (generally denoted as K) and overall accuracy. (V) comparing the classification results with the ROIs (TM, Quickbird, and OLI) with Randomly ROIs points in Sentinel 2 image using confusion matrix (post classification) in the software of Envi 5.1. (VI) BSI and BRBA are calculated using the data of TM and Sentinel 2 and the efficacy were confirmed. These indices include one for built-up area and other index for bare soil extraction from satellite image. To develop Band Ratio for Built-up Area (BRBA). TM band 3 and 5 and Sentinel2 band 4 and 12 were used respectively.

RESULTS

(BRBA) Band Ratio for Built-up Area.

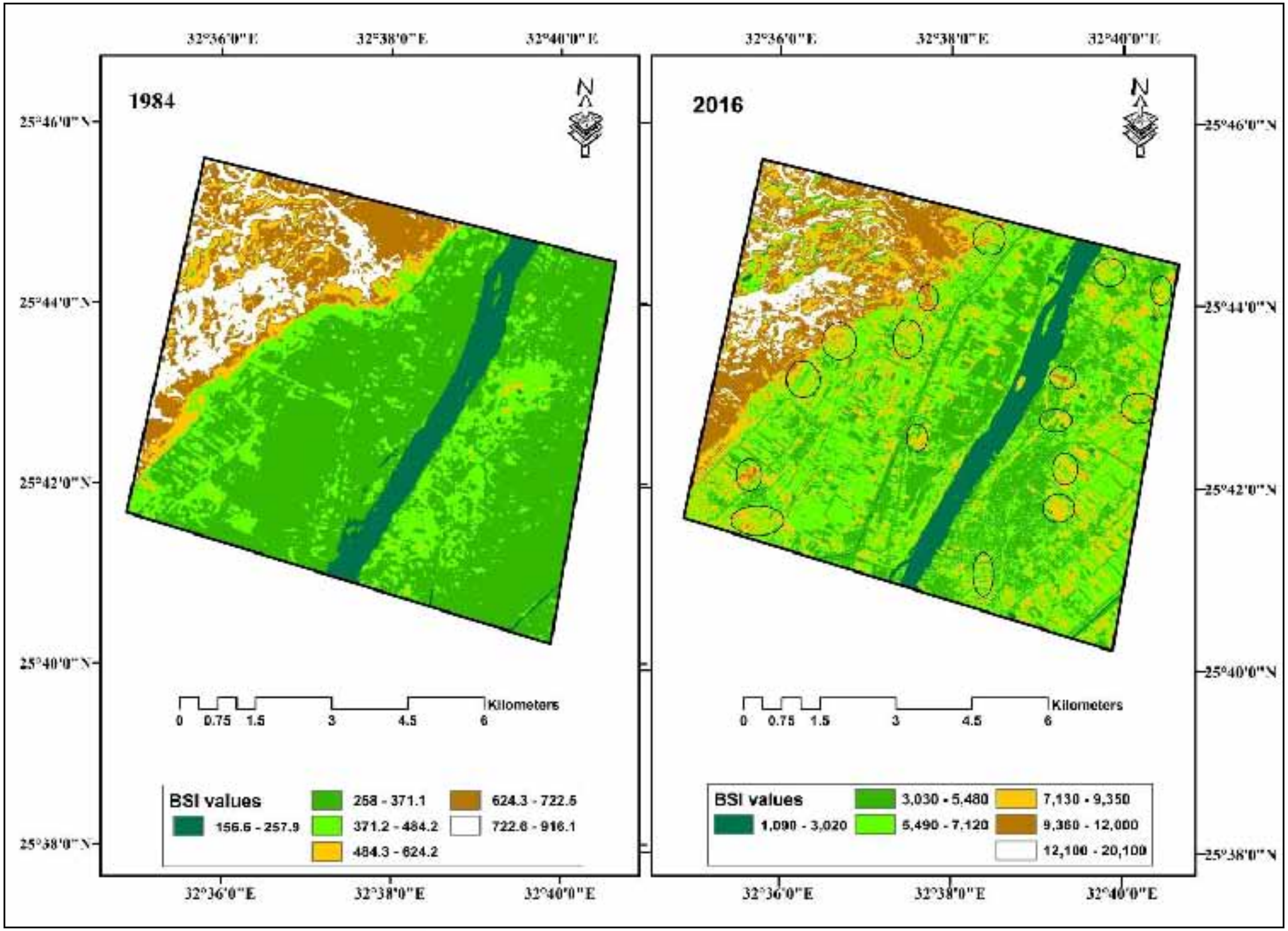


$BRBA_{TM}$ = ((B3 / B5)) in Landsat 4,5 TM = ((Red/SWIR))

$BRBA_{Sent2}$ = ((B4 / B12)) in Sentinel 2 = ((Red/SWIR))

RESULTS

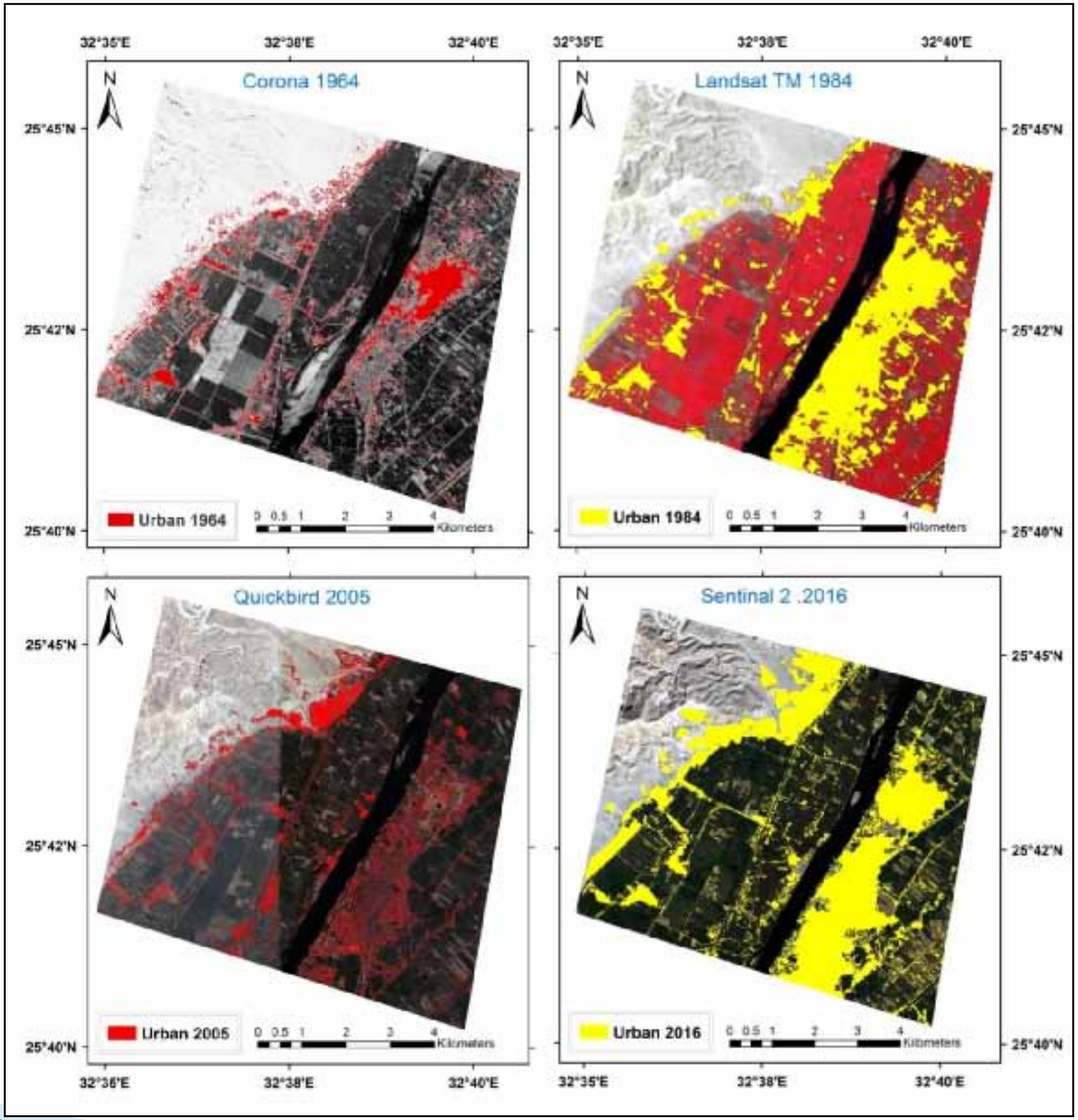
(BSI) Bare Soil Index



BSI_{TM} = ((B5 + B3) – (B4+B1)) / ((B5 + B3) + (B4+B1)) in Landsat 4,5 TM = *((SWIR+Red)-(NIR+Blue))/((SWIR+Red)+(NIR+Blue)).*

BSI_{Sent2} = ((B11 + B4) – (B8+B2)) / ((B11+ B4) + (B8+B2)) in Sentinel 2 = ((SWIR+Red)-(NIR+Blue))/((SWIR+Red)+(NIR+Blue))

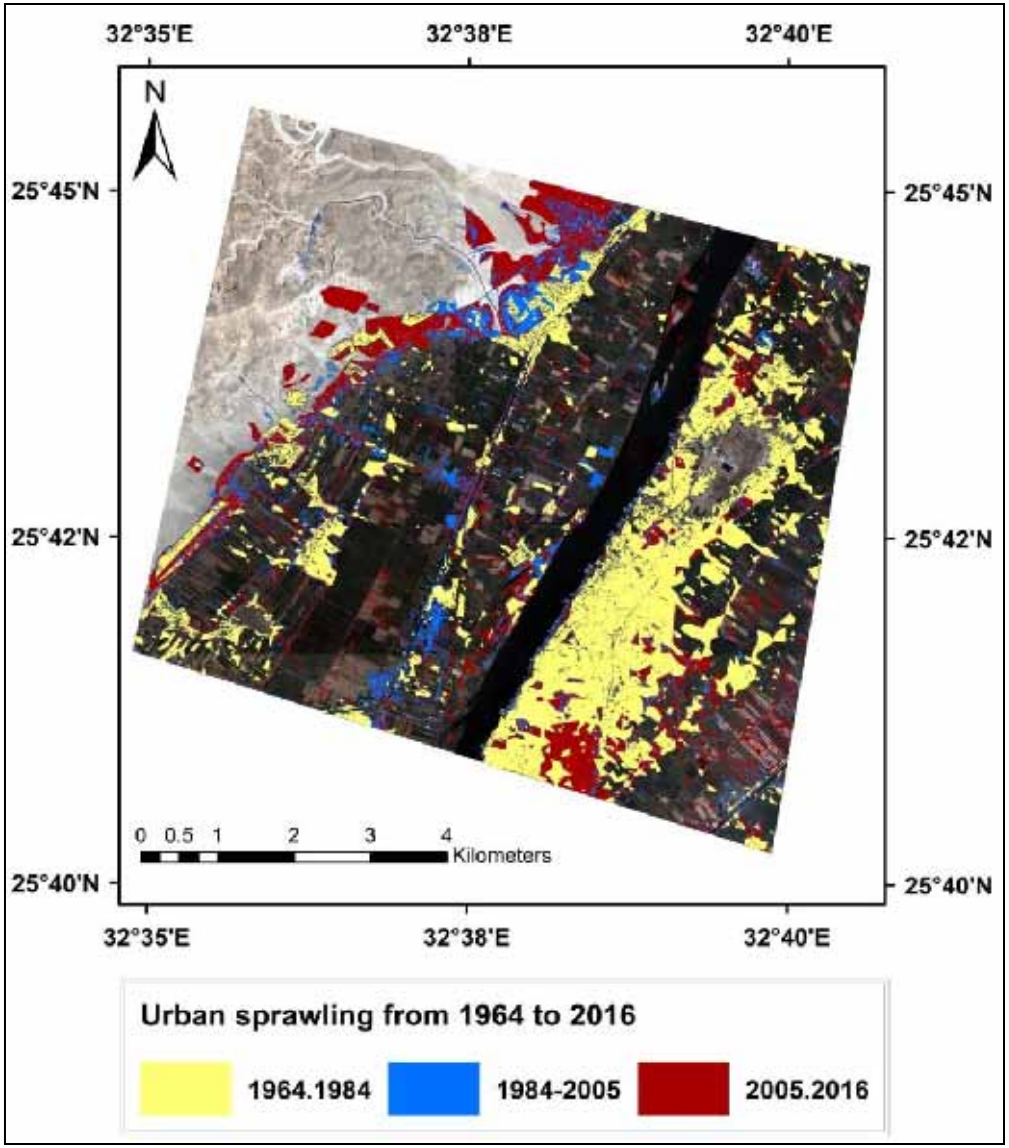
RESULTS



The increasing in urban class between 1964 to 2016

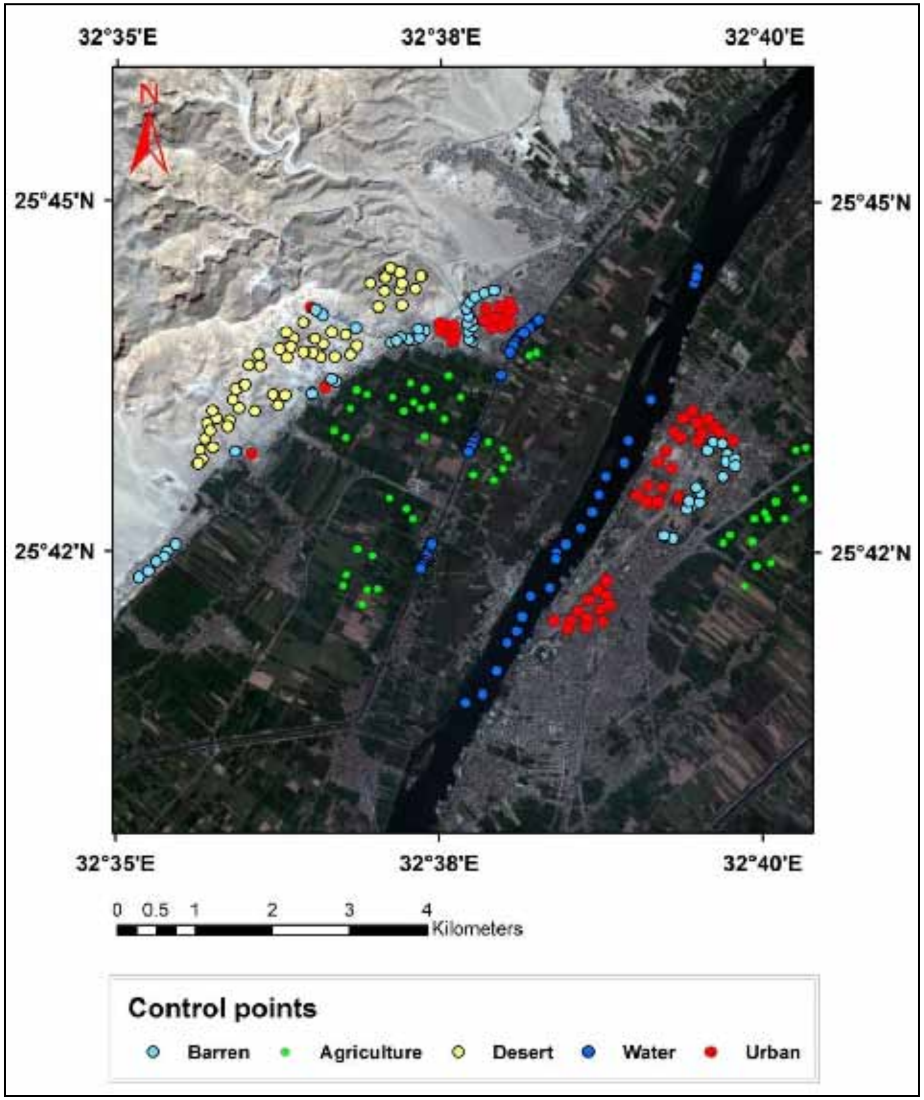
RESULTS

Total changes in urban class between 1964 to 2016



RESULTS

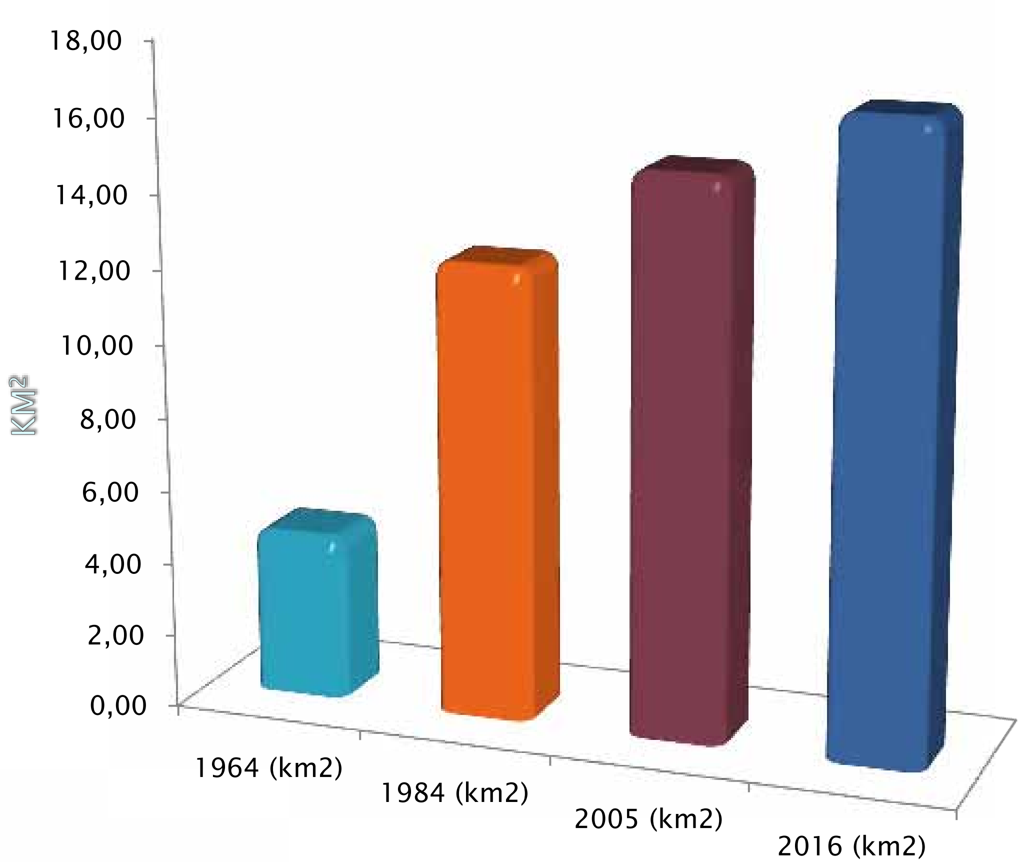
Year	Luxor area	
	Kappa Coefficient	Overall Accuracy
1984	78.5714%	0.7306
2005	72.7135%	0.6501
2016	97.9401%	0.9450



RESULTS

Class	Study area	1964 (KM^2)	Change detection ± KM^2	1984 (KM^2)	Change detection ± KM^2	2005 (KM^2)	Change detection ± KM^2	2016 (KM^2)
Urban	**Luxor**	4.539	7.792	12.331	2.734	15.065	1.763	16.828

Total changes in the Urban area

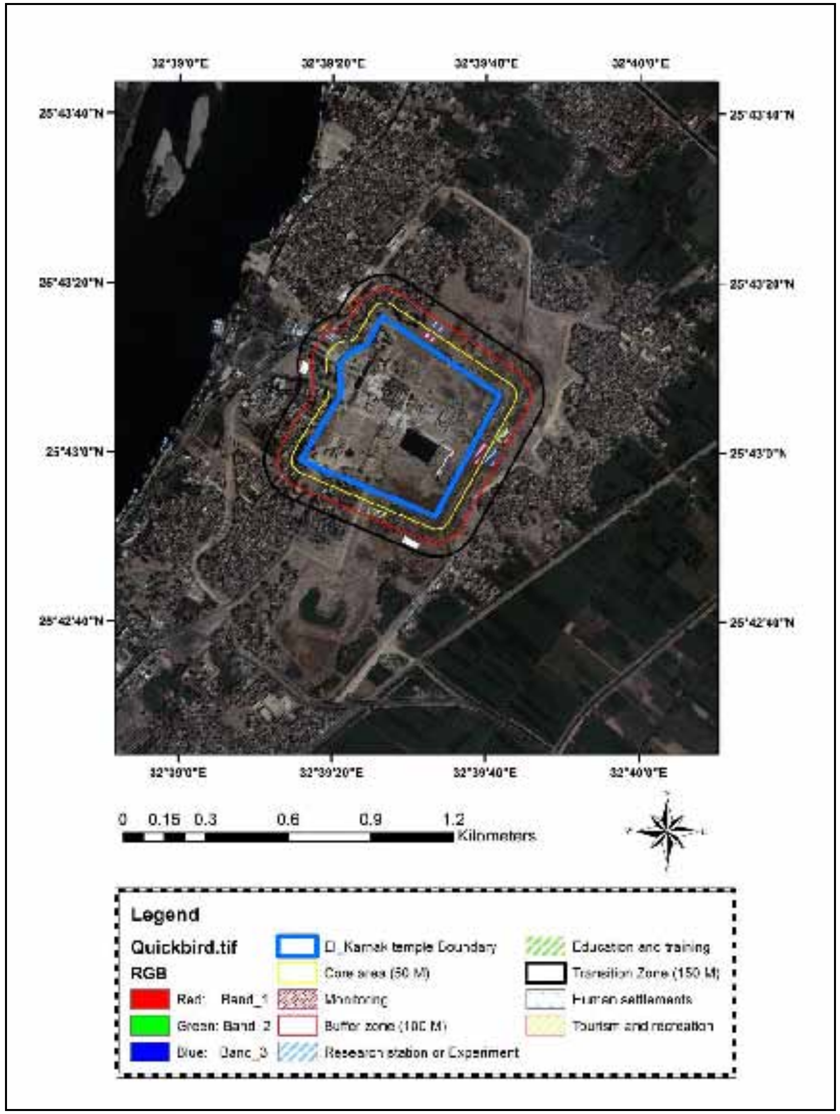


Recommendation

1- Current technologies of space data should be incorporated to optimize the use of traditional technologies adding comfort and environmental quality. New trends in the culture heritage management can be identified on the basis of the concept of sustainable tourism. Due to the environmental problems around the both of the study areas, some of the recommendations can be carried out:

According to Lasaponara et. al (2016), it is believed that the right approach to handle the situation is the application of the concept of "biosphere reserves "as proposed and adopted by the UNESCO Man and Biosphere Program (MAB). This objective can be met by a "*Zonation System" in Luxor and Shush that applies different management policies to different zones {50 meter}. The archaeological area is to be surrounded by three areas, the first area between the archaeological site and core area (monitoring). On the other hand the second are between the core area and buffer zone (research station or experiment, and education and training - human settlements). But the third area between the buffer zone and transition zone (tourism and recreation)

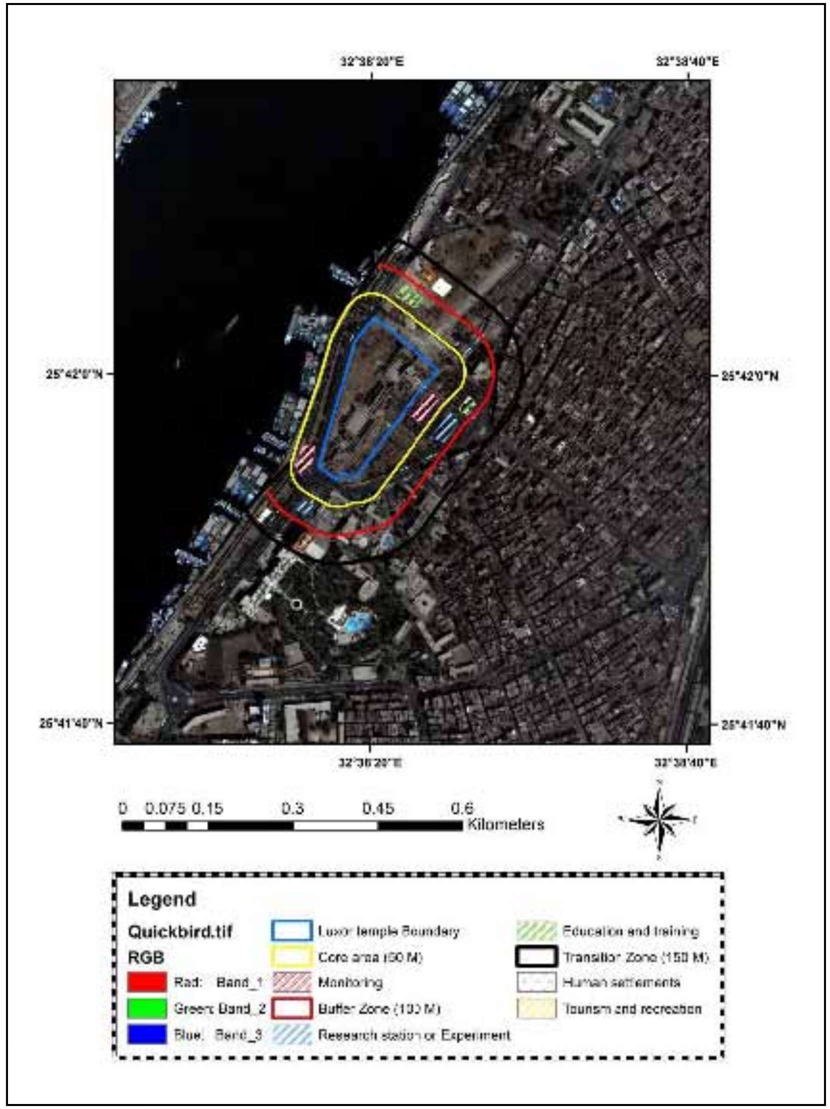
Recommendation



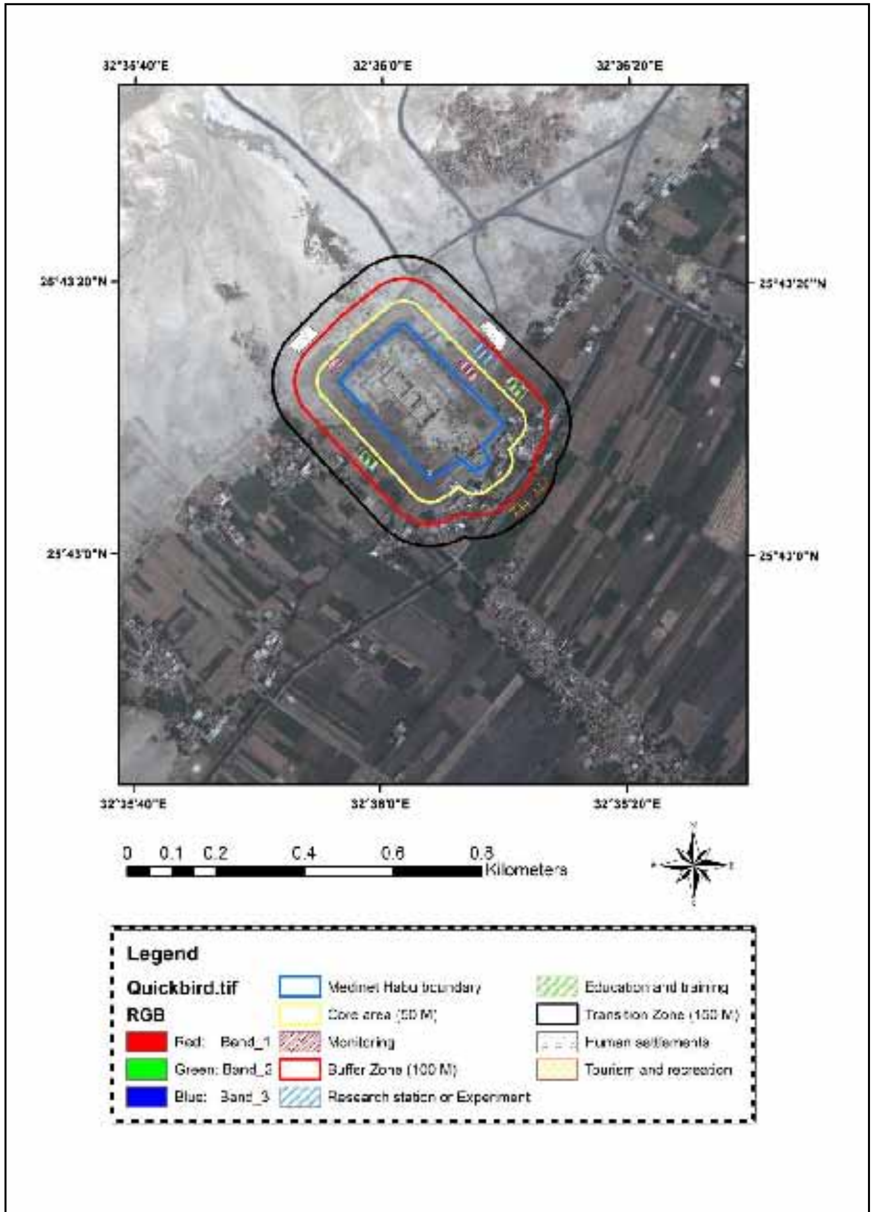
Zonation System around Karnak temple

Recommendation

Zonation System around Luxor temple

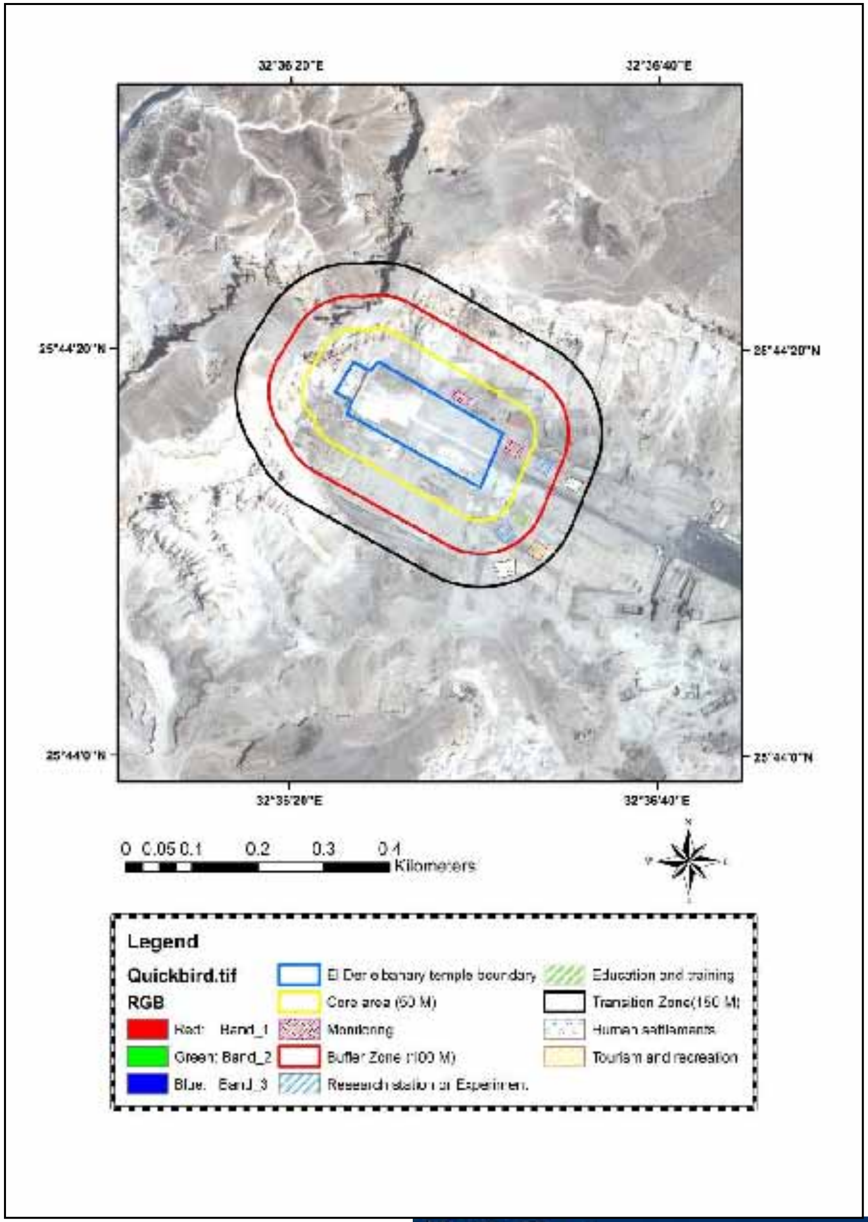


Recommendation



Zonation System around Medinet Habu temple

Recommendation

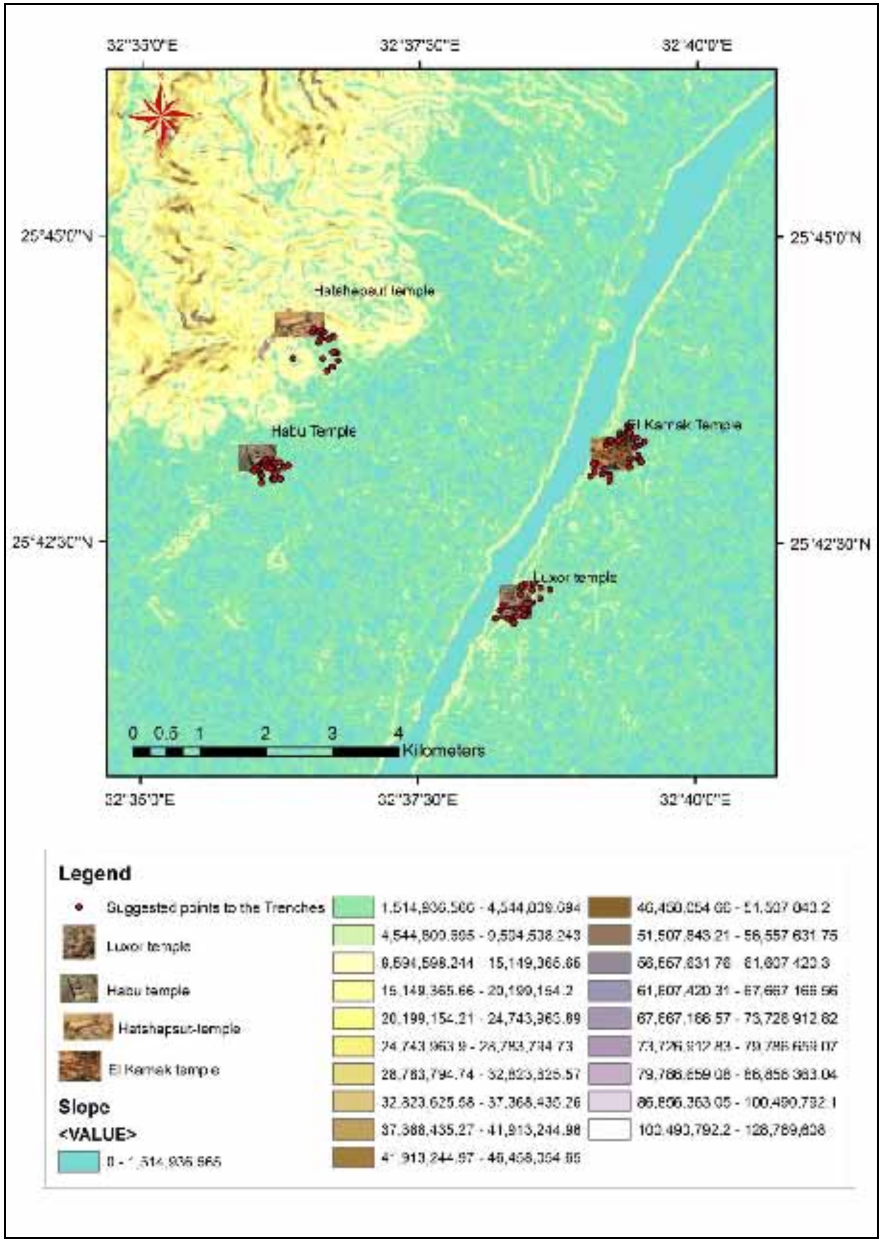


Zonation System around Hatshepsut temple

Recommendation

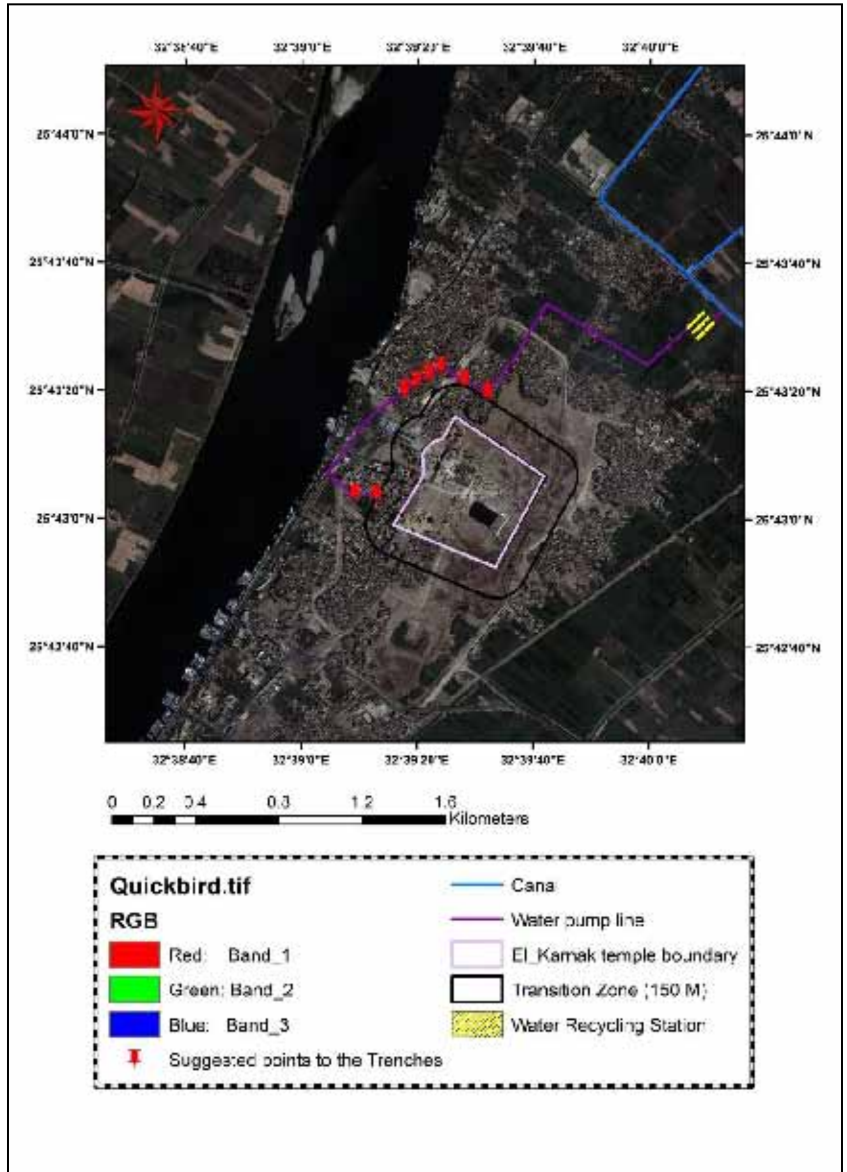
2- As a result of the bad environmental status around the archaeological area of Luxor area, it becomes very necessary to choose some *suitable places to dig some trenches to collect the ground water from the study area of Luxor. With depth more than archaeological high, GIS-modelling methodology is proposed to identify the alternative sites. The methodology involve the phase of GIS technique to identify the potential feasible sites based on external impact factors such as (Roads, DEM, archaeological area, Agricultures)

Recommendation



Proposed Points for the trenches around Luxor city temples

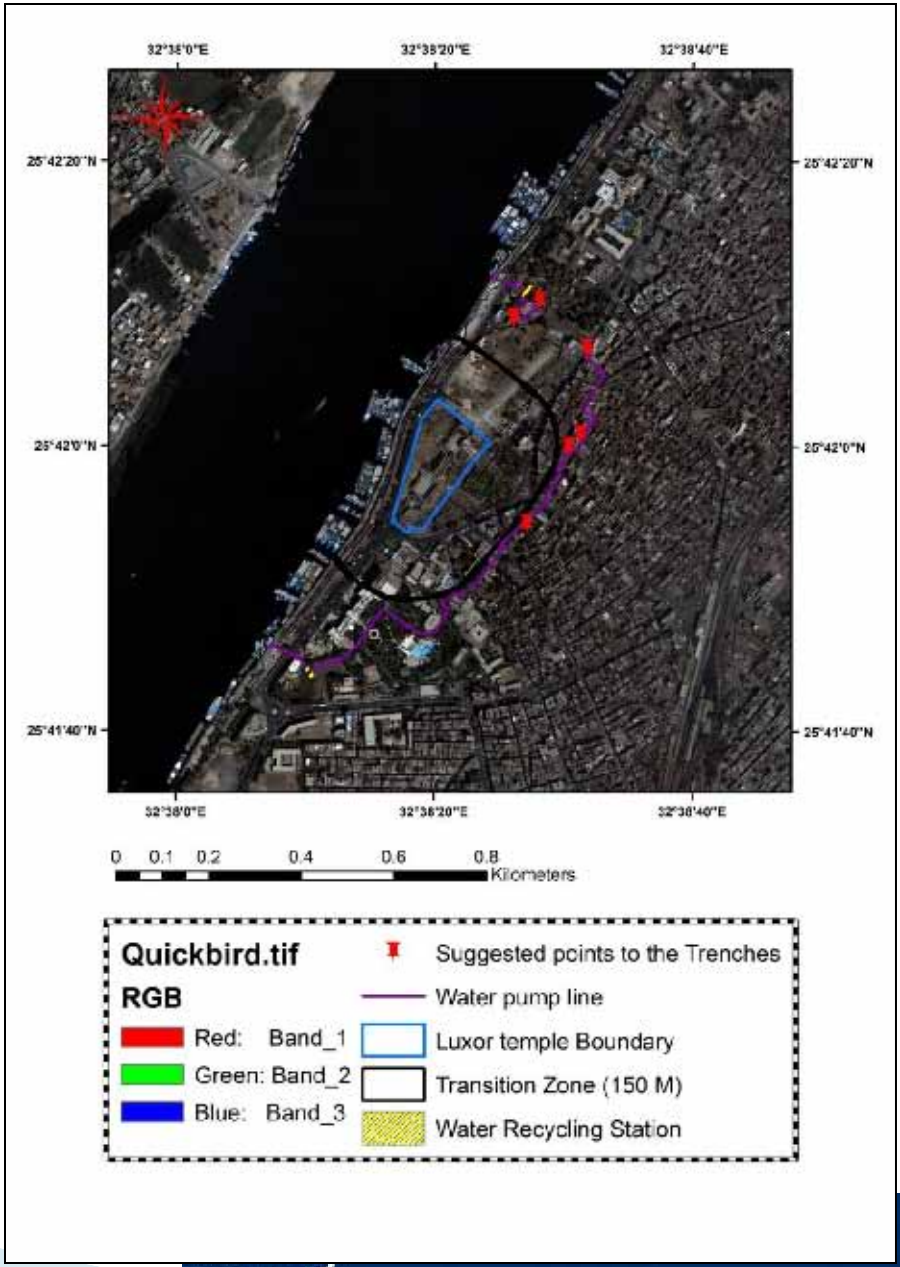
Recommendation



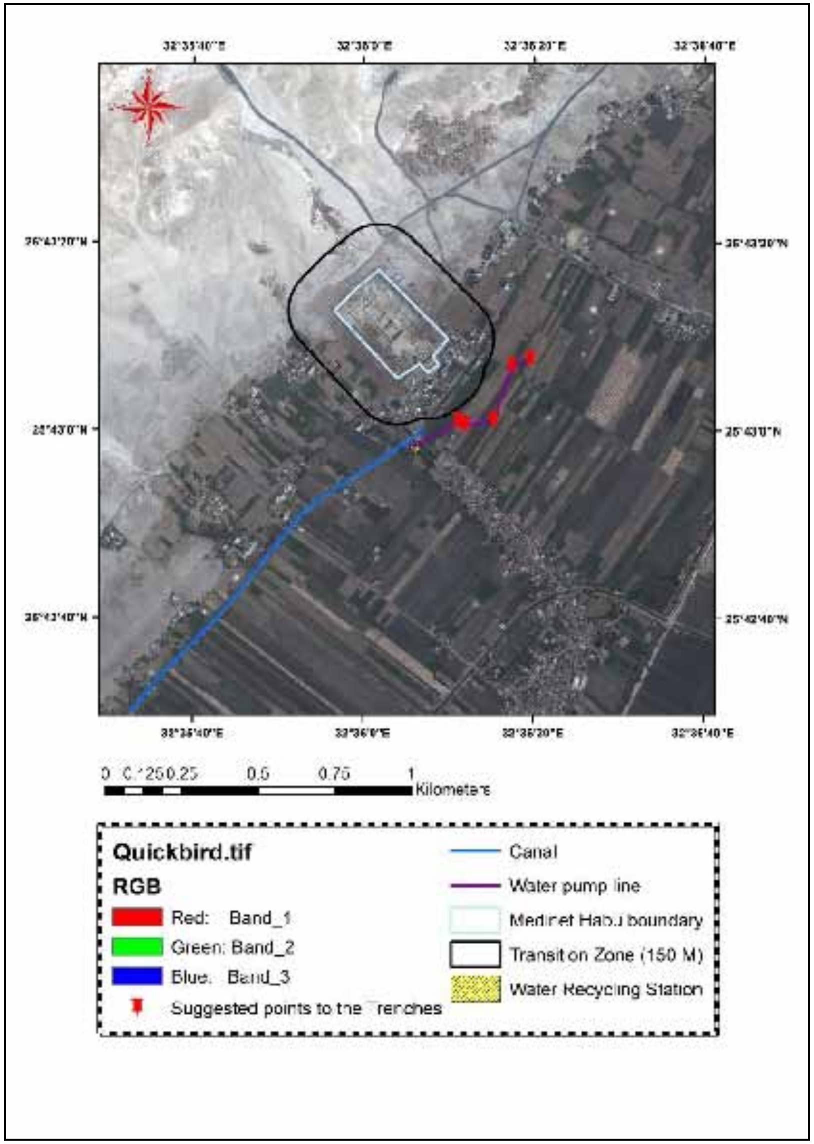
Proposed Points for the trenches around Karnak temple

Recommendation

Proposed Points for the trenches around Luxor temple

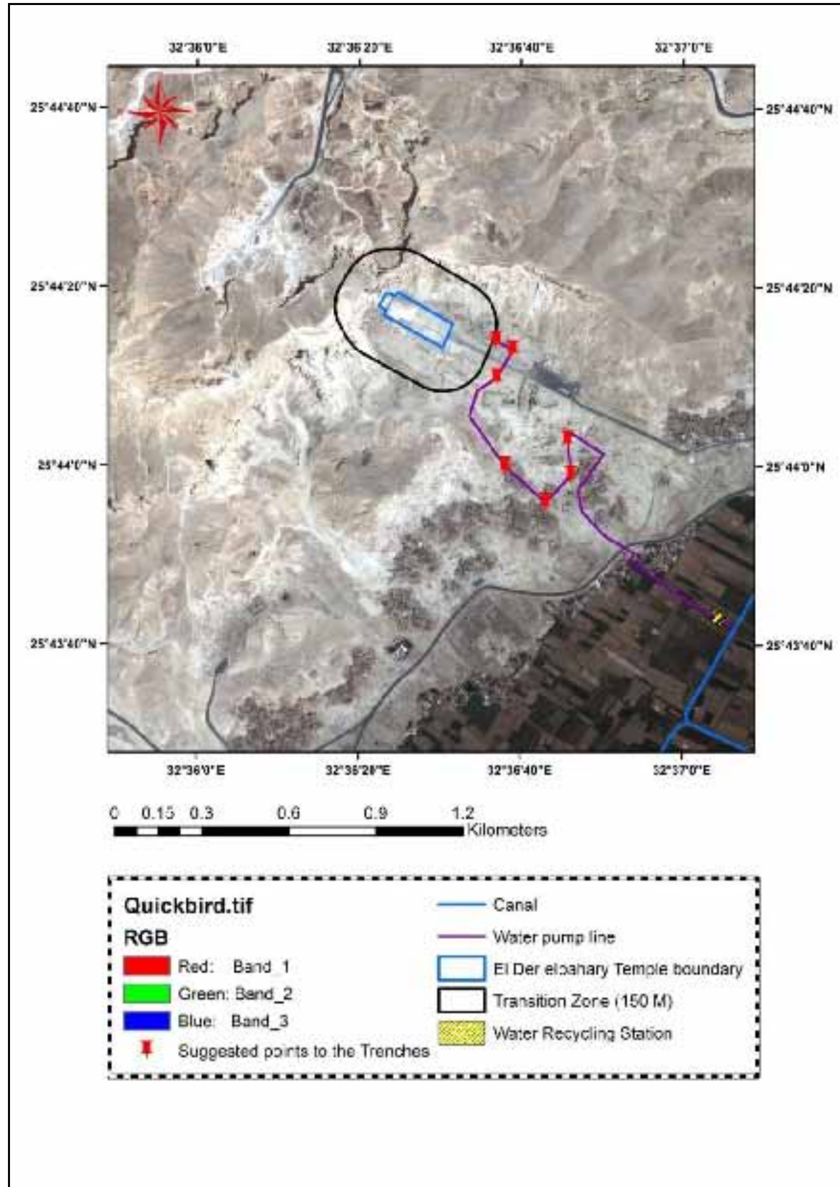


Recommendation



Proposed Points for the trenches around Medinet Habu temple

Recommendation



Proposed Points for the trenches around Hatshepsut temple

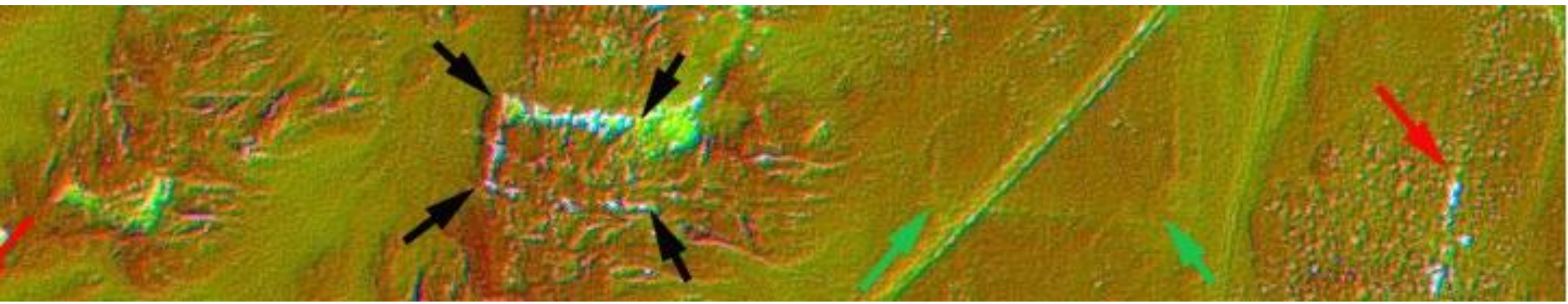

Thank you for your attention!

REMOTE SENSING BASED ARCHAEOLOGICAL RESEARCH IN PERU AND BOLIVIA

Workshop
Remote Sensing for Cultural heritage. Beyond Europe
Paphos (Cyprus), 20 March 2017

Nicola Masini

CNR-Institute for Archaeological and Monumental Heritage (IBAM), Tito (Potenza), Italy
Italian Archaeogeophysics Mission in Peru (ITACA), Tito (Potenza), Italy; Nasca, Peru

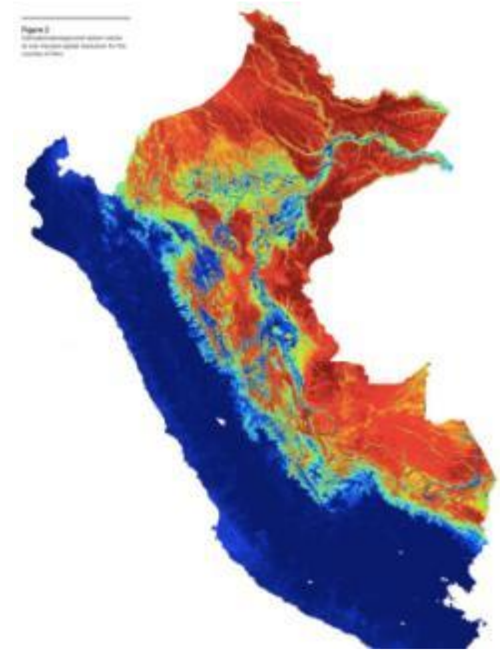


Acknowledgements: The present communication is under the "ATHENA" project H2020-TWINN2015 of European Commission. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691936.

SPACE EARTH OBSERVATION: WHEN IT IS ESSENTIAL /USEFUL

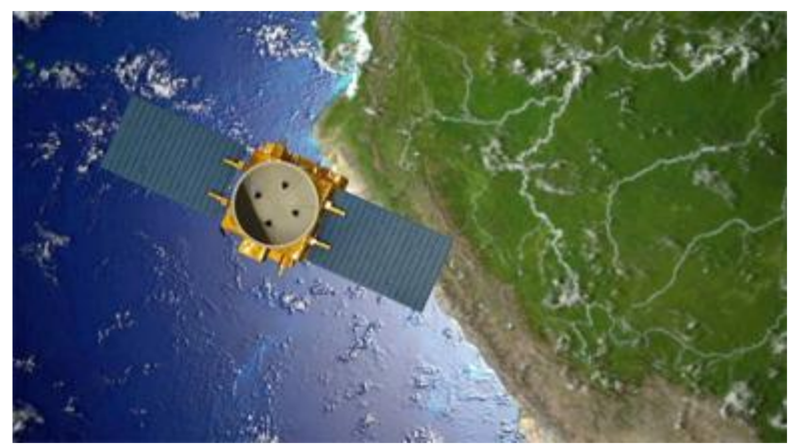
Esential

- ❑Weather
- ❑Climate
- ❑Environmental phenomena at global scale
- ❑Risk monitoring and mitigation at regional scale
- ❑Regional cartography
- ❑ Cultural Heritage management in regions with limited and difficult aerial surveillance



Very useful

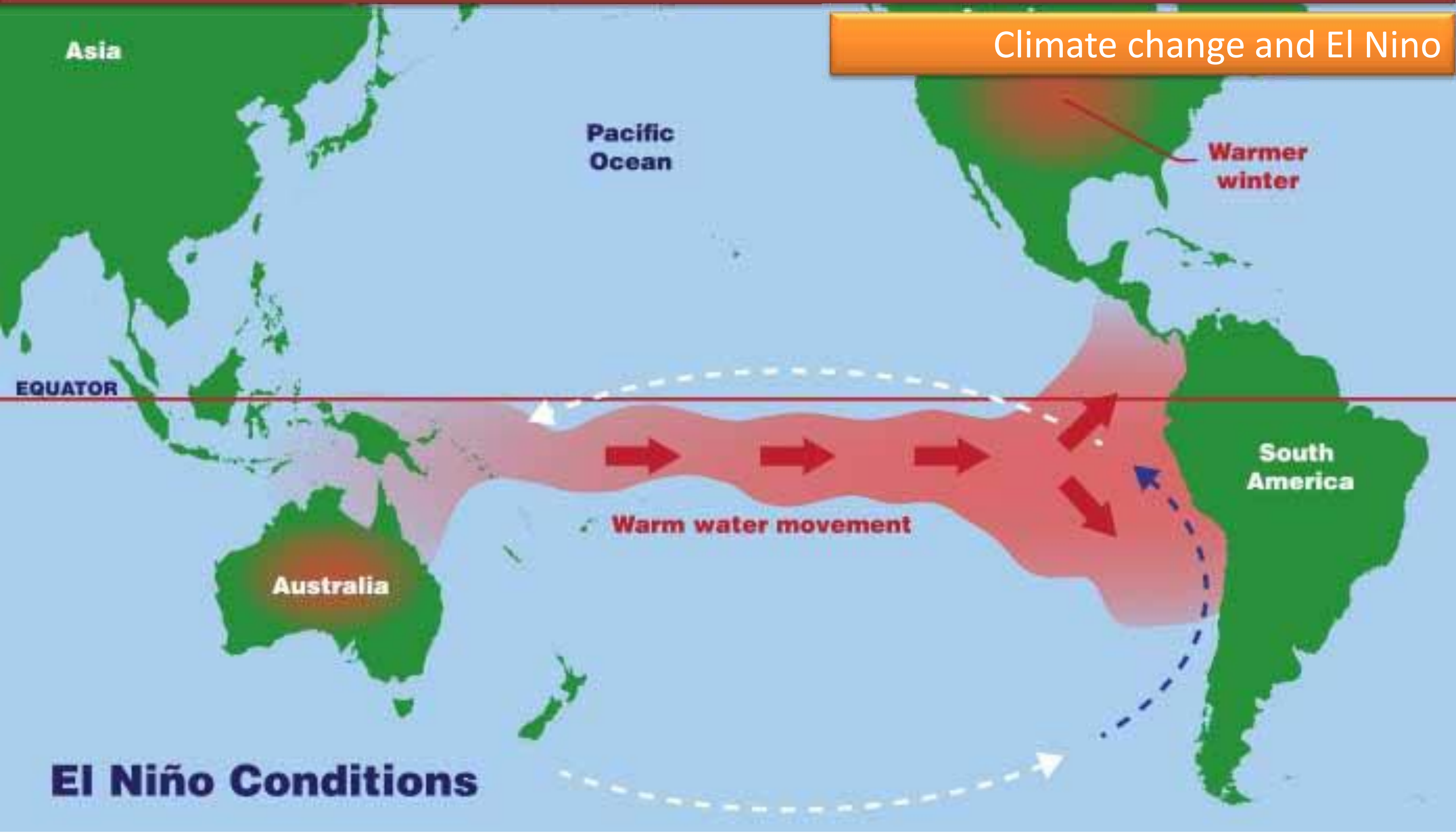
- ❑ Landscape
- ❑ Cultural heritage management and archaeology
- ❑ Urban cartography
- ❑Risk monitoring and mitigation at local scale



Satellite Peru Sat-1

Peru as Earth Observation Laboratory

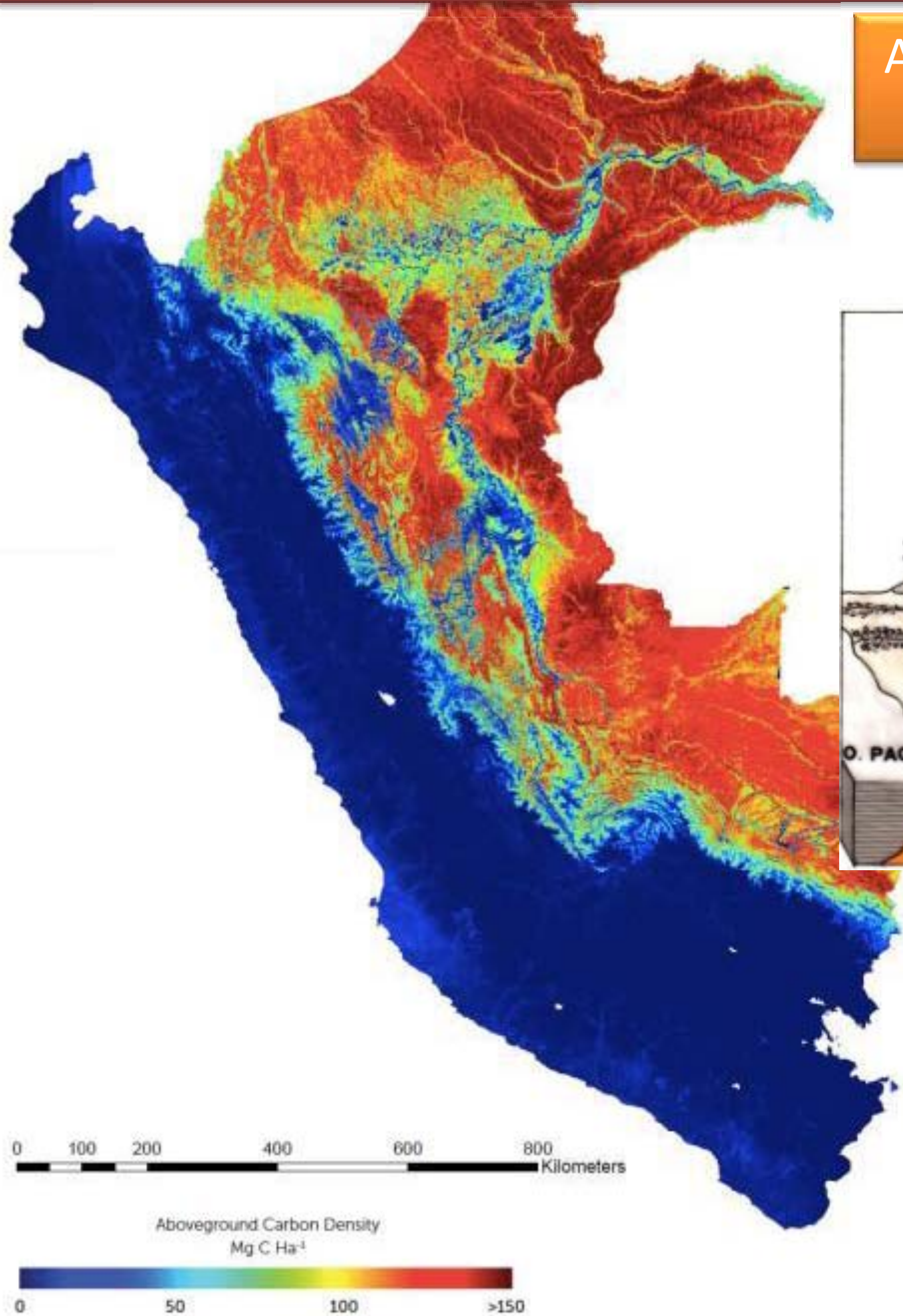
Climate change and El Nino

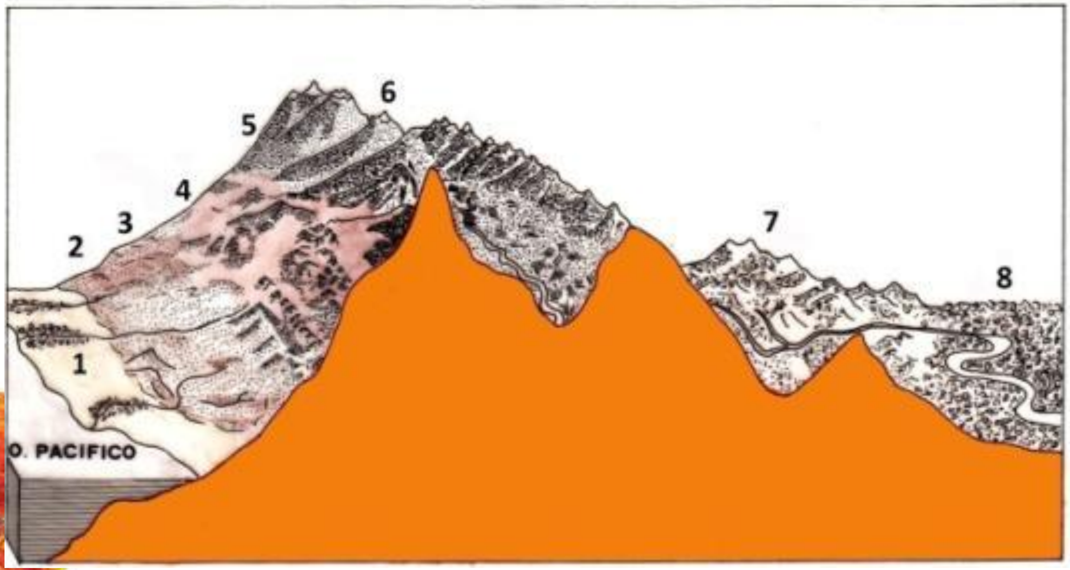


During el Nino, these winds are much weaker than usual. They actually blow the other way (toward South America instead of Indonesia) in October. So the warm surface water along the equator piles up along the coast of South America and then moves north towards California and south toward Chile.

Peru as Earth Observation Laboratory

Agricolture and natural resource management in several ecosystems





1 Costa; 2 Yunga maritima; 3 Quechua; 4 Suni or Jalca; 5 Puna; 6 Cordillera or Janca; 7 Selva Alta or Ruparupa; 8 Selba Baja

Peru as Earth Observation Laboratory for the study of Human Past

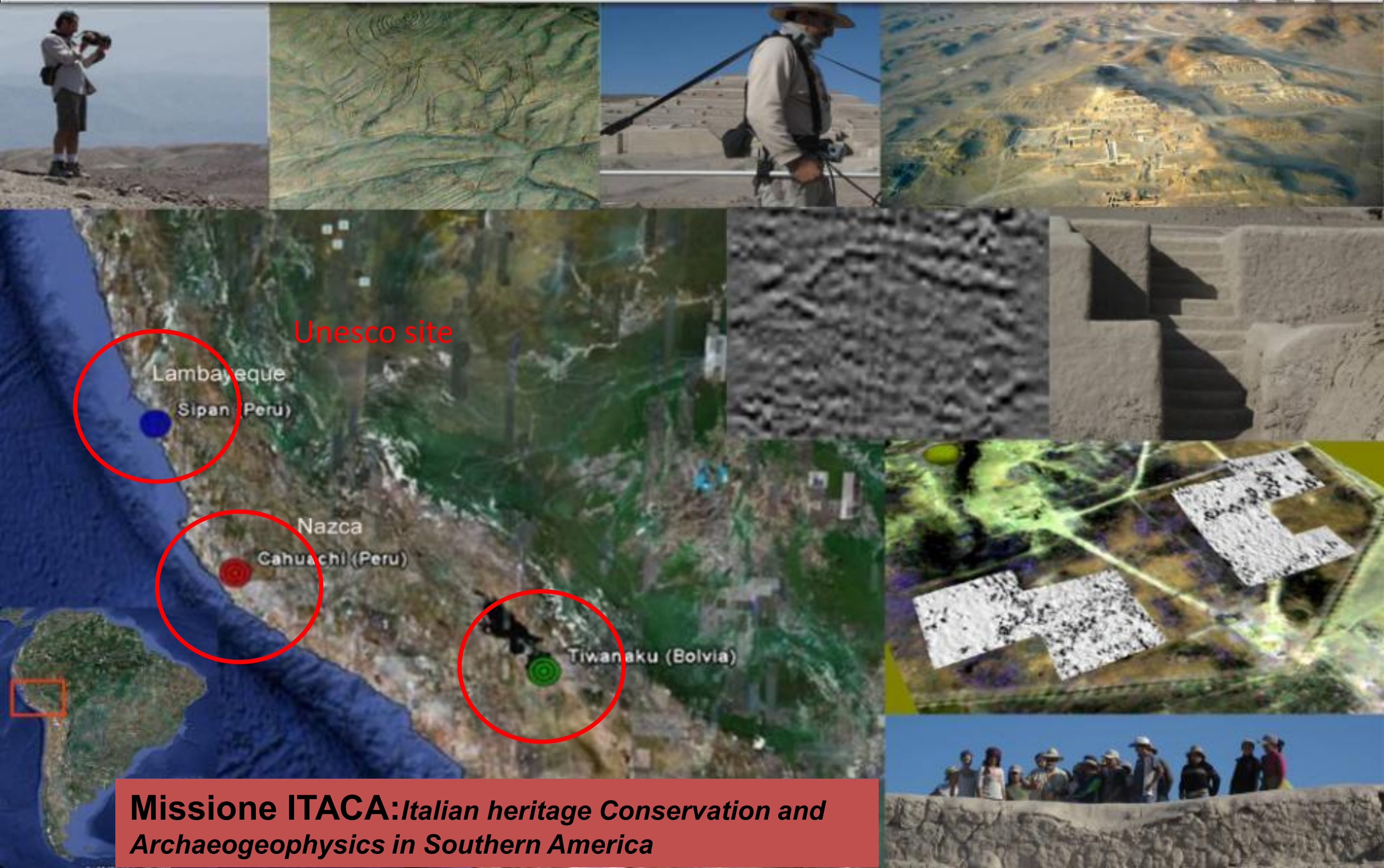
The Andean civilizations, more than other, have established a relationship with the environment not only functional for their survival, but also intimate and mystical. The landscape and the environment are part of the cultural DNA. No action, activities, decision has been taken that does not involve a relationship with the environment, both in the ecological sense, as well as visual perception

The ‘Sacre’ Landscape and Andean Cosmovision

The ceremonial architecture is the result of a successful combination of knowledge and interpretation of the landscape/ environment: mountains are considered sacre and the model in the construction of the pyramids, which in their turn are built exploiting natural mounds and hills

Lasaponara R., Lancho Rojas J., Masini N., (2016). *Puquios*: The Nasca Response to Water Shortage. In: Lasaponara R., Masini N., Orefici G. (Eds). The Ancient Nasca World New Insights from Science and Archaeology. Springer International Publishing, 2016, pp. 279-327,

Remote sensing CNR research activity on Unesco sites



Missione ITACA: ***Italian heritage Conservation and Archaeogeophysics in Southern America***

Who were the Nasca


Cahuachi pyramids


Textiles


Polichrome pottery


Geoglyphs

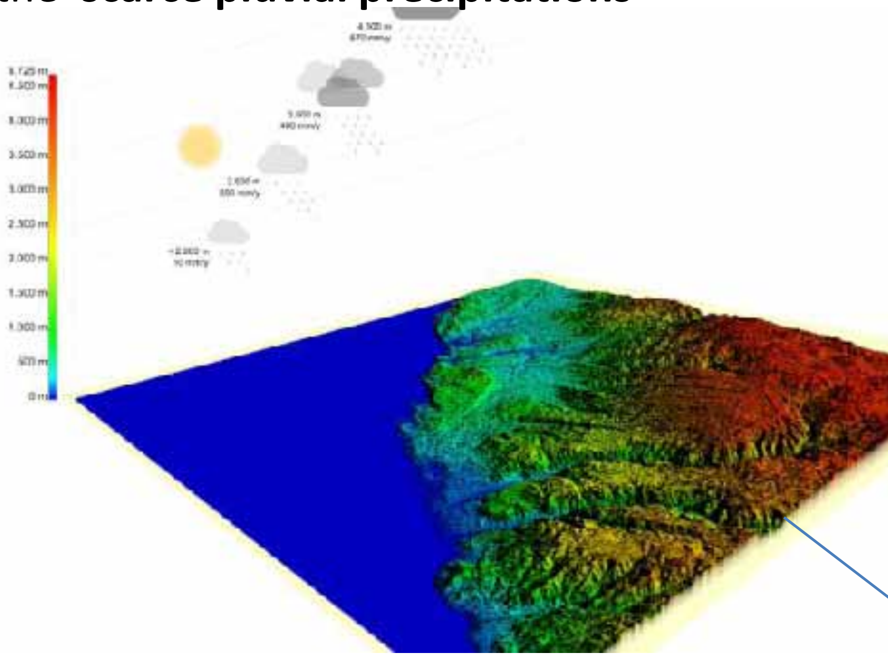

Aqueducts


Music

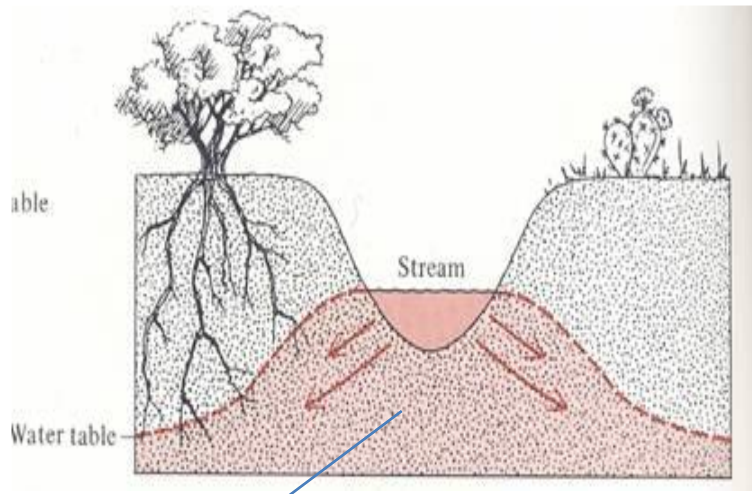
Chronology : 200BC-600 AD
Area of cultural influence : desert southern coast of Peru
Cultural patterns/features : Geoglyphs, aqueduct, ceremonial architecture, polychrome pottery, textiles, musical instruments
Historical phases: 8 (Nasca1,2,3..8) – pottery seriation

Nasca Environment and climate

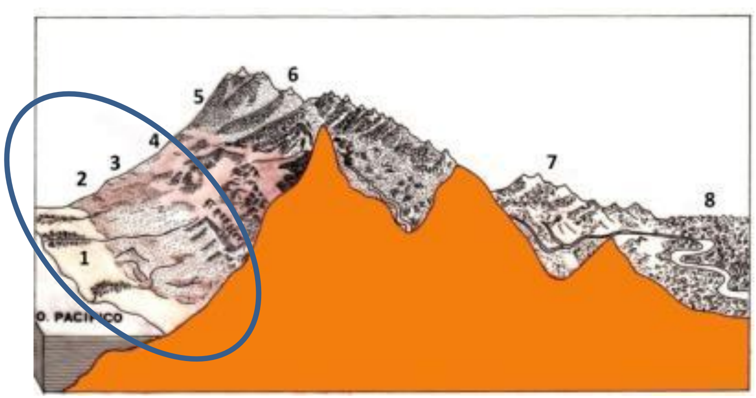
the **scarce pluvial precipitations**



high infiltration capacity



lack of water



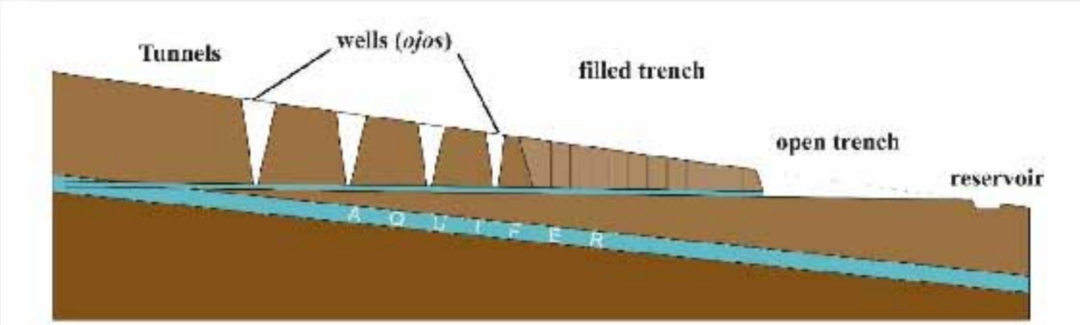
Hidraulic regime

- ❑Perennial
- ❑Influent
- ❑Dry

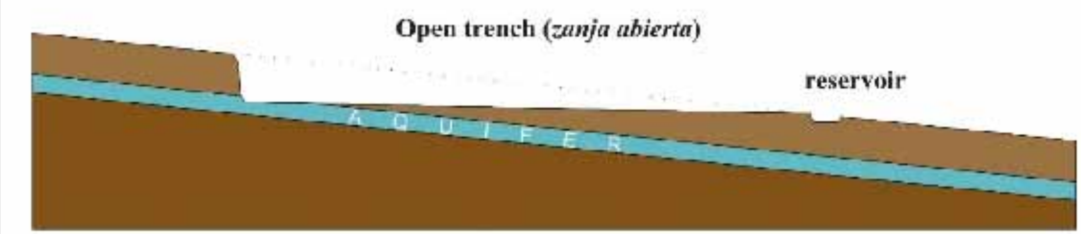
Lasaponara R., Lancho Rojas J., Masini N., (2016). *Puquios*: The Nasca Response to Water Shortage. In: Lasaponara R., Masini N., Orefici G. (Eds). The Ancient Nasca World New Insights from Science and Archaeology. Springer International Publishing, 2016, pp. 279-327,

The 'puquios' as response of Nasca to water problem

The *puquios :* water system composed of horizontal wells or open trenches connecting groundwater to surface , thus making possible to have water available for the whole year not only for irrigation but also for domestic needs.



puquios trench galleries with extension of tunnels

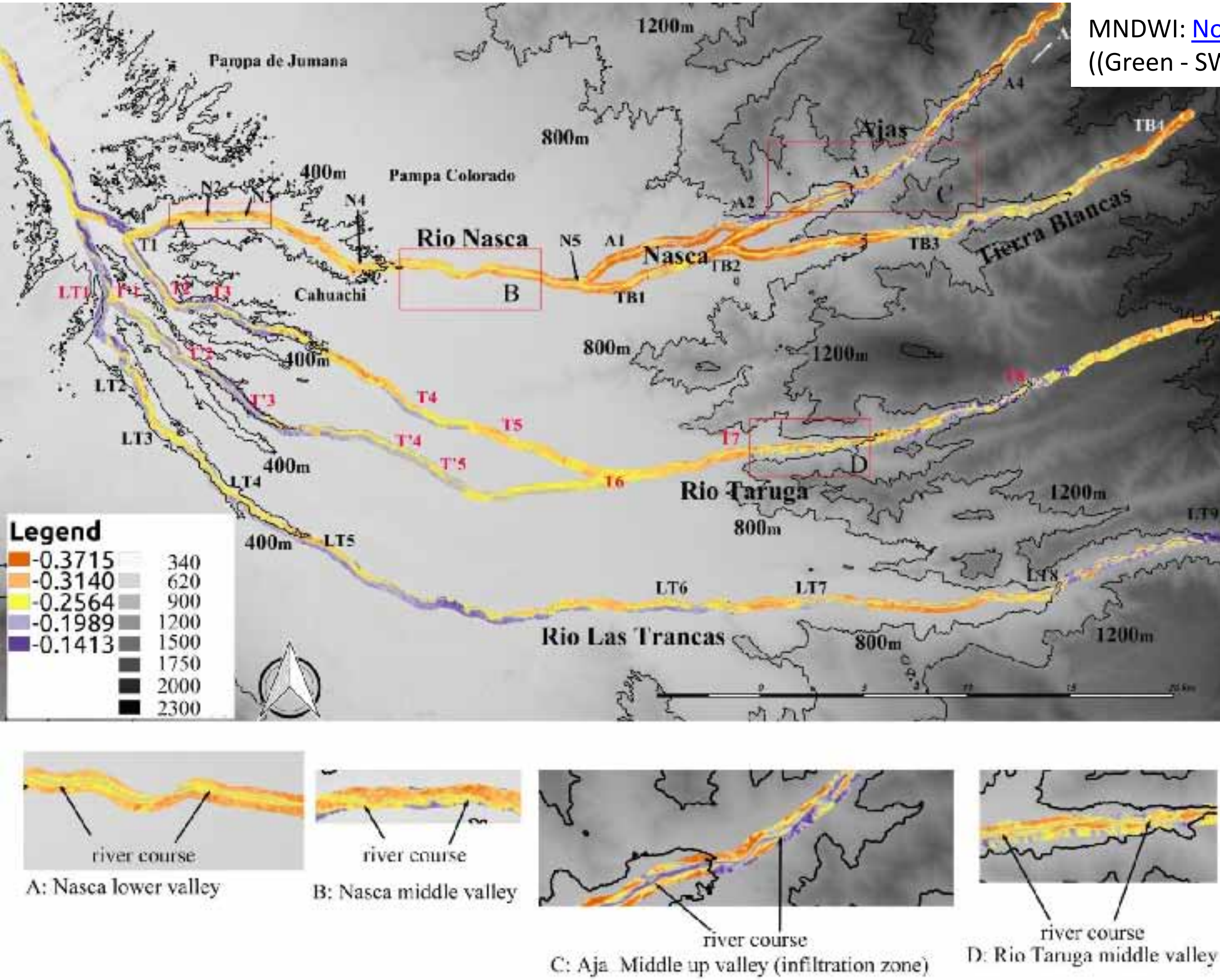


puquios with the shape of open trenches

Lasaponara R., Lancho Rojas J., Masini N., (2016). *Puquios*: The Nasca Response to Water Shortage. In: Lasaponara R., Masini N., Orefici G. (Eds). The Ancient Nasca World New Insights from Science and Archaeology. Springer International Publishing, 2016, pp. 279-327,

Satellite based characterization of the rivers for predicting unknown ancient aqueducts

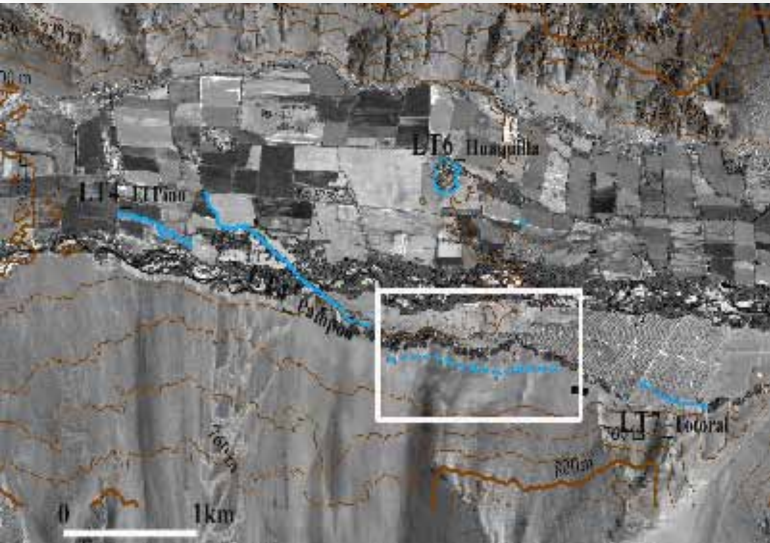
MNDWI: [Normalized Difference Water Index](#)= ((Green - SWIR)/(Green + SWIR))

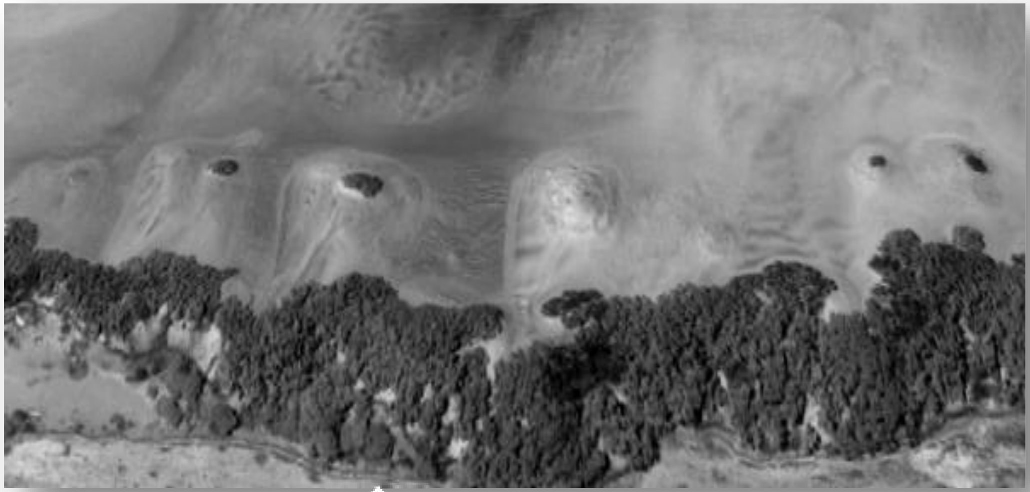


MNDWI average of Landsat data acquired from 1985 to 2010 indicator of moisture content enabled us to assess the intra and inter-year water availability as well as to estimate with high spatial and temporal detail the hydraulic regime (perennial, ephemeral, dry) of the rivers and tributaries of Nasca drainage.

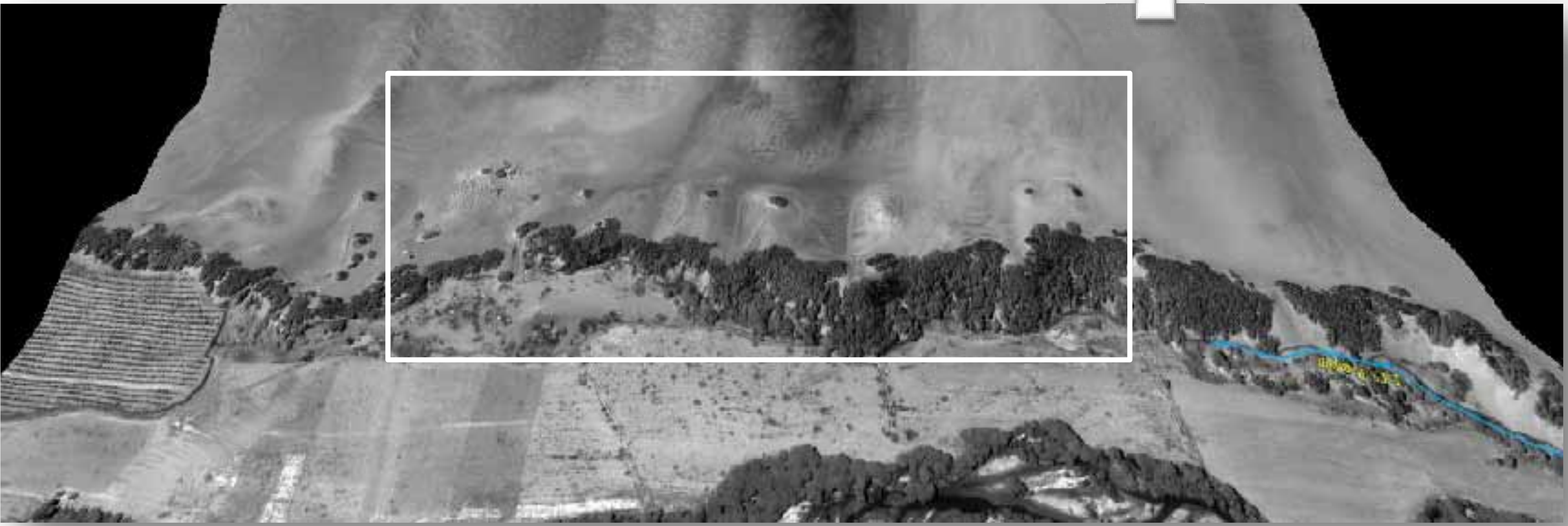
Lasaponara R., Nolè G., Rizzo E., Capozzoli L., Romano G., Danese M., Masini N. (2016). *Puquios*: New Insights from the Integration of Remote Sensing, GIS-Based Analyses and Geophysical Investigations. In: Lasaponara R., Masini N., Orefici G. (Eds). The Ancient Nasca World New Insights from Science and Archaeology. Springer International Publishing, 2016, pp. 543-580, doi: 10.1007/978-3-319-47052-8_22

Discovery of acqueducts





Rio Las Trancas : discovery of an abandoned aqueduct



Lasaponara R., Nolè G., Rizzo E., Capozzoli L., Romano G., Danese M., Masini N. (2016). *Puquios*: New Insights from the Integration of Remote Sensing, GIS-Based Analyses and Geophysical Investigations. In: Lasaponara R., Masini N., Orefici G. (Eds). The Ancient Nasca World New Insights from Science and Archaeology. Springer International Publishing, 2016, pp. 543-580, doi: 10.1007/978-3-319-47052-8_22

Zoomorphic figures in the Nasca Pampa

Photo by Nicola Masini

Geoglyph execution techniques

Geoglyphs of Pampa de Atarco, Nasca (Peru)

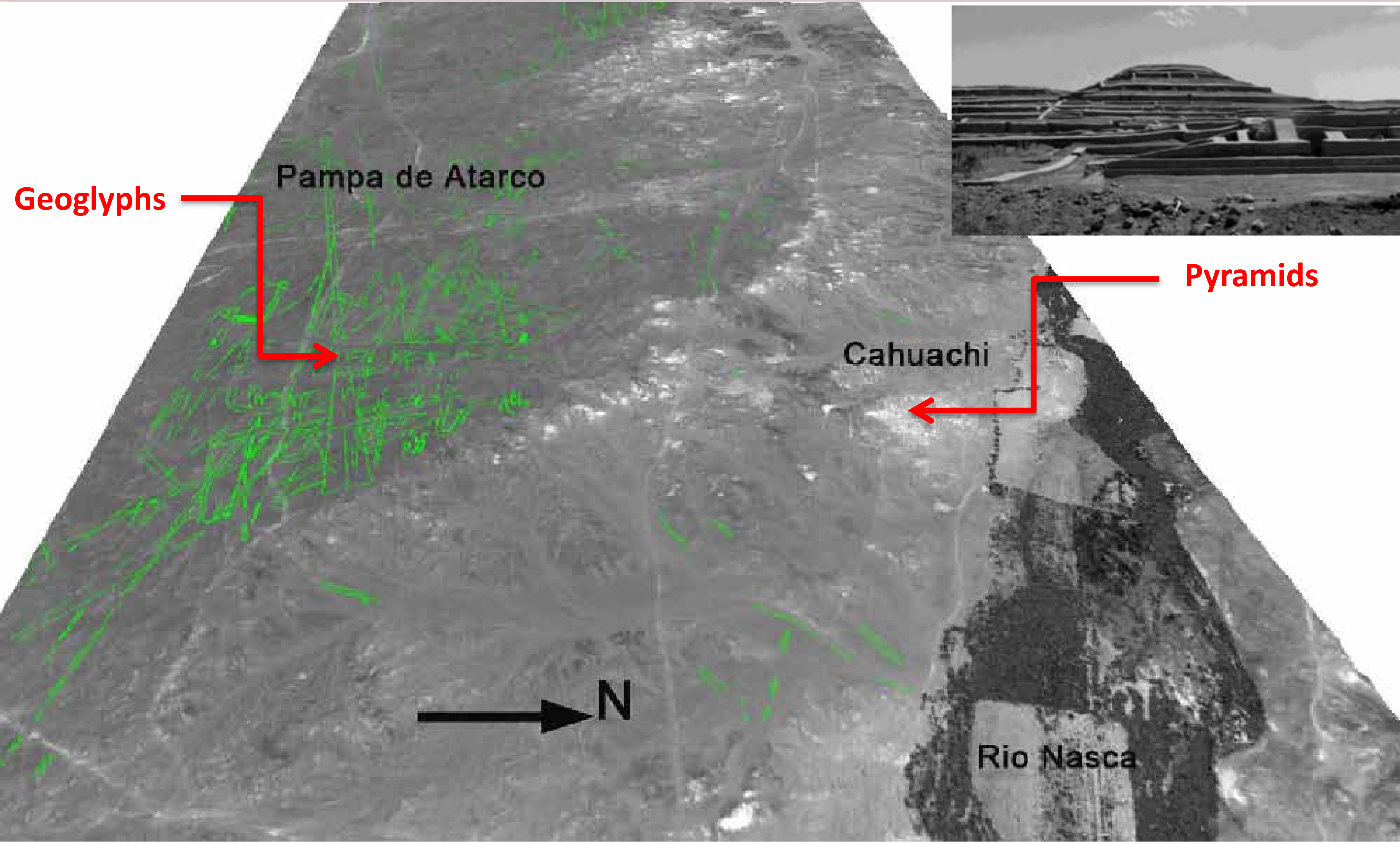
(a) the removal and addition of stone material, (b-c) placing dark color gravels along the lines, (d) creating microrelief by scraping ad placing fine-grained material.

trapezoid : result of subtractive and additive techniques

spiral is drawn alternating the removal of fine-medium grained stone material and their placing on the curves adjacent to the grooves.

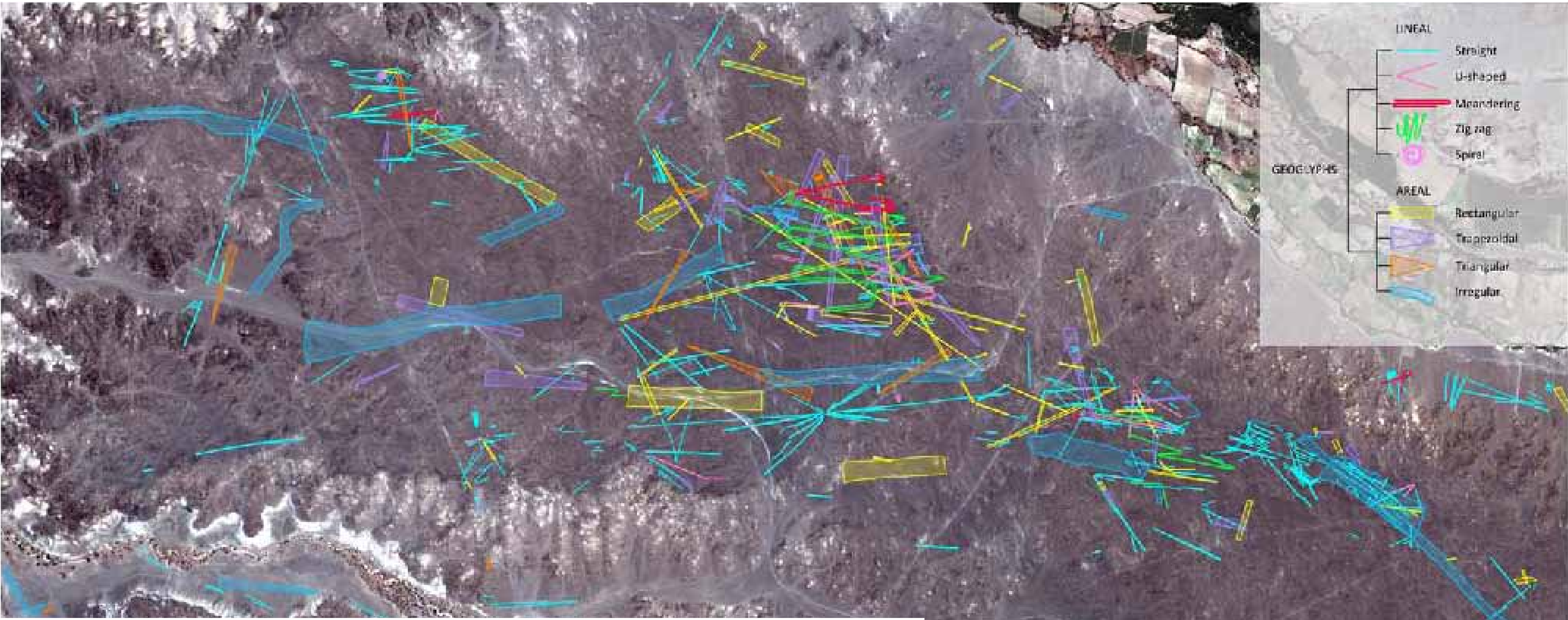
Masini N., Orefici G., Lancho Rojas J. (2016). Nasca Geoglyphs: Technical Aspects and Overview of Studies and Interpretations. In: Lasaponara R., Masini N., Orefici G. (Eds). The Ancient Nasca World New Insights from Science and Archaeology. Springer, 2016, pp. 217-238,

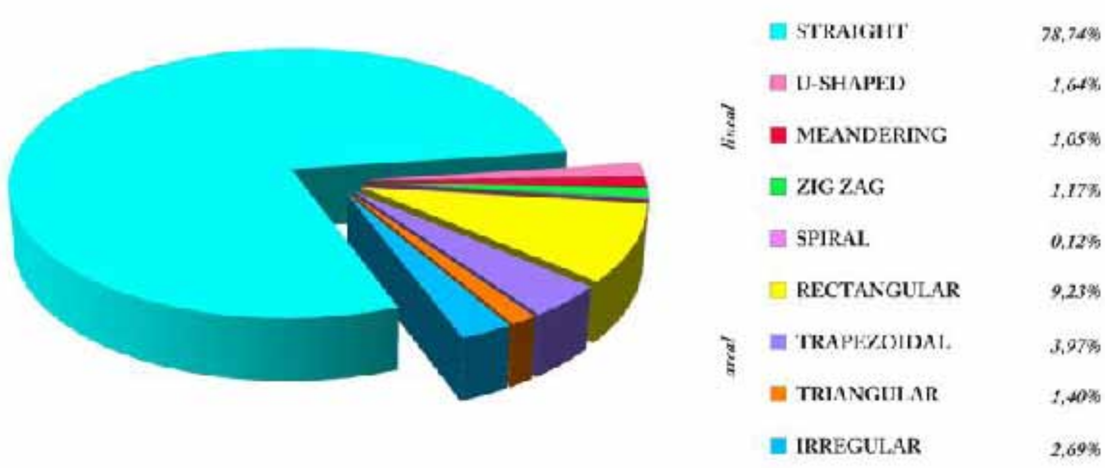
Geoglyphs and pyramids the tribute to Good



Masini N., Orefici G., Danese M., Pecci A., Scavone M., Lasaponara R. (2016). Cahuachi and Pampa de Atarco: Towards Greater Comprehension of Nasca Geoglyphs. In: Lasaponara R., Masini N., Orefici G. (Eds). The Ancient Nasca World New Insights from Science and Archaeology. Springer International Publishing, 2016, pp. 239-278

Geoglyphs in Pampa de Atarco : morphological characteristics



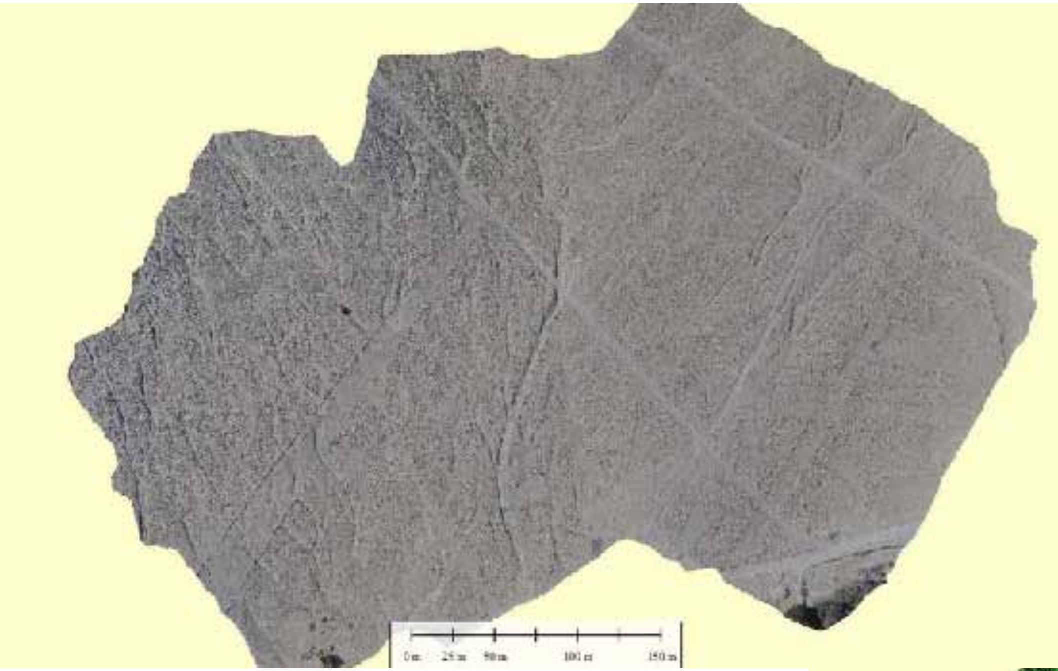


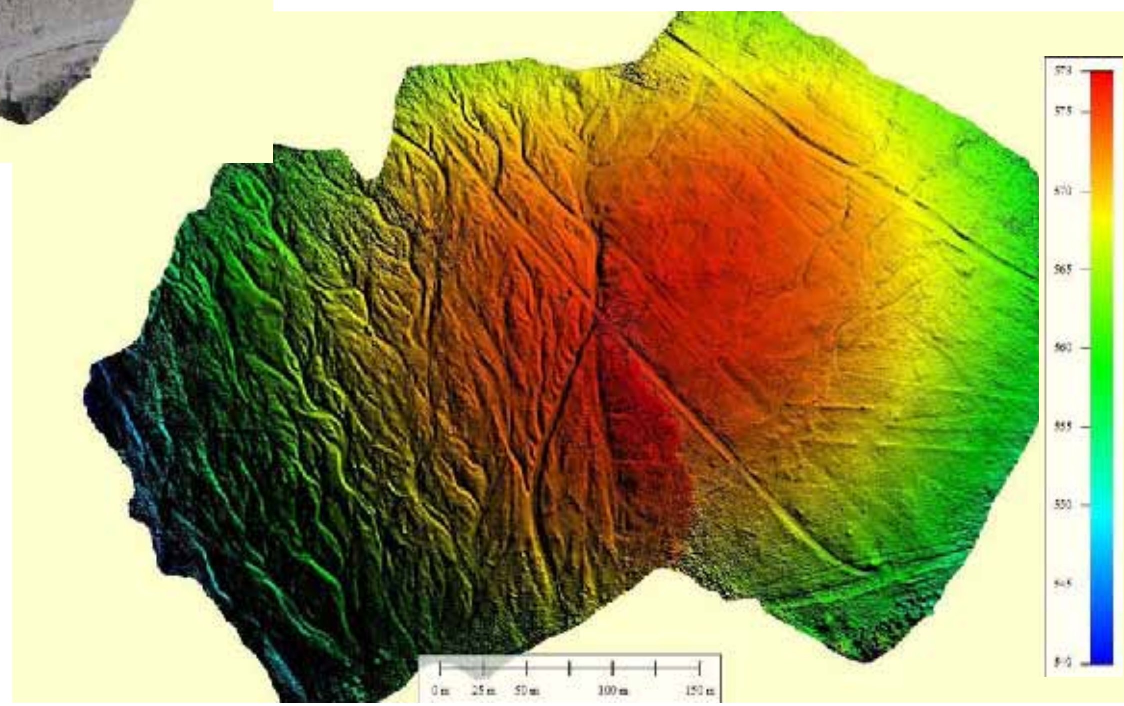
Masini N., Orefici G., et al.R. Cahuachi and Pampa de Atarco: Towards Greater Comprehension of Nasca Geoglyphs. In: Lasaponara R., Masini N., Orefici G. (Eds). The Ancient Nasca World New Insights from Science and Archaeology. Springer International Publishing, 2016, pp. 239-278

Future perspective: very high resolution survey of geoglyphs by UAV

Taruga 1

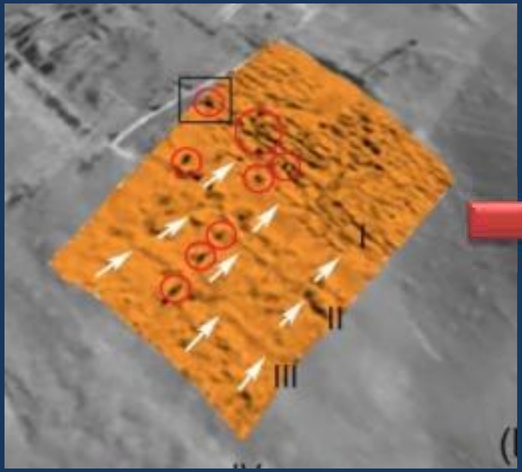
Masini N., Orefici G., et al.R. Cahuachi and Pampa de Atarco: Towards Greater Comprehension of Nasca Geoglyphs. In: Lasaponara R., Masini N., Orefici G. (Eds). The Ancient Nasca World New Insights from Science and Archaeology. Springer International Publishing, 2016, pp. 239-278





PIRAMIDE Naranja de CAHUACHI (2008-09): from satellite image analysis to archaeological finding

Satellite remote sensing

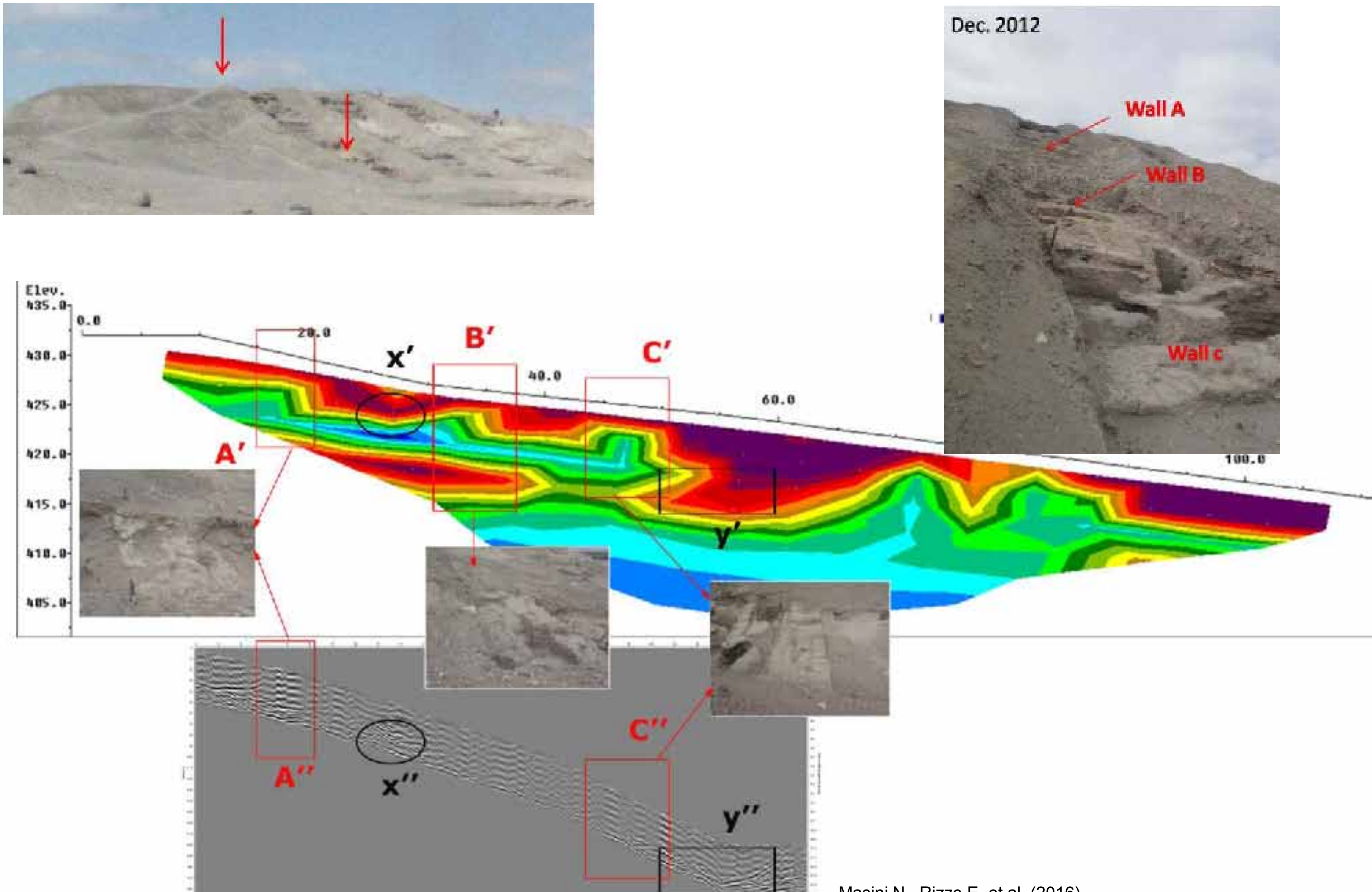


geomagnetometry

georadar

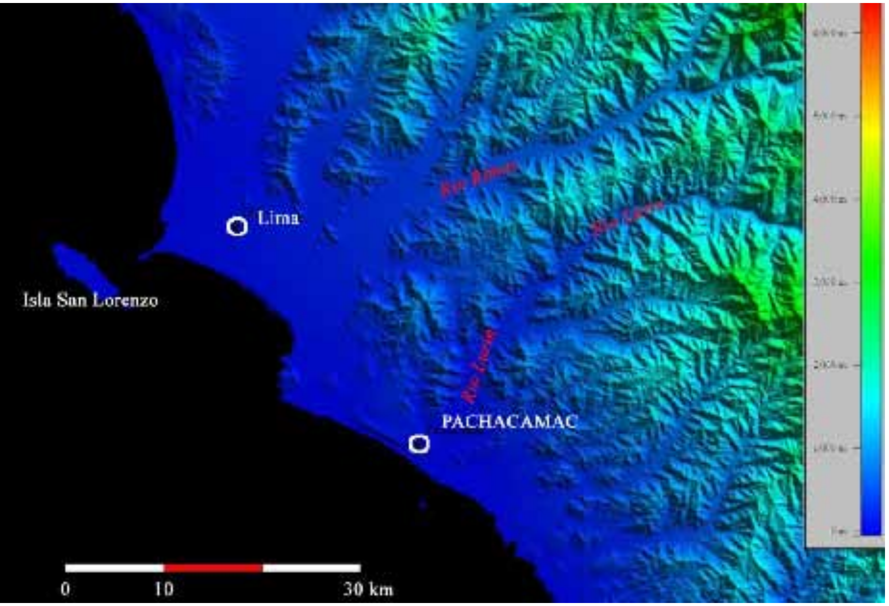
Ritual offering

South Mound in Cahuachi: discovery of a pyramid by geophysics.

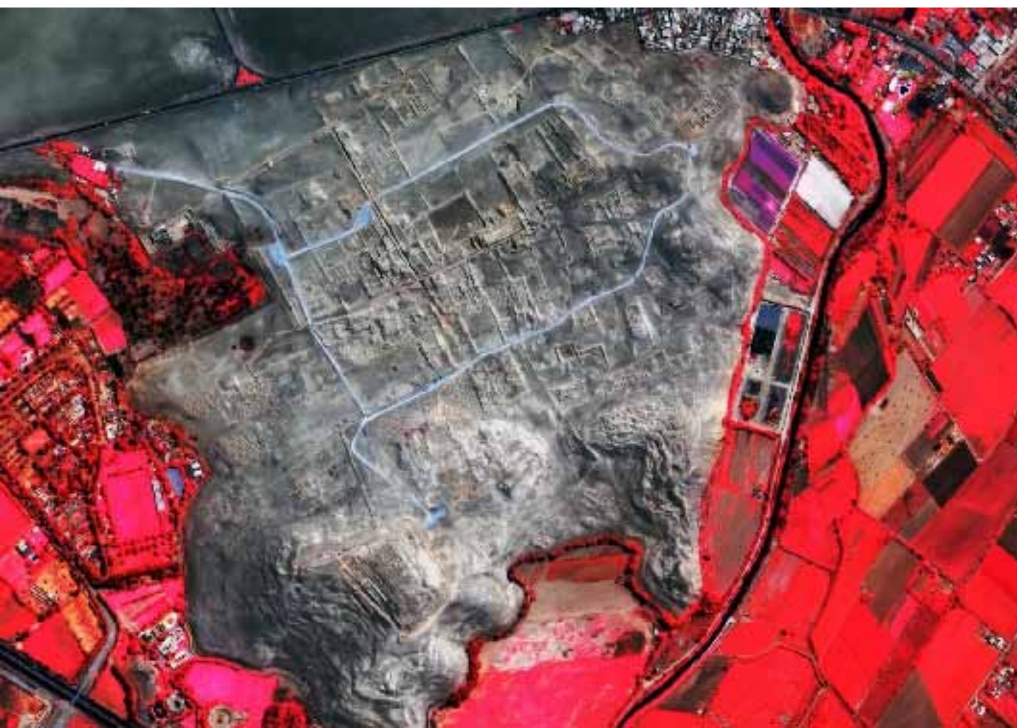


Masini N., Rizzo E et al. (2016).

Pachacamac



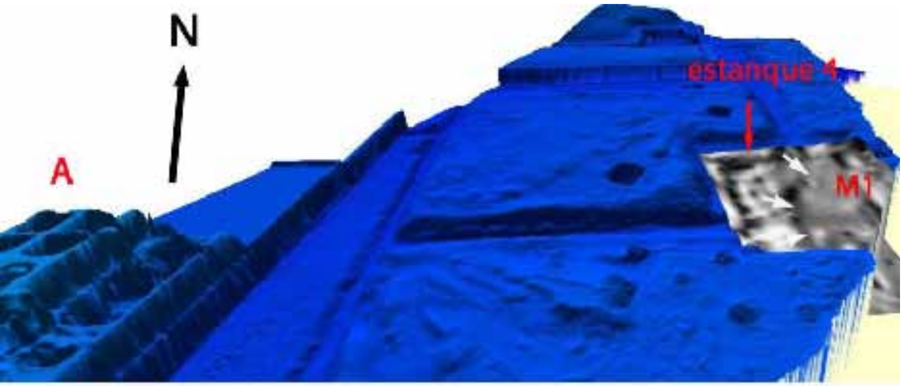
Pachacamac is located on a desert hill about 31 km South East of Lima, on the right bank of Lurin river near its mouth, 800 meters from the Pacific Ocean

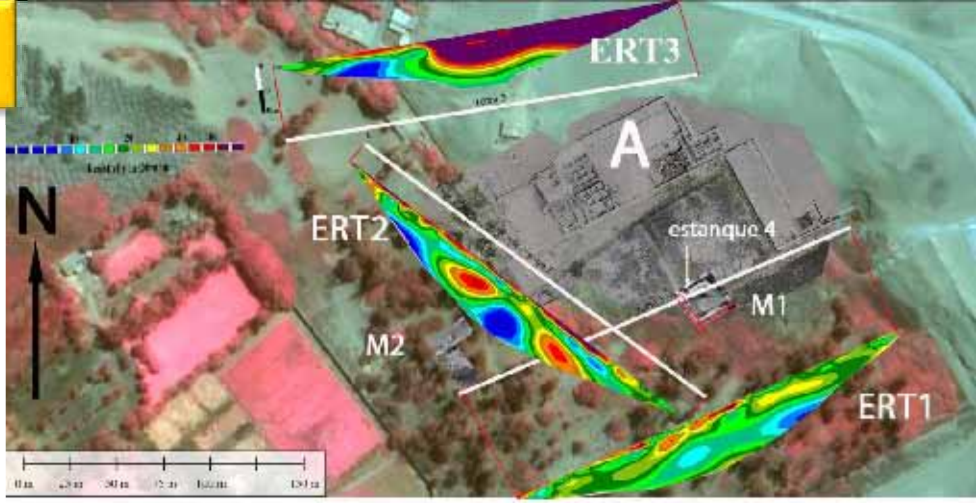


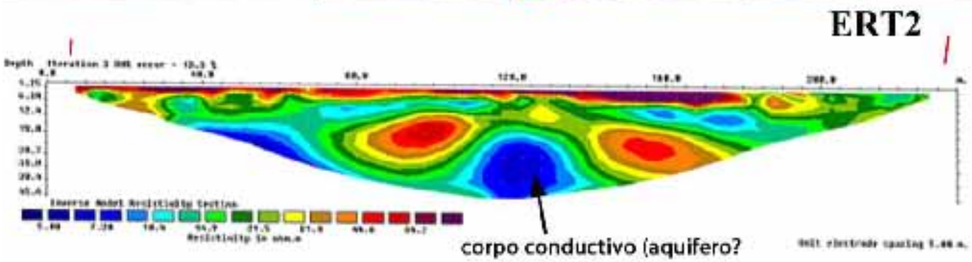
Pachacamac, is one of the largest archaeological sites of Peru. It was one of the main centers of religious cult in different historical periods and for different cultures such as Chavin, Lima Culture (200 BC-600 AD)., Huari (550-1100 AD) , Ychma (1100-1470) and Inca culture (1470-1530)

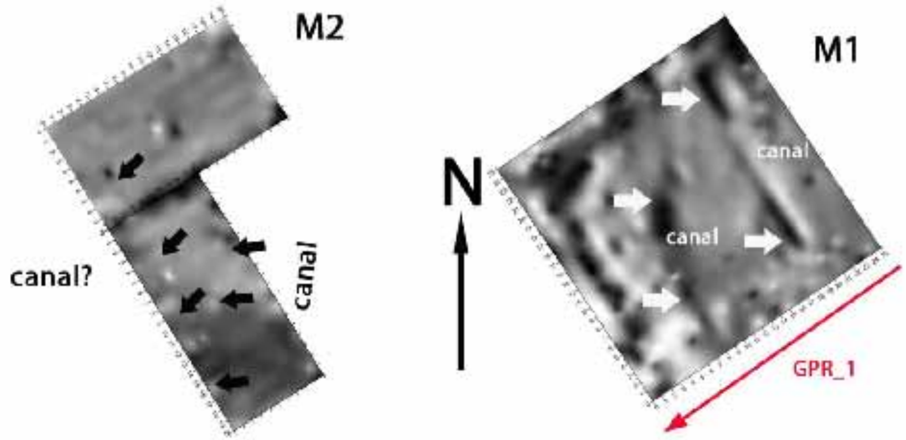
Lasaponara R., Masini N., Pecci A., Perciante A., Pozzi Escot D., Rizzo E., Scavone M., Sileo M. (2016). Qualitative evaluation of COSMO SkyMed in the detection of earthen archaeological remains: The case of Pachamacac (Peru). Journal of Cultural Heritage, http://dx.doi.org/10.1016/j.culher.2015.12.010

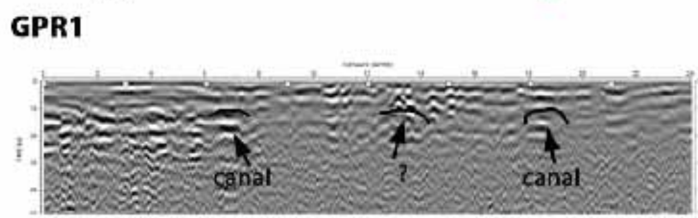
Pachacamac: detection water channeling system in the cerimonial Palace of Acclahuasi





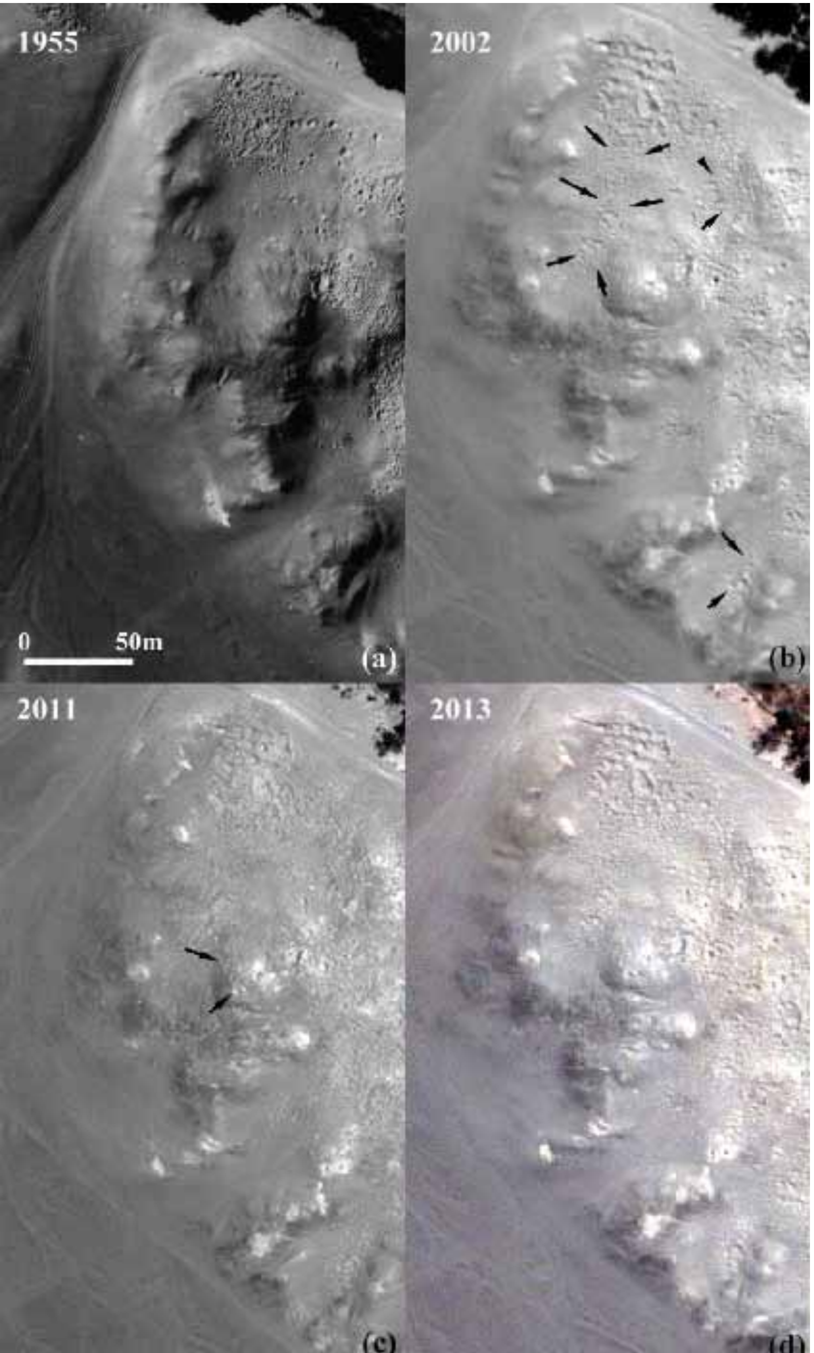


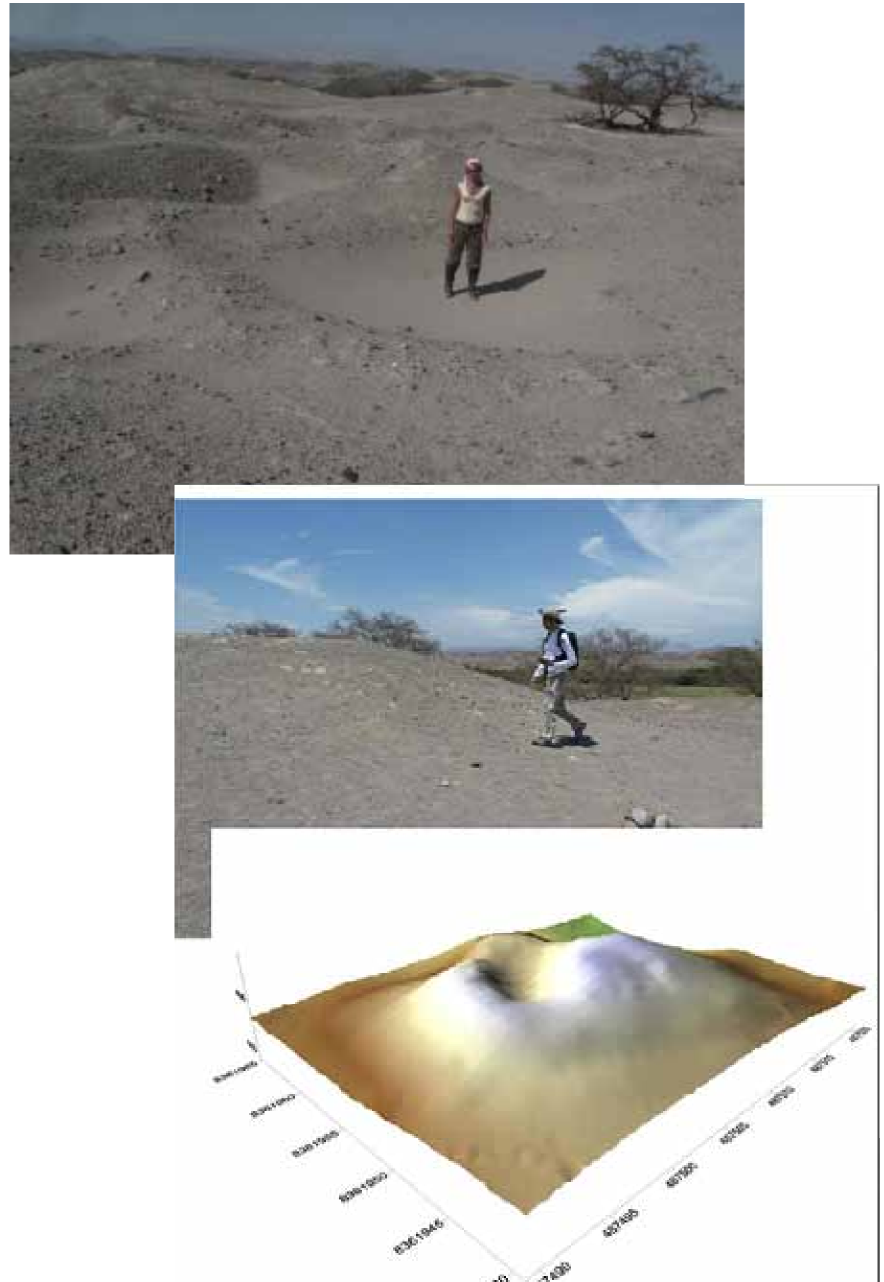




Ceremonial Center of Pachacamac (500-1500 AD): remote sensing data integration

Remote Sensing for documenting and monitoring archaeological looting

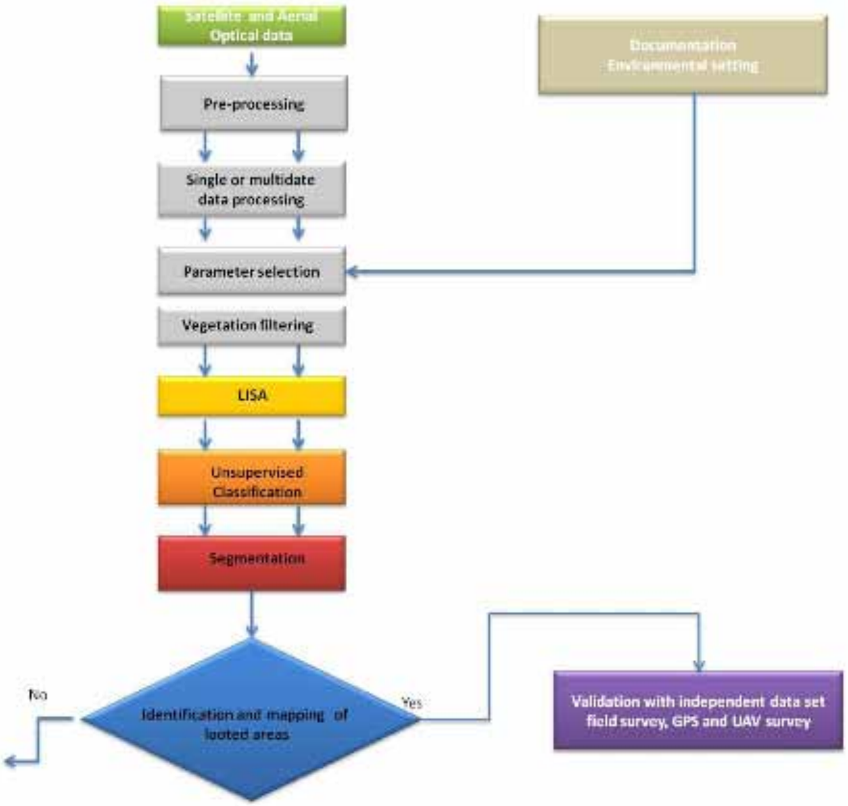


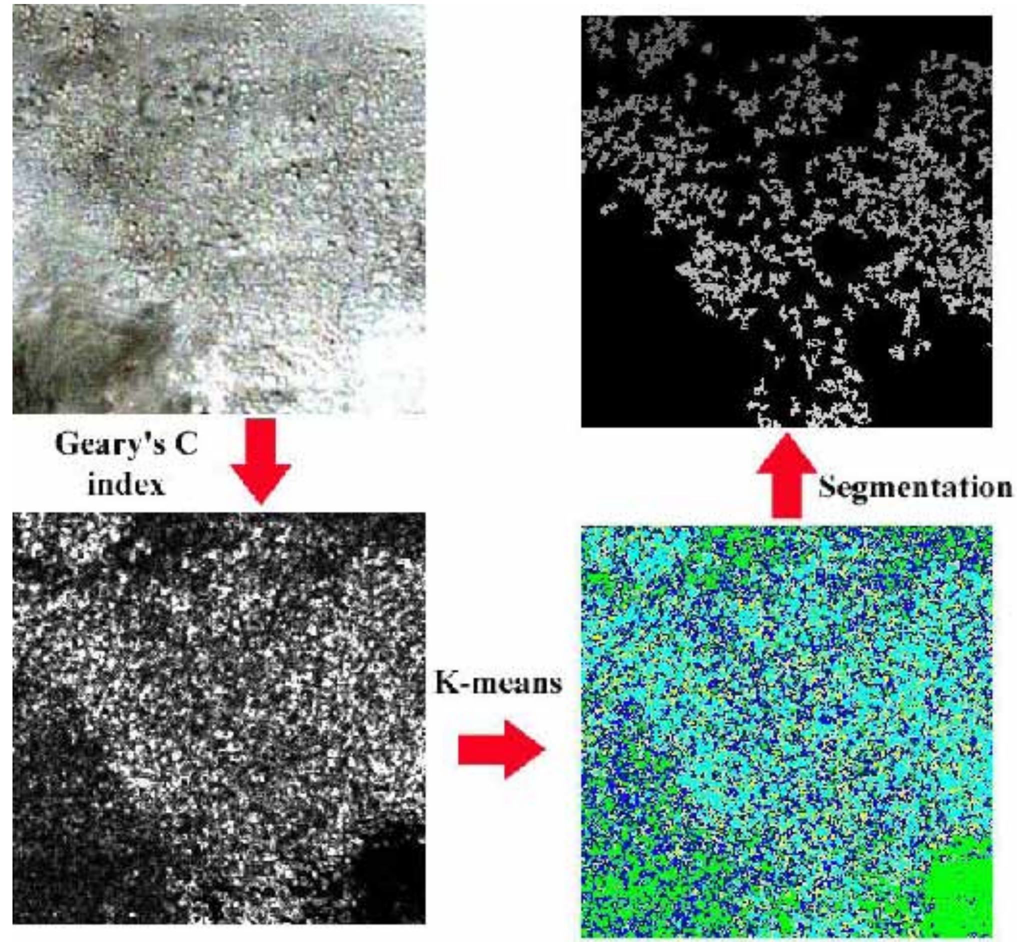


Investigated sites: Cahuachi and Ventarron

Lasaponara R., Masini N. (2016). Combating Illegal Excavations in Cahuachi: Ancient Problems and Modern Technologies. In: Lasaponara R., Masini N., Orefici G. (Eds). The Ancient Nasca World New Insights from Science and Archaeology. Springer International Publishing, 2016, pp. 605-633, doi: 10.1007/978-3-319-47052-8_25

Automatic extraction of archaeological looting fetures



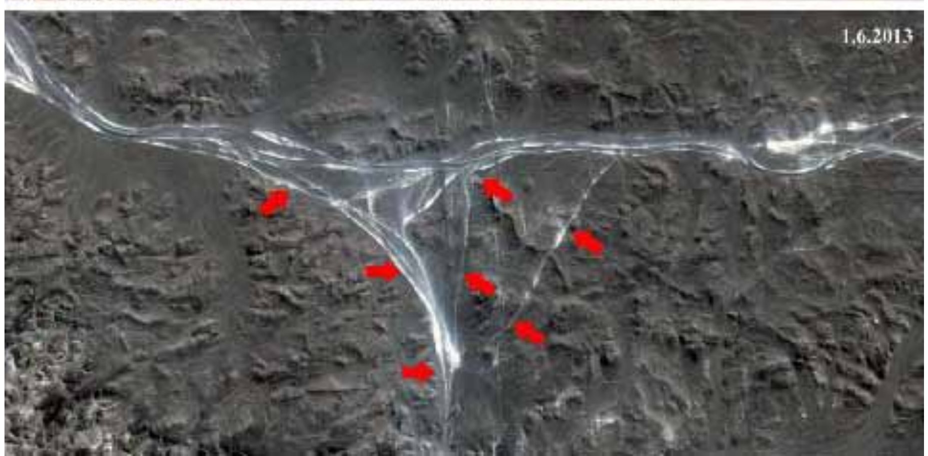


Nasca Lines: space tracking of vandalism

Masini N., Danese M., Pecci A., Scavone M., Lasaponara R. (2016). Nasca Lines: Space Tracking of Vandalism. In: Lasaponara R., Masini N., Orefici G. (Eds). The Ancient Nasca World New Insights from Science and Archaeology. Springer International Publishing, 2016, pp. 635-656, doi: 10.1007/978-3-319-47052-8_26

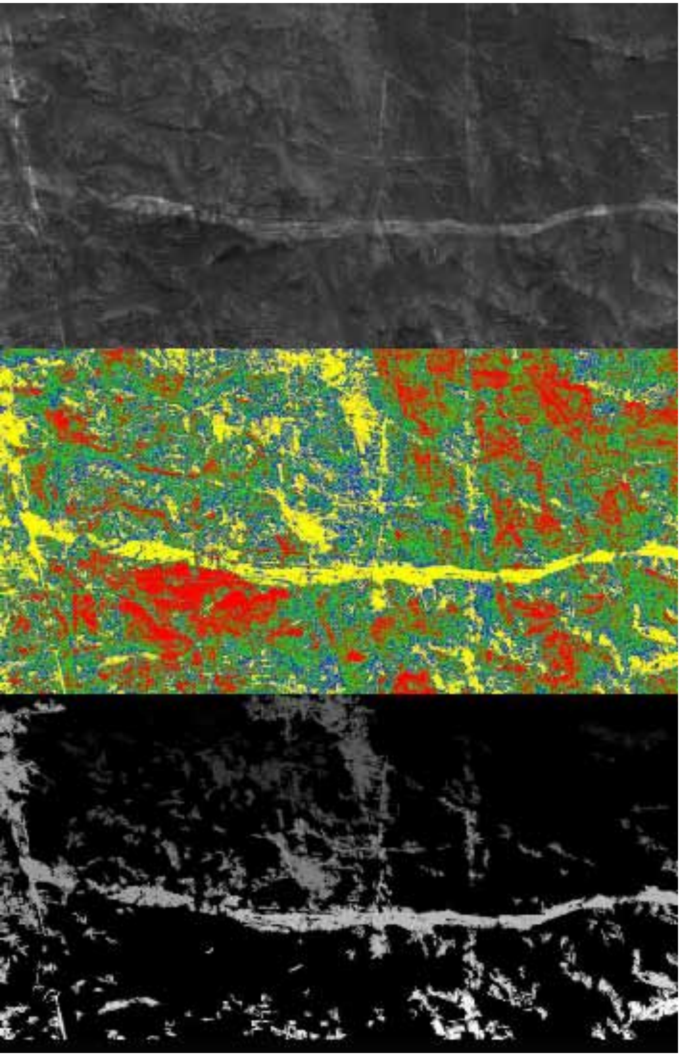
2002

2011

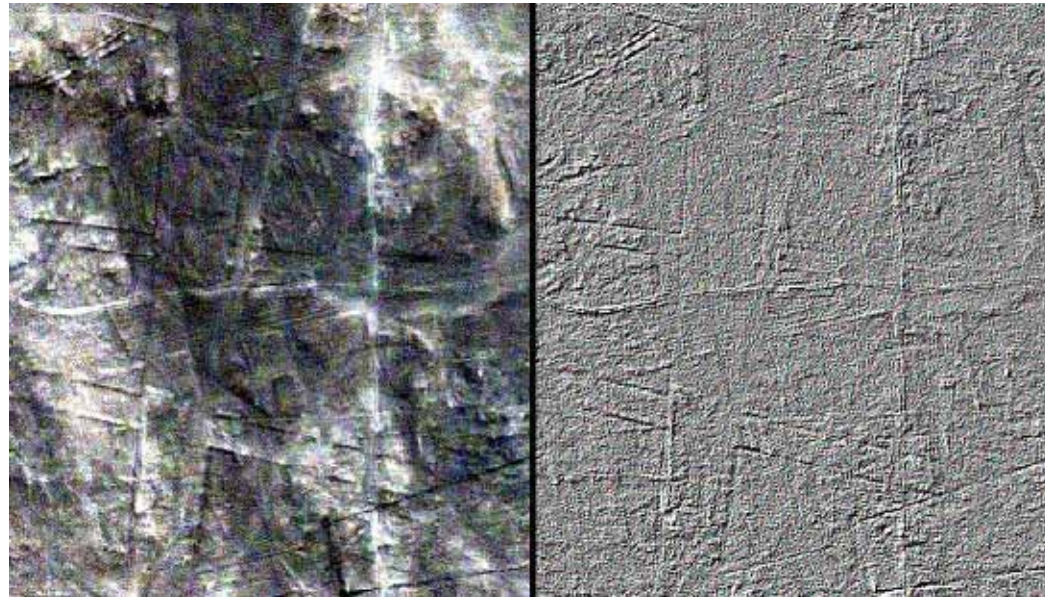


2013

Nasca Lines: space tracking of vandalism. Approaches based on RS



Supervised and unsupervised
Classification



Convolution filtering

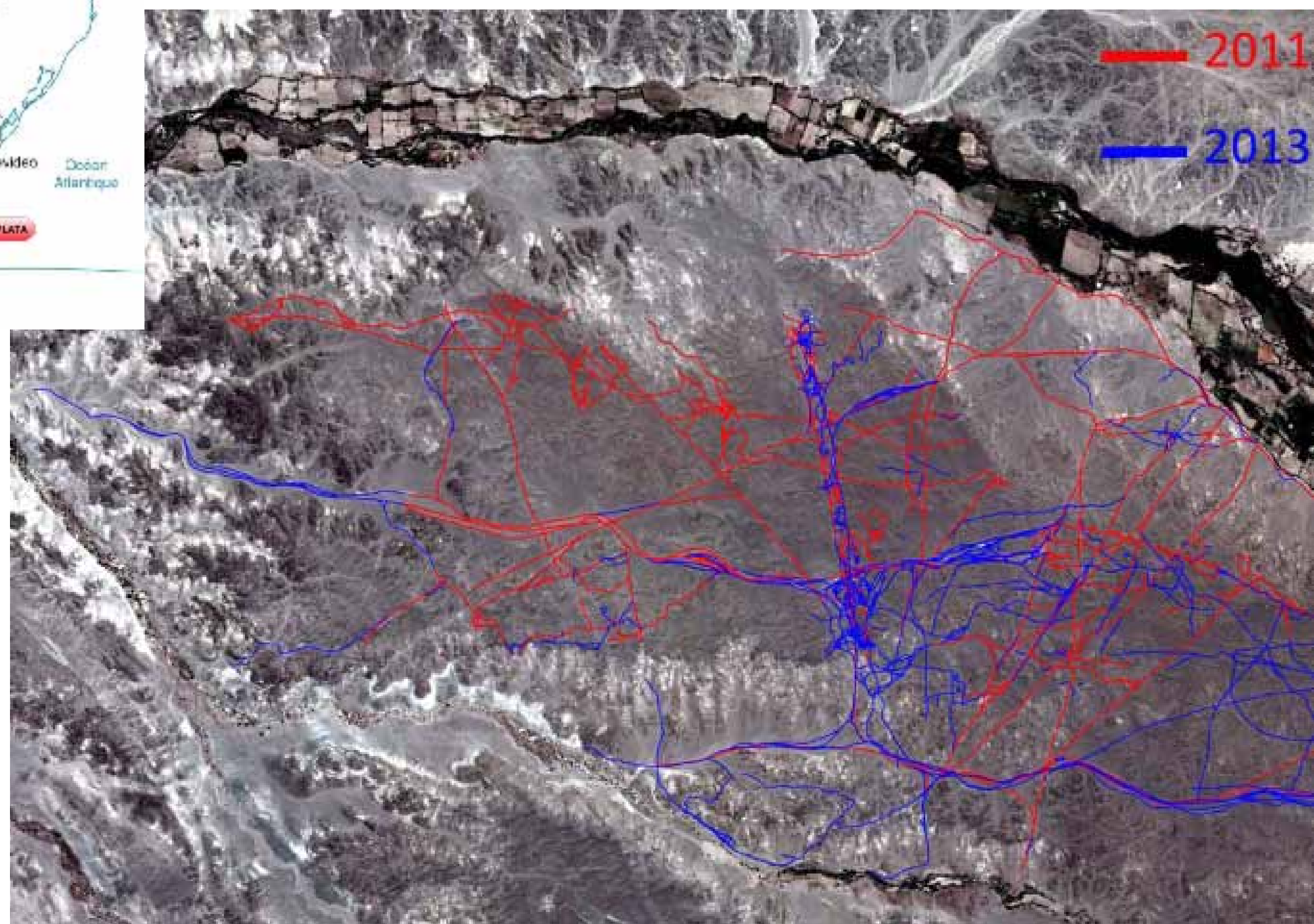
Satellite image

Orthophoto by UAV survey

DEM by UAV

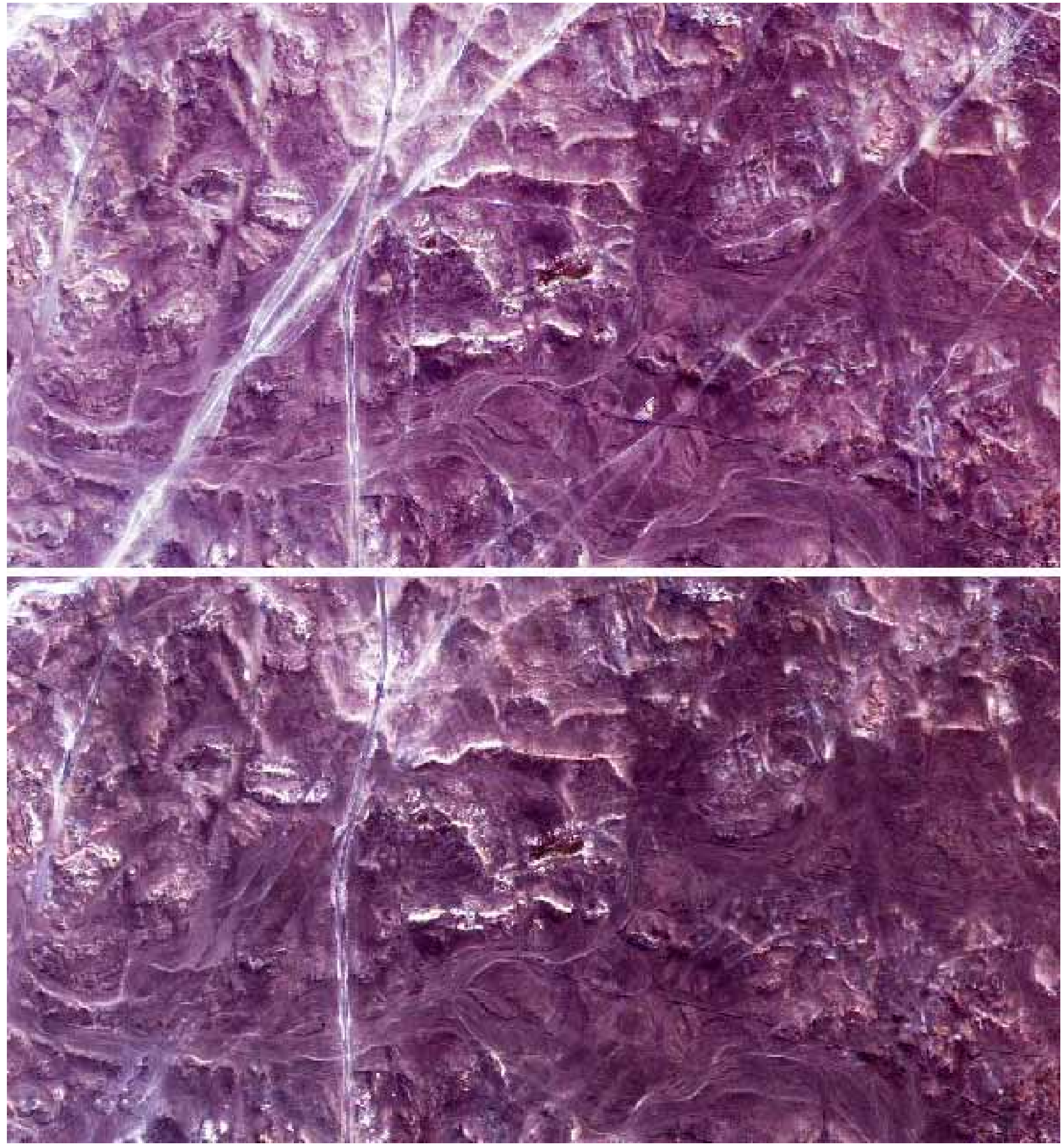
Damage caused by Dakar Rally

Masini N., Danese M., Pecci A., Scavone M., Lasaponara R. (2016). Nasca Lines: Space Tracking of Vandalism. In: Lasaponara R., Masini N., Orefici G. (Eds). The Ancient Nasca World New Insights from Science and Archaeology. Springer International Publishing, 2016, pp. 635-656, doi: 10.1007/978-3-319-47052-8_26



Digital restoration of Nasca geoglyphs

Digital restoration of desert ground drawing by removing vandalism traces and off-road vehicles tracks



Masini N., Danese M., Pecci A., Scavone M., Lasaponara R. (2016). Nasca Lines: Space Tracking of Vandalism. In: Lasaponara R., Masini N., Orefici G. (Eds). The Ancient Nasca World New Insights from Science and Archaeology. Springer International Publishing, 2016, pp. 635-656, doi: 10.1007/978-3-319-47052-8_26

Conclusions

Space Earth Observation technologies in **Archaeology** has been strongly **increasing** during the last twenty years not only for research purposes but also for an operative use

These technologies are also mature for risk monitoring and landscape analyses thanks to the advancement of sensor performance and data processing methods

Some effort need to be made for **improving** the **interpretation** of remote sensing data/results by means the integratation of RS with in situ analyses and interdisciplinary approaches

Workshop
Remote Sensing for Cultural heritage. Beyond Europe
Paphos (Cyprus), 20 March 2017

Exploitation of big data cloud infrastructures for earth observation cultural heritage applications:

mapping the land use changes patterns in the vicinity of "The Great Pyramid at Giza"

Dr. Athos Agapiou
Cyprus University of Technology
athos.agapiou@cut.ac.cy

Acknowledgements: The present communication is under the "ATHENA" project H2020-TWINN2015 of European Commission. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691936.

ATHENA project

www.athena2020.eu

Cyprus University of Technology

DLR

Acknowledgements: The present communication is under the “ATHENA” project H2020-TWINN2015 of European Commission. This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 691936.

Big Data Era….

«…. With the exponential growth of data amount and increasing degree of diversity and complexity, the remotely sensed data are regarded as RS "Big Data". However, since the whole idea of big data is still remaining relatively new, most of the start off efforts are focusing on the definition and discussion of the realm of the big data. **Big data occurs when a large collection of data sets whose volume and rate of data is at a scale that is far beyond the state-of-the-art systems and revolutionize the way of seeking solutions**. ..»

Yan Ma, et al, Remote sensing big data computing: Challenges and opportunities, Future Generation Computer Systems, 51, 2015, 47-60

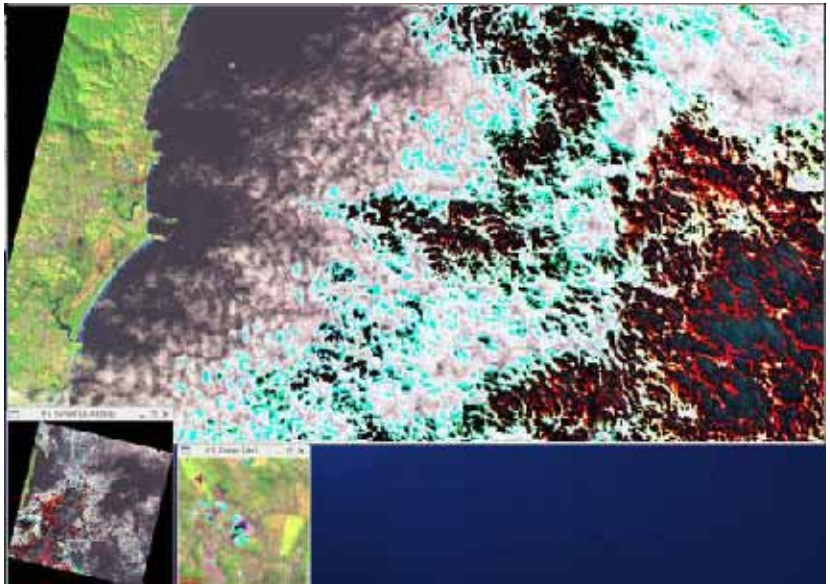
Big Data needs for the future

«…. In the near future, some new requirements together with problems will emerge with the further increasing amount and widespread application of RS data. Obviously, the increasing demand for real-time or near real-time processing capability by many time-critical RS applications have definitely made the data-intensive issue even worse. ..»

Yan Ma, et al, Remote sensing big data computing: Challenges and opportunities, Future Generation Computer Systems, 51, 2015, 47-60

Big Data...Landsat

Since 1972, Landsat satellites have continuously acquired space-based images of the Earth's land surface, providing data that serve as valuable resources for land use/land change research and a number of applications in forestry, agriculture, geology, land cover mapping, and water and coastal studies. Currently, Landsat 8 and Landsat 7 together acquire over 1,200 new images per day

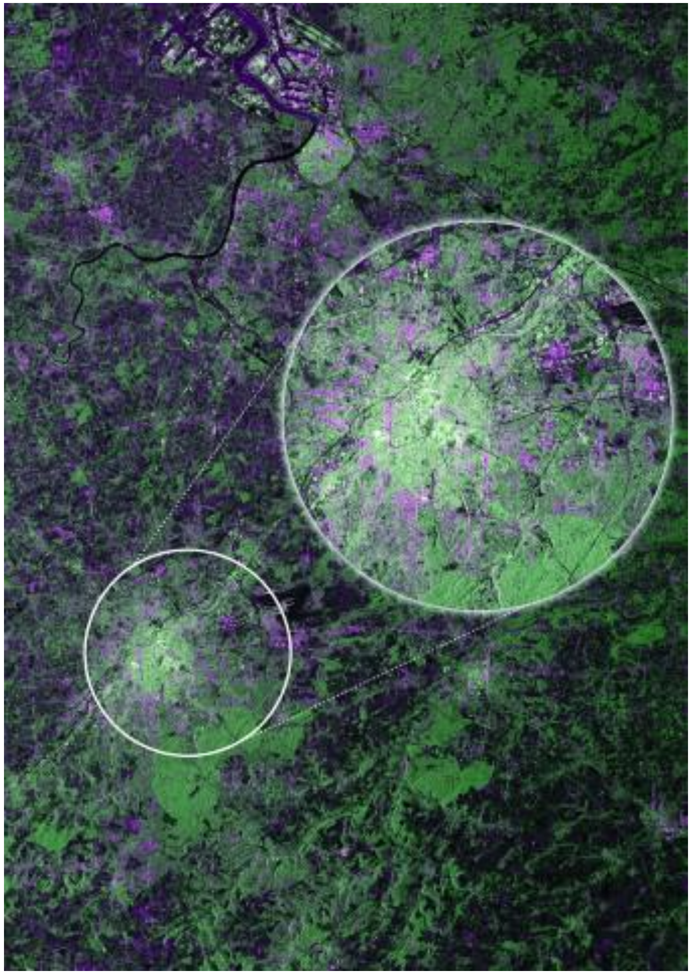


USGS, Landsat Missions, 2015.

Big Data...Sentinel

These satellites will be providing an enormous amount of data: Whereas Envisat provided 0.3 terabyte (TB) per day, each Sentinel-1 will provide 1.8 TB/day, with Sentinel-2s providing 1.6 TB and Sentinel-3s providing 0.6 TB.

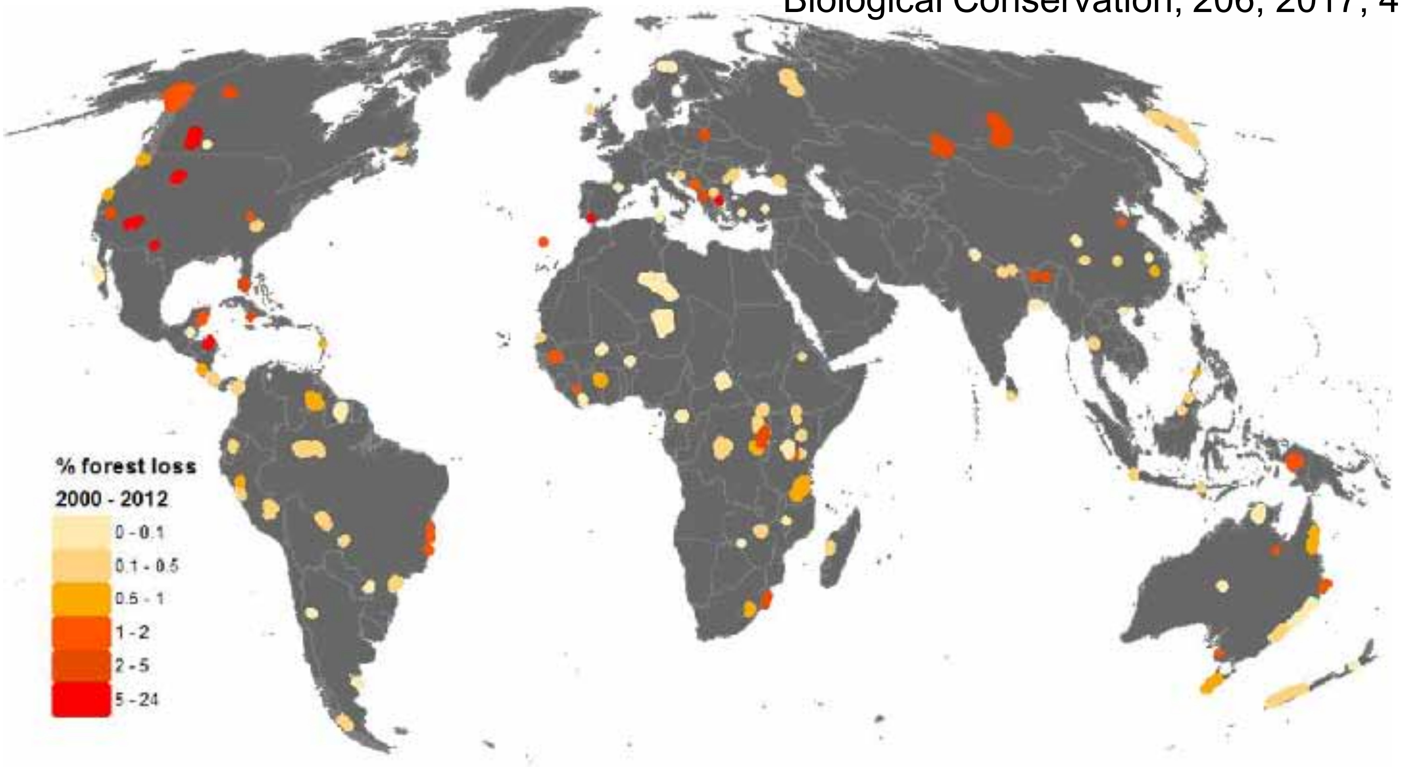
Access to the large volume of Sentinel data "will be a bit of a hurdle at this point in time, but with the advancement of technology, this will be figured out,"



Sentinel Satellites Initiate New Era in Earth Observation

Recent applications for Cultural Heritage for…World-wide scale

James R. et al., Recent increases in human pressure and forest loss threaten many Natural World Heritage Sites, Biological Conservation, 206, 2017, 47-55,



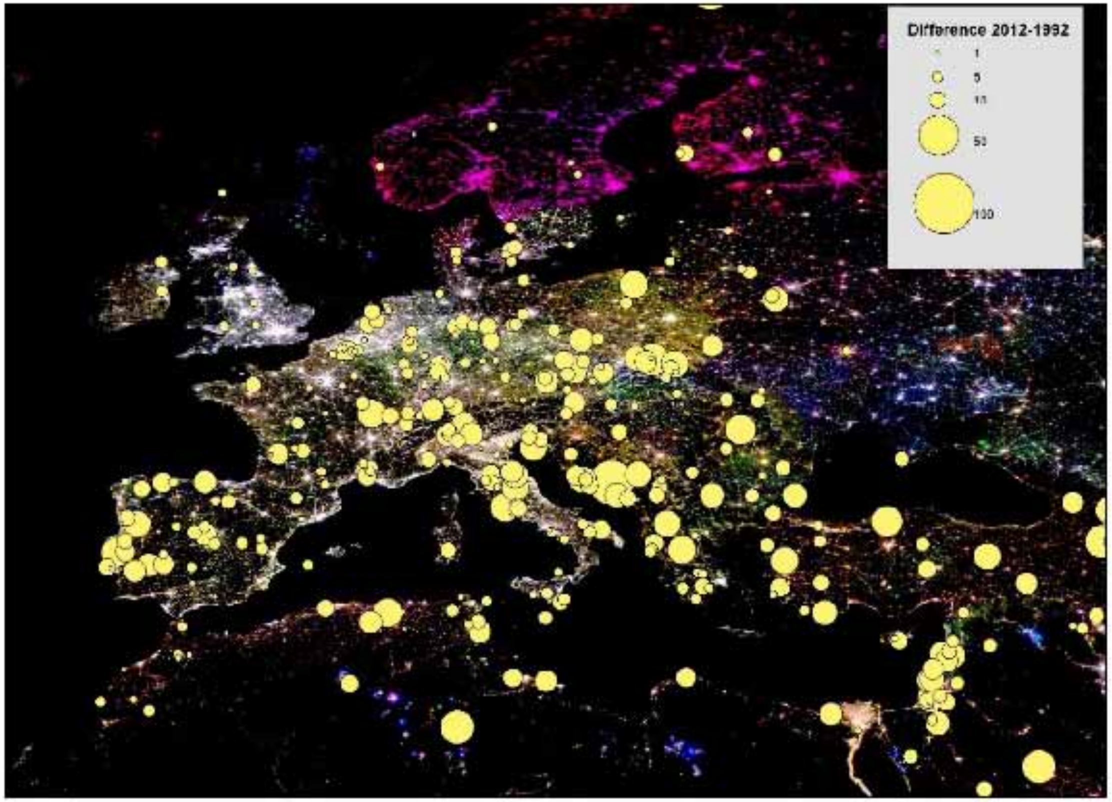
Human Footprint + Global Forest Watch

Percent forest loss between 2000 and 2012 in **Natural World Heritage Sites** inscribed prior to 2000. Sites experiencing substantial forest loss (N5%) are shown in red. Site boundaries are not to scale, and have been enlarged for clarity.

Recent applications for Cultural Heritage for….continent scale

Agapiou A., 2017, Remote Sensing Heritage in a petabyte-scale: Satellite Data and Heritage Earth Engine© applications, International Journal of Digital Earth, 10, (1), 85-102, 10.1080/17538947.2016.1250829

DMSP-OLS Night-time Lights

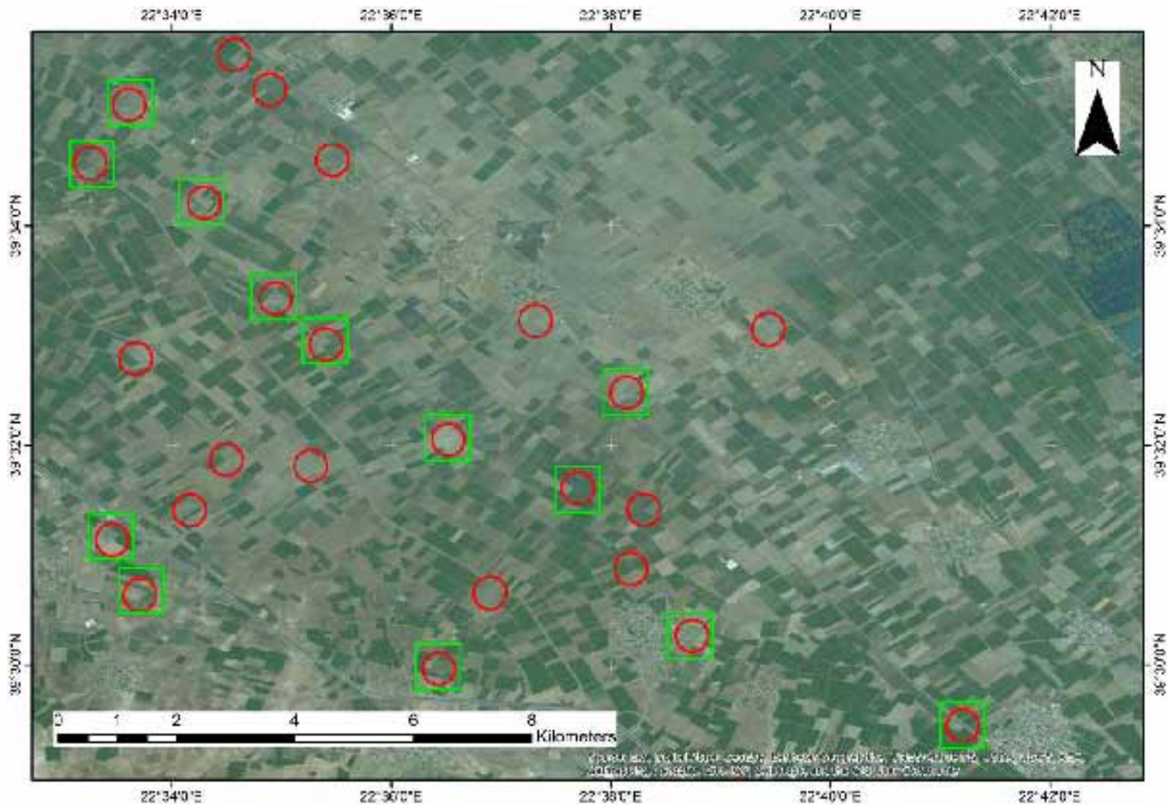


Difference between DMSP-OLS Night-time Lights Time Series Version 4 data over Europe, Middle East and North Africa regions for the period 1992–2012. The background image is a pseudo colour composite of the DMSP-OLS data for the years 2012–2002–1992. (Data generated from Google Earth Engine(c). Background Source Maps: Esri, DigitalGlobe, GeoEye, Earthstar Geographics

Recent applications for Cultural Heritage for…local scale

Agapiou A., 2017, Remote Sensing Heritage in a petabyte-scale: Satellite Data and Heritage Earth Engine© applications, International Journal of Digital Earth, 10, (1), 85-102, 10.1080/17538947.2016.1250829

Landsat series



Overall success results after the application of the orthogonal equations for Landsat 7 ETM+ series for the period 1999–2003. Red squares indicate all the known Neolithic tells of the area (approximately 180 km2). Green squares are the Neolithic tells identified from visual inspection and interpretation.

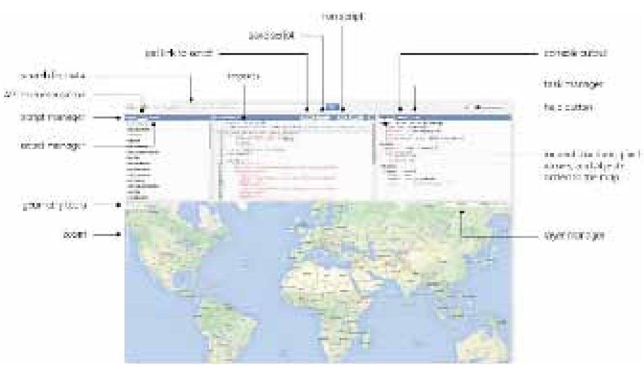
Big Data Infrastructures for RS applications

- Public Sector Initiatives
- Private Sector Offers
- Public-Private Partnerships

ESA

Helix Nebula

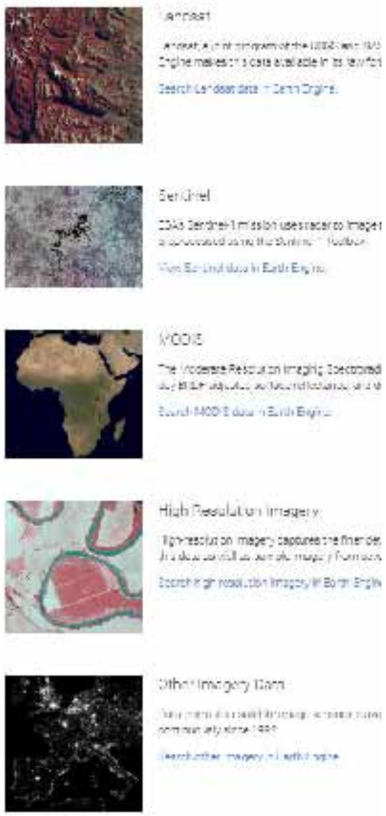
GloudEO

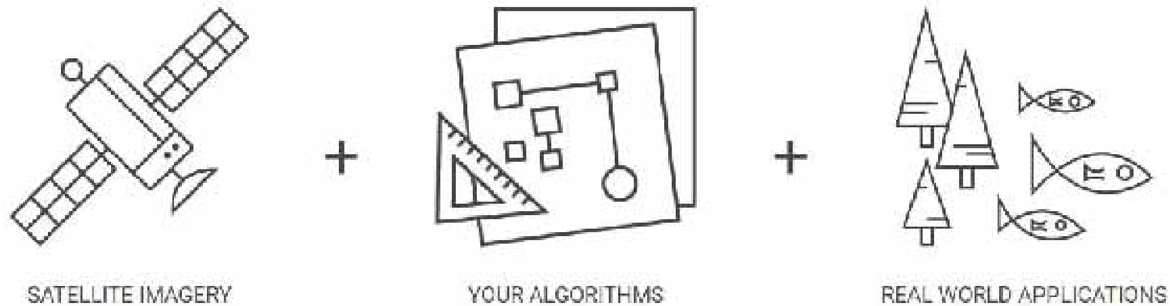


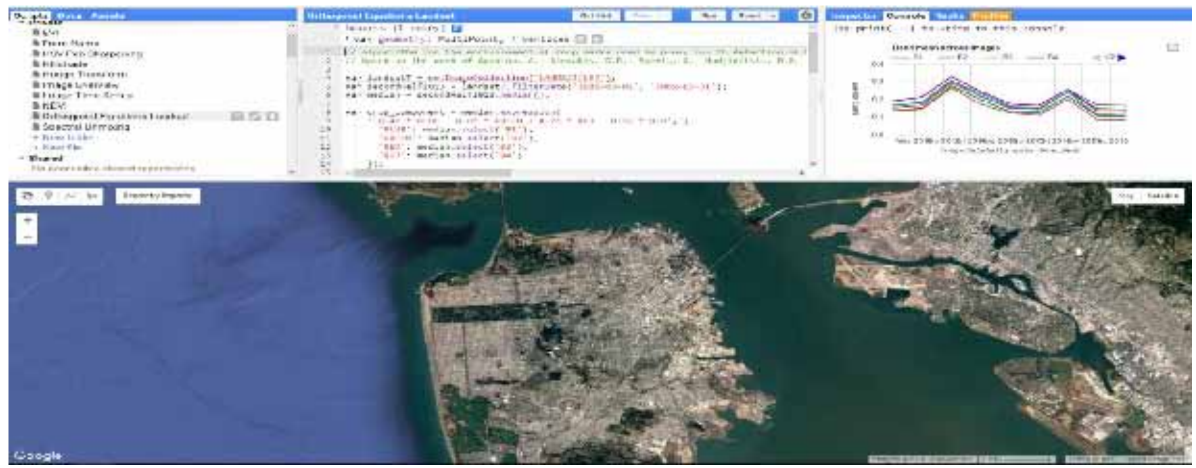
Google Earth Engine

Amazon

Google Earth Engine



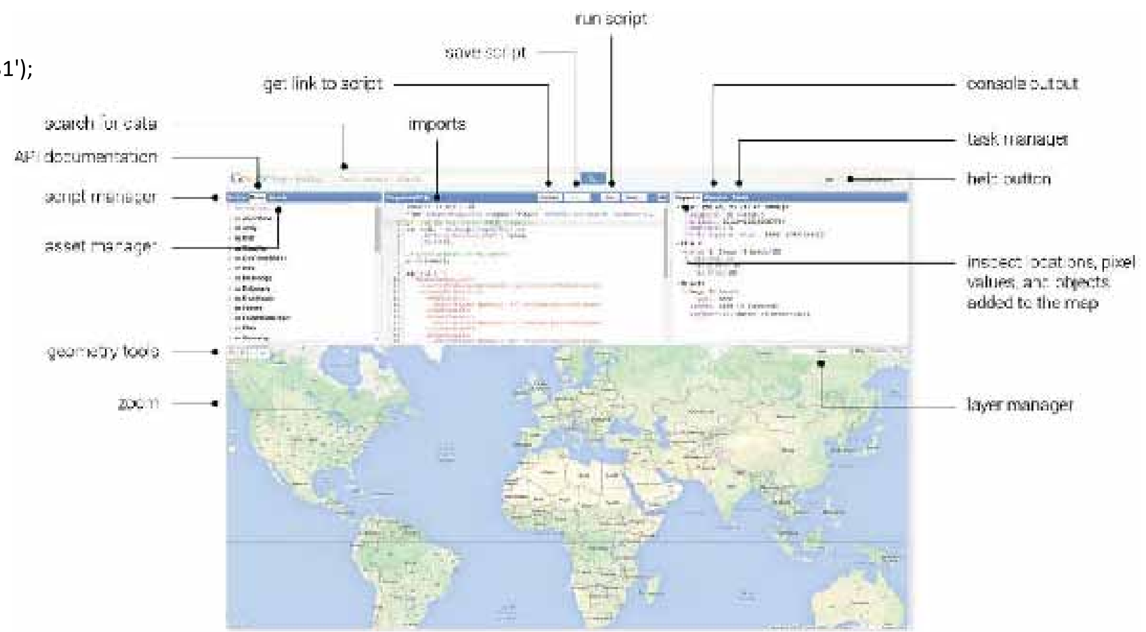


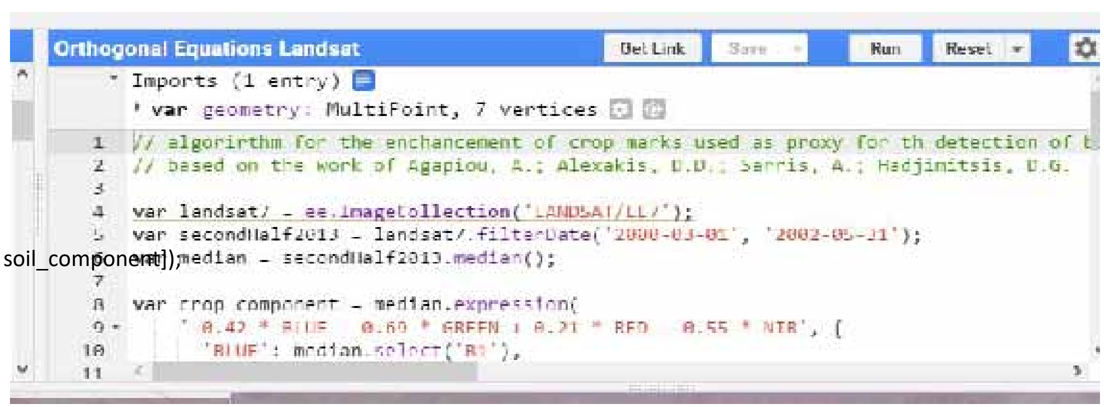


Google Earth Engine is a computing platform that allows users to run geospatial analysis on Google's infrastructure.

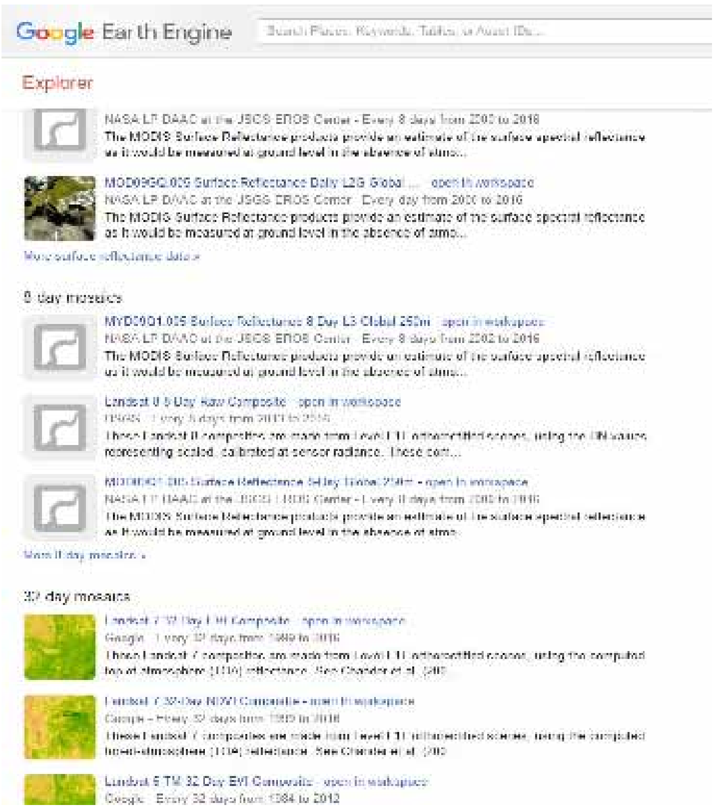
Google Earth Engine....core editor

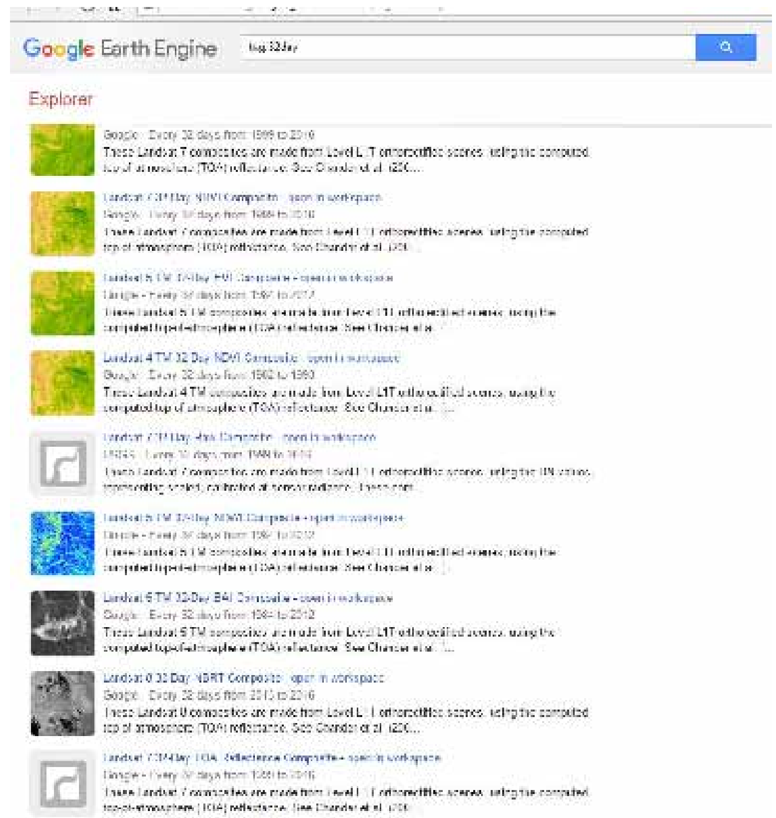
```
var landsat7 = ee.ImageCollection('LANDSAT/LE7');
var secondHalf2013 = landsat7.filterDate('2000-03-01', '2002-05-31');
var median = secondHalf2013.median();

var crop_component = median.expression(
  '-0.42 * BLUE - 0.69 * GREEN + 0.21 * RED - 0.55 * NIR', {
   'BLUE': median.select('B1'),
   'GREEN': median.select('B2'),
   'RED': median.select('B3'),
   'NIR': median.select('B4')
  });

Map.setCenter(22.68, 39.50, 12);
var vegetation_component = median.expression(
  '-0.34 * BLUE - 0.41 * GREEN -0.65 * RED + 0.53 * NIR', {
   'BLUE': median.select('B1'), // 450-520nm, BLUE
   'GREEN': median.select('B2'), //520-600nm, GREEN
   'RED': median.select('B3'), // 630-690nm, RED
   'NIR': median.select('B4') // 760-900nm, NIR
  });


var soil_component = median.expression(
  '0.12 * BLUE +0.22 * GREEN -0.73 * RED -0.64 * NIR', {
   'BLUE': median.select('B1'), // 450-520nm, BLUE
   'GREEN': median.select('B2'), //520-600nm, GREEN
   'RED': median.select('B3'), // 630-690nm, RED
   'NIR': median.select('B4') // 760-900nm, NIR
  });

 // Create a multi-band image from a list of constants.
var multiband = ee.Image([crop_component, vegetation_component, soil_component]);
Map.setCenter(22.68, 39.50, 12);
Map.addLayer(multiband);
```





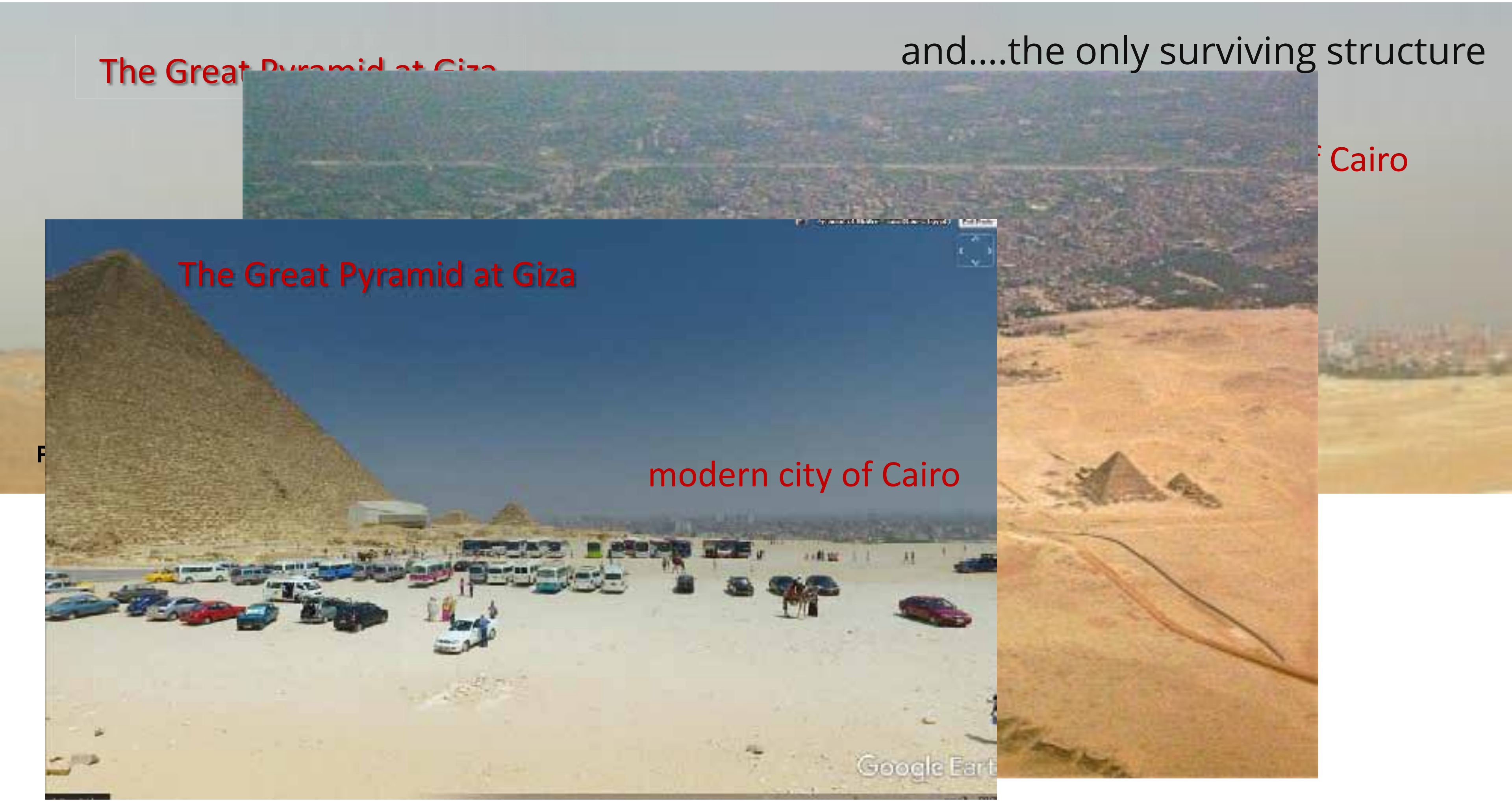
Google Earth Engine Data and Ready Products





Case Study area

the last of the ancient **Seven Wonders** of the World



Giza pyramid complex

Case Study area…from space

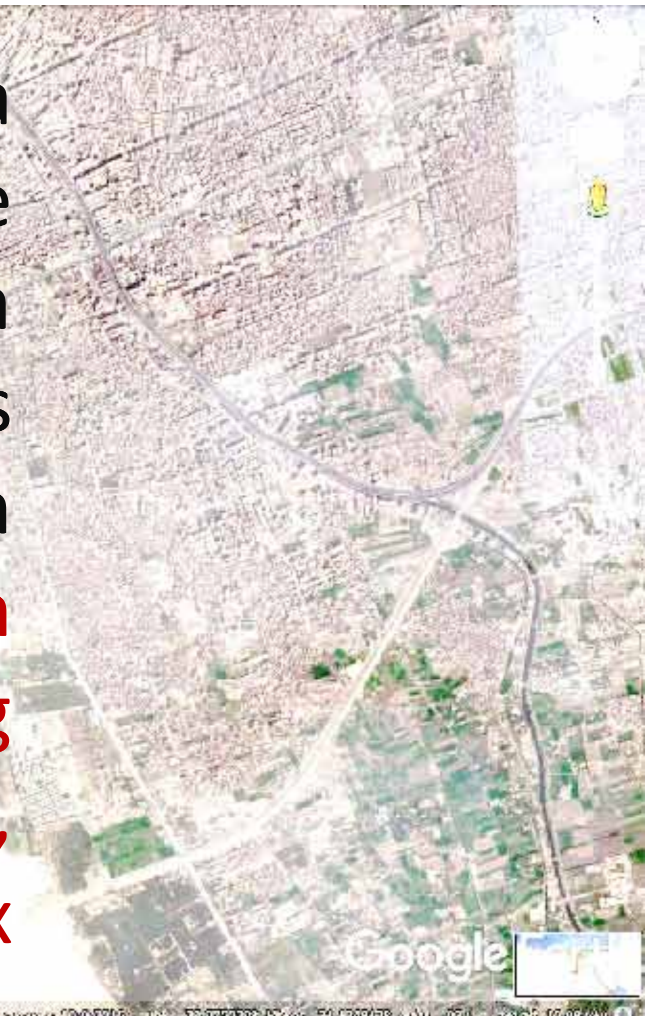
1972

2008

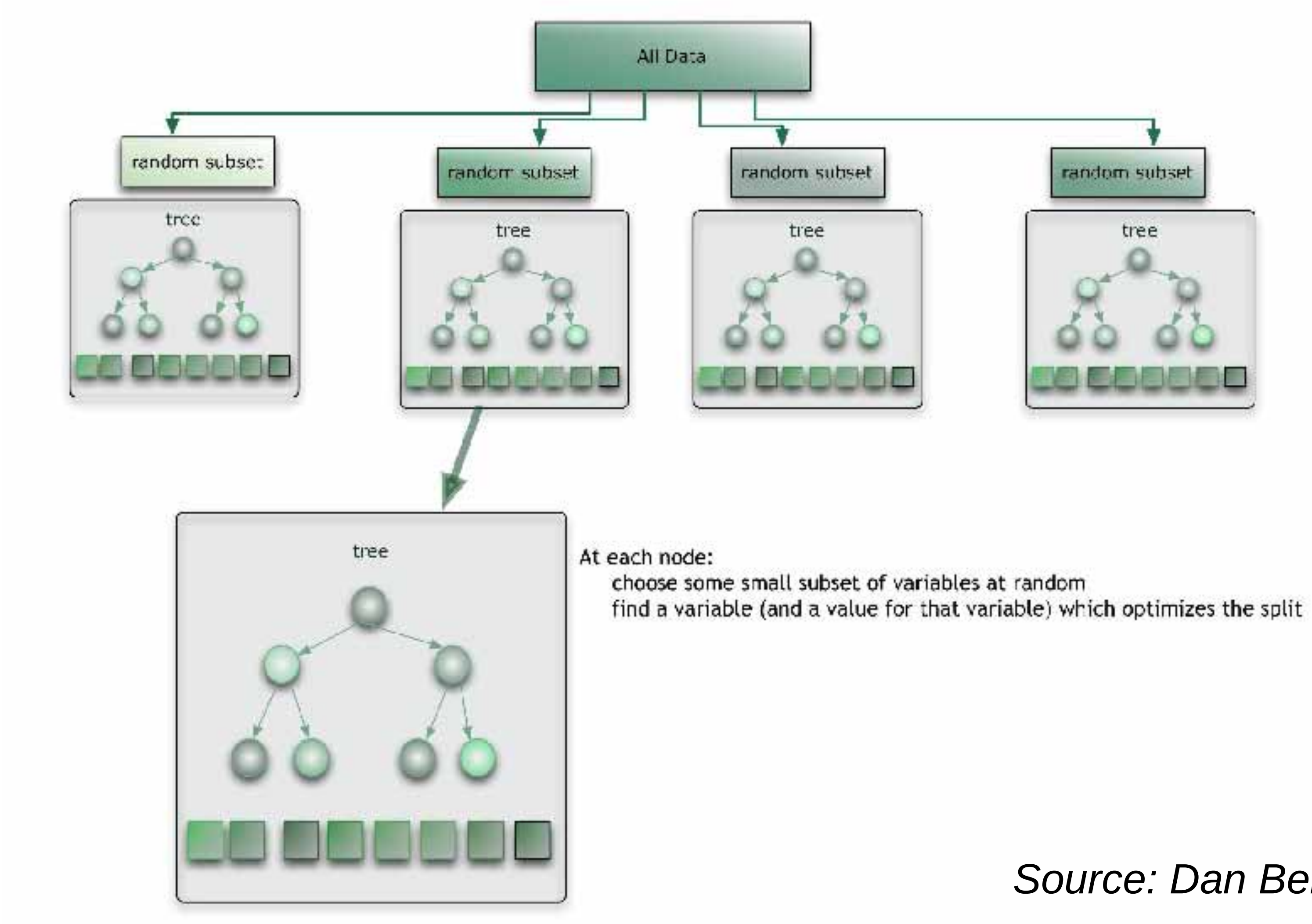
2017

Aims…

To explore Big Data Infrastructures such as Google Earth Engine so as to map urban expansion in the last decades using advance classification algorithms such as Random Forest, Fast Naive Bayes, Voting Support Vector Machine (SVM), Margin SVM and GMO Max Entropy classifiers

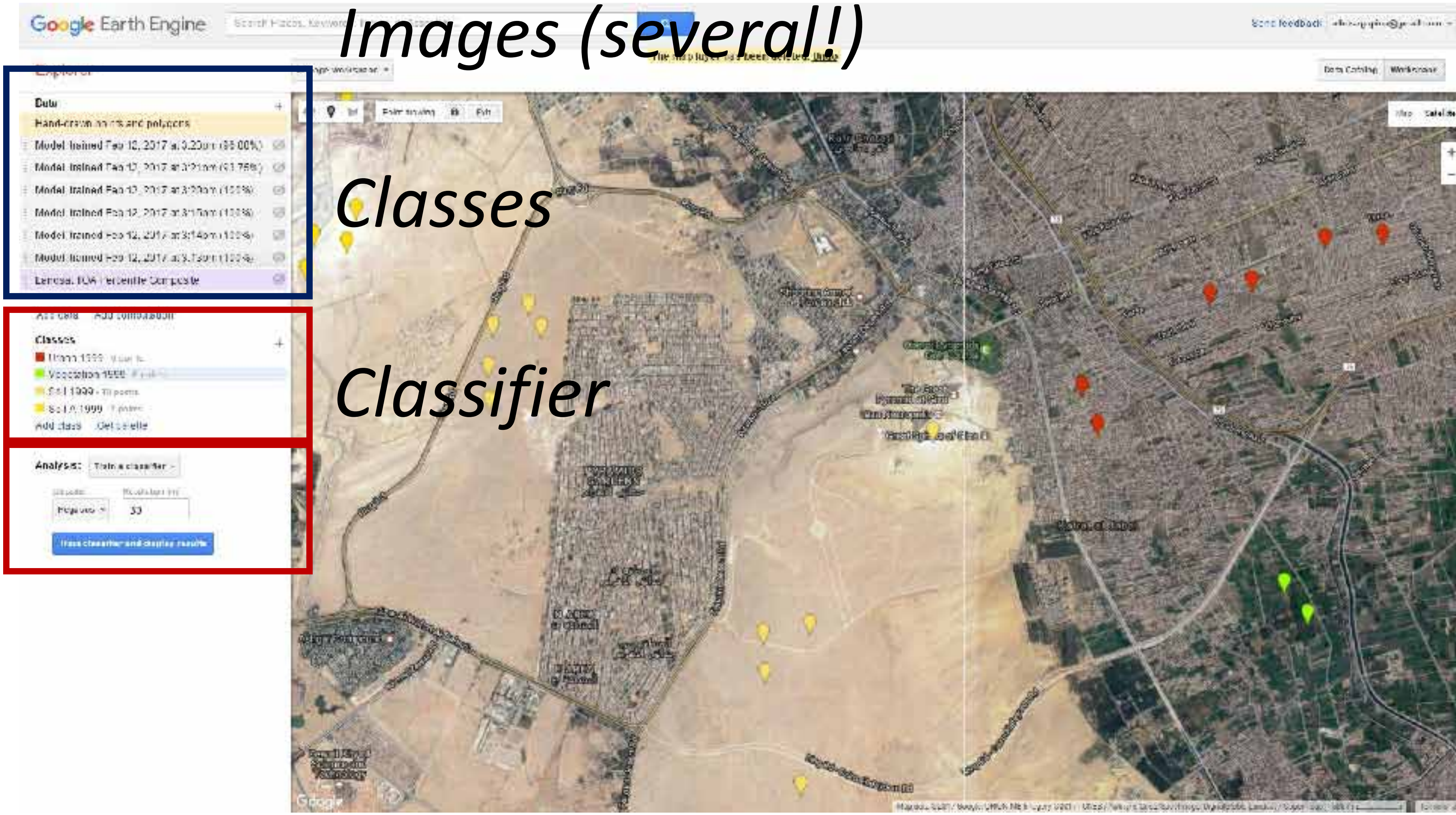


Random Forest



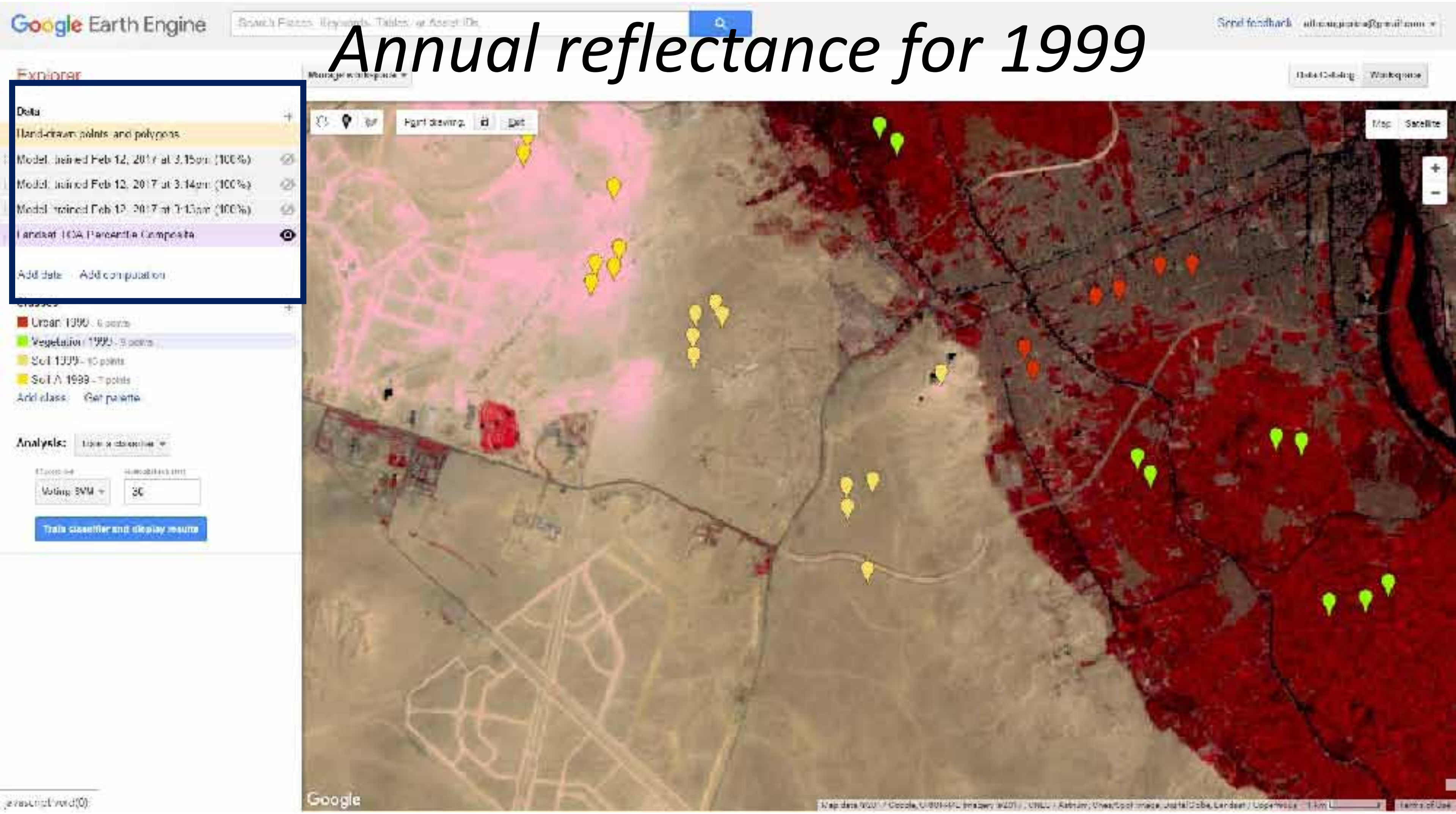
Source: Dan Benyamin

Collecting areas of interest

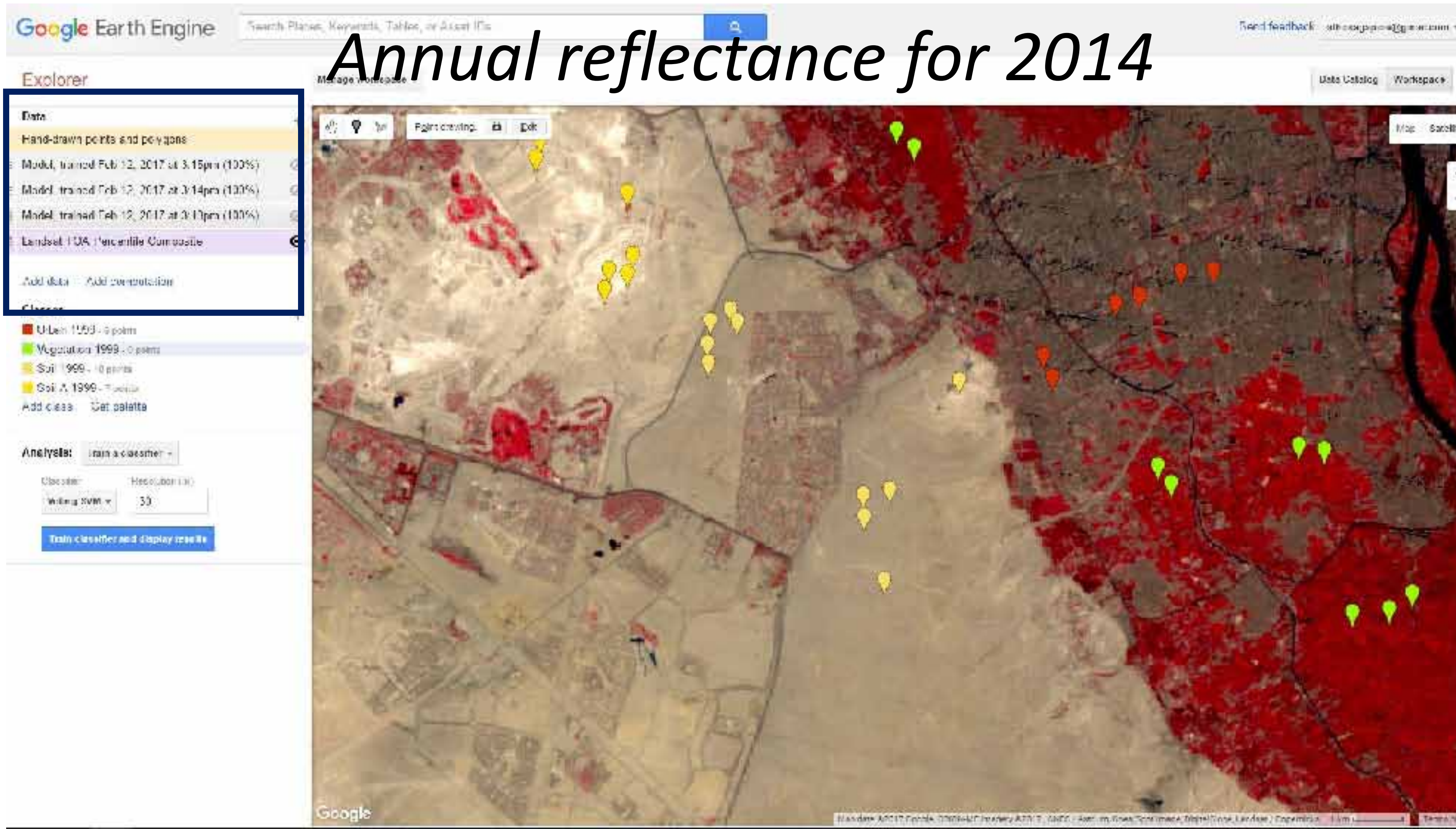


Collecting areas of interest

Annual reflectance for 1999

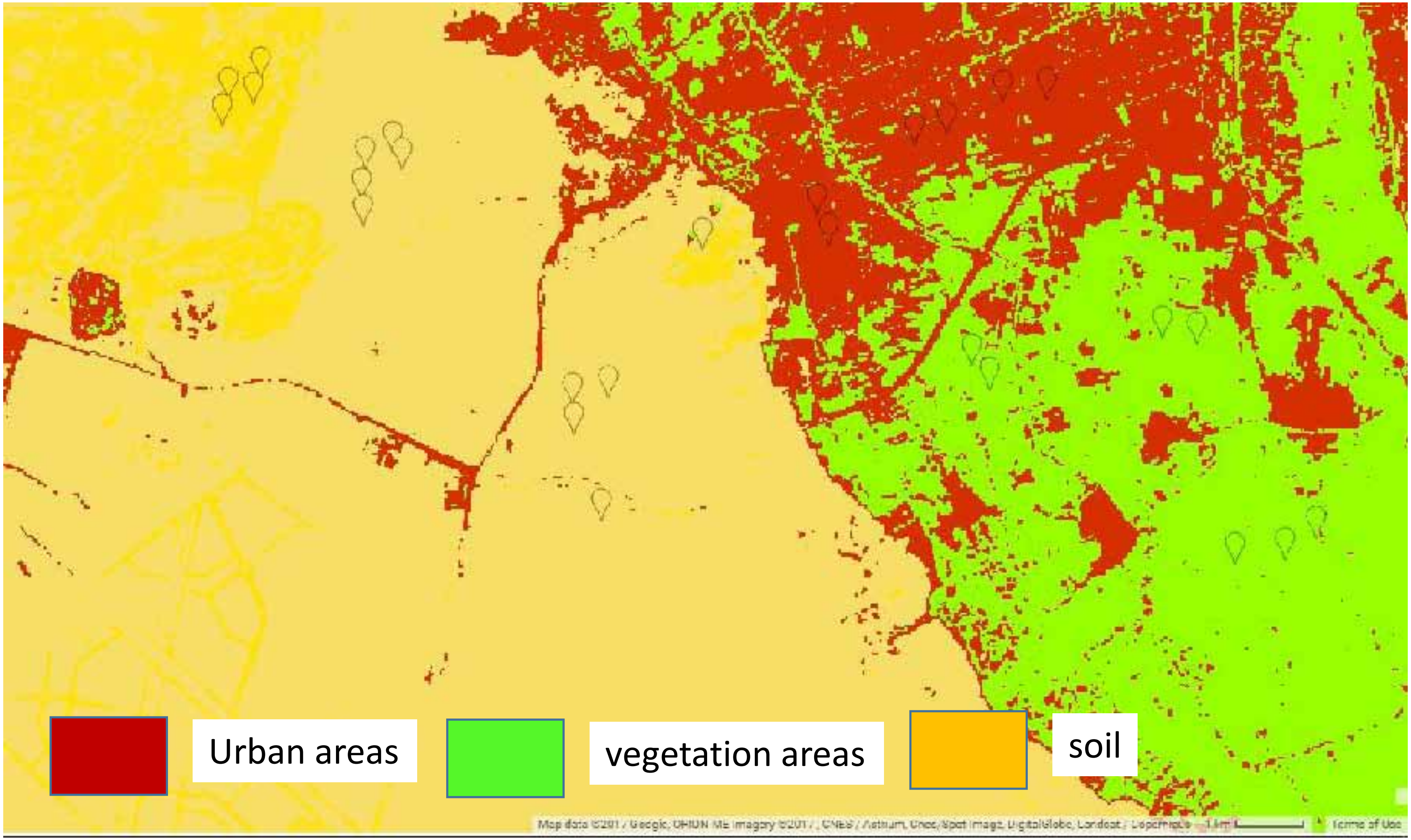


Collecting areas of interest



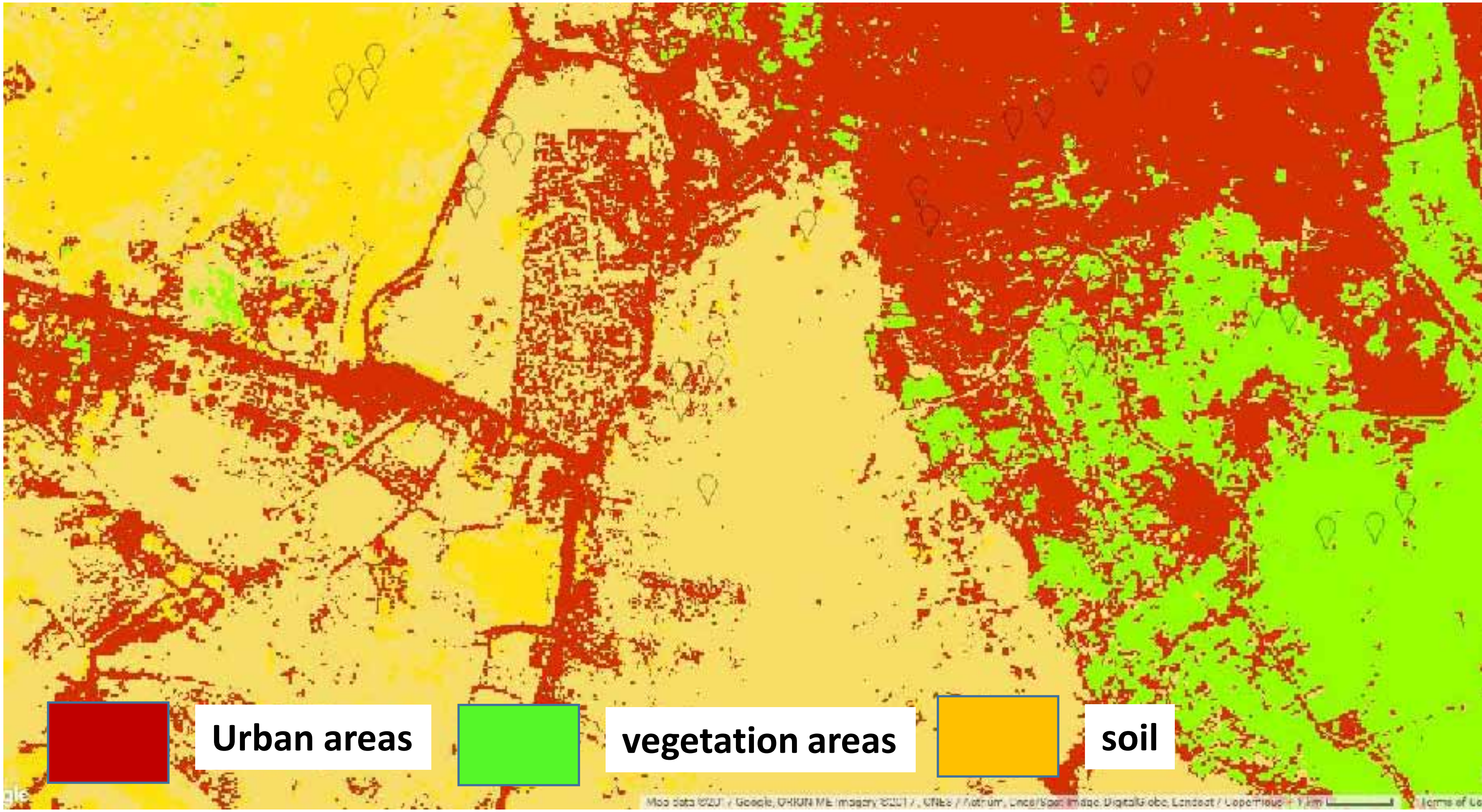
Classification results for 1999

Voting SVM
GMO Max Entropy
Random Forest

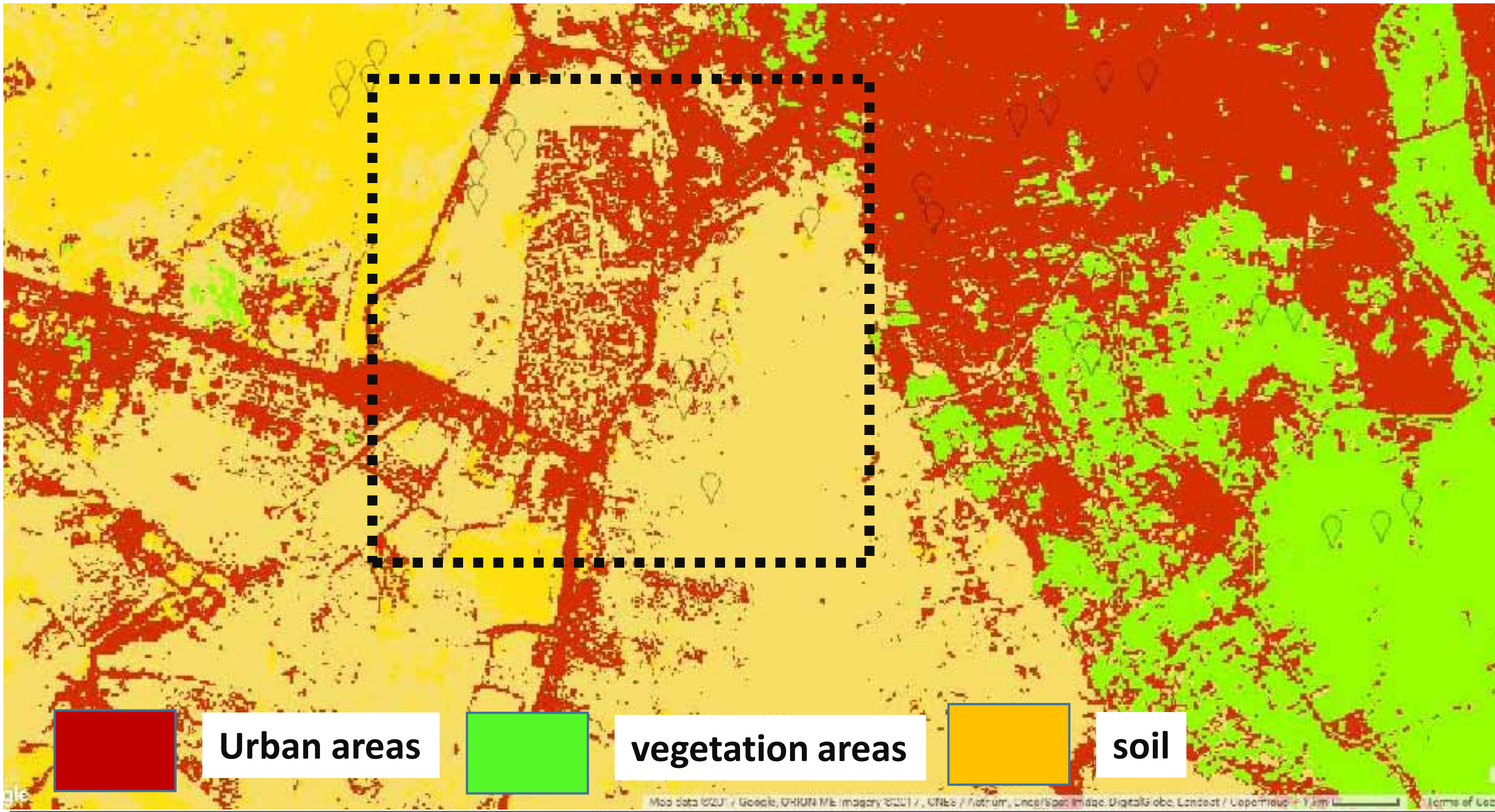


Classification results for 2014

Fast Naive Bayes
Margin SVM
Random Forest

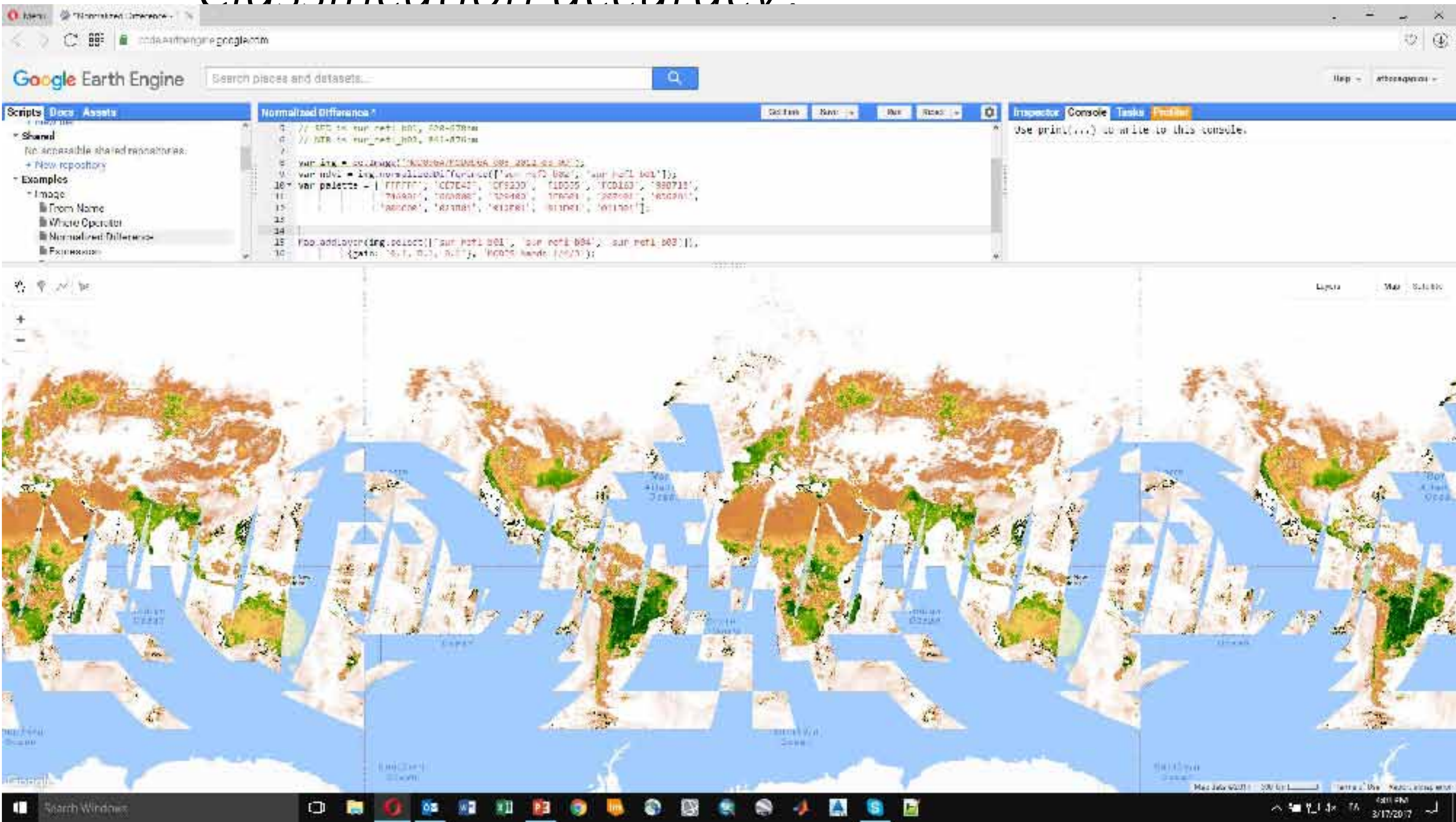


Classification results for 1999-2014



Discussion

Classification accuracy?



Big Data ....Big Opportunities

Exploitation of big data cloud infrastructures for earth observation cultural heritage applications:

mapping the land use changes patterns in the vicinity of "The Great Pyramid at Giza"

Dr. Athos Agapiou
Cyprus University of Technology
athos.agapiou@cut.ac.cy

Acknowledgements: The present communication is under the "ATHENA" project H2020-TWINN2015 of European Commission. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691936.

AUTOMATIC DAMAGE DETECTION FOR SENSITIVE CULTURAL HERITAGE SITES

Daniele Cerra, Jiaojiao Tian, Vasiliki Lysandrou*, Simon Plank, Thomas Krauß

German Aerospace Center (DLR), Weßling, Germany
* Cyprus University of Technology, Limassol, Cyprus

Workshop
Remote Sensing for Cultural
Heritage beyond Europe
RSCy2017, 2017-03-20

DLR

Acknowledgements: The present communication is under the "ATHENA" project H2020-TWINN2015 of European Commission. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691936.

Scope

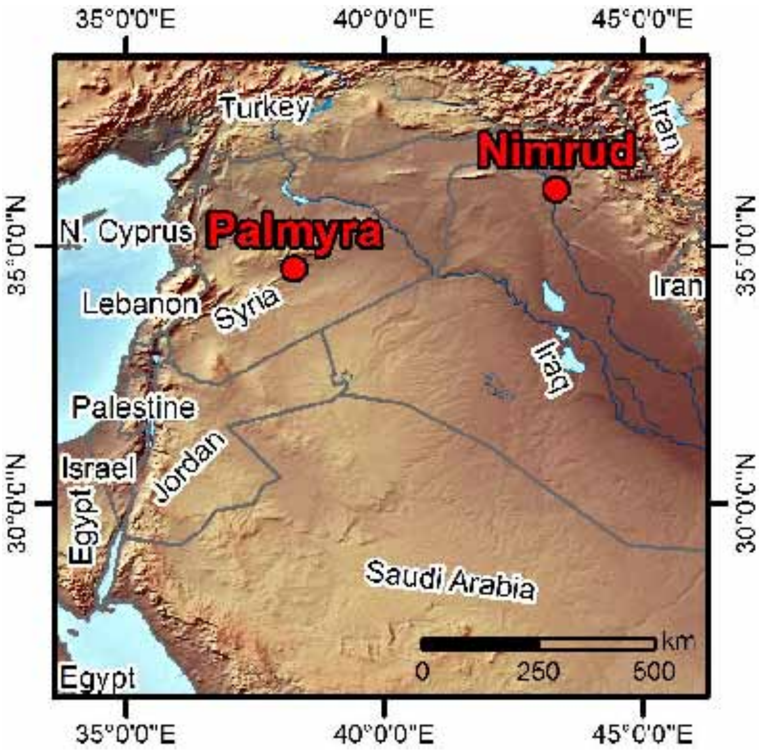
- Since spring 2015: Islamic State (IS) proclaims the destruction of cultural heritage sites, including Palmyra (Syria) and Nimrud (Iraq)

- Difficulties in confirming these damages at first

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

- German Archaeological Institute (DAI) tasked DLR in 2015
  → Remote Sensing as independent & objective information source
  → Visual analysis of changes based on VHR optical satellite data

- This presentation shows only damages in Palmyra



Available Satellite imagery

Sentinel 2, 10 m,
free

WorldView 2, 0.5 m,
100 €/km², min 100 km²

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

Palmyra – Tower Tombs of Elahbel

Image: WorldView-2
Date: 27 August 2015

Palmyra – Tower Tombs of Elahbel: destroyed by IS

Image: WorldView-2
Date: 02 September 2015

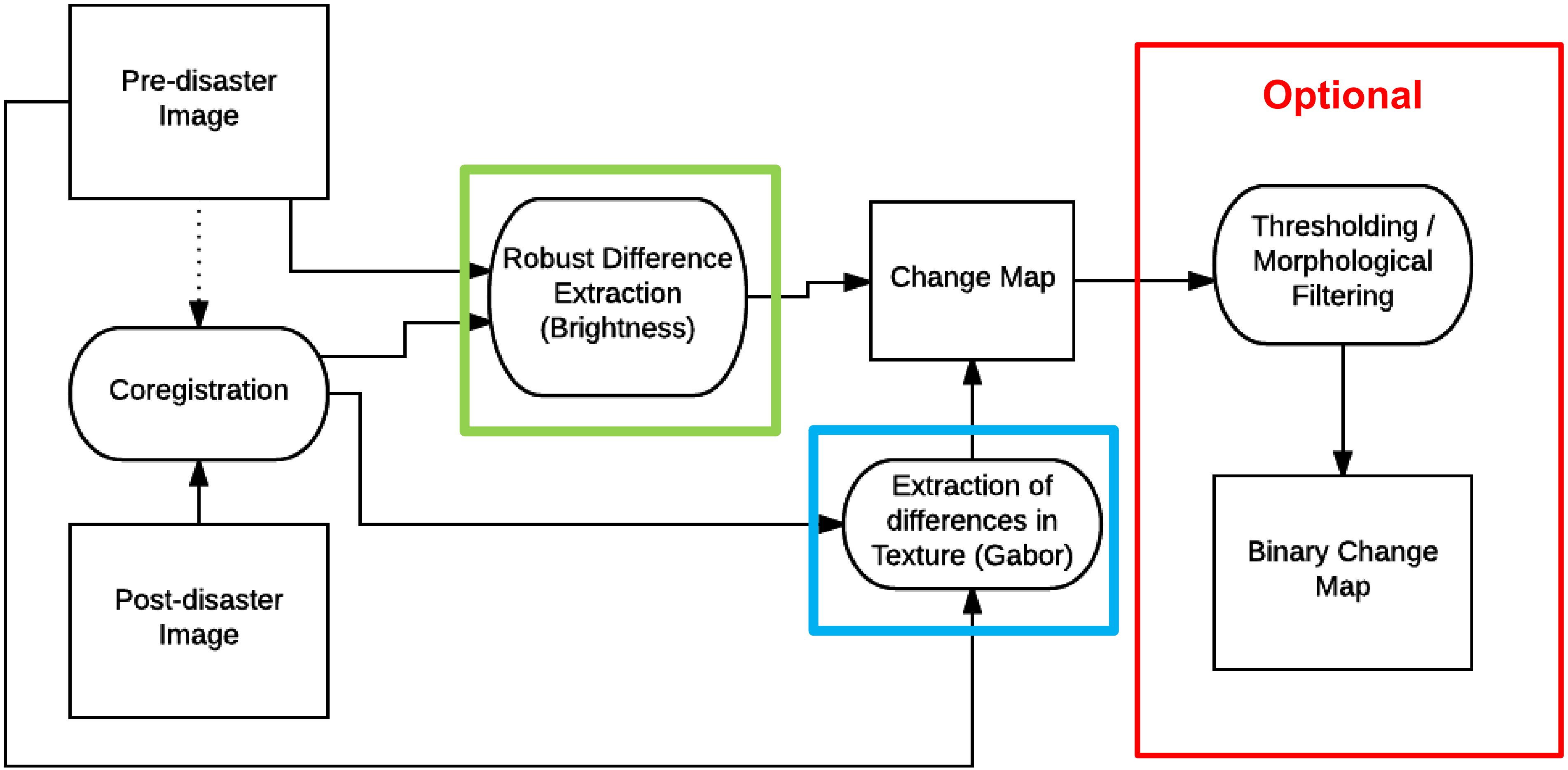
Motivation

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?

Workflow


Pre-disaster Image
Coregistration
Post-disaster Image
Robust Difference Extraction (Brightness)
Change Map
Extraction of differences in Texture (Gabor)
Optional
Thresholding / Morphological Filtering
Binary Change Map

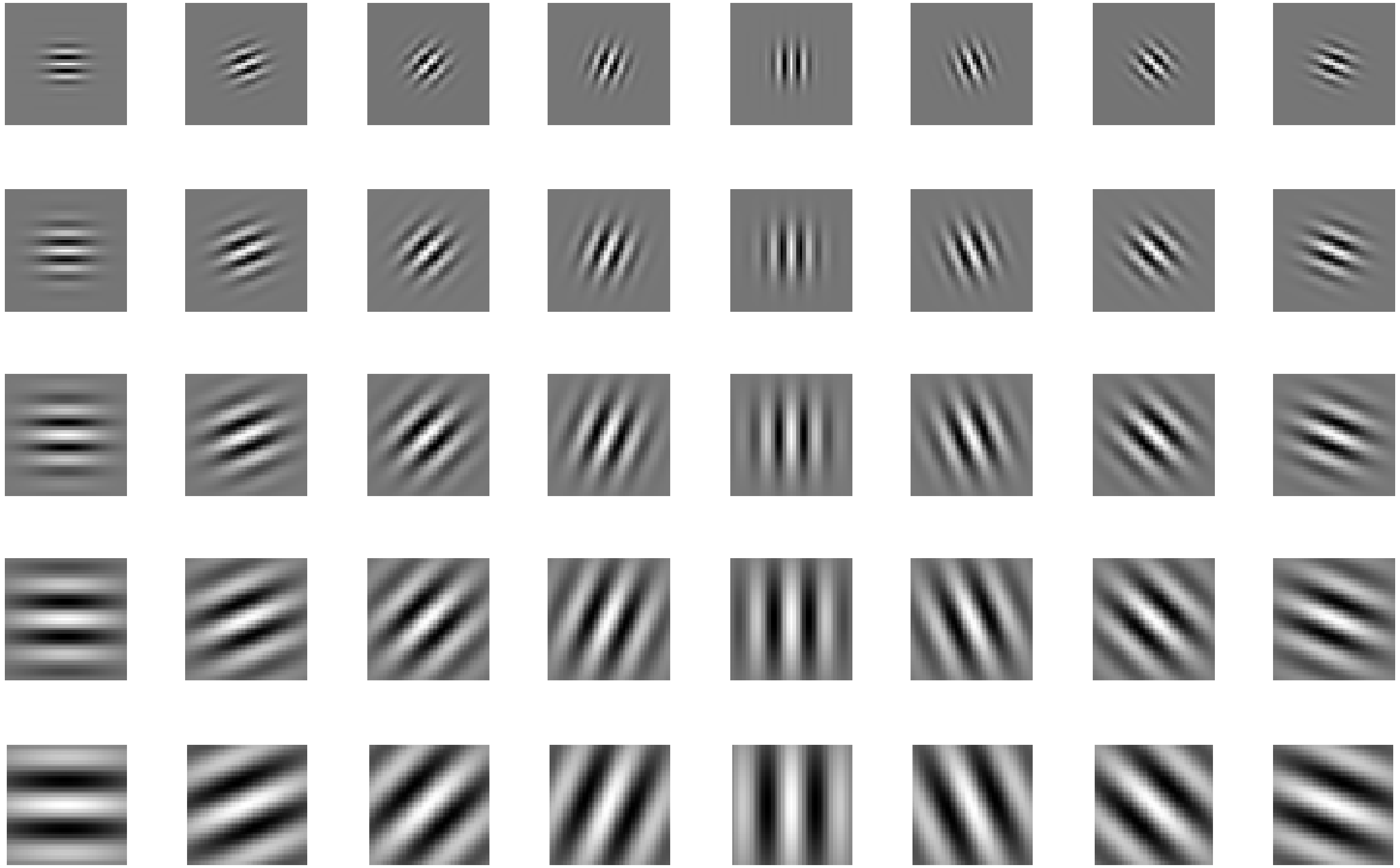
Robust Differences (RD) in brightness

$$RD(i,j) = \min_{k,l} abs(Y(i,j) - X(p_k, q_l)) \quad (5)$$

where:

- (i,j) = image coordinates,
- w = maximum distance in pixels from (i,j),
- $(p_{1...2w+1}, q_{1...2w+1})$ = coordinates of set of pixels in the neighbourhood $\in [i-w, j+w]$ centered around (i,j).

Gabor Texture Features



Selected filter bank

Palmyra, Syria

Temple of Bel

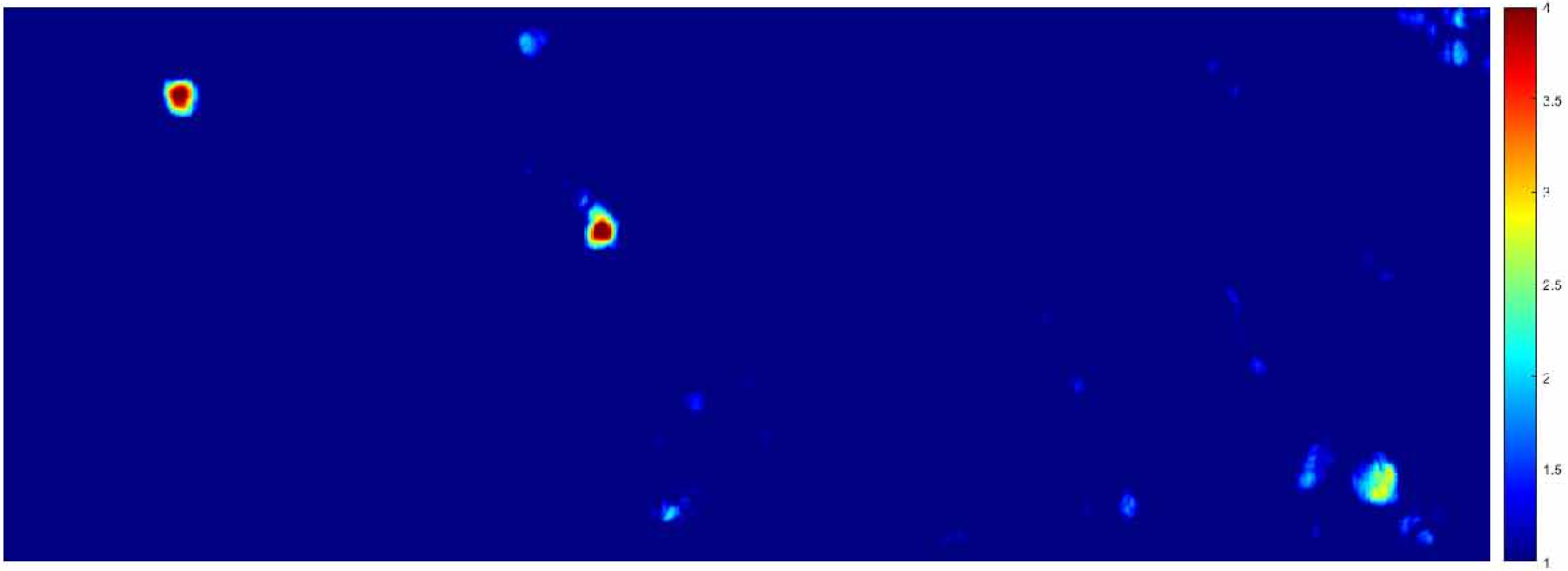
Tower Tombs

WorldView-2 Pre-Desaster Image

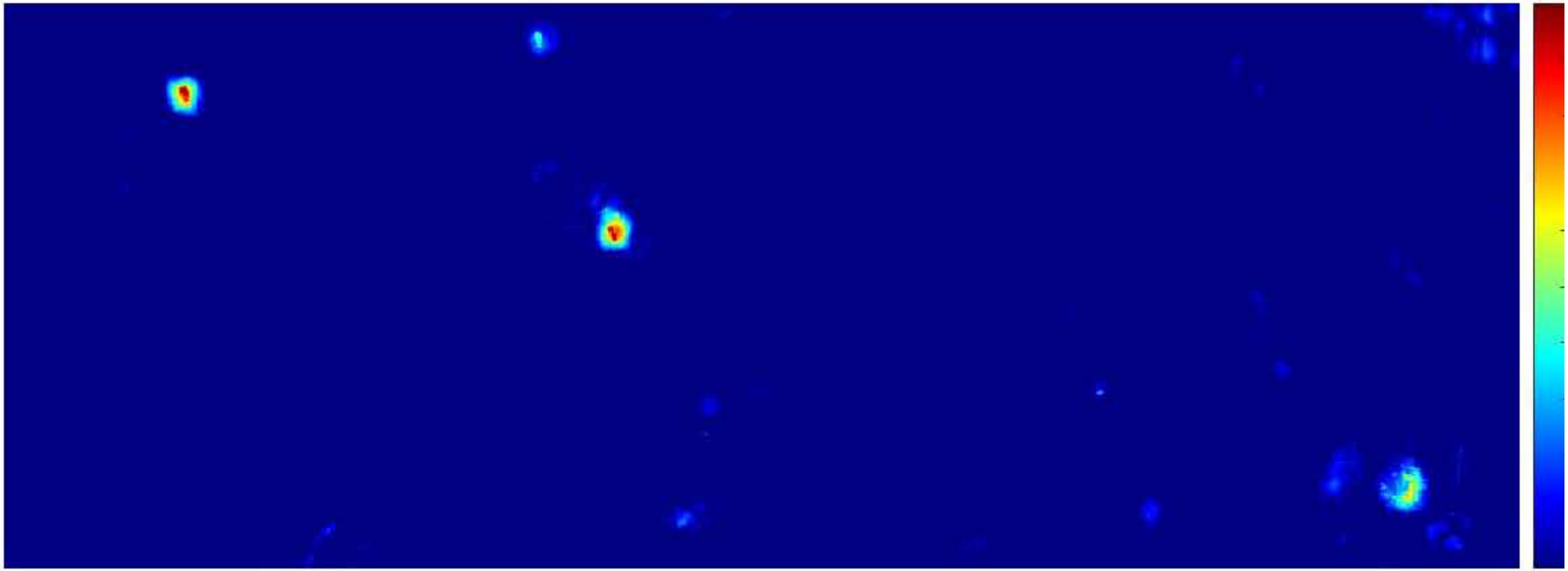
WorldView-2 Post-Desaster Image

Palmyra: Robust Differences

Palmyra: Difference of Gabor Features



Palmyra: RD + Gabor Features



Detected Damages 27.08.2015–02.09.2015

What about previous damages? → Google Earth image 20.02.2014

Palmyra – Baalshamin Temple: destroyed by IS (24.08.2015)

Source: Michael Danti 2010: http://www.asor-syrianheritage.org/special-report-update-on-the-situation-in-palmyra/

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

Palmyra – Baalshamin Temple: destroyed by IS (24.08.2015)

Image: Google Earth
Date: 20th February 2014

Image: WorldView-2
Date: 2nd September 2015

Palmyra – Tetrapylon and Theater: destroyed by IS

Sentinel-2, 09.12.2016

Palmyra – Tetrapylon and Theater: destroyed by IS

Sentinel-2, 08.01.2017

Palmyra – Tetrapylon and Theater: destroyed by IS

©European Space Imaging / DigitalGlobe

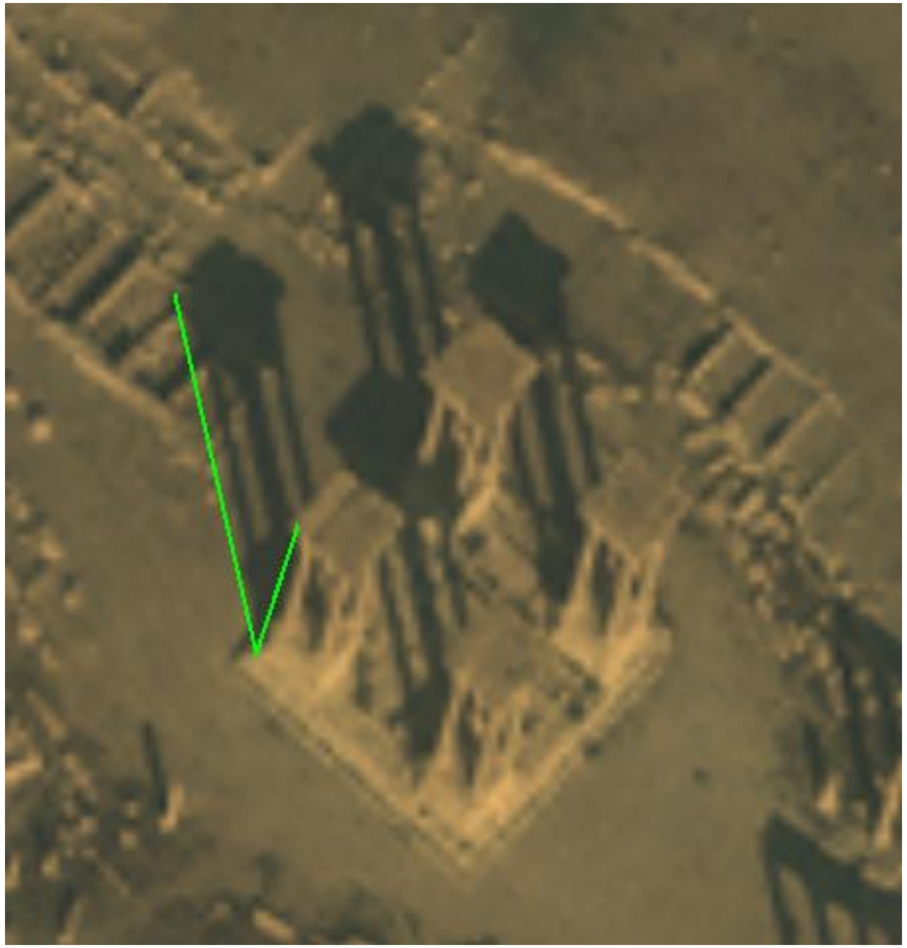
WorldView-3, 26.12.2016

Palmyra – Tetrapylon and Theater: destroyed by IS

©European Space Imaging / DigitalGlobe

WorldView-2, 10.01.2017

Palmyra – Tetrapylon: Height assessment

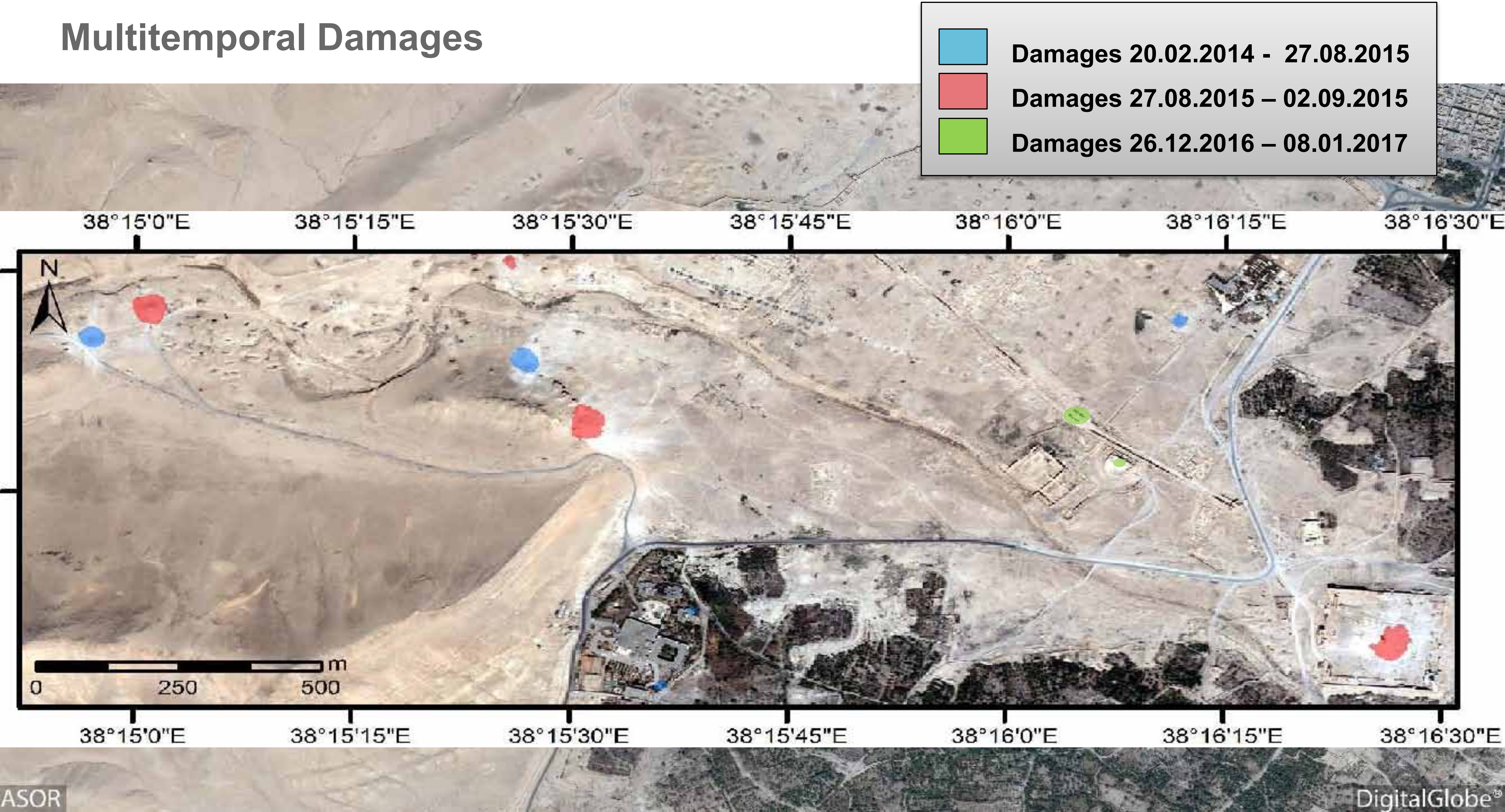


WorldView-3, 26.12.2016
Height of pylon: 7.2 m

WorldView-2, 10.01.2017
Height of pylon: 6.0 m

Calculating heights and foot-points from same points of object and shadow
using sensor-model of satellite-image (sun-azimuth/elevation, view-azimuth/elevation)

Multitemporal Damages



Validation (ASOR, 3.09.2015, http://www.asor-syrianheritage.org/special-report-update-on-the-situation-in-palmyra)

Conclusions

- Satellite images allow observation **of sensitive CH sites in non-accessible areas**
  - **Free images** all 11 days from Sentinel-2 mission – but with a resolution of 10 m **too coarse**
  - For damage detection at lease 0.5 m resolution needed
    → **commercial satellite imagery** like WorldView or Pléiades **needed**
- Automatic change detection developed
  - Succesfully performed for different case studies in Syria and Iraq
  - Experiments show **robustness** of found changes
  - Validation on site shows **reliability** of detected changes
- Using satellite data allows
  - **Frequent** updates
  - **Chronology** of changes / features
- **Outlook**
  - **Automation** degree has **to be increased** in future
  - Sun-synchronous satellites allow automatic **pre-selection of Gabor features** according to the sun‘s elevation angle
  - Determination of **heights of** the **objects** possible from shadows

DLR