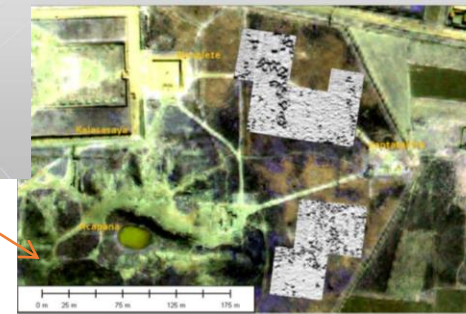


# EXTRACT INFORMATION AND KNOWLEDGE FROM BIG DATA FOR DOCUMENTATION, MONITORING AND PRESERVATION OF NATURAL AND CULTURAL HERITAGE

**ROSA LASAPONARA  
CNR-IMAA  
ARGON LABORATORY**



MULTISENSORS MULTISCALE MULTITEMPORAL INVESTIGATIONS

**NON INVASIVE** Technologies for  
Knowledge,  
Documentation,  
Valorization,  
Monitoring  
Preservation  
of Cultural and Natural Heritage

# OUTLINES



- ✓ **GOLDEN AGE OF DIGITAL EARTH**
- ✓ **EXTRACT INFORMATION FROM BIG DATA: NEEDS AND CHALLENGES**
- ✓ **CASE STUDIES:**
  - ✓ (i) the spatial component (satellites and associated ground infrastructures)
  - ✓ (ii) in-situ measures (aerial and terrestrial measures)
  - ✓ (iii) services for users: the example of ARTEK project (Artes project funded by ESA and ASI)

# EXTRACT INFORMATION FROM BIG DATA



Big Data refers to the flood of digital data from many digital earth sources, including:

- ✓ sensors,
- ✓ digitizers,
- ✓ scanners,
- ✓ numerical modeling,
- ✓ mobile phones,
- ✓ Internet,
- ✓ videos
- ✓ e-mails
- ✓ social networks

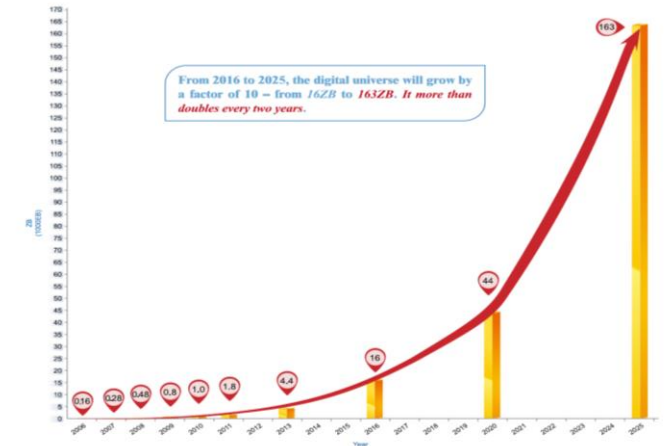


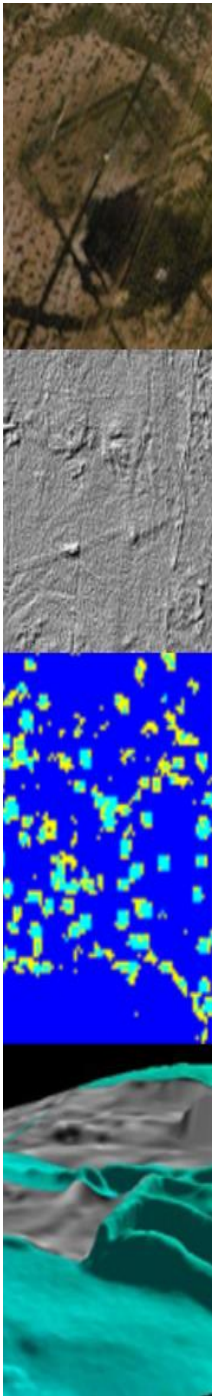
Figure 1. Global growth of data volume from 2016 to 2025.

The data types include texts, geometries, images, videos, sounds and combinations

## EXTRACT INFORMATION FROM BIG DATA: CHALLENGES



- ✓ Petabytes of EO and science data are not exploited as should be
- ✓ Present and future mission/project continuously increase the amount of data and computing power needs
- ✓ A variety of data formats not always standardised
- ✓ Fast access to data relies on WAN connectivity (e.g. still expensive for high throughput)
- ✓ Increasing need to fast response as for security, risk monitoring and alert, etc





### Transformation: from data to (useful) INFORMATION

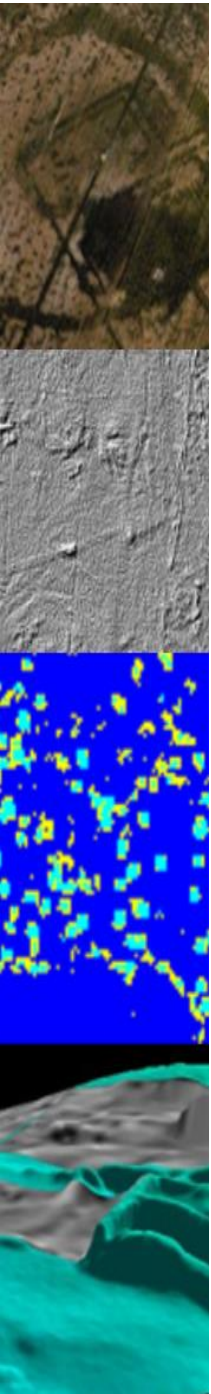
The capability to **extract information** from data is linked with the capability to **integrate data and info** available **from diverse sources**

**EXTRACT INFORMATION AND KNOWLEDGE FROM BIG DATA FOR DISCOVERY, DOCUMENTATION, MONITORING AND PRESERVATION OF NATURAL AND CULTURAL HERITAGE**

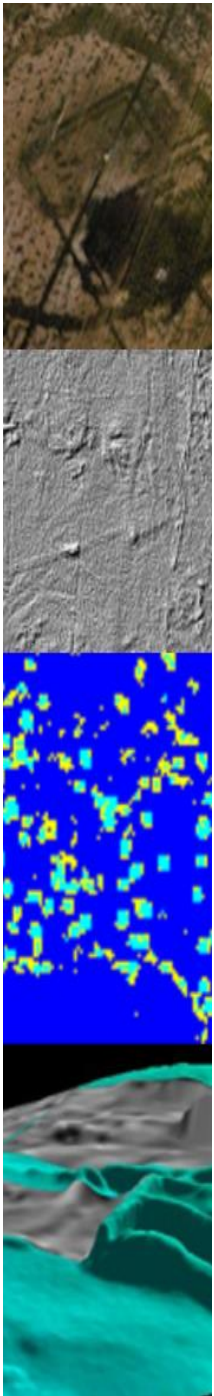
## BIG DATA INTEGRATION NEEDS AND CHALLENGES

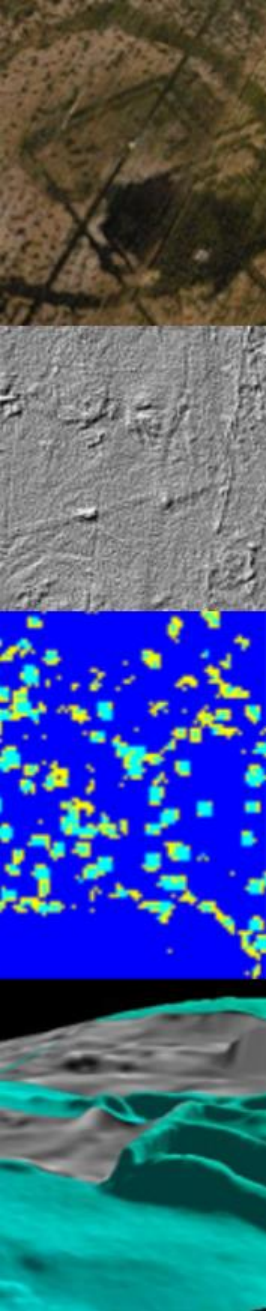


- ✓ No magic: Careful planning and setting goals, vision and narrative important. Once narrative is in place, integration “only” become a technical issue
- ✓ Experimental design, data quality, outlier identification is an important part of the integration –
- ✓ Data integration important, but often challenging - especially for ad-hoc data
- ✓ From single-discipline to multidisciplinary and interdisciplinary approaches



- The constellation Copernicus has changed the paradigm with which the citizen is related to the spatial datum, because it is open access, available to all.
- Therefore, space is a huge opportunity for a society, today, that evolves very quickly and offers challenges and opportunities.
- **In the light of recent sensor developments and data availability, innovative models and methodologies are needed for data analysis and the integration of different information, as well as new strategies for the exploitation.**



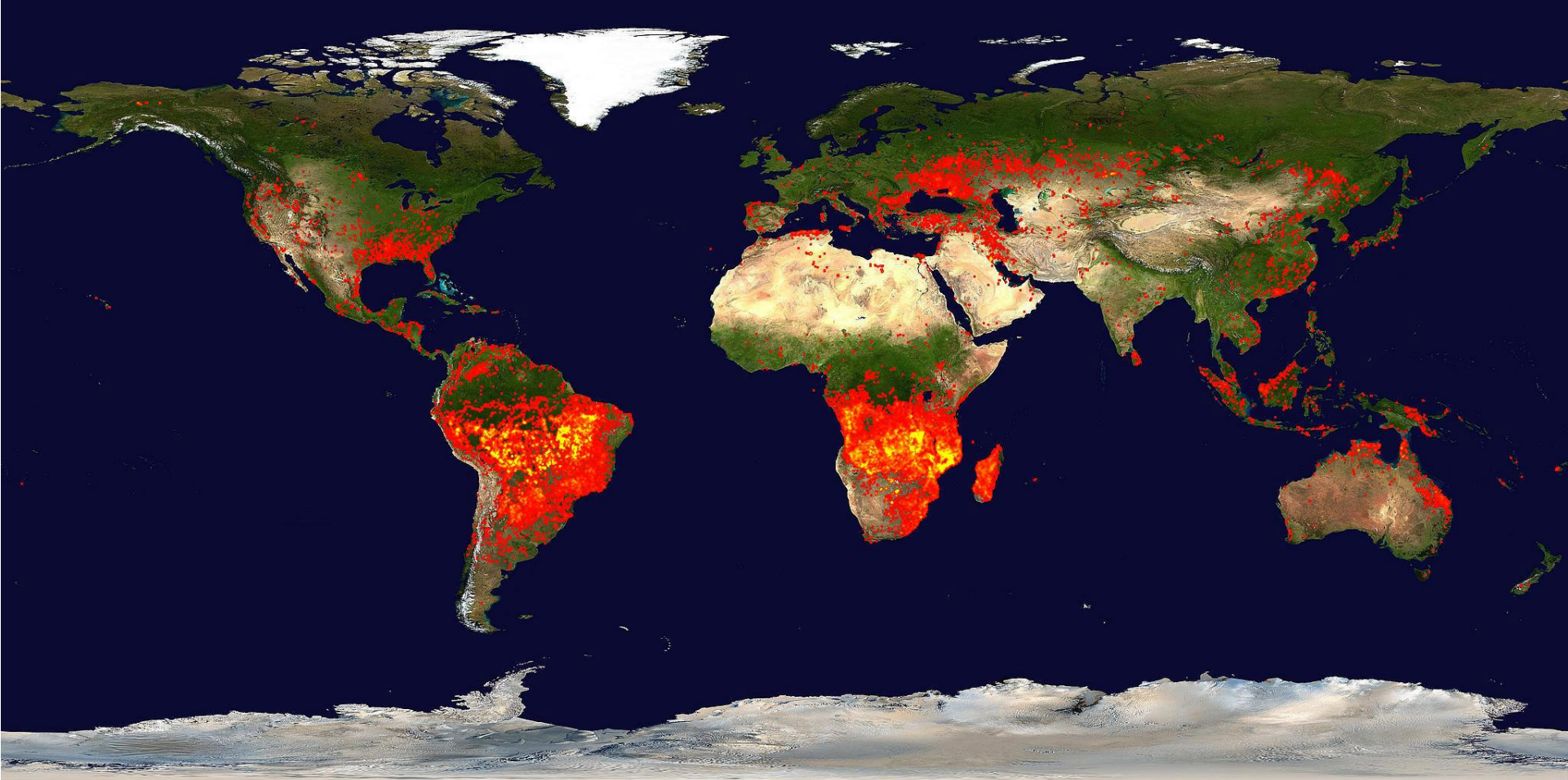


## COPERNICUS DATA

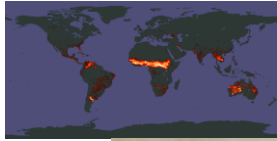
There are four pillars, on which Copernicus is founded:

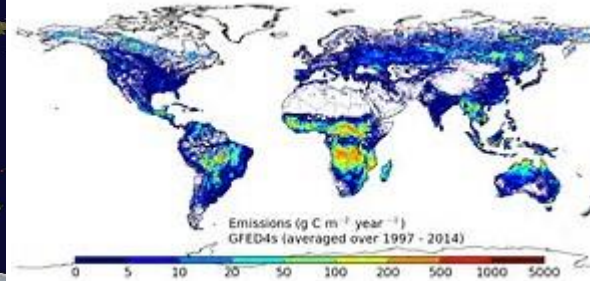
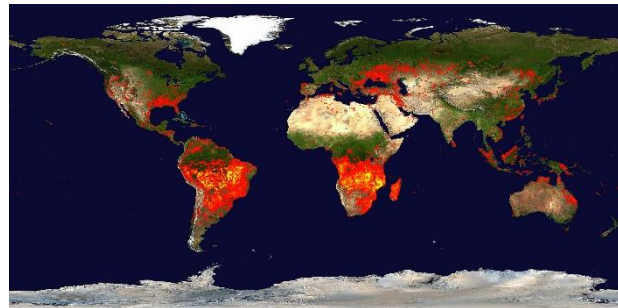
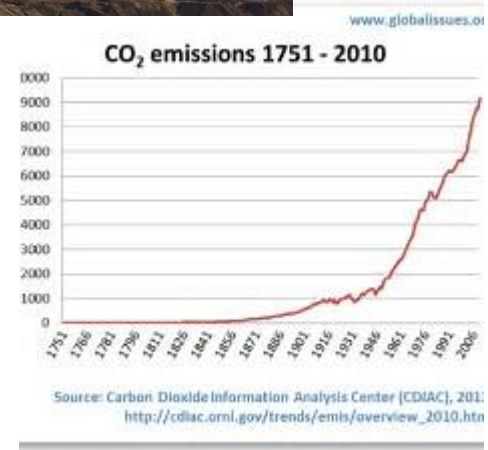
- (i) The spatial component (satellites and associated ground infrastructures),
- (ii) in-situ measures (aerial and terrestrial Measures),
- (iii) harmonisation/standardization of data and
- (iv) services for users.

The Copernicus services are based on information from a constellation of dedicated satellites, called "Sentinels", and dozens of other satellites, the so-called "participating missions". This information is supplemented with data obtained from in situ (i.e. local) sensors. In particular, the spatial component related to the constellation of dedicated satellites, consists of various Sentinel missions with the following objectives.



<http://www.nasa.gov/topics/earth/features/wildfires.html>





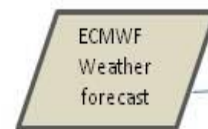






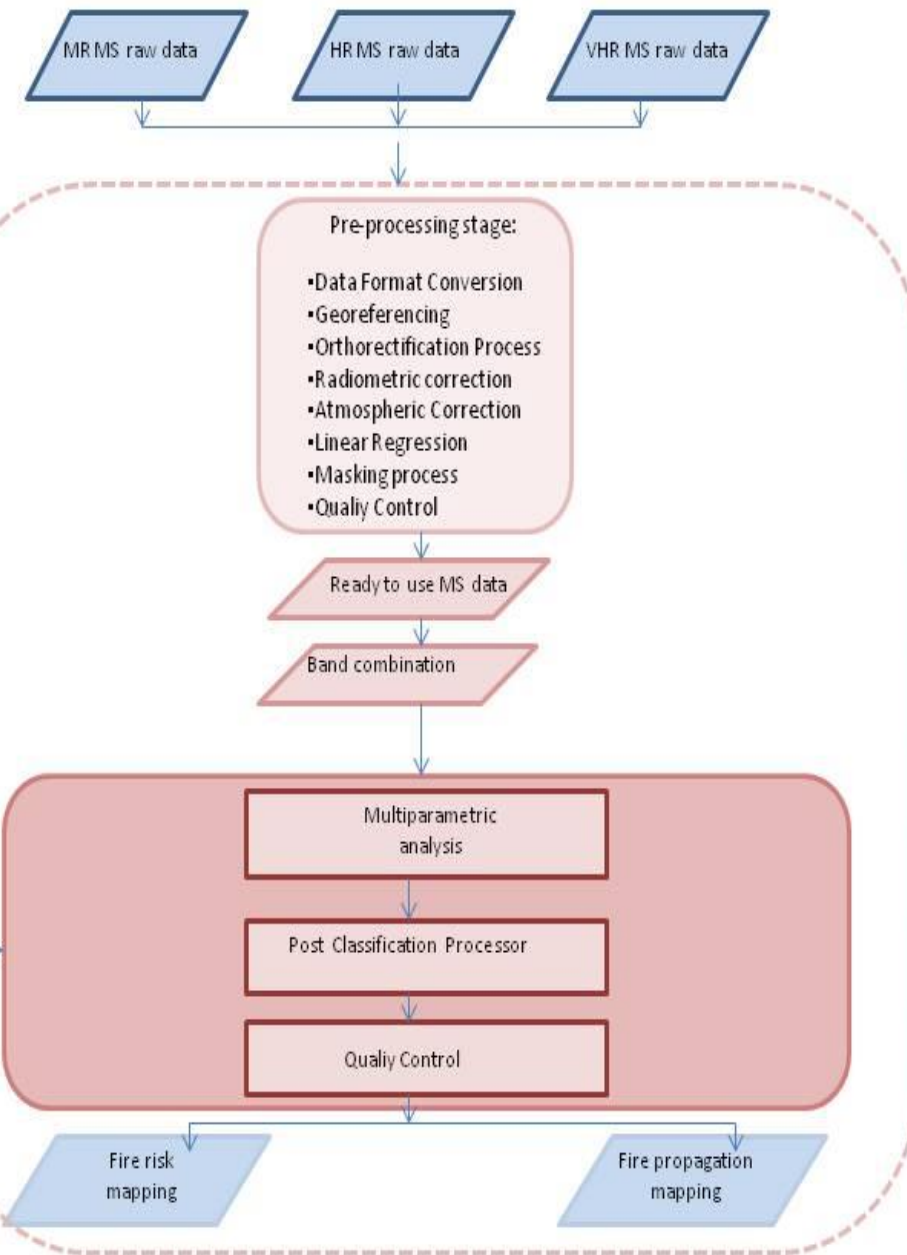


**Lasaponara R lanorte Antonio An Integrated  
system for Fire monitoring Patent prot. 408719  
del 24 agosto 2009**

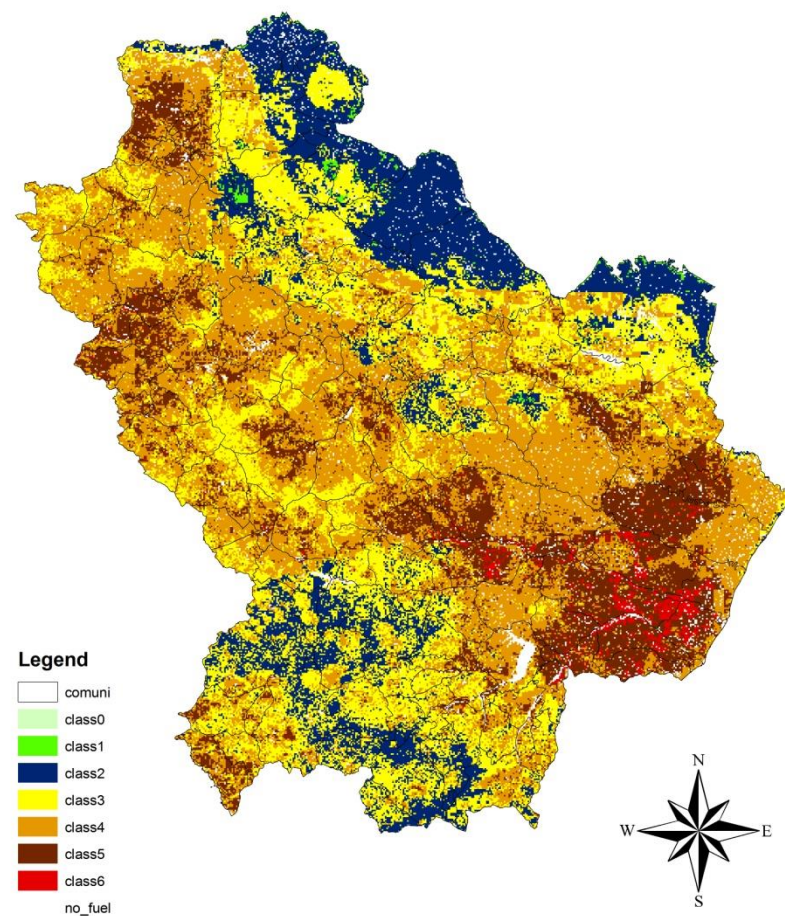


Open source software and  
free of charge data SNAP,  
GRASS, QGIS

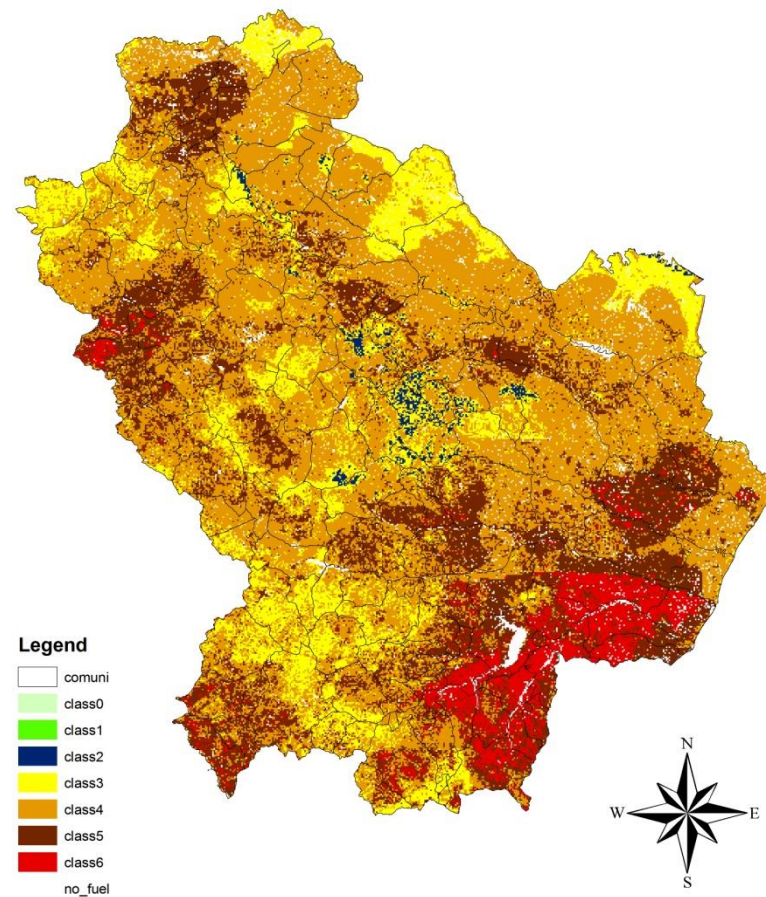
## Description of Processing chains of Fire risk maps



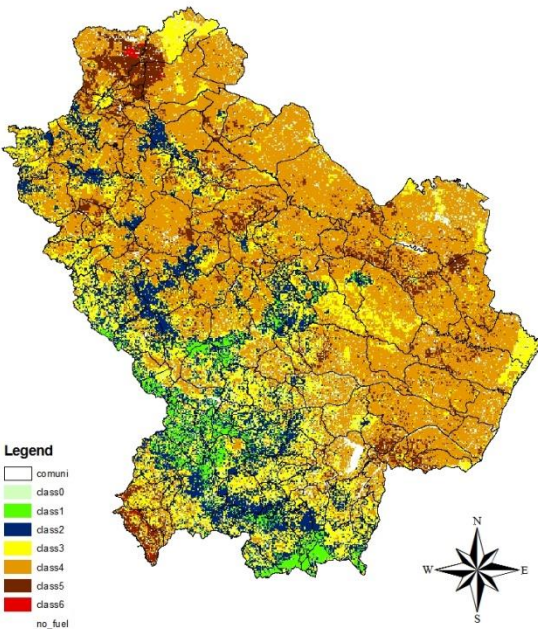
## Mappa Previsione Pericolo Incendi 02 Giugno 2017



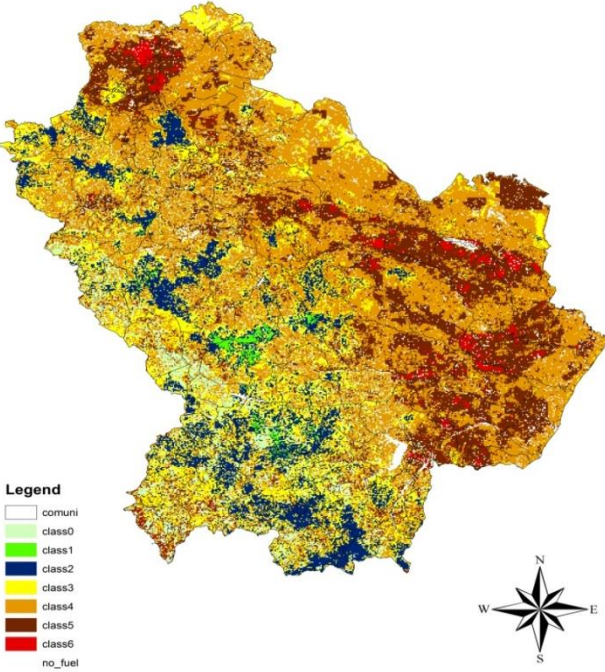
## Mappa Previsione Pericolo Incendi 12 Giugno 2017



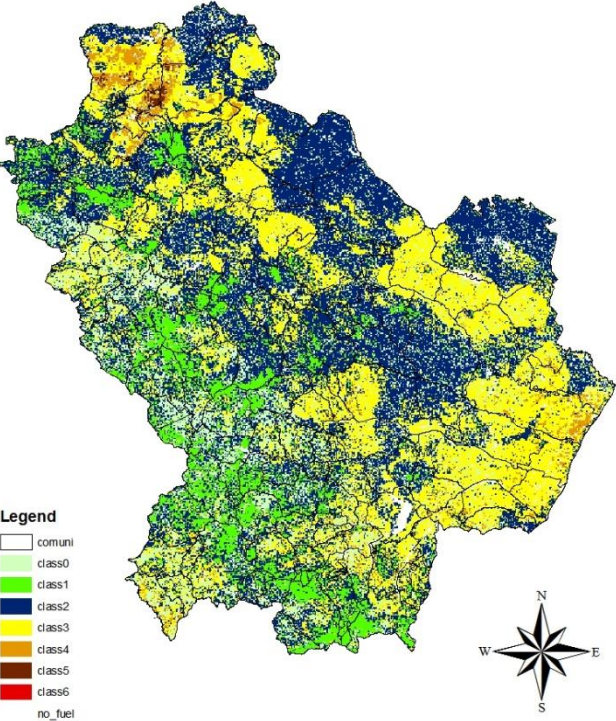
Mappa Previsione Pericolo Incendi  
10 Luglio 2016



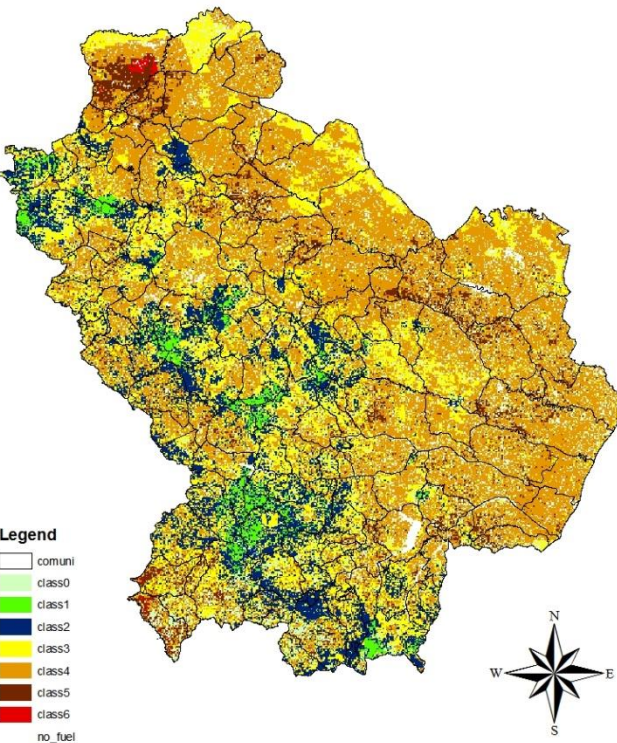
16 August 2016



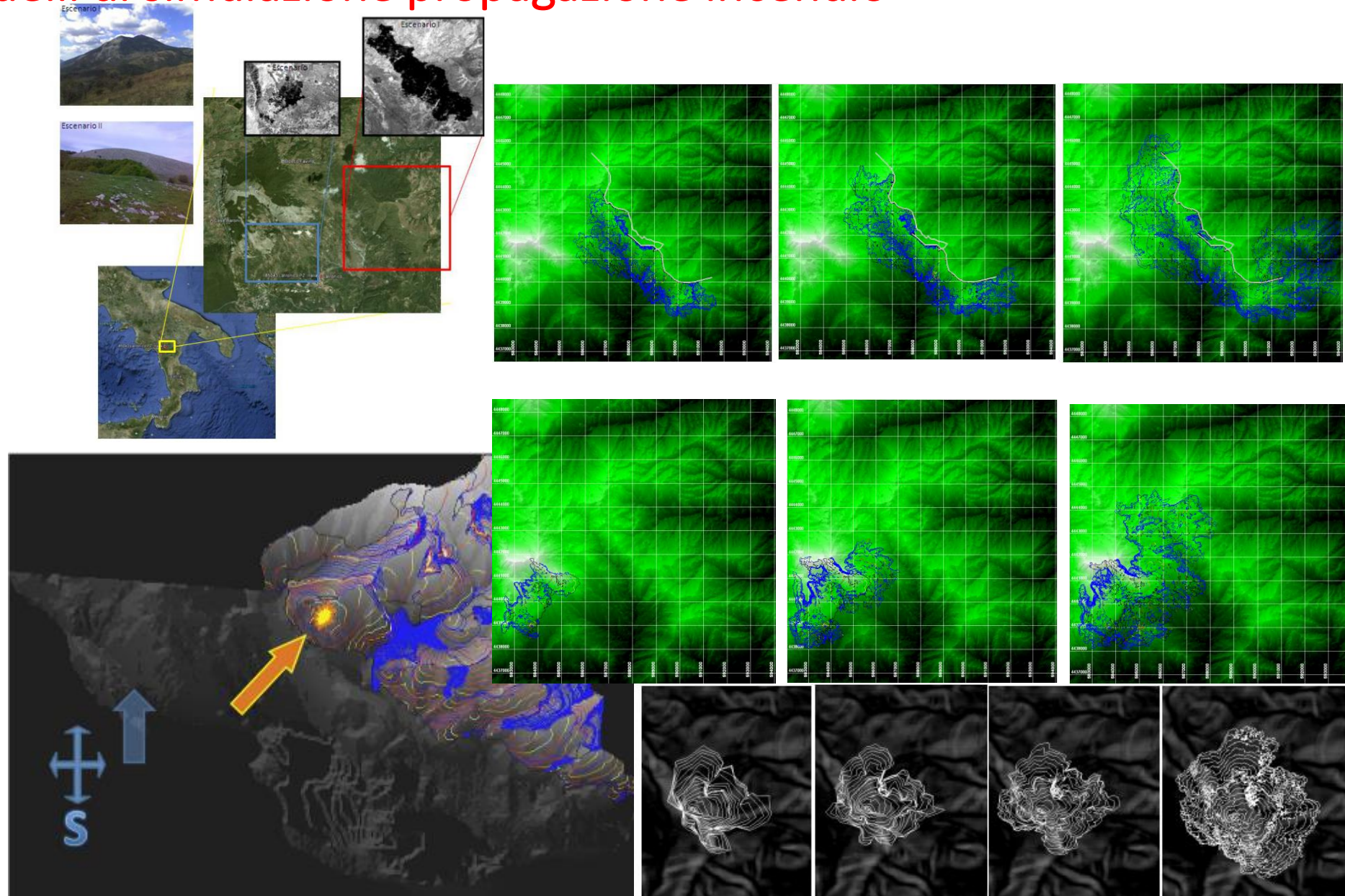
Mappa Previsione Pericolo Incendi  
19 Agosto 2016



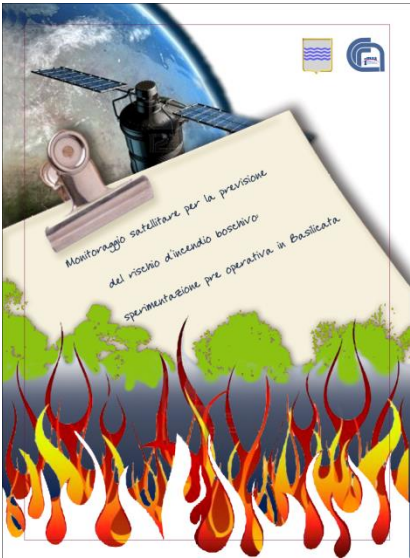
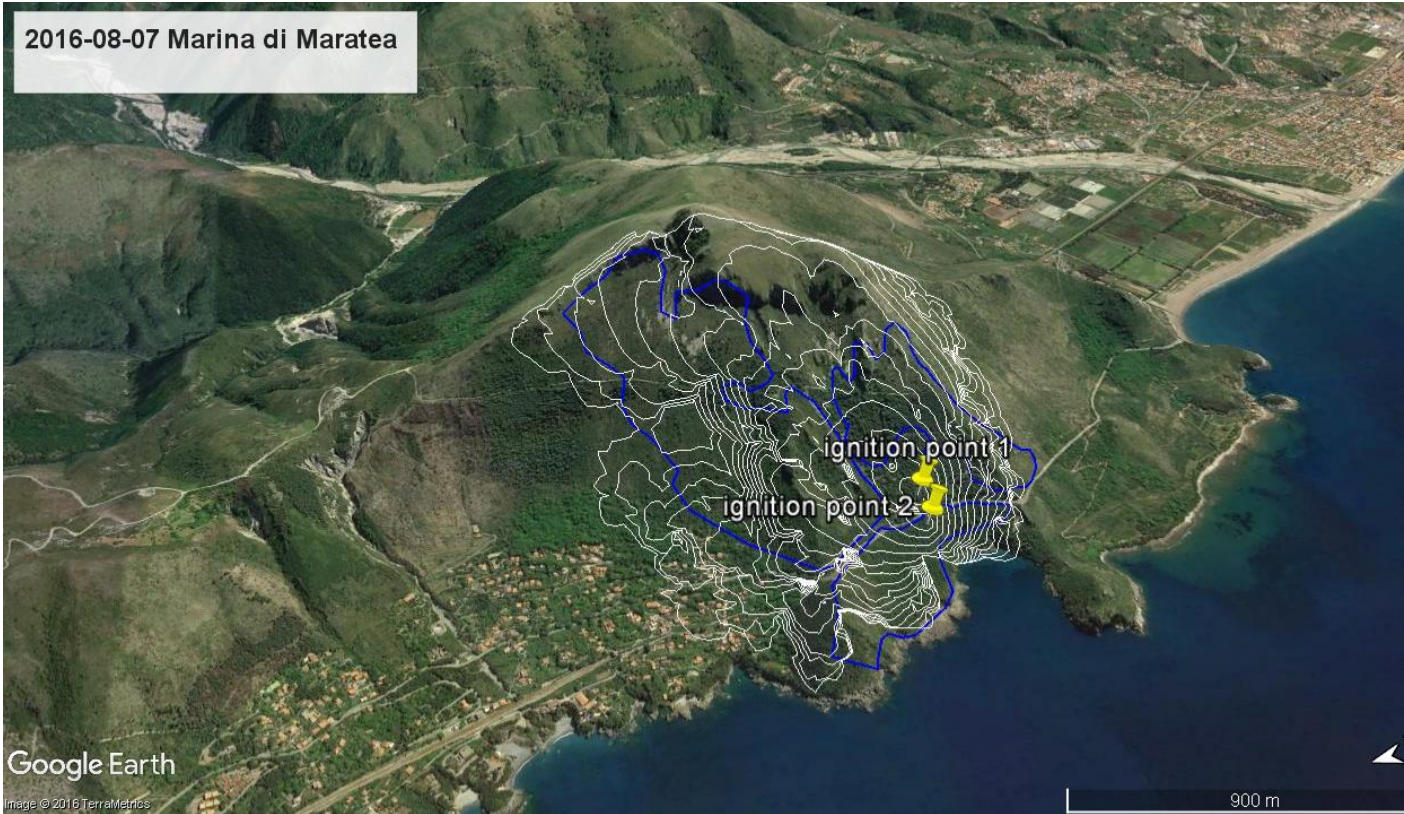
Mappa Previsione Pericolo Incendi  
21 Agosto 2016



# Modelli di simulazione propagazione incendio



# Simulation of the fire expansion using Firesite an open source tool by USGS



2015-09-18 - Latronico (PZ)

Legend  
★ Ignition Point

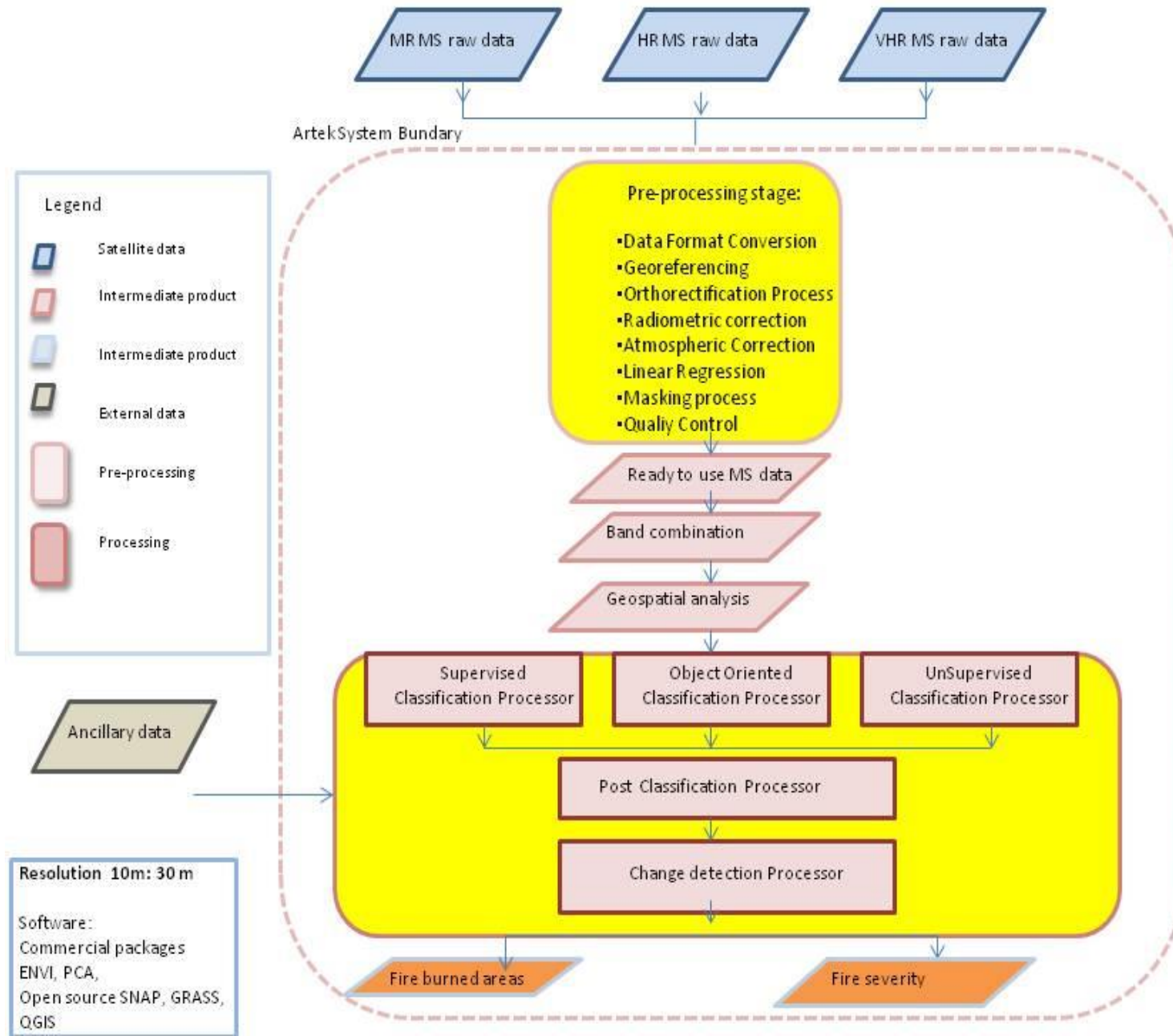


Google Earth

© 2015 Google

500 m

# Description of Processing chains of Multitemporal Burned Thematic maps



ALanorte, M Danese, R Lasaponara, B Murgante  
**Multiscale mapping of burn area and severity using multisensor satellite data and spatial autocorrelation analysis**  
*International Journal of Applied Earth Observation and Geoinformation* 20, 42-51

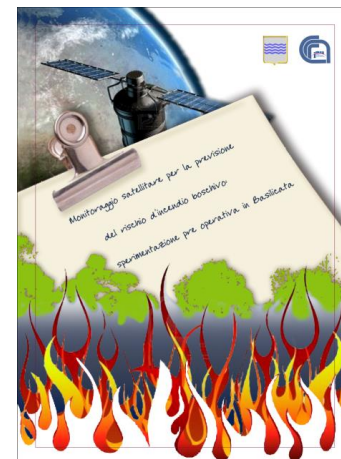
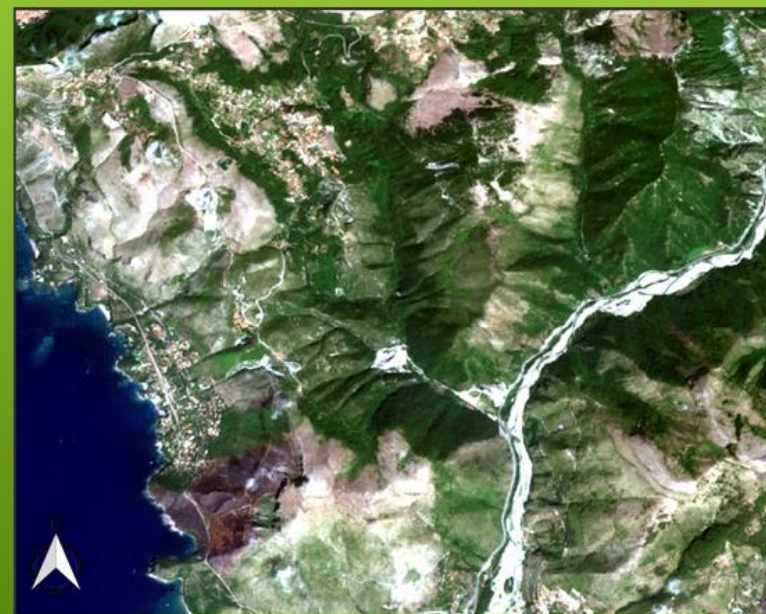
# FIRE SEVERITY – MARINA DI MARATEA 07-08-2016

Utilizzo di immagini Sentinel 2 ad alta risoluzione per lo studio della severità delle aree percorse dal fuoco.

RGB pre-fire Sentinel 2



RGB post-fire Sentinel 2

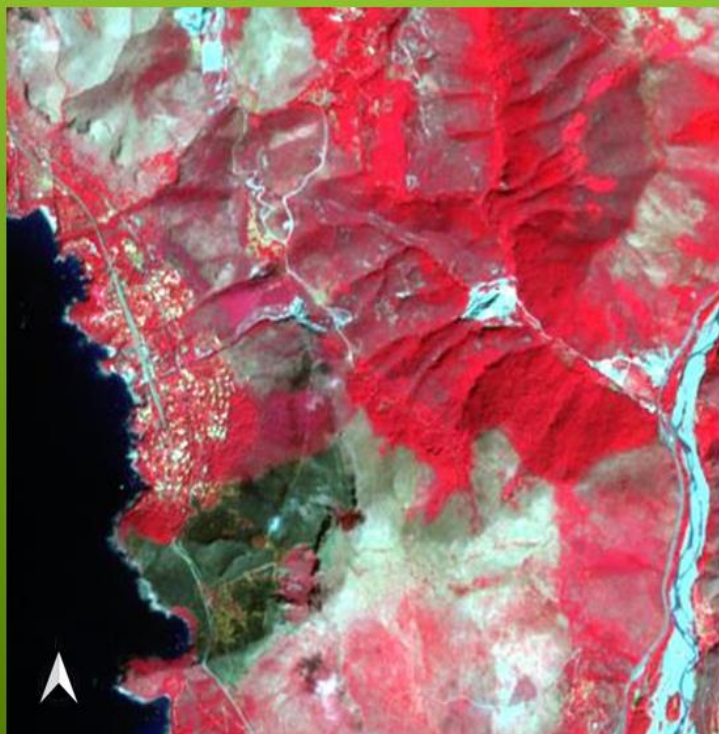




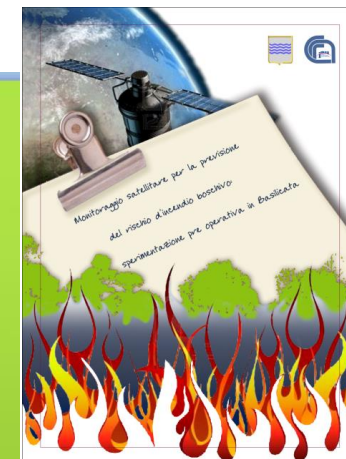
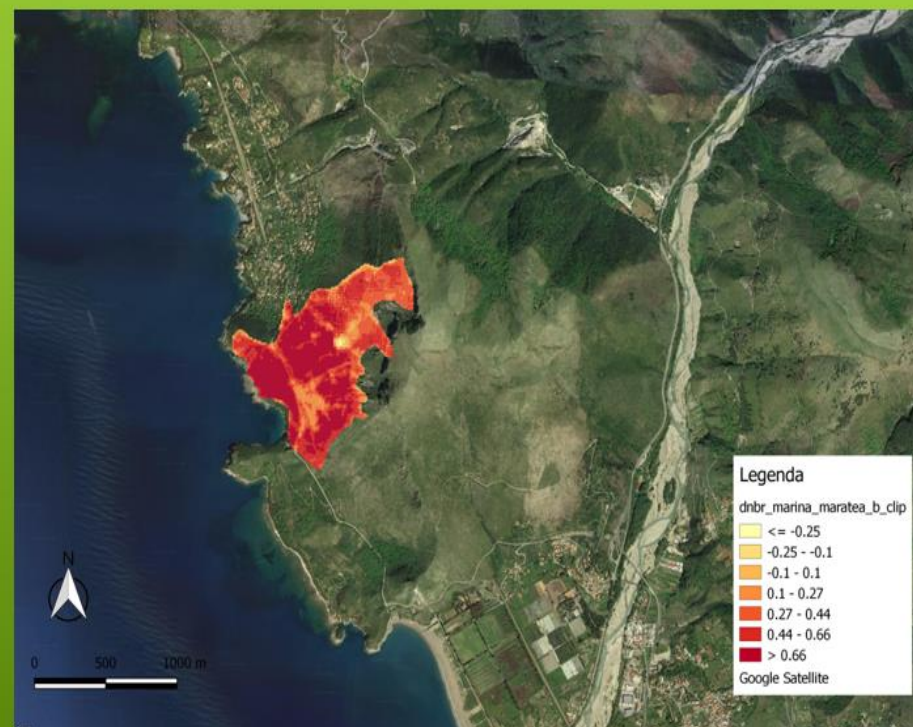


# FIRE SEVERITY – MARINA DI MARATEA 07-08-2016

False Color Sentinel 2



Indice  $\Delta NBR$  per la stima della severità



## Fire management

### Burned area mapping using satellite Aster data

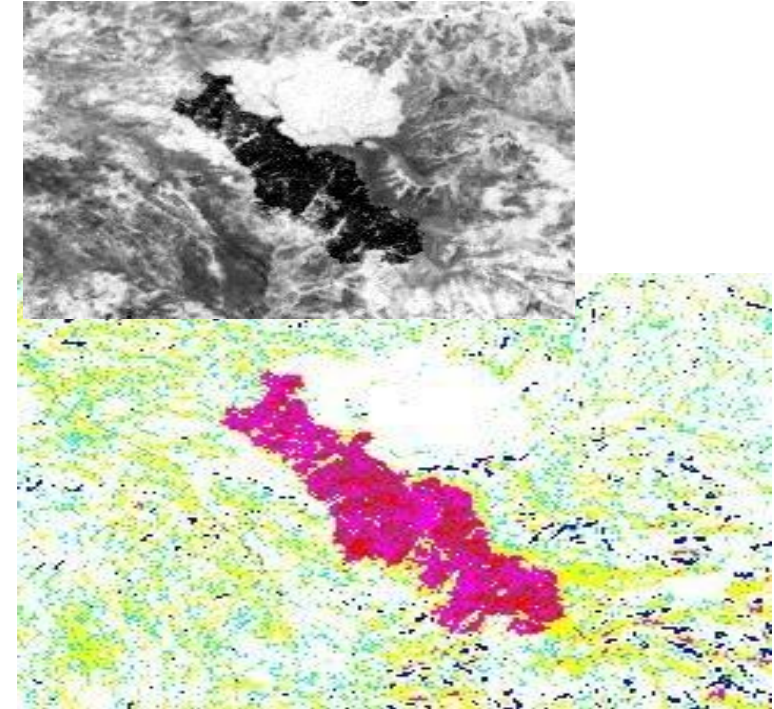
#### Spectral index

$$SVI = \frac{NIR}{R}$$

$$NDVI = \frac{NIR - R}{NIR + R}$$

$$SAVI = \frac{NIR - R}{NIR + R + 0.5} \times 1.5$$

$$TVI = \sqrt{NDVI + 0.5} = \sqrt{\frac{NIR - R}{NIR + R} + 0.5}$$

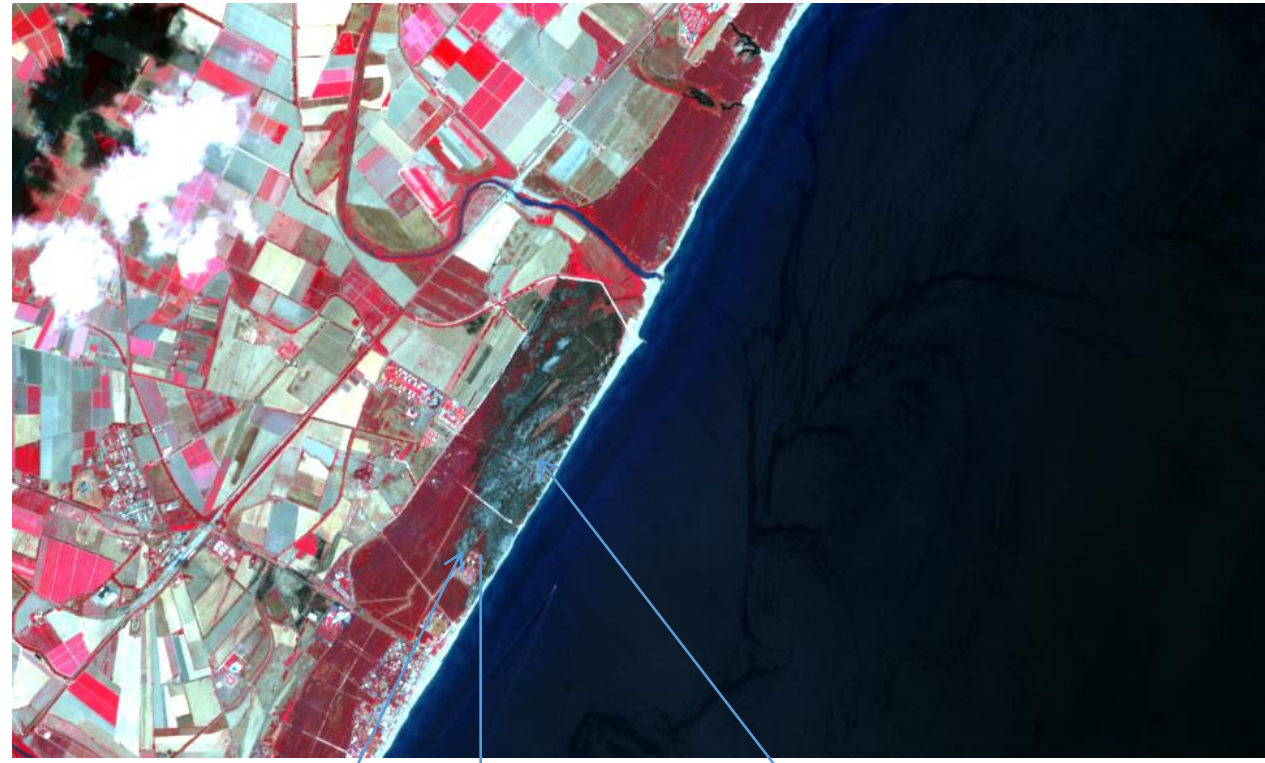


$$NBR = (NIR(ch3) - SWIR(ch7)) / (NIR(ch3) + SWIR(ch7))$$

$$dNBR = NBR_{prefire} - NBR_{postfire}$$

A Lanorte, M Danese, R Lasaponara, B Murgante Multiscale mapping of burn area and severity using multisensor satellite data and spatial autocorrelation analysis *International Journal of Applied Earth Observation and Geoinformation* 20, 42-51

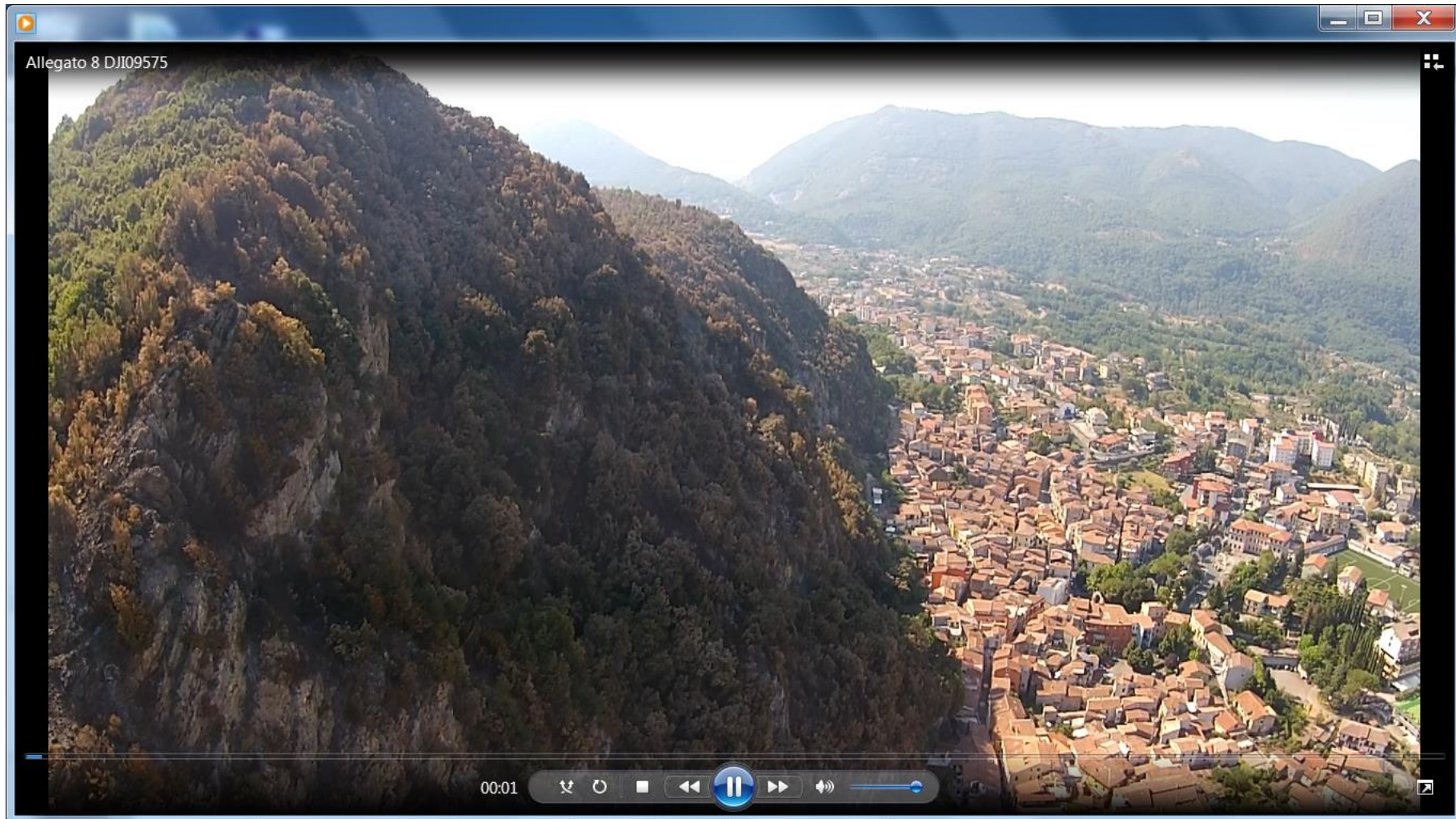
# Metaponto Fire 13 July 2017

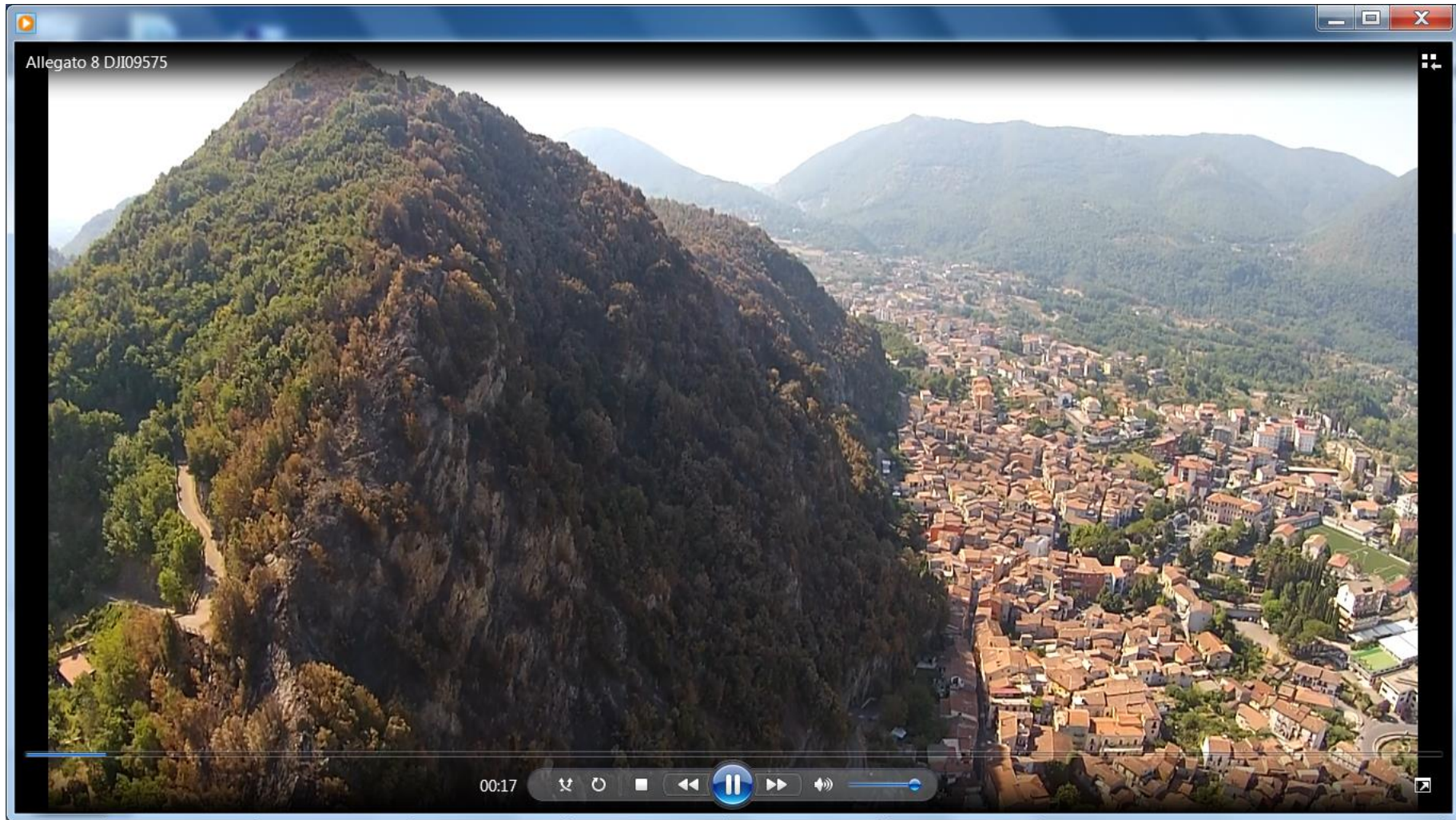


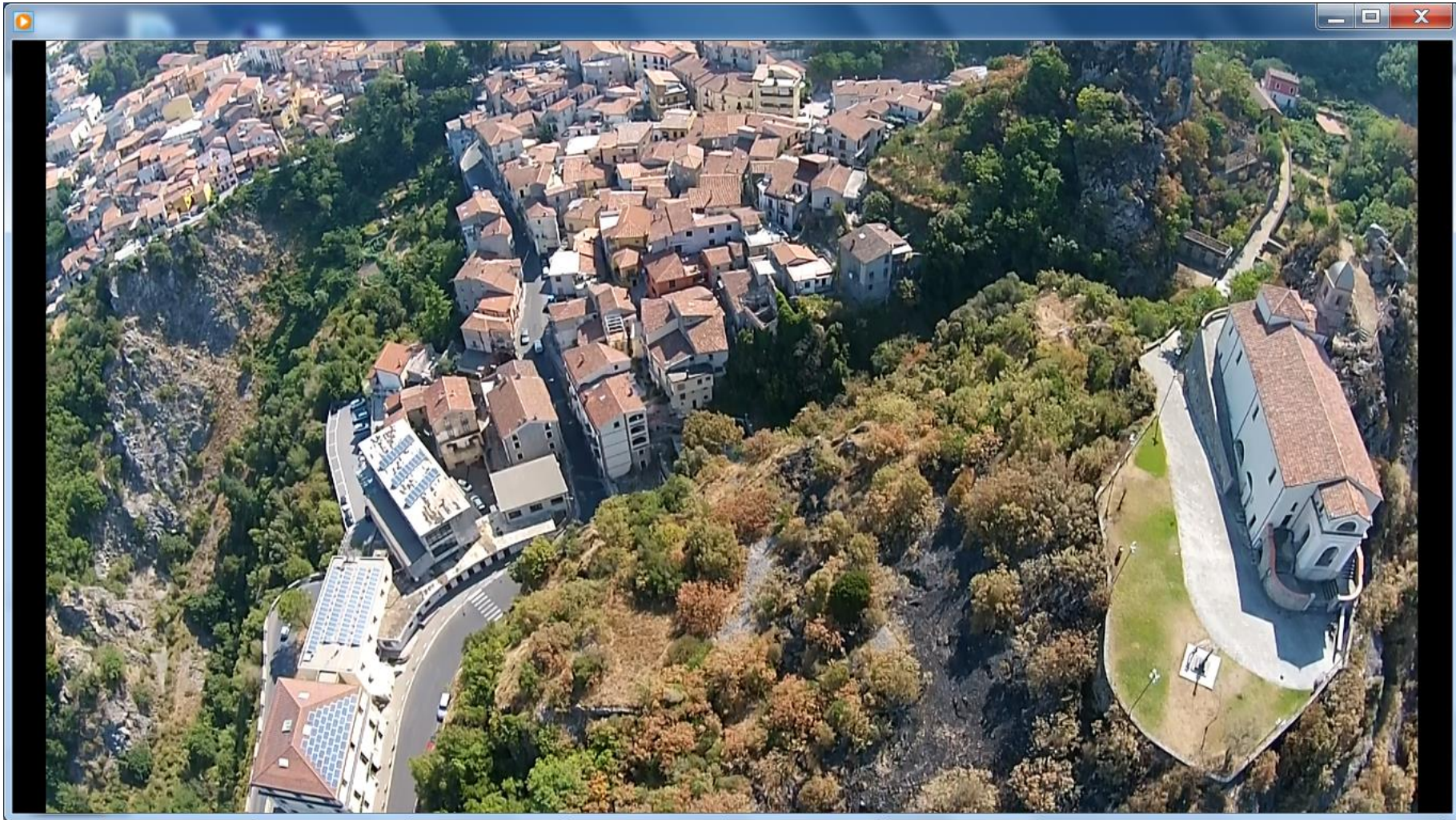
# Pisticci fire 23 agosto 2012

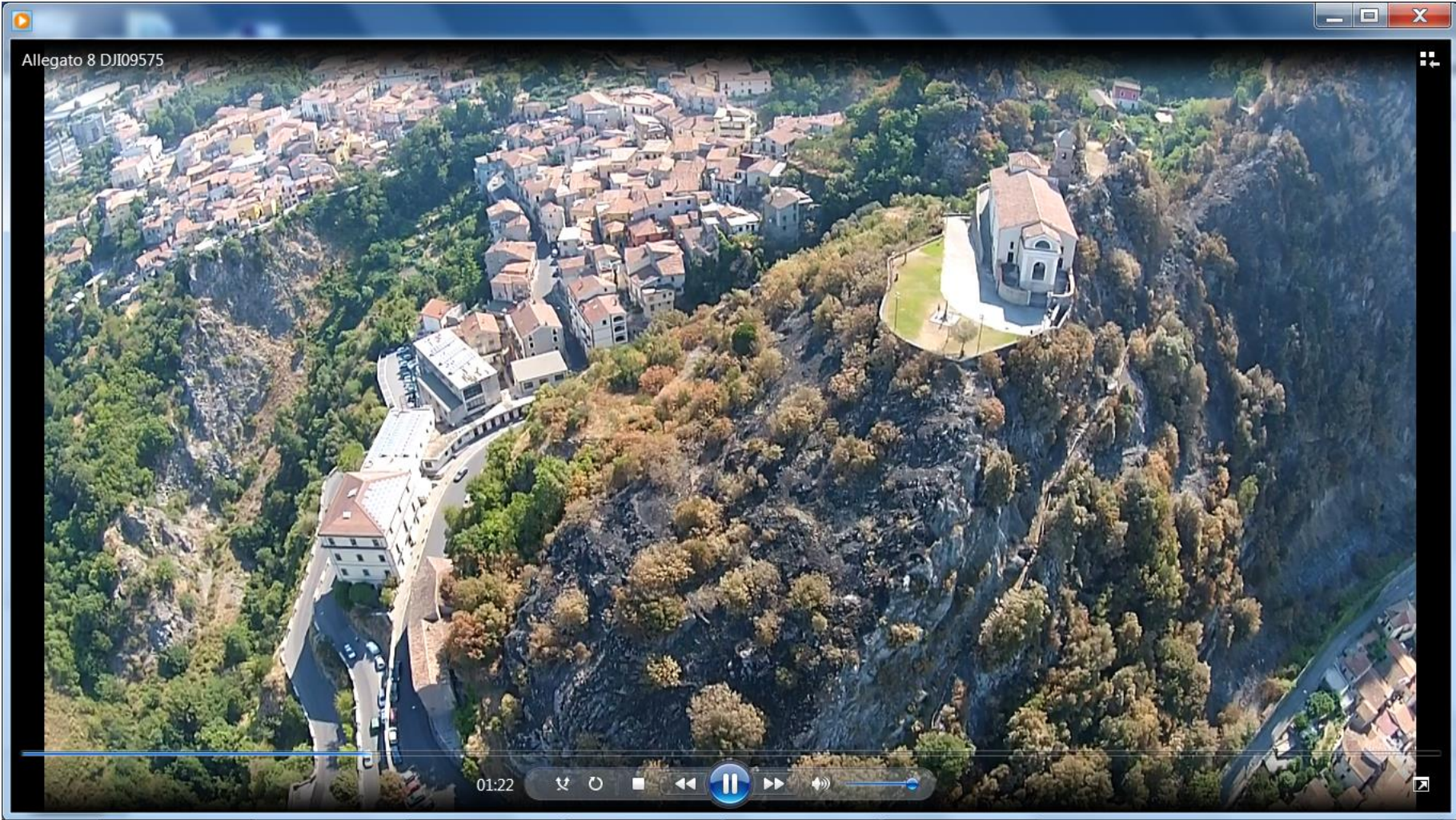


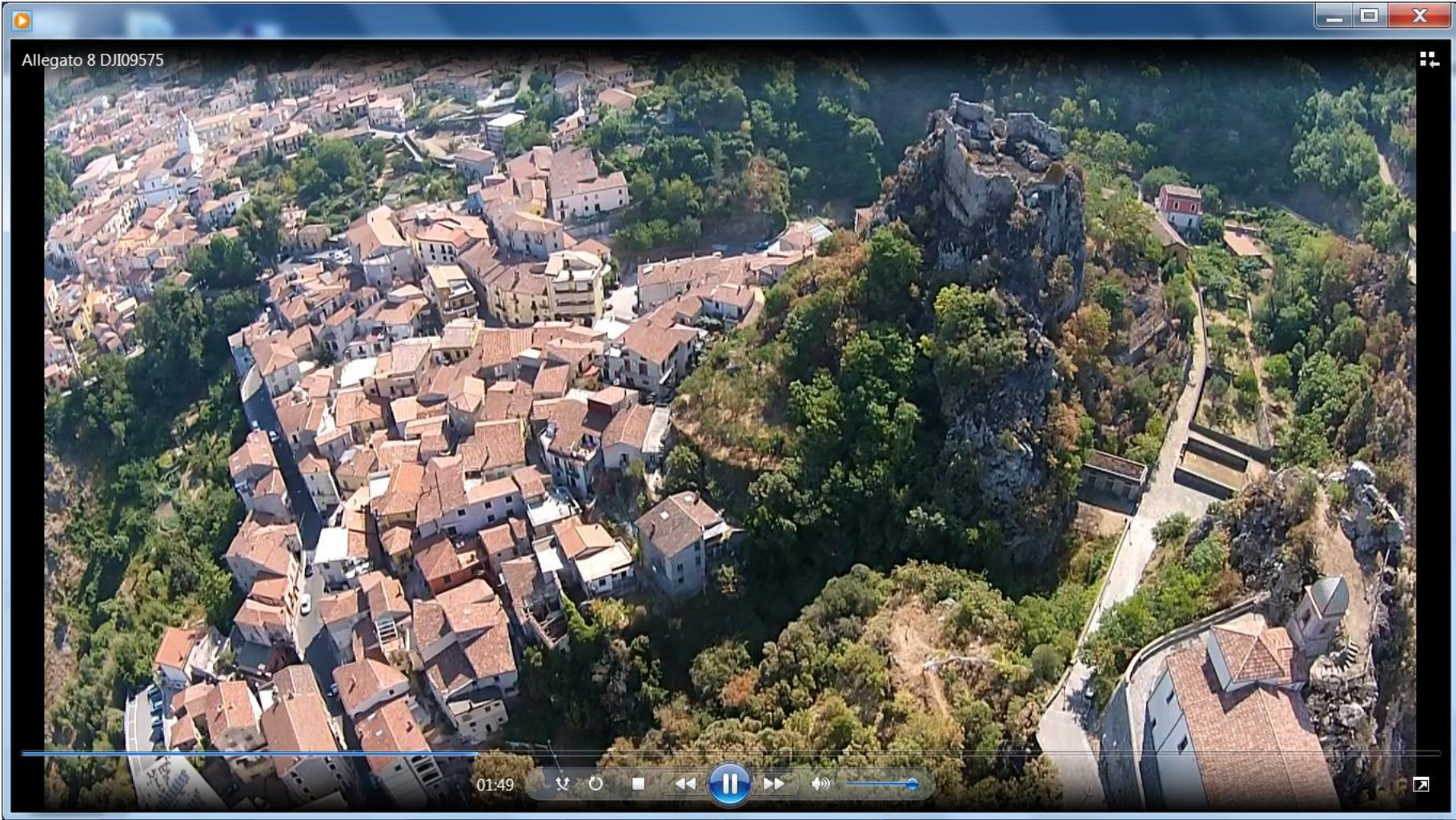
# Lauria Pollino National park interface fire 11 July 2017

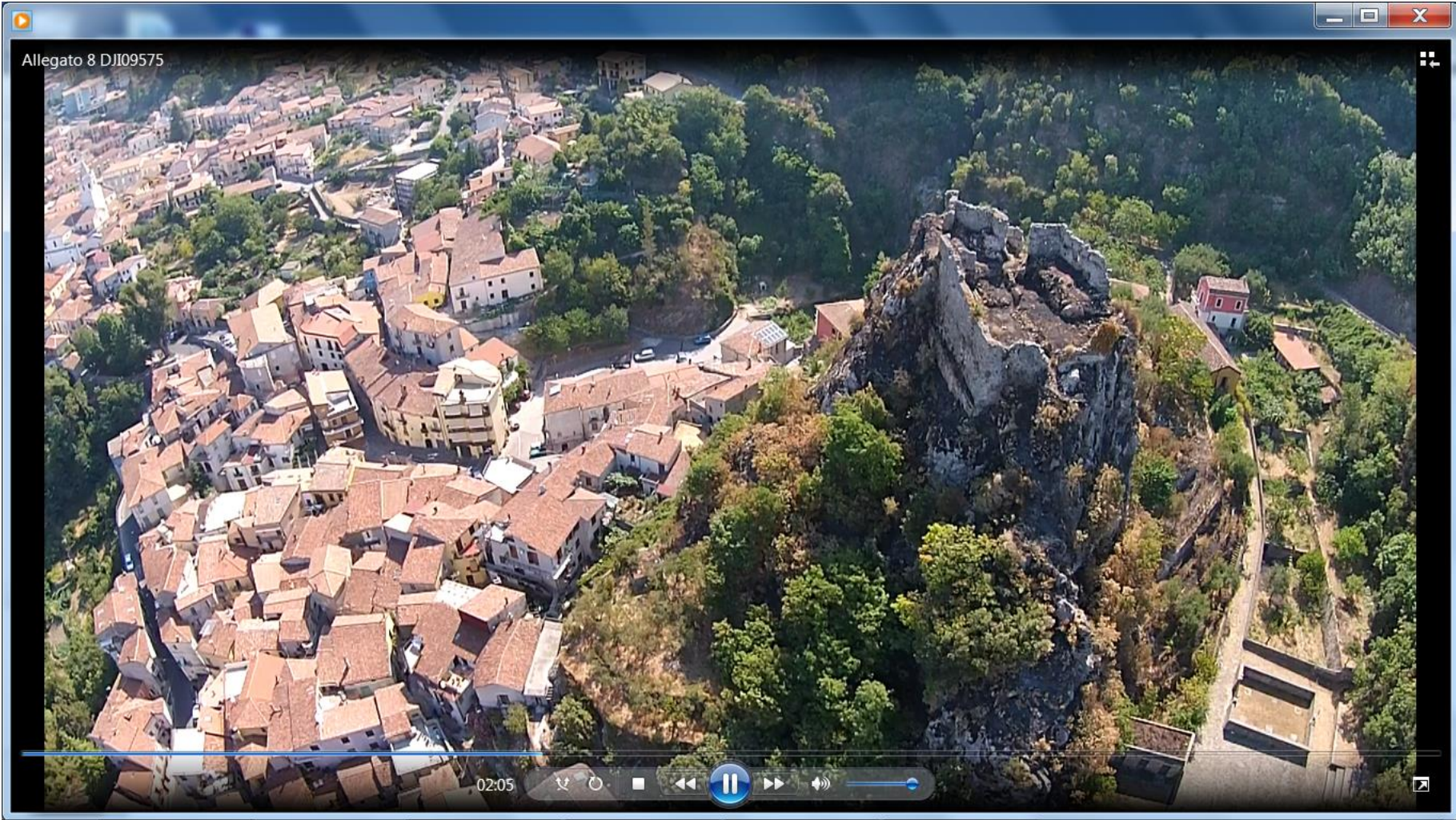












# SERV\_FORFIRE



Integrated services and approaches for  
Assessing effects of climate change and  
extreme events for fire and post fire risk  
prevention

Rosa Lasaponara CNR  
LPI SERV\_FORFIRE coordinator

[http://www.jpi-climate.eu/nl/25223459-SERV\\_FORFIRE.html](http://www.jpi-climate.eu/nl/25223459-SERV_FORFIRE.html)



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Co-alignment

ERA-NET for Climate Services

Funded projects

Joint Calls

2016 Call Description

2016 Call Projects

2015 Call Projects

2013 Call Projects

JPI Climate CSA

## SERV-FORFIRE

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Title

Integrated services and approaches for Assessing effects of climate change and extreme events for fire and post fire risk prevention

Lead PI

Lasaponara Rosa, CNR-DTA, Italia

Research Performing agencies

CNR-DTA, KNMI, FMI, BRGM, NCSRD, UVGZ

Abstract

Fire represents one of the main disturbances for vegetation, causing profound transformations at different temporal and spatial scales which affect ecosystems, landscapes and environments. Climate change is expected to bring increased forest fire risk by altering the water cycle at seasonal time scale, by increasing the occurrence of prolonged droughts and heat waves in the Mediterranean basin, as well as in Alpine ecosystems and boreal forests, with severe environmental and economic consequences. This project aims at creating an international collaborative community , expert in remote sensing soil and vegetation, risk management and mitigation, to provide climate information along with decision makers and planning authorities in order to:• increase efficiency of decision and policy makers authorities response, to improve the preparedness level of our societies and to limit the high economic cost of climate variability impact on fire and post fire risks, develop methods and specific procedures within the framework of fire and post fire risk management in Europe at climatic time scales (from seasonal to longer time scales).• strengthen the science-policy-society nexus using a participatory approach, by improving already operational or experimentally tested climate services in Europe, tailoring relevant information for decision and policy makers through a participatory and circular approach, capacity building user-based tools, specific training programs, dissemination activities,• increase the information regarding the drought conditions on wildfire and post fire risks management at climatic time scales (from seasonal to longer time scales) for national and local authorities decision-making procedures and planning activities,• collect scenarios on the effects of climate change on vegetation and fire occurrence,• investigate adaptation strategies and approaches to deal with future fire occurrence.

# Project partners



**Research National Council of Italy, Department of Earth systems science (CNR DTA), Italy**

**Finnish Meteorological Institute (FMI), Finland**

**Bureau de Recherches Géologiques et Minières (BRGM), France**

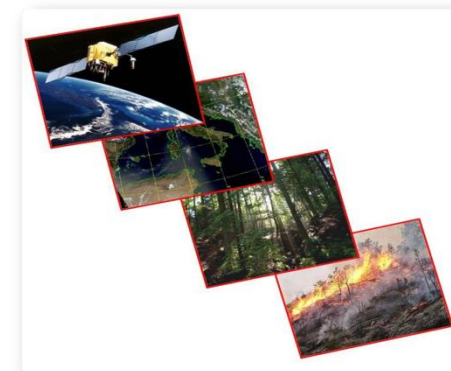
**Environmental Research Laboratory (INRASTES, NCSR), Greece**

**KNMI), Netherlands (Theoyal Netherlands Meteorological Institute (KNMI), Netherlands**

**Global Change Research Centre CAS (GCRI), Czech Republic**

# Associate Project partners

- JRC
  - CONAE (Argentine Space Agency)
  - CAS (Chinese Academy of Science)
  - University of Alcalá
  - University of Lebanon
- 
- Strong cooperation in the field day to day with
  - Italian Protezione civile
  - Carabinieri
  - Forest Directorate of Chania
  - Attika Municipality
  - Finnish Protezione civile
- 
- -----



# Main objectives

The main objectives of SERV\_FORFIRE project are to:

- (i) provide integrated services for forest fire assessment and mitigation strategies, from seasonal up to climatic time scales,
- (ii) create a bridge between observations, model development, operational products, information translation .

to improve the quality of services and approaches for assessing effects of climate change on fire and post fire risk in order to define suitable strategies for prevention and mitigation actions

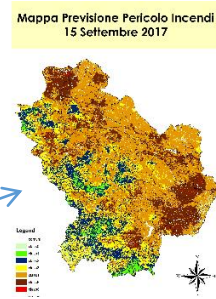
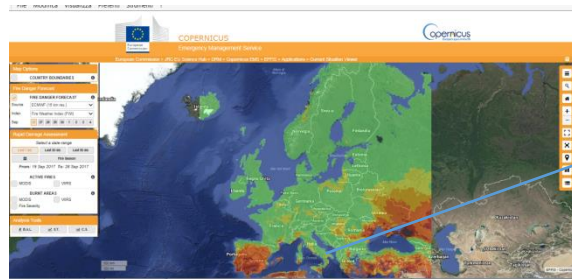
# Main objectives



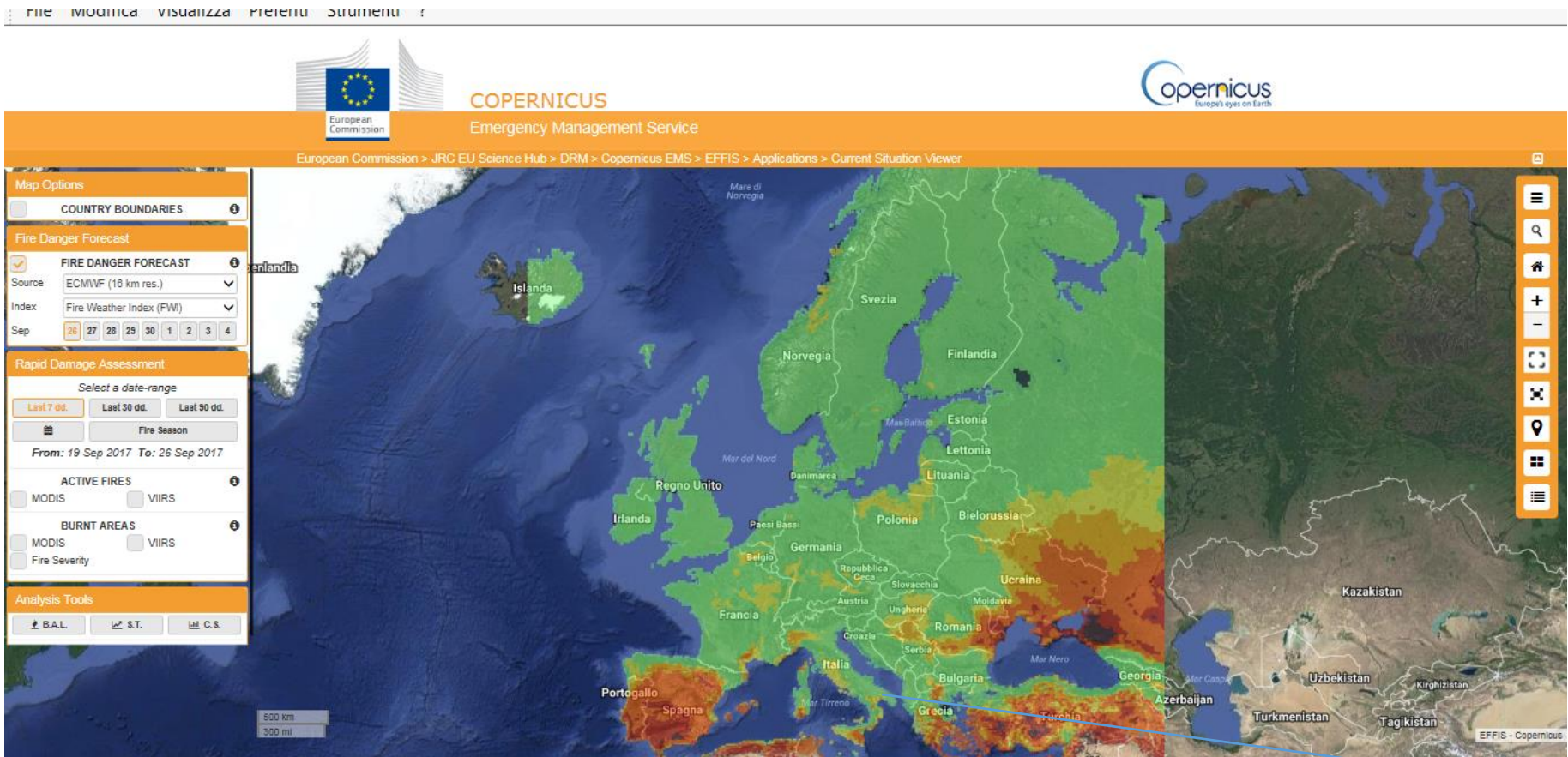
SERV\_FORFIRE project will contribute at creating an international collaborative community of climate information providers, expert in remote sensing, soil and vegetations, risk management and mitigation, along with users, decision makers and planning authorities in order to:

- ❑ strengthen the science-policy-society nexus using a participatory approach, by improving already operational or experimentally tested climate services,
- ❑ tailoring relevant information for decision and policy makers through a participative and circular approach,
- ❑ capacity building user-centric tools, specific training programs, dissemination activities,

To increase efficiency of decision and policy makers authorities response, to improve the preparedness level of our societies and to limit the high economic cost of climate variability impact on fire and post fire risks, develop methods and specific procedures within the framework of fire and post fire risk management in Europe at climatic time scales (from seasonal to longer time scales).



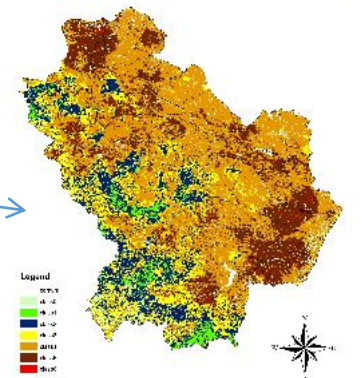
The synergic and complementary activities of all the partners involved in the SERV\_FORFIRE consortium will lead to the development of an improved and integrated “fire and post fire” product portfolio complementary to what EFFIS and the Copernicus Climate Change Service will routinely deliver for fire management



[http://effis.jrc.ec.europa.eu/static/effis\\_current\\_situation/public/index.html](http://effis.jrc.ec.europa.eu/static/effis_current_situation/public/index.html)



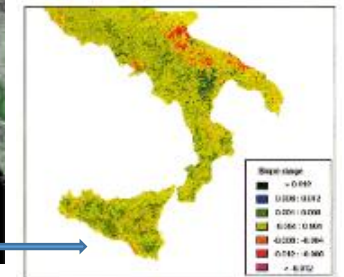
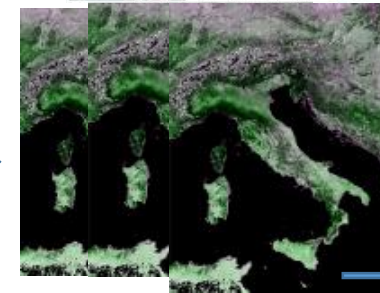
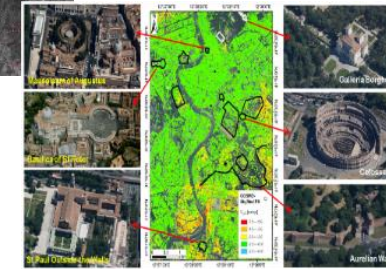
Mappa Previsione Pericolo Incendi  
15 Settembre 2017

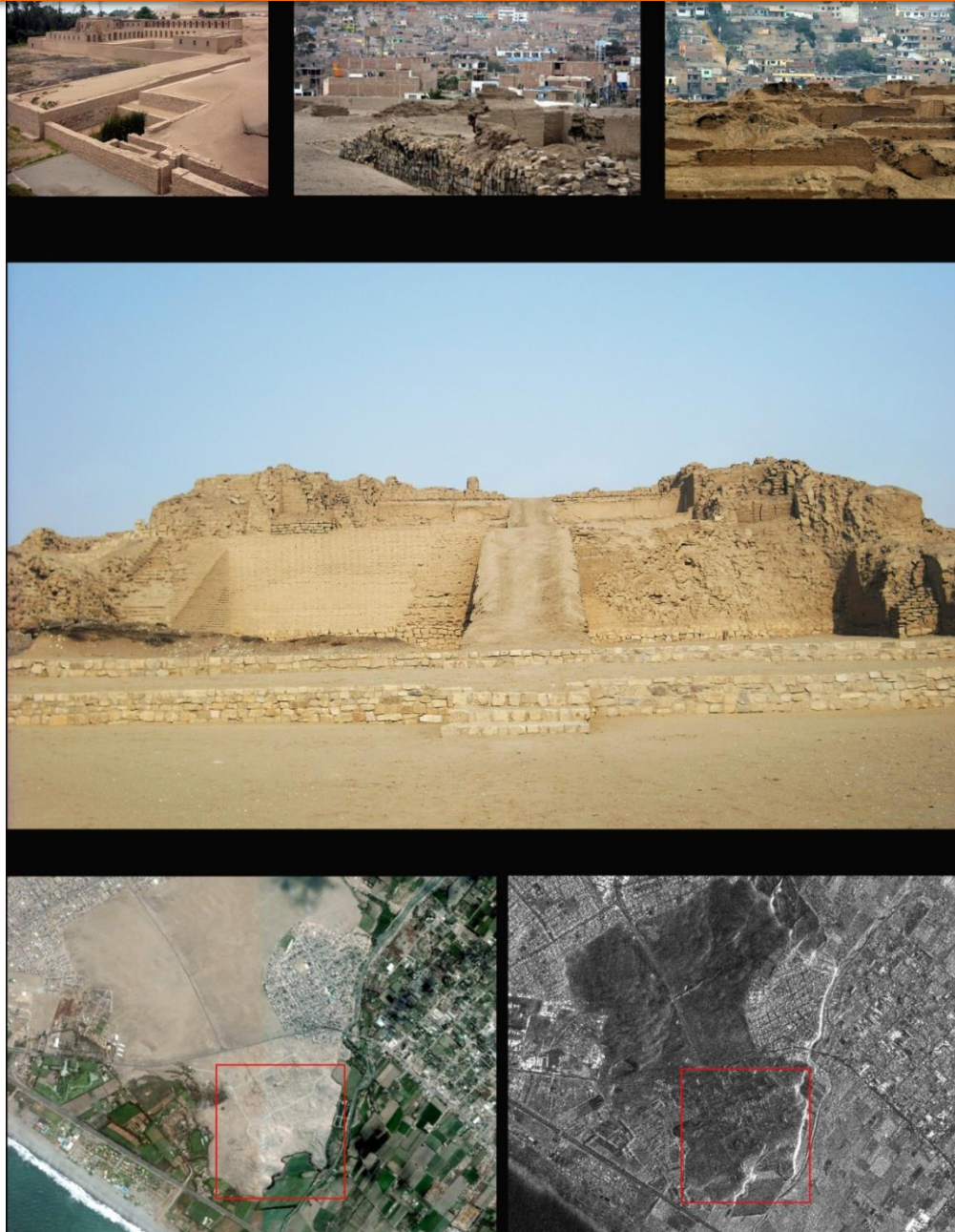


<http://www.protezionecivilebasilicata.it/protcivbas/css/themes/01/images/mappa.jpg>

## UNESCO primary factors/threats affecting the World Heritage properties

1. urban sprawl,
2. pollution,
3. biological resource use/modification,
4. physical resource extraction,
5. local conditions affecting physical fabric,
6. social/cultural uses of heritage,
7. climate change
8. severe weather events,
9. sudden ecological or geological events,
10. management and institutional factors,
11. transportation and utilities infrastructure,
12. invasive/alien or hyperabundant species,
13. the deliberate destruction,
14. terrorism or civil unrest





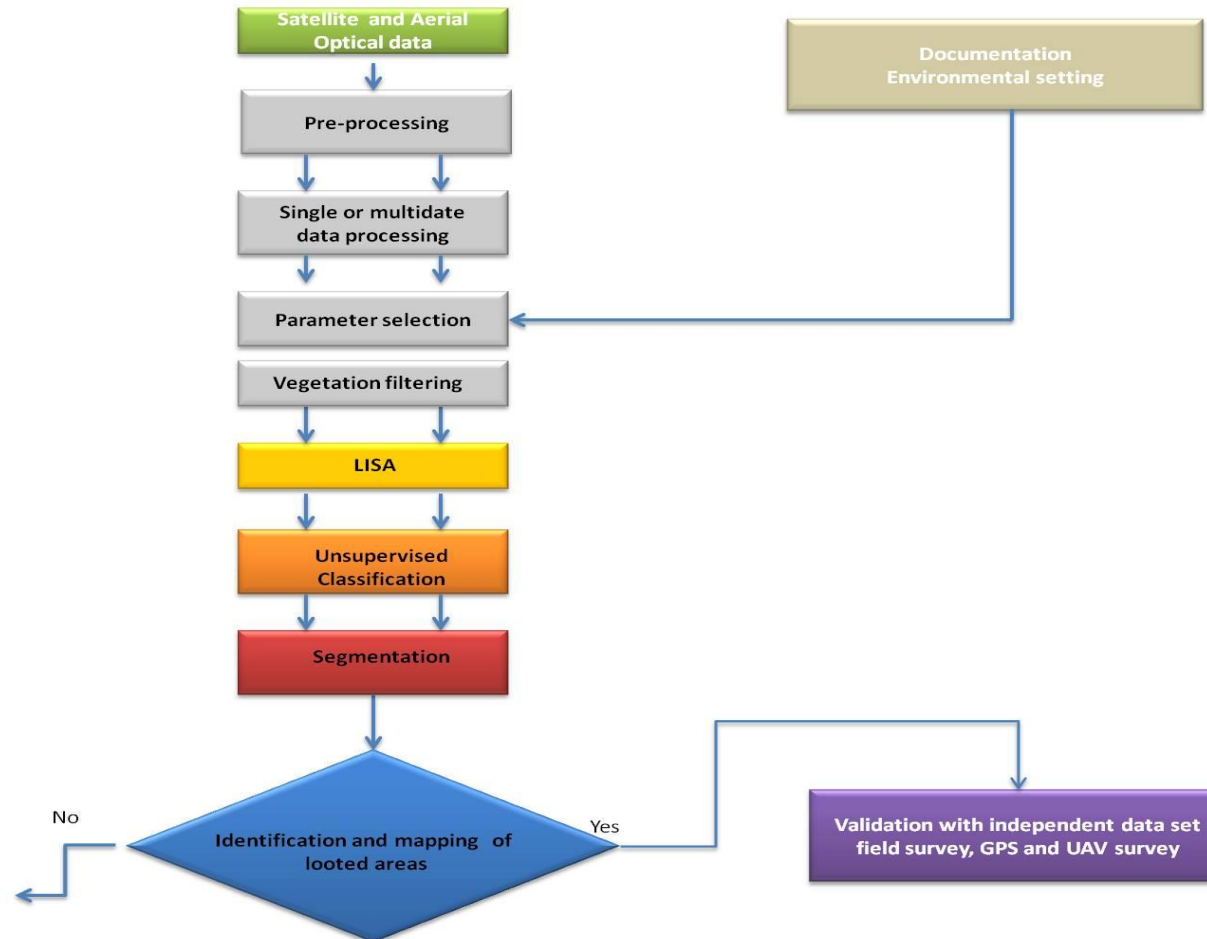
Google Earth image and Cosmo SkyMed strip image himage of **Pachacamac**, pre.Incas ceremonial centre (VI-XIV A.D.) surrounded by the suburbs of Lima

the complementarity of the optical and SAR data as regards the archaeological features. For arid and desert areas the penetration of radar allows us to detect buried remains, including earthen walls as in the case of Pachacamac

Additional info in

**R Lasaponara**, N Masini, A Pecci, F Perciante... - Journal of Cultural heritage, 2017 [Qualitative evaluation of COSMO SkyMed in the detection of earthen archaeological remains: The case of Pachamacac \(Peru\)](https://doi.org/10.1016/j.culher.2015.12.010) vol 23 pp 55-62  
<https://doi.org/10.1016/j.culher.2015.12.010>

# Automatic Monitoring of illegal excavations from space



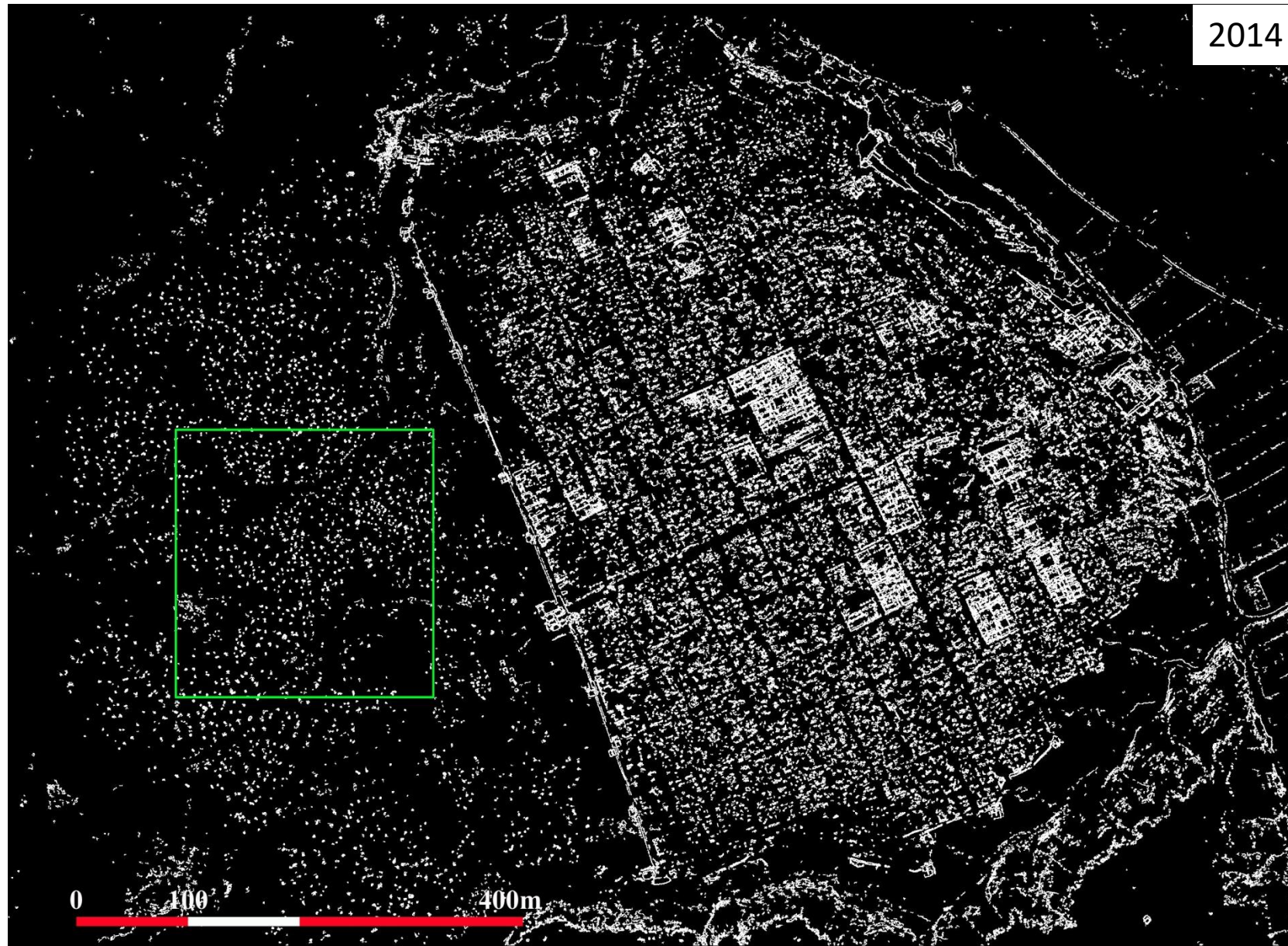
# CASE STUDY 1: DURA EUROPOS

2014



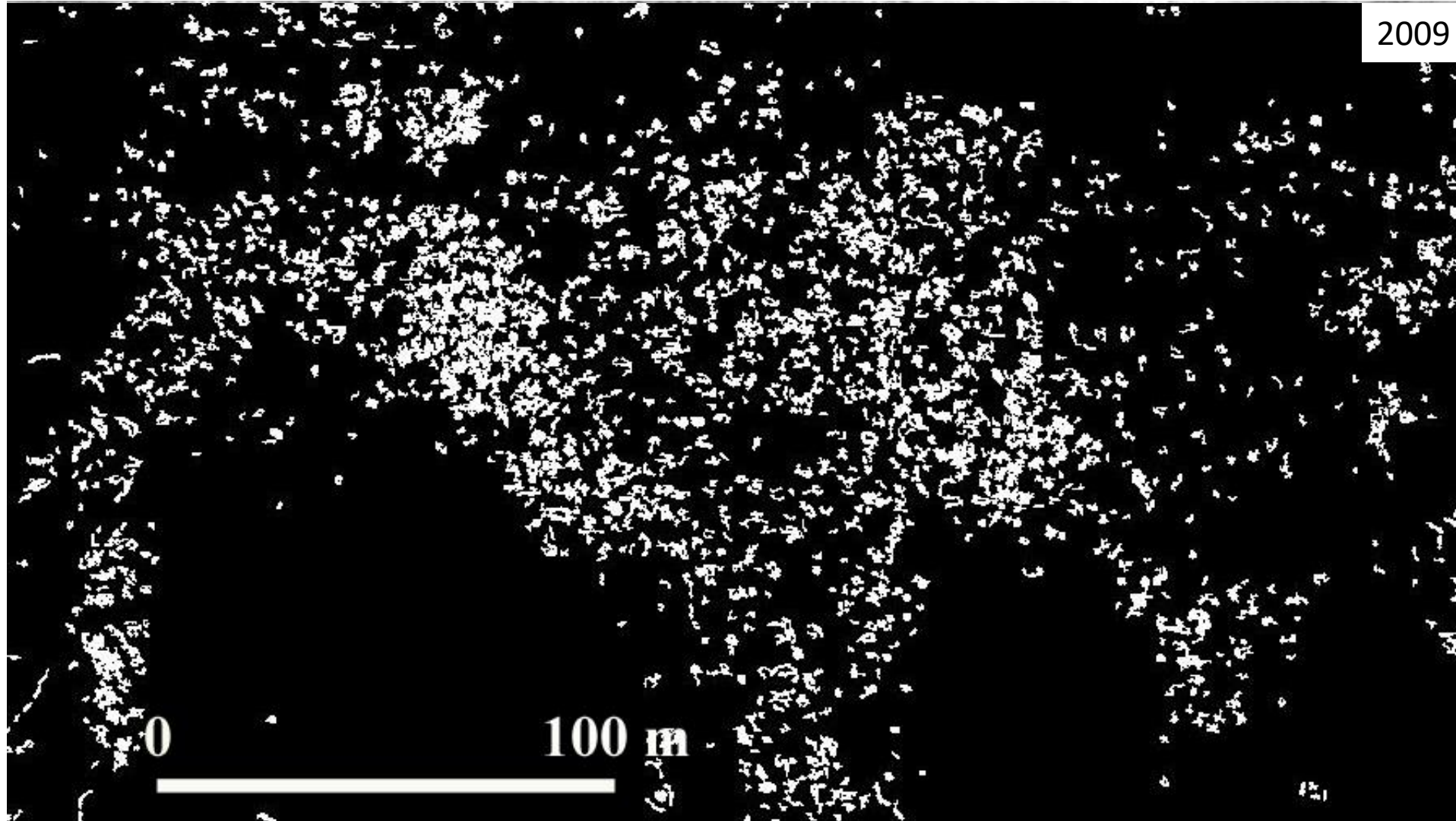
# DURA EUROPOS

## RESULTS FROM ARCHAEOLOGICAL FEATURE EXTRACTION



# CAHUACHI

## RESULTS FROM ARCHAEOLOGICAL FEATURE EXTRACTION



## RATE OF SUCCESS ASSESSMENT

| image 2009 |        |       |    |                               |
|------------|--------|-------|----|-------------------------------|
| NH         | TD     | TnD   | FA | $N_{FA} = \frac{FA}{(FA+TD)}$ |
| 178        | 161    | 17    | 26 |                               |
|            | 90,04% | 9,96% |    | 13,90%                        |
| image 2013 |        |       |    |                               |
| NH         | TD     | TnD   | FA | $N_{FA} = \frac{FA}{(FA+TD)}$ |
| 178        | 173    | 6     | 5  |                               |
| 100,00%    | 97,19% | 3,37% |    | 2,81%                         |

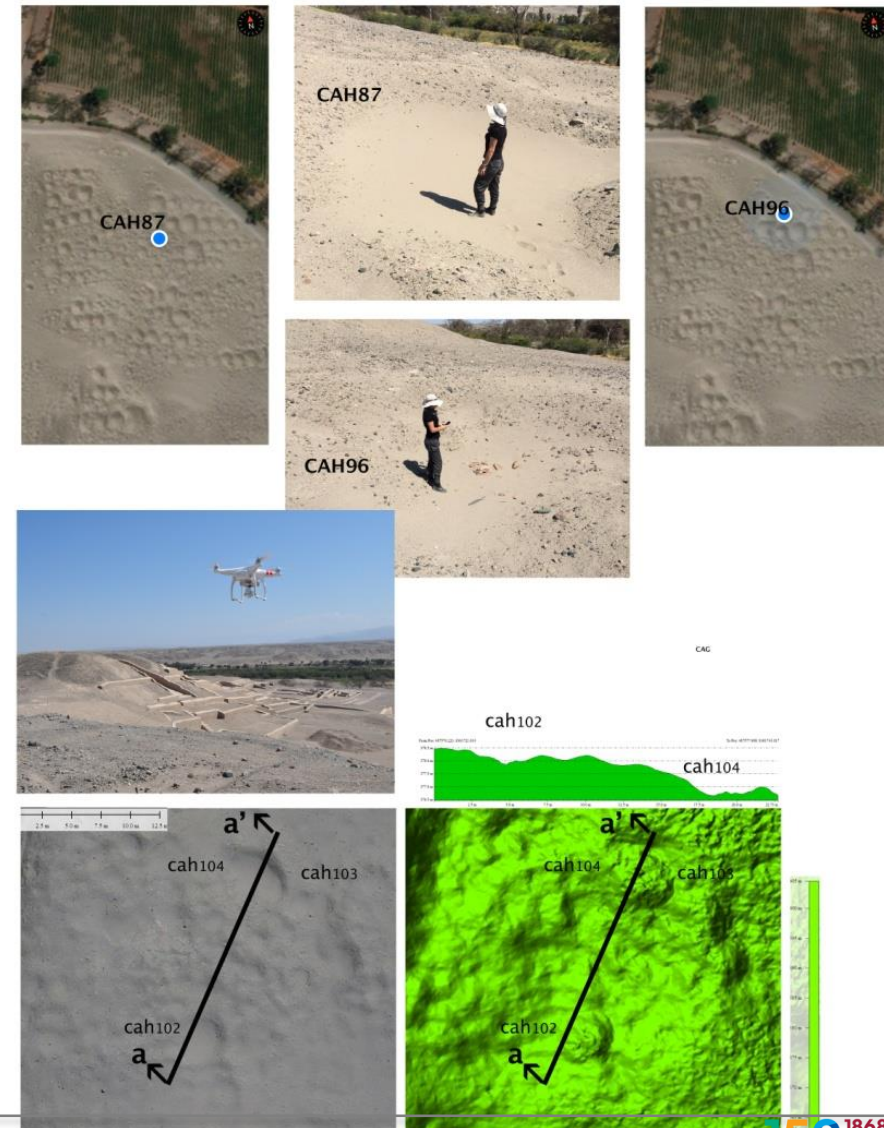
NH: Number of Holes

TD: targets detected

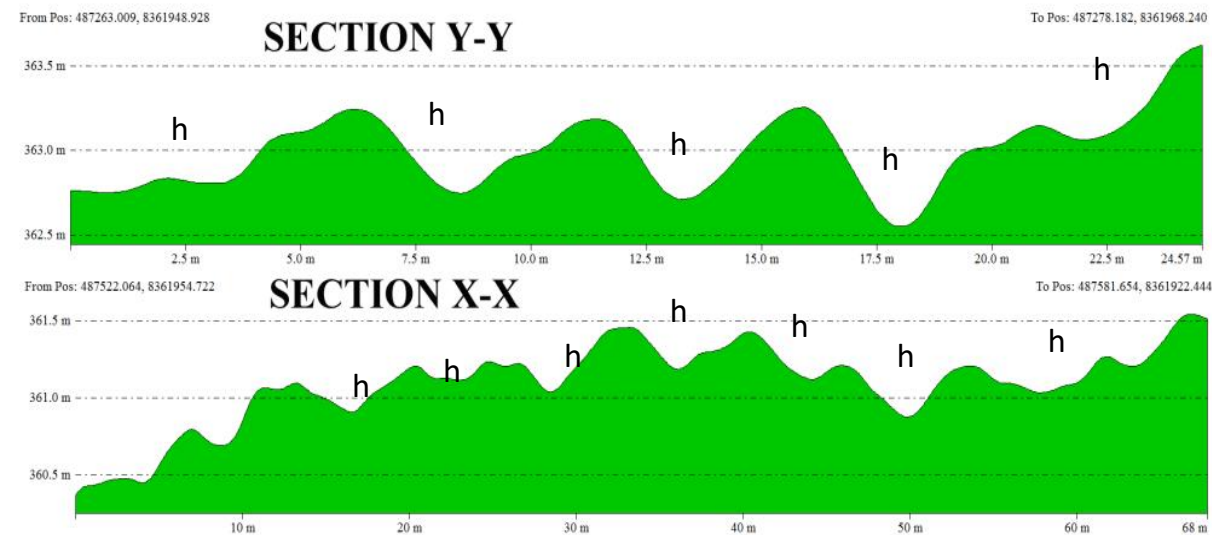
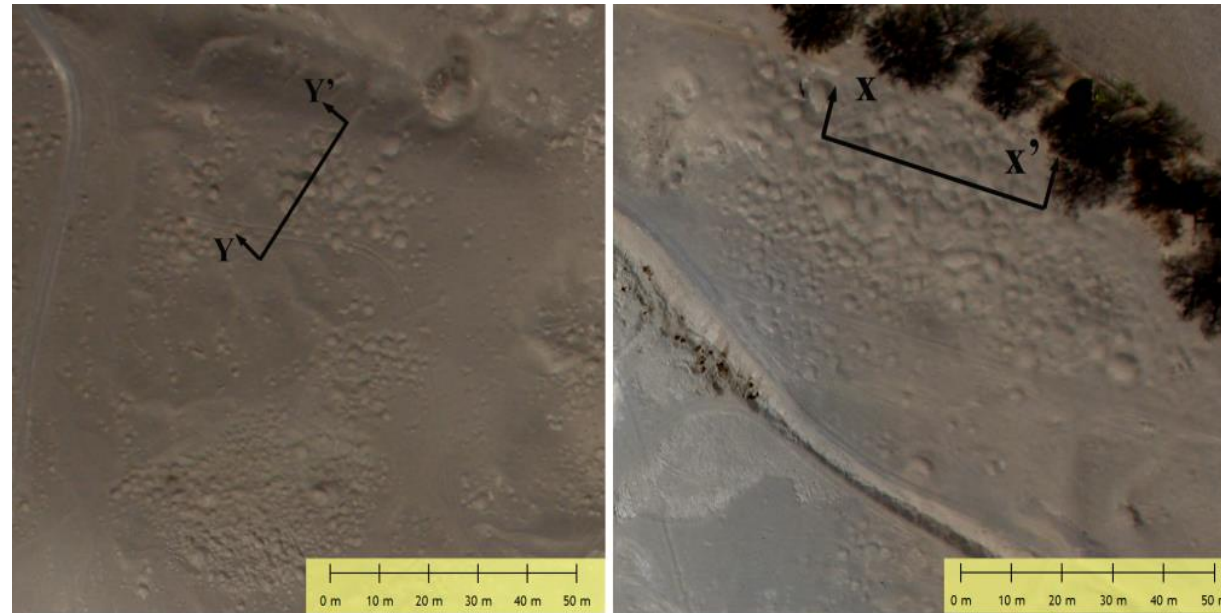
FA: False Alarms

NFA: normalized false alarm index  
( $\frac{FA}{(FA+TD)}$ )

Assessment method: visual inspection of  
satellite imagery, aerial survey by drone  
and field survey

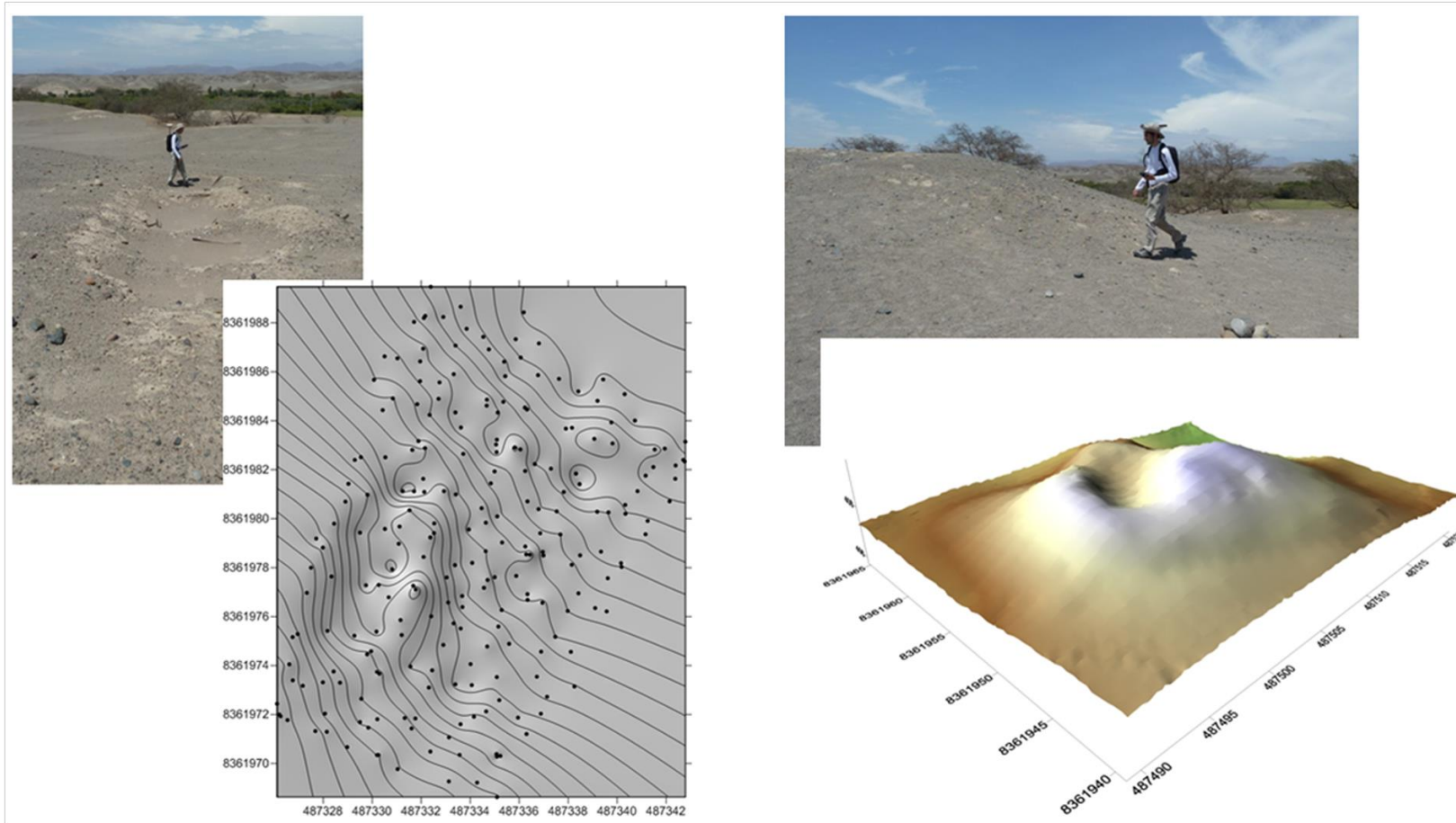


## Assessment of holes detected by aerial photogrammetry



## h: holes

# Assessment of holes detected by GPS



Lasaponara & Masini 2017

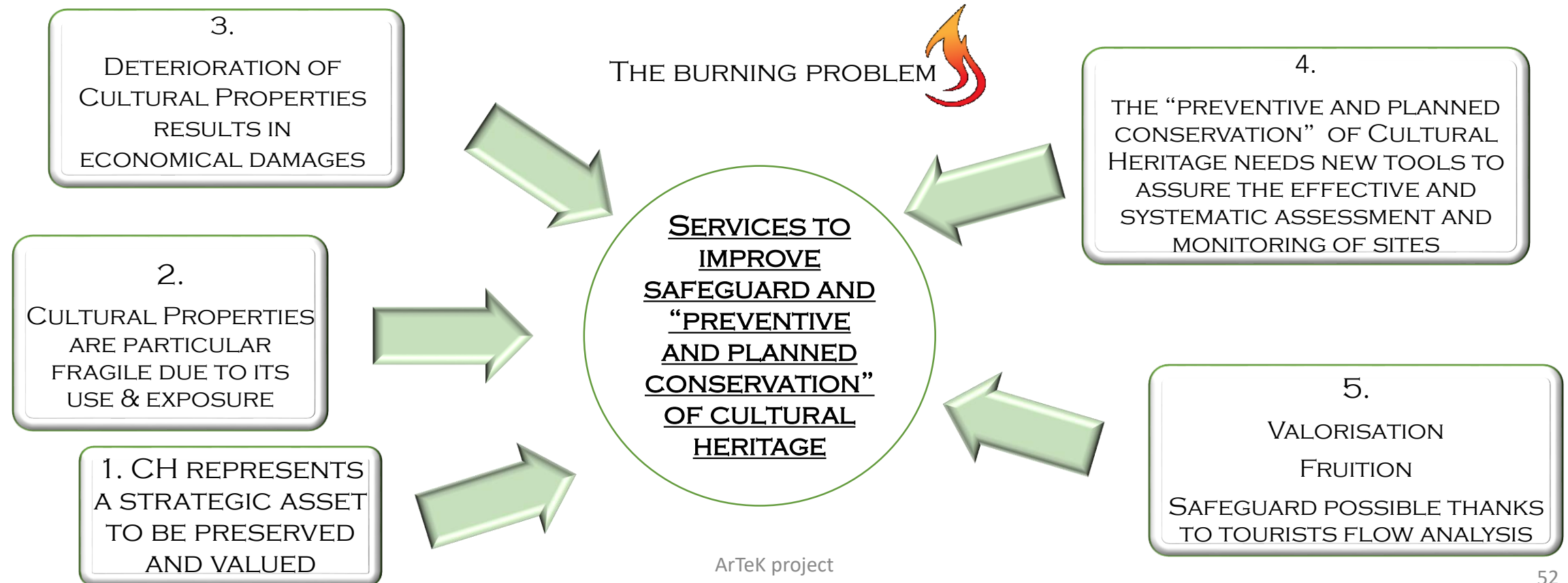
# ArTeK – the opportunity



ESA BUSINESS APPLICATIONS PROGRAM

DURATION: 24 MONTHS

START: 2 NOVEMBER 2016



ArTeK project  
NAIS-

# ArTeK – the Team



**PRIME**



**NEXTANT  
APPLICATION AND  
INNOVATIVE  
SOLUTIONS**



**PUBLIC  
INSTITUTIONS**



**ISTITUTO SUPERIORE PER LA CONSERVAZIONE ED IL  
RESTAURO**



**ISPRA**

**ITALIAN NATIONAL INSTITUTE FOR THE ENVIRONMENTAL  
PROTECTION AND RESEARCH**



**NATIONAL COUNCIL OF RESEARCH –  
INSTITUTE OF METHODOLOGIES AND ENVIRONMENTAL  
ANALYSIS**



**ENAV**

**NATIONAL AGENCY FOR FLIGHT ASSISTANCE**



**SUPERELECTRIC**



**STRALO**



**PRIVAT  
COMPANIES**

ArTeK project  
NAIS-

# ArTek pilot sites



COLLABORATION BETWEEN  
USERS AND SITE MANAGER

# ArTeK web platform



VILLA ADRIANA

The screenshot displays the ArTeK web platform interface. The top navigation bar includes the ArTeK logo and a search bar. The main map area shows a 3D view of the Villa Adriana site, with a yellow polygon labeled 'Piccole Terme'. A red dashed line indicates the 'camerelle' area. The left sidebar, titled 'Livelli', lists various data layers, including 'Vegetazione Infestante (06-2017)' and 'Vulnerabilità Archeologica Globale'. The right sidebar, titled 'Legenda', provides a detailed legend for these layers. An orange arrow points from the 'Vegetazione Infestante (06-2017)' layer in the legend to a small green area on the map. Another orange arrow points from the 'Piccole Terme' label to the same green area. A yellow box labeled 'VEGETATION' is positioned near the green area. The bottom of the interface shows a scale bar (10 m) and coordinates (Lat. 0.0 Lon. 0.0).

**Livelli**

- CTR senza curve di livello
- Sfondo Uniforme
- CTR senza vegetazione
- Villa Adriana**
  - Pericolosità Idraulica**
    - P1
    - P2
    - P3
  - Rischio Annerimento Individuale
  - Vegetazione Monumenti**
    - Monumenti
    - Coperture Monumenti
    - ☒ Vegetazione Infestante (06-2017)
  - Monumenti**
    - Cambiamenti
    - ☒ Vulnerabilità Archeologica Globale
    - Limiti Sito Unesco
    - NDVI
  - Contenuti multimediali**
    - Immagini Geotaggate

**Legenda**

**Vegetazione Infestante (06-2017)**

- Vegetazione bassa
- Vegetazione a medio/alto fusto

**Vulnerabilità Archeologica Globale**

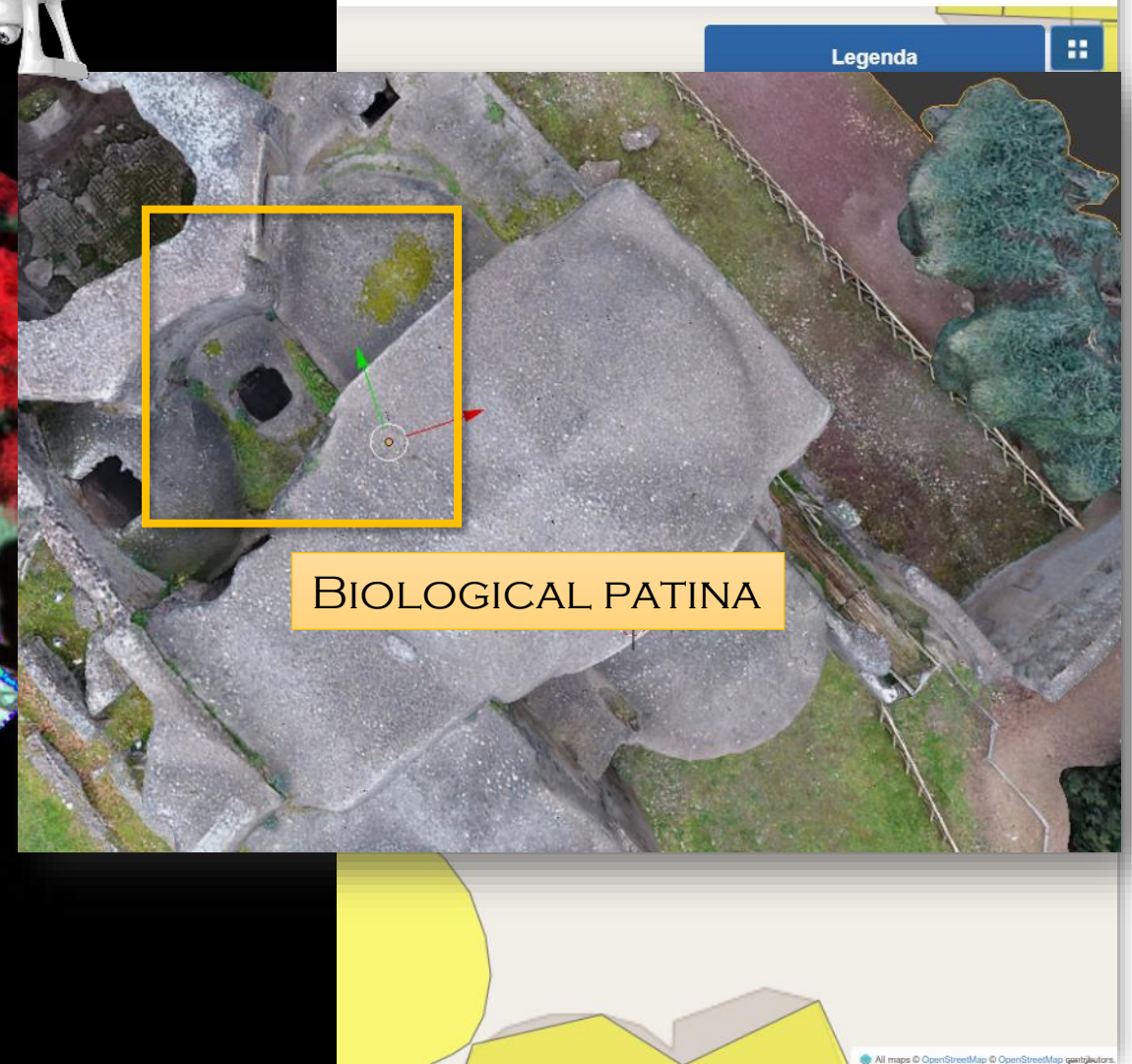
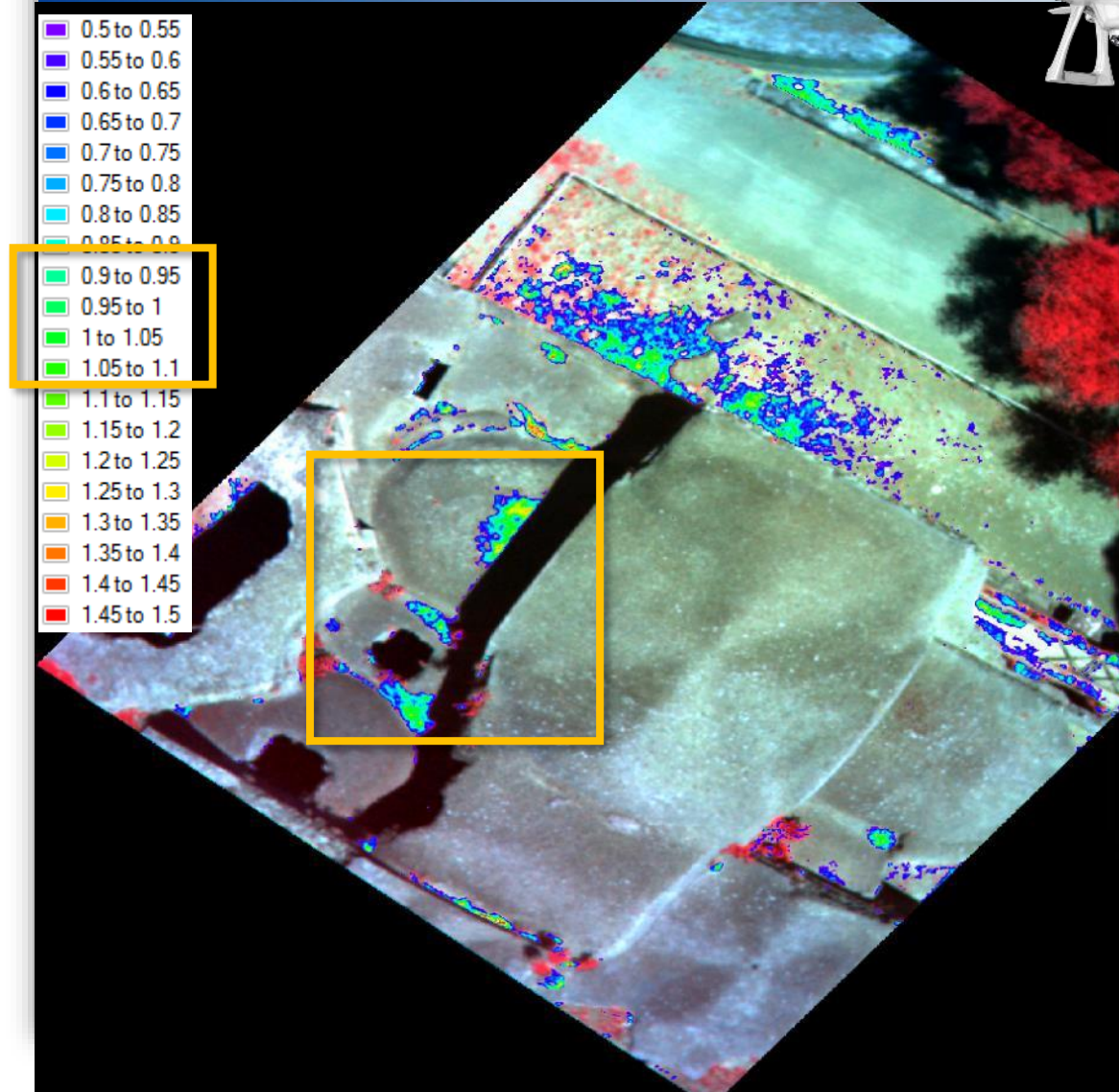
- Nessuna Vulnerabilità
- Non disponibile in ISCR
- Vulnerabilità A Bassa
- Vulnerabilità A Media
- Vulnerabilità A Alta
- Vulnerabilità MA Bassa
- Vulnerabilità MA Media
- Vulnerabilità MA Alta

**VEGETATION**

# ArTeK web platform



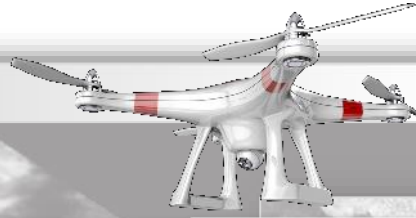
VILLA ADRIANA



# ArTeK web platform



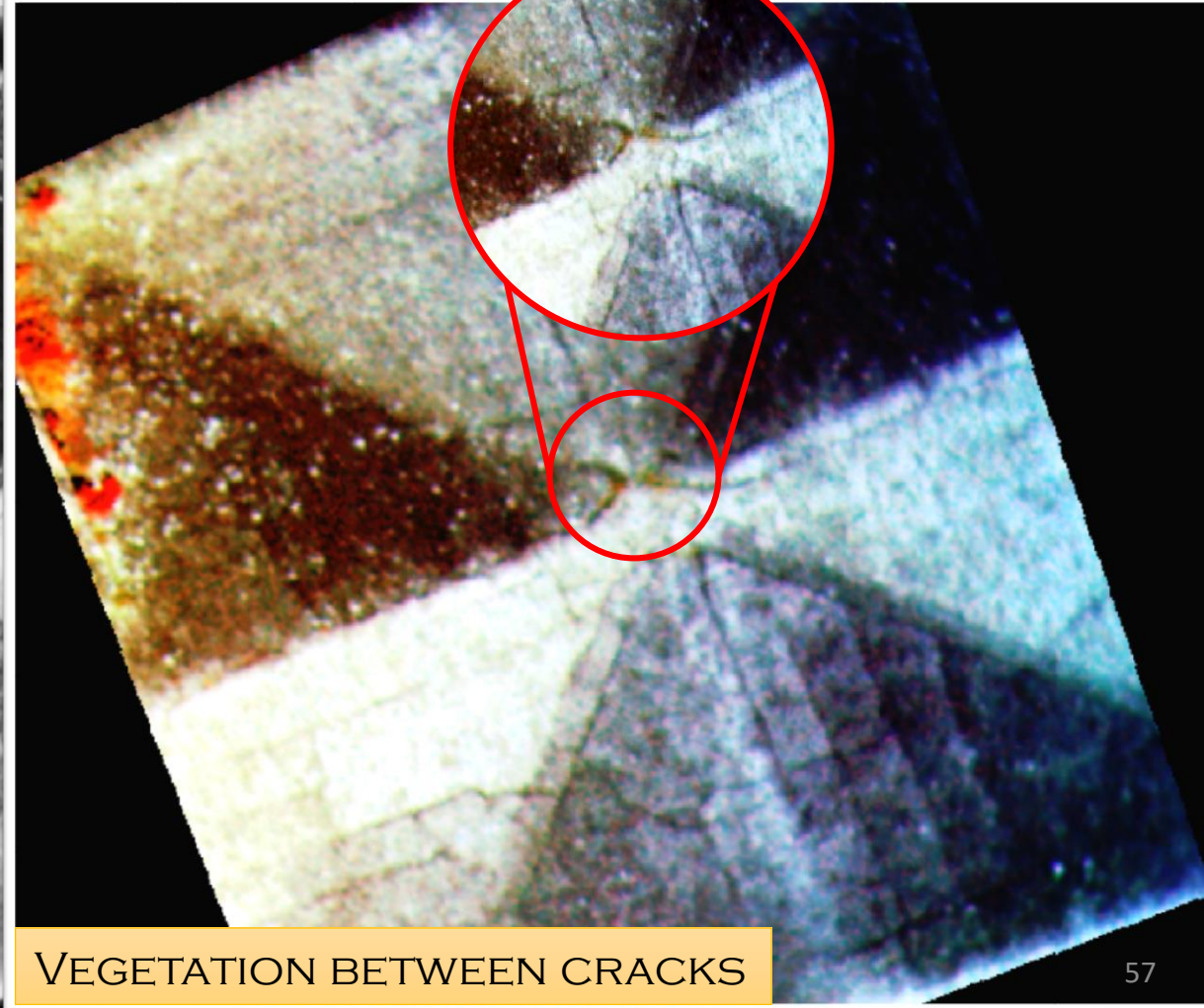
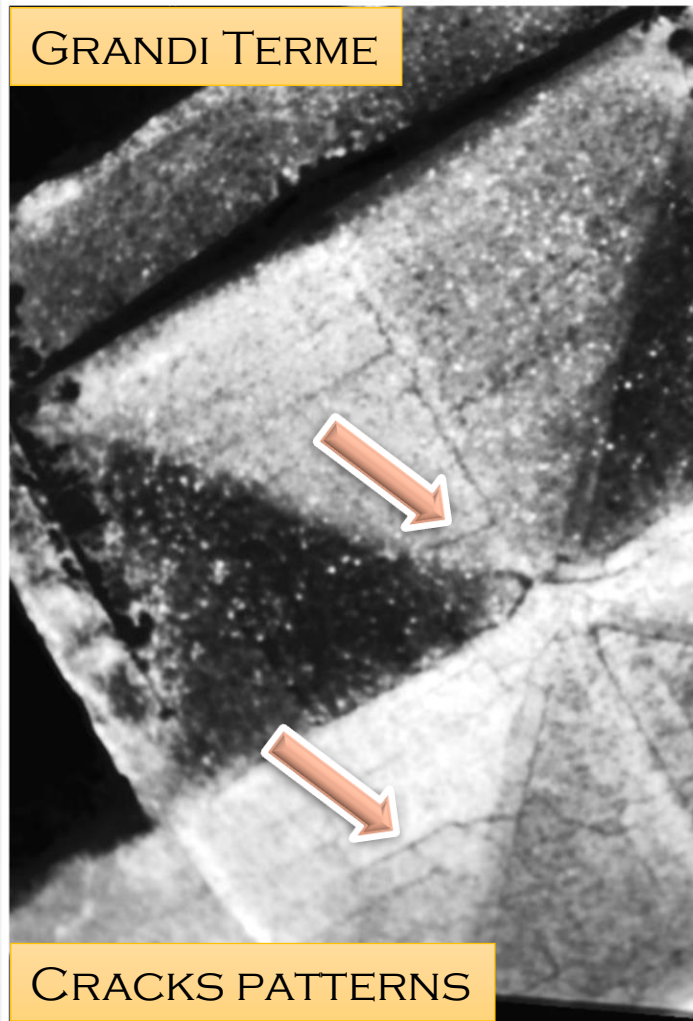
VILLA ADRIANA



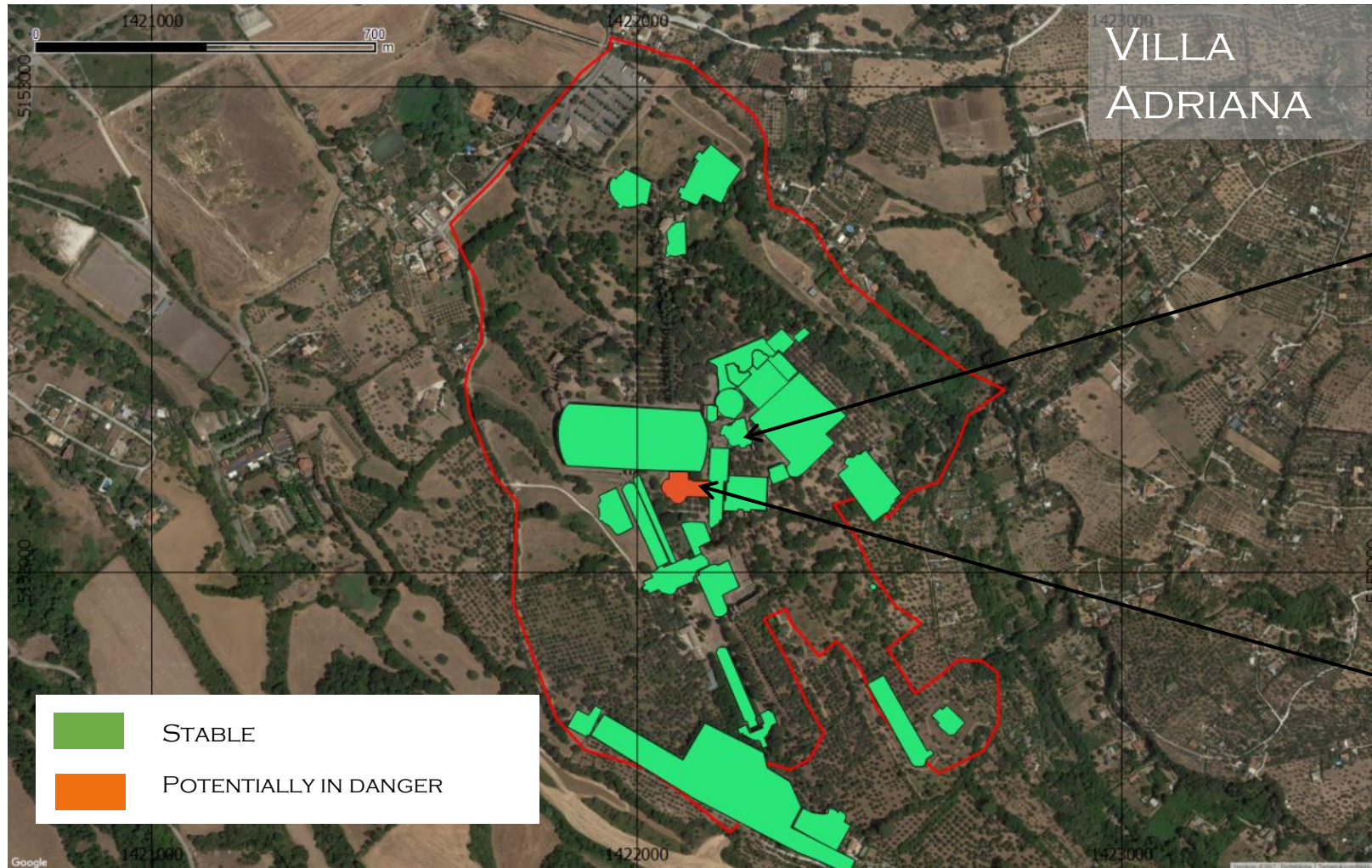
Legenda

- 0.5 to 0.55
- 0.55 to 0.6
- 0.6 to 0.65
- 0.65 to 0.7
- 0.7 to 0.75
- 0.75 to 0.8
- 0.8 to 0.85
- 0.85 to 0.9
- 0.9 to 0.95
- 0.95 to 1
- 1 to 1.05
- 1.05 to 1.1
- 1.1 to 1.15
- 1.15 to 1.2
- 1.2 to 1.25
- 1.25 to 1.3
- 1.3 to 1.35
- 1.35 to 1.4
- 1.4 to 1.45
- 1.45 to 1.5

GRANDI TERME



# Static-structural stability analysis COSMO based Interferometric analysis



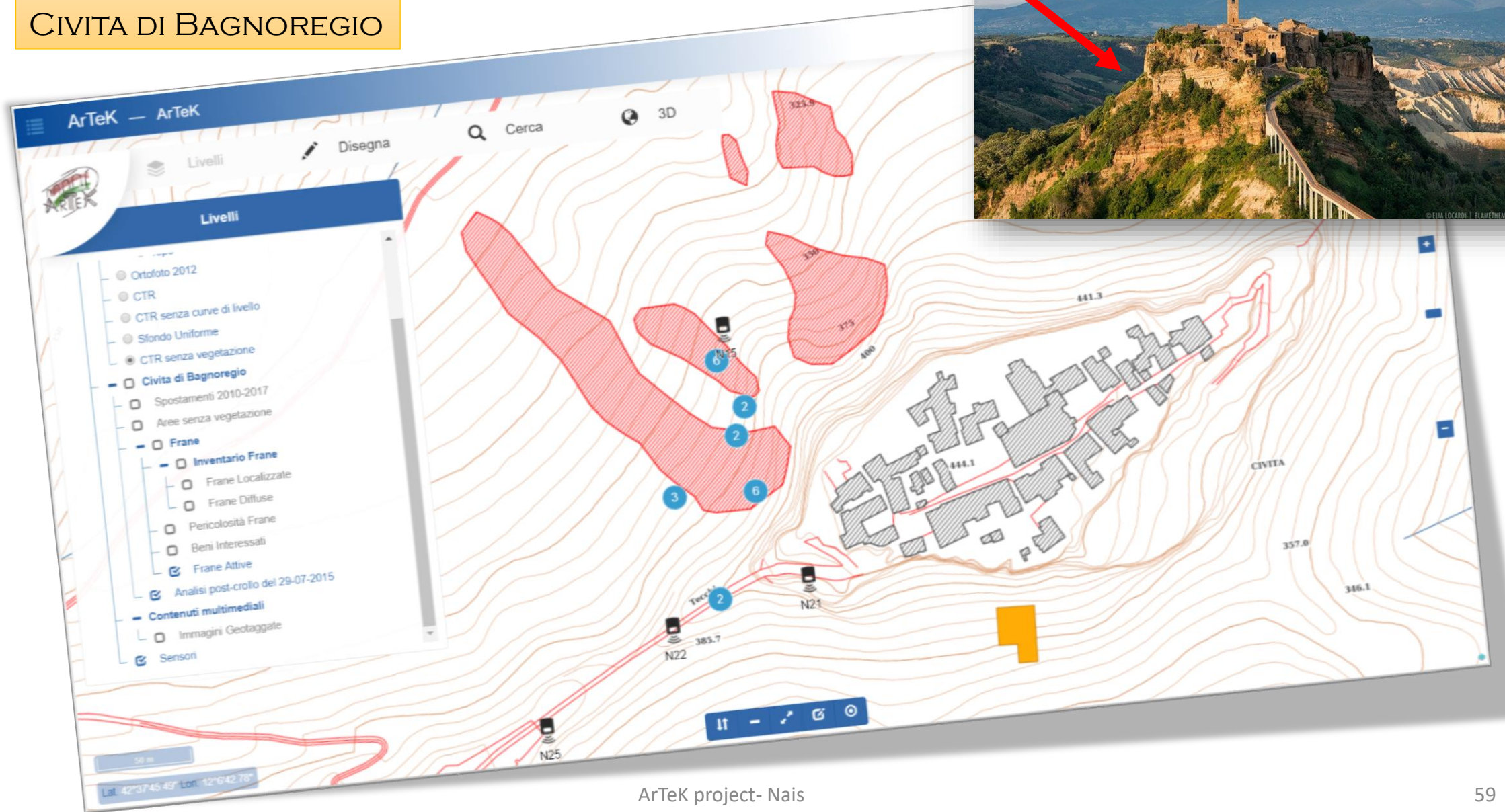
| MONUMENT      | TERME CON HELIOCAMINUS |
|---------------|------------------------|
| PS NUMBER     | 115                    |
| STABLE PS     | 115                    |
| UNSTABLE PS   | 0                      |
| $V_{MAX}$     | 1.4 MM/YEAR            |
| $V_{MIN}$     | -0.85 MM/YEAR          |
| $V_{AVERAGE}$ | 0.21 MM/YEAR           |

| MONUMENT      | TRE ESEDRE   |
|---------------|--------------|
| PS NUMBER     | 60           |
| STABLE PS     | 57           |
| UNSTABLE PS   | 3            |
| $V_{MAX}$     | 1.0 MM/YEAR  |
| $V_{MIN}$     | -6.4 MM/YEAR |
| $V_{AVERAGE}$ | 0.06 MM/YEAR |

PS ARE CONSIDERED STABLE IF  $-1.5 \leq VEL \text{ (MM/YEAR)} \leq 1.5$ . A MONUMENT IS CONSIDERED POTENTIALLY IN DANGER IF IT CONTAINS AT LEAST AN UNSTABLE PS

# ArTeK web platform

CIVITA DI BAGNOREGGIO



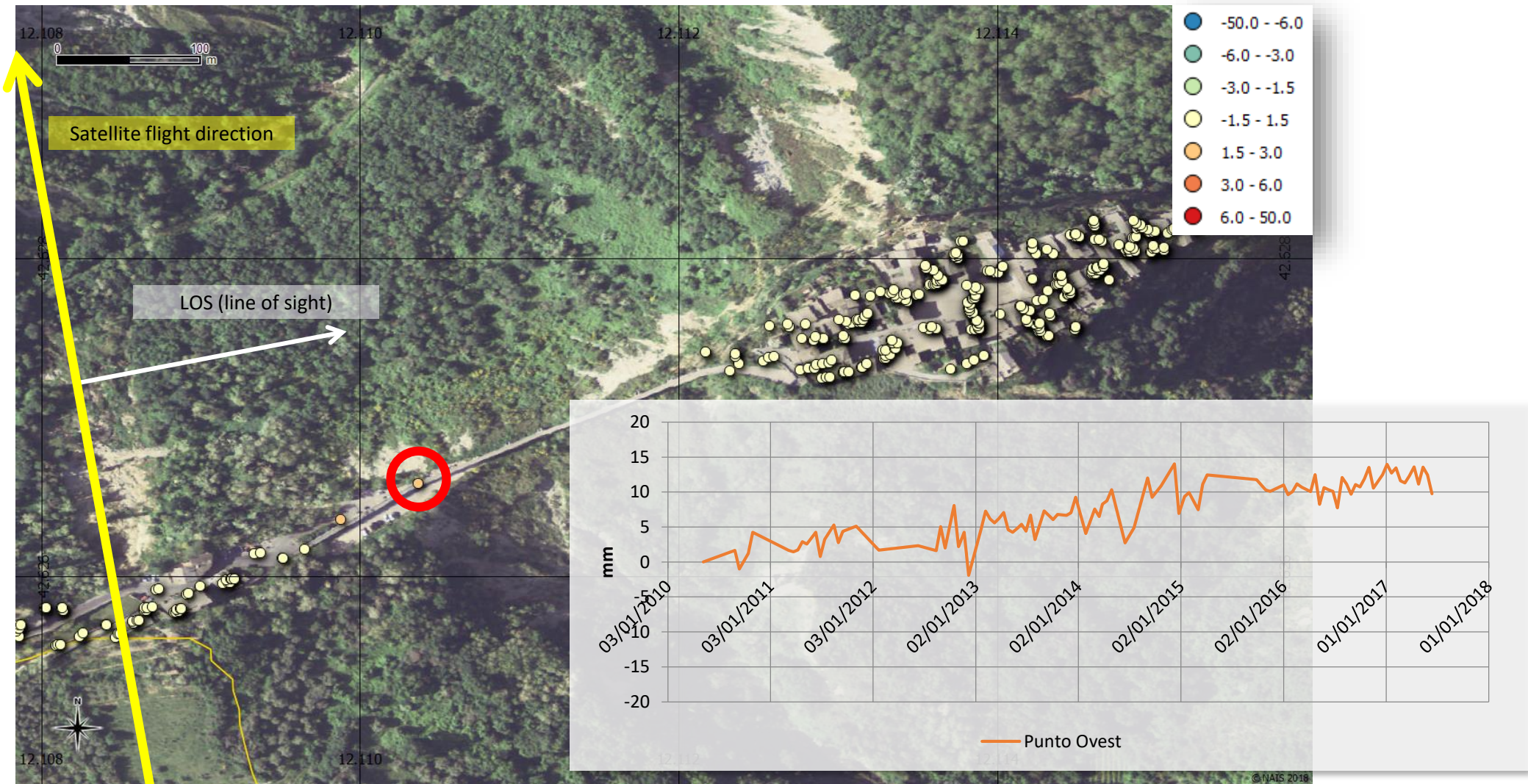
# Interferometric analysis (Civita di Bagnoregio)

09/05/2010-13/06/2017 COSMO-SkyMed slow movement



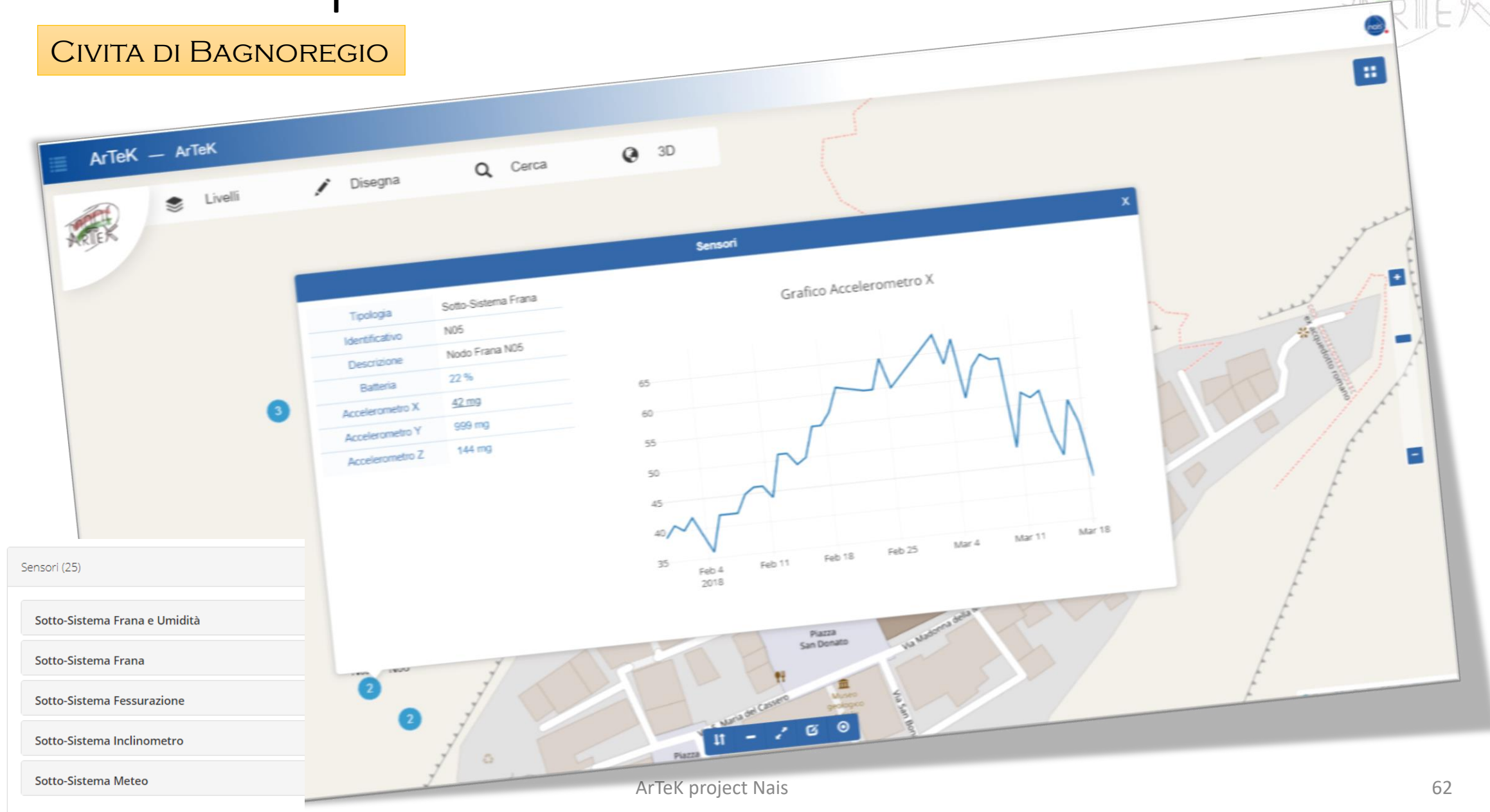
# Interferometric analysis (Civita di Bagnoregio)

09/05/2010-13/06/2017 COSMO-SkyMed



# ArTeK web platform : Fast movement

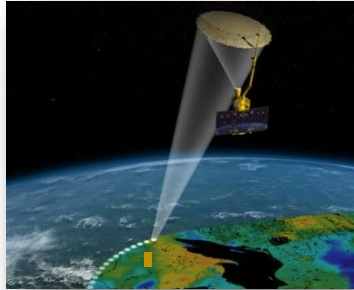
CIVITA DI BAGNOREGIO



# "Smart Cities and Communities and Social Innovation" Project (Call MIUR n.84/Ric 2012, PON 2007 – 2013 del 2 March 2012) Measure IV.1, IV.2, 2013- 2015.



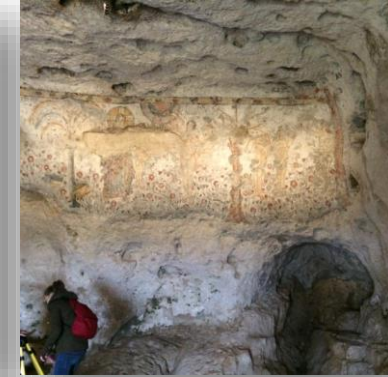
## The case study: The Crypt of Original Sin



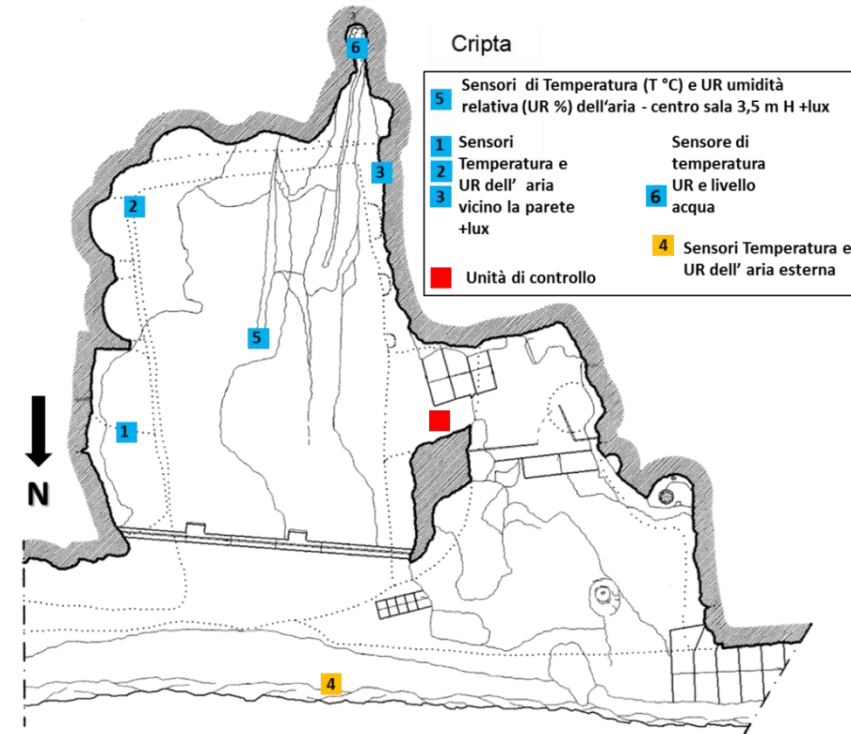
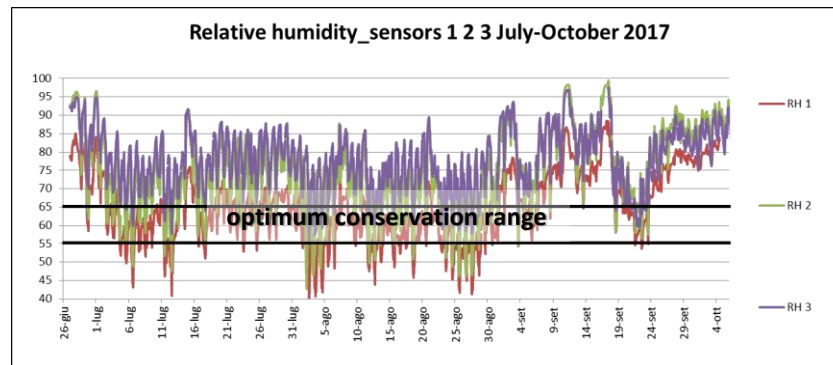
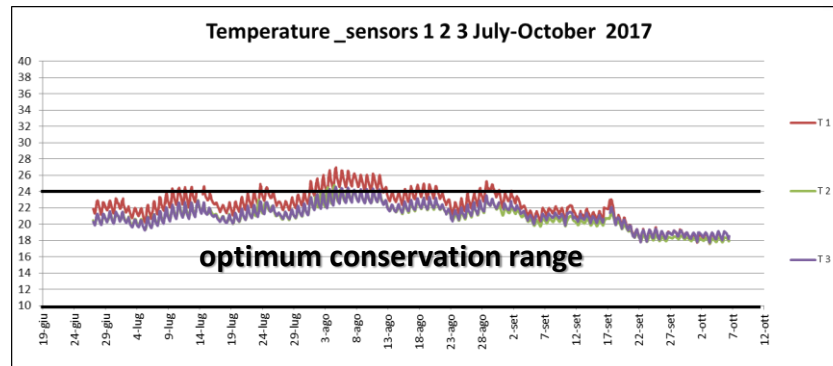
Rilevamento da satellite



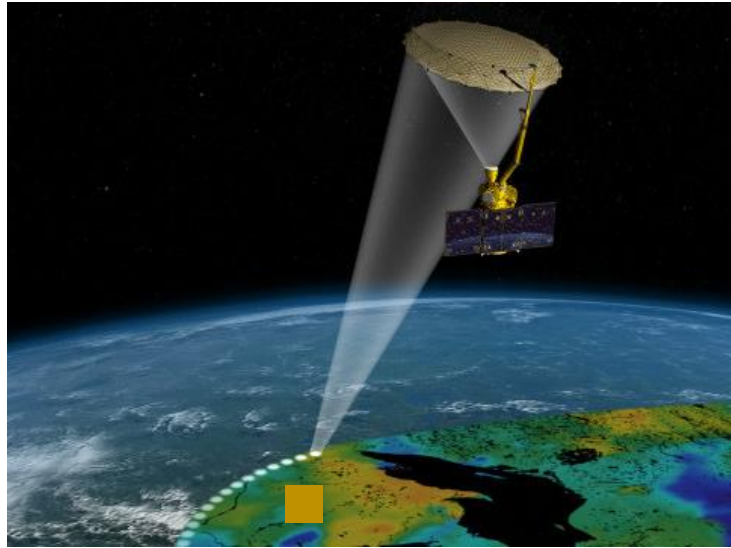
Stazione meteo outdoor



### Monitoraggio microclimatico indoor



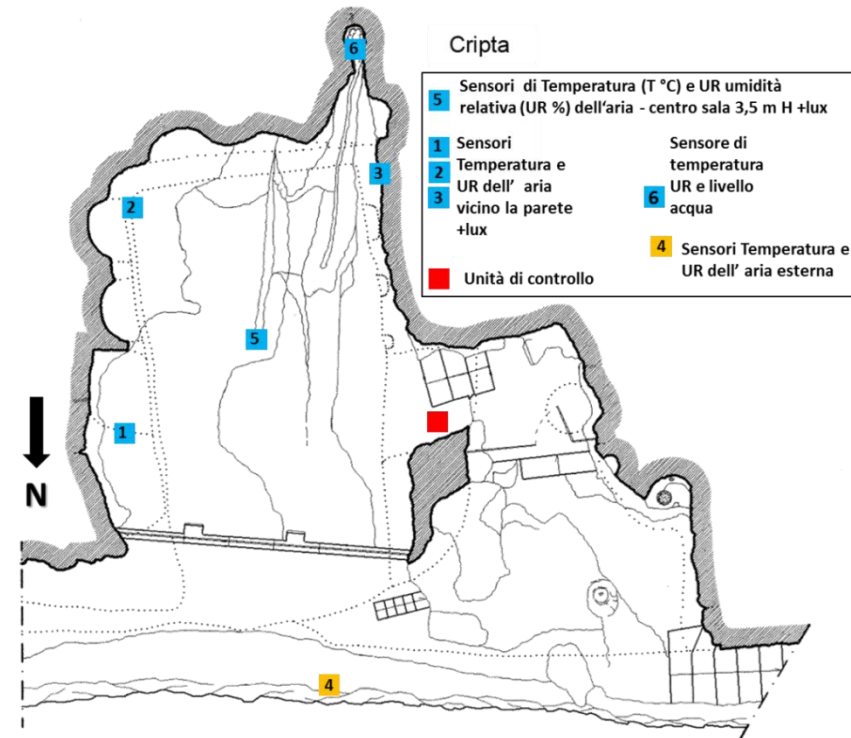
# The Crypt of Original Sin – monitoring system indoor – outdoor - satellite



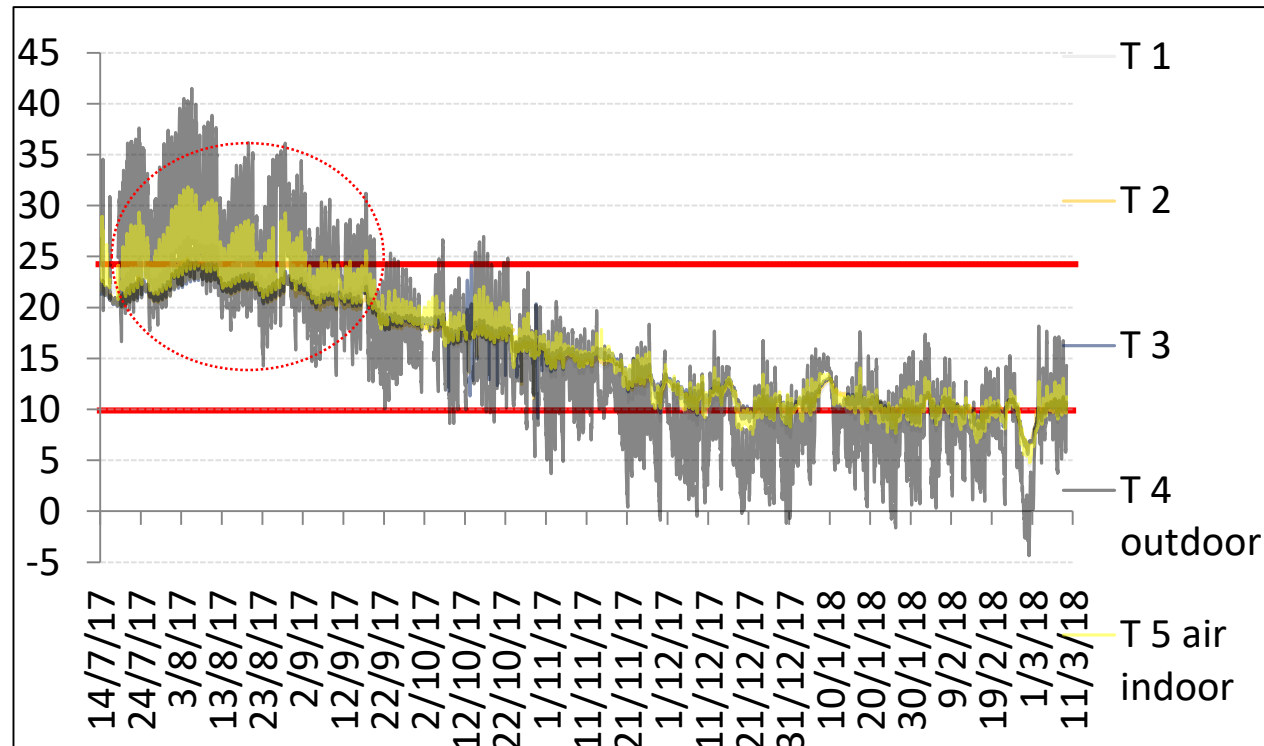
- Satellite surveying - environmental parameters / pollution
- Outdoor weather station (T / UR air, wind rainfall)
- Indoor microclimatic monitoring



## Monitoraggio microclimatico indoor



## PRELIMINARY RESULTS

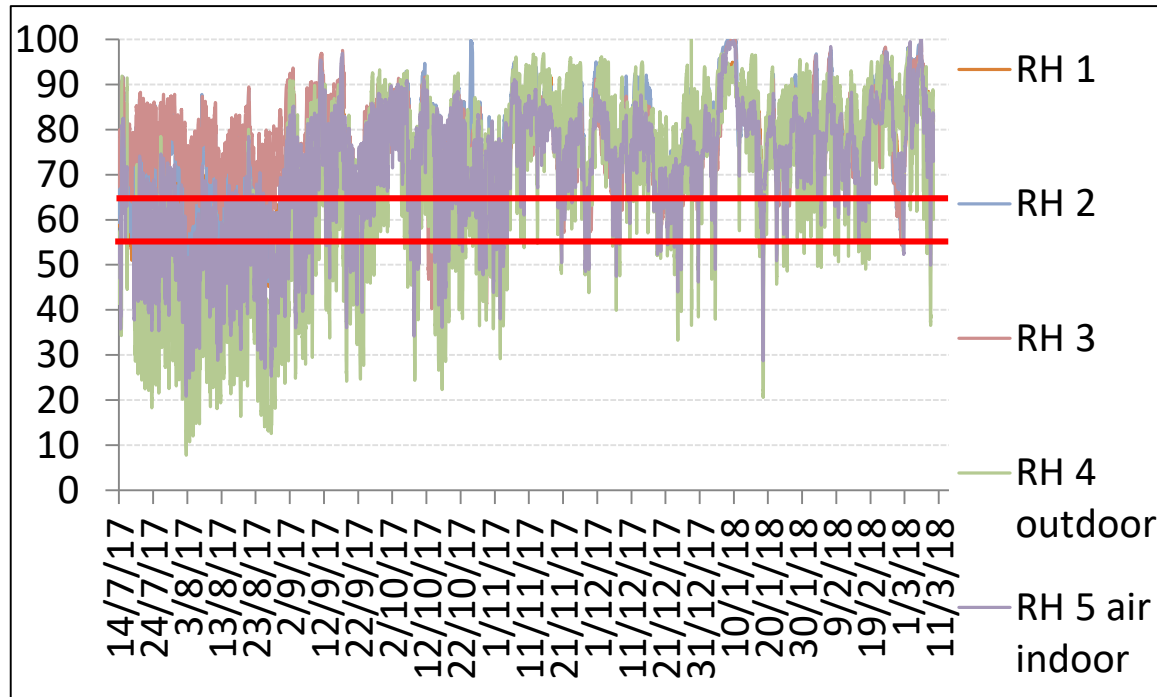


In the summer, the outdoor temperature has been always much higher than the internal one, whereas in the last autumn this value has been always lower than inside. The temperature inside the crypt exhibits very variable average values ranging between 7°C (T1) (March) and 27°C (T5) (August 2017). The daily excursions are on average around 1,5 °C on the surfaces and are around 3,5°C in the air.

Temperature from the Crypt (T1,T2, T4 and T5) and from outdoor (T4)

optimum conservation range 24°C  
10°C

## PRELIMINARY RESULTS

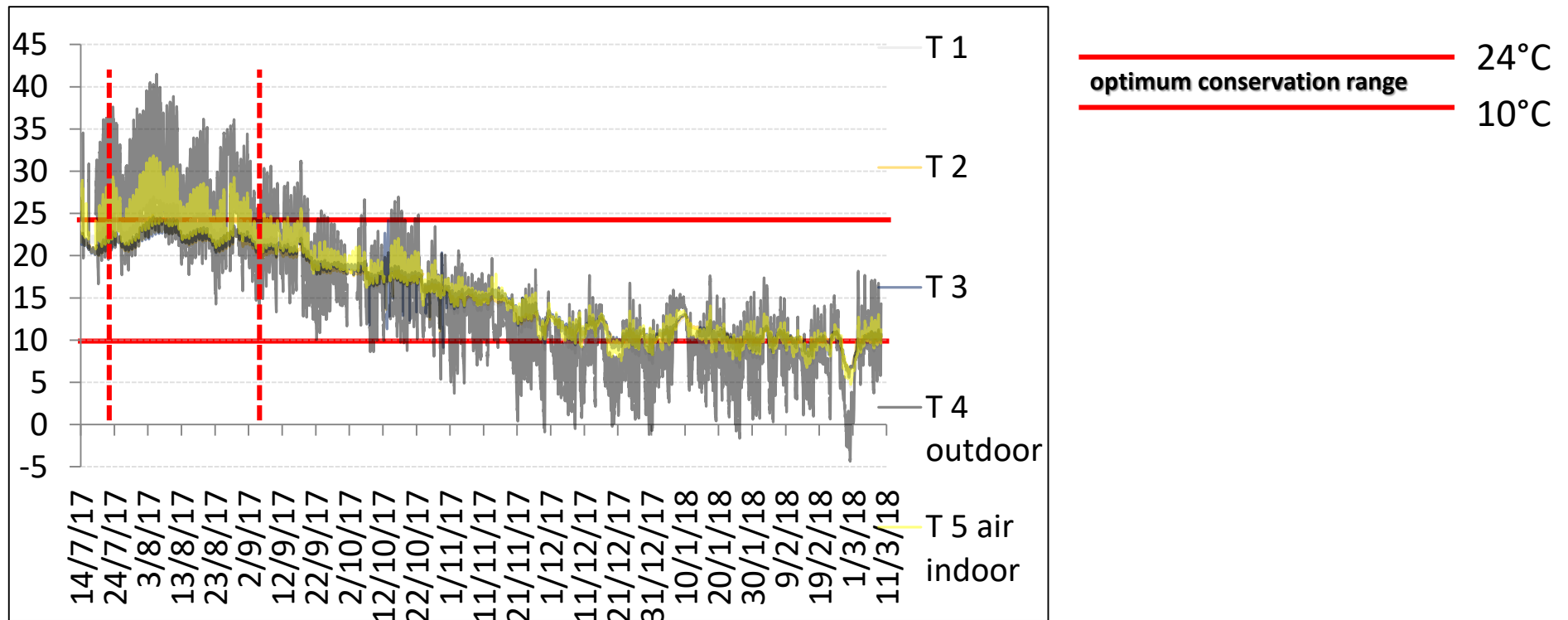


The relative humidity (RH) inside the crypt is very variable (see, Fig. 4) and it assumes average values ranging between 39% (RH5) (August 2017) and 89% (RH") (November 2017).

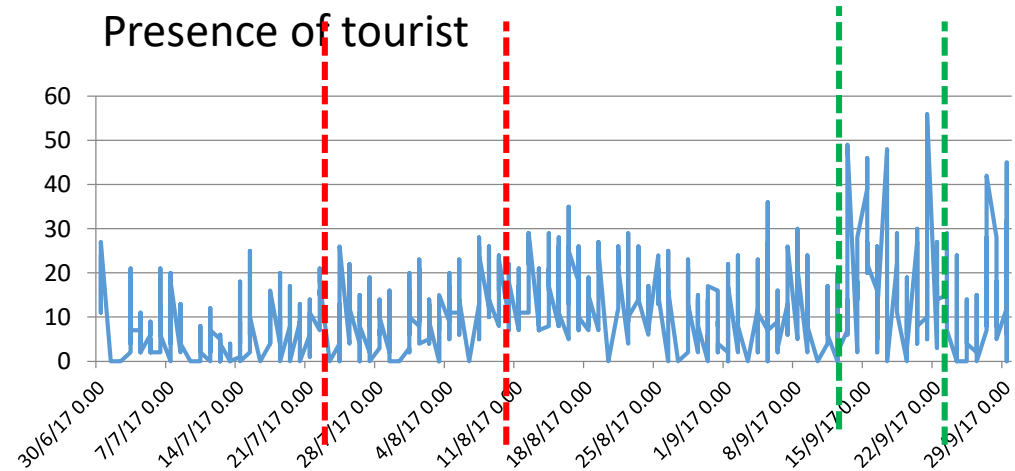
Relative Humidity indoor (T1,T2, T4 and T5)  
and outdoor (T4)

**optimum conservation range** 65%  
55%

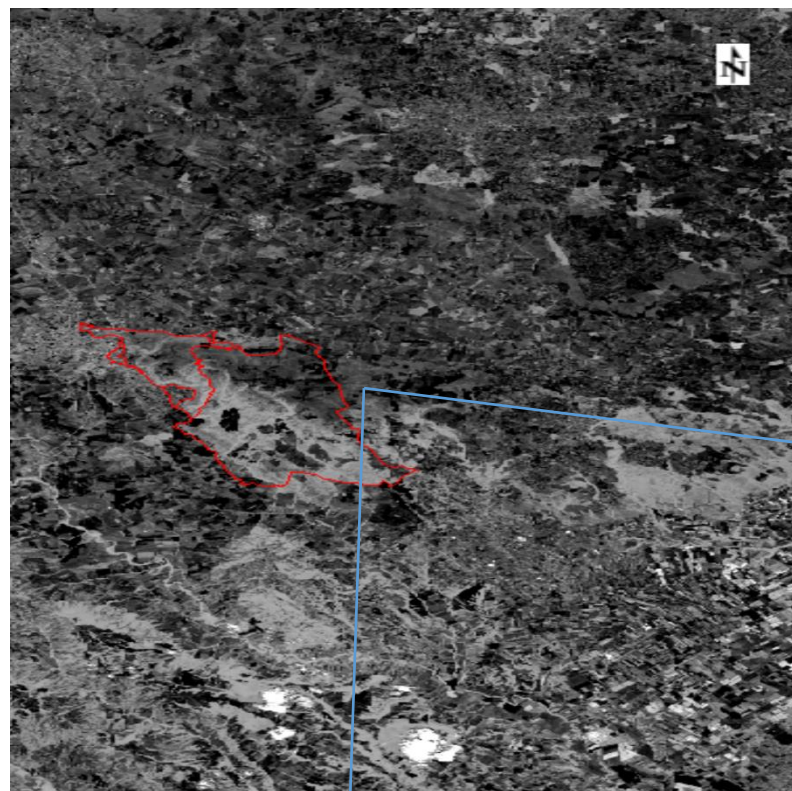
## PRELIMINARY RESULTS



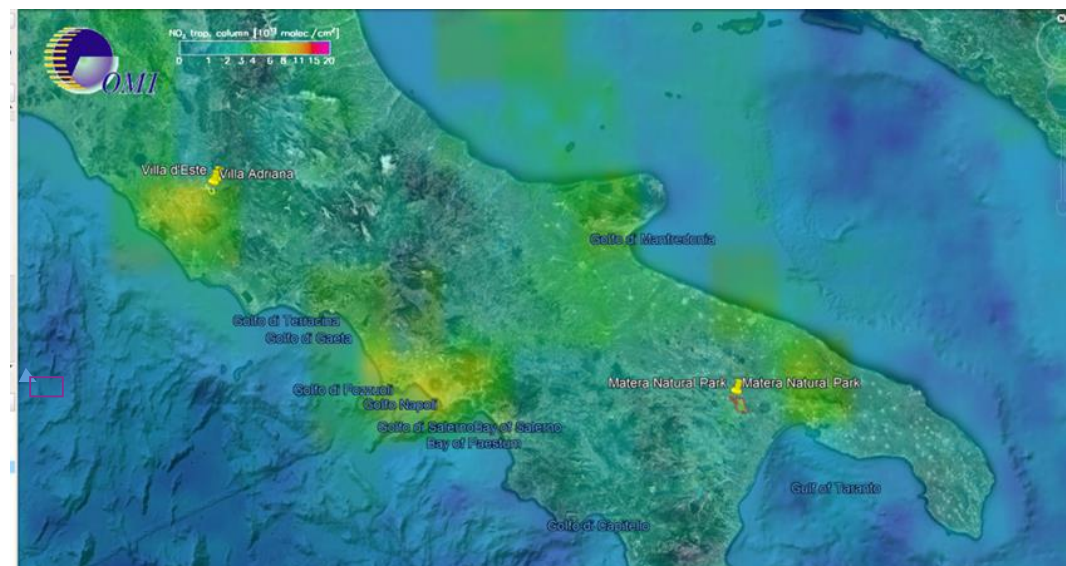
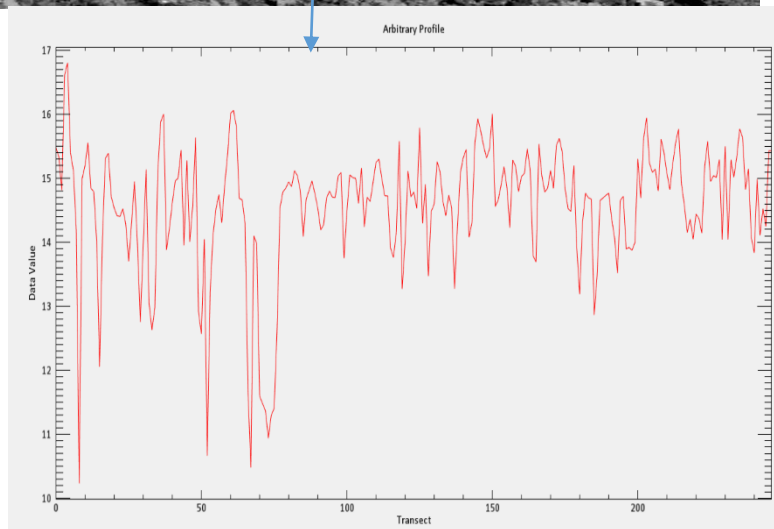
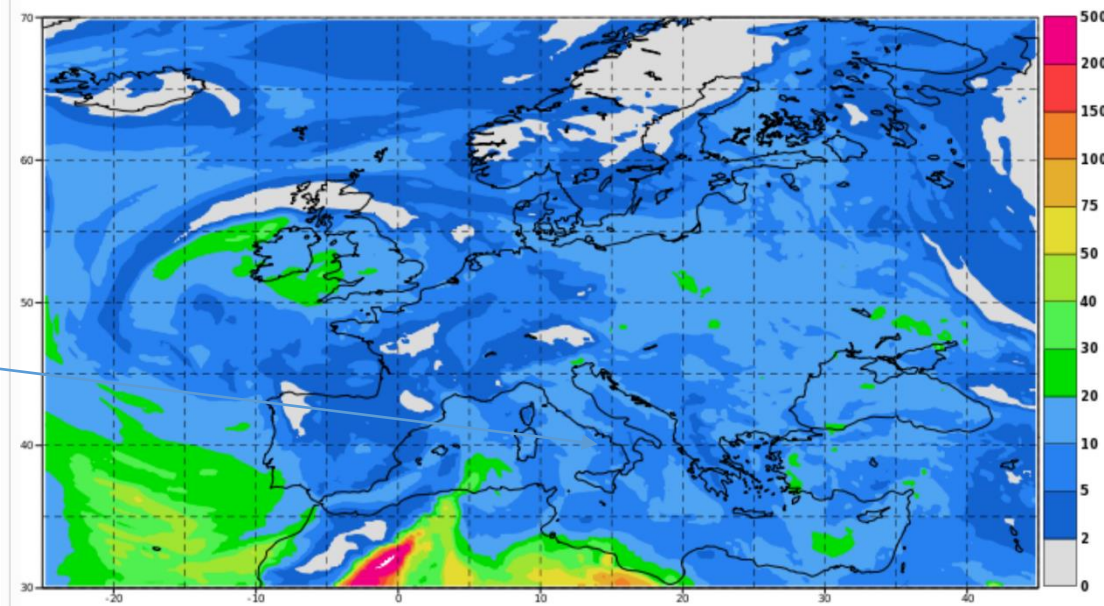
Temperature from the Crypt (T1,T2, T4 and T5) and from outdoor (T4)



# Pm 10 FROM SATELLITE LANSAT TM DATA



Sunday 11 March 2018 00UTC CAMS Forecast t+000 VT: Sunday 11 March 2018 00UTC  
Model: ENSEMBLE Height level: 500m Parameter: PM10 Aerosol [ $\mu\text{g}/\text{m}^3$ ]





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*Thank you*