CIRSA 2019

FORTH INSTITUTE OF COMPUTER SCIENCE

IAASARS

BEYOND Centre of Excellence for EO Sciences and Services

Leveraging the Copernicus Big Data Access Hubs and National Satellite Facilities for Global Emergency Response and Decision Making

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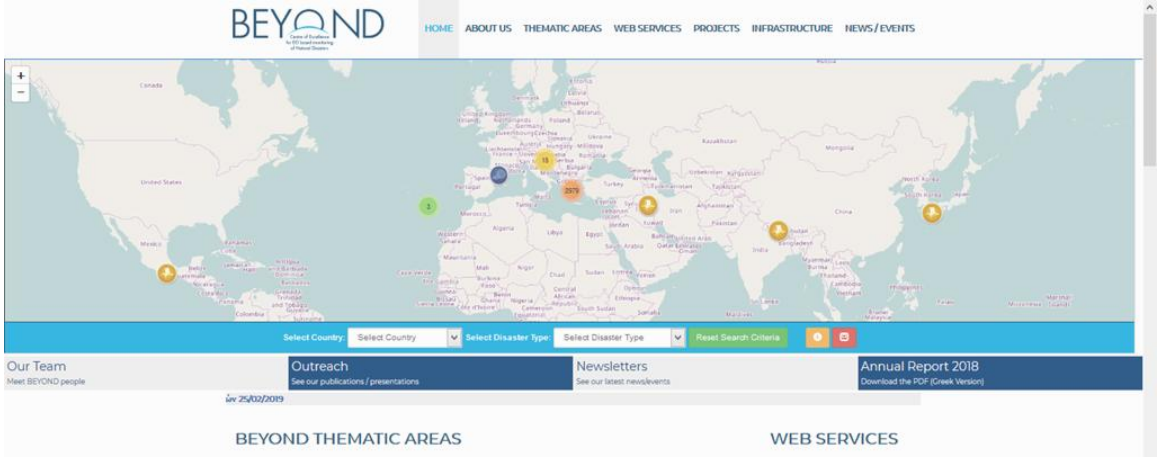
Institute of Astronomy, Astrophysics, Space Applications & Remote Sensing

National Observatory of Athens



Challenge

The continuous provision of **useful, accurate and timely information** through coordinated and sustained **Earth Observation** together with INSPIRE data, Copernicus, and GCI information

is a **key enabler** for **informed decision making**,

in response to global and regional challenges and towards the achievement of the **UN SDGs** and the implementation of the relevant **EU and Global Directives for Societal Benefit** including the **Sendai Framework for DRR, Paris Agreement to combat climate change**

Challenge

To efficiently process big volumes of satellite, in-situ, and crowd data provided from Copernicus Sentinels and third party satellite missions but also low cost sensor networks and media, providing high spatial and temporal resolution ranging from centimeters to up to a few meters on the ground

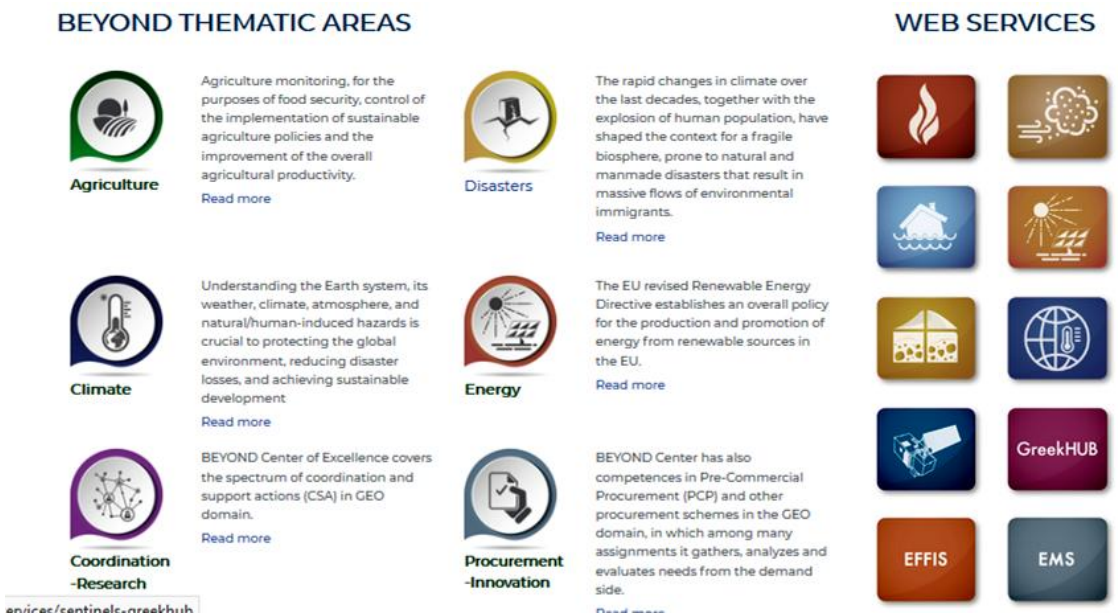
Big Data: More than 110 TiB of satellite data are acquired only in one month, a volume that is equivalent to the entire 7-year archive of the Envisat mission

Building upon the efficient employment of High Performance Cloud Computing (HPC) resources, Datacubes/ Array Data Bases, and ML/AI new capabilities are available for the effective processing of big data to estimate with high accuracy the ongoing physical processes, derive information from data and lead to a data driven decision making

Addressing the Challenge

We established the **Center of Exellence BEYOND**, hosted and operated at the premises of the **National Observatory of Athens**, providing services to **Copernicus EU Space program and Global Institutional Users** in the domains of Natural Disasters, Energy, and Agriculture, through **real time web based services** such as **FireHub, FloodHub, Emergency Management Service Risk&Recovery, EFFIS, geObservatory, DustHub, SolarHub**

The **services offers to the communities of citizens and civil protection authorities ready-to-use information products, but also data analysis** and **data processing solutions** on HPC cloud environment



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BEYOND Centre of Excellence for EO Sciences and Services

BEYOND: EO Based An EU Center for DRR

Copernicus The European Earth Observation Programme

BEYOND


Floods


Land-slides


Earthq uakes-Erosion


Fires


Extreme Weather


Volca-noes


Toxic Emissions


Tsounami

Tasks

Real Time Monitoring of Natural Disaste

Area of Intere

SE Europe, Mediterranean N. Africa, M. E Balkans

Tasks

Risk & Damage Assessment and Mitigation Measures

Area of Interest:

Global Level

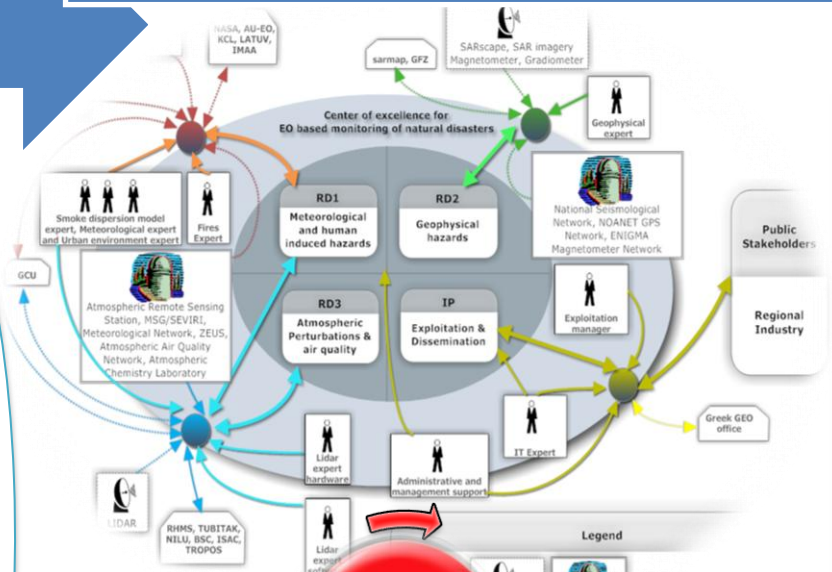
www.beyond-eocenter.eu

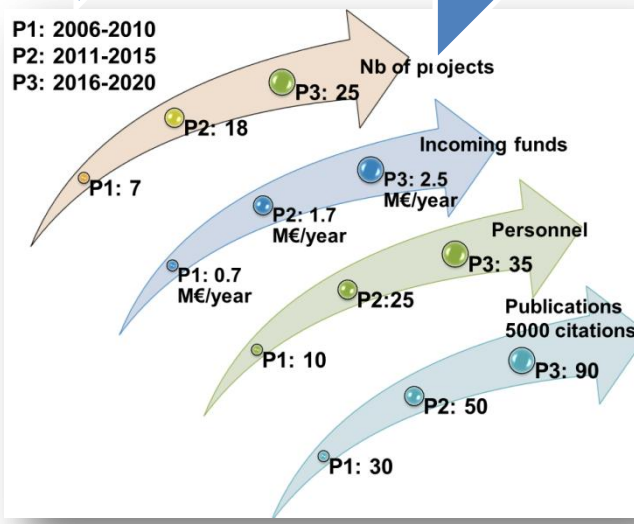
Project funded by the EUROPEAN UNION

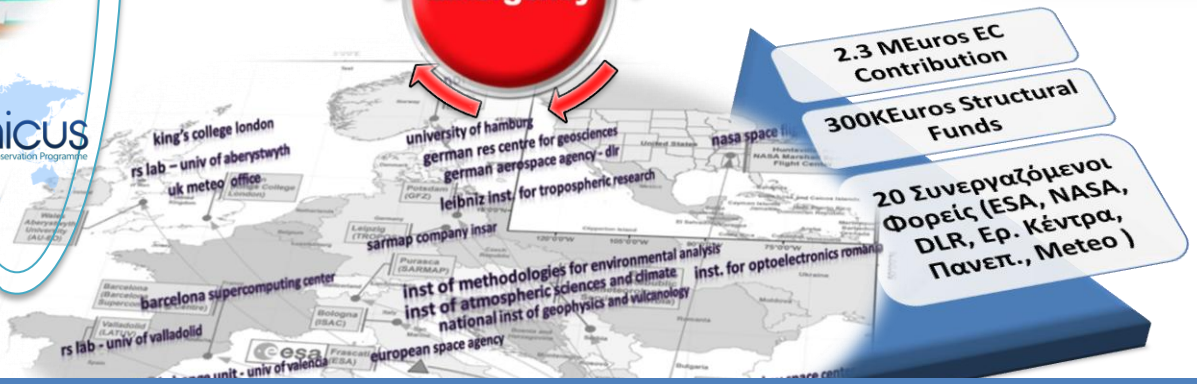
2006-2010

2011-2015

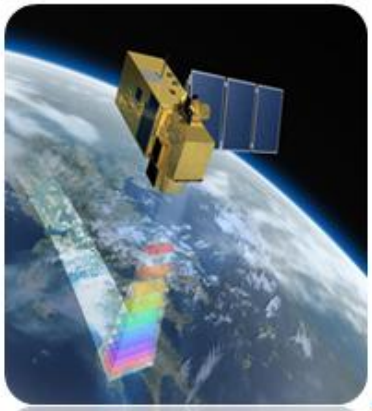
2016-2020







Monitoring Systems

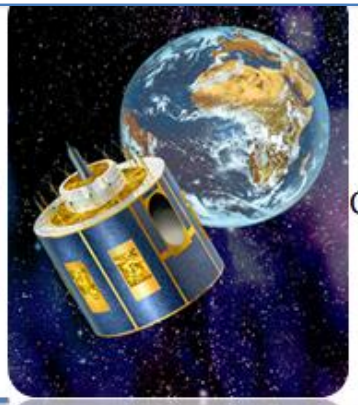


Satellites Polar Orbit

X-/L-band Station

Sentinel Mirror Site

DATA → ANALYSIS/ PROCESSING → INFORMATION/ RESULTS



Satellites Geostationary Orbit

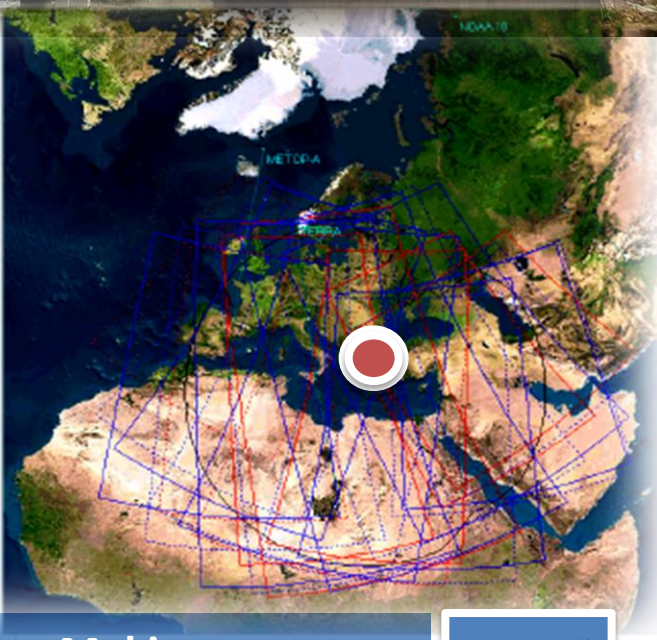
MSG Seviri

in-situ

Aerial Vehicle or Unmanned Aerial Vehicle

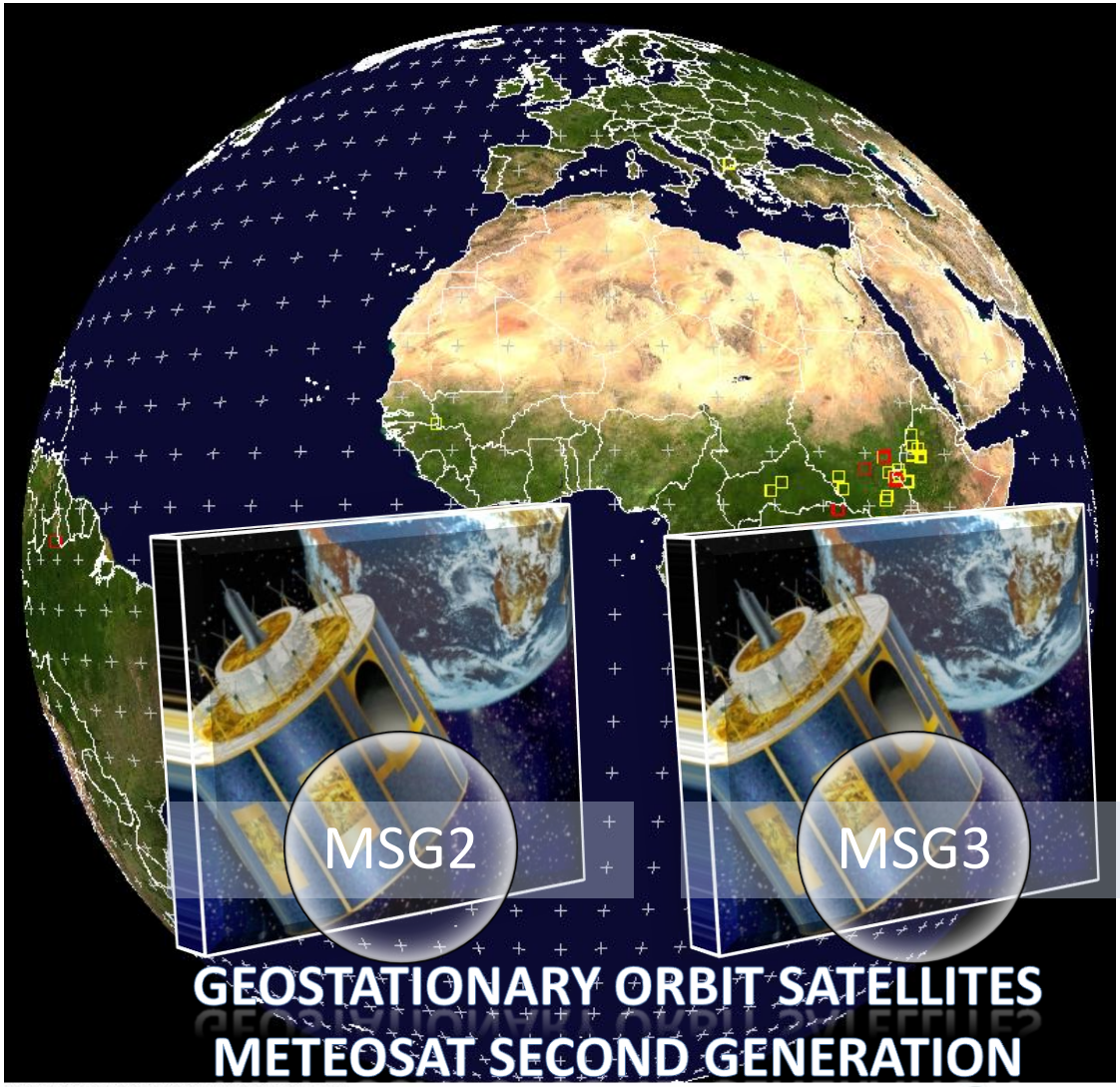
Terrestrial Platforms and Networks

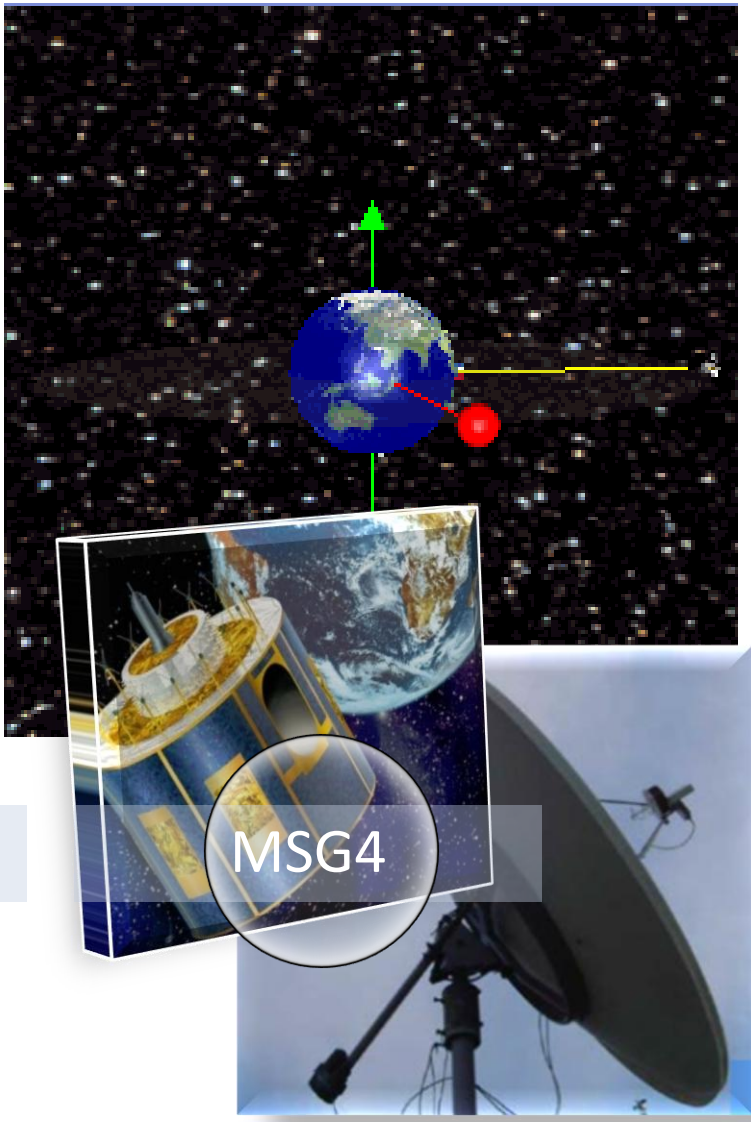
Infrastructure of Satellite EO Data Collection

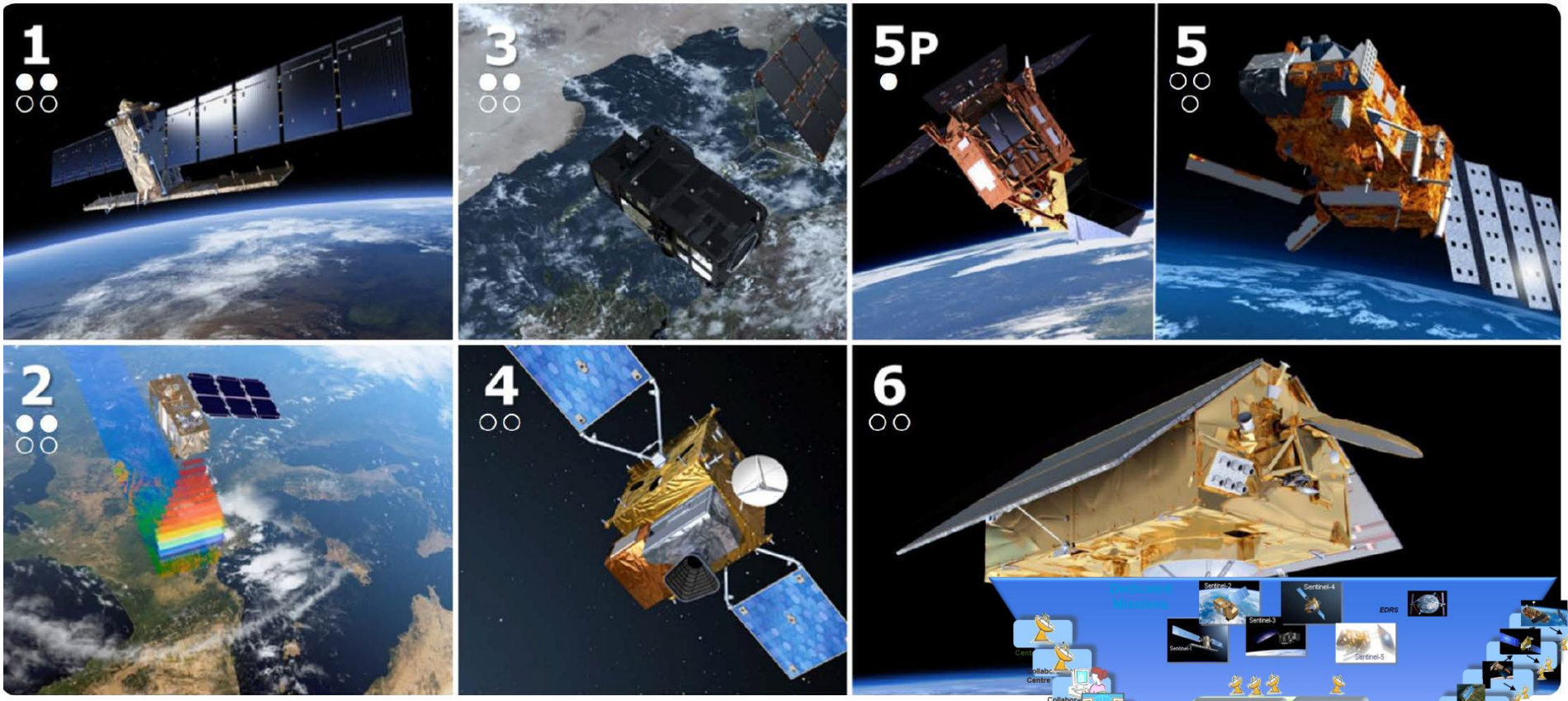


SATELLITES OF POLAR ORBIT, X-/L-BAND – 300TB ARCHIVE – SERVICE 24/7

Infrastructure of Satellite EO Data Collection







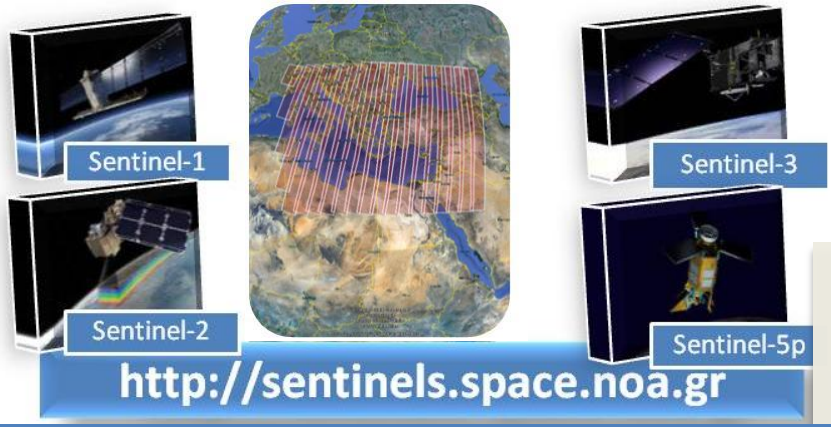
Copernicus Sentinel Missions and Data Access

COPERNICUS DATA HUB
Operations Center

SENTINELS GREEK HUB

- INTHUB #1
- COLHUB #3
- DIASHUB #3
- AfricaCastHub
- S-5p PreOps Hub
- S-5p Expert Users Hub
- TMPHUB #1
- HNSDMS

60 VMs
storage: 800 TiB,
680 CPU cores,
2.2 TiB RAM



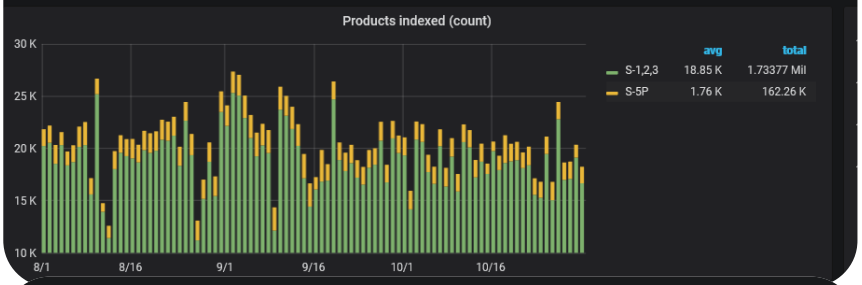
Distributes 55 TB / Day
Operations 24/7/365
GEANT 500-700 Mbps

A **550 TB** network filesystem for storing > **500 thousand** Sentinel products at any time

COPERNICUS DATA HUB Operations Center

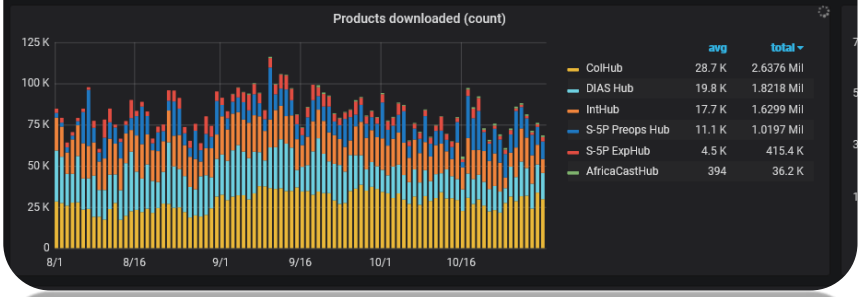
What's coming in

On average:
~20K products (13TiB) / day or
~600K products (390TiB) / month
~2 Gbps



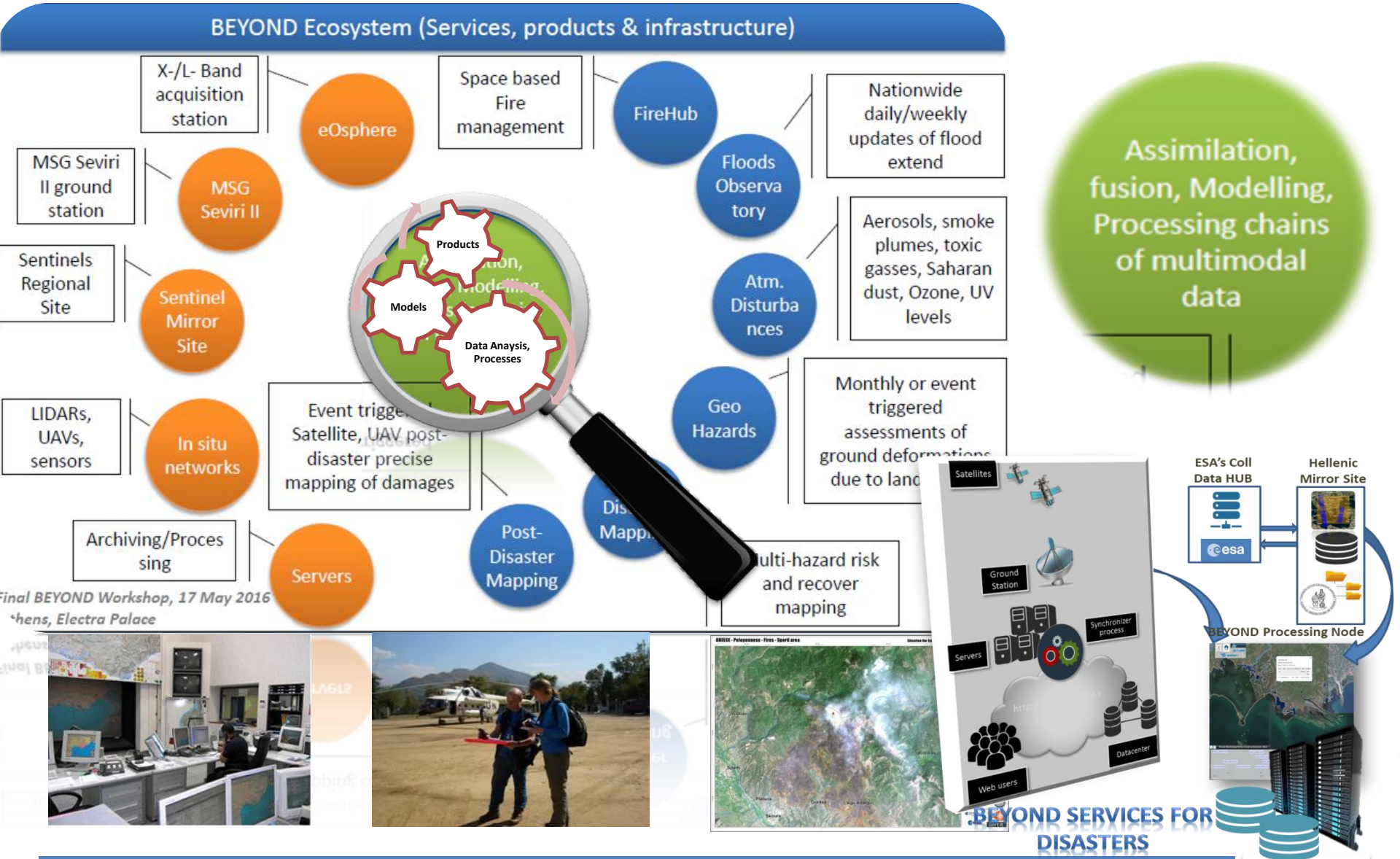
What's going out

On average:
~80K products (50TiB) / day or
~2.5M products (1.5PiB) / month
~6 Gbps



80 VMs
storage: 800 TiB,
680 CPU cores,
2.2 TiB RAM

Distributes 55 TB / Day
Operations 24/7/365
GEANT > 2-6 GBps


BEYOND Ecosystem (Services, products & infrastructure)
X-/L- Band acquisition station
eOsphere
MSG Seviri II ground station
MSG Seviri II
Sentinels Regional Site
Sentinel Mirror Site
LIDARs, UAVs, sensors
In situ networks
Archiving/Processing
Servers
Products
Models
Data Anaysis, Processes
Event trigge
Satellite, UAV post-disaster precise mapping of damages
Post-Disaster Mapping
Space based Fire management
FireHub
Floods Observatory
Nationwide daily/weekly updates of flood extend
Atm. Disturbances
Aerosols, smoke plumes, toxic gasses, Saharan dust, Ozone, UV levels
Geo Hazards
Monthly or event triggered assessments of ground deformations due to land
ulti-hazard risk and recover mapping
Assimilation, fusion, Modelling, Processing chains of multimodal data
Final BEYOND Workshop, 17 May 2016
hens, Electra Palace
Satellites
Ground Station
Synchronizer process
Servers
Datacenter
Web users
ESA's Coll Data HUB
Hellenic Mirror Site
esa
BEYOND Processing Node
BEYOND SERVICES FOR DISASTERS

WildFire Monitoring & Management Service based on EO FIREHUB SYSTEM

Real Time Monitoring
Crisis Management
Situation Awareness
Picture

MANDRA
WEST
ATTICA

15 November 2017

The 3rd worst flooding disaster in Attica History (based on the number of deaths)

MATI
EAST
ATTICA

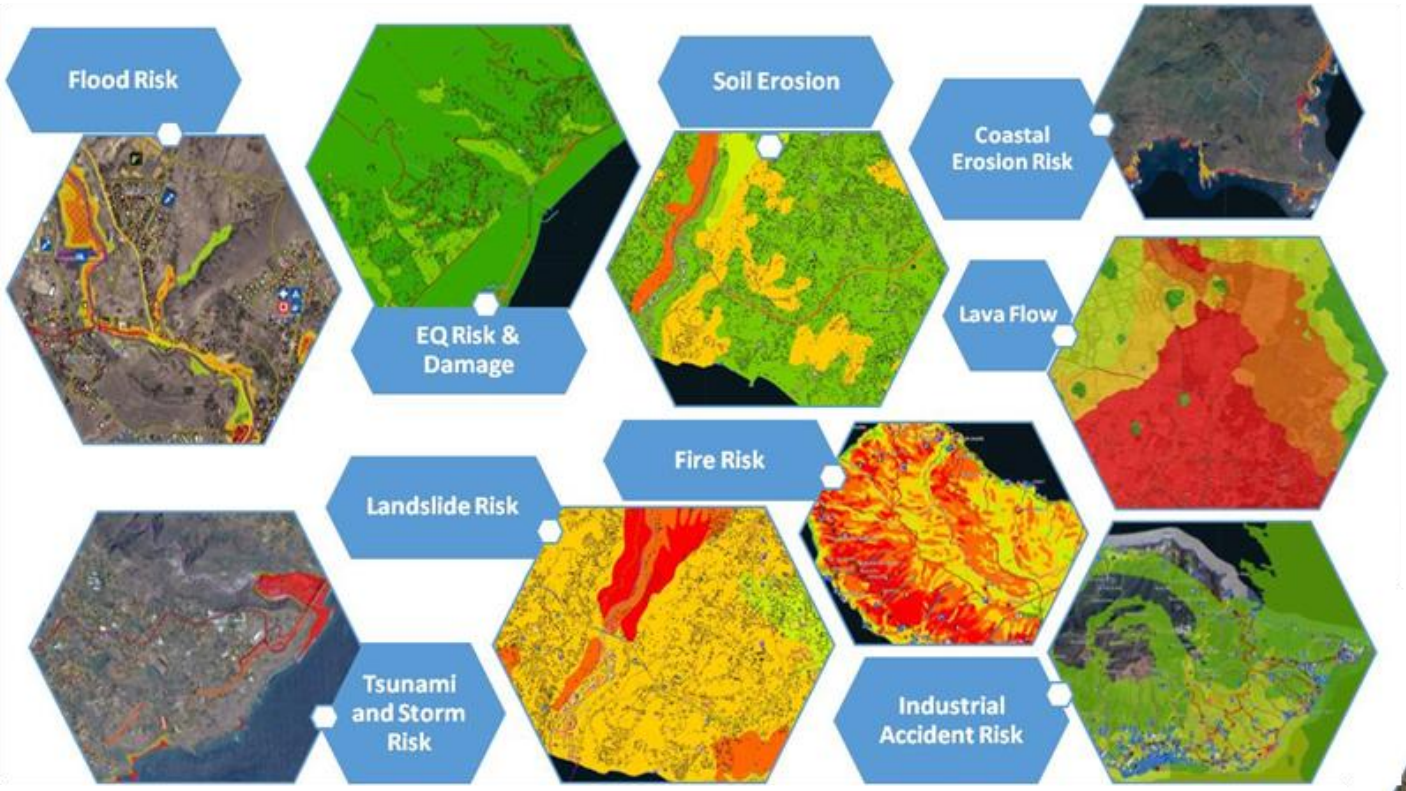
10 August 2018

Deadly
fire

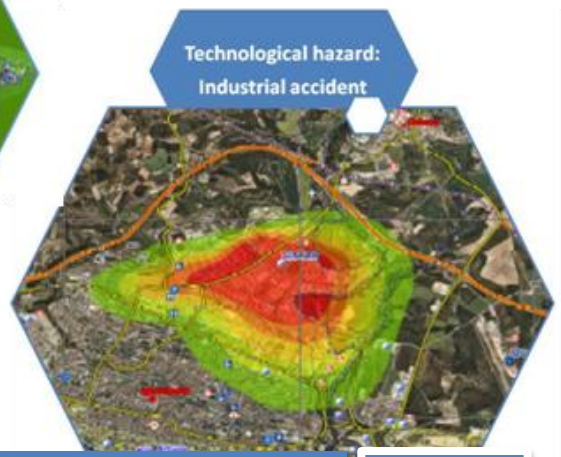
Preparedness, Vulnerability and Risk Assessment, Recovery, and **Mitigation** Planning Services **have been delivered** to **> 20 Civil Protection Authorities worldwide**

BEYOND EO CENTER SERVES COPERNICUS EMS:

PREVENTION - PREPAREDNESS - RISK ASSESSMENT - RESPONSE - MITIGATION



Thousands of Vulnerability, Hazard and Damage Assessment Maps and Reference (Asset) Maps have been delivered in the scale of 1:5000-1:10000 , for a large portfolio of disasters



A vast portfolio of disasters: **fires, floods, draughts, water scarcity, landslides, EQs, volcanic eruption, tsunami, epidemics, industrial accidents, storms/typhoons, etc.**

BEYOND EO CENTER SERVES COPERNICUS EMS:
EUROPEAN FOREST FIRE INFORMATION SYSTEM (EFFIS)

European Commission

COPERNICUS
Emergency Management Service

Copernicus Europe's eyes on Earth

European Commission > JRC EU Science Hub > DRM > Copernicus EMS > EFFIS > Applications > Current Situation Viewer

Early Warning European Forest Fires Information System

DAILY ACTIVE FIRES & BURNED AREA MAPPING OVER EUROPE, N. AFRICA, M. EAST, BALKANS

1. Build upon the knowledge emerging from historical events
2. Process long archives of satellite and attribute data
3. Create long time series, and geo-Data Bases, of environmental essential parameters, e.g. Burned Areas, Water Bodies, Land Surface Temperatures, Air temperatures, Vegetation Indexes, Precipitation, Soil Moisture, Evapotranspiration, Cloud Coverage, Aerosol Optical Depth, to mention a few
4. Perform analytics of data and correlate with reported damaging events and extreme situations (e.g. fires, floods, epidemics, heat waves, solar irradiation)

Early Warning European Forest Fires Information System

Risk and Recovery & Mitigation Measures

Real Time Monitoring Crisis Management Situation Awareness Picture


National Observatory of Athens
Continuous offer to the Scientific Research since 1842
Greek General Secretariat for Research and Technology
Event Logo
http://ocean.space.noa.gr/bsm
DIACHRONIC INVENTORY OF FOREST FIRES OVER GREECE FROM 1984 TO PRESENT, WITH USE OF LANDSAT 4,5,7 SATELLITE DATA
URL: http://www.noa.gr

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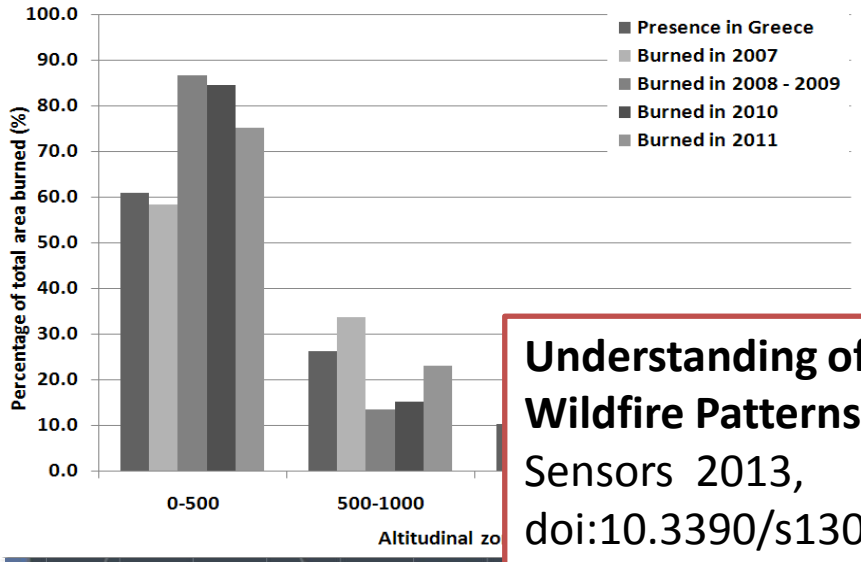
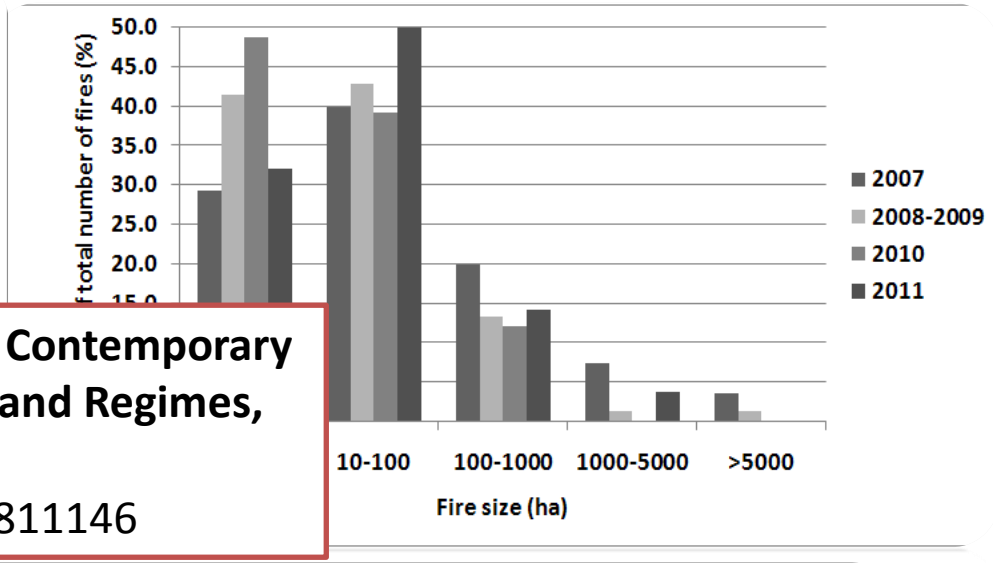
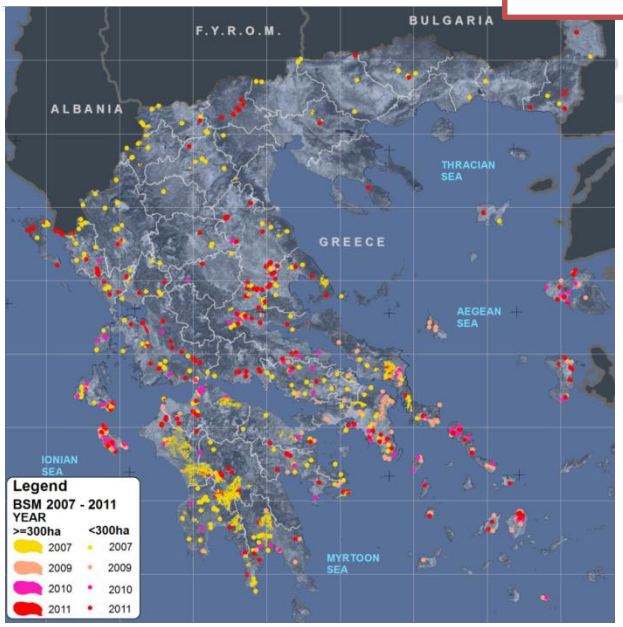
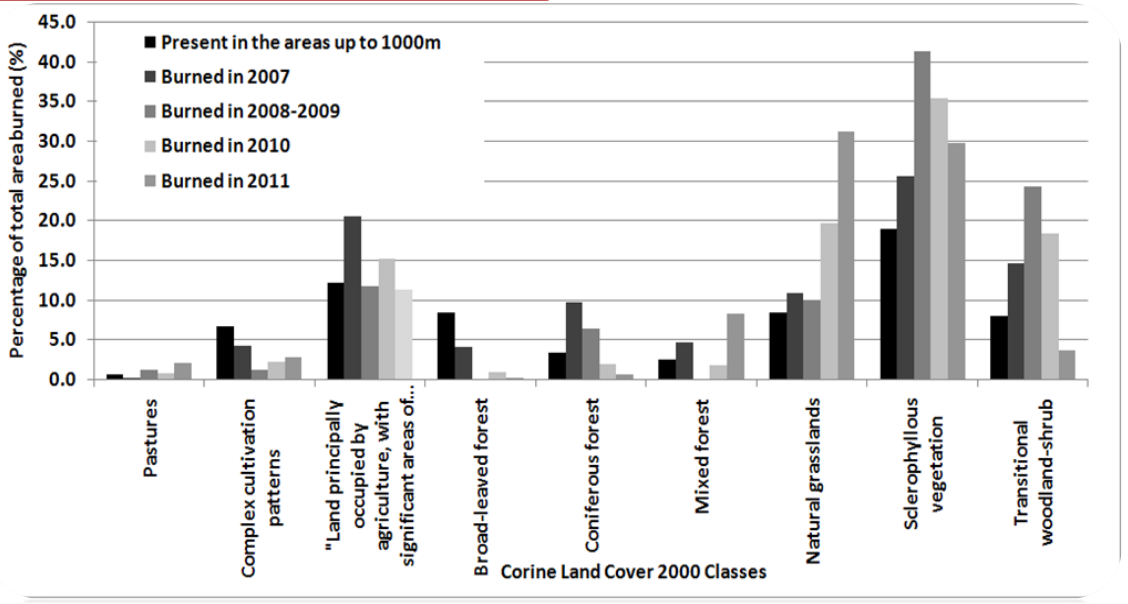




Understanding of Contemporary Wildfire Patterns and Regimes,
Sensors 2013,
doi:10.3390/s130811146





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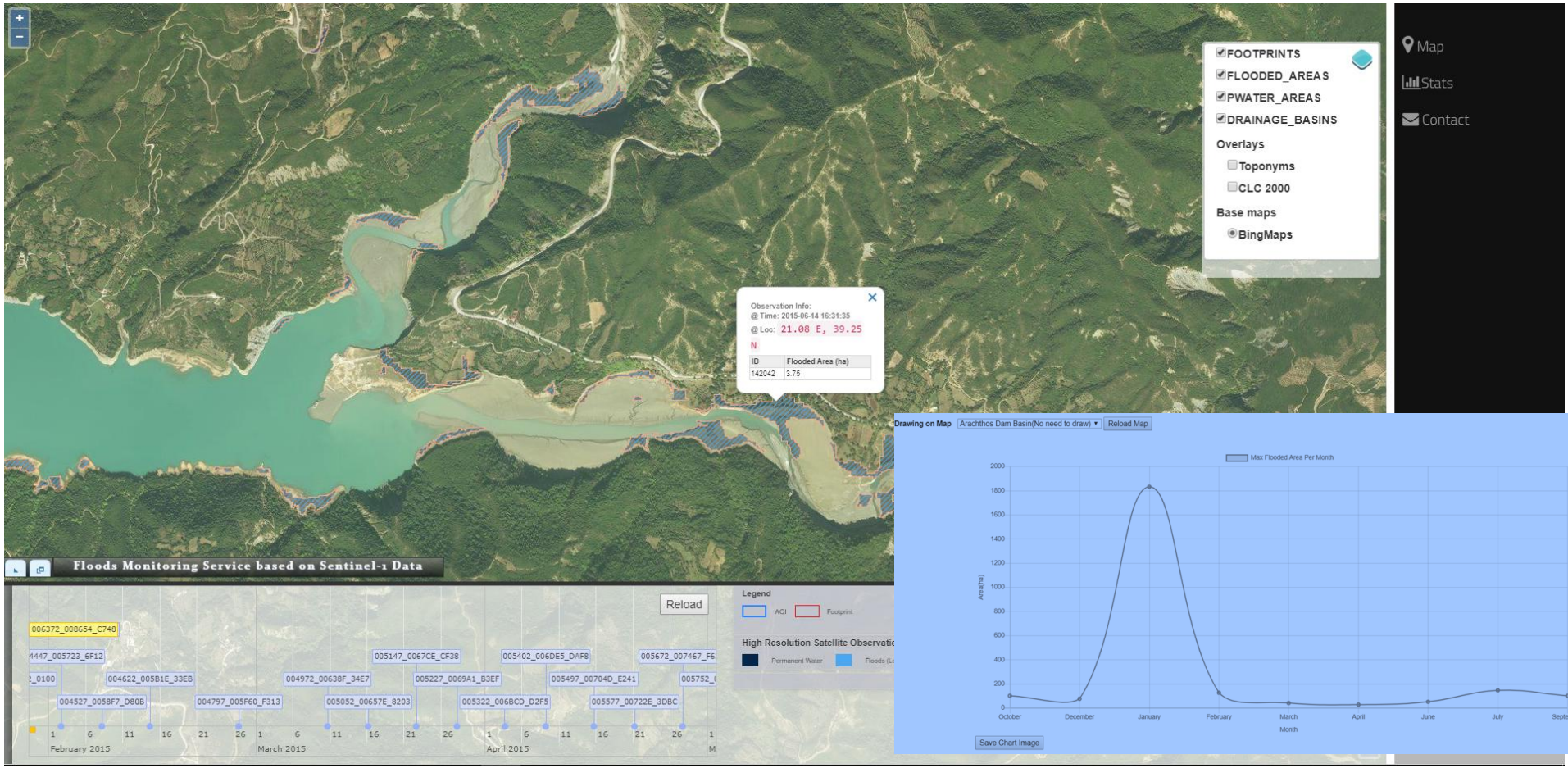
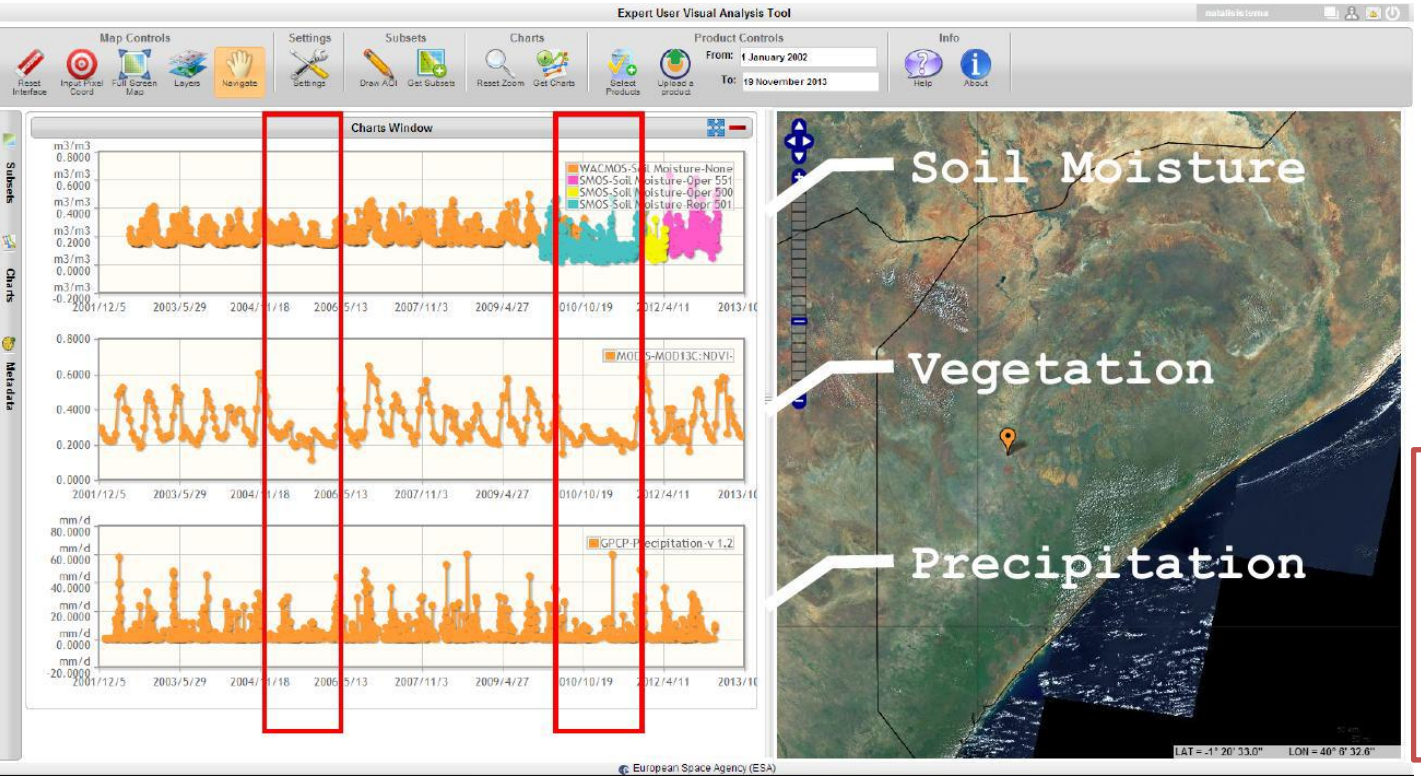
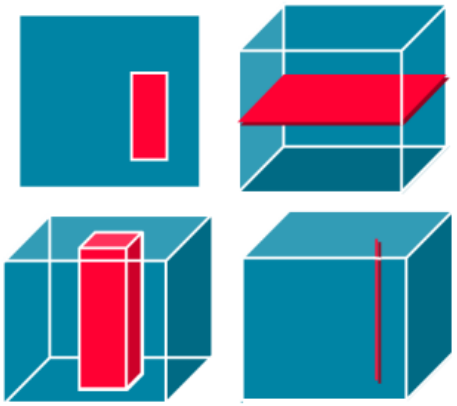
Historical Analysis of flooded areas in the Arachthos river basin for the needs of the Public Power Corporation S.A. Hellas (DEH AE) over the past 5 years based on Sentinel-1 data (Hellenic Mirror Site)



Moving towards integrating Datacubes = Central Building Block for next-generation "analysis-ready" services





Datacubes treat all axes alike, irrespective of an axis having a spatial, temporal, or other semantics

1. **Generate cloud based workflows and perform complex operations on distributed HPC, enabling the processing of big data e.g. 2-10 Tbytes of satellite data in only one iteration pass**

Examples from ongoing research projects and services showcase that:

1. 2,5 TB of Sentinel-1 data (corresponding to a subset of a full image frame) consists the minimum data that is needed to perform one Interferometric pass for Ground Velocity Assessment in a rather short period of 2 years
2. 6,4TB of S-1, and 3,2 TB of S-2 data are needed to perform one processing pass for segmentation, and SVM crop classification at parcel level over the entire Korea and only for one farming season

Early Warning European Forest Fires Information System	Risk and Recovery & Mitigation Measures	Real Time Monitoring Crisis Management Situation Awareness Picture

Early Warning European Forest Fires Information System

Risk and Recovery & Mitigation Measures

Real Time Monitoring Crisis Management Situation Awareness Picture

geObservatory | Cloud based and Scalable DinSAR Solution

Pilot context:
Automation of a demanding processing chain, using big stack of Sentinel-1 data (download S-1 data, pre-processing, generation of interferograms & ground velocities).

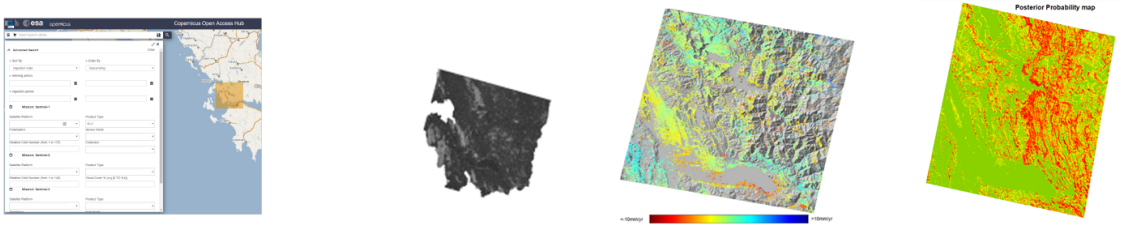
For 2 years of S-1 (Ascending & Descending) over a single pilot area, approximately 2,2 TB.

1st part: Stack of interferograms
- Select and download Sentinel 1 SLC data
- Run ISCE s/w
- Generation of stack (Input for the 2nd part)

2nd part: Ground velocities
- Data Preparation for StaMPSv4
- StaMPSv4 Parallel processing
- StaMPSv4 aggregation and final processing
- Generation of ground velocities

3rd part: Update landslide inventory
- Transform ground velocities into new landslides
- Update the Landslide inventory

4th part: Updated susceptibility map
- Execute the enhanced landslide model
- Generation of updated susceptibility map



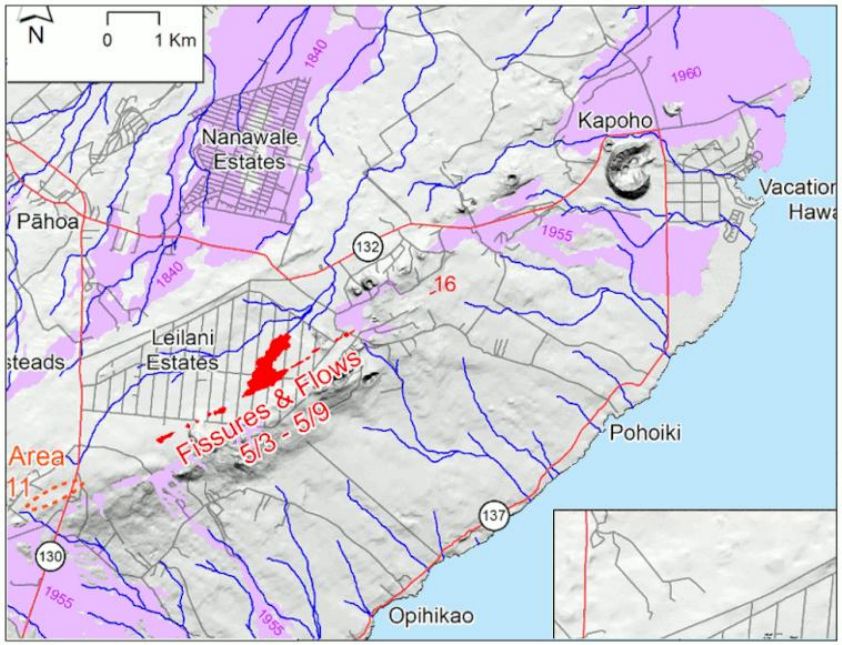
Early Warning European Forest Fires Information System

Risk and Recovery & Mitigation Measures

Real Time Monitoring Crisis Management Situation Awareness Picture

geObservatory | Kīlauea volcano, Hawaii

- ✓ Intense micro-seismic activity in the wider area of the Kīlauea volcano in Hawaii occurred during 26/4-2/5/2018.
- ✓ Suddenly, on Thursday 3/5 a volcanic crack appeared near the road network in lower Puna region, from which lava and hot steam appeared. The Civil Protection instructed residents of the Puna community (~10,000) to leave their homes immediately.
- ✓ On Friday, May 4, 2018, a powerful 6.9 earthquake hit Puna, the largest in the past 43 years.
- ✓ By May 27, 2018, 24 fissures had erupted lava in or near the Leilani Estates and Lanipuna Gardens subdivisions.
- ✓ The Puna Geothermal Venture, which provided one-quarter of the island's electricity, was forced to shut down and was later damaged by lava.
- ✓ By August 7, 35 km^2 of land had been covered by lava flows. The eruption had almost completely subsided, and on December 5, it was declared to have ended after three months of inactivity.
- ✓ Recovery efforts would cost more than $800 million



Early Warning European Forest Fires Information System

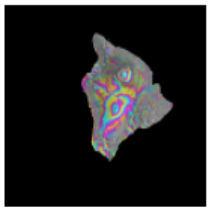
Risk and Recovery & Mitigation Measures

Real Time Monitoring Crisis Management Situation Awareness Picture

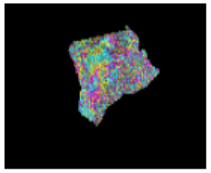
geObservatory | Kīlauea volcano, Hawaii

ISLAND OF HAWAII, HAWAII (2018-05-04 22:32:57)

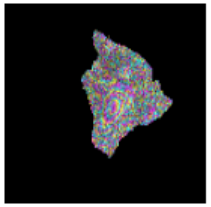
Earthquake location: ISLAND OF HAWAII, HAWAII
Magnitude: 6.5
Depth: 30 km
Time: 2018-05-04 22:32:57
Coordinates: 19.39 , -155.41



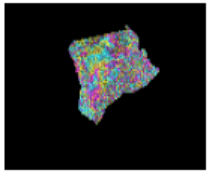
Type: co-seismic
Master: 2018-04-23 16:15:24
Slave: 2018-05-05 16:15:25
Orbit Number: 87
Mode: DESCENDING
Download (TIF) Download (Low Resolution) Preview



Type: co-seismic
Master: 2018-05-02 04:30:26
Slave: 2018-05-08 04:29:48
Orbit Number: 124
Mode: ASCENDING

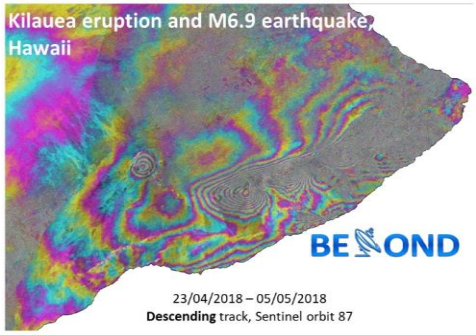


Type: pre-seismic
Master: 2018-04-23 16:15:24
Slave: 2018-04-11 16:15:24
Orbit Number: 87
Mode: DESCENDING
Download (TIF) Download (Low Resolution) Preview



Type: pre-seismic
Master: 2018-05-02 04:30:26
Slave: 2018-04-20 04:30:26
Orbit Number: 124
Mode: ASCENDING

→ Intense subsidence at the top of the volcano as magma material moves along the East Rift Zone and escapes to the eastern edge of the fault. The maximum deformation along this zone, located between the top of the volcano and the area where the lava was firstly observed, is approximately 60-70 cm.



Early Warning European Forest Fires Information System

Risk and Recovery & Mitigation Measures

Real Time Monitoring Crisis Management Situation Awareness Picture

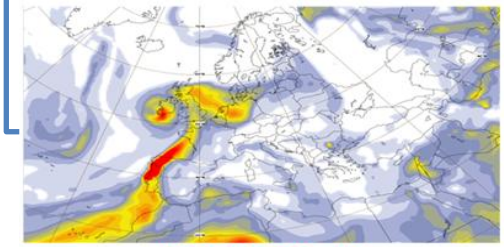
29

2. Speed up the process using ANN to enable millions of model simulations in one minute and address dynamic phenomena

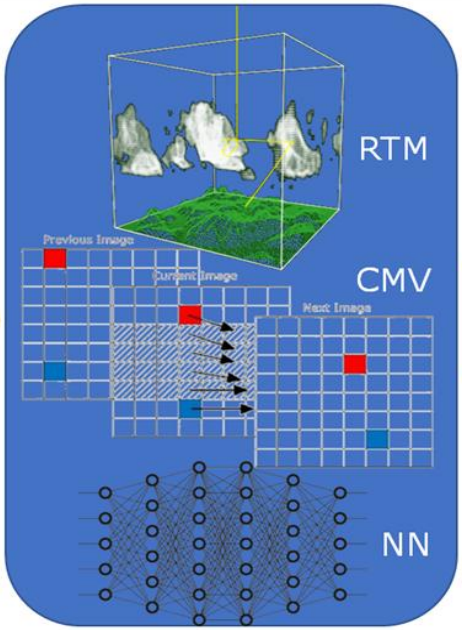
Satellites (MSG4,Sentinel,GOME2)

COT, CT, CP, TOC, WV, EL

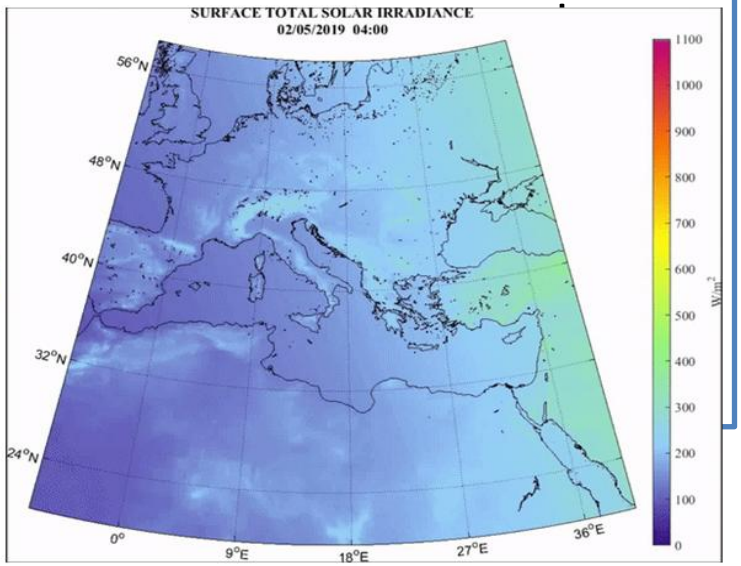
Models (CAMS)



AOD, AE, SSA, AL



Solar energy nowcasting & forecasting



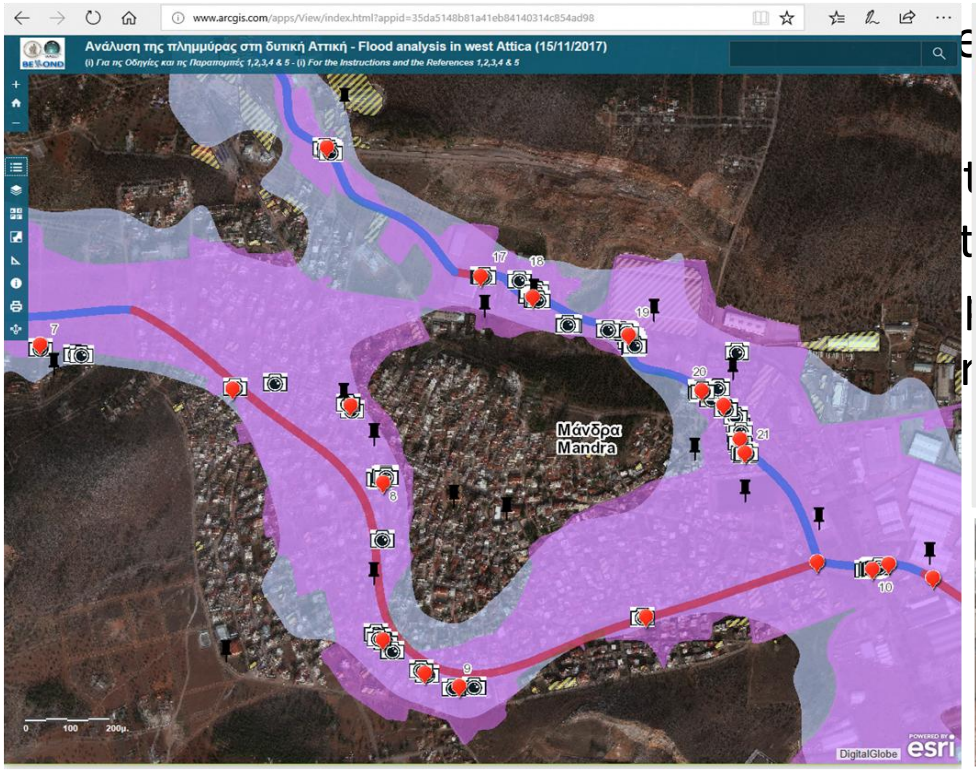
Inputs ----------> nextSENSE ----------> Outputs

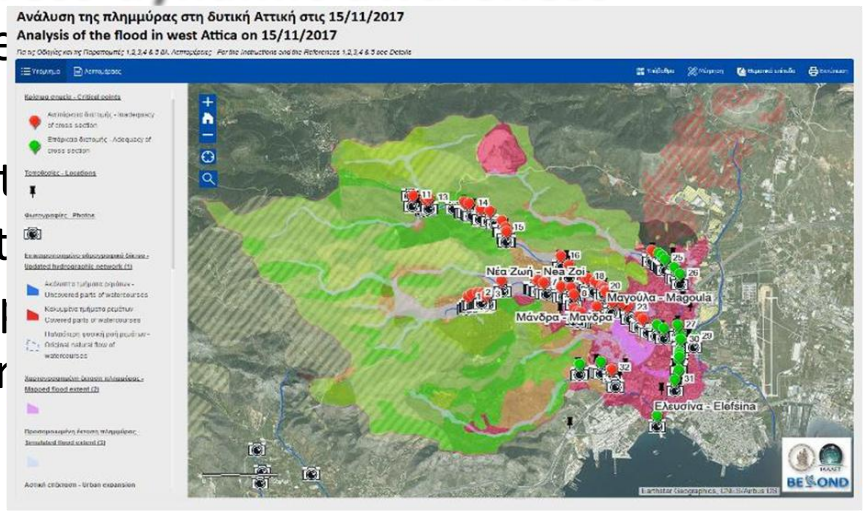
Early Warning European Forest Fires Information System

Risk and Recovery & Mitigation Measures

Real Time Monitoring Crisis Management Situation Awareness Picture

2. Speed up the process using ANN to enable millions of model simulations in one minute and address dynamic awareness





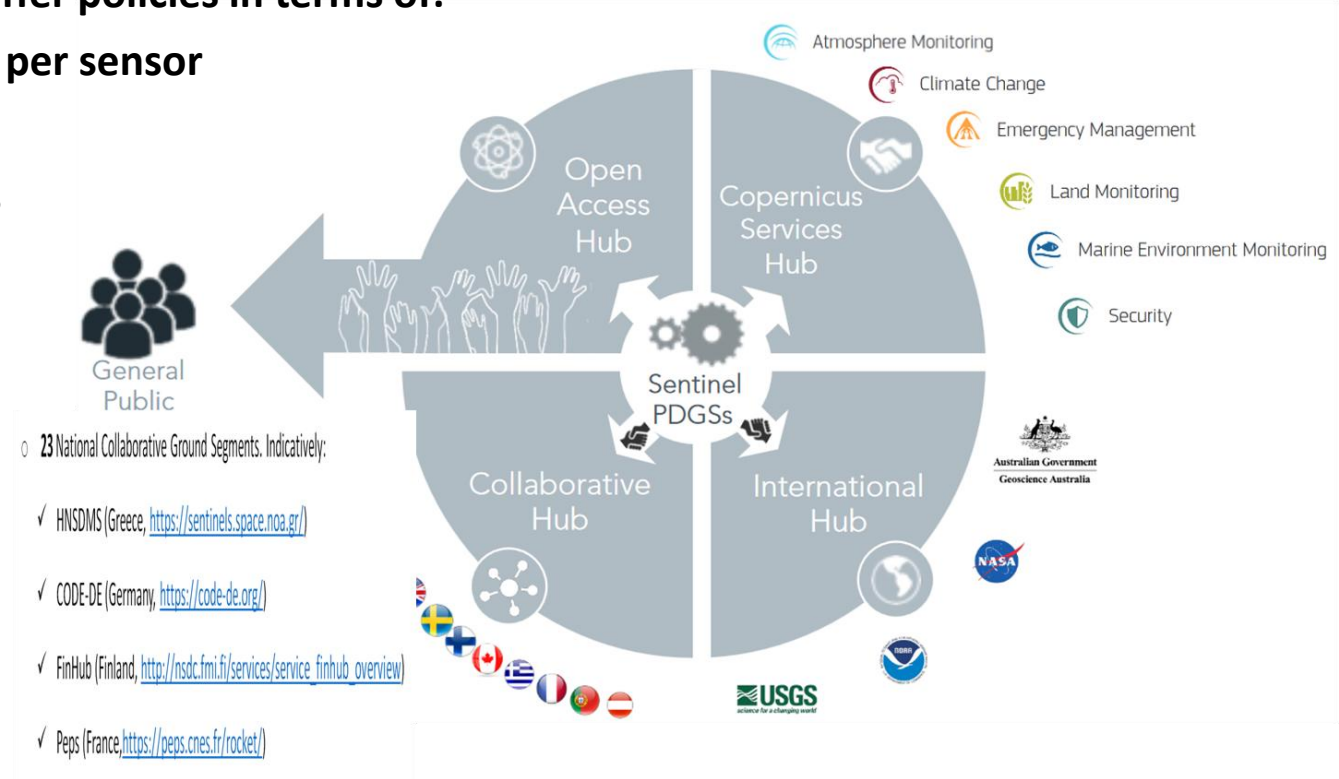
Early Warning
European Forest Fires
Information System

Risk and Recovery &
Mitigation Measures

Real Time Monitoring
Crisis Management
Situation Awareness
Picture

The hubs have different data offer policies in terms of:

- **Missions and products per sensor**
- **Geographic coverage**
- **Concurrent downloads**
- **Rolling policy**
- **User types served**
- **Downloading speed**
- **Data Integrity**
- **Published products**
- **Response times**
- **Availability**
- **Product latency**



Early Warning European Forest Fires Information System

Risk and Recovery & Mitigation Measures

Real Time Monitoring Crisis Management Situation Awareness Picture

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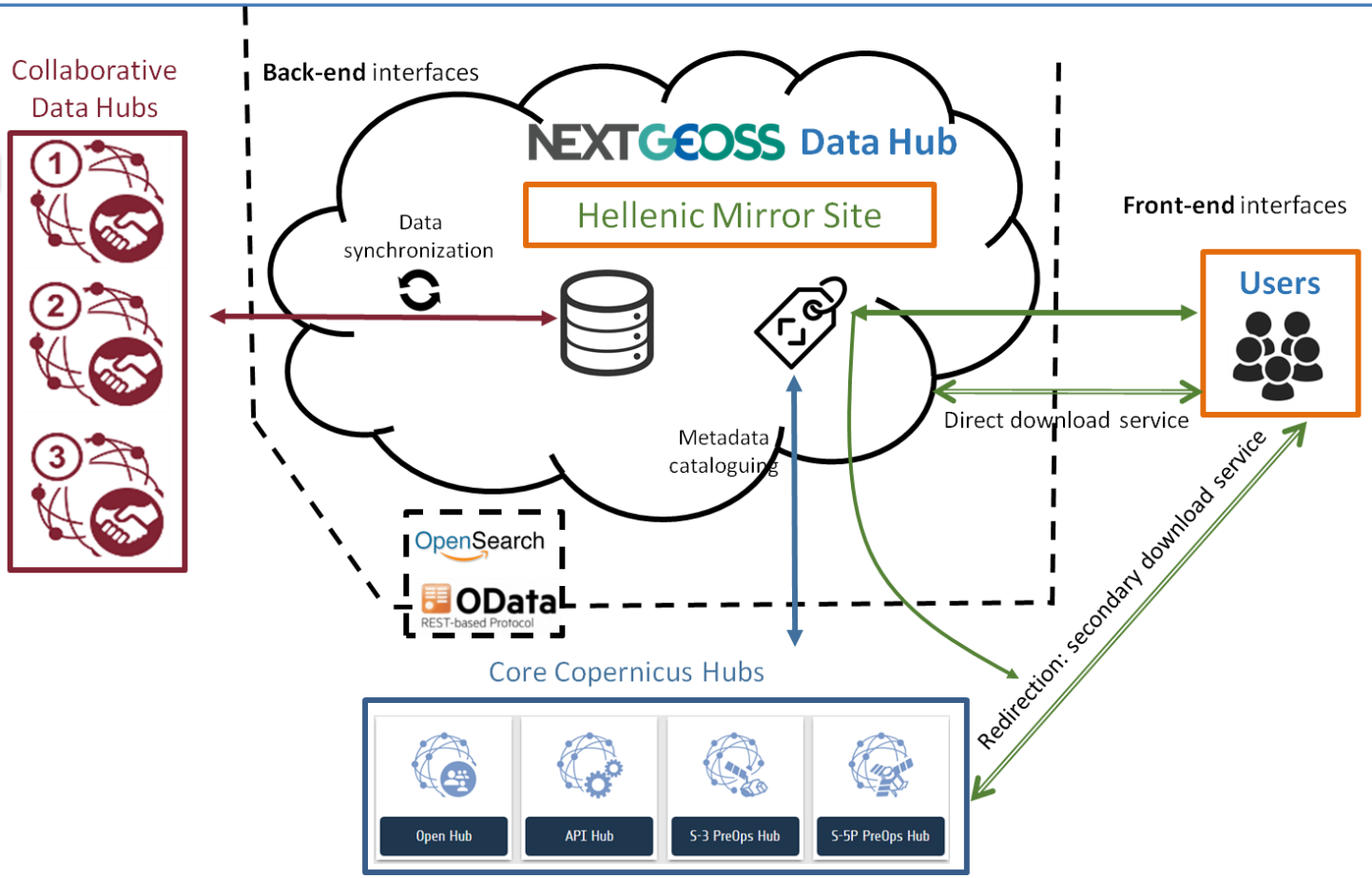
The Sentinel Data Search and Access Engine

developed in BEYOND

Adopted as the solution for the European Data Hub Cloud Platform NextGEOSS

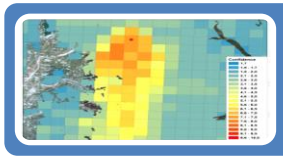


Early Warning European Forest Fires Information System

Risk and Recovery & Mitigation Measures

Real Time Monitoring Crisis Management Situation Awareness Picture

FIREHUB: A SPACE BASED HUB OF FIRE MANAGEMENT SERVICES

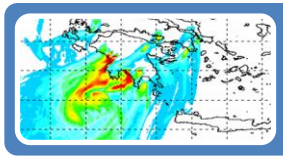


Early fire detection and real-time fire monitoring

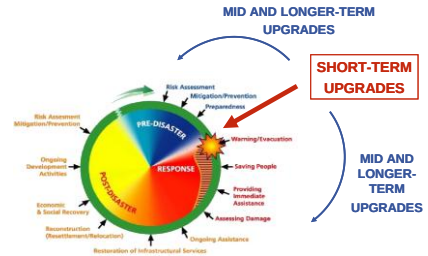
Rapid Burnt Scar and Fire Severity Mapping during crisis

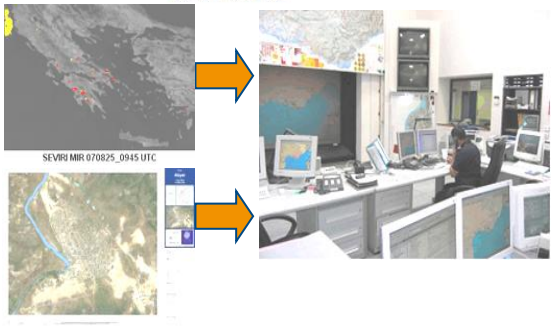
Detailed Burnt Area Mapping and Damage Assessment

Diachronic Burnt Area Mapping and Damage Assessment



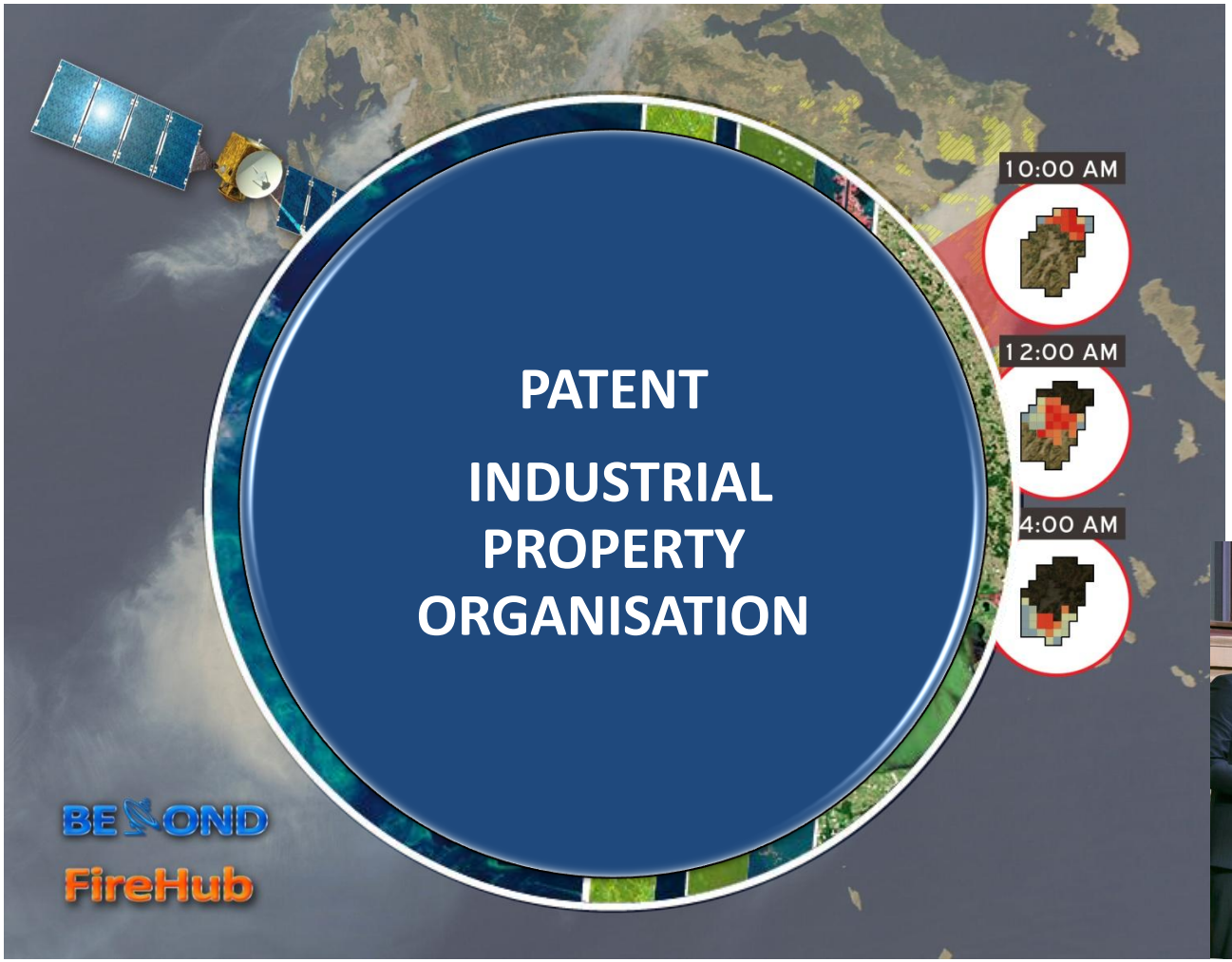
Hourly Forecasting of Fire Smoke Dispersion during crisis

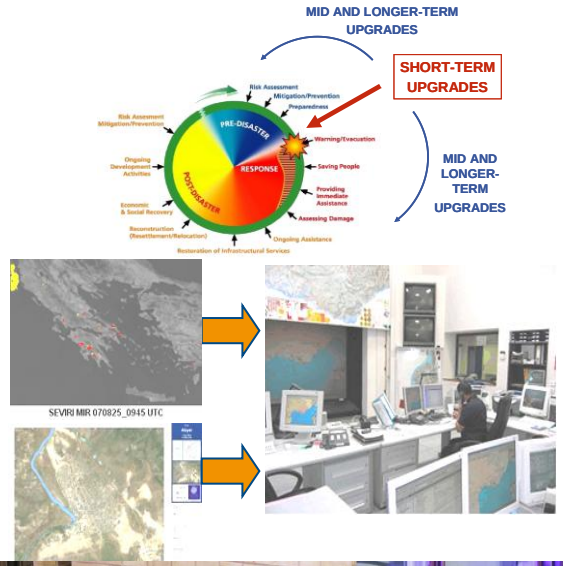




http://ocean.space.noa.gr/FireHub

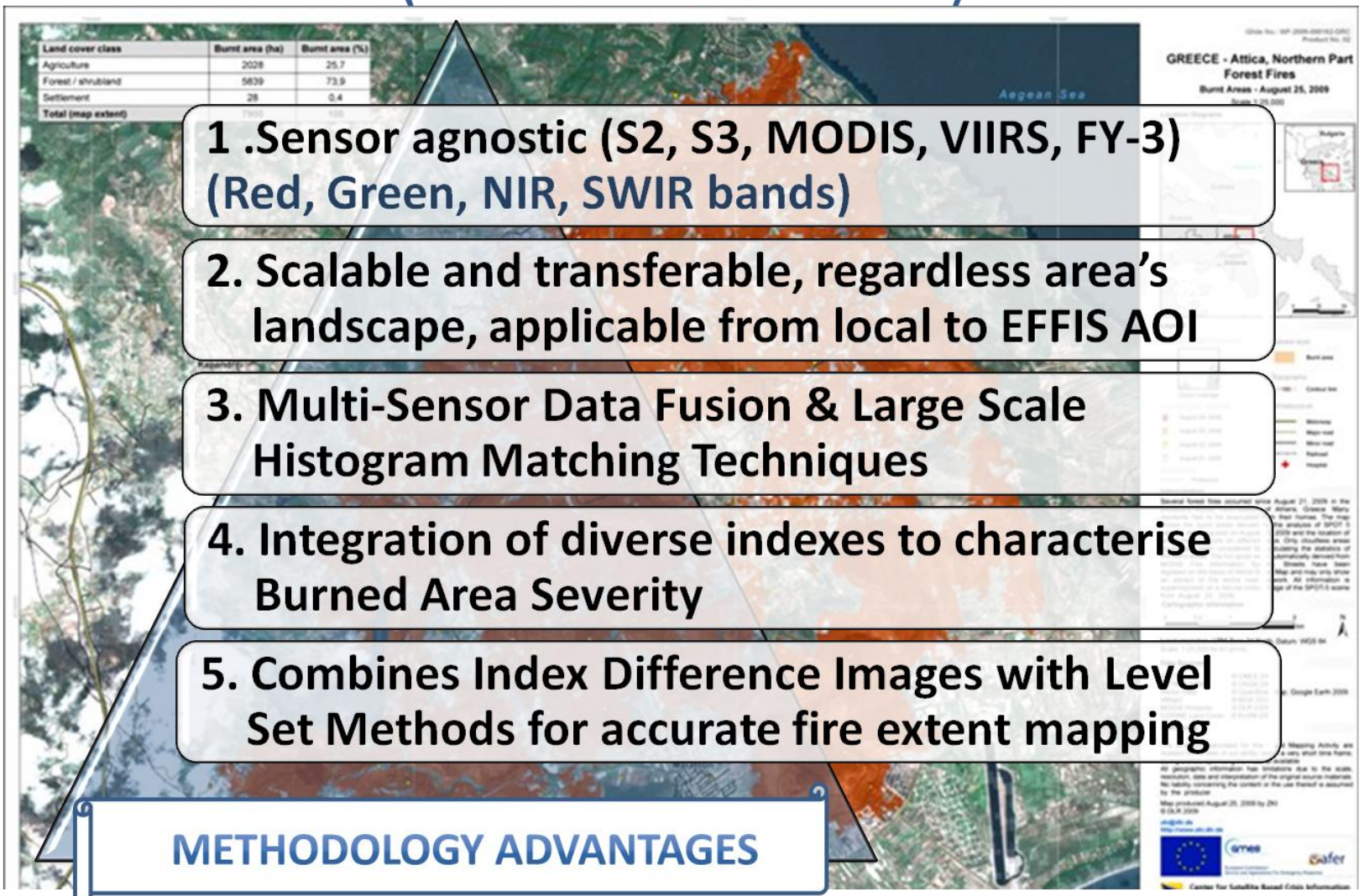
FIREHUB: A SPACE BASED HUB OF FIRE MANAGEMENT SERVICES



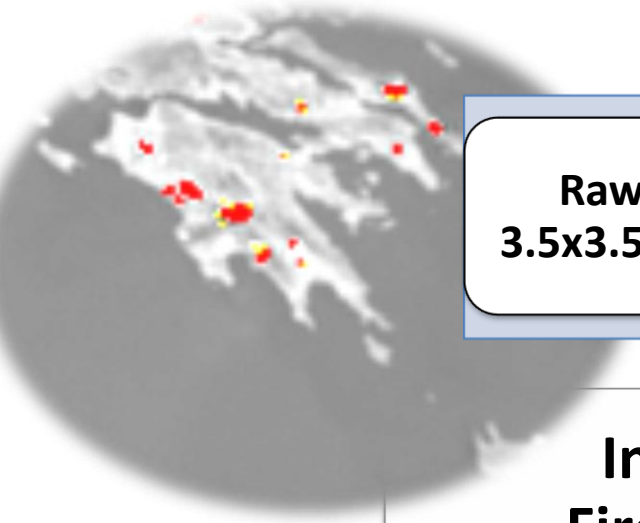


http://ocean.space.noa.gr/FireHub

FIREHUB: BURNED AREA & DAMAGE ASSESSMENT MAPPING (RUSH&NON RUSH MODE)

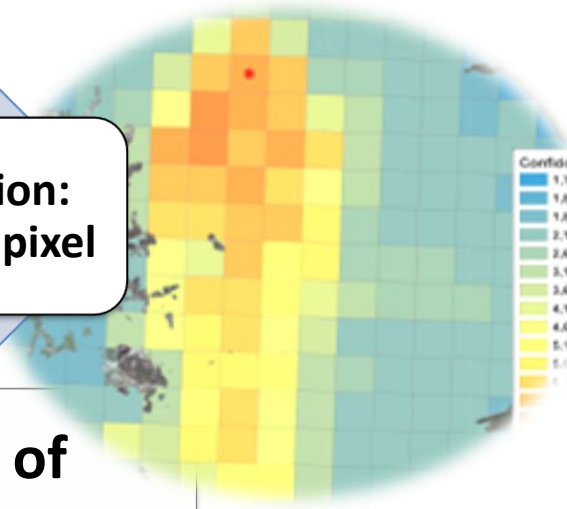


FIREHUB: INNOVATIVE EARLY DETECTION AND RT FIRE MONITORING



Raw resolution: 3.5x3.5 km wide pixel

Refined resolution: 0.5x0.5 km wide pixel



Increased Spatial Resolution of Fire Monitoring by 50 Times – (500mx500m) – Multi Source Multi Resolution EO Data Fusion in RT

Meteo Data (Wind Forecasts direction, speed)

Detailed Fuel Maps & Historical Assessments of Fuel Vulnerability

Geographic Aspects: Altitudinal Zones, Slope/Aspect

Fire Spread Modelling Assimilation with RT SEVIRI Observations

CIRSA 2019

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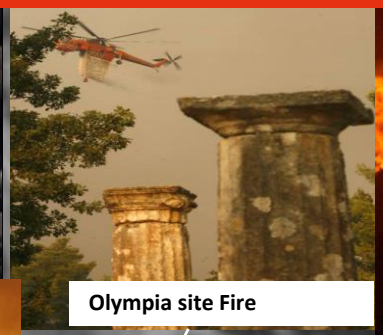
Regional Real Time Fire Monitoring - NOA's MSG SEVIRI Station – Raw Resolution mode

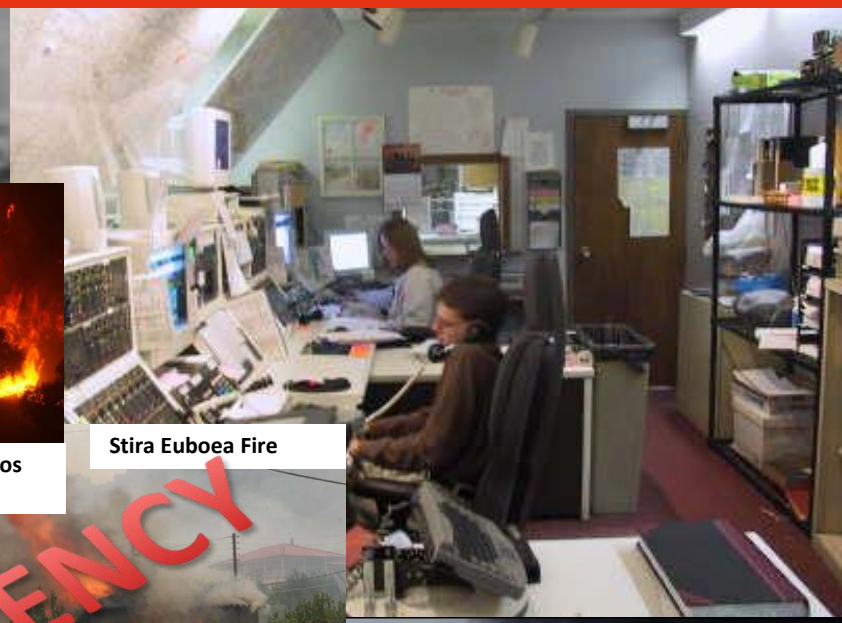
Zaharo Fire



Olympia site Fire

AliveriEuboea Fire

Korinthos Fire



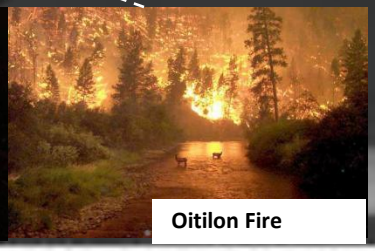
Stira Euboea Fire

Parnon Mt Fire

EMERGENCY

Taygetos Mt Fire

Megalopolis Fire



Oitilon Fire

SEVIRI MIR 070823_1030 UTC

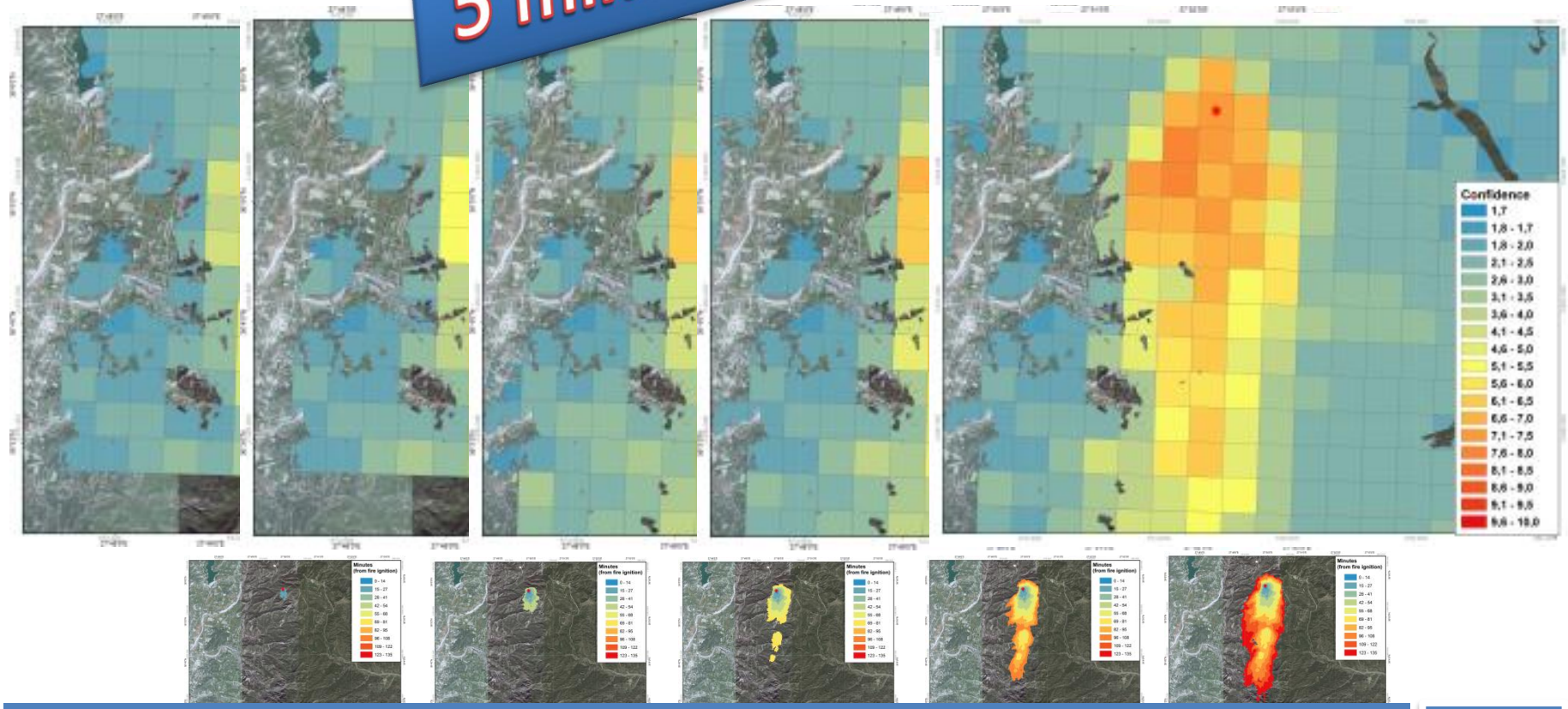
POTENTIAL FIRE

CONFIRMED FIRE

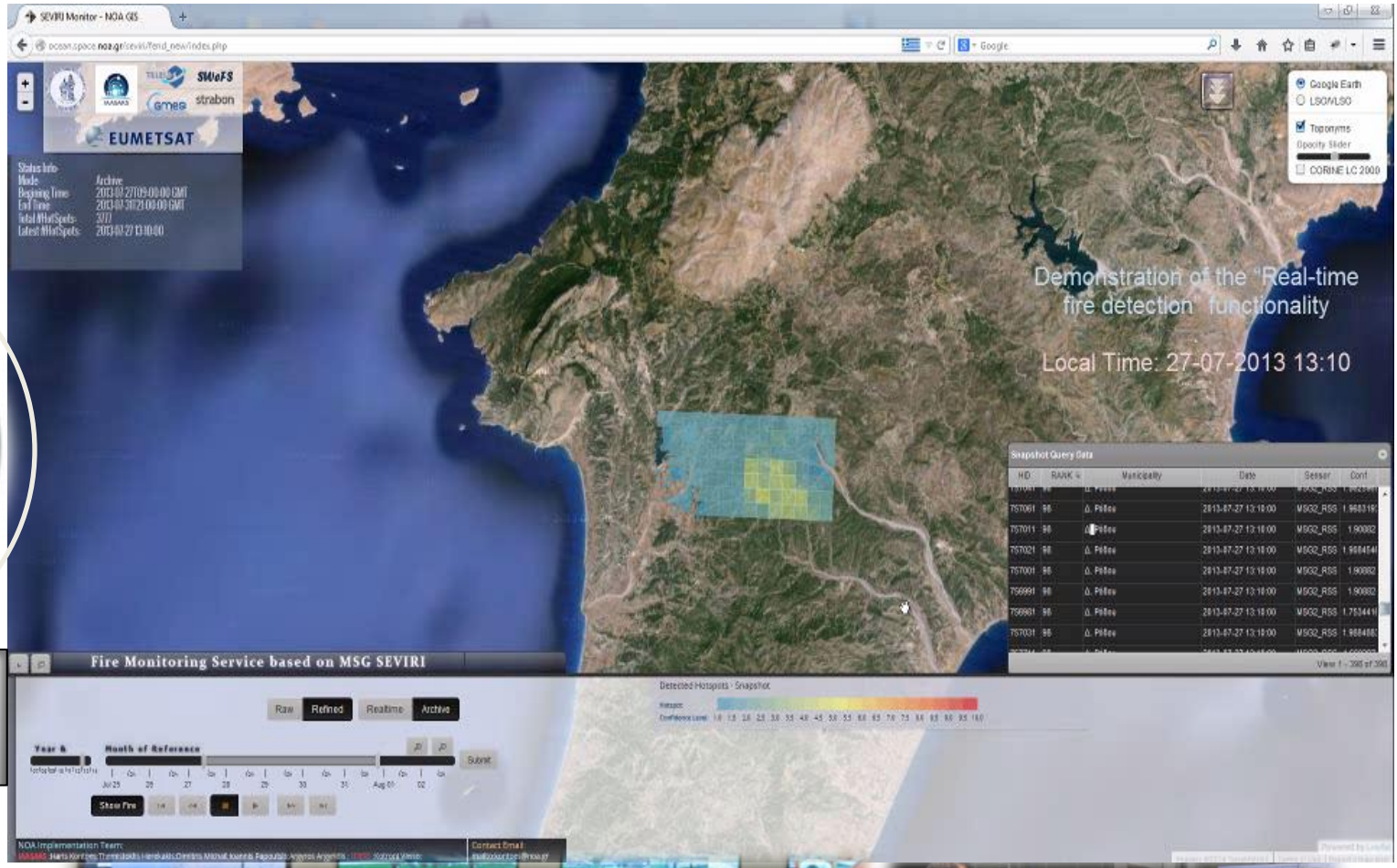
Results @ 150 minutes after fire ignition

+30’ → +35’ → +40’ → +45’ → +50’

5 minutes basis



Rhodes Island
27/7/2013



BEYOND

Fire Smoke Dispersion Service
A FireHub Module

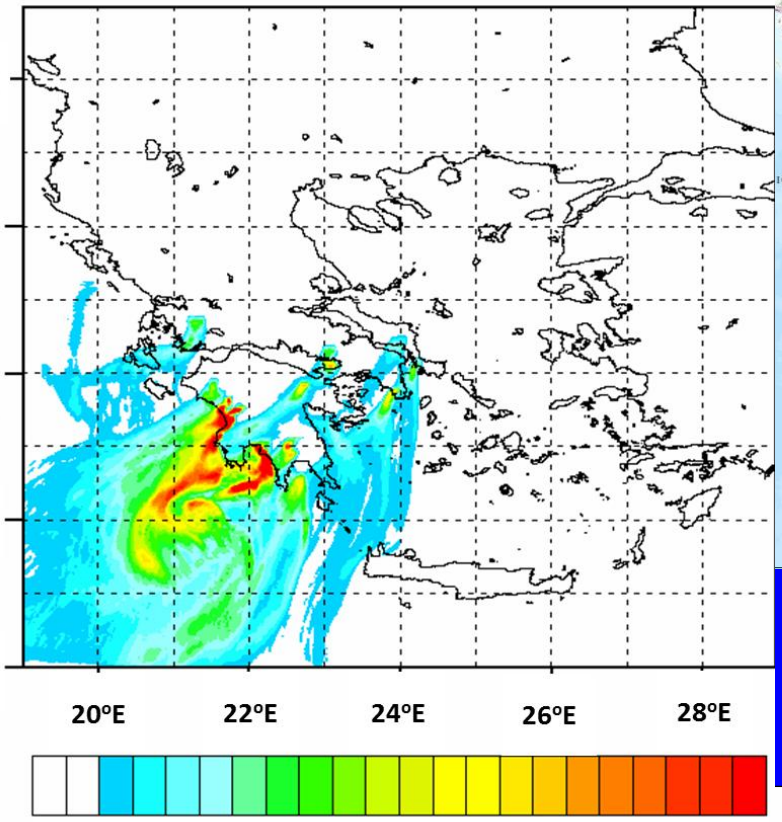
IAASARS

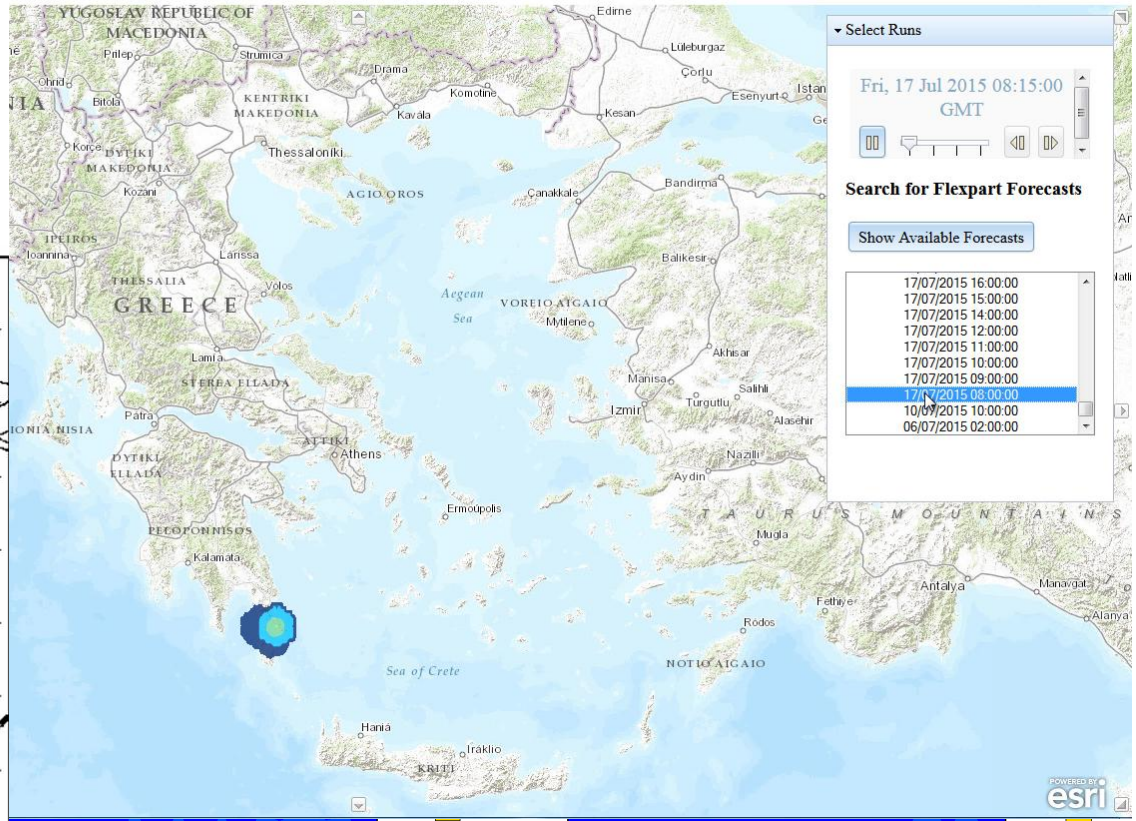
FLEXPART – NOA

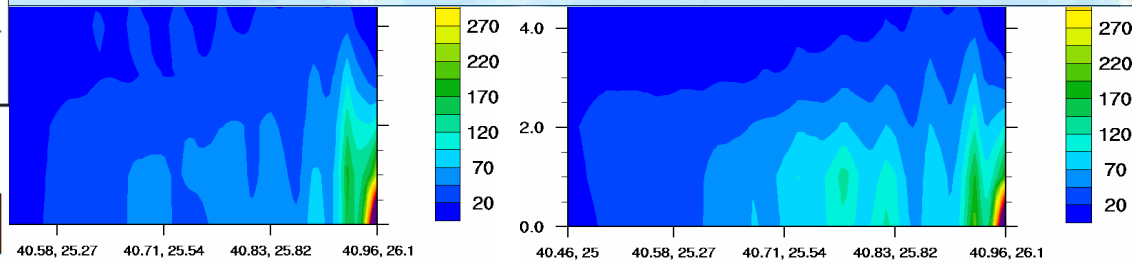
Biomass Burning (Organic Carbon – OC)

Valid Date:26-08-2007 0900UTC

Model layer: Integrated Column (ng m^{-3})







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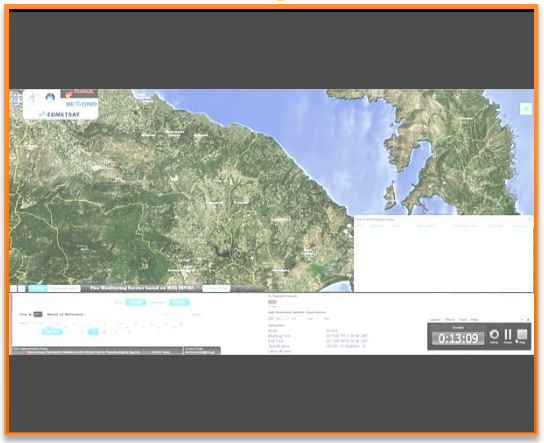
FIREHUB: RT FIRE MONITORING COMBINED WITH BURNED AREA MAPPING IN RUSH MODE

First Detection in 10’

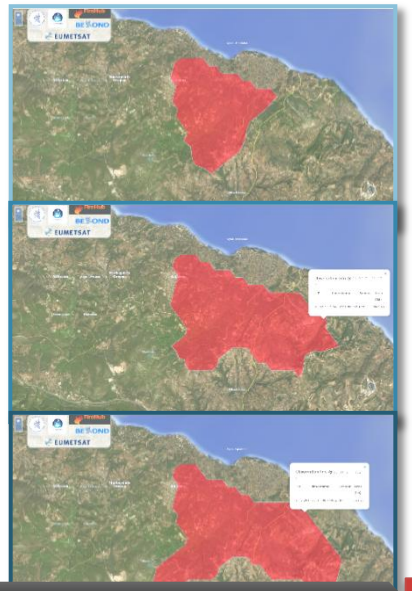


Meteosat SG –SEVIRI

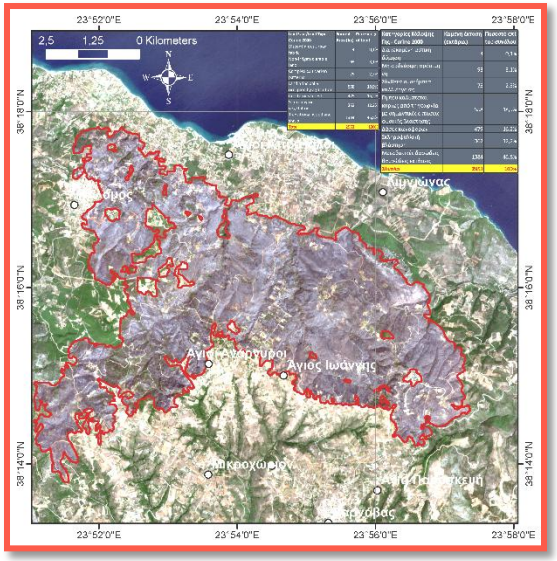
Day #1
NPP-VIIRS
MR=375m
20170817 11:14

Day #2
MODIS-Terra
MR=250m
20170818_1055

Day #3
NPP-VIIRS
MR=375m



Day #4 Sentinel-2 HR-10 m



P1 Detection - Monitoring
Active Fires - Resolution 500 m/5 minutes

P2 Rapid Daily Mapping in Medium Resolution
2-3 times /day

P3 Rapid Daily Mapping in High Resolution
every 5 days

Detection of active fires using FireHUB

Perimeter of burned area Medium Resolution(250μ)

Perimeter of burned area High Resolution (10μ)

T0 minutes

KALAMOS
13/08/2017
2953
HECTARES

T10 minutes

T1 Day

T2 Day

T3 Day

T4 Day

Fire Ignition

Perimeter of burned area Medium Resolution(375μ)

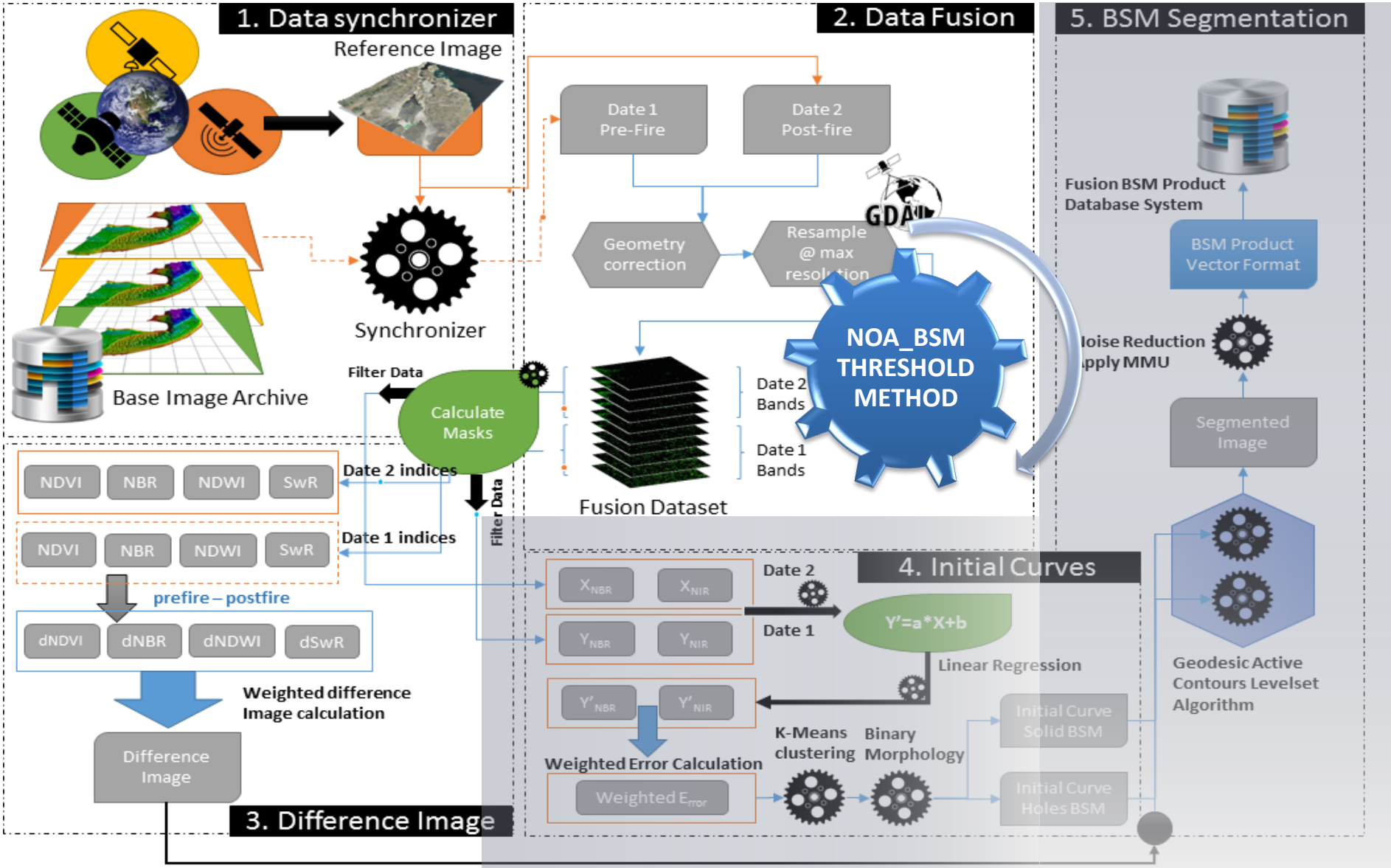
Perimeter of burned area Medium Resolution(375μ)

FIREHUB: DETAILED BURNED AREA & DAMAGE ASSESSMENT MAPPING (RUSH&NON RUSH MODE)

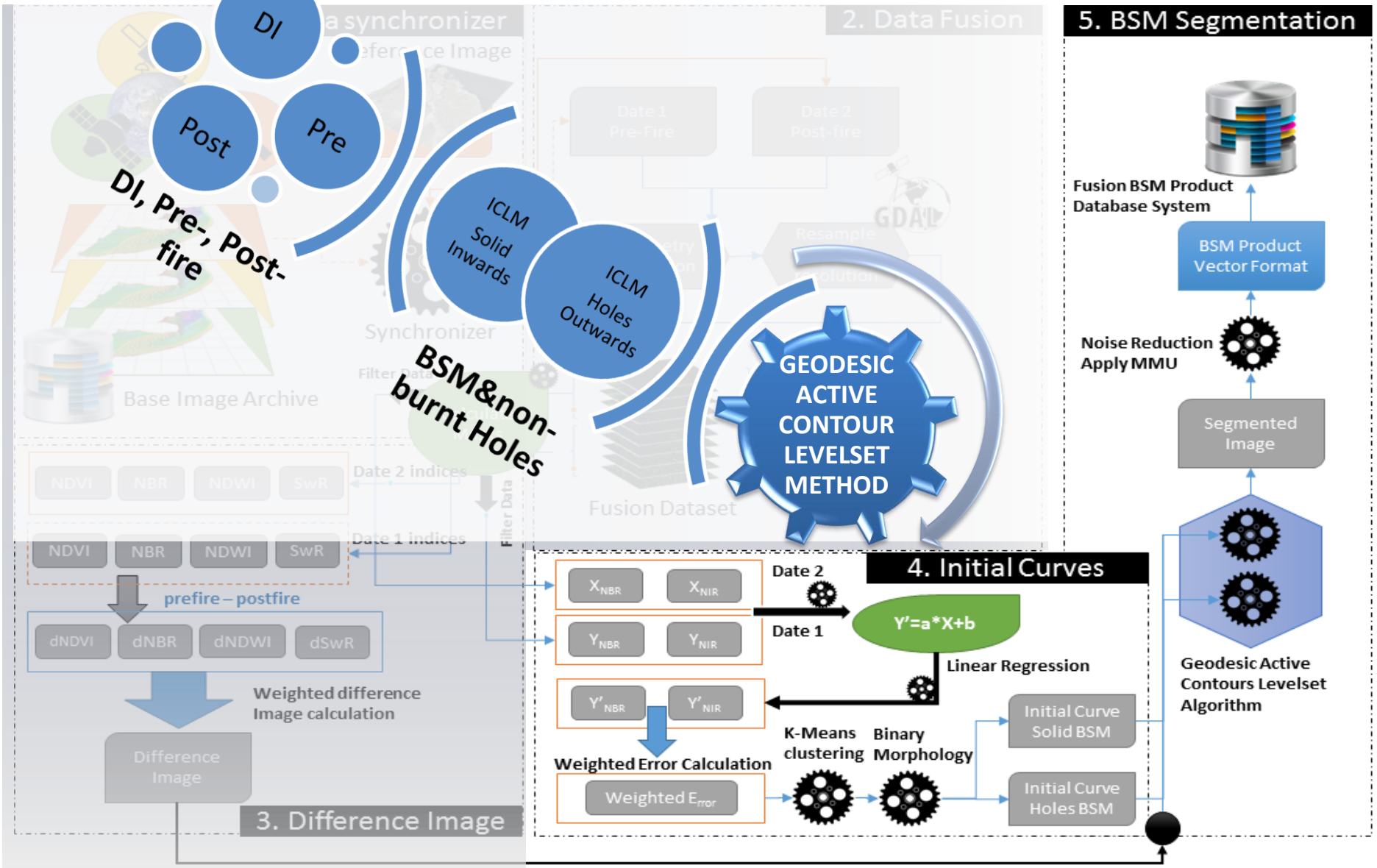
Very High Spatial Resolution (3,5 cm)- Daily delivery

Mati East Attica
23/07/2018
@ 17:05

MULTIPLE INDEX INTEGRATION PROCESSING CHAIN (BLOCKS 1, 2,3)

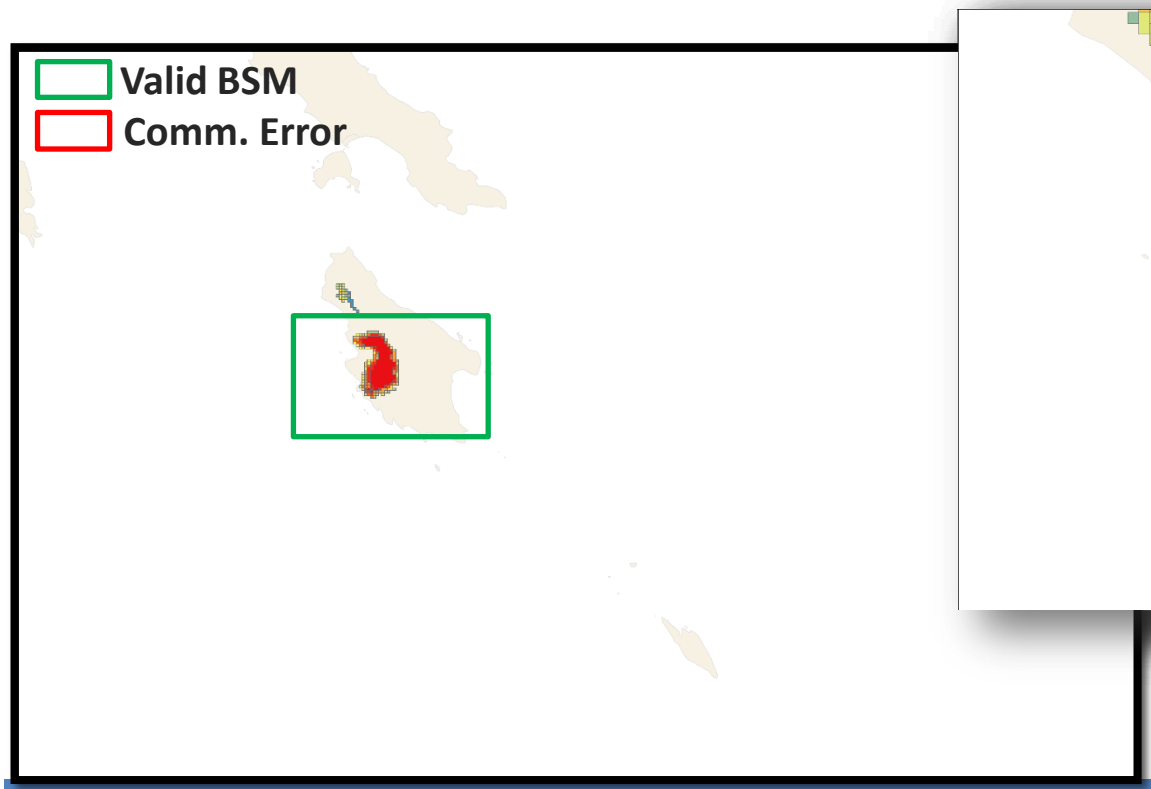


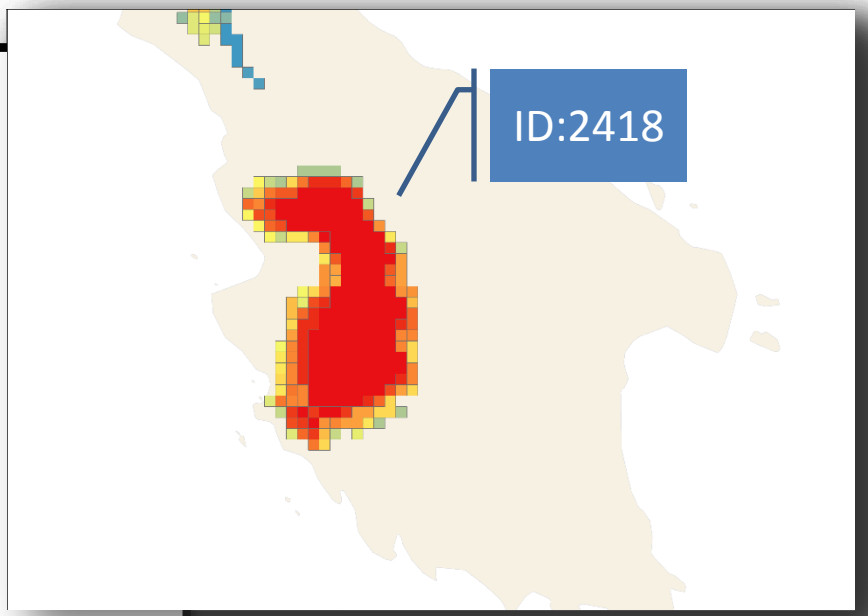
BURNED AREA MAPPING: NOA_BSM → GEODESIC ACTIVE CONTOUR LEVELSET



REAL-TIME BSM POST-PROCESSING

- Post-Processing of raw BSM vectors is applied by designing a prototype algorithm implemented as SQL stored procedures. The implementation makes use of the PostgreSQL Database Management System spatially enabled by PostGIS extension. The derived DB Schema is used to store and distribute the final BSM product.





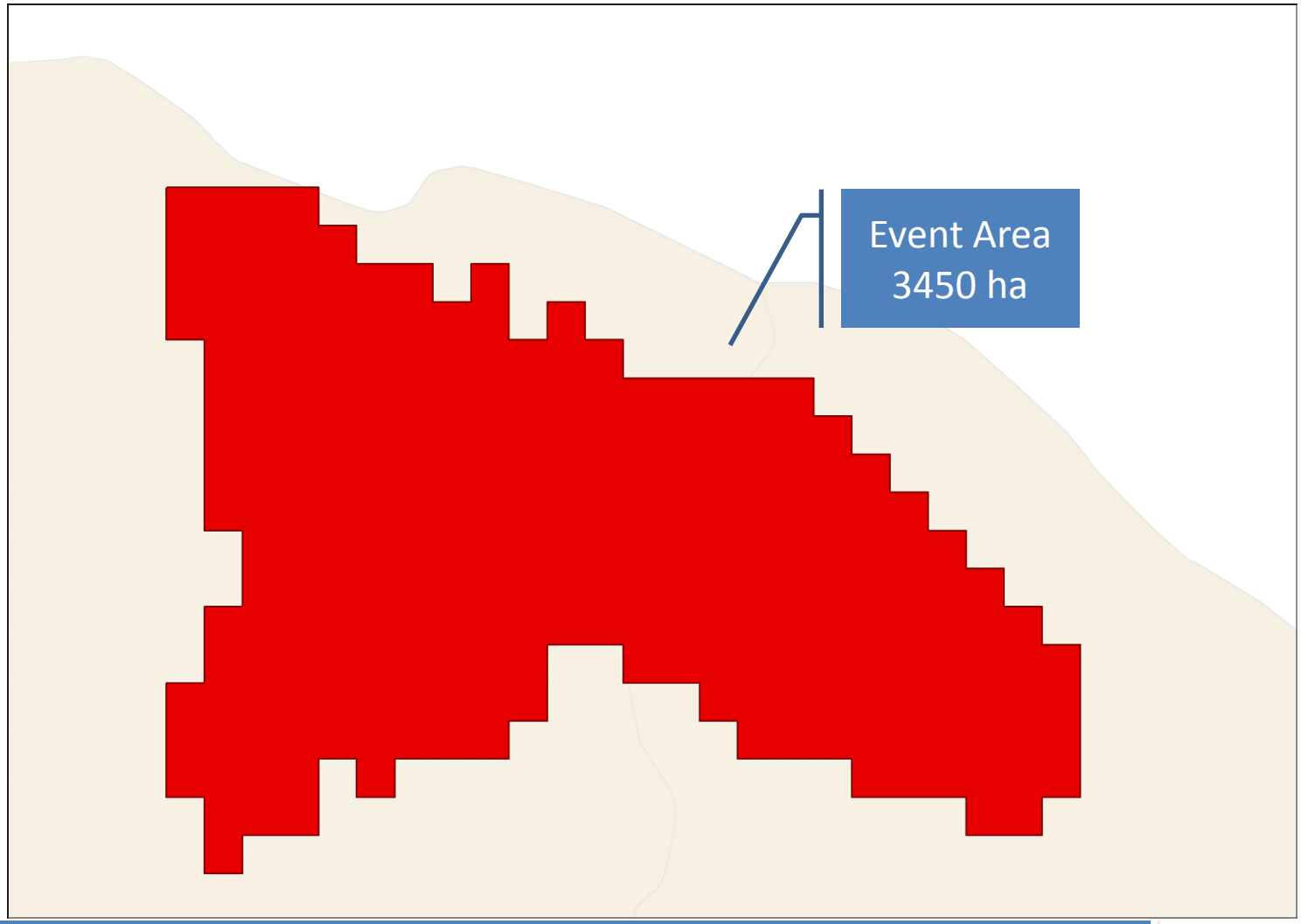
NOA REAL-TIME BSM PROCESSING CHAIN: POST-PROCESSING

2017-08-17

2017-08-18

2017-08-23

2017-09-10

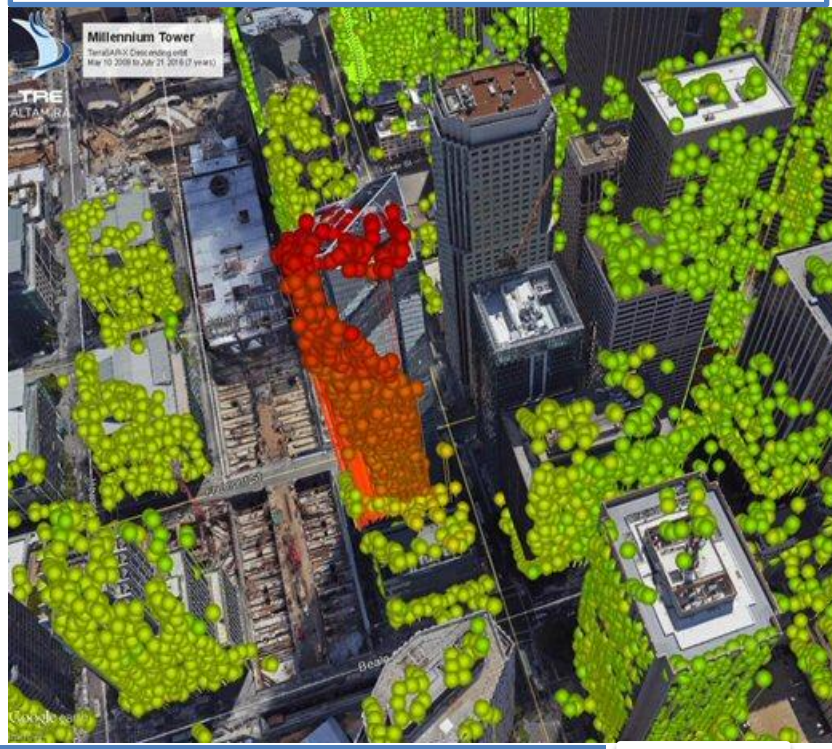


Radar Interferometry (InSAR)

SAR interferometry (InSAR) technique which has been developed to:

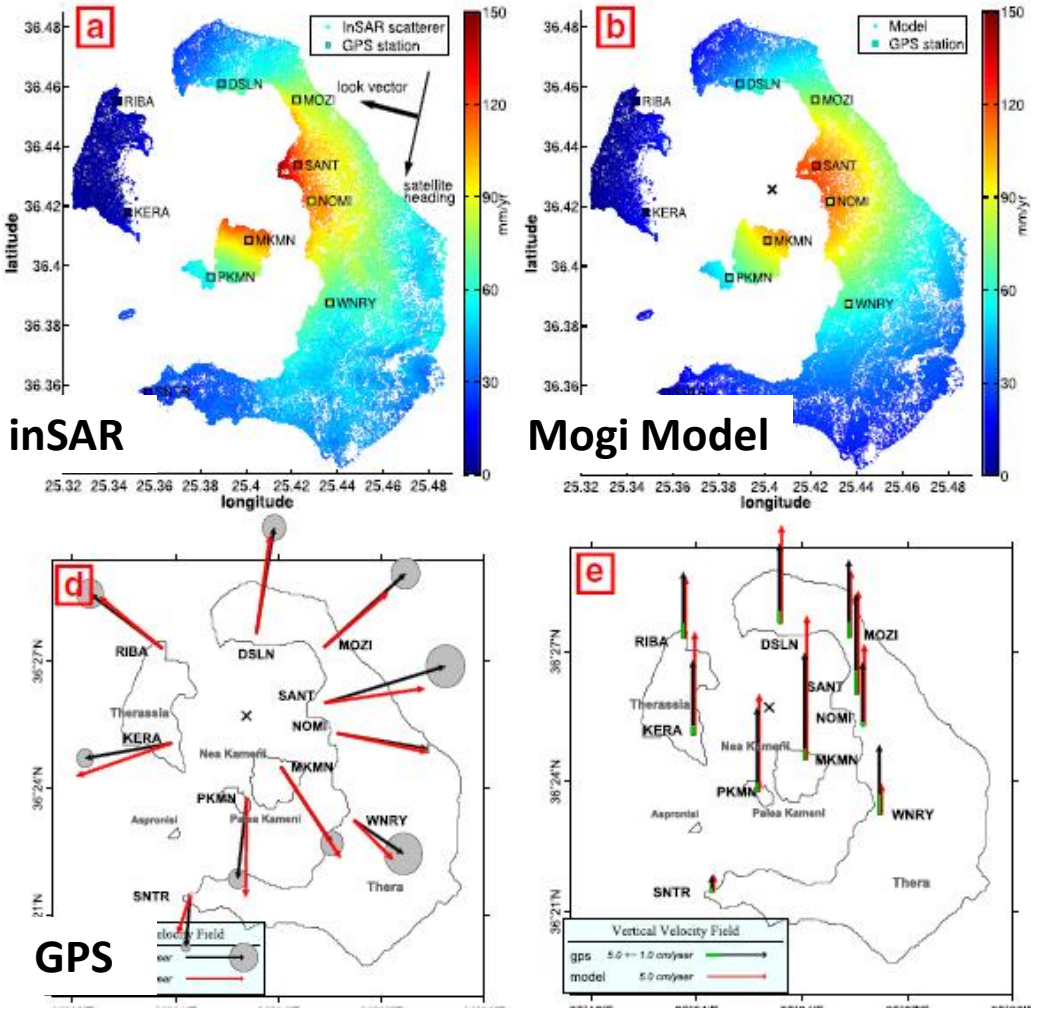
1. Detect, monitor and assess of the **dynamic of Earth's crust**
2. Monitor the surface extensions and assess with high precision **(mm→cm)** the deformations induced by:
   - **I. Extensive fractures** due to earthquakes **(of the order of cm→ a few meters)**
   - **II. Eruptions of active volcanoes** (of the order of cm→ a few meters)
   - **III. Pre-seismic tectonic** deformations (mm/year)
   - **IV. Slow-moving landslides** (mm/year)
3. Monitor changes in the environment due to **industrial and construction** activity
4. Monitor the **millmetric movement of buildings, facilities, and monuments** (mm/year)
5. Support the work of the city/site planners to **make cities resilient against the geophysical hazards**

600 measurement points on the **San Francisco Millennium Tower** capture motion from the foot of the building to the top. Analysis shows that the tower is moving down and away from the satellite as measured along the line of sight from the satellite to the tower at an annual rate of **26 millimetres per year (by TRE ALTAMIRA)**



Interferometric Synthetic Aperture Radar

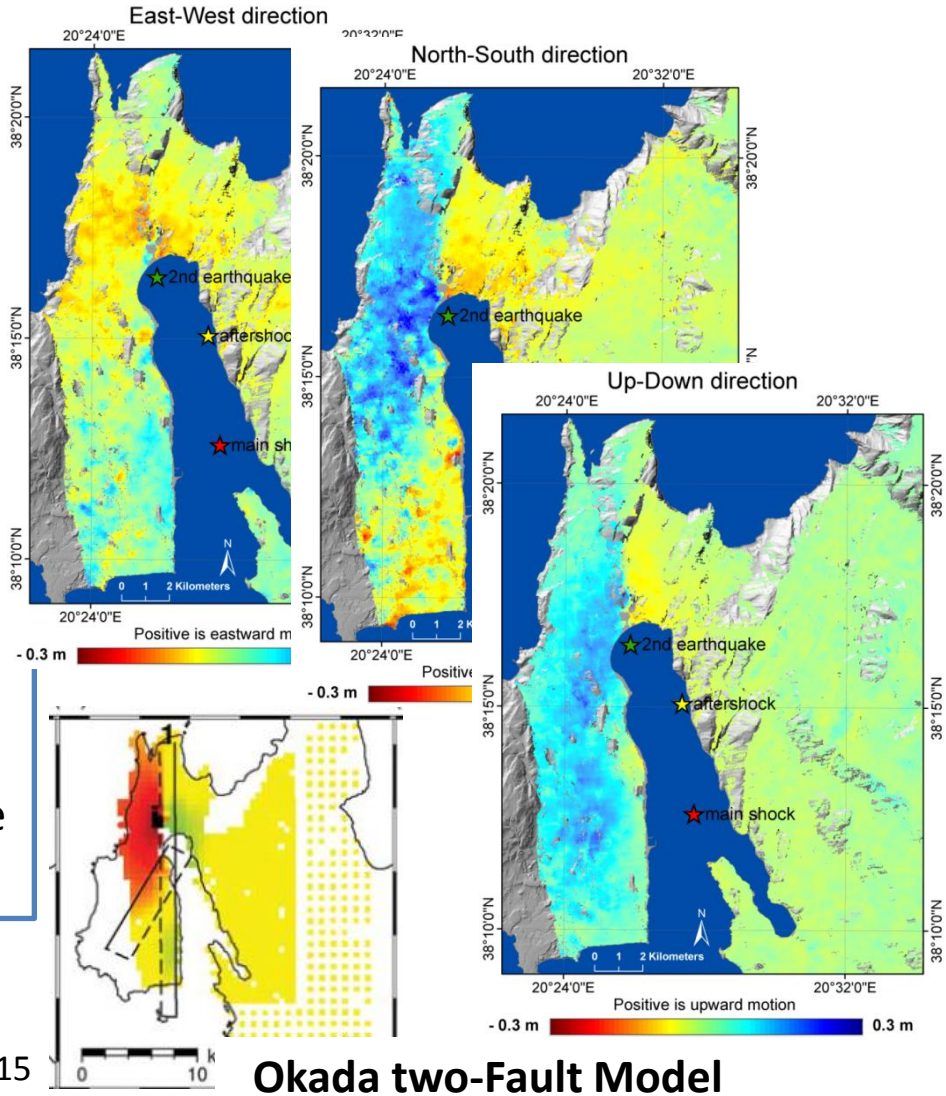
Mapping inflation of Santorini volcano, Greece, from 01/2011 to 02/2012 **using GPS and InSAR (ENVISAT Data processed with PSI&SBAS techniques).** A clear and large inflation signal, **up to 150mm/yr in the LOS direction**, with a radial pattern outward from the center of the caldera is observed. The deformation pattern was model using a Mogi source located north of the Nea Kameni island, at a depth **between 3.3km and 6.3km and with a volume change rate in the range of 12million m^3 to 24 million m^3 per year (by BEYOND GeObservatory)**



Papoutsis et al, Mapping inflation at Santorini volcano, Greece, using GPS and InSAR, GRL, Vol. 40, 267–272, doi:10.1029/2012GL054137, 2013

InSAR for measuring ground deformation after abrupt events

The complex sequence of EQs that struck the island of Cephalonia, Greece, started on 26 January 2014 at 13:55 UTC, Mw 6.0, and followed five hours later by an Mw 5.3 aftershock and by an Mw 5.9 event on 3 Feb 2014 at 03:08 UTC. SAR image pairs spanning the second mainshock were acquired on **descending and ascending passes**, by the **COSMO–SkyMed and TanDEM-X** satellite missions. **East, North, and Up displacement** components associated with the EQ, indicate a **strong horizontal and vertical displacement of up to 30 cm**. Using Okada model a two-fault model reproduced the observed DInSAR surface displacements **(by BEYOND GeObservatory)**

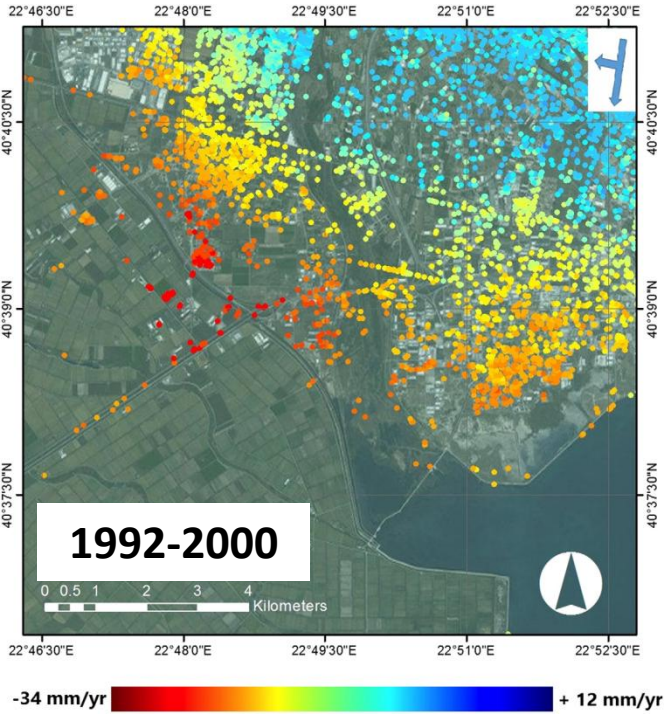


Okada two-Fault Model

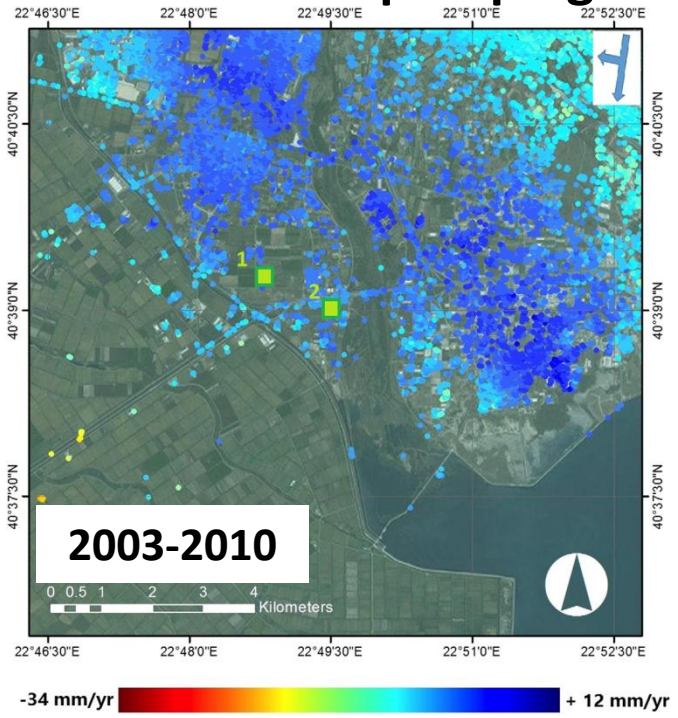
J.P. Merryman Boncori et al, The February 2014 Cephalonia Earthquake (Greece): 3D Deformation Field and Source Modeling from Multiple SAR Techniques, **SRL, Vol86, No 1,** 2015

InSAR for measuring land subsidence due to excessive water pumping

InSAR based land subsidence in the western side of Thessaloniki, recorded since the early 1960s and **reaching gradually up to 3–4 m** was assessed**. PSI and SBAS multi-temporal Interferometry** was applied to analyse the **20 year ERS 1, 2 and ENVISAT** data. The ERS dataset depicted **subsidence up to 35mm/year for the period 1992-2000**.



Svigkas Nikos et al, Land subsidence rebound detected viamulti-temporal InSAR in Kalochori and Sindos regions, Northern Greece, **Engineering Geology 209 (2016) 175–186**



The ENVISAT data (2003–2010) showed that there was a change **from subsidence to uplift, a motion that is well correlated with hydrogeological data that showed a synchronous rise of the aquifer level**. The dominating driver of the human factor concerning the land subsidence phenomena for the last 55 years is obvious

THANK YOU FOR YOUR ATTENTION!

ANY QUESTIONS?