European Center of Excellence for EO based Disaster Management

BEYOND FireHub

FireHub: A Space based Fire Management Hub

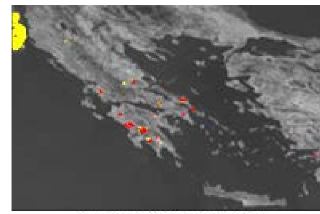
Haris KONTOES, Research Director NOA
BEYOND Coordinator

European Commission

IAASARS

BEYOND participated in the **Best Service Challenge Copernicus - Masters competition**

Submitted Service : The Operational EO based fire management service, known as:



SEVIRI MIR 070825_0945 UTC

“FireHub: A Space Based Fire Management Hub “

The service consists of four pillars:

1. The early fire detection and real-time fire monitoring
2. The large scale Burnt Scar Mapping during and after wildfires
3. The diachronic BSM and damage assessment
4. The hourly forecasting of fire smoke dispersion

"FireHub: A Space Based Fire Management Hub "

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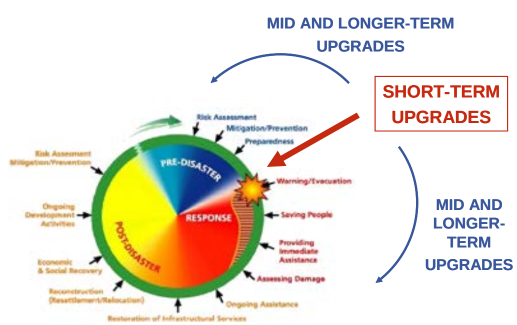
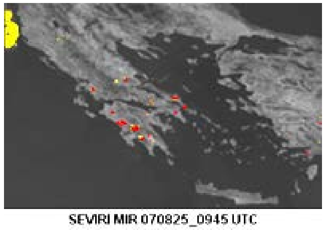
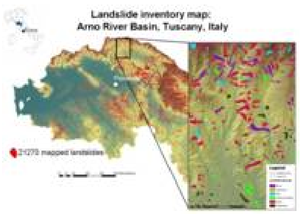
Institutional End Users and stakeholders receiving the fire disaster services:







- The European Copernicus Program (EMS service)

- The Hellenic Fire Brigades Operations' Control Room
- The Ministry of Env. (Directorate for Forests Protection
- The Gen. Sec. Civil Protection
- The Forestry Services over Greece and Europe
- The National Cadastral Organisation
- The Local Authorities & Environmental Organisations
- The Greek Army
- The Public
- The Serbian HydroMet Service
- The BBU - Research Center for Disaster Management- Romania
- The European Fire Monitoring Center

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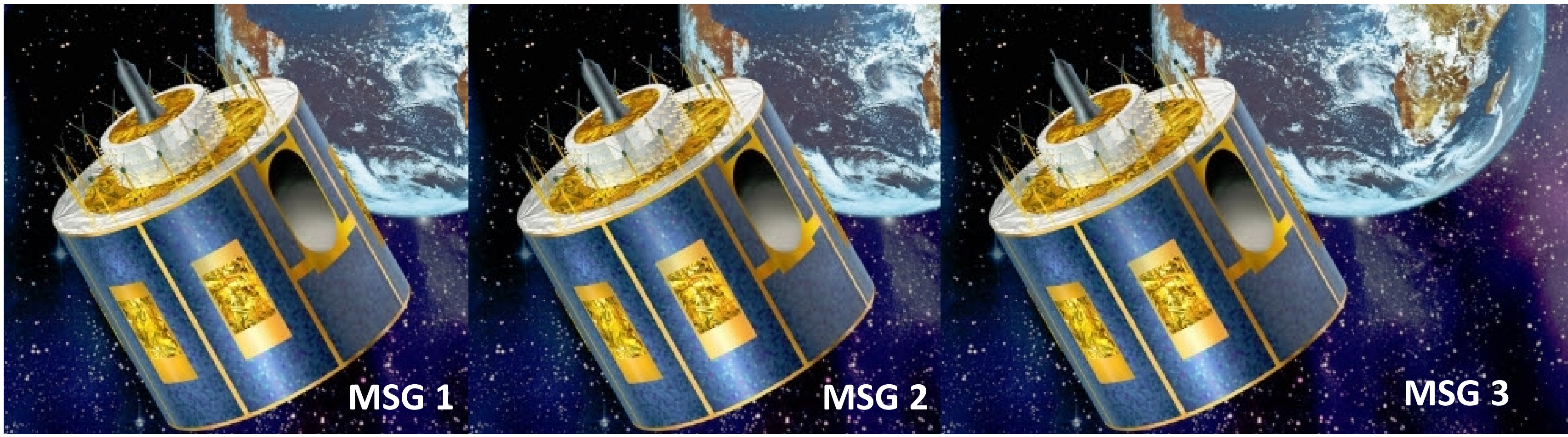
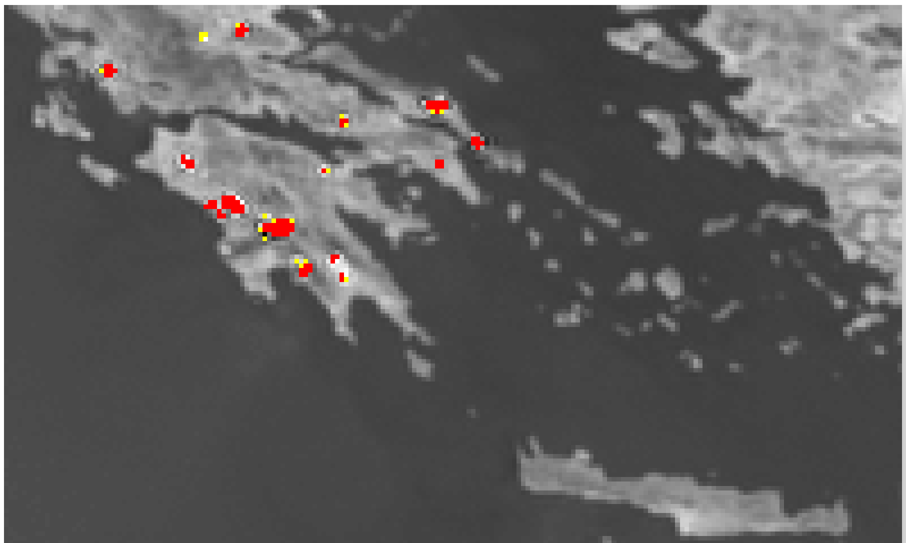
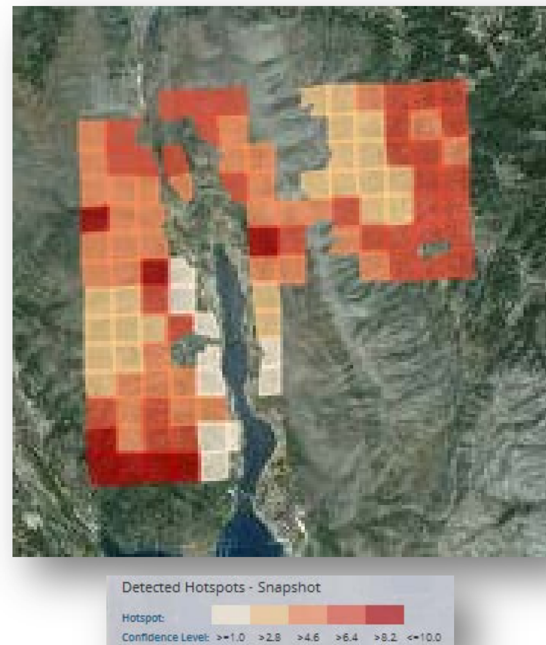
Active Fire Detection by MSG SEVIRI Instrument



1	VIS0.6	0.635	0.56	0.71	Surface, clouds, wind fields
2	VIS0.8	0.81	0.74	0.88	Surface, clouds, wind fields
3	NIR1.6	1.64	1.50	1.78	Surface, cloud phase
4	**IR3.9**	**3.90**	**3.48**	**4.36**	**Surface, clouds, wind fields**
5	WV6.2	6.25	5.35	7.15	Water vapor, high level clouds, atmospheric instability
6	WV7.3	7.35	6.85	7.85	Water vapor, atmospheric instability
7	IR8.7	8.70	8.30	9.1	Surface, clouds, atmospheric instability
8	IR9.7	9.66	9.38	9.94	Ozone
9	**IR10.8**	**10.80**	**9.80**	**11.80**	**Surface, clouds, wind fields, atmospheric instability**
10	IR12.0	12.00	11.00	13.00	Surface, clouds, atmospheric instability
11	IR13.4	13.40	12.40	14.40	Cirrus cloud height, atmospheric instability
12	HRV	Broadband (about 0.4 - 1.1 µm)			Surface, clouds

Regional Real Time Fire Monitoring Service based on EUMETSAT MSG SEVIRI Data Monitoring





Raw resolution: 3.5x3.5 km wide pixel over entire

Refined resolution: 0.5x0.5 km wide pixel over entire Greece

Active Fire Detection by MSG SEVIRI Instrument

The best suited MSG SEVIRI Channels for active fire detection of forest and vegetation fuels and discrimination from ambient temperatures are:

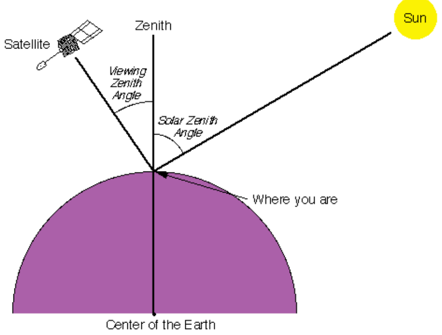
Channel	Central Wavelength (μm)	Spectral Band (μm)
IR 3.9	3.92	3.48 - 4.36
IR 10.8	10.8	9.80 - 11.80

Classification step #1: The EUMETSAT Fire mapping algorithm (FIR) is based on fixed thresholding approach, applied on the spectral bands **IR 3.9** and **IR10.8.** The FIR algorithm uses the following criteria to check for **potential fire and fire pixels**:

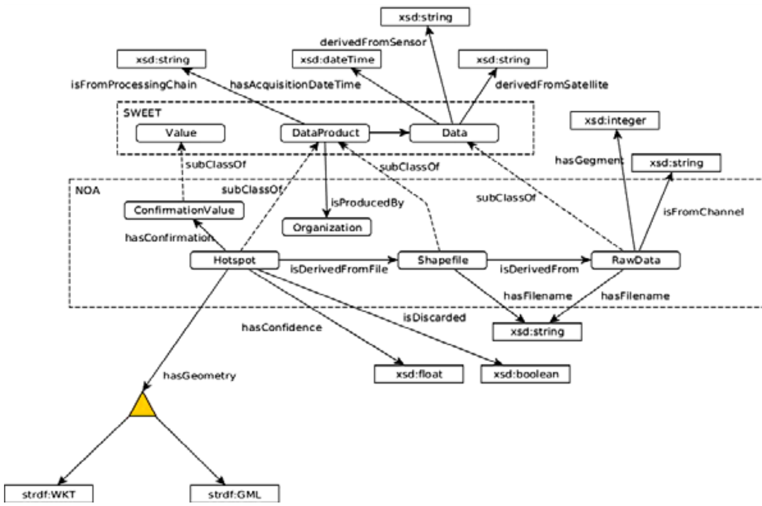
1. Brightness temperature of channel IR3.9 > **threshold 1**
2. Brightness temperature difference of channels IR3.9 and IR10.8 > **threshold 2**
3. Difference of the standard deviations of channel IR3.9 and IR10.8 > **threshold 3**
4. Standard deviation of channel IR3.9 > **threshold 4**
5. Standard deviation of channel IR10.8 < **threshold 5**

(all standard deviations are computed over a 3x3 pixel group)

CLASSIFICATION PROCESS



Classification enhancement # 1: The thresholds are dynamically changing calculated for each image and every pixel location on the basis of the seasonally variations and time depended Solar Zenith Angle.



Classification enhancement # 2 : Create and integrate classification evidence through geo-spatial ontology schemes and reasoning queries, accounting for the

a) thematic consistency by eliminating false alarms

b) account for the time persistence of the fire observations

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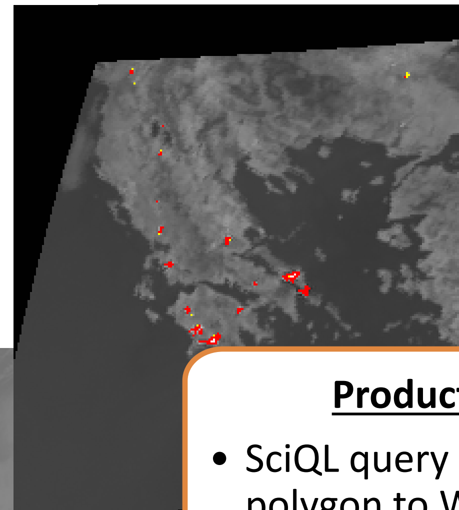
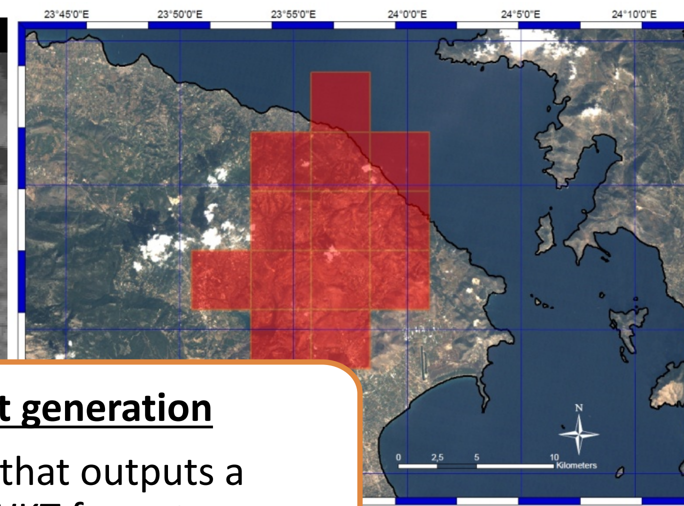
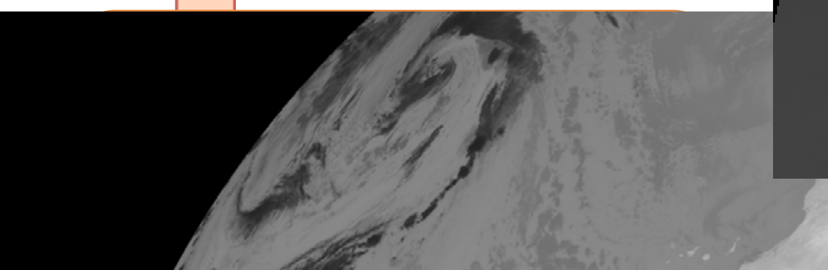
The FIREHUB System

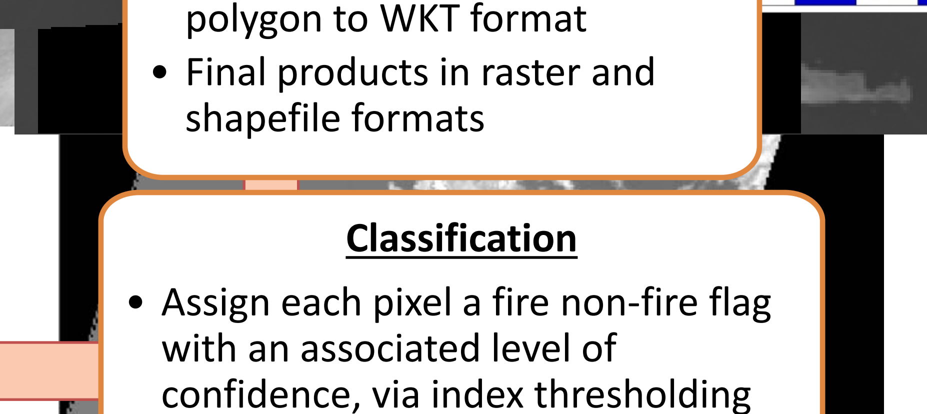




Data Import

- Extention module in MonetDB to load HRIT file into an SQL table or SciQL array
- HRIT_load_image(URIs) function





Product generation

- SciQL query that outputs a polygon to WKT format
- Final products in raster and shapefile formats

Georeferencing

- Initial transformation by hand
- Concise implementation using SciQL

Classification

- Assign each pixel a fire non-fire flag with an associated level of confidence, via index thresholding
- Uses a 3x3 window

IAASARS GMES Because we need to know

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

SEVIRI MIR 070823_1030 UTC

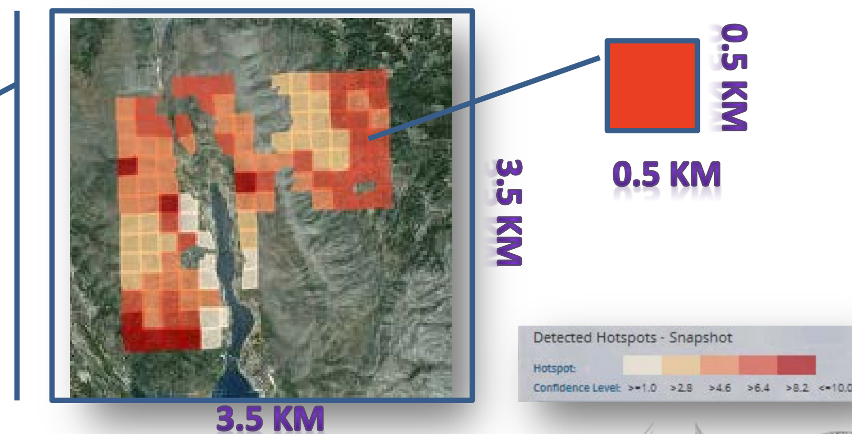
POTENTIAL FIRE

CONFIRMED FIRE

CLASSIFICATION PROCESS

Classification enhancement # 3: Downscaling the first classification output and calculate the fire occurrence probability in sub-areas of 500 m x 500 m wide, inside the initial observation area of 3.5km x 3.5 km, accounting for the real meteorological, physical / ecological, and morphological conditions in the affected area such as,

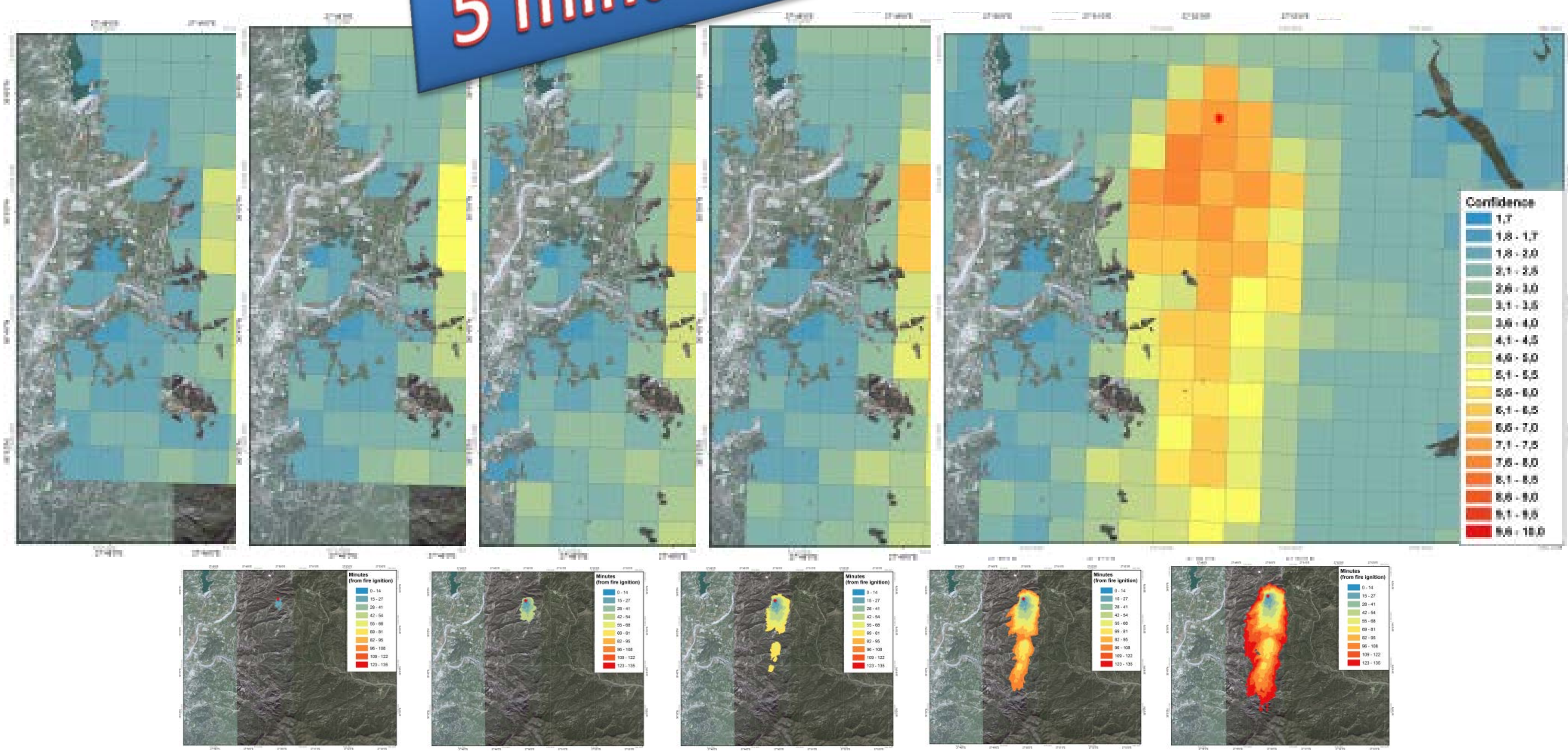
a) Wind conditions (speed/direction), **b)** Fuel types and fuel type's proneness to fire, **c)** Altitudinal zone, **d)** Slope and Aspect elements of each of the 500m x500m area.



Results @ 150 minutes after fire ignition

+30’ +35’ +40’ +45’ +50’

5 minutes basis



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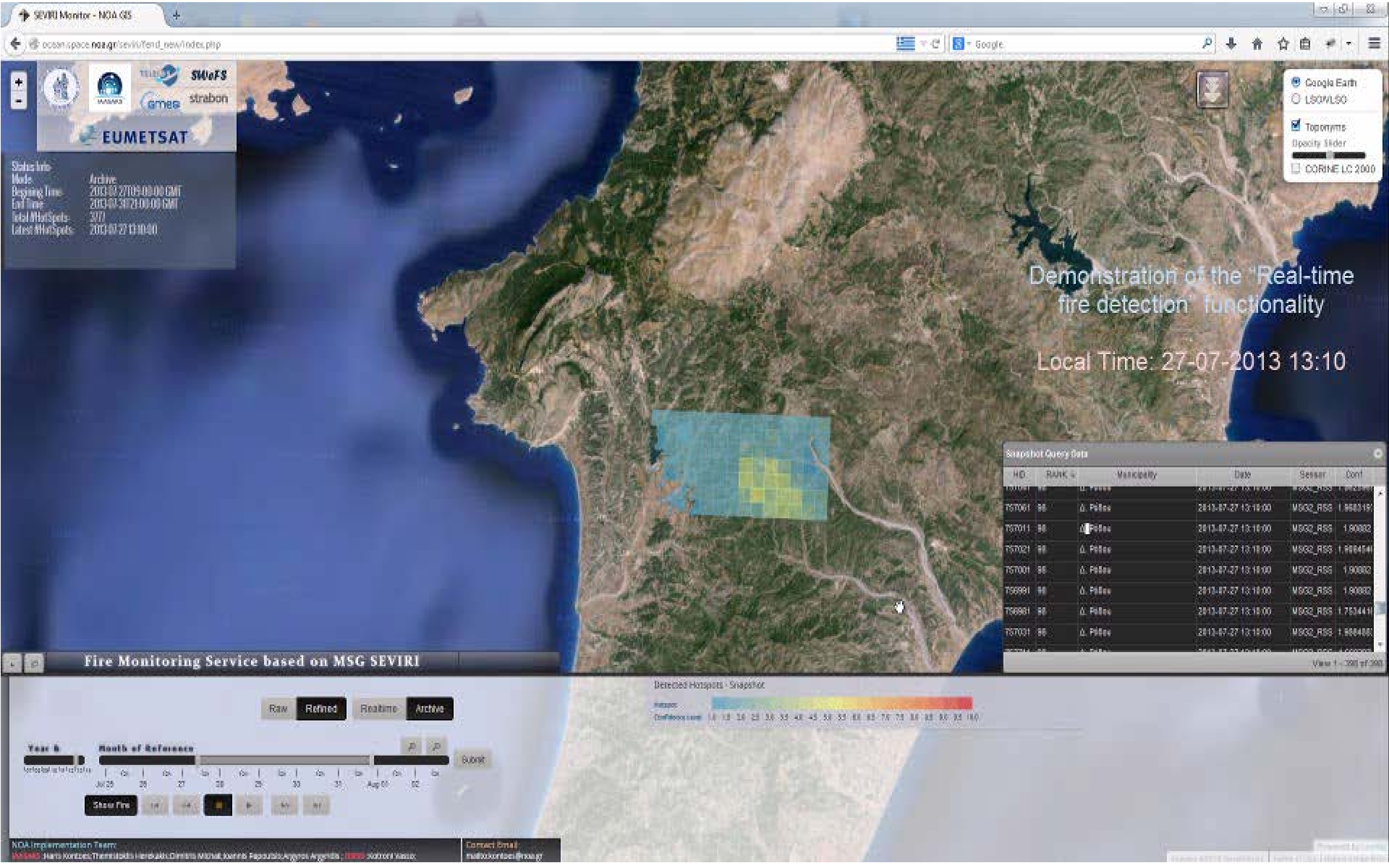

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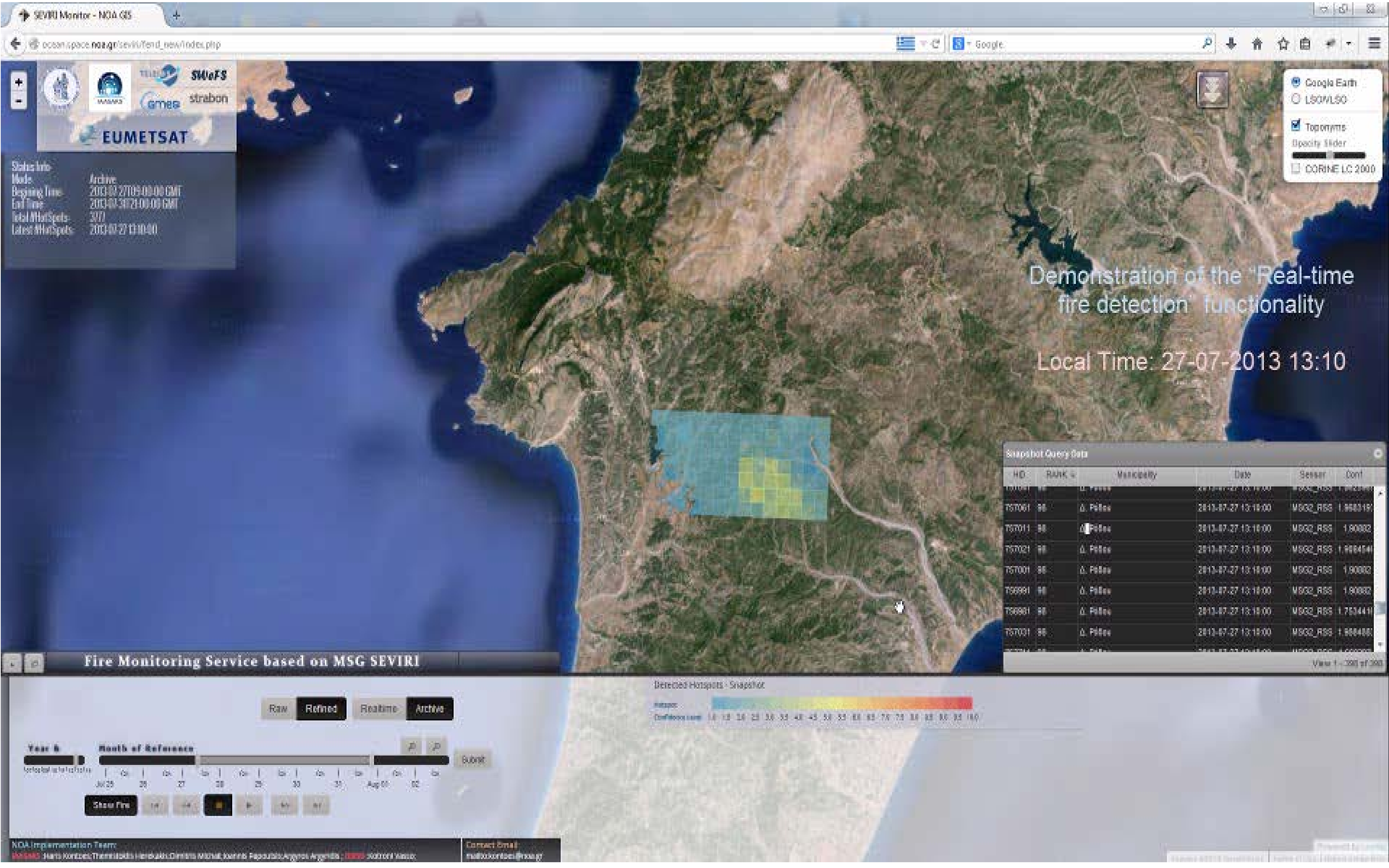

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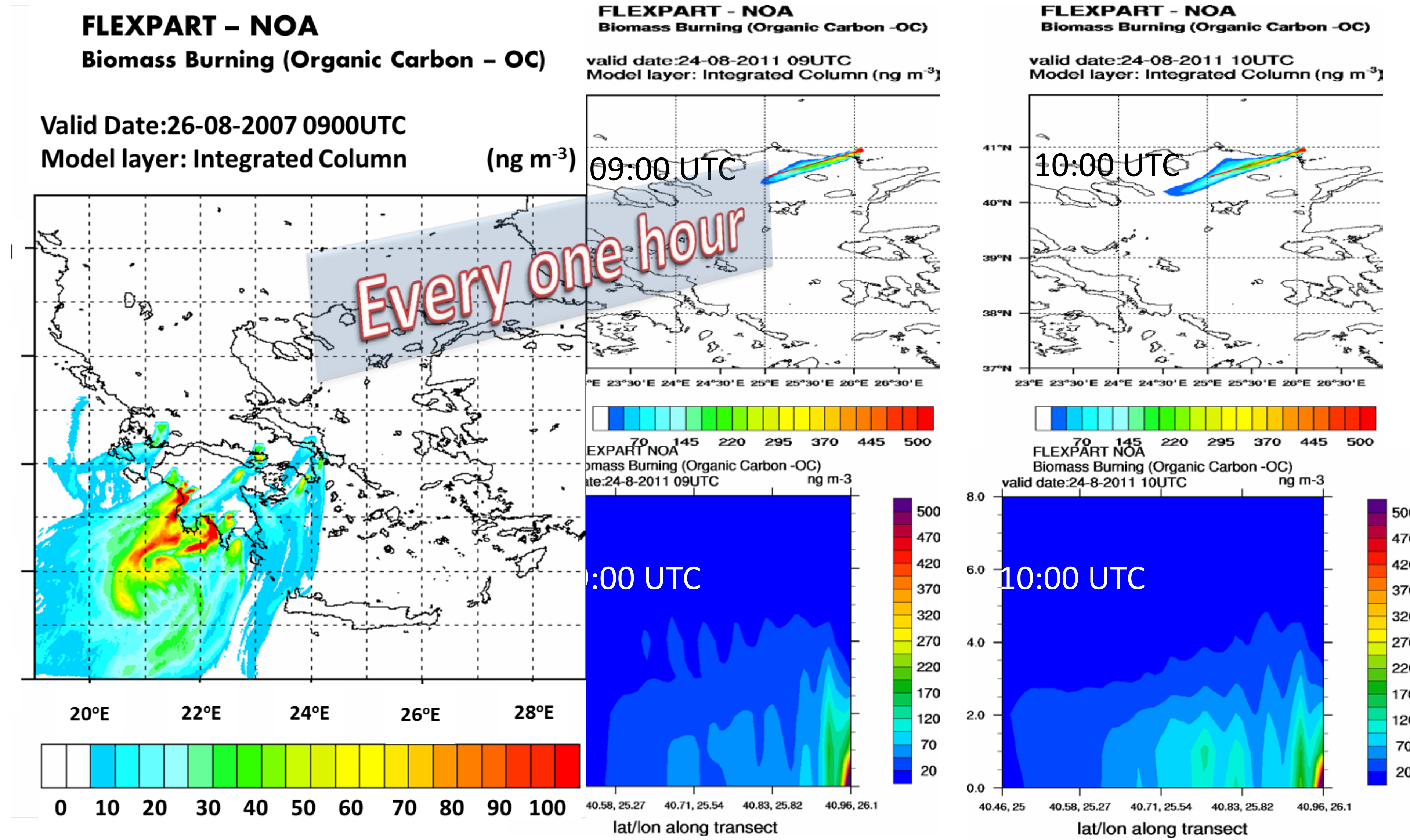

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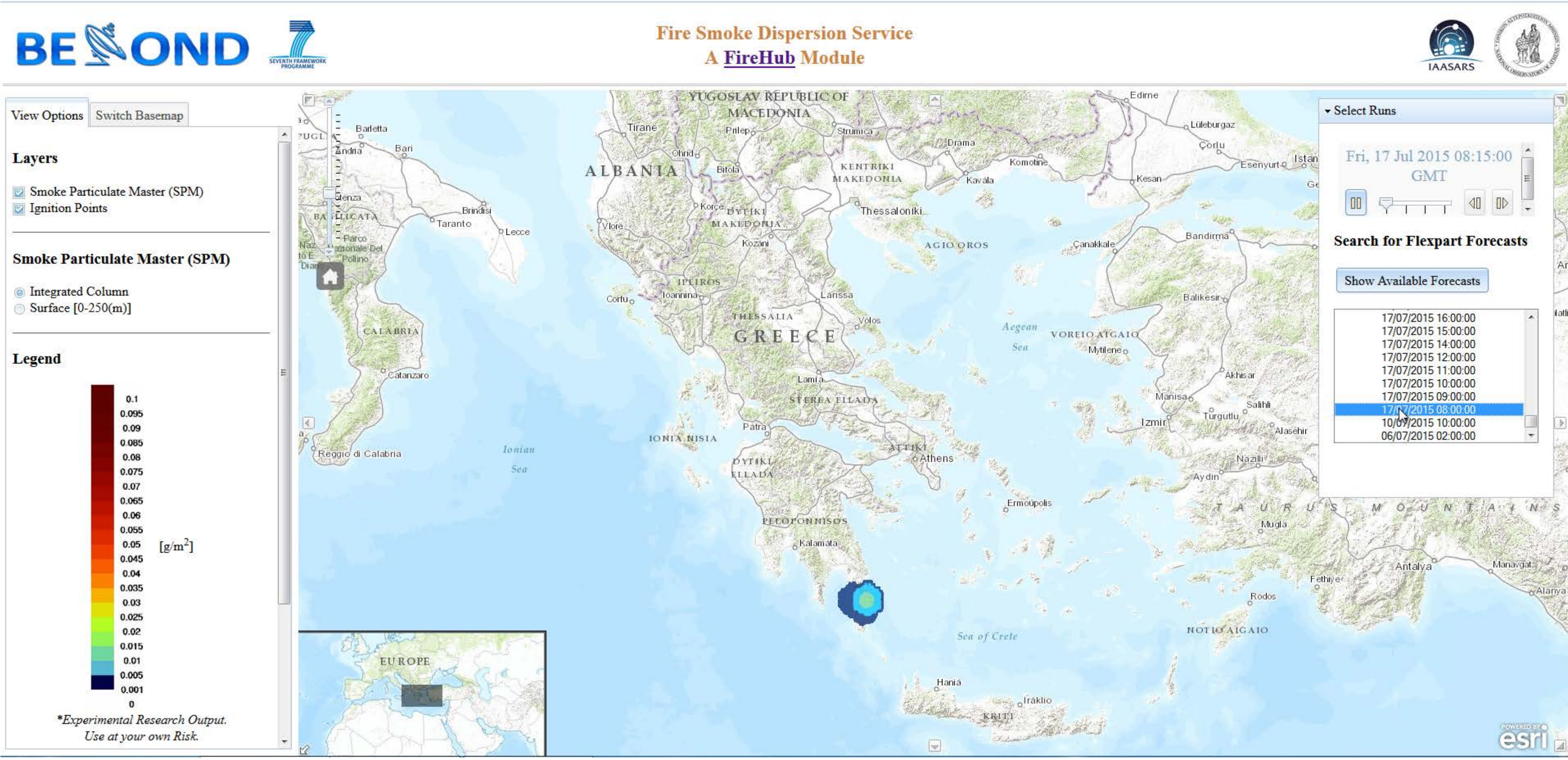

Rapid Mapping During Crisis - Off-line Mapping After Crisis

Fully Automatic Processing Chain

Applies to any type of High and Very High Resolution Satellite Data

(Landsat TM, SPOT XS, IKONOS, Formosat-2, Worldview, Quickbird)

Advanced Informatics Processing Languages

Array Data Base processing - SciQL

Scientific Python, ontology schemes and ontology based queries for linking open geo-spatial data (e.g. geo-names, administrative boundaries)

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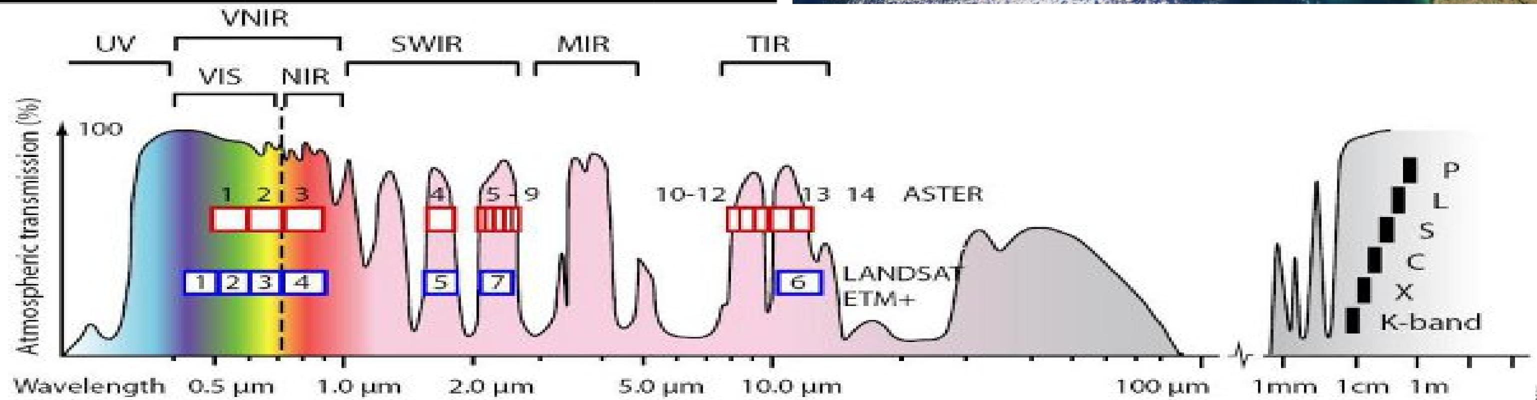
(Single/multi-date) Burn Scar Mapping from reflected Near - Mid Infrared radiation captured by multispectral sensor systems

Landsat-7 ETM+ Bands (µm)			Landsat-8 OLI and *TIRS* Bands (µm)		
			30 m Coastal/Aerosol	0.435 - 0.451	Band 1
Band 1	30 m Blue	0.441 - 0.514	30 m Blue	0.452 - 0.512	Band 2
Band 2	30 m Green	0.519 - 0.601	30 m Green	0.533 - 0.590	Band 3
Band 3	30 m Red	0.631 - 0.692	30 m Red	0.636 - 0.673	Band 4
Band 4	30 m NIR	0.772 - 0.898	30 m NIR	0.851 - 0.879	Band 5
Band 5	30 m SWIR-1	1.547 - 1.749	30 m SWIR-1	1.566 - 1.651	Band 6
Band 6	60 m TIR	10.31 - 12.36	*100 m TIR-1*	*10.60 – 11.19*	Band 10
			100 m TIR-2	*11.50 – 12.51*	Band 11
Band 7	30 m SWIR-2	2.064 - 2.345	30 m SWIR-2	2.107 - 2.294	Band 7
Band 8	15 m Pan	0.515 - 0.896	15 m Pan	0.503 - 0.676	Band 8
			30 m Cirrus	1.363 - 1.384	Band 9



Rapid Mapping During Crisis - Off-line Mapping After Crisis

BSM_NOA Pre- Processing

(1) Separate clouds from vegetation – Create water and shadow masks

(3) Perform sensor radiometric calibration and scene radiometric normalisation to create compatible time series of satellite image acquisitions for multi-date analysis

(4) Geo-reference the input satellite data using fully automatic image co-registration techniques with appropriate sensor geometric models

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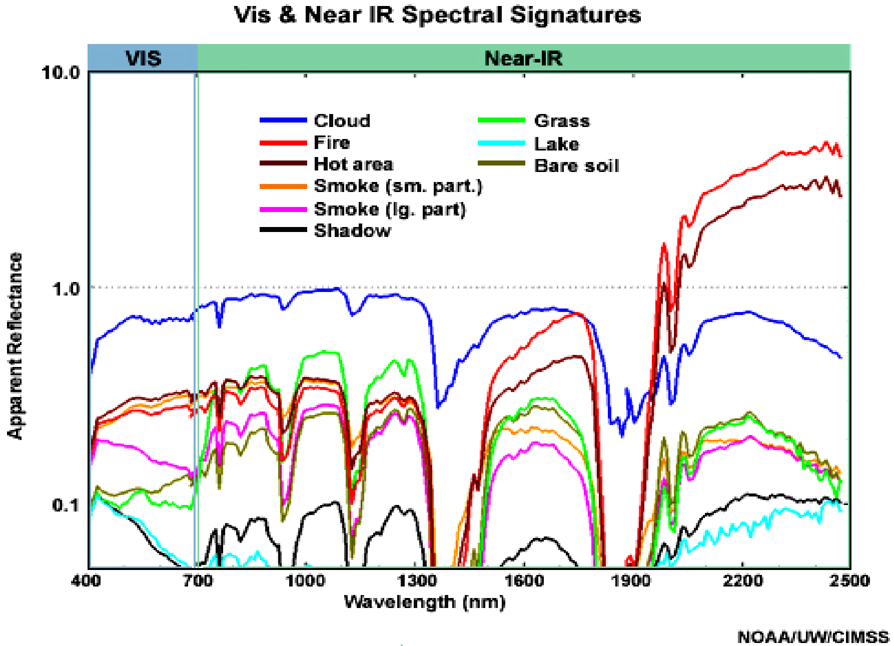
Rapid Mapping During Crisis - Off-line Mapping After Crisis

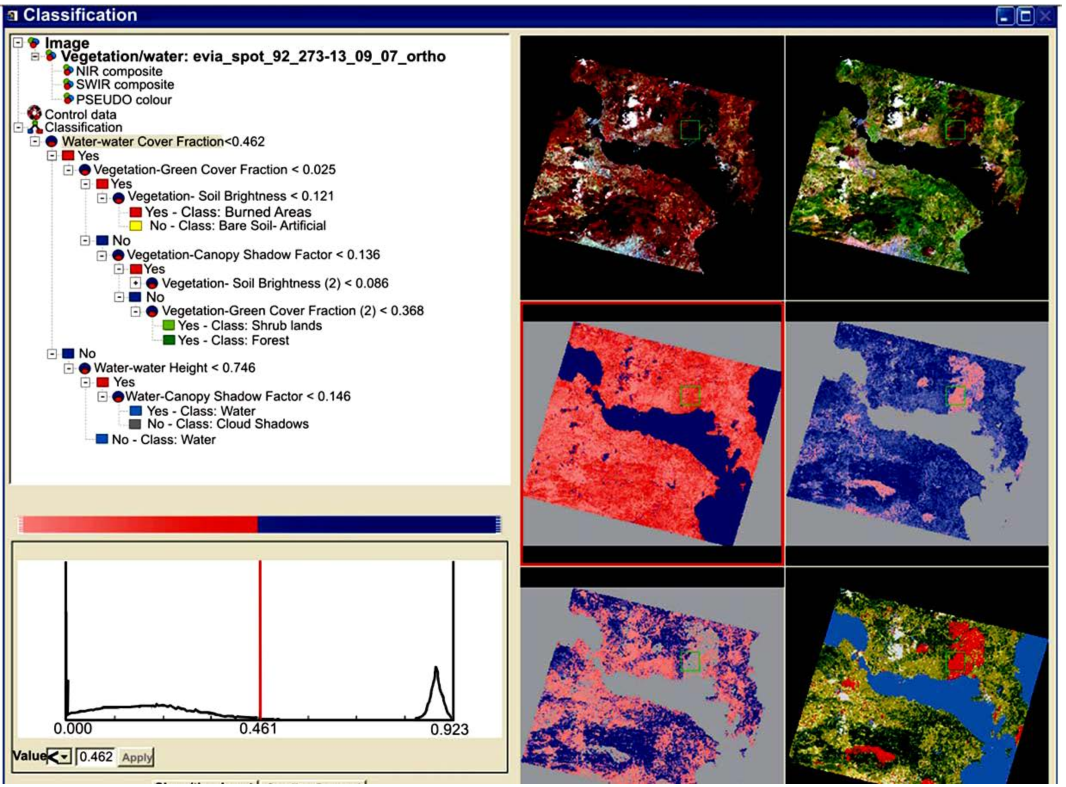


BSM_NOA Processing

(1) Generate band transformation indices

Normalised Burn Ratio Index, Albedo, NDVI, multi-date NDVI, NDVIdiff, multi-date derived Radiometric Change Vectors

(2) Define appropriate image /sensor/land use dependent threshold values and apply to the band transformation indices in order to: a) identify yearly changed from unchanged areas due to fire disasters and other ecosystem disturbances, b) identify burnt spectra on the image plane, and c) resolve for open, urban, and less vegetative areas' confusion



Rapid Mapping During Crisis - Off-line Mapping After Crisis

BSM_NOA Post Processing

(1) **Clean** from isolated pixels, and small area classification noise using a 3x3 smoothing kernel, and proceed with the join of small disconnected fire pixel clubs to larger segments (>1ha) . Filter out objects smaller than 1ha

(2) **Convert** raster fire classification layer to vector fire polygons and **smooth** the fire polygon boundaries to resolve from pixel effect

(3)**Apply** a series of geospatial reasoning queries in GIS using expert knowledge in order to generate refined classifications of Burnt Areas (based on knowledge extracted from over than 30 years of fire occurrence statistical observations)

(4)**Assign** attribute data to the fire vector polygons (administrative data, land cover data, toponyms, area (ha), perimeter, etc)

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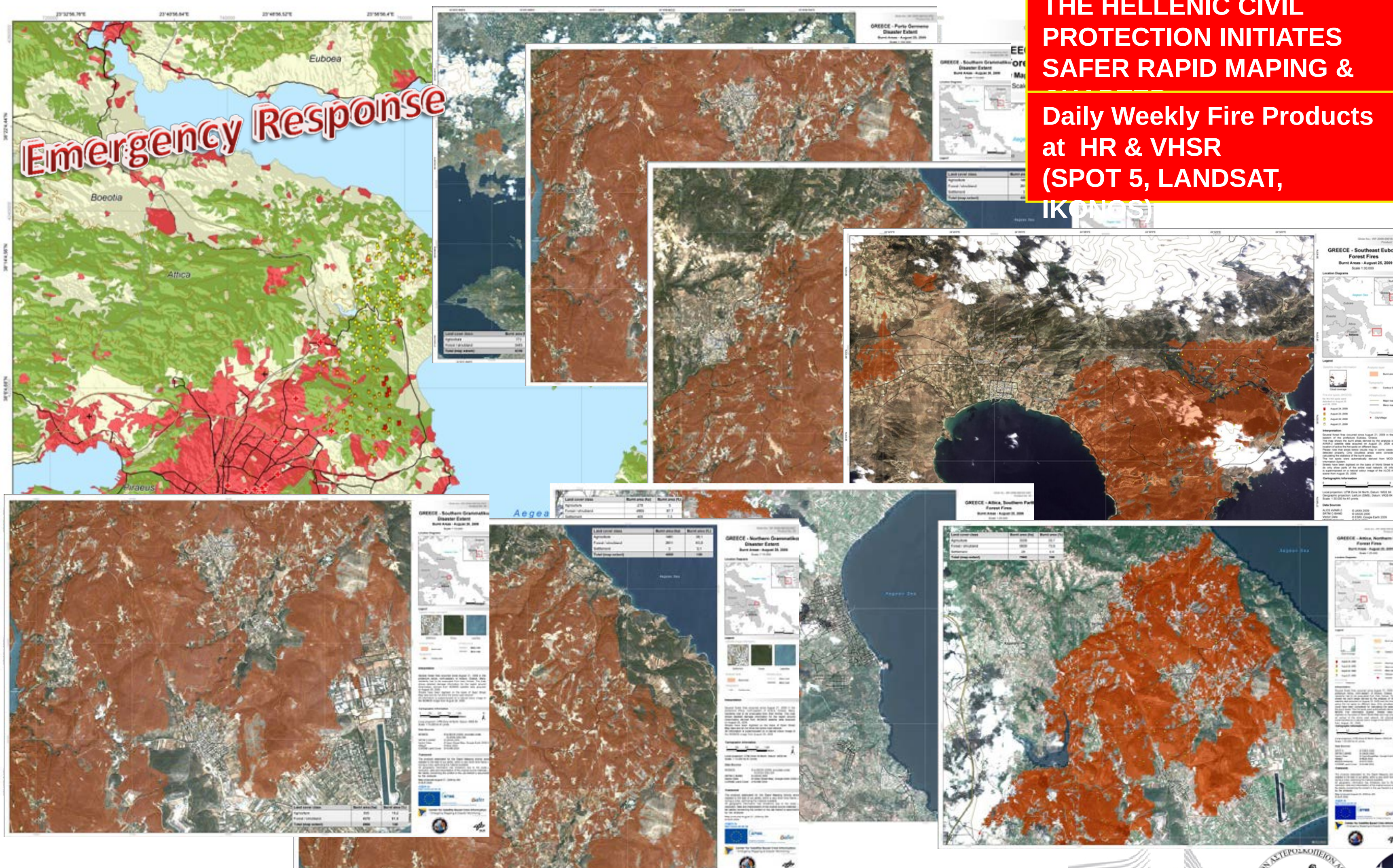
THE HELLENIC CIVIL PROTECTION INITIATES SAFER RAPID MAPING &

Daily Weekly Fire Products at HR & VHSR (SPOT 5, LANDSAT, IKONOS)



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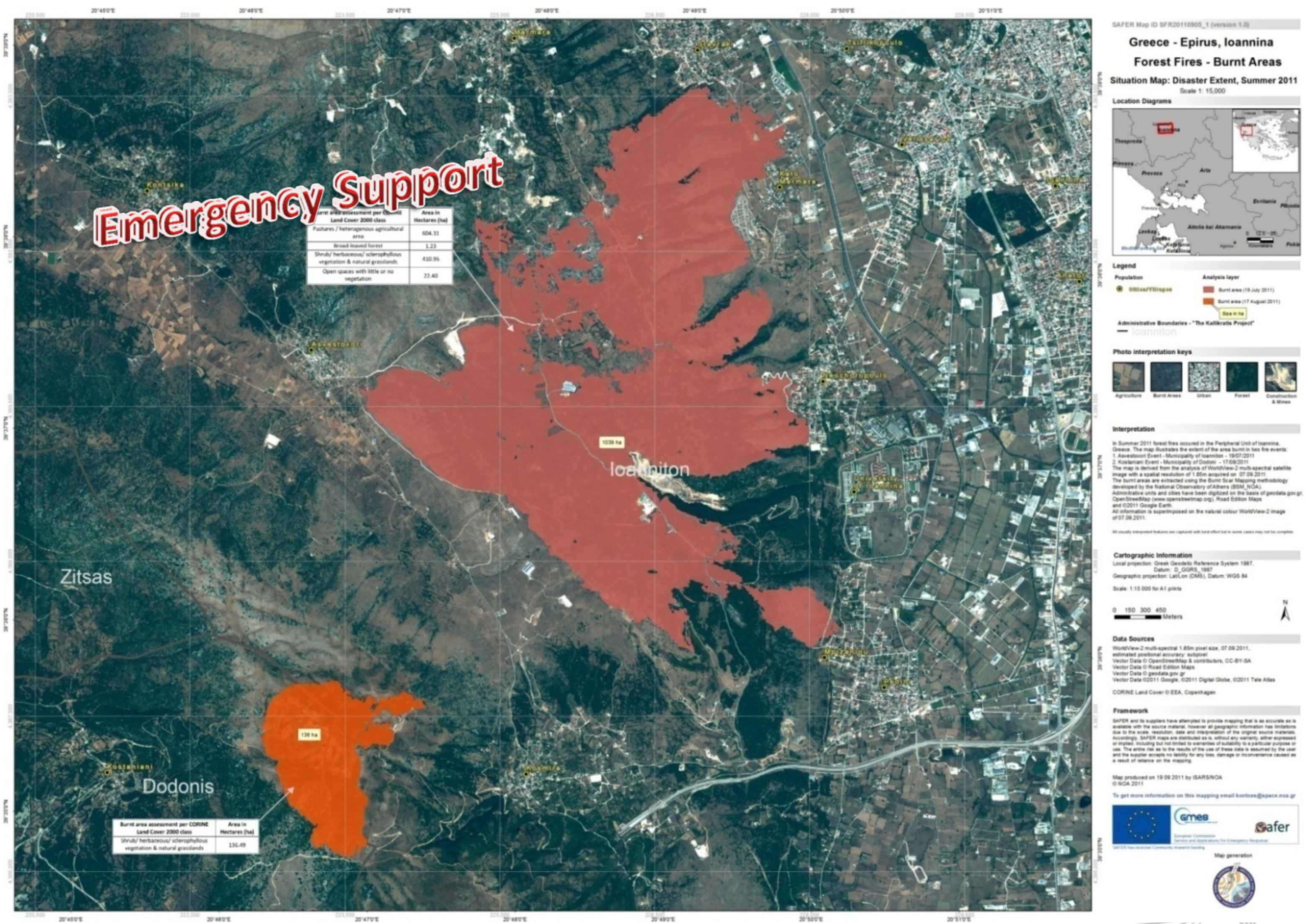
Emergency Support
Greece - Epirus, Ioannina
Forest Fires - Burnt Areas
Situation Map: Disaster Extent, Summer 2011
Zitsas
Dodonis
Ioanniton
Kostaniani
Burnt area assessment per CORINE Land Cover 2000 class | Area in Hectares (ha)
Pastures / heterogenous agricultural area | 604.31
Broad-leaved forest | 1.23
Shrub/ herbaceous/ sclerophyllous vegetation & natural grasslands | 410.95
Open spaces with little or no vegetation | 22.40
Burnt area assessment per CORINE Land Cover 2000 class | Area in Hectares (ha)
Shrub/ herbaceous/ sclerophyllous vegetation & natural grasslands | 136.49

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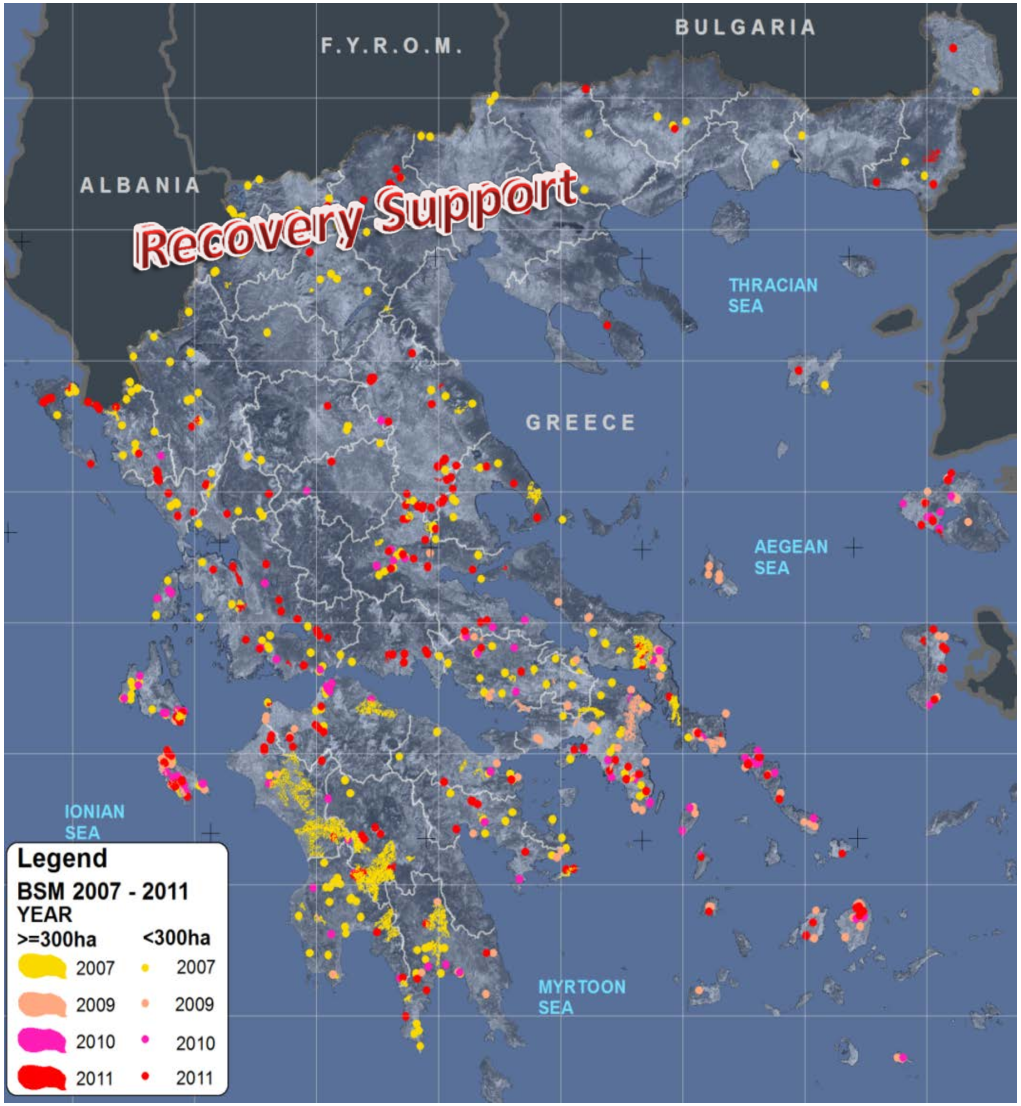

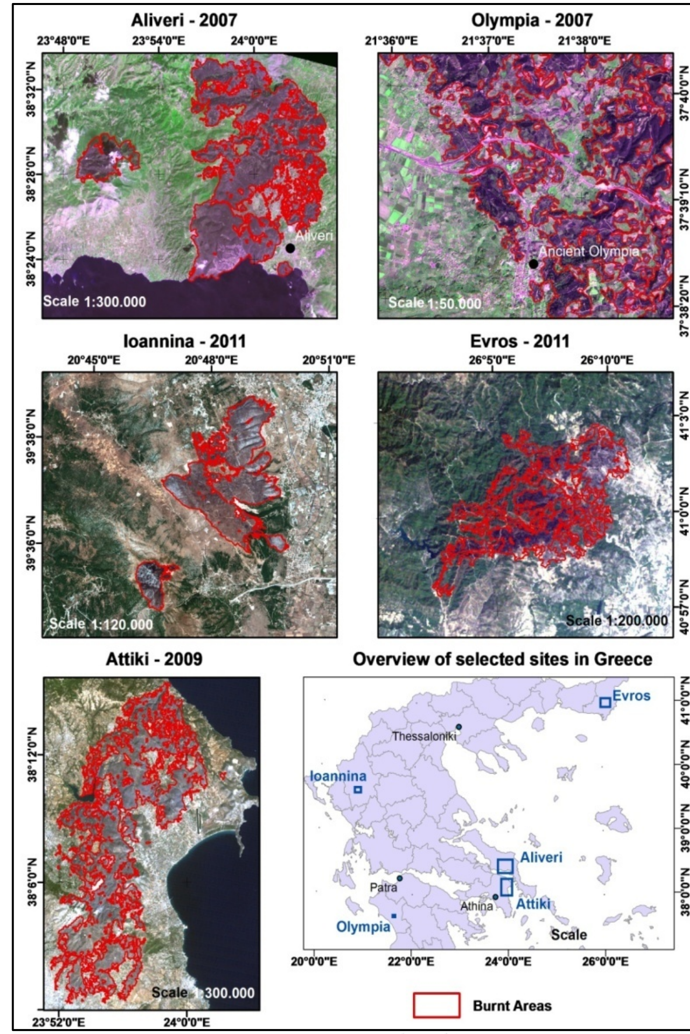

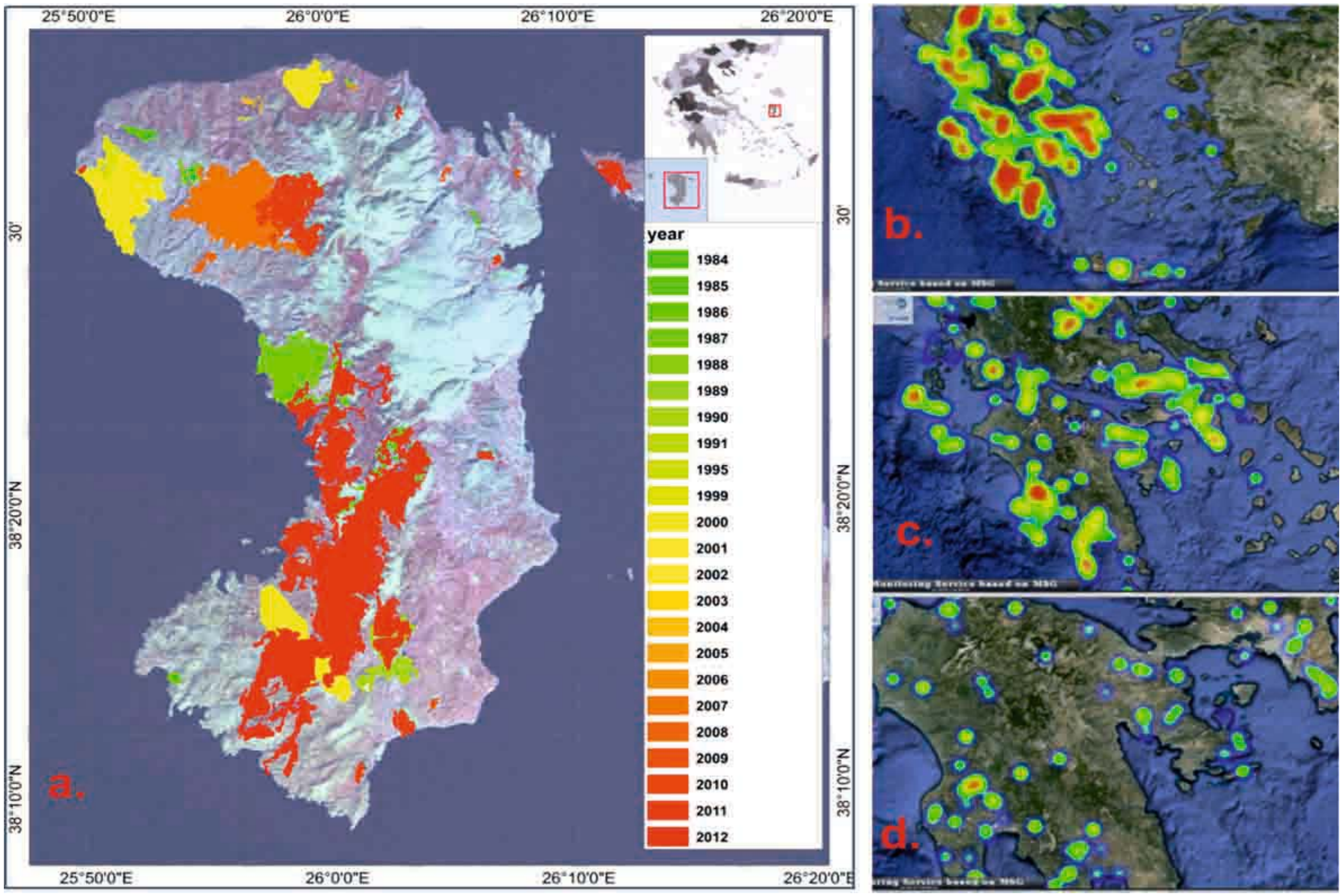

1) More than 700 Landsat TM images acquired over Greece in the period 1984-2014 residing on USGS archives were downloaded and processed fully automatically using the NOA processing chain.

2) Yearly maps of Burned Areas have been produced

3) Yearly statistics per land cover type and administrative data have been generated

4)On-line dissemination of the produced maps and statistics through the NOA's dedicated web interface

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Fire Validation Log files

ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ
ΥΠΟΥΡΓΕΙΟ ΔΗΜΟΣΙΑΣ ΤΑΞΗΣ ΚΑΙ
ΠΡΟΣΤΑΣΙΑΣ ΤΟΥ ΠΟΛΙΤΗ
ΓΕΝΙΚΗ ΓΡΑΜΜΑΤΕΙΑ ΠΟΛΙΤΙΚΗΣ ΠΡΟΣΤΑΣΙΑΣ
ΑΡΧΗΓΕΙΟ ΠΥΡΟΣΒΕΣΤΙΚΟΥ ΣΩΜΑΤΟΣ
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ΣΥΝΤΟΝΙΣΤΙΚΟ ΕΠΙΧΕΙΡΗΣΙΑΚΟ ΚΕΝΤΡΟ
ΥΠΗΡΕΣΙΩΝ ΠΥΡΟΣΒΕΣΤΙΚΟΥ ΣΩΜΑΤΟΣ

ΚΑΤΑΣΤΑΣΗ ΔΑΣΙΚΩΝ ΠΥΡΚΑΓΙΩΝ 01-08-2013

Α/Α	ΠΥΡ/ΚΗ ΥΠΗΡΕΣΙΑ	ΔΗΜΟΣ - ΚΟΙΝΟΤΗΤΑ	ΧΡΟΝΟΛΟΓΙΑ				ΚΑΜΜΕΝΗ ΕΚΤΑΣΗ (Στρέμματα)							ΠΡΟΣΩΠΙΚΟ					ΜΕΣΑ							
Α.ΕΓΓΡ			ΕΝΑΡΞ	Μ.ΕΛ.	ΕΛΓΧ.	ΚΑΤΑ	ΔΑΣ.	Δ.Ε.	ΑΛΣ.	Χ.Ε.	ΚΑΛ.	Γ.Ε.	Υ.Κ.	Π.Υ	ΠΕΖ	ΕΘΕ	ΣΤΡ	Α.Δ.	Π/Ο	ΟΤΑ	ΒΥΤ	ΜΗΧ	ΕΛΙ	ΑΦC	ΑΦΡ	ΑΦG
1		Δ. ΣΑΜΟΥ	21-07	23-07	30-07	01-08		600																		
154504	Π.Υ. ΣΑΜΟΥ	ΑΚΡΩΤΗΡΙ ΖΩΟΔΟΧΟΥ ΠΗΓΗ	15:15	09:15	09:20	08:00								20	46	60			7	20			1	4		
2		Δ. ΧΙΟΥ	25-07	26-07	29-07		1100			100		100		6					3							
154682	Π.Υ. ΧΙΟΥ	ΑΓ. ΙΣΙΔΩΡΟΣ-ΠΙΤΥΟΣ	11:25	19:05	20:50									45	22	100	10		15	5	6		1	5		
3		Δ. ΣΕΡΙΦΟΥ	25-07	26-07	30-07	01-08				300																
154696	Π.Υ. ΕΡΜΟΥΠΟΛΗΣ	ΣΚΛΑΒΟΓΙΑΝΝΗ	15:20	11:35	07:30	19:30								2	9				1	2			1	2		
4		Δ. ΣΕΡΙΦΟΥ	26-07	28-07	30-07	01-08				1000																
154772	Π.Υ. ΕΡΜΟΥΠΟΛΗΣ	ΑΓΙΑ ΜΑΡΙΝΑ	21:00	18:10	07:30	19:35								13	9				[illegible]	1	1		1	6		
5		Δ. ΡΟΔΟΥ	27-07	31-07				35000				3000		80					[illegible]							
154797	Π.Υ. ΡΟΔΟΥ	ΙΣΤΡΙΟΣ	16:10	11:30										1[illegible]	[illegible]34	7	7		39	7	3	5	5	8		
6		Δ. ΠΡΕΣΠΩΝ	29-07	29-07	01-08	01-08				50																
154896	Π.Υ. ΦΛΩΡΙΝΑΣ	"Μπέλα Βόδα"	17:15	23:00	07:00	14:00								[illegible]					8							
7	Π.Υ. ΤΡΙΠΟΛΗΣ	Δ. ΒΟΡΕΙΑΣ ΚΥΝΟΥΡΙΑΣ	30-07	30-07	31-07	01-08		165				[illegible]0														
154921	Π.Κ. ΑΣΤΡΟΥΣ	Ορεινή Μελιγού- Κοδέλες	11:35	21:00	17:00	18:00								34	14				14	2	2			3	2	
8		Δ. ΡΗΓΑ ΦΕΡΑΙΟΥ	31-07	31-07	01-08	01-08		5[illegible]		1[illegible]																
154987	2ος Π.Σ. ΒΟΛΟΥ (ΒΙΠΕ)	Αγ.Αθανάσιος	13:10	18:40	07:00	[illegible]0:00								16	17				7							
9		Δ. ΚΙΛΕΛΕΡ	31-07	[illegible]	[illegible]	[illegible]-08				20			80													
155032	1ος Π.Σ. ΛΑΡΙΣΑΣ	Δ.Δ. ΜΥΡΩΝ	23:50	[illegible]	[illegible]	0[illegible]30								2					1							
10		Δ. ΚΙΛΕΛΕΡ	[illegible]-08	[illegible]	[illegible]	[illegible]							50													
155038	1ος Π.Σ. ΛΑΡΙΣΑΣ	-	[illegible]:4[illegible]	[illegible]	[illegible]	07:25								2					1							
11	Δ.Π.Υ. ΗΡΑΚΛΕΙΟΥ	Δ. ΧΕΡΣΟΝΗΣΟΥ	[illegible]-08	[illegible]-08						110				3					1							
155044	Π.Κ. ΧΕΡΣΟΝΗΣΟΥ	Πεδι[illegible] Βολης [illegible]	[illegible]:13	19:30										18	12				7	3			1			
12	Δ.Π.Υ. ΛΑΡΙΣΑΣ	[illegible] ΦΑ[illegible]Α[illegible]Ν	01-08			01-08							30													
155053	Π.Κ. ΦΑΡΣΑΛΩΝ	[illegible]ΑΣ[illegible]	14:05			14:45								2					1							
13		[illegible] ΧΑΛΚ[illegible]ΔΟΝΟΣ	01-08	01-08		01-08				1	0.5		30													
155055	6ος Π.Σ. ΘΕΣΣΑΛΟΝΙΚΗ	ΞΗΡΟΧΩΡΙ	14:20	16:47		19:00								4					2							
14	Π.Υ. ΓΥΘΕΙΟΥ	Δ. ΚΥΘΗΡΩΝ	01-08											28	24				12	2	6					
155060	Π.Κ. ΚΥΘΗΡΩΝ	Κομινιάνικα- Αγία Ελλέσα	15:23											28	24				12	2	6			2		
15		Δ. ΚΙΛΚΙΣ	01-08	01-08	01-08	01-08				10	5		50													

1) 25-30% of the detected fires are reported 10 -15 minutes earlier than Fire Brigades logs

2) 60% of the detected fires, are reported in the first ~15 minutes after the ignition time stamp reported in the Fire Brigade logs

3) All the larger fires than the 112ha are completely detected without any omission

4) Smaller fires, that are in the range of [4.7ha - 112 ha] are 50% detected

5) The smallest detected fire has been of the order of 4.7 ha

6) The omitted fire detections, are summing up to the 5,8% of the total Burned Area. Omissions are caused mainly due to, a) cloud cover, b) fire intensity (e.g. small fires – small burned areas), c) area topography, and d) fuel characteristics (e.g. less vegetative areas, pasture lands, sparse vegetation resulting in low fire intensities)

7) The 82-85% of the 500mx500m cells which are assigned a high fire occurrence probability that is in the range of [6, 10], are located in the Burned Area Polygons

Future Updates

Real time integration of active fire and burned area evidences, as soon as they are depicted (captured) on the scenes of polar satellite systems acquired on the BEYOND X-/L-band acquisition station (EOS, NPP, NOAA/AVHRR, METOP)

Real time integration of in-field crowd source evidence (e.g. fire locations, and ignition points) returned from the Fire Brigade teams during crisis

Ingest the additional bits of evidence in an assimilation process for deriving more accurate FIREHUB assessments (fire occurrences)

Use mobile platforms for informing about the fire occurrences in addition to the web platform

Expand the FIREHUB concept to other hazards (Floods, & EQs)

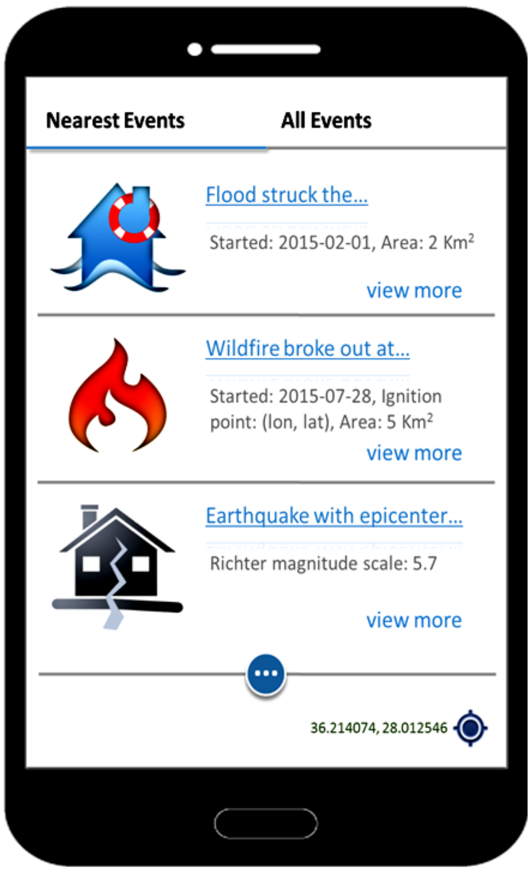
DisasterHub

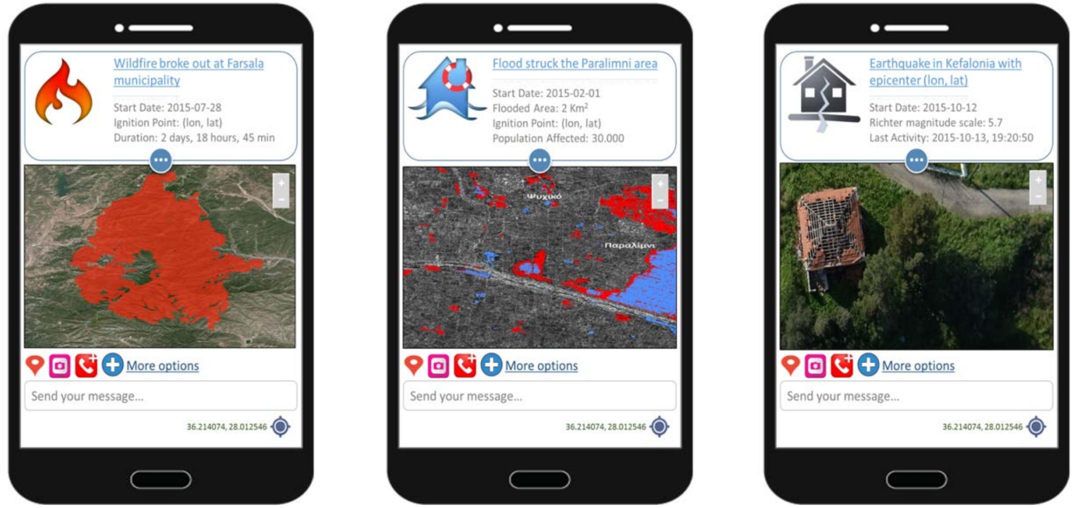
A mobile application for enabling crowd generated data fusion in Earth Observation disaster management services

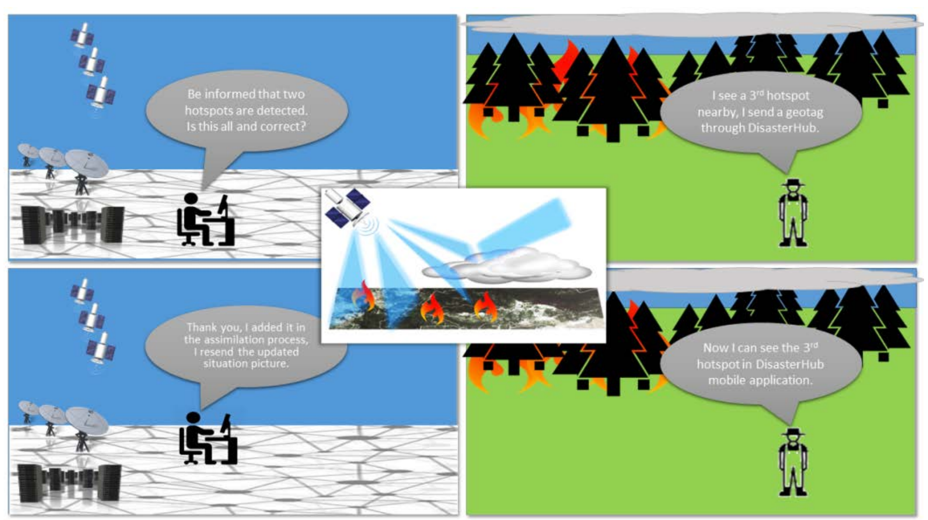
European Center of Excellence for EO based Disaster Management

BEYOND FireHub

DisasterHub







FireHub

A Space based Fire Management Hub

Thank you for your attention!

For more information

ocean.space.noa.gr/FireHub