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“Optical and Radar Copernicus data on the recording of burned areas in the Kalamos area (Attica) due to the fire of August 2017 - impacts on the flora, the area and the local climate"

Abstract

The fire in the area of Kalamos (Attica) in August 2017 left behind a large burned area and threatened to a large extent the local settlement. Events like this are very common, especially in the Mediterranean countries, where up to now, state mechanisms are not fully prepared to deal with them. The present project aims at recording the extent of the fire in Kalamos area through Copernicus optical and radar data, including its impact on the local settlement, the flora of the region and the local climate. Editing (using SNAP and ArcGIS software) and comparing the results of the two types of data (optical and radar) is taking place in order to clarify the best direct fire detection method. At the same time, a geological study of soils is carried out in order to identify how the soil type contributes to optimizing or not the recovery effort of the burnt area and in what way. The aim of the project is a) to map the burned area using Sentinel optical and radar data b) to compare the two satellite data (optical and radar) c) to measure the burned area and also d) the operational function of the sentinel data in corresponding events. The purpose is to capture the results and consequences of such an event in order to obtain the necessary data and conclusions for the optimal management of other similar phenomena around the world.

Introduction

Characteristic of the Attic landscape is its great diversity. There are many mountains, plains, valleys, basins and hills. The geological background and the climate are varied. Man's impact on this landscape has a long history, because there were settlements and intense grazing even during the prehistoric period. The history of human impact on the Attic landscape is divided into different phases of landscape modification. (Economidou E., 1993). Main characteristic of the Greek landscape (as a Mediterranean environment) is the frequent occurrence of fires. A wildfire or wildland fire is a fire in an area of combustible vegetation that occurs in the countryside or rural area (Cambridge Advanced Learner's Dictionary, 2008). Depending on the type of vegetation where it occurs, a wildfire can also be classified more specifically as a brush fire, bush fire, desert fire, forest fire, grass fire, hill fire, peat fire, vegetation fire, or veld fire (BBC Earth, 2015). Fossil charcoal indicates that wildfires began soon after the appearance of terrestrial plants 420 million years ago (Scott A. & Glasspool I., 2006). Wildfire's occurrence throughout the history of terrestrial life invites conjecture that fire must have had pronounced evolutionary effects on most ecosystems' flora and fauna (Bowman D. et all, 2009).

The forest fire season in Greece officially starts on May 1st and finishes at the end of October. However, serious fires are not expected, as a rule, before the end of June.

Wildland - urban interface fires in Greece

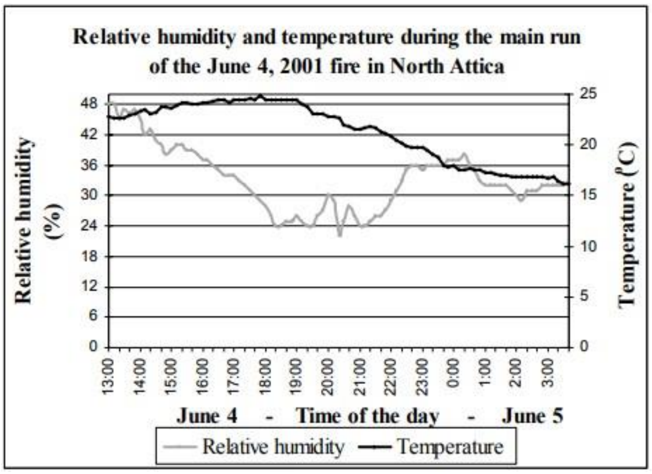
In order to put the specific Northern Attica fire in context, it is needed to develop an understanding of the evolution of the wildland-urban interface fire problem in Greece. Greece has a typical Mediterranean environment. Forest fires are a natural force in this environment, burning historically more than 0,2% of the country's forest land each year. However, until the early 1970s, although a firefighting infrastructure was nearly nonexistent, fire damages to houses were uncommon and limited. The same was true for loss of life (Xanthopoulos, 1988). The development of urban-wildland interface areas, either due to the expansion of large cities and due to the development of summer housing, started in the mid 1970s. This trend chronologically coincides with an increase in the number of forest fires and the yearly burned area, as well as with the beginning of significant losses in life and property. Loss of property, for a time, was surprisingly low, even during fierce wildfires (Xanthopoulos 1988). This was due to the traditional use of noncombustible materials for building of houses in Greece (concrete, bricks, stone, clay roof tiles etc.). Wood is seldom used for building of houses, except for certain specific uses (roof support frames, doors, window frames. etc.). However, as the number of houses grew it became impossible for the firefighting forces to defend all of them. As a result, damages to property started rising sharply (Xanthopoulos 2000). For example, a fierce 1981 fire in the north suburbs of Athens resulted in the complete destruction of at least two houses and partial damage to many others. These losses are surprisingly low, in view of the fact that this fire burned approximately 1120 ha of a wildlandurban interface area in addition to 550 ha of Pinus halepensis forest. Fifteen years later, a large fire in July 1995, on Penteli mountain near Athens, burned 6500 ha and also burned about 100 buildings, many of them homes. A second large fire on Penteli, in August 1998, burned 7500 ha, reburning most of the area that burned in 1995, and resulted in the destruction of even more houses and the death of one civilian (Xanthopoulos 2002). . Damage to property due to wildfires is not limited to buildings. Significant economic losses each year result from forest fires that burn agricultural lands adjacent to forests. Especially important are tree orchards which can be destroyed completely. Production loss of this type expands to the length of time necessary for reestablishment of each burned orchard. Olive (Olea europaea) tree orchards in particular are especially susceptible to complete damage because they are very flammable.

The June 4, 2001 fire in Northern Attica

Before the fire that is being studied in this work, the previous fire of great intensity took place in June 2001. The fire started on June 4, 2001, at 13:50, in the area of the municipality of Aulona, next to the National Road 1 (Figure 1). An electric power transformer may have been the cause but this could not be proven during the investigation that followed, so the cause has been listed as "unknown".

Figure 1. The location where the fire started, next to the National Road 1. Some burned shrubs are seen in the foreground. The electric power transformer suspected for causing the fire is visible at a distance in the middle of the photo (Xanthopoulos G. et all).

At Kalamos, the fire was delayed by sparse fuels and some firefighting effort. However, it finally crossed the asphalt road that links Kalamos to Kapandriti and continued in a SE direction, in a tall pine forest, driven by the NW wind. By dusk, just after 21:00, the fire approached the monastery of "Agios Simeon", in spite of various efforts to control the fire front. It had run 14 km from Sikaminos in approximately five and a half hours, exhibiting a rate of spread of 2,5 km/h, including the delay at Kalamos and the influence of firefighting efforts SE of Kalamos (Xanthopoulos et all.).



Graph 1. Relative humidity and temperature evolution during the main run of the June 4, 2001 fire, based on the NTUA weather data set (Xanthopoulos G. et all).

The total burned area, according to the official report and burn-map filed by the Forest Service Office (Dasarheio) of Kapandriti, reached 3.397 ha (Figure 3). This includes 994 ha of agricultural cultivations and 2.403 of forest vegetation. The latter includes 1.602 ha of regenerating forest and 235 ha of reforested forest. Only 182 ha of the forest land were private. The rest belongs to the State, as most forests in Greece.

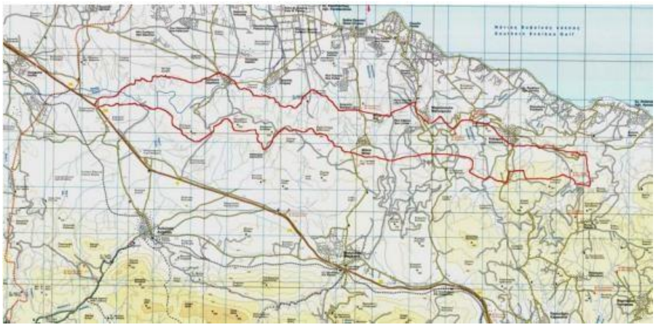


Figure 2. The final burned area of the June 4-5, 2001 fire in North Attica (Xanthopoulos G. et all).

The fire burned in a varying topography which ranged from near-flat to rolling hills of 20-40% slope. Slopes were steeper in only few locations and in general there were no "impossible" sites.

The August 13, 2017 fire in Kalamos area, Attica

The fire broke out on Sunday, August 13, 2017 at 4:30 pm and caused severe damage to dwellings scattered in an area consisting of a dense redeveloped forest. Indicatively, 150 firefighters with 68 vehicles, a hiking section of 58 people, 15 volunteers, 13 ODA (local authority) vehicles, 6 hydrophores of EYDAP (water service), 3 earthmoving machines, and two aircrafts plus two helicopters were carried out water drops. On Monday morning, on August 14, 2017, the flames had reached the Barnabas area in the direction of Kapandriti and Sessi Grammatiko, while houses that were scattered in the area turned into "ashes". In addition, for safety reasons, two children's camps with a total of 320 people and two camps, personnel and ammunition in the Kalamos area were evacuated. The wind constantly changes the direction of the fire, resulting in just before 6 o'clock in the afternoon of the same day reaching the boundaries of the settlement and entering the courtyard of the houses. At the same time, a large front of the fire headed towards the area of Kapandritiou, with the Fire Department not being able to stop. The high temperature developed by the burning of the dense forest creates a microclimate in the area, multiplying the wind's intensity and creating powerful upward flows, prevent air transport from falling too low and dropping while surface forces can not approach. Eventually, the fire expired on August 16, 2017. From the fire service's finding, it is relatively certain that the fire started from the pylons of the public electricity utility, as the inhabitants of the area had described (fireservice.gr).

Affected settlement

Basis on the data from the City Hall, 53 buildings (houses) were damaged, of which 14 were the first houses, which were subsidized with financial support.

State actions after fire

One and a half months after the fire, the relevant study was approved by the relevant public authorities, concerning flood and anti-corrosion projects. The projects that approved for Kalamos, Barnabas, Kapandriti and Polydendri Areas and implemented by the Region of Attica, are projects for anticorrosive protection of soil in an area of 8,500 acres and construction of about 340 small bridges in the catchment areas. Direct protection projects have a budget of 3 million euros. Also, in the framework of the overall actions for the anticorrosion and flood protection of the affected area, the construction of disaster prevention infrastructure and their maintenance for two years is being prepared, such as the construction of 20 larger dams from artificial gullies in streams of the affected area, as well as reforestation with endemic species of about 300 acres, areas that will not be regenerated with the natural process (mnec.gr).

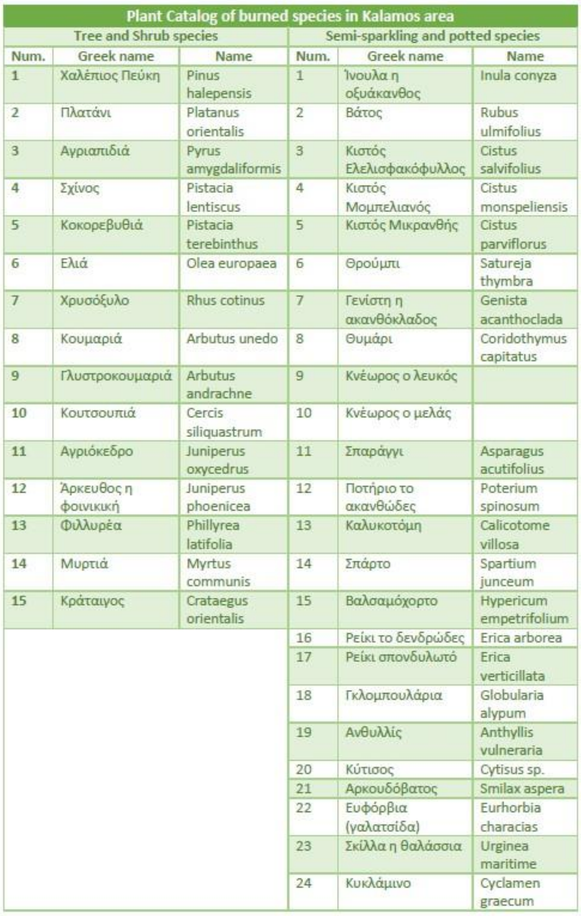
Direct effects of fire on ecosystems

The fire causes destruction of the biomass surface and a drastic reduction in the amount of organic matter at the surface of the soil. There are the beneficial effects of forest and biodiversity. There is loss of animal life and the destruction of a specific living environment of the species. Fire, also affects the physical and chemical properties of the soil. There is degradation of the soil with the loss of organic matter of nutrients and nitrogen. The hydrophobic substances pooled in the surface layer after the fire, affect the permeability of the soil and corrosion by the wind and the rain is enhanced. As a result, we have more drought and more surface run-off and erosion. Generally, the fires occurring in the Mediterranean pine ecosystems, apart from the direct consequences, create different conditions and a significant number of species use the conditions created to regenerate. Better conditions are created for legume species. The regenerative capacity of many species and pine trees is enhanced. In the pine forests, many plant species do not grow because of the dense layer of pine needles that falls into the soil and remains unchanged for a long time. The few species that come under the pine are bulbous, such as cyclamen (Cyclamen graecum, Cyclamen hederifolium) and orchids (Ophrys lutea, Ophrys tenthredinifera, Orchis italica, Orchis quadripunctata) and asparagus (Asparagus acutifolius) (Raison R.J., 1979).

Vegetation – Forest landscape in Kalamos area

Most forest species occurring at low altitudes in our country (eg. pine trees) are adapted to the fire and can recover immediately given that they have not been burned repeatedly in the recent past. Many times, these species may also benefit from the renewal resulting from a fire (Liapatis F. 2015).

The species that cover the area under consideration are presented in Table 1: Plant Catalog of burned species in Kalamos area. Over 85% of the plantation is covered with the species Pinus halepensis.



Plant Catalog of burned species in Kalamos area					
Tree and Shrub species			Semi-sparkling and potted species		
Num.	Greek name	Name	Num.	Greek name	Name
1	Χαλέπιος Πεύκη	Pinus halepensis	1	Ίνουλα η οξυάκανθος	Inula conyza
2	Πλατάνι	Platanus orientalis	2	Βάτος	Rubus ulmifolius
3	Αγριαπιδιά	Pyrus amygdaliformis	3	Κιστός Ελελισφακόφυλλος	Cistus salvifolius
4	Σχίνος	Pistacia lentiscus	4	Κιστός Μομπελιανός	Cistus monspeliensis
5	Κοκορεβυθιά	Pistacia terebinthus	5	Κιστός Μικρανθής	Cistus parviflorus
6	Ελιά	Olea europaea	6	Θρούμπι	Satureja thymbra
7	Χρυσόξυλο	Rhus cotinus	7	Γενίστη η ακανθόκλαδος	Genista acanthoclada
8	Κουμαριά	Arbutus unedo	8	Θυμάρι	Coridothymus capitatus
9	Γλυστροκουμαριά	Arbutus andrachne	9	Κνέωρος ο λευκός	
10	Κουτσουπιά	Cercis siliquastrum	10	Κνέωρος ο μελάς	
11	Αγριόκεδρο	Juniperus oxycedrus	11	Σπαράγγι	Asparagus acutifolius
12	Άρκευθος η φοινικική	Juniperus phoenicea	12	Ποτήριο το ακανθώδες	Poterium spinosum
13	Φιλλυρέα	Phillyrea latifolia	13	Καλυκοτόμη	Calicotome villosa
14	Μυρτιά	Myrtus communis	14	Σπάρτο	Spartium junceum
15	Κράταιγος	Crataegus orientalis	15	Βαλσαμόχορτο	Hypericum empetrifolium
			16	Ρείκι το δενδρώδες	Erica arborea
			17	Ρείκι σπονδυλωτό	Erica verticillata
			18	Γκλομπουλάρια	Globularia alypum
			19	Ανθυλλίς	Anthyllis vulneraria
			20	Κύτισος	Cytisus sp.
			21	Αρκουδόβατος	Smilax aspera
			22	Ευφόρβια (γαλατσίδα)	Eurhorbia characias
			23	Σκίλλα η θαλάσσια	Urginea maritime
			24	Κυκλάμινο	Cyclamen graecum

Table 1. Plant catalog of burned species in Kalamos area

As observed, there is a wide variety of tree planting, bushy, semi-lemon and herbaceous species. Halley pine (Pinus halepensis) plays a predominant role in the plant cover of Kalamos Attica with a percentage of 85%. Halley pine is a species that prefers more deeply alkaline to neutral soils and less deep soils, while avoiding cohesive clayey and encountering problems of good growth in shallow soils. Its seed is a cone.

They mature in the spring and the seeds fall from May to November and the cones usually remain in the trees, while others do not open for the release of the seeds and remain closed for two or more years. Also the seeds have a germination of about 90 - 95% lasting 4-6 years.

Mechanisms for adaptation of Mediterranean pine trees

The natural regeneration of the Mediterranean pine trees is enhanced by mechanisms of adaptation of the species to the fires. In general, these adjustments refer to:

- Seed protection mechanisms
- Maximize the availability of seeds after the fire
- Effective and uniform dispersion of the seeds with the wind after the fire
- Minimization of disasters after dispersal, and
- Excellence of germination of seeds (Thanos C.A. & Doussi M.A., 2000)

Geology in Kalamos area

From the geological point of view, the wider region of Kalamos, and the neighboring areas of Agioi Apostoloi, Kapandriti, etc., belongs to the Pelagonian section (According to N.I. Papanikolaou unreflected subselagenic and belongs to the H3 tertiary layer) and to a small piece of rock in the geological Unity of Olympus - Almiropotamou - Kerketeas (According to N.I. Papanikolaou H1 tertiary layer). In particular, the path followed by the fire consists of the lithologies described below:

In the upper strata of the area there are alternations of marigold limestone with marls, lagoon deposits, clay-marble formations, conglomerates with boulders and sometimes lignite deposits, aged of Ano Miocino, which have been classified as Neogene formations of Malakasa-Oropou. These layers at some points are covered by Pleistocene formations and Holocaust deposits. Subsequently, these formations come in disagreement with the pelagonal zone formations. The Pelagonian zone includes in its upper layers the Flyshi (fg) of the unit, which consists of alternating layers of aluminous shale and sandstone with sanding and limestone slabs of limestone. There are locally occurring intercalations of scallops with cruciferous lime and limestone. In following, there are limestones of upper Cretaceous, and limestones of Asprochorion, aged Middle-TriadicLower Jurassic. Between the two limestone rows are members of the great Iohellenic Tectonic Cloak.

The Iohellenic cover in the area of Attica, particularly in the wider region of Northeast Attica as it appears on the geological map of Eretria, appears firstly with masses of serpentinized peridotti (s), which is a superbasic rock, drenched on the Asbestos of Asprochorion. Volcanic sediments (ocean sediments, such as radiolarites, ceramic chalices, aluminous shale, and limestone miniaturized with pyrotellites accompanied by organogenic limestones of which found microfauna Liasias, usually enclosing Filaments and submarine spills of basic explosive rocks, mainly basalt, which have undergone intense spilitiosis and usually appear in the form of a pillow lavas. In Kalamos area there is a visible thickness of volcanosedimentary formations (b.sh) of about 50 m.

Following the stratigraphic sequence of Pelagonia's formations, we encounter the NeoHellenic tectonic cover. It is a splendid sequence, which includes schistos (sch), mainly muscovites, quartzites, subpopulations and carbonates with glabrous spots and often with marble (mr) and sipolines (sp). We often encounter metabasites and small serpentinite tectonic wedges. In the lower strata we encounter the indigenous unity of Almiropotamos, Attica.

This indigenous unity, Almiropotamos of Attica, which is a series of Mesozoic and Meso-neocene marbles, of a large thickness, with shale-like joints accompanied by metaphysical formations. In particular, it includes in the upper parts of the Slatom marbles, which are an extension of the marbles Marathon (Rafina leaf). They are mediumgrained, off-white to dark, with fine shades of slate and in places with sericity leaflets, karstic and strongly ducted, while in the lower parts there are Sheds (J.sch). These are parapets with low degree of transformation in the greenery phase, mainly muscovite, subchronic, chlorite, quartz and carbonate shale with interference of albite, muscovite and submissive angiospermites and gnusians.

Climate in Kalamos area

Before the start of the fire, the summer climate of August prevailed in the area, as was the case in the rest of the country. Two to three days after the fire, a sharp drop in temperature was observed by about 10 ° C (from 40 ° C to 30 ° C). The atmosphere was overwhelmed by a very sudden increase in the suspended particles, which spread to the wider area of Athens, causing local rainfall, which would not be the case if the Kalamus fire had not been caused. At the same time, there have been other changes that are characteristic of the tropical climate. Between 13th and 15th August the wind intensity is much lower than in the previous period. On August 13th, the day that the fire broke out in the area, we see increased wind intensity at midday hours and a sharp alternation with values from 6 to 9 knots in the evening. At midnight there is a sharp increase in wind and a sharp decrease at 6:00 in the morning of 14 August. The strong wind continued until the early evening, when at 9 am there was again no tension. From midnight until next night there was a very high wind intensity with a maximum of 16 knots at 9 am on the 15th of August. Strong winds continued until August 18, mainly in the morning until midday. The maximum wind intensity was 29 knots on August 13th, ie the date of the fire at 12 to 3 am.

High humidity occurs during the evening hours from August 9 to August 17. While from 18 August there is a significant reduction in humidity even in the evening hours. These changes were maintained for about two weeks in the region. Thus, the effect of the fire on the local climate is observed (National Meteorological Service).

The fire in the area of Kalamos (Attica) in August 2017 is the subject of study in this paper. The aim of the project is a) to map the burned area using Sentinel optical and radar data b)to compare the two satellite data (optical and radar) c) to measure the burned area and also d) the operational function of the sentinel data in corresponding events. The purpose is to capture the results and consequences of such an event in order to obtain the necessary data and conclusions for the optimal management of other similar phenomena around the world.

Description of Study Area

Kalamos (Greek: Κάλαμος) is a town and a former community in East Attica, Greece. Since the 2011 local government reform it is part of the municipality Oropos, of which it is a municipal unit (Kallikratis law). The municipal unit has an area of 44.878 km^2 (Population & housing census, 2001).

Kalamos is located 2 km from the South Euboean Gulf coast. The seaside village Agioi Apostoloi, 4 km to the east, is also part of the community of Kalamos. Kalamos is 4 km east of Markopoulo Oropou, 8 km north of Kapandriti and 36 km northeast of Athens.

Map 1. Map of Kalamos in Greece .peloponnisos.gr)

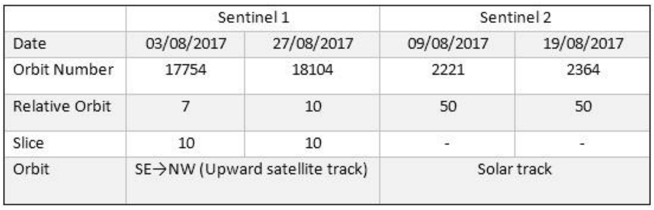
Kalamos is built in a verdant area of northeastern Attica, 39 km from the center of Athens. It is surrounded by important monuments and attractions. Among them is the priesthood of the Amphiaryio. Sights of the wider region are the Monastery of the Transfiguration of the Savior, which is placed in the 6th century AD. and the Byzantine temples of Agios Nikolaos and Agia Paraskevi The most important personality of Kalamos is Saint Timothy the Bishop of Evripos who is also the patron saint of the settlement.

After the liberation of the Greek state, Kalamos was temporarily renamed Perea and was the seat of the newly founded Municipality of Peraia. After 1840 the seat of the municipality became Oropos and after 1871 Skala Oropou (the municipality was renamed Omropion). In 1912 the Kalamos community was founded, with Kalamos, which included the seaside settlement of Agioi Apostoloi. The community was identified in a municipality in 2007. From January 1, 2010, Kalamos joined the new Oropos municipality. (Administrative Changes of Local Authorities).

Methodology

Three postgraduate researchers (two geologists and one environmental engineer) worked for this work.

The data used satellite images of ESA Copernicus Sentinel-1 & Sentinel-2 satellites. The pictures refer to shots before and after the fire. In particular, the image before the fire is taken on August 3, 2017 at 4:31 am (Sentinel-1-radar) and 9th August 2017 at 9:05 am (Sentinel-2-optical), the picture after fire takes place on August 27, 2017 at 4:31 am (Sentinel-1-radar) and on August 19, 2017 at 9:10 am (Sentinel-2-optical). Below are some basic data about satellite imagery.



	Sentinel 1		Sentinel 2	
Date	03/08/2017	27/08/2017	09/08/2017	19/08/2017
Orbit Number	17754	18104	2221	2364
Relative Orbit	7	10	50	50
Slice	10	10	-	-
Orbit	SE→NW (Upward satellite track)		Solar track	

Table 2. Data of Sentinel images

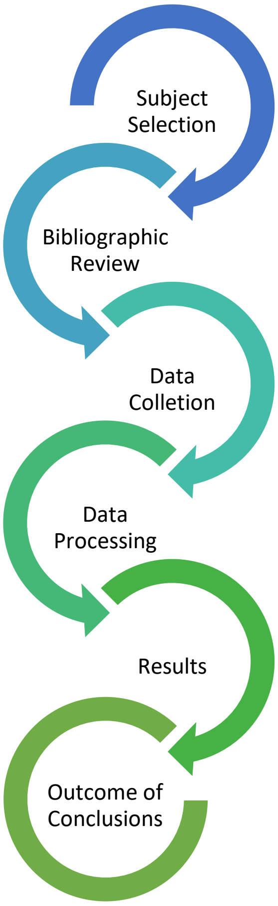
The ESA Snap v.6.0 open source software was used to process satellite images. In order to create, edit and export the final maps and results of the study area, was used the ESRI ArcGIS 10.4 software.

There was a visit to the forest archive (types of vegetation cover and a map of burned area with categorizations) and the town hall of the municipality of Oropos (elements of settlements - demographics) for the collection of data. At the same time climatic data from the National Meteorological Service and geological maps from GEM (Institute of Geological and Mining Research) were received. The land cover file for Greece in the year 2000, according to the European Union Corine program deliveries, was received from the official website (GEODATA.gov.gr).

Finally, there was a visit to the study area in order to take the appropriate pictures.

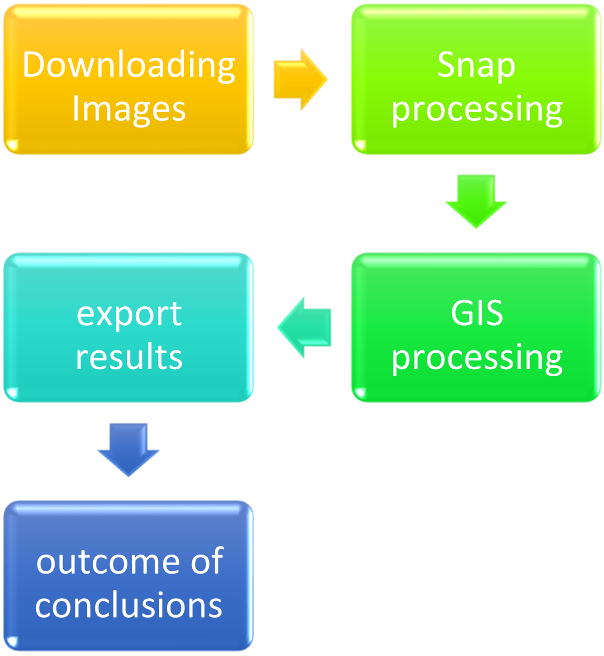
Flow Chart

The flow chart of the current project is:



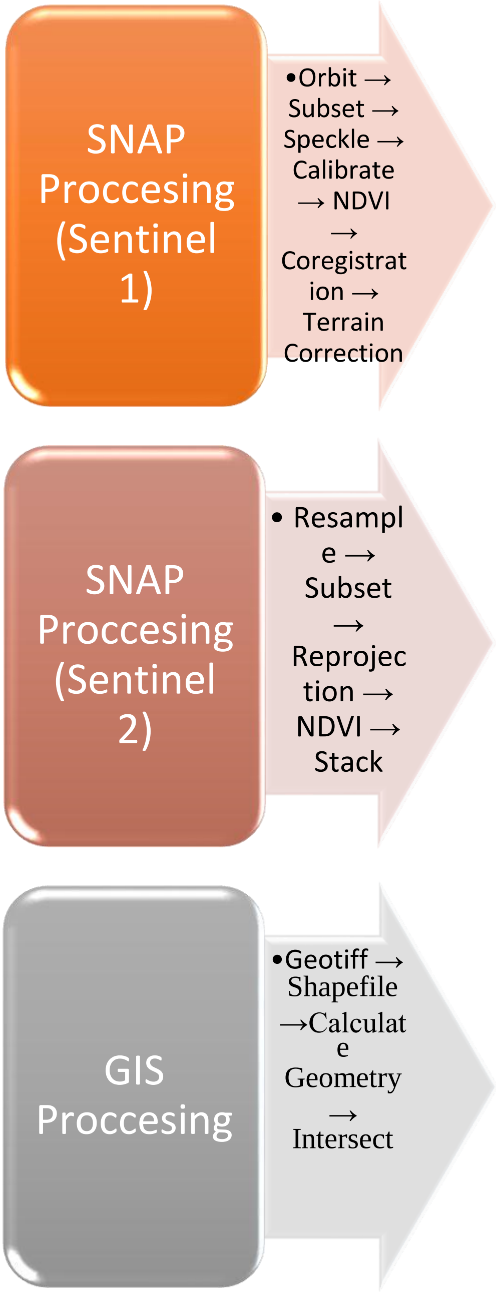
Flow Chart 1. Flow chart of this paper

The flow chart of image processing:



Flow Chart 2. The processing of satellite images

Flow Chart of every method:



Flow Chart 3. The steps of each processing separately

Normalized Difference Vegetation Index (NDVI) – Measuring Vegetation

To determine the density of green on a patch of land, researchers must observe the distinct colors (wavelengths) of visible and near-infrared sunlight reflected by the plants. As can be seen through a prism, many different wavelengths make up the spectrum of sunlight. When sunlight strikes objects, certain wavelengths of this spectrum are absorbed and other wavelengths are reflected.

The pigment in plant leaves, chlorophyll, strongly absorbs visible light (from 0.4 to 0.7 µm) for use in photosynthesis. The cell structure of the leaves, on the other hand, strongly reflects near-infrared light (from 0.7 to 1.1 µm). The more leaves a plant has, the more these wavelengths of light are affected, respectively.

Researchers can measure the intensity of light coming off the Earth in visible and near-infrared wavelengths and quantify the photosynthetic capacity of the vegetation in a given pixel (an AVHRR pixel is 1 square km) of land surface. In general, if there is much more reflected radiation in near-infrared wavelengths than in visible wavelengths, then the vegetation in that pixel is likely to be dense and may contain some type of forest. If there is very little difference in the intensity of visible and near-infrared wavelengths reflected, then the vegetation is probably sparse and may consist of grassland, tundra, or desert.

Nearly all satellite Vegetation Indices employ this difference formula to quantify the density of plant growth on the Earth — near-infrared radiation minus visible radiation divided by near-infrared radiation plus visible radiation. The result of this formula is called the Normalized Difference Vegetation Index (NDVI). Written mathematically, the formula is:

$$NDVI = (NIR - VIS)/(NIR + VIS)$$

Calculations of NDVI for a given pixel always result in a number that ranges from minus one (-1) to plus one (+1); however, no green leaves gives a value close to zero. A zero means no vegetation and close to +1 (0.8 - 0.9) indicates the highest possible density of green leaves (earthobservatory.nasa.gov).

What is Copernicus?

Copernicus is the European Union's Earth Observation Programme, looking at our planet and its environment for the ultimate benefit of all

European citizens. It offers information services based on satellite Earth Observation and in situ (non-space) data.

Copernicus has been specifically designed to meet user requirements. Based on satellite and in situ observations, the Copernicus services deliver near-real-time data on a global level which can also be used for local and regional needs, to help us better understand our planet and sustainably manage the environment we live in.

Copernicus is served by a set of dedicated satellites (the Sentinel families) and contributing missions (existing commercial and public satellites). The Sentinel satellites are specifically designed to meet the needs of the Copernicus services and their users. Since the launch of Sentinel-1A in 2014, the European Union set in motion a process to place a constellation of almost 20 more satellites in orbit before 2030.

Copernicus also collects information from in situ systems such as ground stations, which deliver data acquired by a multitude of sensors on the ground, at sea or in the air.

The Copernicus services transform this wealth of satellite and in situ data into value-added information by processing and analysing the data. Datasets stretching back for years and decades are made comparable and searchable, thus ensuring the monitoring of changes; patterns are examined and used to create better forecasts, for example, of the ocean and the atmosphere. Maps are created from imagery, features and anomalies are identified and statistical information is extracted.

The information provided by the Copernicus services can be used by end users for a wide range of applications in a variety of areas. These include urban area management, sustainable development and nature protection, regional and local planning, agriculture, forestry and fisheries, health, civil protection, infrastructure, transport and mobility, as well as tourism (Copernicus.eu).

Sentinel 1

Sentinel-1 carries an advanced radar instrument to provide an all-weather, day-and-night supply of imagery of Earth's surface. The C-band Synthetic Aperture Radar (SAR) builds on ESA's and Canada's heritage SAR systems on ERS-1, ERS-2, Envisat and Radarsat. As a constellation of two satellites orbiting 180° apart, the mission images the entire Earth every six days. As well as transmitting data to a number of ground stations around the world for rapid dissemination, Sentinel-1 also carries a laser to transmit data to the geostationary European Data Relay System for continual data delivery. The mission benefits numerous services. For example, services that relate to the monitoring of Arctic sea-ice extent, routine sea-ice mapping, surveillance of the marine environment, including oil-spill monitoring and ship detection for maritime security, monitoring land-surface for motion risks, mapping for forest, water and soil management and mapping to support humanitarian aid and crisis situations (esa.int).

Sentinel 2

Sentinel-2 carries an innovative wide swath highresolution multispectral imager with 13 spectral bands for a new perspective of our land and vegetation. The combination of high resolution, novel spectral capabilities, a swath width of 290 km and frequent revisit times provides unprecedented views of Earth. The mission is based on a constellation of two identical satellites in the same orbit, 180° apart for optimal coverage and data delivery. Together they cover all Earth's land surfaces, large islands, inland and coastal waters every five days at the equator. The mission mainly provides information for agricultural and forestry practices and for helping manage food security. Satellite images can be used to determine various plant indices such as leaf area chlorophyll and water content indexes. As well as monitoring plant growth, Sentinel-2 can be used to map changes in land cover and to monitor the world's forests. It also provides information on pollution in lakes and coastal waters. Images of floods, volcanic eruptions and landslides contribute to disaster mapping and help humanitarian relief efforts (esa.int).

Also, its satellite images will be used to determine various plant markers that are related to the presence of leaf chlorophyll and the water content.
The multi-spectral display (MSI) covers 13 spectral bands with spatial analyzes of 10 m (for 4 spectral channels in the visible and near infrared), 20 m (for 6 spectral channels in the mid infrared bands) and 60 m (for 3 channels for atmospheric corrections) (Parcharidis I., 2015).

Processing Sentinel 1: Radar

By opening the image, it is observed that it has another non-geometric perspective.

Step 1: The metadata of the image is updated, because after some time, it is very likely that there will be added new data, which is necessary to update. The command followed is:

Radar → Apply Orbit file

Step 2: Focus on the area of interest. Due to the large size of the images, it is necessary to cut (easier to manage / reduce MB). The command followed is: Raster → Subset

Step 3: Then there is a correction (reduction) of noise.
Radar → Speckle filtering → Single product speckle_filter.
The refined lee filter is selected as the most suitable for this process.

Step 4: Gray gradients are created in the so-called "Calibration" of the image.

Radar → Radiometer → Calibrate

Step 5: The next step is the application ofan algorithm for the normalized difference vegetation index (NDVI).

Optical → Thematic land processing → Vegetation radiometric indices → NDVI processor *Step 6:* As a next step, superposition (placement of the images on top of each other) takes place in order to match the corresponding pixels. In this way, we have information about the differences that the area under consideration has experienced, depending on the time taken for each of the images.

Radar → Coregistration → Coregistration

After the Coregistration command, the image with the RGB categorization is displayed (R & G only in the study before and after the fire). If there is no change between the two images, everything is shown in yellow. In the case of changes, it excels the color of the image where it underwent the change.

Step 7: Finally, the geometric correction of the image takes place in order to move to a geographically correct position.

Radar → Geometric → Terrain correction → Range Doppler terrain correction

Sentinel 2: Optical

For the presentation of the images, we choose projection into a pseudo-chromatic nearby infrared, where the foliage of plants is better represented because of its high reflectivity.

R → B8

G → B4

B → B3

Step 1: Images are imported. 1C processing (almost finished product) has already been done.

Step 2: Resample is applied to the image, at 10 m, because the visual images are composed of several spectral channels of different spatial resolution. With this action, all channels acquire a common spatial resolution. Raster → Geometric operations → Resampling

Step 3: In order to reduce the size of the image, as well as its geometric and geographic correctness, the following are made:

Raster → Subset

Raster → Geometric operations → Reprojection

(in the aforementioned order)

Step 4: For the emergence of vegetation, the NDVI indicator is applied. This gives a better picture of the burned area.

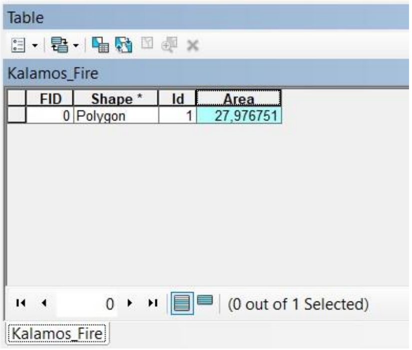
Optical → Thematic land processing → Vegetation radiometric indices → NDVI processor Step 5: The two images (resulting from the above process) are merged into one, and the stack command is used.

Radar → Coregistration → Stack tools → Create stack

As a master, the image is set before the fire and as a slave the picture after it. When viewing, the master is in red, in green the slave and in blue nothing is recorded.

GIS processing

Snap image is imported into a geo-referenced image (Geotiff). It is introduced into ArcGIS and then a shapefile is created with the editor, including the burnt area. A new field is created with the name Area in the Attribute table and using the calculated geometry command from Attribute table the burned area is calculated at 27.97 → 28km^2.



Table

Kalamos_Fire

FID	Shape *	Id	Area
0	Polygon	1	27,976751

(0 out of 1 Selected)

Then having already the shapefiles from Corinne and the geology of the area, it becomes intersect with the shapefile of the fire. The final product is the features that were required but only for the extent of the fire.

Results

Pictures of Kalamos area after fire:

Figure 3. Picture of Kalamos area after fire

Figure 4. Picture of Kalamos area after fire

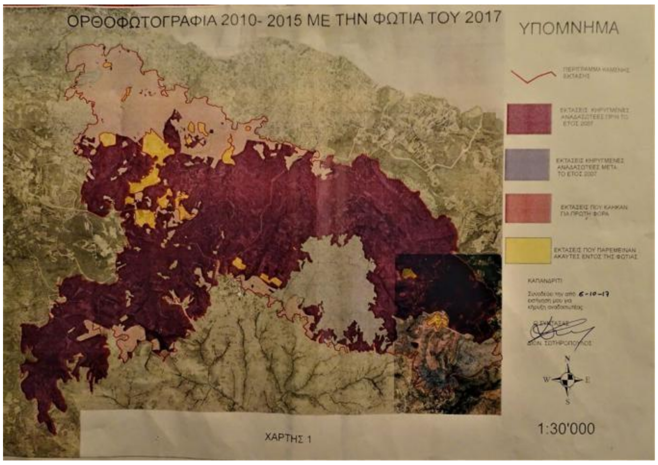
Figure 5. Picture of Kalamos area after fire

Figure 6. Picture of Kalamos area after fire

Figure 7. Picture of Kalamos area after fire

Figure 8. Picture of Kalamos area after fire

Map of land distribution:



Map 2. Map of land distribution (forest archive of Kapandriti) after fire in Kalamos area (August 2017)

- Areas declared reforestrated before the year 2007: ≈ 60%
- Areas declared reforestrated after the year 2007: ≈ 15%
- Land burned for the first time: ≈ 20%
- Land that remained unburned in the burned area:≈ 5%

The Snap Sentinel 1 Procession, produced the following images:

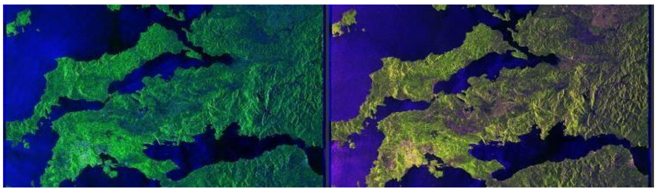


Image 1. The radar images from Copernicus Hub Access (before and after fire)

The image as downloaded from Copernicus Hub.

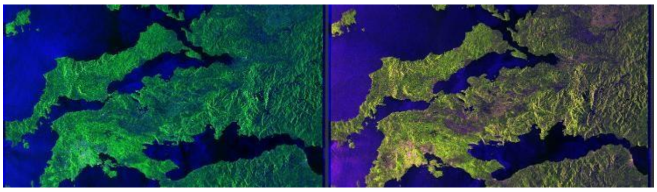


Image 2. Orbit (before and after fire)

Image 3. Subset (before and after fire)

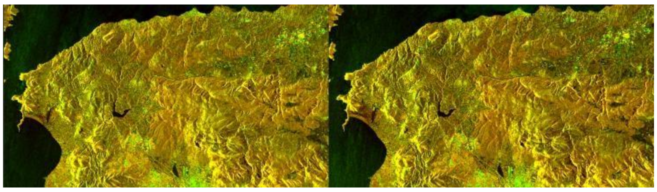


Image 4. Speckle (before and after fire)

Image 5. Calibrate (before and after fire)

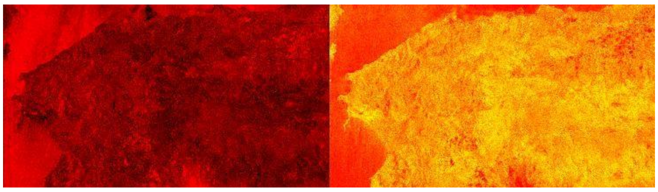


Image 6. NDVI (before and after fire)

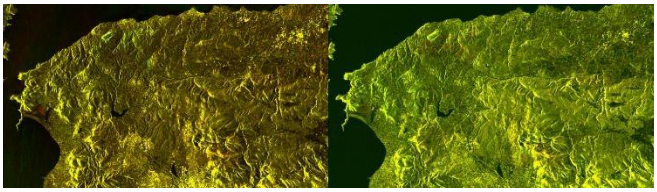


Image 7. NDVI VV(right, after fire, green) and VH (left, before fire, red)

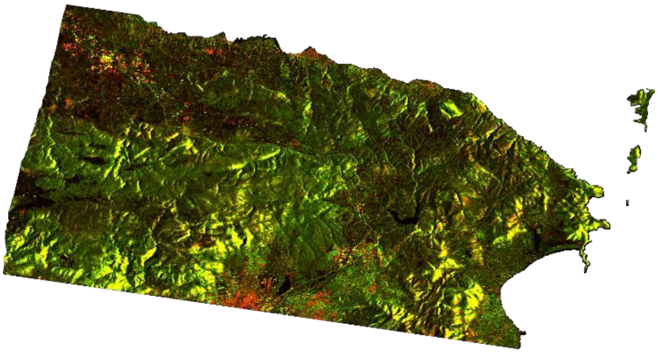


Image 8. Final Image in VV polarization

The final radar image from Sentinel 1, with VV polarization. The VV polarization has been selected in order the capture to be more noticeable.

The Snap Sentinel 2 Procession, produced the following images:

Image 9. The optical images from Copernicus Hub Access (before and after fire)

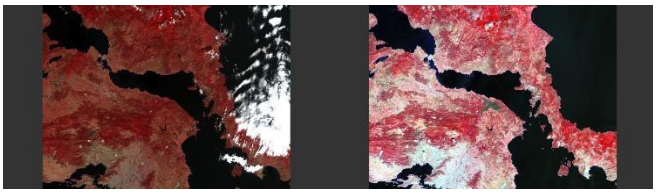


Image 10. The optical images from Copernicus Hub Access (before and after fire) in infrared for better mapping of vegetation

The infrared leads to better mapping of vegetation, so that's selected for capturing.

Image 11. Subset & Resample (before and after fire)

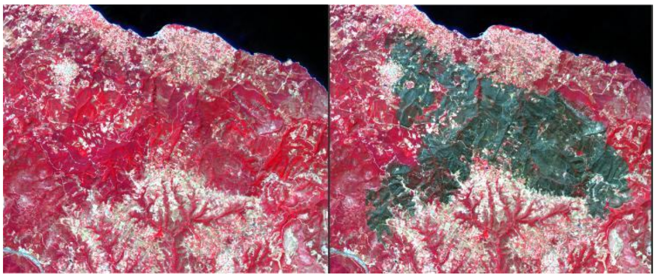


Image 12. Subset & Resample (before and after fire) in infrared for better mapping of vegetation

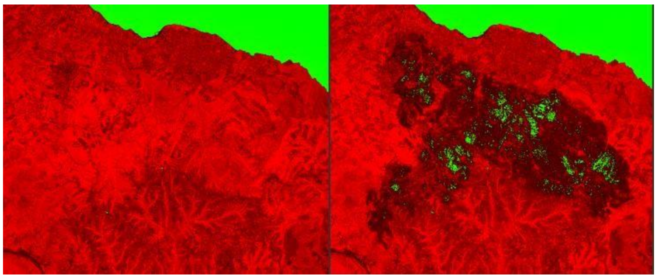


Image 13. NDVI index (before and after the fire)

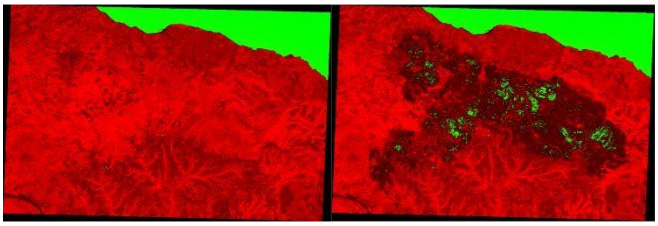


Image 14. NDVI Reprojection (before an d after the fire)

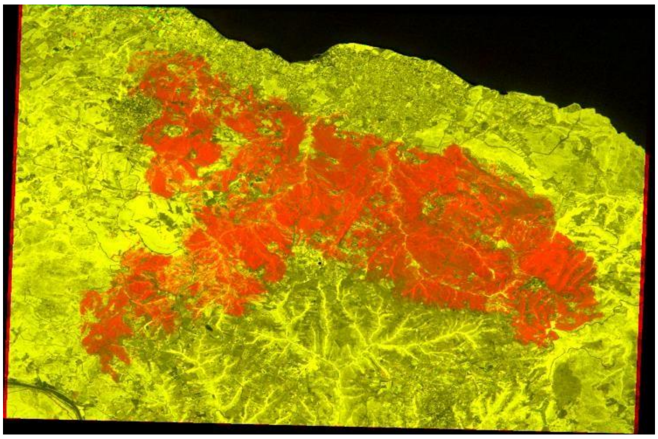
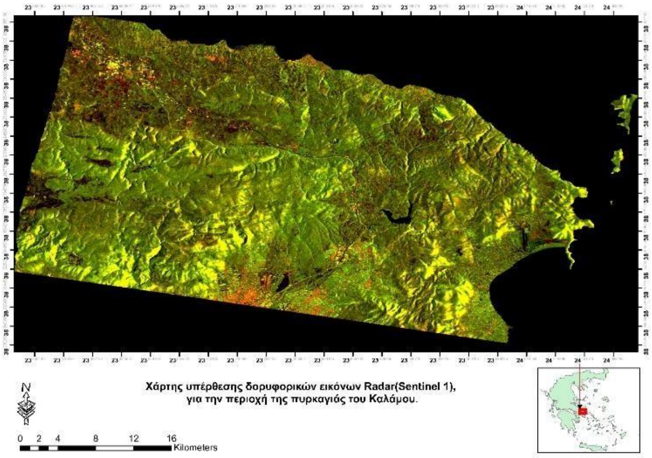


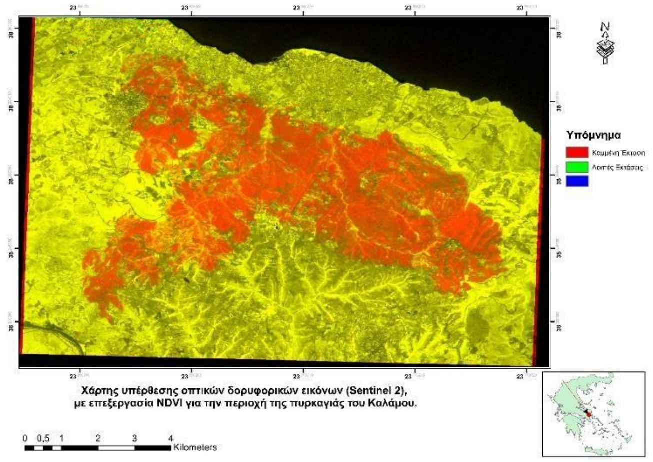
Image 15. Stack final image (after fire)

The final optical image from Sentinel 2.

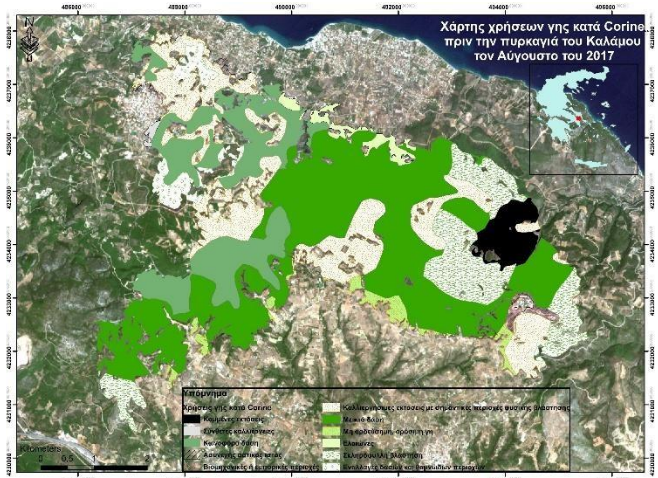
The GIS Procession, produced the following images:



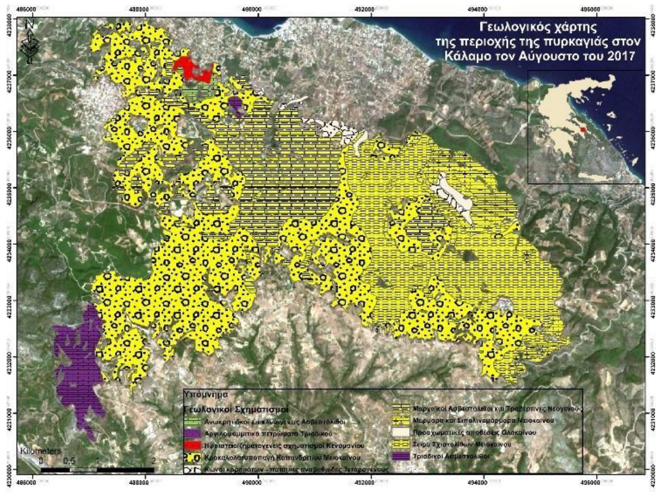
Map 3. Map overlay of satellite data Sentinel 1 for after fire kalamos area



Map 4. Map overlay of satellite data Sentinel 2 for after fire Kalamos area



Map 5. Land use Corine map before the fire in August 2017 in the Kalamos area



Map 6. Geology map of Kalamos area

Discussion – Conclusions

From the above procedure, some interesting conclusions emerge.

Initially, looking at the distribution map (map 2), it is observed that in the burnt area, a percentage of about 5% has remained incombustible. Scattered small unburned areas appear in the entire burnt area. This may be due to factors such as slope, road network, hydrographic network, etc. Looking at these areas one by one it is noticed that they relate to areas such as canyons, mountain peaks, areas surrounded by paths and areas delimited by anti-fire zones. So, those places could not be reached by fire. It is certainly an observation that requires further investigation, mainly because conclusions are likely to be drawn in order to lead to optimal forest management (how to deal with fires).

As far as the effects of radar and optical data are concerned, comparing them, everyone understands that the capture of the radar image produces no visual effect. Only visual imaging clearly shows the burnt area.

Optical data from the Sentinel 2 satellite is more effective for assessing and recording the event, as the incidence of burned area is more distinct.

Unlike radar data equipped with Sentinel 1, no difference can be detected between the image before and after the fire. This is because the trees were burnt, but they still exist as entities.

With the Sentinel 2 optical media, the extent of the burned area is clearly distinguishable and accurately displayed. This is not only due to the black-brown color of the burned area in relation to the green surroundings of healthy plants but also to the property that the plant foliage reflects the nearby infrared. Thus, in false-infrared viewing, this difference is clearly visible.

Thus, radar images are considered unsuitable for phenomena such as fires, while the use of visual images is considered to be the most appropriate method for use in corresponding phenomena.

In addition, with the GIS method was mapped and measured the burned area (28 km^2).

The fire in the Kalamos area had devastating effects, both in the ecosystem and in the local settlement. Houses, trees and animals were burned, and there was a change in the local climate, as tropical features appeared shortly after the fire and affected the rest area of Athens.

Nonetheless, the state mechanism has strengthened the affected people, and has taken care to protect the area by floods (although there has been a little delay).

At the same time, the burnt forest is able to reforest naturally, since the pine cones (the main species in the area) had not been able to open the seeds this time of year.

In conclusion, it is considered that the methods used (with the exception of data radars) contributed to the achievement of the objectives set out in this paper.

This work is a concise study and there is certainly much more to be done in the future to draw further conclusions.

Acknowledgement

We would like to thank all those who helped us to accomplish this work.

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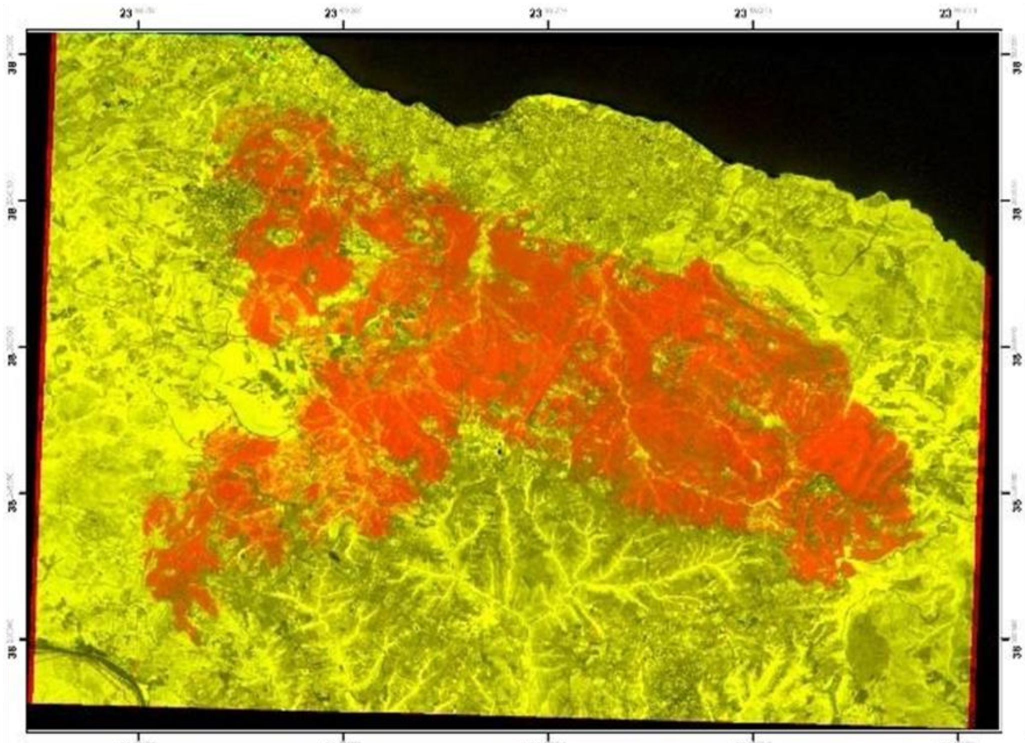
www.mnec.gr



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"Optical and Radar Copernicus data on the recording of burned areas in the Kalamos area (Attica) due to the fire of August 2017 – Impacts on the flora, the area and the local climate"

Overlay map of optical images (Sentinel 2) with NDVI process for the Kalamos burned area

Legend

🟥 Burned area
🟨 Rest (unburned) area

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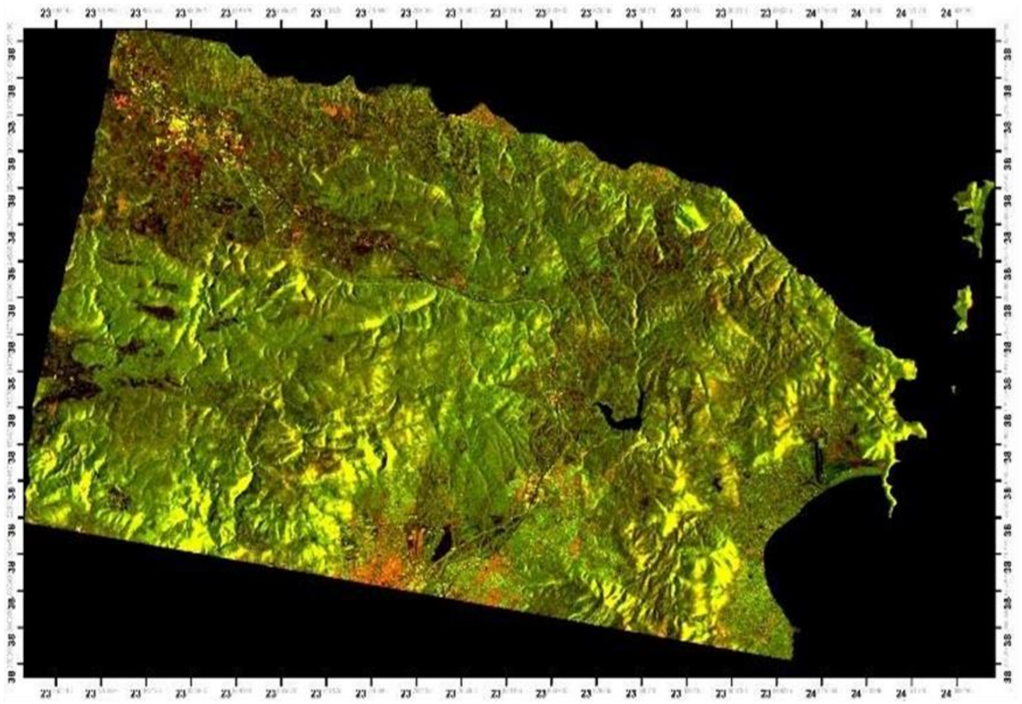

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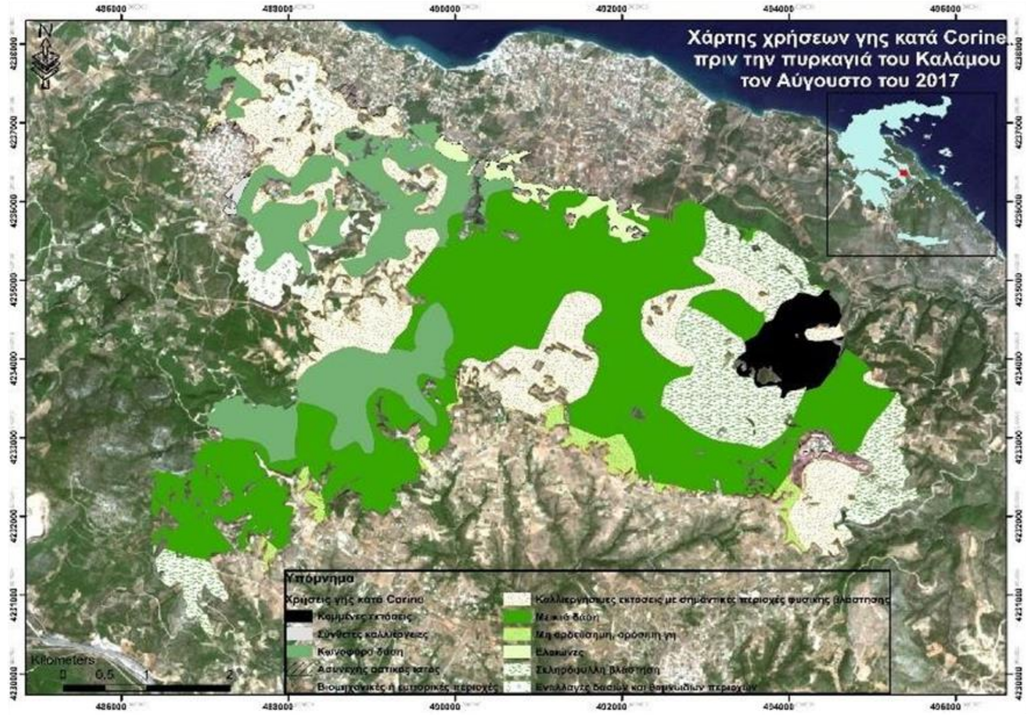

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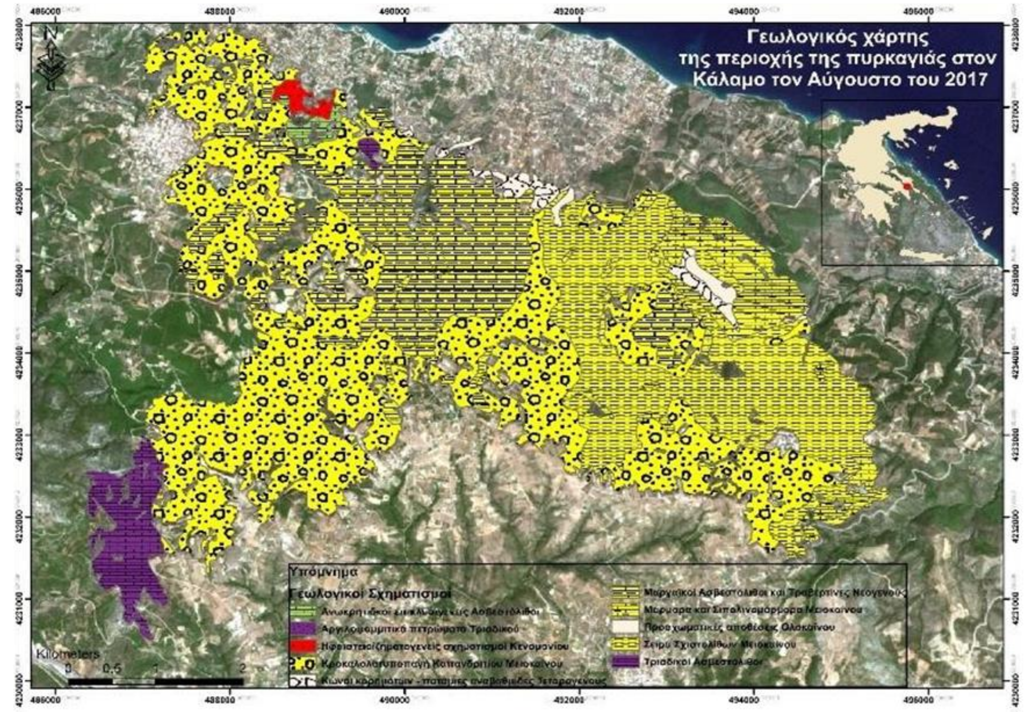
Map of Corine land use before the fire of Kalamos in August 2017



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Geological map of Kalamos burned area in August 2017