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Environmental, Disaster, and Crises Management Strategies

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# THE JULY 2018 ATTICA (CENTRAL GREECE) WILDFIRES

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## About

Non-periodic publication of the Post-graduate Studies Program “Environmental Disasters & Crises Management Strategies" of the National & Kapodistrian University of Athens, issued after significant events for the immediate information of the scientific community and the general public. The publication includes also scientific data from various research teams from universities, organizations and research institutes.

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## Scientific Mission

Of the National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Department of Dynamic Tectonic Applied Geology

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**The scientific team visited the fire-affected area of Mati (Eastern Attica) shortly after the destructive wildfire in order to conduct a reconnaissance of the affected area and to assess the causes and the destructive effects on the natural and built environment.**

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## GENERAL INFORMATION

In the early afternoon of Monday, July 23, 2018 a wildfire broke out in the forest surrounding the settlement of Kallitehnoupolis on Penteli Mt., approx. 20km northeast of Athens and 5 km to the west of the Eastern Attica coastline. The cause of the wildfire remains still unknown. Because of the extreme weather conditions, fire spread swiftly to the east, affecting, as it travelled along, the settlements of Kallitechnoulopis, Neos Voutzas, Rafina and reached Mati, where it finally stopped right at the coastline.
The Fire Service was made aware of the fire ignition point at 16.57 (local time) and responded by sending 60 persons on 24 vehicles, 15 vehicles belonging to registered volunteers, 2 ground forces teams, as well as 3 Canadair aircrafts and a helicopter.
Organized evacuation operations took place at a church charity institution (Lyreion) and all children summer camps of the wider area.




The wildfire, classified as a crown fire, aided by very strong winds of an approximate velocity of 90 km/h, crossed the main highway of the area (Marathonos Av.) within a very short time (estimated approximately 30 to 40 min depending on the location), and moved towards the settlement of Mati, where it reached the sea with a fire front of approximately 1 km, allowing for a minimal response time by the inhabitants and numerous visitors of the area. The difficult weather conditions, the area morphology and the town configuration resulted in the entrapment of a great number of people.

The aftermath is tragic. The fire-affected area is approx. 12.8 $km^2$ (1275.9 ha), estimated by satellite data provided by the COPERNICUS Emergency Management Service – Mapping platform. Within the area, there are approx. 1220 totally destroyed buildings (according to carried out official inspections) and 305 burned vehicles.
The days following the event, the authorities recovered at least 91 bodies from the scene (updated 31/7/2018 at 11.00am). Several missing persons were reported and tens of injured (approximately 200 at some point) were transferred to nearby hospitals.

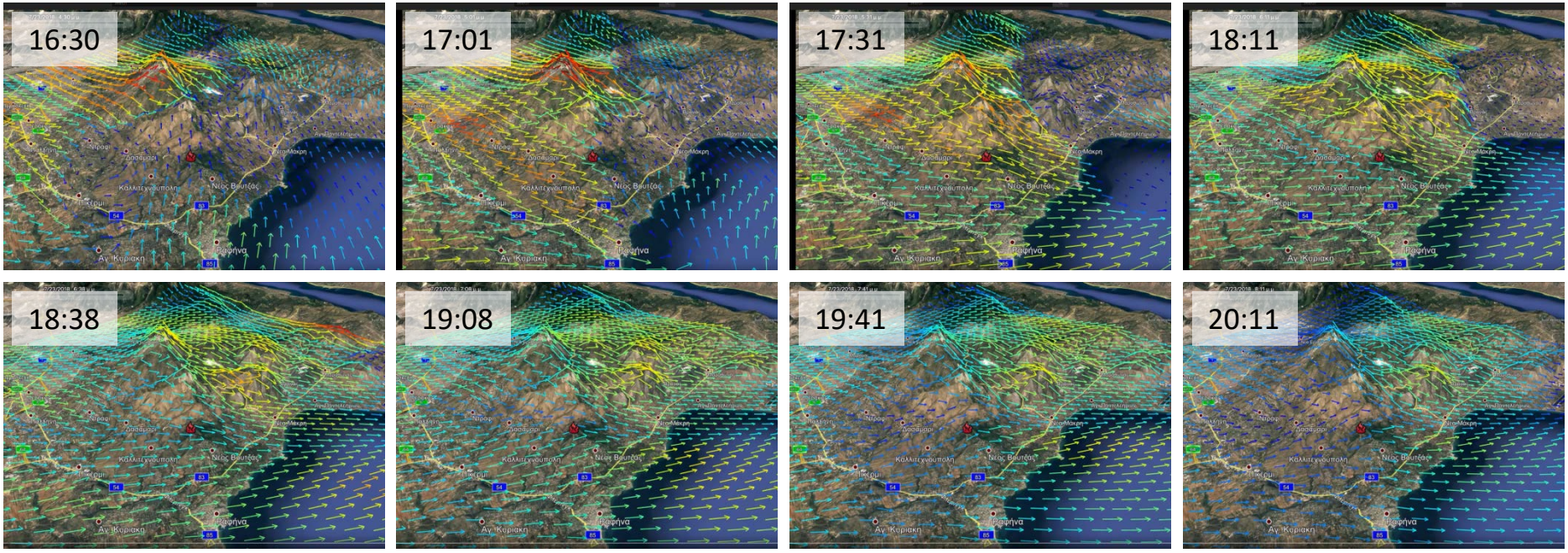
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# METEOROLOGICAL DATA

## Detailed wind modelling

The following video shows the evolution of the speed and direction of the wind in temporal terms over the eastern part of Attica, between **Monday 23/7/18 15.30** (local time) and **Tuesday 24/7/2018 at 06.00** (local time), as it was modelled from the WRF-SFIRE forecasting model (with high spatial resolution of 667m)
Snapshots from the video record the dramatic increase of the wind, of W and SW direction, at the break of the fire (17.00 of 23rd) until 21.00 the same day. This fact is believed to be crucial and contributed largely to the high velocity of the fire front and its quick movement towards Mati town.

**Timeline of wind** direction and intensity, during the event. Strong western winds approach from Penteli Mt. and reach the area of N. Voutzas, Rafina and Mati between 17:00 and 17:30. From that time on, the wildfire has a rapid downslope spread towards the coast.



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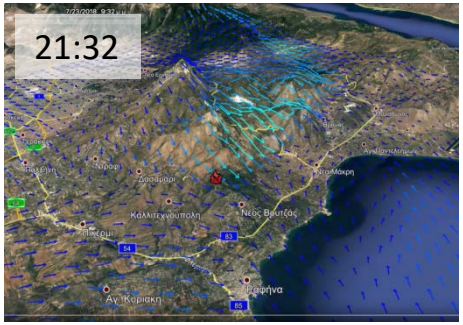
## METEOROLOGICAL DATA

Timeline of wind direction and intensity, during the event. Strong western winds approach from Penteli Mt. and reach the area of N. Voutzas, Rafina and Mati between 17:00 and 17:30. From that time on, the wildfire has a rapid downslope spread towards the coast.





















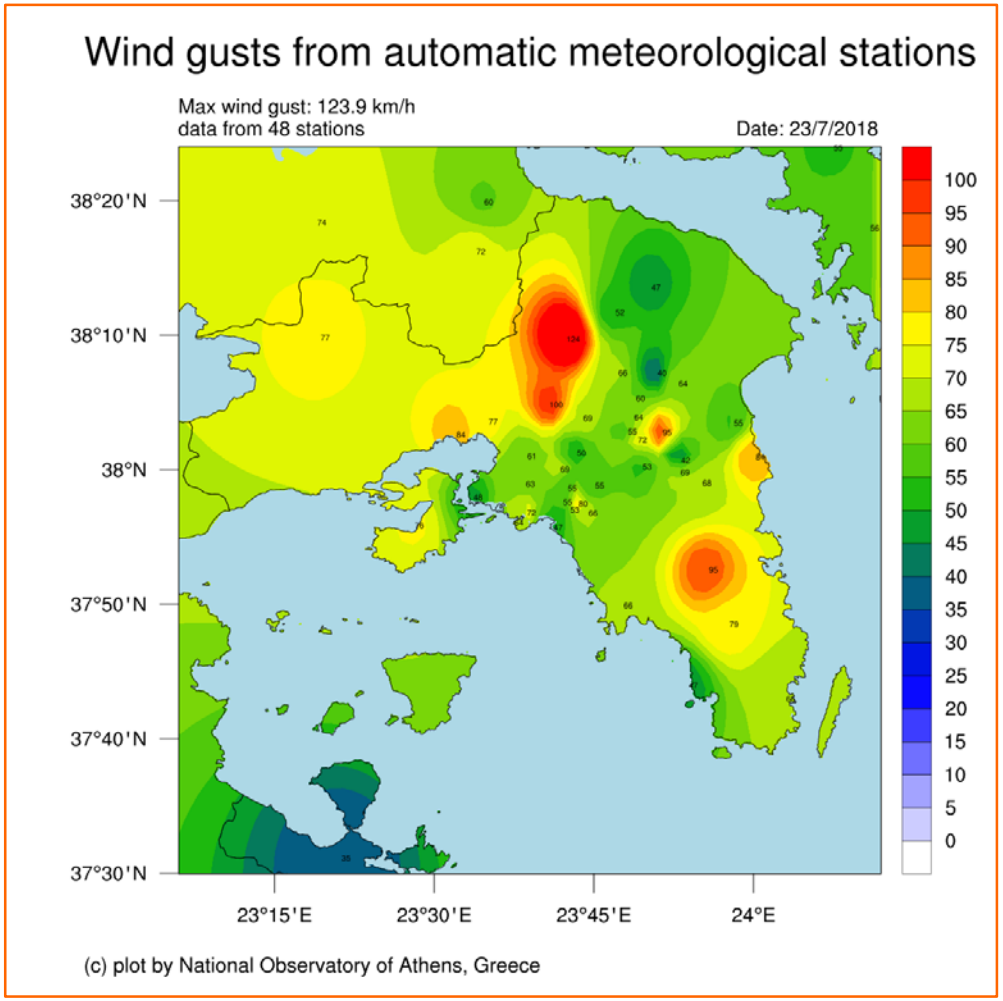
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# METEOROLOGICAL DATA

**Winds in Attica on Monday 23/07**

The condensed situation on Monday 23/07 resulted in the predominance of stormy west-northwest winds in Eastern Sterea and Attica. As the following map displaying the wind gusts from all of our stations in Attica, the bursts reached 100-120 km/h in several areas of Attica, while in the greater part of the Region the bursts exceeded 60 km/h in velocity. It should be noted that the western winds as downslope winds in the eastern regions of Attica result in significant temperature rise (more than 37 °C) and low humidity, creating ideal conditions for rapid fire spreading.

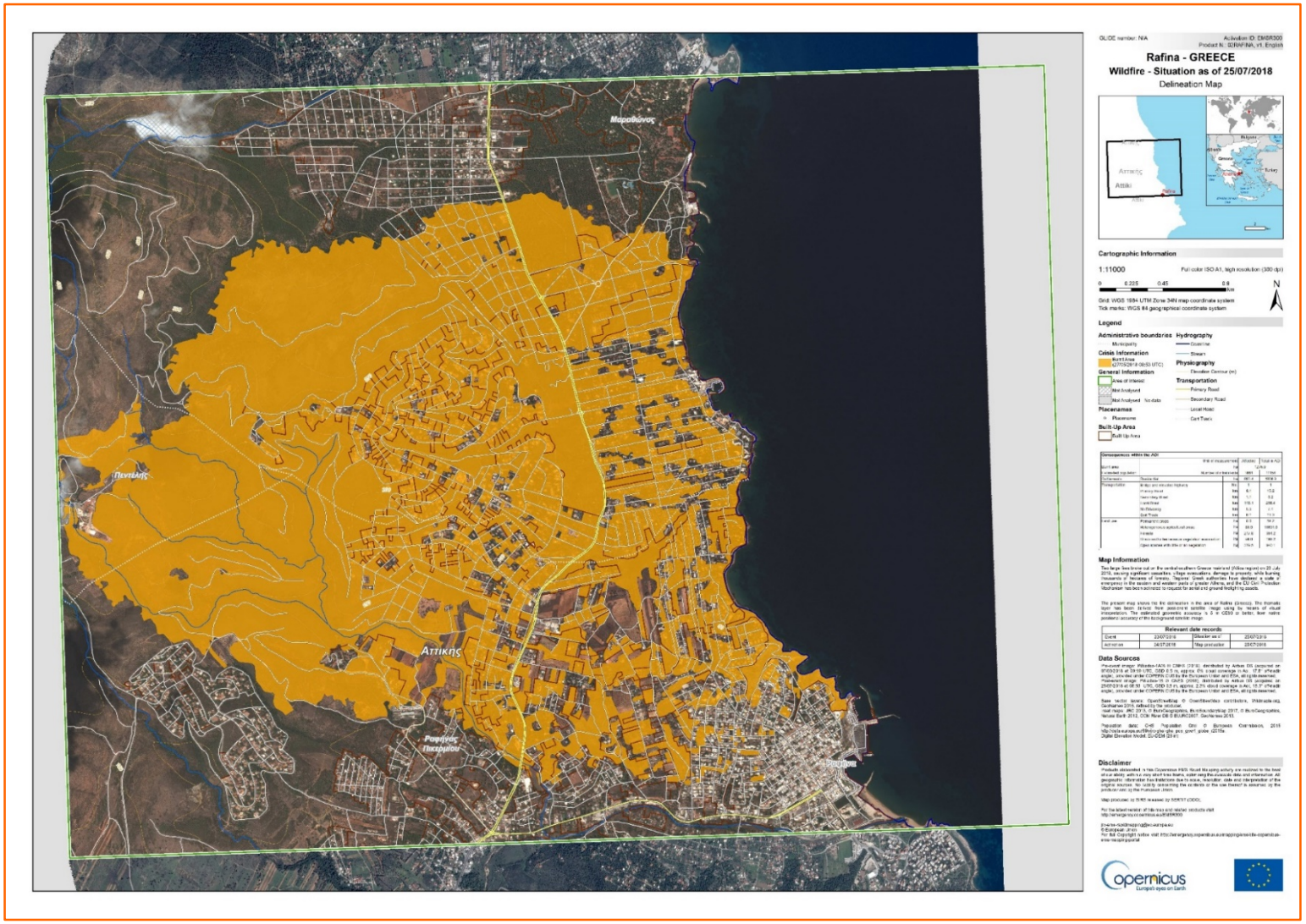
It is noteworthy that the wind gusts recorded on Monday 23/07 by the meteorological stations of the NOA in Isthmos, Agioi Theodoroi, Kapareli Viotia, Parnitha, Penteli, Ano Liosia, Neos Cosmos were the highest recorded in the summer months over the last eight years -since they have been installed in many cases regardless of wind direction.




Lagouvardos K., Dafis S., Kotroni V. (2018)
http://www.meteo.gr/articleview.cfm?id=720

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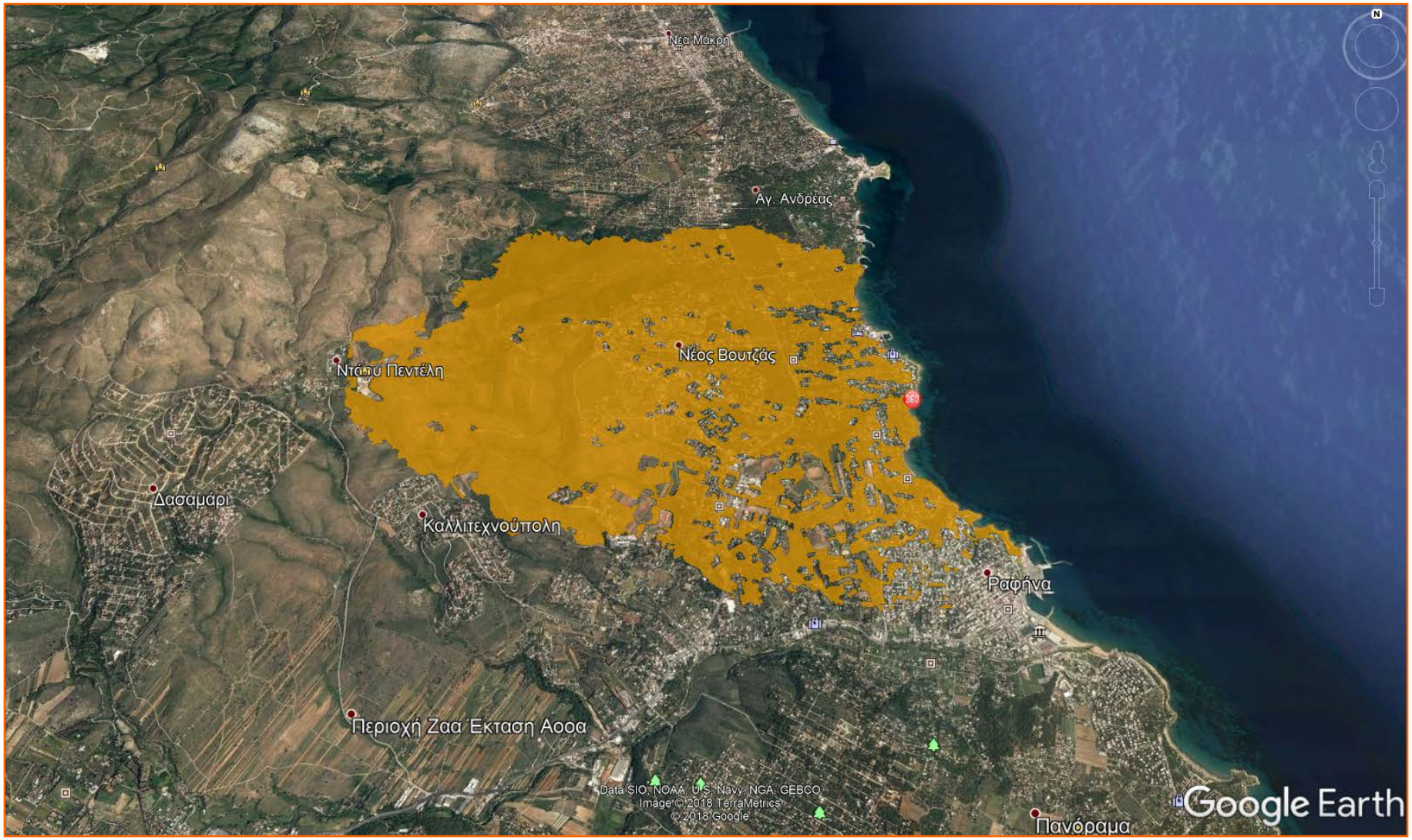
## BOUNDARIES OF THE FIRE-AFFECTED AREA




From **COPERNICUS** Emergency Management Story Mapping
http://emergency.copernicus.eu/mapping/system/files/components/EMSR300_02RAFINA_01DELINEATION_MAP_v1_300dpi.jpg

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## BOUNDARIES OF THE FIRE-AFFECTED AREA




From **COPERNICUS** Emergency Management Story Mapping
*http://emergency.copernicus.eu/mapping/list-of-components/EMSR300*

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# AVERAGE RATE OF SPREAD CALCULATION
## BASED ON EVIDENCE



Video from Panos Kokkinidis facebook page
Went live on Monday 23/7/18 on 17.39 local time

https://www.facebook.com/pkokkinidis/videos/vb.1474624093/10216640578354939/?type=2&video_source=user_video_tab




This is the position from where the video was captured
shown here in google street view imagery

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# AVERAGE RATE OF SPREAD CALCULATION
## BASED ON EVIDENCE

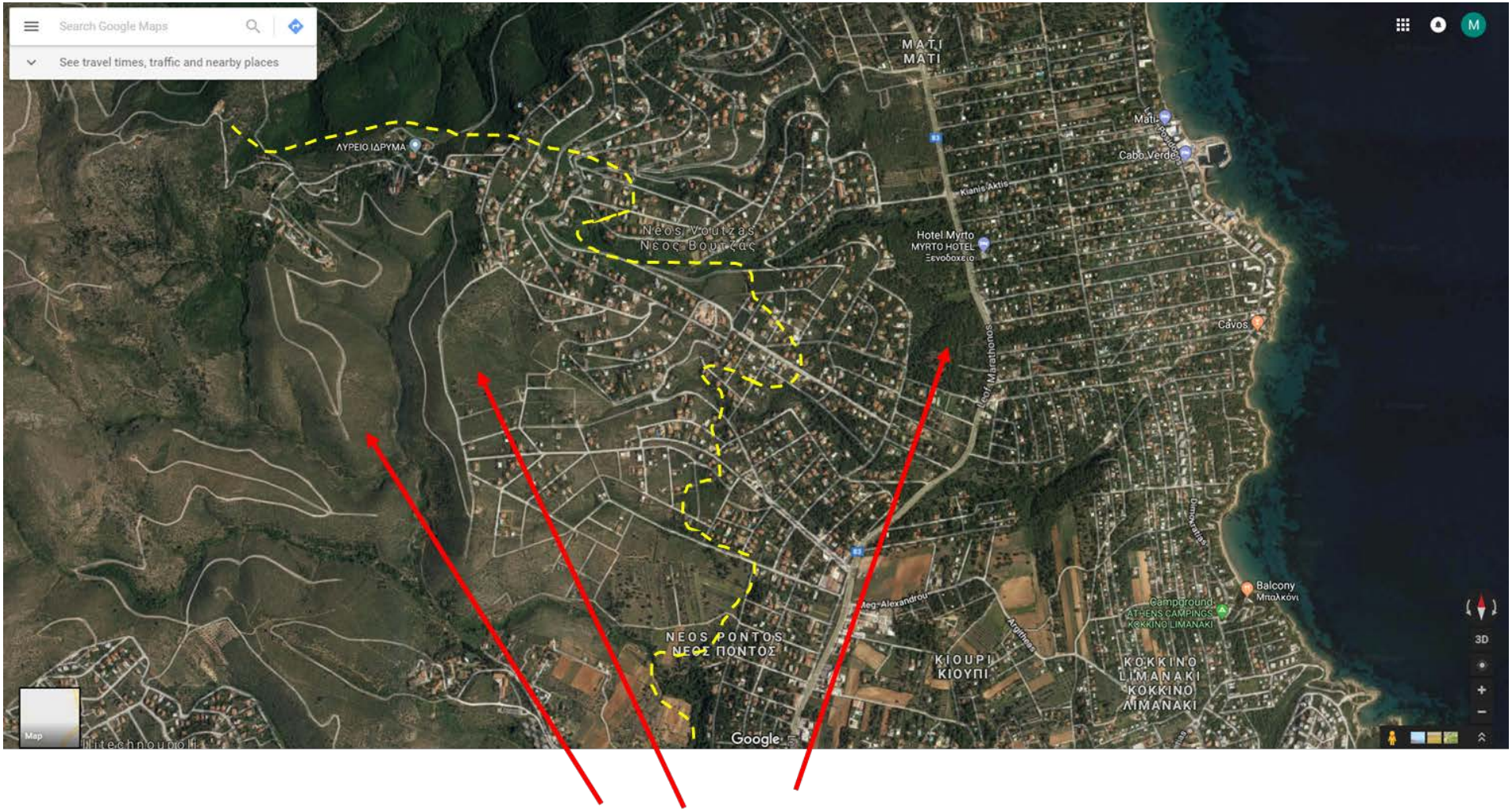



The progress of fire-front is presented with time information based on documentary evidence (videos, pictures and interviews of eyewitnesses).

Based on the presented timing the average velocity of fire movement is between **3-4.1 km/h**. However, there is evidence that in between there were locations were the fire accelerated to higher velocity values

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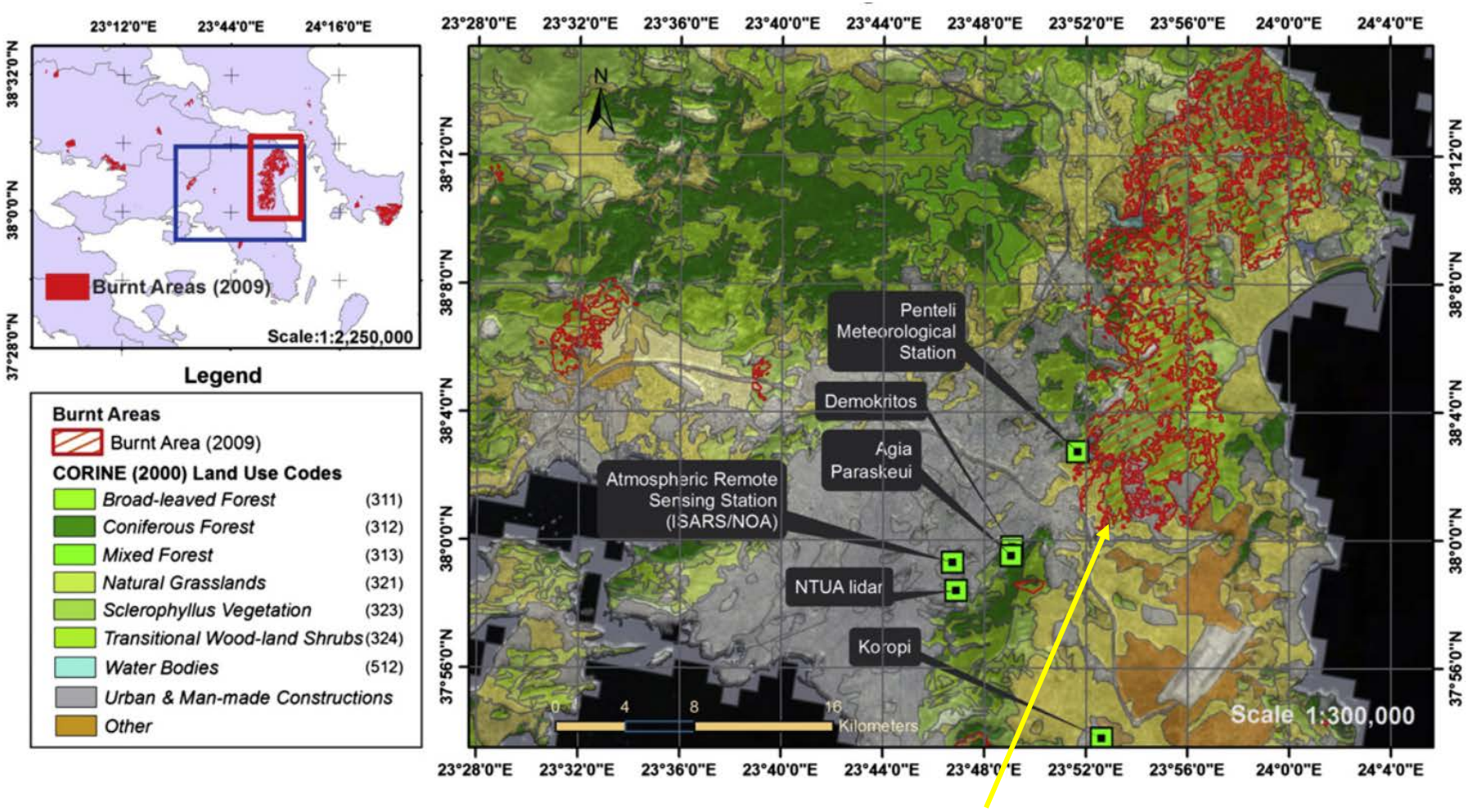
# CHANGE IN FIRE BEHAVIOUR DUE TO DIFFERENCES IN VEGETATION




Differences in fuels (type and amount of vegetation) due to previous fires (2009), could have led to differences in fire behaviour and rate of spread of the fire-front eastwards

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# CHANGE IN FIRE BEHAVIOUR DUE TO DIFFERENCES IN VEGETATION

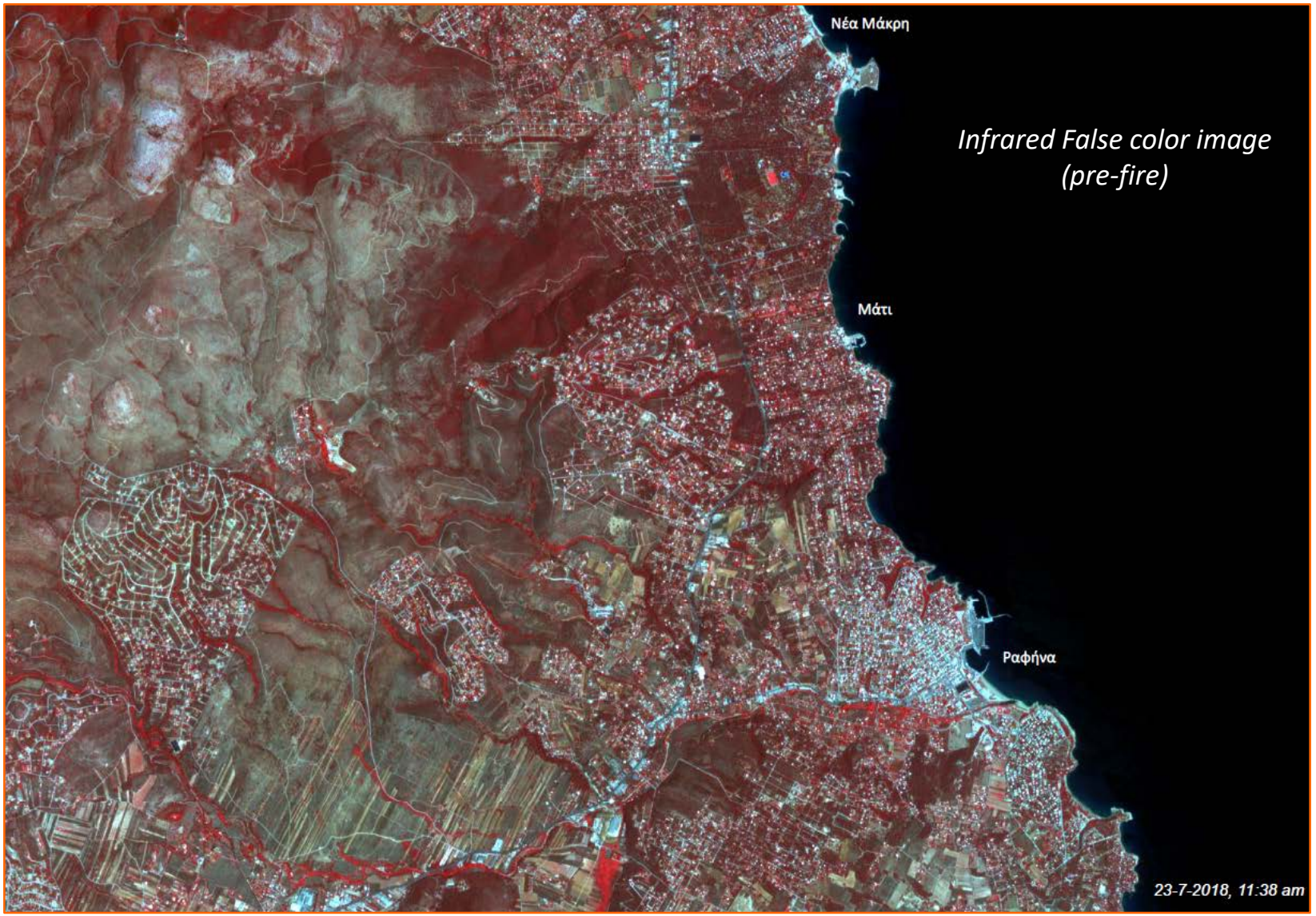



Fire limit of 2009

Amiridis, V., C. Zerefos, S. Kazadzis, E. Gerasopoulos, K. Eleftheratos, M. Vrekoussis, A. Stohl et al. "Impact of the 2009 Attica wild fires on the air quality in urban Athens." *Atmospheric environment* 46 (2012): 536-544.

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## REMOTE SENSING DATA




*Infrared False color image (pre-fire)*

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## REMOTE SENSING DATA

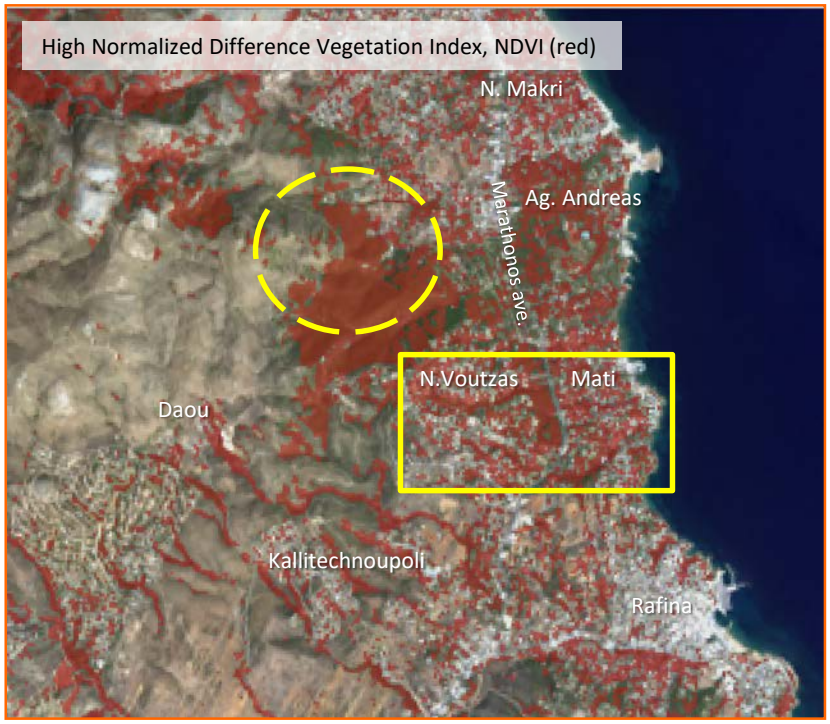


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## REMOTE SENSING DATA



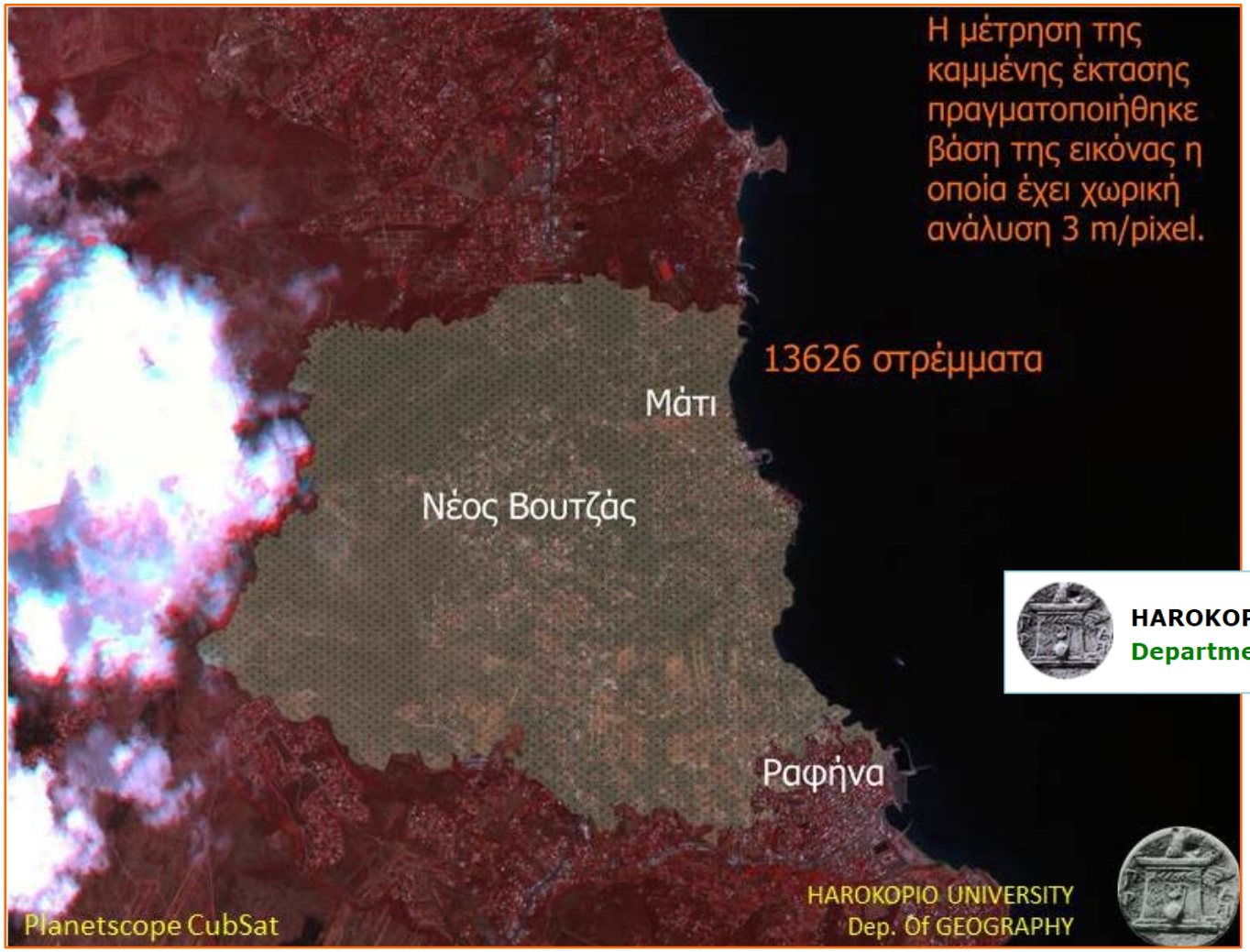

Composite RGB image (Landsat 8, September 2017) of the broader fire affected area. Green color indicates the existence of vegetation.




Dense vegetation areas (high NDVI values) in the fire affected area. Large areas of continuing forest zones from the mountain to the coast are interrupted only by Marathonos Ave. North of N. Voutzas (in yellow circle), forest that had remained unburned from previous wildfires, in contrast to the areas to the west and southwest, which has been repeatedly burned.

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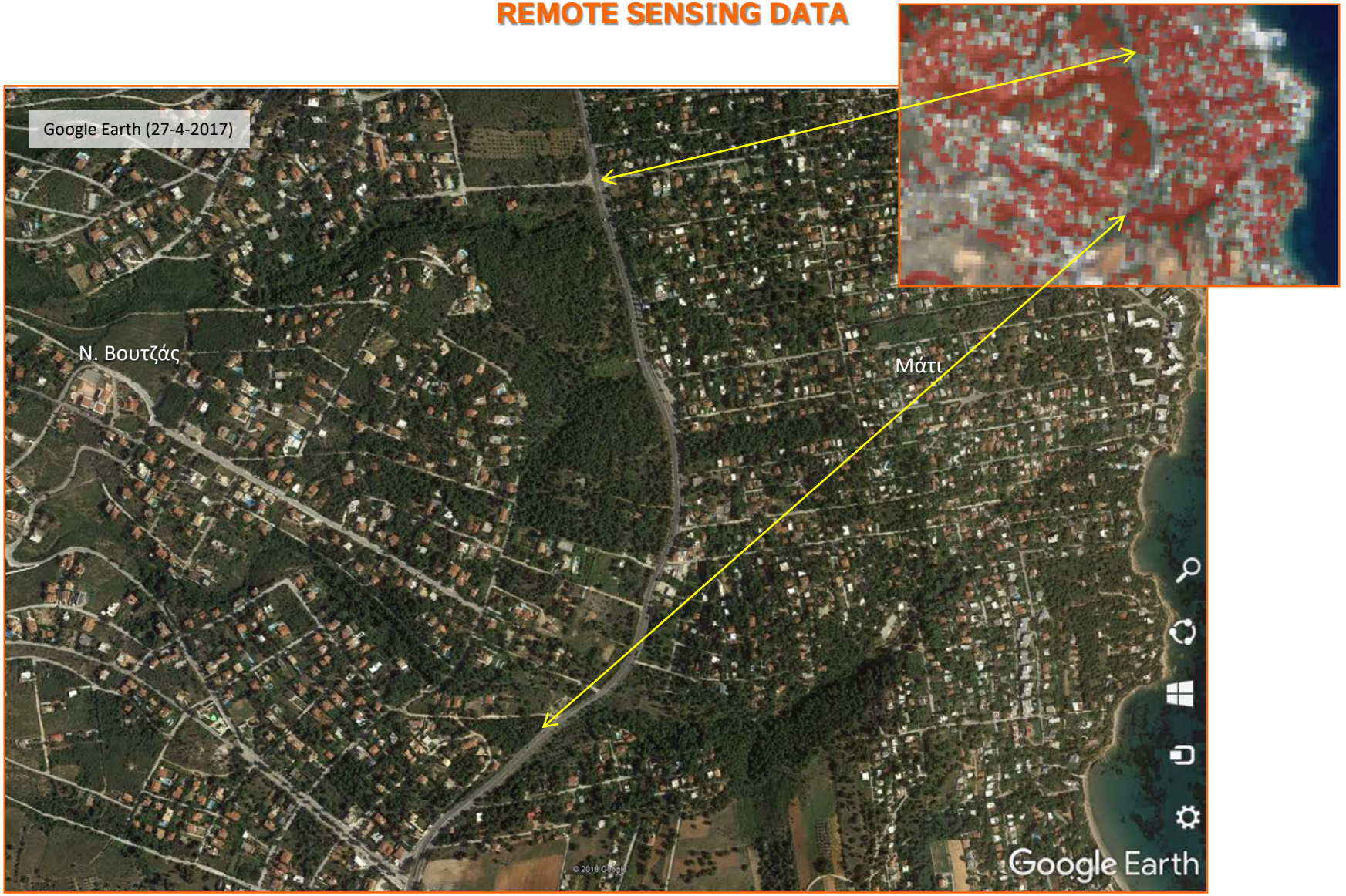
## BOUNDARIES OF THE FIRE-AFFECTED AREA




Cub-Sat constellation satellite image
Date acquisition: 27/07/2018 Time: 11:34

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## REMOTE SENSING DATA




Google Earth imagery of the severely hit area of N. Voutzas - Mati. Forest zones and areas of dense vegetation form corridors that the wildfire followed across Marathonos avenue. Up right: High NDVI (see previous).

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## UAV (DRONE) DATA



Google Earth imagery of the severely hit area of Neos Voutzas



UAV image of the marked area after the wildfire. Corridors that the wildfire followed through the settlement

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## UAV (DRONE) DATA



UAV image from Neos Voutzas settlement to the east (Mati area).
Where forest vegetation continued downhill, Marathonos avenue did not form an obstacle to downspread.

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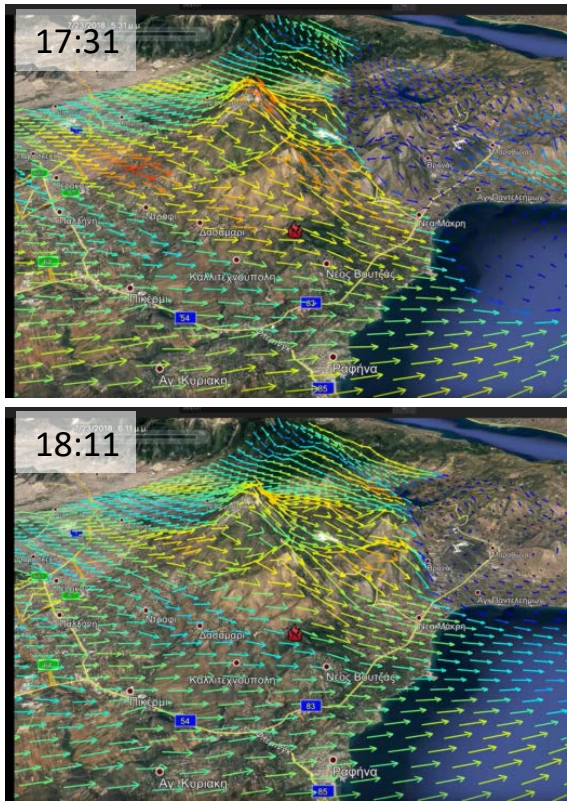
## UAV (DRONE) DATA




Vectors of wildfire uninterrupted spread mapped with the aid of UAS footage from Neos Voutzas to Mati

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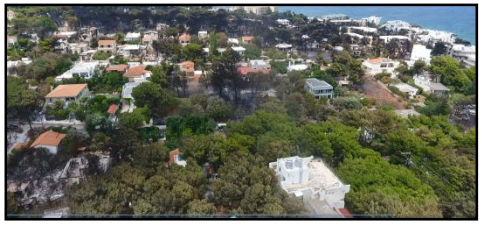
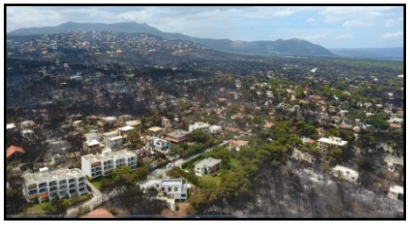
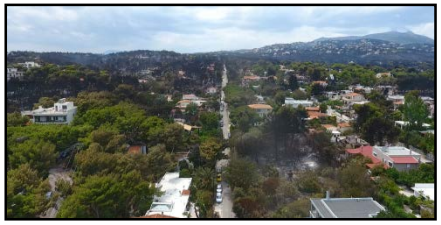
# VECTORS OF WILDFIRE UNINTERRUPTED SPREAD MAPPED WITH THE AID OF UAV







Vectors of wildfire uninterrupted spread mapped with the aid of UAV footage from Neos Voutzas to Mati


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# VECTORS OF WILDFIRE UNINTERRUPTED SPREAD MAPPED WITH THE AID OF UAV







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## IMPACTS ON THE NATURAL ENVIRONMENT

Stands of Aleppo pine trees mixed with Cypress trees and shrubby vegetation







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## IMPACTS ON THE NATURAL ENVIRONMENT

Stands of Aleppo pine trees surrounding the houses; burned branches of shrubs are also present









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## IMPACTS ON THE NATURAL ENVIRONMENT
### Some vegetation patches have remained unburned



A small olive trees plantation which escaped fire

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## IMPACTS ON HUMAN

### Access to the beach of the fire-affected area was full of obstacles

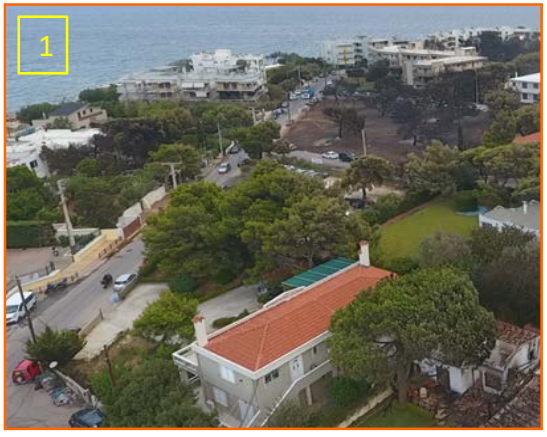




Access to the beach was difficult due to the steep slopes of the coast in the eastern part of the area. Consequently, people have difficulty approaching the coastline during the course of the fire in order to reach a safer environment

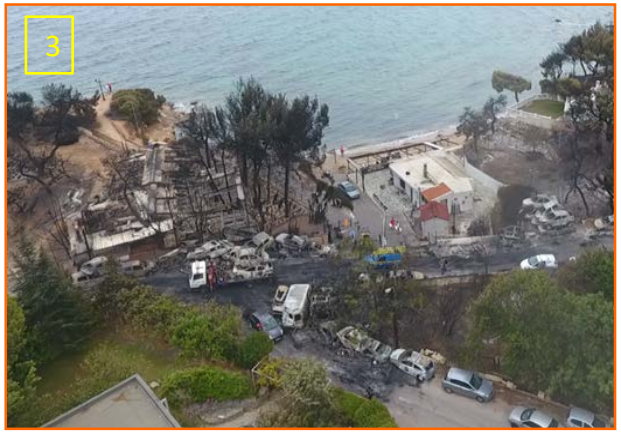
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## IMPACTS ON HUMAN
### Narrow escape routes to the sea












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## IMPACTS ON HUMAN
### Narrow escape routes to the sea



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## IMPACTS ON HUMAN
### Sites of entrapment – vehicle congestion




35 cars congested and abandoned in a small space, totally burned
(Snapshot from published video from military aircraft)

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## IMPACT ON THE BUILT ENVIRONMENT

### Buildings with reinforced concrete frame & masonry infill - partition walls



Destruction of external and internal combustible contents of buildings caused by firebrands attack, radiant heat exposure and/or flame contact

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## IMPACT ON THE BUILT ENVIRONMENT

### Buildings with reinforced concrete frame & masonry infill - partition walls



Destruction of external and internal combustible contents of 2- and 3-storeys buildings caused by firebrands attack, radiant heat exposure and/or flame contact

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## IMPACT ON THE BUILT ENVIRONMENT

### Buildings with reinforced concrete frame & masonry infill - partition walls



Various damage on masonry buildings with load-bearing masonry walls
ranging from destruction of external and internal combustible contents induced
by firebrands attack, radiant heat exposure and/or flame contact, to partial collapse of the building

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## IMPACT ON THE BUILT ENVIRONMENT

*Building with light timber framing system and plasterboards*

Collapse of burned wood roofs, decomposition of the exterior and interior wall materials almost into powder due to extreme temperatures that are hard for materials to endure without degrading, melting and buckling of the galvanized light hexagonal wire mesh and subsequent cracking and collapse of the walls, near total or total collapse of the structure due to failure of the structural elements















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## IMPACT ON THE BUILT ENVIRONMENT
### Building with light timber framing system and plasterboards







Destruction of external and internal combustible contents in buildings constructed with extremely cheap and inadequate materials:
Collapse of burned wood roofs, decomposition of the exterior and interior wall materials almost into powder, melting and buckling of the galvanized light hexagonal wire mesh and subsequent cracking and collapse of the walls, near total or total collapse of the structure due to failure of the structural elements.

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# IMPACT ON THE BUILT ENVIRONMENT

## Buildings with light timber framing system and plasterboards





Buildings comprising inadequate materials or non-fire resistant building materials suffered the most by the fire. The most commonly observed damage was the partial or total collapse of the buildings. The fire-resistant elements remained almost untouched by the fire. Characteristic example was the still standing fireplace and chimney systems.







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# IMPACT ON THE BUILT ENVIRONMENT

## Buildings with light timber framing system and plasterboards







Partial or total collapse of buildings comprising extremely cheap and inadequate for construction materials or non-fire resistant building materials

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## IMPACT ON INFRASTRUCTURES AND LIFE LINES



Damage in the low and medium voltage distribution networks included cut low voltage cables and damaged medium voltage poles respectively

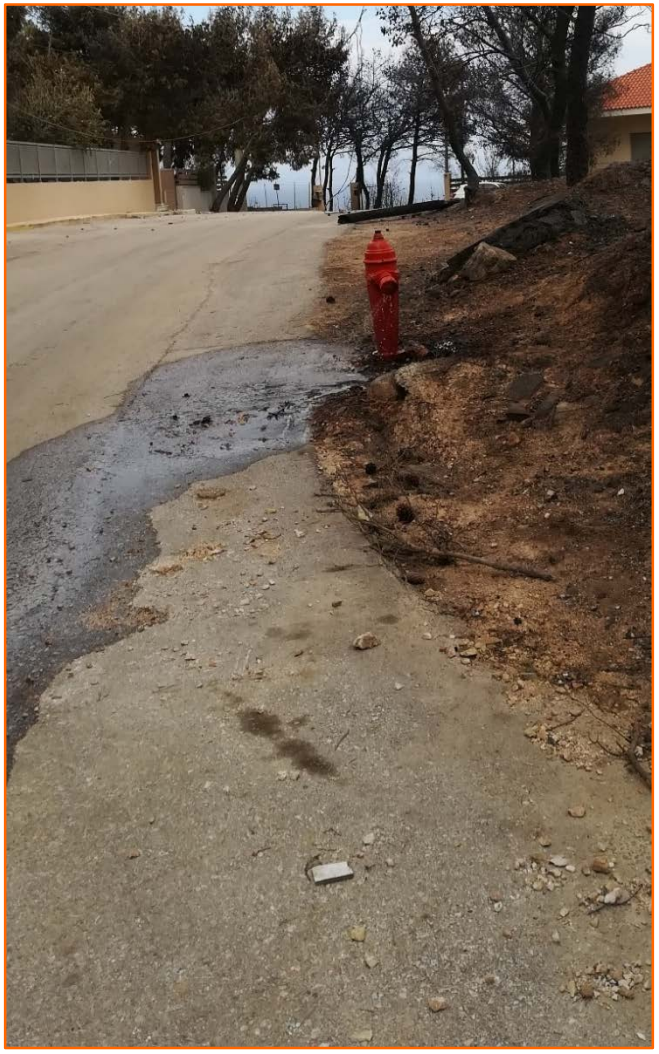






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## IMPACT ON INFRASTRUCTURES AND LIFE LINES


Damage on the water network of the fire-affected area

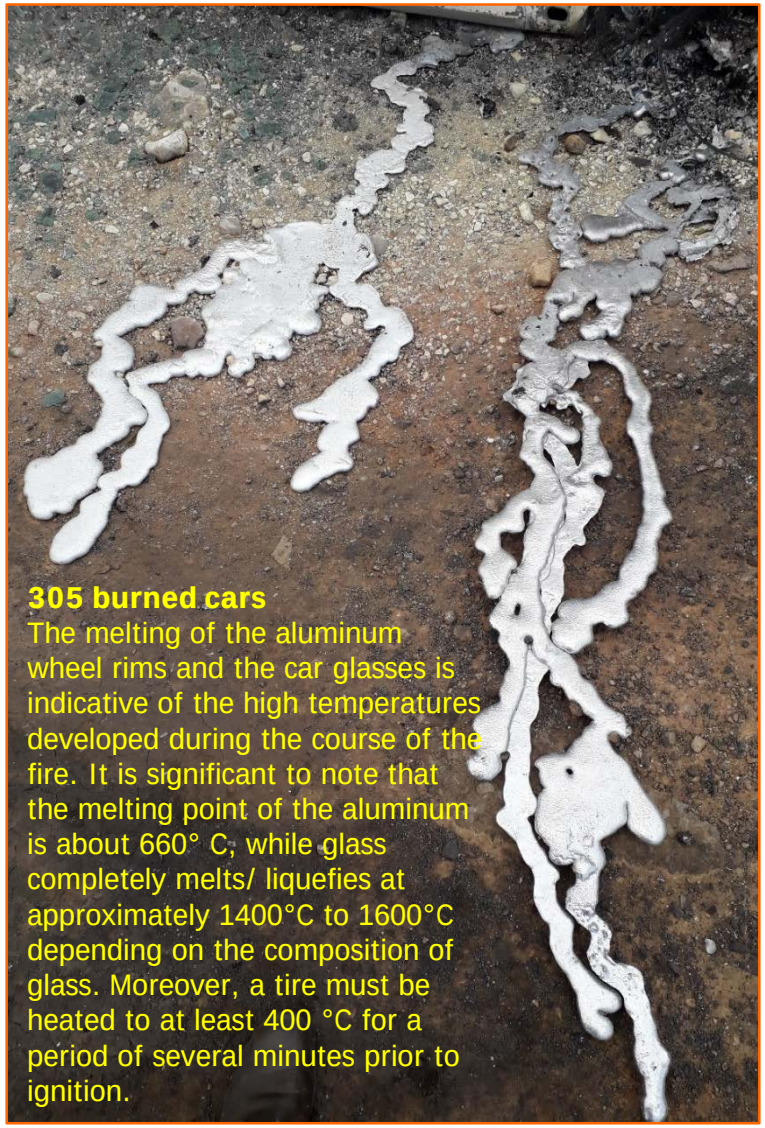
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# IMPACT ON VEHICLES









**305 burned cars**
The melting of the aluminum wheel rims and the car glasses is indicative of the high temperatures developed during the course of the fire. It is significant to note that the melting point of the aluminum is about 660° C, while glass completely melts/ liquefies at approximately 1400°C to 1600°C depending on the composition of glass. Moreover, a tire must be heated to at least 400 °C for a period of several minutes prior to ignition.







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## IMPACT ON VEHICLES



The high melting points of the various parts of the burned vehicles do not indicate that the heat wave of the fire reached these temperatures during the fast spread of the fire. The heat wave of the fire was responsible for the initial engulfing of cars by flames, while the higher temperatures are associated with the ignition and the combustion of the various parts of the cars [tires, wheels, glasses, plastic parts of the cars, oil and fuel (petrol, diesel, autogas) tanks].

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# IMPACT OF BURNT VEHICLES ON THE BUILT ENVIRONMENT

## Buildings with reinforced concrete frame & masonry infill - partition walls affected by explosions of cars engulfed in flames







Destruction of external and internal combustible contents of
the ground floor of a building caused by explosion of cars engulfed in flames

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# ACTIVATION OF THE EU CIVIL PROTECTION MECHANISM

A significant European initiative has been the establishment of the European Civil Protection Mechanism for the coordination of the Civil Protection interventions in cases of disasters. The legislative framework for the assistance offered was defined by a Council Decision in 2001 (Decision 2001/792), establishing a Community mechanism to facilitate reinforced cooperation in Civil Protection assistance interventions within and outside the EU. The Mechanism has been reinforced ever since and accepting all the more calls for assistance. After the evaluation of the Mechanism's actions, it was found out that there was a need to revise its legal framework. On 8.11.2007 the Council Decision 2007/779/EC was issued and amended the previous one. According to the new Decision, the Mechanism's aim is to enhance the cooperation of Member States, in the event of natural and man-made disasters, acts of terrorism and, technological, radiological or environmental accidents, including accidental marine pollution at peaceful times. Every country that is afflicted by major disasters can call for assistance and mobilize operational means that have been voluntarily provided to the EU by the countries of the Mechanism. Its participating countries are 31 countries; 27 Member States and the (3) countries of the European Economic Area (EEA), Iceland, Liechtenstein, Norway and Croatia.

On 23/7/2018 evening Greece requested EU support through the EU Civil Protection Mechanism. In an immediate response, Cyprus, Spain and Bulgaria made swift offers of assistance, which included planes, firefighters, medics, and vehicles. Commissioner for Humanitarian Aid and Crisis Management Christos Stylianides travelled to Athens today and met the Greek civil protection authorities and coordinate the EU's assistance already on its way.

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# GENERAL GUIDELINES FOR SELF CARE & SUPPORT

## Τι μπορεί να βιώσω μετά από την πυρκαγιά;

Μετά από μία τέτοια καταστροφή, μπορεί να βιώσετε κάποια απο τα παρακάτω:

- Λύπη
- Θυμό
- Ενοχές
- Συναισθηματικό μούδιασμα
- Εφιάλτες/Δυσκολίες στον ύπνο
- Συνεχή αίσθηση κινδύνου

**Αυτές είναι όλες ΦΥΣΙΟΛΟΓΙΚΕΣ αντιδράσεις στο στρες και στις περισσότερες περιπτώσεις θα εξαλειφθούν με την πάροδο του χρόνου.**

## Πώς να φροντίσω τον εαυτό μου;

Υπάρχουν ορισμένα πράγματα που μπορείτε να κάνετε για να αντιμετωπίσετε το στρες και να προστατέψετε τη συναισθηματική και σωματική σας ευεξία:

- Φροντίστε πρώτα να είστε ασφαλείς και να καλύψετε τις ανάγκες σας σε νερό, τροφή και κατάλυμα
- Ενημερωθείτε για τις παροχές και την υποστήριξη που μπορείτε να λάβετε από την κοινότητα σας και τις κρατικές υπηρεσίες
- Παραμείνετε ενεργοί. Προσφέρετε εθελοντική εργασία, εάν το επιθυμείτε, ή βοήθεια στις διαδικασίες καθαρισμού και επισκευών, εφόσον αυτό είναι ασφαλές.
- Βεβαιωθείτε ότι κάνετε συχνά διαλείμματα από τις προσπάθειες καθαρισμού και αποκατάστασης.
- Περάστε χρόνο με τους αγαπημένους σας, τους συγγενείς και φίλους σας.
- Προσπαθήστε να συμμετάσχετε σε κάποιες από τις δραστηριότητες που απολαμβάνατε και πριν το συμβάν.
- Συζητήστε για τα συναισθήματά σας ανοιχτά, εάν νιώθετε την ανάγκη να το κάνετε.

## Και αν χρειαστώ επιπλέον υποστήριξη;

Είναι σημαντικό να θυμάστε πως μπορεί να χρειαστεί χρόνος για να επιστρέψετε στο πώς νιώθατε πριν από την καταστροφή. Ωστόσο μη διστάσετε να συμβουλευτείτε έναν ψυχολόγο, έναν κοινωνικό λειτουργό ή έναν επαγγελματία ψυχικής υγείας εάν διαπιστώσετε πως δυσκολεύεστε με τα ακόλουθα:

- Διαχείριση των συναισθημάτων σας
- Ολοκλήρωση των καθημερινών εργασιών σας
- Φροντίδα της οικογένειάς σας

### *Τηλέφωνα έκτακτης ανάγκης*

**197**: Τηλεφωνική Γραμμή Άμεσης Κοινωνικής Βοήθειας
**112**: Ευρωπαϊκός αριθμός έκτακτης ανάγκης.

### *Χρήσιμα τηλέφωνα*

**80011 80015**
Γραμμή «ΜΕ Υποστηρίζω», καθημερινά 9.00-15.00, στη Μονάδα Εφηβικής Υγείας (Μ.Ε.Υ.) της Β΄ Παιδιατρικής Κλινικής του Πανεπιστημίου Αθηνών.
**2294320011**
Κέντρο Υγείας Ραφήνας – Πικερμίου- Ψυχοκοινωνική Στήριξη πληγέντων από Ψυχολόγους του ΚΕΕΛΠΝΟ

Ενημερωτικό φυλλάδιο
Γενικές οδηγίες για φροντίδα εαυτού και υποστήριξη

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## PRELIMINARY RESULTS

**1.** This is a typical case of wildland urban interface fire, that spread as an active crown fire. These zones are among the most probable to suffer human casualties globally. There are many such zones throughout Greece.

**2.** During the fire, strong west winds, with velocity exceeding 90 km/h locally and in certain time spans (between 17:00 – 21:00 on 23/7/2018), as well as their interaction with topography, played a crucial role to the rapid downslope spread of the fire front.

3. The rapid spread of the fire contributed to the minimization of the available time for reaction, leading, in combination with other factors, to a great number of fatalities and casualties.

**4.** According to witnesses and reports that are being systematically analyzed, it is concluded that the population that happened to be near the coast at the time, at least in some locations, were informed about the rapidly approaching fire, not in the form of early warning by some authority, but by people evacuating the western (uphill) part of Mati settlement. This indicates that the population had almost zero available time between the moment of awareness of the threat and the ultimate appropriate moment of decision making for reaction.

**5.** A significant factor that contributed to the disaster is attributed to the urban planning (or the lack of it) in the area, that functioned as a "trap" for the evacuating population. Some of the important features include narrow streets (2.7 m at some locations), numerous dead ends, particularly long road blocks, no possibility of lateral escape, lack of concentration/refuge areas (e.g. sports fields, squares, etc). A wide street parallel to the coastline could have played the role of escape route towards the adjacent settlements.

**6.** Field research found specific weaknesses on structures with vulnerabilities on the roofs, frames, surrounding spaces and other parts. At the same time, a large number of totally destructed buildings was recorded.

**7.** A first estimate is that affected residences and buildings included mostly elevated or storeyed constructions, while ground floors or basements suffered statistically less damage, a typical performance of a crown fire. Moreover, significant differences on impacts were spotted among buildings, probably attributed to building materials and adjacent vegetation.

**8.** The first conclusions, based on witnesses accounts (still under systematic analysis) point to the fact that the escape attempt was uncontrolled and not an organized evacuation procedure. This resulted in a "traffic jam" caused by the large number of people trying to flee the area in a state of panic. In addition to the number of inhabitants, there was also a great number of visitors, many of which were unaware of the geographical particularities of the area.

**9.** The coastline morphology hindered the access to the sea (steep coastline). The access routes were limited and the lack of visibility due to the smoke greatly contributed to the entrapment of people.

**10.** It is possible that the change in fire behavior was caused by the change in vegetation type. The fire started rapidly in previously fire-affected areas of low-lying vegetation and spread to a non-affected area comprising a great fire fuel load. That lead to fire propagation and a higher energy release in the down-slope area between Neos Voutzas and the coastline. East of Marathonos Avenue, the fire, as a wind driven "wall of fire" swept both the low-lying vegetation and the high-standing trees (active crown fire). In addition, tens of firebrands were spread towards the coastline.

**11.** In buildings with reinforced concrete frame and brick infill - partition walls and closed windows, the fire did not spread to the interior. The only observed effect is the surface deformation of the plasters, with no effect to the structural elements of the building, due to the short impact of the fire.

*The present report includes preliminary data and conclusions of an ongoing research (31/7/2018), therefore they may be subject to changes.*

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## PRELIMINARY RESULTS

**12.** On the contrary, in similar buildings with wooden or plastic open windows, the fire spread to the interior, the impact time was longer and higher temperatures developed, due to the combustion of building equipment. This fact lead to the formation of cracks that can affect not only the non-structural elements of the buildings, but also its structural load-bearing frame.

**13.** Unfortunately, these cracks were aggravated by the water used during the fire-fighting operations. The already hot concrete is rapidly cooled down by 50-55$^{o}$C resulting in not only the spreading of the already formed cracks but also the formation of new ones.

14. The well designed and constructed reinforced concrete buildings that were affected by firebrands attack, radiant heat exposure and/or flame contact, but the fire did not spread to the interior, behaved very well and suffered only light damage to the external non-structural elements, such as mainly small cracks on masonry walls and detachment of small pieces of plaster, due to the high temperatures developed on the external walls of the buildings.

**15.** The structural adequacy of the fire-affected buildings greatly depends on the duration of the burning outside the building, on the degree and depth of concrete disintegration and the state of the reinforcement bars caused by the duration of thermal exposure of the buildings interior.

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