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The early September 2023 Daniel storm in Thessaly Region (Central Greece)

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About

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PREFACE OF THE 30th ISSUE OF THE EDCMS NEWSLETTER FOR THE DANIEL STORM

The 30th Issue of the Newsletter of the Environmental, Disaster and Crises Management Stategies is the outcome of a fruitful collaboration and knowledge sharing between geologists, civil engineers, geographers, meteorologists and oceanographers interested in mapping and monitoring the “Daniel” storm and its effects on the natural and built environment and various fields of the daily life in the affected Thessalian Plain and the surrounding semi-mountainous and mountainous areas in the Region of Thessaly. It mainly comprises the following:

- A synoptic analysis of "Daniel" based on the available meteorological data and the related forecasts.
- The monitoring of "Daniel" and its impact by using satellite imagery including the storm initiation and evolution, the evolution and the total extent of the subsequent flooding, the detection of the total suspended matter in the adjacent marine environment among other triggered phenomena and related effects.
- The assessment of the impact of the subsequent flooding on the natural and built environment including residential areas comprising cities, towns and villages of the affected Thessalian Plain and the adjacent semi-mountainous and mountainous areas.
- The assessment of the impact of flooding on rural areas comprising farming husbandry, pastoral husbandry, the livestock and on water bodies such as waste water plants, dams, lowland reservoirs, pond tanks and water gates.
- The assessment of the direct impact on human life including fatalities and injuries as well as the indirect impact during the flood aftermath comprising the potential for emergence of cases, outbreaks and epidemics of infectious diseases due to the adverse effects in the affected area

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PREFACE OF THE 30th ISSUE OF THE EDCMS NEWSLETTER FOR THE DANIEL STORM

- The assessment of the impact on the built environment, especially on buildings and critical infrastructures comprising the networks of roads and bridges, railways, telecommunications and electricity distribution, the embankments constructed along the main overflowed rivers, the port facilities close to river deltas, the water supply networks and the health facilities.
- The identification and the clarification of the most important risk factors for the occurrence of infectious diseases in the storm and flood affected areas along with the prevention measures before, following and after an infectious disease outbreak based on the recent scientific publications and related guidelines.
- The identification of health and environmental hazards related to flood waste management emerging during several phases of debris management and the proposal of measures for the prevention of health impact from disaster waste management.

In this context, the emergency response actions are also presented along with the contribution of several agencies and volunteer teams to the emergency and the recovery in the storm and flood affected areas of the Thessalian Plain and the surrounding semi-mountainous and mountainous areas.

The volume concludes with general findings on the storm and its impacts and mainly with 10 proposals - actions to reduce the risk of hydrometeorological and geodynamic hazards and their impacts.

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN
EVENTS FROM 1684 TO 2018 (1/3)

Year	Description of historical floods and their impact
1684	The flood destroyed part of Larissa, some riverside villages and a large part of arable land.
1729	Larissa, like other areas of Thessaly (Trikala, Moscholouri), suffered significant damage from the great flood of Pineios.
1777	The flood affected three districts of Larissa and two small settlements around it. There were also few casualties and destruction of houses as well as grain in the plain.
1804	Flood in Pineios and Koumerkis River inundating Larisa
1806	Flood in Larisa
1811	Intense and prolonged rain caused Pineios to overflow. People and animals were drowned, and houses and crops were destroyed. After the flood, ditches were opened around the city for drainage of floodwaters of Larisa towards Pineios.
1836	Extensive flooding in Thessaly plain affecting Larisa, drowning a large number of livestock as well as damaging property and infrastructure

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN
EVENTS FROM 1684 TO 2018 (2/3)

Year	Description of historical floods and their impact
1872	Pineios overflowed three times after intense and prolonged rainfall that caused flooding in a large part of Thessaly plain, with noteworthy impact on agricultural land
1882	An unprecedented flood that hit Larissa when the waters of Pineios together inundated the city. The flood caused a large number of flood victims and the damages caused were very significant.
1883	The rain fell for 48 hours and its results were 3 human fatalities, 20 destroyed houses, and other damages incalculable
1902	Flood of Pineios affecting Larissa and Koutsochero impacting infrastructure and properties
1903	Flood of Pineios affecting Larissa
1907	After a long and strong storm, floodwaters raised in Lithaios and the Agia Moni river and drowned the city of Trikala and the wider area. Human casualties were in the range of 100-300, crop damage and dead animals were reported as well. This event shook the entire country and affected heavily the politics of the country as it became source of strong criticism against the government.
1908	Flood in Pineios River

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN
EVENTS FROM 1684 TO 2018 (3/3)

Year	Details
1920	Flood in Larissa affected parts of the city near the river
1948	Flood in Larissa affected property and infrastructure
1963	Flood of Pineios affected Pineiada and other parts of Thessalian plain
1987	Inundation affected the area of Karla Lake, where waters raised for a few days damaging agricultural production
1994	More than 70 houses in about 20 communities were totally destroyed by the flood, more than 200 suffered severe damage and other 90 minor damage, whereas 80 km^2 of agricultural land (cotton fields) were flooded
2018	Flood in Pineios affected agricultural land near Koutsochero and other locations

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN

THE 1883 FLOOD IN LARISSA

Parts of Larissa (Tabakika area) were affected during the October 1883 flood.

Source: I. Ioakimmides (1883) via www.kolydas.gr
Larisa – Images of the past / Edition of the Municipal Gallery of Larisa - G.I. Katsigra Museum (2003)

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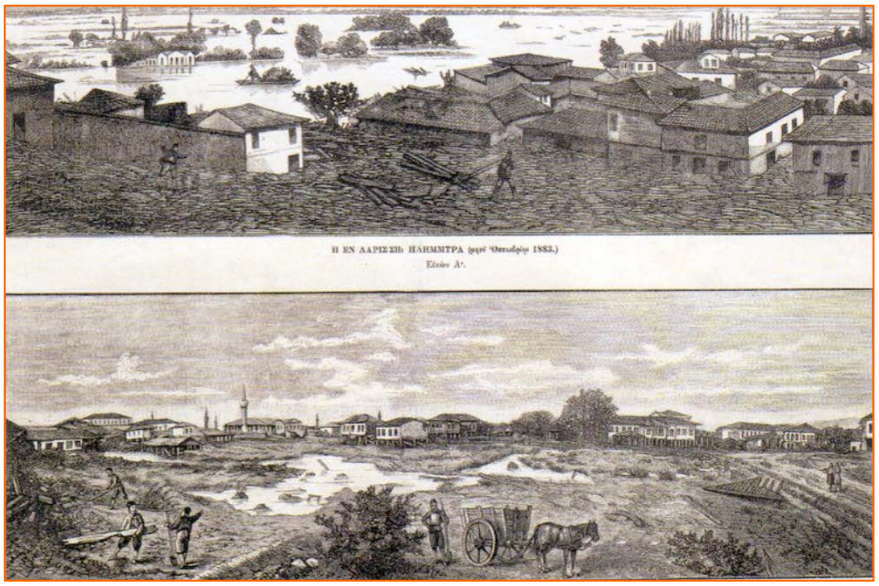
HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN
THE 1883 FLOOD IN LARISSA



1883 Flood in Larissa
illustrating Tabakika - Giannouli - Alkazar inundated

Sources: Esperos Magazine via larissapress.gr / Larisa – Images of the past / Edition of the Municipal Gallery of Larisa - G.I. Katsigra Museum 2003

1883 Flood Larissa
illustrating Alkazar bridge

Sources: Larisa – Images of the past / Edition of the Municipal Gallery of Larissa - G.I. Katsigra Museum 2003

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN
THE 1902 FLOOD

1902 Flood in Larissa
Alkazar bridge and Koutsochero – Pineios
Source: Elia.org

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN

THE 1903 FLOOD IN LARISSA

1903 Flood
showing Alcazar bridge in Larissa
(via Kypraiou 2011)

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN

THE 1903-1904 FLOOD

1903/1904 Flood in Larissa
Pineios bridge

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN

THE DEADLIEST 1907 LITHAIOS FLOOD IN TRIKALA CITY

On June 4 and 5, 1907, one of the worst natural disasters that ever hit Greece occurred, when long hours of heavy rainfall (storm with lightning) resulted in the flooding of the Lithaios River (and some of its tributaries, such as Paralithaios & Agiamoniotis).

The phenomenon was characterized by severity and intense localization. According to the testimonies, the river level rose up to 6 meters above normal and a thick layer of mud was deposited, while smaller but significant flooding episodes had preceded it in previous years (e.g. 1883, 1885, 1886, 1887, 1887, 1888, 1889, 1891, 1896, 1900, 1904, 1905) as well as some "unusual meteorological phenomena" (mainly in early summer).

The flooded city of Trikala (which at that time had 30,000 inhabitants) together with its districts (except for Varousi) was immersed in a vast, boundless lake, where you could not distinguish anything, not even the rivers that surrounded it.

The adverse effects of the flood included: the loss of at least 101 people (some put the number of victims at 200, or even more), the loss of numerous animals, the destruction of numerous houses in the city and districts of Trikala, as well as in villages (in some cases they were completely destroyed) near the riverbed, resulting in thousands of homeless people (who found temporary shelter in schools, churches, public buildings, private shops, etc.), the destruction of bridges (all the stone bridges of the city were washed away except of the central metal bridge) and infrastructure (e.g. telegraph network, electric lighting plant, etc.), the complete destruction of crops in the villages along the Lithaios riverbed, etc.

Source: Bantekas, I., Diakakis, M., Mavroulis, S., Lekkas, E. (2018). The great flood of 1907. One of the greatest natural disasters that hit Greece. International Conference "Pineios River: Source of Life and Development in Thessaly", 2-3 November, Larissa, Greece.

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THE DEADLIEST 1907 LITHAIOS FLOOD IN TRIKALA CITY

Furthermore, due to the many bodies (human & animal) that remained for days under the debris and mud, the emergence of epidemics was a continued challenge for public health.

Among the important social consequences was the economic destruction of the indebted residents in villages, who were unable to service their loans (they had been forced to resort to borrowing due to the country's bankruptcy in 1893 and the temporary Ottoman occupation of 1897-98), which led to an increase in emigration (mainly to America) and the desolation of the countryside. The problem was initially attempted to be tackled by fund-raising and charity, but with meagre results.

The delay of the central administration in realizing the extent of the disaster and the failure to provide immediate and adequate assistance to the affected people led to social unrest.

The causes of the consequences of the great flood of the Lithaios include:

- the absence of flood protection / hydraulic works
- interventions both in the riverbed (e.g. dams and mills) and in the river basin (uncontrolled felling of trees in the adjacent Chassia and Kamvounia mountains)
- the type of building construction (many masonry (brick) houses, absence of stone foundations, etc.)
- heavy rainfall and the localized nature of the phenomenon (mainly confined to the Lithaios River basin).

In the years following the flood, the following were gradually carried out: diversion of the Lithaios River to a new bed, flood control works and hydraulic works (such as draining of marshes, construction of canals, etc.), but also the fall of the water table due to overpumping, etc.

Source: Bantekas, Y., Diakakis, M., Mavroulis, S., Lekkas, E. (2018). The great flood of 1907. One of the greatest natural disasters that hit Greece. International Conference "Pineios River: Source of Life and Development in Thessaly", 2-3 November, Larissa, Greece.

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN

THE DEADLIEST 1907 LITHAIOS FLOOD IN TRIKALA CITY

Characteristic views of the impact of the 1907 Lithaios flood on the local population. This is the deadliest reported flood and among the deadliest natural disasters in Greece.
Photos credit: Vretos, I.A. (1907). Encyclopedic Calendar of 1908. In Athens, Estia Bookshop; Panos, V. (2009). The River of Rage 1907. The Flood of Lithaios. “Agapo tin polin" Publications.

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN
THE DEADLIEST 1907 LITHAIOS FLOOD IN TRIKALA CITY

Characteristic views of the impact of the 1907 Lithaios flood on the local population.
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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN
THE 1907 FLOOD

The Pichtou stone bridge destroyed after the 1907 flood in Trikala due to the overflow of Lithaios River, which is one of the most known tributaries of Pineios and affected the largest part of the Trikala town. Photo credit: Stefanos Stournaras

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN
THE 1920 FLOOD

The 1920 Flood
The inundated Pineios River at Larissa (via Kypraiou 2011)

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN

THE 1948 FLOOD IN LARISSA

The 1948 Flood in Larissa
Source: Takis Tloupas

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN
THE 1962 FLOOD

The 1962 Karla Lake
Photo Credit: Takis Tloupas

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN

THE 1963 FLOOD

View of the area affected by the 1963 flood in Pineiada
Source: Dimitris Letsios

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN

THE 1987 FLOOD

With the floods of March 1987 the landscape resembled a lake. Lake Karla appeared again, for only a few days. After the flood waters receded, it was found that the damage to farmland and existing crops was extensive.

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN

THE 1994 FLOOD IN METAMORPHOSI VILLAGE

On October 22, 1994, when the rushing waters of Enippeas, after 48 hours of heavy rainfall, combined with the waters of Sofaditis, Italikos, Karampalis, Mega, Kalenetzis, Pamisos and Farsalitis began to slowly but steadily reach the end point of the plain, in Metamorfosi (Karditsa).

Earlier, damage had occurred to the Smokovo dam, which was under construction, while the towns of Karditsa and Sofades were also flooded.

The local authorities at the time had been forced to break up the road surface in several places on the provincial network in Kampos, Koskinas, Marathea and Marko, in order to give way to the flood waters that were forming a huge lake.

In Evidrio, the bridge of Enipeas had given way and the village was cut off, there was great damage to houses in Myrini, as well as in Sofades and Rizovouni. In the town of Karditsa, underground parking structures in the town center were flooded, but also houses and businesses, particularly in the flood zone of Karampali, livestock units and shops, as the water level of the Gavra and Karampali rivers was above the siphoning point of the rainwater, causing it to return into the town.

A great “tsunami” from the plateau of Xiniada and from all the tributaries of Pineios was heading towards the end point of the plain, in particular towards Metamorphosi area. In the late afternoon of October 23, the waters flooded the village, which slowly sank under the muddy waters. The situation over the next two weeks was dramatic. The waters had formed a vast lake, more than 3 meters deep, with the houses and property of the inhabitants underneath, who were painfully aware that the absence of flood defenses and the lack of cleaning of canals and tributaries was having tragic consequences. For 20 days, they approached the village in boats. Only the roofs of the houses protruded and the flood waters were not receded.

Source: https://www.ieidiseis.gr/ellada/213291/i-tragiki-istoria-epanalamvanetai-stin-karditsa-29-xronia-meta-i-megali-plimmyra-tou-1994

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN

THE 1994 FLOOD IN METAMORPHOSI VILLAGE

The 1994 Metamorphosi Flood
More than 70 houses in about 20 communities were totally destroyed by the flood, more than 200 suffered severe damage and other 90 minor damage, whereas 80 km^2 of agricultural land (cotton fields) were flooded.
(Mimikou et al., 1995).

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN
THE 1994 FLOOD IN METAMORPHOSI VILLAGE

Snapshots of a video taken from helicopter from the flooded village of Metamorphosi in October 1994.
Video source: https://www.youtube.com/watch?v=p6kLeauyA_Q&t=2s

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN

THE 1994 FLOOD IN METAMORPHOSI VILLAGE

Snapshots of a video from the flooded village of Metamorphosi in October 1994.
Video source: https://www.youtube.com/watch?v=0T4L0Ec7Vs4

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HISTORICAL AND RECENT FLOODS IN THE THESSALIAN PLAIN
THE 2016 AND 2018 FLOODS

The September 2016 Flood
by Lithaios River in Trikala city

The January 2018 Flood
in Pineios River affecting agricultural land near Koutsochero and nearby locations

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SYNOPTIC ANALYSIS OF THE EARLY SEPTEMBER 2023 DANIEL STORM AND ITS IMPACT

Throughout the early September 2023, Europe has been under the influence of a weather phenomenon known as an Omega block, which has resulted in severe weather conditions for many. An Omega block is a synoptic pattern characterized by the presence of a high-pressure system positioned between two low-pressure systems, forming a configuration reminiscent of the Greek letter omega. This atmospheric pattern appeared high persistence over a week in the area. Figure 1 depicts the synoptic conditions with respect to 500 hPa geopotential height along with surface atmospheric pressure from Monday 04 September to Wednesday 13 September 2023.

Storm Daniel emerged in the Ionian Sea, partially attributed to this atmospheric setup and was named by the Hellenic National Meteorological Service. This storm went on to unleash catastrophic flooding across central and eastern Greece. The southern warm and moist air combined with cold upper air established favorable instability conditions to produce extreme precipitation over the region of Thessaly, Greece. Furthermore, the warmth of the region's seas during this time of year contributed to the moisture required for the intensification of the storm. On Monday, September 4, 2023 Storm Daniel moved inland over the Balkans, triggering intense rainfall and thunderstorms in the area. Central Greece bore the brunt of this weather event, experiencing some of the most substantial daily rainfall totals observed in the region since 2006. Remarkably, at least two rain gauges recorded over half a meter of rainfall in less than a 24-hour period.

Storm Daniel, which recently traversed the Mediterranean region, wrought significant devastation in its wake.

In central Greece, this meteorological event claimed the lives of 15 individuals, coinciding with an unprecedented deluge of rainfall that surpassed all previous recorded measurements. The storm originated within the confines of Greece and was christened by the Hellenic National Meteorological Service.

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SYNOPTIC ANALYSIS OF THE EARLY SEPTEMBER 2023 DANIEL STORM AND ITS IMPACT

Notably, Storm Daniel precipitated an extraordinary meteorological occurrence in Greece on September 5 and 6, 2023 during which an astounding 750 millimeters of rain was documented within a mere 24-hour period at a monitoring station situated in the village of Zagora.

Throughout Thessaly, the central agricultural region of Greece, numerous monitoring stations reported receiving between 400 and 600 millimeters of rainfall within the same 24-hour timeframe. Given the agricultural significance of Thessaly, the ramifications of this meteorological event are anticipated to have severe economic consequences.

Subsequently, on September 10, 2023 Storm Daniel made landfall in Libya, inducing adverse meteorological conditions characterized by robust winds and abrupt heavy precipitation. These conditions affected multiple northeastern areas of Libya, specifically Benghazi, Tobruk, Toukra, Talmeitha, Almarj, Taknes (Al Jabal Al Akhdar), Al Owailia, Bayada, Albayda, Shahhat, Sousa, and Derna. Evidently, the storm resulted in substantial infrastructure impairment, including damage to the road network and disruptions to the telecommunications system. Furthermore, it forced the displacement of approximately 410 families, equivalent to roughly 2050 individuals, in addition to 35 migrants, as reported by the International Organization for Migration on September 11, 2023.

In the subsequent days, an extended period of heavy rainfall has particularly impacted the northeastern regions of Libya, precipitating widespread flooding, casualties, and property damage. The precise extent of this impact within the region is currently under assessment by relevant authorities and collaborative partners on the ground. According to media sources, the toll from this meteorological event includes a minimum of 2000 confirmed fatalities, with thousands more individuals unaccounted for. Derna, situated within the Cyrenaica Region of northeastern Libya, emerged as the epicenter of the disaster, where mudslides severely impacted a substantial population. In response to these dire circumstances, Benghazi and several other cities in the eastern part of the country have instituted curfews and suspended educational activities.

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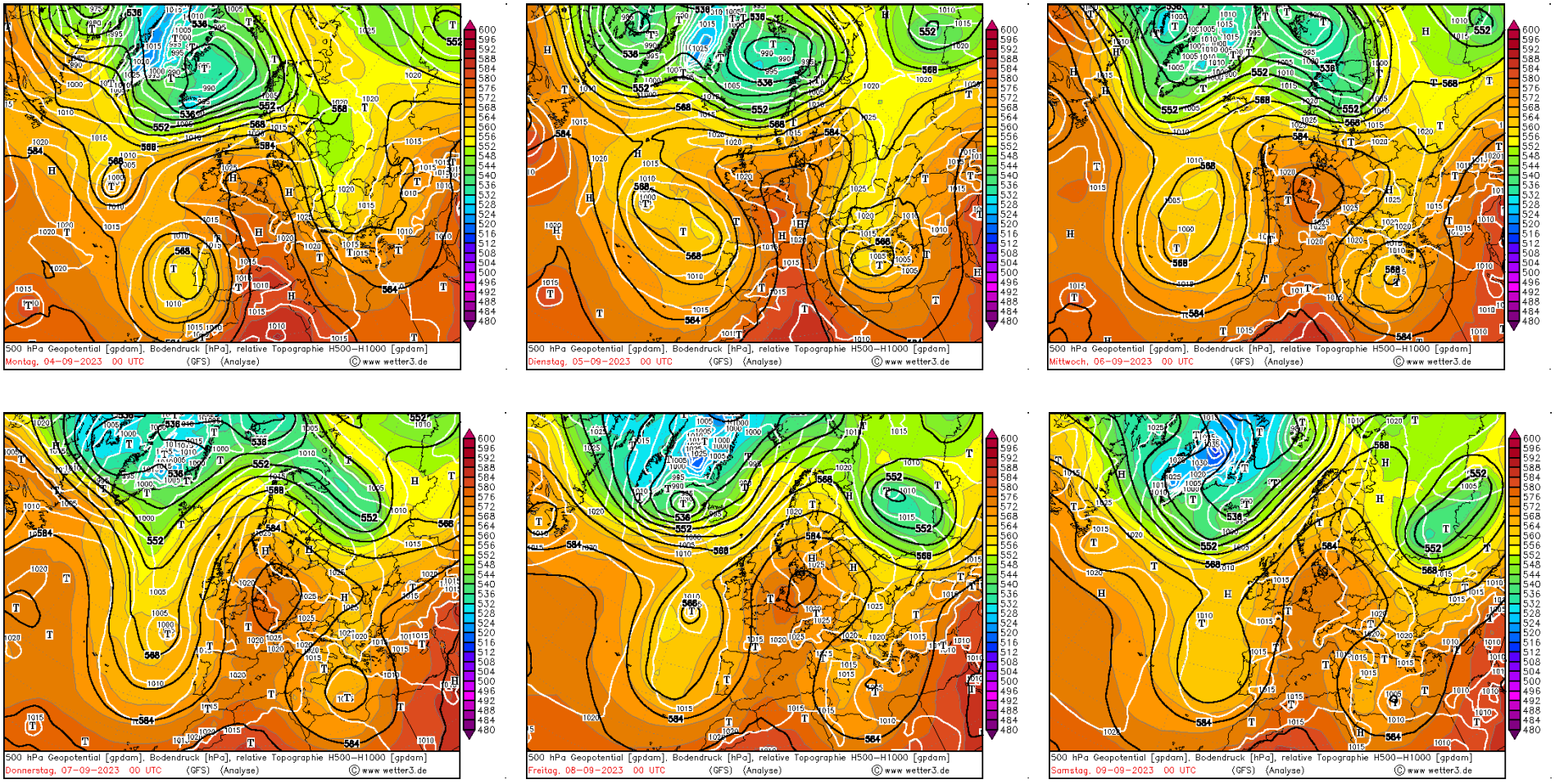
SYNOPTIC ANALYSIS OF THE EARLY SEPTEMBER 2023 DANIEL STORM AND ITS IMPACT



The persistence of Omega block over Europe. The synoptic conditions with respect to 500 hPa geopotential height along with surface atmospheric pressure from Monday 4 to Saturday 9 September 2023.

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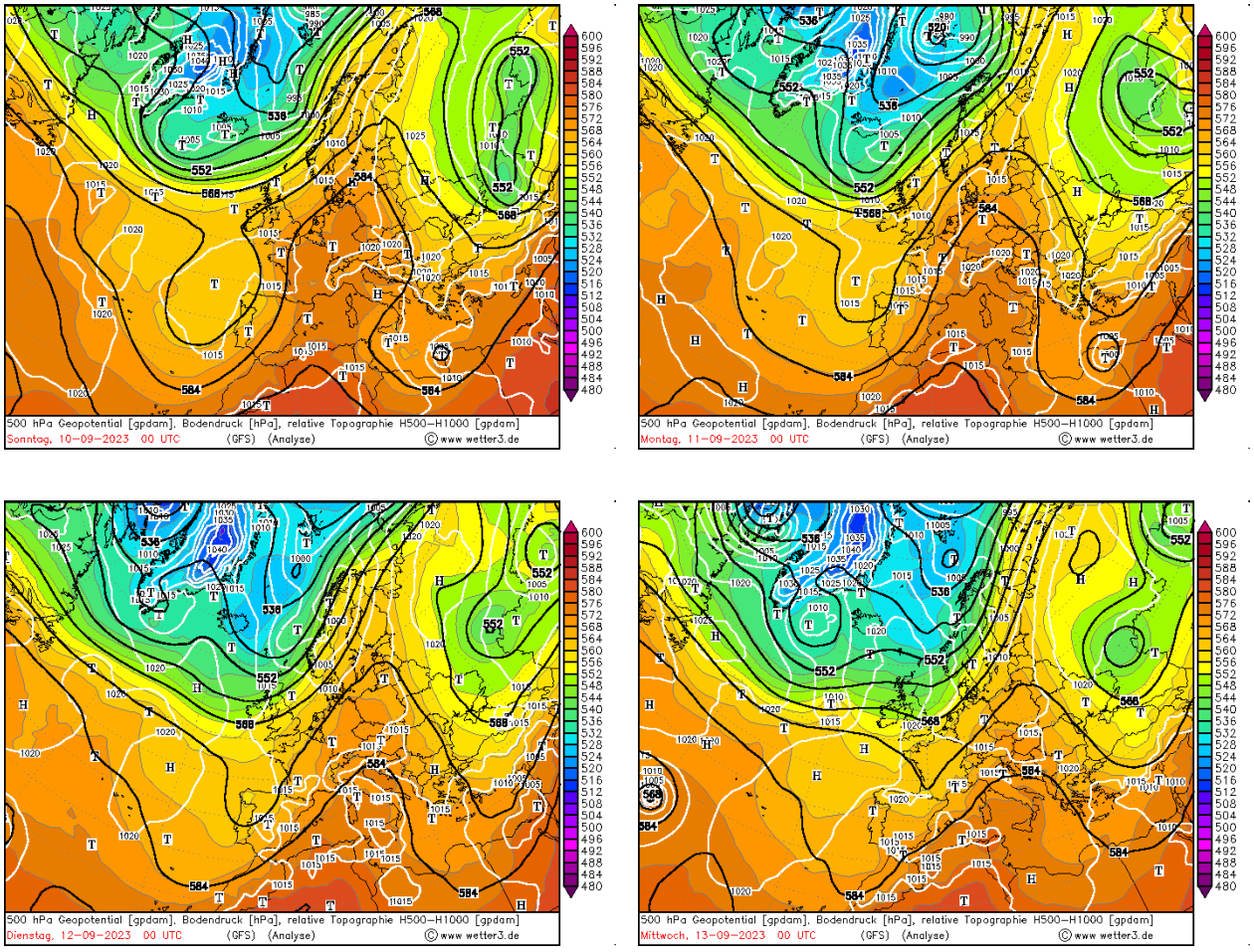
SYNOPTIC ANALYSIS OF THE EARLY SEPTEMBER 2023 DANIEL STORM AND ITS IMPACT



The persistence of Omega block over Europe. The synoptic conditions with respect to 500 hPa geopotential height along with surface atmospheric pressure from Sunday 10 to Wednesday 13 September 2023.

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THE EXTREME FORECAST INDEX (EFI)

The Extreme Forecast Index (EFI), given by the European Centre for Medium-Range Weather Forecasts (ECMWF), is computed from the difference between Cumulative Distribution Function (CDF) curves of the M-climate and the forecast distribution of the current ensemble (ENS). The calculations are made so that more weight is given to differences in the tails of the (climatological) distribution. The M-Climate is derived from a set of medium range re-forecasts. These are created using the same calendar start dates over several years for data times either side of the time of the ensemble run itself. The re-forecast runs are at the same resolution as the medium range ensemble (currently 9km) and run over the 15-day medium range ensemble period.

The following charts depict regions where abnormal precipitation patterns are expected to occur. The primary purpose of these charts is to offer indications of areas where unusual precipitation levels are likely, as determined by the ECMWF ensemble forecast (ENS) system. For each grid point, the ENS distribution of precipitation from a particular ENS run is compared with the model climate (M-climate) distribution of precipitation. The objective of these charts is to provide insights into regions where atypical amounts of precipitation are anticipated in specific periods leading up to the chosen validity time.

The chart on the left represents the Extreme Forecast Index (EFI), color-coded according to the scale depicted above the charts, while the Shift of Tails (SOT) contours are represented in black. EFI values falling between 0.5 and 0.8, regardless of their sign, typically indicate the likelihood of "unusual" weather while EFI values exceeding 0.8, again regardless of their sign, generally signal the likelihood of "very unusual" or extreme weather conditions.

The following charts show the evolution of EFI patterns along with the model climate for 1 day up to 4 days in advance starting from Sunday 03 September 2023. EFI values exceeded 0.8 for 05 Tuesday September 5 and Wednesday September 6, 2023, indicating that ECMWF forecast caught that extreme event over Greece.

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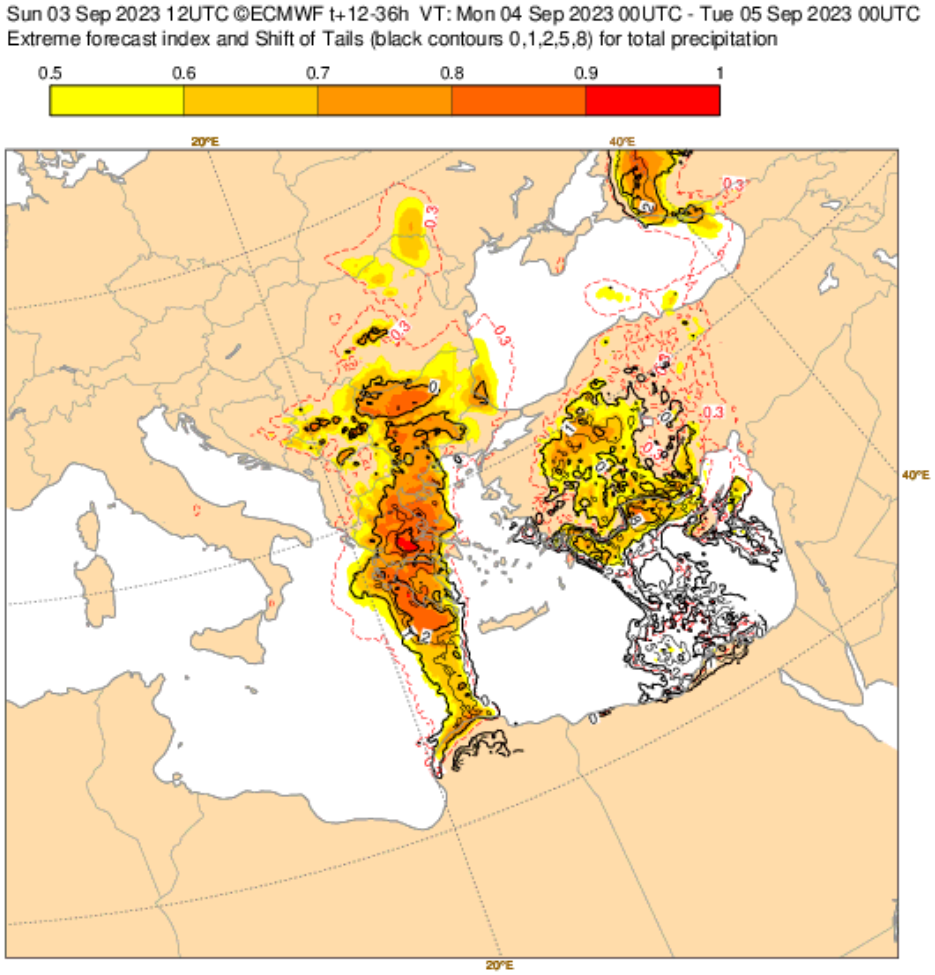
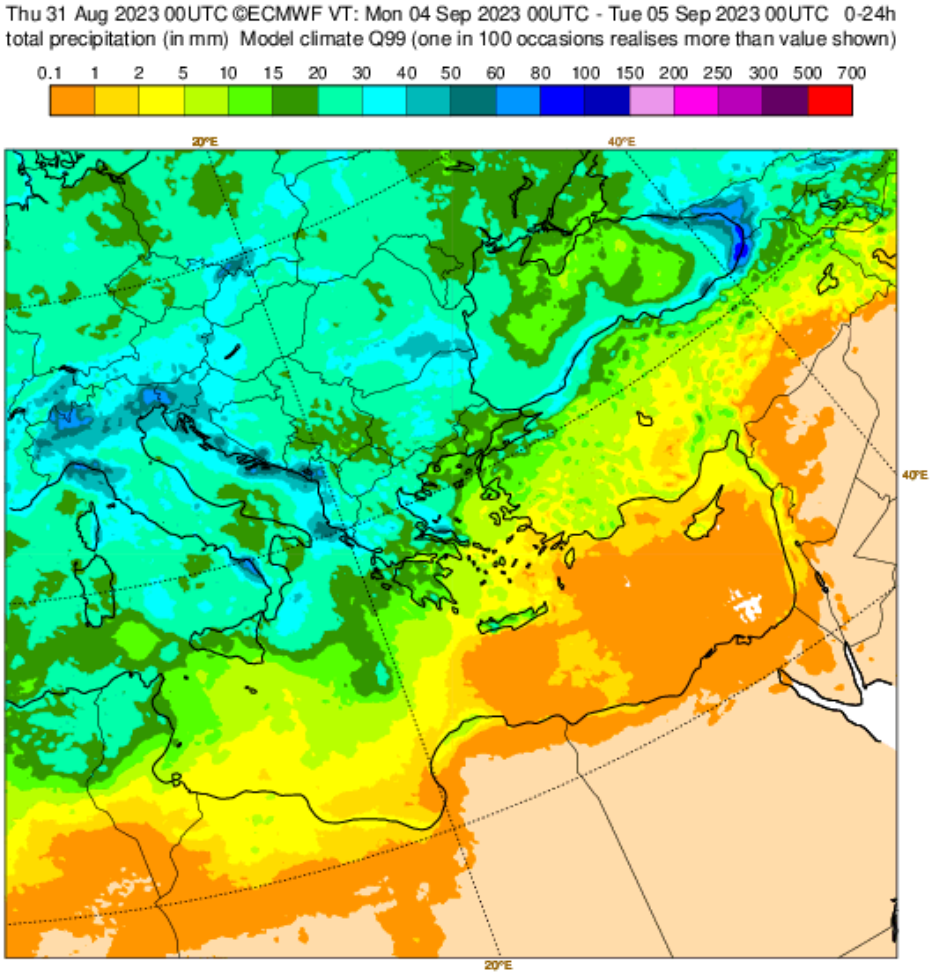
THE EXTREME FORECAST INDEX (EFI)





The Extreme Forecast Index (EFI) (left graph) along with the M-climate (right graph), for 1 up to 4 days in advance from Sunday 03 September 2023

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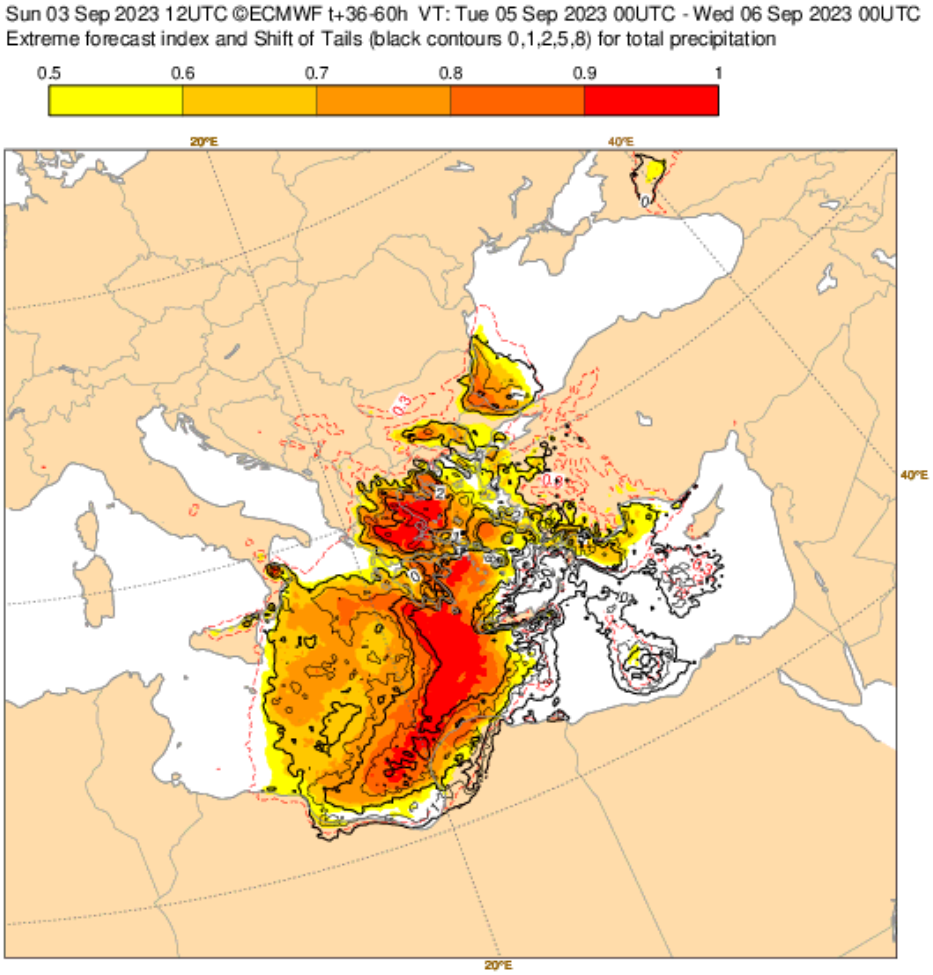
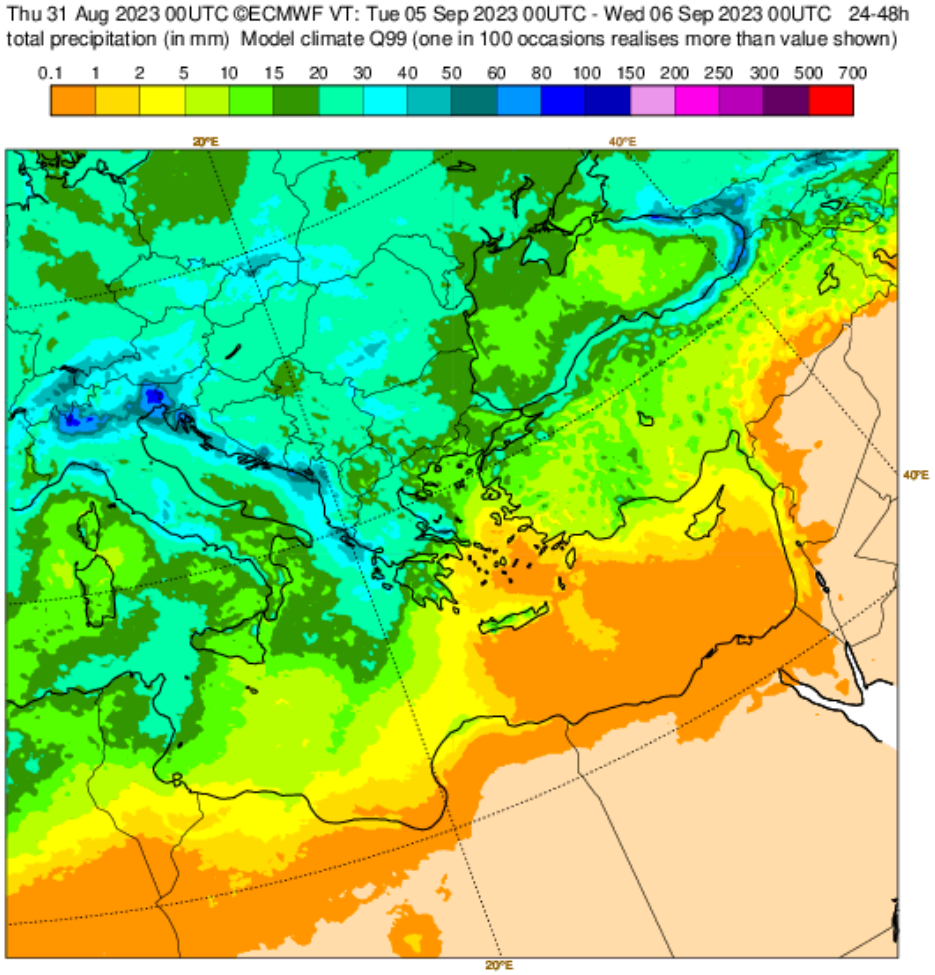
THE EXTREME FORECAST INDEX (EFI)





The Extreme Forecast Index (EFI) (left graph) along with the M-climate (right graph), for 1 up to 4 days in advance from Sunday 03 September 2023

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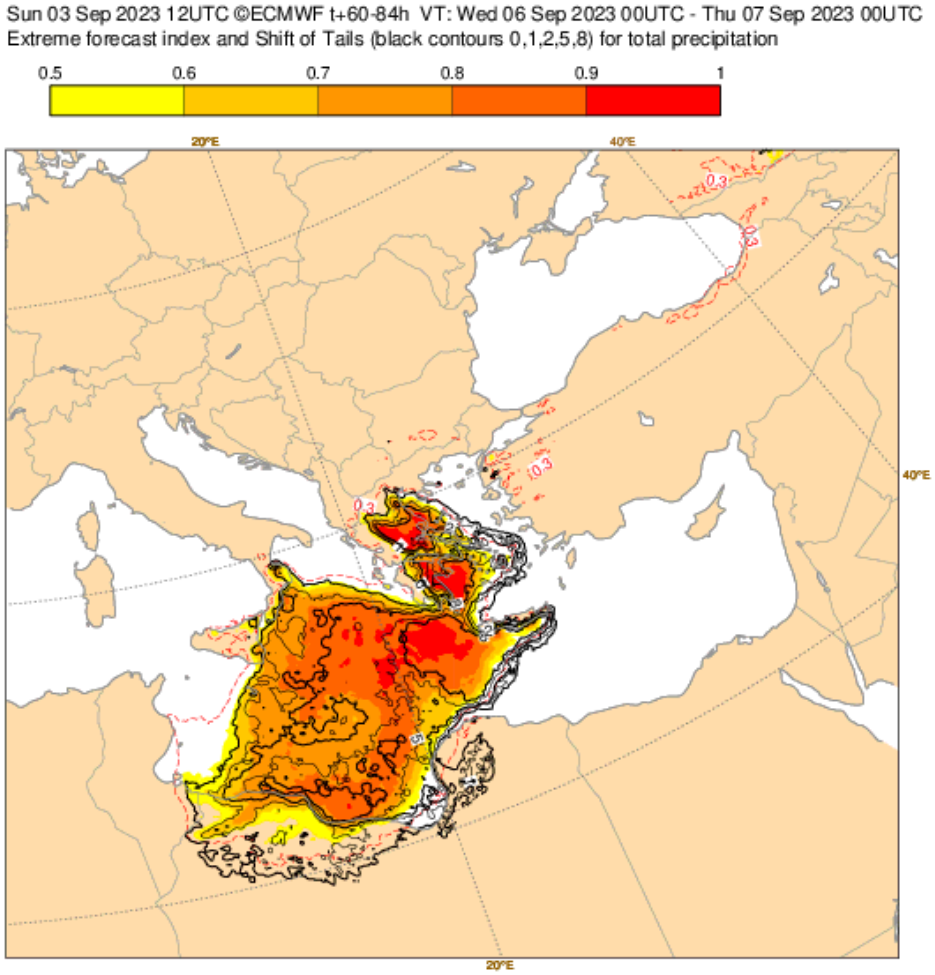
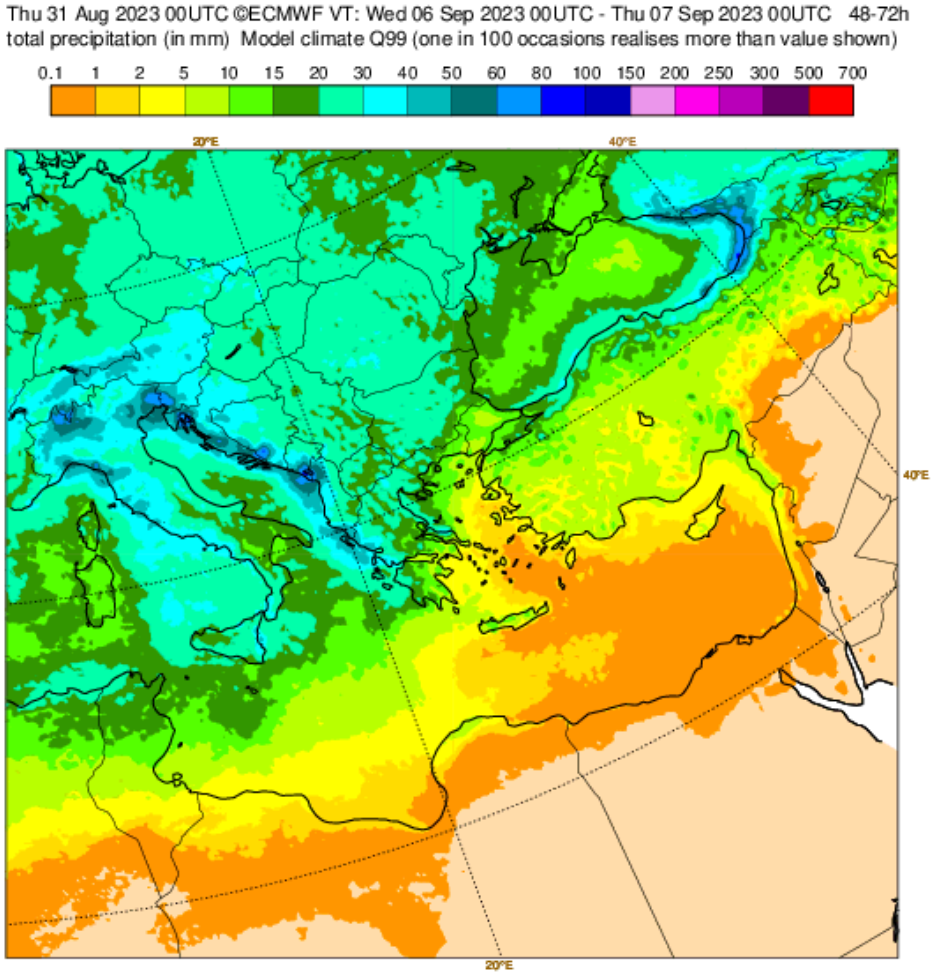
THE EXTREME FORECAST INDEX (EFI)





The Extreme Forecast Index (EFI) (left graph) along with the M-climate (right graph), for 1 up to 4 days in advance from Sunday 03 September 2023

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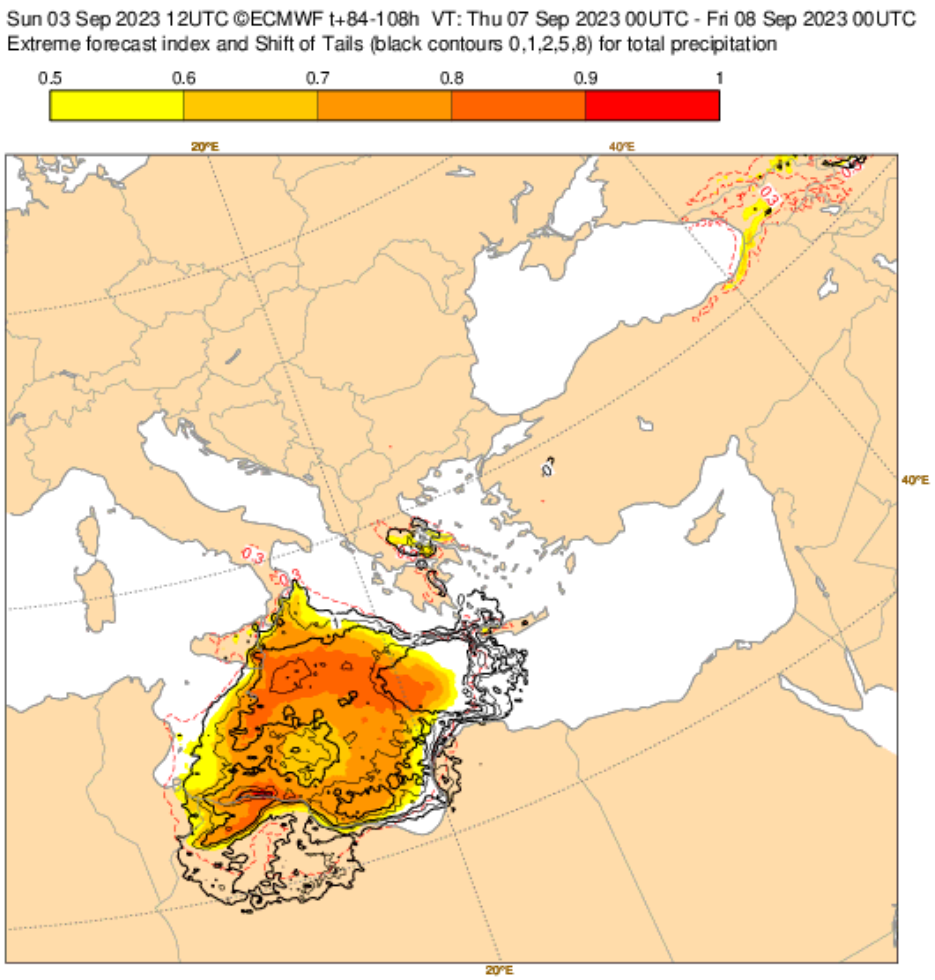
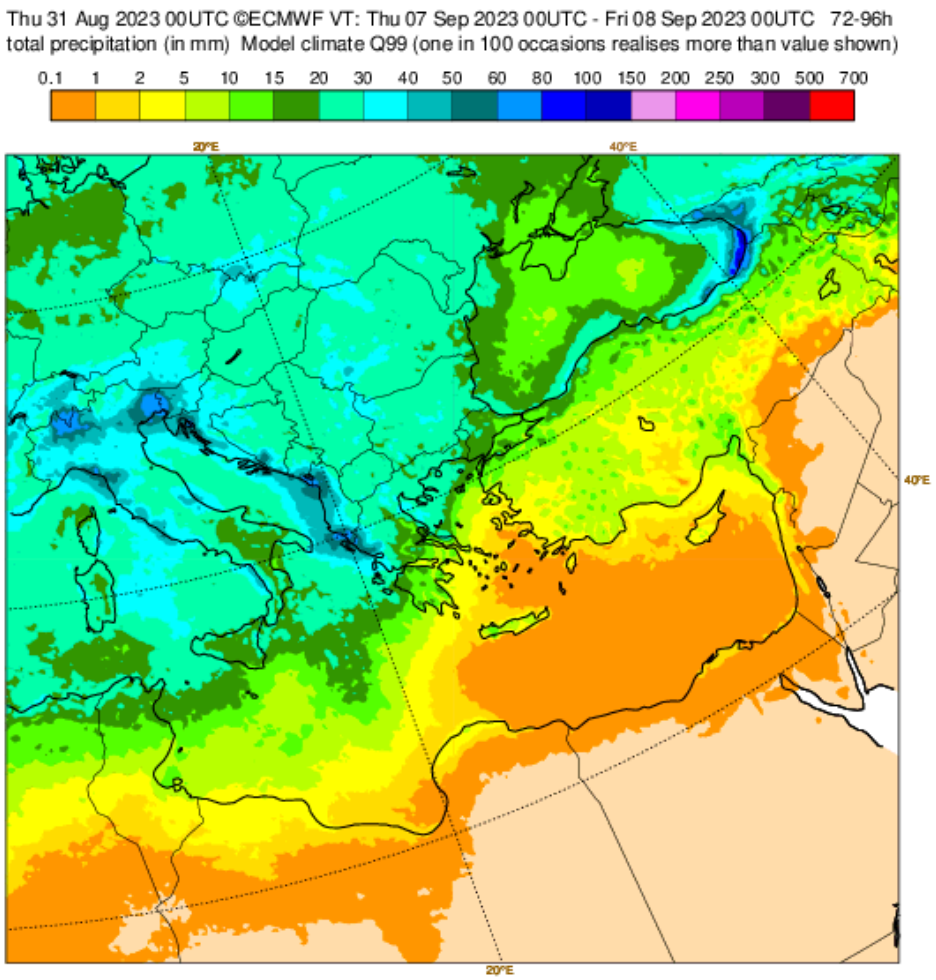
THE EXTREME FORECAST INDEX (EFI)





The Extreme Forecast Index (EFI) (left graph) along with the M-climate (right graph), for 1 up to 4 days in advance from Sunday 03 September 2023

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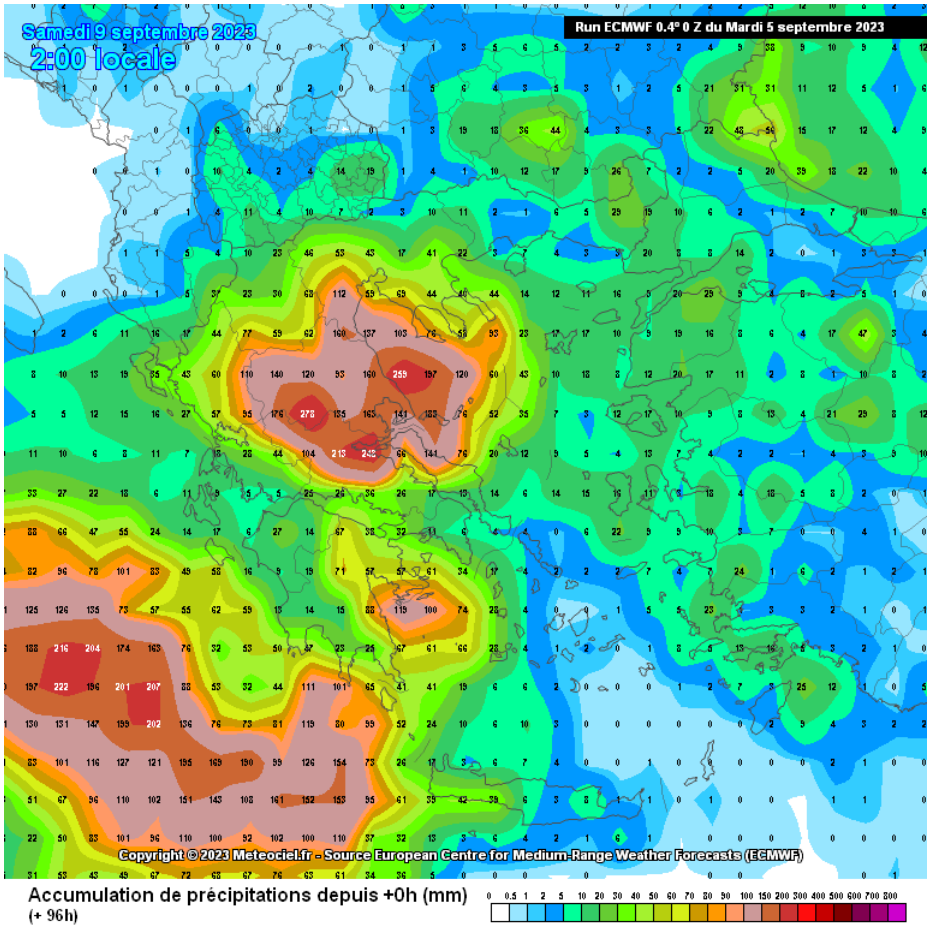
ECMWF FORECAST

The following graph illustrates the 96 hours accumulated precipitation over Greece as it was forecasted by ECMWF from Tuesday September 5, 2023. The forecast succeeded in interpreting the precipitation pattern, underestimating the total precipitation over Thessaly, indicating accumulated precipitation approximately 300mm. However, taking into consideration the spatial resolution (0.4o) of the models, one can say that this extreme event has been forecasted well. According to the emergency bulletin issued by Hellenic National Meteorological Service, a low-pressure system originating from the northern Balkans, accompanied by cold and unstable air masses, was anticipated to shift southward towards the southern Ionian Sea. This movement was expected to give rise to a surface low-pressure system that will influence a wide expanse of Greece. As a result, heavy rainfall and thunderstorms were forecasted, accompanied by occurrences of hailstorms and frequent lightning. Additionally, strong winds were expected, and a notable temperature decline was anticipated as well.



ECMWF runs on Tuesday, September 5, 2023
for accumulated precipitation 96 hours in advance.

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USE OF SATELLITE IMAGERY FOR MONITORING DANIEL STORM AND ITS IMPACT

MONITORING OF FLOOD EXTENT (1/6)

The processing was done with data SAR-GRD from the Sentinel 1A satellite of Copernicus program with downloads on 6 September 2023, 07:23 local time (descending orbit) and 7 September 2023, 19:23 local time (ascending orbit) using the s/w SNAP version 8 following the instructions of UN SPIDER.

Especially for Larissa area, the processing was done with the Google Earth engine and not with SNAP. The extent of the flood was mapped using two Copernicus Sentinel-1A images acquired in descending orbit on 6 September 2023, 07:40 local time (ascending orbit). The images were processed in Google Earth Engine using a “change detection” and thresholding approach, where the after-flood images are divided by the before-flood images (acquired 20 August 2023 and 1 September 2023), resulting in a raster layer showing the degree of change per pixel (Methodology and code: UN SPIDER Knowledge Portal).

Both results indicate that many areas were flooded in the Thessaly plain until morning of 6 September 2023, for sure until 7 September 2023, with most of the water accumulating in the areas of Magoulitsa, Sofades Municipality, Ypereia, Sofiada, Mavrovouni and Chalki, also close to Larissa city, Karditsa city area and Trikala city area as well.

So, for Larissa area there two images of 6 September 2023 in order to make a comparison plus one image of 7 September 2023 following the first processing method. All other images have been created using the first methodology and data used are dated of 7 September 2023.

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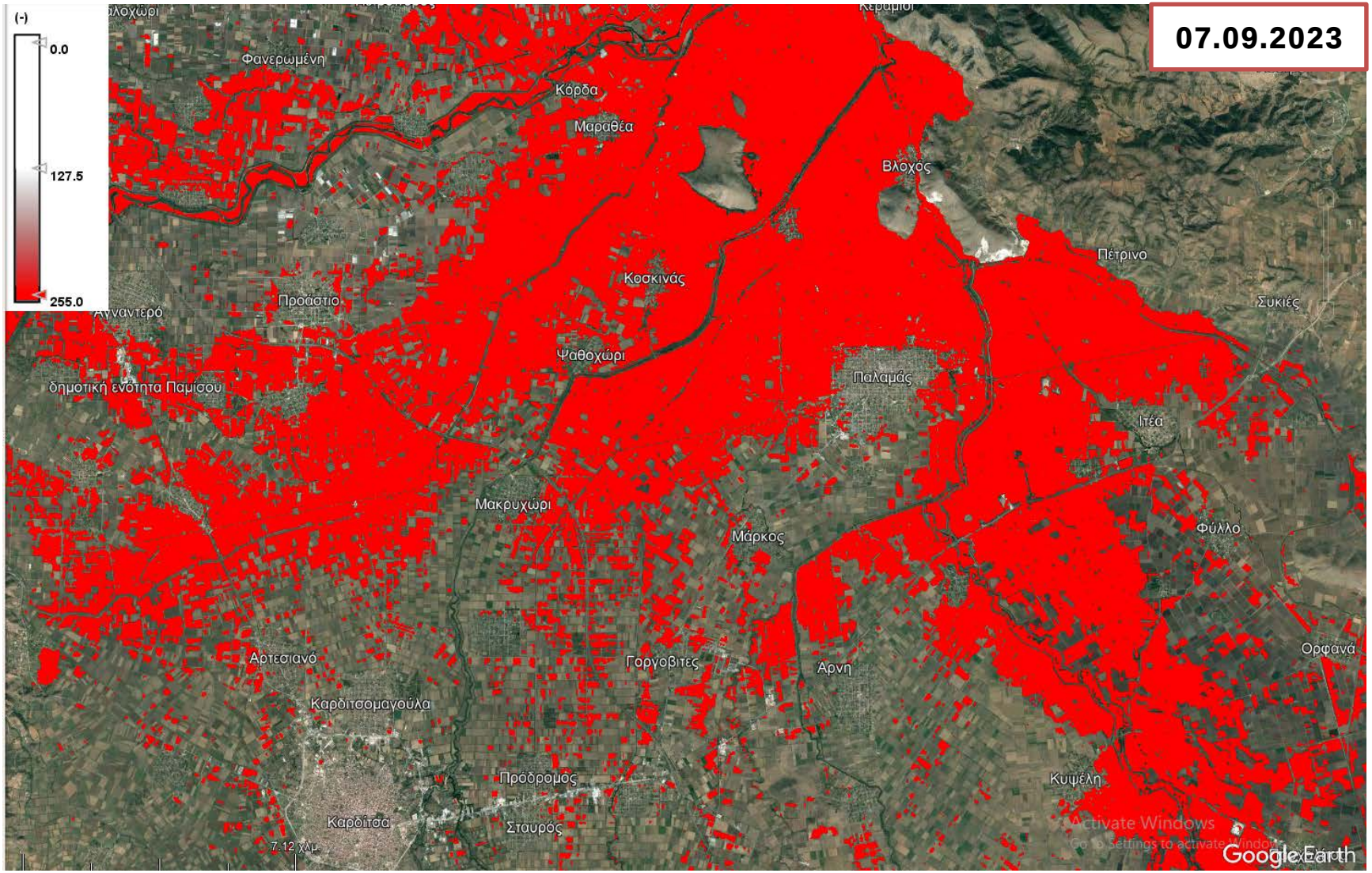
USE OF SATELLITE IMAGERY FOR MONITORING DANIEL STORM AND ITS IMPACT

MONITORING OF FLOOD EXTENT (2/6) – KARDITSA AREA



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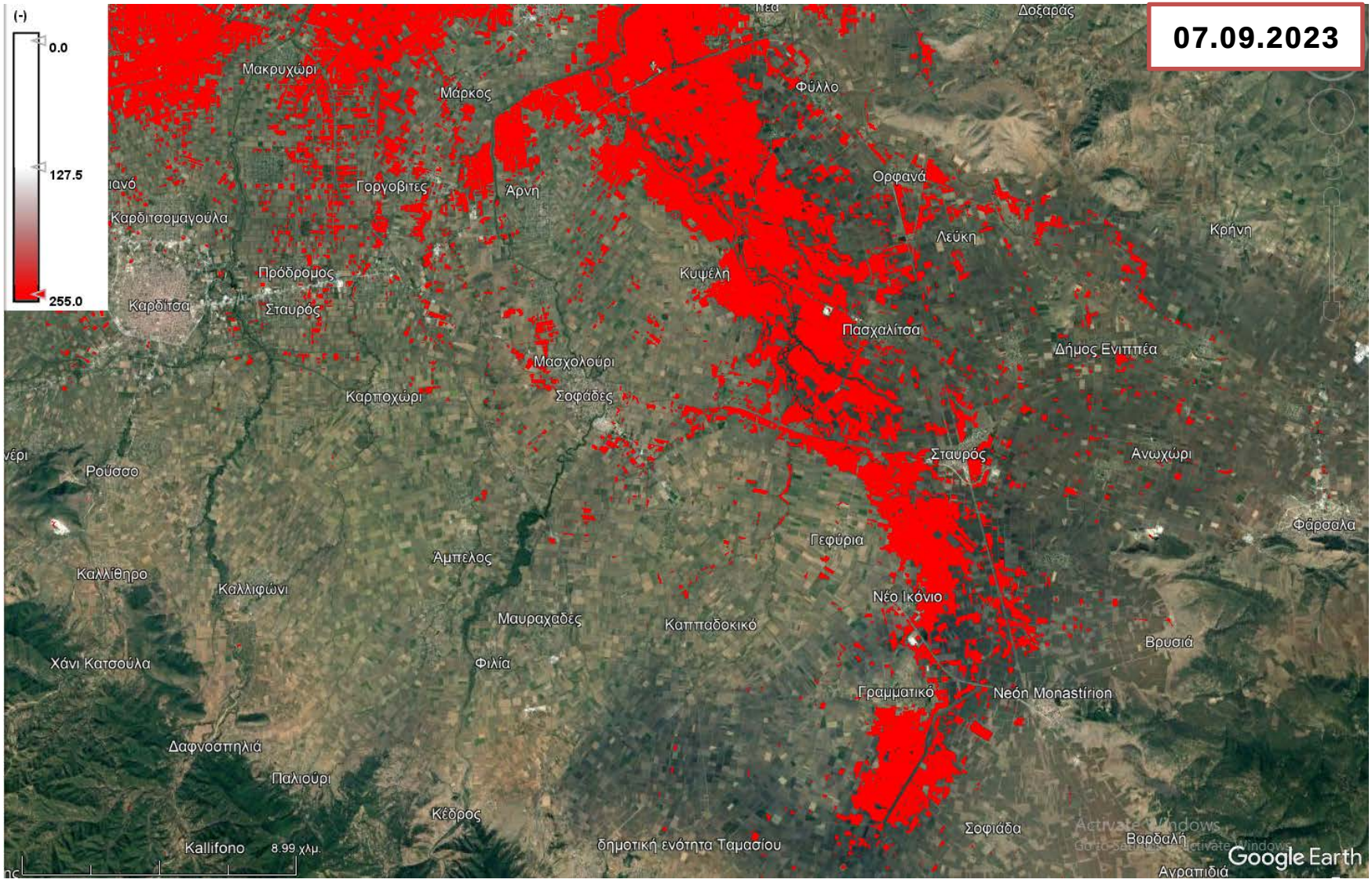
USE OF SATELLITE IMAGERY FOR MONITORING DANIEL STORM AND ITS IMPACT

MONITORING OF FLOOD EXTENT (3/6) – SOUTH OF KARDITSA



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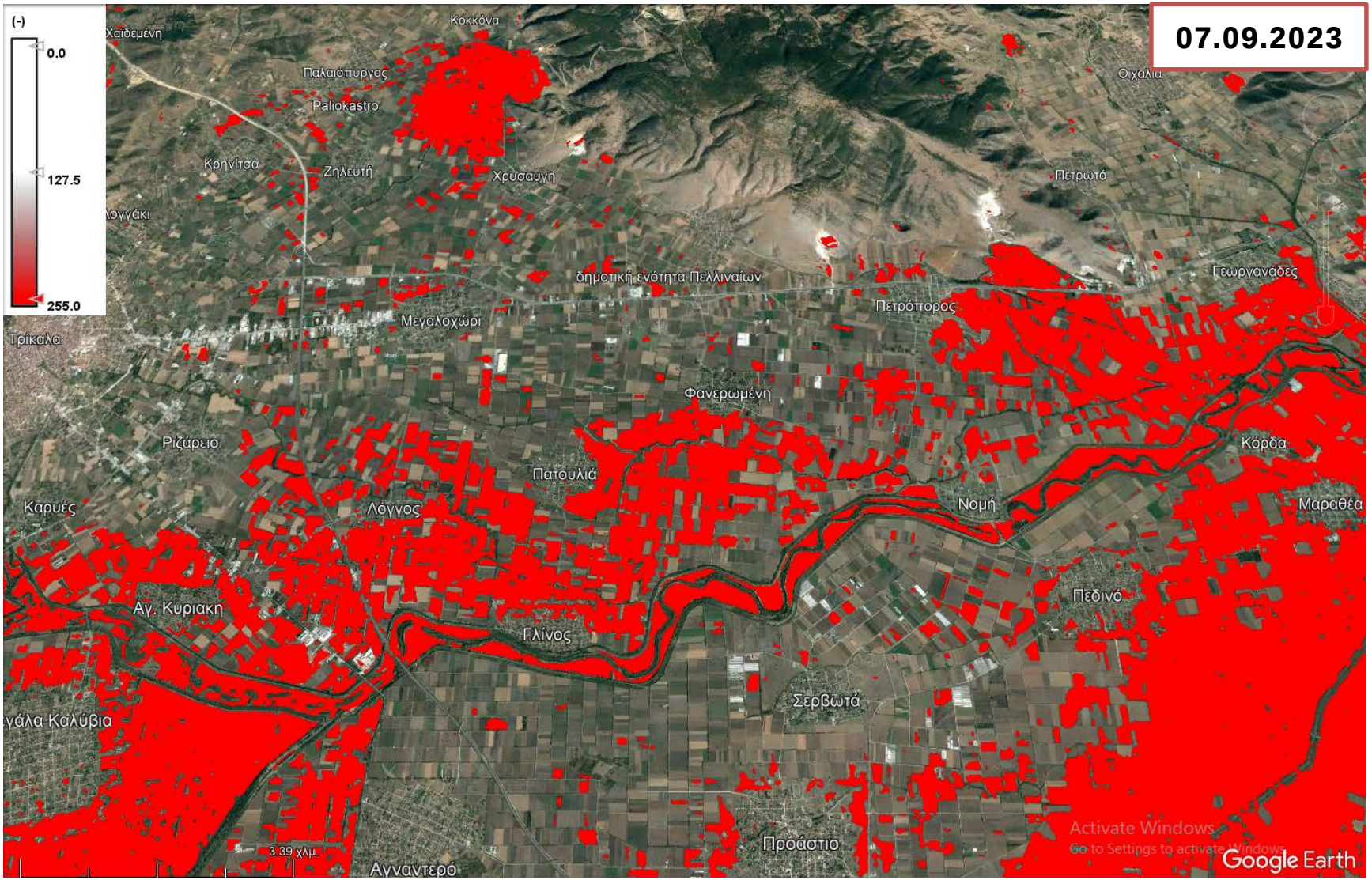
USE OF SATELLITE IMAGERY FOR MONITORING DANIEL STORM AND ITS IMPACT

MONITORING OF FLOOD EXTENT (4/6) – TRIKALA AREA



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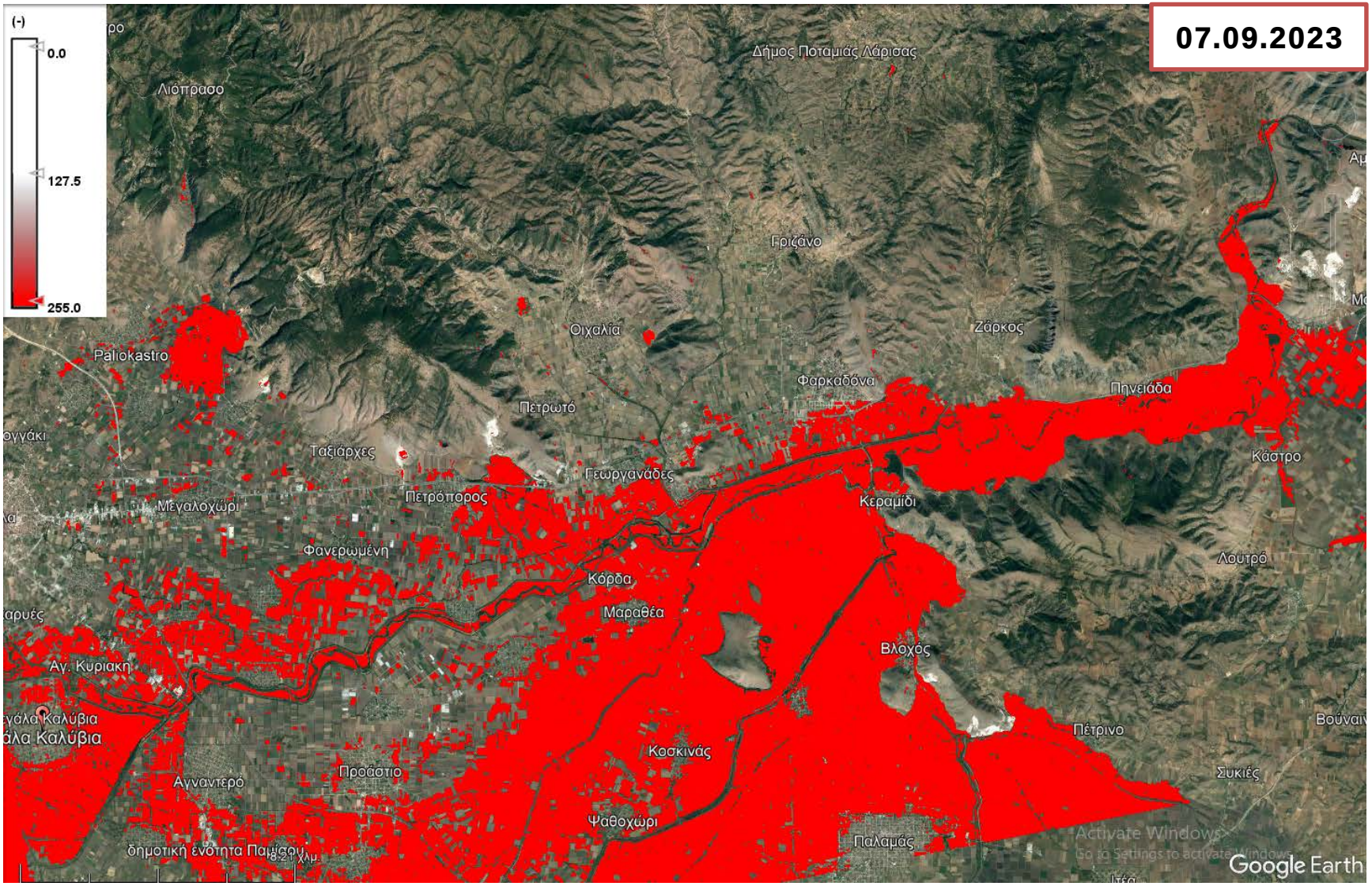
MONITORING OF FLOOD EXTENT (5/6) – MEGALA KALYVIA AREA



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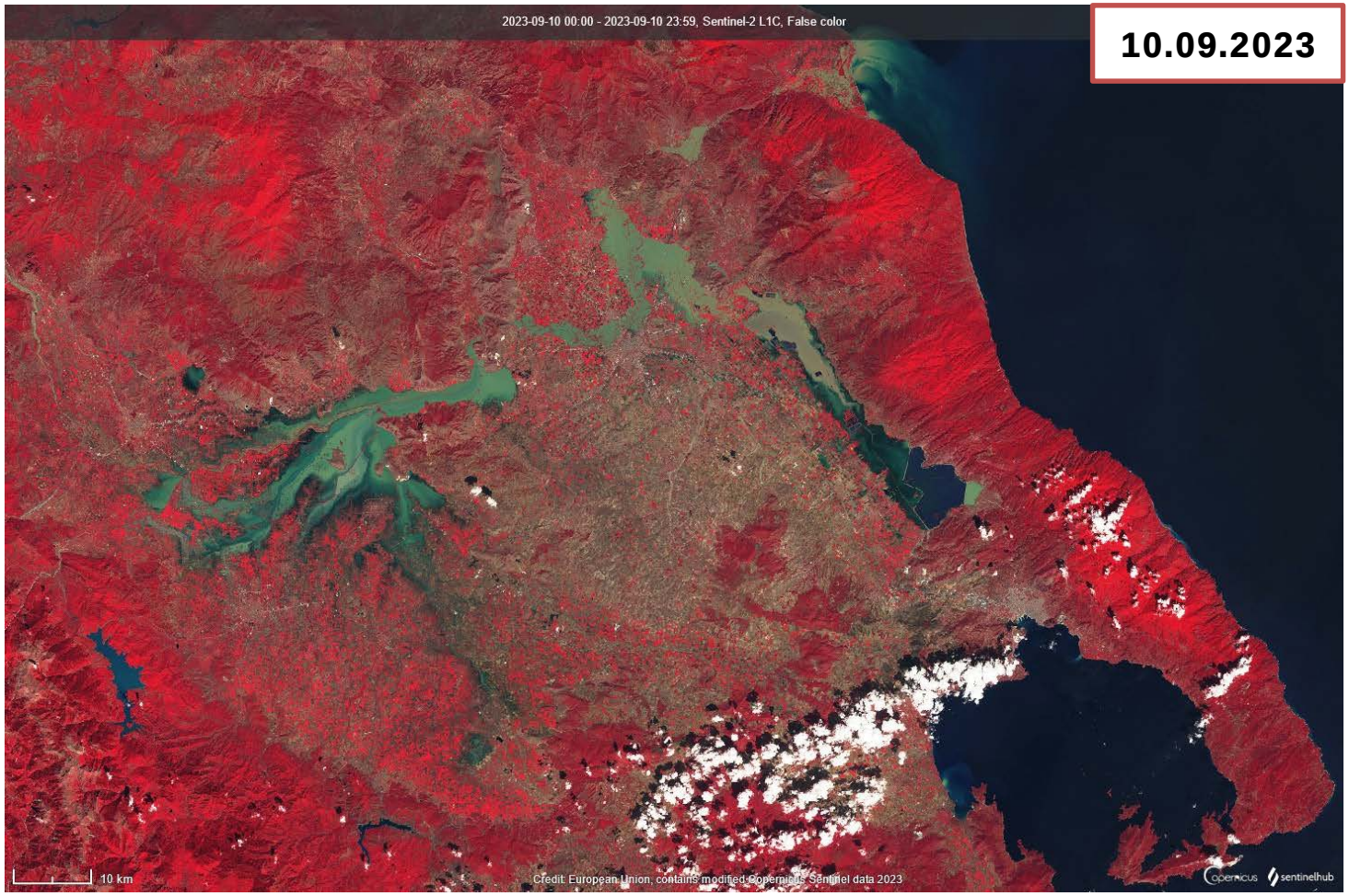
USE OF SATELLITE IMAGERY FOR MONITORING DANIEL STORM AND ITS IMPACT

MONITORING OF FLOOD EXTENT (6/6) – TOTAL EXTENT



An image from optical satellite Sentinel 2 product L 1C false-color on 10 September 2023, showing the total extent of the flood in Thessalian plain.

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USE OF SATELLITE IMAGERY FOR MONITORING DANIEL STORM AND ITS IMPACT

MONITORING OF THE TOTAL EXTENT OF FLOODING

An image from optical satellite Sentinel 2 product L 1C true-color on 10 September 2023, showing the total extent of the flood in Thessalian plain.

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USE OF SATELLITE IMAGERY FOR MONITORING DANIEL STORM AND ITS IMPACT

MONITORING OF THE EXTENT OF FLOODING

An image from optical satellite Sentinel 2 product L 1C true-color on 10 September 2023 showing the geographical extent of the flood event in the area west of Larissa.

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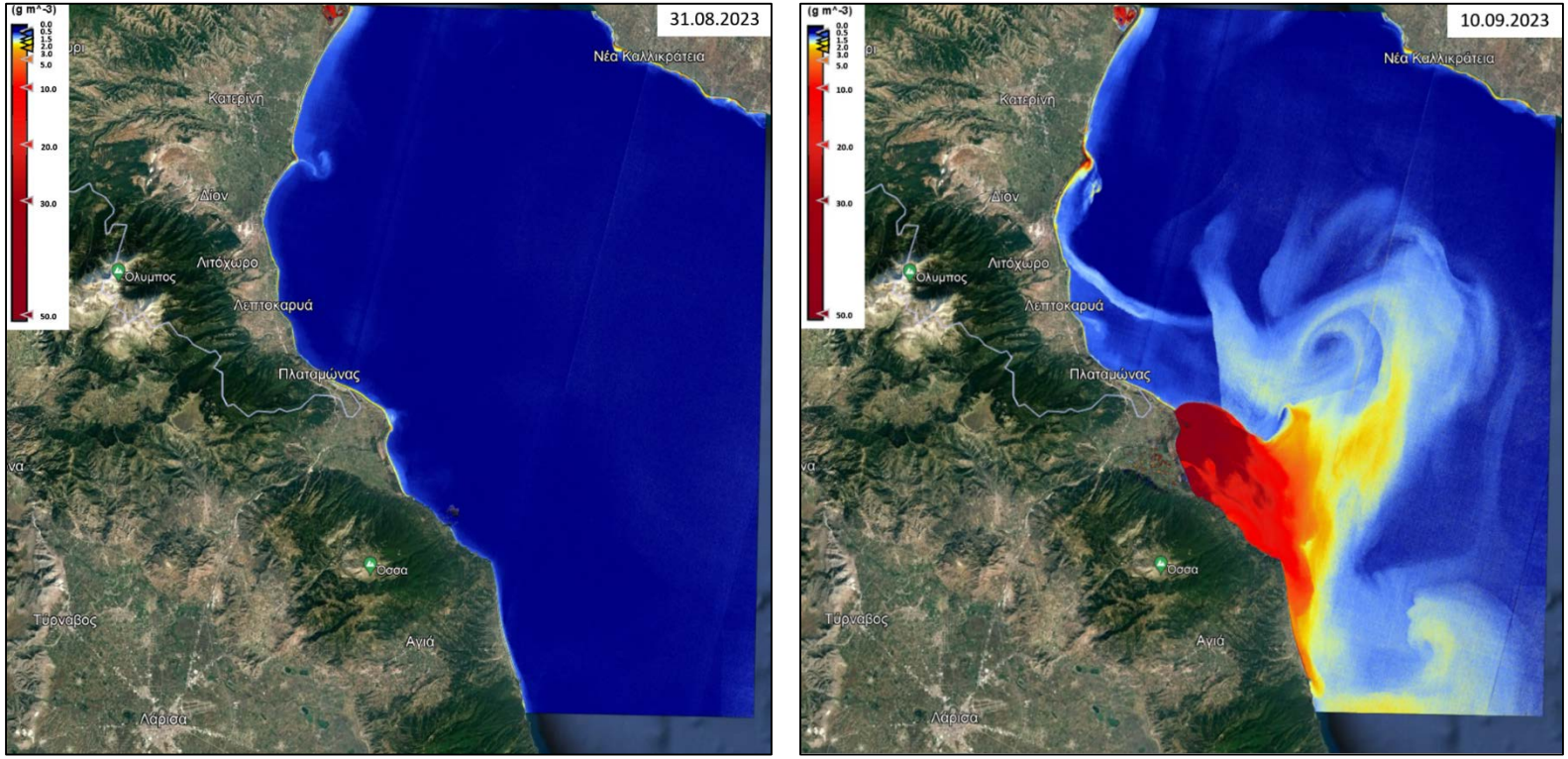
USE OF SATELLITE IMAGERY FOR MONITORING DANIEL STORM AND ITS IMPACT

DETECTION OF THE TOTAL SUSPENDED MATTER (TMS) IN THE PINEIOS RIVER DELTA



The detection of Total Suspended Matter (TSM) in the PIneios River Delta was carried out using a Copernicus Sentinel-2B Level 1C image acquired on 10 September 2023. Processing was performed in the SNAP software using the C2RCC processor algorithm, which performs atmospheric correction and calculates the TSM concentration. Results indicate a high TSM concentration that exceeds 45 g/m^3 in a range of more than 7 km from the Delta, while TSM is also observed along the coastline until Kato Polidendri. Results were compared with a Sentinel-2B Level 1C image from 31 August 2023 (before the event), which indicates almost no presence of TSM in the area.

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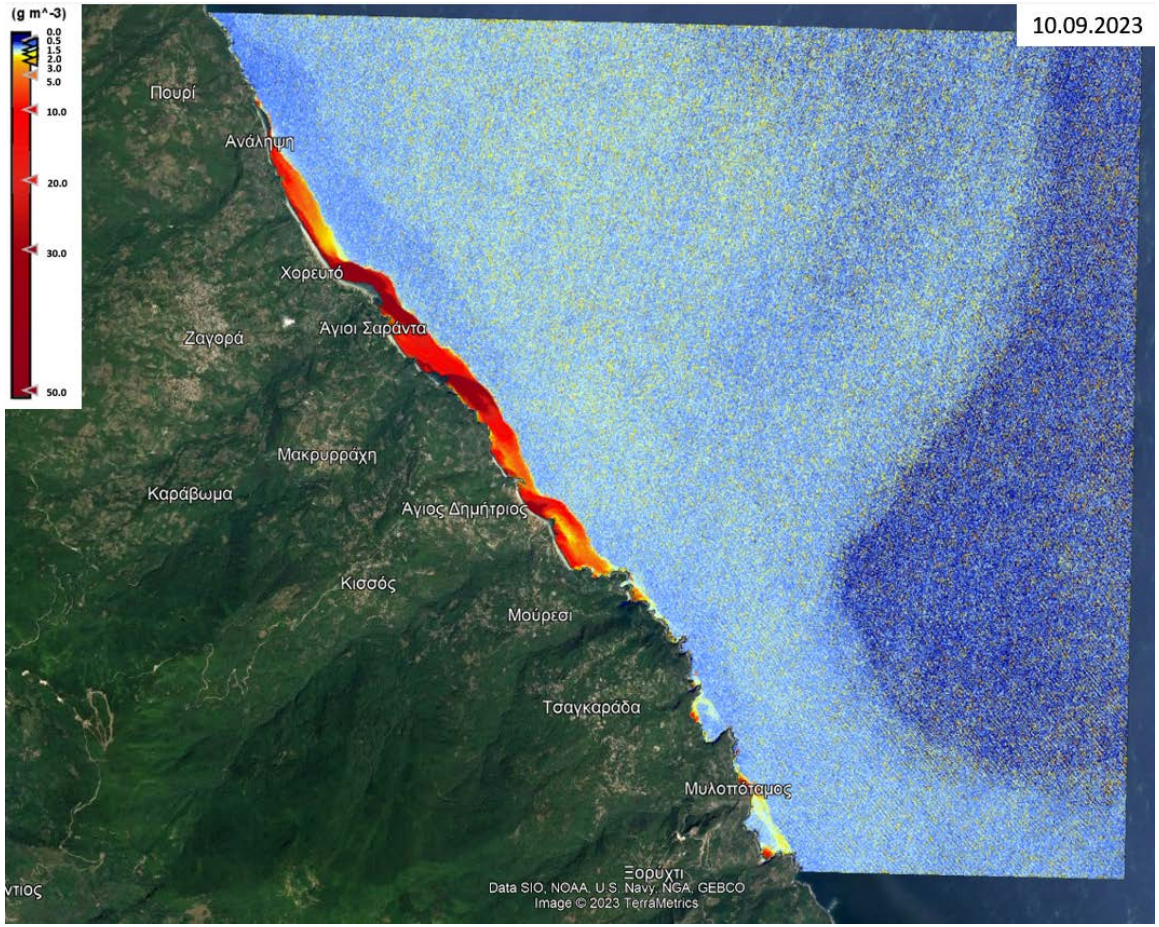
USE OF SATELLITE IMAGERY FOR MONITORING DANIEL STORM AND ITS IMPACT

DETECTION OF THE TOTAL SUSPENDED MATTER (TMS) IN THE AREA OF EAST PELION MT



Data: Sentinel-2B MSI Level-1C

10 September 2023

The detection of Total Suspended Matter (TSM) in the area of East Pelion Mt. was carried out using a Copernicus Sentinel-2B MSI Level-1C (10m spatial resolution) image acquired on 10.09.2023. Processing was performed in the SNAP software using the C2RCC processor, which performs atmospheric correction and calculates the TSM concentration.

- Particles move long distances with sea currents.
- There is a risk for public health due to the quality of the waters of Pineios. Measures will be needed regarding swimming and fishing activities in the area.

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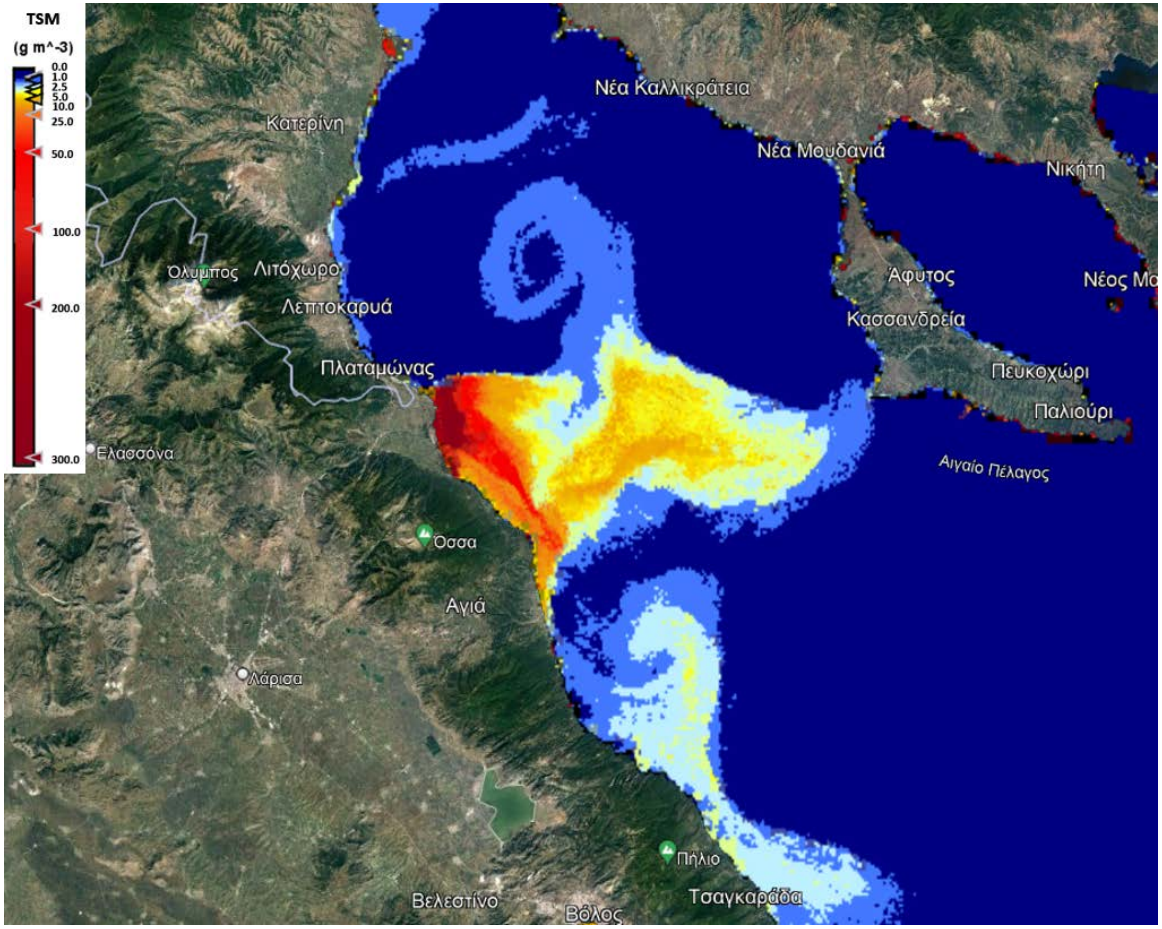
USE OF SATELLITE IMAGERY FOR MONITORING DANIEL STORM AND ITS IMPACT

DETECTION OF THE TOTAL SUSPENDED MATTER (TMS) IN THE PINEIOS RIVER DELTA



Data: Sentinel-3A OLCI EFR

12 September 2023

The detection of TSM in the Pineios River Delta was carried out using a Copernicus Sentinel-3A OLCI EFR (acquisition date: 12 September 2023) processed using the algorithm C2RCC in SNAP software.

Sentinel-3 OLCI (resolution 300m) was used instead of Sentinel-2 MSI because of cloud cover of the later in the 15 September 2023 image.

The image show a high-concentration of TSM in the broad area of the delta, reaching up to 300 g/m^3, while increased concentrations are recorded in the coastal area of Chalkidiki (1-5 g/m^3) in a 50 km distance. TSM concentrations are appearing to reach the coastal area of Pelion Mt.

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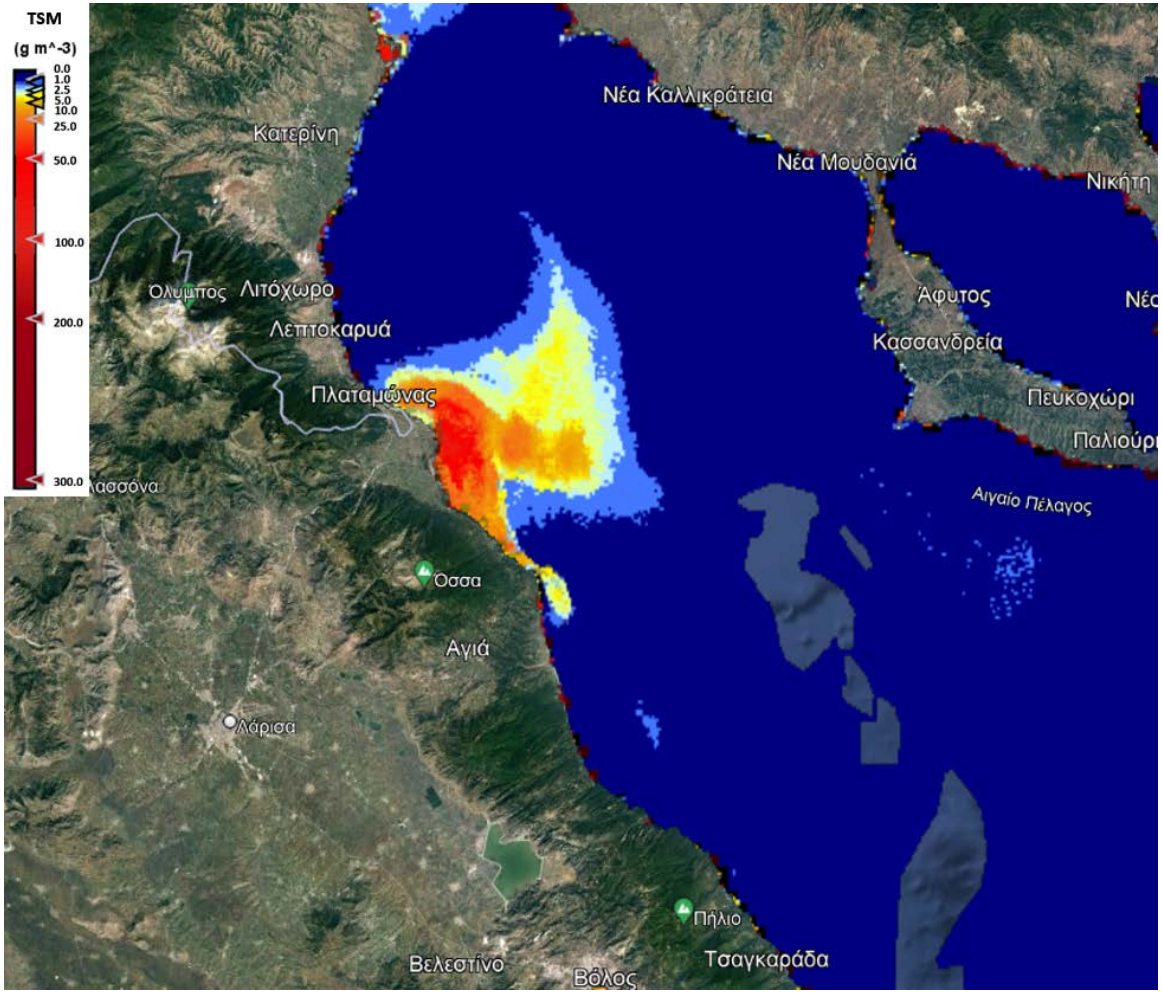
USE OF SATELLITE IMAGERY FOR MONITORING DANIEL STORM AND ITS IMPACT

DETECTION OF THE TOTAL SUSPENDED MATTER (TMS) IN THE PINEIOS RIVER DELTA



16 September 2023

The detection of TSM in the Pineios River Delta was carried out using a Copernicus Sentinel-3A OLCI EFR (acquisition date: 16 September 2023) processed using the algorithm C2RCC in SNAP software.

No data segments of the image are appearing due to cloud cover.

We notice a reduction in the spatial distribution of TSM in the open sea that reaches 27 km in this image, as well as a reduction in concentration, in comparison to the 12 September 2023 image. In particular, the concentration reaches up to 100 g/m^3 near the delta and extends to approximately 25 km with concentrations that fluctuate at about 2-15 g/m^3.

Data: Sentinel-3A OLCI EFR

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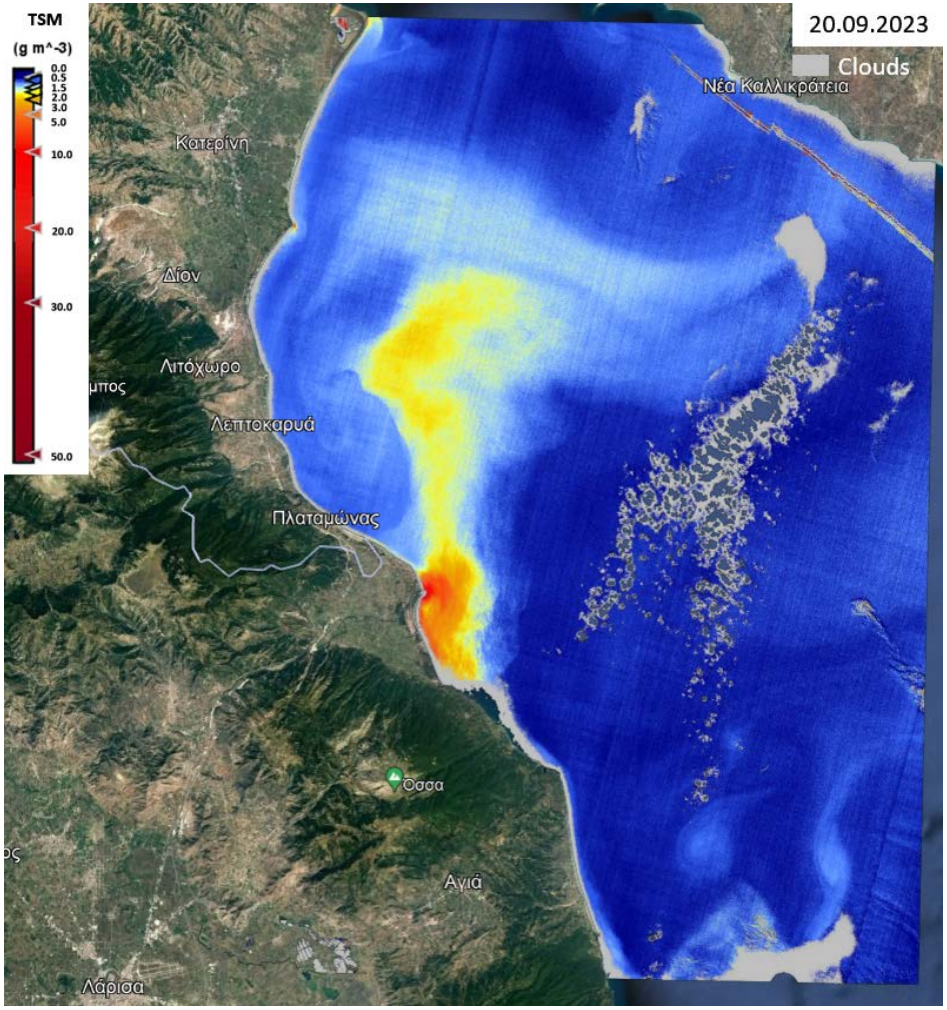
USE OF SATELLITE IMAGERY FOR MONITORING DANIEL STORM AND ITS IMPACT

DETECTION OF THE TOTAL SUSPENDED MATTER (TMS) IN THE PINEIOS RIVER DELTA



Data: Sentinel-2B MSI Level-1C

20 September 2023

The detection of TSM in the Pineios River Delta was carried out using a Copernicus Sentinel-2B MSI Level-1C (resolution 10 m), processed using the algorithm C2RCC in SNAP software.

We notice an noteworthy reduction in the concentration of TSM near the delta, reaching up to 10 g/m^3. However, we still see an important difference with the Sentinel-2B image before the incident (shown in the next slide). The spatial distribution of TSM reaches approx. 20km with a concentration of 1-2 g/m^3.

*Results of Sentinel-2 MSI and Sentinel-3 OLCI images are not directly comparable to each other due to differences in resolution.

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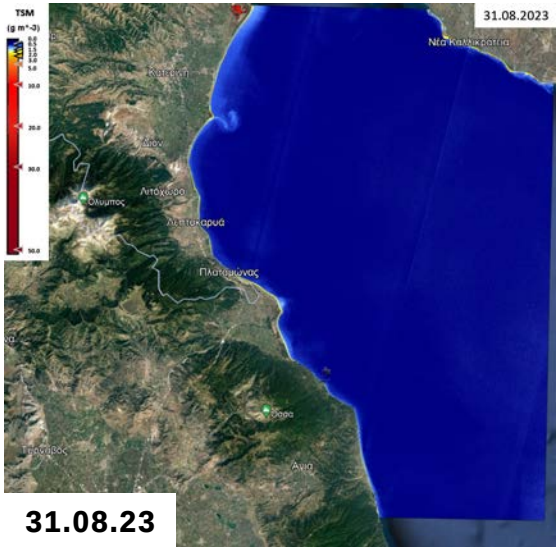
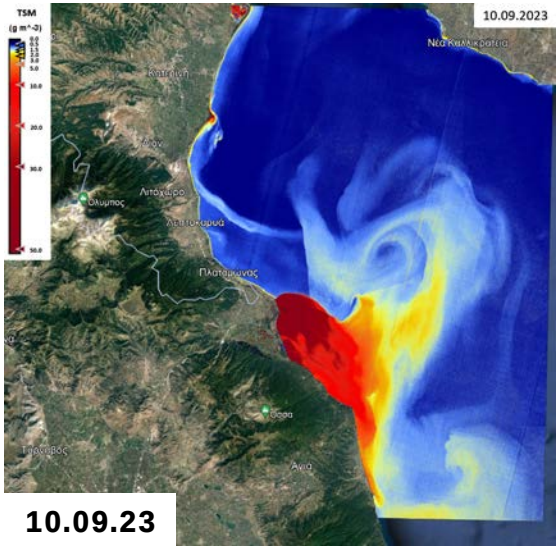
USE OF SATELLITE IMAGERY FOR MONITORING DANIEL STORM AND ITS IMPACT

Data: Sentinel-2B MSI Level-1C image



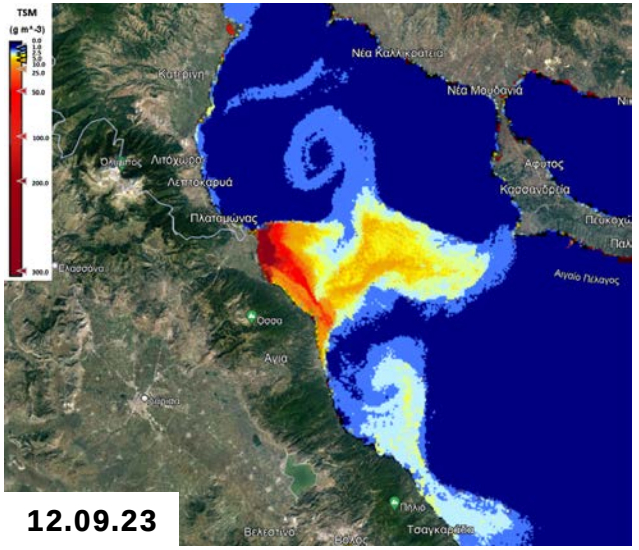
31.08.23

Data: Sentinel-2B MSI Level-1C

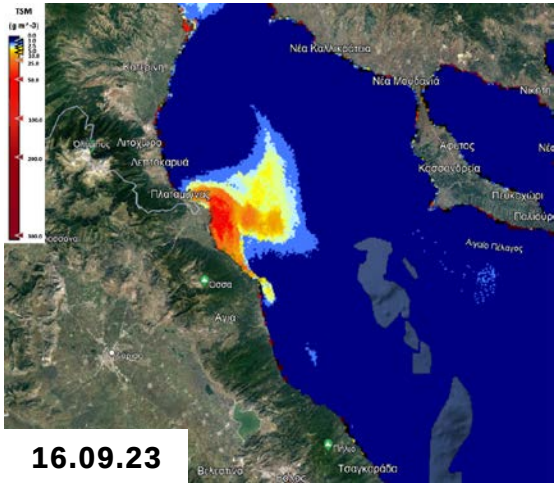


10.09.23

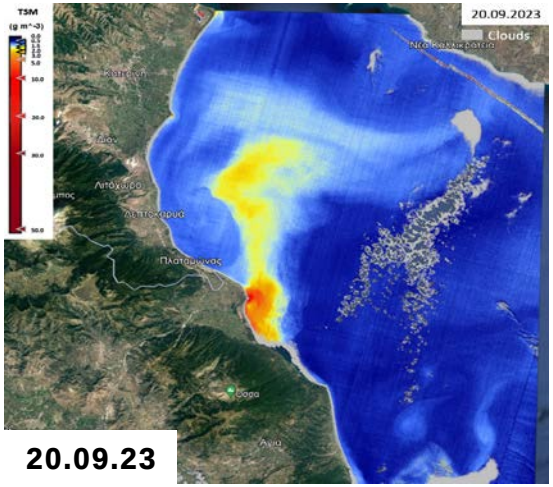
Data: Sentinel-3A OLCI EFR



12.09.23



16.09.23



20.09.23

Data: Sentinel-3A OLCI EFR

Data: Sentinel-2B MSI Level-1C

Evolution of the Total Suspended Matter (TMS) in the Pineios River Deltacarried out using Sentinel imagery

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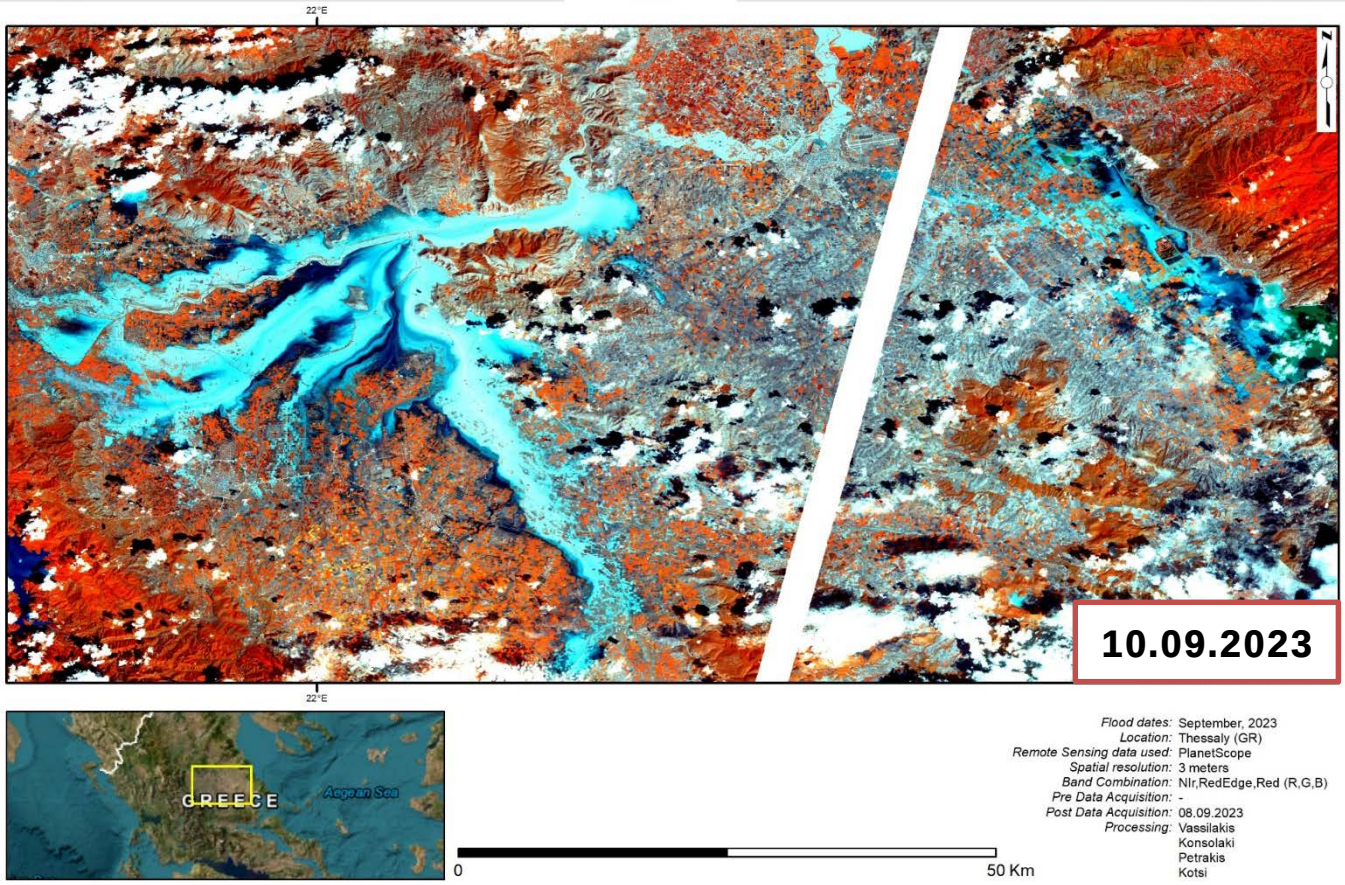
USE OF SATELLITE IMAGERY FOR MONITORING THE IMPACT OF DANIEL
MONITORING OF THE EXTENT OF FLOODING IN KARDITSA AREA



The area inundated by the flood is imaged with Planet multispectral satellite data (spatial segments of a total of 19 scenes acquired on 08/09/2023), with high resolution (3 meters/pixel). Using false-colour images with channel combinations and using the Near Infrared channel in red, the RedEdge channel in green and the Red channel in blue, the areas covered with water and mud (blue/blue shades) are highlighted in contrast to vegetation (red shades) and bare ground (grey/green shades).

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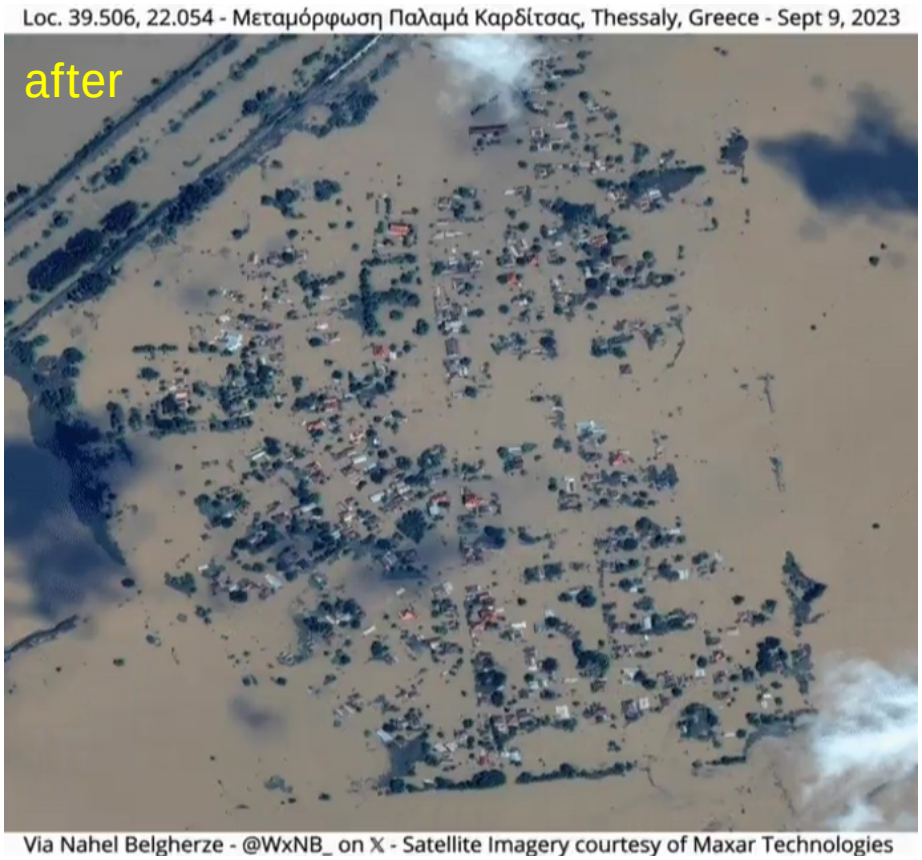
ASSESSMENT OF FLOOD EXTENT AND IMPACT
BY USING HIGH RESOLUTION SATTELITE IMAGERY



The Metamorphosi village in Palamas Municipality of the Karditsa Regional Unit before (acquisition on 16.09.2022) and after (acquisition on 09.09.2023) the flooding generated by the Daniel storm.
Source of satellite imagery: Maxar

MAXAR

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ASSESSMENT OF FLOOD EXTENT AND IMPACT
BY USING HIGH RESOLUTION SATTELITE IMAGERY

The Megala Kalyvia village in the Trikala Regional Unit before (acquisition on 31.08.2023) and after (acquisition on 08.09.2023) the flooding generated by the Daniel storm.
Source of satellite imagery: Maxar

MAXAR

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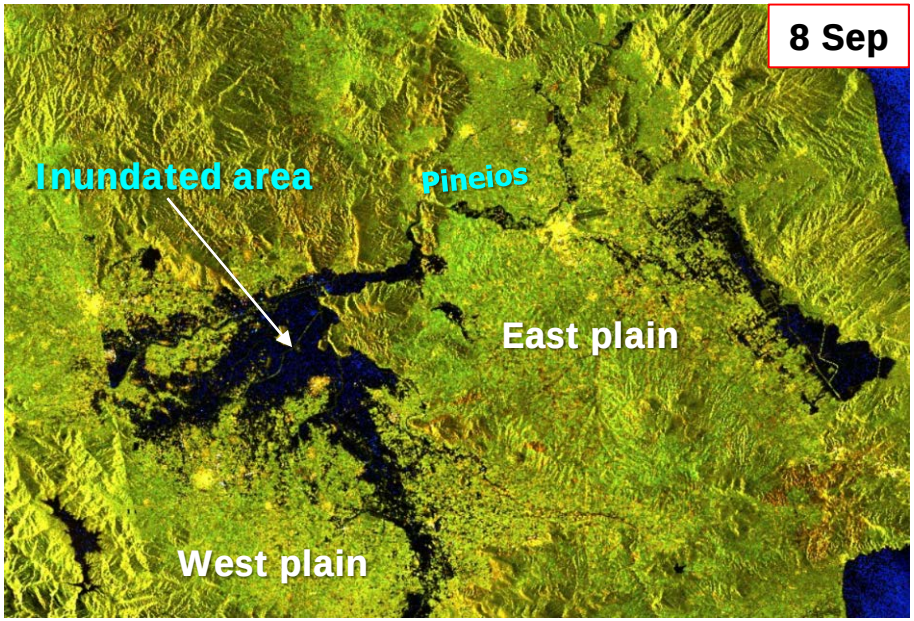
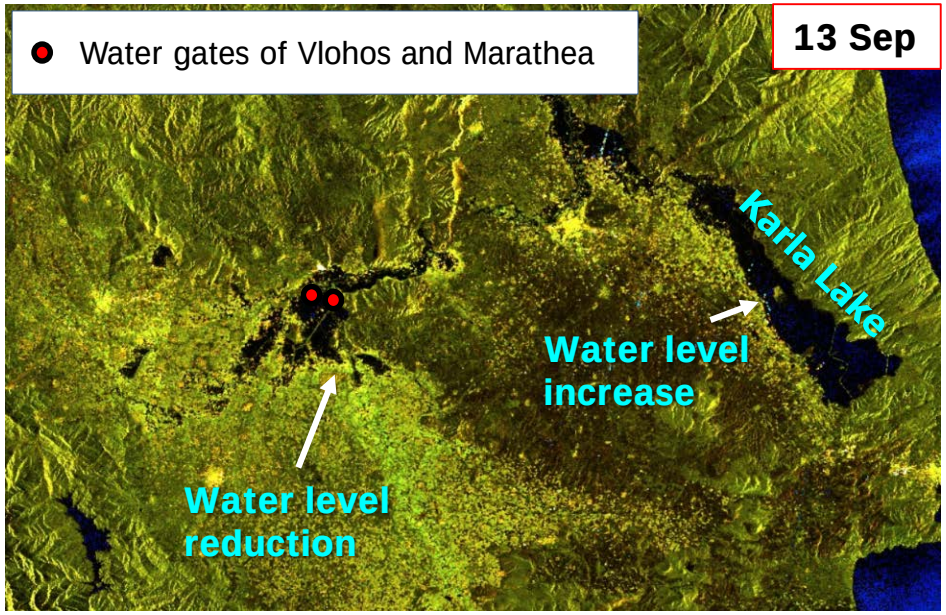
EVOLUTION OF FLOODING



Gradually, since September 8, the large volumes of water in the Western part of the plain (Karditsa – Trikala) were discharged through the Pineios River, which drains the basins of the Enipeas, Kalentzis, Mega Rivers.

The water level of Pineios River was dropping in this period by ~60cm/day as the western part of the plain was discharging water, reducing the level of water stage and the extent of the inundated area.

As in the west part of the plain water is discharged gradually through Pineios River, the eastern part sees increases in water level at Karla Lake due to the failure of Pineios embankment near Gyrtoni.



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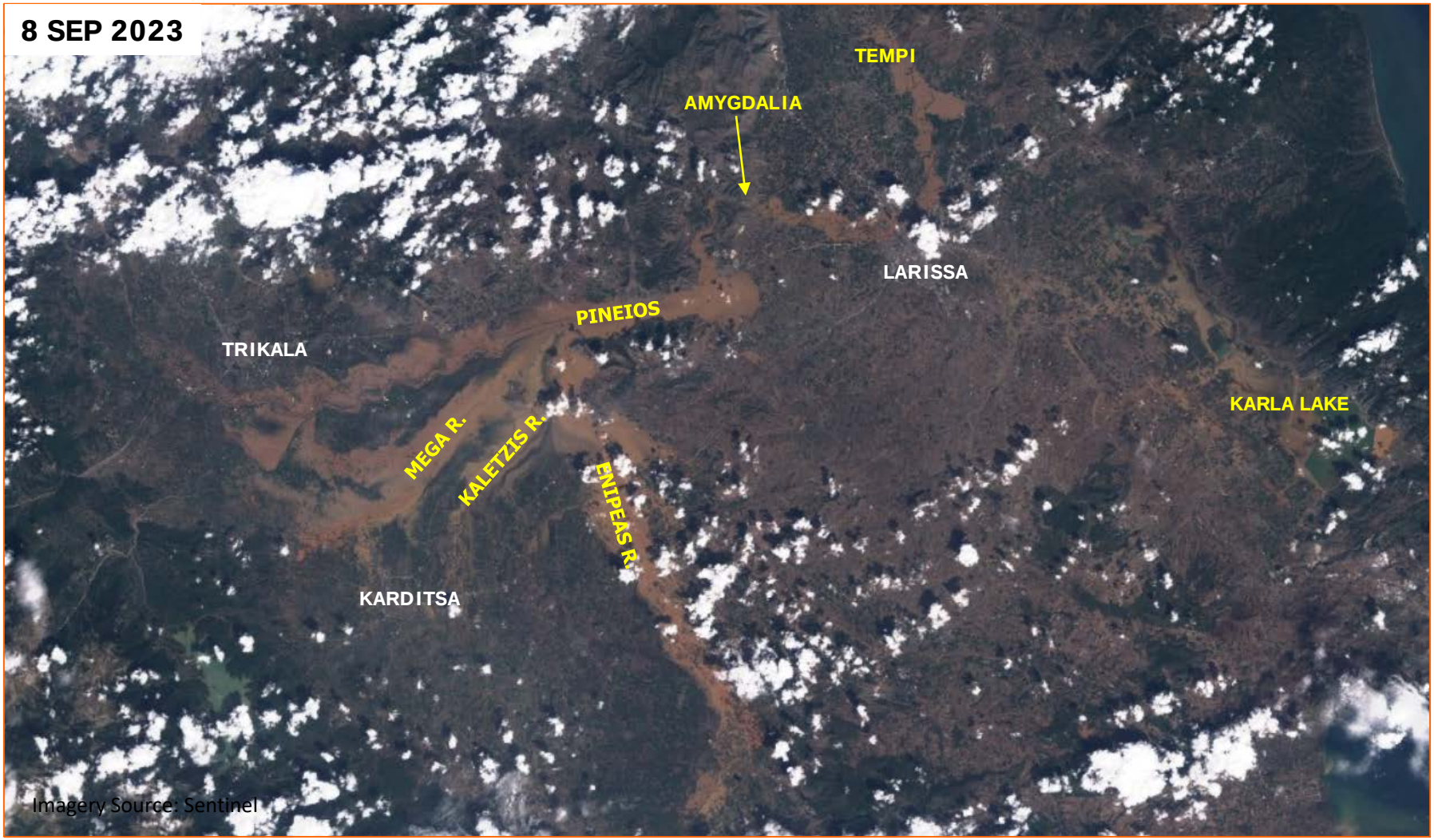
EVOLUTION OF FLOODING



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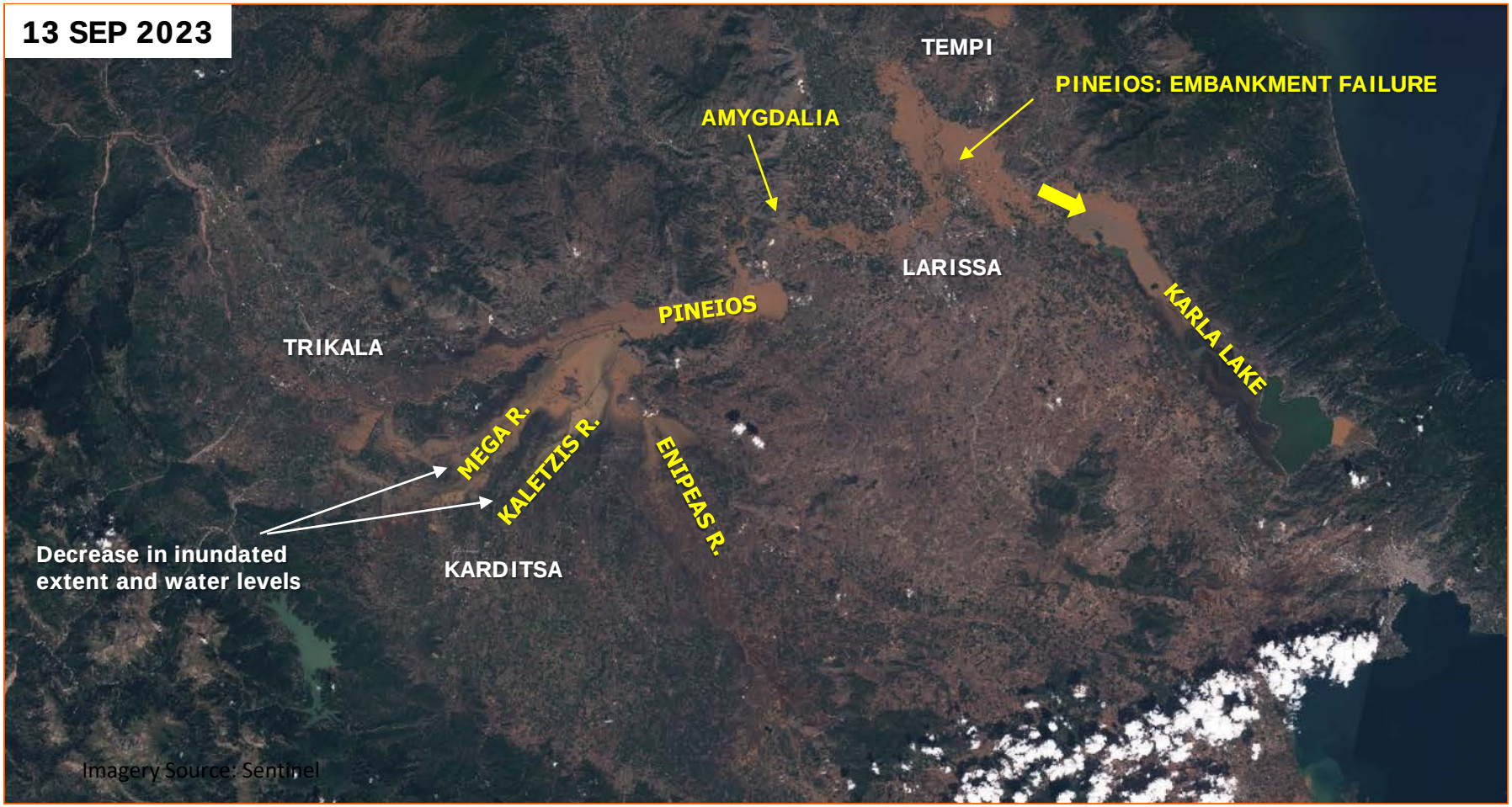
IMPACT ON RIVER NETWORKS



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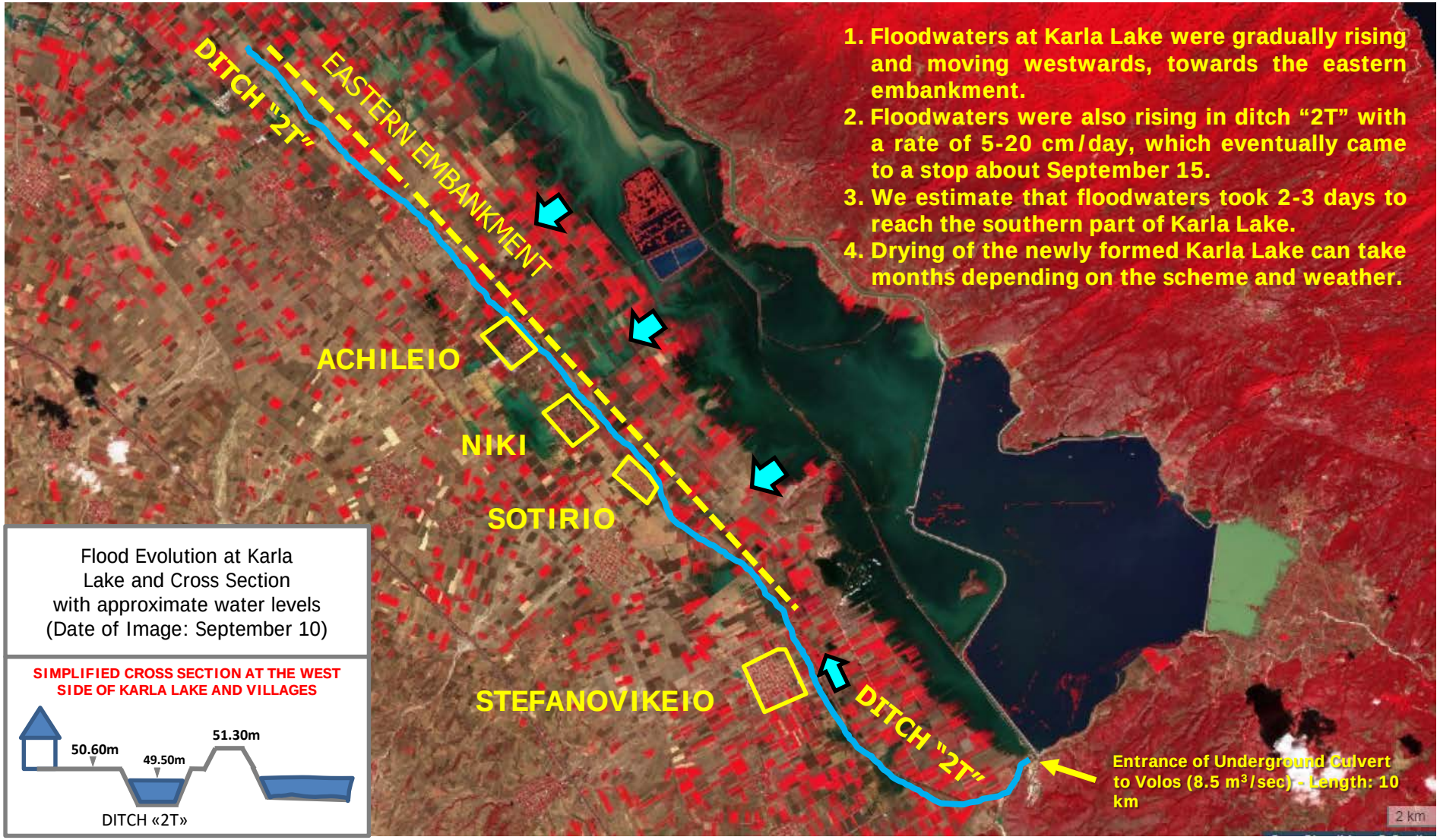
EVOLUTION OF FLOODING



1. Floodwaters at Karla Lake were gradually rising and moving westwards, towards the eastern embankment.
2. Floodwaters were also rising in ditch "2T" with a rate of 5-20 cm/day, which eventually came to a stop about September 15.
3. We estimate that floodwaters took 2-3 days to reach the southern part of Karla Lake.
4. Drying of the newly formed Karla Lake can take months depending on the scheme and weather.

Flood Evolution at Karla Lake and Cross Section with approximate water levels (Date of Image: September 10)

SIMPLIFIED CROSS SECTION AT THE WEST SIDE OF KARLA LAKE AND VILLAGES

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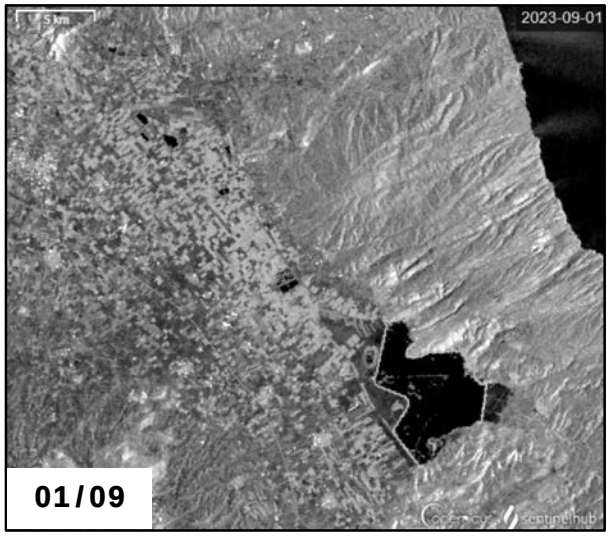
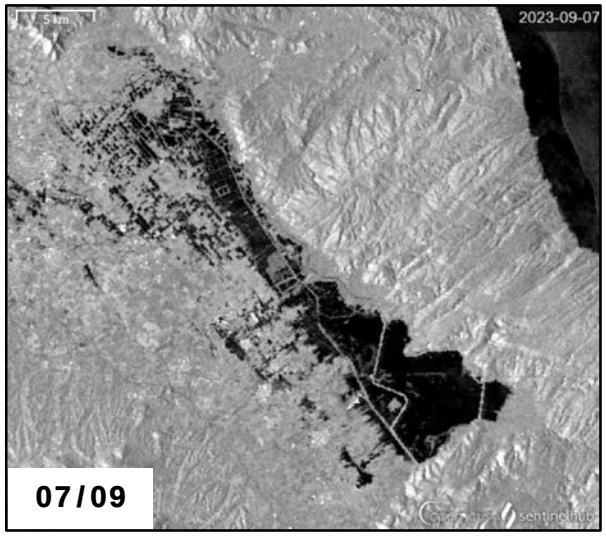
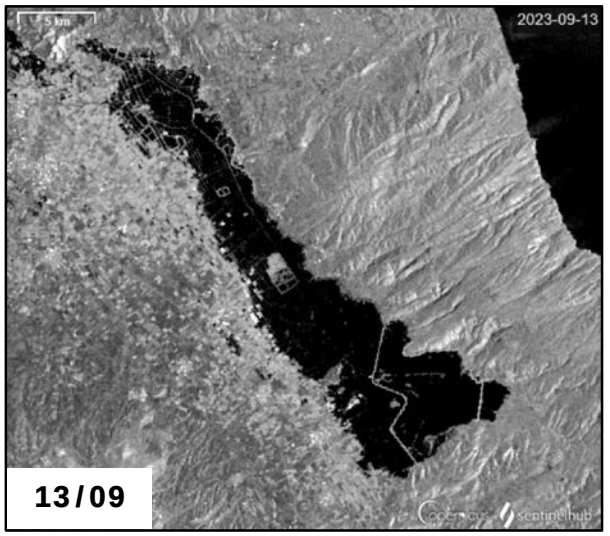
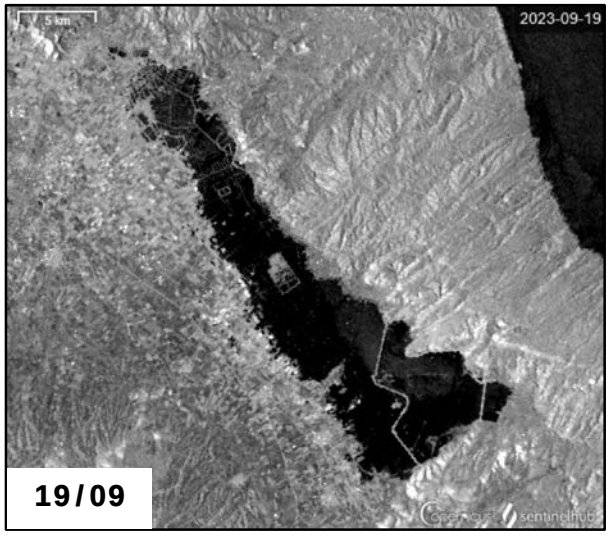
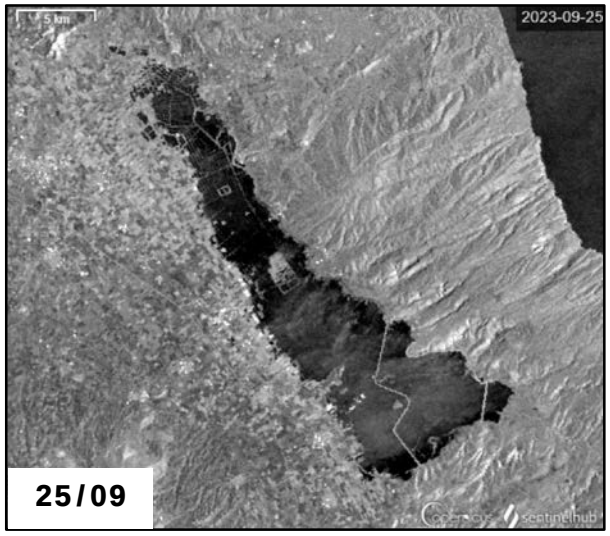
EVOLUTION OF FLOODING
FLOODING IN KARLA LAKE











Evolution of flooding in Karla Lake

Source of satellite imagery: Sentinel

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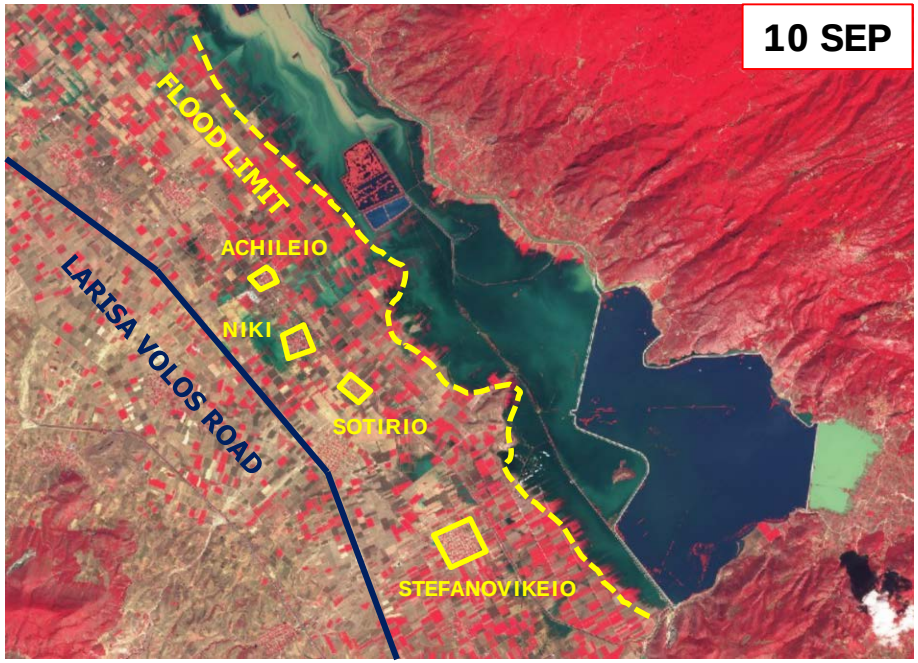
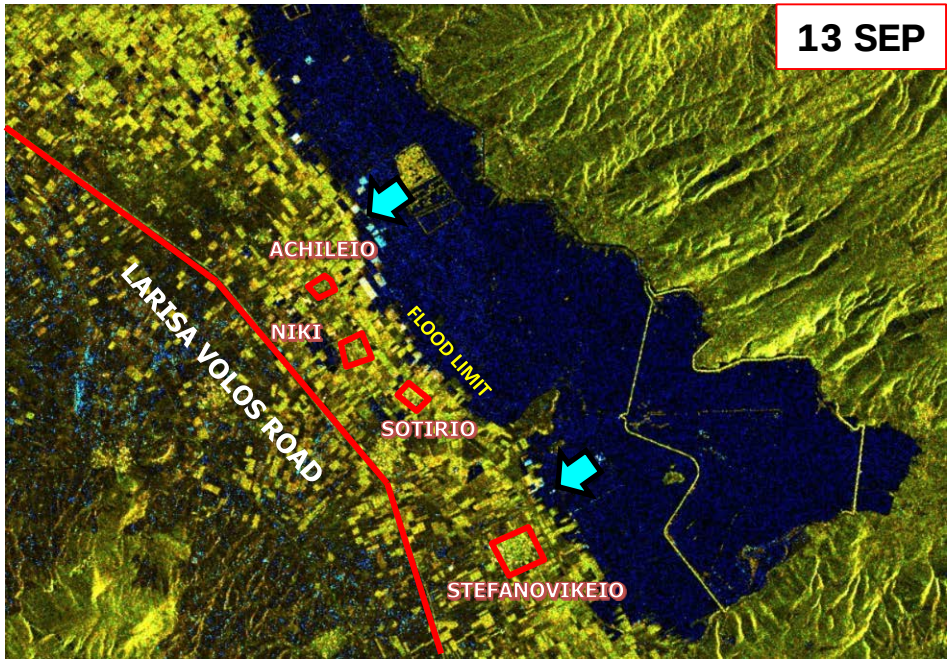
EVOLUTION OF FLOODING
FLOODING IN KARLA LAKE





The two images through comparison show the rising water levels at Karla Lake and the westward expansion of the inundated area.

Sources of satellite imagery: Sentinel

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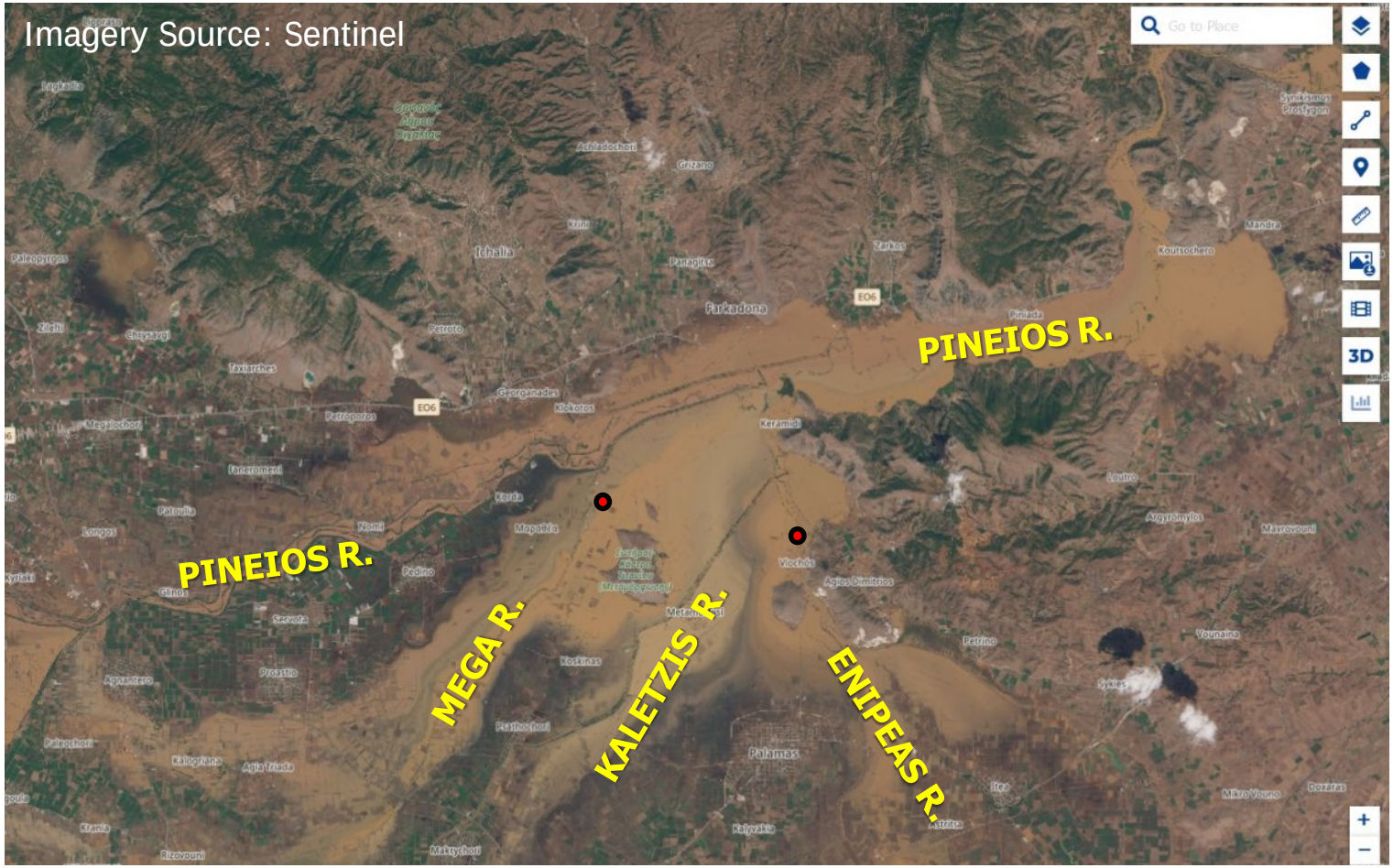
EVOLUTION OF FLOODING



Red symbol indicates the water gates of Vlohos and Marathea. From the satellite images and the evolution of the phenomenon, it appears that the drainage has been going on for days even though the water gates were closed. Opening of water gates was carried out in stages and gradually in an effort to desynchronize discharge.

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IMPACT OF FLOODING ON RESIDENTIAL AREAS
FLOODED AREAS WITHIN CITIES, TOWNS AND VILLAGES

Larissa City, Ayios Thomas District
8 September 2023

Snapshots from a drone video presenting the flooded of Ayios Thomas district located very close to the overflowed Pineios River at the western part of Larissa City
(Video source: https://www.youtube.com/watch?v=ogBH5L2H0I8)

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IMPACT OF FLOODING ON RESIDENTIAL AREAS
FLOODED AREAS WITHIN CITIES, TOWNS AND VILLAGES

Larissa City, Giannouli District
9 September 2023

Snapshots from a drone video presenting the flooded Giannouli district located very close to overflowed tributaries of Pineios River at the southern part of Larissa City
(Video source: https://www.youtube.com/watch?v=Ccvp7kNURgs)

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IMPACT OF FLOODING ON RESIDENTIAL AREAS
FLOODED AREAS WITHIN CITIES, TOWNS AND VILLAGES

Larissa City, Tampakika and D.E.Y.A.L.
8 September 2023

Snapshots from drone videos presenting the flooded Tampakika and D.E.Y.A.L. districts located at the northern and western part of Larissa City respectively, both east of the overflowed Pineios River. (Video sources: https://www.youtube.com/watch?v=3IE9JkKqbwQ for Tampakika, https://www.youtube.com/watch?v=z05Y84K41ts for D.E.Y.A.L.)

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IMPACT OF FLOODING ON RESIDENTIAL AREAS
FLOODED AREAS WITHIN CITIES, TOWNS AND VILLAGES

Larissa Regional Unit, Omorfochori
10 September 2023

Snapshots from a drone video presenting the flooded Omorfochori settlement located northeast of Larissa city and about 1 km east of the overflowed Pineios River.
(Video source: https://www.youtube.com/watch?v=ixfaLzah0Tg)

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IMPACT OF FLOODING ON RESIDENTIAL AREAS
FLOODED AREAS WITHIN CITIES, TOWNS AND VILLAGES

Larissa Regional Unit, Omorfochori
10 September 2023

Snapshots from a drone video presenting the flooded Omorfochori settlement located northeast of Larissa city and about 1 km east of the overflowed Pineios River.
(Video source: https://www.youtube.com/watch?v=ixfaLzah0Tg)

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IMPACT OF FLOODING ON RESIDENTIAL AREAS
FLOODED AREAS WITHIN CITIES, TOWNS AND VILLAGES

Larissa City, Giannouli District
11 September 2023

Snapshots from a drone video presenting the flooded Giannouli district located very close to overflowed tributaries of Pineios River at the southern part of Larissa City.
(Video source: https://www.youtube.com/watch?v=z05Y84K41ts)

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IMPACT OF FLOODING ON RESIDENTIAL AREAS
FLOODED AREAS WITHIN CITIES, TOWNS AND VILLAGES

Larissa Regional Unit, Koulouri and Gyrtoni
11 September 2023




Snapshots from a drone video presenting the flooded Koulouri and Gyrtoni areas located north of Larissa City and very close to the overflowed Pineios River.
(Video source: https://www.youtube.com/watch?v=z05Y84K41ts)

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IMPACT OF FLOODING ON RESIDENTIAL AND RURAL AREAS
FLOODED AREAS WITHIN CITIES, TOWNS AND VILLAGES

Airclub Hermes

Thessalian Plain
1 October 2023

Flooded area between Marathea and Vlohos

Photos credit: Dr. Athanasios Korkovelos and Lorenzo Ronzi (Ermis Airclub, https://www.facebook.com/AirclubHermes)

Flooded area in Metamorphosi

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IMPACT OF FLOODING ON RESIDENTIAL AND RURAL AREAS
FLOODED AREAS WITHIN CITIES, TOWNS AND VILLAGES

Airclub Hermes

Thessalian Plain
1 October 2023

Flooded area between Marathea and Vlohos (looking at Vlohos)

Photos credit: Dr. Athanasios Korkovelos and Lorenzo Ronzi (Ermis Airclub, https://www.facebook.com/AirclubHermes)

Flooded area in Keramidi village

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IMPACT OF FLOODING ON RESIDENTIAL AND RURAL AREAS
FLOODED AREAS WITHIN CITIES, TOWNS AND VILLAGES

Airclub Hermes

Thessalian Plain
1 October 2023

Inundation around Pineios River after recession of the largest part of floodwaters

Photos credit: Dr. Athanasios Korkovelos and Lorenzo Ronzi (Ermis Airclub, https://www.facebook.com/AirclubHermes)

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IMPACT OF FLOODING ON RESIDENTIAL AND RURAL AREAS
FLOODED AREAS WITHIN CITIES, TOWNS AND VILLAGES

Airclub Hermes

Thessalian Plain
1 October 2023

Inundation around Pineios River

Photos credit: Dr. Athanasios Korkovelos and Lorenzo Ronzi (Ermis Airclub, https://www.facebook.com/AirclubHermes)

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IMPACT OF FLOODING ON RESIDENTIAL AND RURAL AREAS
FLOODED AREAS WITHIN CITIES, TOWNS AND VILLAGES

Airclub Hermes

Thessalian Plain
1 October 2023

Flooded area of Enipeas in Vlohos

Photos credit: Dr. Athanasios Korkovelos and Lorenzo Ronzi (Ermis Airclub, https://www.facebook.com/AirclubHermes)

Flooded area of Karla Lake (looking North)

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IMPACT OF DANIEL STORM AND THE SUBSEQUENT FLOODING ON HUMAN LIFE
FATALITIES

The storm lead to 18 fatalities in total in different locations of the Thessaly Region:

1) 5 September 2023, **Male 51 years old** (y.o.) washed away at Agia Aikaterini Volou
2) 6 September 2023, **Female 87 y.o.** Paltsi village at Pelion,
3) 6 September 2023, **Male 82 y.o.** at Ellinopyrgos Karditsa
4) 7 September 2023, **Male 51 y.o.** at Petroto Domokos
5) 7 September 2023, **Female 75 y.o.** found indoors in Astritsa
6) 7 September 2023, **Female 85 y.o.** found indoors in Astritsa
7) 8 September 2023, **Female of old age** found indoors in Marathea
8) 8 September 2023, **Female 97 y.o.** found indoors in Palama
9) 8 September 2023, **Female** found indoors in Palama
10) 8 September 2023, **Female found** outdoors (at Theotokos beach near Lyri - Pelion)
11) 9 September 2023, **Male** found in the sea in Evia island (from Volos)
12) 9 September 2023 **Male 77 y.o.** in Palama
13) 10 September 2023 **Female 85 y.o.** from Metamorphosi
14) 10 September 2023 **Male 65 y.o.** from Metamorphosi
15) 10 September 2023 **Male 42 y.o.** from Agia Aikaterini Volos (vehicle-related incident) (missing since 5/9 and found in Pagasitikos Gulf)
16) 7 September 2023 **Male 35 y.o.** from Austria, died indoors at Potistika At Pelion Mt.
17) 7 September 2023 **Female 35 y.o.** from Austria, died indoors at Potistika At Pelion Mt.
18) 25 September 2023 **Male 42 y.o.** is an indirect fatality of a person that had a boat accident in Karla lake

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IMPACT OF DANIEL STORM AND THE SUBSEQUENT FLOODING ON HUMAN LIFE
FATALITIES

Approximate locations of 18 known fatalities by the Daniel storm and the subsequent flooding

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IMPACT OF DANIEL STORM AND THE SUBSEQUENT FLOODING ON HUMAN LIFE
SEARCH AND RESCUE OPERATIONS

From September 5 to 24, 2023 (07:00, local time) the Hellenic Fire Service has received 10.357 calls for help in the Region of Thessaly.

- 3,720 incidents water had to be pumped out;
- 3,576 people have been rescued and transferred to safe places.

The emergency services were active through various means including:

- helicopters;
- airplanes;
- UAVs.

to transport food, water, medicines and other needed items (including beds, linen, tents) to affected areas of the Region of Thessaly.

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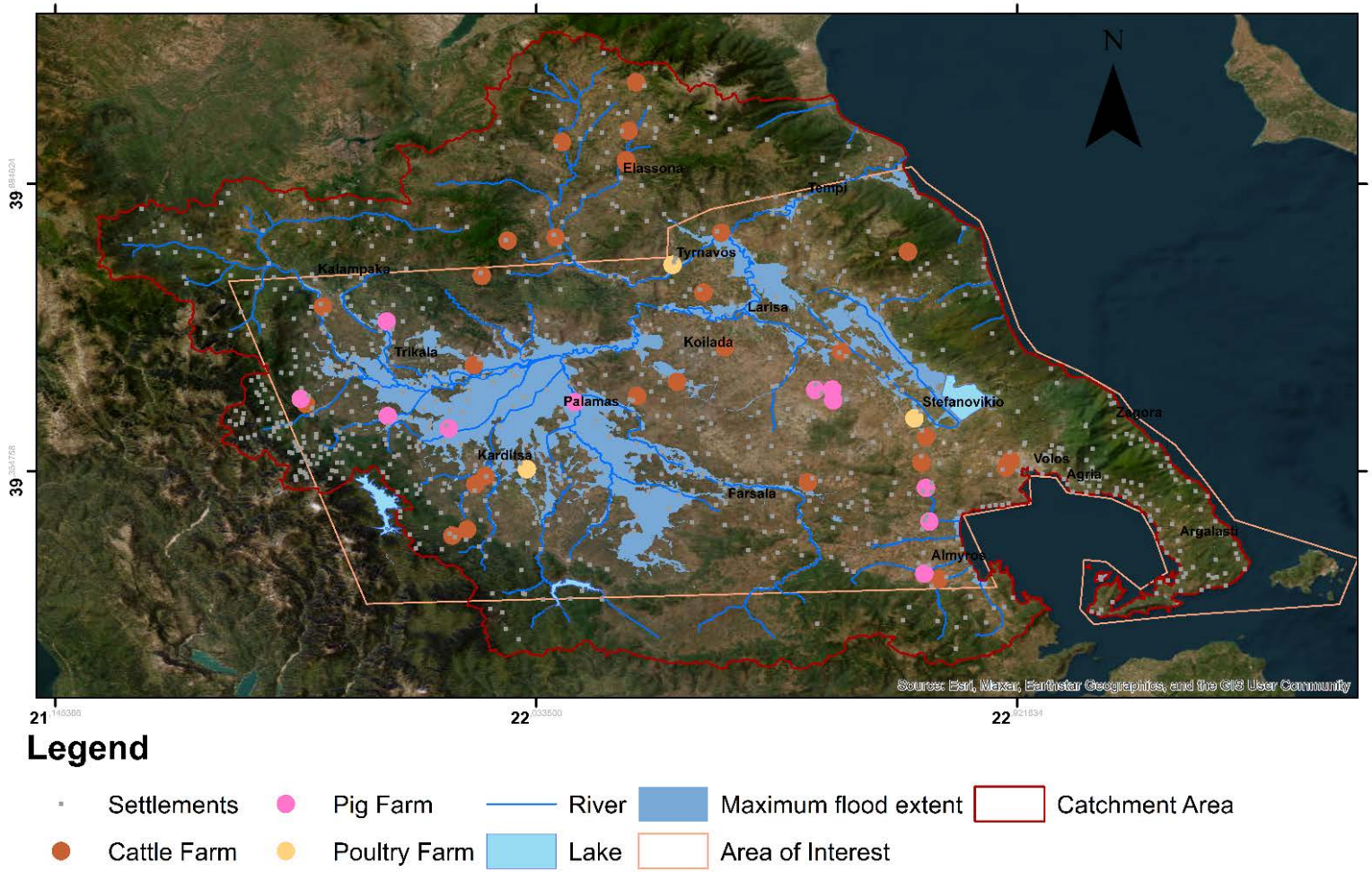
IMPACT OF FLOODS ON LIVESTOCK

ASSESSMENT OF FLOOD IMPACT ON FARMING HUSBANDRY



Map of Thessaly water district (EL08) that depicts the main farming husbandry units together with the maximum flood extend and the area that is affected (orange border).
Source: Copernicus EMS - On Demand Mapping, Ministry of Environment and Energy

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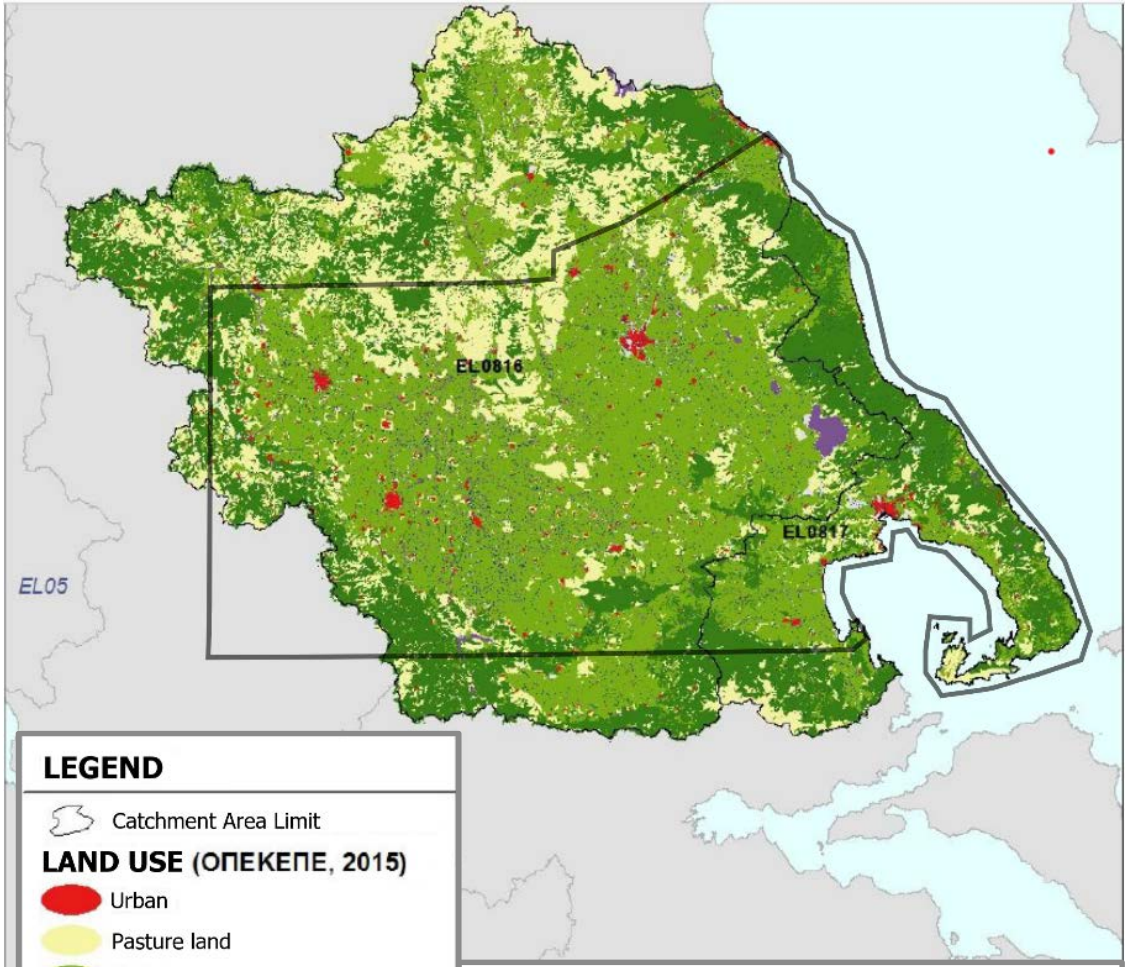
IMPACT OF FLOODS ON LIVESTOCK

ASSESSMENT OF FLOOD IMPACT ON PASTORAL HUSBANDRY



Source: Ministry of Environment and Energy 1st Review of Management Plan of the Catchment Area of Thessaly Water District (EL08) with data from ΟΠΕΚΕΠΕ 2015

Land use of Thessaly water district within two catchment areas EL0816, EL0817 based on the Greek Payment Authority of Common Agricultural Policy (C.A.P.) Aid (2015) (OPEKEPE in Greek)

Land use in **Pineios catchment area** (EL0816):

- Urban: <1%
- Pasture land: 23%
- Crops: 45%
- Forest: 27%
- Road/Water: 5%

Land use in **Almyros-Pelion Streams catchment area** (EL0817):

- Urban: <1%
- Pasture land: 11%
- Crops: 34%
- Forest: 52%
- Road/Water: 2%

The black frame indicates the area of interest affected by the Daniel-induced floods.

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IMPACT OF FLOODS ON LIVESTOCK

FLOOD IMPACT ON LIVESTOCK IN THE AFFECTED AREA OF THESSALY

According to the research study of manmade impact of the 1st Review of Management Plan of the Catchment Area of Thessaly Water District (EL08), farming husbandry comprises 45 main and organized big farming husbandry units. A percentage of 65% comprises cattle farms, 24% pig farms and 11% poultry farms. As shown in the respective maps, the majority of the these units have been affected by the floods.

The largest area of Thessaly water district (EL08) is covered by crops and pasture lands followed by forest land (OPEKEPE, 2015). More precisely, at Pineios catchment area (EL0816) pasture land covers 23% of land uses and at Almyros-Pilio streams (EL0817) covers 11% (OPEKEPE, 2015).

As it stands out in the second picture, the area of interest that seriously affected by the floods has a large expanse of pasture land. Pastoral husbandry has seriously damaged from the floods and the amount of overall damage to livestock is going to take some time to be accounted precisely until the flood water withdraw and the initiation of the assessment studies.

According to the Hellenic Statistical Authority (ELSTAT) and the agricultural and livestock census results of 2021, 248511 farming units are operating at Thessaly Region with the following animal numbers by species:

- Cattle: 120.276
- Sheep:1.004.788
- Goat: 299.936
- Pig: 110.796
- Poultry: 472.753

According to the latest data of the Hellenic Agricultural Insurance Organization (17/9/2023) the livestock loss is as follows:

- Sheep and Goat: 70.935
- Cattle: 6.136
- Pig: 20.326
- Poultry: 131.795

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IMPACT OF FLOODS ON LIVESTOCK

FLOOD IMPACT ON LIVESTOCK IN THE AFFECTED AREA OF THESSALY






The disposal of dead animals in Thessaly has reached 75%, according to the data cited by the Deputy Minister of Climate Crisis and Civil Protection at 25/09/2023. He also stated that 110,000 dead animals and 135,000 dead birds were reported, so that the 7% of the livestock was lost in Thessaly by the floods until September 25, 2023, compared to the total of 1,700,000 registered and declared in the region of Thessaly.

Photos credits: tanea.gr; naftemporiki.gr; left.gr

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IMPACT OF FLOODS ON SURFACE WATER BODIES

ASSESSMENT OF FLOOD IMPACT ON WASTE WATER PLANTS

The following map illustrates the Thessaly water district (EL08) with the location of every waste water plant according to the Monitoring and Wastewater Treatment Plants Monitoring Database of the Special Secretariat for Water (EGY in Greek). Furthermore, the maximum flood extent and the flood-affected provided by the Copernicus Emergency Management Service – Mapping is also presented. The following table includes information about the code of the waste water plant, the annual mean values of BODs volume (kg/day) and the annual mean values of the load income (m^3/day).

The sources for the compilation of this map included:

- the site of the Copernicus Emergency Management Service – Mapping and the related products from delineation monitoring of Magnesia, Palamas, Larissa, Stefanovikio, Karditsa, Keramidi and Kalamaki areas of Thessary Region
  - AOI01 - Magnesia
  - AOI02 - Palamas
  - AOI03 - Larissa
  - AOI04 - Stefanovikio
  - AOI05 - Karditsa
  - AOI06 - Keramidi
  - AOI07 - Kalamaki

The waste water plants data comes from the site of the Monitoring and Wastewater Treatment Plants Monitoring Database of the Special Secretariat for Water.

The related links are the following:

https://rapidmapping.emergency.copernicus.eu/EMSR692/download

http://astikalimata.ypeka.gr/Default.aspx

http://astikalimata.ypeka.gr/Services/Pages/WtpViewApp.aspx

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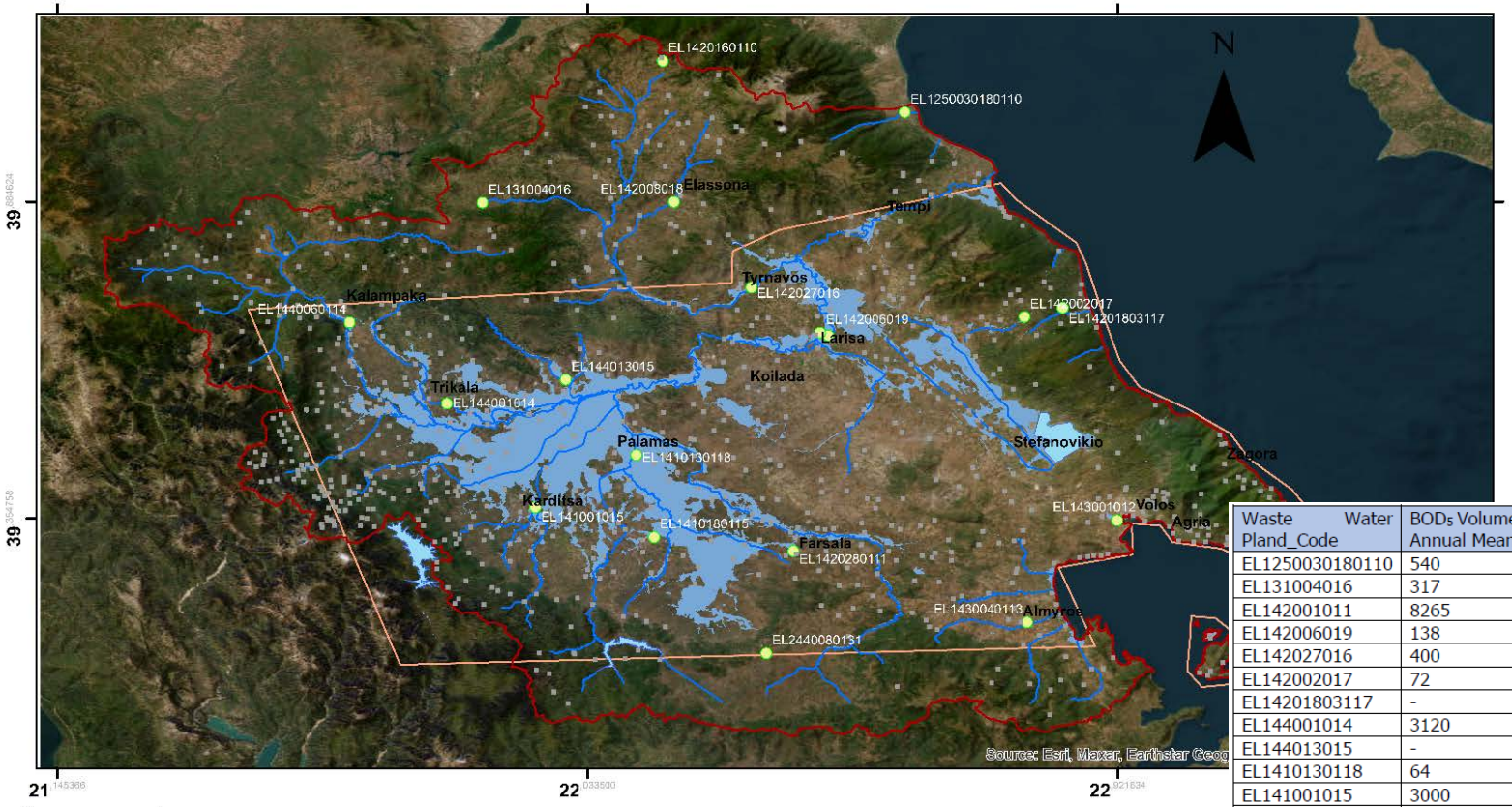
IMPACT OF FLOODS ON SURFACE WATER BODIES

ASSESSMENT OF FLOOD IMPACT ON WASTE WATER PLANTS



Legend

- Settlements
- Waste Water Plant
- River
- Lake
- Maximum flood extent
- Area of Interest
- Catchment Area

Waste Water Pland_Code	BOD_5 Volume (kg/day) Annual Mean	Load Income (m^3/day) Annual Mean
EL1250030180110	540	2348
EL131004016	317	-
EL142001011	8265	27932
EL142006019	138	620
EL142027016	400	1250
EL142002017	72	-
EL14201803117	-	-
EL144001014	3120	-
EL144013015	-	-
EL1410130118	64	614
EL141001015	3000	-
EL1420280111	252	1216
EL1410180115	220	180
EL1440060114	610	-
EL1430040113	361	952
EL2440080131	-	308
EL143001012	9177	43862
EL142008018	542	1445
EL1420160110	60	200
Total	**27138**	
Total (Area of Interest)	**25679**	

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IMPACT OF FLOODS ON SURFACE WATER BODIES

ASSESSMENT OF FLOOD IMPACT ON DAMS, LOWLAND RESERVOIRS, POND TANKS AND WATER GATES

The following map illustrates the Thessaly water district (EL08) with the location of every main dam, lowland reservoir, pond tank and water gate with their beneficial volume, in accordance to the maximum flood extent and the affected area by the flood.

The locations for the dams, lowland reservoirs, pond tanks and water gates and the related qualitative and hydrological information presented on the map on the next slide are taken from the web pages of the Water Resources and Environment of Thessaly web site.

The sources for the compilation of this map included:

- the site of the Copernicus Emergency Management Service – Mapping and the related products from delineation monitoring of Magnesia, Palamas, Larissa, Stefanovikio, Karditsa, Keramidi and Kalamaki areas of Thessary Region
  - AOI01 - Magnesia
  - AOI02 - Palamas
  - AOI03 - Larissa
  - AOI04 - Stefanovikio
  - AOI05 - Karditsa
  - AOI06 - Keramidi
  - AOI07 - Kalamaki

The related links are the following:

https://www.ypethe.gr/

https://rapidmapping.emergency.copernicus.eu/EMSR692/download

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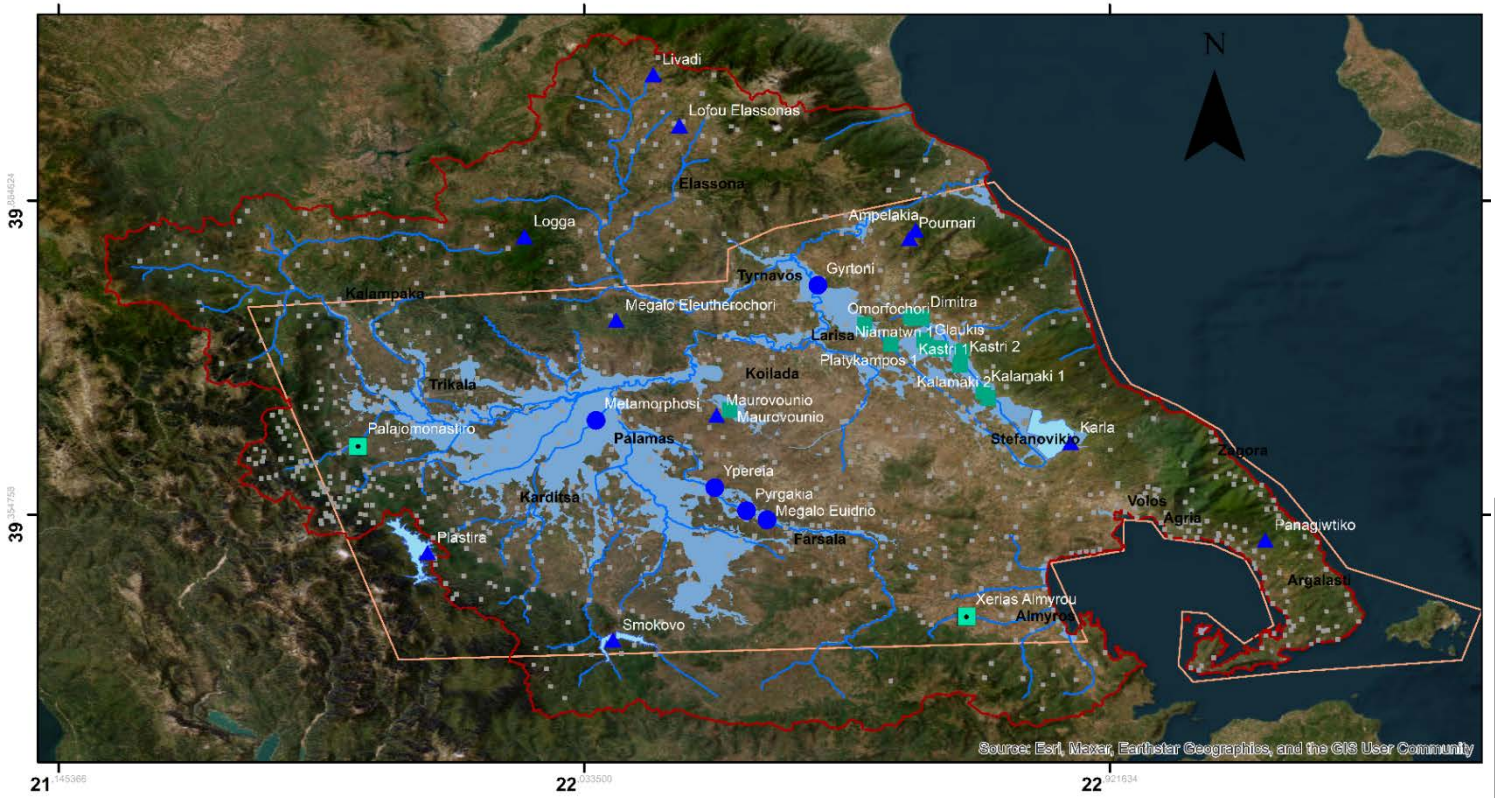
IMPACT OF FLOODS ON SURFACE WATER BODIES

ASSESSMENT OF FLOOD IMPACT ON DAMS, LOWLAND RESERVOIRS, POND TANKS AND WATER GATES



Dam_Name	Volume (m³)
Ampelakia	300000
Karla	180000000
Livadi	1512000
Lofou Elassonas	450000
Logga	350000
Maurovounio	90000
Megalo Eleutherochori	200000
Panagiwtiko	1620000
Plastira	400000000
Pournari	350000
Smokovo	200000000

Pond Tank_Name	Volume (m³)
Palaiomonastiro	251200
Xerias Almyrou	4000000

Lowland Reservoir_Name	Volume (m³)
Dimitra	1000000
Eleutherio 1	900000
Eleutherio 2	800000
Glaukis	2100000
Kalamaki 1	5500000
Kalamaki 2	2500000
Kastri 1	1100000
Kastri 2	800000
Maurovounio	260000
Niamatwn 1	1800000
Niamatwn 2	1100000
Omorfochori	1250000
Platykampos 1	500000
Platykampos 2	1450000

Legend

Lowland Reservoir · Dam · Settlements · Lake · Maximum flood extent
Pond Tank · Water gate · Catchment Area · River · Area of Interest

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IMPACT OF FLOODS ON SURFACE WATER BODIES

ASSESSMENT OF FLOOD IMPACT ON DAMS, LOWLAND RESERVOIRS, POND TANKS AND WATER GATES

Thessaly region has three (3) main artificial dams–reservoirs:

- Plastira Lake,
- Smokovo Lake and
- Karla Lake.

These reservoirs have a great water storing capacity and therefore host huge amounts of water.

Plastira Lake and Smokovo Dam had a significant contribution to the reduction of the impact of the Daniel-induced floods. The first received more than 50 million m^3 of water and its level rose 2.6 m, protecting the wider area, while the Smokovo Dam contributed to the protection of Sofades settlement from the adverse effects of flooding.

Karla Lake is located southeast of Larissa, near the northern slopes of Pelion, on the border of the prefectures of Larissa and Magnesia. It was drained in 1962, because at that time it caused flooding of the surrounding agricultural crops, while some swampy areas around it caused the intense presence of vectors which constituted a threat for public health.

The draining of Karla Lake began at the end of August 1962 with the inauguration of the 10,150-metre-long tunnel, which was one of the most important projects for the development of Greek agriculture. 80,000 hectares of arable land were given to the farmers of Thessaly, at a time when Greek agriculture was taking its first steps towards industrialization and facing European competition.

However, it was later found that the impact on the ecosystem of the area was greater than the benefit of the drainage. The original lake was 180-195 thousand acres in size and was 4-6 m deep.

After the completion of the Daniel storm, the level of the lake started to rise since huge amounts of water that have flooded the plain of Thessaly and were drained through the Pineios River fed the lake. As a result, the lake regained its original pre-1962 area and even larger, 190,000 km^2, making it the largest lake in Greece, after Trichonida Lake in the Aetoloakarnania Regional Unit of the Region of Western Greece.

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IMPACT OF FLOODS ON SURFACE WATER BODIES

OVERALL ASSESSMENT OF FLOOD IMPACT ON SURFACE WATER BODIES

As surface water body is considered the area of the surface that a great amount of water is gathering. At the area of Thessaly that impacted from the floods, the main water bodies are the waste water plants, the dams, lowland reservoirs, pond tanks and water gates. The intense flooding phenomena in the wider region of Thessaly have put out of operation all the waste water plants in the flood affected areas. It is very possible that the water of the floods contains urban waste that channeled to them at the affected area of Thessaly.

According to the data of Monitoring and Wastewater Treatment Plants Monitoring Database of the Special Secretariat for Water, the volume of Biochemical Oxygen Demand (BOD) per day at the waste water plants of the affected area is 25.679 kg. Based the aforementioned volume of BOD in the area per day and on the fact that greater concentration of BODs in the water makes it more polluted, a vast pollution of the water bodies of Thessaly is very possible as the flooding phenomena have spread it to the largest part of the Thessalian plain.

Except from the main dams that are being depicted in the respective maps, there are also 40 dams of smaller capacity and beneficial volume at the municipality of Larissa (part of the Thessaly water district EL08) with total volume of 2.650.000 m^3. Every surface water body like dams, lowland reservoirs, pond tanks and water gates are a possibly area of pollution as the water is gathering at them containing every possible pollutant from waste water plants, dead animals and also debris resulted from the flooding phenomena.

The following map illustrates every surface water body in accordance to the maximum flood extent and the affected area.

The related links are the following:

https://www.ypethe.gr/

https://rapidmapping.emergency.copernicus.eu/EMSR692/download

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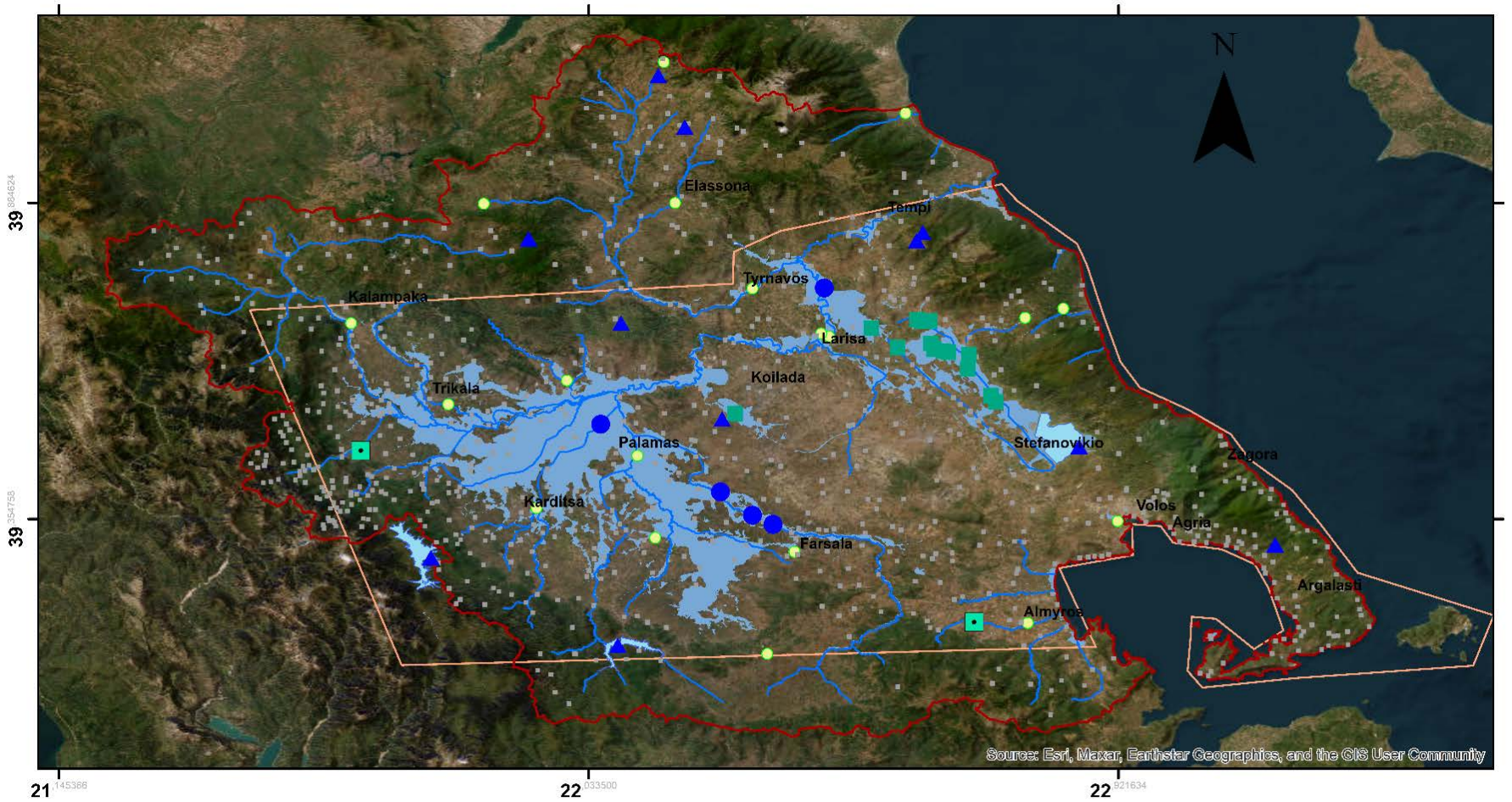
IMPACT OF FLOODS ON SURFACE WATER BODIES

OVERALL ASSESSMENT OF FLOOD IMPACT ON SURFACE WATER BODIES



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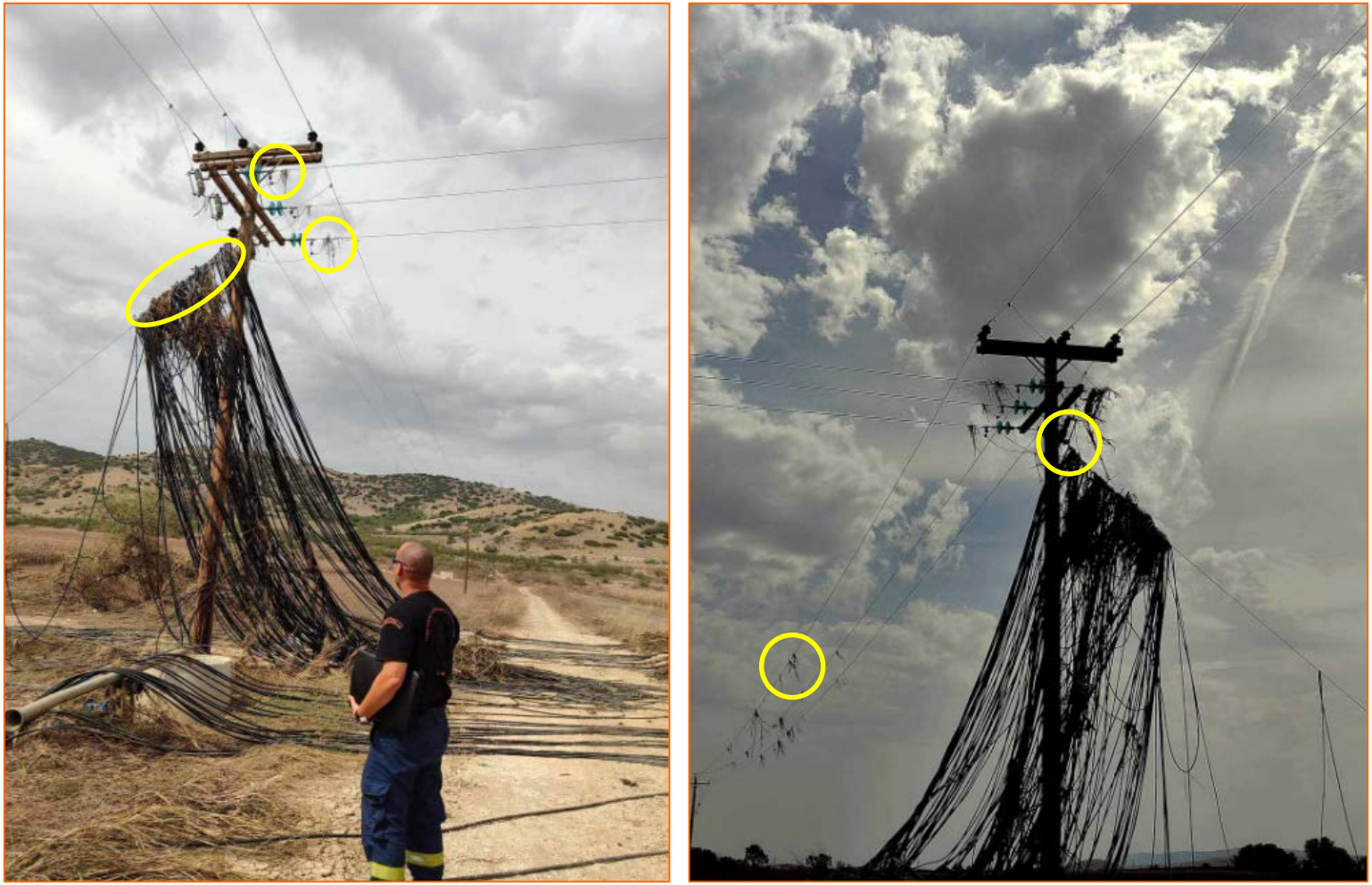
FLOOD IMPACT ON THE BUILT ENVIRONMENT
DETERMINATION OF FLOOD WATER STAGE



Flood water stage at about 9 m was determined in Pineiada area.
Photo credit: Stephanos Gogos (2023)

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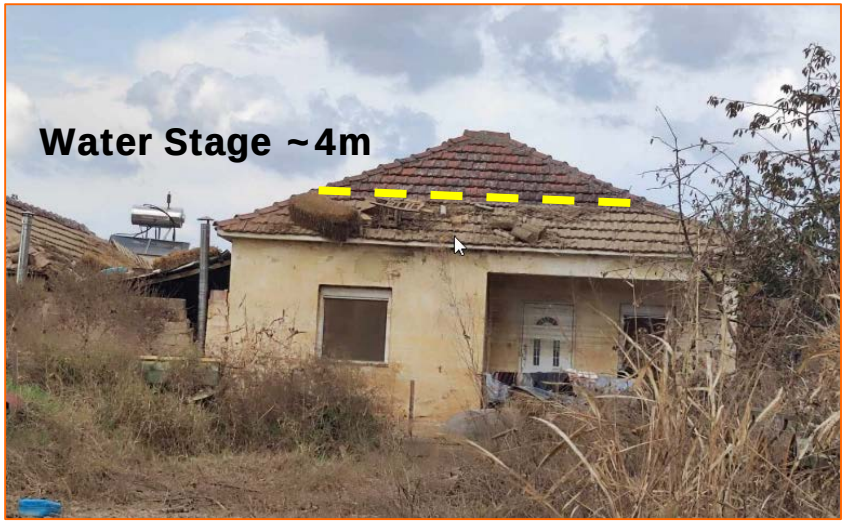
FLOOD IMPACT ON THE BUILT ENVIRONMENT

DETERMINATION OF FLOOD WATER STAGE



Flood water stage (yellow dashed line) at about 4 m was determined in Keramidi area.

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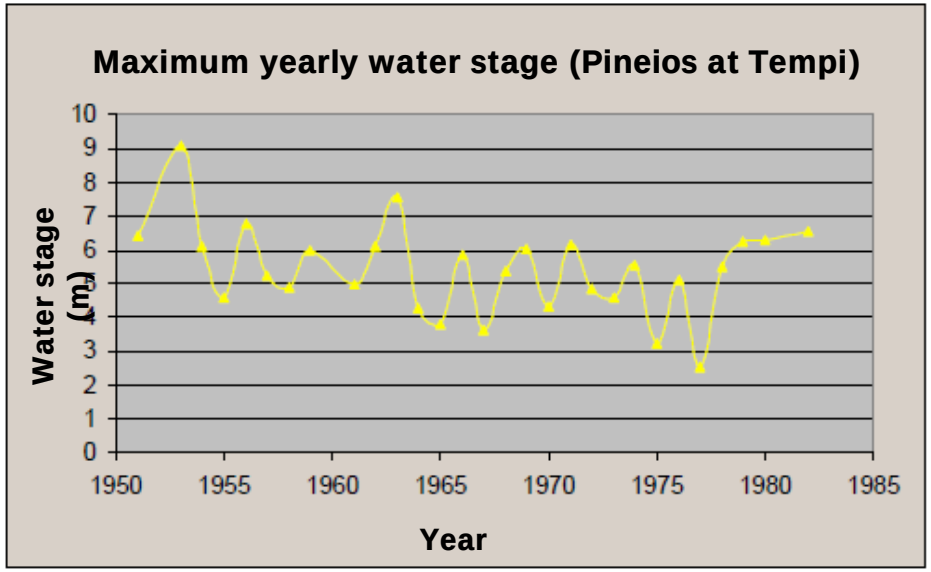
FLOOD IMPACT ON THE BUILT ENVIRONMENT
DETERMINATION OF FLOOD WATER STAGE

Floodwaters of Pineios River demolished the bridge in Tempi valley during the 2023 flood discharge reaching approximately a flood water depth of about 19-20m.



In comparison with previous years, water stage reached extreme levels at Tempi (~19-20m of depth), when in the period 1950-1985 the maximum value was ~9m. The source of the presented data is the former Ministry of the Environment, Spatial Planning and Public Works (via Kypraiou, 2011).

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FLOOD IMPACT ON THE BUILT ENVIRONMENT

IMPACT ON EMBANKMENTS

The dam / embankment about 80 meters long in Gavria stream, at Tsapocha, near the hospital of Karditsa, after the Chilia Dendra area, on the road to Metropolis, was shattered during flooding.
Source: topontiki.gr; libre.gr

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FLOOD IMPACT ON THE BUILT ENVIRONMENT

IMPACT ON EMBANKMENTS

Excavators opened embankments on purpose in some instances to direct floodwaters to parts of the floodplain in order to lower water level in the main river (in last effort to avoid flooding in urban areas).

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FLOOD IMPACT ON THE BUILT ENVIRONMENT
IMPACT ON EMBANKMENTS

Characteristic views of structural failures of embankment close to Larissa city due to the intense flooding (left) and near Giannouli area (Larissa regional unit; right).

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IMPACT OF FLOODS ON THE BUILT ENVIRONMENT

IMPACT ON BUILDINGS

Based on the results of field investigations after the destructive earthquakes in Thessaly in early March 2021, it is found that the buildings in the Thessalian plain include two dominant types of structures: (i) reinforced concrete buildings with infill masonry walls and (ii) buildings with load-bearing masonry walls. The adobe buildings can be also included in the last category.

Adobe buildings are widely used at the affected area for many decades, since their basic construction material (clay) abounds in the region. The used materials and the applied workmanship are technically acceptable. Their seismic response is rather good, but they may lose their structural stability if they are exposed to high levers of humidity and, even more, if they are covered by water*. In general, we may distinguish the existing buildings in two main categories: (i) engineered and (ii) non-engineered buildings. The aforementioned category belongs to the non-engineered buildings.

Other building types were also recorded, including buildings made of metal, wood and other building materials such as plasterboard.

As regards the age of these buildings, the majority of them were built before 1980. This is particularly significant as the majority of the buildings in the area were built according to the first code for seismic-resistant design for Greece published in 1959 (Royal Decree 19-2-1959, Government Gazette 36A/26-2-1959). This code continued to be applied for about 20 years until the large destructive earthquakes that affected the largest urban centers of Greece, the 1978 Thessaloniki (Northern Greece) and the early 1981 Athens (eastern mainland Greece) earthquakes.

Buildings in the area affected by the flooding suffered severe structural damage attributed to various factors. These factors have to do with (i) the location of the construction of these buildings, (ii) the characteristics of their construction and (iii) their exposure to recent catastrophic events, which fall under geophysical hazards including earthquakes and hydro-meteorological hazards including extreme weather events and subsequent flooding.

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IMPACT OF FLOODS ON THE BUILT ENVIRONMENT

IMPACT ON BUILDINGS

Regarding damage related to their location, buildings located at a short distance from the active bed of rushing rivers and torrents experienced problems in their stability due to erosion and undercutting phenomena caused along the banks of the rivers. This type of impact on the stability of buildings is not related to a specific building category, as both old buildings with load-bearing masonry and newly constructed buildings with reinforced concrete load-bearing structures and infill walls were affected. The said effects could be statistically distinguished, into two categories:

i. the engineered buildings were displaced, rotated, tilted or even overturned as rigid bodies including their foundation;

ii. the non-engineered buildings were partially or totally collapsed, or, even more, dissolved.

A typical example of a heavily affected reinforced concrete building is the two-storey structure in Mouzaki (Karditsa Regional Unit). The Pamisos River caused severe erosion and undercutting on its banks, causing the ground on which the building was founded to be washed away by the rushing water and the building to initially tilt and subsequently overturn within the riverbed.

* Carydis, P. (1981). The Extent of the Problem of Earthen Buildings in Greece. Proceedings of the International Workshop "Earthen Buildings in Seismic Areas", University of New Mexico, Albuquerque, May 24-28, 1981, Prepared for The National Science Foundation, Washington, DC, pp 115-126.

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IMPACT OF FLOODS ON THE BUILT ENVIRONMENT
DAMAGE TO BUILDINGS




A reinforced concrete engineered building in Mouzaki built on the bank of Pamisos River was initially tilted and then overturned within the riverbed due to erosion and undercutting phenomena caused by the rushing river

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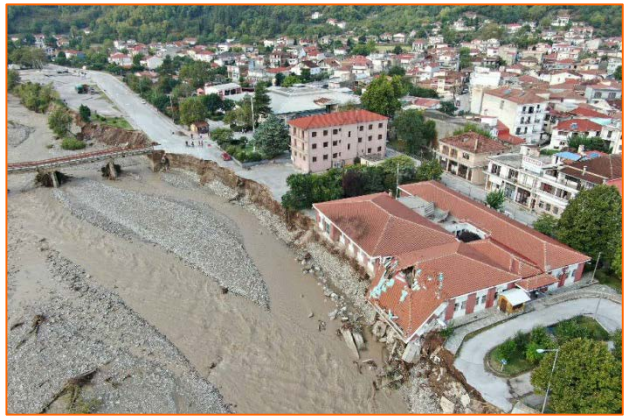
IMPACT OF FLOODS ON THE BUILT ENVIRONMENT
DAMAGE TO BUILDINGS



Ianos Medicane
September 2020
Mouzaki was also affected
Its health center was destroyed
More details on the Newsletter of EDCM, Issue 20, September 2020

Similar effects were observed in the same settlement during the Ianos medicane in mid-September 2020. The Mouzaki health centre was located at a distance of 30 m from the river bank. Due to river erosion and subsidence phenomena along the banks, the Mouzaki Health Centre suffered a partial collapse, while the rest of the structure was on the verge of devastation.

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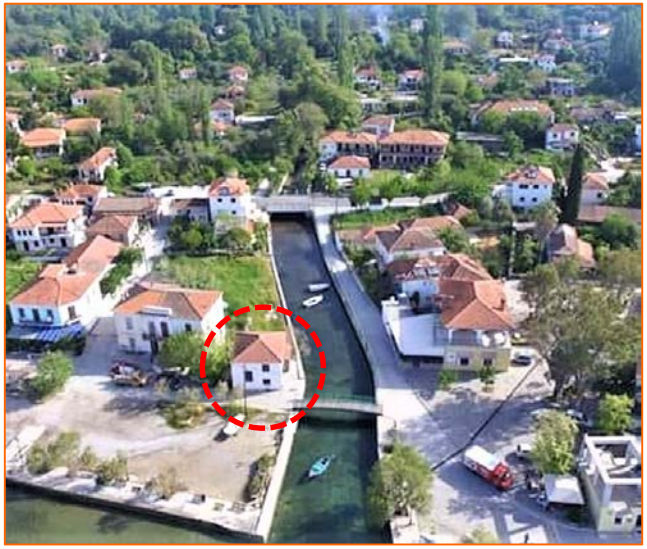
IMPACT OF FLOODS ON THE BUILT ENVIRONMENT

DAMAGE TO BUILDINGS



Similar impact on buildings was detected in the area of the settlement of Horto in Pelion, where a building constructed on the bank of a stream that crosses the settlement suffered severe erosion and undercutting of its foundations, causing it to tilt and be on the verge of total collapse.
Photos credit: Weather News Greece

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IMPACT OF FLOODS ON THE BUILT ENVIRONMENT
DAMAGE TO BUILDINGS

The building in the red dashed frame was marked red after flooding, which means to be demolished. Photos credit: Prof. Efthymis Lekkas

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IMPACT OF FLOODS ON THE BUILT ENVIRONMENT
DAMAGE TO BUILDINGS

Similar impact on buildings was detected in the same area of Horto settlement on a building located upstream of the previous heavily affected one. In this case, the rushing stream caused erosion of the bank under the buildings constructed right next to the stream bed.
Photos credit: Prof. Efthymis Lekkas

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IMPACT OF FLOODS ON THE BUILT ENVIRONMENT

IMPACT ON BUILDINGS

During the flood phenomena, many of the buildings with load-bearing masonry walls (natural stones, baked bricks or adobes) that form part of the residential fabric of the mainly rural areas were inundated for several days by the flood waters. The water level reached in many cases either up to the roof of ground floor residential buildings or up to the first floor of multistory structures. The inundation of these residencies resulted in serious structural damage in many cases, leading to their partial or total collapse. The last case mainly refers to adobe buildings. These damage is attributed to the presence of clay in their structural elements and to the lithology of the deposits in the foundations and the surroundings of the houses. Clay is an important structural element in the older buildings at the region and a cementing agent that can provide protection even during a strong earthquake. However, when it erodes, it goes from being a good binder with strength to becoming slippery, losing its strength and creating stability problems, which are attributed either to its destruction as a binder or to deformation in the foundation of the buildings and the surrounding area.

When it gets wet, it loses its strength and creates stability problems in the building that are attributed either to its destruction as a cementing agent or to deformation phenomena in the foundation of the buildings and the surrounding area. This deformation including bulge, subsidence, etc. has a high potential to cause significant structural damage to buildings and infrastructure including partial or total collapse.

Another element that must be taken seriously into account is the stress on the buildings of the area from the seismic sequence of Thessaly in early March 2021. The main earthquake of this sequence occurred on 3 March with magnitude Mw=6.3, while the next day another Mw=6.1 earthquake occurred, which can be considered as the largest aftershock of the sequence. The main earthquake caused extensive damage to homes and infrastructure, while the aftershock exacerbated the damage and caused widespread concern among residents.

The earthquake-induced building damage was mainly observed in villages founded on recent deposits of the beds of Pineios and Titarissios (tributary of Pineios) Rivers.

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IMPACT OF FLOODS ON THE BUILT ENVIRONMENT

DAMAGE TO BUILDINGS




Many villages of the Thessalian plain stayed for several days under water. This fact greatly affected the performance of buildings with load-bearing masonry walls and particularly the adobe ones, which suffered heavy and very heavy structural damage including partial or total collapse.

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IMPACT OF FLOODS ON THE BUILT ENVIRONMENT
DAMAGE TO BUILDINGS

Characteristic views of the flood-induced damage caused in several villages of Thessaly. The observed damage is mainly attributed to inundation and the high water stage of the area that adversely affected not only the buildings but also their foundation area. The majority of those buildings are non-engineered.

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DAMAGE TO BUILDINGS

Characteristic views of the flood-induced damage caused in several villages of Thessaly. The observed damage is mainly attributed to inundation and the high water stage of the area that adversely affected not only the buildings but also their foundation area. The majority of those buildings are non-engineered.

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DAMAGE TO BUILDINGS

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IMPACT OF FLOODS ON THE BUILT ENVIRONMENT

IMPACT FROM PREVIOUS DESTRUCTIVE EVENTS

The most affected residential areas were located on the alluvial plains comprising recent deposits of Titarissios River and its main tributaries, comprising from north to south the Palaeokastro, Evangelismos, Sykia, Magoula, Domeniko, Praetorio, Amouri, Mesochori, Vlachogianni and Damassi villages. Damage was also induced in villages of Pineios River plain including from W to E the Grizano, Farkadona, Zarkos and Koutsochero villages. Limited damage was observed in other villages located outside the Titarissios and Pineios alluvial plains including Verdikoussa among others.

The worst affected building type was the old unreinforced buildings with load-bearing masonry (namely, non-engineered buildings). They suffered mainly heavy structural damage comprising vertical cracks at wall intersections due to the lack of horizontal band beams (chainage), out-of-plane failures of the upper part of the walls attributed to interaction between roof structure and perimeter walls and to lack of building integrity as well as partial or total collapse due to poor quality mortar and poor workmanship, resulting in disintegration of masonry and loss of support to floors.

Regarding the recently constructed buildings with reinforced concrete frame and infill walls (engineered buildings), they remained intact by the earthquake in general. They suffered damage on their non-structural elements comprising detachment of plasters from infill walls, detachment of infill walls from the surrounding reinforced concrete frame and detachment of tiles from roofs and of cladding from walls.

The synergy of damage observed from the earthquakes of Thessaly in 2021 and the flooding and inundation of many parts of the residential fabric in the same area contributed to the aggravation of the damages already formed by the earthquake, the further stress of the buildings and their total destruction.

The effects on buildings can be long-lasting as their performance in many cases have been adversely affected either by one or by a combination of the above phenomena and their adverse effects. The disaster rehabilitation services carried out inspections of buildings in the affected residential areas, with particular emphasis on those that were inundated for several days by flood waters.

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IMPACT OF FLOODS ON THE BUILT ENVIRONMENT
RESULTS FROM POST-EVENT BUILDING INSPECTIONS

Flood affected area	Number of communities	Total Buildings	Total inspections			With damage			
			With damage	Without damage	Closed	Residential buildings	Business premises	Churches / Public Buildings	Warehouses, Barns etc.
Magnesia	41	2718	2627	91	0	1921	123	14	569
Karditsa	54	3736	3449	253	34	2513	24	18	894
Larissa	49	3122	3097	25	0	2035	70	47	945
Fthiotida	20	534	463	71	0	269	45	7	142
Trikala	26	3095	3062	32	1	2510	61	14	477
Evia	4	67	63	4	0	25	9	0	29
Total (1)	**194**	**13272**	**12761**	**476**	**35**	**9273**	**332**	**100**	**3056**

Source: Region of Thessaly

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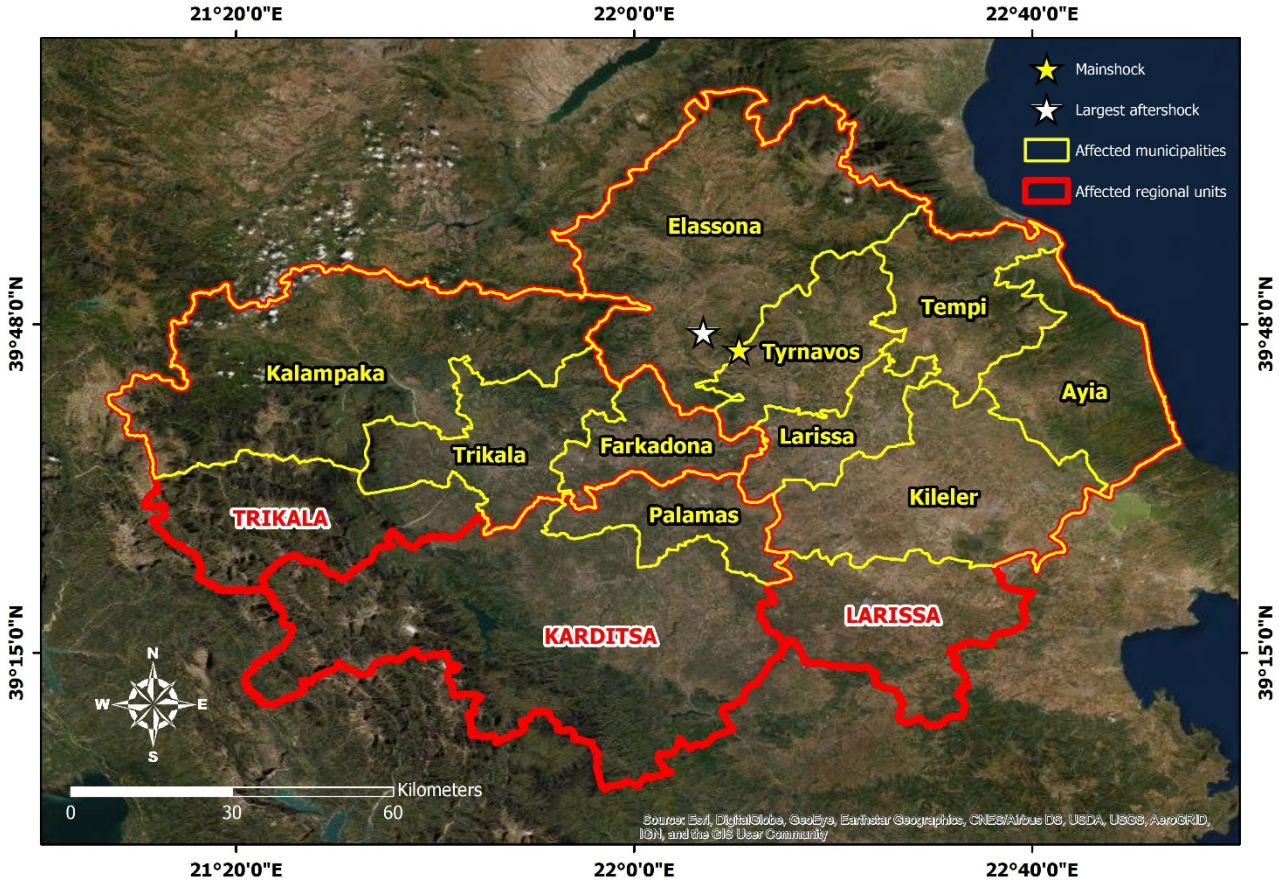
IMPACT ON THE BUILT ENVIRONMENT

IMPACT FROM PREVIOUS DESTRUCTIVE EVENTS

2021 Thessaly earthquakes
Mainshock: 3 March, Mw=6.3
Largest aftershock: 4 March, Mw=6.1



The regional units (red polygons and names) and the municipalities (yellow polygons and names) of Thessaly Region affected by the early March 2021 Thessaly sequence. The earthquake epicenters of the mainshock (yellow star) and the largest aftershock (white star) are also presented.

Source: Mavroulis et al. (2021) in the Bulletin of the Geological Society of Greece, Volume 58, p. 1-36.

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IMPACT ON THE BUILT ENVIRONMENT

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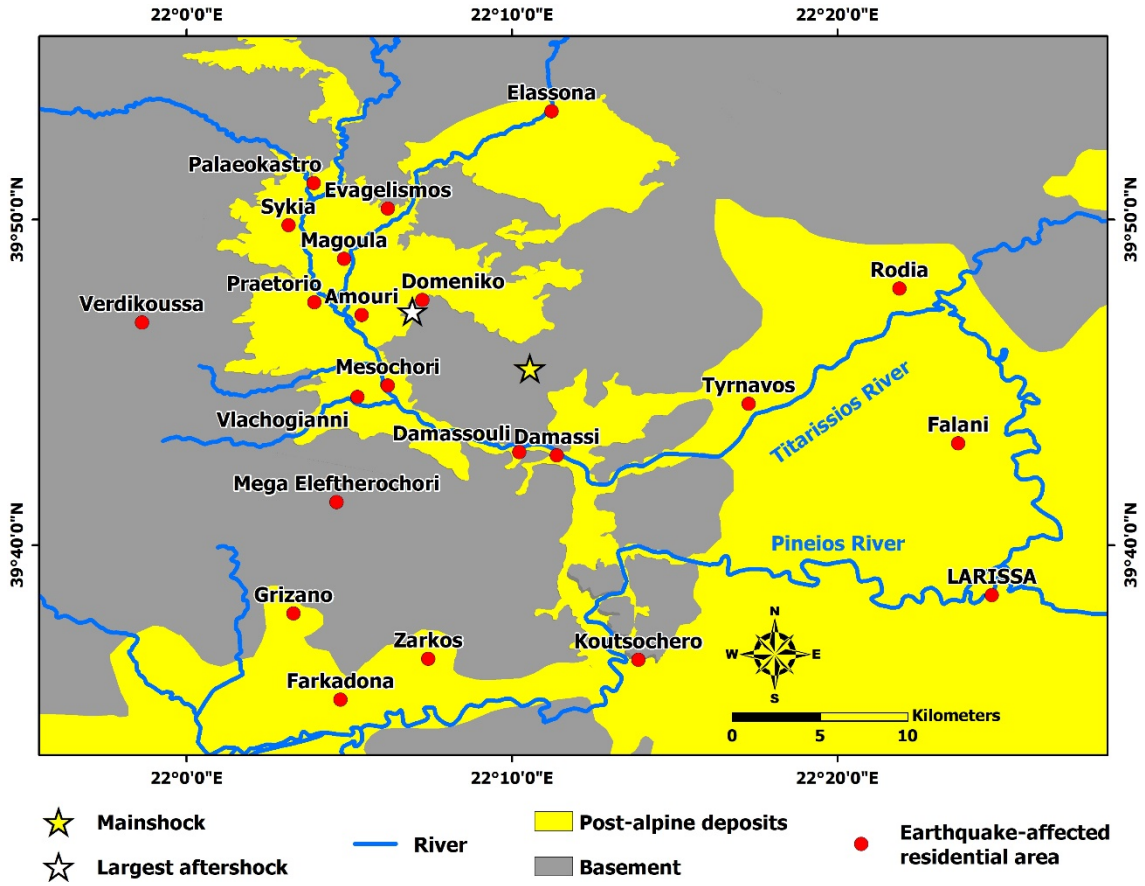

Simplified geological map illustrating post-alpine deposits and their basement along with the distribution of the residential areas affected by the early March 2021 Thessaly earthquakes. The epicenters of the 3 and 4 March earthquakes (yellow and white stars respectively) in the northern part of Thessaly Basin are also presented.

Source: Mavroulis et al. (2021) in the Bulletin of the Geological Society of Greece, Volume 58, p. 1-36.

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IMPACT ON THE BUILT ENVIRONMENT
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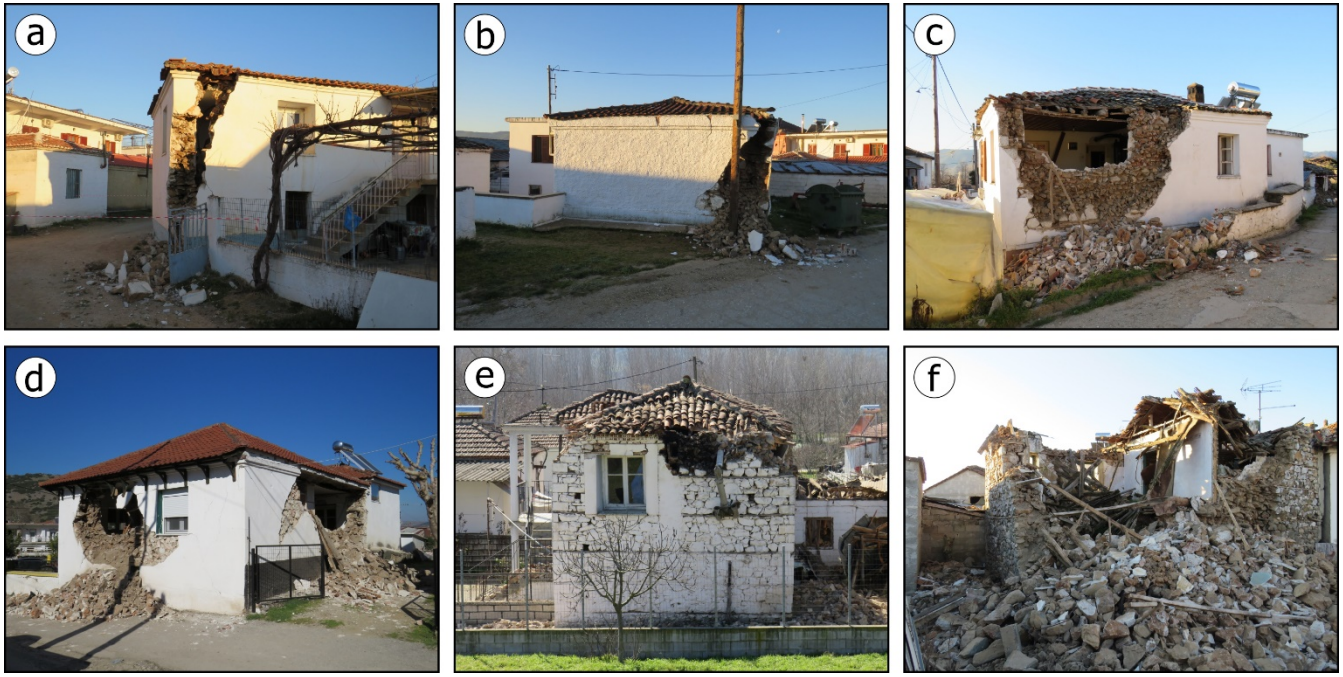

(**a**, **b**) Mesochori village

(**c**, **d**) Mesochori (c) and Damassi (d) villages

(**e**, **f**) Mesochori village

(**a**, **b**) Vertical cracks and gaps were frequently formed and propagated along the height of the bearing wall intersections. (**c**, **d**) Failures of the upper part of the walls were also attributed to the interaction of roof structure and perimeter walls. (**e**, **f**) Damage were also attributed to poor mortar and poor workmanship resulting in partial or total collapse. (Mavroulis et al., 2021)

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IMPACT ON THE BUILT ENVIRONMENT

SYNERGY OF EARTHQUAKE AND FLOOD IMPACT ON BUILDINGS

The recently flooded areas have the following additional static and seismic risk factors:

- The quite high hydrostatic pressure ranging from 4 to 8 meters, and its quite long duration, resulted in the invasion of water in deeper layers of the soil. Natural drainage, with this type of soil (fine-grained clay) and with this particular topography (basin), is slow if not impossible. This means that in the event of a future earthquake, the mobility of the soil is increased and the risk of liquefaction is increased even more.
- The flooded areas have been transported with all kinds of organic and non-organic materials of considerable thickness and are fully saturated, thus forming a new topography of the area, with a much higher level of the new natural soil than before. The organic materials decompose over time and increase subsidence. For these reasons, for many years to come, the construction of buildings for permanent habitation and use should be prohibited.

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IMPACT ON THE COASTAL ENVIRONMENT

A substantial volume of materials has been introduced into the marine environment, posing potential hazards to maritime activities, sailing, and the shipping industry at large.

Sizeable objects, such as containers, driftwood debris, barrels, household appliances, animal carcasses, and other assorted items, are buoyant and can be carried by ocean currents, often far from their point of origin at river outlets that have experienced flooding.

This phenomenon underscores the need for heightened awareness and mitigation strategies in the maritime sector.

Photos credit: Prof. Efthymis Lekkas

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IMPACT ON THE COASTAL ENVIRONMENT
INCREASE OF SUSPENDED MATTER AND FLOOD DEPOSITS IN DELTAS

A typical case of the impact of flooding along the coastline in Milina area of Magnesia Regional Unit. Flood debris and deposits were concetrated in the stream estuary located in the southern part of the settlement and altered the port bathymetry. Photos credit: Prof. Efhymis Lekkas.

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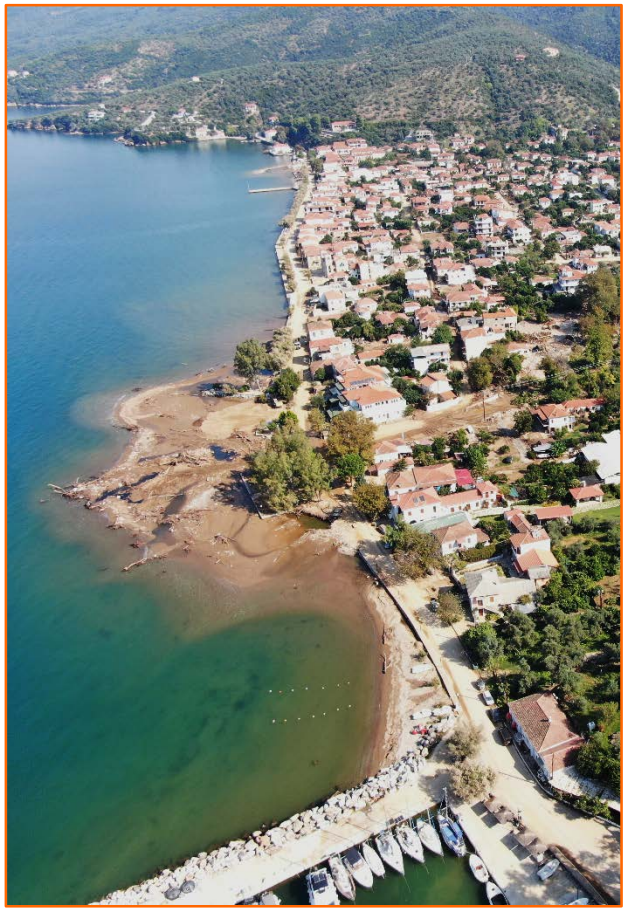
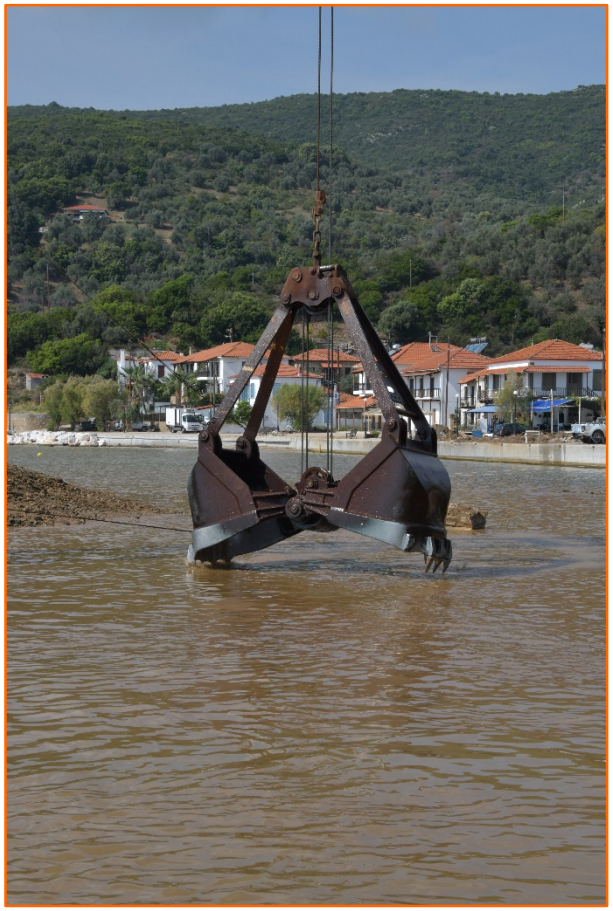
IMPACT ON THE COASTAL ENVIRONMENT
INCREASE OF SUSPENDED MATTER AND FLOOD DEPOSITS IN DELTAS





Flood debris and deposits were concetrated in the stream estuary located in the southern part of Milina settlement and altered the port bathymetry. Special crews removed the deposits in order to reopen the port and ensure the safety of maritime transport. Photos credit: Prof. Efhymis Lekkas.

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IMPACT ON INFRASTRUCTURE

DAMAGE TO ROAD NETWORK, TECHNICAL WORKS AND SCHOOLS

According to the Ministry of Infrastructure and Transport (report on 27 September 2023), the flood-induced damage was recorded in:

Trikala Regional Unit:

- 11.7 km of road network
- 35 bridges
- 28 technical works
- 19 schools

Karditsa Regional Unit:

- 22.3 km of road network
- 21 bridges
- 28 technical works
- 19 schools

Magnesia Regional Unit:

- 13.3 km of road network
- 5 bridges
- 41 technical works
- 22 schools

Larissa Regional Unit:

- 11 km of road network
- 14 bridges
- 30 technical works
- 13 schools

Fthiotida Regional Unit:

- 11.9 km of road network
- 4 bridges
- 3 technical works
- 6 schools

In total:

- 70.2 km of road network
- 79 bridges
- 130 technical works
- 79 schools

In relation to the extent of the disaster, it is estimated that 40.7% of the affected infrastructure was destroyed or suffered very heavy non-structural and structural damage. For example, 24 of the 79 damaged bridges, were fully destroyed.

Source:
https://www.kathimerini.gr/society/562640452/kakokairia-600-ekat-eyro-mono-gia-tis-ypodomes-sti-thessalia/

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IMPACT ON CRITICAL INFRASTRUCTURE

DAMAGE TO HEALTH FACILITIES

The Nursing Home of Volos has been evacuated during the evolution of Daniel. Part of its old wing collapsed due to the extreme weather events and their adverse effects.

The Argalasti Health Center had been also evacuated.

According to information from local media during the night of 6 September, the Non-Commissioned Officers School (SMY in Greek) in Trikala and the Fire Service in Palamas were flooded.

In SMY, there were problems with storage areas and for this reason that night it was not possible for the military officers to help in the efforts to release citizens and repair basic infrastructure.

During the same night in Palamas area, the Fire Station was also flooded and subsequently transferred to an unaffected school complex.

The collapsed old wing of the Volos Nursing Home

Sources:

https://www.thetoc.gr/koinwnia/article/kakokairia-daniel-ekkenonetai-to-girokomeio-tou-bolou---katerreuse-pteruga/

https://www.news247.gr/ellada/girokomeio-volou-katerrefse-tmima-tis-palias-pterigas-apo-tin-kakokairia/

https://www.news247.gr/ellada/girokomeio-volou-katerrefse-tmima-tis-palias-pterigas-apo-tin-kakokairia/

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IMPACT ON INFRASTRUCTURE
ROAD NETWORK DAMAGES

On September 7, 2023, traffic between Athens and Thessaloniki along the national motorway were suspended due to the following reasons:

- Overflow of rivers resulting in inundation of large parts of the Thessalian plain with water and covering with debris
- Rainfall-related and flood-induced landslides due to intense erosion and undercutting phenomena
- Failure of important elements of the road network including failure of bridges
- Destruction of the road surface due to rainfall and subsequent flood and landslide phenomena.

The road network of the wider area suffered severe problems for days. The Hellenic Police made daily announcements about the inaccessible roads in the flood-affected areas.

On September 9, 2023, the Hellenic Police announced the longest catalogue of inaccessible roads (highways and country roads) in all regional units of the Thessaly Region (Larissa, Magnesia, Trikala and Karditsa). This catalogue reduced day by day as the waters receded and restoration works took place.

Impact on bridge in Volos and on road in Ano Meria.
Source: https://www.ertnews.gr/eidiseis/ellada/poia-einai-i-katastasi-sto-odiko-diktyo-tis-thessalias/

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IMPACT OF FLOODS ON THE ROAD NETWORK
THE THESSALONIKI – LARISSA HIGHWAY AFTER THE TEMPI GORGE




The National Road Thessaloniki-Larissa after the Tempi gorge, as mapped by the "Aegean Motorway“ company, which manages this section. The road surface and the adjacent agricultural land have been inundated by flood waters. What testifies to the existence of a road are the rows of trees on the margins of the road as well as the vegetation on the dividing line between the different directions. Photos credit: Aegean Motorway. Source: https://www.youtube.com/watch?v=ZetW7PP7Nts

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IMPACT OF FLOODS ON THE ROAD NETWORK
THE THESSALONIKI – LARISSA HIGHWAY AFTER THE TEMPI GORGE

The Thessaloniki-Larissa National Road after the Tempi gorge. The road surface and the adjacent agricultural land have been inundated by flood waters. What testifies to the existence of a road are the rows of trees on the margins of the road as well as the vegetation on the dividing line between the different directions. Source: https://www.iefimerida.gr/ellada/ethniki-odos-larisas-thessalonikis-adiabati-tempi

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IMPACT ON INFRASTRUCTURE
DAMAGE ON ROAD NETWORK – COUNTRY ROADS

(**1**) Landslide in 5th km of Volos-Agria road (Photo credit: THETOC TEAM)
(**2**) Destruction of a road by flooding (Alexandros Avaramidis, REUTERS)
(**3**) Destruction of the road surface in Makrynitsa (Pelion) (Human Stories)
(**4**) Damage to road attributed to intense erosion and along the road in Platanias village (Alexandros Avaramidis, REUTERS)

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IMPACT ON INFRASTRUCTURE
DAMAGE ON ROAD NETWORK – COUNTRY ROADS

The Iolkos Str. in Volos City before (left column) and after (right column) the Daniel storm in early September.

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IMPACT ON INFRASTRUCTURE
DAMAGE ON ROAD NETWORK – COUNTRY ROADS

The Iolkos Str. in Volos City before (left column) and after (right column) the Elias storm in late September.
Source: https://www.protothema.gr/greece/article/1417979/kakokairia-elias-magnisia-exafanistike-gia-deuteri-fora-o-dromos-pou-odigei-ston-ano-volo-video-kai-fotografies/

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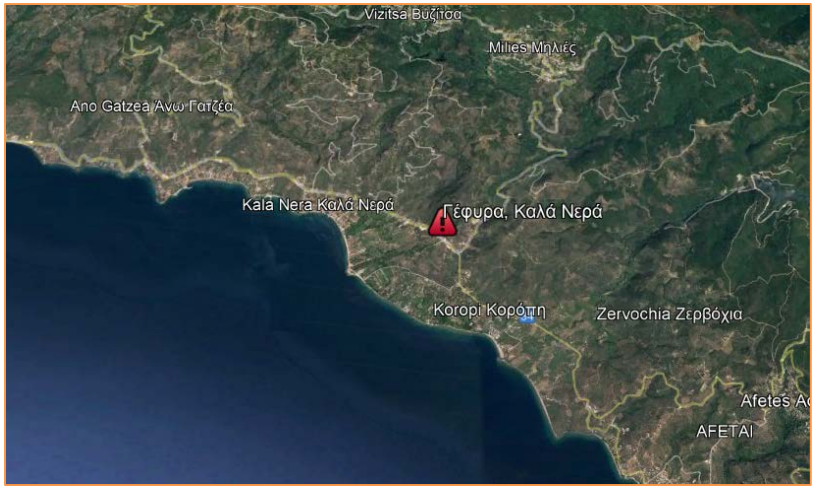
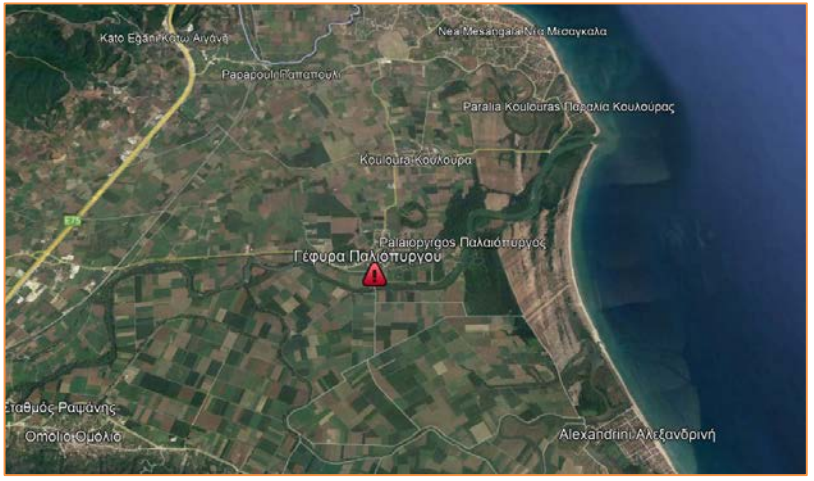
IMPACT ON INFRASTRUCTURE
DAMAGE ON ROAD NETWORK – BRIDGES



Kala Nera, Pelion (Photo credit: Stamos Prousalis, Reuters)



Palaeopyrgos, Larissa (Source: https://www.tanea.gr/2023/09/14/greece/kakokairia-daniel-katerreyse-i-gefyra-ston-palaiopyrgo-larisas/)

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IMPACT ON INFRASTRUCTURE
DAMAGE ON ROAD NETWORK – BRIDGES

Rushing water reached the level of the bridge

The bridge was heavily damaged by the rushing water

The bridge was totally destroyed and swept way by flooding.

Video source: https://www.youtube.com/shorts/iiQXqwYAXDU?feature=share)

Different phases of the impact of the rushing water of the torrent Krafsidonas on the bridge in the city of Volos. The bridge was swept away and completely destroyed on September 5, 2023, after heavy rainfall in the Magnesia Regional Unit of Thessaly Region, which also affected the city of Volos to a large extent.

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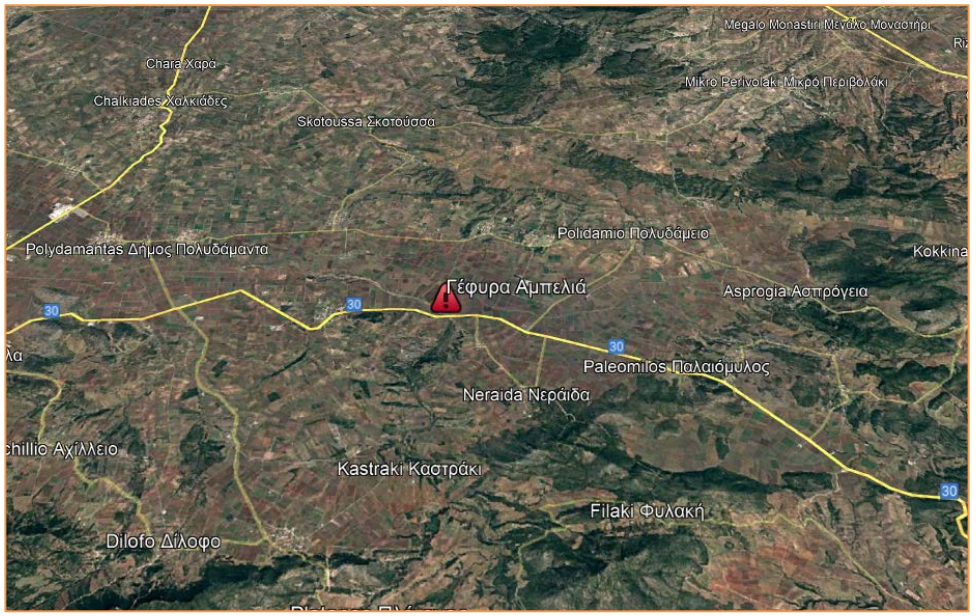
IMPACT ON INFRASTRUCTURE
DAMAGE ON ROAD NETWORK – BRIDGES



Total destruction of the bridge in Ampelia site located in Farsala area was attributed to the flooding waters of Enipeas River.

Source:
https://www.in.gr/2023/09/06/greece/kakokairia-daniel-epese-gefyra-sta-farsala-apokommeni-poli/

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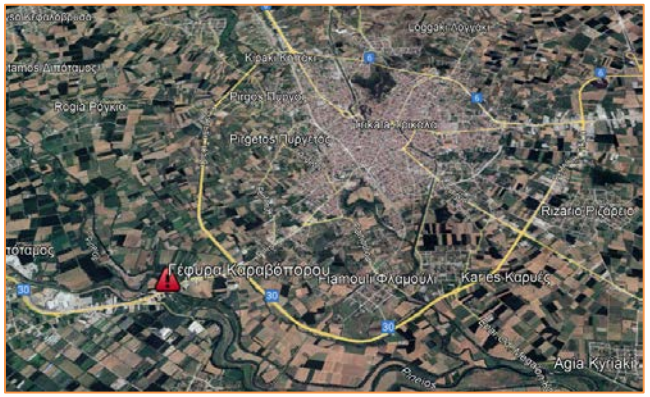
DAMAGE ON ROAD NETWORK – BRIDGES



Karavoporos, Trikala
(Source: https://www.trikalaola.gr/etoimi-gia-katarrefsi-i-siderenia-gefyra-tou-karavoporou-foto/)

Xirias Bridge, Almyros
(Source: https://hellasjournal.com/2023/09/gefira-xiria-tin-xanaktisan-ston-iano-tin-sakatepse-o-daniel-i-stochevmeni-erevna-tou-ariou-pagou-isos-vgali-polla-lavrakia/)

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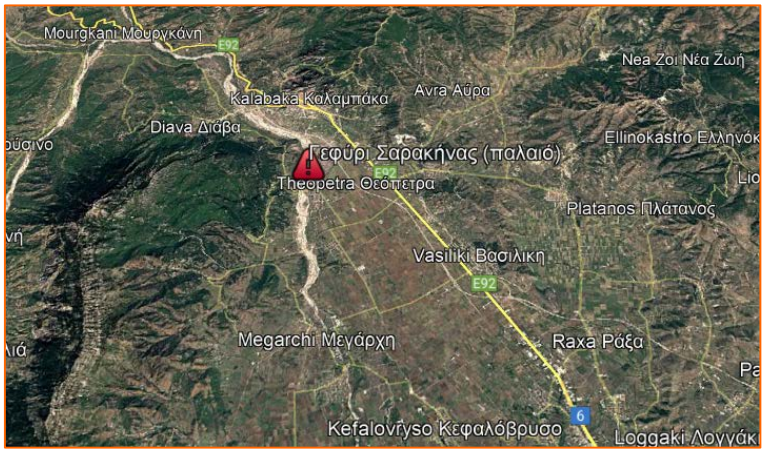
IMPACT ON INFRASTRUCTURE
DAMAGE ON ROAD NETWORK – BRIDGES



Sarakina Bridge, Kalampaka (Source: https://www.youtube.com/watch?v=CW_OYzintu0)

Diava Bridge, Kalampaka (Source: https://www.tameteora.gr/topika/dimos-meteoron/493798/vinteo-kai-eikones-apo-ti-gefyra-kalampakas-diavas-skameni-i-koiti-apo-ta-ormitika-nera/)

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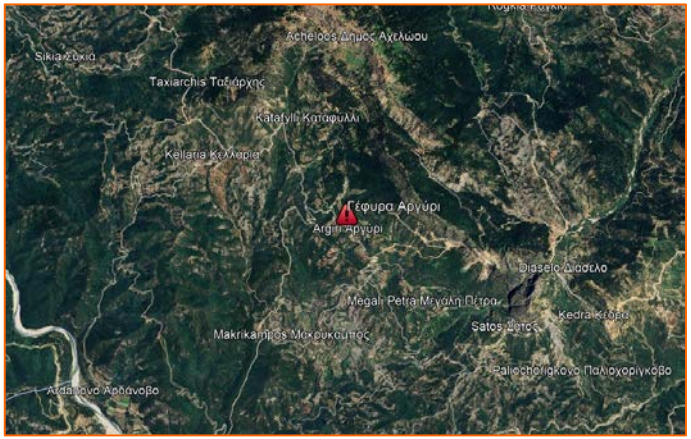
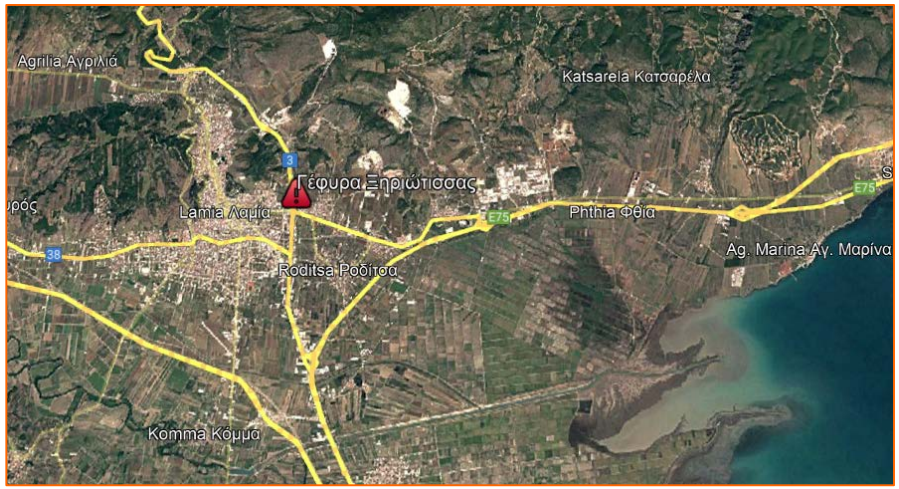
IMPACT ON INFRASTRUCTURE
DAMAGE ON ROAD NETWORK – BRIDGES



Argyri Bridge, Karditsa (Source: https://www.youtube.com/watch?v=0GrzXNIfUdw)



Xyriotissa Bridge, Lamia (Source: https://lamiapolis.gr/lamia-katastrofes-kai-stin-gefyra-stin-xiriotissa-dialythikan-anavathmoi-kai-toichia/)

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IMPACT ON INFRASTRUCTURE
DAMAGE ON ROAD NETWORK – BRIDGES

The red symbols correspond to parts of the road network affected during the evolution of Daniel

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IMPACT ON INFRASTRUCTURE
DAMAGE ON ROAD NETWORK – BRIDGES

The red symbols correspond to parts of the road network affected during the evolution of Daniel

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IMPACT ON INFRASTRUCTURE
DAMAGE TO RAILROAD NETWORK

According to the statements of the Hellenic Railways Organization (OSE in Greek) managing director at ITC 2023 - 6th Infrastructure and Transport Conference, a total of 180 km of network have been destroyed including:

- 50 km of double line on the Athens-Thessaloniki axis;
- 80 km on the Palaiofarsalos-Kalambaka section;
- 50 km on the Larissa-Volos section.

Along with these, two interlocking centers were heavily damaged comprising:

- the interlocking center in Domokos which first became operational in August;
- the interlocking center in Paleofarsalos which controlled Larissa.

It was also noted that the complete restoration of the network is expected in time period of 2 years.

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IMPACT ON INFRASTRUCTURE
DAMAGE TO RAILROAD NETWORK

The flooding caused damage to the railroad network. It affected several components of the railroad infrastructure including rail tracks, rail ties, track beds and catenary masts among others important elements.
Photos credit: Prof. Eftymis Lekkas

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IMPACT ON INFRASTRUCTURE
DAMAGE TO RAILROAD NETWORK

The part of the railway network in Domokos area suffered the most by the generated flood due to Daniel. Several elements of the network including tracks, the electromechanical systems comprising signalling systems were severely damaged. Furthermore, several stations were also affected with Domokos station being devastated.

Source: https://www.makthes.gr/plimmyres-oi-zimies-sto-sidirodromiko-diktyo-xepernoyn-ta-150-160-ekat-eyro-664524

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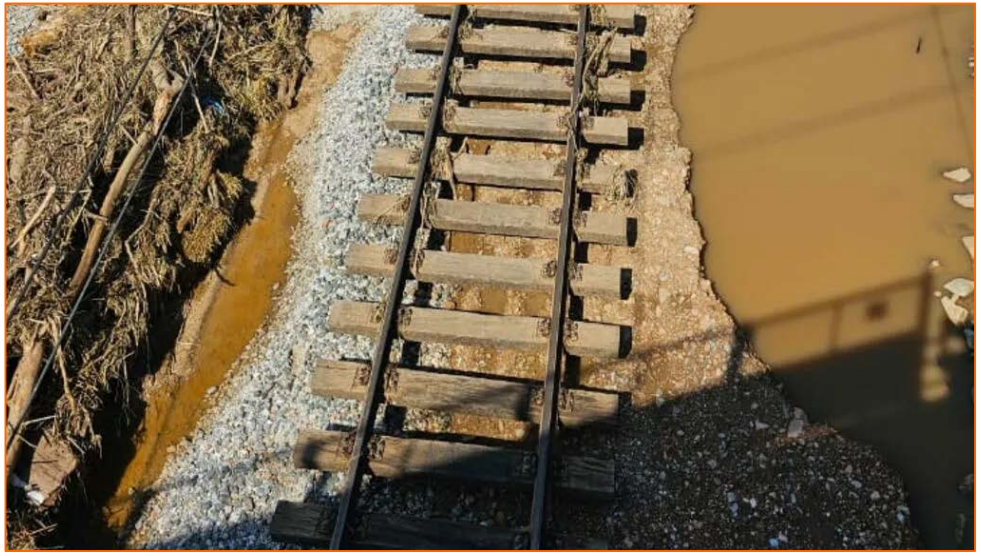
IMPACT ON INFRASTRUCTURE
DAMAGE TO RAILROAD NETWORK



The most common damage to the railway network is the deposition of debris on the rails, the erosion of the material under the rails and the subsequent deformation of the rails, the drifting of various network elements such as rails, signalling, traffic lights, cabling, etc., the deposition of mud and the covering of railways. These failures resulted railway disruptions for a long period of time.

Photos credit:
https://www.efsyn.gr/ellada/koinonia/403430_xethemeliothike-diktyo-stin-periohi-toy-domokoy

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IMPACT ON INFRASTRUCTURE
DAMAGE TO ELECTRICITY DISTRIBUTION NETWORK

The Daniel storm caused extensive damage to the Electricity Distribution Network and power supply problems mainly in Volos, Pelion and other areas of the Magnesia Regional Unit as well as in the island complex of Sporades:

06.09.2023

In **Magnesia Regional Unit**, the following were affected:

- 13 medium voltage lines;
- approximately 750 damaged substations that electrify part of the city of Volos and villages in the mountainous and coastal Pelion;
- power supply problems in Skiathos island.

In **Karditsa Regional Unit** the following were affected:

- 35 substations damaged.

In **Larissa Regional Unit**, the following were affected:

- damages affecting approximately 20 settlements.

10.09.2023

Due to the storm Daniel and the intense flooding phenomena that followed in Thessaly, a pillar on the 400 kV Larissa-Larymna transmission line, in the area of Larissa and a pillar on the 150 kV Domokos-Farsala transmission line fell.

11.09.2023

5000 households remain without power supply, e.g.:

- 200 in southeast Pelion area;
- 1700 in Trikala and Karditsa areas;
- 3000 in Larissa area.

Source:
Independent Power Transmission Operator S.A
Hellenic Electricity Distribution Network Operator

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IMPACT ON INFRASTRUCTURE
DAMAGE TO ELECTRICITY DISTRIBUTION NETWORK

Electricity distribution network damages in area of the mountainous and coastal Pelion.

▲ Ano Meria, Pelion

◀ Platanias, Pelion

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IMPACT ON INFRASTRUCTURE
DAMAGE TO ELECTRICITY DISTRIBUTION NETWORK

Electricity distribution network damages in the Thessalian Plain attributed to flooding after the Daniel storm.
Photos credit: Prof. Efthymis Lekkas

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IMPACT ON INFRASTRUCTURE

DAMAGE TO TELECOMMUNICATION NETWORKS – LANDLINE DAMAGES

The Daniel storm has also caused damage to landline telecom infrastructure in the flood-affected areas.

Damage has occurred to 23 central Fiber Optic Cables (FOC) of the trunk network that handle traffic between the central nodes of the OTE network (e.g. FOC Athens - Larissa - Thessaloniki and FOC Skopelos - Skiathos - Volos), and extensive and constant power outages. Noted that until September 11 many areas were still inaccessible for the technicians.

In order to deal with the problems, the following were done in the first 6 days:

- hundreds of traffic rerouting on alternative optical paths;
- direct transfer of technicians from neighboring areas and enrichment of the central units with additional personnel;
- FOC Repair after the completion of the drainage works, in cooperation with the competent bodies. 8 central fiber optic cables have been repaired, while the rehabilitation of another 8 was in progress;
- portable power generators installation in collaboration with the competent operators in Pelion, Farkadona and in the area of Mouzaki;
- mobile Base Station installation in the area of Palamas;
- fuel oil supply to a critical Base Station, using a helicopter, in cooperation with the relevant agencies;
- continuous supply of equipment on a 24-hour basis.

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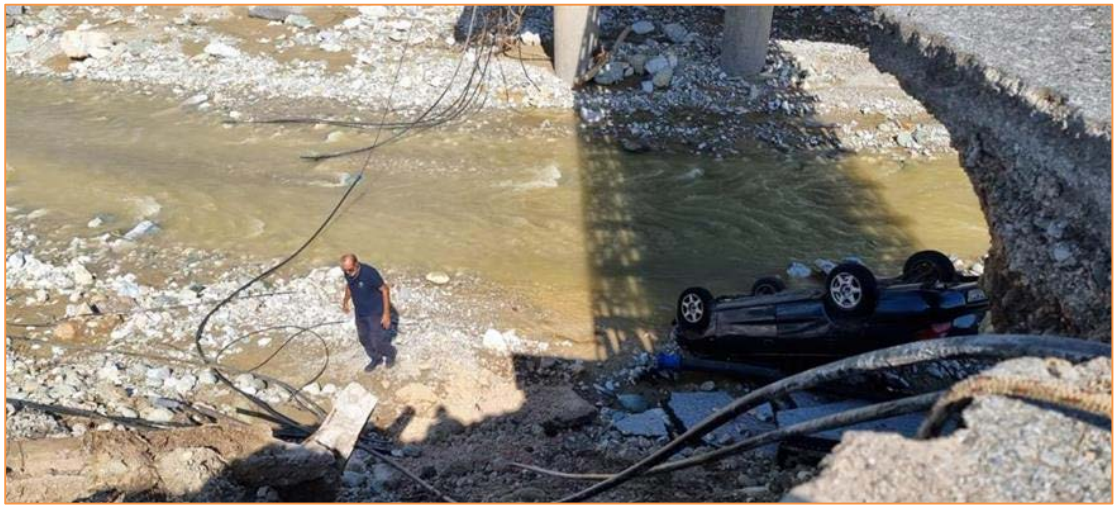
IMPACT ON INFRASTRUCTURE

DAMAGE TO TELECOMMUNICATION NETWORKS – LANDLINE DAMAGES



The most common impacts on landlines relate to damage to individual sections of the road network, damaged by flooding and the rushing waters of rivers and torrents.

Photos credit: AFP/GETTY IMAGES

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IMPACT ON INFRASTRUCTURE

DAMAGE TO TELECOMMUNICATION NETWORKS – MOBILE NETWORKS

The continuous lightning has caused problems to the mobile telecommunication. However the mobile telecommunication network remained operational during the evolution of the extreme weather events and the subsequent flooding and the main mean of communication for residents in the first hours and days of the emergency response.

It is noted that the 112 emergency alert messages were sent to the residents of the affected area through the mobile telecommunication network.

However, the long power outages were a deterrent to the continuous use of mobile phones.

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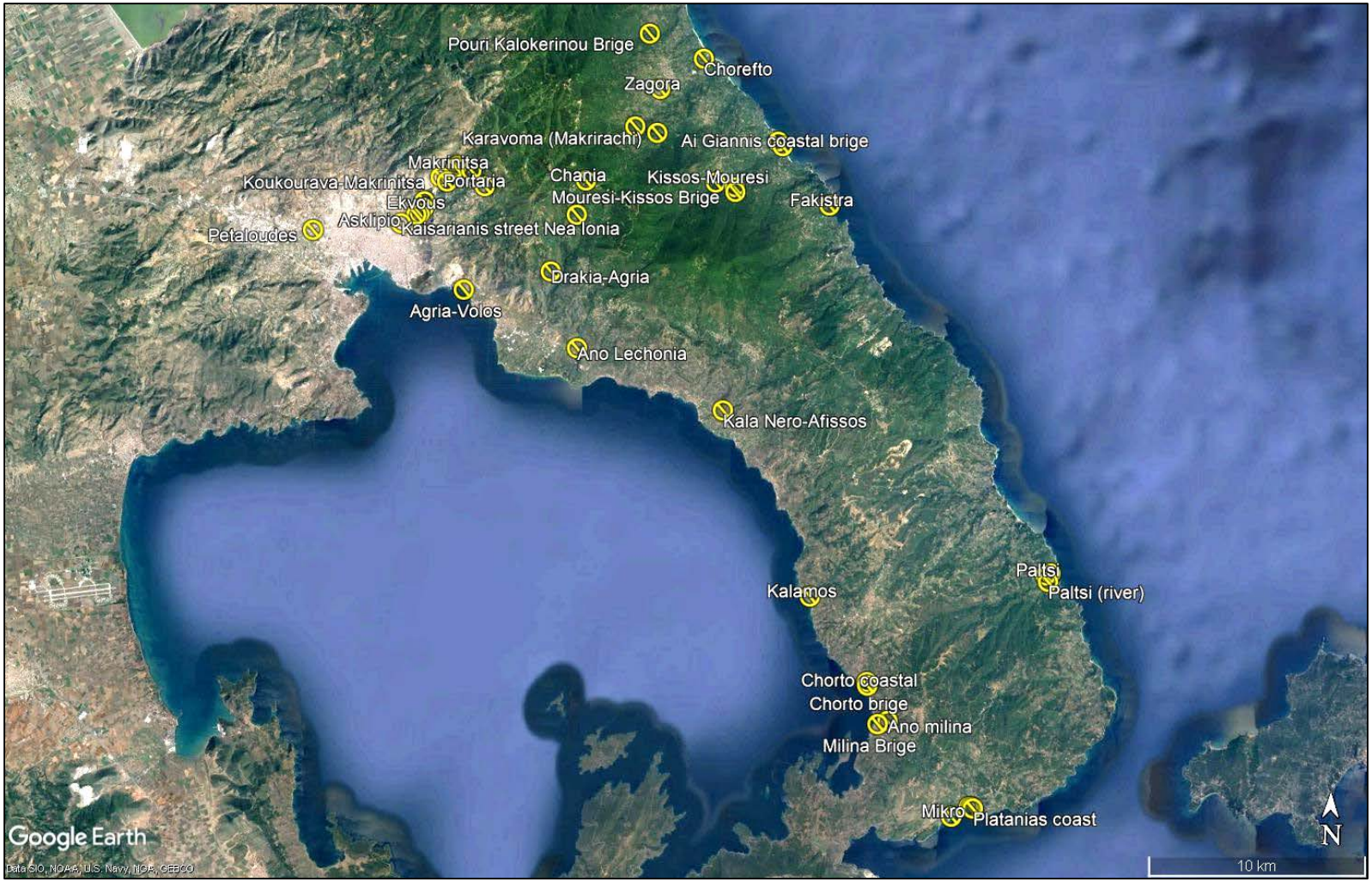
IMPACT ON THE ROAD NETWORK
PELION MOUNTAIN



Spots with total destruction of the road in need of complete reconstruction

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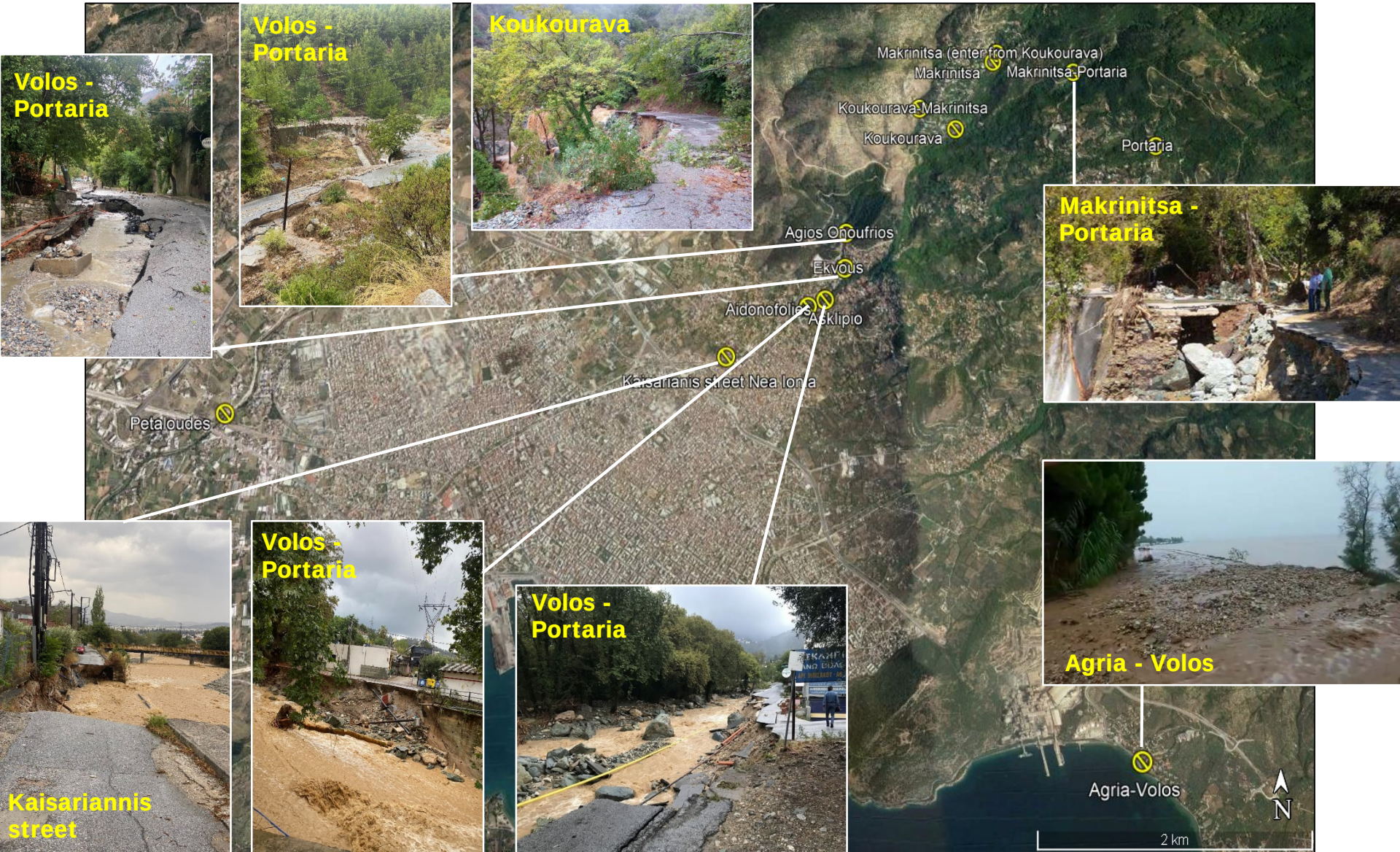
IMPACT ON THE ROAD NETWORK
PELION MOUNTAIN



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IMPACT ON THE ROAD NETWORK
PELION MOUNTAIN

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IMPACT ON THE ROAD NETWORK
PELION MOUNTAIN

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IMPACT ON THE ROAD NETWORK
PELION MOUNTAIN

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IMPACT ON EDUCATION FACILITIES
SCHOOLS AND UNIVERSITIES

The Daniel storm and the subsequent flooding also affected educational facilities in the Region of Thessaly including schools and the University of Thessaly. The effects include the following in detail:

1. 1.034 school units, 98.181 students and about 11.500 teachers were affected.
2. Many of these units were affected by floodwaters and mudflows.
3. Major problems were found in 29 units with 1,226 pupils.
4. The operation was suspended for the majority of schools for at least 2 weeks. For the school complexes that were seriously affected, the suspension lasted longer.
5. The 2023-2024 school year started with distance education on 25 September 2023 for the majority of schools. The schools of the Municipalities / Districts of Palamas, Farkadona, Megala Kalyvia, Falani, Yannouli, Armenio and Kipseli were excluded as distance education became impossible due to the prevailing adverse conditions.
6. Distance learning was implemented for a longer period of time for students of all levels in some villages such as Puri, Kissos, Ayios Dimitrios and Anilios of the municipality of Zagora-Mouresi in Magnesia due to difficulties in the transition of students due to damage on the road network.
7. The relocation solution was applied for the units that were partially or completely destroyed.
8. Afternoon shift was implemented in 2 education schools due to the inability to find classrooms during the relocation.
9. The failure of the affected schools to operate resulted not only in the movement of pupils to neighboring schools but also in the migration of population to other areas.

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IMPACT ON EDUCATION FACILITIES
SCHOOLS AND UNIVERSITIES

10. This migration changed the school population density and school data, creating a new school map. It is possible that these areas, which have been increasingly affected by flooding in recent years, will become deserted, resulting in the closure of schools, while the school population in neighboring towns is expected to increase.

11. Inability to implement distant education was observed in some cases and was attributed to the fact that some students and parents did not have access.

12. Inability to access some schools was observed and was attributed to the destruction of the road network.

13. Power and telecommunication outages were initially recorded during the reopening of some schools due to damage that could not be repaired in time and lack of equipment attributed to mudflow and flood damage.

14. Inadequate school hygiene in schools due to: (i) contamination from dead animals, (ii) spread of disease due to poor sanitary conditions, (iii) lack of drinking water and (iv) electrocution.

15. Difficult living conditions for students, parents and teachers in the affected areas due to: (i) fear of reoccurrence of the phenomenon and more specific psychological effects due to the disaster, (ii) economic problems for pupils and teachers due to loss of property, (iii) lack of food and basic goods.

16. Large economic costs for: (i) repairing the damage to educational facilities, (ii) the transport of pupils to and from the relocated schools.

17. Disruption of the operation of the University of Thessaly: (i) destruction of essential building functions due to water entering in critical facilities, (ii) non-operation of the Computer Centre due to flooding, resulting in the interruption of electronic services (e-mail services, user authentication, web hosting, distant education, distant working, etc.), (iii) library destruction.

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IMPACT ON EDUCATION FACILITIES
SCHOOLS AND UNIVERSITIES

Flood-related disaster in the kindergarten of Farkadona village.

The water level (yellow mark) from the flooding has been imprinted on both the exterior and interior walls of the school.

Photos credit: Prof. Efthymis Lekkas

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IMPACT ON COASTAL AREAS
NORTH AEGEAN – PINEIOS DELTA

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IMPACT ON COASTAL AREAS
NORTH AEGEAN – PINEIOS DELTA

Satellite images (Poseidon System via Terra MODIS NASA, Copernicus Marine)

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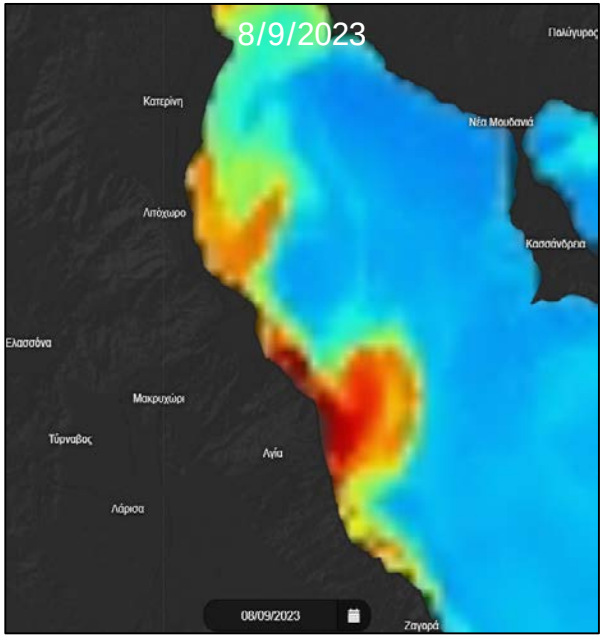
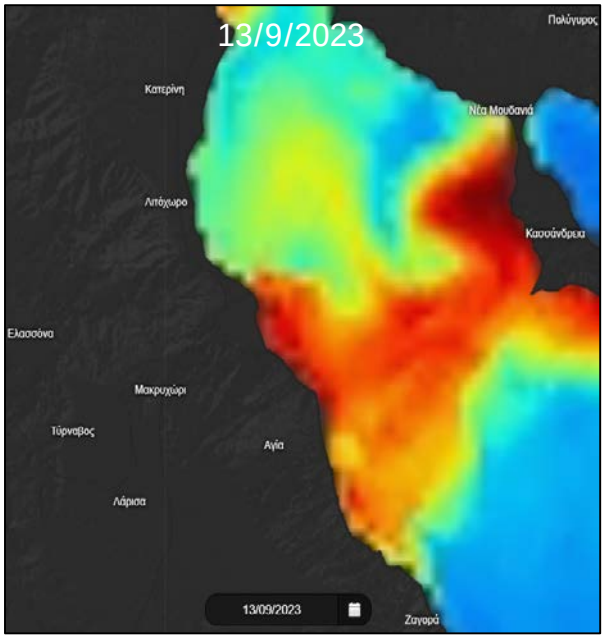
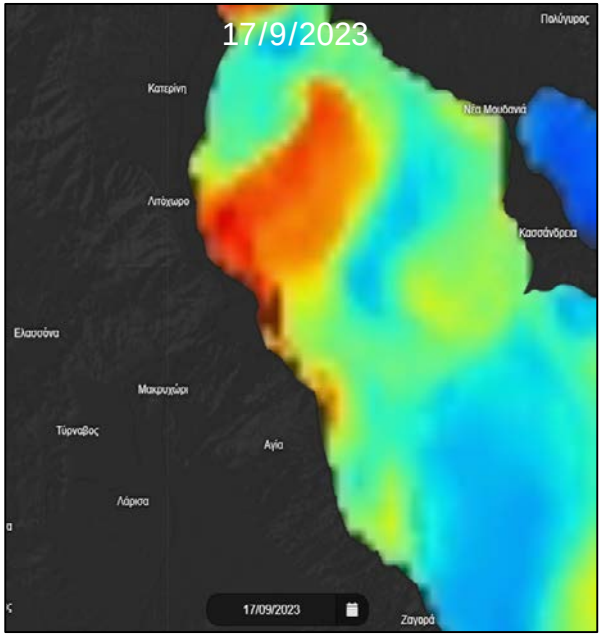
IMPACT ON COASTAL AREAS
NORTH AEGEAN – PINEIOS DELTA







Satellite DATA (Poseidon System, Copernicus Marine): Chlorophyll-A

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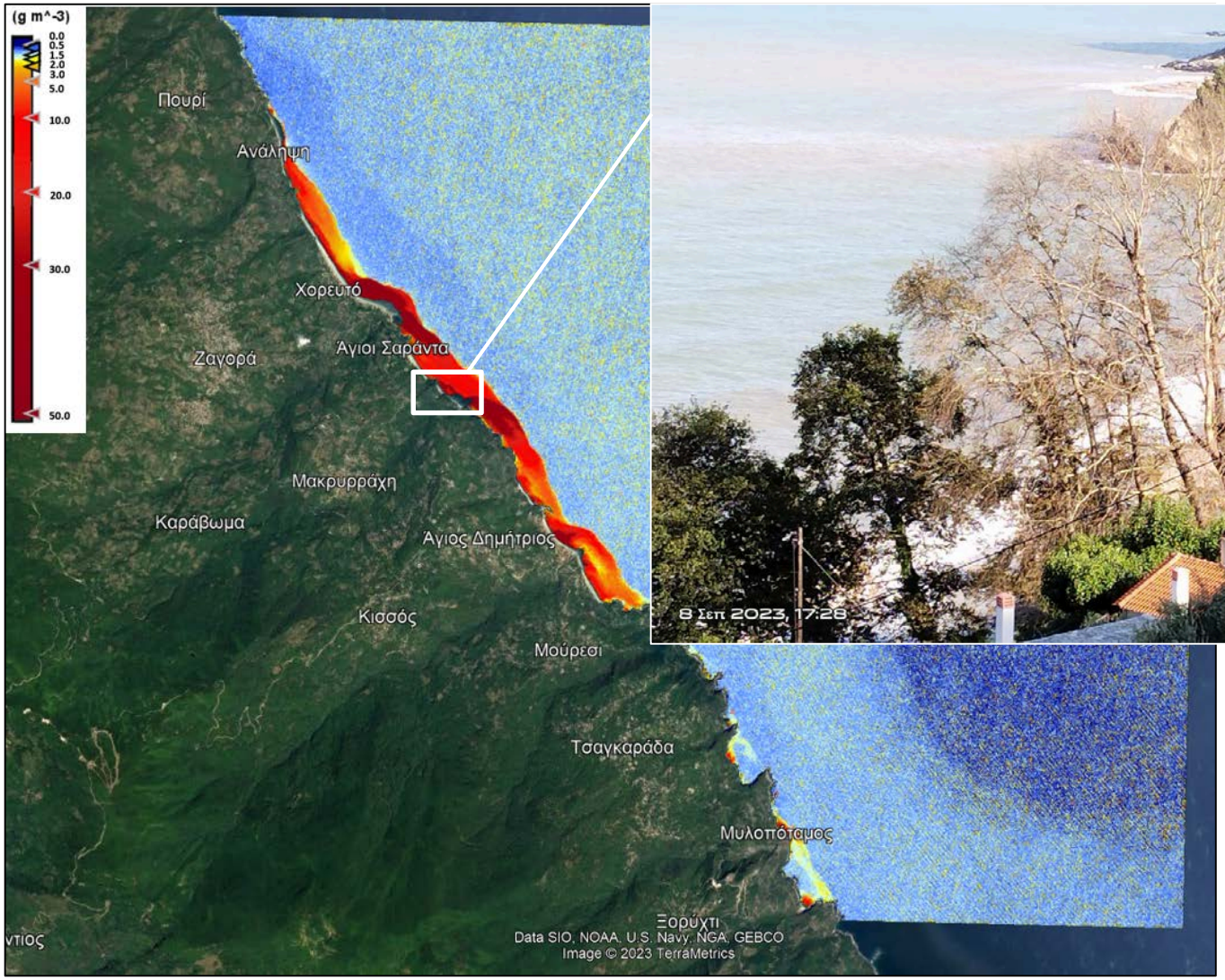
IMPACT ON COASTAL AREAS
NORTH AEGEAN



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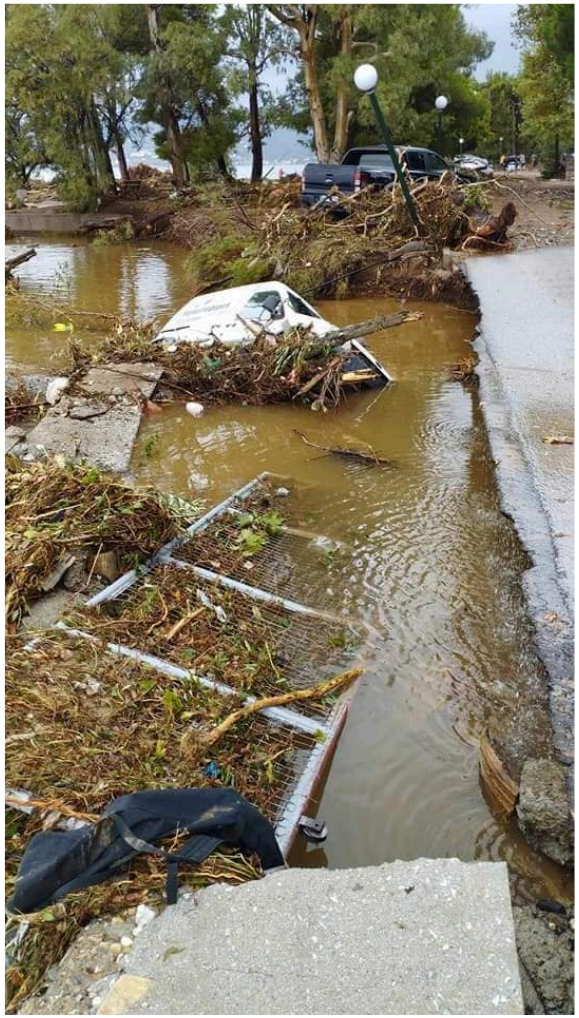
IMPACT ON COASTAL AREAS
NORTH AEGEAN – RIVER NETWORK IN PELION MOUNTAIN



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IMPACT ON COASTAL AREAS
NORTH AEGEAN

Paltsi, South Pelion

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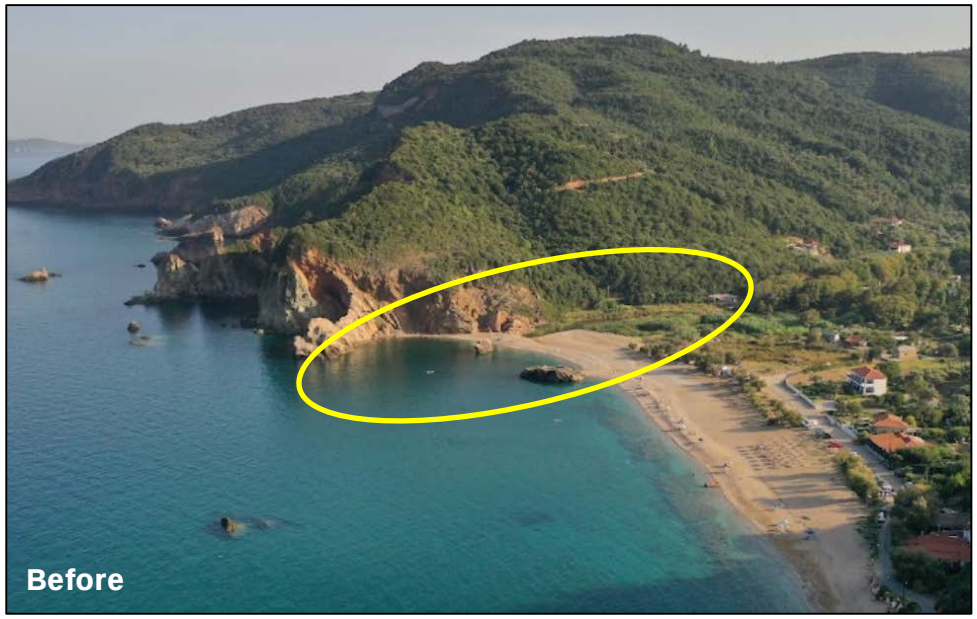
IMPACT ON COASTAL AREAS
NORTH AEGEAN



Coastal morphology changes at Paltsi (Pelion)

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IMPACT ON COASTAL AREAS
SOUTH PELION

Platanias coastal area

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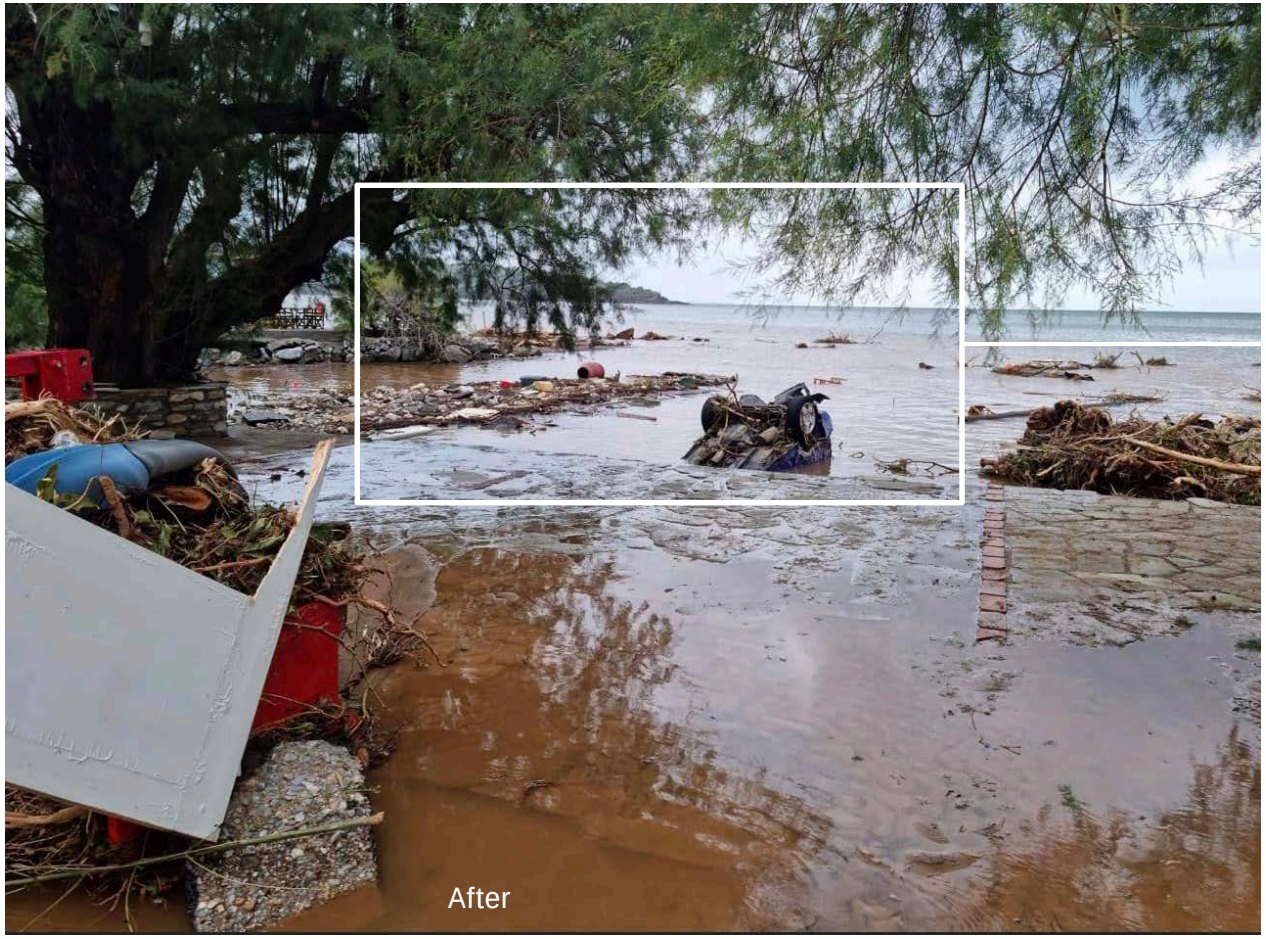
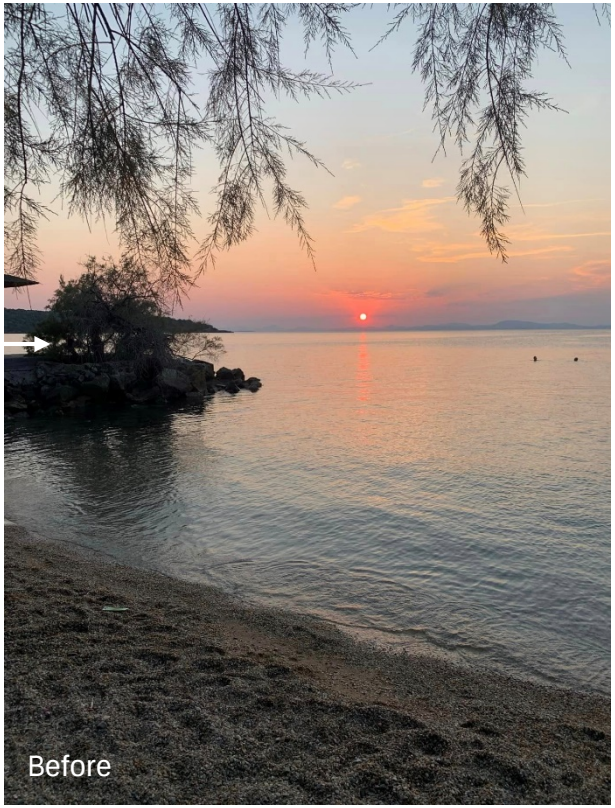
IMPACT ON COASTAL AREAS
PAGASITIKOS GULF





Milina (North Pelion)

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IMPACT ON COASTAL AREAS
PAGASITIKOS GULF

Bathymetry variations were detected in Volos port and attributed to the extreme weather events and the subsequent flooding.

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INSURED LOSSES

The insured damages from the Storm Daniel amount to 6,011, according to the first record, of the Association of Insurance Companies of Greece (EAEE in Greek). The data came from 24 insurance companies, which are estimated to represent 97.6% of property insurance production.

Based on the aforementioned source, 4,307 losses were related to property insurance including:

- 1,714 residential properties;
- 2,032 businesses;
- 69 industrial facilities;
- 116 infrastructure projects;
- 376 solar parks

The remaining 1,699 were related to motor insurance and 5 to boat insurance.

Source: http://www1.eaee.gr/deltia-typoy/6-011-zimies-dilothikan-mehri-simera-stis-asfalistikes-epiheiriseis-apo-tin-kakokairia-daniel

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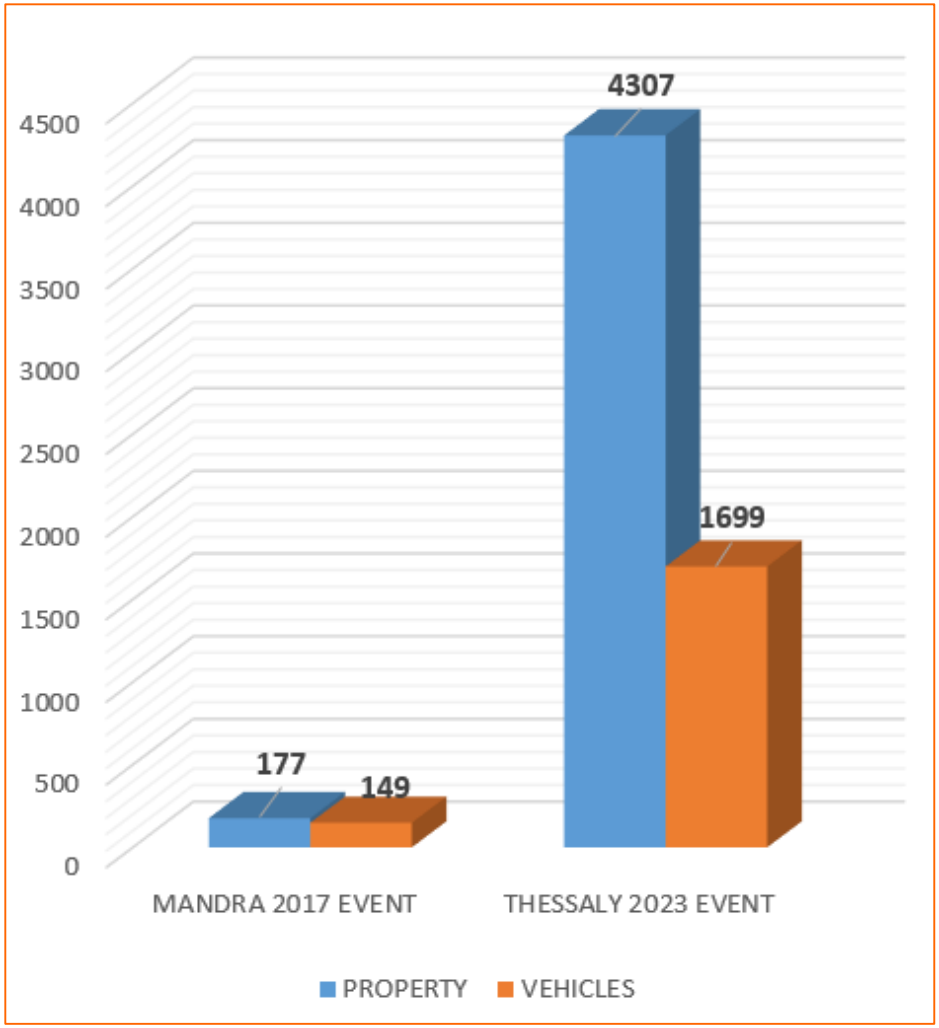
ΕΝΩΣΗ ΑΣΦΑΛΙΣΤΙΚΩΝ ΕΤΑΙΡΙΩΝ ΕΛΛΑΔΟΣ

INSURED LOSSES



The first picture that emerges from the losses of Daniel Storm in terms of insured losses is indicative of how extensive the effects were.

In the diagram, a comparison of the first data of the Association of Greek Insurance Companies (EAEE) in relation to another extreme flood event, that of Mandra area in Attica Region (November 2017), is presented.

The chart shows number of property and vehicle damage reported to companies of the EAEE.

Data source: Association of Greek Insurance Companies (EAEE)

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EMERGENCY RESPONSE
THE CONTRIBUTION OF THE HNDGS TO SEARCH AND RESCUE OPERATIONS

Rescue of residents in Vlochos village of Karditsa regional unit by the Hellenic National Defence General Staff (HNDGS)

Photos credit: https://twitter.com/hndgspio/status/1699720938407805043
(Twitter post on 7 September 2023)

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EMERGENCY RESPONSE
THE CONTRIBUTION OF THE HNDGS TO SEARCH AND RESCUE OPERATIONS

Zodiac vessels and TOMP M113 in assistance of residents from the flood-affected areas of the Thessalian plain

Photos credit:
https://twitter.com/hndgspio/status/1699731002438963223
(Twitter post on September 7, 2023)

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EMERGENCY RESPONSE

THE CONTRIBUTION OF THE HNDGS TO RESTORATION OF DAMAGE TO INFRASTRUCTURES

A metal bridge with a length of 30m and carrying capacity of 16t was constructed in Kala Nera area within 30 hours by a team of the Design - Construction Unit of the Hellenic National Defense General Staff. The bridge was constructed for restoring the road from Volos to South Pelion area after collapse of the previous bridge due to intense river erosion.

Photos credit: ΓΕΕΘΑ-HNDGS
https://twitter.com/hndgspio/status/1700860607480672269
(Twitter post on 10.09.2023)

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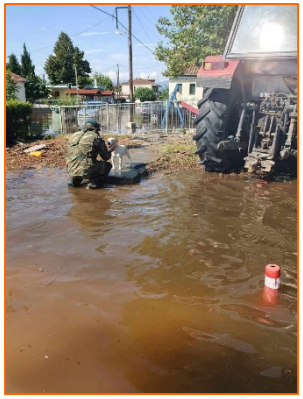
EMERGENCY RESPONSE

THE CONTRIBUTION OF THE HNDGS TO SEARCH AND RESCUE OPERATIONS








The Greek Armed Forces conducted operations with appropriate equipment in the affected areas, day and night, 24 hours a day, saving lives, transporting citizens to safe places, assisting with their machinery, ambulances, buses, boats, warships, helicopters.

Photos credit: ΓΕΕΘΑ-HNDGS
https://twitter.com/hndgspio/status/1700242336305774704 (Twitter post on 08.09.2023)
https://twitter.com/hndgspio/status/1700822375183323552 (Twitter post on 10.09.2023)

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EMERGENCY RESPONSE
THE CONTRIBUTION OF THE HNDGS TO SAFEGUARDING PUBLIC HEALTH

The HNDGS actively contributed to the safeguarding of public health with the removal of dead animals from the flood-affected areas. The personnel of the HNDGS was fully secured with special personal protection equipment including clothes, gloves, glasses and masks. After leaving field, they were disinfected at the special disinfection stations.

Photos credit: ΓΕΕΘΑ-HNDGS
https://twitter.com/hndgspio/status/1702325687624122688
(Twitter post on 14.09.2023)
https://twitter.com/hndgspio/status/1702587165329207764
(Twitter post on 15.09.2023)

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EMERGENCY RESPONSE
ANNOUNCEMENTS OF SELF-PROTECTION MEASURES BY THE HELLENIC FIRE SERVICE

Announcements of self-protection measures by the Hellenic Fire Service at the beginning of Daniel on 5 September. Source: https://twitter.com/pyrosvestiki/status/1699009586085200268

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EMERGENCY RESPONSE
ANNOUNCEMENTS OF SELF-PROTECTION MEASURES BY THE HELLENIC FIRE SERVICE

STORMS – FLOODS

During storm – flood:

IF WE ARE IN A BUILDING / HOUSE

- Move from basements and go to higher place
- If water enters the house, immediately turn off the main power supply
- Help disabled people, do not forget pets

IF WE ARE OUTDOORS

- Do not move and seek a safe, high place
- Never cross rushing water on foot or in a car
- We stay away from power lines

Announcements of self-protection measures by the Hellenic Fire Service at the beginning of Daniel on 5 September. Source: https://twitter.com/pyrosvestiki/status/1699009586085200268

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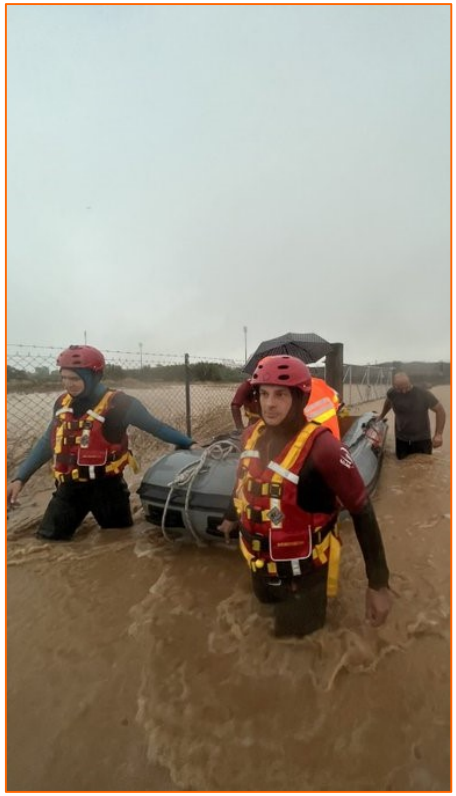
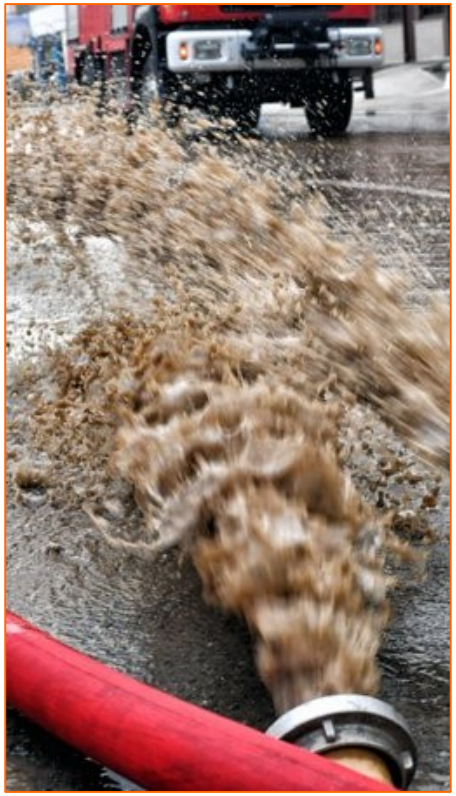
EMERGENCY RESPONSE

EMERGENCY ACTIONS OF THE FIRE SERVICE IN THE FLOOD-AFFECTED AREAS OF THESSALY



The Fire Department's Operations Center from Tuesday, 05-09-2023, 07:00 (local time) to Tuesday 26-09-2023, 07:00 (local time) had received 10.402 calls from the Region of Thessaly and until then 3747 water pumping was carried out, while 3576 people were transferred to safe places.

Photos credit: Hellenic Fire Service (https://twitter.com/pyrosvestiki)

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EMERGENCY RESPONSE

EMERGENCY ACTIONS OF THE FIRE SERVICE IN THE FLOOD-AFFECTED AREAS OF THESSALY

The Fire Brigade forces remained strong in the Region of Thessaly and where required, the Fire Brigade's air and ground assets as well as UAS transported food, water, medicine and bedding to affected people in the areas of the Region of Thessaly.

Photos credit: Hellenic Fire Service (https://twitter.com/pyrosvestiki)

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EMERGENCY RESPONSE
ANNOUNCEMENTS OF SELF-PROTECTION MEASURES BY THE CIVIL PROTECTION

Announcements of self-protection measures by the Civil Protection during Daniel on 6 September.
Source: https://twitter.com/GSCP_GR/status/1699183764943908954

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EMERGENCY RESPONSE
ANNOUNCEMENTS OF SELF-PROTECTION MEASURES BY THE CIVIL PROTECTION

Announcements of self-protection measures by the Civil Protection during Daniel on 6 September.
Source: https://twitter.com/GSCP_GR/status/1699183764943908954

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EMERGENCY RESPONSE

ANNOUNCEMENTS OF SELF-PROTECTION MEASURES BY THE CIVIL PROTECTION

Snap shots from the informative TV spot of the Ministry of Climate Crisis and Civil Protection on self protection measures against floods. Source: https://www.youtube.com/watch?v=zZfQCyGRLqk

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EMERGENCY RESPONSE
ALERT MESSAGES FROM THE EMERGENCY COMMUNICATIONS SERVICE 112

The Emergency Communications Service of the Ministry for Climate Crisis & Civil Protection sent out warnings of impending dangerous weather events (severe thunderstorms - lightning - hail) before the onset and during the evolution of the extreme weather and flood events, which were related to:

- restricting unnecessary movements;
- following the instructions of the authorities;
- facilitating the work of the authorities;
- prohibiting movement of vehicles in areas affected by the extreme weather events;
- immediately evacuating settlements and moving to safe areas;
- evacuating basements and ground floors of buildings due to the evolution of extreme weather events;
- immediately evacuating settlements and areas due to breakage of river embankments;
- immediately evacuating settlements and areas due to possible or imminent overflowing of rivers and subsequent flooding ;
- prohibiting traffic on parts of the road network due to extreme weather events;
- immediately evacuating settlements and other areas due to severe flooding.

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EMERGENCY RESPONSE

PARTICIPATION OF VOLUNTEER TEAMS IN EMERGECY RESPONSE ACTIONS

The contribution of volunteer teams in managing the impact of extreme weather events and subsequent flooding was also important. Volunteer teams from both the Region of Thessaly and other regions of the country arrived in the affected areas and provided support in various actions in cooperation with the state Civil Protection agencies.

The main actions in which they participated always with appropriately trained staff and equipment included:

- evacuation operations from flood-affected areas;
- checking flood-affected areas to provide assistance in cooperation with the Fire Service and the Armed Forces;
- transporting citizens in need;
- distribution of basic necessities;
- distribution of medical equipment to stranded civilians;
- distribution of meals and water;
- organizing actions to collect basic necessities;
- organizing humanitarian aid missions with basic necessities for the affected people;
- pumping water from flooded houses, shops and businesses.

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EMERGENCY RESPONSE

PARTICIPATION OF VOLUNTEER TEAMS IN EMERGECY RESPONSE ACTIONS

Participation of volunteer teams in emergency response actions. They checked flooded residential areas of Volos city for trapped people and for providing assistance where needed.
Photos credit: Hellenic Rescue Team

Hellenic Rescue Team

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EMERGENCY RESPONSE

PARTICIPATION OF VOLUNTEER TEAMS IN EMERGECY RESPONSE ACTIONS





Volunteer teams checked flooded residential areas in Farkadona town for trapped people and for providing assistance where needed.
Photos credit: Hellenic Rescue Team

Hellenic Rescue Team

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EMERGENCY RESPONSE

PARTICIPATION OF VOLUNTEER TEAMS IN EMERGECY RESPONSE ACTIONS




Volunteer teams organized and conducted actions for supporting the flood-affected population of the Thessaly Region. They distributed meals and water to everyone in need after the destructive phenomena. Photos credit: Hellenic Rescue Team

Hellenic Rescue Team

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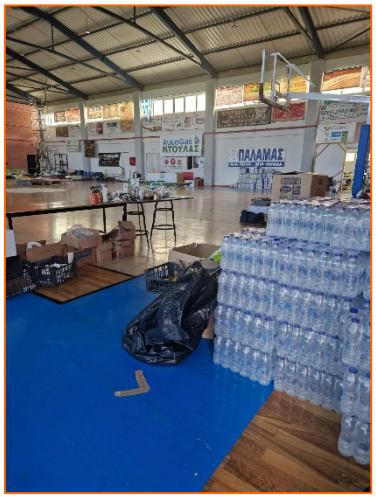
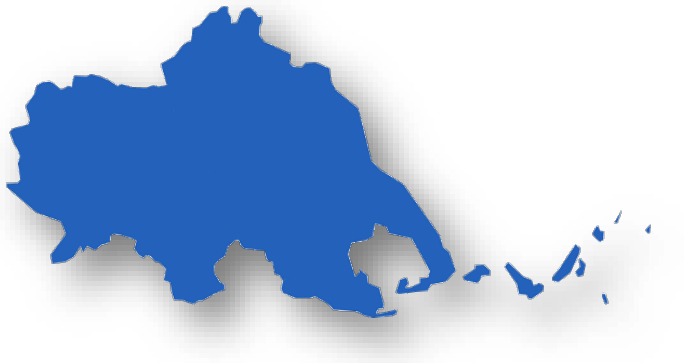
EMERGENCY RESPONSE

CONTRIBUTION OF POSTGRADUATE PROGRAM "ENVIRONMENTAL, DISASTERS, AND CRISIS MANAGEMENT"

Members of the Postgraduate Studies Programme in Environmental, Disaster and Crises Management (EDCM) Strategies of the National and Kapodistrian University of Athens called for collection of essentials for the people of Karditsa affected by Daniel. The items included mainly infant and child care products, dried food, cleaning supplies and personal hygiene items among others. The emergency items were transported to Karditsa affected area by staff of the EDCM Strategies and distributed to those in need following the devastating floods and the adverse effects that formed in urban and rural residential areas.

The collection and distribution of basic essentials either by Civil Protection agencies or by private individuals (non-governmental organizations, voluntary groups, initiatives of citizens' groups, etc.) is among the most important actions that take place during and after the occurrence of a disaster. It contributes drastically to the effective management of the emergency and the faster transition towards the stage of recovery and the gradual return to normalcy.





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RECOVERY ACTIONS

PARTICIPATION OF VOLUNTEER TEAMS IN RECOVERY ACTIONS

The volunteers also contributed to the restoration in the flood-affected areas. They pumped flood water from affected houses, shops and businesses in residential areas of the Thessaly Region.

Photos credit: Hellenic Rescue Team

Hellenic Rescue Team

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RECOVERY ACTIONS

PARTICIPATION OF VOLUNTEER TEAMS IN RECOVERY ACTIONS

Volunteers also participated in collecting and distributing basic needs for the flood-affected population in several areas of the Region of Thessaly.

Photos credit:
Hellenic Rescue Team

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IMPACT OF FLOODS ON PUBLIC HEALTH

INFECTIOUS DISEASES AFTER FLOODS

In addition to the direct impact of floods on human health, these events pose another real and particularly serious threat to public health. This is the risk of infectious diseases both during the course of these events and during the post-disaster recovery phase.

Adverse conditions such as the destruction of lifelines, the lack of drinking water and the supply of water from contaminated springs including wells, fountains and boreholes, direct exposure to sewage contaminated flood waters, and a sudden increase in vector and rodent populations are characterized by a high potential for causing further public health effects.

These effects are an increase in the incidence of infections and the occurrence of epidemics in the affected communities and surrounding areas.

Vulnerable population groups include not only the affected inhabitants of the flooded areas, but also all those involved in managing the effects of floods, such as members of Search and Rescue teams, Civil Protection staff, workers and volunteers involved in actions to support the affected people and restore the natural and built environment.

In Europe, floods and the adverse conditions they create in urban and rural areas have been shown to favor the emergence and transmission of water-, rodent- and vector- borne infectious diseases.

The threat that these population groups may face is revealed by the recent multidisciplinary research, conducted in 2022 by Dr. Maria Mavrouli and Professor Athanassios Tsakris from the Laboratory of Microbiology of the Medical School of the University of Athens (NKUA) and Dr. Spyridon Mavroulis and Professor Efthymis Lekkas from the Laboratory of Study and Management of Natural Hazards of the Department of Geology and Geoenvironment (NKUA). It was published in the International Journal of Environmental Research and Public Health.

Source: Mavrouli et al. (2022); IJERPH;
https://doi.org/10.3390/ijerph191610206

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IMPACT ON PUBLIC HEALTH
WATERBORNE DISEASES

Introduction

Waterborne diseases are caused by the contamination of drinking water supplies by microorganisms (bacteria, viruses and parasites) derived from human or animal faeces. Floodwaters partially or totally affect parts of the drinking water transport and supply network and drainage systems, contributing to the mixing of rainwater with pathogens. Floods have favored the emergence and increased incidence of waterborne diseases in European countries, as an increased number of cases of waterborne diseases caused by parasites, viruses and bacteria have been recorded.

Cases of Waterborne Diseases related to rainfall and subsequent flooding

In Cornwall (south-west England) in August 2004, seven cases of Escherichia coli O157 infection were identified in children on holiday. The source of infection was a freshwater stream running through a coastal area, contaminated by cattle faeces due to heavy rainfall in the days preceding the outbreaks of gastroenteritis.

In Salzburg (Austria) in 2005, direct exposure to floodwater contaminated with raw sewage caused an outbreak of norovirus gastroenteritis among American tourists and firefighters who helped to pump floodwater out of a hotel flooded by extremely heavy rainfall.

In Sicily (Italy) in 2011, the overflow of sewage from septic tanks and latrines as a result of heavy rainfall caused contamination with human faeces of wells and springs feeding the water supply network.

In Amsterdam (Netherlands) in 2015, water contamination by various norovirus strains caused acute gastroenteritis among swimmers after participating in a sporting event. Two days before this event, severe flooding and overflowing of the sewage system in the city's canals had occurred.

Source: Mavrouli et al. (2022); IJERPH; https://doi.org/10.3390/ijerph191610206

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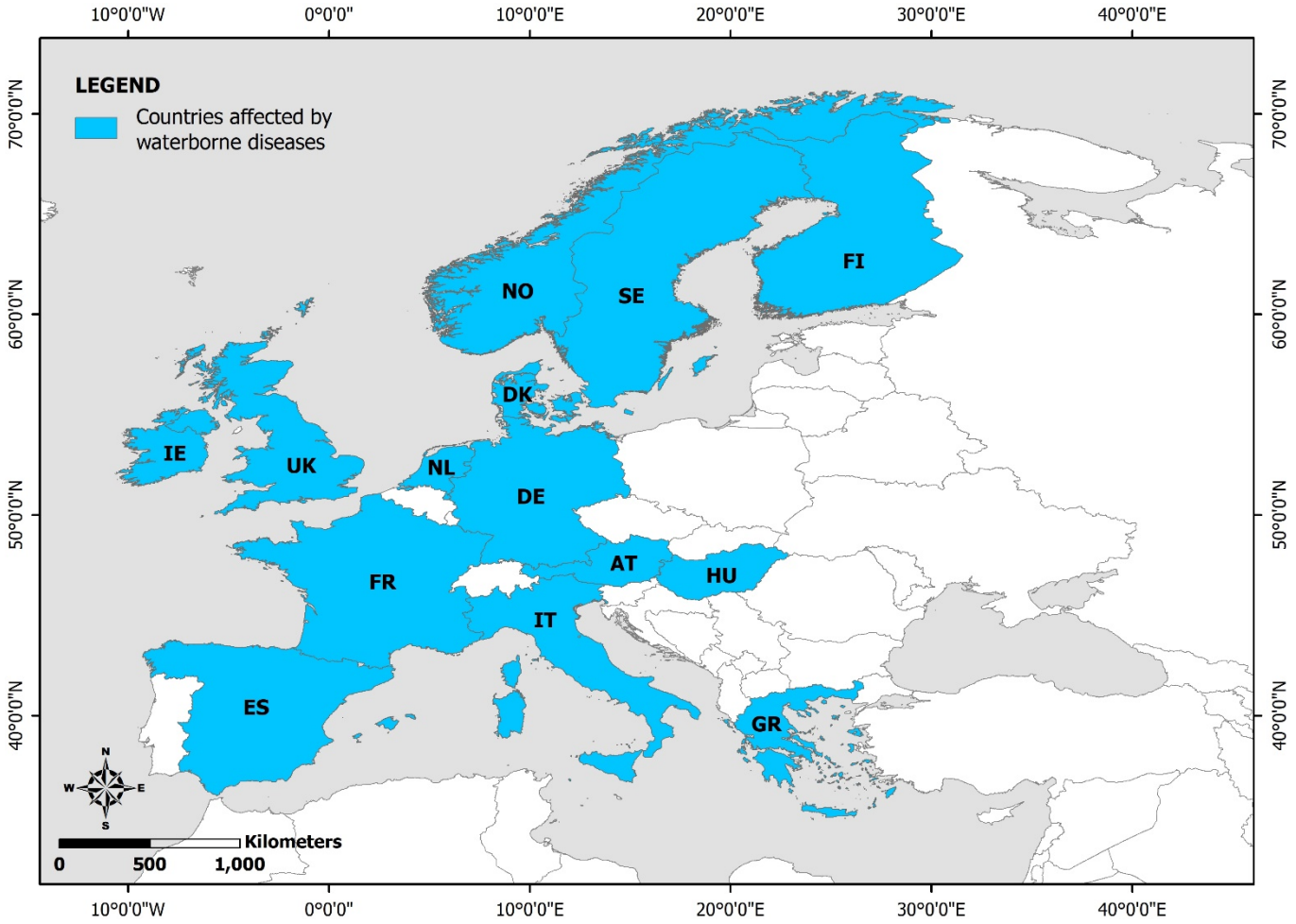
IMPACT ON PUBLIC HEALTH
WATERBORNE DISEASES



NO: Norway
SE: Sweden
FI: Finland
DK: Denmark
NL: Netherlands
IE: Republic of Ireland
UK: United Kingdom;
ES: Spain
FR: France
DE: Germany
AT: Austria
HU: Hungary
IT: Italy
GR: Greece

European countries affected by waterborne diseases attributed to the adverse effects formed by rainfall and subsequent flooding (Source: Mavrouli et al. (2022); https://doi.org/10.3390/ijerph191610206)

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IMPACT ON PUBLIC HEALTH
RODENT-BORNE DISEASES

Introduction

In flood-affected areas there is an increase in the incidence of rodent-borne diseases. The increase in leptospirosis is mainly attributed to the greater exposure of the population to infected rodents and their metabolic products mixed in flood waters.

Cases of Rodent-borne Diseases related to rainfall and subsequent flooding

Outdoor and sporting recreational activities, ideal temperature and rainfall favor the survival of Leptospira in the environment and could reasonably explain the spikes in leptospirosis incidence during the summer months in Bulgaria and among triathletes in Germany in August 2006 and Austria in July 2010.

An outbreak of leptospirosis was detected among seasonal workers from Eastern Europe on farms in North Rhine-Westphalia, Germany in July 2007. The risk of the disease increased with each day of working in the rain and the most likely source of the outbreak was direct contact of hands with contaminated water or soil and infected rodents.

The occurrence of sporadic laboratory-confirmed human cases of leptospirosis in Marseille and Palermo in spring and autumn 2009 was associated with periods of heavy rainfall accompanied by flooding and strikes by waste collection workers.

Source: Mavrouli et al. (2022); IJERPH; https://doi.org/10.3390/ijerph191610206

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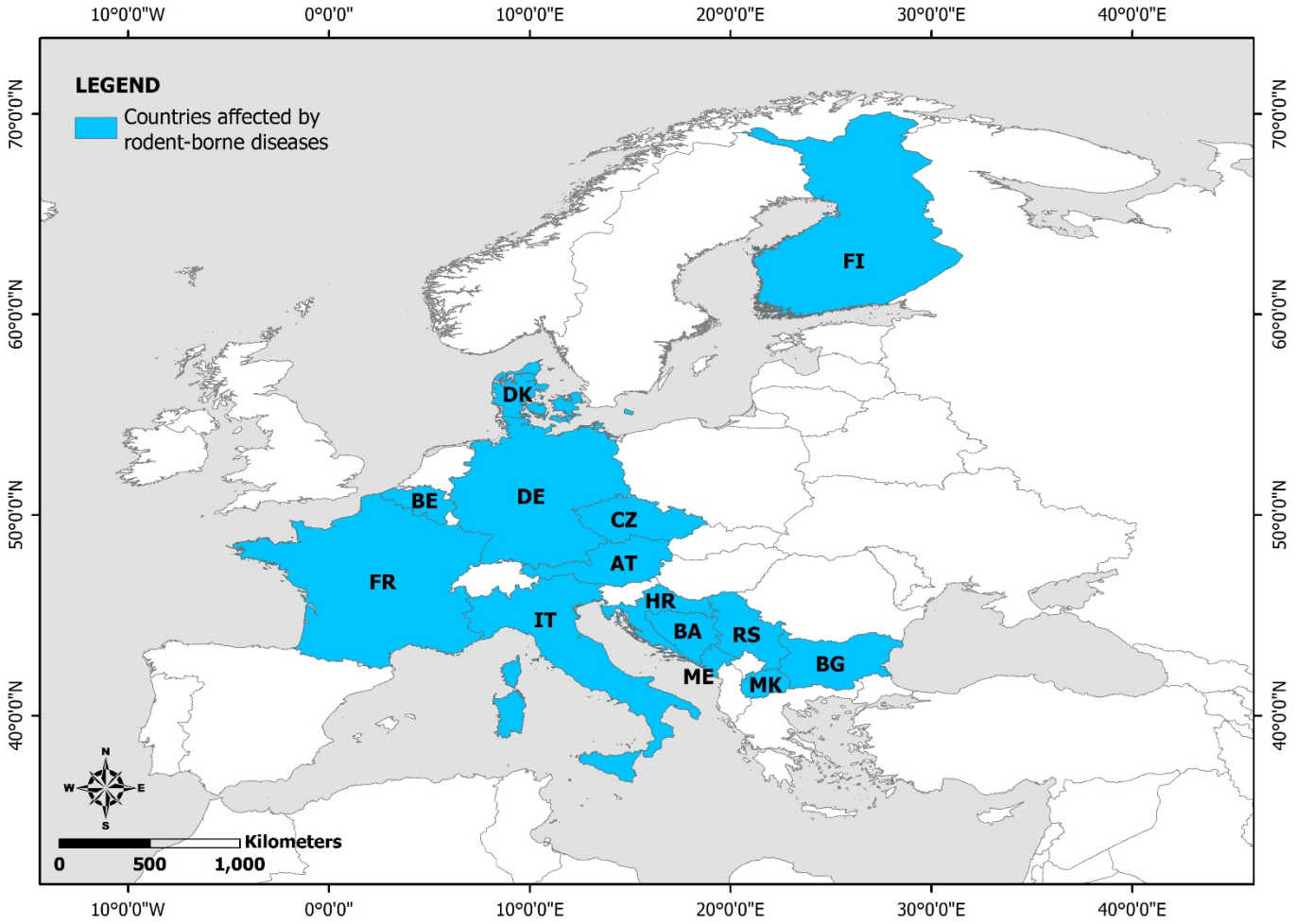
IMPACT ON PUBLIC HEALTH
RODENT-BORNE DISEASES



FI: Finland
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BE: Belgium
DE: Germany
CZ: the Czech Republic
AT: Austria
IT: Italy
HR: Croatia
BA: Bosnia & Herzegovina
RS: Republic of Serbia
ME: Montenegro
MK: North Macedonia
BG: Bulgaria

European countries affected by rodent-borne diseases attributed to the adverse effects formed by rainfall and subsequent flooding (Source: Mavrouli et al. (2022); https://doi.org/10.3390/ijerph191610206)

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IMPACT ON PUBLIC HEALTH
VECTOR-BORNE DISEASES

Introduction

Floods may indirectly increase the incidence of vector-borne diseases by expanding the number and range of their habitats. Flood waters initially inundate vector breeding habitats and temporarily drift their populations. However, receding water could provide ideal vector breeding grounds and therefore increase the likelihood of exposure of the flood-affected population and all those involved in the disaster field to vector-borne pathogens that cause diseases such as the West Nile fever.

Cases of Vector-borne Diseases related to rainfall and subsequent flooding

In Europe, flooding following extreme rainfall events has been mainly associated with the emergence and increased incidence of West Nile virus (WNV), Chikungunya virus (CHIKV) and Tahyna virus (TAHV) in Romania, the Czech Republic, Greece, Italy and France.

In the summer of 1996, an unprecedented epidemic of WNV meningoencephalitis occurred in south-eastern Romania. It was found that WNV infection was associated with certain characteristics of the dwelling, such as the presence of vectors indoors and flooded basements with water contaminated with sewage from poorly maintained plumbing.

Following heavy rainfall in Moravia (Czech Republic), catastrophic flooding of the Morava River occurred in July 1997. In the area affected by the floods, a sharp increase in vectors infected with arboviruses such as WNV and TAHV contributed to the detection of confirmed and probable cases of WNV infection in that area.

Source: Mavrouli et al. (2022); IJERPH; https://doi.org/10.3390/ijerph191610206

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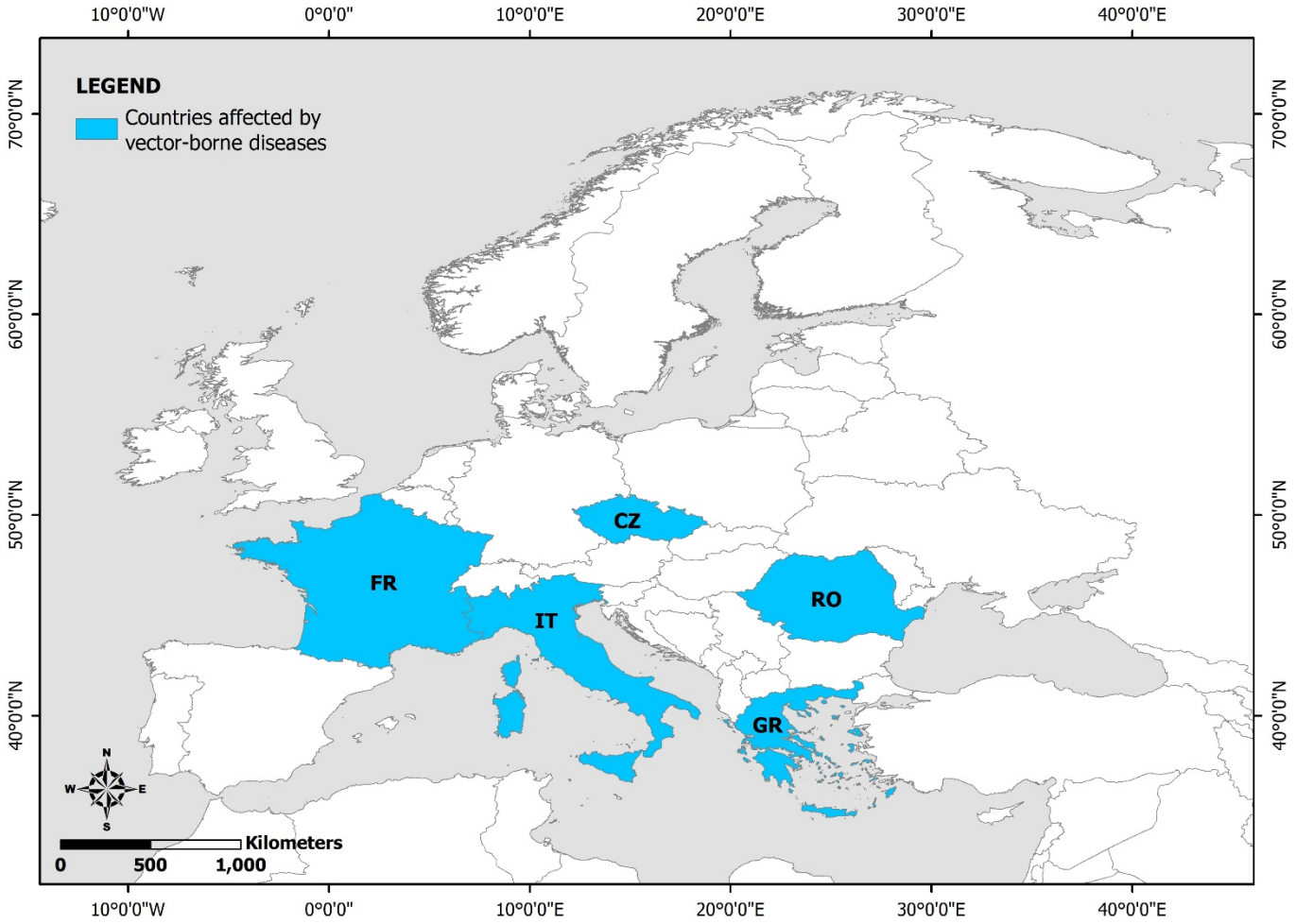
IMPACT ON PUBLIC HEALTH
VECTOR-BORNE DISEASES



FR: France
CZ: the Czech Republic
RO: Romania
IT: Italy
GR: Greece

European countries affected by vector-borne diseases attributed to the adverse effects formed by rainfall and subsequent flooding (Source: Mavrouli et al. (2022); https://doi.org/10.3390/ijerph191610206)

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IMPACT ON PUBLIC HEALTH

RISK FACTORS FOR EMERGENCE OF INFECTIOUS DISEASES IN FLOOD AFFECTED AREAS

The likelihood of an infectious disease outbreak following flooding is related to the incidence of the disease, the type, extent and intensity of the catastrophic flood, the resilience of public health infrastructure and the effectiveness of existing emergency and immediate disaster management plans.

The first important step in preventing an infectious disease epidemic is to identify it and clarify the most important risk factors for its occurrence, such as:

(a) poor economic status and living in flood prone areas;

(b) destruction of infrastructures, disruption of public utilities, and interruption of basic public health services;

(c) direct physical exposure to sewage-polluted flood water;

(d) lack of adequate potable water andwater-supply from contaminated ponds and tube wells along with lack of distribution of water purification tablets;

(e) aggravation of environmental conditions comprising rapid cooling of the environment and heightened humidity;

(f) population displacement resulting in densely populated and overcrowded regions;

(g) unfavorable living conditions in emergency shelters;

(h) improper and inadequate sanitation or no access to clean water and sanitation;

(i) proliferation and abrupt increase of vector and rodent populations after flooding; and

(j) contamination of water, damp soil, mud or vegetation caused by rodent urine, dead animals, and overflow of latrines.

Source: Mavrouli et al. (2022); IJERPH;
https://doi.org/10.3390/ijerph191610206

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IMPACT ON PUBLIC HEALTH

PREVENTION MEASURES BEFORE AN INFECTIOUS DISEASE OUTBREAK

With particular emphasis on the above-mentioned risk factors, education and awareness-raising activities to identify and manage infectious diseases can help to strengthen health surveillance systems and to maintain and provide effective health care services with the aim of reducing related mortality and morbidity.

In particular, to avoid the occurrence of leptospirosis, staying in flooded areas should be avoided, as well as swimming and playing in water bodies such as lakes, rivers and swimming pools that may be polluted and have increased water turbidity after floods.

Residents should avoid disposing waste where they could be exposed to contaminated surface water or urine from infected animals. After floods, all those exposed to environments with a high risk of leptospirosis should receive time-limited chemoprophylaxis to reduce the incidence of leptospirosis, as well as the associated morbidity and mortality during outbreaks.

The application of personal protective measures is vital for the health of the affected population and staff involved in emergency response and rehabilitation activities in the first hours and days after the onset of flooding. Disposable gloves and rubber boots or galoshes are considered essential measures to protect the body and limbs from contact with bodies of water that may have been contaminated by the floods.

Proper hand hygiene with regular hand washing with soap and clean running water, or alternatively hand disinfection with alcohol-based wipes or hand sanitizers containing at least 60% alcohol in the absence of soap and water, especially after contact with flood waters and before eating, drinking, touching the eyes, nose and mouth. This approach can prevent initial infection and further transmission to flood-affected communities. It is also important to seek immediate medical attention if fever or other symptoms indicating the onset and progression of the disease occur.

Source: Mavrouli et al. (2022); IJERPH;
https://doi.org/10.3390/ijerph191610206

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IMPACT ON PUBLIC HEALTH

PREVENTION MEASURES BEFORE AN INFECTIOUS DISEASE OUTBREAK

Personal protective equipment may be contaminated after use, in which case it should be carefully removed and discarded or cleaned and stored properly (for parts that are not discarded). In accordance with the recommendations of the Centres for Disease Control and Prevention, all clothing used in the cleaning process or other activities in the flood-affected area that require contact with flood waters, sediments and debris should be washed separately from uncontaminated clothing with hot water and detergent.

In order to prevent outbreaks of diseases after flooding, the procedures for cleaning and removal of debris from flooded dwellings should be followed by disinfection. All household equipment, including furniture and electrical appliances, as well as non-structural elements including wooden floors, doors and windows, which cannot be disinfected, should be removed.

Mechanical disinfection should be followed by the removal of sludge from surfaces such as walls, ceilings and floors. Chemical disinfection should complete the process by mechanical spraying of surfaces with chlorine-based disinfectants.

Within the first week of the flood, a rapid assessment should be carried out of the risk of infectious diseases, with particular emphasis on waterborne and mosquito and rodent-borne diseases, and the extent of the impact of the flood on the functioning of public health infrastructure. The recording of relevant information concerns the flooded area and the affected population, which includes residents who evacuated their homes and all those who came into contact with flood waters during actions in flooded areas.

The information gathered from the above actions contributes to the establishment of appropriate disease surveillance systems and the identification of appropriate interventions to manage and mitigate the adverse effects of infectious disease outbreaks that may occur at the same time as or after a flood disaster.

Source: Mavrouli et al. (2022); IJERPH; https://doi.org/10.3390/ijerph191610206

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IMPACT ON PUBLIC HEALTH

MITIGATION MEASURES FOLLOWING AN INFECTIOUS DISEASE OUTBREAK

When an infectious disease outbreak occurs, preventive measures give way to mitigation actions. In the event of a waterborne disease outbreak following a flood, affected people can adopt protective measures including immediately stopping use of contaminated water, boiling drinking water or using different sources of drinking water in order to mitigate the adverse effects of the outbreak. As regards the effective disinfection of public water supply works, chlorination and flushing of water supply pipes could be applied to eliminate pathogens attached to the pipes.

In terms of long-term prevention, there is a need for flexible planning and preparedness measures that can quickly and effectively incorporate unforeseen circumstances and associated adverse impacts. This approach requires improving our knowledge of the relationship between infectious diseases and disasters caused by hydrometeorological hazards. Measures to prevent infectious disease outbreaks and mitigate their impact on the affected population and personnel should be integrated into emergency response planning for disasters caused by natural hazards.

Furthermore, these measures should be communicated in a timely and effective manner not only to the personnel involved in the prevention and management of these emergencies but also to the general public and in particular to residents belonging to certain groups within communities who may be more vulnerable to the adverse effects of flood events. These groups include the elderly population, people with disabilities, children, women, people with low incomes and the homeless.

Conclusions

Hydro-meteorological risks and related disasters are already on the rise amid the evolving climate crisis. This increase in hydrometeorological risks and associated disasters may trigger a parallel evolution of hydrometeorological and biological risks including floods and infectious disease epidemics respectively. Their effective management requires multidisciplinary and multi-hazard approaches, which can ensure early prevention, more effective and immediate response to the emergency as well as faster recovery and rehabilitation.

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ΕΘΝΙΚΟΣ ΟΡΓΑΝΙΣΜΟΣ ΔΗΜΟΣΙΑΣ ΥΓΕΙΑΣ

SAFETY OF PUBLIC HEALTH

CONTRIBUTION OF THE NATIONAL ORGANIZATION OF PUBLIC HEALTH

The National Public Health Agency has created a special page on its website on floods and public health protection measures against sporadic events, outbreaks and epidemics in flood-affected areas (https://eody.gov.gr/disease/plimmyra/). The website included:

- Instructions for returning home after a flood (https://eody.gov.gr/odigies-gia-tin-epistrofi-sto-spiti-sas-meta-apo-plimmyra/)
- Instructions for cleaning and disinfecting school buildings (kindergartens, primary schools, secondary schools, high schools) after a flood (https://eody.gov.gr/odigies-gia-ton-katharismo-kai-apolymansi-scholikon-ktirion-nipiagogeia-dimotika-gymnasia-lykeia-meta-apo-plimmyra-septemvrios-2023/)
- Brief instructions for the operation of schools in the region of Thessaly after the recent floods (https://eody.gov.gr/synoptikes-odigies-gia-ti-leitoyrgia-ton-scholeion-stin-periochi-tis-thessalias-meta-tis-prosfates-plimmyres-septemvrios-2023/)
- Summary instructions for the protection of public health after flooding (https://eody.gov.gr/odigies-prostasias-tis-dimosias-ygeias-meta-apo-plimmyra/)
- Summary guidelines for the prevention-treatment of infectious diseases associated with natural disasters caused by flooding (https://eody.gov.gr/odigies-gia-tin-prolipsi-antimetopisi-loimodon-nosimaton-poy-syndeontai-me-fysikes-katastrofes-apo-plimmyra/)
- Methodology for vector management in flood-affected areas of Thessaly (https://eody.gov.gr/wp-content/uploads/2023/10/methodologia-diaxeirisis_kounoupia_thessalia-202310.pdf)
- Guidelines for the preparation of a vector management plan in the flood affected areas of Thessaly 2023 (https://eody.gov.gr/wp-content/uploads/2023/09/kateuthintiries_odigies_kounoupia_thessalia-2023.pdf)

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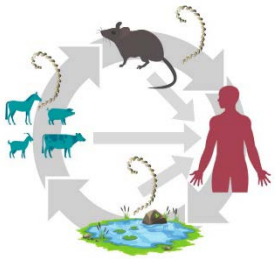
ΕΘΝΙΚΟΣ ΟΡΓΑΝΙΣΜΟΣ ΔΗΜΟΣΙΑΣ ΥΓΕΙΑΣ

SAFETY OF PUBLIC HEALTH
CONTRIBUTION OF THE NATIONAL ORGANIZATION OF PUBLIC HEALTH

- Recommendations for the prevention of foodborne/waterborne diseases in case of overcrowding in shelters (https://eody.gov.gr/systaseis-toy-eody-gia-prolipsi-trofimogenon-ydatogenon-nosimaton-se-periptosi-sygchrotismoy-plimmyropathon-se-choroys-filoxenias/)
- Information about leptospirosis for Health Professionals (https://eody.gov.gr/wp-content/uploads/2023/09/leptospeirosi_odigies_ver_1.5.pdf)
- Leaflets about leptospirosis (https://eody.gov.gr/wp-content/uploads/2019/01/Fylladio_leptospeirosi_ver5.3.pdf and https://eody.gov.gr/wp-content/uploads/2019/01/Leptospirosis-poster-2023.pdf)



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EMERGING HEALTH AND ENVIRONMENTAL HAZARDS RELATED TO DISASTER WASTE MANAGEMENT

DISASTER WASTE CATEGORIES

One of the challenges that emerge during the emergency and recovery phase after a disaster that has significantly affected the built environment is the disaster waste management. This challenge is due to the harmful materials contained in the debris and the potential hazards that their management may pose to public health and natural habitats.

Debris after a flood disaster can be divided into the following categories:

- **Green waste**: Vegetation such as fallen trees, soil, agriculture products, farms, and timbers.
- **Building rubble**:
    - Timber, wood chips, waste wood (such as column, beam wall-material), bulky items, cables
    - Concrete/bricks
    - Steel, rebar, aluminium material, etc.
- **Household material**: Food wastes, wastes mixed with fibres, paper, wood chips, packaging materials, household furnishing and belongings, other wastes (such as plastics, cardboard, paper).

Related information: OCHA; UNEP (2018)
Photo credit: Prof. Efthymis Lekkas

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- **Mixed waste**: Mixed wastes consisting of a small amount of concrete, wood chips, plastics, glass, soil, and sand, etc.
- **Electrical appliances**: Televisions, washing machines, and air conditioners discharged from affected houses, which are damaged by disasters and become unusable
- **Automobiles**: Vehicles, motorcycles, and bicycles that are damaged by disasters and cannot be used
- **Vessels**: An unusable ship damaged by a disaster
- **Waste difficult to treat properly**: Dangerous goods, such as fire extinguishers, cylinders; and items which are difficult to treat at local government facilities, such as pianos and mattresses (including radiation sources for non-destructive inspection), fishing nets, gypsum boards, etc.
- **Hazardous waste**: Hydrocarbons, such as oil and fuel; paint; varnishes and solvents; pesticides and fertilizers; medical waste in debris; waste posing healthcare risks; asbestos-containing waste; PCB; infectious waste; chemical substances; toxic substances, such as chlorofluorocarbons, CCA (waste using chromium copper arsenic wood preservative), and tetrachloroethylene; pharmaceuticals; pesticides hazardous waste; solar panels and accumulators; etc.
- **Mementoes waste**: Photos, albums, cash, precious materials
- **Industrial waste, commercial waste**: Food waste, raw materials, fertilizers, machinery, equipment's, shops specific waste.
- **Household waste**: Daily waste, discharged from the households.
- **Waste from evacuation centers**: Waste from relief camps and evacuation centres.
- **Excreta**: From temporary toilets fixed to facilitate water sanitation and hygiene

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DISASTER WASTE CATEGORIES

Typical views of the waste resulted after flooding in the Thessalian Plain. The disaster waste resulted from residential buildings can be classified into household material, mixed and hazardous waste. Photos credit: Prof. Efthymis Lekkas

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EMERGING HEALTH HAZARDS RELATED TO DISASTER WASTE MANAGEMENT

Among the most hazardous phenomena during debris management is the formation of dust clouds at collapse, demolition, and debris disposal sites that can contain damaged structural and non-structural materials with asbestos fibers.

All workers, volunteers, and residents exposed to asbestos fibers are characterized by a high probability of developing infectious diseases including asbestosis, lung cancer, mesothelioma, cancer of the esophagus, stomach, colon, and pancreas, pleural plaques, pleural thickening, and pleural effusion.

Another hazard to which all those involved in debris management can be exposed is perishable products, which spoil and constitute a breeding ground for bacteria such as Salmonella, Escherichia coli, and Campylobacter spp. If consumed, these bacteria can cause foodborne illnesses, presenting with symptoms such as diarrhea, abdominal pain, nausea, and vomiting. Additionally, food left exposed to moisture and inadequate ventilation could create conditions favorable for mold growth and formation of mold substances, which can lead to allergic reactions, respiratory issues, and, in some cases, mycotoxicosis via inhalation, ingestion, and skin contact.

Heavy metals including chromium, copper, and arsenic used as preservatives to increase the resistance of wood to corrosive agents have a high potential to threaten all involved in earthquake debris management.

Treated wood included in the debris is a detrimental factor especially when arsenic, copper, and chromium are leached in large concentrations, when mixed with untreated wood in recycling operations where the resulting product is contaminated to such an extent that it cannot be applied to soil, and when incinerated and heavy metal emissions require the use of appropriate air pollution control equipment.

Source: Mavroulis et al. (2023); Applied Sciences
https://doi.org/10.3390/app13158823

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The exposure of those involved in various steps of disposing treated wood to decaying materials leached into soils and waters as well as residents who may come into contact with the residues and products of this treatment through the natural environment (surface water and groundwater bodies and soils) may suffer damage to

- mucous membranes in the peripheral and central nervous system,
- parts of nervous tissue and hearing ability,
- increasing incidence of cancer in the urinary bladder, kidney, liver, lung and skin,
- irritation and rashes on the skin
- irritation of the respiratory tract airways causing damage to mucous membranes and development of lung cancer.

Another infectious disease that can affect workers, volunteers, and residents taking part in debris management is tetanus, an infectious disease caused by exposure of wounds to Clostridium tetani spores. During the evacuation and debris removal, and subsequent recovery, there is an increased risk of causing injuries, e.g., punctures to the skin, cuts and abrasions. Any break in skin continuity is a way for bacteria to penetrate the human body and cause tetanus.

Milder debris management impact but equally important for returning residents to normality and ensuring the balance of the natural environment comprises the noise and visual pollution in debris disposal sites. This type of pollution can be attributed to many factors and practices adopted during debris management such as the use of heavy machinery and equipment during transport, the selection of inappropriate debris disposal sites near either residential areas or sites with scenic ecological value and sensitive natural landscape. These actions can significantly affect the tranquility in a residential area and the equilibrium in sensitive natural habitats.

Source: Mavroulis et al. (2023); Applied Sciences
https://doi.org/10.3390/app13158823

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In addition to these effects of the hazardous elements of debris on humans, debris management can have also adverse effects on the environment in a number of ways, the most important of which are water and soil contamination and the destruction of natural habitats.

Debris can introduce pollutants such as heavy metals and other chemicals that can contaminate nearby water bodies including rivers and streams, lakes, lagoons, marshes, and the sea with long-term effects on surface water ecosystems. When these materials enter water bodies, they have the potential to cause deterioration in water quality and make it unsafe for supply and irrigation and dangerous for aquatic life.

Debris debris can have an impact on air quality. The processing of debris from flood-affected areas can create a significant amount of dust and particles which can become airborne and contribute to poor air quality.

As regards natural habitats, improper disposal practices such as dumping debris within or close to water bodies can disrupt natural ecological processes and water flow patterns, cause sediment accumulation, and affect aquatic organisms by limiting available oxygen and blocking sunlight.

Segmentation and destruction of habitats can obstruct wildlife migration routes, disrupt breeding areas, prevent nutrient recycling, and alter food and shelter availability. The ecological balance can be disrupted by debris containing soil, seeds, or other materials that contain non-native or invasive species. These changes have the potential to cause cascading effects on the entire ecosystem, its biodiversity, its population dynamics, and the overall resilience of natural habitats.

Source: Mavroulis et al. (2023); Environments
http://dx.doi.org/10.3390/environments10110192

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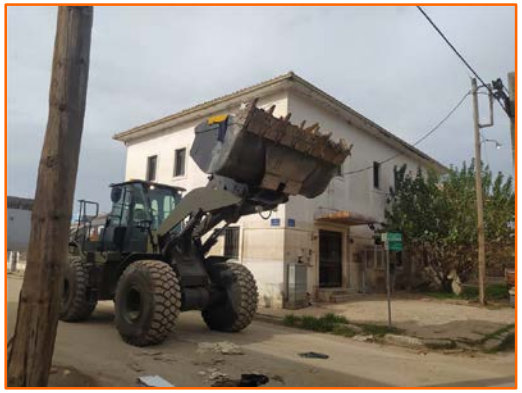
EMERGING HEALTH HAZARDS RELATED TO DISASTER WASTE MANAGEMENT

SEVERAL PHASES OF DEBRIS MANAGEMENT



The Armed Forces also participated in the operation of removing debris from flooded houses in various affected areas of the Thessalian Plain [Giannouli in Larissa Regional Unit (RU), Farkadona in Trikala RU and Palamas in Karditsa RU). They assisted affected Municipalities especially in transporting bulky objects with heavy machinery.
Photos credit: Region of Thessaly. Source:
https://www.thessaly.gov.gr/enimerosi/deltiotypou/46325

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SEVERAL PHASES OF DEBRIS MANAGEMENT

Threats to public health can emerge at any stage of debris management. Residents must comply with the instructions of the authorities and apply personal protective measures to avoid sporadic cases, outbreaks and epidemics of infectious diseases, and must not approach debris disposal sites or come into contact with debris piles. In uncontrolled waste disposal areas there is an increased presence not only of rodents and insects but also of harmful elements, which have the potential to be a source of threat for both the local population and people from other areas that reside and work in the disaster field and the disposal sites.

Photos credit: Prof. Efthymis Lekkas

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EMERGING HEALTH HAZARDS RELATED TO DISASTER WASTE MANAGEMENT

MEASURES FOR THE PREVENTION OF HEALTH IMPACT FROM DISASTER WASTE MANAGEMENT

No concessions shall be made at any stage of the management of debris from the disaster with regard to the health and safety of workers at the collapse, demolition, and debris disposal sites, volunteers working therein and residents living close to these sites. Best health and safety practices and procedures should be followed to ensure that direct and indirect impacts on all involved in debris management are minimized or eliminated.

The measures should be divided into the following categories:

- Protection measures against exposure to dust containing asbestos;
- Protection measures against exposure to treated wood;
- Prevention and control measures for tetanus;
- Preparation and implementation of debris management plans;
- Dissemination of related information to the affected population.

Related publications:

Mavroulis, S.; Mavrouli, M.; Vassilakis, E.; Argyropoulos, I.; Carydis, P.; Lekkas, E. Debris Management in Turkey Provinces Affected by the 6 February 2023 Earthquakes: Challenges during Recovery and Potential Health and Environmental Risks. Appl. Sci. 2023, 13, 8823. https://doi.org/10.3390/app13158823

Mavroulis, S.; Mavrouli, M.; Lekkas, E.; Tsakris, A. Managing Earthquake Debris: Environmental Issues, Health Impacts, and Risk Reduction Measures. Environments 2023, 10, 192. https://doi.org/10.3390/environments10110192

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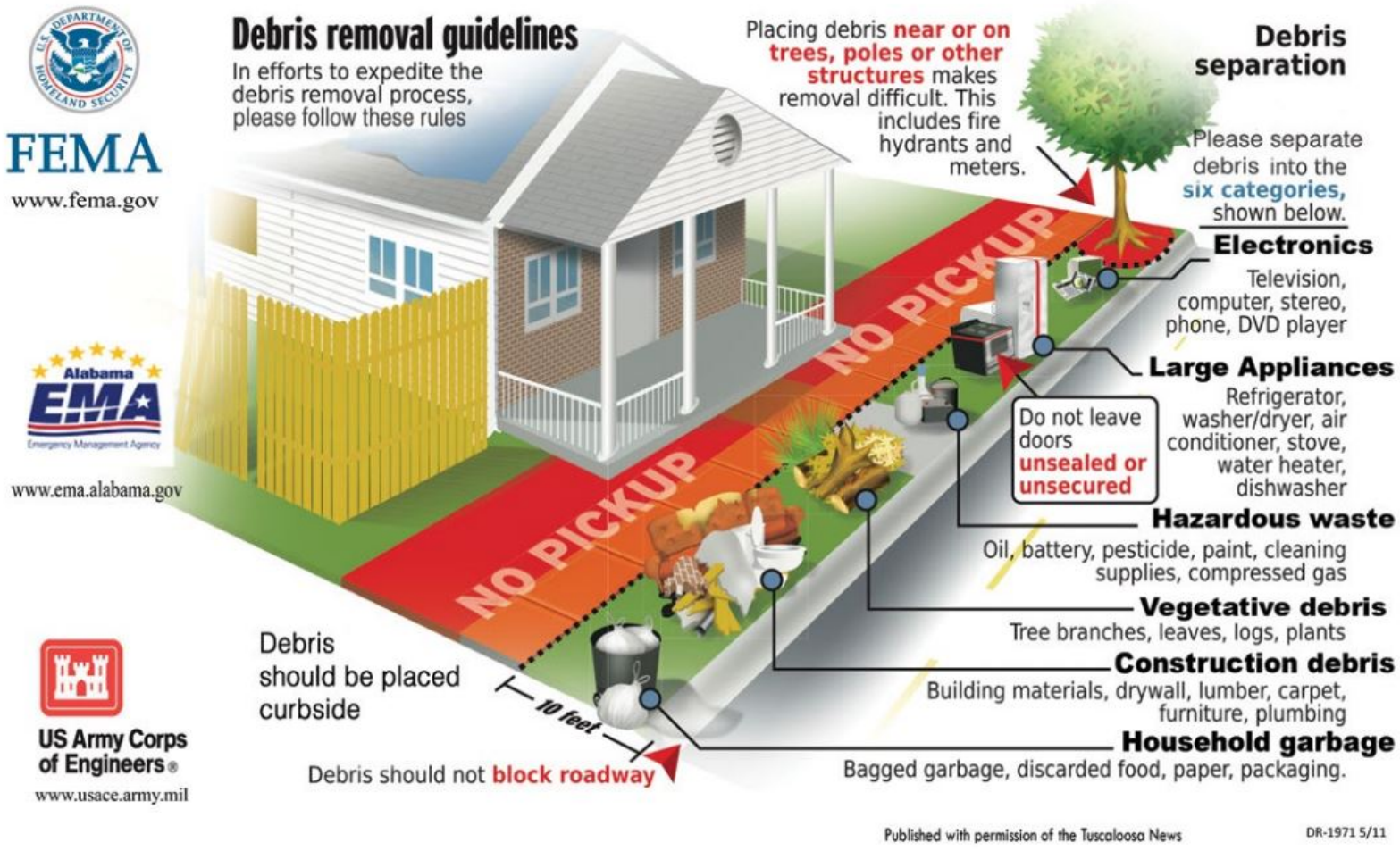
EMERGING HEALTH HAZARDS RELATED TO DISASTER WASTE MANAGEMENT

DEBRIS REMOVAL GUIDELINES



Source: https://tools.niehs.nih.gov/wetp/public/hasl_get_blob.cfm?ID=9295

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DEBRIS REMOVAL GUIDELINES

NIH

FEMA
www.fema.gov

US Army Corps of Engineers
www.usace.army.mil

Unstable Structures and Confined Spaces

Disasters can damage and collapse structures, so follow these tips:

- Never assume that damaged structures or ground are stable. Instead, have them certified safe by a registered professional engineer or architect.
- Assume all stairs, floors and roofs are unsafe until inspected
- Unstable ground or flooring can give way
- Watch for leaning structures and trees and avoid them
- Entering confined spaces can kill you! Only trained and authorized personnel should enter confined spaces (Not designed for continuous occupancy, limited entry, large enough to work in)
- If you find a trapped person, call 911 IMMEDIATELY and do not attempt rescue as you could become the victim. Stay clear and, if you will be safe, throw a rescue line.

Leave immediately if you hear shifting or unusual noises - A COLLAPSE MAY BE OCCURRING

Hazardous Chemicals

Hazardous chemicals include household and industrial (small business use or displaced from other property) chemicals

- Do not handle any containers that are damaged/leaking
- Do not handle any chemical containers if you are unsure of their contents
- Do not handle any industrial chemical containers
- Use gloves and safety glasses when handling household hazardous chemicals
- Do not mix chemicals
- Do not place chemicals near open flames/hot surfaces (e.g., a running motor)

Your first concern is life safety!

https://tools.niehs.nih.gov/wetp/public/hasl_get_blob.cfm?ID=9295

Other Post-Disaster Cleanup Hazards

- Heat and cold stress
- Sunburns
- Injuries to your body from lifting and strain
- Animals, insects and harmful plants
- Infection from polluted water and surfaces
- Overhead hazards, such as falling glass, tree limbs, debris and low-hanging utility lines
- Working around heavy equipment
- Vehicle/ driving safety
- Cuts, punctures
- Eye injuries
- Fall injuries
- Fatigue

Harmful Dusts

Dusts created by a disaster or during cleanup may have asbestos, heavy metals, silica or other toxic materials. Avoid driving over debris material as this could cause hazardous material to become airborne. These dusts can present serious health hazards. If you lack the expertise and equipment to control these hazards, consult with your local government authority and seek professional assistance.

If you must disturb dust, use:

- Water to mist material and keep it wet
- High Efficiency Particulate Air (HEPA) vacuum

Do not use:

- Common shopvac that does not have a HEPA filter
- Do not dry sweep

If you or another person gets injured, know how to get help.

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CONCLUSIONS

Storm Daniel was a very extreme precipitation event that can be considered rare (based on the currently available statistics and IDF curves) that created extensive impacts over a sizeable part of Greece, that is the Region of Thessaly.

The disaster occurred in different terrains with different geomorphological and geological characteristics, that include:

(a) the mountainous area of Pelion Mt.,

(b) the dense urban fabric of the city of Volos, both with small catchments, dry mountain torrents and

(c) the extensive plains of Thessaly, drained by Pineios River.

The floods that caused a variety of direct damages on:

- property,
- infrastructure,
- human lives,
- livestock,
- cultivated areas and
- the environment,

as well as a range of indirect effects including impacts on:

- physical and psychological health,
- agricultural production,
- local economy, and
- many other sectors,

some of which will last for months to years.

At the early stages of the disaster, the area suffered impact in Pelion Mt and the Western part of the Thessalian Plain, which received the highest amounts of rainfall, whereas limited damages were recorded in its eastern part.

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CONCLUSIONS

However, within few days major failures in the embankments of the largest river in the area (Pineios) near Gyrtoni. led to massive flooding in the eastern part of the Plain, around Karla Lake. As substantial amounts of water flowed towards the easternmost part of the plain, they concentrated in the artificially dried area of Lake Karla, creating the largest lake in the country, inundating large agricultural areas.

The impermeable geological formations and the narrow spillway (overflow conduit, used to dry the lake in the 1960s) lead to the conclusion that the inundation will be a long term issue in the area which depending on possible interventions and the climate could last from a few months to a few years.

At the later stages of Daniel storm, disaster inundation at the western part of the plain started to recede, with an exception of the area where Enipeas, Mega, and Kalentzis Rivers converge flowing into Pineios (area of Keramidi, Farkadona, Vlohos, Marathea villages). As embankments of Pineios were being repaired, the flow towards Karla Lake stopped, initially reducing and later stopping the rate of water stage increase in the lake, averting an additional disaster for the villages surrounding the lake.

In less that one month a second storm, named “Elias” hit the area of Thessaly, leading to extensive flooding around Pelion Mt. again, as well as the north part of Evia (Euboea) Island, and parts of the plain. Satellite pictures showed that inundated areas in western Thessaly increased in extent for a few days.

The meteorological aspect, and the extent and severity of impacts raised numerous questions regarding the role of climate change and the resilience of our society in such extreme events, as well as our understanding on the frequency and probability of occurrence of extremes in general.

All of the above require a new approach for the Operational Risk Reduction Planning in Central Greece. In particular, for Central Greece and especially for the Region of Thessaly, the following 10 actions are proposed for the reduction of the total risk from hydrometeorological and geodynamic phenomena.

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10 ACTIONS TO REDUCE THE OVERALL RISK OF HYDRO-METEOROLOGICAL AND GEODYNAMIC HAZARDS

1. **Hazard Assessment and Analysis**. Detailed mapping of all natural hazards in Thessaly and their mapping on an appropriate scale and determination of the level of risk, spatial development and time of their recurrence (extreme weather events, flooding phenomena, seismic faults, landslides, rockfalls, subsidence, erosion, liquefaction, undercutting, changes in topography, etc.)

2. **Assessment of the vulnerability level of systems and especially of basic infrastructures** comprising road and railway networks, structures and lifelines, tourist infrastructure, agricultural, industrial and craft infrastructure, health facilities, ports, power stations, etc. Particular attention and priority should be given to research for reducing the vulnerability of Critical Infrastructures and Systems.

3. **New spatial and urban planning** with urban interventions, microzonation studies and infrastructure planning, with the aim of increasing capacity and resilience and mitigating disasters in future extreme events.

4. **Formations of a Unified Water Management Body** in Thessaly, which will be responsible for the implementation of the Master Plan that is under implementation. This body will be responsible for the overall management of surface and groundwater and will initiate, after detailed studies, a large number of actions, such as the design and implementation of mountain hydrology projects, dike management, projects along rivers, management of Karla Lake and the deltaic fields. In addition, it will be responsible for monitoring of underground aquifers, water quality, etc.

5. **Risk and early warning systems**, including satellite monitoring, a fully developed network of instruments for measuring a large number of parameters, modelled on Japan's JMA network of stations, the establishment of an information base for transmitting information to the central coordination center of the Region.

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10 ACTIONS TO REDUCE THE OVERALL RISK OF HYDRO-METEOROLOGICAL AND GEODYNAMIC HAZARDS

6. **Modern equipment and means** to deal with all kinds of hydrometeorological and geodynamic hazards as well as required material for the disaster risk reduction before, during and after disaster.

7. **Drafting of new Regulations and Regulatory Provisions for all natural hazards**, corresponding to the Seismic Regulation and the modern regulatory framework (KANEPE-KADET), which have been developed and implemented by the Earthquake Planning and Protection Organization (EPPO-OASP) in adaptation to the new data recently emerged.

8. **Compilation – Update – Adaptation of the General Plans for emergencies** according to the new data for the municipalities of the Region of Thessaly, in order to specify and define the basic requirements and needs, for an integrated operational planning and a model operational organization of each municipality of the Region of Thessaly, in the form of clear and autonomous steps.

9. **Full Deployment Operational Field Exercises** for the management of complex hazards and disasters with realistic scenarios adapted to the risk analysis of hydrometeorological and geodynamic characteristics and the vulnerability assessment of resilience systems, such as the one scheduled to take place in April 2024 in the Region of Crete, which is the first full deployment exercise in the country.

10. **Training, educational and awareness-raising activities** for elected officials, executives of local authorities, the general population and special groups in the Region on natural disaster management issues, in order to (**a**) acquire documented and usable knowledge on the types, characteristics, impacts and methodologies of risk and crisis management, (**b**) train them in risk and crisis management and environmental management, (**c**) acquire the ability to deal with risks that may occur in their area of responsibility.

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ΣΥΜΠΕΡΑΣΜΑΤΑ

Οι ακραίες βροχοπτώσεις, οι οποίες εκδηλώθηκαν στο χώρο της κεντρικής Ελλάδας, δρομολόγησαν την εμφάνιση μεγάλων υδρομετεωρολογικών συνοδών φαινομένων και ιδιαίτερα έντονες ποτάμιες ροές, καταλαμβάνοντας εκτάσεις, κυρίως στο Θεσσαλικό χώρο, μεταβάλλοντας συνολικά το χώρο.

Εκτιμάται ότι η ανάπτυξη των συγκεκριμένων πλημμυρικών φαινομένων αντιστοιχεί σε επίπεδο χιλιετίας και αυτά αποτελούν ένα από τα μείζονα φαινόμενα που διαμόρφωσαν τα τελευταία 2 εκατομμύρια χρόνια τη Θεσσαλική πεδιάδα.

Παράλληλα η εκδήλωση του Μεσογειακού Κυκλώνα «Ιανός», το 2020, αναδεικνύει επιτακτικά το θέμα της Προσαρμογής στην Κλιματική Κρίση καθώς επίσης και της Ανθεκτικότητας των Δομών και των Υποδομών στο Θεσσαλικό χώρο.

Όλα τα ανωτέρω επιβάλλουν μια νέα προσέγγιση στον Επιχειρησιακό Σχεδιασμό Μείωσης της Διακινδύνευσης στην Κεντρική Ελλάδα, ο οποίος θα πρέπει να αποτελεί πρότυπο και για όλες τις άλλες περιοχές της χώρας, η οποία οφείλει την μοναδική φυσικογεωγραφική της εικόνα σε αυτήν ακριβώς την σύμπλεξη υδρομετεωρολογικών και γεωδυναμικών κινδύνων και σχετικών φαινομένων.

Ειδικά, για την Κεντρική Ελλάδα και ιδιαίτερα για την Θεσσαλία, προτείνονται οι ακόλουθες 10 δράσεις για την μείωση της Ολικής Διακινδύνευσης από Υδρομετεωρολογικούς και Γεωδυναμικούς κινδύνους.

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10 ΔΡΑΣΕΙΣ ΓΙΑ ΜΕΙΩΣΗ ΤΗΣ ΟΛΙΚΗΣ ΔΙΑΚΙΝΔΥΝΕΥΣΗΣ ΑΠΟ ΥΔΡΟΜΕΤΕΩΡΟΛΟΓΙΚΟΥΣ ΚΑΙ ΓΕΩΔΥΝΑΜΙΚΟΥΣ ΚΙΝΔΥΝΟΥΣ

1. **Εκτίμηση και Ανάλυση Κινδύνων**. Λεπτομερής χαρτογράφηση του συνόλου των φυσικών κινδύνων στο Θεσσαλικό χώρο και αποτύπωση τους σε κατάλληλη κλίμακα και προσδιορισμό του επιπέδου κινδύνου, της χωρικής ανάπτυξης και του χρόνου επαναφοράς τους (καιρικά φαινόμενα, πλημμυρικά φαινόμενα, σεισμικά ρήγματα, κατολισθήσεις, καθιζήσεις, καταπτώσεις, πεδία διάβρωσης, λασπορροές, ρευστοποιήσεις, υποσκαφές, μεταβολές ανάγλυφου κ.λπ.)

2. **Εκτίμηση Επιπέδου Τρωτότητας Συστημάτων των βασικών Υποδομών**, του οδικού και σιδηροδρομικού δικτύου, των κατασκευών και οικιστικών περιοχών, των αγροτικών, τουριστικών, βιομηχανικών και βιοτεχνικών υποδομών, των δικτύων νοσοκομειακών μονάδων, των λιμενικών εγκαταστάσεων, των σταθμών ενέργειας κ.λπ. Ιδιαίτερη προσοχή και προτεραιότητα θα πρέπει να δοθεί στην έρευνα για τη μείωση της Τρωτότητας των Κρίσιμων Υποδομών και Συστημάτων.

3. **Νέος Χωροταξικός και Πολεοδομικός Σχεδιασμός** με νέες χωροθετικές, πολεοδομικές παρεμβάσεις, μικροζωνικές μελέτες και σχεδιασμό υποδομών, με στόχο την αύξηση ανθεκτικότητας και αντοχής και τον μετριασμό των καταστροφών σε μελλοντικά ακραία φαινόμενα.

4. **Δημιουργία Ενιαίου Φορέα Διαχείρισης Υδάτων στο Θεσσαλικό χώρο**, ο οποίος θα είναι υπεύθυνος της εφαρμογής του Master Plan που εκπονείται. Ο Φορέας αυτός θα έχει την συνολική διαχείριση των επιφανειακών και υπόγειων υδάτων και θα δρομολογήσει, μετά από λεπτομερείς μελέτες, ένα μεγάλο αριθμό δράσεων, όπως τον σχεδιασμό και υλοποίηση έργων ορεινής υδρονομίας, διαχείρισης αναχωμάτων, έργα κατά μήκος των ποταμών, διαχείρισης της λίμνης Κάρλας και των δελταϊκών πεδίων. Επιπρόσθετα, παρακολούθηση υπόγειων υδροφόρων οριζόντων, ποιότητας υδάτων κ.λπ.

5. **Συστήματα έγκαιρης προειδοποίησης εκδήλωσης κινδύνων**, που περιλαμβάνουν δορυφορική παρακολούθηση, πλήρως ανεπτυγμένο δίκτυο οργάνων παρακολούθησης μεγάλου αριθμού παραμέτρων, κατά το πρότυπο σταθμό του Δικτύου JMA της Ιαπωνίας, την δημιουργία βάσης μετάδοσης πληροφοριών στο κεντρικό συντονιστικό κέντρο της Περιφέρειας κ.ά.

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10 ΔΡΑΣΕΙΣ ΓΙΑ ΜΕΙΩΣΗ ΤΗΣ ΟΛΙΚΗΣ ΔΙΑΚΙΝΔΥΝΕΥΣΗΣ ΑΠΟ ΥΔΡΟΜΕΤΕΩΡΟΛΟΓΙΚΟΥΣ ΚΑΙ ΓΕΩΔΥΝΑΜΙΚΟΥΣ ΚΙΝΔΥΝΟΥΣ

6. **Σύγχρονος εξοπλισμός και μέσα αντιμετώπισης** κάθε είδους υδρομετερεωλογικών και γεωδυναμικών κινδύνων καθώς επίσης και απαιτούμενο υλικό για το προκαταστροφικό, συνκαταστροφικό και μετακαταστροφικό στάδιο.

7. **Σύνταξη νέων Κανονισμών και Κανονιστικών Διατάξεων** για όλους τους φυσικούς κινδύνους, αντίστοιχους με τον Αντισεισμικό Κανονισμό, το ΚΑΔΕΤ και τον ΚΑΝΕΠΕ, που έχουν αναπτυχθεί και εφαρμοστεί από τον ΟΑΣΠ, και προσαρμοσμένους στα νέα δεδομένα που προέκυψαν.

8. **Σύνταξη – Επικαιροποίηση – Προσαρμογή των Γενικών Σχεδίων Πολιτικής Προστασίας** (Εγκέλαδος, Δάρδανος, Ιόλαος, Βορέας), σύμφωνα με τα νέα δεδομένα για τους δήμους της Περιφέρειας Θεσσαλίας, με στόχο να προδιαγράψει και να καθορίσει τις βασικές απαιτήσεις και ανάγκες, για έναν ολοκληρωμένο επιχειρησιακό σχεδιασμό και μια πρότυπη επιχειρησιακή οργάνωση κάθε Δήμου της Περιφέρειας Θεσσαλίας, σε μορφή σαφών και αυτόνομων βημάτων.

9. **Επιχειρησιακές Ασκήσεις Πλήρους Ανάπτυξης Πεδίου** για τη διαχείριση σύνθετων κινδύνων και καταστροφών με ρεαλιστικά σενάρια προσαρμοσμένα στην ανάλυση κινδύνων των υδρομετερεωλογικών και γεωδυναμικών χαρακτηριστικών και στην εκτίμηση της τρωτότητας των συστημάτων, όπως αυτή που έχει προγραμματιστεί να γίνει τον Απρίλιο του 2024, για την περιφέρεια Κρήτης και αποτελεί την πρώτη άσκηση πλήρους ανάπτυξης στη χώρα.

10. **Δράσεις Εκπαίδευσης και Ενημέρωσης** αιρετών, στελεχών ΟΤΑ και ενημέρωσης - ευαισθητοποίησης Γενικού πληθυσμού και Ειδικών ομάδων στην Περιφέρεια, σε θέματα διαχείρισης φυσικών καταστροφών, με σκοπό (**α**) την απόκτηση τεκμηριωμένης και αξιοποιήσιμης γνώσης για τα είδη, τα χαρακτηριστικά, τις επιπτώσεις και μεθοδολογίες διαχείρισης των κινδύνων και των κρίσεων, (**β**) την επιμόρφωση στη διαχείριση κινδύνων και κρίσεων και τη διαχείριση του περιβάλλοντος, (**γ**) την απόκτηση ικανότητας να αντιμετωπίσουν κινδύνους που είναι δυνατό να εμφανιστούν στο γεωγραφικό χώρο των Δήμων τους.

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The early September 2023 Daniel storm in Thessaly Region (Central Greece)

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Thessalian Plain, 2023