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ΜΕΤΕΩΡΟΛΟΓΙΚΗ
ΥΠΗΡΕΣΙΑ
HELLENIC NATIONAL METEOROLOGICAL SERVICE

Annual Bulletin on the Climate in Greece 2020

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Notable weather and climate events in Greece 2020

There were few significant weather and climate events in 2020 including heat wave, storms, extra-tropical cyclone and floods.

Heavy Precipitation, Storms and Floods

- On **April 4-8**, 2020: Intense rainfall caused floods and extensive damage across Chalkidiki, Evia, Pelio and Sporades islands, particularly to the infrastructure network. Thessaloniki station recorded total monthly precipitation 111 mm, ranging this April as the wettest April on record during the 62 years history of the observation station. The previous record was 108 mm on April 1982.

- On **August 08**, 2020: Severe thunderstorms and heavy precipitation caused destructive floods on the island of Evia and eight people lost their lives.

- On **September 17-19**, 2020: Ionian islands and southwest Greece were impacted by an extra-tropical cyclone so-called Medicane, bringing high winds and waves, torrential rain and flooding. Also, severe thunderstorms developed along a convergence zone extending to the eastern parts of central Greece caused floods and landslides in Thessalia as well as four deaths.

- On **October 20-22**, 2020: Severe thunderstorms and heavy rainfall affected Crete and caused flooding episodes and extensive landslides along the national and provincial road network of Crete

- On **November 7 and 10**, 2020: Crete was hit by thunderstorms and heavy precipitation that caused flooding and damages in the water supply network. Prolonged rainfall caused soil erosion and increased sediment loads.

Temperature

- On **May 15-20**, 2020: Heat wave affected mainly mainland. Greece experienced the hottest mid-May heat wave in 50 years, while warm weather is not unusual in May, temperatures above 38 ^{o}C and especially in the middle of the month are quite rare.

Drought

- On **January**, 2020: Extremely dry conditions prevailed in many areas, ranking January 2020 among the top ten driest Januaries on record.

- On **November**, 2020: Extremely dry conditions prevailed in continental Greece.

1. Annual Survey

This section presents an overview of the spatial patterns of mean annual climate conditions in 2020 and anomalies related mainly to the normal period 1971-2000 of the following basic climate variables: temperature and precipitation.

1.1 Temperature

Mean annual temperature in 2020 in Greece varied from +0.8 to + 2.2 ^{o}C above the 1971-2000 average values. The greatest positive departures from normal values occurred in the northeastern mainland and the lowest ones in eastern Peloponnese and west Crete (Figure 1).

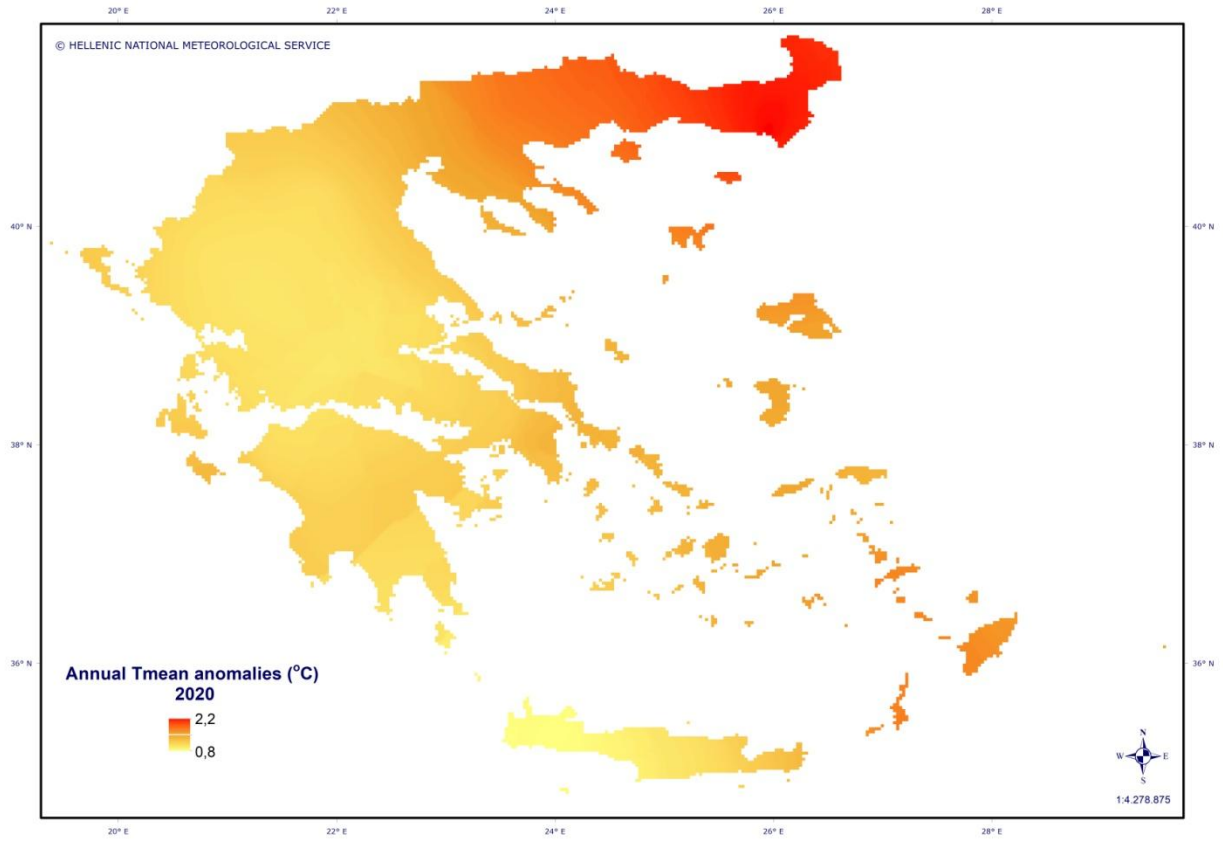

Figure 1 *Annual mean temperature anomalies (°C) in 2020 in Greece according to the 1971-2000 climatology.*

1.2 Precipitation

Annual precipitation anomalies in 2020 in Greece expressed as a percentage of the (1971-2000) average, ranged from 55% to 170 %. Drier than normal conditions were observed in west and southwest Greece and Ionian islands, which are generally wetter than the east parts of the Pindus mountain range and typically receive the greatest amount of precipitation. Total precipitation in these areas accounted for less than 70 % of normal values (1971-2000). On the contrary, wetter than normal conditions prevailed in the central Macedonia, the Skyros island, which is part of the Sporades archipelago in northwest Aegean. The highest percentage value was observed in the island of Crete. Figure 2 shows the annual precipitation anomalies, with respect to 1971-2000.

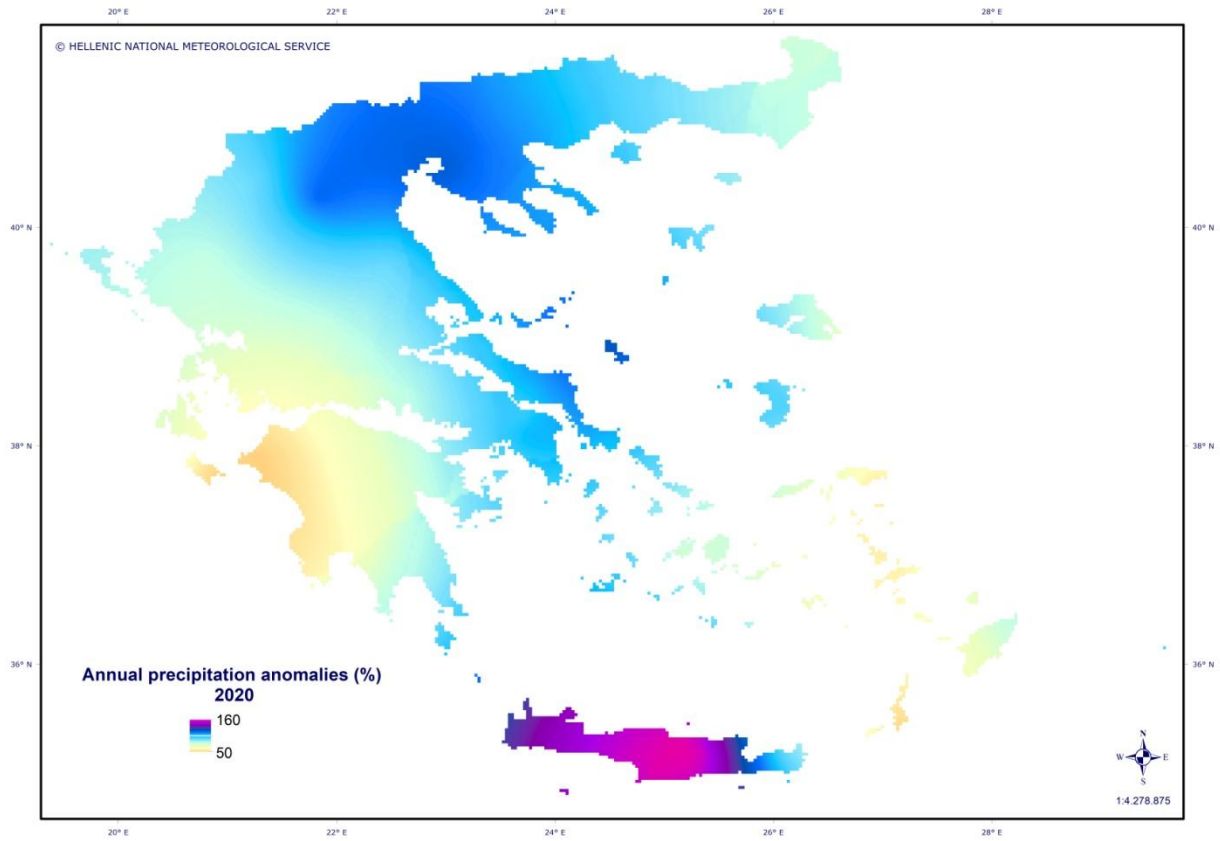

Figure 2. *Annual precipitation anomalies in 2020 in Greece (%) compared to 1971-2000 climatology.*

2. Seasonal Survey

This section presents an overview of the spatial patterns of seasonal mean climate conditions in 2020 in Greece and anomalies related mainly to the normal period 1971-2000 of the following basic climate variables: temperature and precipitation.

2.1 Temperature

Mean temperature in **winter of 2019/2020** ranged from 4.7 °C to +14.5 °C, the greatest mean temperature values were recorded over southeast areas (east Crete, Karpathos and Rhodes islands) and the lowest ones over northwest mainland (Figure 3). Temperature in winter 2019/20 in Greece was above normal values compared to the 1971-2000 climatology. The departure of mean air temperature from the normal values (1971-2000), in winter ranged from 0.3 °C to + 2.0 °C, with the greatest positive values occurring mainly in the northern and eastern parts of the country (Figure 4).

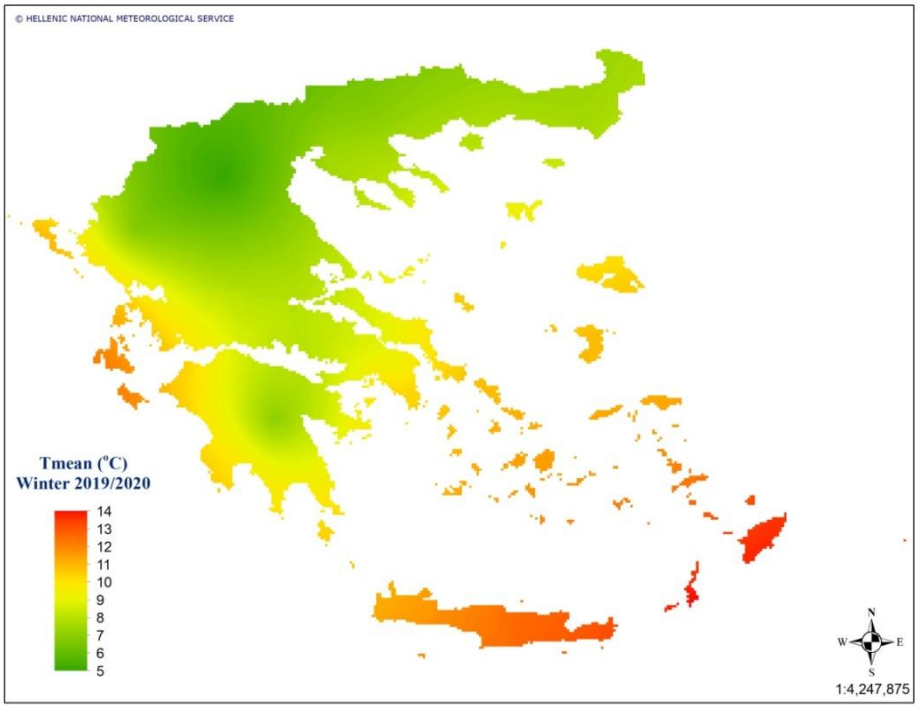

Figure 3. *Mean temperature (°C) in Winter 2019/20 in Greece.*

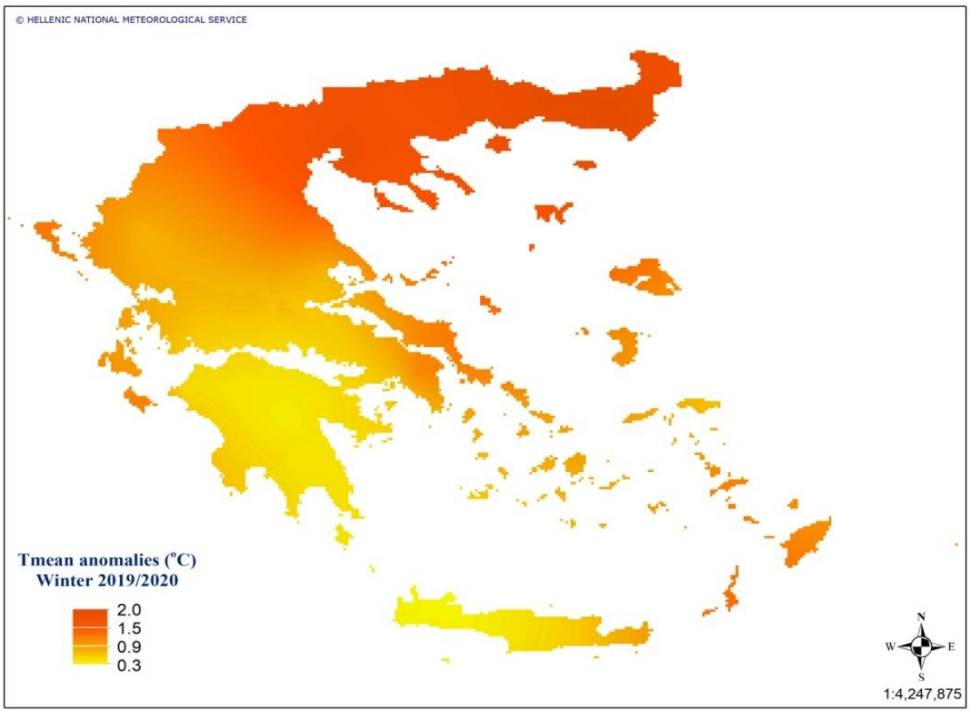

Figure 4. *Mean temperature anomalies (°C) for winter 2019/20 in Greece according to the 1971-2000 climatology.*

Above average temperatures dominated in Greece during **spring 2020**. Mean temperatures ranged from +0.1 to +1.6 ^{o}C above seasonal temperature normal values (Figure 5). The greatest positive anomalies are found over northwest parts, southeast Aegean islands and Attica.

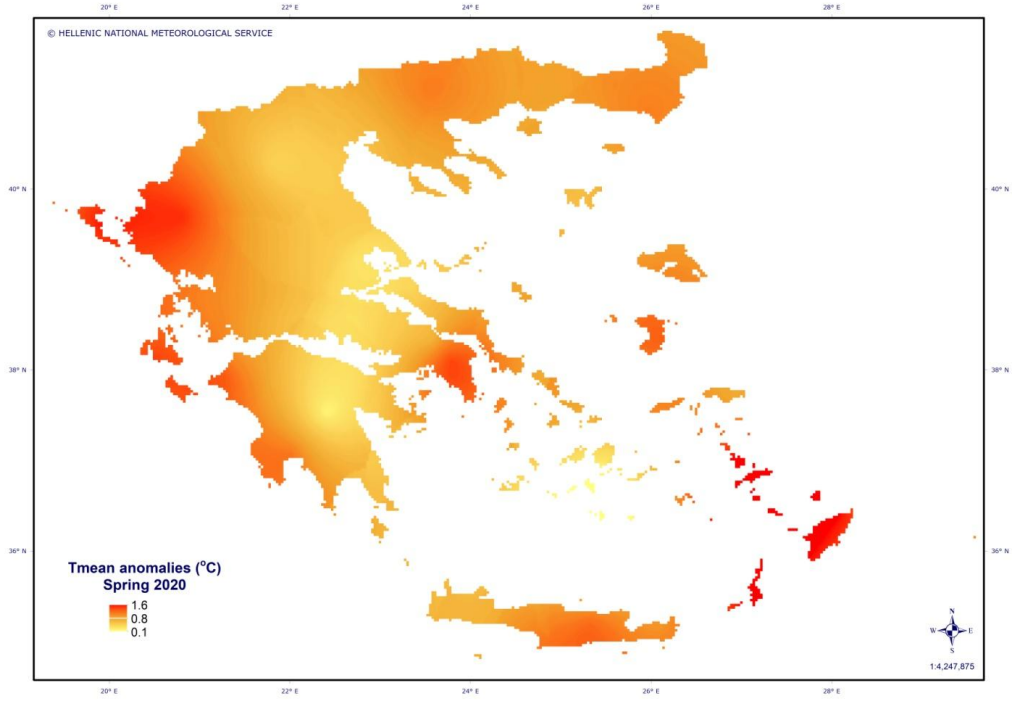

Figure 5. *Mean temperature anomalies (°C) for spring 2020 in Greece according to the 1971-2000 climatology.*

Warmer than normal conditions dominated in Greece during **summer 2020**, however this summer is not ranked among the top 10 warmest summers for Greece. Summer mean temperature anomalies were on average +0.8 ^{o}C above normal values (long term data series of 31 meteorological stations were used to derive summer average mean temperature for the whole country). The highest positive anomalies occurred in eastern Macedonia and Thrace (Figure 6).

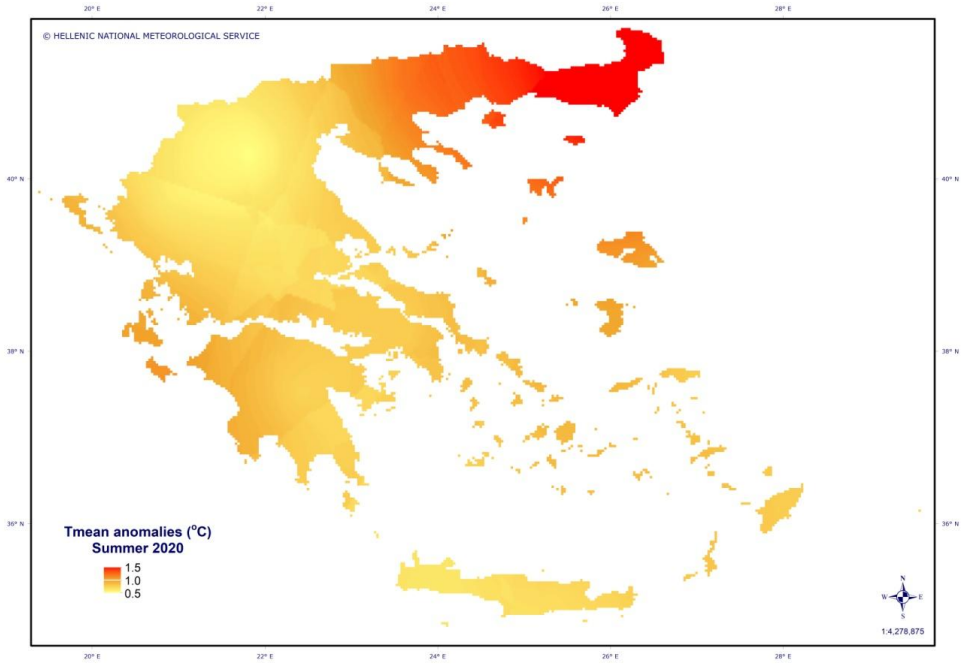

Figure 6. *Mean temperature anomalies (°C) for summer 2020 in Greece according to the 1971-2000 climatology.*

The summer average mean temperature anomalies in Greece from 1960 to 2020 are given in Figure 7. It is noticeable that the summer mean temperature remained relative low before 1992, and then started to rise and reached a local peak in 2012 which was the warmest summer on record. The second warmest summer in Greece remains 2007. Also during the last twenty summers (2001-2020) mean temperature anomaly exceeded 1.5 ^{o}C eight times.

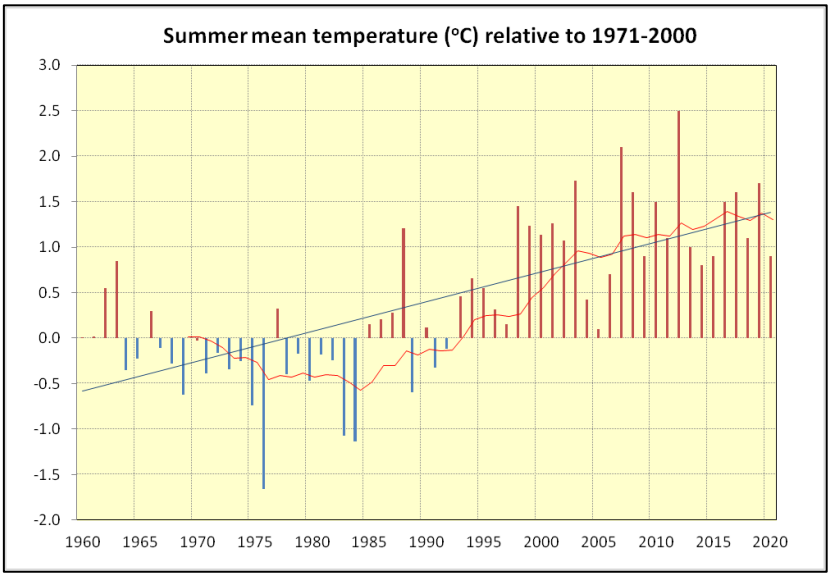

Figure 7. *Summer 2020 (June through August) averages of mean surface air temperature anomalies for Greece (taking into account 31 stations) relative to 1971-2000. The red line indicates the ten-year moving average, and the blue line indicates the long-term linear trend.*

Autumn of 2020 (September, October, November) in Greece was warmer than average. The average mean temperature in autumn varied from +0.9 to +3.0 ^{o}C above normal values (1971-2000) for most of the territory (Figure 8). The greatest values above normal (1971-2000) occurred mainly over eastern and northeastern regions and the islands of north Aegean and Dodecanese.

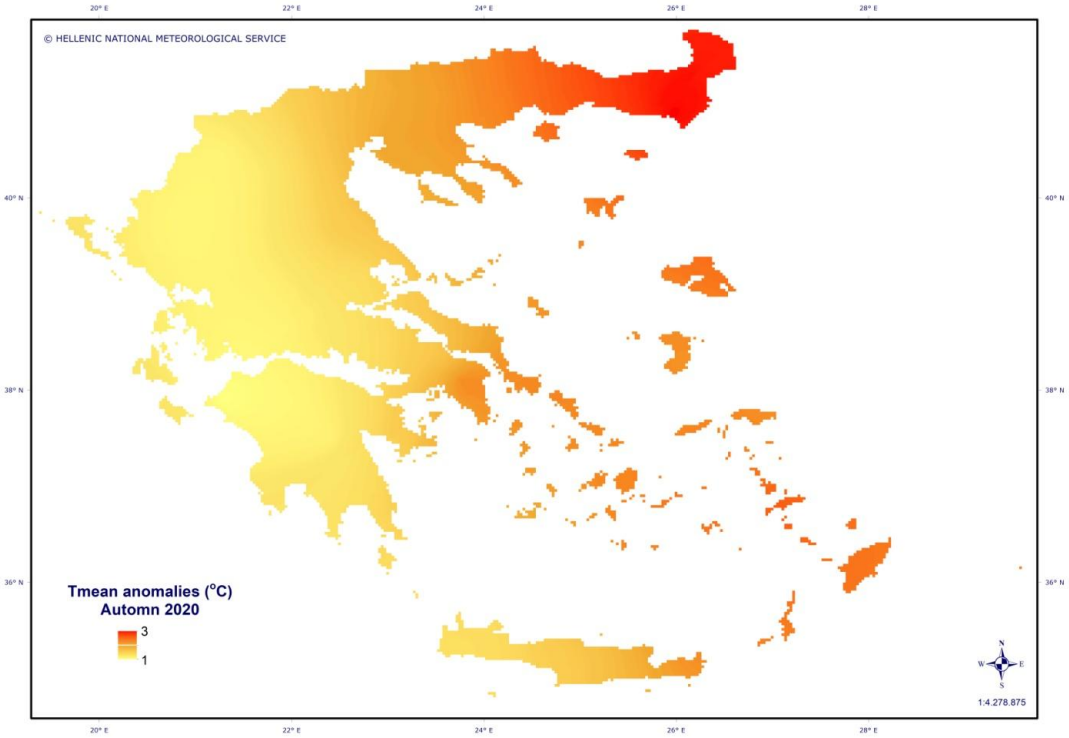

Figure 8. *Mean temperature anomalies (°C) for autumn 2020 in Greece according to the 1971-2000 climatology.*

2.2 Precipitation

Winter of 2019/20 was drier than normal in west and northern parts and in east Aegean islands. However above normal values prevailed in the east Sterea area, including Attica region and locally in Sporades islands. Total winter precipitation heights ranged from 60.0 mm up to nearly 380.0 mm and anomalies ranged from 40 % to 230 % with the greatest values occurring in the central and eastern mainland, as well as in Sporades islands (Figure 9).

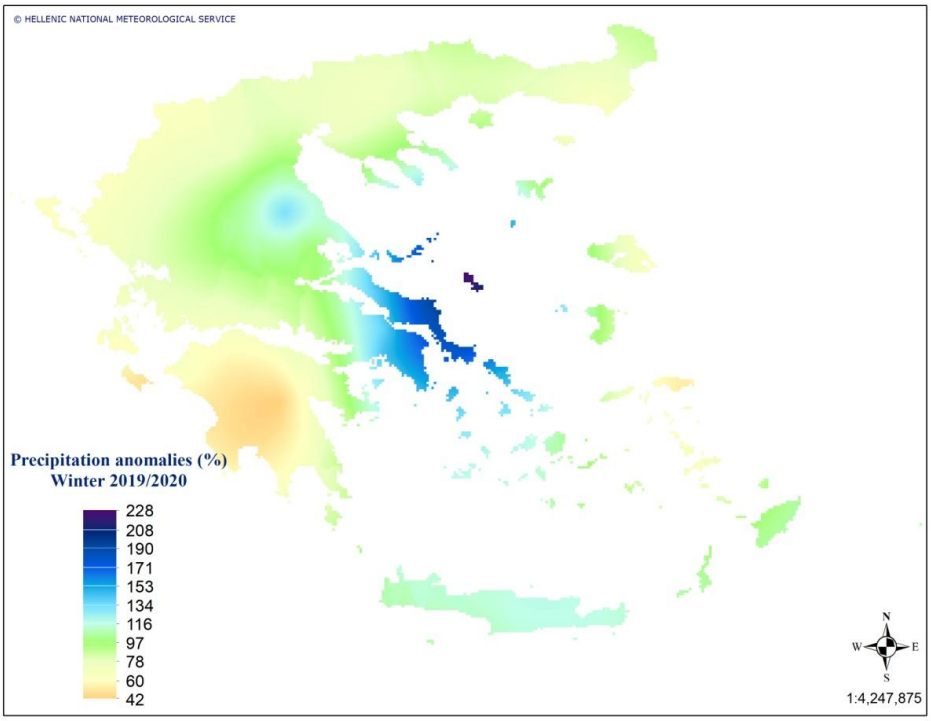

Figure 9. *Winter 2019/20 precipitation anomalies in Greece (compared to 1971-2000 climatology) given in percentages (%).*

Spring of 2020 was wetter than normal for the eastern mainland and the north Aegean islands, where spring precipitation totals accounted for more than 150 % normal values (1971-2000) (Figure 10). On the other hand, it was drier than normal for western parts including Ionian islands, where spring precipitation totals accounted for less than 70 % of normal values (1971-2000).

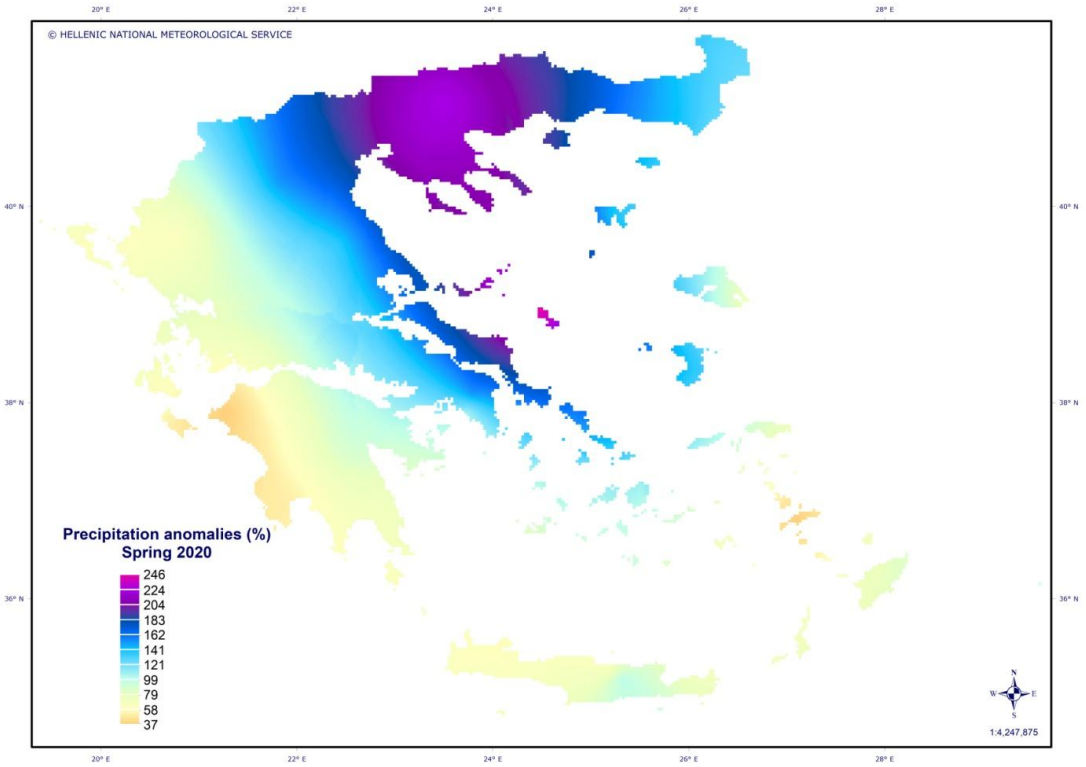

Figure 10. *Spring 2020 precipitation anomalies in Greece (compared to 1971-2000 climatology) given in percentages (%).*

Summer 2020 was wetter than normal for many regions and especially for the north Ionion, the northwest and southeast mainland and the northeast Aegean islands. Notable precipitation amounts recorded over the southern portion of the peninsula, including Athens and east Peloponnese which are typically more arid than the northern areas of the country. Total precipitation in these areas accounted for more than 200 % of normal values (1971-2000) (Figure 11). Also few thunderstorms in June over the northeast Aegean islands, along with the fact that normal conditions are characterized by the absence of summer precipitation, resulted in high summer precipitation anomalies.

Autumn 2020 (September, October, November) was drier than normal for most parts of the country, with the exception of the area of Crete, where wetter than normal conditions prevailed and the total autumn precipitation anomalies reached values of 450% greater than normal (Figure 12).

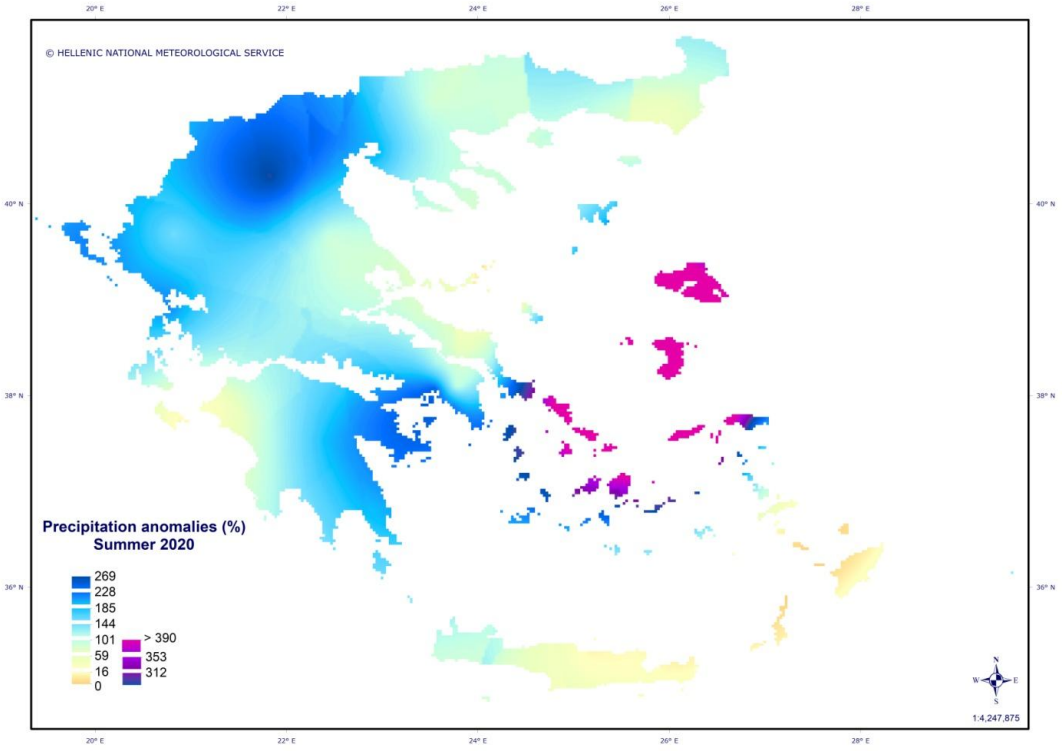

Figure 11. *Summer 2020 precipitation anomalies in Greece (compared to 1971-2000 climatology) given in percentages (%).*

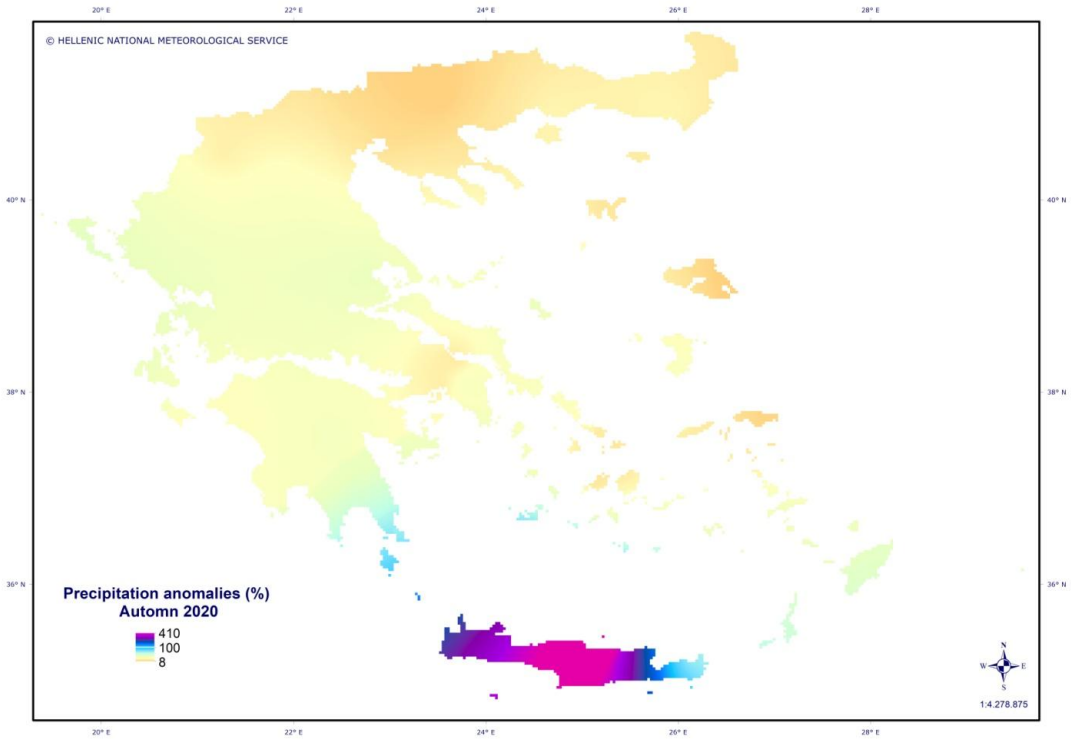

Figure 12. *Autumn 2020 precipitation anomalies in Greece (compared to 1971-2000 climatology) given in percentages (%).*

3. Monthly Survey

This section contains notable weather and climate events, high impacts events as well as monthly means and anomalies of temperature and precipitation in 2020 in Greece.

3.1 Extremely dry January

Extremely dry conditions prevailed in many areas during January 2020. More specific west Greece, which traditionally receives great amount of precipitation, was exceptional drier than normal, accounting for less than 20 % of normal values (1971-2000), ranking January 2020 among the top ten driest Januaries on record. Kerkyra station located in the north Ionian Sea, recorded only 20 mm meaning 5.5 times below the normal value 1971-2000, ranking this January as the 6th drier January since 1901.

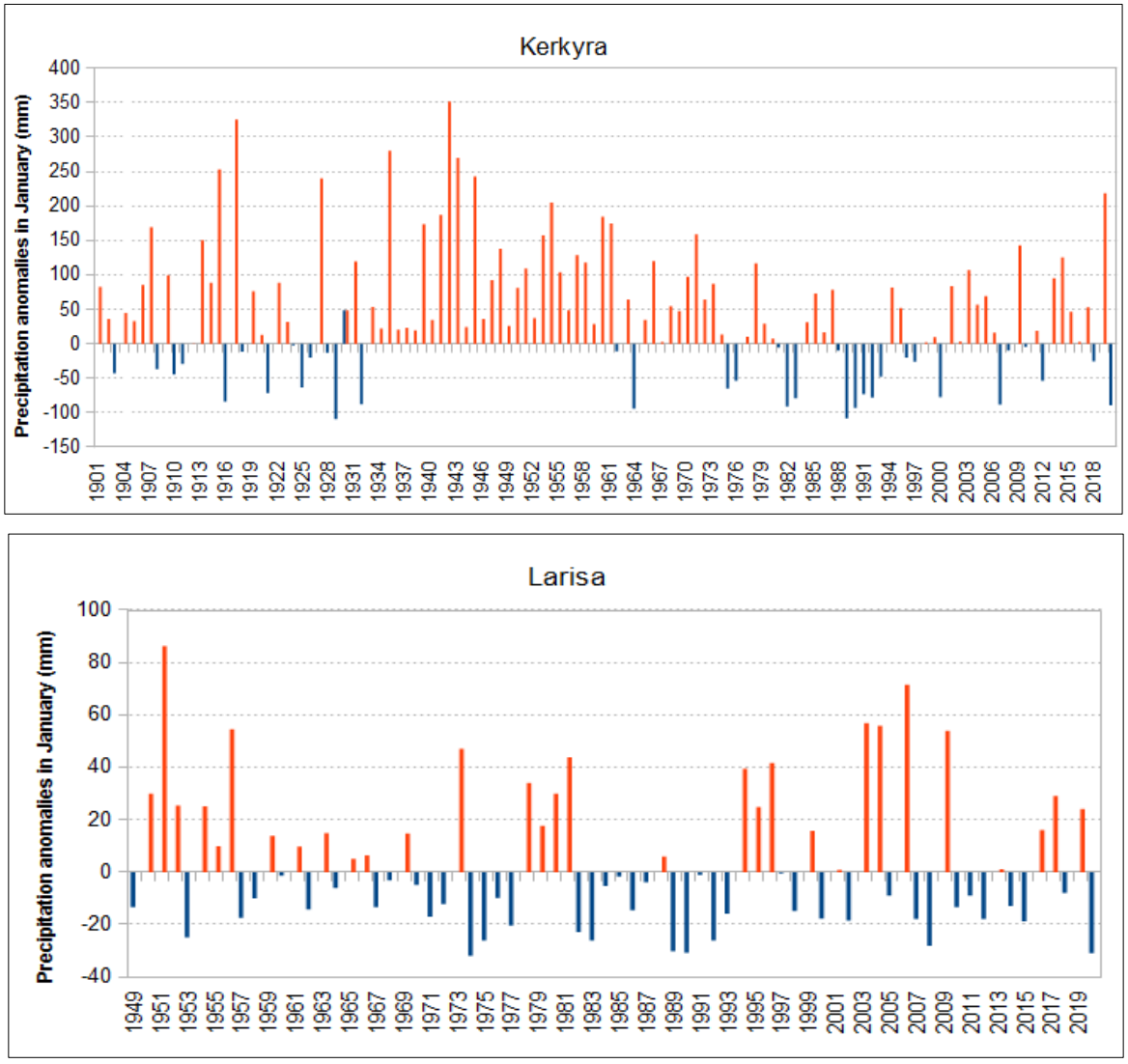

Figure 13. *Precipitation anomalies in January (mm)- Differences from 1971-2000 normal values; blue bars show precipitation values which are below the 1971-2000 average and red bars above this mean value.*

Additionally, Kalamata station in south Peloponnese had the 5th drier January since the beginning of 20th century and Andravida station in west Peloponnese had the 2nd drier January since records began 1959. Also, below average precipitation occurred across much of eastern areas. Larisa station located in Thessaly (central Greece), recorded only 1 mm while its monthly normal value is 32 mm, ranking this January as the 2nd driest January since 1949. Precipitation anomalies in January are shown in the following picture (Figure 14)

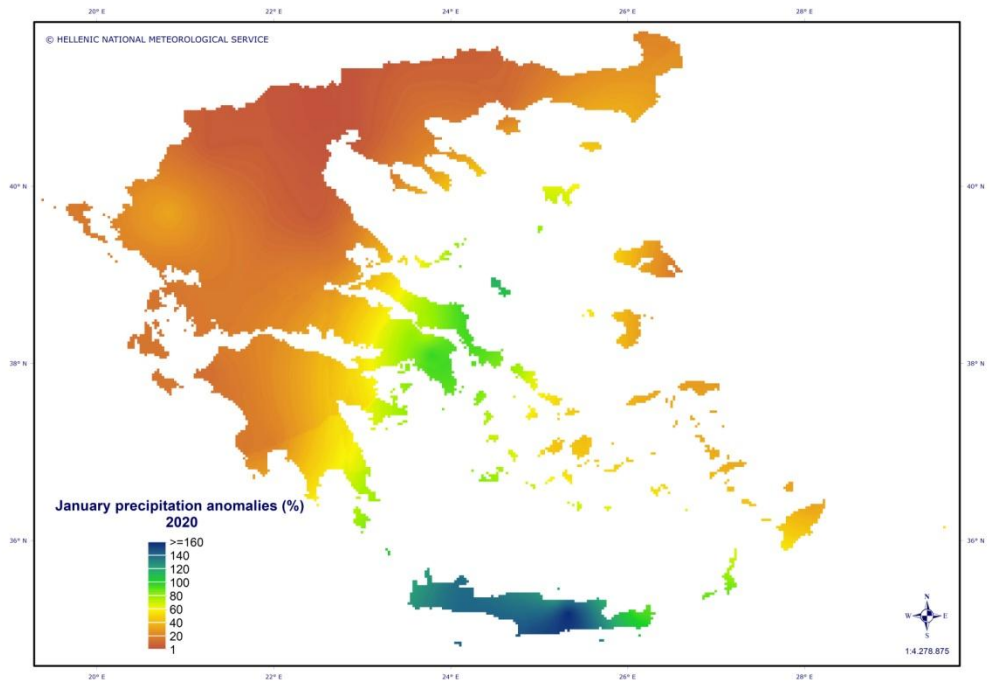

Figure 14. *January's precipitation anomalies in Greece (compared to 1971-2000 climatology) given in percentages (%).*

3.2 February's and March's warmth

Temperatures in **February** 2020 were much above the 1971-2000 average over almost all of Greece. The maximum temperatures were 2.0 to 4.5 °C above normal values in many areas. The greatest positive anomalies (above 3.0 °C) occur over central and northern areas (Figure 15). Similarly to maximum temperatures, mean temperatures throughout Greece were about 0.7 to 2.6 °C above normal values. The greatest positive anomalies (above 2.0 °C) occur over Thessaly and eastern Macedonia and Thrace.

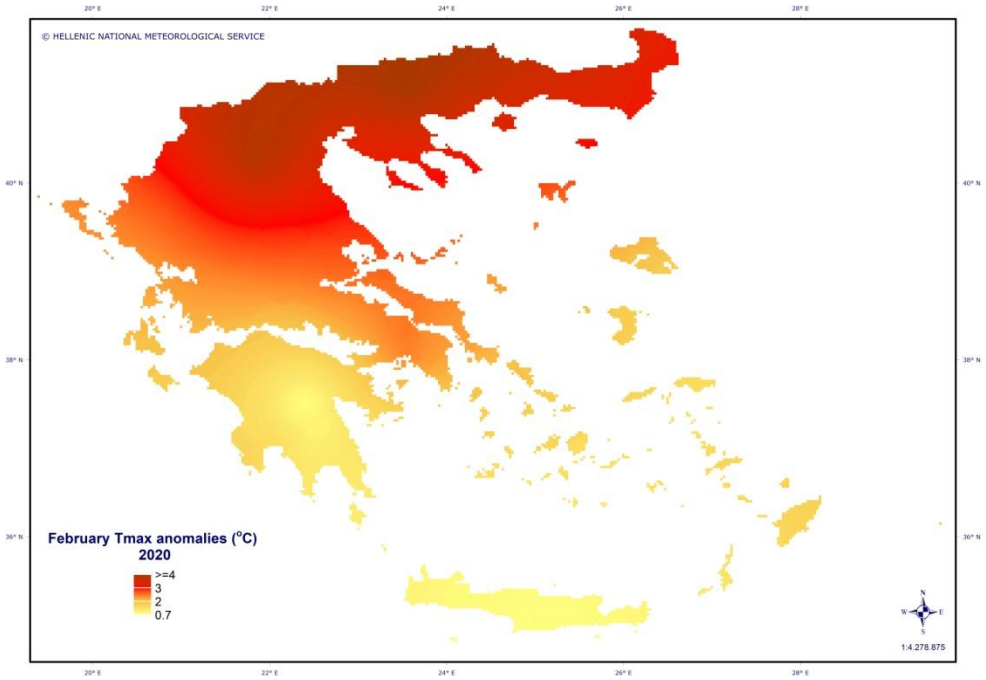

Figure 15. *February's maximum temperature anomalies (°C) in Greece according to the 1971-2000 climatology.*

March following February's warmth was warmer than the average 1971-2000.The average maximum temperature was about 1.7 °C warmer than the average March temperature for 1971-2000. The greatest positive difference from reference period (1971-2000) recorded over Alexandoupoli station in eastern Macedonia and Thrace and was 2.8 °C.

3.3 Locally wet April

Although April was drier than normal in west Greece and south Aegean islands accounting for less than 70 % of normal values (1971-2000), it was much wetter than normal in central and northeast areas accounting for more than 150 % of normal values (1971-2000) and locally more than 250 % of normals.

It is worth mentioning that April 2020 was one on the top ten wettest Aprils on record for a few locations of Greece. The monthly total precipitation in Thessaloniki station (code: 16622) was 111 mm i.e almost 3 times above the normal value, ranking this April as the wettest April on record since 1959. Also, Alexandroupoli station (code: 16627) ended up with the third wettest April since 1947; it recorded monthly total precipitation 77 mm which means two times above the normal value (1971-2000). Figure 16 shows the precipitation anomalies of Thessaloniki station in April from 1959 onward, where blue bars show precipitation values which are below the 1971-2000 average and red bars above this mean value.

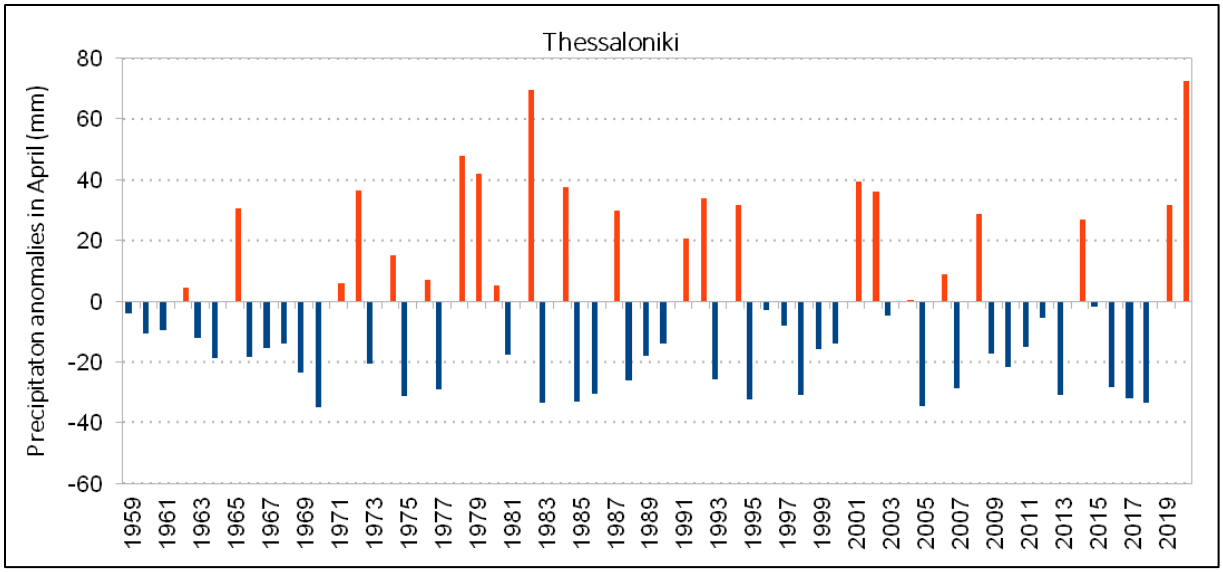

Figure 16. *Precipitation anomalies in April (mm)- Differences from 1971-2000 normal values; blue bars show precipitation values which are below the 1971-2000 average and red bars above this mean value.*

3.4 Heat wave in May

Very high daily maximum temperatures were recorded during the second ten days of May in Greece. Warm air masses originated from Africa affected Greece for several days. Although high temperatures are often registered in May, temperatures above 38 °C during the first half of the month are quite rare. During 15 and 17 May 2020, some stations in central mainland and Peloponnese, recorded daily maximum temperatures above 40 °C while the average maximum temperature in Athens during the second ten days of May is about 25.8 °C, in Kalamata (south Peloponnese) 24.0 °C and in Argos (east Peloponnese) 26.2 °C. The monthly maximum temperatures anomalies exceeded +2.5 °C in mainland.

Table 1*: Very high Daily maximum temperatures in May 2020 in Greece*

Station code	Station name	Year	Month	Day	Maximum temperature
16649	Tithorea	2020	5	15	40.7
16791	N.Filadelfeia	2020	5	16	40.6
16792	OAKA	2020	5	16	39.1
16724	Argos	2020	5	16	39.7

16791	N.Filadelfeia	2020	5	17	40.6
16726	Kalamata	2020	5	17	39.9
16718	Eleusis	2020	5	17	38.2

3.5 Severe thunderstorms in August

On August 4, 2020 an upper tropospheric cut-off low pressure system developed over north Italy, moved slowly south-southeastern wards, approaching South Adriatic Sea on August 6, 2020. It prevailed over the area of South Adriatic Sea for about 36 hours before moving southeast over mainland Greece on August 8, 2020. In the early hours of 9th August it was over east Sterea. Moreover, low level convergence zones were developed in northwest and central Aegean triggering convection of unstable air masses. The presence of strong northeasterly winds in north Aegean blowing against Evia mountains forced unstable air masses to orographic lift. Also, the vertical wind shear led to the development of severe thunderstorms. Thunderstorms slammed into Evia, causing torrential floods, blackouts, overflowing rivers, destruction of property and crops and trapping residents and tourists.

In the following satellite images (Figure 17), the cloud systems over central Greece are recognized at 21.00 UTC (left image), whereas a mesoscale convective system is clearly depicted over Evia at 00:00 and 03:00 UTC (middle and right image).

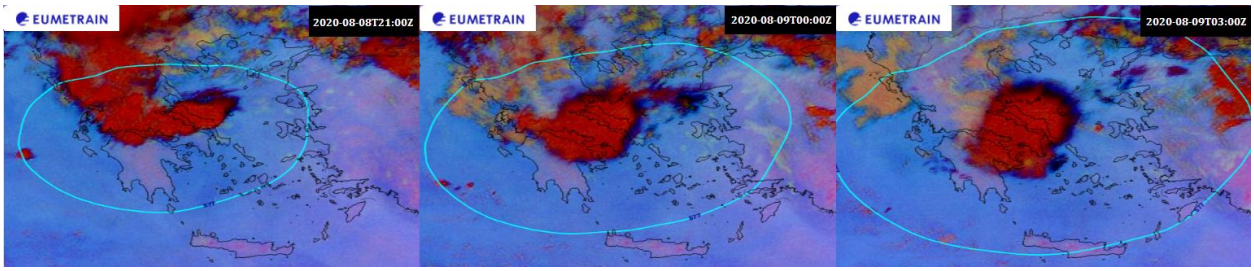

Figure 17. *24-hour Microphysics RGB, August 2020 .*

Impacts

The Greek government declared a state of emergency on the island of Evia

- Eight people included an eight-month-old baby lost their lives in flooding caused by thunderstorms and heavy rain
- The flooding has damaged houses and affected road network
- Six main bridges of Lilas River collapsed
- Dozens of people have been evacuated from affected areas
- The large volume and intensity of the storm caused severe erosion phenomena

Figure 18. *Scenes from a collapsed bridge (left) and floods (right) (eviaportal.gr); 9 August 2020.*

3. 6 Medicane in September

Greece was impacted by a so-called Medicane (MEDIterranean hurriCANE), a cyclonic low pressure system with tropical characteristics that caused high winds, waves, torrential rain and extensive flooding during 18 – 20/9/2020.

On 14 September 2020, a low-pressure system began to develop over the Gulf of Sidra, quickly developing in the coming hours while slowly moved north-northeastwards. The cyclone gradually intensified over the warm waters of the Mediterranean Sea, acquiring an eye-like feature, making landfall over the Greek island of Kefalonia on 17 September 2020 evening, with maximum winds gusts 120 km/h (65 knots) and a surface pressure in the vicinity of 993 hPa (Figures 19, 20).

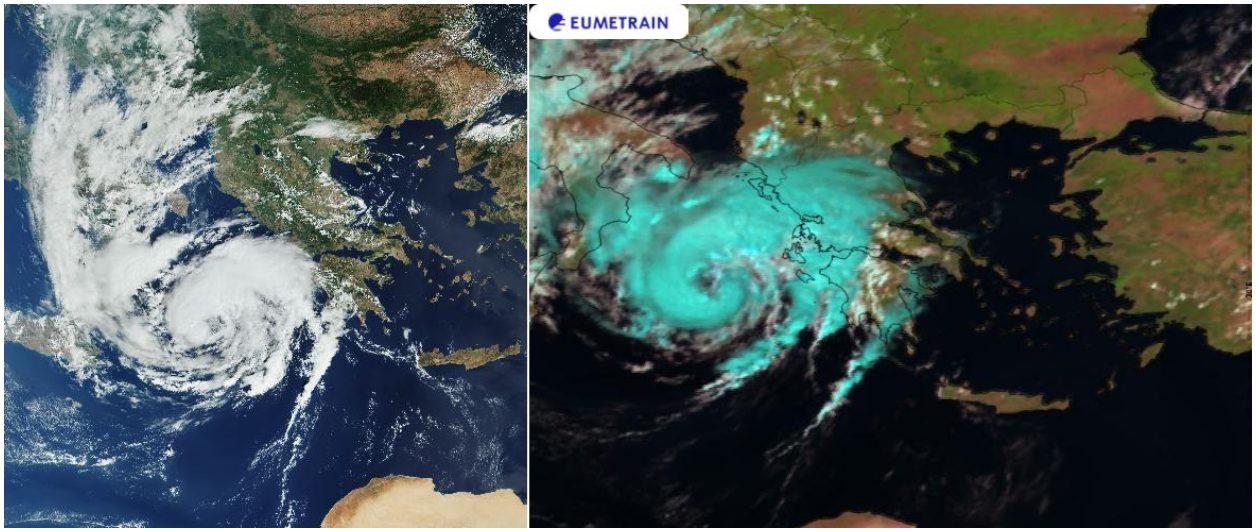

Figure 19. *(Left) The Copernicus Sentinel-3 mission captured this image of Medicane, crossing the Ionian Sea and approaching west Greece on 17 September 2020 at 10:48 CEST; (Right) Day natural colors at 12:00 UTC.*

The Hellenic National Meteorological Service had issued top-level Red Alerts to warn people of hazards. Greece was last hit by a strong explosive cyclogenesis in 2018. Due to its long life, its tropical

characteristics and its intensity, it can be classified as one of the most powerful Mediterranean Cyclones recorded since 1969, that is, from the beginning of satellite observations.

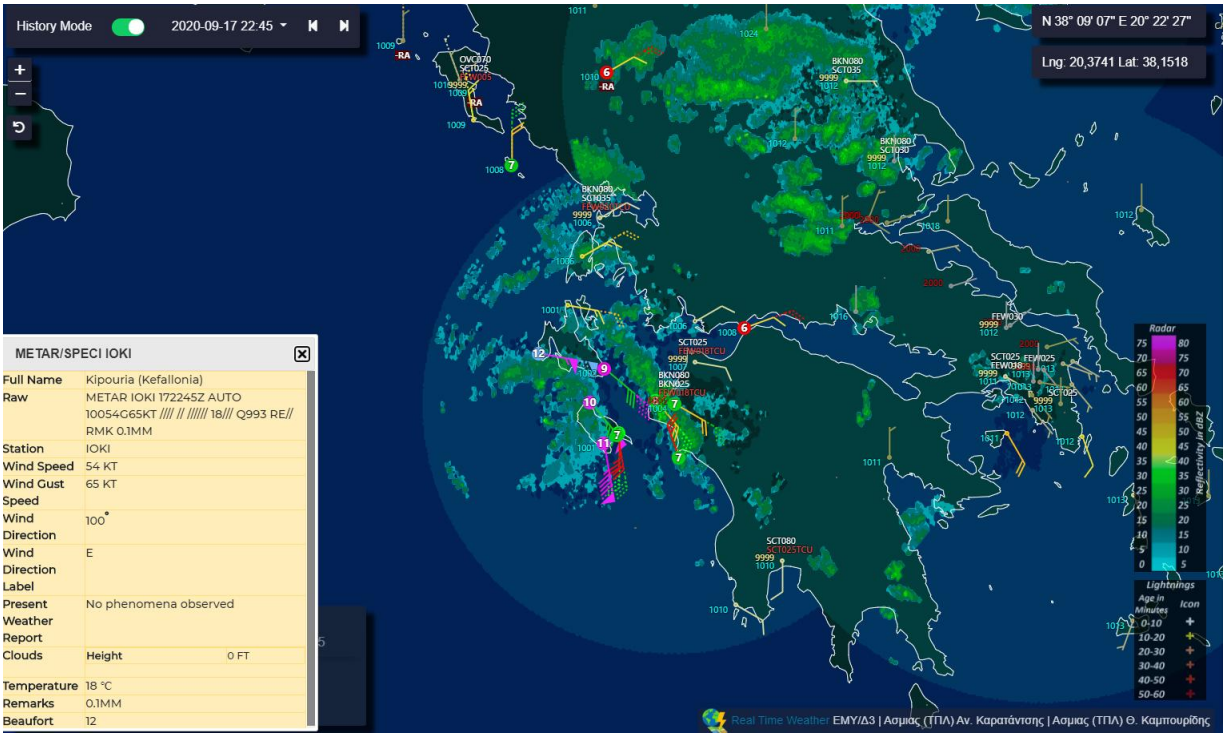

Figure 20. *Radar image and station observations on 2020-09-17 22.45 UTC; A station located in the westernmost point of Paliki peninsula in Kefalonia island, recorded wind gust 65 knots (12 Beaufort) and pressure 993hPa.*

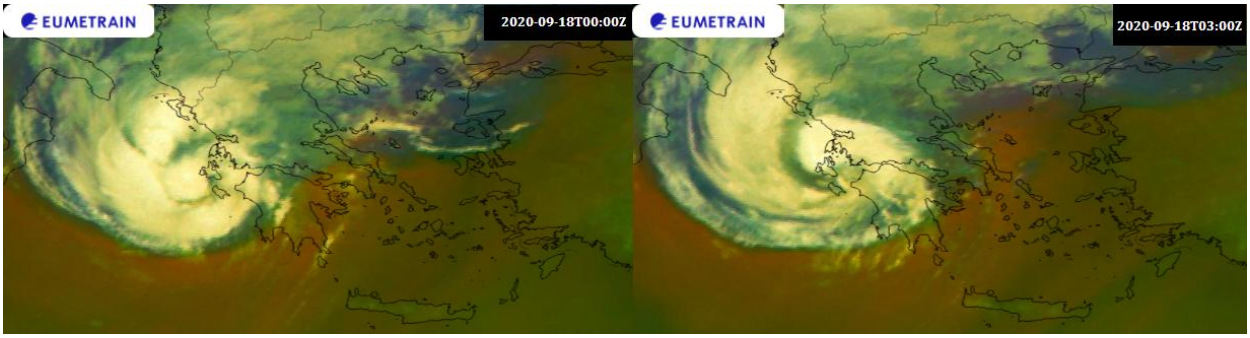

Figure 21. *Airmass on RGB composite on 18 September 2020 at 00:00 UTC(left) and 03:00 UTC (right).*

As the medicane shifted eastwards, strong convergence conditions were established in Thessalia and central Greece, resulted in heavy rains for prolonged period, mainly in the areas around the cities of Karditsa and Farsala. Although the medicane didn't swept across east mainland since it moved south southeast to the area of Crete, the large scale circulation brought warm moist air masses in the area of Thessalia. The eastward movement of an upper level trough enhanced the strength of the easterly - northeasterly winds. Also, the impact of orography caused convergence zones leading to deep convection. The following satellite images verify the presence of convective storm and heavy rainfall in

the area of Thessaly (Figure 22). By 19/9/20 evening, the medicane had reached the island of Crete, bringing heavy rainfall that flooded streets and properties.

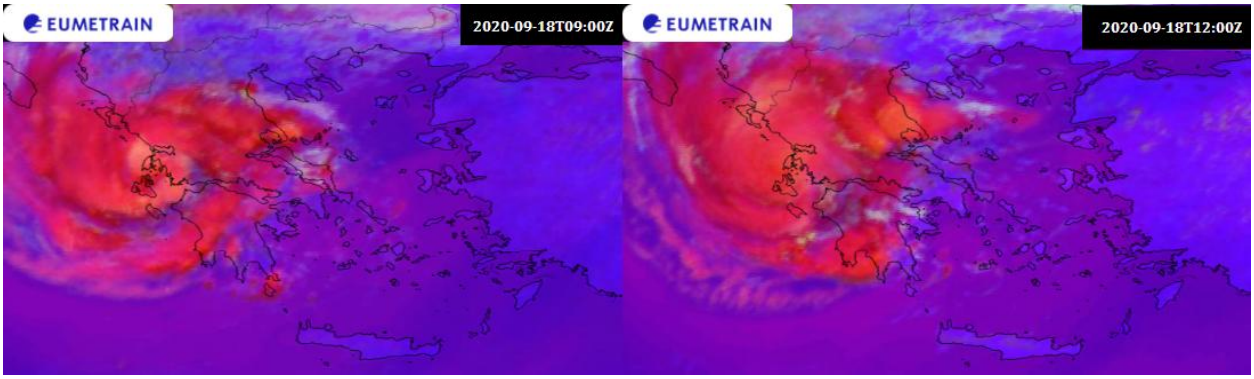

Figure 22. *Convection RGB on 18 September 2020 at 09:00 UTC(left) and 12:00 UTC (right).*

Impacts

- The Ionian Sea islands of Zakynthos, Kefalonia and Ithaca were badly hit by the cyclone, as winds reaching 120 kilometres per hour damaged buildings, uprooted trees, sank sailboats and left thousands along Greece's western coast without power, while huge waves lashed the beaches.
- Flights and ferry services were canceled and people were advised to stay indoors.
- The torrential rain caused flash flooding and landslides.
- The tourist village of Assos, in Kefalonia, was buried under mud and stones, while many houses were uninhabitable (Figure 23).
- The areas of Karditsa and Mouzaki in Thesallia were flooded and triggered significant landslides. A bridge collapsed and about 5,000 homes in the area were affected by flooding, while roads were also damaged. A river flooded its banks and damaged roads and a medical centre in the town of Mouzaki (Figure 24).
- Greece's cotton crop was at maturity with harvest set to begin soon, and the storm resulted in significant impacts and crop losses where rain was heaviest, most notably in Thessalia and central Greece.
- Throughout the country, over 1000 people were rescued by the national firefighting service and four people lost their lives.

Figure 23. *Assos village in Kefalonia was buried under mud and stones (kefalonitikanea.gr).*

Figure 24. *Floods and landslides in Mouzaki village in the area of Karditsa (photo Eurokinissi).*

3. 7 October and November

Although **October** 2020 was drier than normal in most of continental Greece accounting for less than 80% of the normal value 1971-2000, it was exceptionally wetter than normal in Crete. Between 20 and 22 October cold air masses moving over warm Aegean in combination with very strong northerly winds blowing in Aegean caused severe thunderstorms and heavy rain in south Aegean. Heraklio station in Crete experienced its wettest October since 1931, reporting 304 mm which is 6.5 times above the average 1971-2000 October precipitation height. Also, Souda station in northwest Crete recorded 312 mm, ranking October 2020 as the 2nd wetter October on record (Figure 25).

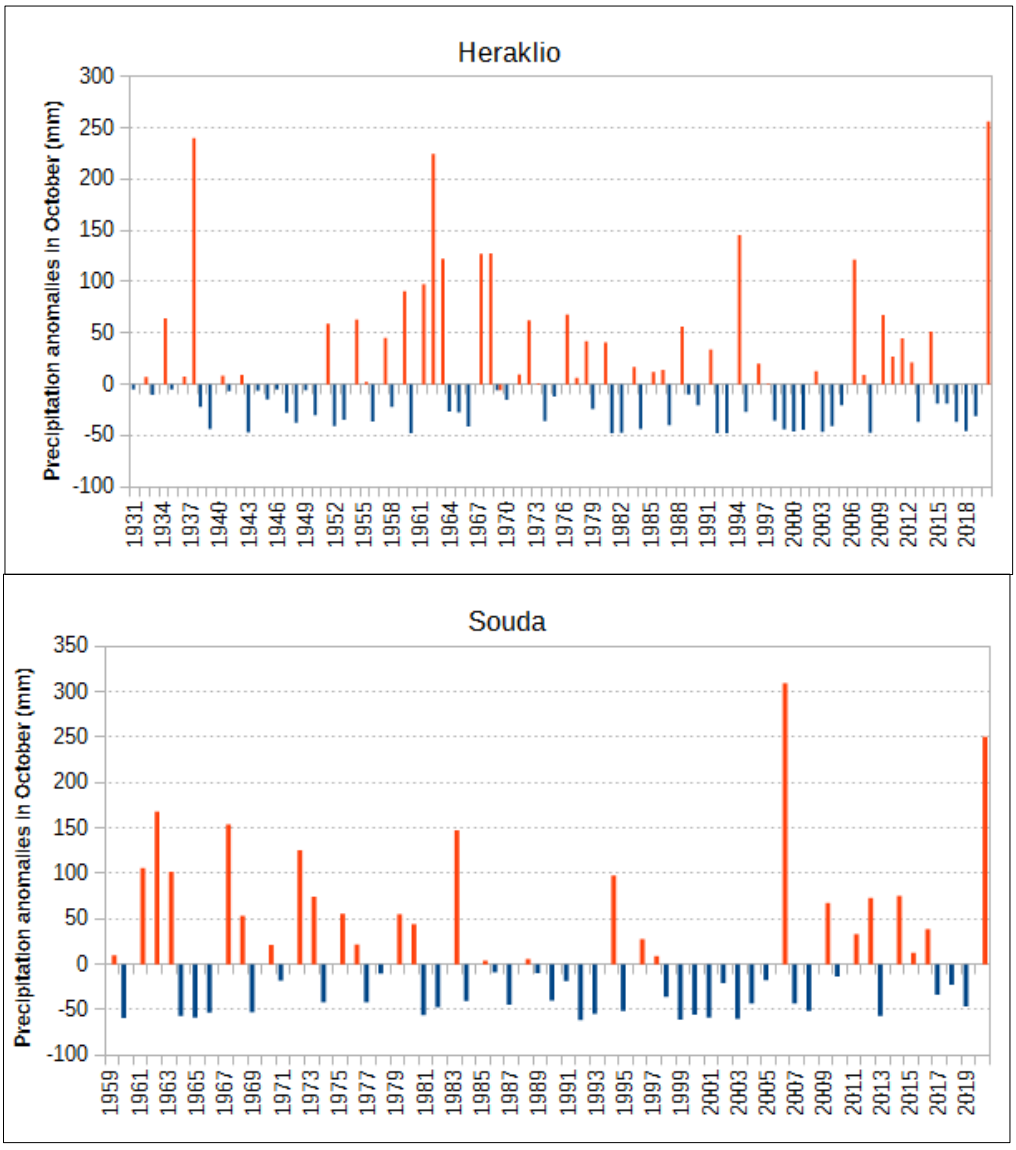

Figure 25. *Precipitation anomalies in October (mm)- Differences from 1971-2000 normal values; blue bars show precipitation values which are below the 1971-2000 average and red bars above this mean value.*

Impacts

- Heavy precipitation caused extensive landslides along the national and provincial road network of Crete and flooding.

Following October, **November** 2020 was characterized by very high precipitation amounts over Crete while serious precipitation deficiency observed in the rest Greek regions. Many continental areas received much less precipitation than normal, accounting for less than 20 % of the 1971-2000 average. Ioannina station in Epirus had its drier November on record, reporting only 6 mm accounting for 3.7 % of the 1971-2000 normal value (Figure 26). Also, Aktio station in west Greece, had its drier November on record, reporting only 9 mm accounting for 5.3 % of the 1971-2000 normal value.

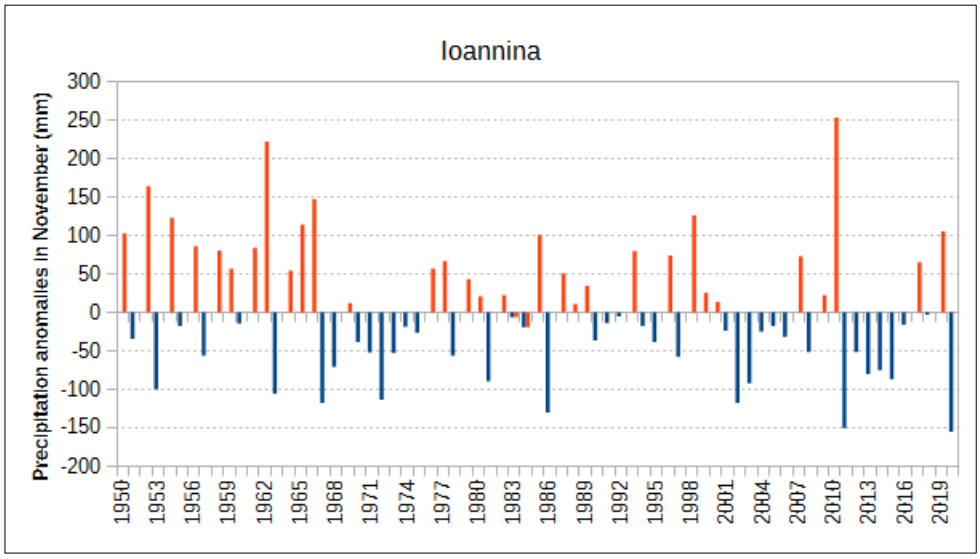

Figure 26. *Precipitation anomalies in November (mm)- Differences from 1971-2000 normal values; blue bars show precipitation values which are below the 1971-2000 average and red bars above this mean value.*

On the other hand, on 7 and 10 November 2020 Crete slammed by thunderstorms and heavy precipitation. Kastelli station in Crete had its wettest November on record, giving total monthly precipitation 415 mm accounting for 471 % of normal value (Figure 27). Also, Heraklio station recorded 177mm, ranking November 2020 as the 2nd wetter November since 1931. Precipitation anomalies in November with respect to normal values (1971-2000) are shown in Figure 28.

Impacts

- Prolonged rainfall caused flooding and damages in the water supply network, soil erosion and increased sediment loads.

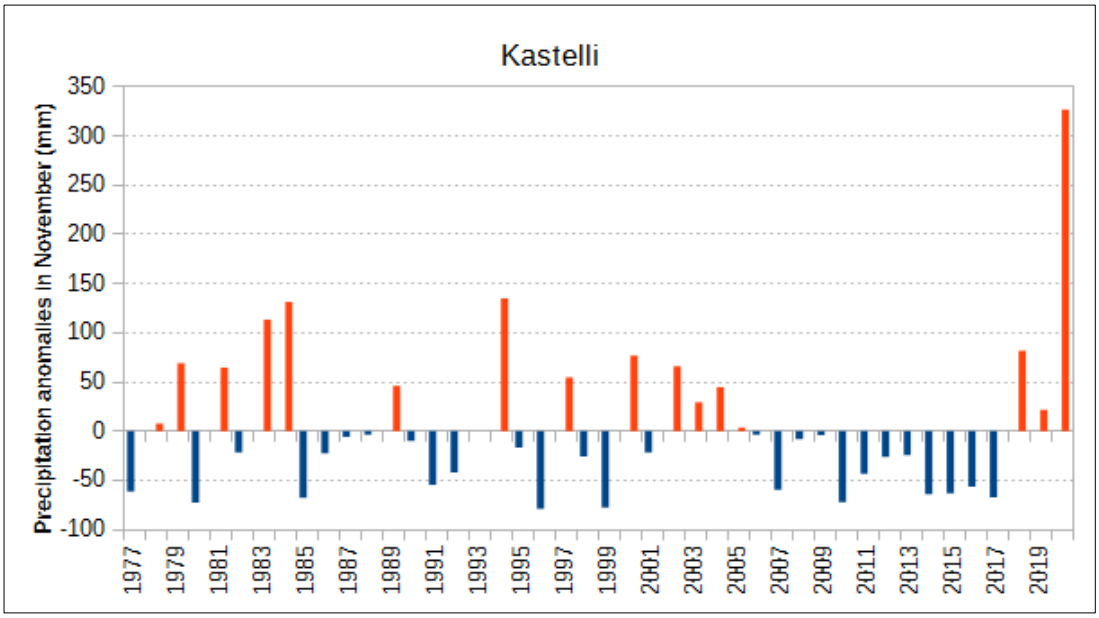

Figure 27. *Precipitation anomalies in November (mm)- Differences from 1971-2000 normal values; blue bars show precipitation values which are below the 1971-2000 average and red bars above this mean value.*

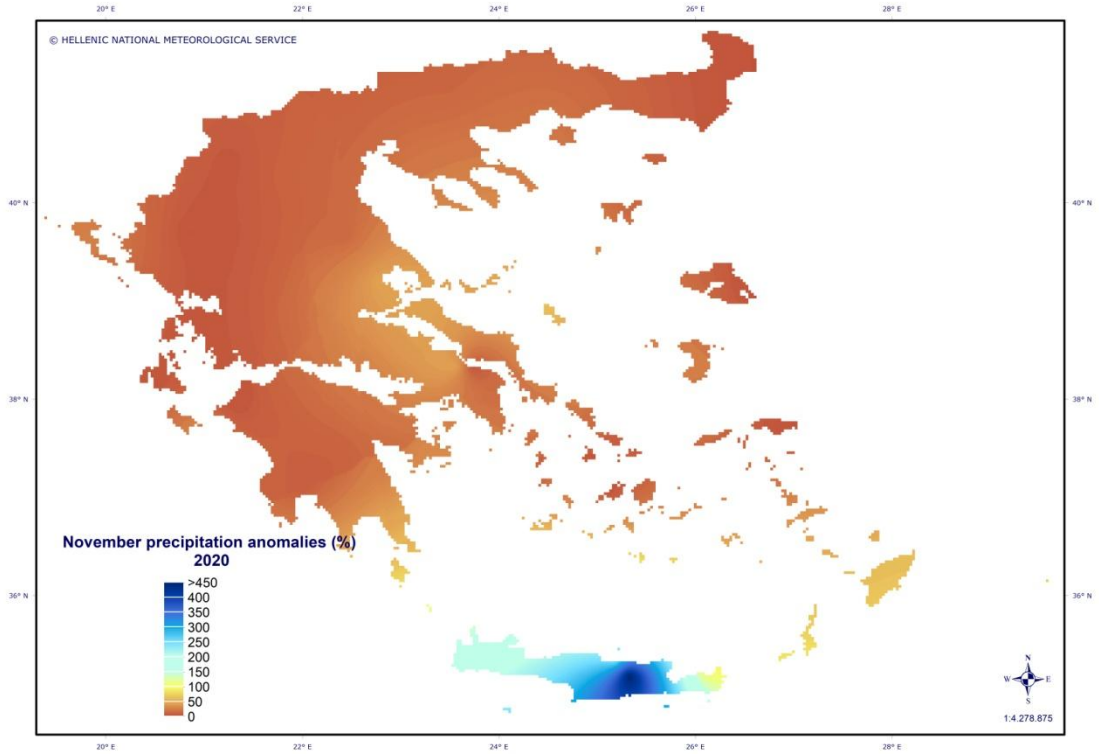

Figure 28. *November 2020 precipitation anomalies in Greece (compared to 1971-2000 climatology) given in percentages (%).*