

Effects of climate change on the Mediterranean Sea

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*But what if all this really was a salvation for the planet?
One fine morning the light bulbs do not turn on,
the refrigerator is off; banks and insurance companies fail;
money is no longer worth anything;
bicycles and clean energy are back in vogue;
it is finally stated: oil wars no longer have any reason to exist.
Imagination?
But if humanity does not come to its senses,
the apocalypse will really come.*

Dario Fo, 1997 Nobel Prize in Literature.

The drama of unstoppable global warming does not seem to raise excessive fears and worries among the majority of the planet's population. On the other hand, on the contrary, a certain number of citizens think that the problem is becoming a desperate obsession. Personally, I must admit that I have long been part of this tormented latter category. We don't know if it will be an apocalypse, but the data, and their trends, are certainly not reassuring. Compared to an average global warming of 1.5 °C, a 2.3 °C increase has been estimated for Europe. This is associated with fires, heat or cold waves, melting of Alpine glaciers (with a loss of 5 km³ of ice), damage to coastal structures (8000 km long for Italy alone).

The Mediterranean Sea, which normally has a temperature 4 °C higher than the Atlantic Ocean, has warmed three times more than other seas, while paradoxically the slowdown of the Gulf Stream¹ could lead to a significant drop in temperatures over the North Atlantic coasts (Great Britain, Scandinavia). The weakening of the Gulf Stream's mitigating effect could bring places on the eastern Atlantic coasts to temperatures close to those of the Canadian Atlantic coasts².

Figures 1 and 2, based on the *Copernicus Marine Service* data, show the sea surface temperature (SST) anomalies recorded in June and October 2022 in the Mediterranean Sea. These anomalies were influenced by the heatwaves in Europe that occurred in late spring/early summer and late summer/early autumn 2022. In particular, SST anomalies in certain areas of the Mediterranean Sea peaked at +5 °C above historical average values, such as the areas off the coasts of north-western Italy and south-eastern France and Spain.

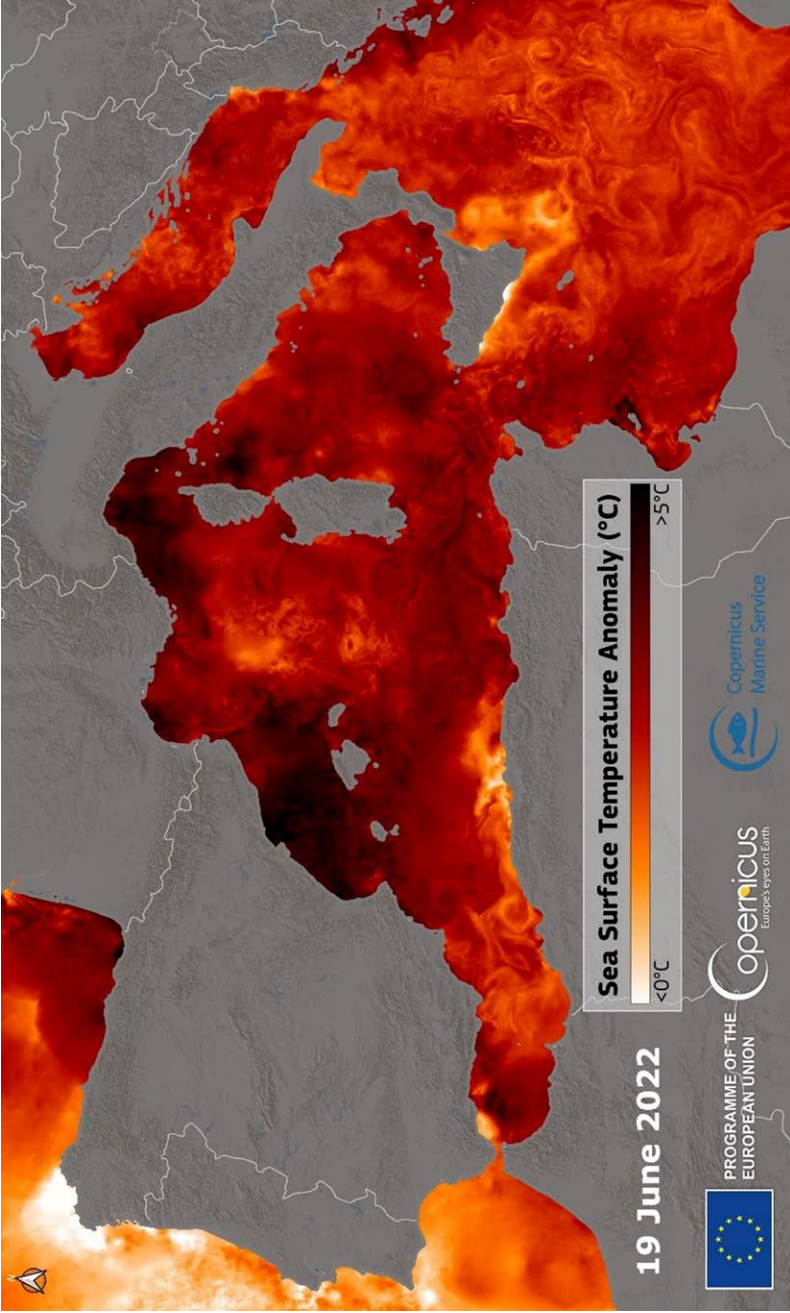


Figure 1 – Sea Surface Temperature anomaly in the Mediterranean, recorded on 19 June 2022. The data shows a thermal anomaly reaching +5°C along the Spanish, French and Italian coasts. Credit: *European Union, Copernicus Marine Service* [1].

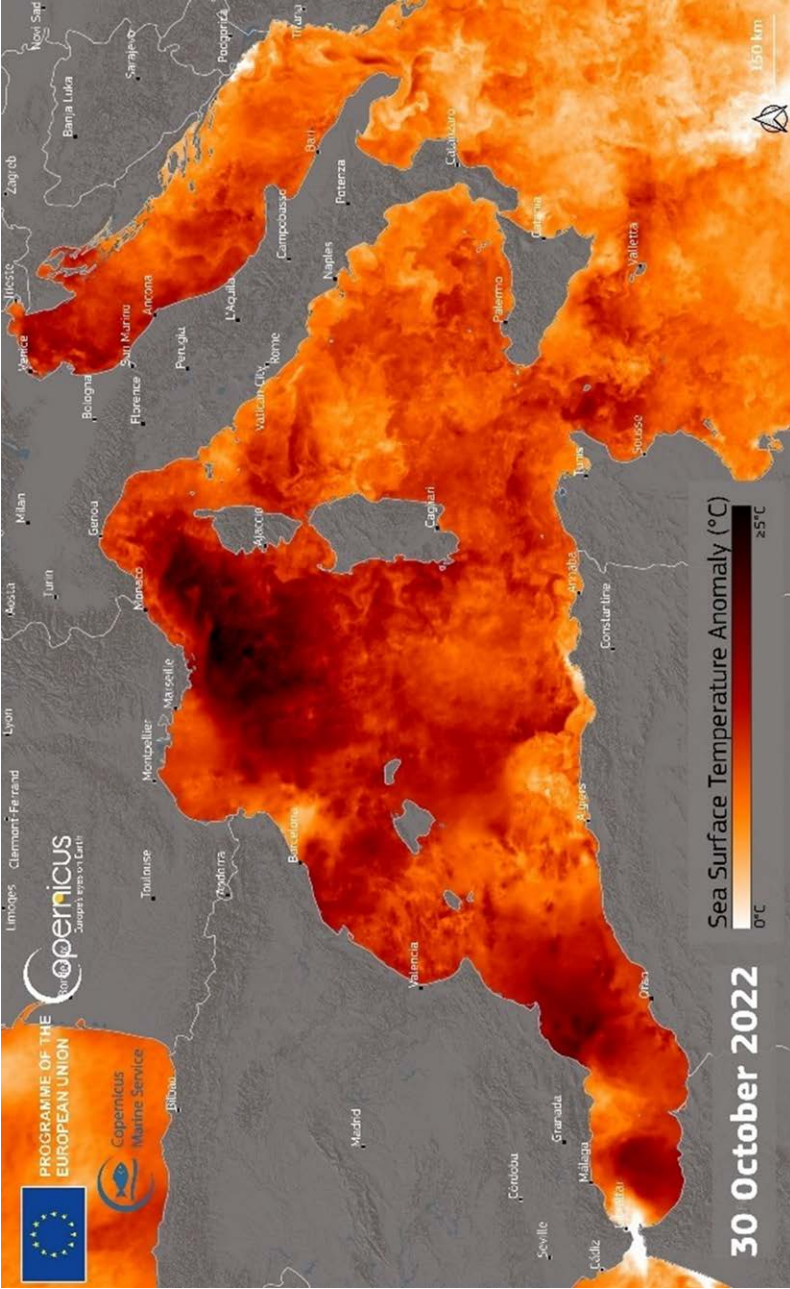


Figure 2 – Sea Surface Temperature anomaly in the Mediterranean, in October 2022. Credit: European Union, Copernicus Marine Service data [2].

Sea level rise projection – rcp 8.5
2099

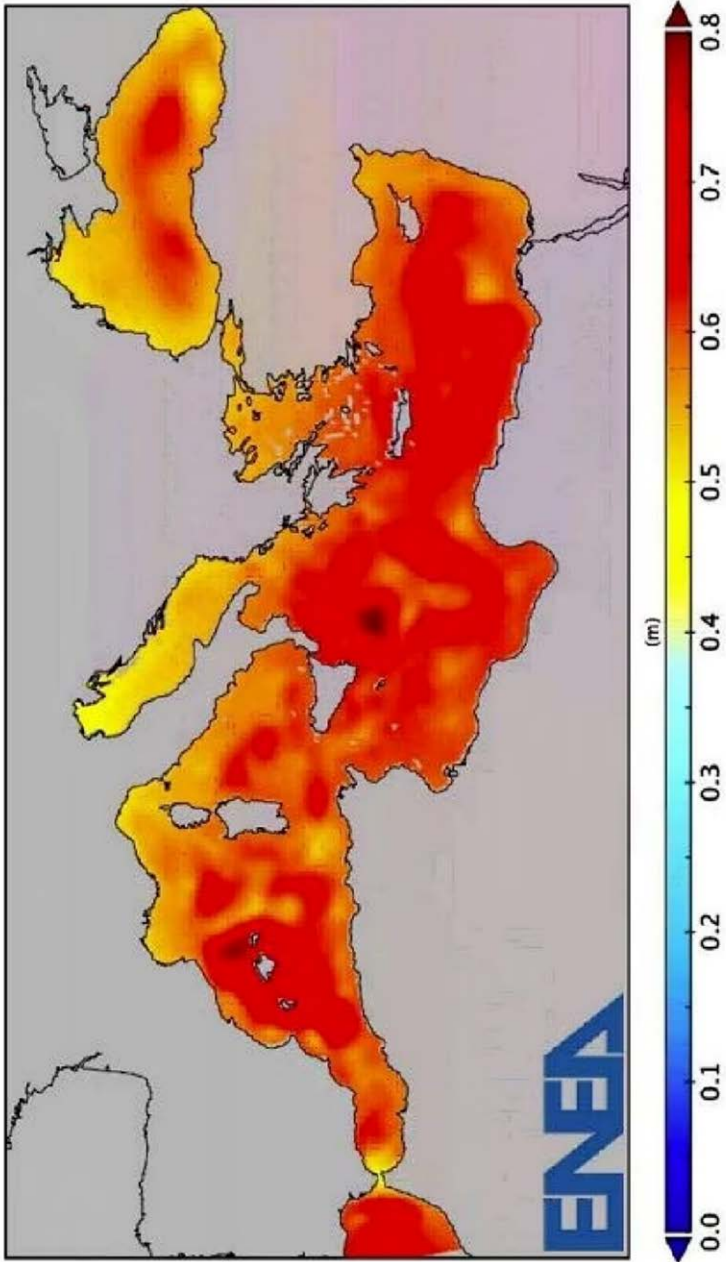


Figure 3 – Mediterranean Sea Level Rise Projections 2100 without cuts in greenhouse gas emissions. *ENEA Processing* [3] [4].

Anthropogenic climate change has contributed to the rise in the average level of the Mediterranean Sea by more than 25 centimeters in the last 130 years.

The particular configuration of this sea makes the still ongoing phenomenon more evident than in the oceans.

The Mediterranean is a semi-enclosed basin, with relatively high mountains in the western countries and low coasts in the south-eastern areas, with a not very high average depth (1430 m) and small extension (just 0.82 % of the total surface of seas and oceans). As a result, the water level rise, even just due to thermal expansion because of overheating, occurs more rapidly than in the oceans. As a result, water levels are rising faster than in the oceans, even if only due to thermal expansion because of overheating.

According to ENEA³ forecasts [4], if the current increase in global temperature is not reversed, in 80 years the level of the Mediterranean will be about 60 centimeters higher than today's level (figure 3).

The rising level of the Mediterranean has increasingly serious consequences that may lead to the disappearance of all current ports. Figure 4 shows the forecast for 2100 of the risk of floods and *storm surge*⁴ on the Italian coasts. [5]



Figure 4 – Scenario 2100 on the Italian coasts at risk due to the rising level Mediterranean: harbours at flooding risk or storm surges. ENEA elaboration [5].

The rise in the Mediterranean Sea level is, and will increasingly be, due essentially to:

- Melting ice: Greenland, Antarctica⁵;
- Melting glaciers: Alpine ones with an ice loss of 5 km³ so far;
- Low pressures: intermittent, *Medicane*⁶.

In particular, in the Arctic region, climate change has had a considerable effect on sea level due to: warming of the Arctic Ocean; declining of the Greenland ice sheet; melting of glaciers in Alaska and the Svalbard archipelago; thawing of permafrost in Siberia and increased freshwater flow from Arctic rivers [7].⁷

Regarding the Alpine region, an increase in the average air temperature of about 2 °C has been observed between the end of the 19th century and the beginning of the current century, more than the double that observed for the entire Northern Hemisphere (0.8 °C). Therefore, it is estimated that since 1850, glacial areas in the Alps have decreased by about half. Since the 1980s, the reduction rate has accelerated [8, 9].

While the melting phenomena cause permanent increases in sea level, low-pressure systems, particularly Mediterranean cyclones known as *medicane*s (Figure 5) produce sea level rises that lead to significant flooding well beyond coastal areas, that gradually shrink once the phenomenon has ceased.

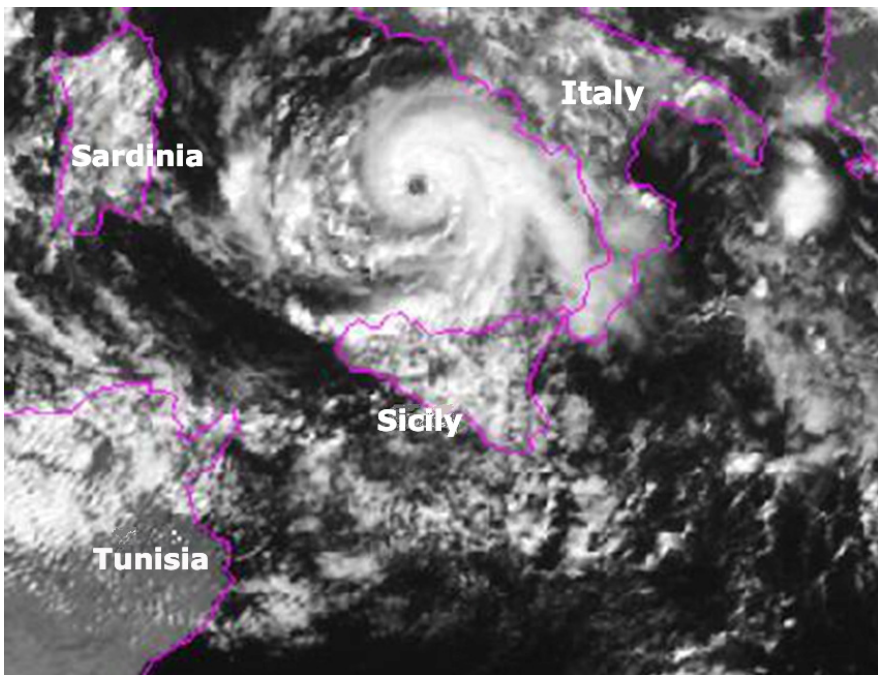


Figure 5 – Medicane *MEDIterranean hurricane*: Mediterranean cyclone with characteristics like tropical cyclones, the eye of the cyclone is clearly visible in the center of the spiral. In the figure Mediterranean Hurricane *Cornelia* (October 9th, 1996). Source *Nasa Dundee* [11] [12].

Other side effects of increased seawater temperature include:

- *Seawater Acidification*⁸; it is caused by the absorption of excess CO₂ produced by human activities; in the Mediterranean, we can observe today a pH values range from 8.13 to 7.95. At values below 7.8, many marine species could face extinction [13].

Marine ecosystems could "give" much more if correctly used.

- *Decrease in biodiversity*; in the Mediterranean are estimated to be 17 000 species, corresponding to 7,5 % of the world's marine fauna. However, these numbers can rapidly decline due to climate change and the increasing presence of micro and macro plastics in the waters.

The balance of ecosystems is threatened even by the disappearance of a single species.

*Nature is balanced like a house of cards:
fragile, each card supports the other, if one falls.....*

References

- [1] <https://www.copernicus.eu/en/media/image-day-gallery/sea-surface-temperature-mediterranean-affected-heatwave-southwestern-europe>
- [2] <https://www.copernicus.eu/en/media/image-day-gallery/sea-surface-temperature-anomaly-mediterranean-0>
- [3] <https://www.media.enea.it/en/press-releases-and-news/years-archive/year-2022/environment-from-enea-new-model-to-estimate-mediterranean-sea-level-change.html>
- [4] Sannino G., Carillo A., Iacono R. *et al.* (2022) - *Modelling present and future climate in the Mediterranean Sea: a focus on sea-level change*. Clim. Dyn. 59, 357–391.
- [5] <https://www.italiaclima.org/coste-italiane-a-rischio-per-linnalzamento-del-mediterraneo-intervenire-subito/>
- [6] <https://www.nhc.noaa.gov/surge/#TIDE>
- [7] <https://articomostra.cnr.it/index.php/sezione-1/livello-dei-mari-e-ghiaccio>
- [8] <https://www.irpi.cnr.it/focus/ghiacciai-italiani/>
- [9] Nigrelli G, Lucchesi S, Bertotto S, Fioraso G, Chiarle M. 2014. Climate variability and Alpine glaciers evolution in Northwestern Italy from the Little Ice Age to the 2010s. Theoretical and Applied Climatology. DOI:10.1007/s00704-014-1313-x.
- [10] Svensson P. (2023) – *L'uomo con lo scandaglio*. Iperborea, Milano
- [11] <http://earthobservatory.nasa.gov/>
- [12] https://commons.wikimedia.org/wiki/File:Mediterraneanhurricane_1996_uragano_mediterraneo_ciclone_tropicale_tropical_cyclones.jpg#metadata
- [13] Fasano G. (2003) - *L'acqua negli oceani nei mari* in Benicasa F. (ed) *L'acqua sulla terra*, Quaderno n. 13 Collana Tecnico-scientifica CNR-IBIMET, Firenze

Endnotes

¹ Gulf Stream: warm ocean current that originates in the Gulf of Mexico, at 27 °C and, through the Atlantic, and reaches Northern Europe (with a maximum flow rate of 74 million m³/s), with a temperature water at 20 °C, mitigating the climate of its coasts. [ED. =Editor's Note].

² For example, consider two sites at the same latitude, about 52° N, such as London, whose average annual temperature is about 13 °C, and Labrador City, a small town near the Canadian east coast, whose average annual temperature is -3 °C; without the effect of the Gulf Stream, London might find itself living with a temperature of -3 °C. [ED].

³ ENEA former *Ente Nazionale Energia Alternativa* actually *Italian National Agency for New Technologies, Energy and Sustainable Economic Development*. [ED].

⁴ Storm surge is a coastal flooding phenomenon caused by an anomalous rise in sea level, above the predicted astronomical tide, generated by a storm (low pressure weather systems) Storm surge is primarily caused by the strong onshore winds of a hurricane or tropical storm. The wind circulation around the eye of a hurricane causes a vertical circulation in the ocean. While in deep water, there is no indication of storm surge because there is nothing to interfere with this circulation. However, once the storm reaches the shallower waters near the coast, the vertical circulation is disrupted by the ocean bottom. The water can no longer move downward, so it begins to move upward and inland, resulting in storm surge [6]. [ED],

⁵ It can be noted that the Arctic polar cap is not mentioned, as it is floating; unlike the Antarctic ice pack, it does not rest on land. The melting ice from the Arctic cap causes an uplift of the cap while leaving sea level virtually unchanged. Similarly, the summer reduction of polar ice pack has a negligible effect, as the ice that melts is floating and thus in equilibrium with sea level [7]. [ED].

⁶ The term *Medicane* is a contraction of the locution “Mediterranean Hurricane” (also known as TLC: *Tropical Like Cyclone*); it indicates a super-low-pressure system that produces a quasi-tropical cyclone in the Mediterranean characterized as follows:

- Decrease in the barometric pressure trend by 1 hPa/hour for at least 24 hours.
- Superadiabatic lapse rate even above 30° N latitude.
- Wind force 12 (*hurricane-force* >118 km/h or 65 kn).
- Average rainfall rate up to 500 mm/h.
- Diameter 200÷400 km.
- Duration 24÷48 hours.

⁷ Since the *thermal equilibrium* of the 1970s and 1980s, when the climate was colder than it is today, ice loss has increased by about 20 billion tons each year. [7] [ED].

⁸ It has been observed that in the last two centuries, due to increasing CO₂ emissions, oceanic pH has dropped from 8,2 to 8,1; currently, the oceans are about thirty percent more acidic (the more accurate expression is less basic, as acidity begins with a pH below 7) than they were before the Industrial Revolution. If this trend continues at the same rate, it is hypothesized that by the end of this century, the pH will decrease to 7,8. Therefore, at least one third of marine species would disappear, and coral reefs would be wiped out in just a few decades [10]. [ED].