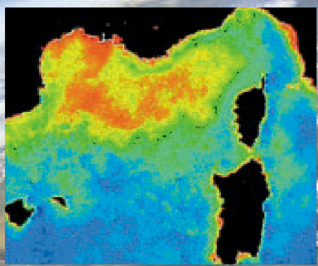
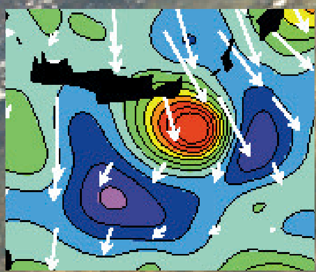
Observing the oceans from space

Satellites monitor the Mediterranean pulse

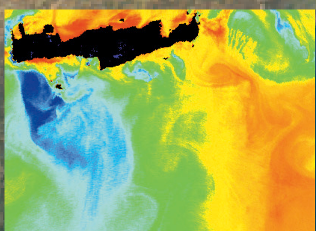
Jason-1



Rhone Plume (Ocean colour)



Eddy abroad Crete (altimetry)



Eddy abroad Crete
(Sea Surface Temperature)

Throughout history, the Mediterranean has been a cradle for civilizations and a crossroads between peoples.
But today it is a sea under threat. With nearly 400 million people living along the Mediterranean coastline, intense shipping traffic and a booming tourist industry, its ecosystems are under increasing pressure from human activities. As a result, the Mediterranean's natural equilibrium, both at sea and on the shore, is in danger of collapsing. It also exerts a strong influence on the climate and water resources of the countries bordering it.

Ocean-observing satellites are helping to further our understanding of the Mediterranean and improve our forecasting capability through ocean models and research programmes. Tomorrow, this kind of knowledge should enable us to devise more effective solutions —and even help us to prevent problems before they arise.

National Aeronautics and Space Administration
Jet Propulsion Laboratory

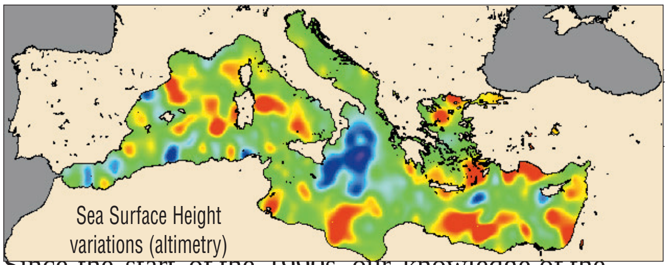
CENTRE NATIONAL D'ETUDES SPATIALES

A satellite's eye view

Satellites continuously measure sea level, ocean colour and temperature to keep the Mediterranean under close observation.

Altimetry

A satellite altimeter measures the round-trip time of a radar signal between the satellite and the ocean surface. This technique is used to measure sea level, which makes it possible to observe currents and current variations at the ocean surface, and to monitor mean sea level, wave height, wind speed and tides.

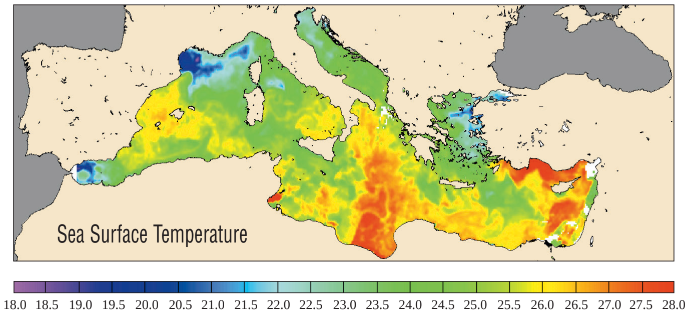


Since the start of the 1990s, our knowledge of the oceans has made giant strides thanks to altimetry data collected by the European Space Agency's ERS satellites and above all by TOPEX/POSEIDON, developed jointly by NASA and the French space agency CNES. Envisat (ESA) and Jason-1 (CNES/NASA) will continue to measure ocean parameters into the next century, providing altimetry data in real time.

Sea surface temperature

Sea surface temperature, observed in the infrared portion of the spectrum, is a key factor in ocean dynamics. It strongly influences atmospheric water vapour content and temperature, and has an important effect on weather conditions.

Sensors flown on satellites such as NOAA and ERS have provided uninterrupted measurements of sea surface temperature since 1978. Many other satellites are scheduled to continue this mission in the years ahead.



Ocean colour

Satellites observe the ocean at visible wavelengths and can detect colour variations caused mainly by phytoplankton and sediments.

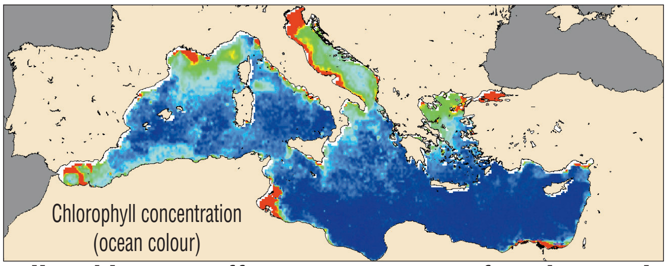
CZCS (NASA, 1978-1986), POLDER (CNES, 1996-1997) and then SeaWiFS (NASA, 1997) have observed ocean colour variations for several years. MERIS (on ENVISAT) and POLDER-2 in particular will soon be ready to take over this mission.

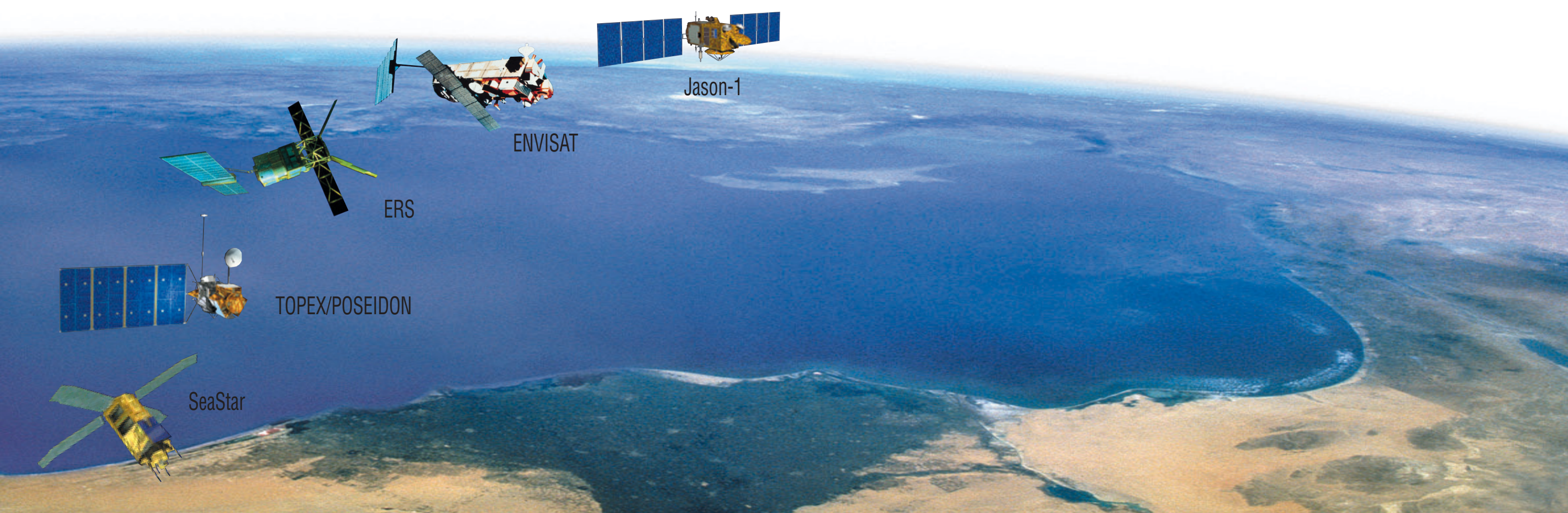
Other sensors

Other satellite-based instruments observing the oceans include:

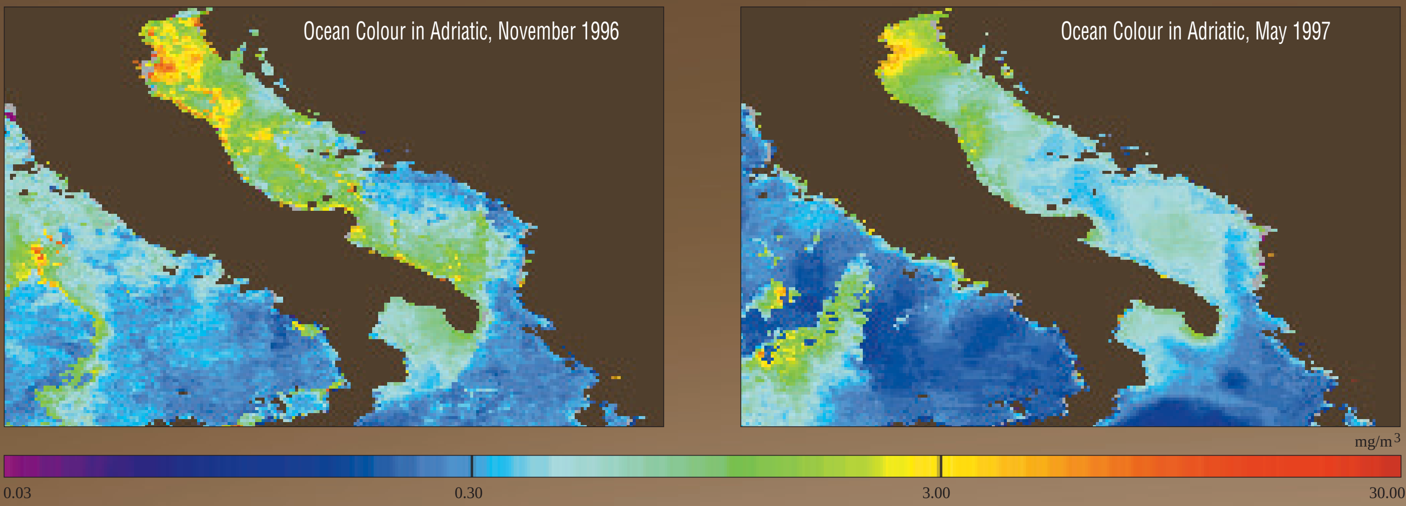
- scatterometers (for measuring surface winds),
- synthetic aperture radar (for measuring peaks and troughs in the sea surface, and waves).

Tomorrow, instruments capable of measuring salinity will enable more effective monitoring of another vital parameter affecting ocean dynamics.



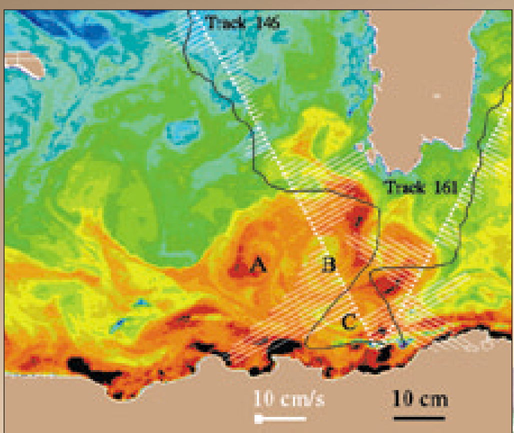


The Mediterrane



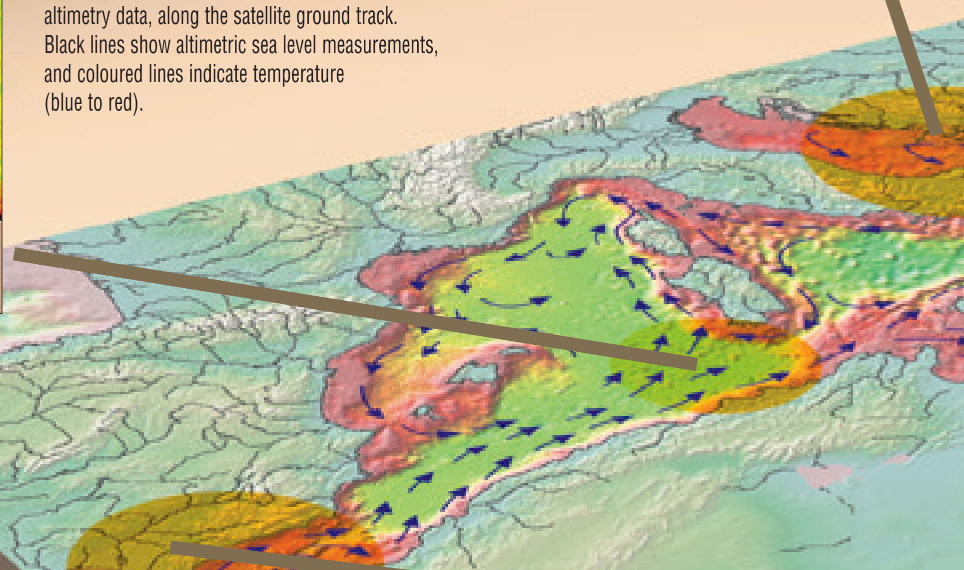
Adriatic seasons

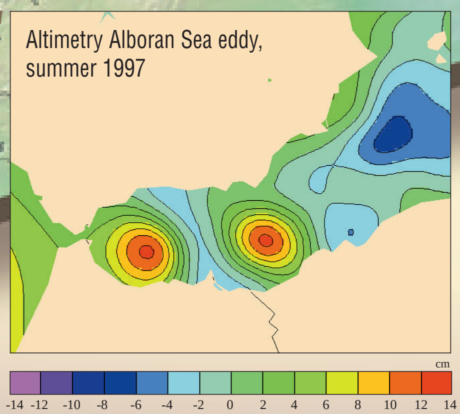
Measuring ocean colour shows how much silt is being deposited at the mouth of a river, as this is where higher concentrations of phytoplankton and sediments are found. Similar concentrations are also located along the coastline and near Gibraltar, whereas phytoplankton does not proliferate as much in deeper waters. Satellites track these concentrations as they evolve through the seasons.



Sea surface temperature and altimetry
Algerian current eddy

White lines show current velocity, derived from altimetry data, along the satellite ground track. Black lines show altimetric sea level measurements, and coloured lines indicate temperature (blue to red).

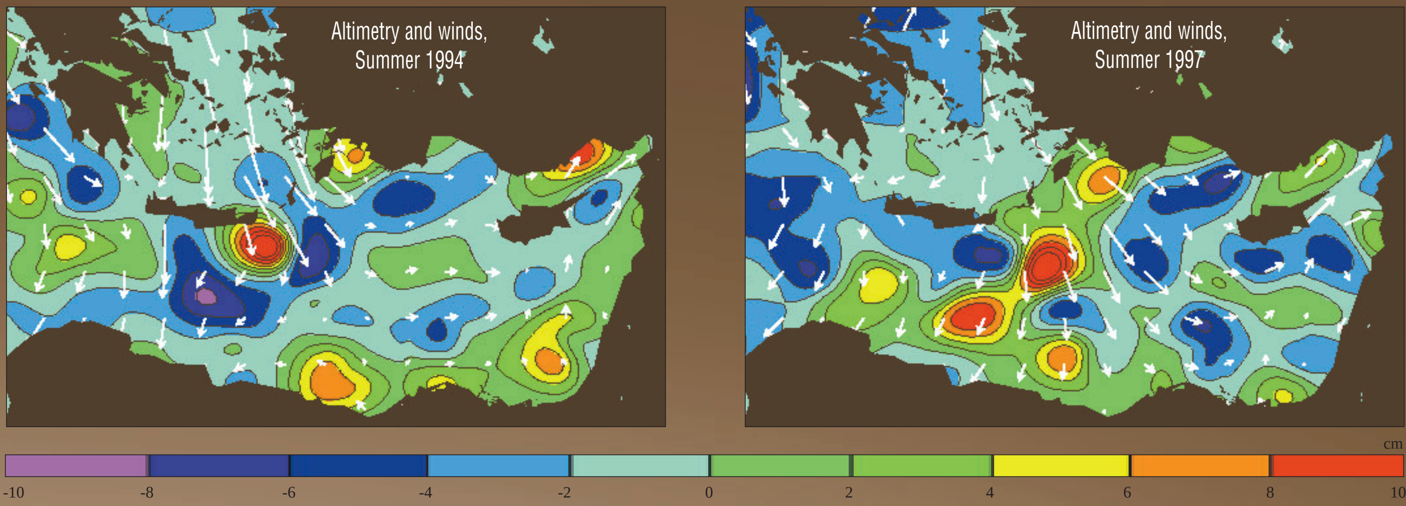




Monitoring ocean circulation

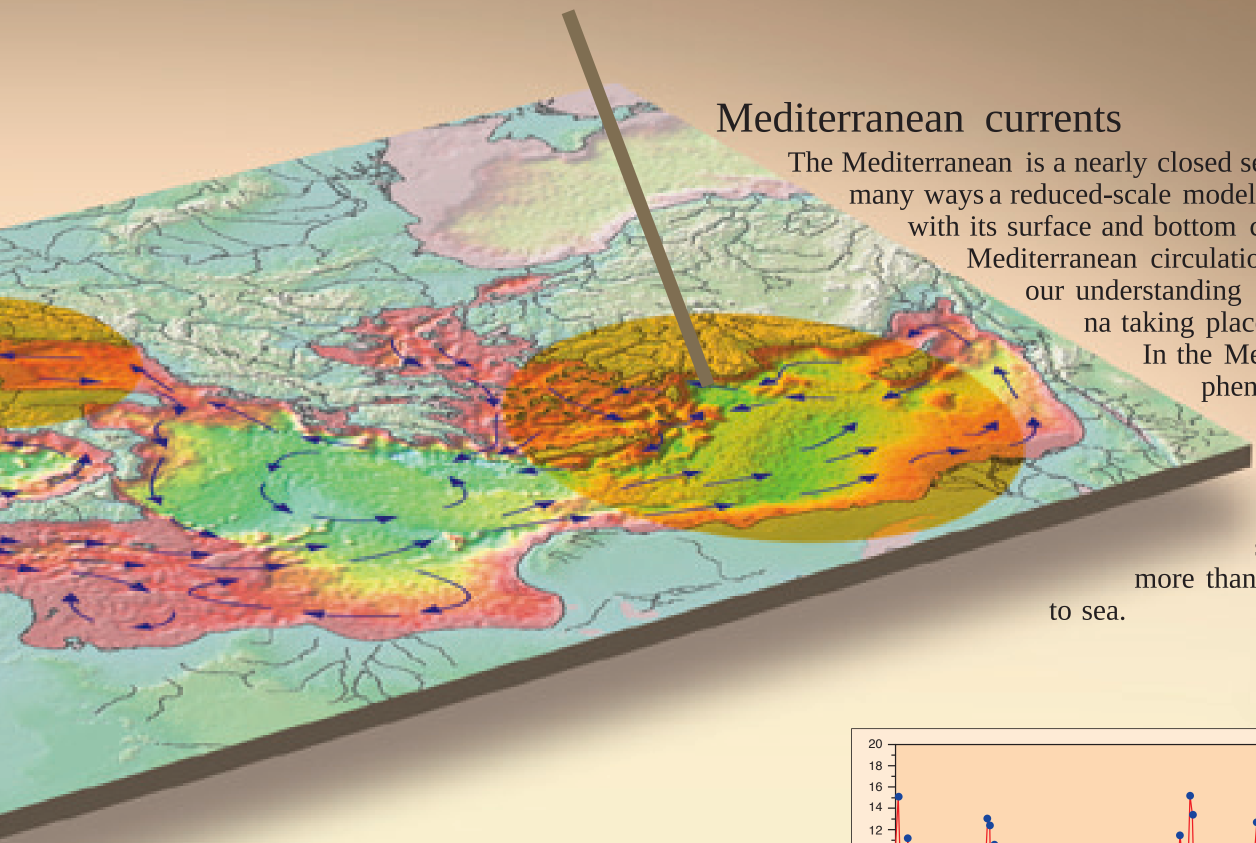
Large volumes of water flow between the Atlantic Ocean and the Mediterranean through the Strait of Gibraltar: warm and salty deep water flows out of the Mediterranean, while cold, less salty surface water enters from the Atlantic. On its way through the Alboran sea, the Atlantic jet generates two anticyclonic eddies. Satellites continuously monitor the variability and intensity of these eddies.

an through time



An eddy blown by the wind

The Ierapetra gyre, south-east of the island of Crete, varies with the seasons, reaching peak intensity in summer. This anticyclonic gyre may forms as a result of interactions between the summer winds and the relief on Crete. Satellites have revealed big variations of the gyre, which fails to appear some years, probably as a result of changing wind patterns.

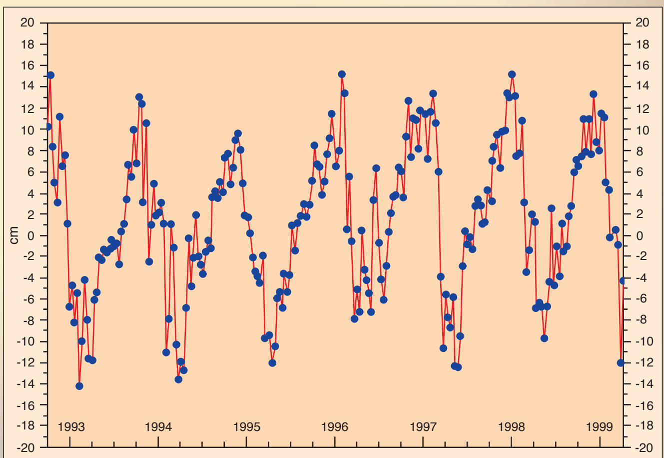


Mediterranean currents

The Mediterranean is a nearly closed sea. It is also in many ways a reduced-scale model of the global ocean, with its surface and bottom currents. Studying Mediterranean circulation helps to improve our understanding of similar phenomena taking place on a global scale. In the Mediterranean, such phenomena are easier to measure because we rarely need to go further than 50 kilometres from shore, and never more than 300 kilometres out to sea.

Mean sea level variations

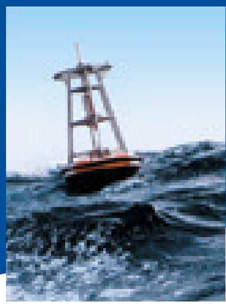
The main factors affecting mean sea level in the Mediterranean are the inflows and outflows through the Strait of Gibraltar, and evaporation and precipitation. Since 1992, TOPEX/POSEIDON has observed interannual and seasonal variations in mean sea level, with peaks in October and low points in March. These variations are out of step with the atmospheric seasons because of the thermal inertia of the sea.



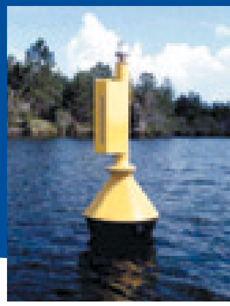
Observing...

In situ

Sensors at sea or on shore provide in situ point measurements, at a particular moment in time and space, that complement and validate satellite-derived data. By acquiring readings at any depth, such sensors allow us to generate a three-dimensional picture of the ocean, whereas satellites essentially observe the sea surface. Satellite-based systems such as Argos, for example, make it possible to retrieve data in near-real time.


Moored Buoy

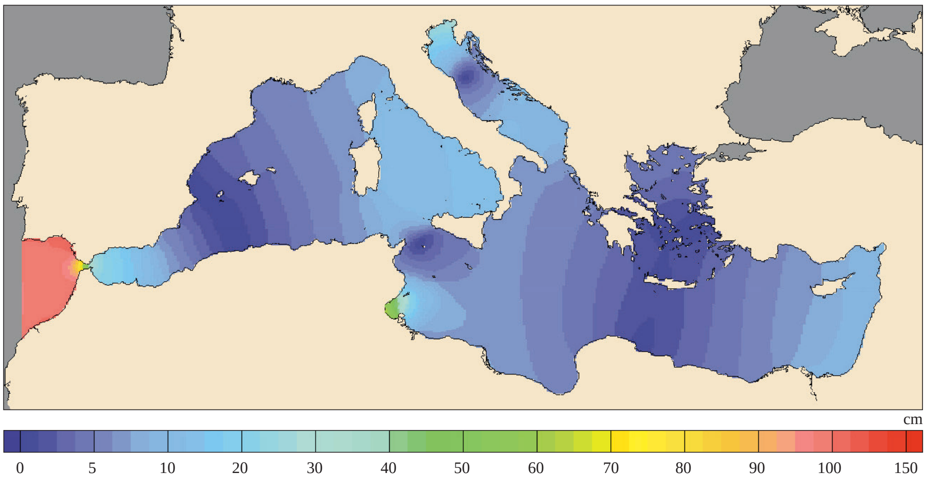

Tide Gauge


Drifting Buoy

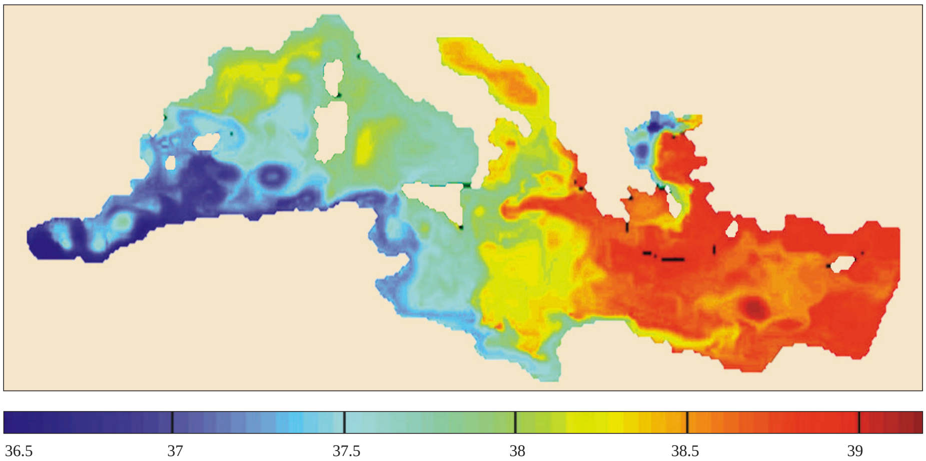
... to predict

Modelling

Models help us to predict ocean variations and how oceans interact with climate by adding a fourth dimension—time. We can also feed sea surface data obtained by satellites into models to reconstruct what is happening in the ocean depths. Ocean models incorporate physical or biological parameters, or may combine the two.



Modelled Amplitude (in cm) of the principal (M2) lunar tide in the Mediterranean



Modelled Salinity at 50 m depth in the Mediterranean on Nov. 4, 1993

Assimilation

Satellite observations of the Mediterranean coupled with in situ measurements and assimilated into models are a key component of European Union research programmes. These programmes are studying the Mediterranean from all angles to discover its underlying mechanisms so that it can be modelled, thus paving the way for improved forecasting and more effective management of this sea and its coastlines.

The Mediterranean Forecasting System Pilot Project (MFSPP), for example, is a first step towards developing an operational forecasting system for the Mediterranean, based on altimetry data, sea surface temperature and ocean colour measurements, and a range of other data sources. MFSPP has benefited from research on previous programmes such as MATER (Mass Transfer and Ecosystem Response), the main aim of which was to study the Mediterranean ecosystem.

Predicting to prevent

The advent of satellite-based and in situ ocean-observing systems, ocean models and data assimilation methods, and European research programmes studying the Mediterranean have all made ocean forecasting possible. Future ocean forecasting systems will help us to:

Forecast sea state and weather conditions

Wave height and wind speed measurements integrated into marine meteorology models allow us to forecast sea state.

Conserve fish stocks

Observing and modelling ecosystems should help to gain a closer insight of the movements of fish species, making it easier to conserve and control stocks.

Track pollutants

Domestic wastewater, industrial and household waste—some biodegradable, some less so—vehicle emissions, oil flushed from ships' tanks, and other kinds of pollution all find their way into the sea, where they are transported by the currents. Pollutants then accumulate in deep waters or are washed up on the shore. Mediterranean flora and wildlife, already declining in numbers and under pressure due to overfishing, are suffering the consequences.

Develop and protect the coastline

Improving our knowledge of how currents affect coastal engineering projects, and the impact of phytoplankton concentrations and sea temperature on fish stocks and tourism is vital to ensure sustainable development and effective protection of the Mediterranean coastline.

Anticipate climate change

Coupled ocean-atmosphere models can tell us several months ahead how climate will evolve on a global scale. This capability is of prime importance for farming and tourism along the southern coastline of the Mediterranean, where rational management of water resources is crucial.

For more information:

MFSPP: http://sirio.cineca.it/~mfspp000/
MEDIAS:http://medias.meteo.fr/
Altimetry: http://www-aviso.cnes.fr
Ocean colour: http://seawifs.gsfc.nasa.gov/; http://polder@www-projet.cnes.fr:8060/
Sea surface temperature: http://podaac.jpl.nasa.gov/sst/

Sources:

CLS, CNES, CNRS/LEGOS,ESA, IFA/CNR, IFREMER, NASA, NOAA/Scripps Institution of Oceanography.

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