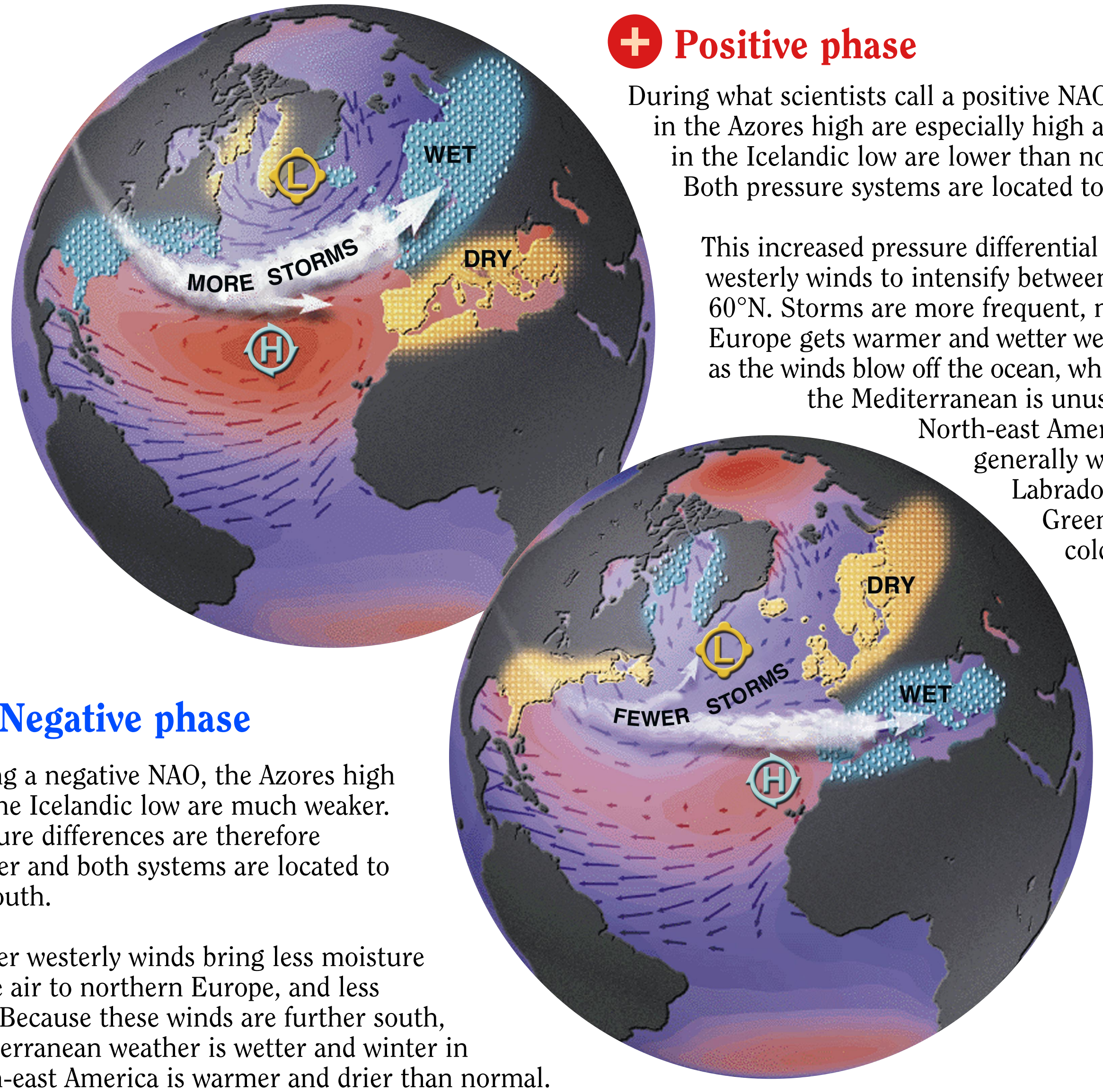
The North Atlantic Oscillation

One of the most remarkable recurring atmospheric phenomena over the Atlantic makes its presence felt in winter. Called the North Atlantic Oscillation (NAO), it is driven by pressure differences between a high-pressure system over the Azores and a low-pressure system over Iceland, with which the ocean interacts.

Positive phase

During what scientists call a positive NAO, pressures in the Azores high are especially high and pressures in the Icelandic low are lower than normal. Both pressure systems are located to the north.

This increased pressure differential causes westerly winds to intensify between 50° and 60°N. Storms are more frequent, northern Europe gets warmer and wetter weather as the winds blow off the ocean, while the Mediterranean is unusually dry. North-east America is generally wet, while Labrador and Greenland are cold and dry.

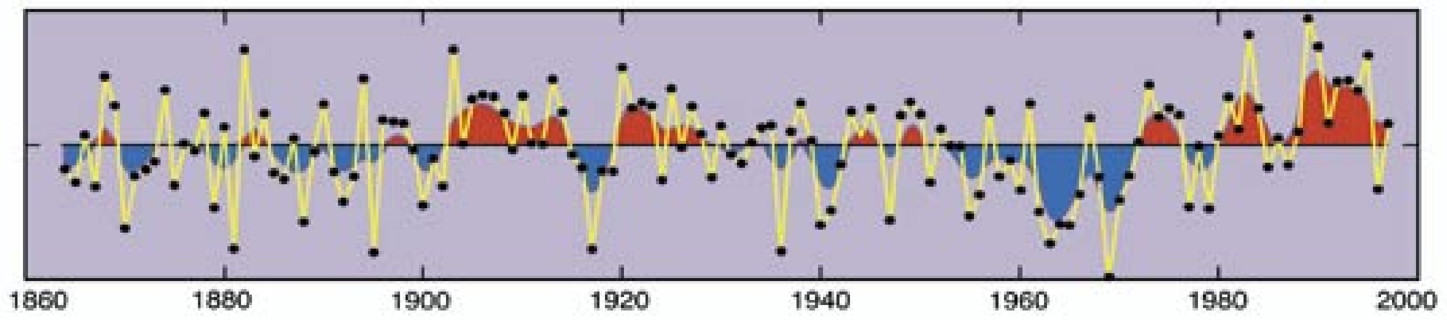


Negative phase

During a negative NAO, the Azores high and the Icelandic low are much weaker. Pressure differences are therefore smaller and both systems are located to the south.

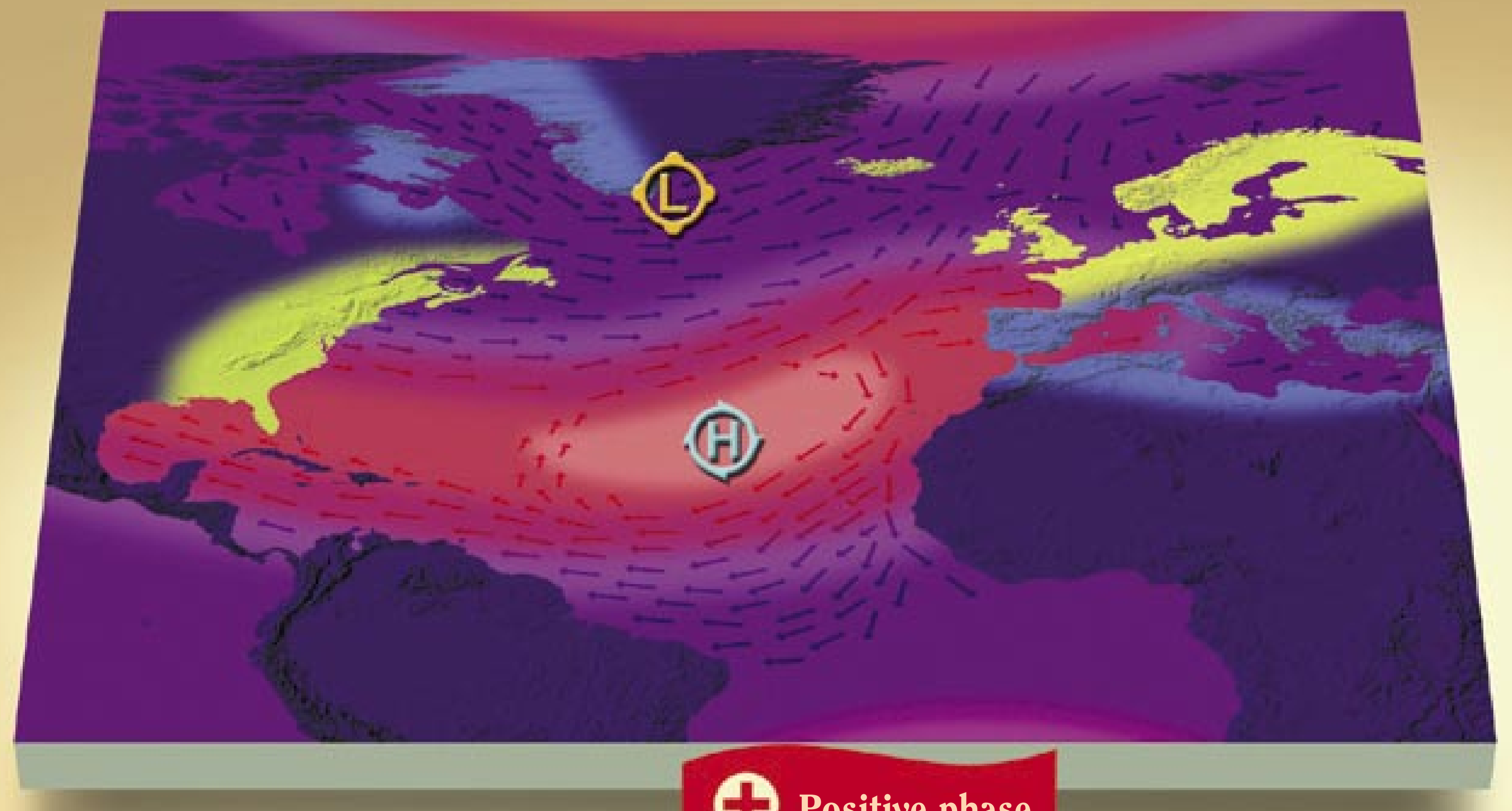
Weaker westerly winds bring less moisture in the air to northern Europe, and less heat. Because these winds are further south, Mediterranean weather is wetter and winter in North-east America is warmer and drier than normal.

Pressure over the Northern Atlantic, with wind directions

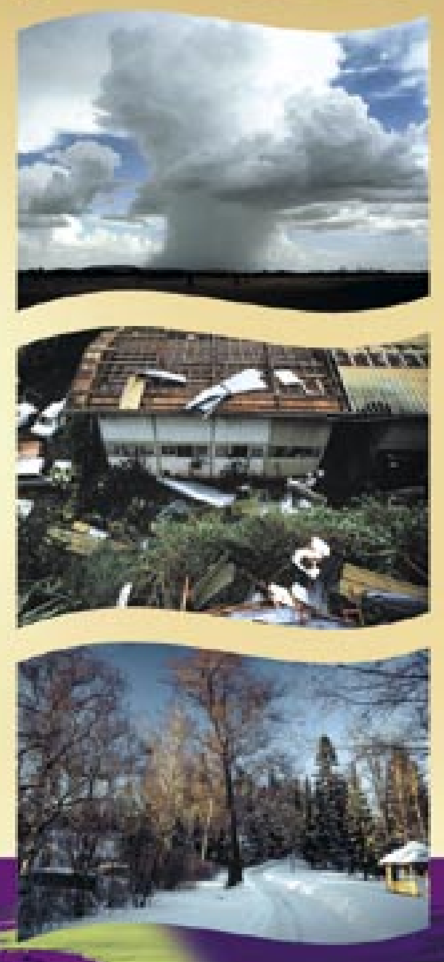


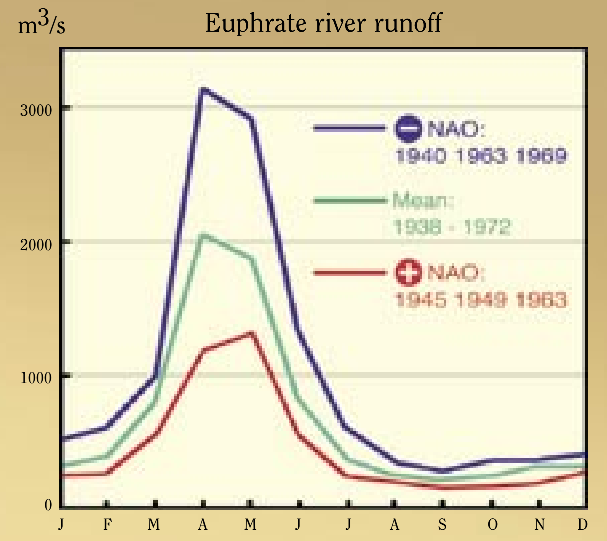
Positive (red) and negative (blue) phases of the NAO over the last 150 years

Two sides to the story



Negative phase

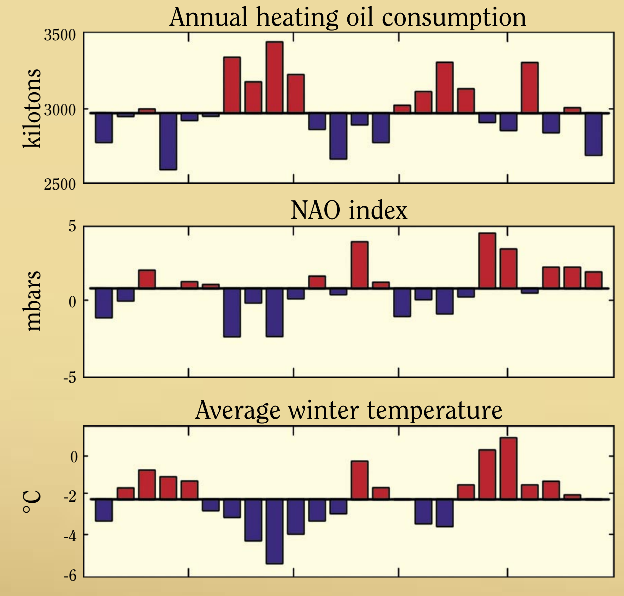


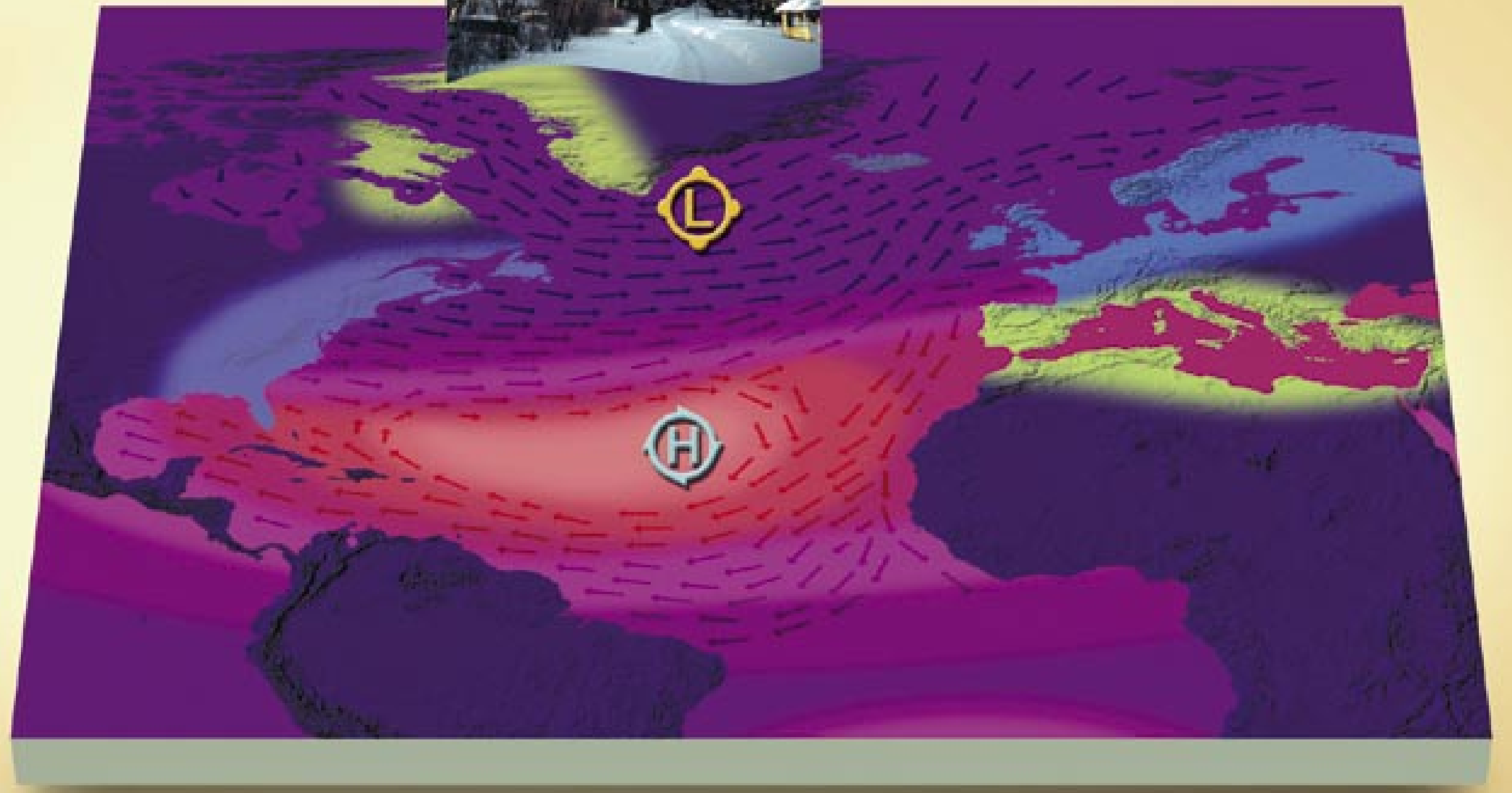


Throughout the Middle East, water resources are a priceless asset. The discharge of the Euphrates, one of the region's principal rivers, varies with the North Atlantic Oscillation, slowing during a positive NAO and flowing faster during a negative NAO. So predicting NAO events and accompanying precipitation will help to manage water resources more efficiently.

Positive phase

Winter temperatures in Norway vary in step with the NAO. These variations can mean a difference of 10 to 15% in fuel oil consumption for heating. Better prediction will mean better management of fuel stocks.



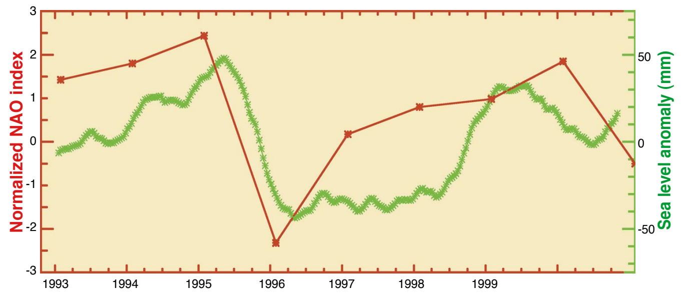


Combining the close-up view with the big picture

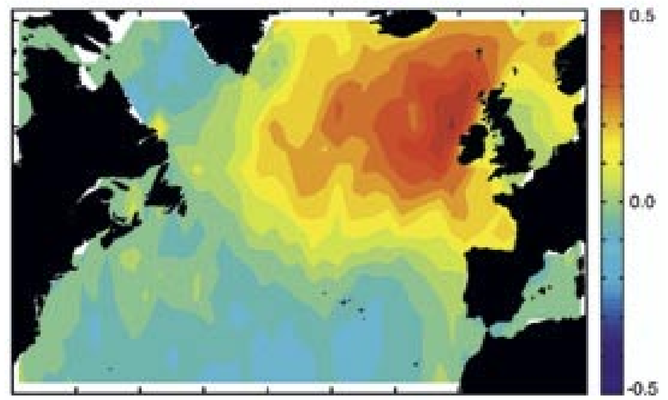
Since the middle of the 19th century, the North Atlantic Oscillation has been measured from land and, increasingly, at sea. In recent years, satellites have made it possible to monitor this phenomenon continuously and systematically.

NAO as seen by altimeters

The fluctuations of the North Atlantic Oscillation and the temperature variations that go with it lead to changes in sea level. The ocean reacts to shifts in the prevailing winds, which drive the currents, waves, sea surface temperature… Temperature swings also cause sea surface height to vary. We can observe these variations using altimetry satellites such as TOPEX/POSEIDON and Jason-1.
All these measures can thus serve as indicators for NAO phases and be used in climate prediction models.



Sea level variations over the North Atlantic (seasonal and turbulent variation removed) computed from TOPEX/POSEIDON. NAO index variation is also reported.

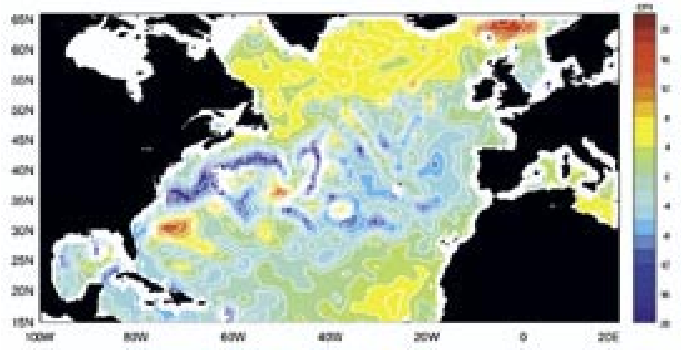


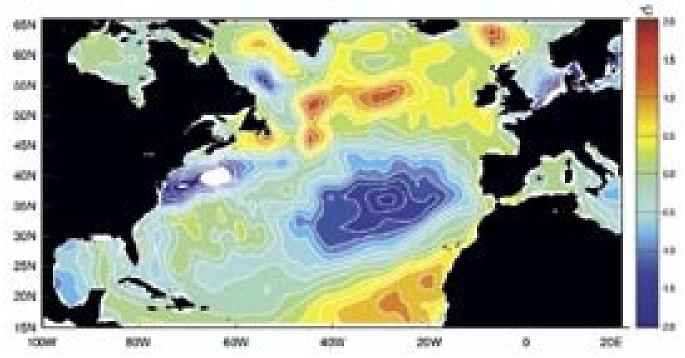
Wave heights in winter are very sensitive to pressure variations over the North Atlantic. West of Ireland, for example, waves are significantly higher when the NAO index is positive (in metre per NAO index unit).

Other satellites observe sea surface temperature and wind speed, from which we can derive information about heat exchanged between the ocean and atmosphere. By combining these data acquired over relatively long periods with in-situ measurements deeper down, we are beginning to understand what role the ocean plays in the NAO.

1995 - 1996, a sharp variation

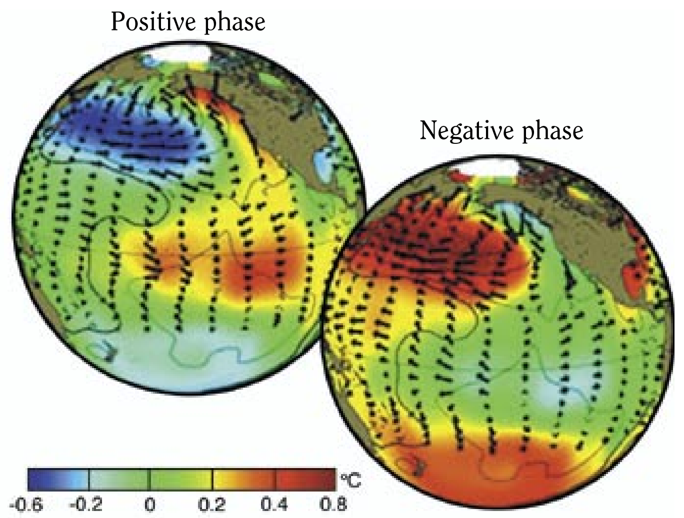
Between the winters of 1995 and 1996, sea level rose around Iceland and fell further south. The NAO index for the same period also varied sharply. This swing causes the westerly winds around Iceland to weaken, which in turn leads to rising temperatures in the upper layers of the ocean. In-situ measurements suggest that such temperature fluctuations could be largely responsible for variations in sea level.


Sea surface height variation between the winters of 1996 and 1995


Variation in sea surface temperature between the winters of 1996 and 1995

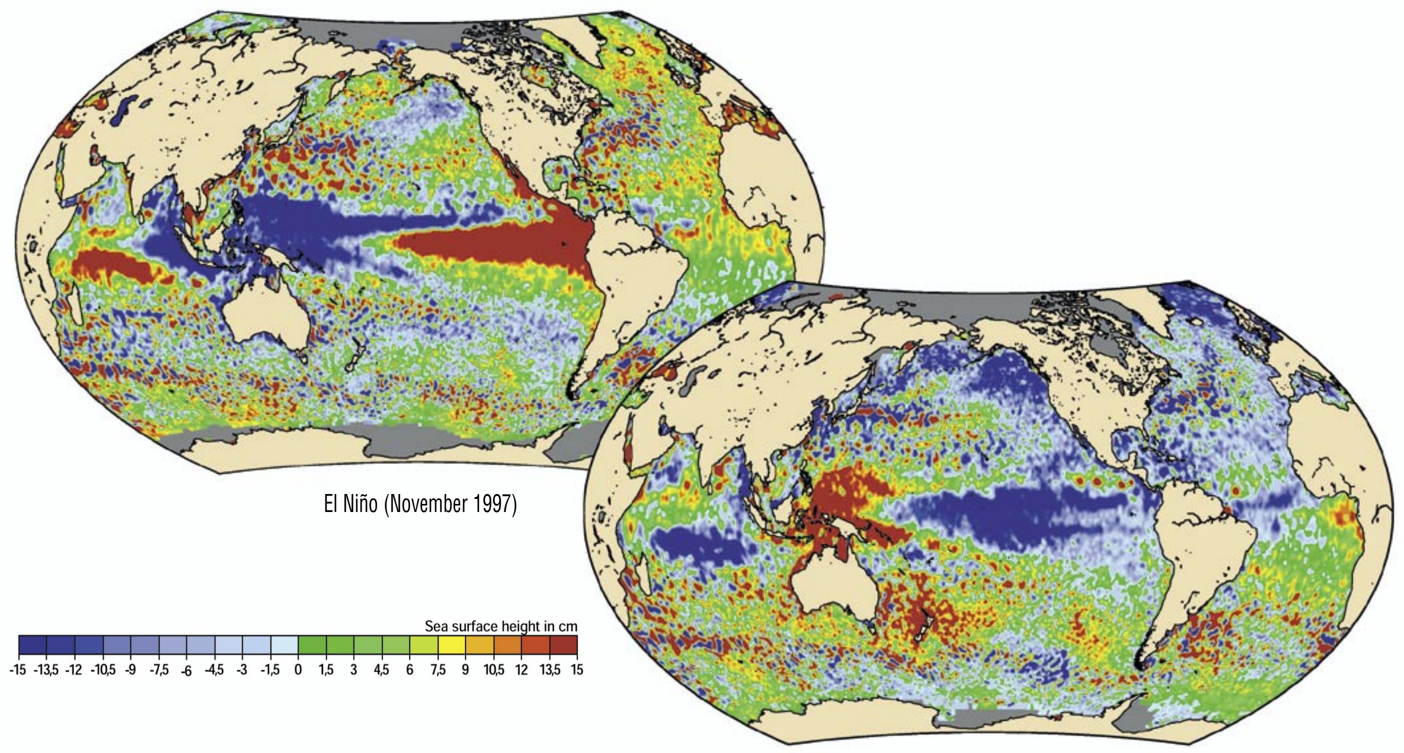
Decadal variations

The North Atlantic Oscillation is by no means unique. Similar phenomena of greater or lesser intensity, varying over periods of several years, are observed across the oceans of the globe.



Pacific decadal oscillation

Extended time series of satellite data now allow us to study ocean variations over several years. Today, the Pacific Decadal Oscillation (PDO), North Atlantic Oscillation (NAO) and El Niño Southern Oscillation (ENSO) are well documented. The next step will be to predict these phenomena. To achieve this goal, we need to gain a closer understanding of how they might be interacting and how they are affected by other oceanic and atmospheric variations. Continued monitoring by a permanent series of ocean-observing satellites should yield vital clues.



El Niño (November 1997)

La Niña (April 1999)

To find out more:

AVISO/Altimetry: http://www-aviso.cnes.fr
North Atlantic Oscillation:
http://www.ldeo.columbia.edu/NAO/

Sources:

CLS, CNES, CNRS/LEGOS,
CNRS/LODYC, JPL,
LDEO/M. Visbeck, NASA, SOC

Creation-conception: CLS / Design: Active Design / Publisher: CNES 2001

Observing the oceans from space

Shifting pressure patterns in the North Atlantic

The weather along the Atlantic seaboard may appear unsettled, but it in fact exhibits trends that recur over the years in close step with the ocean. From North America to Siberia, regions bordering the Atlantic are exposed in turn to rain or drought, cold or mild temperatures, and strong winds or dead calm.
We have observed weather variations in this way since the 17th century. But it was only when satellites arrived on the scene that we could begin continuous, long-term monitoring of the oceans and atmosphere to unlock the secrets of the mechanisms that drive our weather. Improving our understanding of these variations over periods of ten years and more is key to reliable climate forecasting. In this respect, the permanent ocean-observing capability afforded by TOPEX/POSEIDON and Jason, in combination with other satellites and in-situ measurements, is a vital aid.

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