IS THERE A CONNECTION BETWEEN THE FLUCTUATIONS OF THE NORTH ATLANTIC OSCILLATION AND THE INTERANNUAL VARIABILITY OF THE CIRCULATION IN THE NW MEDITERRANEAN ?

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Abstract

A possible connection between the climatic fluctuations associated with the North Atlantic Oscillation (NAO) and the interannual variability of the water transport through the Corsica Channel is investigated. The latter has been considered an indicator of the changes of the large scale circulation in the NW Mediterranean. The data sets used here cover most of a decade since 1985. Over this period, NAO index tends towards increasing positive values. Similarly, the winter (December through March) air temperature and vapor pressure over the basin show a positive tendency while the total transport through the Corsica Channel undergoes a progressive and substantial decrease. A clear reversal of this tendency involving all the considered parameters, occurs at the end of the data period. These preliminary results seem to indicate that a prolonged period of anomalous atmospheric patterns over the North Atlantic can produce changes in the local atmospheric conditions which determine the strong interannual variability of the NW Mediterranean circulation.

Key-words: air-sea interactions, currents, gulf of Lions, water transport

Introduction

The motivation for the present study comes from a renewed attention to the climatic role of the Mediterranean region within the general climatic questions pertinent to the large scale atmospheric circulation (1). Different processes affect the climate patterns of the two basins of the Mediterranean (2); the western part has been found to be significantly influenced by the fluctuations of North Atlantic climate, especially in winter. The North Atlantic Oscillation (NAO) is the dominant mode of climate variability in the North Atlantic-European region. Its state reflects changes in the strength and orientation of the surface Atlantic westerlies across the North Atlantic as well as the temperatures on both sides of this ocean (3). A NAO index, defined by Hurrell (3), exhibits a seasonal evolution being most fully developed during the colder season, and alternatively weaken every 6-10 years. A significant feature is that the highest values have occurred since 1980 and the persistence of the positive phase (4) is unprecedented in the past years. According to Hurrell (3), concurrent conditions over most of Europe and the Mediterranean are anomalously mild.

The circulation of the water masses has been recognized to be an important component of the climatic scenario. In the Northern part of the Western Mediterranean Sea (Figure 1), many oceanographic observations (5) have provided evidence of distinct seasonality in the basin wide response indicated by an intensification of processes during winter season and a strong year-to-year variability that can be correlated with local climatic fluctuations. Among all the involved processes, the exchange of the water masses through the Corsica Channel between the Northern Basin and the Tyrrhenian Sea appears to be most significant. Using a three-year moored current time series, Astraldi and Gasparini (6) found that the water transport towards the Northern Basin increases significantly during winter and that this feature undergoes a significant interannual decrease in response to an improvement of the atmospheric-climatic conditions over the basin. Due to the effect that this current has on the general circulation of the NW Mediterranean, a substantial change in the winter conditions of the whole basin must exist.

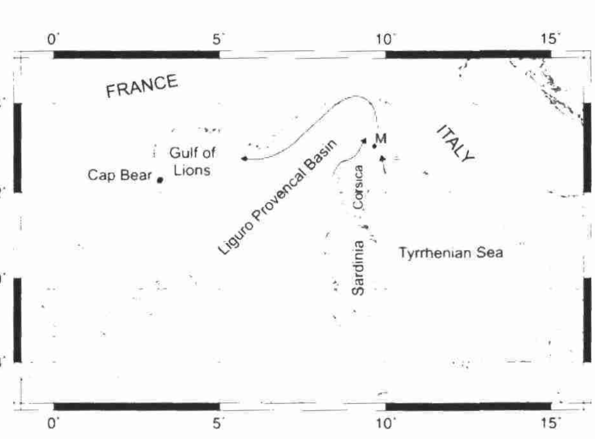

Figure 1: Survey area and mean current paths. M indicates the position of the mooring in the Corsica Channel.

The transport estimates in the Corsica Channel provide us with a clear signal of the marine environment representative of the large scale circulation processes and sensitive to the atmospheric events affecting the northern part of the Mediterranean. Since current velocities in the Corsica Channel continue to be monitored, the resulting longer time series can aid in the identification of the atmospheric parameters directly responsible of the basin wide winter variability and, through them, to verify if a connection can be established with the large scale atmospheric processes. In this framework a preliminary comparison of some primary variables, playing a key role in explaining the previous linkage, is carried out.

Data and methods

Current velocities were measured at four levels near the sill of the Corsica Channel (see Figure 1 for location), in 450m of water, from December 1985 to March 1996, with a two-year interruption in 1989-1990. The total transport through the channel was computed using these observed speeds and the cross-sections are approximately centered at each current meter level. The resulting time series, obtained from on going current mooring, is the most complete and long-term current data set in the Western Mediterranean Sea.

Observations of wind velocities and direction as well as air temperature and vapor pressure, provided by the French weather station at Cap Bear, were used. Due to its location, this station is a suitable place for the evaluation of weather conditions in the NW Mediterranean (7).

Three-hour observations of the atmospheric and oceanographic parameters were used to estimate mean winter (December through March) evolution over the considered years.

The winter (December through March) index of NAO was computed using the difference of the normalized sea level pressures at Lisbon (Portugal) and Stykkisholmur (Iceland). The sea level pressure anomalies were normalized by dividing each seasonal pressure by the long-term (1864-1893) standard deviation.

Preliminary results and future plans

Calculation of the winter total transport through the Corsica Channel is shown in Figure 2a. Consistent with the results of Astraldi and Gasparini (6), a progressive and substantial decrease in water transport is estimated throughout the whole period, which leads in 1995 to a transport about 70% less than that estimated at the beginning of the observation period. It is interesting to note that during winter 1996 the transport suddenly increases reversing the trend initiated in 1986.

Concurrent winter air temperature (Figure 2b) and vapor pressure (Figure 2c) measurements at Cap Bear indicate a tendency towards a progressive improvement of the weather conditions over the basin. Under these persistent conditions exchange processes at the air-sea interface are expected to decrease. It should be noted that an inversion of this tendency is seen by these parameters in the final year. In contrast, the wind speed (Figure 2d) does not exhibit any specific trend.

Confirming the previous indications (6), the comparison of these time series clearly indicates that the air-sea heat fluxes at the basin interface, rather than the direct wind stress, are to be considered the major forcing of the winter transport through the Corsica Channel. The