ATMOSPHERIC TELECONNECTIONS AND CONCOMITANT OCEANOGRAPHIC PROCESSES IN THE NORTH WESTERN MEDITERRANEAN SEA AND THE BAY OF BISCAY

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Abstract

The ocean response to atmospheric forcing is critical to many oceanographic processes. Data on air temperature, heat and buoyancy losses, and water temperature from winter 2005 allowed detecting the formation of dense water in the NW Mediterranean Sea, both on the continental shelf and offshore, which led to cascading and open sea convection, respectively. This was synchronous with the deepening of the mixed layer depth in the Bay of Biscay. Our study shows that the geographical proximity of both basins favors atmospheric forcings to simultaneously trigger significant oceanographic processes. This is indicative of the relevance of teleconnections in between these two regions when a high-pressure center west of the British Islands modulates the penetration of cold and dry continental air masses during winter months

Keywords: Air-sea interactions, North-Western Mediterranean, Gulf of Lyon

The study of the interannual variability of the deep winter mixing and of dense water formation has grabbed the attention of multiple studies over the past decades (e.g. Kolodziejczyk et al., 2015 and references there in). In the Gulf of Lion (GoL, NW Mediterranean Sea), the density increase of shelf waters during winter months and their spreading and cascading down the slope is a major oceanographic process affecting the hydrology of the whole basin, as it contributes to the formation of the Western Mediterranean Deep Water. Likewise, in the nearby Bay of Biscay (BoB), intense winter convective mixing events significantly modifies the hydrography of the upper ocean and the properties of the water masses below the mixed layer. Studies conducted both in the BoB and in the GoL (e.g. Somavilla et al., 2009; López-Jurado et al., 2005) showed that the abnormally dry, windy and cold winter of 2005 strongly altered the hydrography of both regions, which pointed to atmospheric teleconnections. To verify the existence and check the spatial structure of such atmospheric connection, a correlation map of surface winter averaged air temperature anomalies between the GoL and the entire grid points existing elsewhere around the world has been carried out. Figure 1 shows that a major part of the air temperature anomalies vary in parallel ($r \geq 0.8$) within a radius of about 1000 km.

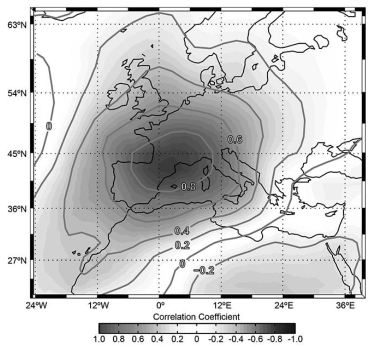

Fig. 1. Correlation map of surface air temperature anomalies between the GoL and the global grid of data points from the NOAA Global Surface Temperature Dataset. To be consistent with the extensive NOAA (http://www.noaa.gov/) published data, anomalies have been calculated using the period 1981-2010 as a reference.

The correlation length between both regions is not the typical of long-range teleconnection patterns but just the expected for points that are within a relative short distance. Several striking consequences result from such atmospheric connection.The quasi-permanent synchronic atmospheric (and therefore air-sea heat exchange) forcing over the BoB and the GoL ultimately favors a concomitant hydrographic response, which achieves its maximum expression especially during severe winters and leads to (1) intense events of open sea convection and dense shelf water cascading in the GoL and (2) extreme events of convective mixing in the BoB, as in winter 2005 and 2006.

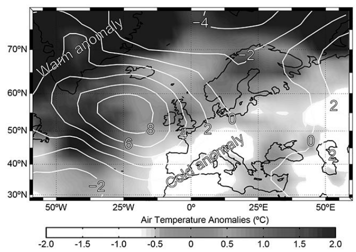

Fig. 2. Large-scale fields of winter averaged sea level pressure (white lines, in millibars) and air temperature (gray scale, in ºC) anomalies over the NE Atlantic and Mediterranean regions leading to severe heat losses and dense water formation over the continental shelf and offshore in the NW Mediterranean Sea, and to the deepening of the mixed layer in the Bay of Biscay. The image corresponds to winter 2005. Anomalies calculated using the period 1981-2010 as a reference.

The synchronicity between both regions is directly dependent on atmospheric pressure distribution, which itself depends on the location of an anomalous high-pressure center west of the British Islands during winter. This center governs the penetration of continental cold air masses to the BoB and GoL latitude and ultimately controls ocean to atmosphere surface heat exchanges and the subsequent oceanographic responses (Fig. 2).

References

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