ESTIMATION OF THE ATLANTIC INFLOW THROUGH THE STRAIT OF GIBRALTAR FROM CLIMATOLOGICAL AND IN SITU ADCP DATA

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Abstract
A combined reanalysis, satellite and experimental dataset has been used to calculate a four-year time series of the Atlantic inflow through the Strait of Gibraltar. An indirect estimation of the net flow through the strait from the hydrological cycle has been combined with direct Mediterranean outflow measurements, collected in the Espartel sill (western Strait of Gibraltar), resulting a mean inflow of 0.814 Sv with a seasonal cycle of 0.026 Sv amplitude peaking in September. Two possible forcing mechanisms are suggested for this cycle: a main barotropic one, related to the ocean-atmosphere water deficit and a secondary baroclinic one related to the hydrological conditions in the strait.

Keywords: Strait Of Gibraltar, Water Transport, Air-Sea Interactions, Hydrology, Sea Level

The importance of the exchange through the Strait of Gibraltar for the Mediterranean termohaline circulation and hence for the entire Mediterranean climate is well known. Several works have studied this exchange, most of them focusing on the evaluation of the net flow and the Mediterranean outflow, but only a few of them describe the Atlantic inflow. The latter are based on experimental measurements of about two-year long time series [1, 2, 3]. In this work we make an indirect estimation, climatologically and experimentally based, of a four-year long time series.

$$\frac{dM}{dt} = S\frac{d\xi_M}{dt} = P - E + R + B + G$$

Eq.1 describes the mass budget in the Mediterranean Sea that is used to calculate the net flow, where the left-hand side, dM/dt , is the mass time-variation, S the Mediterranean surface and ξ_M the mass-induced sea level anomaly. The rigth-hand side terms are the different contributions to the budget: precipitation, P, evaporation, E, river discharge, R, the exchange with the Black Sea through the Turkish Straits, B, and the net flow through the Strait of Gibraltar, G. NCEP monthly mean data has been used to evaluate evaporation and precipitation. The mass contribution to the sea level anomaly has been calculated subtracting from AVISO total level the steric contribution computed from the water column salinity and temperature data of the ECCO model dataset. Data of river discharge and exchange with the Black Sea have been obtained from the works of [4] and [5] respectively. Once estimated the net flow, direct ADCP measurements of the outflow collected in the Espartel sill (western Strait of Gibraltar) have been used to calculate the inflow. A mean value of 0.814 Sv, with a seasonal cycle of 0.026 Sv amplitude peaking in September, has been obtained, in good agreement with the previous works [1, 2, 3].

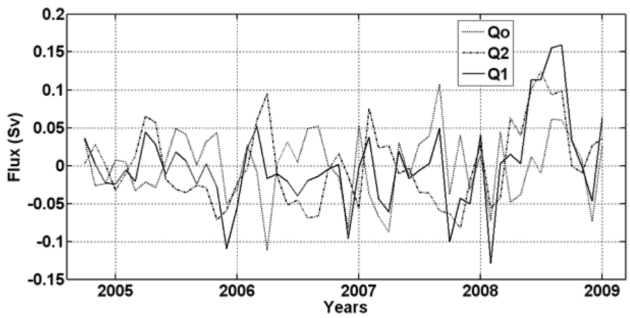

Fig. 1. Inflow (Q_1), outflow (Q_2) and net flow (Q_0) through the Strait of Gibraltar anomalies. The anomalies has been represented for a better visualization of the importance of the seasonality of each component, Q_0 and Q_2 , to the inflow calculation.

Two possible forcing mechanisms have been considered to explain the seasonal cycle of the Atlantic inflow. The first and main one of barotropic nature, related to the ocean-atmosphere water deficit, strongly dependent of E-P, whose seasonal cycle also peaks in September. The second one has baroclinic nature and is related to the hydraulics conditions in the strait, which implies that both the inflow and outflow velocity depends on the square root of their density difference [6]. This means that an increase (decrease) in the outflow (inflow) density produces an increase in both velocities and vice versa. Thus, during summer, when sea surface temperature reaches its maximum, the surface layer density decreases due to the associated volume increase. This feature is also reflected in the maximum of the steric sea level in September [7] and produce an increase in the inflow velocity that contributes to the September peak.

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