Geophysical Research Abstracts,
Vol. 10, EGU2008-A-06093, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-06093
EGU General Assembly 2008

Theoretical and numerical modelling study of the exchange flow regimes in the strait of Gibraltar.

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The mean circulation within the strait of Gibraltar is an inverse estuarine circulation characterized by a two-way exchange, with an upper flow of fresh and warm Atlantic water spreading in the Mediterranean basin, and an lower flow of cold and salty Mediterranean water sinking in the North Atlantic down to a depth of around 1000 m where it becomes neutrally buoyant. While this mean circulation is driven by an excess of evaporation over precipitation and river runoff in the Mediterranean sea, its magnitude and hydrological properties strongly depend on the physical configuration of the strait. In fact, it is well known that the Strait of Gibraltar is a place where the water exchange is subject to hydraulic control. If the exchange is subject to only one control the flow regime is called submaximal, while if the flow exchange is controlled in more than one section at the same time the regime is called maximal. The effect of these two regimes on the conditions in the strait, in terms of mass transports, are very different. While in case of maximal regime the strait will respond relatively slowly to an internal change of the thermohaline circulation of the Mediterranean Sea due to air-sea interaction over the whole basin, a more rapid adaptation of the transports in the strait will be exhibit in case of submaximal regime. From the above descriptions it rises that these two regimes have a different impact on the exchange of heat and salt between the Atlantic Ocean and the Mediterranean Sea, making the Strait of Gibraltar, despite its small dimension, a key point for the circulation of whole Mediterranean Sea and the North Atlantic Ocean. However a key issue that is still an open question regards the number and location of these hydraulic controls.

This issue is addressed in this work combining very recent theoretical developments

and numerical modelling efforts. A new formulation defining critical hydraulic conditions for a generic transversely varying three-layer flow has been developed. This new formulation has been subsequently applied to study the hydraulic exchange in the strait of Gibraltar by means of an high resolution three-dimensional numerical model. The model uses a coastal-following curvilinear orthogonal grid, that includes the Gulf of Cadiz and the Alboran Sea, with very high resolution in the Strait (less than 500 m). It is forced by imposing the four major semidiurnal and diurnal tidal constituents (M_2, S_2, O_1, K_1) along the Atlantic and the Mediterranean open boundaries. The experiment covers an entire tropical month.

Results have shown a new detailed picture of the hydraulic controls: a permanent control west of Espartel Sill, and an intermittent control, at semidiurnal tidal frequency, at Camarinal Sill and Tarifa Narrow making the exchange regime intermittently maximal.