# THE HYDRODYNAMICS OF THE STRAIT OF MESSINA: TIDALLY-INDUCED DYNAMICS AND STRATIFICATION EFFECTS

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**Abstract**

For the first time, a very high resolution numerical model has been used to investigate the three-dimensional structure of the hydrodynamics of the Strait of Messina. In particular, the role of climatologic as well as anomalous stratifications in the generation and evolution of tidally induced currents is investigated.

*Keywords : Strait Of Messina, Circulation Models, Stratification, Tides.*

A very high resolution, 3D numerical model based on curvilinear, boundary-fitted coordinates is used to investigate in detail the three-dimensional structure of the hydrodynamics in the Strait of Messina for different climatic scenarios. Firstly, superficial as well as internal currents are investigated and compared to observed features for a stratification within the strait similar to that observed climatologically in the area. In particular, the generation and propagation of tidally induced internal disturbances and the vertical structure of submesoscale whirls are discussed. Secondly, tidally induced surface and subsurface water jets are studied for a stratification characterized by a reverse in the horizontal gradients of temperature and salinity along the strait, which resembles an observed anomalous stratification. The strait of Messina separates the Italian Peninsula from the Italian island of Sicily. It is a narrow channel (its smallest cross-sectional area is 0.3 $km^2$) connecting the Tyrrhenian and the Ionian seas. In the approaches to the Strait of Messina very strong tidal phenomena take place [1]. This is due to the fact that, although tidal elevations are in general small in the Mediterranean, a very strong gradient of tidal displacement is present along the Strait of Messina as the semidiurnal tide north and south of it are approximately in phase opposition [1].

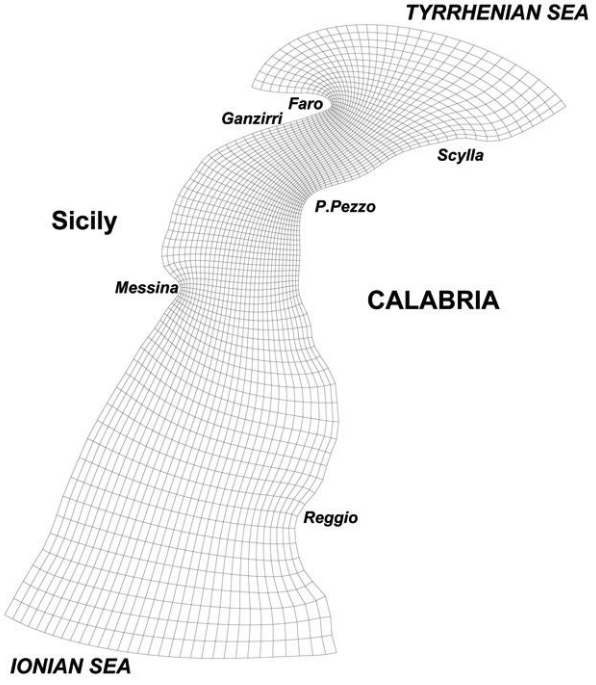


Fig. 1. Model domain.

Mainly through the interaction of the predominantly semidiurnal tide with bathymetric features within the Strait, large, sometimes jet-like disturbances are produced in the stratified fluid, which may evolve into trains of southward as well as northward propagating internal solitary waves [2, 3]. There is, however, a large asymmetry between northward and southward propagating, tidally induced disturbances, which is mainly due to the morphological asymmetry of the Strait, and to the structure of the local vertical stratification [3]. In order to investigate realistically the behavior of such tidally induced phenomena, we implemented a 3D numerical model. A boundary value problem was considered for the three dimensional equations describing the dynamics of the local density field and turbulence characteristics in curvilinear coordinates and in sigma-coordinate in the vertical, fitted to the geometry of the Strait of Messina.

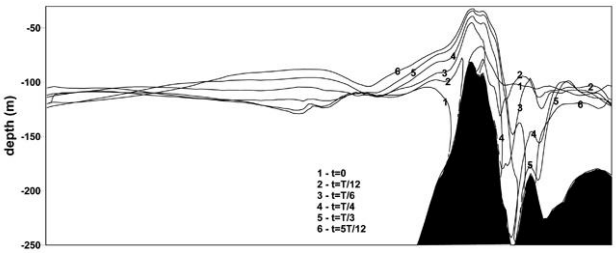


Fig. 2. Evolution of the main interface for 6 selected times within a semidiurnal period.

The numerical method used is based on composite schemes for split operators. The schemes allow one to control numerical viscosity and solution smoothness in regions of steep gradients. The Strait of Messina is discretized in 33x83 cells on the horizontal and 40 vertical levels. The maximum resolution (55 m) is achieved at the Strait sill, the minimum one (670 m) at the southern open boundary (Figure 1). The model is forced at the two open boundaries imposing there the semidiurnal tidal displacement. In Figure 2 the evolution of the main interface as a function of the semidiurnal time is depicted for a climatologic stratification. Note that the model is able to capture the development of hydraulic disturbances at the Strait sill, which evolve in propagating internal waves. Associated with these disturbances are near-surface and intermediate water jets: in particular, with the given stratification a near-surface jet is produced which transports Tyrrhenian surface water toward the Ionian sea, and an intermediate jet arises that transports Ionian water toward the Tyrrhenian sea. Assuming, instead, an anomalous stratification characterized by a near-surface reverse in the horizontal gradients of temperature and salinity along the strait, a near-surface jet emerges thath transports Ionian water toward the Tyrrhenian sea, whilst an intermediate jet transports Tyrrhenian water toward the Ionian sea. This anomalous tidally induced dynamics is characterized by features which correspond to features observed in the strait of Messina [3] in a period characterized by a large inflow of Atlantic Water in the southern approaches to the Strait of Messina caused by an anomalous path of the Atlantic-Ionian Stream.

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