ASSESSING THE IMPACT OF TIDES AND WINDS ON THE CIRCULATION OF THE GULF OF LA SPEZIA WITH HIGH-RESOLUTION, THREE DIMENSIONAL SIMULATIONS

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Abstract: A high-resolution (~ 50 m), three-dimensional numerical model is used to study the water exchanges between the inner and outer parts of the Gulf of La Spezia (Ligurian Sea, Fig.1). Several simulations are run by varying idealized forcings, namely a) the semidiurnal tide, b) winds and c) the stratification (Tab.1). Differences in the runs are quantified in terms of mass transports at the two openings of a breakwater. The integral effects of tides and breezes are negligible and result in almost null net water exchanges at the two openings. Maximum water exchanges are registered under southeasterly "Scirocco" winds and in stratified conditions, due to the development of a cyclonic circulation which forces waters to enter at east and leave at west. In all cases, the west opening is about two-fold more energetic than the east one, and variability in both openings is independent of the different forcings.

Exp#	Wind	Initial stratification (N^2)	Mass Transport (mc/s)			
			East (S1)		West (S2)	
			Average	St. dev.	Average	St. dev.
1	-	0 s^{-2}	2.99	83.07	1.97	171.46
2	Breeze	0 s^{-2}	3.30	87.44	1.58	173.47
3	Scirocco	0 s^{-2}	46.86	84.36	-41.98	169.50
4	-	10^{-3} s^{-2}	69.68	82.18	-64.80	166.37
5	Breeze	10^{-3} s^{-2}	65.44	87.47	-60.55	168.67
6	Scirocco	10^{-3} s^{-2}	92.30	80.49	-87.43	167.98

Table 1. Idealized forcing configurations for the numerical experiments considered in this study and statistics for the total mass transports at both openings. Positive values stand for net transport in the Gulf.

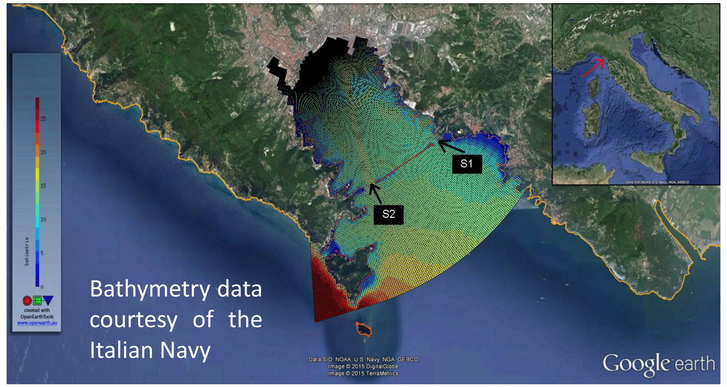

Figure 1. Study area: numerical domain, bathymetry and locations of the openings and breakwater (in red).

Setup: DELFT3D model. Grid: 286x167 horizontal points, 5 vertical levels. Initial conditions: at rest. Boundary conditions: sinusoidal sea-level oscillation, period: 12 hrs and 25 mins, amplitude: 0.15 m.

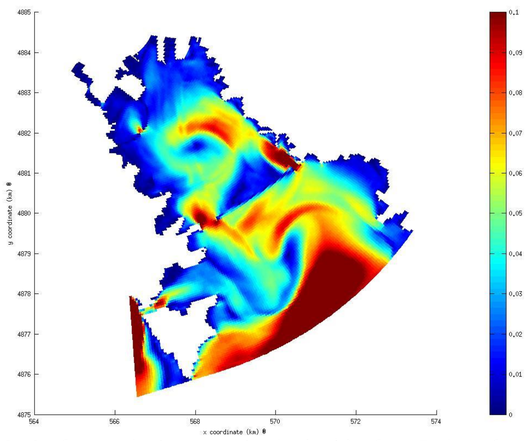

Figure 2. Surface velocity magnitude (m/s) after 5 days for Exp4. Two cyclonic structures are evident in both inner and outer parts of the Gulf.

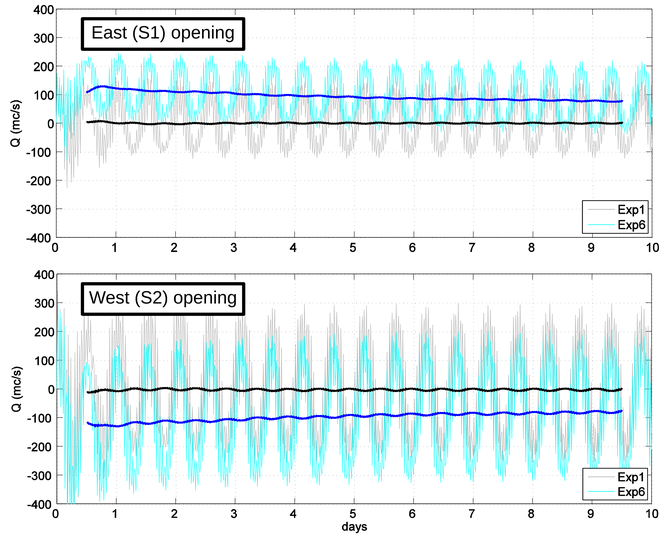

Figure 3. Time evolution for the total mass transports (mc/s) across the openings for Exp1 (in gray) and Exp6 (in cyan). Running averages are in thick black (blue) lines for Exp1 (Exp6).

Conclusions: Results provide important information even in the very simplified and idealized conditions considered in this study. For example, they seem to suggest that water exchanges are enhanced in summer, when stratification is expected to be stronger and "Scirocco" winds more frequent, with maximum average transport values in (out of) the Gulf of about 92 (87) mc/s. Further experiments are needed to investigate sensitivity to other forcing combinations (e.g. diurnal tides, northerly winds, different open-sea water masses) and to assess the reliability of the simulated fields.

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