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Tidal dynamics in inter-connected basins: from the ocean to coastal lagoons

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The Mediterranean Sea - which opens to the Atlantic Ocean only through the Strait of Gibraltar - and the Black Sea represent an exceptionally complex system of semi-enclosed connected basins. They are part of a chain of adjoining regional seas - the Mediterranean Sea, the Marmara Sea, the Black Sea and the Azov Sea - connected by straits. All these basins, at different spatial scales, actively exchange waters, energy, pollutants and nutrients through narrow straits. Therefore, straits have an extremely important role in forming the hydrographic and ecological conditions in these semi-enclosed basins. Through the application of an unstructured grid hydrodynamic model to the whole system, we investigated the tidal transformation and tidal driven water exchanges at the straits connecting the different water basins. In the micro-tidal Mediterranean Sea the tides are generated by the sum of the direct action of the equilibrium tide and the incoming Atlantic tidal waves. The resulting tidal wave interacts with the sea bottom and with the natural modes of the basins producing significant tidal oscillations only in certain areas, namely, the North Adriatic Sea, the Gulf of Gabes, and the North Aegean Sea. Even if the Turkish Strait System act as a barrier for the tidal sea surface oscillations, our numerical results demonstrated that the tidal along-strait interface slope produces water fluxes between the Mediterranean and the Black seas of the same order of magnitude of the climatological transports.
This structure of inter-connected basins is even more complex since within the Mediterranean Sea, the Adriatic Sea represents a semi-enclosed regional basin connected through the Otranto Strait. The Adriatic tidal regime has been interpreted as co-oscillations with the Mediterranean Sea, forced through the strait of Otranto, and amplified by resonance phenomena along its longitudinal direction from south to north. Moreover, in the Northern Adriatic Sea, tides are the main driver of the water exchange between the open sea and the several lagoons. Numerical experiments confirm that natural and anthropogenic morphological changes are responsible for the alteration of tidal regime inside lagoons. Moreover, results show that these shallow coastal systems significantly affect the entire Adriatic Sea tidal dynamics by enhancing tidal range and currents. The back-effect of the lagoons on the open-sea tide is due to the waves radiating from the co-oscillating lagoons into the adjacent sea. With the same mechanism, called radiation damping, the Adriatic Sea is back influencing the dynamics in the Mediterranean Sea through the Otranto Strait.