Two-way nested high-resolution model of the Gibraltar Strait

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Abstract

The Strait of Gibraltar is the only communication channel between the Atlantic Ocean and the Mediterranean Sea. Ignoring larger frequency phenomena, the exchange can be modelled by a two-layer flux where a larger surface component carries fresher Atlantic waters into the Mediterranean, while at depth a smaller outflow discharges saltier water back to the Atlantic Ocean. The resulting netflow is an inflow to the Mediterranean Basin to compensate its excess evaporation[1]. The strait's constrictive bathymetry, tidal currents and the temperature and salinity imbalances between the two bodies of water strongly influence both basins' circulation patterns at all scales[2]. In this project a fixed 1/24° resolution year-long run of the Nucleus for European Modelling of the Ocean (NEMO)[3] in the Mediterranean domain is compared to an identical run that includes a two-way nested embedded zoom with a refinement factor of 3 centered in the Strait of Gibraltar (lat: 32.62°N − 37.76°N, lon: 8.18°W − 1.03°W) and its feature-rich surroundings. Timeseries of mass transport of the two-way flux, outflow and inflow's temperature and salinity, height of the interface between the fluxes, kinetic energy and SSH and kinetic energy maps are compared to estimate the local and whole basin circulation's effects of the nested zoom. Smaller scale processes such as those present in the Gibraltar Strait are usually parametrized in ocean model runs for the whole Mediterranean. Explicitly resolving them can help evaluate and improve the parametrization quality. The higher resolution zoom is implemented with the 2-way nesting technique provided by the Adaptive Grid Refinement in Fortran (AGRIF) library[4]. The experiment demonstrated that increased horizontal resolution in the Gibraltar Strait significantly improved the representation of key dynamical processes, such as water mass exchange. The high-resolution model simulated a net transport of 0.044 Sv, closely aligning with literature values. Analysis revealed that these improvements had a significant impact on the broader Mediterranean Sea, leading to observable changes in water circulation patterns.

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