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Interannual variability in the water column structure of the Black Sea (1971 - 2001)

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The Black Sea is a strongly stratified basin characterized by shallow mixed-layer depths and a permanent halocline at ∼150 m depth, which prevents deep winter convection. The Cold Intermediate Layer (CIL), another prominent feature of the Black Sea, is a temperature minimum layer that forms during periods of winter convection and typically persists throughout the year below the seasonal thermocline. A semi-permanent pycnocline at the base of the CIL inhibits ventilation of the suboxic waters below. Results from a hydrodynamic model reanalysis covering the period 1971-2001 are described, focusing on interannual variability and trends in water column structure over this period. The model is validated against individual CTD casts and satellite data, and consistency between model results and observations is demonstrated. Our results suggest a warming and freshening of super-pycnocline waters over the study period (trends are 0.7 ºC and -0.4 respectively). Coincidently, mixed-layer depths show a shallowing trend of -6.3 m and the stability of the seasonal thermocline shows an increasing trend. Taking the commonly assumed definition of the CIL (as water temperatures below 8oC), the upper and lower boundaries of the CIL show shallowing trends of -5.6 m and -12.9 m respectively, meaning the CIL has thinned by 7.3 m over this 30 year period. Whilst the CIL remains a prominent feature throughout the study period, the mean temperature of the CIL has increased and is often higher than 8 oC towards the end of the study period. We therefore pertain that the standard definition of the CIL is not always appropriate, rather the entire thickness of the temperature minimum layer should be considered. The model results show no distinct trend in the depth or stability of the semi-permanent density gradient which resides at the base of the CIL, at ∼68 m depth. However, our results suggest that salinity becomes increasingly more important than temperature in maintaining this density interface. The increased stability of the upper water column and shallowing of the mixed-layer depth is likely to have a profound impact on ecosystem functioning. However, as there is little change in the intermediate pycnocline at the base of the CIL, our results imply little change in the rate of suboxic layer ventilation or the upward entrainment of nutrients from below the pycnocline.