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A numerical study of the relationship between atmospheric forcing, cold intermediate layer generation and primary production in the Black Sea over interannual time scales

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The Cold Intermediate Layer (CIL) is a characteristic feature of the Black Sea formed during winter when cool surface waters penetrate to the depth of the upper halocline. The CIL typically persists throughout the year and is defined at its upper and lower boundaries by the 8 °C isotherm. CIL formation is concentrated in the central regions of the Black Sea basin and on the NW shelf, although the relative contribution of these two sources is still debated. Previous studies have suggested that CIL formation on the NW shelf may play an important role in the subduction of nutrient rich shelf waters into the upper pycnocline, thus removing nutrients from the euphotic zone and impacting rates of primary production. A 20 year hydrodynamic model (Princeton Ocean Model) simulation extending from 1990-2009 and forced by the DMI atmospheric reanalysis is used to investigate (i) interactions between atmospheric forcing and regional CIL formation and (ii) rates of CIL formation and the subduction of NW shelf waters to depths below the euphotic zone. Model skill in simulating CIL characteristics is demonstrated. Results suggest that the ratio of CIL waters formed in the central regions of the Black Sea basin and on the NW shelf varies considerably from one year to another due to sub-domain scale atmospheric variability. Exceptionally warm years when CIL formation is considerably reduced are associated with anomalously high concentrations of fresh riverine water residing in the euphotic zone, and hence a higher percentage of riverine nutrients are available to fuel primary production. Years when anomalously large volumes of CIL water are formed on the NW shelf are not necessarily cold years when considering the domain as a whole. During these years an anomalously high volume of riverine water is subducted into the CIL where it remains trapped throughout the following spring and summer. This study provides a physics based explanation for the occurrence of higher phytoplankton biomass in the Black Sea during anomalously warm years, as seen in satellite observations.