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Vertical Mixing in the Dead Sea

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For hundreds of years, the Dead Sea was characterized by a stable haline stratification, supported by runoff. The penetration of the winter convection was limited to an upper mixed layer (UML) of about 30–50 m. Below the UML, a stable halocline prevented the mixing. As a result of the runoff reduction, the UML salinity increased and the gravitational stability diminished. During the winter of 1978–1979, the sea water overturned, ending the long-term stable hydrological regime. Since 1979, the haline stratification structure reoccurred twice after extremely rainy winters, in 1980–82 and 1992–1995. In other years, the sea was entirely mixed by winter thermal convection (which occurs from November to March) and had a seasonal pycnocline beneath the UML during summer.

Profiles of temperature and quasi-salinity (density anomaly from $1000kg/m^3$ for the chosen reference temperature of $32^\circ C$) during the last 19 years, show the formation of summer "overturning halocline" beneath the UML, and the thermocline that supports the stable stratification.

Another warm and saline layer is formed also during the summer period near the bottom. This layer spreads from the southern part of the sea, where end-brine is discharged to the sea from the Israeli and Jordanian salt plants' evaporation ponds. The end-brine has extremely high salinity ($\sim 350g/kg$) and, in spite of the high temperatures ($\sim 45^\circ C$), high density ($1350kg/m^3$), it therefore spreads as a gravitational current in the Dead Sea deep basin.

Estimation of the density ratio (R_ρ) for the Dead Sea water (where measurements of water salinity is quite difficult) was done using quasi-salinity (σ_{32}) and potential temperature (θ) : $\mathrm{R}_\rho = [\alpha(\partial\theta/\partial z)]/[\beta(\partial\sigma_{32}/\partial z)]$, where α and β are temperature expansion and quasi-salinity contraction coefficients respectively. The values of α and β for the Dead Sea water were defined from water samples collected during 2008. The R_ρ values confirm that the summer Dead Sea thermohaline structure is appropriate for double diffusion mixing. A salt fingers regime beneath the UML ($1.3 < R_\rho < 2$), as well as a staircase regime above the end brine bottom layer ($0 < R_\rho < 1$) generate intensive positive salt and heat fluxes to the middle layer of the water body. As result of the two sided double diffusion processes, the middle layer (40–200 m) is already well mixed in October, which is about two months before the first convective overturn.