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Dead Sea seasonal stratification: metalimnion sharpening and the role of Double Diffusive diapycnal flux

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Summer thermo-haline stratification in a hypersaline lake involves conditions favorable for double diffusion (DD) diapycnal flux and precipitation (or dissolution) of halite crystals. Quantifying these processes and their role on the stratification of the Dead Sea is the aim of this study. The thermal structure of the metalimnion of the Dead Sea was investigated in high spatial and temporal resolution by means of fiber optics temperature sensing during May-Dec 2012. This high resolution method enabled achieving very detailed and unique information of the thermal morphology: a continuous record of temperature- depth profiles allowing quantitative investigation of the thermal morphology dynamics by defining objective parameters as metalimnion's thickness, depth, slope (dT/dz max), and sharpness of the thermocline's boundaries (d2T/dz2 max and min). Along the season sharpening of the thermal profile occurs gradually with the build-up of stratification, from a relatively wide curved temperature profile in early spring to a very sharp step metalimnion (<1m, >10°C) at mid-summer-fall time. The sharpening was expressed by the thinning of the metalimnion and thermocline, increase in slope of the thermocline, and increase in sharpness of the boundaries of the thermocline. The transition from a gradual to a sharp interface initiated with the formation of a staircase of 5 sharp steps in the thermal profile, merging gradually and collapsing into a single abrupt change in temperature. This sharp single step lasted from early September until stratification diminished in early December.

We calculate diapycnal flux (salinity and heat) based on measured data (rise in temperature and salinity of the hypolimnion, expected salinity increase from level measurements and water balance). The Maximum slope and sharpness of the metalimnion was achieved at the beginning of September, synchronous with the onset of heat and salinity diapycnal flux. Having the basic conditions for salt fingering type DD in the Dead Sea (warm salty water above cold fresher water) our structure observations support the hypothesis that the source of heat and salinity increase in the hypolimnion is a DD dyapicnal flux. Being an advective flux, the salt fingering DD flux transports the heat and salt away from the interface zone and leads to sharpening of the metalimnion, in contrary to "regular" molecular diffusion processes that smooth up gradients within the interface zone.