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# Deriving Equations of State for Specific Lakes and Inland Seas from Laboratory Measurements

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The equation of state is the dependence of water density on temperature, salinity, and pressure. It is important in many respects, in particular, for numerical modeling of marine systems. The widely used UNESCO equation of state, as well as the more recent and general TEOS-10 equation, are intended for the ocean waters. Hence, they are confined to salinities below 40 ‰ and, even more restrictively, valid only for ionic salt composition characteristic for the ocean. Both conditions do not hold for many lakes. Moreover, significant deviations of the ionic composition from the oceanic one have been documented for coastal zones, especially those exposed to river discharges. Therefore, the objective of this study was to find equations of state for areas or water bodies with non-oceanic ionic salt composition.

In order to obtain the required equations, we analyzed water samples obtained in expeditions of 2014-2016 from the Black Sea, the Aral Sea, Lake Issyk-Kul and Caspian Sea. The filtered samples were submitted to high accuracy (up to 0.00001 g/cm3) density measurements in laboratory using the Anton Paar DMA 5000M in the temperature range from 1 to 29°C. The absolute salinity values of the initial samples were obtained through the dry residue method. Further, we diluted the samples by purified deionized water to produce different salinities. To control the accuracy of the dilution process, we used a reference sample of standard IAPSO-certified seawater at 35‰The density versus salinity and temperature data obtained thereby were then approximated by a best fitting 2-order polynomial surface using the least squares method. This procedure yielded the approximate empirical equations of state for the selected marine areas (the Russian Black Sea shelf) and inland water bodies (the Aral Sea, the Lake Issyk-Kul, the Caspian Sea). The newly derived equations - even the one for the Black Sea shelf – are different from the oceanic equation significantly within the confidence intervals. We also analyzed the salt content in all samples using the ionic chromotography method and the potentiometric titration method and discussed the relations between the ionic composition on the one hand and density on the other.