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The Cooling Box Problem: Numerical and Laboratory Fluxes[1]
JASON OLSTHOORN, EDMUND W. TEDFORD, GREGORY A. LAWRENCE, University of British Columbia — In very cold freshwater, density increases with temperature so that the surface water will actually be colder than the water below. This counter-intuitive temperature structure results from the density of freshwater depending nonlinearly with temperature. Through surface cooling and mixing, many lakes transition between the intuitive hot-over-cold temperature stratification in the summer, and the reverse cold-over-warm stratification in the winter. The division between these two regimes occurs at the temperature of maximum density T_{MD} (for fresh water, $T_{MD} \approx 4\ ^{\circ}C$). We want to understand how the transport of heat is changed during this transition period, near T_{MD}. We perform a set of numerical and laboratory experiments by taking a body of warm water $T > T_{MD}$ and instantaneously cooling its surface temperature. We are interested in quantifying the rate of change in bulk water temperature as it approaches T_{MD}. We develop a model for the rate of cooling within the domain and demonstrate its dependancy on the surface water temperature. The model agrees well with the simulations and laboratory measurements. We highlight the key parameters of interest in this problem, and elaborate on how these results may be applicable to field measurements.

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Jason Olsthoorn
University of British Columbia

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