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A study of the Nusselt-Rayleigh and Sherwood-Rayleigh scaling laws for water undergoing free-surface natural convection[1] S.M. BOWER, J.R. SAYLOR, Clemson University — An experimental study is presented of free-surface natural convection, with a focus on the $Nu - Ra$ relationship. This relationship is typically studied using the traditional Rayleigh-Benard convection setup, where a fluid layer is bounded above and below by solid plates of different temperatures. Power laws of the form $Nu = ARa^n$ are typically used in these studies to correlate the data, giving exponents that are usually close to $n = 1/3$. The experimental data obtained in this study yields values of n that do not deviate significantly from $1/3$ for $10^7 < Ra < 10^{11}$. This result is surprising in that the effect of the free-surface boundary condition on n is quite small when compared to the solid plate case. However, the prefactor A in the $Nu - Ra$ relationship is significantly smaller than for the solid plate case. The Sherwood number, Sh was also related to Ra via a power law of the form $Sh = BRa^m$, where Sh is the dimensionless mass transfer coefficient for evaporation. The exponent m differed from that obtained by prior researchers. However, the prior research on evaporation that utilizes this scaling law is considerably smaller than for the heat transfer case. The effect of the tank aspect ratio on both scaling laws is also discussed.

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