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Overdetermined Differential Equation Problems.

The continuity equation is used for calculating vertical velocity in a 3-D shallow water model. This first order equation is overdetermined, because boundary conditions are imposed at both the upper and lower surfaces. A linear derivate of the continuity equation gives a second order differential equation that satisfies the two boundary conditions. This equation is alternatively derived from an exponentially weighted variational statement, including boundary terms, which satisfy natural boundary conditions of the first, second or third type, and lowers the continuity equation residual of the solution. The methods herein are precursors to 1) finding a variational statement for flow problems applicable to finite element methods, and 2) using integrating factors to transform advection-diffusion problems into diffusion problems.