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On the vertical velocity in a layer with constant buoyancy frequency

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A hydrostatic layer of dry air will be considered of which the buoyancy frequency is uniform with height. We will discuss the vertical profiles of temperature, pressure and density in such a layer and assume that these profiles do no not change in time. Then it will be shown that, as in the isentropic and isothermal cases, the horizontal pressure gradient term in the momentum equation is independent of height. As a consequence, also the horizontal velocity field is independent of height if this is the case initially. Under these conditions it is possible to obtain an expression for the vertical velocity - and thus of the full three-dimensional flow structure inside the layer - in terms of the conditions at the bounding interfaces. We will show how this opens up the perspective of constructing dynamically consistent atmospheric models based on layers with uniform buoyancy frequency as an alternative to models based on layers with uniform potential temperature.