2.22 The adiabatic lapse rate

The adiabatic lapse rate Γ is the change of *in situ* temperature with pressure at constant entropy and Absolute Salinity, so that (McDougall and Feistel (2003))

$$\Gamma = \Gamma(S_A, t, p) = \left.\frac{\partial t}{\partial P}\right|_{S_A,\eta} = \left.\frac{\partial t}{\partial P}\right|_{S_A,\Theta} = -\frac{g_{TP}}{g_{TT}} = \left.\frac{\partial^2 h}{\partial \eta \partial P}\right|_{S_A} = \left.\frac{\partial v}{\partial \eta}\right|_{S_A,p} = \frac{(T_0 + t)\alpha^t}{\rho c_p}$$

$$= \frac{(T_0 + \theta)}{c_p^0}\left.\frac{\partial v}{\partial \Theta}\right|_{S_A,p} = \frac{(T_0 + \theta)}{c_p^0}\left.\frac{\partial^2 h}{\partial \Theta \partial P}\right|_{S_A} = \frac{(T_0 + \theta)\alpha^\Theta}{\rho c_p^0} = \frac{(T_0 + \theta)\alpha^\theta}{\rho c_p(S_A, \theta, 0)}. \quad (2.22.1)$$

The adiabatic (and isohaline) lapse rate is commonly (and incorrectly) explained as being proportional to the work done on a fluid parcel as its volume changes in response to an increase in pressure. According to this explanation the adiabatic lapse rate would increase with both pressure and the fluid's compressibility, but this is not the case. Rather, the adiabatic lapse rate is proportional to the thermal expansion coefficient and is independent of the fluid's compressibility. Indeed, the adiabatic lapse rate changes sign at the temperature of maximum density whereas the compressibility and the work done by compression is always positive. McDougall and Feistel (2003) show that the adiabatic lapse rate is independent of the increase in the internal energy that a parcel experiences when it is compressed. Rather, the adiabatic lapse rate represents that change in temperature that is required to keep the entropy (and also θ and Θ) of a seawater parcel constant when its pressure is changed in an adiabatic and isohaline manner. The reference pressure of the potential temperature θ that appears in the last four expressions in Eqn. (2.22.1) is $p_r = 0$ dbar.

The adiabatic lapse rate Γ output of both the SIA and the GSW computer software libraries is in units of K Pa^{-1}.

Reference:

McDougall, T. J. and R. Feistel, 2003: What causes the adiabatic lapse rate? *Deep-Sea Research,* **50**, 1523-1535.