5. Conservative Temperature Θ

Because the TEOS-10 properties of seawater are all derived from a Gibbs function, it is possible to find thermodynamic properties such as enthalpy, internal energy and entropy. Hence potential enthalpy and Conservative Temperature (which is simply proportional to potential enthalpy) are readily available.

Conservative Temperature is in some respects quite similar to potential temperature in that the same artificial thought experiment is involved with their definitions. In both cases one takes a seawater sample at an arbitrary pressure in the ocean and one imagines decreasing the pressure on the seawater parcel in an adiabatic and isohaline manner until the sea pressure $p = 0\ \text{dbar}$ is reached. The temperature of the fluid parcel at the end of this artificial thought experiment is defined to be the potential temperature θ. Similarly, the enthalpy at the end of this artificial thought experiment is defined to be the potential enthalpy h^0, and Conservative Temperature Θ is simply potential enthalpy divided by the fixed "heat capacity" $c_p^0 \equiv 3991.867\,957\,119\,63\ \ \text{J}\,\text{kg}^{-1}\,\text{K}^{-1}$.

Conservative Temperature Θ represents the "heat content" of seawater much more accurately than does potential temperature θ (McDougall (2003), Graham and McDougall, 2013). Θ can be evaluated from *in situ* temperature t from the function **gsw_CT_from_t**. The difference between potential temperature and Conservative Temperature can be as large as $\theta - \Theta = -1.4°\text{C}$ but is more typically no more than $\pm\,0.1°\text{C}$ (see Figure A.17.1 of IOC *et al*. (2010) which is reproduced below). To put a temperature difference of $0.1°\text{C}$ in context, this is the typical difference between *in situ* and potential temperatures for a pressure difference of 1000 dbar, and it is approximately 40 times as large as the typical differences between t_{90} and t_{68} in the ocean.

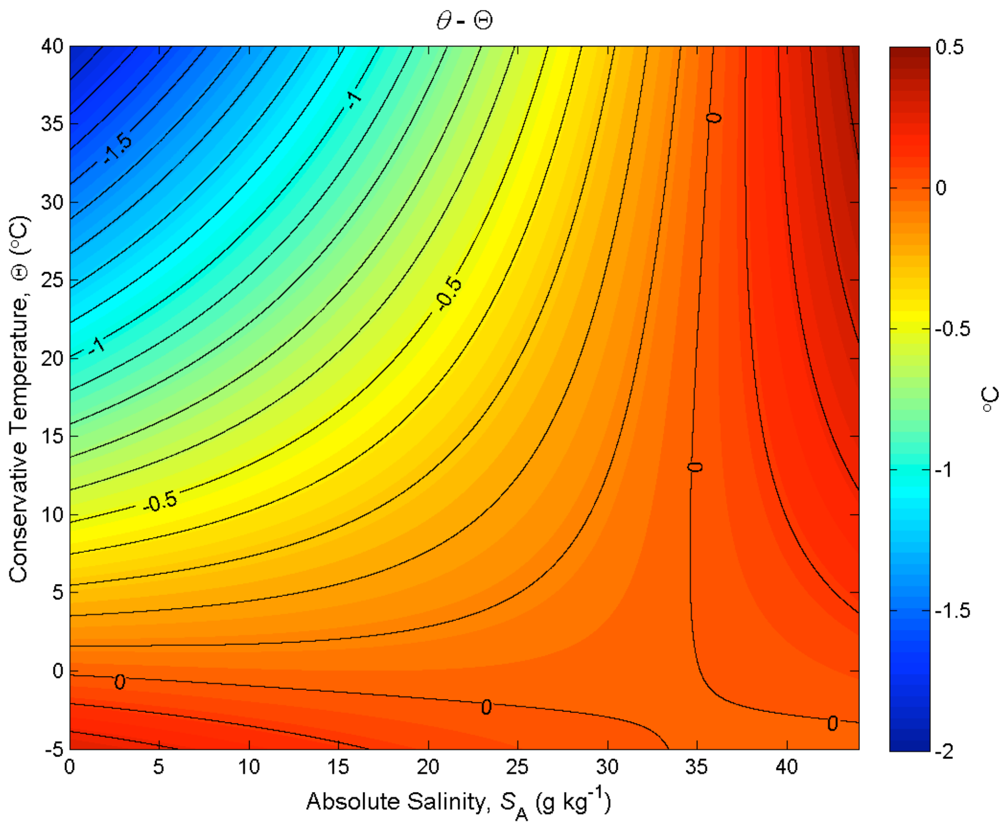

Figure A.17.1. Contours (in $°\text{C}$) of the difference between potential temperature and Conservative Temperature $\theta - \Theta$. This plot illustrates the non-conservative production of potential temperature θ in the ocean.

The air-sea heat flux is exactly proportional to the flux of Conservative Temperature, and because Θ is almost a perfectly conservative variable, the meridional "heat" flux is very accurately given by the meridional flux of Θ (as opposed to the meridional flux of potential temperature). Also, the parameterized lateral diffusion of "heat" along neutral tangent planes can be more than 1% different when such lateral diffusive heat fluxes are estimated using gradients of potential temperature rather than gradients of Conservative Temperature (see Figure A.14.1 of IOC *et al*. (2010) which is reproduced below).

For these reasons Conservative Temperature Θ is the appropriate temperature variable to be used in ocean analyses. Just as Absolute Salinity S_A is now to be used in oceanographic publications instead of Practical Salinity, so too Conservative Temperature Θ takes the place of potential temperature θ under TEOS-10.

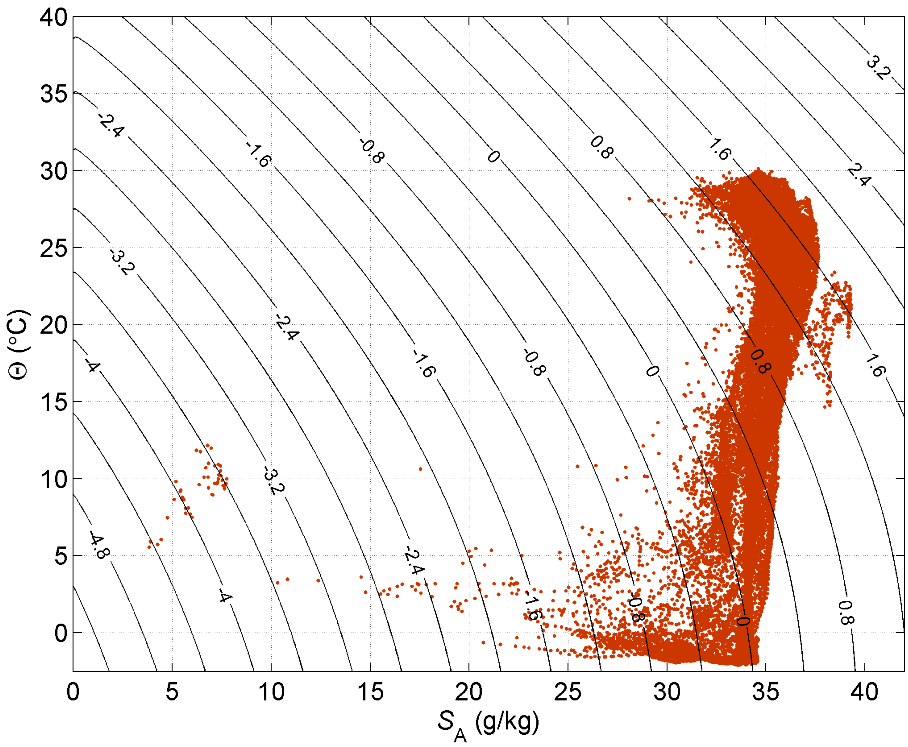

Figure A.14.1. Contours of $\left(|\nabla_n\theta|/|\nabla_n\Theta| - 1\right)\times 100\%$ at $p = 0$, showing the percentage difference between the epineutral gradients of θ and Θ. The red dots are from the global ocean atlas of Gouretski and Koltermann (2004) at $p = 0$.