

## Notes on the function gsw\_sigma4(SA,CT) (which is identical to gsw\_sigma4\_CT(SA,CT))

Potential density anomaly is defined by Eqn. (3.6.1) of IOC *et al.* (2010), namely

$$\begin{aligned}\sigma^\Theta(S_A, t, p, p_r) &= \rho^\Theta(S_A, t, p, p_r) - 1000 \text{ kg m}^{-3} \\ &= \hat{\rho}(S_A, \Theta, p_r) - 1000 \text{ kg m}^{-3}.\end{aligned}\tag{1}$$

This function, **gsw\_sigma4(SA,CT)**, (which is identical to **gsw\_sigma4\_CT(SA,CT)**) evaluates the potential density anomaly of seawater as a function of Absolute Salinity and Conservative Temperature, and with respect to a reference pressure  $p_r$  of 4000 dbar using the 48-term expression,  $\hat{\rho}(S_A, \Theta, p)$  of the GSW function **gsw\_rho(SA,CT,p)**. This 48-term rational function expression for density and specific volume is discussed in McDougall *et al.* (2011) and in appendix A.30 and appendix K of the TEOS-10 Manual (IOC *et al.* (2010)).

### References

IOC, SCOR and IAPSO, 2010: *The international thermodynamic equation of seawater – 2010: Calculation and use of thermodynamic properties*. Intergovernmental Oceanographic Commission, Manuals and Guides No. 56, UNESCO (English), 196 pp. Available from <http://www.TEOS-10.org>

McDougall T. J., P. M. Barker, R. Feistel and D. R. Jackett, 2011: A computationally efficient 48-term expression for the density of seawater in terms of Conservative Temperature, and related properties of seawater. submitted to *Ocean Science Discussions*.

Here follows section 3.6 of the TEOS-10 manual (IOC *et al.* (2010)).

### 3.6 Potential density anomaly

Potential density anomaly,  $\sigma^\theta$  or  $\sigma^\Theta$ , is simply potential density minus  $1000 \text{ kg m}^{-3}$ ,

$$\begin{aligned}\sigma^\theta(S_A, t, p, p_r) &= \sigma^\Theta(S_A, t, p, p_r) = \rho^\theta(S_A, t, p, p_r) - 1000 \text{ kg m}^{-3} \\ &= \rho^\Theta(S_A, t, p, p_r) - 1000 \text{ kg m}^{-3} \\ &= g_p^{-1}(S_A, \theta[S_A, t, p, p_r], p_r) - 1000 \text{ kg m}^{-3}.\end{aligned}\tag{3.6.1}$$

Note that it is equally correct to label potential density anomaly as  $\sigma^\theta$  or  $\sigma^\Theta$  because both  $\theta$  and  $\Theta$  are constant during the isentropic and isohaline pressure change from  $p$  to  $p_r$ .