

## Notes on the function `gsw_sigma4_CT_exact(SA,CT)`

Potential density anomaly  $\sigma^\Theta$  is defined by Eqn. (3.6.1) of IOC *et al.* (2010), namely

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

The present function, `gsw_sigma4_CT_exact(SA,CT)`, calculates potential density with a reference pressure of 4000 dbar, and uses the full TEOS-10 Gibbs function  $g(S_A, t, p)$  of IOC *et al.* (2010), being the sum of the IAPWS-09 and IAPWS-08 Gibbs functions.

This function is simply two calls to other GSW functions, as follows,

```
pr4000 = 4000*ones(size(SA));
t = gsw_t_from_CT(SA,CT,pr4000);
sigma4_CT_exact = gsw_rho_t_exact(SA,t,pr4000) - 1000;
```

### References

- IAPWS, 2008: Release on the IAPWS Formulation 2008 for the Thermodynamic Properties of Seawater. The International Association for the Properties of Water and Steam. Berlin, Germany, September 2008, available from [www.iapws.org](http://www.iapws.org). This Release is referred to in the text as **IAPWS-08**.
- IAPWS, 2009: Supplementary Release on a Computationally Efficient Thermodynamic Formulation for Liquid Water for Oceanographic Use. The International Association for the Properties of Water and Steam. Doorwerth, The Netherlands, September 2009, available from <http://www.iapws.org>. This Release is referred to in the text as **IAPWS-09**.
- 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>

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 kg m<sup>-3</sup>,

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

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  $p_r$ .