Notes on the function, gsw_t_freezing_poly(SA,p,saturation_fraction), which evaluates the in situ freezing temperature of seawater

This function, **gsw_t_freezing_poly**, finds the *in situ* temperature at which seawater of Absolute Salinity SA freezes at pressure p (dbar). The third argument is optional and is the saturation fraction (between 0 and 1.0) of dissolved air in seawater. That is, if the seawater is air-free, then saturation_fraction is 0, and if the seawater is saturated with air, saturation_fraction is 1.0. If this third argument is missing, it is assumed that the seawater is air free. This function, **gsw_t_freezing_poly**, is essentially the following calls to two other GSW functions,

```
CT_freezing = gsw_CT_freezing_poly(SA,p,saturation_fraction);
t_freezing  = gsw_t_from_CT(SA,CT_freezing,p);
```

In the region of validity of the TEOS-10 Gibbs function, the r.m.s. accuracy of the freezing temperature is estimated to be 1.5 mK (see section 6.3, figure 4 and table 7 of Feistel (2008)). The polynomial of **gsw_CT_freezing_poly** fits the full TEOS-10 Θ freezing temperature to within ± 0.6 mK over both the valid TEOS-10 $S_A - p$ range and the extrapolated region. The present function, **gsw_t_freezing_poly**, has the same accuracy as this, namely ± 0.6 mK. Hence we conclude that the use of **gsw_t_freezing_ploy** is essentially as accurate as the full TEOS-10 approach for calculating the freezing temperature. The SIA code of TEOS-10 from which we obtained the freezing temperatures that underlie this fit returns values for the freezing temperature down to about -12 °C. This *in situ* freezing temperature corresponds approximately to the line in (S_A, p) space connecting $(50\,\mathrm{g\,kg^{-1}},\ 10\,000\,\mathrm{dbar})$ to $(120\,\mathrm{g\,kg^{-1}},\ 5\,000\,\mathrm{dbar})$, and **gsw_CT_freezing_poly** and **gsw_t_freezing_poly** return Nans if the input Absolute Salinity and pressure lie beyond this line in $S_A - p$ space.

Reference

Feistel, R., 2008: A Gibbs function for seawater thermodynamics for −6 to 80 °C and salinity up to 120 g kg^{-1}, *Deep-Sea Res. I*, **55**, 1639-1671.

McDougall, T.J., P.M. Barker, R. Feistel and B.K. Galton-Fenzi, 2014: Melting of Ice and Sea Ice into Seawater and Frazil Ice Formation. *Journal of Physical Oceanography*, **44**, 1751-1775.