Introductory Dynamical Oceanography HW#1

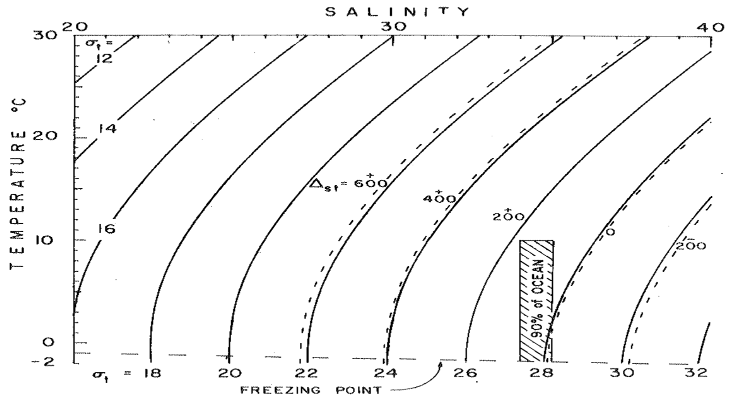

Fig. Values of density (as σ_t) and thermosteric anomaly ($\Delta_{s,t}$) as functions of temperature and salinity over ranges appropriate to most of the oceans.

A.3.2 Internal Equation of State of Sea Water, 1980

The new equation of state is presented by Millero and Poisson (1981) and also given in Unesco Technical Paper in Marine Science Number 36 (Unesco, 1981). The density of sea water as a function of practical salinity (S), temperature (T°C) and sea pressure (p bars) is given by

$$\rho(s,t,p) = \rho(s,t,0)/[1-p/K(s,t,p)]$$

where $K(s, t, p)$ is the secant bulk modulus. The specific volume is given by

$$\alpha(s,t,p) = \alpha(s,t,0)[1-p/K(s,t,p)].$$

The polynomial expressions for $\rho(s, t, 0)$ and $K(s, t, p)$ are given below.
For the IES 80, the density of sea water at one standard atmosphere pressure (p = 0) is given by:

$$
\begin{aligned}
\rho(s,t,0) = \\
&+999.842\ 594 && +6.793\ 952\times10^{-2}\times T \\
&-\ 9.095\ 290\times10^{-3}\times T^2 && +1.001\ 685\times10^{-4}\times T^3 \\
&-\ 1.120\ 083\times10^{-6}\times T^4 && +6.536\ 332\times10^{-9}\times T^5 \\
&+\ 8.244\ 93\ \times10^{-1}\times S && -4.089\ 9\ \times10^{-3}\times T\times S \\
&+\ 7.643\ 8\ \times10^{-5}\times T^2\times S && -8.246\ 7\ \times10^{-7}\times T^3\times S \\
&+\ 5.387\ 5\ \times10^{-9}\times T^4\times S && -5.724\ 66\ \times10^{-3}\times S^{3/2} \\
&+\ 1.022\ 7\ \times10^{-4}\times T\times S^{3/2} && -1.654\ 6\ \times10^{-6}\times T^2\times S^{3/2} \\
&+\ 4.831\ 4\ \times10^{-4}\times S^2.
\end{aligned}
$$

For the IES 80, the secant bulk modulus is given by:

$$
\begin{aligned}
K(s,t,p) = &\\
&+19\,652.21\\
&+ 148.420\,6 \times T \qquad - 2.327\,105 \times T^2\\
&+ 1.360\,477 \times 10^{-2} \times T^3 \qquad - 5.155\,288 \times 10^{-5} \times T^4\\
&+ 3.239\,908 \times p \qquad + 1.437\,13 \times 10^{-3} \times T \times p\\
&+ 1.160\,92 \times 10^{-4} \times T^2 \times p \qquad - 5.779\,05 \times 10^{-7} \times T^3 \times p\\
&+ 8.509\,35 \times 10^{-5} \times p^2 \qquad - 6.122\,93 \times 10^{-6} \times T \times p^2\\
&+ 5.278\,7 \times 10^{-8} \times T^2 \times p^2\\
&+ 54.674\,6 \times S \qquad - 0.603\,459 \times T \times S\\
&+ 1.099\,87 \times 10^{-2} \times T^2 \times S \qquad - 6.167\,0 \times 10^{-5} \times T^3 \times S\\
&+ 7.944 \times 10^{-2} \times S^{3/2} \qquad + 1.648\,3 \times 10^{-2} \times T \times S^{3/2}\\
&- 5.300\,9 \times 10^{-4} \times T^2 \times S^{3/2} \qquad + 2.283\,8 \times 10^{-3} \times p \times S\\
&- 1.098\,1 \times 10^{-5} \times T \times p \times S \qquad - 1.607\,8 \times 10^{-6} \times T^2 \times p \times S\\
&+ 1.910\,75 \times 10^{-4} \times p \times S^{3/2} \qquad - 9.934\,8 \times 10^{-7} \times p^2 \times S\\
&+ 2.081\,6 \times 10^{-8} \times T \times p^2 \times S \qquad + 9.169\,7 \times 10^{-10} \times T^2 \times p^2 \times S
\end{aligned}
$$

The above polynomials are taken from Unesco *Technical Papers in Marine Science* No. 26, 1981.

The following values may be used for checking the correct use of the IES 80, ρ being in kg m^{-3} and p in bars:

S	T°C	p bars	$\rho(s, t, p)$	$K(s, t, p)$
0	5	0	999.966 75	20 337.803 75
		1000	1044.128 02	23 643.525 99
	25	0	997.047 96	22 100.721 06
		1000	1037.902 04	25 405.097 17
35	5	0	1027.675 47	22 185.933 58
		1000	1069.489 14	25 577.498 19
	25	0	1023.343 06	23 726.349 49
		1000	1062.538 17	27 108.945 04

In the above polynomials, the pure-water terms are those not containing salinity (S).