Short comment on ‚Thermodynamic properties of seawater, ice and humid air – TEOS-10, before and beyond' by R. Feistel

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TEOS-10 is the step to theoretical consistency in the description of thermodynamic properties of humid air, seawater and ice. I have questions that are more or less related to accuracies.

Page 6 Line 11: The ITS-90 is an empirical temperature scale as described. The thermodynamic temperature T therefore differs from the ITS-90 temperature T_{90}. Based on a request from the Consultive Committee for Thermometry (BIPM-CCT), Fischer et al. (2011)[1] gave updated data (and accuracies) of $\Delta T = T - T_{90}$. For 20 °C (and 30 °C), $\Delta T \approx 2$ mK (and $\Delta T \approx 4$ mK) with an accuracy of 0.8 mK.

In addition to the triple point of water, where no difference is expected in the new temperature scale, it may be interesting to know the expected ΔT for other temperatures, say 30 °C, as the 4 mK given by Fischer et al. are usually not considered in calculations.

Page 7 Line 26–30: Since the sound speed measurements of Del Grosso & Mader (1972)[2] and Chen & Millero (1977)[3] there has been a discussion, because the datasets have been inconsistent. Any correction or discussion on the measurements of Chen & Millero led to a correction towards the sound speeds of Del Grosso & Mader, especially the correction suggested by Millero & Li (1994)[4].

In developing TEOS-10, the sound speeds of Del Grosso & Mader (1972), i.e. those calculated by the equation of Del Grosso (1974)[5], were used instead of those of Chen & Millero (1977) or Millero & Li (1994) (Feistel, 2003[6], 2008[7]). Since Chen & Millero (1977) measured the sound speed in seawater relatively to those in water, there was the approach to replace the water sound speeds used by Chen & Millero by IAPWS-95 sound speeds. The result of this approach was summarized as (Feistel, 2003, p. 61):

"The new IAPWS95 sound speed formula suggested the hope that these problems with Chen-Millero sound speeds may now be eventually resolved in a natural way, but unfortunately this could not be achieved by a simple replacement of the pure water parts [..]."

However, in the article under discussion (p. see above):

"In TEOS-10, the IAPWS-95 equation replaced the earlier equations of state of liquid water [..]. This change of the pure-water equation made it possible to resolve systematic problems previously encountered with the sound speed of seawater at high pressures (Dushaw et al., 1993; Millero and Li, 1994; Feistel, 2003)."

What is meant by this second statement, as it somehow seems to contradict that first statement?

[1] Fischer J et al. (2011), Int J Thermophys, 32, 12-25, https://doi.org/10.1007/s10765-011-0922-1.
[2] Del Grosso VA & Mader CW (1972), J Acoust Soc Am, 52, 961-74, https://doi.org/10.1121/1.1913202.
[3] Chen C-T & Millero FJ (1977), J Acoust Soc Am, 62, 1129-30, https://doi.org/10.1121/1.381646.
[4] Millero FJ & Li X (1994), J Acoust Soc Am, 95, 2757-59, https://doi.org/10.1121/1.409844.
[5] Del Grosso VA (1974), J Acoust Soc Am, 56, 1084-91, https://doi.org/10.1121/1.1903388.
[6] Feistel R (2003), Progr Ocean, 58, 43-114, https://doi.org/10.1016/S0079-6611(03)00088-0.
[7] Feistel R (2008), Deep Sea Res I, 55, 1639-71, https://doi.org/10.1016/j.dsr.2008.07.004.

Page 10 Line 27: Figure 3 is introduced exemplifying the use of the salinity anomaly dSA. Figure 3 suggests a negative mean salinity anomaly of about -0.008g/kg for Atlantic surface water although TEOS-10 suggests a value of about 0.000g/kg for the region of interest (http://www.teos-10.org/pubs/gsw/pdf/SAAR.pdf, Figure 2).

What are the reasons for the significant negative anomaly shown in Figure 3?

Page 12 Line 27: "[..] SA is as accurate as SP [..]"

TEOS-10 uses the absolute salinity SA as input variable for calculations. However, SA cannot be measured directly in the ocean. Instead, the practical salinity SP is measured and converted to SA using the factor f=1.004715g/kg. For standard seawater it is <u>assumed</u> that SA matches the reference salinity SR. However, SR is based on measurements of standard seawater with an estimated accuracy of 0.014g/kg (Millero et al., 2008, p. 60)[8]. By contrast, practical salinity of standard seawater can be measured with an accuracy of 0.002 (=0.002g/kg) or reproduced even more accurately.

How can SR or SA be as accurate as SP?

Page 19 Line 19–31: Measurements of standard seawater density in addition to salinity „[..] could grant the requisite long-term stability of the SSW standard [..]"

SSW is essential in practical salinity measurement, as it cannot pe prepared artificially with the required accuracy nor stored without changes in its composition in the long term. Density measurement can detect changes in the standard seawater composition or preparation. It is possible to substitute the KCl solution in the preparation process to normalize standard seawater to S=35 with a significant loss in accuracy (0.0004 vs 0.003 in practical salinity).

How can density measurement grant long-term stability of standard seawater?

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[8] Millero et al. (2008), Deep Sea Res I, 55, 50-72, https://doi.org/10.1016/j.dsr.2007.10.001.