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Discussions

Interactive comment on "The sound speed anomaly of Baltic Seawater" *by* C. von Rohden et al.

Anonymous Referee #2

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Review of "The sound speed anomaly of Baltic Seawater"

An important feature of the new TEOS-10 standard is that it contains procedures that can be used to account for variations in the relative composition of sea salt. Thus a conductivity-based measurement of Practical Salinity (and, by a simple scaling, of the Reference Salinity) can be modified by the addition of a Salinity Anomaly to form an estimate of the TEOS-10 Absolute Salinity of seawater. However, the precise definition of Absolute Salinity is not straightfoward, and in TEOS-10 a choice was made to identify this Absolute Salinity with the so-called "density salinity", that is, the numerical value of salinity that would provide the best estimate of the density of seawater. The Salinity Anomaly is thus directly related to a density anomaly.

Note that it is not a priori clear that this same numerical correction will provide equally

useful improvements for the values of other thermodynamic parameters. In a modelling study of modified seawater in the Baltic, Feistel et al., (2010) suggested that sound speed would exhibit anomalies far greater than might be accounted for by the TEOS-10 Salinity Anomaly; that is, the "sound speed salinity" would be different than the "density salinity".

If so, this would suggest that sound-speed measurements were sensitive to composition variations in a different manner than density, which would either prove a limitation of the TEOS-10 approach, or conversely might suggest that combined sound-speed/conductivity/density measurements could be used to identify specific composition variations.

In this paper, very careful measurements of sound speed in Baltic and diluted North Atlantic seawater, both in the lab and in the field, are described. The conclusion seem to be that a) the Feistel et al., (2010) estimates of sound speed anomalies, based on chemical modelling, are far too large, and b) The TEOS-10 Absolute Salinity may give reasonably accurate sound speeds as well.

I believe this paper to provide important information about the accuracy and utility of TEOS-10 and should be published. It is very well-written, well-presented, and well-argued.

I do have several minor comments:

1) The source of the Baltic seawater is well-described, but the source of the North Atlantic water is not specified. To the extent that this water is meant to be a proxy for "Standard Seawater" a source location (latitude, longitude, depth, time) should be given somewhere. Near-surface waters may have variable composition due to biological productivity, which is not captured in the constant values of the McDougall et al., (2012) atlas.

2) I am a little uneasy about casual invocation of "Millero's rule". It is not really true

that "the thermodynamic properties of water with a solute mixture depend primarily on the mass of dissolved material, and secondarily on the composition" (pg 2570), or, to the degree that this is true, it is not necessarily true at the level of uncertainty relevant here (4th significant digit in salinity and 6th in density), and I am not sure it has ever been invoked for anything other than density. Simple counterexamples are effects of dissolved oxygen and nitrogen, which hardly change density at all. Carbonates are another particular problem because it is not clear if their source is (for example) dissolved CO2 gas, or dissolved salts of some kind. Silicic acid is yet another problem (a more detailed discussion is present in Pawlowicz et al., 2011). On that basis I think it would be more precise to say something like "for many common ions, the change in density caused by very small additions is within measurement error of a similar change in the mass of sea salt" - or, at the very least, suggest that "Millero's rule" is an empirical assumption which seems to hold in some cases but whose general validity is unclear.

3) Although Fig. 1 shows that at S_P=7.766 the density-salinity-based sound speed and measured sound speed are approximately equal, it might be useful to show a similar line in Fig. 6. That is, show the calculated sound speed changes that result when the correction in eqn. (1) is used. In particular, this might show that the measurements near S_R=20 g/kg are somewhat higher than such a correction.

Feistel et al., 2010: Thermophysical property anomalies of Baltic Seawater, Ocean Sci., 6, 949-981.

McDougall et al., 2012: A global algorithm for estimating Absolute Salinity, Ocean Sci., 8, 1123-1134.

Pawlowicz et al., 2011: The effects of biogeochemical processes on oceanic conductivity/salinity/density relationships and the characterization of real seawater, Ocean Sci., 7, 363-387.

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