Ocean Sci. Discuss.,
https://doi.org/10.5194/os-2018-139-RC2, 2019


Ocean Science
Discussions

# *Interactive comment on* "Characteristics of Water Masses in the Atlantic Ocean based on GLODAPv2 data" *by* Mian Liu and Toste Tanhua

**Steven van Heuven (Referee)**

s.m.a.c.van.heuven@rug.nl

Received and published: 4 April 2019

Liu and Tanhua present an enumeration of statistical properties of selected sets of seawater samples, thereby defining 'Source Water Types', likely for further use in Optimal Multiparameter analysis (OMPa) in a separate manuscript. Although of laudable intentions (having 'true' or 'universal' SWT definitions would make many a PhD student's life easier), I do not see why this paper should be published in its current shape – or at all. My main criticism is, in increasing order of importance:

A) The ms. has not been carefully proofread, and glaring oversights remain.

B) Fundamental concepts in water mass analysis appear lost on the authors, rendering the findings of reduced usefulness for use by other investigators, who may work with a



different conceptual framework of water mass analysis / OMPa.

C) The findings are trivial, and possibly not application-appropriate. (although I did not read the companion manuscript).

The large and rather thorough central portion of the manuscript may have merit as a review of literature on Atlantic oceanography – however I do not consider myself qualified to judge whether it may hold value over existing work in this regard.

I can imagine this entire paper to constitute, in severely condensed form, the first three paragraphs of a/the application paper. Almost all figures may then be moved to supmat.

Below, I'll list for each of the above categories — non-exhaustively —- some illustration to my criticism stated above, and provide further general commentary.

***

*** A) "The ms. has not been carefully proofread, and glaring oversights remain". Writing is worryingly sloppy. References are made to obviously wrong papers. Abbreviations are jumbled. Example: – For GLODAP, reference is made to Lauvset et al (of the excellent mapped product). Given that the (bias-minimized) original bottle observations are used, reference should be to Olsen et al. That paper contains a fully self-contained explanation of the employed QC methods. This makes reference to Key et al., 2010 superfluous. Given the second authors exceedingly heavy involvement in these earlier publications, this slipup is surprising.

Phrasing is occasionally imprecise and terminology (e.g., "variable", "value", "definition" etc.) is used inaccurately. Please carefully re-read. As an example: the caption to Table 1 now reads: "Table 1: Table of all the water masses and the four main layers as defined in this study. The variables defined are used to select water samples that defines water masses in the formation regions." but perhaps, much less ambiguously, should read: "Table 1: Summary of the criteria used to select (from GLODPAv2) the water samples considered to represent the source water types discerned in this study.

For convenience, they are grouped into four depth layers."

*** B) "Fundamental concepts in water mass analysis appear lost on the authors, rendering the findings of reduced usefulness for use by other investigators, who may work with a different conceptual framework of water mass analysis / OMPa."

For instance, already the initial review section betrays a lack of understanding of the fundamentals of OMP. Line 67: "SWTs describe the original properties of water masses in their formation area, and can thus be considered as the original form of water masses (Tomczak, 1999)" is incomplete. For watermasses defined as originating from a single SWT, this is correct. However, for WMs defined as being on the mixing line between two distinct SWTs (i.e., central waters), the statement is incorrect. Throughout the text, the terminology "SWT" and "Water Mass" is mixed up. The authors appear to not be aware of (or to subscribe to) the very specific, and non-identical, definitions of SWT and WM as provided by Tomczak 1999 (although that paper is cited). Rather, the terminology is used loosely, often incorrectly, and certainly confusingly. Tomczak states (paraphrasing) that "a water mass may be defined as either a point in parameter space, or as a line between two such points". All water masses discussed in the manuscript as treated as point sources, while in wider literature many (notably the Central waters) are generally considered to be "line sources". Please re-read Tomczak 1999 and follow its protocol. For highly relevant examples of what a hierarchy of water masses and their constituent water types could look like for the Atlantic, again, consider [Middag et al., ESPL 2018] or the chapter 7 of the thesis of Van Heuven, 2012.

*** C) "The findings are trivial, and possibly not application-appropriate." Effectively, the paper is an enumeration of means and standard deviations of properties of seawater samples encountered in (slightly arbitrarily drawn) multidimensional boxes in the ocean. Such defining of SWT properties would likely be re-performed by any investigator of Atlantic water masses. Presenting them here thus has little added value for the community. (exceptions may be long-term tracing of changing Atlantic water mass distributions, always employing the same SWT definitions. Such a 'climate change' application



though, would require a less subjective or circular approach to the defining). The exact SWT definition used in a particular study may be very much application-dependent. E.g., where this study employs 'formations region' SWT definitions, other studies (e.g., Middag et al., 2018) employ 'edge-of-section' definitions for the watermasses that have not been sampled at their formation regions. Other 'ad hoc' definitions may be envisaged, and may be equally valid for the application at hand. That is, the definitions are subjective. Likely, for high-detail application, the results presented in this manuscript are too general. Conversely, for largest-scale application (i.e., basin-wide OMP), much more coarse approximations of the SWT's may suffice (see for example Middag et al., EPSL 2018).

*** Assorted commentary, in no specific order

– Although I'm a great fan of GLODAPv2, I do not see demonstrated that that data product is "uniquely ideal for use for SWT definition" (paraphrased from LINE 99), given its limited physical oceanographical detail. While GLODAPv2 is a very good biogeochemical data product, it features limited vertical resolution (vs. CTD), rather lax accuracy constraints for the exceedingly precise measurements of S and T. Without further corroboration of this statement, it is not evident why Gv2 should serve this purpose better than any other dataproduct that features S,T and O. Please elaborate. (Evidently, there may be additional value in having colocated values for N, P and Si, but I'd wager that will prove of little discriminating value for OMPa).

– The CDW in the Weddell Sea, I believe is more commonly locally referred to as the "Warm Deep Water". It evidently does not include freezing waters. However, such samples are visible at 34.65/-1.9 in Figure 20 (likely located on the continental shelf of the Antarctic Peninsula). Please select more carefully – these skew your averages...

– Table 3: What is the use of stating "potential density" statistics (particularly for deep and bottom waters)? These would not likely be used for OMPa, because no information is contained additional to what is already contained in S and T. Also, they are for

many SWT's pre-described through the sample selection criteria, so this is constitutes a rather circular result.

– Line 34: change "sea water type" to "source water type".

– On conceptual grounds I have some trouble with referring to CDW as an SWT. Rather, it may be considered to be an aged mixture of the other SWTs presented. Large-scale (extended-)OMP-analysis that considers CDW will prove unusably under-constrained for samples from the CDW (i.e., such samples might be found to consist of 100% CDW, or of 33% of each of the other SWT, or any possible combination between). (However, OMP users may obviously choose to not include CDW an a candidate SWT). Same goes for "North East Atlantic Bottom Water". That water mass is not "formed" (F19 even mentions its "formation region"). It is merely AABW that flowed there, aging, and with admixture from (already defined) deep water. This is an intermediate to other more extreme STWs, that would already be accounted for in OMPa. Obviously, for a local study of, say, NE Atl. water masses, the NEABW SWT may be used, but please refrain from using "formation region" in its context.

– Line 82: "our analysis is relatively course" ==> "coarse"

– I do not clearly see what the role is of the 4 density intervals discerned in this study? Are they merely to steer the reader's eye? Or are they used as additional boundaries to the vertical extent of selections of samples? Whatever the case, I believe that the two conceptually different ways of separating water masses by means of (i) OMP and (ii) density intervals are not necessarily compatible, and that these two methods should ideally not be mixed within a single paper, to avoid confusion.

– Line 120: "for some SWTs, key properties such as salinity, oxygen or silicate are also necessary". It may warrant some discussion as to why this does not constitute circular reasoning. For example, if one pre-defines the S-range for the samples, then the resultant average S is of little intrinsic value! This is pertinent for example to the definition of MOW ("36.35-36.65"), which in reality has salinities well beyond the stated



range.

– Most (panels of most) figures should be moved into supmat. Please maintain only an interesting subset of figures for the main ms.

– Figure 1 – this cruise is not drawn in on the map. Consider plotting it in F2. You can't expect readers to google the cruise track themselves.

– Figure 22: no characters in circles in legend. I believe it to be a shame that the paper does NOT present alternative property-property presentations of the definitions derived. Possibly, nothing beats a set of theta_vs_x plots (or similar) for visualizing the multidimensional separation of the various SWTs. For inspiration, please refer to, for instance, figure 7.5 in the thesis of van Heuven (2012). Also, from F22 I recon that there's some extremes of the samples in the S-T diagram that are not accounted for by any watertype. For example, in F22, panel B, the few hundred (?) samples at -1/34.9 have no closely associated SWT. These samples – while indeed part of the Atlantic Gv2 – are located in the Norwegian Sea, which is not covered in your work. Remove these from the figures to improve legibility and aid understanding. Also, many hundreds of samples are located at salinities well below that of AAIW (several standard deviation of the AAIW SWT definition). Are these surface samples? If not, how would these ever be represented accurately in an OMPa? For an example fix, please consider the SWT definitions in figure 7.5 of van Heuven (2012).

– Line 128 "[...] the standard deviation of the distribution (the amplitude of the curve defined as 2/3 of the highest bar)". This does not ring a bell as being a definition of standard deviation. Please rephrase.

---

Interactive comment on Ocean Sci. Discuss., https://doi.org/10.5194/os-2018-139, 2019.