The reviewer's comments are in black, and the author's reply below are in red.

Review of "Thermodynamic Concepts used in Physical Oceanography"
by Trevor McDougall (2025) for Ocean Science
Julian Mak
02 January 2026

I read this from fresh and made some comments, then went back to cross-check with the other referee comments and it seems my comments largely echo theirs (which I hope means I am not spouting completely rubbish). Some of their comments I will repeat below. There are quite a few comments, but most of them are clarifications and writing.

- Comment about targeted audience: As discussed with the author already, there was a suggestion about this being an entry for the encyclopedia of geophysics or whatever it is called. The present content and presentation is targeting a sufficiently specific audience for that. I don't mean this as a criticism at all however: technical subjects require using technical language and content, and some things do need to be "worked on" to be understood, and this is probably one of those. While it is true some presentation and points here could be clarified (probably will some additional schematic diagrams maybe), I personally would think it is a shame if the technical content is removed/lessened in favour of a wider appeal. OK.
- I agree with referee 1's point about "salinity" being placed where it is, it did seem slightly odd to me. The author's call on this: does going after the current section 4 "potential and conservative variables" work? Thanks. I have now moved the salinity section down to what is now section 8.
- line 75: "Pawlowicz eT al, 2012" (missing a "t" in "et"). Done.
- Line 80 and elsewhere: Most usages of "which" I would personally have used "that" (or put a comma before the "which" and a comma to wrap the end of the secondary clause to denote the things between the commas as additional material supporting the principal clause). The author's call on whether to adjust accordingly. I have gone through the whole paper and checked every occurrence of "which" and changed a few to "that".
- current section 3: Referee 1 raises the point about "quasi-static" vs. "reversible", would probably be good to make the point here (since we are going reasonably technical already). Indeed. I should have addressed this in the first draft. It is discussed thoroughly in section 2 of the new manuscript.
- line 175: Comma after "FTR" to break up the sentence a bit. Thanks. Done.
- line 177: Comma after "change" to break up the sentence a bit. Thanks. Done.
- line 181: Comma after close bracket. OK. This sentence has been changed a bit now.
- line 183: I would remove the commas surrounding \mu but put comma after "represents" instead. Thanks. Done.
- line 185: "Fundamental Thermodynamic Relation" -> "FTR", since it's been defined already. OK. Done.
- line 193: Comma before "which". Done.
- line 194: More of a comment here since the important part of the statement is true. Landau & Lifshitz (1959) seems a bit of an old reference (and I don't agree it is the clearest text on the subject; David Tong's lecture notes on thermodynamics and/or statistical physics now turned into books spring to mind). I have changed the words "clearest text" to "classic text". Landau & Lifshitz (1959) is very mathematical, very exact, and I like that style. It is trustworthy, and every step is obvious. Of the older thermodynamic texts, very few are written for fluid flow (total derivatives, advection, source terms as flux convergence etc.), and Landau & Lifshitz (1959) was a watershed for fluid dynamicists interested in thermodynamics.

- line 197: Echoing referee 1's point, I suggested "quality" -> "standard" or just remove that adjective, since there are perfectly good quality fluids textbooks that don't deal with thermodynamics. Thanks. Done.
- line 211: "obtaining" -> "resulting in" Thanks. Done.
- line 215: I would do "...models; such equations..." since the two parts are sufficiently connected. The two sentences have been changed to address this point.
- line 235: "BE positive" feels more natural to me (because of the presence of "both" I think). Thanks. Done.
- paragraph including line 235: Echoing referee 1's point, can probably expand this a bit more with some additional linking equations. Thanks. I have now expanded this paragraph.
- line 269: Would add a comma after "flux". Thanks. This whole sentence has now been reorganised.
- line 283: Would add a comma after "quantity". Thanks. Done.
- line 289 and 306: "Leibniz" (no "t"). Many thanks. Done.
- line 292 and eq 16: I would have "Eq. (16):", then show equation, and then start the text again. Thanks. Done.
- eq 16: Echoing referee 1's point about definition of control volume and probably having a schematic. Thanks. I have addressed this issue of mixing over a finite volume with an extra paragraph at the end of section 3 and with an extra sub-section, 5.3. This was a probing question to address. The extra material in these two places in new, but as referee 1 suggested, the issue needed to be addressed in this review.
- line 307 and eq 17: As above, show the equation and then justify the steps, having "Eq. (17):", show equation, and then start the text again. Thanks. Done.
- text after eq. 17: (Geoff's comment) Useful to link to Fig 8. Thanks. Done.
- eq 18: Echoing all comments, define the meaning of hats here (bring/repeat some of the text from line 829 forward to here). Also needs a full stop to end the equation. Thanks. Done both these things.
- line 336: No "expression (R.02)" here. Thanks. Fixed this typo.
- line 345: Suggest comma before "while". Thanks. Done.
- line 355: Suggest comma after "correctly". Thanks. Done.
- line 365: Comma before "while". Thanks. Done.
- line 367: Common to replace the semi-colon. Thanks. Done.
- Section 6 title: Doesn't really talk or define temperature? If this section included section 7 then it's probably fine. Thanks for this. Yes, the definition of Conservative Temperature was missing. I have added material and renamed this section to be “Ocean heat content and Conservative Temperature”, and sections 5.1 and 5.2 together provide the motivation and definition of both ocean heat content and Conservative Temperature.
- line 417: Suggest comma before "and". Thanks. Done.
- line 436: Sentence "Because the four coefficients..." is redundant since it is covered by the sentence before already. Thanks. I have now deleted this sentence.
- line 439 to 441: Authors call on this; I just think this sentence is unnecessary. Thanks. I agree. This sentence has now been deleted.
- line 461: Instead of "t" (which is time), suggest \Delta T or \delta T but define it explicitly. I have now explained these different temperatures.

- line 475: Remove first two "nor"s, and "nor potential temperature" -> "or potential temperature", ending the sentence there (the bit after the semi-colon is unnecessary). Thanks. Done.
- line 491: Second "m_1" -> "m_2" Thanks. This typo has been corrected.
- line 492: I assume since m_1 + m_2 = m, so either

  m_1 = m_2 = 1/2 m => 1/2 m_1 m_2 / m^2 = 1/2 * (1/2 m)^2 / m^2 = (1/2)^3 = 1/8, or

  1/2 m_1^2 / (2 m_1)^2 = 1/2 * 1/4 = 1/8,

  so I think one of Geoff's comments can be ignored? This typo has been corrected.
- line 533: "on" -> "upon"? Thanks. Done.
- section 9.1: I thought the point about BGC affecting salt content and therefore density is interesting, may want to echo this at the end (see a later comment). Thanks. I do now make a much bigger point of this in the Summary section 14.
- line 726: Remove floating closed bracket. Thanks. Done.
- line 742: "2 1/2%" -> "2.5%". Thanks. Done.
- line 746: missing degree sign in "2C". Thanks. Done.
- line 756: Comma before "and", otherwise too many "and"s floating around. Thanks. I've fixed both issues by breaking the sentence into two sentences.
- line 760: Full stop replaced by colon since opening the list. Thanks. Done.
- line 763-764: Round brackets instead of square brackets probably. Thanks. I've now used round brackets.
- line 786: Comma before "a". Thanks. Done.
- line 798: Remove "of". Thanks. This typo has now been corrected.
- line 815: add "= 0" to in-line equation, and probably a comma as well. Thanks. Both things have been fixed.
- line 829: "...pressure \tilde{P}, T_b is the..., AND the over-hats AGAIN indicate that..." Thanks. Done.
- line 845: Just because it looks a little odd having a sentence start with a lower case letter, would suggest passive voice as "A variable called orthobaric density \rho_v, which is a function..., was introduced by de Szoeke et al (2000)." Thanks. Done.
- line 892: "neutral" density? Thanks. Done.
- line 924: Semi-colon to colon. Thanks. Done.
- line 932: Clarify and/or expand what is meant by "epineutral" (echoing Geoff's comment). Thanks. I have included the explanation in a bracket.
- 1st paragraph of sec 12: See Geoff's comment about this not being a "proof", and clarify accordingly, and some content in the paragraph of line 971. Thanks. I have now addressed this in the text, and in my response to Geoff Stanley.
- eq 47: Suggest comma instead and move the bracketed text before to after the equation and remove the brackets (state first, then define). Thanks. Done.
- line 1080: NSPV is already defined so can just use it, remove expanded text. Thanks. Done.
- line 1093: Remove brackets (to be consistent with two points before). Thanks. Done.
- eq 52: Needs a comma after the zero vector. Done.
- eq 53: Suggest full stop and starting next sentence with "Taking the epineutral gradient of this equation, WE find that..." Thanks. Done.

- eq 54: Need a comma and a full stop here. Thanks. Done.
- line 1106: "its" -> "the" Thanks. I've changed this sentence.
- line 1108: Can just use NSPV again without the expansion (or just don't use the acronym at all actually). OK. Done.
- eq 55: Need a comma and a full stop here. Thanks. Done.
- line 1113: No "Eq. (113)" here. Thanks. I've fixed this typo.
- line 1122: Can just use NSPV again without the expansion. Thanks. Done.
- eq 57: Needs a comma after the zero vector. Done.
- eq 59: Needs a comma after the zero vector. Done.
- line 1135: Can just use NSPV again without the expansion. Done.
- eq 61: Is "\kappa" defined? Might be good to redefine it as a reminder if so. Done.
- eq 65: As above, state equation, replace full stop with comma, and move the bracketed text to after the equation removing the square brackets. Thanks. Done.
- sentence of line 1177: Would suggest moving or repeating sentence further up as some sign-posting for the reader. Thanks. I have now placed a pointer about this at the very beginning of section 13.
- line 1200: Would add comma before brackets and remove the brackets. Yes, good, thanks, done.
- line 1225: Commas surrounding "which depends on the electrical conductivity of seawater" since this is the secondary clause. Thanks, done.
- line 1244-1245: "...very little research, and... as preliminary AND unfinished business". Yes, this wording was wrong. I've changed/softened this now.
- section 14: Echoing Geoff's point, I would have liked to see some key summaries and some call-to-action by providing/highlighting some research outlook directions (e.g. I thought the BGC model coupling to salinity was interesting) the author would like to see in due course. It makes the end a bit less abrupt, and I think that while a review a paper certainly looks to the past, some vision towards the future would be desirable. I have done this now in the final paragraphs of the Summary section 14.
- Figures: Doesn't need to go in the back even for the draft. OK, I will stay with the figures being at the back for now, as I remember reading this in the instructions to authors.
- Figure 2 and 3: If possible, please make the black dots bigger to be consistent with Figure 5. Sorry, I am unable to change this.
- Figure 4: We generally prefer authors to not use jet/rainbow colour schemes now. Would suggest a Red/Blue one (for positive and negative values) or similar. Sorry, I am unable to change this.
- Figure 12: Would prefer not jet/rainbow, but this might be more difficult to achieve. Sorry, I am unable to change this.