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Ocean Science Discussions

Interactive comment on “Climatological mean distribution of specific entropy in the oceans” *by* Z. Gan et al.

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Specific entropy as an important thermodynamic state function can be considered to provide insight into the physical properties of seawater, but for a long time, specific entropy was only estimated by using the empirical expression and it would only be exact within a linear function of salinity (Original words on pp.18, Fundamentals of Ocean Dynamics by V.M .Kamenkovich, Translated by R.Radok, Elsevier Scientific Publishing Company, New York, 1977) The purpose of our manuscript is to using the excellent work of Feistel (2003) to determine the specific entropy of sea water and link it to potential temperature and potential density in the ocean. The results show that an isopycnal is not the same as an isentrope in the ocean.

1. About the comment of referee #2, “In the ocean this is not the case and as a result the surfaces are known to intersect... In fact this is not true; entropy is only conserved

if any changes are adiabatic. Conversely adiabatic movement in any direction will conserve entropy of the water particles. Later authors have followed Montgomery and this has led to the confusion in the present paper."

Of course, it is very reasonable for referee #2 to doubt about our ability to understand the word "isentropic", but there has no doubt about that exists in the well-known physical oceanography textbook, such as "Descriptive Physical Oceanography —-"Since processes that change density are weak below the surface layer, ocean flow is much more likely to follow surfaces of constant entropy, or isentropic surfaces. (Entropy is conserved if a process is adiabatic, that is, has no change of heat or salt.) This concept was introduced in the 1930s, and closely follows meteorology practice. In the ocean, isentropic surfaces are difficult to determine because of the complicated empirical equation of state (chapter 3). Surfaces of constant potential density (isopycnals) referenced to a nearby pressure (if working close to the sea surface, if working close to 4,000 dbar, etc) are a close approximation to isentropic surfaces. Surfaces of constant neutral density (isoneutrals) have been argued to be almost identical to isentropic surfaces (chapter 3.5.4). Therefore it has become common to map properties on isopycnal (or isoneutral) surfaces. " (Original words cited On Page 7, Section 7.4.2: Horizontal mapping of the well-known textbook "Descriptive Physical Oceanography" By William J. Emery, Lynne D. Talley and George L. Pickard, to be published by Elsevier, 2007. See http://www-pord.ucsd.edu/˜ltalley/sio210/pickard_emery/emery_talley_pickard_index.pdf)

2. About the comment of referee #2 "Why does salinity have a strong effect on density and only a little effect on the entropy?". This is an interesting issue, but since density and entropy are both calculated by using Gibbs function of Feistel (2003), if we want to answer this question, we should go back to check Gibbs function of Feistel and it is outside the scope of this manuscripts. Discussion about this issue will be made on our next manuscript.

3. About the comment of referee #2 "Physically the most important thing about entropy

is its rate of change with time." Yes, the second law of thermodynamics is concern with the change of entropy with time. The changes of entropy in the oceans have been discussed in our papers (see Entropy budget of the ocean system. Geophysical Research Letters, 2004, 31 (14), 14311and Entropy budget of the earth, atmosphere and ocean system Progress in Natural Science, 2004, 14 (12), 1088-1094. In this manuscript, it is not necessary to consider the change of entropy, because what we discuss is "Climatological mean distribution of specific entropy", which means that the entropy is stable.

4. About the comment of "the use of different color scales on related figures", we need to note that since these variables are different quantify and have different magnitude, if we use the same color scale that means we have to enlarge one or compress the other two.

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Interactive Comment