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Ocean Science Discussions

Interactive comment on "On available energy in the ocean and its application to the Barents Sea" *by* R. C. Levine and D. J. Webb

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This paper is an attempt to address the following issues: 1) Theoretical formulation related to available potential energy in the ocean; 2) application to the Barents Sea.

First, it is surprising to see that no previous oceanographic papers related to this subject were cited. It may give the reader the wrong impression that this is an entirely new field and the authors are pioneers in this field. On the contrary, this is a classical topic, and many people have written papers about this subject. The authors should search and study the relevant theory discussed in previous publications. As a scientific research paper, the authors should present an overview of the previous studies and clearly state what is new in their paper, in comparison with previous studies.

The following is a short list of papers published in open journals:

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Discussion Paper

Bray, N. A. and N. P. Fofonoff, 1981: Available potential energy for MODE eddies. *J. Phys. Oceanogr.*, **11**, 30-47.

Huang, R. X., 1998. Mixing and available potential energy in a Boussinesq ocean. *J. Phys. Oceanogr.*, **28**, 669–678.

Huang, R. X., 2005: Available Potential Energy in the World Oceans, *J. Mar. Res.*, **63**, 141-158.

Magules, M., 1905: Uber die energie der sturme, Wein: K. K. Hof-und. Stattsdruckerei, 26pp.

Oort, A. H., S. C. Ascher, S. Levitus, and J. P. Peixoto, 1989. New estimates of the available potential energy in the world ocean. *J. Geophy. Res.*, **94**, 3187-3200.

Oort, A. H., L. A. Anderson, and J. P. Peixoto, 1994. Estimates of the energy cycle of the oceans. *J. Geophy. Res.*, **99**, 7665-7688.

Reid, R. O., B. A. Elliott and D.B. Olson, 1981. Available potential energy: A clarification. *J. Phys. Oceanogr.*, **11**, 15-29.

Second, the specific definition of available energy introduced in this paper is not new and some part of the reasoning is not convincing.

Starting from the definition of available potential energy (APE), the authors should point out that this was first introduced by Magules in 1905. Lorenz (1955) introduced the approximated definition of APE for the atmospheric circulation, and it has been used extensively in meteorology. This definition has been applied to oceanography, .e.g., Oort et al. (1989, 1994).

In 1981, two papers were published in *J. Phys. Oceanogr.*, as cited above. In these papers enthalpy was used in the study of APE in the ocean; thus, the suggestion made by Levine and Webb is not new. However, Huang (2005) argued that using enthalpy in formulating the APE may introduce errors for the case with bottom topography.

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The application of APE to oceanography must overcome several difficulties. Searching for a reference state with minimum potential energy for the ocean with realistic topography and a nonlinear equation of state is a major challenge. Oort used the density profile obtained by horizontally averaging the potential density at each level. Although such a profile might be very useful for meso-scale problems, it may not be suitable for basin-scale circulation. Fofonoff, Reid and others proposed to use enthalpy; however, it has its own problem, as discussed above.

A computational algorithm was proposed by Huang (2005), which can be used to find the reference state with minimal gravitational potential energy in the world oceans with realistic topography. Most importantly, the algorithm applies to the case with a realistic equation of state of sea water.

There are other problems in the approach discussed in this paper:

Although internal energy was mentioned in the introduction, it is not discussed in the main text.

In previous studies, APE was clearly defined as the difference in energy between the physical state and the reference state. This paper, however, does not follow the same approach. As in the classical approach, APE is defined as a global quantity, thus, the meaning of APE defined as the difference between two water columns is unclear. In particular, if a water parcel is moved from one location to a new location, gravitational potential energy of the original column should be reduced. This reduction of gravitational potential energy of the original water column is, however, not included in the definition introduced in this paper.

It is clear that this manuscript needs to go through a major revision, including a comprehensive review of the previous publications and a careful definition of the available potential energy. Although the authors may introduce a new and potentially better definition, they should compare such a definition with those used in previous studies.

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