

Rainer Feistel 17 Oct 2025

Discussion (started: 2 October 2025) of the preprint at egusphere:

Is the Lorenz reference state global or local and observable?

By Rémi Tailleux, <https://doi.org/10.5194/egusphere-2025-4595>

Discussion:

Estuaries with a pronounced, slanted halocline between discharged brackish river water at the surface, and ocean water intruding along the sea floor in opposite direction, represent typical oceanographic examples for substantial amounts of available potential energy (APE) stored in the water column. Such systems may offer a very transparent demonstration of the advantageous approach suggested by Rémi Tailleux's proposal. In such cases, the distinct water masses above and below the halocline may each be assumed for simplicity to be well-mixed so that high-energy buoyancy oscillations with high frequencies are restricted to the halocline itself. Then, the related APE may easily be estimated quantitatively from available local CTD profiles, assumingly in total being proportional to the lateral surface area of the halocline. By contrast, globally the APE is expected to be proportional to the pycnocline slope and the related up- and downwelled water volumes above and below.

To assist readers in taking advantage, the author should explicitly demonstrate his new method at a simple analytical tutorial example, perhaps in an appendix of the paper.

The Baltic Sea is a special marine system that is extremely well studied by dense spatial and temporal oceanographic long-term monitoring (Feistel et al. 2008). Its typical estuarine circulation (Reissmann et al. 2009, Burchard et al. 2018) is mainly driven by strong lateral salinity gradients (Feistel et al. 2010) and the related Available Potential Energy (APE). The recent paper of Rémi Tailleux, as I understand it, suggests an elegant method of regularly estimating the Baltic APE from routine CTD profiles in combination with the TEOS-10 seawater standard (IOC et al. 2010) for computing the local vertical stability with respect to fluctuations of pressure at constant salinity S and entropy η , as

$$\left[\frac{d\rho}{dp} - \left(\frac{\partial \rho}{\partial p} \right)_{S,\eta} \right] = \left[\left(\frac{\partial \rho}{\partial S} \right)_{p,\eta} \frac{dS}{dp} + \left(\frac{\partial \rho}{\partial \eta} \right)_{S,p} \frac{d\eta}{dp} \right], \text{ see the paper's eq. (4).}$$

The Baltic Sea may provide such a simple idealized system for tutorial purpose. For simplicity, let the Baltic basin itself be represented by a box homogeneously filled with brackish water, and the North Sea by a similar box with salty ocean water, as shown in Fig. 1. The natural shallow connection between the two, given by the Danish Belt Sea, may be modelled by narrow openings permitting gentle exchange between the basins in both directions, which in nature is enforced by tidal oscillations (Feistel et al. 2004) or wind-driven anomalies of the sea level (Matthäus 2006).

Of the schematic model in Fig. 1, the state of minimum potential energy is easily constructed by global displacement of the water parcels as shown in Fig. 2. Note that the situation of Fig. 1 may be arbitrarily close to rest as the salinity difference between the basins may be imagined as small as required.

Comparing Figs. 1 and 2, the available potential energy results from the difference between a vast volume of dense water transferred from the North to the Baltic Sea and lowered to the bottom there, and an equal volume of less dense water in opposite direction raised to the surface. In reality, this potential energy drives the natural estuarine circulation of the Baltic. It is unclear, however, how this amount of energy may be computed from the size, shape and local steepness of the halocline in

the shallow transition zone of Fig. 1. Moreover, the halocline in Fig. 2 is much more extended than before, while there is no APE associated anymore with the reference state of Fig. 2, by definition. Clarification is desired.

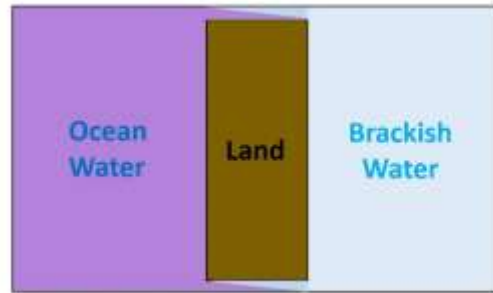


Fig. 1 Simplified schematic of the Baltic Sea as a basin with brackish water, on the right-hand side, and the North Sea as a basin with salty ocean water, on the left. Haloclines separating the two water masses are located in narrow connections with volumes negligible in comparison to the basins.

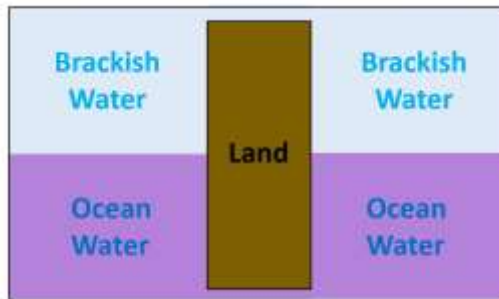


Fig. 2 Theoretical state of minimum potential energy obtained from Fig. 1 by global rearrangement of the water parcels. The APE of Fig. 1 is easily estimated from the differences between the two figures. Although Fig. 2 has zero APE, the pycnocline is still existing and is even larger than in Fig. 1. Buoyancy oscillations are possible only at that pycnocline because elsewhere the water bodies are assumed to be neutrally stratified with vanishing vertical gradients of salinity $\frac{dS}{dp} = 0$ and entropy $\frac{d\eta}{dp} = 0$ (turbulently mixed with isentropic lapse rate, McDougall and Feistel 2003).

If it possibly turns out that the proposed Tailleux method of estimating the APE from local CTD profiling is not applicable to cases of an estuarine like the Baltic, the related validity limits should be explicitly addressed in the article.

Minor issues:

- The term “equilibrium” in the abstract and elsewhere should be more specific: is it thermodynamic, hydrodynamic or mechanic equilibrium, for example?
- The “static energy function” Σ should be specified in terms of proper conventional thermodynamic energies of TEOS-10, such as enthalpy h or Helmholtz energy f , etc. How is Σ to be computed from the TEOS-10 software library?
- How is Σ_{heat} related to potential enthalpy (McDougall et al. 2021) ?
- In eq. (5) and below, the partial derivatives should be written in thermodynamic convention, indicating which variables are kept constant.

- Eqs. (10) and (11) are typical thermodynamic Legendre transforms (Alberty 2002). Presenting exact differentials of Σ , Σ_{dyn} , Σ_{heat} , E_p , E_a , E_b along with explaining the physical quantities of the implied partial derivatives in terms of standard textbook thermodynamics would greatly help the reader to follow the given arguments.

Conclusion:

It is recommended that the submitted paper will be subject to a **MAJOR REVISION** before it may be published.

References

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