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Ocean Science Discussions

Interactive comment on "Understanding mixing efficiency in the oceans: do the nonlinearities of the equation of state for seawater matter?" *by* R. Tailleux

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Subject: Non-uniqueness of energy conversions

I thank the author for making his manuscript Tailleux (2008) available on the web. I see that my earlier comment

"Energy conversions are inherently non-unique... the reader... needs the explicit mathematical formulae"

is to be contrasted with page 5 of Tailleux (2008), where I read

"Physical energy conversions... are necessarily unique, for in Nature, it _seems obvi-

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ous_" (my emphasis) "that energy must flow throughout the different existing energy reservoirs in a definite and reproducible manner."

My comment is also to be contrasted with the statement in the author's last interactive comment that "there _must_" (my emphasis) "exist a rigorous way to look at the issue of energy conversions that eliminates the... arbitrariness."

However, I'd argue that to assert that something "seems obvious" or "must" exist is only an expression of faith, and not a proof in any more or less rigorous sense. So I remain unconvinced that I should withdraw my comment that energy conversions are inherently non-unique. Indeed, the author admits, on page 27 of Tailleux (2008), that

"salinity complicates the definition of Lorenz (1955)'s reference state to such an extent that it is not even clear that such a state can be uniquely defined..."

Here I agree. "The" available potential energy, which depends on "the" reference state used, is again not a uniquely definable quantity.

There's a good reason why. How much energy is available for conversion depends on which process does the conversion. For instance, the energy reservoir available to a classical Eady-type baroclinic instability is obviously different from that available to salt-fingering, and again different from that available to cabbeling.

Less serious, but also relevant in principle, are the standard ambiguities such as the dependence of kinetic energy on reference frame, of total potential energy on reference altitude, and of internal energy on salinity.

So even in thinking in terms of "the" reservoir of each form of energy can be perilous. (See for intance the reference to the "four free constants" on page 50 of the cited paper by Feistel (2003), referring to various fundamental thermodynamic quantities including chemical potentials.)

I must also disagree, by the way, that there is a simple dichotomy between "physical truth" and "mathematical games", as if they were two distinct entities. That's a false

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dichotomy – one of many such that tend to confuse us. (For clear evolutionary reasons, there is a deep-seated human instinct to polarize things in this way, a fact routinely exploited by politicians and others.)

Mathematics is not something distinct and separate from "physical truth". Rather, it is, and always has been, intimately and inextricably involved in the discovery of "physical truth". There's a good reason for this. Mathematics is a language whose built-in checks for self-consistency are much stronger than those in verbal language. That's why mathematics is so valuable in helping to build models of reality to be tested against observation. (And of course energy budgets are merely one aspect of our models, not complete descriptions of them.)

I am not saying that mathematics is the only valuable language in science and that verbal language is useless. On the contrary, all our modes of thought and perception – mathematical, verbal, visual, tactile, proprioceptive, etc. – seem to me valuable. In science we have the difficult task of making them mutually consistent as well as consistent with observation. Indeed, I would go so far as to argue – and I'm in good company here (with Einstein, Feynman, G. I. Taylor, James Lighthill, and many other great scientists) – that understanding something, in the most powerful scientific sense of the word "understanding", means being able to use all the different modes of thought and perception to apprehend a single phenomenon from as many angles as possible, for instance via equations, pictures, and verbal descriptions all saying the same thing in different ways.

Interactive comment on Ocean Sci. Discuss., 6, 371, 2009.