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On the definition of heat in the ocean: A new heat variable more conservative than Conservative Temperature

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The excess of energy imparted to the equatorial regions by the external differential solar heating drives a poleward heat transport in both the ocean and atmosphere that climate models strive to predict accurately. In the ocean, poleward heat transport has been primarily diagnosed in terms of a heat variable defined as the product of potential temperature times a constant heat capacity. This approach, however, was challenged by McDougall (2003) over 15 years ago as being significantly inaccurate. Indeed, McDougall pioneered the idea that the accuracy and usefulness of a heat variable should be assessed by the degree of its non-conservativeness. On this basis, McDougall showed that potential enthalpy (that is, enthalpy referenced to mean atmospheric surface pressure) was significantly more conservative than potential temperature, and hence that it should be the heat variable that one should use to diagnose heat transport in ocean climate models. What has remained unclear so far, however, is whether potential enthalpy necessarily represents the definitive answer to how to define heat in the ocean, or whether a more conservative heat variable exists. The main aim of this talk is to demonstrate that the definition of 'heat' in the ocean (and more generally in the climate system) should be defined in relation to 'work'. Since work is classically associated with the concept of available potential energy, the main aim of this talk will be to show that a locally defined background potential energy is significantly more conservative than potential enthalpy and Conservative Temperature, and therefore likely the best possible definition of heat in the ocean. Further properties and advantages of this new heat variable will be discussed.