Reappraising the appropriate calculation of the potential temperature

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The potential temperature is a widely used quantity in atmospheric science since it corresponds to the entropy and is conserved for adiabatic changes of dry air. As such, it is routinely employed in applications ranging from atmospheric dynamics to transport modeling. The common formula to compute the potential temperature is based on the assumption of a constant specific heat capacity for the dry air, even though the latter is known to vary with temperature.

We re-derive the (dry air) potential temperature for a recent temperature-dependent formulation of the specific heat capacity of dry air. The result is expected to provide values which are much closer at the true entropy value (expressed as a temperature) and hence serves as the reference potential temperature. However, its computation is less straightforward compared to the classical one, motivating the development of efficient approximations. Moreover, similarities and differences are discussed between the newly derived reference potential temperature and the classical one based on a constant specific heat capacity. The new reference shows different values and vertical gradients, in particular in the stratosphere and above. Applications of the new reference potential temperature are discussed in the context of common computations in the atmospheric sciences, including the potential vorticity or diabatic heating rates.