

Using Enthalpy for Thermodynamic Equation

Hann-Ming Henry Juang
Environmental Modeling Center, NCEP, NOAA, USA

Abstract

The thermodynamic equation, used in most operational and research atmospheric models, has temperature and/or its variation as the prognostic variable. The most popular one is potential temperature or virtual potential temperature for mesoscale models, and temperature or virtual temperature for global models. In this paper, we will illustrate the reasons and derivation of the thermodynamic equation with enthalpy as its prognostic variable.

Based on the equation of state for different gases and internal energy equation with gas constant R and specific heat capacity C_p as function of gases or tracers, the thermodynamic equation can be treated more accurate by using enthalpy as a prognostic variable instead of temperature. The property of enthalpy is proximity to the property of temperature. In addition to the adiabatic condition used for potential temperature, potential enthalpy can be conserved under the condition of no sink/source of gases and/or tracers.

To demonstrate the usage of enthalpy, the primitive equation used in NCEP GFS with enthalpy as a prognostic variable instead of virtual temperature is derived and discretized as in Juang (2005). The numerical results will be shown and compared to the results from operational NCEP GFS, which uses virtual temperature as a prognostic variable.

References

Juang, H.-M. H., 2005: Discrete Generalized Hybrid Vertical Coordinates by a Mass, Energy, and Angular Momentum Conserving Finite-Difference Scheme. *NCEP Office Note*, **455**, 35pp.