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Fast and Accurate Calculation of Wet-bulb Temperature for Humid-Heat Extremes

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It is well known that heat extremes have increased in frequency, intensity, and duration over recent decades. However, since extreme heat is typically examined using dry-bulb temperature, the reported changes do not fully reflect the impacts these events may have on human health. By accounting for humidity in measures of extreme heat, we can gain a better understanding of the health risk associated with these events in current and future climates.

A variety of indices are used to examine humid heat. One of the simplest is wet-bulb temperature (T_w), which is defined as the temperature of a parcel of air cooled to saturation by the evaporation of water into it. T_w is typically calculated using empirical equations (e.g., Stull 2011, Davies-Jones 2008); however, these can be inaccurate for extreme values or slow due to the need for iterations in the solution. Here, we present a fast and highly accurate calculation of T_w, which we call NEWT (Noniterative Evaluation of Wet-bulb Temperature). This method follows the diagrammatic approach to evaluating T_w, where a parcel is lifted dry adiabatically to its lifting condensation level (LCL) and then brought pseudoadiabatically back to its original level. To avoid the need for iterations, NEWT uses exact equations for the LCL from Romps (2017) and a modified version of the high-order polynomial fits to pseudoadiabats from Moisseeva and Stull (2017).

A comparison of NEWT with three other methods for calculating T_w (Stull, MetPy, and Davies-Jones) reveals a marked improvement in accuracy, with maximum errors of ~0.01°C (cf. ~1.3°C for Stull,

~0.4°C for MetPy, and ~0.05°C for Davies-Jones). The accuracy of each method is further assessed using Automatic Weather Station data from the Bureau of Meteorology, with a focus on extreme values.