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Temperature and equivalent temperature over the United States (1979–2005)

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ABSTRACT: Temperature (T) and equivalent temperature (T_E) trends over the United States from 1979 to 2005 and their correlation to land cover types are investigated using National Centers for Environmental Prediction North American Regional Reanalysis data, the Advanced Very High Resolution Radiometer (AVHRR) land use/cover classification, the National Land Cover Database (NLCD) 1992–2001 Retrofit Land Cover Change and the Normalised Difference Vegetation Index (NDVI) derived from AVHRR. Even though most of the magnitude of T_E is explained by T, the moisture component induces larger trends and variability of T_E relative to T. The contrast between pronounced temporal and spatial differences between T and T_E at the near-surface level (2 m) and minor-to-no differences at 300–200 mb is a consistent pattern. This study therefore demonstrates that in addition to temperature, atmospheric heat content may help to quantify the differences between surface and tropospheric heating trends, and hence the impact of land cover types on the surface temperature changes. Correlations of T and T_E with NDVI reveal that T_E shows a stronger relationship to vegetation cover than T, especially during the growing season, with values that are significantly different and of opposite signs (−0.31 for T *vs* NDVI; 0.49 for T_E *vs* NDVI). Our results suggest that land cover types influence both moisture availability and temperature in the lower atmosphere and that T_E is larger in areas with higher physical evaporation and transpiration rates. As a result, T_E can be used as an additional metric for analysing near-surface heating trends with respect to land cover types. Moreover, T_E can be tested as a complementary variable for assessing the impact of land surface and boundary layer processes in re-analysis and weather/climate model studies. Copyright © 2010 Royal Meteorological Society

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1. Introduction

Temperature variability and trends have been extensively investigated. Results from the huge body of studies indicate that significant warming took place over the last century (e.g. Jones *et al.*, 1986; Vinnikov *et al.*, 1990; Crowley and Lowery, 2000; IPCC, 2001, 2007; Mann and Jones, 2003; Soon *et al.*, 2004; Moberg *et al.*, 2005). Furthermore, climate model experiments and multiple observational datasets suggest that the warming observed in the ocean, at the surface and in the troposphere is consistent with anthropogenic greenhouse forcing of the climate system (Mears and Wentz, 2005; Barnett *et al.*, 2005a, 2005b; Santer *et al.*, 2005; Sherwood *et al.*, 2005; IPCC, 2007; Santer *et al.*, 2008).

Recent study also shows that atmospheric moisture content has increased in the past decades (Wentz and Schabel, 2000; Held and Soden, 2006; Santer *et al.*, 2007; Wentz *et al.*, 2007). Although positive trends in moisture content are consistent with positive trends in temperature, relatively few studies have focused on a simultaneous analysis that integrates temperature and moisture. Steadman (1979, 1984) derived a scale of apparent temperature, which expresses the combined effects of air temperature, vapour pressure, wind and solar radiation. Using observed temperature and humidity datasets over the 1961–1995 period, Gaffen and Ross (1999) found upward trends in apparent temperature over the United States. More recent studies focus on moist enthalpy (or, alternatively, equivalent temperature), which combines both air temperature and humidity in a single variable, to assess surface heating trends. Results from such studies suggest that the utilisation of temperature as a monitor of climate change may not provide a complete evaluation of the heat storage changes to the earth system (Pielke,

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