CONTROL ID: 1473897

TITLE: Response and Sensitivity of the Nocturnal Boundary Layer Over Land to Added Longwave Radiative Forcing

AUTHORS (FIRST NAME, LAST NAME): Richard T McNider[1], Gert-jan Steeneveld[2], Bert Holtslag[2], Roger A Pielke[3], Scott Mackaro[4], Udaysanakr S Nair[1], Arastoo Poor Biazar[1], John R Christy[1], Justin Walters[5]

INSTITUTIONS (ALL): 1. Earth System Science Center, University of Alabama in Huntsville, Huntsville, AL, United States.
2. Meteorology and Air Quality Section, Wageningen University, Wageningen, Netherlands.
3. CIRES, University of Colorado, Boulder, CO, United States.
4. Vaisala,Inc, Boulder, CO, United States.
5. Southern Company, Birmingham, AL, United States.

ABSTRACT BODY: . One of the most significant signals in the thermometer-observed temperature record since 1900 is the decrease in the diurnal temperature range (DTR) over land. CMIP3 climate models only captured about 20% of this trend difference. An update of observed trends through 2010 indicates that CMIP5 models still only capture about 28%. Because climate models have not captured this asymmetry, many investigators have looked to forcing or processes that models have not included to explain the lack of fidelity of models. Our paper takes an alternative view of the role nonlinear dynamics of the stable nocturnal boundary layer (SNBL) may provide as a general explanation of the asymmetry. This was first postulated in a nonlinear analysis of a simple two layer model that found slight changes in incoming longwave radiation might result in large changes in the near surface temperature as the boundary is destabilized slightly due to the added downward radiation. This produced a mixing of warmer temperatures from aloft to the surface as the turbulent mixing was enhanced. In the present study we examine whether this behavior is retained in a more complete multi-layer column model with a state of the art radiation scheme for the stable boundary layer. The response of a nocturnal boundary layer to an added increment of downward radiation from CO2 and water vapor (4.8 W m -2) was compared to the solution without this forcing. These experiments showed that indeed the SNBL grew slightly and was less stable due to the added longwave radiation. The model showed that the shelter temperature warmed substantially due to this destabilization. Moreover, the budget calculations showed that only about 20% of the warming was due to the added longwave energy. Most of the warming at shelter height was due to the redistribution. Budget calculations in the paper also showed that the ultimate fate of the added input of longwave energy was highly sensitive to boundary layer parameters and turbulent parameterizations. The model showed that at light winds (weak turbulence) the atmosphere was not able to lift this energy off the surface and into the atmosphere. Thus, more radiation was emitted from the surface. If soil conductivity or heat capacity were large then more of the energy would heat the ground. Parameterizations of the type used in large scale models added much more sensible heat to the atmosphere. Based on these model analyses, it is likely that part of the observed long-term increase in minimum temperature is reflecting a redistribution of heat by changes in turbulence and not by an accumulation of heat in the SNBL. Because of the sensitivity of the shelter temperature to parameters and to uncertain turbulence parameterization in the SNBL, there should be caution about the use of minimum temperatures as a global warming metric in either observations or models.

KEYWORDS: [1631] GLOBAL CHANGE / Land/atmosphere interactions, [1610] GLOBAL CHANGE / Atmosphere, [3307] ATMOSPHERIC PROCESSES / Boundary layer processes.

(No Image Selected)

(No Table Selected)

Additional Details

Previously Presented Material: 80% of the material to be presented was just published in JGR

Atmospheres July 18, 2012. It has received some attention in the blogoshere but I have not had a chance to present it at an AGU meeting. Updated information includesCMIP5 model diurnal trend differences and observed diurnal trend differences through 2010.

Contact Details

CONTACT (NAME ONLY): Richard McNider

CONTACT (E-MAIL ONLY): mcnider@nsstc.uah.edu

TITLE OF TEAM: