Soil Temperatures and Heat Flux in Oklahoma

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ABSTRACT

Soil temperature fluctuations and soil heat flux affect biotic and abiotic processes that can play a role in atmospheric CO_2 concentrations. In this study we examined soil temperature trends and determined the direction and magnitude of the soil annual heat flux in a section of 12 Oklahoma counties with soil temperature data retrieved from the Oklahoma Mesonet. We analyzed nine years of temperature data to estimate the soil heat flux over the temperature record and examined how the soil heat flux compared with those predicted by climate models.

INTRODUCTION

Soil temperature is an important component in seed germination, respiration and plant growth (Baker and Baker, 2002; Hillel, 2003). Soil respiration is positively correlated with soil temperature. An increase in CO_2 emissions is expected as soil temperatures rise. Soil carbon is the second largest pathway for CO_2 to the atmosphere with a pool that releases 68×10^{15} g C annually (Fang *et al*, 1998). A change in soil temperature may result in a large change in CO_2 concentration in the atmosphere.

Soil heat flux in some global climate change models unrealistically represents below-ground heat storage by an estimated 20%. Soil temperatures affect biotic and abiotic soil processes (Baker and Baker, 2002). Climate models representing zero soil heat flux may produce unrealistic results invalidating any decisions made that are based on these results.

The purpose of this paper is:

1. investigate if soil temperatures in Oklahoma are changing and if so, what factors are contributing to that change.
2. determine the direction and magnitude of the average annual soil heat flux and compare the rate of the heat flux to global climate change models.

MATERIALS AND METHODS

To determine the state of soil temperatures in region B, which includes 12 counties in west central Oklahoma, daily data was retrieved from the Oklahoma Mesonet from January 1, 1994 to December 31, 2008. Stations were not equipped with the Campbell Scientific 229 – L sensor for soil moisture until May of 1999. The data was examined for Average Daily Soil Temperature at 5, 10 and 30cm under sod and Average Soil Moisture at 5 and 25cm beginning with the first available soil moisture readings. The data was compared using average soil temperatures for each year and season and also by region (North and South).

To determine the direction and magnitude of the average annual heat flux, if any, the soils for each station were evaluated for matric potential, volumetric water content (Illston *et al*, 2008 eq. 5 and 6), thermal conductivity (Bristow, 1998 eq 5-10) and heat flux (Hillel, 2008 eq 12.8) using values from the ROSETTA Class Average Hydraulic

Parameters for each station textural classes provided by the Agricultural Research Service. Bulk density values were determined using the latitude and longitude of each station to locate soil surveys using the online Web Soil Survey provided by the USDA Natural Resources Conservation Service.

The values calculated for soil heat flux were then graphed across the years of data collected and also for the northern and southern halves of the region. Average seasonal and yearly soil temperatures were graphed for each depth and by northern and southern portions of the regions.

RESULTS AND DISCUSSION

Temperature trends for 5, 10 and 30 cm are shown in Figure 1. They show a general steady trend at all depths. Steady soil temperatures indicate seed germination, respiration and plant growth will also remain unchanged.

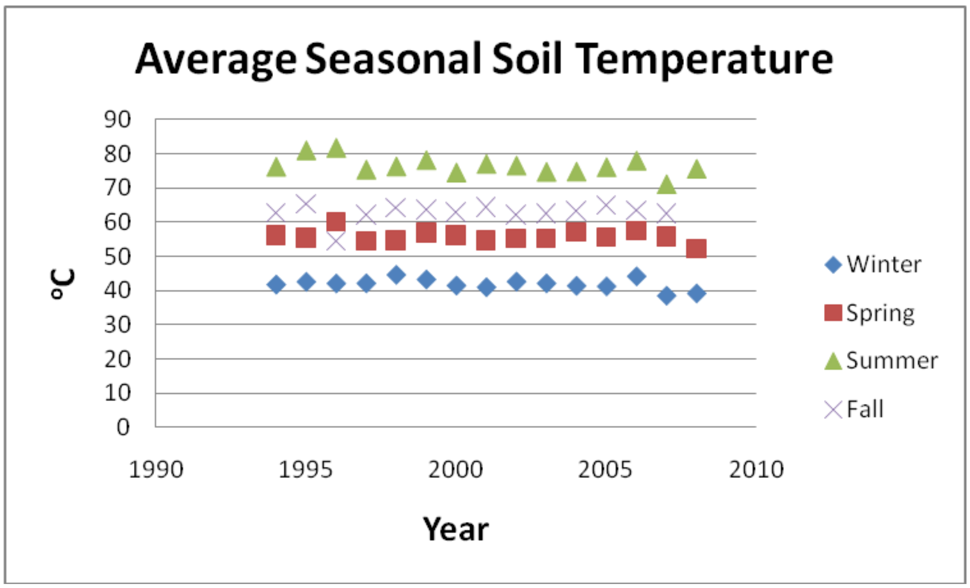

Fig. 1. Average Soil Temperature for 22 soil stations over fourteen years

Figure 2 shows an average annual soil heat flux of -14.79 MJ m^{-2} $year^{-1}$. According to recent literature (Baker and Baker, 2002; Beltrami *et al*, 2002, Hugo, 2002) global climate change models often assume zero soil heat flux. Considering the magnitude of the heat flux found in Oklahoma this assumption is unrealistic. The above mentioned studies found soil heat fluxes of approximately 1.1 MJ m^{-2} $year^{-1}$. The difference in magnitude in our soil heat flux and the other studies may be contributed to changes in latitude. Further research needs to be done to account for these differences.

More accurate results would be obtained by gathering data from deeper depths of the soil profile, some climate change studies have addressed this by sampling depths greater than 10m to determine soil heat flux. By sampling deeper depths the heat flux changes given the increase in gradient. The Mesonet sites only allow for readings down to 0.3m for soil temperature and 0.25m for soil moisture. This only accounts for a small portion of the total depth of soils in the region.

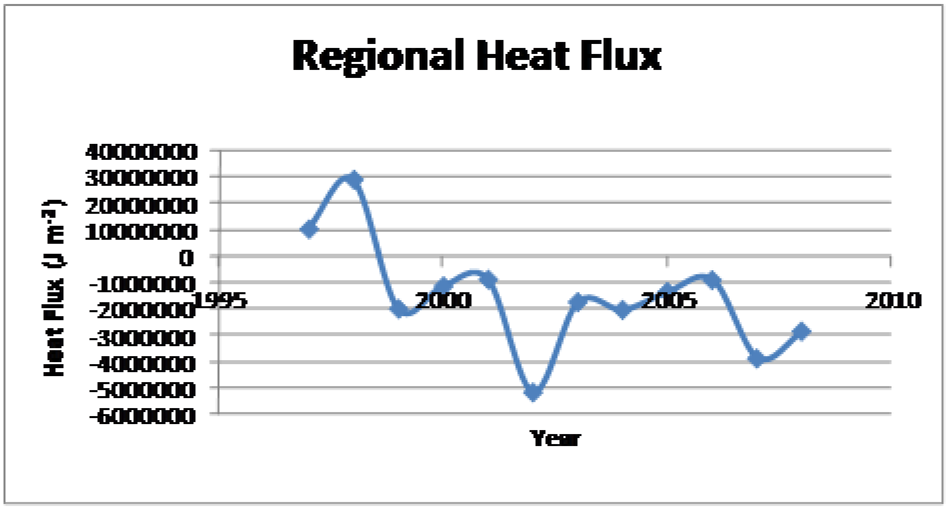

Fig. 2. Average soil heat flux for 22 soil stations over nine years.

Based on the results of our investigation we can summarize the following conclusions:

1. Soil temperatures in region two of Oklahoma are remaining stable.
2. The average annual soil heat flux is an upward flux of approximately -14.79 MJ m^{-2} $year^{-1}$.

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