Do oaks genetically related to warmer climates emit more isoprene?

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Abstract

The hydrocarbon isoprene plays an important role in atmospheric chemistry, particularly in regards to air pollution and climate change. It is important to know why certain plant species emit isoprene and what factors affect its production in order to predict future air quality. Past research has indicated that isoprene aids in coping with heat stress, so I hypothesized that source latitude (a proxy for climate) would significantly impact isoprene production. 12 Bur Oaks collected from a latitudinal range (30-45°) were assayed for their isoprene emission rate. There was no significant effect of source latitude on isoprene emission rate. As an alternative explanation, I considered the influence of average daily temperature on isoprene emission rate, but there was also no significant effect. Future statistical analysis will be conducted to investigate the interactive effects of source latitude and daily average temperature.

Introduction

Isoprene, a hydrocarbon that many plant species produce, has been found to have a significant impact on atmospheric chemistry. As a volatile organic compound (VOC), isoprene reacts easily with other compounds in the air, and the products of its reactions can contribute to the creation of ground-level ozone and secondary organic aerosols (Sharkey et al. 2008). Both ground-level ozone and aerosols lower air quality and can cause various respiratory health issues (U.S. Environmental Protection Agency). Since isoprene can impact air quality and health, it is vital to understand the factors that influence isoprene emission rates.

This study further investigates the questions of why plants produce isoprene and how temperature impacts isoprene emission rates. Several previous studies have suggested that plants produce isoprene as a defense against heat stress, indicating that temperature is an important factor (Sun et al. 2013). The focus of this experiment is to determine whether the heat tolerance provided by isoprene is genetically associated with climate. If isoprene heat tolerance is genetically related to climate, then plants from warmer climates should emit more isoprene.

Figure 1. Bur Oak leaf in Li-Cor cuvette

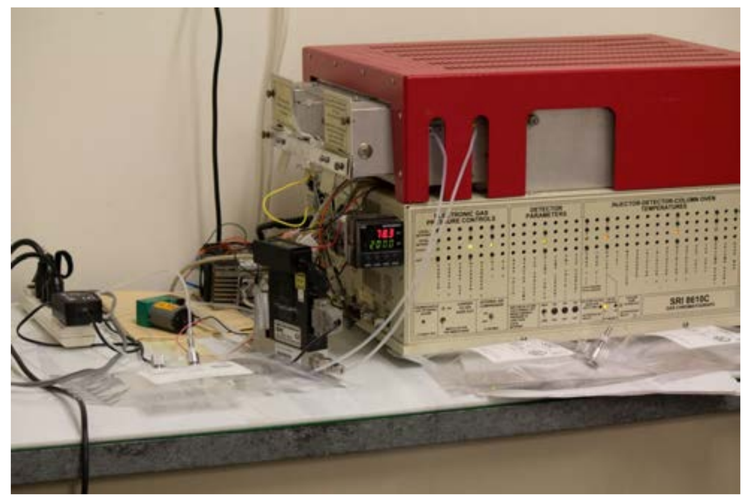

Figure 2. Air sample connected to gas chromatograph

Methods

This study took place at the Morton Arboretum and focused on oak trees due to their naturally high isoprene emission rates. The Morton Arboretum *Quercus* database was used to determine the genetic origins of the oaks, and the species *Quercus macrocarpa*, Bur Oak, was chosen based on the range of individuals from widely different latitudes. In total, 12 Bur Oaks were chosen ranging from Texas to Illinois. Between 6 and 9 air samples were collected from the leaves of each tree, and the isoprene of each sample was measured using a gas chromatograph. A Li-Cor was used to keep the CO_2, leaf temperature, and light levels constant for each leaf. An algorithm (Guenther et al. 1993) was applied to the data to correct for slight temperature variation and obtain the basal rate at 30°C. The average basal rate was graphed by date. The average isoprene emission rate for each tree was graphed as a function of latitude based on the county where each tree was collected. Latitude data were collected from Google Maps. The average daily isoprene emission rate was graphed as a function of average daily temperature. Temperature data were obtained from the Naper Blvd. station of Weather Underground.

Results

The average isoprene emissions graphed by date demonstrate a significant difference between days (Chart 1). Error bars indicate that several days are statistically different from each other. I tested whether this was due to differences in source latitude or daily temperature.

There is a slight negative correlation between average isoprene emission rate and latitude with R^2=.09 (Chart 2). Further statistical analysis indicated that the slope is not significantly different from zero.

Average isoprene emission rate shows a slight positive correlation with average daily temperature with R^2=.13 (Chart 3). Further analysis indicated that this slope is also not significantly different from zero.

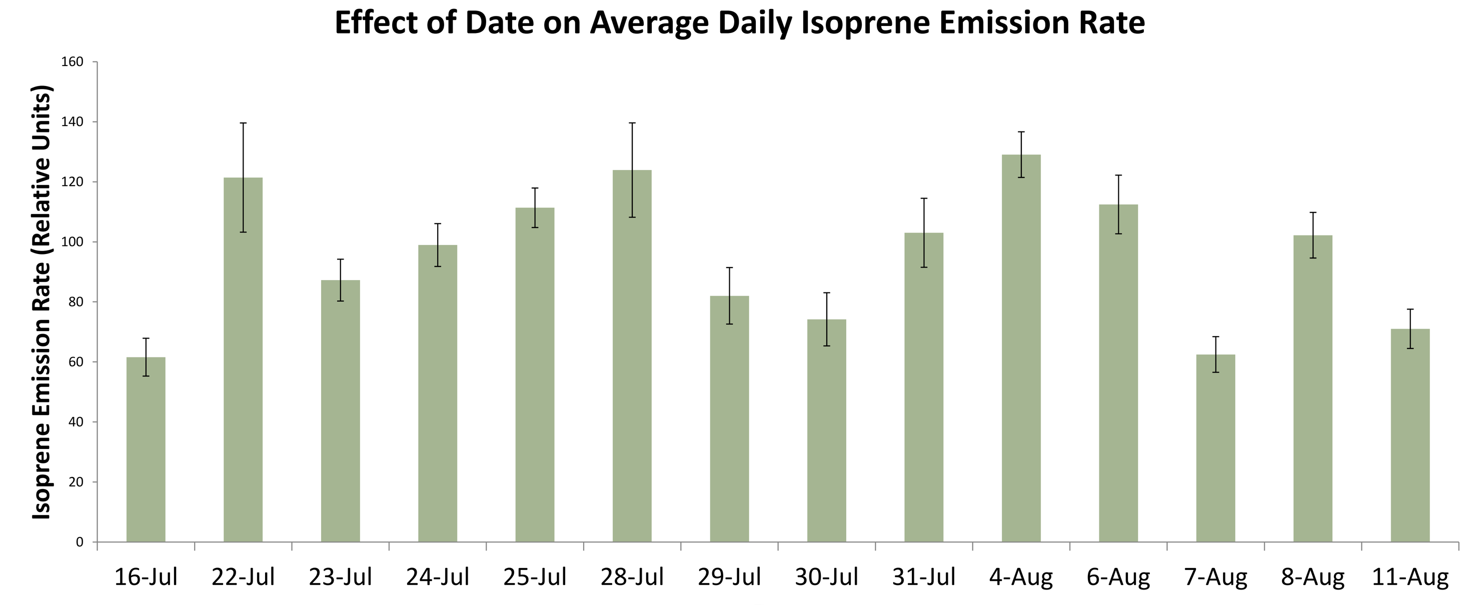

Chart 1. Average isoprene emissions by date including ±1SE.

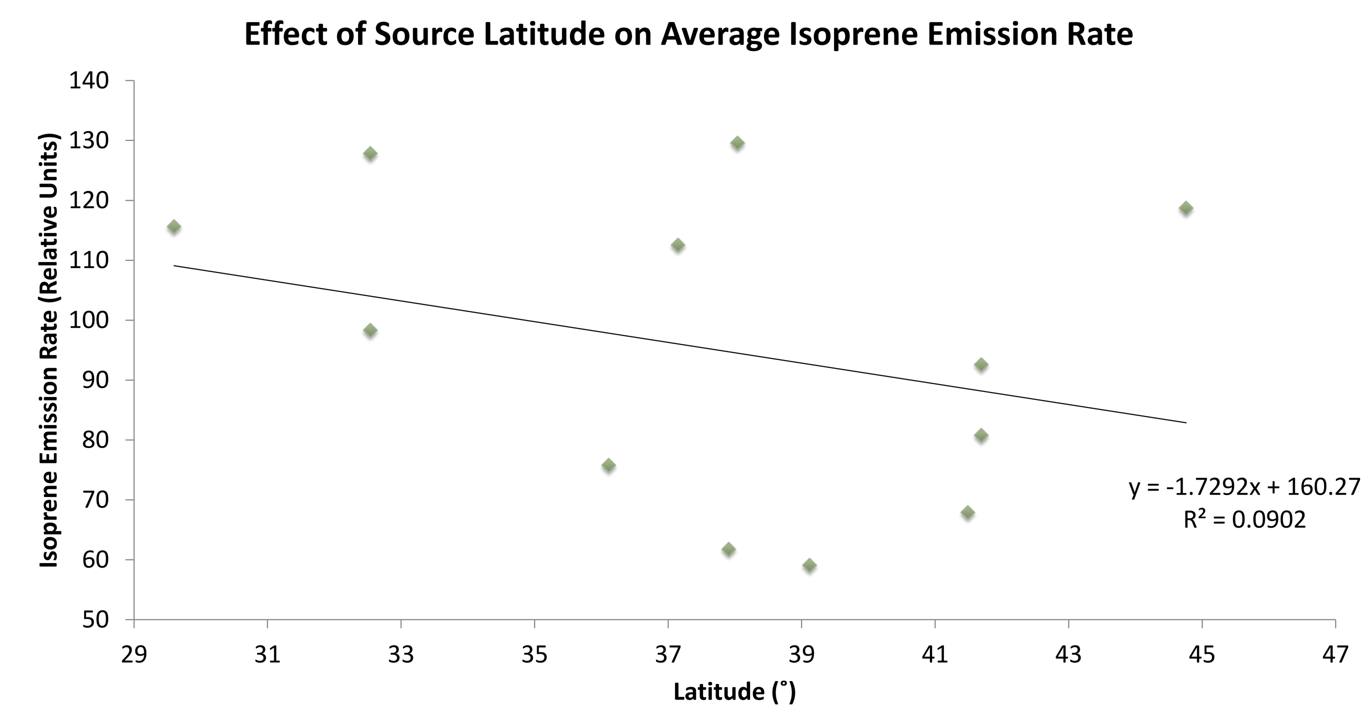

Chart 2. Average isoprene emission rates from 12 Bur Oaks across a range of latitudes.

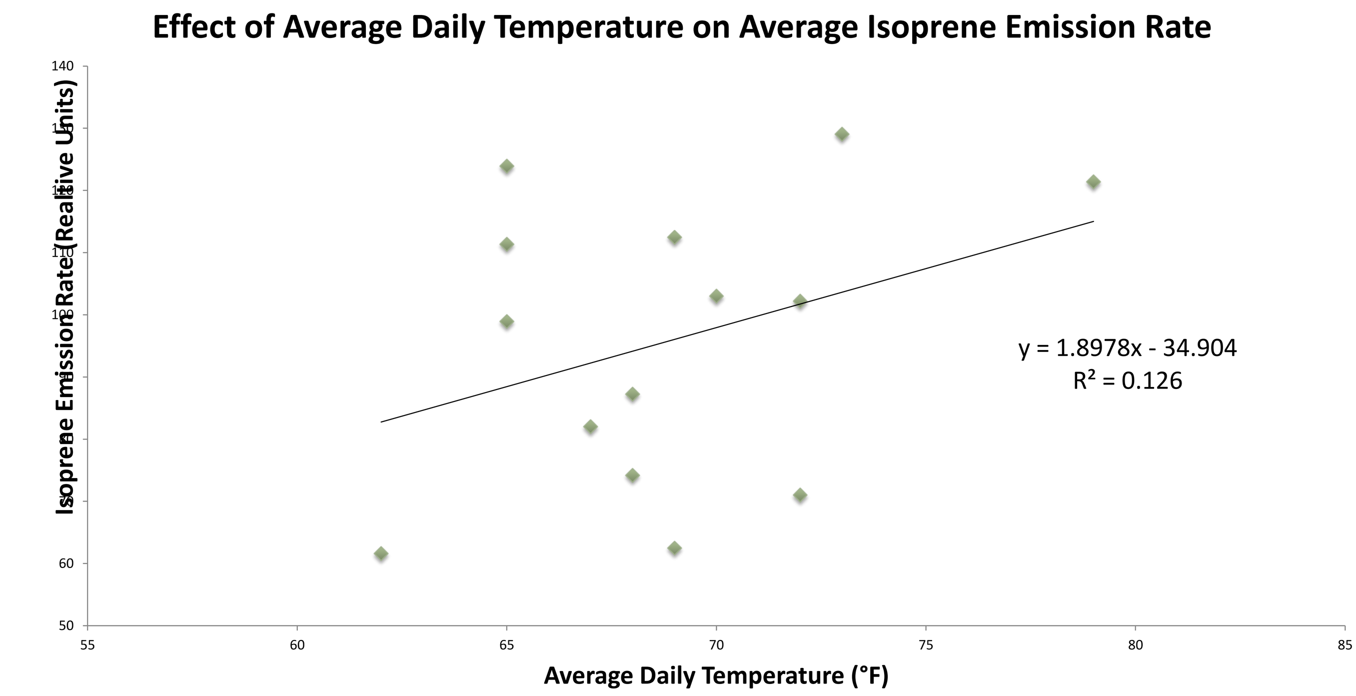

Chart 3. Average isoprene emission rate as a function of average daily temperature (°F) for 14 days.

Conclusion

In this study, neither source latitude nor average daily temperature were found to significantly affect isoprene emission rate. The slight correlations with source latitude and temperature may indicate that stronger correlations would be evident if more data were collected. Since there are significant differences between average daily isoprene emission rates, this suggests that at least one factor is responsible for these differences. Further statistical analysis will explore the potential interactive effect of source latitude and average daily temperature on isoprene emission. Other possible factors influencing isoprene emission include tree herbivory, tree age, soil nutrient composition, and microclimate effects.

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