A first year evaluation of springtime temperature inversion conditions throughout three California counties

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Abstract

There is increasing interest in the use of wind machines for frost protection as water supplies for sprinkler frost protection become more limited. The ability of wind machines to provide useful levels of frost protection depends upon the strength and reliability of the temperature inversion conditions during frost events. However, little information currently exists to describe inversion conditions on a regional basis in California, which creates uncertainty in choosing frost protection strategies. To address this shortcoming, we measured springtime temperature inversion conditions at 65 locations throughout vineyard regions of Sonoma, San Luis Obispo and Santa Barbara Counties in 2012, as the first year of a planned three-year assessment. At each location, a 10.7 m tall tower was installed in early to mid-March 2012 and remained in place until June 2012. Each tower had temperature data loggers at 1.5 m and 10.7 m heights, programmed to record air temperatures at five minute intervals. On average throughout the three counties, when the 1.5 m nightly minimum temperature fell to within the range of 0 to -1 °C, useful temperature inversions (defined as being greater than 1 °C) were observed on 71% of the nights with an average strength of 1.90 °C (the difference in temperature from 1.5 to 10.7 m). When the 1.5 m nightly minimum temperature was within the range of -1 to -2 °C, useful inversions were observed on 75% of the nights with an average strength of 1.91 °C. When the 1.5 m nightly minimum temperature was below -2 °C, useful inversions were observed on 74% of the nights with an average strength of 1.95 °C. The variability of the inversion patterns amongst individual towers was large; this indicates the strong influence that local conditions have on the formation of temperature inversions in these regions of characteristically hilly terrain.

Introduction

The temperature gains expected from the operation of wind machines for frost protection are related to the temperature inversion conditions that occur at the particular site. Therefore, information about the inversion conditions will be very useful for estimating the potential benefits of wind machines for frost protection in a given region or location. The cost to measure the temperature inversions is quite low, particularly as compared to the purchase price of one or more new wind machines. If wind machines are purchased for sites without any knowledge of the inversion characteristics beforehand, this poses the risk that they may not perform as desired if the site tends to have weak inversions on frost nights. Conducting detailed assessments of the inversion conditions before making substantial investments in wind machines would allow growers to have the confidence that they are making the most informed decisions possible with regards to frost protection methods. This project builds on a pilot project conducted in 2011 that demonstrated the benefits of conducting a detailed assessment of the inversion conditions at a single future vineyard site in Paso Robles, CA. By expanding the same types of measurements to vineyard areas throughout three counties over a three-year period, we hope to produce the most detailed information to date on inversion conditions and the expected benefits of wind machine operation in these areas. However, even the very comprehensive nature of this study cannot provide site-specific information for all locations; growers who need such data for making decisions at their own sites are encouraged to duplicate our method and produce their own data. Numerous growers in California and elsewhere have done so in 2013.

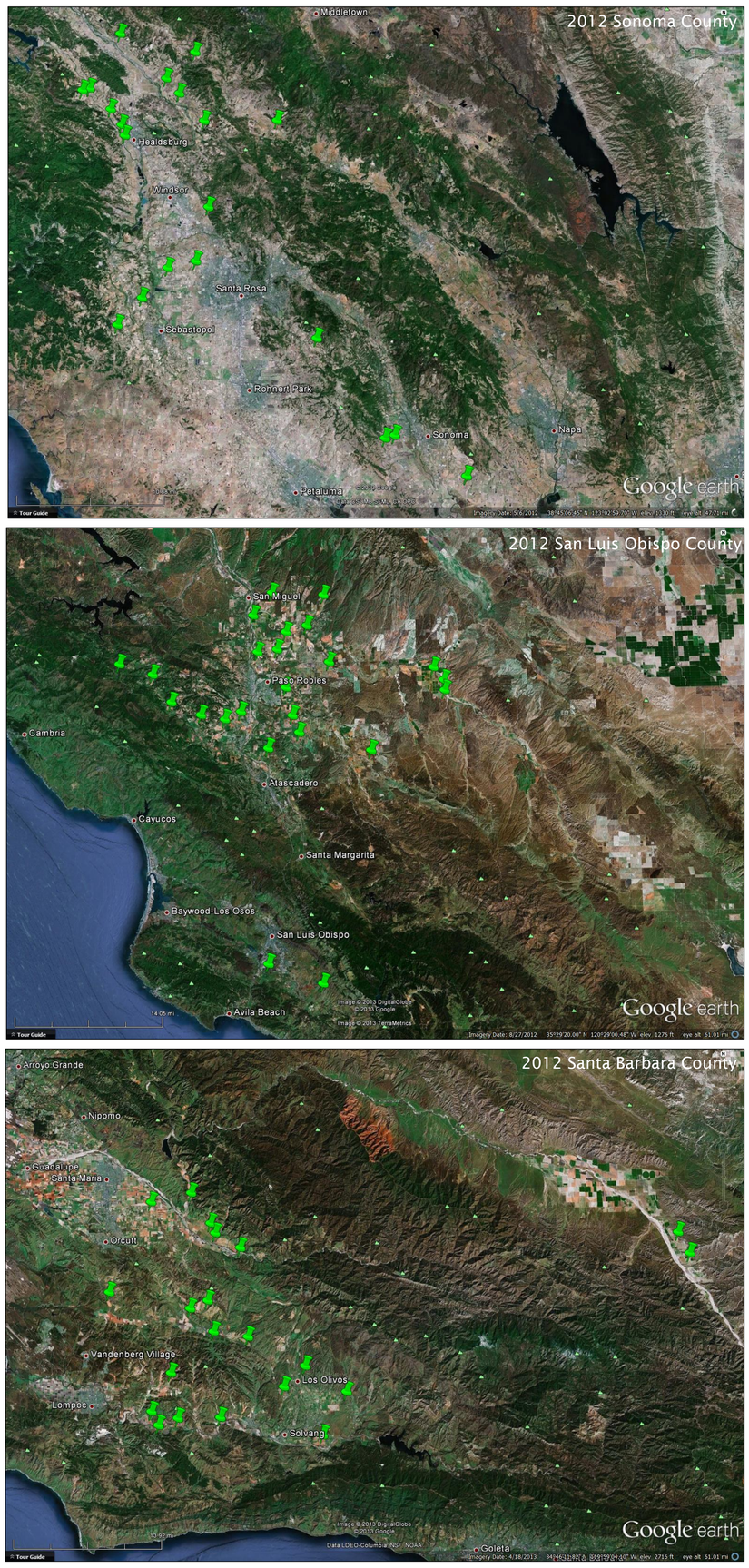

Figure 1. The locations of the temperature inversion towers during the spring of 2012 in the three study counties of Sonoma (top), San Luis Obispo (middle) and Santa Barbara (bottom). Measurements were repeated in 2013, and will continue in 2014. Measurements encompass most of the major vineyard areas of each county.

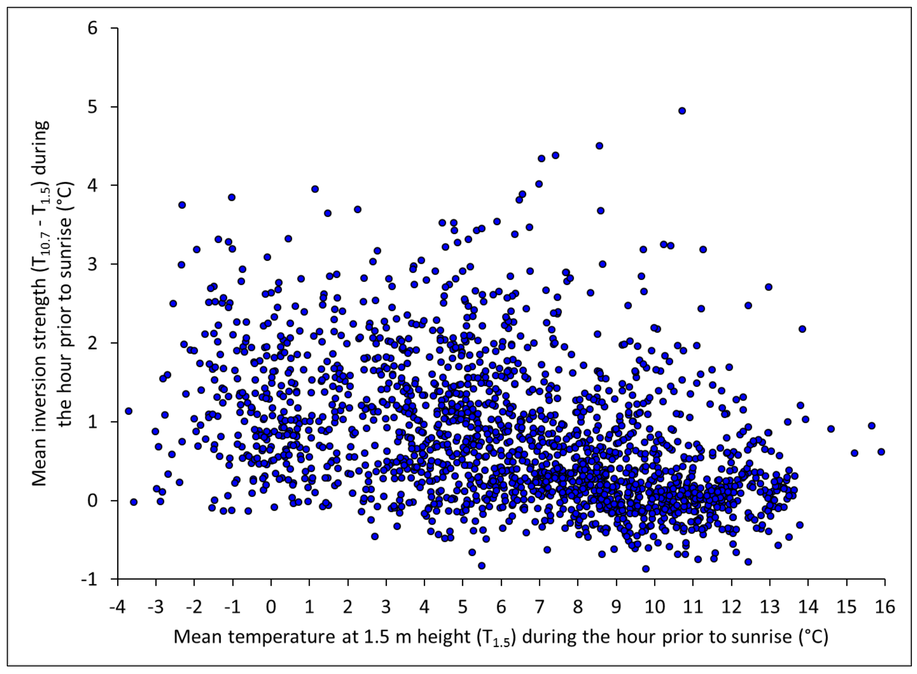

Figure 2. The mean 1.5 m temperature and the temperature inversion strength during the hour before sunrise for all nights measured by the 20 towers in Sonoma County during the spring of 2012.

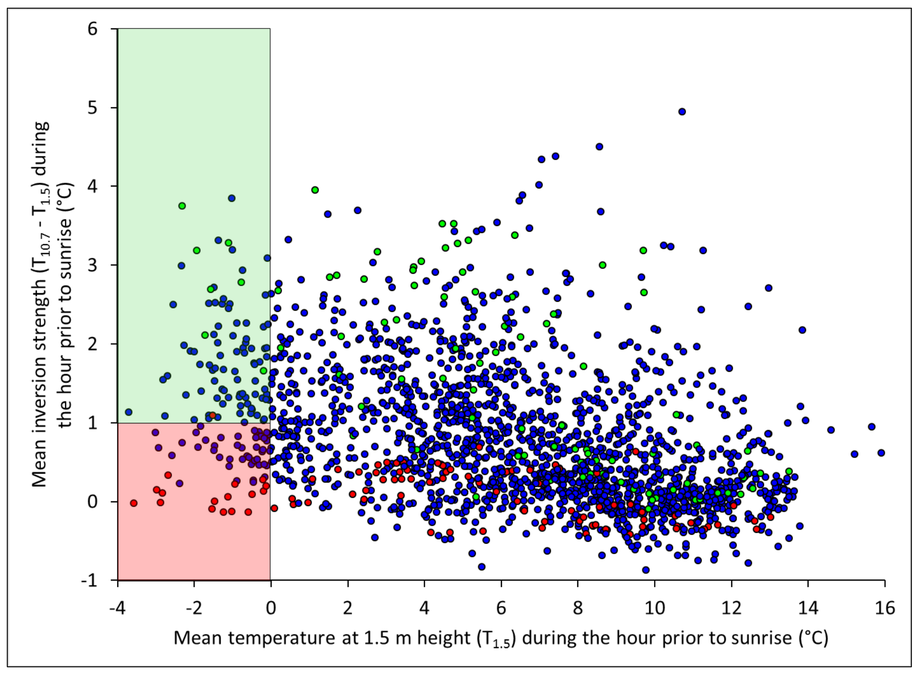

Figure 3. The same Sonoma County data as in Figure 2. The green shaded area indicates events when the 1.5 m temperatures were below freezing and useful temperature inversions occurred, while the red shaded area indicates events with non-useful inversions. The data points for a tower with consistently strong inversions are highlighted with green markers; the data points for a tower with consistently weak inversions are highlighted with red markers. The former tower was in a low coastal area, while the latter tower was in a hilly area; both of these vineyard sites utilized wind machines.

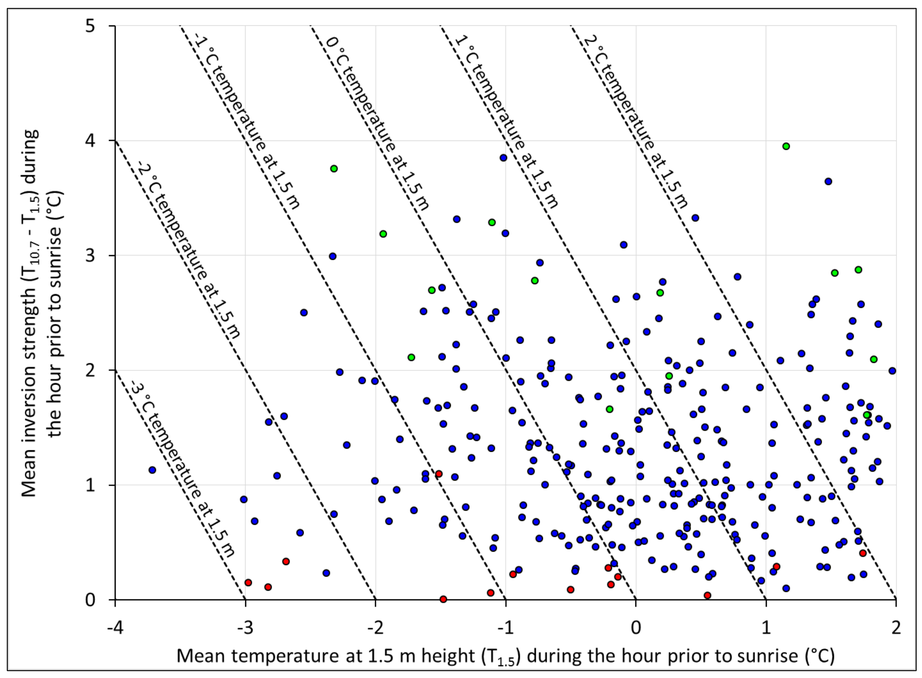

Figure 4. The same Sonoma County data as in Figures 2 and 3, but focusing only on the colder nights. The slanted dashed lines indicate the expected 1.5 m temperatures that would result from conventional wind machine operation under the observed combinations of 1.5 m temperatures and inversion strengths. For example if the observed 1.5 m temperature is -1 ˚C and the inversion strength is 2 ˚C, the operation of a conventional wind machine would be expected to increase the 1.5 m temperature to 0 ˚C.

Conclusions

The first year results of this three-year project have demonstrated the usefulness of the method for evaluating temperature inversions very comprehensively over a broad region. The continued measurements in 2013 and 2014 will allow us to produce a detailed assessment of expected wind machine performance in these areas. We expect the final data product to be of significant value and benefit to the vineyard industries in the three study counties.

Support

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