A Pilot Study to Explore the Possibility of Combining Field and Remotely Sensed Data for Agricultural Resources Management

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Abstract

Soil moisture and temperature are important measures of soil productivity, but monitoring agricultural stresses such as water shortage and extreme temperature at large scale farming can be difficult. This research is a pilot study conducted on a research plot to explore the possibility of utilizing both field data and remotely sensed data for agricultural management. The DJI Inspire 1 drone was used to collect aerial images of the plot while Davis soil moisture and temperature station was used to collect field measurements from the plot. Results from the study show field data on soil moisture and temperature can provide insights on to movement of soil water and remotely sensed data such as aerial images and digital surface models can be used to quantify crop conditions with normalized difference vegetation index (NDVI) Such combination of on-ground and off-ground data could provide a holistic approach to observe field conditions and crop health that allows monitoring crops throughout growth and development cycle and planning for optimal harvest.

Keywords-- *Soil Moisture, Soil Temperature, Remotely sensed data, aerial images*

I. INTRODUCTION

Soil moisture and temperature are important field parameters that for agricultural crop and water management. The field parameters have direct impact on crop growth and yield. Generally, soil moisture and temperature are monitored using field equipment, but monitoring crop health can be difficult, especially at large scale farming. However, recent studies have shown remotely sensed data such as satellite images or aerial images from drones could be used to predict crop growth and yield (Yang et al. 2015; Zhuo et al. 2016). The use of remote sensing data for precision agriculture started in early 1980s, and the data were used to study variations for crop and soil conditions. Remote sensing technology applications for monitoring vegetation condition has been studied extensively during the past several decades, providing timely assessment of changes in growth and development of agricultural crops. Multispectral remote sensing plays a major role in precision agriculture due to its ability to detect crop growth conditions that are beyond human vision. Drone use is expected to continue to grow in agriculture. The Association for Unmanned Vehicle Systems International, a trade group representing producers and users of drones, predicts that 80 percent of the future commercial market for drones will be comprised of agricultural drones (Doering 2014). Improved computer processing in smartphone technology, including gyroscopes, altimeters, and compasses, has made affordable domestic drone use possible and increasingly popular (Wihbey 2015). Hassan-Esfahani et al. (2015) observed that artificial neural network model could be used to translate aerial imagery collected using unmanned aerial system such as AggieAir into surface soil moisture estimates. Remotely sensed data does not require physical collection of field data, so it could make soil and water management at large scale easier and economically feasible. Lobell et al. (2005) showed that combination of field and remotely sensed data along with crop models can be used to adjust agricultural management practices to increase crop production. The main objective of the project is to explore the possibility of utilizing both field data and remotely sensed data for agricultural management.

II. STUDY AREA

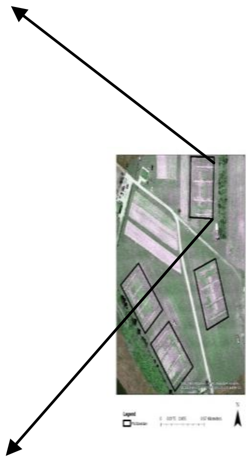


Figure 1 Study area located at Harold R. Benson Research and Demonstration Farm, Kentucky State University, 2017 (right) and location of four upslope and downslope location for soil moisture and temperature measurement in the research plot (left)

Among the four research plots located in the Harold R. Benson Research and Demonstration Farm, one of the research plot with visible slope effects was selected for the study. Four pairs of soil moisture sensors and temperature probes were installed in upslope and downslope areas (Figure 1).

III. METHODS

Aerial images of the research plot was collected using the DJI Inspire 1 drone using the Drone Deploy phone application for June 5-June 21, 2017. The images were processed using Pix4D software (Pix4D 2017) and analyzed in ArcMap v. 10.5 (ESRI 2016) to generate digital surface models, NDVI and other maps. Davis Complete Wireless Soil Moisture and Temperature Station (Product ID #ZZ24433) were installed at 0.3 meter depth in both upslope and downslope regions of the study plot. Data from the sensors were then collected using Vantage Pro2 console. Microsoft Excel v.2016 was used to analyze soil moisture and temperature data to create graphs.

IV. RESULTS AND DISCUSSION

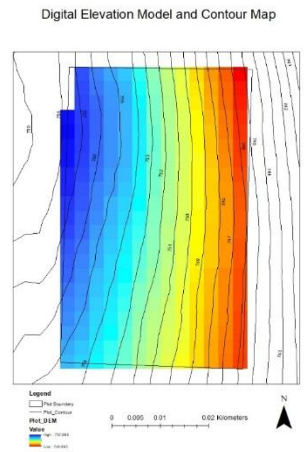


Figure 2 Hourly change in soil moisture and temperature in the upslope region of the research plot (June 21, 2017)

Figure 2 shows hourly trends of soil moisture and temperature for a 24-hour period (June 21, 2017). An overall increasing trend in soil moisture is observed for soil moisture for Station 1 from 12:00 am to 11:59 PM, which showed the highest soil moisture measurement. No major trends were observed for other stations except for Station 2 that had no moisture measurements. For temperature, Station 1 had comparatively lowest temperature corresponding to high moisture measurement in the station, and Station 2 had comparatively highest temperature corresponding to no moisture measurement in the station.

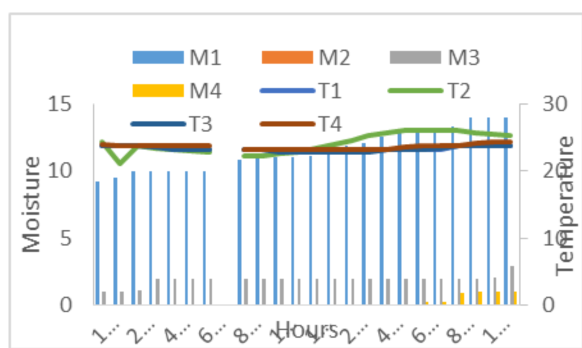


Figure 3 Digital Elevation Model and Contour map (left) and slope map (right) of the research plot created using LiDAR data

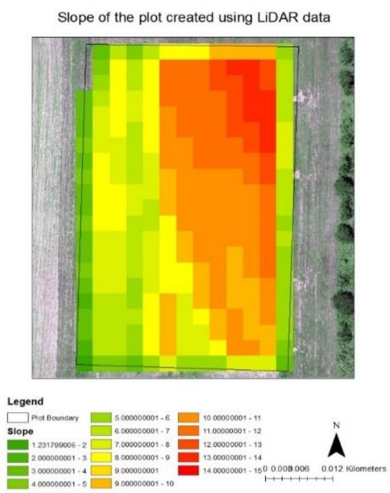
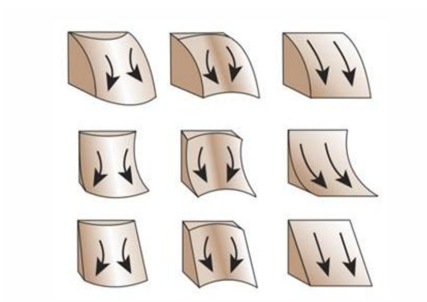
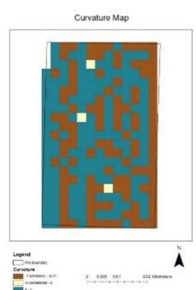


Figure 4 Digital surface model (DSM) of the research plot generated using aerial imagery obtained using DJI Inspire 1 on June 14, 2017.





The reason for higher soil moisture measurement in Station 1 could be because it is located in lower elevation compared to remaining upslope stations (Figure 4). No soil moisture measurement in Station 2 and 4 could be contributed by the positive field curvature that encourages outward water flow. Further, since the soil moisture measurements were taken only from 0.3 meter depth, soil water could have evaporated. Disturbance from the farm machinery used on the plot such as trucks to dig trenches may have affected soil water movement. Measurement error from the temperature and moisture probes could be another possible source of error. Limitations included technical errors in the downslope data, time duration, and malfunctions in the consoles

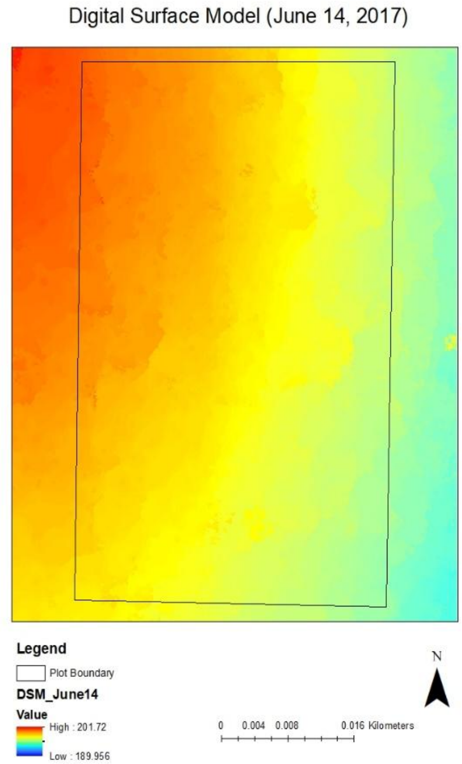


Figure 5 Digital surface model (DSM) and normalized difference vegetation index (NDVI) of the research plot generated using aerial imagery obtained using DJI Inspire 1 on June 14, 2017.

Figure 5 shows the DSM and NDVI maps for the research plot generated using aerial imagery of the research plot. DSM over time could be used to monitor crop growth throughout growth and development cycle. NDVI, on the other hand, can help in quantifying crop health and detection of diseases. A significant implication for the findings is that it is useful in agriculture and soil health studies. For example, if a farmer had a sloped plot that they are trying to irrigate for raising crops or livestock, results from this study can be used to determine the amount of water is needed to supplement the crops or to determine the type of crops that would be best suited to the slope.

V. CONCLUSION

Results from the study indicate coupling of field and remotely sensed data could be an effective integrated approach to address agricultural resource management. Measurement error, technical malfunction and time constraint were the major limitations of the study. Unfortunately, soil moisture and temperature data could not be collected from the downslope stations to assess the effect of slope on water movement. However, there is possibility of coupling field and remotely sensed data to investigate temporal and spatial variation in soil moisture and temperature.

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