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THE DIONYSUS PROJECT: CLASSIFYING AND MONITORING VINEYARDS WITH SATELLITE REMOTE SENSING & IMAGE ANALYSIS

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1) ABSTRACT
Climate change is expected to impact the wine industry by shifting suitable growing regions away from established regions and increasing the demand for freshwater supplies to maintain vineyard health. This creates challenges for maintaining vineyards since the grapevine need to be appropriately stressed to produce quality grapes for quality wine. This requires precision management of freshwater application and canopy management to produce a grape that has the appropriate concentration of flavors and sugars. Vineyards in the US are typically monitored by vineyard managers at the large scale, lacking the resolution needed to identify grapevine growth at the subfield level. Vineyard managers make decisions from planting and tending to water schedules and harvesting. Unfortunately, since vineyards are large areas, it will require more vineyard managers to monitor and identify grapevine health which will cost more for resources and labor. Remote sensing provides coverage over large areas, a cost-effective tool to monitor large vineyard areas, giving growers insights into decisions on irrigation timing and amounts related to vineyard grape development. By using remote sensing, it will allow vineyard managers to improve in decision-making to maintain grapevine health.

In our research, satellite remote sensing data was used to analyze two varieties - Chardonnay and Cabernet Sauvignon - at a vineyard in the North Fork of Long Island, NY during the 2017 and 2018 growing seasons. This research used Landsat-8 and Sentinel-2 satellite data to generate Normalized Difference Vegetation Index (NDVI), an indicator of vegetation “leafiness”, for the following research goals. First, to identify how well each satellite tracks grapevine growth and health between the two growing seasons (May to November 2017 and 2018) using differences maps and time-series analysis. Second, to use image classification to determine how well each satellite dataset identifies the vineyard by varietal type in terms of location and through the growing season. Ground data collected during each growing season will verify the accuracy of Landsat-8 and Sentinel-2 observations.

2) INTRODUCTION
Vineyards are sensitive to their local climate. They require a certain amount of precipitation and temperature. Grapes require precise irrigation and canopy trimming to make quality grapes for quality wine. With climate changes occurring, it is expected to impact the wine industry by shifting suitable growing regions away from established regions and increasing the demand for freshwater supplies for irrigation (Mozaffar & Thach, 2014).

The goal of our research is twofold. First, to identify how well each satellite tracks grapevine growth and health between the two growing seasons (April to November 2017 and 2018) using differences maps and time-series analysis. Second, to use image classification to determine how well each satellite dataset identifies the vineyard by varietal type in terms of location and through the growing season. Ground data collected during each growing season will verify the accuracy of Landsat-8 and Sentinel-2 observations. Improving our understanding of satellite monitoring can lead to better identification of vineyard conditions which can lead to vineyard managers having improved decision-making abilities, such precision irrigation of specific areas to maintain grapevine health.

3) METHODOLOGY
- Landsat-8 datasets were requested from the earthexplorer.usgs.gov website for two growing seasons (April 2017 to July 2017 and 2018). Each dataset was processed on the geographic information system application called QGIS in order to create maps based on their Normalized Difference Vegetation Index (NDVI), an indicator of vegetation “leafiness”. The maps that we based on NDVI have an index from 0 to 1. A 0 signifies no vegetation and 1 signifies a high NDVI. The maps that are based on the NDVI differences have an index from -1 to 1. A 1 signifies 2017 had a higher NDVI, 0 signifies no difference and -1 signifies 2018 had a higher NDVI. The Normalized Difference Vegetation Index (NDVI) determine the condition of the vegetation or vegetation “leafiness”. NDVI is calculated as a ratio between the difference of the red (0.636 um - 0.673um) and near infrared (0.851um - 0.879um) bands and the sum of these values. We used bands 5 and 4 from Landsat 8 to calculate the NDVI.
- Sentinel-2 satellite datasets were requested from the European Space Agency (ESA; solis.eo.esa.int). These datasets were used to generate NDVI for both seasons.
- Field work was done for this study. Canopy measurements were measured in the field to estimate vineyard leaf area index (LAIv). Leaf and shoot samples were used to estimate water content and soil moisture measurements were sampled at each sample location.

4) RESULTS

4.1) NDVI
The NDVI was calculated in QGIS by using bands 5 and 4 from Landsat 8 to calculate the NDVI. These values were used to create NDVI maps for both seasons. The NDVI values were compared using the NDVI difference of the red (0.636 um - 0.673um) and near infrared (0.851um - 0.879um) bands and the sum of these values. We used bands 5 and 4 from Landsat 8 to calculate the NDVI.

4.2) Field Data

- Cabernet Sauvignon - at a vineyard in the North Fork of Long Island, NY during the 2017 and 2018 growing seasons. This research used Landsat-8 and Sentinel-2 satellite data to generate Normalized Difference Vegetation Index (NDVI), an indicator of vegetation “leafiness”, for the following research goals. First, to identify how well each satellite tracks grapevine growth and health between the two growing seasons (May to November 2017 and 2018) using differences maps and time-series analysis. Second, to use image classification to determine how well each satellite dataset identifies the vineyard by varietal type in terms of location and through the growing season. Ground data collected during each growing season will verify the accuracy of Landsat-8 and Sentinel-2 observations.

5) DISCUSSIONS & CONCLUSION
Overall, according to the NDVI maps and the NDVI plot, there was a higher NDVI in 2017 than in 2018. In Fig. 5, Fig. 8 and in Fig. 13, it is demonstrating that the previous season had a higher NDVI. The NDVI plot confirmed what the satellite is viewing.

In terms of fields, for the 2017 season, overall the CS field had a higher NDVI average than the CH field. In terms of fields, for the 2018 season, overall the CS field had a higher NDVI average than the CH field.

For Leaf Area Index, the year 2017 had a higher LAIv than the year 2018. In terms of fields for the 2017 season, the CS field had a higher LAIv than the CH field because it had higher peaks than CH field. In terms of fields for the 2018 season, the CS field had a higher LAIv than the CH field.

However, in terms of water content, the 2018 season had a higher water content than in 2017. In Fig. 9 and in Fig. 10, it is demonstrating that CH and CS had a higher soil moisture than the previous year. In Fig. 11 and in Fig. 12, the samples that were collected in 2018 demonstrated that CH and CS fields had more water than in 2017. This signifies that there was more rain in 2018 than in 2017.

Lastly, field measurements confirmed NDVI observations from April 2017 to July 2018 growing seasons. Therefore remote sensing does allow us to monitor vineyard growth.

Vineyards require a lot of management to produce quality grapes. By using remote sensing, it can lead to vineyard managers having improved decision-making abilities such as developing better timing and application of irrigation during vineyard development to maintain grapevine health.

REFERENCES