INTRODUCTION

Saudi Arabia and California recently experienced water availability stresses which can be analyzed from space with the Normalized Difference Vegetation Index (NDVI). NDVI values range from (-1) to (+1) based on red and infrared radiance where positive values indicate low concentrations of dead biomass surfaces and high concentrations of living biomass surfaces (Figure 1). California is the top producer of Almonds in the world harvesting over 80% of the world’s almonds in 2013, but the 2011-2014 drought caused setbacks as trees were cut and water rights sold (Figure 2). Despite the absence of any lakes or rivers, Saudi Arabia bloomed with agriculture due to well water irrigation starting in the 1970s, yet much of Saudi’s agriculture has returned to sand due to unsustainable irrigation methods. Monthly composited NDVI data was used to determine the difference before and after the Central Valley drought (2010-2015) as well as through the rise and fall of Saudi Arabian agriculture (1985-1995).

MATERIALS

Google Earth Engine (GEE) is the most advanced cloud-based geospatial processing platform in the world. GEE Code Editor provides all public data pre-processed for immediate use via Cloud storage such as National Aeronautics and Space Administration’s (NASA) launched satellites, Landsat 5 and 8. The 32 day composite NDVI data from 2010 and 2015 determines the difference before and after the Central Valley drought. In Saudi Arabia Landsat 4, 5, and 8’s 32 day composite NDVI data. Most importantly, a 32 Day NDVI composite data set ensures data with little missing data or atmosphere affected data with the best precision in off-nadir views and sensor precision at large solar zenith angles. Another dataset called the Crop Data Layer (CDL) from the United States Department of Agriculture masks the NDVI for specific crops in California and in particular to monitor the top grossing product - Almonds.

METHODS

Changes in vegetation are found with an image math function called difference. Between two years, the NDVI satellite pictures are subtracted to display a single image with green showing increased photosynthetic activity and red showing a decrease in the specified time span. For California, a Crop Data Layer from the United States Department of Agriculture filtered the data for Almond cropland. Then final calculations are completed in the Geographical Information System program called Microdem for histograms of the NDVI. The final images had 30x30m resolution which is one of the best resolutions available for NDVI remote sensing via satellite data.

RESULTS

After 1991, the Hail region lost 812,338 acres averaging 98.2% loss the very next year in cropland which has not grown back (Figure 4). During the same time, Riyadh lost 59% of its crop. Both coincided with the drying of wells in each region and loss of government subsidies or buy off. Although no crop mask existed for Saudi Arabia, the background interference was minimal because the NDVI values for barren sand and cropland overlapped very little. Desert sand on average was between +0.2 and -0.2 in the NDVI difference calculations meaning that generally the dead crops were anything below -0.2 and the living crops anything above +2.0.

In the Central Valley, XXX acres decreased in photosynthetic activity between 2010 and 2015 (Figure 5). Although the total cropland increased by 11.2% from 2010 to 2015 the land cultivated in 2015 was less than that of 2010 due to the doubling of fallow or idle cropland before and after the drought. For almonds, drought years showed stronger bimodal NDVI graphs than healthy years because the water stressed fields dropped in photosynthetic activity or the farmers sold the water rights (Figure 7). The higher concentration of larger NDVI values in the 2014 drought year accounts for the maturity of the trees that grow denser over time. Also, there was a new planting of 672,258 acres of almonds from 2009 to 2010 where the total almond acreage more than tripled in the Central Valley. The most intense growth occurs in the first 4 years before the trees begin bearing almonds where as in 2014 there was no planting from the previous year; instead it experienced a decrease of about 200,000 acres.

CONCLUSION

The use of GEE made interaction with data immediate and easily accessible, even from my phone. Of the two study areas, Saudi Arabia wasted lots of money and water for agriculture which quickly became unsustainable as seen by the case studies of the Hail and Riyadh regions. In the Central Valley, drought years showed stronger bimodal NDVI graphs than healthy years. For future research, the application of NDVI for determining economic impacts could be very useful for humanitarian aid situations and market behavior predictions.

REFERENCES