Drought Identification and Impact Assessment in California between 2001 anc 2010

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Abstract

Drought is a prolonged period of low amounts of precipitation resulting in water shortages. This general definition can differ depending on the region being considered. Nevertheless, the efforts of this study are concentrated on the identification and impact assessment of drought on vegetation health. This study focuses on the California drought using precipitation and vegetation data from 2001 to 2010. Drought and vegetation health recognition is based on the analysis of the Standardized Precipitation Index (SPI) and normalized difference vegetation index (NDVI) respectively. Using ArcGIS, May, 2008 was detected as the driest month. In addition, October, 2004 was identified as the wettest month. The data also showed 63% correlation between the

Figure 1: Impact of drought in California

Introduction

Drought is considered a disastrous natural phenomenon that has had multi-severe impacts on society and environment. The difficulty of studying such phenomenon arises from the fact that it is not practical to recognize when the drought starts or even when it ends. In most cases, its impact persists even far after the ending of the drought event. Furthermore, the drought definition varies among regions of different climates. In this project, temporal and spatial changes of drought and precipitation, and their impact on vegetation health have been investigated for California for 2001-2010. Drought and vegetation health recognitions are based on the analysis of the Standardized Precipitation Index (SPI) and normalized difference vegetation index (NDVI), respectively. In recent years, Geographic Information System (GIS) has played a key role in studying different types of hazards, including drought. GIS tools enable us to create shapes, features, rasters and even animations based on the temporal changes of data values at a stationary location, which provides with more informative outputs and better decision making opportunities.

Study area is the state of California (Figure 2). A quick search about ...eveals the importance of drought in this State ...e **most populous state in the U.S.**, with a ...ly 38 million .

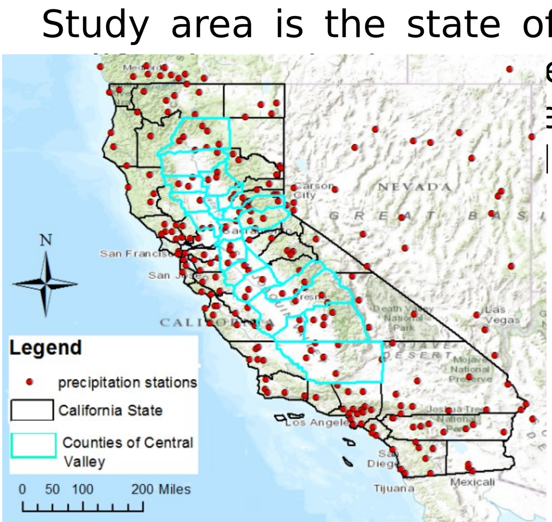

Figure 2. Study area and precipitation stations

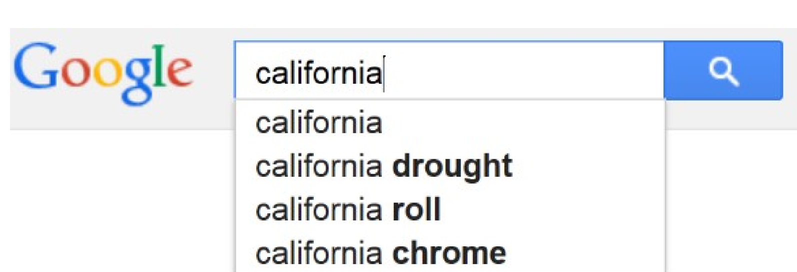

Figure 3. The importance of California drought

SPI concept

SPI is an ingenious index based on standardized probability to quantify precipitation deficit. The calculation procedure of SPI is based on long-term precipitation observations. In this method wetness is expressed by positive SPI values while dryness is expressed by negative values. Basically, SPI is a number between -3 and 3.

NDVI definition

The Normalized Difference Vegetation Index (NDVI) is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum. The NDVI is calculated from the following equation:

$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{RED}}{\mathrm{NIR} + \mathrm{RED}} \quad \text{(eq.1)}$$

Generally, healthy vegetation will absorb most of the visible light that falls on it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light (Figure 4). Since NDVI is directly related to plant vigor, density, and growth conditions, it can be used to detect unfavorable environmental variables.

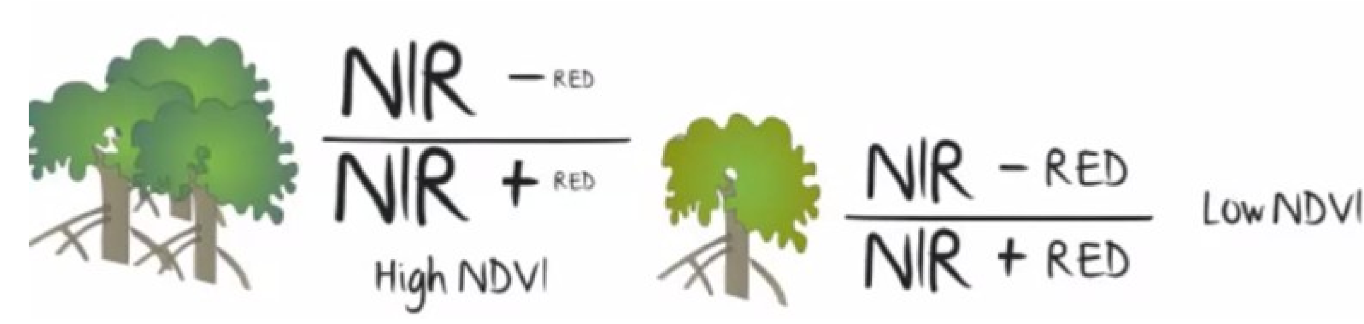

Figure 4. A schematic illustration of NDVI

Methodology

In this project, 235 stations, which had more than 96% precipitation data for 50 years (2001-2010) were chosen for this study. The values of months without data were obtained using interpolation. Then with ArcGIS software Ordinary Kriging method is used to get the spatial pattern of SPI and precipitation for each month. Kriging has provided optimal areal estimates in any given situation and is applicable both for drought and flood. This procedure preceded for all months of years between 2001 and 2010. After this step the results were clipped using California state boundary. Then the monthly average of California's SPI and precipitation for each month was calculated. The similar process was done for the remotely sensed images NDVI. Figure 5 shows a schematic view of the iterative processes regarding the work with the data.

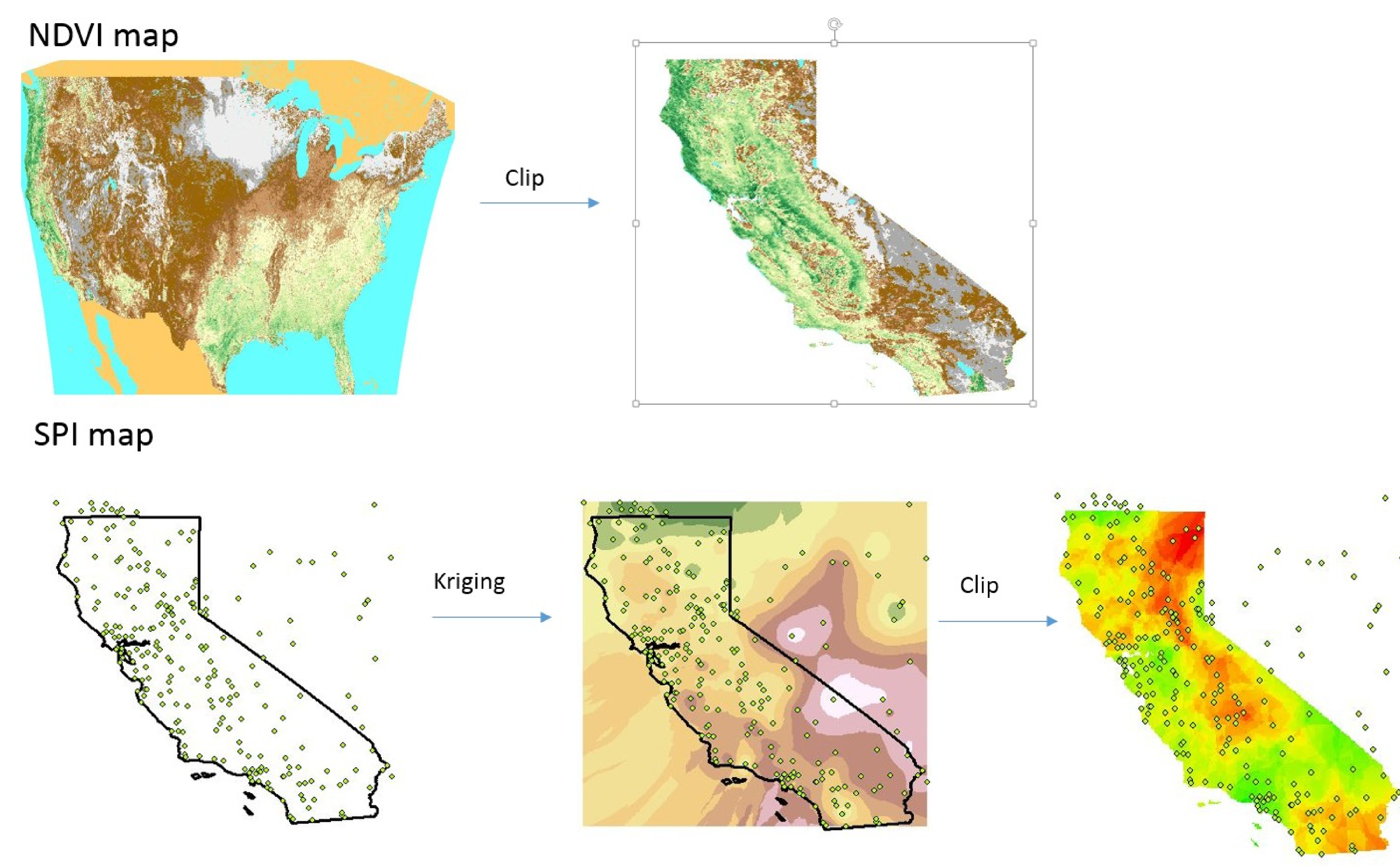

Figure 5. A schematic view of working with GIS

Data

Monthly precipitation data for stations were obtained from the NOAA website. The remotely sensed images of monthly NDVI were obtained from remote sensing phenology of USGS and United States Department of Agriculture (USDA).

Results

Figure 6 illustrates the fluctuation of SPI and NDVI between 2001 and 2010. Figure 6 shows that California has experienced droughts with various severities during this decade. The driest and wettest months during this 10 years were May 2008 and October 2004, with mean SPI equal to -1.5 and 1.12, respectively. The spatial distribution of SPI of these two months are shown in figure 7. The intensity of drought in the northern part of the state was significantly higher than in the southern areas. In addition there was a correlation (61%) between SPI and vegetation health, this correlation shows the impact of drought on vegetation health.

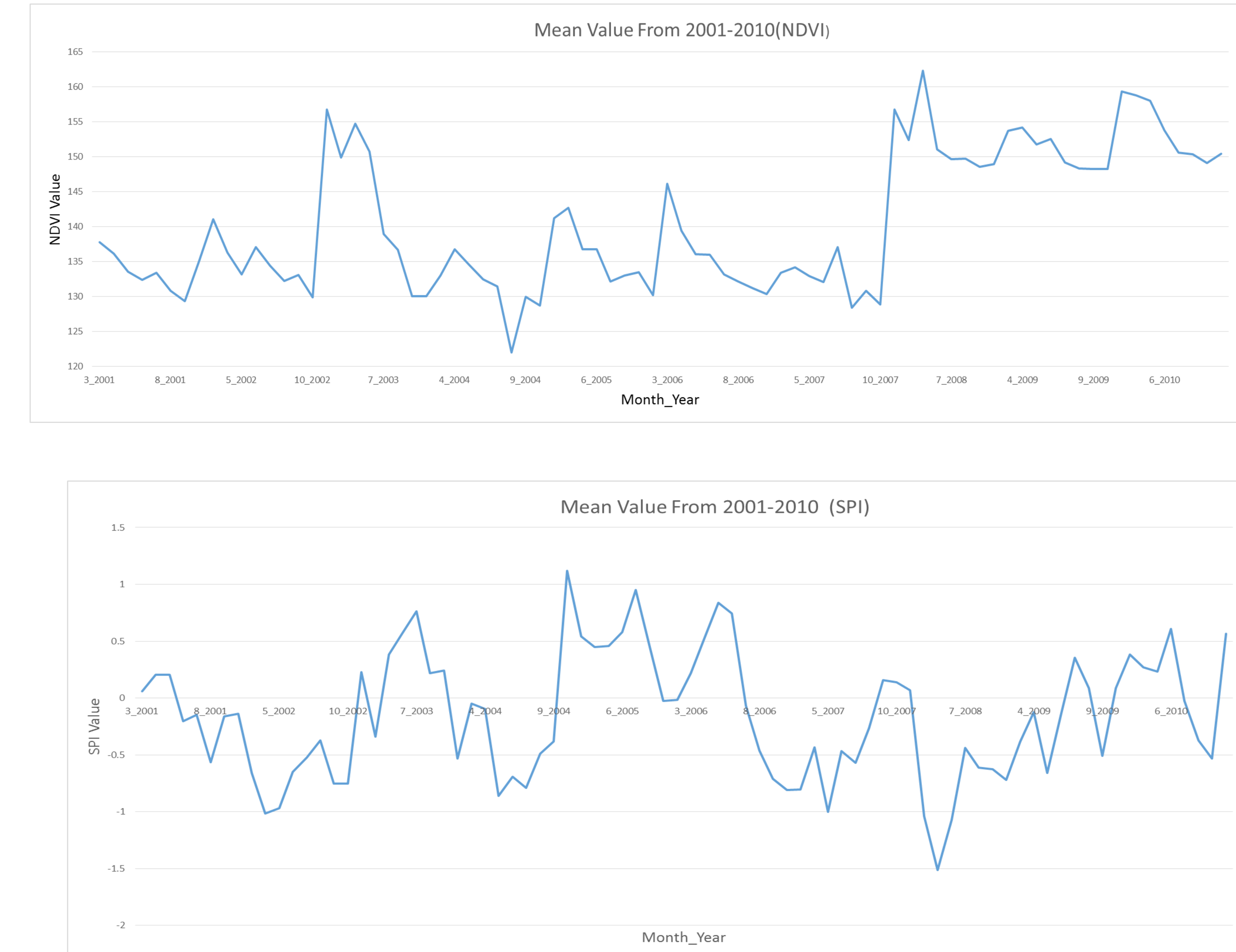

Figure 6. Fluctuation of SPI and NDVI between 2001 and 2010

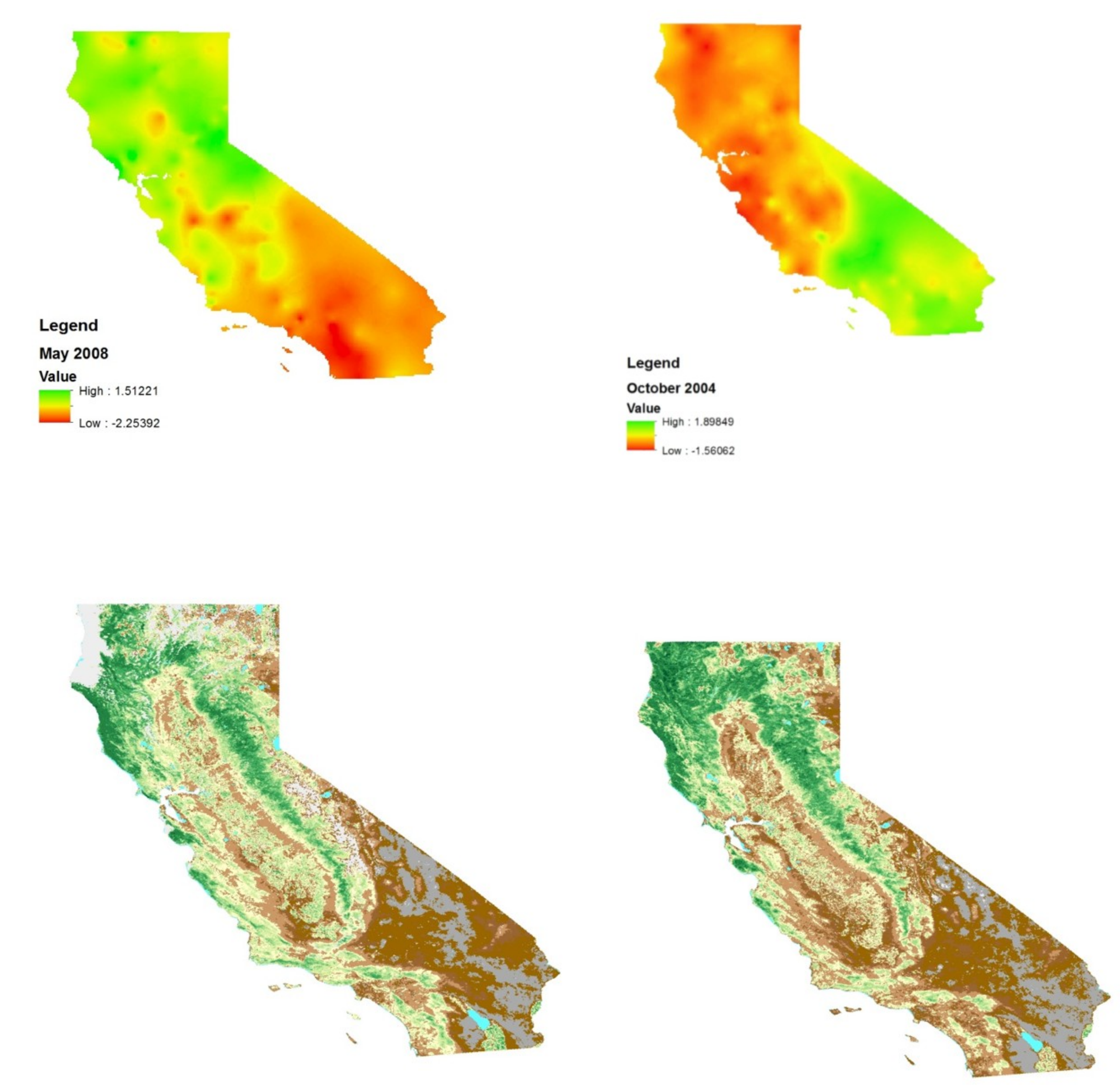

Figure 7: Top left: (SPI) Driest month, Average SPI: -1.51, Top right: (SPI) Wettest month, Average SPI: 1.12, Bottom left: (NDVI) May, 2008, Average NDVI Value: 162.31, Bottomright: NDVI) October, 2004, Average NDVI Value: 128.75
*Here the scale of NDVI is different.

Conclusion

GIS is a very helpful tool in examining and analyzing data over time. In this project, it was especially useful in comparing areas of drought to the vegetation health in that same area. It aided in calculating the average SPI and NDVI values for each month in California over the course of 10 years. Using this data, a positive correlation was found between precipitation and vegetation health. Overall, with the correlation between SPI and NDVI data, some of the years have showed a great correlation. Still, the data that we analyzed only include ten years. If the dataset is around the range of thirty years, it will probably show a good correlation.

Acknowledgements
This research was supported by NOAA CREST (NOAA CREST- Cooperative Agreement No: NA11SEC4810004) an