Geovisualization of Sierra Nevada Snowfall Data 2011 - 2016

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Introduction

California residents are dependent on the Sierra Nevada snowpack because it is a major source of the State's water supply. The Sierra Nevada snowpack has been declining due to the impact of global warming (Dimick 2015). This project evaluated snowfall statistics using Inverse Distance Weighted (IDW) interpolations. Monthly snowfall for winter years between 2011-2016 were interpolated using Inverse Distance Weighted interpolation method. Results were displayed using a variety of complex visualization methods. These map products show the declining snowfall during the middle years of the study, indicating a portion of drought for several years and higher winter precipitation in 2015-16.

The El Niño phase of the El Niño Southern Oscillation (ENSO) cycle during the winter of 2015-16 had an impact on the Sierras improving the snowfall totals for that winter and slightly improving the California snowpack .

Figure 1. *Digital elevation model of the study area.*

Data and Data Sources

The National Oceanic and Atmospheric Administration (NOAA) provides highly credible atmospheric data worldwide such as snowfall, snow depths, precipitation, and temperature data for any time period starting from the year 1900. NOAA's data portal provides easy access to all sorts of atmospheric data. The web page has interactive tools to query data which is convenient for those in search of atmospheric data.

Spatial datasets were obtained from the United State Geological Survey (USGS). Digital elevation models (DEMs) were downloaded for the area of interest and aided in providing detailed 3D topographic images for the IDW interpolated raster files.

Dataset	Source
NOAA snowfall data	http://www.ncdc.noaa.gov/
USGS DEM rasters	http://viewer.nationalmap.gov/basic/
Sierra Nevada Boundary Shapefile	http://www.sierranevada.ca.gov/our-region/map-downloads

Table 1. *List of data and data sources used in the project*

Methodology

Snowpack data were downloaded from NOAA weather data portal for the winter months of study (figure 2). These files were converted into a CSV format for use in ArcMap. The "Display XY Data" tool was used to plot snowpack-related data values in ArcGIS. Each of the plotted points contain attributes such as snowfall totals, elevation, and station name. The snowfall total was selected to perform IDW spatial interpolations to predict snowfall totals between weather stations. This was done for all five winters yielding a total of twenty-five interpolated raster images. These images were brought into different GIS software applications to display the data using a variety of visualization methods. The visualization methods used include: 2D images from ArcMap, 3D maps and animations using ArcScene, interactive 2D and 3D maps using QGIS, and 2D animated maps using Microsoft MovieMaker. Figure 3 provides a spatial model of the methodology.

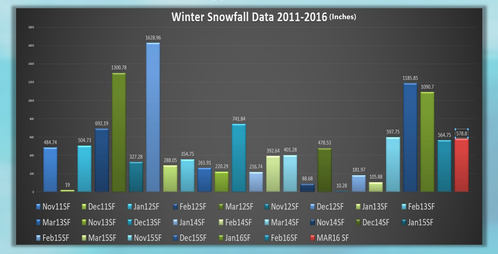


Figure 2. *Total monthly (Nov-Mar) snowfall (inches) for the years 2011-2016.*

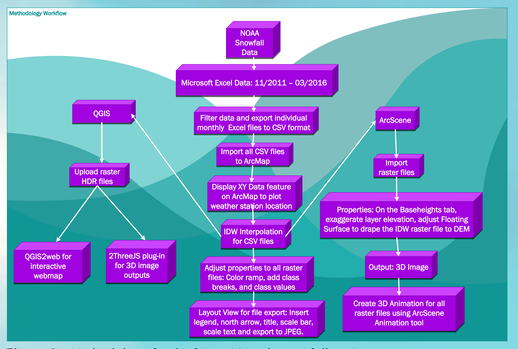


Figure 3. *Methodology for the Sierra Nevada snowfall project.*

Timeline

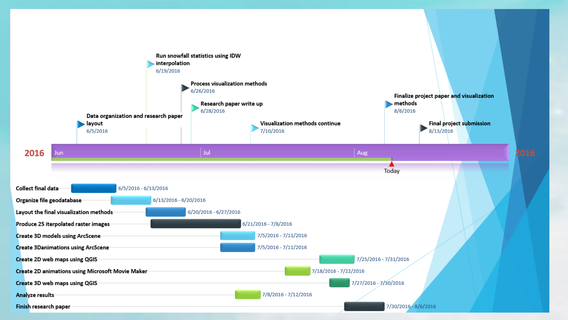
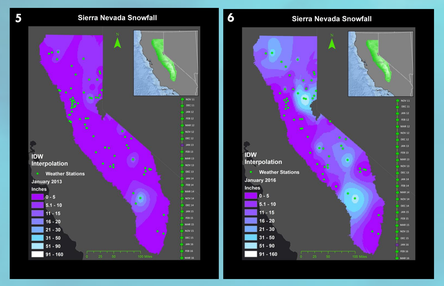
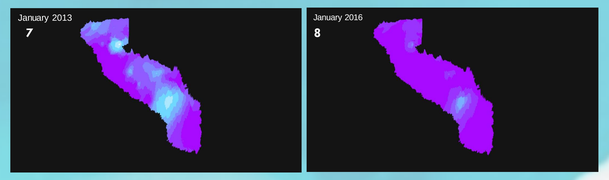


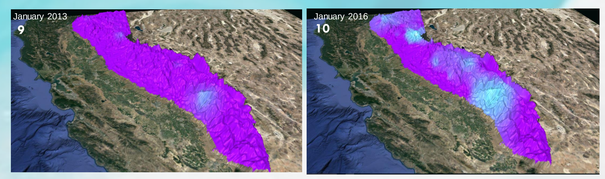
Figure 3. *The timeline of steps taken to complete the project.*

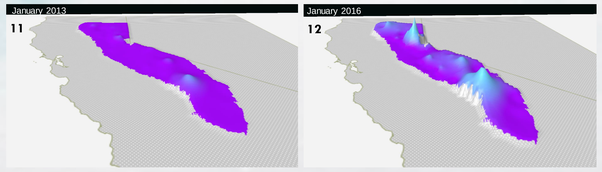
Results

The IDW interpolation process provided an output of twenty-five raster images that depict the Sierra Nevada snowfall totals during the period of evaluation (2011-2016). ArcMap was used to display the results in 2D (Figure 5/6). These maps show areas of greater snowfall for some winter months and minimal snowfall for the others during the study time period. The same 2D maps from ArcMap were utilized in Microsoft Movie Maker to develop a temporal animation of the winter years researched. These animations display the change over time of the Sierra Nevada snowfall, indicating winters with low monthly snowfall totals. With the help of a DEM, ArcScene was able to produce 3D maps with average detail throughout the Sierra Nevada Mountains (Figure 7/8). ArcScene was also able to develop animations of the study area and view areas that produced high levels of snow and make general assessments based on the elevation areas. QGIS was also used to produce high quality 2D and 3D interactive web maps to display the monthly snowfall changes (Figure 9-11). All maps displayed conclusive evidence of the fluctuating snowfall during the study time period of the project.









Figures 5, 7, 9, and 11 (Jan 2013) and Figures 6, 8, 10, and 12 (Jan 2016). *(5 & 6) 2D interpolation using ArcMap. (7 & 8) 3D interpolation map using ArcScene. (9 & 10) 3D interactive web map of interpolation snowfall with DEM. (11 & 12) Interactive 3D geovisualization web map*

Discussion

The intent of this Sierra Nevada snowfall project was to use a variety of methods to display snowfall data. The same high quality NOAA data was utilized throughout the project, in both ArcGIS and QGIS software to display the IDW interpolated analysis of the Sierra Nevada snowfall winter data for the years of 2011-2016. The data sources utilized for the project are US government agencies and their strong representation supports the validity of the results which show fluctuating snowpack in the Sierras.

The choice of visualization methods can depend on the overall goal of the author. The 2D interpolated maps for this project show sufficient information of the snowfall data. If I was interested in knowing why some areas of the Sierras have more consistent snowfall than others, then I would consider using 3D modelling method. Utilizing 3D modelling gives the access to toggle throughout the map and make assessments using the topographic environment. The choice solely depends on what the map maker is trying to achieve.

The variety of visualization methods can influence mapping techniques for those who produce mapping images in the geospatial field. These mapping software programs provided tools to develop easy-to-read maps for the amateur map reader in order to process the important information. Making an easy-to-read map using valid data is the ultimate goal of the map developer.

Conclusion

The visualization methods used for this project displayed the significant fluctuations of the Sierra Nevada snowfall using a variation of programs. The commonalities between ArcMap, ArcScene, and QGIS was the ability to use the same raster files to produce identical maps. The only differences in using multiple platforms was that ArcScene provided 3D animations that were beneficial to the analysis but QGIS had better detailed maps when it came to visual quality of the map. The details provided from QGIS were constructive when it came to making general analysis.

The Sierra Nevada snowfall geovisualization project was an overall success, although there are areas that can be improved. There were a few discoveries late in the project using different methods like Model Builder in ArcMap that could have helped with the overall project management. Learning from these discoveries has improved my overall geospatial skills that can be utilized in future projects or career. It was a goal of mine to provide useful information to my peers and professionals in the field and to hopefully make this project useful for those who want to pursue further research of Sierra Nevada snowfall.

References

Dimick, Dennis. "Lack of Snow Leaves California's 'Water Tower' Running Low." National Geographic News. Last modified March 4, 2015. http://news.nationalgeographic.com/news/2015/03/150304-snow-snowpack-california-drought-groundwater-crisis/.

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