Project 4: Avalanche Forecast for April 11th, 2016

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November 12, 2020

1 Introduction

Natural disasters have long been a plague of the creations of mankind. We have to constantly fight off nature to hold our place in it. Avalanches have consistently been one of the forces we have sought to hold back. One great display of the shear force and damage that can come with an avalanche was shown in Wellington, Washington on below Stevens pass in 1910. A passenger train was stalled on the tracks in a dangerous area due to an 11 day long blizzard. The passenger train was derailed by a an immensely large avalanche that resulted in the death of nearly 100 people. This remains one of the most disastrous avalanches as of today that has occurred on US soil. Instances like this in history have spurred more consistent avalanche research in order to prevent more disasters like the Wellington, Washington instance.

2 Motivation

Although railroad use has gone exponentially down and a lot of major avalanche paths have been mitigated to avoid highway damage. Reliable avalanche prediction systems are still very important to mankind. Recreational use of outdoors areas that are in dangerous avalanche zones has gone up drastically in the last ten years. Anyone traveling in these zones must rest their lives in the predictions from professionals. Using data sets like the Berthoud pass avalanche data sets can be used to potentially identify trends and correlations that cause avalanches.

3 Problem

Using the Berthoud pass avalanche slide data can a basic prediction be made as to how many avalanches may have occurred on April 11th, 2016

4 Hypothesis

Using a few key factors that cause avalanches a nearest neighbor approximation can be made as to what day in the Berthoud pass data set is closest to the weather and snow traits of April 11th, 2016. The closest correlating day can be used to make a simple prediction as to how many avalanches may occur on April 11th, 2016.

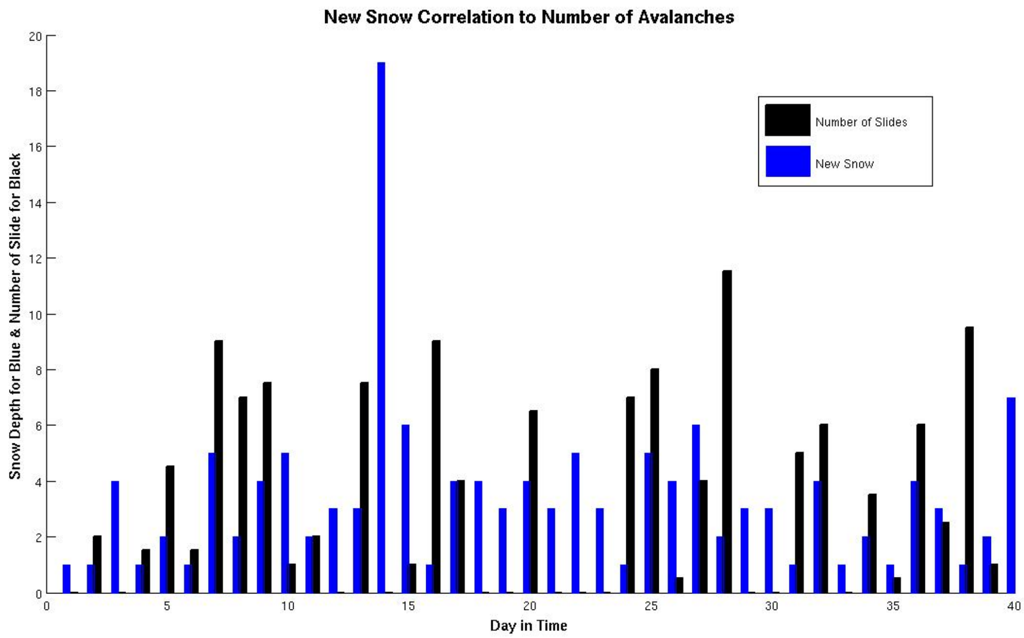
5 Data

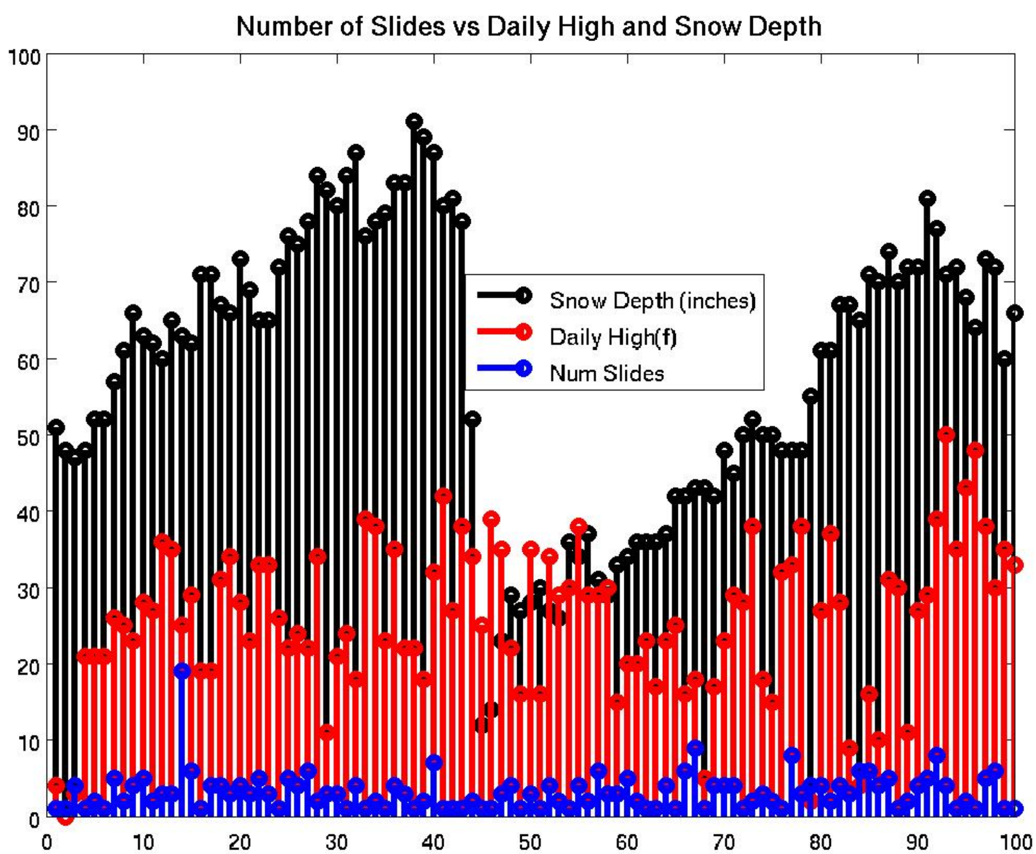
5.1 Avalanche Criteria

Avalanche Criterion			
Data-set Indicator	Greatest Avalanche potential	Data correlation	Avalanche trigger
Weather History	generally cold and dry	no rain below freezing	weak layer formation
Recent Avalanches	24 Hour Window	multi-avalanche group	seismic activity
Snow pack discript	shallow,weak,	erratic temp gradient	poor bonding potential
Snow pack stability	unstable	erratic temp gradient	poor bonding potential
Snow surface	hard, smooth, cold	long cold spell	slab formation
New Snow amount	above12inches;in 24 hrs	continuous snow	Slab formation
Temp above freezing	more than 24 hrs	long colds spell	slab formation
Time between snowfall	relative to data source	periods w/o avalanche	weak layer formation

5.2 Visual Correlation of Weather Variables and Number of Slides

Interesting graph showing how there is a one to two day delay between a layer of new snow and an increase in number of avalanches. The dates do not really matter as this graph is just to show how new snow increases the avalanche danger in the days following a storm.


New Snow Correlation to Number of Avalanches
Snow Depth for Blue & Number of Slide for Black
Day in Time
Number of Slides
New Snow


Number of Slides vs Daily High and Snow Depth
Snow Depth (inches)
Daily High(f)
Num Slides

6 Methodology

- Classify the weather factors that play a key role in avalanche development
- Characterize an avalanche and come up with basic factors that play in its creation
- Edit weather and slide data that correlates with Berthoud pass data set
- take all -99's and turn them into the average of their neighbors
- Make nearest neighbor function
- Use function to characterize 5 closest days to April 11th,2016
- Graph 5 closest days to April 11th, 2016
- Make basic prediction as to how many slides could have potentially occurred based on the data.

7 Results

The nearest neighbor values are a description of how close the variables of a particular day in time are to the April 11th, 2016. The closer the values are to zero means that the days variables are most similar to the day of inspection.

Date	Value
4-25-1984	5.3852
5-17-1982	7.9530
5-8-1973	8.4261
5-15-1982	8.83
4-23-1983	9.274

The following table shows the

Date	Number of Slides
4-25-1984	3
5-17-1982	5
5-8-1973	1
5-15-1982	1
4-23-1983	22

8 Discussion

The analysis of avalanche data is a very difficult task and the process used in this paper only touches the surface as to how the variables truly effect the creation of avalanches. Using a process where only day to day observations are used does not take into account the previous weather and snow pack creation. Depending on the region and weather patterns and even micro climates,snow packs can be adversely different on slopes that right next to each other. The results of using the nearest neighbor did manage to yield days that were around the same time period as the prediction day, but more in depth information is needed to truly make a prediction of how many slides could occur on a given day.

9 Conclusion

Through using the nearest neighbor analysis the day in the past that contained the closest weather and snow variables to April 11th,2016 was April 25th, 1984. This day had a total of 3 avalanches and by the analysis performed we can assume that on April 11th, 2016 there will be a similar number of avalanches. To wrap up it needs to be said that this prediction does not take into account time dependent factors that cause avalanches. As seen earlier new snow appears to increase avalanches the day after the storm and oscillating warm and cold trends can make temperature gradients in the snow that may cause unstable snow crystals over time.

10 References

Mitterer, C. and Schweizer, J.: Analysis of the snow-atmosphere energy balance during wet-snow instabilities and implications for avalanche prediction, The Cryosphere, 7, 205-216, doi:10.5194/tc-7-205-2013, 2013. Snowpack and Its Assessment, http://meted.ucar.edu/afwa/snowpack/

11 Appendix

11.1 Code for finding Correlating Weather to Berthoud Pass Data Set

```
for i = 1:11438
for j = 1:1380
if(SlideDatesNormal(j) == Weatherdates(i)
DL(j) = dailyLow(j)
DH(j) = dailyHigh(j)
NS(j) = newSnow(j)
SD(j) = SnowDepth(j)
end
end
end
```

11.2 Finding How many Slide in One Day (Both Stations)

```
SlideDatesNormal = unique(SlideDates)
```

```
for j = 1:5749
for i = 1:1380

if Slidedates(j) == SlideDatesNormal(i)
NumSlides(j) = NumSlides(j) + 1;
end
end
end
```

11.2.1 Nearest Neighbor Function

```
function[h] = neigh(TH, TL, TNS, TSD, x, SD, NS, DH, DL)
i = 1

while(i<= length(x));
x(i) = ((TH - DH(i))^2 + (TL - DL(i))^2 + (TNS - NS(i))^2 + (TSD - SD(i))^2)^(1/2)
i = i + 1;
end
end
```