Turnagain Pass Avalanche Mapping

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For Professor Don Davis, University of Alaska Anchorage, GIS 460

Skier triggered avalanche on Big Chief. Photo courtesy of Snowdynamics.com

Introduction

As winter recreation becomes more popular and technology puts people further and higher into the backcountry the rate of avalanche mishaps has increased. Alaska has the highest per capita avalanche death rate in the nation and ranks second only to Colorado in deaths per state. Located in the mountains of Alaska's Kenai Penninsula, Turnagain Pass has been responsible for a disproportionate number of these deaths. In 1992 six snowmachiners were killed in a massive avalanche. Concerned about this growing trend the Chugach National Forest established an Avalanche Information Center in Girdwood, Alaska with two trained Avalanche Forecasters. Quality data and maps of this area are limited. My project idea was to create some useful GIS data and maps for avalanche forecasters, rescue workers, and the general public. This data would be published on a website free of charge so that everyone may benefit. Until this project there were no maps of Turnagain Pass with the unofficial names of peaks, ridges, and bowls recreational users commonly go by. It is my hope that labeling these features properly will help recreational users and rescue workers in the advent of a mishap. In addition, I wanted to learn more about Enterprise GIS technologies so I created a Web Mapping Server for interactive online viewing of the GIS data, a Web Mapping Service for connecting directly to desktop GIS software via the internet, and a Web Feature Service for server side GIS software such as ArcIMS.

Materials and Methods:

As I learned more about avalanches I quickly learned that avalanches are very complex, difficult to predict, and virtually impossible to model accurately with the publicly available data. The combination of terrain, weather, snowpack, and unknown triggers creates a degree of uncertainty. Several avalanche experts warned me to be very careful when claiming to predict avalanche hazards. To work around this limitation I decided to focus on the only constant ingredient, terrain. This project cannot predict avalanches but rather aspires to give people with proper avalanche knowledge some useful tools to assess avalanche hazards. This project alone is not designed to predict avalanches in any way, shape, or form as terrain is only one ingredient to trigger an avalanche.

For data I started with GIS data from the Chugach National Forest website and created my own layers for Historical Avalanche Paths, Unofficial names, bowls, trails etc. The Historical Avalanche Paths were obtained from Carl Skustad, Director of the Chugach National Forest Avalanche Information Center. I scanned his map and digitized it to GIS polygons. ArcGIS 9.1 software by ESRI and Spatial Analysis extension were used to create slope, aspect, hillshade, and curvature both plan and profile. As slope is the most important ingredient for avalanches I broke the slope into ten layers for fine grain resolution and detailed analysis. Unfortunately the Digital Elevation Model used for this was based on USGS 15" quad 100 foot contour lines. As a result the accuracy of this data is limited. At the request of several backcountry users I created a three layer breakdown for simplified maps. To create the names layer I consulted over a dozen people who routinely ski in this area and solicited help from the backcountry skiing community via the internet. For complete details see my step by step instructions.

Setting up my server and creating the Map Server application, WMS, and WFS consumed most of my efforts. Much of this was an educational experience as I have never done this before. Originally, I was hoping for some grant software however ESRI was unwilling to give me any software for this project and no funds were available. I turned to the Open Source community for all my software. After an extensive search I decided on the MapServer project. This software seemed to be the most popular and mature of the open source mapping software I looked at. A book on MapServer was published this year. HostGIS Linux was selected for my operating system. This installation has most of the tools I need and is based on Slackware Linux, a good choice for servers. I created my web application with HTML, JavaScript, and MapScript, a special language for MapServer. Learning MapScript and the details of how MapServer works and integrates with JavaScript and HTML was time consuming but this knowledge will be useful for future projects. MapServer is able to read and display Shapefiles and GIS Raster images directly. An HTML template is used to create the look and feel of the webpage. A separate MapScript file is used to specify each layer, their location, properties and projection. MapServer itself is a CGI executable written in C and must be installed and configured properly on a webserver with all the supporting libraries. MapServer also have a built in WMS and WFS web service. This allowed me to easily extend my web application to offer these services and read the same GIS data. See my website: http://www.neilmoomey.com/gis/gis460 to view these services.

Discussion:

Because slope is the most important ingredient to an avalanche the ability to view slope in a thematic map is very useful. 38 degrees is considered by most avalanche experts to be the optimum angle for an avalanche start zone. Anything greater or less than 38 degrees reduces the likelihood of an avalanche to occur. About 95 percent of all avalanches occur on slopes between 30 and 46 degrees. I was surprised how many slopes in Turnagain Pass were in this range. Even the 38 degree slopes are very prevalent on the popular mountains. The use of an interactive map allows people to do their own analysis of the terrain based on the factors they consider to be most important. Putting this interactive map online makes it available to the widest audience possible. No other form of publishing and reach such a wide audience and produce the same results. Factors other than terrain such as weather and snowpack can be indirectly observed from my map server. For example, I broke aspect down into four zones. If a recent storm with strong winds from the East came in aspect could be used to mask or show the western or lee side of the slopes where wind loading is most likely to occur. In late Spring the South aspect can be used to find slopes with isothermal instability. Early winter Northern slopes are usually less stable.

Conclusions:

Matching my final product to my original goals was a serious challenge because of the many unknown factors, lack of funding, lack of experience with this technology, lack of knowledge of avalanches, and absence of accurate data. In the end I did the best I could with the resources and time constraints of this project. The accuracy of my raw data was my biggest limitation. 100ft contours are simply not accurate enough to show all

hazardous slopes. A 100 ft cliff of 38 degrees or more could easily hide on an otherwise safe slope. If I were to do this project again I might consider selecting a different region where more accurate GIS data was available giving me a more useful end product. As long as people understand this limitation I think this project can be very useful. Hopefully, more accurate data will become available someday and I will be able to easily update my project by replacing the GIS data on the server. The biggest victory for me was educating myself on Avalanche Hazards, and open source Enterprise GIS technologies.

Bibliography:

Fredston, Jill A. and Fesler, Doug. Snow Sense: A Guide to Evaluating Snow Avalanche Hazard, Alaska Mountain Safety Center, Incorporated, 1999.

Kropla, Bill. Beginning MapServer: Open Source GIS Development, Apress, 2005

Mitchell, Tyler. Web Mapping Illustrated, O'Reilly, 2005

Interview with Carl Skustad, Chugach National Forest Avalanche Forecaster

Interview with Andy Sullivan, Avalanche Instructor,

Interview with Doug Scott, GIS Expert and owner of Avalanchemapping.org

Contributions from Sean Dewalt of Snowdynamics.com, Todd Kelsey, William Finley, Steve, Skip, and Bob Sullivan.

MapServer: http://mapserver.gis.umn.edu/

HostGIS Linux: http://www.hostgis.com/linux.html

Appendices:

Step by step instructions for this project

My Website http://www.neilmoomey.com/gis/gis460/

- Maps
- Map Server
- WMS
- WMF