

Reporting Avalanche Danger Using Spatial Data

A GIS-Based Avalanche Hazard and Risk Assessment for Mt. Washington, NH



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Introduction

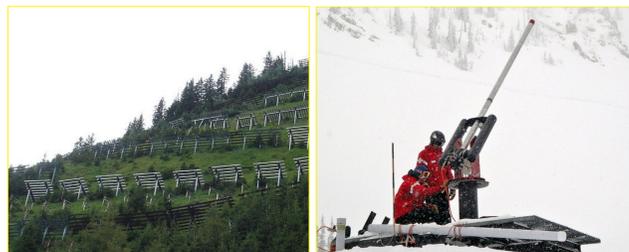
- ▶ An avalanche is one of the deadliest disasters a person can face when traveling on or near mountains or glaciers.
- ▶ In the U.S. alone, avalanches cause an average of 25 fatalities per year (34 last season), and many more injuries that may or may not have been reported.
- ▶ Any natural disaster is difficult to predict, but there are many complex variables that affect avalanche conditions, including weather, terrain, snow conditions, and human factors.
- ▶ This uncertainty makes avalanches especially difficult to model on a large scale or for variable conditions, which makes them harder to predict and avoid.

So how can we use GIS to estimate and convey avalanche danger effectively for a given region?

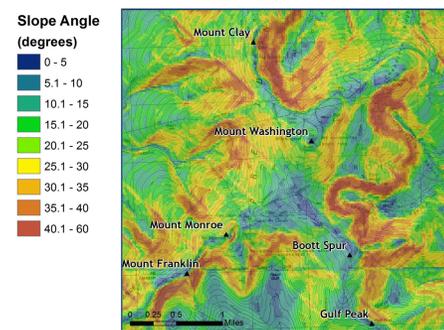
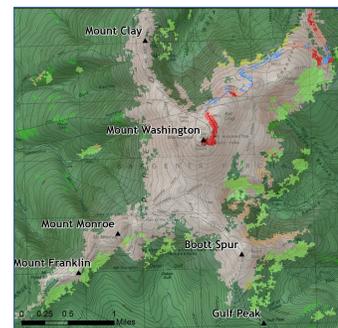
Utility

Possible uses of GIS for avalanche work include:

- ▶ Locating trigger zones by finding open areas that can support a high level of snow loading and are steep enough to start an avalanche
- ▶ Modeling runout, or avalanche track, by creating a watershed-type map downslope from the trigger zones (extremely variable based on conditions and avalanche size)
- ▶ Recording locations of past avalanches for statistical use (ex. finding suitable locations for avalanche controls like cannons or snow fences)
- ▶ Displaying up-to-date avalanche forecasting and current risk levels in areas where snowpack and other variables are easily measured.

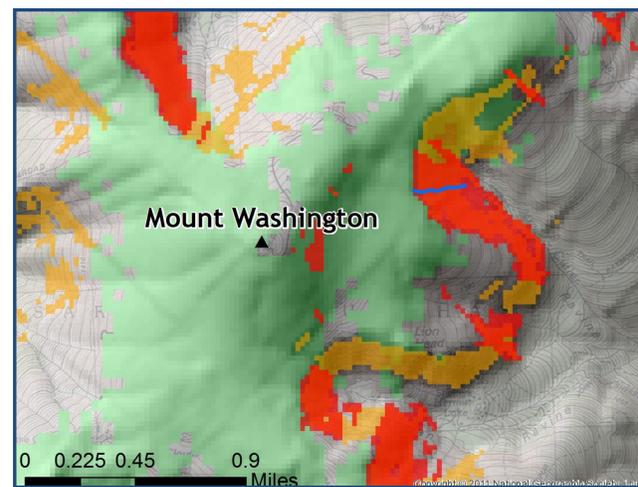


▶ Snow fences in Switzerland and an avalanche gun in Arapahoe Basin, Colorado (top), Large avalanches (right) ▶

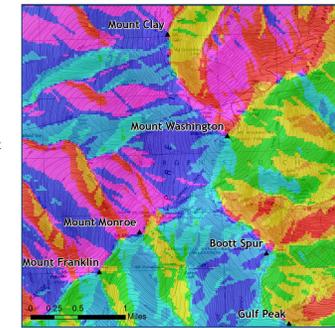


Risk Map

- O'Dell's Gully
- Low-Risk Area
- High-Risk Area
- Steep Area
- Barren Land



- Slope Aspect | |
- | | |
|-----------|-------------|
| North | Red |
| Northeast | Orange |
| East | Yellow |
| Southeast | Light Green |
| South | Green |
| Southwest | Light Blue |
| West | Blue |
| Northwest | Light Blue |
| North | Red |



Mt. Washington, NH (elev. 6288 ft.)

▶ The spatial data above shows the factors that contributed to high avalanche risk in O'Dell's Gully at the time of the 1/18/08 avalanche, which caused the death of a climber on Mt. Washington. Using GIS tools and minimal onsite measurement, this kind of analysis could be used on a day-to-day basis to provide danger levels to visitors and guides and assist in forecasting events.

Methodology

To assess avalanche danger in a given region at any time, several types of data can be combined:

- ▶ Digital Elevation Model (DEM) and slope: important in determining areas prone to slope failure (most avalanches occur at slopes over 35°), as well as slope aspect (for estimating wind loading) and for runout modeling.
- ▶ Land Use: Forested or developed areas are generally low-risk areas for avalanches.
- ▶ Proximity of hazard areas to points of human contact: trails, roads, hiking routes, etc.
- ▶ Snowpack characteristics: Depth, density, slab width, etc.- observed or estimated by meteorologic data
- ▶ Other useful data: Past avalanche events and conditions, locations of snow fences, barriers, etc.

These layers can be combined using GIS tools to create visually accessible warning maps for climbers, skiers, hikers, etc.



Case Study: 1/18/2008

On January 18, 2008, an avalanche caused the death of a climber in O'Dell's Gully in Huntington Ravine on Mt. Washington. It was rated a D2R3 meaning it was destructive enough to bury, injure, or kill a person, and medium in size relative to the slope.

The conditions on the mountain were as follows:

- ▶ Snowfall: Between 3.1" and 3.9" of new snow beginning at 4am on the 18th
- ▶ Snow Density: Average 12.8% water by volume (on the heavier side)
- ▶ Summit Temp: Max 15°F, Min. 8°F
- ▶ Wind: 60-70mph out of the South, shifted to West
- ▶ Gusts: Peak 86mph out of the West at the summit

Because O'Dell's gully has an E/NE aspect, it experienced heavy loading during this storm. Snow conditions indicate that a friction angle of 30-35° would be sufficient to start an avalanche, especially with a human trigger.

Findings

By using GIS data in conjunction with other factors, it is possible to accurately estimate avalanche risk on a given slope, and thereby inform people exactly which areas are most dangerous. Highlighting on a map which areas are at risk is much more effective than an general warning level.