Mount Mansfield Precipitation Study:

Spatial Variability of Precipitation on the Eastern Slope of Mt. Mansfield, Stowe, VT.

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Geomorphology Term Project
Fall, 2001

Abstract-

This report focuses on the spatial variability of precipitation with elevation. Data were collected using a tin can-gauge technique. The gauges were spread along relatively equally spaced elevation intervals near the Stowe Ski Resort, Mount Mansfield. Data were collected bi-weekly. The data for each collection were graphed in an attempt to determine the relationship between precipitation and elevation.

The approach of the study was trial and error; many alterations in our techniques were necessary to collect data. The harshness and variability of the Mansfield microclimate made the sampling treks into this environment particularly grueling. Individual storm totals were difficult to deduce because often multiple events would occur between collections. More often, as is expected in the fall, the freezing altitude hovered around the 820-meter elevation, causing precipitation on more than half the mountain to fall as heavy wet snow, skewing data collection. From the single all-rain event measured in the period between October 27th and November 17th, a linear relationship was observed with an R^2 value of 0.954. This collection supported our initial expectations of finding an increasing linear trend of precipitation with gained elevation.

Introduction-

Varying precipitation patterns over mountainous terrain affect ecological systems. These affected ecosystems vary from the streams and waterways fed by runoff, to the soil types, fostering multitudes of vegetation species. The interrelationship between elevation and precipitation is important to recognize and understand because it plays a pertinent role in the processes that govern alpine and lowland ecosystems.

The intention of this study is to provide evidence that higher elevations receive more precipitation than neighboring lower elevations. **Figure 1** illustrates the statewide variation of precipitation with elevation. **Figure 2** shows this correlation by comparing National Weather Service precipitation data measured in Burlington (elevation 104m) and on the summit of Mount Mansfield (1,221m) for the same period of time. This project measures the positive correlation between precipitation amounts and elevation for all storms occurring within the time span of 10/27/01 through 11/17/01.

The spatial variability of precipitation was analyzed along a single ridge on the Mount Mansfield watershed. The chosen ridge will be referred to here as the Toll Road Ridge, and was chosen because of its easy accessibility, its relatively gradual elevation change over distance, and its unobstructed exposure to free-falling precipitation. **Figure 3a** shows an aerial view of the mountain with the locations of the gauges superimposed. The collection equipment was accessed on foot by hiking up the Stowe Ski Resort's Toll Road, an off-reason auto road and winter ski trail, and other nearby ski trails. The elevations range from 420 meters (1,300 ft) on Route 108 to 1,221 meters (4,062 ft) at the

Nose, one of Mansfield's prominent summits. The length of the ridge is 5.2 km (3.2 mi). Precipitation measurements were collected at nine sites along the ridge, each at a different elevation. The graph in **Figure 3b** depicts the difference in elevation between gauges.

The gauges were installed on October 27^{th} and were removed November 17^{th}, allowing for a 21-day observation window. This window of observation turned into more of a 'snapshot' after factoring in the technical difficulties associated with designing such a study and adapting it to the encountered challenges. Large snow accumulations presented us with the most difficulty because the cans were often too short to contain the frozen precipitation, and during the largest snow events snow actually drifted up over the cans, which were perched two feet above the ground. The goal of this study was to acquire numerous complete data sets and to perform regression analyses on them. Comparing multiple regression analyses would give a clear perspective on how precipitation varies with elevation over multiple storm events. As it happened, only one collection event was unambiguous. A linear relationship was observed, verifying our hypothesis.

Methods-

<u>Can Construction</u>

The precipitation collectors were produced by duct taping 12oz. Soup cans to wooden dowel supports. The soup can lids were removed in order to collect falling rain and snow. A distance of about 2 feet was left from the bottom of the dowel to the can in order in to elevate the can over accumulating snow and keep out debris. Olive oil was put into each can to minimize evaporation of the collected precipitation.

Can Placement

The cans were placed at equally spaced elevations along the Toll Road Ridge. (See **Table 1**) Each site was chosen to allow for maximum exposure to falling precipitation. This included low tree cover and safe distances from snowmaking machines. Elevations of the chosen collection sites are listed in the data section.

Measurement

Data were collected four times within a 21-day period. Results were collected by pouring the captured rain and snow into a 200ml graduated cylinder. Collected ice and snow often needed to be melted using hot water and/or our own breath in order to return it to a liquid state.

Data-

Table 1- ***Gauge Elevations***

Gauge #	Elevation (m)	Elevation (ft)	Change, _ (ft)
1	420	1378	482
2	567	1860	436
3	700	2296	443
4	835	2739	394
5	955	3132	272
6	1038	3405	272
7	1121	3677	128
8	1160	3805	200
9	1221	4005	

<u>Table 2-</u> ***Trip Data Collected in Can Gauges***

		10/31/01	11/5/01	11/8/01	11/17/01
Gauge #	Elevation	Precip (mm)			
1	420	.24	31.06	6.45	18.64
2	567	.96	33.45	5.97	18.64
3	700	1.19	41.33	6.21	20.07
4	835	2.15	X	9.56	15.29
5	955	2.87	X	X	26.28
6	1038	3.34	X	X	X
7	1121	3.82	X	X	20.07
8	1133	4.78	X	X	19.11
9	1221	4.3	X	X	X
X= Undeterminable Precipitation Amount (either buried or overflowing)					

<u>Table 3-</u> ***Calculations***

(ml collected in graduated cylinder)(1cm^3/mL) = 1 cm^3
1mL = 1 cm^3
(Volume Collected in Can) / (Can Oriface Area) = cm precipitation
(cm precip)(10 mm/cm) = mm precipitation
Can Oriface Area = 41.854 cm^2
Short Calculation = (Volume collected) (0.2389258) = mm of Precipitation

<u>Table 4</u>
Comparison between our data and data comprised by official gauge on Mansfield *(NWS)*

Collection Period	Gauge Data (mm)	NWS Data (mm)
10/27-10/31	18	12
10/31-11/5	41.33	42
11/5-11/8	9.56	6.3
11/8-11/17	20.07	33

Discussion-

Precipitation is one of the most influential factors in the geomorphology of a mountain range, especially on those of the northern Appalachian range since the retreat of the last glaciation. Heavy and persistent rains, constant cycles of freezing and thawing, and the inevitable spring thaw and subsequent floods can put the soil on a slope like Mount Mansfield through many changes. ‘Vermont’s topography and the intense small storms that have occurred over the last few years have led to severe road damage, such as the recent rains on July 16th 2000, that created a federally declared disaster with over two million dollars in damage statewide.’(USGS) By gauging precipitation around Vermont scientists can better understand the effects of precipitation on erosion and apply that knowledge towards use in ecological and economic planning.

Our study showed an overall pattern of increasing precipitation levels with increasing elevation. The collection period of 10/27 to 10/31 is clearly the most complete of the measurements. (**See Table 2)** A single light rain event occurred during these five days and the skies remained overcast. The lack of sunlight prevented considerable evaporation. These data are graphed in **Figure 4** and the linear regression equation ($y = 0.0066x - 2.3521$) and an R^2 value (0.9537) are computed.

The other collections were less accurate due to many factors. Snow and freezing rain made the readings most difficult. The limiting depth of our gauges prevented the measurement of rain or snow deeper than about 4 inches. The NWS station on the summit reported three 4+ inch 24-hour storm totals over the period of the study. Wind drifting and transport were also a concern when considering the accuracy of our readings. Rime ice was a problem on the more-exposed summit gauge.

Table 4 depicts the comparison between our data and the data collected by the weather station near the summit of Mansfield. Our readings were at times almost identical to those taken by the Mansfield weather station while others were off by several millimeters.   Our results are all still very close to those taken by the weather station giving us a good reference point for our data against a professional and reliable source.

Data Applications

The pattern of precipitation fall in our data can lead to future hypotheses relating to erosion and soil structure changes at different elevations due to increased rain and snow fall as elevation increases. The Stowe Mountain Resort is currently interested in collecting such data to be used to defend a proposal for expansion, which would involve clear-cutting for ski trails, and would have a direct effect on the forest ecology and hydrology. Erosion causes streams to change paths and soil to move, something that must be monitored for every type of land use, whether that is a hiking trail, ski trail, or highway.

Summary-

Our data generally supported our hypothesis that precipitation increases in a linear pattern with increased elevation. Our best example of this pattern is displayed in our results from the 10/27-10/31 collection period. Other collection periods showed more variable results due to evaporation and overflow problems.

Future Project Improvements

Several alterations could be made on our approach to this project in order to collect more accurate and relevant results. The implementation of larger gauge cans would eliminate the overflow problems that we experienced during heavy snowfall. Using synthetic oil instead of olive oil would greatly decrease evaporation after periods of freezing. Installing heated cans or adding an anti-freeze mixture would also eliminate any freezing problems we experienced. Choosing more uniform collection sites would help to eradicate data variability due to tree cover or overexposure to wind and sunlight. More systematic checks would produce results that are more directly linked to each storm event.

Figure 1

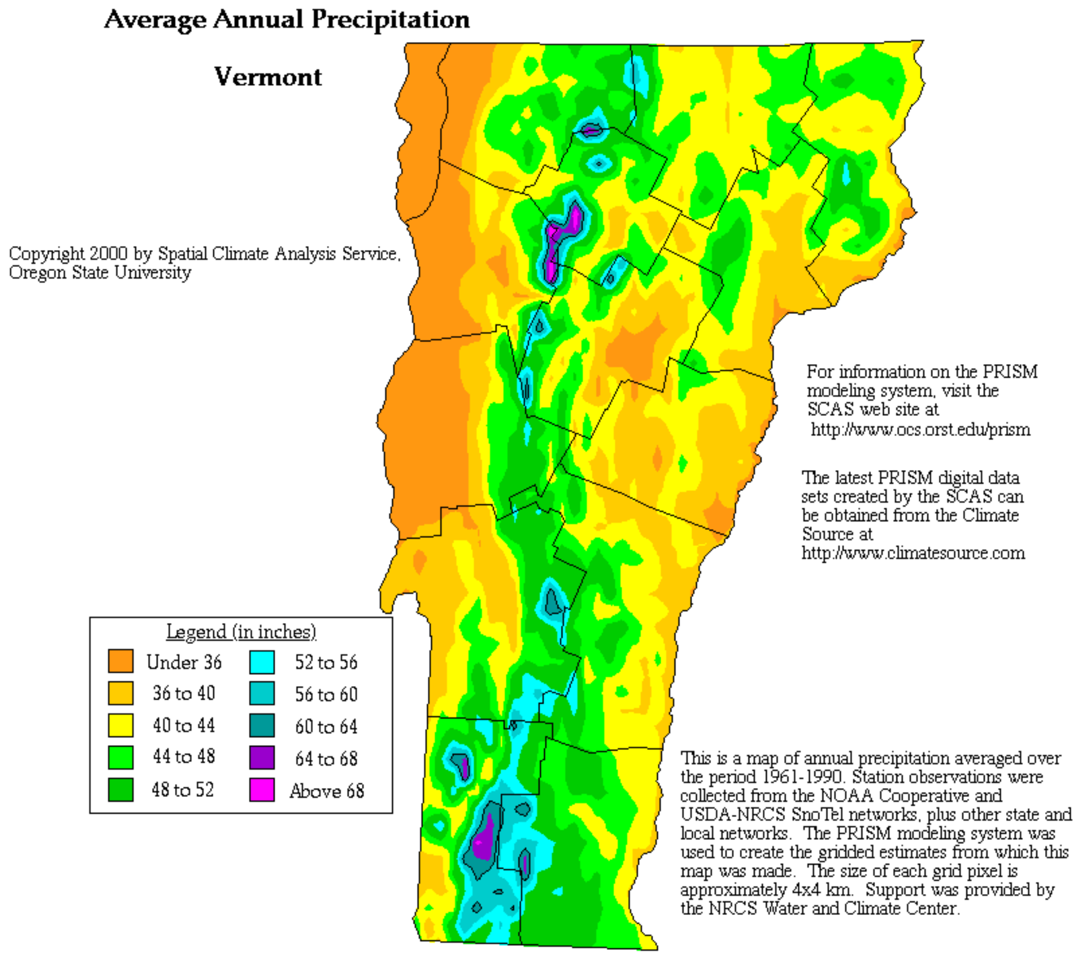

Figure 1: A Vermont map of annual precipitation. Notice concentrated precipitation on highest elevations of the spine of the Green Mountains. Spatial Climate Analysis Service, Oregon State University.

Figure 2

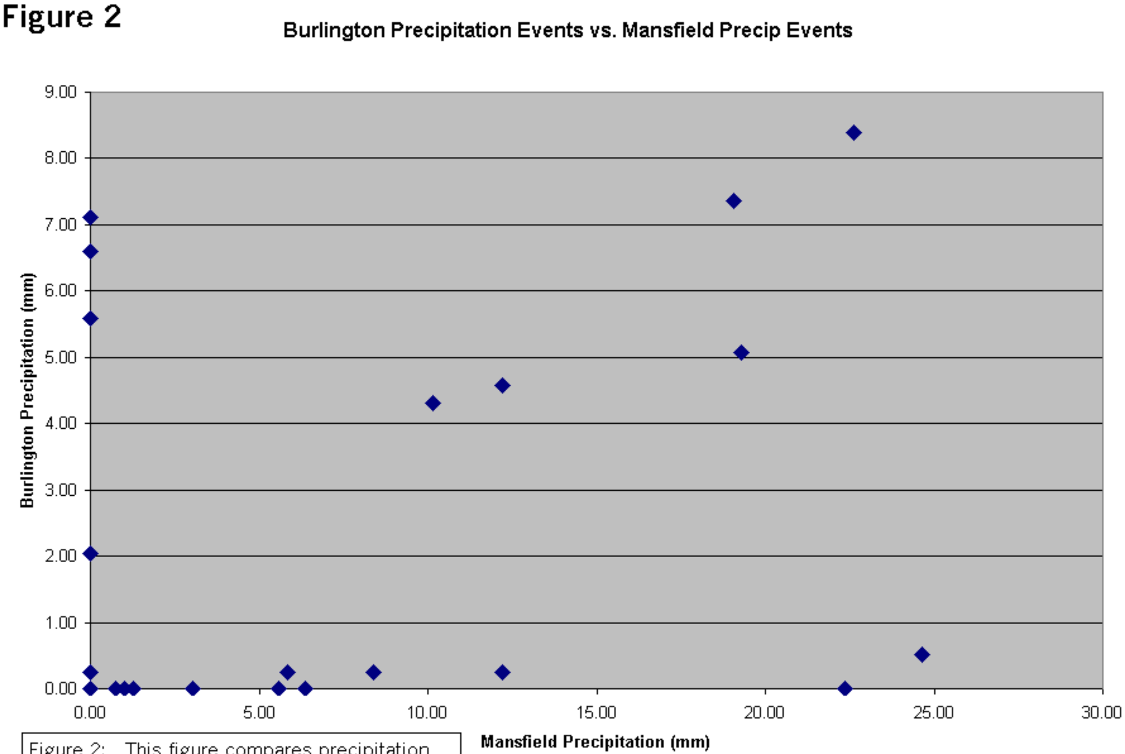

Figure 2: This figure compares precipitation events occuring at Mount Mansfield and Burlington, VT. between 10/15/01 and 11/17/01. Data points in the center of the graph correspond to events occurring at both locations during a 24 hr period.

Figure 3

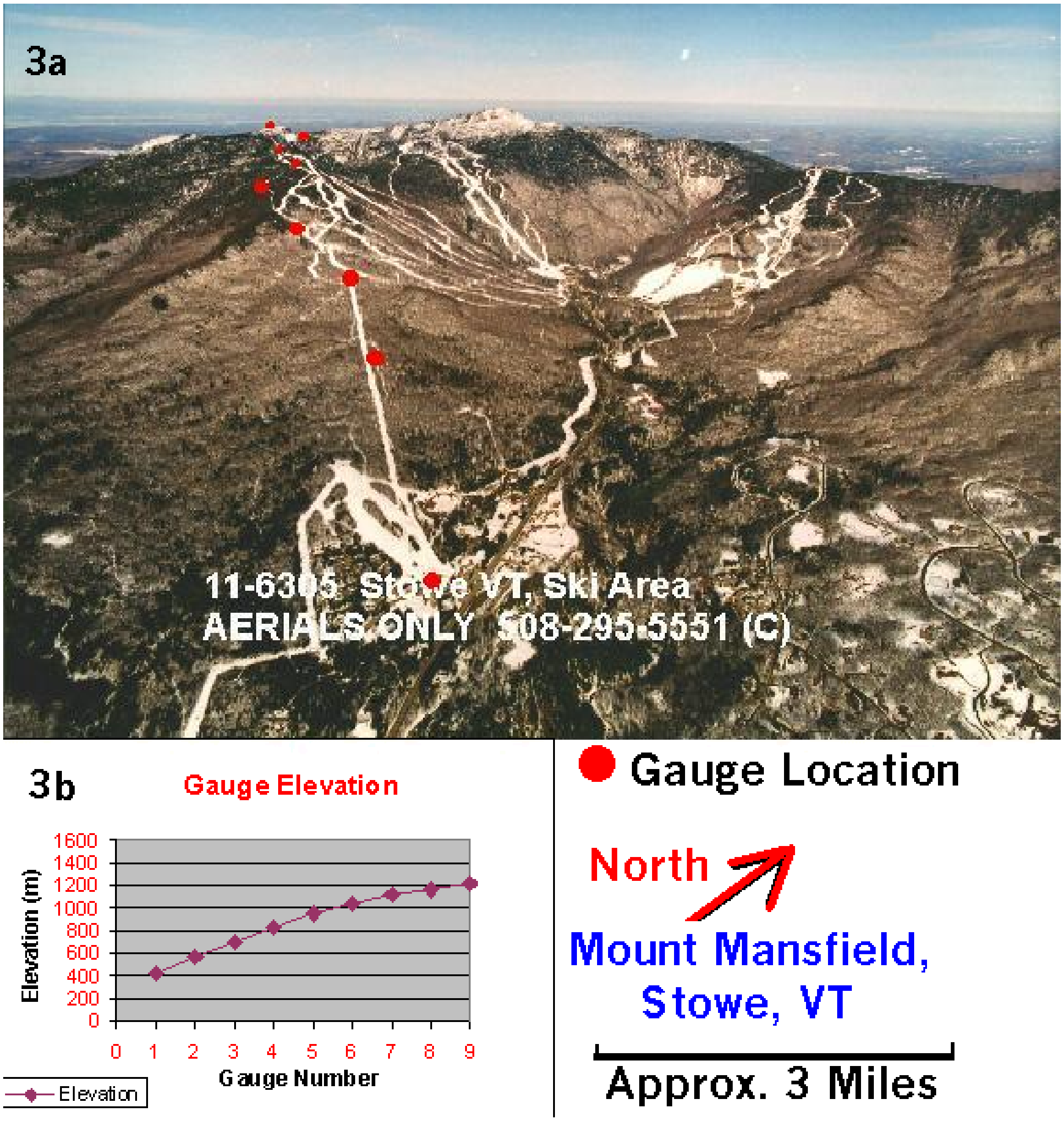

Figure 3 Caption: 3a) An aerial view of Mount Mansfield and Stowe. The location of the gauges along the Toll Ridge are superimposed.
3b) This graph shows the relative elevation of each precipitation gauge.

Figure 4

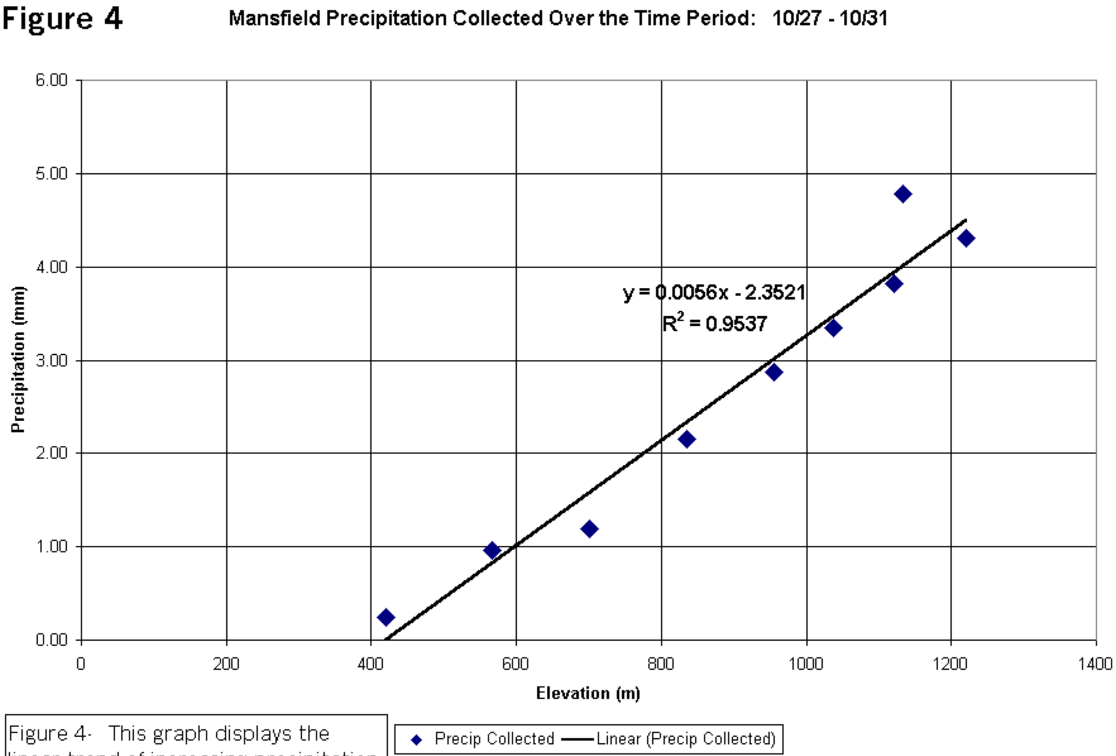

Figure 4- This graph displays the linear trend of increasing precipitation with increased elevation that we expected to see.
Collection: 10/27-10/31

References:

- **SkiVT-L Computing and Information Technology** **http://www.uvm.edu/skivt-l//depths.html (2001)**

- **The National Weather Service; Burlington Vermont Station: Data Retrieval System** **http://www.nws.noaa.gov/dataprod.html (2001)**

- **USGS: Water Resources of Vermont and New Hampshire** **http://nh.water.usgs.gov/whatsnew/newsreleases/gage.ayersVT.htm (2001)**

- **Oregon State University; PRISM Climate Mapping Project** **http://www.ocs.orst.edu/pub/maps/precipitation/Total/States/VT/vt.gif (2001)**

- **Topographic Map of Mount Mansfield:** **http://www.topozone.com (2001)**