Mount Mansfield Precipitation Study:

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

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Abstract-

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 environments.

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 on the Stowe Ski Resort side of Mount Mansfield. Data were collected bi-weekly. The data for each collection were graphed in an attempt to find some relationship between increased precipitation amounts with increased elevation.

The approach of the study was completely trial and error; and many alterations in our techniques were necessary to collect truly valid data. The variability of the Mansfield microclimate made any solid conclusions nearly impossible. Individual storm totals were difficult to deduce because often multiple events would occur between collections. More than 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 surprisingly linear regression was observed with an R-squared value of 0.954. This collection complimented our initial expectations of finding an increasing linear trend of precipitation with gained elevation.

Introduction-

It is generally accepted 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 precipitation measured by the National Weather Service in Burlington (elevation 104m) to precipitation measured by The University of Vermont on the summit of Mount Mansfield (1,221m) for the same period of time. The scope of this project is to prove a positive correlation between increased precipitation amounts with gained elevation.

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 3** 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 was determined to be 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 3** depicts the difference in elevation between gauges.

The gauges were installed on October 27th and were removed November 17th, 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 adapting it to the encountered challenges. Large snow accumulations presented us with the most difficulty because the cans were often too small 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. These tribulations are avoidable, but more research time would be required to correct them. Ideally 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. As it happened, only one collection was without flaw or variability. A linear regression was observed, and this complements our hypothesis.

Methods-

As stated in the introduction, nine precipitation collectors were placed at approximately equal intervals along the Toll Road Ridge.

Can Construction

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 o 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. Each site was chosen to allow for maximum exposure to falling precipitaion. 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 the 21-day testing 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 liquid.

Data-

Gauge Locations

Gauge #	Elevation	Feet	Change
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	

Trip Data

		10/31/01	**11/5/01**	**11/8/01**	**11/17/01**
Gauge #	**Elevation**	**Precip (mm)**			
1	420	100.35	23.98	6.45	18.64
2	567	135.47	32.37	5.97	18.64
3	700	167.25	39.96	6.21	20.07
4	835	199.50	x	9.56	15.29
5	955	228.17	x	X	26.28
6	1038	248.00	x	X	X
7	1121	267.84	x	X	20.07
8	1133	270.70	x	X	19.11
9	1221	291.73	x	X	X

X= Undeterminable Precipitation Amount (either buried or overflowing)

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

Comparison between our data and the data comprised by the NWS on Mansfield

Period	Gauge Data (mm)	National Weather Service (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-

Above is the data collected between 10/27 and 11/17 2001. The collection period of 10/27 to 10/31 is clearly the most complete of the measurements. Light rain fell during these five days and the skies remained overcast. The lack of sunlight prevented considerable evaporation. The fact that more rain than snow was collected allowed us to obtain the most accurate of readings. These data are graphed in **Figure 4** and the linear regression equation and R^2 value are computed.

The other collections were more variable and often invalid due to many factors that were nearly unavoidable. Snow and frozen liquid precipitation made the readings most difficult. The limiting depth of our gauges prevented the measurement of snow deeper than about 4 inches. Certainly the mountain received more accumulation than this numerous times. 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.

The last table in the Data Section depicts the comparison between our data and the data collected by the weather station near the summit of Mansfield.

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. Even though the trips on 11/5 and 11/8 were cut short due to freezing and overflow of our gauges, the increasing pattern is present in the results for those two days.

Data Application

A solid understanding of spatial variability of precipitation with elevation is pertinent to understanding several important geological processes. One of these processes is surface runoff, which has a direct effect on land use and persons interested in such a practice. 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. Our conclusions may be of interest to the Stowe Resort. A process that is spurred by surface runoff and indirectly affected by precipitation variability is weathering, more specifically, erosion. This process is of interest to engineers designing drainage culverts alongside and crossing ski trails and elsewhere in the watershed, and is of ecologic interest because it rules the nutrient cycles necessary for life at these elevations. Erosion causes streams to change paths and characteristics, something that must be monitored for every type of land use, whether that is a hiking trail, ski trail, or highway.

Future Project Improvements

Several alterations could be made on our approach to this project in order to collect more accurate and relevant results. 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

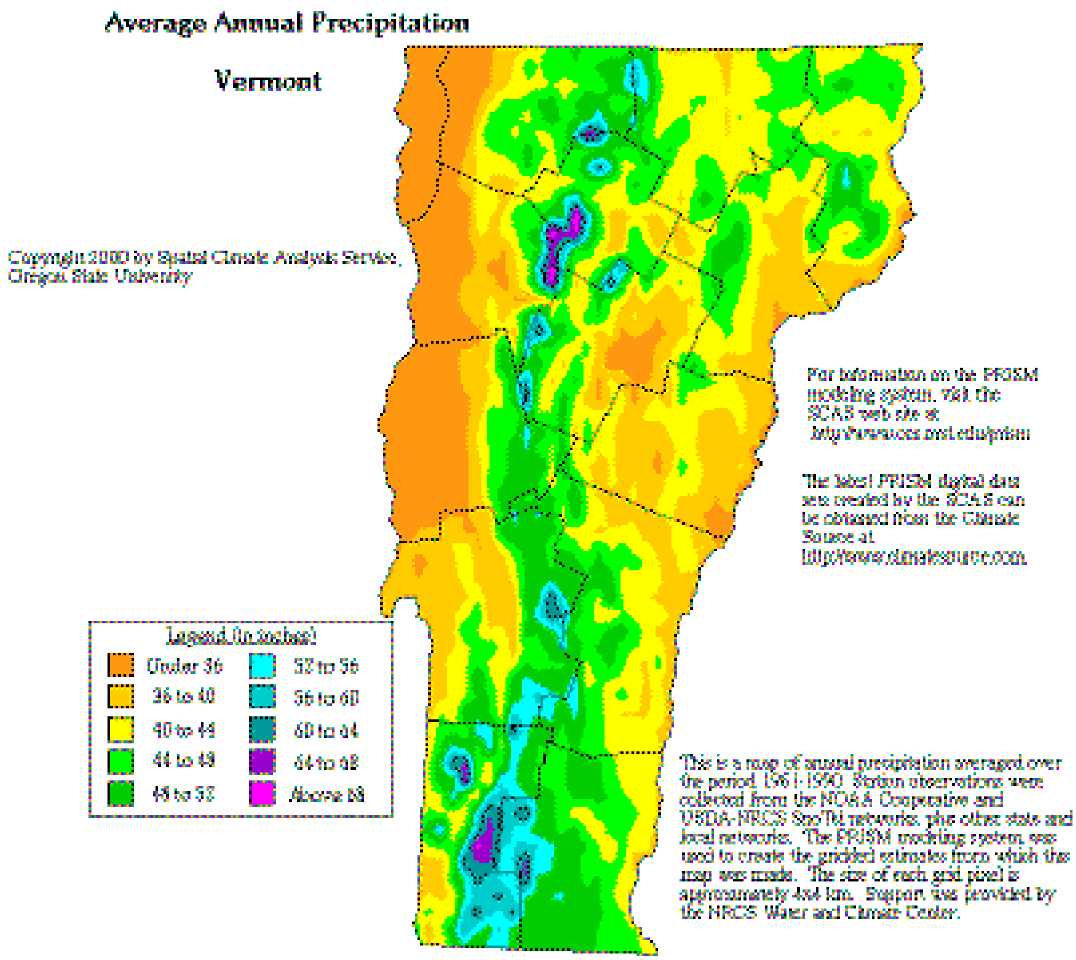

Figure 1: A Vermont map of annual precipitation. Notice concentrated precipitation on highest elevations of the spine of the Green Mountains. NRCS Water and Climate Center.

FIGURE 2

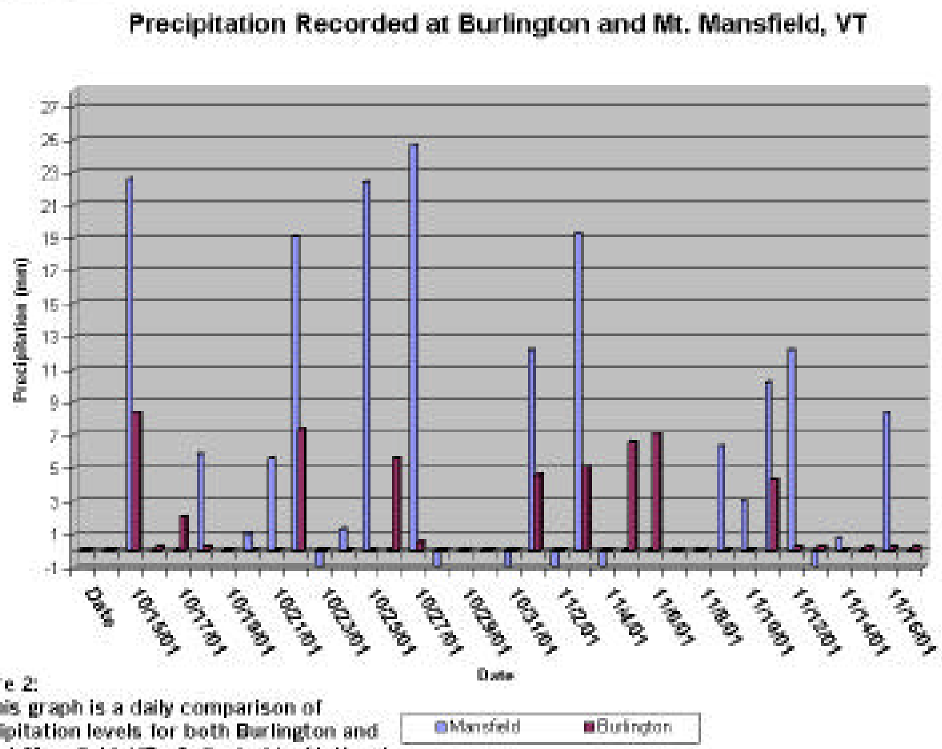

Figure 2:
This graph is a daily comparison of precipitation levels for both Burlington and Mount Mansfield, VT. Collected by National Weather Service.

The negative values are recording errors experienced by the Mansfield station, thus more precipitation may have fallen on the summit than was recorded.

Figure 3

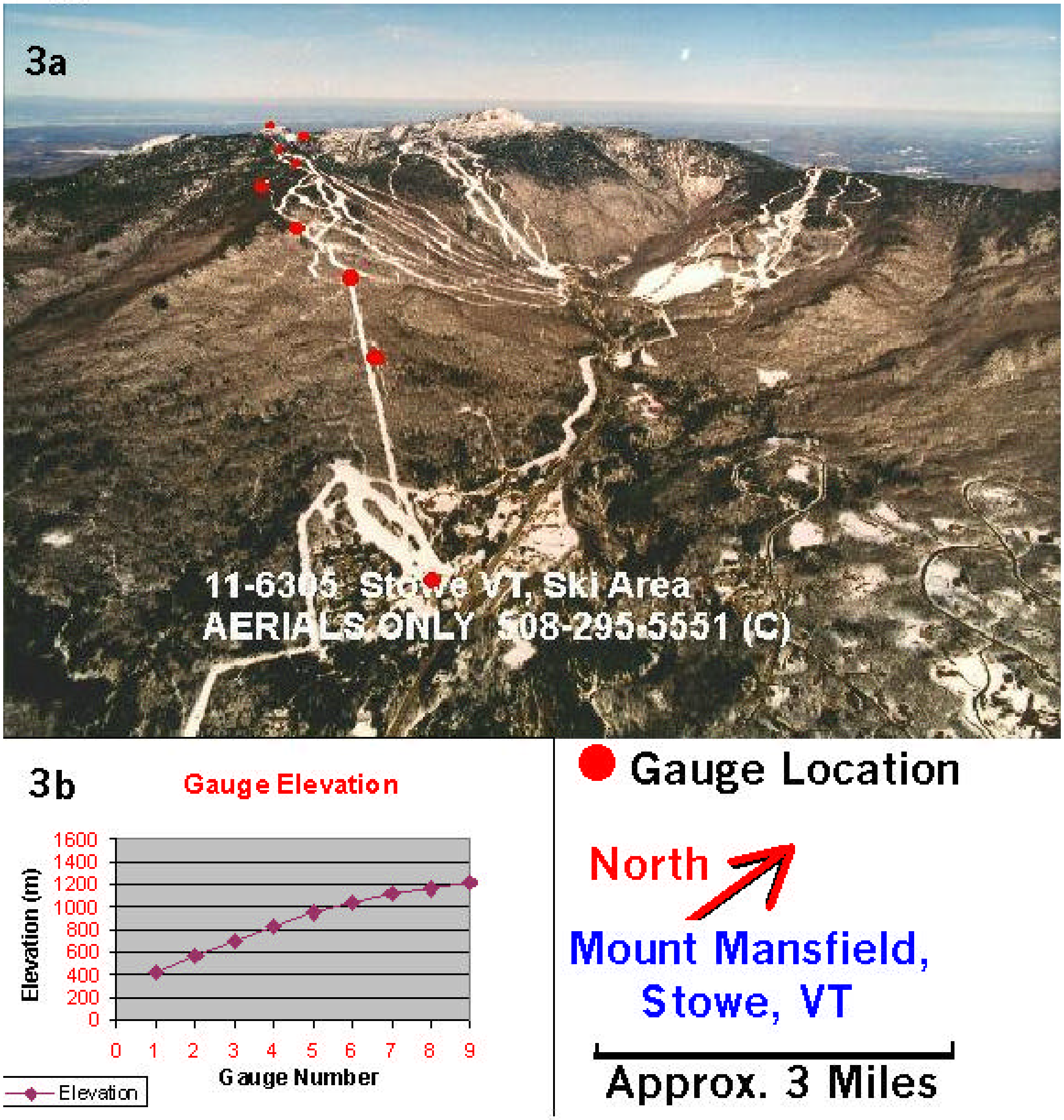

Figure 3 Caption: 3a) An aerial view of Mount Mansfield and Stowe. The location of the gauges along the Toll Ridge are superimposed.
3b) This graph shows the relative elevation of each precipitation gauge.

Figure 4 Mansfield Precipitation Collected Over the Time Period: 10/27 - 10/31

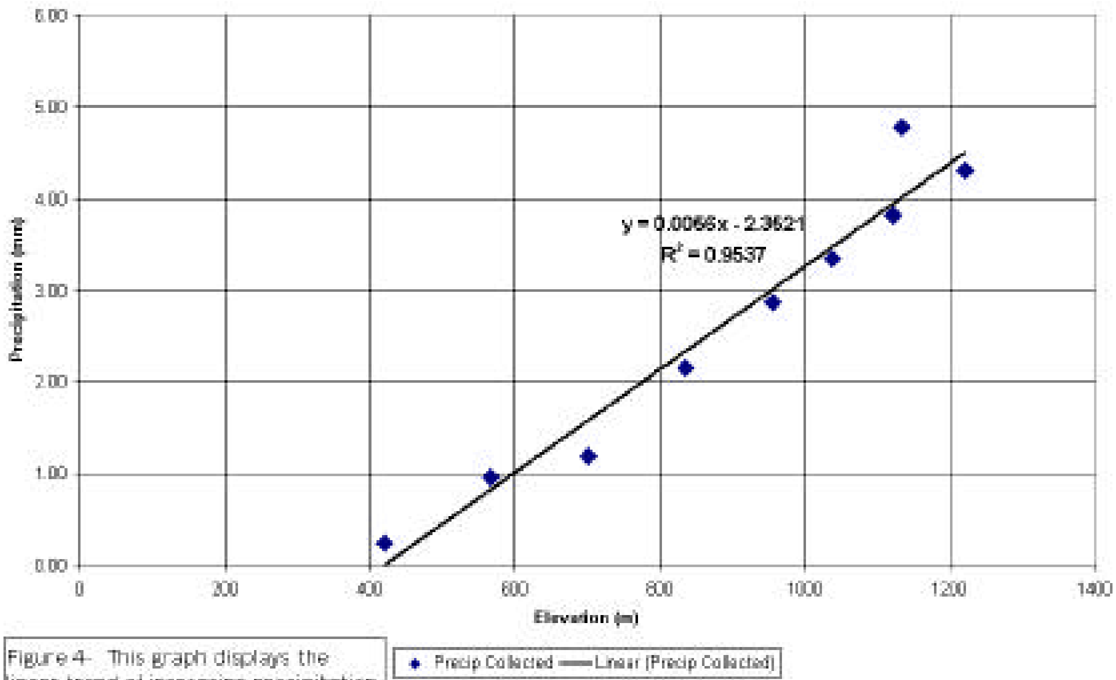

Figure 4- This graph displays the linear trend of increasing precipitation with increased elevation that we expected to see.
Collection: 10/27-10/31

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)**