INVESTIGATING THE SNOW CLIMATE OF TURNAGAIN PASS, ALASKA

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ABSTRACT: Turnagain Pass, Alaska, which is a popular destination for backcountry enthusiasts located 40 miles southeast of Anchorage, does not fit neatly into one of the three snow climate categories (coastal, intermountain and continental). The following study investigates this fit by analyzing the past 28 seasons of SNOTEL data recorded in the heart of Turnagain Pass along with records kept by the Chugach National Forest Avalanche Information Center. Preliminary findings suggest Turnagain Pass is a combination of snow climates that can fluctuate dramatically from season to season. The most extreme examples include three seasons with continental characteristics and fourteen seasons representative of a coastal climate. The variability is reflected by the wide range of avalanche characteristics which include seasons marked with direct action activity followed by a quickly stabilizing snowpack to seasons plagued with depth hoar and deep slab instability. This paper concludes with a brief discussion of challenges encountered as well as future data necessary for a more complete study.

1. INTRODUCTION

Turnagain Pass, Alaska has been a hot spot for backcountry skiers, snowboarders and snowmachiners for many years. Each year, as this area increases in popularity, more and more people are recreating in avalanche terrain. This is precisely why the Chugach National Forest Avalanche Information Center (CNFAIC) defines Turnagain Pass as its core forecast zone. In order to gain a more in depth understanding of the Turnagain Pass region and its potentially differing aspects compared to its more understood neighbor Alyeska, the follow study attempts an analysis of the limited historical data collected in the area. Frist, a look at estimating the snow climate for each of the past 28 seasons was completed with a comparison to the Summit Lake region, another location gaining in popularity about 12 miles southwest of Turnagain Pass. Secondly, a brief comparison is shown with adjacent areas containing snowpack information.

Located in the northern Kenai Mountains, Turnagain Pass is part of the Chugach National Forest which extends along the Seward Highway corridor from the southern end of Turnagain Arm to Johnson Pass trailhead (Figure 1). The northwest side of the highway is open to motorized use while the southeast side is non-motorized.

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Differences in snow and avalanche climates in the western U.S. were first discussed in 1949 by Andre Roch (1949) and later by Ed LaChapelle (1966). Armstrong and Armstrong (1987) took the idea further and verified, using data analysis, the three defined categories for snow and avalanche climates (maritime, intermountain and continental), still used today. Later in 2000, Mock and Birkeland (2000) developed a method using specific parameters to categorize a location's snow and avalanche

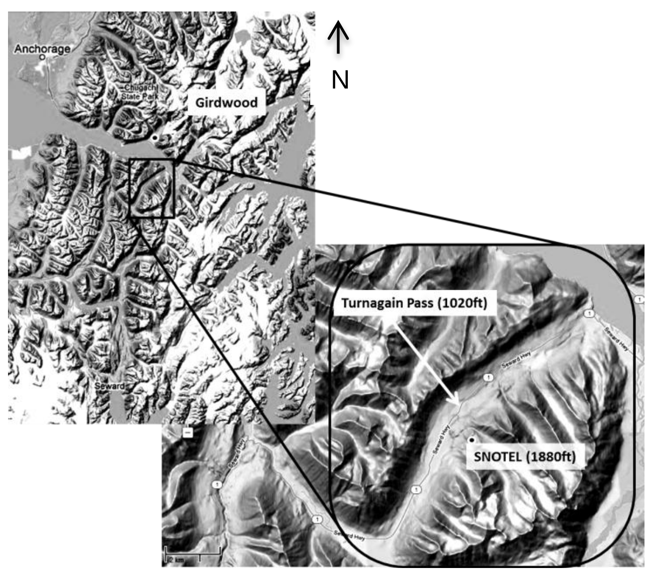

Figure 1: Turnagain Pass and the Turnagain Pass SNOTEL are marked within the bounds of the CNFAIC's core forecast zone. (map: googlemaps).

climate. In 1996 Mock (1996) analyzed 20 winter seasons at Alyeska Resort in Girdwood, Alaska for the first detailed look into the snow and avalanche climate in Alaska. While these studies emphasized both the snow and the avalanche climates, the following project will focus on the snow climate due to limited detailed avalanche data for the Turnagain Pass region.

2. DATA COLLECTION

Snow cover and atmospheric data were collected from the Turnagain Pass SNOTEL site. This site is located at 573m (1880ft) in the heart of Turnagain Pass (Figure 1). Additional snowpack information was collected from the National Resource Conservation Service (NRCS) snow course, located near Bertha Creek in the Turnagain Pass area at 290m (950ft).

Outside of the core Turnagain Pass zone, three other data sets were used for comparison and quality control: (1) Summit Creek SNOTEL (427m, 14000ft), ~12 miles southwest of Turnagain Pass near Summit Lake, (2) Mt. Alyeska SNOTEL and Alyeska Mid-Mountain (470m, 1500ft), ~12 miles north in Girdwood and (3) Girdwood Yard (18m, 60ft), also in Girdwood.

Air temperature and snow water equivalent were available for over 20 seasons while snow depth was available for 8 seasons.

3. METHODOLOGY

3.1 Snow climate approximation

To determine the snow climate, average air temperature, snow water equivalent, snow depth and December temperature gradient were calculated from the Turnagain Pass SNOTEL site and input into a decision tree that was developed by Mock and Birkeland (2000). Only data between 1 December through 31 March were calculated. This was to be consistent with Mock and Birkeland's method. Five parameters are used in the decision tree: (1) seasonal rain, (2) average air temperature, (3) December average temperature gradient, (4) snow water equivalent and (5) snowfall. Average December temperature gradient was calculated by dividing average December snow depth with average December air temperature using the assumption that the ground-snow interface is 0˚C.

Two important parameters, seasonal rain and snowfall, were not available from the SNOTEL data, nor any other source to the best of the author's knowledge, and therefore have been omitted. Hence, the use of the decision tree is closer to an approximation than a determination.

In order to approximate the snow climate for the Summit Lake region a similar analysis was completed with data from the Summit Creek SNOTEL site.

3.2 Comparison with neighboring areas

A direct comparison was completed with data from Turnagain Pass, Mt. Alyeska, Summit Creek and the Bertha Creek snow course. Snow water equivalent was the only comparable parameter with over 20 years of records.

4. RESULTS

In order to calculate the data needed for input into the decision tree, several interesting graphs were analyzed. Illustrating two of these are Figures 2 and 3. Figure 2 displays both average temperature gradient for each month between 2005 and 2012 and the average snow depth. The December temperature gradient is the month used in the snow climate classification, though often the November temperature gradients can be the largest and most concerning for weak layer formation.

Average monthly air temperature is shown in Figure 3. Interestingly, January 2012 was the coldest month on record at this site. Not shown is the 4 month average from 1 December to 31 March which is the parameter input into the decision tree.

The snow climate approximation for Turnagain Pass can be seen in Table 1. Each year between 1984 and 2012 has been

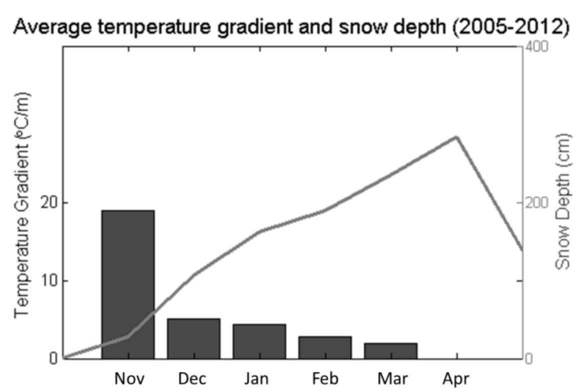

Figure 2. Turnagain Pass average monthly temperature gradient (2005 - 2012) is shown by the bars and average monthly snow depth is illustrated with the line.

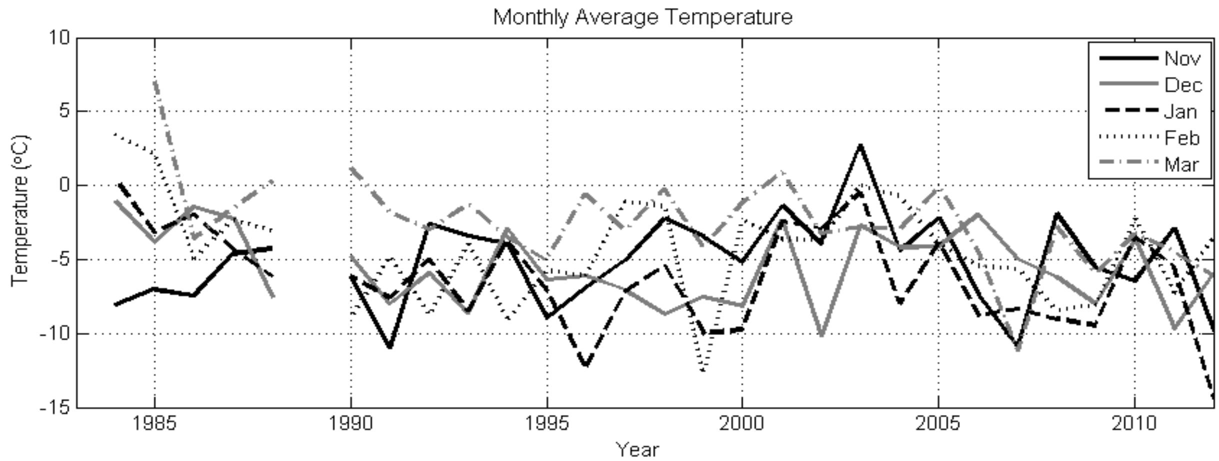

Figure 3. Turnagain Pass SNOTEL (573m, 1880ft) average monthly temperature is illustrated per year.

Table 1. Snow climate approximation per year

Turnagain Pass SNOTEL (573m - 1880ft)						
Winter Seasons	Rain> 8cm	Temperature > -3.5°C	December TG >10°C/m	SWE >100cm	Temperature < -7°C	Climate
82-83				Yes		N/A
83-84		Yes		No	No	Coastal
84-85		Yes		No	No	Coastal
85-86		Yes		No	No	Coastal
86-87		Yes		Yes	No	Coastal
87-88		No		Yes	No	Coastal
88-89				No		N/A
89-90		No		No	No	Intermountain
90-91		No		No	No	Intermountain
91-92		No		No	No	Intermountain
92-93		No		No	No	Intermountain
93-94		No		No	No	Intermountain
94-95		No		No	No	Intermountain
95-96		No		No	No	Intermountain
96-97		No		No	No	Intermountain
97-98		Yes		Yes	No	Coastal
98-99		No		No	Yes	Continental
99-00		No		Yes	No	Coastal
00-01		Yes		Yes	No	Coastal
01-02		No		Yes	No	Coastal
02-03		Yes		No	No	Coastal
03-04		No		No	No	Intermountain
04-05		Yes	No	No	No	Coastal
05-06		No	No	No	No	Intermountain
06-07		No	No	No	Yes	Continental
07-08		No	No	Yes	No	Coastal
08-09		No	No	No	Yes	Continental
09-10		Yes	No	Yes	No	Coastal
10-11		No	No	No	No	Intermountain
11-12		No	No	Yes	Yes	Coastal

Table 2. Snow climate approximation per year

Summit Creek SNOTEL (427m – 1440ft)						
Winter Seasons	Rain> 8cm	Temperature > -3.5°C	December TG >10°C/m	SWE >100cm	Temperature < -7°C	Climate
90-91		No		No	No	Intermountain
91-92		No		No	No	Intermountain
92-93		No		No	No	Intermountain
93-94		No		No	No	Intermountain
94-95		No		No	Yes	Intermountain
95-96		No		No	Yes	Intermountain
96-97		No		No	No	Intermountain
97-98		No		No	No	Intermountain
98-99		No		No	Yes	Continental
99-00		No		No	No	Intermountain
00-01		No		No	No	Intermountain
01-02		No		No	No	Intermountain
02-03		No		No	No	Intermountain
03-04		No	Yes	No	Yes	Continental
04-05		No	No	No	No	Intermountain
05-06		No	No	No	Yes	Continental
06-07		No	Yes	No	Yes	Continental
07-08		No	Yes	No	Yes	Continental
08-09		No	Yes	No	Yes	Continental
09-10		No	No	No	No	Intermountain
10-11		No	Yes	No	Yes	Continental
11-12		No	No	No	Yes	Continental

Table 3. Snow climate Summary

Total winter seasons		
Snow climate approximation	**Turnagain Pass SNOTEL (573m - 1880ft) 1984 - 2012**	**Summit Creek SNOTEL (427m - 1400ft) 1991 - 2012**
Coastal	14	0
Intermountain	11	14
Continental	3	8

categorized independently. Table 2 shows Summit Creek's categorization for the years 1991 to 2012. In Table 3 a simple comparison of each snow climate is illustrated. Turnagain Pass clearly has seasons both coastal and intermountain with three seasons continental. Alternatively, Summit Lake has seen no coastal seasons for the record period and the majority of their climate is classified intermountain.

In Figure 4, April 1 snow water equivalent at Turnagain Pass is compared with Mt. Alyeska, Summit Creek and the Bertha Creek snow course. Though the altitude of the Summit Creek SNOTEL site is similar to those of Turnagain Pass and Alyeska, it receives much less precipitation due to its interior location. This is also seen in Table 3 where no years were classified as coastal.

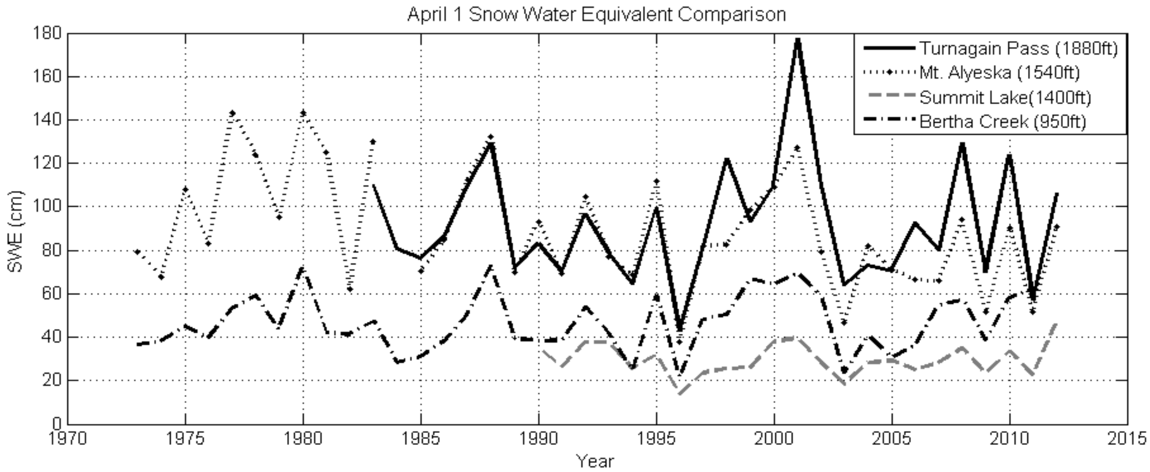

Figure 4. Turnagain Pass yearly April 1 snow water equivalent is shown for two adjacent SNOTEL sites and one snow course site (Bertha Creek).

5. DISCUSSION

Many challenges were encountered during this project. First, there is very little data available in the Turnagain Pass area to form a robust study at this point. The use of SNOTEL data, designed for seasonal hydrological purposes, is not ideal for daily analysis. Though over 30 years of quality data exist from Alyeska Resort in the Girdwood valley, the observed differences in snowpack structure and weather between Alyeska and Turnagain Pass question the use of Alyeska as a representative site.

With limited data from one source the snow climate classifications in Tables 1-3 should be seen as approximations. Average temperature and snow water equivalent are the predominant deciding factors. Rainfall can be common in winter and without that parameter the decision tree is limited.

In conclusion, the Turnagain Pass region is shown to be a mix between coastal and intermountain climates with occasional continental extremes. The results are similar to Mock’s (1996) findings for neighboring Alyeska Resort. Furthermore, these conclusions also reflect the seasonal differences seen in snowpack structure. For example, avalanche problems have varied considerably, consisting of weak layers formed around buried rain/sun crusts, buried surface hoar, rapidly stabilizing new snow instabilities and, on more rare occasions, depth hoar and deep slab instabilities. However, further study, as years pass and additional snowpack, weather and avalanche data become available, is needed in order to form more robust conclusions.

6. ACKNOWLEDGMENTS

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