INVESTIGATION OF THE WALLOWA MOUNTAINS SNOW AVALANCHE CLIMATE

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ABSTRACT: The Wallowa Avalanche Center's first year of operation (2009/10) has lead to an interest in determining and/or verifying the snow avalanche climate of the Wallowa Mountain Range. Until recently there has been no formal avalanche hazard dissemination for the general public within the Wallowa Mountains of northeast Oregon. Additionally, there has been no routine daily meteorological or avalanche related recordkeeping within this mountainous region to the best of the authors' knowledge. In fact, no commercial ski resorts or highway snow safety study plots exist in this area to broaden the database. The supporting data analyzed incorporates a combination of SNOTEL stations, commercial outfitter and guide records, Remote Automated Weather Station (RAWS) and National Weather Service (NWS) records. Qualitative and quantitative data was collected from these sources over the previous 15 years. The analysis compares similarly acquired datasets from the Wasatch Range for consistency. The use of existing methodology and snow avalanche classification schemes places this region in the Intermountain climate. However, this investigation suggests the snow avalanche climate is a combination of Intermountain and Coastal/Continental.

1. INTRODUCTION

The Wallowa Avalanche Center's (WAC) first year of operation (2009/2010) has lead to an interest in determining and/or verifying the snow avalanche climate of the Wallowa Mountain Range. This is the first time sufficiently accurate qualitative and quantitative data could be gathered and processed for an investigation into the snow avalanche climate of the Wallowa Mountain Range of northeast Oregon.

The Wallowa Mountain Range is approximately 25 miles wide by 50 miles long, including the Eagle Cap Wilderness, a non-motorized, undeveloped, natural area established in 1940. Congress placed this area into the National Wilderness Preservation System in 1964.This wilderness zone encompasses 350,000 acres or about 1400 square kilometers. Elevations range from 4000 feet to just shy of 10000 feet. Nearly all human-powered backcountry avalanche terrain winter recreation takes place within the wilderness bounds and all motorized winter recreation with some avalanche hazard takes place in the National Forest abutting the wilderness area. All of the data recorded for this study was retrieved within the bounds of the Wallowa-Whitman National Forest.

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There have been numerous studies on snow avalanche climates (Roch 1949; LaChapelle 1966; Armstrong and Armstrong 1987; Mock and Birkeland 2000; Hägeli and McClung 2003) and so the currently recognized climatic regions in the U.S. are classified as Coastal, Intermountain/Transitional and Continental. In a very basic sense the coastal climate generally has warm temperatures, some winter rainfall on snow and relatively deep snowpacks. The continental climate has cold temperatures, no rainfall on snow and thin snowpacks. The intermountain climate falls between these two. Comparisons of data sets between the Wallowas and Wasatch (where the authors' experience lies) help to corroborate the regional classifications. This paper attempts to further refine the snow-avalanche climate of the Wallowa Mountains.

2. DATA COLLECTION

Atmospheric and snowpack data for the Wallowas was collected through a variety of sources including SNOTEL stations, guiding operations and other manual observations. When possible, fifteen years of data was used; however many of the SNOTEL stations could only provide snow depth from the year 1998 (or later) forward. In addition to automatic recording stations, rather complete qualitative yearly weather summaries were kept by a local backcountry guiding service from the winter season 1996/1997 to the present. Lastly, during

the winter season of 2009/2010, detailed standard weather, avalanche and snowpack observation records were kept of the Wallowa Mountain Range by WAC.

2.1 Qualitative Data

Primary qualitative data was extracted from detailed written summaries compiled by the manager of Wing Ridge Ski Tours, Joseph, OR for the winter seasons of 1996/1997 through 2009/2010. These summaries were comprised of weather happenings each month along with general avalanche activity. More often than not these summaries highlight hazard levels or snow stability concerns encountered as guides and guests returned from the backcountry. The data is representative of only a small portion of the entire range where winter recreation takes place. Wing Ridge Ski Tours operates on and around Wing Ridge of the Wallowas, where typically the vast majority of recreationists not affiliated with the guiding service enjoy the backcountry, because of the easy access by automobile to the 6100' elevation trailhead and a short 1.5 mile approach to reach avalanche terrain.

2.2 Quantitative Data

Primary quantitative data was acquired from 3 representative SNOTEL stations in both the Wallowas and Wasatch regions. Two stations from each region were from higher elevation locations and one station each was lower in elevation. In the case of the Wallowas, one station was purposely chosen as a representative of the southern reaches of the region where it is known a higher snowfall occurs. This was done to provide the best average possible with consideration given to temperature, snowfall and regional variations. Occasional comparisons with RAWS stations and NWS records provided confirmation when inconsistent or erroneous data appeared. To assist in quality control, ancillary study plot data was acquired from infrequent monitoring of sites adjacent to two professional USFS permitted backcountry-guiding base camps at elevations around 7500'.

Wallowa SNOTELs
Mt. Howard (station 653): Elev. 7910'
Aneroid #2 (station 302): Elev. 7400'
Schneider Meadows (station 736): Elev. 5400'

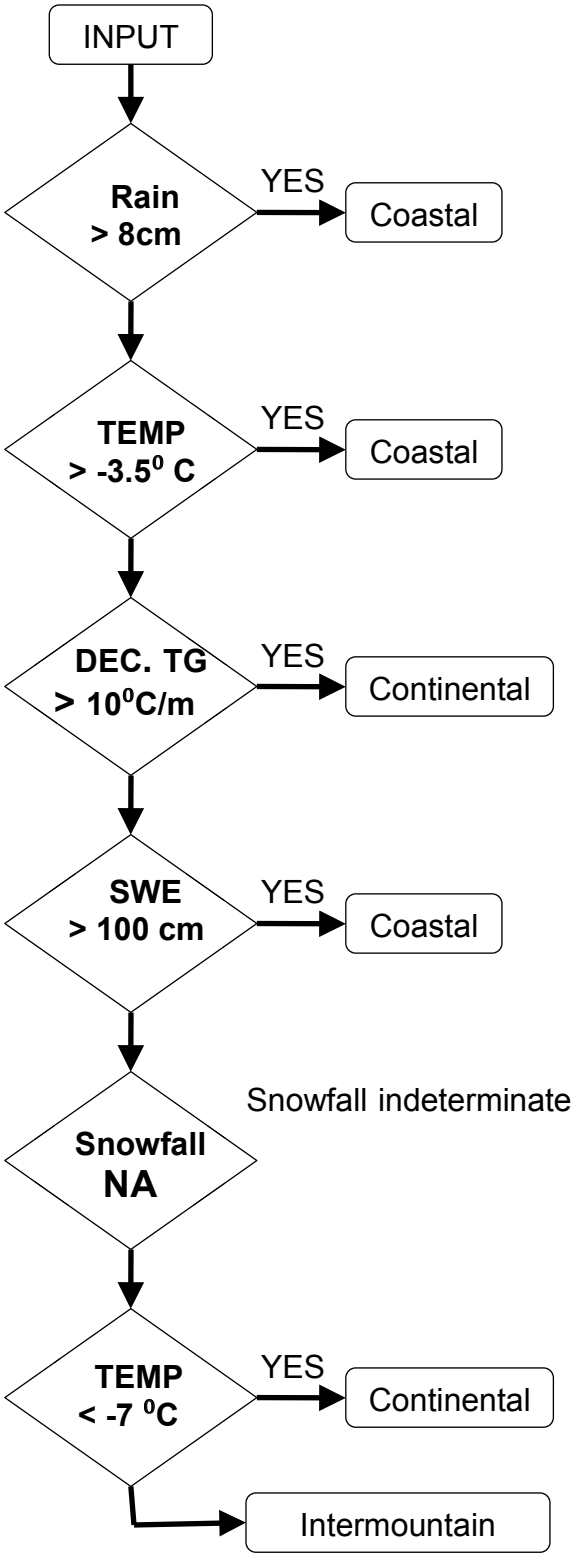


Figure 1 METHOD. Flowchart for seasonal snow climate classification (after Mock and Birkeland, 2000).

Wasatch SNOTELs
Snowbird (station 766): Elev. 9640'
Brighton (station 366): Elev. 8750'
Parleys (station 684): Elev. 7500'

3. METHODOLOGY

Two procedures were developed to process the data. These procedures were independent of one another but both used a flow chart decision tree developed by Mock and Birkeland in their 2000 paper, —Snow Avalanche Climatology of the Western United States Mountain Ranges" (Figure 1). The decision tree requires 5 major questions be answered to determine the snow-avalanche climate of a particular region: seasonal rain total, average air temperature, December average Temperature Gradient (TG), Snow Water Equivalent (SWE) and Snowfall (hereinafter referred to as the METHOD).

3.1 Procedure A

Using the qualitative data first, without bias from quantitative data results, the yearly winter summaries were studied and interpreted to make a -best guess" as to each season's atmospheric and snowpack properties. These properties were then inputted into the flow chart to develop a table to categorize the values. This procedure required a measure of judgment on the part of the analyzer.

3.2 Procedure B

Next, numerical processing was employed to generate hard numbers for atmospheric and snowpack properties. For each season and each SNOTEL site, raw data was filtered and processed between 1 December through 31 March. This is consistent with the procedure called for in the METHOD. Values for rain, temperature, SWE, and TG were averaged for each site and all years then inputted to the METHOD. Neither rain nor snowfall could be obtained to a sufficiently accurate degree (SNOTEL numerical analysis); therefore rain and snowfall were considered indeterminate and not included in the flow chart analysis.

4. RESULTS

Table 1 displays the qualitative results culminating in 2 coastal years, 7 intermountain years and 5 continental years. Table 2 shows the quantitative results. For Table 2, values only exist for average air temperature, December TG and SWE. Though rain and snowfall have been omitted, classifications resulted in 2 coastal years, 9 intermountain years and 3 continental years. Average air temperature, SWE and December TG for both the Wallowas and the Wasatch Range are shown in Figures 2, 3 and 4.

Table 1 Written Summaries

		WALLOWA	MOUNTAINS	SEASONAL	DATA	14 YEARS	
Winter Seasons	Rain> 8cm	Temperature > -3.5°c	December TG >10°c/M	SWE >100cm	Snowfall >560cm	Temperature < -7°c	Climate Cstl/Cont/I
96-97	yes	yes	no	yes	yes	no	Cstl
97-98	no	no	yes	no	no	no	Cont
98-99	no	yes	no	yes	yes	no	Cstl
99-00	no	no	yes	no	no	no	Cont
00-01	no	no	yes	no	no	no	Cont
01-02	no	no	no	no	no	no	I
02-03	no	no	yes	no	yes	no	Cont
03-04	no	no	no	no	yes	no	I
04-05	no	no	no	yes	yes	no	I
05-06	no	no	no	yes	yes	no	I
06-07	no	no	no	no	no	no	I
07-08	no	no	no	no	yes	no	I
08-09	no	no	no	no	yes	no	I
09-10	no	no	yes	no	no	no	Cont

Table 2 Numerical Data

	WALLOWA	MOUNTAINS	SEASONAL	DATA	14 YEARS		
Winter Seasons	Rain> 8cm	Temperature > -3.5°c	December TG >10°c/M	SWE >100cm	Snowfall >560cm	Temperature < -7°c	Climate Cstl/Cont/I
96-97	NA	no	NA	no*	NA	no	I*
97-98	NA	no	NA	no	NA	no	I
98-99	NA	no	NA	no*	NA	no	I*
99-00	NA	no	NA	no	NA	no	I
00-01	NA	no	no*	no	NA	no	I*
01-02	NA	no	no	no	NA	no	I
02-03	NA	no	no*	no	NA	no	I*
03-04	NA	no	no	no	NA	no	I
04-05	NA	yes	yes*	no	NA	no	Cstl*
05-06	NA	no	no	no	NA	no	I
06-07	NA	yes	no	no	NA	no	Cstl
07-08	NA	no	yes	no	NA	no	Cont
08-09	NA	no	yes	no	NA	no	Cont
09-10	NA	no	yes	no	NA	no	Cont

- * denotes number close to threshold. NA = Not Available

Figure 2 Comparisons: Average air temperature

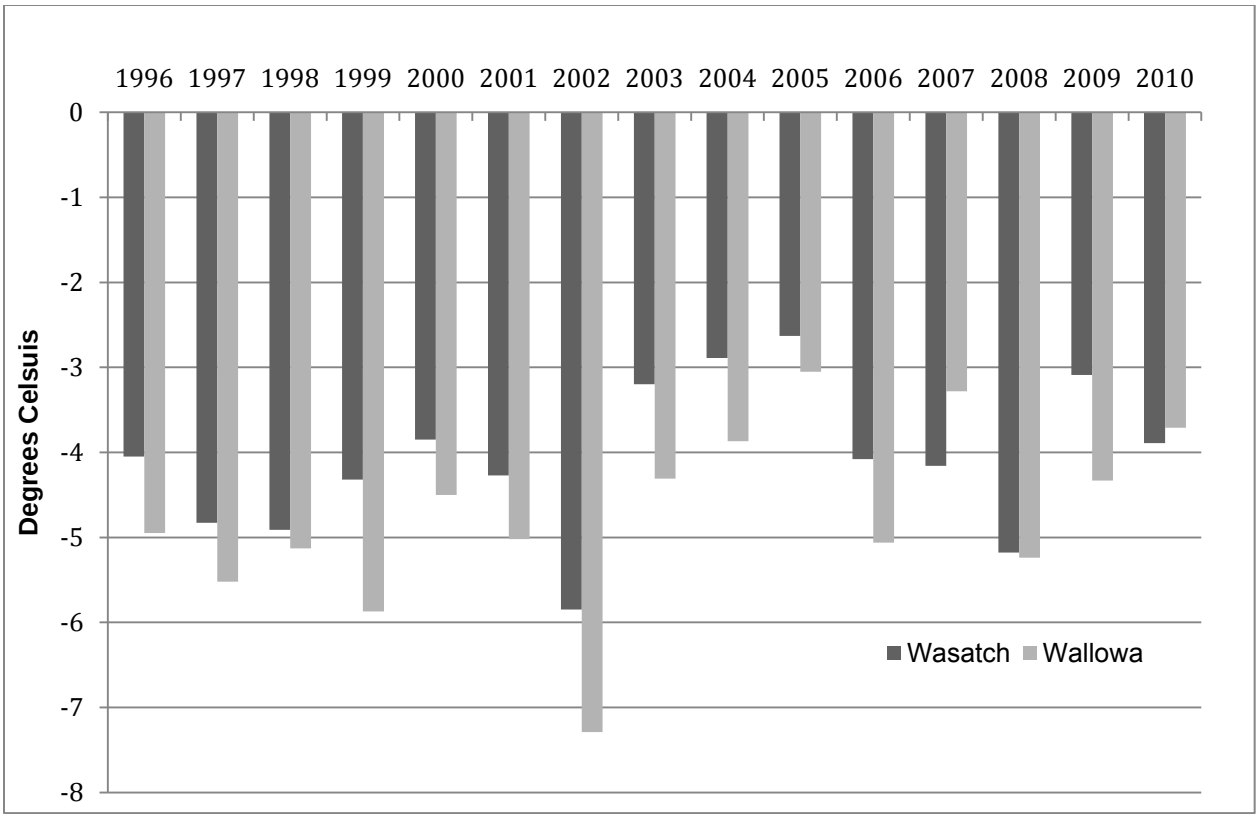


Figure 3 Comparisons: SWE

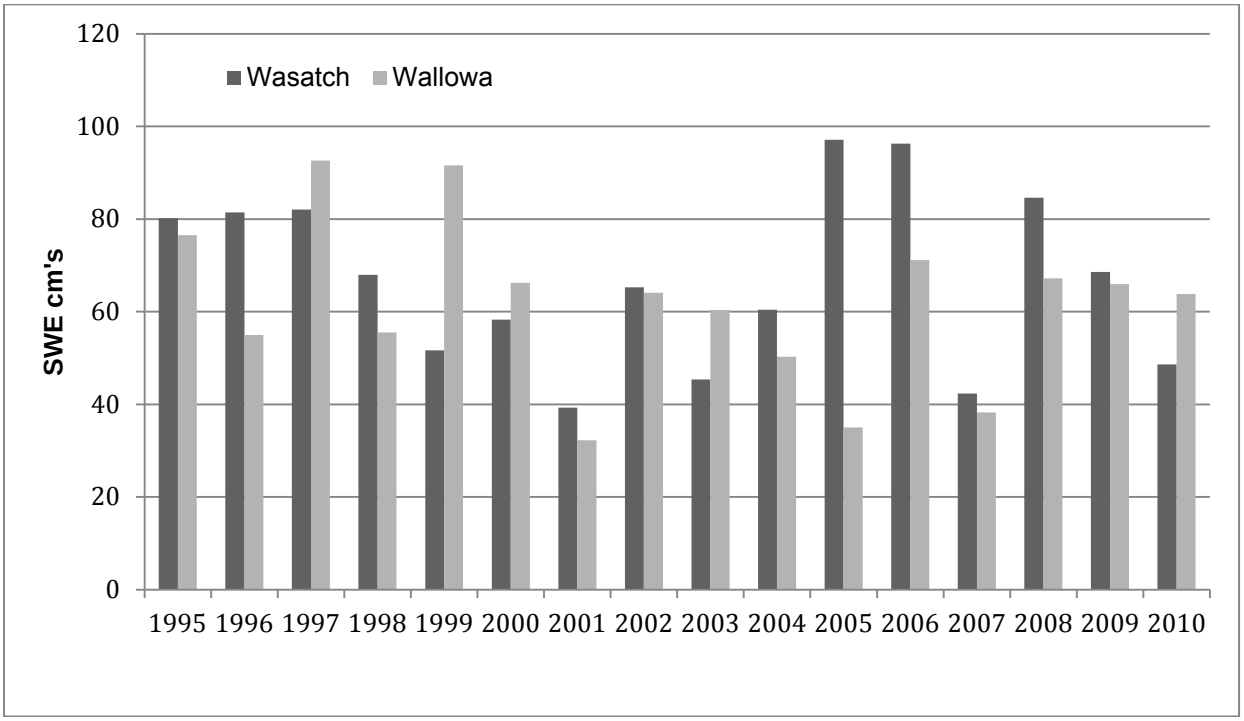
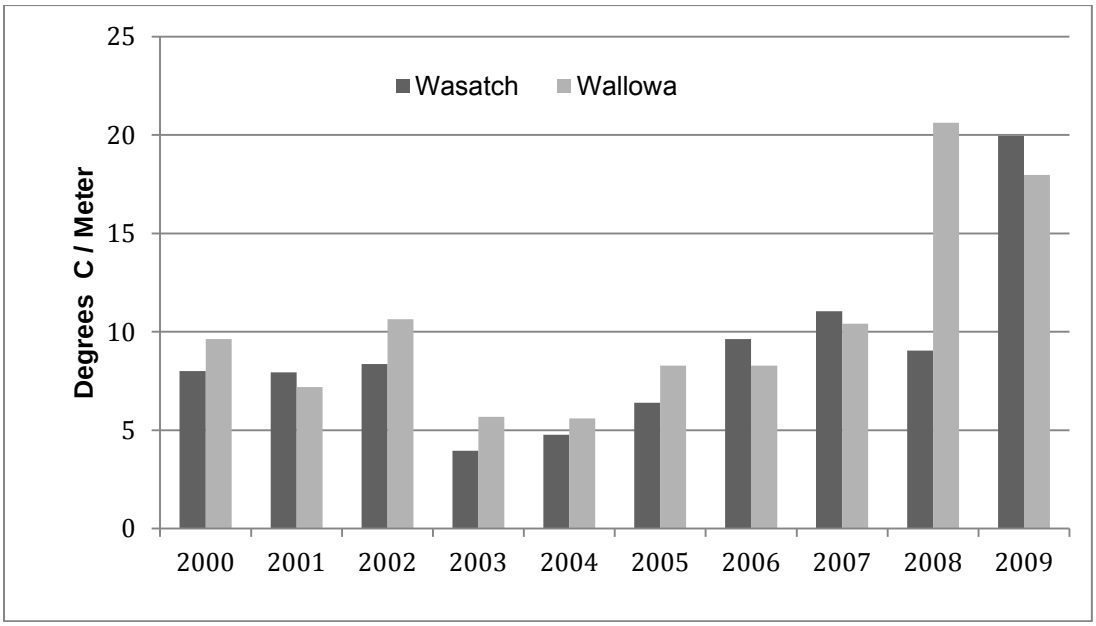


Figure 4 Comparisons: December average temperature gradient



5. DISCUSSION AND CONCLUSION

The two procedures relate fairly well. In comparing Table 1 and Table 2 results, the data of Table 2 for the asterisk items are very close to the threshold for the categories in Table 1. This could cause each table results to match even closer. The one exception is 2004/2005 where an unusual year provided a December high TG but with a very warm average temperature. This

leads to the question whether the SNOTEL stations used for the numerical data, when comparing to the weather summaries, truly reflect conditions at avalanche starting zones.

The predominate deciding factor from the decision tree was average temperature during the period and this determined the intermountain and coastal categories. Of note: the primary factor determining a Continental climate was whether or not there existed a December TG greater than 10 degrees C per meter. Generally the outlier years matched what was experienced during frequent travelling in the backcountry.

In comparing the Wallowas to the Wasatch, average temperatures are warmer in the Wasatch than the Wallowas; however, the total SWE within the period is very close between the regions. The Wasatch is known to be intermountain and hence the average colder temperatures of the Wallowas may hint at a slightly continental shift rather than a coastal.

Additionally, the most observed weather pattern associated with wintertime precipitation in the Wallowas consists of prefrontal southwesterly flow events. Experiential evidence along with the SNOTEL data suggests snow totals on the southern end of the range may be close to double that on the northern. This would suggest a possible coastal climate shift in the southern Wallowas and a continental shift for the Northern.

Further study incorporating expanded data from the Payette National Forest or from mountainous regions within northeast Oregon, but outside of the Wallowa Mountains, may help generate a more accurate model of the snow avalanche climate regionally. At the very least this could aid in a comparative analysis. Particularly, inclusion of avalanche characteristics would be a necessary next step in a future study of the Wallowa Mountains snow avalanche climate.

The Wallowas are predominately intermountain with coastal and continental extremes. The Wallowas can potentially have many types of avalanche hazards due to the reasonable probability of occurrence of the 3 climatic snowpacks. These climate zones are but human conceptions and the question remains as to how these categories assist in avalanche forecasting. Forecasters must be mindful of the variations occurring in the Wallowas and to recognize how these variations could lead to difficulty in seasonal forecasting norms.

6. ACKNOWLEDGMENTS

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