EFFECTS OF El Niño AND La Niña ON SNOW AVALANCHE PATTERNS

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ABSTRACT: El Niño and La Niña affect global climate and atmospheric circulation to determine winter temperature and precipitation patterns. Both the winter temperatures and the associated precipitation patterns have effects on mountain snow deposition and snow avalanche occurrences. In this paper, approximately 25,000 slab avalanches collected over 30 winters are analyzed with respect to their relation to snowfall patterns contrasted for El Niño and La Niña winters for two avalanche areas in two different snow climates in British Columbia (B.C.), Canada. La Niña winters are shown to produce more snow, more avalanches and a higher percentage of dry avalanches compared to wet avalanches. For the data analyzed, it is suggested that the results depend on the altitude and snow climate. Analysis of snowfall data from the Andes of Chile suggests the opposite behavior to British Columbia. El Niño winters in central Chile produce the most snow and, by inference, the most avalanches.

1. INTRODUCTION

In this paper, the amount of snow received and the character of avalanching are contrasted for El Niño and La Niña winters for two avalanche areas in British Columbia (Bear Pass: 18985 avalanches; maritime snow climate and Kootenay Pass: 5575 avalanches; transitional snow climate) from 1981 -2011 (30 winters). Total amounts of snow received, number of slab avalanches recorded stratified by avalanche size, water content (dry or wet) are considered for each snow climate. The definition of El Niño and La Niña winters is similar to that by Redmond (2005) based on analysis of sea surface temperatures : SST (relative to the long term mean, NOAA, 2011) off the west coast of South America for each of the last six months of each year averaged to give a single index for each year: positive in El Niño years and negative in La Niña years.

2. RESULTS FROM BRITISH COLUMBIA

The results are believed to be the first comprehensive study contrasting the effects of El Niño and La Niña winters on snow avalanche activity. Fitzharris (1981) made an extensive study of the frequency and climatology of major avalanches at Rogers Pass, B.C. but the effects of La Niña/El Niño were not considered. The results here show more snow, more avalanches and a higher percentage of avalanches being dry for La Niña winters.

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The avalanche data analyzed are for slab avalanches of sizes ≥ 2 on the Canadian size scale. Avalanches of size 1 are excluded since they consist mostly of small sloughs which are usually not harmful and are not considered in planning. Also, many of size 1 are small and likely not to be recorded in highways operations since they often may not reach highway level and lack of visibility may prevent accurate recording. The effect of avalanche size is best shown from the data at Bear Pass which indicate correlation of maximum annual snow depth and total large dry avalanches (≥ size 3) is negligible.

The results show that altitude and snow climate affect both the temperature regime and the amount of snow which control the pattern of avalanching. In British Columbia, more snow arrives during La Niña winters (Moore and McKendry, 1996; Stahl et al., 2006) and this is linked to the higher numbers of avalanches. Warmer temperatures during El Niño years affect the mix of water content with a higher percentage of wet and moist avalanches compared to La Niña years. For El Niño, the temperature effects are more evident for the lower altitude, maritime location (Bear Pass) than the higher altitude interior location (Kootenay Pass). From the perspective of global climate change, the results suggest that both mountain snowfall amounts and winter temperatures must be predicted a long time in the future to specify the pattern of snow avalanching.

3. RESULTS FROM CENTRAL CHILE

Analysis of snow data from high mountain stations in north central Chile suggest the

opposite behavior to British Columbia. In that sector of Chile, El Niño winters deliver the most snow correlated with positive values of the SST index. In addition, even though there are no comprehensive avalanche records, compilation of data from avalanche accidents in Chile shows that the fatal accidents are strongly concentrated in El Niño winters.

These results are opposite those observed for British Columbia which is characterized by high snow amounts in La Niña years and negative correlation with the SST index. For the largest value of the SST index (+ 2.2, 1997), the third highest snow total was measured at El Indio (7.0 m) and the largest storm total (7.2 m) was measured at Minera Los Pelambres (both in central Chile). By contrast, for 1997– 1998, Bear Pass had the lowest total number of avalanches for the 30 years of record. The corresponding prediction for this sector of the central Chilean Andes would be close to the opposite: a relatively high number of avalanches for 1997. Such is likely since snow supply is a primary determiner of avalanche frequency (Smith and McClung, 1997; McClung, 2003).

4. DISCUSSION

El Niño and La Niña winters are predictable in advance. The results here suggest that the general character of a winter on snow avalanche activity can also be predicted which may facilitate planning. In B.C., La Niña brings more and colder snow which is good for tourism since better skiing is likely. However, there should also be an increase in the total number of avalanches and percentage of dry ones. Dry avalanches are the major concern for the industries since they generate the highest impact forces, run the furthest (McClung and Schaerer, 2006) and kill the most people (Canadian Avalanche Association ,2011). In central Chile, El Niño brings the snow and likely the avalanches which are of concern for transportation routes, mining and tourism (León, 1976). The link to climate is also of interest for the study of glaciers since snow avalanching is an important contribution to mass balance for glaciers (Benn and Evans ,1998), whose accumulation zones are bordered by steep terrain.

The results showing lack of correlation for avalanches of size ≥3 must be used carefully. Size 2 avalanches are important for backcountry safety considerations since they account for a significant number of avalanche fatalities (Canadian Avalanche Association, 2011). Size 2 avalanches can also block highway and railway lines. For land-use planning such as for occupied buildings where return periods of avalanches are on the order of hundreds of years, the results suggest El Niño / La Niña effects are not significant.

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