P3.29 CLIMATOLOGY OF THE SIERRA NEVADA MOUNTAIN-WAVE CLOUDS

Vanda Grubišić*
Desert Research Institute, Reno, Nevada
and
Stephanie Cardon
Bringham Young University, Provo, Utah

1. INTRODUCTION

There are several geographical locations in the U.S. downwind of mountain ranges that are well known for the frequent occurrence of strong mountain waves. While the most thoroughly documented among them is the Colorado Front Range with its famous severe downslope windstorms (e.g., Lilly and Zipser 1972; Clark et al. 2000), the Sierra Nevada in California (Fig. 1) is equally known among scientists as well as amateur and professional pilots as a generator of large-amplitude lee waves, rotors, strong updrafts and clear-air turbulence (Holmboe and Klieforth 1957; Kuettner 1959; Whelan 2000).

The Sierra Nevada is an approximately 100 km wide and 600 km long quasi-two dimensional mountain range that forms part of the western rim of the Great Basin. Several factors, including the gentle upwind and steep lee-side slopes and absence of significant topography upwind, make the Sierra Nevada an excellent mountain wave generator. The proximity of the Pacific Ocean provides the source of upper-level moisture that gives rise to clouds atop mountain wave crests.

2. DATA AND METHODOLOGY

The 1-km GOES-10 visible satellite images from several recent cold weather seasons (October-May), obtained from the Naval Research Laboratory (NRL) and archived at DRI, were analyzed for wave-cloud signatures downwind of the Sierra Nevada. Individual images, available at 30 minute intervals during the daylight hours, were visually examined for signatures of mountain-wave clouds. In this paper, we show results obtained for the winter seasons of 1999/2000 and 2000/2001.

* *Corresponding author's address:* Dr. Vanda Grubišić, Desert Research Institute, Division of Atmospheric Sciences, 2215 Raggio Pkwy, Reno, NV 89512–1095; e-mail: grubisic@dri.edu

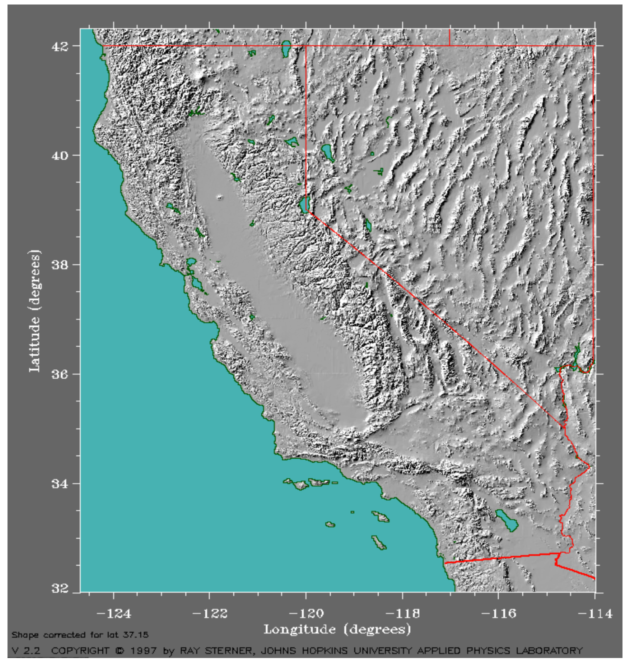

Figure 1: Landform map of California and Nevada. The map source at http://fermi.jhuapl.edu/states/.

3. RESULTS

Our analysis yielded two broad wave-cloud categories: trapped lee waves and single large waves, both of which are illustrated in Fig. 2. In addition to the wave type, we have determined the locus (north, middle, south or the entire Sierra), the beginning time and duration of wave cloud episodes, and in the case of trapped lee waves, the wavelength. These preliminary results show a bimodal frequency distribution in which November and April are the months with the highest frequency of wave-cloud occurrence. In April, on average, a wave event occurs somewhere along the Sierra every 3.5 days. The majority of cloud-wave events are trapped lee waves, which were found to occur twice as often as large single waves. Trapped-lee waves are also more fre-

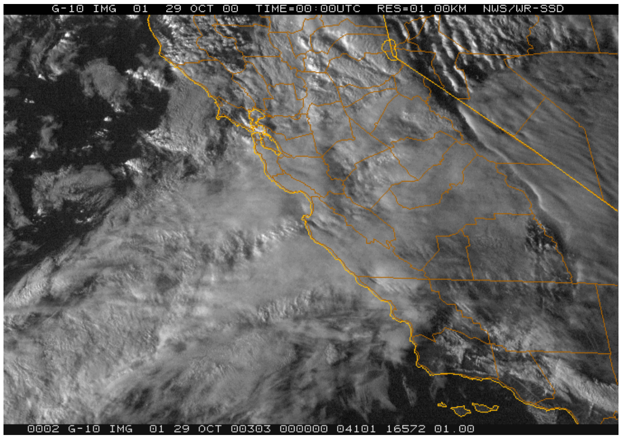

Figure 2: GOES-10 visible satellite image from OO UTC 29 October 2000. Horizontal resolution of the image is 1 km. Trapped lee waves are visible downwind of the Lake Tahoe in the northern portion of the Sierra, together with an uninterrupted single wave cloud downwind of the central and southern portion of the Sierra Nevada.

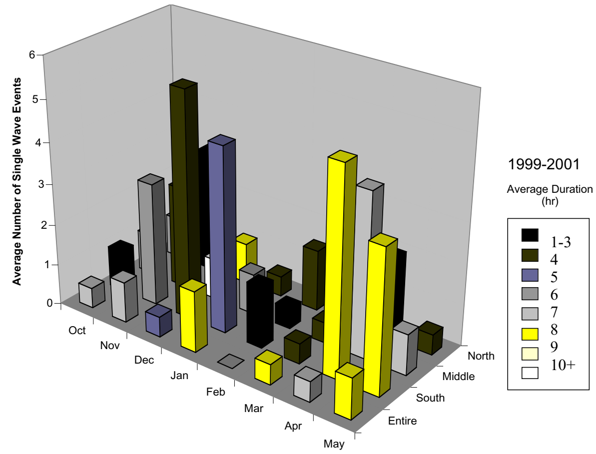

Figure 3: Frequency of single large wave-cloud occurrence in the lee of the Sierra Nevada from October to May for two recent cold seasons of 1999/2000 and 2000/2001. The grey shading of columns denotes the average duration (in hours) of recoreded wave events in the northern, middle, and the southern part of the Sierra Nevada. The fourth category, with the smallest frequency of occurrence, is comprised of single wave clouds extending downwind of the entire range.

quently observed in the northern part of the Sierra, whereas single large wave clouds are found to occur more frequently in the southern Sierra. The histogram of single wave-cloud occurrence (Fig. 3) indicates that the average duration of these wave-cloud events in April was significantly longer than those in November.

4. FUTURE DIRECTIONS

We plan to continue our analysis to include several more years in the wave-cloud satellite climatology. The final results should yield information on the spatial and temporal (from diurnal to monthly) variability of mountain-wave clouds in the lee of the Sierra Nevada, and extend our current knowledge of the Sierra Nevada mountain waves based largely on the summary of the 1950s Sierra Wave experiment (Holmboe and Klieforth 1957). This information should be helpful in determining the optimal timing of any future field study of waves and turbulent rotors in the lee of the Sierra Nevada.

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