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VIRGINIA PEAK WSR-88D DETECTS LEE-WAVE TURBULENCE OVER WESTERN NEVADA

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Introduction

The development of lee-side waves is among the myriad of ways in which mountains can affect local airflow. Spectacular wave conditions develop regularly on the lee of the Sierra Nevada's Carson Range (Fig. 1) during periods of strong westerly flow aloft. Soaring pilots in the Reno/Carson City area often take advantage of these conditions to achieve diamond altitude flights (16,404 ft above the release point of the glider). The Virginia Peak WSR-88D has detected a pattern of elevated base spectrum width and velocity values in a line parallel and downwind from the Carson Range (Fig. 2) during many periods of strong westerly flow over the Sierra Nevada. These patterns have occurred with the radar operating in both VCPs 21 and 32. Some forecasters at NWSFO Reno have speculated that these values represent lee-side wave conditions. Accordingly, a correlation has been found between these patterns and the development of standing-lenticular clouds. This Technical Attachment gives a brief overview of one such case which occurred on the lee of the Carson Range on March 4, 1995.

Requirements for Wave Formation

Certain conditions are considered essential for the development of lee waves (Figs. 3c and d). Ideally, flow perpendicular to the mountain ridge line is considered optimum. However, lee waves will form if deep flow exists within 30° from that perpendicular to the ridge line. Stable lower atmospheric conditions are preferred, either in the form of an inversion or isothermal layer aloft (particularly near the ridge line). Wind speeds should increase or remain constant with height with winds speeds at mountain top level greater than 15 to 25 kts (Nicholls 1973). Typically, these conditions are met when a jet stream is located over or just north of the area (Gard and Neyland 1992).

Synoptic Overview

Soaring conditions were ideal given that lee wave formation was virtually imminent on this day. The ETA initial analyses for 1200 UTC 4 March 1995 at 700 mb, 500 mb, and 300 mb had west to northwest flow nearly perpendicular to the Carson Range ridge line ahead of a developing 500 mb trough (Figs. 4a-d). Jet maxima are apparent at both 500 mb and 300 mb approaching the West Coast near the California/Oregon border.

The REV raob (Reno) wind profile also appeared highly favorable with steadily increasing wind speeds with height and little directional shear (Fig. 5). A surface inversion was present to about 6,000 ft AGL with a stable layer aloft between 8,000-12,000 ft AGL. Model forecasts had the 500 mb trough digging southward with the jet maxima moving into far northern Nevada and increased westerly flow over the Sierra (not shown).

Discussion

Conventional forecast procedures verified that favorable conditions existed for lee wave and/or rotor formation. The fact that several diamond altitude flights took place on this day further verifies the forecast (Doug Armstrong, personal communication). Increased base spectrum width and velocity values have been observed on the lee of the Carson Range on several occasions during periods of lee wave formation by NWSFO Reno forecasters. Subsequently, a correlation has been drawn between the sets of phenomena.

Two of the things that high base spectrum width values are indicative of are turbulence and wind shear. At 1835 UTC, a narrow north-south oriented line of high base spectrum width values is present at the 0.5° elevation angle slice (Fig. 2a) with the corresponding velocity pattern showing inbound velocities (Fig. 2c). At the 1.5° elevation angle slice, these signatures almost disappear (Figs. 2b and d). The line of higher spectrum width values (12-20 kts) and velocities is nearly parallel to the orientation of the Carson Range (Fig. 1). Radar calculated elevations at 0.5° along the line range from about 9,500 ft MSL at the northern periphery to 11,000 ft MSL at the southern periphery. At 1.5°, these values increase to approximately 11,000 ft MSL and 14,500 ft MSL. These elevations correspond roughly to where wave activity would occur on the lee of a mountain range based on Corby's schematic diagram (Fig. 3). Additionally, standing lenticular clouds formed and were observed later that day (Fig. 6) as mid and high level moisture increased over the area (after a clear morning).

Given the position of the narrow line of increased base spectrum width values and recurrence of this pattern during periods of lee wave formation, it's reasonable to conclude that the pattern is indicative of lee waves. The environmental flow is almost perpendicular to the radar beam at this location making the elevated base spectrum width and velocity values even more remarkable. Although it's unlikely that the Virginia Peak WSR-88D will be able to serve as a forecast tool for lee wave formation, the use of base spectrum width and velocity values is useful for soaring briefing and forecast verification purposes.

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References

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Nicholls, J.M., 1973: The Airflow over Mountains, Research 1958-1972. WMO Technical Note No. 127, Geneva, WMO.

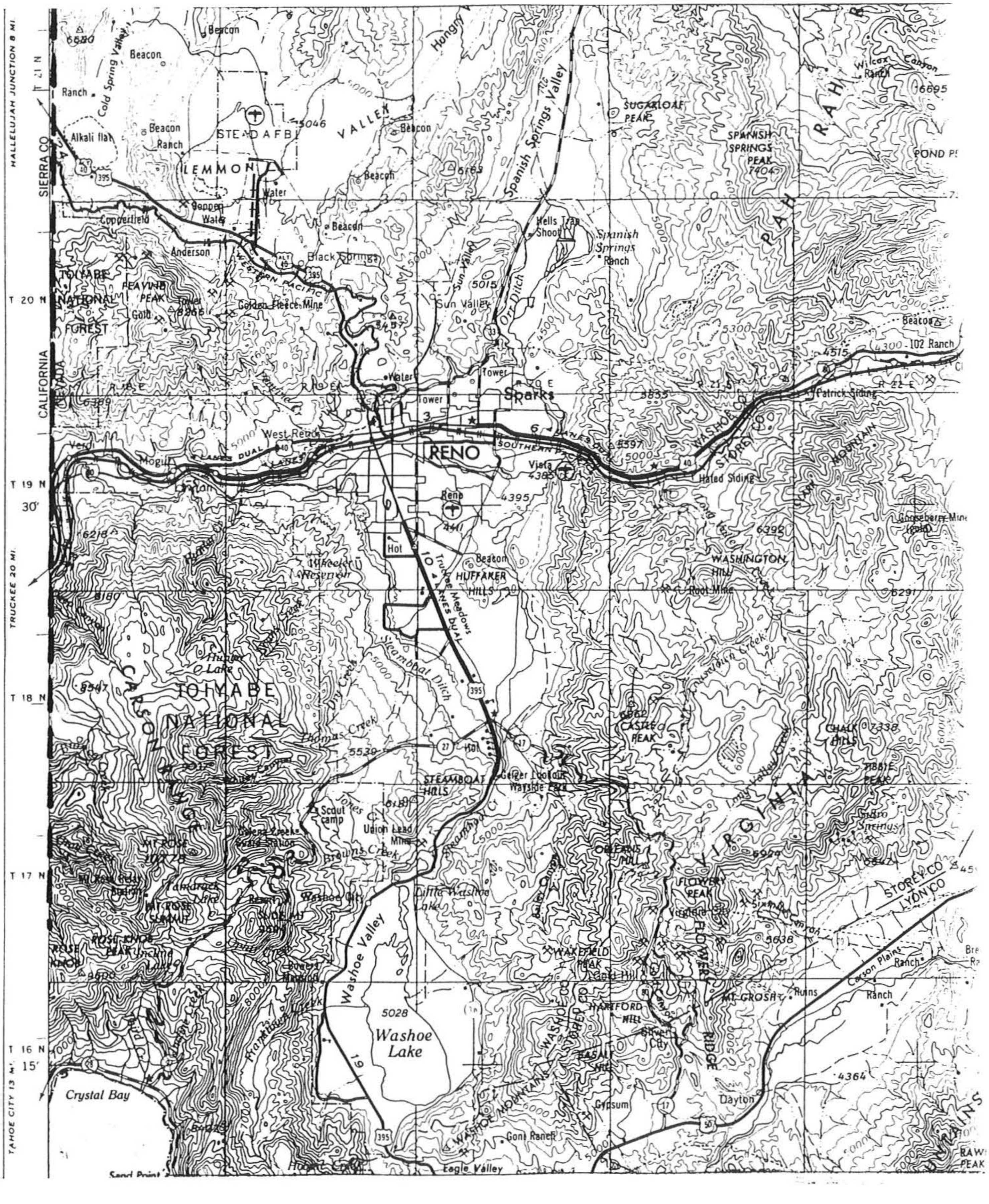

Fig. 1 Topographical map of the Carson Range and Reno/Sparks area

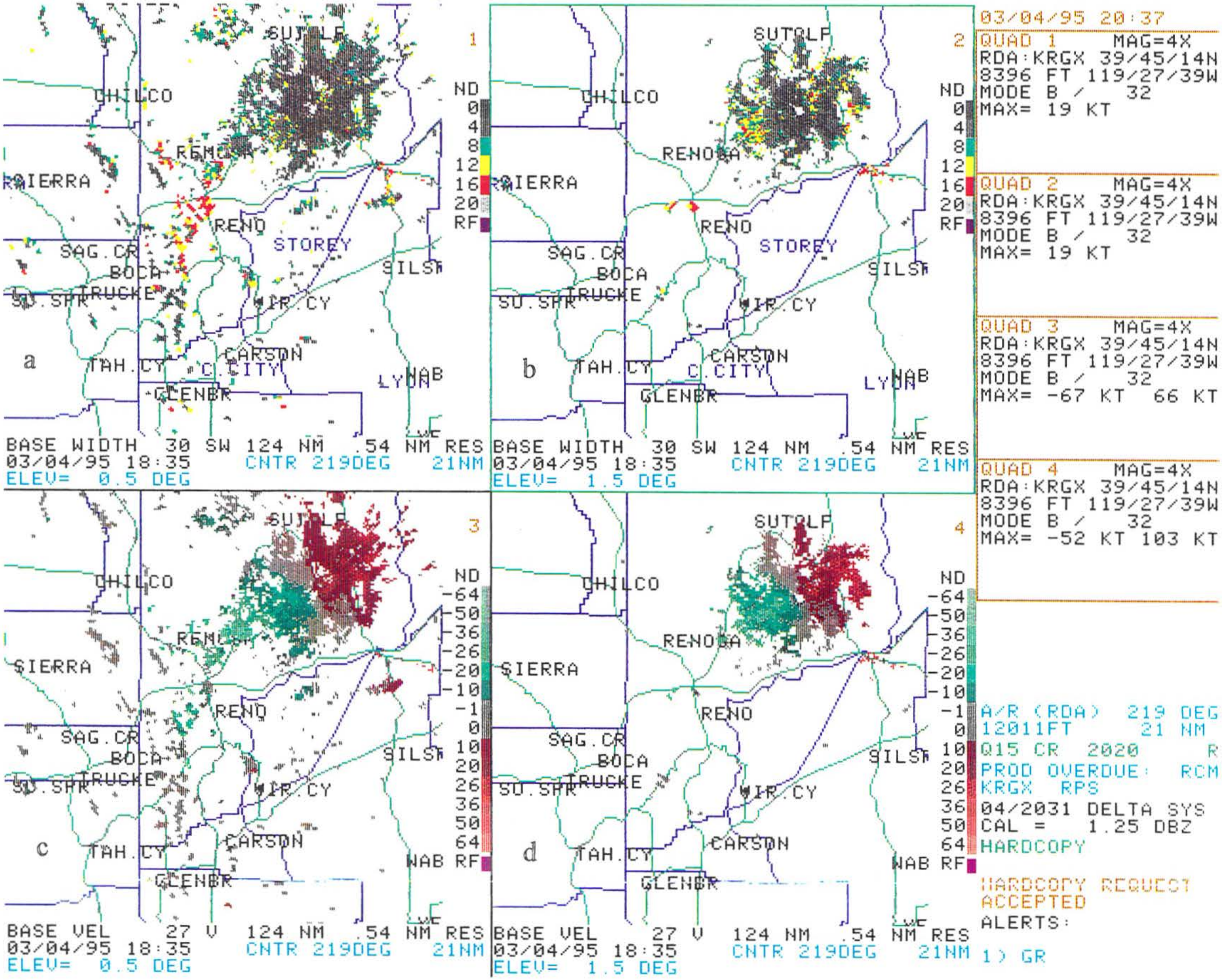

Fig. 2 KRGX WSR-88D Base Spectrum Width and Velocity data at 1835 UTC

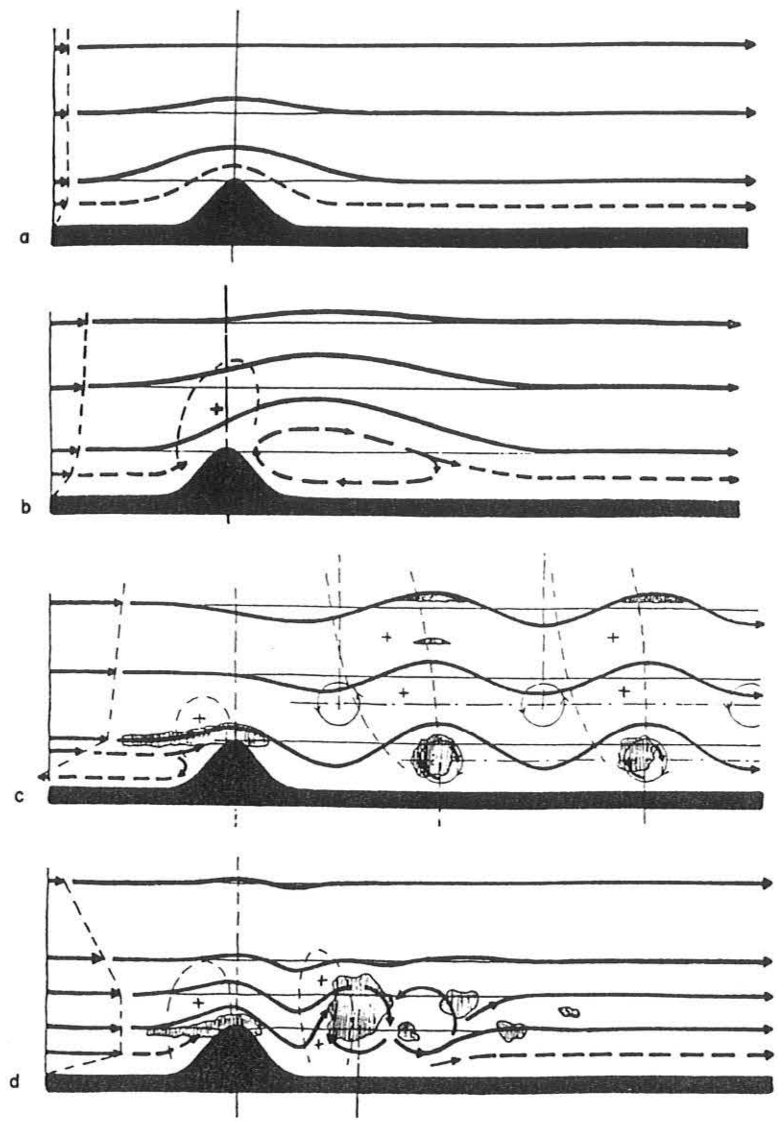

Fig. 3 Types of airflow over a mountain barrier in relation to the vertical profile of wind speed. Represented are (a) laminar streaming; (b) Standing eddy streaming; (c) Wave streaming, with a crest cloud and downwind rotor clouds; (d) Rotor streaming.

Source: From Barry 1992, after Corby

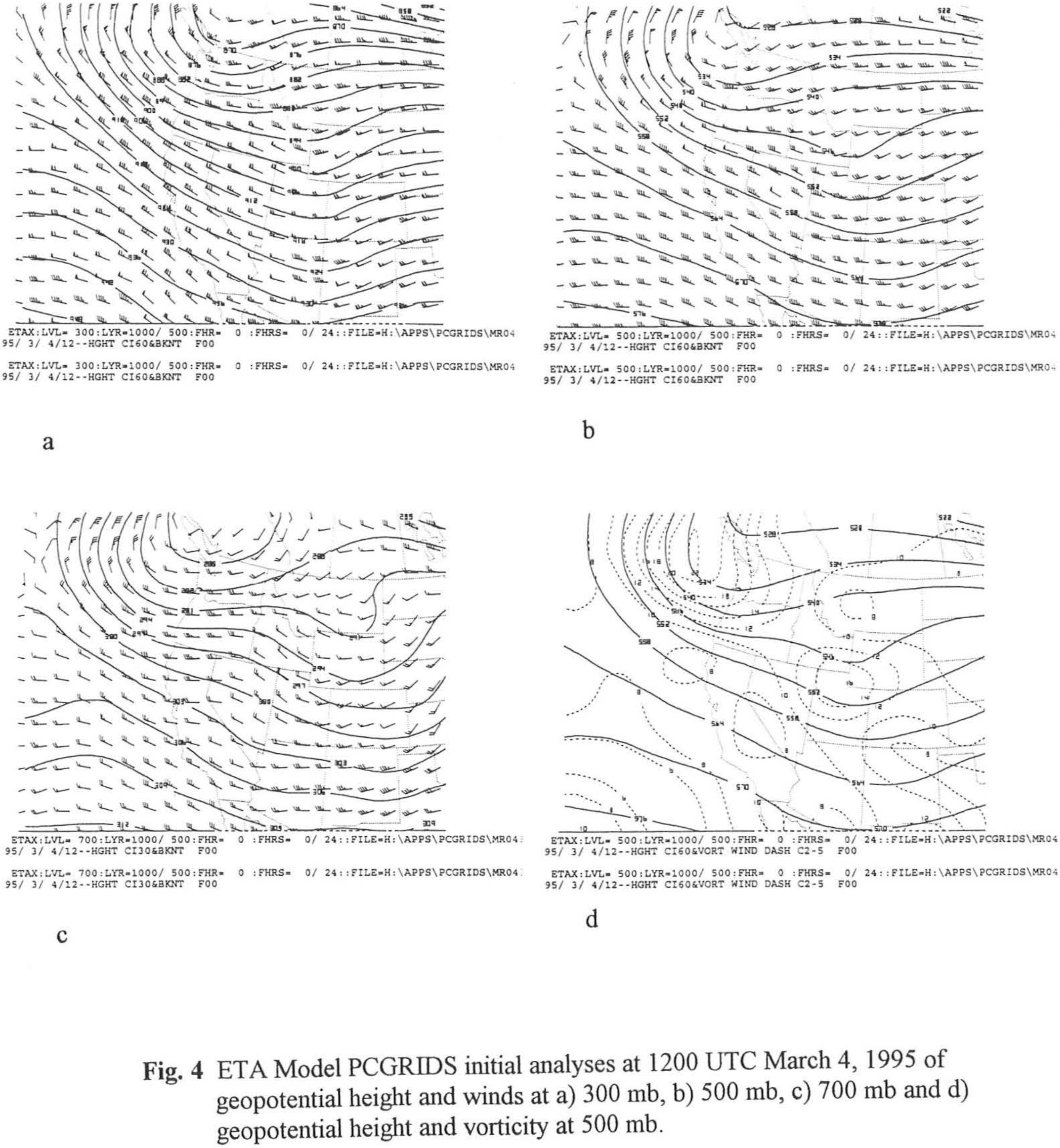

Fig. 4 ETA Model PCGRIDS initial analyses at 1200 UTC March 4, 1995 of geopotential height and winds at a) 300 mb, b) 500 mb, c) 700 mb and d) geopotential height and vorticity at 500 mb.

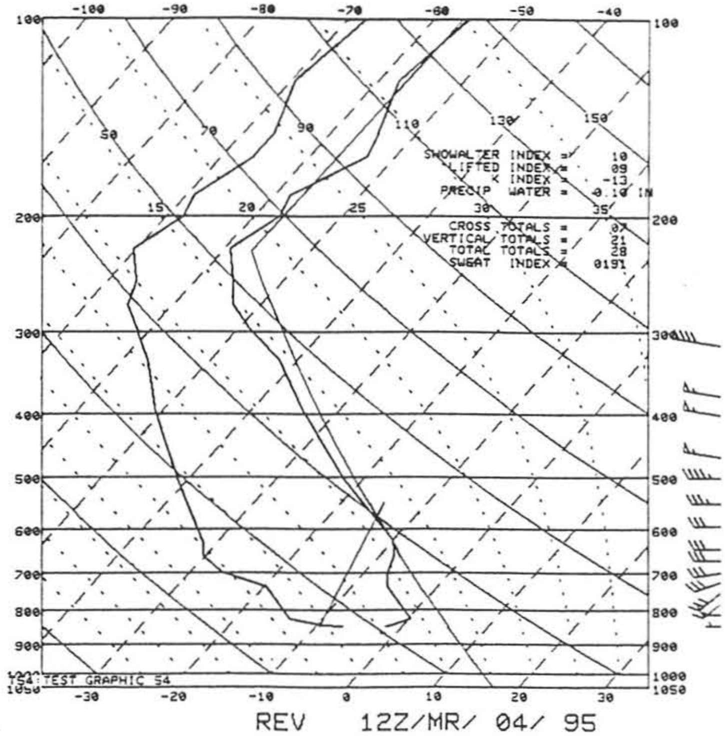

Fig. 5 REV sounding for 1200 UTC March 4, 1995

RNO SA 0050 70 SCT 150 SCT E200 OVC 40 104/48/21/2305G12/983/ ACSL SE-NW/ SLIDE MTN 18/M/2361G78

RNO SA 0151 70 SCT 150 SCT E200 OVC 20 104/45/21/1820/982/ ACSL E-NW PK WND 1828/43/ SLIDE MTN 16/M/2465G75

RNO SA 0252 70 SCT 150 SCT E200 OVC 15 101/44/19/2020G25/981/ ACSL DSNT SE-NW/ 8/148/ 57007/ SLIDE MTN 16/M/2470G87

RNO SA 0351 70 SCT 150 SCT E200 BKN 15 094/44/16/2217G25/980/ ACSL DSNT SE-NW PK WND 2331/33/ SLIDE MTN 15/M/2468G81

Fig. 6 Surface Aviation Observations for the Reno/Tahoe International Airport between 0000 UTC and 0400 UTC March 5, 1995