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HODOGRAPH SHOWS SACRAMENTO VALLEY LOW LEVEL JET

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Prior to the passage of Pacific cyclones, a low-level jet often forms just west of the Sierra Nevada Mountains in the Sacramento Valley of California. Often inconsistent with the prevailing synoptic pressure gradient, the jet blows from the southeast, parallel to the mountain range. Using wind measurements from rawinsondes and aircraft flights, Parish (1982) constructed vertical cross sections which showed the jet over the eastern edge of the valley and the adjacent foothills. Waight (1984) offered a general explanation for the formation of barrier winds:

1. A stable air mass approaches perpendicular to an elongated mountain range;

2. The low-level flow is blocked by the barrier and forced to rise over it;

3. Becoming negatively buoyant as it cools adiabatically, the air increasingly resists orographic lifting;

4. The lifted air is colder than air at the same level upwind that has not been lifted;

5. This difference in temperature will be reflected in a local area of high pressure over the windward slopes of the range;

6. The resulting pressure gradient retards air approaching the range and diverts it along the mountain under the influence of the earth's rotation (coriolis force)..

Waight incorporated this explanation into a numerical model of the Sierra Nevada jet. One simulation predicted that ten hours would be required for the jet to reach steady state equilibrium after the initial onset of favorable conditions.

The Sierra Cooperative Pilot Project (SCPP) is a wintertime precipitation enhancement experiment in the northern Sierra Nevada. During storm periods, soundings are taken every three hours at Sheridan -- a station located about 40 km north of Sacramento at the base of the mountain range. In general, the soundings show that the jet is more prominent in stable, prefrontal conditions than in convective, post-frontal conditions. Upper air wind climatologies suggest that the low level jet occurs frequently during the months of data collection, December through March. The following case study gives an example.

Persistent southwesterly flow and overrunning precipitation characterized the synoptic situation over northern California on 4-5 January 1986. Figure 1 is an ~~IR satellite picture of the western states at 00 GMT on 5 January 1986. It shows~~ a large area of cloudiness associated with a Pacific storm. Figure 2, the concurrent 500 mb analysis, shows a broad, long-wave trough over the eastern pacific and weak warm air advection over the west coast. It also shows a weak, short-wave trough approaching California. A persistent, high-amplitude ridge over the western United States prevented a direct hit by the storm. In fact, none of the NMC three-hourly, surface charts (not presented) showed significant, frontal passages on either day. Despite the absence of prominent, synoptic, triggering mechanisms, substantial precipitation occurred over the region on both days. Figure 3 shows the 00 GMT 850 mb analysis with the locations of Oakland (elevation 6 meters) and Sheridan (elevation 60 meters) annotated. The annotated Sheridan 850 mb wind, from a concurrent sounding not using in the map analysis, represents flow just to the west of the Sierra Nevada. The gradient shown in the vicinity of the two stations (Figure 3) yielded a geostrophic speed of approximately 24 knots, closely matching Oakland's report of 22.5 knots. The general orientation of the contours also agreed with Oakland's reported direction of 225°. Sheridan, on the other hand, reported 180° at 36 knots. This wind formed a significant angle with respect to the contours and blew at supergeostrophic speed.

Figure 4 shows a hodograph of the Oakland (solid) and Sheridan (dotted) soundings. Oakland's profile shows winds increasing and veering with height, especially in the lower layers. Marked topographic influence is not apparent. The low-level winds at Sheridan increase even more sharply above the surface than at Oakland but veer little because of the blocking influence of the Sierra Nevada Mountains. Low-level wind speed reaches a maximum of 36 knots at about 850 mb, then decreases sharply to a minimum of 20.6 knots at about 815 mb. Above this level the Sheridan and Oakland profiles become more similar in direction as the influence of topography decreases.

Understanding of the Sierra Nevada low-level jet is important for several reasons. For one, Sacramento Valley flight service stations must often rely on the Oakland sounding to estimate aviation ascent winds. The example here shows that this source can err seriously concerning speed and direction of the low-level jet. In particular, underestimation of the strength of the jet may hinder the accurate analysis of low-level, wind shear. The low-level jet also plays havoc with Sierra Nevada cloud seeding operations. Seeding from ground-based, silver iodide generators in the Sierra foothills is intended to increase precipitation in the mountains located immediately upslope. However, if a low-level jet develops, the seeding agent may never reach its intended target but is transported well to the north instead. Seeded precipitation increases may still occur under these circumstances, but the location and timing of such effects are unpredictable.

References:

1. Parish, T.R., 1982: Barrier Winds Along the Sierra Nevada Mountains, J. Appl, Meteor., 21, 925-930.

2. Waight, K.T., 1984: A Numerical Study of the Sierra Nevada Jet. Report No. AS 148, University of Wyoming.

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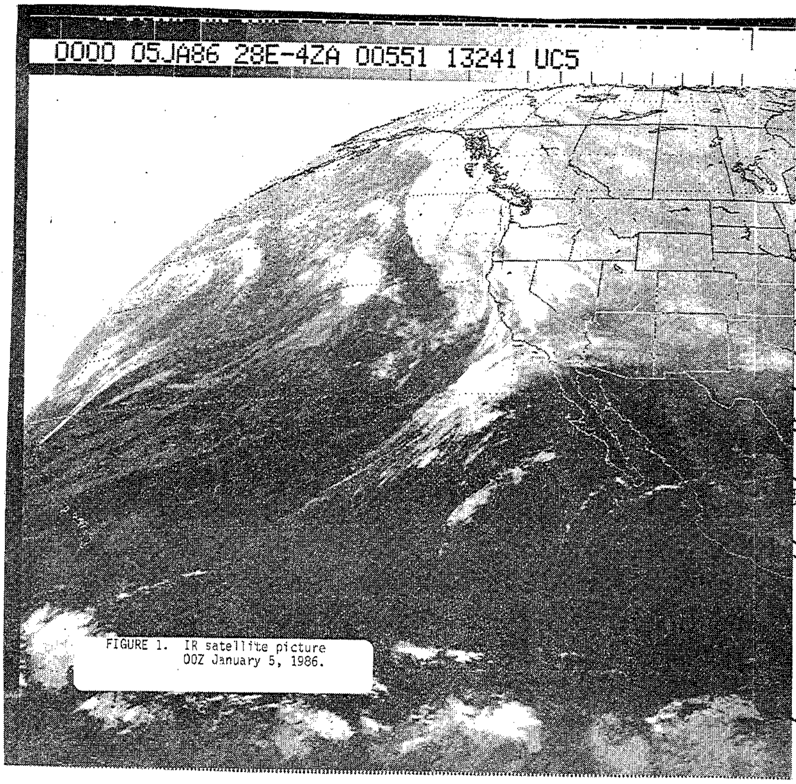

FIGURE 1. IR satellite picture 00Z January 5, 1986.

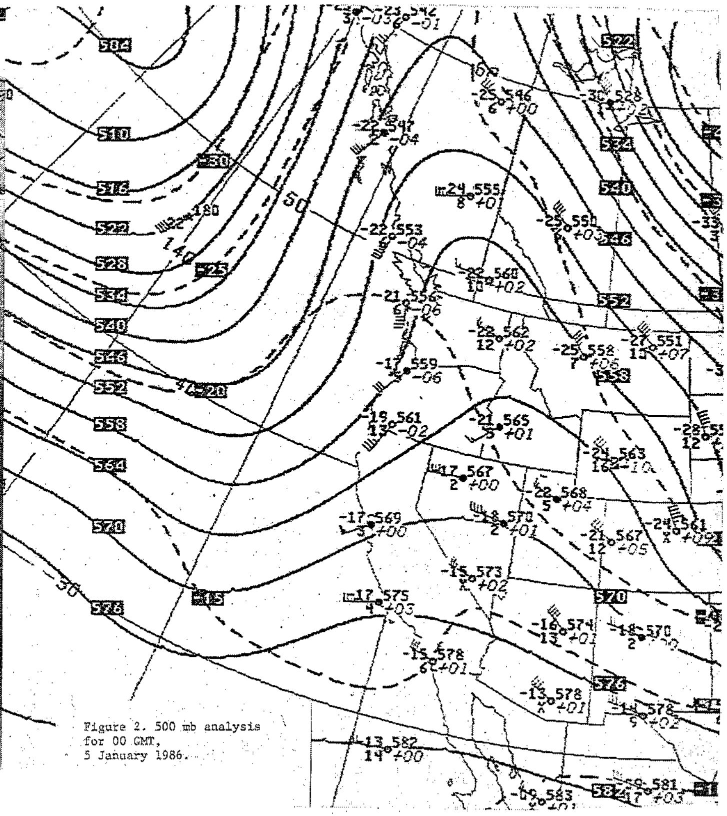

Figure 2. 500 mb analysis for 00 GMT, 5 January 1986.

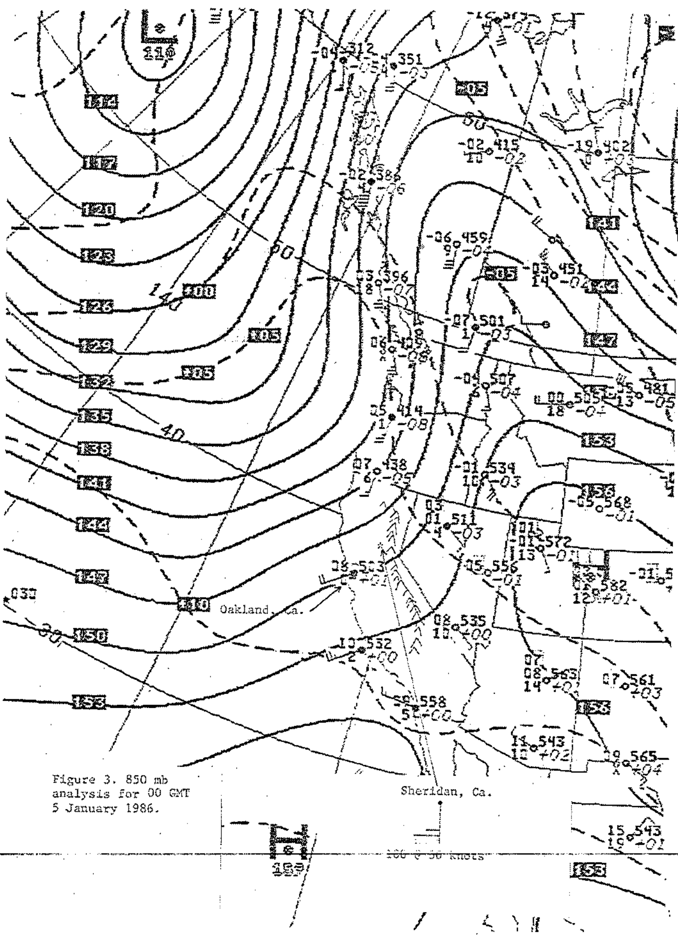

Figure 3. 850 mb analysis for 00 GMT 5 January 1986.

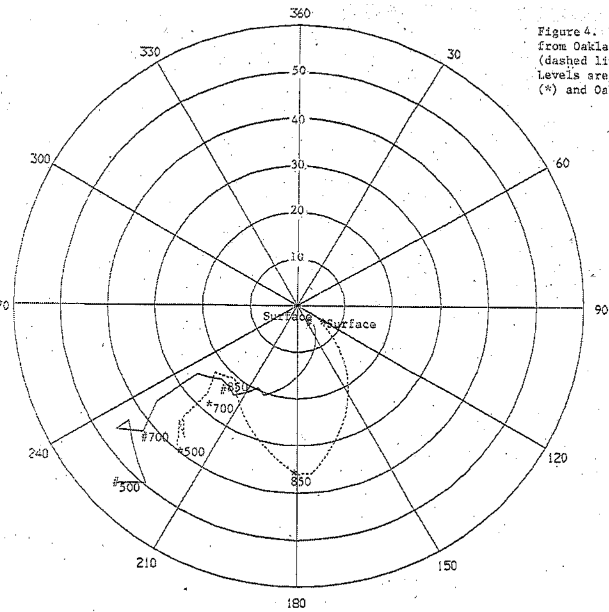

Figure 4. Hodograph of rawinsonde winds from Oakland (solid line) and Sheridan (dashed line) for 00 GMT, 5 January 1986. Levels are indicated in kPa for Sheridan (*) and Oakland (#). Speed in knots.