An Examination of a Barrier Jet in the Sacramento Valley Using the Weather Event Simulator (WES)

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Introduction

Barrier winds or barrier jets are common occurrences in the Sacramento valley due to the orientation of the topography. The Sacramento valley is bounded by the Sierra Nevada Mountains to the east and the coastal range to the west. These mountains often cause terrain-induced winds in the Sacramento valley. As an example, onshore flow from the Pacific Ocean causes air to be forced through the gap in the coastal range mountains called the Golden Gate. Once the air passes through the Carquinez Strait east of the Golden Gate, it spreads out as it reaches the valley and results in a southerly wind direction for the Sacramento valley. Usually, these wind speeds are not strong enough to cause significant problems. However, on occasion, southerly winds can result in the formation of the southerly barrier jet along side the Sierra Nevada Mountains (Parish, 1982).

Given unique circumstances, wind speeds can become significant to the public and wind advisories, high wind warnings, or Red Flag Warnings are issued to highlight this phenomenon. Staudenmaier (1994) discussed the formation of a northerly barrier jet and the implications to extreme fire behavior. Staudenmaier offered three conditions forecasters should examine for the potential development of a northerly barrier jet: (1) a sufficiently deep surface or near-surface based layer (at least 150 mbs deep) of northeasterly flow over the Sacramento valley for at least 6 hours, (2) strong stability as shown by the Oakland, CA (KOAK) sounding extending from around 800 mbs to at least as high as the terrain and, (3) enhancement of gusty surface winds if the stable layer caps a slightly less stable layer allowing for momentum transfer to the surface.

This WES (Weather Event Simulator) case reinforced the concepts and findings from this study. The forecasters were challenged to identify this phenomenon and issue the appropriate wind forecast, and any advisories, watches or warnings they deemed necessary.

The WES Exercise

The weather event used for the WES case was 15 November 2005. Initially, the forecasters viewed water vapor imagery to determine the strength of the upper level jet and the locations and strength of the upper level trough and ridge over the western half of North America. It was important to note the transverse cloud bands over Nevada and the strong subsidence over northern California (Fig. 1). This was the result of a strong northwest 160 knot meridional jet that carved out a deep upper level

trough over the interior United States and the strong upper level ridge that prevailed upstream, over the west coast and eastern Pacific Ocean (Fig 2).

Pressure rises over the Pacific Northwest and the Great Basin resulted in a strong surface pressure gradient over northern California that persisted for more than 6 hours. Initially, the surface high was over the Pacific Northwest, then moved east into Idaho and strengthened to 1040 mbs. This subtle shift in position of the surface high had a direct impact on which part of the Sacramento valley received the strongest winds, and will be discussed later. Model output forecasts of 850 mb winds, 700 mb winds, and the 1200Z 15 November 2005 NAM BUFKIT forecast sounding illustrated a sufficient depth of northeasterly flow from 1200Z 15 November 2005 to 0000Z 16 November 2005 (Figs. 3-5). This information satisfied Staudenmaier's first condition for the development of a northerly barrier jet.

An examination of the 1200Z 15 November 2005, Oakland, CA (KOAK) sounding verified conditions two and three (Fig. 6). A stable layer existed from the surface to 830 mbs. Gusty surface winds were enhanced as the stable layer above 900 mbs capped a slightly less stable layer from 1000 mbs to 900 mbs. The forecasters were also instructed to examine the developing barrier jet from the VAD Wind Profile (VWP) on the Davis, CA (KDAX) radar where winds in excess of 40 kts were indicated in the 0-2 km AGL layer.

Tables 1 and 2 show the wind directions and speeds for 15 November 2005 at Redding, CA (KRDD) and at Sacramento International Airport (KSMF). While wind advisory criteria (sustained winds $\geq$ 25 mph for more than one hour and/or any peak wind gusts $\geq$ 40 mph) was reached at KSMF as early as 1350Z, the winds were not nearly as strong at Redding, CA and remained below wind advisory criteria. This is due to the northeast orientation of the pressure gradient which caused the barrier jet to develop on the west side of the Sacramento valley. It was noted that during the event, winds remained below wind advisory criteria over the eastern portion of the Sacramento valley as well.

Summary and Conclusions

The development of a northerly barrier jet occurred on 15 November 2005. The three conditions for the development of a northerly barrier jet discussed by Staudenmaier directly applied to this case and were emphasized to the forecasters during the WES simulation. Satellite imagery, upper air soundings and model guidance provided sufficient clues and lead time to the development of this northerly barrier jet along the western portion of the Sacramento valley.

References

Parish, T., 1982: Barrier winds along the Sierra Nevada mountains. *J. Appl. Meteor.*, **12**, 925-930.

Staudenmaier, Jr., M., 1994: WSR-88D Evidence of a Northerly Barrier Jet in the Sacramento Valley. Western Region Technical Attachment No. 94-36.

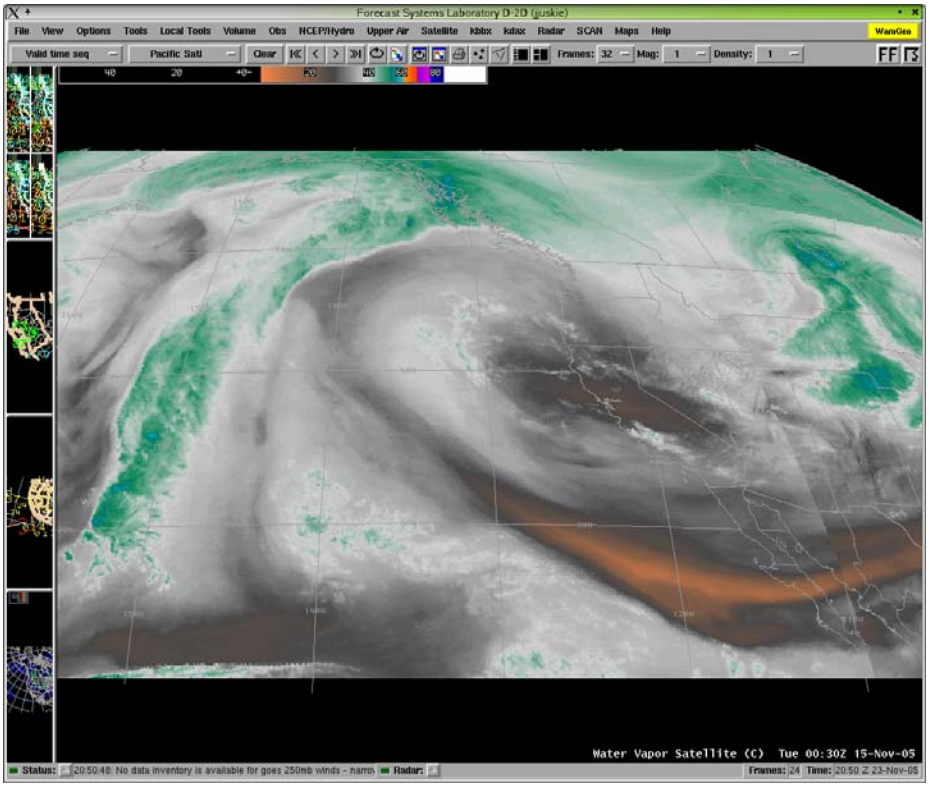

Figure 1. 15 November 2005 0030Z Water Vapor Image

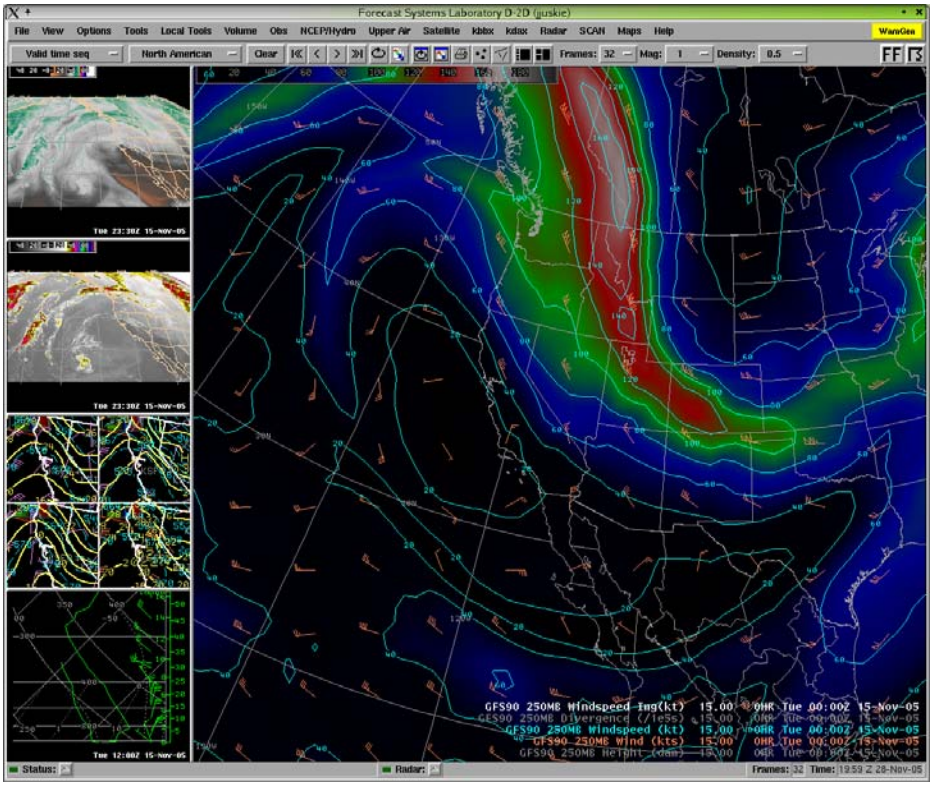

Figure 2. 15 November 2005 0000Z GFS 250 mb Winds

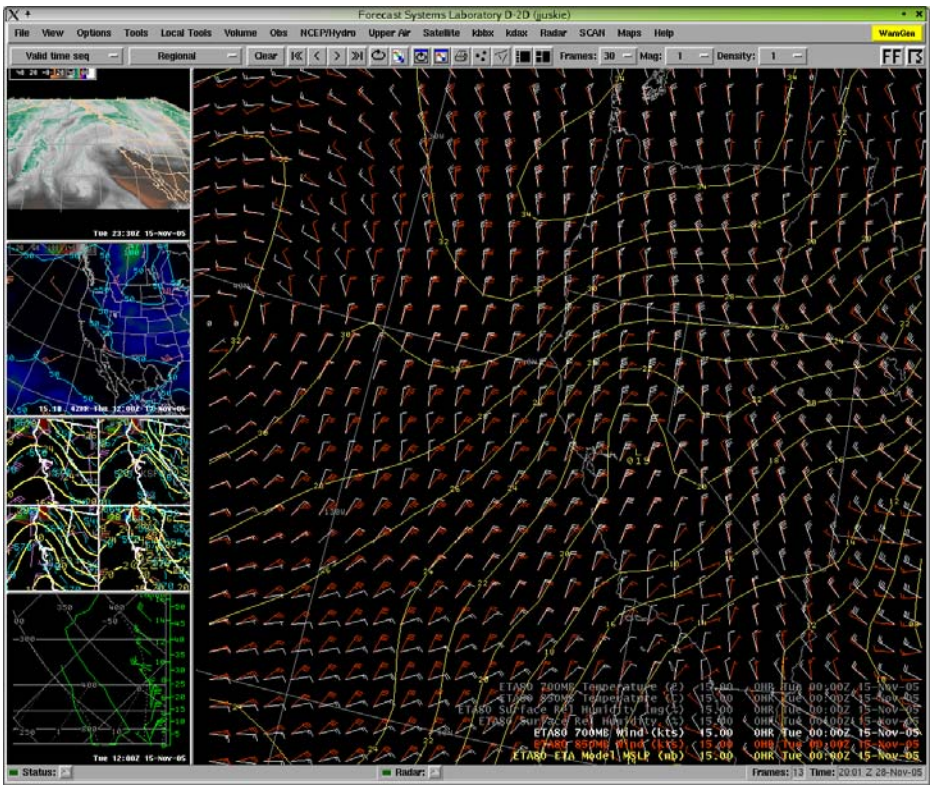

Figure 3. 15 November 2005 0000Z NAM MSLP, 850 mb Winds, and 700 mb Winds

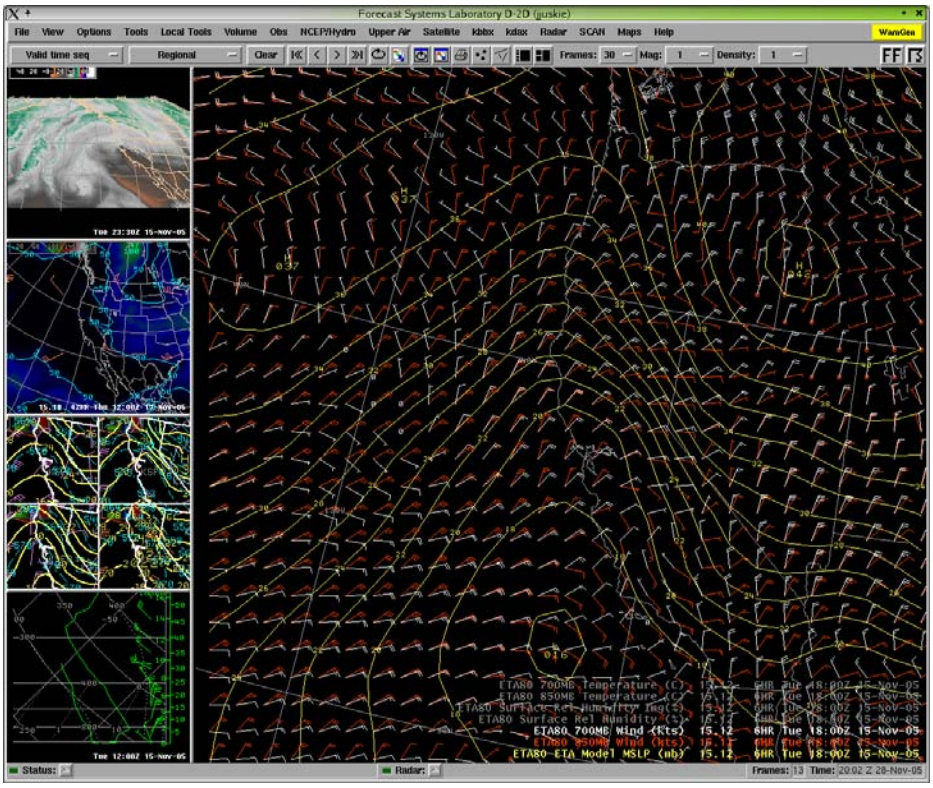

Figure 4. 15 November 2005 1800Z NAM MSLP, 850 mb Winds, and 700 mb Winds

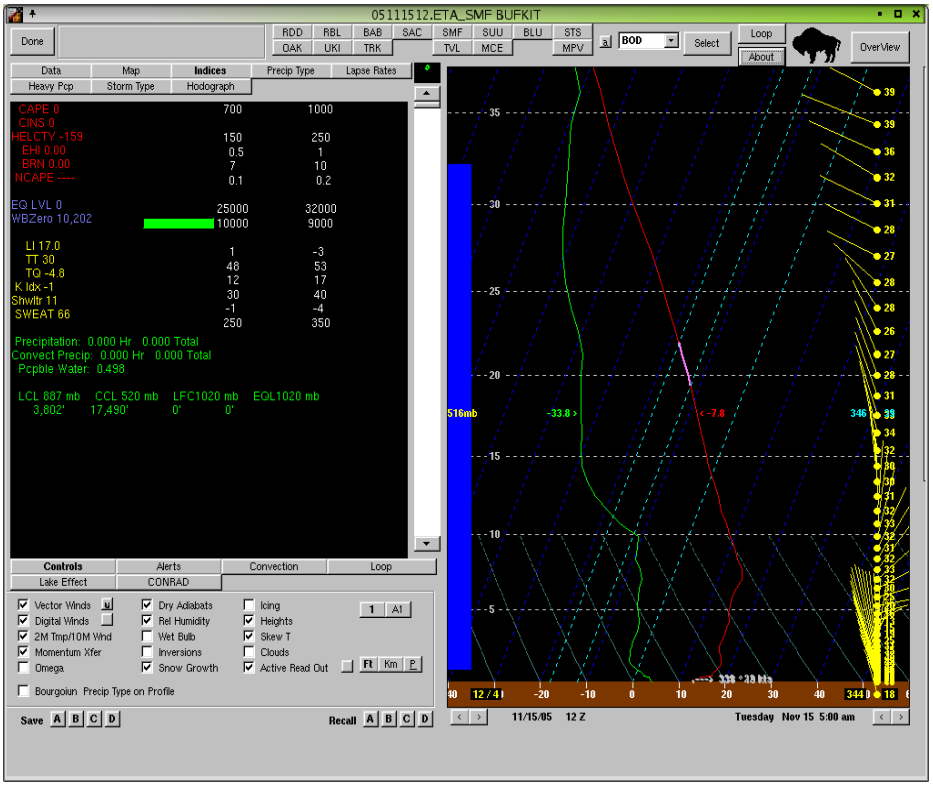

Figure 5. 15 November 2005 1200Z NAM Bufkit Forecast Sounding

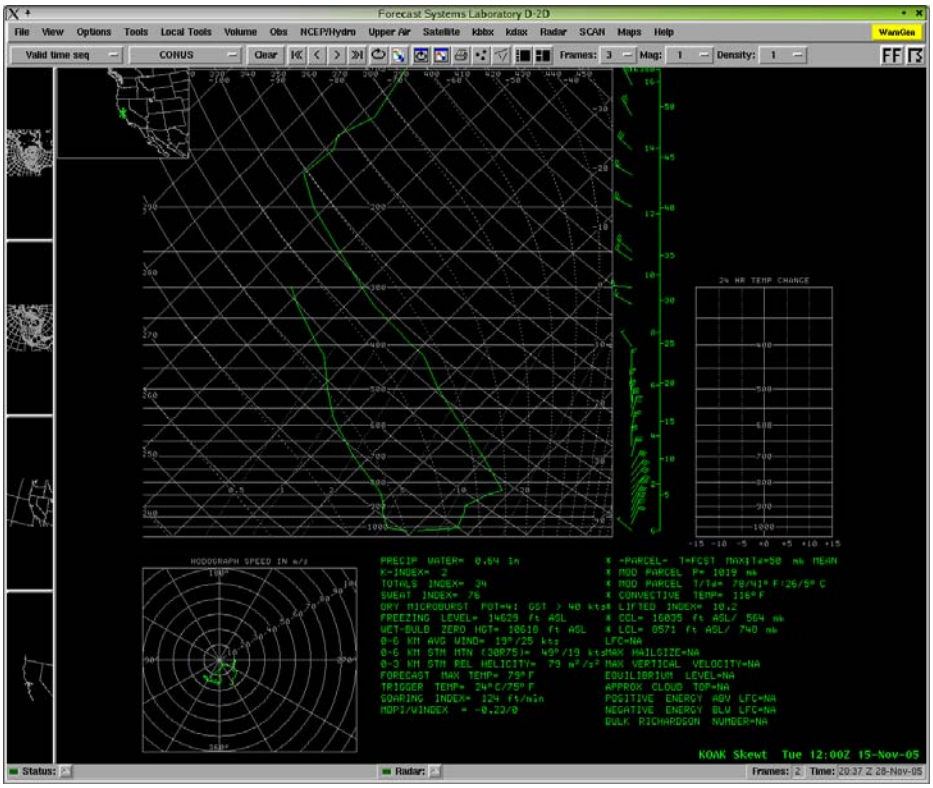

Figure 6. 15 November 2005 1200Z Oakland (KOAK) Sounding

Time	Wspd	Gust	Direction
23:50	14	21	N
22:50	15		N
21:50	13		N
20:50	13		N
19:50	16		N
18:50	13		N
17:50	9		N
16:50	6		N
15:50	12		NNE
14:50	10		N
13:50	12		N
12:50	12	16	NNE
11:50	10		N

Table 1. November 14, 2005 - 0:00 through November 15, 2005 - 00:00 PST for Redding (KRDD)

Time	Wspd	Gust	Direction
22:50	28	41	NNW
20:50	20		NW
18:50	26	32	NNW
17:50	22	29	NNW
16:50	23		NNW
15:50	26	32	NNW
14:50	23	32	NNW
13:50	25	35	NNW
12:50	24	28	NNW
11:50	16		NNW
10:50	8		NW

Table 2. November 14, 2005 - 0:00 through November 15, 2005 - 00:00 PST for Sacramento International Airport (KSMF)