An Analysis of the December 16, 2002 Grapevine Wind Event

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Introduction

The chief longitudinal transportation route across California, Interstate 5, extends from the Oregon border in the north to the Mexican border in the south. The segment of highway extending from the southern San Joaquin Valley, south of Bakersfield, to the Los Angeles Basin, is commonly referred to as the "Grapevine." This eight lane highway winds through the Tehachapi mountains and achieves its maximum elevation at Tejon Pass, situated 4,183 feet above mean sea level. Given the orientation of the canyons and the typically different airmass characteristics residing on opposing sides of the pass, the Grapevine is a favored site for intense, short-lived high wind events. Such an event occurred during the morning hours of December 16, 2002. A map is provided in Figure 1 for familiarization of local topography and observing sites.

Synoptic and Mesoscale Event Precursor

A deep upper low registering 5030 meters at 500 mb was located over the Gulf of Alaska early in the morning. Low pressure with sea level pressures below 968 mb was also reflected quite well at the surface in the vicinity of British Columbia's Queen Charlotte Islands. In California, the upper flow was quasi-zonal, with the 12Z Global Forecast System (GFS) model indicating the nose of a 140 knot jet at 300 mb approaching the San Francisco Bay Area (see Figure 2). This jet extended west, over the Pacific Ocean, and exhibited further increase in wind speed, eventually reaching above 160 knots. Rapid Update Cycle (RUC) data suggested that pronounced downward vertical motion was already present at several levels over the southern San Joaquin Valley and Grapevine by this time (see Figure 3) and was also well corroborated by the Mesoscale-ETA model.

At the surface, Automated Surface Observing System (ASOS) reports from Merced (KMCE) indicated that the sea level pressure fell 6 mb from 10Z to 13Z, with similar drops in pressure noted at nearby Madera (KMAE). During this time frame, the wind at Sandberg (KSDB), located at 4,517 feet elevation near Tejon Pass, was fairly innocuous, with southerly gusts of only 24 knots at 13Z. Skies were generally overcast across the region, with light to moderate rain reported in central portions of the San Joaquin Valley. Additionally, several local surface gradients were also scrutinized, with anchor points including Bakersfield (KBFL), Burbank (KBUR) and Los Angeles International Airport (KLAX). Figure 4 depicts the observed pressure pattern at 13Z.

13Z Surface Data

Stations Pressure - - - Gradient (mb) - - - Distance (miles) / Gradient (1 mb)

KBFL - KMCE - - - - - - - - 6.4 - - - - - - - - - - - - - - 24
KSDB - KBFL - - - - - - - - 2.3 - - - - - - - - - - - - - - 22
KBUR - KSDB - - - - - - - - 3.0 - - - - - - - - - - - - - - 14
KLAX - KSDB - - - - - - - - 4.0 - - - - - - - - - - - - - - 15

Forecasters at WFO San Joaquin Valley routinely evaluate two surface pressure gradients in particular: San Francisco (KSFO) to Las Vegas, Nevada (KLAS) for an overview of the synoptic pressure pattern, and KSFO to Sacramento (KSAC) for a more local analysis. At 13Z, these gradients stood at -5.7 mb and 0.1 mb, respectively. Neither the synoptic offshore gradient nor the slightly onshore local gradient would be considered suspiciously tight given the time of year.

Event Analysis

The upper level jet continued to progress east, and the 18Z run of the GFS showed the nose having reached Inyo and Mono counties, along the Nevada border (see Figure 5). This orientation placed the Tehachapi mountains below the right front quadrant of the jet, an area generally favored for enhanced downward vertical motion. Interestingly, RUC (and Mesoscale-ETA) data show the greatest downward velocities now south of the Grapevine, with a distinct gradient between upward and downward vertical motion at 700 mb right over the Grapevine at 18Z (see Figure 6). At the surface, sea level pressure at KMCE and KMAE, well to the north of the Grapevine, reversed their former downward trend and began exhibiting stable or slight increases through 18Z. Meanwhile, the pressure at KBFL fell another 3.7 mb. The data below underscore the resultant changes to the surface pressure pattern (see Figure 7 for graphic).

18Z Surface Data

Stations Pressure - - - Gradient (mb) - - - Distance (miles) / Gradient (1 mb)

KBFL - KMCE - - - - - - - - - - 0.6 - - - - - - - - - - - - - - - - 260
KSDB - KBFL - - - - - - - - - - 1.8 - - - - - - - - - - - - - - - - - 28
KBUR - KSDB - - - - - - - - - - 6.5 - - - - - - - - - - - - - - - - 6.6
KLAX - KSDB - - - - - - - - - - 6.9 - - - - - - - - - - - - - - - - 8.6

Especially noteworthy is the extent by which the gradient across the Valley (KBFL-KMCE) relaxed over the course of these five hours, with an observed drop of an entire order of magnitude. Conversely, the KBUR-KSDB gradient, which extends across only 43 miles and includes the southern portion of the Grapevine, more than doubled. Interestingly, the 18Z observation actually represents a slight decrease in the strength of the KBUR-KSDB gradient from its peak at 16Z, when a magnitude of 7.1 mb was attained. Incidentally, at 18Z the KSFO-KLAS surface gradient decreased slightly to -4.9 mb while KSFO-KSAC increased to a still unimpressive 1.6 mb.

The first verification of the sensible impact of these tight gradients came at 1816Z, when the California Highway Patrol (CHP) received the report of a semi truck overturned north of KSDB on the Grapevine. An anemometer at a truck weighing station located at the southern end of the Valley, near the base of the Grapevine's initial incline, registered a 91 knot (105 MPH) wind gust around this time. Published reports further indicate that these strong winds persisted "for about an hour," and eventually resulted in a total of three toppled semi trucks on this stretch of roadway (Vance 2002). Fortunately, no injuries resulted from these incidents. Later consultation with the CHP dispatcher indicated that there was sufficient concern as early as 1445Z to issue a self-proclaimed "wind advisory" for the afflicted area, alerting motorists to the potential for gusty winds via electronic message boards stationed along the Interstate.

MSAS Analysis and Model Performance

The 13Z Mesoscale Surface Analysis System (MSAS) mean sea level pressure chart performed reasonably well, although it did slightly underestimate the gradient in the southern portions of the Valley (Figure 4). However, by 18Z, MSAS overestimated the gradient in the Valley, while substantially underestimating the magnitude of the gradient across the Grapevine (Figure 7). In fact, while the actual KBUR-KSDB gradient stood at 6.5 mb, the MSAS analysis only indicated about 3.5 mb. Unfortunately, this small scale gradient was also missed by the Mesoscale-ETA and RUC numerical models. Inspection of the 18Z initialization time (the same time when the event was transpiring) of these fine-resolution models indicated that although they did depict a tightening of the gradient across the Grapevine, the magnitude of the underestimation was still very significant, as reflected in the chart below.

- - - - - - - - - 18Z Model Comparison of Pressure Gradients - - - - - - - -
Stations - - - - *Mesoscale ETA (mb) - - - -*RUC (mb) - - - - Actual (mb)

KBFL - KMCE - - - - - - - - - - 4.0 - - - - - - - - - - - - 1.6 - - - - - - - - - - - -0.6
KSDB - KBFL - - - - - - - - - - 2.8 - - - - - - - - - - - - 2.2 - - - - - - - - -- - - 1.8
KBUR - KSDB - - - - - - - - - - 3.7 - - - - - - - - - - - -3.3 - - - - - - - - - - - - 6.5
KLAX - KSDB - - - - - - - - - - -4.0 - - - - - - - - - - - -4.8 - - - - - - - - - - - - 6.9
* Values are approximate

Summary

Despite the inability to successfully predict this local wind occurrence, there are several aspects concurrent with this event which should aid in subsequent identification of future, similar episodes. One of which is to approach these events with less dependence on examining traditional "fair weather gradients" such as KSFO-KLAS, which are too broad to possibly capture the small scale of Grapevine wind events. Instead, increased attention must be given to local gradients such as KBUR-KSDB to help identify potential events. Additionally, casual observation of MSAS mean sea level pressure charts, along with mesoscale model solutions, such as the RUC, is also insufficient as these analyses are often too coarse to accurately gauge this particular gap wind phenomenon. Although perhaps purely coincidental or just unique to this particular event, the pronounced drop in surface pressure in the central San Joaquin Valley prior to the wind event might serve as a forewarning, especially if continued tightening of the surface gradient is observed across the Grapevine. Furthermore, RUC and Mesoscale-ETA depictions of a pronounced vertical motion gradient along the Grapevine, while perhaps also coincidental, may help in identifying these wind events before they commence. Finally, even though the presence of extensive cloud cover would normally serve to diminish the downward transport of momentum (i.e., winds) due to turbulent mixing, the presence of a strong jet along with the established surface pressure pattern were more than enough to compensate for the overcast conditions. Perhaps the most crucial aspect this event illustrated was the obvious importance of active and constant monitoring of observational parameters (satellite imagery for jet positioning and hourly observations for surface gradients), rather than passive monitoring of these parameters and over-reliance on model data, especially when it pertains to small-scale phenomena.

Acknowledgments

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Reference

Vance, C. (2002) 'Under the weather'. The Bakersfield Californian. 17 Dec. p.1.

Figure 1

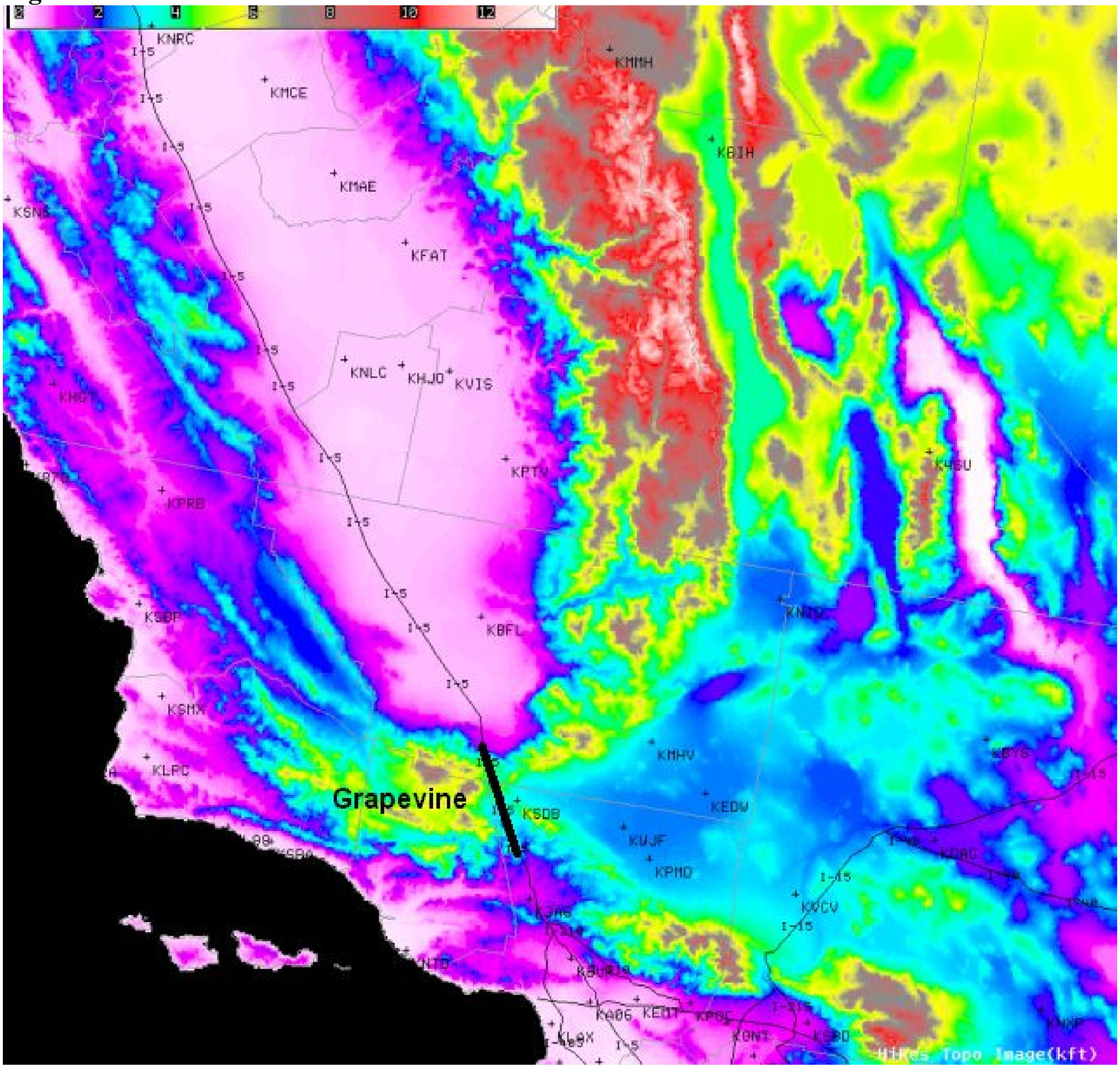
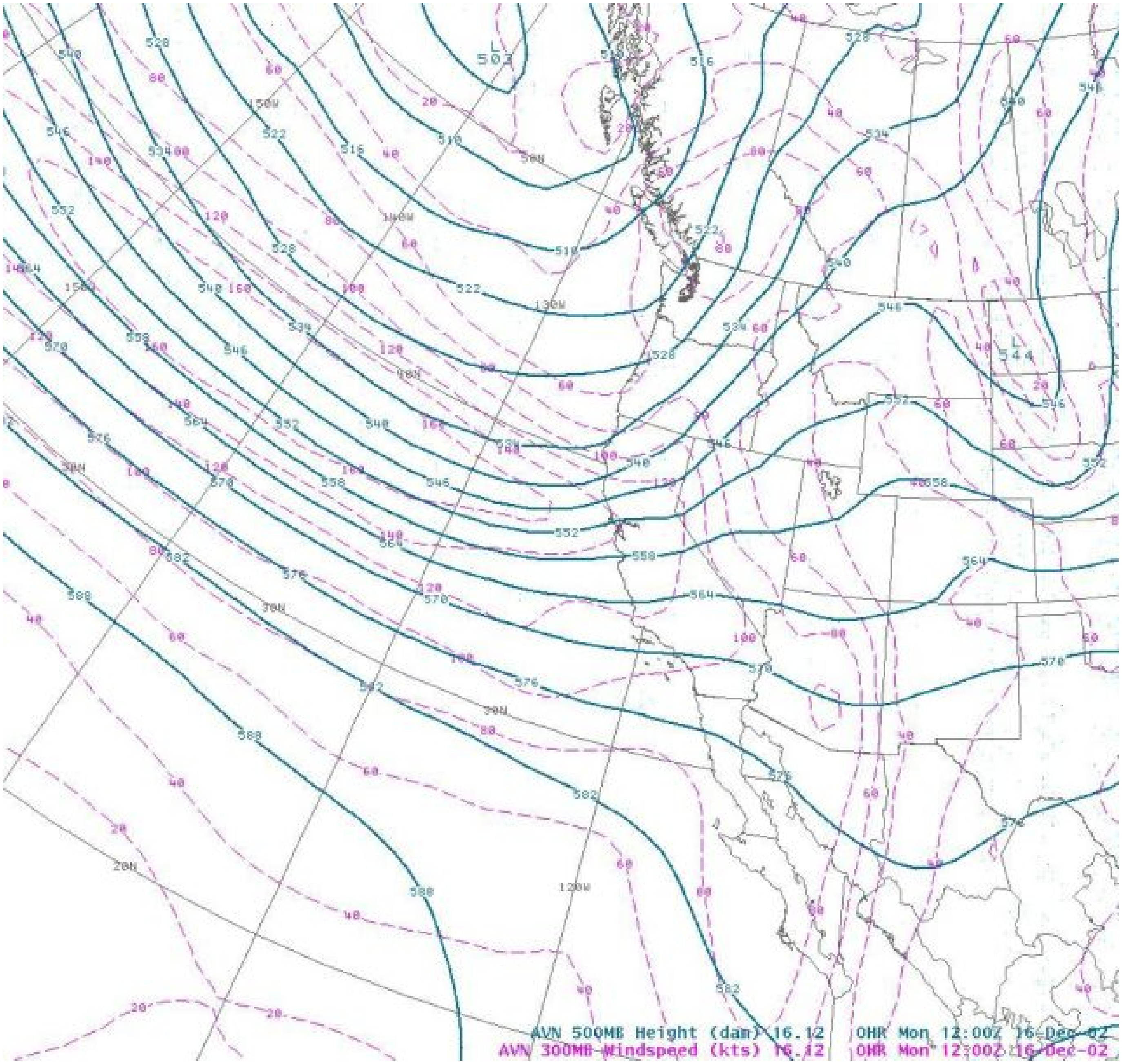


Figure 2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AVN 300MB Windspeed (kts) 16.12 0HR Mon 12:00Z 16-Dec-02

Figure 3

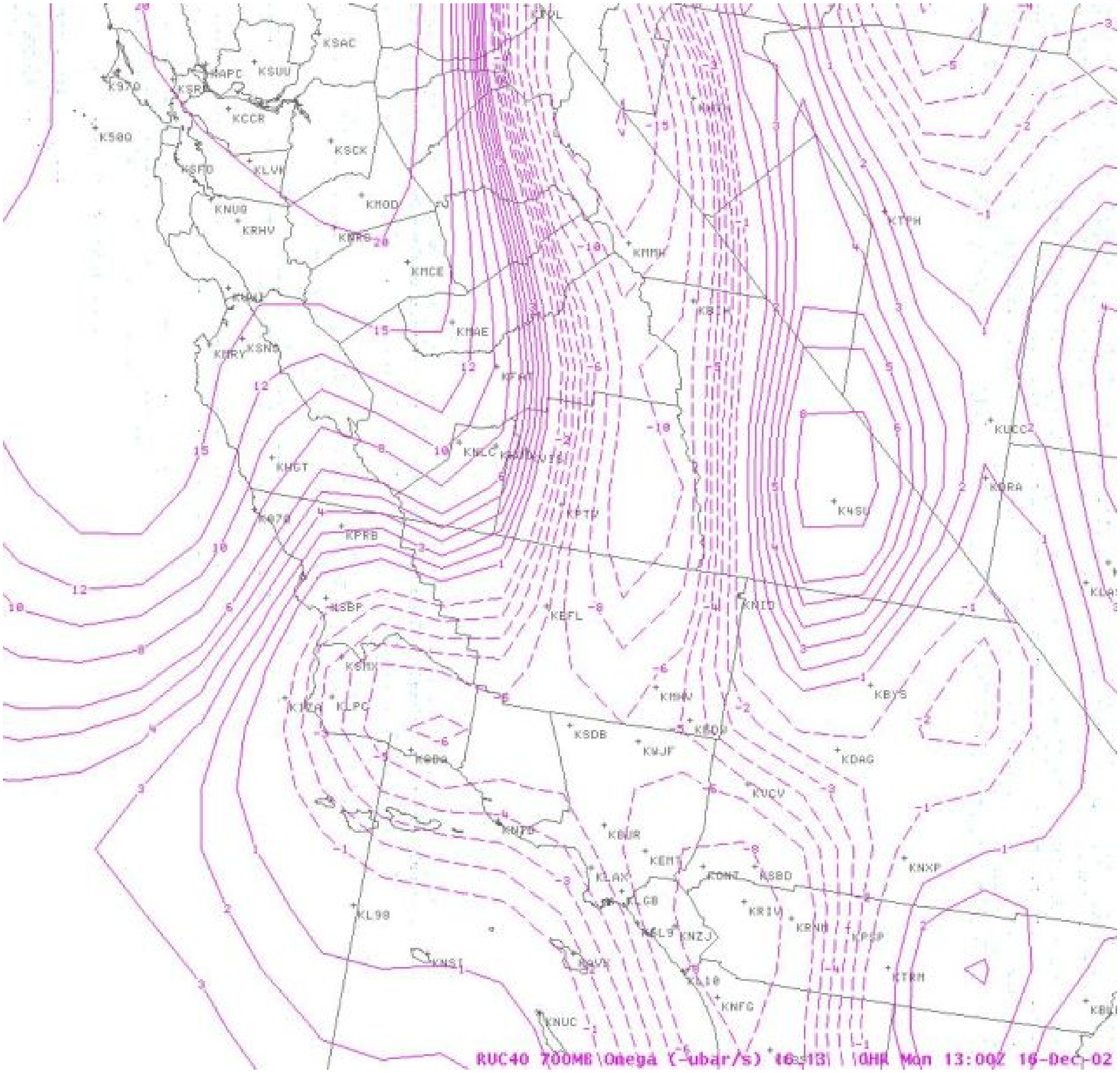
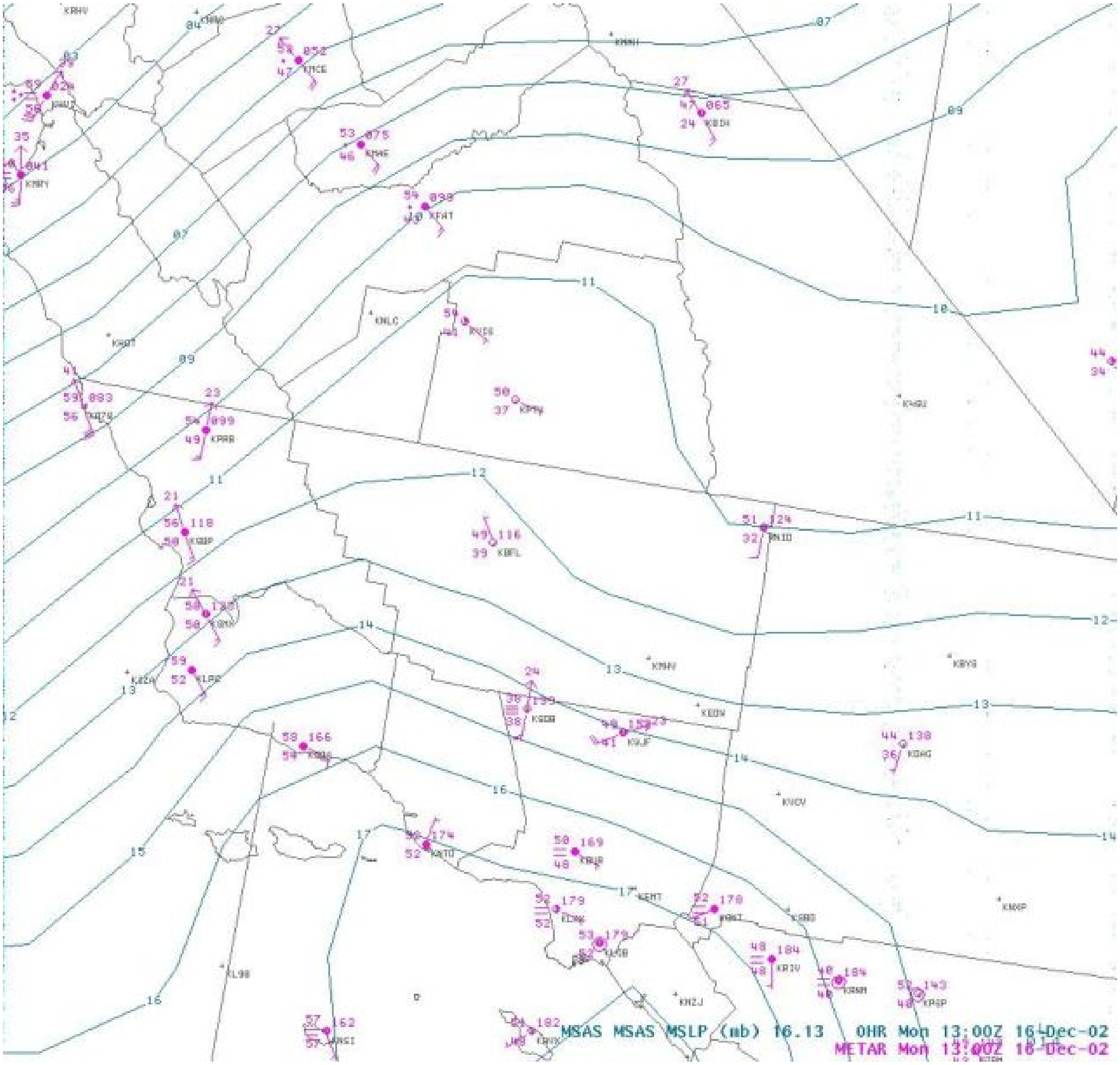


Figure 4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METAR Mon 13:00Z 16-Dec-02

Figure 5

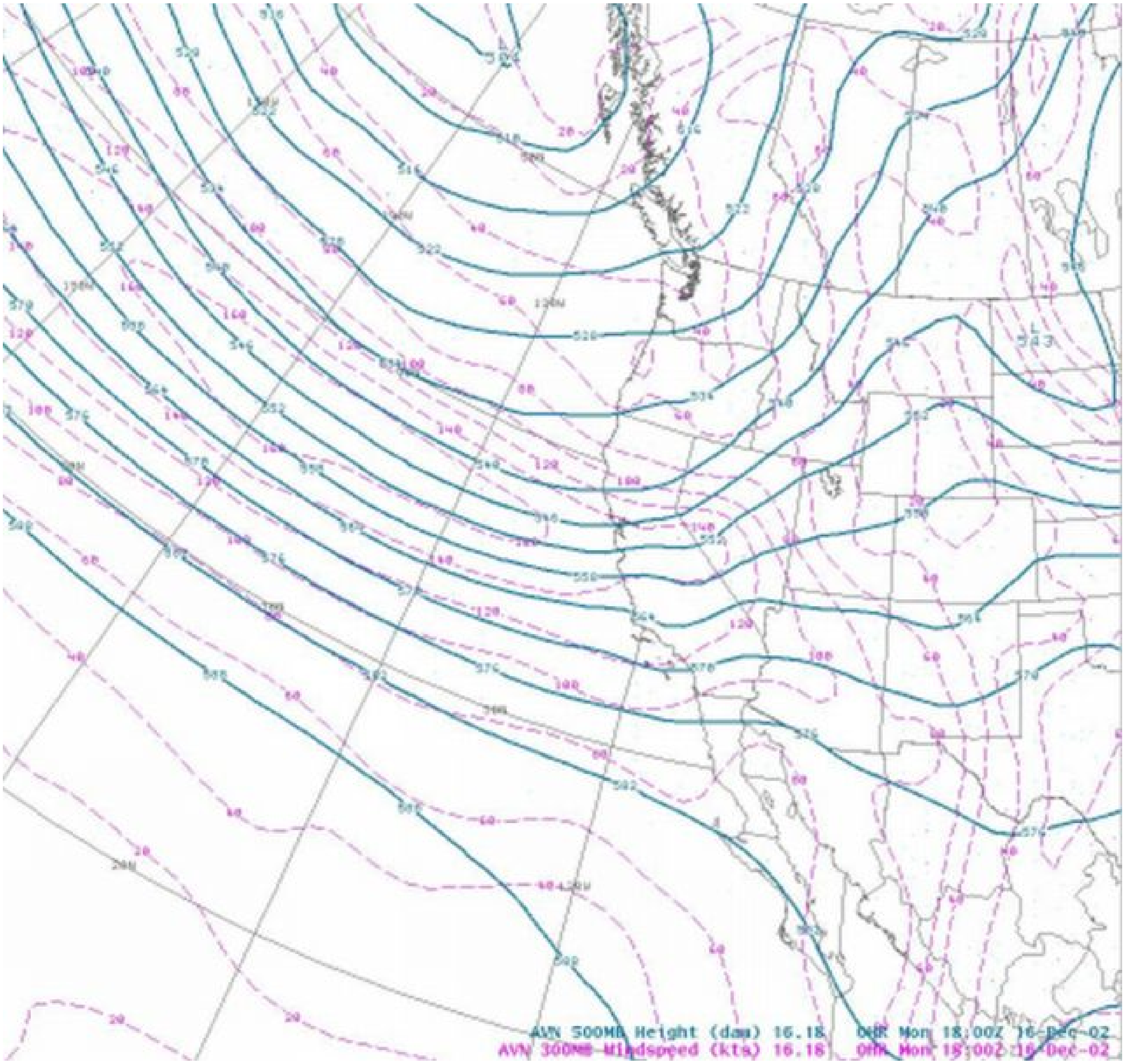
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Figure 6

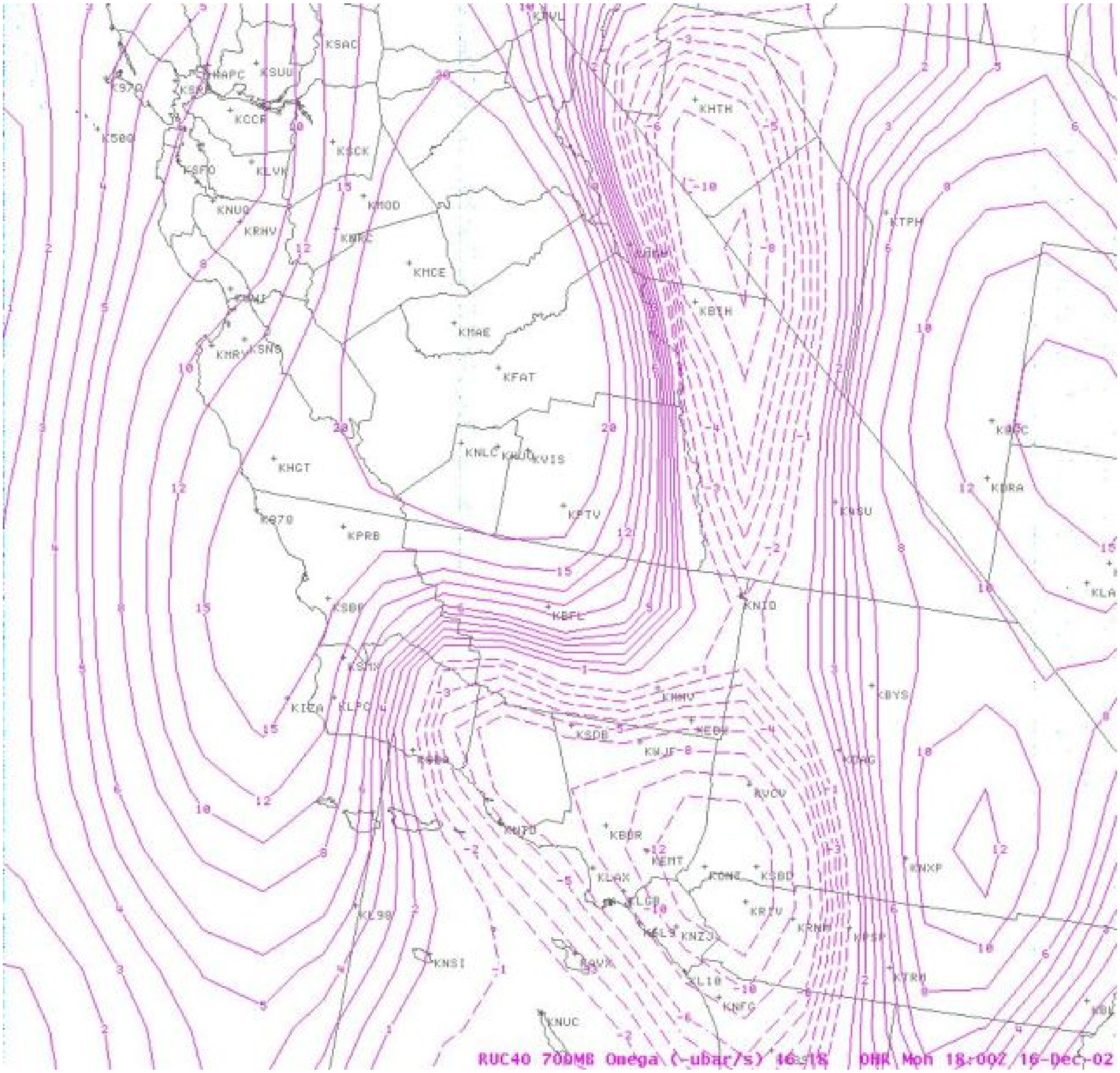
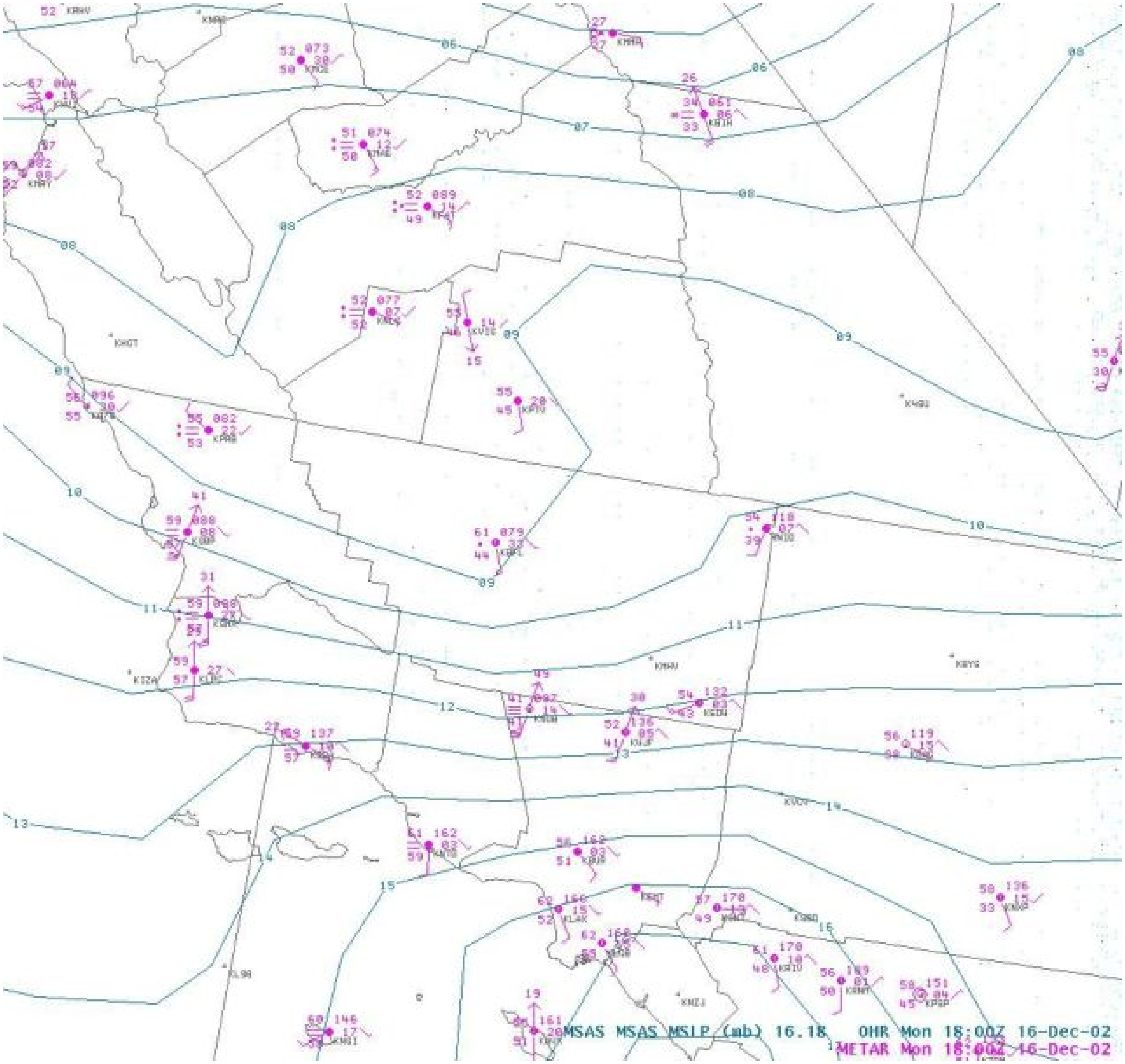


Figure 7


MSAS MSAS MSLP (mb) 16.18 0HR Mon 18:00Z 16-Dec-02
METAR Mon 18:00Z 16-Dec-02