24 November 2001 Snow Event Using the Weather Event Simulator (WES)

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Introduction

A rapidly developing extratropical cyclone moved across northern California early on 24 November 2001. Model output and related locally developed snow forecast tools indicated snow levels and hence any significant snow fall would occur generally above 3500-4000 feet across northern sections of the WFO Eureka County Warning Area (CWA). Across the northeast part of the CWA snow fall overnight reached valley floors below 1000 feet, and significant snow accumulations of 6-8 inches occurred down to 2000 feet. The focus of this scenario is to investigate this recurring phenomena. Prior to this WES investigation, hypotheses of cold air trapping, dynamic cooling associated with rapid pressure falls, and below cloud evaporative cooling have been put forth as explanations of significant lowering snow levels. Situations of significantly lower than forecast snow levels have been somewhat common over northeast portions of the CWA. All of the processes previously stated play a roll in lowering the snow levels during these events. But, the primary mechanism appears to be cool dry air just north of a warm front that is continually reinforced by low level easterly flow. In this scenario we investigate and review one meteorological pattern that can lead to this sustained easterly flow.

Synoptic and Mesoscale Features

Antecedent conditions that are favorable to cool dry air (fig. 1) over and to the northeast of the affected area were present a few days prior to the event. Late on November 23, 2001 a deep extensive upper level trough was located over the eastern Pacific just off the west coast. At that same time a rapidly deepening short wave was approaching the coast. Water vapor imagery between 0630 and 0930 UTC 24 November 2001 (fig. 2) clearly indicate the rapid drying just west of the baroclinic leaf approaching NW California. This combined with Equivalent potential vorticity analysis (fig. 3) show the environmental potential for rapid cyclogenesis being realized southwest of Cape Mendocino. Subsequently a rapidly deepening surface low is observed (fig. 4) and (fig 5). The associated low level wind flow, frontal convergence and associated temperature gradient indicating the approximate location of the developing warm front can be seen in (fig. 6). During this same time period the favorable juxtaposition of the entrance and exit regions of two jet streaks was enhancing upper level support.

As offshore rapid cyclogenesis progressed (1001mb to989mb from 0900 UTC to 1300 UTC 24 Nov 2001) inland pressure falls and some Northeast cross gradient flow were indicated. This lead to a situation were dynamic cooling of the column was taking place and cool dry air was advected from the NE across the resultant heavy snow zone in the eastern half of Trinity Co. As the southeasterly flow in the warm sector intensified it rapidly transported warm saturated air along isentropic surfaces northward over the warm front. These two relatively low level effects can be seen in (fig. 6) and (fig. 7) and were not well modeled due to the inability of the models to capture the rapid development of the surface cyclone and associated effects. As these two processes came together the resultant rapidly developing cloud shield and associated precipitation can be seen in (fig. 8). Due to and during the rapid deepening phase of the extratropical cyclone the easterly translation of the center of the low stopped just south of Cape Mendocino for 6 hours, and provided the final ingredient needed for a significant snow event at lower elevations.

Discussion

Situations of sustained low level easterly flow over inland valleys of NW California have the potential to lead to significantly lower snow levels accompanied by heavy snow events. If the associated short wave is progressively forcing a warm front through the affected area and stopping the NE flow, heavier and lower snow level events are less likely. As in this case, when the warm front becomes quasi-stationary the cooling processes have time to develop and maintain lower snow levels, leading to significant events. This assumes antecedent conditions that are favorable to cool dry air being present over and to the northeast of the affected area i.e. A few dry days followed by relatively clear skies the night before a morning event. This situation will lead to enhanced cooling of inland valleys.

It is important to understand that radiation cooling over an inland valley and the associated trapped cool air by itself is likely insufficient to lead to a significant snow event. It should be pointed out that this is the extreme case of this process chosen for best illustration.

Figure 1

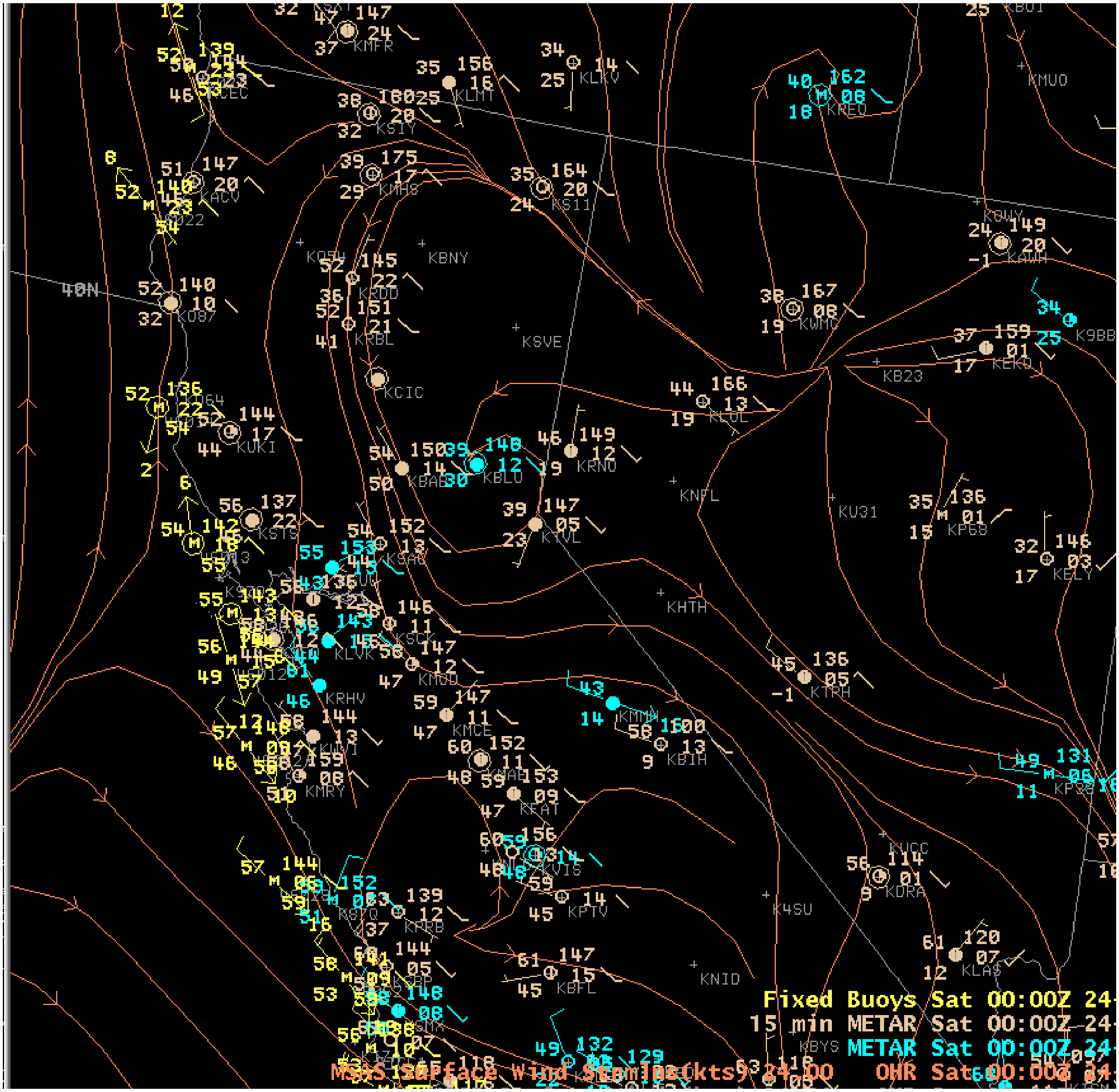
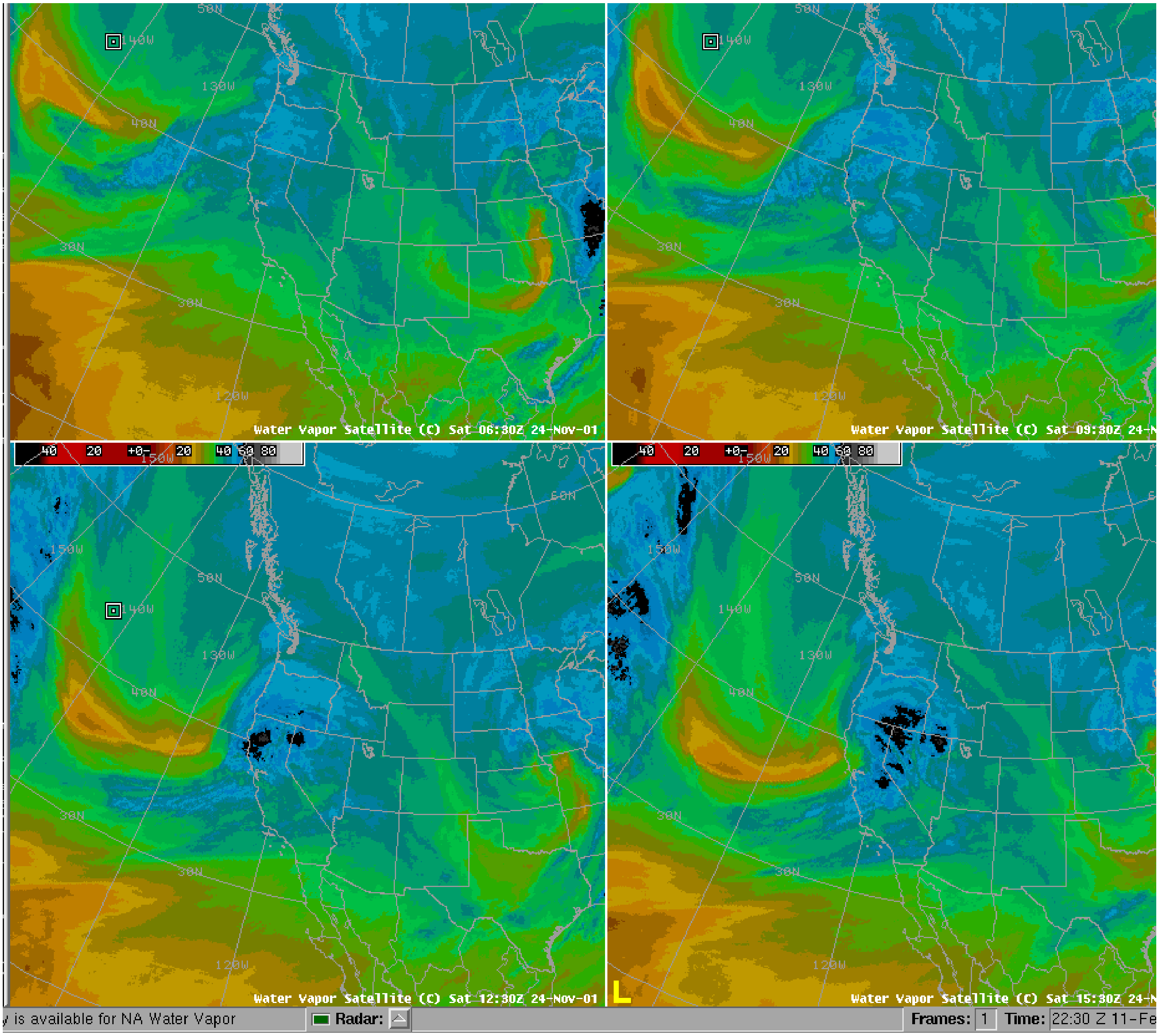

Fixed Buoys Sat 00:00Z 24-
15 min METAR Sat 00:00Z 24-
METAR Sat 00:00Z 24-
40N

Figure 2



Water Vapor Satellite (C) Sat 06:30Z 24-Nov-01
Water Vapor Satellite (C) Sat 12:30Z 24-Nov-01
Radar:
Frames: 1
Time: 22:30 Z 11-Fe

Figure 3

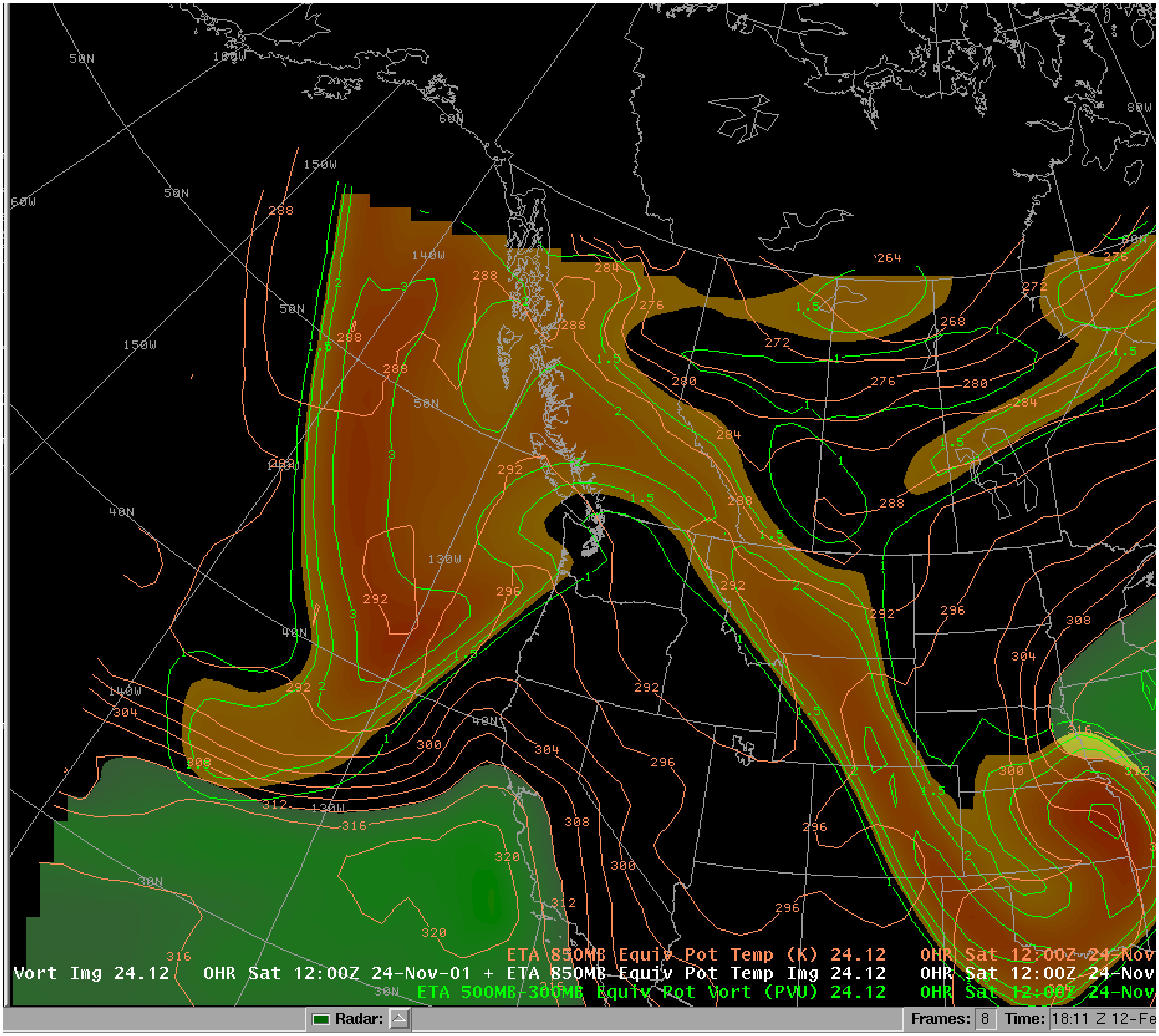

ETA 850MB Equiv Pot Temp (K) 24.12 0HR Sat 12:00Z 24-Nov
Vort Img 24.12 0HR Sat 12:00Z 24-Nov-01 + ETA 850MB Equiv Pot Temp Img 24.12 0HR Sat 12:00Z 24-Nov
ETA 500MB-300MB Equiv Pot Vort (PVU) 24.12 0HR Sat 12:00Z 24-Nov
Radar:
Frames: 8
Time: 18:11 Z 12-Fe

Figure 4

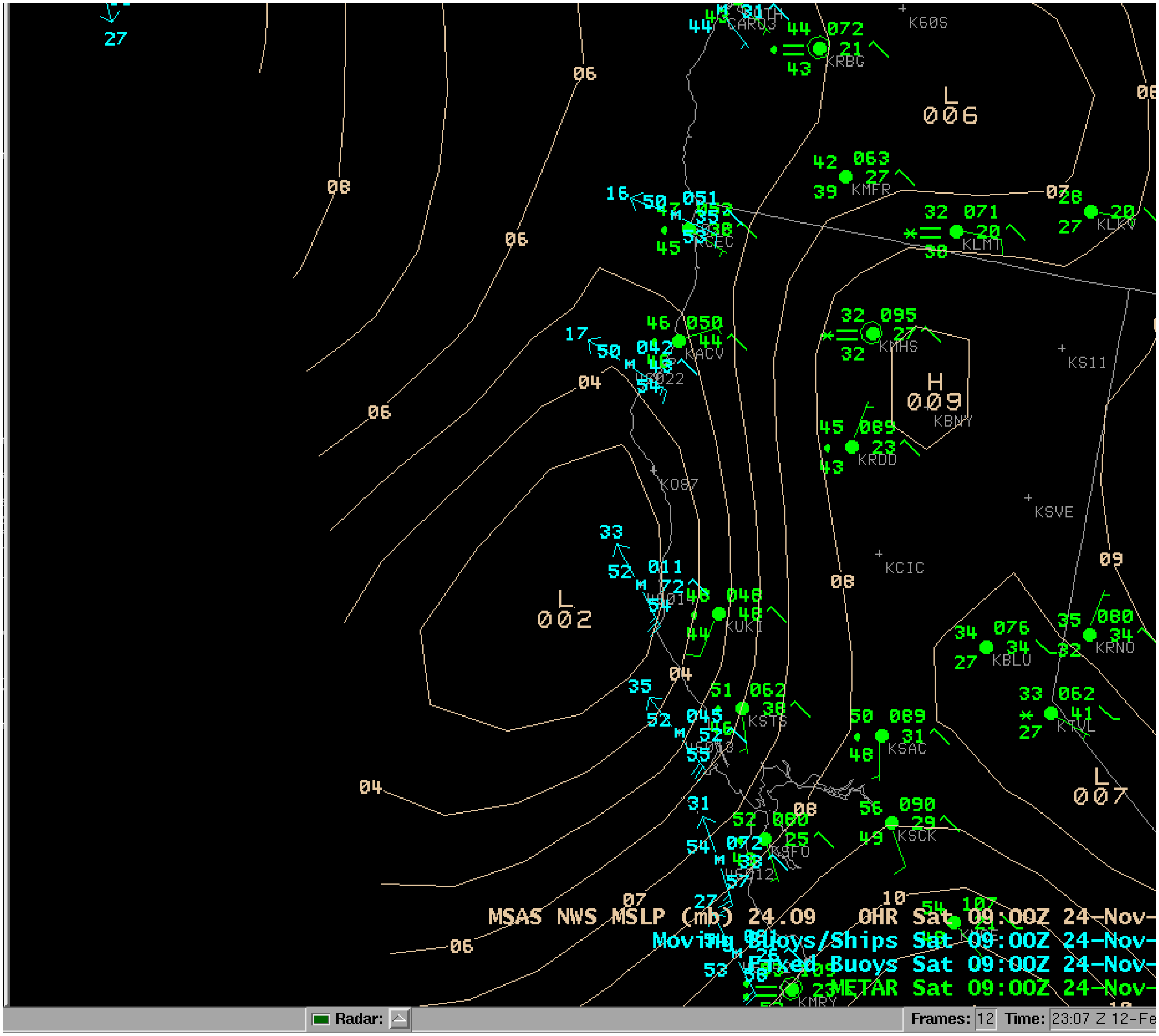

MSAS NWS MSLP (mb) 24.09 0HR Sat 09:00Z 24-Nov-
Moving Buoys/Ships Sat 09:00Z 24-Nov-
Fixed Buoys Sat 09:00Z 24-Nov-
METAR Sat 09:00Z 24-Nov-
Radar:
Frames: 12
Time: 23:07 Z 12-Fe

Figure 5

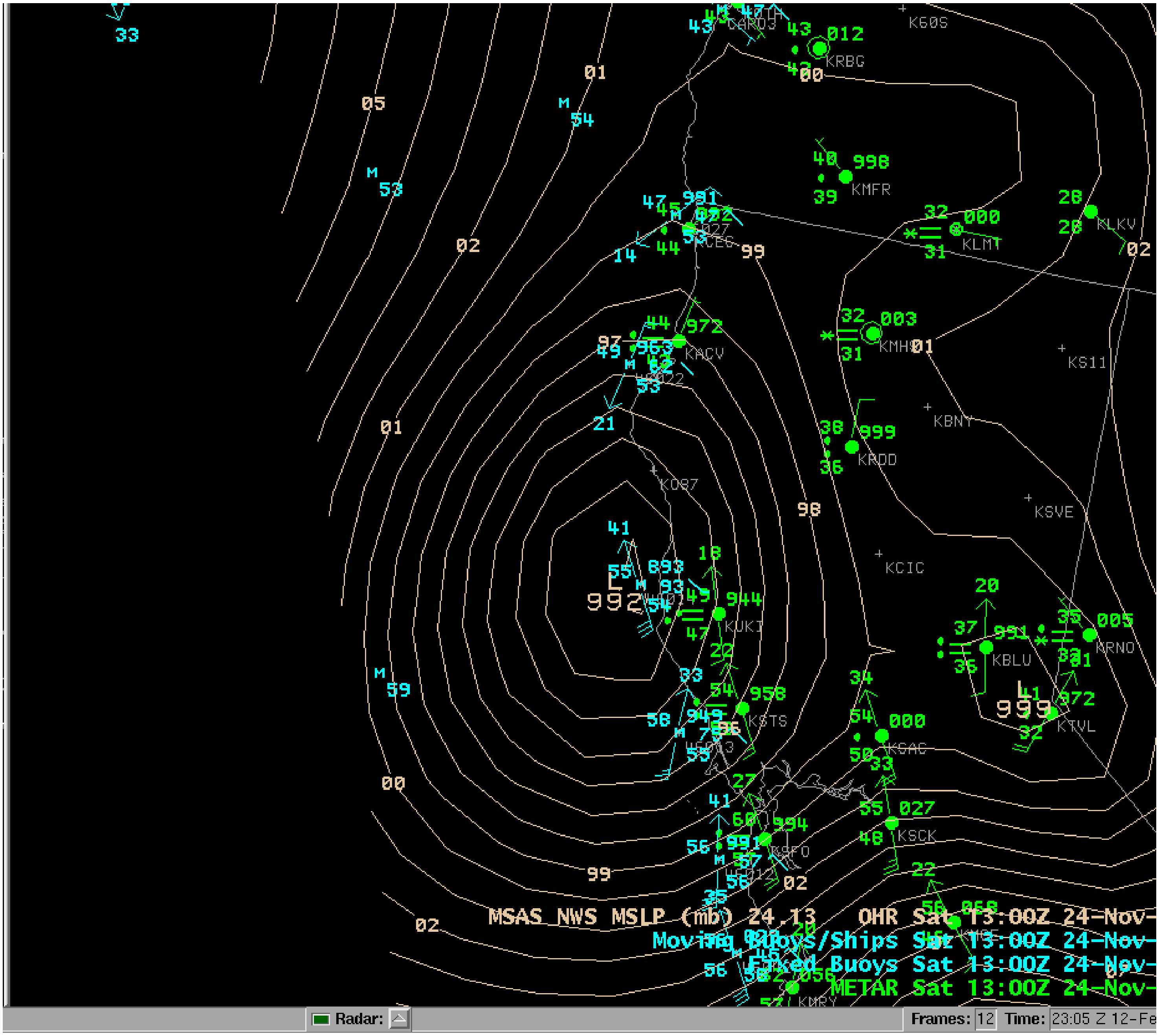

MSAS NWS MSLP (mb) 24.13 0HR Sat 13:00Z 24-Nov-
Moving Buoys/Ships Sat 13:00Z 24-Nov-
Fixed Buoys Sat 13:00Z 24-Nov-
METAR Sat 13:00Z 24-Nov-
Radar:
Frames: 12
Time: 23:05 Z 12-Fe
KRBG
KMFR
KLMT
KLKV
KMHS
KS11
KBNY
KRDD
KSVE
KCIC
KUKI
KBLU
KRNO
KTVL
KSTS
KSAC
KSCK
KSFO
KMRY
K60S
KACV
K087
992
999

Figure 6

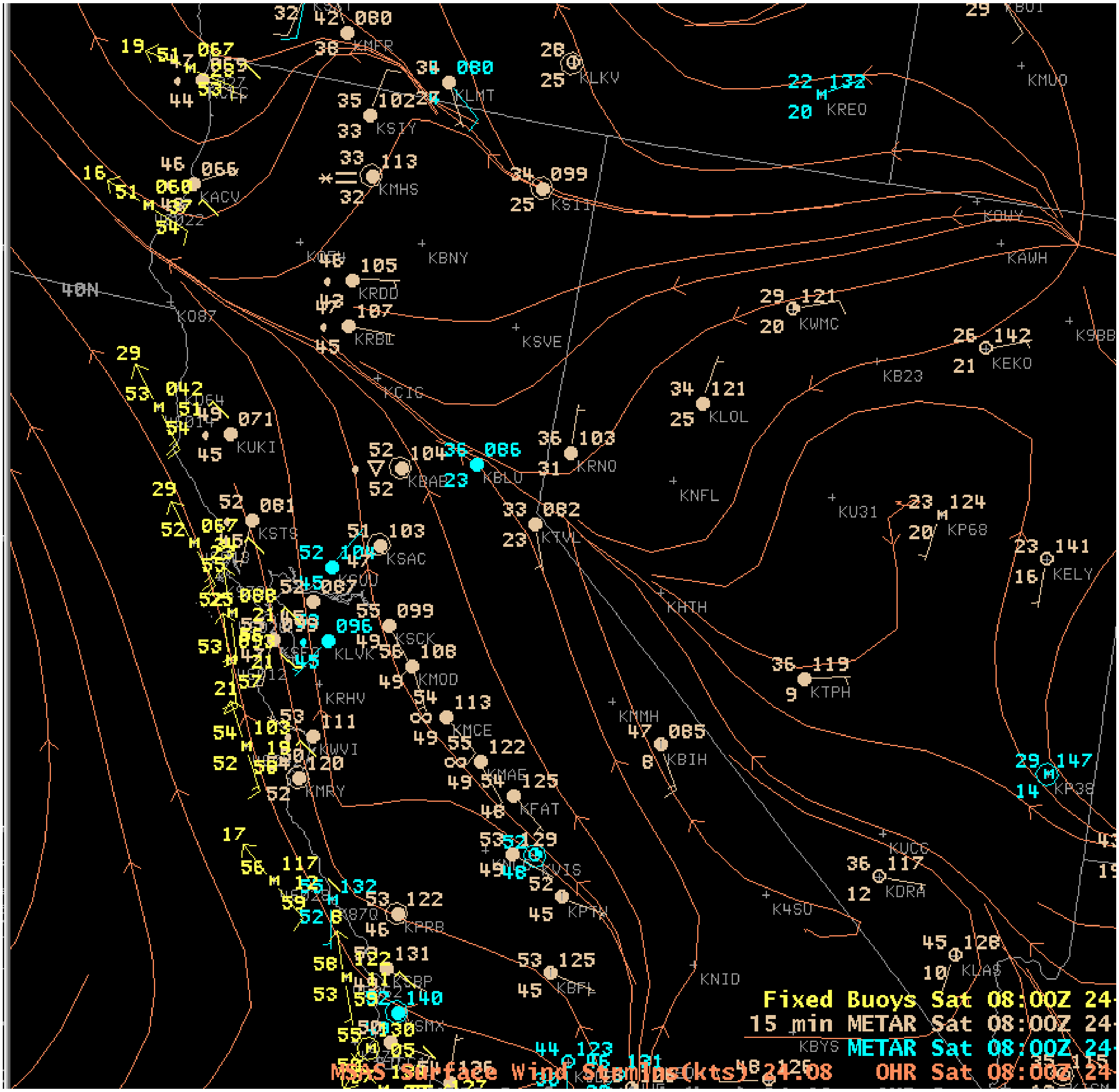

40N
Fixed Buoys Sat 08:00Z 24-
15 min METAR Sat 08:00Z 24-
METAR Sat 08:00Z 24-
MSAS Surface Wind Streamlines(kts) 24-08
OHR Sat 08:00Z 24-

Figure 7

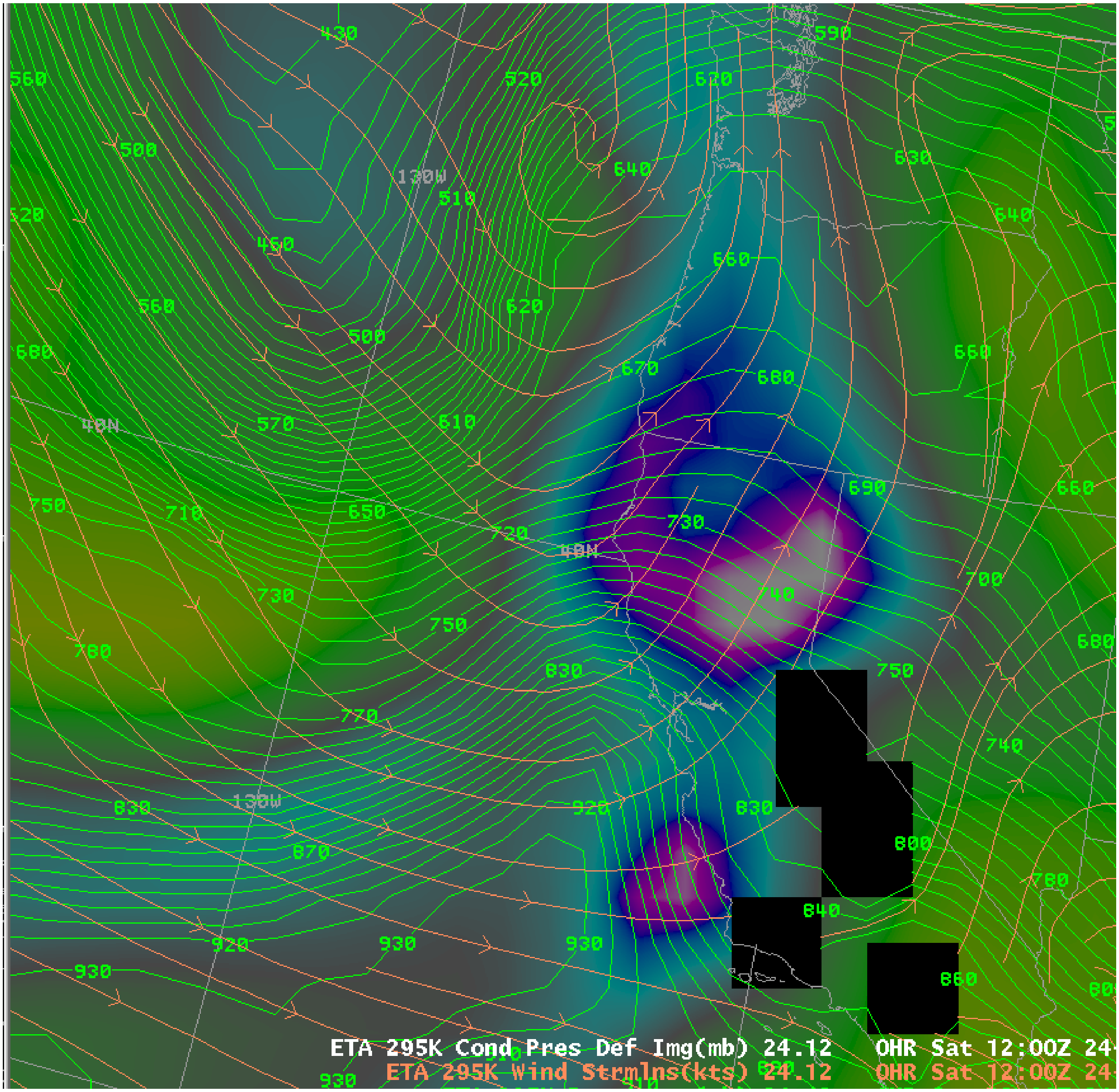
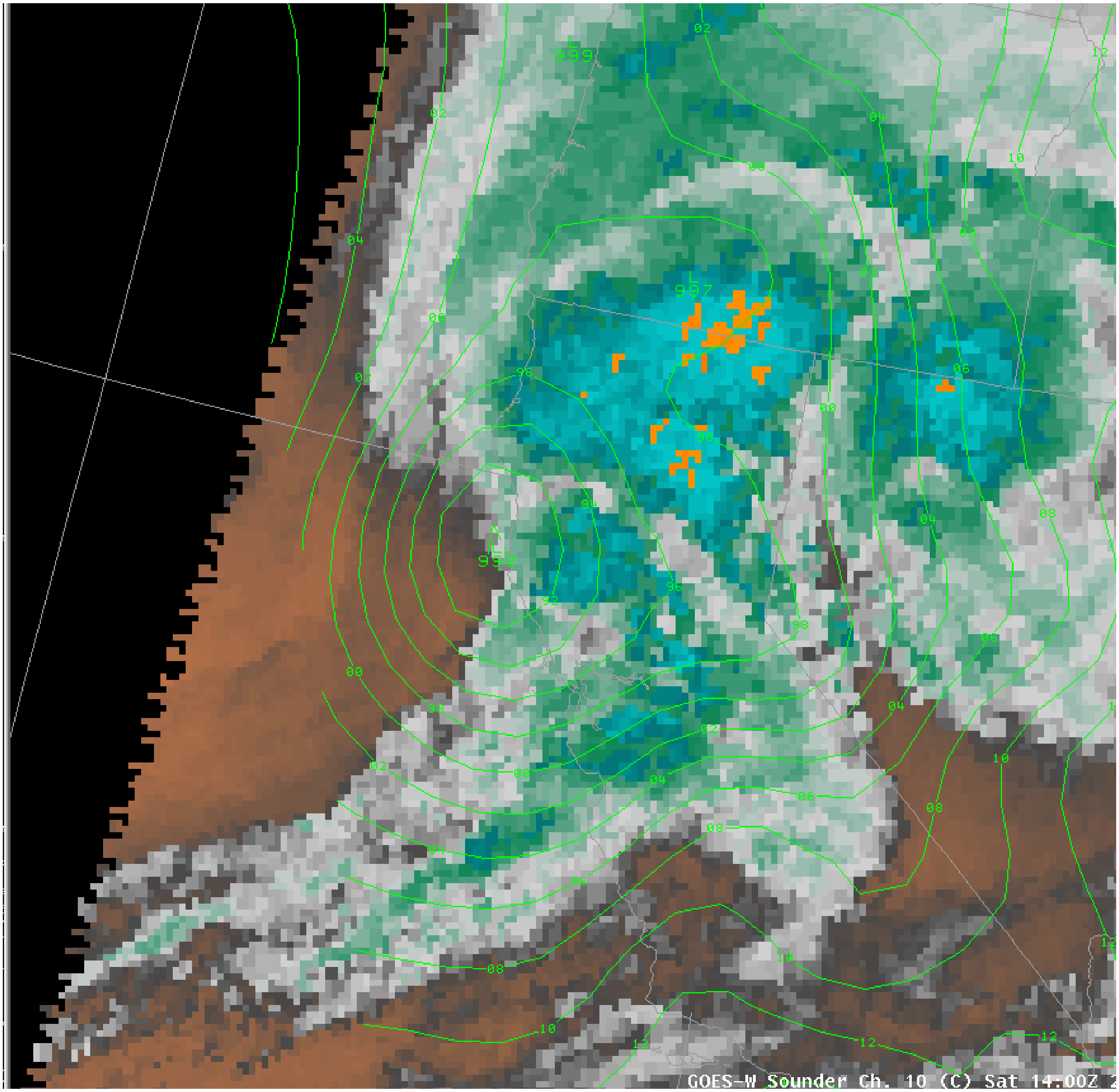

ETA 295K Cond Pres Def Img(mb) 24.12 OHR Sat 12:00Z 24
ETA 295K Wind Strmlns(kts) 24.12 OHR Sat 12:00Z 24

Figure 8


GOES-W Sounder Ch. 10 (C) Sat 14:00Z 2