An Examination of an Intense Land-falling Narrow Cold Frontal Rainband Using the Weather Event Simulator (WES)

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Introduction

This WES case involves an intense narrow cold frontal rainband (NCFR) which moved onshore and then southeastward through the WFO Monterey County Warning Area during the afternoon of Saturday 14 December 2002. This occurred in association with one of several very intense storm systems that each brought strong winds and heavy rain to northern and central California during the month of December 2002. Peak winds in the San Francisco Bay Region in the present event occurred in the strong southerly flow shortly preceding and accompanying the cold frontal passage, with maximum wind speed observations including 80 mph (69.5 kts) at Cazadero in northern Sonoma County, 56 mph (48.6 kts) at Pigeon Pt (on the coast about 60 km south of San Francisco), and 50 mph (43.4 kts) at both San Francisco and Oakland International Airports. By Saturday night almost 300,000 homes in the region had lost electrical service; in addition, heavy rains brought local hydrological problems and very high waves battered the coast.

The most intense portion of the storm occurred in association with the passage of the NCFR, which had developed squall line-like intensity by the time it moved onshore. The WES exercise itself focused on the slightly more than1.5 hour period from 2225Z 14 December through 0000Z 15 December (2:25-4:00 pm LST 14 December) during which the NCFR moved through the heart of the district. Previous cases of intense NCFRs ,with at least superficial similarity to the one seen here, have sometimes been associated with severe convective weather, including tornadoes.

Overview of WES Exercise

The first part of this WES exercise, then, was for the forecaster to monitor the onshore progression of the NCFR during the aforementioned 1.5 hour period and determine whether any severe weather warnings were needed. If the assessment was in the affirmative, the forecaster was then asked to specify what type of warning would be issued and the area and time for which it would be in effect, and to provide an evaluation of the likelihood that the warned-on severe weather phenomenon would in fact occur. Alternatively, if a negative assessment was made, the forecaster was to explain what key ingredient(s) was (were) absent – and how this could be determined through examination of the available observational and/or numerical model data.

The second part of the WES exercise was to determine, as precisely as possible, the predicted locations of the cold front at 00Z 15 December from the 18Z 14 December output of the GFS and Eta models, respectively – and to explain the procedure followed to determine the precise location of the cold front itself from the model output. The forecaster was then asked to evaluate the relative success of these two model runs in projecting the 00Z frontal location.

Synoptic Overview

A 4-km resolution infrared satellite image from 2100 UTC 14 December (Figure 1) shows a large frontal cloud mass moving onshore over northern and central California. Superimposed on this satellite image are 3-hr forecast 500 mb height contours and 850 mb winds from the 1800 UTC run of the Eta model. Strong synoptic-scale dynamical forcing is implicit ahead of the pronounced upper-level short-wave trough, while model output winds at 850 mb in the vicinity of the front exceed 70 kts. Surface ASOS and marine buoy observations taken at 2100 UTC are overlaid on a simultaneous 1-km resolution visible satellite image (Figure 2), and show the strong sea level pressure gradient and accompanying south-southeast winds preceding the front.

Mesoscale Structure and WES Exercise on Severe Weather

Base elevation reflectivity and velocity images from the KMUX doppler radar showed the embedded front itself had acquired the structure of a NCFR. Reflectivity and velocity images from 2231 UTC (Figures 3 and Figure 4, respectively) show the heavy precipitation band and accompanying wind shear line making landfall on the southern San Mateo County coast, and then extending south-southwestward offshore over the coastal waters. In interpreting these images, it should be noted that the radar is sited near the summit of a 1063 m mountain– and thus even for near-shore portions of the NCFR, mean base elevation scan height is far above the ocean surface.

Severe convective weather, including tornadoes of F0 to F2 intensity, have previously been observed in conjunction with such intense NCFRs. To the best of our knowledge, however, no severe convective weather occurred in this case. Previous research studies have shown that the key environmental ingredients associated with severe cool-season convection in coastal northern and central California are the following: strong low-level vertical wind shear, positive (and usually strong) dynamic forcing, and at least a few hundred Joules per kg of positive buoyancy. The missing ingredient in the present case was the positive buoyancy. This WES case thus provided a rare "null" case study of a situation which superficially appeared conducive to the occurrence of severe weather.

WES Exercise on Model Forecast vs Observed Cold Frontal Locations

Hourly plots of ASOS and marine buoy observations over heart of the greater San Francico Bay Region for the period 21 UTC 14 December through 00 UTC 15 December are shown in Figure 5a, 5b, 5c, 5d. Comparison of exact reported wind shift times in the METARS (where available) with base radar reflectivity data indicated the surface cold frontal passage occurred about 15-20 min prior to the passage of the center of the NCFR as indicated by the radar. This appears to be a consequence of a combination of the backward tilt with height of the frontal surface, and the elevation of the base reflectivity radar scan.

Determination of the Eta and GFS forecast frontal locations verifying at 00 UTC 15 December proved to be a fairly challenging exercise. Several factors contributed to this, including the limited spatial and temporal resolution of the model output, the presence of multiple frontal features in the model solutions, and the distortion away from classical frontal signatures as interaction with the coastal topography occurred.

Figure 1

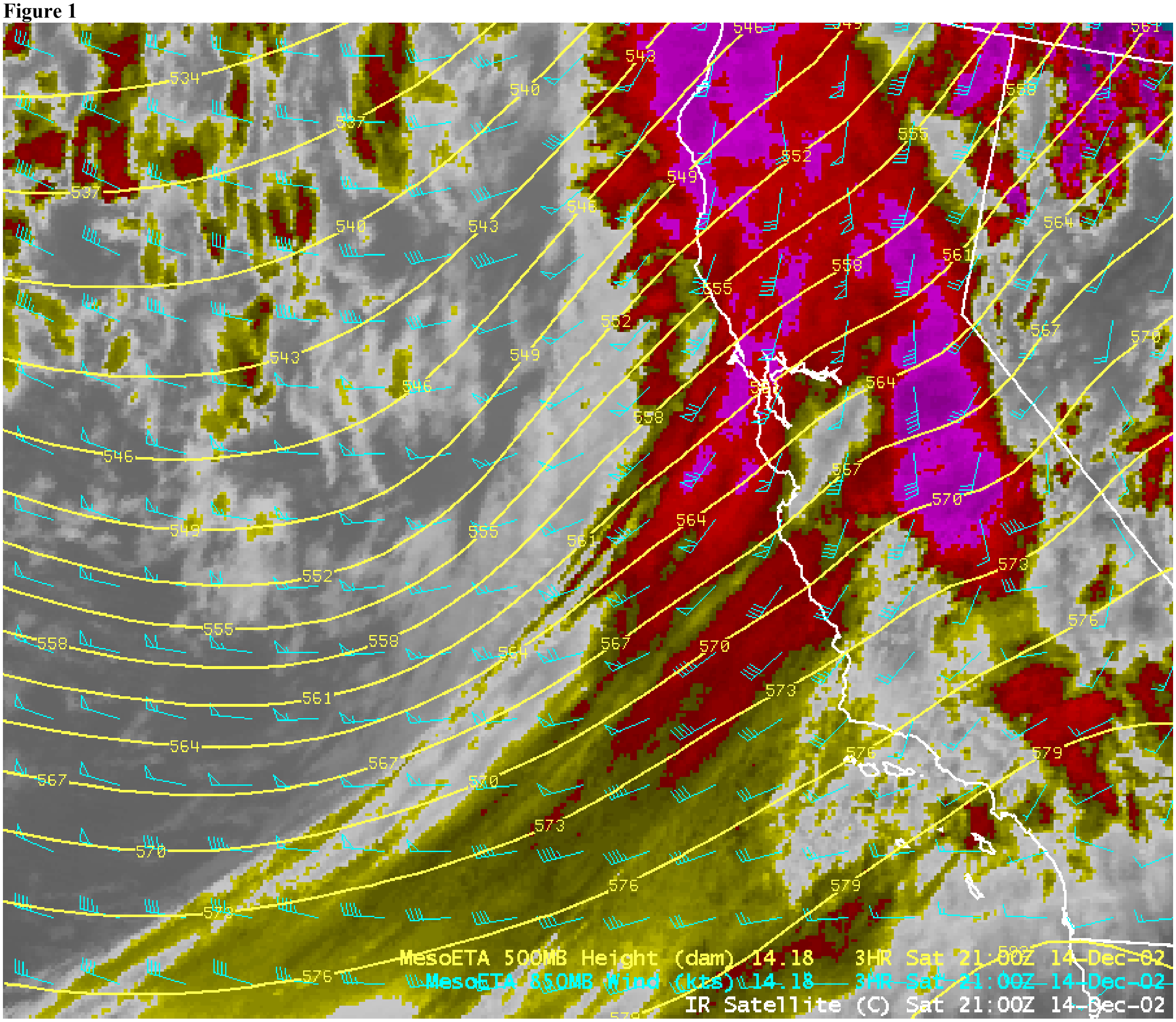


Figure 2

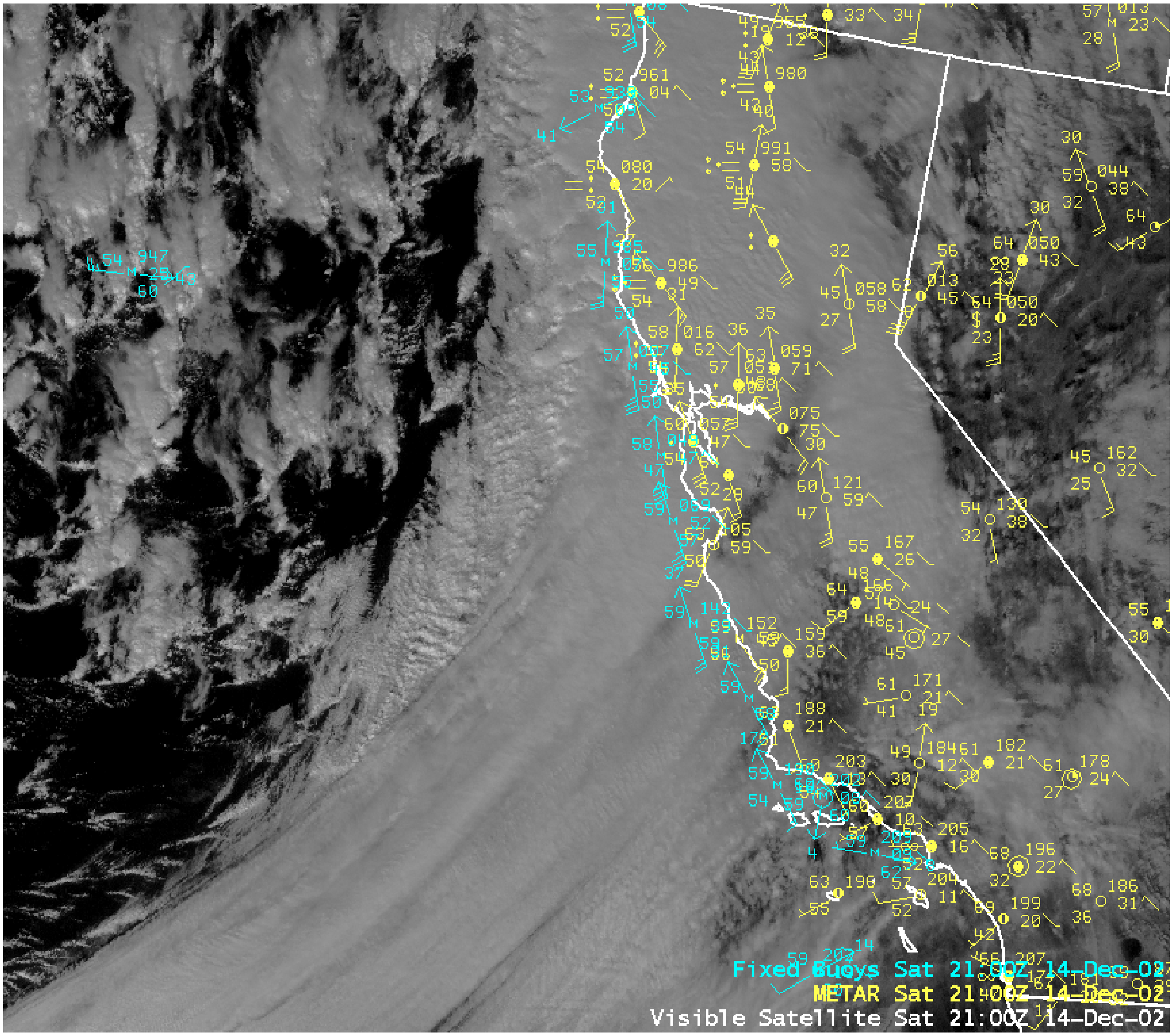

Fixed Buoys Sat 21:00Z 14-Dec-02
METAR Sat 21:00Z 14-Dec-02
Visible Satellite Sat 21:00Z 14-Dec-02

Figure 3

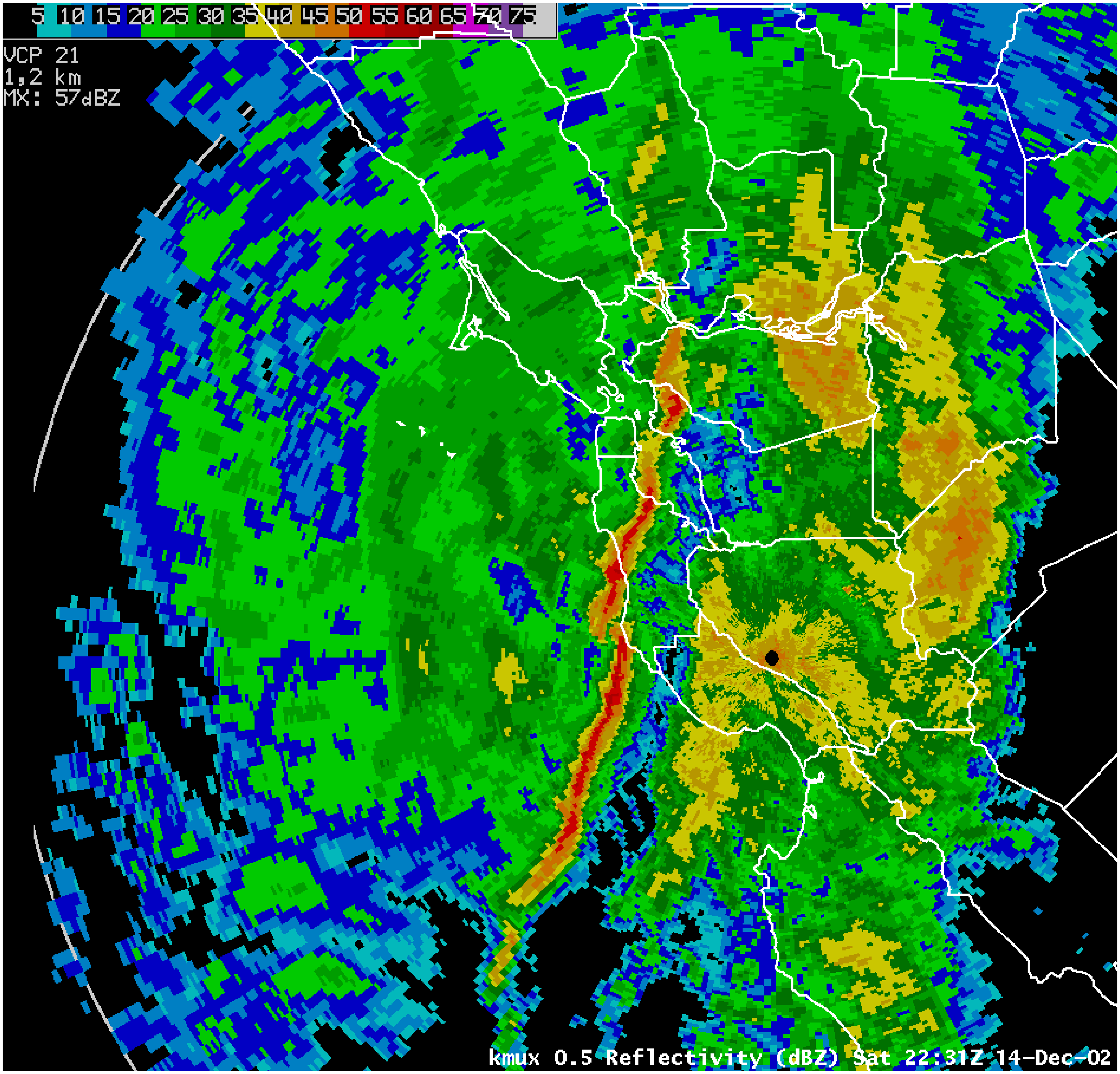

5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
VCP 21
1,2 km
MX: 57dBZ
kmux 0.5 Reflectivity (dBZ) Sat 22:31Z 14-Dec-02

Figure 4

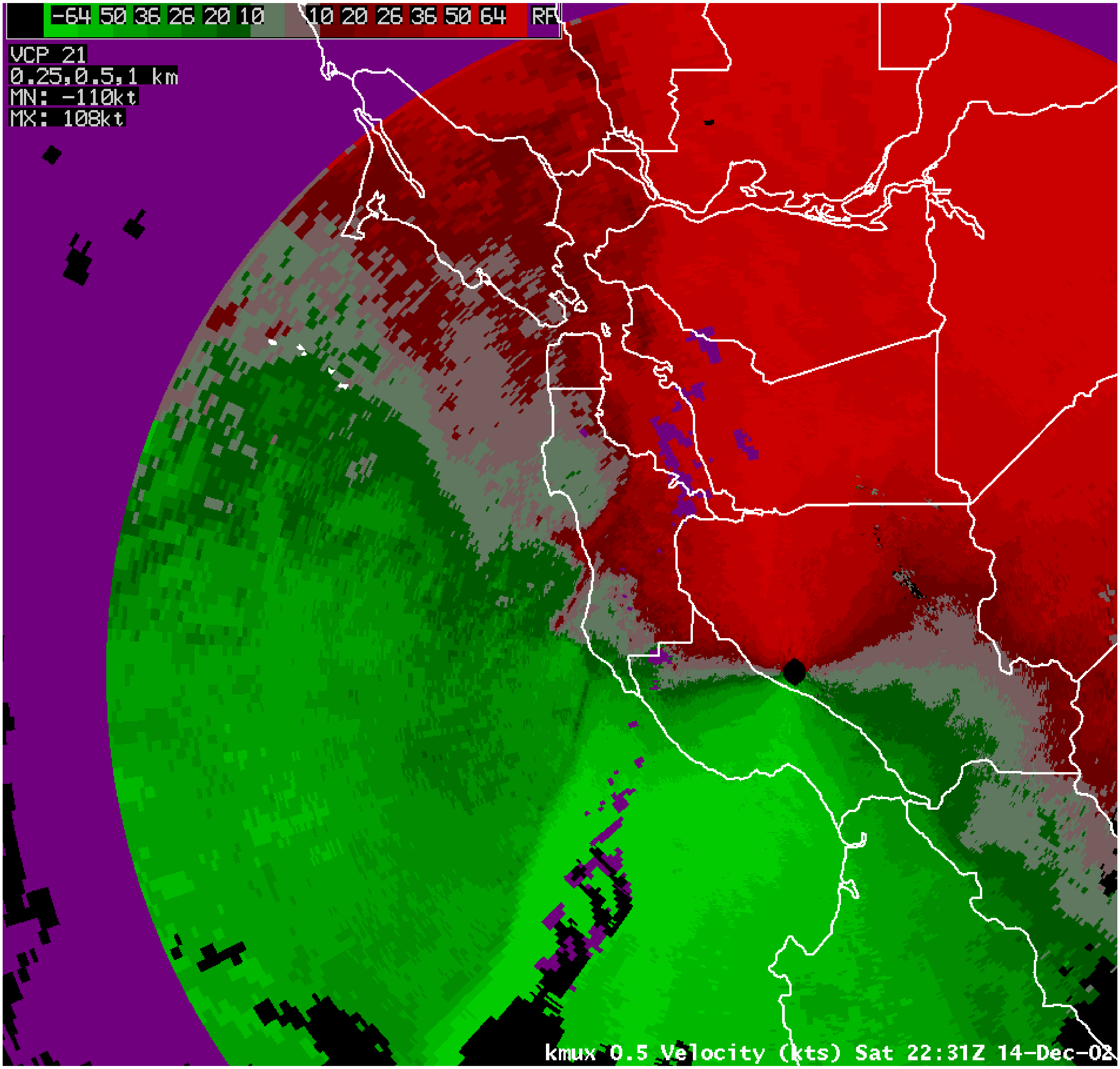
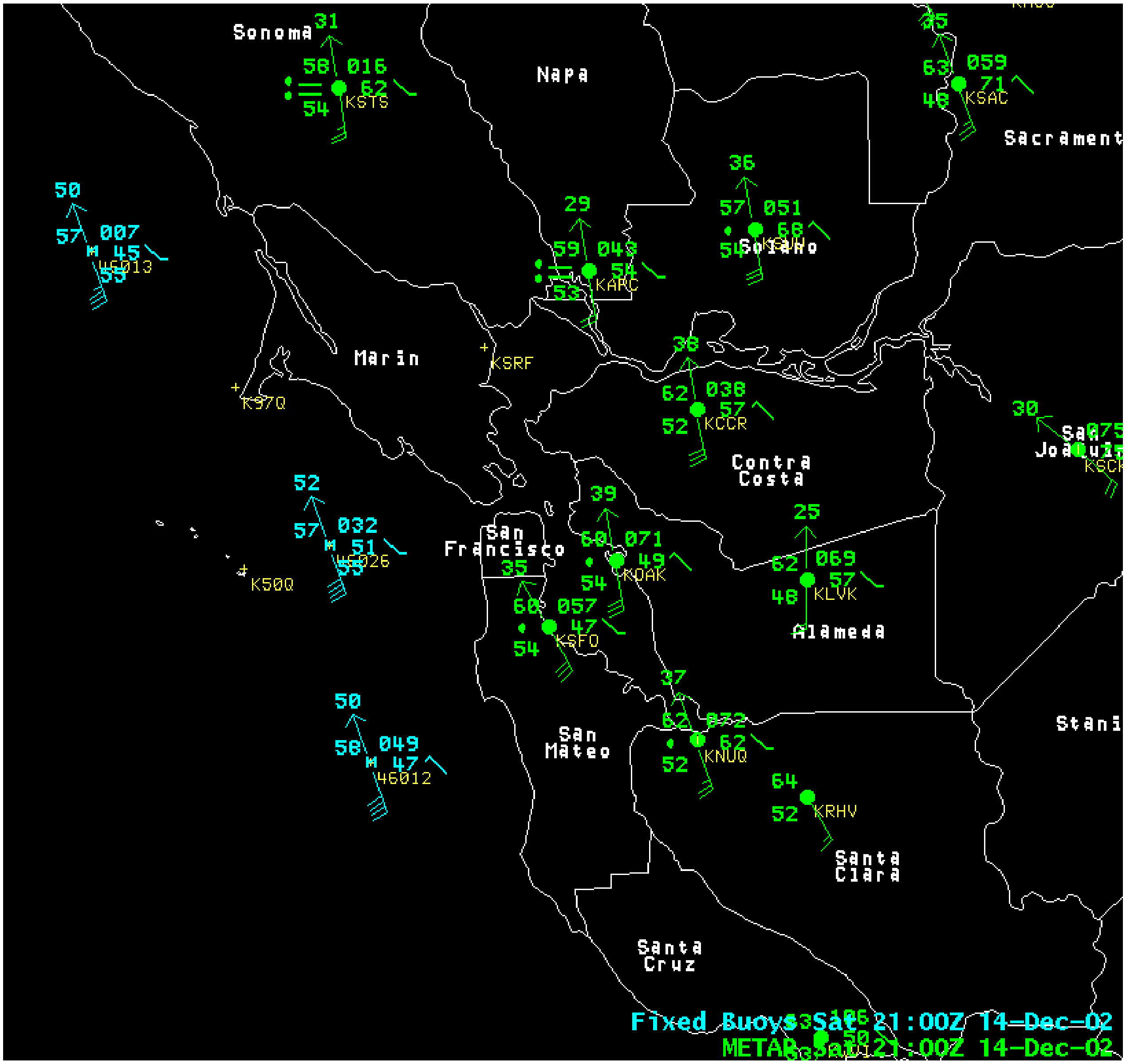

-64 50 36 26 20 10
10 20 26 36 50 64
RF
VCP 21
0.25,0.5,1 km
MN: -110kt
MX: 108kt
kmux 0.5 Velocity (kts) Sat 22:31Z 14-Dec-02

Figure 5a



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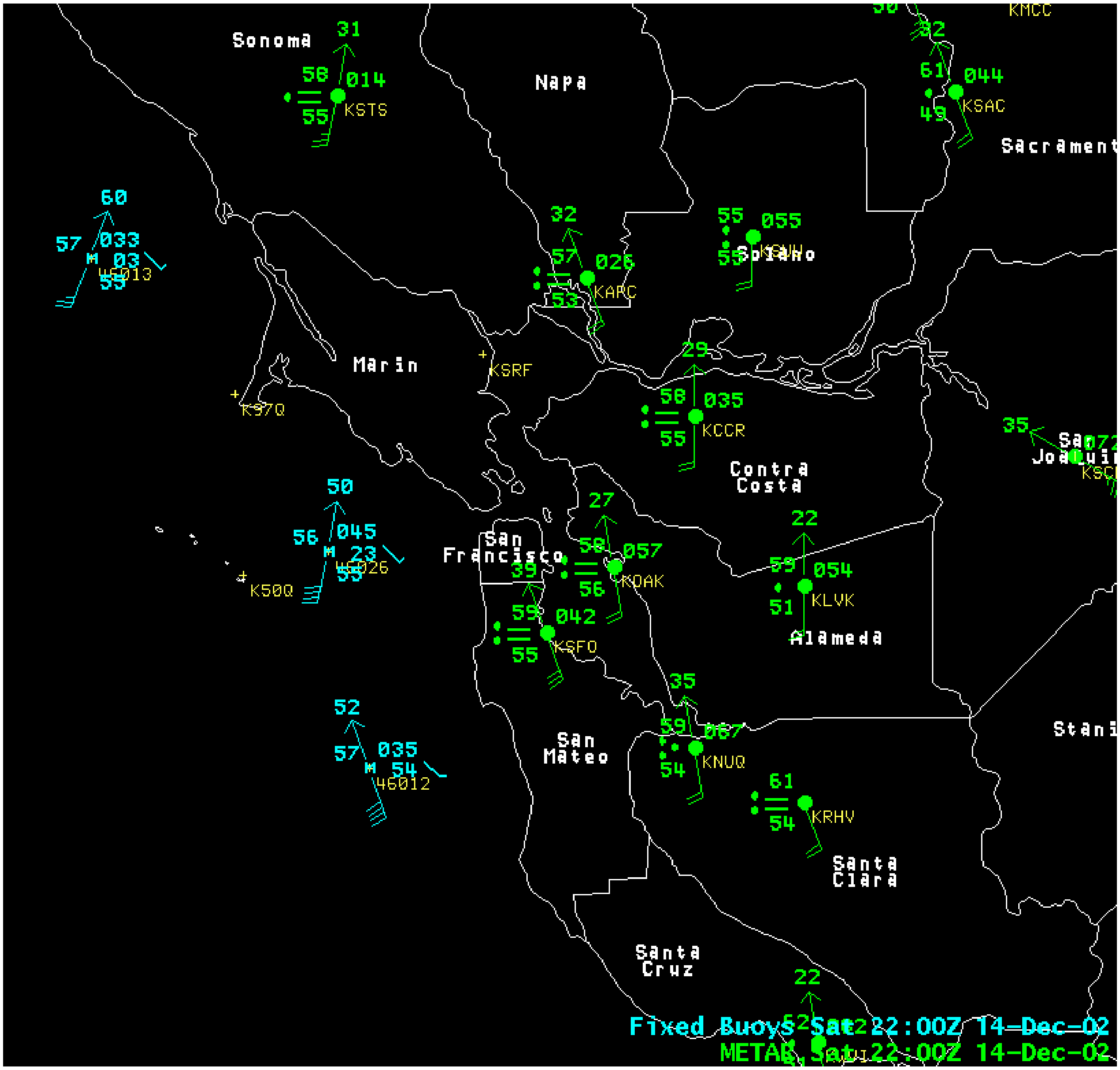
Fixed Buoys Sat 21:00Z 14-Dec-02
METAR Sat 21:00Z 14-Dec-02

Figure 5b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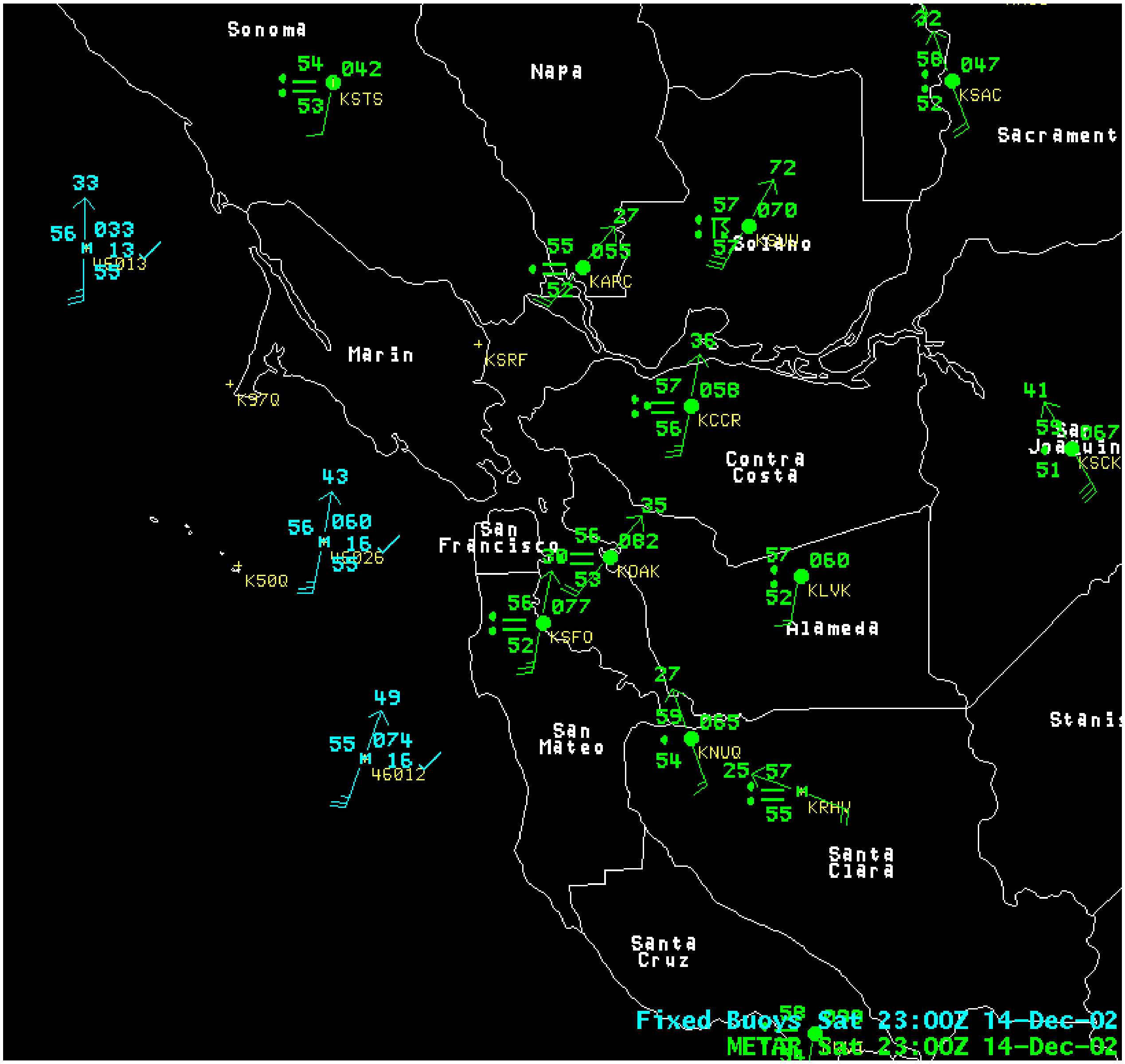
Fixed Buoys Sat 22:00Z 14-Dec-02
METAR Sat 22:00Z 14-Dec-02

Figure 5c



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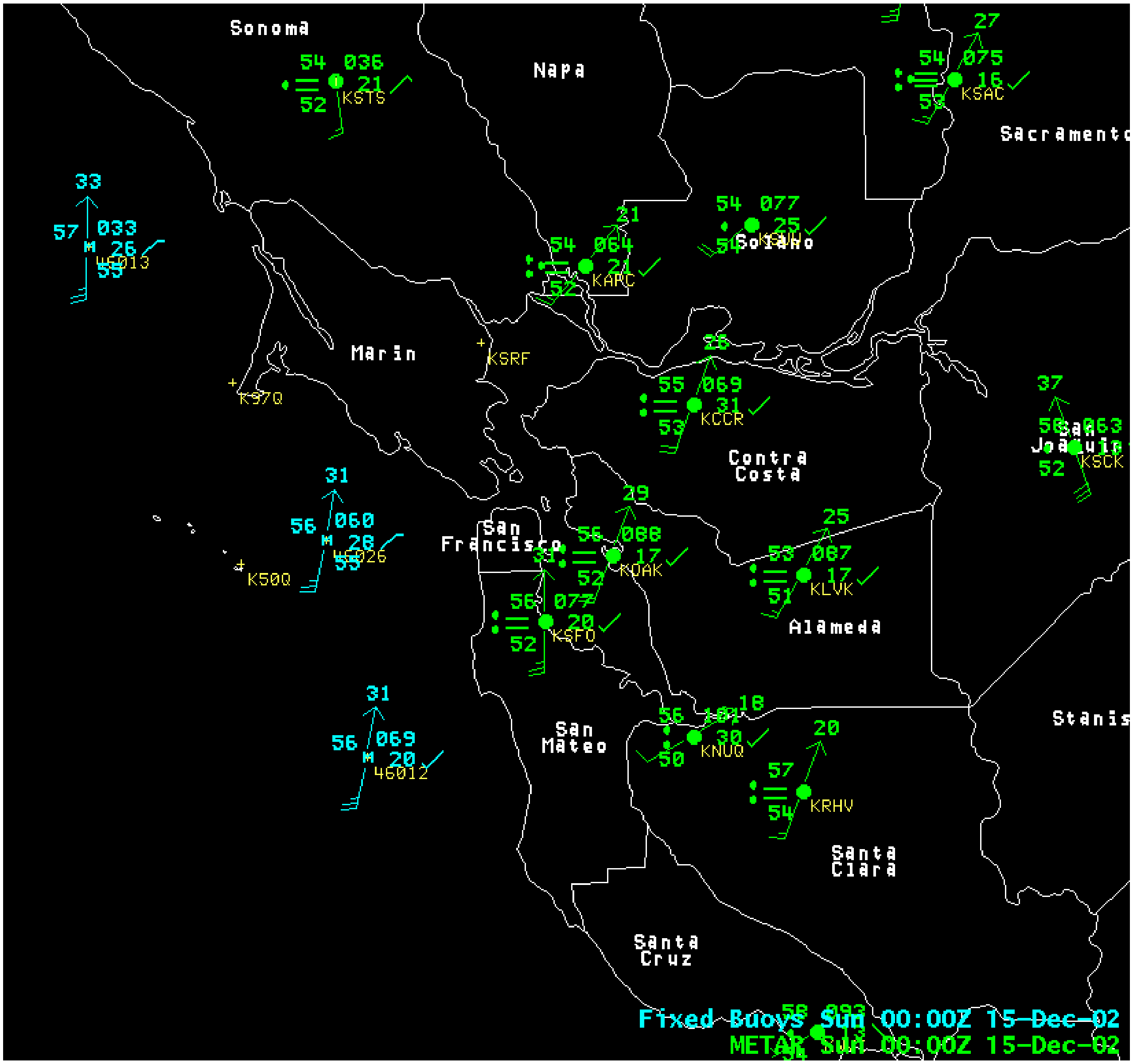
Fixed Buoys Sat 23:00Z 14-Dec-02
METAR Sat 23:00Z 14-Dec-02

Figure 5d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Fixed Buoys Sun 00:00Z 15-Dec-02
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