Integration of Aviation Weather Information Systems with Roadside Weather Information Systems for Rural Air Fields and Heliports

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Western Transportation Institute

Disclaimer

The opinions, findings and conclusions expressed in this presentation are those of the authors and not necessarily those of the California Department of Transportation, San Jose State University or Montana State University.

Abstract

Under contract with the California Department of Transportation (Caltrans), the Western Transportation Institute (WTI) at Montana State University, in partnership with the Mineta Transportation Institute (MTI) at San Jose State University, conducted a research and development study of a proof-of-concept system for integrating aviation weather information systems with Roadside Weather Information Systems (RWIS). The project was started in 2008. The goal of the project was to meet the needs of providing airport managers, air traffic controllers, pilots, and related operators of air ambulance services with more comprehensive and accurate meteorological data by integrating currently used weather systems with systems used by related agencies. Implementing such an integrated system is expected to improve safety and increase efficiency. The project was targeted at small, underserved rural airfields and heliports. The principal deliverable of the project is a website that integrates weather information from multiple sources including Caltrans and the National Weather Service, to present rural aviation users with an easy to use and useful mechanism for investigating current and forecast weather conditions.

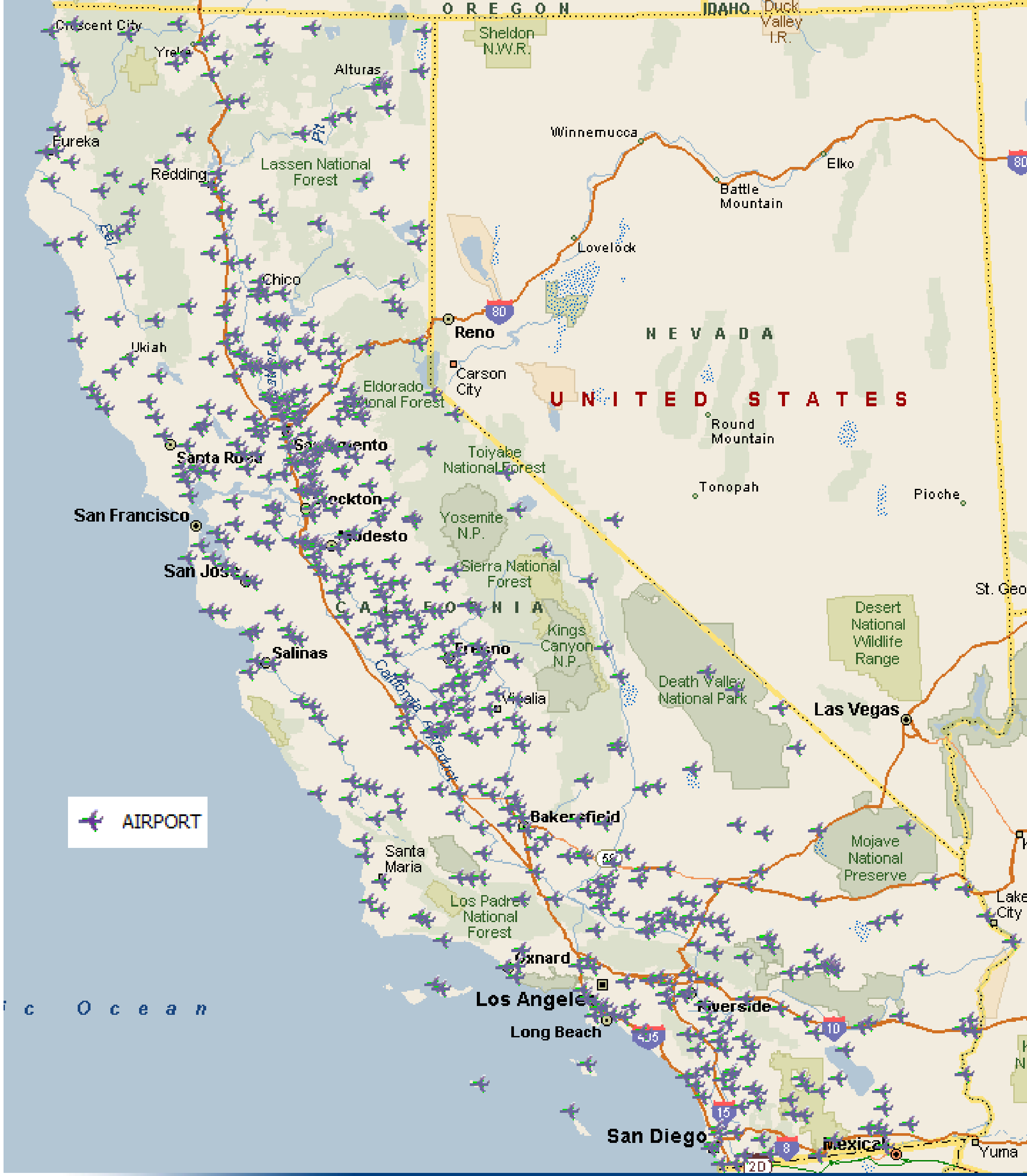
Problem

Underserved, rural airfields and heliports may not have access to comprehensive and accurate local meteorological data.

535 Airports

All airports in California, as reported by the FAA, are shown.

(includes public use and private use; general aviation, military, commercial, commuter)

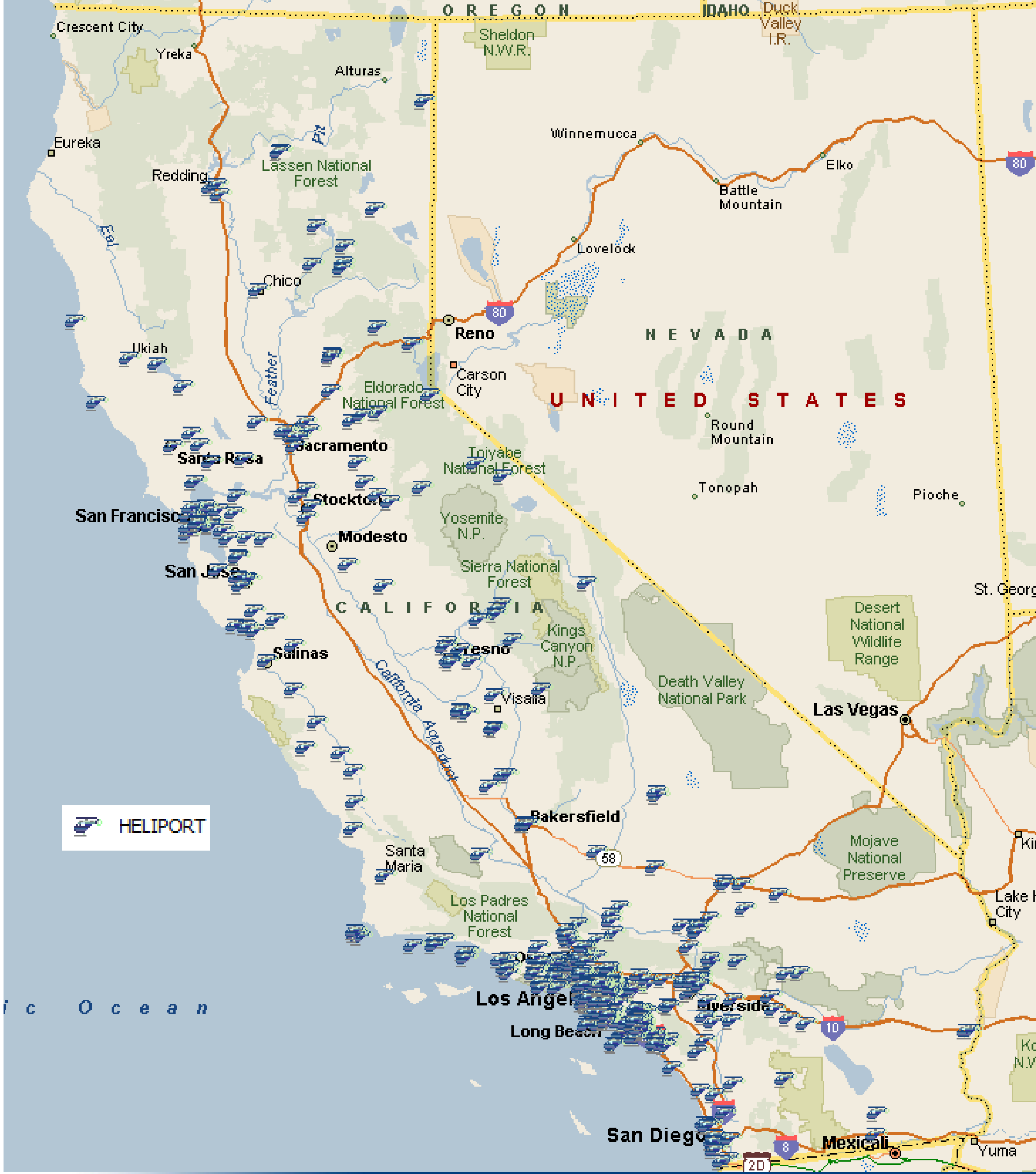


Source: FAA

419 Heliports

All heliports in California, as reported by the FAA, are shown. Heliports not reported by the FAA are not included.

A separate but overlapping list of 476 permitted heliports was used in the study and included 146 hospital heliports, 189 corporate heliports, 50 police heliports, 2 commuter heliports and 57 private heliports



Source: FAA

1 Ultra-light Facility
3 Glider Ports
9 Seaplane Bases

These sites are also reported by the FAA and are included in the proximity analysis shown in this report.

Source: FAA

Aviation Weather Systems

Automated Surface Observing System (ASOS) reports:

- Sky condition : cloud height and amount (clear, scattered, broken, overcast) up to 12,000 feet
- Visibility (to at least 10 statute miles)
- Basic present weather information: type and intensity for rain, snow, and freezing rain
- Obstructions to vision: fog, haze
- Pressure: sea-level pressure, altimeter setting
- Ambient temperature, dew point temperature
- Wind: direction, speed and character (gusts, squalls)
- Precipitation accumulation
- Selected significant remarks including- variable cloud height, variable visibility, precipitation beginning/ending times, rapid pressure changes, pressure change tendency, wind shift, peak wind.

Source: National Weather Service - http://www.weather.gov/ost/asostech.html

Aviation Weather Systems

Automated Weather Observing System (AWOS) reports:

- **AWOS A:** Dual-pressure sensor measures pressure and reports altimeter setting
- **AWOS I:** Wind Speed, Wind Gust, Wind Direction, Variable Wind Direction, Temperature, Dew Point, Altimeter Setting, Density Altitude
- **AWOS II:** Same as **AWOS** I + Visibility, Variable Visibility, Precipitation, Day/Night
- **AWOS III:** Same as **AWOS** II + Cloud Height & Sky Condition
- **AWOS III-P:** Same as **AWOS** III + Present Weather Identification Sensor
- **AWOS III-PT:** Same as **AWOS** III + Present Weather & Lightning Detection
- **AWOS III-PTZ:** Same as **AWOS** III + Present Weather & Lightning Detection, Freezing Rain Detection
- An Ultrasonic wind sensor can be used in place of the standard anemometer and wind vane in any of the above configurations. Ultrasonic configurations are indicated by a **U** at the end of the model number (for example, **AWOS III-PTU**)

Source: All Weather, Inc.- http://www.allweatherinc.com/aviation/awos_dom.html

Aviation Weather Systems

Automated Weather Sensor System (AWSS) may include the following with readings reported on a minute-by-minute basis:

- Forward Scatter Visibility Sensor: an active, electro-optical instrument that determines visibility by measuring the optical extinction coefficient of a beam of light as it passes through a known volume of air; advanced four-head, dual beam design measures fog, dust, rain, snow, haze, smoke, and sand.
- Ceilometer: a GaAs laser diode emits a laser pulse that is partially reflected from the cloud; the time when a pulse leaves the transmitter to when the reflected portion reaches the receiver varies with cloud height.
- Present Weather Sensor: measures precipitation by detecting the optical irregularities induced by particles falling through a beam of partially coherent infrared light.
- Wind Speed Sensor: a low-threshold, three-cup anemometer mounted to the top of the tower that measures wind speed.
- Wind Direction Sensor: a highly sensitive vane mounted to the top of the tower that measures wind direction.
- Freezing Rain Sensor: detects an occurrence of freezing rain by the change in the probe tip's oscillating frequency caused by ice accretion.
- Tipping Bucket Rain Gauge: precision sensor used to measure rainfall volume or rate.
- Motor Aspirated Radiation Shield with Temperature & Relative Humidity Sensor: precision temperature/humidity sensor housed in a Motor Aspirated Radiation Shield; designed for ventilation, and shielding from direct and reflected solar radiation and from direct moisture contact.

Source: All Weather, Inc.- http://www.allweatherinc.com/aviation/awss.html

Aviation Weather Stations

In California:

110 ASOS
1 AWOS I
1 AWOS II
54 AWOS III
14 AWOS IIIP
2 AWOS IIIP/T
3 AWSS

185 Aviation Weather Stations

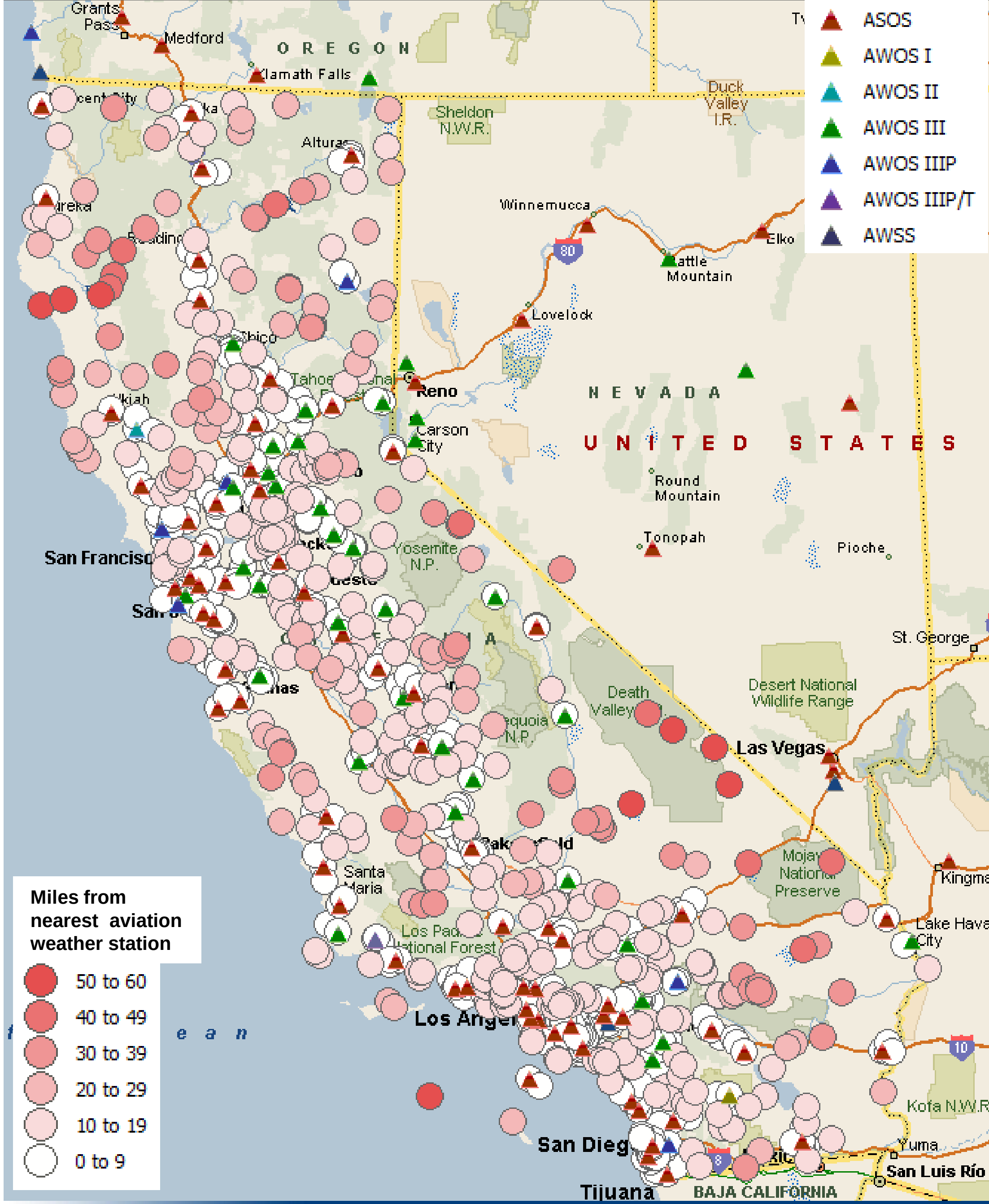
Others in proximity in Oregon, Nevada and Arizona are shown.

Source: FAA

Distances from airfields to nearest aviation weather stations:

Distance (mi)	count
dist < 5	298
5 ≤ dist < 10	262
10 ≤ dist < 20	261
20 ≤ dist < 30	82
30 ≤ dist < 40	46
40 ≤ dist < 50	10
50 ≤ dist	8

	mi
Min	0
Q1	3.88
Median	8.63
Q3	14.49
Max	59.77



Road Weather Information Systems (RWIS)

RWIS may report the following types of information:

Atmospheric data including:

- air temperature
- humidity
- visibility distance
- wind speed and direction
- precipitation type and rate
- cloud cover
- tornado or waterspout occurrence
- lightning
- storm cell location and track
- air quality.

Pavement data including:

- pavement temperature
- pavement freezing point
- pavement condition (e.g., wet, icy, flooded)
- pavement chemical concentration
- subsurface conditions (e.g., soil temperature).

Water level data including:

- stream, river, and lake levels near roads
- tide levels (i.e., hurricane storm surge).

Source: FHWA - http://ops.fhwa.dot.gov/weather/faq.htm

171 Caltrans RWIS

Not all sites are equipped with the same suite of sensors and not all sites publish their data outside their respective district.

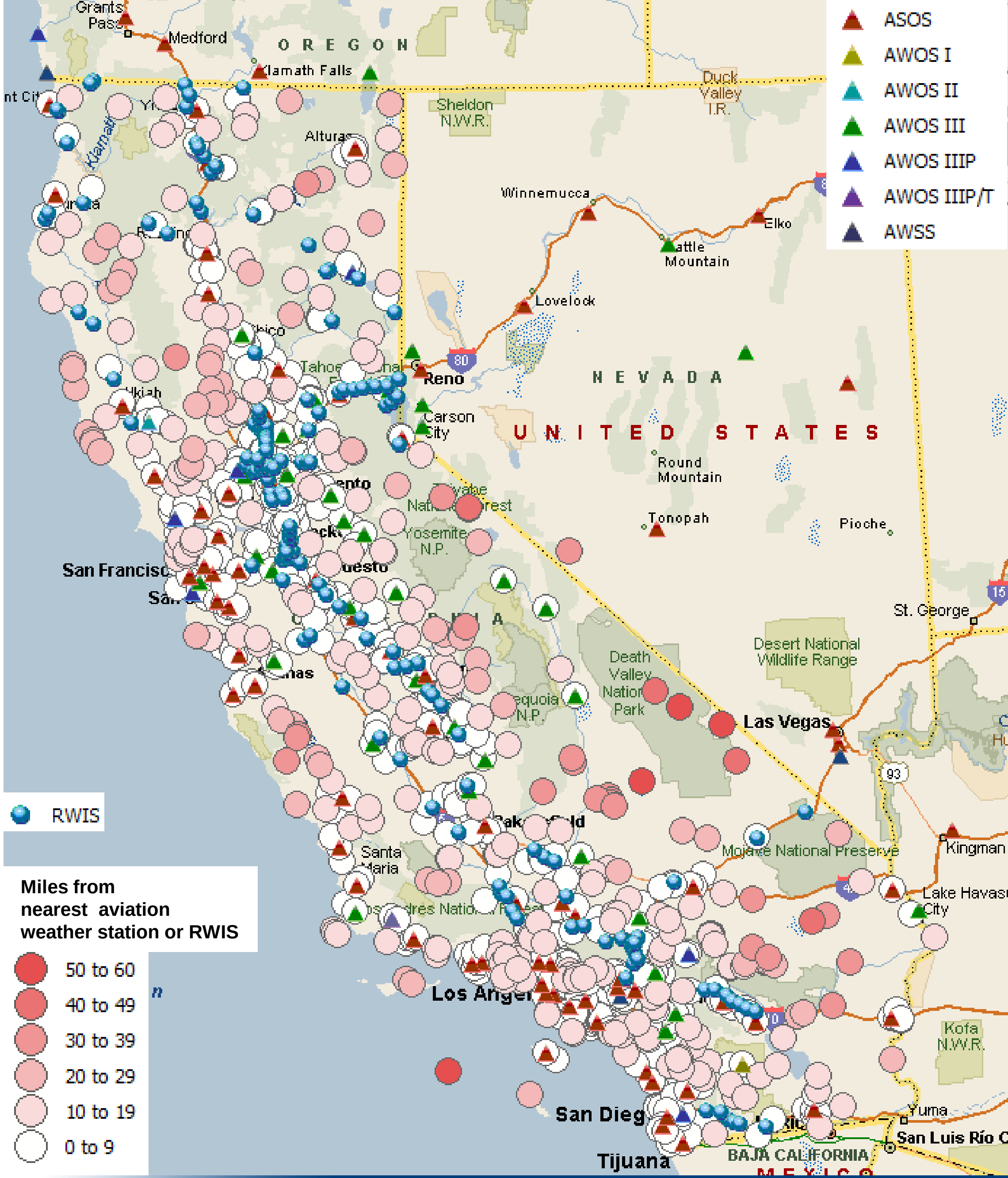
Data was combined from several sources and several sites may be inactive, so this count is approximate.

Source: Caltrans

Distances from airfields to nearest aviation or road weather stations:

Distance (mi)	count
dist < 5	366
5 ≤ dist < 10	288
10 ≤ dist < 20	219
20 ≤ dist < 30	63
30 ≤ dist < 40	22
40 ≤ dist < 50	5
50 ≤ dist	4

	mi
Min	0
Q1	3.09
Median	6.92
Q3	11.83
Max	59.77



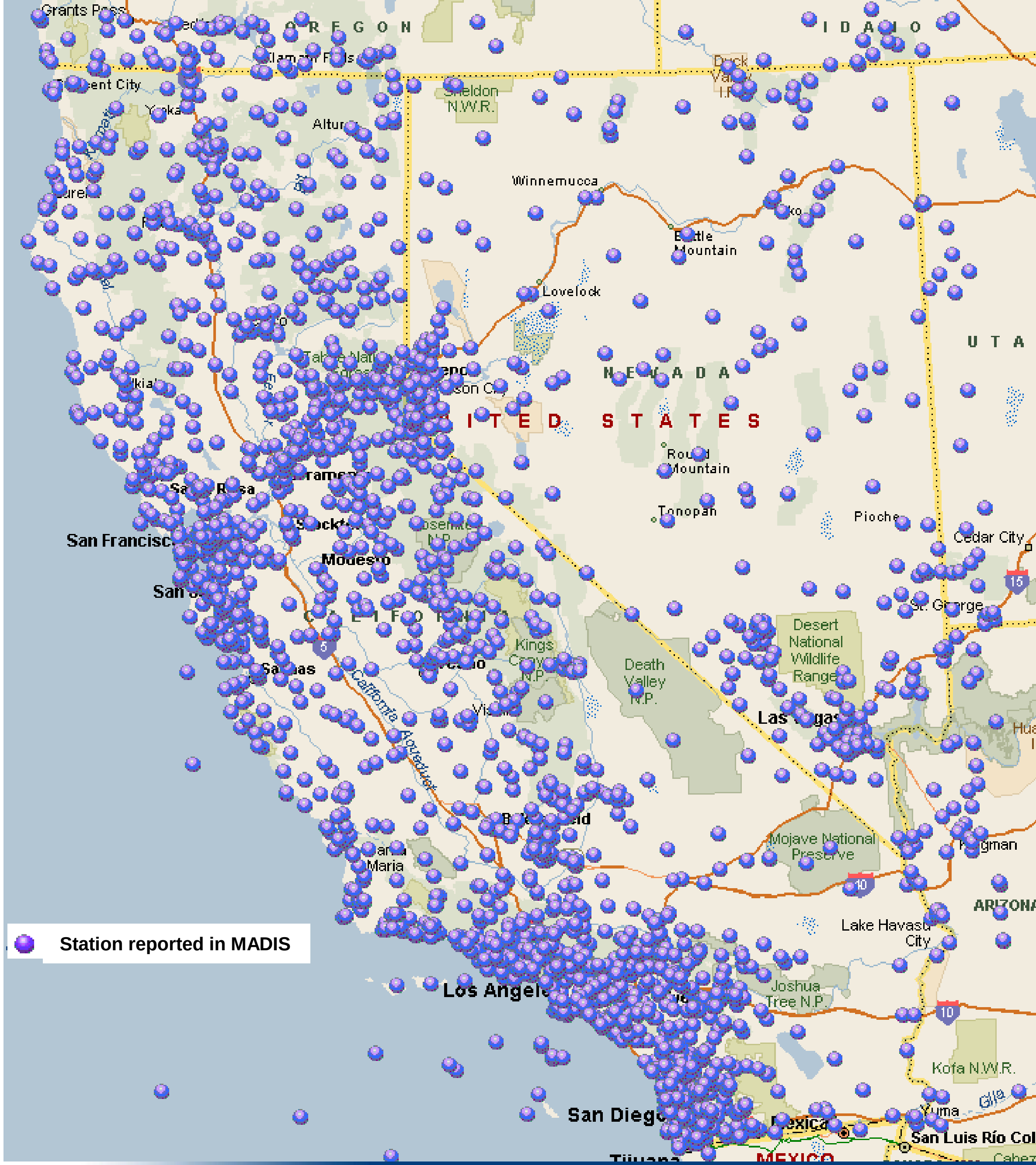
Approximately 2000 weather stations via MADIS.

NOAA's Meteorological Assimilation Data Ingest System (MADIS) aggregates weather sensor data from numerous sources.

MADIS sites for California come from the following sources, among others:

- CA-Hydro
- Edwards Air Force Base
- Hydrometeorological Automated Data System (HADS)
  - California Dept. Water Resources
- Mesowest
  - National Resources Conservation Service (RAWS)
  - California Nevada River Forecast Center
  - Mt. Shasta Avalanche Center
  - California Department of Transportation
  - Bay Area Mesoscale Initiative
  - Santa Barbara County Air Pollution Control District
  - Monterey Weather Forecast Office
  - California Management Information System
- Non-Federal AWOS
- Remote Automated Weather Stations (RAWS)

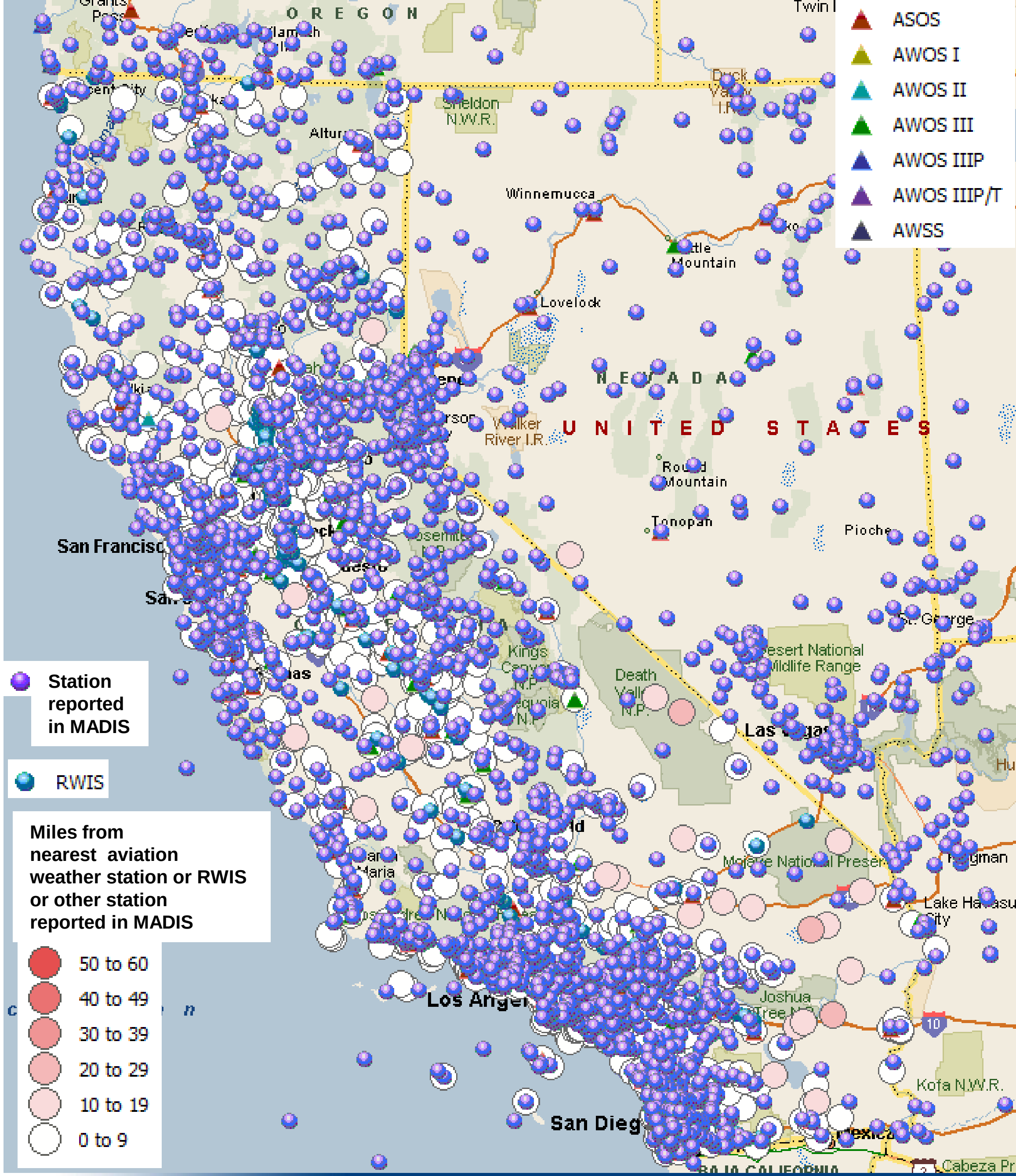
Source: NOAA



Distances from airfields to nearest aviation or road weather stations or station reporting via MADIS:

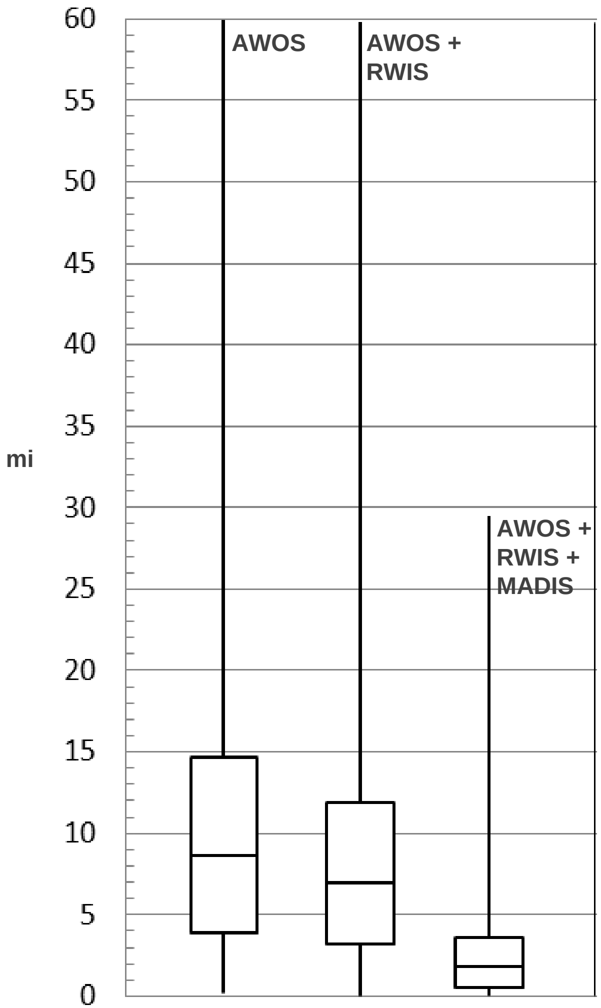
Distance (mi)	count
dist < 5	801
5 ≤ dist < 10	138
10 ≤ dist < 20	25
20 ≤ dist < 30	3
30 ≤ dist < 40	0
40 ≤ dist < 50	0
50 ≤ dist	0

	mi
Min	0
Q1	0.69
Median	1.83
Q3	3.61
Max	29.53



More than 82.8% of the airfields are within 5 miles of a weather station.

More than 97.1% of the airfields are within 10 miles of a weather station.



Distance (mi)	AWOS	AWOS + RWIS	AWOS + RWIS + MADIS
dist < 5	298	366	801
5 ≤ dist < 10	262	288	138
10 ≤ dist < 20	261	219	25
20 ≤ dist < 30	82	63	3
30 ≤ dist < 40	46	22	0
40 ≤ dist < 50	10	5	0
50 ≤ dist	8	4	0
Min	0	0	0
Q1	3.88	3.09	0.69
Median	8.63	6.92	1.83
Q3	14.49	11.83	3.61
Max	59.77	59.77	29.53

Discussion

- The suite of weather sensors at these sites do not meet all aviation needs. Some may be of no use at all.
- Use of weather sensor data from non-FAA-approved sites may be questionable.
- It isn’t feasible to equip all sites so that they would be FAA-approved.
- Is some non-approved information better than no approved information? (Particularly for sites that are nearly 60 miles from the nearest AWOS or ASOS?)

System Concept

- The project team developed a system concept document to serve as an early “paper prototype” for the data integration system that could be used as a “straw-man” for subsequent discussion and development.
  - The current practice and a statement of need were identified and documented.
  - A web-based application using a Google Maps user interface with multiple aviation data layers was proposed to meet identified needs.
  - The desired system would provide reliable access to quality-controlled surface weather information, Caltrans CCTV, radar, satellite, winds aloft, and several other aviation-related weather data feeds from various sources.
  - All of this information would be integrated into the system with one user-friendly interface.
  - The end user will be able to select any of the weather layers for view and save their preferences as a profile via a URL.

Requirements Analysis

- The project team conducted a preliminary, high-level requirements analysis based on the focus group survey summary as well as a literature review.
- The survey results indicated that the weather-related needs of small airports are not currently being met in an easy to understand and reliable way. A system that is easy to read, access, and understand, and that contains data from a variety of sources could help meet this need.
- A literature review also helped identify many valuable functional requirements that could be incorporated into the system.
- The project team identified and documented the functional, data, interface, performance, and non-functional requirements that are necessary for development of the system concept.

First Survey

- Responses were received from:
  - City of Eureka
    - Eureka Municipal Airport (O33)
  - Humboldt County (Arcata/Eureka Airport (ACV))
    - Eureka Murray Field (KEKA)
    - Rohnerville Airport (KFOT)
    - Dinsmore Airport (KD63)
    - Garberville Airport (KO16)
    - Kneeland Airport (KO19)
  - Siskiyou County
    - Weed Airport (O46)
  - Santa Clara County
    - Reid-Hillview Airport (RHV)
    - Palo Alto Airport (PAO)
    - South County/San Martin Airport (E16)
  - Redding Municipal Airport (KRDD)

First Survey

Some key responses:

- Redding stated that receiving weather updates every 15 minutes is the absolute minimum interval to get an accurate picture of conditions and even then it is sometimes not enough.
- Eureka Municipal Airport said the data it uses from the nearby AWOS station is not very accurate and that the station is too far away to provide accurate weather data for that airport.
- Redding stated that a video/photo that is taken every five minutes at every nearby station would be helpful in determining the weather conditions in the area. Humboldt also would like weather cameras as well as more thunderstorm information and additional visibility sensors.
- Siskiyou reported interest in surface conditions and surrounding area conditions and forecasts.
- Several commented that reports in “simple English” are desirable.
- All were willing to provide further evaluation and feedback.

System Prototype

A web-application was developed that aggregates available weather information into a user-friendly, map-based interface:

http://aviation.weathershare.org/

Data Sources

- Surface weather data layers via WeatherShare (MADIS and Mesowest are primary sources)
- NWS Radar Mosaic—Pacific Southwest Sector
- National Digital Forecast Database layers from the National Weather Service via WeatherShare
- National Weather Service Watches, Warnings, and Advisories layer from the National Weather Service via WeatherShare
- National Weather Service wind/temperature aloft
- (Pilot Reports) PIREPS
- METAR Reports Layer
- Terminal Aerodrome Forecasts (TAF) data layer
- USGS Elevation Data for Flight Path Profile (not shown in prototype)
- Caltrans CCTV

Data– Surface Layers Detail

MADIS(690 stations): every 15 minutes

- *Air Temperature, Relative Humidity, Avg Wind Speed, Avg Wind Direction, Max Wind Gust Speed, Max Wind Gust Dir, Dewpoint Temp, Atmospheric Pressure, Fuel Moisture, Fuel Temperature, Precipitation Rate, Precipitation in 24 Hours*

MesoWest(2474 stations): every 15 minutes

- *Air Temperature, Relative Humidity, Avg Wind Speed, Avg Wind Direction, Max Wind Gust Speed, Atmospheric Pressure, Solar Radiation*

Caltrans RWIS(107 stations): every 15 minutes

- *Air Temperature, Dewpoint Temp, Max Temp, Min Temp, Avg Wind Speed, Max Wind Gust Speed, Avg Wind Direction, Max Wind Gust Dir, Relative Humidity, Precipitation Intensity, Precipitation Rate, Cumulative Precipitation, Visibility*

NWS Observed 24 Hours precipitation: Twice in 24 hrs

Caltrans CCTV(26 sites): every 15 minutes

NDFD Forecast data: every 60 minutes

- *Air Temperature, Humidity, Avg Wind Speed, Avg Wind Direction, Max Wind Gust Speed, Max Wind Gust Dir, Sky cover, 12 Hour Probability of Precipitation, 6 Hour Amount of Precipitation, Snow, Weather*

NWS Warnings, Watches and Advisories: every 15 minutes

- **Warnings:** *Tornado, Flash flood, Blizzard, Winter Storm, High Wind, Storm, Avalanche, Severe weather statement, Flood, Red flag, Heavy Freezing Spray*
- **Watches:** *Flash Flood, Winter Storm, Flood, High Wind, Fire Weather, Coastal Flood Statement, Special Weather Statement, Short Term Forecast*
- **Advisories:** *Winter Weather, Flood, High Surf, Small Craft, Brisk Wind, Lake Wind, Wind*

Data – Aviation Layers Detail

<u>METAR (91 stations): every 60 minutes</u>

- *Air Temperature, Relative Humidity, Wind Speed and direction, Visibility, Sky condition, Dewpoint Temp, Atmospheric Pressure*

<u>PIREPS: every 15 minutes</u>

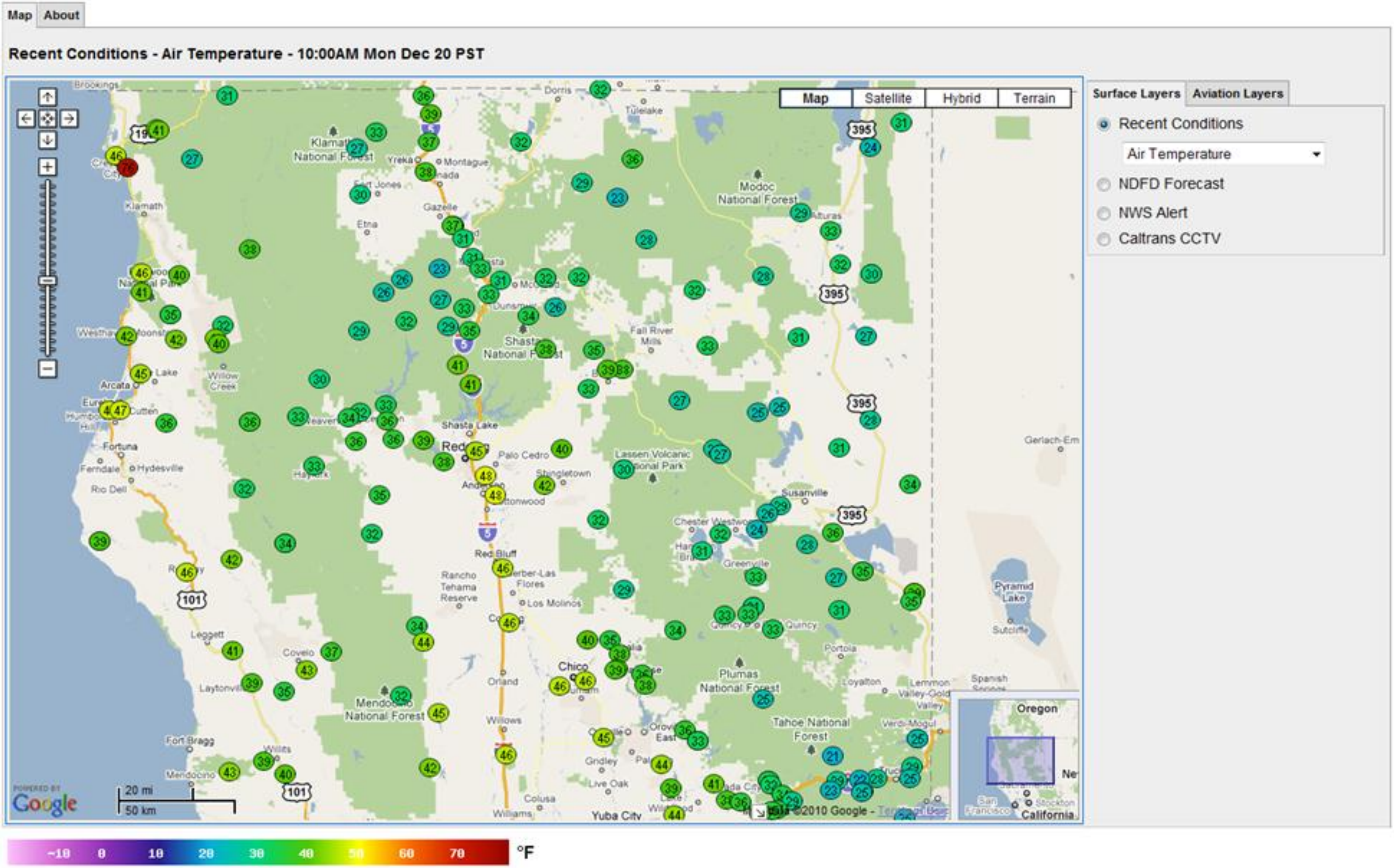
- *Air Temperature, Relative Humidity, Avg Wind Speed, Avg Wind Direction, Max Wind Gust Speed, Atmospheric Pressure, Solar Radiation*

<u>TAF(107 stations): every 15 minutes</u>

- *Air Temperature, Dewpoint Temp, Max Temp, Min Temp, Avg Wind Speed, Max Wind Gust Speed, Avg Wind Direction, Max Wind Gust Dir, Relative Humidity, Precipitation Intensity, Precipitation Rate, Cumulative Precipitation, Visibility*

<u>Radar: every 15 minutes</u>

<u>Satellite: every 15 minutes</u>


Map
About
Recent Conditions - Air Temperature - 10:00AM Mon Dec 20 PST
Map
Satellite
Hybrid
Terrain
Surface Layers
Aviation Layers
Recent Conditions
Air Temperature
NDFD Forecast
NWS Alert
Caltrans CCTV
Klamath National Forest
Modoc National Forest
Shasta National Forest
Lassen Volcanic National Park
Plumas National Forest
Tahoe National Forest
Mendocino National Forest
Redding
Red Bluff
Chico
Susanville
Alturas
Arcata
Eureka
Fortuna
Yreka
Willows
Orland
Yuba City
Pyramid Lake
Oregon
California
20 mi
50 km
-10
0
10
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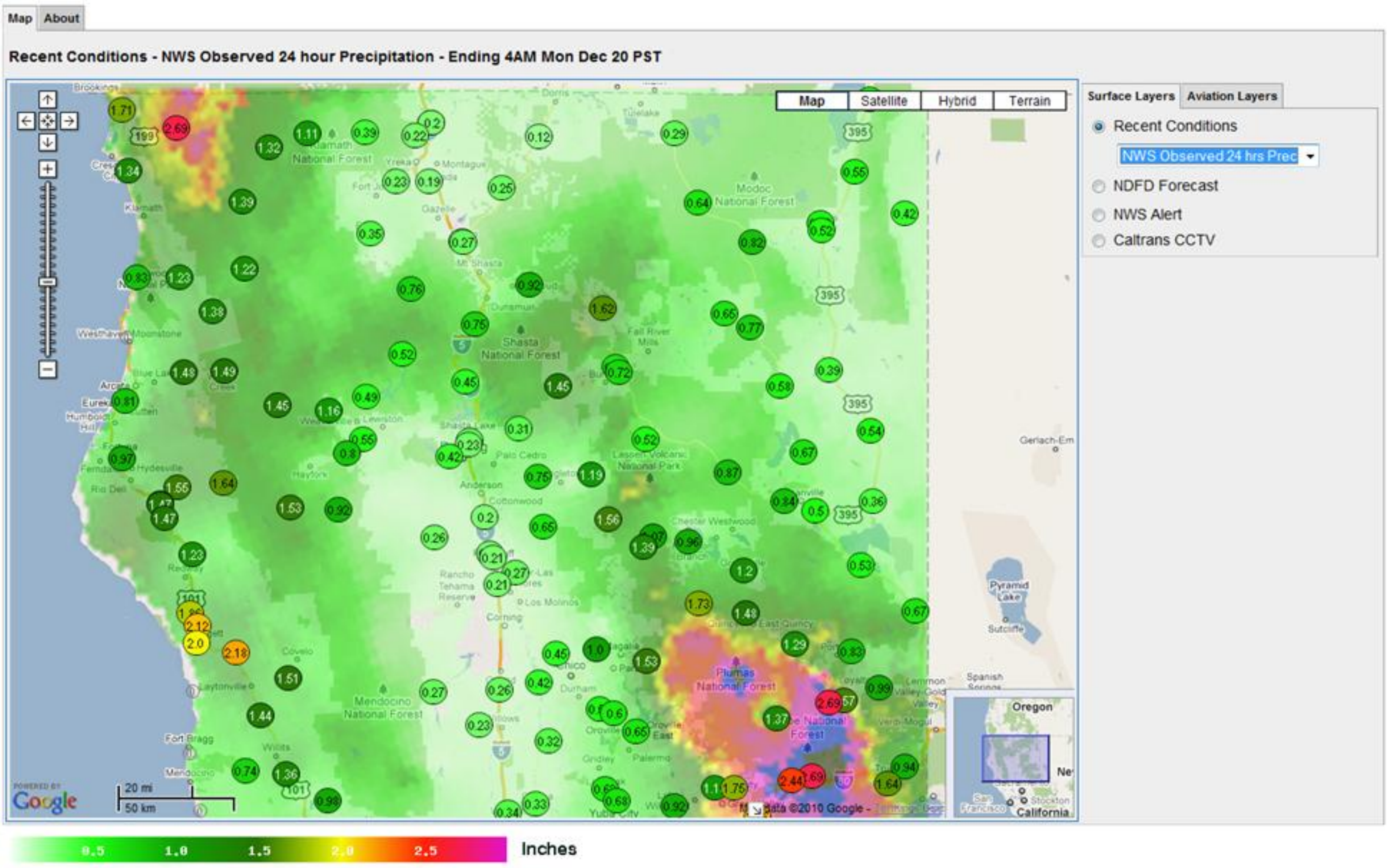
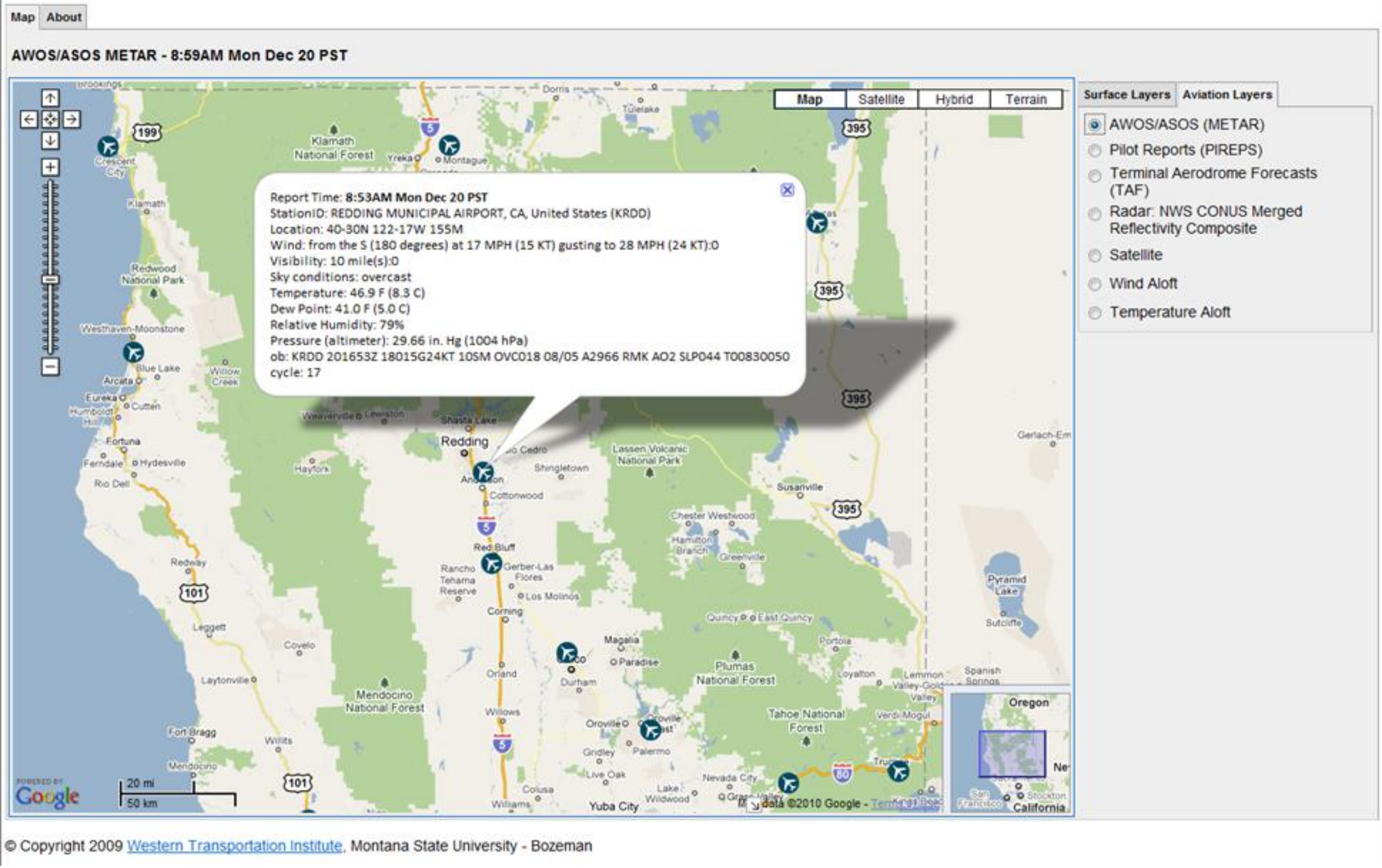
30
40
50
60
70
°F


Map
About
Recent Conditions - NWS Observed 24 hour Precipitation - Ending 4AM Mon Dec 20 PST
Map
Satellite
Hybrid
Terrain
Surface Layers
Aviation Layers
Recent Conditions
NWS Observed 24 hrs Prec
NDFD Forecast
NWS Alert
Caltrans CCTV
Klamath National Forest
Modoc National Forest
Shasta National Forest
Lassen Volcanic National Park
Mendocino National Forest
Plumas National Forest
Pyramid Lake
Oregon
California
20 mi
50 km
0.5
1.0
1.5
2.0
2.5
Inches



Map
About
AWOS/ASOS METAR - 8:59AM Mon Dec 20 PST
Map
Satellite
Hybrid
Terrain
Report Time: 8:53AM Mon Dec 20 PST
StationID: REDDING MUNICIPAL AIRPORT, CA, United States (KRDD)
Location: 40-30N 122-17W 155M
Wind: from the S (180 degrees) at 17 MPH (15 KT) gusting to 28 MPH (24 KT):0
Visibility: 10 mile(s):0
Sky conditions: overcast
Temperature: 46.9 F (8.3 C)
Dew Point: 41.0 F (5.0 C)
Relative Humidity: 79%
Pressure (altimeter): 29.66 in. Hg (1004 hPa)
ob: KRDD 201653Z 18015G24KT 10SM OVC018 08/05 A2966 RMK AO2 SLP044 T00830050
cycle: 17
Surface Layers
Aviation Layers
AWOS/ASOS (METAR)
Pilot Reports (PIREPS)
Terminal Aerodrome Forecasts (TAF)
Radar: NWS CONUS Merged Reflectivity Composite
Satellite
Wind Aloft
Temperature Aloft
Redding
Red Bluff
Klamath National Forest
Lassen Volcanic National Park
Mendocino National Forest
Plumas National Forest
Tahoe National Forest
Susanville
Yuba City
Oregon
California
20 mi
50 km
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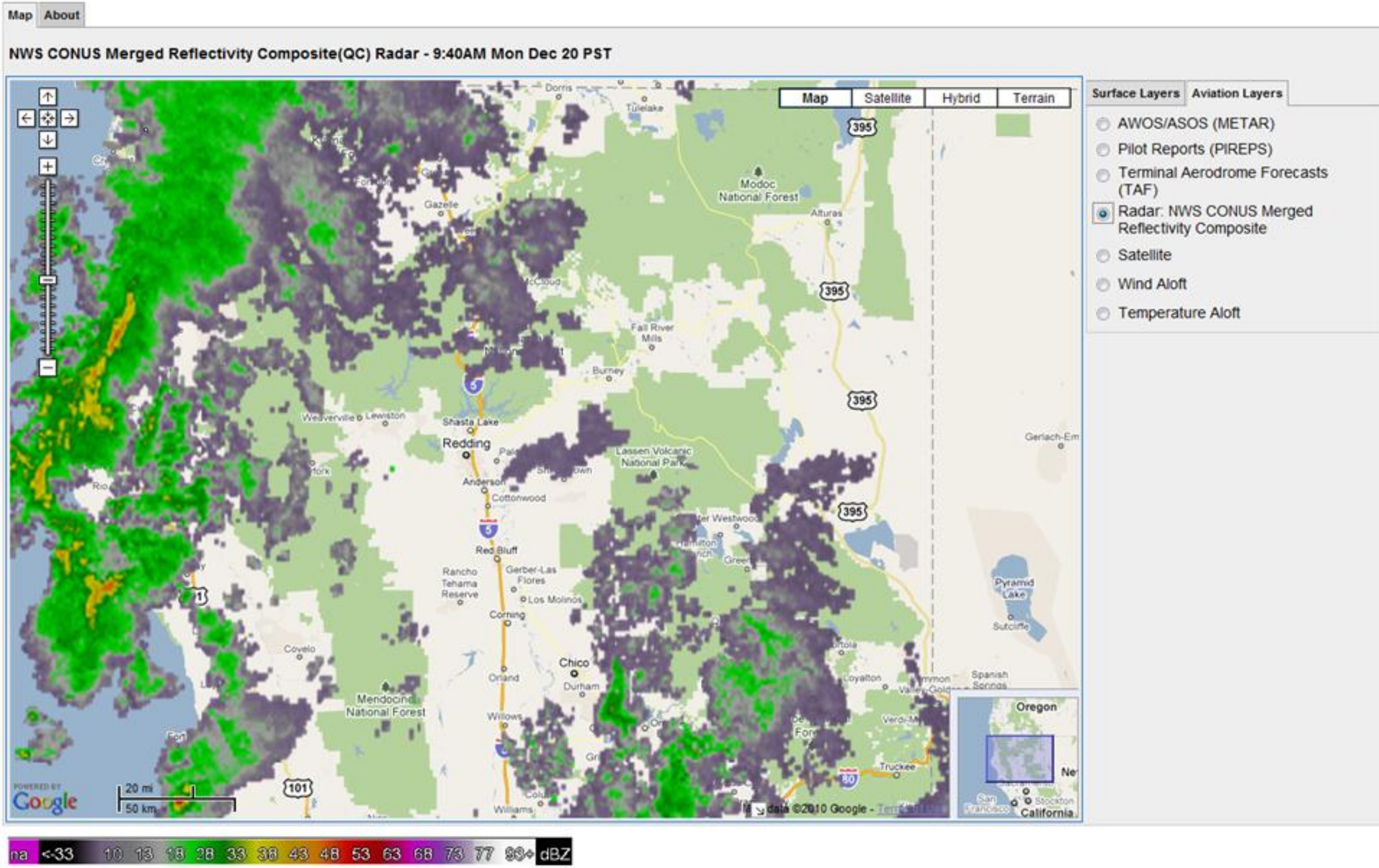
Map
About
NWS CONUS Merged Reflectivity Composite(QC) Radar - 9:40AM Mon Dec 20 PST
Map
Satellite
Hybrid
Terrain
Surface Layers
Aviation Layers
AWOS/ASOS (METAR)
Pilot Reports (PIREPS)
Terminal Aerodrome Forecasts (TAF)
Radar: NWS CONUS Merged Reflectivity Composite
Satellite
Wind Aloft
Temperature Aloft
Modoc National Forest
Alturas
Redding
Shasta Lake
Anderson
Cottonwood
Red Bluff
Corning
Chico
Durham
Orland
Willows
Lassen Volcanic National Park
Mendocino National Forest
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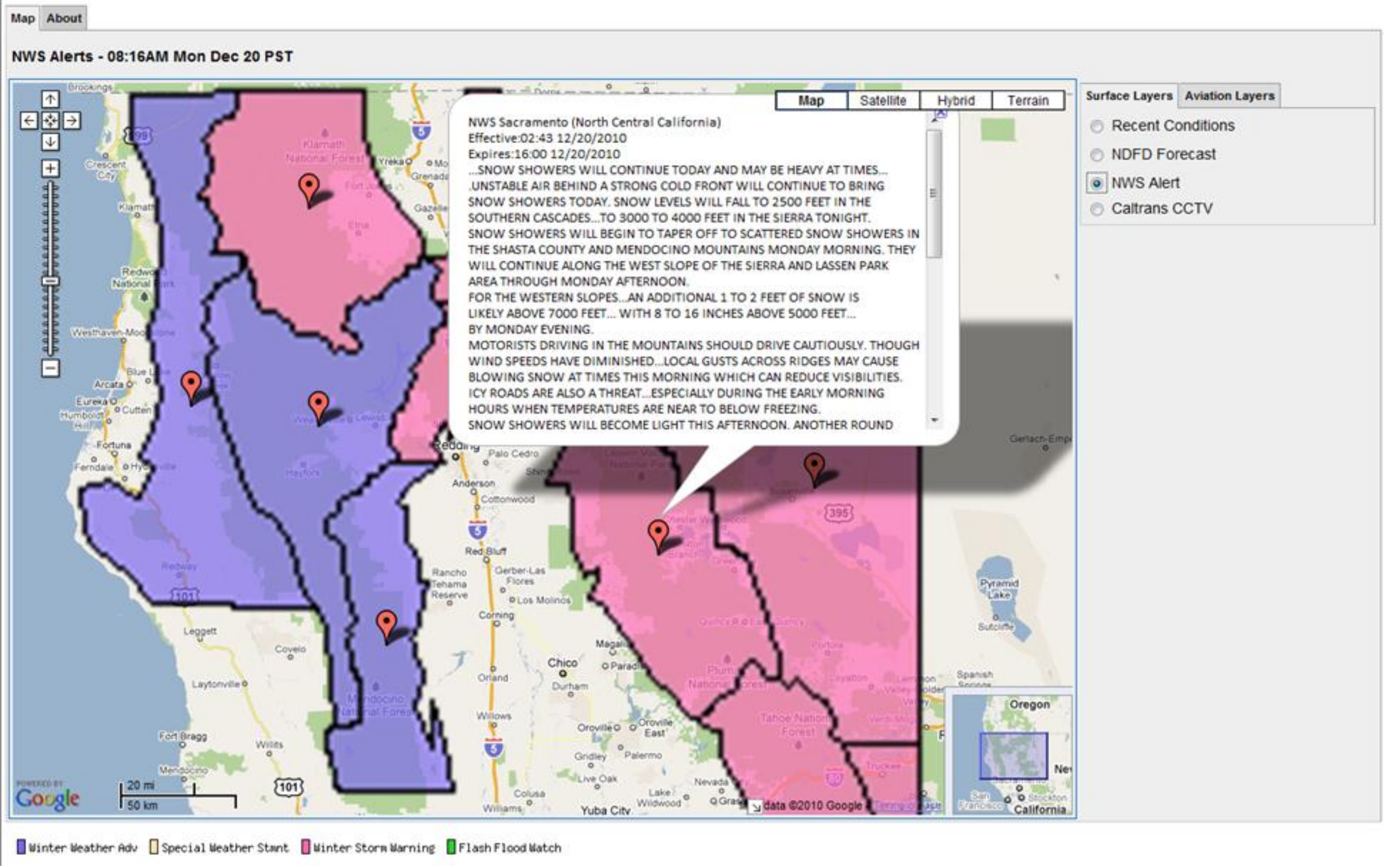
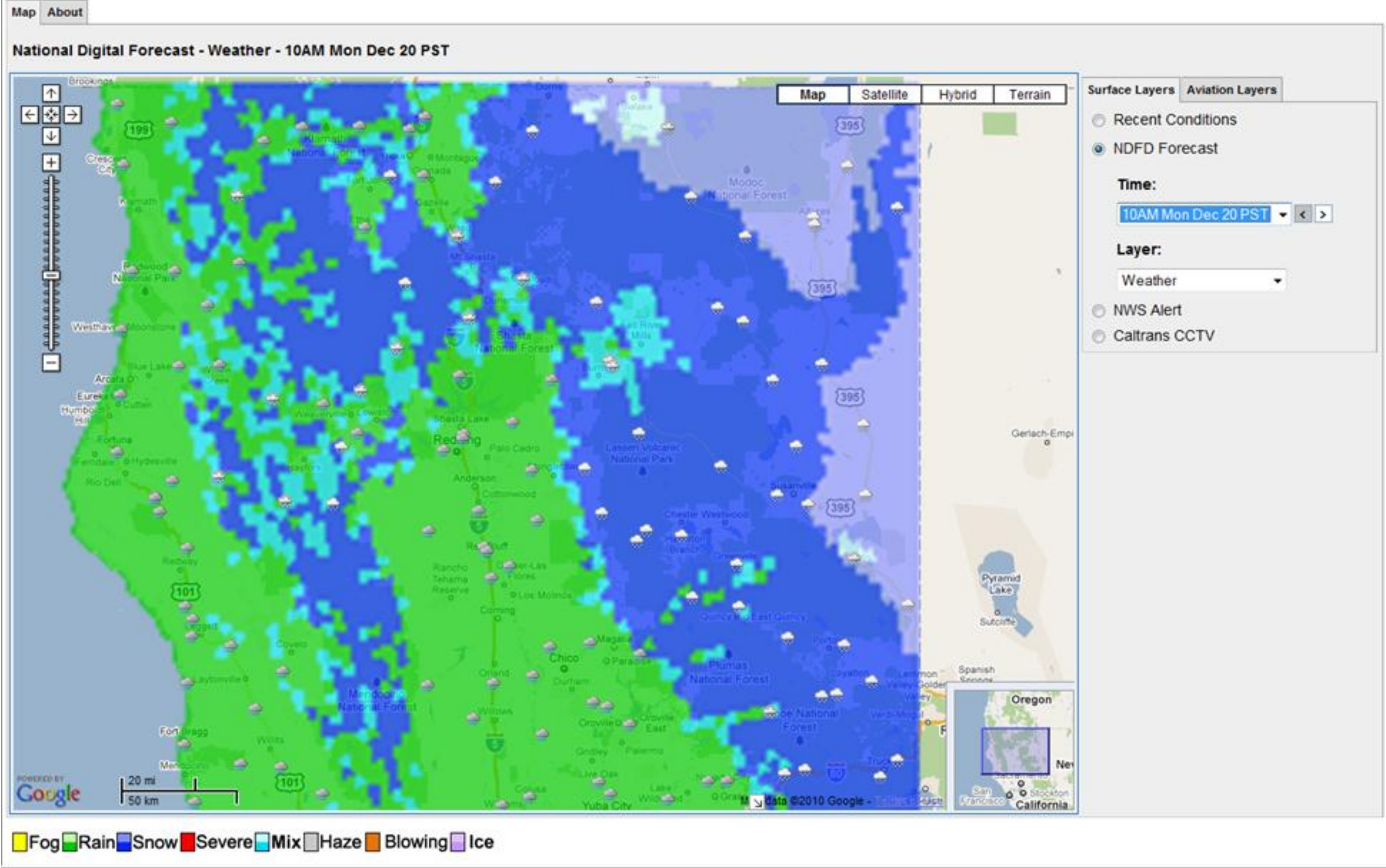
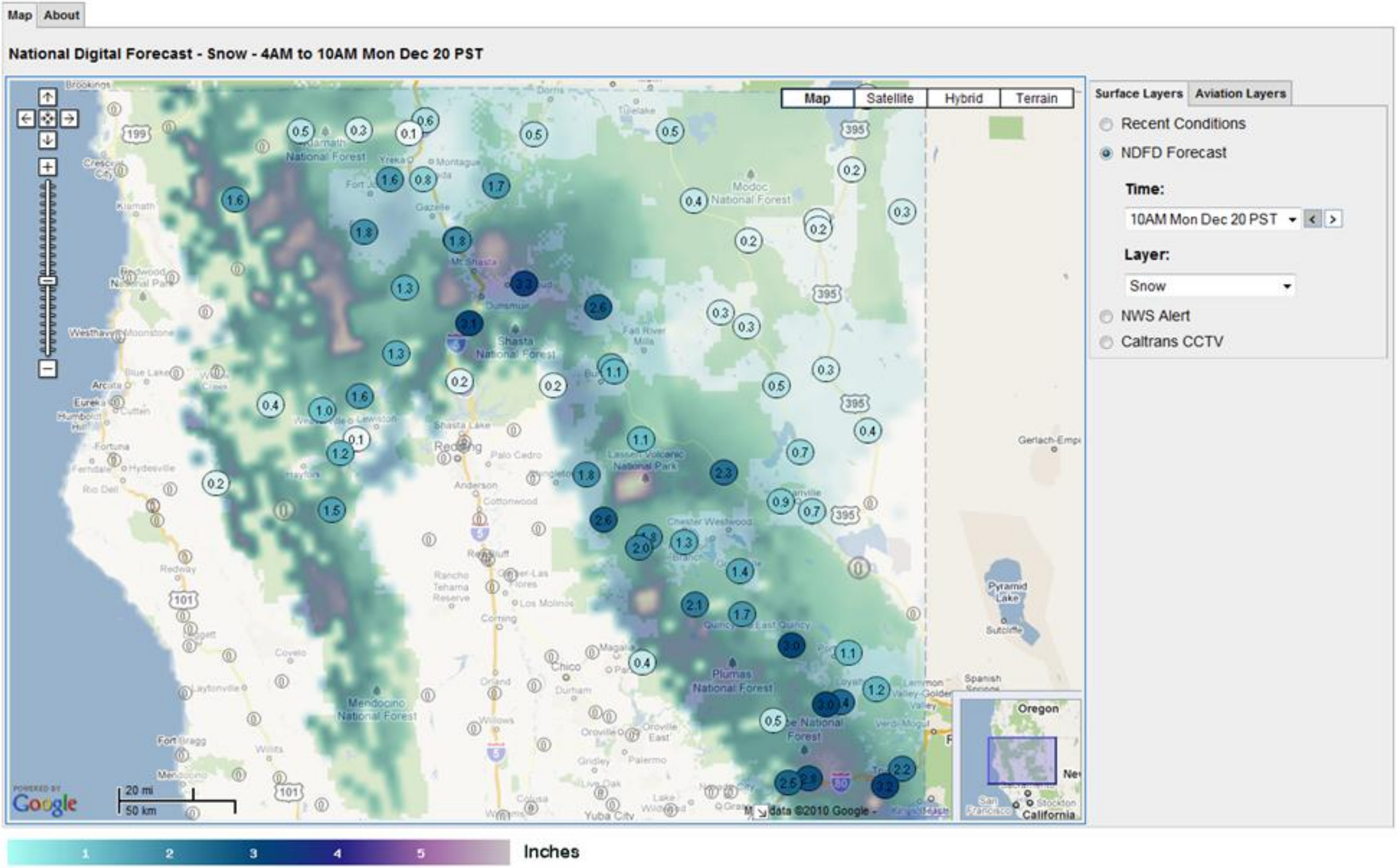

Map
About
NWS Alerts - 08:16AM Mon Dec 20 PST
Map
Satellite
Hybrid
Terrain
NWS Sacramento (North Central California)
Effective:02:43 12/20/2010
Expires:16:00 12/20/2010
...SNOW SHOWERS WILL CONTINUE TODAY AND MAY BE HEAVY AT TIMES...
.UNSTABLE AIR BEHIND A STRONG COLD FRONT WILL CONTINUE TO BRING SNOW SHOWERS TODAY. SNOW LEVELS WILL FALL TO 2500 FEET IN THE SOUTHERN CASCADES...TO 3000 TO 4000 FEET IN THE SIERRA TONIGHT. SNOW SHOWERS WILL BEGIN TO TAPER OFF TO SCATTERED SNOW SHOWERS IN THE SHASTA COUNTY AND MENDOCINO MOUNTAINS MONDAY MORNING. THEY WILL CONTINUE ALONG THE WEST SLOPE OF THE SIERRA AND LASSEN PARK AREA THROUGH MONDAY AFTERNOON.
FOR THE WESTERN SLOPES...AN ADDITIONAL 1 TO 2 FEET OF SNOW IS LIKELY ABOVE 7000 FEET... WITH 8 TO 16 INCHES ABOVE 5000 FEET... BY MONDAY EVENING.
MOTORISTS DRIVING IN THE MOUNTAINS SHOULD DRIVE CAUTIOUSLY. THOUGH WIND SPEEDS HAVE DIMINISHED...LOCAL GUSTS ACROSS RIDGES MAY CAUSE BLOWING SNOW AT TIMES THIS MORNING WHICH CAN REDUCE VISIBILITIES. ICY ROADS ARE ALSO A THREAT...ESPECIALLY DURING THE EARLY MORNING HOURS WHEN TEMPERATURES ARE NEAR TO BELOW FREEZING.
SNOW SHOWERS WILL BECOME LIGHT THIS AFTERNOON. ANOTHER ROUND
Surface Layers
Aviation Layers
Recent Conditions
NDFD Forecast
NWS Alert
Caltrans CCTV
Redding
Anderson
Red Bluff
Corning
Chico
Orland
Willows
Oroville
Yuba City
Oregon
California
20 mi
50 km
Google
Winter Weather Adv
Special Weather Stmt
Winter Storm Warning
Flash Flood Watch


Map
About
National Digital Forecast - Weather - 10AM Mon Dec 20 PST
Map
Satellite
Hybrid
Terrain
Surface Layers
Aviation Layers
Recent Conditions
NDFD Forecast
Time:
10AM Mon Dec 20 PST
Layer:
Weather
NWS Alert
Caltrans CCTV
Redding
Chico
Oregon
California
Pyramid Lake
20 mi
50 km
Map data ©2010 Google
Fog
Rain
Snow
Severe
Mix
Haze
Blowing
Ice


Map
About
National Digital Forecast - Snow - 4AM to 10AM Mon Dec 20 PST
Map
Satellite
Hybrid
Terrain
Surface Layers
Aviation Layers
Recent Conditions
NDFD Forecast
Time:
10AM Mon Dec 20 PST
Layer:
Snow
NWS Alert
Caltrans CCTV
Redding
Chico
Modoc National Forest
Shasta National Forest
Lassen Volcanic National Park
Plumas National Forest
Mendocino National Forest
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California
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50 km
Map data ©2010 Google
1
2
3
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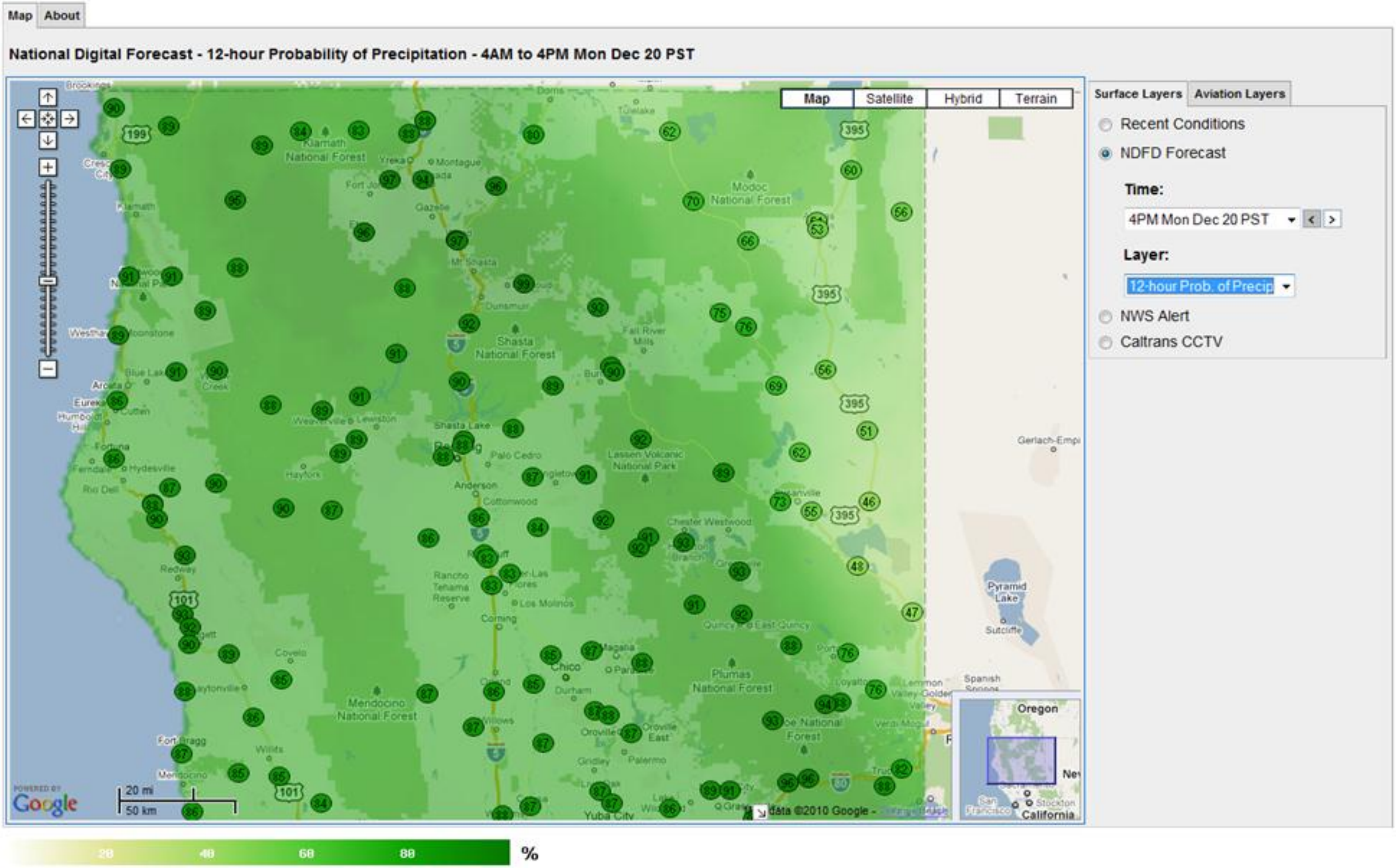
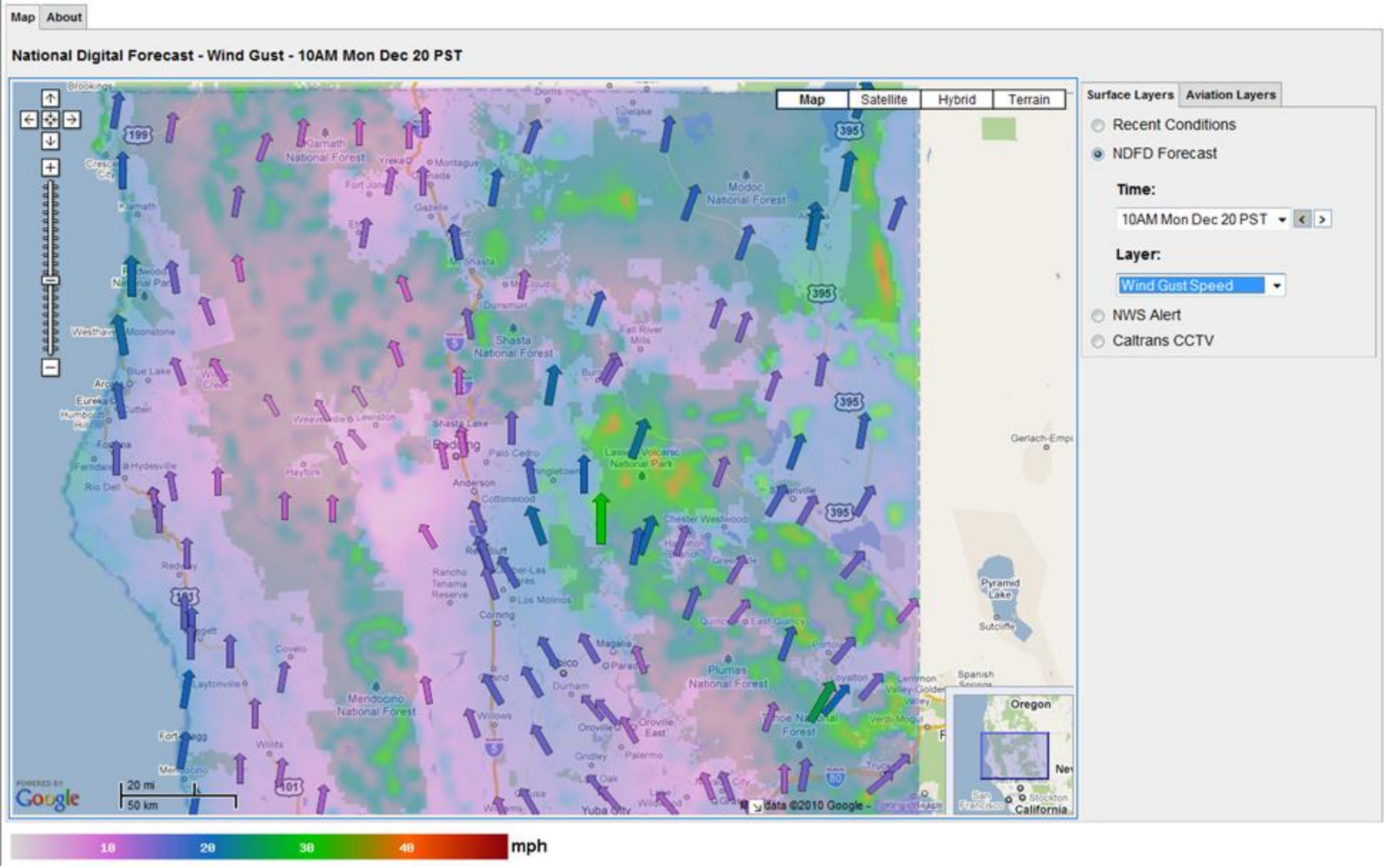
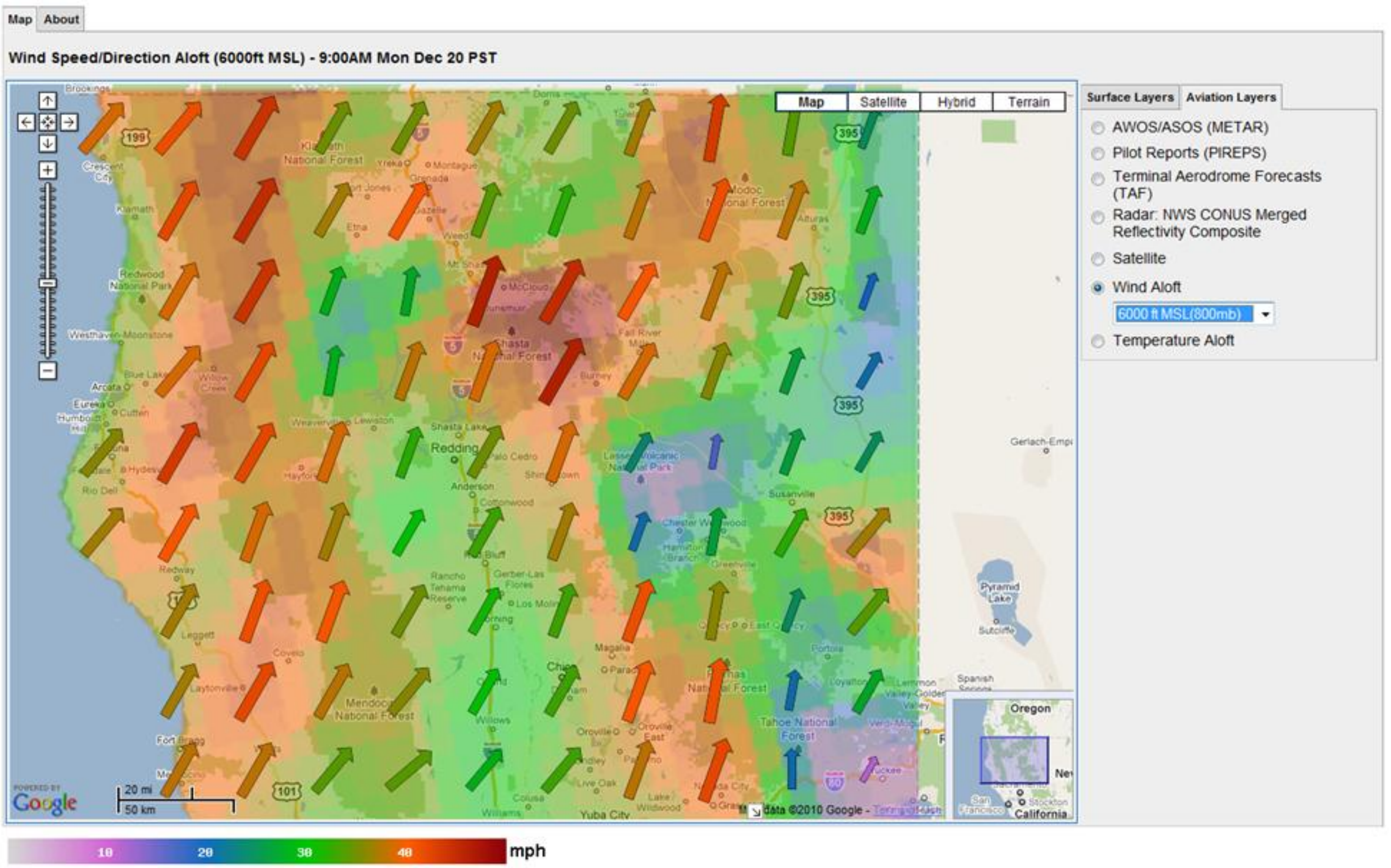
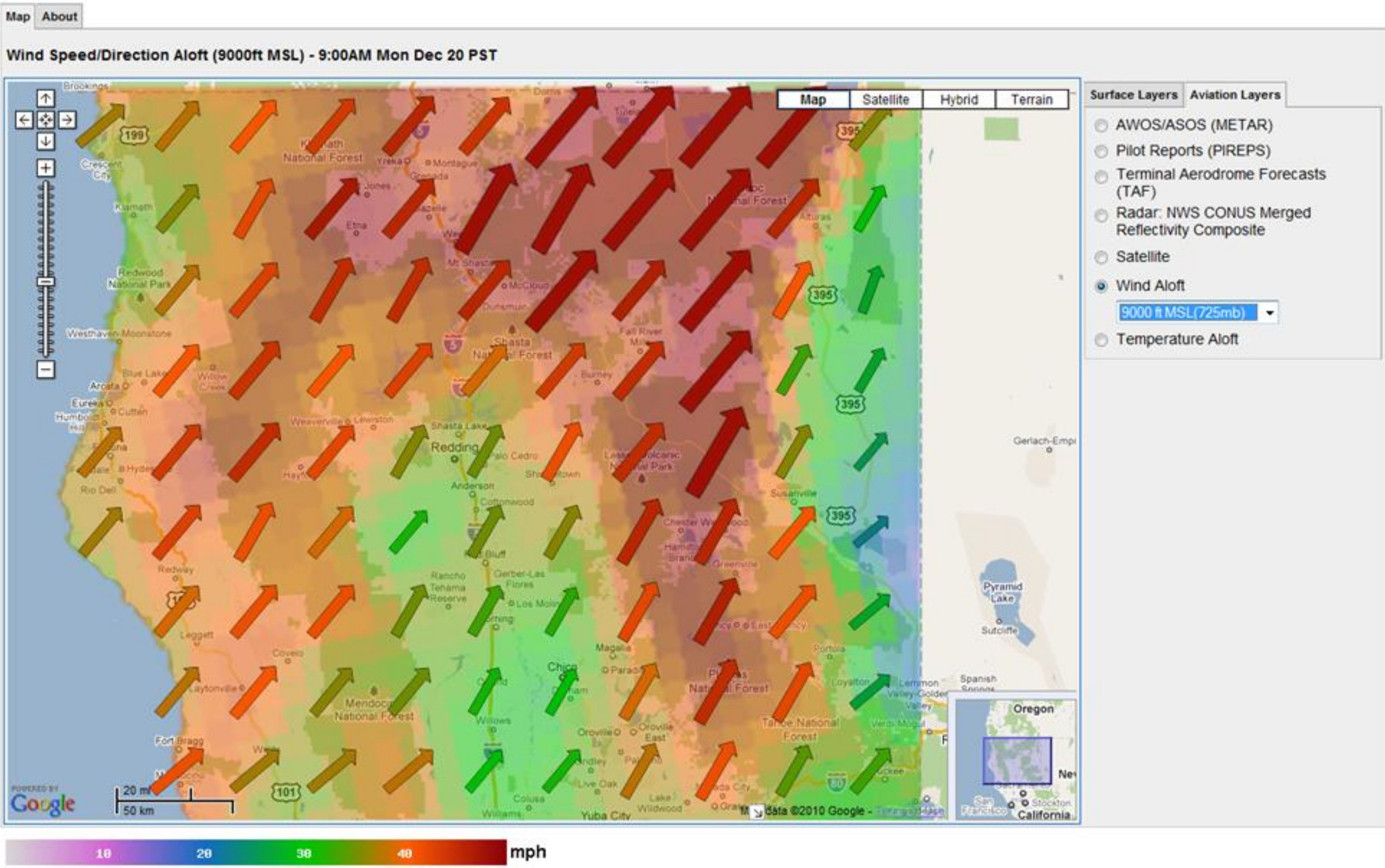
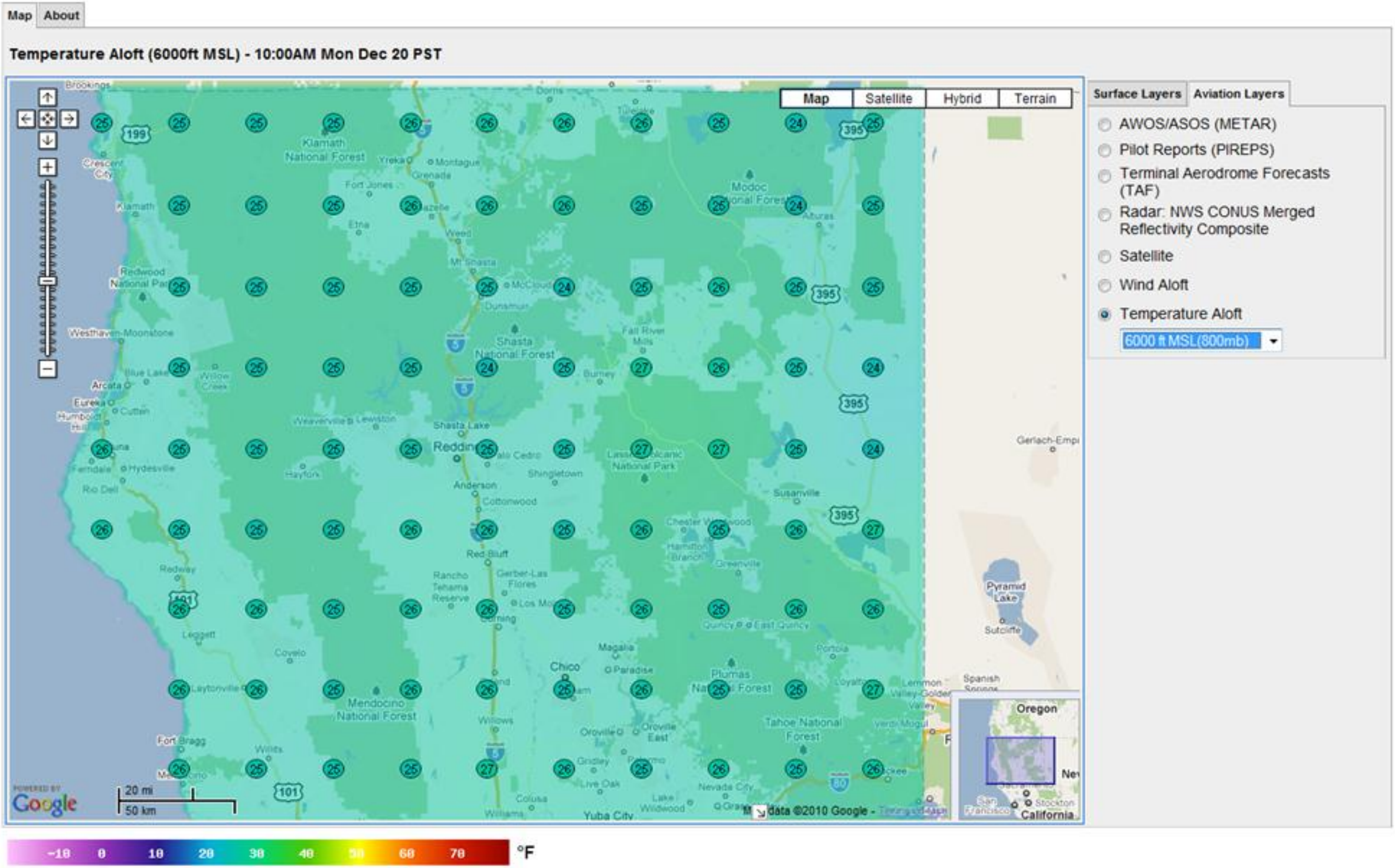
5
Inches

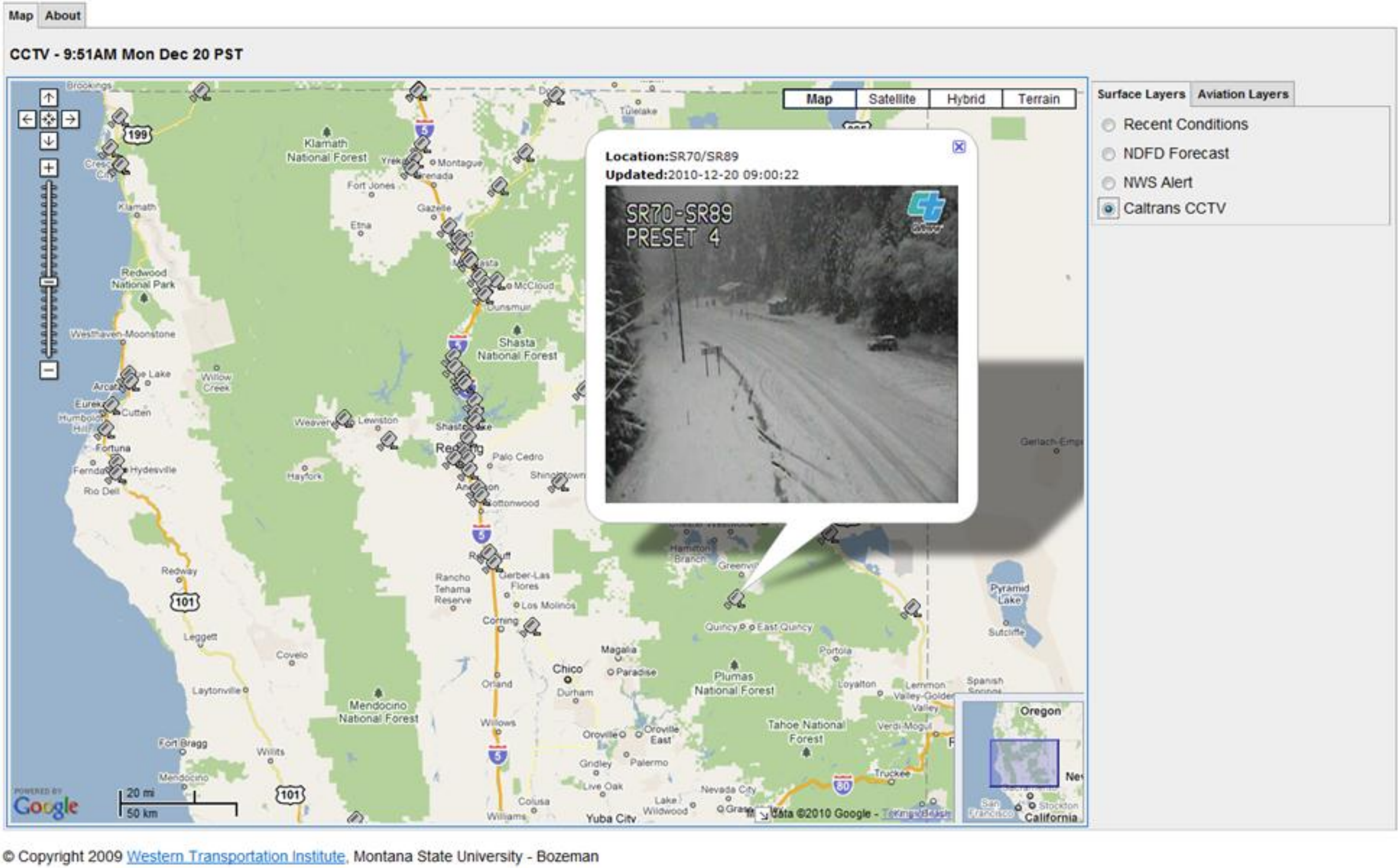

Map
About
National Digital Forecast - 12-hour Probability of Precipitation - 4AM to 4PM Mon Dec 20 PST
Map
Satellite
Hybrid
Terrain
Surface Layers
Aviation Layers
Recent Conditions
NDFD Forecast
Time:
4PM Mon Dec 20 PST
Layer:
12-hour Prob. of Precip
NWS Alert
Caltrans CCTV
Klamath National Forest
Modoc National Forest
Shasta National Forest
Lassen Volcanic National Park
Plumas National Forest
Mendocino National Forest
Pyramid Lake
Oregon
California
20 mi
50 km
data ©2010 Google
20
40
60
80
%


Map
About
National Digital Forecast - Wind Gust - 10AM Mon Dec 20 PST
Map
Satellite
Hybrid
Terrain
Surface Layers
Aviation Layers
Recent Conditions
NDFD Forecast
Time:
10AM Mon Dec 20 PST
Layer:
Wind Gust Speed
NWS Alert
Caltrans CCTV
Klamath National Forest
Modoc National Forest
Shasta National Forest
Lassen Volcanic National Park
Mendocino National Forest
Plumas National Forest
Pyramid Lake
Oregon
California
20 mi
50 km
10
20
30
40
mph


Map
About
Wind Speed/Direction Aloft (6000ft MSL) - 9:00AM Mon Dec 20 PST
Map
Satellite
Hybrid
Terrain
Surface Layers
Aviation Layers
AWOS/ASOS (METAR)
Pilot Reports (PIREPS)
Terminal Aerodrome Forecasts (TAF)
Radar: NWS CONUS Merged Reflectivity Composite
Satellite
Wind Aloft
6000 ft MSL(800mb)
Temperature Aloft
Redding
Oregon
California
20 mi
50 km
10
20
30
40
mph


Map
About
Wind Speed/Direction Aloft (9000ft MSL) - 9:00AM Mon Dec 20 PST
Map
Satellite
Hybrid
Terrain
Surface Layers
Aviation Layers
AWOS/ASOS (METAR)
Pilot Reports (PIREPS)
Terminal Aerodrome Forecasts (TAF)
Radar: NWS CONUS Merged Reflectivity Composite
Satellite
Wind Aloft
9000 ft MSL(725mb)
Temperature Aloft
10
20
30
40
mph


Map
About
Temperature Aloft (6000ft MSL) - 10:00AM Mon Dec 20 PST
Map
Satellite
Hybrid
Terrain
Surface Layers
Aviation Layers
AWOS/ASOS (METAR)
Pilot Reports (PIREPS)
Terminal Aerodrome Forecasts (TAF)
Radar: NWS CONUS Merged Reflectivity Composite
Satellite
Wind Aloft
Temperature Aloft
6000 ft MSL(800mb)
Klamath National Forest
Shasta National Forest
Redding
Red Bluff
Chico
Mendocino National Forest
Plumas National Forest
Tahoe National Forest
Lassen Volcanic National Park
Pyramid Lake
Oregon
California
20 mi
50 km
Map data ©2010 Google
-10
0
10
20
30
40
50
60
70
°F



Map
About
CCTV - 9:51AM Mon Dec 20 PST
Map
Satellite
Hybrid
Terrain
Surface Layers
Aviation Layers
Recent Conditions
NDFD Forecast
NWS Alert
Caltrans CCTV
Location:SR70/SR89
Updated:2010-12-20 09:00:22
SR70-SR89
PRESET 4
Klamath National Forest
Redwood National Park
Shasta National Forest
Mendocino National Forest
Plumas National Forest
Tahoe National Forest
Redding
Chico
Oregon
California
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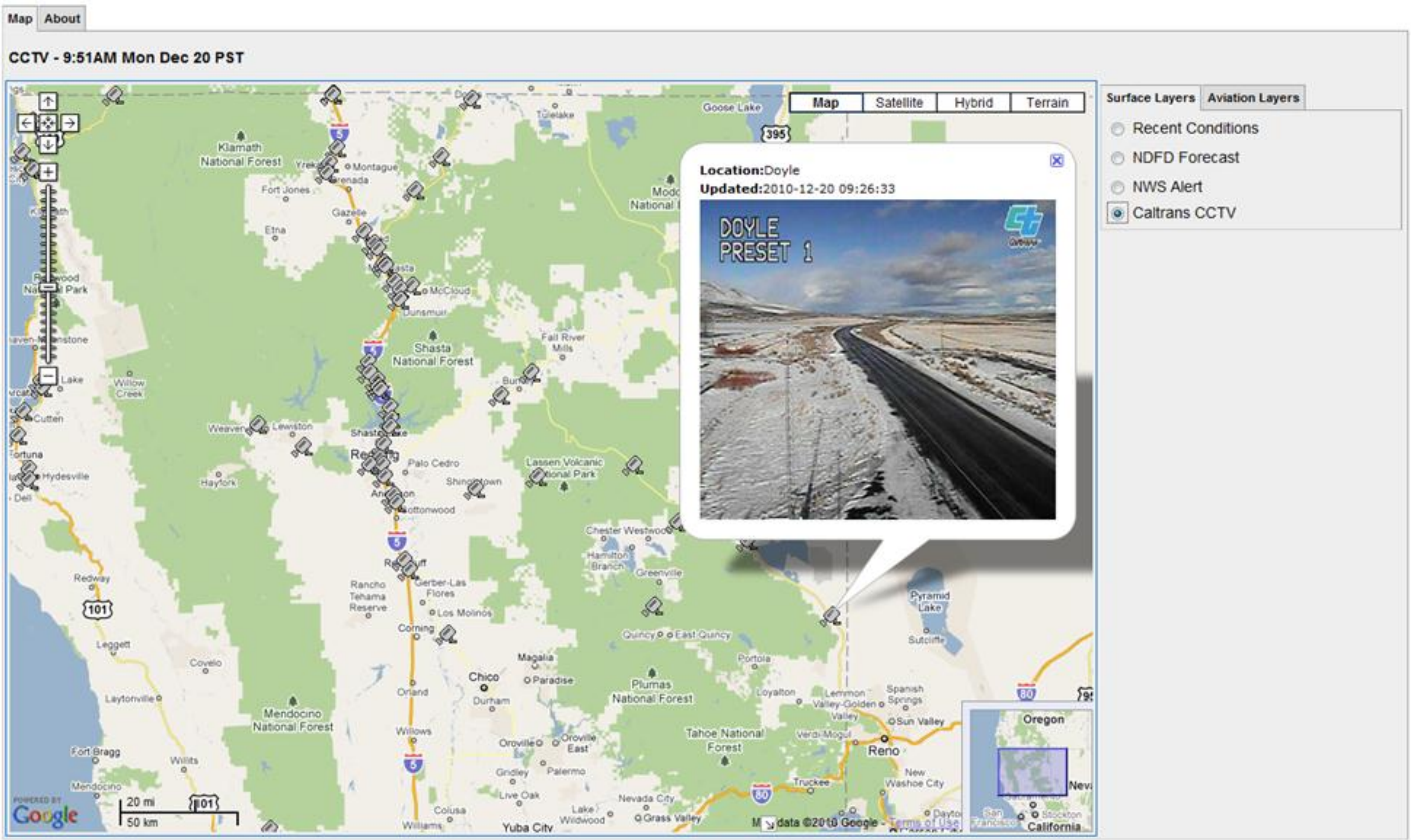
Map
About
CCTV - 9:51AM Mon Dec 20 PST
Map
Satellite
Hybrid
Terrain
Surface Layers
Aviation Layers
Recent Conditions
NDFD Forecast
NWS Alert
Caltrans CCTV
Location:Doyle
Updated:2010-12-20 09:26:33
DOYLE
PRESET 1
Goose Lake
Klamath National Forest
Montague
Fort Jones
Etna
McCloud
Dunsmuir
Shasta National Forest
Fall River Mills
Lewiston
Weaverville
Palo Cedro
Shingletown
Lassen Volcanic National Park
Cottonwood
Hydesville
Fortuna
Redway
Leggett
Covelo
Laytonville
Fort Bragg
Willits
Mendocino
Mendocino National Forest
Rancho Tehama Reserve
Gerber-Las Flores
Los Molinos
Corning
Orland
Chico
Durham
Paradise
Magalia
Willows
Oroville
Oroville East
Gridley
Palermo
Live Oak
Colusa
Williams
Yuba City
Lake Wildwood
Nevada City
Grass Valley
Plumas National Forest
Quincy
East Quincy
Greenville
Portola
Loyalton
Tahoe National Forest
Truckee
Reno
Verdi-Mogul
Sun Valley
Spanish Springs
New Washoe City
Pyramid Lake
Sutcliffe
Oregon
California
20 mi
50 km
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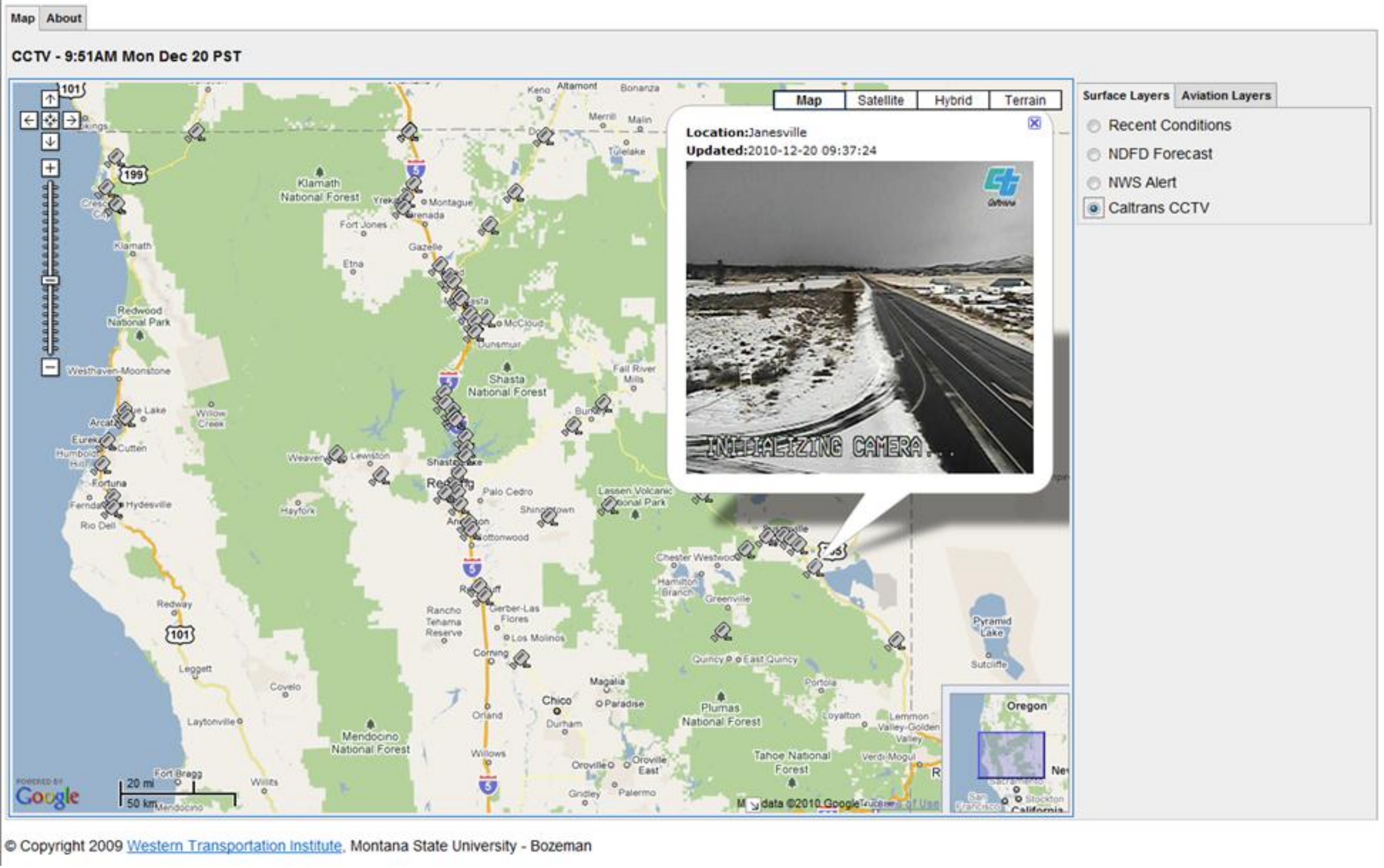

Map
About
CCTV - 9:51AM Mon Dec 20 PST
Map
Satellite
Hybrid
Terrain
Location:Janesville
Updated:2010-12-20 09:37:24
INITIALIZING CAMERA...
Surface Layers
Aviation Layers
Recent Conditions
NDFD Forecast
NWS Alert
Caltrans CCTV
Klamath National Forest
Redwood National Park
Shasta National Forest
Mendocino National Forest
Plumas National Forest
Tahoe National Forest
Lassen Volcanic National Park
Pyramid Lake
Chico
Oregon
20 mi
50 km
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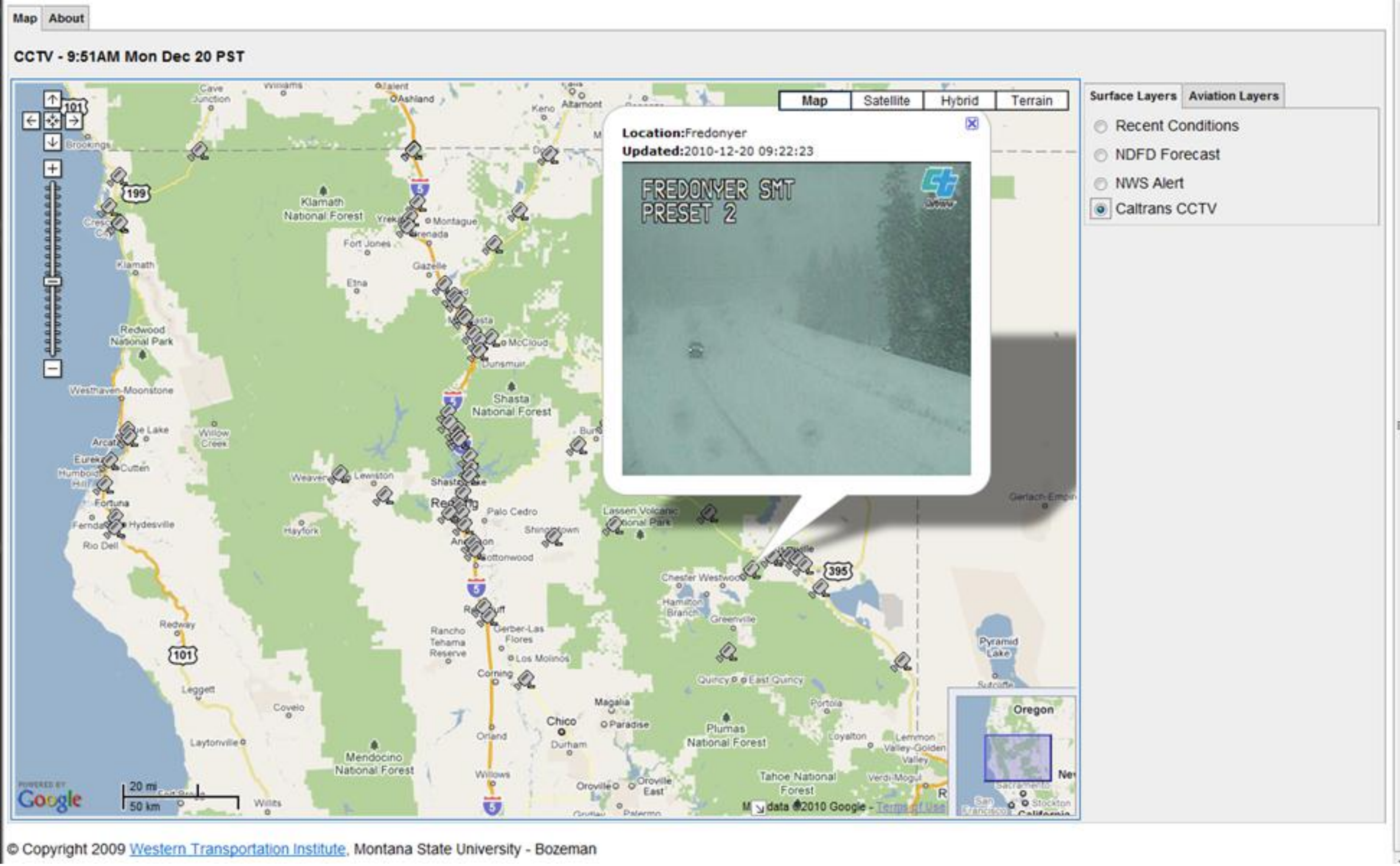
Map
About
CCTV - 9:51AM Mon Dec 20 PST
Map
Satellite
Hybrid
Terrain
Location:Fredonyer
Updated:2010-12-20 09:22:23
FREDONYER SMT
PRESET 2
Surface Layers
Aviation Layers
Recent Conditions
NDFD Forecast
NWS Alert
Caltrans CCTV
Klamath National Forest
Redwood National Park
Shasta National Forest
Lassen Volcanic National Park
Plumas National Forest
Mendocino National Forest
Tahoe National Forest
Oregon
20 mi
50 km
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Evaluation

16 respondents to an online survey administered in Spring 2010:

Organization	**count**
Caltrans-Division of Aeronautics	2
Caltrans, District 2	1
Caltrans	2
AirCarriage, LLC	1
EAA Chapter 427 Chico. CA	1
PACE Engineering	1
County of Siskiyou	1
EAA/AOPA	1
Emergency Medical Services Authority	1
No Response	4
TOTAL	16

A small, but relatively diverse group.

Frequency of Visits to Site

Response	Percent	Count
Website is open all the time	0.0%	0
Hourly	0.0%	0
Daily	18.8%	3
Weekly	31.3%	5
Monthly	6.3%	1
Not at all	25.0%	4
Other (please specify)	18.8%	3
	answered question	16

Other:

- *I just saw it for the first time*
- *When I have a need to travel or just up date my awareness*
- *twice monthly w/o RWIS*

No users were using the website all the time or on an hourly basis. These responses were consistent with this being a prototype that was introduced only several months prior.

When Information is Used

Response	Percent	Count
Daytime hours	61.5%	8
Nighttime hours	15.4%	2
Under changing conditions	53.8%	7
During incident conditions (storm/fire, etc.)	23.1%	3
When Supervisor on-duty	7.7%	1
When Supervisor off-duty	0.0%	0
Other (please specify)	23.1%	3
answered question		13
skipped question		3

- *I just saw it for the first time*
- *Assessing the go no go decision*
- *Before a flight or driving*

Information from the system was primarily used during daytime hours and under changing conditions.

Usefulness of Information – Current Surface Conditions

Answer Options	Very Useful	Somewhat Useful	Not Very Useful	Aware of it	Not Aware of it	Response Count
a. Station locations	5	4	0	0	1	10
b. Air Temperature	5	4	0	0	1	10
c. Wind direction & speed	8	0	0	0	2	10
d. Relative Humidity	2	6	0	0	2	10
e. Precipitation Last Hour	2	6	0	0	2	10
f. Precipitation Last 24 Hours	3	5	0	0	2	10
g. NWS Observed 24 Hour Precip	3	5	0	0	2	10
h. RWIS specific information such as Pavement Conditions	4	3	1	0	2	10
i. Station detail bubble information	4	5	0	0	1	10
					answered question	10
					skipped question	6

Usefulness of Information – Surface Forecast Conditions

Answer Options	Very Useful	Somewhat Useful	Not Very Useful	Aware of it	Not Aware of it	Response Count
a. Air Temperature	5	2	0	0	2	9
b. Wind direction & speed	8	0	0	0	2	10
c. Wind Gust Speed and direction	8	0	0	0	2	10
d. Relative Humidity	2	6	0	0	2	10
e. Sky cover	6	2	0	0	2	10
f. 12-hour Probability of Precipitation	8	0	0	0	2	10
g. 6-hour Amount of Precipitation	4	3	0	0	2	9
h. Snow	6	2	0	0	2	10
i. Weather	7	1	0	0	2	10
j. data provided at 3 hour intervals for next 24 hours	7	0	0	0	2	9
					answered question	10
					skipped question	6

Usefulness of Information – Various Aviation Layers

Answer Options	Very Useful	Somewhat Useful	Not Very Useful	Aware of it	Not Aware of it	Response Count
a. AWOS/ASOS (METAR) data	10	1	0	0	0	11
b. Encoded Pilot Reports (PIREPS)	8	2	0	0	1	11
c. Terminal Aerodrome Forecasts (TAF)	8	2	0	0	1	11
d. Radar: NWS CONUS Merged Reflectivity Composite	8	1	0	0	2	11
e. Satellite: IR Temperature	6	4	0	0	1	11
f. Satellite: Water Vapor	9	2	0	0	0	11
g. Satellite: Visible	9	1	0	0	1	11
					answered question	11
					skipped question	5

Usefulness of Information – Wind Aloft

Answer Options	Very Useful	Somewhat Useful	Not Very Useful	Aware of it	Not Aware of it	Response Count
a. 3000 ft MSL (900mb)	10	0	0	0	1	11
b. 6000 ft MSL (800mb)	10	0	0	0	1	11
a. 9000 ft MSL (725mb)	10	0	0	0	1	11
d. 12000 ft MSL (650mb)	5	4	0	0	1	10
e. 15000 ft MSL (575mb)	6	4	0	0	1	11
					answered question	11
					skipped question	5

Usefulness of Information – General Website Features

Answer Options	Very Useful	Somewhat Useful	Not Very Useful	Aware of it	Not Aware of it	Response Count
a. Google Map display & zoom function	10	0	0	0	2	12
b. Color-coded weather information and graphic representation	9	1	0	0	2	12
c. Historical data access for surface weather stations through screen display	3	3	2	1	3	12
d. Historical data access for surface weather stations through CSV file export	2	3	2	0	4	11
e. Having the NDFD forecast data mapped to highway mileposts at one mile intervals in addition to the background raster	5	2	0	1	4	12
f. Different data layers switching using tab display and radio button	6	1	0	0	5	12
g. Auto refresh web page every 3 minutes	5	1	0	0	6	12
					answered question	12
					skipped question	4

Usefulness of Information – Miscellaneous

Answer Options	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Disagree	Response Count
a. The site is well organized and user friendly.	8	3	1	0	0	12
b. I would like to see NDFD forecast information for more than 24 hours.	5	5	1	0	1	12
c. I would like to see more/different Radar images (please specify in comments section).	2	3	6	0	0	11
d. I would like to see more/different Wind/Temperature aloft at higher altitude (please specify in comments section).	3	1	5	1	1	11
e. I would like to see Wind/Temperature aloft at time intervals further out than 1 hour (please specify in comments section).	5	1	5	0	0	11
					answered question	12
					skipped question	4

Desired Additional Weather Information

- *Winds and temperature aloft forecasts*
- *Two- to three-hour forecasts are particularly helpful for GA pilots since this is the outside edge of their operational envelope.*
- *I have no additional needs at this time.*
- *Little more information in bubble.*
- *Density altitude report at each AWOS location which is on an airport.*
- *NWS Winds aloft (FD) have standard forecast times. Those times could be used.*

Chief Benefits of the Site

- *Situational awareness of weather for pilots*
- *It is another convenient tool in evaluating current and future weather conditions.*
- *We can use it today to help plan our fly-in visits to GA airports statewide.*
- *This site is potentially valuable for skiiers seeking fresh cold snow, and seeking road information on highway routes. Unfortunately higher elevations holding resorts are not represented. There is blank space where resorts could be included. As a reminder to carry appropriate survival gear....*
- *Not as much in my current position, but as a pilot, it's nice to have all this data in an easy to use format.*
- *Assisting in deciding whether or not to launch for a project at a distant location and allowing time necessary to arrive on schedule. Excellent resource!*
- *I use the site to help plan aviation flight plans.*
- *Quick brief aviation weather synopsis*
- *Getting aviation weather. Appreciate the different layers of info available.*

Ways to Improve the Site

- *Winds and temperature aloft forecasts*
- *From an aviation perspective, forecast data is critical to flight planning. The more frequent the updates the safer the flight. Also, the system is robust in that it provides information in areas where there are not typically weather stations. The better we can link multiple weather data sources, the better we can plan flight activities, and by flight activities I am including emergency medical flights, firefighting, cargo and business aviation, not just typical commercial flights that use altitudes well above regional operational needs.*
- *I tried to use the route-making line but I got no action. I perhaps needed more instruction on how to create the line using the mouse.*
- *I appreciate the effort being used and with no previous awareness I still believe it will be very useful.*
- *Check with Wm. Hill regarding informal sources of information, from experienced observers scattered around the region who can give eyewitness reports of conditions.*
- *I will have to review over a longer period of time to decern if improvements are needed.*
- *Thank You*
- *Have the ability to go full screen if possible.*
- *Aviation tab, AWOS, Airport wx data, add link to last 3 (plus or minus) AWOS readings to get trend info. I appreciate actual METAR is included at bottom of Airport wx data page.*
- *Aviation tab, winds aloft, altitude choices are great. Want to know what time frame data is from. Is it actual (current) or forecast? NWS WD forecasts have standard forecast valid times. Choice of forecast valid times would be useful, to me.*

Evaluation Summary

- The site was generally well-received.
- There are some things that can be improved or added to the site.
- We need more feedback.
- We need more users.
- The system will need to be prepared for greater use.

Benefits

As always, benefits are challenging to quantify accurately and realistically.

Airports

- Such a system might be used, at the discretion of aviation users, in the absence of an installed, dedicated weather station and in conjunction with other information sources, if an AWOS or ASOS installation is infeasible.
- We stress that <u>such a system is not a replacement for a local AWOS or ASOS weather station</u>.
- One approach to quantify the benefit of such a system is to determine how the system can improve the safety and efficiency of airport operations by comparing with situations without weather information.

General Aviation Weather Accidents in 2005

Weather Condition	Accidents	Fatalities	Weather Condition	Accidents	Fatalities
Crosswind	68	1	Snow	4	4
Gust	57	6	Variable Wind	3	0
Tailwind	48	3	Haze/Smoke	3	3
High Density Altitude	33	5	Temperature High	2	0
Low Ceiling	33	30	Whiteout	2	1
Carburetor Icing conditions	18	0	Unfavorable Wind	2	1
Fog	18	10	Dust Devil/ Whirlwind	2	0
Downdraft	15	0	Turbulence, clear air (CAT)	1	0
Icing conditions	12	5	Mountain Wave	1	1
Clouds	10	7	Turbulence in clouds	1	0
High Wind	10	2	Thunderstorm, outflow	1	0
Obscuration	7	7	Below approach/landing minimums	1	1
Windshear	6	0	Drizzle/Mist	1	1
Rain	6	4	Microburst/dry	1	1
Thunderstorm	5	4	Other	1	0
Turbulence	5	2	Lightning Strike	1	0
No thermal lift	5	0	Total	309	67

Source: NTSB (2009a).

Value of Lost Life and Injuries

AIS Code	Injury Severity Level	Avoided Cost of Injury	Selected Injuries
AIS 1	Minor	$11,600	Superficial abrasion or laceration of skin; digit sprain; first-degree burn; head trauma with headache or dizziness (no other neurological signs)
AIS 2	Moderate	$89,900	Major abrasion or laceration of skin, cerebral concussion (unconscious less than 15 minutes); finger or toe crush/amputation; closed pelvic fracture with or without dislocation
AIS 3	Serious	$333,500	Major nerve laceration; multiple rib fracture (but without flail chest); abdominal organ contusion; hand, foot, or arm crush/amputation
AIS 4	Severe	$1,087,500	Spleen rupture; leg crush; chest-wall perforation; cerebral concussion with other neurological signs (unconscious less than 24 hours)
AIS 5	Critical	$4,422,500	Spinal cord injury (with cord transaction); extensive second or third-degree burns; cerebral concussion with severe neurological signs (unconscious more than 24 hours)
AIS 6	Fatal	$5,800,000	Fatalities and injuries which although not fatal within the first 30 days after an accident, ultimately result in death

Source: Office of the Secretary of Transportation Memorandum (2008).

Airports

Since the system exists only in prototype form and has not been fully deployed, it is not clear yet how many accidents could be reduced or mitigated through its use. Considering the number of smaller airports and general aviation in California, one can see that even if a single “severe injury” can be avoided each year for the whole state of California, the cost savings would be significant.

Airline Cost Based on Block Hours

FY09$	Variable Cost ($) Per Airborne Hour	Variable Cost ($) Per Ground Hour	Variable Cost ($) Per Block Hour	Fixed Cost per Block Hour ($)	Total Per Block Hour ($)
Air Carrier - Passenger	3,771	1,899	3,471	800	4,272
Air Carrier - Cargo	7,388	3,721	6,801	1,834	8,635
Air Carrier - TAF	4,045	2,037	3,724	878	4,602
Air Taxi - TAF	1,059	533	975	577	1,551
General Aviation	589	297	542	848	1,390
Military	7,404	3,729	6,816	1,838	8,654

Sources: GRA, Incorporated (2007).

For general aviation aircraft, if we assume that 100 block hours of aircraft delay can be reduced annually due to more detailed weather information disseminated by an integrated system, then the cost savings for general aviation would be $139,000 per year.

Standard Passengers' Value of Time

Category	Recommended Value per Hour	Sensitivity Range	
		Low	High
Commercial:			
Personal	$23.30	$20,00	$30.00
Business	$40,10	$32.10	$48.10
All purposes	$28.60	$23.80	$35.60
General Aviation:			
Personal	$31.50	(No Recommendation)	
Business	$45.00		
All purposes	$37.20		

Source: Office of the Secretary of Transportation Memorandum (2003).

While it is not clear how much delay can be avoided due to the use of an integrated system since the system has not been deployed yet, if we assume that it could save 1 minute for 1,000 passengers each day in California, then the total cost savings for passengers will be at least $200,000 per year.

Heliports/helipads

- An integrated weather system would complement existing AWOS or ASOS, particularly in areas that are not served locally with an AWOS or ASOS.
- Such a system could be useful to the users of the heliports and helipads, where no AWOS or ASOS is located.
- It could also be beneficial to helicopters such as air ambulances, which need to land in such areas as highways, a parking lot, a field, or a mountain in order to pick up a patient.
- The benefit of an integrated weather system is generally to improve the safety of helicopter operations at heliports/helipads, or at some specific locations even without heliport/helipad facilities, as mentioned above.

Heliports/helipads

- Ambulance and rescue helicopters pose a greater risk for an accident than any other helicopter operation because they often fly in adverse weather and operate in areas such as forest roads, rocky cliffs, and mountainous terrain, with little or no source of weather information.
- According to the NTSB, helicopter EMS accident rates are 3.5 times more likely than for other non-scheduled Part 135 Air Taxi helicopter operations. According to FAA (2009), there were approximately 840 emergency medical service helicopters operating in the U.S; and between the mid-1990s and the early 2000s, the accident rates for EMS helicopters nearly doubled.
- There were 9 accidents in 1998, and there were 15 accidents in 2004, 5 of which resulted in 17 fatalities. The increase of accident rate is largely due to terrain and object collisions during unexpected Instrument Meteorology Conditions (IMC), and pilot disorientation. NTSB (2009b) reports that there were 55 EMS accidents between January 2002 and January 2005, which included 41 helicopters and 14 airplanes. More recently, there were 12 EMS helicopter accidents in 2008, which resulted in 28 deaths and 8 injuries, according to Nolan Law Group (2009).

Heliports/helipads

- There are few systematic or quantitative studies on the impact of weather information on the accidents of EMS helicopters.
  - NTSB (2009b) reports that “13 of 55 accidents may have benefited from use of NVIS (Night Vision Imaging Systems)”, and “17 of 55 accidents may have been prevented with TAWS (Terrain Awareness and Warning System)”.
  - According to FAA (2009), FAA has funded the development and implementation of a “graphical flight planning tool for ceiling and visibility assessment along direct flights in areas with limited available surface observation capability.”, and also claims that the responses from the users are very favorable.
- It is expected that an integrated weather system, providing weather information from various sources, could provide a better image of the weather occurring at the EMS helicopter’s destination or origin, which could reduce the number of accidents caused by unexpected weather. (It should be noted, though, that the prototype system does not include functionality to assist with night visibility).

Heliports/helipads

More quantitative studies can be carried out after the installation of the system, so that the operations before and after the implementation can be compared, and the responses from the users can also be collected for analysis.

Ground Transportation

- There may be opportunities for shared maintenance agreements.
- Similarly, there may be opportunities for RWIS to be better supported, including better siting, calibration, etc. by learning from AWOS/ASOS deployments and collaboration and by using similar services.
- An integrated system, as a complement to RWIS, promotes surface transportation weather services for maintaining and operating California's highways.
- RWIS provides real time weather and road conditions for developing more effective and efficient treatment strategies in winter maintenance, and has become an essential component to winter maintenance and snow removal operations.
- The implementation of RWIS requires a large capital investment and dedicated resources for procurement, maintenance, effective coordination, and data dissemination. The cost of deploying a single RWIS is approximately $100,000 per site (Abernethy, 2003), and the monthly maintenance cost is about $450 per site to $900 per site (Albert, 2002).
- Due to the cost and limited funds within state DOTs, the deployment of RWIS has been limited with deployments prioritized to trouble spots with significant winter conditions.
- By integrating AWOS/ASOS data as well as other current and forecast surface weather data, such a system would provide an integrated picture of weather for winter maintenance decision making.

Ground Transportation

- The integrated weather system can help to identify the problematic RWIS Environmental Sensor Station (ESS) sensors.
  - RWIS has a poor reputation regarding reliability and accuracy: data is not always available; observed conditions do not correlate with data; and there is no independent way to ensure data integrity (Ken, 2009).
  - With the integration of nearby weather stations data from AWOS/ASOS and other sources, quality control (QC) processes, such as Spatial Consistency Check, can be implemented to flag problematic sensor readings that provide a better way for state DOT ESS administrators or end users to spot sensors that require additional investigation.
  - Especially for remote RWIS sites, this could help to save time and money if the remote problematic RWIS ESS sensor could be identified without unnecessary site visits.
- The project team has looked at additional cost-benefits related to RWIS maintenance.
  - The success of winter road maintenance relies on accurate and effective operation of RWIS, which requires routine maintenance.
  - The proper calibration of RWIS surface sensors is critical to operation because calibration will drift over time and with the amount of traffic (Ken, 2009) .
  - Considering AWOS and ASOS have a similar suite of sensors as RWIS, which require similar calibration and maintenance, but have a better reputation regarding reliability and accuracy, there could be some combined efforts where the same entities that provide installation, calibration and maintenance for AWOS and ASOS could be contracted to provide similar service for RWIS to improve the maintenance service of RWIS.

Phase 2 (in contracting process)

- Task 2-0: Project Management
- Task 2-1: Business Case Analysis
- Task 2-2: Research Additional Sources
- Task 2-3: Detailed System Requirements
- Task 2-4: Develop System
- Task 2-5: Implementation
- Task 2-6: Evaluation
- Task 2-7: AWOS/ASOS Gap Analysis
- Task 2-8: Determine Usage Status and Recommendations
- Task 2-9: Final Project Report and Presentation

Acknowledgments

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- *Brian Simi*
- *Derek Kantar*
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- *Gary Cathey (Caltrans Division of Aeronautics)*

More information and future updates can be found at www.westernstates.org

Questions?