From AWOS/RWIS to Caltrans Aviation Weather Information (AWI)

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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, Montana State University or Utah State University.

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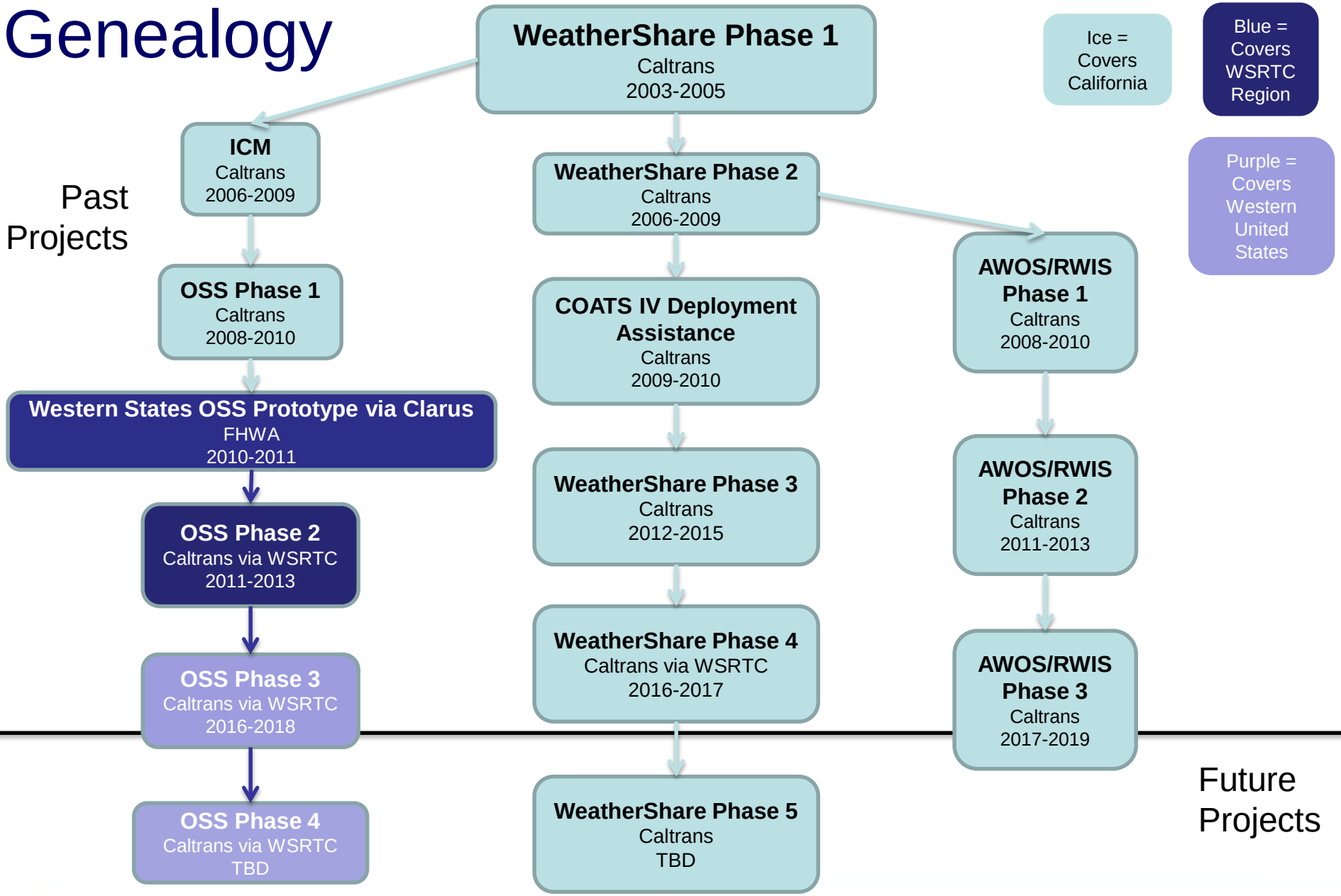
Genealogy


WeatherShare Phase 1
Caltrans
2003-2005
Ice = Covers California
Blue = Covers WSRTC Region
Purple = Covers Western United States
Past Projects
ICM
Caltrans
2006-2009
OSS Phase 1
Caltrans
2008-2010
Western States OSS Prototype via Clarus
FHWA
2010-2011
OSS Phase 2
Caltrans via WSRTC
2011-2013
OSS Phase 3
Caltrans via WSRTC
2016-2018
OSS Phase 4
Caltrans via WSRTC
TBD
WeatherShare Phase 2
Caltrans
2006-2009
COATS IV Deployment Assistance
Caltrans
2009-2010
WeatherShare Phase 3
Caltrans
2012-2015
WeatherShare Phase 4
Caltrans via WSRTC
2016-2017
WeatherShare Phase 5
Caltrans
TBD
AWOS/RWIS Phase 1
Caltrans
2008-2010
AWOS/RWIS Phase 2
Caltrans
2011-2013
AWOS/RWIS Phase 3
Caltrans
2017-2019
Future Projects

Abstract

Weather significantly affects safety as related to transportation, which includes regional surface transportation (highways and local streets) and aviation (airports, hospital heliports and flight paths). Starting in 2008, the Western Transportation Institute (WTI) at Montana State University (MSU) conducted a research and development study of a proof-of-concept system for integrating Automated Weather Observing System (AWOS) with Roadside Weather Information System (RWIS).

This multi-phase project targets small, underserved rural airfields and hospital heliports. The goal is to provide airport managers, flight departments, pilots, and other 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.

This presentation will summarize work conducted in Phases I, II and III of this research project, which is culminating with the migration from research and development at Montana State University to long-term implementation within Caltrans.

This document summarizes work conducted in Phases I - III of the research project, which ends February 19, 2019.

Original Problem Statement

AWOS (Automated Weather Observing Systems), ASOS (Automated Surface Observing Systems) and RWIS (Roadside Weather Information Systems) equipment provide similar meteorological information to support safe and efficient transportation across multiple modes, but are operated independently of each other. Continued deployment and operation of similar but independent systems in close proximity to each other may result in redundancy and increased costs. Linkage consolidation of such systems will provide system managers and users (airport managers, flight departments and pilots) more comprehensive and accurate meteorological data and may reduce cost.

Phase I

February 1, 2008 – June 30, 2010

Phase I
Research Outcomes

- Identified aviation industry needs, requirements and benefits, and compare current capabilities, costs, coverage, and operation and maintenance requirements of AWOS / ASOS and RWIS by respective agencies.
- Summarized lessons learned from similar integration projects.
- Conducted a cost-benefit analysis for both an integrated data system and for cooperative maintenance and deployment, and determine related institutional issues.
- Created a controlled field demonstration prototype system.
- Evaluated the controlled field demonstration prototype system.
- Made recommendations based on the cost-benefit analysis and the evaluation of the field demonstration prototype system.

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

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185 Aviation Weather Stations

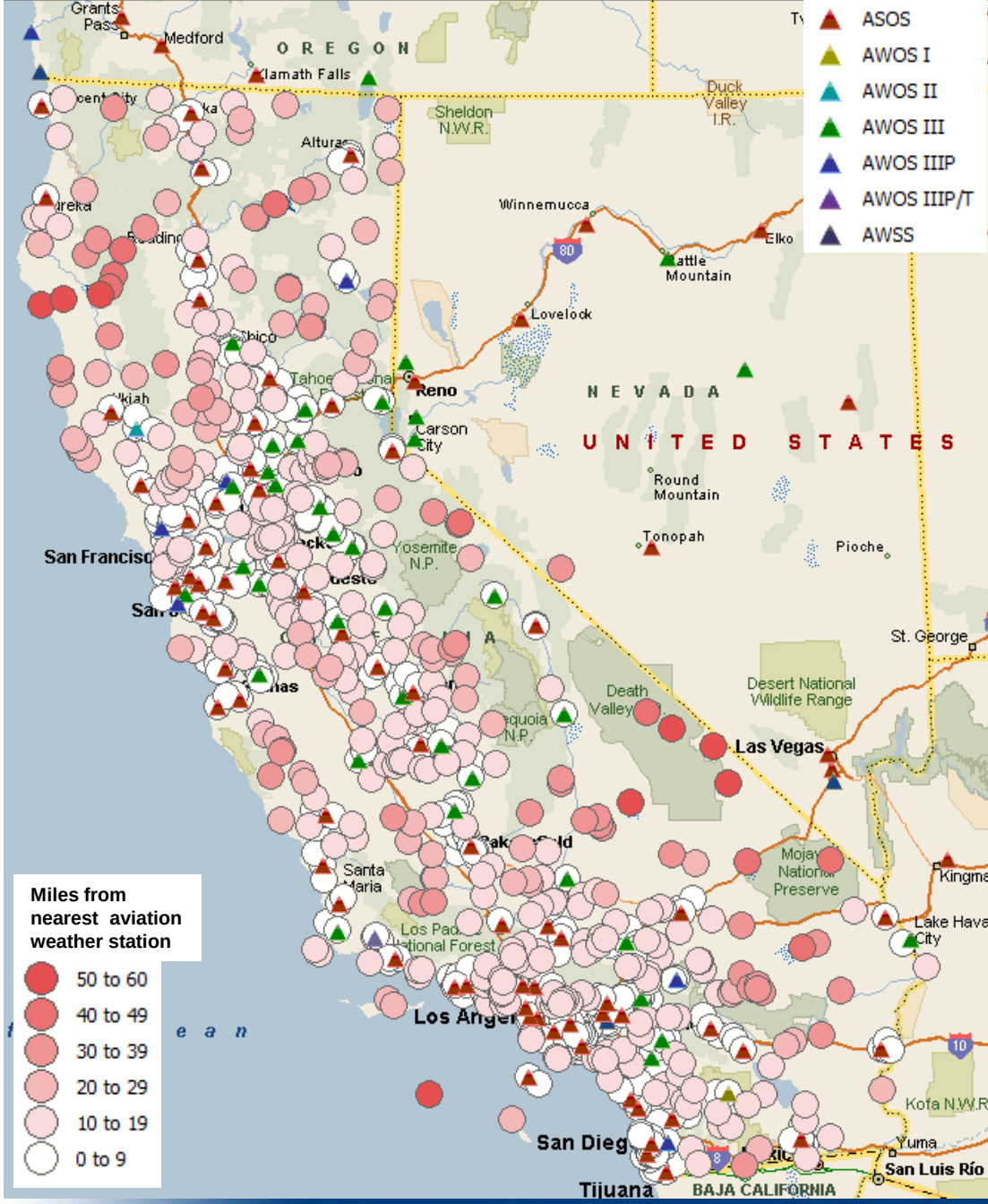
Others in proximity in Oregon, Nevada and Arizona are shown.

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



171 Caltrans RWIS

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

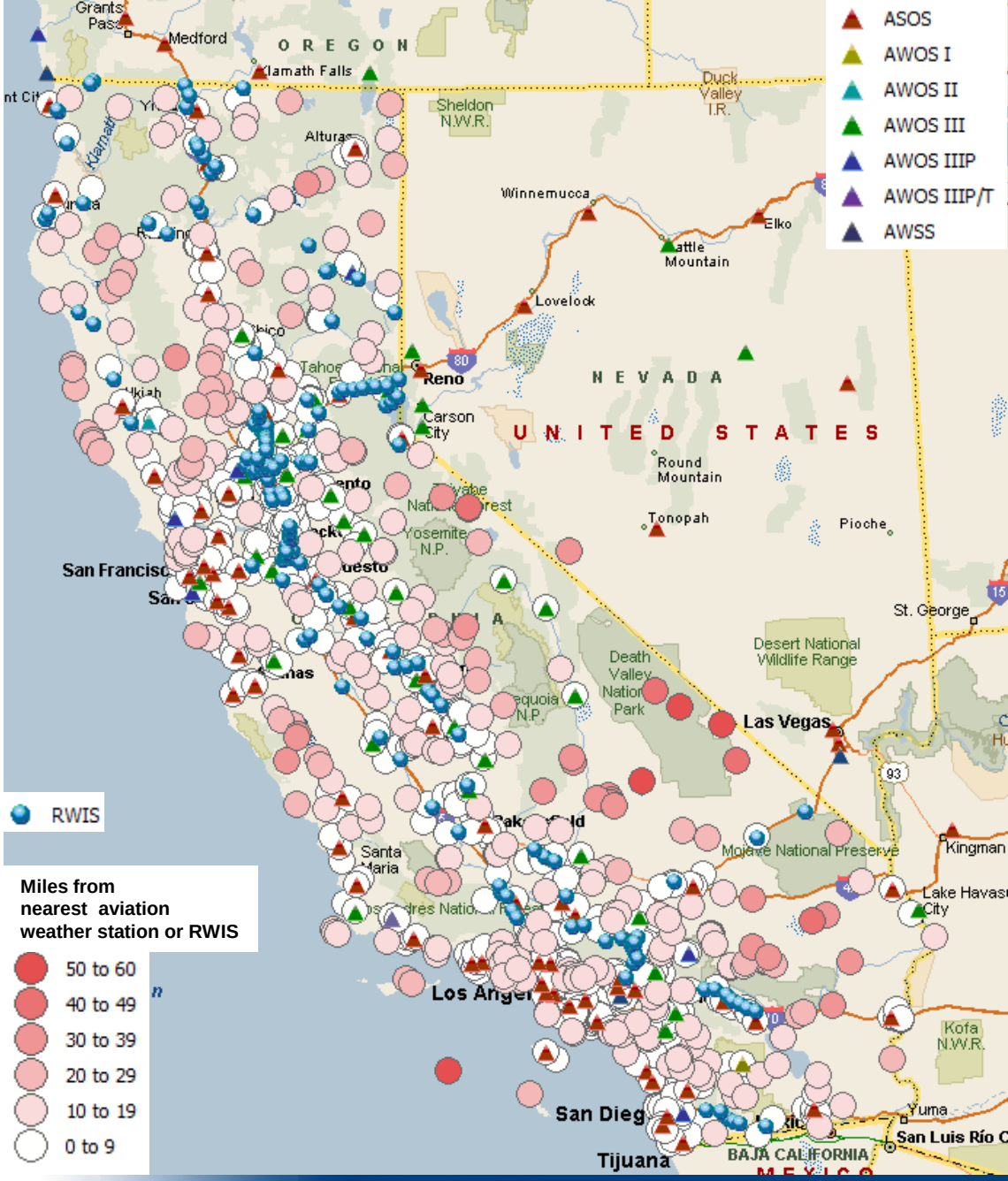
Data was combined from several sources and sites which may be inactive, so this count is approximate.

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



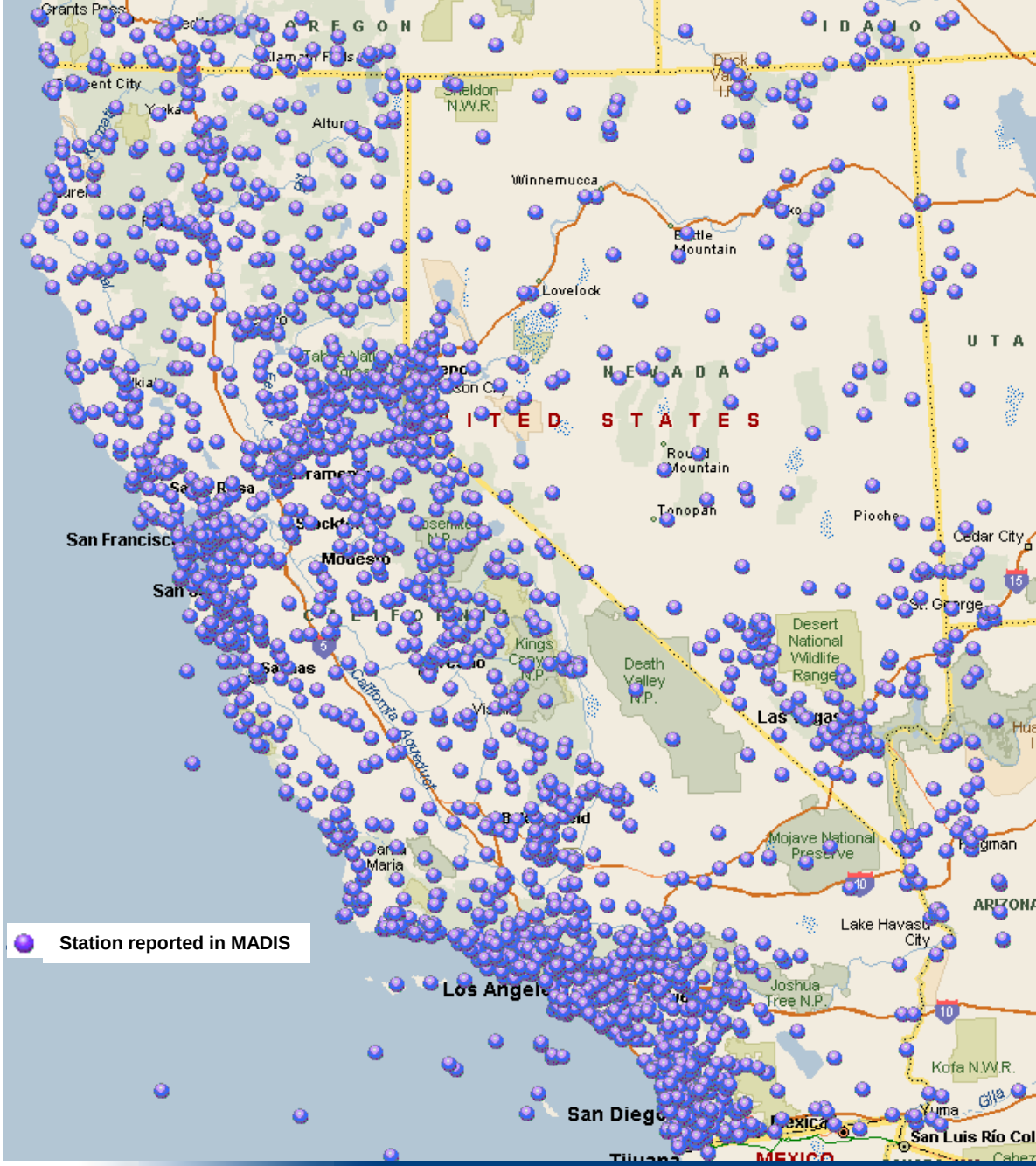
Approximately 2000 weather stations via MADIS.

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)

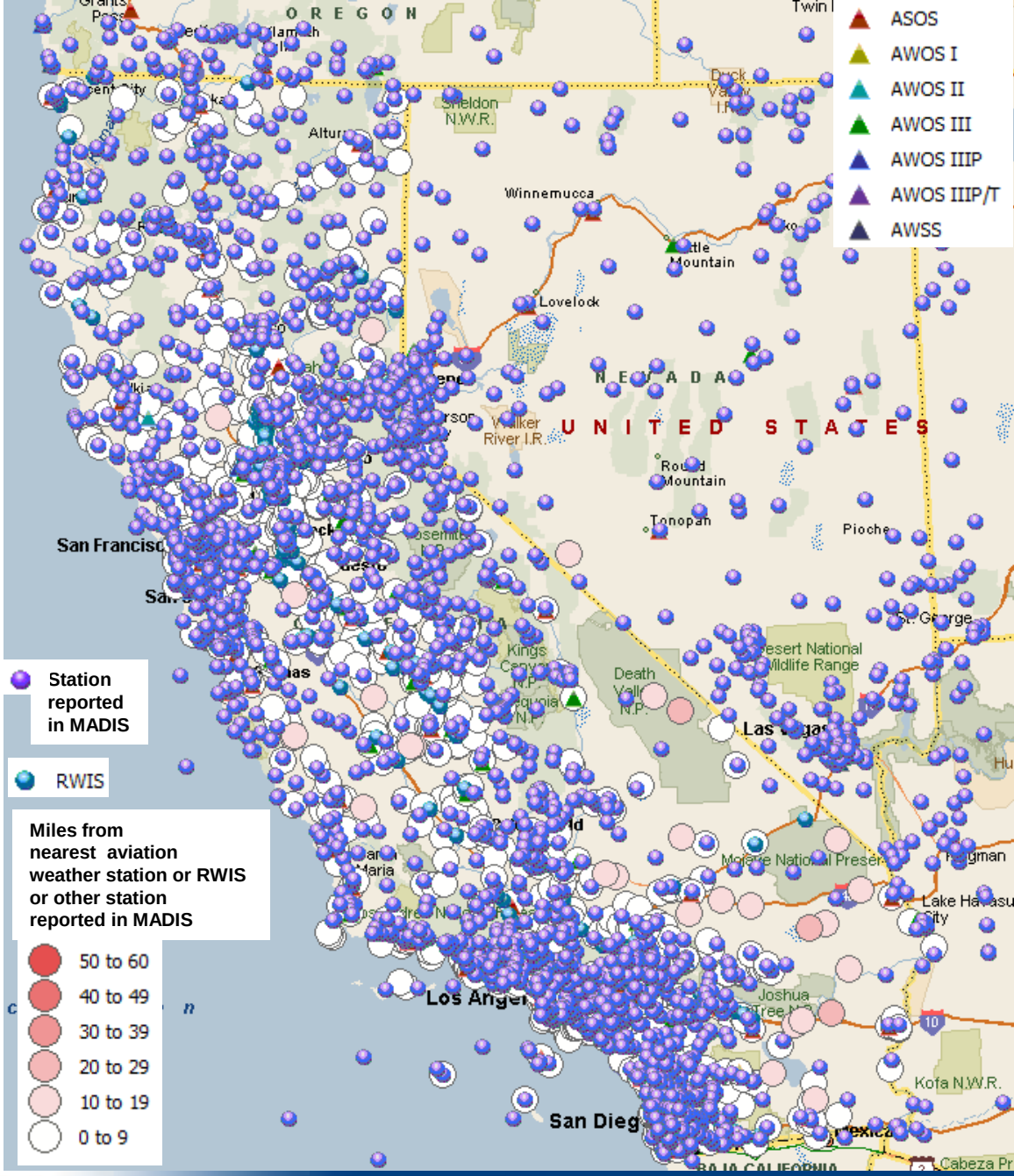
Source: NOAA



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

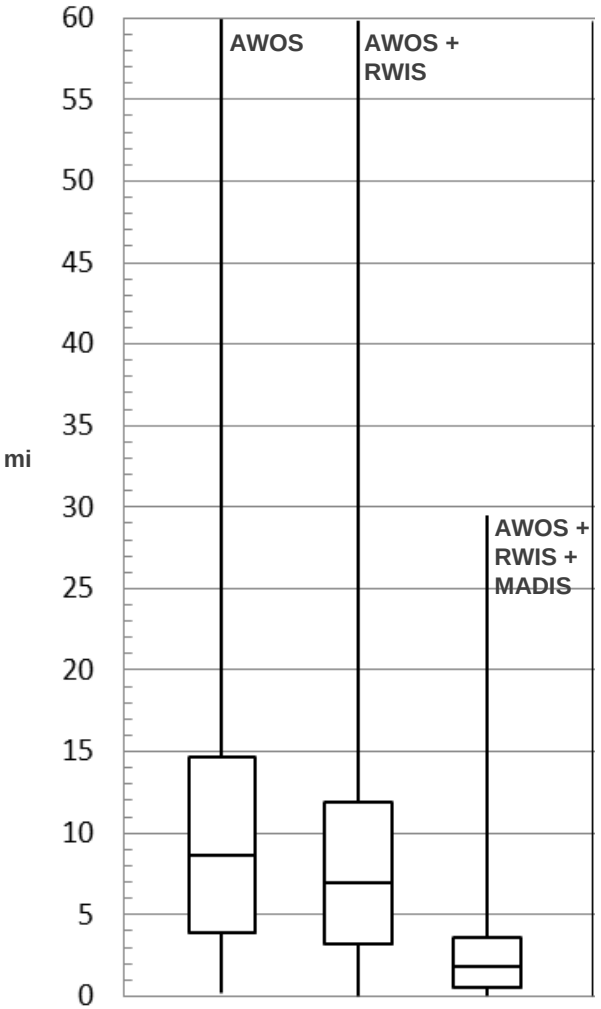
Distance (mi)	count
dist < 5	801
5 ≤ dist < 10	138
10 ≤ dist < 20	25
20 ≤ dist < 30	3
30 ≤ dist < 40	0
40 ≤ dist < 50	0
50 ≤ dist	0

	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

Phase 2

July 3, 2012 – December 31, 2015

Phase 2
Research Outcomes

- Conducted a Business Case Analysis.
- Researched Additional Data Sources.
- Developed Detailed System Requirements.
- Developed and Implemented the Phase II Prototype System.
- Evaluated the Phase II Prototype System.
- Conducted an AWOS/ASOS Gap Analysis.

Outcome: Business Case Analysis

Deliverable:

- Benefit Analysis of the Aviation WeatherShare System by Wenbin Wei, San Jose State University (SJSU). Finalized February 2, 2014.

Outcome: Research Additional Sources

Deliverable:

- Integration of Aviation Automated Weather Observation Systems (AWOS) with Roadside Weather Information Systems (RWIS) Phase II Data Sources Summary, by Daniell Richter and Douglas Galarus, Western Transportation Institute, Montana State University. Finalized April 27, 2015.

Outcome: Detailed System Requirements

Deliverable:

- Integration of Aviation Automated Weather Observation Systems (AWOS) with Roadside Weather Information Systems (RWIS) Phase II Detailed Prototype System Requirements Specification, by Daniell Richter and Douglas Galarus, Western Transportation Institute, Montana State University. Finalized August 13, 2014.

Outcome: Develop System

Deliverable:

- Phase II System in Development and Testing Environment

Outcome: Implementation

Deliverable:

- Phase II System in Production Hosting Environment: http://aviation.weathershare.org/.

Outcome: Evaluation

Deliverable:

- Evaluation Summary (Included in the Project Final Report)
  - SJSU Survey Results
  - Online Survey Results
  - Google Analytics Results

Outcome: AWOS/ASOS Gap Analysis

Deliverable:

- Integration of Aviation Automated Weather Observation Systems (AWOS) with Roadside Weather Information Systems (RWIS) Phase II Gap Analysis, by Douglas Galarus and Daniell Richter, Western Transportation Institute, Montana State University. Finalized July 10, 2015.

The Phase 2 Prototype System

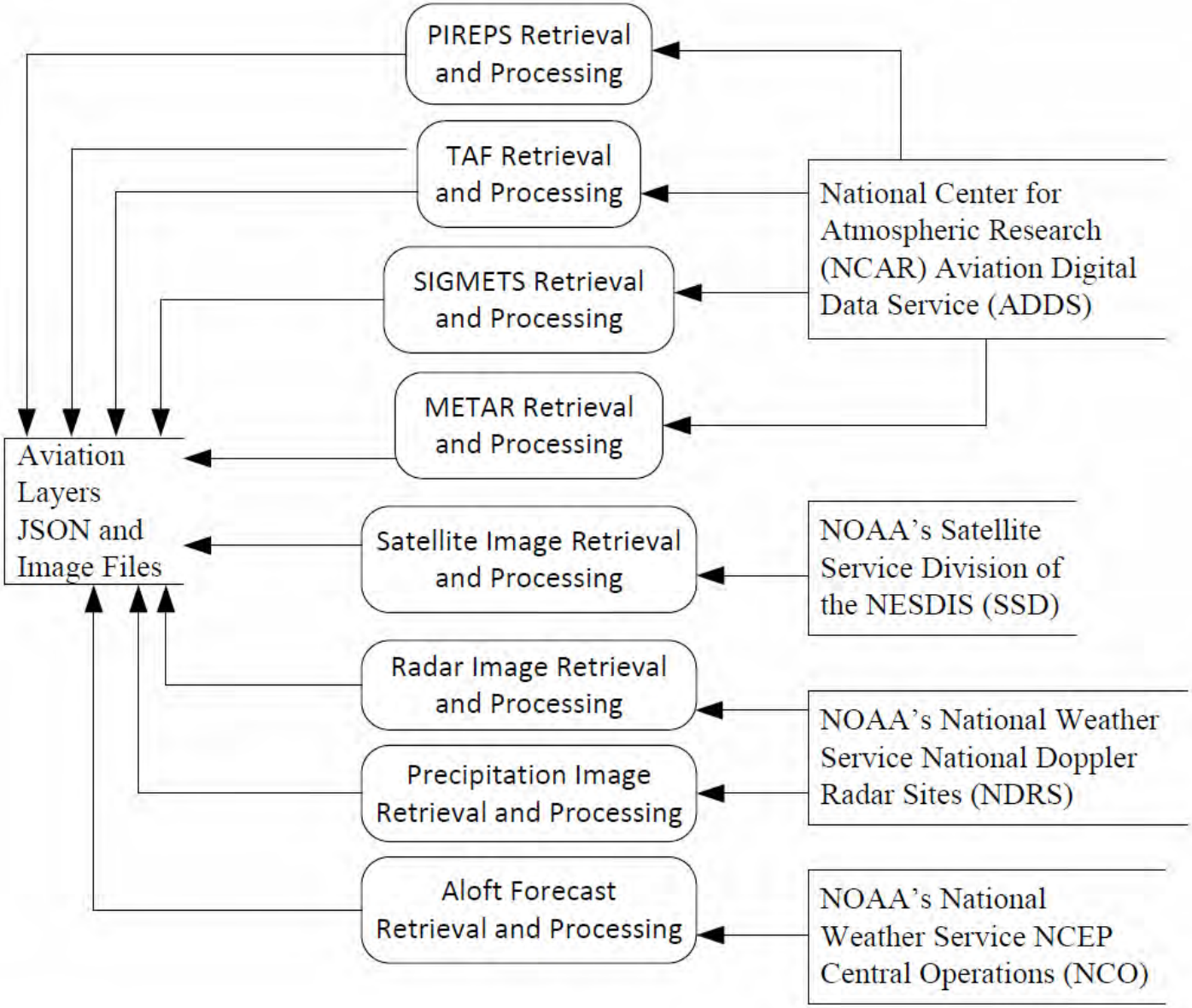
Data Retrieval and Processing…

Dynamic Data Layers & Sources

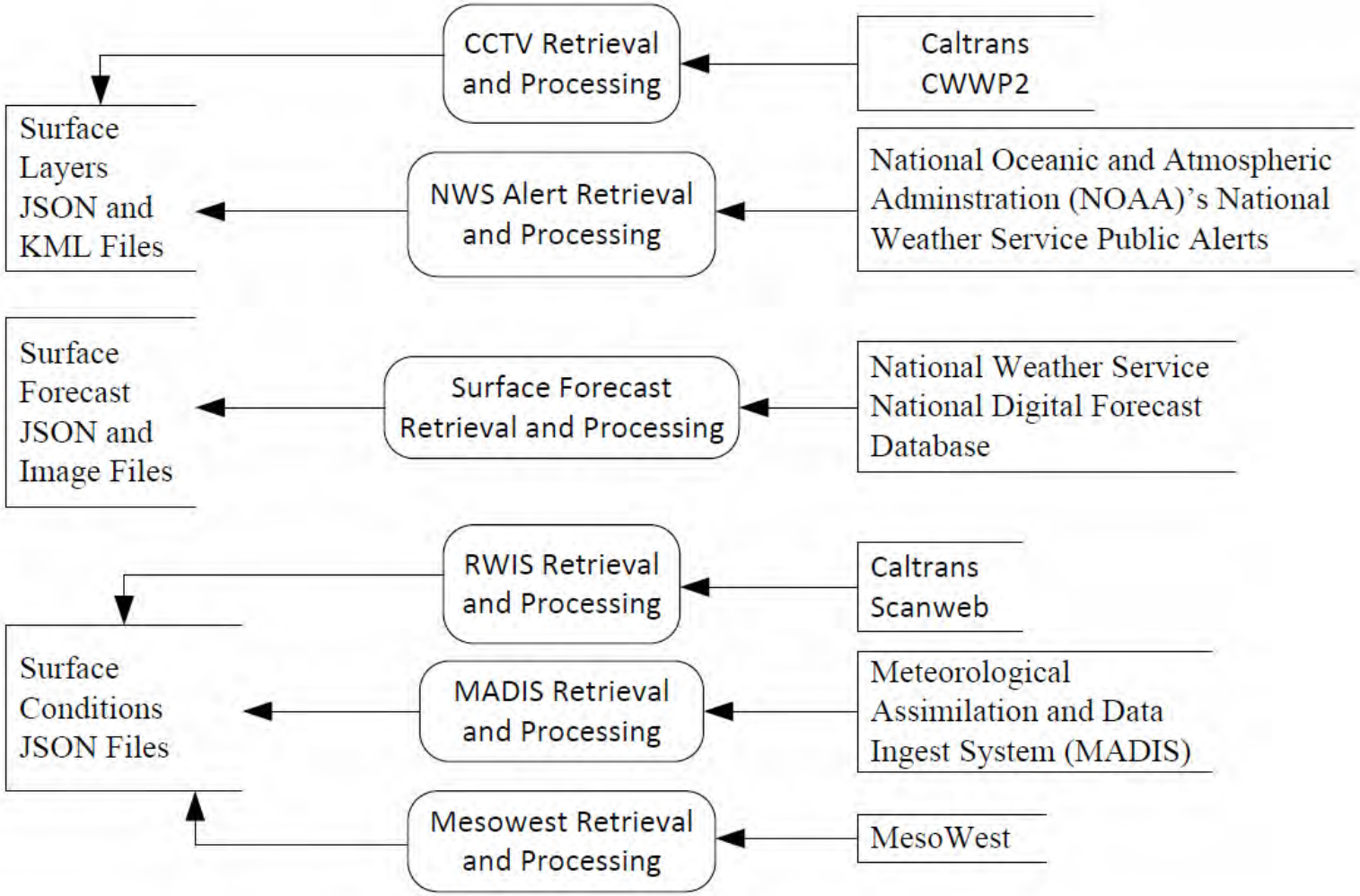
- National Center for Atmospheric Research (NCAR) Aviation Digital Data Service (ADDS):
  - PIREPS
  - TAF
  - SIGMETS
  - METAR
- NOAA's Satellite Service Division of the NESDIS (SSD):
  - Satellite Images
- NOAA's National Weather Service (NWS) National Doppler Radar Sites (NDRS):
  - Radar Images
  - Precipitation Images
- NOAA's National Weather Service NCEP Central Operations (NCO):
  - Wind Aloft
  - Temperature Aloft
- Caltrans CWWP2:
  - Caltrans CCTV
- National Oceanic and Atmospheric Administration (NOAA)'s National Weather Service Public Alerts:
  - NWS Alerts
- National Weather Service National Digital Forecast Database:
  - Surface Forecasts
- Caltrans Scanweb:
  - Caltrans RWIS
- Meteorological Assimilation and Data Ingest System (MADIS):
  - Surface Conditions
- MesoWest:
  - Surface Conditions

Airport, Heliport and Military Aviation Facilities are presented as a static layer using data provided by Caltrans.

Aviation Layers



Surface, Surface Forecast and Surface Conditions Layers



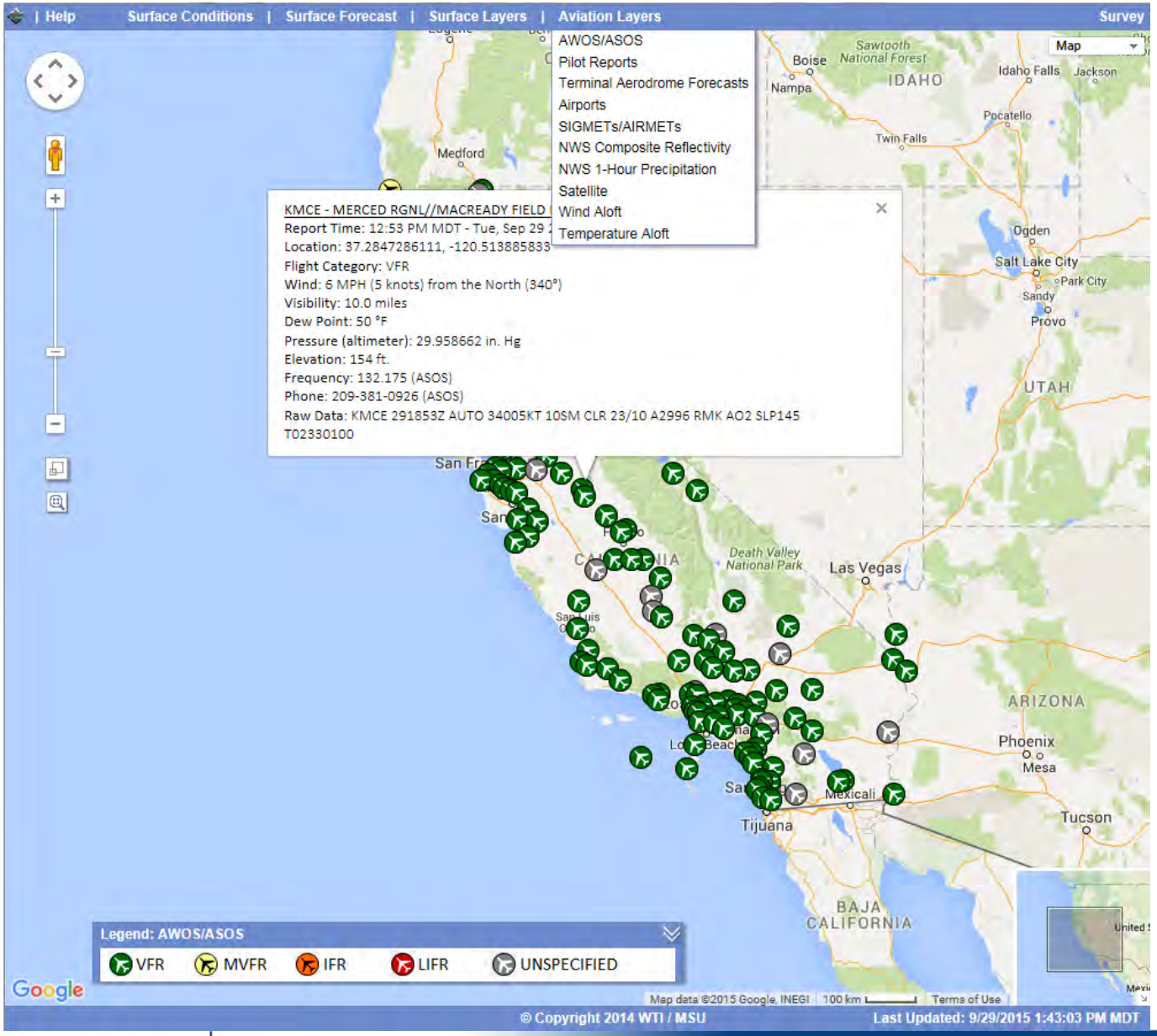
The Phase 2 Prototype System

A Pictorial Overview …

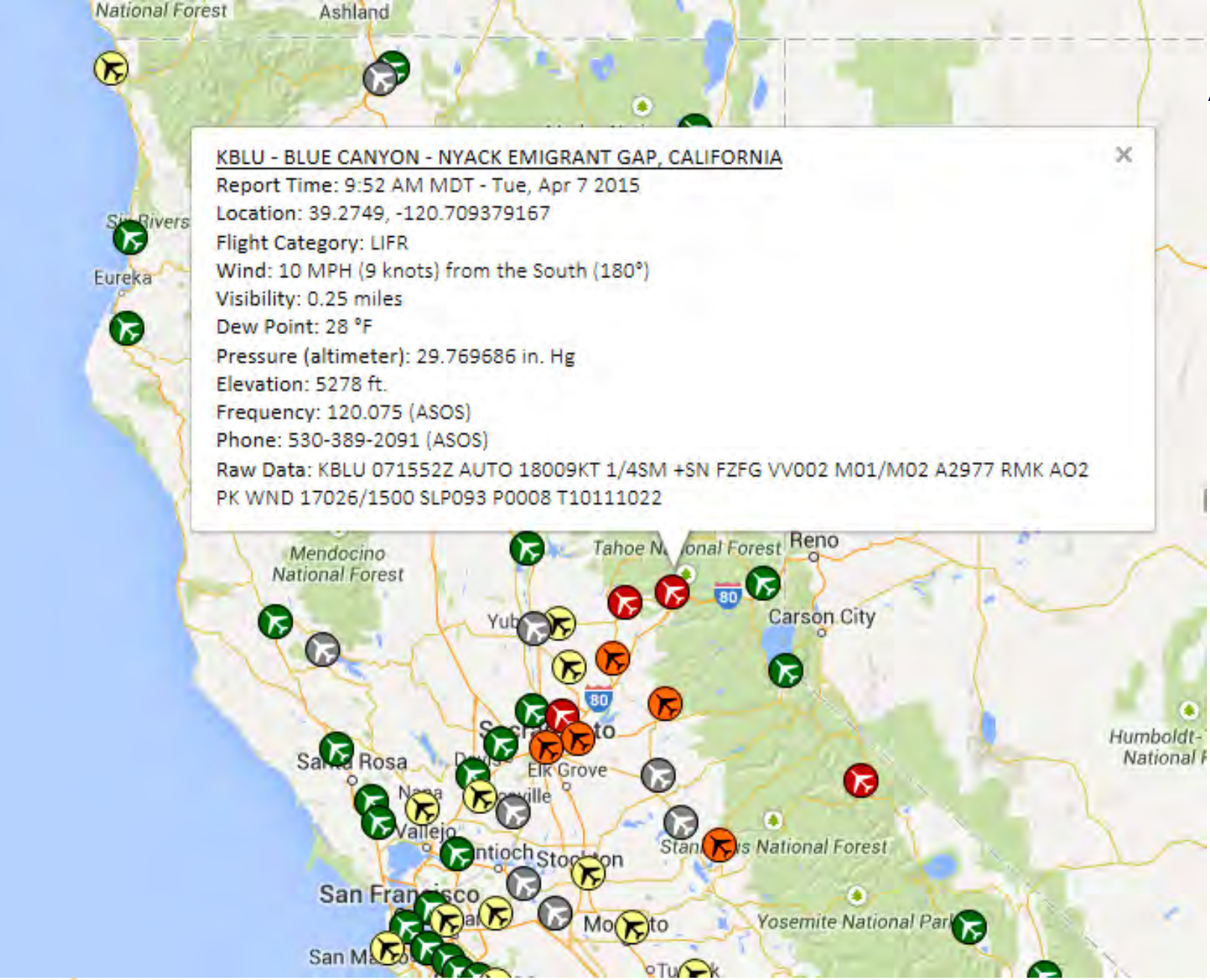
Aviation Layers

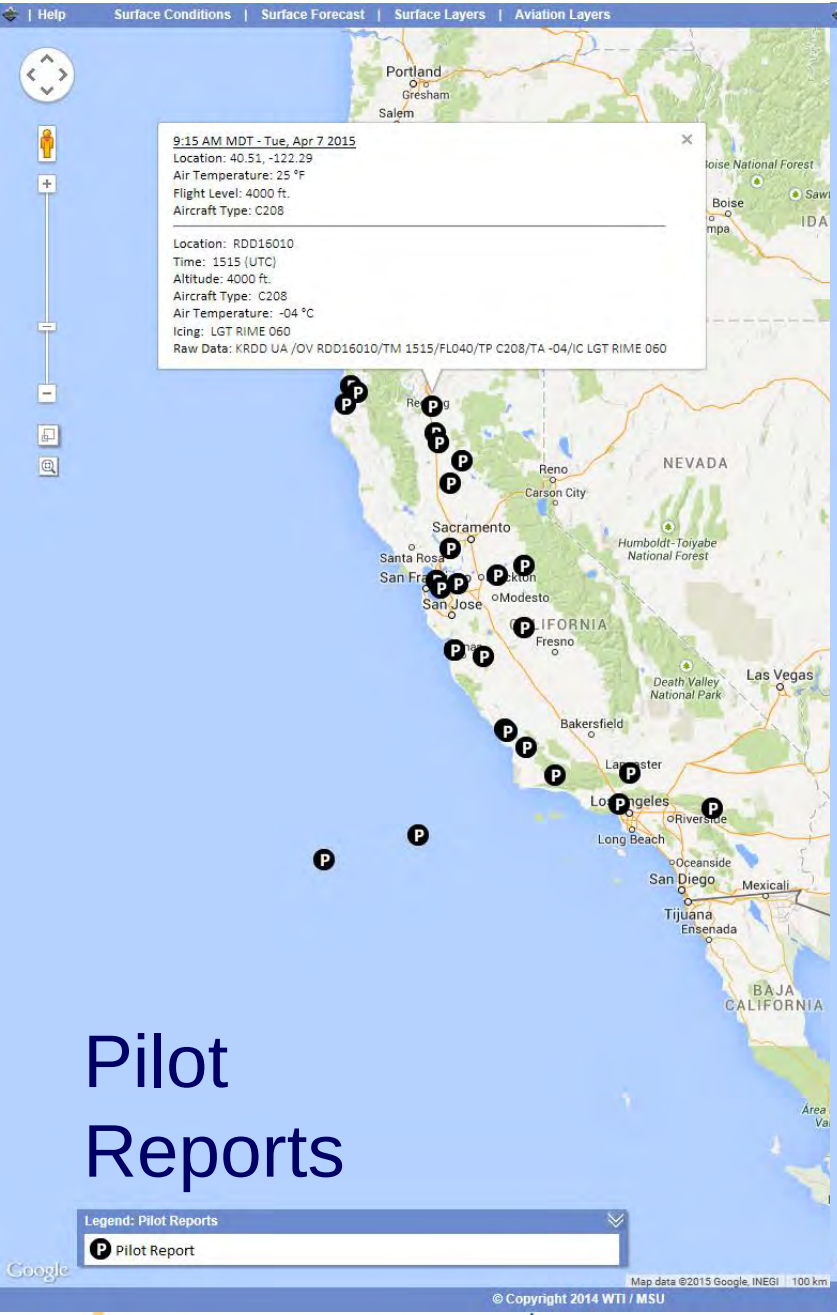
Aviation Layers
AWOS/ASOS
Pilot Reports
Terminal Aerodrome Forecasts
Airports
SIGMETs/AIRMETs
NWS Composite Reflectivity
NWS 1-Hour Precipitation
Satellite
Wind Aloft
Temperature Aloft

http://aviation.weathershare.org/

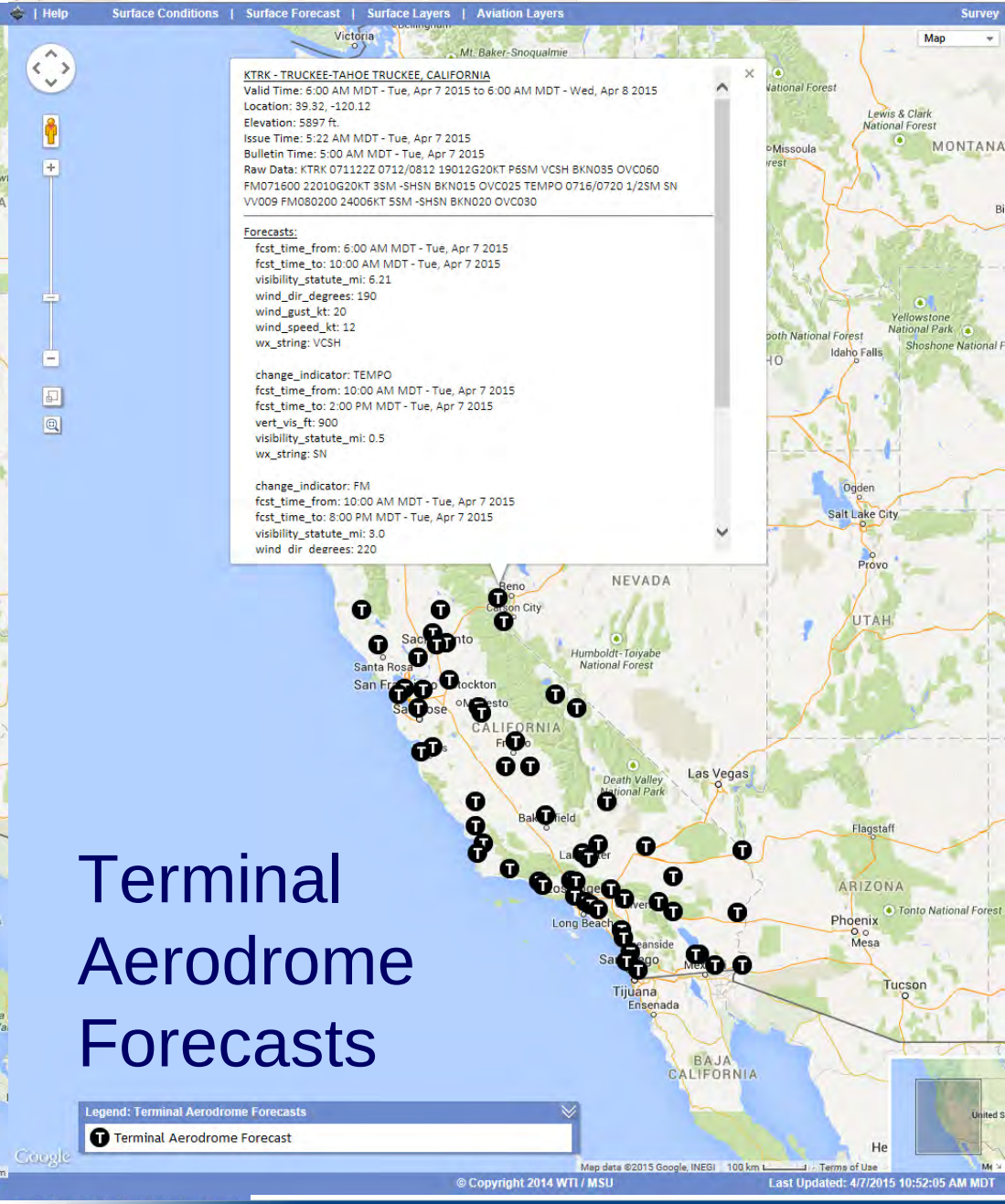


AWOS / ASOS

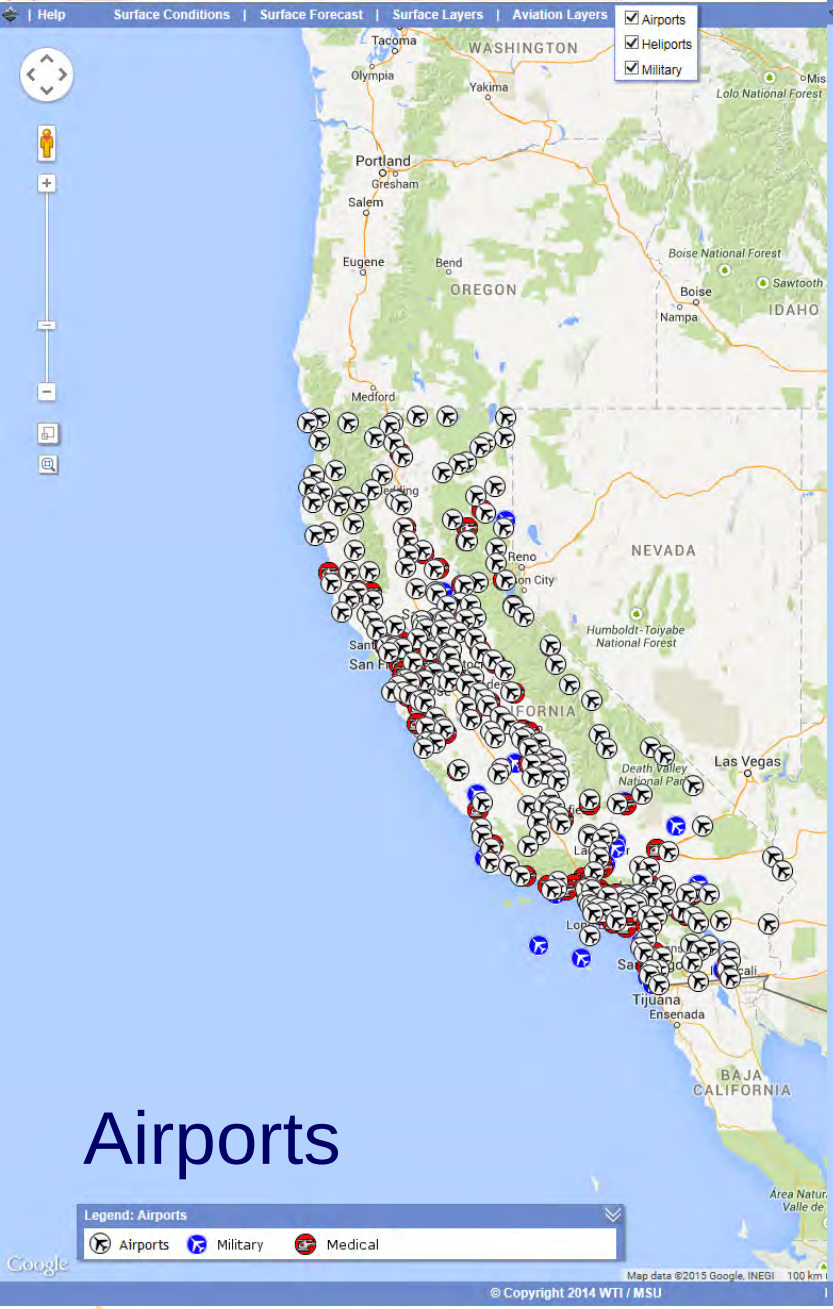

KBLU - BLUE CANYON - NYACK EMIGRANT GAP, CALIFORNIA
Report Time: 9:52 AM MDT - Tue, Apr 7 2015
Location: 39.2749, -120.709379167
Flight Category: LIFR
Wind: 10 MPH (9 knots) from the South (180°)
Visibility: 0.25 miles
Dew Point: 28 °F
Pressure (altimeter): 29.769686 in. Hg
Elevation: 5278 ft.
Frequency: 120.075 (ASOS)
Phone: 530-389-2091 (ASOS)
Raw Data: KBLU 071552Z AUTO 18009KT 1/4SM +SN FZFG VV002 M01/M02 A2977 RMK AO2
PK WND 17026/1500 SLP093 P0008 T10111022
National Forest
Ashland
Eureka
Mendocino
National Forest
Reno
Carson City
80
Elk Grove
Santa Rosa
Vallejo
Stockton
San Francisco
Yosemite National Park
Humboldt-



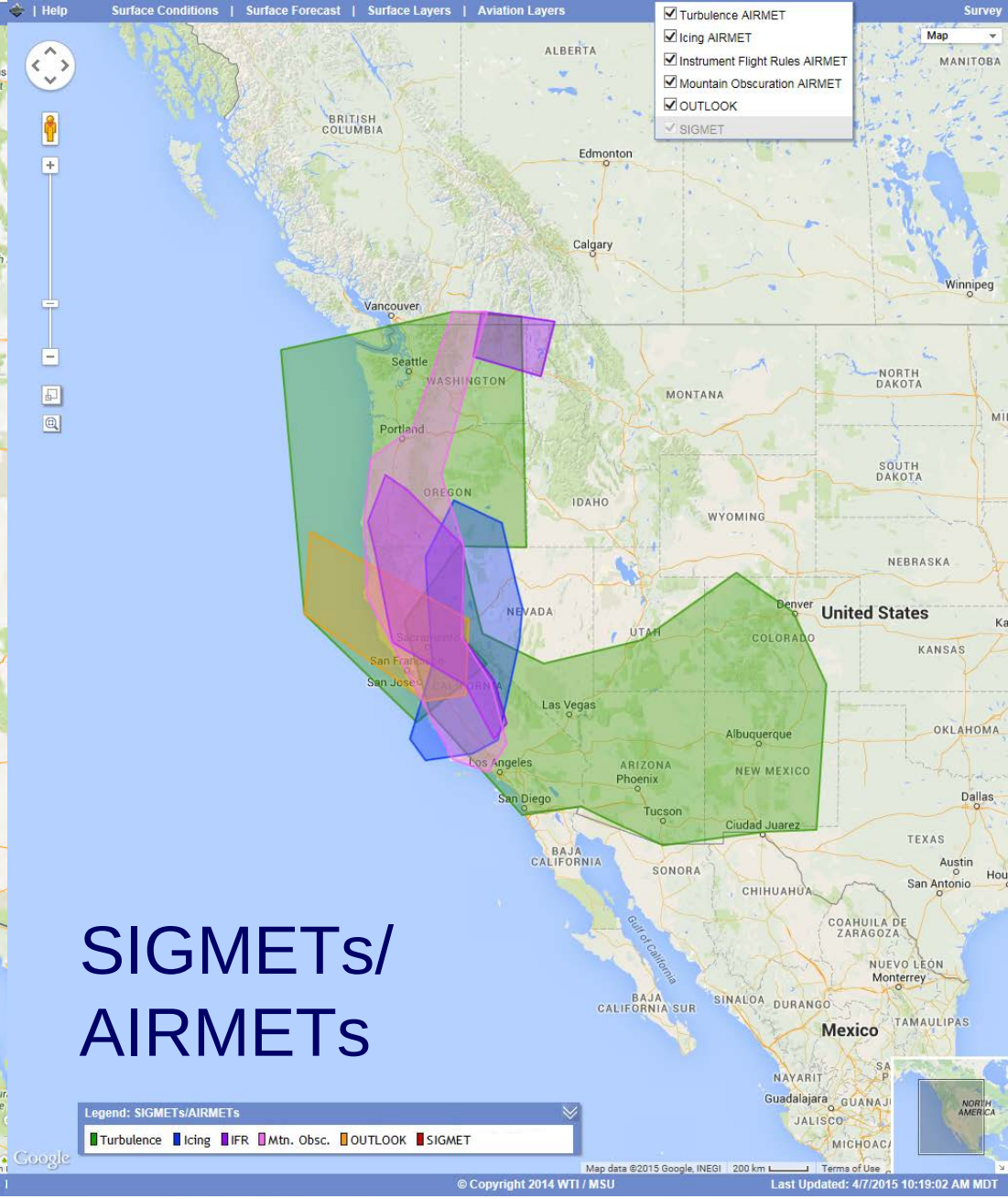
Pilot Reports



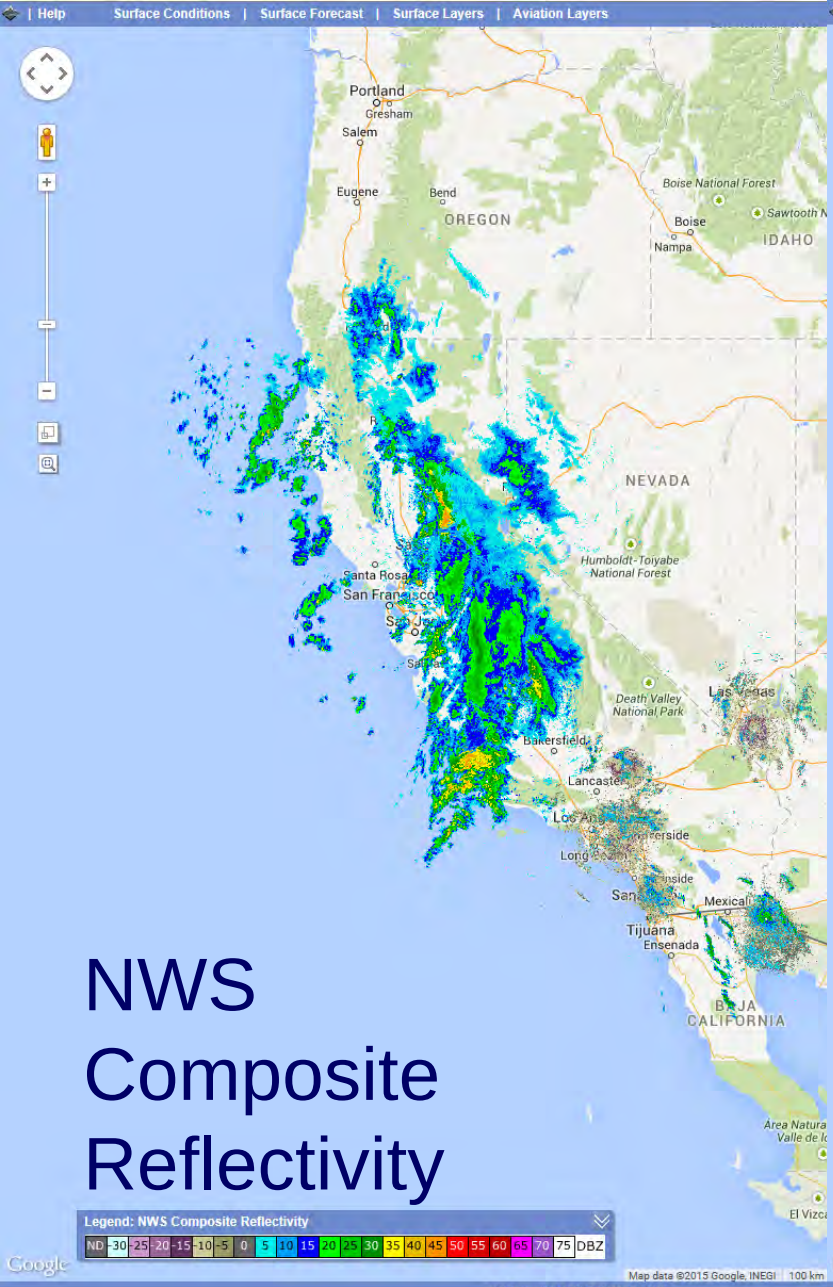
Terminal Aerodrome Forecasts



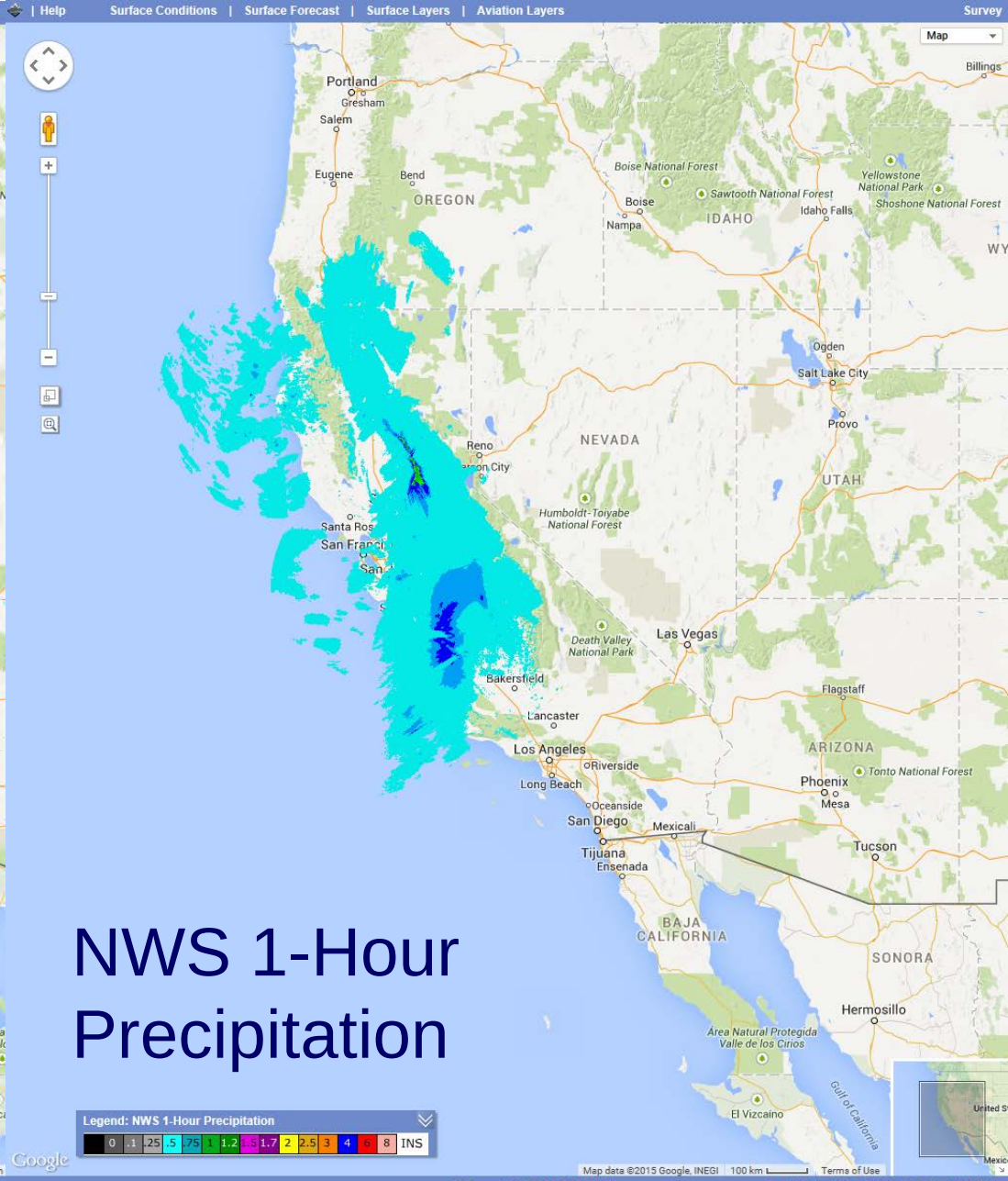
Airports



SIGMETs/
AIRMETs

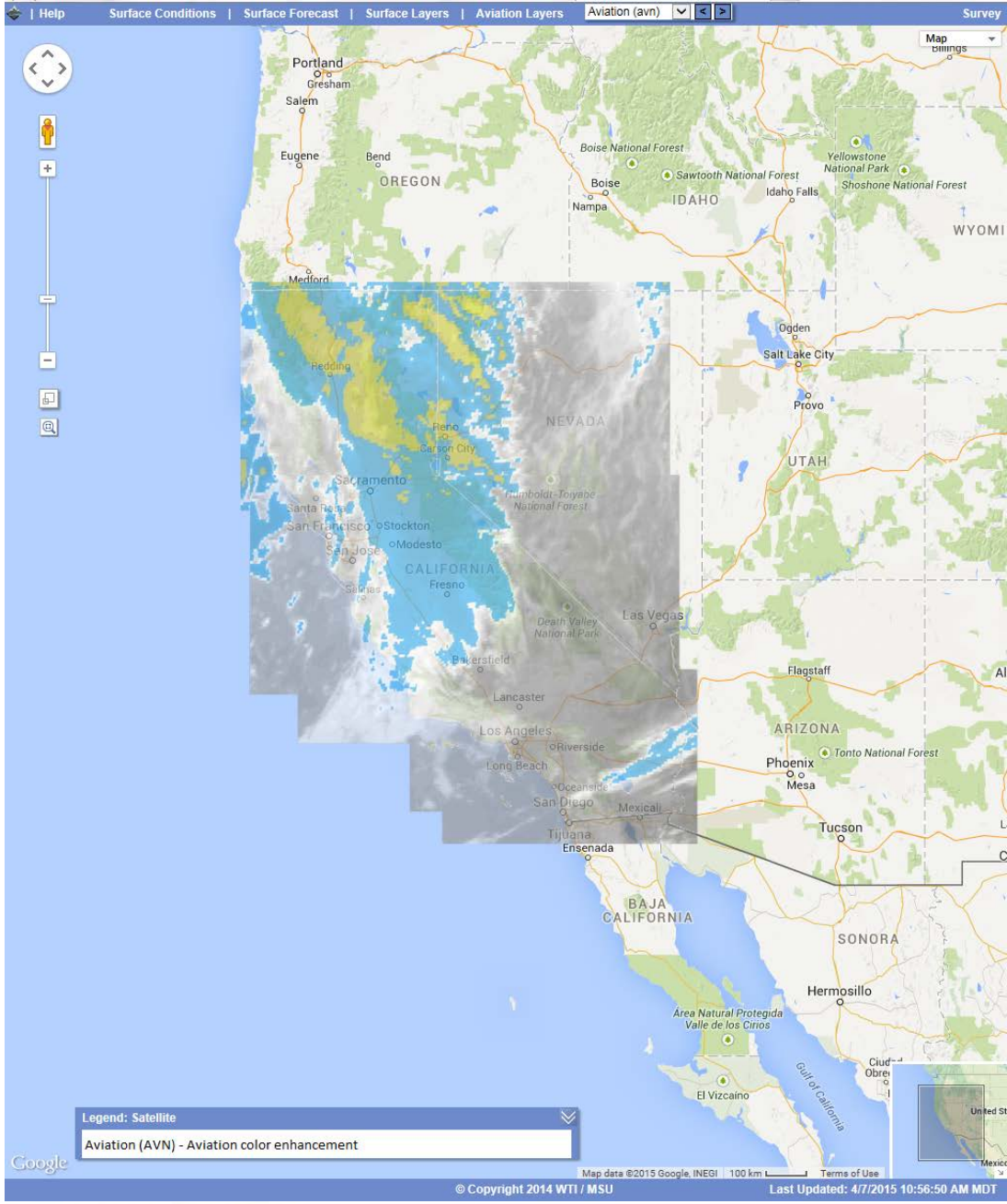


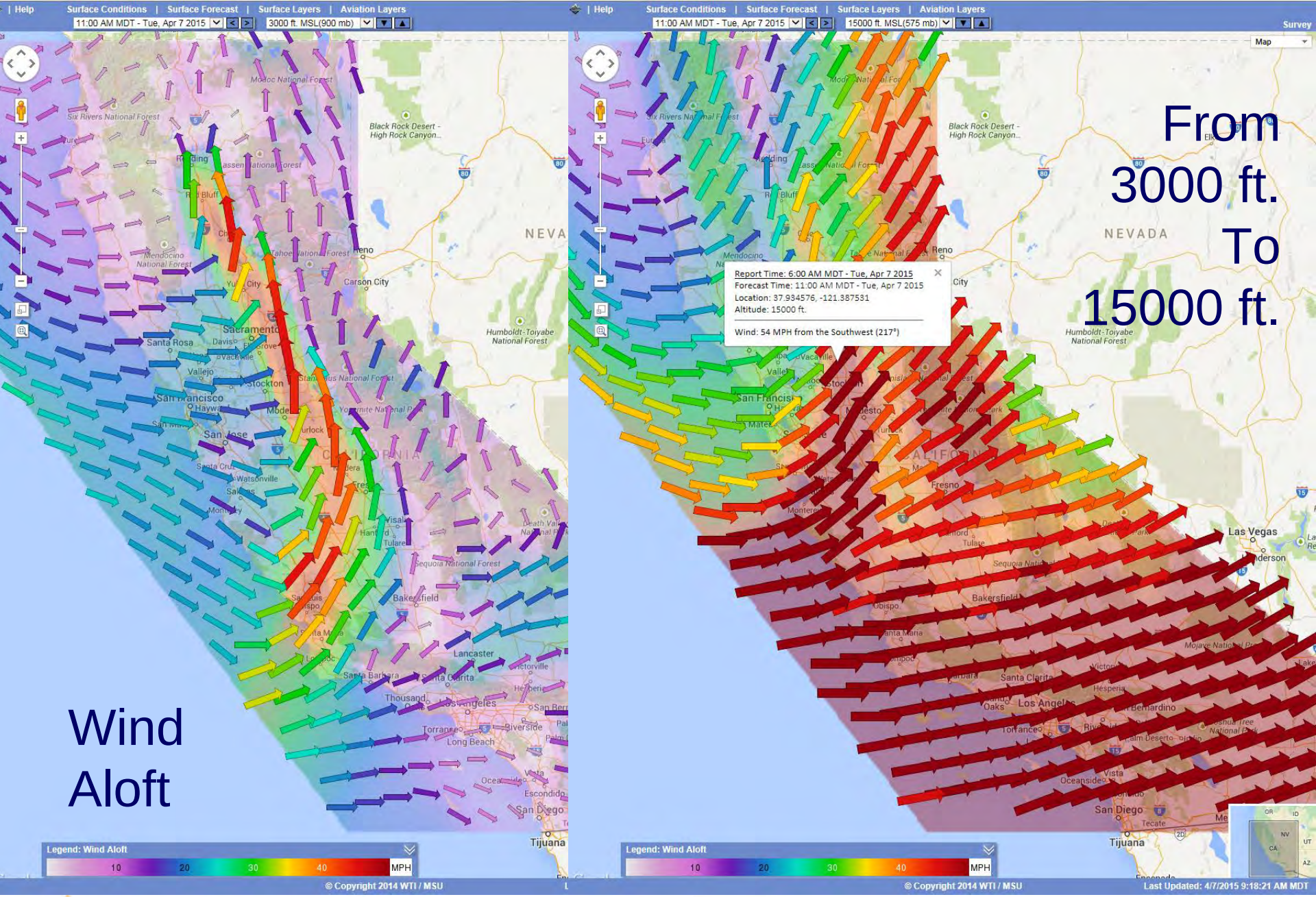
NWS Composite Reflectivity

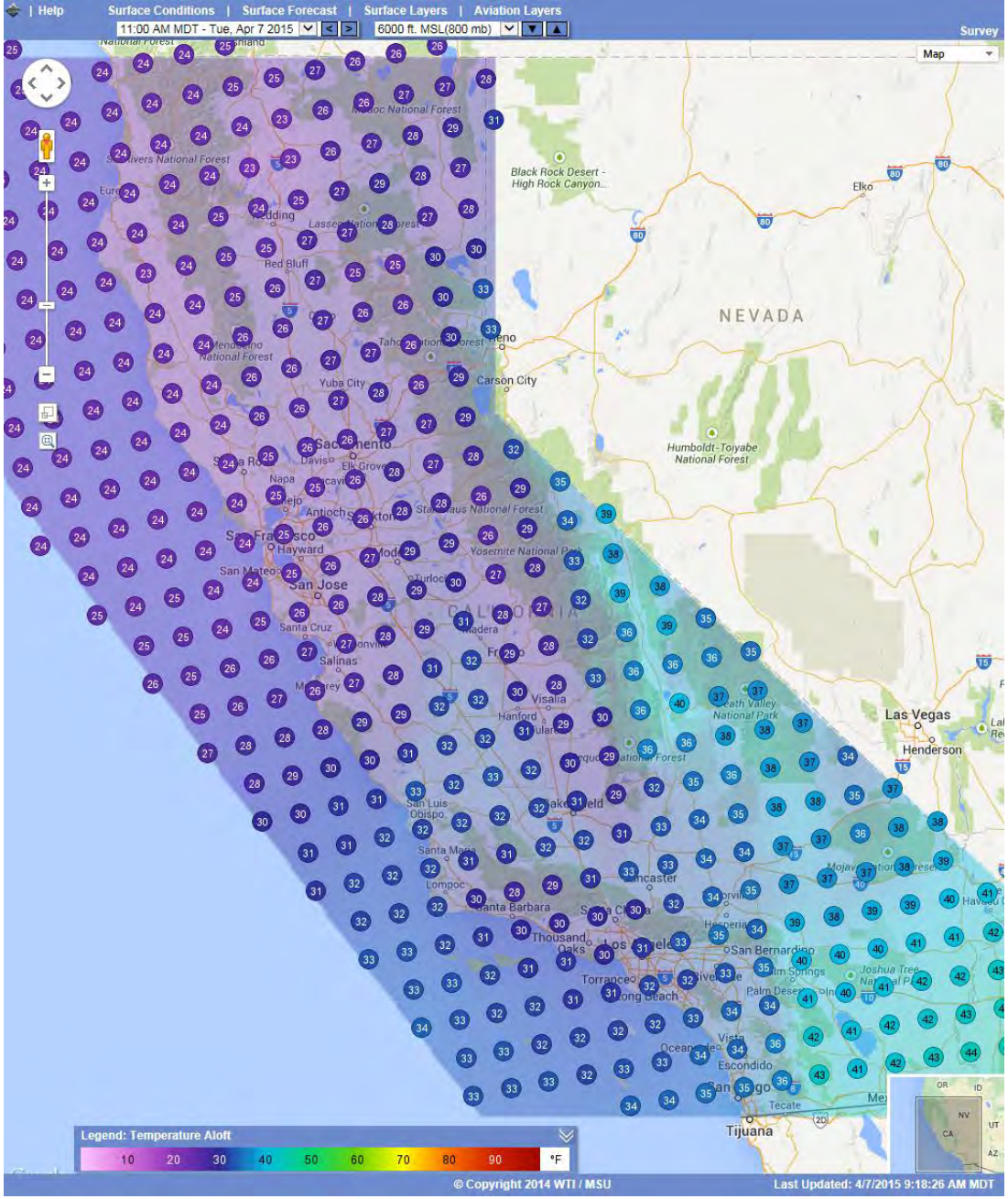


NWS 1-Hour Precipitation

Satellite


Help
Surface Conditions
Surface Forecast
Surface Layers
Aviation Layers
Aviation (avn)
Survey
Map
Portland
Gresham
Salem
Eugene
Bend
OREGON
Boise National Forest
Boise
Nampa
Sawtooth National Forest
IDAHO
Idaho Falls
Yellowstone National Park
Shoshone National Forest
WYOMI
Medford
Ogden
Salt Lake City
Provo
Redding
NEVADA
Reno
Carson City
UTAH
Sacramento
Humboldt-Toiyabe National Forest
Santa Rosa
San Francisco
Stockton
Modesto
San Jose
CALIFORNIA
Fresno
Salinas
Death Valley National Park
Las Vegas
Bakersfield
Flagstaff
Lancaster
Los Angeles
Riverside
Long Beach
ARIZONA
Tonto National Forest
Phoenix
Mesa
Oceanside
San Diego
Mexicali
Tijuana
Tucson
Ensenada
BAJA CALIFORNIA
SONORA
Hermosillo
Área Natural Protegida Valle de los Cirios
El Vizcaino
Gulf of California
Legend: Satellite
Aviation (AVN) - Aviation color enhancement
Google
Map data ©2015 Google, INEGI
100 km
Terms of Use
© Copyright 2014 WTI / MSU
Last Updated: 4/7/2015 10:56:50 AM MDT


Help
Surface Conditions
Surface Forecast
Surface Layers
Aviation Layers
11:00 AM MDT - Tue, Apr 7 2015
3000 ft. MSL(900 mb)
15000 ft. MSL(575 mb)
Survey
Map
Report Time: 6:00 AM MDT - Tue, Apr 7 2015
Forecast Time: 11:00 AM MDT - Tue, Apr 7 2015
Location: 37.934576, -121.387531
Altitude: 15000 ft.
Wind: 54 MPH from the Southwest (217°)
From 3000 ft. To 15000 ft.
Wind Aloft
Legend: Wind Aloft
10 20 30 40 MPH
© Copyright 2014 WTI / MSU
Last Updated: 4/7/2015 9:18:21 AM MDT

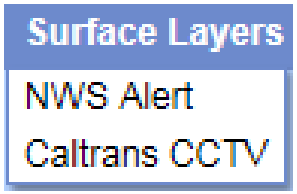


Temperature Aloft

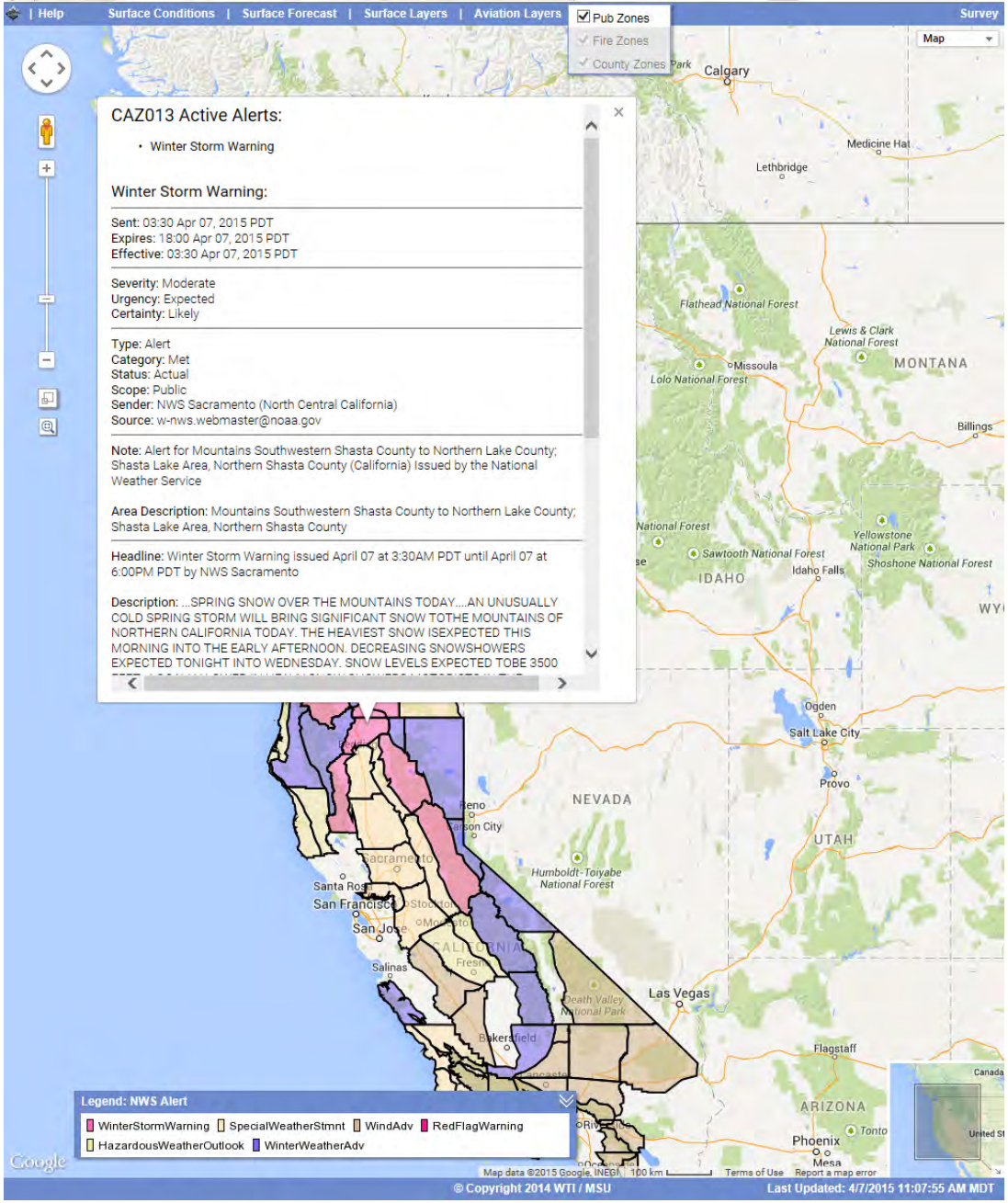
From
3000 ft.

To
15000 ft.

Surface Layers

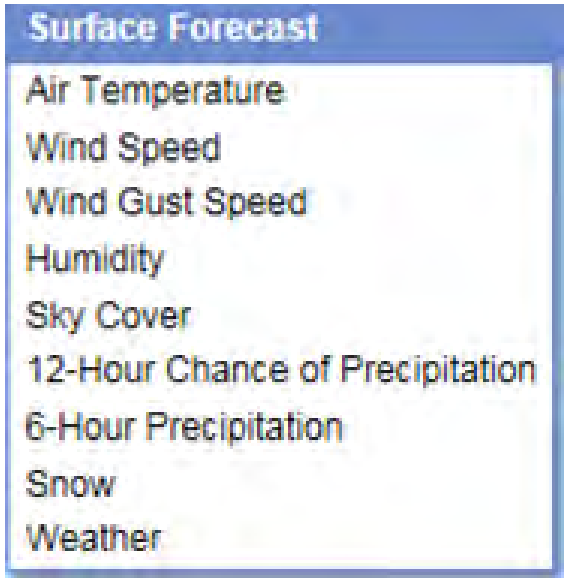


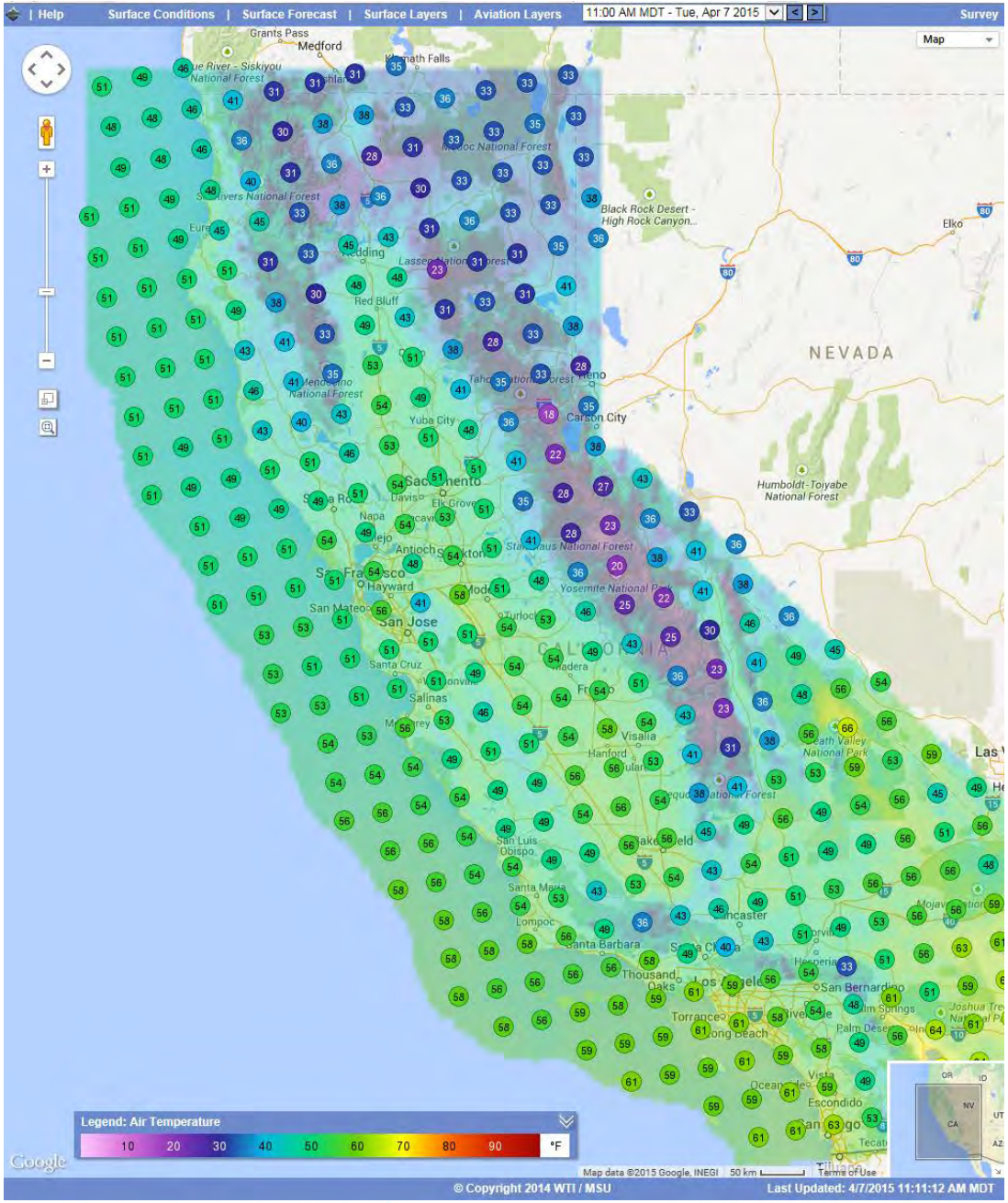
NWS Alerts


Help
Surface Conditions
Surface Forecast
Surface Layers
Aviation Layers
Pub Zones
Fire Zones
County Zones
Survey
Map
CAZ013 Active Alerts:
Winter Storm Warning
Winter Storm Warning:
Sent: 03:30 Apr 07, 2015 PDT
Expires: 18:00 Apr 07, 2015 PDT
Effective: 03:30 Apr 07, 2015 PDT
Severity: Moderate
Urgency: Expected
Certainty: Likely
Type: Alert
Category: Met
Status: Actual
Scope: Public
Sender: NWS Sacramento (North Central California)
Source: w-nws.webmaster@noaa.gov
Note: Alert for Mountains Southwestern Shasta County to Northern Lake County; Shasta Lake Area, Northern Shasta County (California) Issued by the National Weather Service
Area Description: Mountains Southwestern Shasta County to Northern Lake County; Shasta Lake Area, Northern Shasta County
Headline: Winter Storm Warning issued April 07 at 3:30AM PDT until April 07 at 6:00PM PDT by NWS Sacramento
Description: ...SPRING SNOW OVER THE MOUNTAINS TODAY....AN UNUSUALLY COLD SPRING STORM WILL BRING SIGNIFICANT SNOW TOTHE MOUNTAINS OF NORTHERN CALIFORNIA TODAY. THE HEAVIEST SNOW ISEXPECTED THIS MORNING INTO THE EARLY AFTERNOON. DECREASING SNOWSHOWERS EXPECTED TONIGHT INTO WEDNESDAY. SNOW LEVELS EXPECTED TOBE 3500
Calgary
Medicine Hat
Lethbridge
Flathead National Forest
Lewis & Clark National Forest
MONTANA
Missoula
Lolo National Forest
Billings
Yellowstone National Park
Shoshone National Forest
Sawtooth National Forest
IDAHO
Idaho Falls
Ogden
Salt Lake City
Provo
NEVADA
UTAH
Reno
Carson City
Sacramento
Humboldt-Toiyabe National Forest
Santa Rosa
San Francisco
San Jose
Salinas
Las Vegas
Death Valley National Park
Bakersfield
Flagstaff
ARIZONA
Phoenix
Mesa
Tonto
Legend: NWS Alert
WinterStormWarning
SpecialWeatherStmnt
WindAdv
RedFlagWarning
HazardousWeatherOutlook
WinterWeatherAdv
Google
Map data ©2015 Google, INEGI
100 km
Terms of Use
Report a map error
© Copyright 2014 WTI / MSU
Last Updated: 4/7/2015 11:07:55 AM MDT

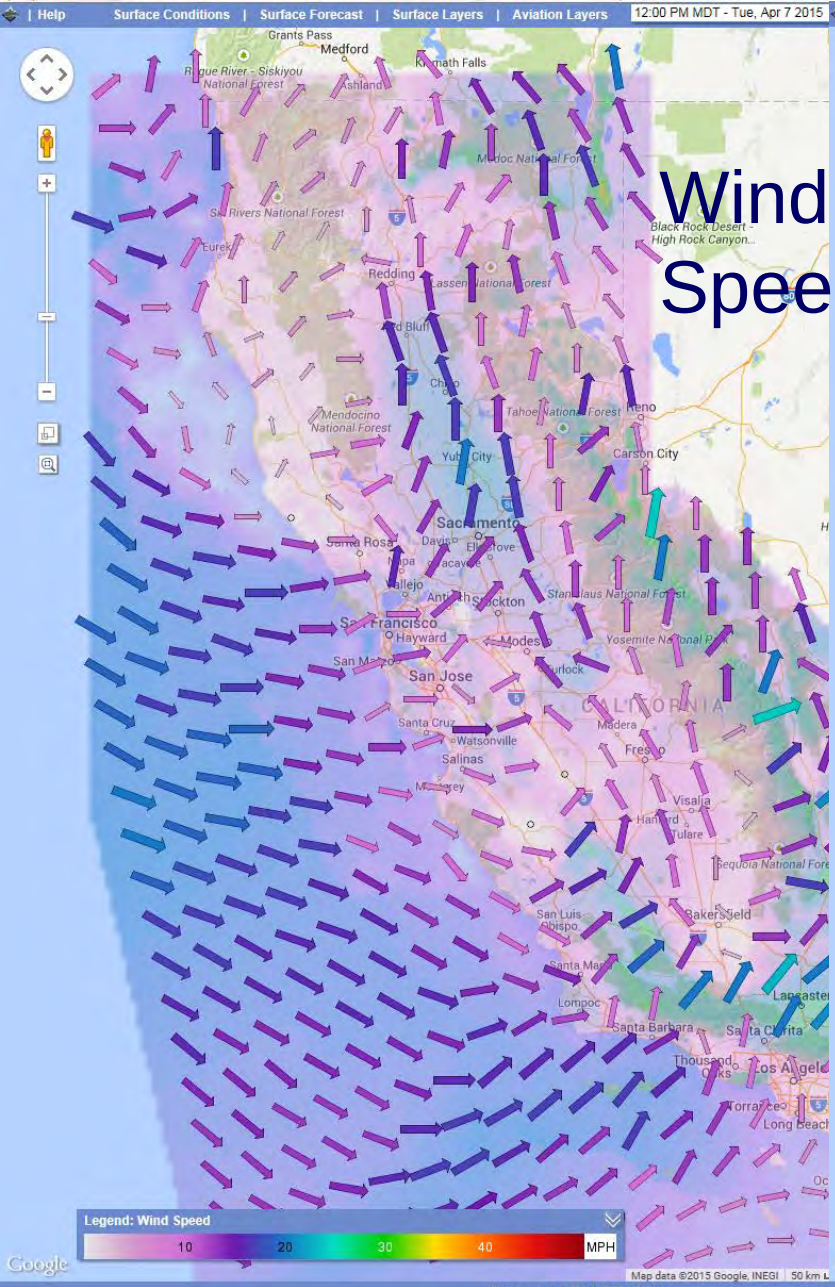

Salt Creek
SALT CREEK PRESET 1
Tuesday, April 07, 2015 09:34:16 PDT
Antlers Bridge
ANTLERS BRIDGE PRESET 3
Tuesday, April 07, 2015 10:10:04 PDT
Lakehead
LAKEHEAD PRESET 3
Tuesday, April 07, 2015 10:11:04 PDT
Vollmers
VOLLMERS PRESET 1
Tuesday, April 07, 2015 10:06:08 PDT
La Moine
LA MOINE PRESET 3
Tuesday, April 07, 2015 10:09:03 PDT
Pollard Flat
POLLARD FLAT PRESET 1
Tuesday, April 07, 2015 09:15:15 PDT
Gibson
GIBSON PRESET 3
Tuesday, April 07, 2015 09:14:45 PDT
Donner Lake
I-80 AT DONNER LAKE INT
2015-04-07 10:13:54
Dunsmuir
DUNSMUIR PRESET 1
Tuesday, April 07, 2015 10:06:25 PDT
Snowman
SNOWMAN PRESET 1
Tuesday, April 07, 2015 09:45:02 PDT
Caltrans CCTV
I5-SR89
I5-SR89
Tuesday, April 07, 2015 09:18:33 PDT
Castle Peak
I-80 AT CASTLE PEAK
2015-04-07 10:13:51
Soda Springs Eastbound
I-80 AT EB SODA SPRINGS
2015-04-07 10:13:51
Kingvale Westbound
I-80 AT WB KINGVALE LOW PRESSURE
2015-04-07 09:14:13
Kingvale Eastbound
I-80 AT EB KINGVALE PRESET 1
2015-04-07 10:09:34
Whitmore Grade
I-80 WHITMORE GRADE
2015-04-07 10:05:53
I-80 AT CRYSTAL SPRINGS
2015-04-07 10:13:50
ADJUST C38 TO BALANC
2015-04-07 09:18:21
BOGARD PRESET 2
Tuesday, April 07, 2015 10:02:30 PDT
OBRIEN PRESET 1
Tuesday, April 07, 2015 10:12:02 PDT
Nevada City
Nevada City

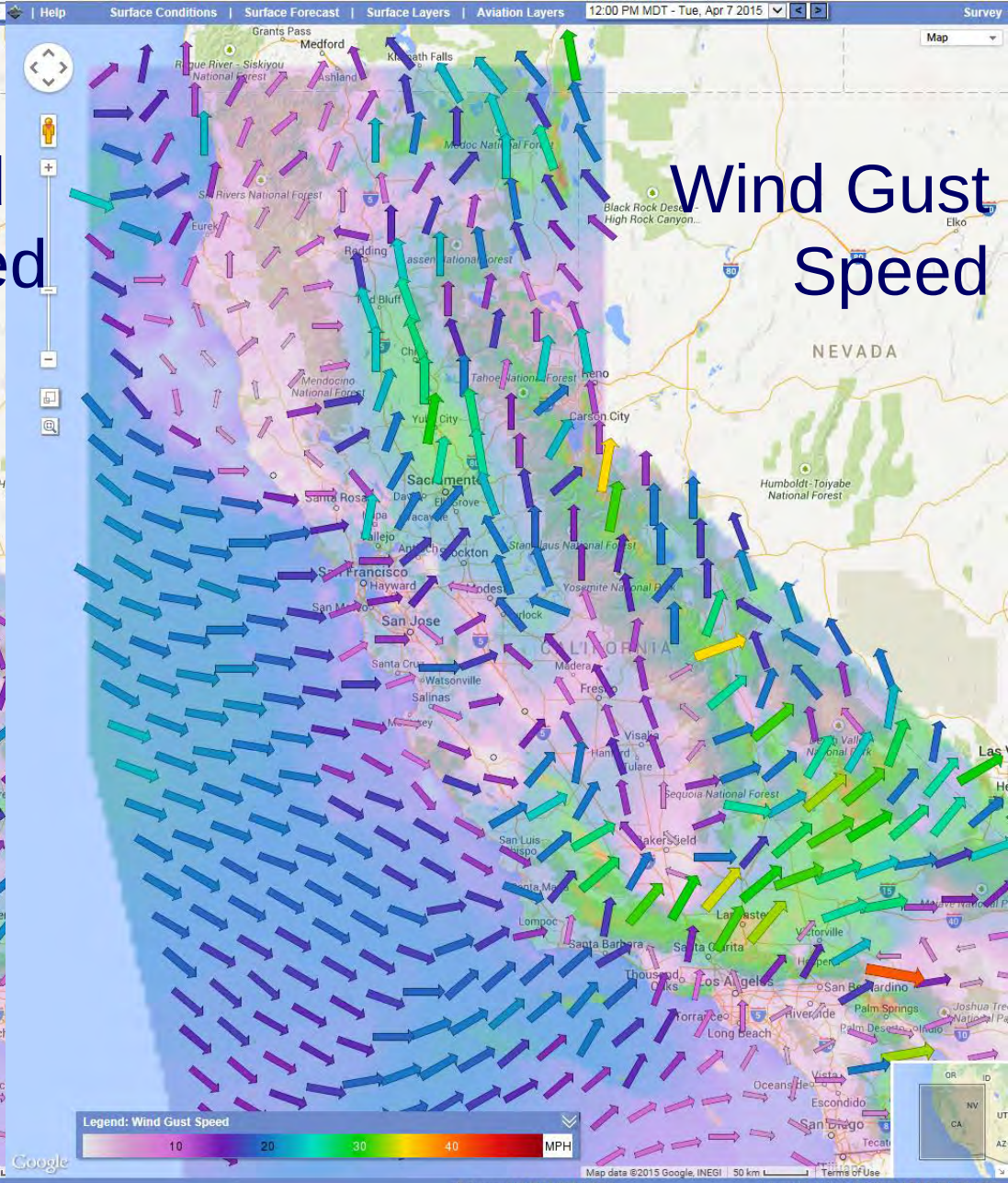
Surface Forecast Layers

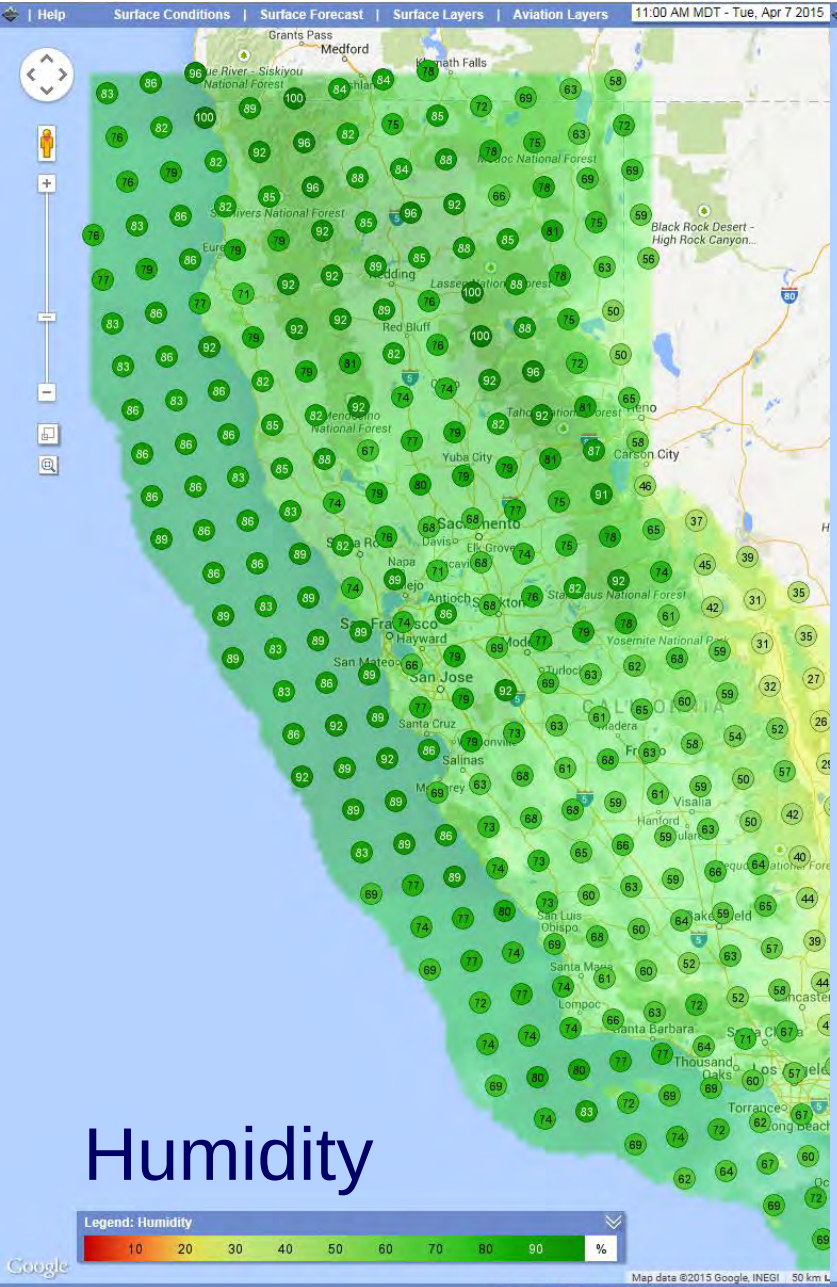




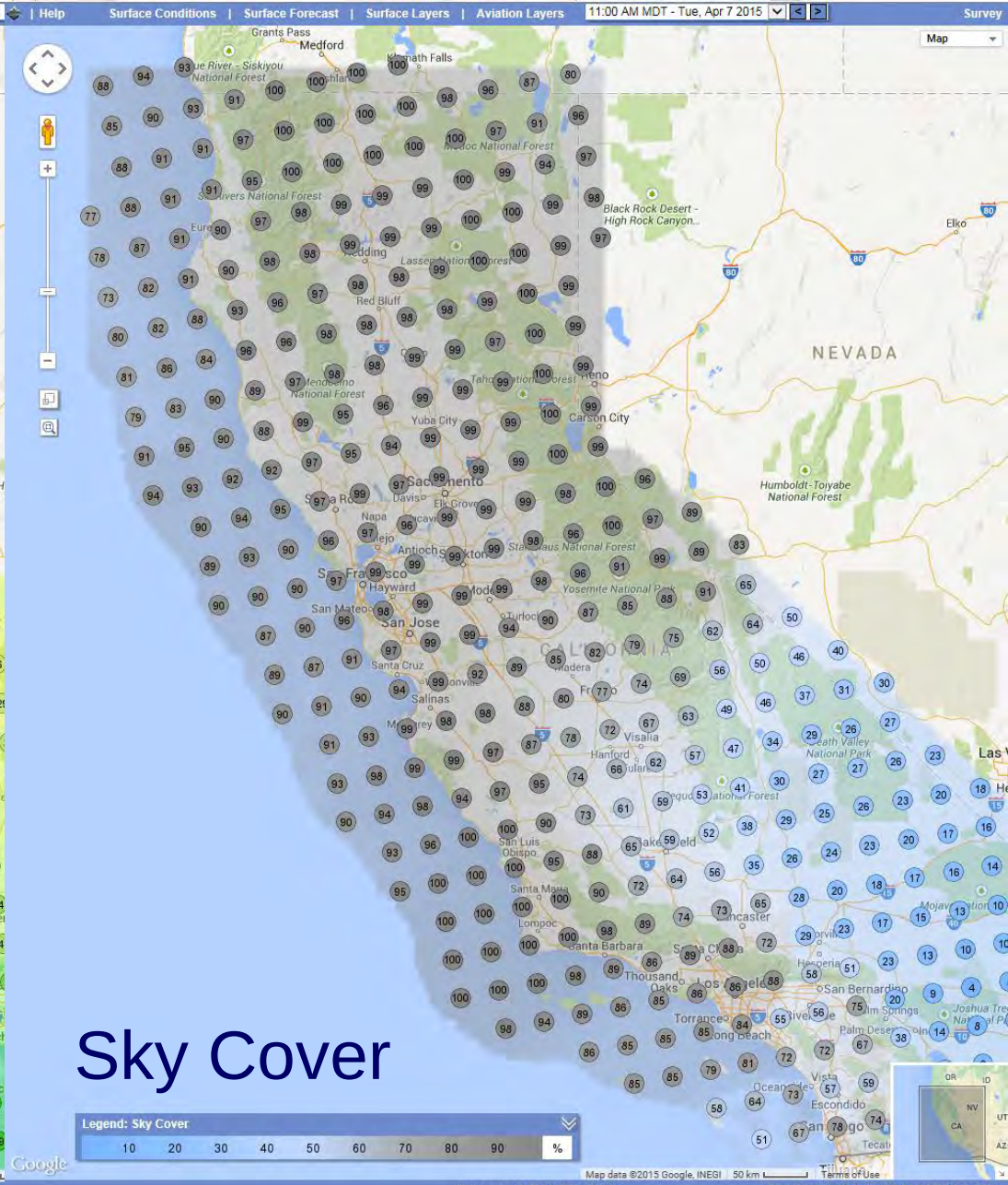
Air Temperature


Help
Surface Conditions
Surface Forecast
Surface Layers
Aviation Layers
12:00 PM MDT - Tue, Apr 7 2015
Wind Speed
Legend: Wind Speed
10
20
30
40
MPH
Google
Map data ©2015 Google, INEGI
50 km
© Copyright 2014 WTI / MSU

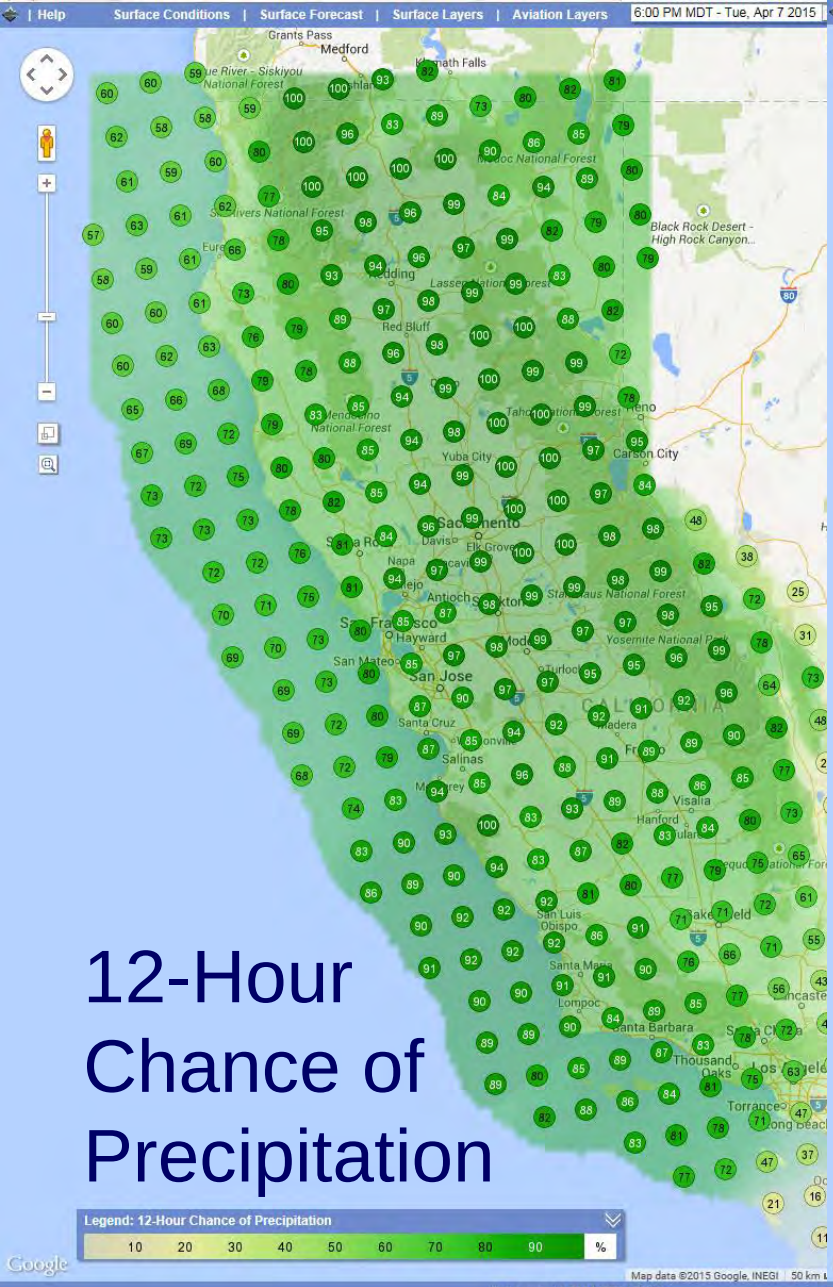

Help
Surface Conditions
Surface Forecast
Surface Layers
Aviation Layers
12:00 PM MDT - Tue, Apr 7 2015
Survey
Map
Wind Gust Speed
NEVADA
Legend: Wind Gust Speed
10
20
30
40
MPH
Google
Map data ©2015 Google, INEGI
50 km
Terms of Use
© Copyright 2014 WTI / MSU
Last Updated: 4/7/2015 11:11:38 AM MDT



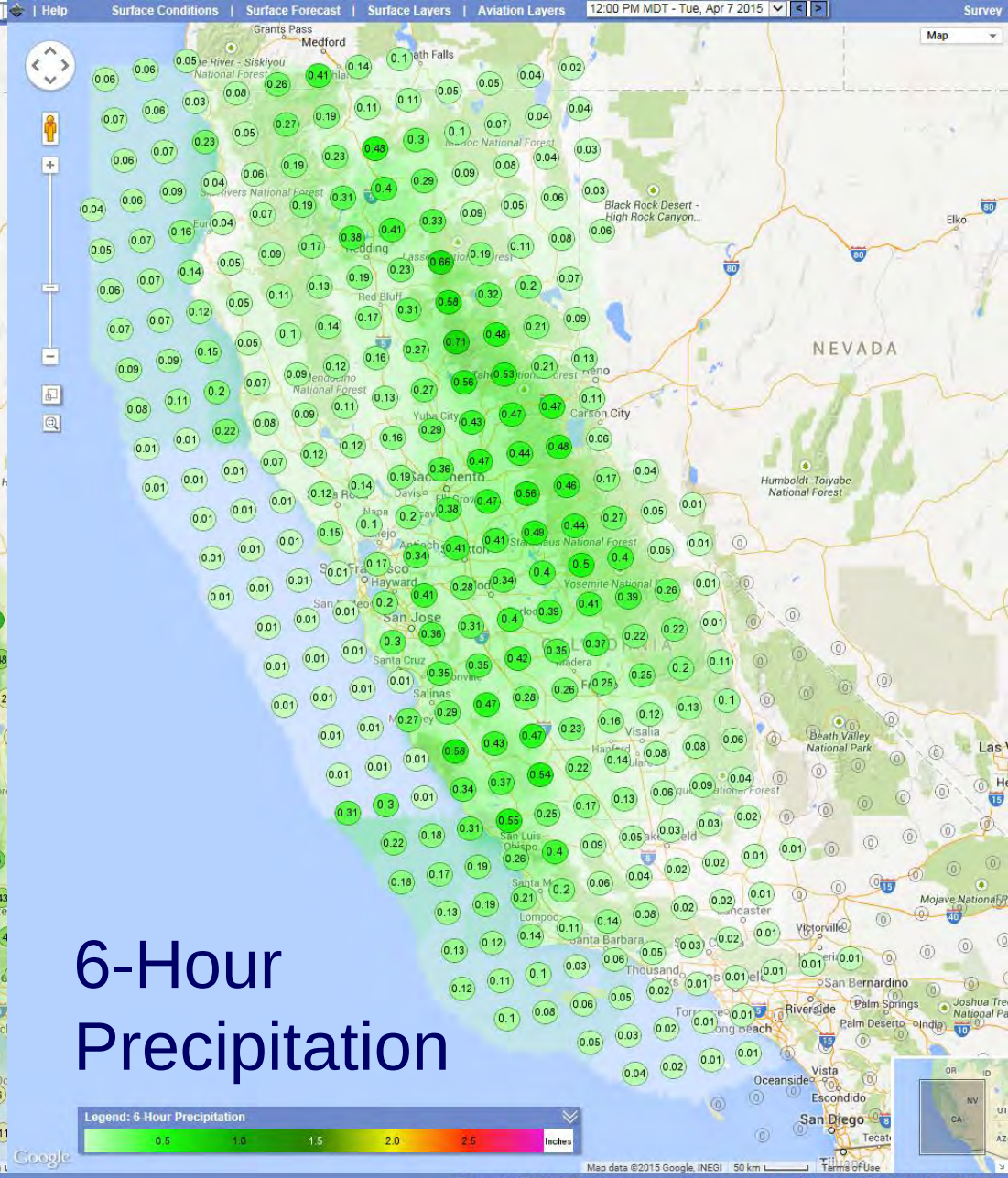
Humidity



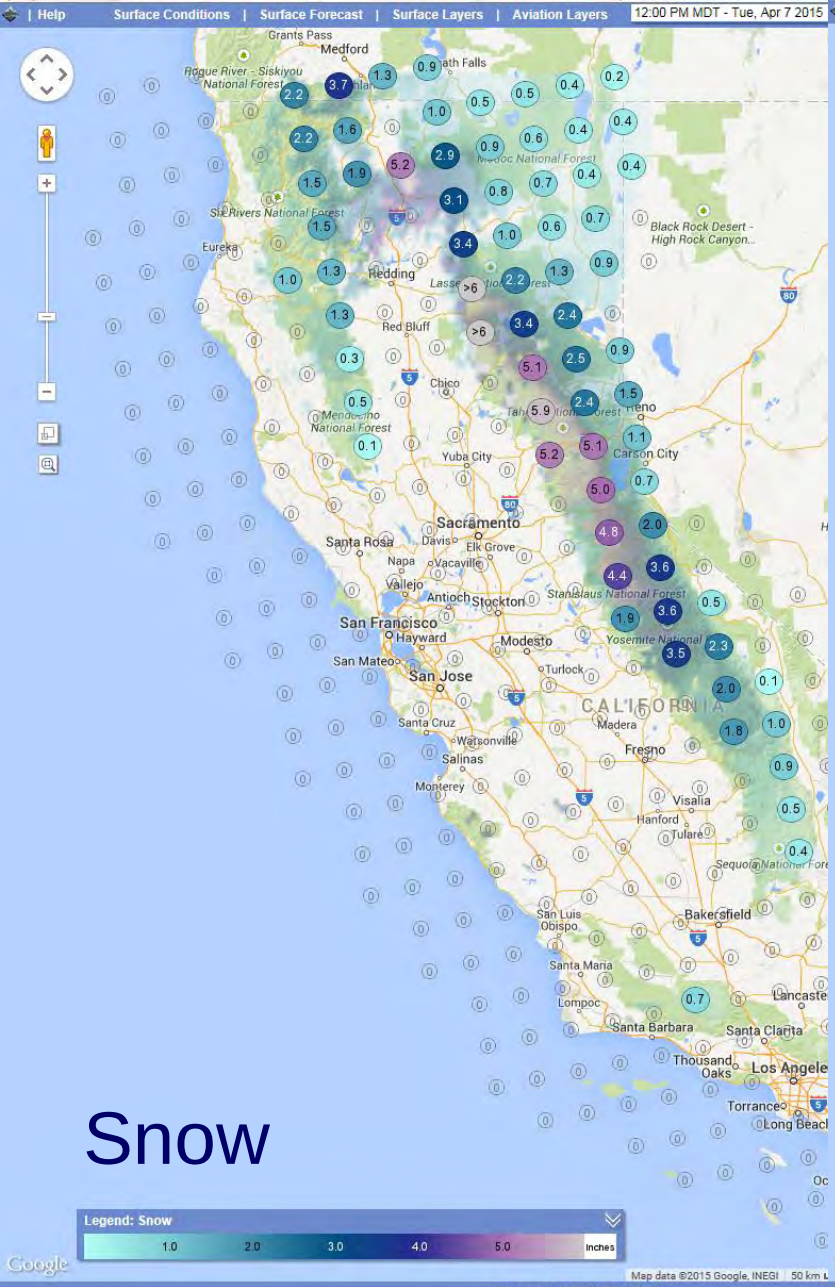
Sky Cover



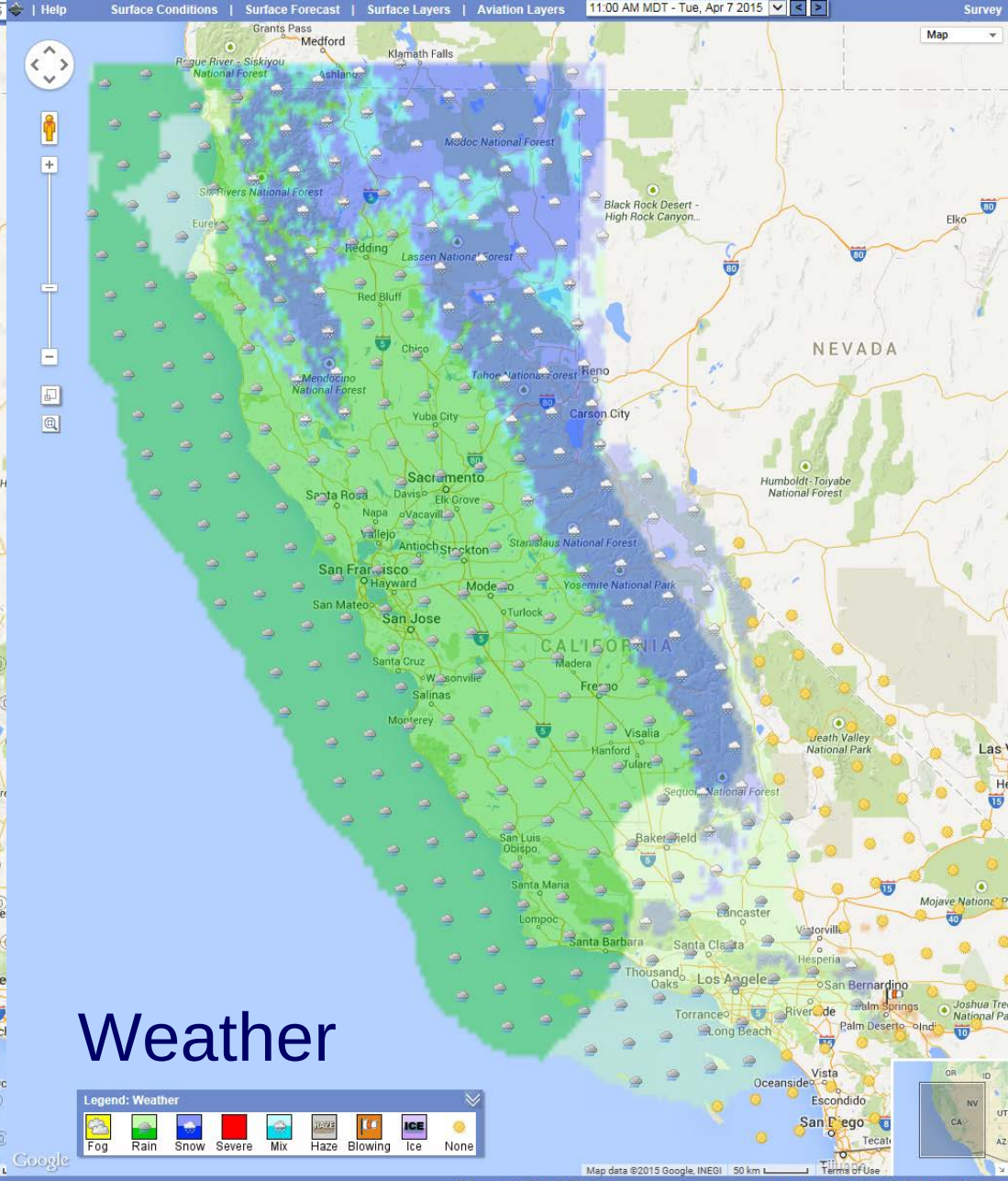
12-Hour Chance of Precipitation



6-Hour Precipitation

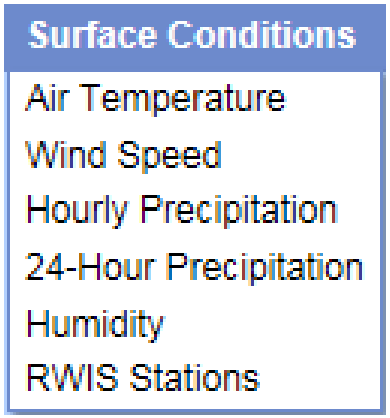


Snow

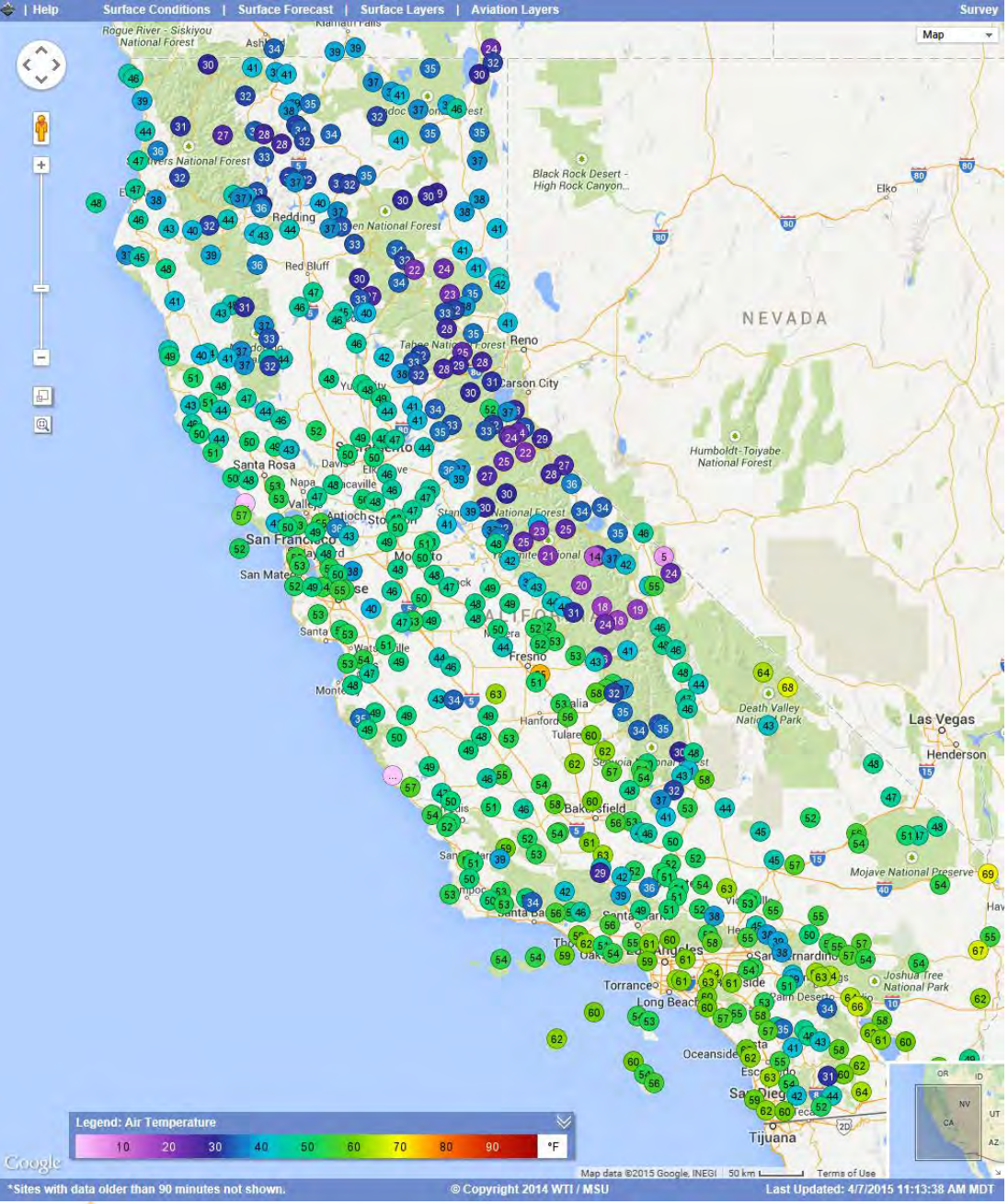


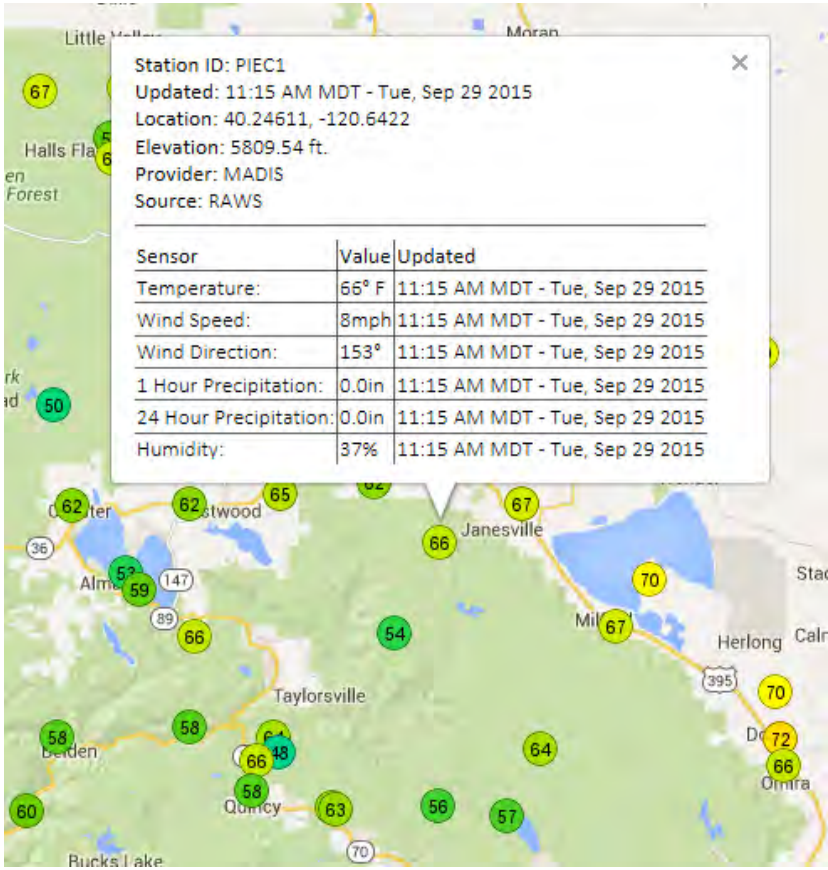
Weather

Surface Conditions Layers

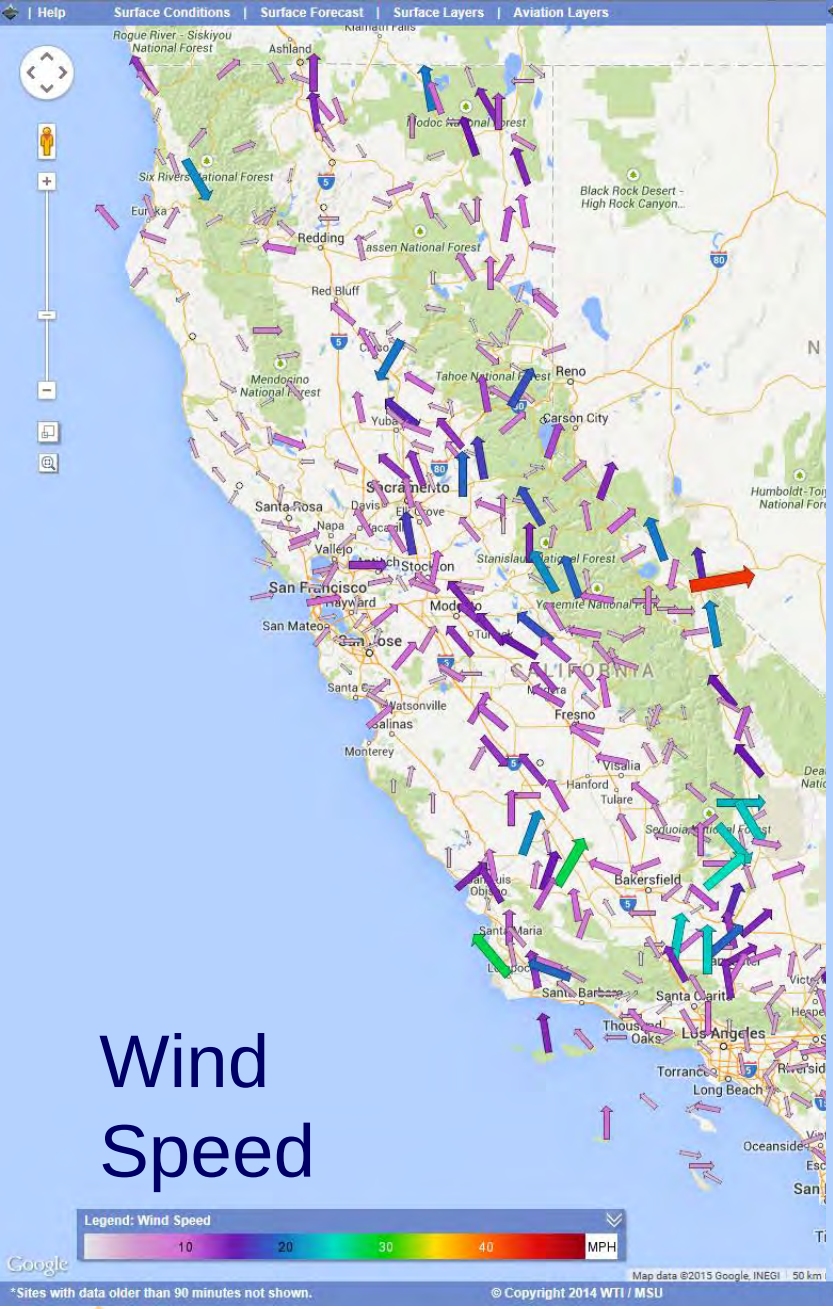


Air Temperature





Sensor	Value	Updated
Temperature:	66° F	11:15 AM MDT - Tue, Sep 29 2015
Wind Speed:	8mph	11:15 AM MDT - Tue, Sep 29 2015
Wind Direction:	153°	11:15 AM MDT - Tue, Sep 29 2015
1 Hour Precipitation:	0.0in	11:15 AM MDT - Tue, Sep 29 2015
24 Hour Precipitation:	0.0in	11:15 AM MDT - Tue, Sep 29 2015
Humidity:	37%	11:15 AM MDT - Tue, Sep 29 2015


Help
Surface Conditions
Surface Forecast
Surface Layers
Aviation Layers
Wind Speed
Legend: Wind Speed
10
20
30
40
MPH
*Sites with data older than 90 minutes not shown.
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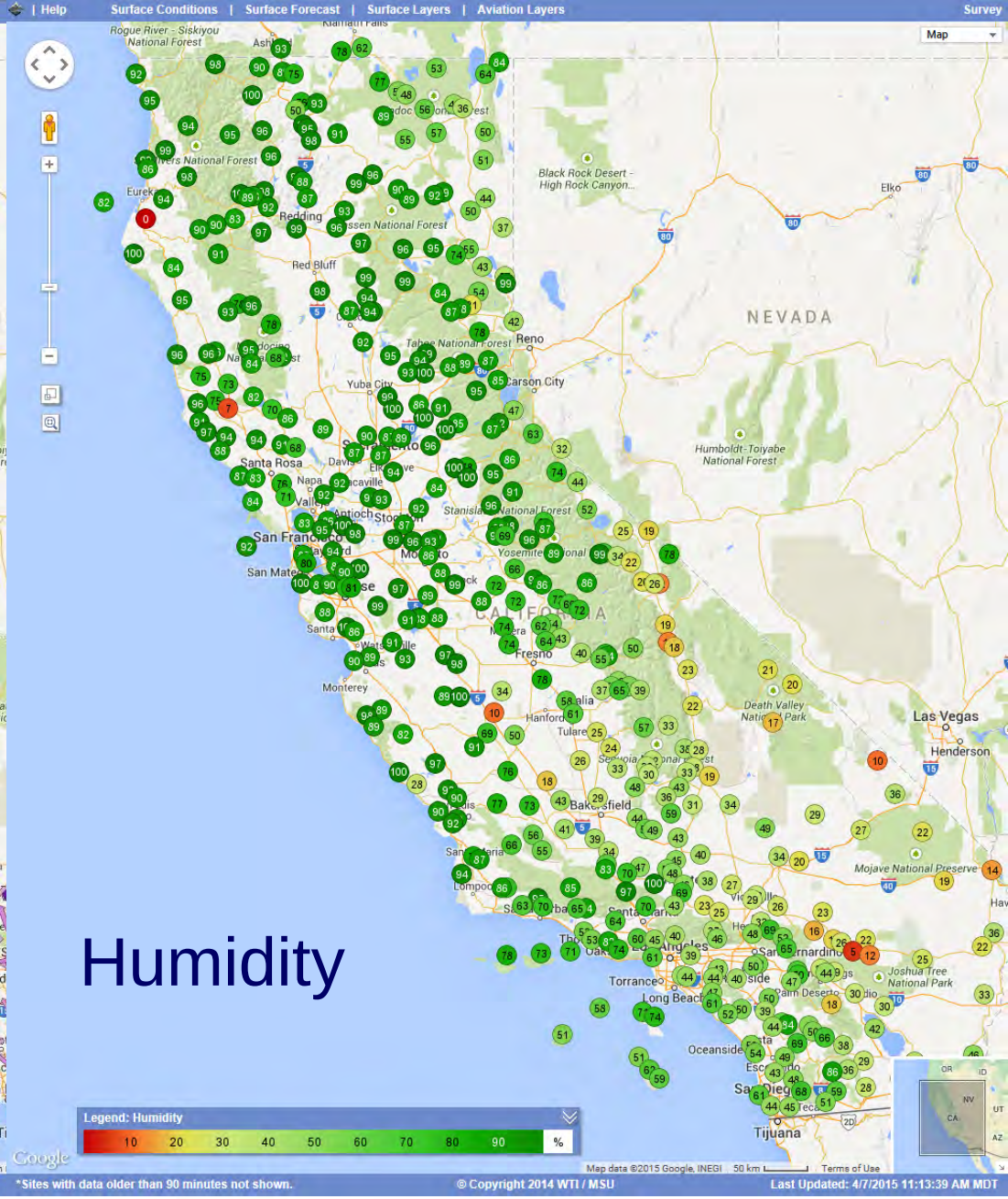
Help
Surface Conditions
Surface Forecast
Surface Layers
Aviation Layers
Survey
Map
Humidity
Legend: Humidity
10
20
30
40
50
60
70
80
90
%
*Sites with data older than 90 minutes not shown.
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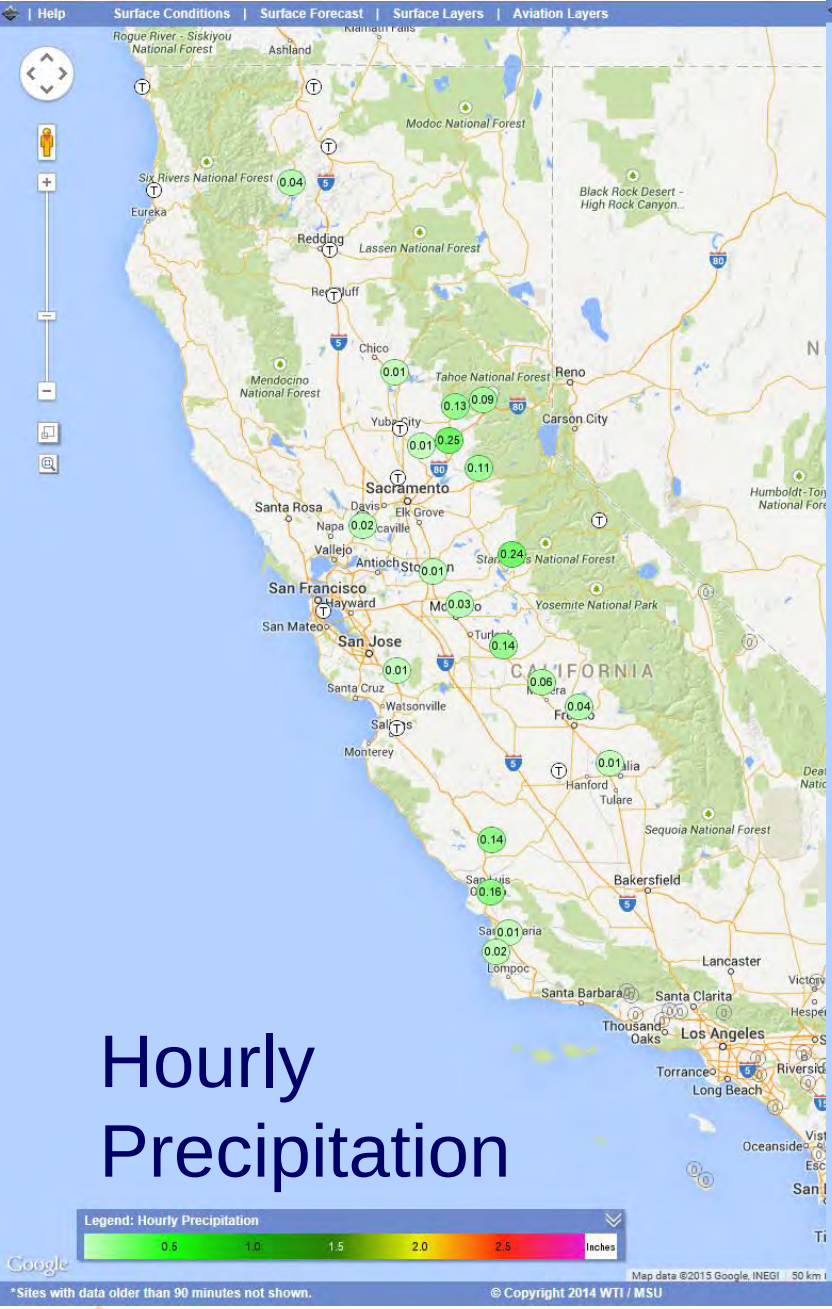
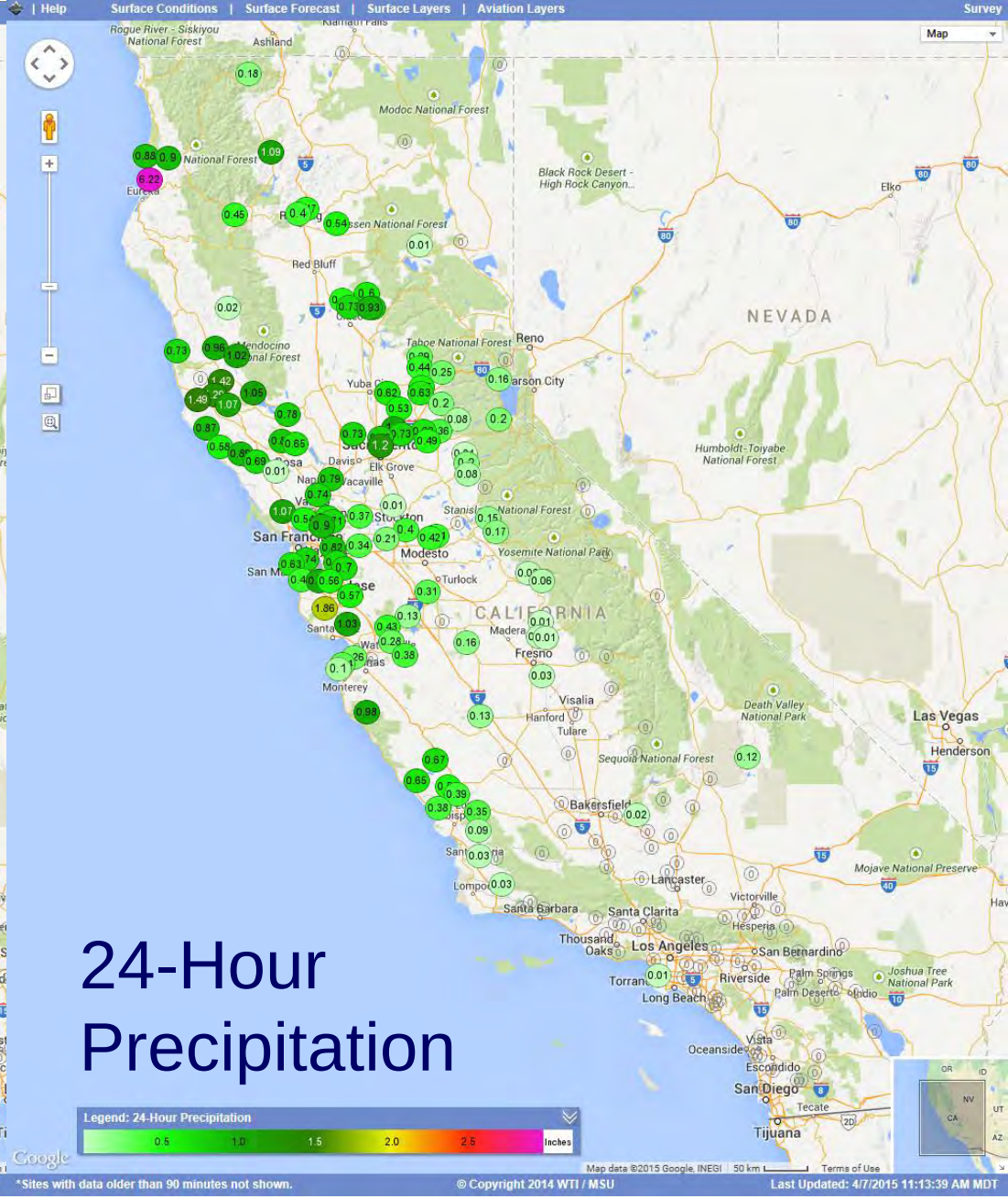
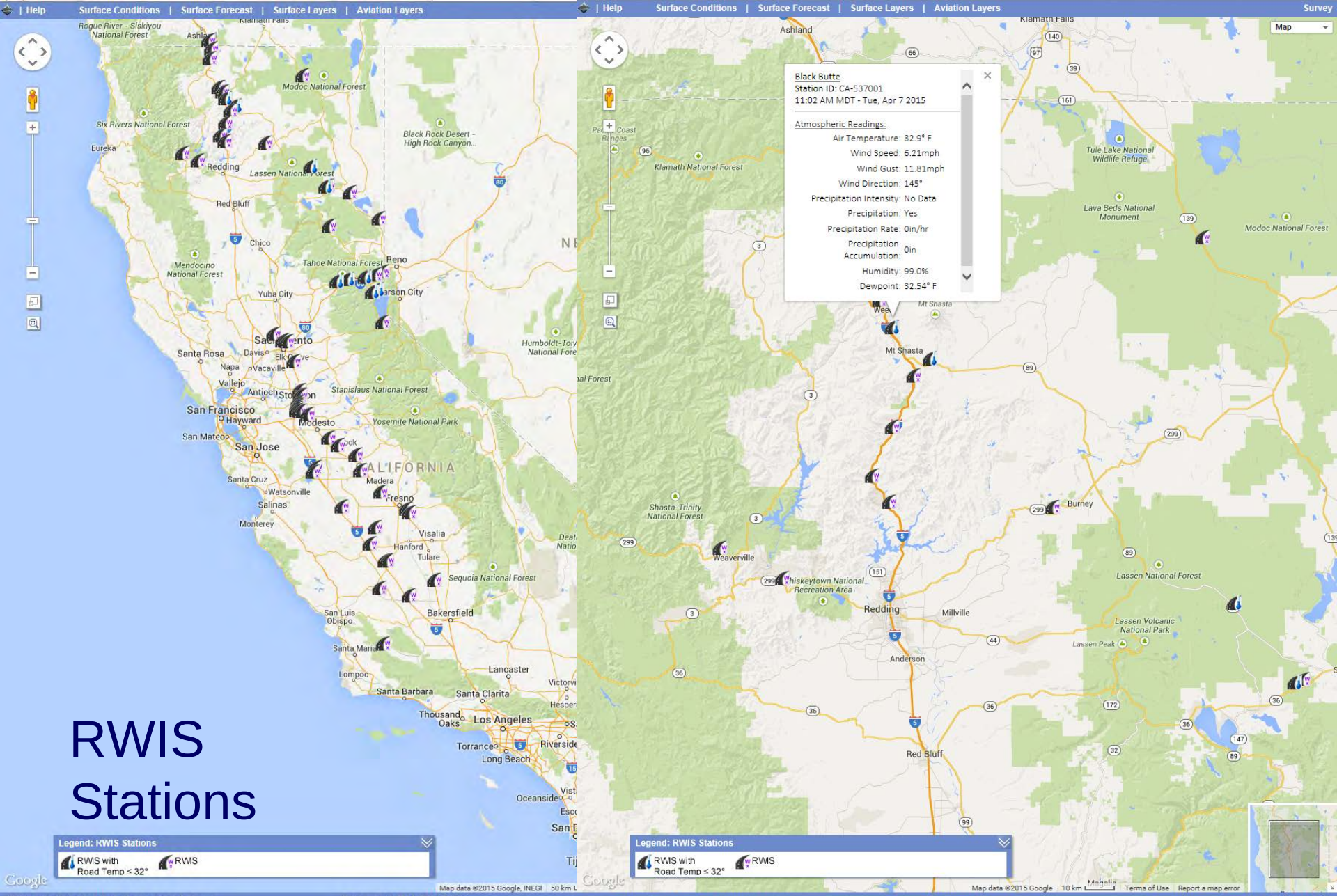
Last Updated: 4/7/2015 11:13:39 AM MDT



Hourly Precipitation



24-Hour Precipitation



RWIS Stations

Evaluation

Focus Group Survey (SJSU)

Online Survey

Google Analytics System Usage Statistics

(Gap Analysis)

Focus Group Survey

- San Jose State University conducted an open-ended survey of a focus group of prospective users once the Phase II prototype was available for use.
- Caltrans provided San Jose State University with a list of nine participants for this survey.
- Some of these participants forwarded the survey to others, resulting in sixteen total participants.
- Eleven of the participants were pilots, four were airport managers or government officials, and one was not specified.
- SJSU sent the survey to the focus group on October 22, 2013

Question #1. What are the strengths of the prototype integrated weather system? For example, do you find necessary weather information in the system or not?

- *It is nice to have the AWOS and Cal-Trans info in a single location.*
- *Flying: Found the information I need for local flying. No information for trips leaving or entering California beyond the border. Even for local flying, I would like to see large scale systems such as weather extend far beyond the state's boundaries.*
- *Intuitive operations (don't really need instructions).*
- *after several times on the site I found that each time was better and that I can get real time information from anywhere.*
- *Good job it is a keeper.*
- *like the proposed site...great utility...easy to manipulate...cannot think of any thing lacking....when finished it will become my # 1 WX site for both aviation and surface operations...thanks for the opportunity to "take an early look" .*

Question #1. What are the strengths of the prototype integrated weather system? For example, do you find necessary weather information in the system or not?

(Continued …)

- *There's a wealth of information available, which may be an obstacle for some people. It might seem overwhelming.*
- *The Caltrans roadcam layer is a good idea, many pilots might not think to check this resource if it hadn't been integrated.*
- *Being able to see all the surface wind vectors on the map could be infinitely useful for low level planning as well as educational to see how the terrain effects wind locally in different weather systems.*
- *As a pilot, I use ADDS because it consolidates so many items. Your graphical navigation of many of those items is very useful for California trips. However, since I live in far northwest California, I would find it useful to see Oregon data as well. Any plans to expand this to the full set of Pacific NW states as well as California?*

Question #2. In what specific areas do you think that the system should be improved? For example, what additional weather information or features should the system have?

- *It would be nice if the airport icon colors indicated the current conditions at the field ie: VFR, MVFR, IFR, LIFR.*
- *Having density altitude reporting at airports is important in our area of mountains and short runways. Cloud ceilings I noticed are not reported which is important.*
- *I noticed that the weather for awos and forecast aviation weather is not fully decoded.*
- *Plain English instead of raw data would be helpful.*
- *Cloud ceilings and tops are common needs for pilots*
- *I like the "Flight Path Tool" on the ADDS website*
- *Any way to integrate icing?*
- *It would really be something if this were expanded to other states.*

Question #3. What other suggestions do you have for the developers of this integrated weather system?

- *Hopefully have it available as an iPhone app.*
- *In proposing an integrated weather system, make sure you can sustain it over the long haul. If pilots begin to depend on it and then it's not there……..*
- *Add coverage to other states like Oregon, Washington, Nevada and Idaho.*
- *It would be good if you could somehow note the differences between this info and other sources. I think you are using RAW, RWIS etc that most of the other sources do not use. Also having the CT Web cams is great – not available on any other weather info site.*
- *If there are a "Quick Start Guide" or a "Basic Usage Video", they should be findable. Do NOT use a "video"; they use "Flash Player"!! ..see next...*
- *Your site needs a name. "Integrated Weather System" doesn't cut it from a marketing standpoint. Am I going to ask my friends if they use Integrated Weather System or IWS? We don't need another TLA (three-letter acronym). How about if we just call it "WeatherShare"?*

Question #4. Any other comments?

- *Hopefully this can catch on in more than California, I'd be a little afraid of getting too dependant on this system and then forget how to read hieroglyphics in DUATS/Aviationweather.gov when flying out of State.*
- *I think that you are on the right track. From both a pilots and aviation safety officer aspect I feel that it is critical to have a centralized and easily manipulated source of weather information to make informed Go / No-Go decision making. The good geographical layout along with cameras to reinforce conditions at particularly remote locations will serve users well in better planning their activities.*
- *The interface has been very well thought out.*
- *Your project is developing an excellent tool. Thank you for your efforts. Think about the marketing point. Many potential users are not necessarily all that tech-savy, and some of the ease-of-use features will need some work.*

Online Survey

- The Phase II prototype includes a link to an online survey to solicit further input from prospective users.
- To date, seven people have responded to the online survey.
- No effort was made advertise this survey beyond placement of a link in the application.
- An excerpt of survey responses through September 30th, 2015 are presented here.

Question: Please rate the usefulness of the following surface condition layers:

	Very Useful	Somewhat Useful	Not Very Useful	Not Aware of it	Response Count
Air Temperature	4	1	1	0	6
Wind Speed & Direction	4	1	1	0	6
Precipitation Last Hour	2	3	1	0	6
Precipitation Last 24 Hours	2	3	1	0	6
Relative Humidity	3	2	1	0	6
RWIS Stations	4	0	2	0	6

Question: Please rate the usefulness of the following surface forecast layers:

Answer Options	Very Useful	Somewhat Useful	Not Very Useful	Not Aware of it	Response Count
Air Temperature	5	0	1	0	6
Wind Speed & Direction	5	0	1	0	6
Wind Gust Speed & Direction	5	0	1	0	6
Relative Humidity	3	1	1	0	5
Sky Cover	2	3	1	0	6
12-hour Chance of Precipitation	2	3	1	0	6
6-hour Amount of Precipitation	2	3	1	0	6
Snow	2	3	1	0	6
Weather	3	2	1	0	6

Question: Please rate the usefulness of the following surface layers:

Answer Options	Very Useful	Somewhat Useful	Not Very Useful	Not Aware of it	Response Count
NWS Alerts	4	1	1	0	6
Caltrans CCTV Images	4	0	1	1	6

Question: Please rate the usefulness of the following aviation layers:

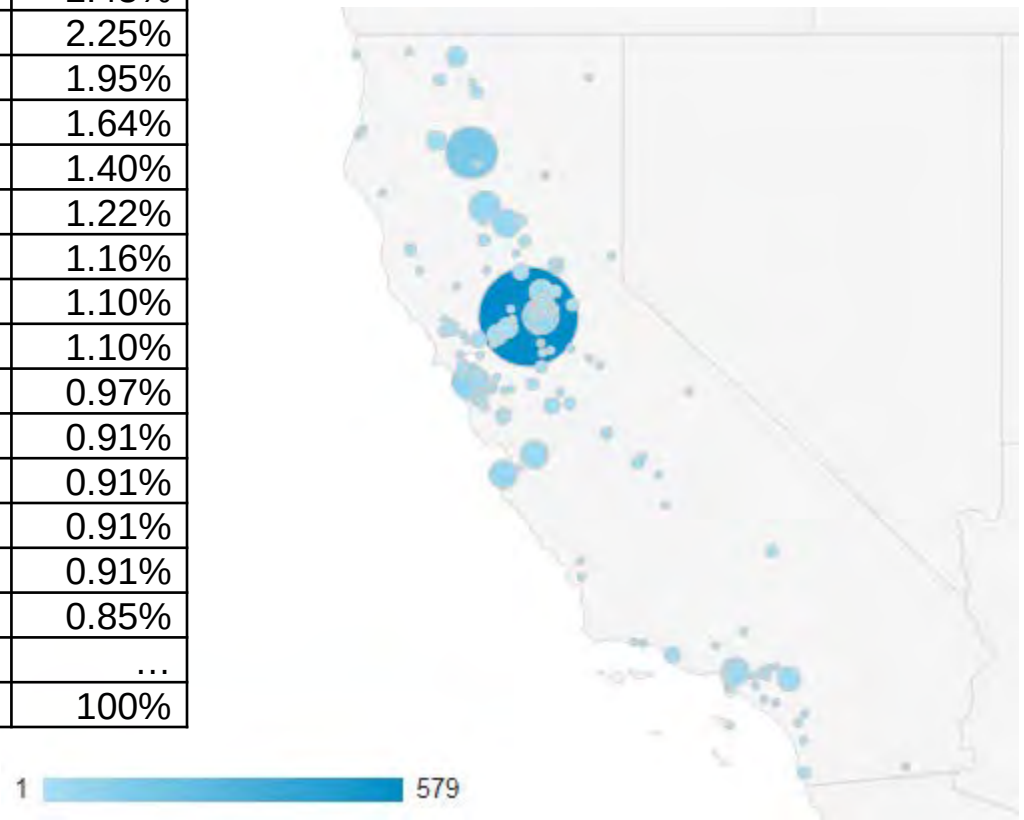
Answer Options	Very Useful	Somewhat Useful	Not Very Useful	Not Aware of it	Response Count
AWOS/ASOS (METAR)	5	0	1	0	6
Pilot Reports (PIREPS)	3	2	1	0	6
Terminal Aerodrome Forecasts (TAF)	2	3	1	0	6
Radar: NWS CONUS Merged Reflectivity Composite	3	2	1	0	6
Radar: NWS 1-Hour Precipitation	3	2	1	0	6
Satellite: Visible (vis)	2	3	1	0	6
Satellite: Rainbow (rb)	2	2	2	0	6
Satellite: Visible (rgb)	2	3	1	0	6
Satellite: Shortwave (ir2f)	1	3	1	1	6
Satellite: JSL2 (jsl)	0	3	1	2	6
Satellite: Aviation (avn)	1	2	1	2	6
Wind Aloft	1	2	2	1	6
Temperature Aloft	1	2	2	1	6

Google Analytics System Usage Statistics

- System usage is tracked via Google Analytics.
- The project team has implement tracking mechanisms to record user selection of layers and markers.
- Additionally, Google Analytics provides information about users and user sessions including the locations of users.
- Tracking via Google Analytics started during Phase 1 on June 1st, 2010.
- The Phase 2 prototype system went live on August 13th, 2013, and additional tracking of layers and markers was implemented at that time.
- Google Analytics data from August 13th, 2013 through September 30th, 2015 is presented here.

1	**Sacramento**	**579**	**35.24%**
2	Redding	153	9.31%
3	San Francisco	74	4.50%
4	Rancho Cordova	65	3.96%
5	Corning	61	3.71%
6	Chico	49	2.98%
7	Monterey	44	2.68%
8	Los Angeles	40	2.43%
9	Hollister	37	2.25%
10	Lincoln	32	1.95%
11	Riverside	27	1.64%
12	Oakland	23	1.40%
13	Weaverville	20	1.22%
14	Vacaville	19	1.16%
15	Dixon	18	1.10%
16	Yreka	18	1.10%
17	Patterson	16	0.97%
18	Folsom	15	0.91%
19	Rocklin	15	0.91%
20	Santa Rosa	15	0.91%
21	Yuba City	15	0.91%
22	Napa	14	0.85%
		…	…
	TOTAL	1643	100%

- 2883 sessions
- 1261 users
- 1643 Sessions from 128 Communities in California



Surface Condition Events

Layer and Sublayer Events

Main Menu Select	**1377**
Wind Speed	346
Air Temperature	259
24-Hour Precipitation	160
RWIS Stations	148
Hourly Precipitation	137
Humidity	118

Marker Selection Events

Air Temperature	**925**
Wind Speed	714
RWIS Stations	551
Humidity	124
Hourly Precipitation	100
24-Hour Precipitation	88

Surface Forecast Events

Layer and Sublayer Events

Main Menu Select	**1221**
Wind Speed	207
Weather	155
Wind Gust Speed	142
12-Hour Chance of Precipitation	117
SkyCover	108
6-Hour Precipitation	87
Air Temperature	67
Snow	62
Humidity	36

Marker Selection Events

Weather	**158**
Wind Gust Speed	74
Wind Speed	41
Air Temperature	38
12-Hour Chance of Precipitation	16
Sky Cover	14
6-Hour Precipitation	12
Snow	6
Humidity	1

Surface Layer Events

Layer and Sublayer Events

Main Menu Select	**1243**
Caltrans CCTV	294
NWS Alerts	163

Marker Selection Events

Caltrans CCTV	**2832**
NWS Alerts	492

Aviation Layer Events

Layer and Sublayer Events

Main Menu Select	**1744**
Wind Aloft	441
AWOS/ASOS	312
SIGMETs/AIRMETs	277
Pilot Reports	252
Terminal Aerodrome Forecasts	241
Satellite	239
NWS Composite Reflectivity	181
NWS 1-Hour Precipitation	168
Airports	161
Temperature Aloft	136

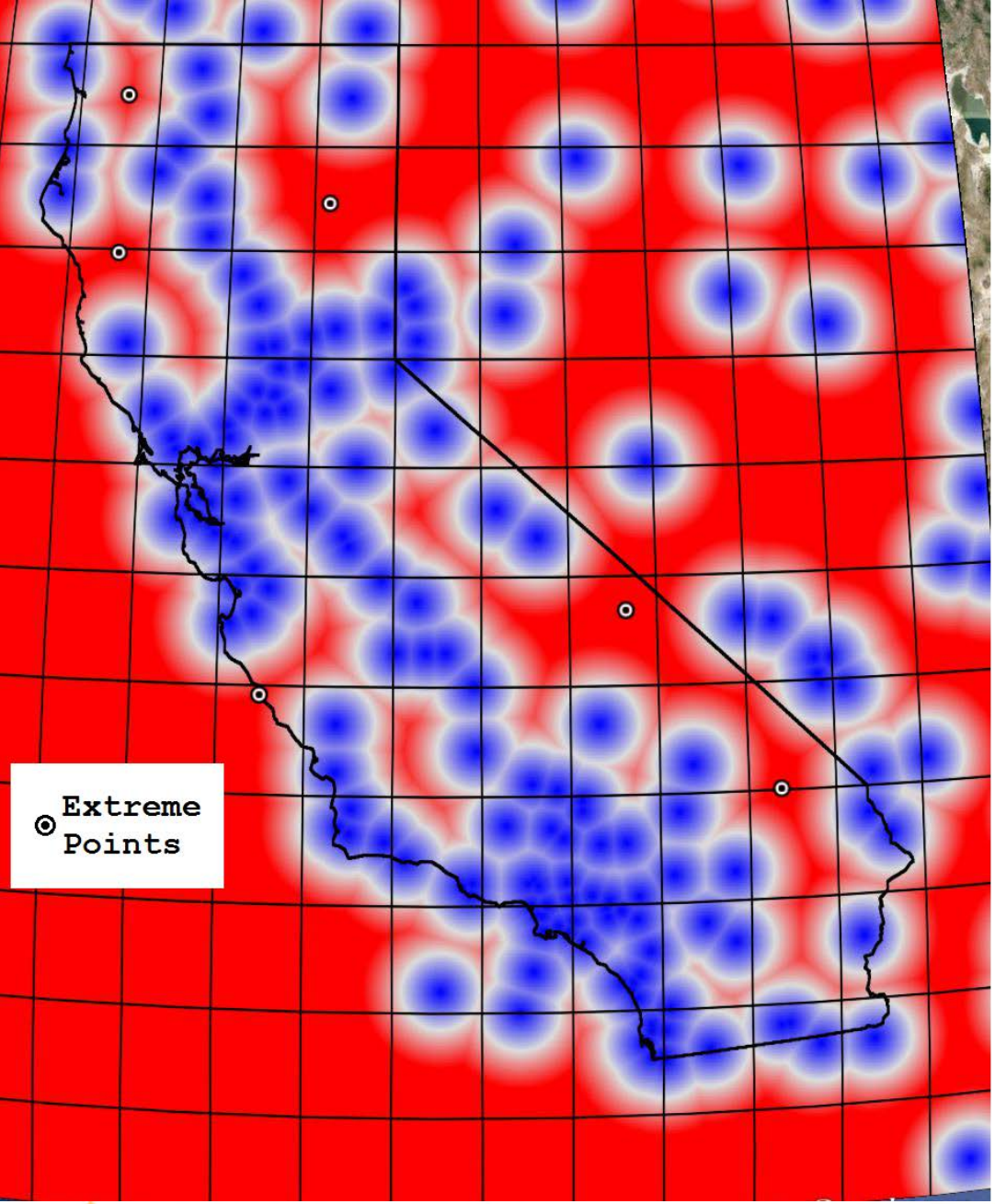
Marker Selection Events

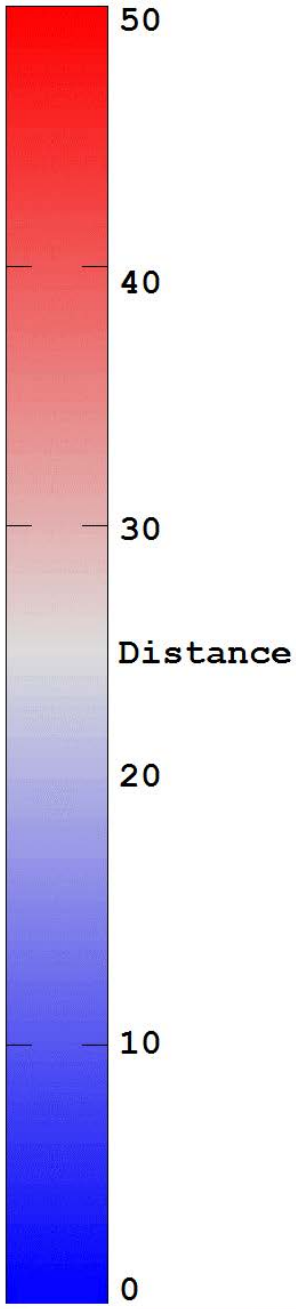
AWOS/ASOS	**6845**
Pilot Reports	634
Terminal Aerodrome Forecasts	569
Wind Aloft	409
SIGMETs/AIRMETs	188
Airports	192
Temperature Aloft	95

Gap Analysis

For further information see:

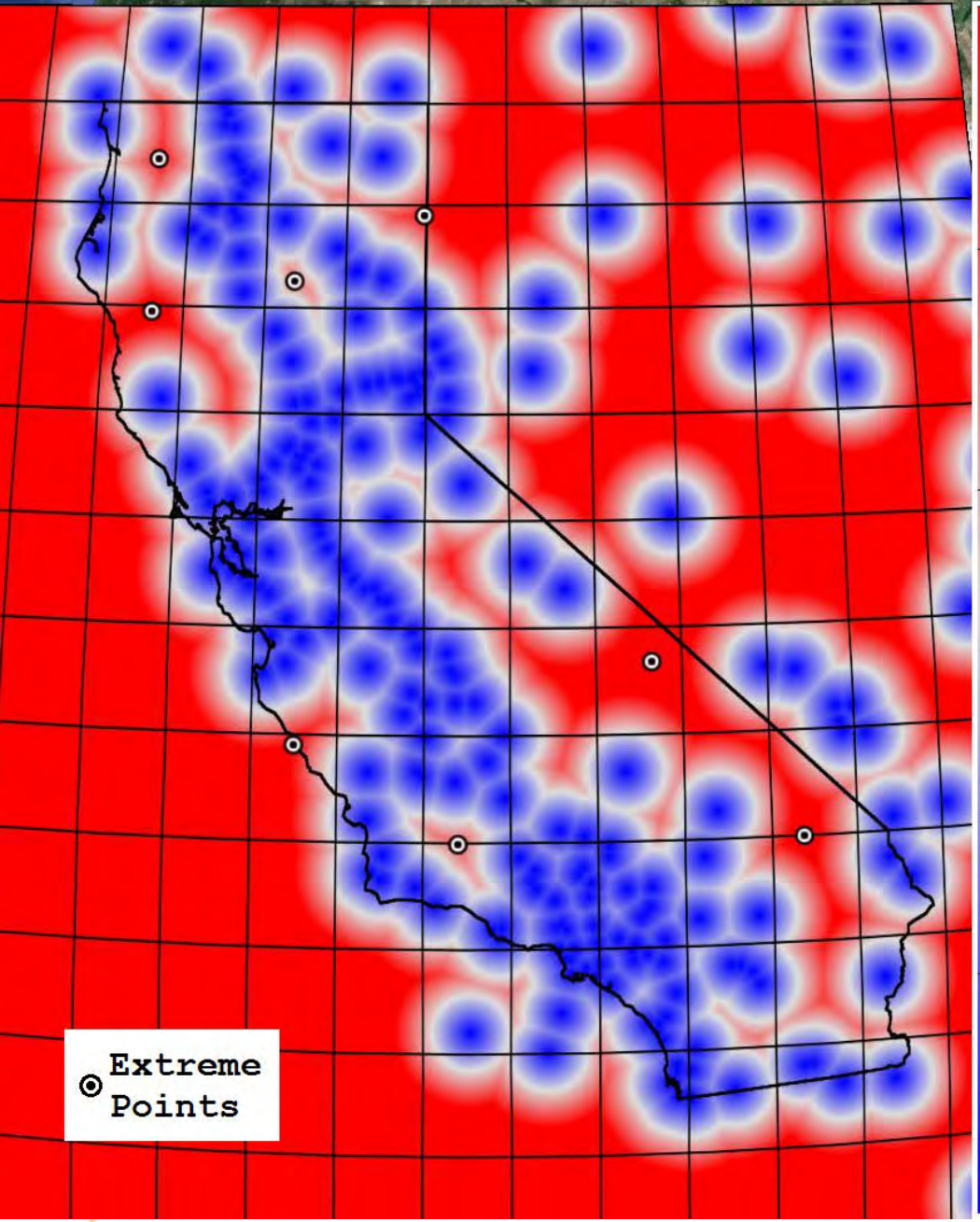
- Integration of Aviation Automated Weather Observation Systems (AWOS) with Roadside Weather Information Systems (RWIS) Phase II Gap Analysis, by Douglas Galarus and Daniell Richter, Western Transportation Institute, Montana State University. Finalized July 10, 2015.

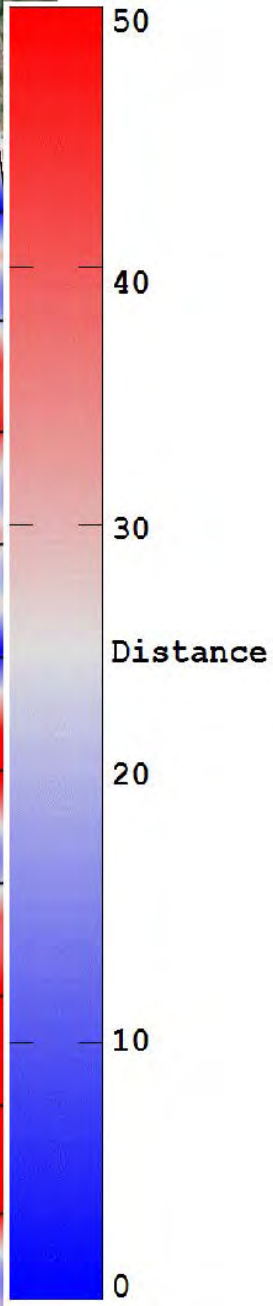




Heat Map Showing Distances (mi) to the Nearest Reporting AWOS / ASOS Site from All Locations in California and Extreme Points within Areas of Poor Coverage

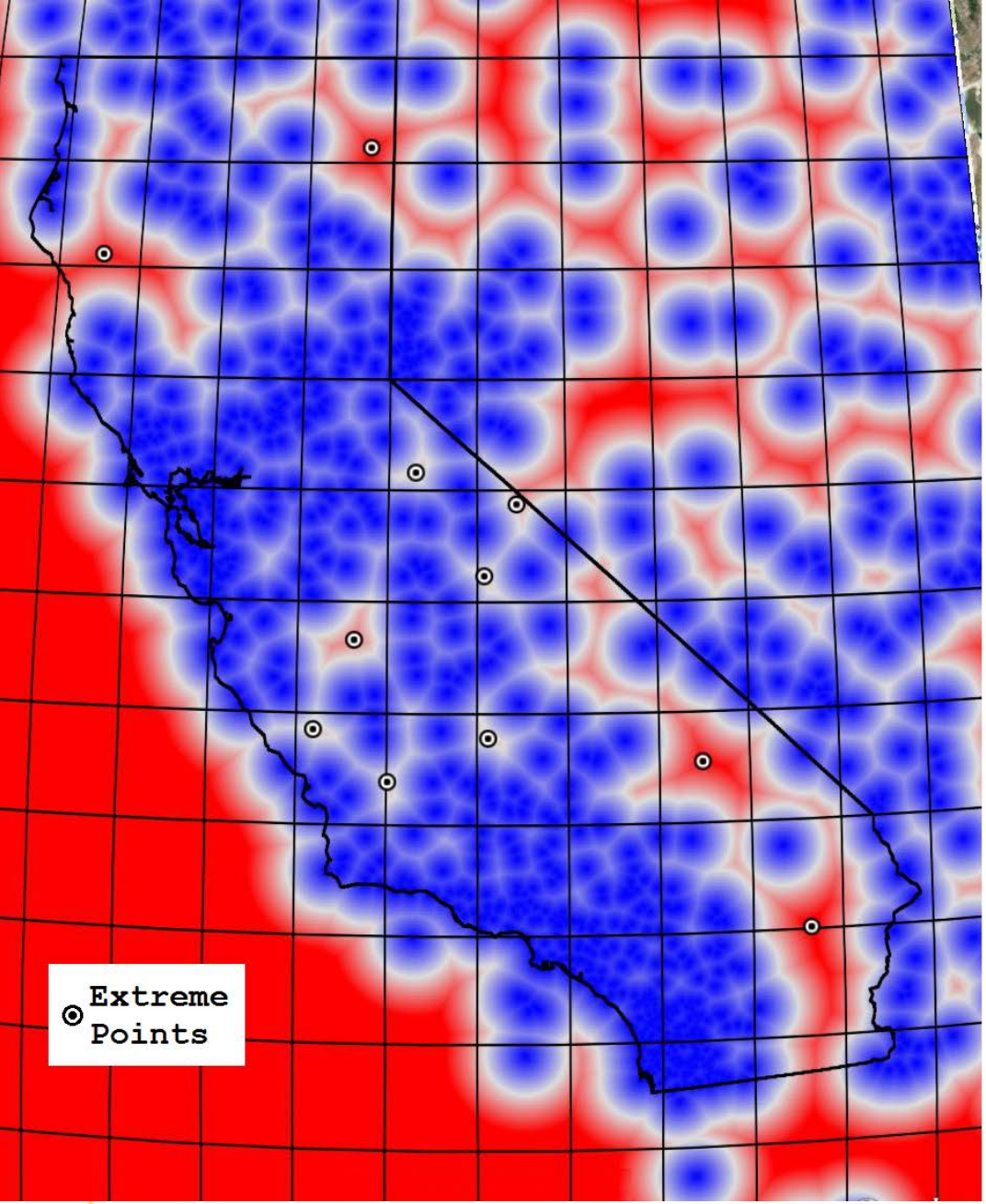
(Blue = less than 25 miles from nearest site, White = 25 miles from nearest site, Red = more than 25 miles to nearest site)

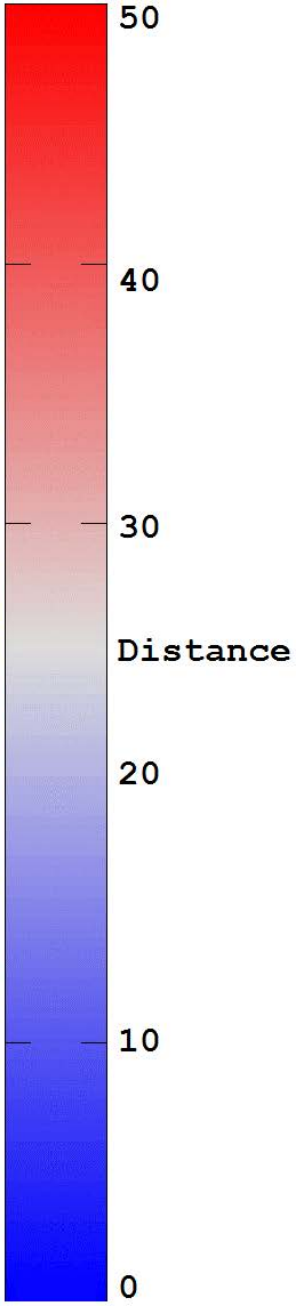




Heat Map Showing Distances (mi) to the Nearest Reporting AWOS / ASOS / RWIS Site from All Locations in California and Extreme Points within Areas of Poor Coverage

(Blue = less than 25 miles from nearest site, White = 25 miles from nearest site, Red = more than 25 miles to nearest site)





Heat Map Showing Distances (mi) to the Nearest Reporting AWOS / ASOS / RWIS / MADIS / MesoWest Site with QC-Passed Observations and Reporting Frequency of 15 Minutes or Better from All Locations in California and Extreme Points within Areas of Poor Coverage

(Blue = less than 25 miles from nearest site, White = 25 miles from nearest site, Red = more than 25 miles to nearest site)

40 airports fall more than 25 Miles from the nearest reporting AWOS/ASOS site.

Name	City	County	Distance to AWOS/ASOS
STOVEPIPE WELLS AIRPORT	Death Valley National Park	Inyo	62.64
SUSANVILLE MUNICIPAL AIRPORT	Susanville	Lassen	61.08
SPAULDING AIRPORT	Susanville	Lassen	58.26
LONE PINE AIRPORT	Lone Pine	Inyo	56.46
FALL RIVER MILLS AIRPORT	Fall River Mills	Shasta	50.60
FURNACE CREEK AIRPORT	Death Valley National Park	Inyo	48.48
RAVENDALE AIRPORT	Ravendale	Lassen	47.94
GANSNER AIRPORT	Quincy	Plumas	47.12
SHOSHONE AIRPORT	Shoshone	Inyo	46.94
ROGERS FIELD	Chester	Plumas	46.64
ROUND VALLEY AIRPORT	Covelo	Mendocino	46.45
HAPPY CAMP AIRPORT	Happy Camp	Siskiyou	42.85
RUTH AIRPORT	Ruth	Trinity	42.18
KERN VALLEY AIRPORT	Kernville	Kern	40.98
MESA DEL REY AIRPORT	King City	Monterey	40.48
INDEPENDENCE AIRPORT	Independence	Inyo	39.25
LOST HILLS KERN COUNTY AIRPORT	Lost Hills	Kern	38.19
SOUTHARD FIELD AIRPORT	Bieber	Lassen	37.14
SHELTER COVE AIRPORT	Shelter Cove	Humboldt	36.21
GARBERVILLE AIRPORT	Garberville	Humboldt	36.13
HERLONG AIRPORT	Herlong	Lassen	36.06
OCOTILLO AIRPORT	Ocotillo Wells	San Diego	33.39
NEW CUYAMA AIRPORT	New Cuyama	Santa Barbara	31.83
LITTLE RIVER AIRPORT	Little River	Mendocino	31.23
BAKER AIRPORT	Baker	San Bernardino	30.32
HYAMPOM AIRPORT	Hyampom	Trinity	30.06
MARIPOSA YOSEMITE AIRPORT	Mariposa	Mariposa	29.78
TAFT AIRPORT	Taft	Kern	29.75
SALTON SEA AIRPORT	Salton City	Imperial	29.65
ADIN AIRPORT	Adin	Modoc	28.38
OCEAN RIDGE AIRPORT	Gualala	Mendocino	28.28
LEE VINING AIRPORT	Lee Vining	Mono	28.13
DINSMORE AIRPORT	Dinsmore	Humboldt	28.13
WILLOWS GLENN COUNTY AIRPORT	Willows	Glenn	27.51
NERVINO AIRPORT	Beckwourth	Plumas	27.28
BORREGO VALLEY AIRPORT	Borrego Springs	San Diego	27.06
CHIRIACO SUMMIT AIRPORT	Chiriaco Summit	Riverside	26.54
GRAVELLY VALLEY AIRPORT	Upper Lake	Lake	26.29
TULELAKE AIRPORT	Tulelake	Modoc	25.91
LOS BANOS MUNICIPAL AIRPORT	Los Banos	Merced	25.26

18 airports fall more than 25 Miles from the nearest reporting AWOS/ASOS, RWIS, MADIS or Mesowest site.

Name	City	County	Distance to Weather Station
BAKER AIRPORT	Baker	San Bernardino	42.44
RUTH AIRPORT	Ruth	Trinity	40.11
SHELTER COVE AIRPORT	Shelter Cove	Humboldt	37.34
GARBERVILLE AIRPORT	Garberville	Humboldt	37.11
ALTURAS MUNICIPAL AIRPORT	Alturas	Modoc	34.23
BRAWLEY MUNICIPAL AIRPORT	Brawley	Imperial	32.26
WILLIAM R. JOHNSTON (MENDOTA) AIRPORT	Mendota	Fresno	31.83
RAVENDALE AIRPORT	Ravendale	Lassen	31.79
CALEXICO INTERNATIONAL AIRPORT	Calexico	Imperial	31.03
CALIFORNIA PINES AIRPORT	Alturas	Modoc	30.39
DINSMORE AIRPORT	Dinsmore	Humboldt	28.22
BLYTHE AIRPORT	Blythe	Riverside	27.64
IMPERIAL COUNTY AIRPORT	Imperial	Imperial	27.59
CLIFF HATFIELD MEMORIAL AIRPORT	Calipatria	Imperial	26.99
HYAMPOM AIRPORT	Hyampom	Trinity	26.81
WILLOWS GLENN COUNTY AIRPORT	Willows	Glenn	26.49
ROUND VALLEY AIRPORT	Covelo	Mendocino	26.43
CHIRIACO SUMMIT AIRPORT	Chiriaco Summit	Riverside	25.47

Phase 2 Conclusions

- Feedback has been generally positive and both the focus group and participants in the online survey have provided useful suggestions.
- The system does appear to be on the right track.
- The Google Analytics data helps to augment the survey data in identifying the most used and useful data layers in the system.
- Not surprisingly, users seem most interested in wind speed data.
- One potential data set identified as missing and beneficial is cloud ceilings. Users also requested additional icing data.

Phase 2 Conclusions

- The gap analysis identified areas that are underserved by existing weather stations, relative to data that is accessible by the prototype system.
- Not surprisingly the underserved areas are extremely rural and located in the northeast, northwest, west-central, east-central and southeast portions of the state.
- While rural, there are a number of air fields in these areas that could benefit from having more local weather information. Emergency Medical Service (EMS) flights certainly occur in these areas as well.
- Aside from identifying gaps, the gap analysis helped to demonstrate the utility of the prototype system over AWOS/ASOS alone.
- Otherwise, the gap analysis results may prove helpful in determining locations in which to deploy future AWOS/ASOS or RWIS.

Phase 3

February 20, 2017 – February 19, 2019
(in progress)

Phase 3
Research Outcomes

- Site Review and Update
- Stand-alone Demonstration CentOS Installation
- System Documentation
- Technical Support

Phase 3
Events to Date

- WTI conducted the site review and update, and the stand-alone installation very quickly at the start of the project.
- WTI produced a Data and System Estimated Requirements document for Caltrans IT's reference.
- Code and preliminary documentation was turned over to Caltrans IT early.
- Caltrans IT initiated their install early.
- WTI provided support throughout the install.
- Caltrans went "live" with their system in March 2018.
- Final documentation produced subsequently.

Phase 3 Issues

- Path issues:
  - Some paths had to be adjusted and/or corrected.
- Firewall issues – Caltrans needed to open access to MADIS and other sources:
  - MADIS service comes from multiple server farms with multiple addresses.
  - Couldn't isolate to one or several stand-alone IP addresses that could be entered in the firewall as exceptions.
- ImageMagick issues affecting surface and aloft forecast rasters.
  - Processing of MVG files disabled for security in ImageMagick.
  - MVG needed to be enabled.
- SIGMET Issue
  - There was a bug that hadn't been noticed previously causing several of the reports to not be written.

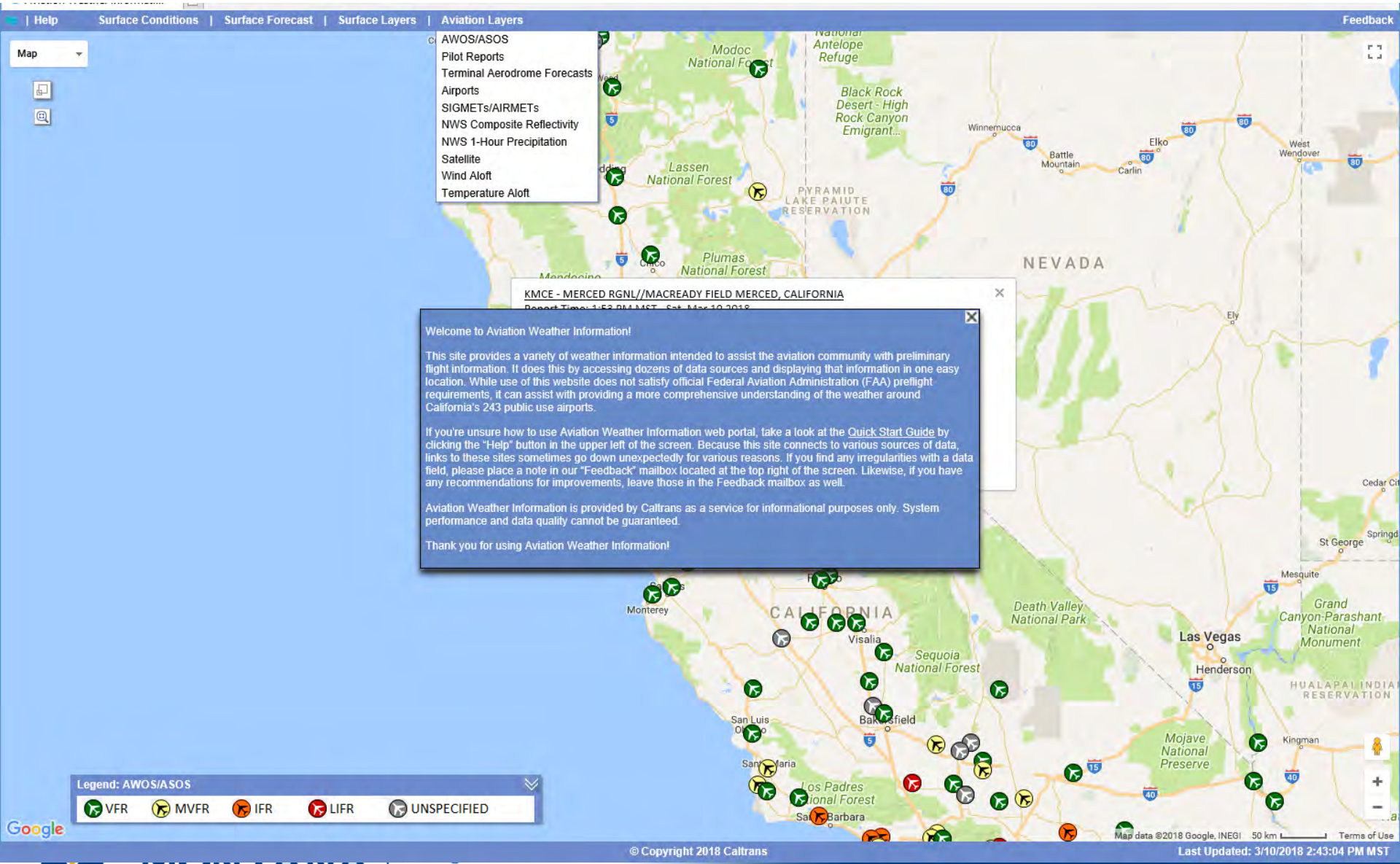
Phase 3 Issues

- Satellite Data
  - There was a bug in a regular expression that was not correctly matching image file names.
- PIREPS Issue
  - The source site and format changed. Retrieval and preparation scripts had to be modified.
- Source switched to redirection to secure site.
  - Aviationweather.gov started redirecting http requests to https.
- Several mal-formed JavaScript issues that arose when data retrieval failed.
  - JavaScript was mal-formed in instances when there was no data.
- Overall, Caltrans IT is taking a closer look at projects like this one, increasing “implementation challenges.”

Distinction Between Caltrans Aviation Weather Information and WeatherShare

- Initially this project was viewed as “WeatherShare for Aviation”, or “Aviation WeatherShare.”
- It was formally referred to as “Integration of Aviation AWOS/ASOS with RWIS”.
- Ultimately inclusion of “WeatherShare” in the name and URL caused confusion since both projects had gone in their own, separate directions.
- The aviation project was renamed Caltrans Aviation Weather Information to alleviate this confusion.
- WeatherShare now focuses exclusively on being the repository for Caltrans RWIS data, and providing associated functionality.

http://awi.dot.ca.gov/



Outreach

Caltrans has demonstrated the system to emergency responders and public safety personnel from other agencies during real incidents and events including:

- California Aviation Day at the Capitol,
- Wildfires and floods,
- South Napa earthquake,
- Oroville Dam crisis,
- Super Bowl 50.

All situations received positive responses for this beneficial tool.

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For Further Information see:

http://awi.dot.ca.gov/

http://www.westernstates.org/Projects/Aviation/