Integration of Aviation Automated Weather Observation Systems (AWOS) with Roadside Weather Information Systems (RWIS)

Phase II

Final Report

by

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1.0	October 19th, 2015	First draft
2.0	December 9th, 2015	Final Version

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1. INTRODUCTION

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), in partnership with the Mineta Transportation Institute (MTI) at San Jose State University, conducted a research and development study of the proof-of-concept system for integrating Automated Weather Observing System (AWOS) with Roadside Weather Information System (RWIS). The goal of this multi-phase project is to provide 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 is targeted at small, underserved rural airfields and hospital heliports.

Data from aviation AWOS, ASOS (Automated Surface Observing Systems) and surface transportation RWIS have been integrated along with data from third-party providers National Oceanic and Atmospheric Administration (NOAA) Meteorological Assimilation Data Ingest System (MADIS) and MesoWest into the Aviation WeatherShare System to provide greater coverage for multiple agencies. Treating these independent systems as a larger, integrated system provides greater spatial coverage while using existing resources compared to the use of AWOS-ASOS alone.

During Phase I of this project, a small-scale systems engineering process was followed to develop a prototype. Literature review, AWOS/ASOS and RWIS sites analysis, user survey and requirements analysis, and cost–benefits analysis research activities have been conducted. In addition, the prototype was tested by a small set of prospective users and feedback has been positive. The prototype was viewed as a good tool to collect and disseminate weather information among aviation personnel, particularly in rural, underserved areas where AWOS/ASOS are not already deployed.

This document summarizes work conducted in Phase II of the research project, which ends December 31st, 2015. Following are descriptions of major project tasks and associated deliverables:

Task 0: Project Management

This task covered all activities related to project management.

The project champion, project manager, and principal investigators (PIs) attended an initial kick-off meeting to review and discuss project objectives and to address project issues. Prior to the kick-off meeting, a Project Technical Advisory Panel (PTAP) was formed to oversee project work and progress. The PTAP consisted of the Caltrans project champion, project manager and a small number of representative project stakeholders from Caltrans.

Through all phases of the project, the project team communicated with the Caltrans project champion and project manager to ensure that Caltrans' needs are fully understood and addressed. In addition to the kick-off meeting, subsequent project meetings were conducted as needed, either in-person or via phone or video conference. Throughout the project, the project team submitted periodic (quarterly) progress and financial reports as required by Caltrans. These

progress reports highlighted the current status of the project in terms of work accomplished and future work to be completed.

A sustained, publicly available web presence was developed to provide updates on the project's status.

Deliverables:

- A kickoff meeting was held on Thursday, February 28th, 2013 in Sacramento.
- Quarterly Reports were sent via email approximately midway through the months of January, April, July and October throughout the duration of the project.
- Other meetings were held via teleconference and web conference, as needed. These meetings were held as frequently as on a monthly basis at peak times of project activity and less frequently / as-needed at other times.
- A special meeting was held in conjunction with "California Aviation Day at the Capitol" on Wednesday, April 23, 2014. Further information and a photo of the project team's exhibit can be found at: http://www.westernstates.org/Projects/Aviation/Updates/2014-04-29.html
- The project web presence for background and updates is located at the following address: http://www.westernstates.org/Projects/Aviation/Default.html

Task 1: Business Case Analysis

This task was conducted principally by San Jose State University. The intent was to provide business case documentation that could eventually be used by Caltrans in a Feasibility Study Report (FSR). Note that FSR development is an internal process for Caltrans, and the intent here was not to have the project team directly assist with FSR development.

The project team will work with Caltrans to conduct a business case analysis and to produce documentation for use in a subsequent feasibility study report. This will include developing the partnerships and plans for long-term maintenance and management of the system.

Deliverables:

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

Task 2: Research Additional Sources

In this task the project team identified current and prospective aviation weather sources for the integrated system. Accessibility and usability of such information may be limited, so not all data sources could be used. Further, the system has been built using only free, publicly available data, and the project team did not consider the inclusion of paid data even though some private, paid sources of potentially useful data were identified.

Deliverables:

- 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.

Task 3: Detailed System Requirements

The high-level user needs and requirements that were identified in Phase I were converted and further developed into low-level detailed system requirements. The Federal Highway Administration (FHWA) System Engineering Guidebook for Intelligent Transportation Systems (ITS) was followed throughout the process of defining user requirements. The Guidebook defines seven categories of requirements: functional, performance, interface, data, non-functional, enabling, and constraints. These requirements together define what the system is supposed to do, how well the system functions, and operational conditions and constraints. The specific requirements developed in this task guided development of the prototype system.

Deliverables:

- 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.

Task 4: Develop System

The project team created a development and testing version of the system that complies with the detailed system requirements from Task 3. The system is a web-based application using a Google Maps user interface with multiple aviation-related data layers. Building on the Phase 1 prototype, data sources were expanded; usability was improved, reliability and scalability issues were addressed; and the system was enhanced with additional functionality. For the purposes of development and testing, a version of system is maintained

Deliverables:

- Phase II System in Development and Testing Environment

Task 5: Implementation

The implementation and hosting of the Phase II system was principally done on WTI/MSU servers for the purposes of demonstration to the PTAP and other prospective end-users and for review acceptance of the system by Caltrans. The Phase II system is fully functional, and supports numerous simultaneous users. It continues to be referred to as a prototype system because Phase 2 was conducted as a research phase. The Phase 2 system went live on August 13th, 2013.

The Phase II system was further installed on an external host site for the purposes of potential backup and failover. The Phase II system was not installed on Caltrans servers because arrangements could not be reasonably completed within the timeframe of the current Phase of the project to do so. As such, only high-level documentation related to operation, system administration and maintenance were produced within this phase of the project. It is understood that a smaller, additional phase will be used to migrate the system to Caltrans once accommodations are made within Caltrans to host and support the system.

Training materials were provided to Caltrans and the general users of the system by way of an online Quick Start Guide (http://aviation.weathershare.org/QSG.htm) and a basic usage video (https://www.youtube.com/v/G7GPCLPiJus?autoplay=1). Members of the PTAP tested and reviewed the system to determine that the system works and that all baseline requirements were met.

Deliverables:

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

Task 6: Evaluation

Under this task, the research team solicited input from prospective end users. Multiple methods, both direct and indirect, were used to solicit input. San Jose State University conducted an open-ended survey of 16 prospective users once the Phase II prototype was available for use. The Phase II prototype has also included a link to an online survey to solicit further input from prospective users. Finally, system usage is tracked via Google Analytics to provide feedback on system usage.

The results from this task are summarized in this document.

Deliverables:

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

Task 7: AWOS/ASOS Gap Analysis

In this task, the project team conducted an AWOS/ASOS (coverage) gap analysis. The intent of this task, following discussions in Phase 1, was to assist Caltrans in determining locations in which weather systems were needed and subsequently to develop cooperative maintenance agreements. Then and at present, planning for future deployment of both AWOS/ASOS and RWIS systems was conducted separately, and cooperative maintenance and deployment of these systems was not considered. It was anticipated that a natural shared cost and benefit for both surface transportation and aviation communities could be achieved if cooperative maintenance and deployment agreements could be developed. The development of such agreements is outside the scope of this project, and it is unclear if such agreements will be pursued. Even so, the gap analysis conducted in this project relative to the data sources available for use with the prototype system developed in this project is useful in assessing the coverage (and gaps) of the system.

Deliverables:

- 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.

Task 8: Determine Usage Status and Recommendations

The prototype system is viewed as providing non-Federal Aviation Administration (FAA)-approved "supplementary information" versus FAA-certified "use for flight planning purposes" information. This is the chief distinction between aviation use of AWOS/ASOS, provided by certified sources, and data from other sources such as RWIS and systems re-distributing AWOS/ASOS data. This task was intended to conduct outreach to the FAA and others to document and assess the viability of achieving FAA-certified status. Subsequently, the PTAP determined that this step would be premature and perhaps unnecessary given anticipated use of

the prototype system. Instead, the project team was asked to present users of the prototype system with the following disclaimer: "Aviation WeatherShare is provided by Caltrans as service or for informational purposes only. System performance and data quality cannot be guaranteed." See Figure 1.

Deliverables:

- Disclaimer on the splash screen, shown upon entry to http://aviation.weathershare.org/.

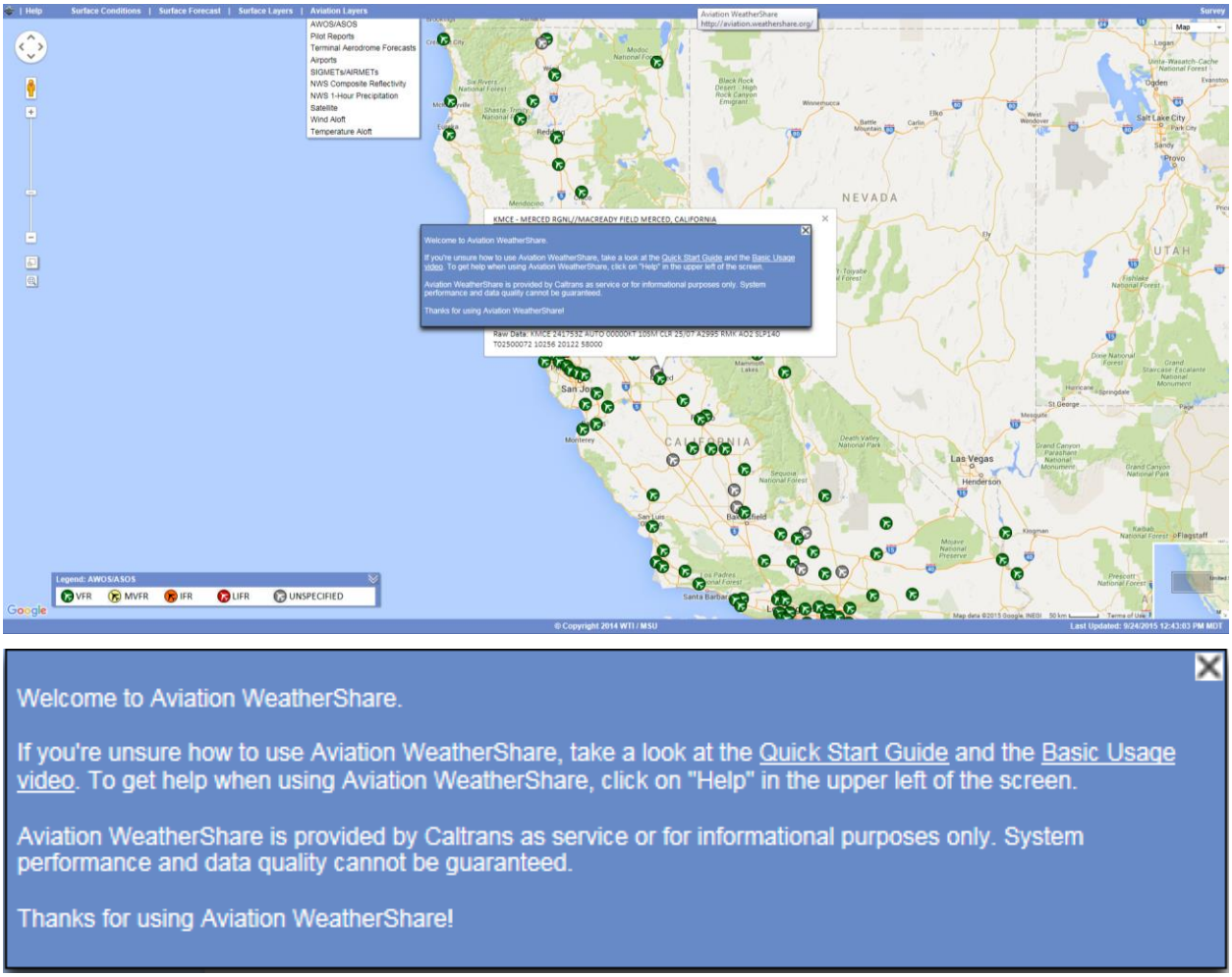

Figure 1: Prototype System Main Screen and Splash Screen

Task 9: Final Project Report and Presentation

The final deliverables for the project are the final project report (this document) and a corresponding presentation. The final report documents the prototype system that was developed as well as associated detailed from the project evaluation. Deliverables:

- Final Project Report (this document) will be finalized prior to the conclusion of the project: December 31st, 2015.
- The Final Project Presentation is scheduled for Wednesday, October 21st, 2015.

1.1. Definitions, acronyms, and abbreviations

The following abbreviations are used in this document:

ADDS	Aviation Digital Data Service
AIRMET	Airman's Meteorological Information
AMSL	Above Mean Sea Level
ASOS	Automated Surface Observing System
AWOS	Automated Weather Observing Station
Caltrans	California Department of Transportation
CCTV	Closed Circuit Television (Camera)
CWWP2	Caltrans Commercial Wholesale Web Portal, version 2
D3	(Caltrans) District 3 (similar for D1-D12)
DOT	Department of Transportation
EMS	Emergency Medical Services
ESS	Environmental Sensor Station
GMT	Greenwich Mean Time
HP	Heliport
I-5	Interstate 5 (similar for other Interstate roadways)
IFR	Instrument Flight Rules
IT	Information Technology
ITS	Intelligent Transportation Systems
JSON	JavaScript Object Notation
KML	Keyhole Markup Language
LIFR	Low Instrument Flight Rules
MADIS	Meteorological Assimilation Data Ingest System
MesoWest	MesoWest at the University of Utah
METAR	Aviation Routine Weather Report
mi	miles
MSL	Mean Sea Level
MVFR	Marginal Visual Flight Rules
MSU	Montana State University
MTI	Mineta Transportation Institute
MVFR	Marginal Visual Flight Rules
NCAR	National Center for Atmospheric Research
NCEP (NCO)	National Centers for Environmental Prediction Central Operations
NDFD	National Digital Forecast Database
NDRS	National Doppler Radar Sites
NESDIS(SSD)	National Environmental Satellite, Data, and Information Service (Satellite Products and Services Division
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
PIREP	Pilot Report
QC	Quality Control
RWIS	Road Weather Information System
SIGMET	Significant Meteorological Information
SJSU	San Jose State University

SR	State Route
TAF	Terminal Aerodrome Forecast
TXT	Text
URL	Universal Resource Locator
US	United States
VFR	Visual Flight Rules
WTI	Western Transportation Institute

1.2. Organization of This Report

In Section 2 we present an overview of the prototype system including a summary of data retrieval and processing and the presentation mechanisms for the system. In Section 3 we present evaluation data for the system gathered from a focus group survey, and online survey of application users, and Google Analytics usage statistics. In Section 4 we present the results of the gap analysis, indicating sites and areas for which there are coverage gaps from weather stations. Finally, in Section 5 we present a summary.

For further information, refer to the documents listed in the following references section, the project website, and the project updates website ….

1.3. References

The following project documents were also used to develop this document:

- Western Transportation Institute, May 2010, Integration of Aviation Automated Weather Observation Systems (AWOS) with Roadside Weather Information Systems (RWIS) Final Report.

- A proposal for the project entitled: Integration of Aviation Automated Weather Observation Systems (AWOS) with Roadside Weather Information Systems (RWIS) Phase 2, Galarus, D., Wei, W. June 23, 2011.

- 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.

- 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.

- 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.

2. THE PROTOTYPE SYSTEM

In this section we document the prototype system from a high level, primarily by way of screenshots. Certainly the best way to understand the system is to use it. However, there are times when certain layers will be more interesting and relevant than others. We have made an effort to present screenshots here of all of the layers during relevant times such as winter weather events. For the sake of reference and overview we also present a high-level listing for the data sources and the general processing and presentation mechanisms used to present application information to end users.

2.1. Data Retrieval and Processing

The System consists of server-side scripts that retrieve and process data from numerous sources, format the data as JSON, KML and image files, a web server that serves the data via a web server to web clients, and a browser-based client that presents the data on top of Google Maps.

The data retrieved and presented dynamically in the system is summarized by the following data sources and data layers:

- 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 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 Closed Circuit Television (CCTV)
- National Oceanic and Atmospheric Administration (NOAA)'s National Weather Service Public Alerts:
  - National Weather Service (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.

Figure 2 shows overall data retrieval and processing (data flow) at a high level:

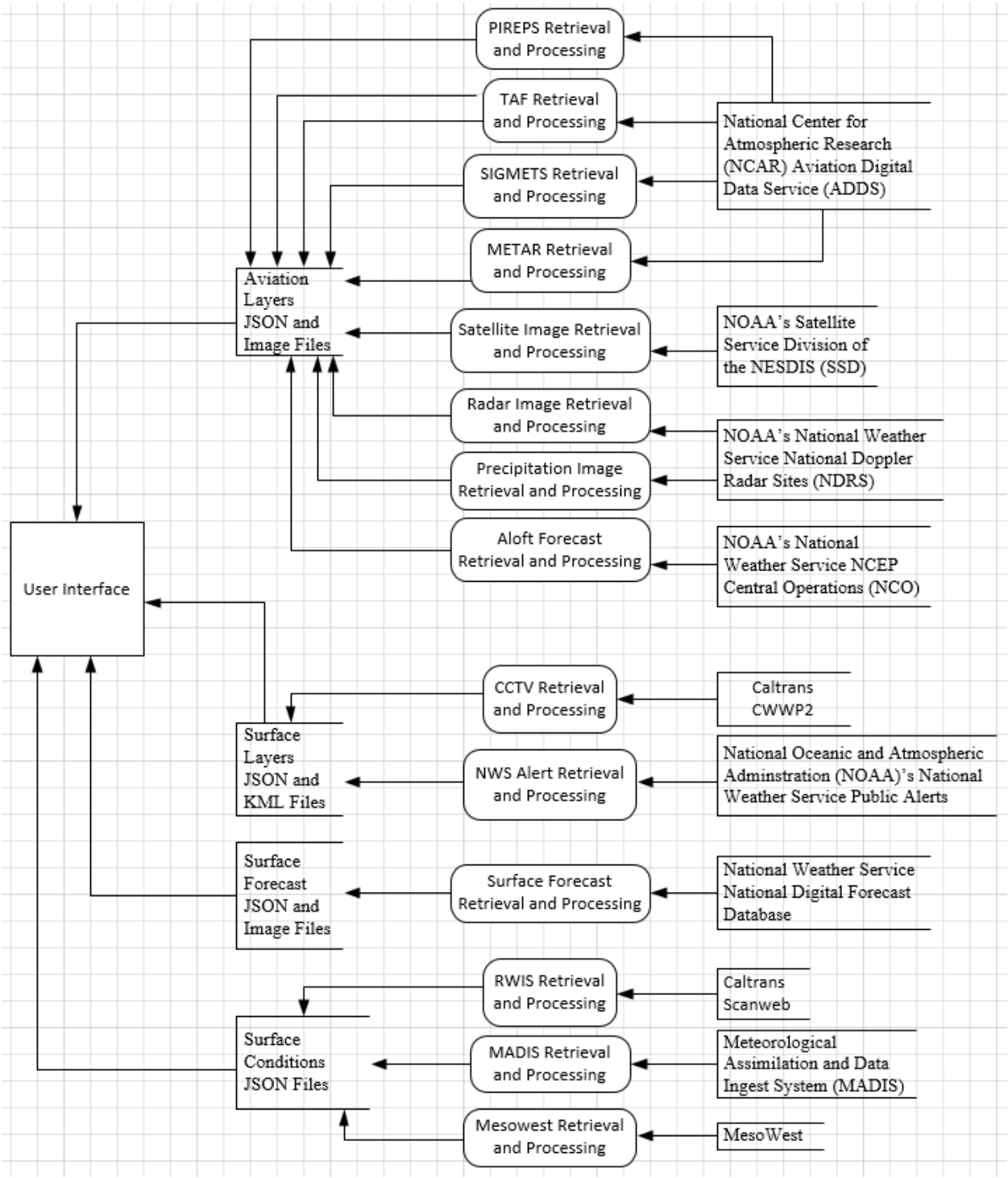

Figure 2: AWOS/RWIS Data Flow Diagram

2.2. Presentation

The application is presented to users via a Google Maps -based, web interface. Standard map navigation and selection controls are included. Data layers are selected via menus at the top of the screen and are shown as markers and, for some layers, raster images on top of the map. Markers can be selected to show further detail for a particular item. See Figure 3.

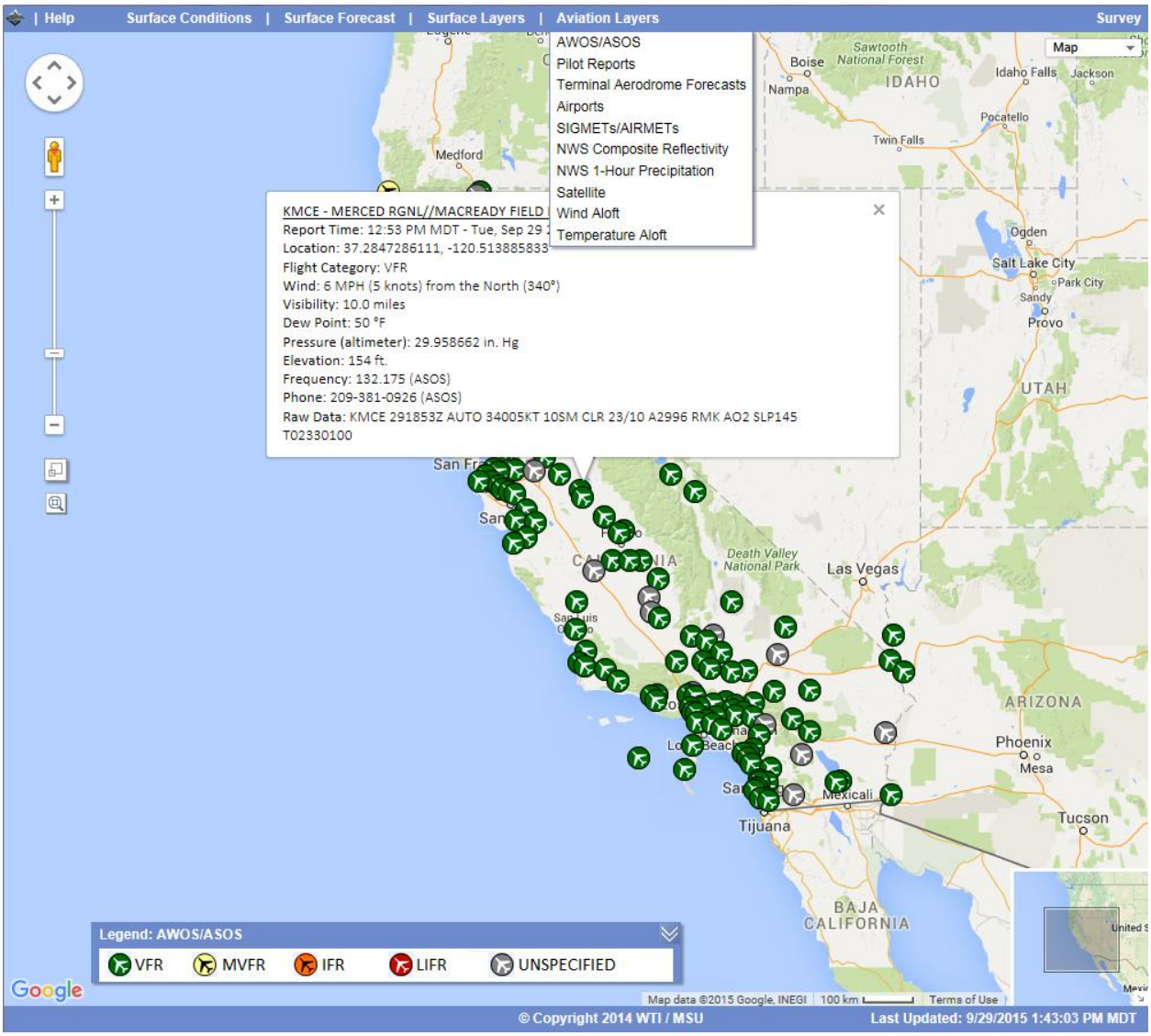

Figure 3: Prototype System Google Maps-based Web Interface

The four menus for selection of data layers are titled Aviation Layers, Surface Layers, Surface Forecast and Surface Conditions. See Figure 4, Figure 5, Figure 6 and Figure 7.

Figure 4: Aviation Layers Menu Items

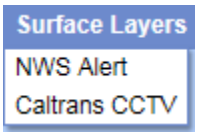

Figure 5: Surface Layers Menu Items

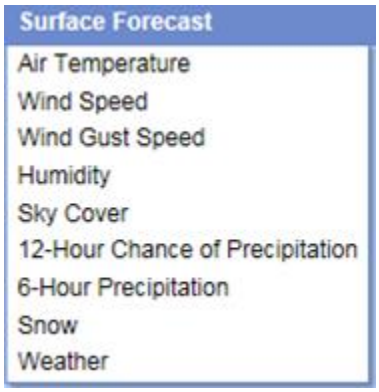

Figure 6: Surface Forecast Menu Items

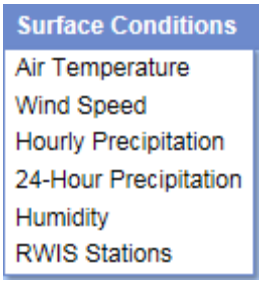

Figure 7: Surface Conditions Menu Items

Following are screenshots and descriptions of individual layers:

The AWOS/ASOS layer, found in the Aviation Layers menu, is the default layer that is shown when users first visit the system. AWOS/ASOS sites with available data are located with markers that are color-coded to indicate their recently-reported flight category: VFR, MVFR, IFR, LIFR, or UNSPECIFIED. See the National Weather Service's Aviation Weather Center[1] for definitions of these flight categories. See Figure 8.

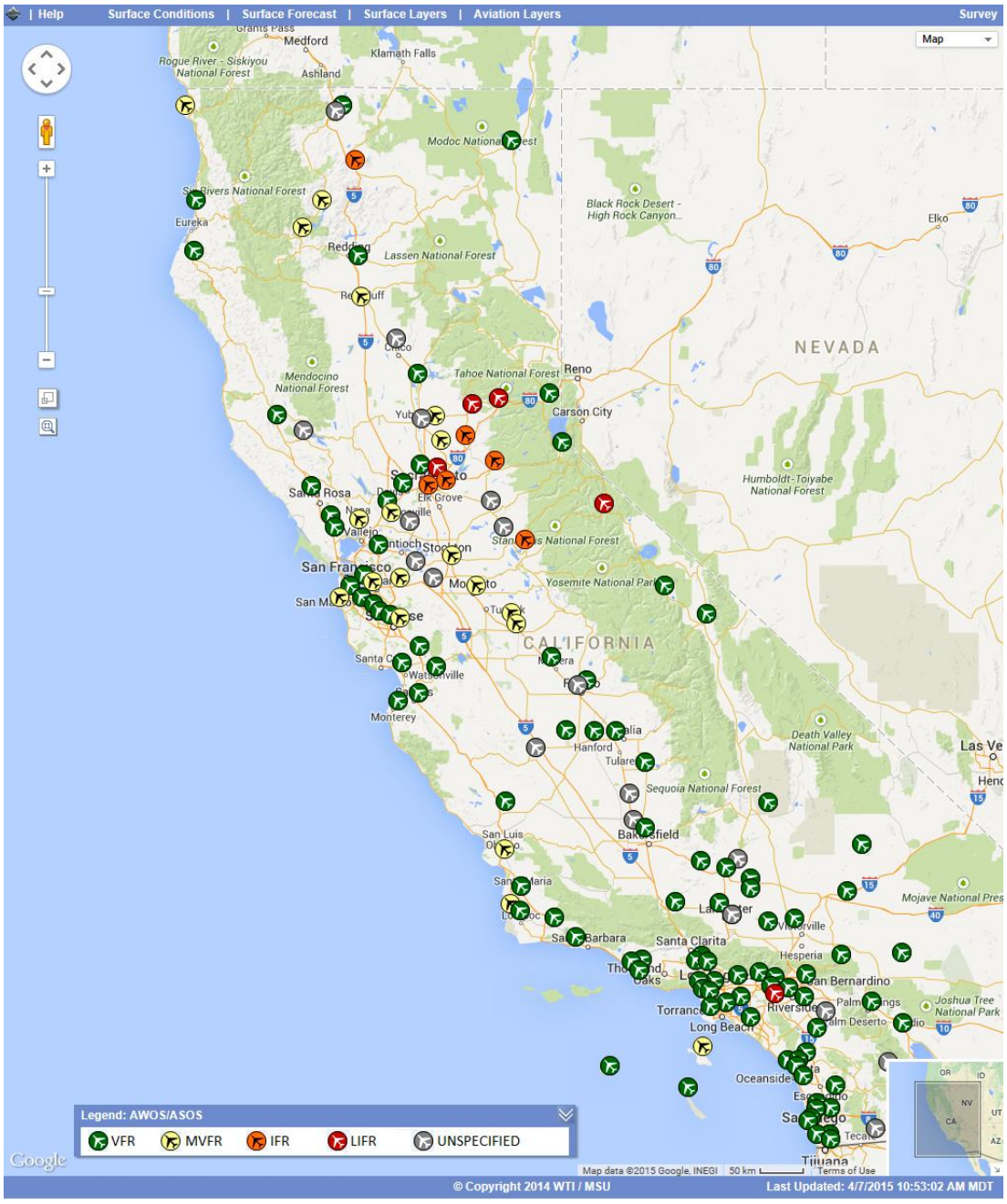

Figure 8: AWOS/ASOS Layer

[1] http://www.aviationweather.gov/adds/metars/description/page_no/4

Users can click on individual markers to display detailed observations from the corresponding AWOS/ASOS site. See Figure 9.

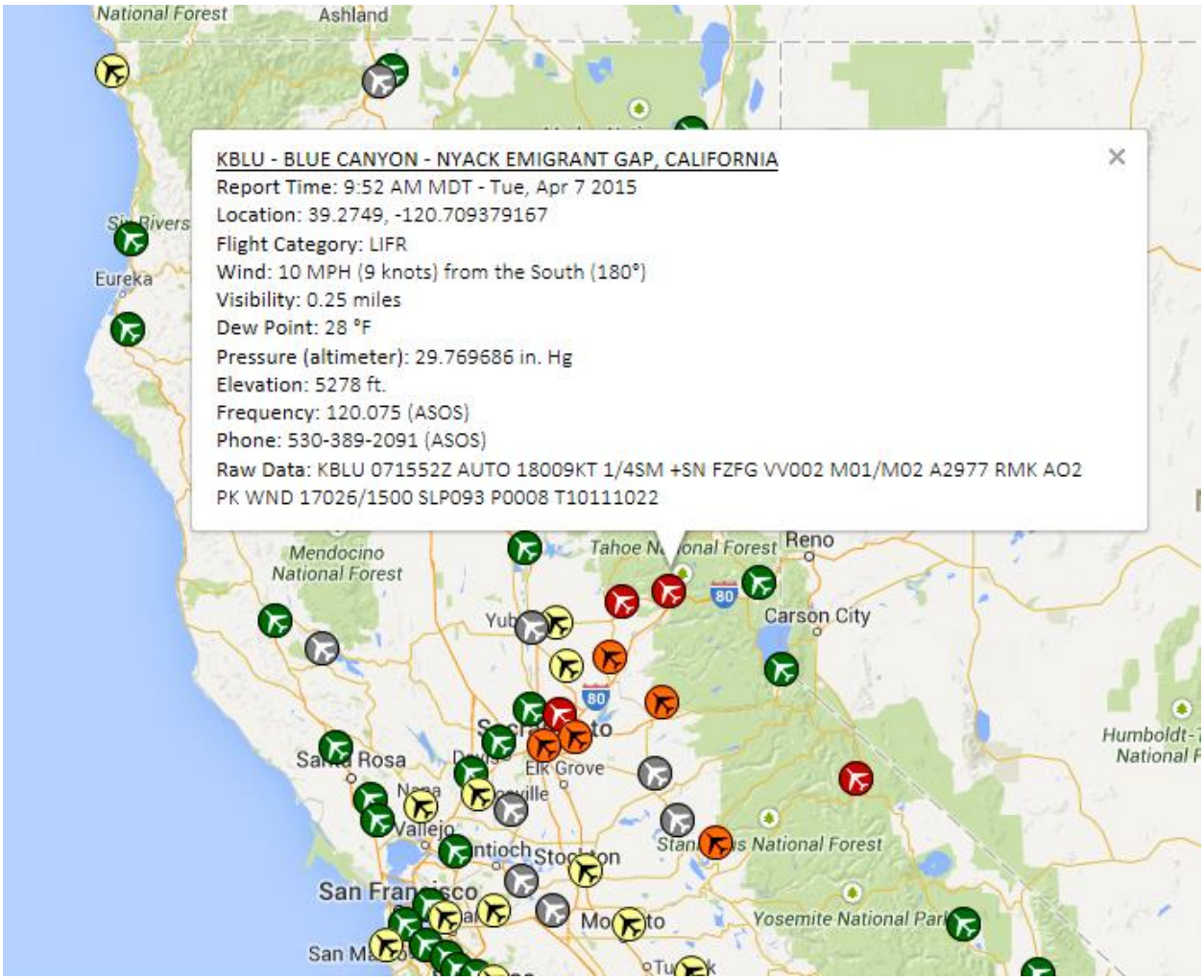

Figure 9: Detailed Observations from AWOS/ASOS Site

The Pilot Reports (PIREPS) layer, located in the Aviation Layers menu, shows Pilot Reports of inflight weather conditions. See Figure 10.

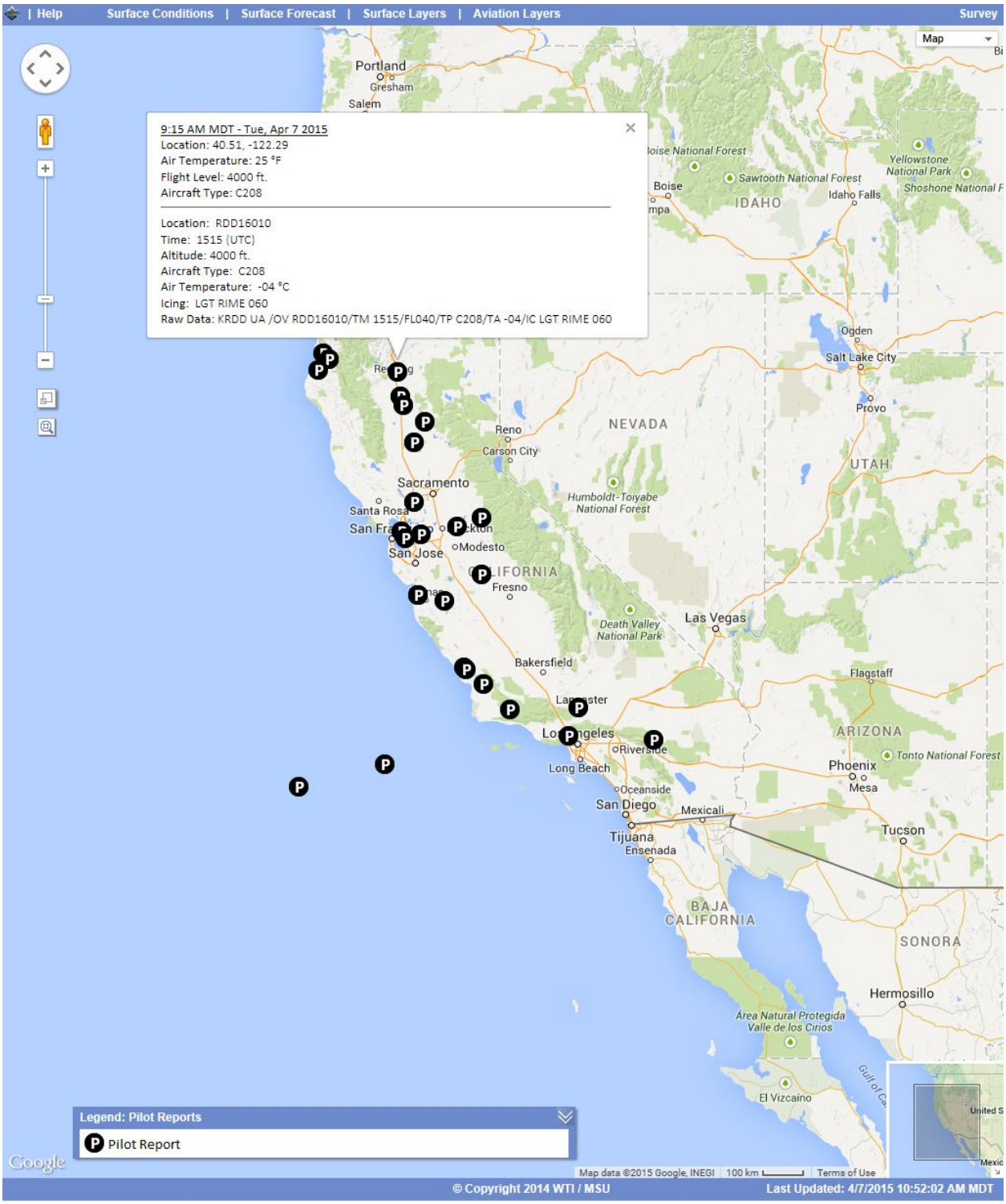

Figure 10: Pilot Reports Layer and Detailed Observation

The Terminal Aerodrome Forecasts (TAF) layer, located in the Aviation Layers menu, shows forecast conditions at airport locations. For more information about Terminal Aerodrome Forecasts, see NOAA's National Weather Service Aviation Weather Center[2]. See Figure 11.

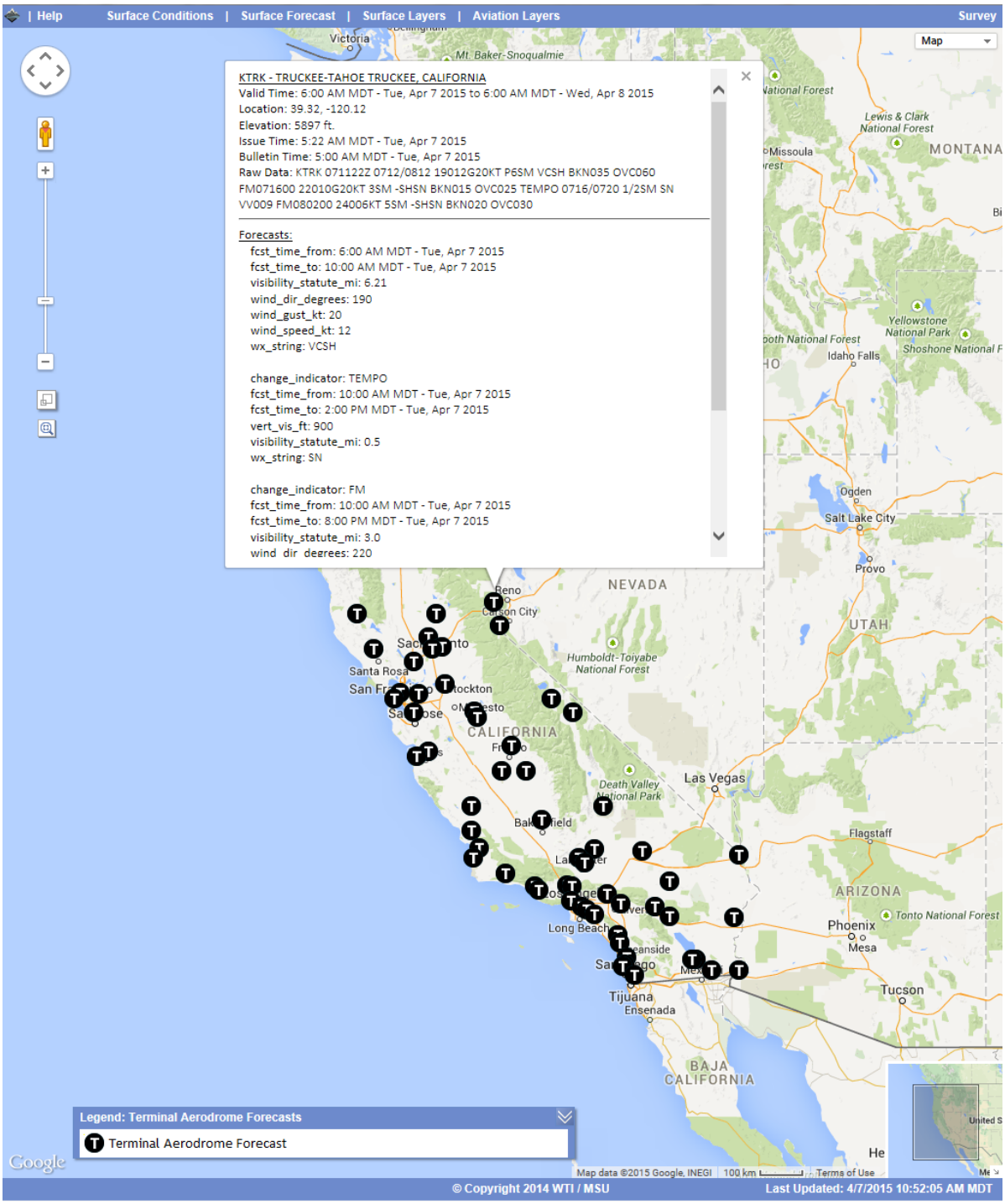

Figure 11: Terminal Aerodrome Forecasts Layer and Detail

[2] https://www.aviationweather.gov/static/help/taf-decode.php

The Airports layer, located in the Aviation Layers menu, shows locations of airports, heliports and military air fields. See Figure 12.

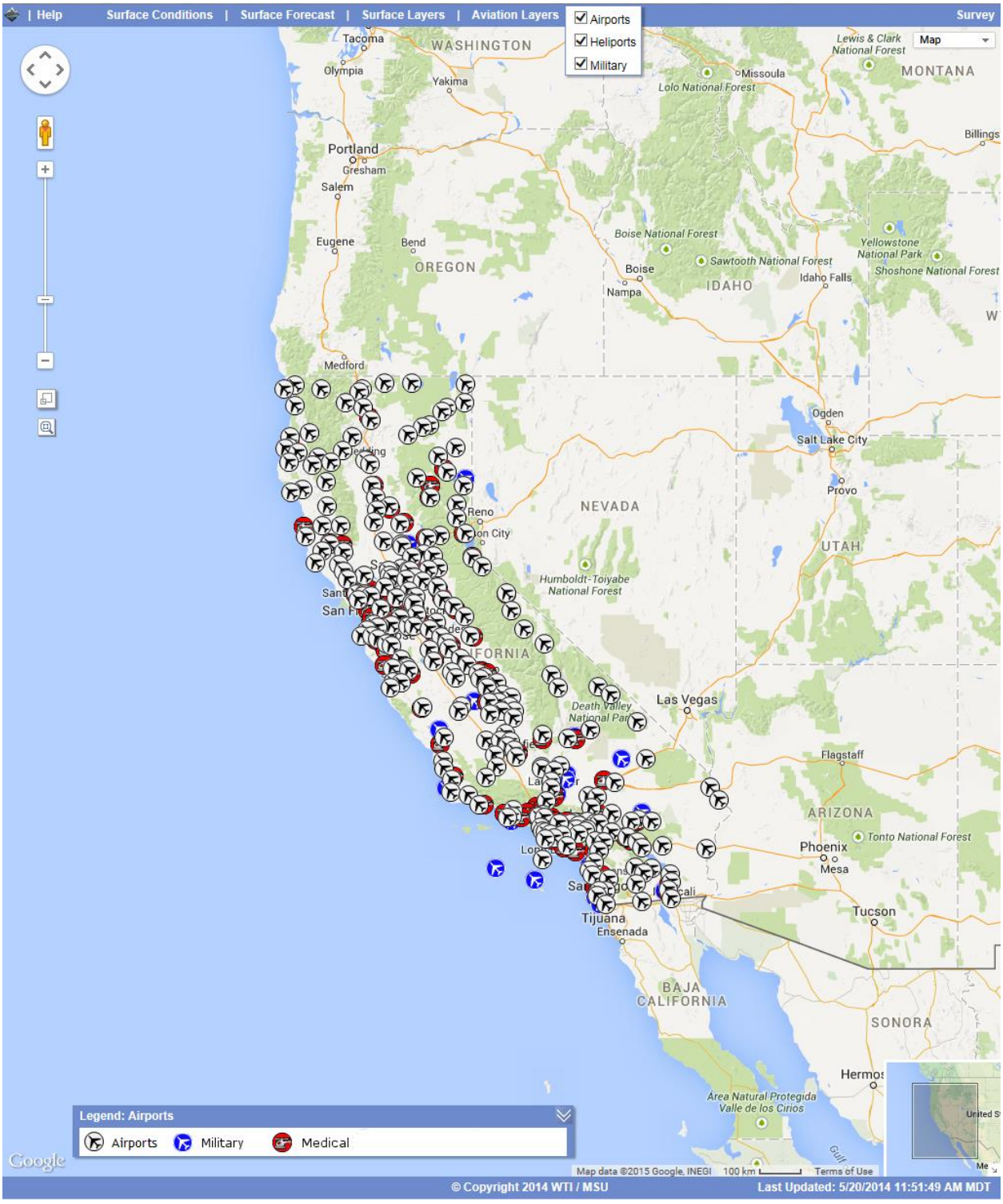

Figure 12: Airports Layer

Users can click on airport / heliport / military air field markers to view additional facility information including Caltrans data plates. See Figure 13.

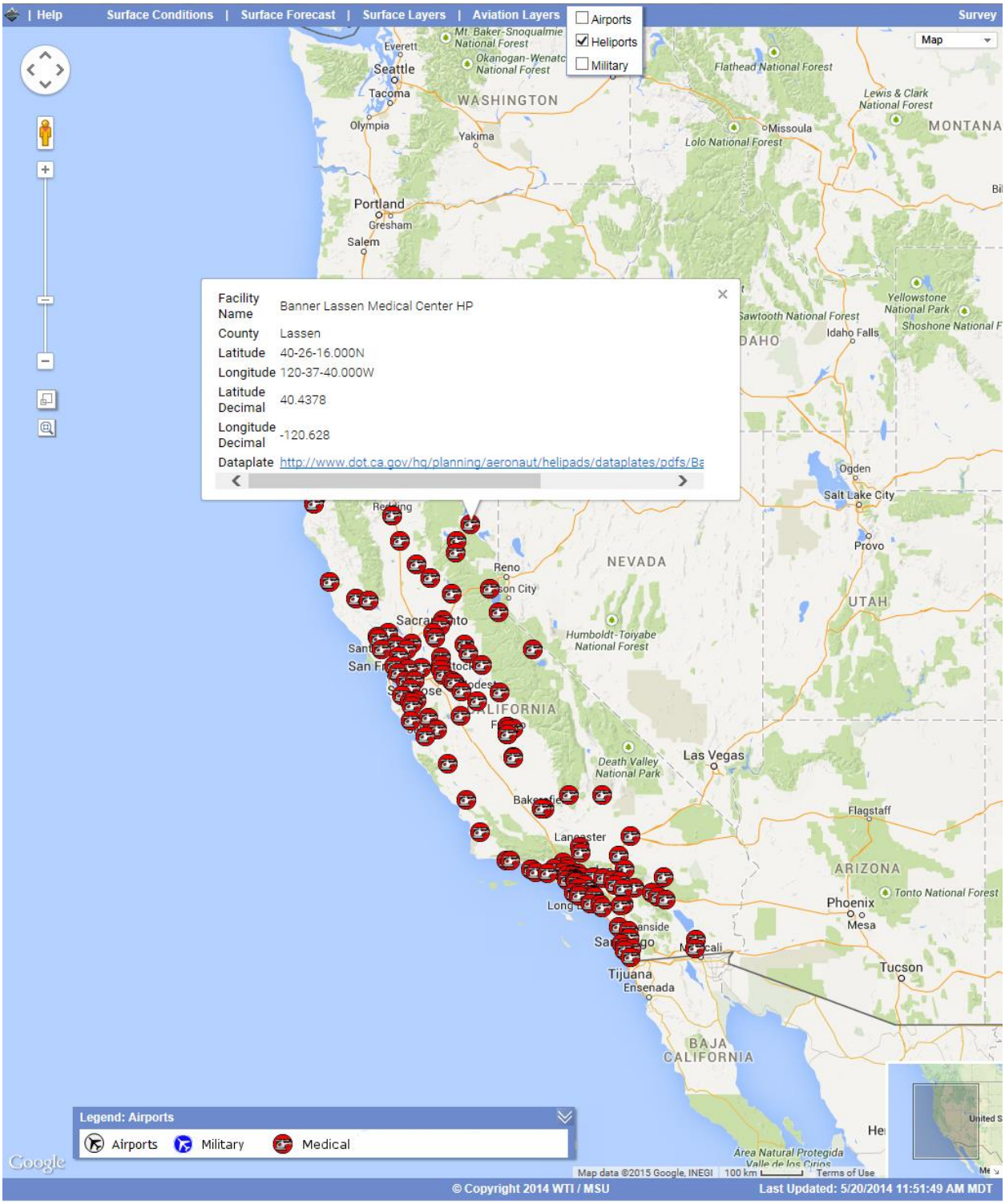

Figure 13: Heliport Detail Including Link to Caltrans Data Plate

The SIGMETs/AIRMETs layer, located in the Aviation Layers menu, shows regions corresponding to current warnings for hazardous weather including turbulence, icing, etc. See the National Weather Service Aviation Weather Center[3] for further information about SIGMETs/AIRMETs. See Figure 14.

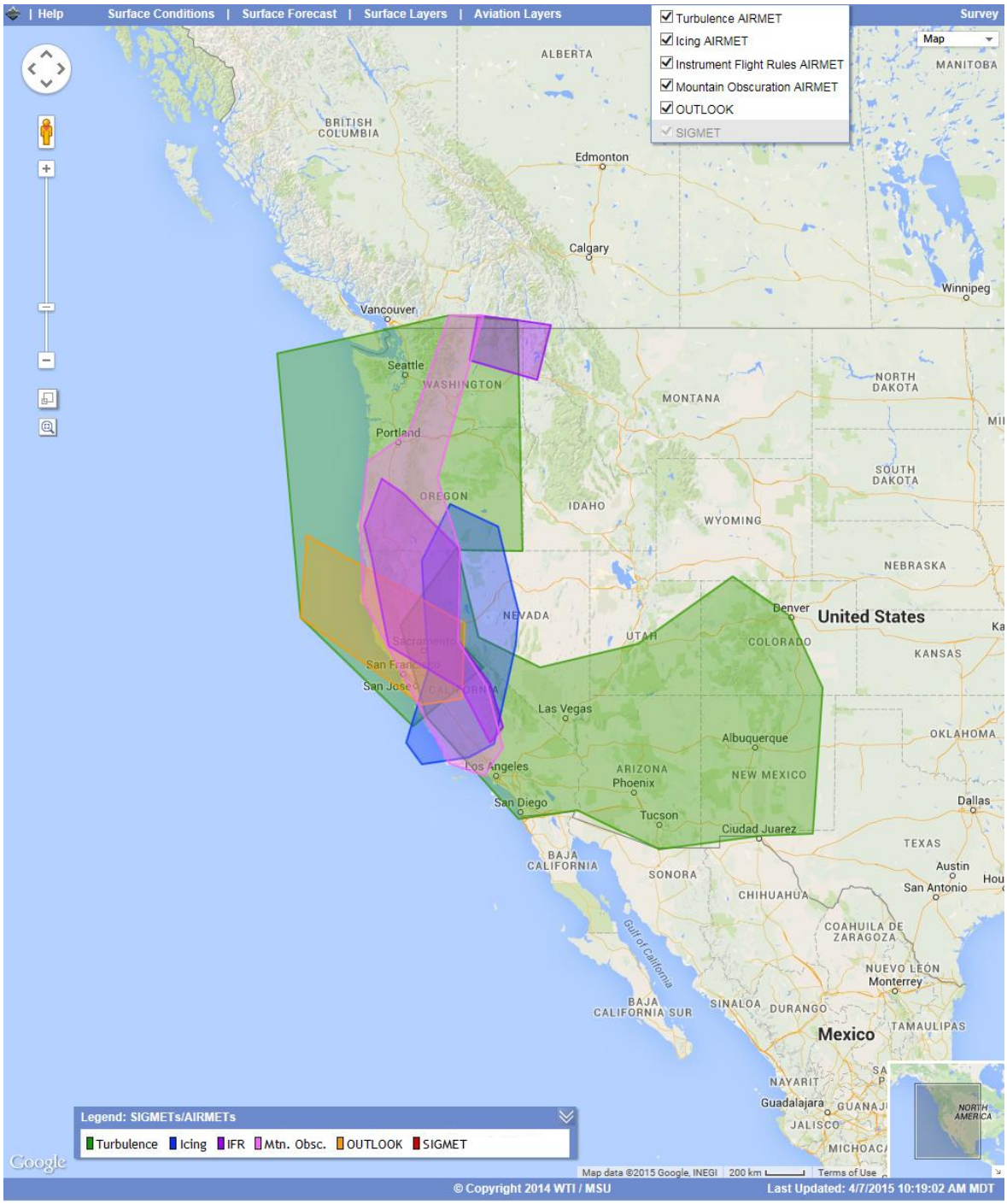

Figure 14: SIGMETs/AIRMETs Layer

[3] https://www.aviationweather.gov/sigmet/help

Users can click within regions for detail on the specific advisories. If overlapping advisories apply to the selected location, a list is presented showing the individual advisories with links for details. See Figure 15.

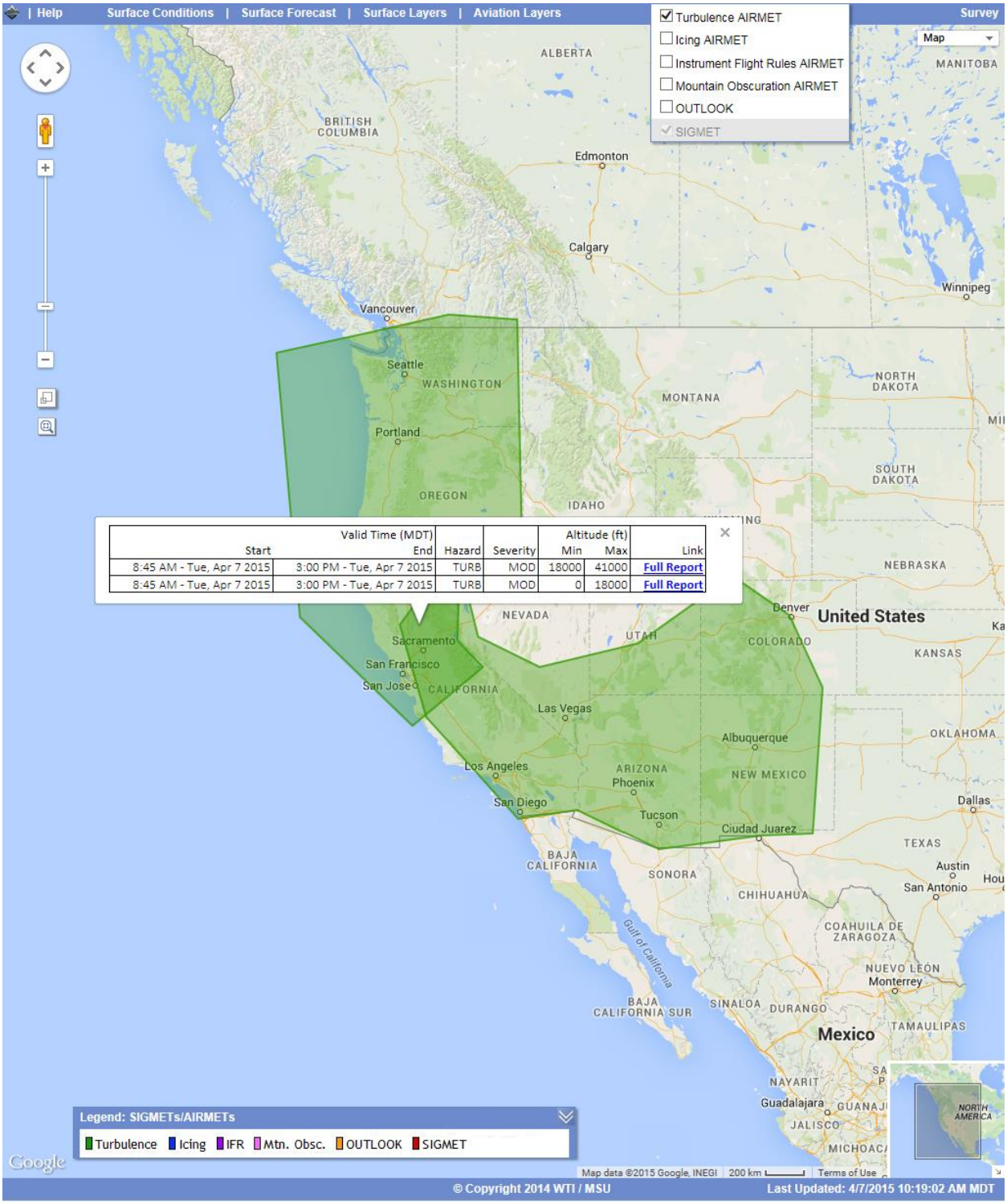

Figure 15: Overlapping AIRMETs

AIRMET warnings include start and end times as well as minimum and maximum altitudes defining the range of the warning. An indication of severity may also be included. See Figure 16, Figure 17, Figure 18, Figure 19 and Figure 20.

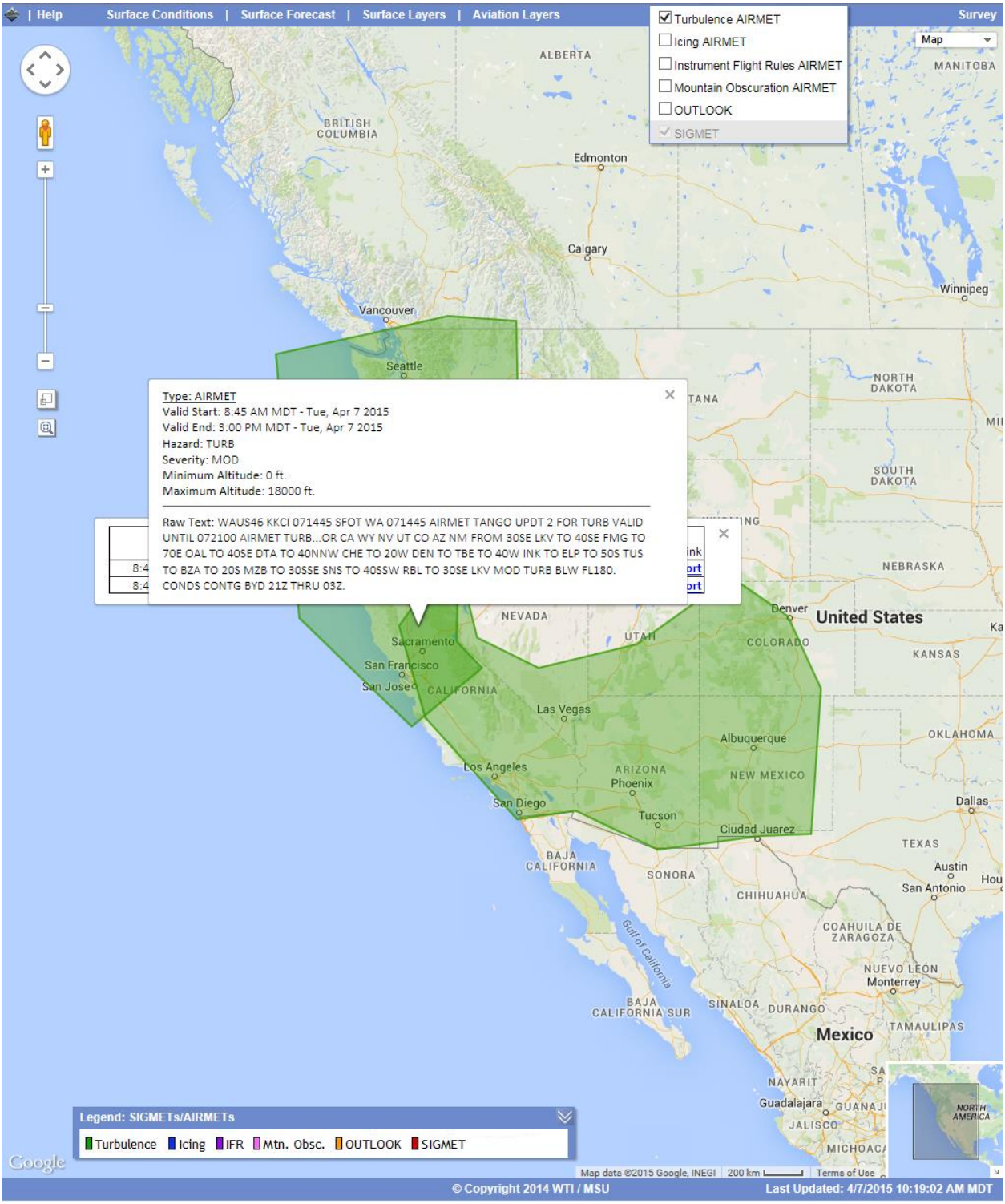

Figure 16: Turbulence AIRMET Detail

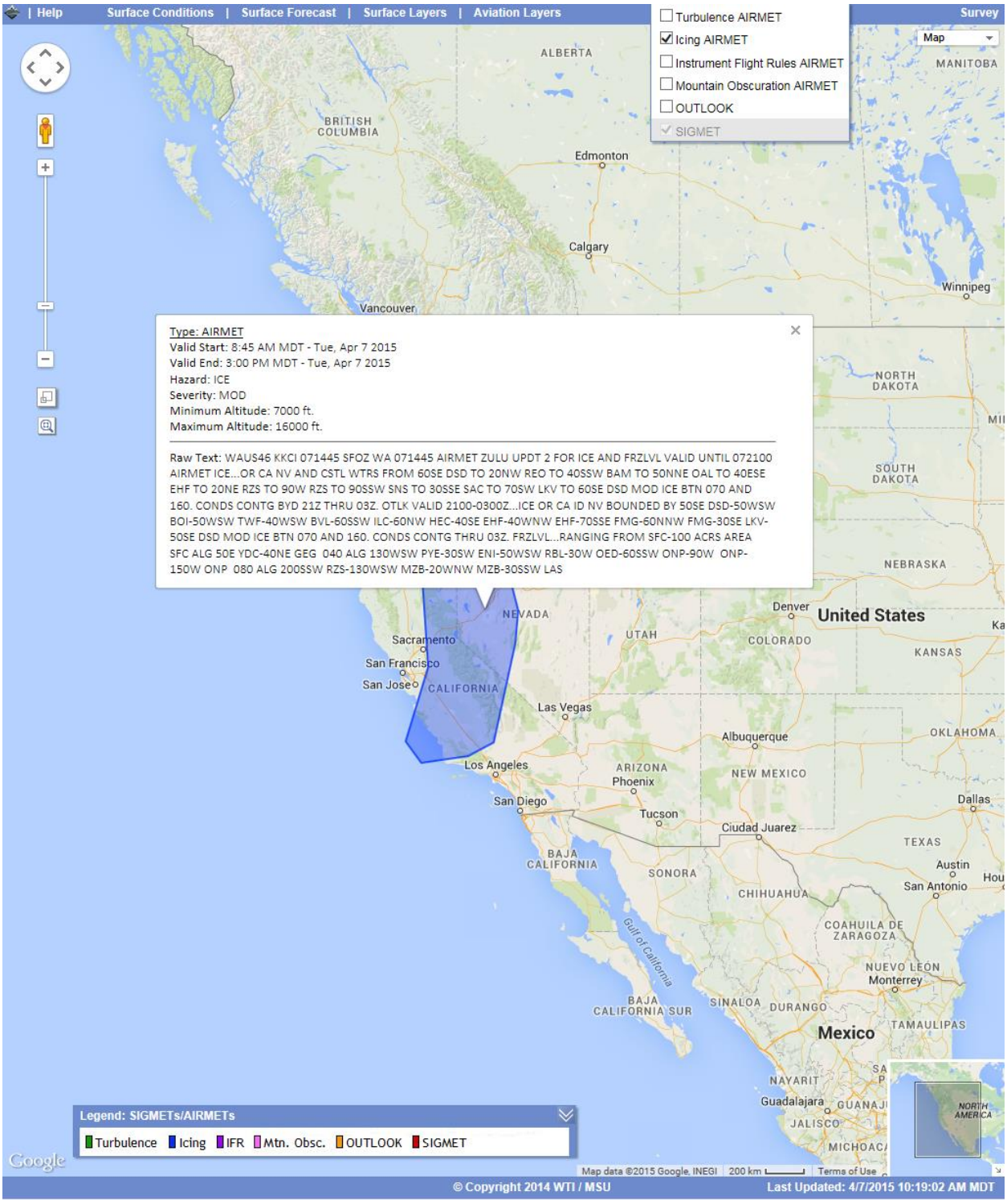

Figure 17: Icing AIRMET Detail

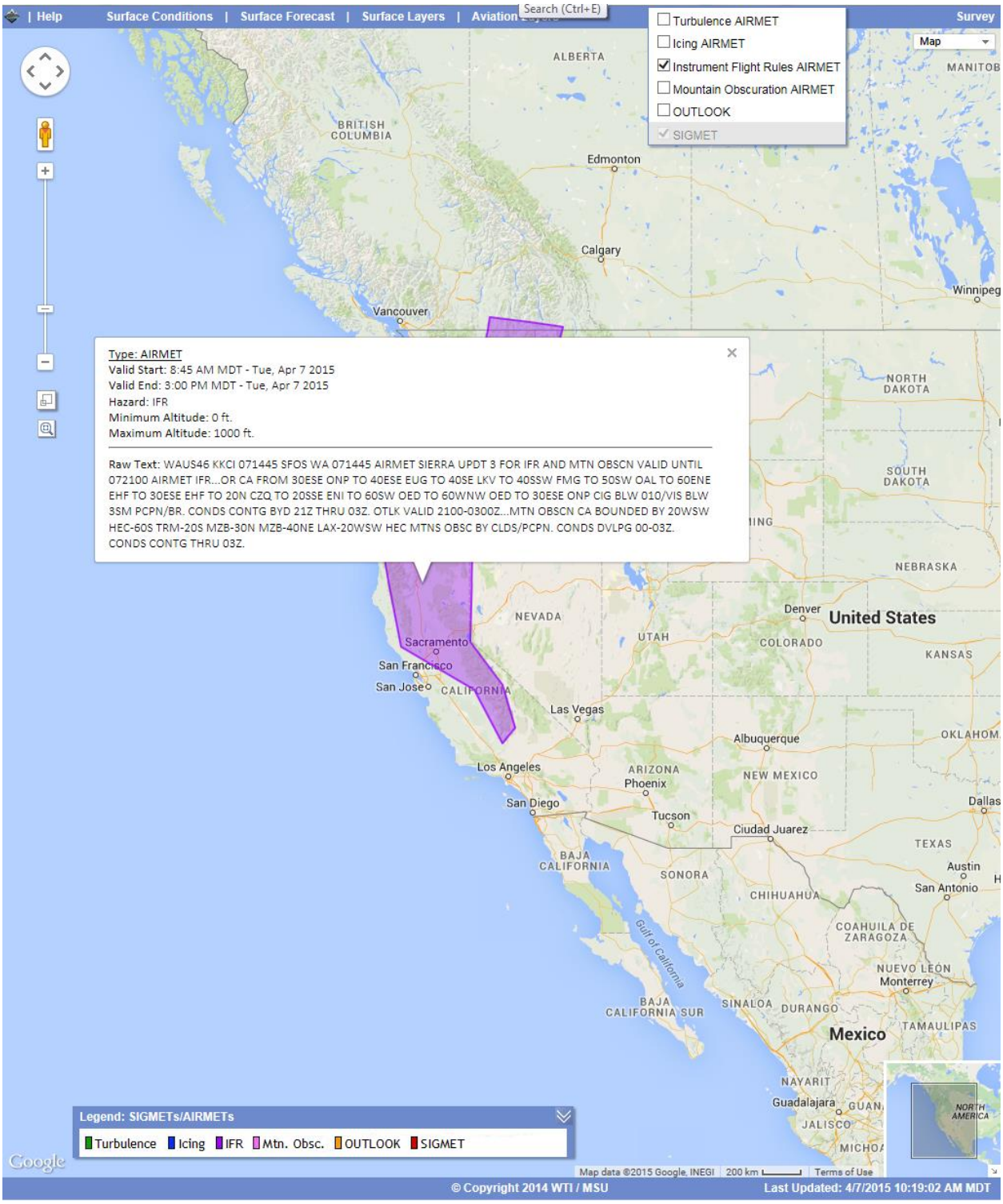

Figure 18: Instrument Flight Rules AIRMET Details

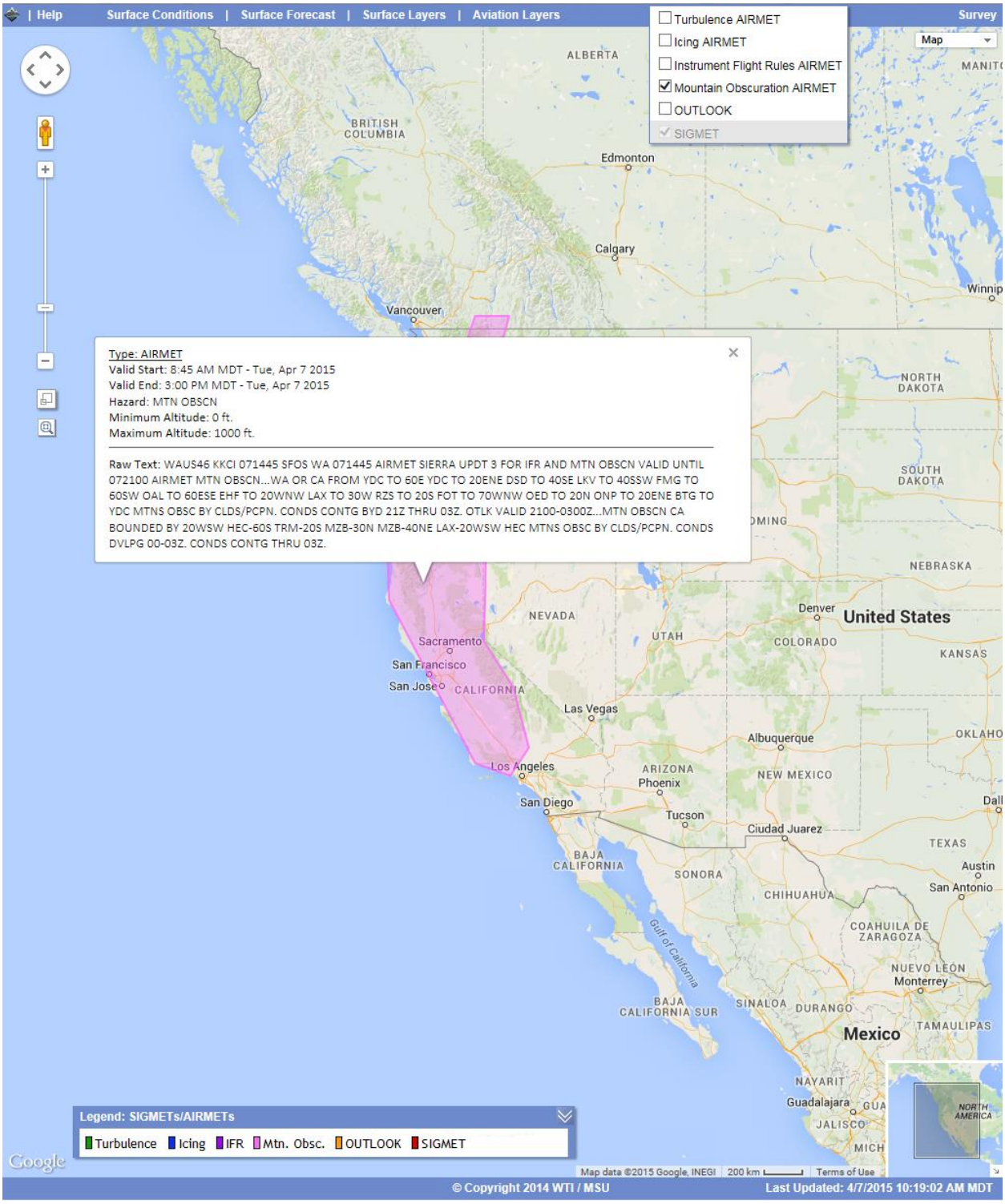

Figure 19: Mountain Obscuration AIRMET Details

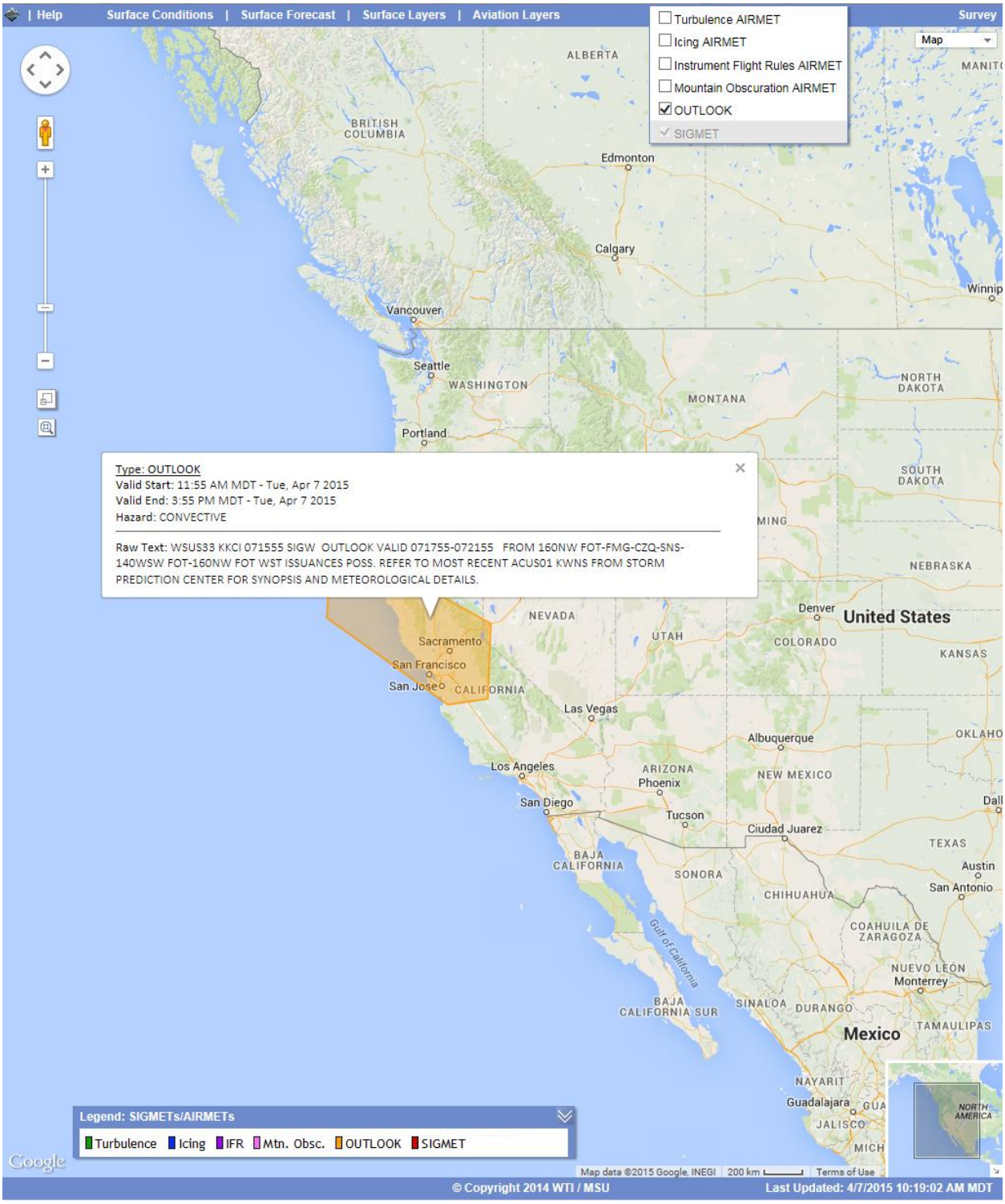

Figure 20: Convective Outlook Detail from SIGMETs/AIRMETs Layer

The NWS Composite Reflectivity layer, located in the Aviation Layers menu, shows radar imagery. See Figure 21.

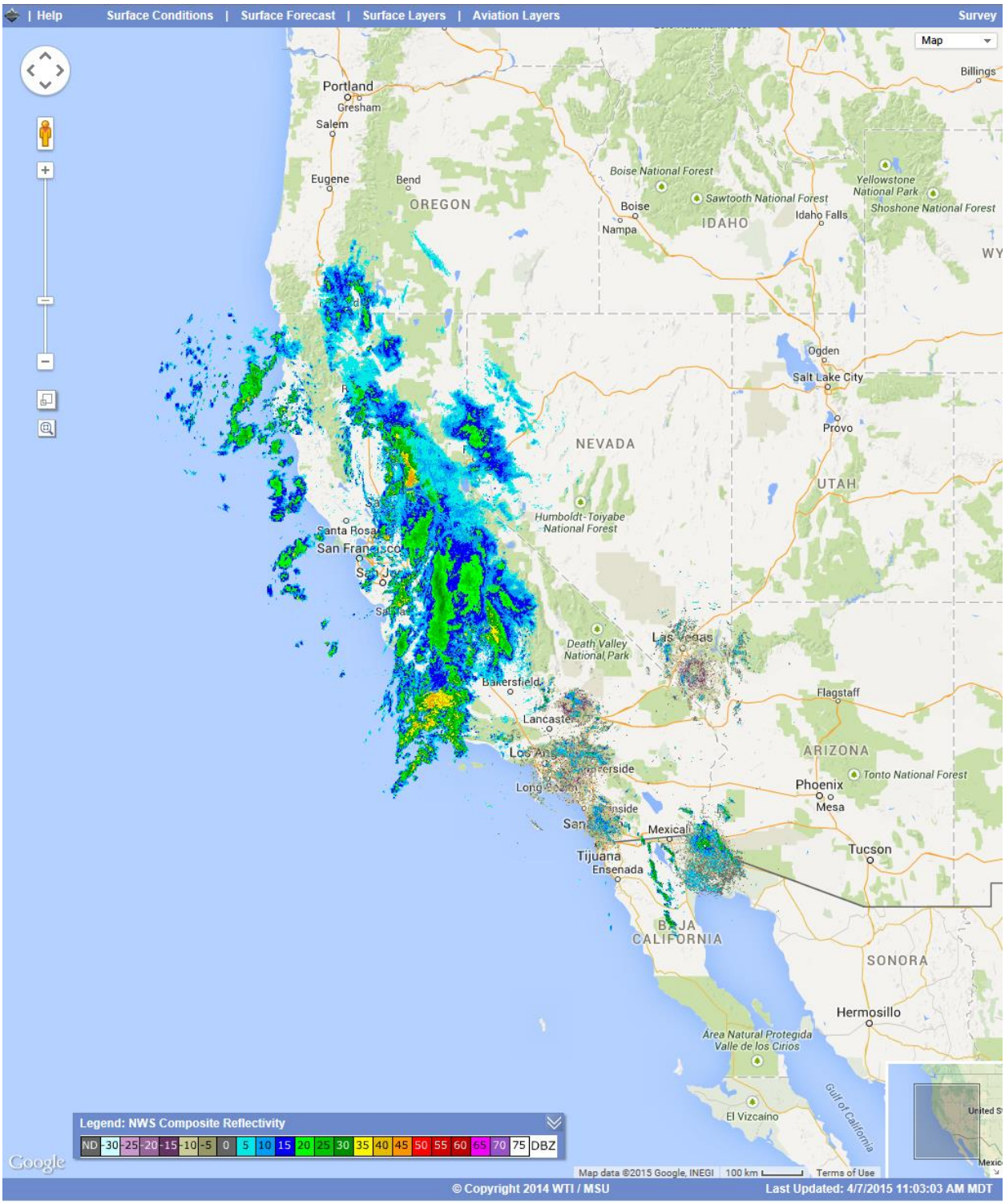

Figure 21: NWS Composite Reflectivity Layer

The NWS 1-Hour Precipitation layer, located in the Aviation Layers menu, shows precipitation amounts derived from radar. See Figure 22.

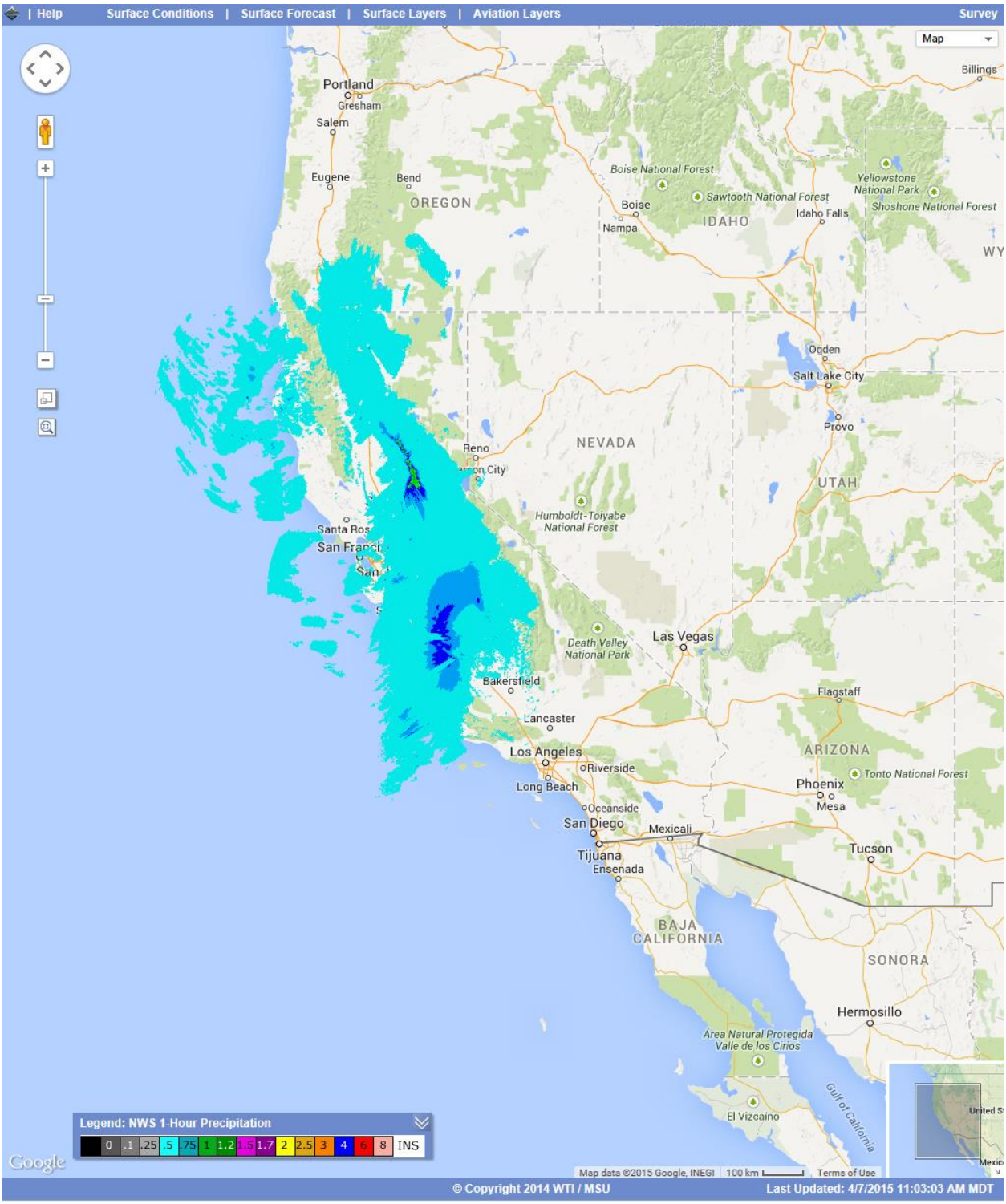

Figure 22: NWS 1-Hour Precipitation Layer

The Satellite layer, located in the Aviation Layers menu, shows satellite imagery using various image enhancement techniques. See the NOAA Office of Satellite and Product Operations[4] for further information on these image enhancement techniques. See Figure 23, Figure 24, Figure 25, Figure 26, Figure 27 and Figure 28.

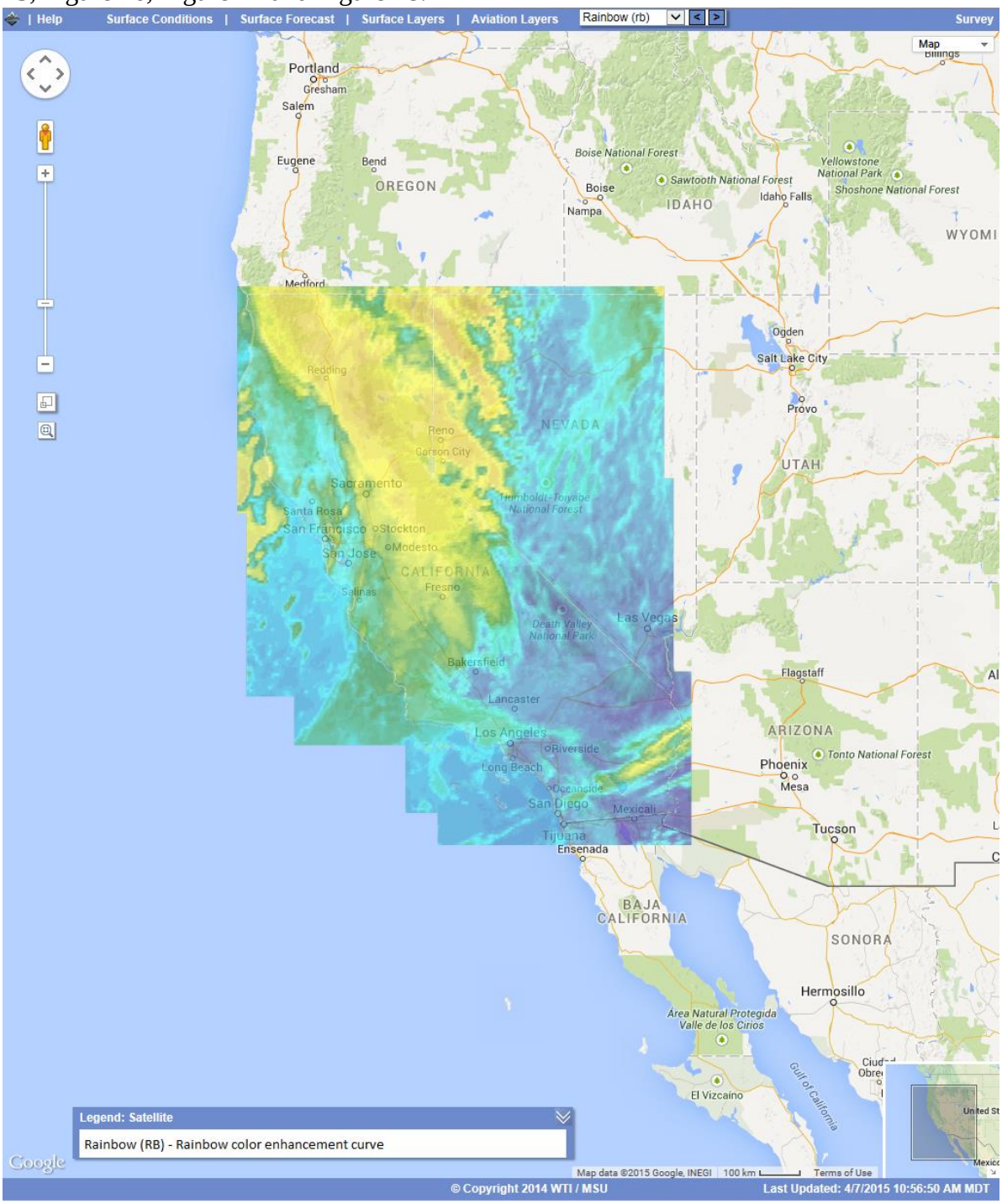

Figure 23: Satellite Rainbow (rb) Layer

[4] http://www.ospo.noaa.gov/Organization/FAQ/enhancements.html

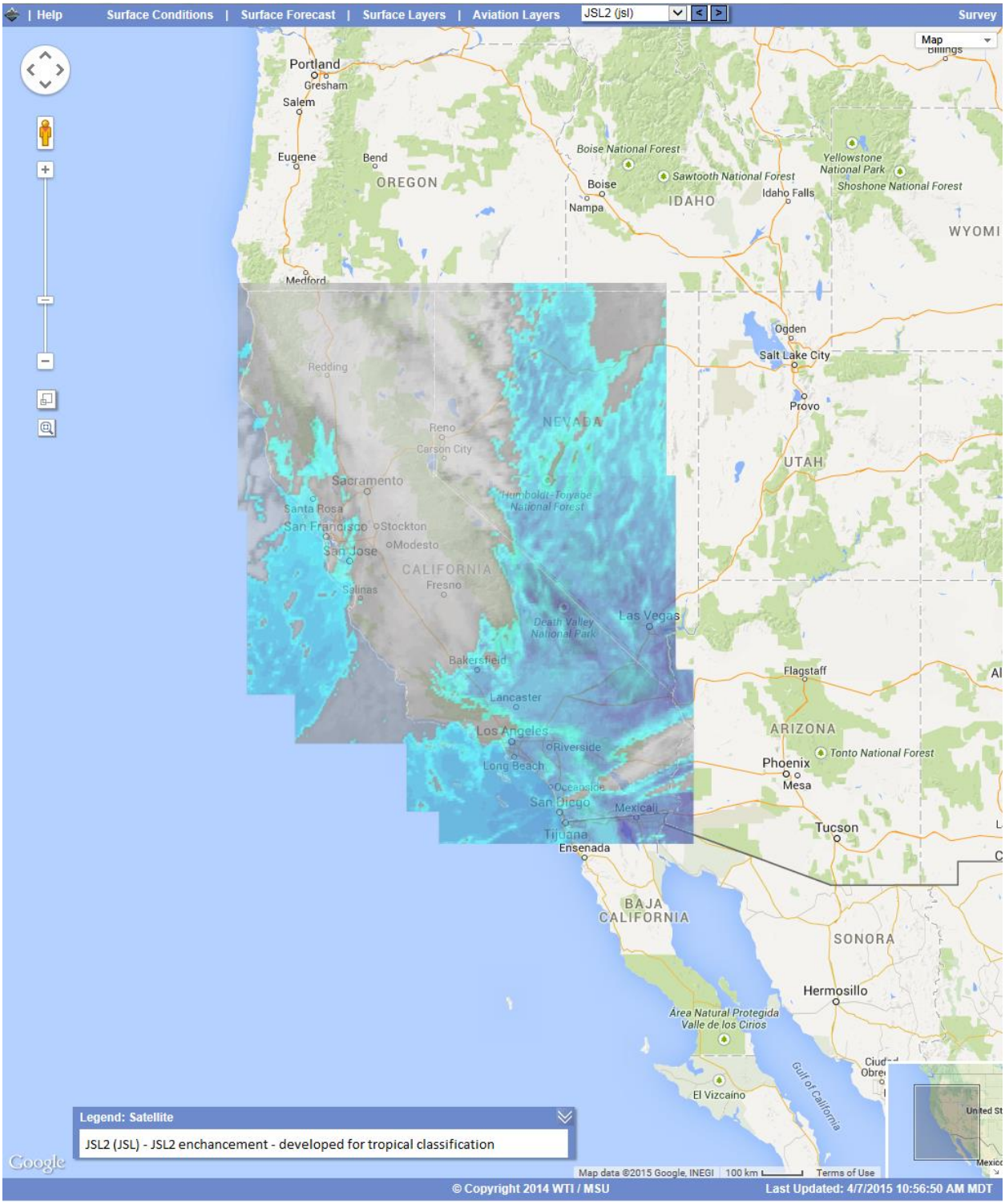

Figure 24: Satellite JSL2 (JSL) Layer

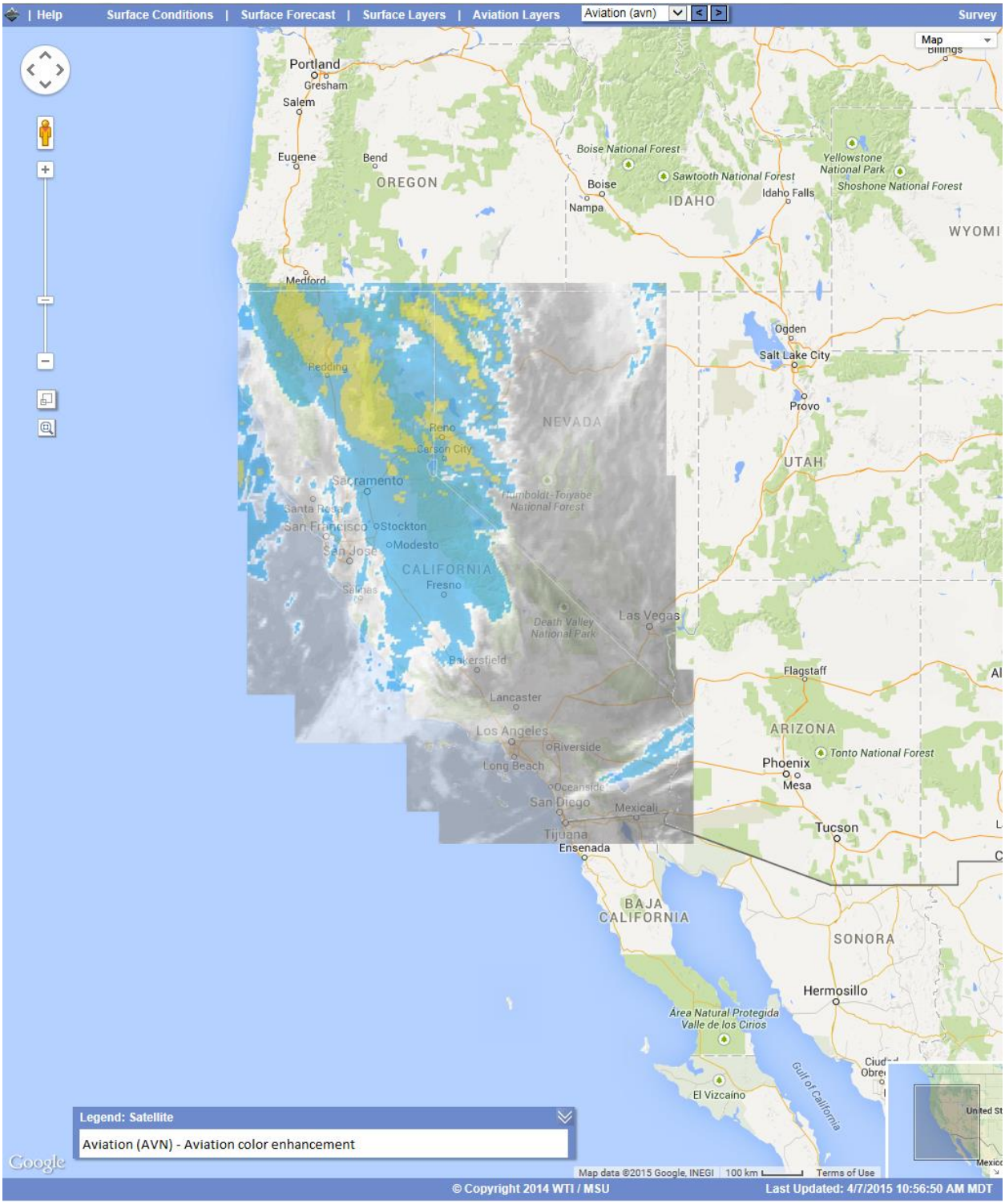

Figure 25: Satellite Aviation (AVN) Layer

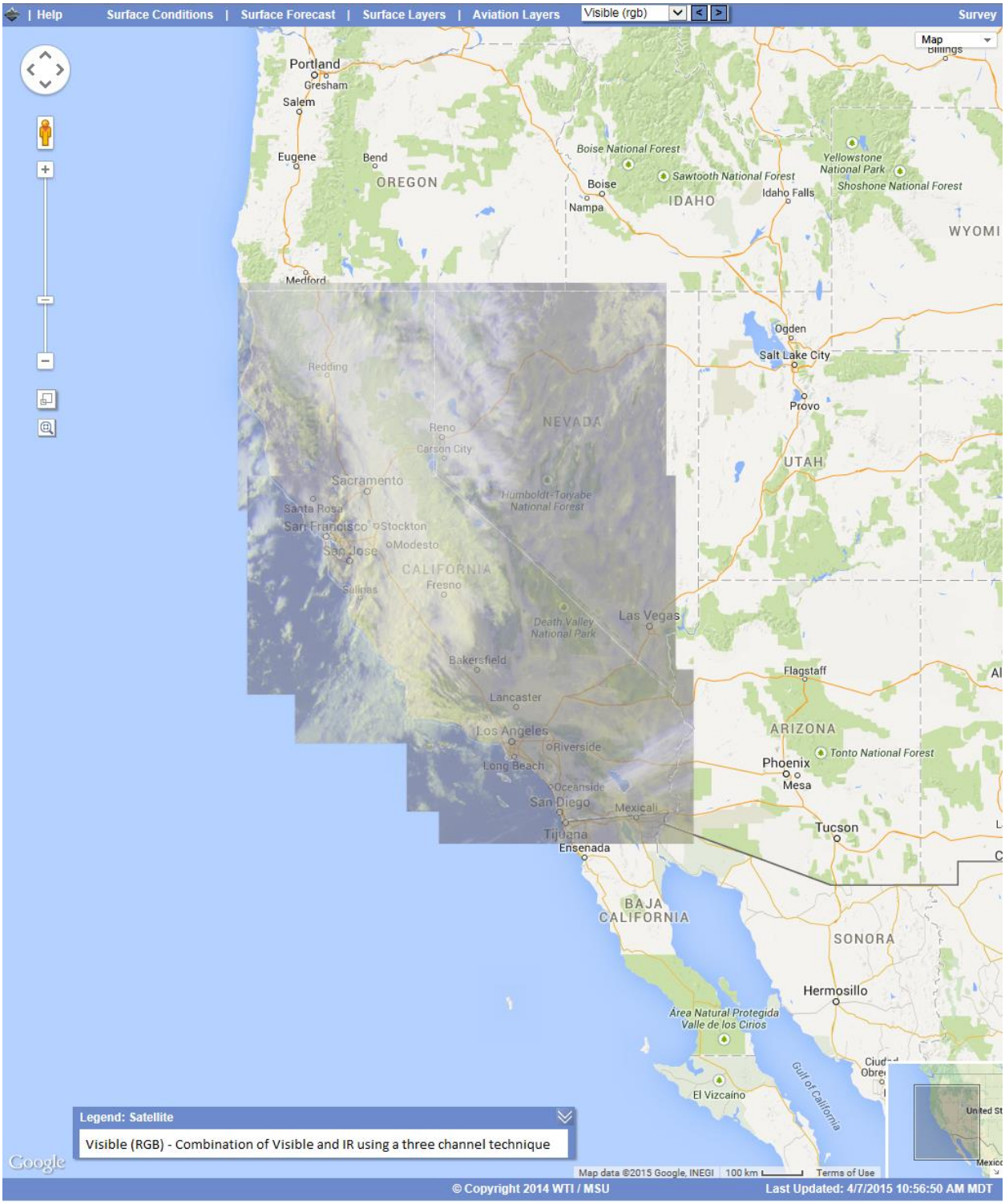

Figure 26: Satellite Visible (RGB) Layer

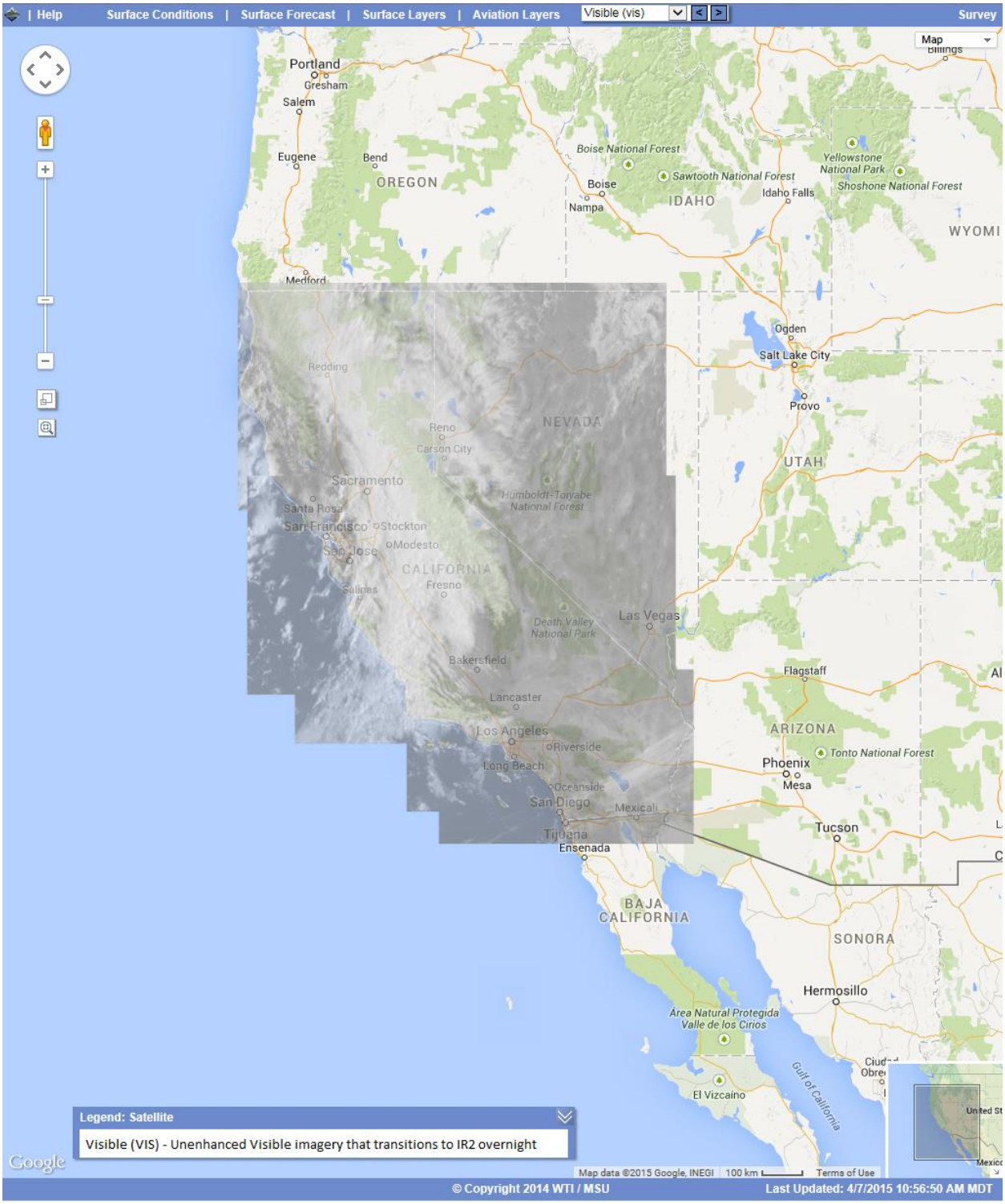

Figure 27: Satellite Visible (VIS) Layer

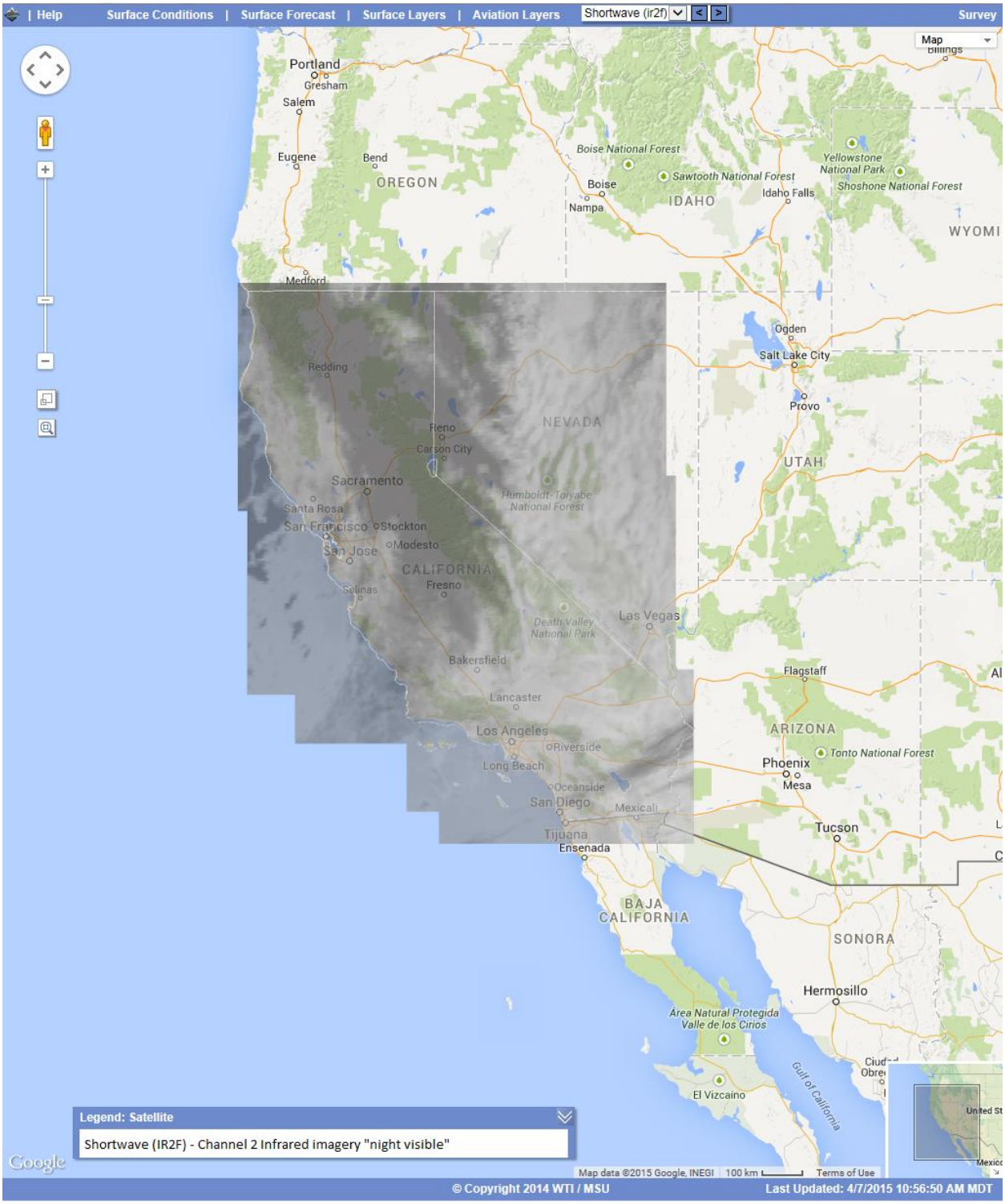

Figure 28: Satellite Shortwave (IR2F) Layer

The Wind Aloft layer, located in the Aviation Layers menu, shows forecast wind speeds aloft. Sublayers show predictions at 3000 ft. Above Mean Sea Level (AMSL), 6000 ft. AMSL, 9000 ft. AMSL, 12000 ft. AMSL and 15000 ft. AMSL and at 1-hour intervals covering approximately 24 hours. Colored arrows indicate the magnitude and direction of forecast winds. A raster image is also shown covering the state and indicating forecast wind speeds. See Figure 29, Figure 30, Figure 31, Figure 32, Figure 33 and Figure 34

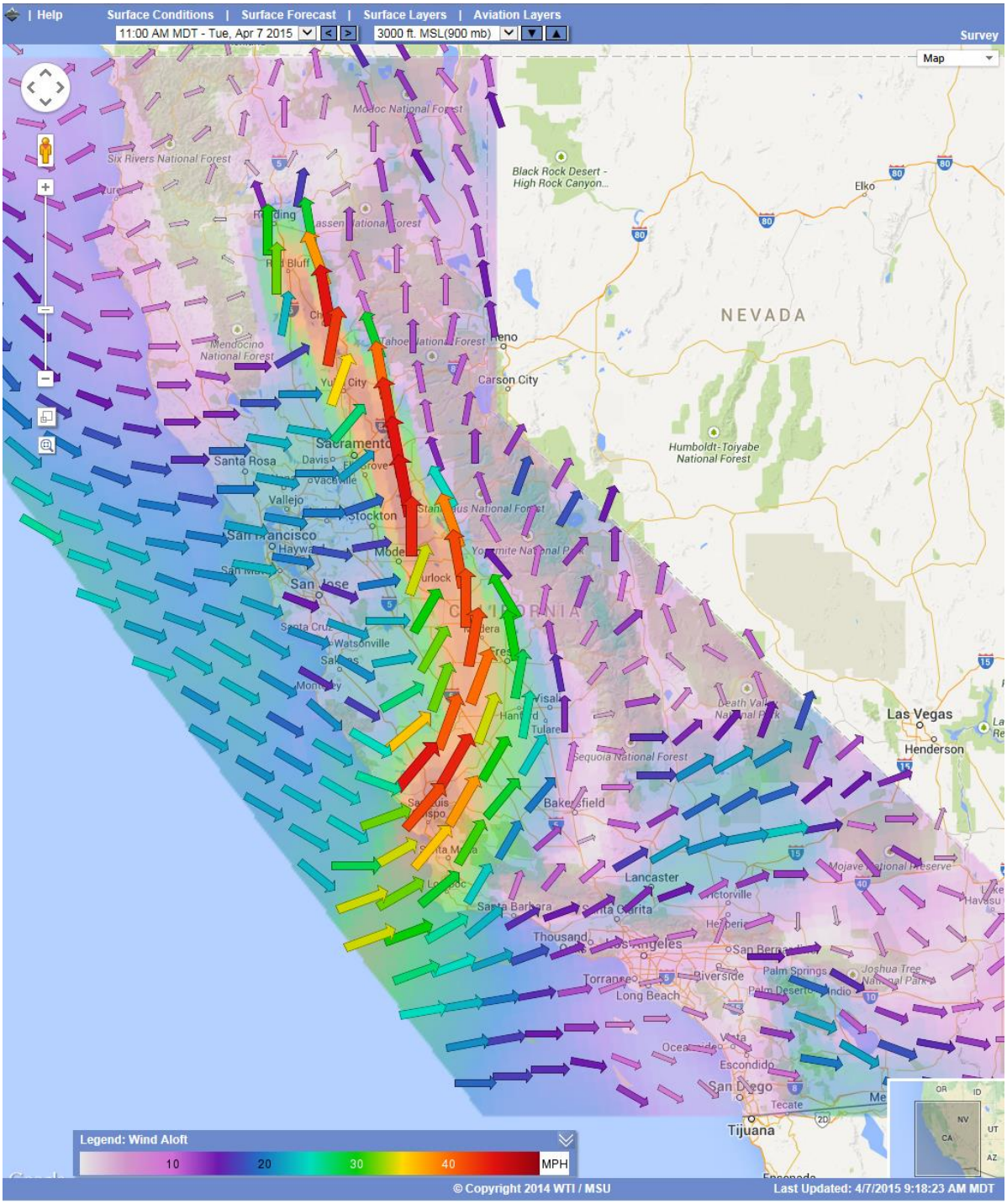

Figure 29: Wind Aloft Layer 3000 ft. AMSL

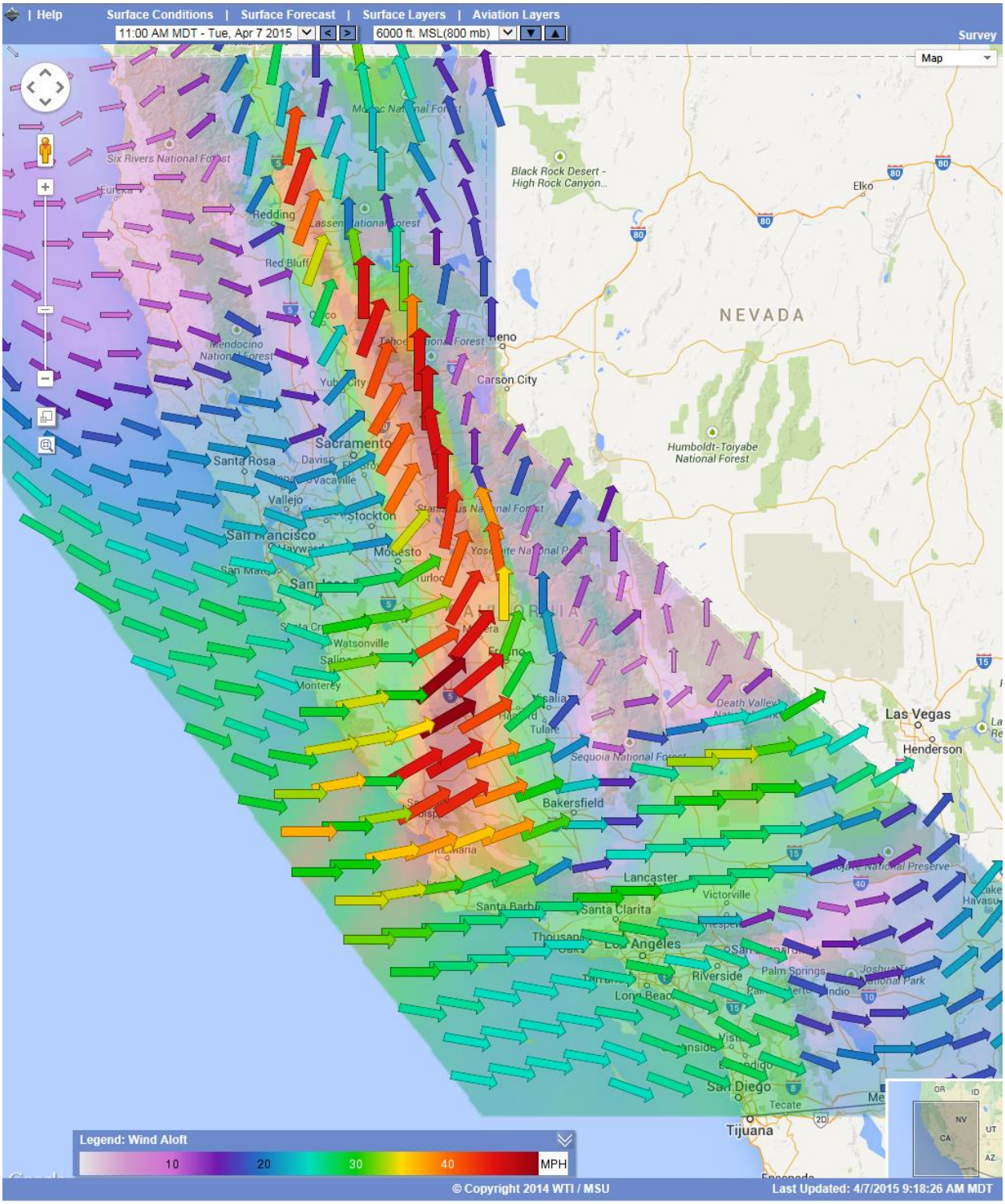

Figure 30: Wind Aloft Layer 6000 ft. AMSL

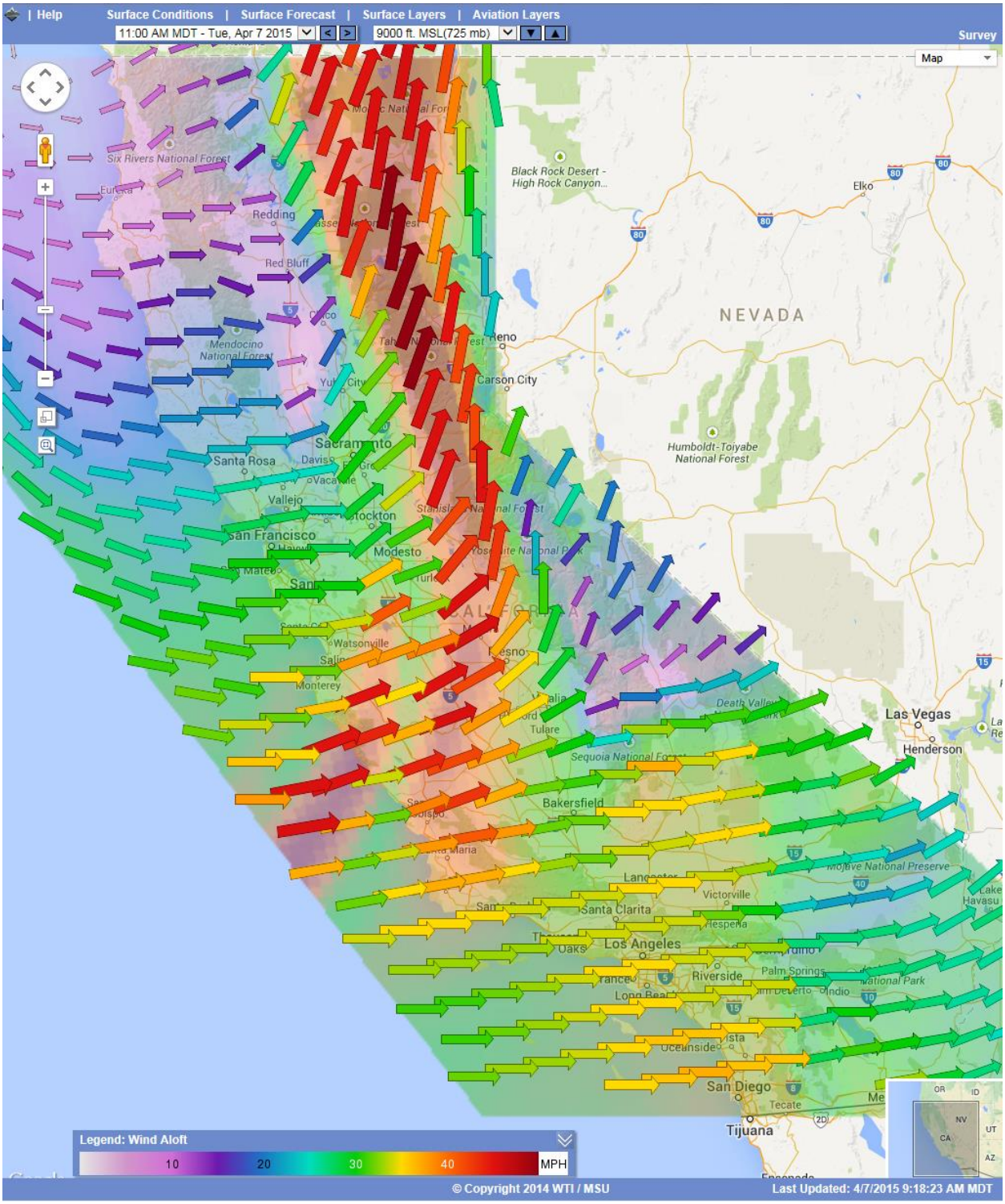

Figure 31: Wind Aloft Layer 9000 ft. AMSL

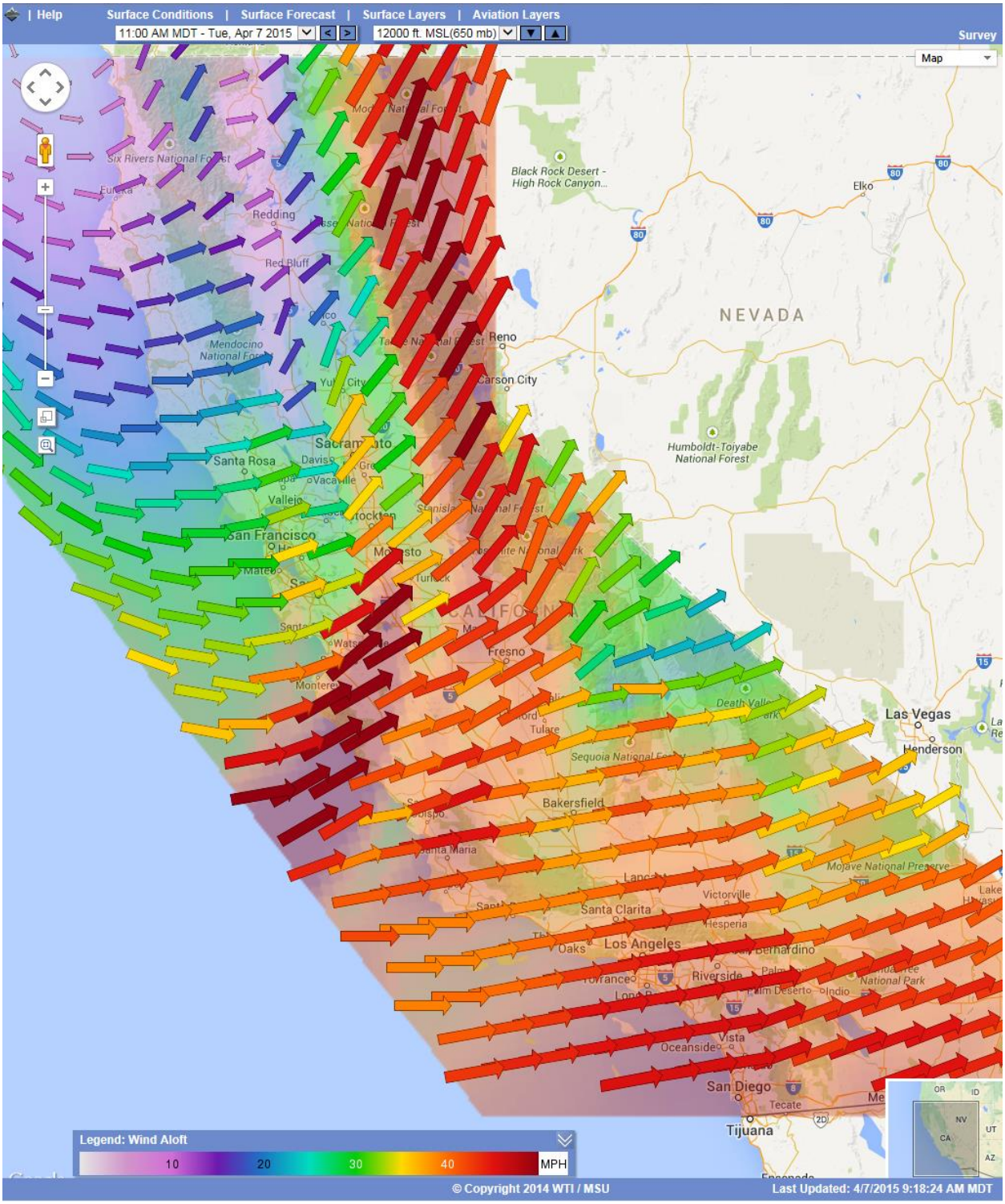

Figure 32: Wind Aloft Layer 12000 ft. AMSL

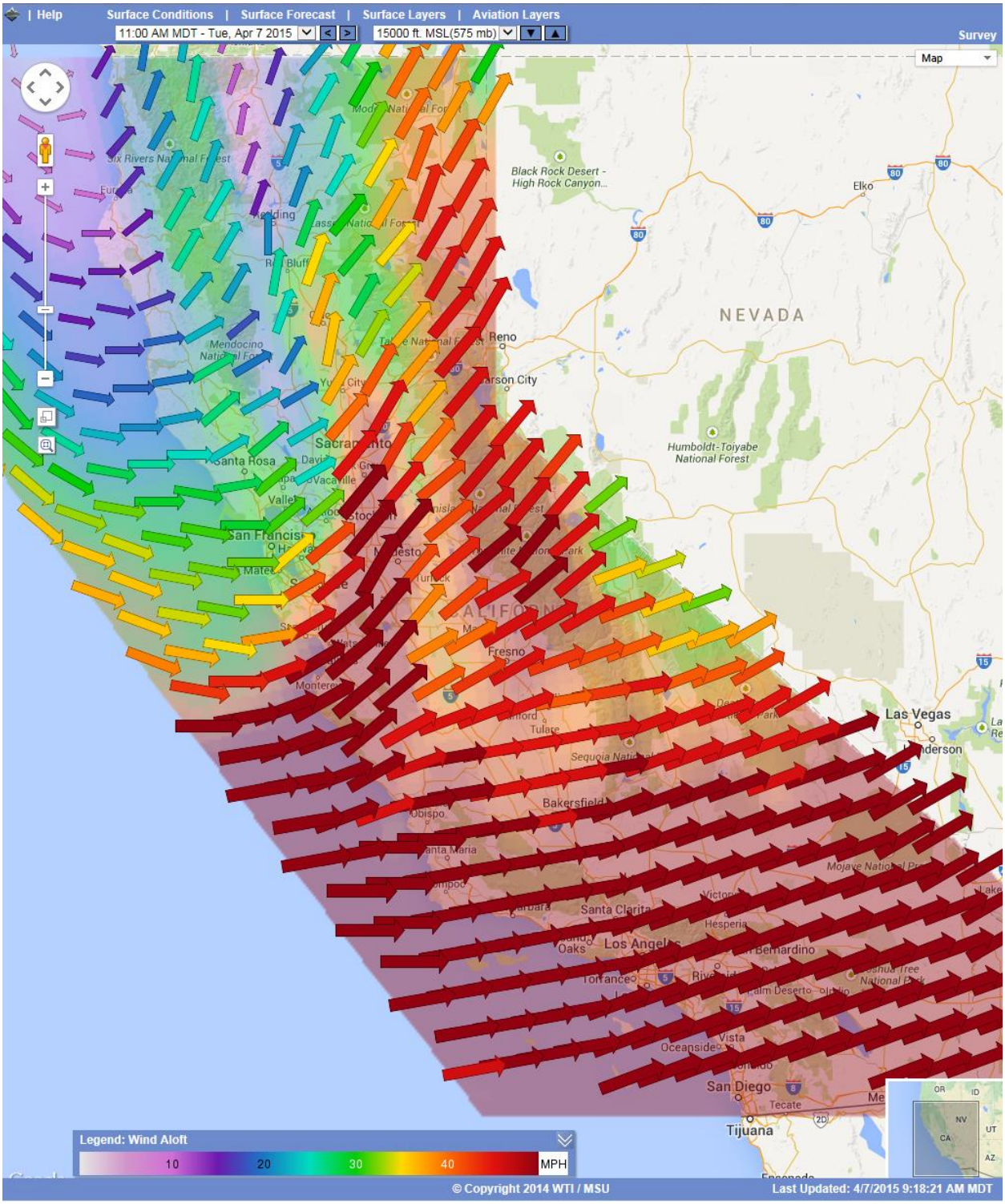

Figure 33: Wind Aloft Layer 15000 ft. AMSL

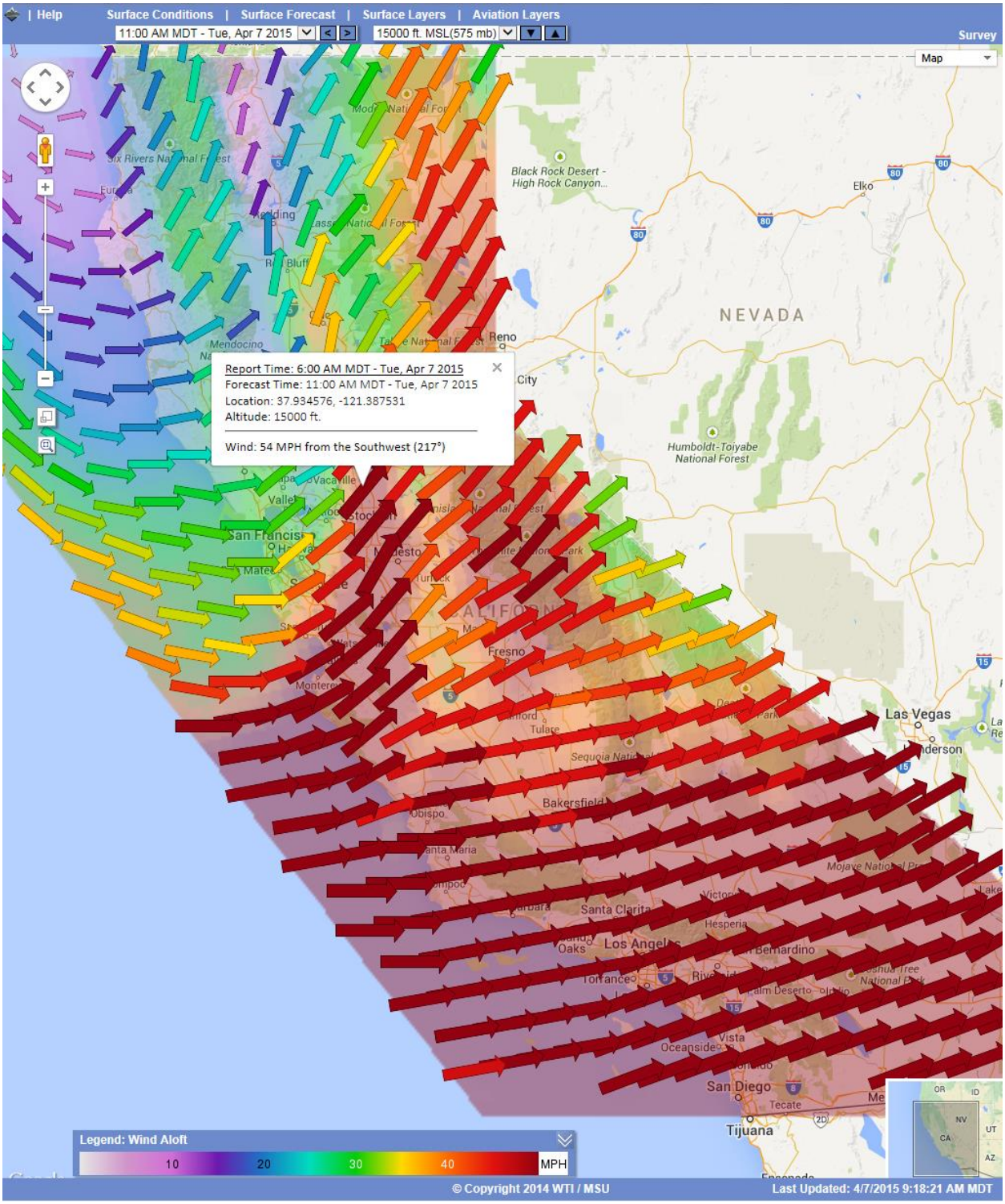

Figure 34: Wind Aloft Layer Details

The Temperature aloft layer, located in the Aviation Layers menu, shows forecast air temperatures aloft. Sublayers show predictions at 3000 ft. AMSL, 6000 ft. AMSL, 9000 ft. AMSL, 12000 ft. AMSL and 15000 ft. AMSL and at 1-hour intervals covering approximately 24 hours. Colored, labeled circles indicate the forecast temperatures. A raster image is also shown covering the state and indicating forecast temperatures. See Figure 35.

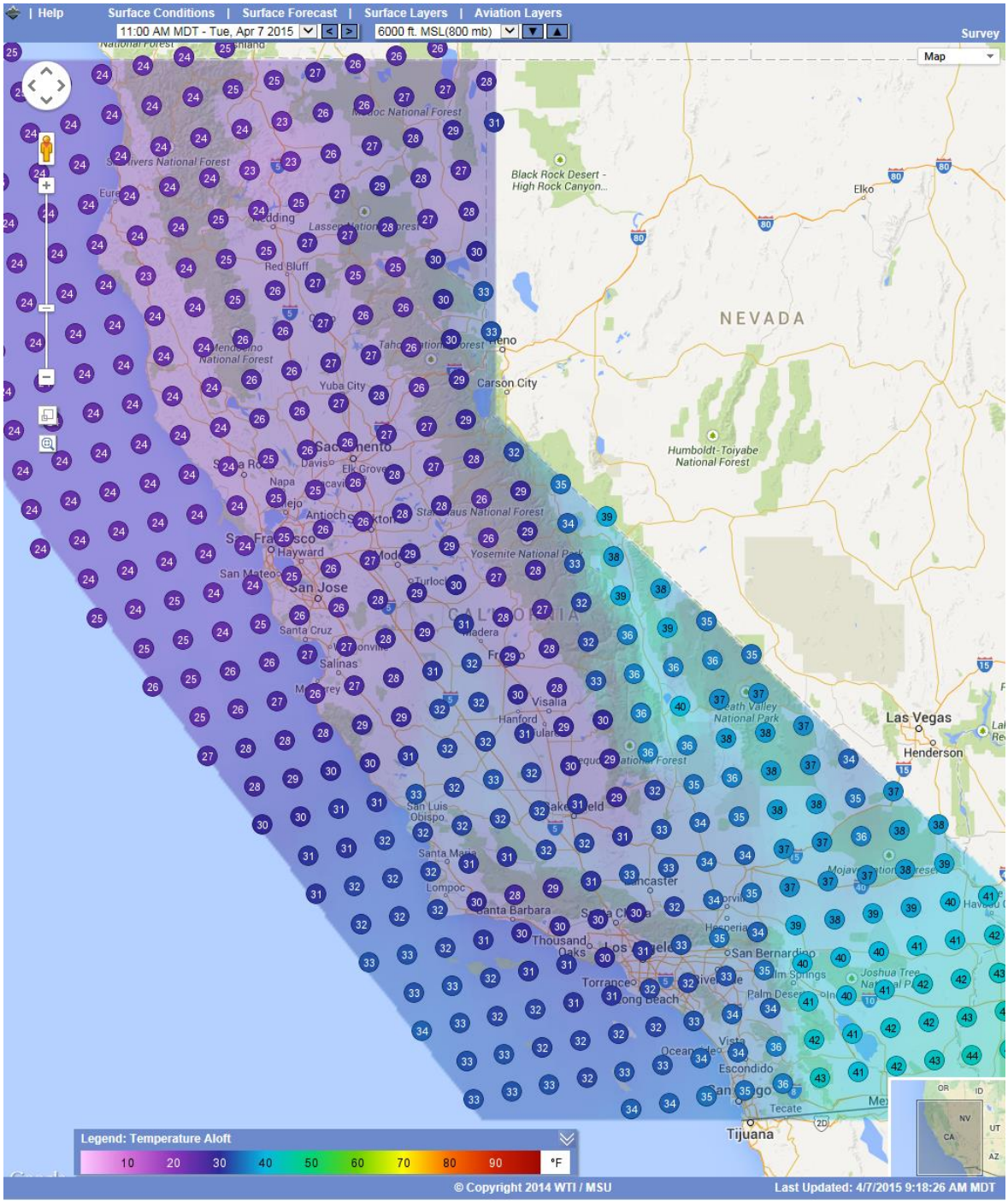

Figure 35: Temperature Aloft Layer 6000 ft. AMSL

The NWS Alert layer, found in the Surface Layers menu, shows current surface weather alerts and warnings. See Figure 36.

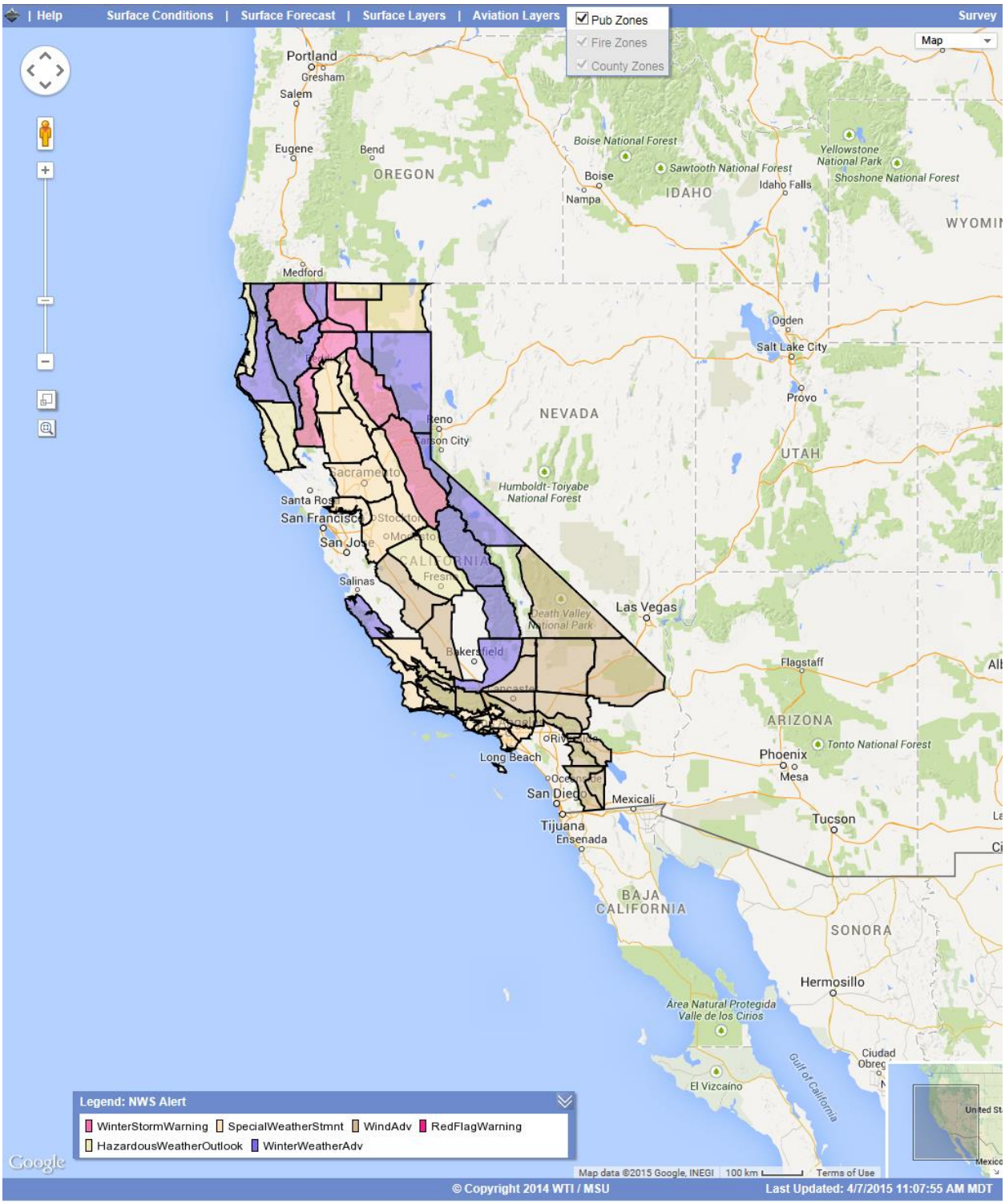

Figure 36: NWS Alerts Layer

Users can view alert detail by clicking on the polygon corresponding to the alert. If alerts overlap, the top-most alert detail will be shown. Users can toggle between Public Forecast (Pub) Zones, Fire Zones and County Zones, where available, to view separate alerts. Alerts include but are not limited to Winter Storm Warnings, Winter Weather Advisories and Wind Advisories. See Figure 37, Figure 38 and Figure 39.

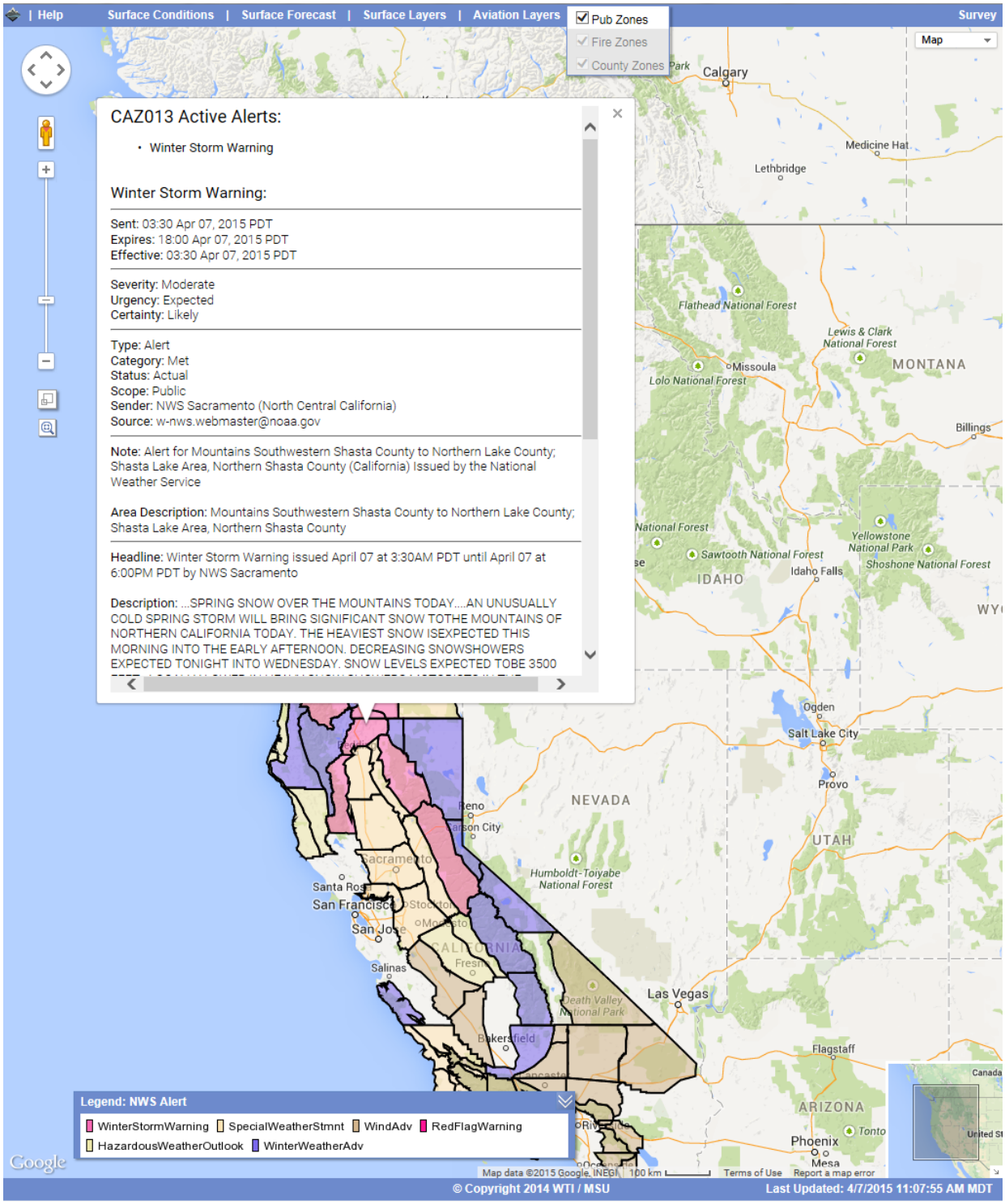

Figure 37: NWS Alerts - Winter Storm Warning

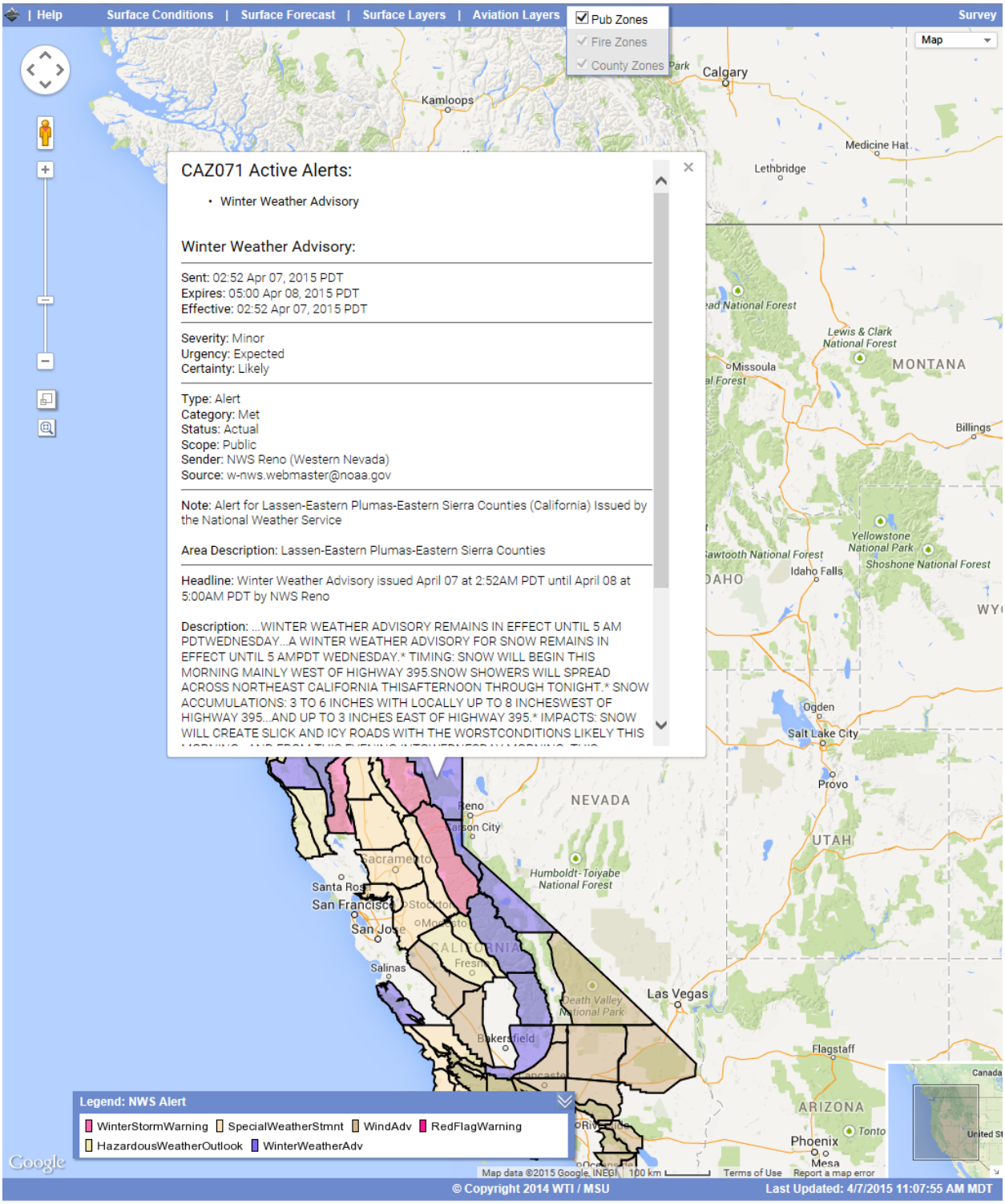

Figure 38: NWS Alerts - Winter Weather Advisory

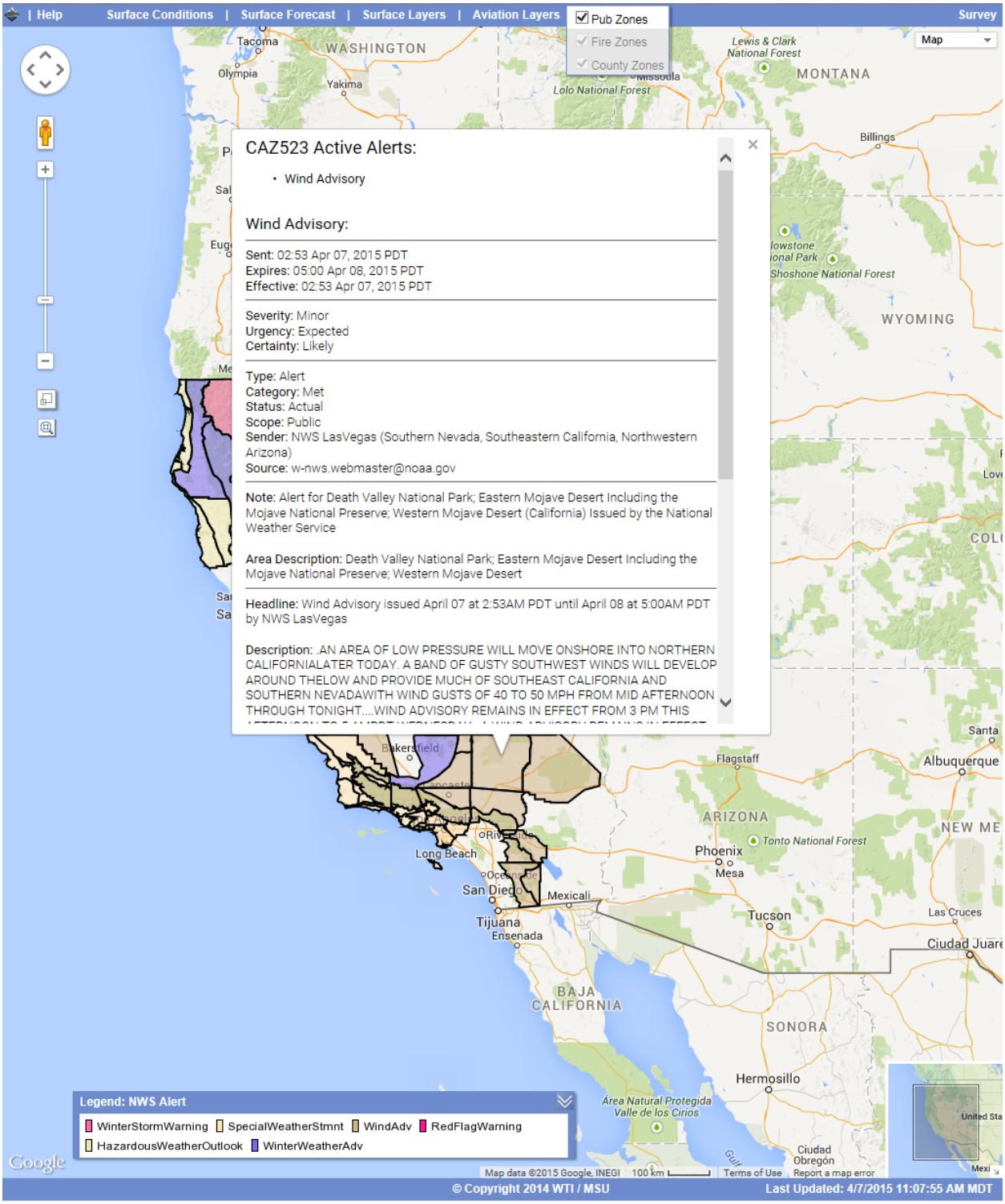

Figure 39: NWS Alerts - Wind Advisory

The Caltrans CCTV layer, found in the Surface Layers menu, shows Caltrans CCTV sites. To view camera images, click on the corresponding markers. See Figure 40.

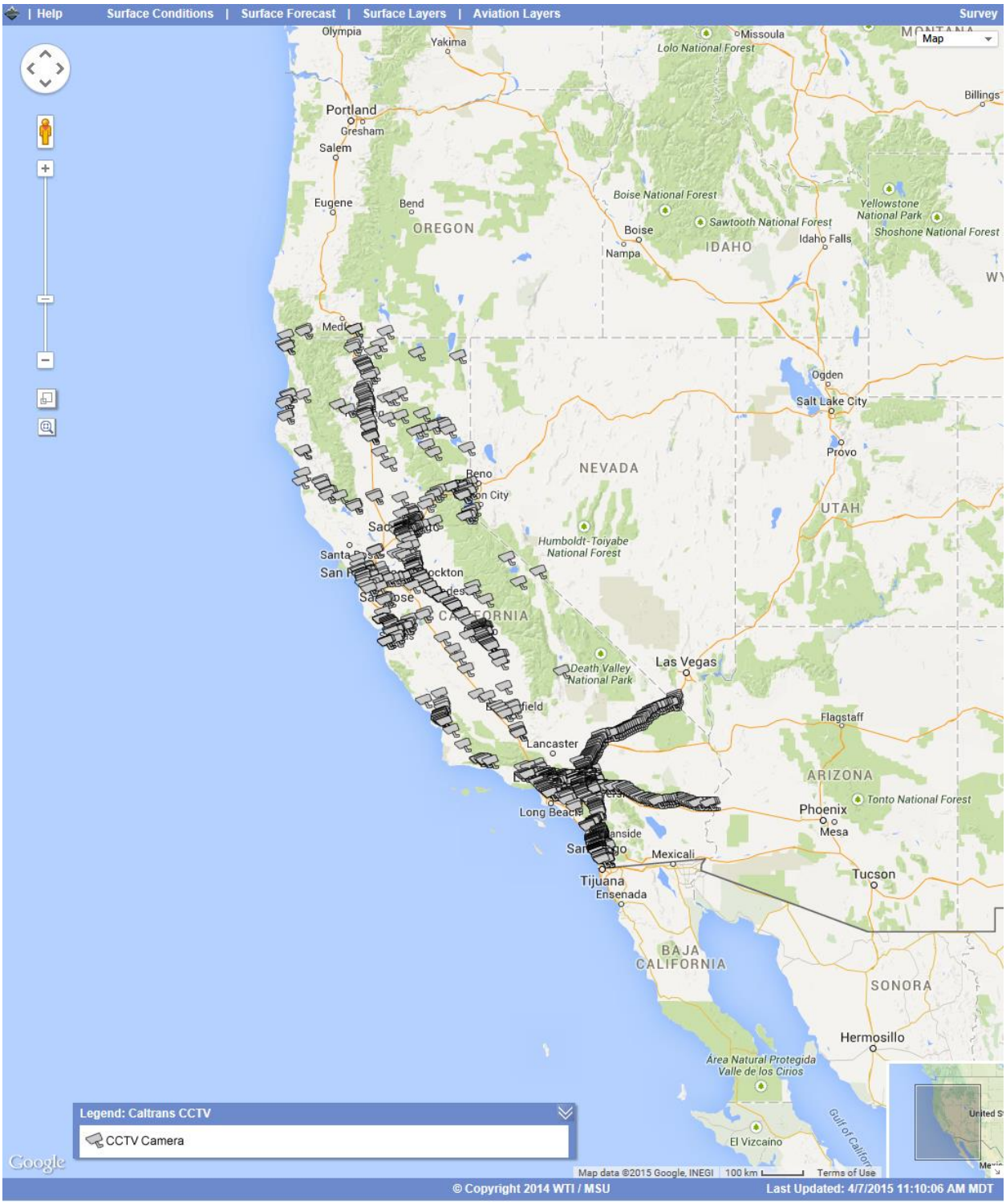

Figure 40: Caltrans CCTV Layer

Even though the Caltrans CCTVs are pointed at the roadway, the images they produce provide a great deal of relevant information, particularly during weather events. See Figure 41 and Figure 42.

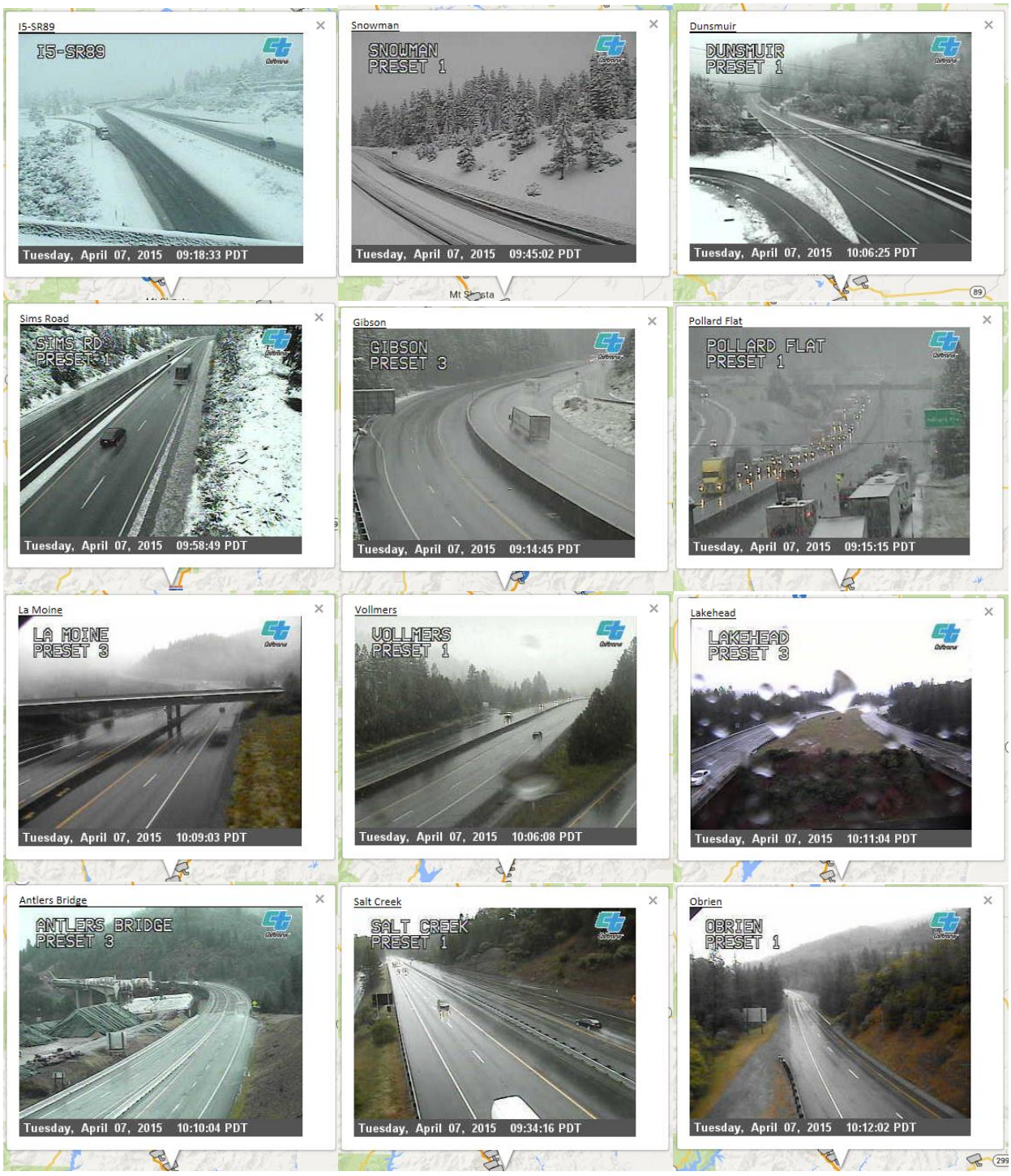

Figure 41: Caltrans CCTV Images

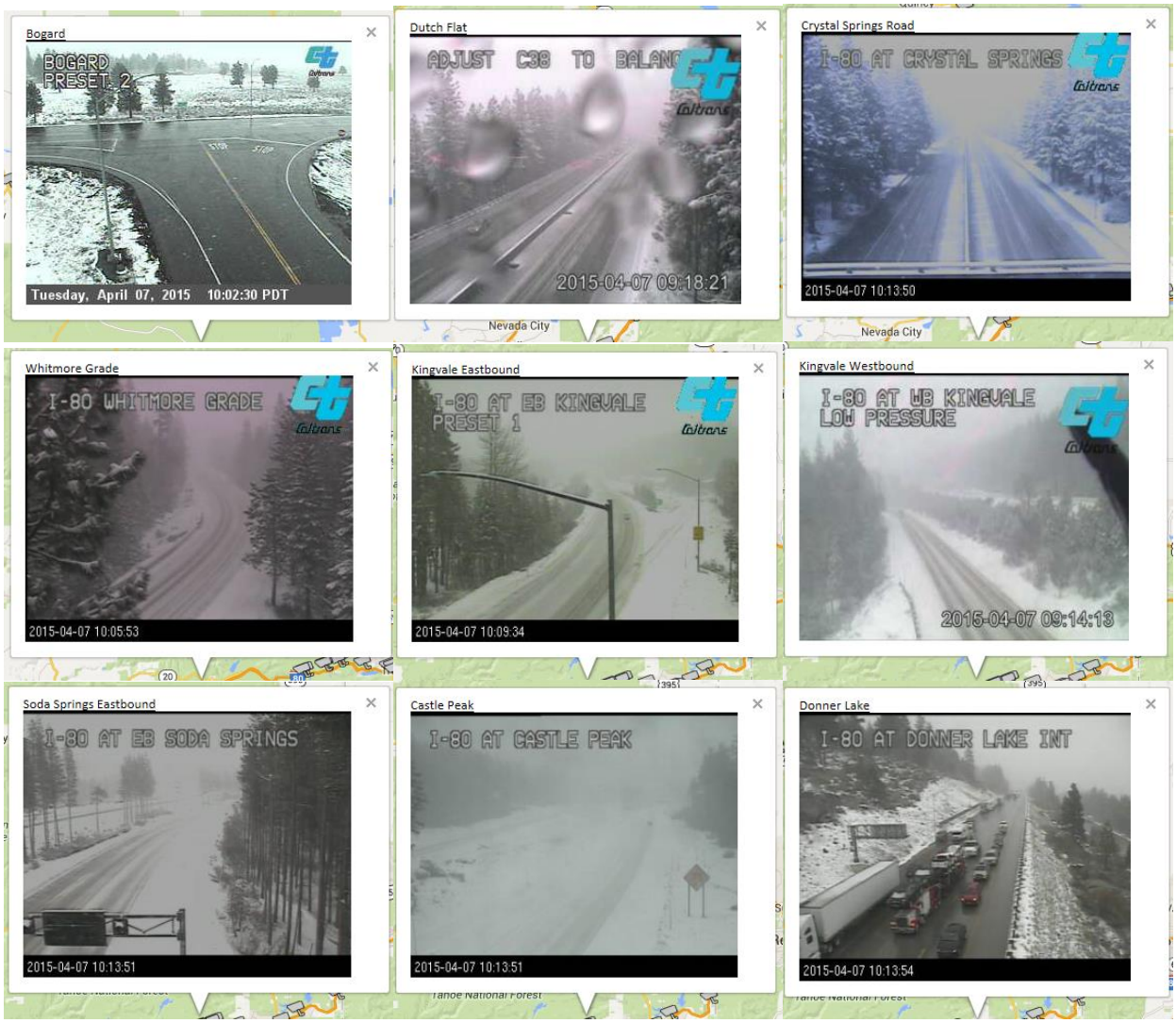

Figure 42: More Caltrans CCTV Images

The Forecast Air Temperature layer, found in the Surface Forecast Layers menu, shows forecast air temperatures for up to three days from present. Colored, labeled circles indicate the forecast temperatures. A raster image is also shown covering the state and indicating forecast temperatures. See Figure 43.

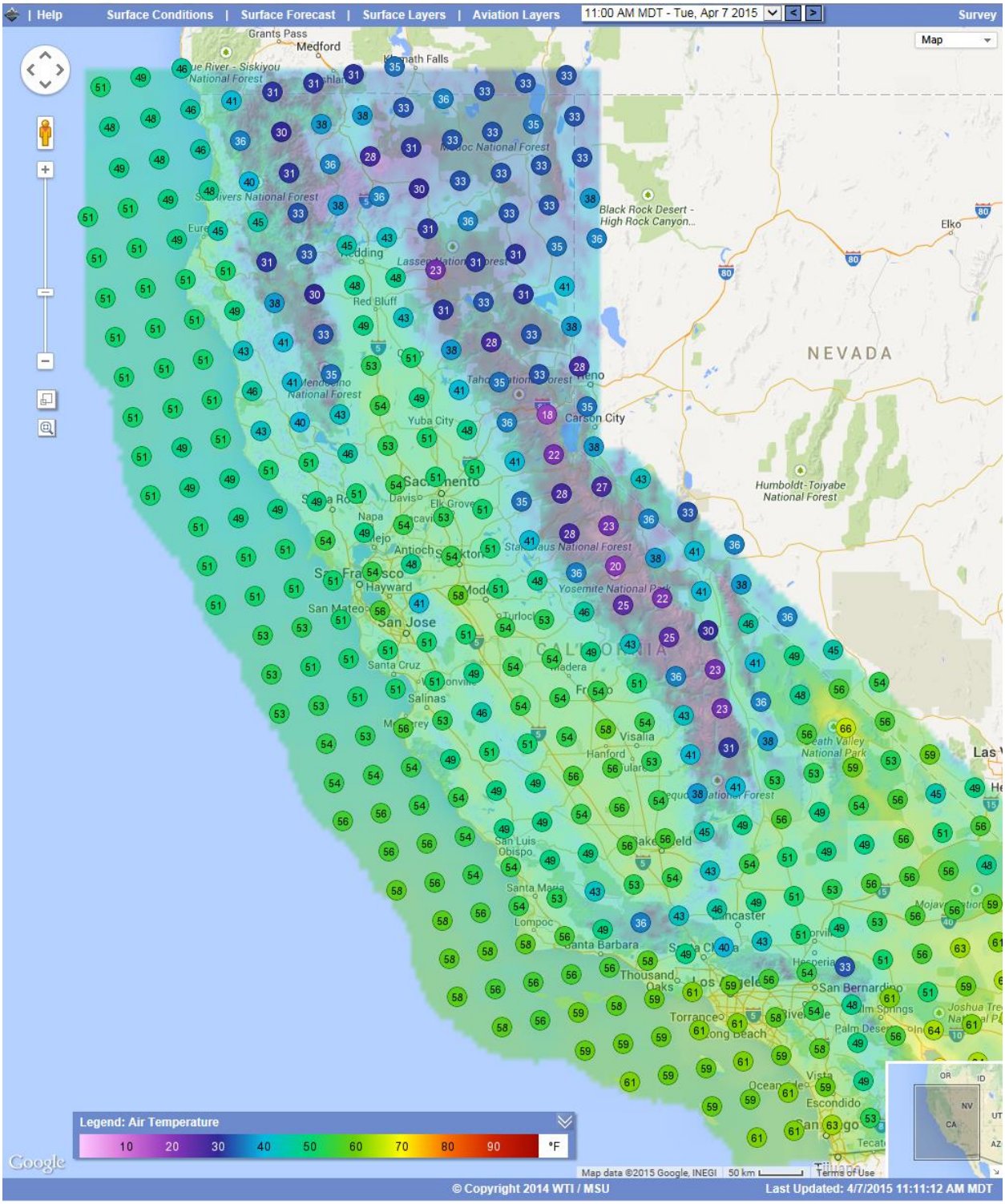

Figure 43: Forecast Air Temperature Layer

The Forecast Wind Speed layer, found in the Surface Forecast Layers menu, shows forecast wind speed and direction for up to three days from present. Colored arrows indicate the forecast wind speed and direction. A raster image is also shown covering the state and indicating forecast wind speeds. See Figure 44.

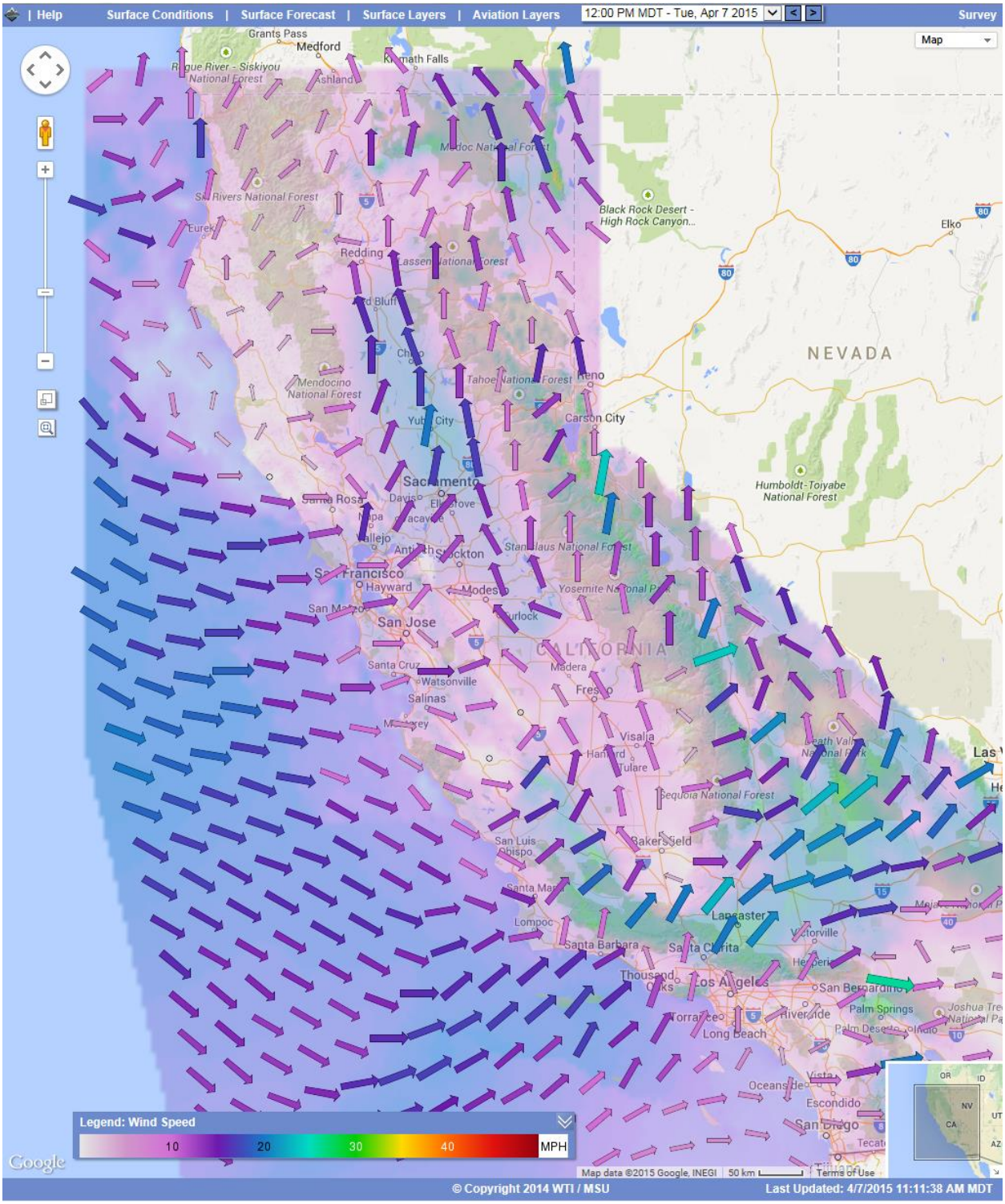

Figure 44: Forecast Wind Speed Layer

The Forecast Wind Gust Speed layer, found in the Surface Forecast Layers menu, shows forecast wind gust speed and direction for up to three days from present. Colored arrows indicate the forecast wind gust speed and direction. A raster image is also shown covering the state and indicating forecast wind gust speeds. See Figure 45.

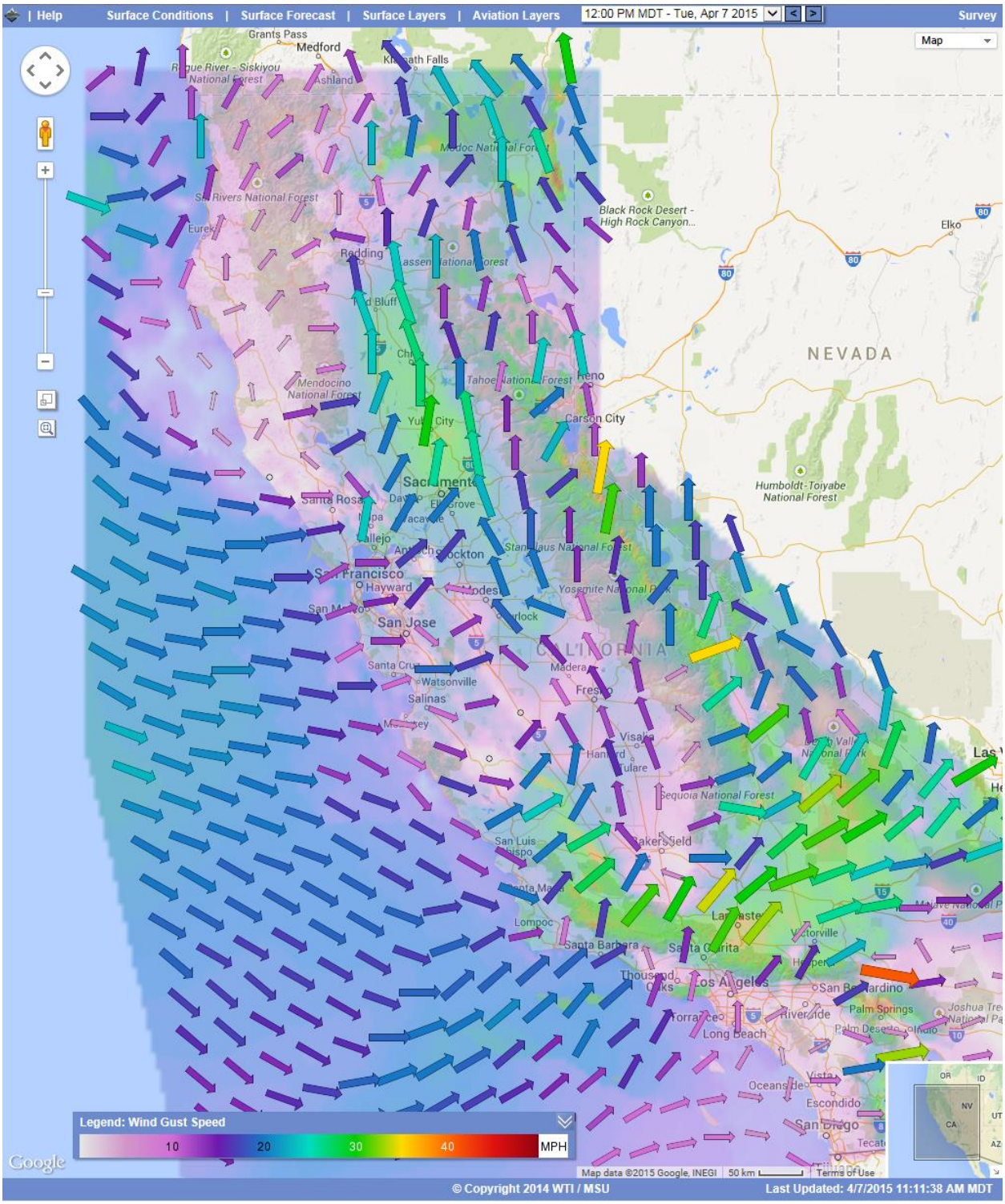

Figure 45: Forecast Wind Gust Speed Layer

The Forecast Humidity layer, found in the Surface Forecast Layers menu, shows forecast humidity for up to three days from present. Colored, labeled circles indicate the forecast humidity. A raster image is also shown covering the state and indicating forecast humidity. See Figure 46.

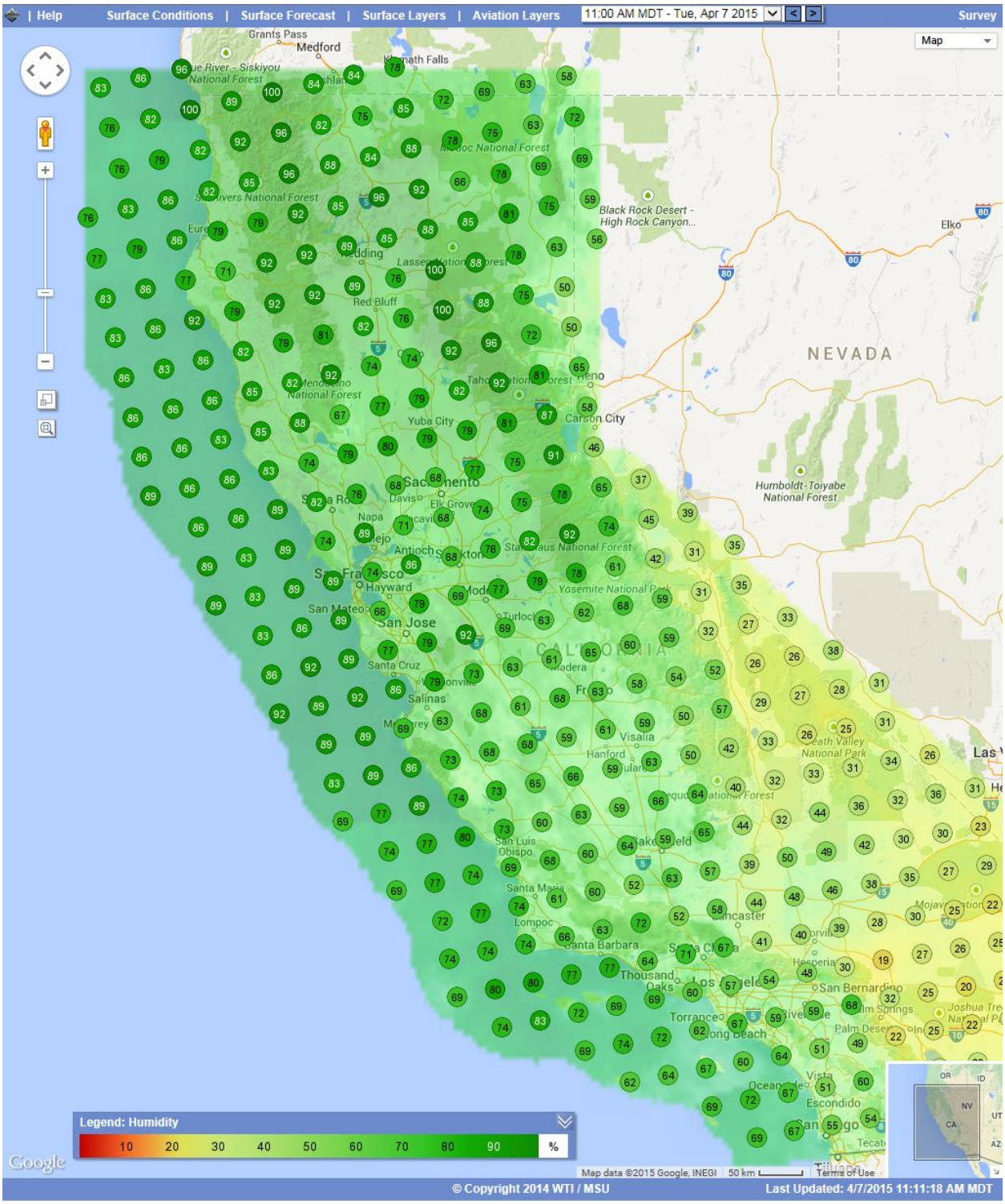

Figure 46: Forecast Humidity Layer

The Forecast Sky Cover layer, found in the Surface Forecast Layers menu, shows forecast sky cover for up to three days from present. Colored, labeled circles indicate the forecast sky cover. A raster image is also shown covering the state and indicating forecast sky cover. See Figure 47.

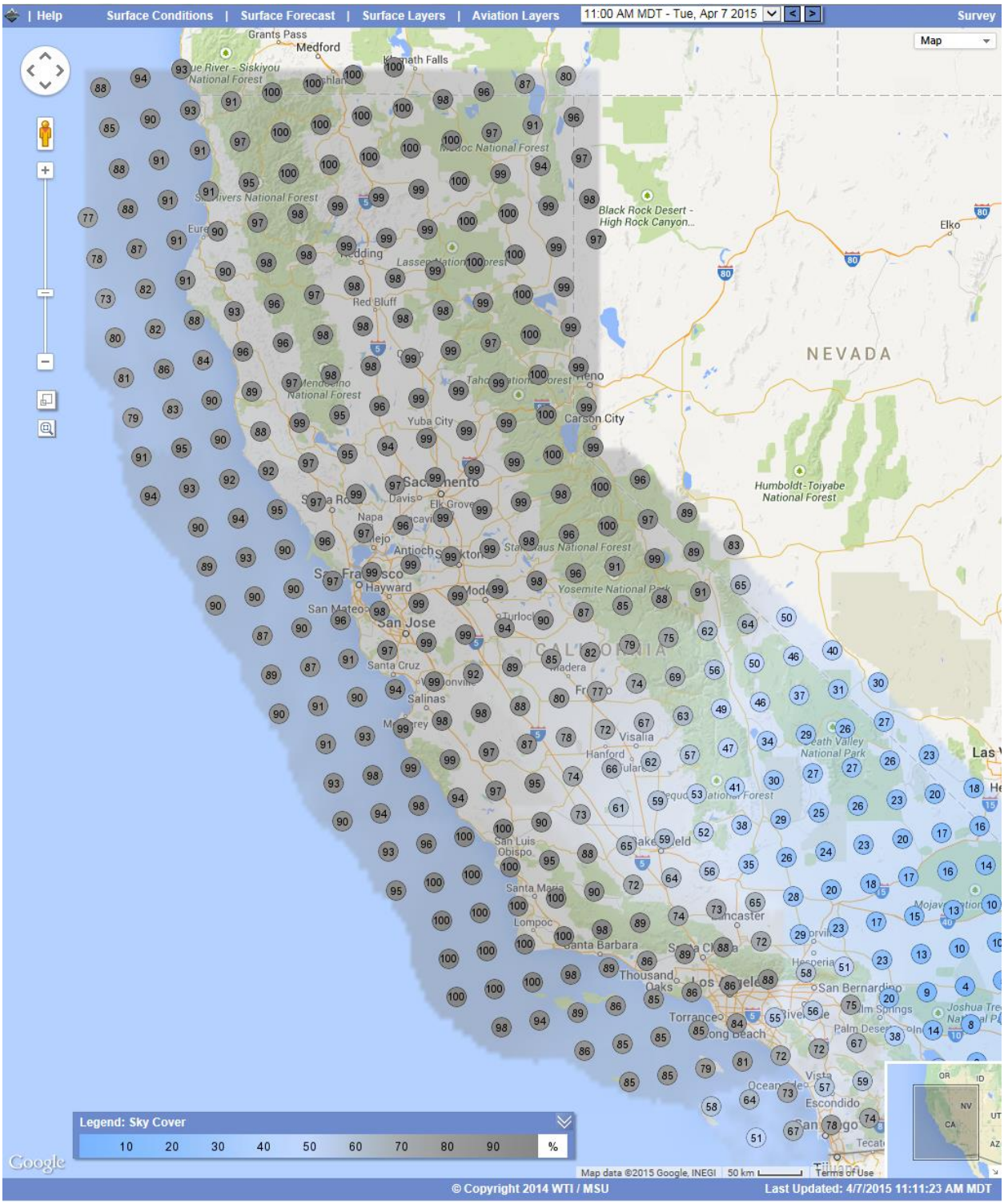

Figure 47: Forecast Sky Cover Layer

The Forecast 12-Hour Chance of Precipitation layer, found in the Surface Forecast Layers menu, shows forecast chance of precipitation for up to three days from present. Colored, labeled circles indicate the forecast chance of precipitation. A raster image is also shown covering the state and indicating forecast chance of precipitation. See Figure 48.

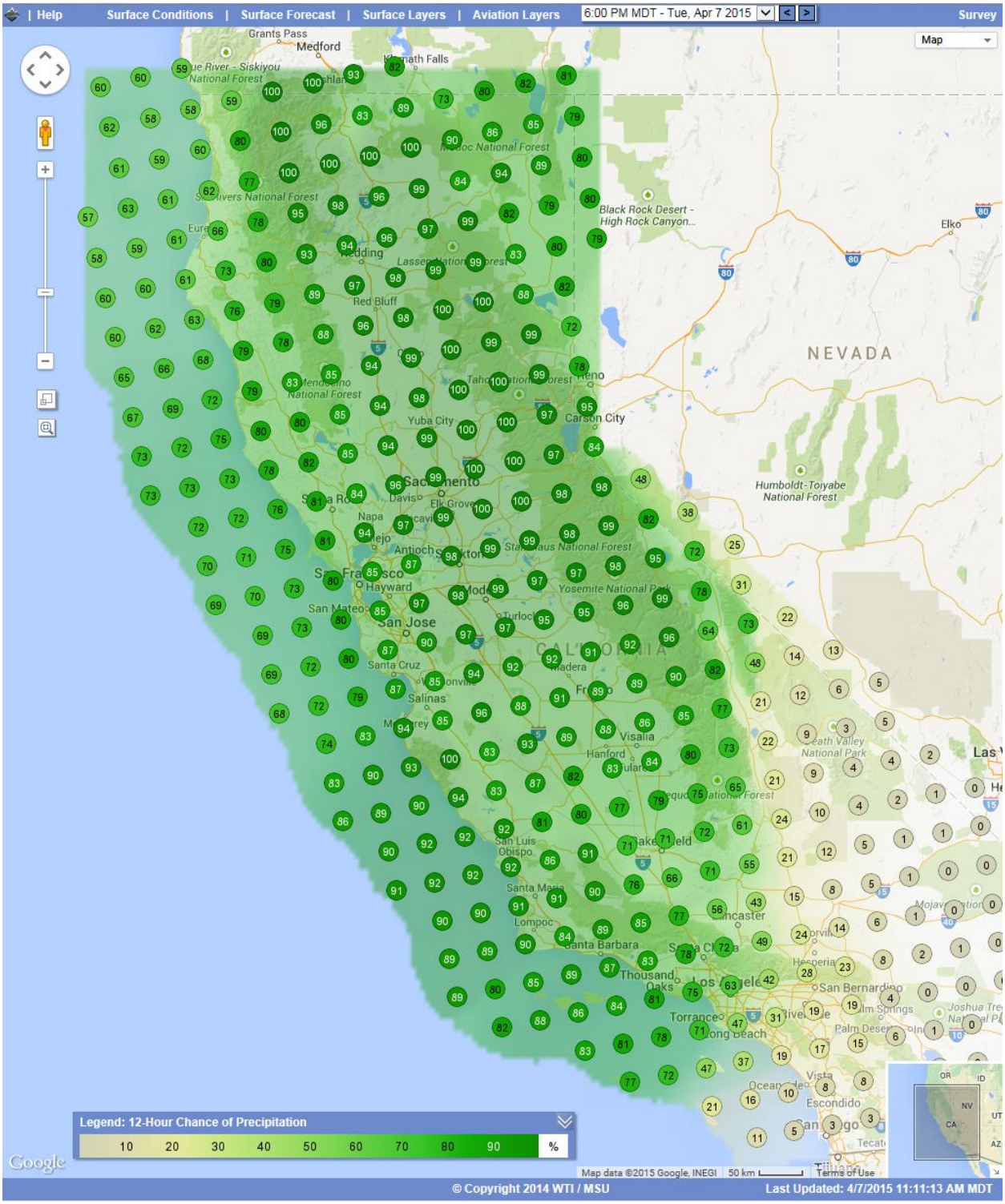

Figure 48: Forecast 12-Hour Chance of Precipitation Layer

The Forecast 6-Hour Precipitation layer, found in the Surface Forecast Layers menu, shows forecast amount of precipitation for up to three days from present. Colored, labeled circles indicate the forecast amount of precipitation. A raster image is also shown covering the state and indicating forecast amount of precipitation. See Figure 49.

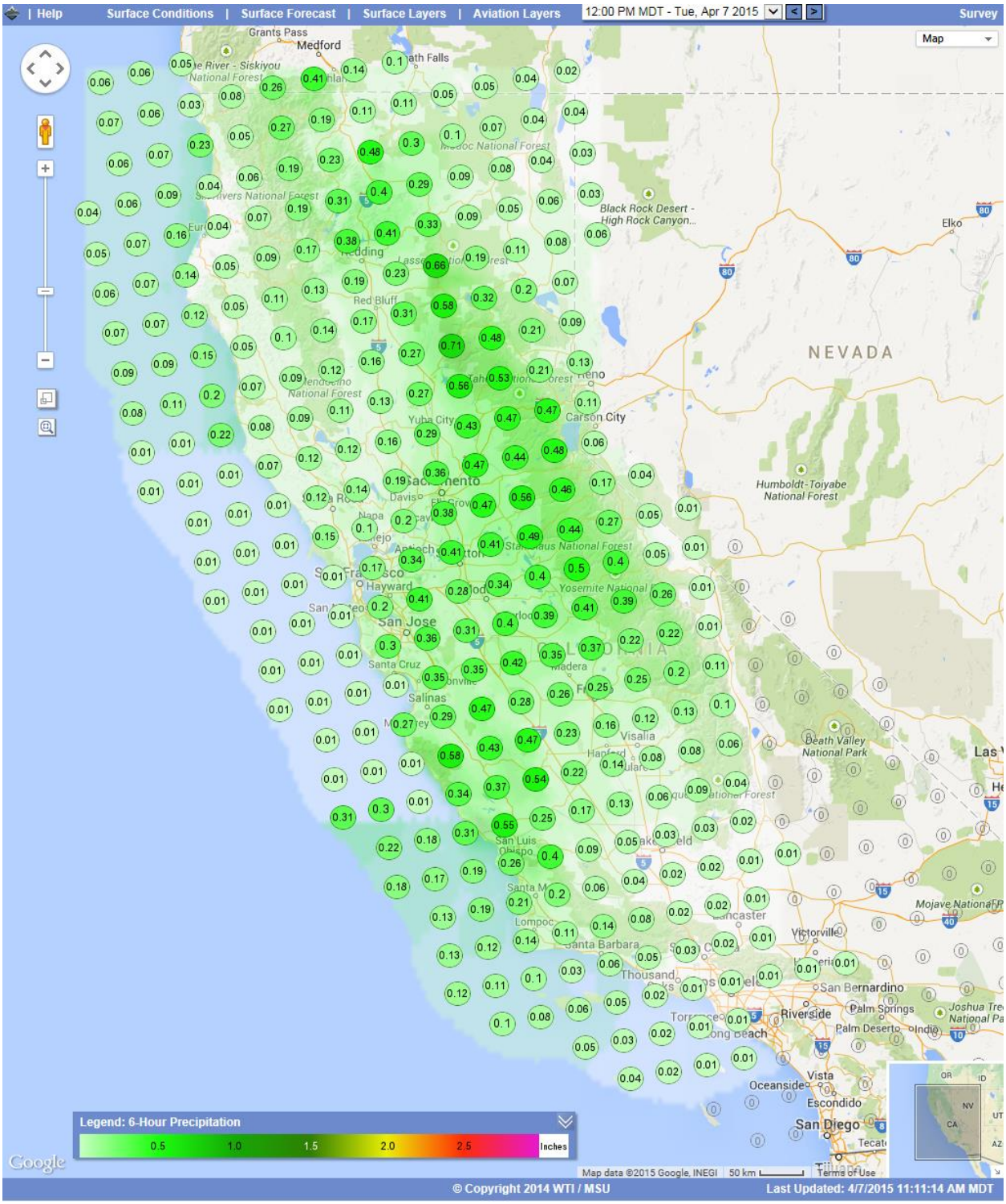

Figure 49: Forecast 6-Hour Precipitation Layer

The Forecast 6-Hour Snow layer, found in the Surface Forecast Layers menu, shows forecast amount of snow for up to three days from present. Colored, labeled circles indicate the forecast amount of snow. A raster image is also shown covering the state and indicating forecast amount of snow. See Figure 50.

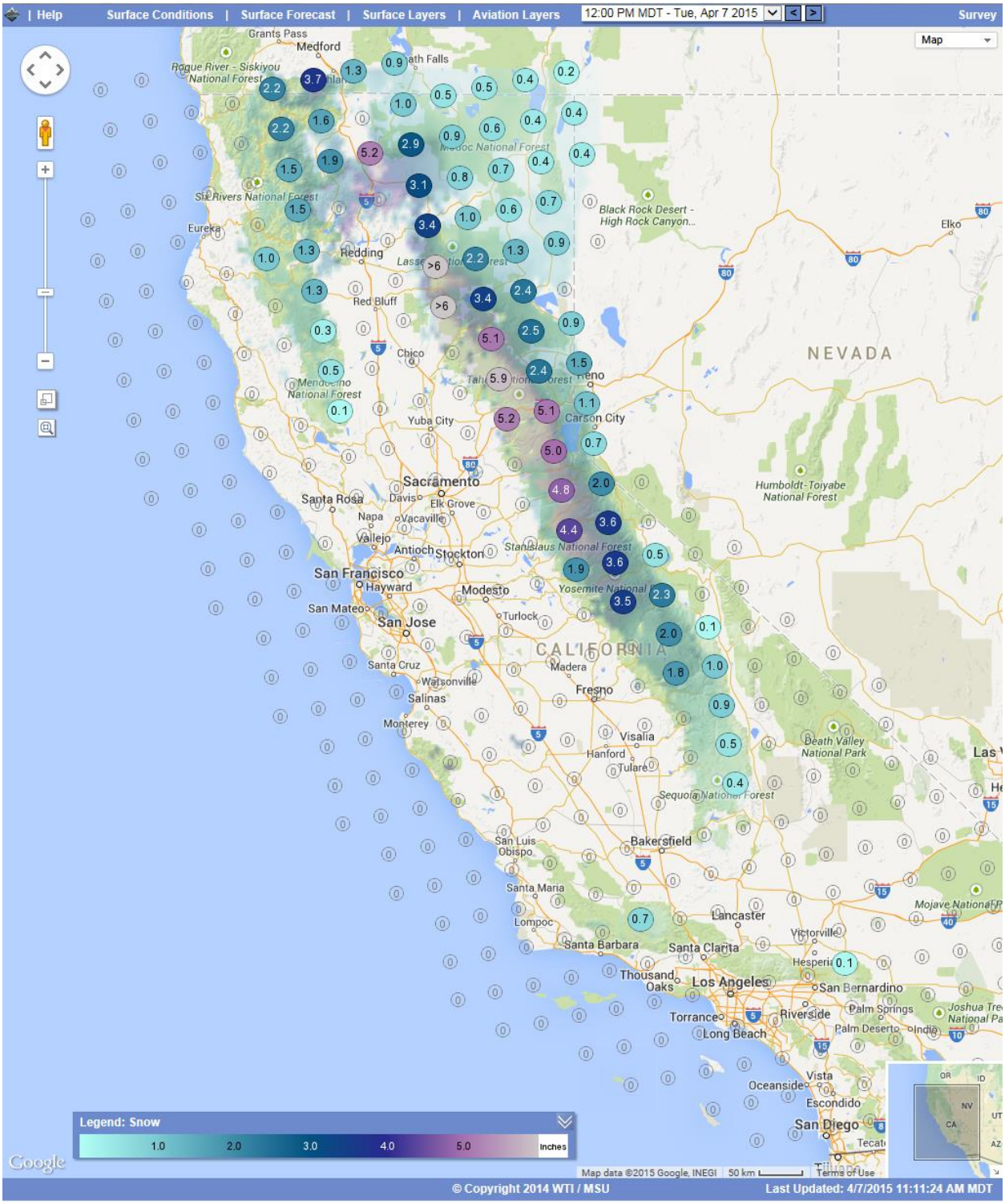

Figure 50: Forecast Snow Layer

The Forecast Weather layer, found in the Surface Forecast Layers menu, shows forecast weather for up to three days from present. Colored, labeled circles indicate the forecast weather type (e.g., Fog, Rain, Snow, etc.). A raster image is also shown covering the state and indicating forecast weather type. See Figure 51.

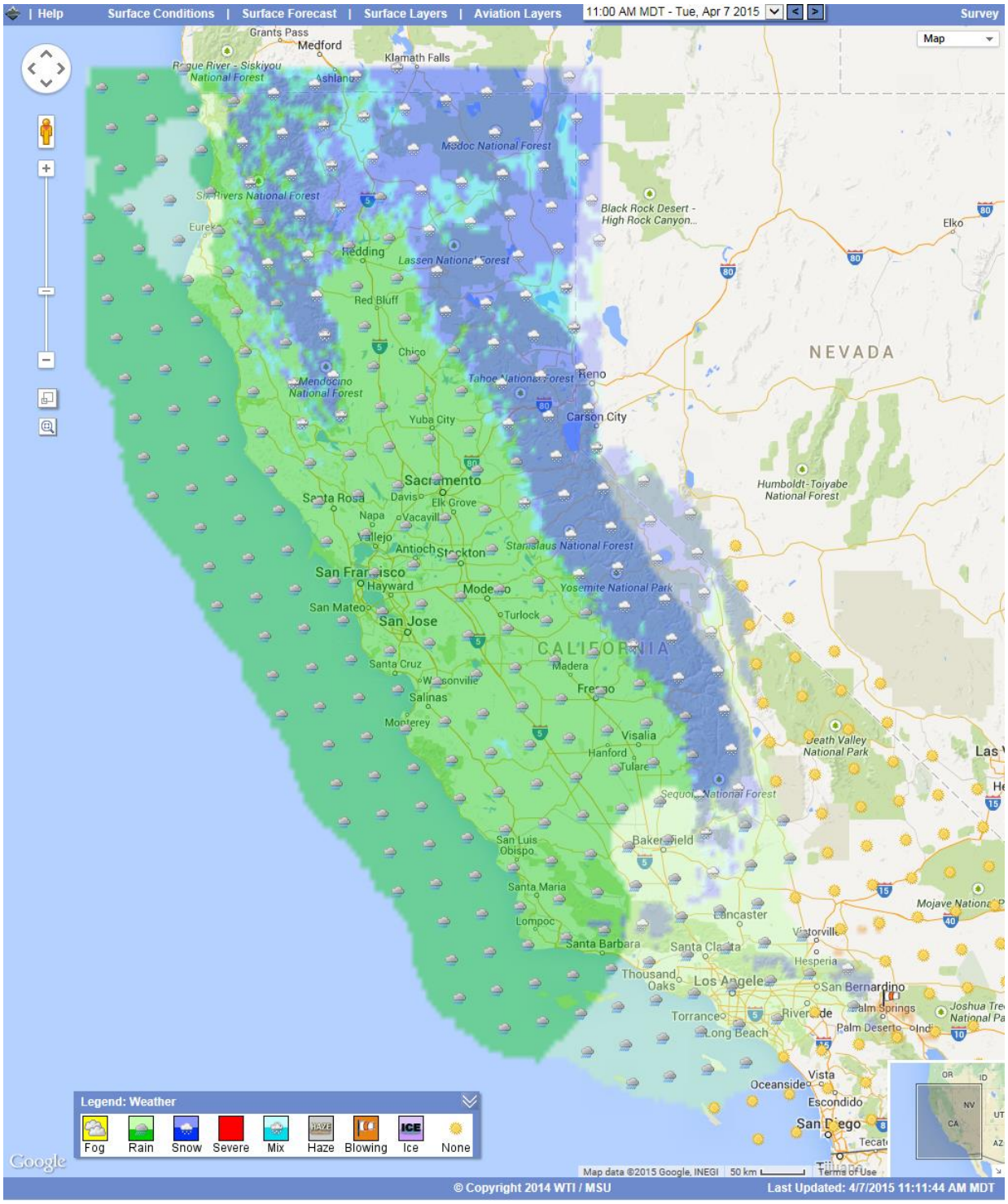

Figure 51: Forecast Weather Layer

The current surface Air Temperature layer, found in the Surface Conditions Layers menu, shows air temperature readings from within at most the past 90 minutes. Colored, labeled circles indicate the temperature at numerous observation stations. See Figure 52.

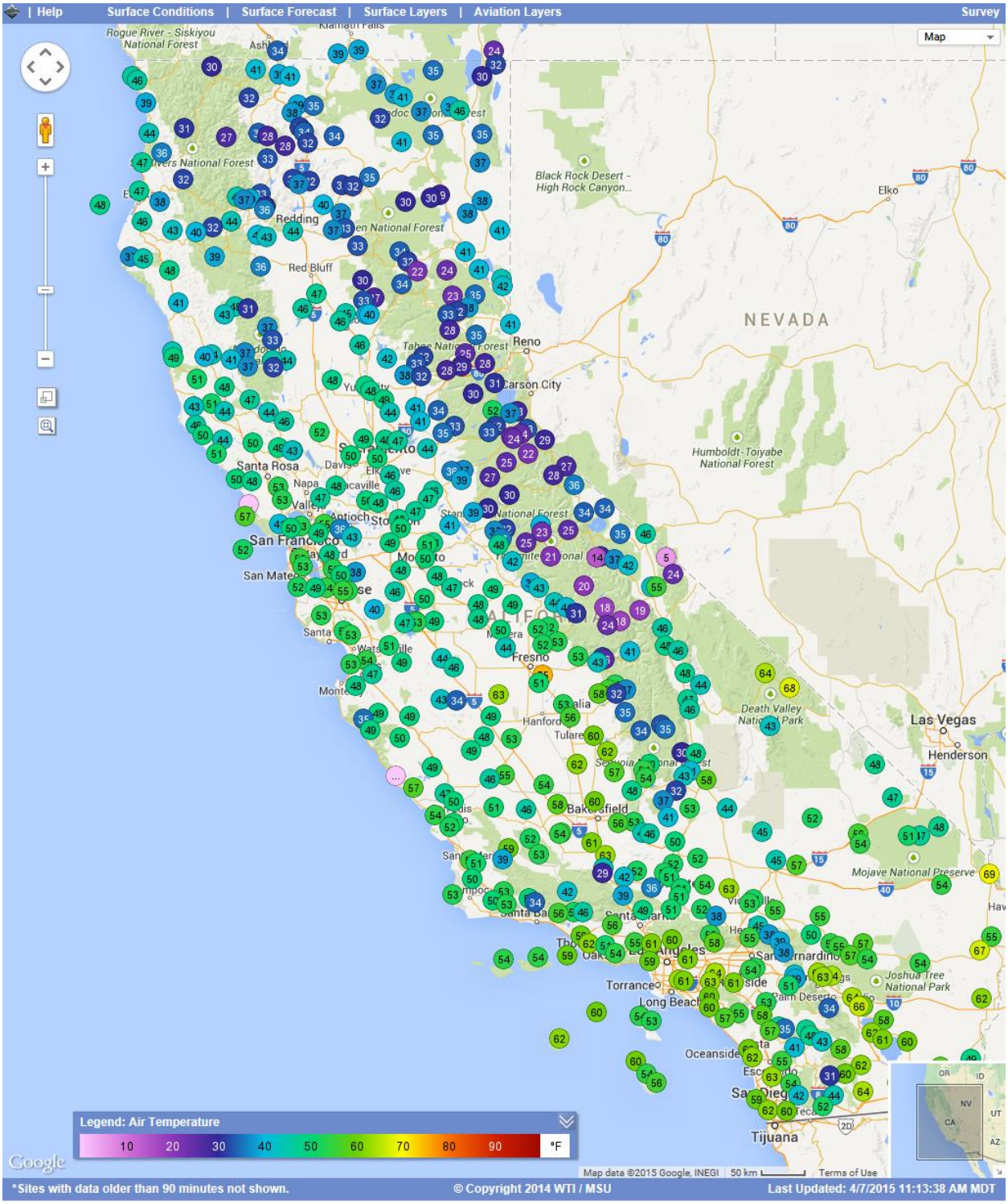

Figure 52: Current Air Temperature Layer

Users can click on individual markers to display detailed current observations from the corresponding site. Note that different sites are equipped with different sensors. See Figure 53.

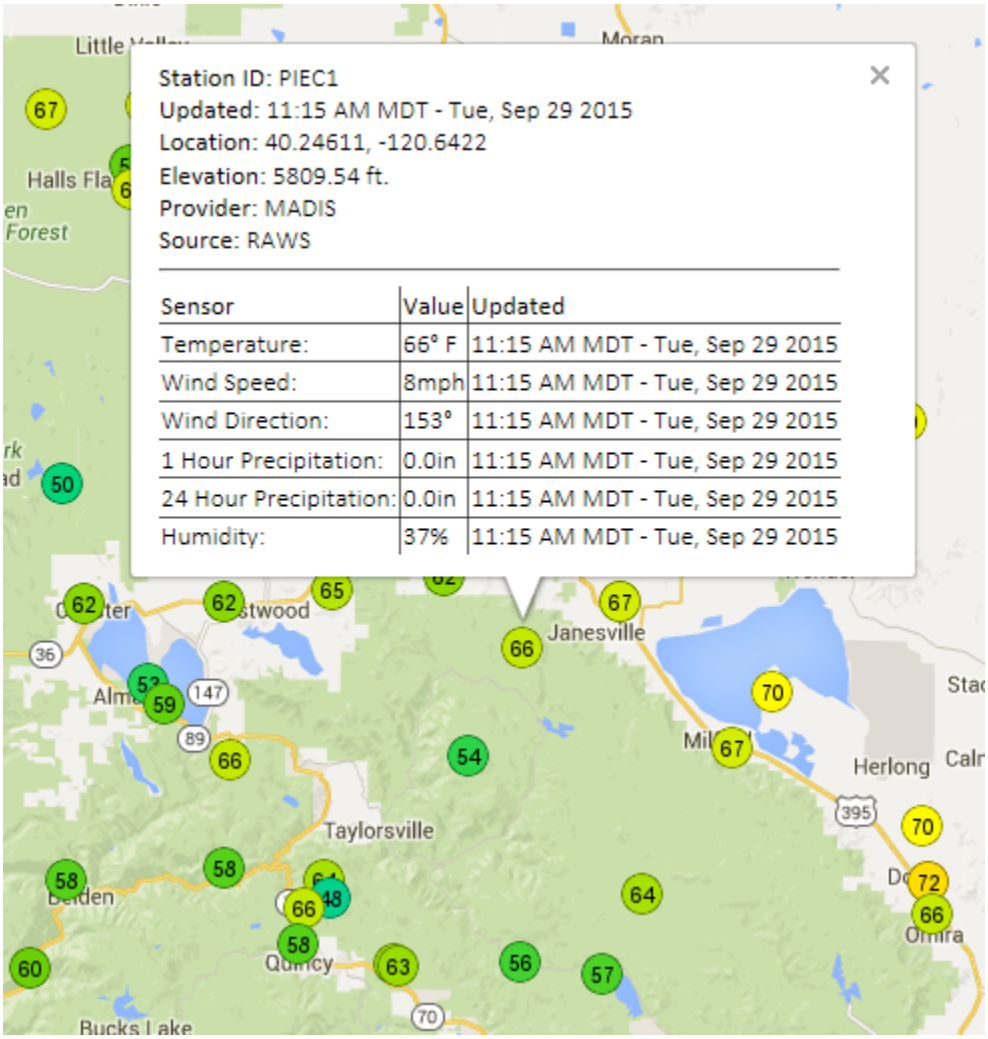

Figure 53: Current Condition Detail Shown by Clicking on a Temperature Icon

The current surface Wind layer, found in the Surface Conditions Layers menu, shows wind readings from within at most the past 90 minutes. Colored, directed arrows indicate the wind speed and direction at numerous observation stations. See Figure 54.

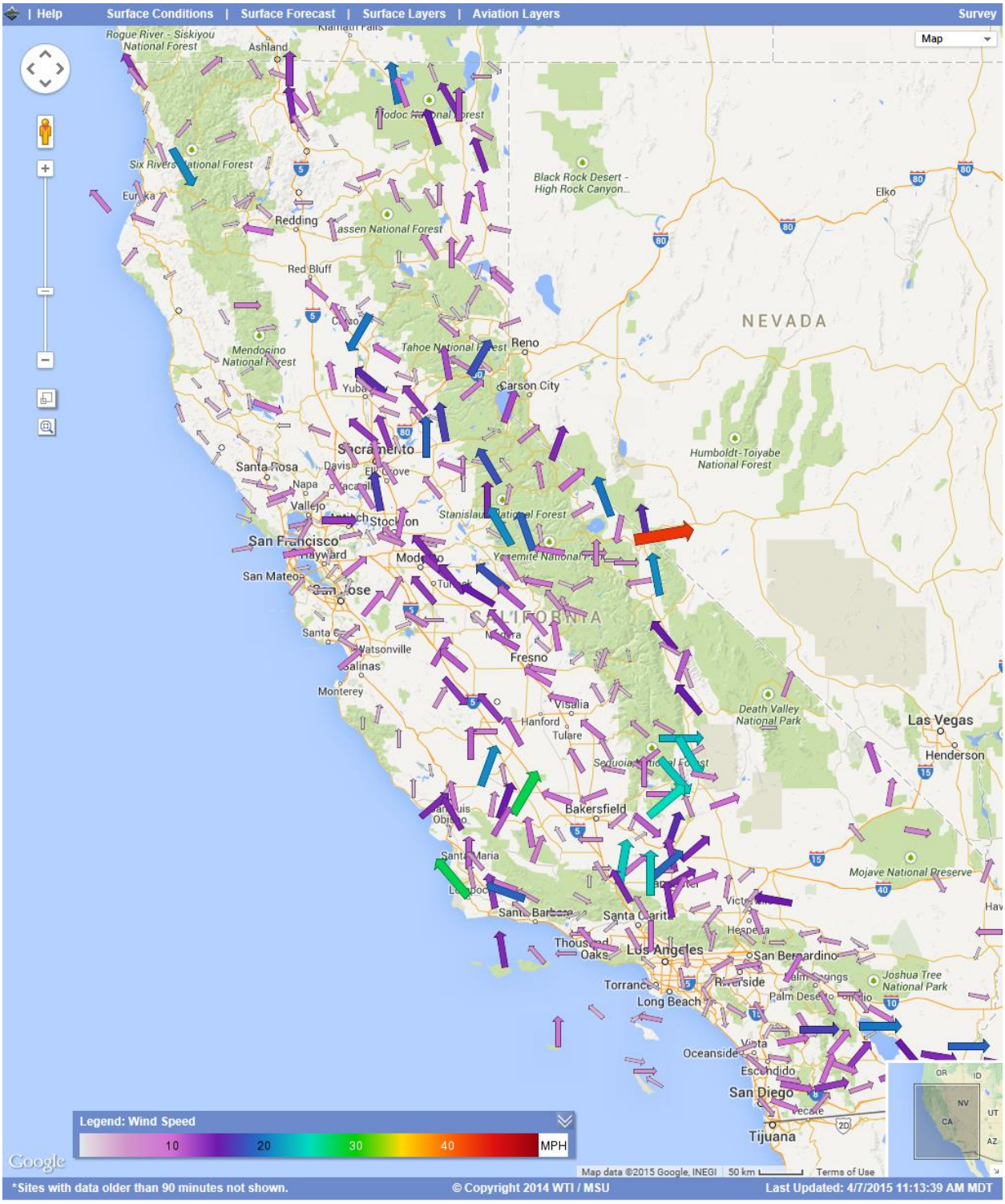

Figure 54: Current Wind Speed Layer

The current surface Hourly Precipitation layer, found in the Surface Conditions Layers menu, shows hourly (cumulative) precipitation readings from within at most the past 90 minutes. Colored, labeled circles indicate the amount of precipitation at numerous observation stations. See Figure 55.

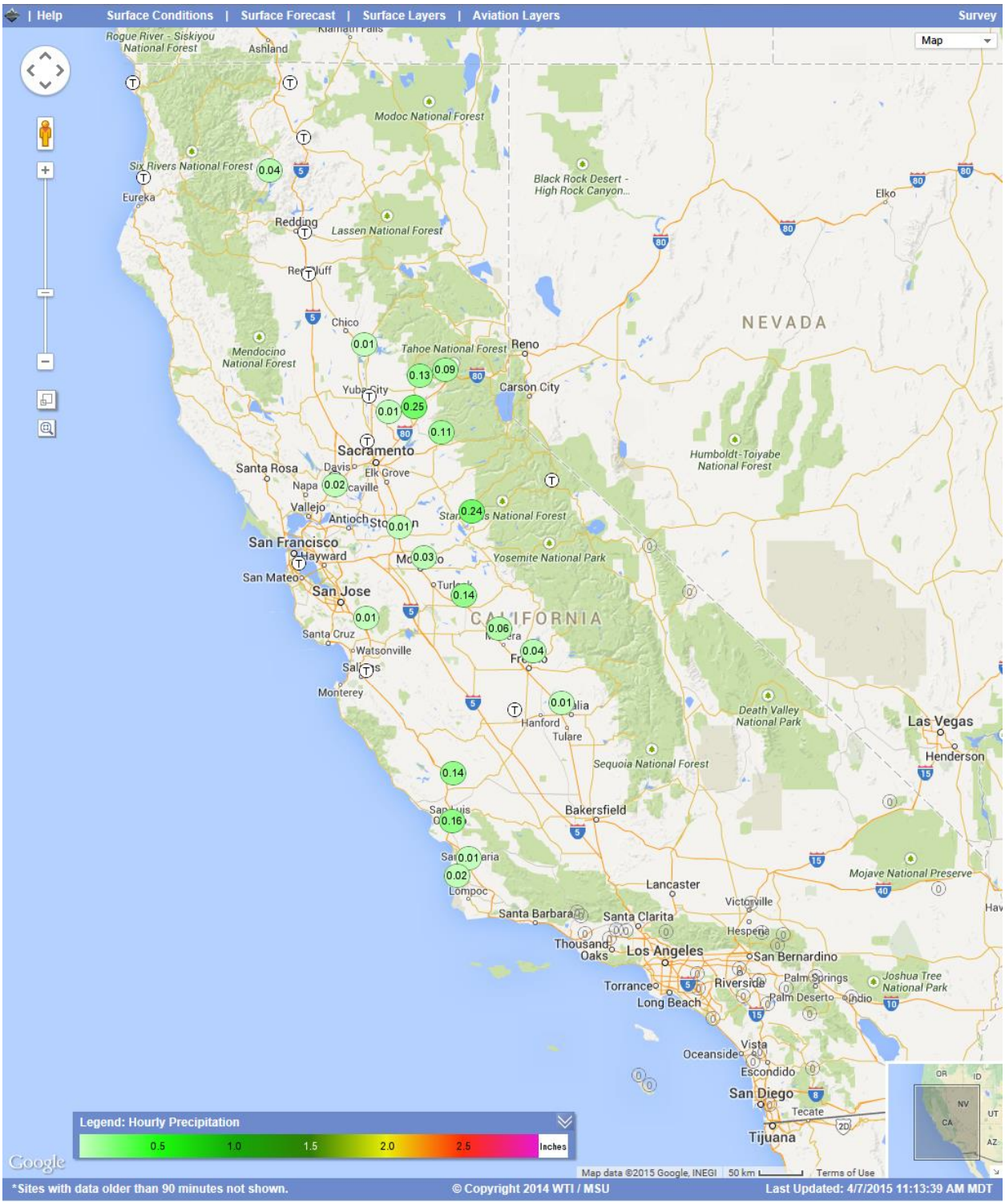

Figure 55: Current Hourly Precipitation Layer

The current surface 24-Hour Precipitation layer, found in the Surface Conditions Layers menu, shows 24-Hour (cumulative) precipitation readings from within at most the past 90 minutes. Colored, labeled circles indicate the amount of precipitation at numerous observation stations. See Figure 56.

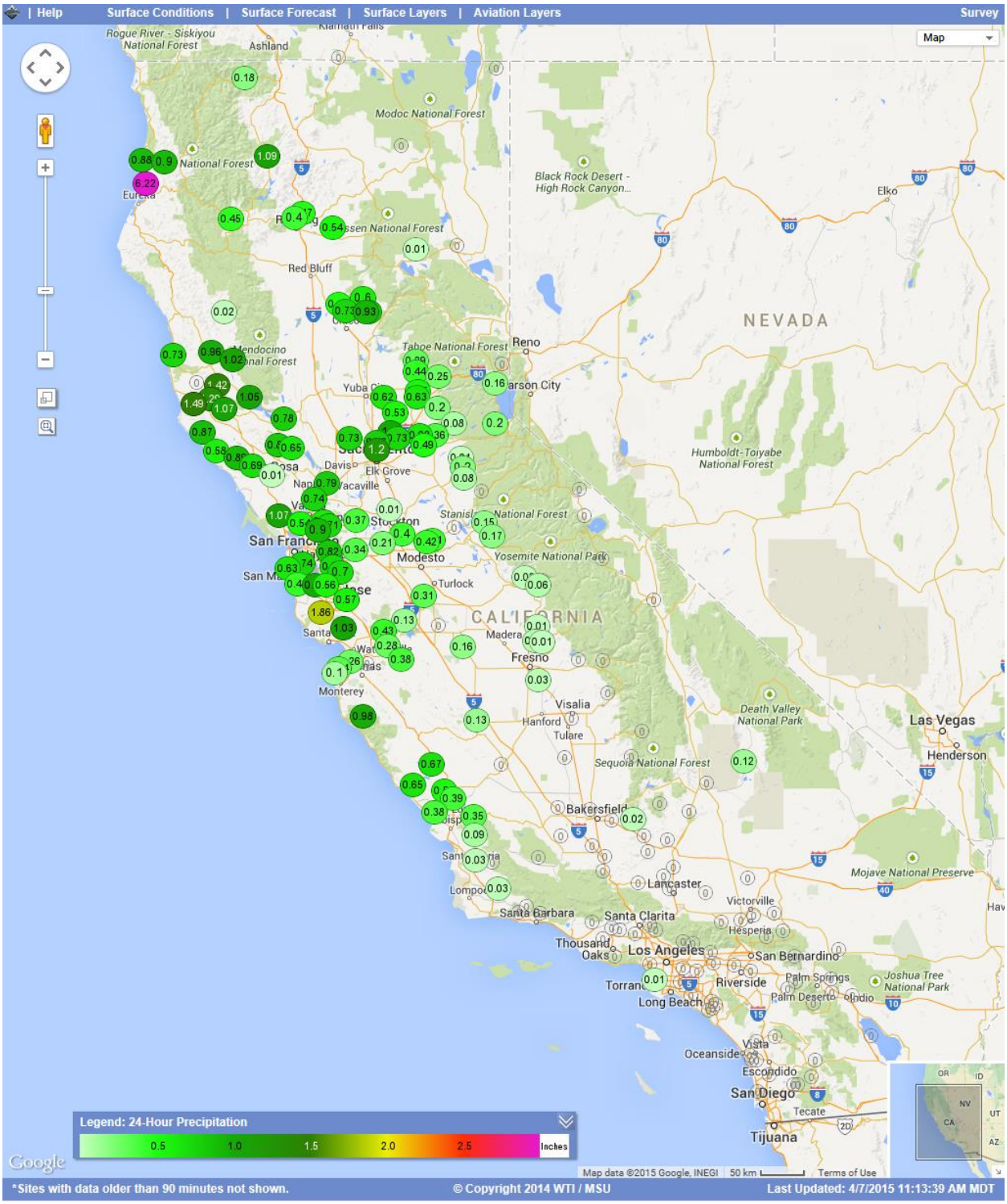

Figure 56: Current 24-Hour Precipitation Layer

The current surface Humidity layer, found in the Surface Conditions Layers menu, shows humidity readings from within at most the past 90 minutes. Colored, labeled circles indicate the humidity at numerous observation stations. See Figure 57.

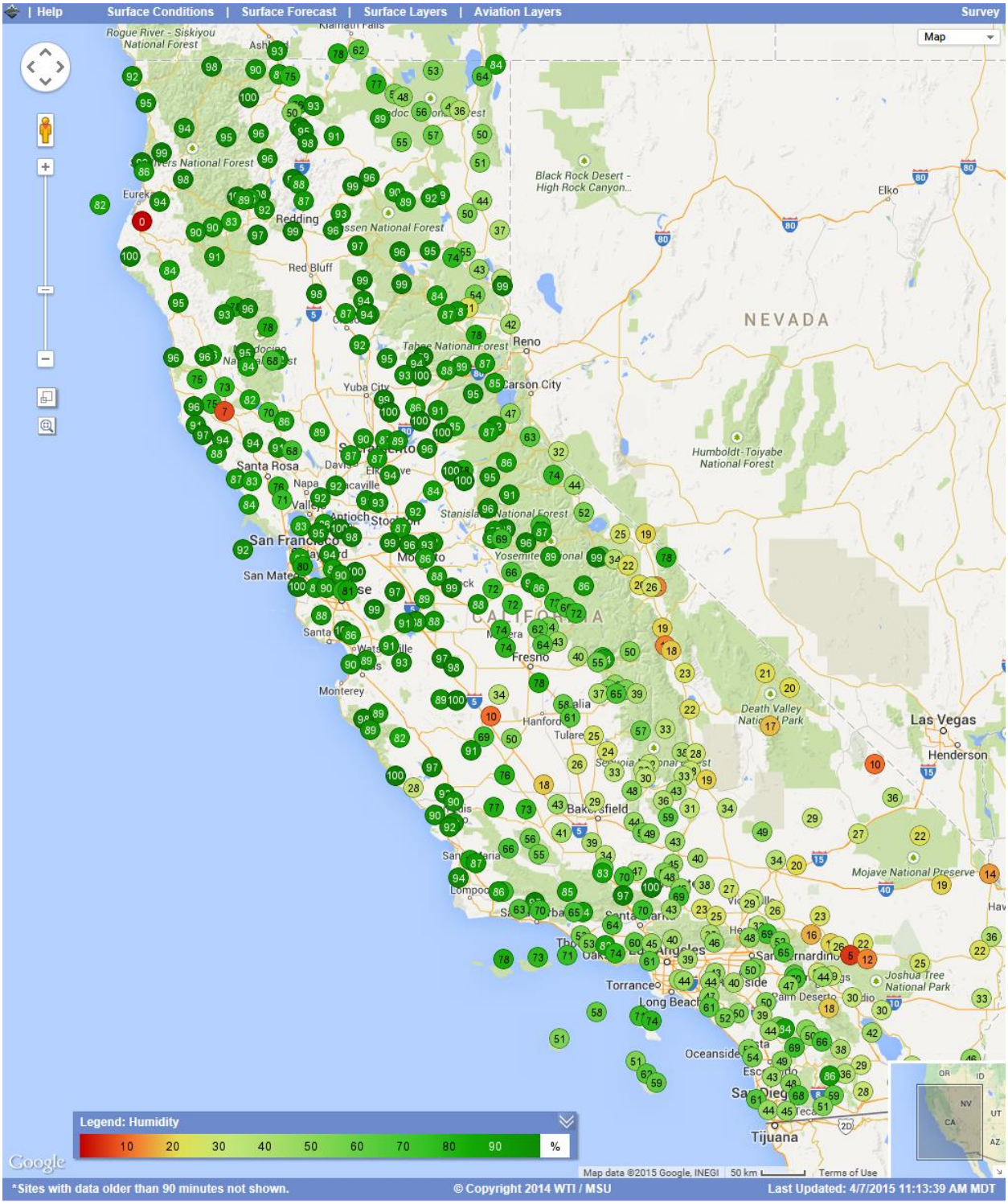

Figure 57: Current Humidity Layer

The RWIS Stations layer, found in the Surface Conditions Layers menu, shows reporting RWIS station locations. Colored, icons indicate station locations. See Figure 58.

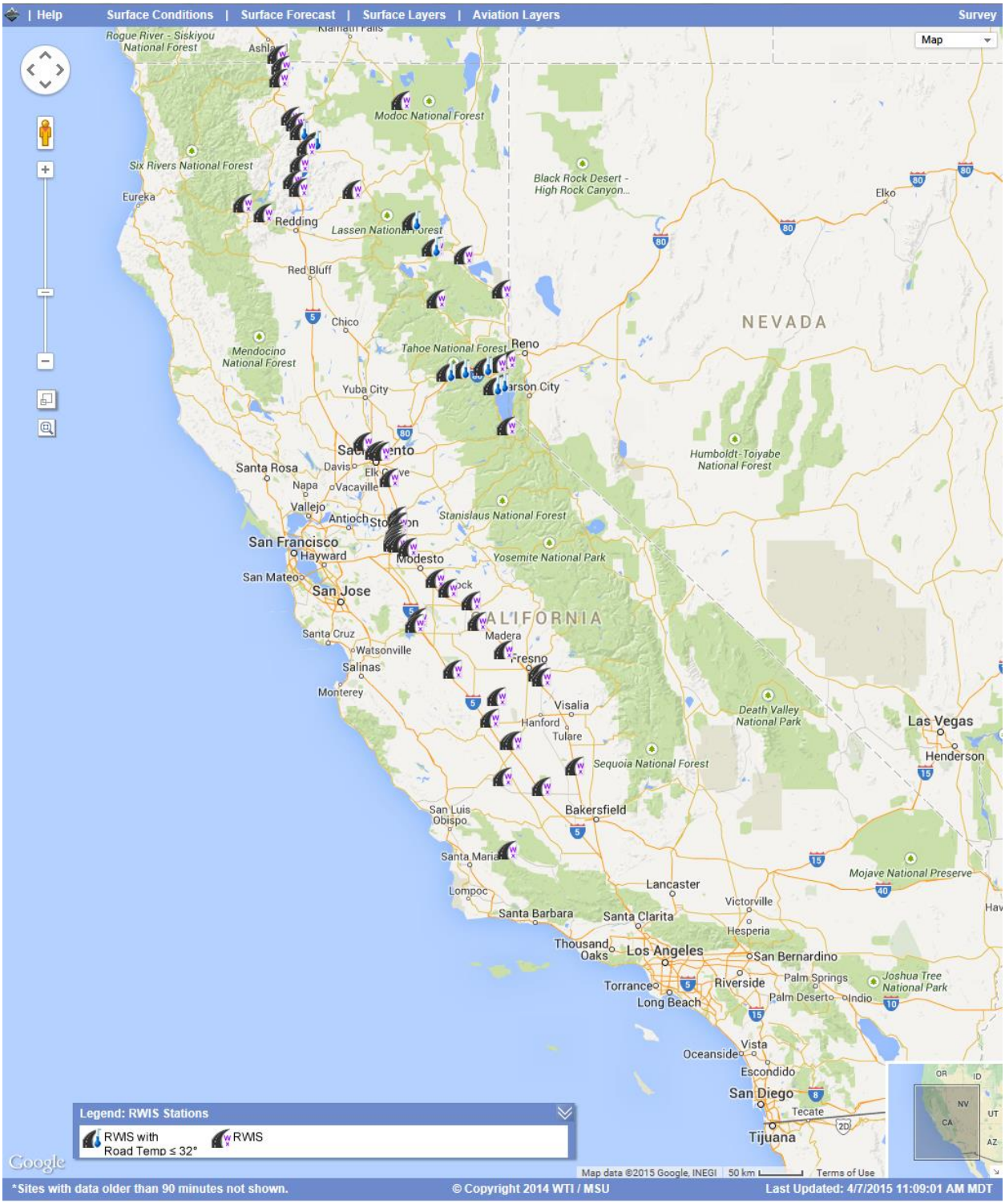

Figure 58: RWIS Stations Layer

If the air temperature or road surface temperature at an RWIS site is 32° F or below indicating freezing conditions, then the marker for the site changes to a blue thermometer. See Figure 59 and Figure 60.

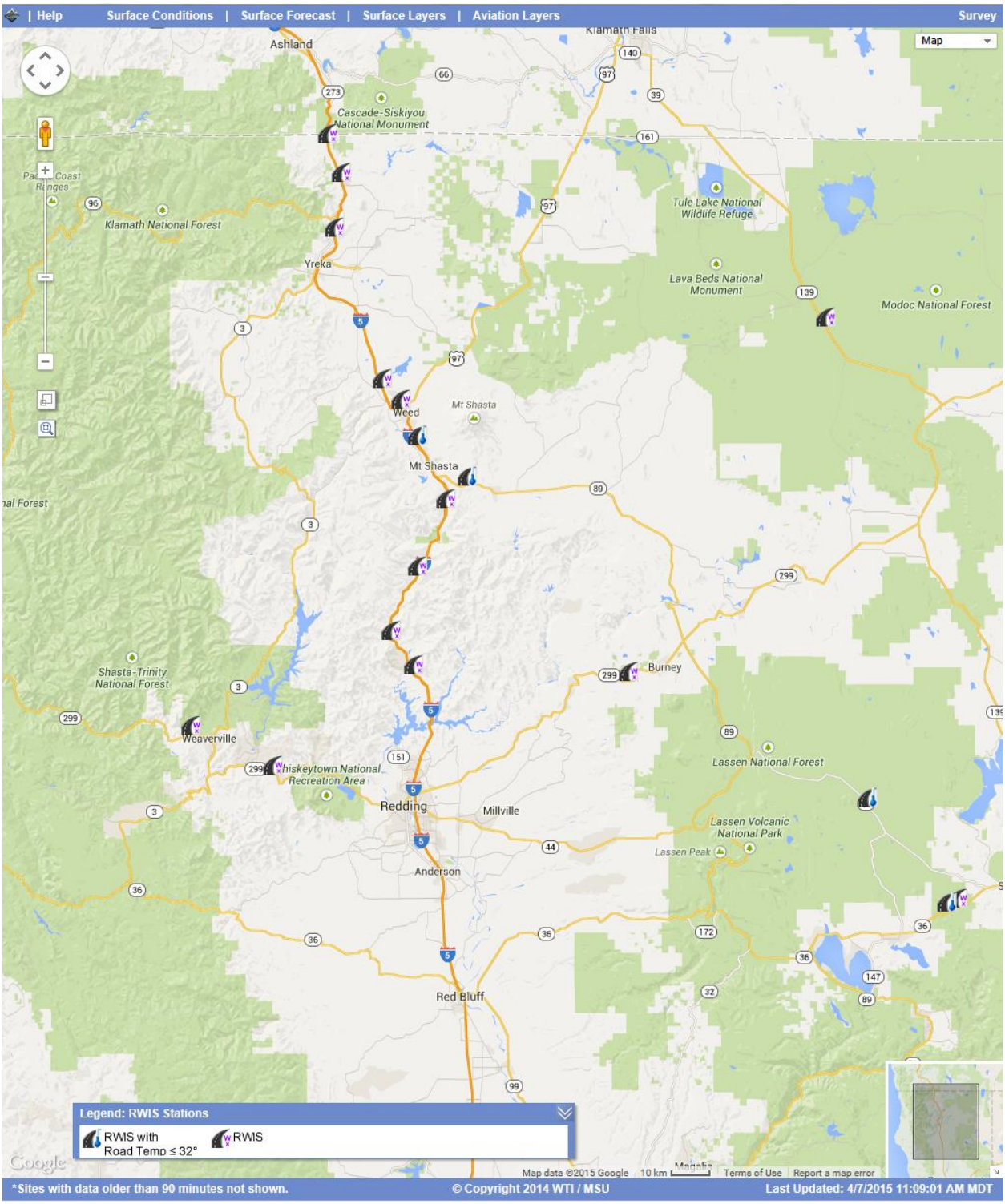

Figure 59: RWIS Stations Layer Showing Freezing Conditions

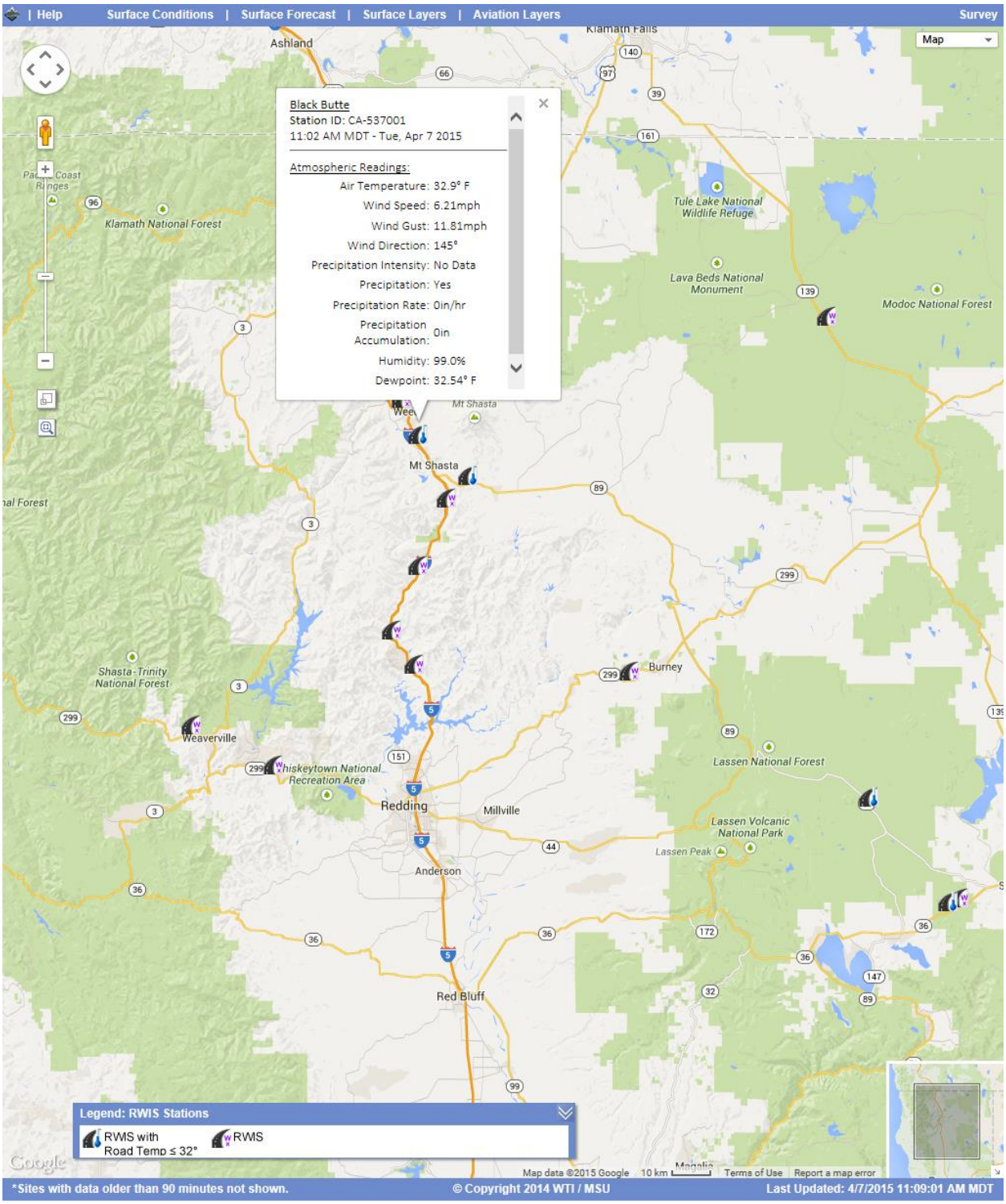

Figure 60: RWIS Station Detail

3. EVALUATION

In this section we present the results of the project evaluation task. Multiple evaluation methods were used in this phase of the project:

- 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.

- 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. Survey responses through September 30th, 2015 are presented in this report.

- 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 June 1st, 2010 through September 30th, 2015 is presented in this report.

For the sake of completeness and transparency, we provide detailed survey responses and comments as well as our own commentary and interpretation for the two surveys. We also provide detailed tables showing the Google Analytics data.

3.1. Focus Group Survey

3.1.1. Responses

Responses from individual focus group members are listed separately for each question. For the sake of completeness, we list responses verbatim, with responses from each individual corresponding to bulleted items.

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?

Responses:

- *It is nice to have the AWOS and Cal-Trans info in a single location.*
- *It is presented well in plain language. The balloon containing the report blocks other reporting stations which may be the next desired. Certain other vital information is missing.*
- *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.*

  Other features: For travel, the ability to find a wide range of surface temperatures, etc. to be very useful.
- *Yes I do. But then I am a VFR pilot.*
- *Intuitive operations (don't really need instructions).*

  Good display of info.

  Fairly complete info (except as noted below).
- *Yes, specifically useful:*

  a) Surface Forecast:

  Wind Speed / Gust overlay(s)

  b) Aviation Layers:

  PIREPs

  AWOS / ASOS

  Composite reflectivity

  TAFs
- *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" .*

- *There's a wealth of information available, which may be an obstacle for some people. It might seem overwhelming.*
- *Very intuitive, I didn't watch the start guide video but was able to figure everything out.*

  Decades ahead of the frustrating and obsolete DUATS website.

  Having all the data in one place with a familiar interface (google maps) is a huge plus.

  Being able to just switch data layers without having to change location or zoom level is a huge timesaver. It lets you see how all the weather works together in locations you previously had to make an attempt at interpolating in your head (which I'm horrible at).

  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.
- *Easy to read, well integrated.*
- *Tuff question, really...*

  a) It must have serious strengths to get people to use this, rather than the systems they/we use at the present. A quick look at this says it has possibilities; BUT, will people take as long a look as I did? Answer = No.

  b) If I were a real Pilot (not a 'Sim Pilot'), I'd find all my weather info ash Oh HELL!! now this got truncated. ..lost the body of this answer...

  c) Also, People are learning how to use I-pads, etc; that's the future where you need to be, if you want this to be used in real-time, because of their portability. Real-time weather is already there. You can take it with you in the plane or car.
- *The weather information was complete and answered all of my questions, and. in some areas more than I needed. The entire temperature was so condensed that it blocked out city locations. In the numbers for temperatures they only varied one or two degrees. The mountain temperatures were good and I assumed they were surface. Not enough airports to cross check with their surface figures.*
- *I like this site a lot. I find it very useful to have this information in one app. I use other sources for most of this data, but your consolidation is extremely useful and I would switch to using your site. For example, having one map of the state that provides access to all CalTrans webcams is much more useful than CalTrans' site that requires navigating by CalTrans district. It is tricky due to the flakiness of linking off of your site, but having a layer of 3rd that we use to check weather where there is little or no weather reporting (such as the webcams at Shelter Cove Airport). Any way to integrate a such a layer? Perhaps you allow me to create my own list of webcams (or other items) to present in a layer, much like Google Earth allows me to create objects in "My Places" and store them locally.*

  In fire season, I monitor weather conditions such as temperature/wind/humidity forecasts. It is useful to have this information consolidated.

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?

You've got a lot of what I look at in one spot, with very nice navigation – good use of Google maps.

Nice job picking the weather sources. Good use of CalTrans' data.

For my less technical friends, more Help will eventually be useful. I can give more on this topic when you are planning or polishing your final version. party webcams would be useful. I imagine we all have our list of favorites.

- *I find the weather information in the prototype to be very useful, centralized, and relatively simple to negotiate. What is presented is pretty basic, but very useful as a pilot to get the big picture look at what is out there. I think it is quite handy to be able to see the Caltrans weather info and access the camera system. It's nice to get a visual look without being totally reliant on computer generated data.*
- *Live and visual indications of conditions in various locations is very helpful for all kinds of activities. This presentation is very easy to use and to interpret. The aviation weather is great for pilots as is, but it could be even better if the current and forecast weather there could be given better plain english as it is on the AOPA website or as in the ForeFlight App. Having raw data there too is good for the pilots.*

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?

Responses:

- *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. The sky conditions are not decoded.*

  I also noted that some remote ground weather stations would disappear when the data became stale. I would like to be able to find any station at any time and get the most recent data for it.

  For any station, it would be nice to be able to pull up several hours of history.

  I don't know if remote ground stations record winds and precipitation but if it is available, it should be included, at least by pushing into it.
- *Plain English instead of raw data would be helpful.*

- *Cloud ceilings and tops are common needs for pilots – I know many of the sources don't have this info, but a composite map showing the ceilings/tops using available info (most of the airport AWOS/ASOS and TAF etc has this info in metars format) would be great.*

  Radar info would also be helpful and composite radar info.

  The NWS Composite reflectivity is a little confusing – it appears to show clouds where the AWOS says it's clear

  The satellite images aren't showing up? Maybe because it's still a little dark outside?

  Baro pressure charts are also helpful to pilots (there's a NWS term for these, but I can't think of it) Airmets and Sigmets are good info for pilots. Avail from DUATS and NWS

  IFR/MVFR depictions would be good.

  An option of using the CA aeronautical chart as the base map would be very helpful

  I don't know how to get there, but being able to provide this info to enroute pilots would be good. For instance, the Weed airport does not have AWOS, but there's a CT RWIS right next to the airport that can provide wind info to the pilot before he lands.

  Showing TFR's would be very helpful.

- *None identified.*
- *As stated above, there's an enormous amount of information available.*
- *I'm having difficulty interpreting the color layers when they are overlaid on top of an area that is already colored on the map (ie.green national forest areas). For example, the Surface Forecast > Air Temperature layer overlaid on Mt. Shasta (14,000+ft) forecasts a temperature that, judging by the color alone, is either in the 80 F degree or 10-20 F degree range. Obviously it's the later, but it seems like an area that is a more open for mistakes.*

  Is it possible for the mouse location on the map to show interpolated data somewhere on the screen? Kind of like in google earth, you can move the mouse over terrain and see the lat/lon and the elevation near the bottom on the screen. In this case I would be interested in seeing what the estimated temperature or wind is between 2 stations or 2 forecast points.

  I had a couple instances of the site hanging up my browser (Google Chrome on Win7 x64) for either an extended time or until it just stopped responding. Usually it would say "Downloading Data, Please Wait…"

  A Sectional Chart overlay might be useful.

- *Looks pretty comprehensive for my use.*
- *Answer to this in #3...*
- *You have covered the basics that I look for as a VFR pilot. For IFR pilots icing is important. At what elevation will it be encountered and for what distance.*

  Ceilings and tops are important if cloud cover exists and what areas they cover.

- *Navigation:*

I'm not sure if this is a navigation issue or not, but I would like to see time-series animation. It is very useful to see the evolution of weather over time. Many of both surface and aviation items could benefit from animation – how have the winds aloft forecasts changed over the past 24 hours? How have surface winds evolved in my fire watch area? Etc. Obvious ones are satellite images and radar.

This may go beyond "simply" integrating weather sources, but I would REALLY like to see something that compares forecasts with actuals. For example, toggling between forecast winds aloft and pireps or soundings with actual winds aloft, forecast icing/turbulence/cloud cover vs. actual, etc. We need better forecasting, and by comparing actual weather with forecast weather, we can build confidence in the forecasts.

It would be useful to allow simultaneous display of multiple layers. For example, seeing surface temp and humidity together would be useful in fire season.

I don't know if this is browser behavior (Chrome Version 31.0.1650.57 m) or not, but when I select a layer (for example, Aviation -> NWS Composite Reflectivity), the drop down Aviation menu stays dropped down. How can I get rid of it? If you go with my idea of multiple layers, and you use check boxes on the menus to select layers, then I wouldn't want the menu to close until I had selected all the desired items. But eventually,

I want the menu to close.

Surface Weather:

I can't think of much to add other than items already mentioned above (such as animation), but I'll keep thinking about it as I use the prototype.

Aviation Weather:

I like the "Flight Path Tool" on the ADDS website: http://www.aviationweather.gov/adds/fptapplication. Some of the information there is redundant with WeatherShare, but the 3D icing forecast is very useful and, in my experience, surprisingly accurate. Any way to integrate icing?

WeatherShare color codes temperature, wind speed, etc. How about color coding the AWOS symbols with VFR/MVFR/IFR/LIFR colors to get the "conditions at a glance perspective"? I like this page: http://www.wrh.noaa.gov/zoa/mwmap3.php?map=usa

NWS Alerts are available, but how about Airmets and Sigmets (by type, of course).

This would be a useful layer to combine with others.

- *I think it would be useful to be able to click on a drop down tab and for it to stay highlighted so you can confirm just what you are viewing.*

  When hovering over weather location identifiers it would help for it to display the weather info rather than to display "no weather."

- *I think you have it pretty well covered!*

  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?

Responses:

- *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…….*
- *Mentioned above.*

  I have no leads on other data that might be available, but if it is weather related, I would like to have it.
- *Add coverage to other states like Oregon, Washington, Nevada and Idaho.*
- *Much of this info (and more) is available through other sources (NWS, DUATS etc) – so some might say this is redundant info that's not worth the expense of generating.*

  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.

  The advantages with the other typical sites is they cover larger areas (beyond CA0, so a pilot on a long cross country can get a bigger picture from the other sources.
- *Dew Point spread / icing as a layer vs pulling from the METAR under the airport ID. Certainly not a not a need to have, just easier to glance at the entire area as a layer.*
- *The drop down boxes should disappear automatically after a selection is made. In some cases, the location I was trying to look at was obscured by the box. Moving the map worked, as did clicking the header, but I don't see the need to have the box stay open.*
- *I didn't see PIREPS, those might be useful.*
- *Make menu at top of page a pull down instead of covering part of the map.*
- *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...*
- *No other suggestions.*
- *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"?*
- *Under Terminal Aerodrome Forecasts – Forecasts: The format could be made a little more clear, but not a big deal.*
- *None.*

Question #4. Any other comments?

Responses:

- *Thanks for pursuing this project.*
- *I like having all of the relevant data put on the map so that I can plan for travel by knowing only where I'm going and what I am riding in.*

  Note that I have only used the site for about one hour. If features that I found lacking are actually there, you might want to make the availability more obvious.
- *When I tried to use this on my IPad, it kept shutting down. This could be an issue if you use and IPad in the cockpit.*
- *Airport information and associated NOTAMS.*
- *The integration of data from many sources is great. I currently use this site for flying weather information: http://www.wrh.noaa.gov/zoa/mwmap3.php?map=usa*

  Your site expands this information greatly.

  Perhaps the map zoom function could be a little less sensitive. I found it very easy to zoom in or out too much.
- *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 love it!*
- *a) My Air-card might not be functioning properly - If I were to find the "Basic Usage Video", I might not be able to view it. Be sure NOT to use "Flash Player"!!! (Not enough emphasis added!!) Update pop-ups take you to a false site where you download trojans, malware and viruses!! ..catch 22; If you don't update, you can't watch video's.*
  b) Guys; you're trying to re-invent the wheel.
- *Thank you for checking in with the end users. There will be additions as you use and tune the system.*
- *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.*
- *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.*

3.1.2. Summary

The detailed responses provided by the focus group are very useful. Since the focus group survey was conducted when the Phase 2 System was brought online, the project team was able to address some of the concerns raised by the group. Other concerns such as a need for a mobile version (tablet or phone) were discussed at length, but were considered outside the current scope.

Many of the focus group responses, particularly the positive responses, speak for themselves and will not be repeated here. Rather, we focus on potential short-comings identified by the focus group:

- There may be a need to expand the system to provide coverage outside of California. This is due not only to potential flights outside the state, but also due to a desire to have information from other states for those who operate near the border.
- There is a learning curve, with repeated visits necessary to grasp the volume of information that is available. This may turn-off first time visitors.
- The system does not work well on tablets and phones, yet these platforms are being used more and more by pilots.
- Users may desire the ability to customize and incorporate additional information into the system. For instance, one user expressed an interest in adding their own list of web cameras.
- Users requested coloring AWOS/ASOS airport sites by color according to VFR, MVFR, IFR, and LIFR. (Note that the project team subsequently implemented this change.)
- There may be an interest in showing weather station locations and past data even when the data becomes stale.
- A respondent requested more plain English in place of raw data. (Note that the project team subsequently made an effort to address this.)
- There is an interest in including a cloud ceiling layer.
- There is some confusion on the radar and satellite layers. (Note that the project team tried to address this, but the layers themselves may still be confusing.)
- There was a request to use the California aeronautical chart as a base map.
- There is an interest in providing information to pilots while en-route. (Note that the System has been posed as informational only, so accomplishing this could be challenging.)
- There was some confusion with data shading and similar colors used in the base maps. (Note: Since we use transparent overlays, it isn't surprising that such conflict in colors can occur.)
- A respondent requested the ability to interpolate data between data points that are displayed and show these via mouse-over. (Note: The raster image overlays serve this purpose in part, although they do not directly show numerical values.)
- A respondent indicated that their browser stalled in several instances. There were several other reports of quirky browser behavior. (Note: The project team has tried to streamline the system to address these problems.)
- Time-series animation for forecasts was requested.
- A visual comparison or evaluation of forecasts was requested.
- A flight path tool was requested.

- Color highlighting of the selected layer was requested. There may be room for further improvement in the menus including ensure that they don't block map information.
- One respondent recognized that it is critical that the system be sustainable over the long term so that people don't start using it and then find it has gone away.
- One respondent suggested that an effort be made to point out data that is unique to this system relative to other, similar systems.
- There is a desire for icing information.
- One respondent noted that they could not easily find the Quick Start Guide and the Basic Usage Video. They further noted problems with using Flash-based videos. (Note: The project team subsequently tried to address this by adding links to these items in the informational dialog that is shown to users when they open the system.)
- One respondent indicated that the system tries to "reinvent the wheel".

Again note that we have only focused on the items identified as negatives and/or for improvement. The grand majority of these comments were constructive and deserve further consideration. There were a large number of very positive comments on the System and these seem to indicate its utility and usability.

3.2. Online Survey

3.2.1. Responses

QUESTION: How often do you anticipate using the AWOS with RWIS prototype system?

Table 1: Focus Group Survey Response Tallies – Anticipated Usage Frequency

Answer Options	Response Percent	Response Count
At all Times	0.0%	0
Several Times per Day	14.3%	1
Once per Day	14.3%	1
Several Times per Week	14.3%	1
Once per Week	28.6%	2
Once per Month	14.3%	1
Rarely	14.3%	1
Not at all	0.0%	0
(optional) Comments:		0
answered question		**7**
skipped question		**0**

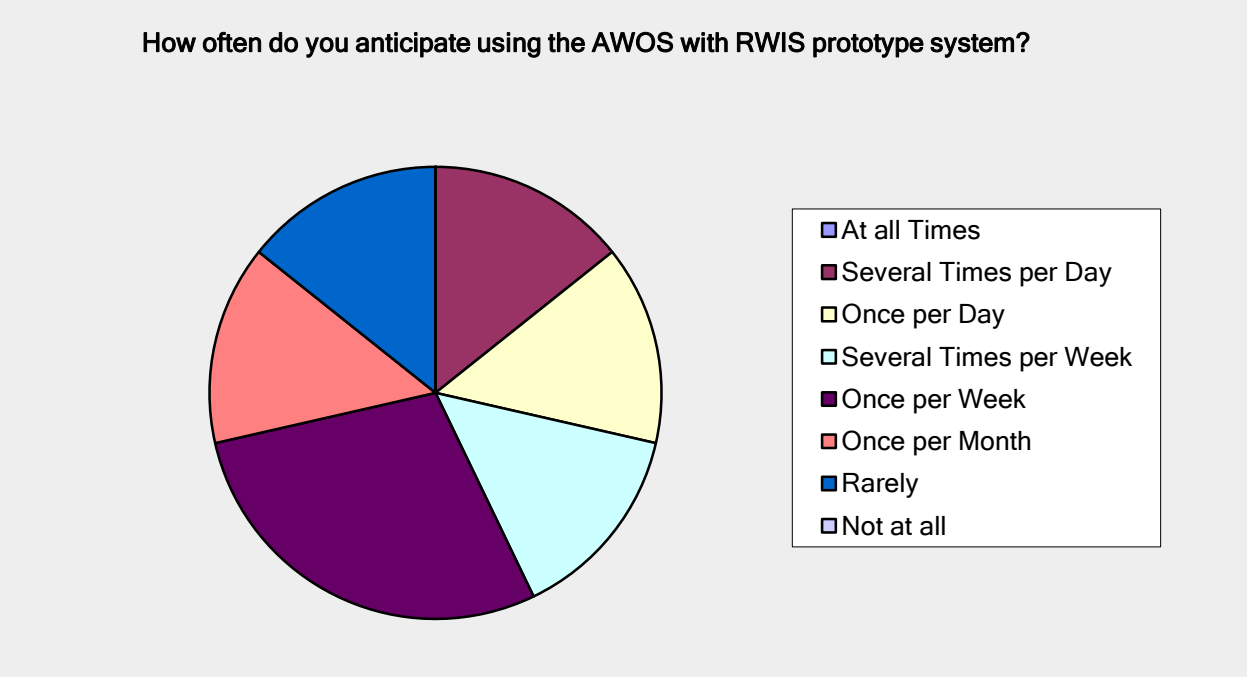

Figure 61: Focus Group Survey Response Chart – Anticipated Usage Frequency

QUESTION: When do you anticipate using the prototype system? (check all that are applicable)

Table 2: Focus Group Survey Response Tallies – Anticipated Usage Time

Answer Options	Response Percent	Response Count
Daytime Hours	42.9%	3
Nighttime Hours	14.3%	1
Business Hours Only	42.9%	3
Under Changing Conditions	14.3%	1
During Bad Weather	14.3%	1
At all Times	0.0%	0
(optional) Comments:		0
answered question		**7**
skipped question		**0**

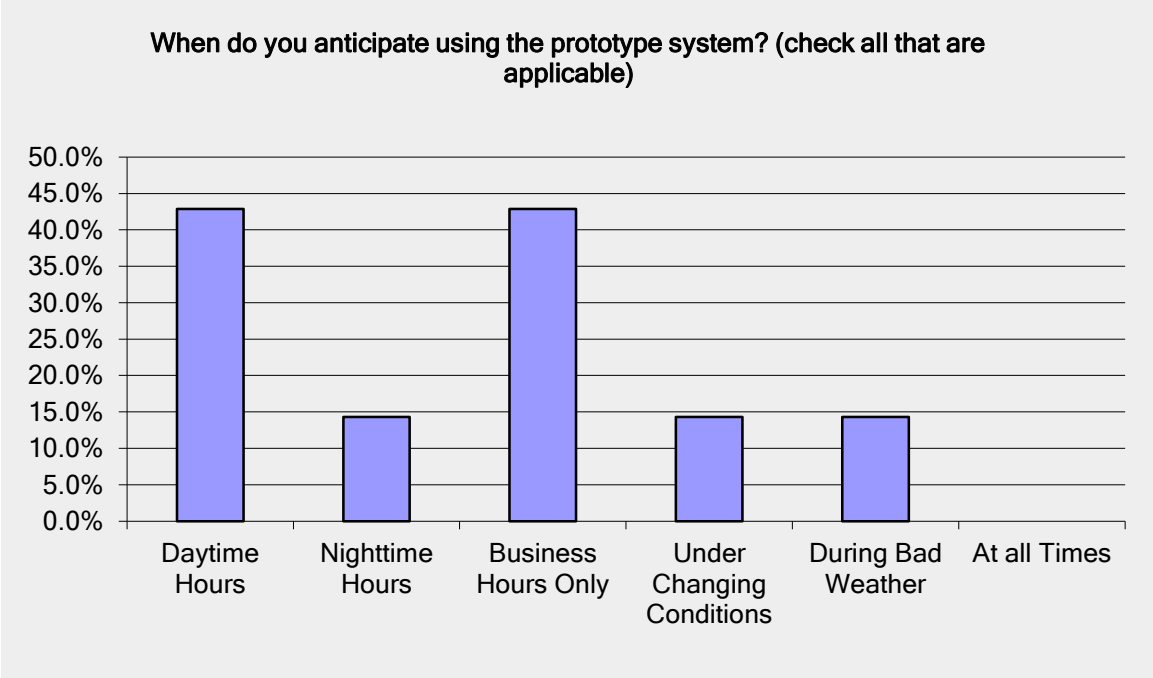

Figure 62: Focus Group Survey Response Chart – Anticipated Usage Time

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

Table 3: Focus Group Survey Response Tallies – Usefulness of Surface Condition Layers

Answer Options	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
				(optional) Comments:	1
				answered question	**6**
				skipped question	**1**

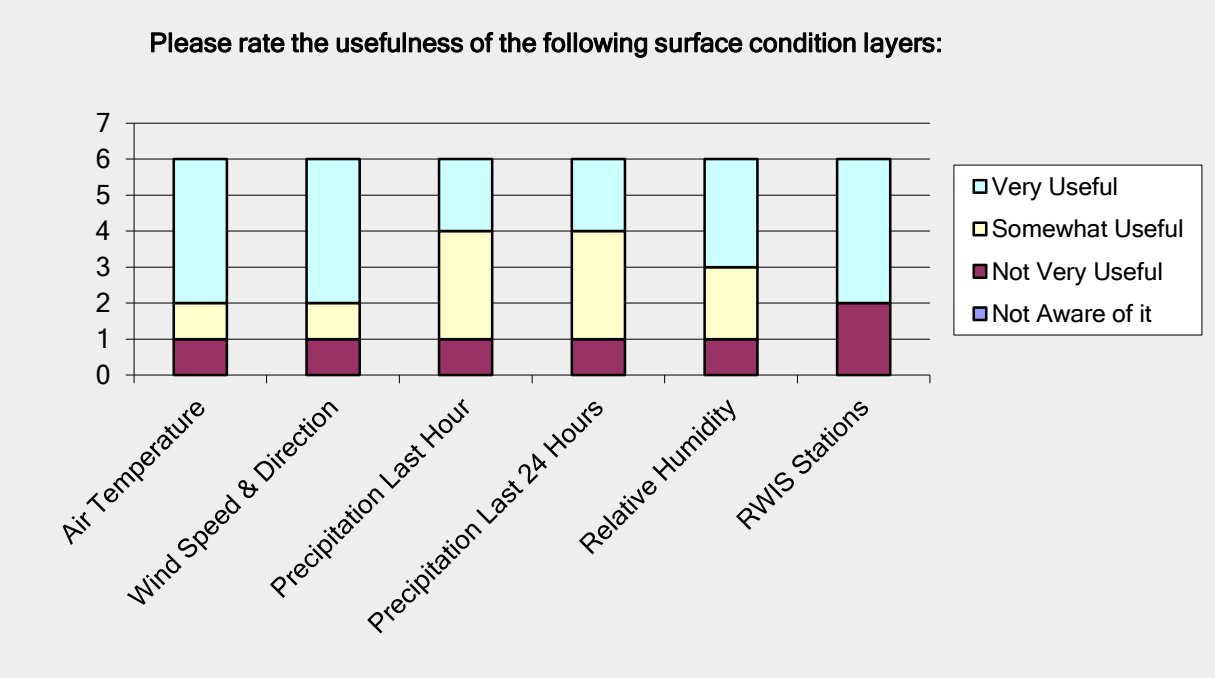

Figure 63: Focus Group Survey Response Chart – Usefulness of Surface Condition Layers

Comments:

- *I like the fact you show all the stations that are available. Still, I wish you had a better link to the station.*

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

Table 4: Focus Group Survey Response Tallies – Usefulness of 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
				(optional) Comments:	0
				answered question	**6**
				skipped question	**1**

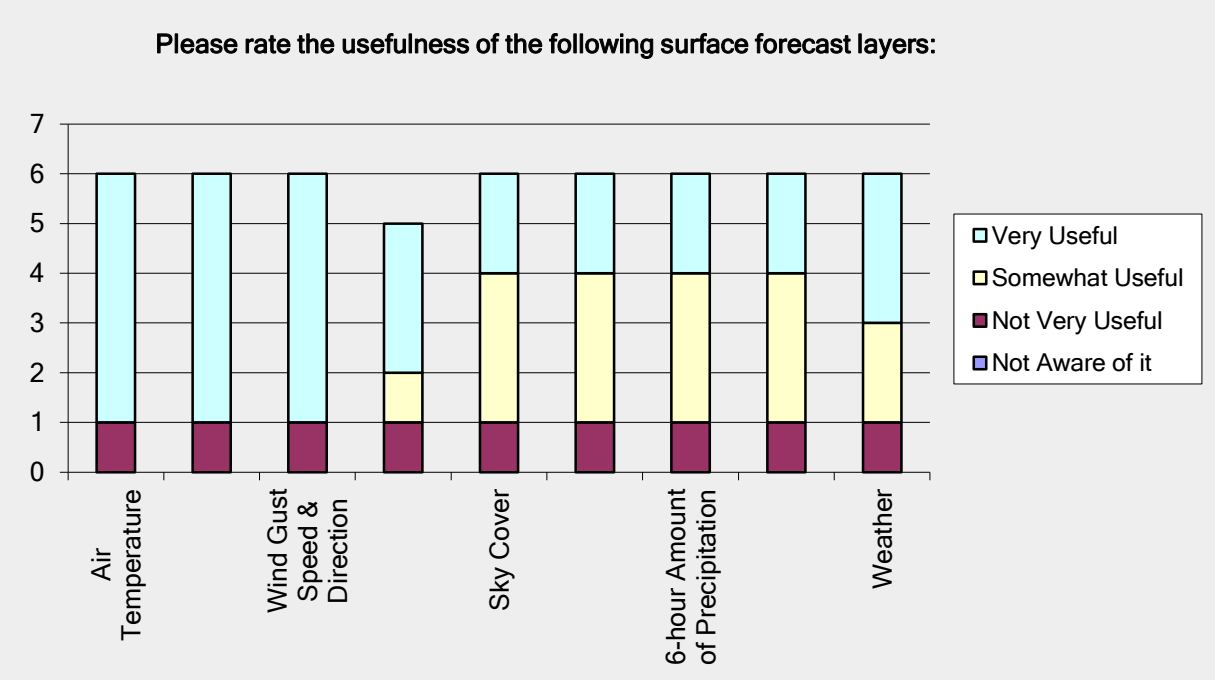

Figure 64: Focus Group Survey Response Chart – Usefulness of Surface Forecast Layers

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

Table 5: Focus Group Survey Response Tallies – Usefulness of 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
(optional) Comments:					0
answered question					**6**
skipped question					**1**

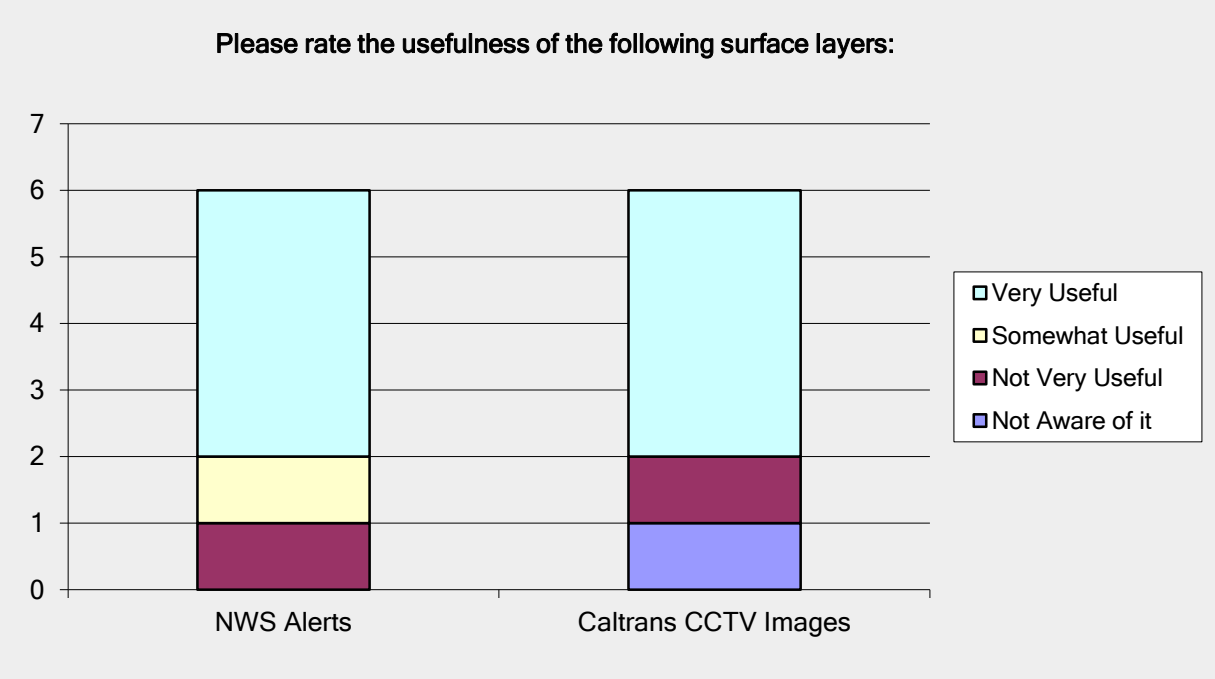

Figure 65: Focus Group Survey Response Chart – Usefulness of Surface Layers

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

Table 6: Focus Group Survey Response Tallies – Usefulness of 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
				(optional) Comments:	1
				answered question	**6**
				skipped question	**1**

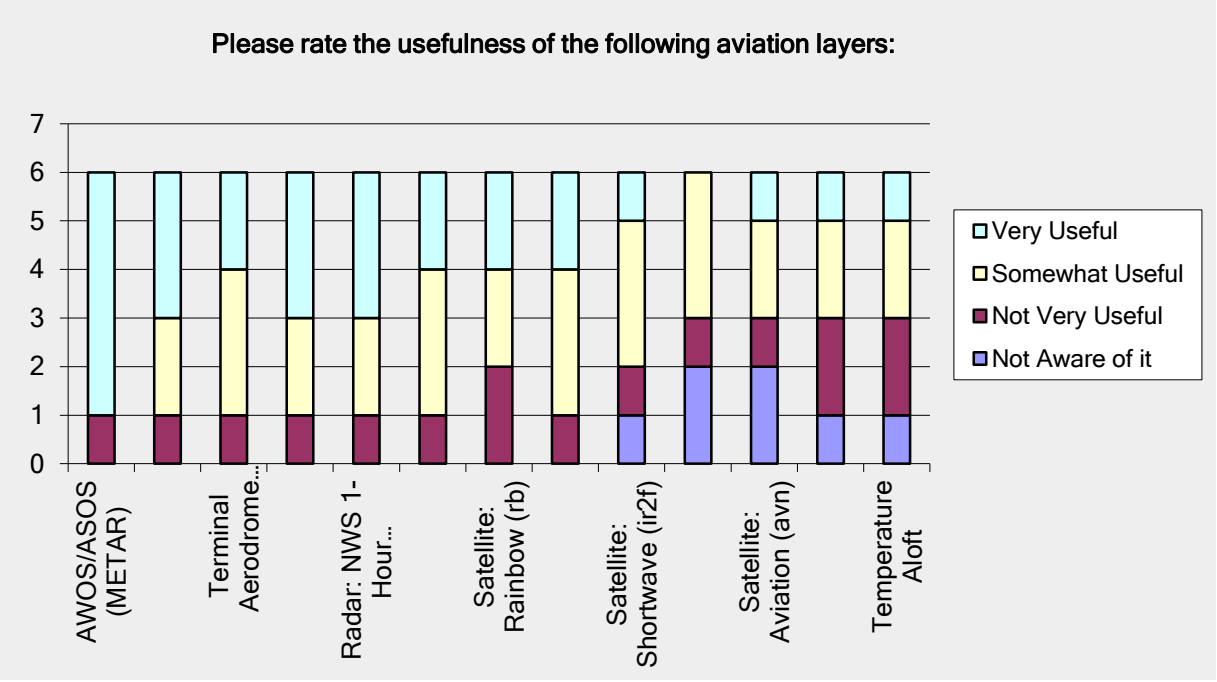

Figure 66: Focus Group Survey Response Chart – Usefulness of Aviation Layers

Comments:

- *I use it for getting weather info together, it seems to be more streamline then the Meso charts*

QUESTION: What is the greatest altitude for which you would use wind aloft and temperature aloft forecasts?

Table 7: Focus Group Survey Response Tallies – Altitudes of Wind and Temperature Aloft Forecasts

Answer Options	Response Percent	Response Count
3000 ft MSL (900 mb)	40.0%	2
6000 ft MSL (800 mb)	0.0%	0
9000 ft MSL (725 mb)	40.0%	2
12000 ft MSL (650 mb)	0.0%	0
15000 ft MSL (575 mb)	0.0%	0
Above 15000 ft MSL	20.0%	1
(optional) Comments:		1
answered question		**5**
skipped question		**2**

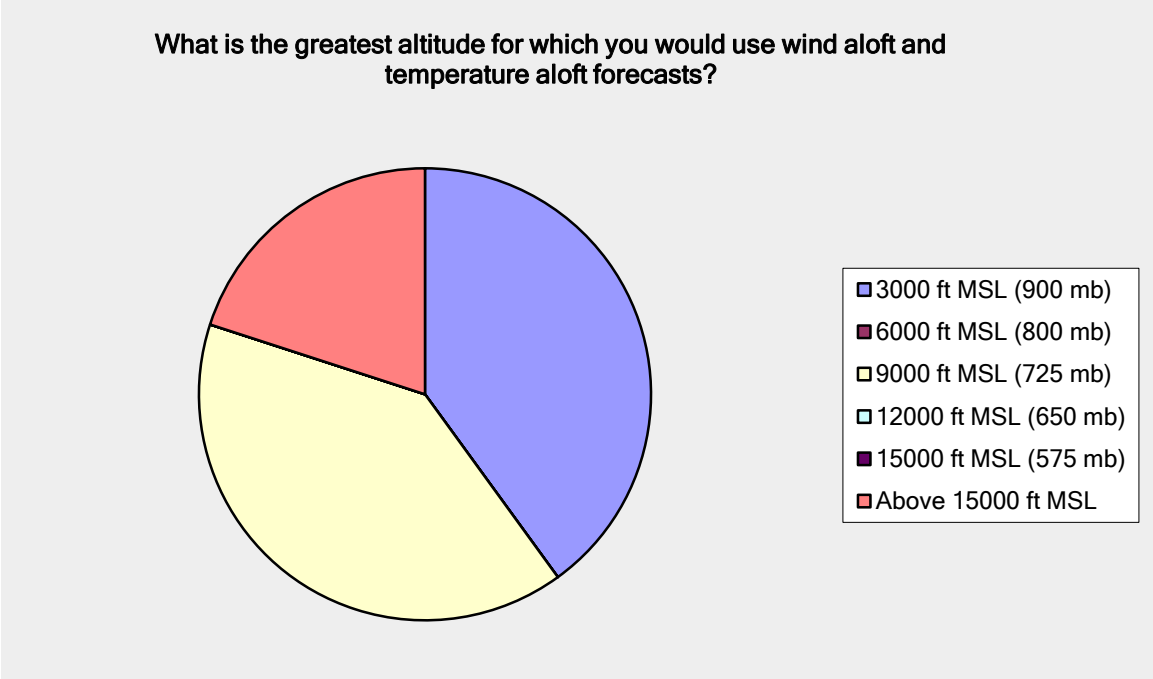

Figure 67: Focus Group Survey Response Chart – Altitudes of Wind and Temperature Aloft Forecasts

Comments:

- *Living in the mountains, it helps know what it is like up on the ridge*

QUESTION: What is the greatest timeframe for which you need wind and temperature aloft forecasts?

Table 8: Focus Group Survey Response Tallies - Timeframes of Wind and Temperature Aloft Forecasts

Answer Options	Response Percent	Response Count
Current Time Only	50.0%	3
1 Hour into the Future	0.0%	0
2 Hours into the Future	0.0%	0
3 Hours into the Future	16.7%	1
6 Hours into the Future	16.7%	1
12 Hours into the Future	0.0%	0
24 Hours into the Future	0.0%	0
36 Hours into the Future	0.0%	0
48 Hours into the Future	0.0%	0
72 Hours into the Future	16.7%	1
(optional) Comments:		0
answered question		**6**
skipped question		**1**

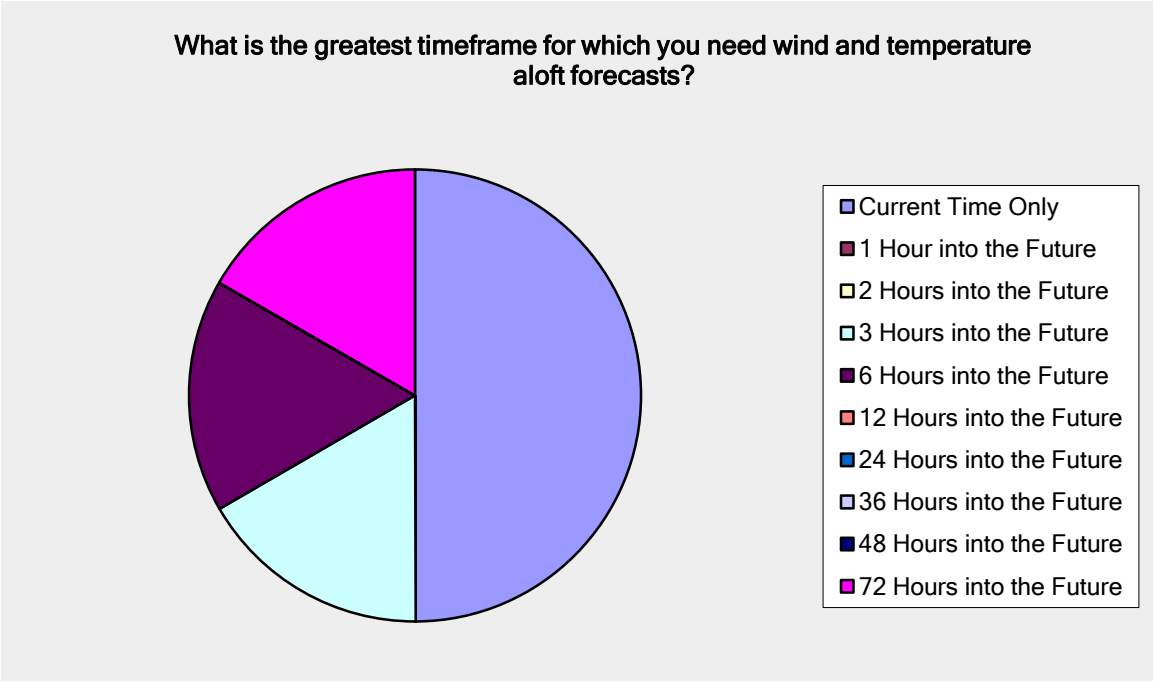

Figure 68: Focus Group Survey Response Chart - Timeframes of Wind and Temperature Aloft Forecasts

QUESTION: Please rate the usefulness of the following help features:

Table 9: Focus Group Survey Response Tallies – Usefulness of Help Features

Answer Options	Very Useful	Somewhat Useful	Not Very Useful	Not Aware of it	Response Count
Quick Start Guide	2	0	1	3	6
Basic Usage Video	2	0	1	2	5
(optional) Comments:					0
answered question					**6**
skipped question					**1**

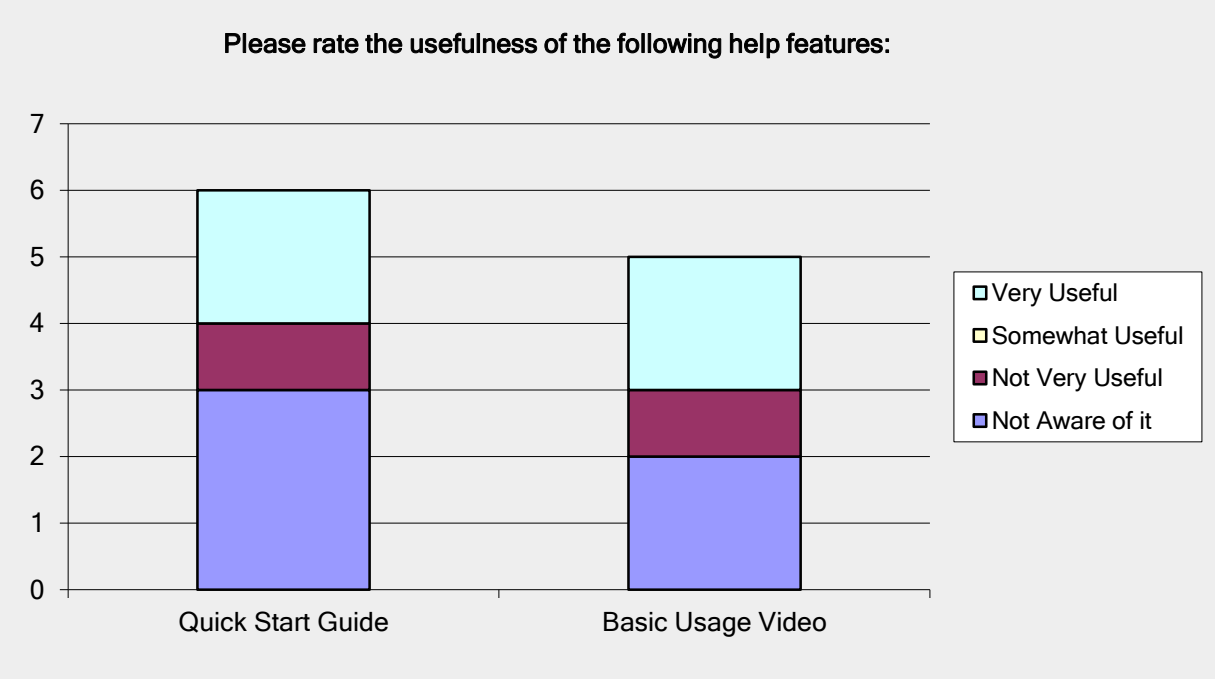

Figure 69: Focus Group Survey Response Chart – Usefulness of Help Features

QUESTION: Please rate the prototype system on the following criteria:

Answer Options	Excellent	Good	Poor	Very Poor	No Opinion	Response Count
Google Maps used for Base Maps	5	1	0	0	0	6
Click-able Icons and Information Balloons	4	2	0	0	0	6
Color-coded Information and Graphic Representation	4	2	0	0	0	6
Menus for Layer Selection	3	2	1	0	0	6
General Organization and Presentation of Website	2	4	0	0	0	6
Intuitive Display and Use	2	4	0	0	0	6
Auto Refresh of Display every 5 Minutes	3	1	0	0	2	6
Performance (Speed, etc.) of the Application	3	2	0	0	1	6
Accuracy of Information	4	2	0	0	0	6
Timeliness of Information	4	2	0	0	0	6
Reliability of the Website	3	3	0	0	0	6
Ease of Use	4	1	0	0	0	5
(optional) Comments:						2
answered question						**6**
skipped question						**1**

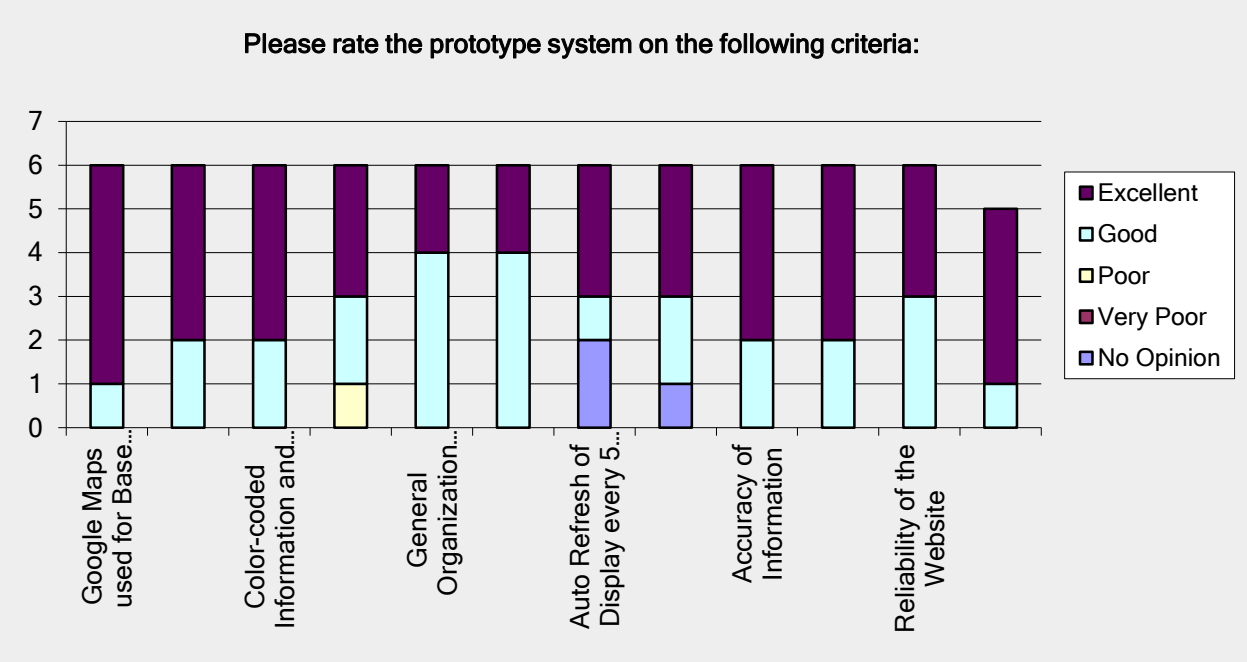

Figure 70: Focus Group Survey Response Chart – Usefulness of Other System Features

Comments:

- *Auto refresh should be 2 minutes.*

- *I wish there was a feature to be able to tweet the information to my followers in the County*

QUESTION: What additional information or functionality would you like to have, which is not available currently in the prototype system?

Table 10: Focus Group Survey Response Tallies – What additional information is needed?

Answer Options	Response Count
answered question	**1**
skipped question	**6**

Comments:

- *Being in a remote area, this is a great system to tap into to get automate results. We find it seamless and informative.*

QUESTION: What are the chief benefits of the prototype system to you? Please be as specific as possible.

Table 11: Focus Group Survey Response Tallies – Chief Benefits of the System

Answer Options	Response Count
answered question	1
skipped question	6

Comments:

- *i use it to teach student pilots about WX. It gives them an overall picture when they start using NOAA WX. It is surprising how few people understand WX and it's effects.*

QUESTION: Please indicate how the prototype system could be improved to better meet your needs. Consider information content, ease of use, quality of information, ability to understand what is presented and anything else that could make this site better.

Table 12: Focus Group Survey Response Tallies – How can the System be improved?

Answer Options	Response Count
answered question	2
skipped question	5

Comments:

- *It is great as is!*
- *Ability to forward information.*

QUESTION: How did you find out about the prototype system?

Table 13: Focus Group Survey Response Tallies – How did you find out about the System?

Answer Options	Response Percent	Response Count
Word of Mouth	16.7%	1
Recommendation of a Colleague	16.7%	1
Search Engine	16.7%	1
Social Media	0.0%	0
Email	33.3%	2
From another Website	16.7%	1
(optional) Comments:		2
answered question		**6**
skipped question		**1**

Comments:

- *State Aviation personnel told me about the web site. I started checking each section and learned what & how the information was presented and what it would offer. Each time it seem I get a better picture in my mind about it us and what it is telling me.*
- *I think NWS Eureka sent a tweet about it.*

QUESTION: What is your role in aviation and how does it relate to this project?

Table 14: Focus Group Survey Response Tallies – Role in Aviation

Answer Options	Response Count
answered question	3
skipped question	4

Comments:

- *Flight Instructor*
- *Pvt pilot*
- *I operate five airports in Trinity County.*

3.2.2. Summary

While the number of survey participants (seven) is small to date, those who participated provided useful feedback. Three participants identified their aviation role as being very relevant to the project: flight instructor, private pilot and airport operator in a rural county. Participants found out about the system in a number of ways including word of mouth, colleague recommendation including from state aviation personnel, email, search engine and links from other sites. One participant commented that the National Weather Service sent information via Twitter about the System.

Feedback was positive, with a number of constructive suggestions provided. One individual remarked that they learned more about the site and how to use it with each visit. This is a positive response given the amount of information presented by the System. Someone indicated that the ability to forward information would be an improvement. We interpret this to mean that they would like a mechanism to share information via social media sites such as Twitter or Facebook. Separately, a flight instructor indicated use of the system to teach student pilots about weather and its importance to flying. One other general suggestion included auto-refreshing the data every two minutes rather than every five minutes. While in principal it is desirable to have data as up to date as possible, care would need to be taken in implementing this so as not to have an adverse impact on users such as screen flash, closing markers that the user has opened and is reading, etc. Otherwise, users seemed satisfied with the auto-refresh rate and the performance of the application.

In terms of general system features, the only one that received a "Poor" rating was the menu system. One user rated this as poor while others rated it as "Good" or "Excellent". While a positive overall response regarding menus, perhaps the single negative response indicates room for improvement. For instance, it may be the case that this user considered the menus to be too small. Otherwise, all other general system features were ranked as "Good" or "Excellent". The use of Google Maps scored particularly high.

The System help features were given mixed ratings. Two respondents found the Quick Start Guide and Basic Usage Video to be "Very Useful" while one scored them as "Not Very Useful". Perhaps more concerning is that three indicated they were not aware of the Quick Start Guide while two indicated the same for the Basic Usage Video. These responses are likely a consequence of users not exploring the Help menu. While readily available via a link in the upper left corner of the application at all times, the Help menu is (intentionally) small and subtle. Note that links to the Quick Start Guide and Basic Usage Video were added to a welcome dialog that appears when the application is loaded and this adjustment was likely made subsequent to the responses to this survey question.

Respondents indicated that they anticipated using the system with varying frequency ranging from several times a day to rarely. Somewhat surprisingly, no one responded that they would use the system "At all Times". Given the small sample size and composition, perhaps this shouldn't be a surprise given the many responsibilities of people involved with general aviation in rural areas. Surprising also is that some respondents indicated usage on less than a daily basis. Depending on the type of system user, these responses could give an indication on the timeframes that should be included for forecast data in the system. Respondents also indicated potential use of the system at different times of day and in light of bad weather.

In regard to surface condition weather layers, respondents found all of these useful, although there was one response of "Not Very Useful" for each layer other than RWIS Stations and two responses of "Not Very Useful" for RWIS Stations. It may be the case here that users did not find it worthwhile to select the RWIS station markers for display versus seeing the more informative markers for other layers. Still, four respondents indicated that they thought the RWIS stations were "Very Useful". Air Temperature and Wind Speed & Direction were scored highest. In the comments, someone indicated a desire for a "better link to the station". It is unclear what specifically they were asking for.

The surface forecast layers ranked high as well, although again one respondent indicated "Not Very Useful" for all of these. No comments were provided for this question, so it is unclear why these low rankings were given. Otherwise, Air Temperature, Wind Speed & Direction and Wind Gust Speed & Direction received five "Very Useful" rankings and no "Somewhat Useful" rankings, indicating that these were viewed as most important to respondents. Other layers had responses split between "Very Useful" and "Somewhat Useful". The lower relative ranking of precipitation is somewhat surprising.

One respondent indicated that they were not aware of the Caltrans CCTV images in the surface layers menu. Again, this may indicate a short-coming of the menu system. One respondent indicated "Not Very Useful" for both Caltrans CCTV images and NWS Alerts. At this point it seems that one respondent may have simply clicked on the middle option for many of these questions. Otherwise, respondents seemed to find both NWS Alerts and Caltrans CCTV Images to be useful.

The aviation layers showed the most mixed results collectively of any of the data groupings in the System. Again, one respondent indicated "Not Very Useful" for all of these layers. An additional respondent indicated that one of the satellite layers and both the Wind Aloft and Temperature Aloft layers were not very useful. This was most surprising since it has been thought that the wind aloft layer was perhaps the most useful layer in the system. Wind Aloft and Temperature Aloft only received one vote each as being "Very Useful". Another concern here is that several respondents were unaware of the several of the Satellite layers and one respondent indicated unawareness of the Wind Aloft and Temperature Aloft layers. Arguably, since there are multiple satellite layers and an additional control is required to toggle between them, users may not dig far enough to find them. But, it is surprising that a respondent did not find the Wind Aloft and Temperature Aloft layers. The high ranking layer was the AWOS/ASOS layer. Since this layer is displayed by default, users certainly should be aware of it. And, the high ranking here may also be an indication of respondents' level of trust in this data.

Since the Wind Aloft and Temperature Aloft forecasts are given at multiple altitudes and different times, the project team has been interested in know which altitudes and times are relevant to prospective users of the system. Only one respondent indicated a need for forecasts at altitudes above 15,000 ft. AMSL. However, given this response, consideration may need to be given to showing forecasts at higher altitudes. In terms of timeframe, respondents indicated a need ranging from Current Time Only to 72 Hours into the Future. No change appears to be merited here.

Again, survey responses were positive. Some items were identified for further investigation. For example, there may be a need to refine the menu structure and to help users to be aware of the data layers that are available within the system. However, such a change must be balanced with

general usability and best use of screen space. To date efforts have been made to maximize the map and data displays on the screen. Enlarging menus would reduce the space available for displaying data.

3.3. Google Analytics Results

Google Analytics has been used to track system usage since Phase 1 of this project. In the Phase 1 prototype system, only sessions and users were tracked. A session corresponds to a single user's individual session in using the system. In the Phase 2 prototype system, event tracking was also implemented to provide feedback on what information users were accessing.

Google Analytics results are split into two subsections within this section corresponding to the Phase 1 and Phase 2 tracking approaches. Analysis of the data is presented with these subsections rather than as a separate subsection. Note that the Phase 1 tracking approach was used in early portions of the Phase 2 project while the Phase 2 system was developed.

3.3.1. Google Analytics Statistics: 6/1/2010 through 8/12/2013

Tracking via Google Analytics in Phase 1 initiated on June 1st, 2010 and concluded on August 12th, 2013. During this time there were 1141 sessions and 586 users who accessed the system. 1056 sessions came from locations in the United States; only a handful of sessions from other countries. Sessions were reported every US state except Maine. Table 15 shows session counts for the top eight states. Montana and California provided far and away the most sessions. Presumably these counts reflect access primarily from the WTI project team and from Caltrans. Access from other states was far lower, and likely resulted from related web searches.

Table 15: Phase 1 Session Counts by Top States and Corresponding Percent of US Sessions

1	Montana	469	44.41%
2	California	312	29.55%
3	Maryland	21	1.99%
4	Texas	21	1.99%
5	New York	19	1.80%
6	Florida	17	1.61%
7	Illinois	16	1.52%
8	Virginia	15	1.42%
	…	…	…
	TOTAL	**1056**	**100%**

The Phase 1 system was accessed from 45 communities in California. The top access counts by community are shown in Table 16. Sacramento provided the most sessions, again likely due to Caltrans access. Other communities such as Corning, Los Molinos, Redding and San Jose provided double-digit numbers of sessions. Note that most if not all of the sessions from San Jose likely came from the San Jose State project team.

Table 16: Phase 1 Session Counts by California Communities and Percent of California Sessions

1	Sacramento	129	41.35%
2	Corning	48	15.38%
3	Los Molinos	30	9.62%
4	Redding	17	5.45%
5	San Jose	10	3.21%
6	San Francisco	9	2.88%
7	Folsom	8	2.56%
8	Los Angeles	8	2.56%
9	Davis	5	1.60%
10	Santa Rosa	5	1.60%
	…	…	…
	TOTAL	**312**	**100%**

Table 17 shows referring sites for access to the Phase 1 system. Referring sites are those that provide links that were followed to initiate user sessions. Nearly 70% of all access to the site came via a direct link. Almost 18% of sessions came via Google searches. Bing and Yahoo, as well as other search engines, provided a lesser number of sessions. The westernstates.org website, which provides documentation and background on the project, served links that resulted in nearly 7% of all sessions. There also was at least one reference to the site on Facebook, and cessna172club.com provided links that resulted in 14 sessions, just over 1% of all sessions.

Table 17: Phase 1 Session Counts by Referring Site

1	(direct) / (none)	777	68.10%
2	google / organic	204	17.88%
3	westernstates.org / referral	79	6.92%
4	cessna172club.com / referral	14	1.23%
5	bing / organic	12	1.05%
6	yahoo / organic	7	0.61%
7	facebook.com / referral	5	0.44%
8	strongmail.multiview.com / referral	5	0.44%
		…	…
	TOTAL	**1141**	**100%**

3.3.1. Google Analytics Statistics: 8/13/2013 through 9/30/2015

Tracking via Google Analytics in Phase 1 initiated on August 13, 2013.

Tracking via Google Analytics in Phase 2 initiated on August 13, 2013 and continued through Phase 2. In this section, we present data from on August 13, 2013 through September 30, 2015. During this time there were 2883 sessions and 1261 users who accessed the system. 2833 sessions came from locations in the United States; only 50 sessions came from other countries. The most sessions in one day was 50 which occurred on Tuesday, October 22nd, 2013.

Figure 71 shows sessions over time for the Phase 2 system. Note that there was more activity in late 2013 and early 2014 than during the remainder of the time shown. This likely is due to development and outreach activity that occurred during that time.

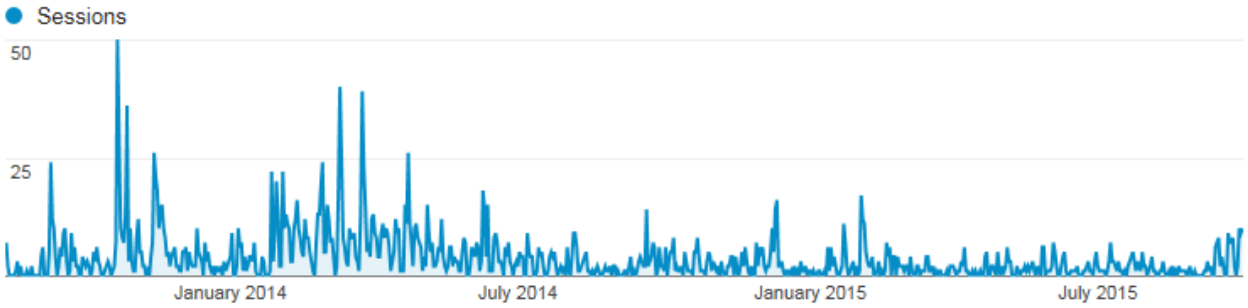

Figure 71: Phase 2 Sessions over Time

Of the 2833 sessions that originated in the U.S., 1643 came from California and 1049 came from Montana. Again, this is likely a reflection of heavy use from Caltrans and the WTI project team. Sessions originated from a total of 39 states. Table 18 shows sessions counts from the top states for Phase 2.

Table 18: Phase 2 Session Counts by California Communities and Percent of California Sessions

1	California	1,643	58.00%
2	Montana	1,049	37.03%
3	Nevada	21	0.74%
4	Texas	14	0.49%
5	New York	10	0.35%
6	Washington	10	0.35%
7	South Dakota	7	0.25%
8	Arizona	6	0.21%
9	Florida	6	0.21%
10	Oregon	6	0.21%
		…	…
	TOTAL	**2833**	**100%**

Sessions originated in 128 communities in California. Figure 72 the locations and relative amounts of sessions from California communities and Table 19 shows the top communities in terms of session counts. Note that while Sacramento and Redding provided the most sessions, presumably from Caltrans use, a large number of other communities sent users to the system.

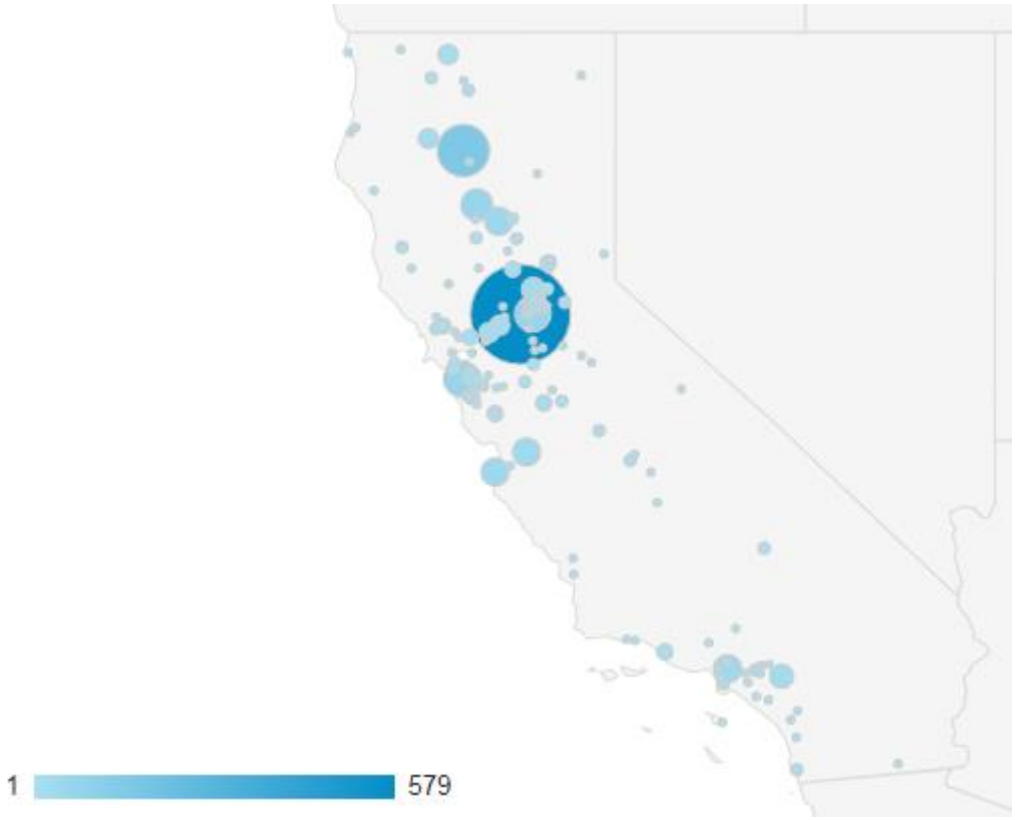

Figure 72: Phase 2 Sessions from California Communities

Table 19: Phase 2 Session Counts by California Communities and Percent of California Sessions

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%

The inclusion of event tracking in the Phase 2 system provided a greater opportunity to observe what users did while using the system. An event was used to track what can be loosely defined as a user interaction with the system. Items tracked by way of events include layer and sublayer selections, clicking on markers, changing the map type and following links. While an effort was made to track as much detail as possible, there were some inadvertent omissions. For instance, top-level selections of the Help menu were not tracked. This omission was not intentional.

From August 13, 2013 through September 30, 2015, 33,314 events were recorded. There were 18,048 layer and sublayer selection events, 15,118 marker selection events, and 122 map type change events.

Table 20 shows events generated by the selection of items from the Help menu. Again note that selections of the Help menu were not recorded. All items in the Help menu received usage, with the Quick Start Guide being access 49 times, the most for any of these items.

Table 20: Help Menu Selections

Quick Start Guide	49
Basic Usage Video	47
About	38
Provide Feedback (Survey)	26

In Table 21 we show selections of the surface conditions menu and its sublayers. By default, selection of the surface conditions menu will display the menu as well as the sublayer that was last selected from the menu. The Air Temperature sublayer will be shown if no prior selections have been made from this menu. A menu select event is generated when the surface conditions menu is selected. No event is generated to indicate the default sublayer that was shown. As such, users will have viewed the air temperature layer more than is indicated in the table. The wind speed sublayer was most frequently accessed. Air temperature was accessed fairly frequently as well, particularly given that it was shown by default upon first access to the menu. Other sublayers were less popular, with the humidity sublayer receiving the least access.

Table 21: Surface Conditions - Layer and Sublayer Events

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

Table 22 shows marker selection events for surface conditions markers. These markers are intended to be as informative as possible, using size, shape and color-coding in addition to labeled to indicate the condition represented. Again, Air Temperature and Wind Speed received more clicks than other markers. RWIS station markers received a large number of clicks too. This isn't surprising since it is necessary to click on these markers to see conditions at the RWIS sites.

Table 22: Surface Conditions - Marker Selection Events

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

In Table 23 we show selections of the surface forecast menu and its sublayers. By default, selection of the surface forecast menu will display the menu as well as the sublayer that was last selected from the menu. The Air Temperature forecast sublayer will be shown if no prior selections have been made from this menu. A menu select event is generated when the surface forecast menu is selected. No event is generated to indicate the default sublayer that was shown. As such, users will have viewed the air temperature forecast layer more than is indicated in the table. The wind speed sublayer was most frequently accessed. The weather sublayer was accessed fairly frequently as well, followed by the wind gust speed forecast. Other sublayers were less popular, with the humidity sublayer receiving the least access. The snow sublayer also received a relatively small number of selections. This is likely attributable to the limited time (and locations) in which there is snow in the state. The air temperature sublayer received a low number of selections too, which may be attributable to its usage as the default forecast layer.

Table 23: Surface Forecast - Layer and Sublayer Events

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 for the surface forecast layer results in little added information beyond what is shown by the marker alone. See Table 24. Again, efforts were made to make the markers as informative as possible, minimizing user's need to seek further information. Unlike some of the markers for other sublayers such as those for precipitation, sky cover, snow and humidity, the wind markers do not shown exact numeric indications of forecast wind speeds. Instead they show color-coded, sized and directed arrow-shaped markers to indicate forecast magnitude and direction of wind. As such, users may desire more specific information resulting in a larger number of wind-related marker selections. The most marker selections for surface forecast markers was for the weather markers. Markers such as sunshine, clouds, rain clouds, etc. are used to represent the corresponding forecast condition. Perhaps these markers are not fully recognized by users, causing them to select the markers for further information. Snow markers and humidity markers results in very few selections.

Table 24: Surface Forecast - 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

Table 25 shows selection events for the surface layers menu and its sublayers: Caltrans CCTV and NWS Alerts. Table 26 shows marker selection events for these sublayers. Both Caltrans CCTV and NWS alerts require clicks to show further detail, camera images for CCTV and descriptions for NWS alerts, so it isn't surprising that these makers received a lot of clicks. The Caltrans CCTV markers received the most clicks of any marker type other than AWOS/ASOS, showing the popularity of CCTV images in the system.

Table 25: Surface Layers - Layer and Sublayer Events

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

Table 26: Surface Layers - Marker Selection Events

Caltrans CCTV	2832
NWS Alerts	492

In Table 27 we show selection events for the aviation layers and sublayers. The aviation layer is the default layer for the system, and is shown when users first access the system. Menu select events for the layer are not generated for this default display. They are generated only for direct selection of the aviation menu. The AWOS/ASOS sublayer is the default sublayer for the aviation layers. And event is not generated for the default display of this sublayer. As such, the AWOS/ASOS sublayer appears to be very popular in addition to its usage as the default layer. Otherwise, the wind aloft sublayer appears to be most popular. Most sublayers in this set receive a higher number of selections that those in other layers, so it appears that all are considered useful. The temperature aloft layer, if any, would be considered the least useful, with less selections than the static airports layer.

Table 27: Aviation Layers - Layer and Sublayer Events

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

Table 28 shows marker selection events for aviation sublayers. Note that the satellite, NWS composite reflectivity and NWS 1-Hour precipitation layers do not use markers. The AWOS/ASOS markers received the most selections of any markers in the system. However, detail for a default marker is always shown open in this layer and this is counted as a selection event. This is done to show users what information is available and to encourage them to select other markers. So, reducing the count to reflect approximately 2883 sessions that displayed and counted this default marker selection would result in approximately 4000 events for AWOS/ASOS marker selections, which still more than that for CCTV. The pilot reports and terminal aerodrome forecasts markers show only locations, so it not surprising that users selected these markers many times to see further detail. Wind aloft markers were selected quite often too, indicating that users were seeking information beyond just the colored arrows. Note that when forecast wind aloft speeds are high, there can be many markers representing speeds over 50 mph, and there is little difference in these markers. While we have intentionally used the same markers as for the surface forecasts, it may be necessary to do more to differentiate the markers for strong winds.

Table 28: Aviation Layers - Marker Selection Events

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

Table 29 shows map type change events, indicating user selection of a different map type. While there weren't a lot of events of this type, there were enough to show that this functionality is useful to some users. The hybrid view was the change selected most, and shows satellite imagery with road and label information superimposed on top. The terrain view shows a topographic relief map version of the Google Maps base map, and was also selected a number of times. The map view is the default map view, and selections of that option represent users returning to the default map view from another view.

Table 29: Map Type Change Events

Hybrid	59
Terrain	33
Map	29
Satellite	1

Table 30 shows referring sites for access to the Phase 2 system. Referring sites are those that provide links that were followed to initiate user sessions. Over 80% of all access to the site came via a direct link. 3% of sessions came via Google searches and other search engines provided a lesser number of sessions. The Western States Rural Transportation Consortium (www.westernstates.org) website, which provides documentation and background on the project, served links that resulted in approximately 3.5% of all sessions. There were also references to the site on Facebook. The only noticeable link from a pilot-oriented site was from calpilots.org, which posted an issue of a Cal Aero newsletter published by Caltrans that included an article about the project:

http://calpilots.org/attachments/article/2778/CalAero-Newsletter-Winter-January%202014%20-2.pdf.

This link resulted in 36 sessions.

Table 30: Phase 2 Session Counts by Referring Site

1	(direct) / (none)	2,310	80.12%
2	westernstates.org / referral	103	3.57%
3	google / organic	94	3.26%
4	similarsites.com / referral	69	2.39%
5	us-mg204.mail.yahoo.com / referral	50	1.73%
6	calpilots.org / referral	36	1.25%
7	t.co / referral	33	1.14%
8	webmail.inreach.com / referral	29	1.01%
9	wtiwebdev.coe.montana.edu / referral	28	0.97%
10	bing / organic	26	0.90%
11	facebook.com / referral	20	0.69%
12	semalt.semalt.com / referral	20	0.69%
13	us-mg5.mail.yahoo.com / referral	12	0.42%
14	yahoo / organic	11	0.38%
		…	…
	TOTAL	**2883**	**100%**

4. AWOS/ASOS GAP ANALYSIS

In the AWOS/ASOS Gap Analysis Report we presented an analysis of the spatial coverage of the Aviation WeatherShare System versus that of AWOS/ASOS alone and other configurations of actively reporting weather sensing sites such as AWOS/ASOS plus RWIS sites and AWOS/ASOS plus RWIS plus MADIS plus MesoWest. We demonstrated that the coverage of the state is increased dramatically by way of the Aviation WeatherShare System. We further identified regions where coverage is still lacking in terms of coverage for weather information.

It is important to note that the gap analysis was conducted in light of the data feeds used by the prototype System and data from early 2015. As such, it may not fully reflect the current availability of this data nor the full extent to which weather stations have been deployed. For instance, we understand that there are RWIS units deployed in Caltrans District 9 (near Bishop), but the data from these RWIS units is not available to us. As such, further investigation should be conducted before using the analysis presented here for the purpose of deploying new sites.

In this section we present the results of our gap analysis at a high level. For further detailed information, please see the following 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.

We first investigated the coverage of the various configurations of weather sites relative to the entire state of California. This situation represents the potential for flight paths and landings of Emergency Medical System (EMS) flights to occur nearly anywhere within the state, particularly in rural areas. Relative to reporting AWOS/ASOS sites, the coverage of the state is poor, with much of the far northern part of the state falling more than 25 miles from the nearest site. The east central and southeastern portions of the state are also poorly covered, as is a portion of the west central part of the state. See Figure 73.

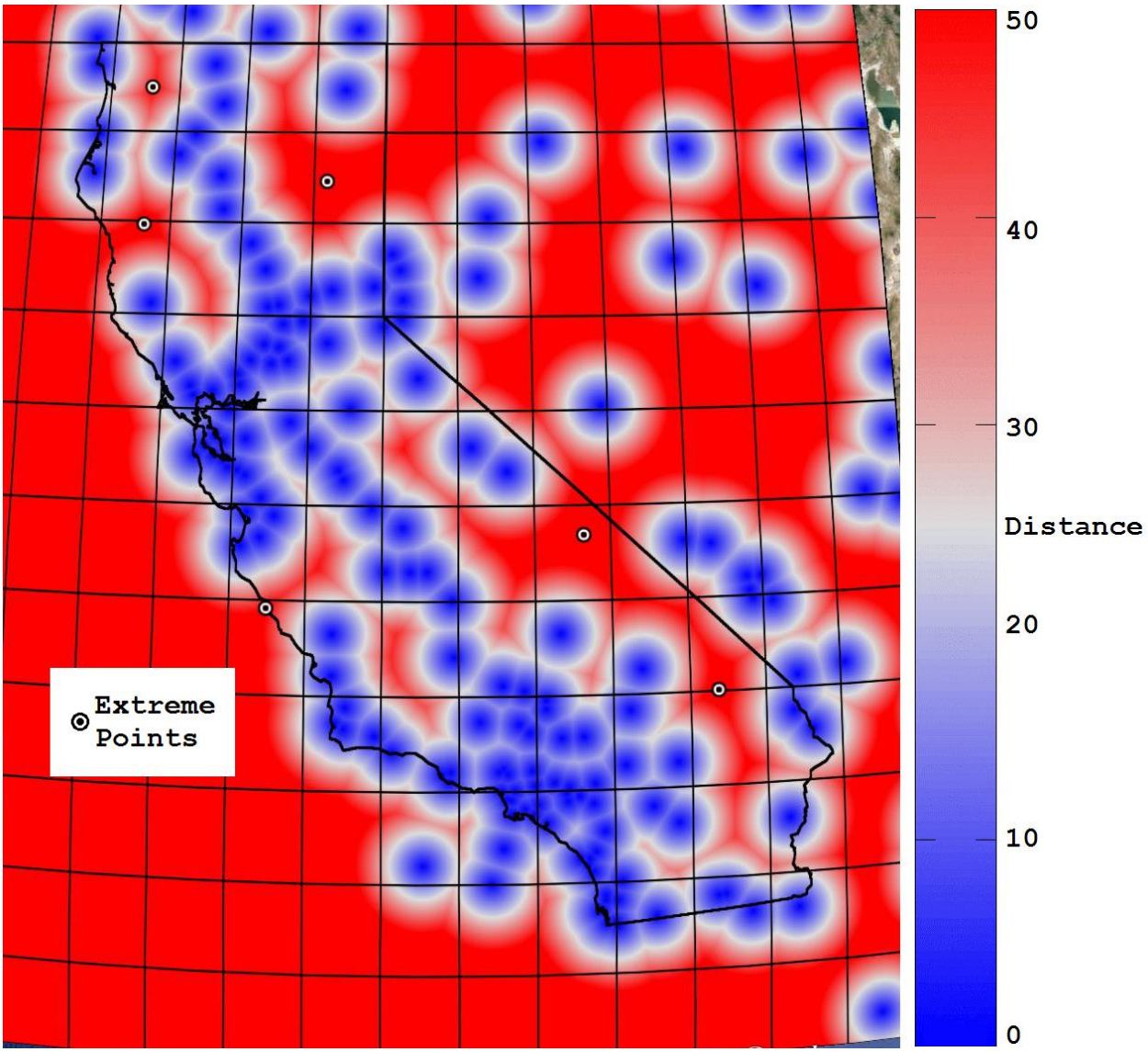

Figure 73: Heat Map Showing Distances (mi) to the Nearest Reporting AWOS / ASOS Site from All Locations in California and Extreme Points within Areas of Poor Coverage (Blue = less than 25 miles from nearest site, White = 25 miles from nearest site, Red = more than 25 miles to nearest site)

If RWIS sites are included along with AWOS/ASOS sites, then coverage improves in the far northeastern portion of the state and a little in the west central areas, but not in other areas. See Figure 74.

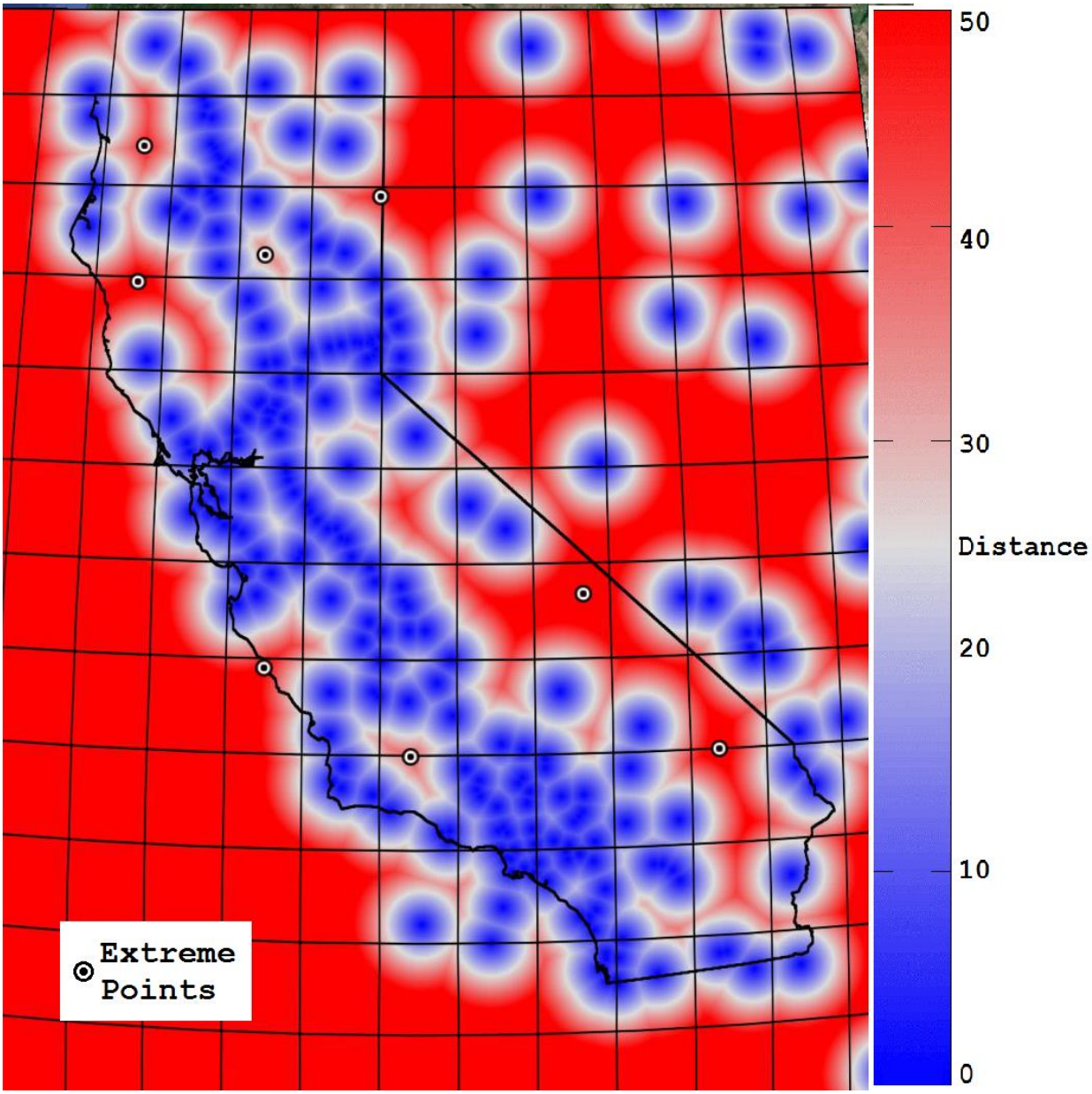

Figure 74: Heat Map Showing Distances (mi) to the Nearest Reporting AWOS / ASOS / RWIS Site from All Locations in California and Extreme Points within Areas of Poor Coverage (Blue = less than 25 miles from nearest site, White = 25 miles from nearest site, Red = more than 25 miles to nearest site)

The addition of MADIS and MesoWest data provides a dramatic improvement in coverage of the state, even with the requirement of including only sites that report with 15 minute or better frequency for data that has passed provider quality control checks. However, some large areas still remain poorly covered, particularly in the east central and south eastern portion of the state as well in the northern part of the state. See Figure 75.

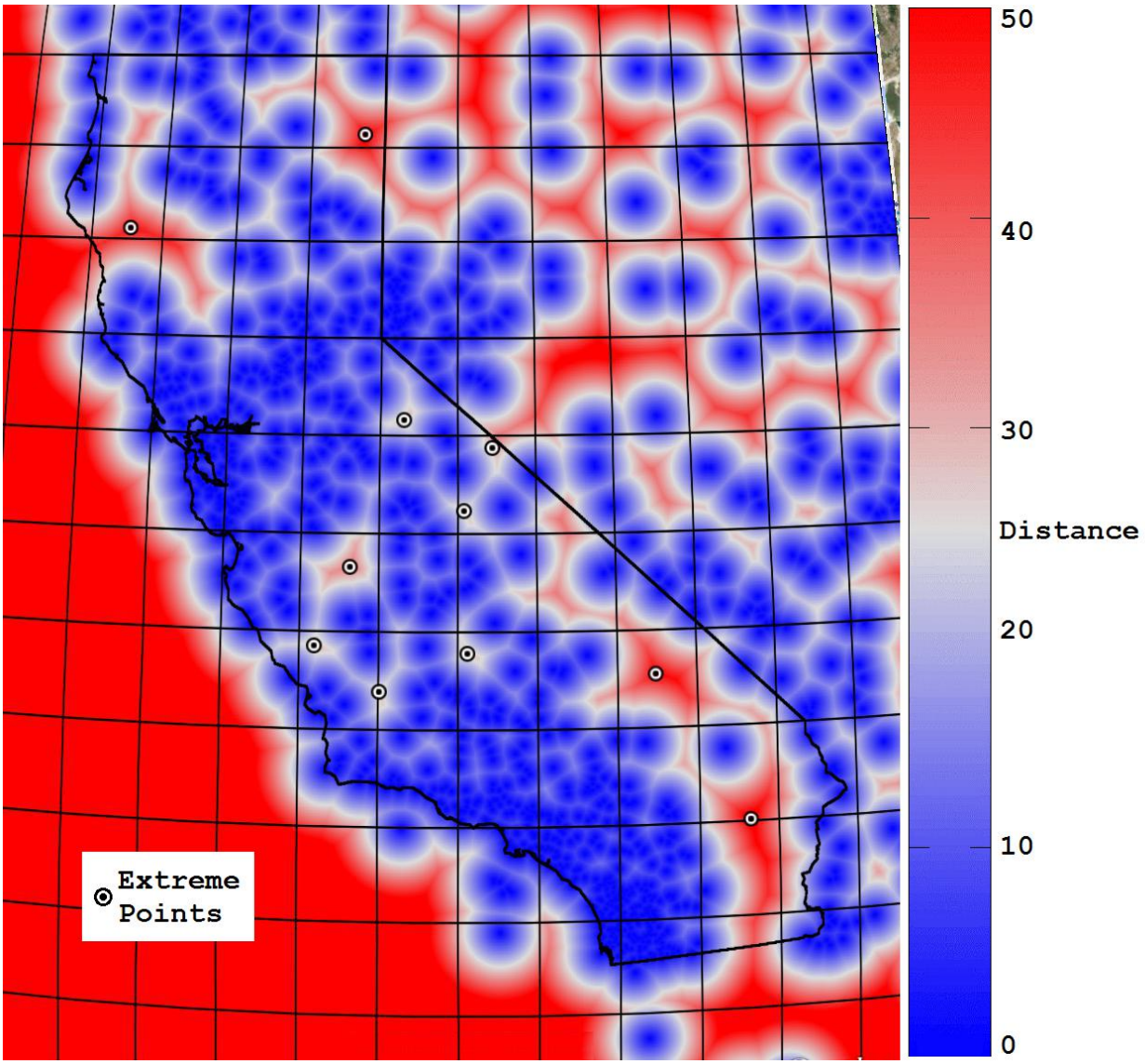

Figure 75: Heat Map Showing Distances (mi) to the Nearest Reporting AWOS / ASOS / RWIS / MADIS / MesoWest Site with QC-Passed Observations and Reporting Frequency of 15 Minutes or Better from All Locations in California and Extreme Points within Areas of Poor Coverage (Blue = less than 25 miles from nearest site, White = 25 miles from nearest site, Red = more than 25 miles to nearest site)

We next investigated the coverage of various configurations relative to airports. As might be expected, many of the airports are located near or have their own reporting AWOS or ASOS and we believe others may have onsite AWOS/ASOS that do not report data to the providers we use. There are 40 airports, 16.7% of those we analyzed, that fall 25 miles or more from the nearest reporting AWOS/ASOS. See Figure 76 and Table 31.

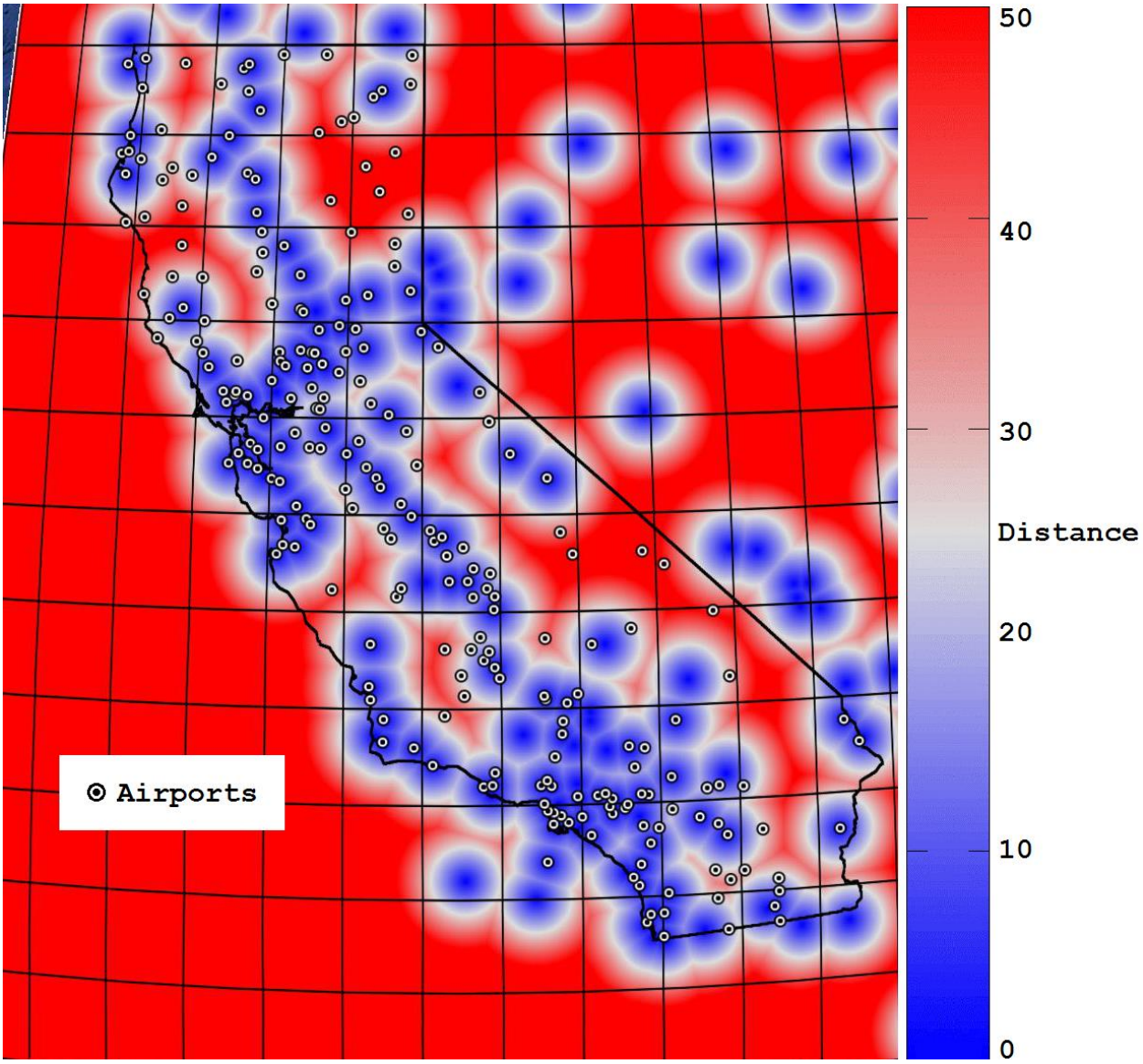

Figure 76: Airports Relative to Heat Map for Coverage from Reporting AWOS-ASOS (Blue = less than 25 miles from nearest site, White = 25 miles from nearest site, Red = more than 25 miles to nearest site)

Table 31: Airports that are More Than 25 Miles from the Nearest Reporting AWOS/ASOS Site

Name	City	County	AWOSASOS
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

When reporting RWIS sites are added to AWOS/ASOS, the number of airports that are 25 miles or further from the nearest reporting site is reduced to 30 (12.%) of the airports. See Figure 77 and Table 32.

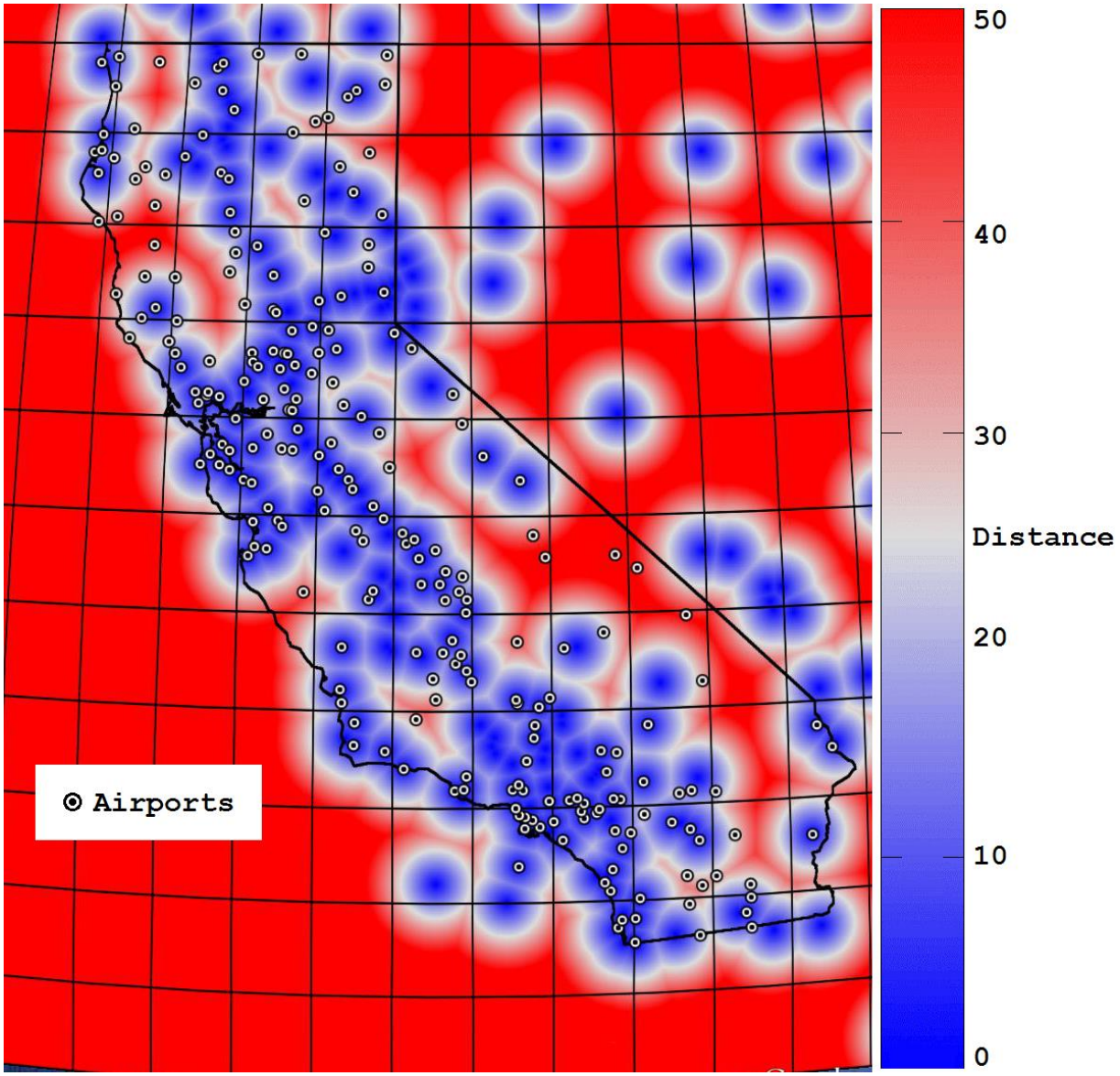

Figure 77: Airports Relative to Heat Map for Coverage from Reporting AWOS-ASOS or RWIS (Blue = less than 25 miles from nearest site, White = 25 miles from nearest site, Red = more than 25 miles to nearest site)

Table 32: Airports that are More Than 25 Miles from the Nearest Reporting AWOS/ASOS or RWIS Site

Name	City	County	AWOSASOSRWIS
STOVEPIPE WELLS AIRPORT	Death Valley National Park	Inyo	62.64
LONE PINE AIRPORT	Lone Pine	Inyo	56.46
FURNACE CREEK AIRPORT	Death Valley National Park	Inyo	48.48
SHOSHONE AIRPORT	Shoshone	Inyo	46.94
ROUND VALLEY AIRPORT	Covelo	Mendocino	46.45
HAPPY CAMP AIRPORT	Happy Camp	Siskiyou	41.20
KERN VALLEY AIRPORT	Kernville	Kern	40.98
MESA DEL REY AIRPORT	King City	Monterey	39.89
RUTH AIRPORT	Ruth	Trinity	39.85
INDEPENDENCE AIRPORT	Independence	Inyo	39.25
SHELTER COVE AIRPORT	Shelter Cove	Humboldt	36.21
GARBERVILLE AIRPORT	Garberville	Humboldt	36.13
RAVENDALE AIRPORT	Ravendale	Lassen	35.97
OCOTILLO AIRPORT	Ocotillo Wells	San Diego	33.39
SOUTHARD FIELD AIRPORT	Bieber	Lassen	32.38
NEW CUYAMA AIRPORT	New Cuyama	Santa Barbara	31.83
LITTLE RIVER AIRPORT	Little River	Mendocino	31.23
BAKER AIRPORT	Baker	San Bernardino	30.32
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
MARIPOSA YOSEMITE AIRPORT	Mariposa	Mariposa	27.13
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
HYAMPOM AIRPORT	Hyampom	Trinity	26.28

And, when MADIS and MesoWest sites with reporting frequency of 15 minutes or better for observations that pass provider quality checks, the number reduces further to 18 airports that are 25 miles or further from such a site. If any of these 18 sites is not served by a local AWOS or ASOS, then consideration should be given to deploying there. See Figure 78 and Table 33.

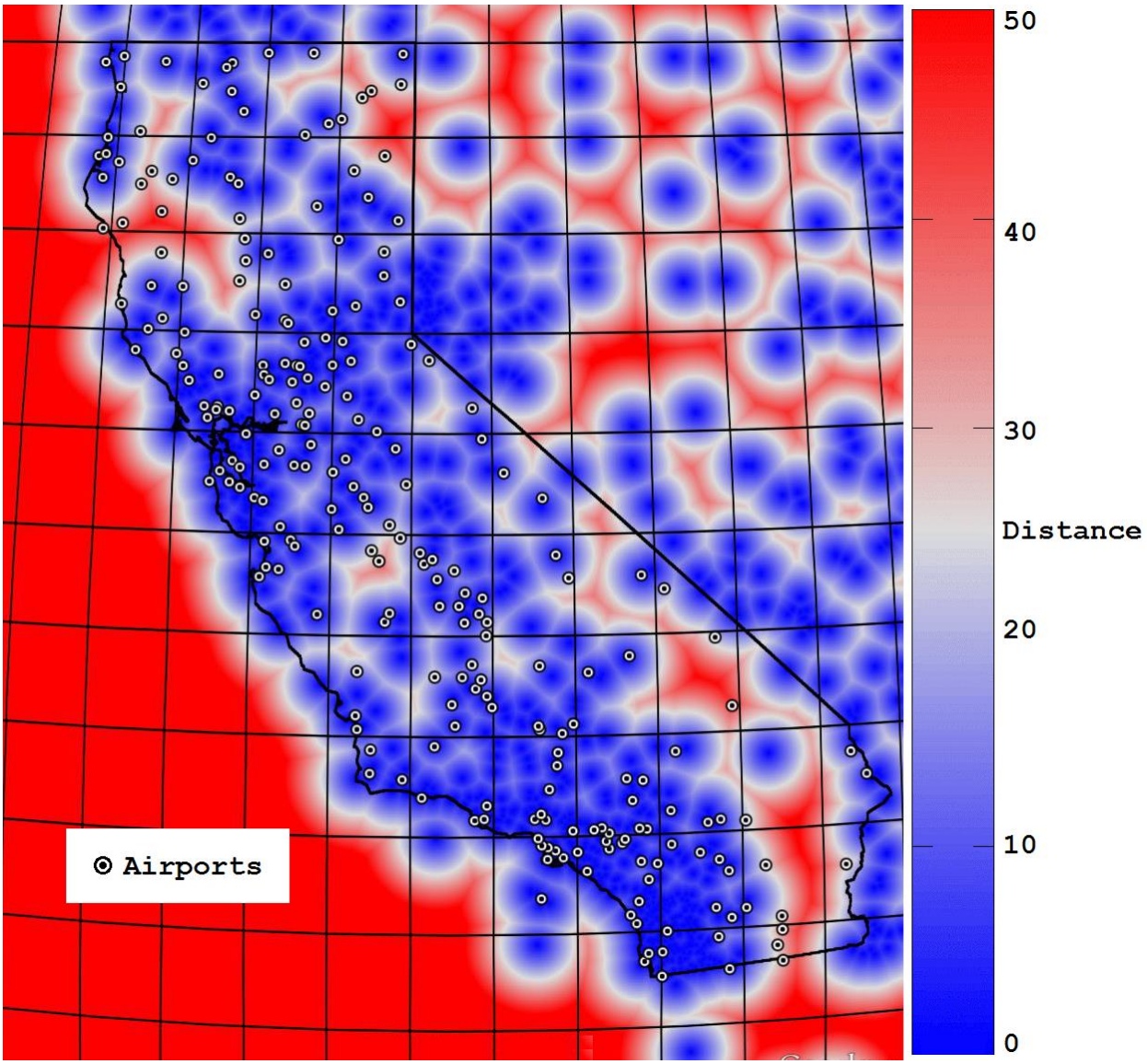

Figure 78: Airports Relative to Heat Map for Coverage from Reporting AWOS / ASOS / RWIS / MADIS / MesoWest Site with QC-Passed Observations and Reporting Frequency of 15 Minutes or Better (Blue = less than 25 miles from nearest site, White = 25 miles from nearest site, Red = more than 25 miles to nearest site)

Table 33: Airports that are More Than 25 Miles from the Nearest Reporting AWOS / ASOS / RWIS / MADIS / MesoWest Site with QC-Passed Observations with Reporting Frequency of 15 Minutes or Better

Name	City	County	ALL
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

We finally investigated the coverage of various configurations of weather sites relative to hospital heliports. This analysis corresponds to take-offs and landings from these facilities, but not to the flight paths or landings used for incidents in the field. Refer to the analysis for coverage of the state to better assess situations. Most of the hospital heliports are located in urban areas and are located in proximity to existing AWOS/ASOS sites, and especially to other weather sites. Thus, the gaps aren't as great for these facilities. There are 8 (5%) of the hospital heliports located 25 miles or more from the nearest reporting AWOS/ASOS site. See Figure 79 and Table 34.

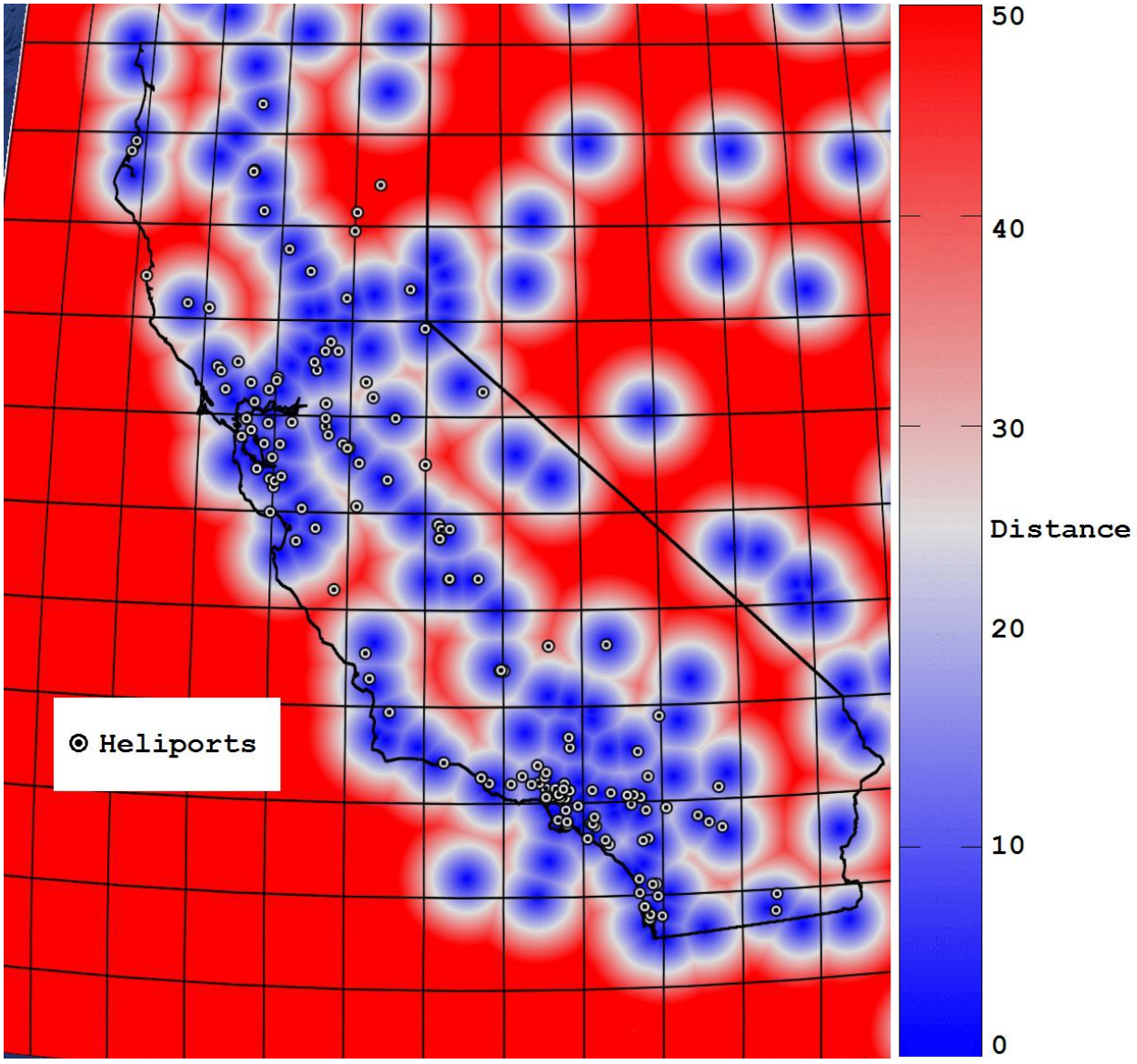

Figure 79: Heliports Relative to Heat Map for Coverage from Reporting AWOS-ASOS (Blue = less than 25 miles from nearest site, White = 25 miles from nearest site, Red = more than 25 miles to nearest site)

Table 34: Hospital Heliports that are More Than 25 Miles from the Nearest Reporting AWOS / ASOS Site

Name	City	County	AWOS-ASOS
Banner Lassen Medical Center HP	Susanville	Lassen	66.17
Indian Valley Hospital HP	Greenville	Plumas	53.46
Plumas District Hospital HP	Quincy	Plumas	46.37
George L Mee Memorial Hospital HP	King City	Monterey	41.30
Mendocino Coast District Hospital HP	Fort Bragg	Mendocino	38.60
Kern Valley Hospital HP	Lake Isabella	Kern	34.88
John C Fremont Healthcare District HP	Mariposa	Mariposa	32.50
Sutter Amador Hospital HP	Jackson	Amador	25.52

If RWIS sites are included, then the number of hospital heliports that are more than 25 miles from the nearest reporting site reduces to 5. See Figure 80 and Table 35.

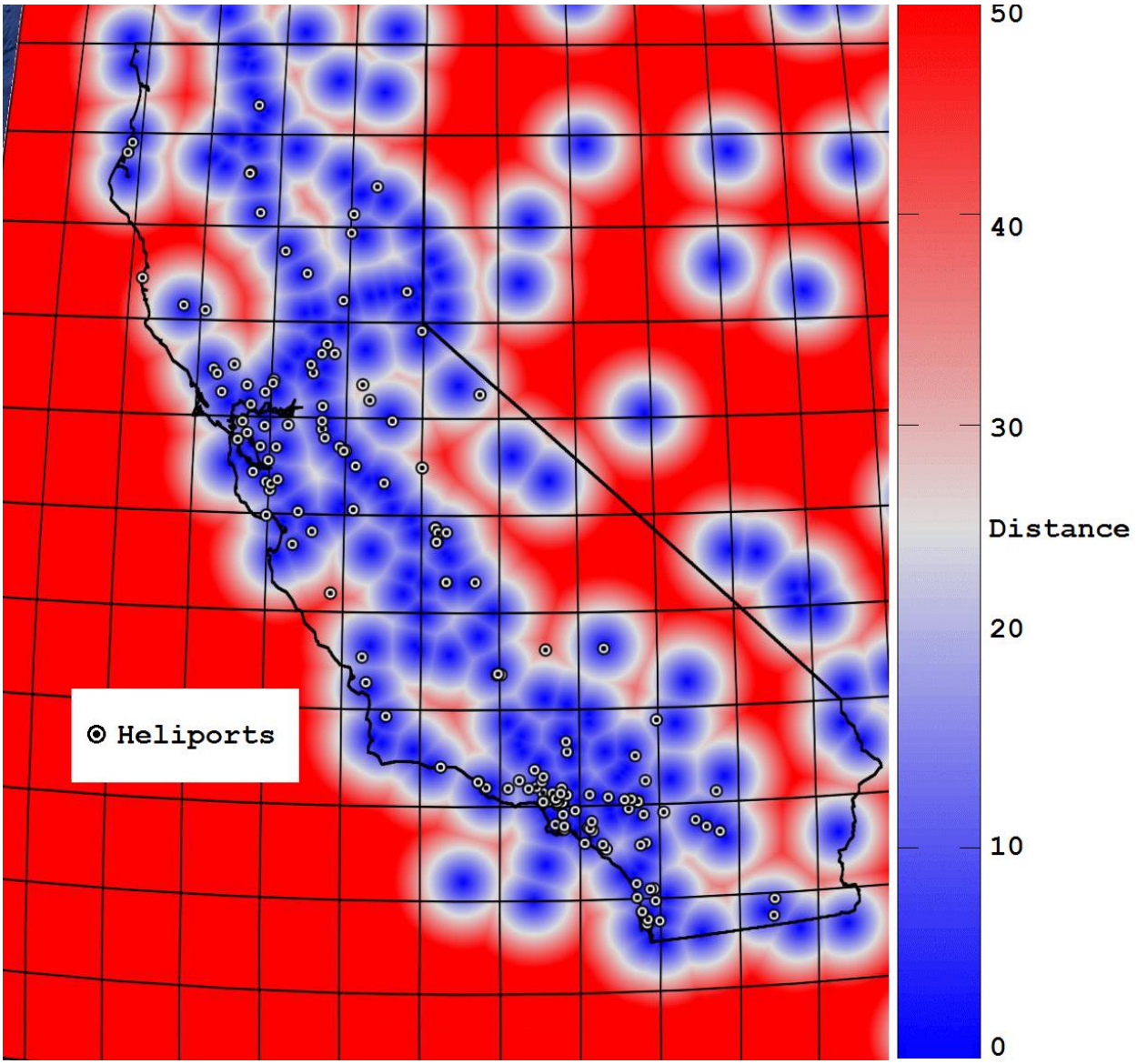

Figure 80: Heliports Relative to Heat Map for Coverage from Reporting AWOS-ASOS or RWIS (Blue = less than 25 miles from nearest site, White = 25 miles from nearest site, Red = more than 25 miles to nearest site)

Table 35: Hospital Heliports that are More Than 25 Miles from the Nearest Reporting AWOS/ASOS or RWIS Site

Name	City	County	AWOS-ASOS-RWIS
George L Mee Memorial Hospital HP	King City	Monterey	41.30
Mendocino Coast District Hospital HP	Fort Bragg	Mendocino	38.60
Kern Valley Hospital HP	Lake Isabella	Kern	34.88
John C Fremont Healthcare District HP	Mariposa	Mariposa	29.57
Sutter Amador Hospital HP	Jackson	Amador	25.52

When data from MADIS and MesoWest is included as previously described, then only two hospital heliports are located 25 miles or more from the nearest weather station. Both of these heliports are located in Imperial County, and further investigation may be merited to determine if these sites are truly underserved. See Table 36 and Figure 81.

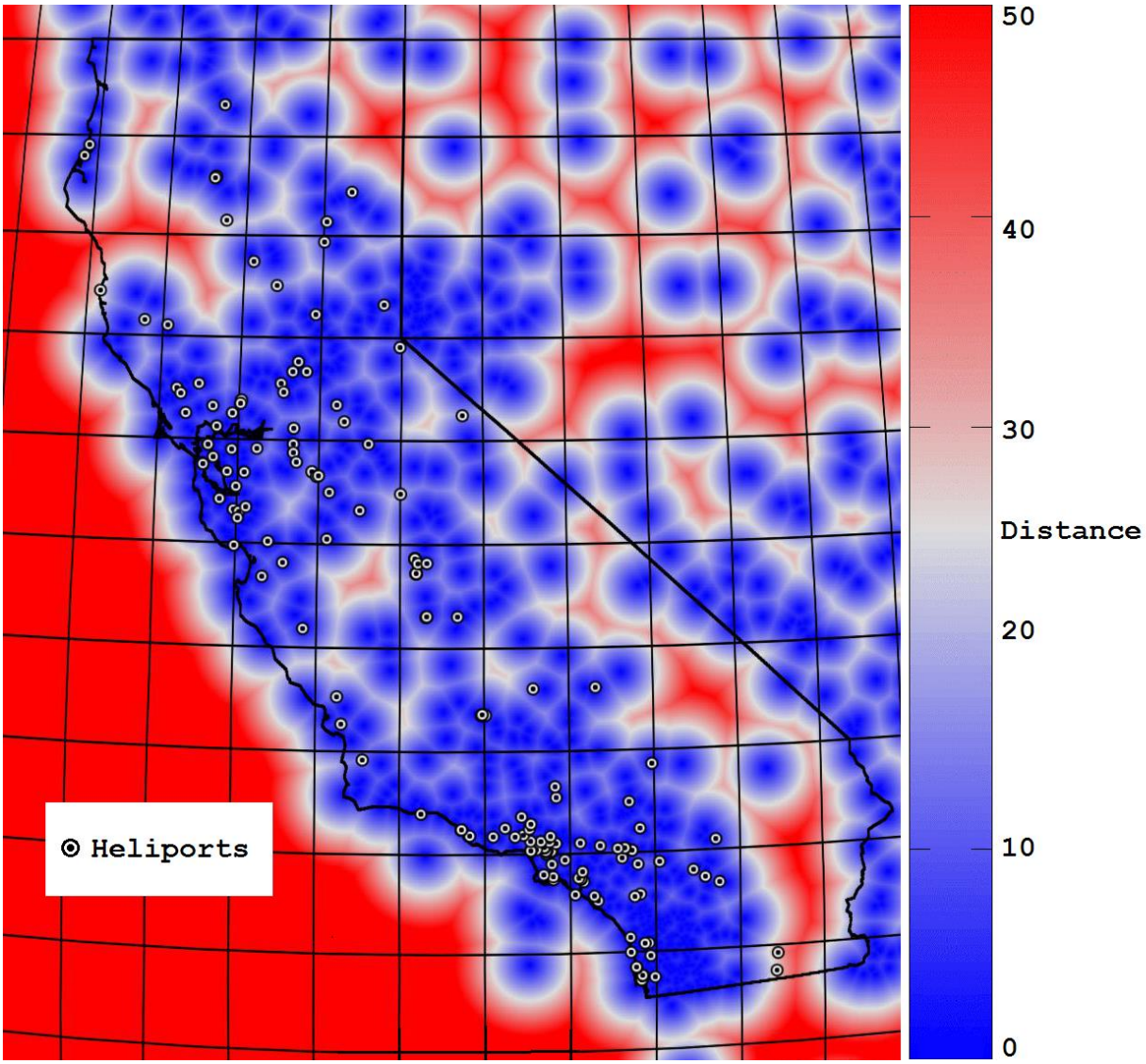

Figure 81: Heliports Relative to Heat Map for Coverage from Reporting AWOS / ASOS / RWIS / MADIS / MesoWest Site with QC-Passed Observations and Reporting Frequency of 15 Minutes or Better (Blue = less than 25 miles from nearest site, White = 25 miles from nearest site, Red = more than 25 miles to nearest site)

Table 36: Hospital Heliports that are More Than 25 Miles from the Nearest Reporting AWOS / ASOS / RWIS / MADIS / MesoWest Site with QC-Passed Observations with Reporting Frequency of 15 Minutes or Better

Name	City	County	ALL
Pioneers Memorial Hospital HP	Brawley	Imperial	31.07
El Centro Regional Medical Center HP	El Centro	Imperial	27.54

In general, our analysis shows that the Aviation WeatherShare provides a dramatic improvement in coverage relative to AWOS/ASOS sites alone and with RWIS sites included. There are still some gaps that might be addressed if data from existing but non-externally reporting AWOS/ASOS or RWIS sites make their data available externally. Other gaps would likely require the development of additional weather sensing sites, and it could be an expensive process to build these sites and associated infrastructure necessary to disseminate data from them. We believe this document can serve as a starting point for discussion in the event that deployment of additional sites is a consideration.

5. SUMMARY

The focus of this project was the development of a prototype system that integrates weather data from aviation Automated Weather Observing Systems (AWOS) and Automated Surface Observing Systems (ASOS) and surface transportation Roadside Weather Information System (RWIS), as well as surface and aloft weather forecasts alerts and warnings, satellite and radar imagery, roadside cameras and more. In addition to system development, the project team conducted a business case analysis, researched additional sources of relevant data, documented detailed system requirements, analyzed gaps in existing weather station coverage, and used three separate mechanisms to evaluate the system.

The prototype system delivers information to users by way of a web-based interface, with data aggregated from numerous sources including Caltrans and the National Weather Service. A Google Maps-based interface was used to present users with a familiar and easy to use display. Color-coded, thematic markers indicate site locations and present further detail upon selection. Raster images present forecast data covering the entire state as well as radar and satellite imagery. Efforts were made to make the display informative, easy to interpret and responsive. The system is accessible via the address http://aviation.weathershare.org/.

The prototype system was first evaluated by way of an open-ended survey of a sixteen member focus group of prospective users. An online survey is linked from the site, providing a second, ongoing mechanism for evaluation. And, the system was implemented using Google Analytics tracking mechanisms to count users and user sessions, and to tabulate user interactions with the site. While usage of the site has been limited and has gone with little advertisement, there does appear to be sufficient usage and feedback to assess the system in this prototype stage. Feedback has been positive and both the focus group and participants in the online survey have provided useful suggestions. As such, 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. 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.

The gap analysis identified areas that are underserved by existing weather stations, relative to data that is accessible by the prototype system. 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. 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.

It is anticipated that the prototype system will be imported into Caltrans in a subsequent, smaller project phase. At that point Caltrans will assume responsibility for operating and maintaining the system. In the meantime, the system continues to be housed at the Western Transportation Institute at Montana State University.