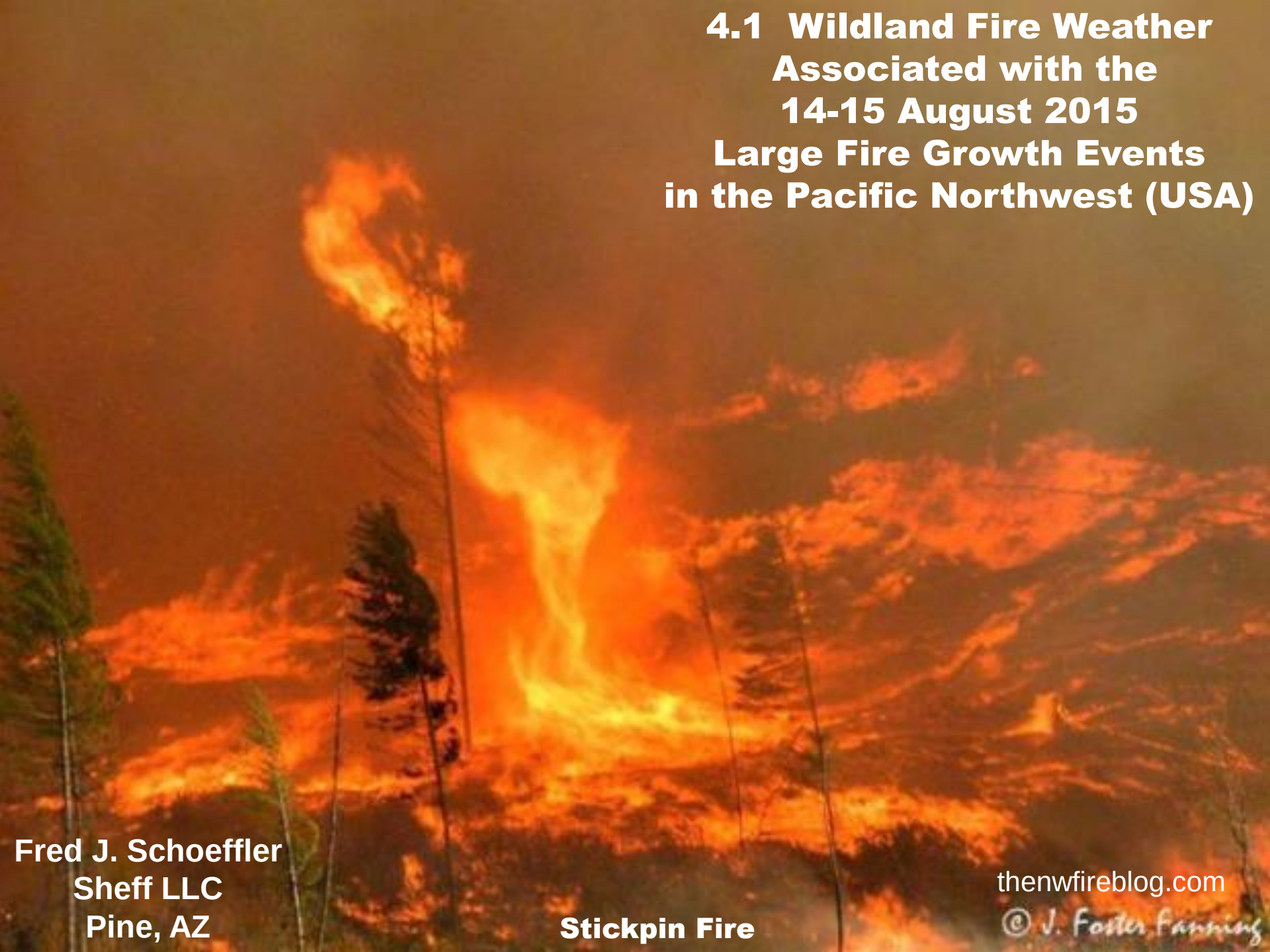
4.1 Wildland Fire Weather Associated with the 14-15 August 2015 Large Fire Growth Events in the Pacific Northwest (USA)



Stickpin Fire

Fred J. Schoeffler
Sheff LLC
Pine, AZ

Abstract

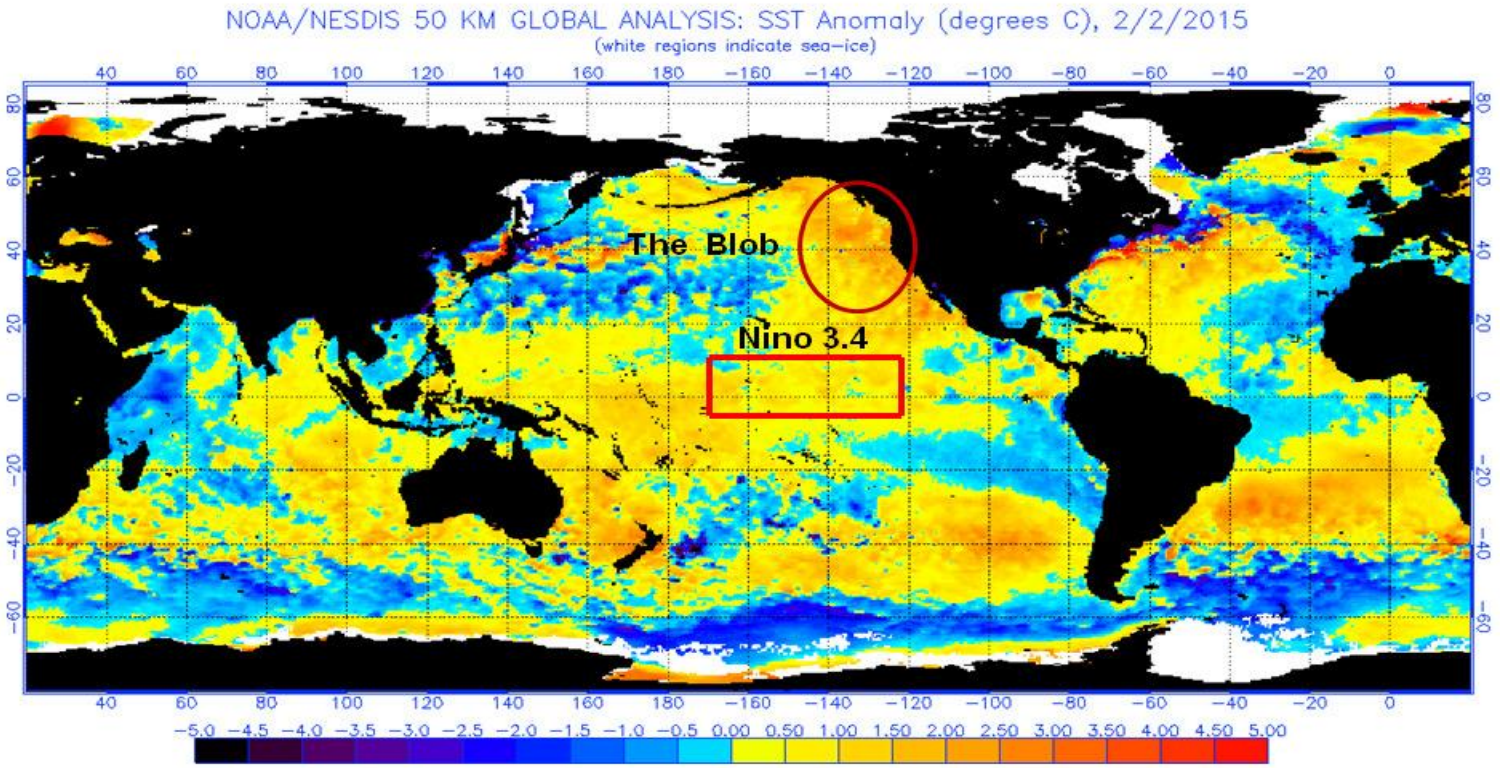
The accurately forecast epic 2015 Pacific Northwest (PNW) Wildland Fire season was the worst on record, burning more than 1.8 million acres and hundreds of structures. These wildfires resulted from a significant number of small lightning-ignited wildfires as early as late-June and continued throughout mid-August, with these wildfires being the most troublesome.

The intent of this presentation is to analyze fire weather conditions between 14-15 August 2015, and the common climatological and atmospheric weather phenomena that contributed to the aggressive and extreme fire behavior observed.

Sea surface temperature (SST) anomalies in the Nino 3.4 region of the central Pacific Ocean were slightly above normal during the 2015 winter which indicated a weak El Nino, record low Winter and Spring snowpack and SWE values, anomalously low soil moisture values, abnormally high regional drought indices, as well as low fuel moistures. Also considered are the causal factors and indicators of dynamic dry intrusions and dry slots; the Red Flag conditions for abundant lightning that ignited most of the fires, as well as dry cold fronts, thermal troughs, subtle and dynamic subsidence inversions and their associated thermal belts, low-level jets, and mesoscale and microscale downslope winds.

Each of the large wildland fires and/or complexes examined, also shared several common climatological and meteorological conditions during the examined period. There were strong associations between falling 500mb heights and large fire growth, consistent with a ‘Breakdown of the Upper Ridge,' a recognized Critical Fire Weather pattern among operational wildland fire weather meteorologists. Most of the fires and complexes, examined in more detail, revealed that there were wide-ranging mesoscale, synoptic, as well as microscale regions of relatively warm to hot daytime and nighttime temperatures throughout the PNW, with the nighttime temperatures being the most indicative of aggressive to explosive fire behavior and large fire growth. Consistent with the high temperatures were anomalously low relative humidity and dew point values and high dew point depressions, which cumulatively contributed to the large fire growth.

Pacific Ocean
Sea Surface Temperature (SST) Anomalies
February 2015



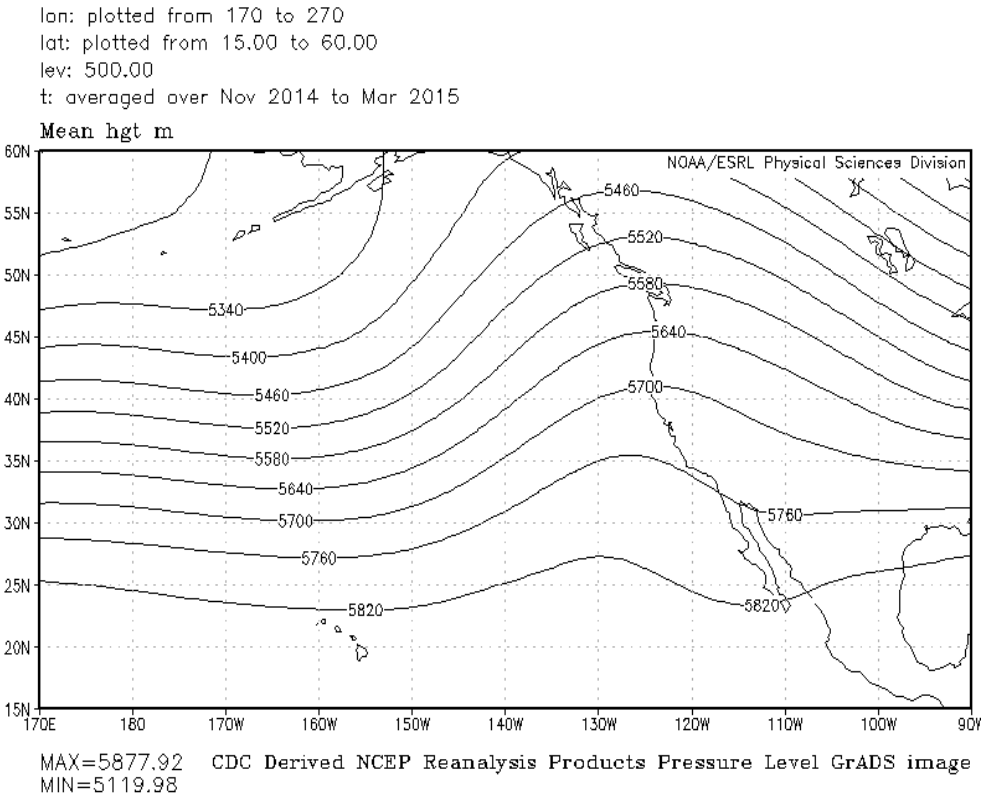
SST anomalies in the Nino 3.4 region of the central Pacific Ocean were slightly above normal and resulted in a weak, yet more normal, El Nino. In other Pacific Ocean regions, the SST anomalies had warmer eastern Pacific water and cooler central and western Pacific water. During the winter, the Blob, an unusually warm pool of water, was situated along the Pacific Coast, where it had a major influence on weather throughout the United States. The Blob's atmospheric interaction resulted in a persistent and robust upper level high pressure system over the Western U.S.

Source: Weather Research and Consulting, Inc.

Pacific Northwest Topography

Brewer, Mass, and Potter (2012) The West Coast Thermal Trough: Climatology and Synoptic Evolution. Monthly Weather Review, 140, 3820-3843.

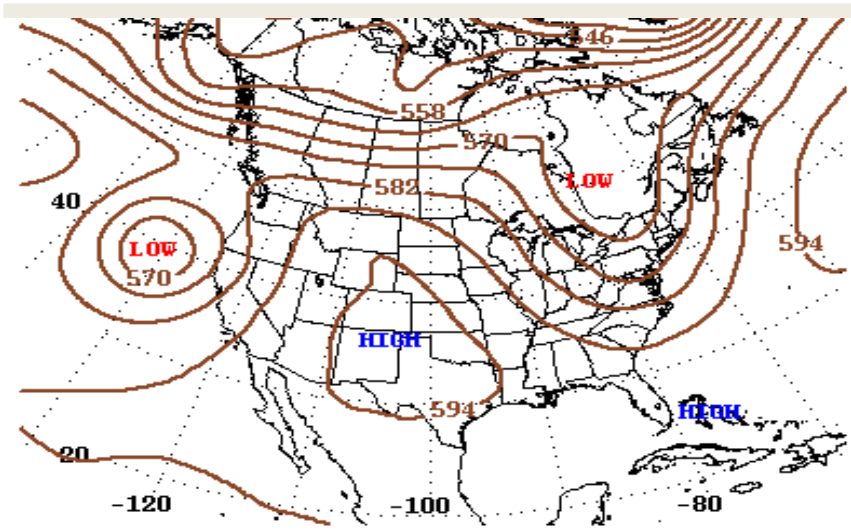
Average 500 hPa winter pattern (November 2014 - March 2015)



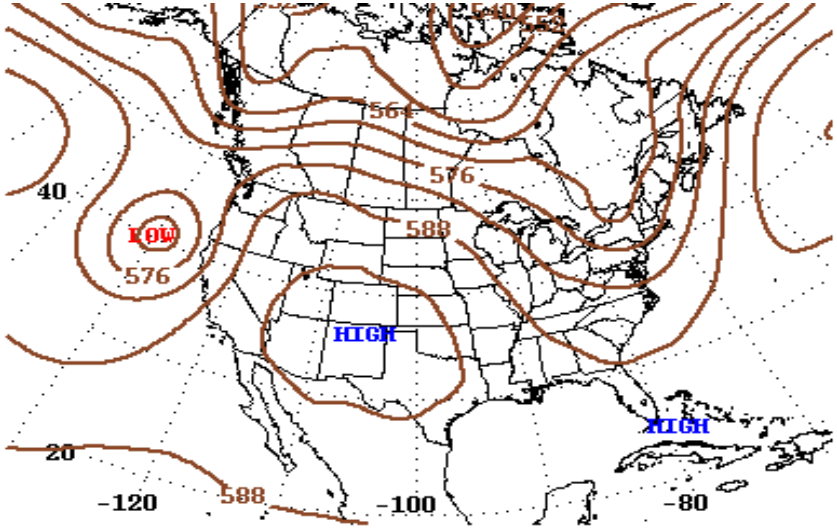
The near seventy-year (1949) record was broken when the mean WA and OR 500 hPa height values were 70 meters higher than normal. This unusual weather resulted in very mild temperatures, coupled with below normal precipitation, which led to record low mountain snowpack and low Snow Water Equivalents across the PNW. A strong upper level ridge dominated the upper atmosphere and affected weather patterns east of the Rockies by driving the Polar Jet Stream far into northern Canada, then southward into Central and Eastern U.S. This dominant upper ridge produced drastically distinct winter weather across the U.S.; anomalously warm and dry weather in the West and record cold and wet weather in the East.

Source: Weather Research and Consulting, Inc.

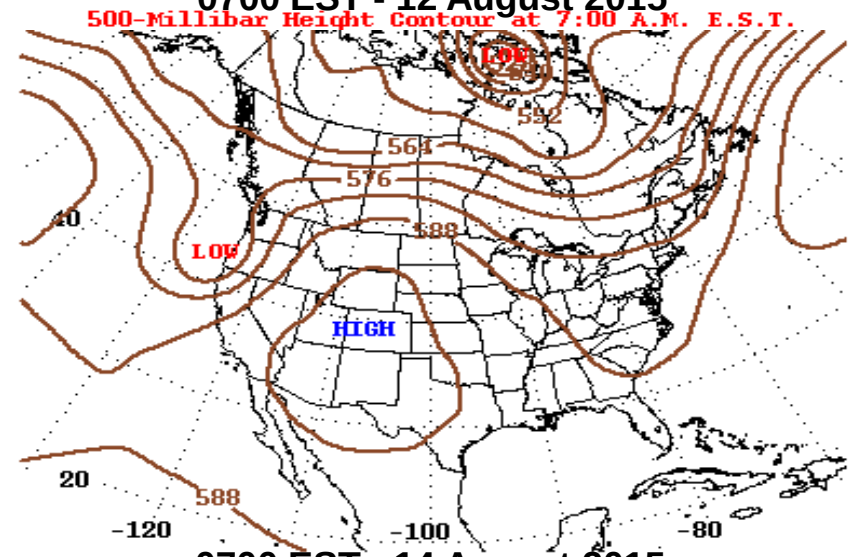
500 mb Height Contour Maps
12 to 15 August 2015



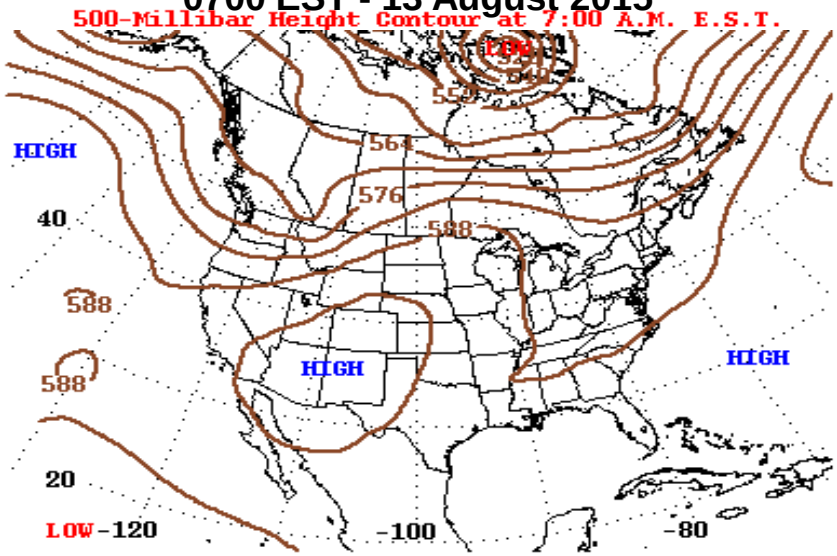
0700 EST - 12 August 2015



0700 EST - 13 August 2015



0700 EST - 14 August 2015

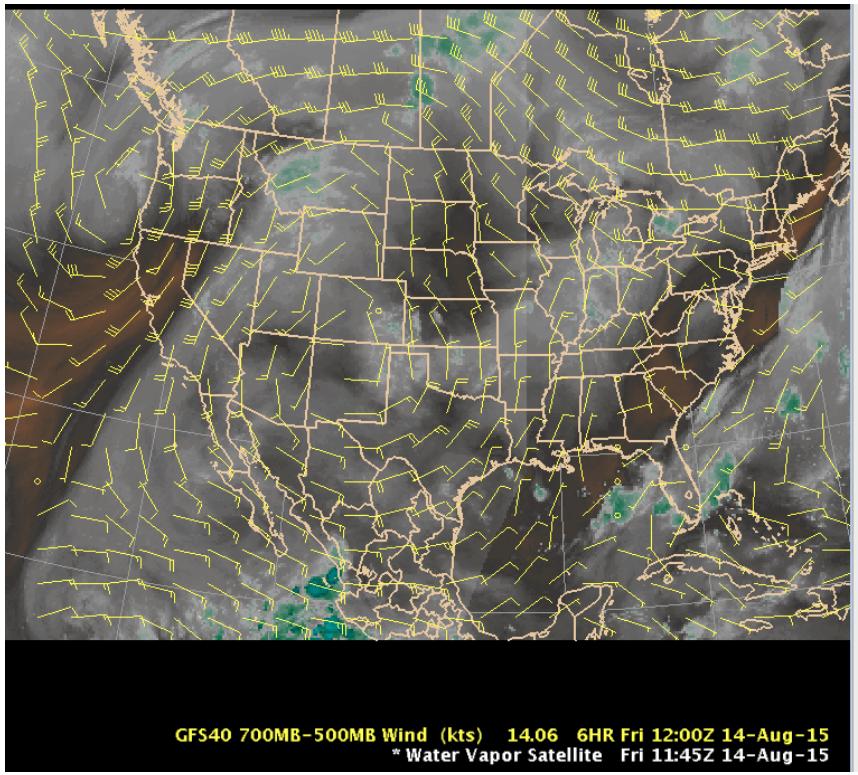


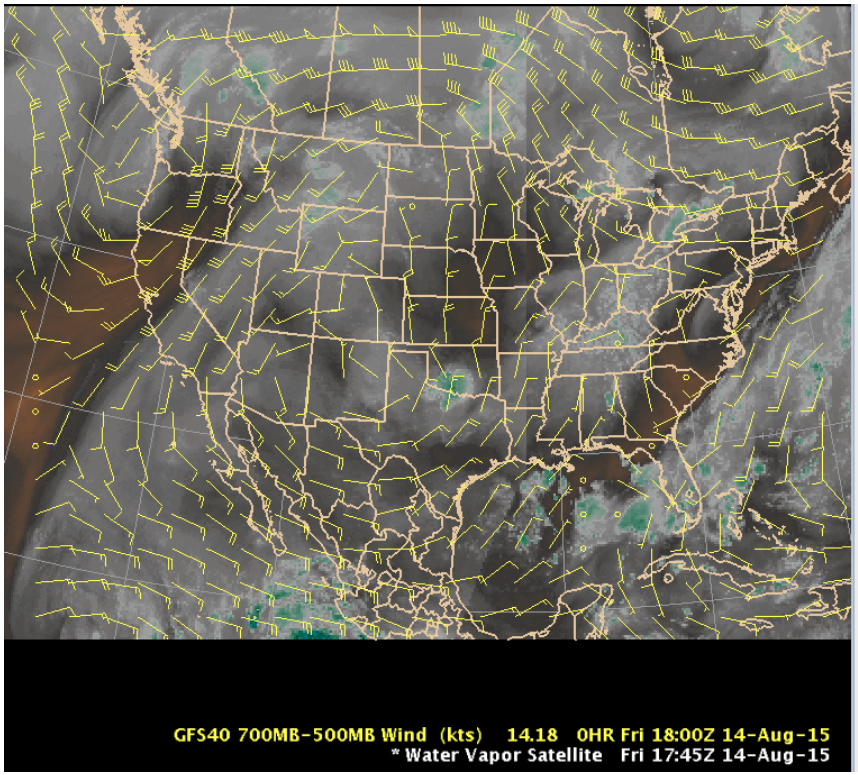
0700 EST - 15 August 2015

Note the low pressure trough dominating the PNW.

NOAA Daily Weather Maps – www.wpc.ncep.noaa.gov/dailywxmap

700mb to 500mb Wind Overlay and WVI
14 August 2015
12Z (left) and 18Z (right)

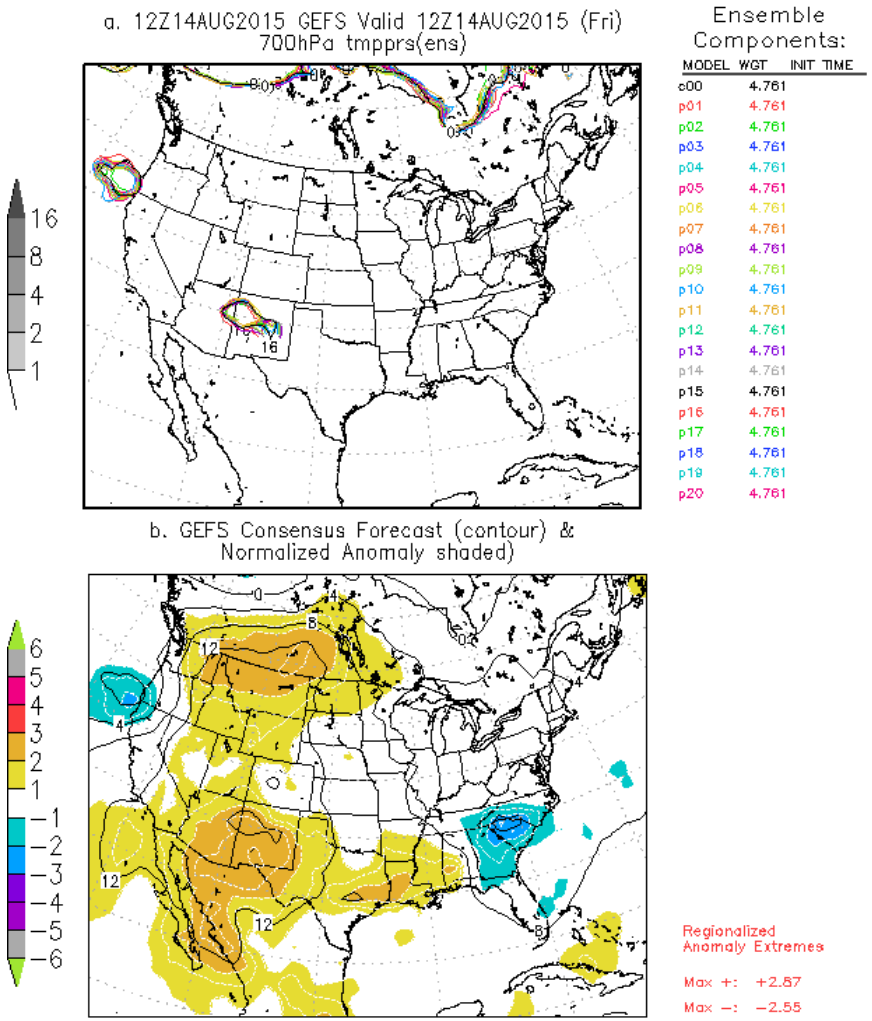


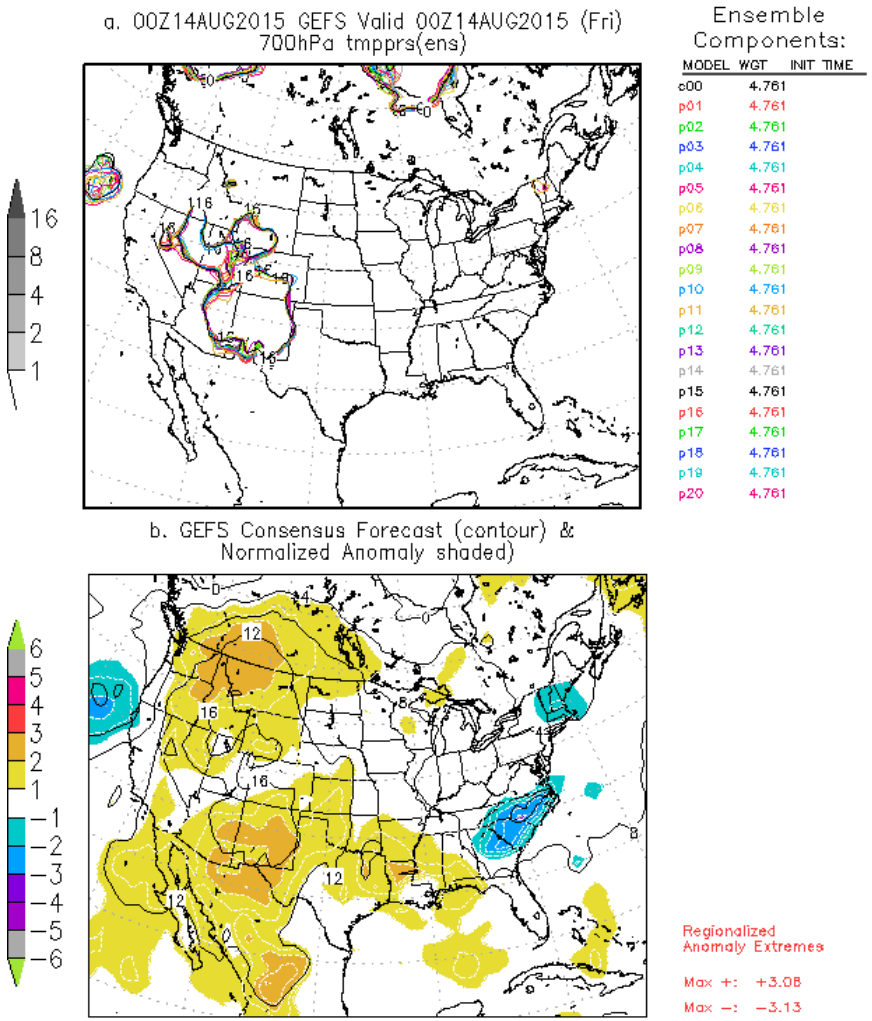


700mb to 500mb winds indicating dynamic dry intrusion and strong winds advecting into the PNW from the southwest.

Source - Brent Wachter – NWS ABQ

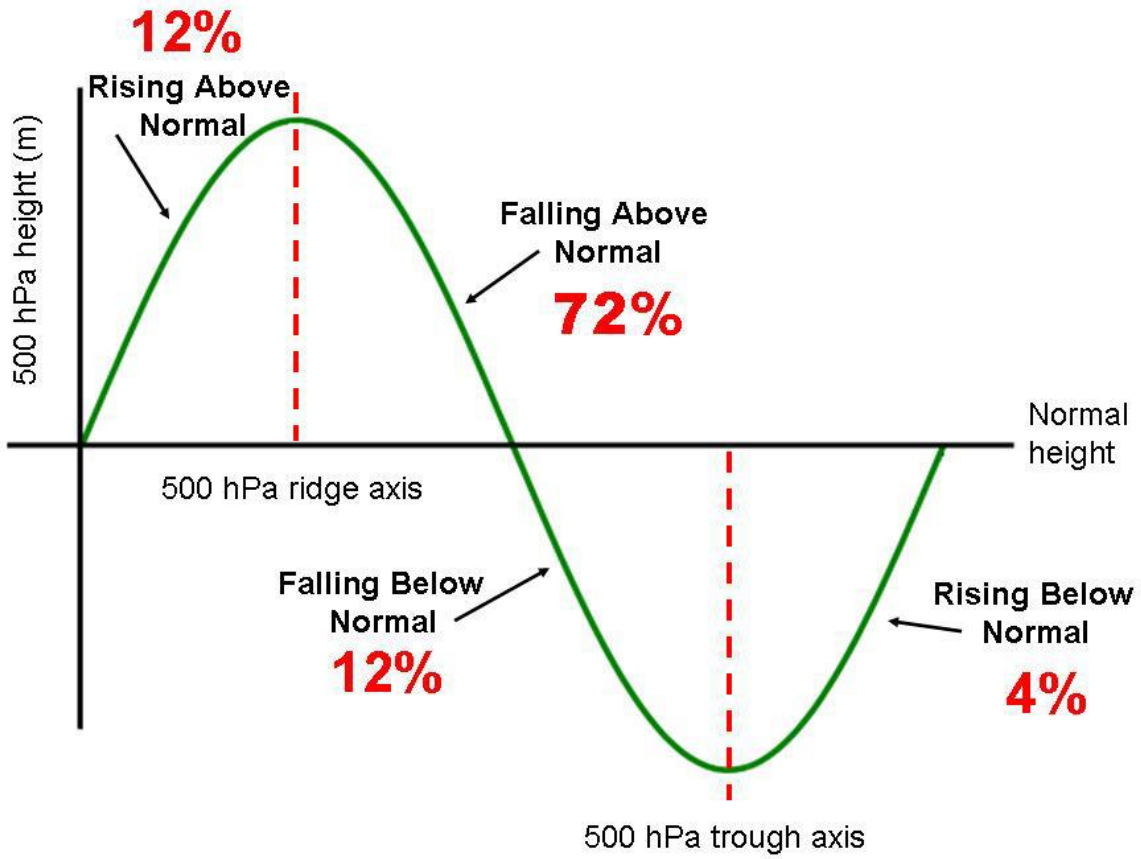
GFES 700 mb Temperature Anomalies
12Z (left) and 00Z (right) 14 August 2015





Proxy graphic indicating the strength of the mid-level thermal ridge.
These were above normal ahead of the break down of the upper ridge.
A classic signature. Source - Brent Wachter – NWS ABQ

500mb Height Field Interactions



Percentage of large PNW fires per 500mb height field phase.

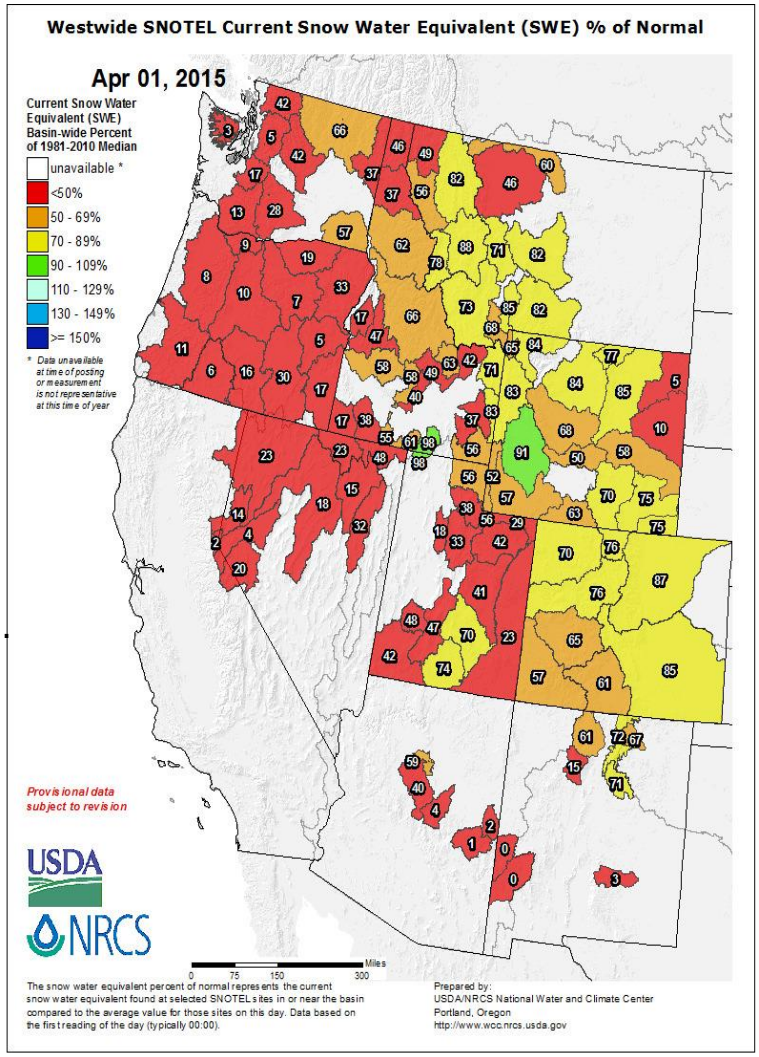
Weather Research and Consulting Inc.

01 April 2015 Snow Water Equivalent (SWE) Percent of Normal

The 2014-2015 Winter snowpack resulted from the strong upper level ridge that persisted over the Western U.S. The 1 April snowpack was much below normal from WA through OR and CA into UT and AZ.

Many of their river basins reported near and record low snowpack levels. This was in contrast to the prior 2013/2014 Winter when the Rocky Mountain snowpack was well above normal.

The first six months of 2015 were the warmest initial six months of any year over much of OR and WA since record keeping began in 1895.

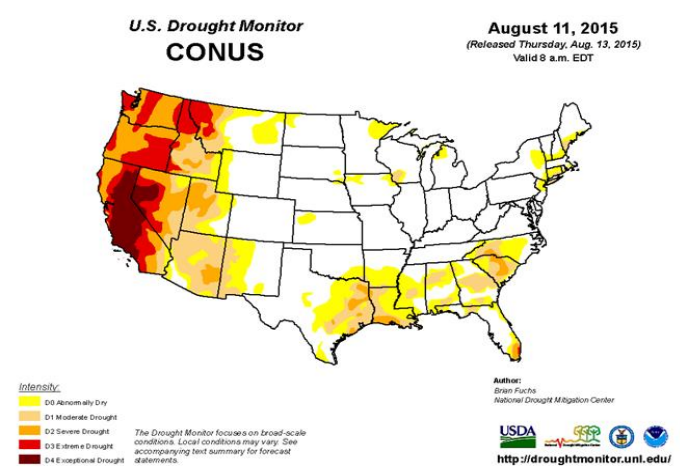


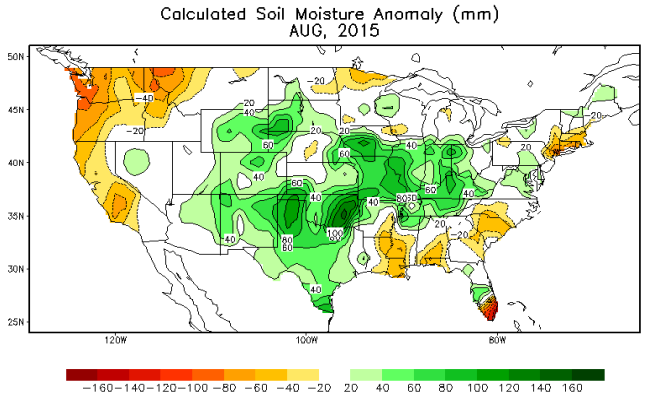
For the third year in a row, the OR winter snowpack was below normal. The WA, 1 April 2015 Snowpack wasn't much better at 29% compared to 104% in 2014. The 1 April 2015 PNW snowpack was the lowest since 1981. Because of above normal temperatures and below normal moisture, the May 2015 OR and WA snowpacks were anomalously low at 4% and 21% respectively

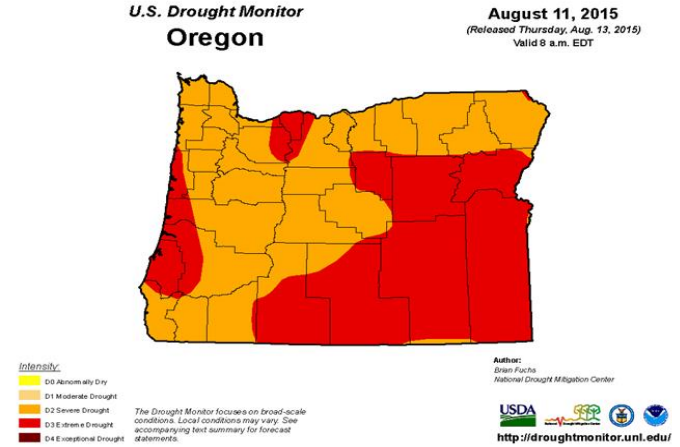
Weather Research and Consulting, Inc.

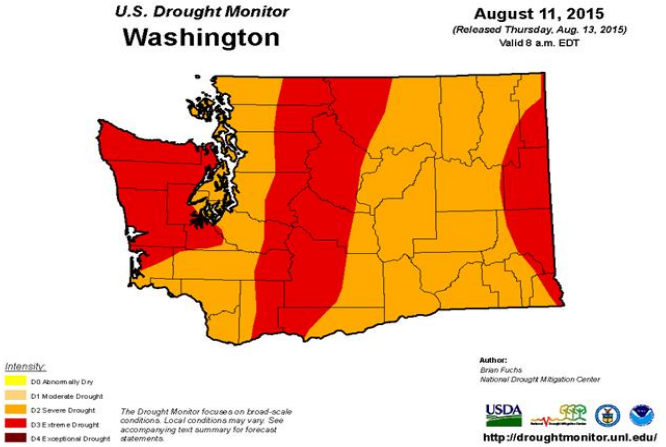
USFS Narrative Timeline of the PNW 2015 Fire Season

US-OR-WA Drought Monitors – Calculated Soil Moisture Anomaly
August 2015 – NOAA – National Drought Mitigation Center and Climate Prediction Center



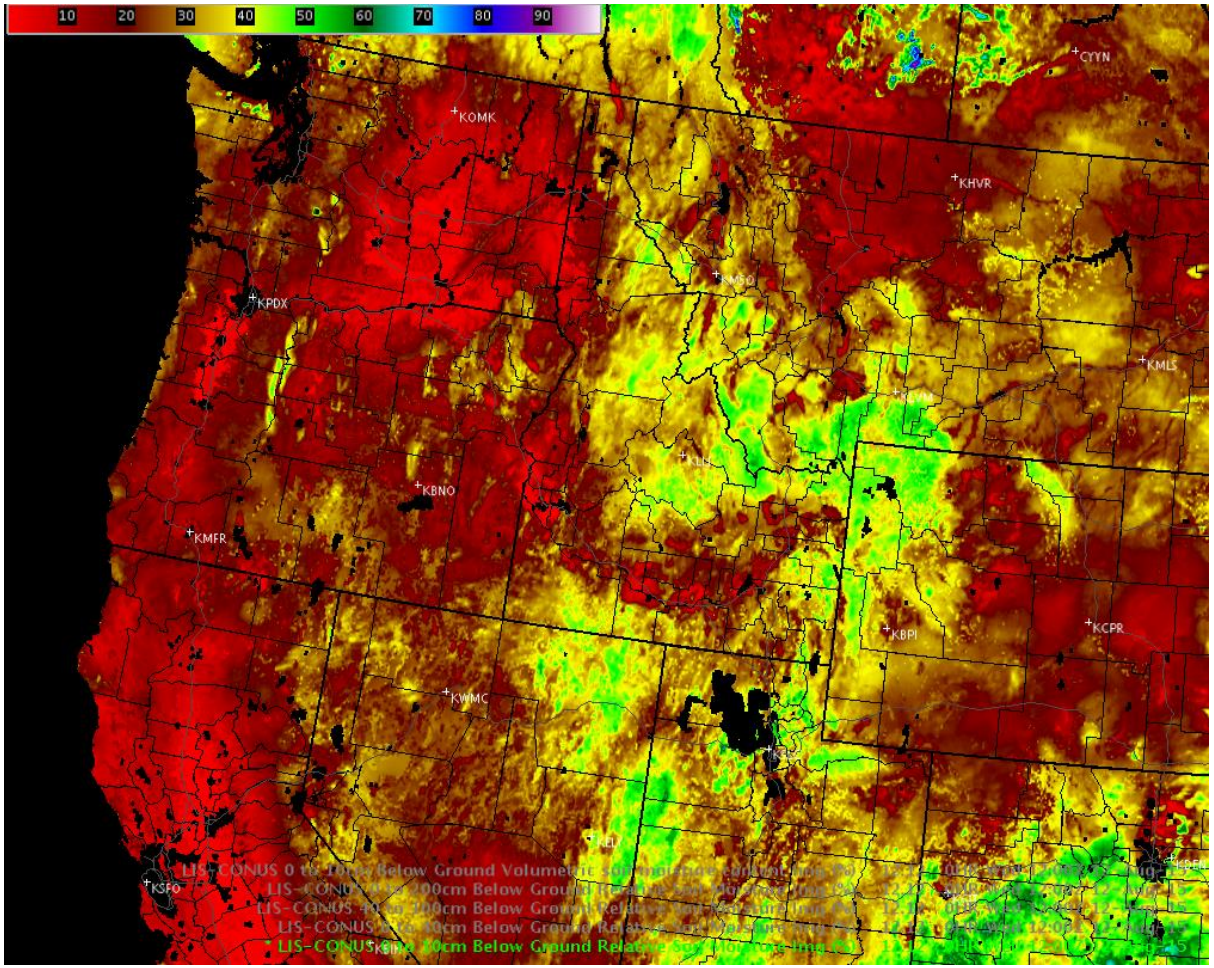






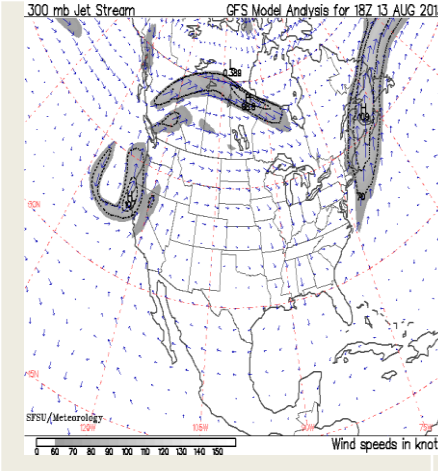
The strong winter high pressure system that resulted in the anomalously low snowpack and SWE values worsened drought conditions throughout the Western US, clearly represented in the August 2015 U.S. Drought Monitor and Calculated Soil Moisture Anomaly charts.
(NOAA, USDA, NDMC, CPC)

Soil and Duff Moisture
12Z, 15 August 2015

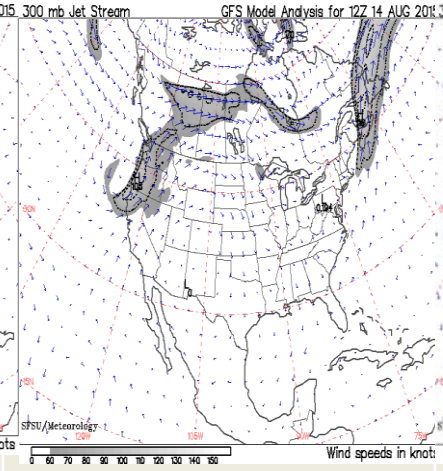


USFS researchers Fast and Heilman found that when air masses advected over a parched soil region, they took on those regional dry characteristics and were capable of entrainment a sizeable distance downwind. They also concluded that low soil and fuel moistures “affected not only the surface, but the entire lower atmosphere,” (1996). Tardiff (2006) found that dry soil anomalies had noticeable impact at the 700 mb to 500 mb levels with steep lapse rates, linked to downwind severe weather outbreaks. Miralles et al (2014) examined land-atmosphere interactions between anomalously dry soils and higher temperatures that induced the 2003 and 2010 European mega-heatwaves. Source: Brent Wachter – NWS ABQ

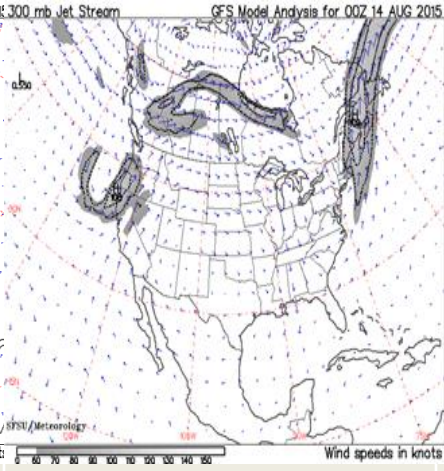
300 mb Jet Stream Analysis
13-16 August 2015



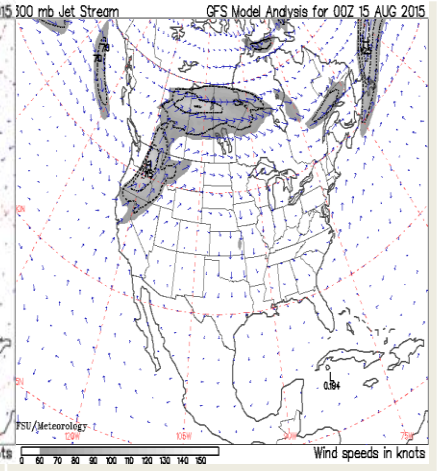
18Z 13 August 2015



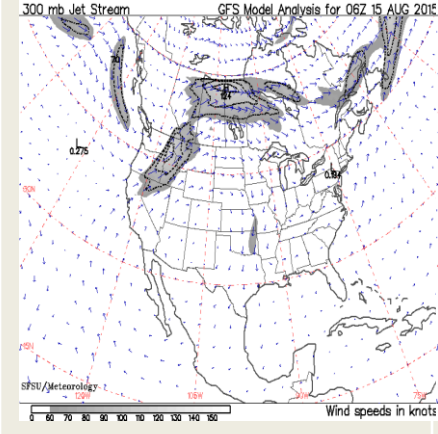
12Z 14 August 2015



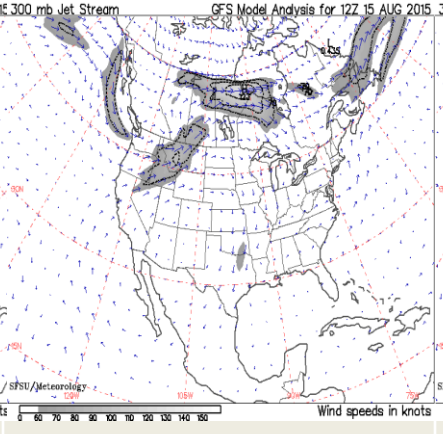
00Z 14 August 2015



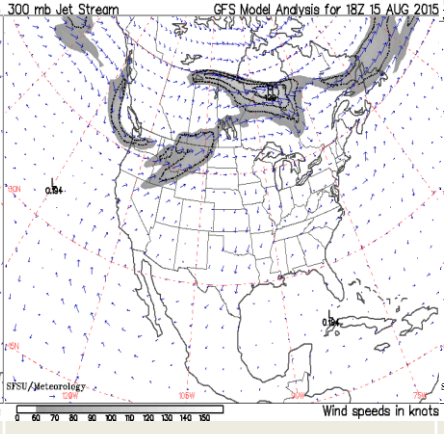
00Z 15 August 2015



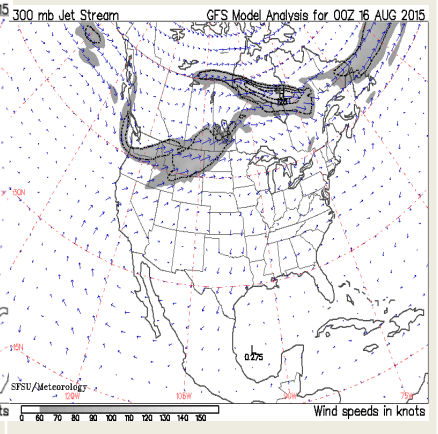
06Z 15 August 2015



12Z 15 August 2015



18Z 15 August 2015

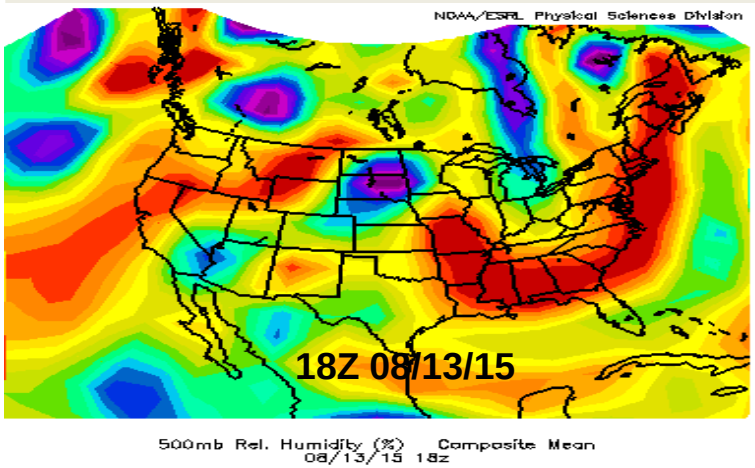


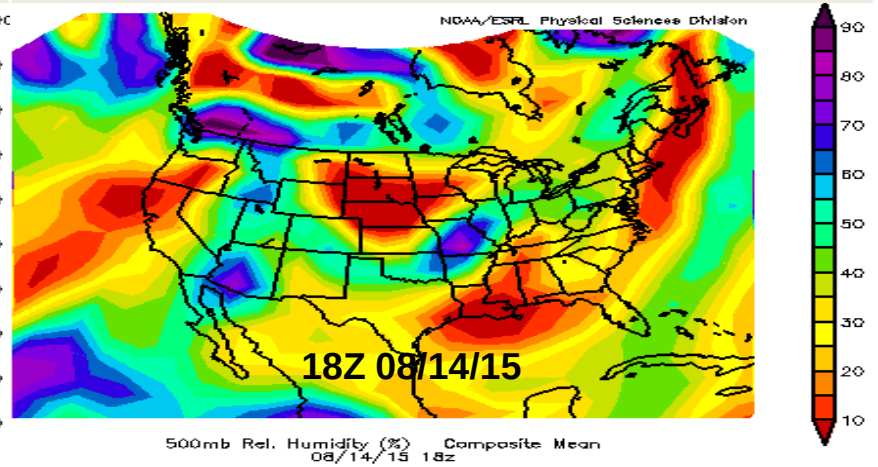
00Z 16 August 2015

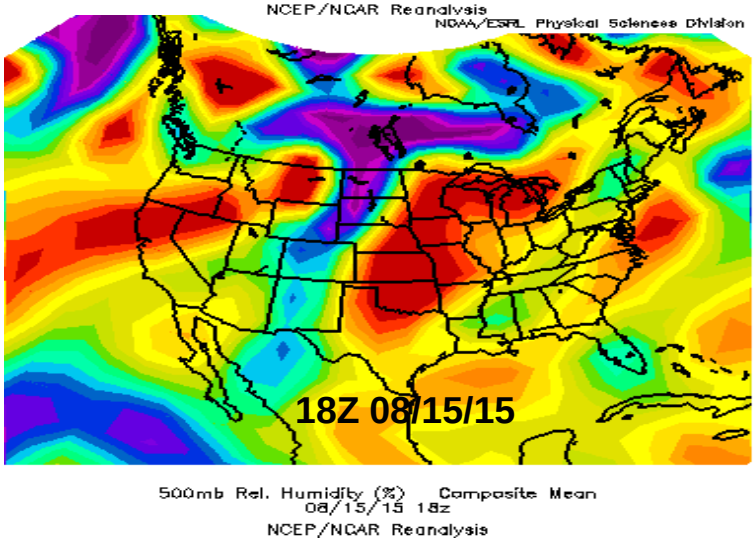
Jet stream influence through the PNW from 13-16 August 2015

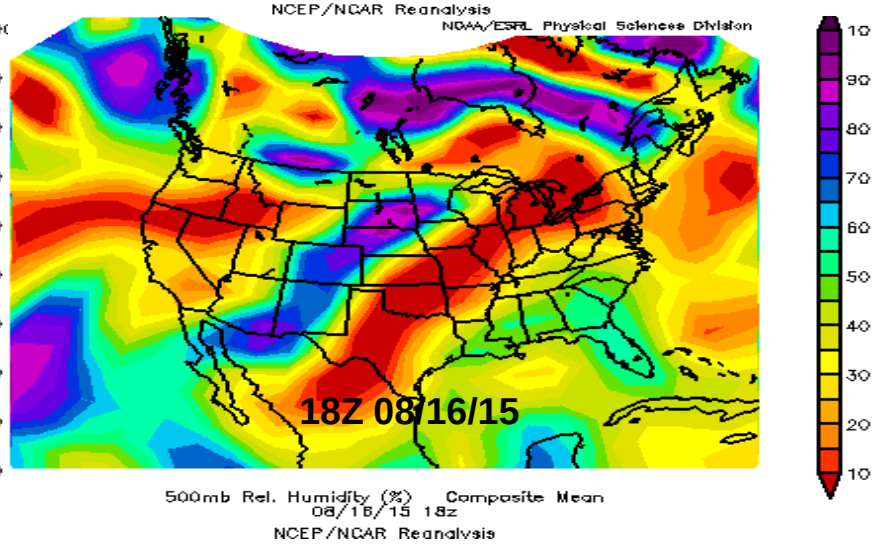
California Regional Weather Server – http://squall.sfsu/crws/jetstream/html

500 mb RH Composite Mean
18Z 13-16 August 2015
NCEP/NCAR Reanalysis



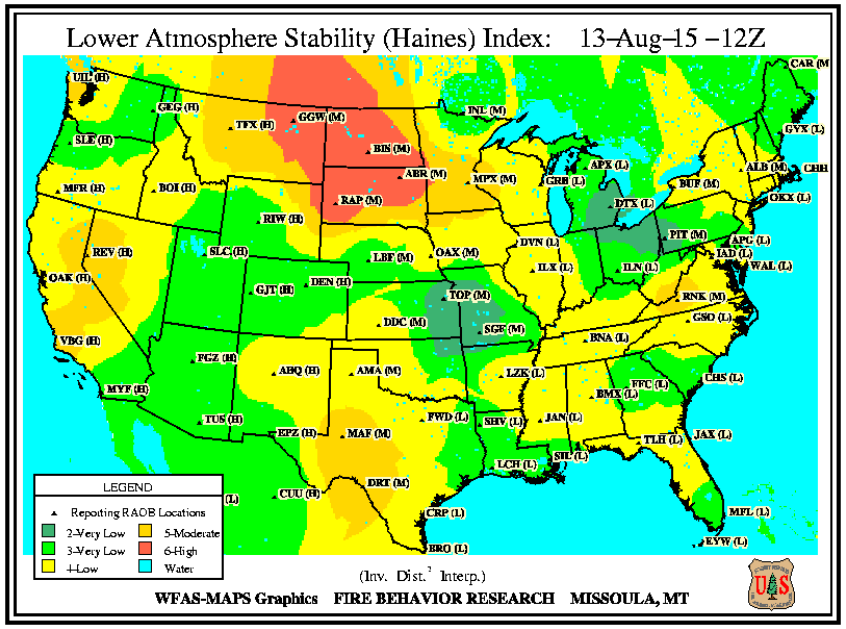


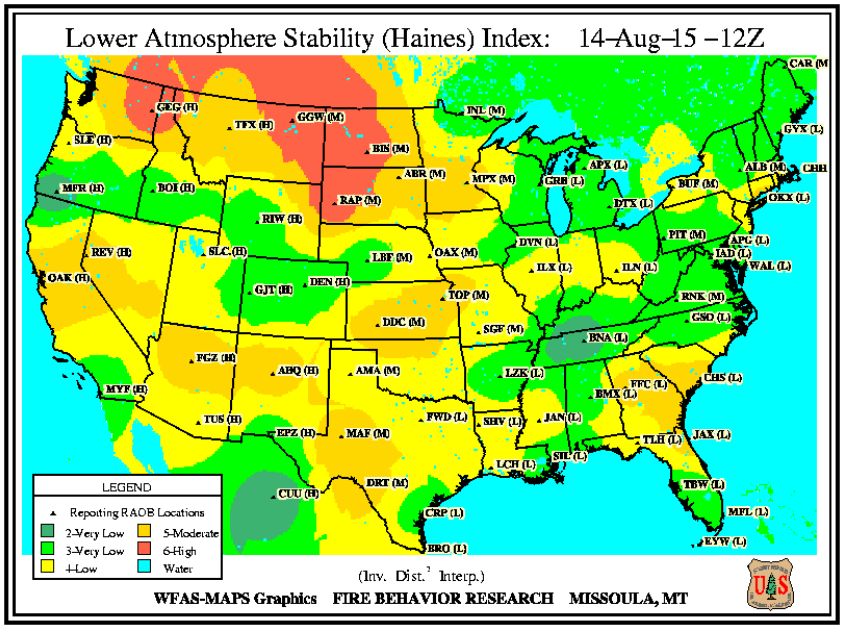




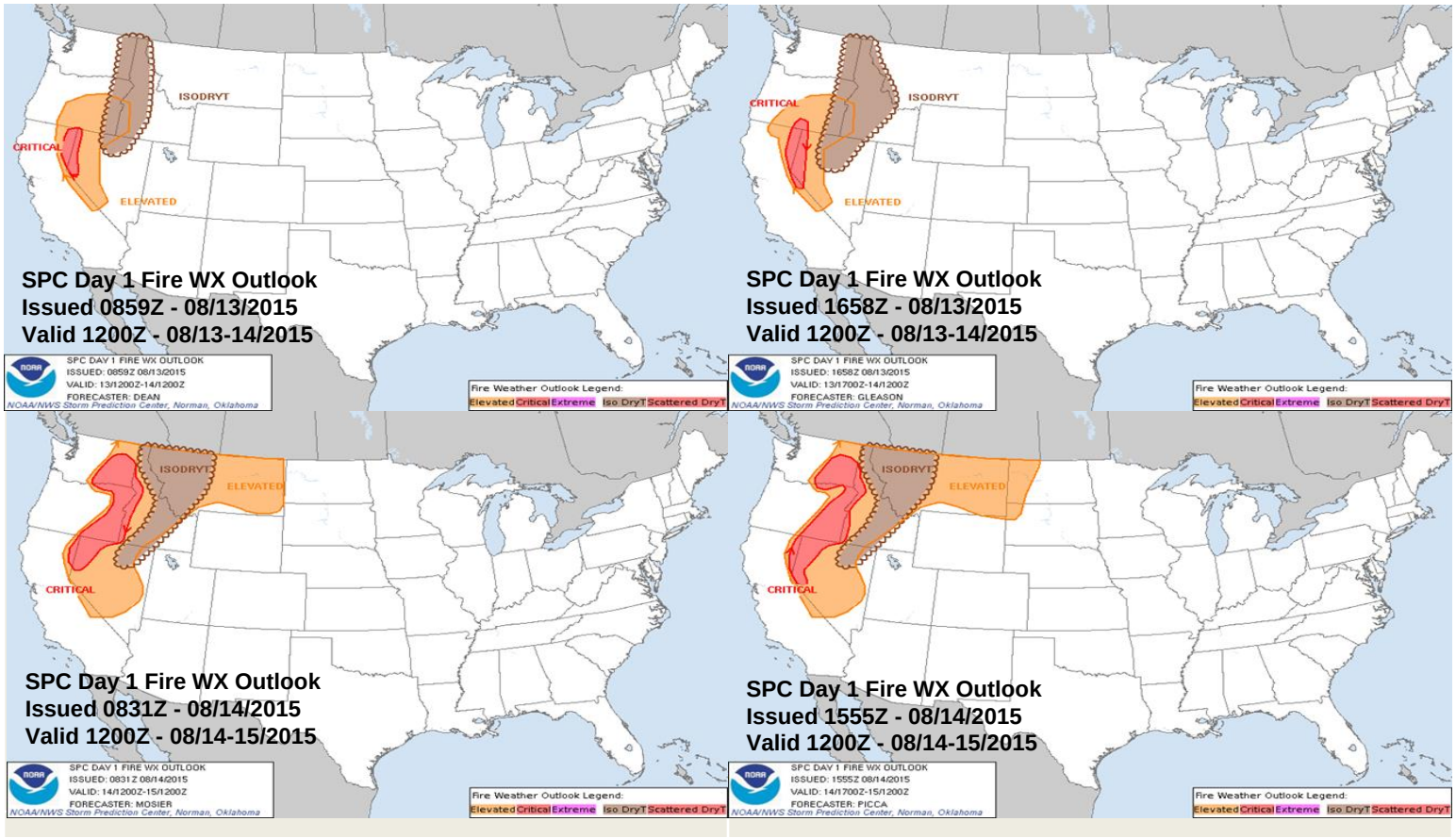
Mid-level dry air advecting from the West through the PNW 13-16 August 2015

Lower Atmospheric Stability Index
Haines Index
(12Z) 13 and 14 August 2015





Haines 3 Very Low to 4 Low at 12Z both days (13-14) in PNW then Haines 6 High in eastern WA. Calculated Haines at 00Z both days the same as 12Z values. Calculated for 12Z both days at Boise, ID; Salem, OR; Medford, OR; Spokane, WA, and Quinault, WA was Haines 6 for Spokane and Haines 4-5 for all others. (WFAS-USFS)

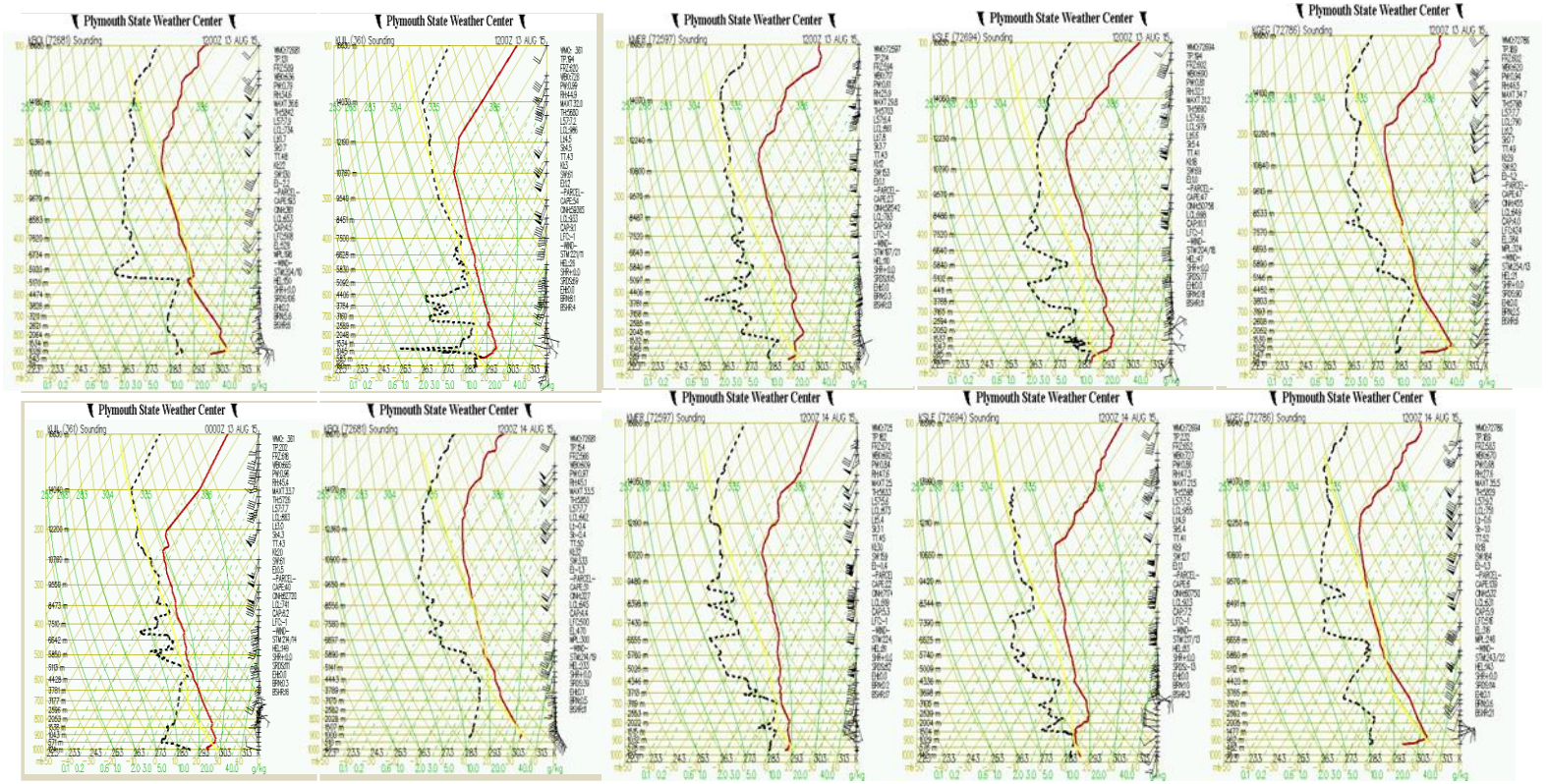


August 13-15, 2015 - a persistent upper low off the PNW coast ejected to the northeast on 13 August, as a downstream ridge axis shifted eastward across the central/northern Rockies. A belt of stronger flow ahead of the trough supported Critical Fire Weather winds from the eastern slopes of the Sierras and Southern Cascades eastward into western Great Basin.

Borderline critical conditions were forecast across the eastern slopes of the Cascades into southeastern OR and the critical area was expanded northward. High nighttime temperatures and poor overnight recovery persisted Across most of the elevated and critical areas. Dry thunderstorms were forecast for the Interior NW with isolated thunderstorms across northeastern OR and western ID into southeastern WA during the afternoon and evening, driven primarily by strong heating and terrain-enhanced circulations.

NOAA Storm Prediction Center – Fire Weather Outlooks (Dean, Gleason, Mosier, Picca 08/13-14/2015)

Skew-T Soundings
13 August 2015
12Z (top) 00Z (bottom)

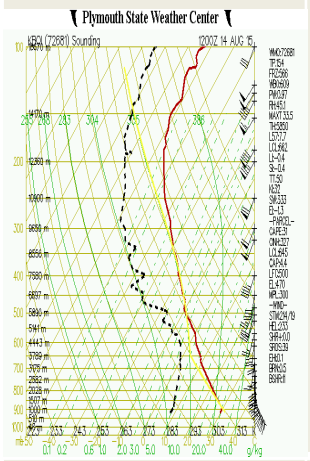


Boise, ID **Quinault, WA** **Medford, OR** **Salem, OR** **Spokane, WA**

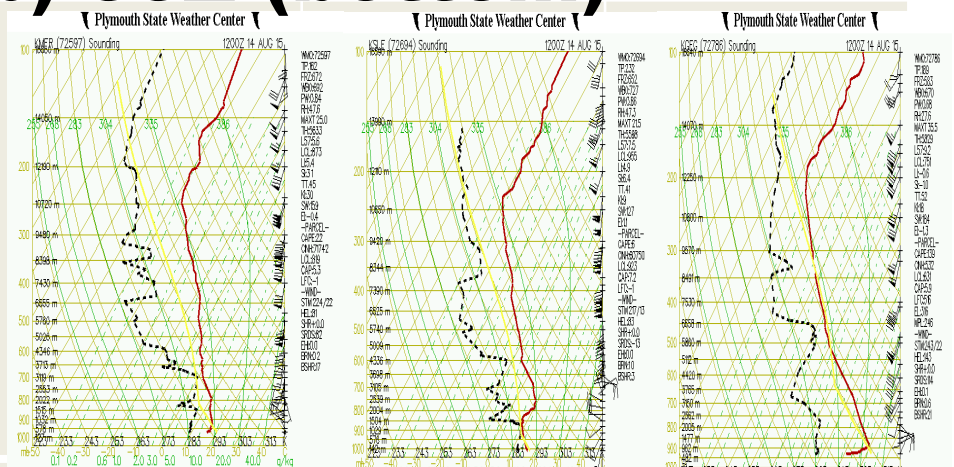
Skew-T soundings indicate moderately dry air at the surface and aloft, with consistent strong winds in the 500mb and 300 mb ranges respectively

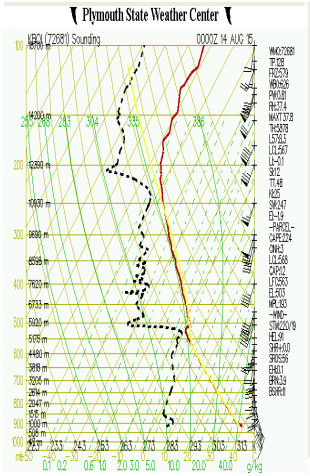
Plymouth State Weather

Skew-T Soundings
14 August 2015
12Z (top) 00Z (bottom)



NO QUINAULT DATA





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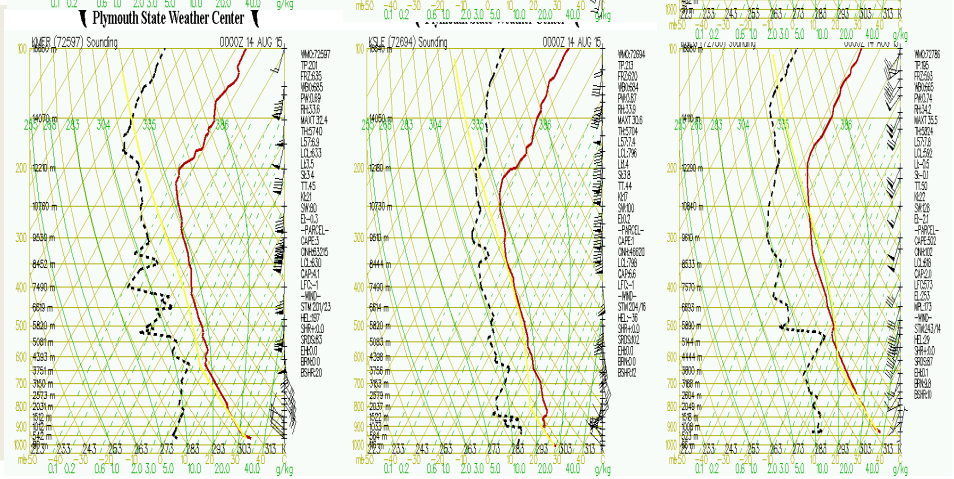


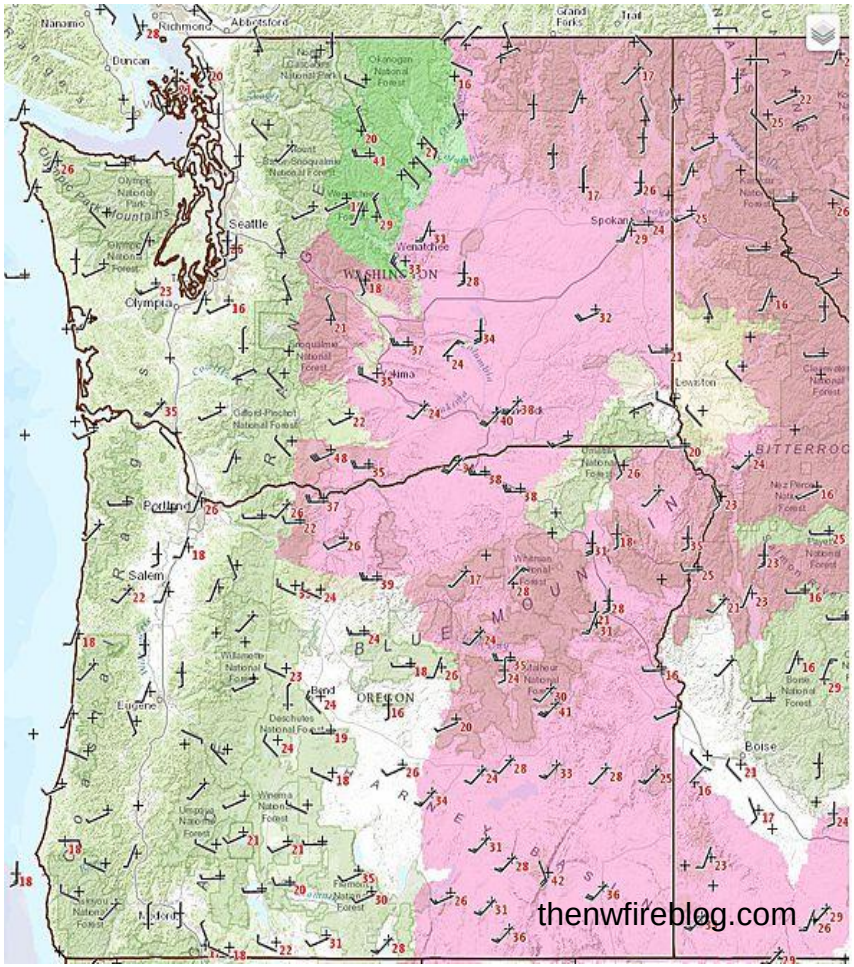
Boise, ID **Quinault, WA** **Medford, OR** **Salem, OR** **Spokane, WA**

Skew-T soundings indicate moderately dry air at the surface and aloft, with consistent strong winds in the 500mb and 300 mb ranges respectively

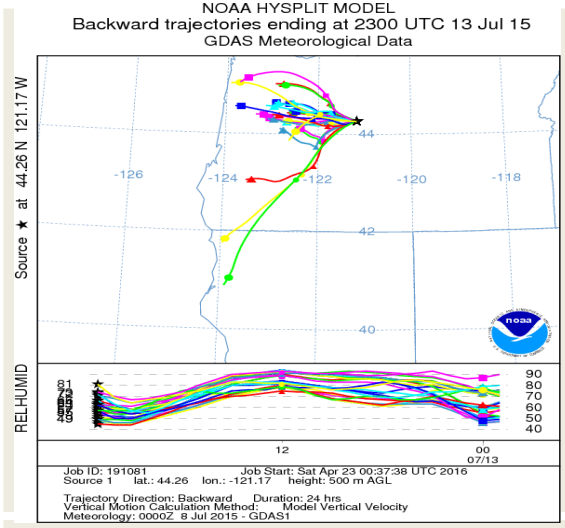
Plymouth State Weather

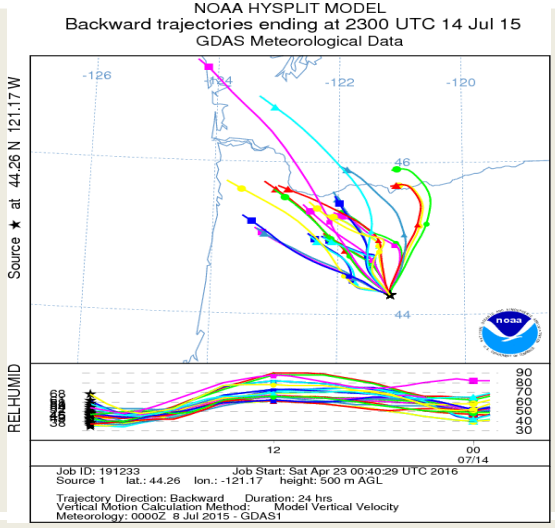
The mid-August PNW wildfires regularly exhibited aggressive to extreme fire behavior, most often resulting in large fire growth.

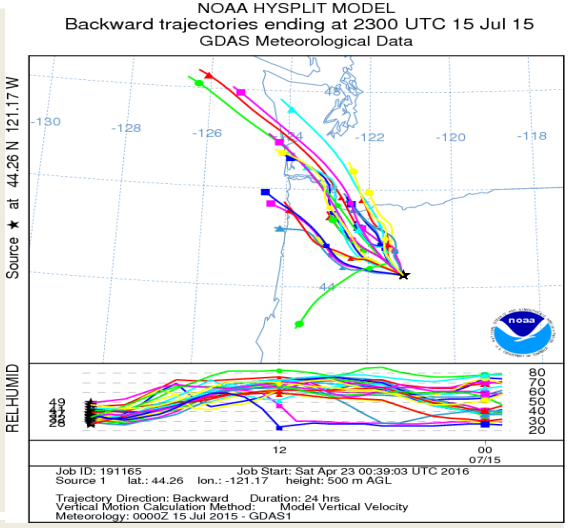
2015 PNW Large Fire and Wind Maps

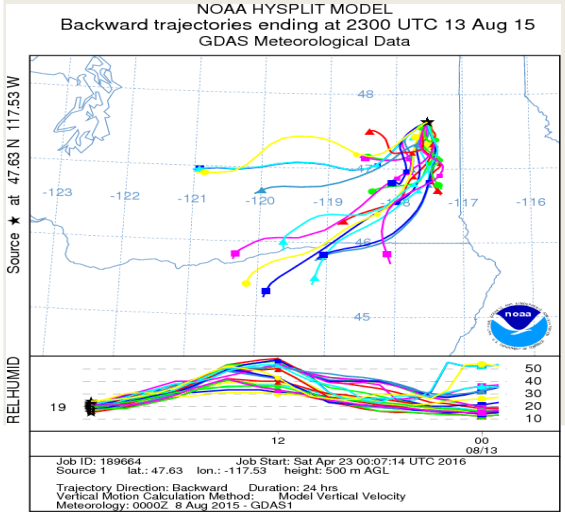


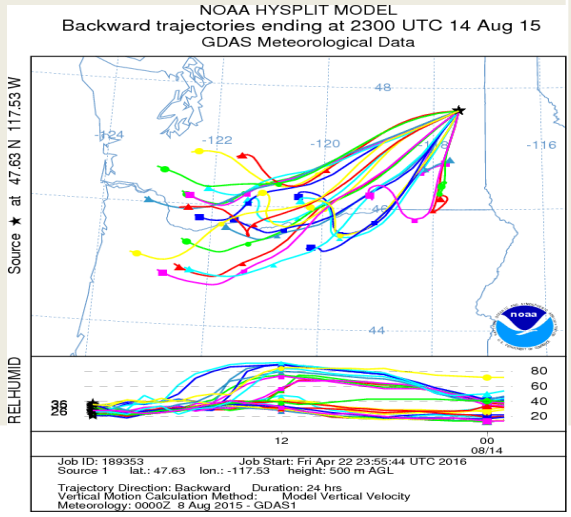
NOAA ARL HYSPLIT
13-15 August 2015 - Backward Trajectories
Redmond, OR (top) - Spokane, WA (bottom)

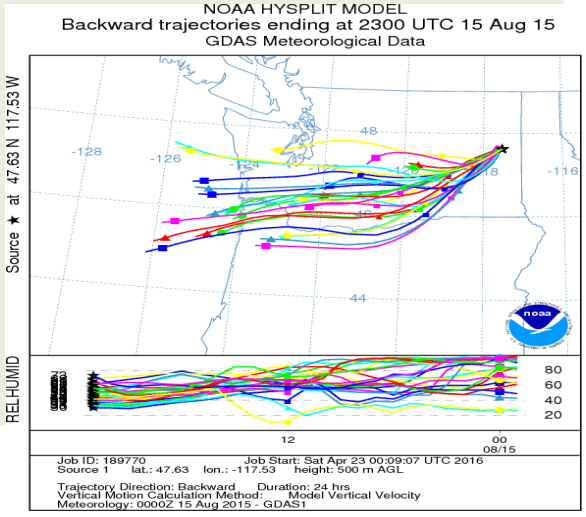












Note dry air advecting into OR from the West and Northwest and into WA from the West and Southwest

Conclusion - Summary

The 14-15 August 2015 wildfire outbreak resulted from of a combination of environmental and weather factors, the leading factor of which was the hot, dry, and windy conditions. In addition to the weather on the 14th and 15th, wetter than normal conditions over the previous year played a major role which led to a significant amount of fine fuels (grasses, shrubs, etc.) available to burn. This significant growth period was followed by a drier and warmer Fall 2014 into Winter 2014/2015. Moreover, because it was mid-August, most of the fuel was well cured and/or dormant, which also led to conditions more conducive to burning.

A lightning storm that moved through Washington State's Chelan Valley early on the morning of August 14 ignited multiple fires, including: the Reach, Cagle, Black Canyon, Squaw Creek (later renamed McFarland), Antoine, and First Creek (eventually combined into the Chelan Complex) fires. All of these fires—driven by steady 30 mph winds—spread rapidly. On August 14, the forecast dry cold front that swept across eastern Oregon and Washington brought the strongest general winds of the fire season east of the Cascades. These winds fanned both the new fire starts as well as the ongoing fires, exacerbating an already busy fire situation. On August 14, several more Large Fires occurred: the Lime Belt, Tunk Block, Beaver Lake, and First Creek Fires on the Okanogan-Wenatchee National Forest; Graves Mountain, Renner, and Roy fires on the Colville National Forest; and the Eldorado Fire on Oregon's Bureau of Land Management's Vale District.

The PNW Region had the highest priority in the nation for firefighting resources during these dates: July 25 and 26, August 14-31, and September 8-13. On the morning of August 14, new fires in the Chelan area rapidly threatened structures in Chelan and the surrounding communities. Resources from the nearby Wolverine Fire were heavily committed to Initial and Extended Attack on these new priority fires.

Source: Narrative Timeline of the 2015 Pacific Northwest Fire Season (USFS) http://www.wfmrda.nwcg.gov/docs/_Reference_Materials/2015_Timeline_PNW_Season_FINAL.pdf