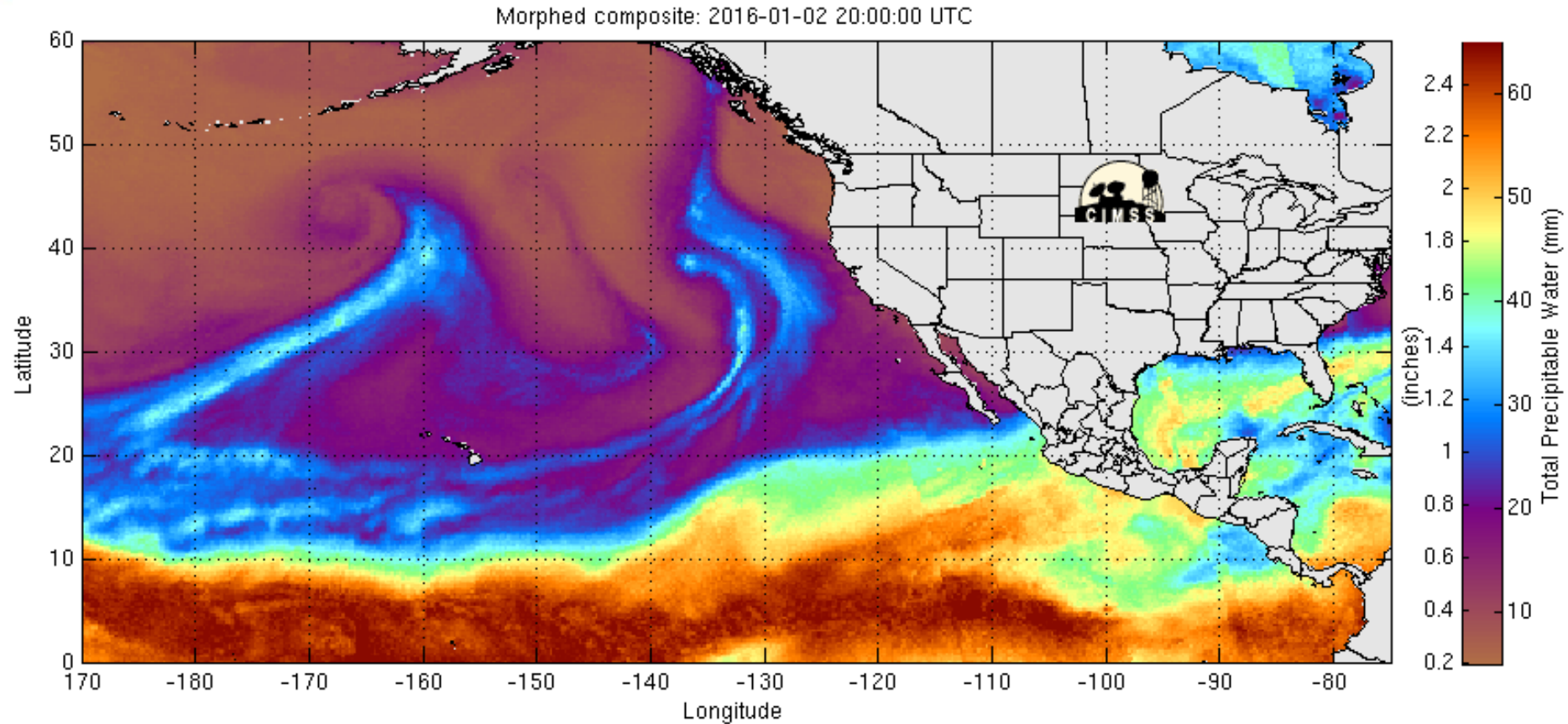




Center for Western Weather  
and Water Extremes



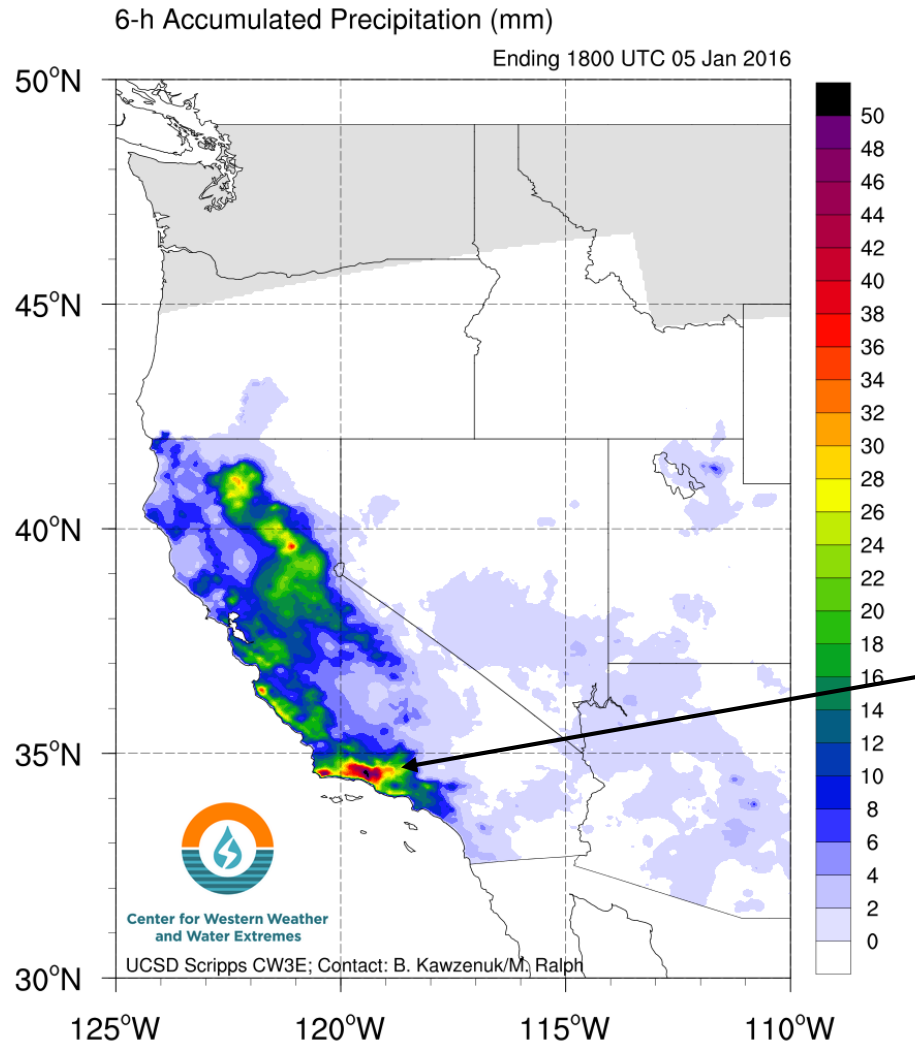
# California Storm of 5 January 2016: A Preliminary Synopsis of a Marginal Landfalling Atmospheric River

Brian Kawzenuk, Scott Sellars; CW3E  
Nina Oakley; DRI

# Synopsis

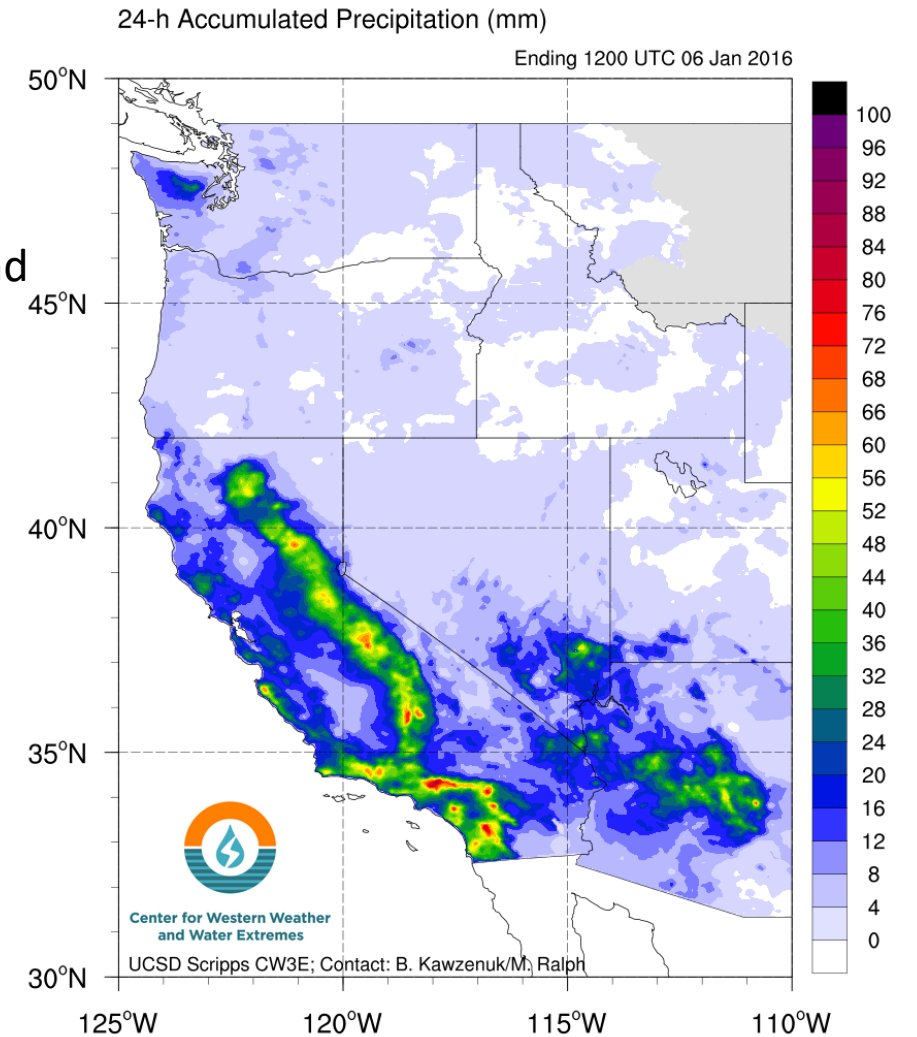
- Widespread precipitation in the Northern and Southern California due to a marginal landfalling Atmospheric River
- Precipitation rates greater than 50 mm in six hours have been observed
- Many rivers and streams are experiencing increased flows
  - Many flows have peaked from the first wave of precipitation in Northern California (January 5, 2016).
- Reservoirs are seeing much needed increased inflows.
- Multiple weather systems are expected over the next week and impact California and the surrounding region.
- River and stream flows will continue to be elevated during this time period with localized flooding possible.

# Accumulated Precipitation



Sierra Nevada, Transverse, and  
Peninsular Ranges all  
received > 50 mm of 24-h  
precipitation

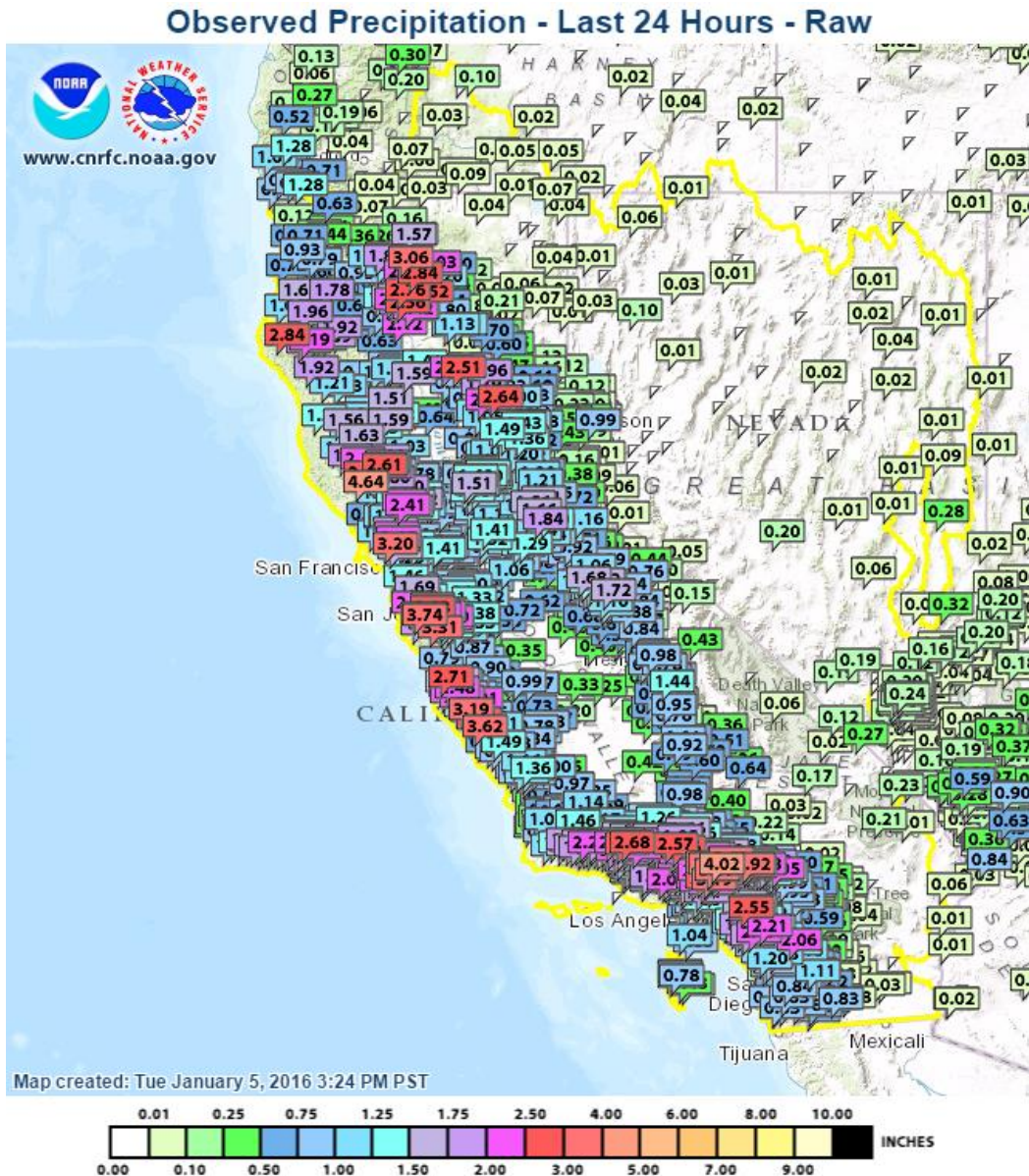
>50 mm over Los Padres  
National Forest in 6 hours



\*Note change in scales

Stage IV Precipitation

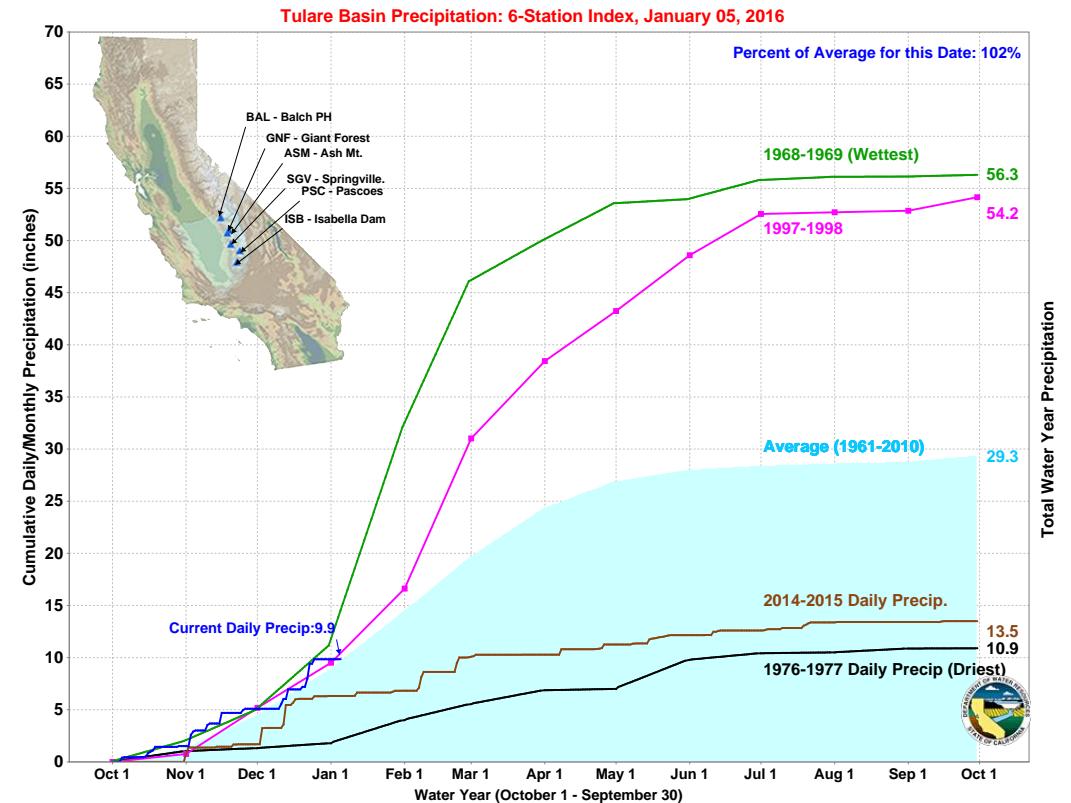
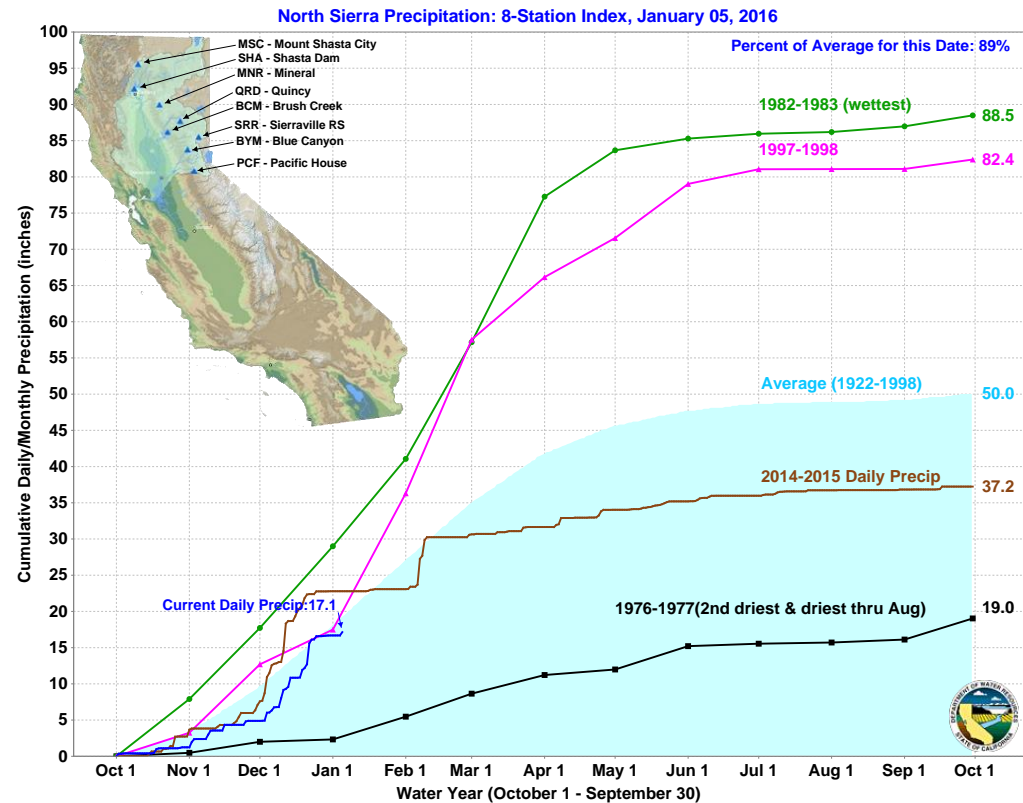
# Accumulated Precipitation



- 24-hr accumulated precipitation >4 inches observed near the Transverse Ranges and Cazadero
- 24-hr accumulated precipitation >2 inches over nearly all of the California coast and northern Sierra Nevada



# Current California Precipitation Conditions



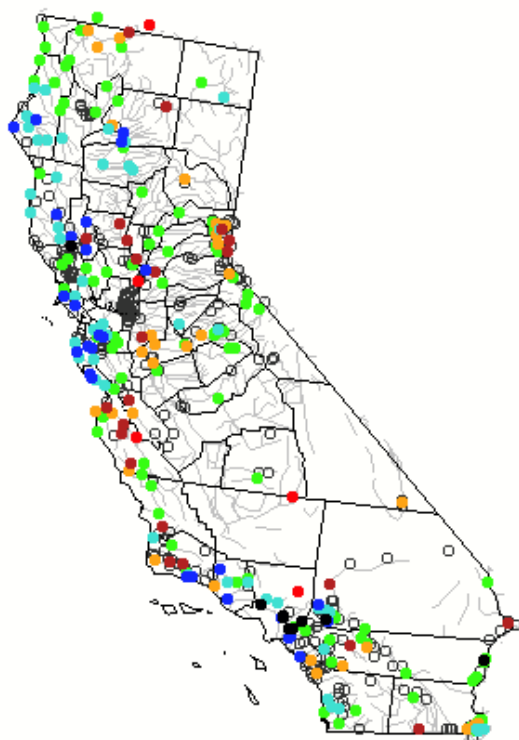
Water year precipitation has been close to the historical average for the 8-Station and 6-Station Indices prior to this event

# Current California Streamflow Conditions

## Daily Streamflow Conditions

Select a site to retrieve data and station information.

Tuesday, January 05, 2016 15:30ET



### Explanation

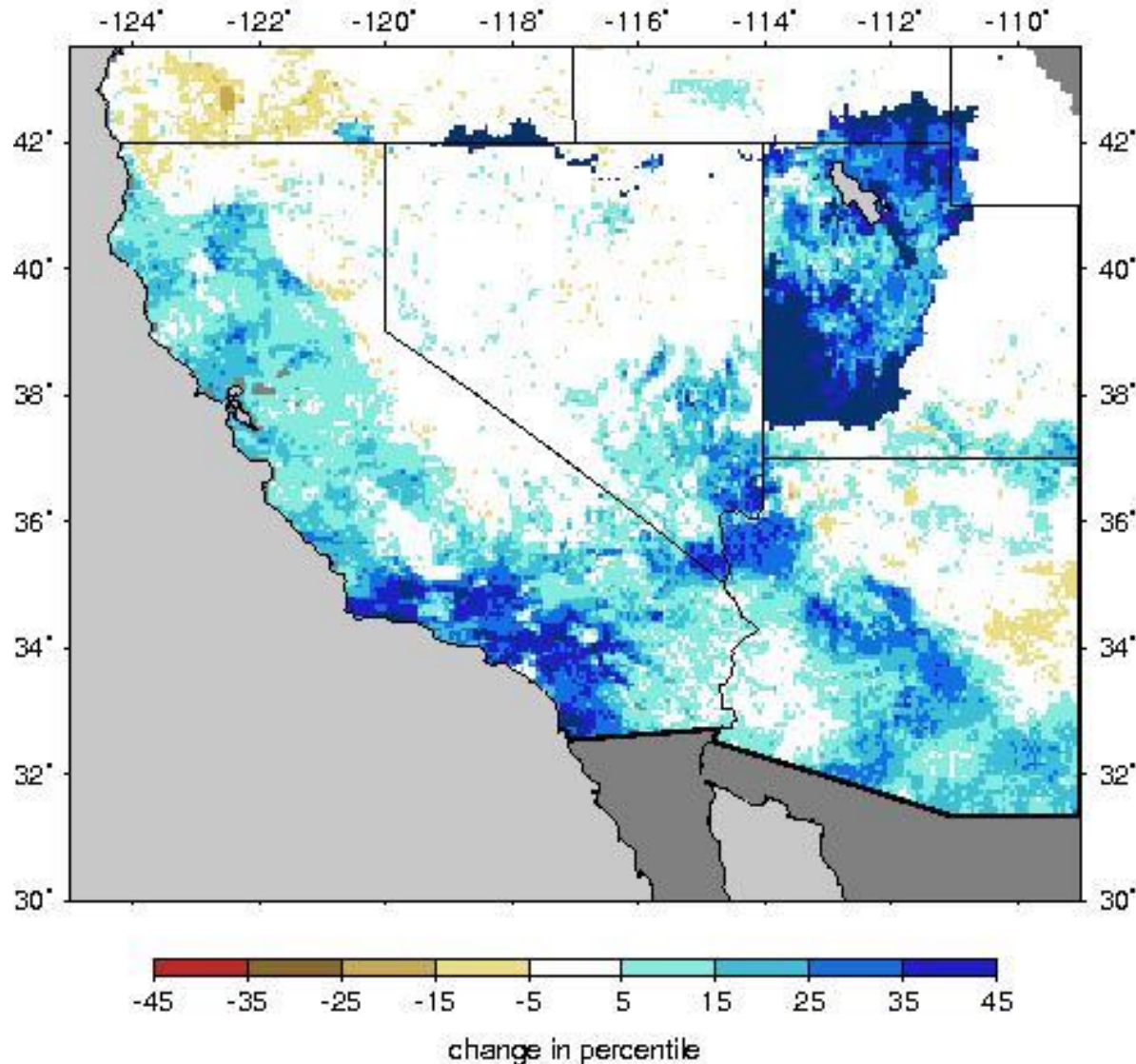
- High
- > 90th percentile
- 76th - 90th percentile
- 25th - 75th percentile
- 10th - 24th percentile
- < 10th percentile
- Low
- Not ranked

The colored dots on this map depict streamflow conditions as a [percentile](#), which is computed from the period of record for the current day of the year. Only stations with at least 30 years of record are used.

The **gray circles** indicate other stations that were not ranked in percentiles either because they have fewer than 30 years of record or because they report parameters other than streamflow. Some stations, for example, measure stage only.

# Change in Soil Moisture

VIC Soil Moisture Percentiles (wrt/ 1920-2010)  
for the period: 20160104 to 20160111



- Precipitation from this event resulted in significant increases in soil moisture
- Soil moisture percentiles increased >25% over most of coastal southern CA during the week of this event

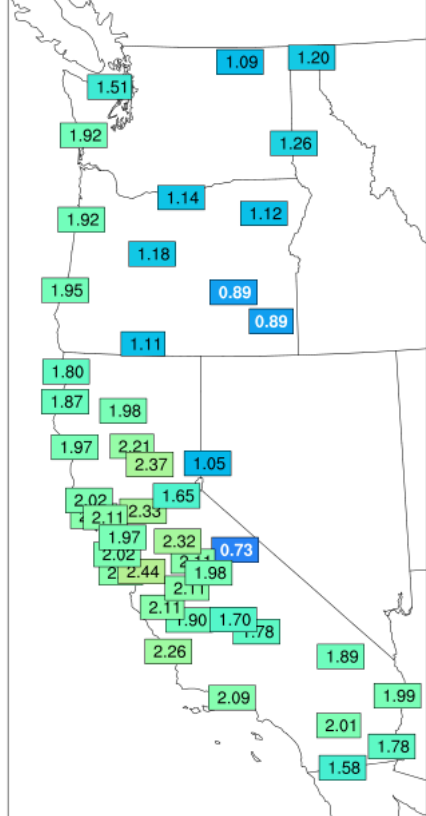
# SSM/I Water Vapor



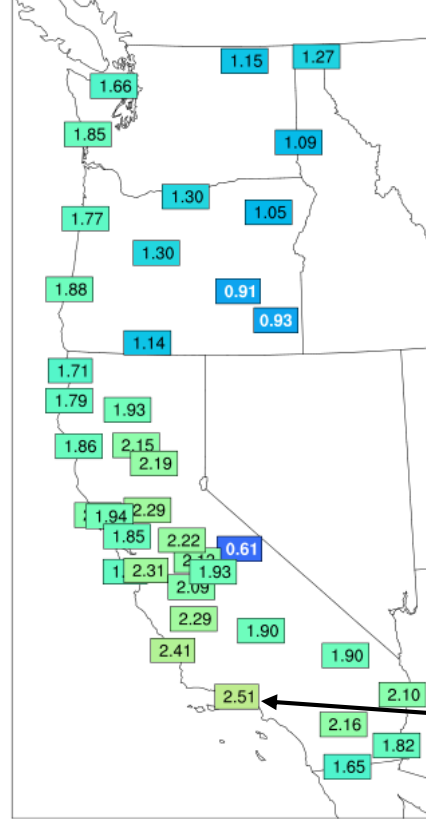
# GFS IVT Analysis

# GPS-Met IWV

GPS Derived Integrated Water Vapor (IWV)

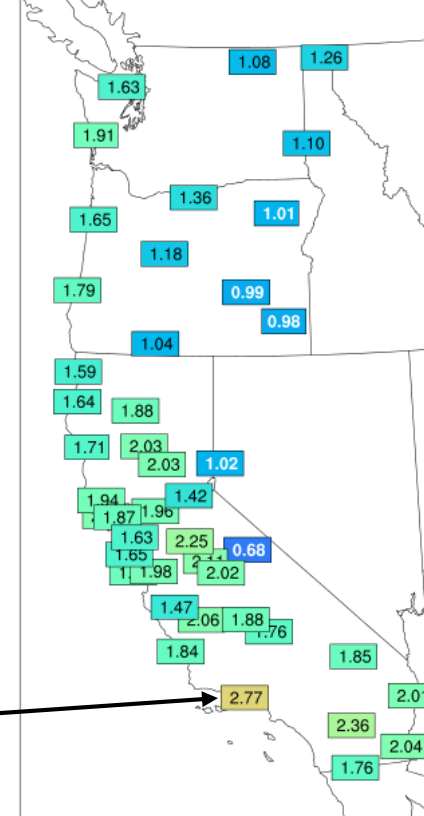


GPS Derived Integrated Water Vapor (IWV)

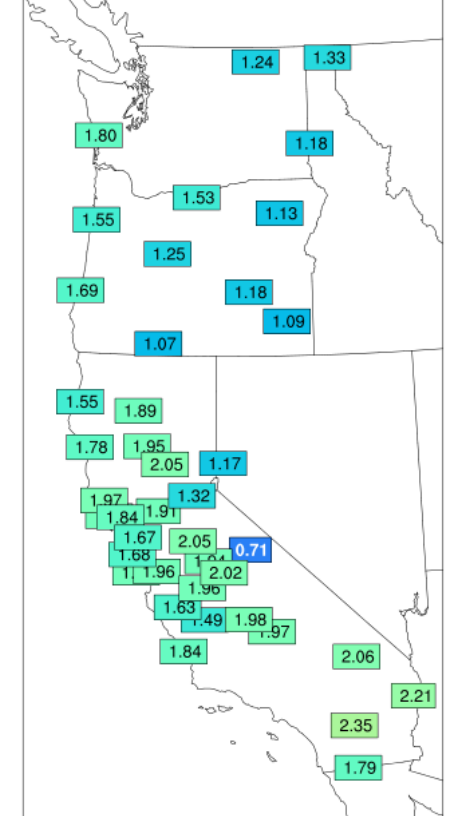


Somis (sms)  
Only station  
that reported  
IWV >2.5 cm

GPS Derived Integrated Water Vapor (IWV)



GPS Derived Integrated Water Vapor (IWV)

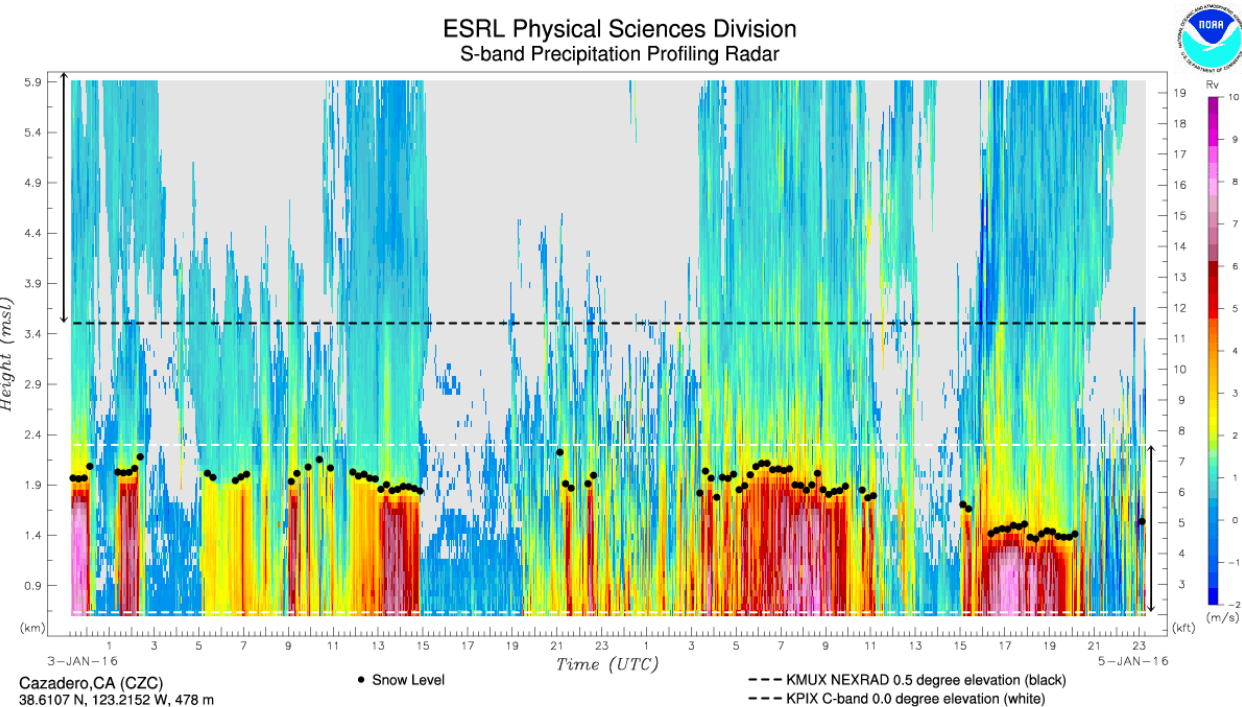


- IWV >2 cm throughout the Central Valley indicate southerly flow carrying moisture north through the valley

# Snow Level Radars

## Cazadero

ESRL Physical Sciences Division  
S-band Precipitation Profiling Radar



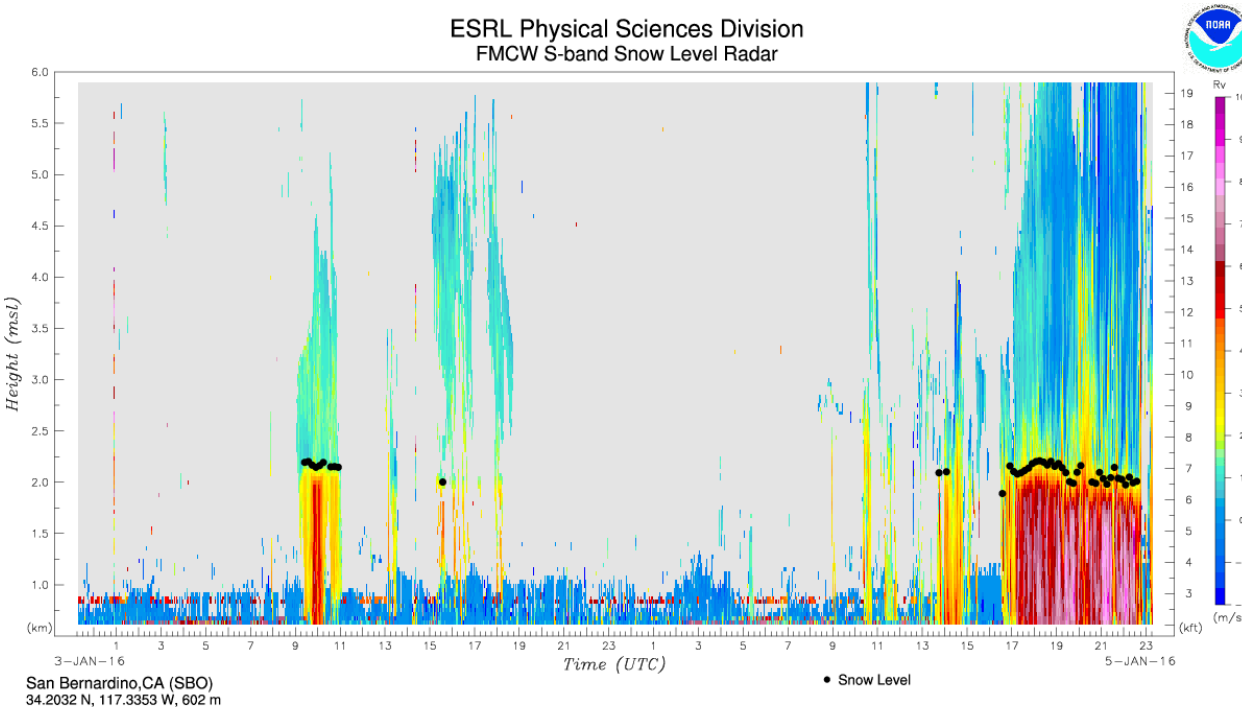
Cazadero, CA (CZC)  
38.6107 N, 123.2152 W, 478 m

Time (UTC)	2345	0045	0145	0245	0345	0445	0545	0645	0745	0845	0945	1045	1145	1245	1345	1445	1545	1645	1745	1845	1945	2045	2145	2245
Snow Level (m)	1969	none	2026	2179	none	none	1996	1979	none	1935	2046	2111	2008	1963	1871	1865	none	none	none	none	none	2225	1891	1954
Snow Level (ft)	6458	none	6645	7147	none	none	6546	6491	none	6346	6712	6924	6586	6440	6138	6117	none	none	none	none	none	7298	6202	6410
Sfc Temp (C)	6.67	7.44	7.37	6.85	7.03	7.25	7.73	6.85	6.18	5.41	5.61	6.56	6.61	6.39	6.20	6.03	6.05	6.12	6.13	6.29	7.00	7.68	8.02	8.68

Time (UTC)	2345	0045	0145	0245	0345	0445	0545	0645	0745	0845	0945	1045	1145	1245	1345	1445	1545	1645	1745	1845	1945	2045	2145	2245
Snow Level (m)	none	none	none	none	1893	1970	2041	2055	1898	1877	1844	1794	none	none	none	1707	1663	1455	1492	1425	1386	none	none	1538
Snow Level (ft)	none	none	none	none	6210	6463	6696	6742	6227	6158	6048	5884	none	none	none	5598	5454	4772	4895	4674	4546	none	none	5044
Sfc Temp (C)	9.53	9.56	8.95	8.97	9.33	9.47	9.36	9.65	9.96	9.45	7.96	8.12	8.77	8.55	8.15	8.03	8.11	7.57	7.42	6.87	6.91	7.27	8.11	8.66

## San Bernadino

ESRL Physical Sciences Division  
FMCW S-band Snow Level Radar



San Bernardino, CA (SBO)  
34.2032 N, 117.3353 W, 602 m

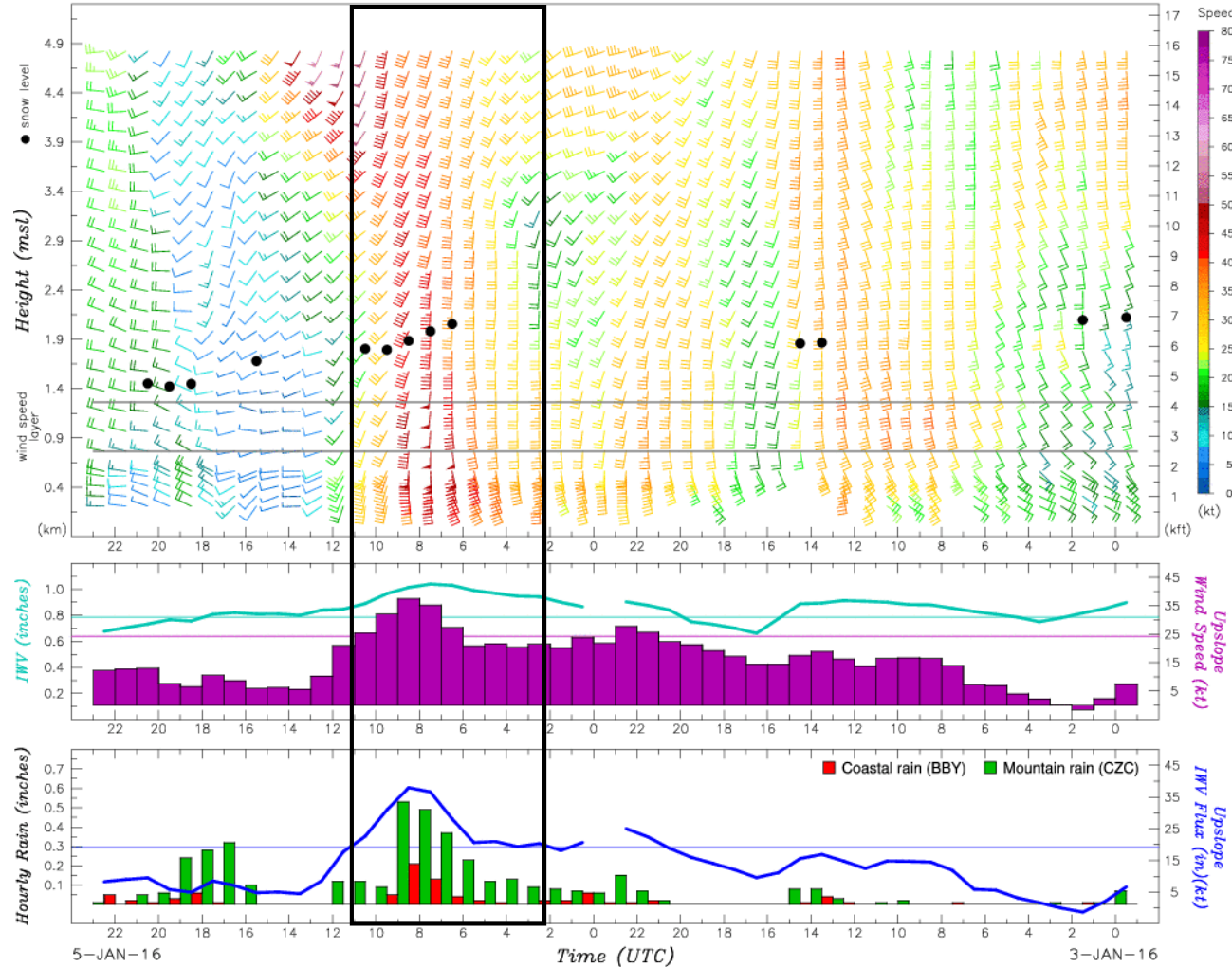
Time (UTC)	2345	0045	0145	0245	0345	0445	0545	0645	0745	0845	0945	1045	1145	1245	1345	1445	1545	1645	1745	1845	1945	2045	2145	2245
Snow Level (m)	none	none	none	none	none	none	none	none	none	none	2167	2151	none	none	none	none	2002	none	none	none	none	none	none	none
Snow Level (ft)	none	none	none	none	none	none	none	none	none	none	7107	7056	none	none	none	none	6566	none	none	none	none	none	none	none
Sfc Temp (C)	13.96	12.28	10.66	10.22	9.73	8.96	9.40	9.92	9.74	10.35	10.72	10.73	9.30	10.22	11.99	11.62	11.16	12.04	12.41	13.95	15.28	16.11	15.72	16.03

Time (UTC)	2345	0045	0145	0245	0345	0445	0545	0645	0745	0845	0945	1045	1145	1245	1345	1445	1545	1645	1745	1845	1945	2045	2145	2245
Snow Level (m)	none	none	none	none	none	none	none	none	none	none	none	none	none	none	2097	none	none	2105	2126	2190	2095	2018	2033	2009
Snow Level (ft)	none	none	none	none	none	none	none	none	none	none	none	none	none	none	6878	none	none	6904	6974	7183	6871	6620	6669	6589
Sfc Temp (C)	15.81	14.48	13.44	12.73	12.18	11.57	10.87	10.64	10.60	10.20	10.21	10.30	10.25	10.04	10.01	9.18	9.62	10.02	9.75	9.51	9.25	9.19	9.46	9.52

- Snow level at Cazadero decreased ~0.7 km in 10 hours, indicating the passing of a cold front
- Snow level at San Bernadino is above 2 km indicated it is still prefrontal

# Bodega Bay ARO Water Vapor Flux

ESRL Physical Sciences Division  
Coastal Atmospheric River Monitoring and Early Warning System



Bodega Bay, CA (BBY)  
38.3191 N, 123.0728 W, 15 m  
Cazadero, CA (CZC)  
38.6107 N, 123.2152 W, 478 m

Upslope Direction = 230 deg  
BBY 48-hr precip: 0.86 in  
CZC 48-hr precip: 4.11 in

- Strong southerly winds and high IWP between 0600 and 0900 UTC on 5 January resulted in strong upslope IWP flux and precipitation
- Change in winds at 1200 UTC indicates the passage of a cold front
- AR conditions lasted ~9 hours
  - Began 0200 UTC
  - Ended 1100 UTC

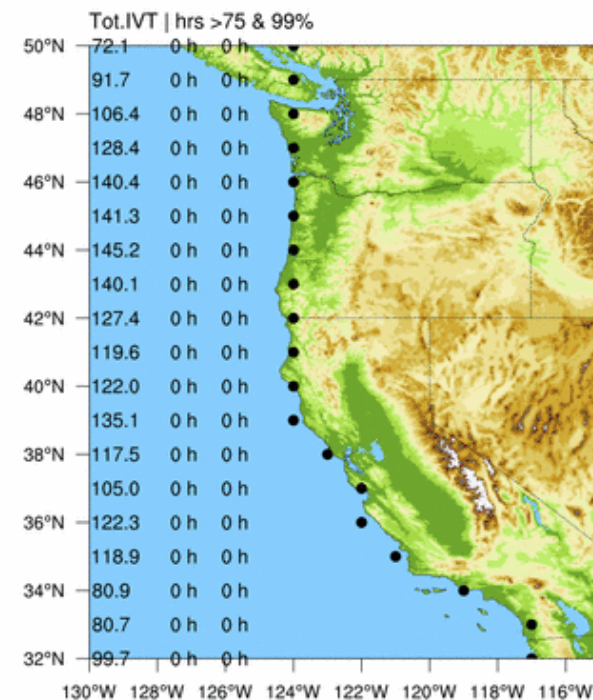
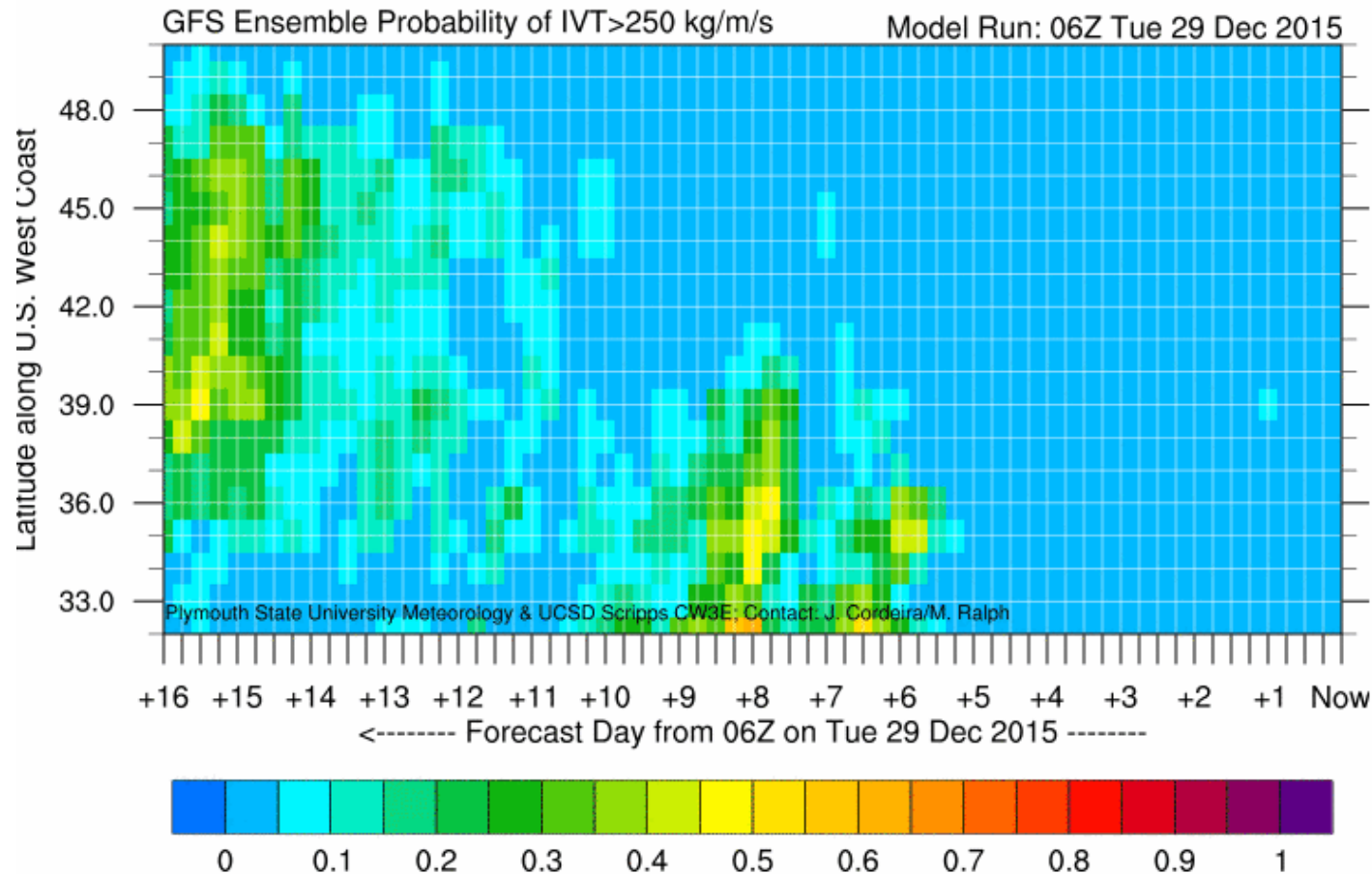


# Observed Snow Levels



- ~4500 ft in northern California
- 5000-6000 ft in central California
- ~6600 near the transverse Ranges
- Freezing levels below terrain (Sierra Nevada) allow for accumulation of snow pack
  - Important to water supply and less likely to cause flooding

# AR Landfall Tool (dProg/dt)



- >50% of ensemble members predicted the landfall of the AR ~8 days in advance
- >85% of ensemble members predicted the landfall of the AR ~3 days in advance
- AR conditions were not forecasted over southern CA until ~5 days in advance
- Between days 8 and 3 duration of AR conditions forecasted ranged from ~18–48 hours
- Duration and location of AR conditions remained constant and accurate during days 0–3 forecasts

# Summary

- Was this an AR?
  - Yes, but it was relatively weak and dissipating at the time it made landfall
  - The region of IVT  $>250 \text{ kg m}^{-1} \text{ s}^{-1}$  and IWV  $>20 \text{ mm}$  was  $>2000 \text{ km}$  and  $<1000 \text{ km}$  for several days over the Pacific Ocean
  - IVT conditions were observed over BBY for  $\sim 9$  hours
- Greater than 4 inches of 24-hr accumulated precipitation observed
- Streamflow has increased well above normal in most streams and rivers throughout California and reservoirs are receiving much needed inflow
- San Diego county received  $\sim 17\%$  of its average annual precipitation
- Multiple mudslides, debris flows, and widespread flooding throughout southern CA