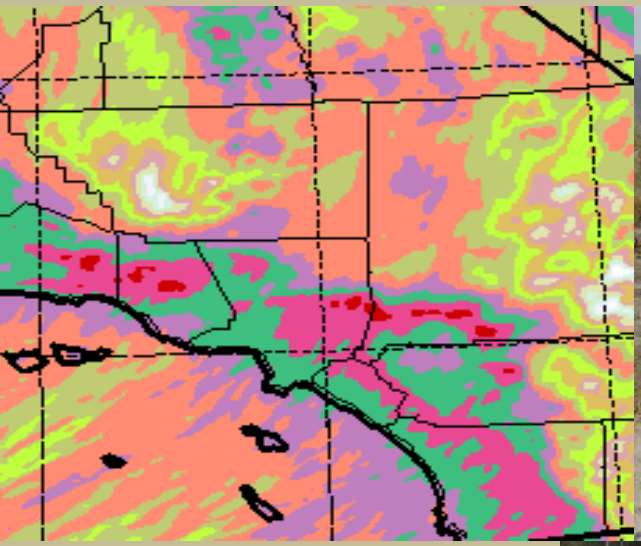
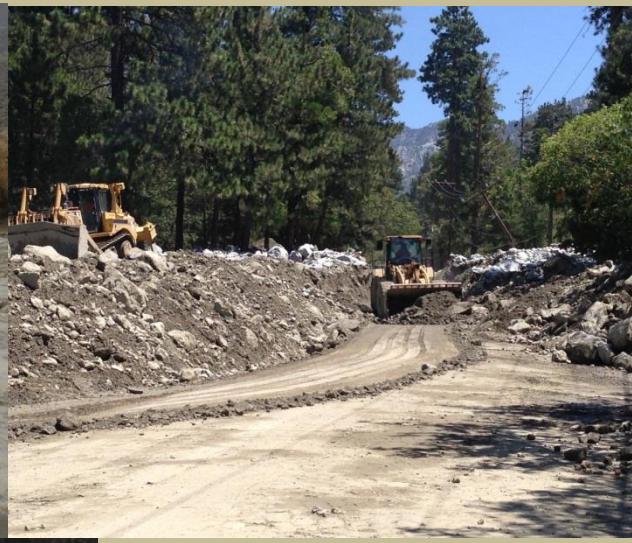
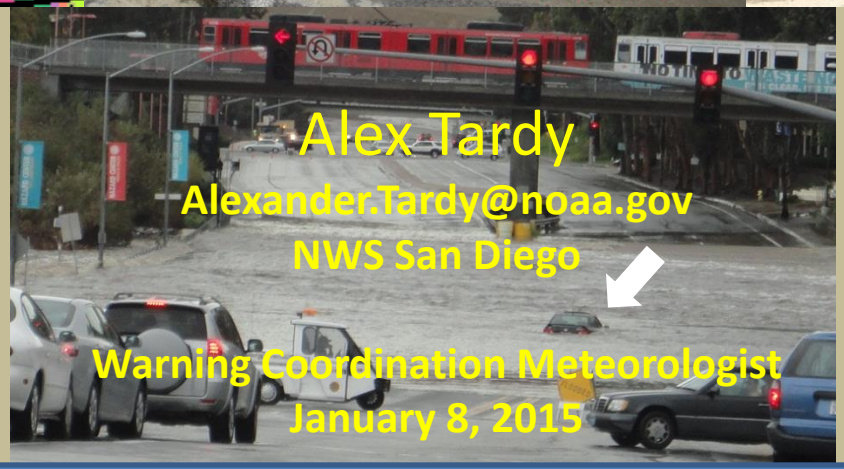
Strengths and Weaknesses of High Resolution NWP in Precipitation Forecasting for Coastal Mountain Desert Climate Regimes







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NWS San Diego
Warning Coordination Meteorologist

January 8, 2015

CANSAC WRF
WRF-EMS ARW
NAM4
HRRR

Motivation

- Orographic precipitation is significant in Southwest California (wet slopes 2 to 4x annual precipitation)
- NWP has improved significantly and can be used to fine tune orographic and convective precipitation forecasts, however experience with timing, intensity and location is necessary otherwise the guidance can be dismissed
- Over generation of precipitation can occur in high resolution NWP, as much as 50 percent too high
- NWS tendency to forecast “orographic signatures” as default and rely on legacy NWP output
- Can the NWP be utilized in a wide variety of weather regimes (coastal, orograghic, convective, elevated, etc)?
- High resolution NWP can significantly increase confidence in a forecast following the use of other tools such as analogs, anomalies (R-climate), ensemble spreads, reforecasts (M-climate) and synoptic –scale patterns

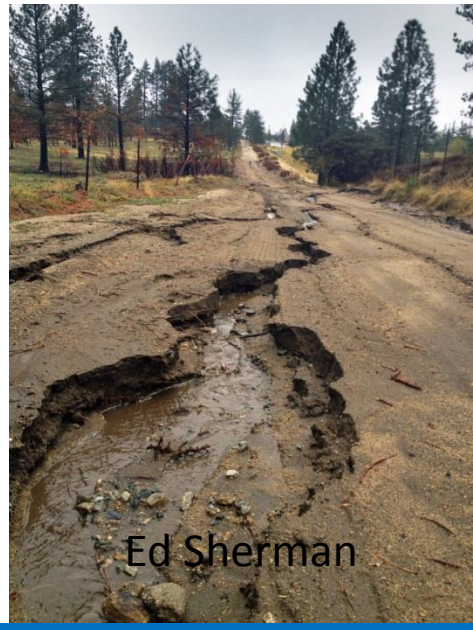
Outline

- NWP events where precipitation forecasts (QPF) were grossly over estimated and needs to be used with caution. Cross check with other confidence tools such as anomalies and reforecasts (adjust timing and location)
- High resolution NWP effective in resolving non-orographic precipitation patterns (synoptic forcing)
- Small scale orographic effects are well forecast by high resolution NWP
- NWP cases where precipitation forecasts (QPF) are precise (location and amounts) and provide detailed accurate resolution which forecasters need to use
- High resolution NWP can accurately forecast moist convection intensity and location of high threat areas for enhanced impact decision support services

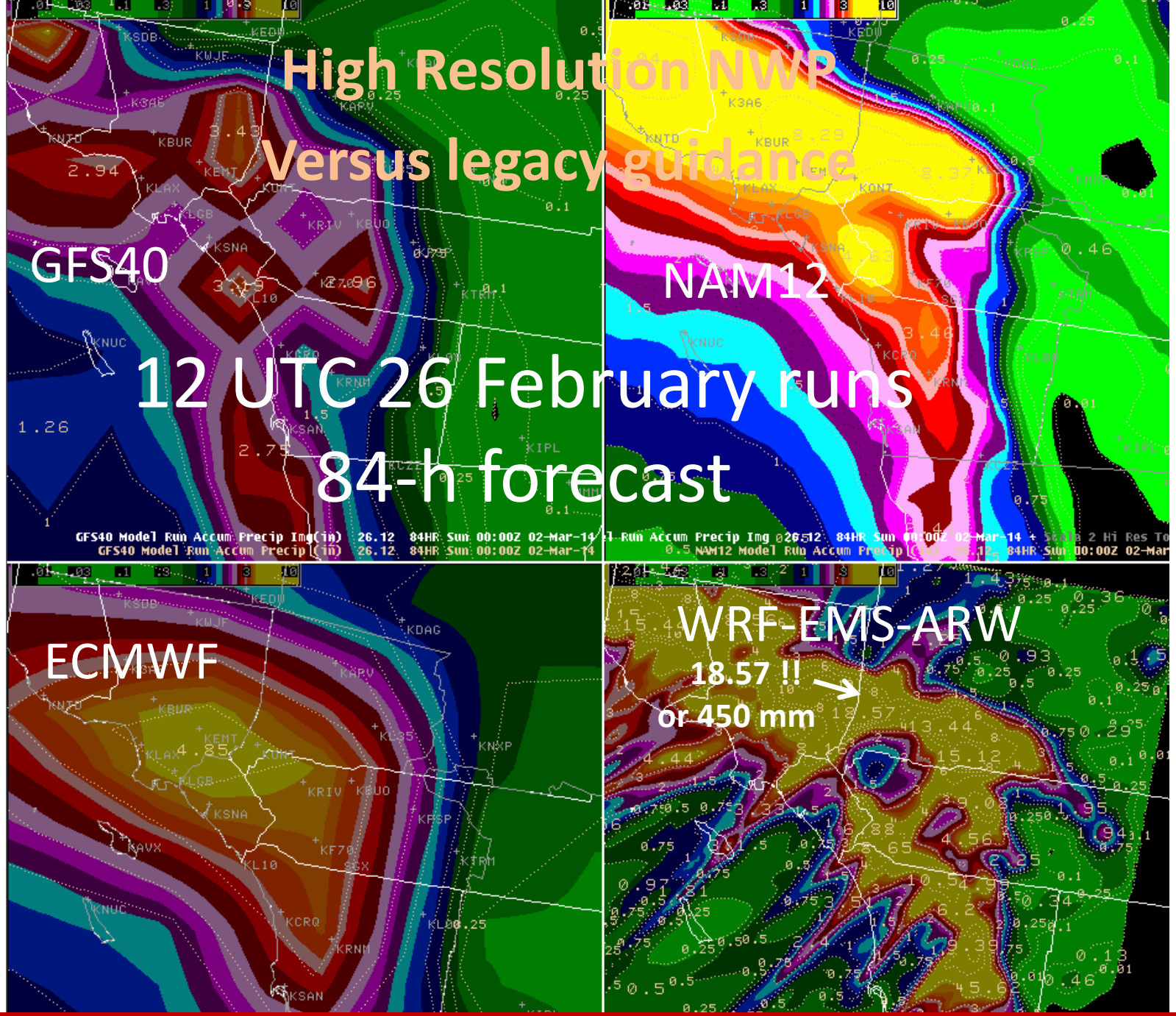
NWS San Diego Service Area

Confidence Tools for evaluation of excessive precipitation forecast

- Analogs (pattern recognition)
- Reforecast (M-climate)
- Standardized anomalies (R-climate)
- Ensemble extremes and means
- Probabilities of exceedance
- Measure of predictability (RMOP)

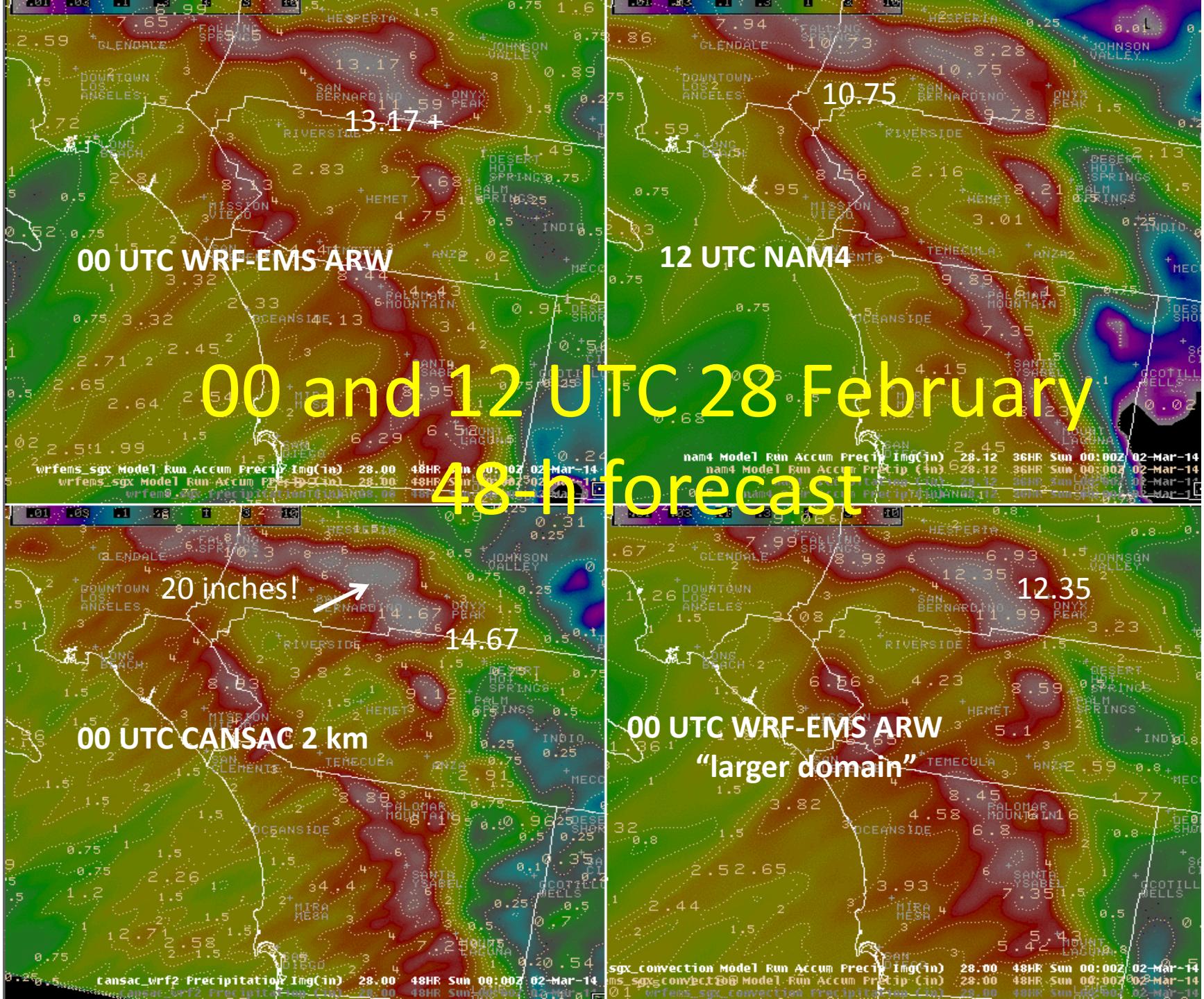


Use with other forecast tools



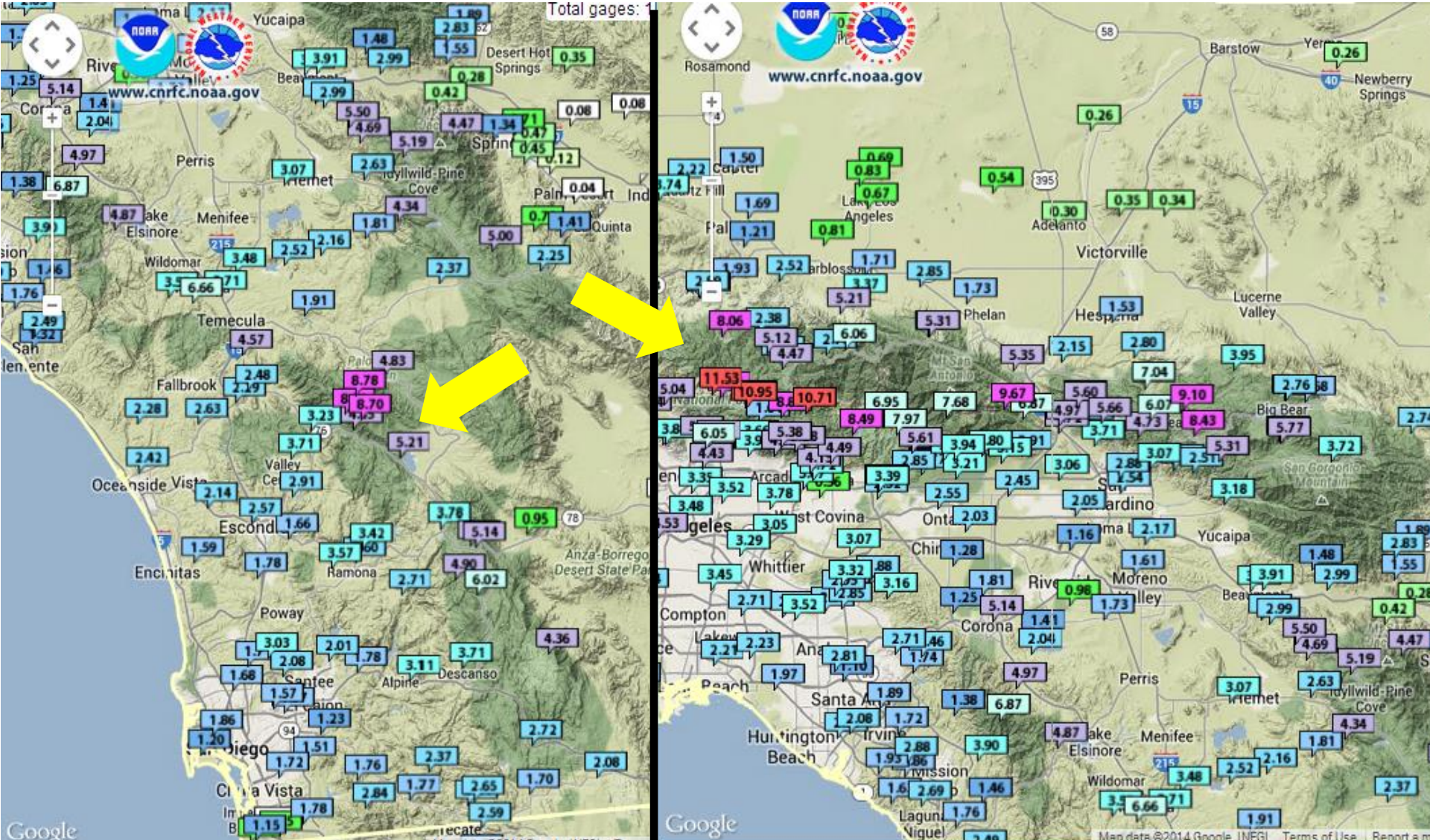
Caution Case

Case 1 – excessive QPF

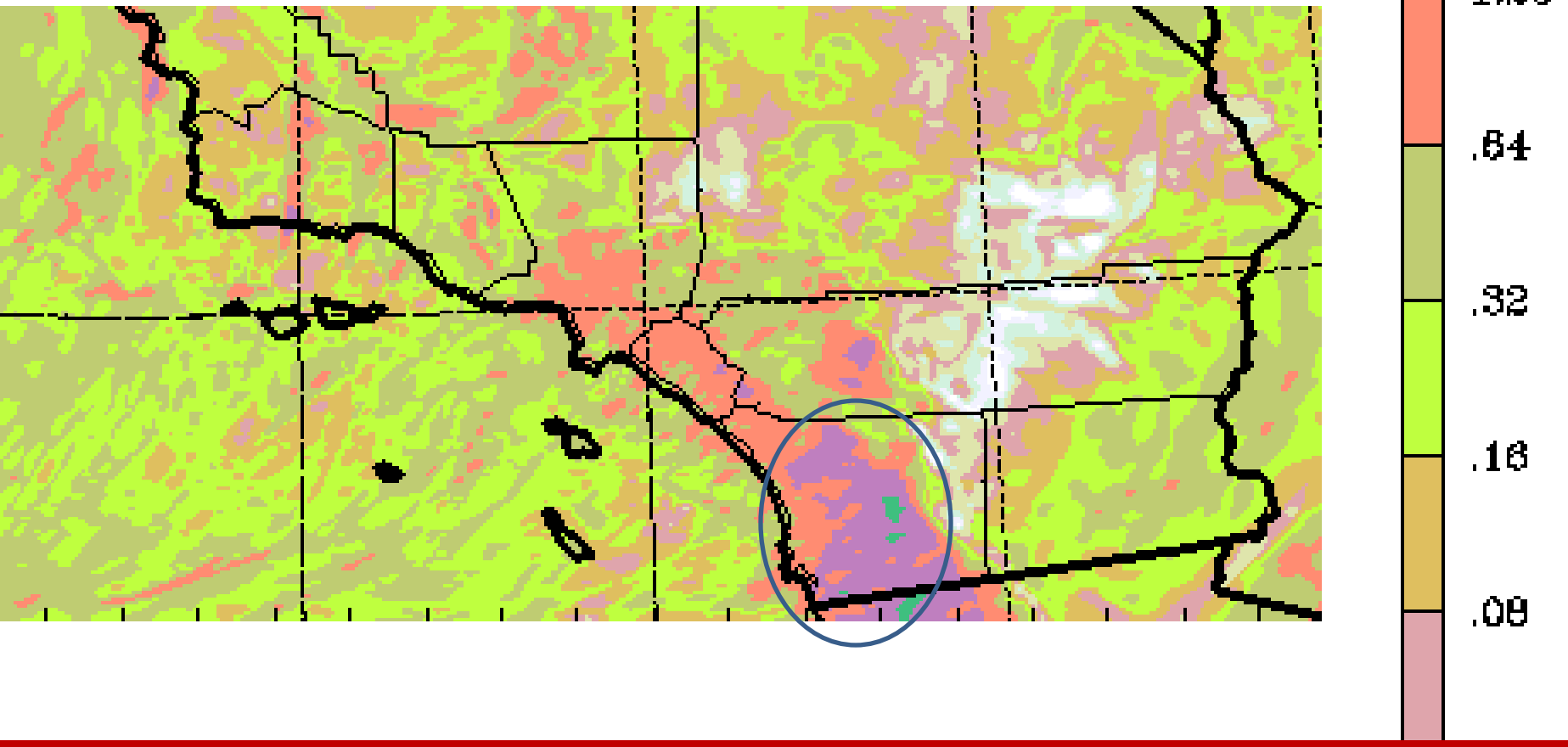

13.17 +
00 UTC WRF-EMS ARW
10.75
12 UTC NAM4
00 and 12 UTC 28 February
48-h forecast
20 inches!
14.67
00 UTC CANSAC 2 km
12.35
00 UTC WRF-EMS ARW
"larger domain"

Storm Total 4 day

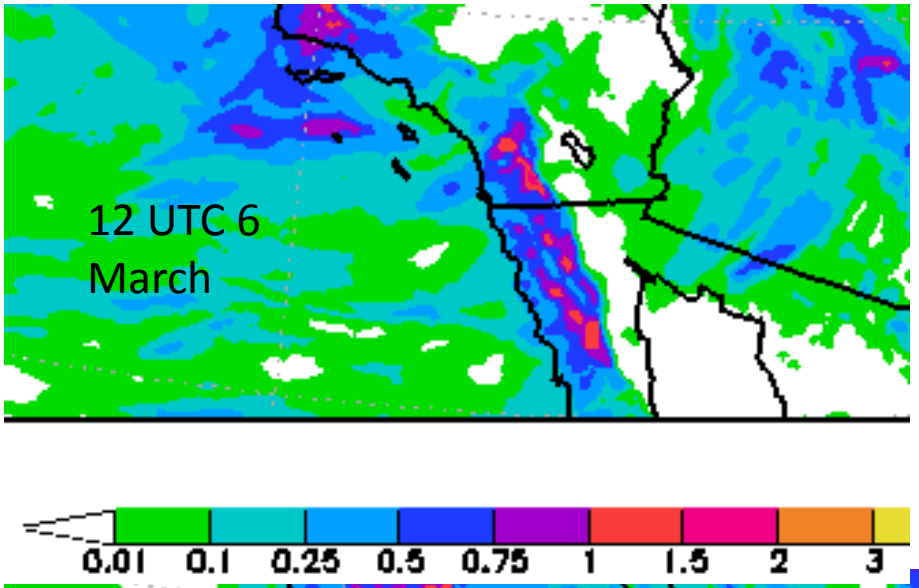
February 27 to March 2, 2014

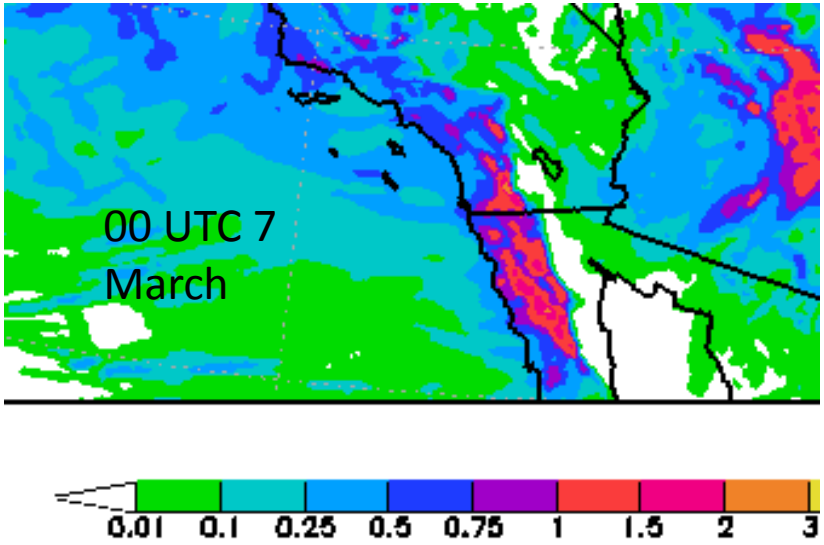


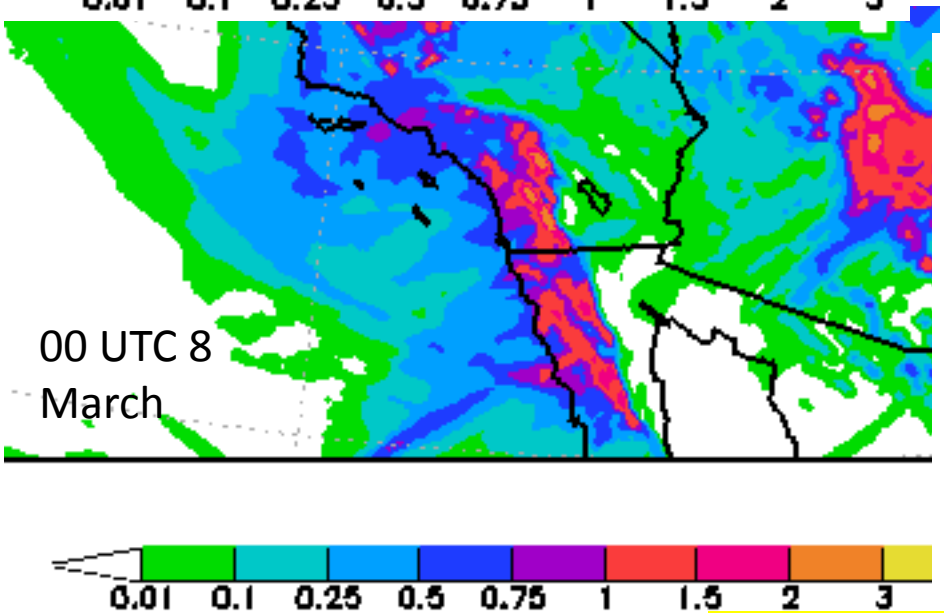
00 UTC 7 March 2013 run total QPF

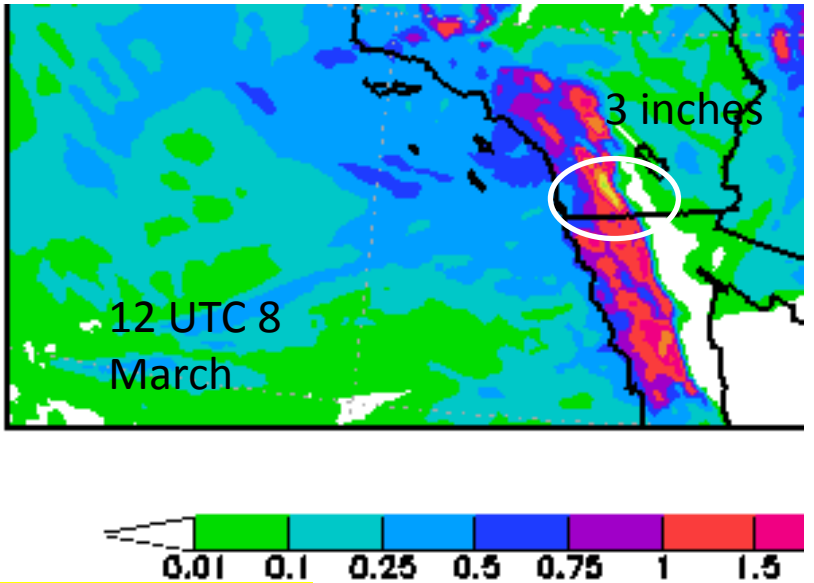


NAM4 QPF run totals



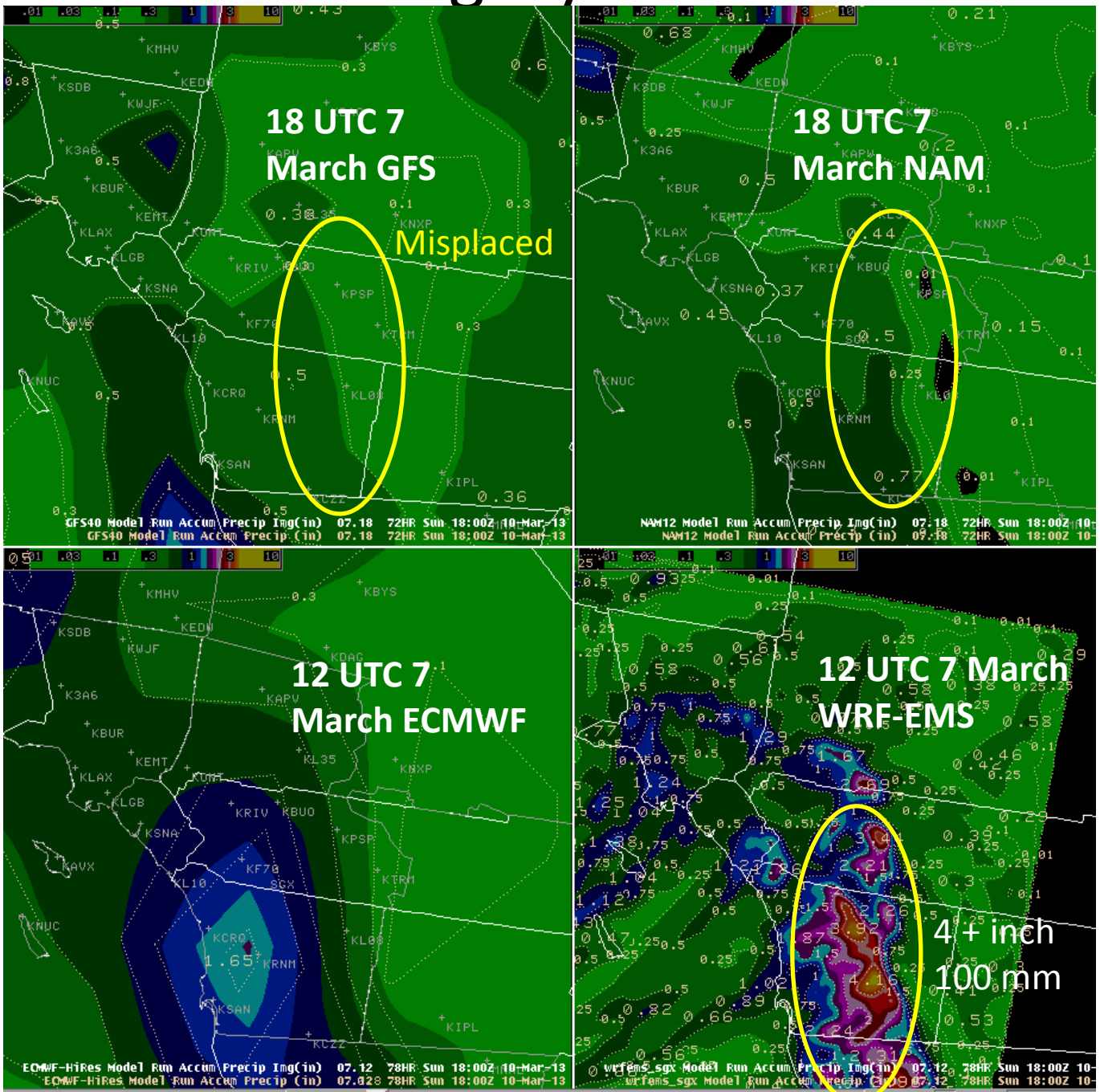




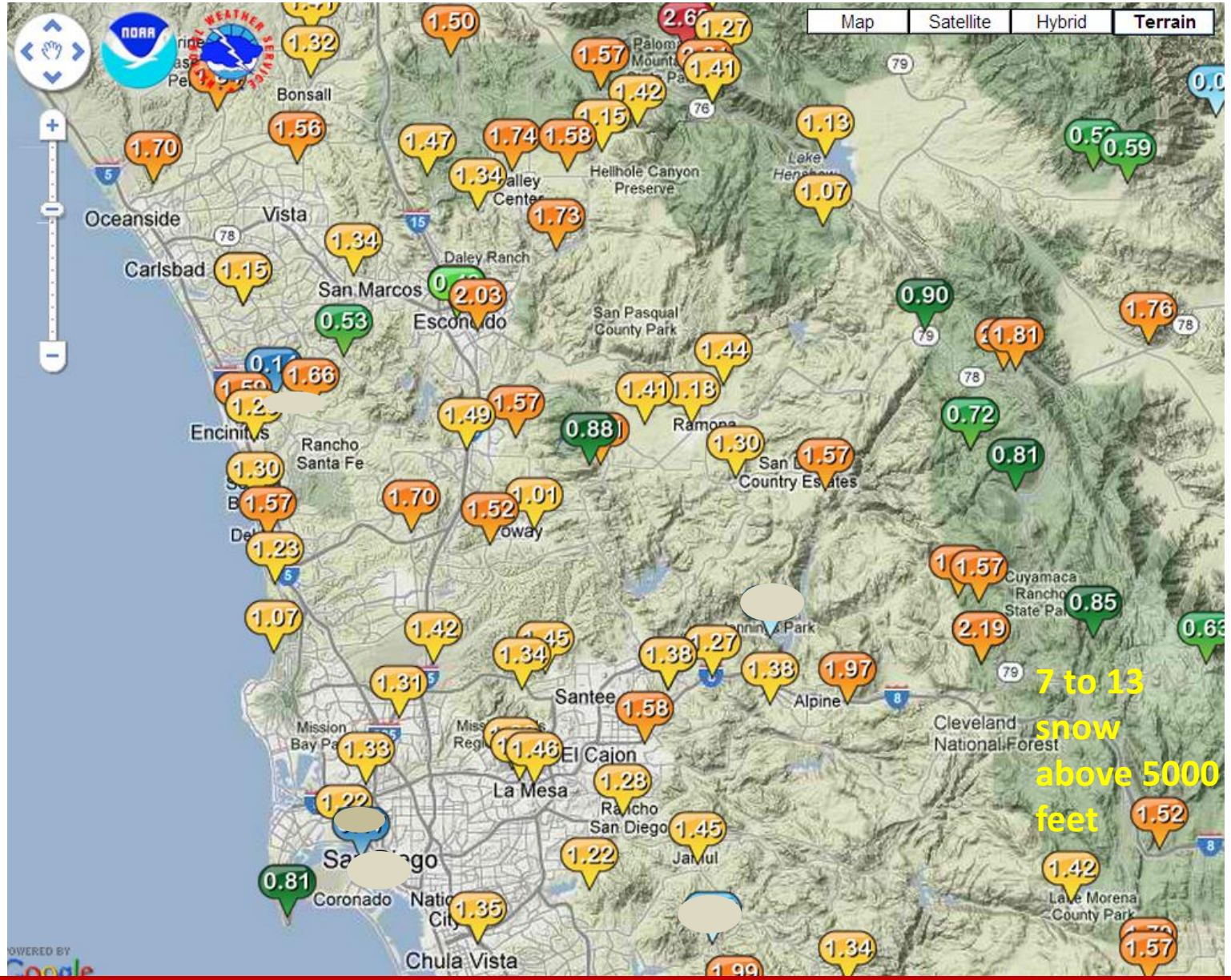


Newer runs = wetter

Legacy NWP

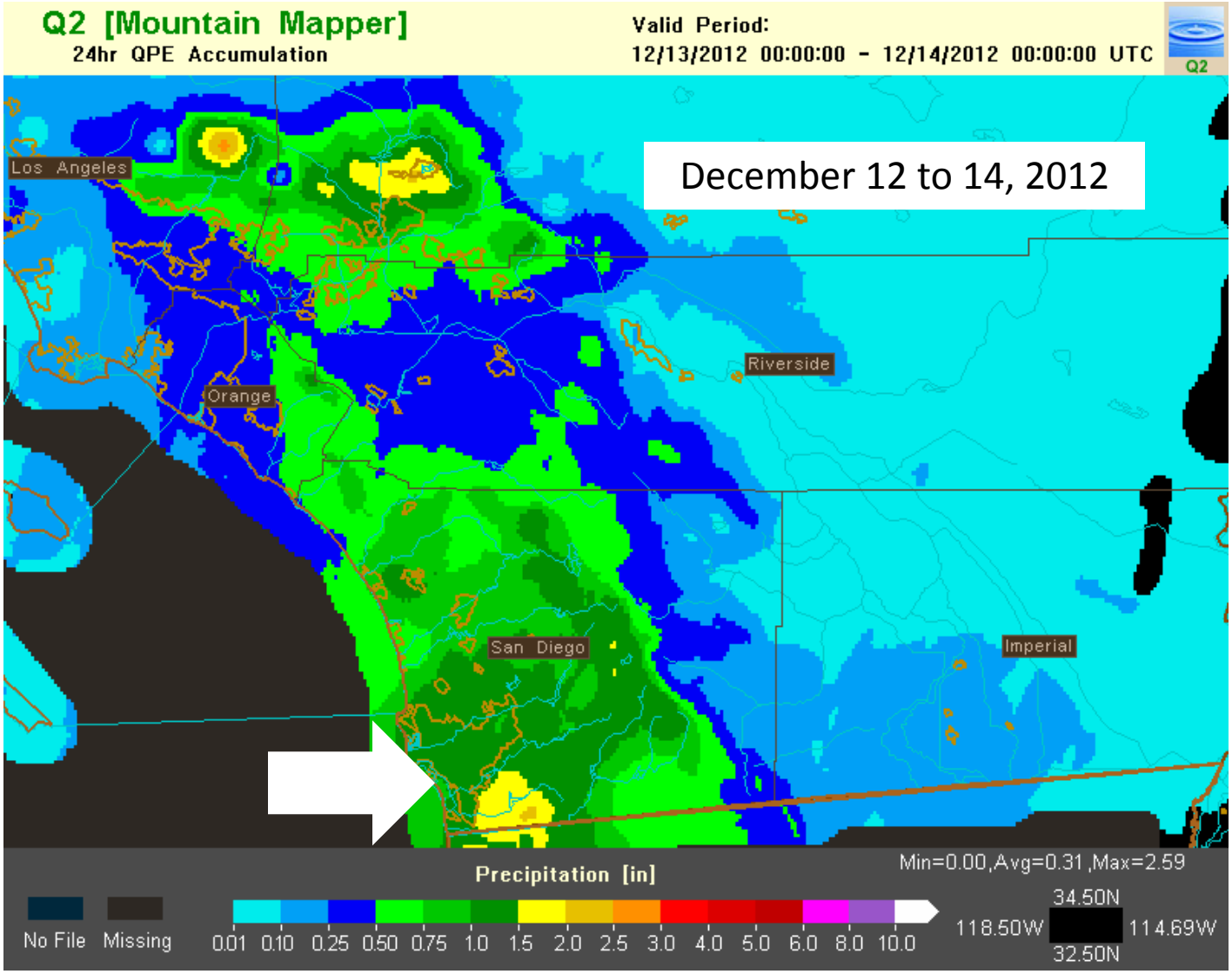

18 UTC 7
March GFS
Misplaced
18 UTC 7
March NAM
12 UTC 7
March ECMWF
12 UTC 7 March
WRF-EMS
4 + inch
100 mm

San Diego County totals



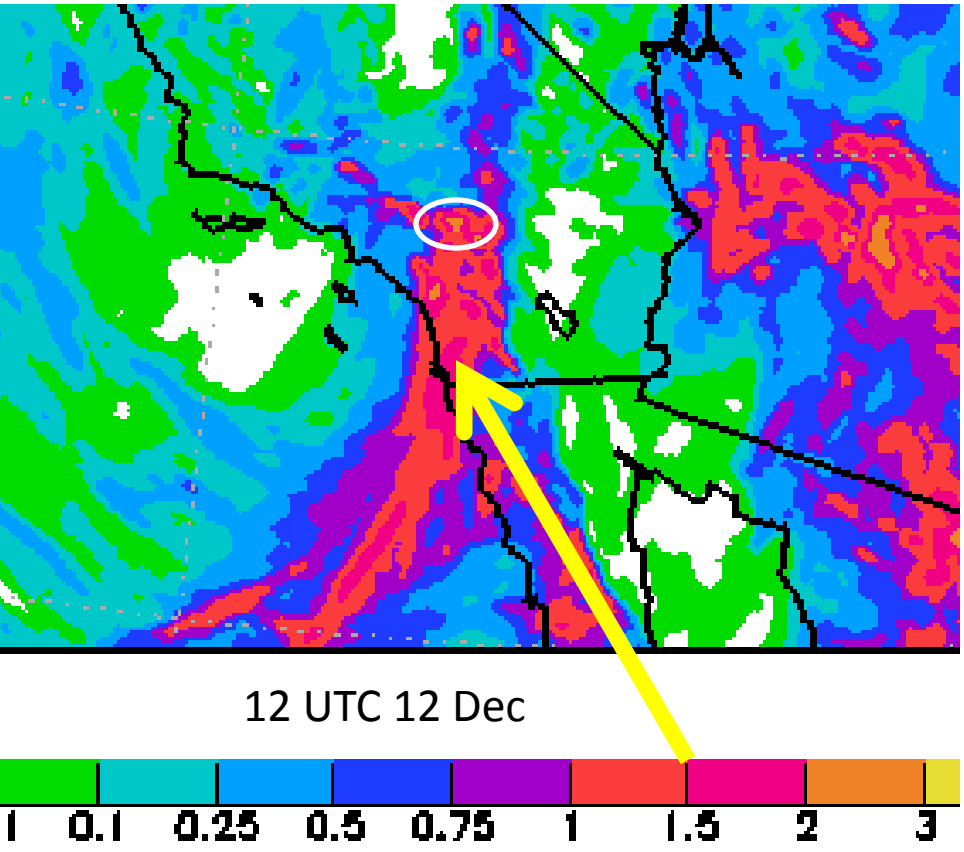
Case 2 – excessive QPF

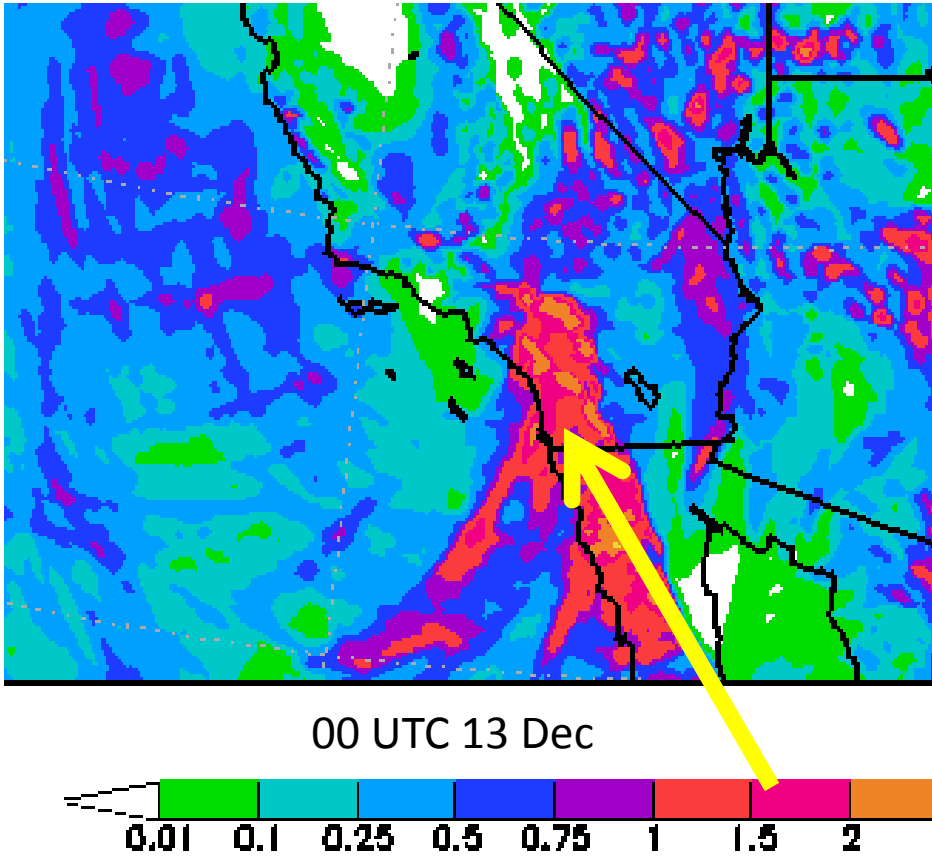
Non-orographic coastal precipitation



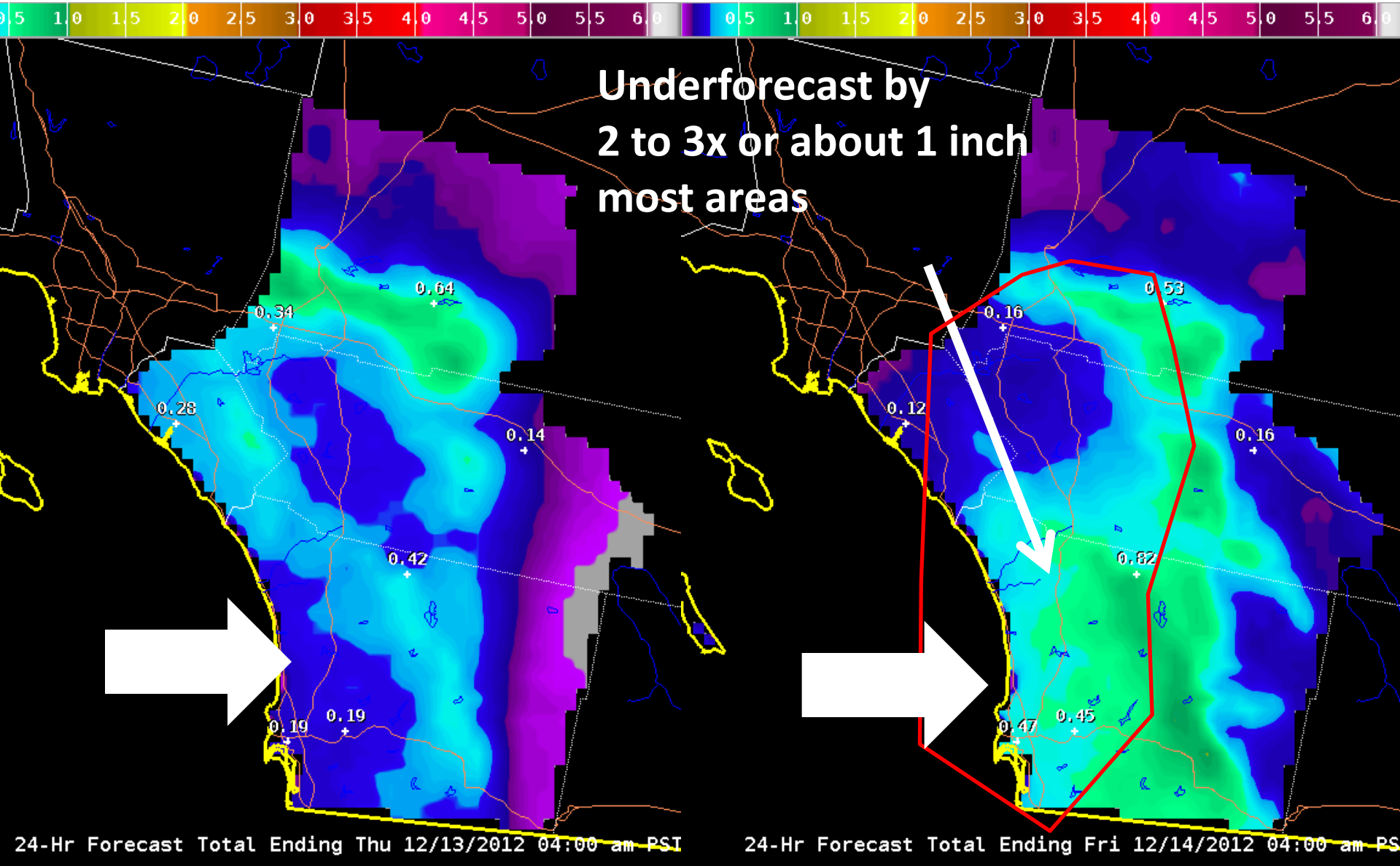
12 UTC 12 December NAM (4km) – 18 to 30 hour lead time
00 UTC 13 December NAM (4km) – 6 to 18 hour lead time

Widespread 1 to 1.5 inches (west of Mountains), and favored south slopes 2 to 2.5





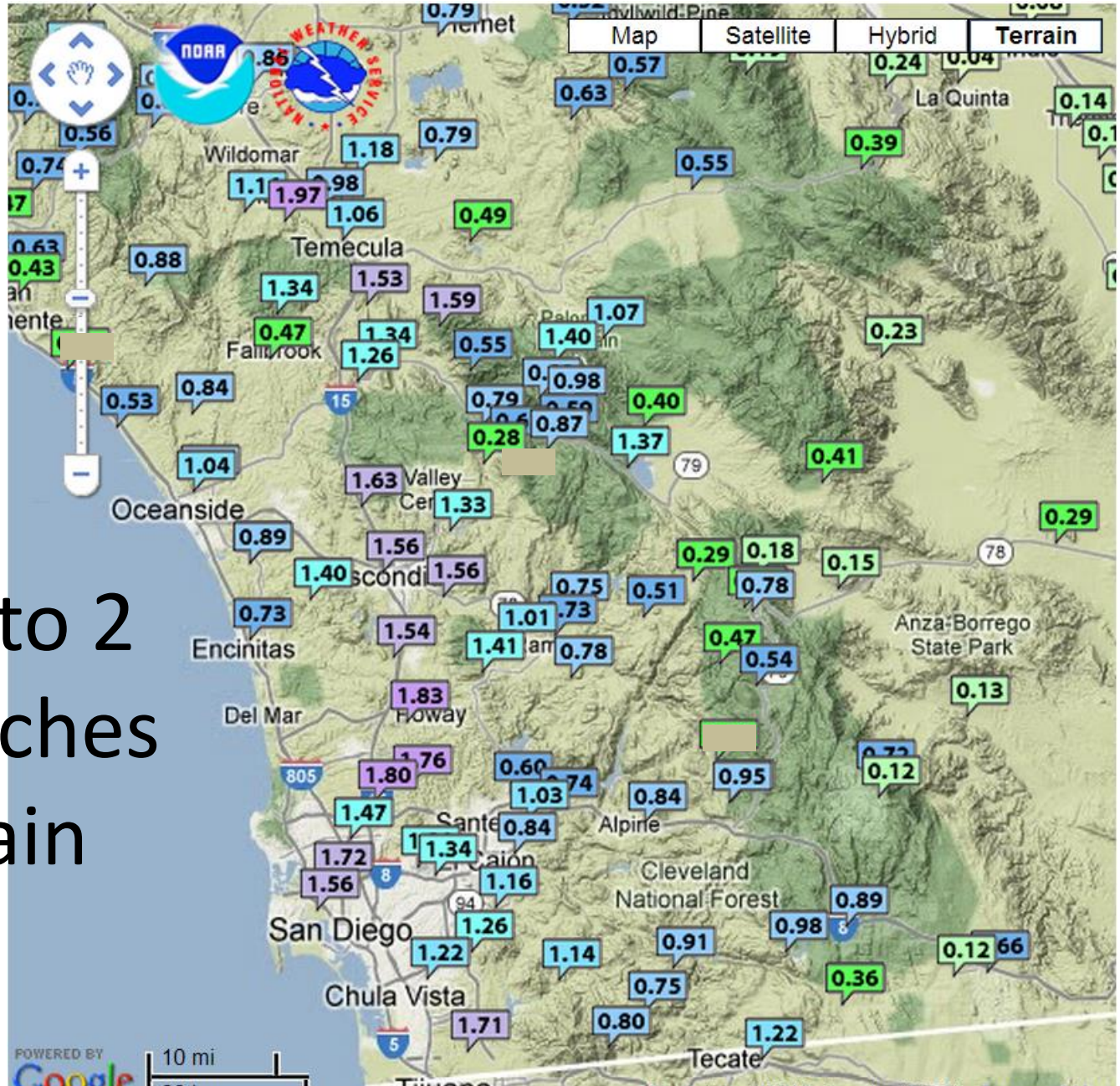
CNRFC Day 2 and 3
RFC model relies on orographics



24 hour precipitation San Diego County

1 to 2 snow above 5000 feet

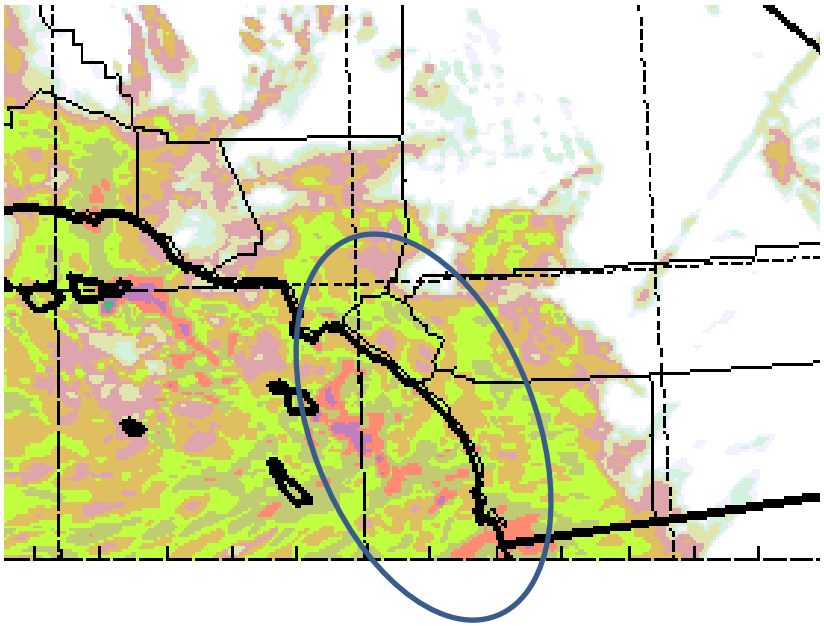
1 to 2 inches rain

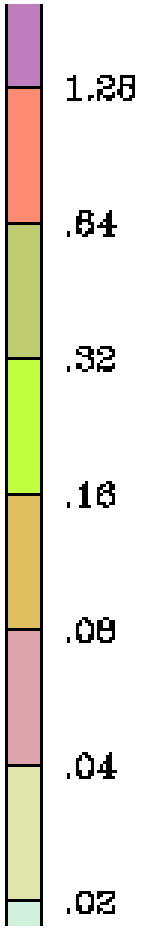


CANSAC total for December 29-30, 2012

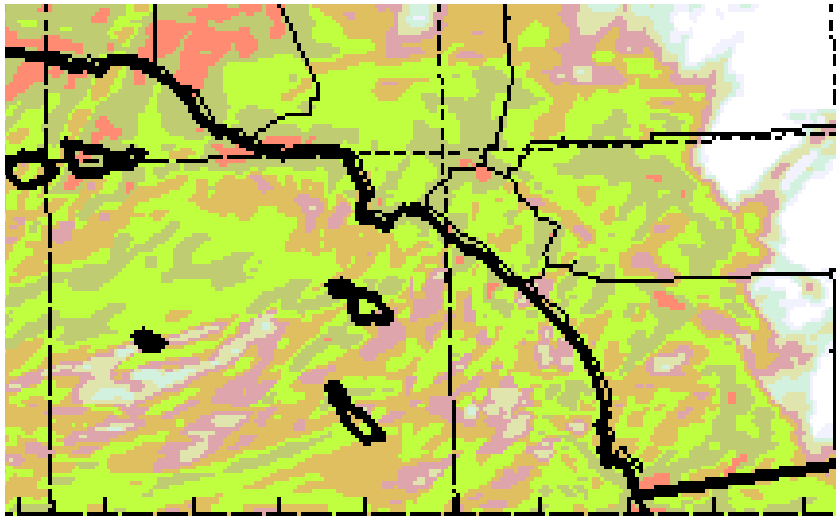
00 UTC 28 and 00 UTC 29 December

Evenly distributed



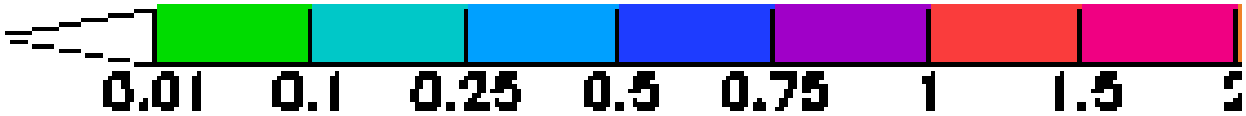


Coastal Showers

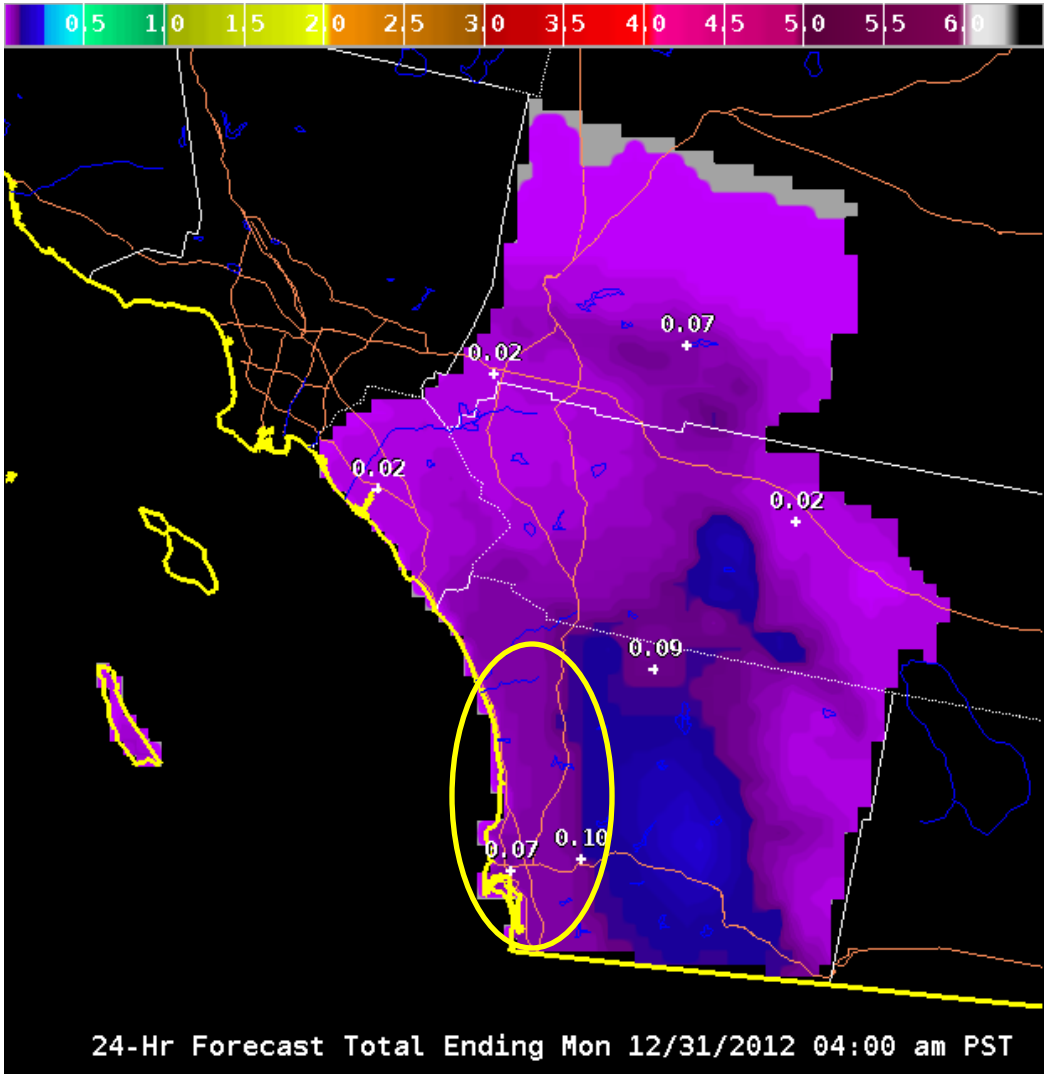


NAM4 run total for December 29-30, 2012

12 UTC 29 December run



CNRFC QPF depict orographic rainfall when coastal areas of SD county had the most on Sunday December 30



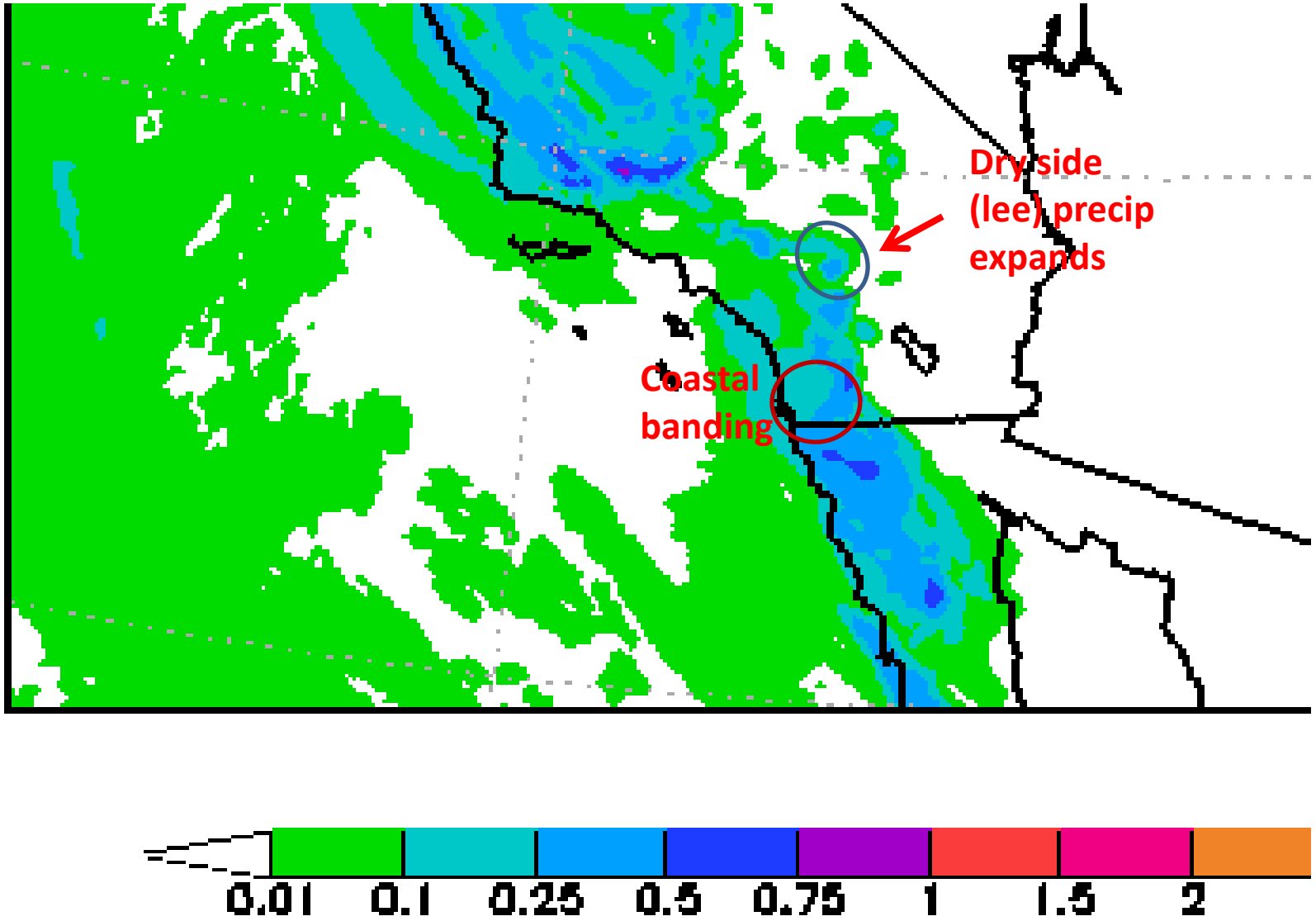

San
Diego

Tardy view
From San
Marcos
Double Peak


Batiquitos
Lagoon

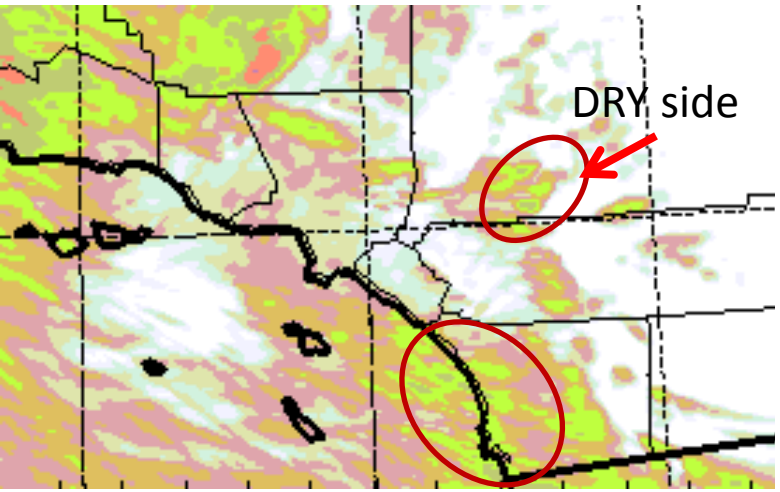
High resolution models (4 km NAM)

12 UTC 6 January 2013 run total

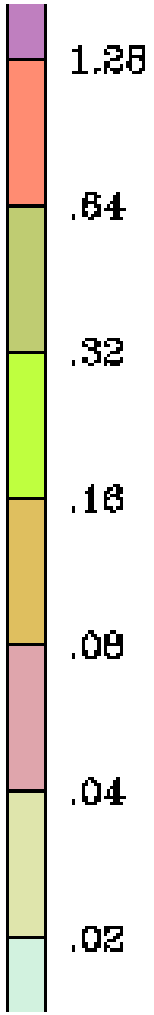


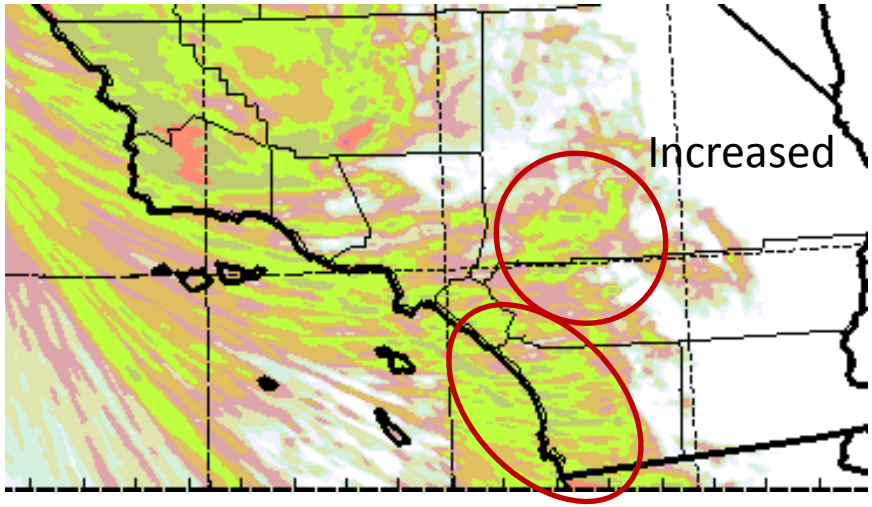
CANSAC 2 km

00 UTC and 12 UTC 6 January runs



Coastal shower bands

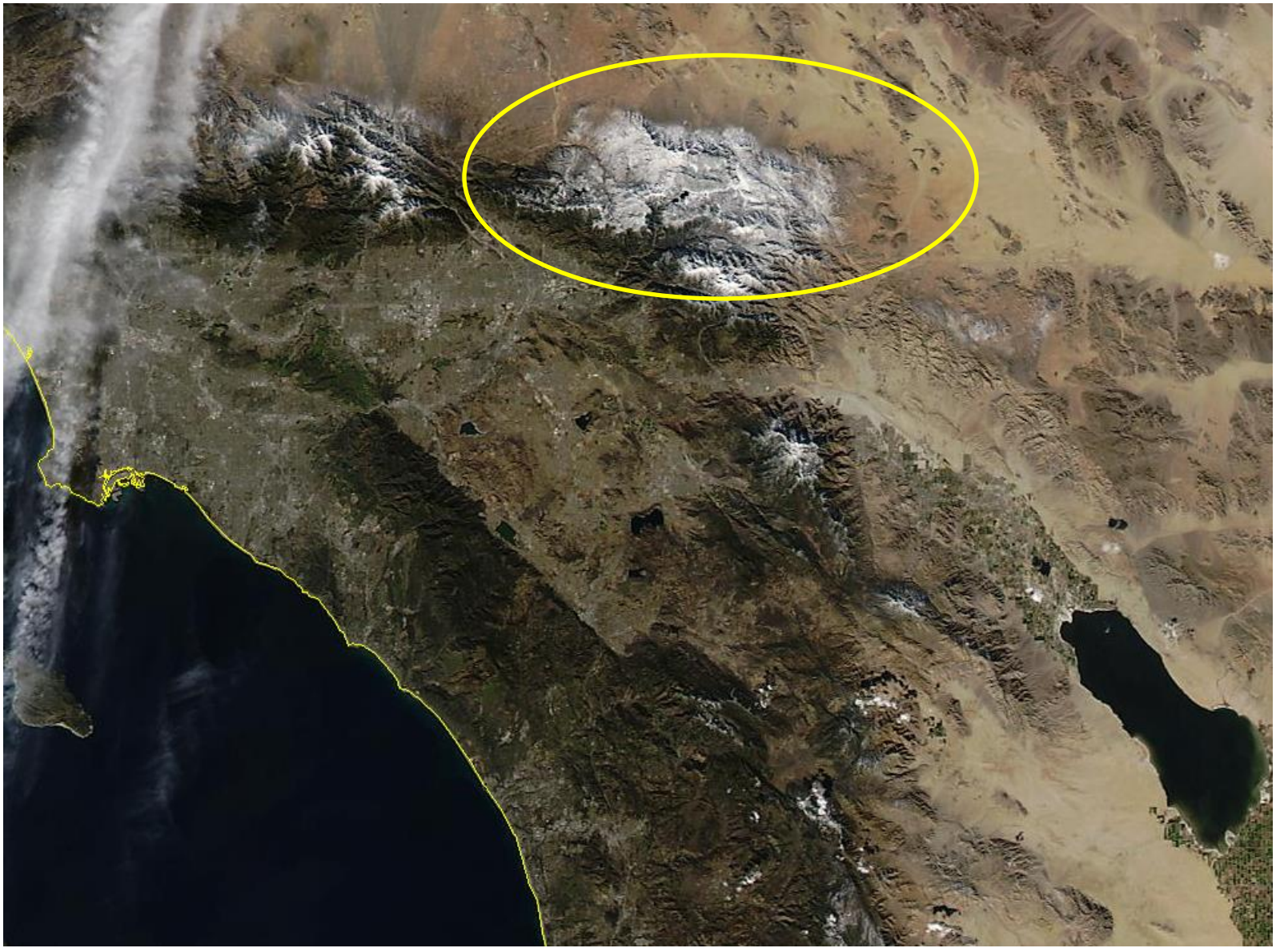


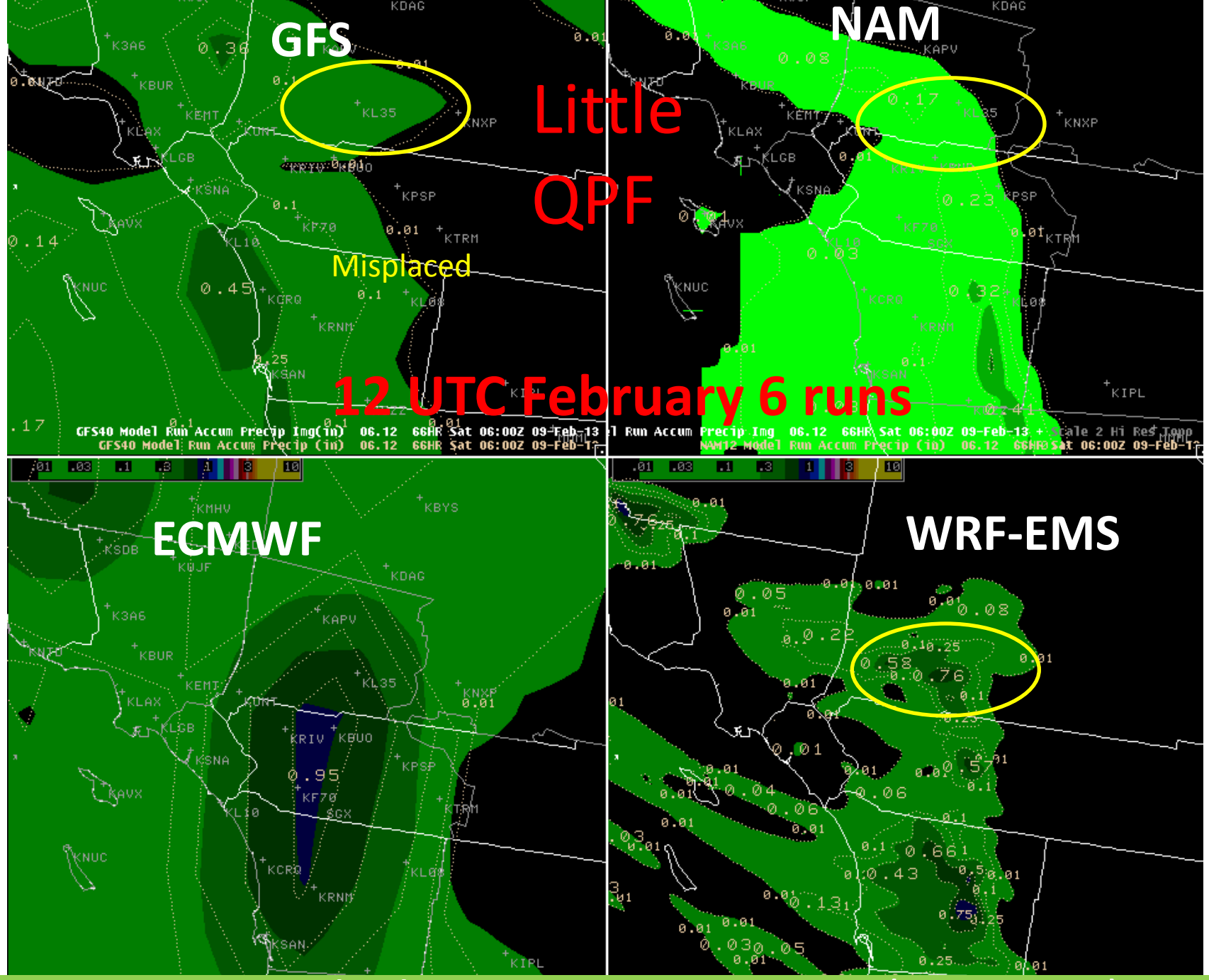


Increased

3 to 5 inches snow on the desert side Lucerne Valley

January 7, 2013
3 to 5 inches snow in high desert

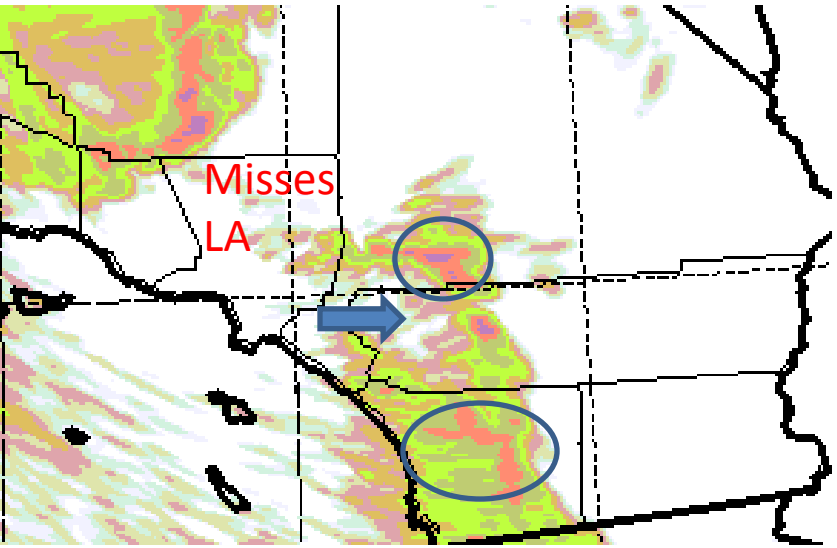


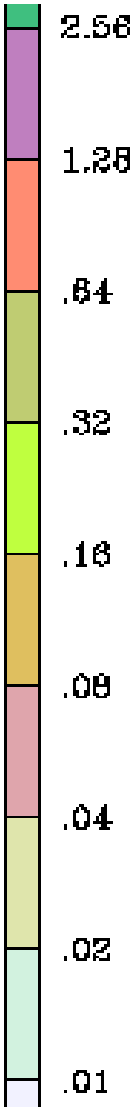


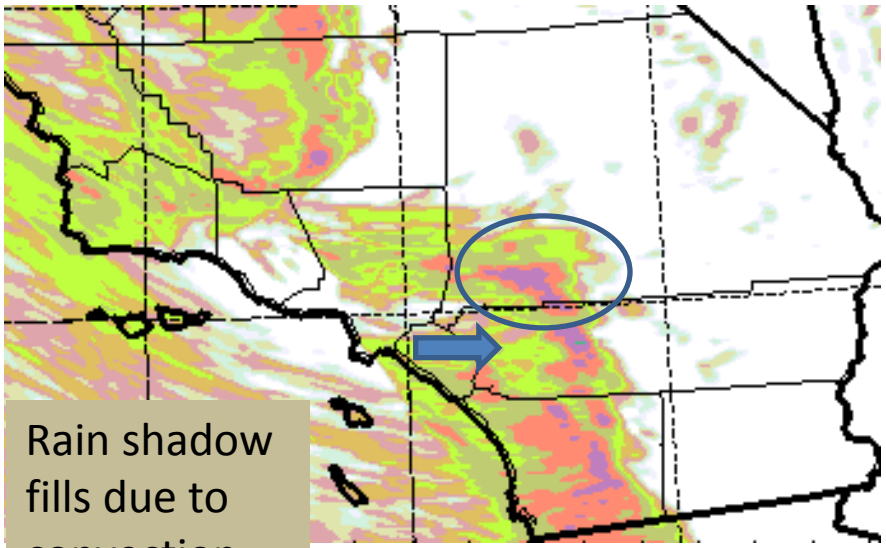
Effective Case Case 6 – high impact precipitation (mountain)

12 UTC 6 February and 00 UTC 7 February 2013

CANSAC WRF at 2 km







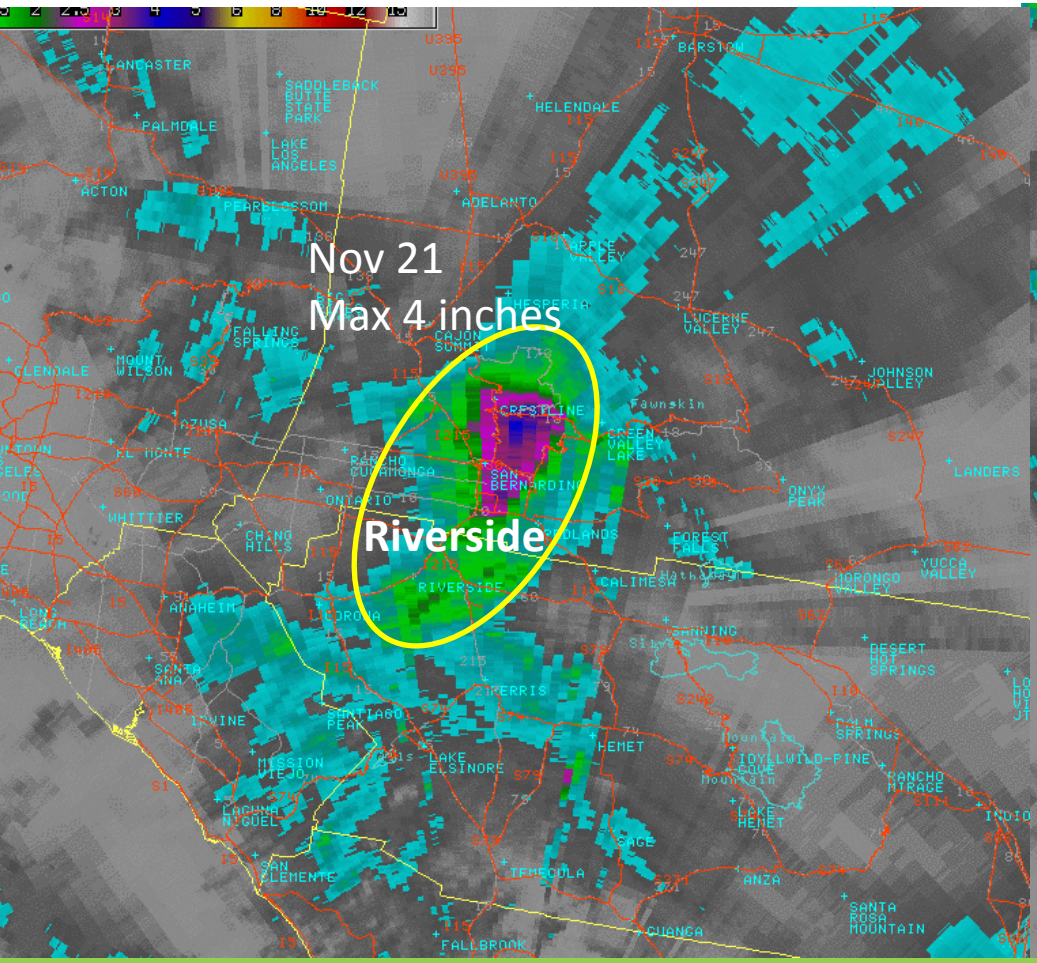
Rain shadow fills due to convection

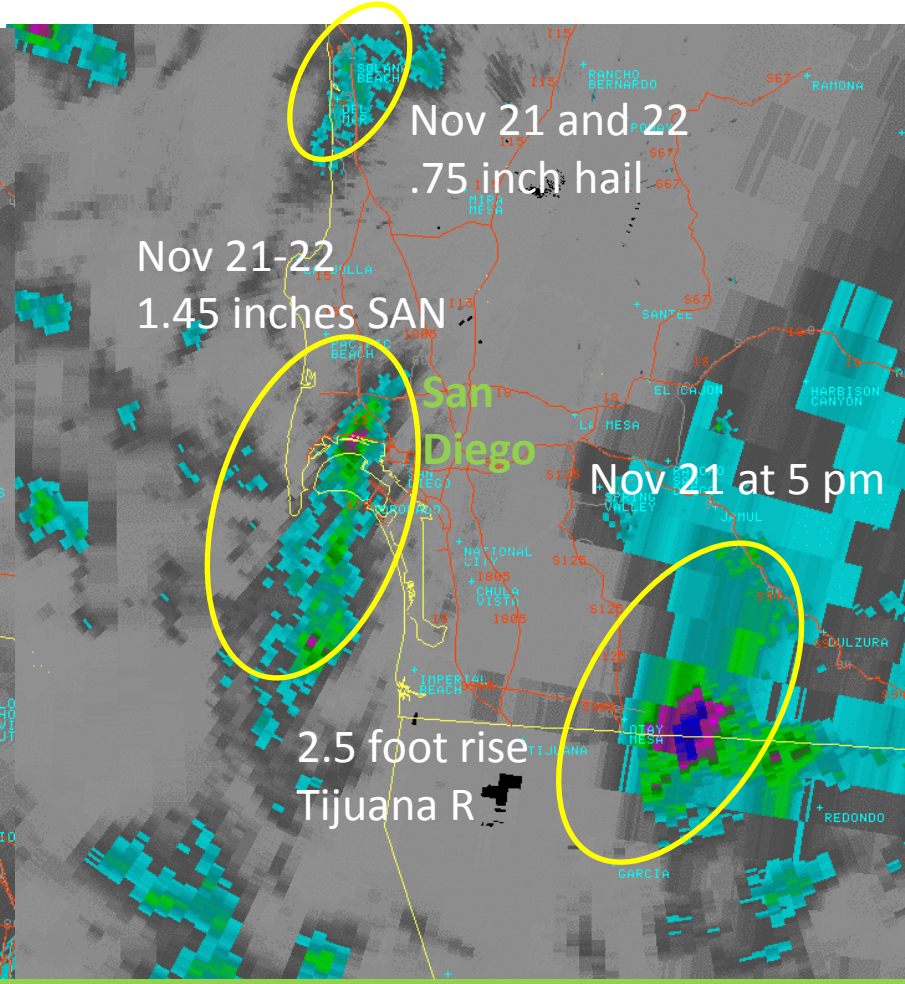
Heavier trend

“Dry Inside Sliders”

6 to 14 inches snow above 6500 feet

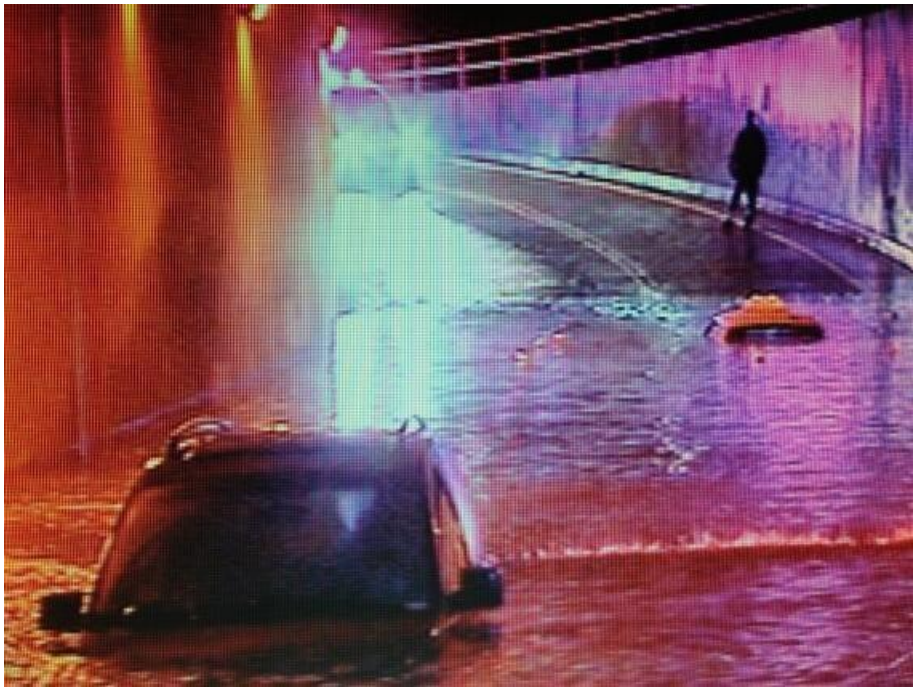
Dual Pol Mosaic Storm Total
November 21-22, 2013

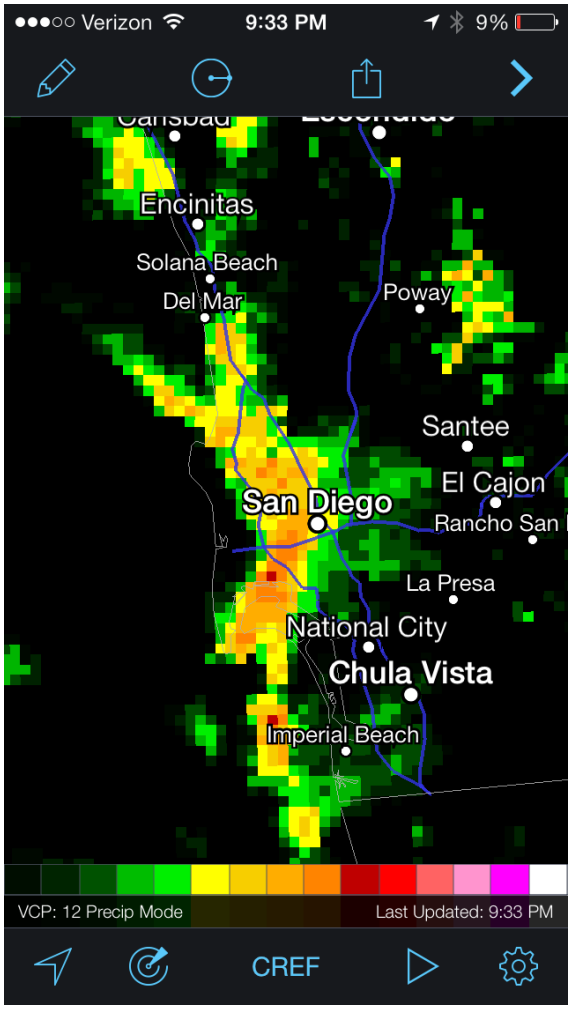




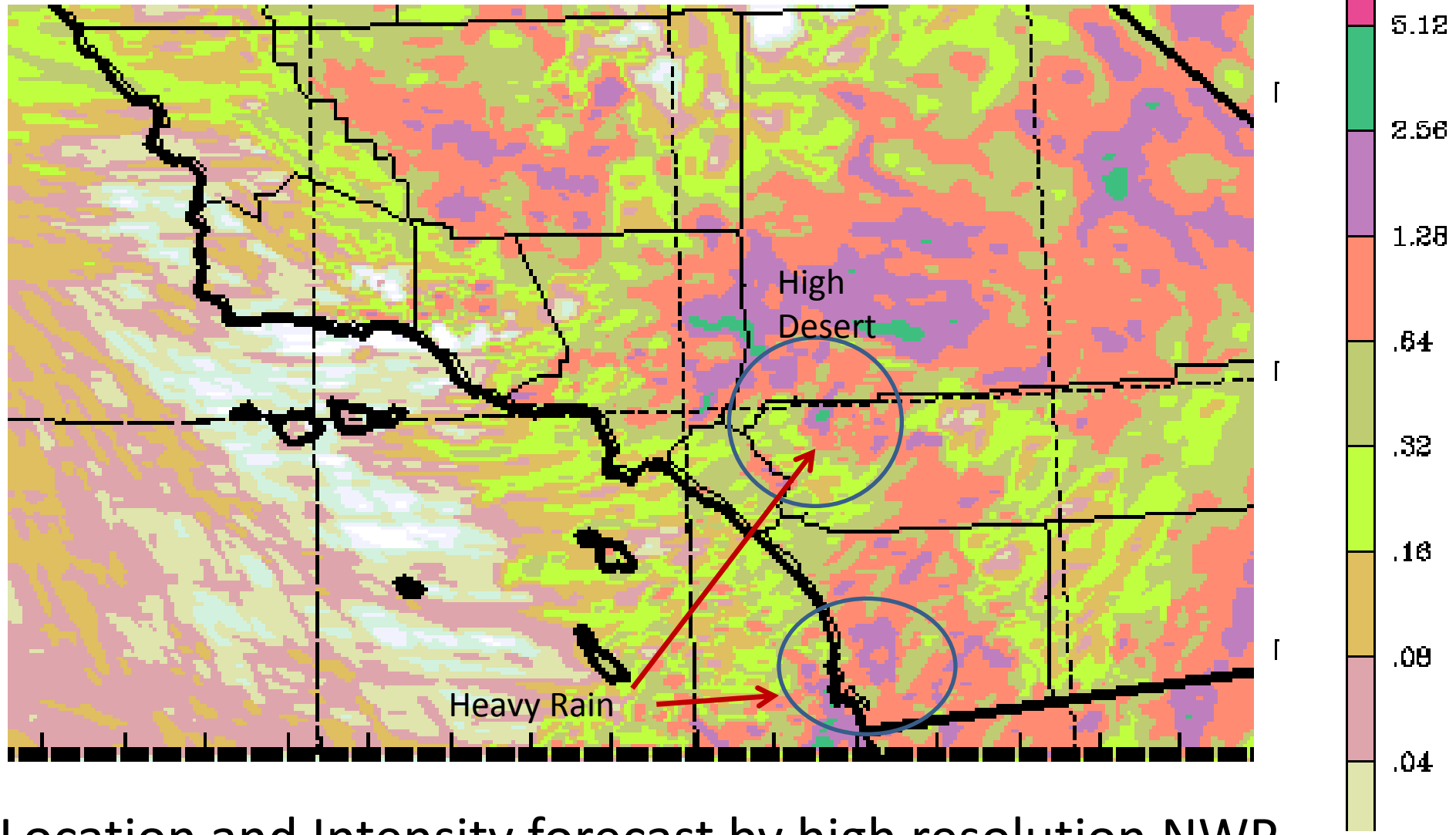
Effective Case Case 7 – high impact convective valley precipitation

Urban Flooding (Day 1)
1.4 inch rainfall and pump failure





12 UTC 20 November run total
2 km CANSAC WRF



Location and Intensity forecast by high resolution NWP

WRF EMS-ARW 18 UTC 21 Nov run

Day 1

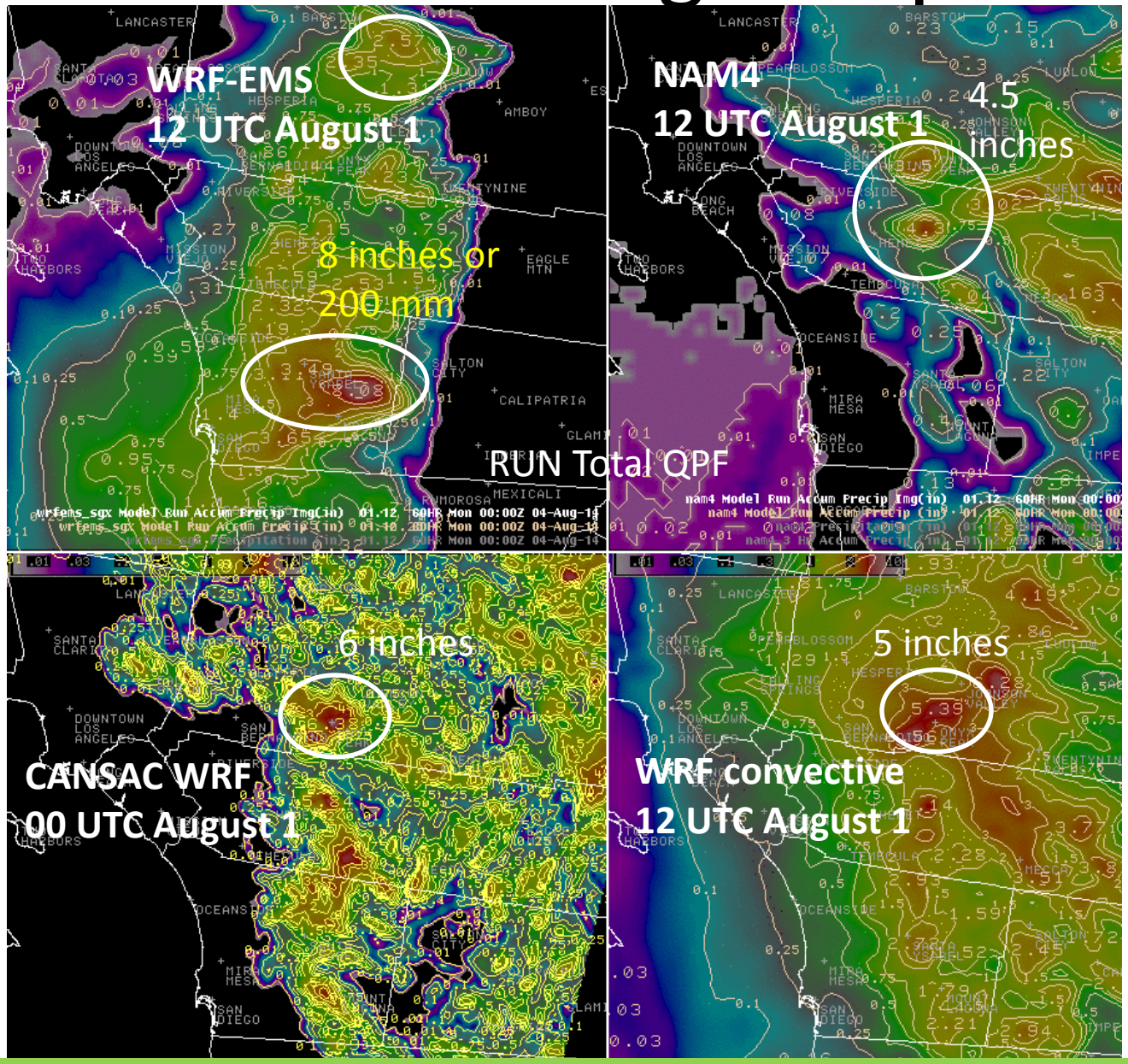
Riverside

San Diego

Evening Heavy Rain over SAN

wrfems_sgx Model Run Accum Precip Img(in) 21.18 21HR Fri 15:00Z 22-Nov
wrfems_sgx Model Run Accum Precip (in) 21.18 21HR Fri 15:00Z 22-Nov

NWP indicates big rain potential



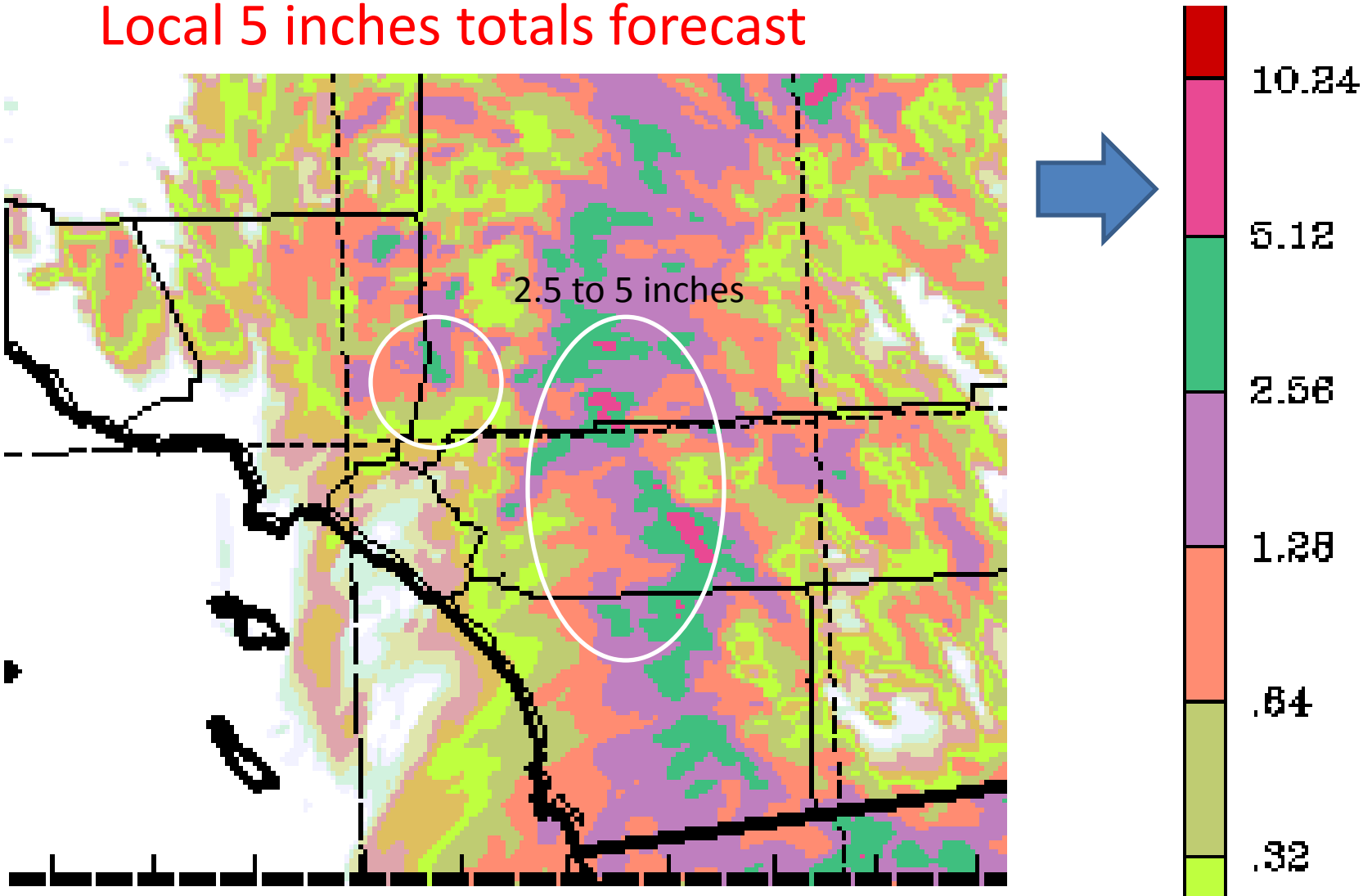
Caution with location

Effective Case

Case 8 – high impact convective precipitation

00 UTC 2 August 2014
72-h run total

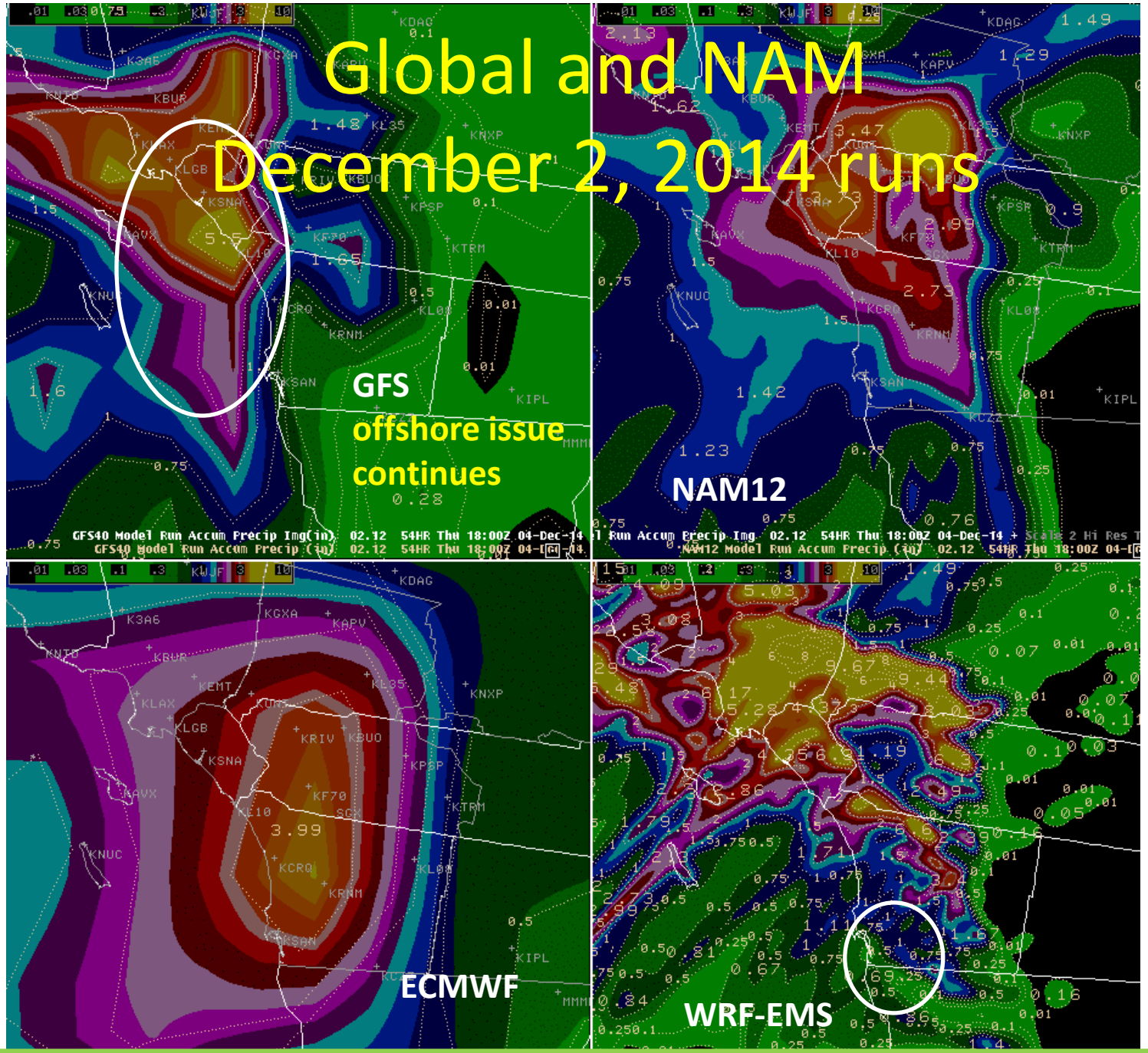
Local 5 inches totals forecast



Valley of the Falls - Flash Flood

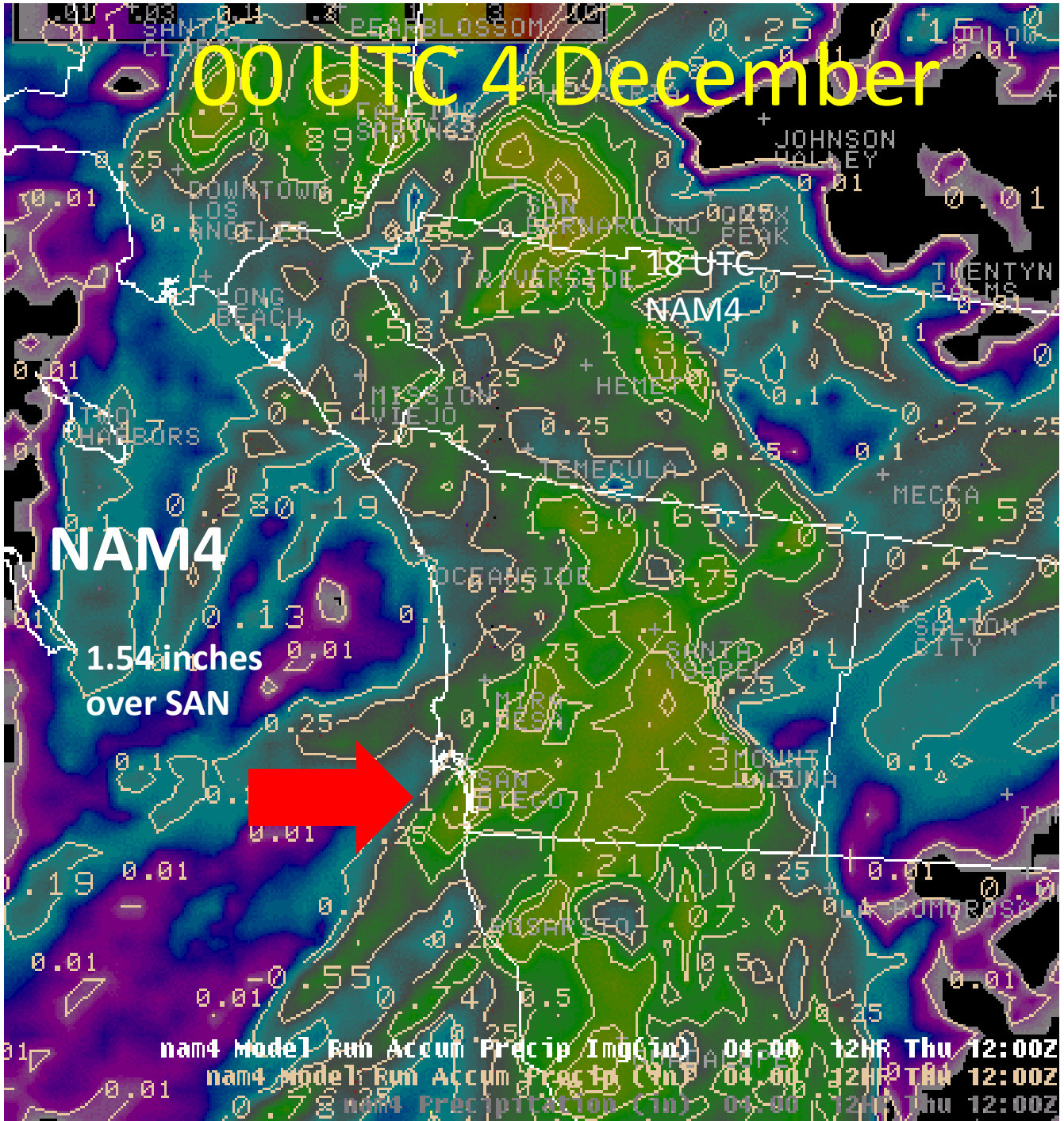
Main Road

Global and NAM December 2, 2014 runs

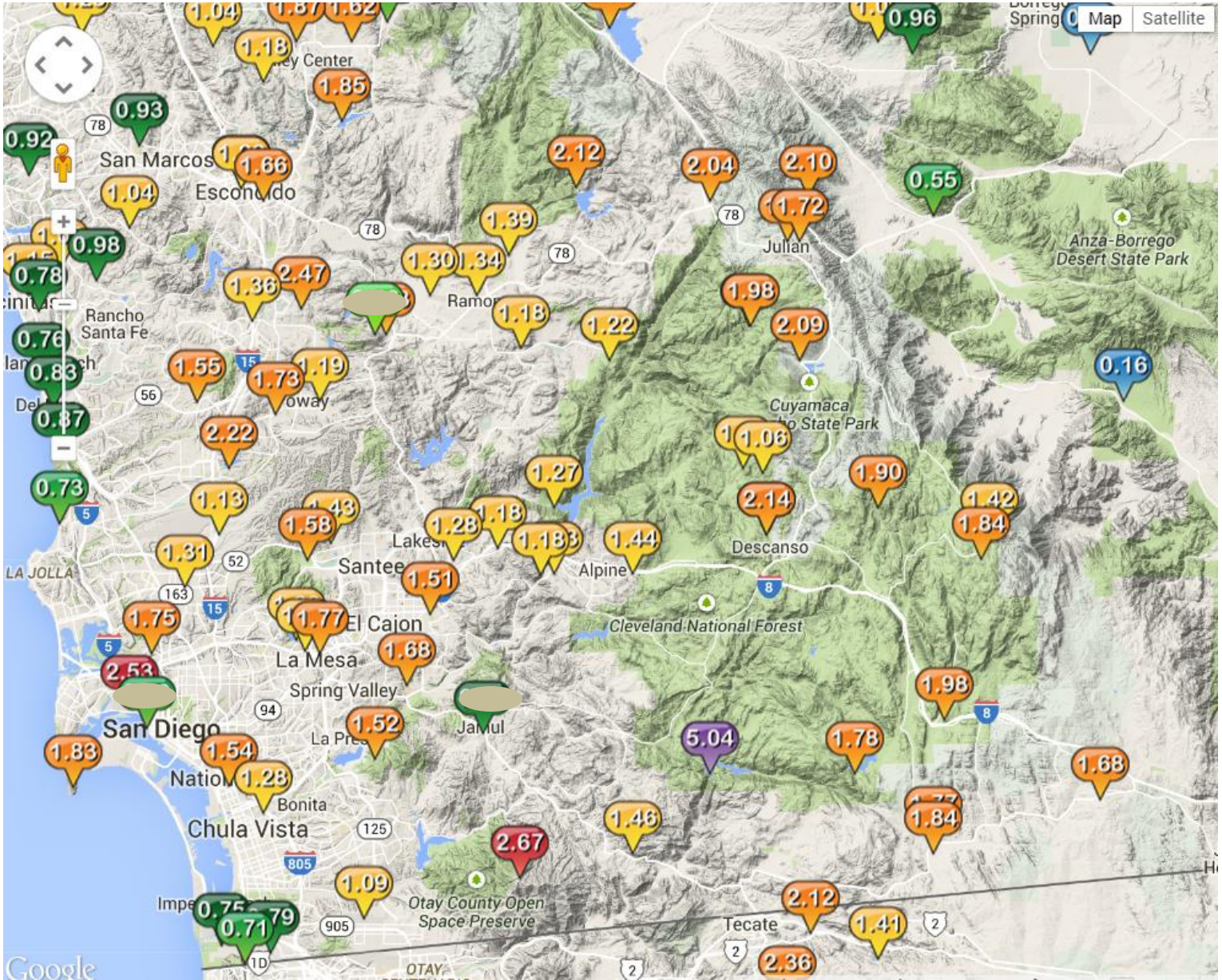


Effective Case

Case 9 – high impact convective precipitation


00 UTC 4 December
18 UTC
NAM4
NAM4
1.54 inches
over SAN
nam4 Model Run Accum Precip Img(in) 04:00 12HR Thu 12:00Z

San Diego County



Twitter Photos
San Diego Mission Hills

Summary of Advantages

- The information in the high resolution NWP can and should be used to effectively communicate the threat during impact decision support services (especially less than 60-h)
- High resolution NWP effective in low and high impact, or low-end and significant precipitation events (gives you the correct threat even if location is wrong or variable)

- High resolution NWP very valuable for local orographic enhancement and downslope effects
- High resolution NWP effectively can locate small scale features (micro and mesoscale QPF patterns) and magnitude
- High resolution NWP (convection allowing) far superior to all other NWP legacy QPF guidance for stratiform and convective precipitation regimes in southern California

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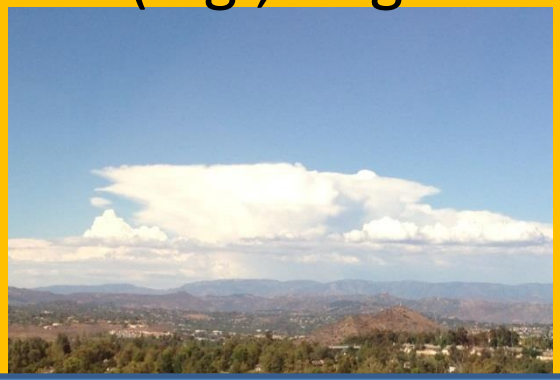
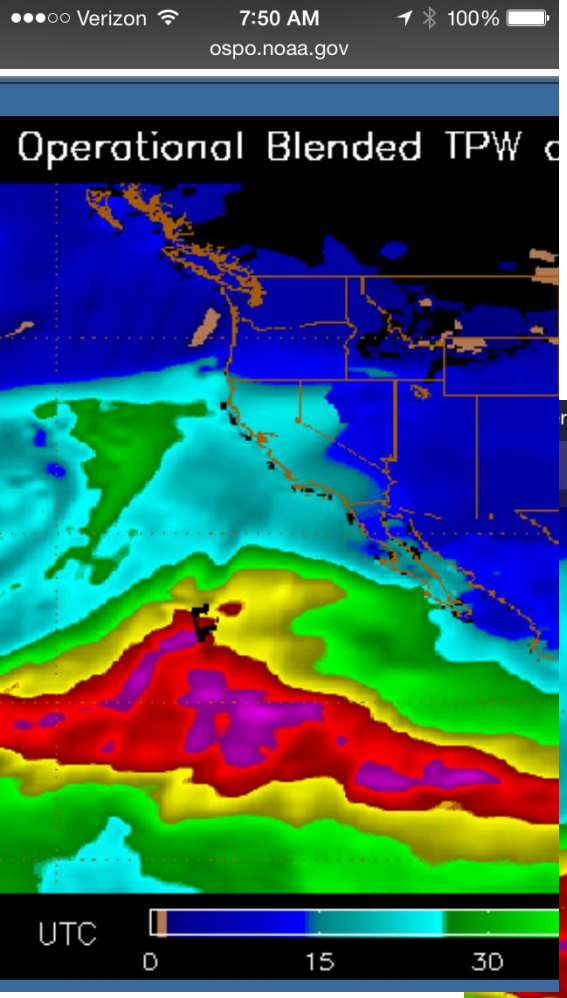
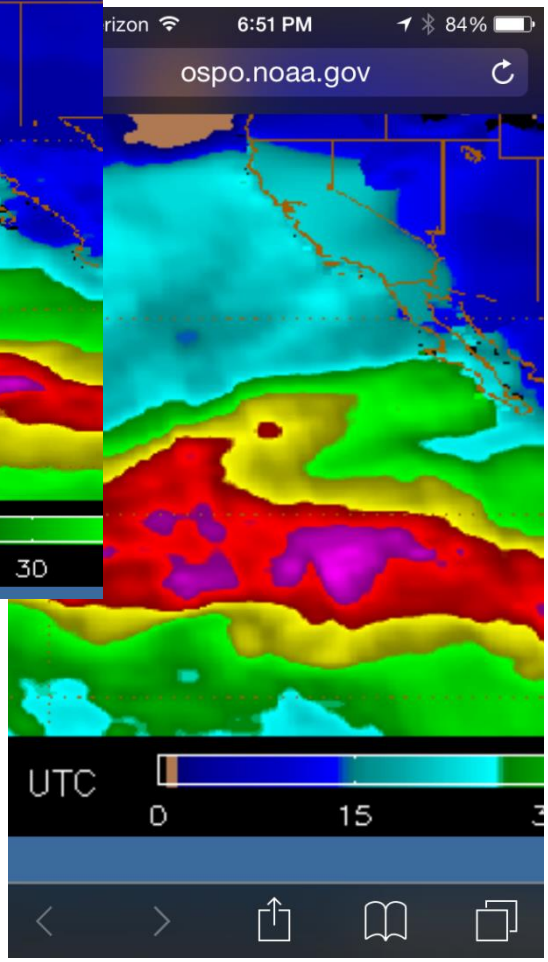
Summary of Limitations

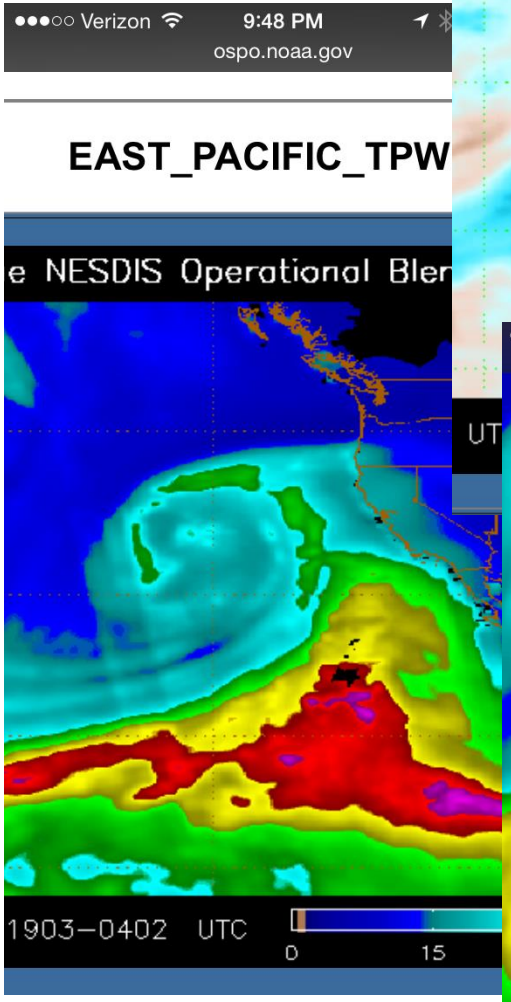
- High resolution NWP can overproduce QPF in shallow instability forced across terrain
- High resolution NWP needs to be used with other tools such as anomalies, analogs, ensemble extremes, percentiles and conceptual models
- High resolution NWP still highly dependent on the synoptic scale patterns correctly timed and resolved
- Variability in convection allowing NWP and extremes can be misleading (Storm-Scale Ensemble will improve)
- Poor performance in elevated convection (e.g., August 20)

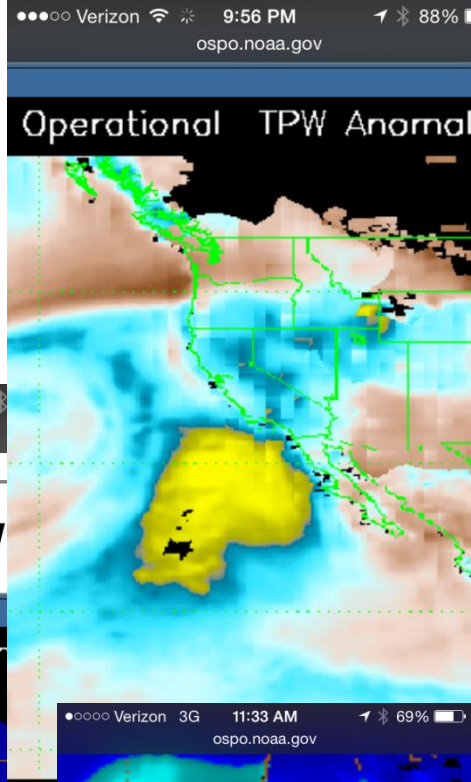


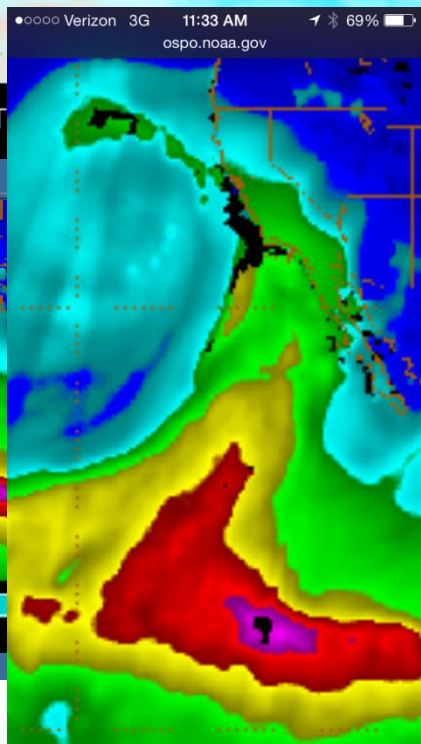
PW Plume evolution











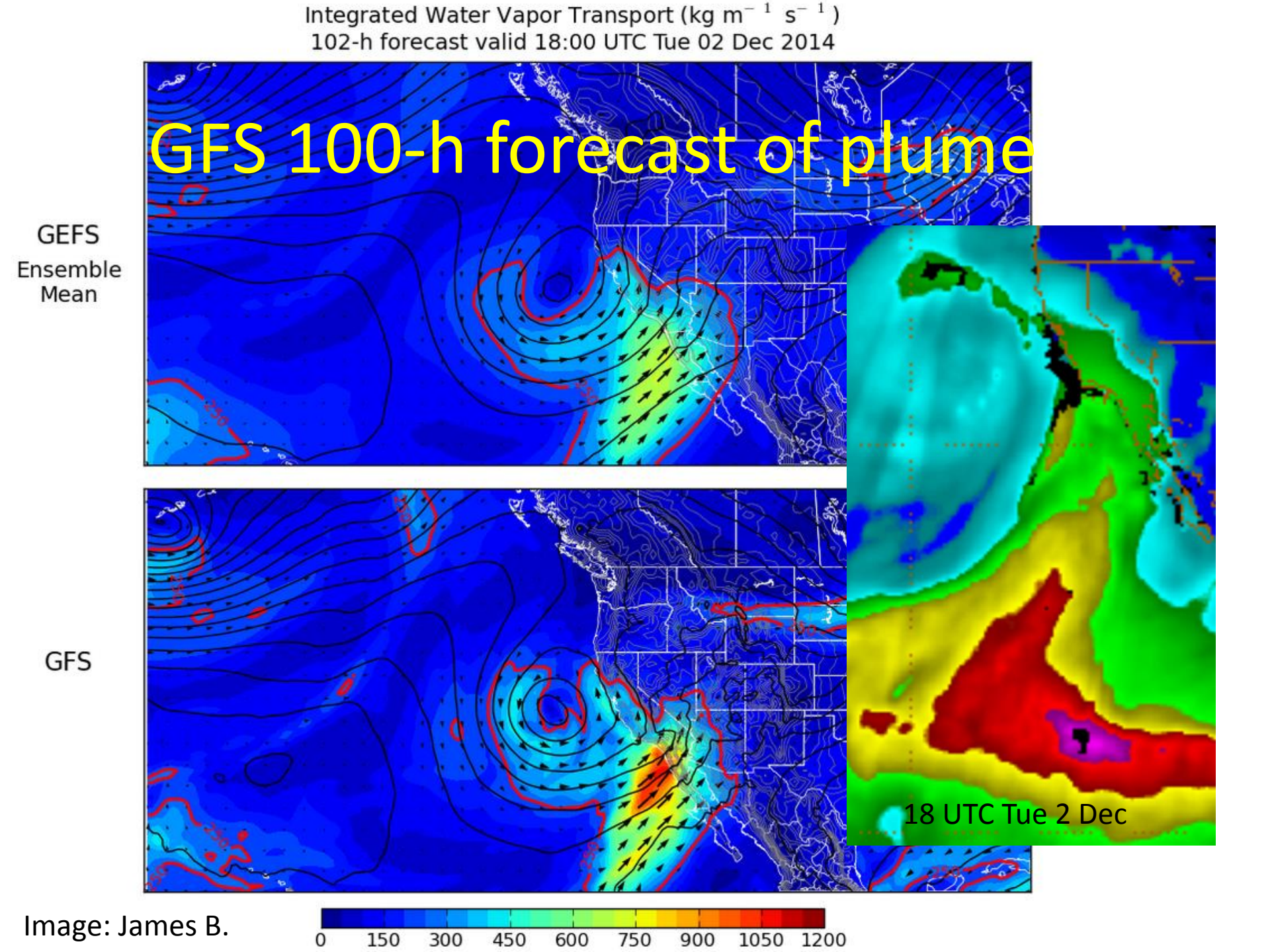
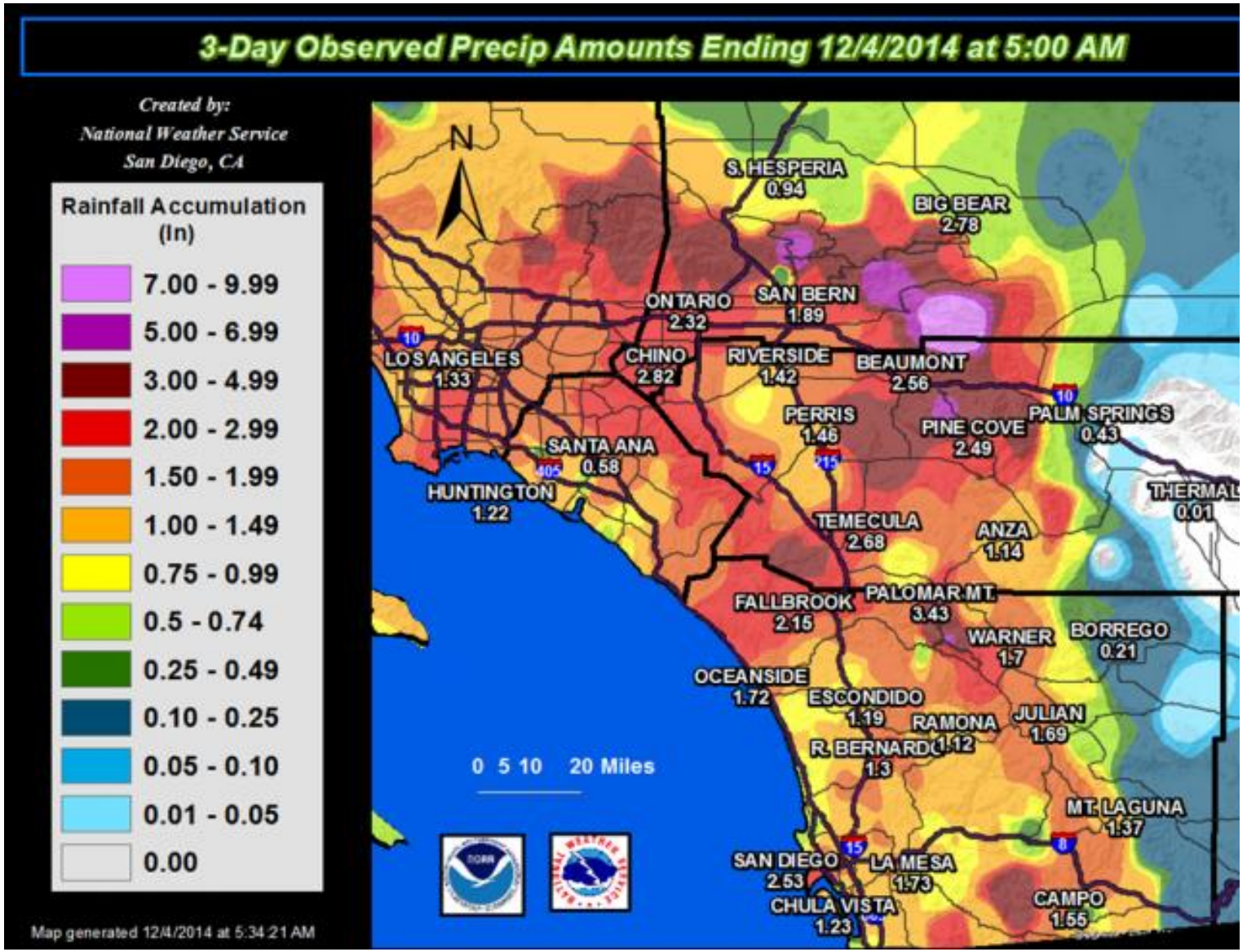
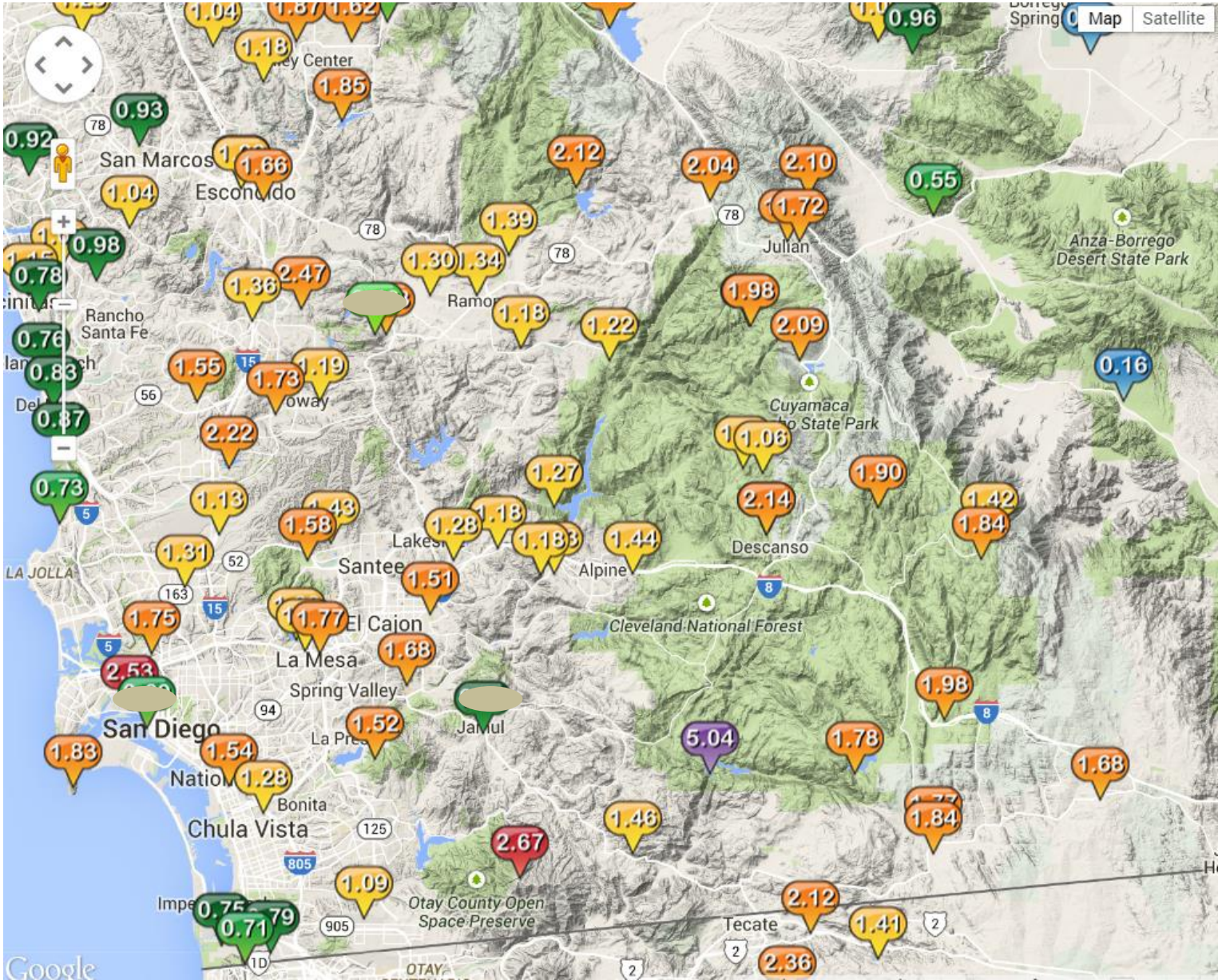


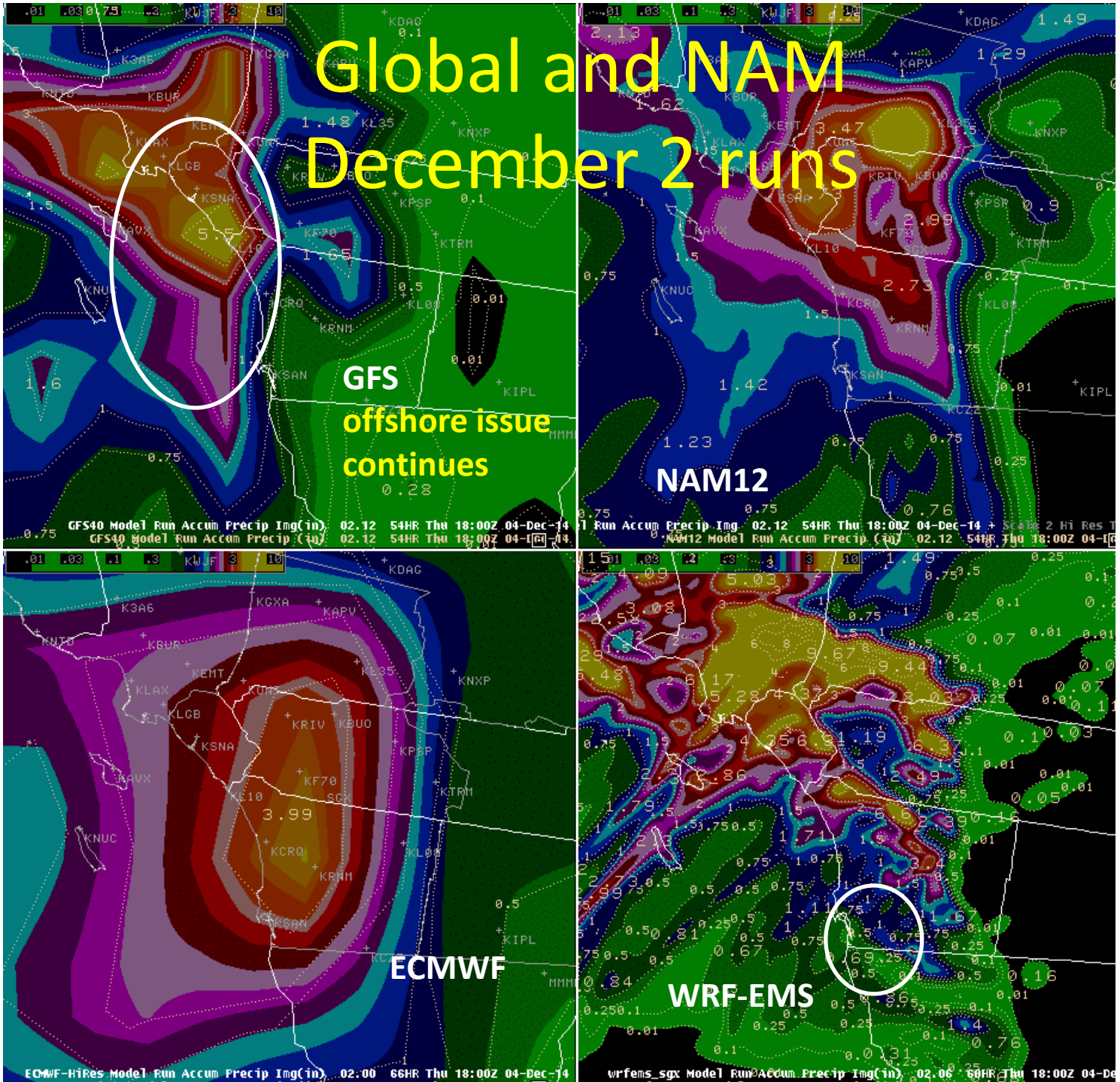
Image: James B.

Storm Total Precipitation
December 2 to 4, 2014

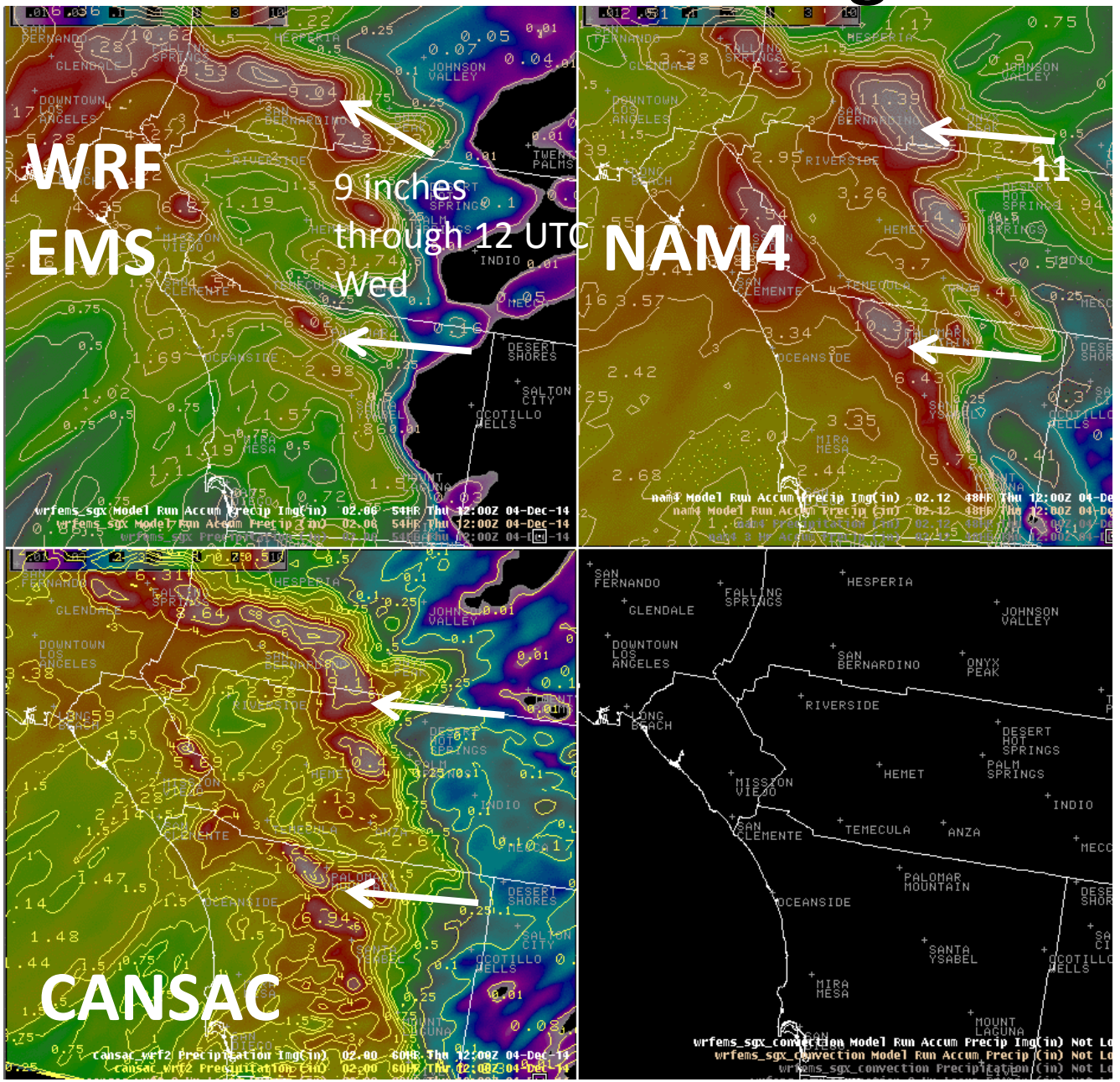


San Diego County



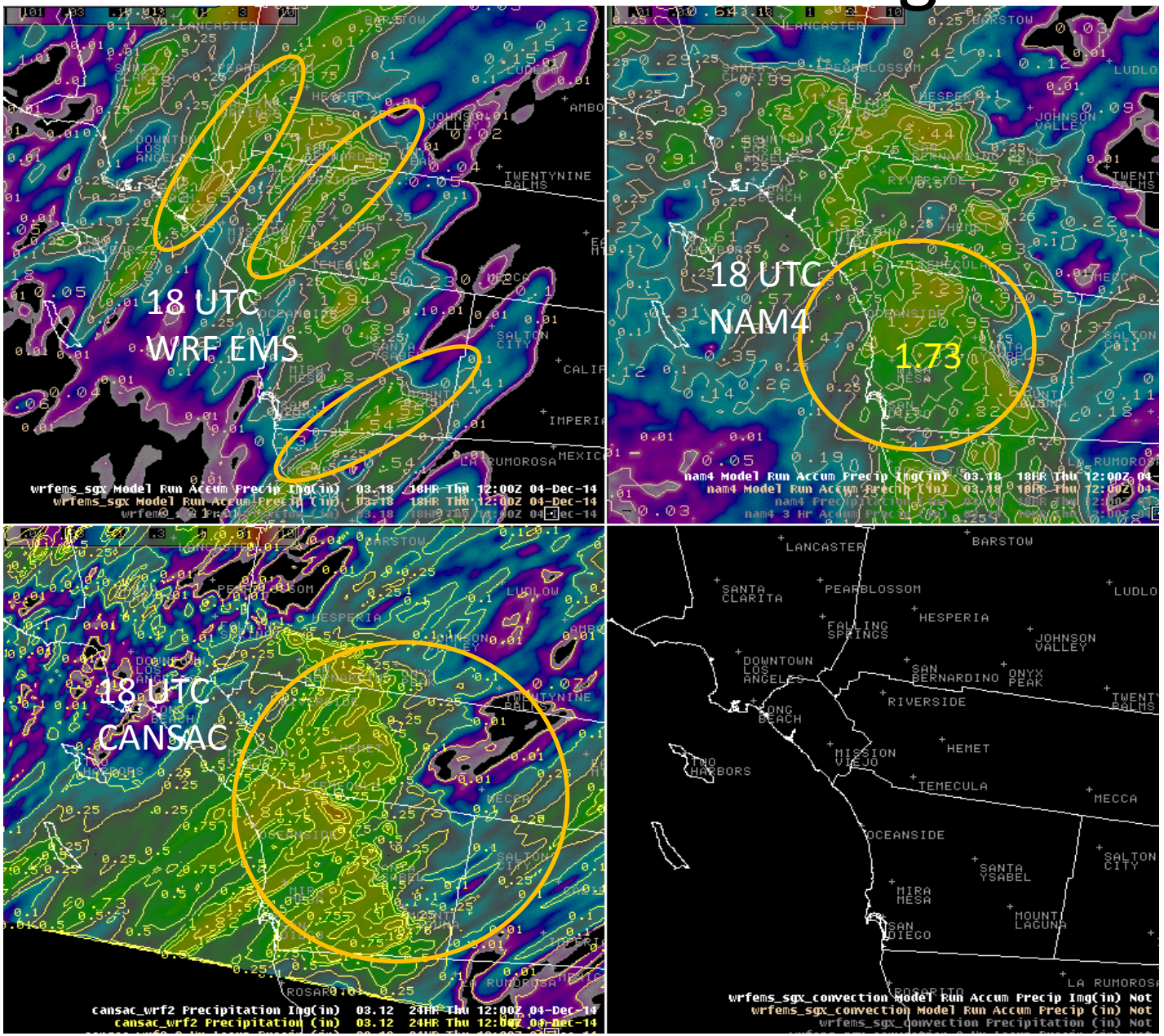

Global and NAM
December 2 runs
GFS
offshore issue
continues
NAM12
ECMWF
WRF-EMS
GFS40 Model Run Accum Precip Img(in) 02.12 54HR Thu 18:00Z 04-Dec-14
NAM12 Model Run Accum Precip (in) 02.12 54HR Thu 18:00Z 04-Dec-14
ECMWF-HiRes Model Run Accum Precip Img(in) 02:00 66HR Thu 18:00Z 04-Dec-14
wrfems_sgx Model Run Accum Precip Img(in) 02.06 60HR Thu 18:00Z 04-De

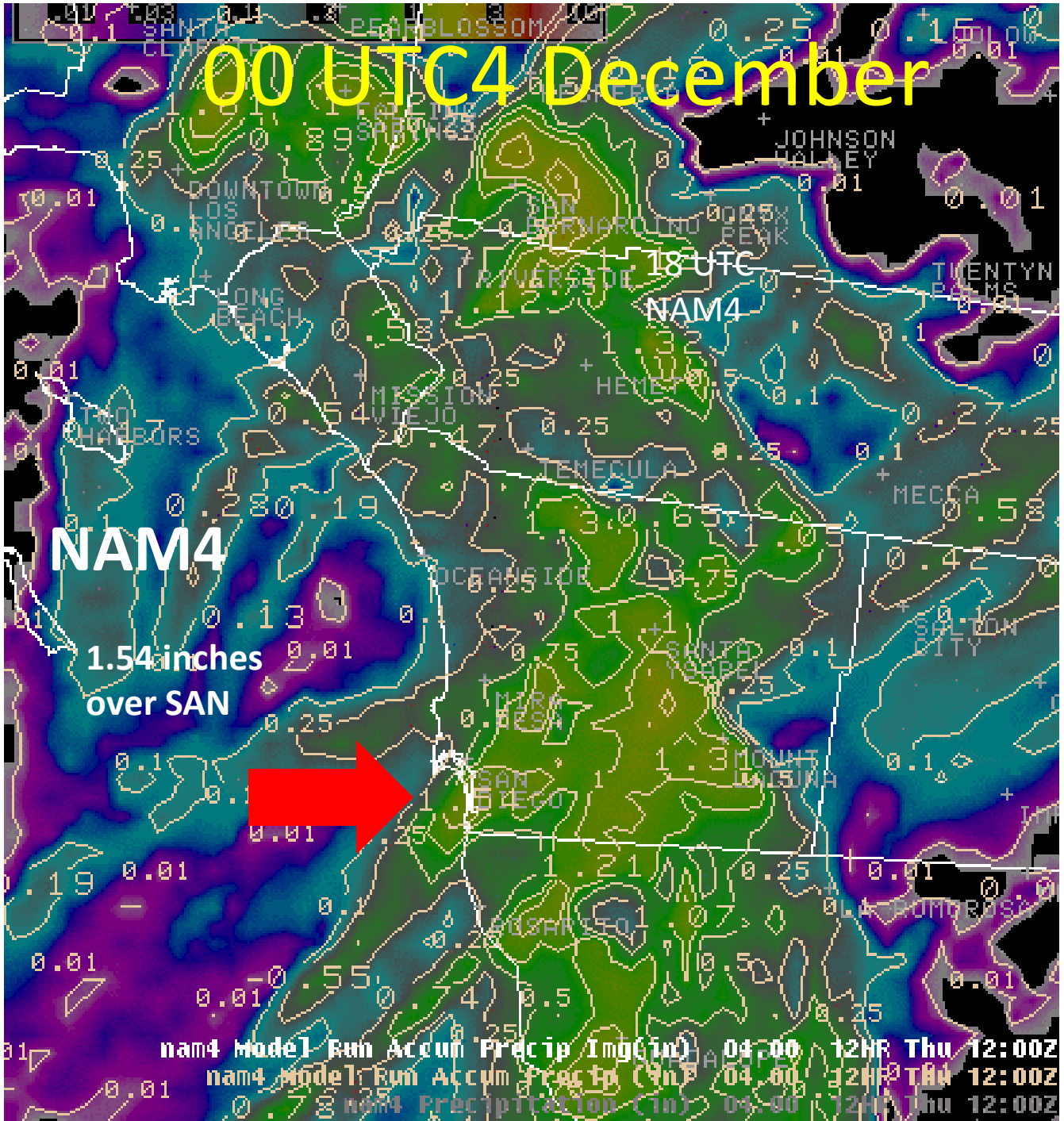
00 to 12 UTC 2 December high res NWP



Through 12z Thursday

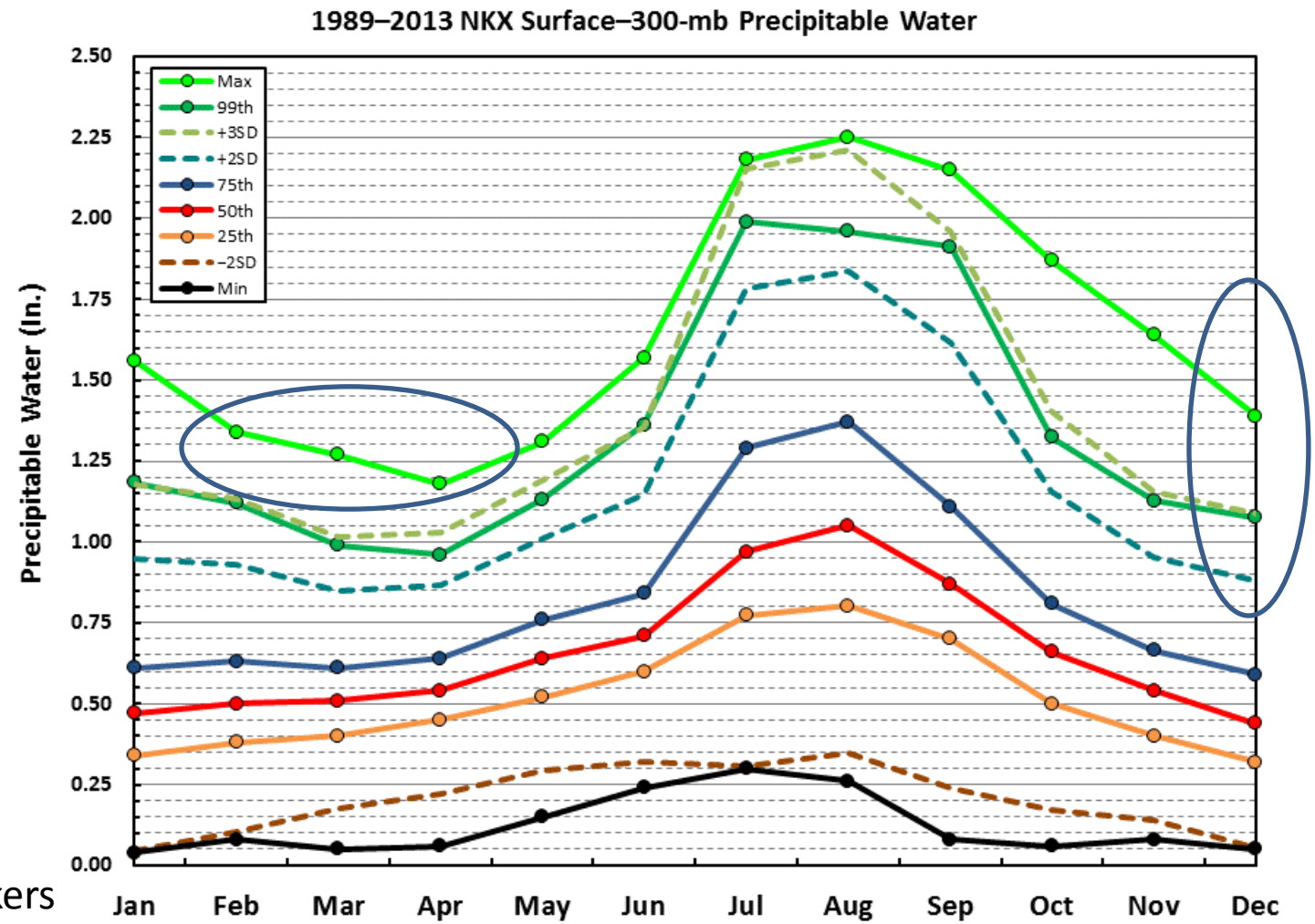
12 and 18UTC 3 December high res NWP




00 UTC4 December
18 UTC
NAM4
NAM4
1.54 inches
over SAN
nam4 Model Run Accum Precip Img(in) 04.00 12HR Thu 12:00Z

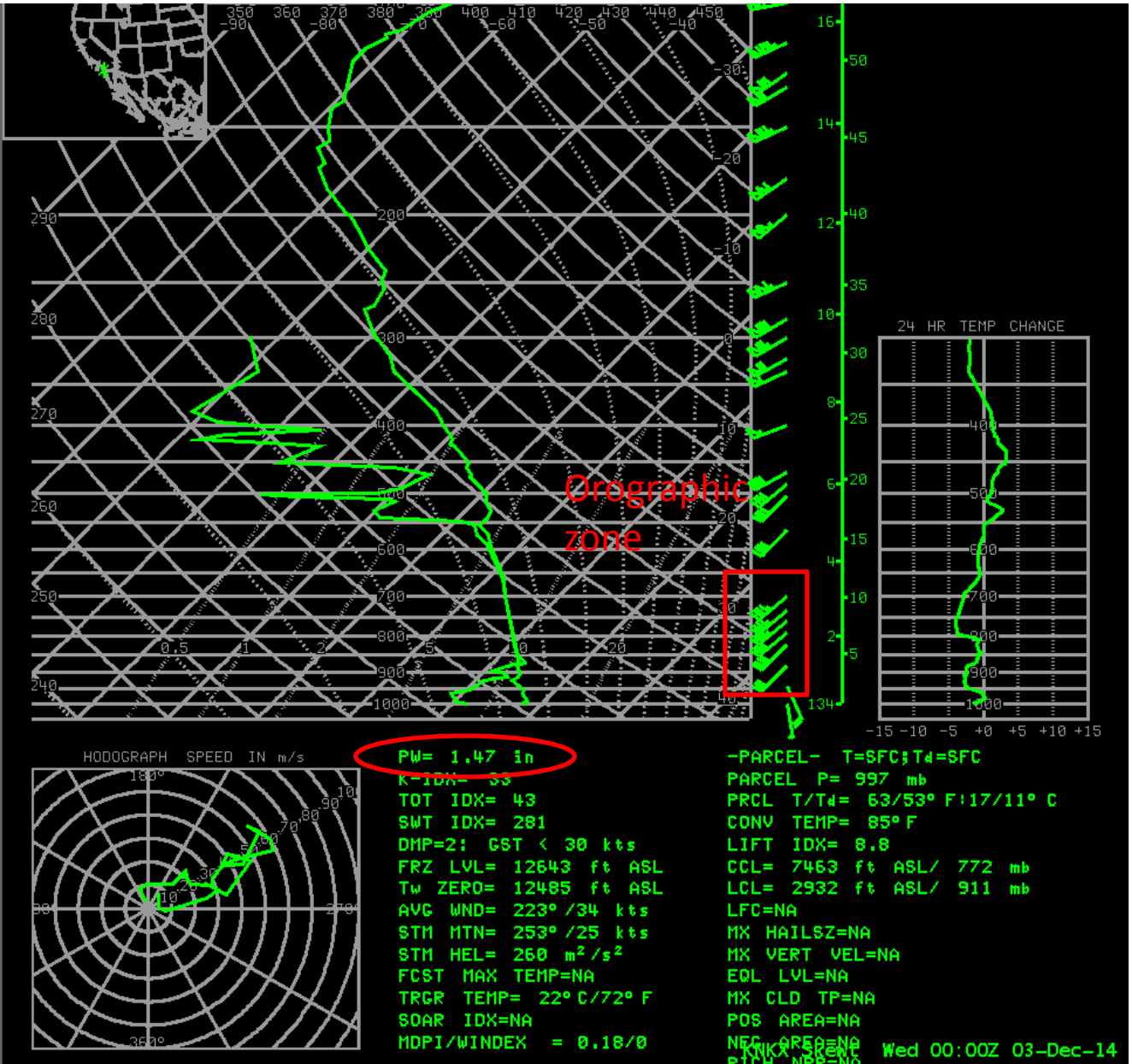
Record Precipitable Water

1.57 inch NKX “winter” record

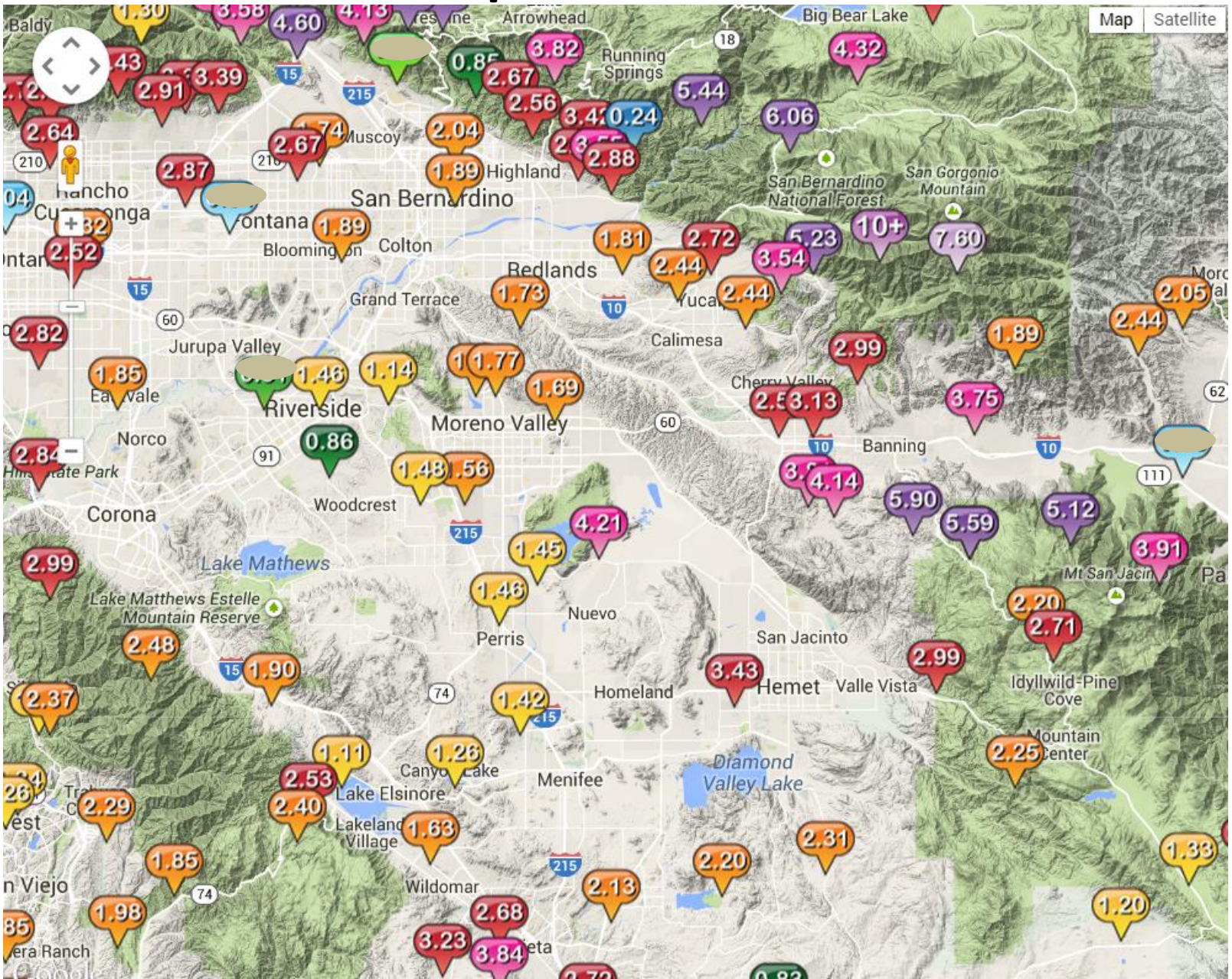


Matt Bunkers

Record PW values
Tropical Saturation



Inland Empire Storm Total



Twitter Photos
San Diego Mission Hills

Hemet Mud Slides
Twitter Post