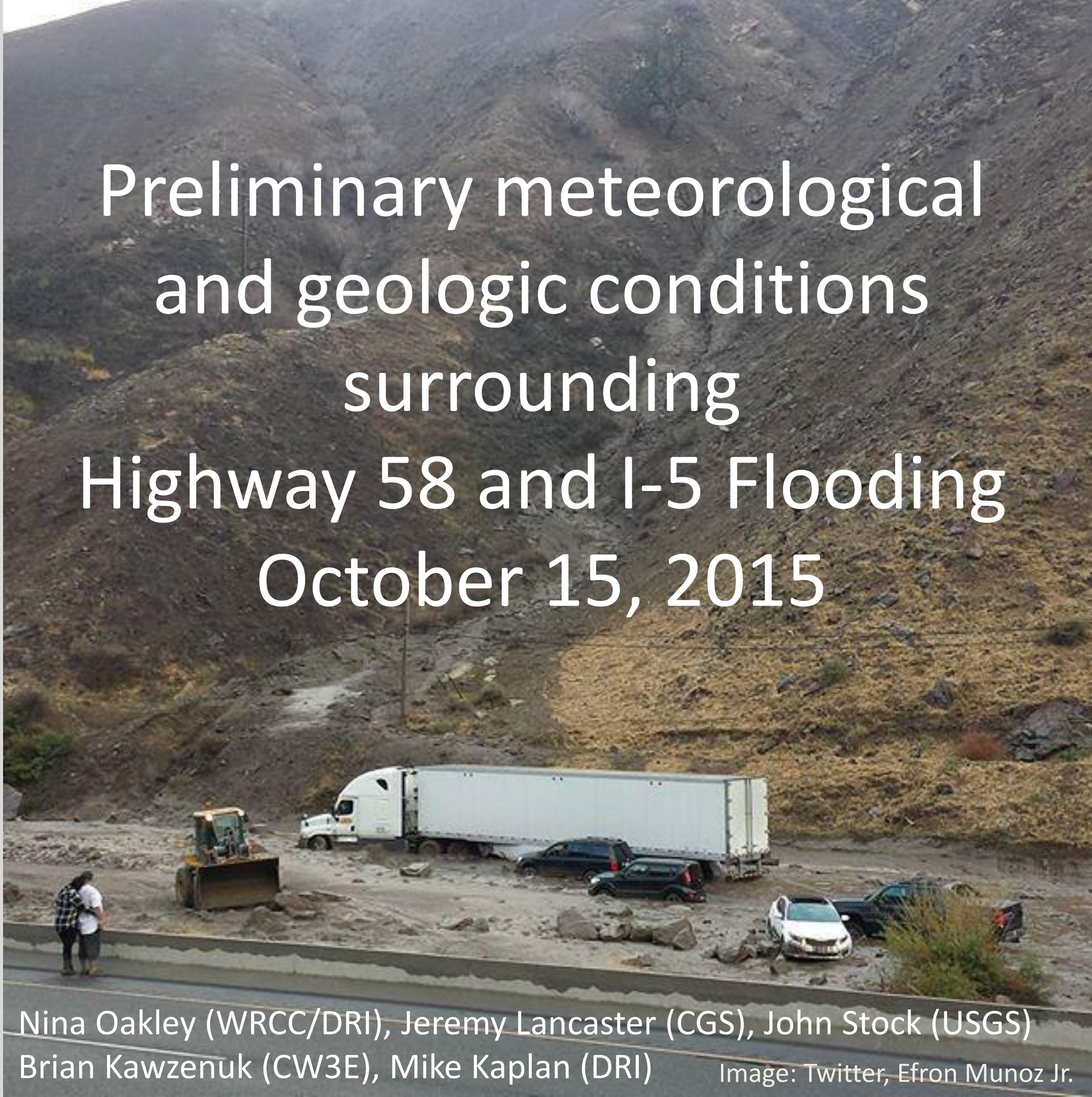
Preliminary meteorological and geologic conditions surrounding Highway 58 and I-5 Flooding October 15, 2015



Nina Oakley (WRCC/DRI), Jeremy Lancaster (CGS), John Stock (USGS)
Brian Kawzenuk (CW3E), Mike Kaplan (DRI)

Image: Twitter, Efron Munoz Jr.

CW3E

Western Regional Climate Center

USGS science for a changing world

CGS CALIFORNIA GEOLOGICAL SURVEY

DRI Desert Research Institute

Meteorology Summary

- Cutoff low moved into the Transverse Range area from southwest, bringing moist low-level air and cold temperatures at upper levels
- Large amounts of instability present due to upper level low moving over warm surface and strong upper level divergence over southern Central Valley
- Convective cells developed and moved slowly to southeast over Tehachapi Mountains
- Rain rates interpreted from radar returns show over 2 in/hour; very localized convection

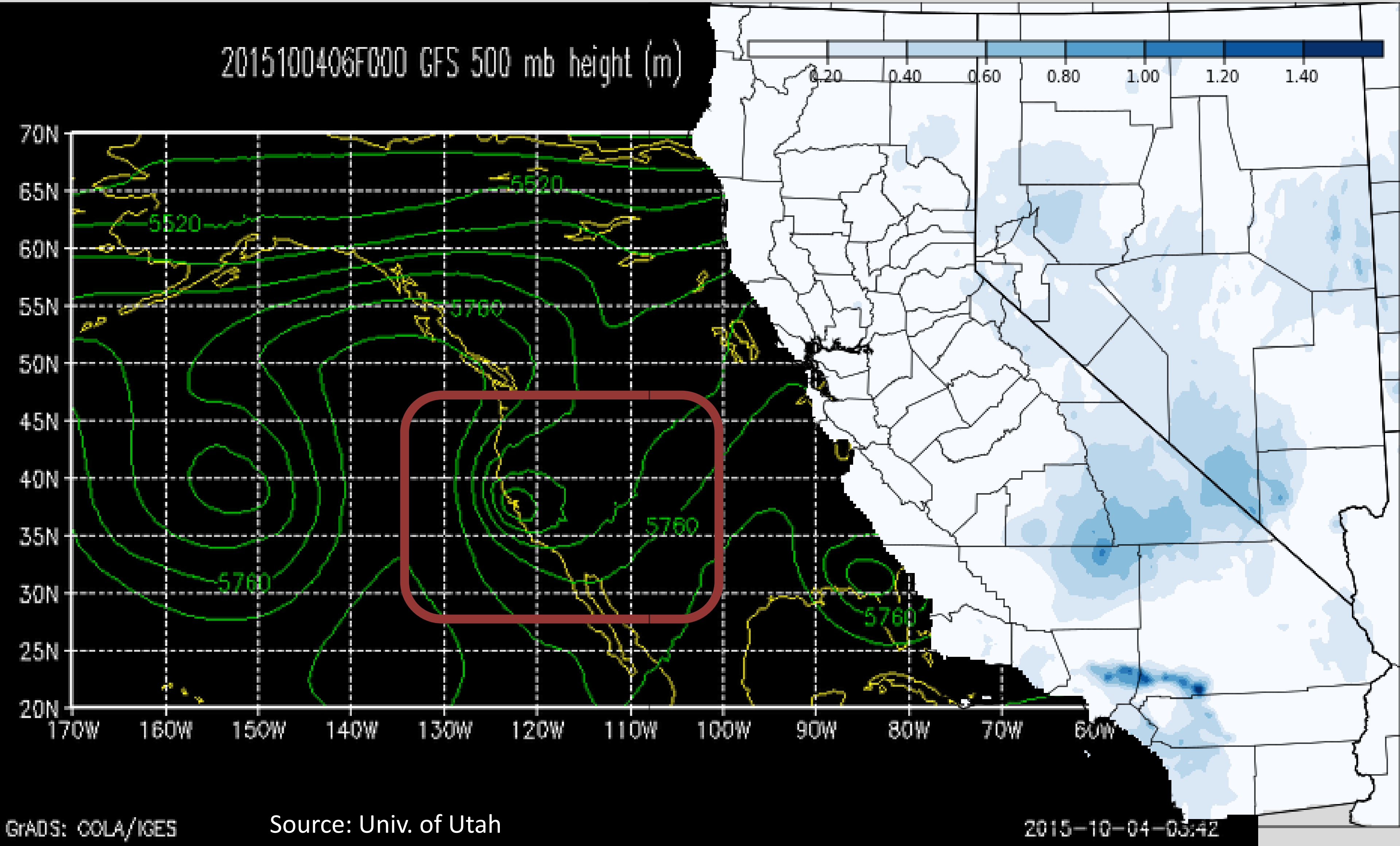
Geomorphic Summary

<u>Grapevine Canyon (I-5, Kern County)</u>

- High relief and steeply sloping drainages
- Very little vegetative cover (low interception)
- Fractured crystalline granitic and metamorphic bedrock
- Sediment and debris available in swales and channels
- Steeply sloping alluvial fans at the base of canyons
- Last major event: February 5, 1978 (Cronin et al., 1990), preceded by 1975-1977 drought, no activity reported 1933-1978.

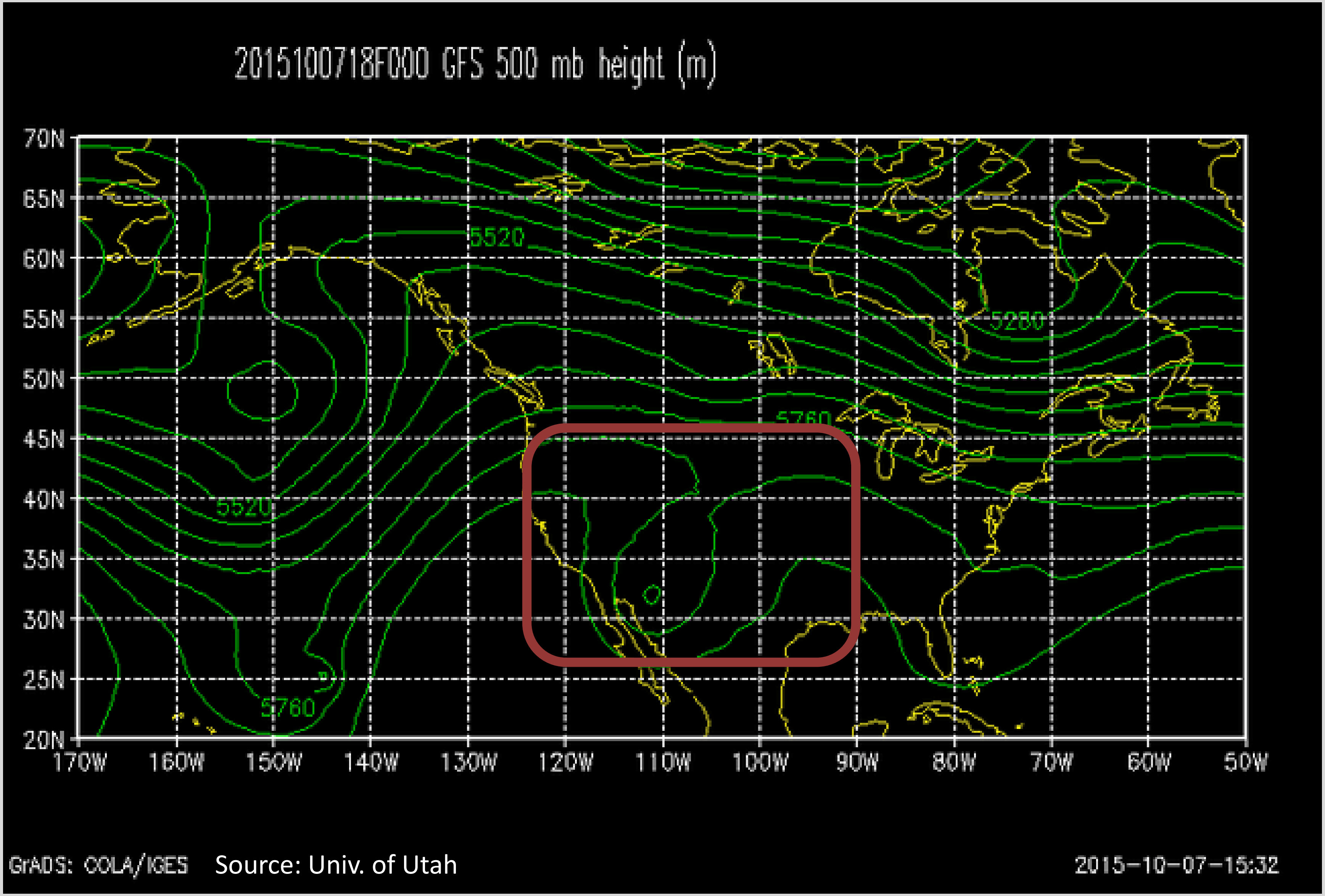
Meteorological Analysis

"Inside Slider" low brought precipitation to CA/NV on Oct 4, 5



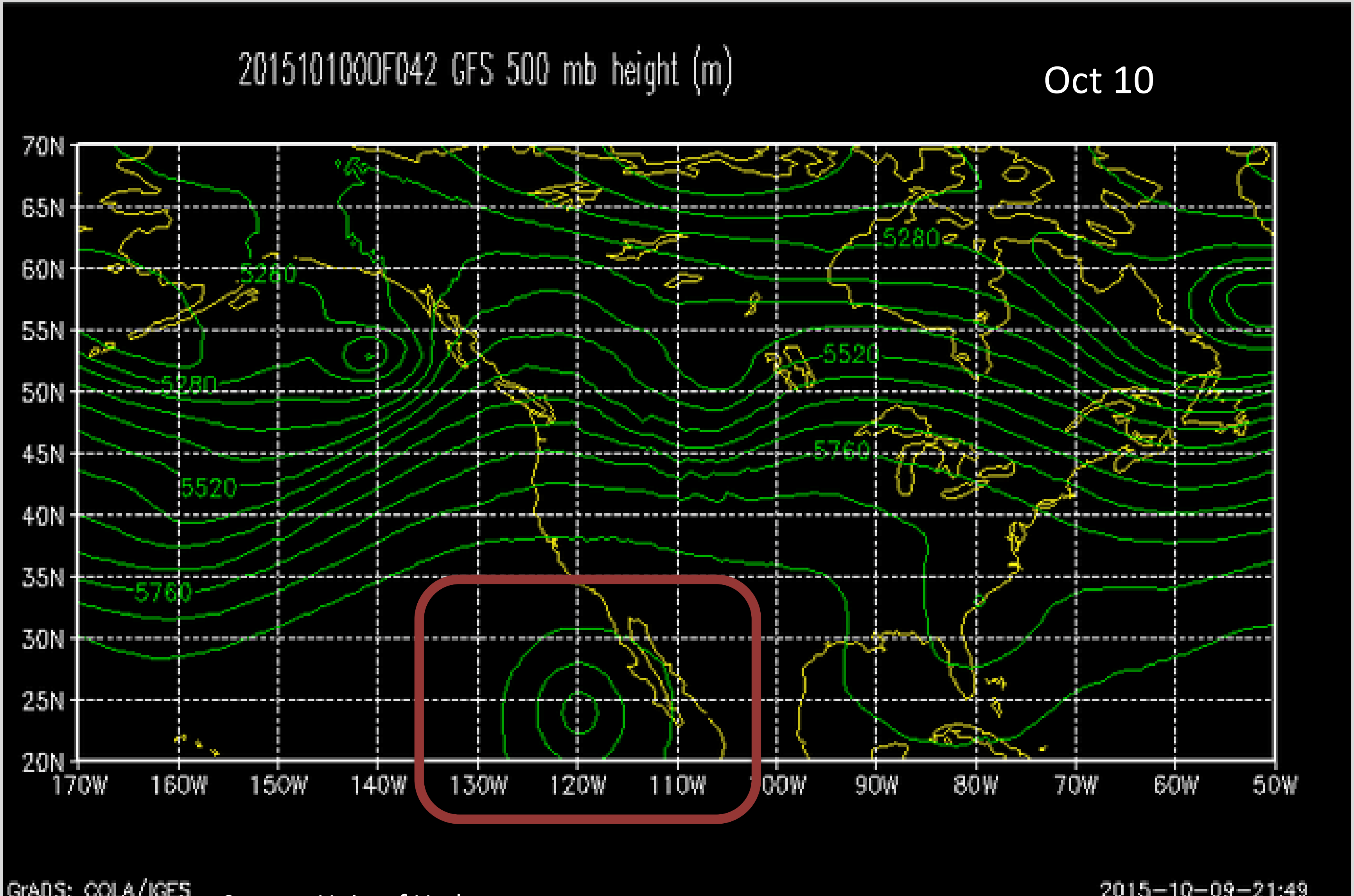
Source: Univ. of Utah

Low moves east, becomes "cut-off" over northern Mexico on Oct 7



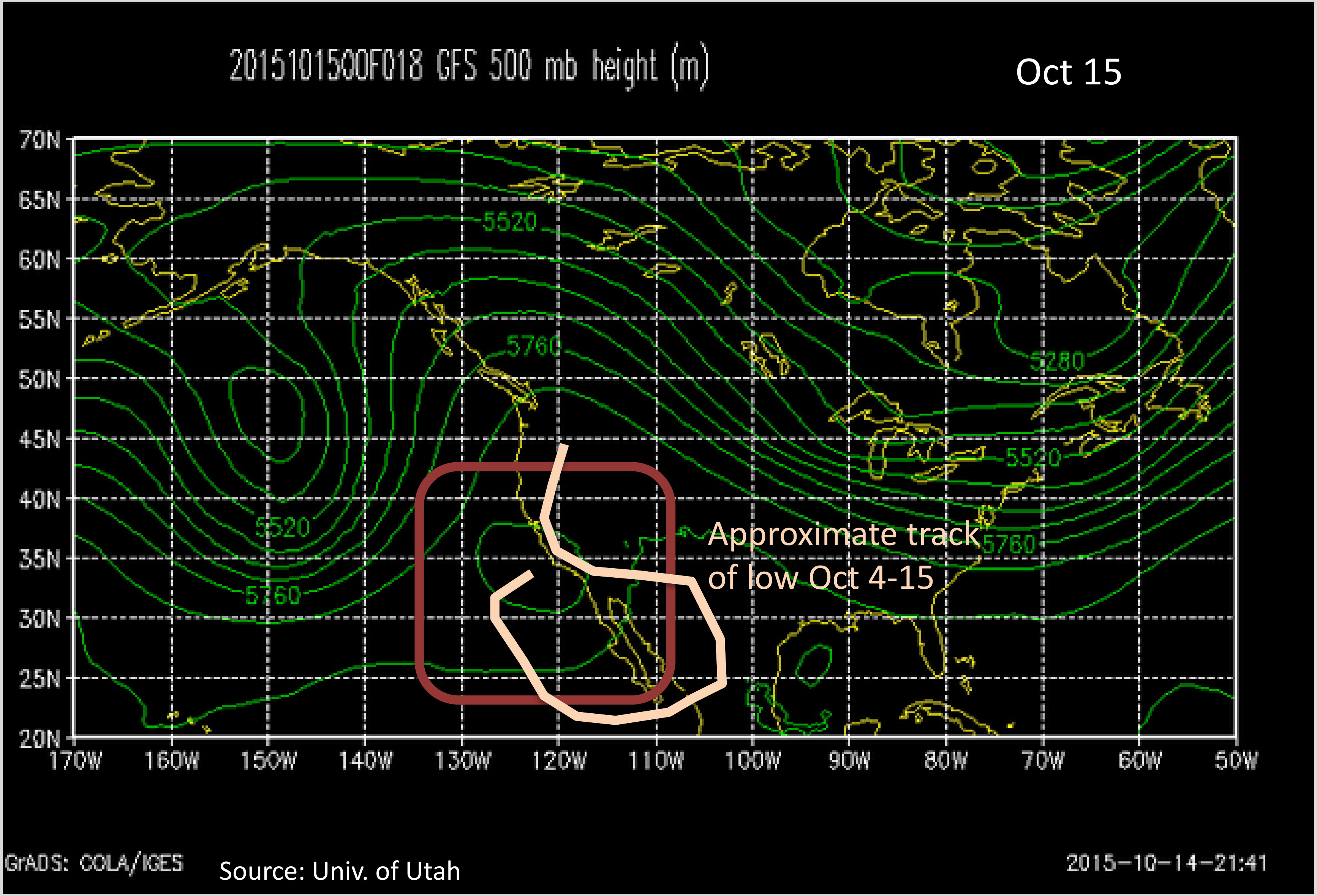
Source: Univ. of Utah

Cutoff low drifts south over Mexico then west over the Pacific Oct 7-12



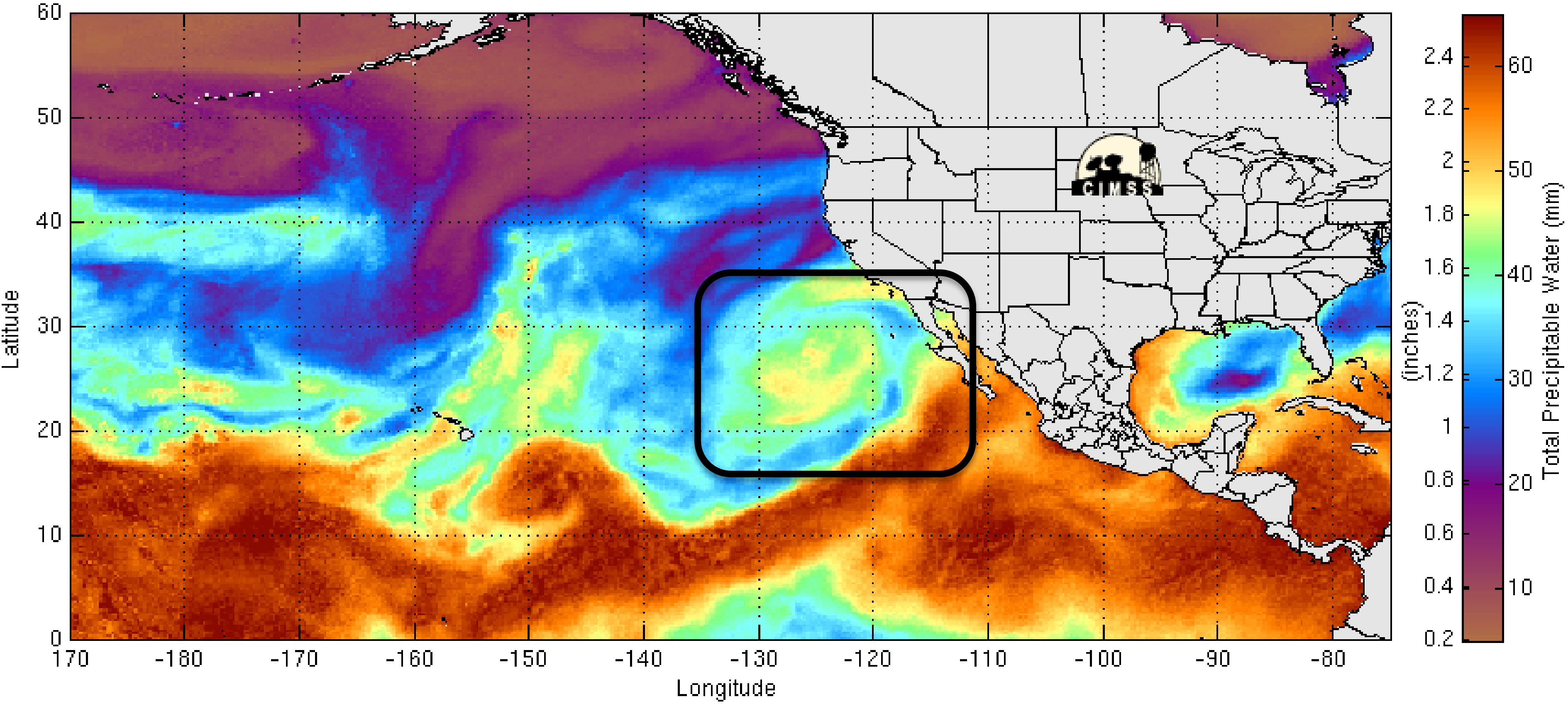
Source: Univ. of Utah

Low drifts north-northeast Oct 14-15, moving over southern CA- makes full circle!



Low entrains moisture during its time in sub-tropics, provides moisture for Oct 15 storms

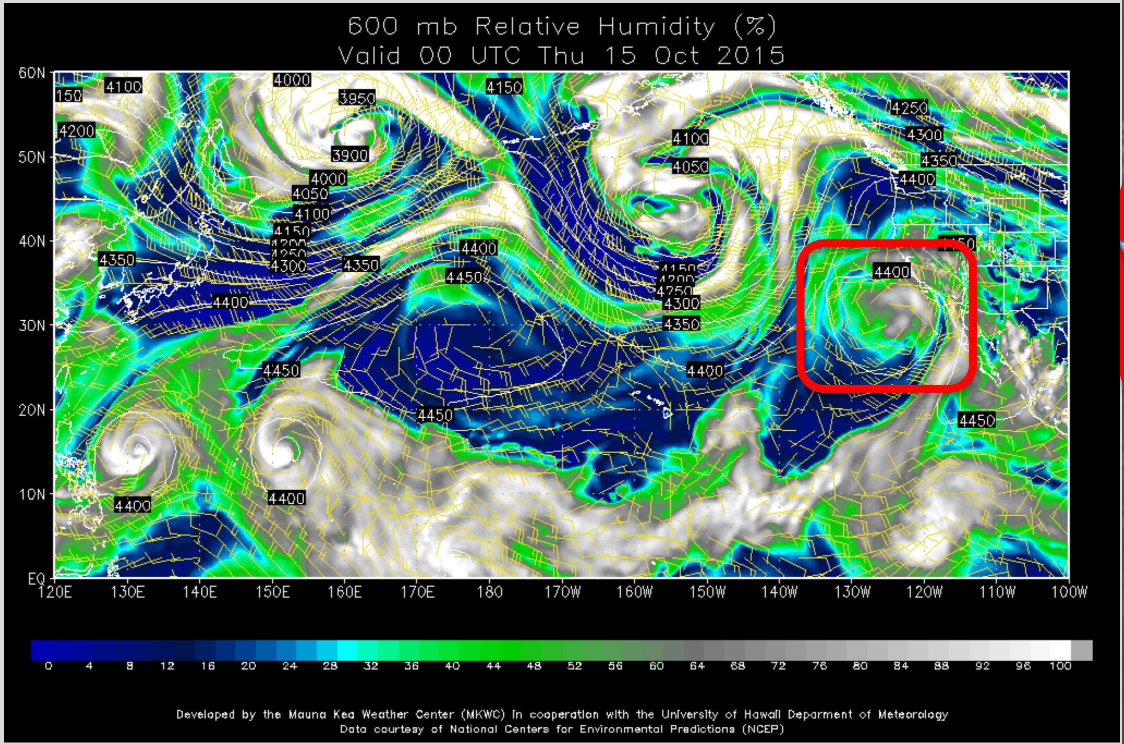
Water Vapor: October 13 14:00 UTC

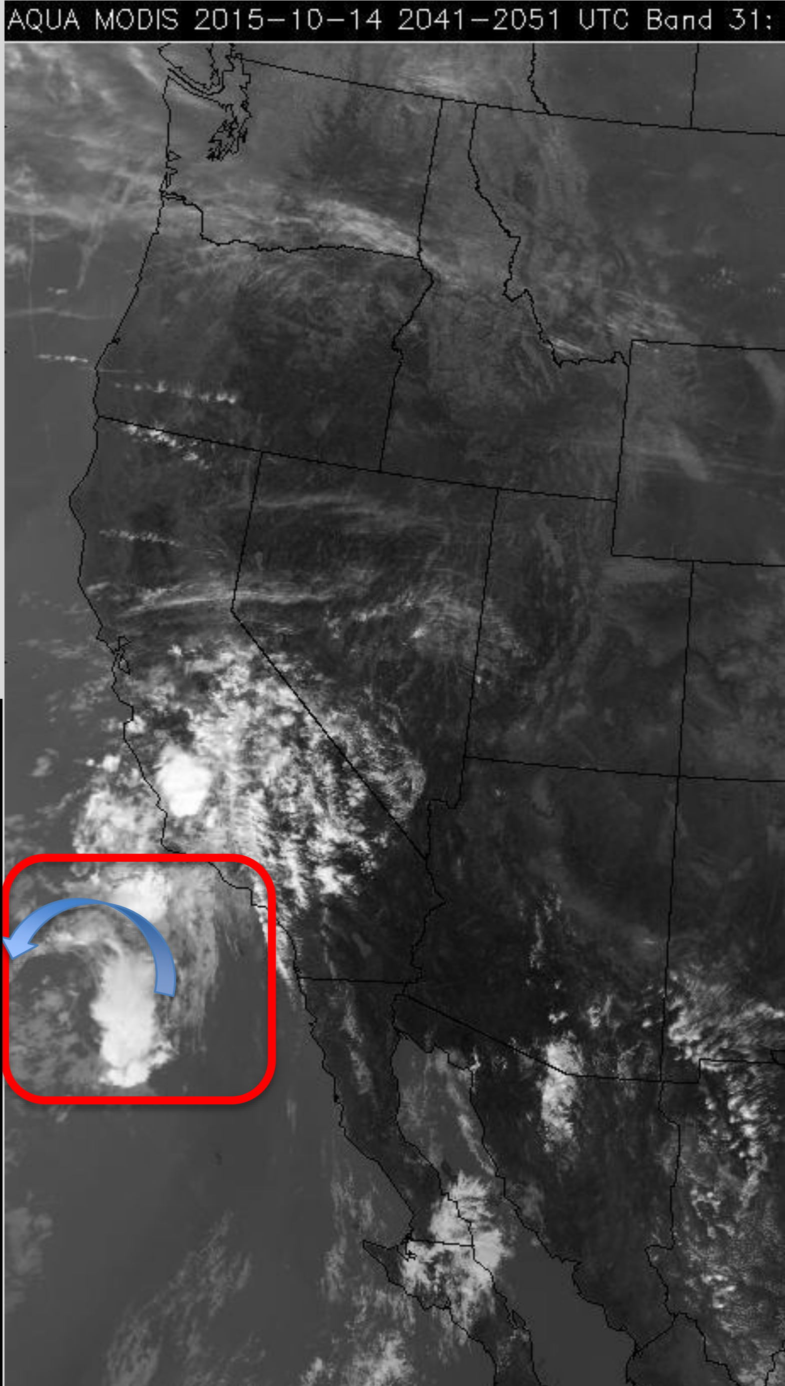


Source: Univ. of Wisconsin

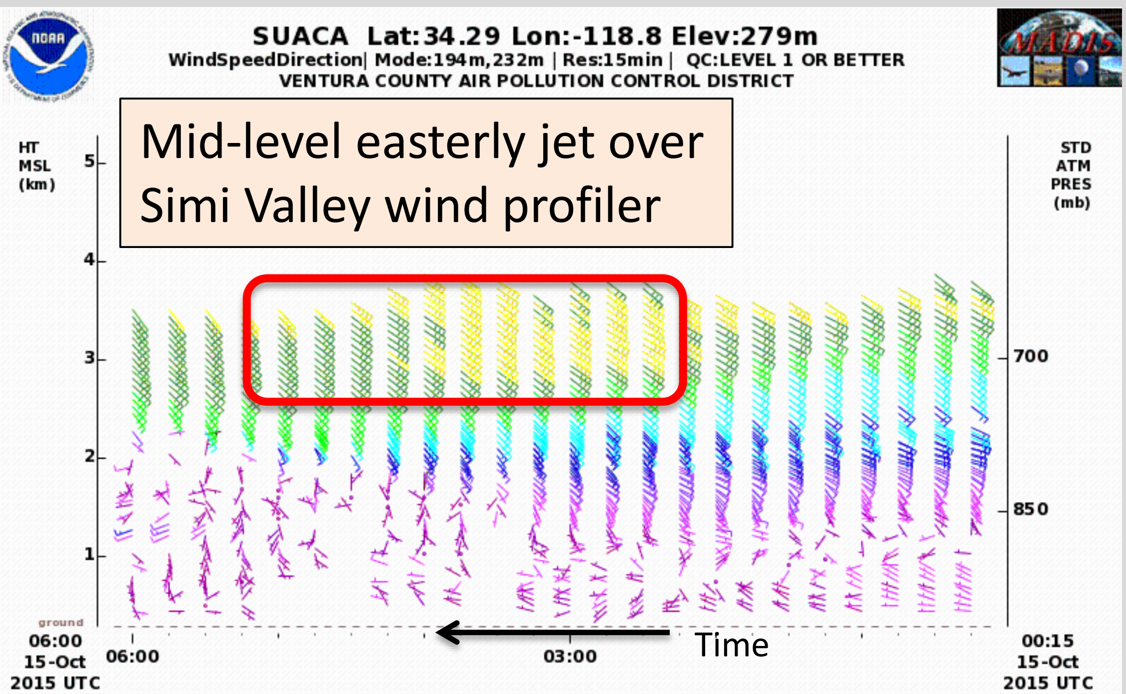
Afternoon/evening before event: Strong convection offshore associated with small vortex within cutoff low

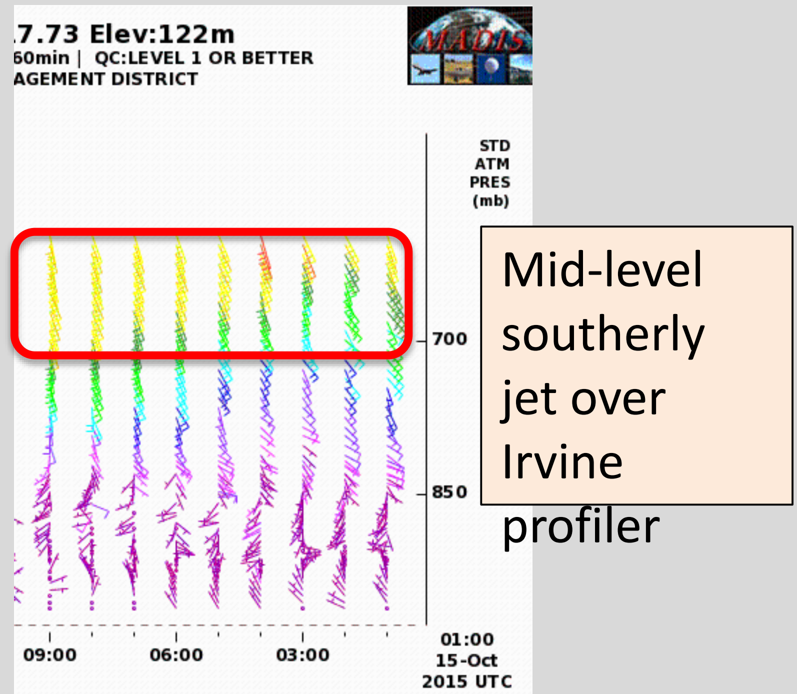
Vortex seen in NE quadrant of low in model RH field



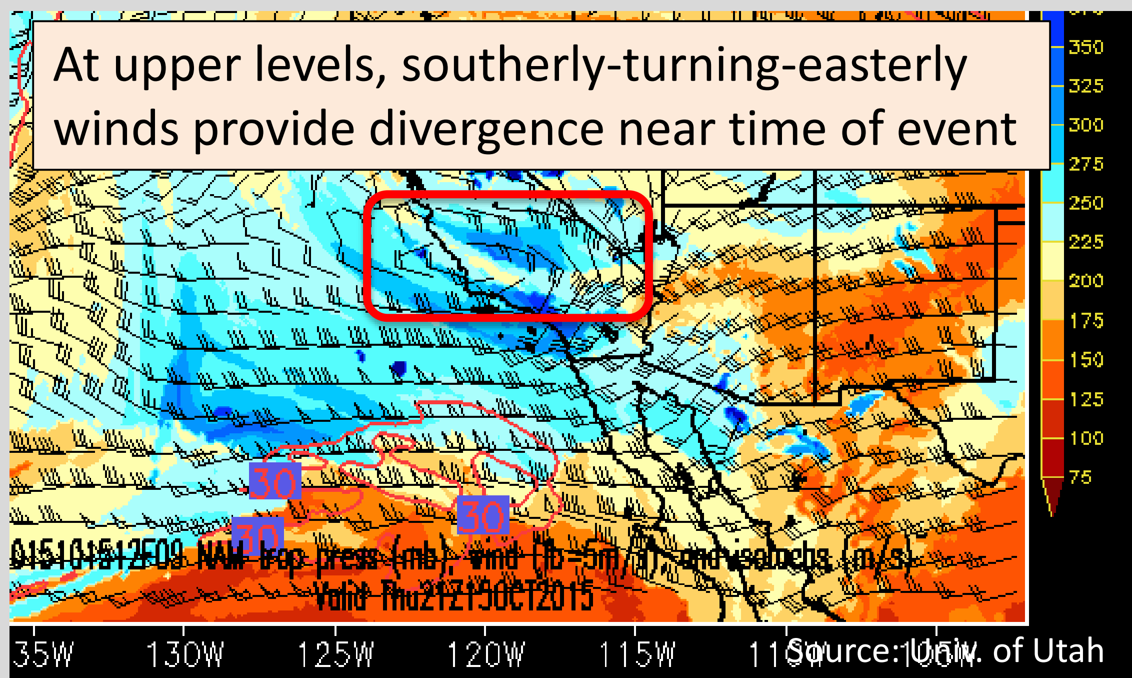


Source: Univ. of Madison, WI

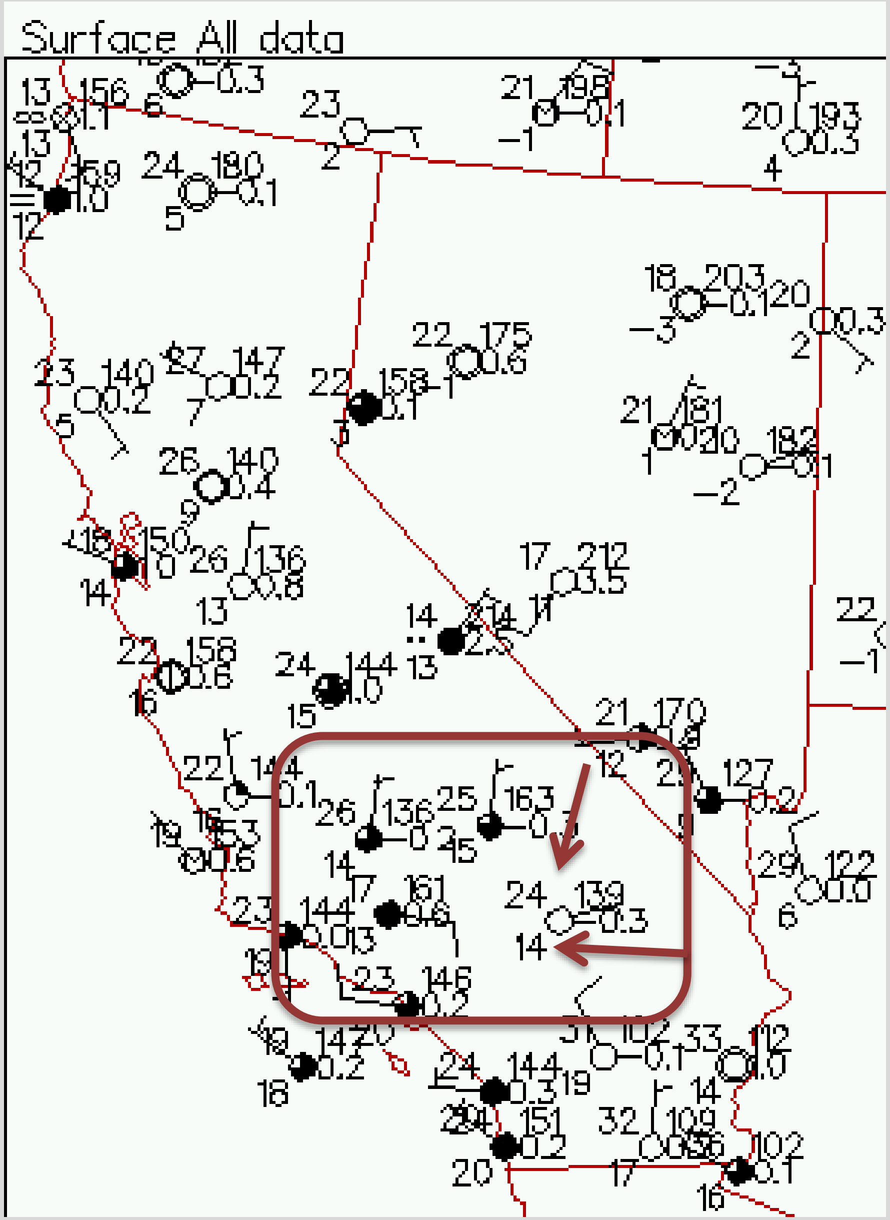




- Outflow from offshore convection produces southerly, easterly mid-level jet streaks (above)
- Convergence between these streaks helps force convection
- Divergent upper level flow (right) also helps force convection



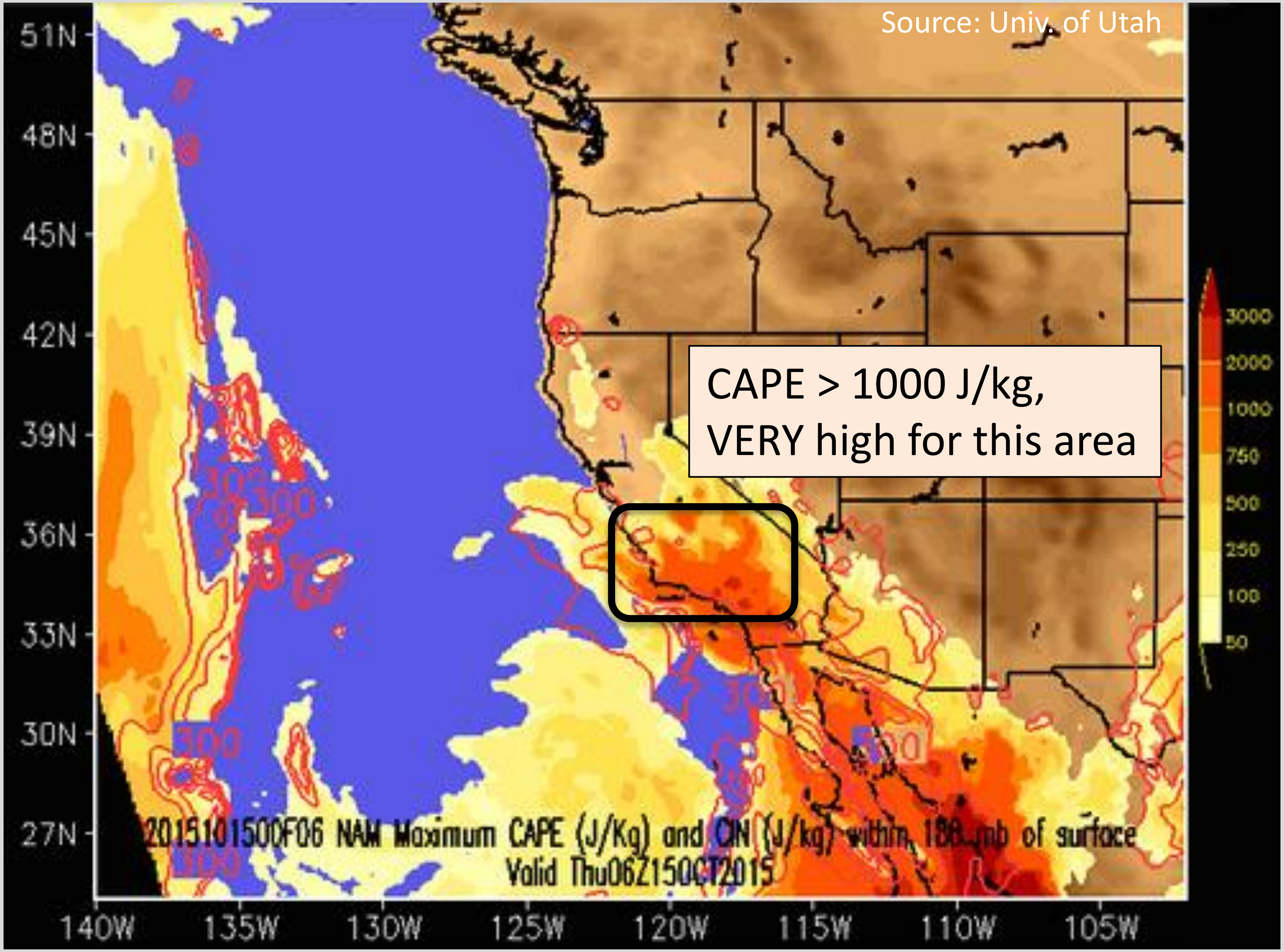
Convergent surface winds also show conditions favorable for convection



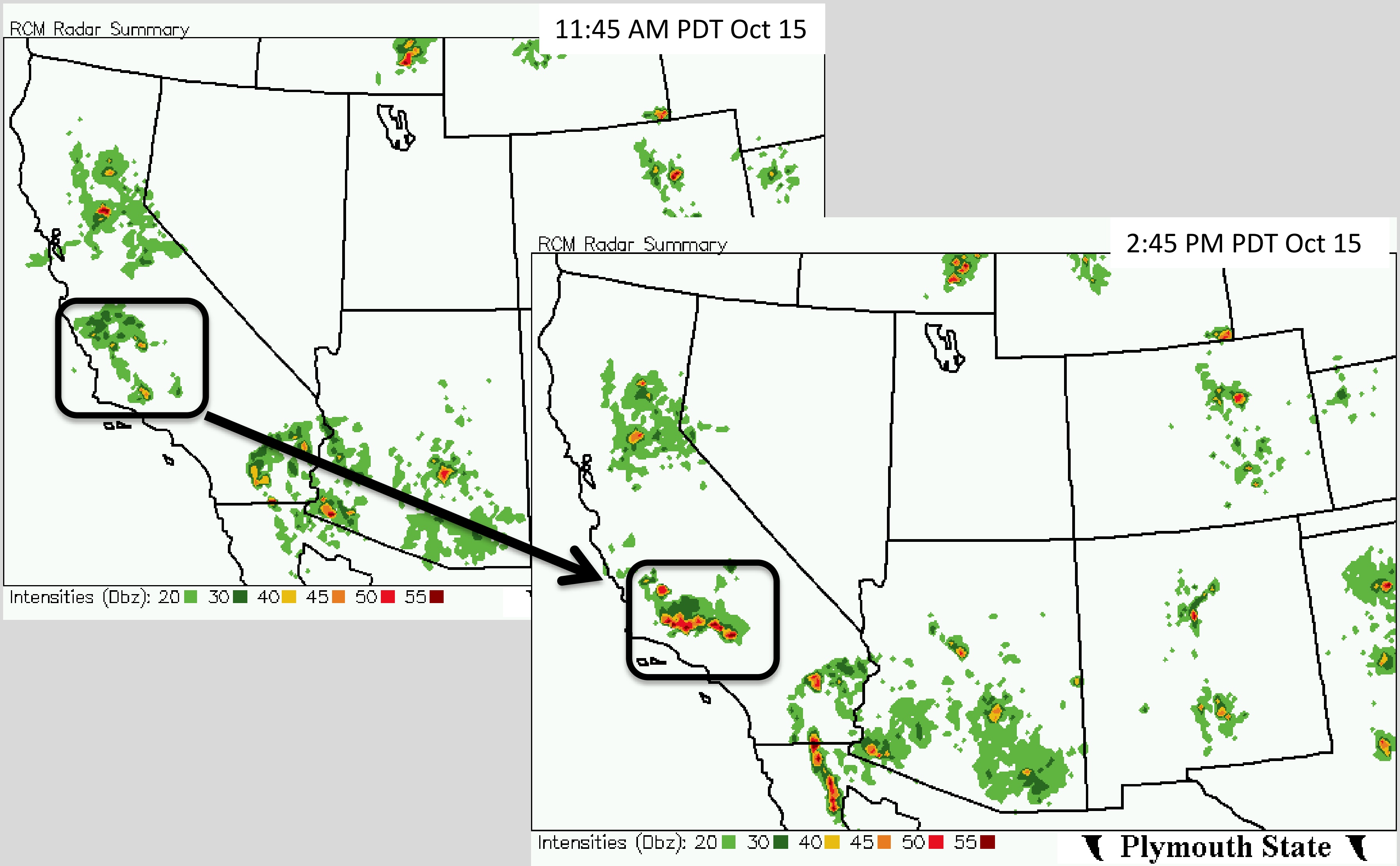
- Converging of northerly and easterly low level winds may have helped intensify convection
- Northerly winds in Central Valley helped move area of convection south over Tehachapi Mtns.
- Possible Kelvin wave propagating N to S along eastern side of Central Valley

Large values of Convective Available Potential Energy (CAPE) as upper level cold low moves over warm surface (80+ F) and divergent flow aloft– indicates high potential for strong convection

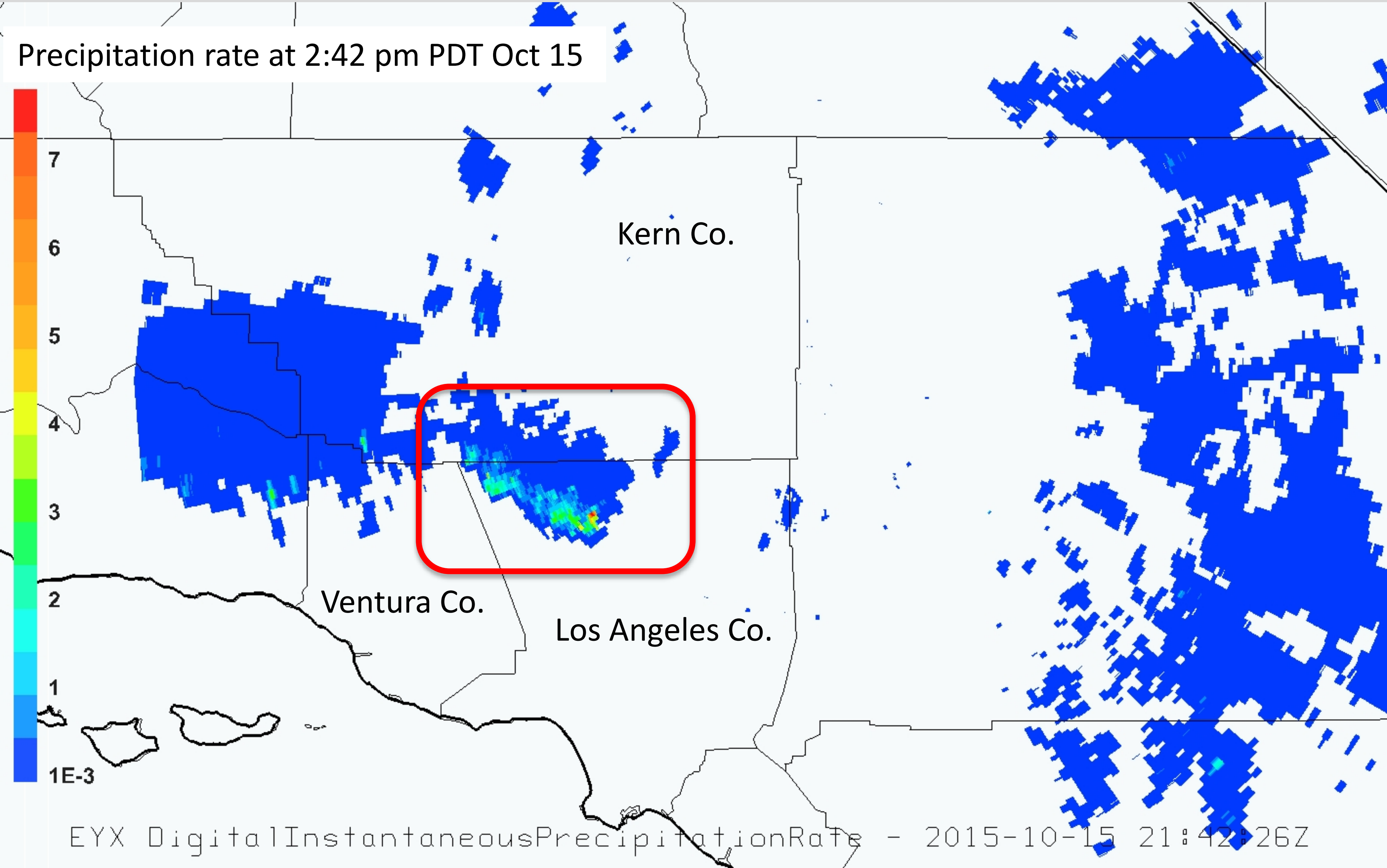
CAPE (J/kg): October 15 06:00 UTC



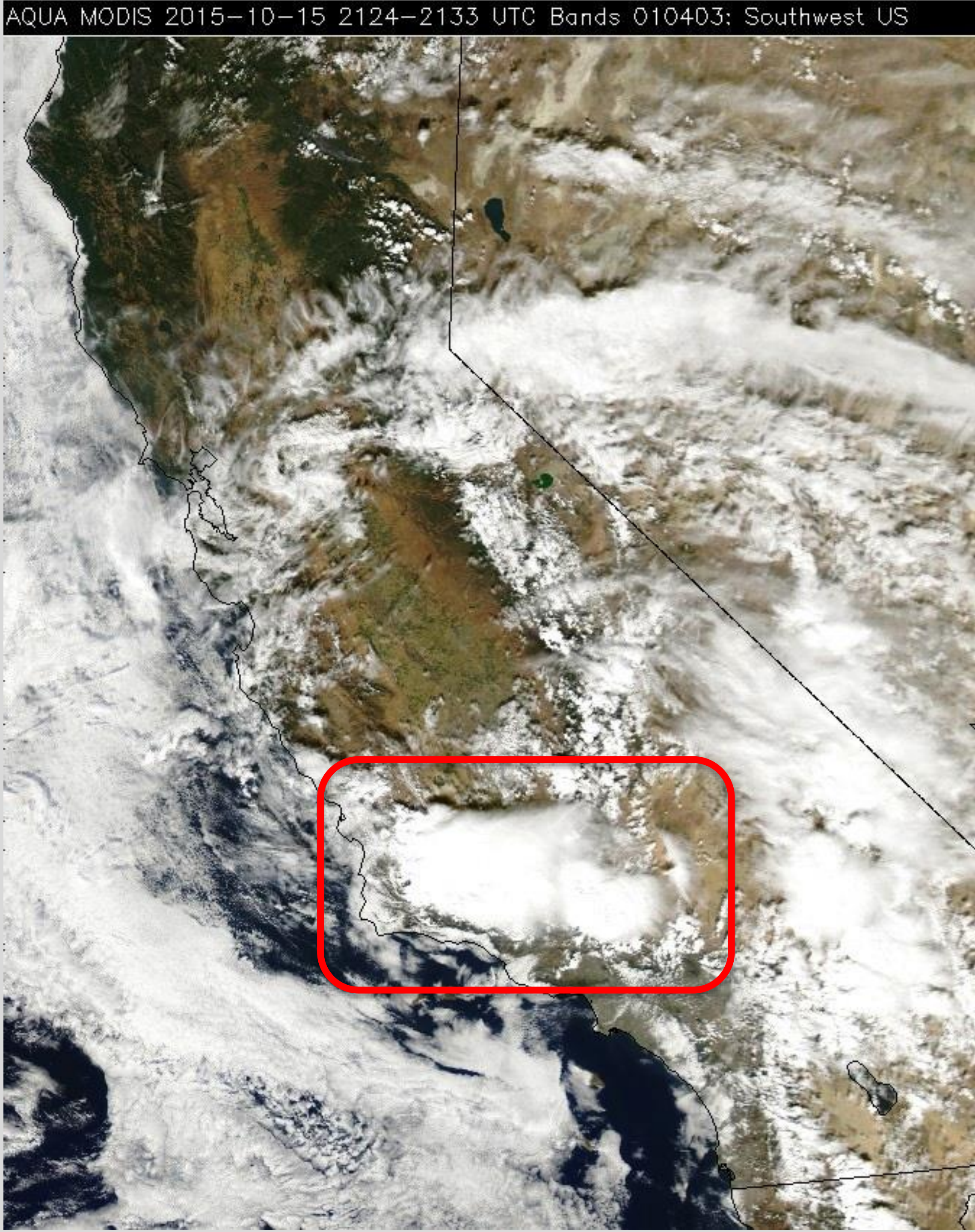
Convective cells develop, move southeast and strengthen, as they encounter area of low level confluence and upper level divergence



High rain rates (2-3+ in/hour) were observed during the convective storms– though not observed by many stations



View from above- large area of deep convection Oct 15 ~2:30 PM PDT

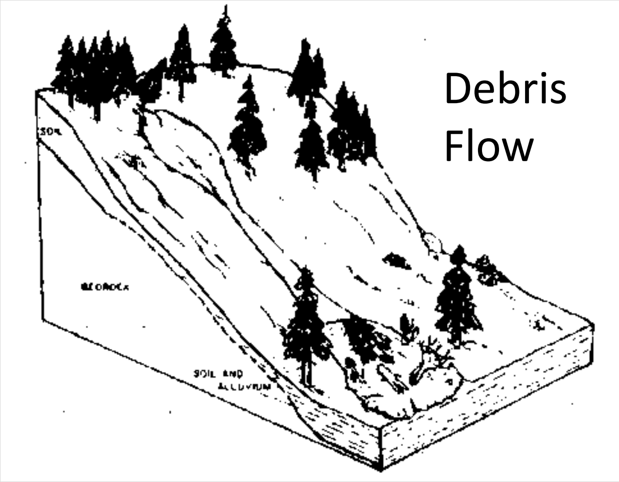


Source: University of Madison, WI

Geologic Analysis

Debris Flows Initiated by Landsliding

- Some landslides mobilize as debris flows : flowing mixtures of soil, water, rock and vegetation, whose motion is dominated by the solid particles as they roll, slide, bounce or fall downslope (below left).
- These flows are inherently dangerous because large, solid boulders, trees and other objects are moving quickly down slope.
- The image below right shows a house that was demolished by this kind of flow, killing the inhabitants.



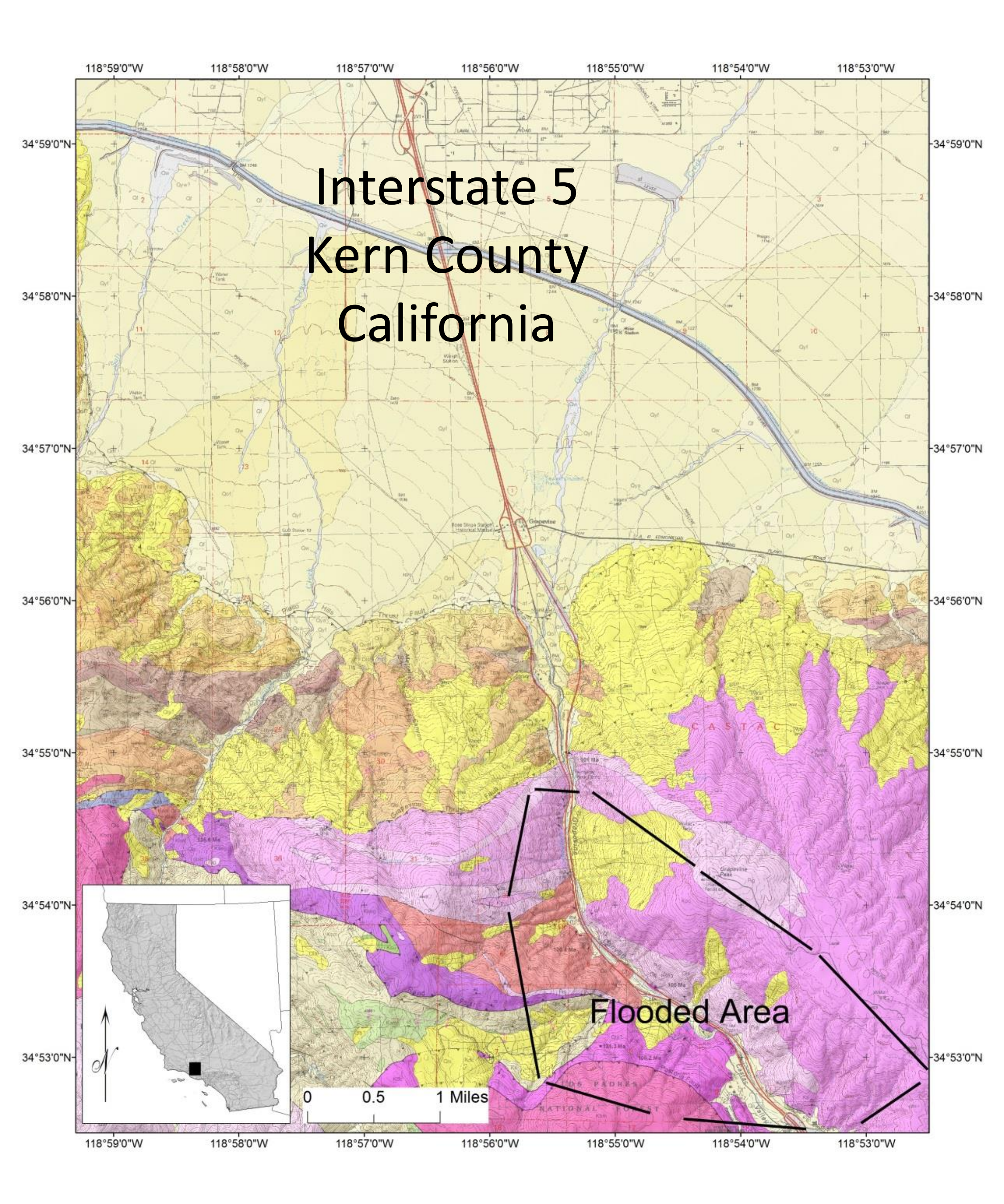
Flooding Initiated by Runoff

- Hillslopes can also produce sediment-rich runoff when heavy rainfalls exceed the soils ability to absorb water.
- These flows can occur suddenly, in the 10-30 minutes following downpours
- As water runs off hillslopes it erodes soils and converges into valleys where it entrains even more sediment.
- The sediment in these flows is moved by the turbulent stresses of water, and the resulting flows often have the properties we associate with traditional water, including waves (see on bottom right), and ponding at the lowest points in the landscape.
- Sediment-water ratios can reach those of debris flows (see images on bottom left).



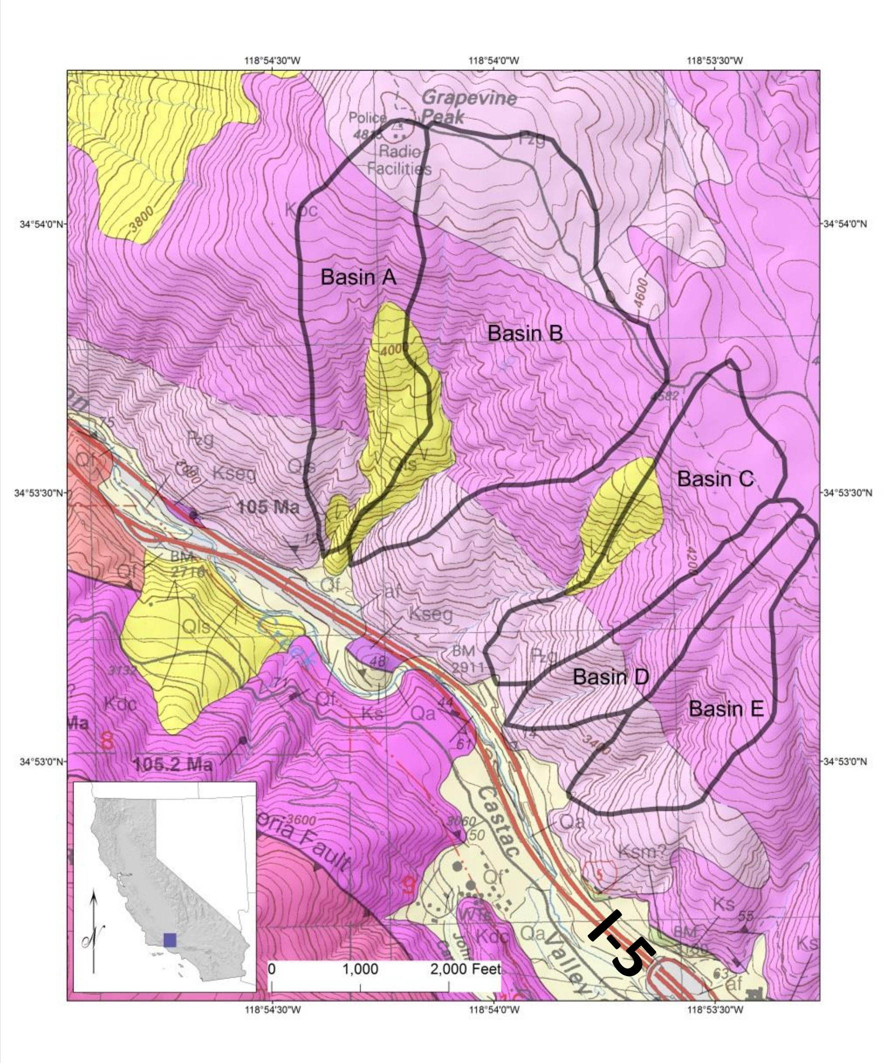

Summary (geology)

- Geology comprised of crystalline granitic and metamorphic rock (Map units in pink and magenta, See: ftp://ftp.consrv.ca.gov/pub/dmg/rgmp/Prelim_geo_pdf/Grapevine_24k_v1.0.pdf)
- Existing deep-seated landslides
- Alluvial fans present at toe of slope



Geologic Summary - selected basins that showed runoff response

- Bedrock geology composed of crystalline granitic and metamorphic rock; intensely fractured and erodible (Map units Pzg, Kdc, Kpc in pink and majenta)
- Alluvial fans mapped at toe of slope (Map units Qf)
- Existing deep-seated landslides present but were not mobilized during rainfall event (Map unit Qls in yellow)

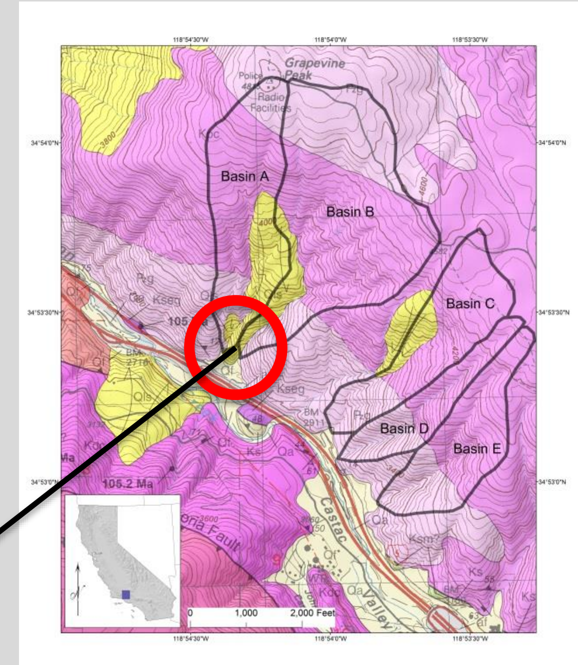


Basin Metrics

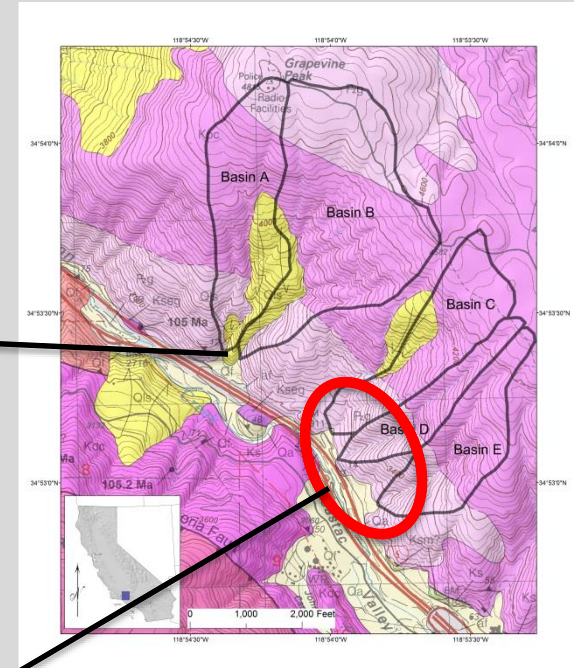
Basin_ID	Avg Slope %	Relief (m)	Meltons #	Plannimeteric Length (km)
A	39	596	0.86	1.2
B	39	580	0.62	1.1
C	37	486	0.79	1.1
D	46	411	0.91	1.3
E	44	427	0.74	1.5

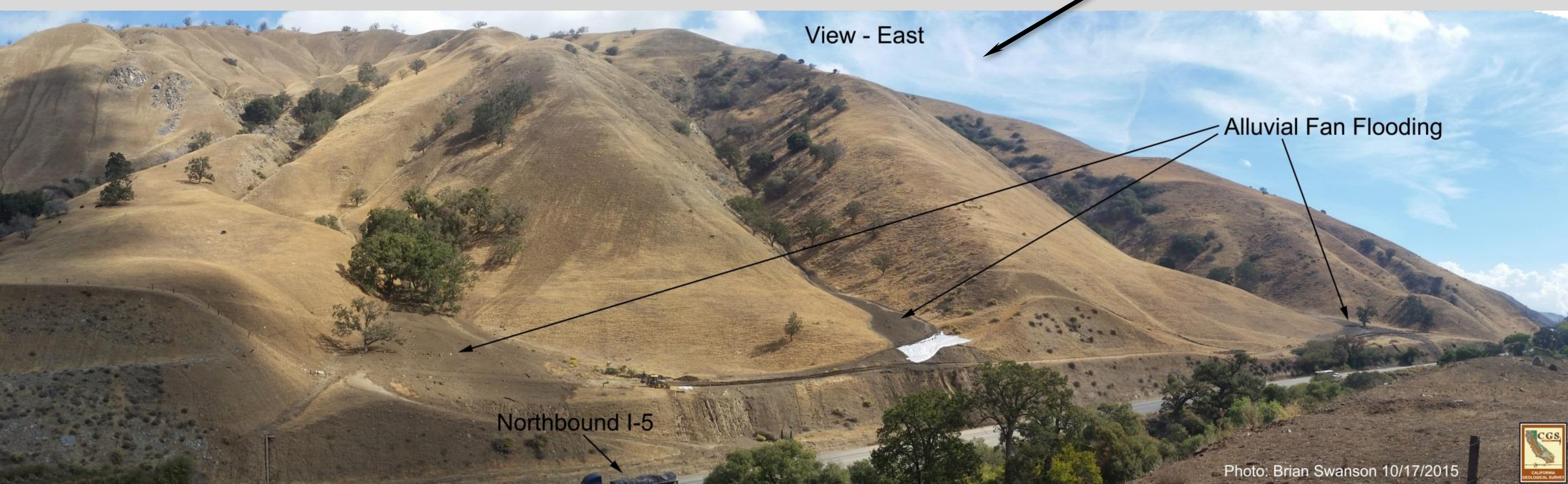
Likely sequence leading to Alluvial Fan Flooding

- Intense rainfall rates (likely > 10-20 mm/hour) exceed local soil infiltration rates
- Horton Overland flow moves water and sediment from hillslopes to valleys via unconfined flow, rilling and gullying.
- Channel scour and further entrainment of sediment bulks up flows.
- Debris laden flows move through steep alluvial fans and onto roadways.
- Shallow landslides possible, but not confirmed.



Alluvial Fan Flooding





Preliminary Conclusions

Based on review of available photography, these events were:

- Initiated in part by intense convective rainfall generating overland flow on hillslopes
- Concentration of that flow in steep valleys where it entrained further sediment before inundating steep alluvial fans and flooding roadways.

Recent events at I-5 and Highway 58 were debris-laden floods that inundated alluvial fans.

Similar Alluvial Fan Flooding on Highway 58, Tehachapi, and near Palmdale (aqueduct overtopped)