Atmospheric Conditions Associated with Extreme Precipitation and Post-fire Debris Flows on Alluvial Fans Transverse Ranges, southern California

NASA – ASTER Nov. 18, 2003

CWEMF – Flood Modeling Session No. 1
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CALIFORNIA GEOLOGICAL SURVEY

DRI Desert Research Institute

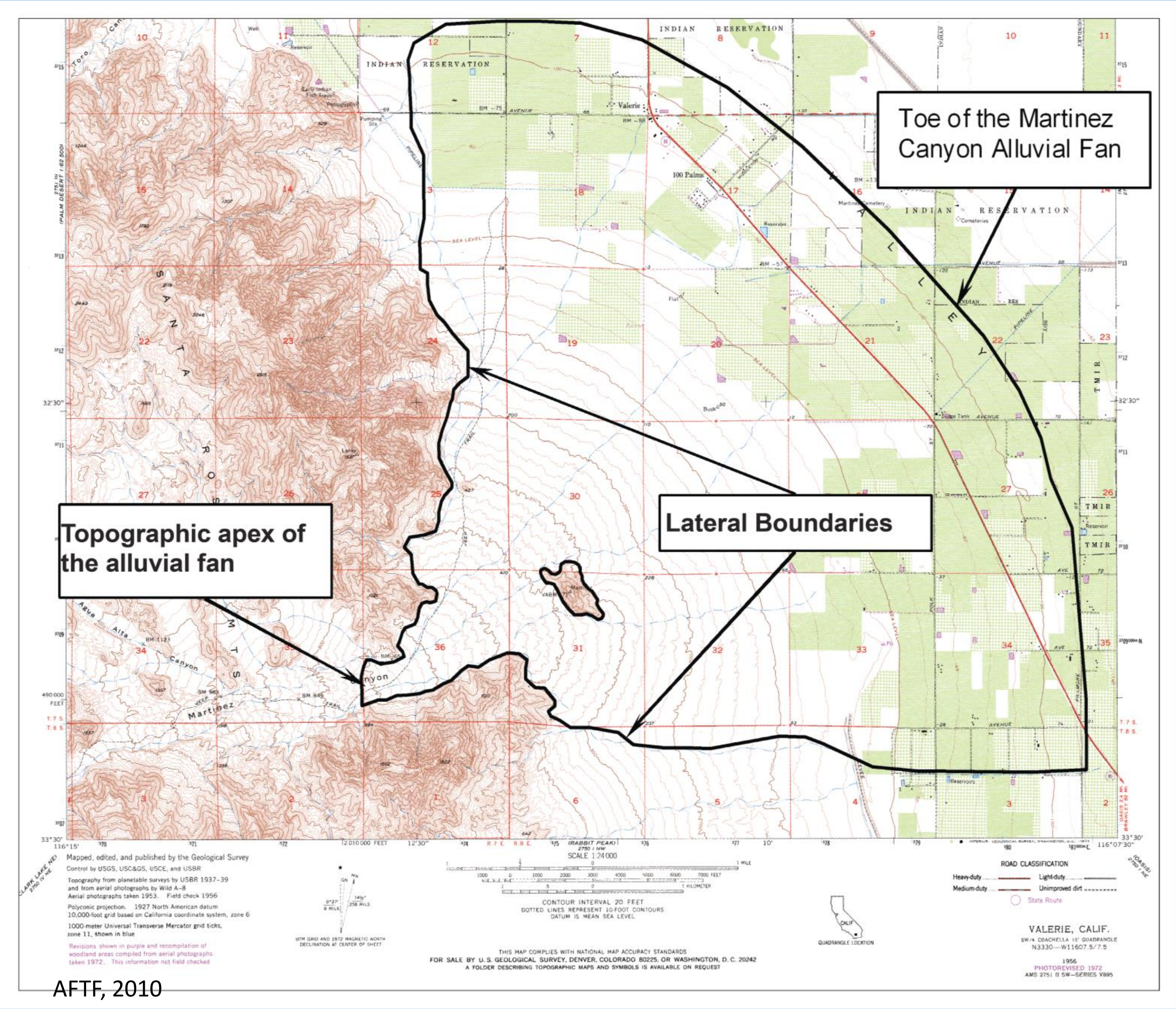
Western Regional Climate Center

CW3E

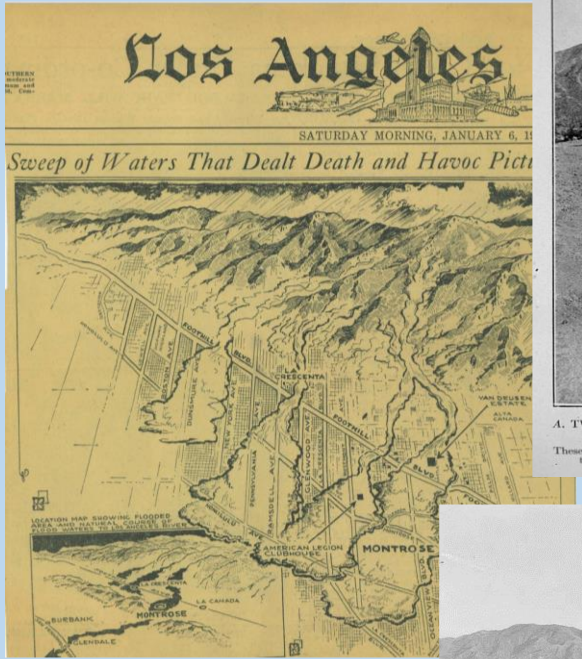
DEPARTMENT OF WATER RESOURCES STATE OF CALIFORNIA

Alluvial Fan Flooding

- Flooding occurring on the surface of an alluvial fan … which originates at the apex and is characterized by high-velocity flows; active erosion and deposition, and unpredictable flow paths.

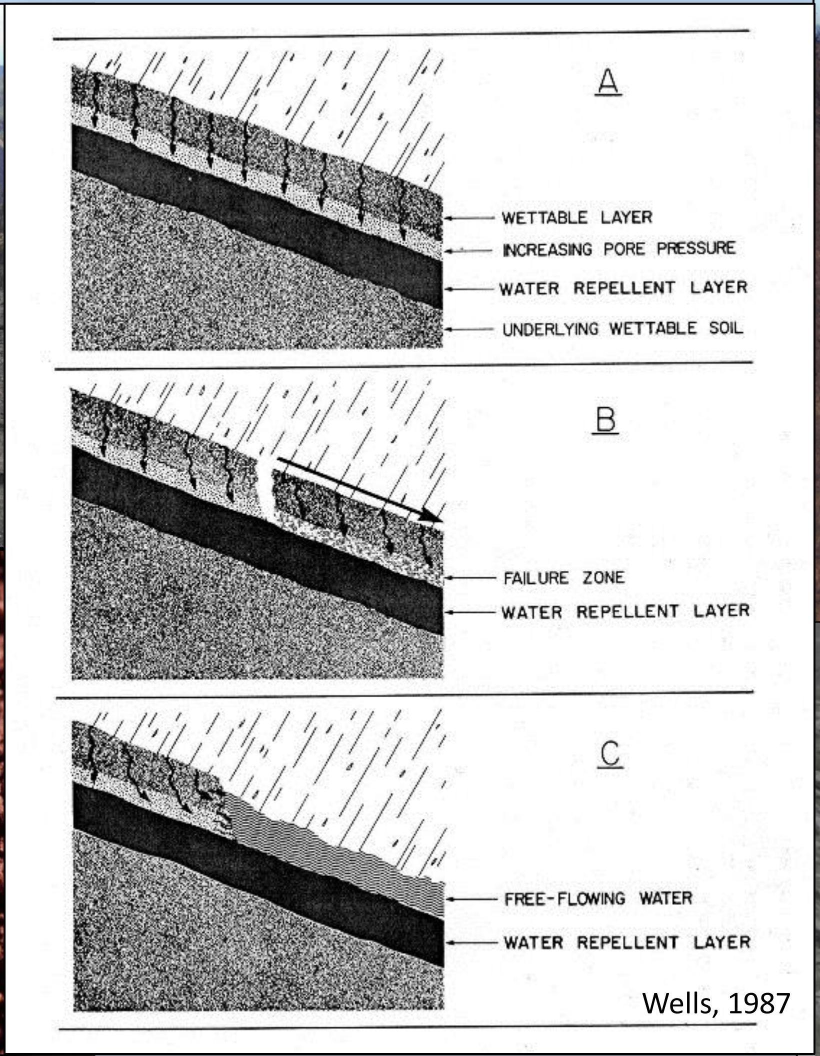


AFTF, 2010

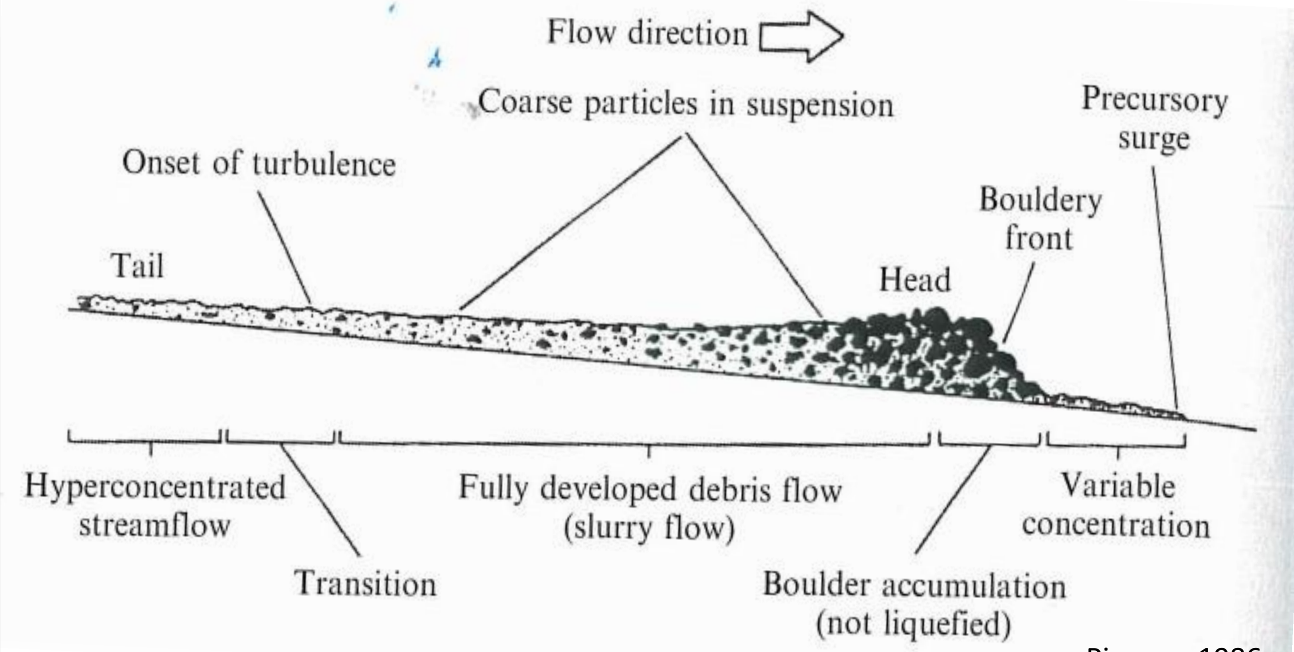


A. TWO BOULDERS ON PAVEMENT AT END OF NEW YORK AVENUE.
These boulders were brought down Dunsmore Creek by the flood. Estimated weight over 60 tons each.

Post Fire Runoff Processes



Anatomy of a Debris Flow



Pierson, 1986

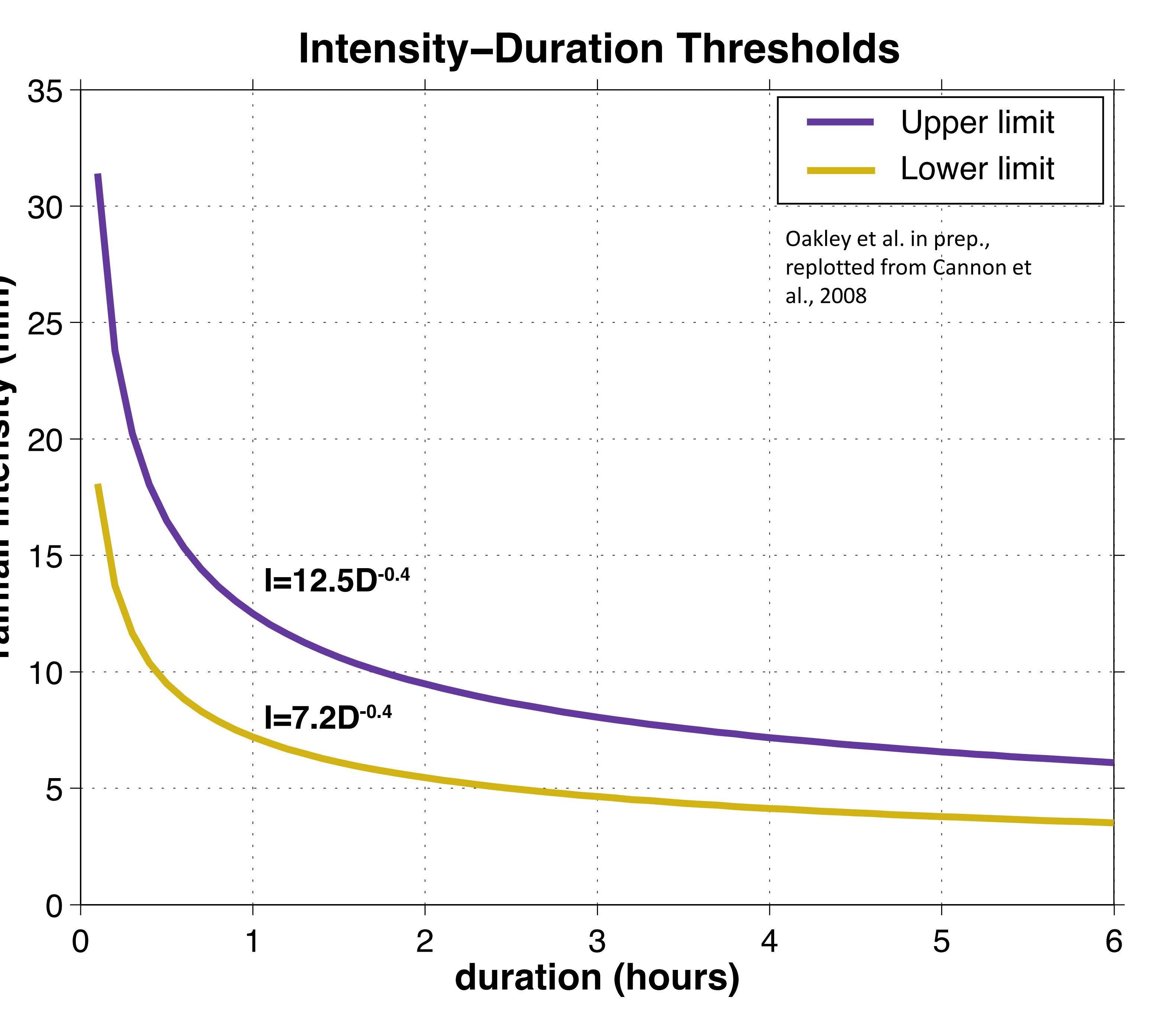
- Debris flow: a form of rapid mass movement in which a combination of loose soil, rock, organic matter, air, and water mobilize [and liquefy] in a slurry the flows down slope (USGS)

Extreme Events

- 1978, 10 February (Los Angeles County - 20 Deaths)
  - 20ft Wall of mud and debris in Town Hidden Springs (Mill Creek); 12 Dead
    - ~300,000 CY of Debris Deposited
  - 17ft Wall of mud and debris in Ebey Canyon, Sun Valley
  - Debris Basins - Zachau, Oliver, overtopped, Sun Valley
  - Winter 1978 Damage Estimates $150,000,000
  - 4,898 damaged homes reported by LA County and City
- 2003, Christmas Day (San Bernardino County – 16 Deaths)
  - 12ft Wall of mud and debris in St. Sophia Camp (Waterman Canyon); 14 Dead
    - ~864,000 CY of Debris Deposited
  - KOA Campground Devore (Cable Canyon), 2 Deaths
- 2010, 6 February (Los Angeles County – 41 Homes Damaged or Destroyed
  - Emergency Management: 500 Homes under Evacuation Notice
  - Debris Basins Overtopped in La Cresenta Valley

Shields Canyon, USFS

Photo 18. Aerial view northeast shows Zachau Canyon drainage and debris basin, Sunland. Basin overflowed during intense rainfall of February 9-10, causing destruction downstream (photo 19). Photograph courtesy of the City of Los Angeles.



- Debris flows occur in response to both short and long duration high intensity rainfall
- Storm rainfall with return periods as little as 2yrs
- Kean and Staley, 2011: Little lag time between triggering intensity and debris flow runoff
- Emergency Response Planning?

A Complex and Challenging Problem

- Alluvial fan flooding, especially PFDF continues to be a hazard
- Fire season, frequency and duration are increasing in a warming climate
- PFDF magnitudes may also increase
- Runoff forecasting is NOT SIMILAR TO RIVERS
- Forecasting and Emergency Response Planning

Clues and Possible Solutions

"Convection" cited as cause of post-fire debris flows

Under what atmospheric conditions do these convective cells typically develop?

Research exists on this; not tailored to post-fire debris flow hazards

Approach: Present meteorological information such that it can be used by geologists, post-fire runoff assessments, emergency managers

Event Database

19 storm events; 89 Post-fire Debris Flows

Date	Location-burn area
01-09-1980	Daley (western SB)
01-13-1980	Daley (western SB)
01-28-1980	Daley (western SB)
02-16-1980	Daley (western SB) Creek Road (Topa Topa)
12-20-1984	San Dimas (SG)
02-02-1998	Grand (Topa Topa)
02-06-1998	Hopper/Grand (Topa Topa)
1995-01-10	Steckel (Topa Topa)
2003-12-25	Grand Prix/Old (SG/SB) Simi (Santa Susana)

Date	Location- burn area
2009-02-05	Sayre (western SG)
2009-02-13	Sayre (western SG)
2009-02-16	Sayre (western SG)
2009-11-13	Station (western SG)
2009-12-13	Station (western SG)
2010-01-18	Station (western SG)
2010-02-06	Station (western SG)
02-27-2010	Station (western SG)
10-31-2014	Springs (western SM)
12-12-2014	Springs (western SM)


DEVELOPERS TARGET HARGRAVE STREET COMMUNITY IN BANNING | B1

THE SUN

THE CHRISTMAS FLOOD

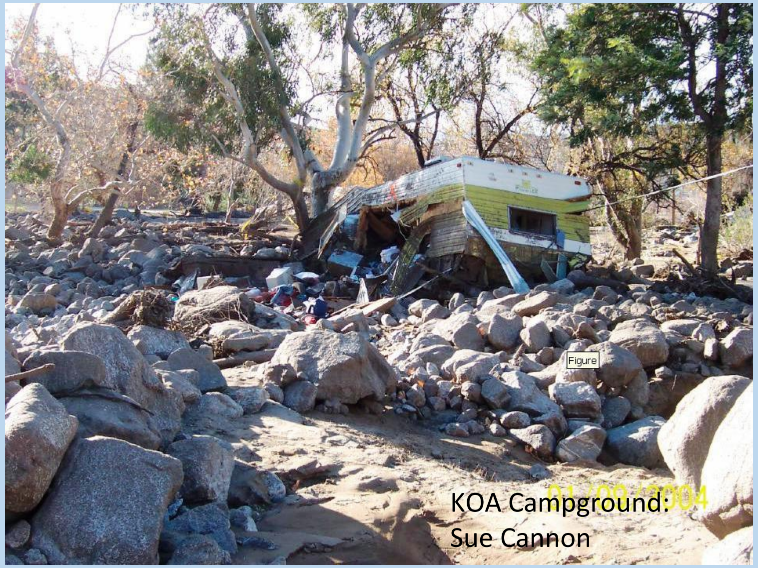
SEVEN FOUND DEAD, 14 STILL MISSING

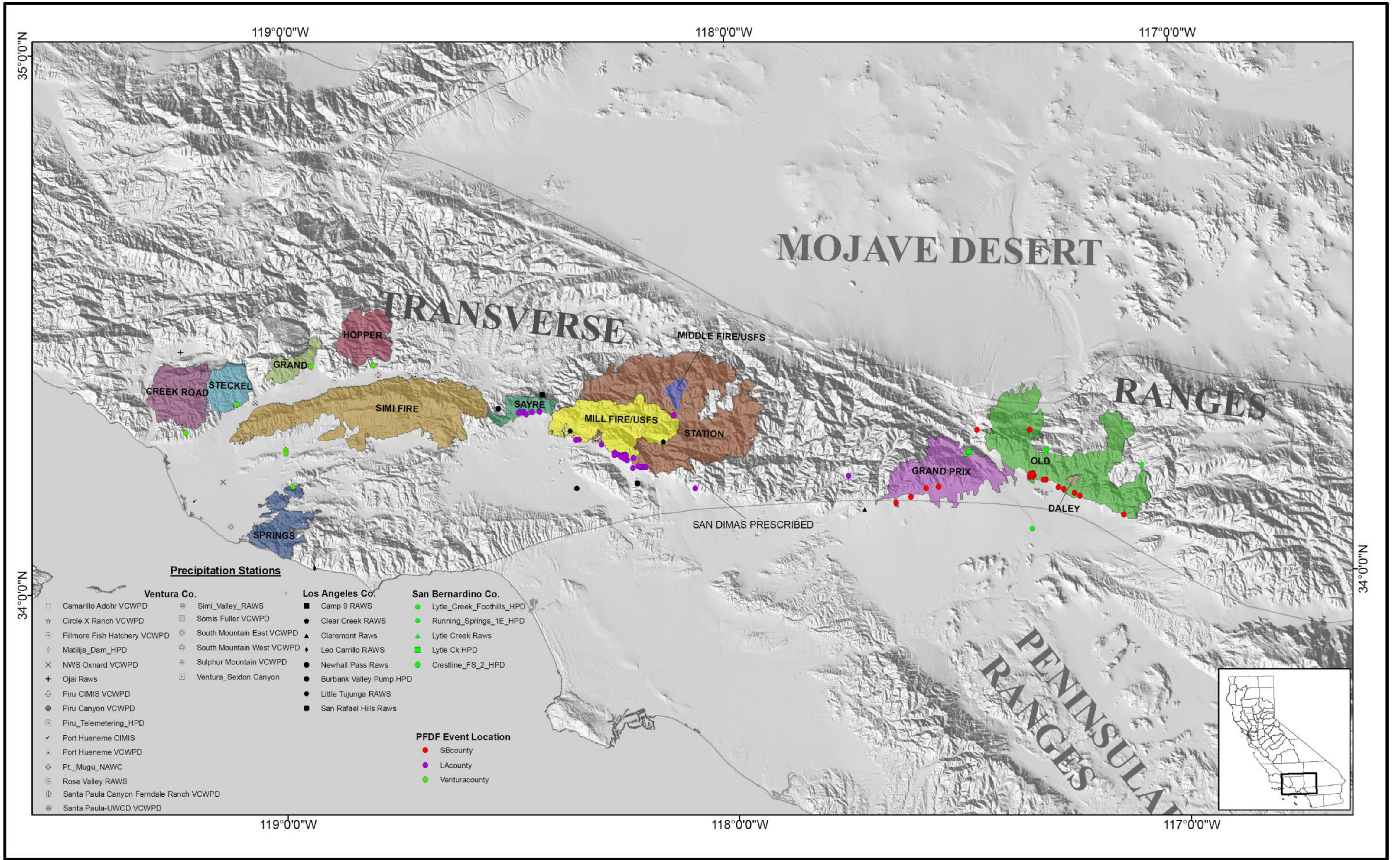
SURVIVORS TELL OF 20 SECONDS OF TERROR

Kin, friends gather at park for news of camp's missing

THE OLD FIRE | LESSONS LEARNED

Firefighters' efforts doomed as city resources fell short



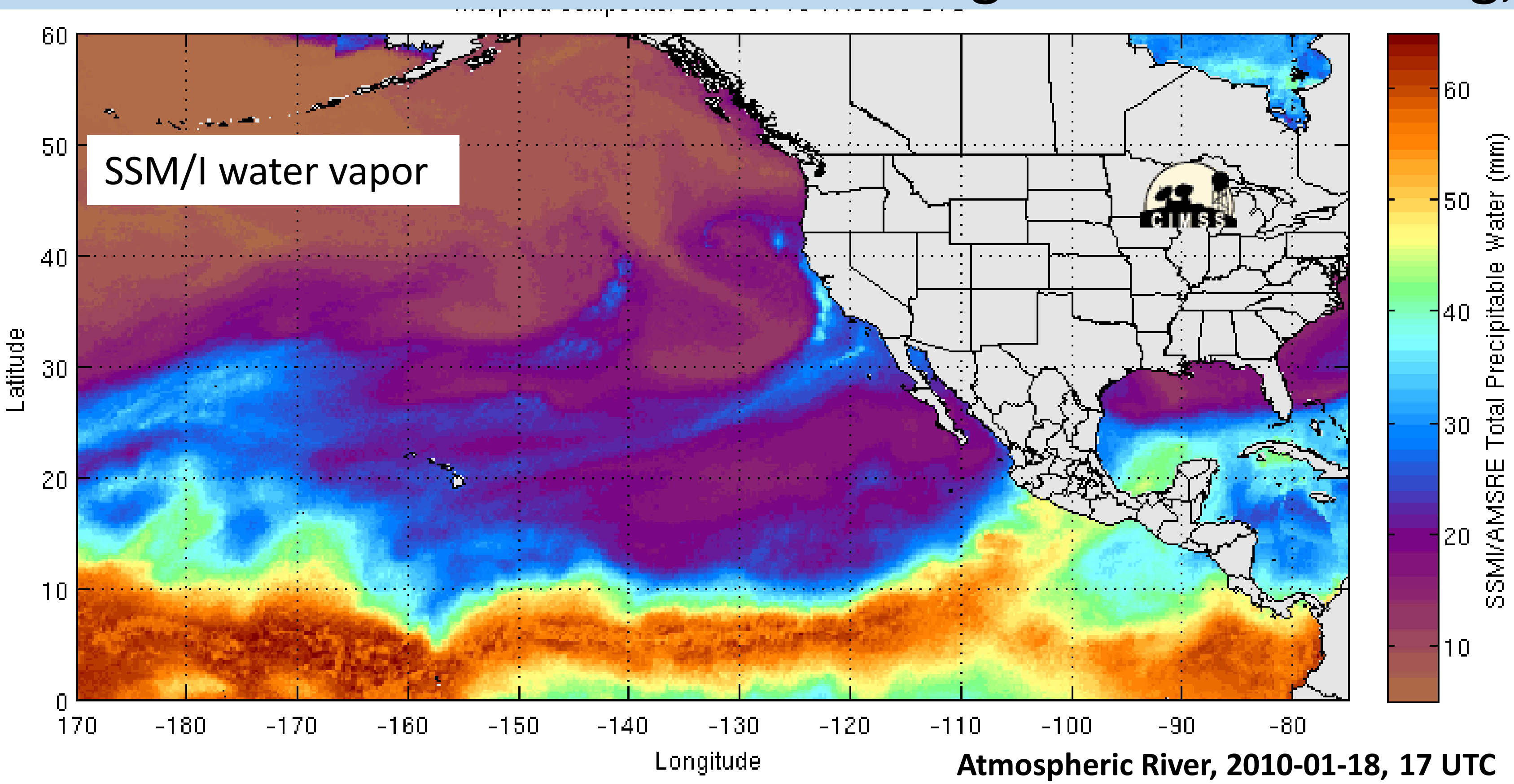

119°0'0"W
118°0'0"W
117°0'0"W
35°0'0"N
34°0'0"N
MOJAVE DESERT
TRANSVERSE
RANGES
PENINSULAR
RANGES
HOPPER
GRAND
CREEK ROAD
STECKEL
SIMI FIRE
SAYRE
MIDDLE FIRE/USFS
MILL FIRE/USFS
STATION
SPRINGS
SAN DIMAS PRESCRIBED
GRAND PRIX
OLD
DALEY
Precipitation Stations
Ventura Co.
Camarillo Adohr VCWPD
Circle X Ranch VCWPD
Fillmore Fish Hatchery VCWPD
Matilija_Dam_HPD
NWS Oxnard VCWPD
Ojai Raws
Piru CIMIS VCWPD
Piru Canyon VCWPD
Piru_Telemetering_HPD
Port Hueneme CIMIS
Port Hueneme VCWPD
Pt._Mugu_NAWC
Rose Valley RAWS
Santa Paula Canyon Ferndale Ranch VCWPD
Santa Paula-UWCD VCWPD
Simi_Valley_RAWS
Somis Fuller VCWPD
South Mountain East VCWPD
South Mountain West VCWPD
Sulphur Mountain VCWPD
Ventura_Sexton Canyon
Los Angeles Co.
Camp 9 RAWS
Clear Creek RAWS
Claremont Raws
Leo Carrillo RAWS
Newhall Pass Raws
Burbank Valley Pump HPD
Little Tujunga RAWS
San Rafael Hills Raws
San Bernardino Co.
Lytle_Creek_Foothills_HPD
Running_Springs_1E_HPD
Lytle Creek Raws
Lytle Ck HPD
Crestline_FS_2_HPD
PFDF Event Location
SBcounty
LAcounty
Venturacounty

Models for Developing Meteorological Case Studies

- Developed using North American Regional Reanalysis (Messinger et al. 2006)
  - A model interpretation of past weather
  - 32 km resolution
  - 1979-present
- Variables examined:
  - Jet stream strength, position
  - Presence of atmospheric river, closed low
  - Winds at different levels
  - Stability profile in atmosphere

Results

- Atmospheric rivers dominant feature
- Strong (>45 m/s) WSW upper level jet south of study area
- Moist low-level southerly flow orthogonal to mountain range
- Not appreciable instability, typically moist-neutral
- Not new to meteorological understanding, but new to PFDF Research



Atmospheric River, 2010-01-18, 17 UTC

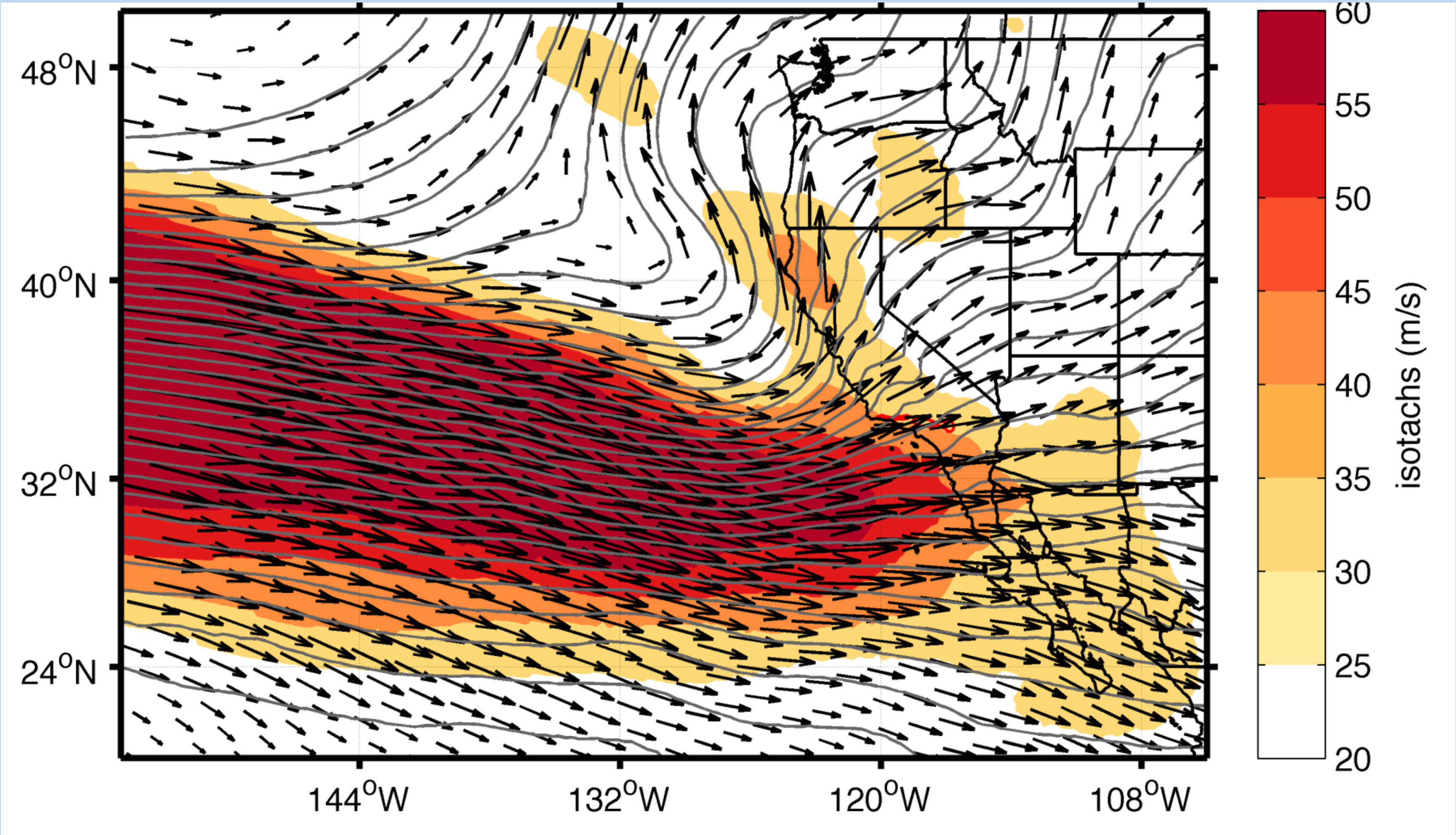
-14/19 events associated with atmospheric river
(IWV>20mm, 2000km long, <1000km wide)

-5/19 events have closed low (4 have both AR and CL)

-4/19 events had neither

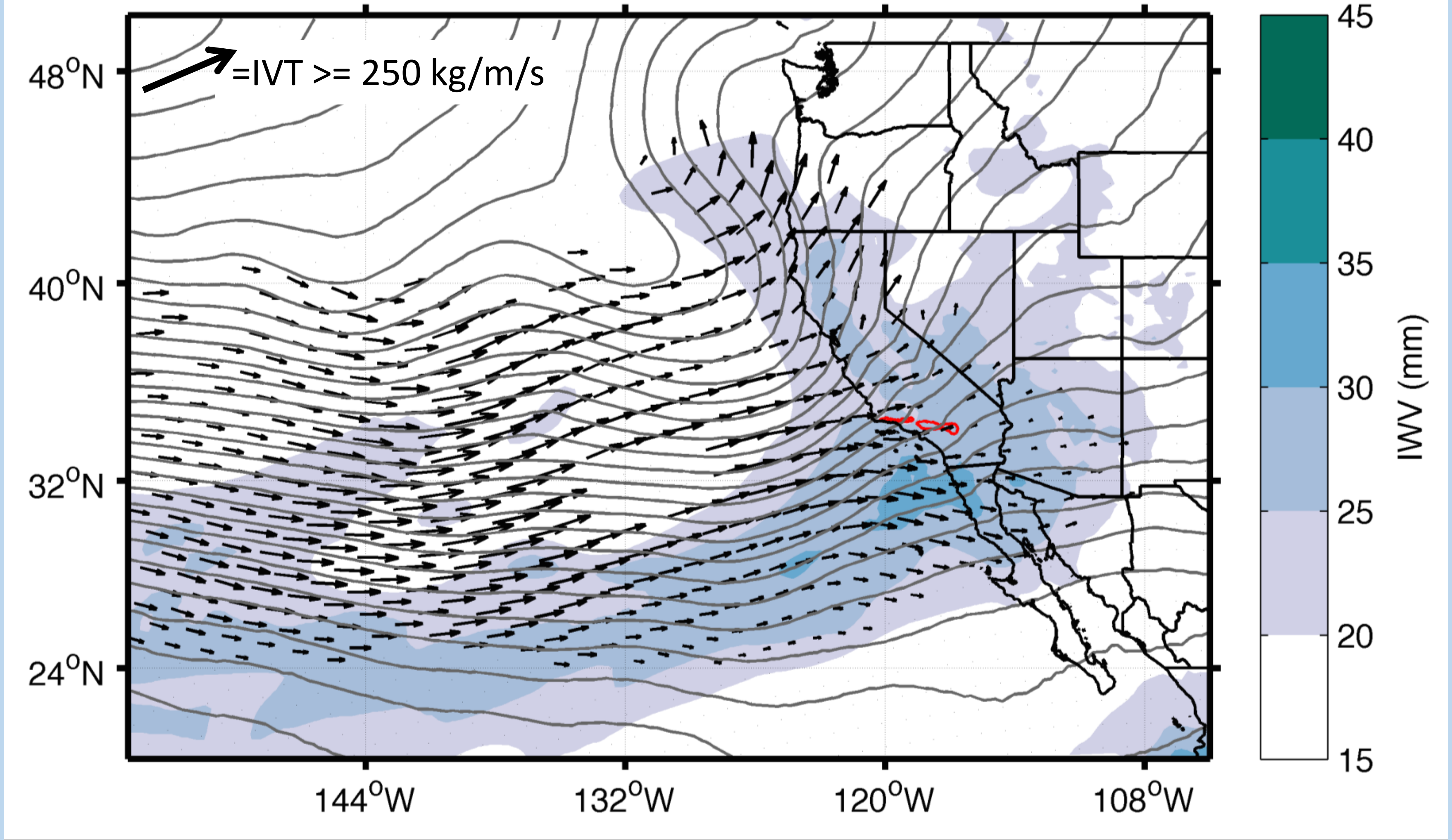
MODEL RESULTS
Event Example- 18 Jan 2010 18 UTC

300 hPa geopotential height, winds, isotachs

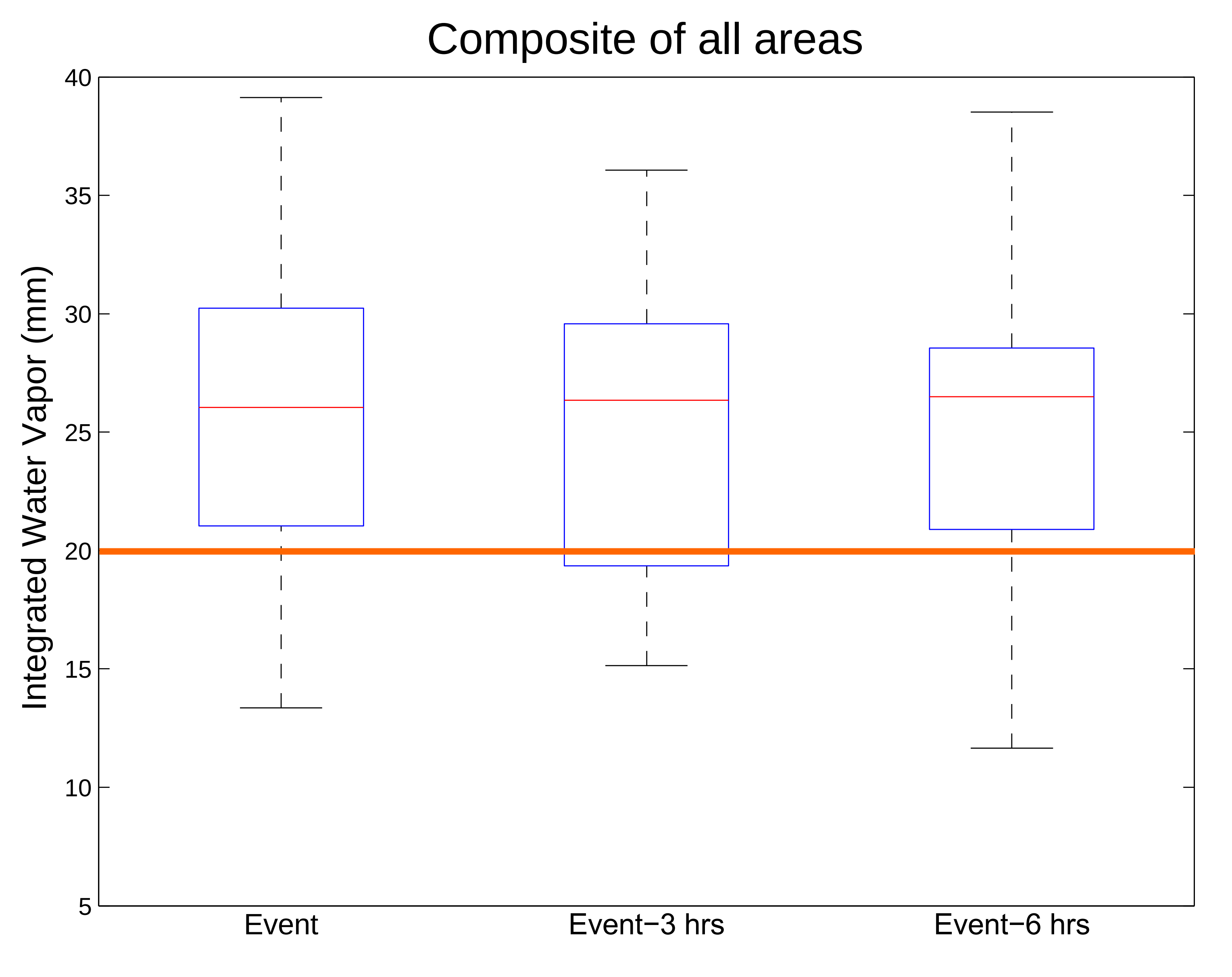


MODEL RESULTS
Event Example- 18 Jan 2010 18 UTC

500 hPa geopotential height, IVT >250 kg/m/s, IWV

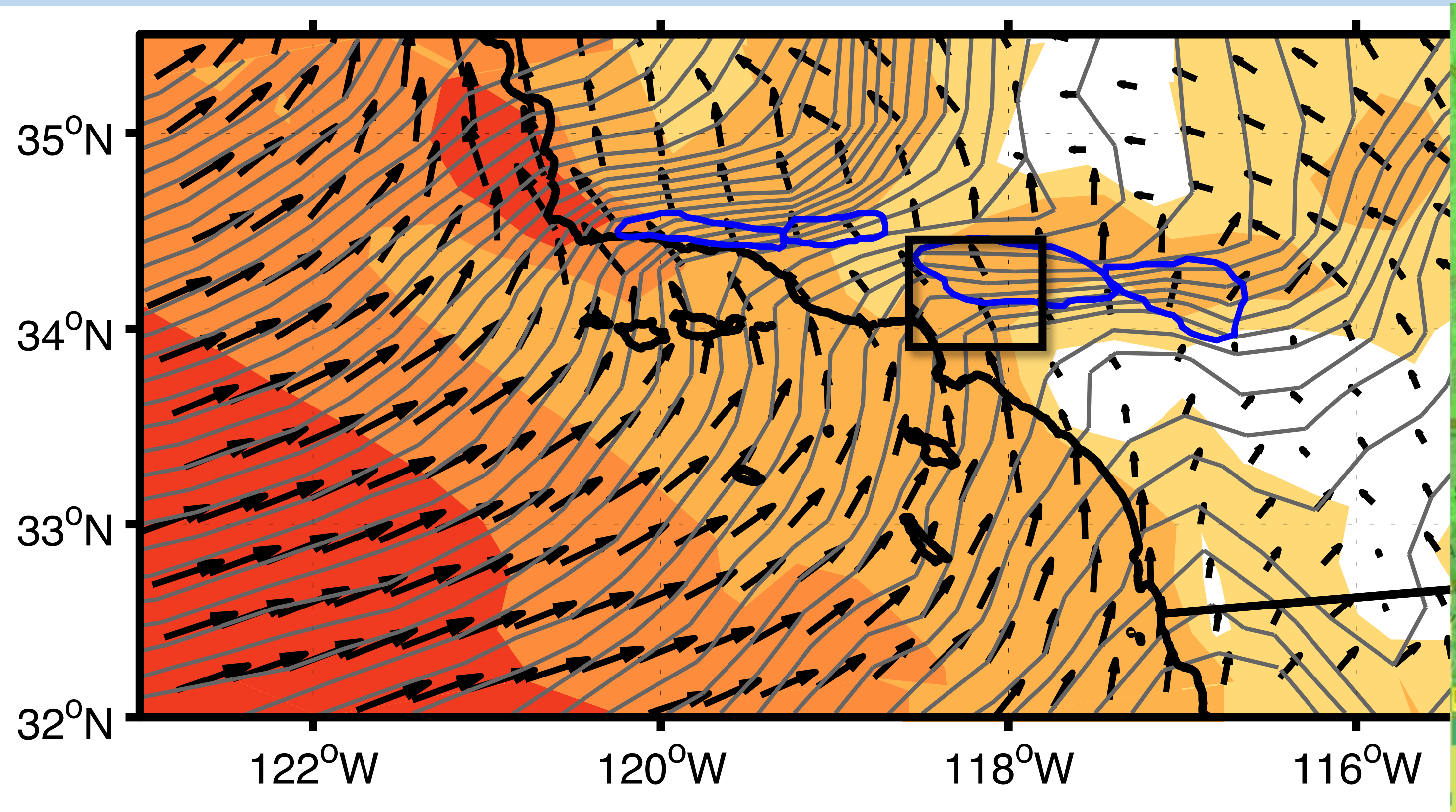


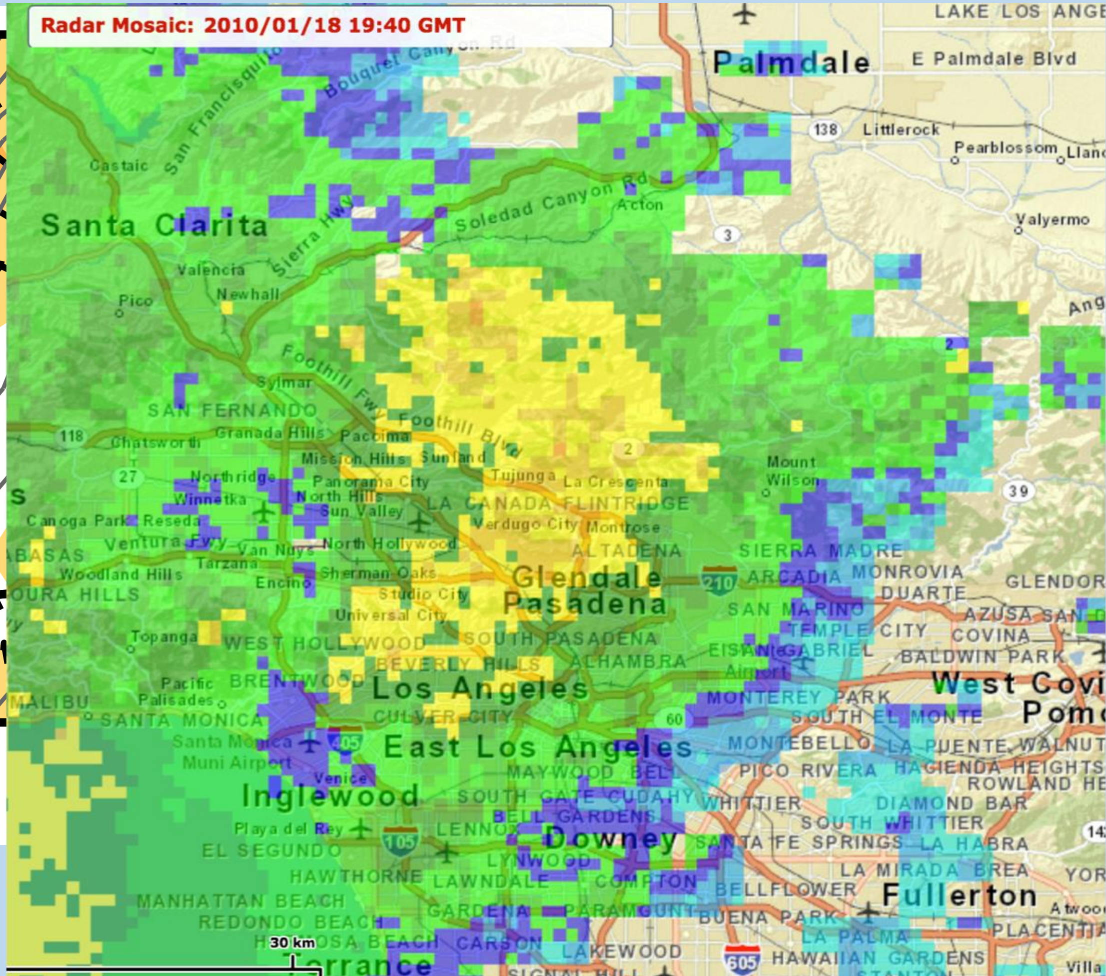
MODEL RESULTS
Integrated Water Vapor



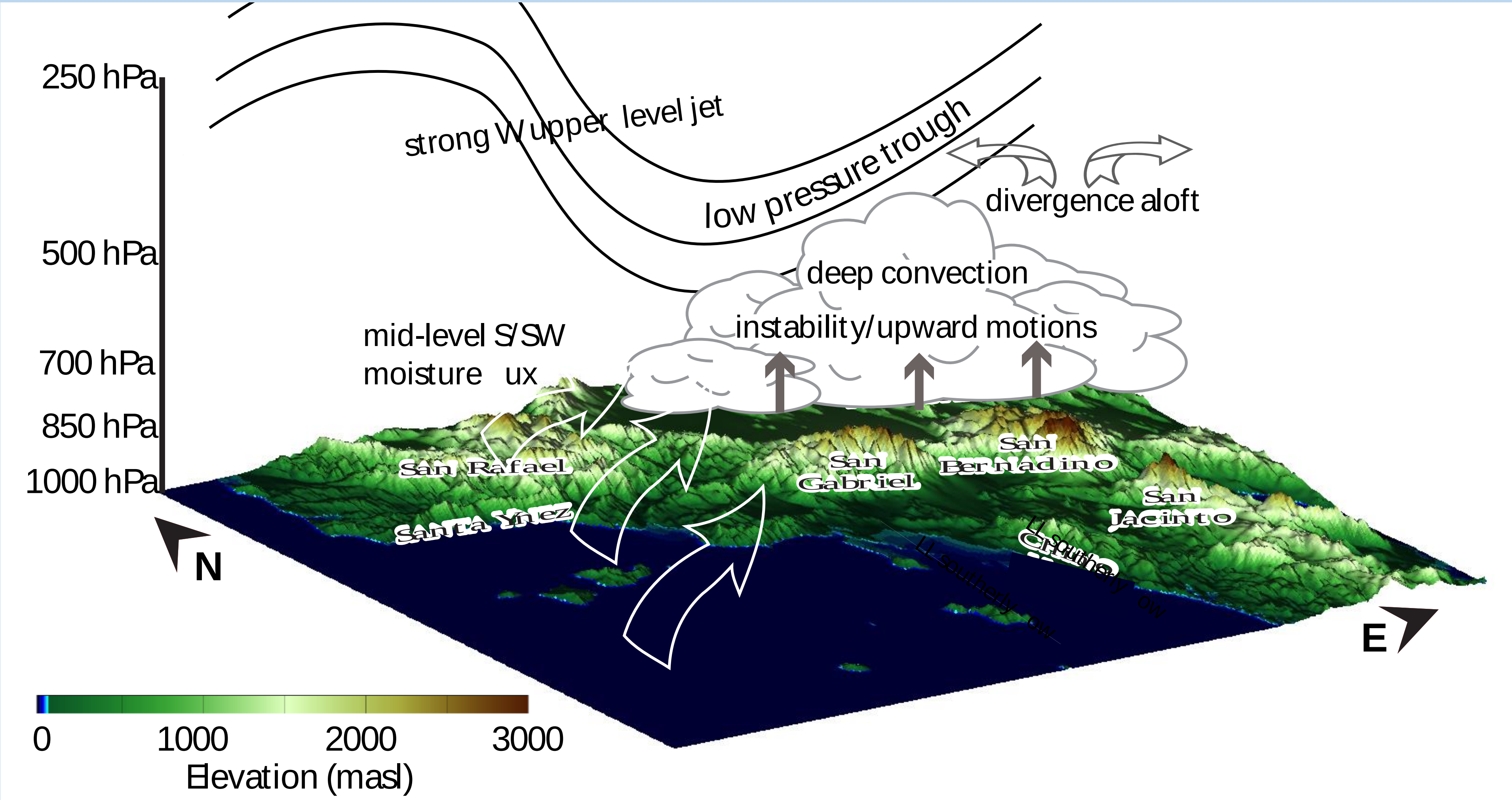
MODEL RESULTS
Event Example- 18 Jan 2010 18 UTC

925 hPa geopotential height, wind, isotachs





Conceptual Model- PFDF Events



Project Benefits

- Brings meteorological information to the geology community
  - Can use forecasting tools to watch for potential for PFDFs
- Helps forecasters reduce uncertainty by seeing wide range of events
- Sets stage for future cross-disciplinary work

Next Steps

- High-resolution modeling to determine favored locations for convective cell development
- *Natural Hazards Publication*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