Atmospheric rivers as triggers for post-fire debris flows in the Transverse Ranges of Southern California

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CW3E

CGS
CALIFORNIA GEOLOGICAL SURVEY

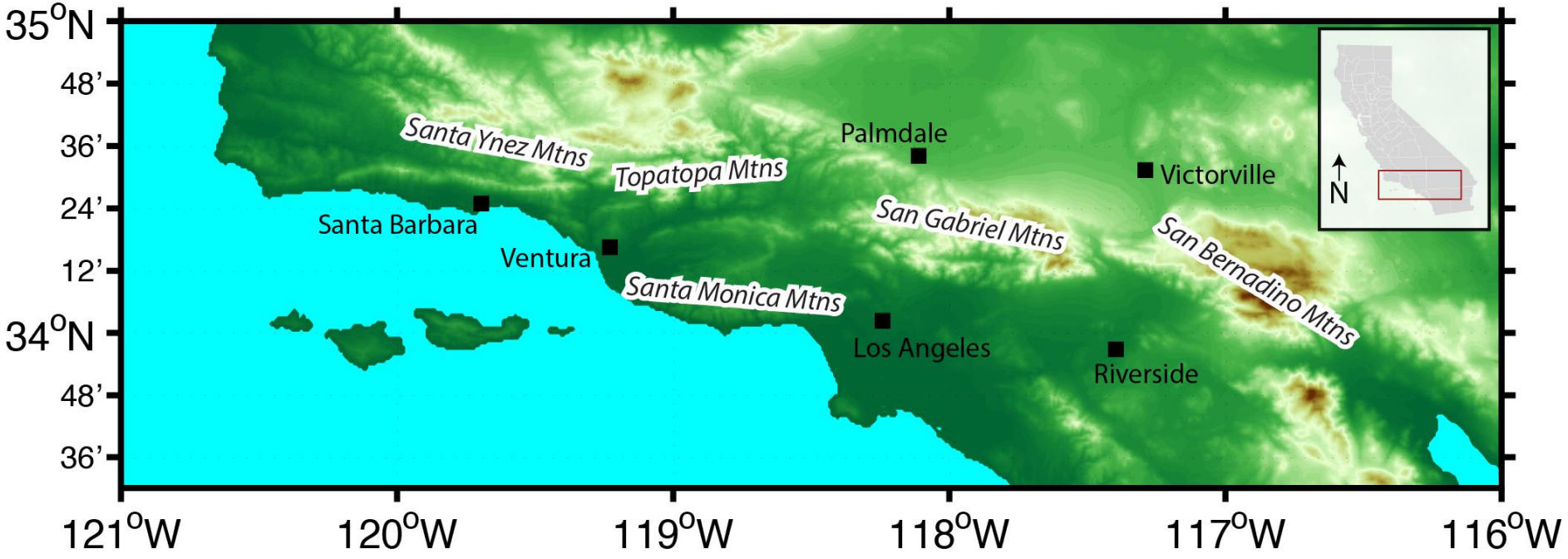
DRI
Desert Research Institute

Western Regional Climate Center

DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA

Nevada NASA Space Grant Consortium
Since 1991

Transverse Range Study Area



Fire and Flood

Debris flows from the Old/Grand Prix Fires killed 16 people 25 Dec 2003


Solimar Fire creates landslide possibility

The Solimar Fire charred large swathes on either side of Highway 101 north of Ventura on Christmas night. More than 1,300 acres were consumed by the blaze.

HELENA DAY BREESE / NEWS-PRESS

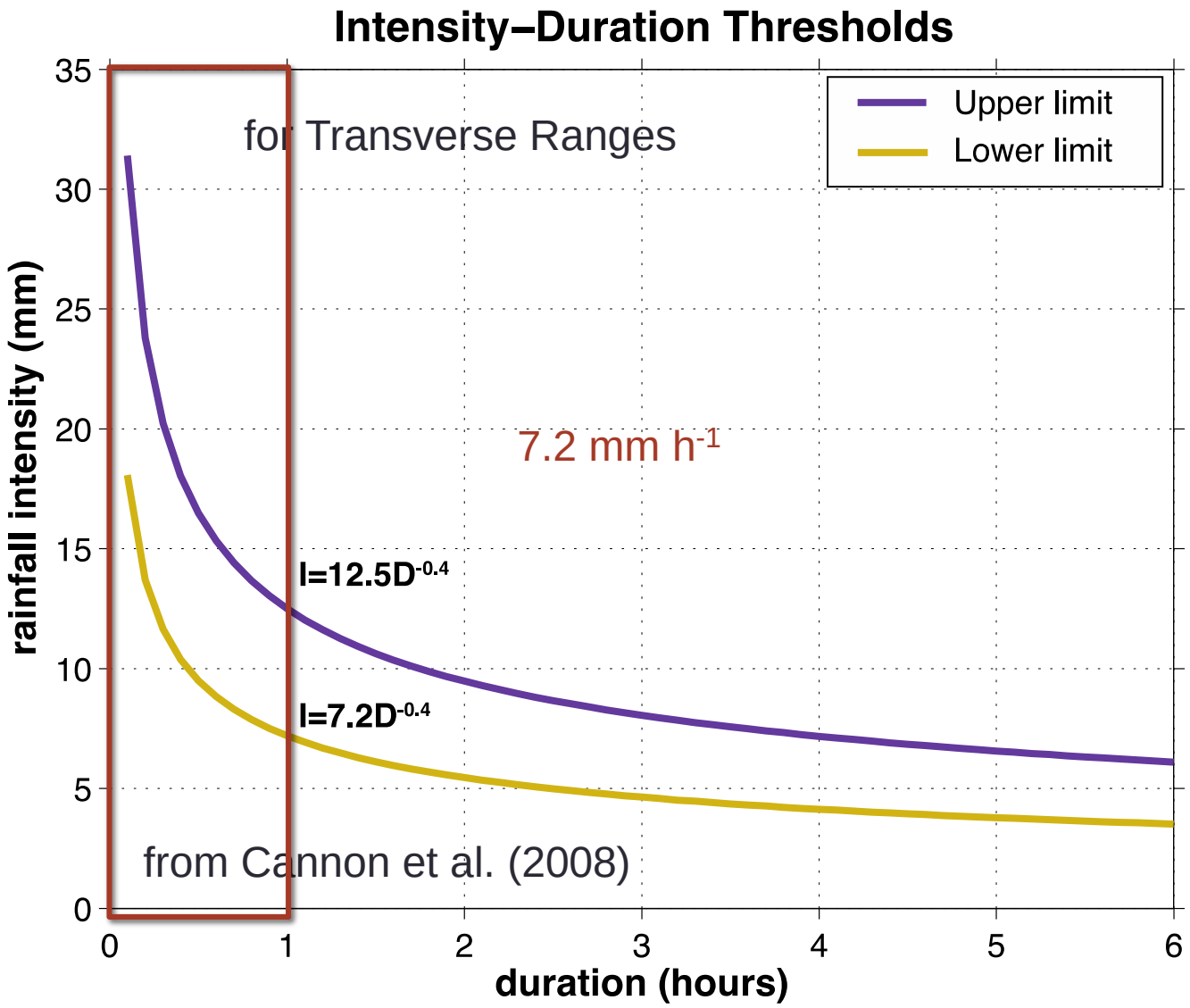
Caltrans working to secure slopes with looming El Niño

By EMILY LESLIE

ren slopes looms over the roadways in the went up in flames, leaving only loose soil

Santa Barbara News Press front page, 29 Dec 2015

Previous work- post-fire debris flows



Purpose of study

- Identify common atmospheric features among post-fire debris flow events
- Communicate findings to non-meteorological audience (geomorphology, natural hazard communities)
- Help NWS forecasters put potential post-fire debris flow events in context of historic events

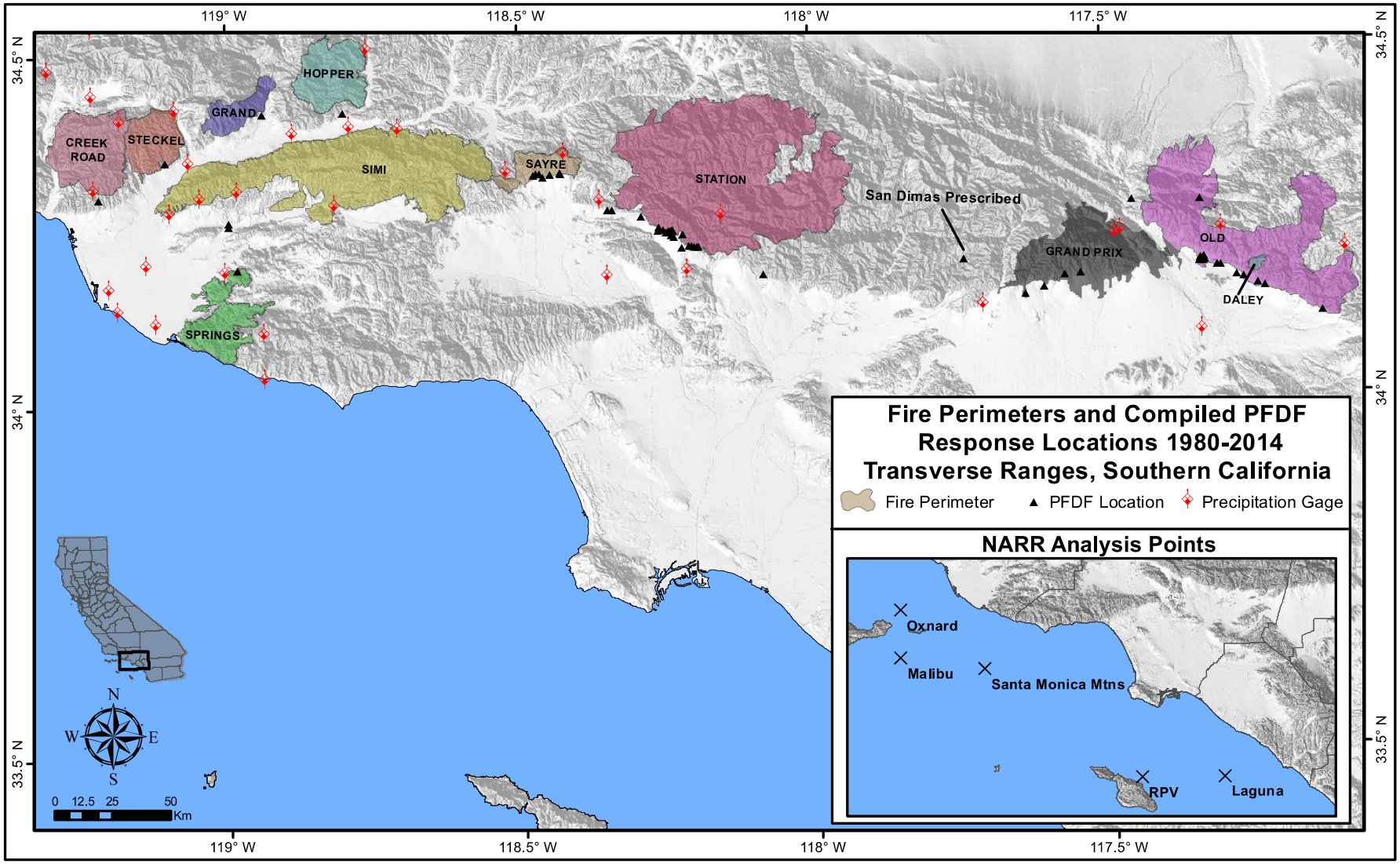
Event Database

19 storm dates, 21 debris flow events 1980-2014

Date	Location- burn area
1980-01-09	Daley (western SB)
1980-01-13	Daley (western SB)
1980-01-28	Daley (western SB)
1980-02-16	Daley (western SB) Creek Road (Topa)
1984-12-20	San Dimas (SG)
1995-01-10	Steckel (Topa)
1998-02-02	Grand (Topa)
1998-02-06	Hopper/Grand (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)
2010-02-27	Station (western SG)
2014-10-31	Springs (western SM)
2014-12-12	Springs (western SM)

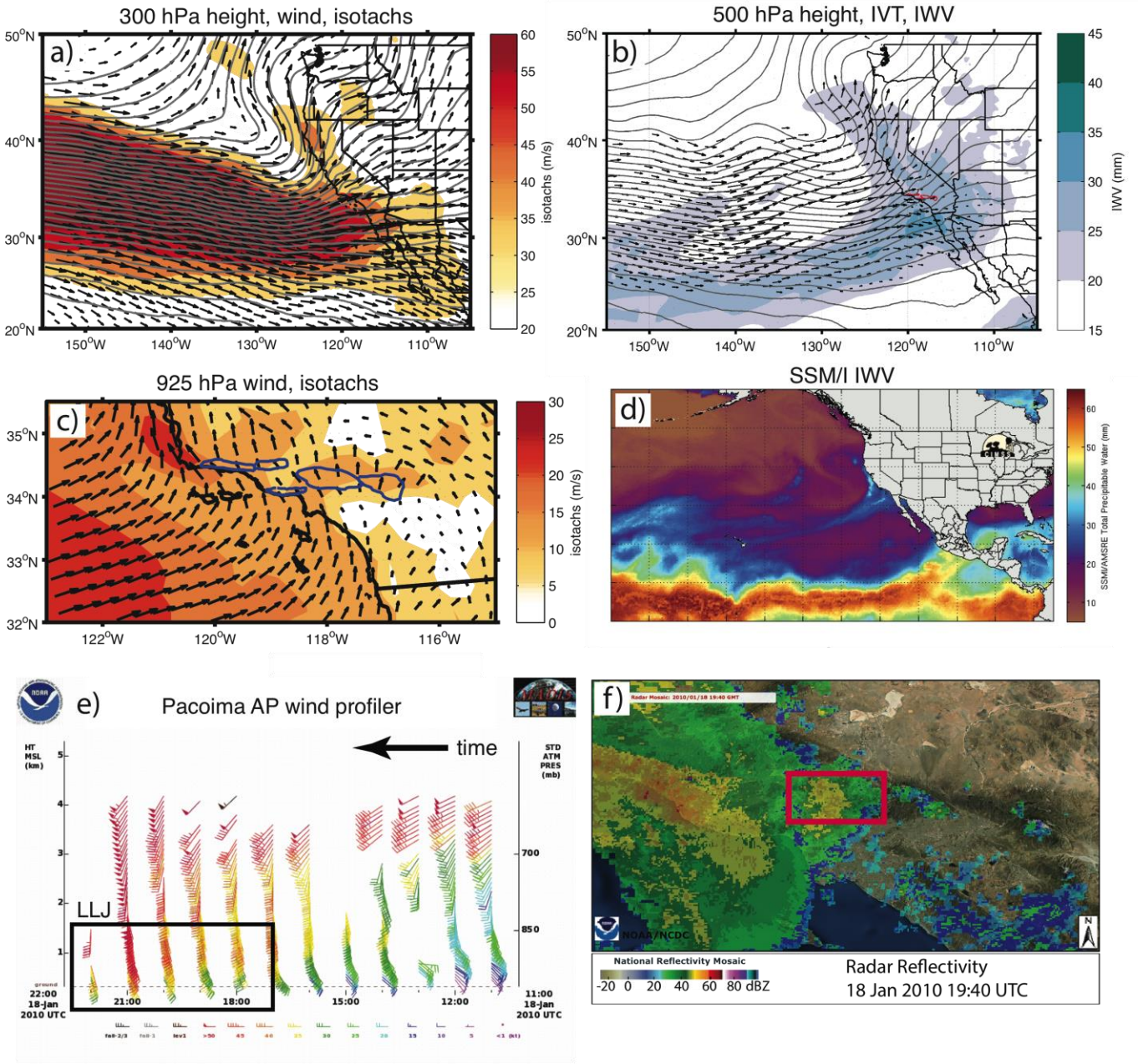
Fire perimeters



Case studies

Generated for each event from variety of data sources:

- NARR (32 km)
- SSM/I
- Radar
- ESRL profilers
- Precipitation gauges



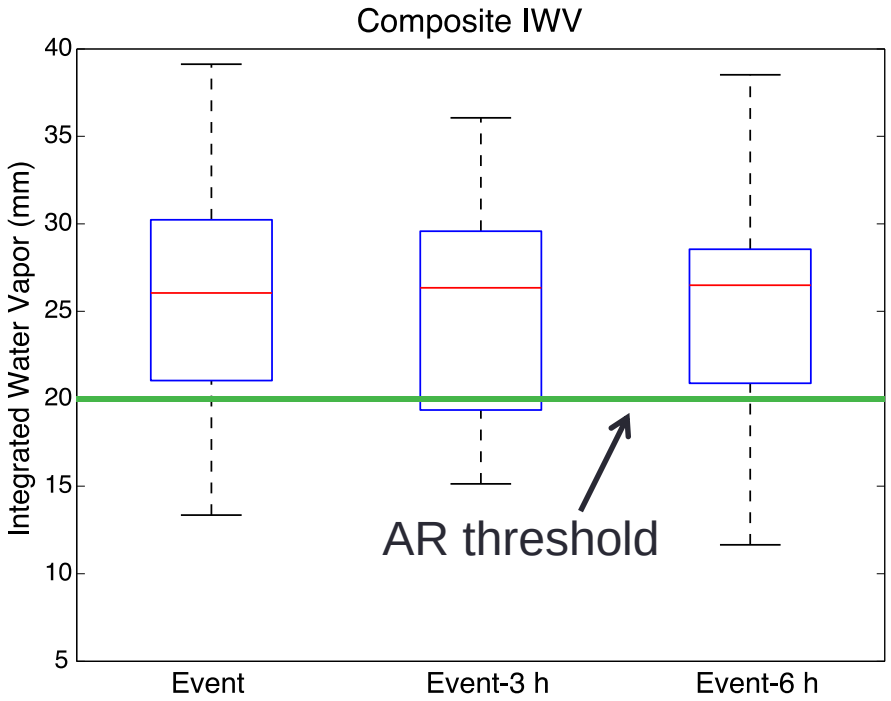
Subset of plots for individual case study: 18 Jan 2010

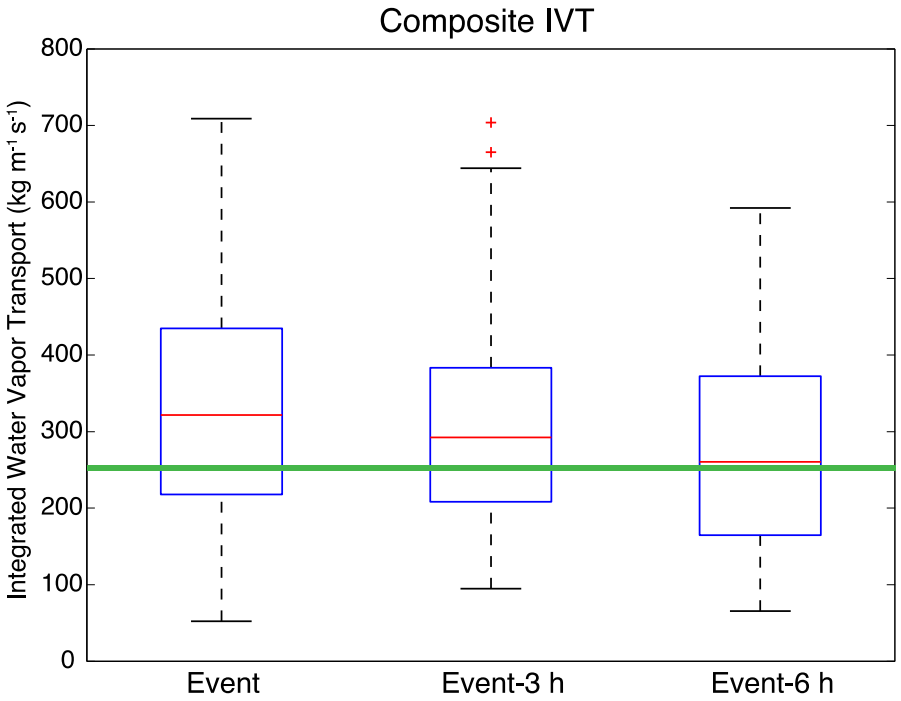
Was it an AR event?

- Compared to AR catalog (Rutz et al. 2014)
- Compared to closed low (CL) catalog (Oakley and Redmond 2014)
- At grid point closest to study area
- If event occurred within +/- 12 h of AR/CL, associated

Classification of Events (total 19 events)			
AR only	CL only	AR/CL	Other
10	1	4	4
Total events with AR		Total events with CL	
14 (of 19)		5 (of 19)	

Composites- IWV and IVT

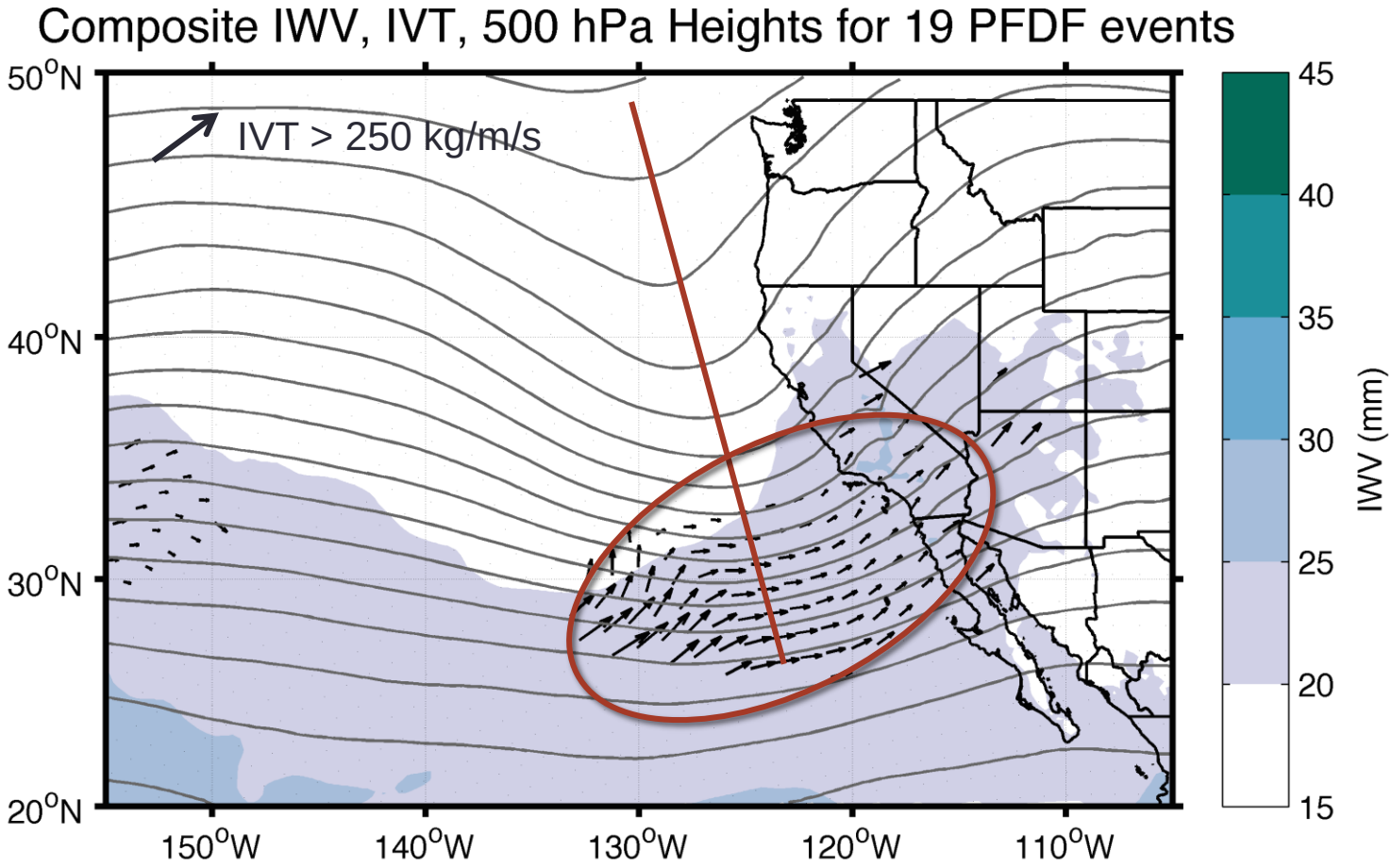




Compositing of values at 12 NARR grid points pertinent to each of the 21 debris flow events (two storm dates have debris flows in 2 locations)

Thresholds: 20 mm IWV (Ralph et al. 2004) 250 kg/m/s IVT (Rutz et al. 2014)

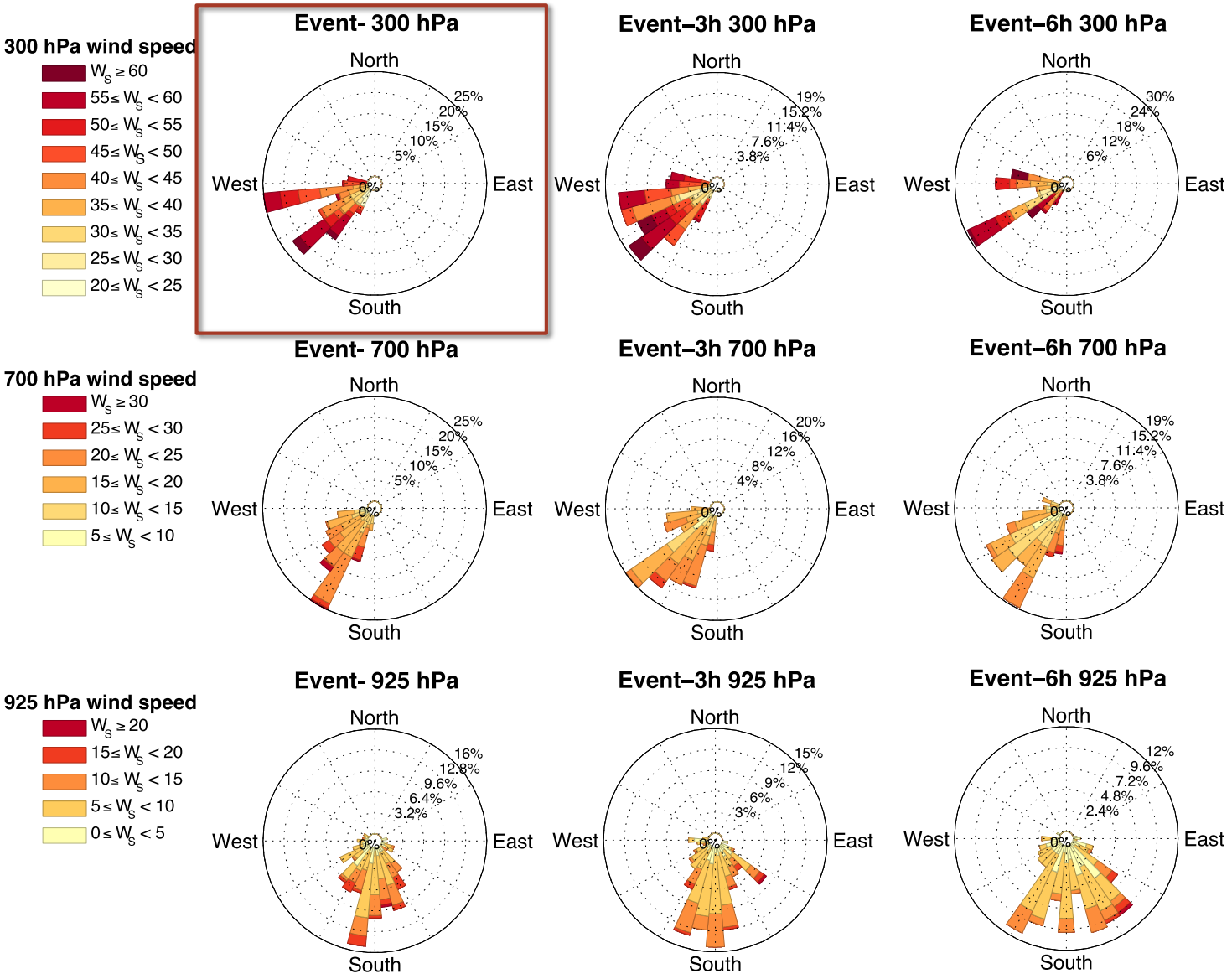
Composites- IWV and IVT



Composite of 19 storm events

Composite Winds

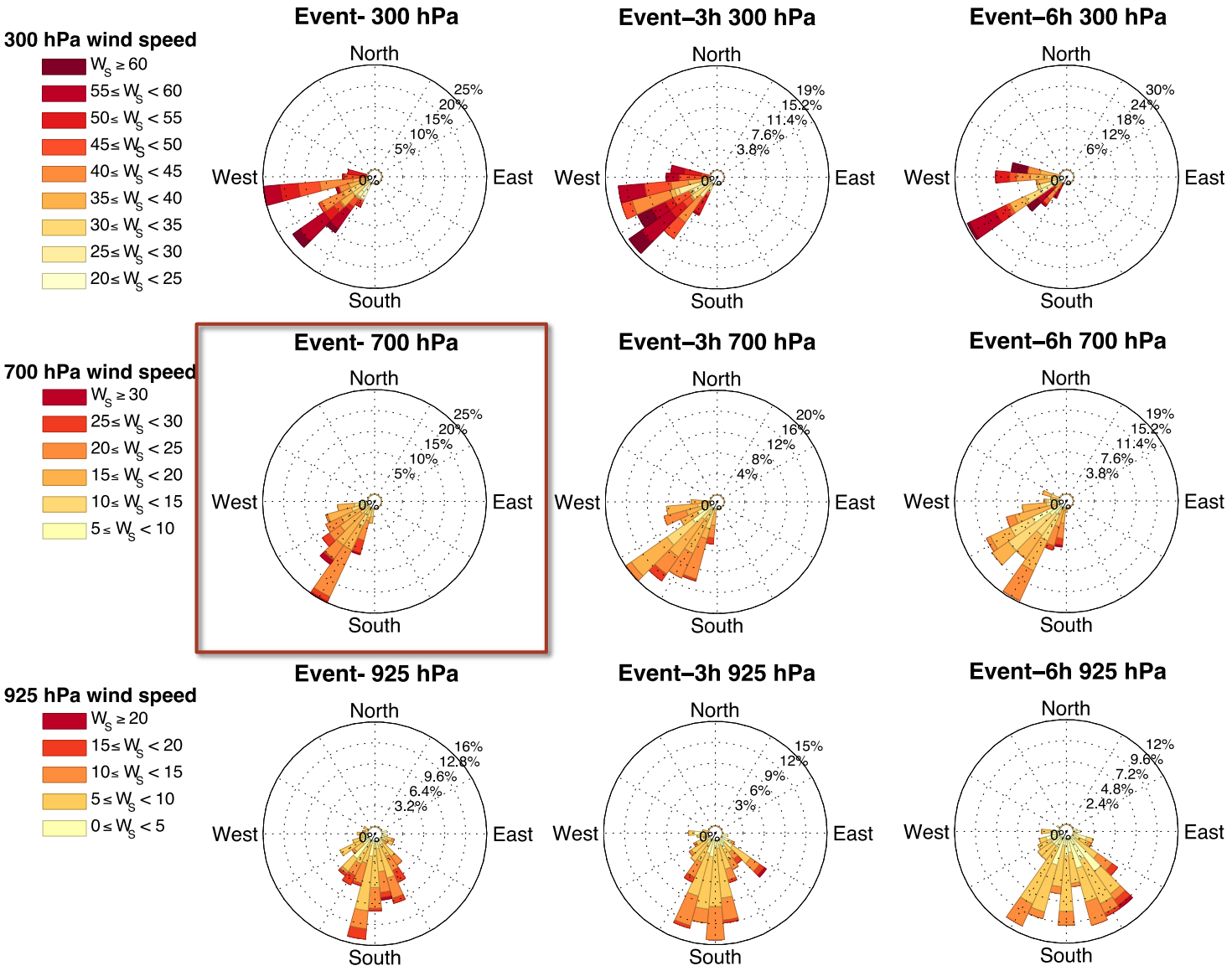
- 300 hPa winds from WSW, >= 40 m/s



Composite of values at 12 NARR grid points pertinent to each event

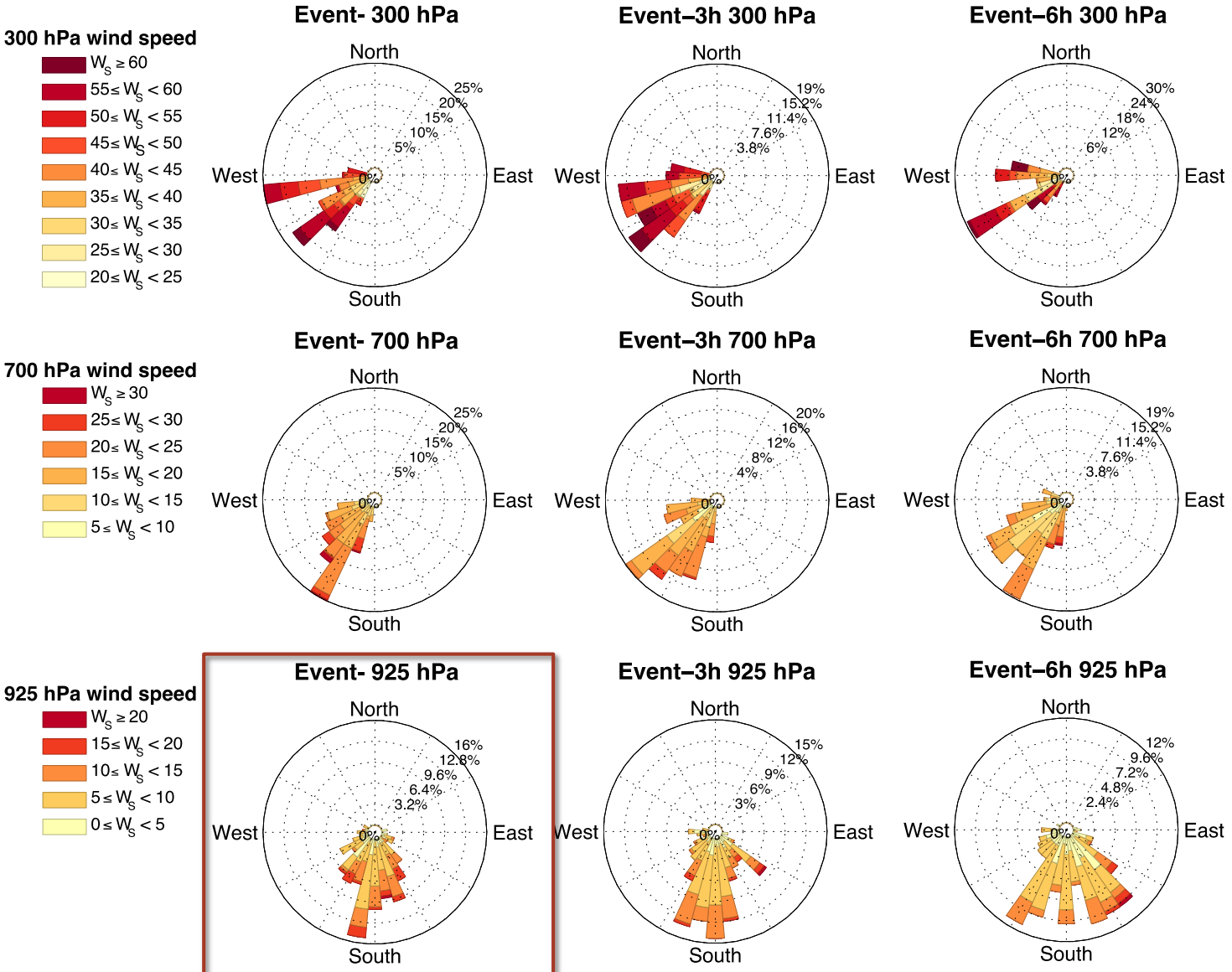
Composite Winds

- 700 hPa winds from SW, >= 20 m/s



Composite of values at 12 NARR grid points pertinent to each event

Composite Winds

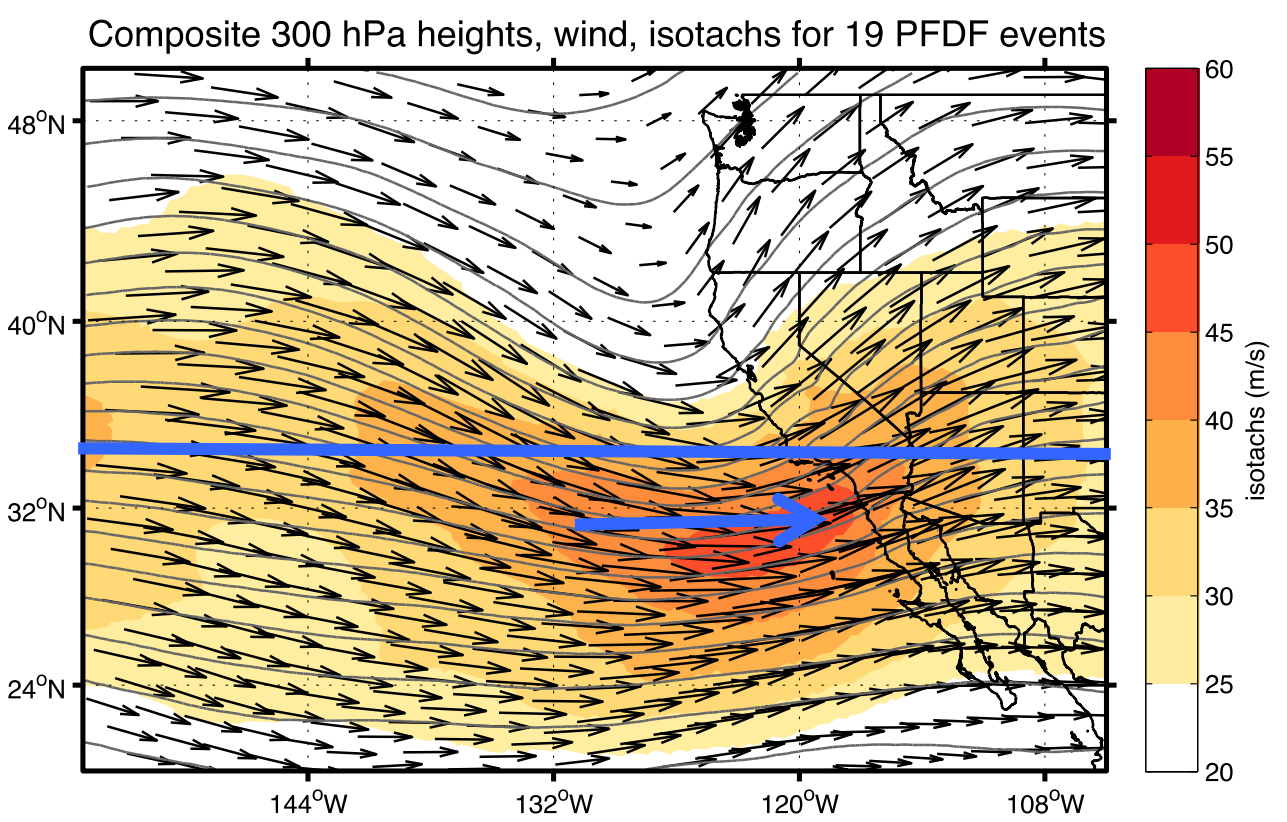


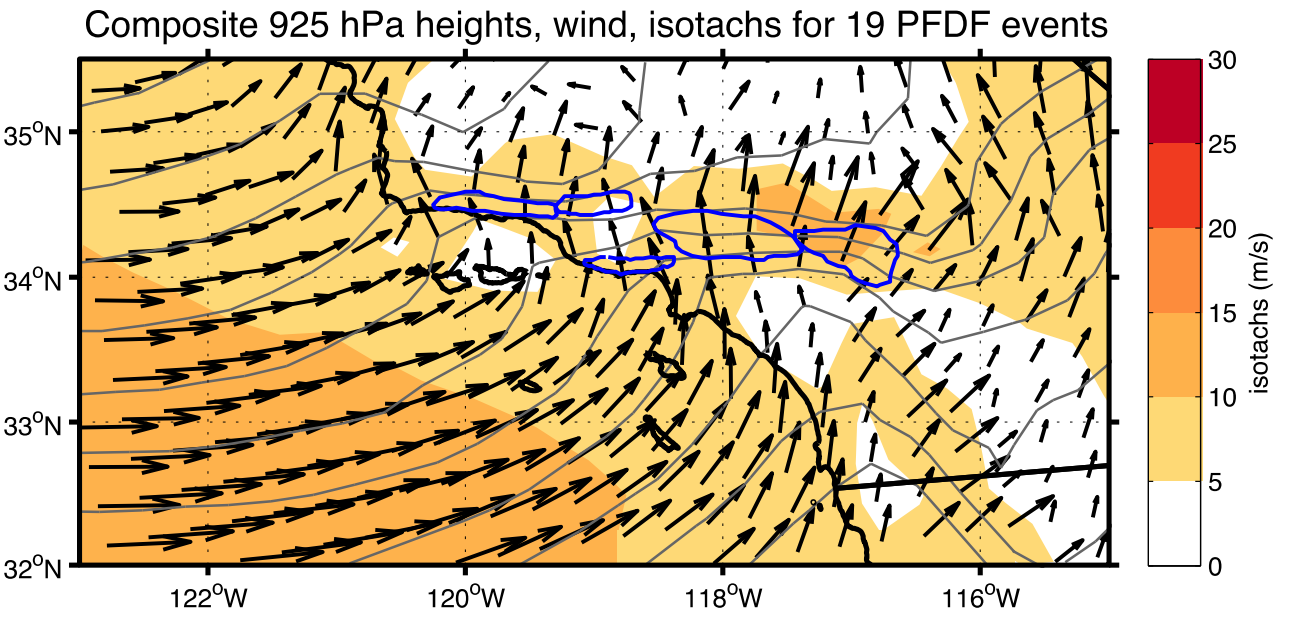
- 925 hPa winds from south, >5 m/s
- favorable for orographic enhancement on south facing slopes

Composite of values at 12 NARR grid points pertinent to each event

Composites- 300 hPa and 925 hPa wind

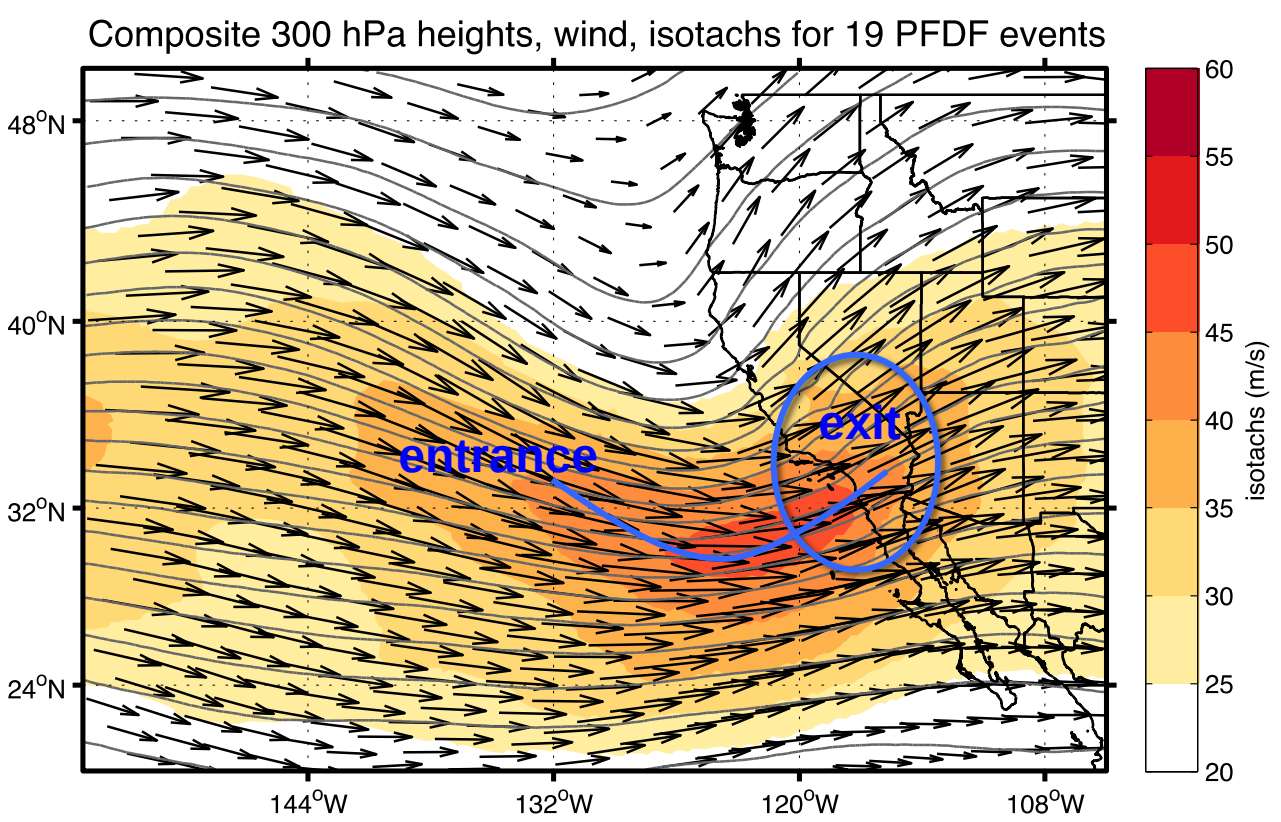
- Upper level jet to south of study area

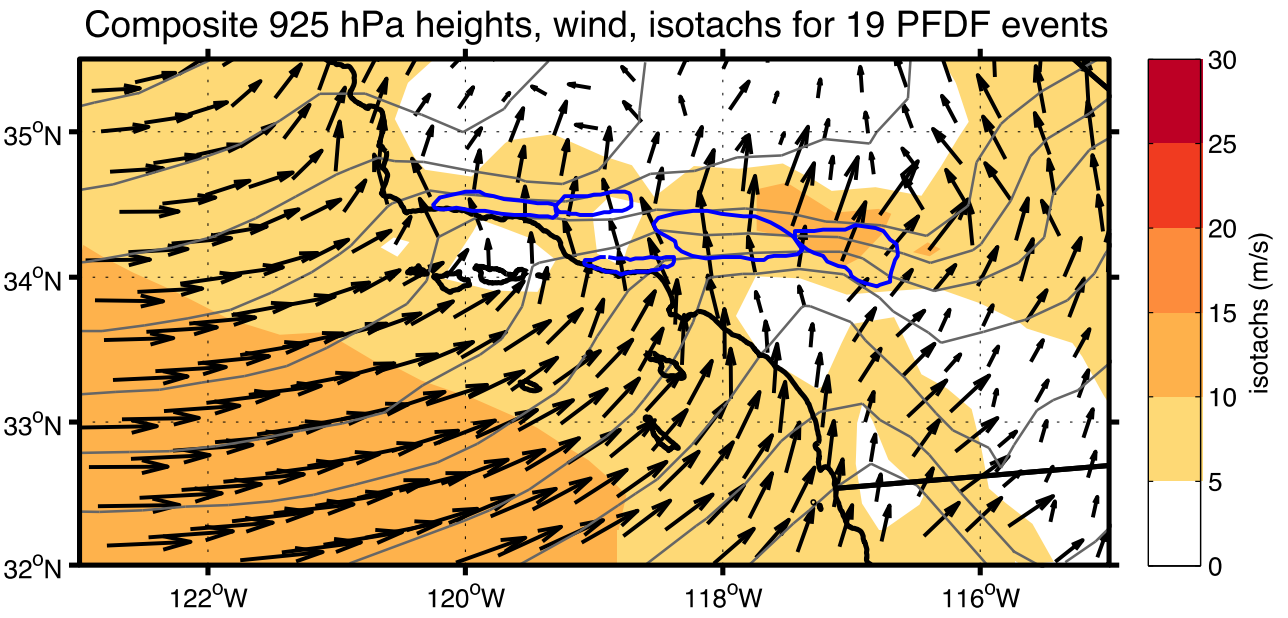




Composites- 300 hPa and 925 hPa wind

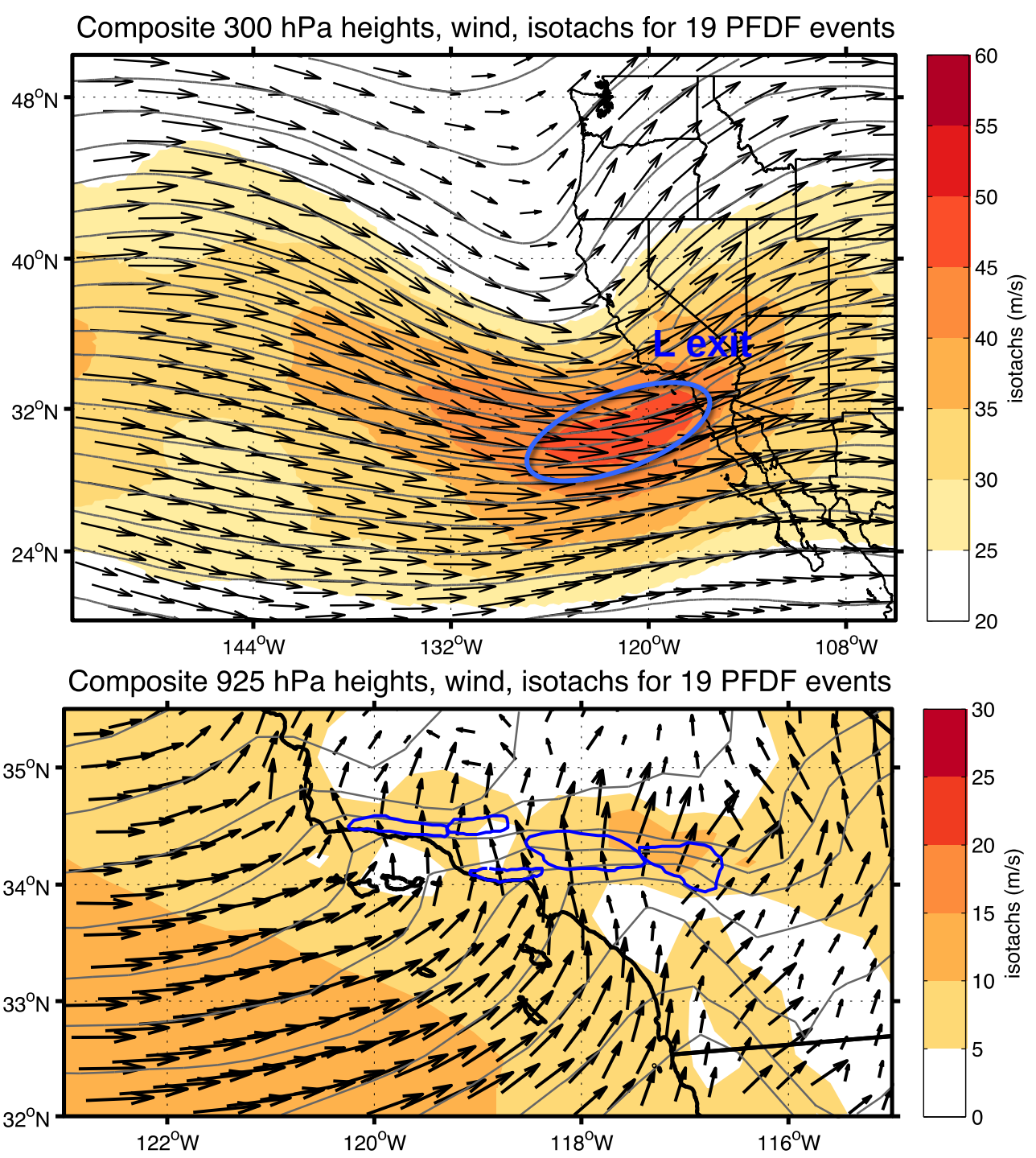
- Study area lies in curved jet exit





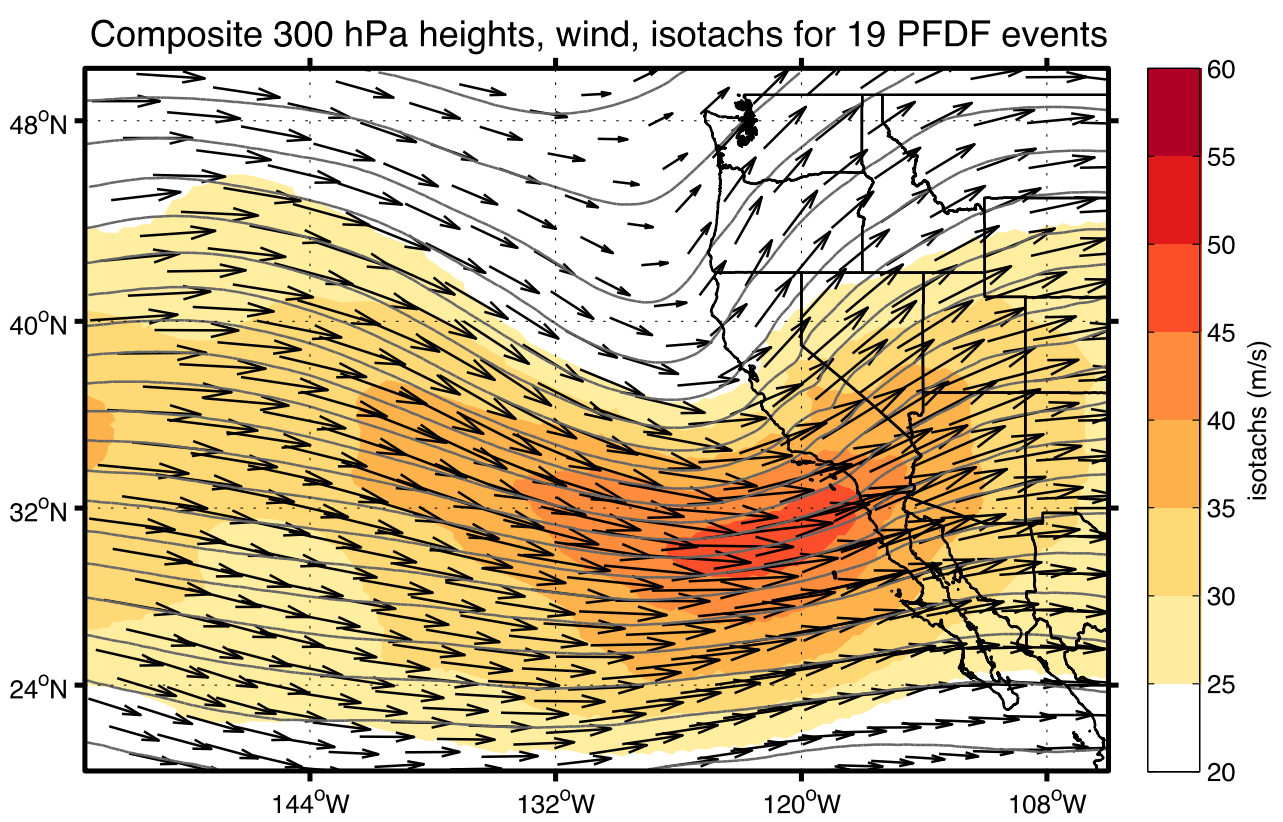
Composites- 300 hPa and 925 hPa wind

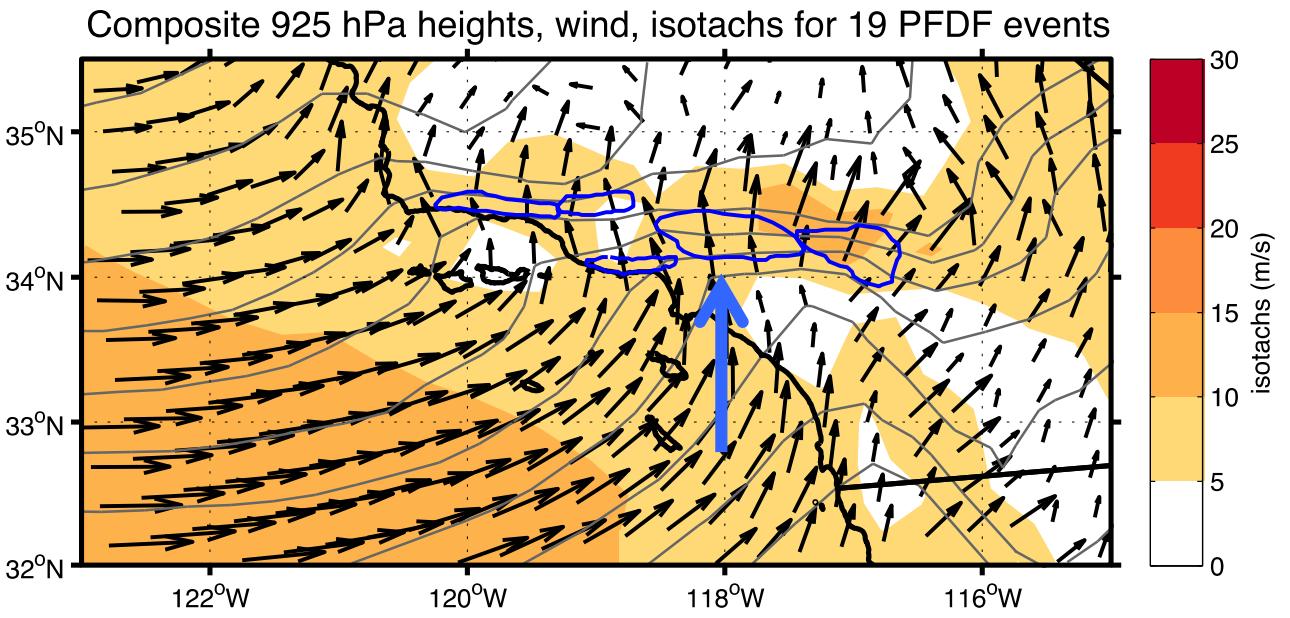
- Study area lies left jet streak exit



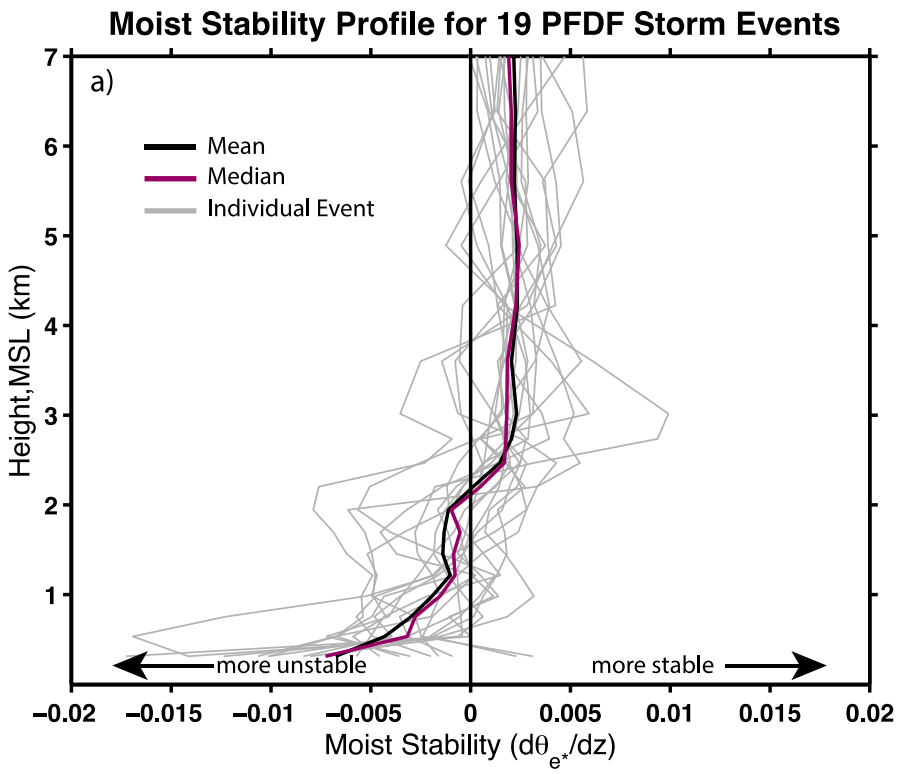
Composites- 300 hPa and 925 hPa wind

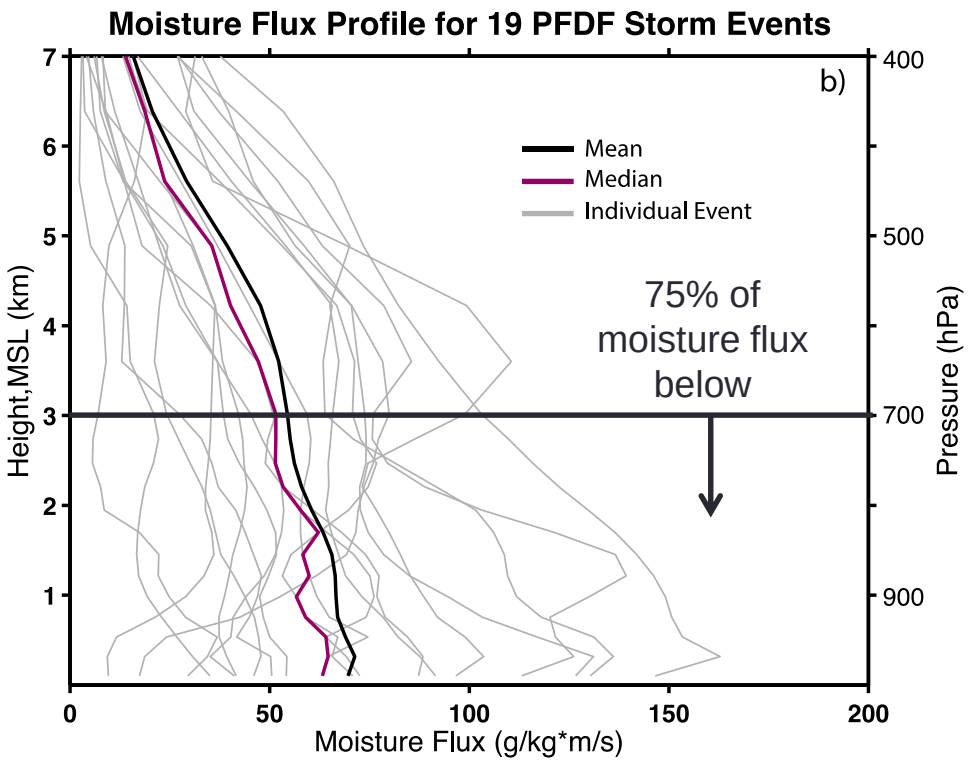
- Southerly low level winds





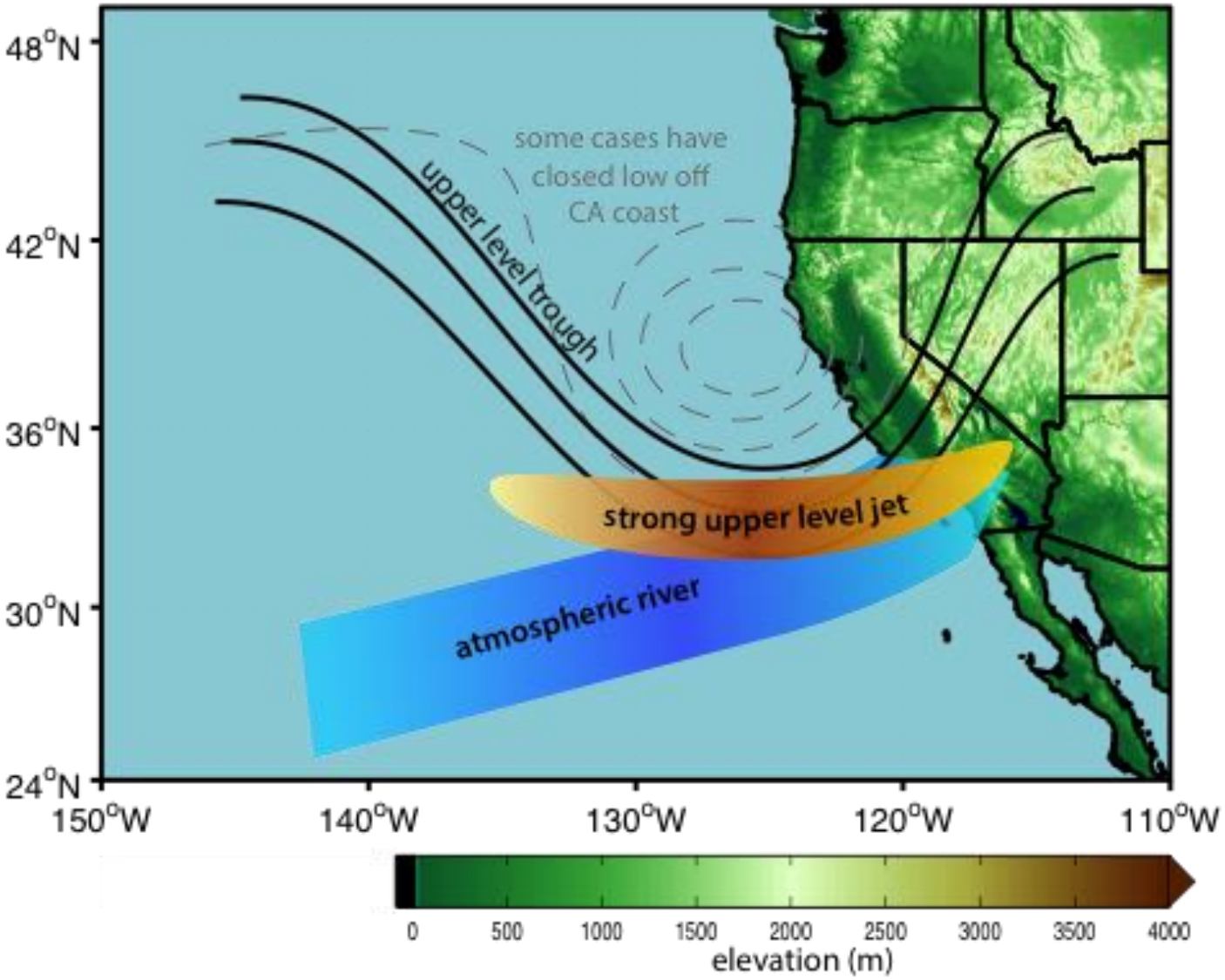
Stability and Moisture Flux



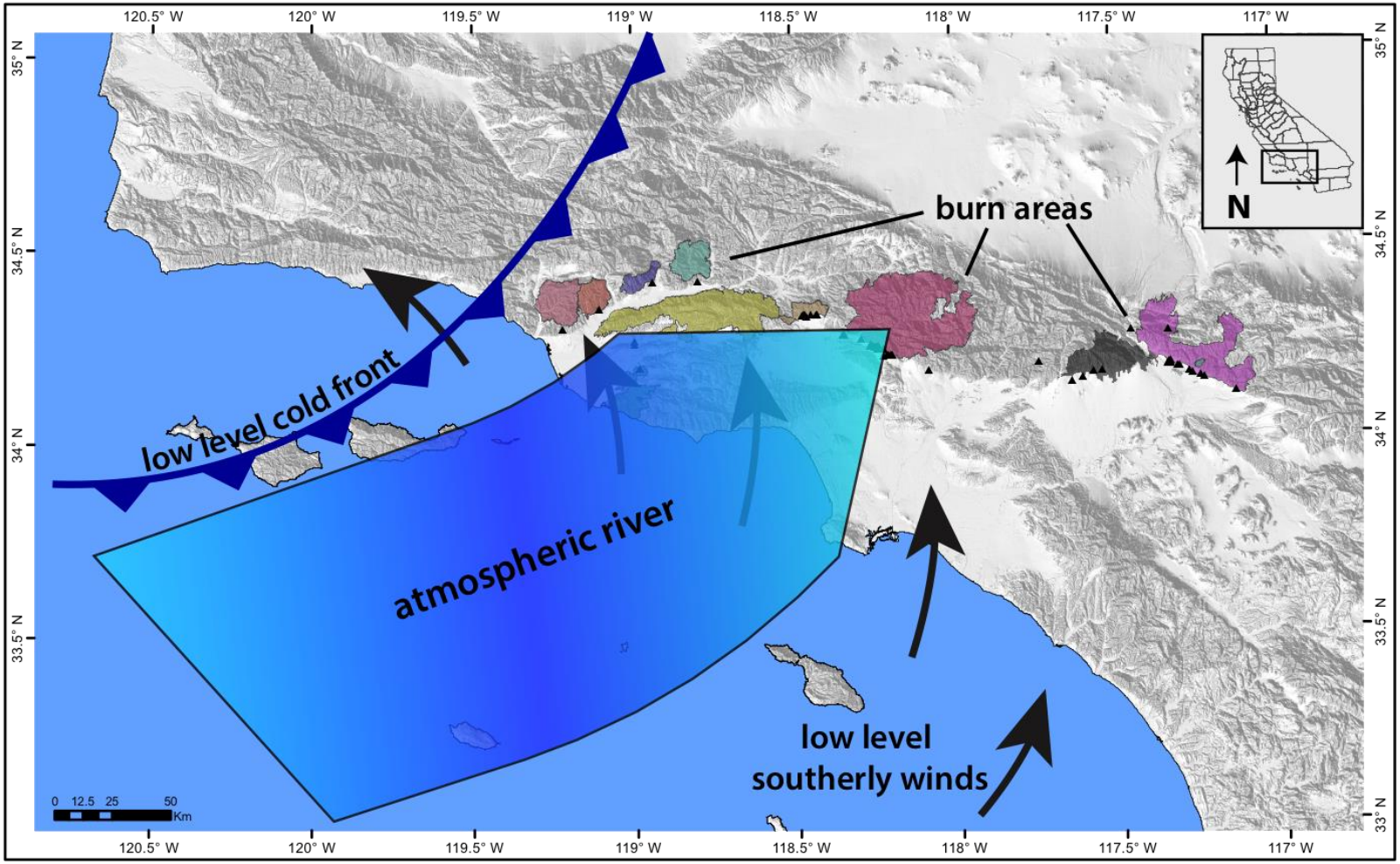


based on NARR grid point over ocean upstream of each burn area at time of event

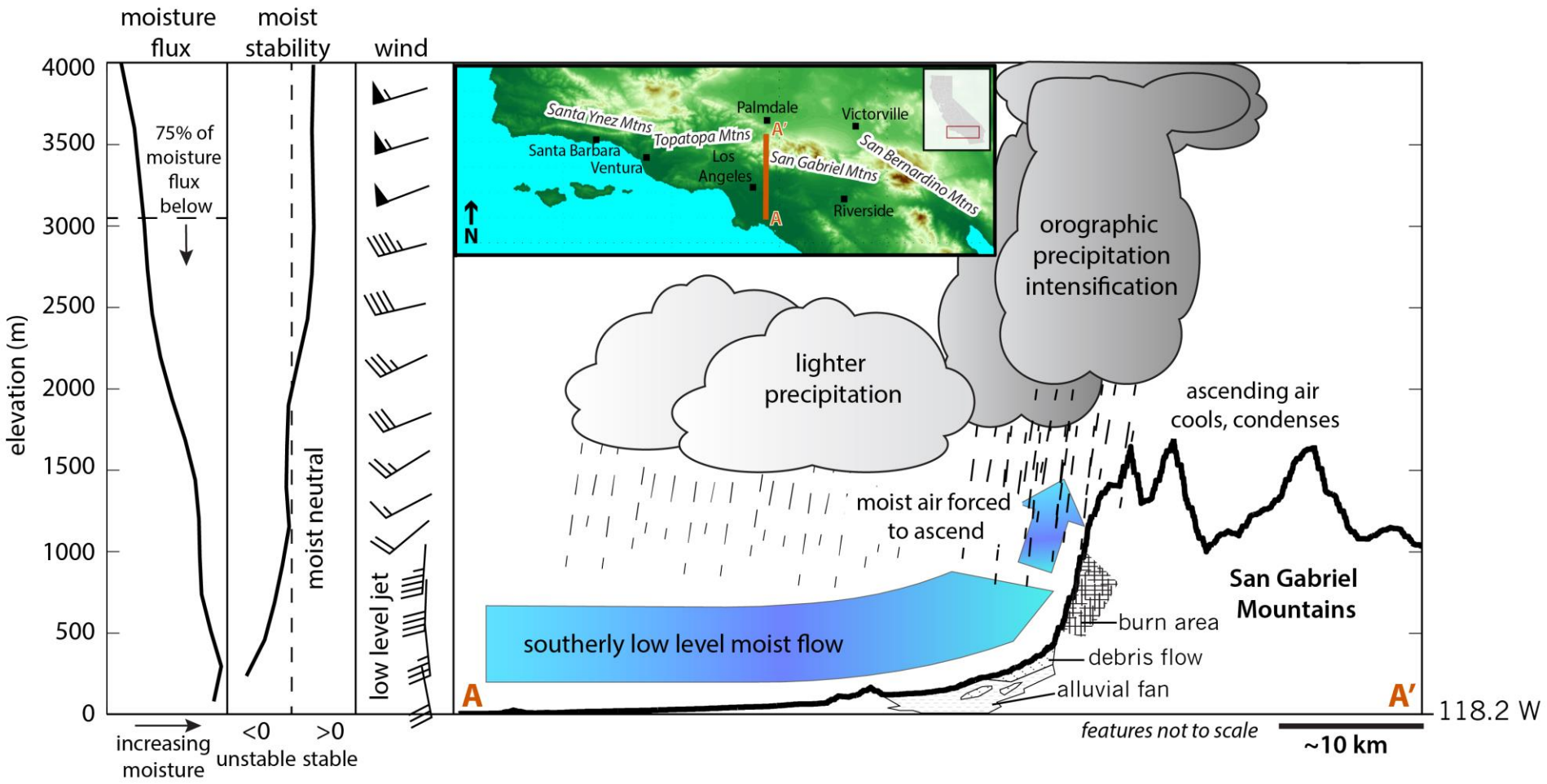
Conclusions- synoptic scale



Conclusions- mesoscale



Conclusions- transect



after Ralph et al. 2005

Next steps

- Product: manuscript to *Natural Hazards*
  - Includes table of event details with both met and geomorphology focus
- Communicate findings, AR science to geology/geomorphology community
  - Share and promote AR tools with this community
- Events without AR?
- High resolution modeling of PFDF event
  - Need more debris flow obs!
- Similar projects for shallow landslides throughout CA

Thank you!

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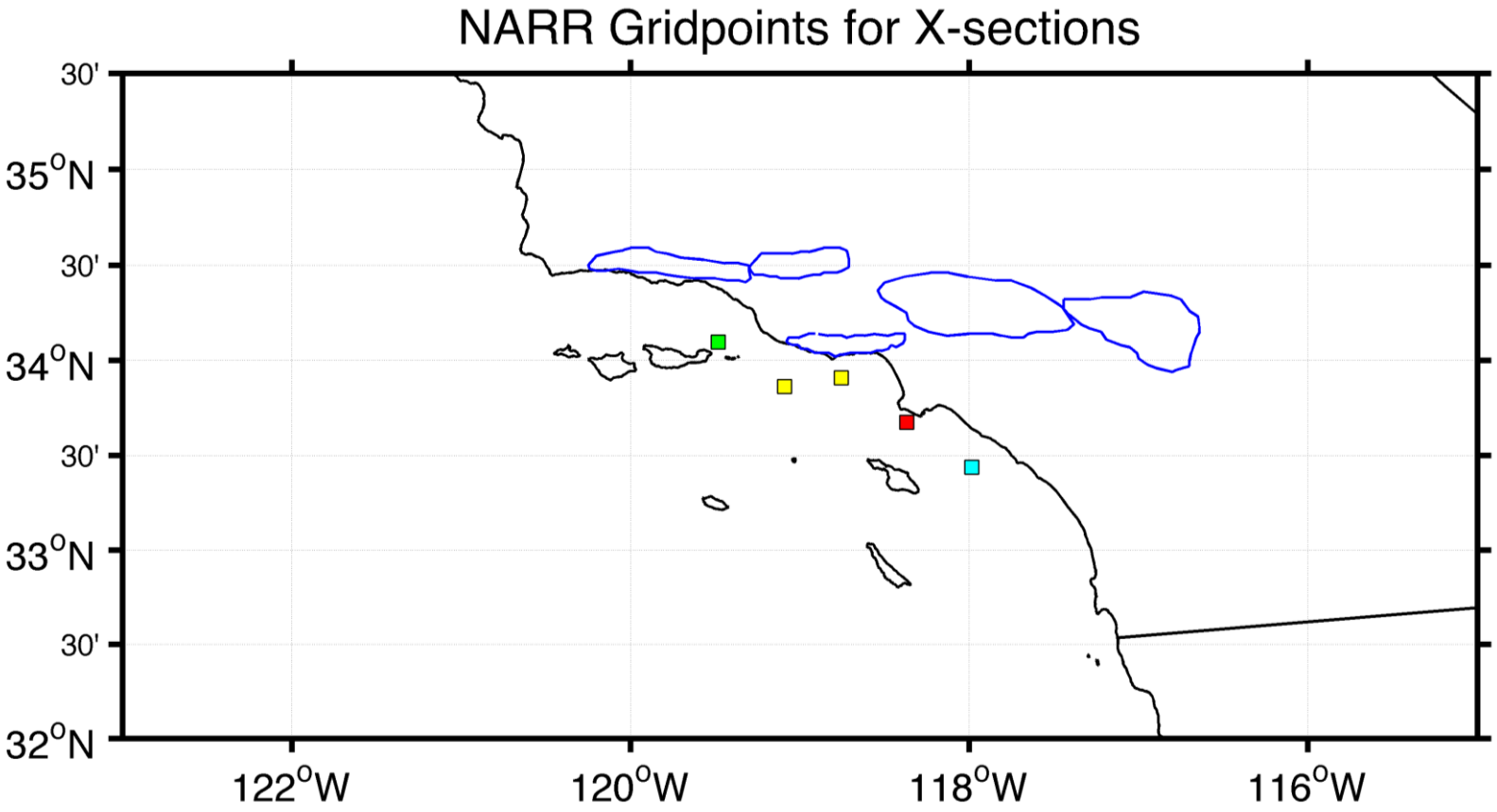
Camarillo Springs post-fire debris flow, 12 Dec 2014 Photo: Ventura County Star

Extra slides

Cross section location



Features in PFDF events			
1. Maximum precipitation intensity at stations in vicinity of burn area (n=21 events)			
x ≤ 7mm h	7mm< x ≤ 12mm	12mm < x ≤ 20 mm h	x > 20 mm h
3	2	10	6
2. Atmospheric river (AR) or closed low (CL) presence (n=19 storm events)			
AR only	CL only	AR and CL	None
10	1	4	4
Total events with AR		Total events with CL	
14		5	
3. Upper level trough orientation (n=19 storm events)			
Positive tilt	Negative tilt	Neutral	
4	7	8	
4. Jet position in relation to Transverse Range study area (n=19 storm events)			
Jet to south	Jet overhead/splitting	Jet to north	
12	6	1	
5. Stability Profile (surface to 700 hPa; n=19 storm events)			
Weakly unstable, $\frac{\partial \theta_{e*}}{\partial z} < 0$, slightly	Moist neutral, $\frac{\partial \theta_{e*}}{\partial z} \cong 0$	Unstable to moist neutral	
3	10	6	
6. Features in radar imagery (n=14, only post-1995 available)			
NCFR	Isolated cell	Other convection	
5	1	8	

Table for publication showing some of the common features extracted from the individual case studies

CAPE/LI Composites