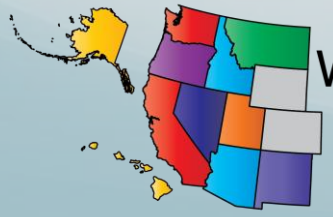
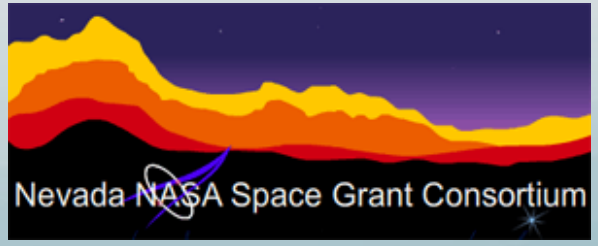
Atmospheric conditions associated with extreme precipitation and landslides in southern California

Nina Oakley
Nevada NASA Space Grant Fellow
National Council of Space Grant Directors' Fall Meeting
Oct. 1 2015 – Tucson, AZ



Western Regional Climate Center



DRI
Desert Research Institute

About me

- BA Geography and Spanish (UCSB)
- Teaching Credential (UH), Licensed secondary science teacher in HI, CA, NV
- MS Atmospheric Science (UNR)
- Climatologist for WRCC

Presenting weather station to 6th graders in Susanville CA

Paddling canoe on Lake Tahoe

Problem: Extreme precipitation* can trigger landslides

Study area

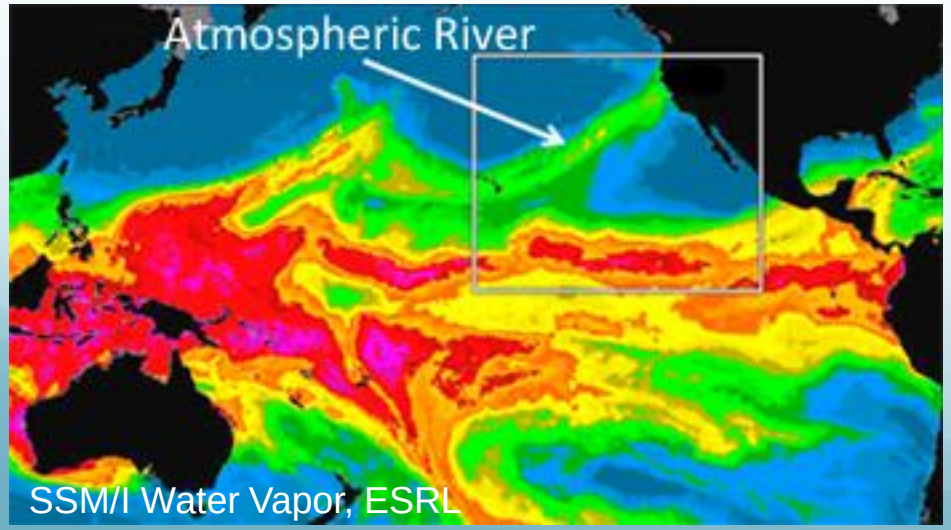
Extreme precipitation: Daily values in the 99th percentile for a station/index record

La Conchita landslide January 2005,10 killed

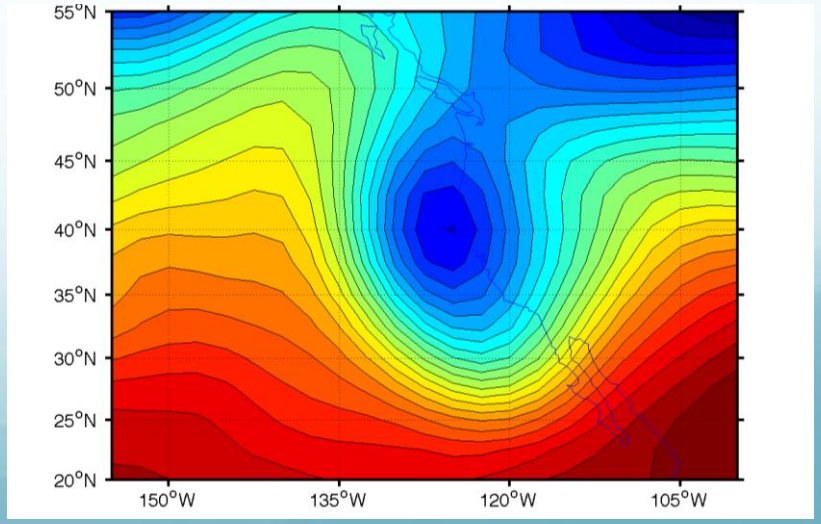
Photo: USGS

Hypotheses

- Characterizing atmospheric features that produce extreme precipitation will facilitate forecasting of landslide hazard areas
- Atmospheric Rivers and Closed Lows are associated with most events
- Different mountain ranges may be favored with different atmospheric conditions



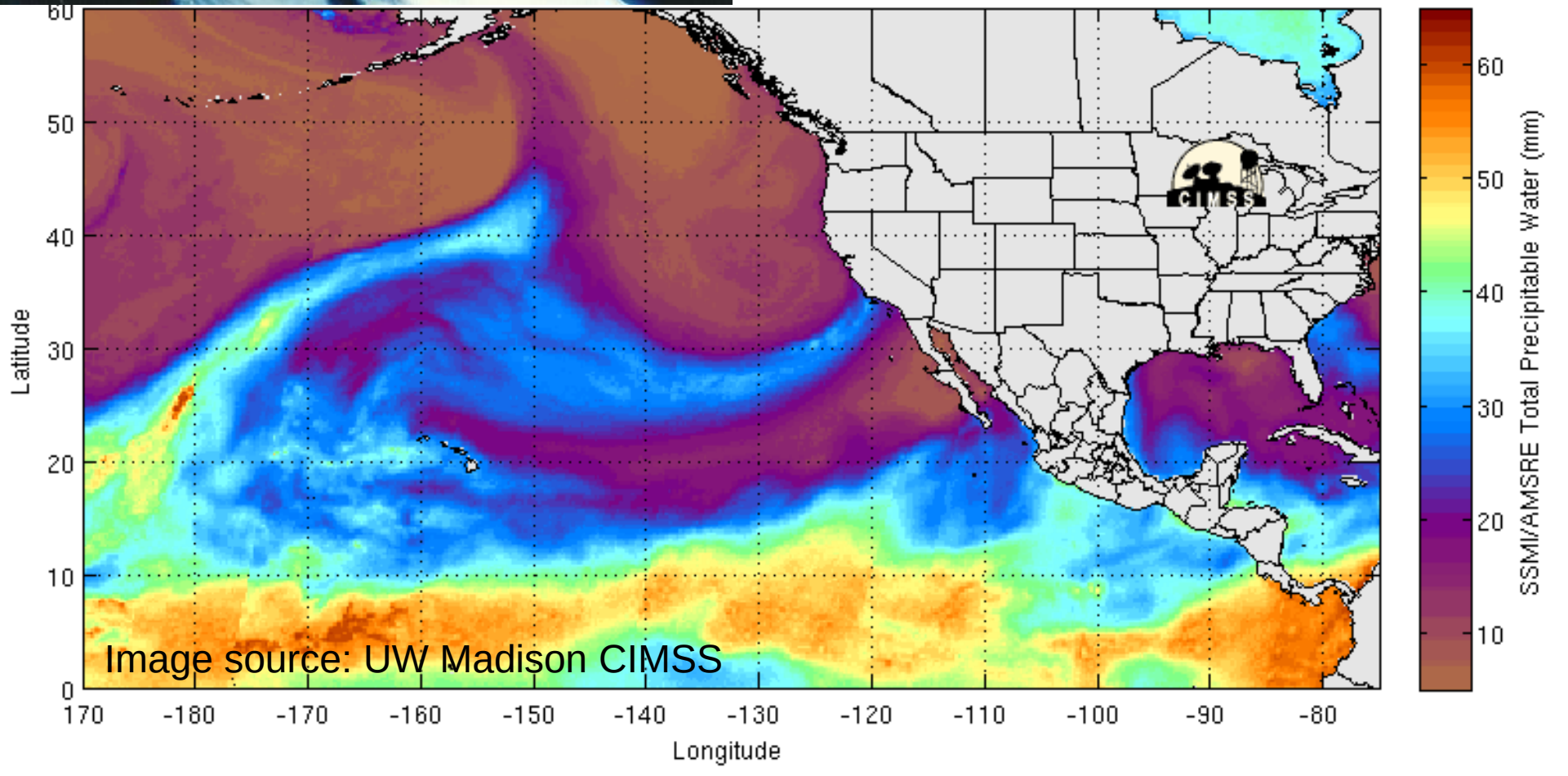
Closed low over West Coast



Special Sensor Microwave Imager (SSM/I) flies on several DoD polar orbiting satellites: F8, F10, F11, F13-17

Part of NASA MEaSUREs Program

Total Precipitable Water, 2011-03-20



Method

1. Create station networks for each range, identify extreme events, associate with atmospheric feature
2. Assess if significant difference between ranges during extreme events
3. Examine atmospheric features at the synoptic scale
4. Examine atmospheric features at the mesoscale
5. Based on similarities/ among events, methodology

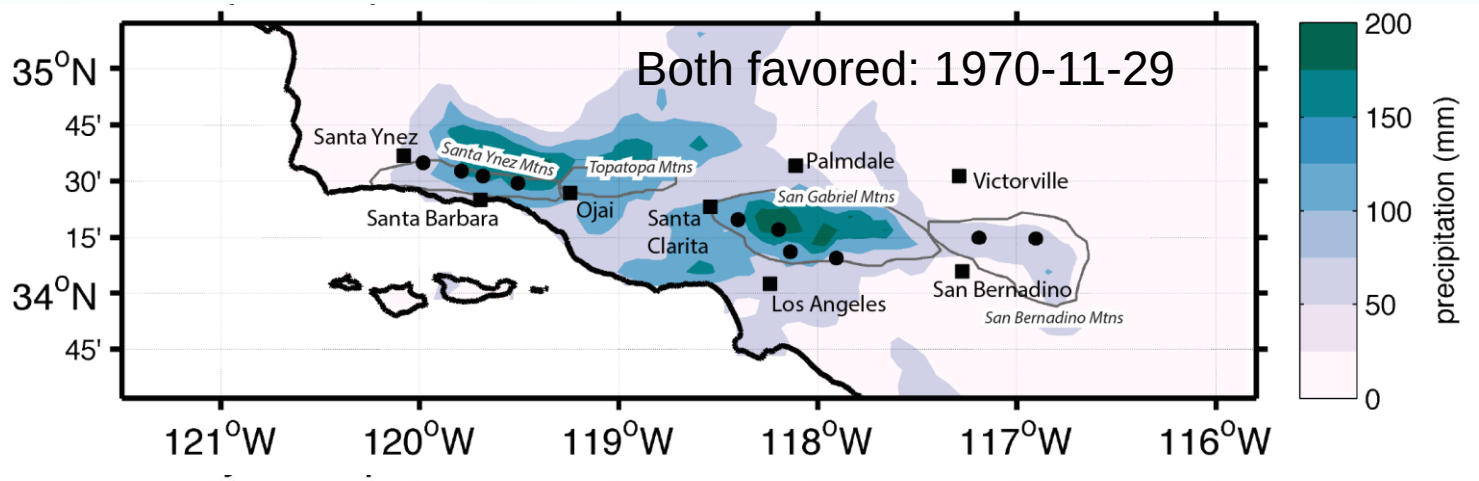
COOP station at Manzanita Lake, CA

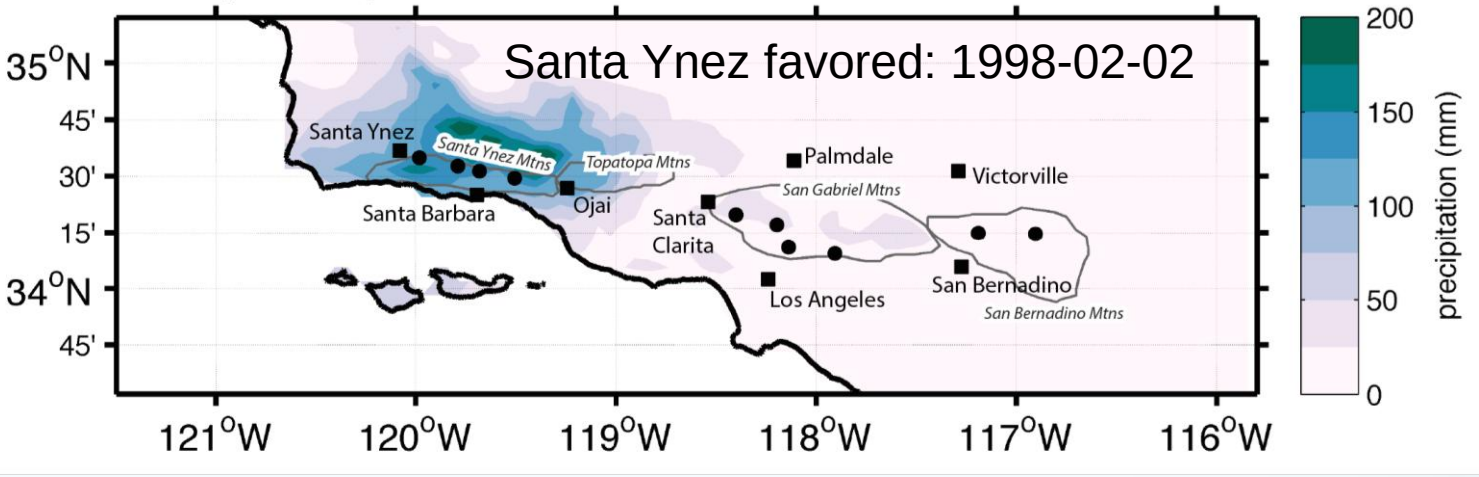
Step 1, 2: Evaluating extreme rainfall and differences between ranges

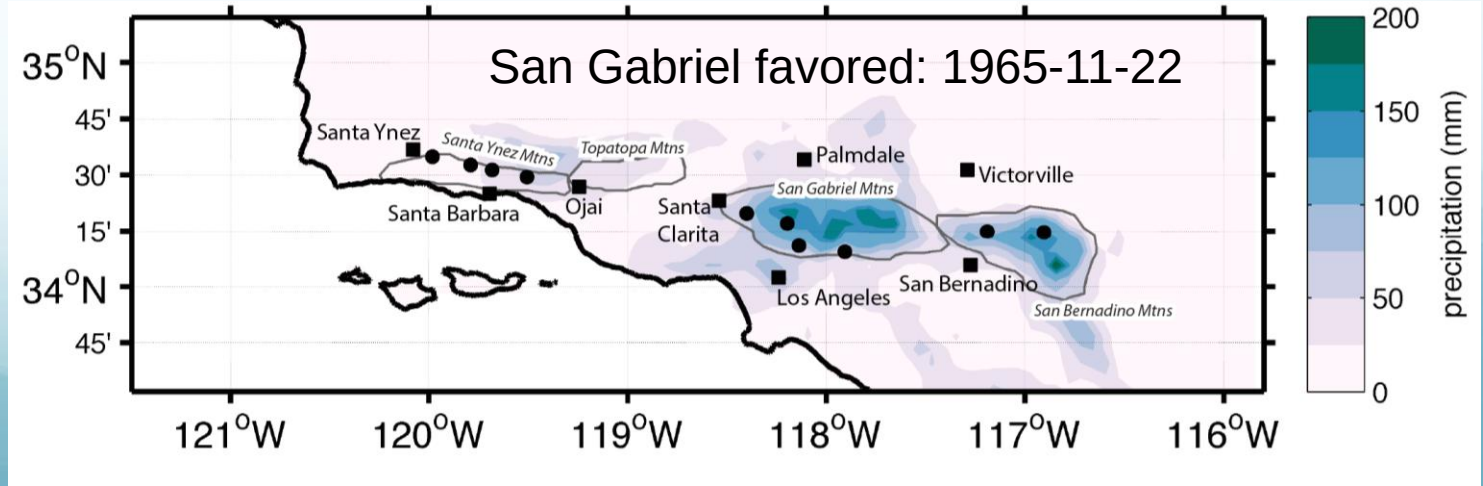
1-day events with precipitation in the 99th percentile

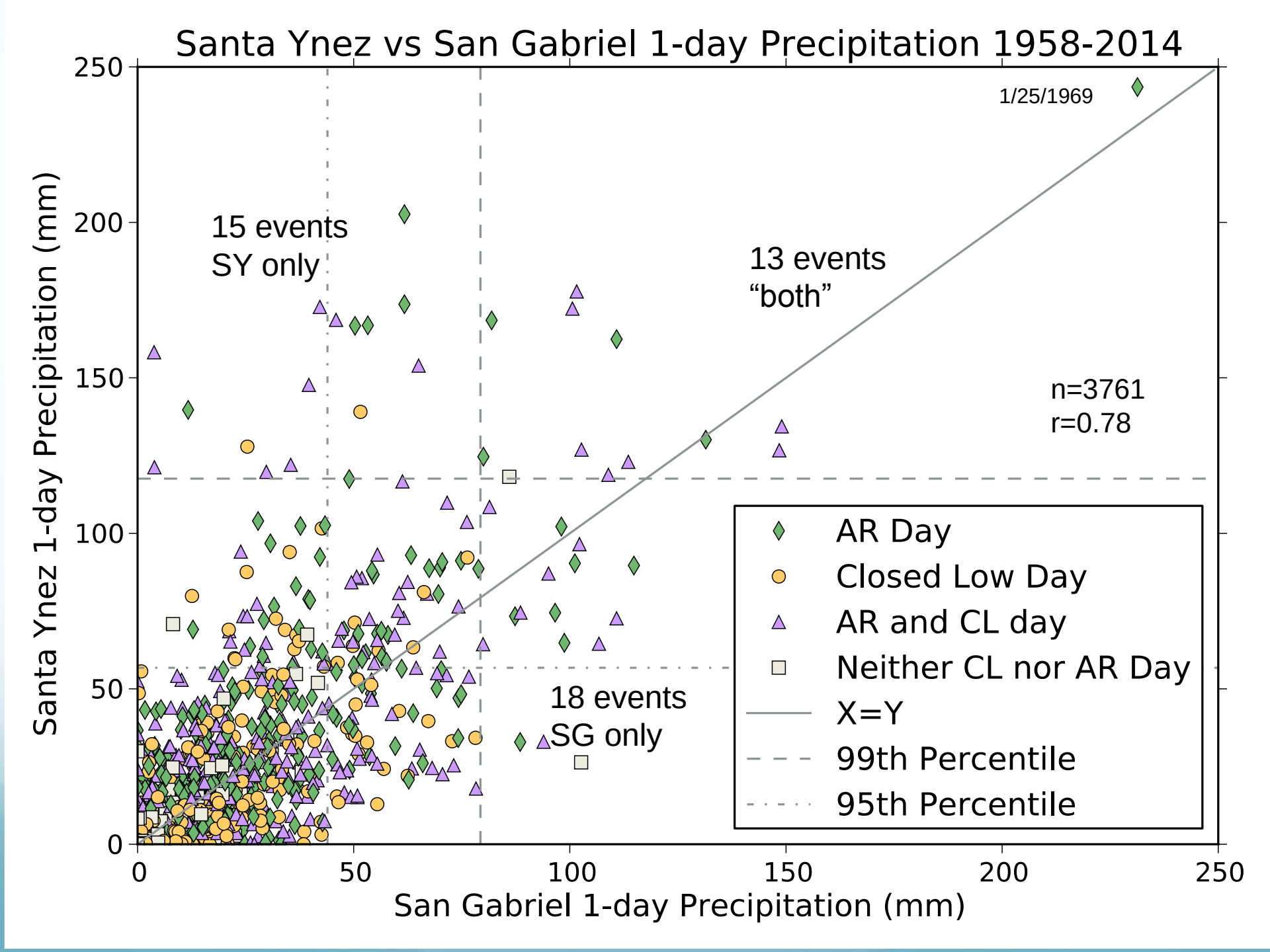
- = Station used in network

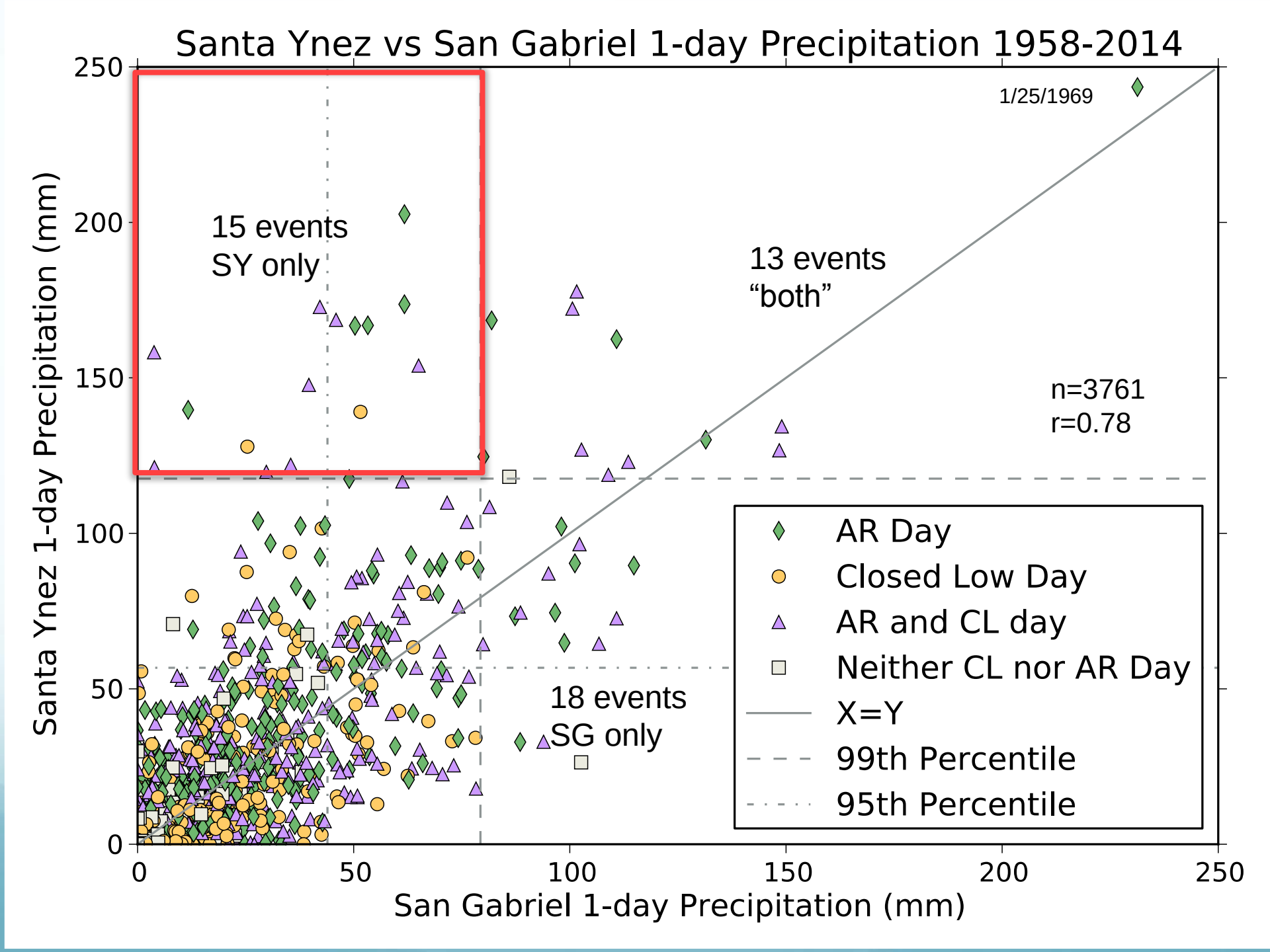
Data source: Livneh et al 2013

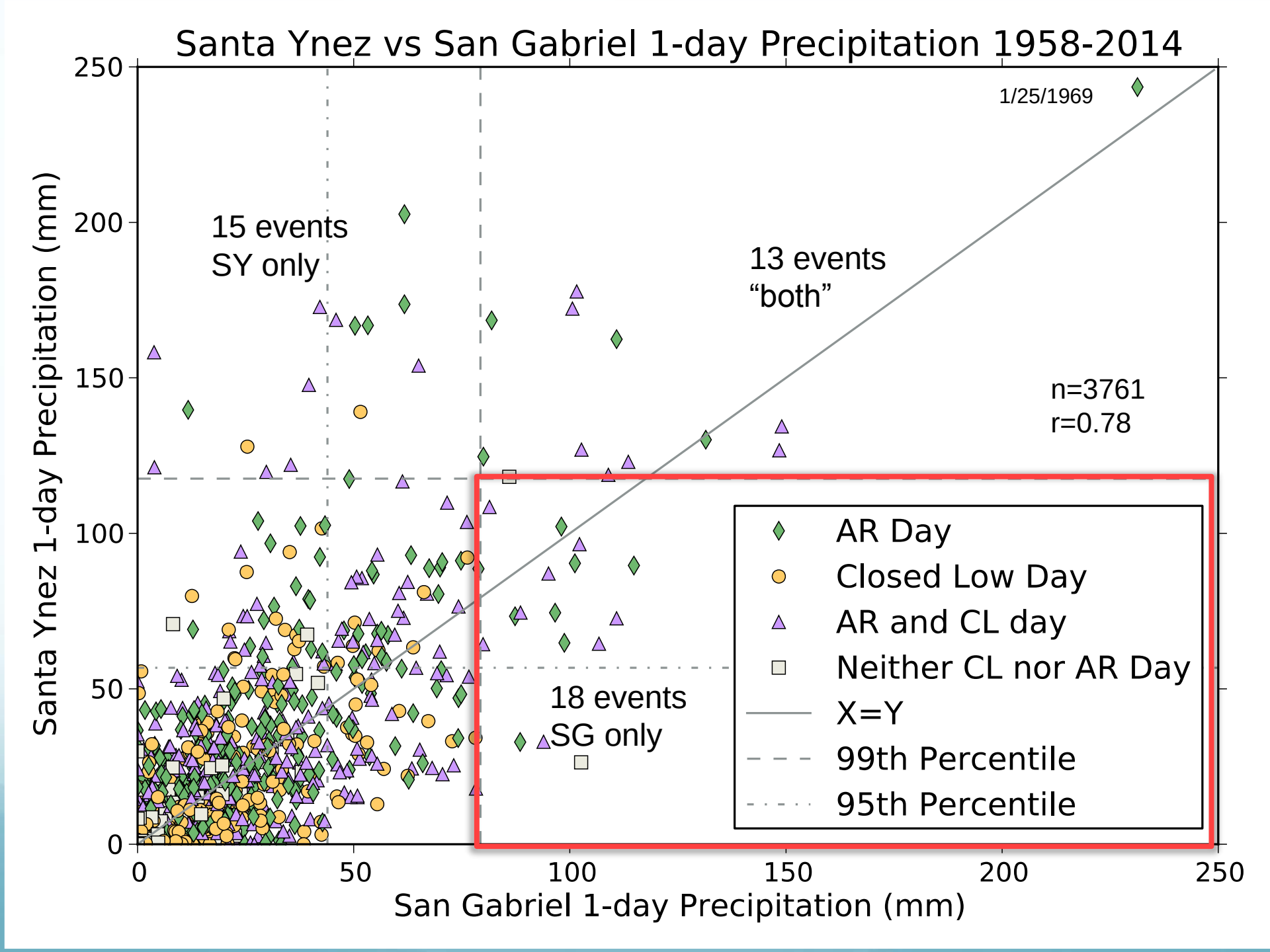


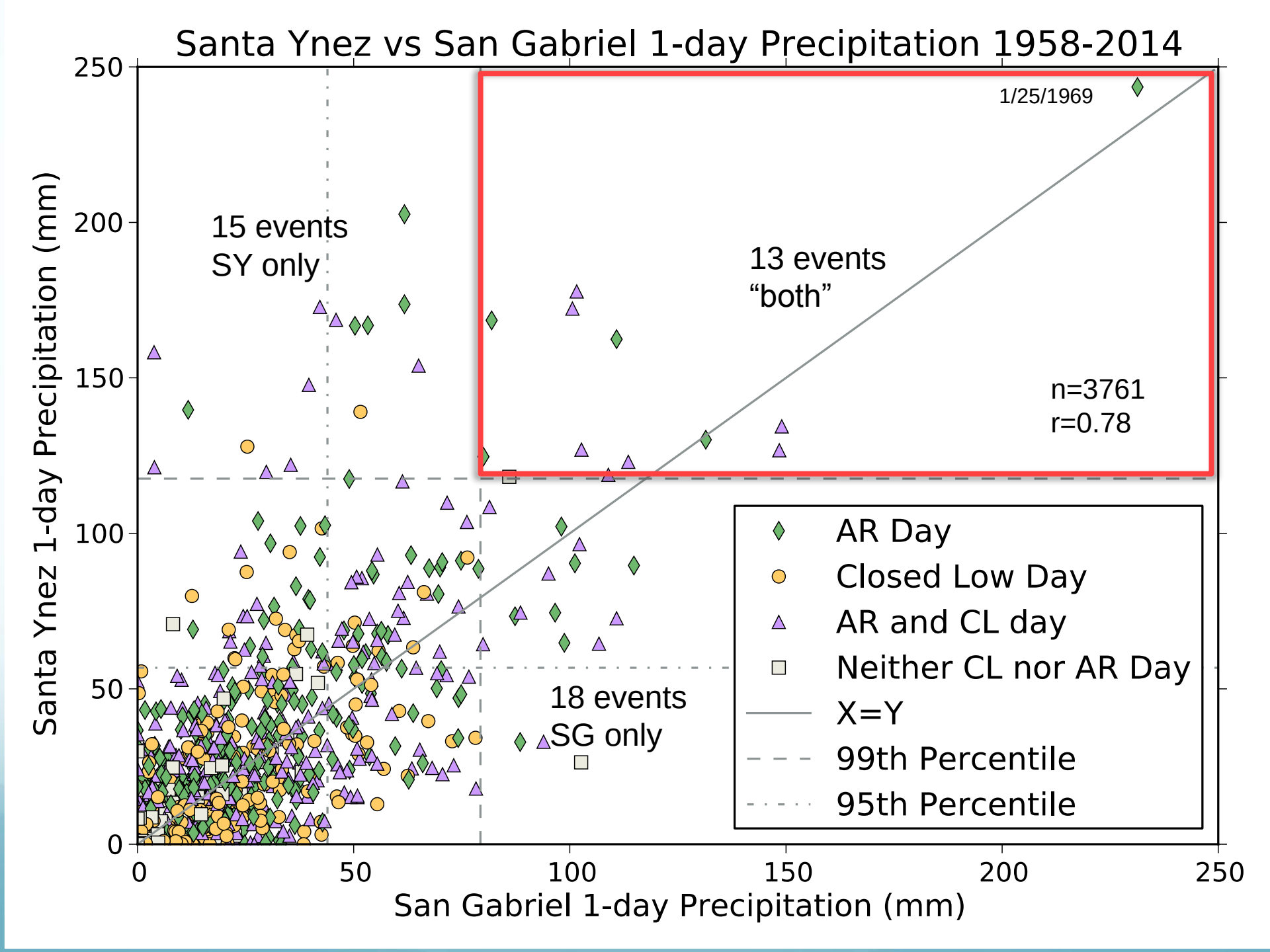





Santa Ynez vs San Gabriel 1-day Precipitation 1958-2014
1/25/1969
15 events
SY only
13 events
“both”
18 events
SG only
n=3761
r=0.78
AR Day
Closed Low Day
AR and CL day
Neither CL nor AR Day
X=Y
99th Percentile
95th Percentile
Santa Ynez 1-day Precipitation (mm)
San Gabriel 1-day Precipitation (mm)
0
50
100
150
200
250

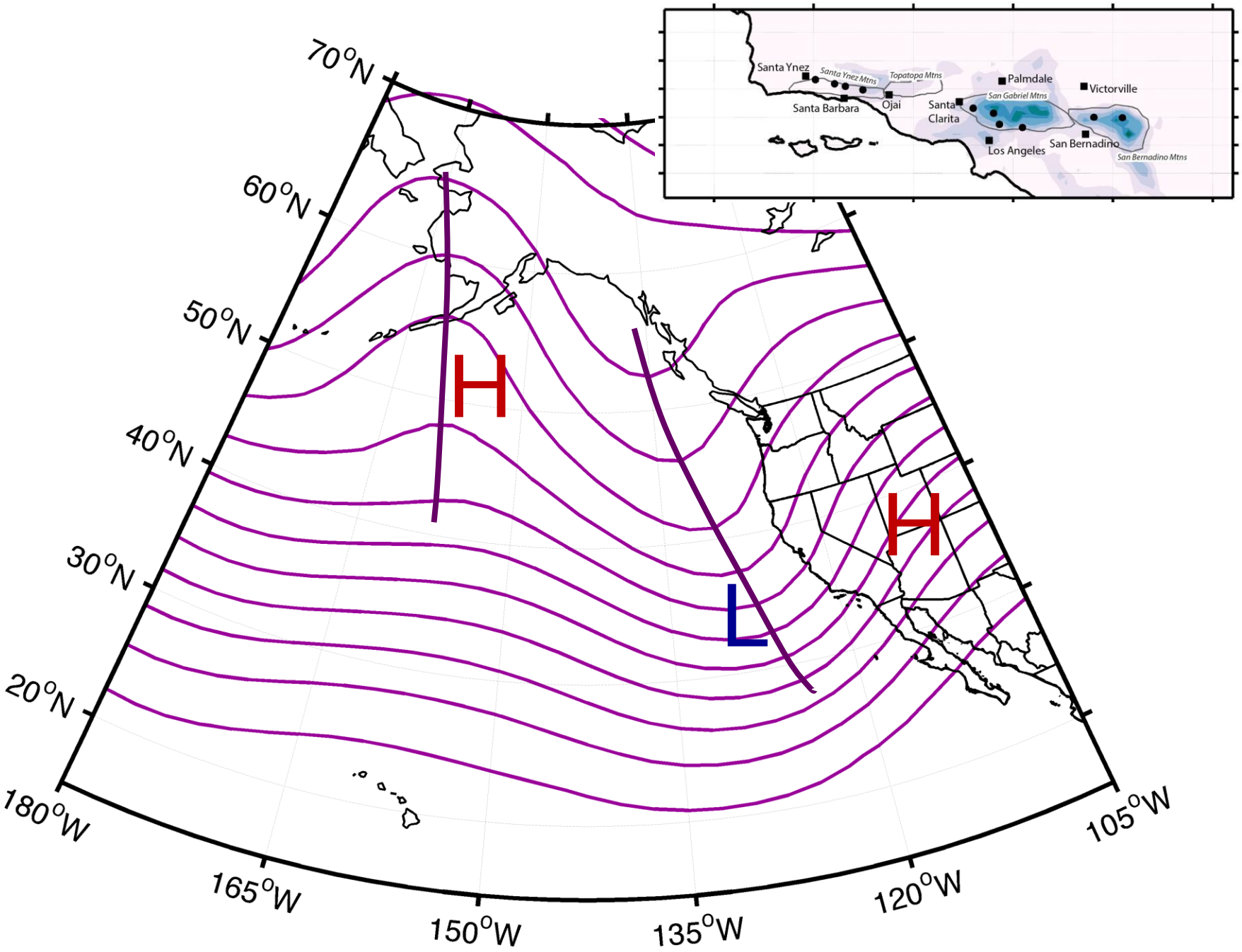

Santa Ynez vs San Gabriel 1-day Precipitation 1958-2014
1/25/1969
15 events
SY only
13 events
"both"
n=3761
r=0.78
18 events
SG only
AR Day
Closed Low Day
AR and CL day
Neither CL nor AR Day
X=Y
99th Percentile
95th Percentile
Santa Ynez 1-day Precipitation (mm)
San Gabriel 1-day Precipitation (mm)
0
50
100
150
200
250


Santa Ynez vs San Gabriel 1-day Precipitation 1958-2014
1/25/1969
15 events
SY only
13 events
“both”
n=3761
r=0.78
18 events
SG only
AR Day
Closed Low Day
AR and CL day
Neither CL nor AR Day
X=Y
99th Percentile
95th Percentile
Santa Ynez 1-day Precipitation (mm)
San Gabriel 1-day Precipitation (mm)
0
50
100
150
200
250

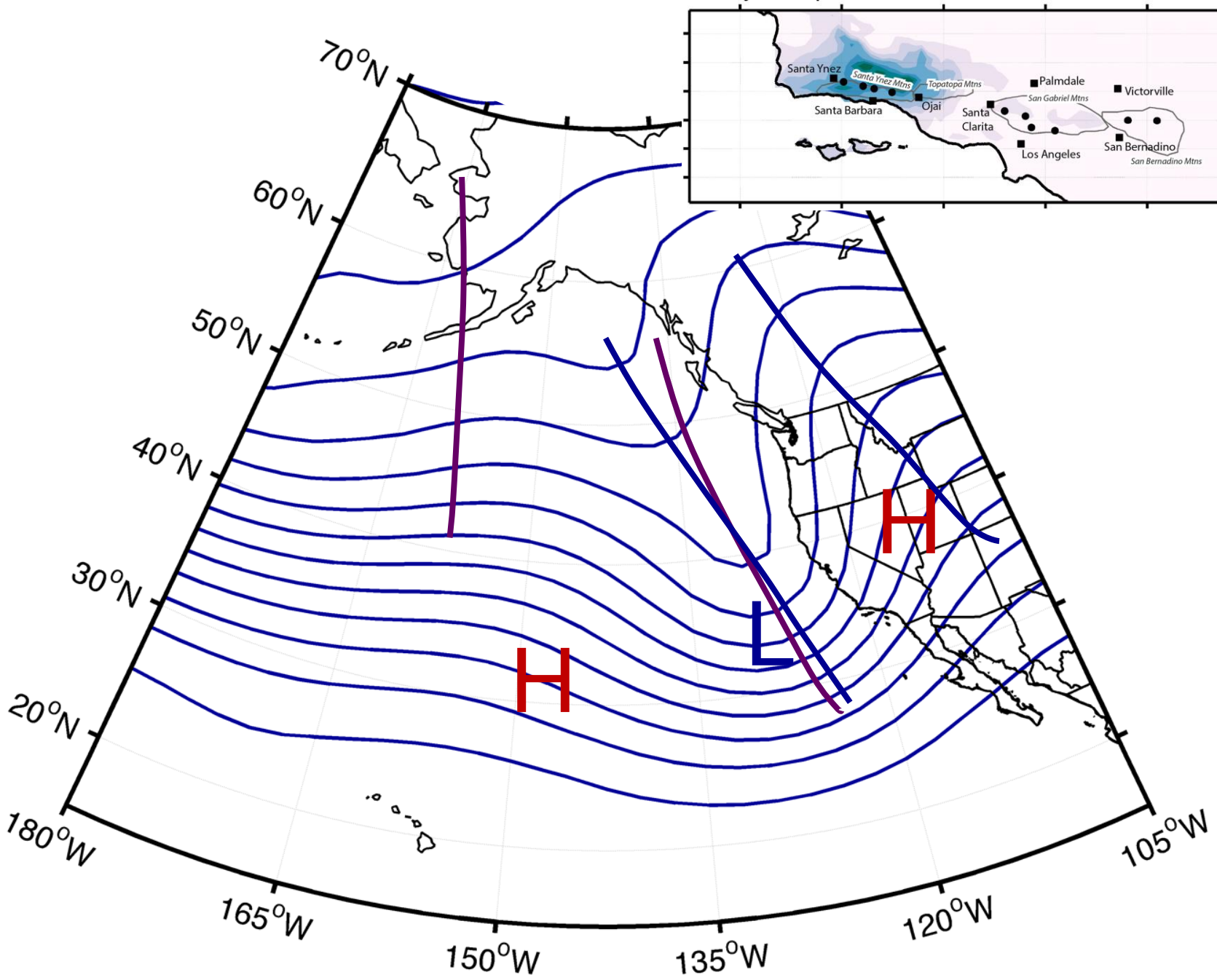

Santa Ynez vs San Gabriel 1-day Precipitation 1958-2014
Santa Ynez 1-day Precipitation (mm)
San Gabriel 1-day Precipitation (mm)
0
50
100
150
200
250
1/25/1969
15 events
SY only
13 events
“both”
n=3761
r=0.78
18 events
SG only
AR Day
Closed Low Day
AR and CL day
Neither CL nor AR Day
X=Y
99th Percentile
95th Percentile

Step 3: Evaluating synoptic scale features

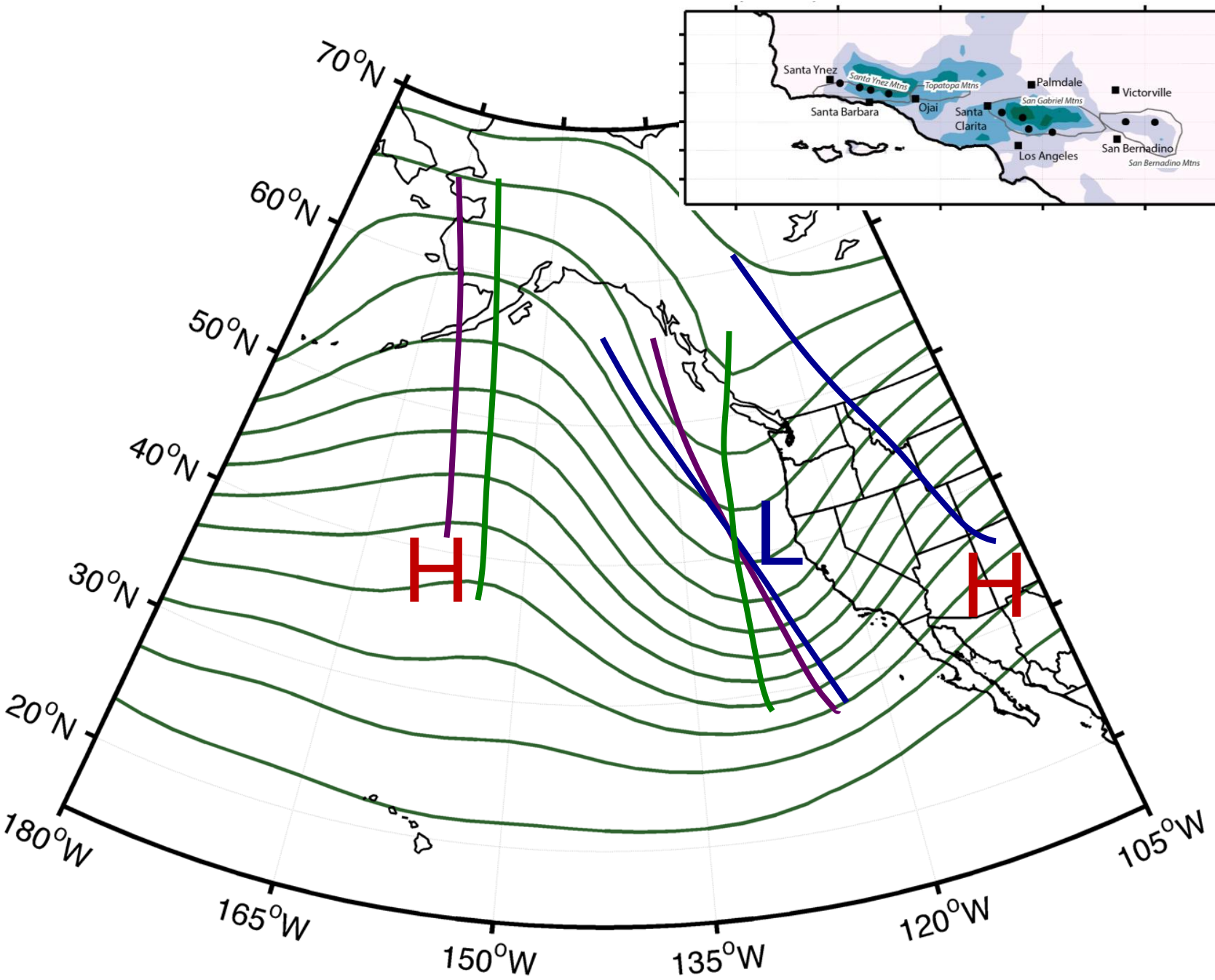
with NCEP/NCAR Reanalysis (1948-present)



Composite 500 hPa heights for events in San Gabriel

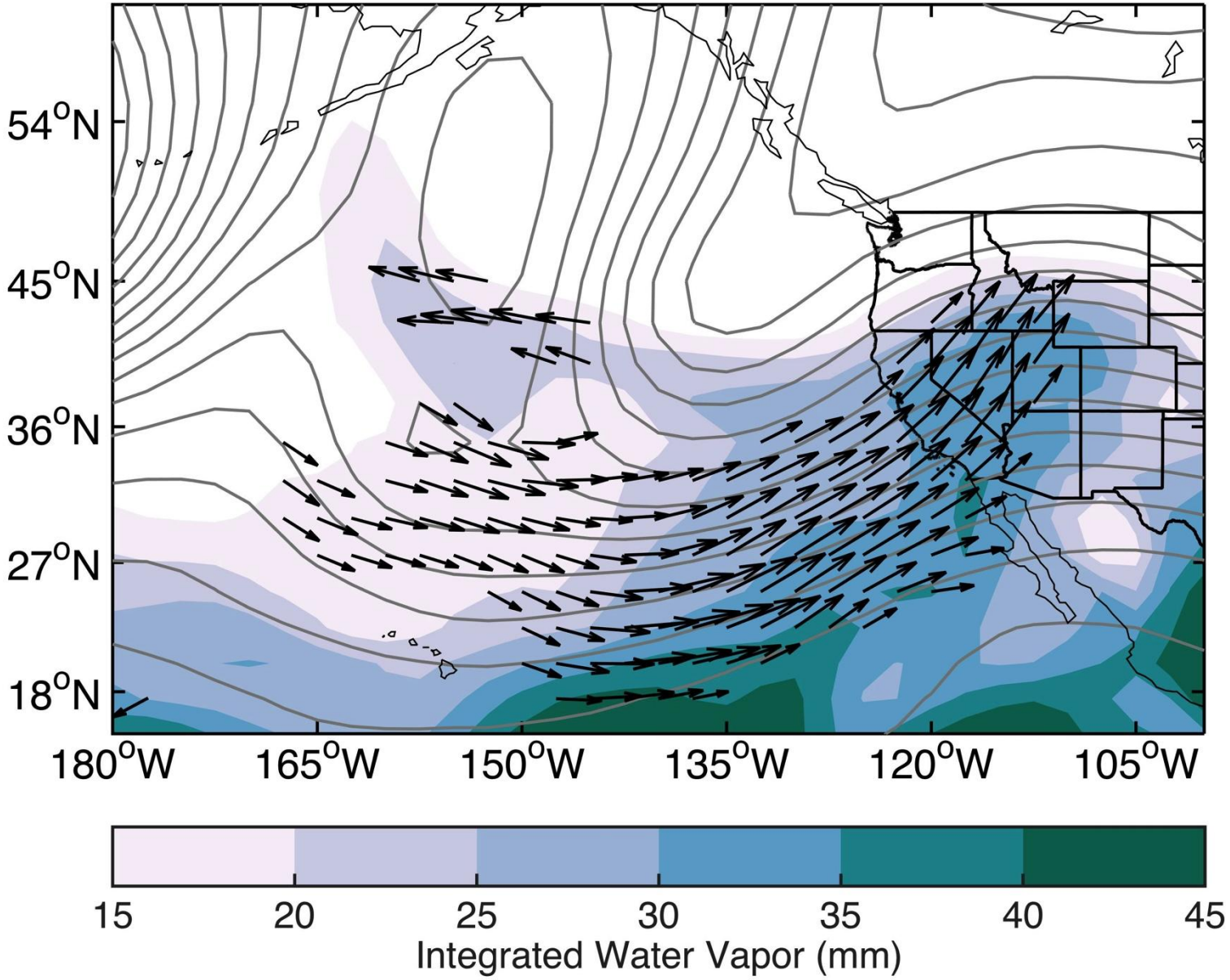


Composite 500 hPa heights for events in Santa Ynez



Composite 500 hPa heights for events in both ranges

1969-01-25 Atmospheric River



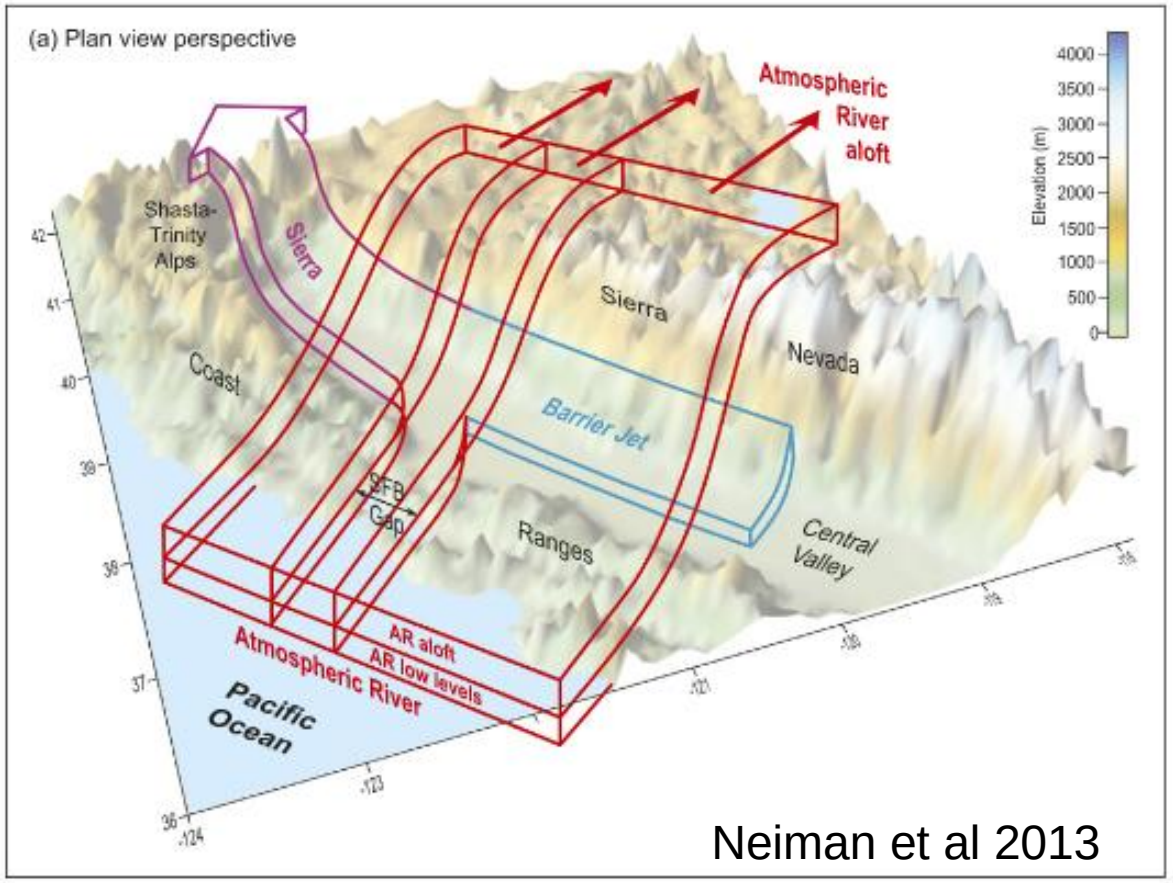
Lines= 500 hPa heights, Vectors= Integrated Water Vapor Transport

Conclusions thus far:

- Each (or all ranges) have a unique synoptic scale wave pattern that favors extreme precipitation
- Magnitude and direction of moisture transport important
- Atmospheric rivers and/or closed lows are typically associated with extreme precipitation in the Transverse Ranges
- Extreme precipitation events overlap with landslide events

Next steps

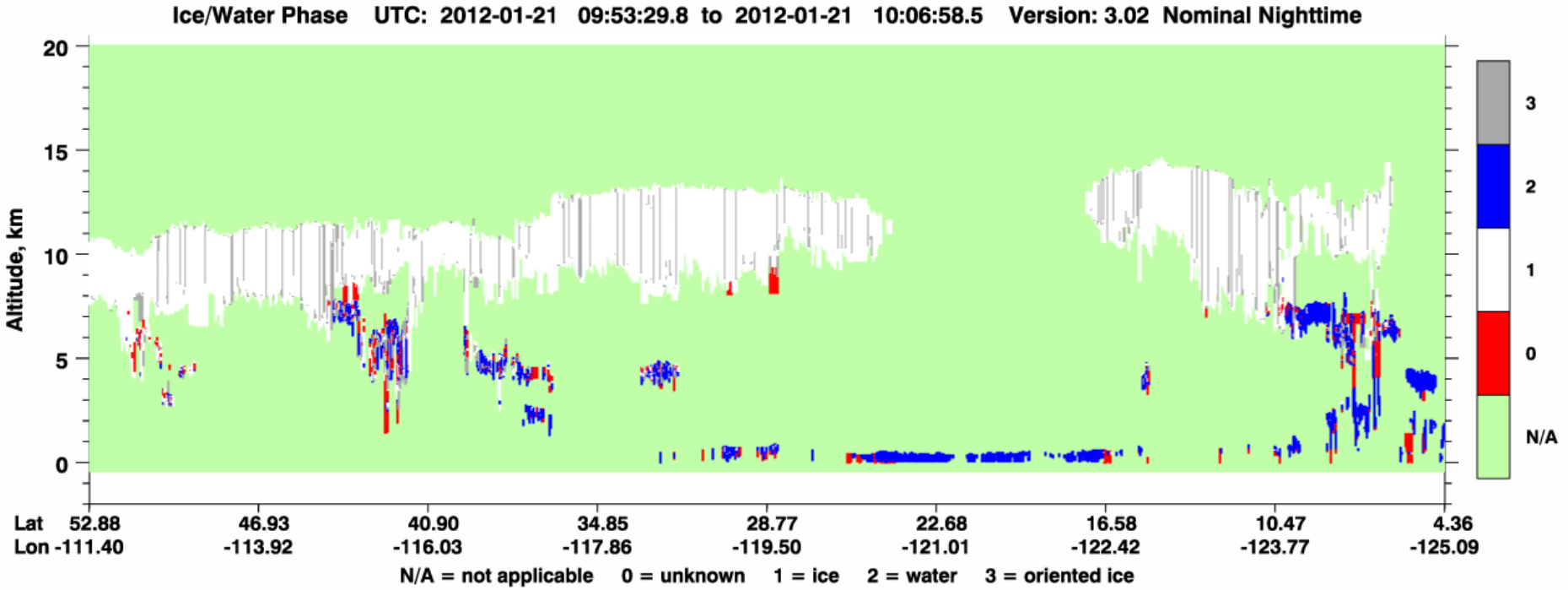
- Examine mesoscale features (Step 4)
  - Low level winds
  - Barrier jet present?
  - Vertical structure of the atmosphere
- Develop forecast methodology
- Look at hourly where compare with landslide catalogs



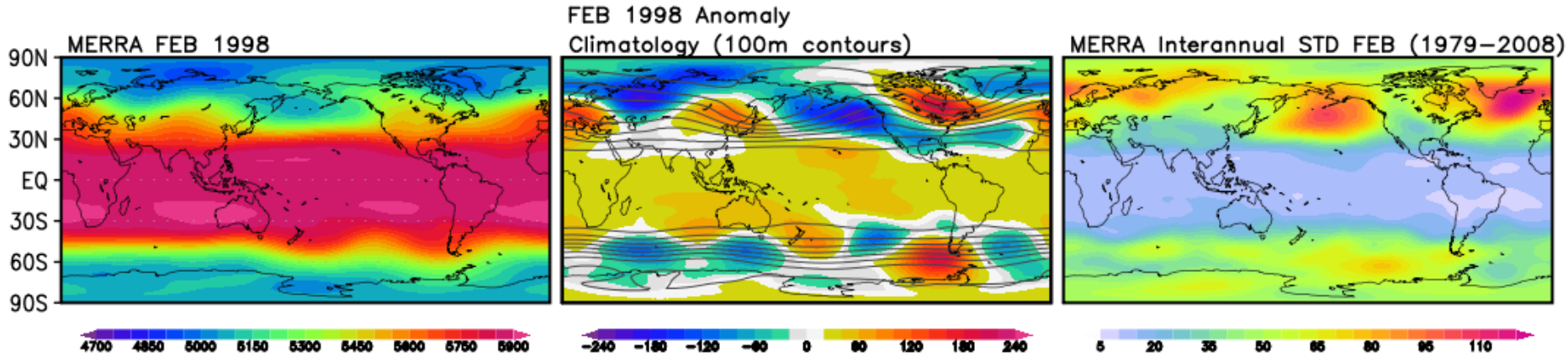
Neiman et al 2013

CALIPSO– Can provide information about cloud top height, cloud composition

2012-01-21 (not extreme event)



MERRA Reanalysis– 1979-present atmospheric data



Thank you!

Small landslide in Santa Ynez Mtns December 2014, following atmospheric river event

Contact:
nina.oakley@dri.edu

Data Sources

- USGS landslide, CGS post-fire debris flow catalogs
  - Very spotty, incomplete!
- Station-based precipitation data– NWS COOP
- Gridded precipitation data (PRISM/Livneh)
- Atmospheric data:
  - NCEP/NCAR global reanalysis (2.5°)
  - NCEP/NCAR North American Regional Reanalysis (32 km)
- Atmospheric River catalog
  - Rutz et al 2014
- Closed low catalog
  - Oakley and Redmond 2014

COOP station at Manzanita Lake, CA