Atmospheric conditions associated with extreme precipitation and landslides in southern California

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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

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

La Conchita landslide January 2005, 10 killed

Photo: USGS
Hypothesizes

- 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
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

Image source: UW Madison CIMSS
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

- Santa Ynez favored: 1998-02-02
- San Gabriel favored: 1965-11-22

Data source: Livneh et al 2013
Santa Ynez vs San Gabriel 1-day Precipitation 1958-2014

15 events
SY only

13 events
“both”

18 events
SG only

n=3761
r=0.78

1/25/1969

AR Day
Closed Low Day
AR and CL day
Neither CL nor AR Day

X=Y

99th Percentile
95th Percentile
Santa Ynez vs San Gabriel 1-day Precipitation 1958-2014

15 events
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Legend:
- AR Day
- Closed Low Day
- AR and CL day
- Neither CL nor AR Day
- X=Y
- 99th Percentile
- 95th Percentile
Santa Ynez vs San Gabriel 1-day Precipitation 1958-2014

1/25/1969

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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 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)

Ice/Water Phase UTC: 2012-01-21 09:53:29.8 to 2012-01-21 10:06:58.5 Version: 3.02 Nominal Nighttime

N/A = not applicable 0 = unknown 1 = ice 2 = water 3 = oriented ice

MERRA Reanalysis—1979-present atmospheric data

FEB 1998 Anomaly Climatology (100m contours)

MERRA Interannual STD FEB (1979–2008)
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