Introduction

Northern California's mountain ranges and proximity to the Pacific Ocean subject the region to major storms that are often difficult to forecast. This region also relies heavily on mountain snow produced by these major storms for its fresh water supply. To improve flood forecasts and fresh water supply planning, more accurate prediction of the spatial pattern of heavy precipitation, in terms of elevation and watershed, is needed.

Watershed Basins

1. Stony Creek
2. Ball Mountain
3. Shasta Bally
4. Fiddling
5. Whimine
6. Tehama
7. Eastern Tehama
8. Butte Creek
9. Feather
10. Yuba
11. Bear
12. American

Dataset

We use data from the Beale and Sacramento weather radars to analyze the spatial patterns of precipitation within 12 watersheds in northern California for 64 major storms that occurred between 2005 and 2010. We examine wind direction at Bodega Bay as well as Sierra Barrier Jet occurrence and altitude at Chico to see if these factors have an effect on the spatial distribution of precipitation.

The Sierra Barrier Jet is a region of strong surface winds directed parallel to the ridge of the Sierra Nevada Mountains. It is generally associated with diverging precipitation northward.

Methods

I. Group Composite Maps

1. The 64 radar composite maps are divided into 8 storm classes based on wind direction and Sierra Barrier Jet characteristics (shown below).
2. Radar composite maps from each storm are added together in each class.
3. The resulting maps are normalized by the maximum number of hours of precipitation in the map to allow comparisons to be made among storm classes while minimizing effects from sample size discrepancies.
4. Data obscured by mountain ranges are removed.

Wind Direction Classes

- Westerly
- West-Southwesterly
- South-Southwesterly
- Southerly
- Low Altitude
- Middle Altitude
- High Altitude
- No Sierra Barrier Jet

Sierra Barrier Jet Classes

- High Altitude
- Middle Altitude
- Low Altitude
- No Sierra Barrier Jet

II. Change of Precipitation with Elevation

We examine how the normalized hours of precipitation in the 8 storm classes above changes with increasing elevation in all 12 basins. This information is summarized in terms of a best fit slope, \( \Delta P/\Delta H \):

\[
\Delta P = \frac{\Delta \text{normalized hours of precipitation}}{\Delta \text{elevation}}
\]

Previous studies have found an idealized precipitation distribution for the Feather, Yuba, and American basins that shows an increase in precipitation up to 1000 m and constant precipitation above 1000 m.

Example Precipitation Change with Elevation within 3 Basins for Low Altitude Sierra Barrier Jet Storms

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Analysis

How does \( \Delta P/\Delta H \) vary among storm classes and watershed basins?

Wind Direction Classes

- \( \Delta P/\Delta H \) in the lowest 1 km tends to decrease as winds become more southerly in basins along the Sierra Nevada.
- Westerly storms in the Sierra Nevada basins most closely match the lowest 1 km idealized \( \Delta P/\Delta H \).
- Basins along the Coastal mountains show no clear association between \( \Delta P/\Delta H \) and wind direction class.

Sierra Barrier Jet Classes

- \( \Delta P/\Delta H \) in the lowest 1 km tends to decrease as Sierra Barrier Jet Altitude increases in basins along the Sierra Nevada.
- Low altitude Sierra Barrier Jet storms in the Sierra Nevada basins most closely match the lowest 1 km idealized \( \Delta P/\Delta H \).
- Basins along the Coastal mountains show no clear association between \( \Delta P/\Delta H \) and Sierra Barrier Jet class.

Conclusions

1. Sierra Barrier Jet height tends to be lower when wind direction is westerly.
2. The geographic distribution of hours of precipitation significantly varies from storm to storm and among storm classes.
3. Basins along the Coastal mountains show no clear association between \( \Delta P/\Delta H \) and storm class.
4. The only clear pattern among \( \Delta P/\Delta H \) and storm class is in the lowest 1 km of basins along the Sierra Nevada.

References: