The Impacts of Precipitation Whiplash Events Across the Continental United States (CONUS)

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Background and Motivation

- Rapid transitions in precipitations extremes, also known as precipitation whiplash events, can have direct critical impacts to agriculture, infrastructure, water quality, and water quantity.
- Transitions from drought conditions to excessive rainfall can be critical for the recovery of water resources and these whiplash events have been documented and shown to be increasing with time [Christian et al. 2015]. However, such transitions can also pose a ***significant flood risk.***
- The green-up of vegetation during periods of excessive rainfall can pose a ***considerable fire risk*** during a transition into drought conditions as desiccation of the land surface can yield fuel available for wildfires [Scasta et al. 2016].

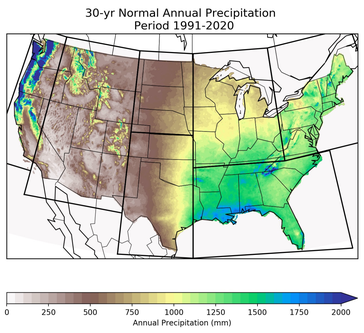
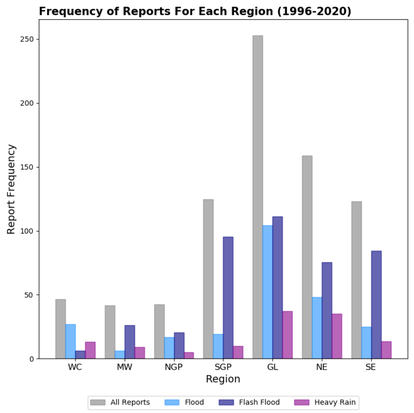


Fig 1: 30-yr normal annual precipitation for the period 1991-2020 calculated using PRISM precipitation data. The seven regions of study for the Flood Impact Analysis are outlined by the black-outlined polygons. PRISM Climate Group, Oregon State University (2004)

Datasets

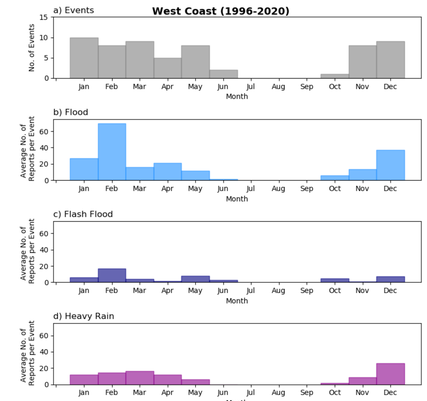
- Daily precipitation from the Parameter-Elevation Regressions on Independent Slopes Model (PRISM) [1981-2020] dataset.
  - Spatial resolution: 4 km.
- National Centers for Environmental Information (NCEI) storm events database [1996 -2020] was utilized to understand the flood-related impacts of precipitation whiplash.
  - Specifically, Flash Flood, Flood, and Heavy Rain Reports.
- Regional 2 m temperature data [1981-2020] was obtained from the ERA5 reanalysis dataset.
  - Spatial Resolution: 0.25 degrees.
- Vegetation Indices from the Moderate Resolution Imaging Spectroradiometer (MODIS) [June 2017 and July 2018]; specifically, the Normalized Difference Vegetation Index (NDVI) and the Enhanced Vegetation Index (EVI).
  - Spatial Resolution: 5 km.
- Number of Wildfires and Number of Acres burned [June 2017 and July 2018] was acquired from the Monitoring Trends in Burn Severity (MTBS) program.

Association Between Whiplash and Flood Events



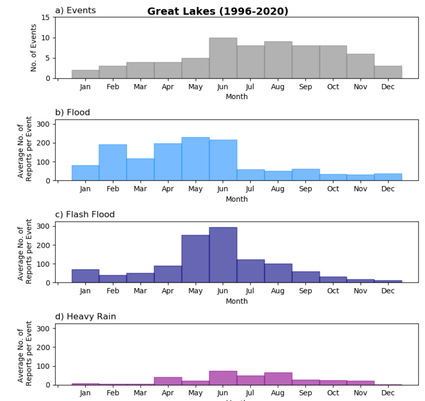
- Per event, the **GL** had a greater number of flood, flash flood, and heavy rain reports than any other region with **253 total reports per event.**
- WC, MW, and NGP were associated with fewer reports, with less than 50 total reports per event.
- Across all regions, **flash flood** reports were the most common report type, except the WC.

Fig 2: The average number of NCEI flood, flash flood, and heavy rain reports per precipitation whiplash event, between 1996 and 2020 for each region. All NCEI reports are for event months only.



- Total: **60 Events**
- Most likely timing of events: **during the distinct WC wet season (October - April)**.
- Most common report type: **Flood**
- Most likely month for events to be associated with a damaging flood event across the WC: **February**

Fig 3: Number of a) drought-pluvial precipitation whiplash events, b) NCEI flood reports, c) NCEI flash flood reports and d) NCEI heavy rain reports per month between 1996 and 2020 for the West Coast. All NCEI reports (b-d) are for event months only and have been normalized by the number of events per month.

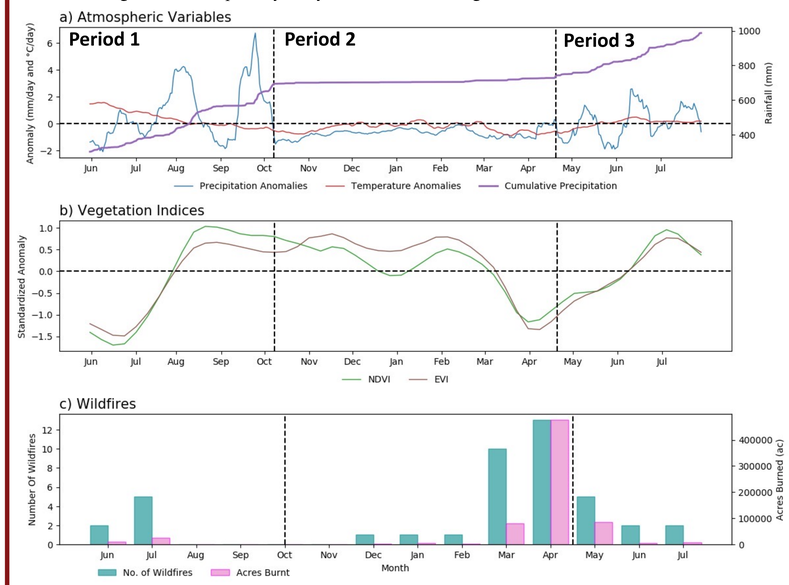


- Total: **70 Events**
- Most likely timing of events: **June, July, August, September, October.**
- Most common report type: **Flash Flood**
- Most likely month for events to be associated with a damaging flash flood event across the WC: **May/June**

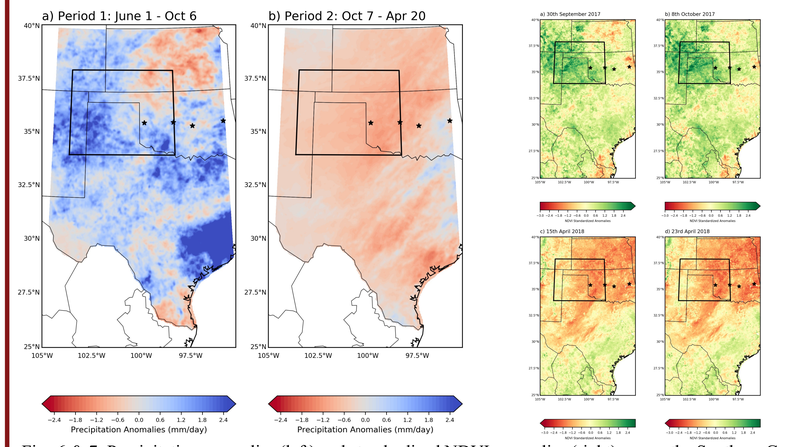
Fig 4: Same as above but for the West Coast

The Precipitation Whiplash of Fall 2017

Fig 5: a) Time series of precipitation (blue) and temperature (red) anomalies and cumulative precipitation totals (purple); b) NDVI (green) and EVI (brown) standardized anomalies; and c) the number of wildfires (blue) plus the number of acres burned by wildfires (pink) per month for the primary domain. All values are domain-averaged across the primary study domain shown in Figures 6 and 7.



- Precipitation anomalies that were **137% of normal** during the growing season of 2017 rapidly cascaded into drought conditions with precipitation anomalies **21% of normal** throughout the cool winter season.
- The excessive precipitation supported vigorous vegetation recovery and growth with vegetation indices peaking at approximately **1 standard deviation** above average during August 2017, before the subsequent drought period rapidly desiccated the terrestrial surface.



Figs 6 & 7: Precipitation anomalies (left) and standardized NDVI anomalies (right) across the Southern Great Plains. Black box outlines area averaged to create the timeseries above (Fig 8).

Conclusions and Future Work

- **Flood Impacts:** *Per event, the GL region had a greater number of storm reports with an average of 253 reports per event; Flash flood reports were the most common report type across all regions, excluding the WC; Tended to occur during February along the WC, and during the late spring and summer months across all other regions.*
- **Wildfire Impacts**: *Excessive precipitation 9 months prior followed by reduced precipitation 2 months prior can significantly impact the severity of the wildfire season.*
- ***Create a database of precipitation whiplash events, their association with flood events and wildfire events across the CONUS. How do we "best" define a precipitation whiplash event?***

NSF EPSCoR Research Infrastructure Improvement Award No. OIA-1946093

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