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Changes to Maine's Winter Weather

Alexander Ingalls

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INTRODUCTION

The properties of winter weather in Maine have experienced remarkable changes over the past hundred years, one of the most notable being the 3.2ºF increase in state-wide average annual temperature as seen in *Figure 1*. [1][2] However, the emphasis on temperature changes when studying the effects of climate change often leave inadequate attention to changes in precipitation patterns. Understanding such changes are vital when considering the impacts to environmental and agricultural sustainability, as well as economic and civic business throughout the state.

This study seeks to explore changes to three major components of weather in the winter season; precipitation (rain, ice, sleet), snowfall, and snow depth. Typical analyses show the effect of climate change on the state scale, however since Maine has such a diverse range of geographical features, special care is taken to visualize trend changes in five regions of the state as seen in *Figure 2*. These regional areas contain collections of weather monitoring stations that have similar geographical features and climate values. Daily averaged records for each region are organized by magnitude and frequency.

METHODS & DATA

Data are gathered from NOAA's GHCN (Global Historical Climate Network) database and include a set of weather stations (60 to 120 depending on the particular year) across Maine [3]. For each station, averaged daily records for 6-month intervals (Nov – Apr) include precipitation (in), snowfall (in), and snow depth (in) variables.

Data cleansing techniques are used to remove obvious recording errors, as well as null entries that otherwise distort the ensuing analysis. Additionally, the map in *Figure 2* is generated through a two-part process:

1. The first is using a k-means clustering algorithm to group stations based on geographic location (excluding elevation), and similarity of atmospheric variable values.
2. The second is using a Thiessen polygon technique in which all station groups (clusters) are triangulated into an irregular network in which perpendicular bisectors form the edges of the cluster polygons.

From this 'Thiessen cluster map', each cluster is analyzed by breaking the season into three sub seasons, early, mid, and late winter. An example of how to interpret the magnitude analysis is displayed below in *Figure 3*. Additionally, analysis for each cluster's storm frequency can be seen in the upper right.

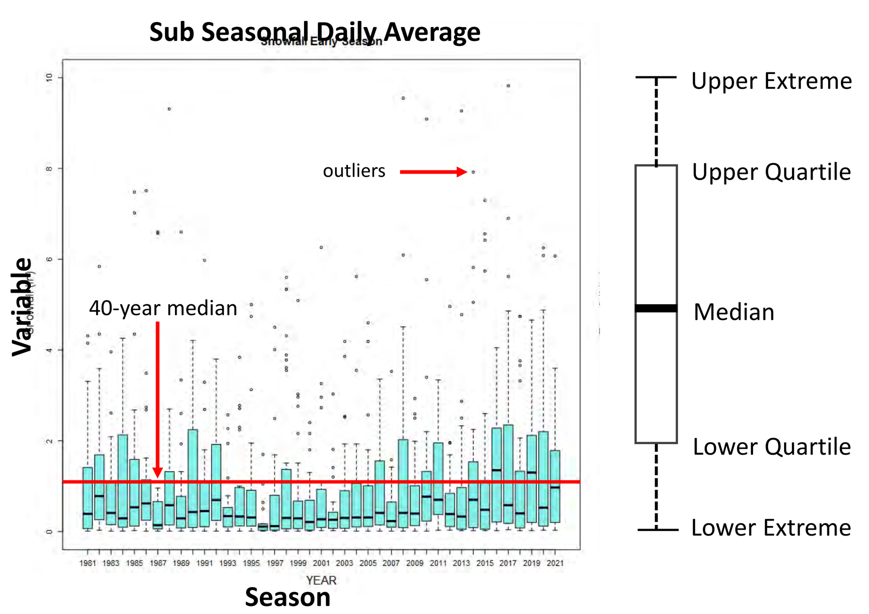


Fig 3. Example of magnitude/ variation analysis

CONCLUSION

A regional map of Maine is generated from a collection of weather stations with similar geographic and atmospheric variable values. By excluding station elevation values due to their skewed weight in the k-means cluster analysis, the Thiessen polygon technique considers statewide changes to variables in five clusters rather than three bands as seen in the 2020 Maine climate future update [2].

Following previous studies, the analysis agrees with the expected overall increase for precipitation during the winter season [4]. However, comparing the frequency and magnitude analyses shows that in most cases this increase comes from storms occurring more often rather than greater accumulation.

Several questions remain open to the results including the effect of synoptic scale weather patterns such as the North Atlantic Oscillation as well as the impact of a speculative increase in rain/sleet precipitation across the state moving forward.

REFERENCES

[1] Scientific, Maine Climate Council. "Scientific assessment of climate change and its effects in Maine." (2020).

[2] Fernandez, Ivan J., Sean Birkel, Julia Simonson, Bradford Lyon, Andrew Pershing, Esperanza Stancioff, and George L. Jacobson. "Maine's climate future: 2020 update." (2020): 1.

[3] Menne, Matthew J., Imke Durre, Bryant Kuznetsky, Shelley McNeal, Kristy Thomas, Xungang Yin, Steven Anthony, Ron Ray, Russell S. Vose, Byron E.Gleason, and Tamara G. Houston (2012): Global Historical Climatology Network - Daily (GHCN-Daily), Version 3. [Daily Summary, Maine, 1980 - 2020]. NOAA National Climatic Data Center. doi:10.7289/V5D21VHZ [1/31/22].

[4] Hodgkins, Glenn A., and Robert W. Dudley. "Changes in late-winter snowpack depth, water equivalent & density in Maine, 1926–2004." Hydrological Processes: An International Journal 20, no. 4 (2006): 741-751.

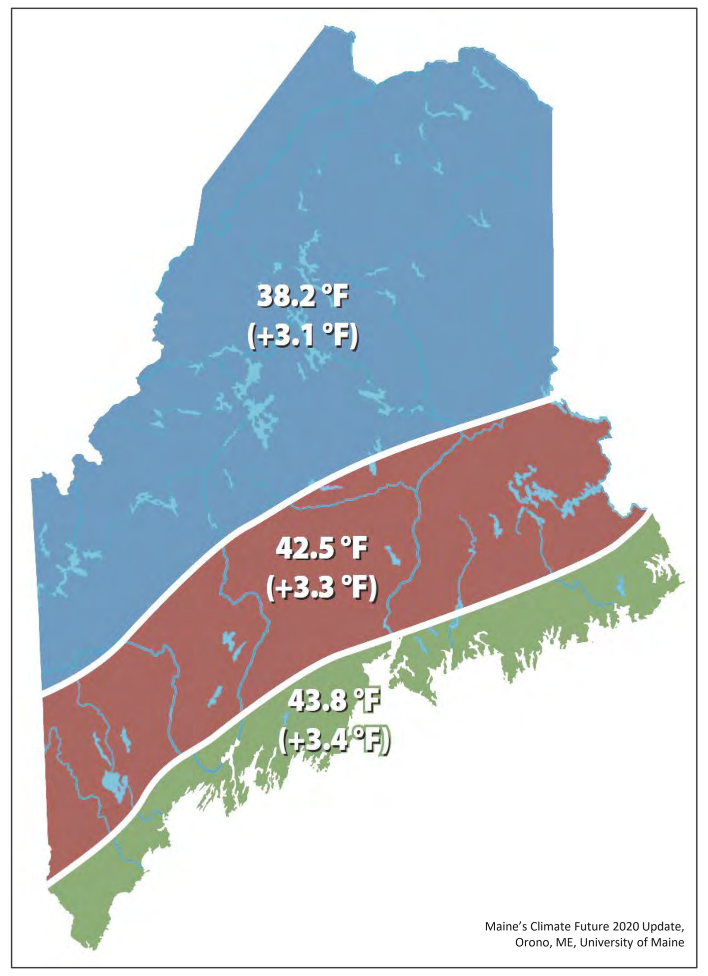


Fig 1. Average temperature increase from 1895 – 2009

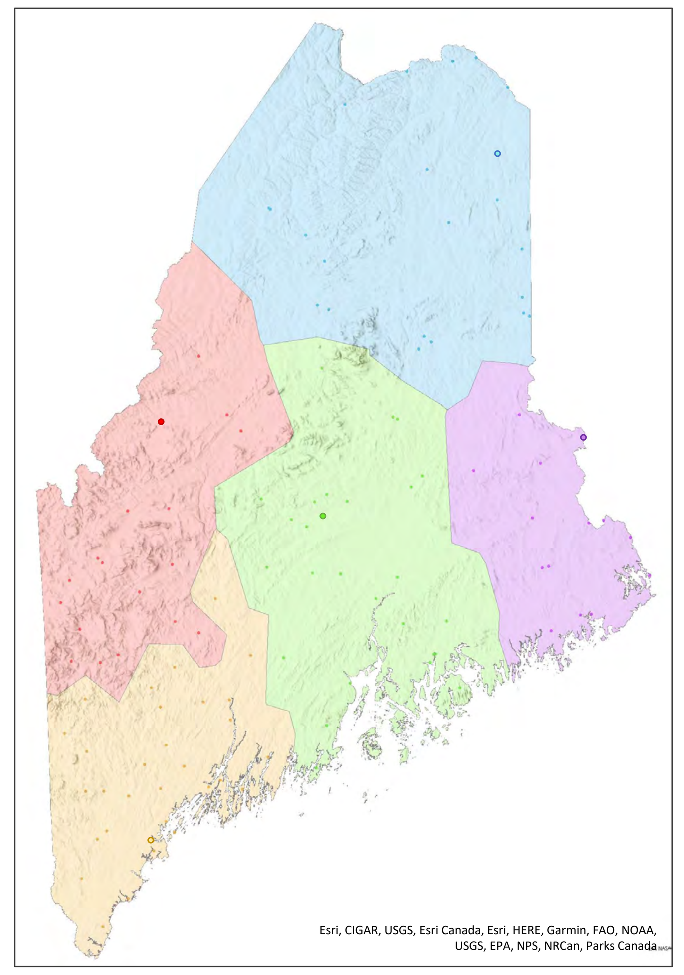
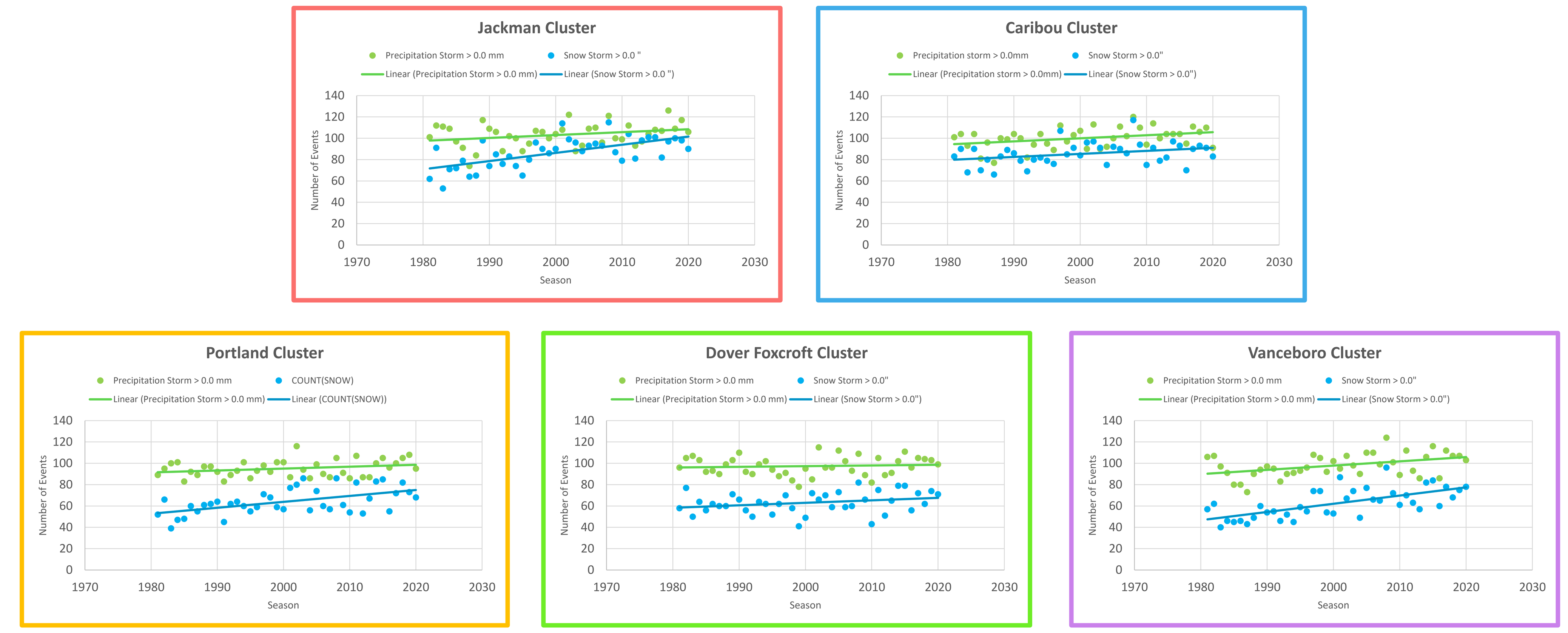


Fig 2. Thiessen cluster analysis

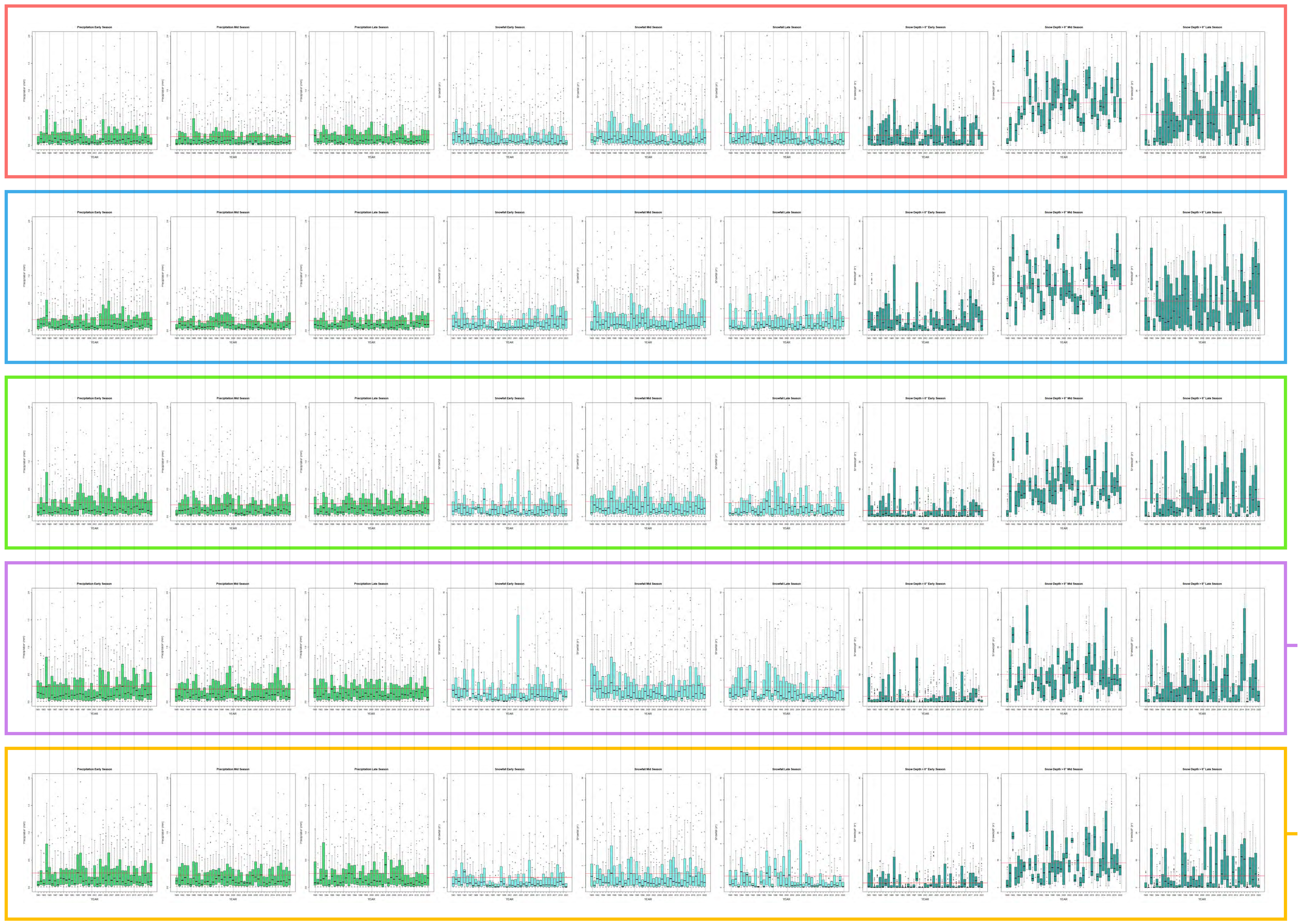
STORM FREQUENCY



PRECIPITATION

SNOWFALL

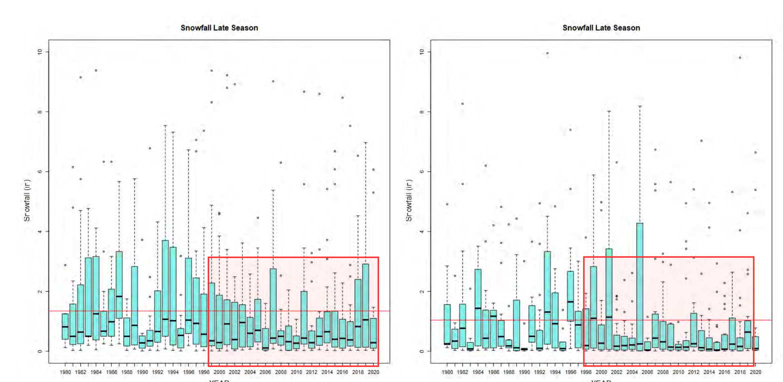
SNOW DEPTH



NOTABLE CASES

Decreased Snowfall in Costal Clusters

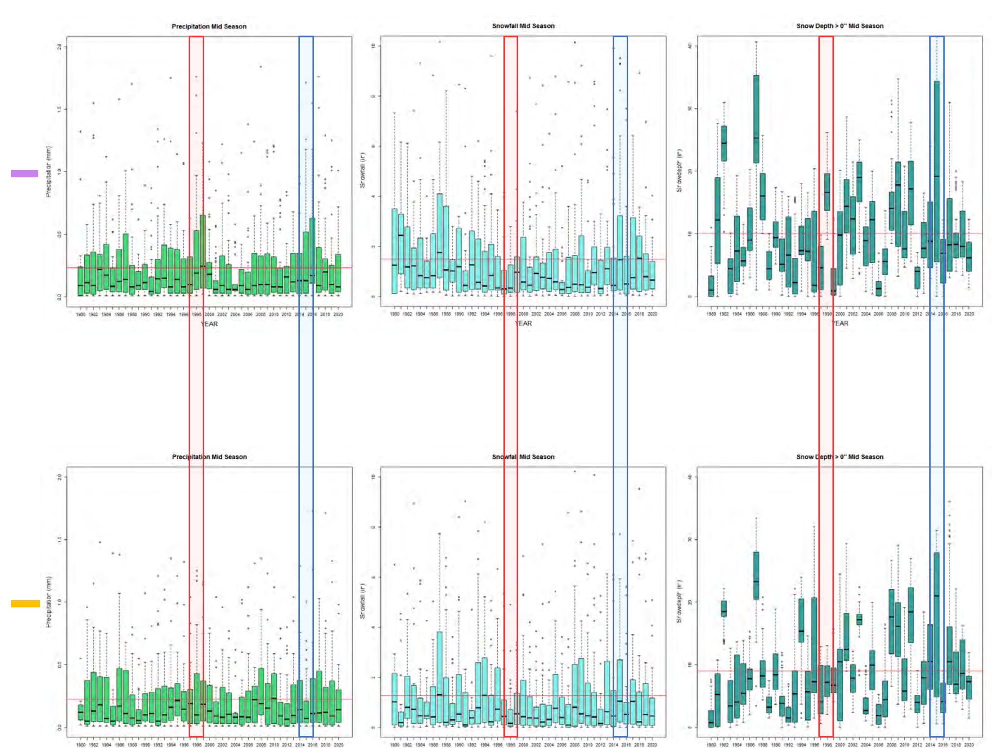
The results show that costal areas of Maine have experienced a general decrease in late season snowfall accumulation from 2000 onward. While there are several years where the daily average snowfall is quite high, the frequency of these high snowfall years is much less when compared to 1980 – 2000. When comparing northern regions to the costal regions, the daily average snowfall amount for late season tends to be consistent across the forty-year time slice. This may suggest that the costal regions of the state are experiencing an acceleration in late season warming, shortening the traditional winter season for those areas.



Anomalous Events

Two major winter events are seen in the magnitude analysis. The January *Ice Storm of 98'* and *Winter Storm Juno* can be seen in both the Portland and Vanceboro clusters. For the Ice Storm, notice the Portland cluster which has a particularly low snowfall average versus a high precipitation average for mid season. Winter Storm Juno has high values across both clusters for all three variables in 2015. This storm was reported to have accumulated up to three feet of snow over the course of three days in the northeast. Extreme weather events are predicted to increase in frequency as a consequence of climate change.

Ice Storm 98' *Winter Storm Juno 15'*



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