Snow Depth Over Central North America: 1966-2018

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Introduction

While a number of previous studies have explored snow cover extent over central North America, few have examined snow extent and depth.

- Knowledge of snow depth contributes to a better understanding of snow's role in ecological systems, weather forecasting and flood prediction.
- We report here on a study that first develops a climatology of snow depth from 1966-2018 using in-situ measurements of the United States Cooperative Observer Program (COOP) and the Meteorological Service of Canada.
- With a background climatology in place, analyses of the spatial and temporal variability of snow depth are conducted. This includes an analysis of means, extremes, and seasonal timing of depth on local to regional scales.

Study Site

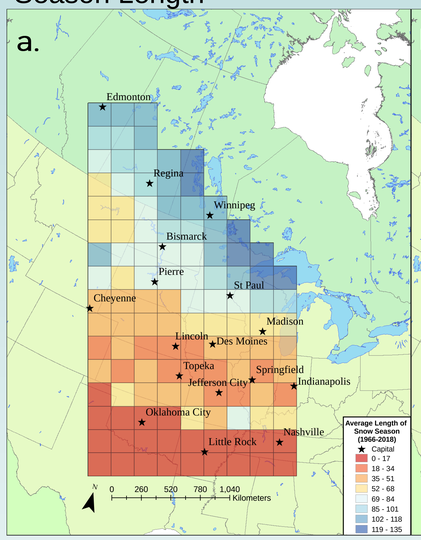
- The Central United States and Canada covers an area of roughly 4 million km², most of which is used for agriculture.
- As a region that is subject to widespread drought, snow serves as an important hydrologic and economic resource.
- It is estimated that **snowfall is twice as valuable as rain as a resource for agriculture**. In Canada, for example, snow accounts for more than 80% of the surface runoff, but only represents 30% of annual precipitation (Hughes 1993).

Data and Methods

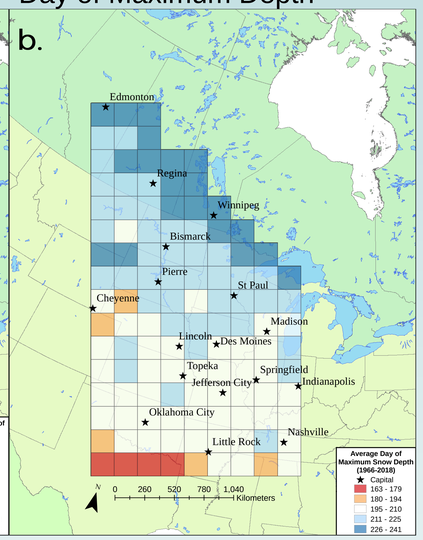
- In-situ observations of precipitation, snow depth and snowfall for the entire Northern Hemisphere are gridded, using a **polar stereographic projection with a central meridian at -80**, into 89 cells left to right by 89 cells top to bottom (Rutgers Global Snow Lab). **The values within the cells are averaged from reporting cooperative observers.**
- For the purposes of this study, **snow depth and snowfall measurements are based on observations from the National Weather Service's Cooperative Observer's Program (COOP) in the United States and the Meteorological Service of Canada's Cooperative Climate Network (CCN).**

Climatology

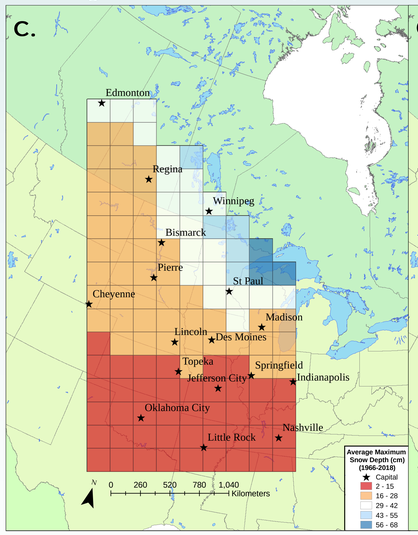
Season Length



Day of Maximum Depth



Average Maximum Depth



Percentage of Days Above 7.6cm

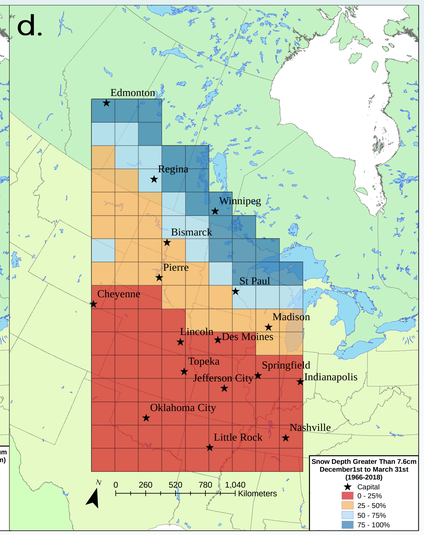
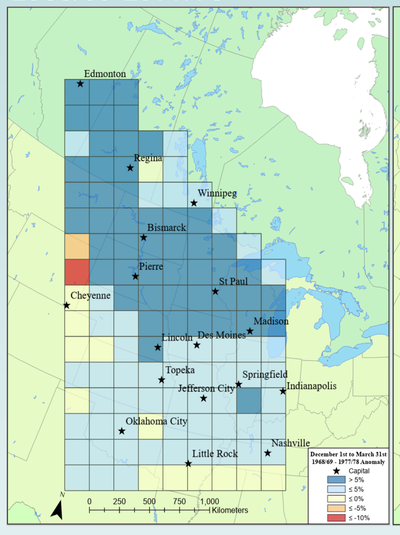


Figure 1. The 52 year climatology (seen in the figures above) **shows a northward gradient of increasing snow depth.** Distinct transitional areas are apparent for all snow depth with outliers being seen in cells just east of the Rocky Mountains.

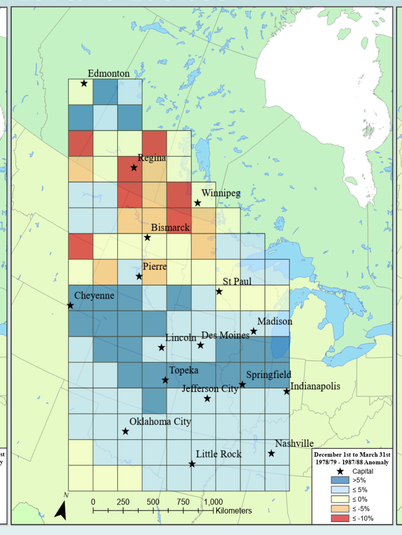
- **Figure 1a** shows the **difference in the First and Last occurrence of 7.6cm or more for a 7 day period**. This figure indicates the average length of the significant snow season
- **Figure 1b** shows the **average day when maximum snow depth was reached, in # of days since July 1st.**
- **Figure 1c** is the **average annual maximum depth**. This figure reveals that the maximum snow depth is reached earlier in southern cells compared to more northerly cells.
- **Figure 1d** shows these transition zones as the **average percentage of snow depth greater than 7.6cm between December 1st and March 31st.**

Decadal Trends

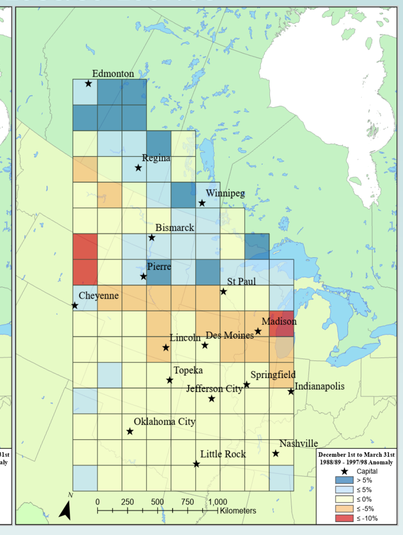
1968/69-1977/78



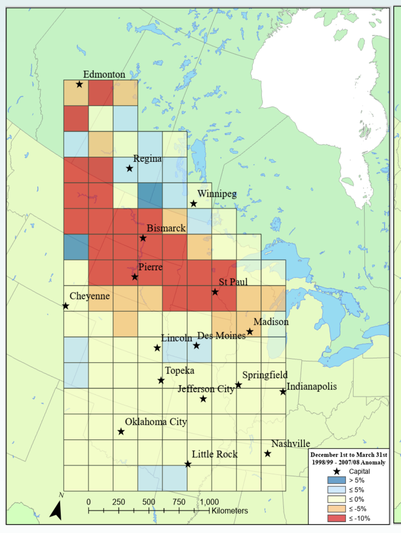
1978/79-1987/88



1988/89-1997/98



1998/99-2007/08



2008/09-2017/18

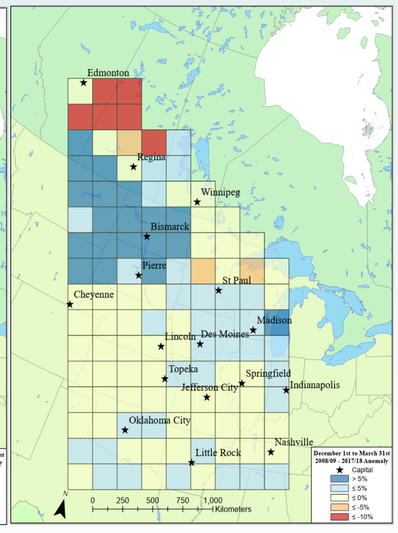


Figure 2. The time series shows decades with varying numbers of days with snow depths greater than 7.6cm between December and March when compared with the 52 year average (figure 2).

- There is **not a decadal trend in snow depth changes during the season with deepest snow depths.**
- The positive snow depth anomaly is seen in **1968/69-1977/78** with a distinct zone of >10%. This same area shows a large negative anomaly of >10% in **1998/99-2007/08.**

Conclusions and Future Work

The climatology reveals a **transitional pattern** with **distinct zones of snow depth**. Many of the **southern cells** in this period spend most of the snow season **below significant depth, but the trend progressively amplifies to deeper depths northward. The effect of a warming climate on snow depth in this region are still unclear.** Future work will explore snow depth changes in the early and late parts of the season with different depths.

References

Hughes, M. G. and D. A. Robinson (1993). Creating Temporally Complete Snow Cover Records Using A New Method for Modelling Snow Depth Changes. Snow Watch '92, Detection Strategies for Snow and Ice: 150-163

Kluver, D., et al. (2015). "Creation and Validation of a Comprehensive 1° by 1° Daily Gridded North American Dataset for 1900-2009: Snowfall." Journal of Atmospheric and Oceanic Technology 33(5): 857-871.

Robinson, D. A. and M. G. Hughes (1991). "Snow Cover Variability on the Northern and Central Great Plains." Great Plains Research: A Journal of Natural and Social Sciences 9.