# A SOM-based approach for analyzing daily precipitation extremes over the North American Arctic

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## EXPERIMENTAL GOALS

1. **Use Self Organizing Maps (SOMs) to differentiate large-scale circulations and relate them to widespread precipitation events over southern Alaska and eastern Polar Canada**
2. **Examine frequency plots of WRF precipitation to determine whether there are preferred regions of SOM space where circulations are more conducive for extreme events**

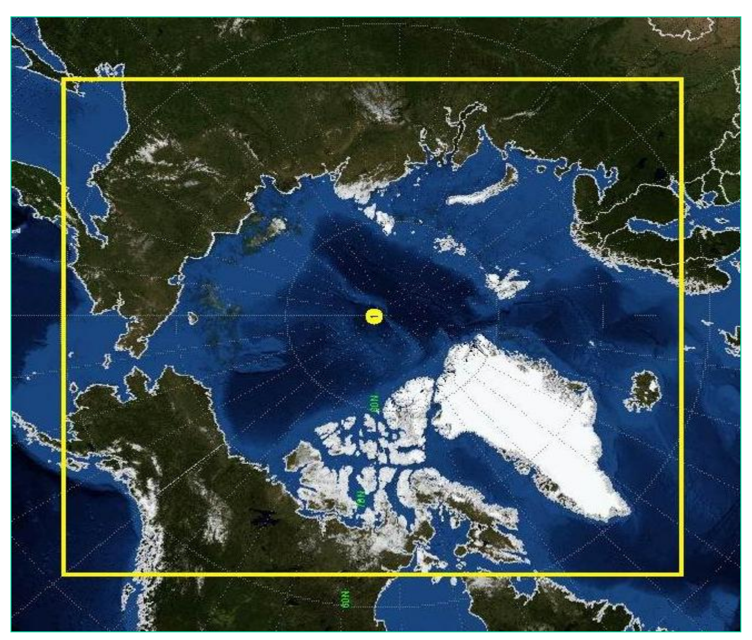

Figure 1: CORDEX Arctic 50-km domain

## Simulation Setup

- For this study, we used a polar-modified version of the Weather Research and Forecasting (WRFv3.1) model for the simulation period of 1989 - 2007
- Model initial and boundary conditions were provided by the ECMWF ERA-Interim reanalysis and NSIDC sea ice concentration
- Four input fields were nudged with WRF's default spectral nudging: U and V wind components, temperature, and perturbation geopotential height
- Simulations used the CORDEX Arctic domain, covering:
  - Most of the Arctic's sea ice and most major surface drainage systems
  - Critical inter-ocean exchange and transport features important for regional climate modeling

# Daily Widespread Precipitation Extremes Southern Alaska Analysis Master SOM DJF: 1989 – 2007

- The Self Organizing Maps (SOM) algorithm employs an artificial neural network that uses an unsupervised training process
  - Determines generalized patterns in the input data
  - Organizes similarly grouped data records into a 2D array
- Our SOM training uses MSLP anomalies (shown here) or 500-hPa geopotential height anomalies
- Data (e.g., precip. and 2mT) can then be mapped onto the Master SOM for more in-depth analysis

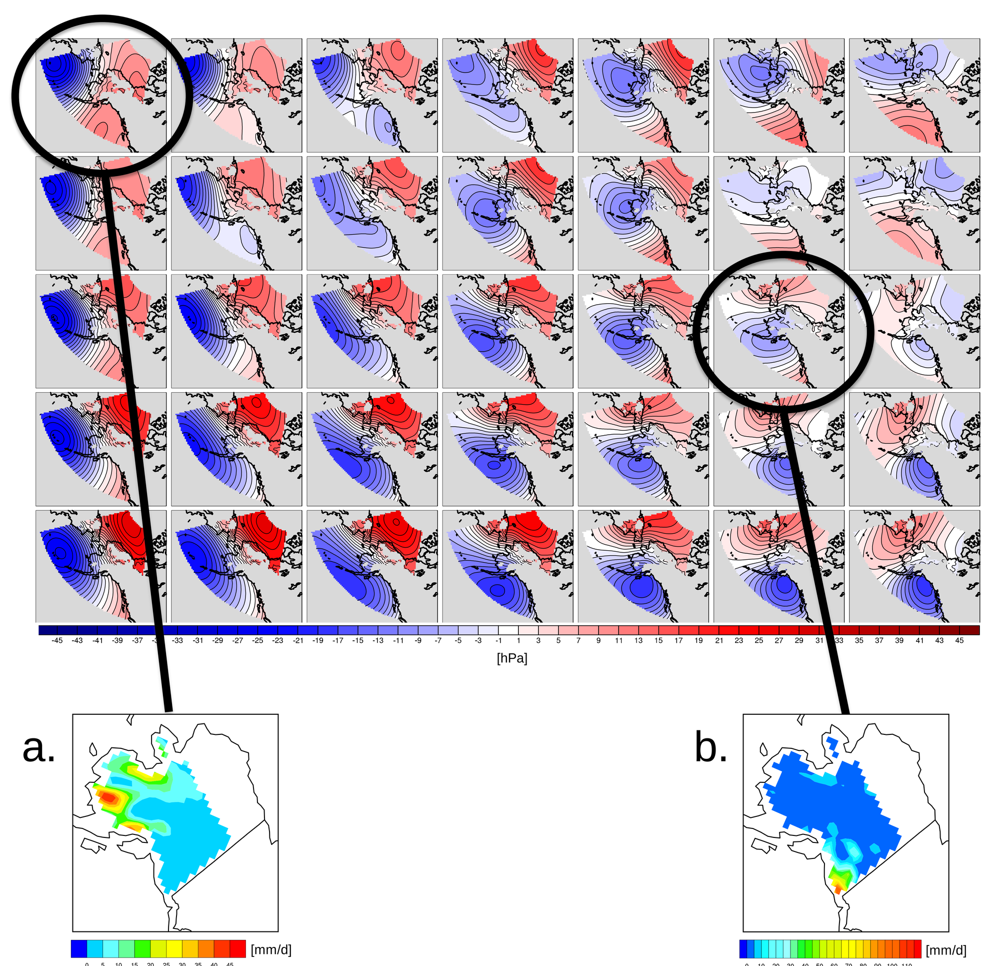


Figure 2: Alaska South Master SOM trained with 1989 – 2007 DJF MSLP anomalies. Inset figures (a) and (b) represent widespread extreme daily precipitation events and their associated node circulation.

- Widespread extreme events are defined by top 1% of daily precipitation occurring on 25 or more grid points
- Mapping of WRF precipitation extremes onto Master SOM highlights regions in SOM space that have circulations conducive to extreme events
- The spatial location of events within the analysis region, coupled with the node(s) being accessed gives us a better idea of how different circulations produce different widespread extremes
- Fig. 2 shows two unique extreme events occurring in different parts of the Alaska South region. Nodes being accessed by each event show how SOMs can be used to differentiate circulation types

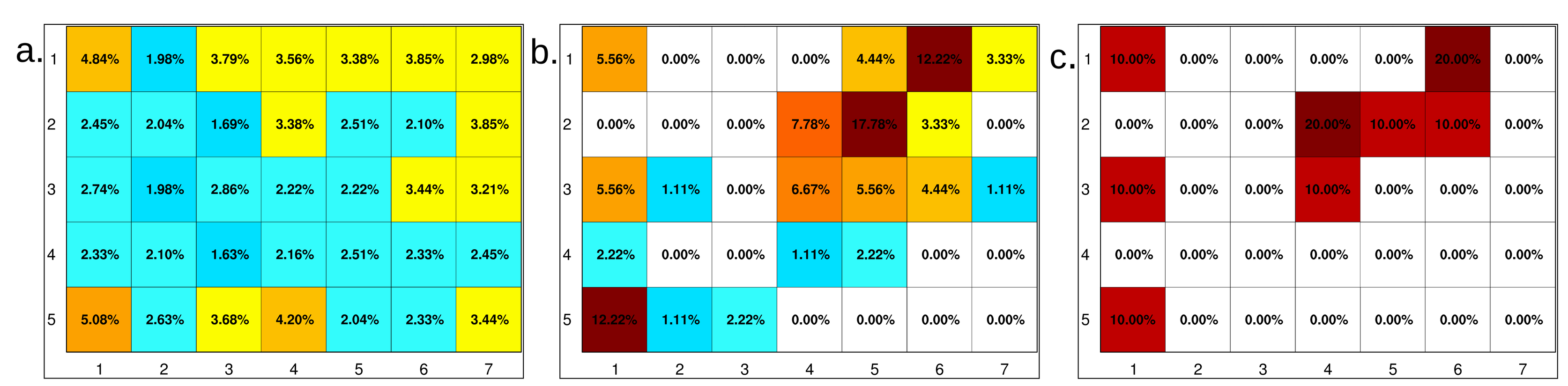


Figure 3: Frequency plots of WRF DJF precipitation mapped onto the Alaska Master SOM for (a) climatology, (b) widespread 99th percentile, and (c) top ten most extreme events.

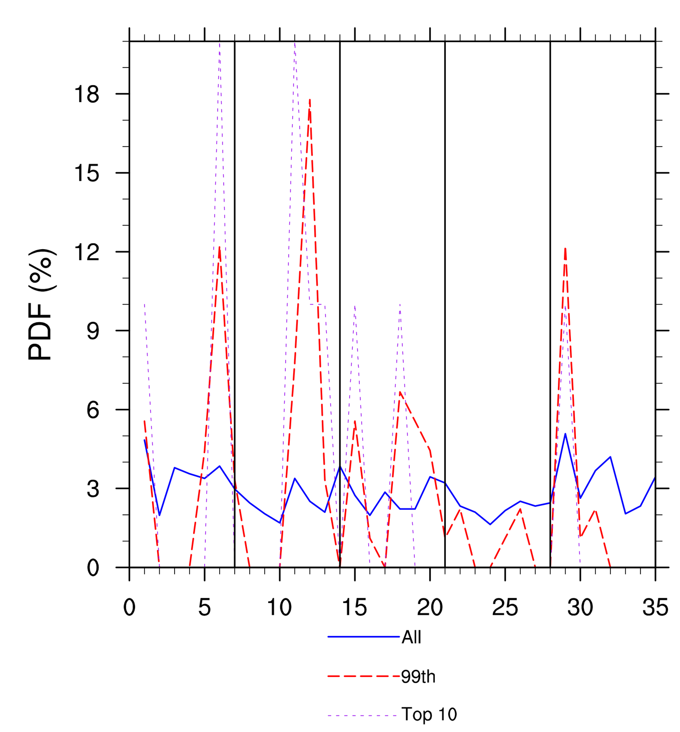


Figure 4: Probability distribution function of WRF DJF precipitation mapped onto the Master SOM. Blue curve represents climatology, red-dashed represents the 99th percentile, and purple dotted curve represents the top 10 extreme events.

- The WRF climatology of daily precipitation (Fig. 3 (a)) shows higher concentration of precipitation mapping to the exterior nodes of the Master SOM
- Fig. 3 (b) and (c) show two regions of SOM space producing the majority of extreme events in Alaska South during DJF. These regions correspond to the two events found in Fig. 2
- Overlap of PDF curves for extremes (Fig. 4) -- 99th percentile (red) and 99th top 10 events (purple) – emphasizes that certain parts of SOM space are being accessed at a higher frequency, and thus the associated circulations play a greater role in producing extreme events

# Daily Widespread Precipitation Extremes Eastern Polar Canada Analysis Master SOM DJF: 1989 – 2007

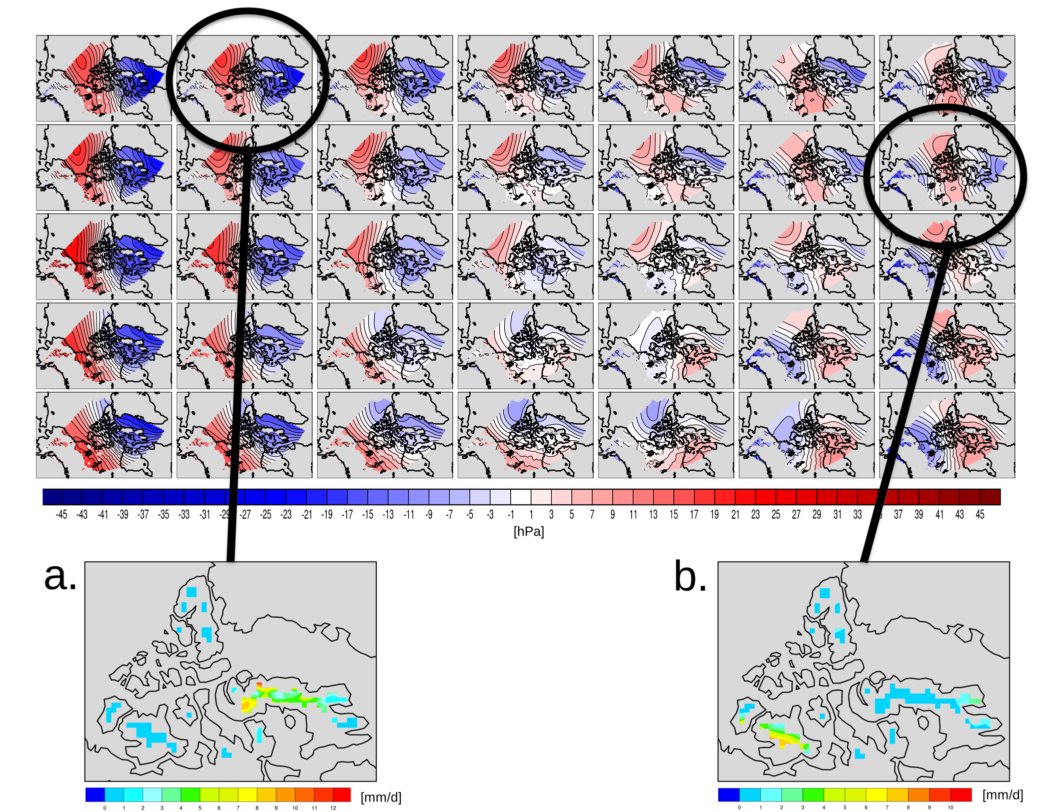


Figure 5: As in Fig. 2 but for the Eastern Polar Canada analysis region

- The Master SOM for Eastern Polar Canada shows at least two different regions where extreme daily precipitation is occurring
- We find general similarities in the circulation patterns found on the nodes being accessed by each type of extreme precipitation event
- Variations in the strength -- and more importantly, location -- of the low pressure center appears to cause the resultant widespread extreme event

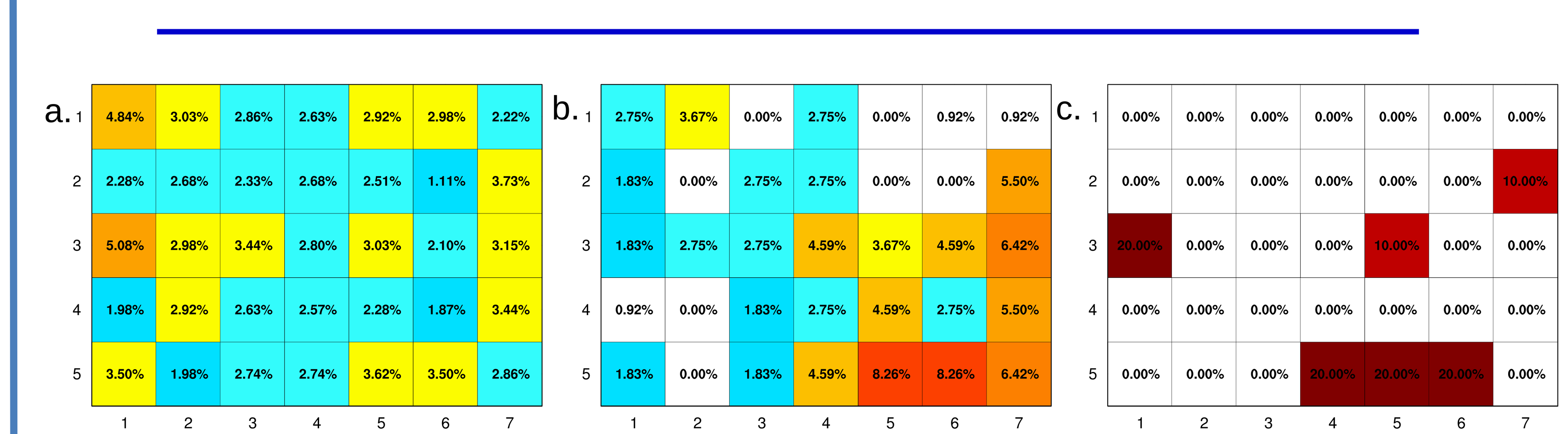


Figure 6: As in Fig. 3 but for Eastern Polar Canada

- Climatological daily precipitation for this region (Fig. 6 (a)) shows a more distributed pattern in SOM space than found in the Alaskan frequency plot shown in Fig. 3 (a)
- Widespread daily extreme precipitation events are mapping primarily to lower right side of SOM space
- We find a general pattern of a low (high) pressure over the western (eastern) part of the Canadian Archipelago. Extreme events in this region are focused on the western islands of the archipelago

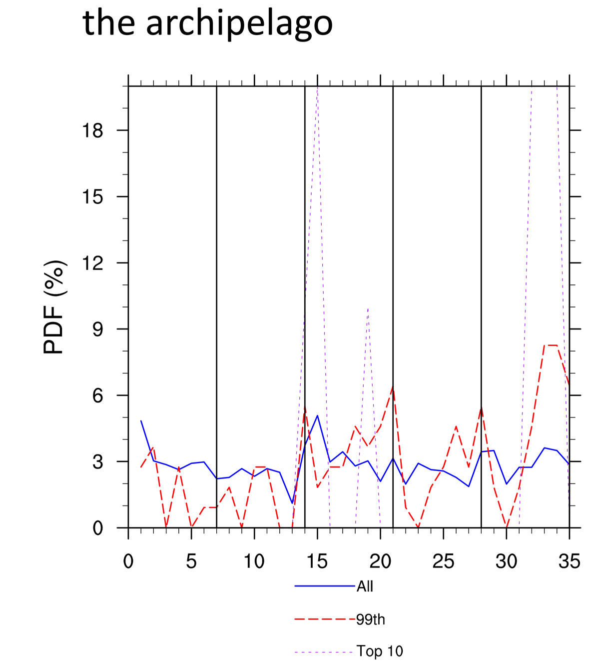


Figure 7: As in Fig. 4 but for Eastern Polar Canada

- Overlap of PDF climatological and extreme curves (Fig. 7) shows similar behavior to that of the Southern Alaska analysis region
- However, extreme daily precipitation events (red curve) show a more uniform probability of occurrence across SOM space

## CONCLUSIONS

- SOMs do a good job in differentiating large-scale circulations, especially in terms of how they relate to specific extreme precipitation events occurring in different parts of our two analysis regions
- SOMs are a good tool for exploring the physical climatology of extremes
- Frequency plots give us a better understanding of whether or not specific parts of SOM space are more (or less) conducive for extreme events
- Precipitation events in both analysis regions have an orographic component, which is related to flow associated with circulations found on highly accessed SOM nodes