Analyzing Arctic Heat Transport Using Self-Organizing Maps

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1 Introduction

- Arctic Amplification (AA) induces a change in the meridional temperature gradient, which might lead to changes in the circulation
- Result into more meridional transports (Cohen et al., 2014)
- The impact of atmospheric heat transport into the Arctic on the surface temperature unknown
- The contribution of transport changes to the AA needs to be quantified
- Cluster analysis is used to extract transport pattern from reanalysis data
- Clustering make it possible to find corresponding changes in temperature for each heat transport pattern

2 Data & Method

- Calculating vertically integrated heat transports from ERA-Interim data (Dee et al., 2011)
- Daily data for the winters from 1979/80 to 2015/16
- Using simple neural network called Self-Organizing Map (SOM) for pattern extraction and clustering (Kohoen, 1998)
  - SOM algorithm seeks to map user-defined number of pattern to a distribution of input data
  - No linear assumptions
  - Preserve probability density function of analyzed data
  - Resulting patterns are representation of the probability density function of the given data

3 Results

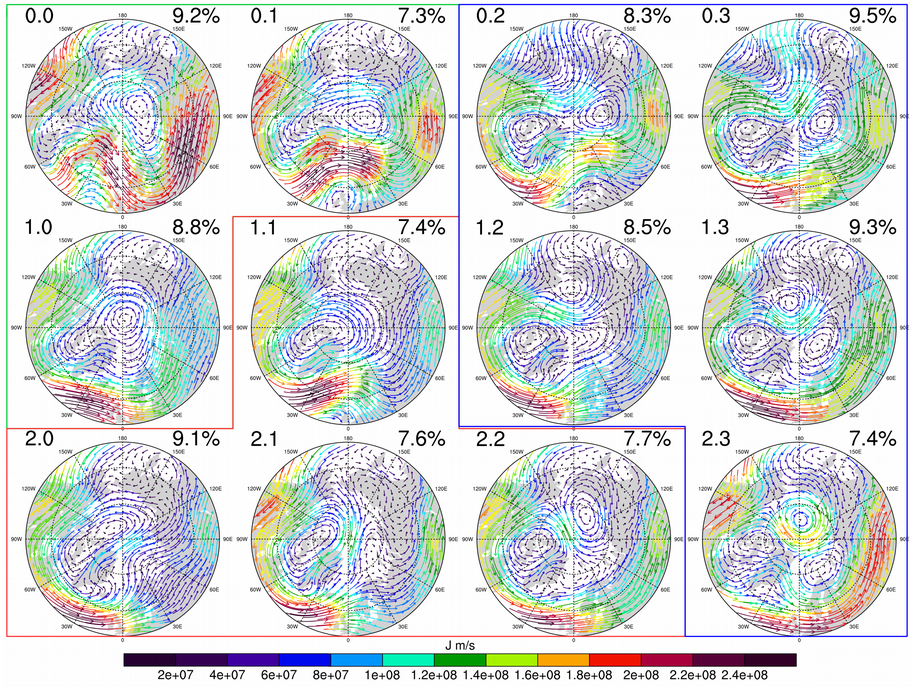

Fig. 1: SOM of mean tropospheric (1000 hPa-200 hPa) heat transport (c_p*v*T) using ERA-Interim daily mean data for Winter 1979/80-2015/16; contour units are Jm/s, numbers on the upper right corner of the respective panels show occurrence frequency in %. Red and blue lines between panels show grouping of related patterns.

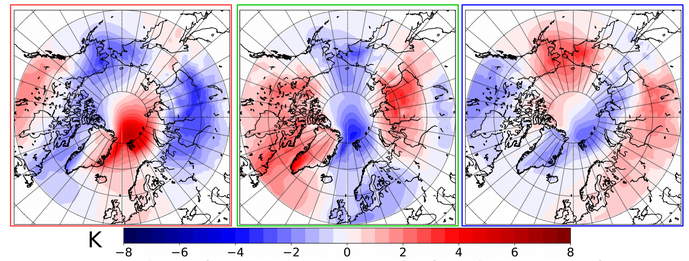

Fig. 2: Corresponding surface air temperature anomalies for each group pattens from Fig. 1, red colors denotes warmer and blue colors denotes colder temperatures than the ERA-Interim winter mean.

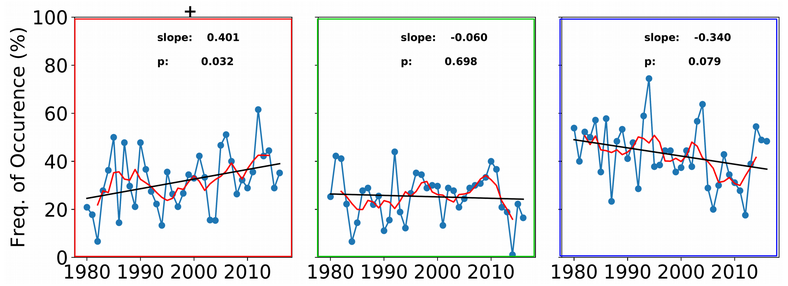

Fig. 3: Change in frequency of occurrence for each group of pattern, blue dots show occurrence frequency of each pattern group for a given winter of a year, red line shows 5 year running mean black line shows the respective linear fit, two-sided p-value for a hypothesis whose null hypothesis is that slope is zero using t-test are shown for each group of pattern.

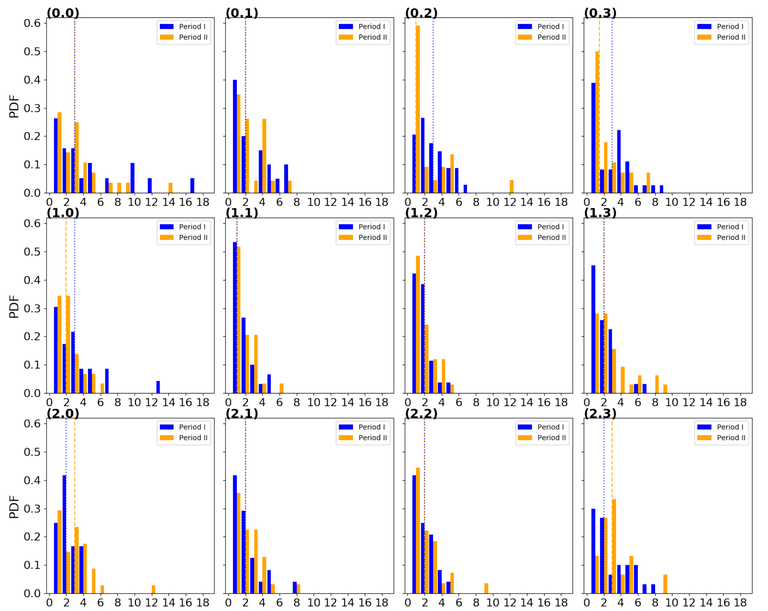

Fig. 4: Probability density function of the persistence of each pattern of the SOM shown in Fig. 1 for two time periods, blue shows Period I with winters from 1979/80 to 1994/1995 and orange shows Period II with winters from 2000/2001 to 2015/2016, vertical lines show the respective median of the distributions.

4 Conclusion

- The analysis shows that transport through the North Atlantic is getting more frequent (in agreement with the literature, e.g. Dahlke and Maturilli, 2017)
- This change in transport is connected with an increase in surface air temperature
  - Similar results are obtained when using the SOM on surface air temperature fields and looking at the corresponding heat transports (not shown)
- Patterns (2.3) and (2.0) show both increases of their persistence when comparing first and last 15 years of the considered time interval
  - While pattern (2.3) is getting less frequent, pattern (2.0) is getting more frequent
  - Thus, if transports pattern like pattern (2.3) occur, they will be more persistence compared to the early 15 years of ERA-Interim
  - Pattern (2.0) is getting significantly more frequent while also being more persistent
  - This results into an increased probability of blocking events for transport pathways that can be associated to those pattern

References

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- Using SOM to compare atmospheric states of tropospheric heat transport
- Three major pathways could been identified:
  1) Through northern Atlantic into central Arctic
  2) Through northern Pacific
  3) Mostly transport through northern Siberia
- Patterns are grouped into the respective transport pathways
- Transports through northern Atlantic are connected with a warmer than usual central Arctic
- Transports through Siberia are connected to a colder than usual Arctic
- Pattern with transport through North Atlantic are getting more frequent since the last decades, while patterns that favor a colder Arctic and warmer Bering Strait are getting less frequent
- Persistence of patterns/states changes compared between late 20th century and early 21th century
- Some patterns are switching from transitional pattern to more persistent pattern and vice versa (e.g. pattern (0.2) and (0.3))

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