Synoptic Climatology for the Troposphere Over the Southern Beaufort Sea

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1. Introduction & Objectives

Atmospheric dynamic processes in the troposphere are responsible for cyclogenesis, steering storms, and atmospheric stability, all which drive surface pressure patterns and surface winds (Stull, 2000). These processes can be investigated using techniques of synoptic climatology. The synoptic climatology of the Southern Beaufort Sea has previously been analysed using PCA and subsequent k-means clustering on gridded mean sea level pressure data from 1979 – 2011 (*Asplin et al.*, 2009). This synoptic climatology yields twelve distinct atmospheric circulation patterns that characterize ~90% of the surface pressure circulation types, and provides a daily catalogue of regional daily surface circulation types.

Of particular interest is the increase in frequency of strong easterly wind events in recent years of sea ice decline (Moore and Pickart, 2002) in the southern Beaufort Sea during the fall (October – November – December, OND). Strong winds combined with increased fetch can lead to large wave development, which can persist later into the fall with delayed freeze-up. This study will focus upon the circulation characteristics of the twelve synoptic weather patterns identified by *Asplin et al.*, (2009), and investigate the following:

1) What are the corresponding tropospheric conditions within each synoptic type during OND?
2) What are the corresponding surface wind statistics for the region within each synoptic type?
3) What is the nature of variability in upper-level atmospheric circulation variability on controlling variability in surface winds? (Within-type variability 1979-1998/1999-2011)

2. Field Data and Study Bounds (2009 - 2011)

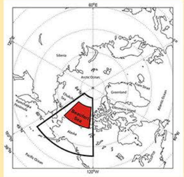


Figure 1. Left: Southern Beaufort Sea Region (SBSR) Black boundary: Atmospheric synoptic classification region: Red area: ArcticNet Programs study region,

Gridded daily NCEP-NCAR II Reanalysis data (2.5° x 2.5°) (Kalnay et al., 1996) is retrieved for 1979 – 2011. A set of synoptic circulation types (synoptic types), is classified from the daily MSLP data using PCA and subsequent k-means cluster analysis (Dahni and Ebert, 1998). Six principal components explain 89% of the variability, and are retained, and the k-means analysis yields a 12-cluster optimal solution. MSLP composite maps are created to visualize each synoptic type and show the characteristics of the geotropic flow (Figure 4).

Figure 2.

Hourly wind data (m/s) is retrieved from Environment Canada for the Weather station located at Pelly Island, NWT (Figure 2). The wind data Is available at a 1-hour frequency

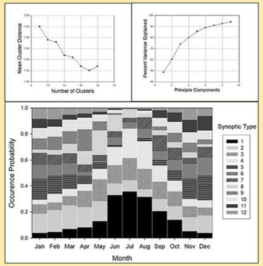


Figure 3. Top Left: Principle component and cluster scores for atmospheric synoptic classification process. Right: Twelve synoptic types with prevailing 850 – 1000mb vector winds. Warm (cold) temperature advection is shown in red (blue). Bottom Left: cumulative synoptic type probabilities.

3. Synoptic Climatology (1979 – 2012)

Figure 4. Mean Sea Level Pressure Synoptic Climatology

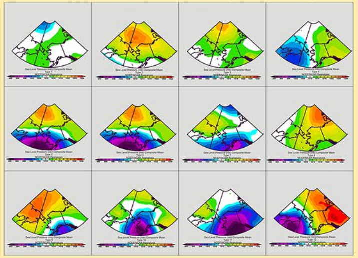


Table 1. Chi Square frequency test for seasonal synoptic types (1979-1998 vs 1999-2012)

Synoptic Type	JFM	AMJ	JAS	OND
Type 1			⊗	
Type 2				⊗
Type 3	⊗		⊗	⊗
Type 4		⊗		
Type 5		⊗		
Type 6	⊗			⊗
Type 7			⊗	
Type 8		⊗	⊗	
Type 9		⊗		⊗
Type 10				
Type 11				⊗
Type 12				

Changes in annual and seasonal synoptic type frequencies attributed to declining sea ice extent were assessed using chi-squared frequency analysis by comparing mean synoptic type frequencies during 1999 – 2011 where declining summer Arctic sea ice extents are observed to be accelerating to those from 1979 – 1998. Significant changes ($p < 0.05$) are presented in Table 1 (left).
Of note, Types 2, 3, 6, 9 and 11 exhibit significant changes in frequencies for OND.

Hourly wind data from Pelly Island, NWT are grouped by synoptic type and plotted for the two periods (1979 – 1998 and 1999 – 2012 (Right).

- Easterly winds are common during OND for all five synoptic types, and stronger
- During 1999 – 2012 Type 2 and 6 exhibit increased variability in wind direction in 1999 – 2012, including
- stronger northwest winds.
- Type 3 exhibits stronger wind magnitude for all directions.
- The occurrence of northwesterly winds durings types 9 and 11 decreases to near-zero
- During 1999 -2012.

4. Tropospheric Circulation Patterns (October – December)

Figure 5. Mean Composites 1979 - 2012

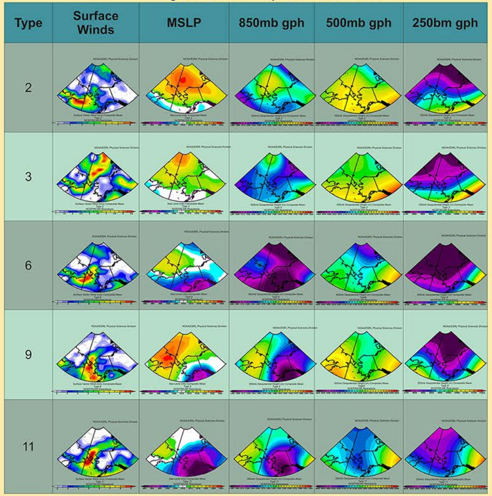
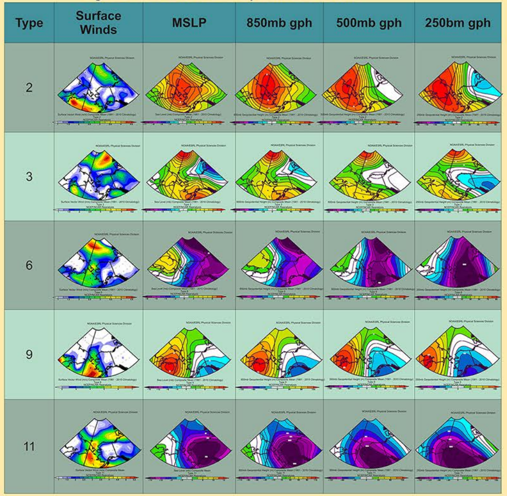
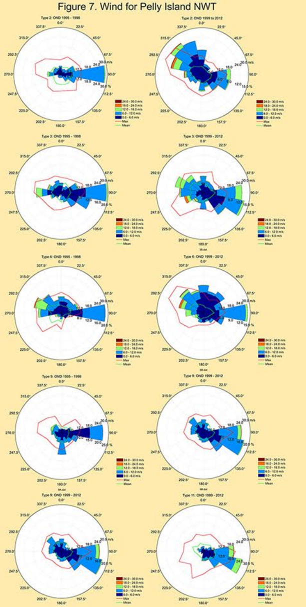


Figure 6. 1999 – 2012 Anomaly From 1981 – 2010



5. 1979-1998 vs 1999-2012)

Figure 7. Wind for Pelly Island NWT



6. Discussion and Conclusions

Synoptic types based upon sea level pressure provide a basis for further analysis of the troposphere. Seasonal geopotential composites for 1000mb, 700mb, 500mb and 250mb composites for 700mb are investigated for conditions favorable to cyclogenesis. From this analysis, it would appear that easterly winds are increasing in strength and frequency during OND. Easterly wind magnitudes are noted to increase particularly in types 9 and 11 for 1999 - 2012. Furthermore, the frequency of types 9 and 11 have increased significantly during OND, coinciding with delayed freeze-up of the sea ice cover.

Key References

Asplin, M.G., Lukovich, J.V., Barber, D.G. 2009, Atmospheric forcing of the Beaufort Sea ice gyre: Part I: Surface pressure climatology and sea ice motion, *Jour. Geophys. Res. (2008JC005127)*

Data sources and Acknowledgments

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