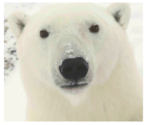
Wind Field Climatology and Extremes in the Chukchi/Beaufort Seas and Alaska North Slope



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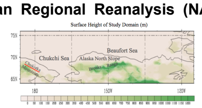
Motivation and Background

Further oil development in the Chukchi/Beaufort Seas requires improved understanding of the surface wind field, an important variable for driving ocean currents. Thus, a study has been established to investigate the mesoscale and climatological features of the surface wind field throughout the Chukchi/Beaufort Seas and Alaska North Slope. In this presentation, the wind field climatology for the entire study region was analyzed with the 3-hourly North American Regional Reanalysis (NARR) for the period of 1979-2009.



Data and Methods

- NARR 32km, 3 hourly gridded wind vector (10 meter U,V), and the latent heat flux during 1979-2009.
- Monthly mean, the 95th percentiles wind speeds were calculated.
- Occurrence frequency of wind direction were checked.
- PDF's and CDF's are calculated.
- Linear trends of average wind speeds and 95th percentile wind speeds are calculated at the 95th % confidence level.

Climatology of Monthly Mean & 95th Percentile Winds

Monthly average wind speeds in the Chukchi/Beaufort Seas (Figure 1b) show a clear seasonal cycle:

•The minimum wind speeds occur in May at ~2.5-4 m/s.

•The maximum wind speeds reach 6 m/s in the Beaufort Sea and 9 m/s in the Chukchi Sea in October.

•Overall seasonal variation starts in May/June, then increases to a maximum in September/October with the highest wind speeds in the Chukchi Sea, decreases in November until the minimum again in May

The 95th percentile wind speeds show a similar cycle, strong winds in fall (15 m/s) and calm winds (9 m/s) in spring (not shown).

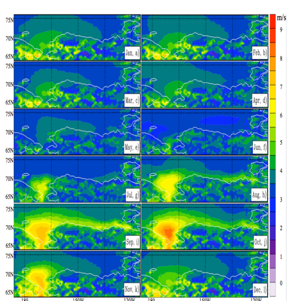


Fig.1a. Monthly average wind speed (m/s)

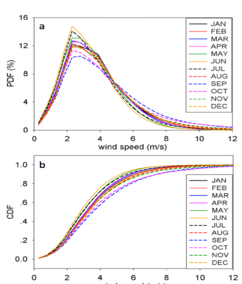


Fig 1b. Monthly PDF's and CDF's of wind speed (m/s)

Climatology of Wind Direction: Dominant Northeast Winds

- Monthly wind direction for the Northeast, expressed as a percent.
- Clearly the dominant direction in the Chukchi/ Beaufort Sea for all months of the year, with values up to and above 60%, especially for the winter months.

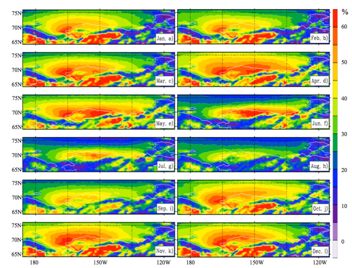


Figure 2. Monthly Northeast wind direction for 1979-2009 for each month, January through December. The values are expressed as percent from 0% to 60%.

Climatology of Monthly Wind Direction: Mesoscale Features

- During the winter months there are anomalous Southwest winds along the Brooks Range and anomalous NW winds long the Chukotka Mountains in Siberia.

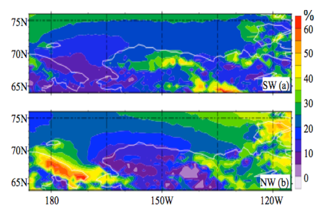


Figure 3. Frequency of southwest (a) and northwest (b) winds during the cold months (Jan.-May, Oct.-Dec.) of 1979-2009.

Arctic air is very stable. When the stably stratified airflow approaches a mountain barrier the flow can't go over the mountain and will be blocked. The pressure force exerted by the wind on the windward slope will slow down the flow, the original balance between synoptic pressure gradient force (PGF) and the decreased Coriolis force won't exist. Large PGF causes the flow moves to the left (lower pressure) in the Northern Hemisphere, a mountain barrier wind parallel to the longitudinal axis of the mountain is setting up.

Diurnal Cycle over Land and Ocean

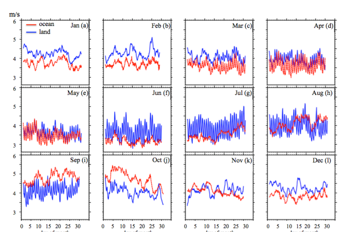


Figure 4. 31-year domain averaged 3-hourly wind speed (m/s) in each month over ocean (red) and land (blue).

- There is a clear diurnal cycle over ocean in spring.
- Clear diurnal cycle over land during summer.
- Weaker radiation forcing during winter and larger heat capacity over open water reduce the diurnal signal in the wind field variations the rest of the year.

Increasing Trend of Extreme Winds

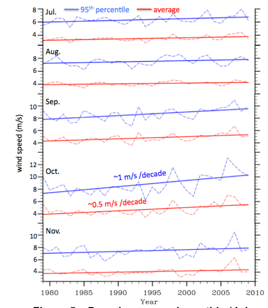


Figure 5a. Domain averaged monthly (July through November) mean (blue) and 95th percentile (red) wind speeds from 1979 to 2009.

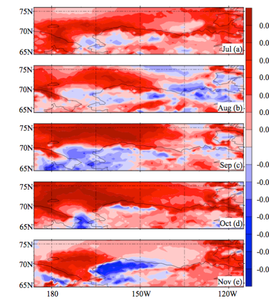


Figure 5b. The monthly (July through November) linear trend distributions during 1979-2009.

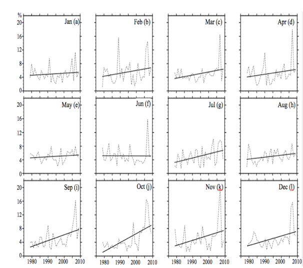


Figure 5c. Monthly frequency of extreme wind events from 1979 to 2009.

• There is a clear increasing trend in wind speeds from 1979-2009.
• Largest increasing trend occurs in October
• Geographically the largest increasing trend is over most of the Chukchi/Beaufort Seas (Figure 5b.
• The trend of extreme wind events also shows an increasing trend (figure 5c). The largest increasing trend is in Sep to Nov with the largest increase in Oct.

Summary and Future Plan

- Strongest winds in the Chukchi/Beaufort Seas occur in September/ October.
- Relatively weak winds occur in the late winter and spring months.
- A striking anomalous SW wind flow occurs in the winter along the Brooks Range near Deadhorse.
- The mean wind speeds from 1979-2009 show a positive trend, especially in Sep/Oct.
- Extreme wind speeds also show on increasing trend in Sep/Oct.
- Future work to investigate the wind stress and Ekman pumping in the region to define areas of upwelling and downwelling.
- Future work also to include the effects of sea ice, bathymetry, and internal Kelvin waves on wind stress and Ekman pumping in the region also.

Acknowledgements

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