Characterizing Upwelling Events in the Western Arctic

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Abstract

Mooring data from the shelfbreak of the Beaufort Sea are used to identify and characterize the upwelling events over the period 2002-2003. An objective scheme is used to define the events, of which there are 22 between September and May. Using the timeseries of temperature, salinity and velocity, as well as wind data from Pt. Barrow, Alaska weather station, a conceptual upwelling event is described. The variation about this canonical state is investigated using two indices, one that measures the effectiveness of the winds in driving upwelling, and the other measuring the magnitude of the water-column response. Comparison of these indices shows a high correlation as expected; however, it reveals that other factors, such as pack-ice or the tracks of the storms, must play an important role in dictating how the shelfbreak current responds to the upwelling-favorable winds.

Defining Upwelling

A reversal of the current from eastward to westward and a simultaneous appearance of a warm and saline water are considered evidence of upwelling. Accordingly, three criteria were applied, one to each one of the timeseries obtained from the moored profilors:

1. Wind direction of the alongsetream velocity from 180° to 150°
2. Salinity ≥ 34.5
3. Temperature ≥ 0.8°C

22 groups were found and they were characterized as upwelling events.

• All of the events occurred from September to May.
• November is the dominant month with 6 events (the most intense event also occurred in this month)

The time distribution of events correlates well with wind direction. During the upwelling period (September to May) the winds are predominantly easterly, while in summer they are westerly.

How do the upwelling events affect the properties of the water?

Figure 2: The cross-shelf bathymetry of the Beaufort shelfbreak and slope, and the spatial arrangement of the mooring array. The blue lines indicate moored profilers that were equipped with CTD sensors, and upward-facing ADCPs.

In this study the salinity, temperature and velocity timeseries of the BS3站点 were used.

Correlation with the wind

For each upwelling event two indices were used in order to correlate the upwelling events with the wind.

1. The Relative Favorable Wind index, W, measures the effectiveness of the winds in driving upwelling.

\[ W = f(V, \delta) \]

V: wind speed, \( \delta \): the deflection of the wind direction from the mean wind direction (UH T).

Both the wind speed and the wind deflection were scaled from 0 to 100, with 100 corresponding to the maximum value, and they were added. The number that resulted was again scaled to a 100-basis scale.

2. The Relative Upwelling Index, S, measures the magnitude of the water-column response.

\[ S = f(t, d, \delta, T) \]

t: time duration of the event, \( d \): effective depth, \( s \): mean salinity at 130 m, \( T \): mean temperature at 130 m

As before, each one of these factors was scaled from 0 to 100, with 100 corresponding to the maximum value, and they were added. The resulting number was scaled from 0 to 100.

Summary

• 22 events occurred in a yearlong period, all of them from September to May.
• The mean depth that the upwelled waters reach at the BS3 station (bottom depth of 150m on the upper slope) is 85m.
• Comparison of the W and S indices shows a high correlation of the wind to the upwelling, as expected. However, the cases where the two indices have a different behavior reveal that other factors, such as pack-ice or the tracks of the storms, must play an important role in dictating how the shelfbreak current responds to the upwelling-favorable winds.