

DYNAMICS OF WIND AND BUOYANCY FORCED MOTIONS ON THE BEAUFORT SHELF

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LONG TERM GOALS

Understanding of inner shelf dynamics impacted by both wind and buoyancy forcing.

OBJECTIVES

The input of fresh water from Siberian and Canadian rivers impacts the ice cover in the Arctic Ocean as well as the dispersal of sediments, pollutants, and contaminants. The physical processes of buoyancy and wind driven motions on shelves an Ekman layer depth deep are poorly understood both in the Arctic and at mid-latitudes. The main objective of this project is to describe and physically explain the dominant processes on the Canadian Mackenzie shelf prior to the onset of winter freezing. More specifically, the project will answer the following questions:

1. Does the outflow from the Mackenzie force an along-shore current?
2. How do overlapping surface and bottom Ekman layers respond to strong wind forcing?
3. What is the spatial extend of the buoyancy and wind forced motions?
4. How do particles disperse on the shelf as the result of this forcing?

APPROACH

In the fall of 1994 I led an 8-day oceanographic expedition in support of the multi-national and multi-disciplinary Beaufort Arctic Storms Experiment (BASE). While BASE is largely a meteorological experiment to better predict Arctic polar lows, this project concentrates on the physical oceanography and, more specifically, the evolving velocity fields on the shelf. For this purpose I mounted 2 acoustic Doppler current profilers (ADCP) to the Canadian Coast Guard Ship (CCGS) Arctic Ivik, deployed 15 satellite tracked surface mixed layer drifters, deployed an S4 current meter mooring, and collected about 86 shallow conductivity-temperature-depth (CTD) profiles. Extensive supplemental data such as winds, river discharge, ice maps, and sea level data from Canadian archives supplements this data set.

ACCOMPLISHMENTS

The velocity data from a vessel-mounted 1228 kHz NarrowBand (NB) ADCP were both calibrated and detided. This allowed me to study the subtidal flow fields on the shallow (<35 m) inner shelf where this instrument tracked the bottom at all times. In deeper waters a 307 kHz

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BroadBand (BB) ADCP provided vertical velocity profiles along the ship track. An inter-comparison of data from this instrument with data from a NB-ADCP revealed good agreement for the bottom-track but not for the water-track data. This discrepancy required an additional calibration step for the BB-ADCP data. I also processed thermistor data from surface mixed layer drifters and constructed maps of sea surface temperature. Drifter derived surface velocity data were analyzed for their differential kinematic properties such as vorticity and divergence.

SCIENTIFIC/TECHNICAL RESULTS

The transition from weak downwelling favorable to strong upwelling favorable winds resulted in an unsteady, spatially variable flow field. The along-shelf local acceleration term is of the same magnitude as both the Coriolis and bottom friction terms in the along-shelf momentum balance. The winds appear slightly sheared across the 120 km wide shelf. Weaker winds occur both over land and over the ice pack offshore. Inshore of the 15 m isobath waters are weakly stratified, however, the inner shelf surface flow is both intense and in the direction of the winds. At the location of the maximum winds near the center of the shelf, the oceanographic surface flow is about 60 degrees clockwise from the wind direction. An upwelling front separates an inshore from offshore circulation regime. This hydrographic pattern persists for most of the period prior to the onset of freezing.

In 1994 freezing begins with scattered ice advecting onto the shelf from the northeast. This ice extracts the heat from the ocean's surface layer as it melts. A melt water lens thus covers most of the shelf. Only on the inner shelf is salty bottom water brought to the surface and it is this zone which thus experiences the most effective brine production in the absence of estuarine fresh water. It appears from ADCP and CTD observations that the warm and relatively fresh estuarine Mackenzie discharge from the East Channel enters the shelf as a narrow jet in contact with the bottom in water less than 15 m deep. The jet interacts with the upwelling front, becomes locally unstable, and disintegrated rapidly into a multitude of eddies.

IMPACT FOR SCIENCE

The conditioning of shelf waters prior to freezing partly determines the amount of salty brines that are formed during subsequent sea ice formation. Locally wind-driven upwelling brings salty bottom waters into the surface layer thus increasing the amount of brines formed during freezing.

TRANSITIONS

None

RELATED PROJECTS

Two projects relate to the present grant. The PI presently receives support from the National Science Foundation (NSF) to observationally study the dynamics of wind driven flows on the shallow (<25m) and wide (>100 km) mid-latitude shelf off New Jersey. The project is entitled "Coastal upwelling dynamics on a wide shelf." The Office of Naval Research (ONR) also sponsors observational work on the equally shallow and wide shelf off eastern Siberia through the Arctic Nuclear Waste Assessment Program (ANWAP). This project is entitled "Lagrangian flow field observations of the East Siberian Coastal Current." The physical processes studied of the present project are similar to those of the 2 related projects. The shelf geometries are similar, too, however, the geographical setting is different.

PUBLICATIONS

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