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Seasonal Variability of the East Greenland Coastal Current

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Summary

The East Greenland Coastal Current (EGCC) is a cold (θ < 4 °C), freshwater (28 < S < 34) wedge which resides close to the East Greenland coast, extending up to 40 km from the shore. It is a major conduit of freshwater from the Arctic Ocean. However, the seasonal cycle, transport and drivers of the EGCC are unknown due to the lack of wintertime measurements. Here we describe the EGCC seasonal cycle from moorings, transport values using the global model, NEMO, and postulate what could be driving the EGCC. The moorings recorded salinity, temperature and velocities from 2000-2004 showing the EGCC exists throughout the year, strengthening in the winter. Annually, freshening occurred during the spring ice melt, as expected. The model, corroborated by the moorings, calculated freshwater transport (referenced to 35.0) at 84 mSv, peaking in winter (106 mSv) and reducing in summer (59 mSv). Further calculations showed that the cross-shelf density is more important in driving the EGCC than the wind through sea surface height variability. However, the strong equatorward winds over the winter are influential as they force the wedge via Ekman transport towards the coast causing steeper isopycnals thereby increasing the winter velocities and transport.

Introduction

Understanding the Arctic system is of great importance due to the influence it has on oceanic and atmospheric circulations. One particular area, Fram Strait, has the largest liquid and solid freshwater export (Koenigk et al., 2007) which either recirculates north of Denmark Strait, or travels to Cape Farewell. The East Greenland Current (EGC) is made up of liquid freshwater from Fram Strait and, south of Denmark Strait, overlays the warmer, saltier Irminger Current forming the East Greenland Irminger Current (EGIC). Inshore of the EGIC is the East Greenland Coastal Current (EGCC) which is both cold (θ < 4 °C) and fresh (28 < S < 34) extending up to 40 km offshore (Sutherland and Pickart, 2008). The source of the freshwater in the EGCC is uncertain: Greenland terrestrial runoff (Bacon et al., 2002), sea-ice melt (Bacon et al., 2008) and a bifurcation of the EGC (Sutherland and Pickart, 2008) have all been suggested. Seawater (freshwater) transports, derived from summer measurements, range between 0.5 – 2 Sv (<0.1 Sv) (Bacon et al., 2008 and references therein). However, as we do not know the EGCC seasonality, we do know the realistic transport or drivers of the EGCC.

Material and Methods

A model and 2 moorings were used to compliment one another in describing the EGCC seasonal cycle. Inner and outer moorings were deployed at ~20 km and ~40km respectively (either side of the EGCC front), off the East Greenland coast (63°N) in waters ~300 m deep. The inner mooring was deployed from 2001-2003 and the outer moorings yearly from 2000-2004. Most moorings had a shallow CTD (~20 dbar), two middle CTs (~40 dbar, ~60 dbar), and a deeper Valeport CTD/current meter (~90 dbar) recording 10-60 minutes. The Valeport often failed, with most lasting 3-4 months, though one record does cover 11 months. The pressures for the middle CTs were calculated using a basic trigonometric model using the shallowest and deepest pressure recordings. The first outer mooring had two CTDs at ~25 dbar and ~65 dbar. Data was visually checked for errors; knockdowns were scrutinized further. Half the data collected from one Microcat (2001-2002) was lost after a major winter knock. A salinity filter was created by checking the vertical gradient was compatible with surrounding values. Once the data had been quality controlled, we averaged the data monthly to create an annual cycle every 10 dbar from 20-150 dbar.

The global model used was the Nucleus for European Modelling of the Ocean (NEMO) which has a 1/12° horizontal resolution, and 29 (unevenly spaced) levels in the top 150 m. The extracted data covered 2000-2007 in 5-day averages. 'Virtual' moorings were extracted to compare as closely as possible to the real moorings. A cross-section of the shelf salinities, temperatures and velocities were obtained (500 m) after validation.

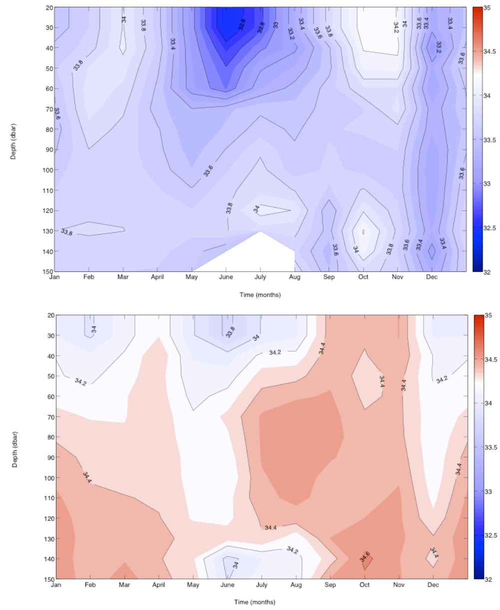

Figure 1: Inner (top) and outer (bottom) mooring annual salinity profile at 63°N

Results and Discussion

The EGCC exists throughout the year. The highest salinities are found in late autumn (Figure 1) relating to Atlantic waters flowing onto the shelf. The freshest waters (< 33.8) exist in late spring where local ice melt, ice melt transported from further north and sea-ice melt combine. The EGCC is much stronger in winter with velocities and transports nearly double that of those in the summer (Figure 2). The 11-month velocity empirical record shows highest values in the winter.

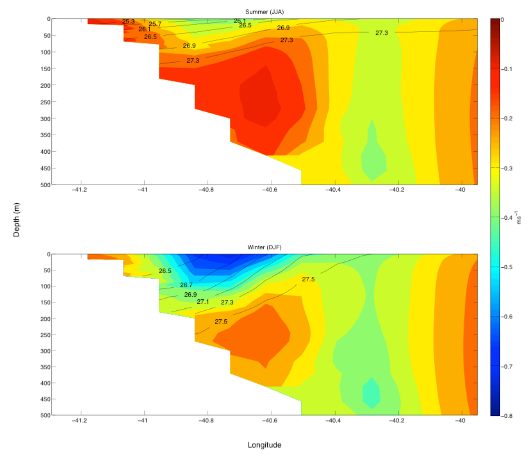

Figure 2: Summer (top)/winter (bottom) downstream (south-west) velocities with density cross-section

The wind forcing component of the EGCC (cross-shelf gradient in sea surface height) is 0.02-0.12 ms^{-1} and the buoyancy forcing component (cross-shelf density gradient) is 0.19-0.45 ms^{-1}, following the methods of Whitney and Garvine (2005). Thus, the EGCC is predominately buoyancy-forced.

The winter transport is stronger likely due to increased winds. In winter, strong winds blow equatorwards. The resulting Ekman transport forces the wedge towards the coast where the isopycnals become steeper increasing velocities thus transport. Additionally, increased wind stress and the increased wind-ice-ocean transfer of momentum may cause the EGCC to strengthen. Though the buoyancy forcing dominates the strength of the EGCC, it is the along-shelf winds that shape the EGCC density structure causing the variability in the intensity.

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