The East Greenland Coastal Current: a subarctic freshwater pathway

David A. Sutherland
MIT/WHOI Joint Program, Woods Hole, MA (*dsutherland@whoi.edu*)

Robert S. Pickart
Woods Hole Oceanographic Institution, Woods Hole, MA

1 Introduction

Limited hydrographic and drifter data indicate that a fresh ($S <$ 34), intense (velocities ~ 1 m/s) current can be found over the inner shelf off of southeast Greenland (Bacon, et al. 2002). Named the East Greenland Coastal Current (EGCC), this flow was initially thought to be a purely meltwater driven current. However, new observations suggest that it is partly of Arctic origin, as a component of the East Greenland/Irminger Current (EGC/IC) system (Sutherland and Pickart, 2007).

Previous research has indicated that freshwater may exit the Arctic Ocean in one of two predominant pathways, depending on the phase of the Arctic Oscillation (e.g. Steele, et al. 2004). One of these pathways is through Fram Strait in the EGC, and thus, potentially in the EGCC farther south.

Our goals in this study are:

- to describe the alongstream evolution of the EGCC's hydrographic and velocity structure,
- to estimate the EGCC's volume and freshwater transport,
- to quantify the freshwater composition (sea ice melt, meteoric water, Pacific-origin water) of the EGCC.

2 Overview of circulation

We present data from a 2004 summertime cruise (JR105) aboard the ice-strengthened vessel *RRS James Clark Ross* that occupied the six sections shown in Fig. 1. These data include:

- 170 conductivity/temperature/depth (CTD) casts
- velocities from vessel-mounted acoustic Doppler current profiler (ADCP)
- nutrient (NO_3, PO_4, SiO_4) and oxygen isotope samples

These data, combined with additional observations from the WOCE-A1E line in 2001-2003, allowed the first picture of the summertime circulation to be drawn that included the EGCC (Sutherland and Pickart, 2007).

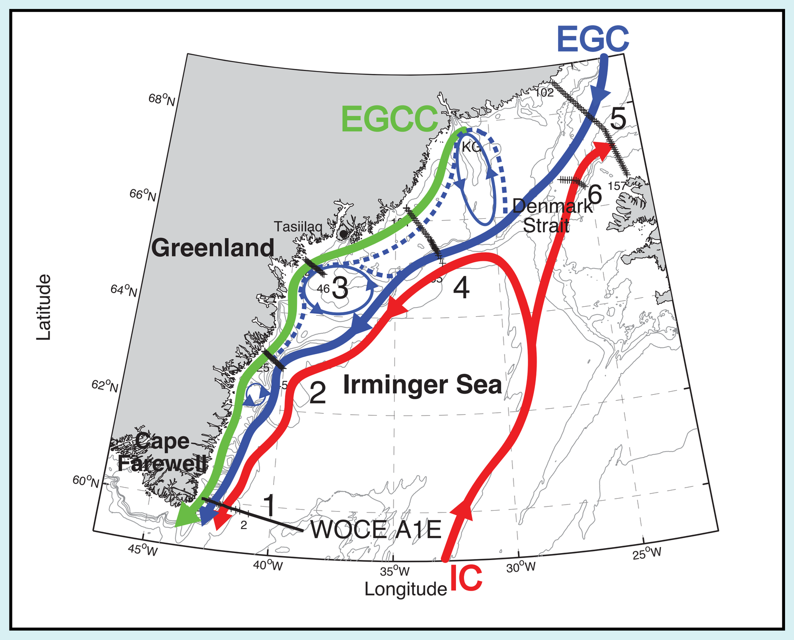


Figure 1. Map of the southeast Greenland shelf area, showing a schematic of the observed summertime circulation. Dashed lines indicate possible pathways of the EGC. Also plotted are the station locations (+) from a 2004 cruise, JR105, along with section numbers (1-6) and the position of the WOCE repeat hyrography line.

4 Freshwater composition

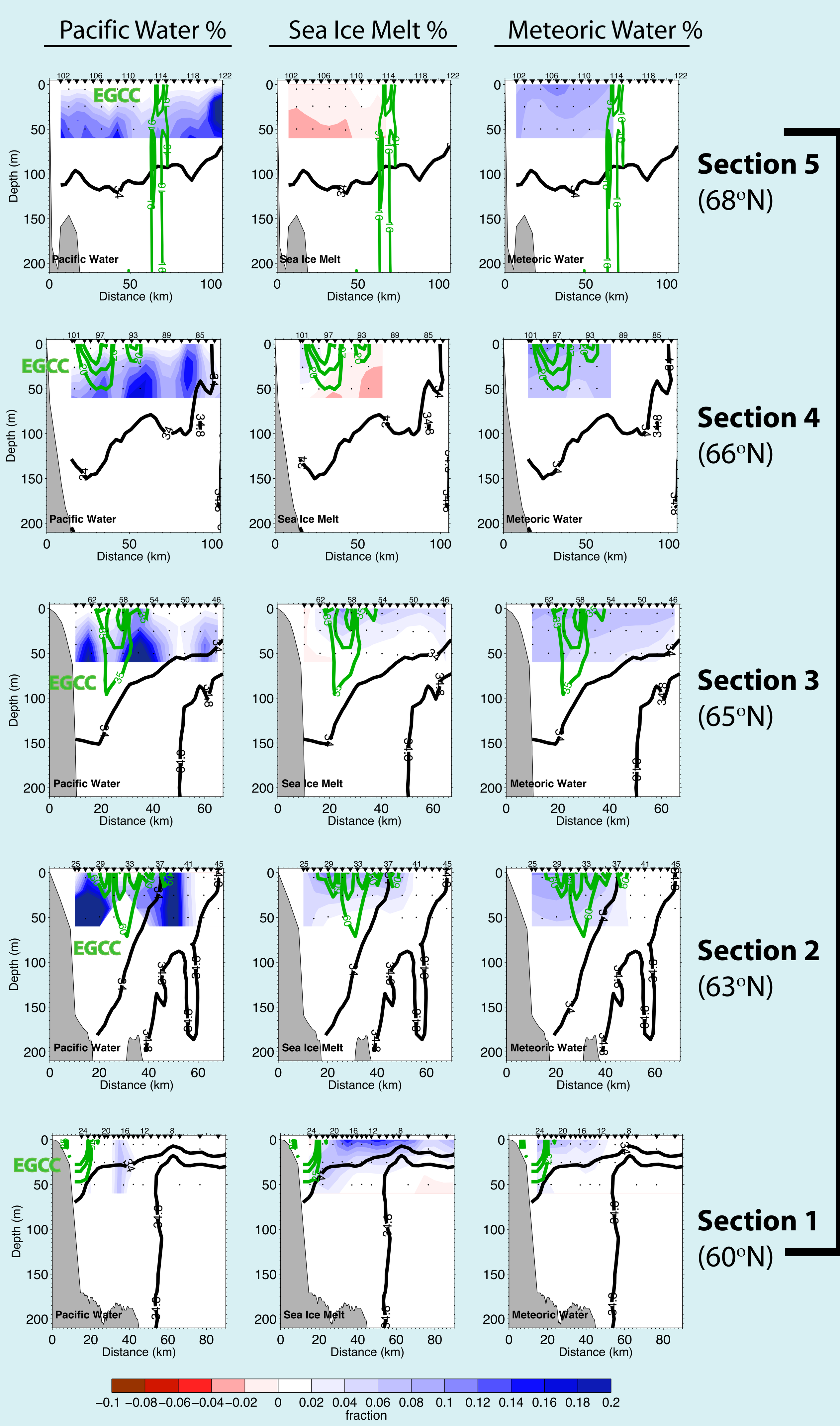


Figure 3. Fractions of Pacific Water, PW, (left panels), sea ice melt, SI, (middle panels), and meteoric water, MW (right panels) for each JR105 section from north to south (top to bottom). The colorbar for all plots is at the bottom. Velocity contours (green, cm/s) indicate the EGCC jet, with isohalines overlaid (black). Dots show JR105 bottle locations. Note the vertical scale stays constant (though some shelves are deeper than 200m), but the horizontal scale changes to reflect the shelf width at each section (see Fig. 1).

Summary of tracer analysis

- Significant fractions of Pacific-origin water are found in the EGCC (up to 20%)

- These high Pacific water fractions are subsurface and eroded in the core of the EGCC jet

- Fractions of sea ice melt increase from negative (indicating Arctic origin water from which ice has formed) at section 5 to positive by section 3 and continue increasing to Cape Farewell

- Maximum meteoric water fractions are ~10% at every section, and typically decrease offshore and in deeper water

- By Cape Farewell, most Pacific water has been mixed away, and only sea ice melt shows a strong signal

3 Nutrient and isotope data

We use the JR105 tracer data to differentiate between the freshwater sources in the EGCC. First, we solve a three end-member balance (see box) to get fractions (*f*) of sea ice melt (SI), meteoric water (MW), and a combined oceanic water (Taylor, et al., 2003). Then, we separate the oceanic water fraction into Pacific (PW) and Atlantic components (AW) based upon the PO_4:NO_3 relationship (Jones, et al. 2003), shown in Fig. 2, *right*.

$$f_{OW} + f_{MW} + f_{SI} = 1 \quad (1)$$

$$f_{OW}S_{OW} + f_{MW}S_{MW} + f_{SI}S_{SI} = S_{obs} \quad (2)$$

$$f_{OW}\delta^{18}O_{OW} + f_{MW}\delta^{18}O_{MW} + f_{SI}\delta^{18}O_{SI} = \delta^{18}O_{obs} \quad (3)$$

Table 1. End member values and uncertainties for the freshwater fraction calculation in equations 1-3. These all are estimated based on the published literature (e.g. Taylor, et al. 2003).

	Oceanic water	Sea ice melt	Meteoric water
Salinity	34.85 (±0.1)	4 (±1)	0
$\delta^{18}O$	0.3 (±0.1)	1 (±0.2)	-21 (±2)

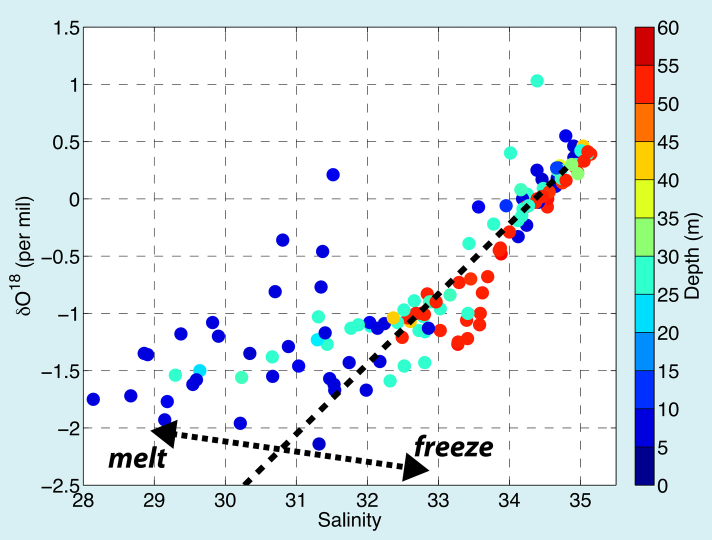
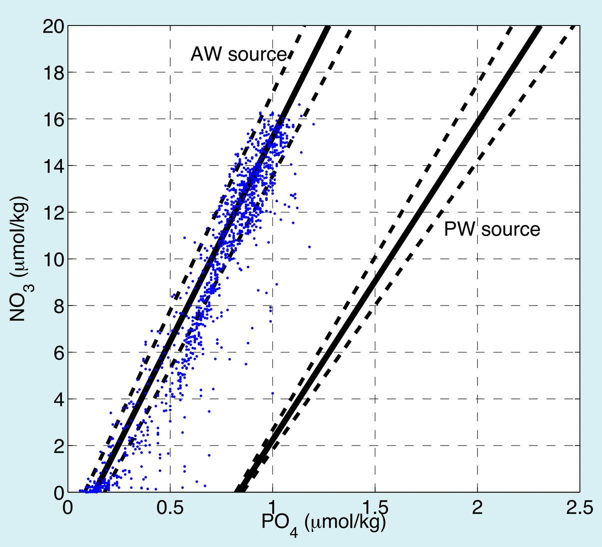


Figure 2. *(left)* Salinity vs. δO^{18} for JR105. Color indicates the depth at which the sample was taken. The dashed line is the mixing line between oceanic water, at top right, with meteoric water (S = 0). The arrows indicate what effects sea ice melting/freezing processes have on the relationship. *(right)* PO_4 (μmol/kg) vs. NO_3 (μmol/kg) JR105 data (blue dots). The solid lines show the PO_4:NO_3 relationship for waters taken from Atlantic Water and Pacific Water source regions. Variability in these source regions leads to the dashed error bars.



5 EGCC variability

Characterized by a wedge-like salinity shape, the EGCC's depth and width scales can change dramatically on short time scales, with a strong dependence on the alongshelf wind stress. This behavior has been seen before in smaller scale coastal currents (Lentz and Largier, 2006), but has never been observed in large rscale flows. However, on longer time scales (seasonal to interannual), not much is known.

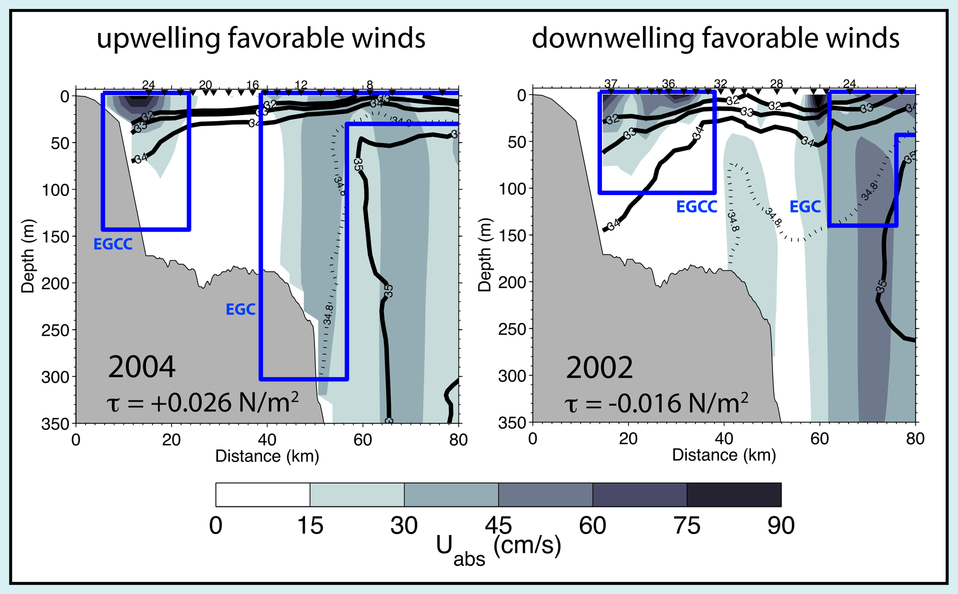


Figure 4. Alongstream absolute velocity (color, U_{abs}, cm/s) and salinity contours (black) for two sections taken at Cape Farewell. Blue boxes roughly indicate the defined regions of the EGCC (inshore) and EGC (shelfbreak) found during each year. The alongshelf wind stress, τ (N/m²), is a two-day average of twice-daily QuikSCAT data. (τ > 0 is upwelling favorable)

6 Volume and freshwater fluxes

The observed EGCC volume transport along the shelf ranges from 0.5-2.2 Sv during JR105, while at Cape Farewell it ranges from 0.5-1.0 Sv (2001-2004). Using the correlation between the alongshelf wind stress and the volume transport, we construct an adjusted volume transport trend along the shelf during 2004. Similarly, we can adjust the observed freshwater transport (relative to S = 34.8). The combined EGCC/EGC system has an approximately constant total volume transport, while the corresponding freshwater flux increases down the shelf. This increase is presumably due to the input of sea ice melt, runoff from Greenland, and net precipitation.

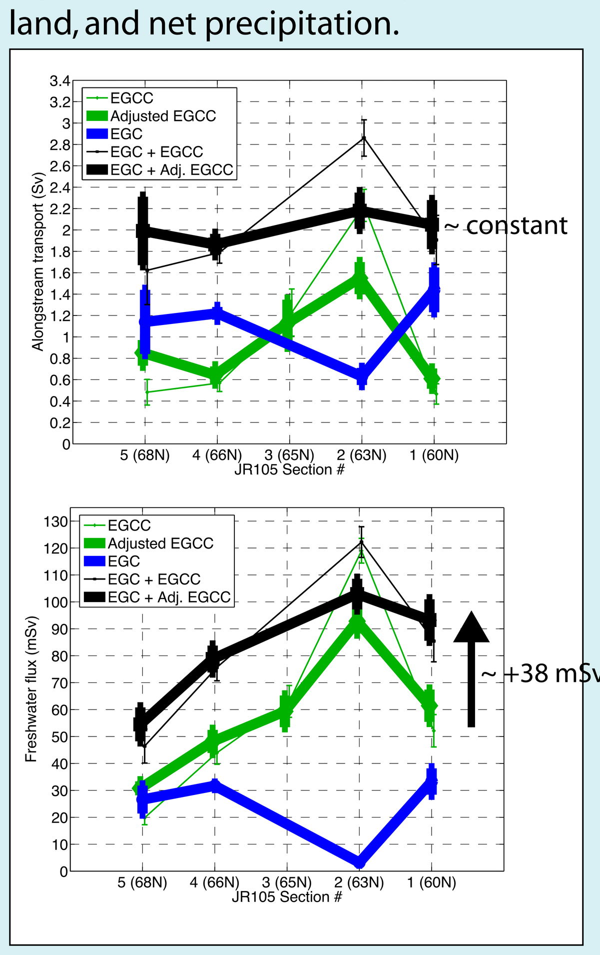


Figure 5. *(top)* Alongstream transport (Sv) for the EGCC and EGC in 2004. Thin lines show the observed transports. Thick lines have been adjusted to account for the alongshelf wind forcing as described above. *(bottom)* Similar to the top panel, but for freshwater flux (mSv, referenced to S_{ref} = 34.8). The number to the right is the net increase in total freshwater flux from section 5 to section 1 at Cape Farewell.

7 Summary

- The EGCC is a robust feature of the summertime circulation on the southeast Greenland shelf, and together with the EGC carries a significant volume (~ 2 Sv) and freshwater transport (up to ~90 mSv) that is similar in magnitude to the freshwater transport leaving Fram Strait

- Alongshelf wind forcing alters the structure of the EGCC, suggesting it is highly variable on synoptic time scales

- Significant fractions of Pacific-origin water (up to 20%) are found in the EGCC, although they are less than observed in the EGC at similar latitudes (but in different years, so this may be due to interannual variability)

Acknowledgments and references

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