Atlas of ocean currents in eastern Canadian waters

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Les établissements de l’ancien secteur des Sciences et Levés océaniques dans les régions et à l'administration centrale ont cessé de publier leurs diverses séries de rapports en décembre 1981. Vous trouverez dans l'index des publications du volume 38 du *Journal canadien des sciences halieutiques et aquatiques*, la liste de ces publications ainsi que le dernier numéro paru dans chaque catégorie. La nouvelle série a commencé avec la publication du rapport numéro 1 en janvier 1982.

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ABSTRACT

Seasonal ocean currents from Canadian East Coast Ocean Model are presented in graphical forms: horizontal maps of current fields at different depths and vertical sections of normal component of currents. The horizontal maps are displayed separately for the entire model domain, Baffin Bay, northern Labrador Sea, the N.E. Newfoundland Shelf and the Grand Banks, the Gulf of St. Lawrence and the Scotian Shelf. The vertical sections include Davis Strait, mid-Labrador Sea Section, Bonavista Section, Flemish Cap Section, southeast Grand Banks Section, Cabot Strait, northwest Gulf of St. Lawrence Section, Louisbourg Section and Halifax Section.

RESUME

Les courants océaniques saisonniers du modèle couplé glace-océan de la côte Est du Canada sont représentés graphiquement sous forme de cartes horizontales des champs de courant à différentes profondeurs et de coupes transversales des composantes normales des courants. Les cartes horizontales sont affichées séparément pour tout le domaine visé par le modèle : la baie de Baffin, le nord de la mer du Labrador, le nord-est du plateau continental et les Grands Bancs de Terre-Neuve, le golfe du Saint-Laurent et le plateau néo-écossais. Les coupes transversales portent sur le détroit de Davis, le centre de la mer du Labrador, Bonavista, le Bonnet flamand, le sud-est des Grands Bancs, le détroit de Cabot, le nord-ouest du golfe du Saint-Laurent, Louisbourg et Halifax.

1.0 INTRODUCTION

Quantitative information about ocean currents can be obtained by a variety of measuring instruments and analysis techniques including mechanical current meter, drifter, acoustic Doppler current profiler, electromagnetic current meter, high frequency radar, coherence analysis of satellite data and dynamical calculations based on temperature and salinity data. Direct measurement using moored instruments or drifters is generally considered to give the most accurate speeds and directions of ocean currents. However, the spatial and temporal coverage of direct measurements is usually very limited and must be used in conjunction with other methods to construct circulation patterns or velocity fields. In recent years, model simulated ocean currents calibrated by data from direct measurements have been increasingly used for ocean research. They fill the gaps in in-situ measurements and provide a more complete picture of the circulation.

In this report, ocean currents computed from Canadian East Coast Ocean Model (CECOM) are presented in graphical forms. The model currents, which cover 11 years, have been validated using current meter and drifter data collected by various organizations.

2.0 MODEL SETUP AND SIMULATION

CECOM is a coupled ice-ocean model. The ocean component of the model is the latest version of Princeton Ocean Model (Blumberg and Mellor, 1987). The ice component is a multi-category sea ice model in which the internal ice stress is derived from the viscous plastic rheology of Hibler (1980) and ice thickness is characterized by a thickness distribution function from which ice concentration and mean ice thickness can be calculated. A full description of the model can be found in Yao et al. (2000) and Tang et al. (2008).

The model domain extends from the northern Baffin Bay to the northern wall of the Gulf Stream, and from the St. Lawrence Estuary to 42°W (Fig. 1). The horizontal resolution is 0.1°×0.1°. The grid is defined in a rotated spherical coordinate system. Monthly climatological ocean temperature and salinity are used as the initial state and as open ocean boundary conditions. The monthly climatologies were obtained from an objective analysis of historical temperature and salinity data archived at BIO (Tang, 2007).

The model is driven by wind stress, heat and moisture fluxes calculated from atmospheric parameters of North American Regional Reanalysis (NARR, Mesinger et al., 2006). The atmospheric variables include surface winds, air temperature, cloud cover, dew point temperature, air pressure and precipitation.

In order to obtain a best representation of the current field from the model, the time periods of the model simulation were selected to match the time periods of available current meter data (Fig. 2), which were used to calibrate and validate the model. In these periods, the data cover an extensive area within the model domain. The total time of the model run is 11 years, which consists of four separate periods, 1987-1989; 1994-1996; 2002-2004 and 2007-2008. In the model runs, daily sea surface temperatures derived from satellite images (Reynolds et al., 2010) were assimilated using the method of Wu et al. (2010). In addition, a 3-D nudging of the temperature and salinity was employed with a constant time scale of 90 days to reduce long-term drift in deep waters.

In the following section, the seasonally mean current fields from the 11-year model run are presented. There are two types of plots: horizontal velocity field at given depths and 10 m from the ocean bottom, and normal velocity in vertical sections. In the horizontal velocity plots, velocities less than 0.02 m s^{-1} are not drawn. The locations of the vertical sections are shown in Fig. 3.

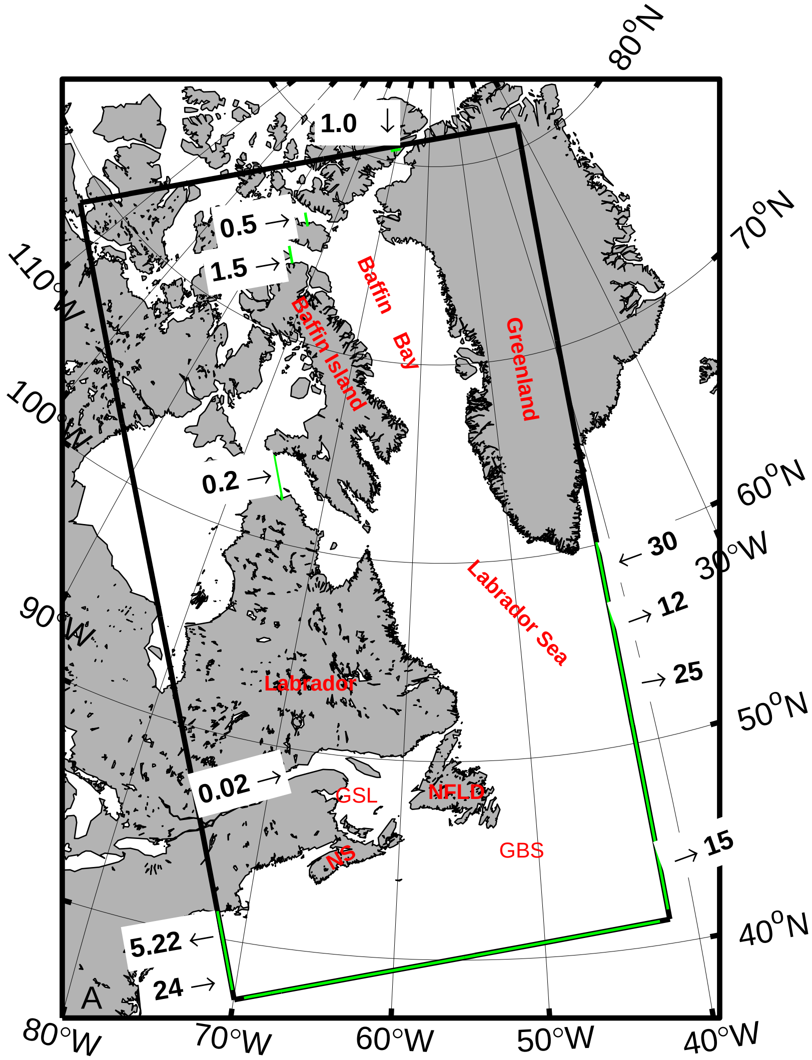

Fig. 1 Map showing model domain, open boundaries. The black dash line represents the model domain. The green lines represent the exterior open boundaries. The arrows and the number show the directions and the barotropic transports. The unit is Sv (1 Sv=10^6 m^3 s^{-1}). The abbreviations are: GBS - the Grand Banks; NFLD - Newfoundland; NS - Nova Scotia; GSL - the Gulf of St. Lawrence.

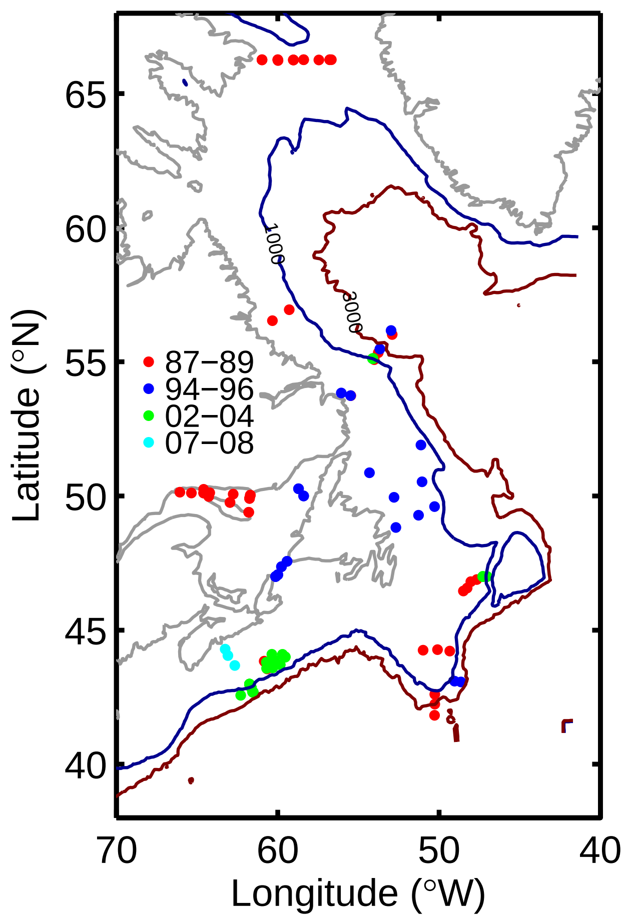

Fig. 2 Sites of current meter in 1987-1989 (red), 1994-1996 (blue), 2002-2004 (green) and 2007-2008 (cyan). The two contour lines represent the 1000 m and 3000 m bottom topography, respectively

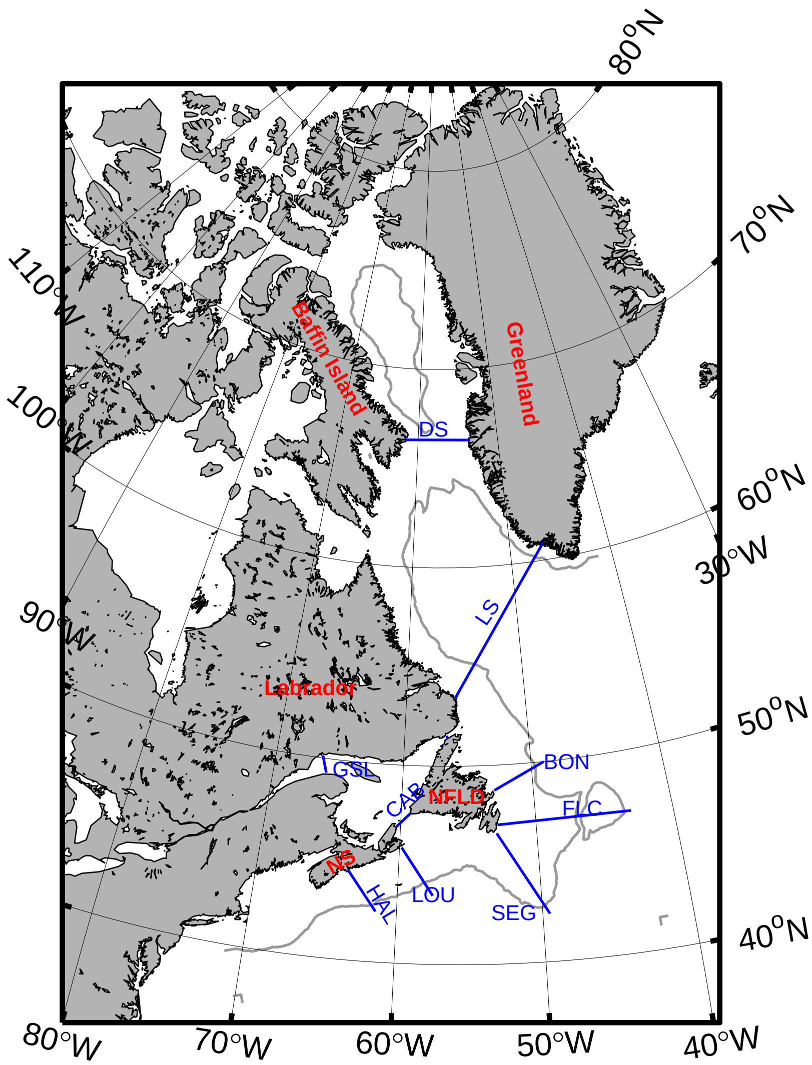

Fig. 3. Locations of vertical sections. DS–Davis Strait; LS–Labrador Sea Section; BON–Bonavista Section; FLC–Flemish Cap Section; SEG–Southeast Grand Banks Section; LOU–Louisbourg Section; HAL–Halifax Section; CAB–Cabot Strait Section; GSL–Northwest Gulf of St. Lawrence Section. The grey line is the1000 m bottom contour.

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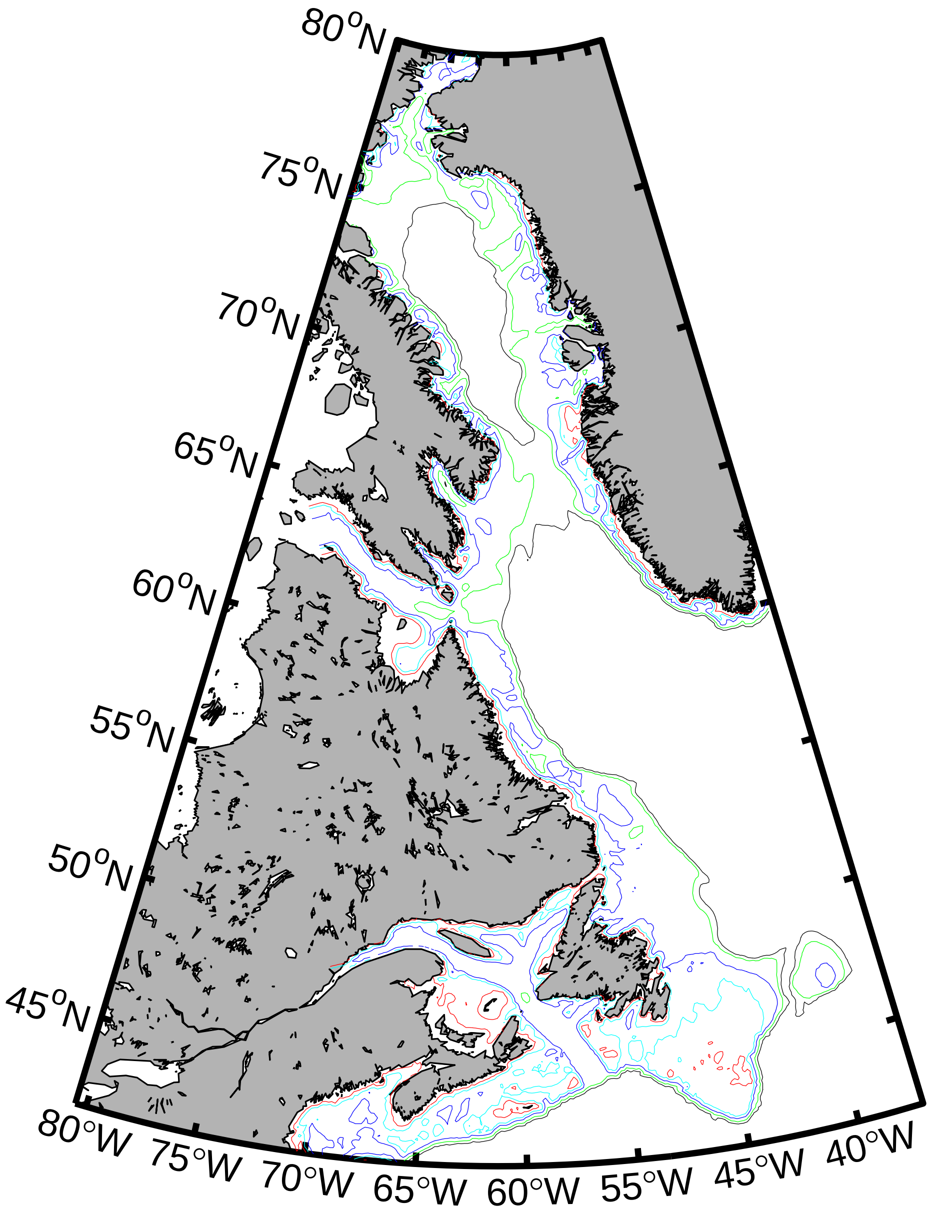
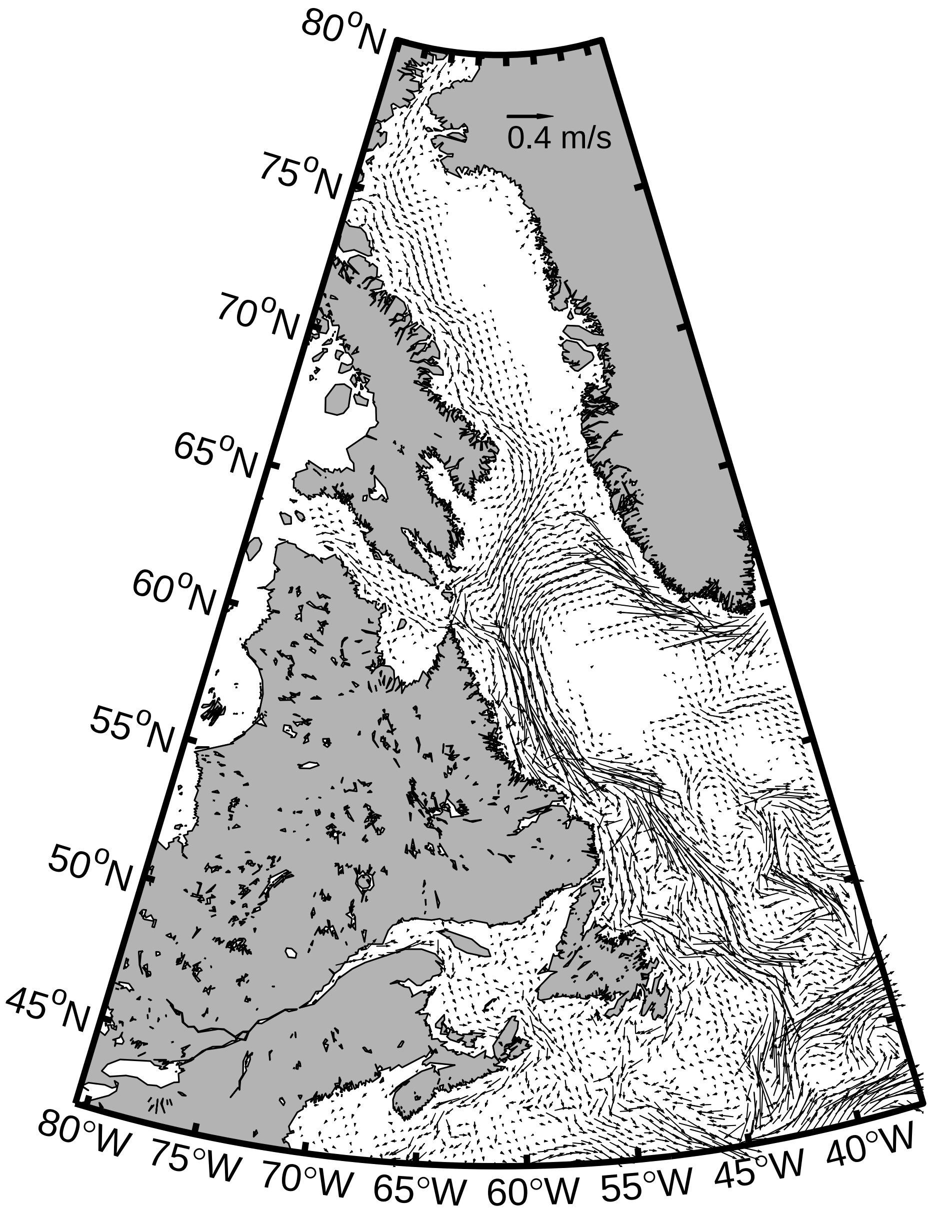
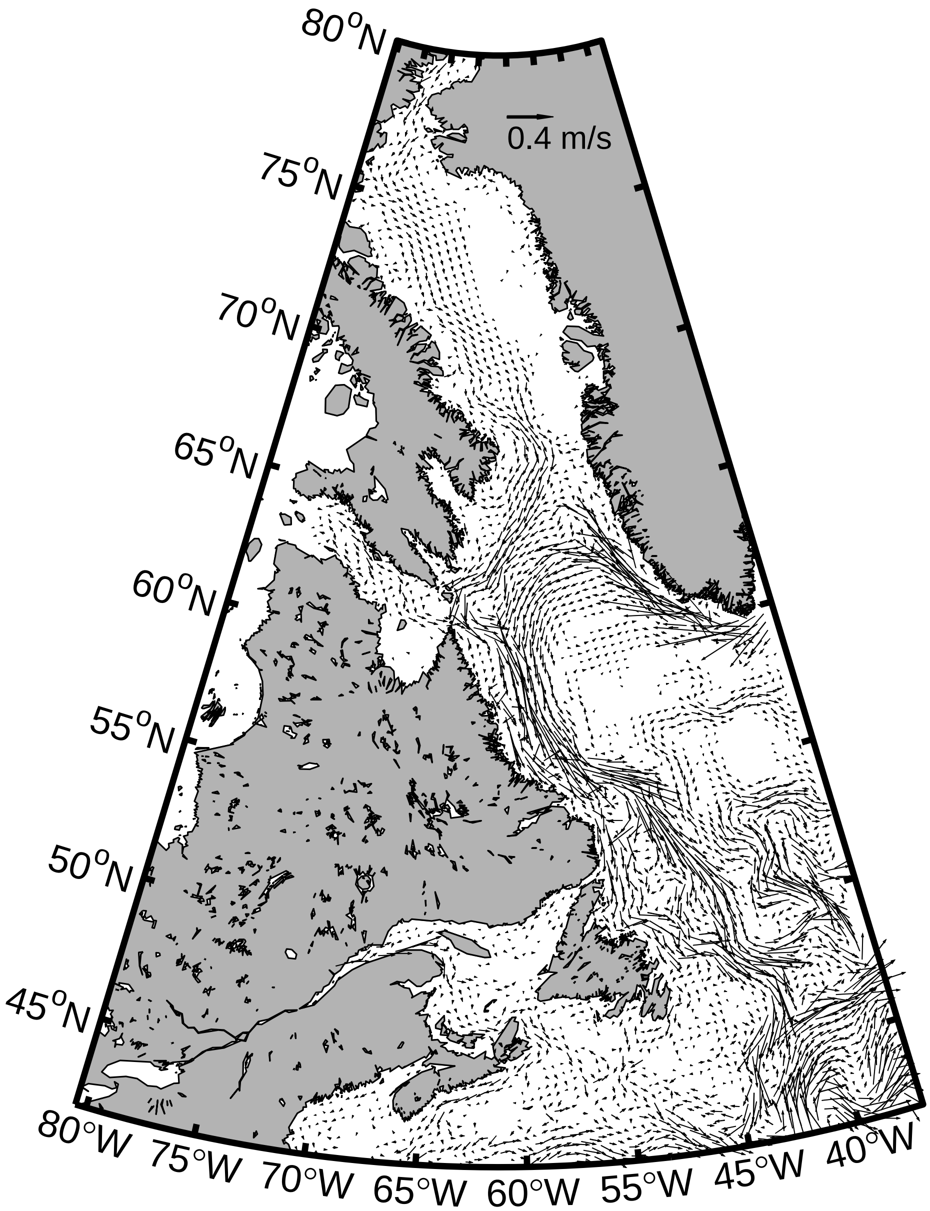


Bottom topography showing 50 (red), 100 (cyan), 200 (blue), 500 (green) and 1000 m (black) isobaths. Depth contours greater than 1000 m are not shown.



Velocity field at 0 m for winter



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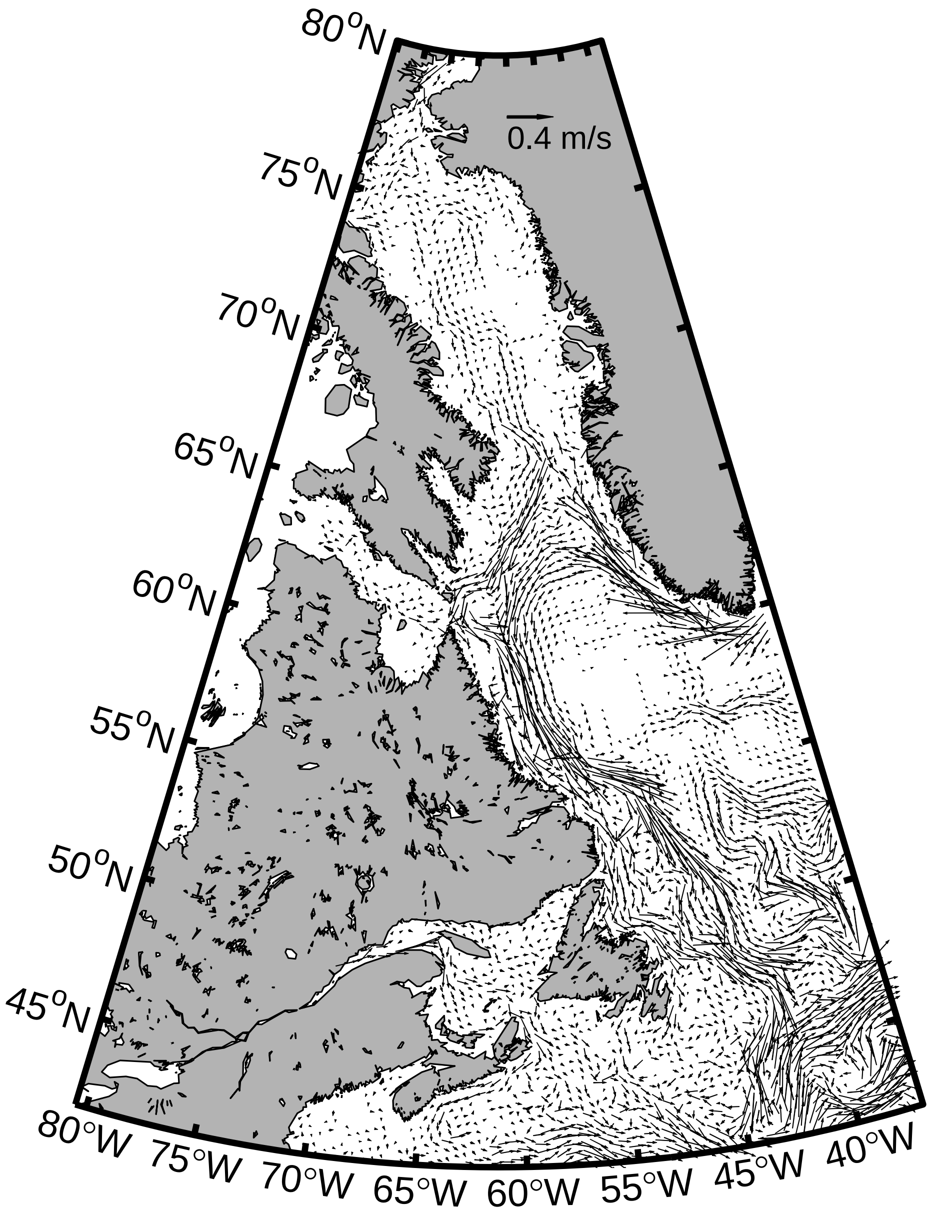

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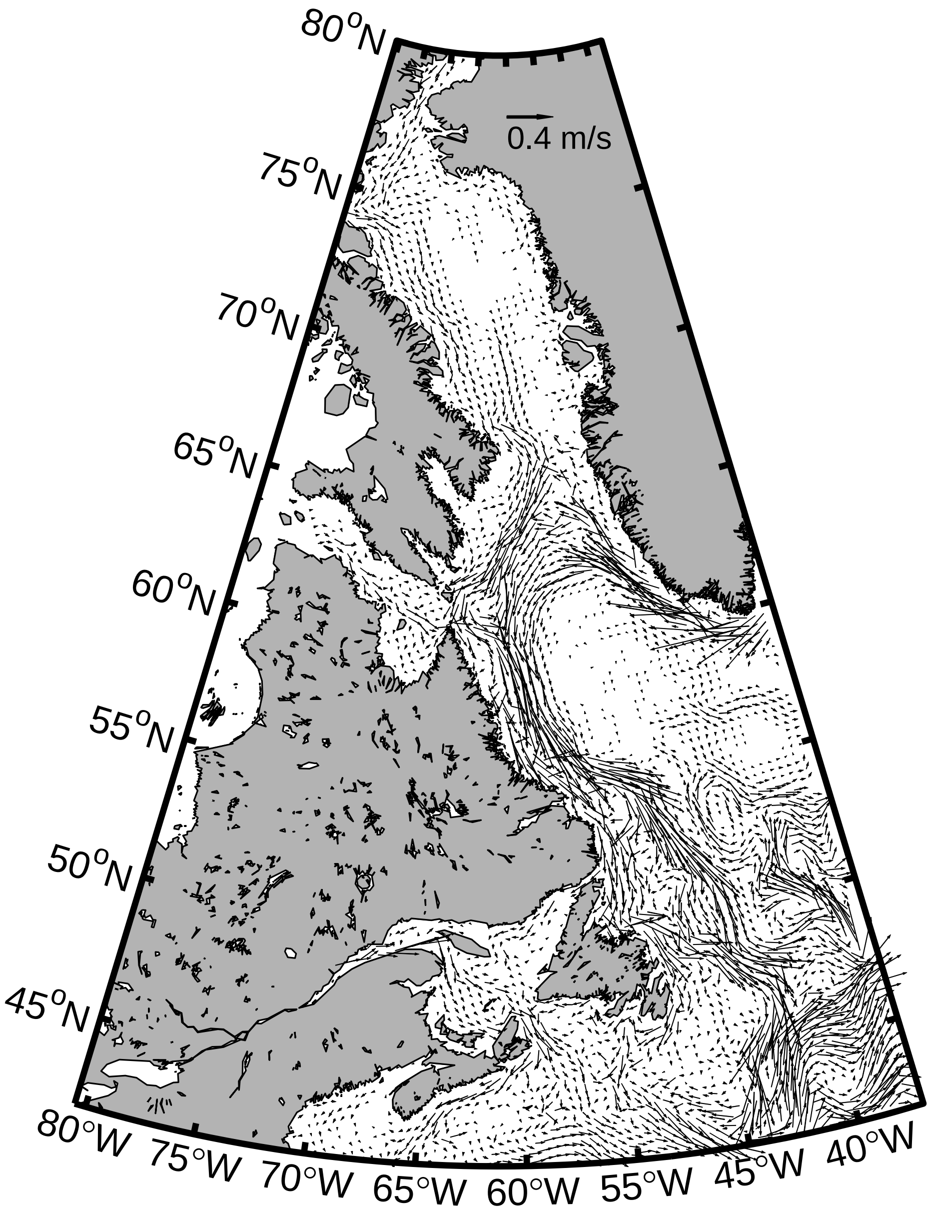

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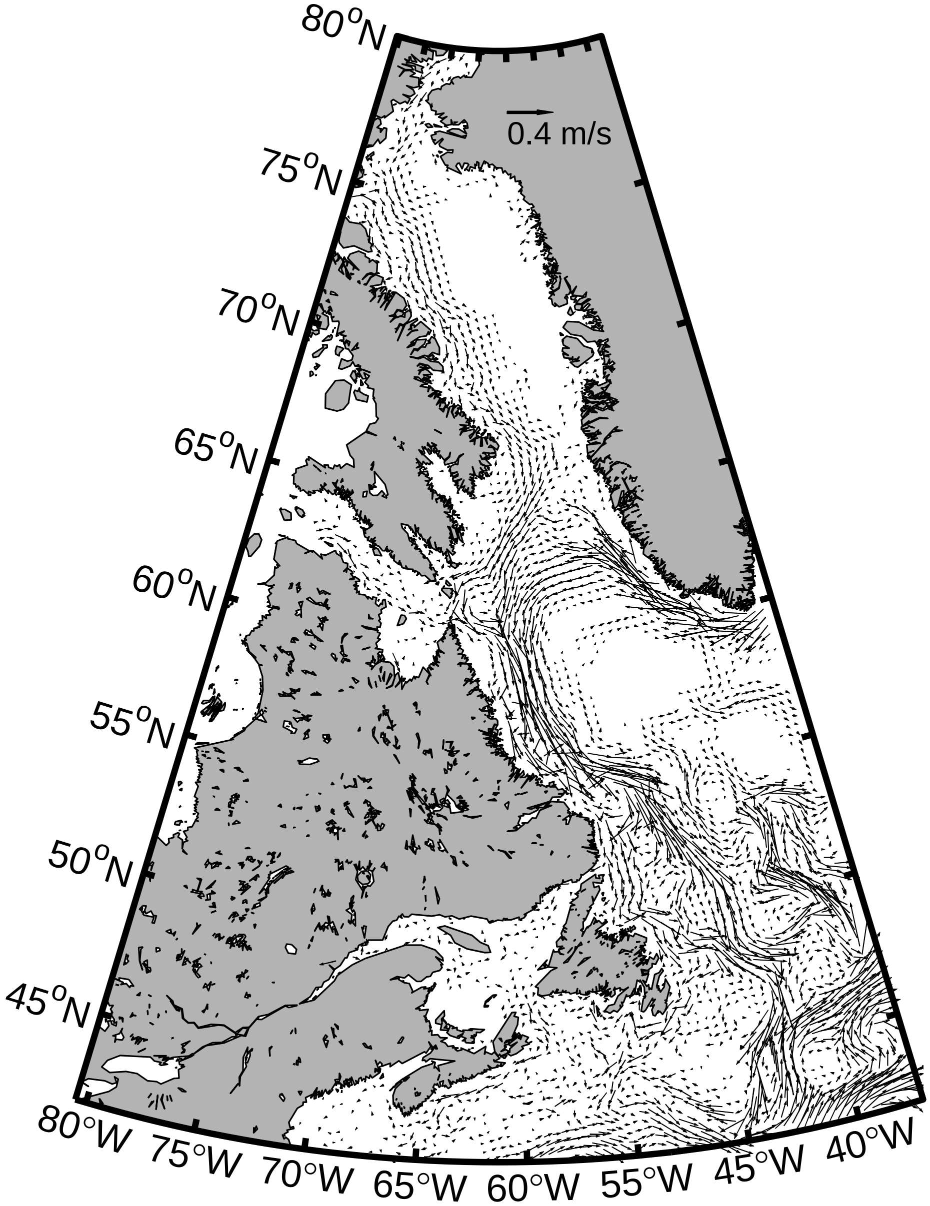

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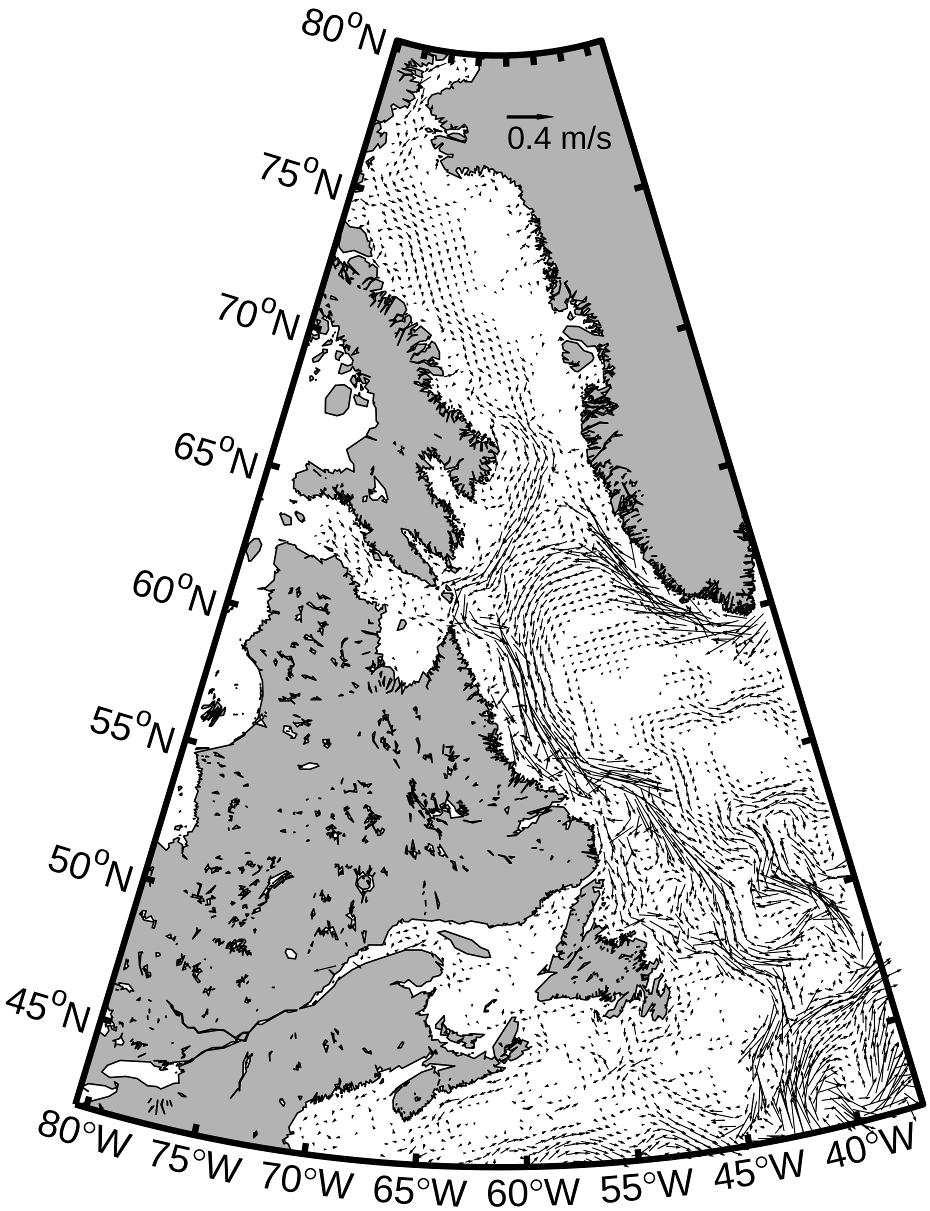

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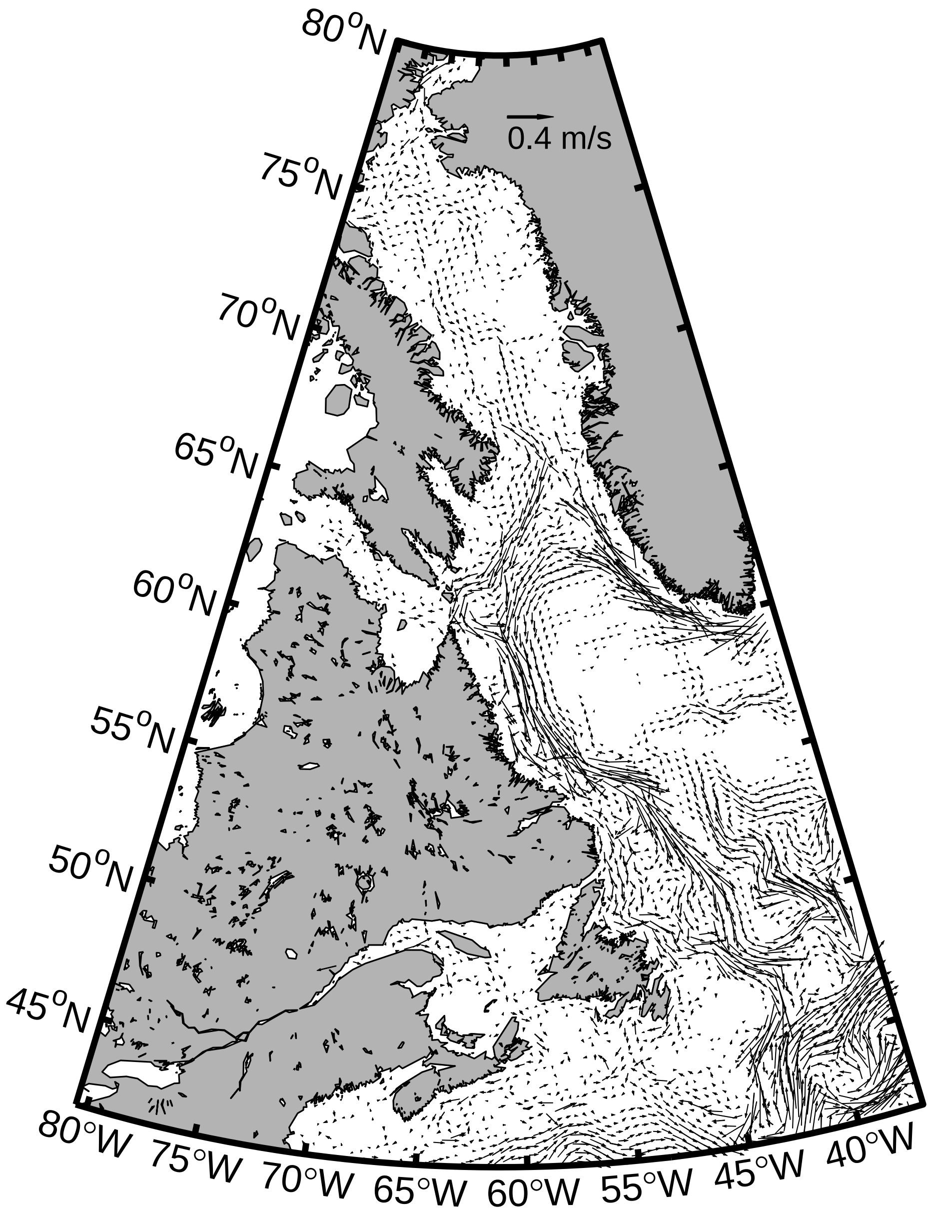

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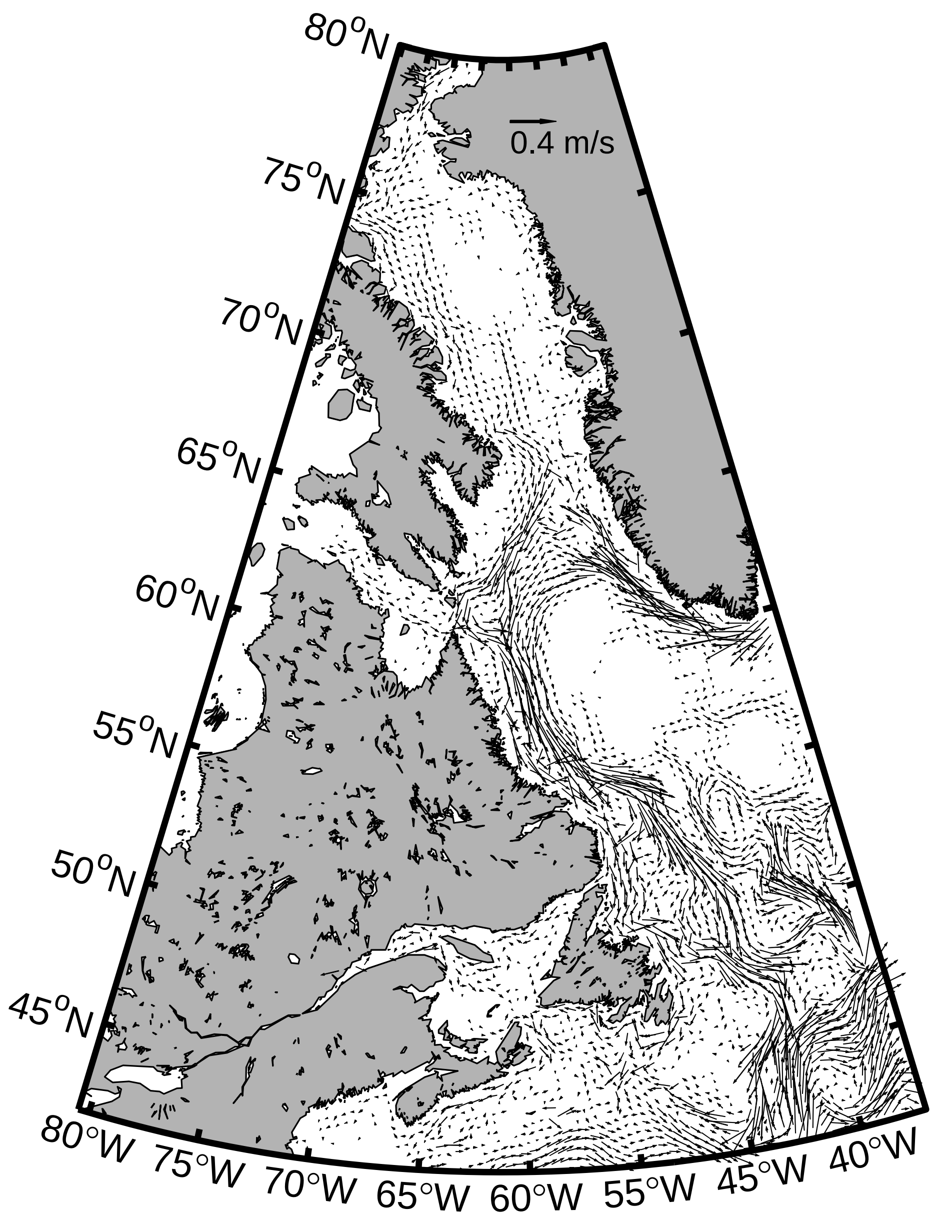

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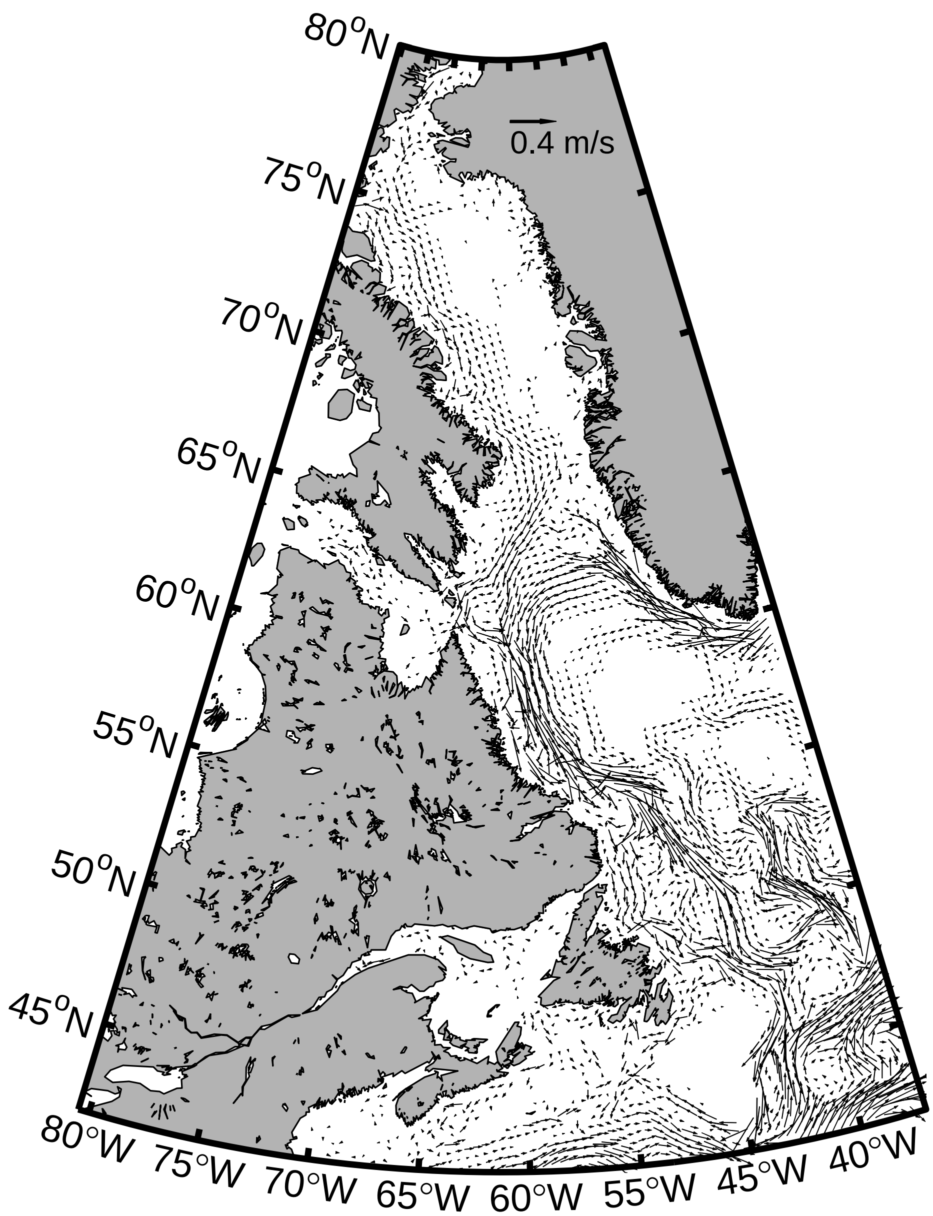

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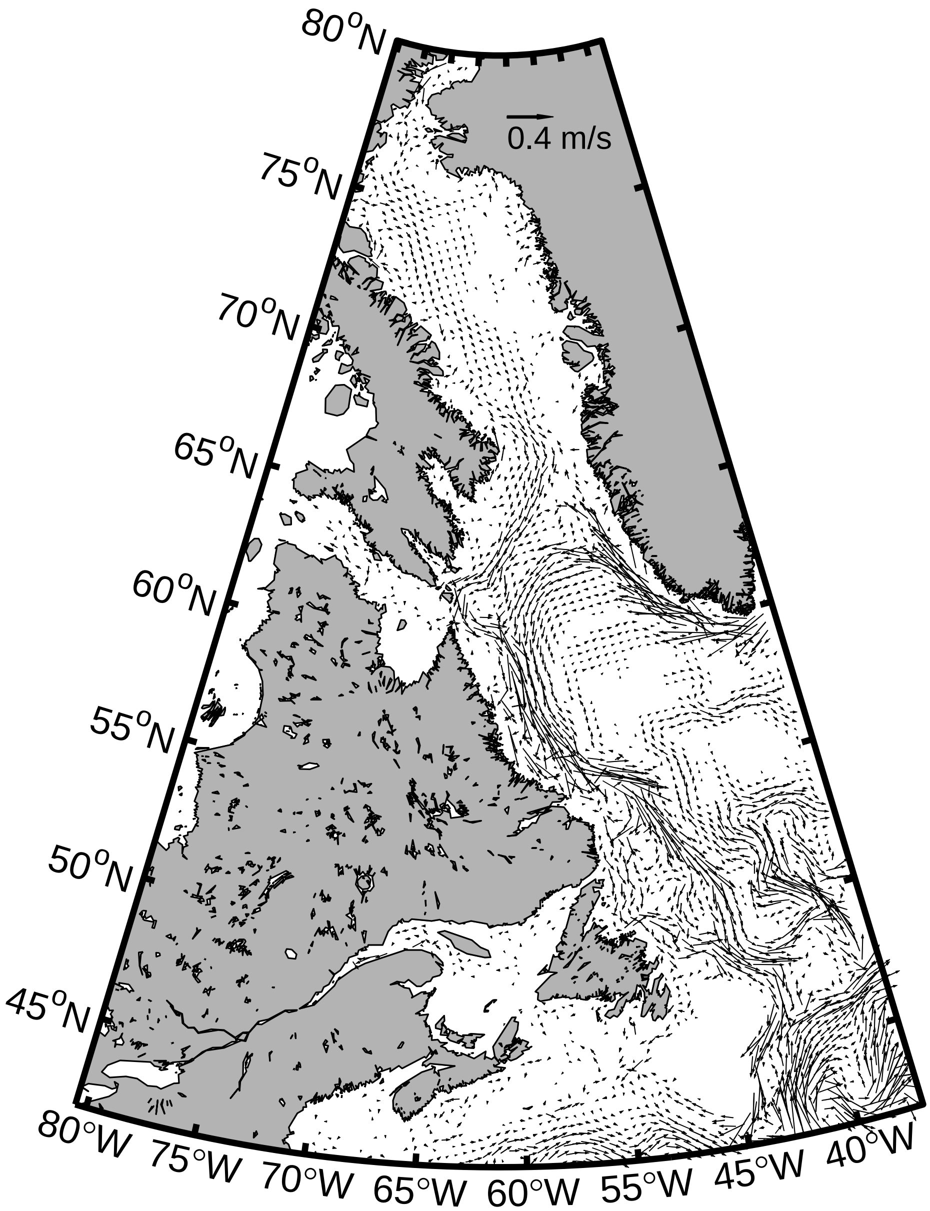

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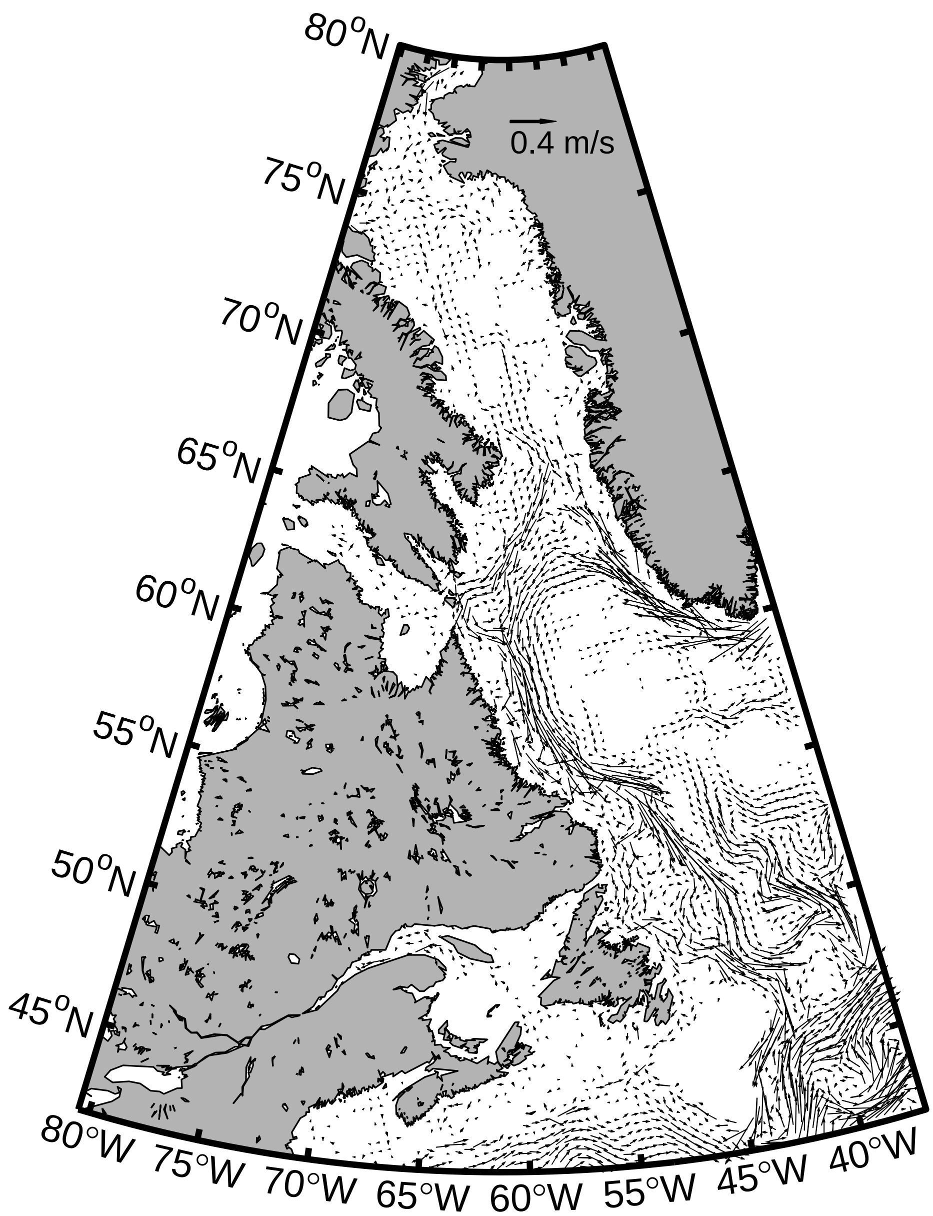

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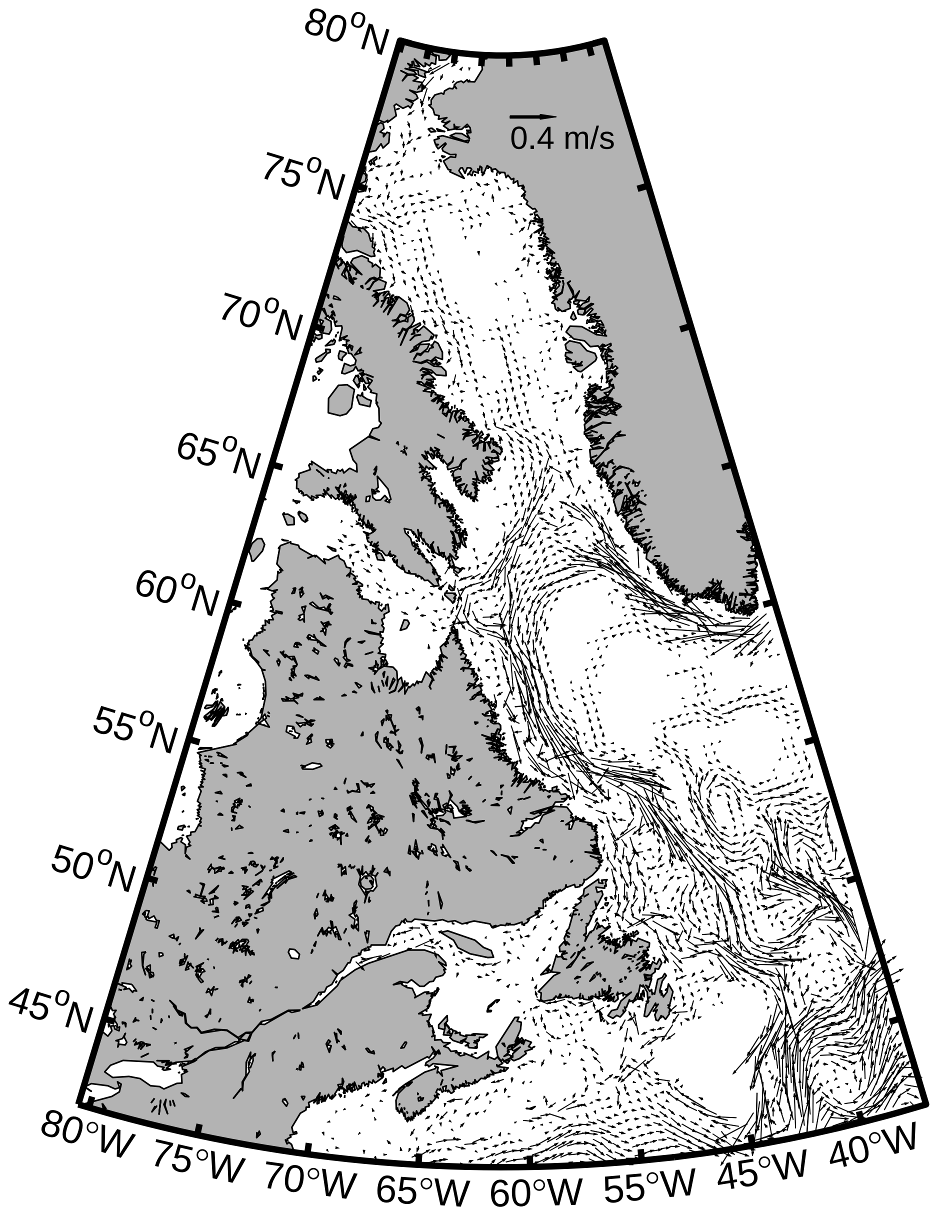

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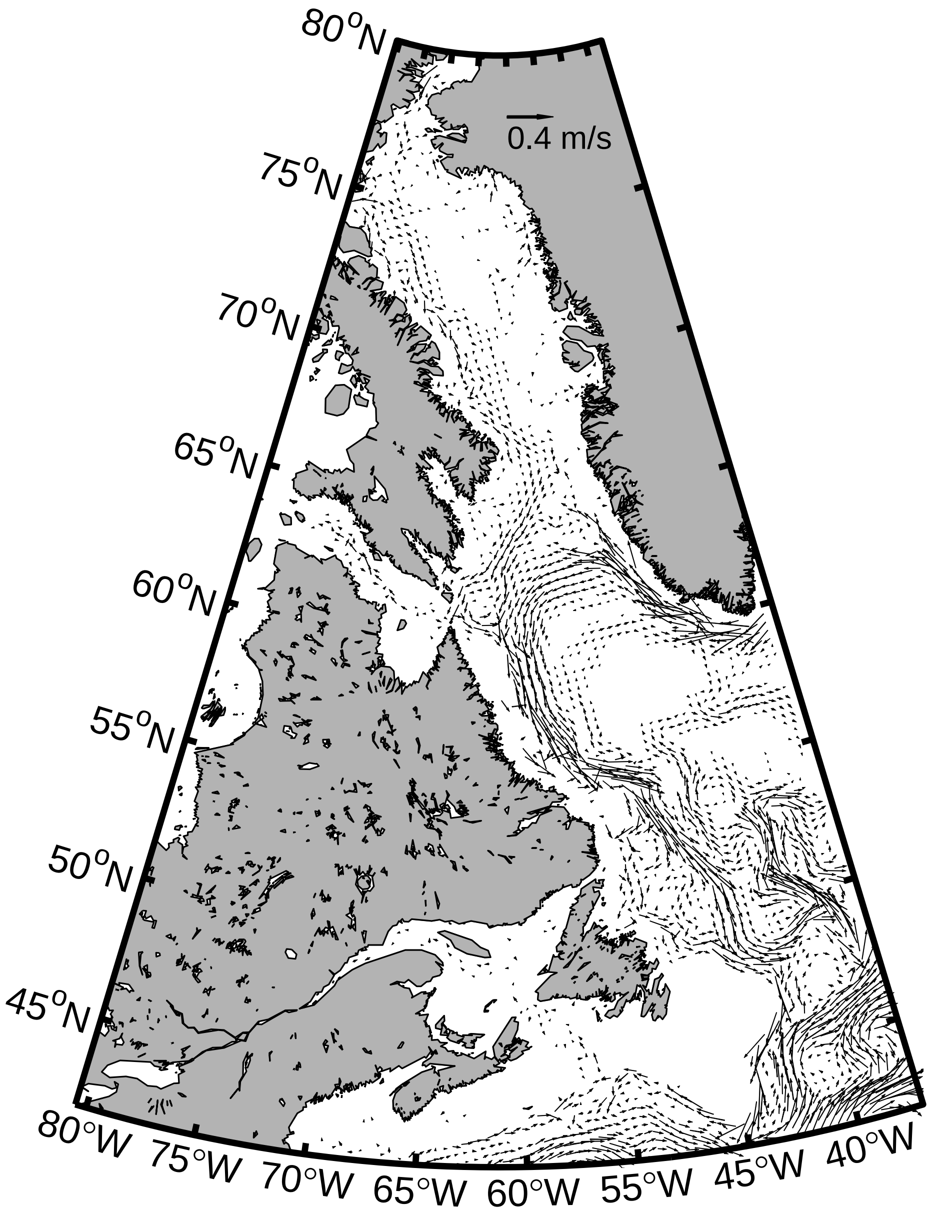

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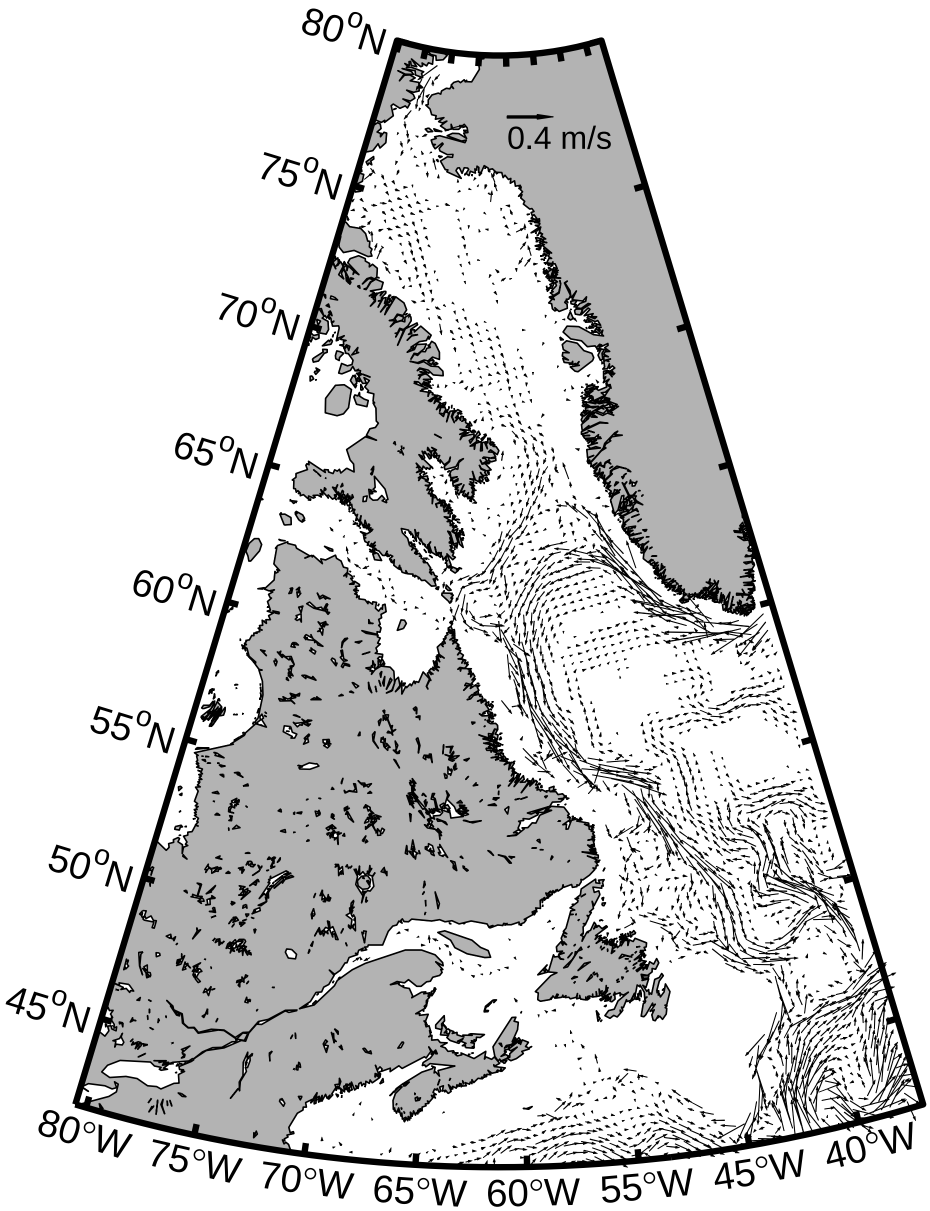

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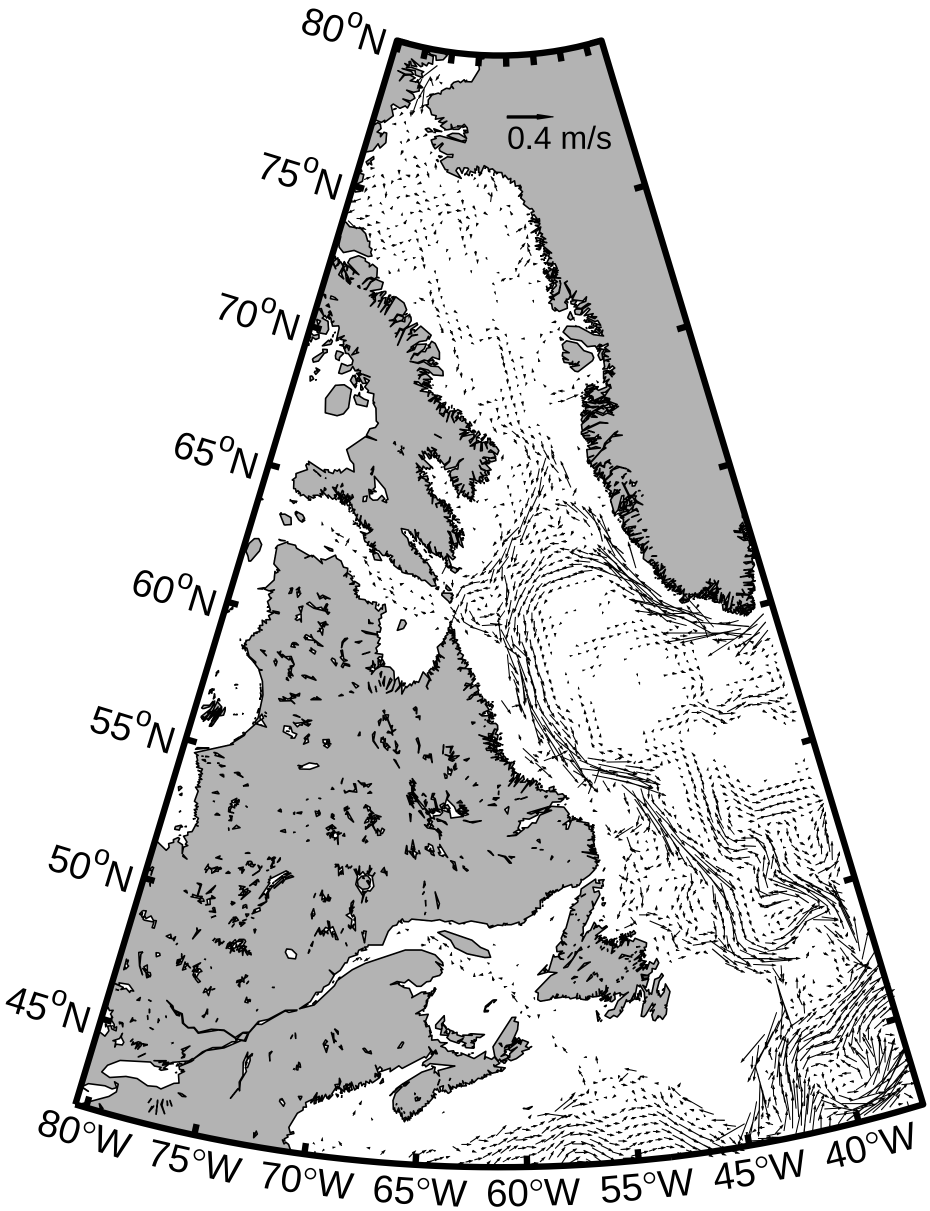

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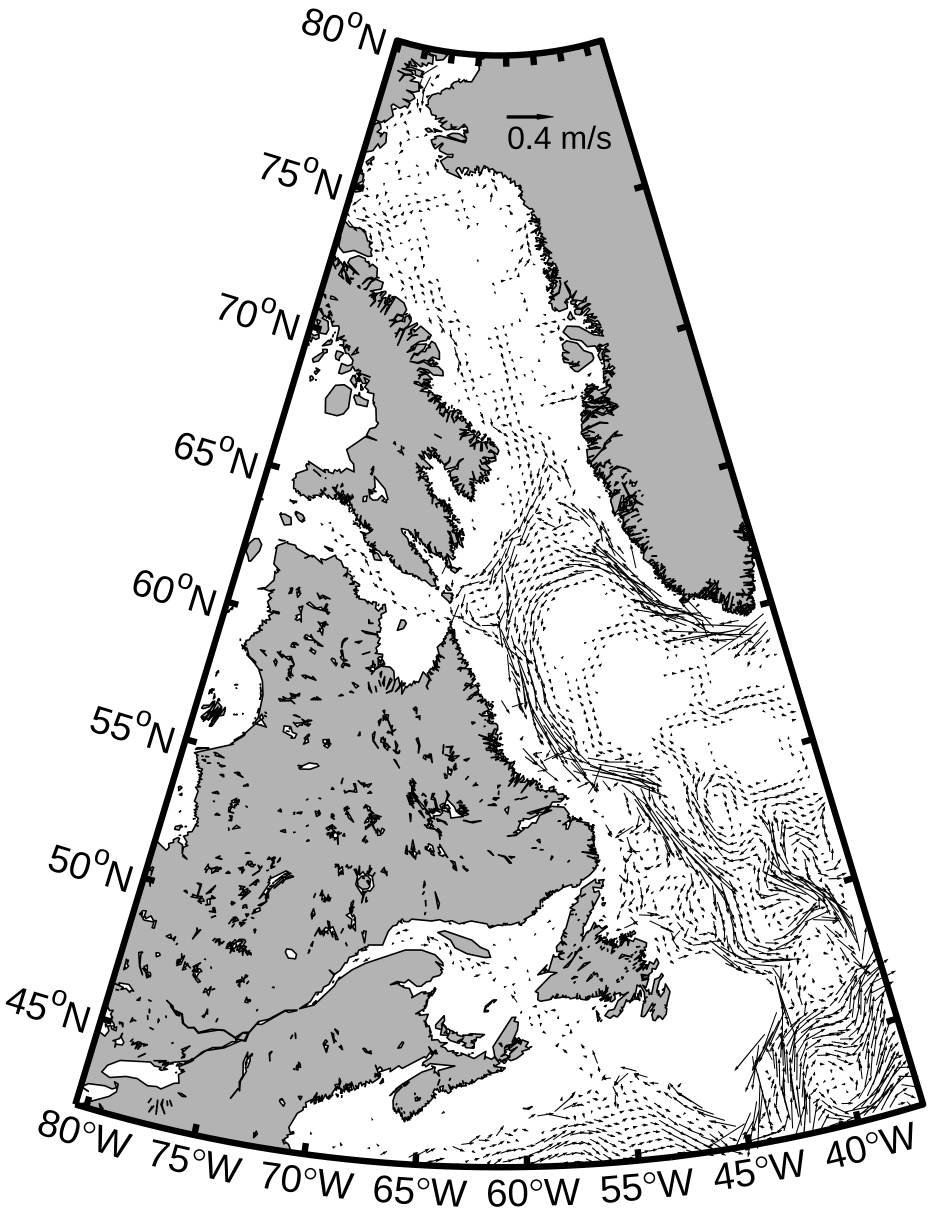

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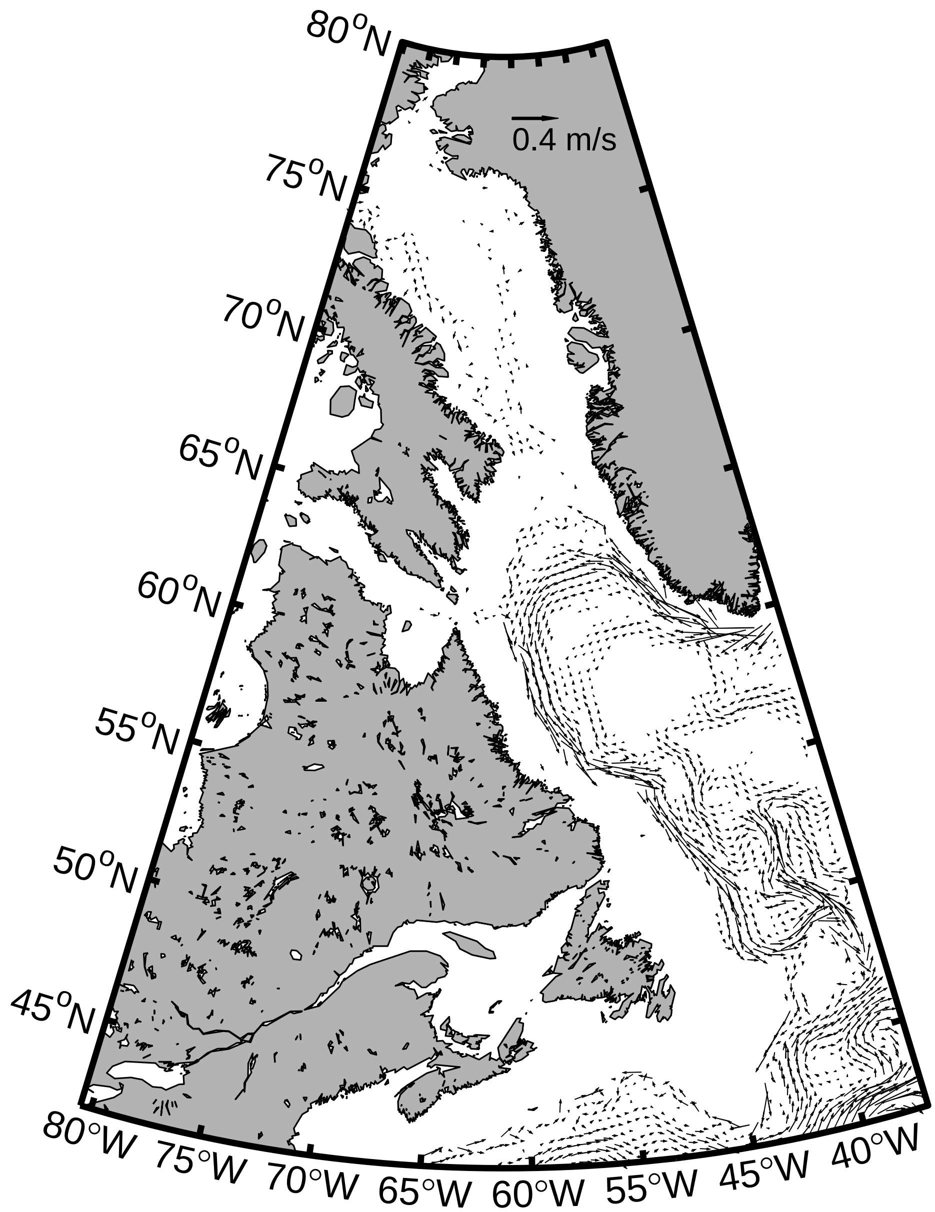

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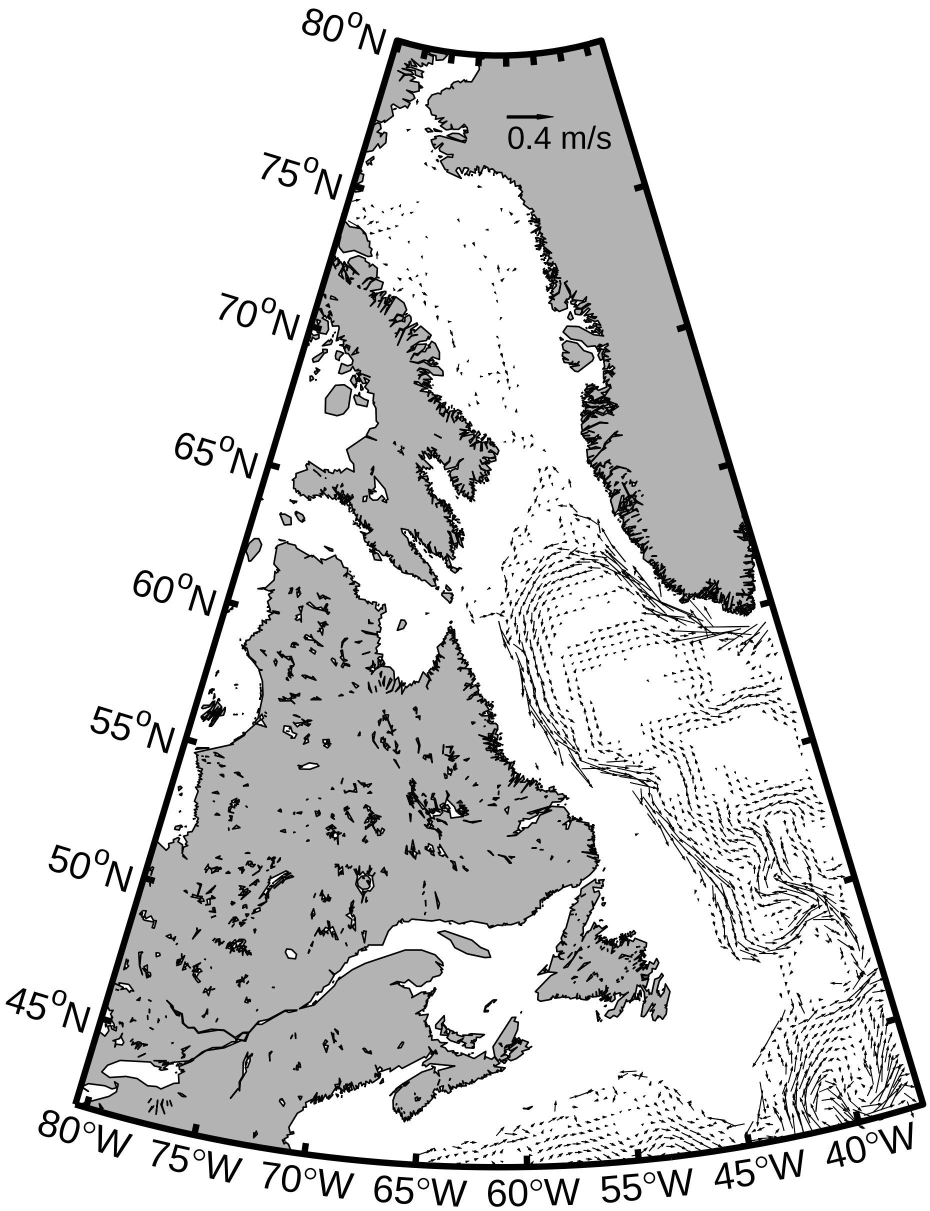

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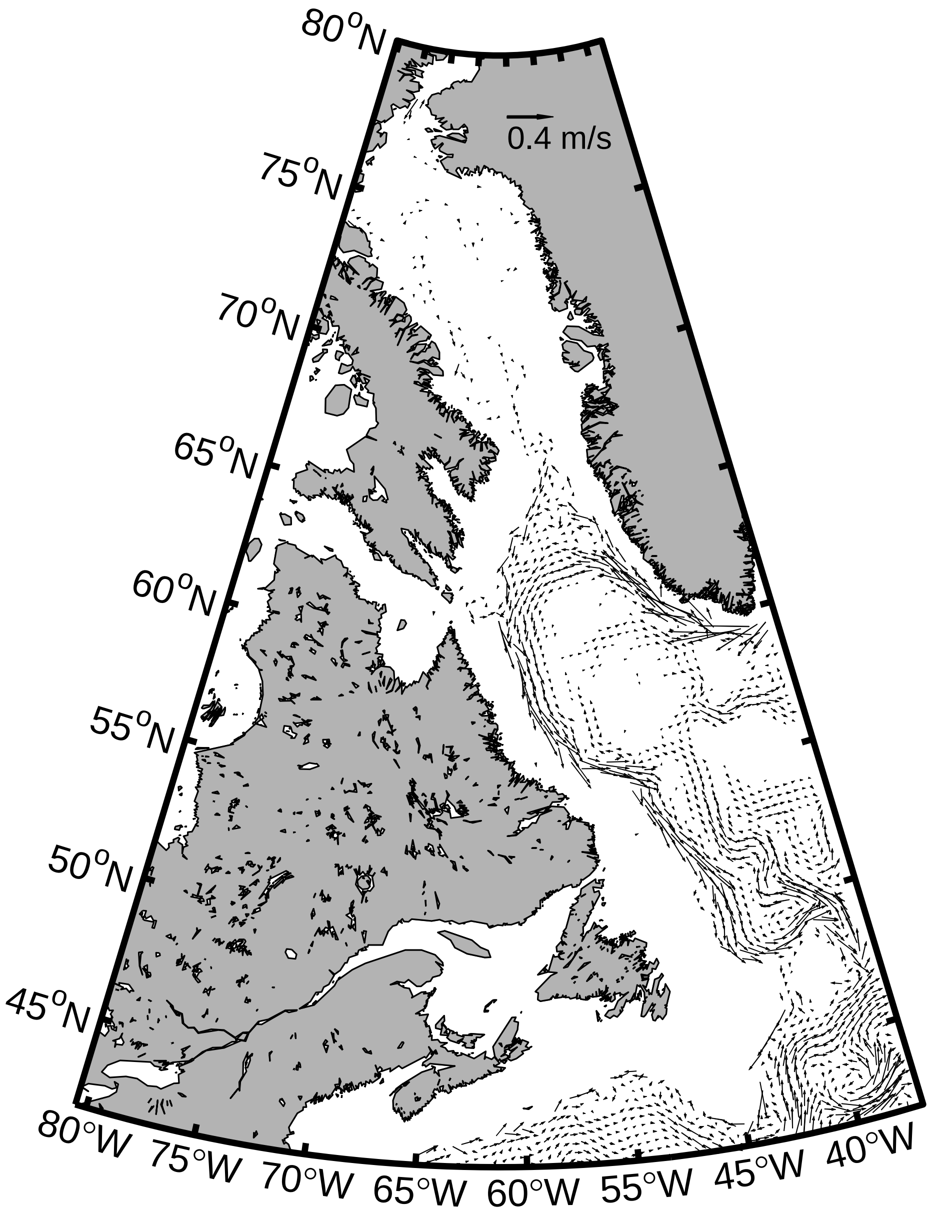

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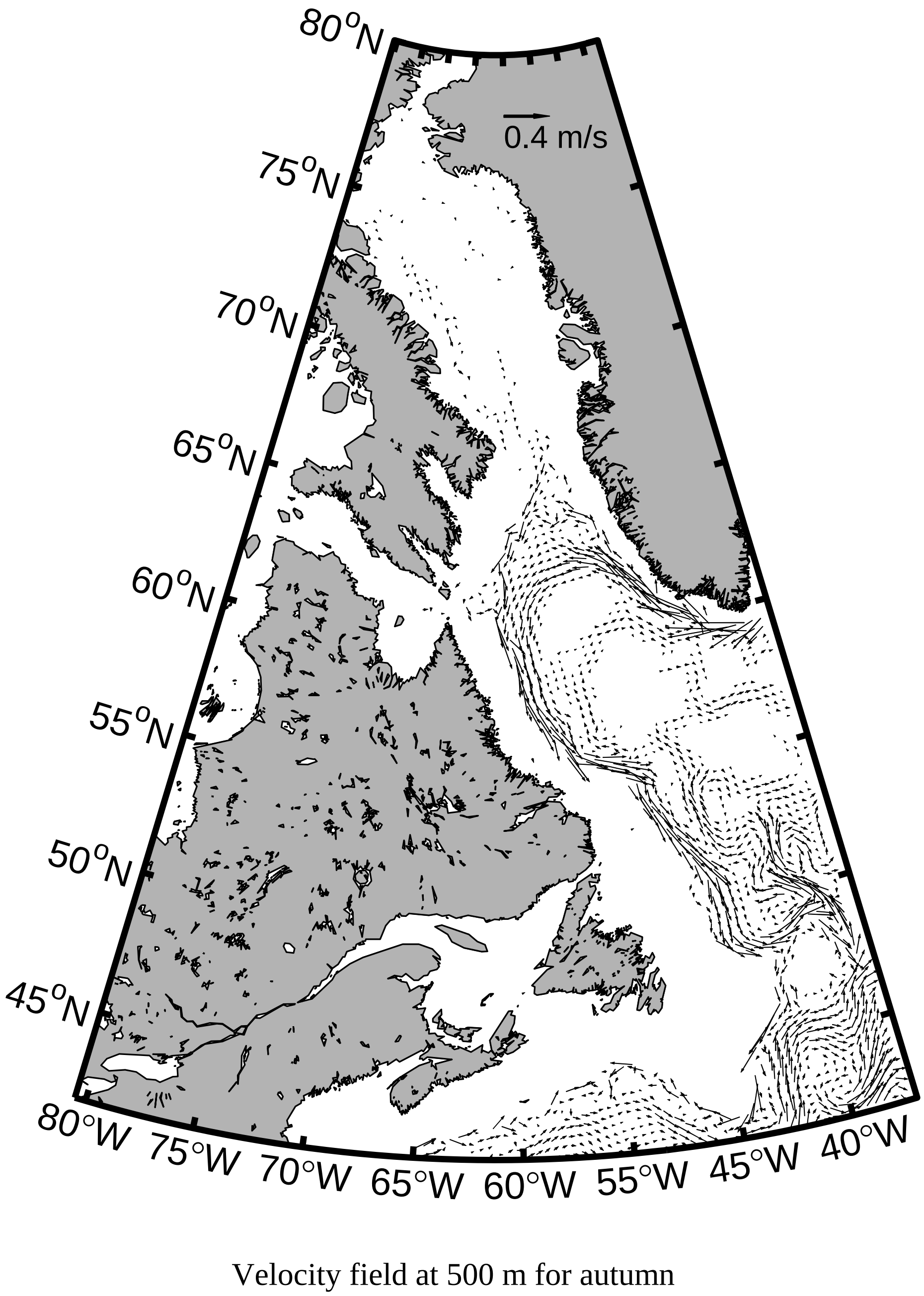

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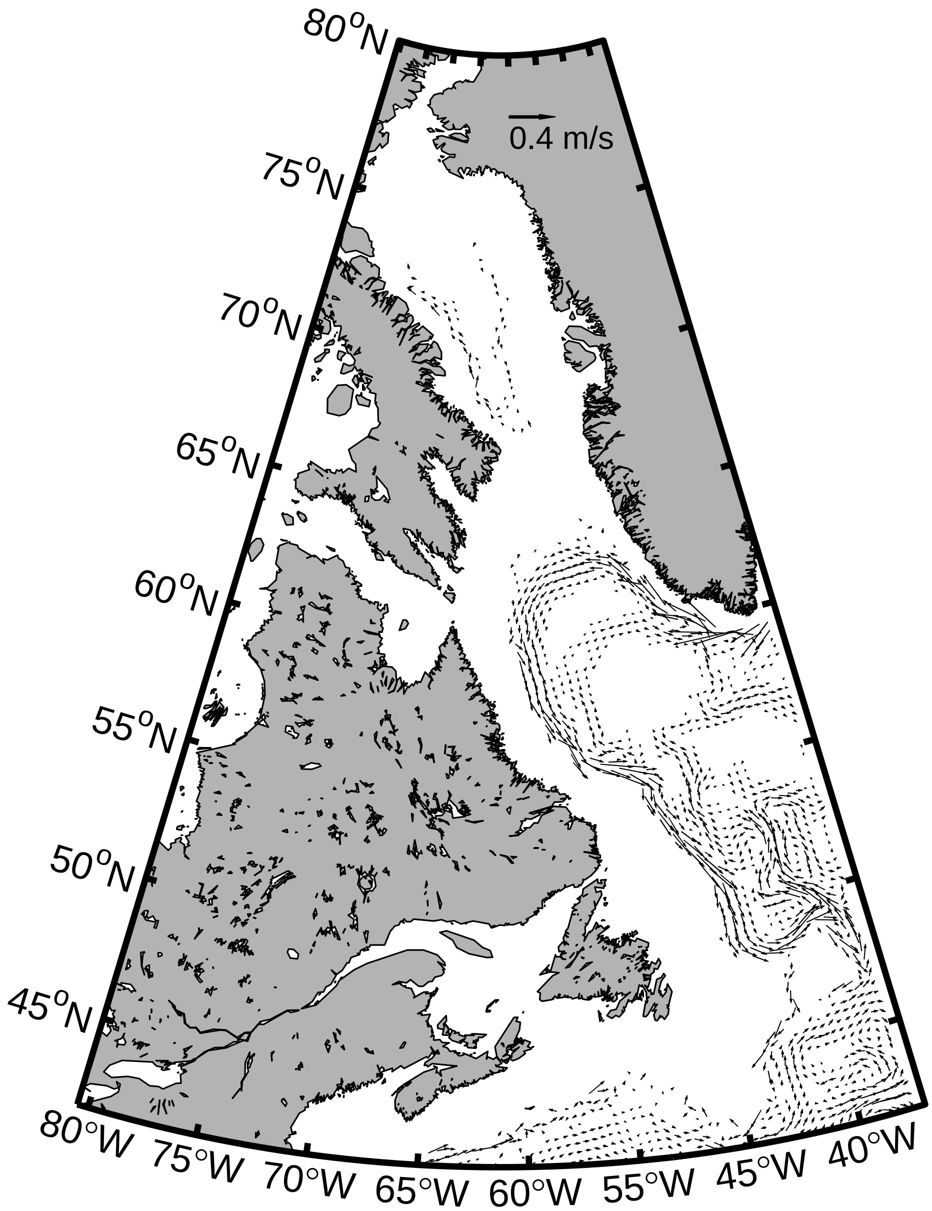

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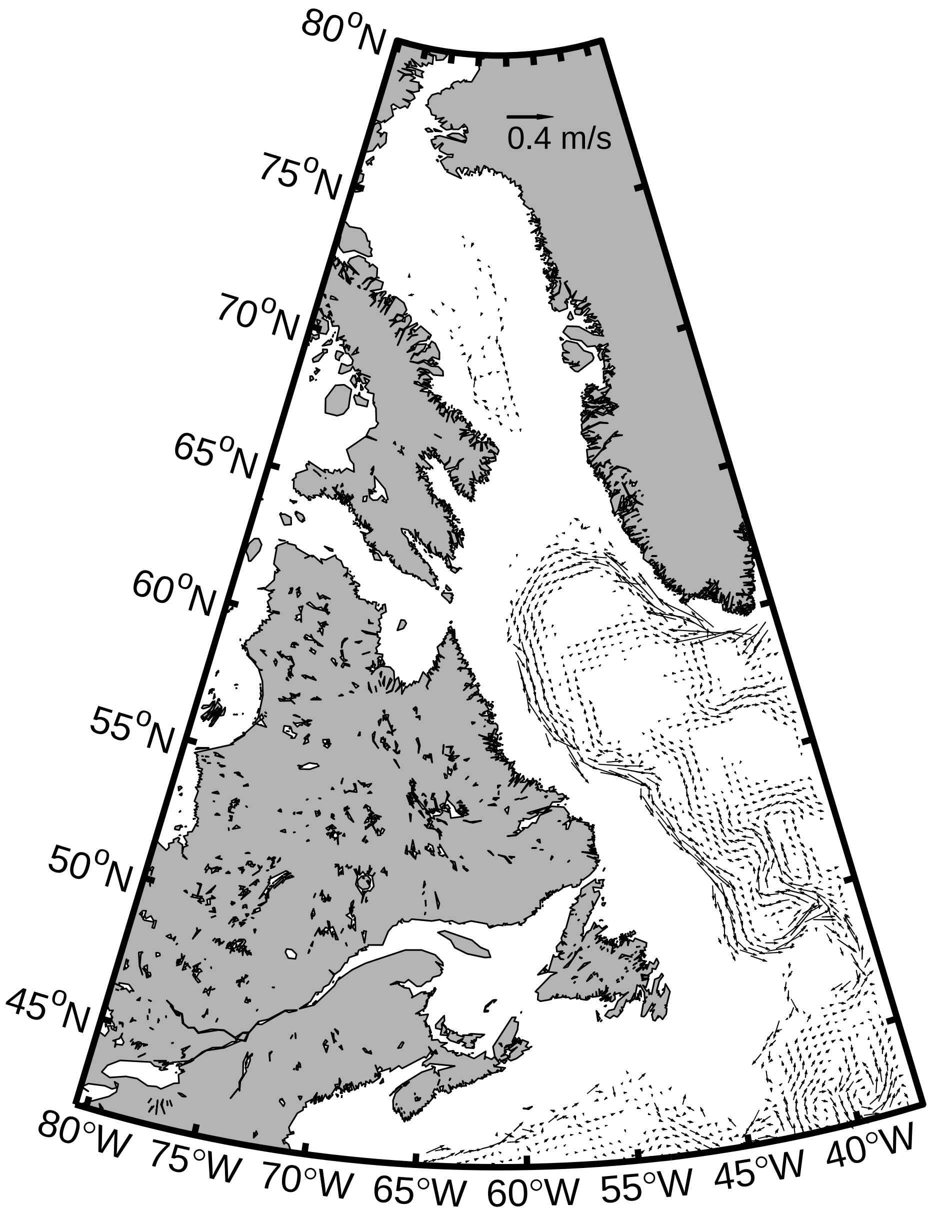

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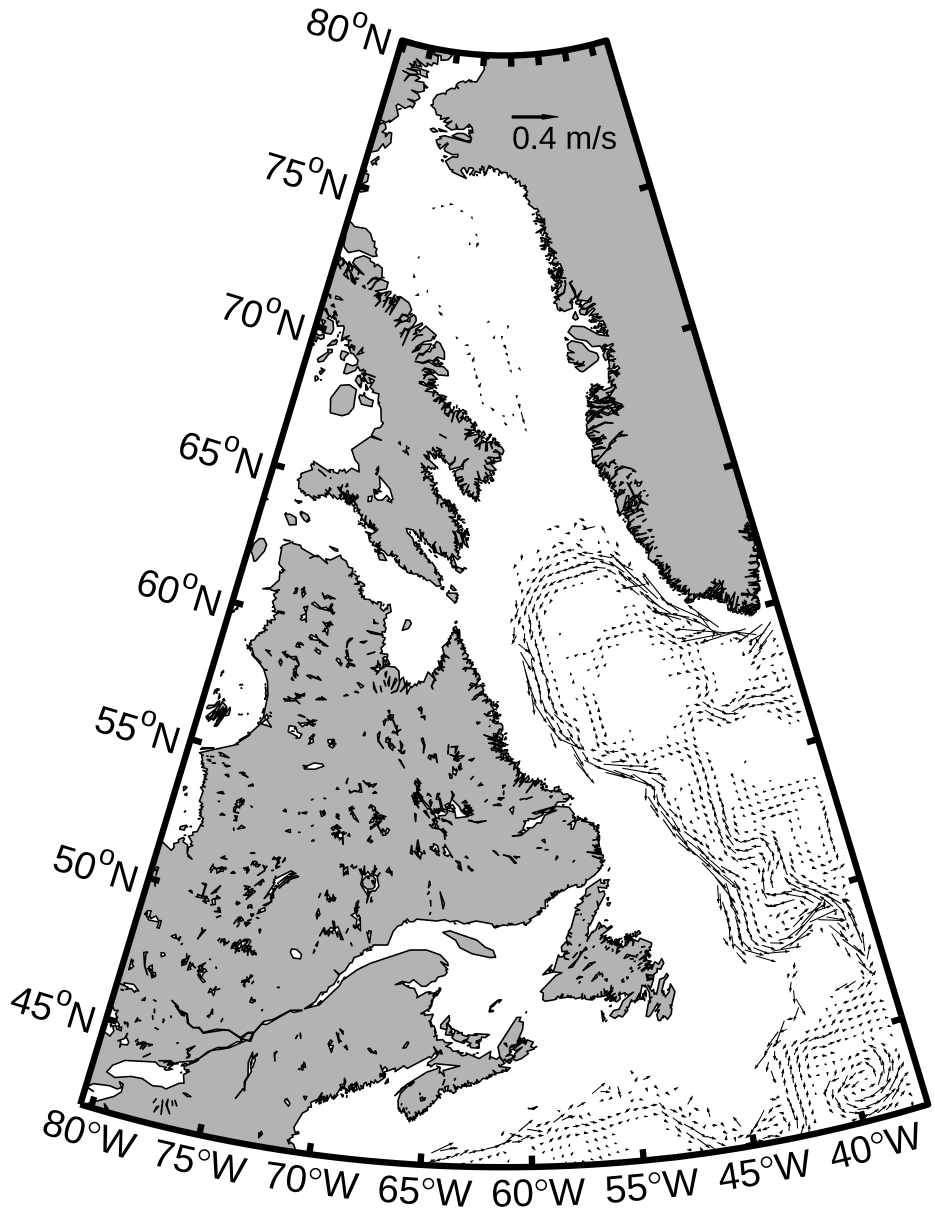

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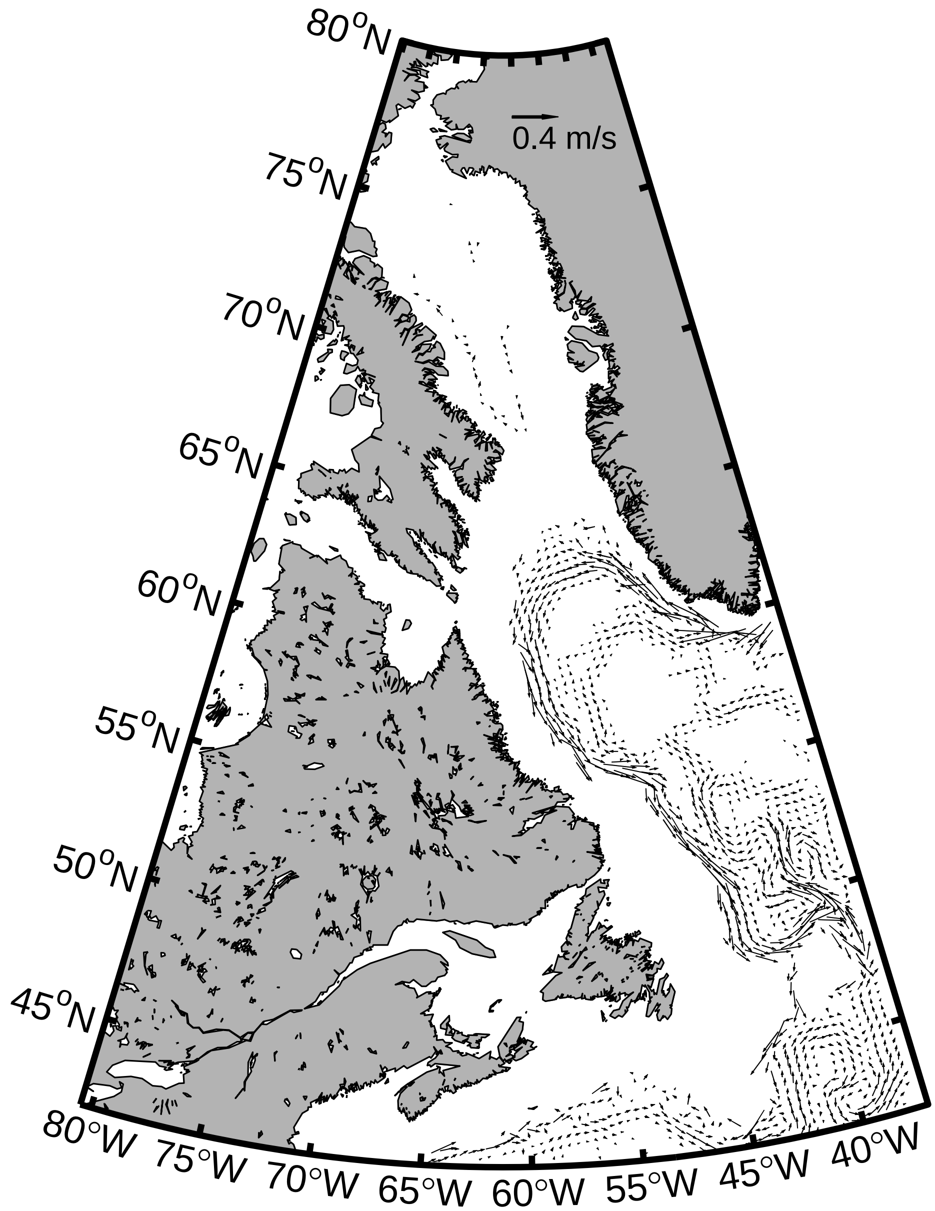

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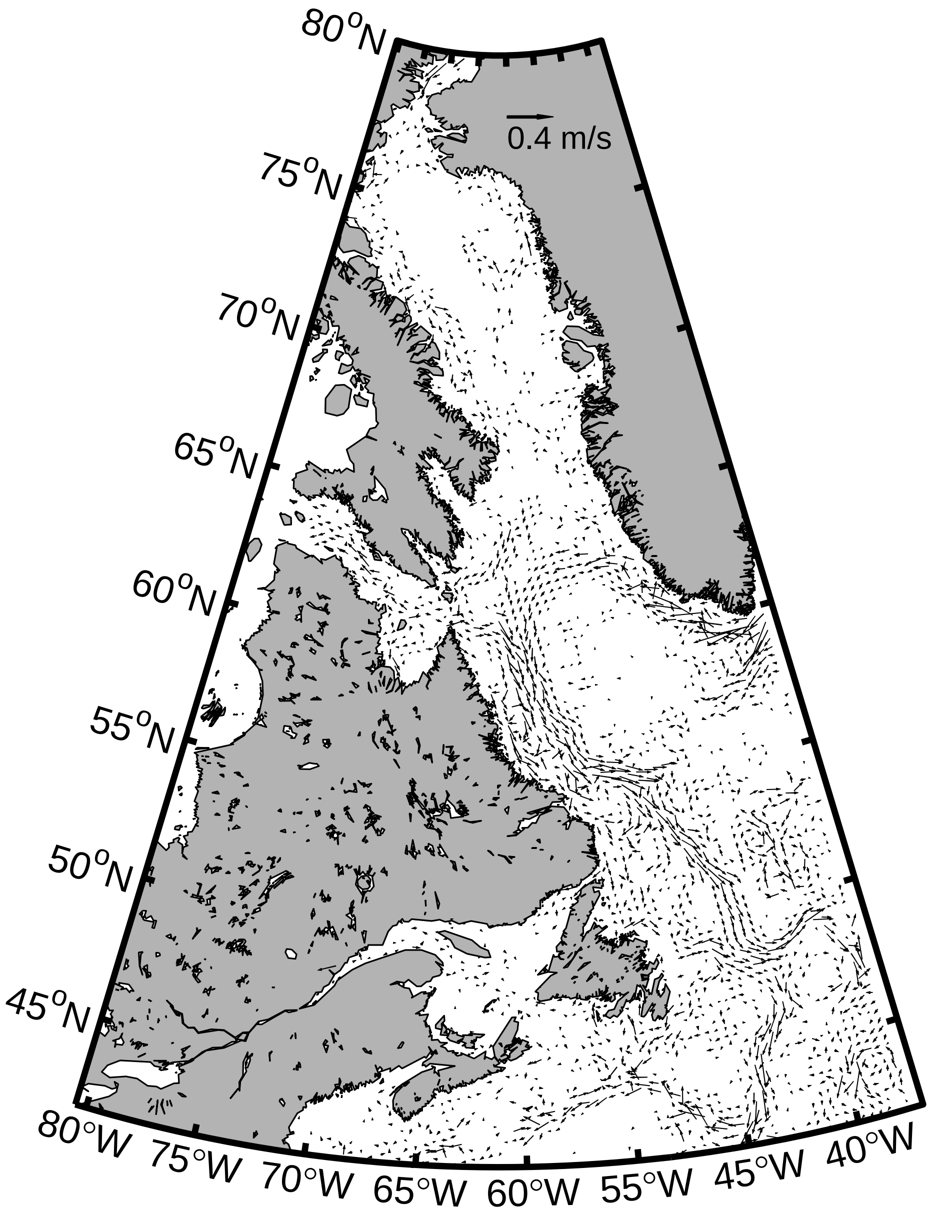

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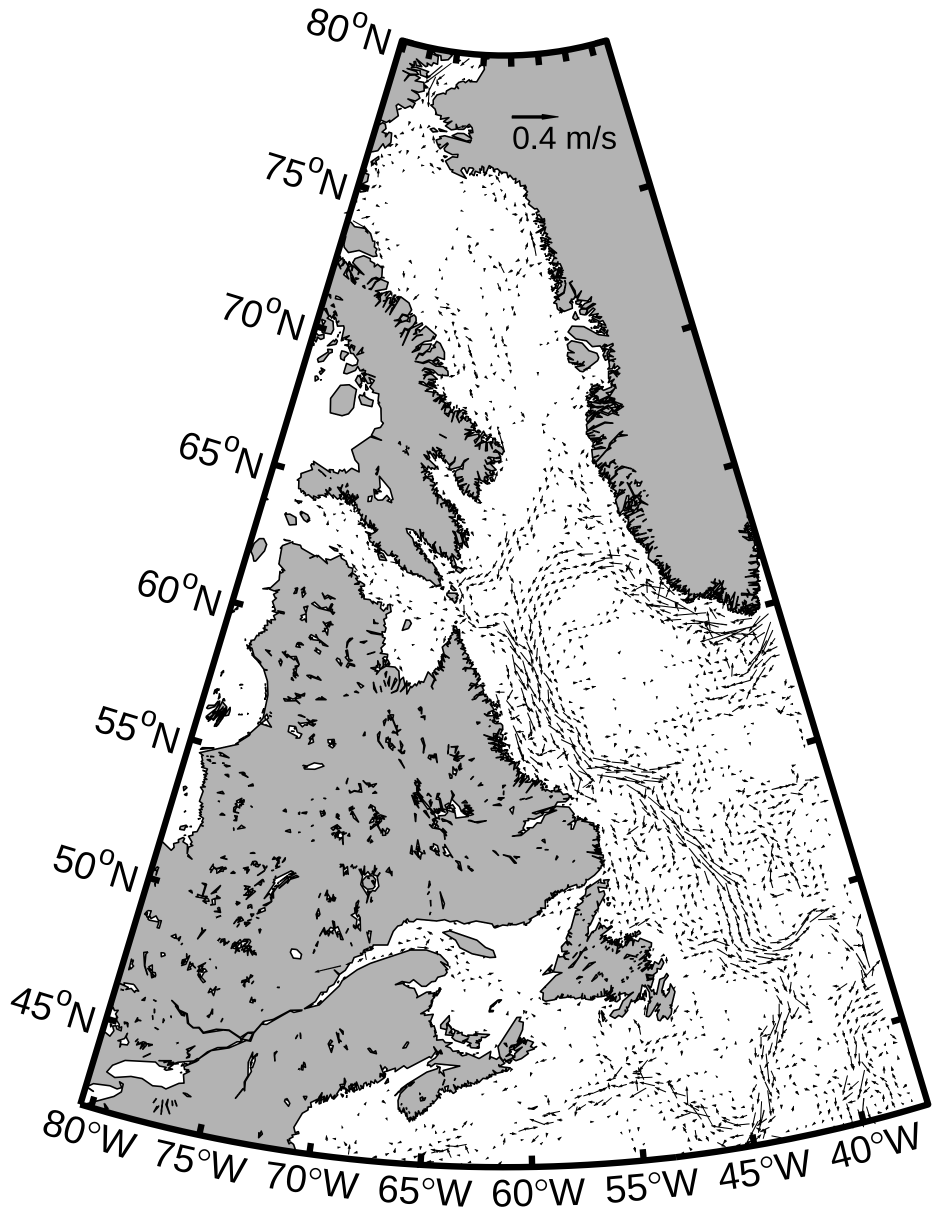

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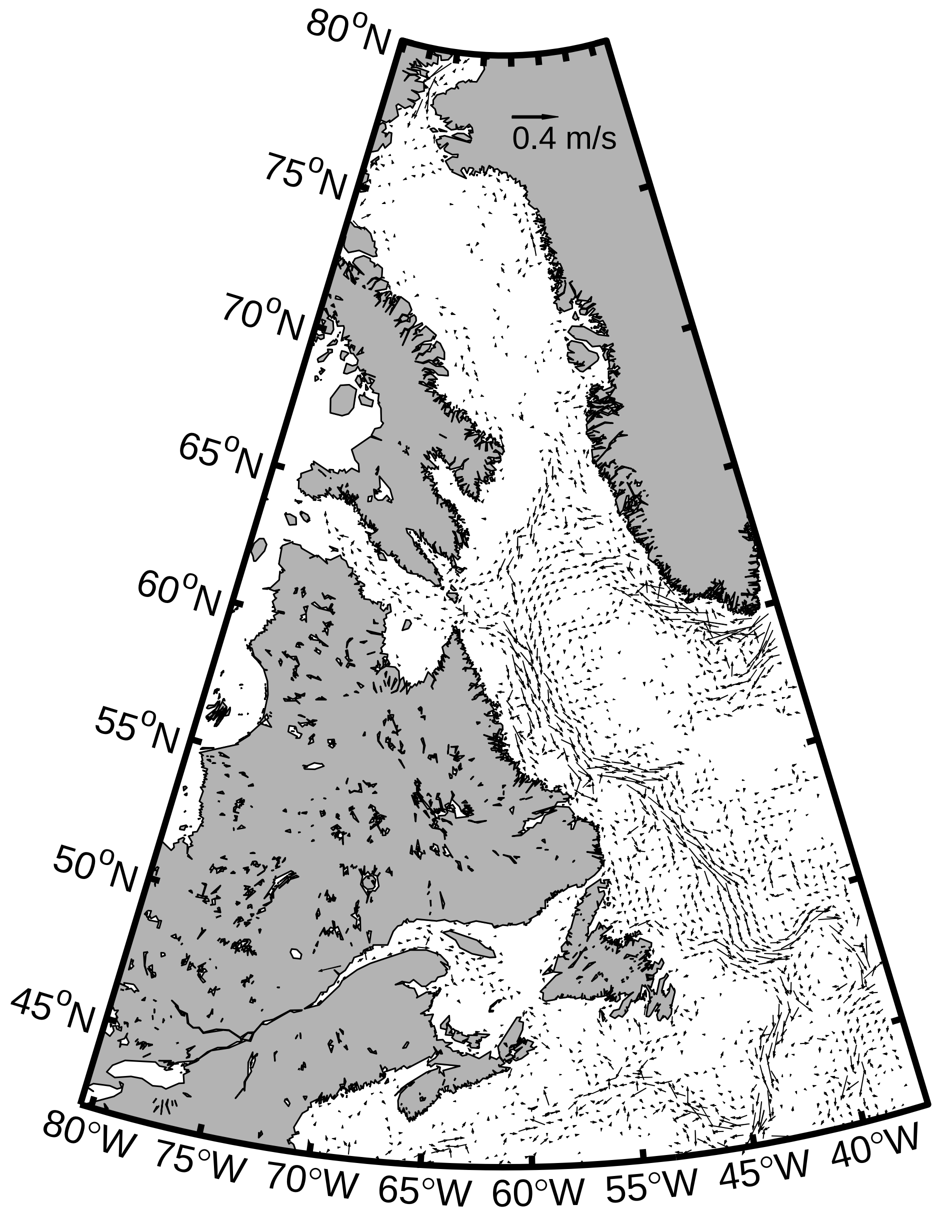

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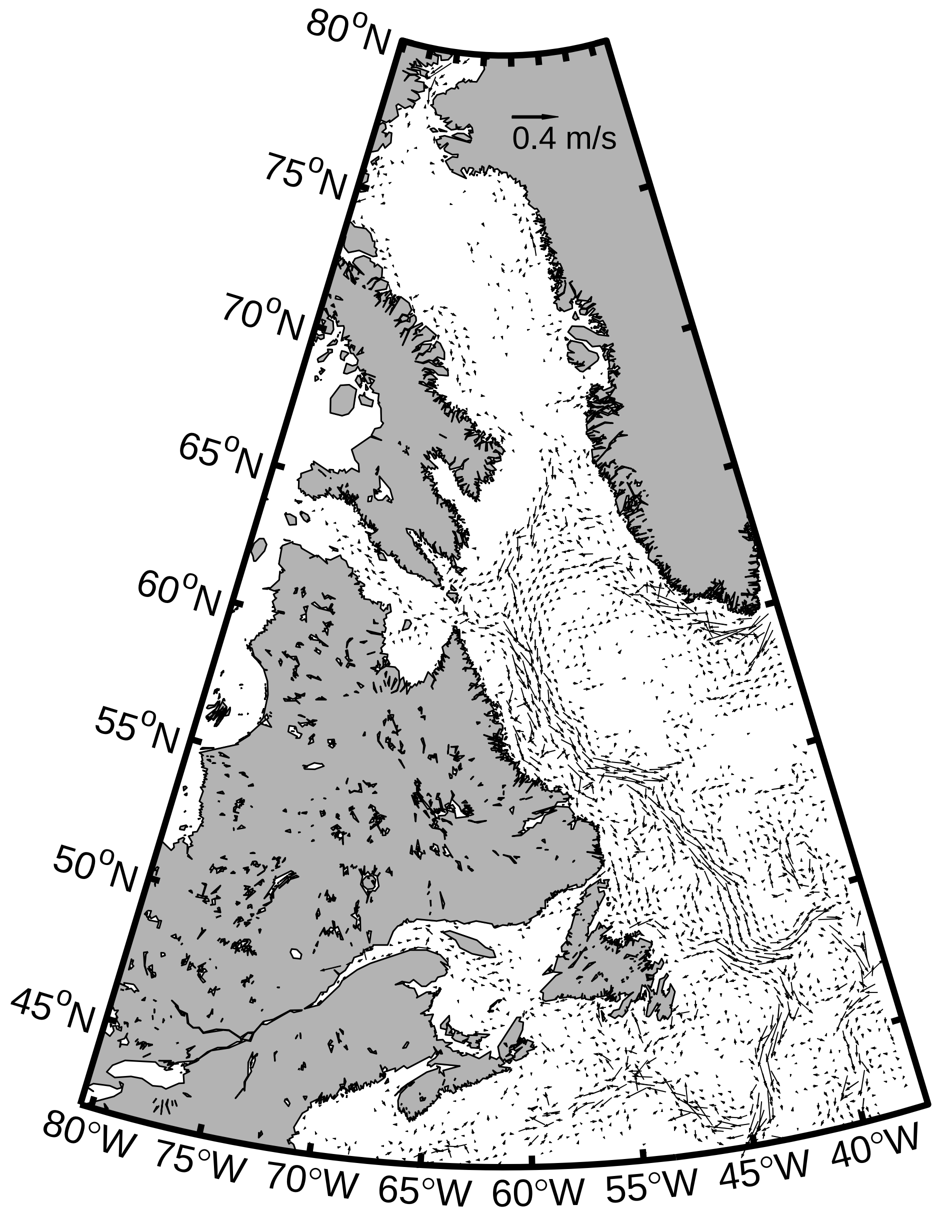

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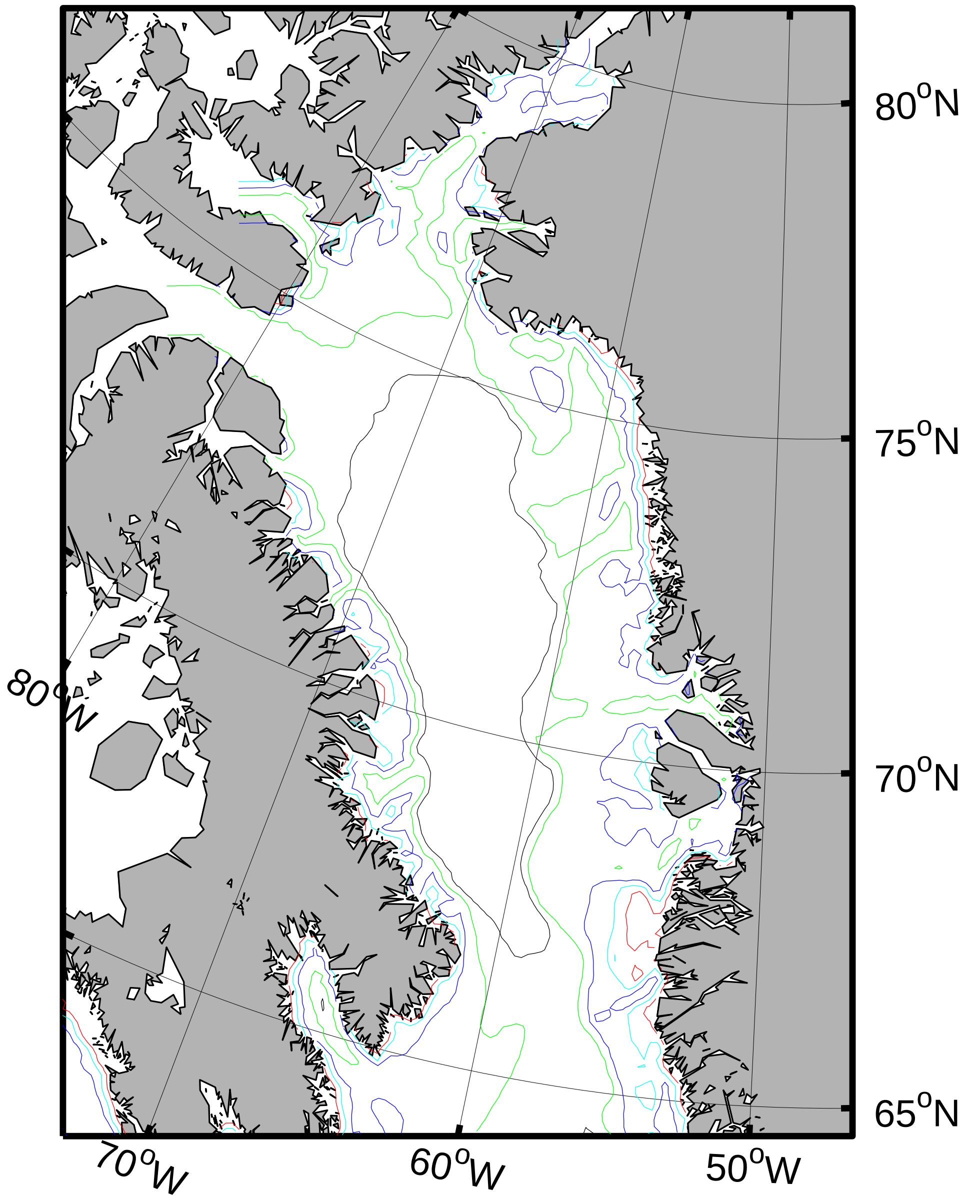
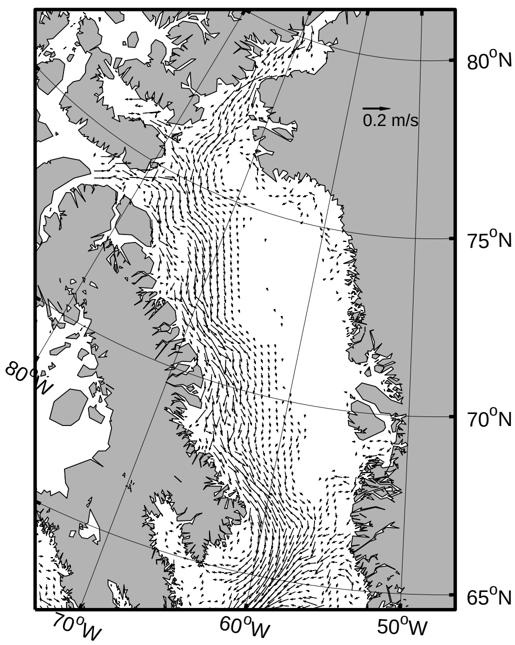


Bottom topography showing 50 (red), 100 (cyan), 200 (blue), 500 (green) and 1000 m (black) isobaths. Depth contours greater than 1000 m are not shown.



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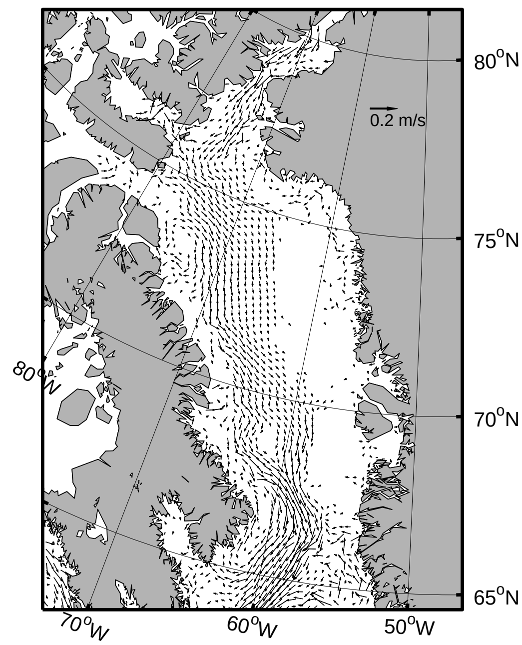

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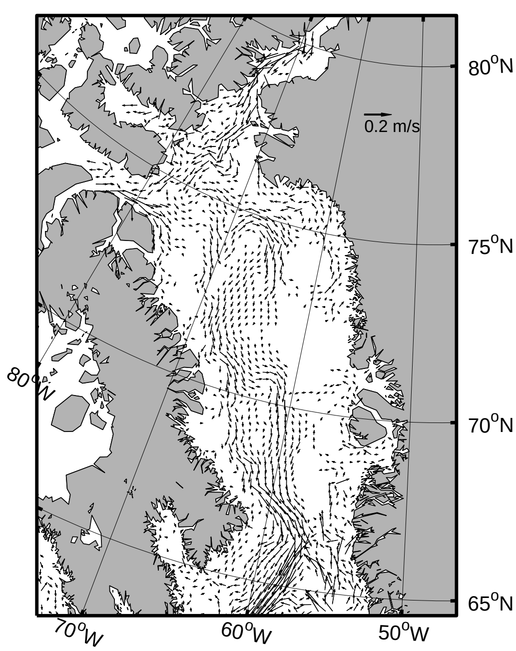

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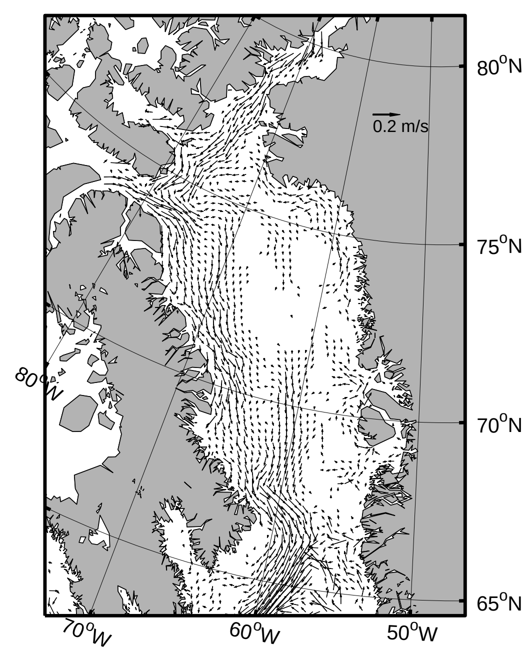

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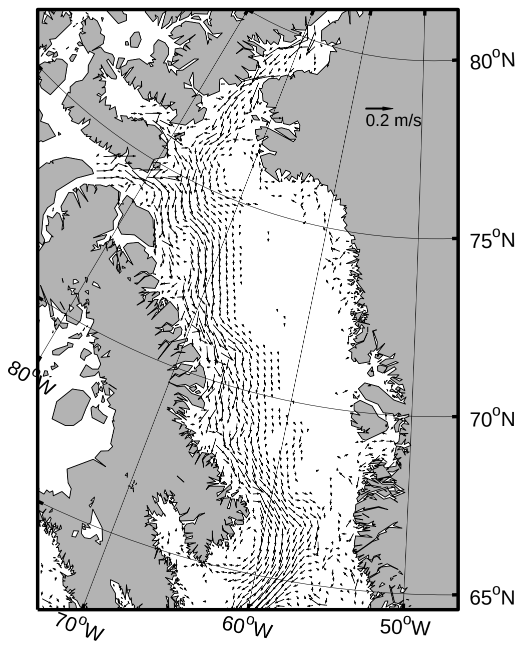

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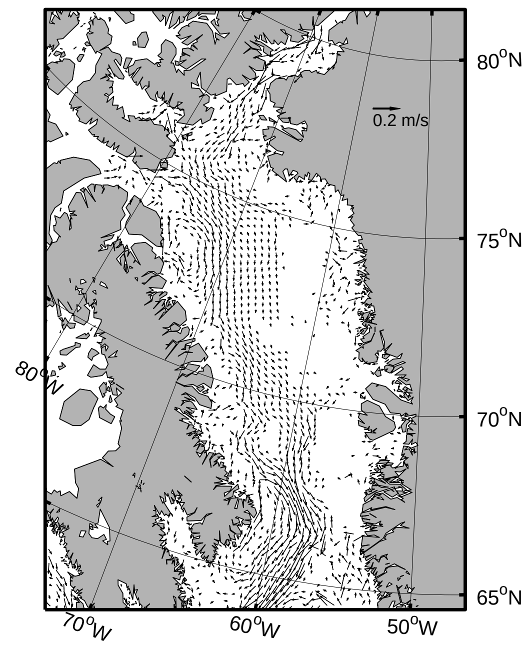

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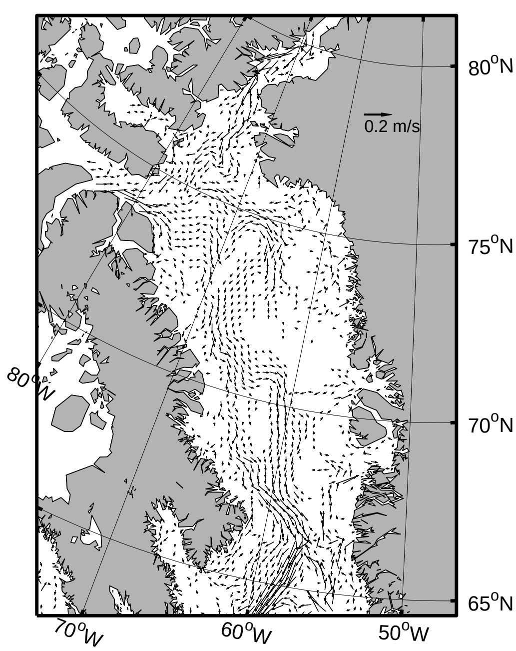

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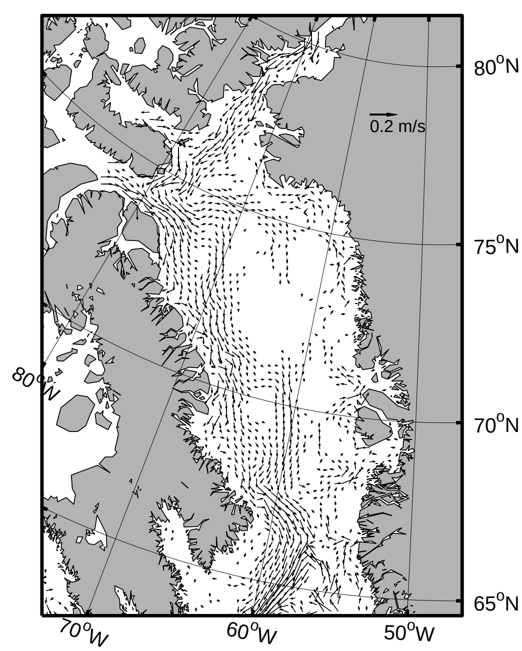

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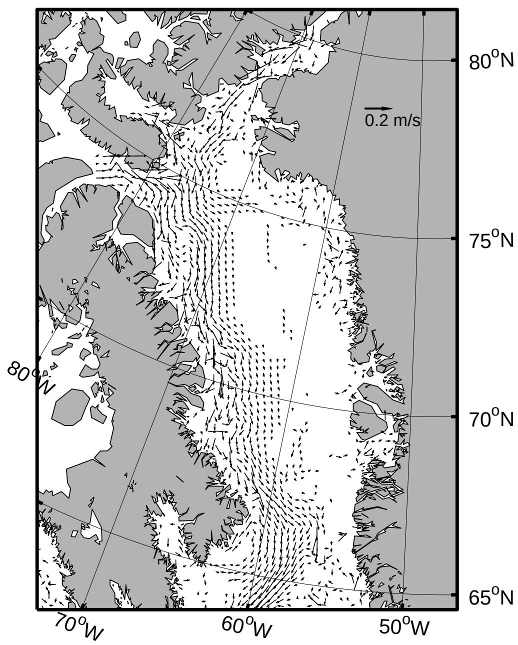

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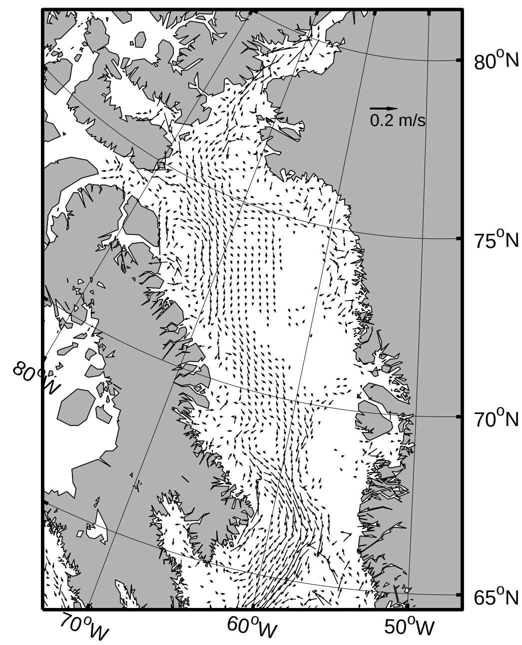

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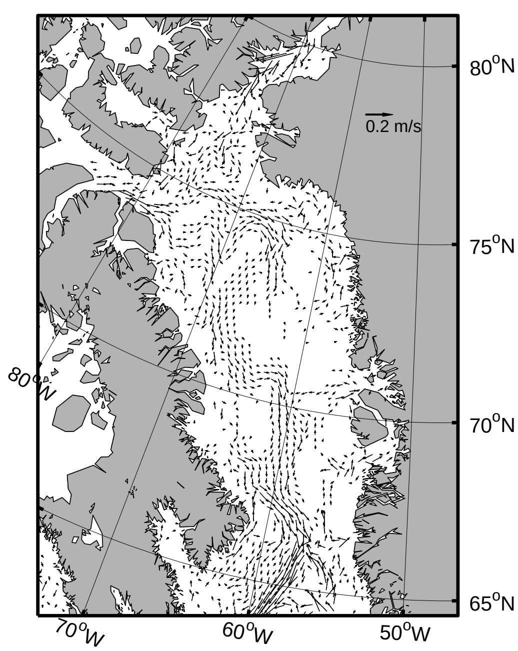

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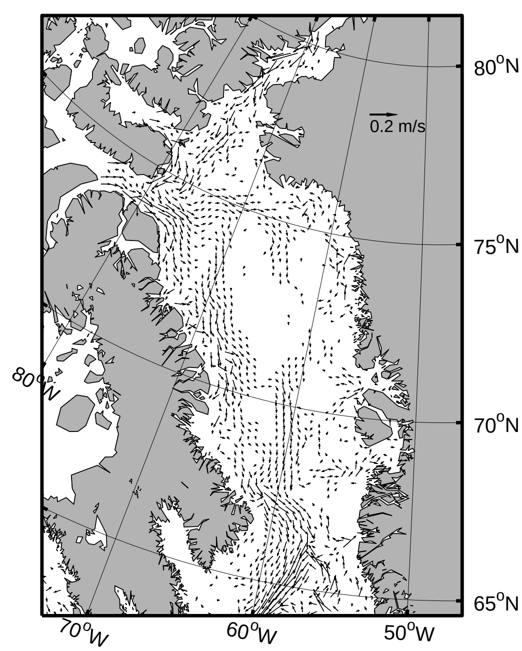
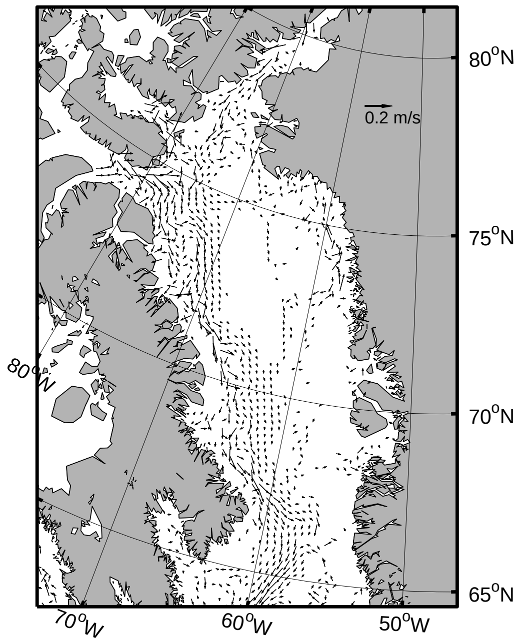
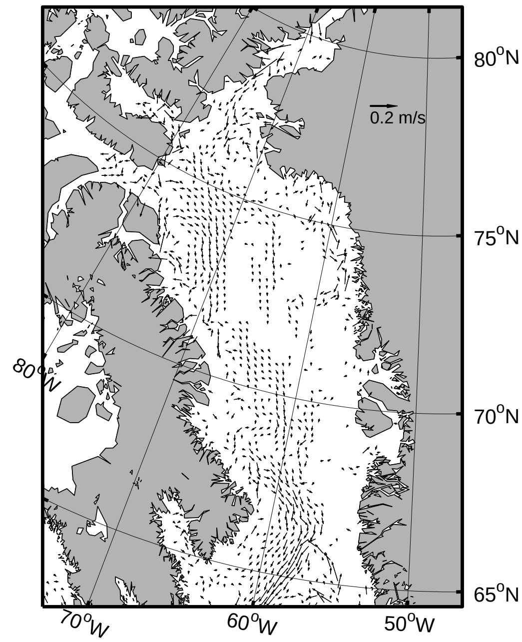


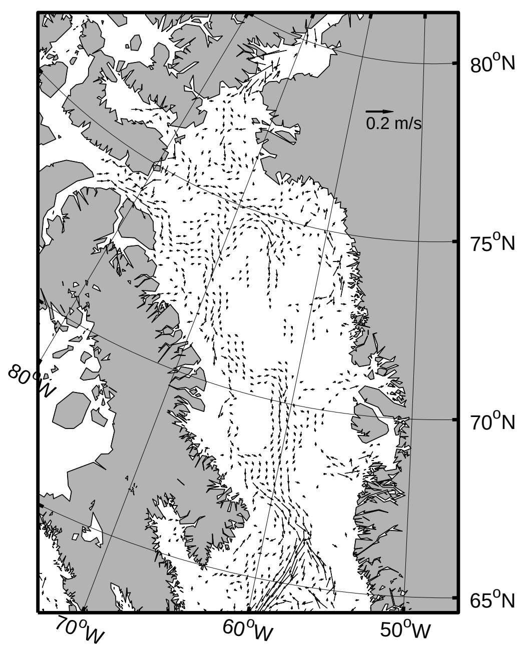
Velocity field at 100 m for autumn



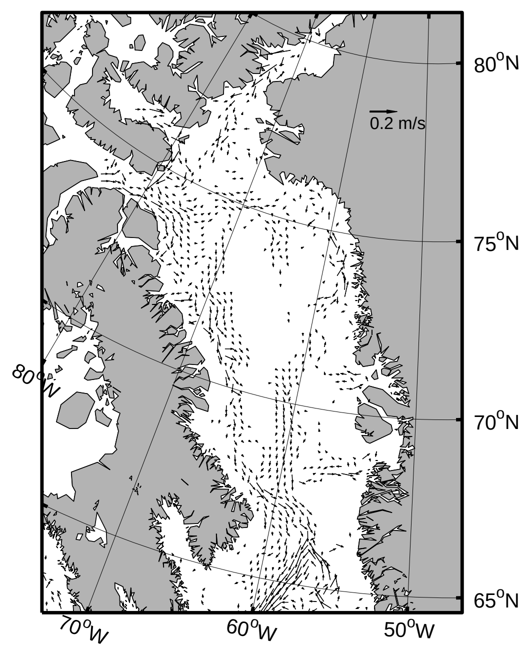
Velocity field at 200 m for winter



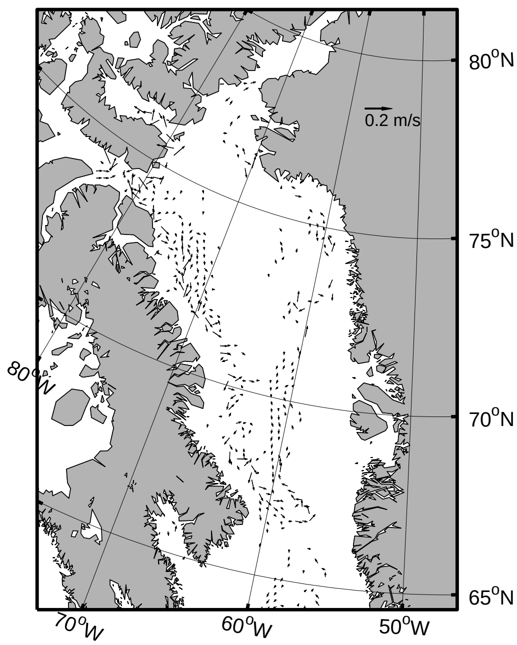
Velocity field at 200 m for spring



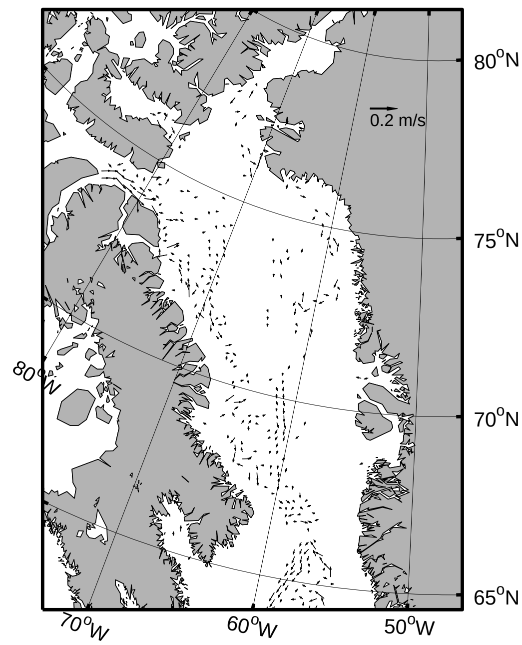
Velocity field at 200 m for summer



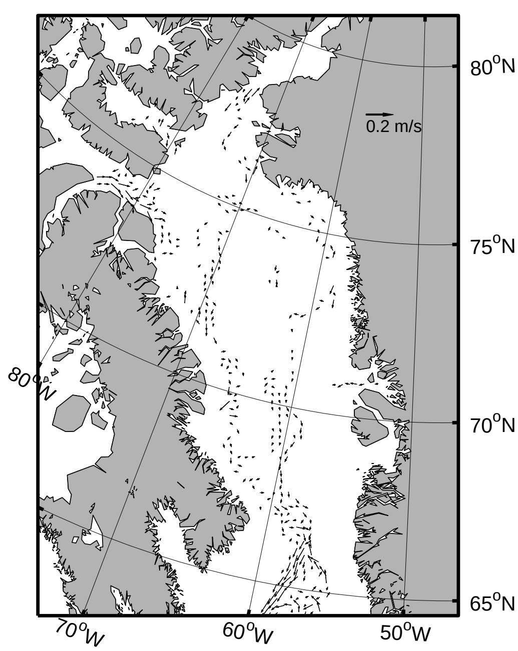
Velocity field at 200 m for autumn



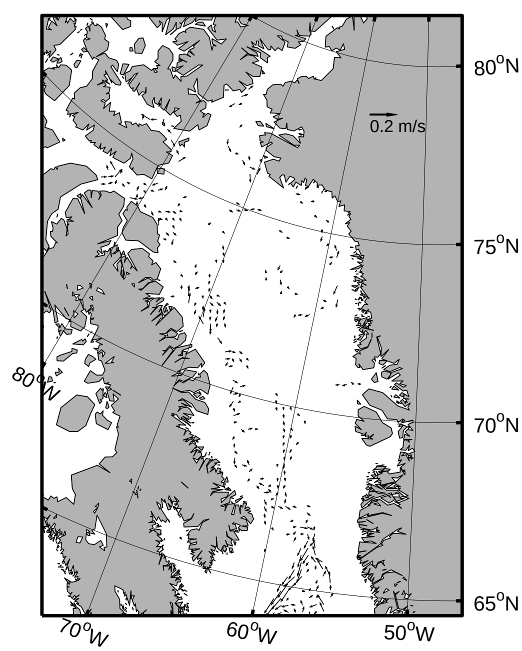
Velocity field at 500 m for winter



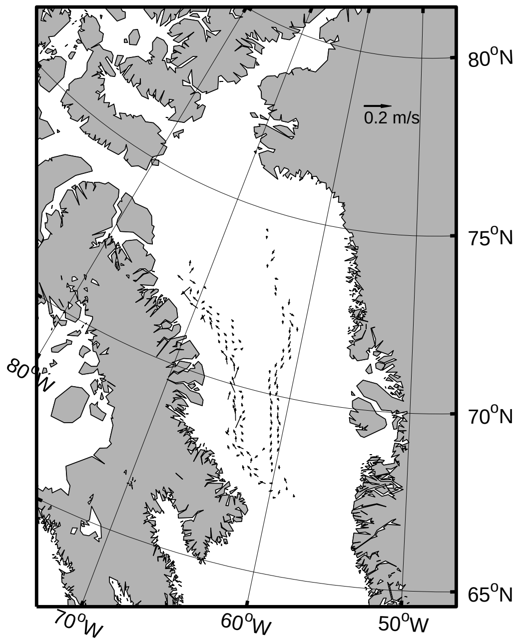
Velocity field at 500 m for spring



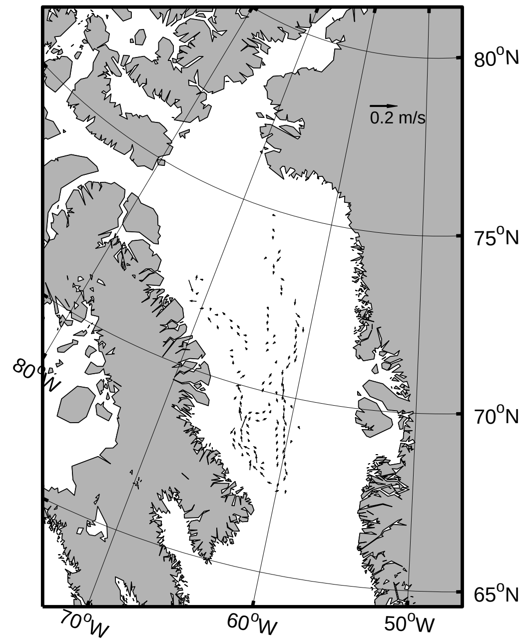
Velocity field at 500 m for summer



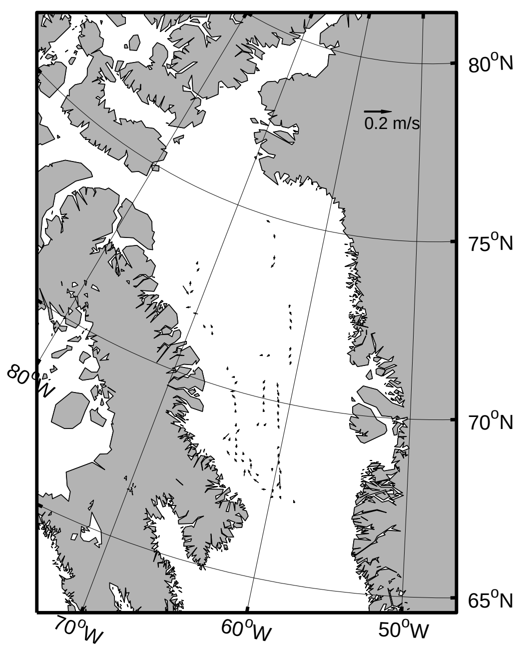
Velocity field at 500 m for autumn



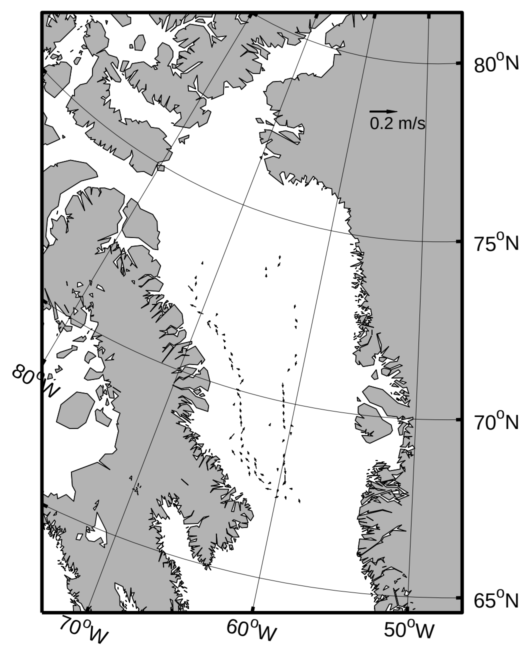
Velocity field at 1000 m for winter



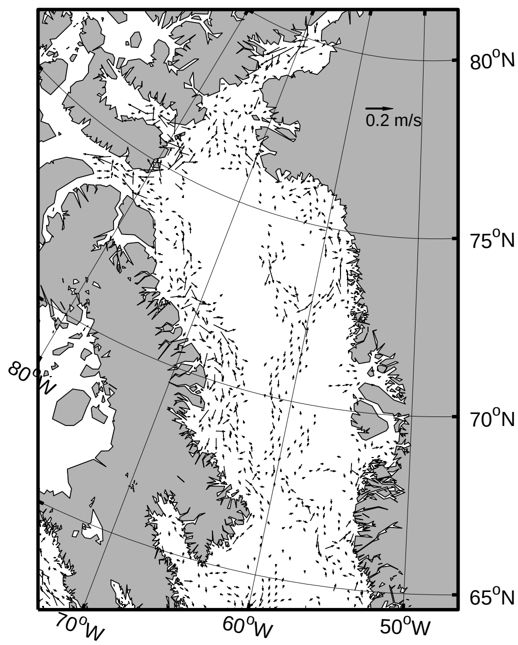
Velocity field at 1000 m for spring



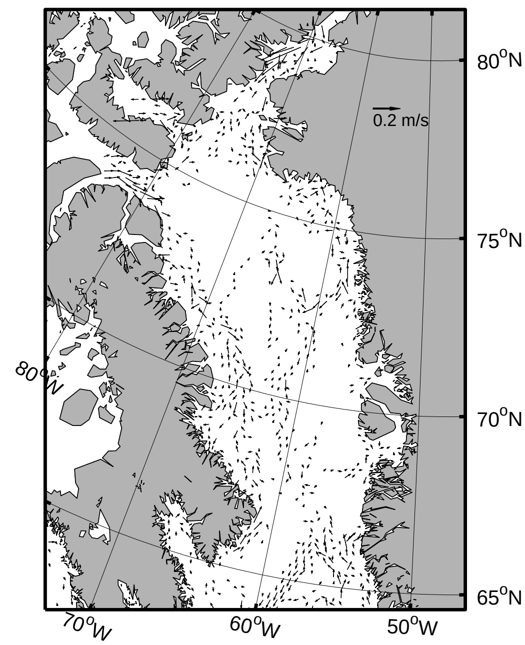
Velocity field at 1000 m for summer



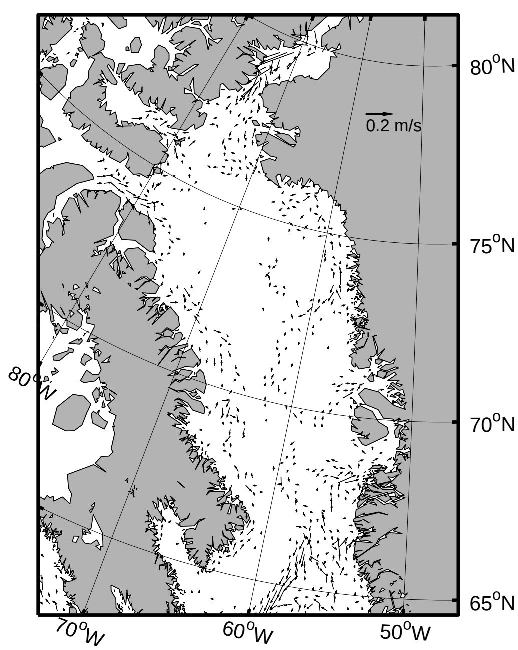
Velocity field at 1000 m for autumn



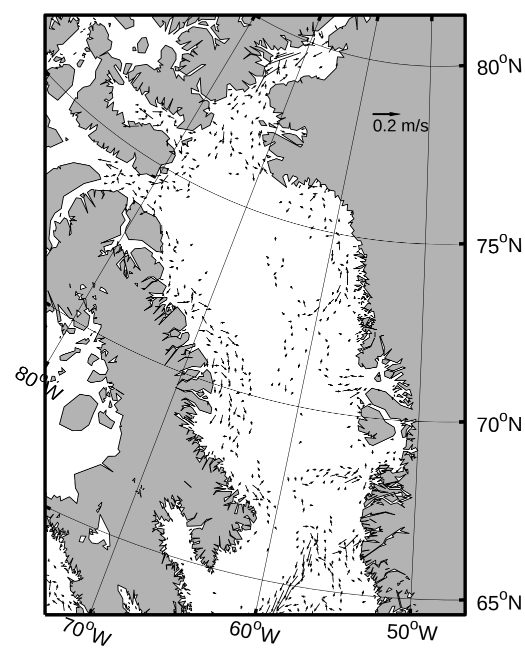
Velocity field at 10 m from the bottom for winter



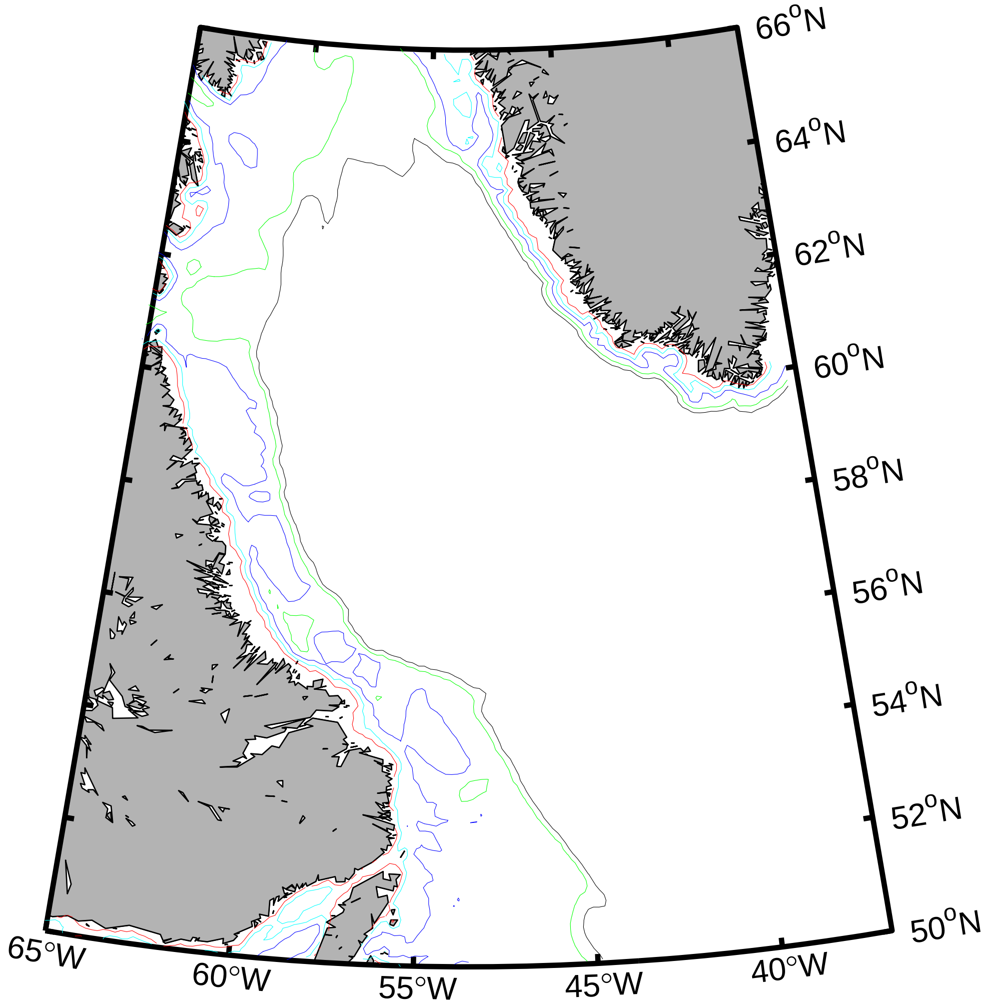
Velocity field at 10 m from the bottom for spring



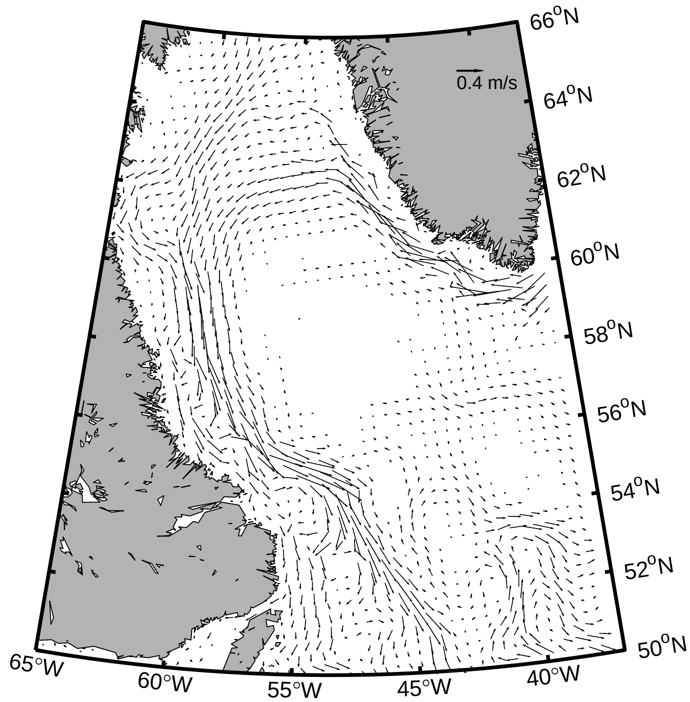
Velocity field at 10 m from the bottom for summer



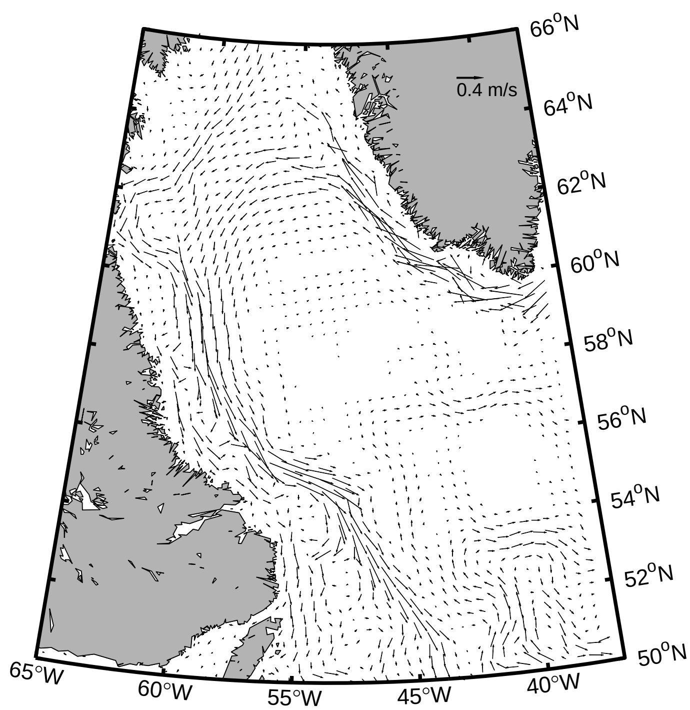
Velocity field at 10 m from the bottom for autumn



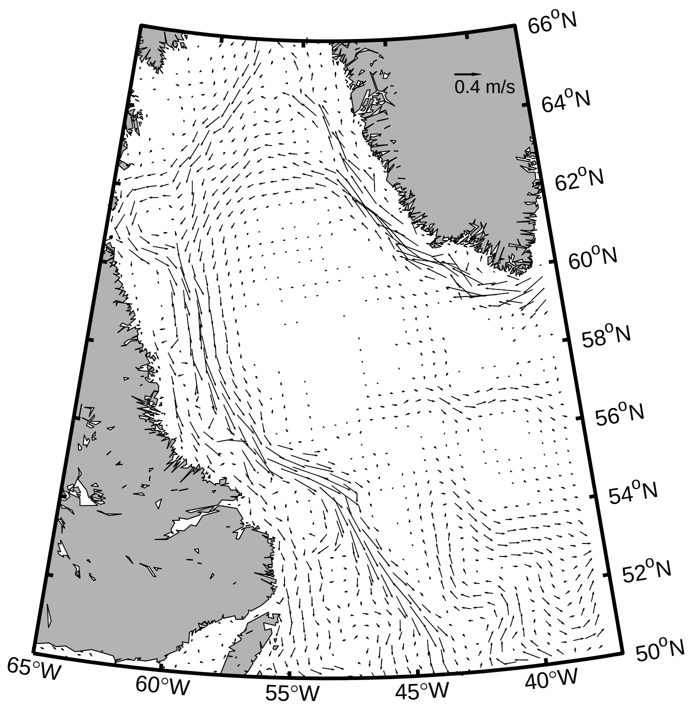
Bottom topography showing 50 (red), 100 (cyan), 200 (blue), 500 (green) and 1000 m (black) isobaths. Depth contours greater than 1000 m are not shown.



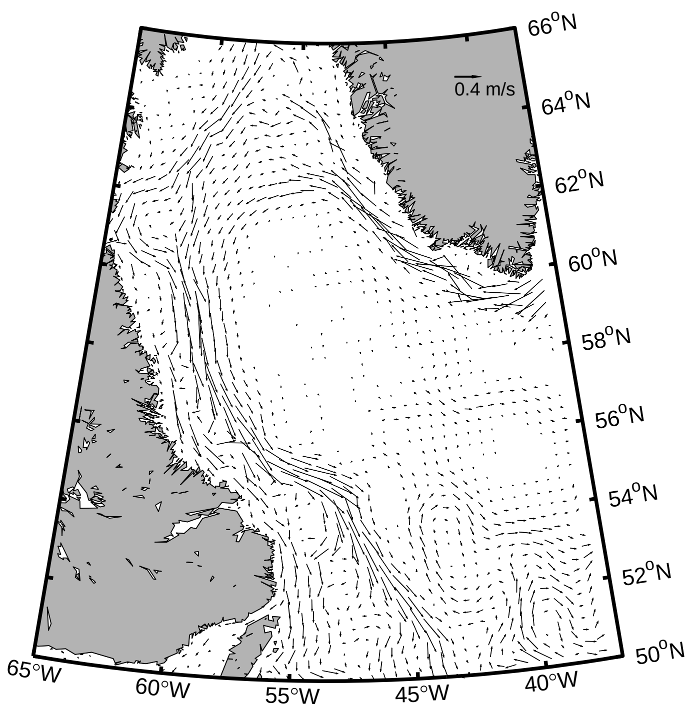
Velocity field at 5 m for winter



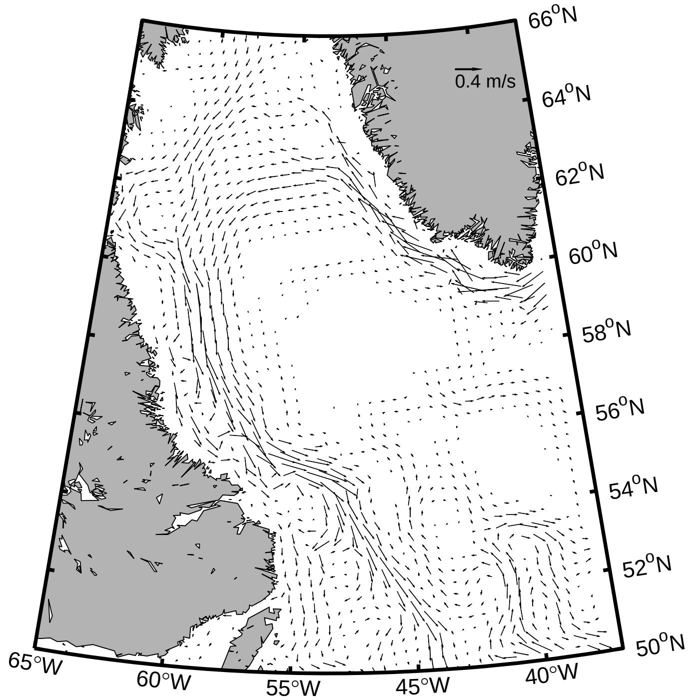
Velocity field at 5 m for spring



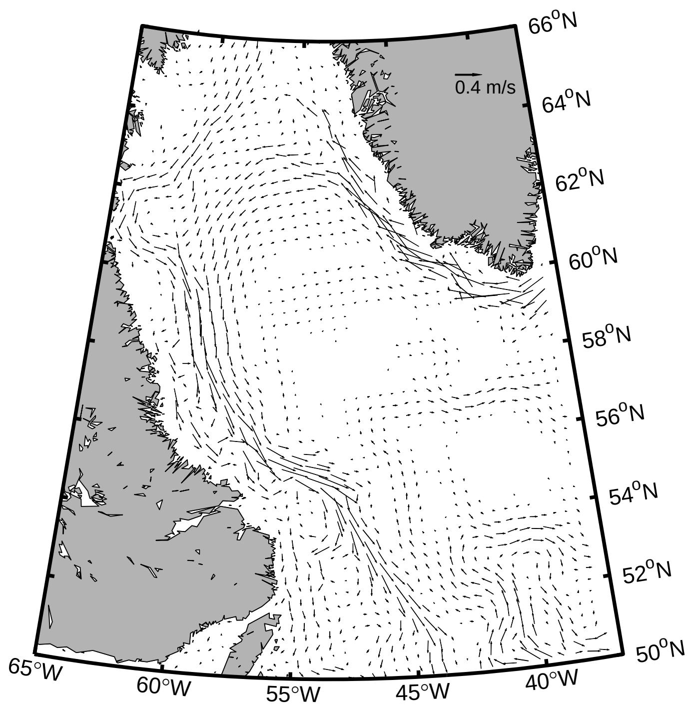
Velocity field at 5 m for summer



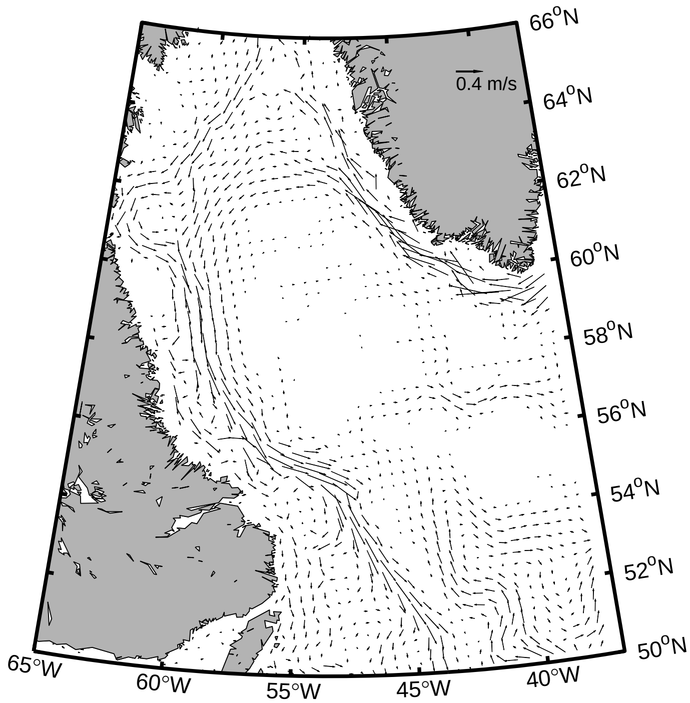
Velocity field at 5 m for autumn



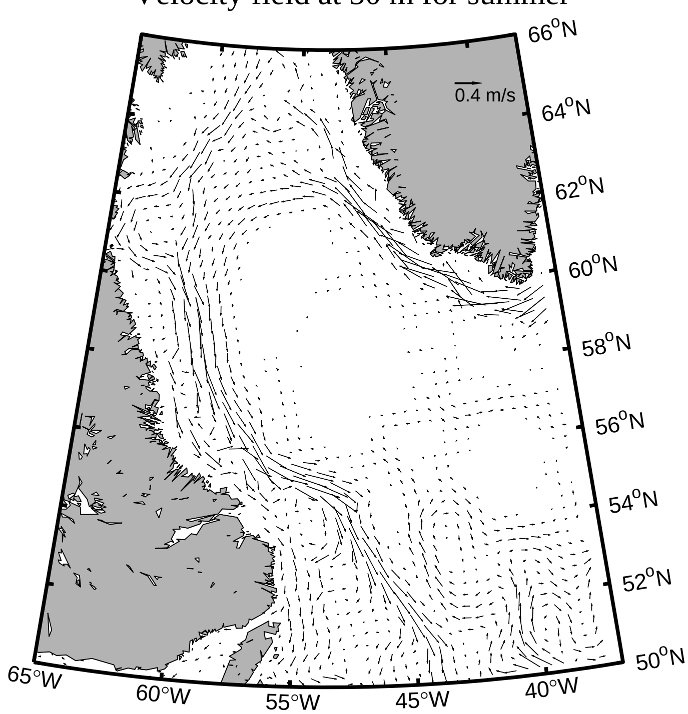
Velocity field at 50 m for winter



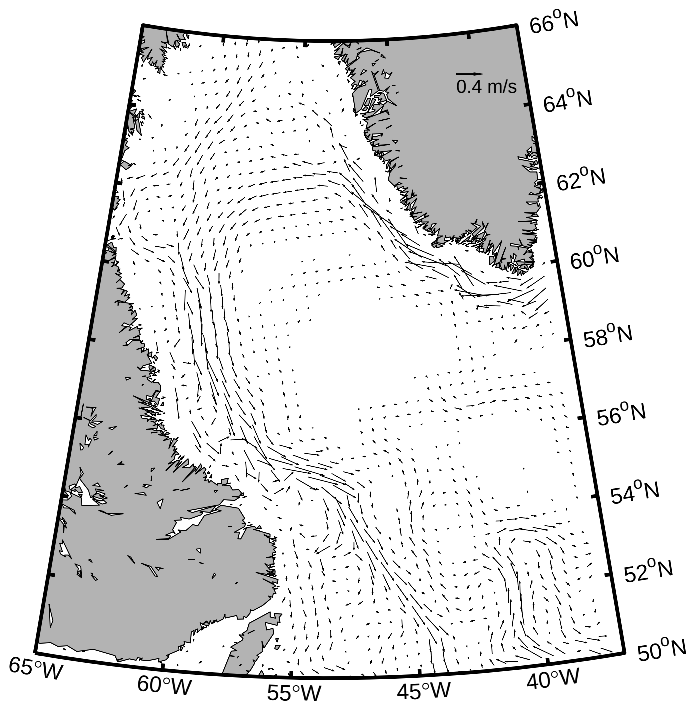
Velocity field at 50 m for spring



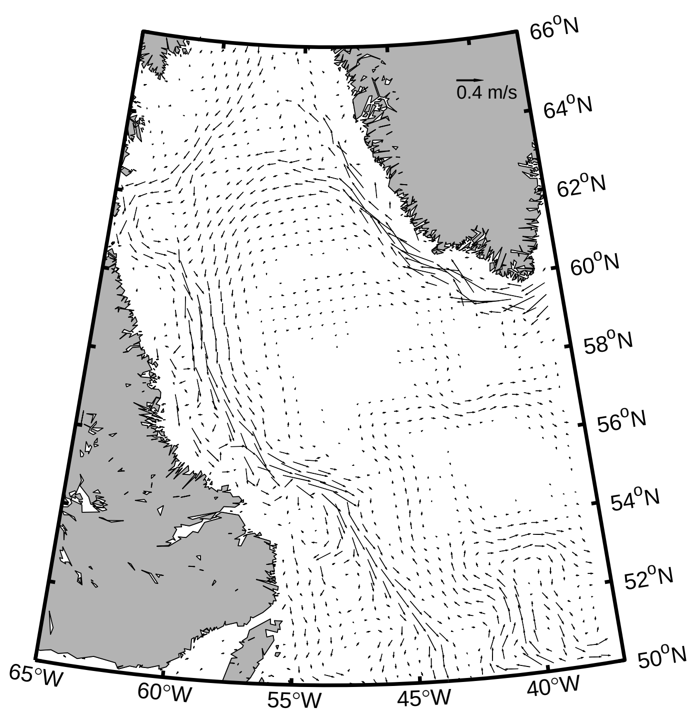
Velocity field at 50 m for summer



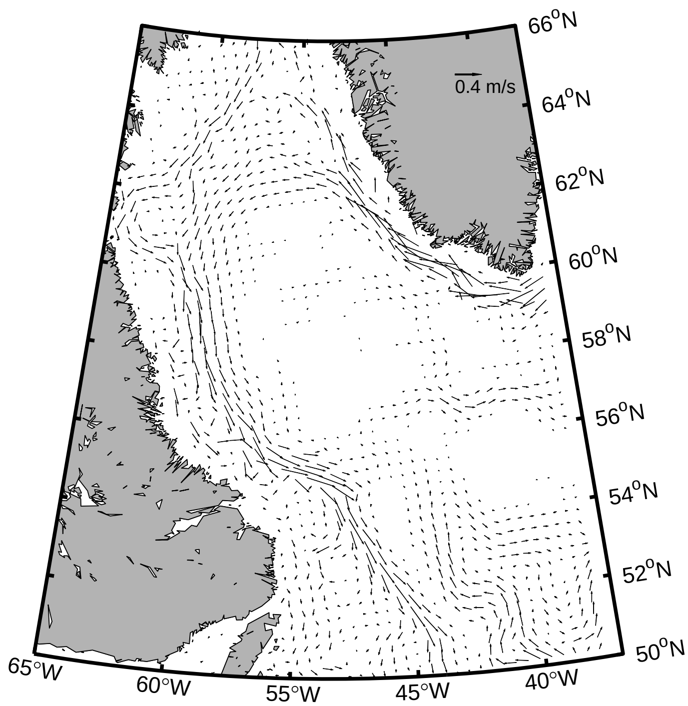
Velocity field at 50 m for autumn



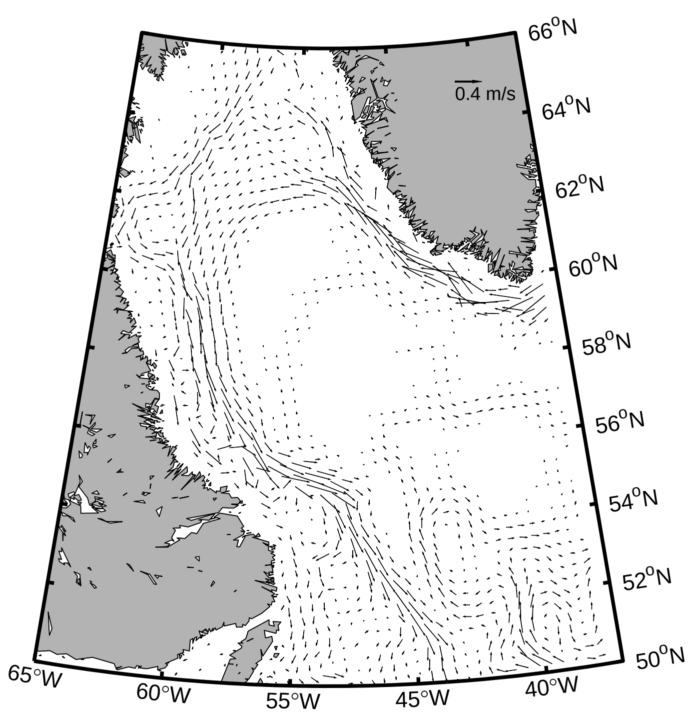
Velocity field at 100 m for winter



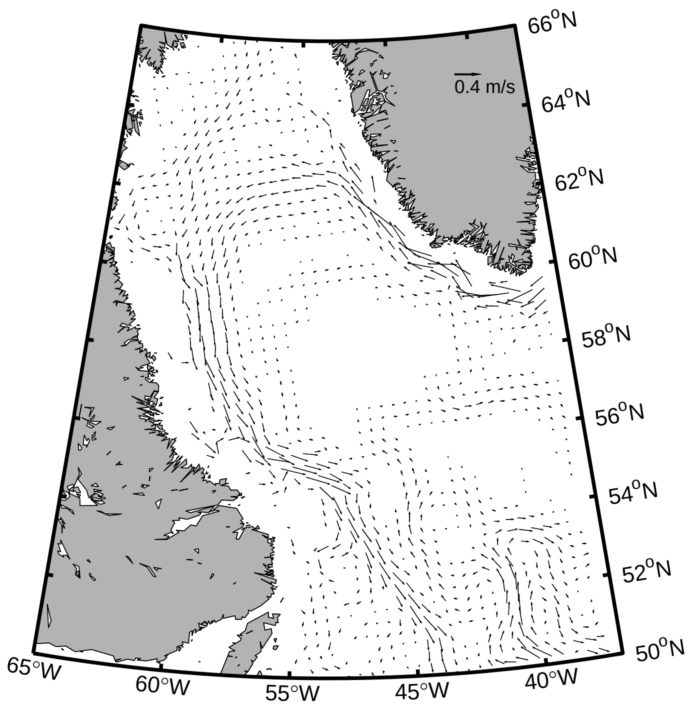
Velocity field at 100 m for spring



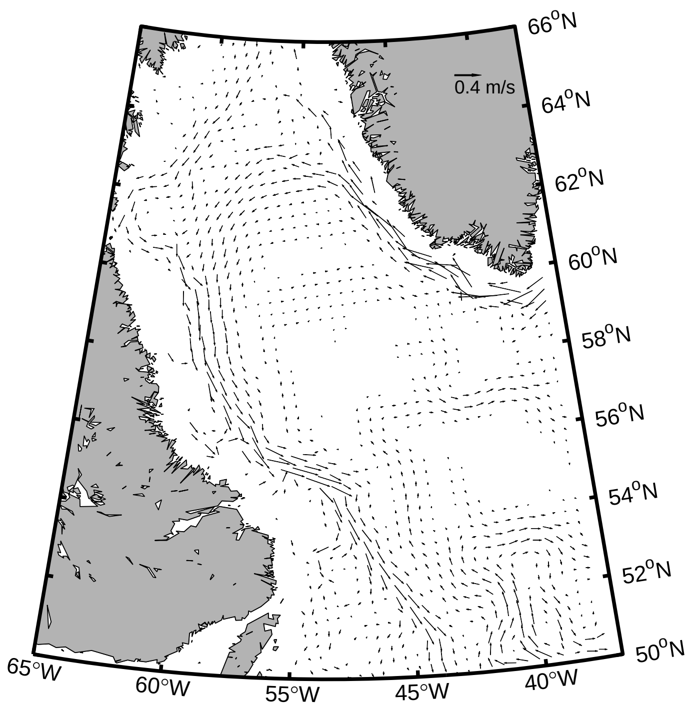
Velocity field at 100 m for summer



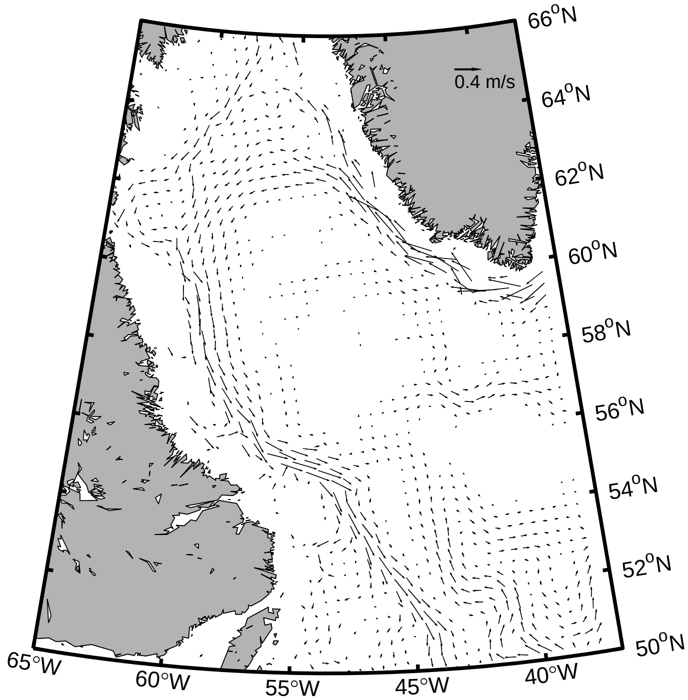
Velocity field at 100 m for autumn



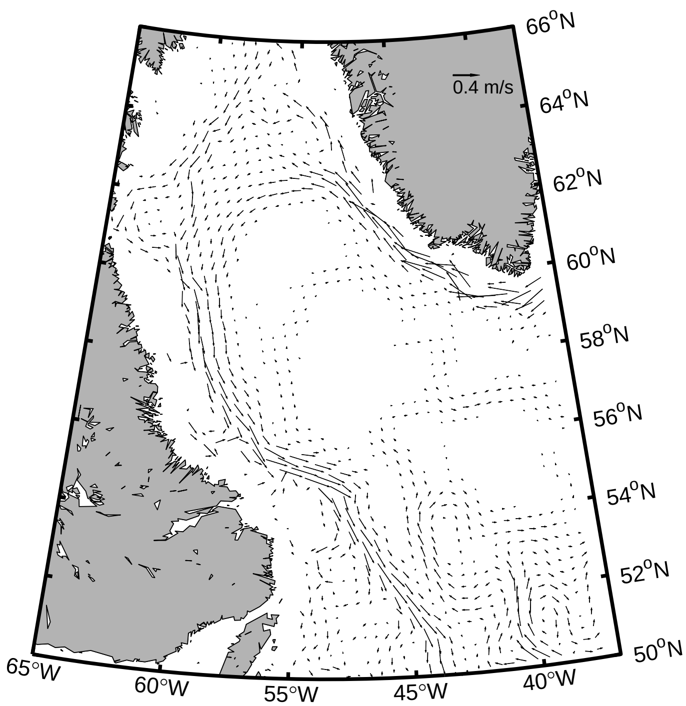
Velocity field at 200 m for winter



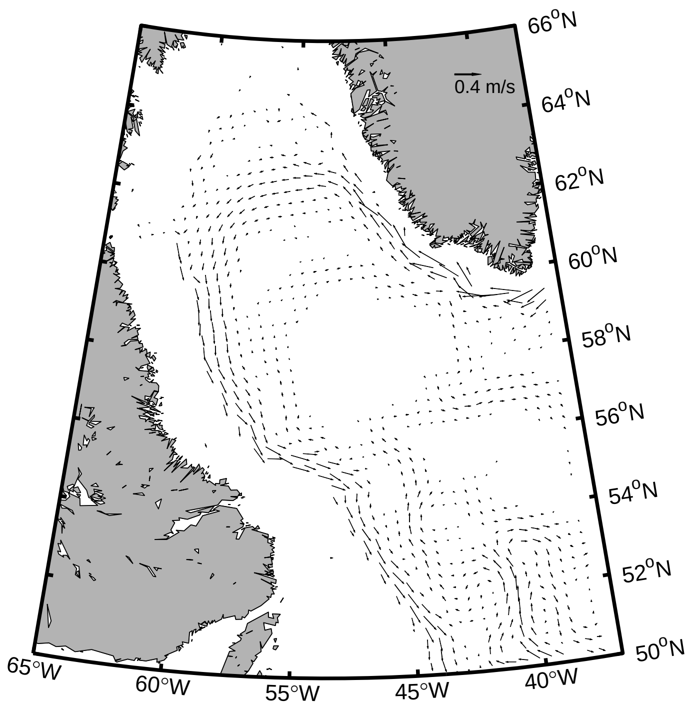
Velocity field at 200 m for spring



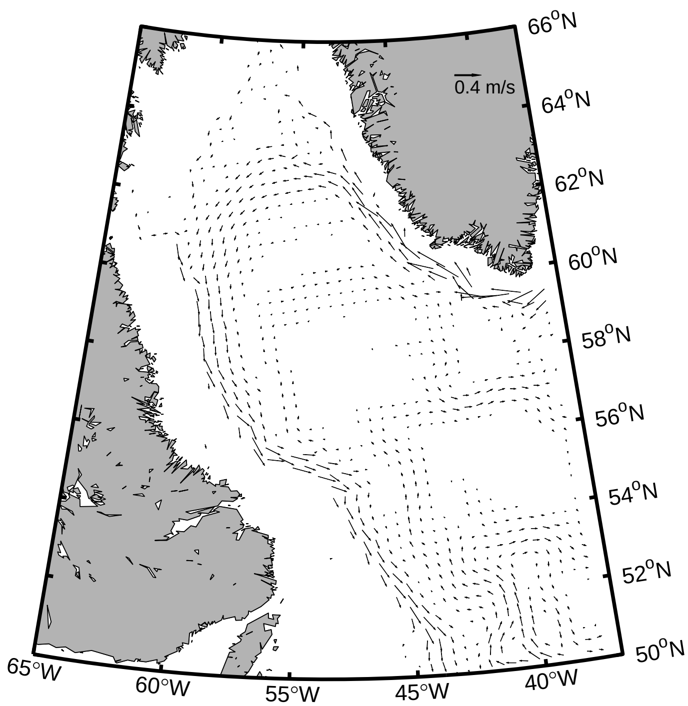
Velocity field at 200 m for summer



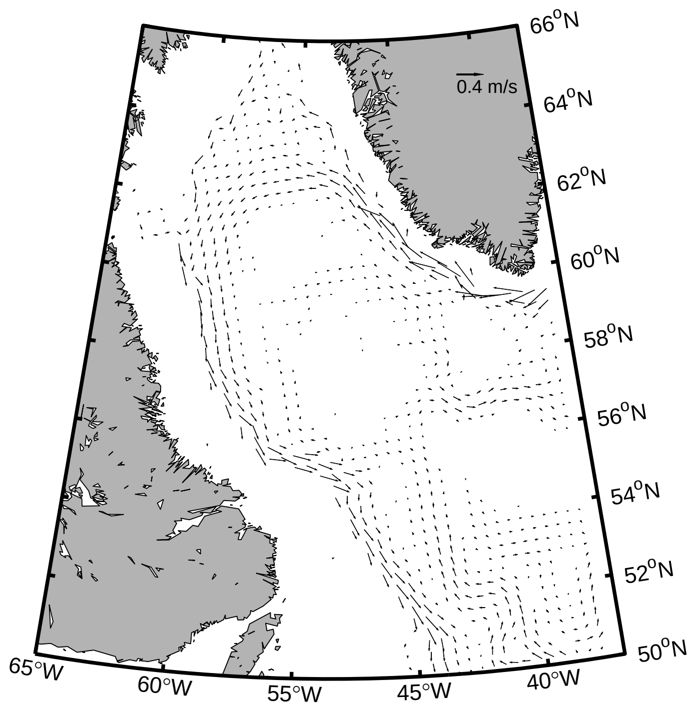
Velocity field at 200 m for autumn



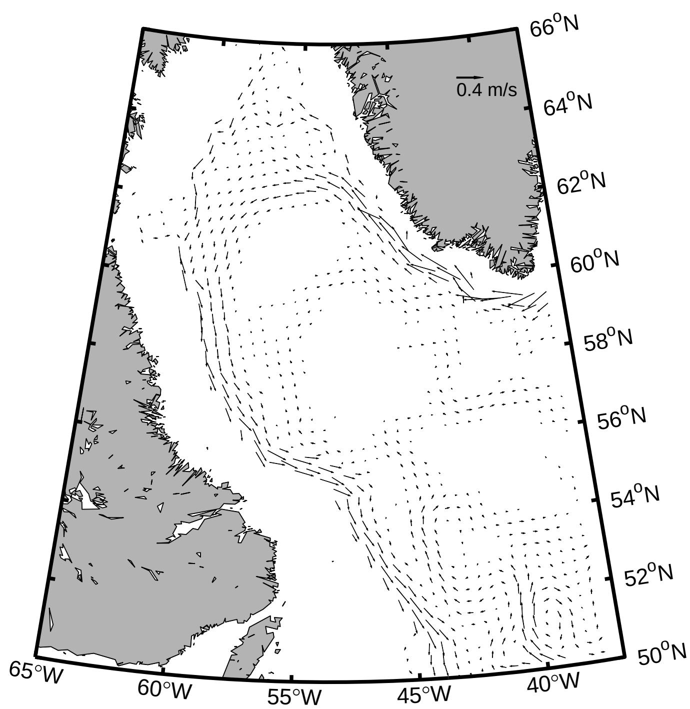
Velocity field at 500 m for winter



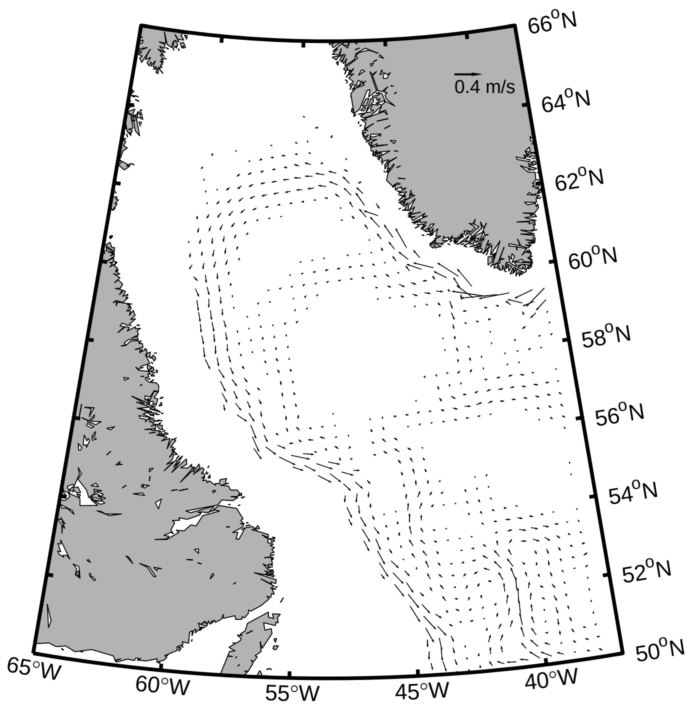
Velocity field at 500 m for spring



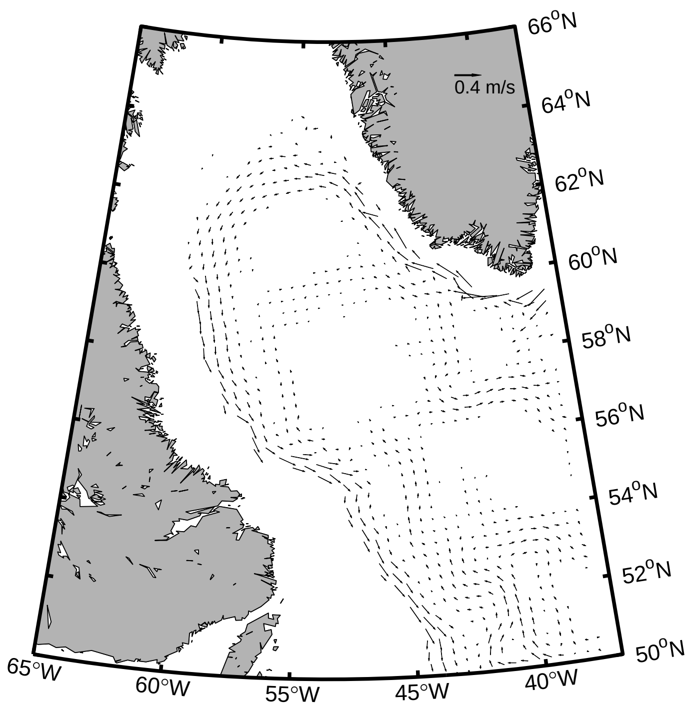
Velocity field at 500 m for summer



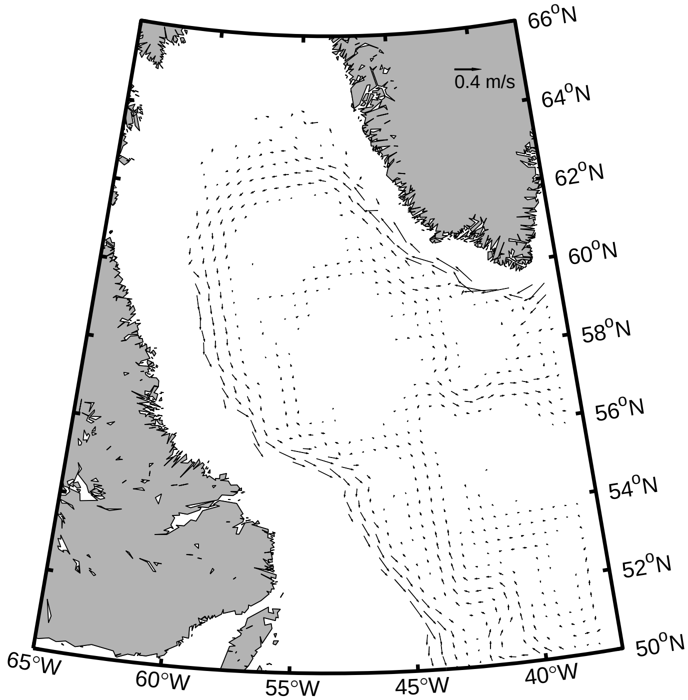
Velocity field at 500 m for autumn



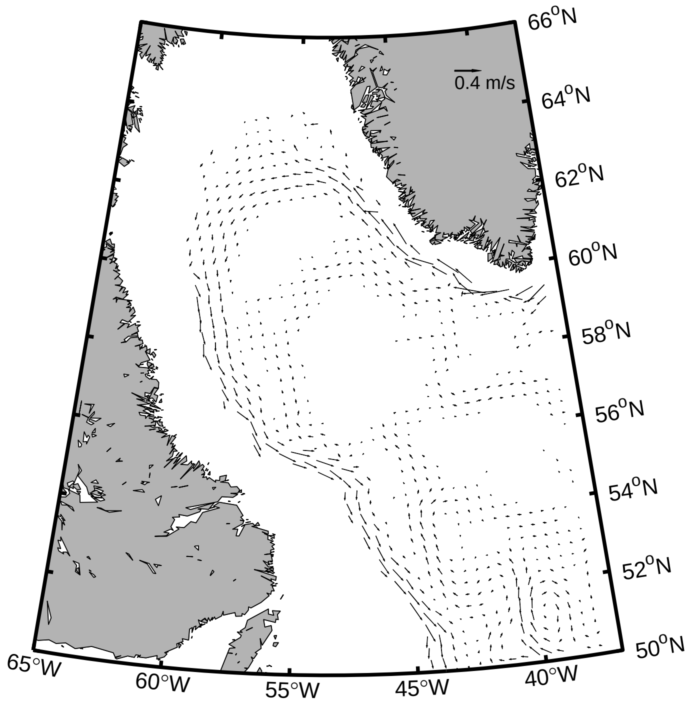
Velocity field at 1000 m for winter



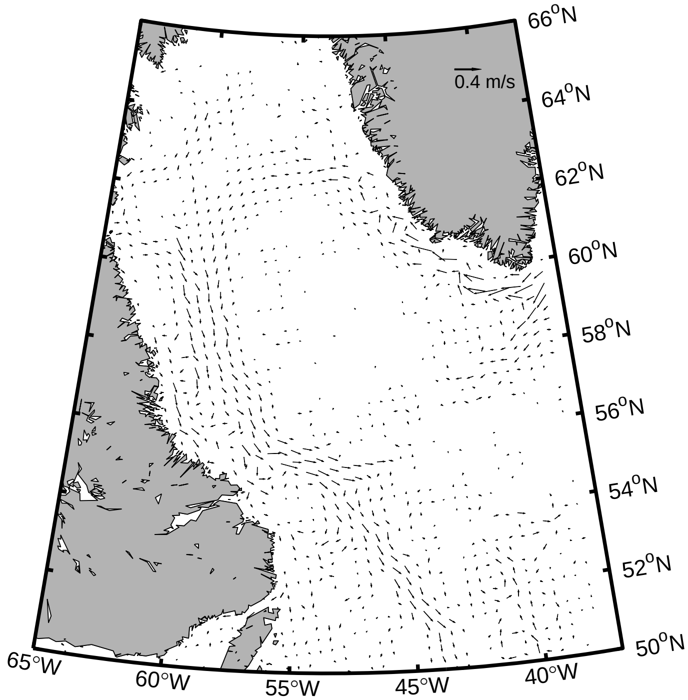
Velocity field at 1000 m for spring



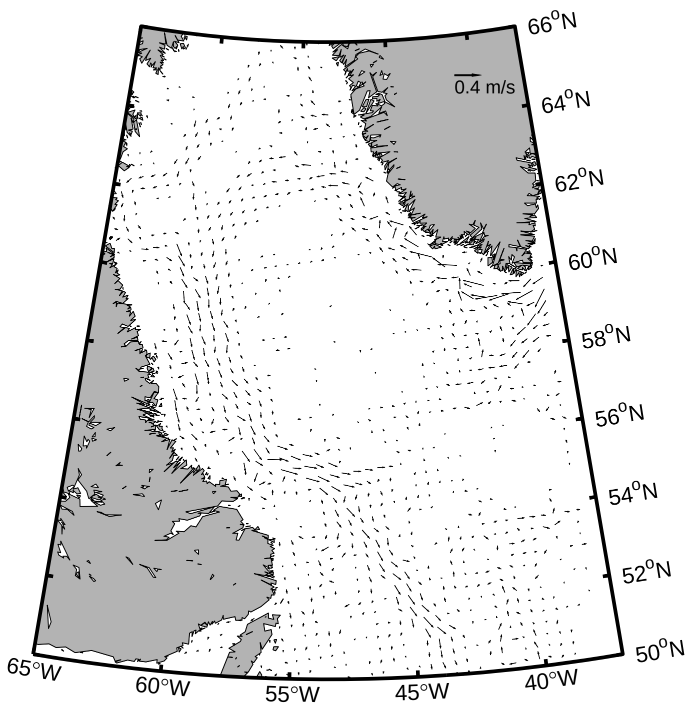
Velocity field at 1000 m for summer



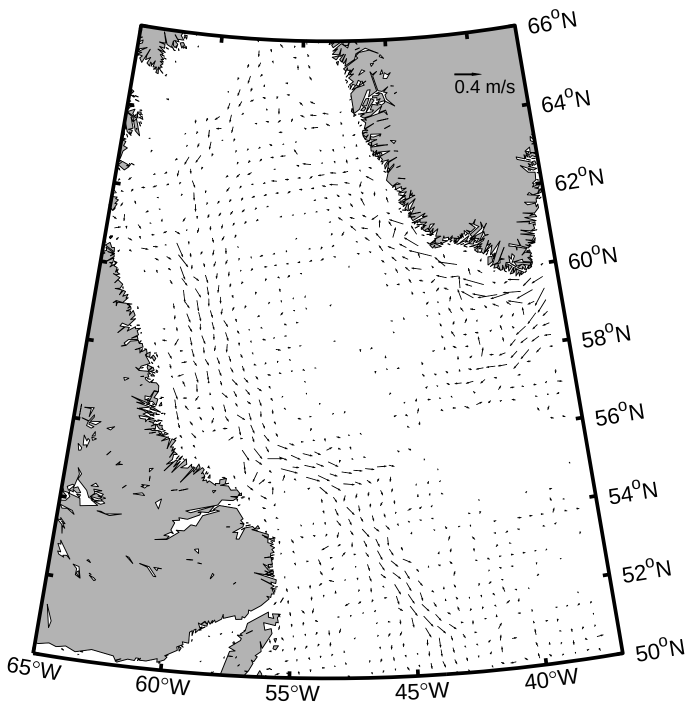
Velocity field at 1000 m for autumn



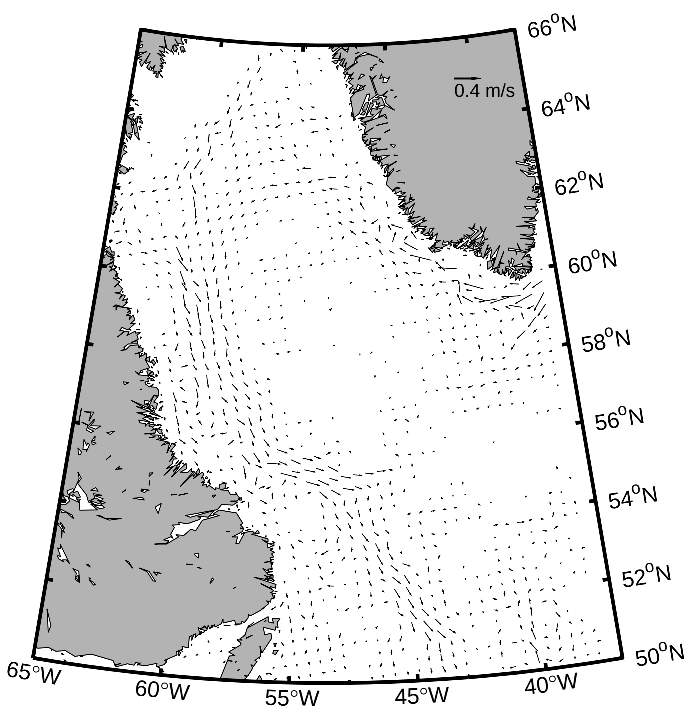
Velocity at 10 m from the bottom for winter



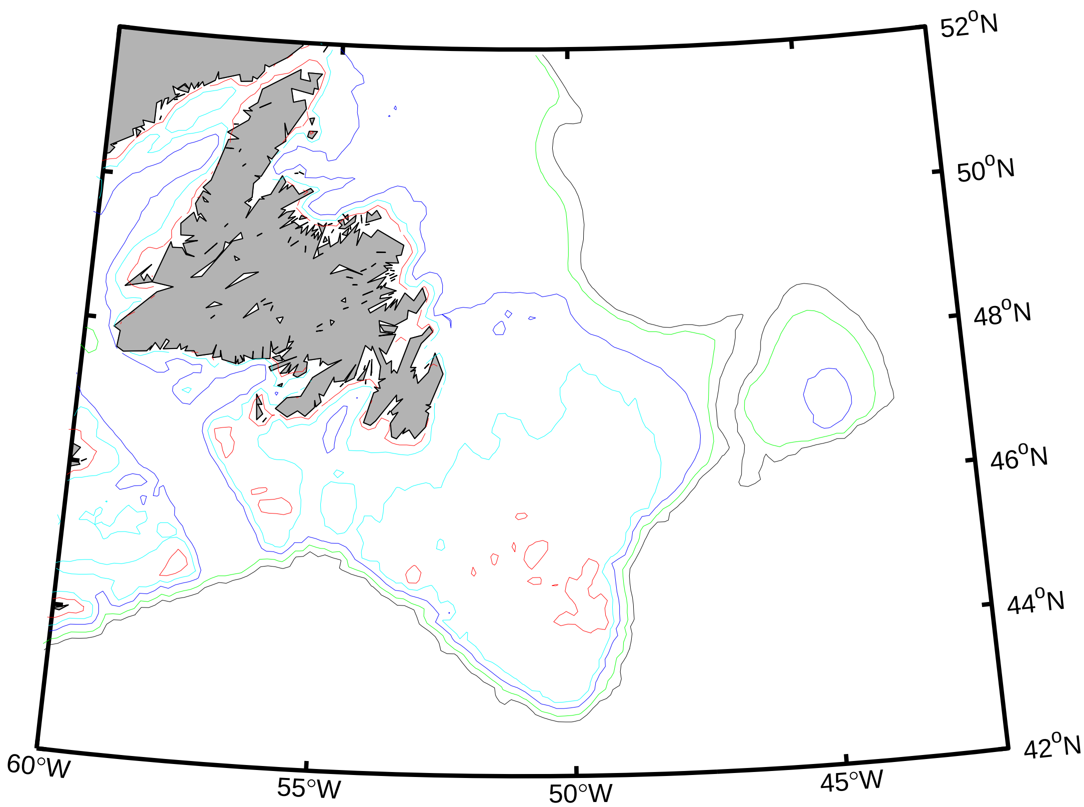
Velocity field at 10 m from the bottom for spring



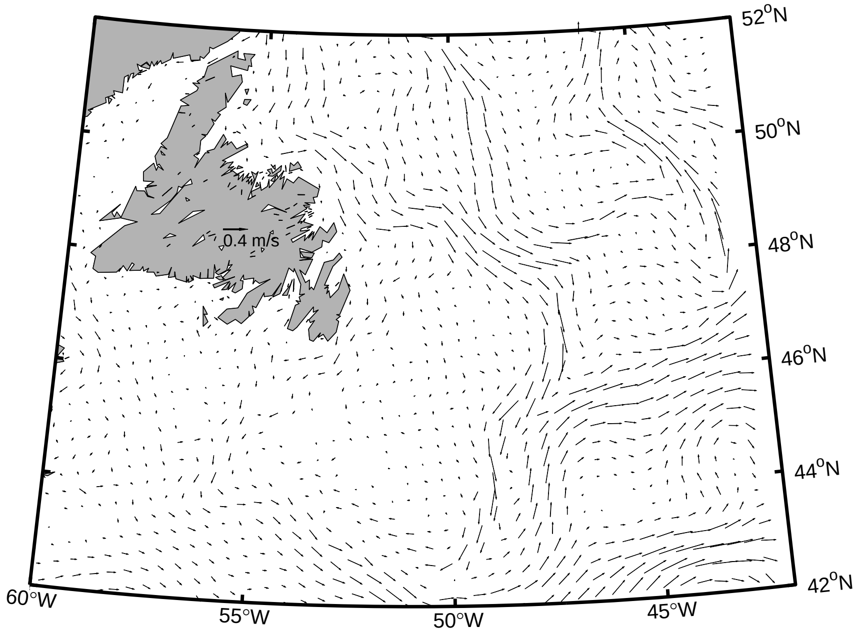
Velocity field at 10 m from the bottom for summer



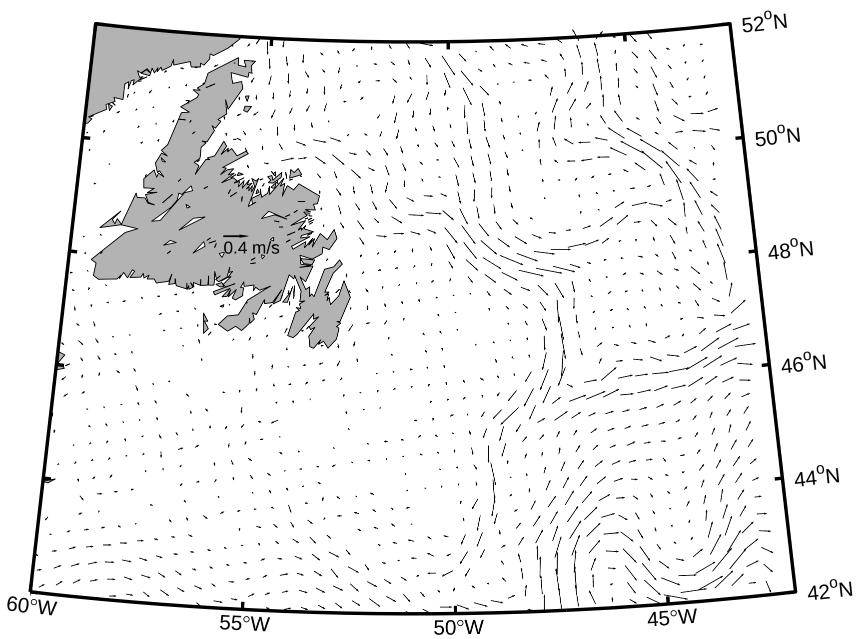
Velocity field at 10 m from the bottom for autumn



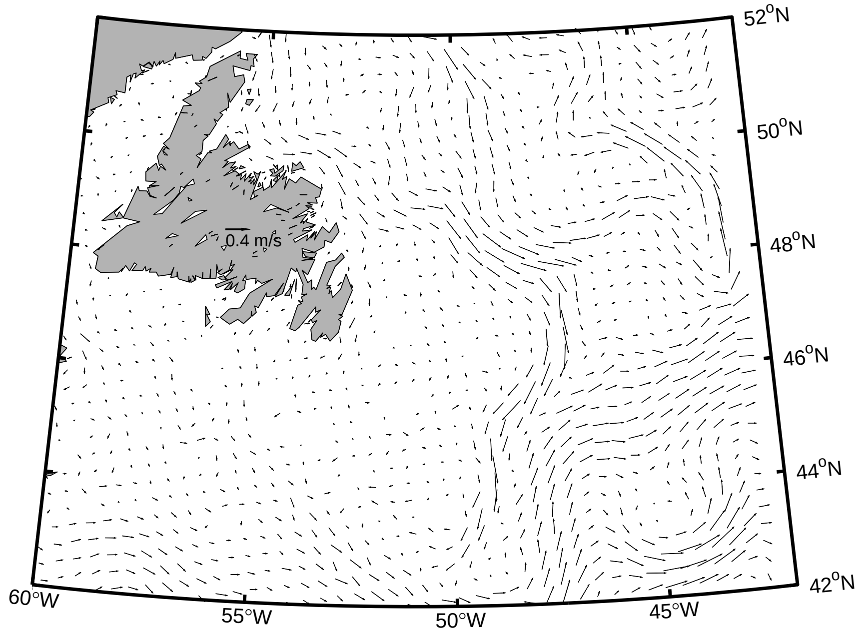
Bottom topography showing 50 (red), 100 (cyan), 200 (blue), 500 (green) and 1000 m (black) isobaths. Depth contours greater than 1000 m are not shown.



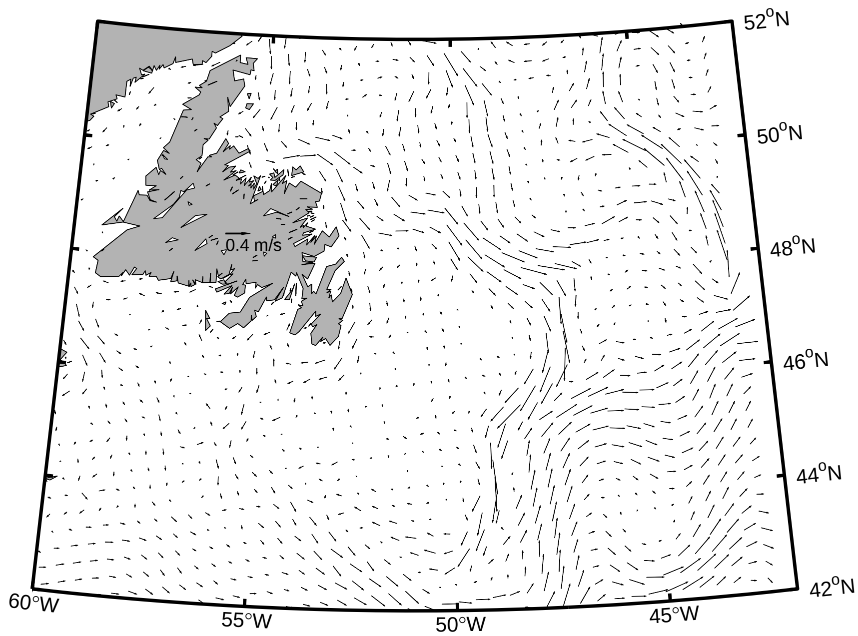
Velocity field at 5 m for winter



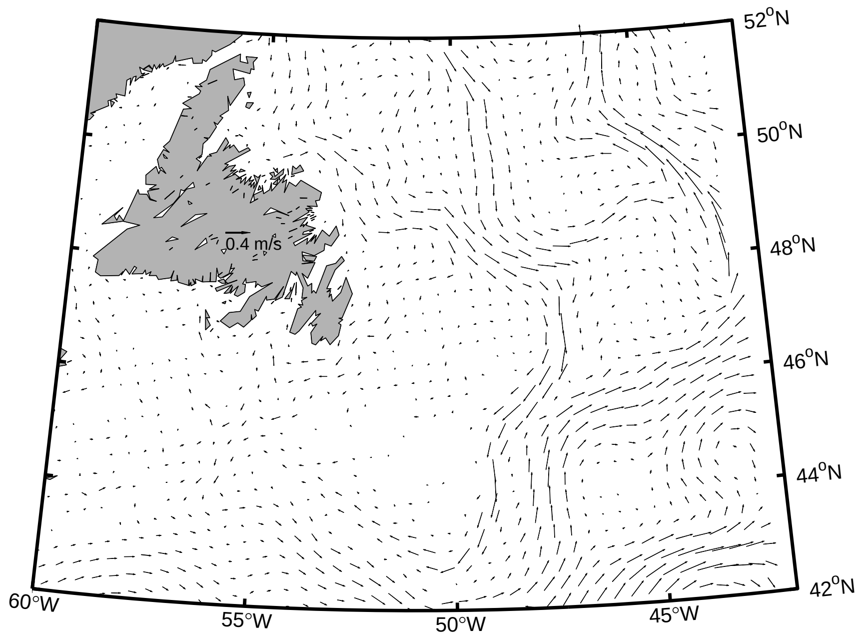
Velocity field at 5 m for spring



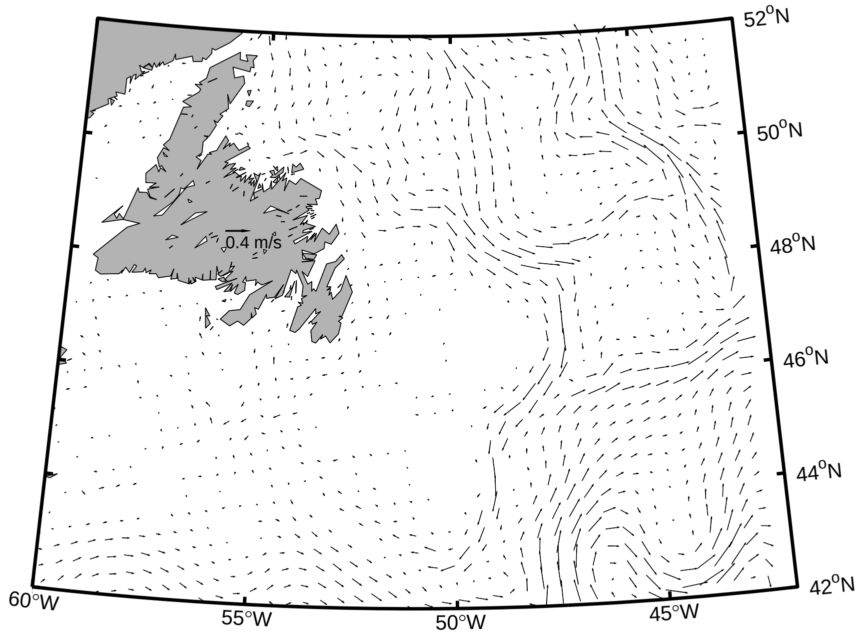
Velocity field at 5 m for summer



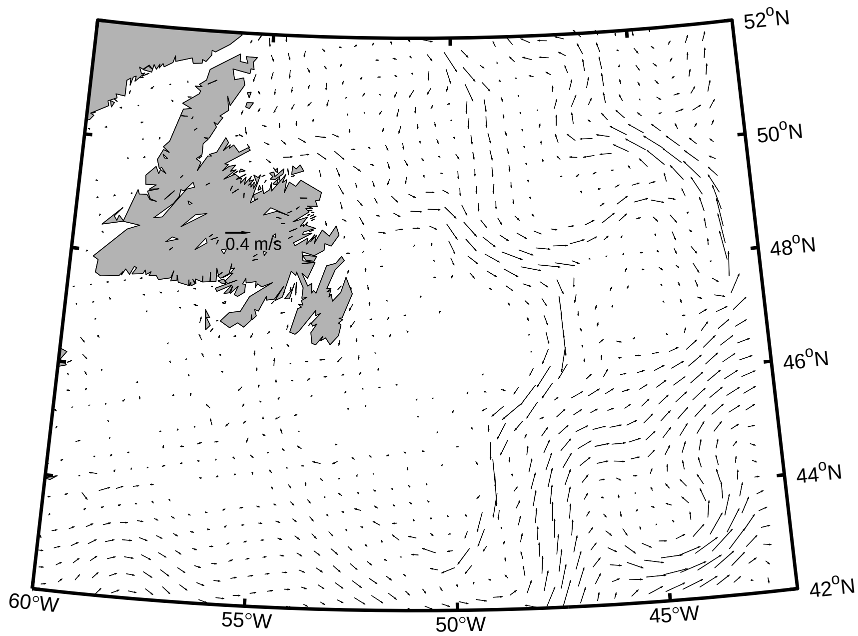
Velocity field at 5 m for autumn



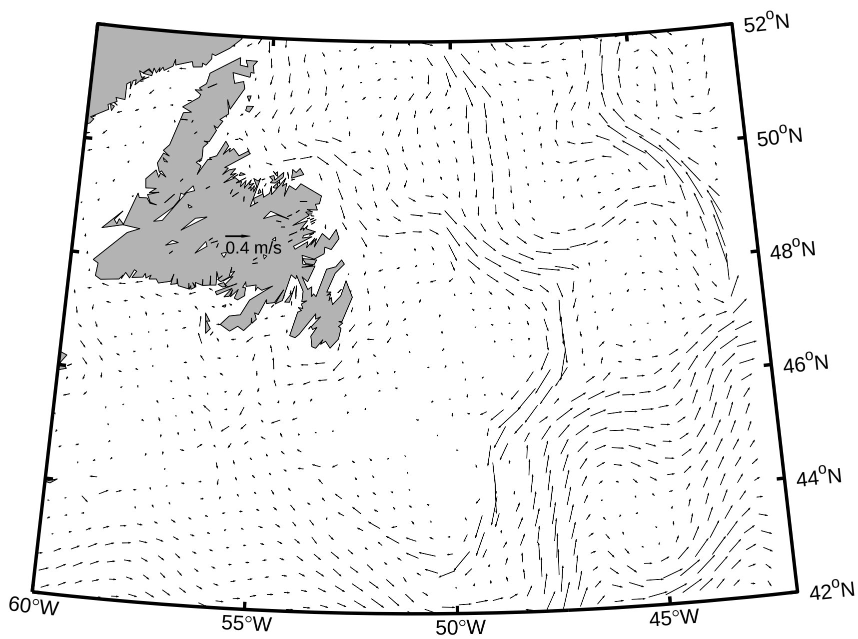
Velocity field at 50 m for winter



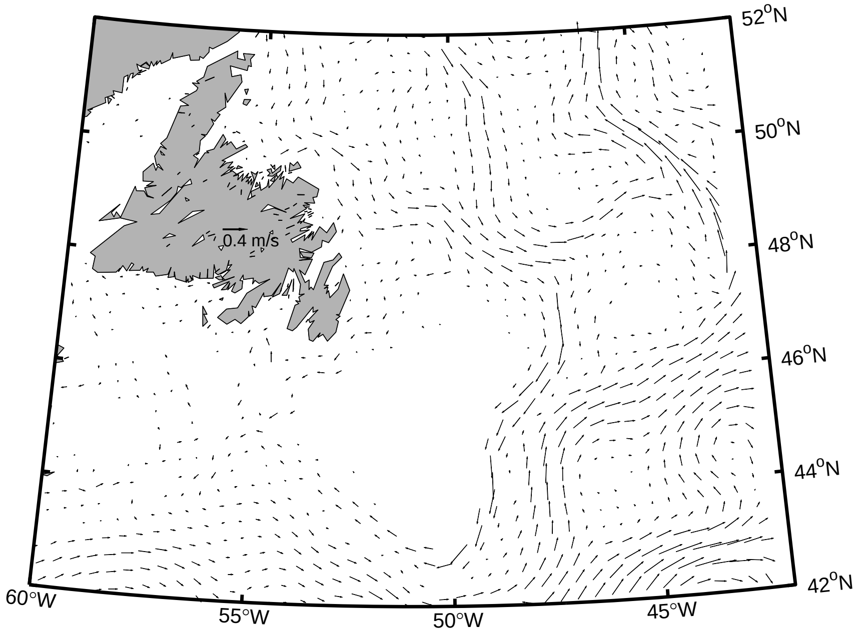
Velocity field at 50 m for spring



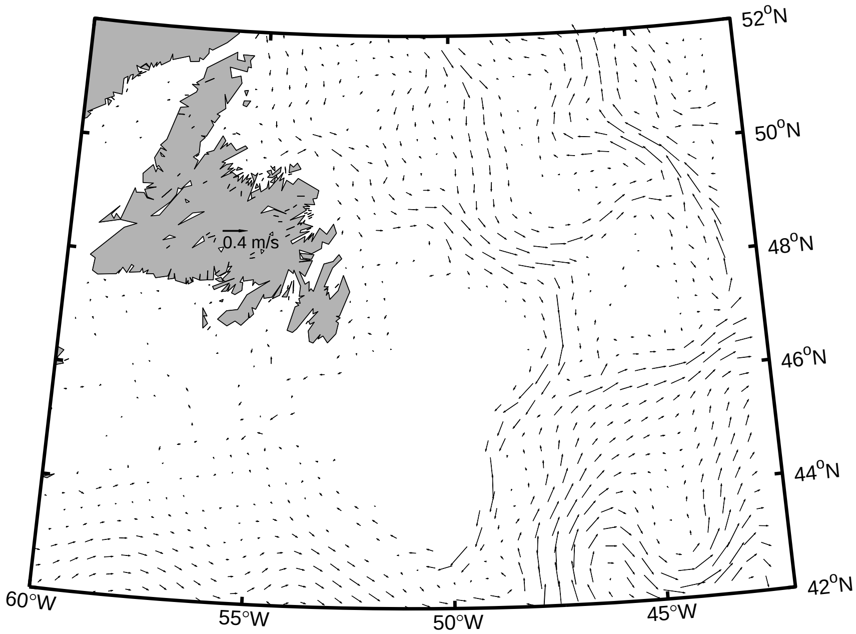
Velocity field at 50 m for summer



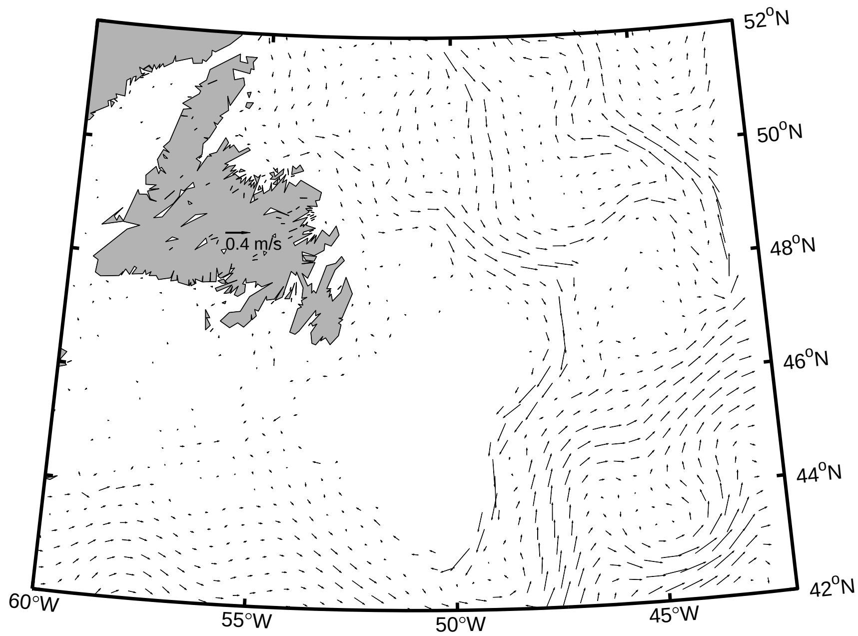
Velocity field at 50 m for autumn



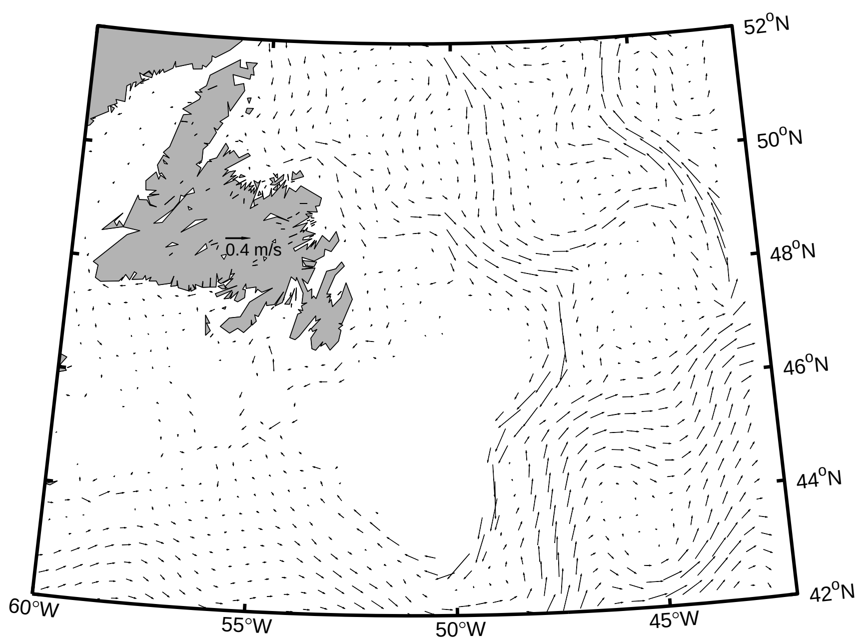
Velocity field at 100 m for winter



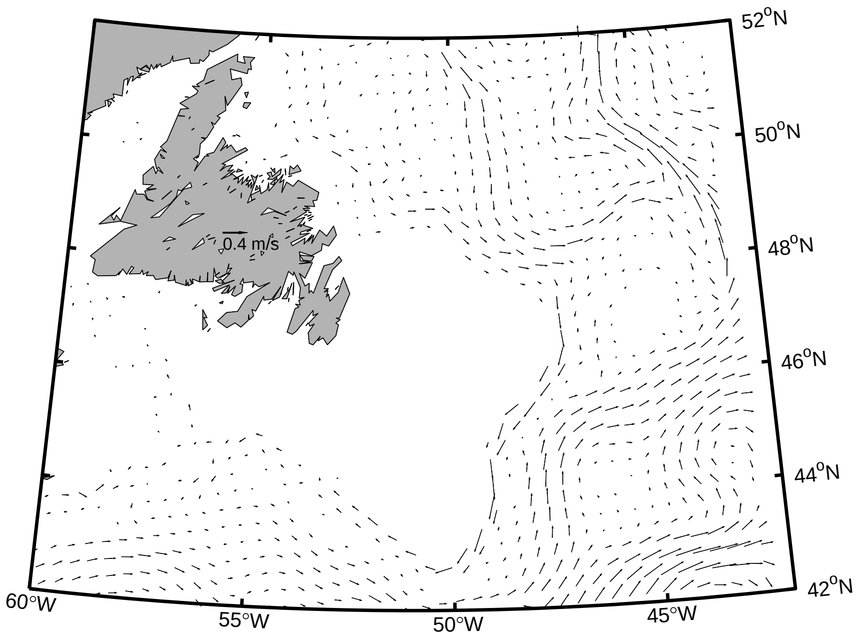
Velocity field at 100 m for spring



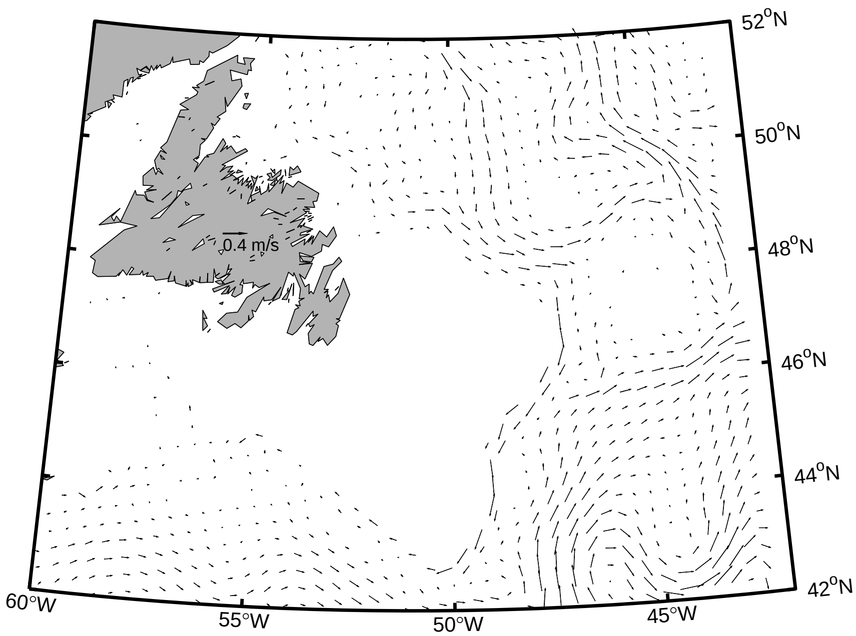
Velocity field at 100 m for summer



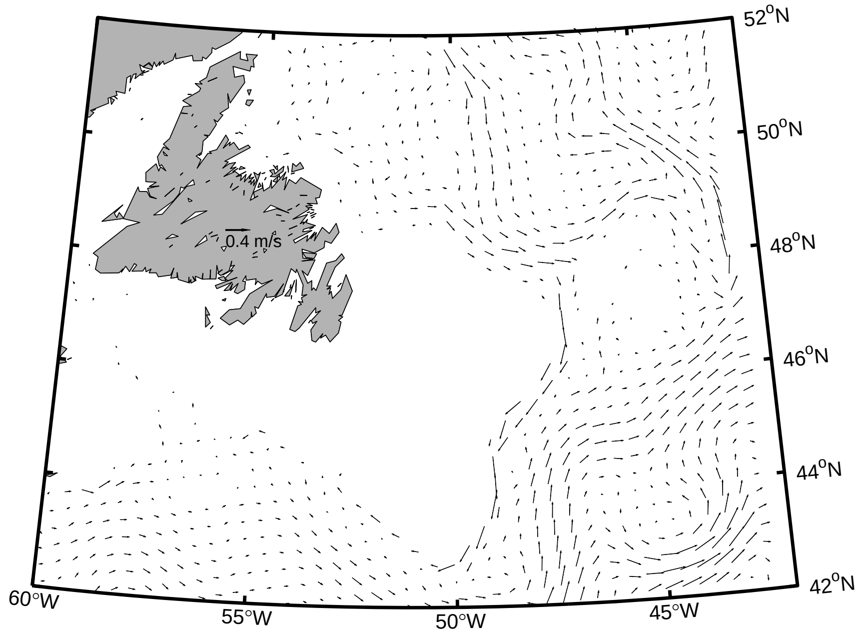
Velocity field at 100 m for autumn



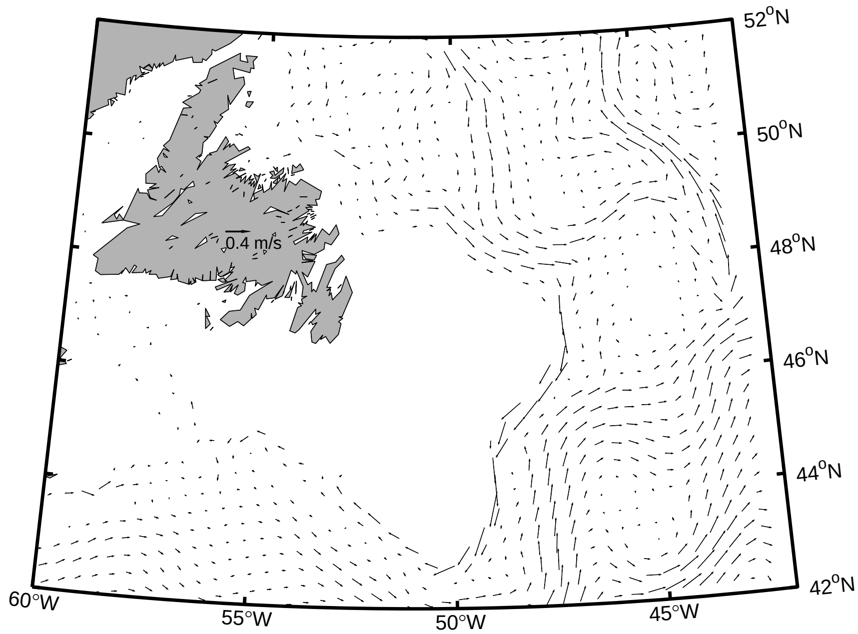
Velocity field at 200 m for winter



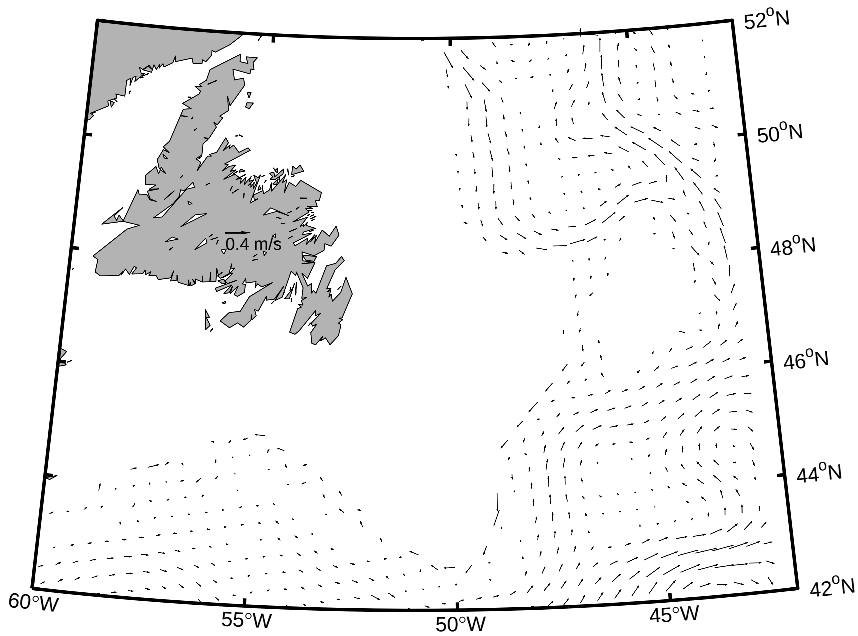
Velocity field at 200 m for spring



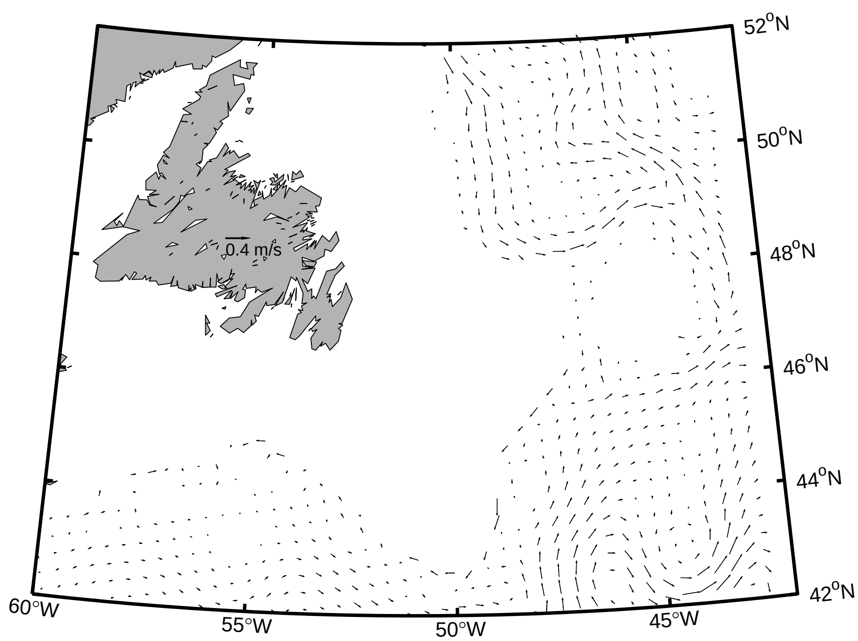
Velocity field at 200 m for summer



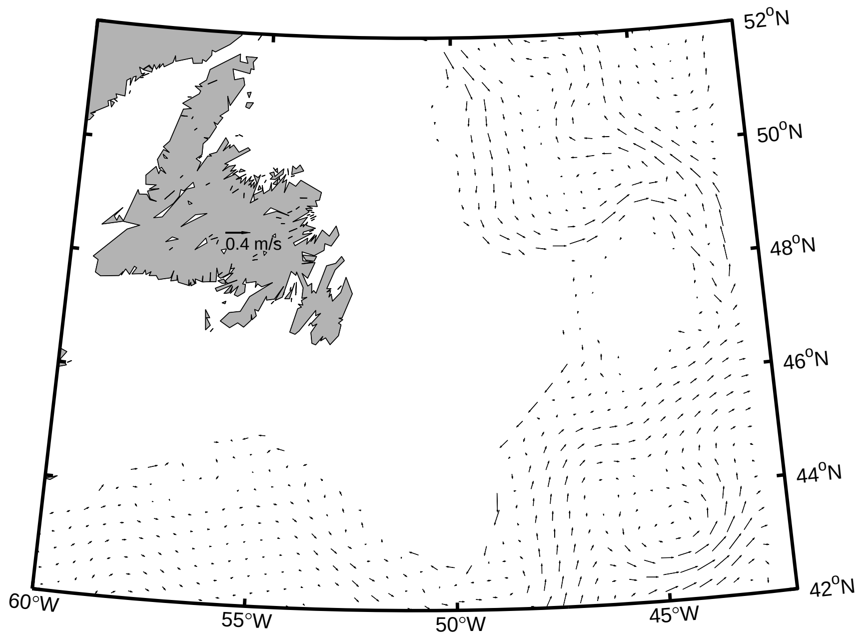
Velocity field at 200 m for autumn



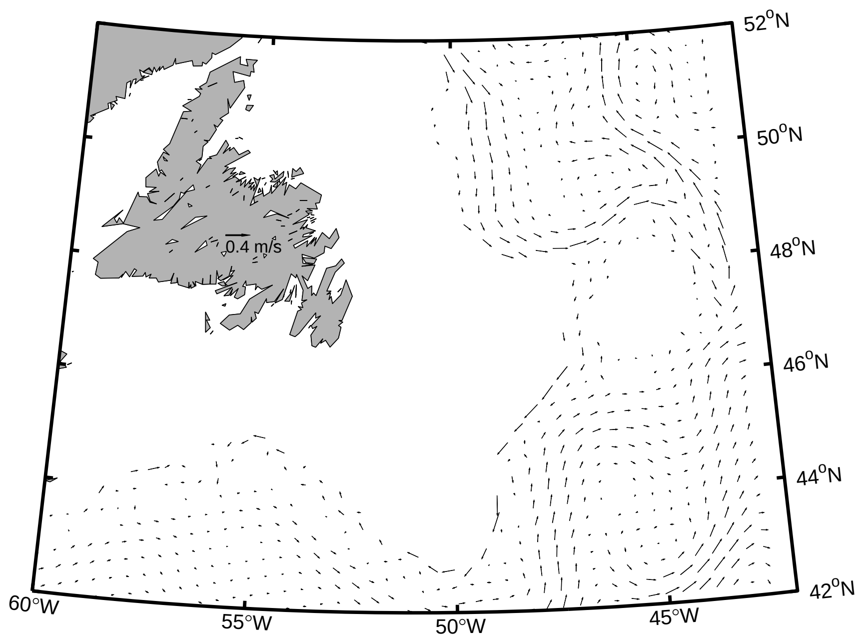
Velocity field at 500 m for winter



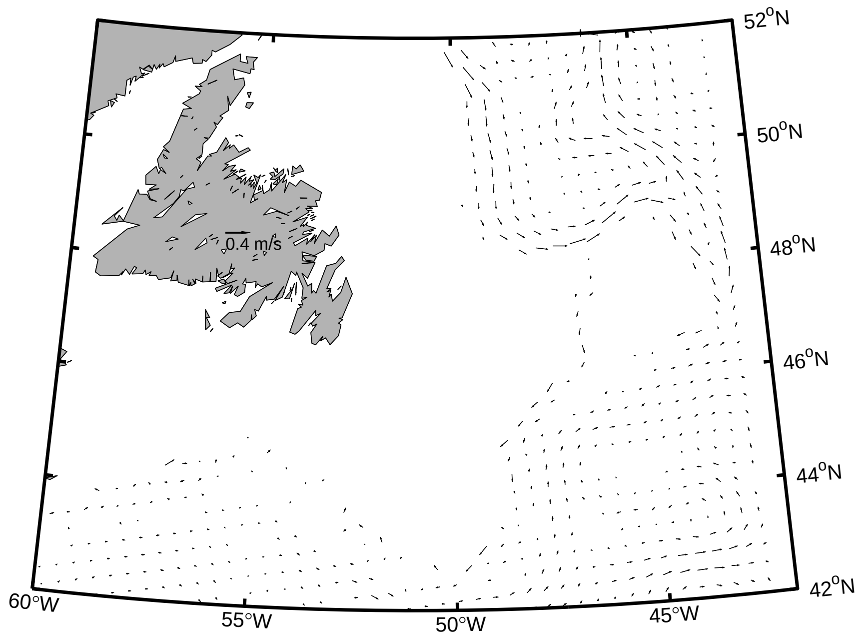
Velocity field at 500 m for spring



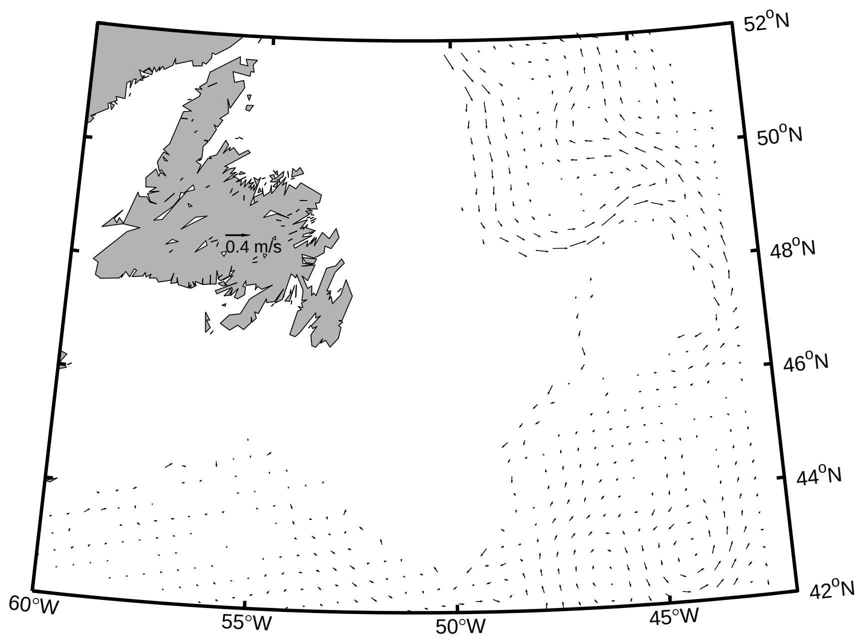
Velocity field at 500 m for summer



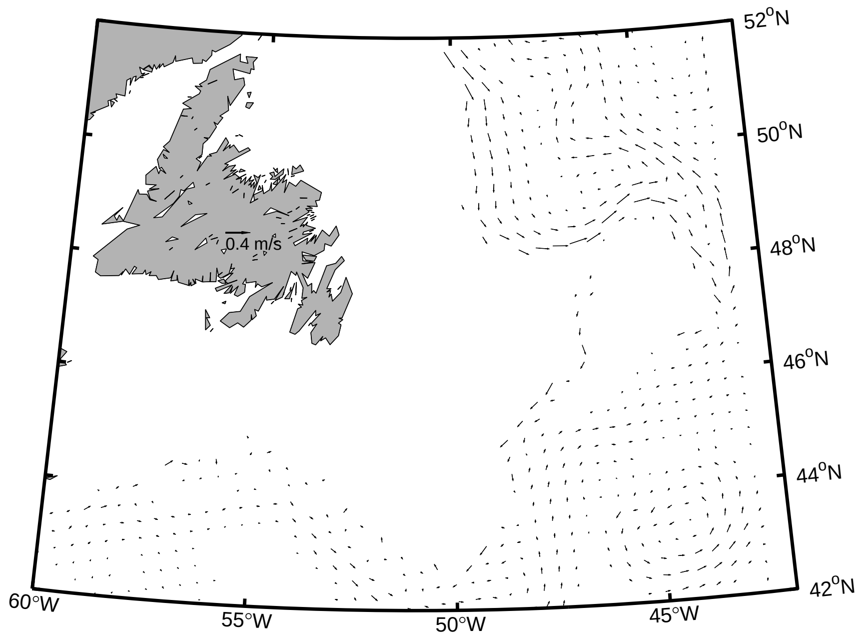
Velocity field at 500 m for autumn



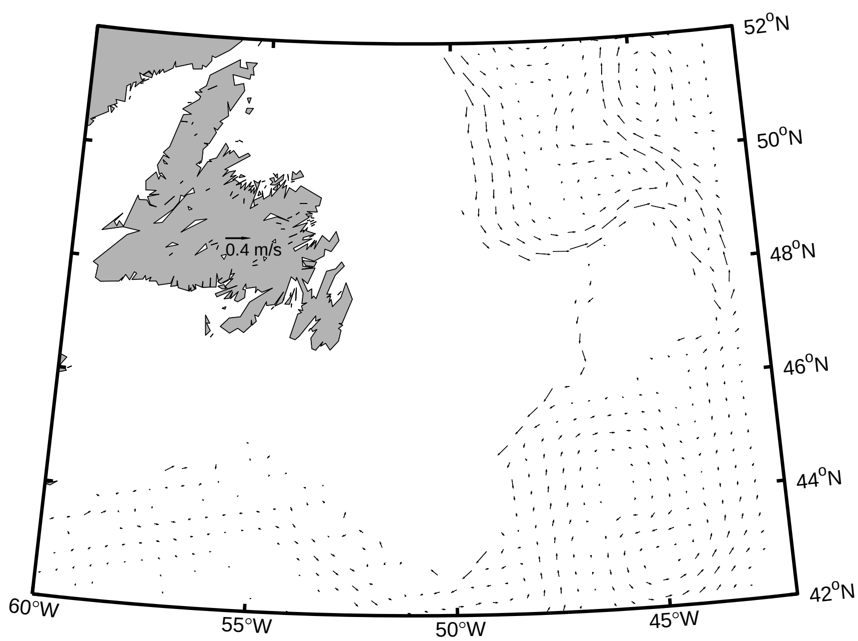
Velocity field at 1000 m for winter



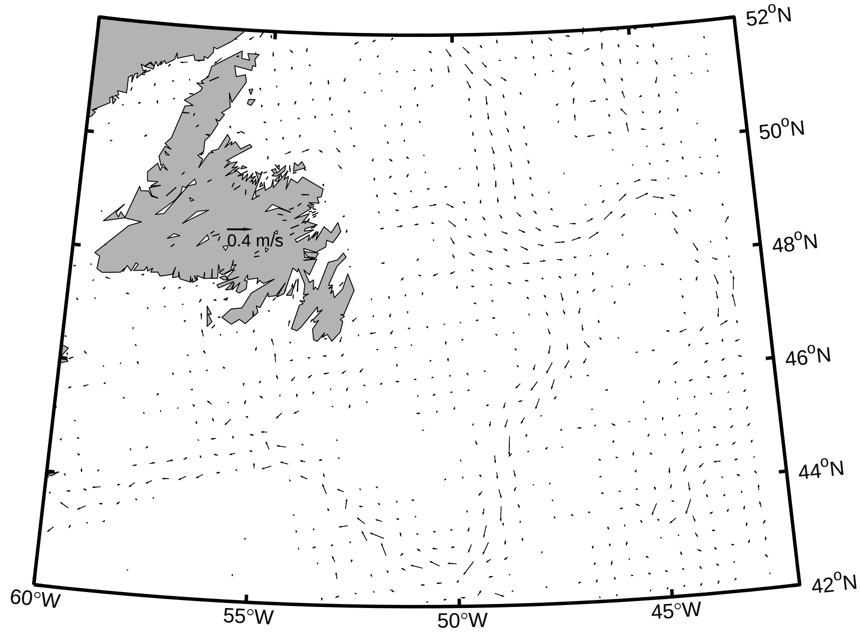
Velocity field at 1000 m for spring



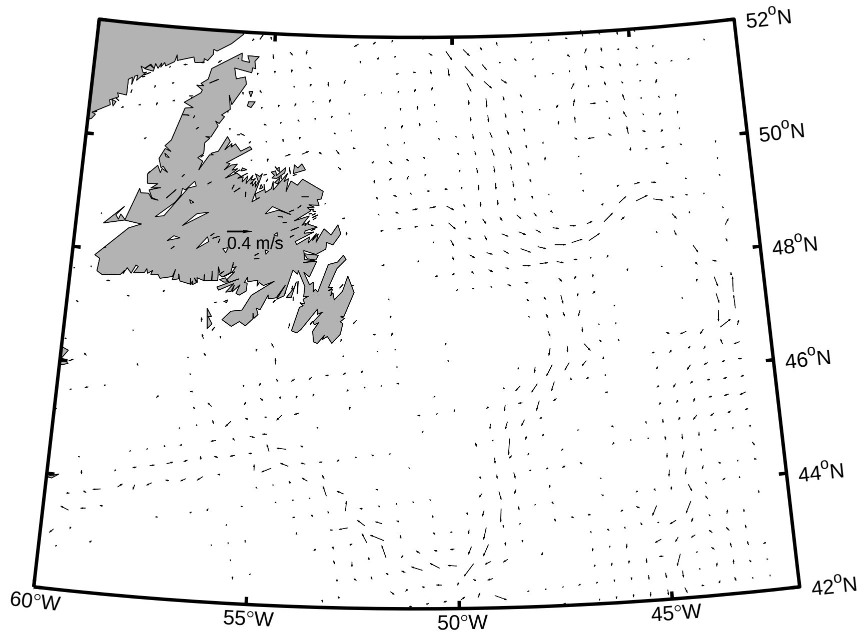
Velocity field at 1000 m for summer



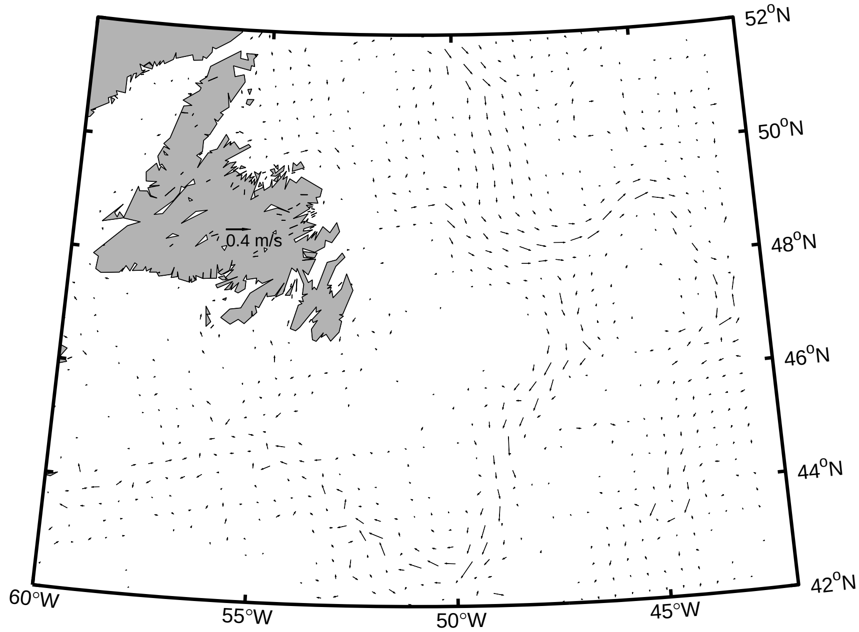
Velocity field at 1000 m for autumn



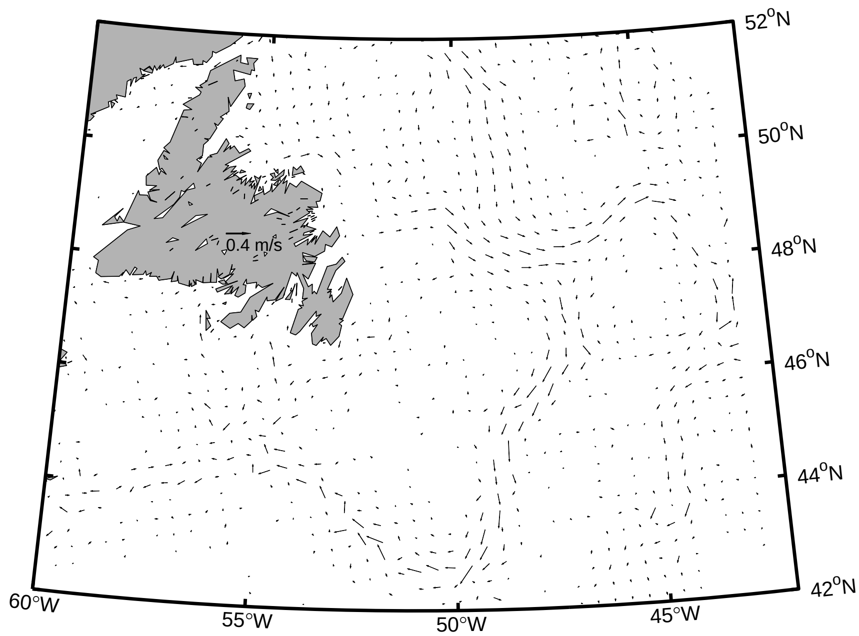
Velocity field at 10 m from the bottom for winter



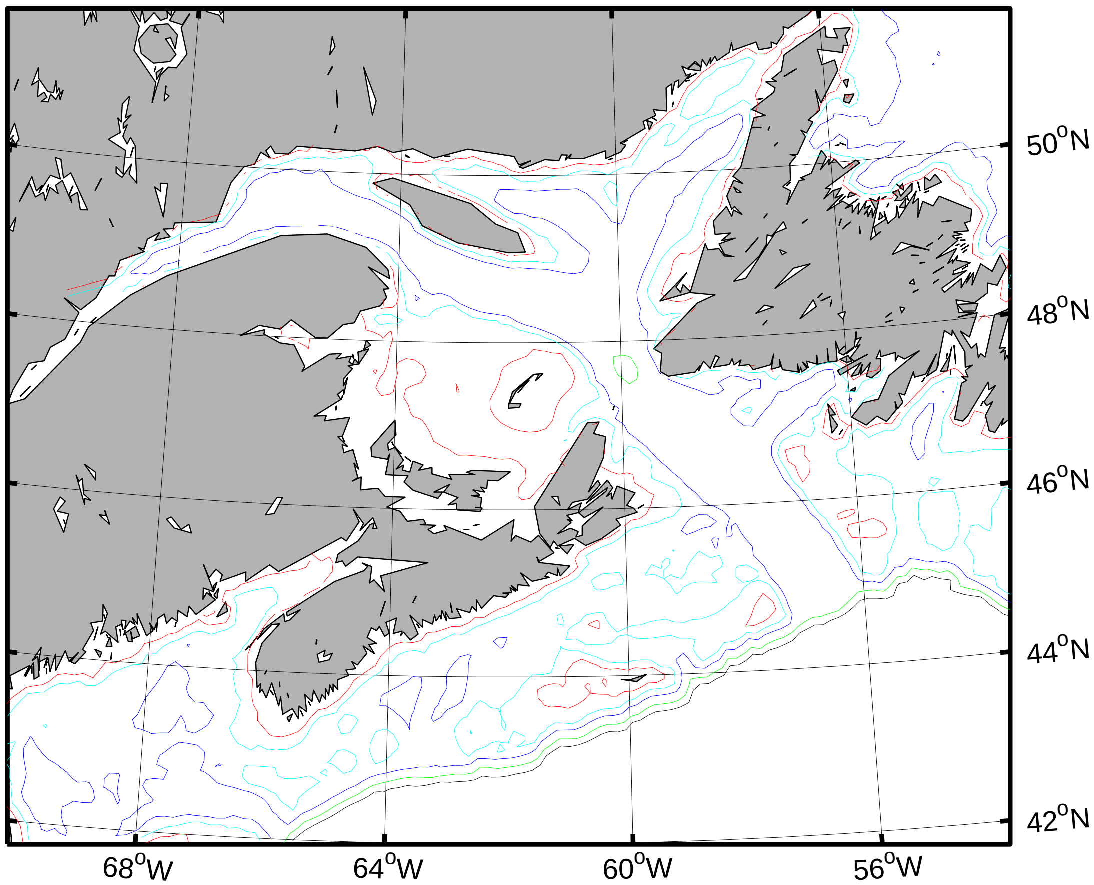
Velocity field at 10 m from the bottom for spring



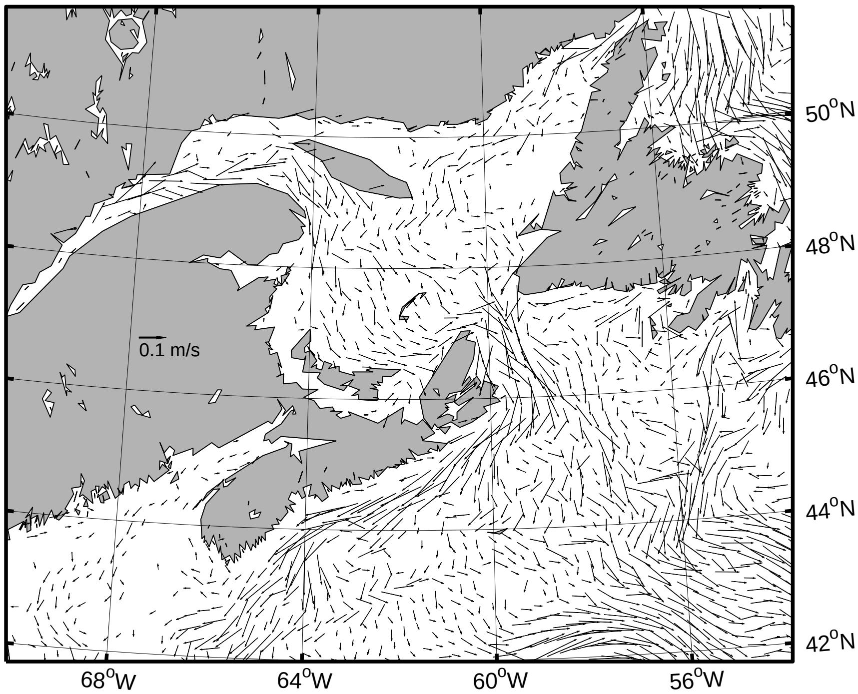
Velocity field at 10 m from the bottom for summer



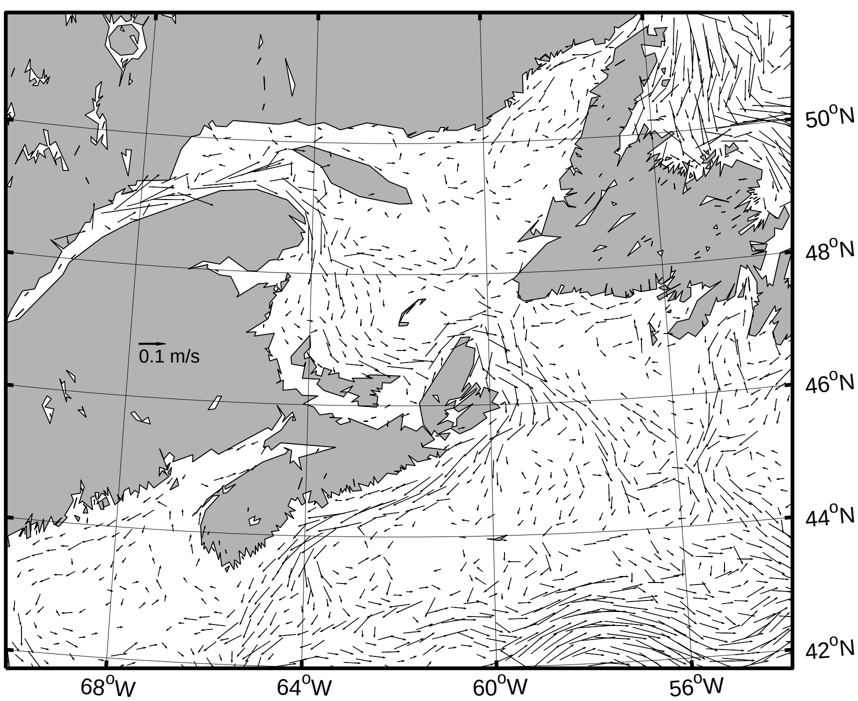
Velocity field at 10 m from the bottom for autumn



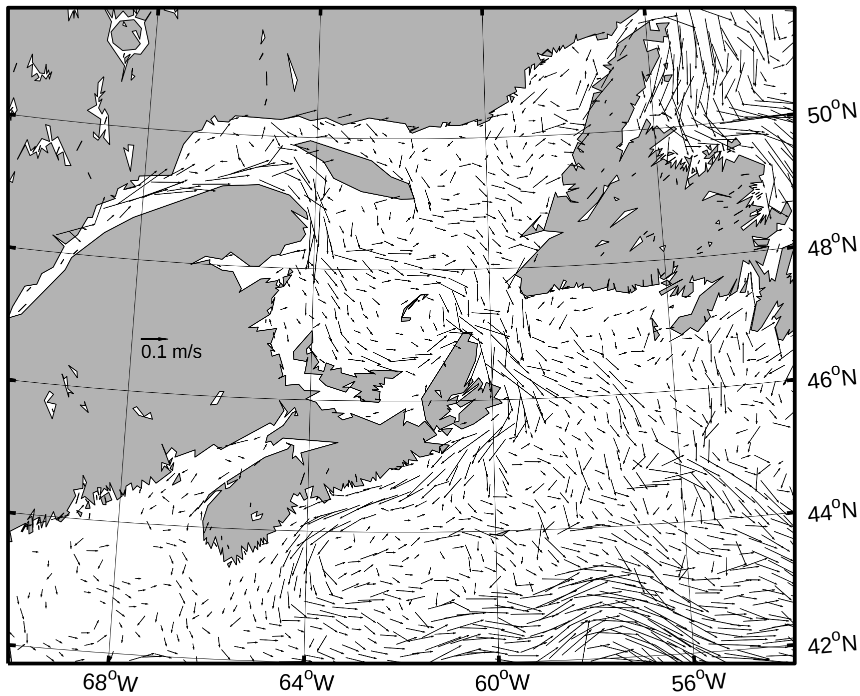
Bottom topography showing 50 (red), 100 (cyan), 200 (blue), 500 (green) and 1000 m (black) isobaths. Depth contours greater than 1000 m are not shown.



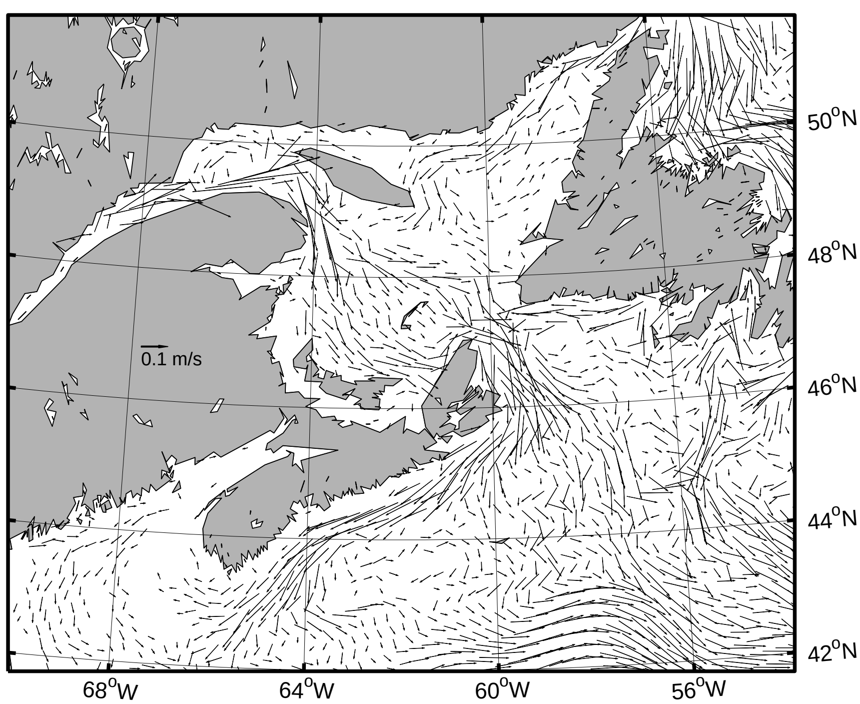
Velocity field at 5 m for winter



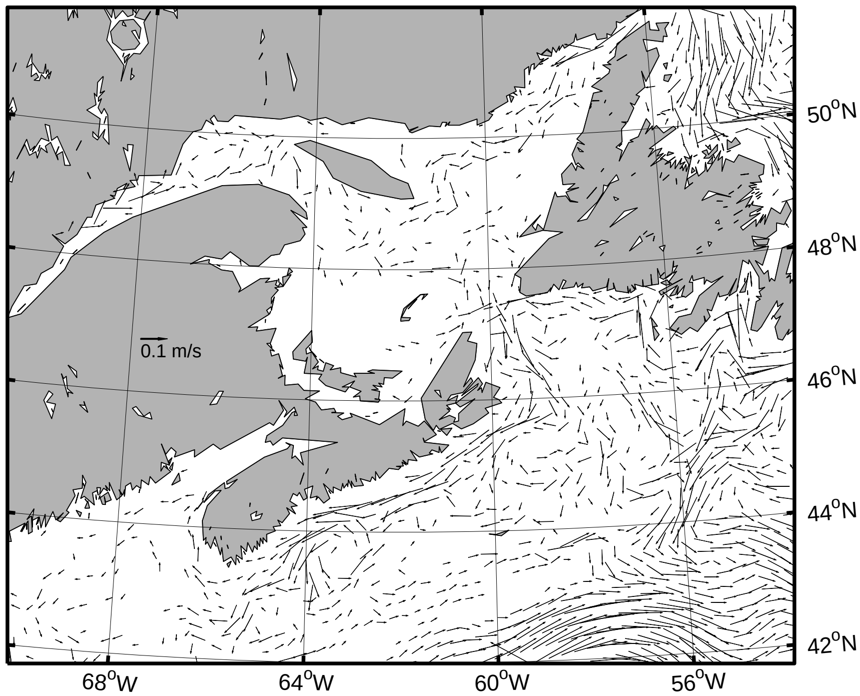
Velocity field at 5 m for spring



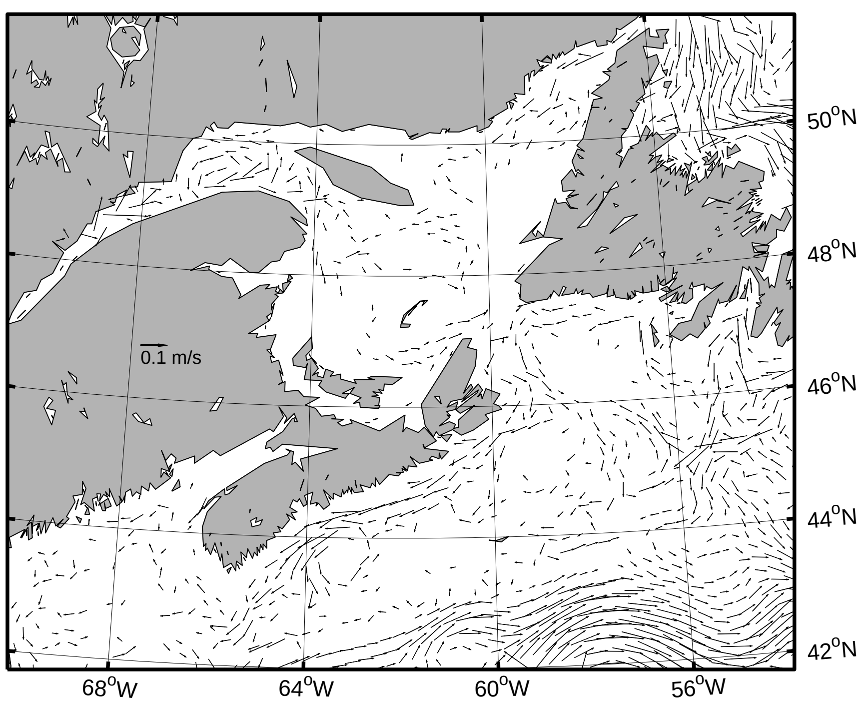
Velocity field at 5 m for summer



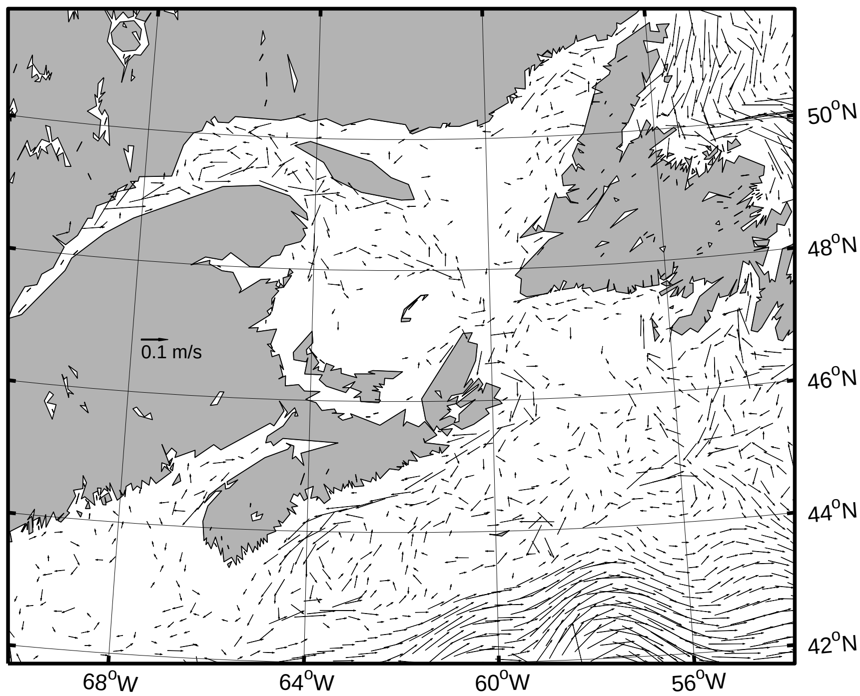
Velocity field at 5 m for autumn



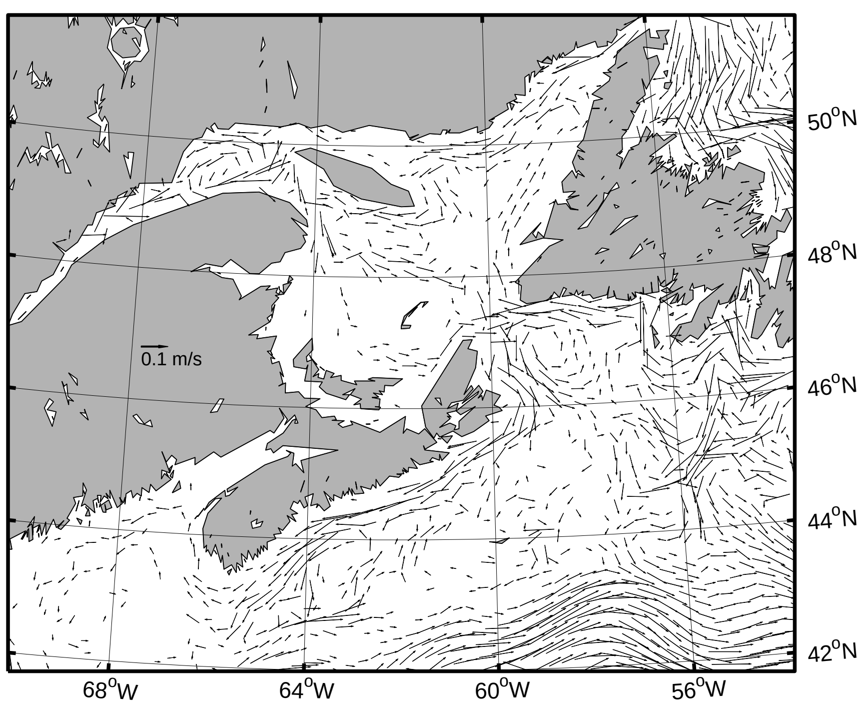
Velocity field at 50 m for winter



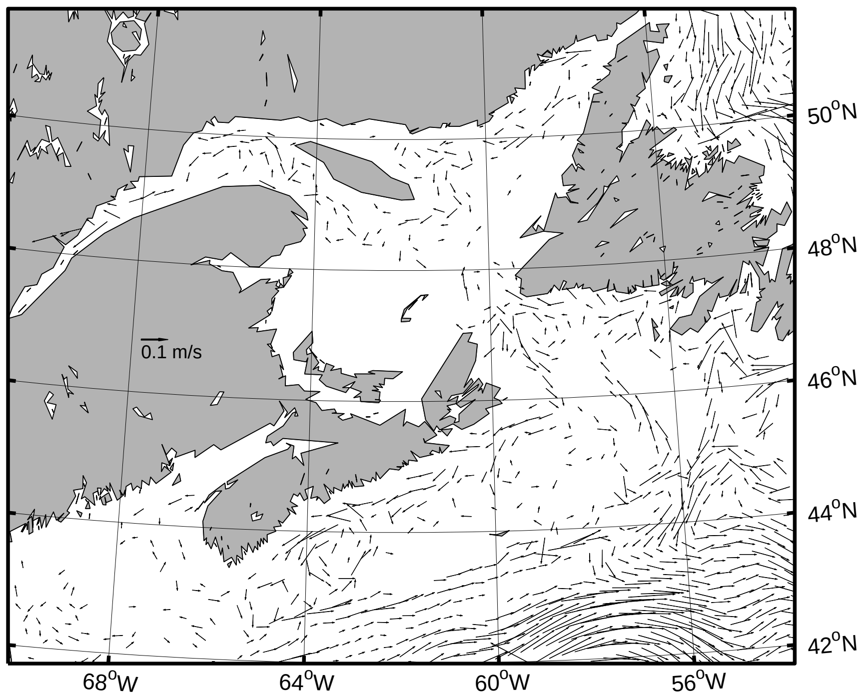
Velocity field at 50 m for spring



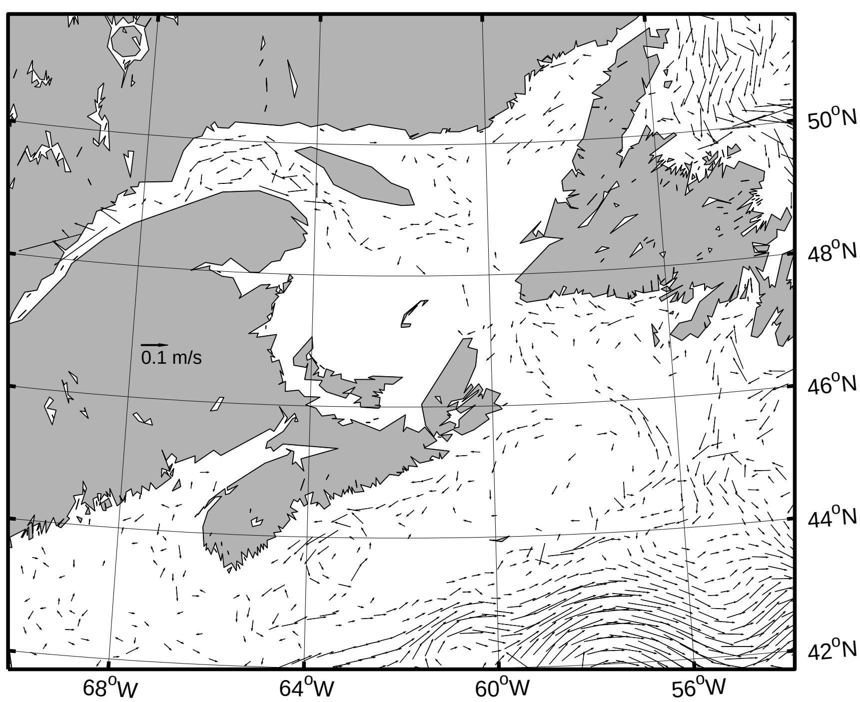
Velocity field at 50 m for summer



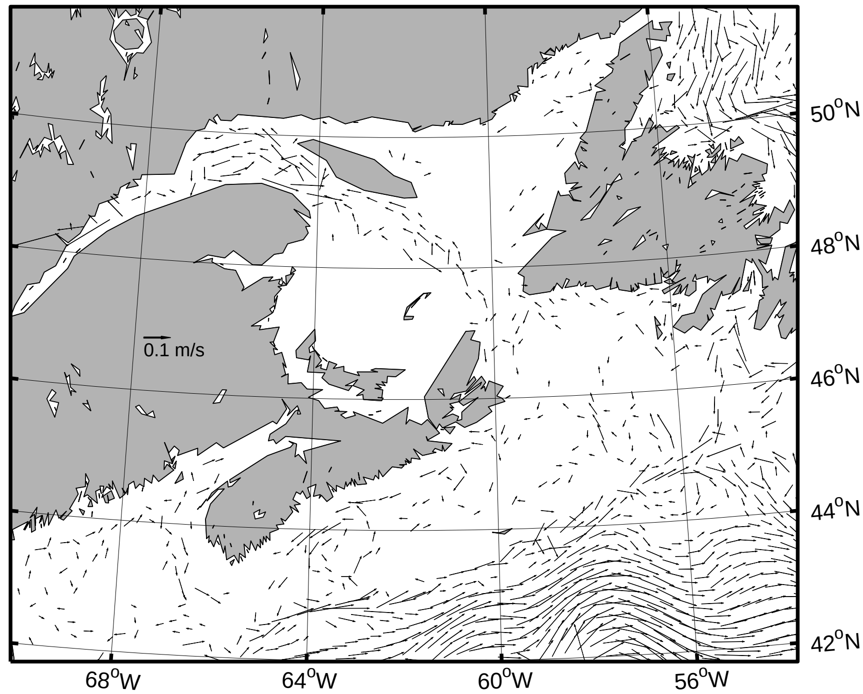
Velocity field at 50 m for autumn



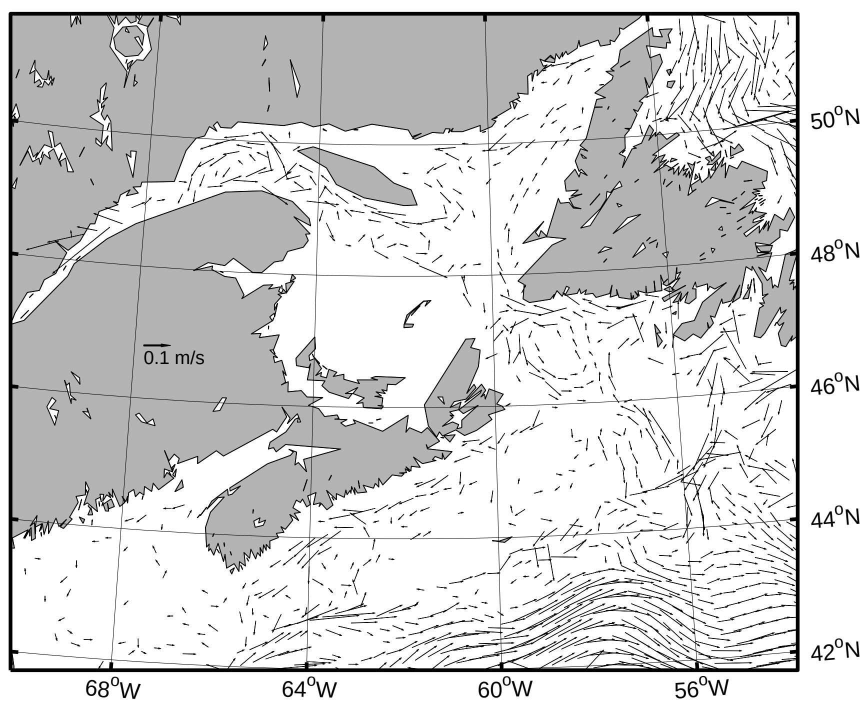
Velocity field at 100 m for winter



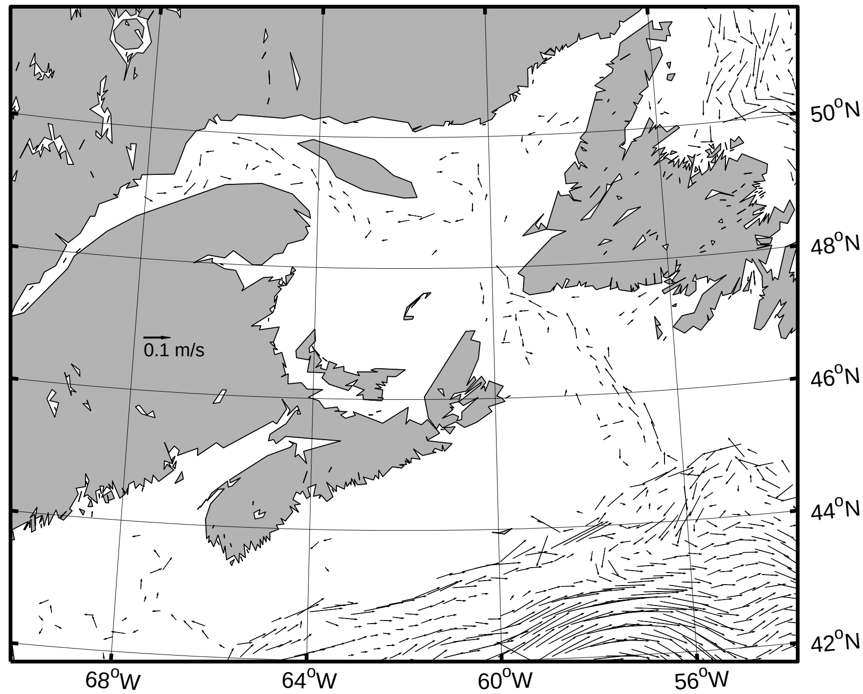
Velocity field at 100 m for spring



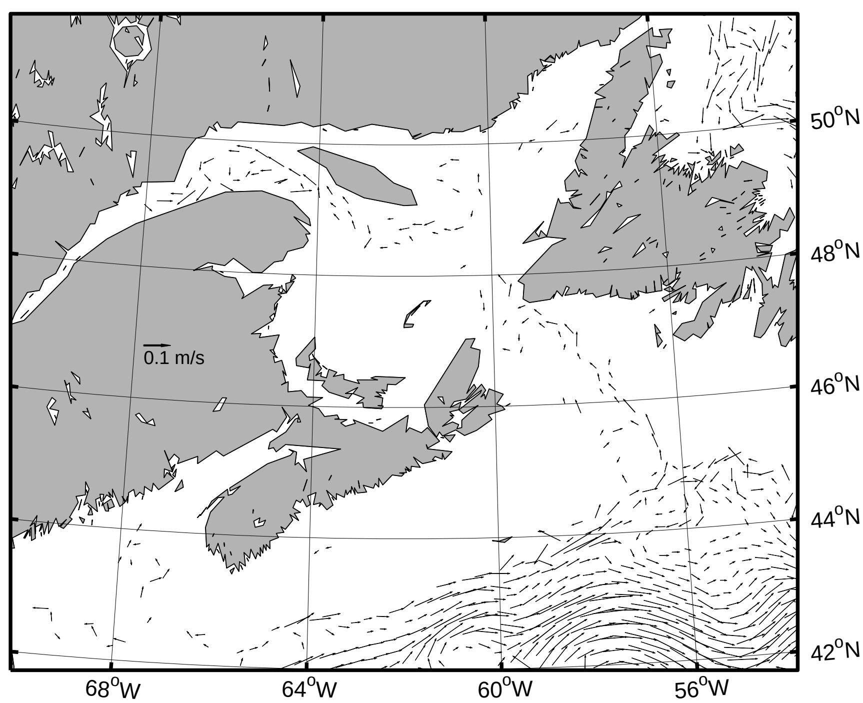
Velocity field at 100 m for summer



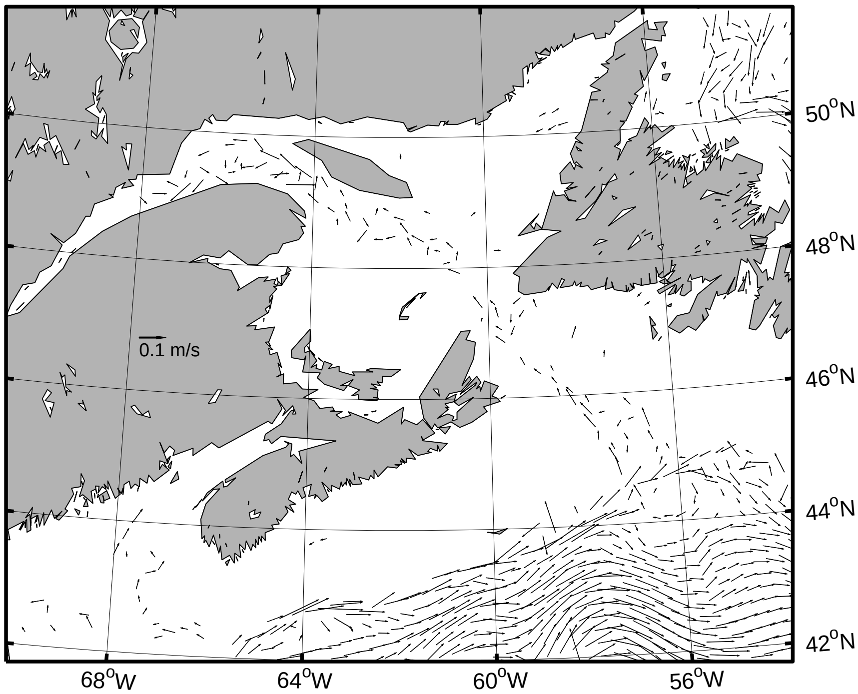
Velocity field at 100 m for autumn



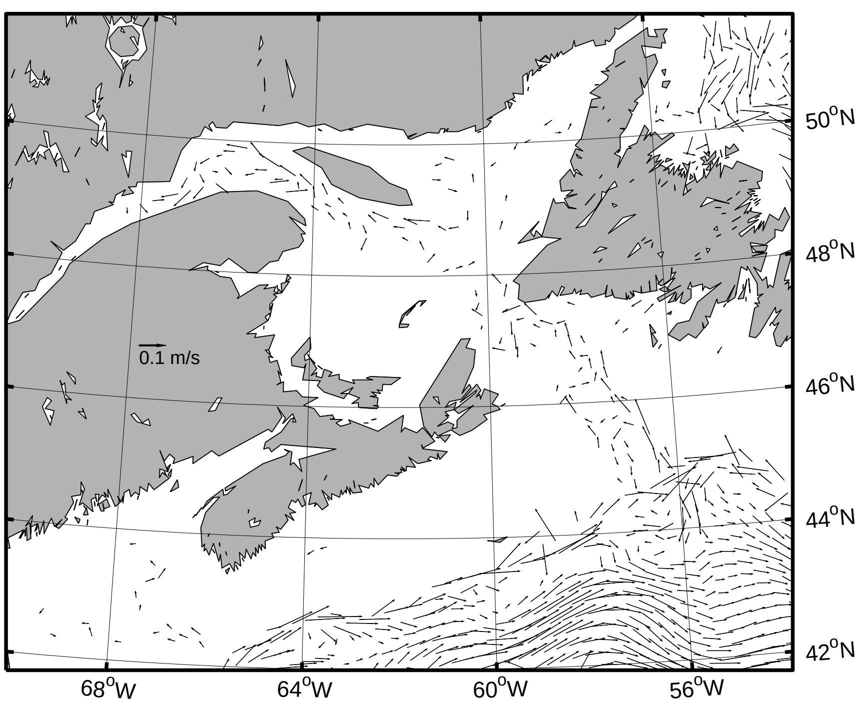
Velocity field at 200 m for winter



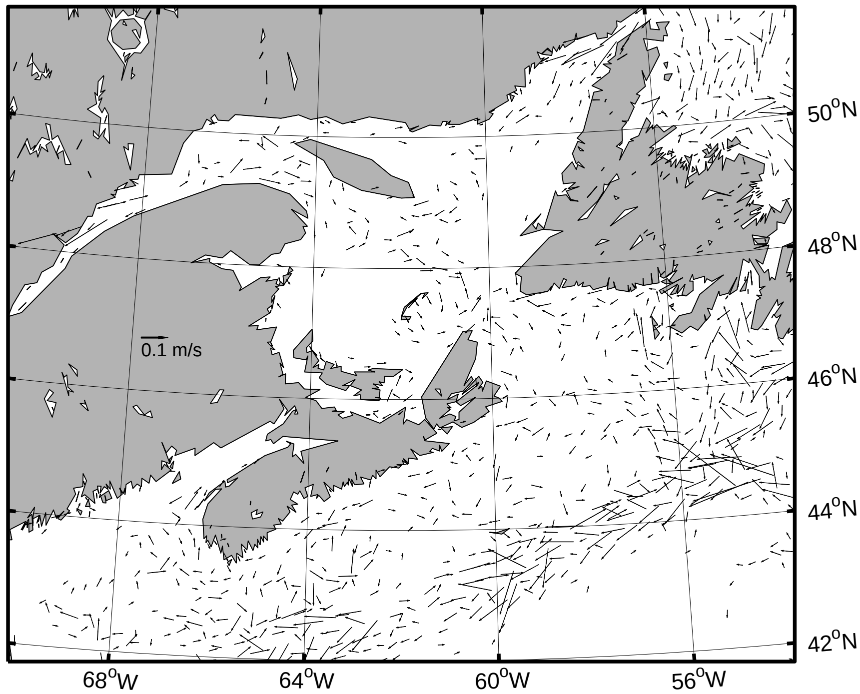
Velocity field at 200 m for spring



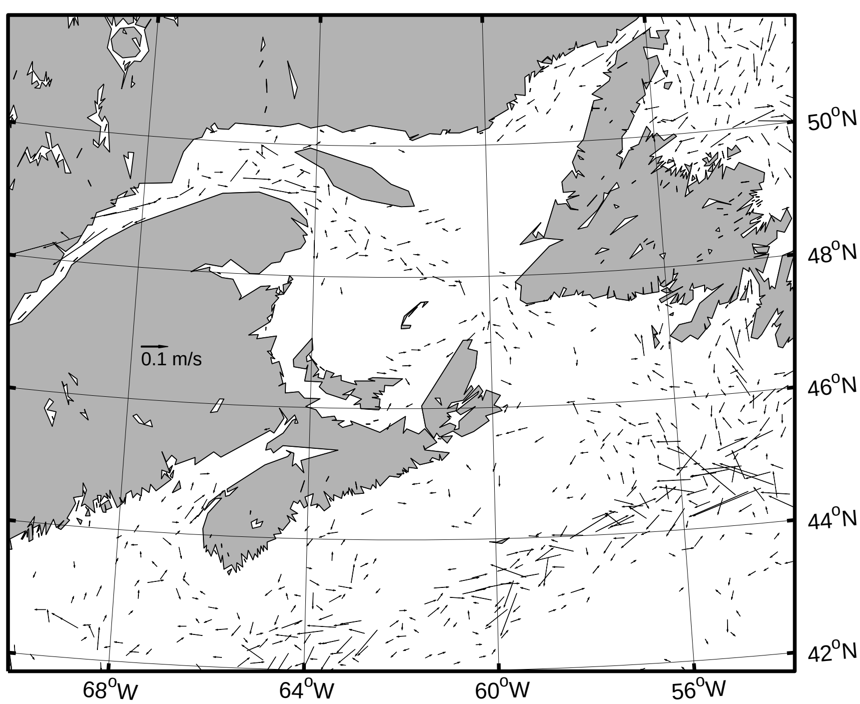
Velocity field at 200 m for summer



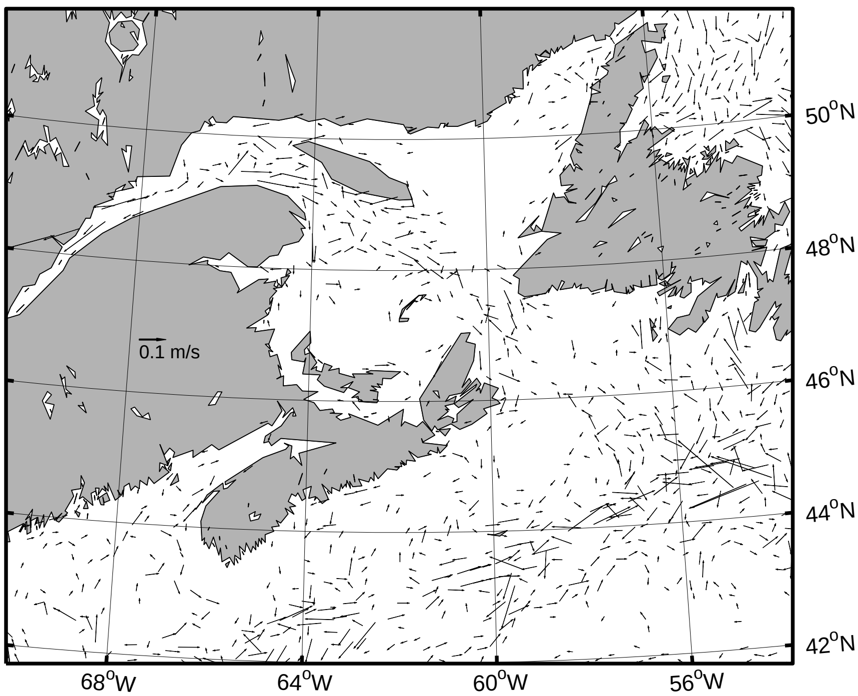
Velocity field at 200 m for autumn



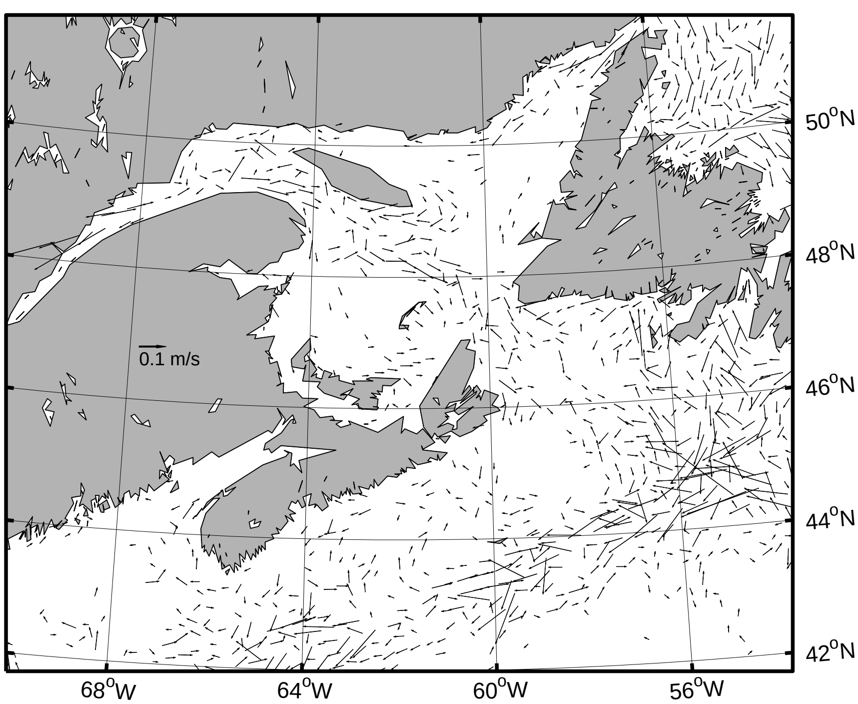
Velocity field at 10 m from the bottom for winter



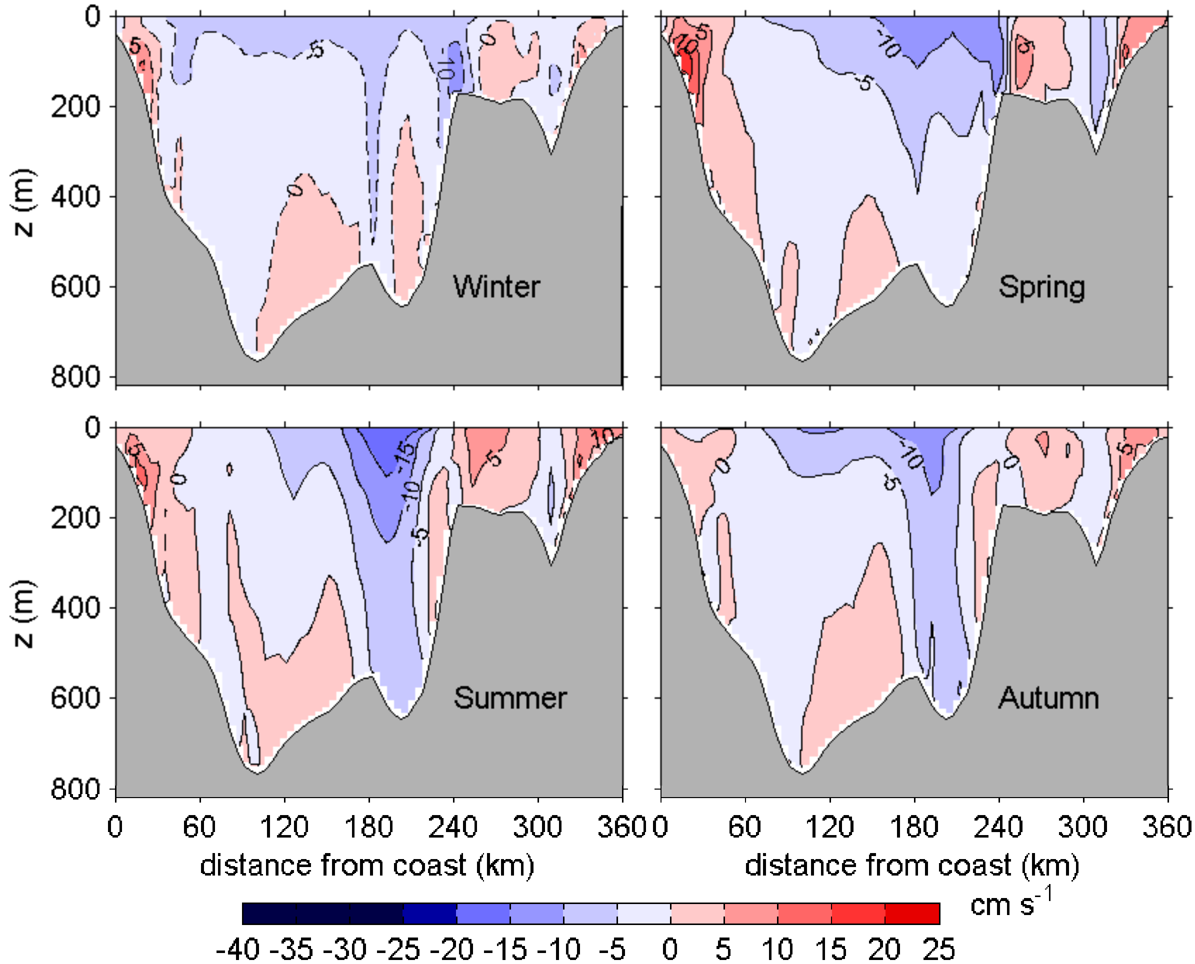
Velocity at 10 m from the bottom for spring



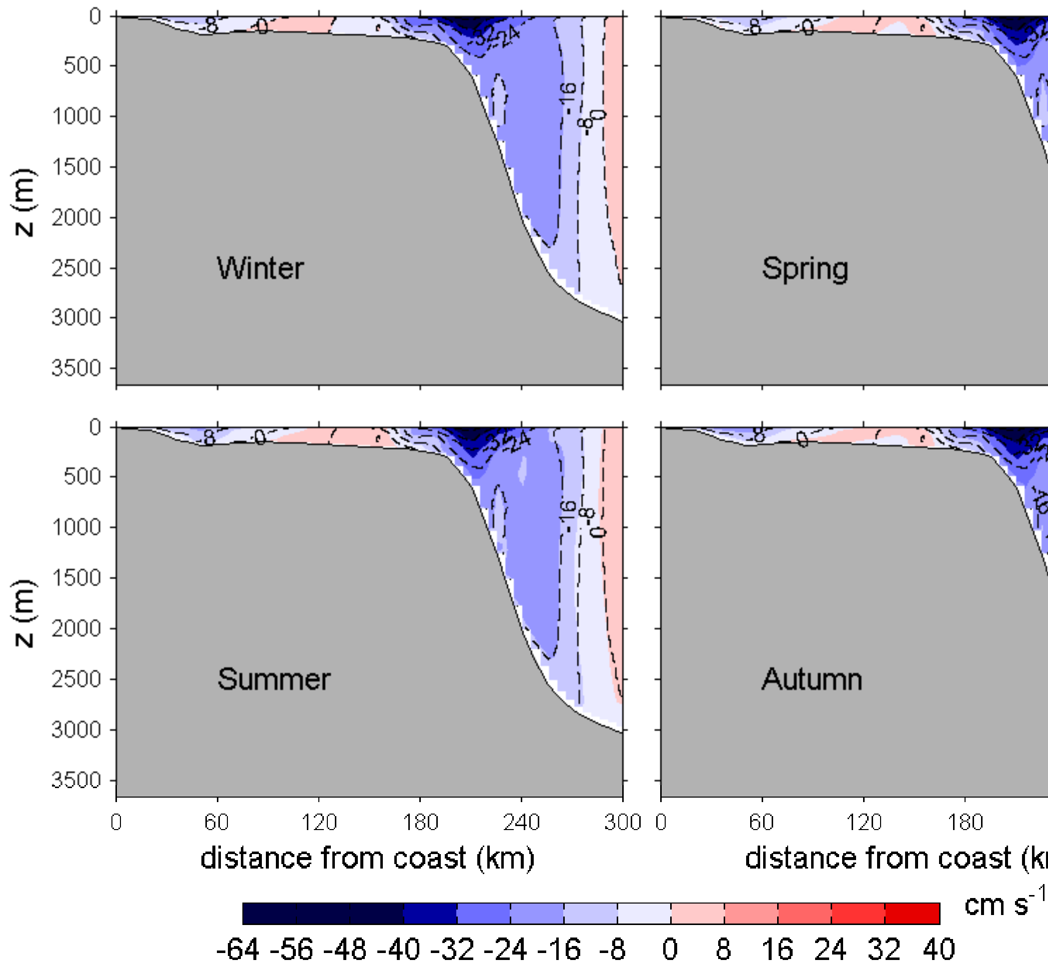
Velocity field at 10 m from the bottom for summer



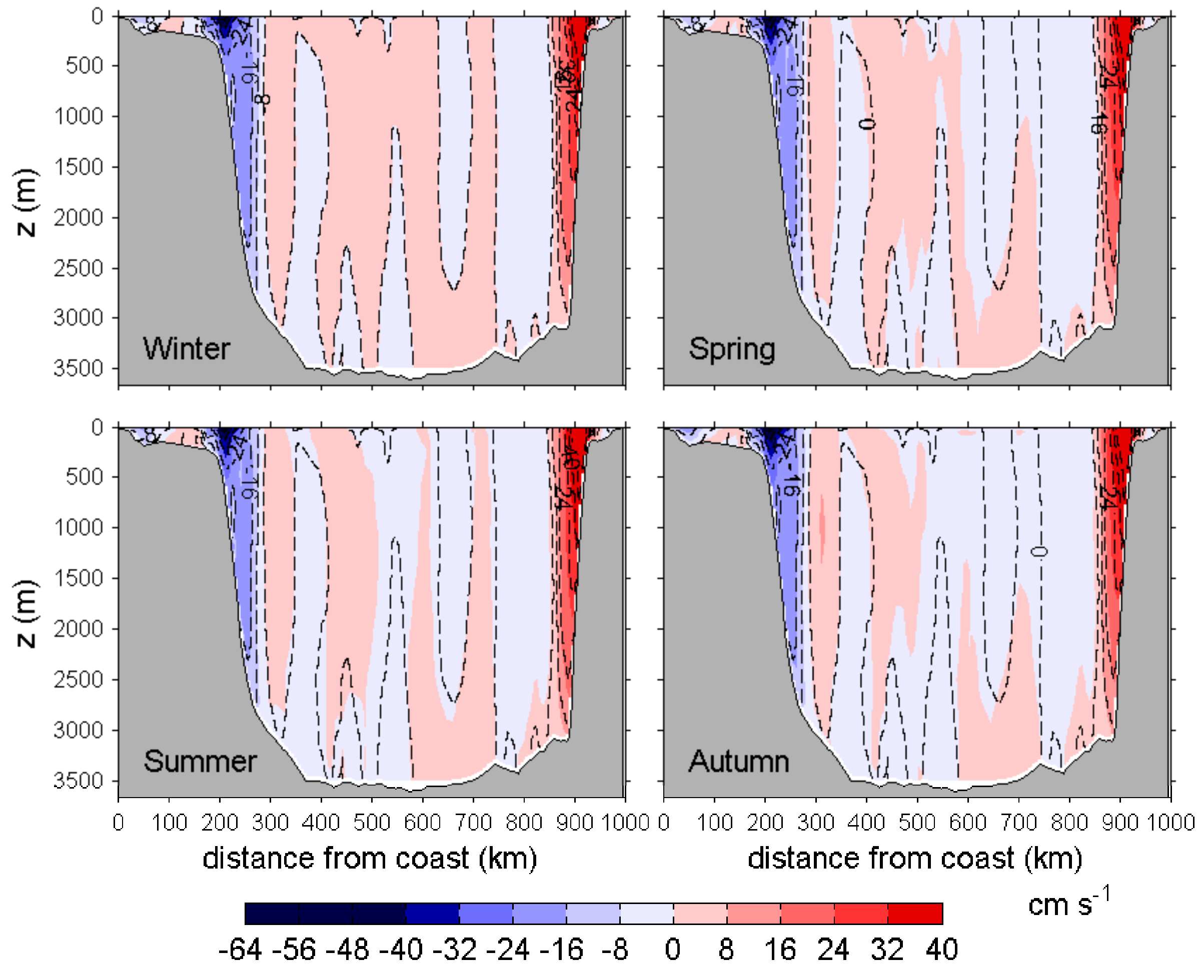
Velocity field at 10 m from the bottom for autumn



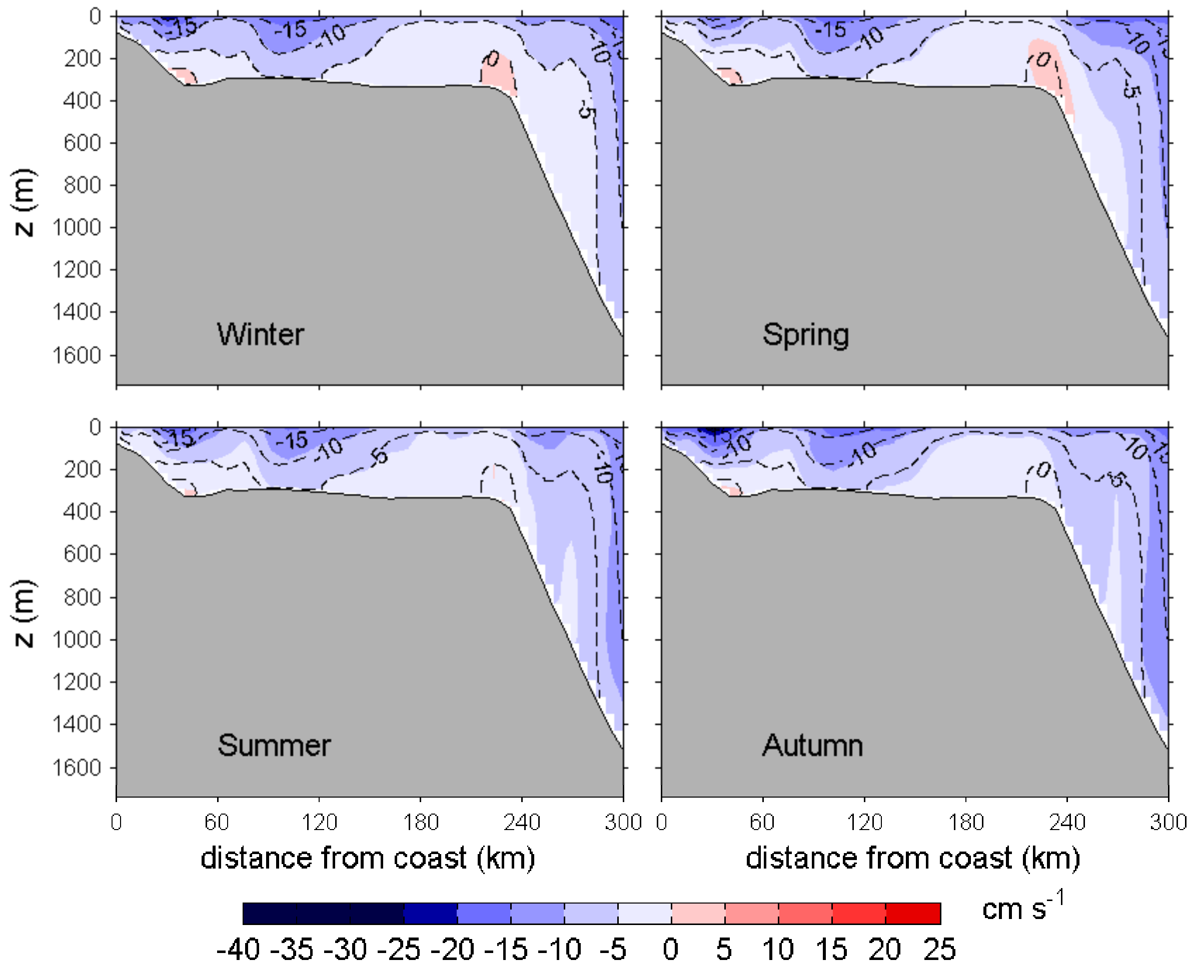
Normal velocity for the Davis Strait. Positive velocities correspond to northward currents. The contour interval is 5 cm s^{-1}



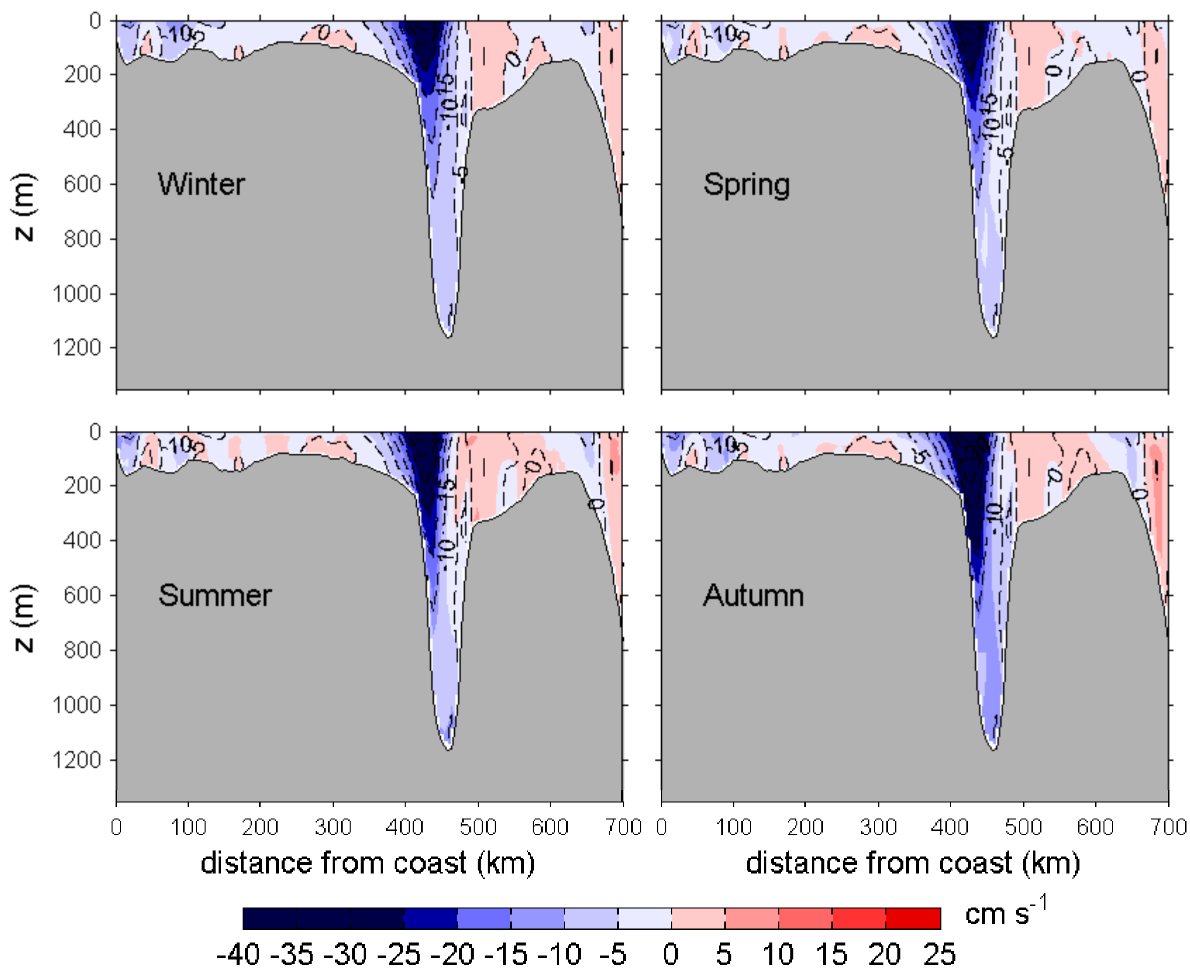
Normal velocity for the Labrador Sea section (western shelf). Positive velocities correspond to currents towards the north. The contour interval is 8 cm s^{-1}



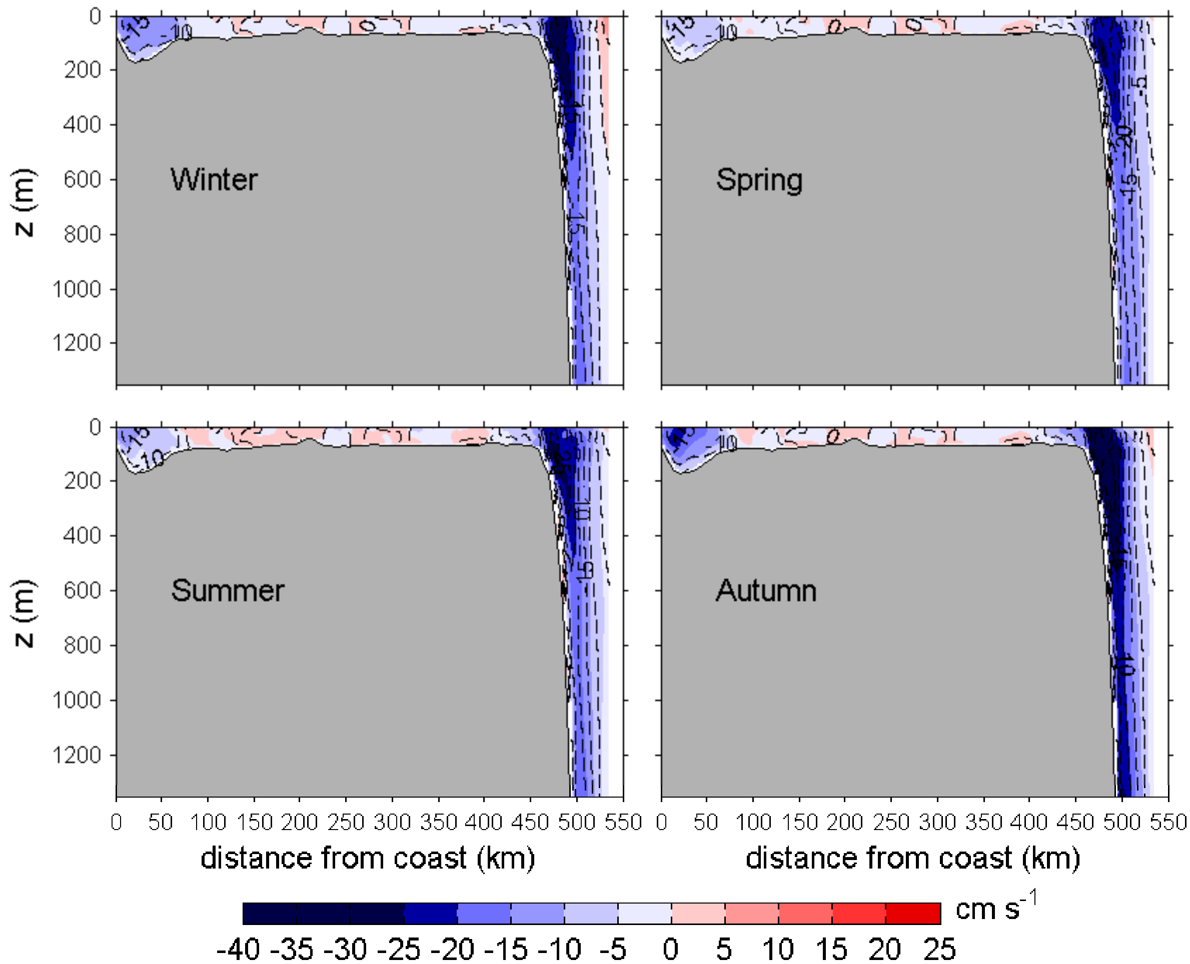
Normal velocity for the Labrador Sea section. Positive velocities correspond to currents towards the north. The contour interval is 8 cm s^{-1}



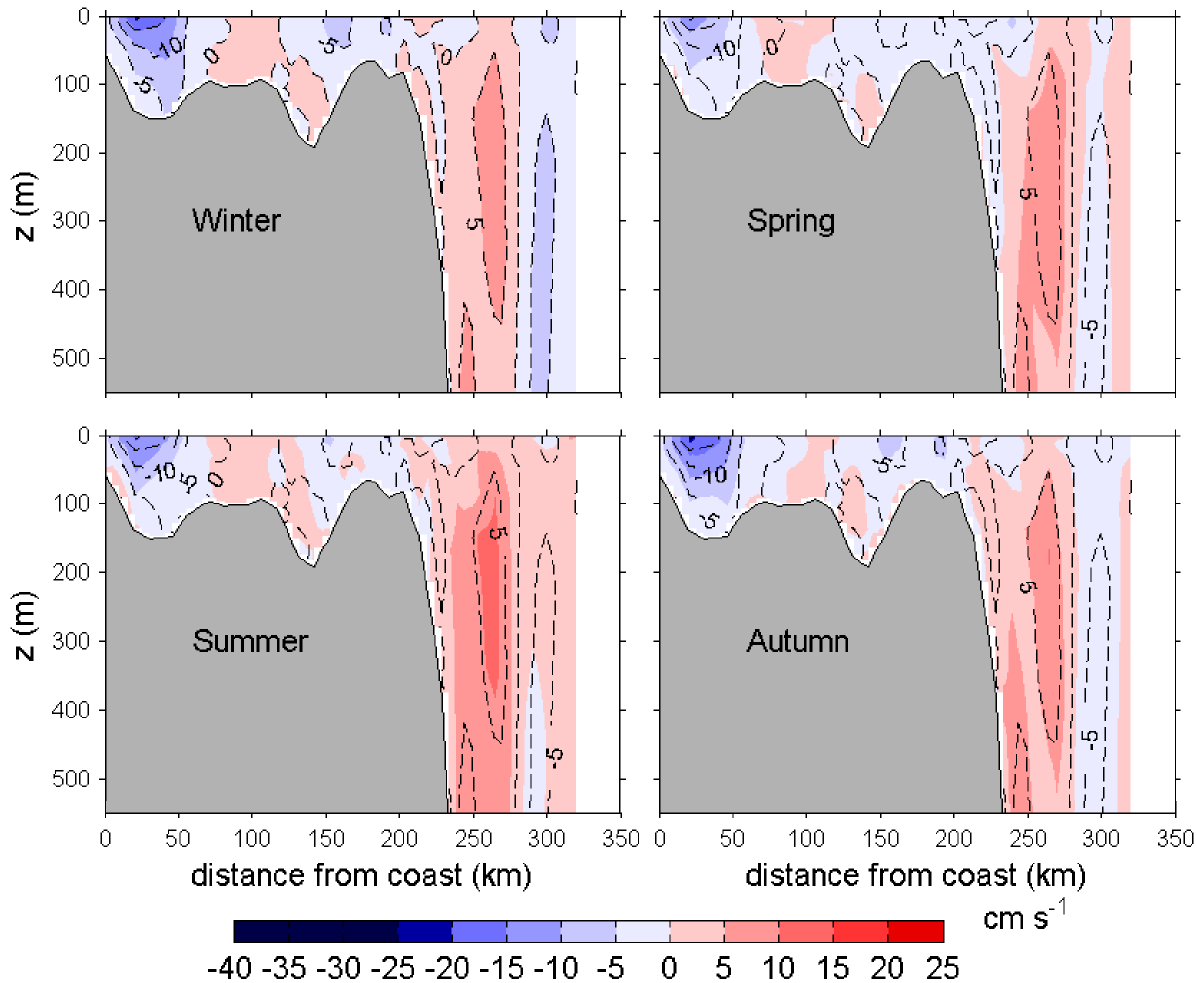
Normal velocity for the Bonavista section. Positive velocities correspond to currents towards the north. The contour interval is 5 cm s^{-1}



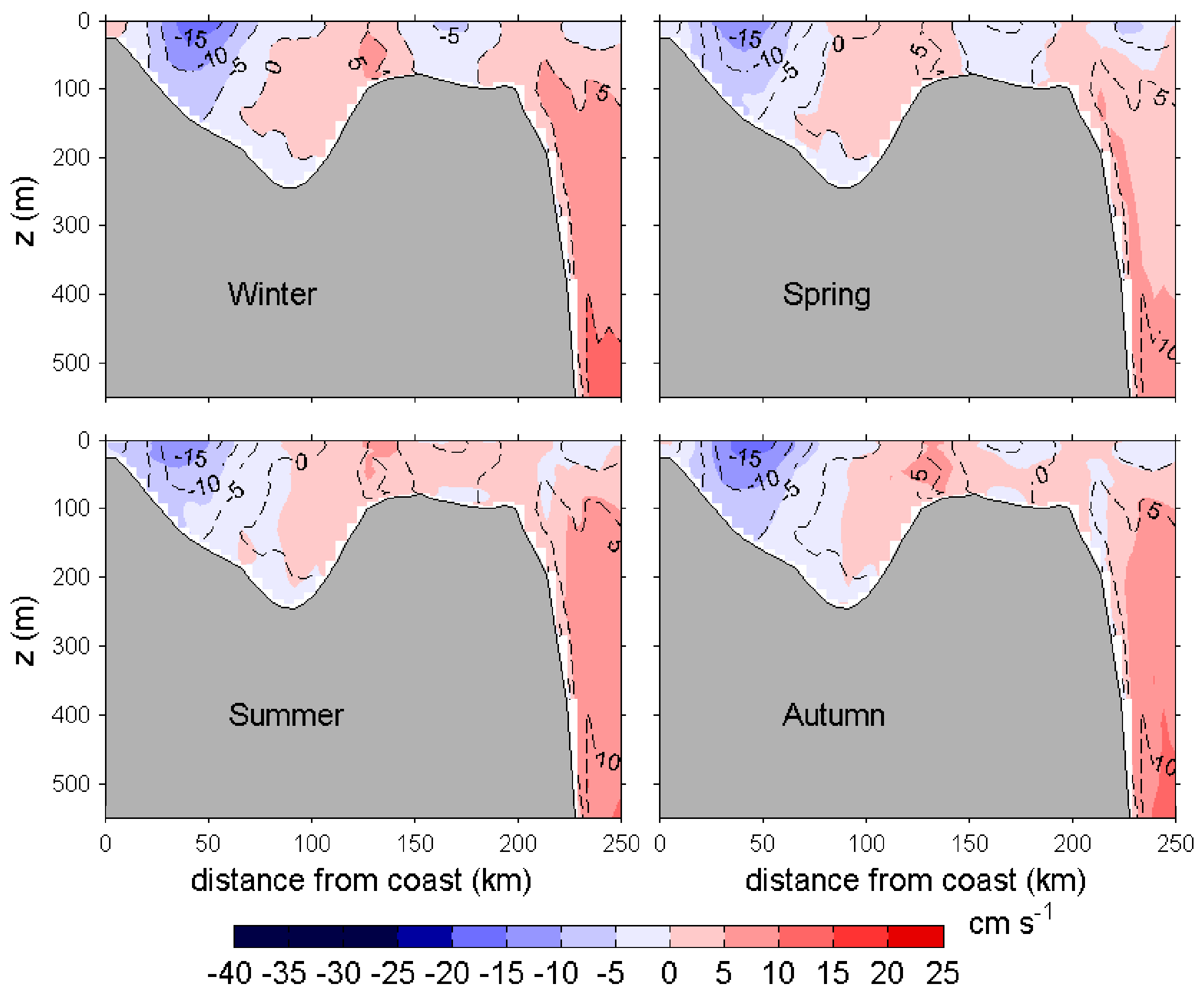
Normal velocity for the Flemish Cap section. Positive velocities correspond to northward currents. The contour interval is 5 cm s^{-1}



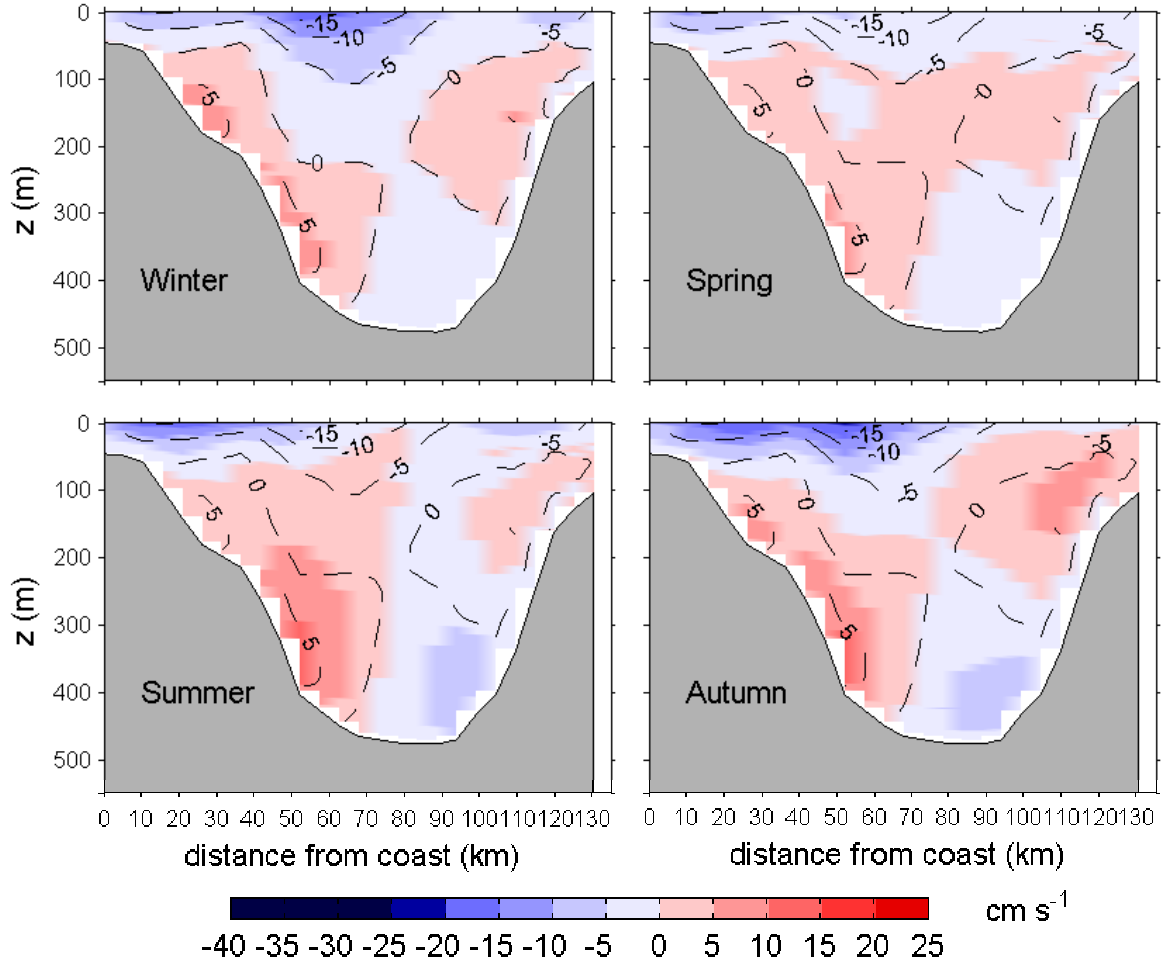
Normal velocity for the Southeast Grand Banks section. Positive velocities correspond to currents towards the east. The contour interval is 5 cm s^{-1}



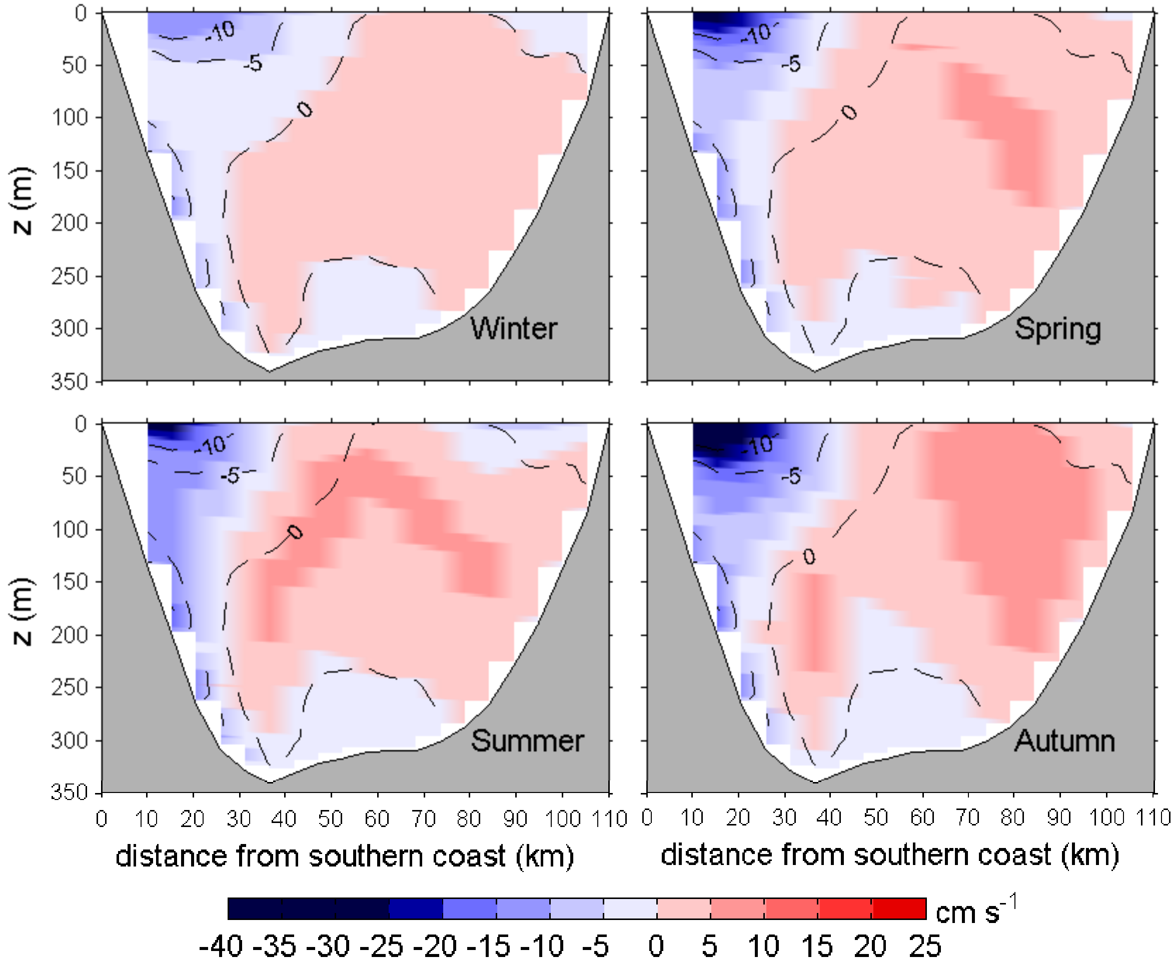
Normal velocity for the Louisbourg section. Positive velocities correspond to currents towards the north. The contour interval is 5 cm s^{-1}



Normal velocity for the Halifax section. Positive velocities correspond to currents toward the east. The contour interval is 5 cm s^{-1}



Normal velocity for the Cabot Strait. Positive velocities correspond to inflows into the Gulf of St. Lawrence. The contour interval is 5 cm s^{-1}



Normal velocity for the northwest Gulf of St. Lawrence section. Positive velocities currents towards the west. The contour interval is 5 cm s^{-1}