Can the Atlantic inflow be described by geostrophic dynamics?

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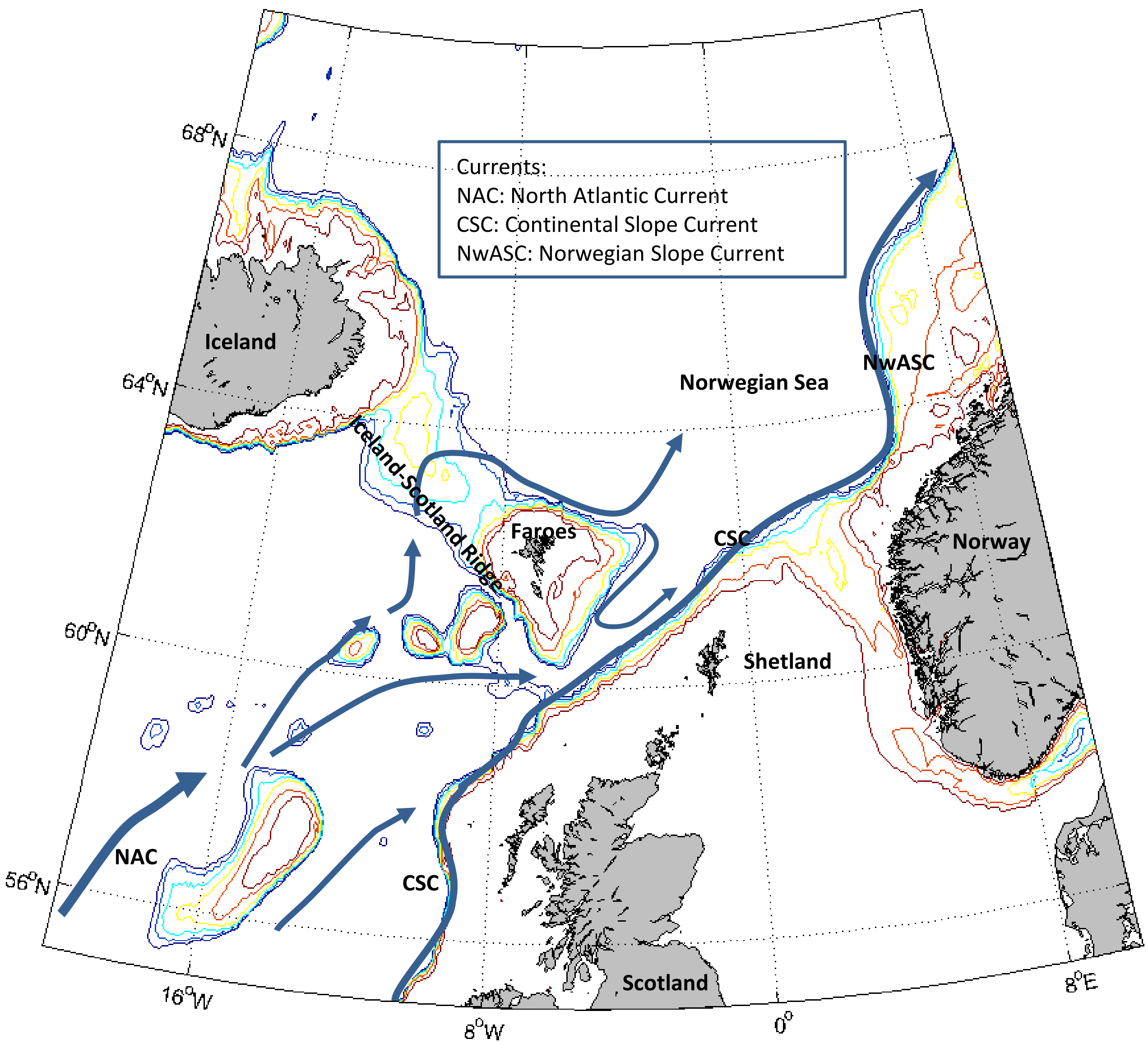
Outline

- Introduction and motivation
- Theory
- Data and results
- Conclusion

Major pathways of Atlantic water inflow



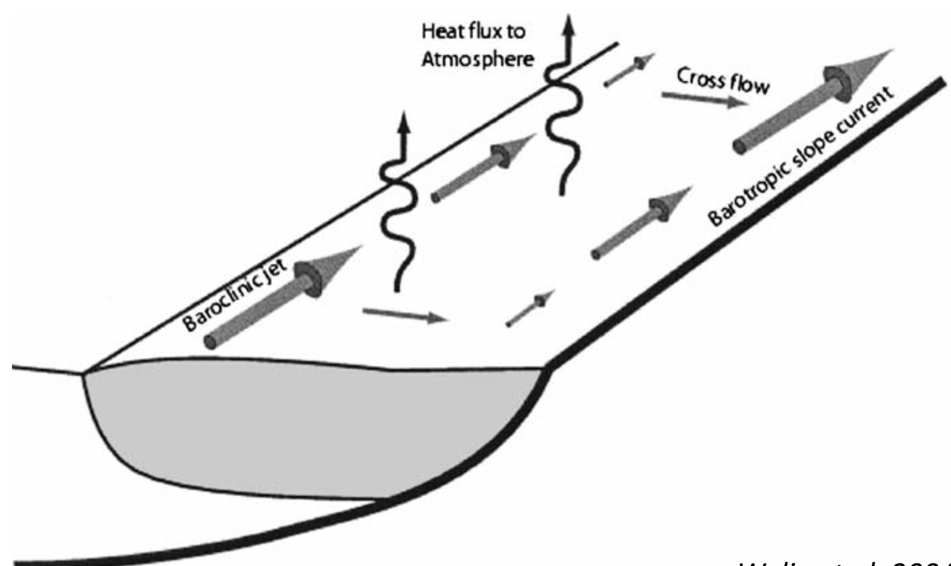
- **The Atlantic inflow through the FS channel consists of two seperate flow, NAC & CSC. And NwASC is a continuation of CSC.**
- **The mean currents of CSC and NwASC are barotropic and following topography, with increasing speed and transport (*Huthnance and Gould,1989; Orvik et al., 2001*).**
- **The dynamics of the Atlantic inflow is not well known.**

Motivation

- As the Atlantic inflow proceeds northward, its density increases mainly due to losing heat from ocean to atmosphere.

- In a context of geostrophic flow, density variation along a slope will lead to a transformation between a barotropic flow and a baroclinic flow.

- **We expect that this theory can describe dynamics of the Atlantic inflow along the slope.**



Walin et al. 2004

Theroy

- Assuming geostrophic and hydrostatic balance ,

$$\boldsymbol{k} \times f\boldsymbol{v} = -\frac{1}{\rho_0}\nabla p \qquad (1)$$

$$\frac{\partial p}{\partial z} = -g\rho \qquad (2)$$

- Inserting $p = -g\int_{-H}^{z} \rho dz + p_b$ into (1),

$$\boldsymbol{v}(z) = \underbrace{-\frac{g}{f\rho_0}\boldsymbol{k} \times \int_{-H}^{z} \nabla\rho dz}_{\text{Baroclinic flow } v_s} \underbrace{- \frac{g}{f\rho_0}\rho_b \boldsymbol{k} \times \nabla H + \frac{1}{f\rho_0}\boldsymbol{k} \times \nabla p_b}_{\text{Barotropic flow } v_b} \qquad (3)$$

Baroclinic flow v_s **Barotropic flow v_b**

Baroclinic and barotropic transformation

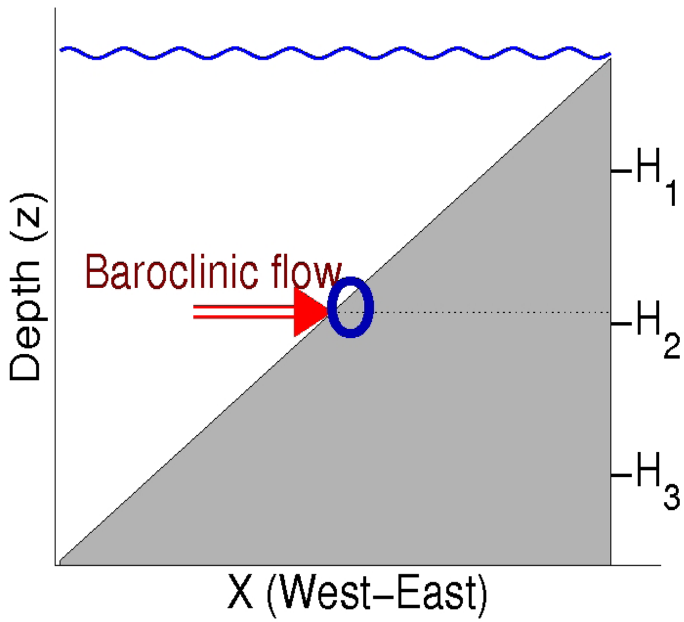
- Assuming $p_b = p_b(H)$ and f-plane, then

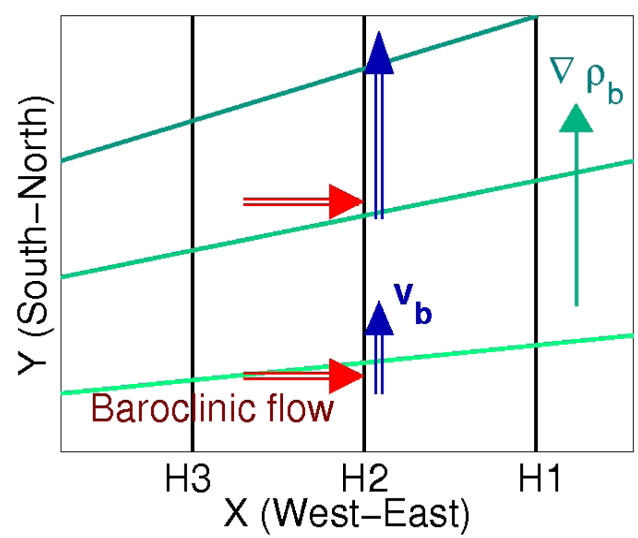
$$\boldsymbol{v_b} = \frac{1}{f\rho_0}\left(-g\rho_b + \frac{dp_b}{dH}\right)\boldsymbol{k} \times \nabla H$$

$$\boldsymbol{v}_s(z) = -\frac{g}{f\rho_0}\boldsymbol{k} \times \int_{-H}^{z} \nabla \rho dz$$

Geostrophy →

$$\nabla \cdot (\boldsymbol{v}_b + \boldsymbol{v}_s) = 0$$





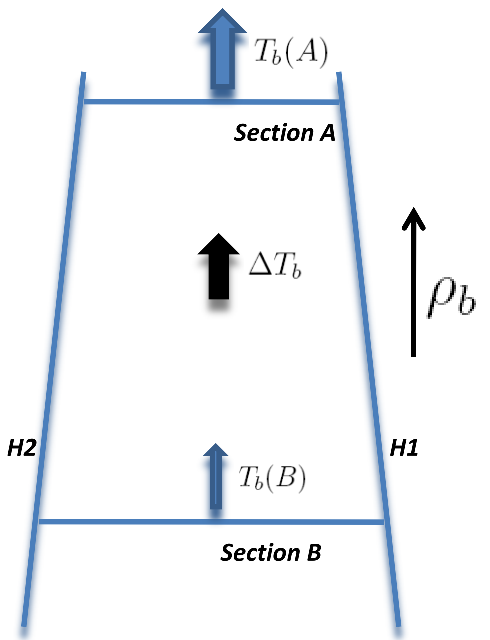
Formula of barotropic transport change

Barotropic transport

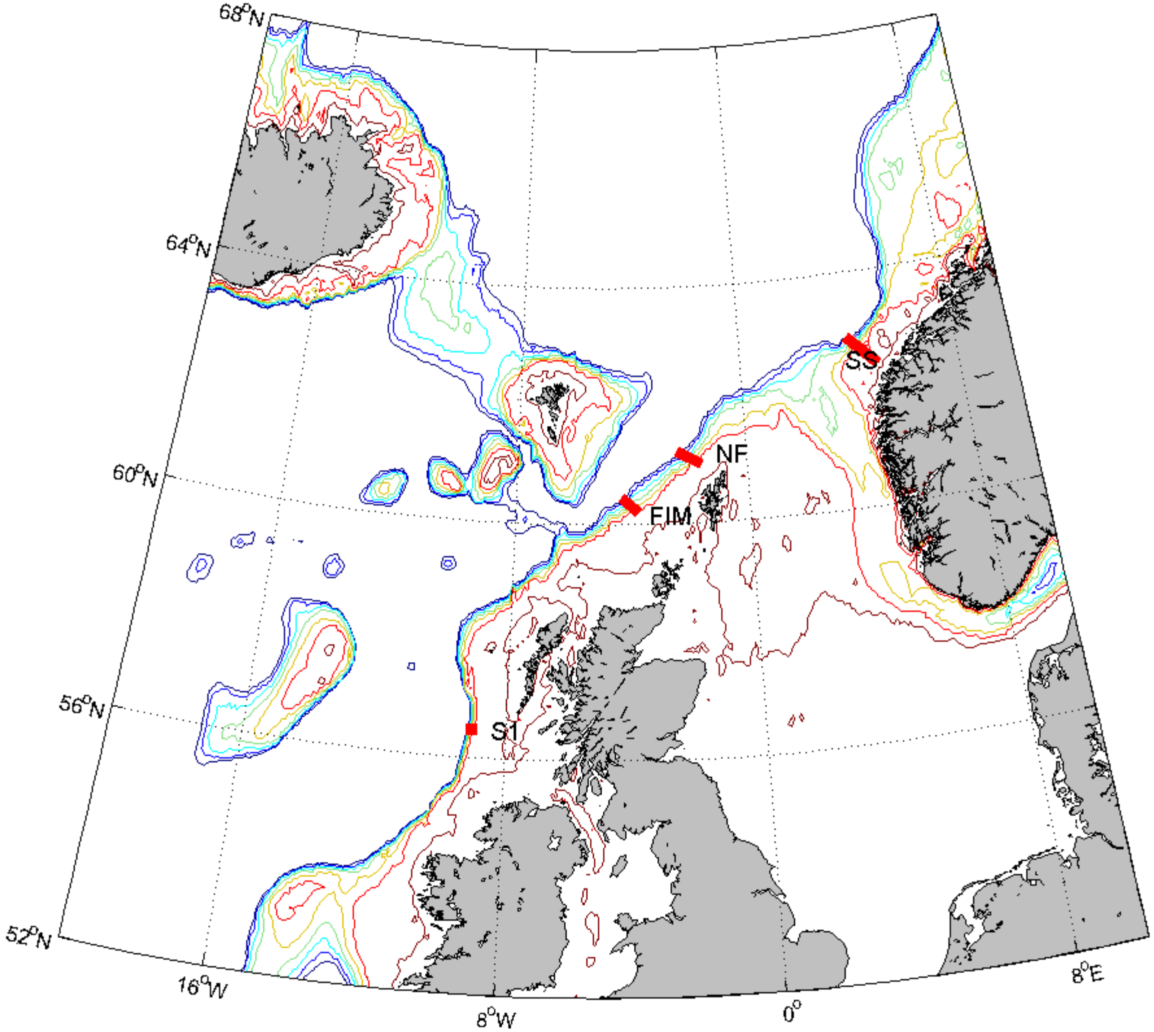
$$T_b = \frac{1}{f\rho_0}\int_{H_1}^{H_2} H(g\rho_b - \frac{dp_b}{dH})dH$$

Transport change

$$\Delta T_b = T_b(A) - T_b(B) = \frac{1}{f\rho_0}\int_{H_1}^{H_2} H(g\rho_b(A) - \frac{dp_b}{dH} - g\rho_b(B) + \frac{dp_b}{dH})dH$$

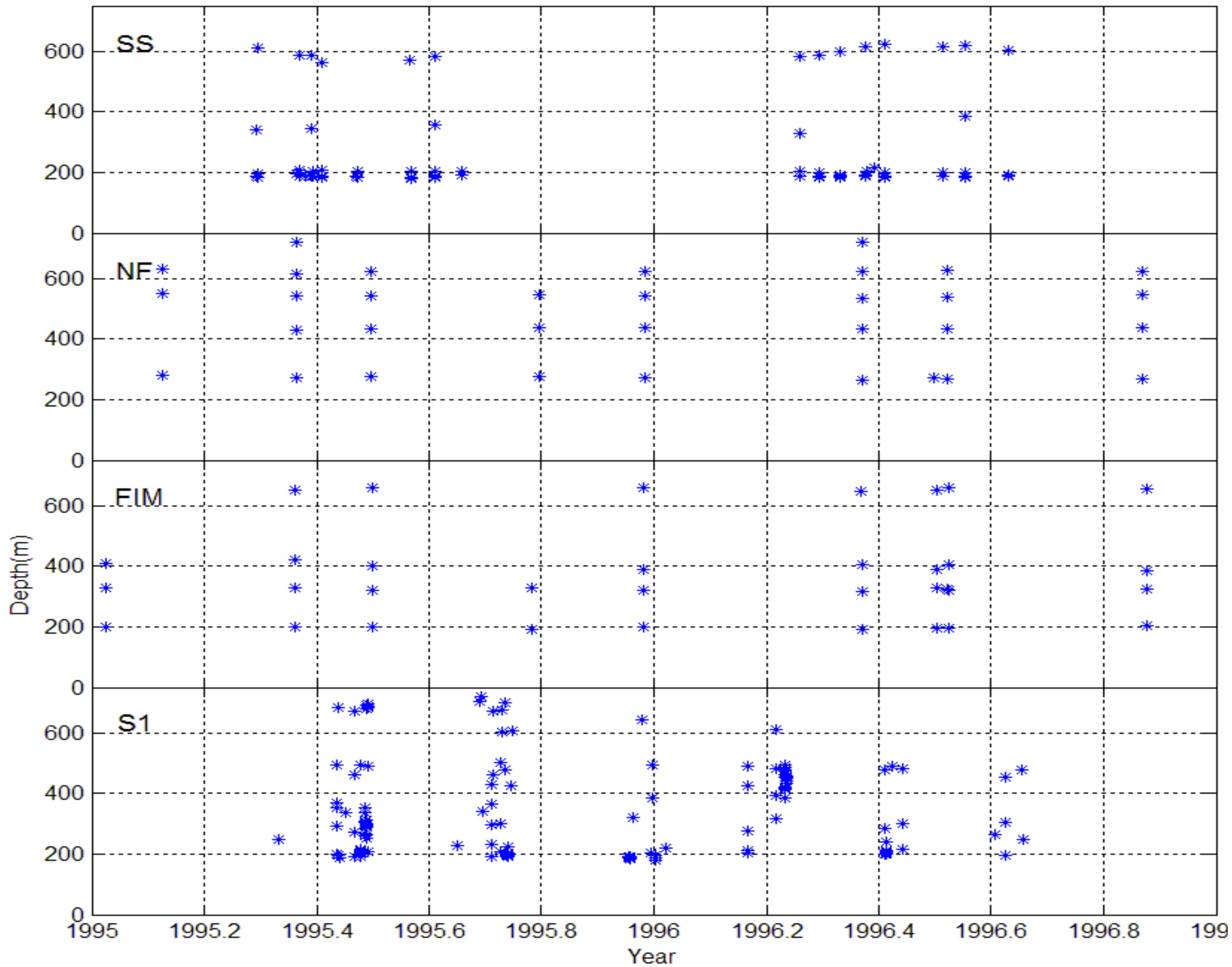


Hydrographic Data



- CTD data at approximately the same period of four sections across the slope are from Hydrobase 2, ICES and BODC.
- The bottom observation is defined as an observation with instrumental depth less than 20 meters above the floor.

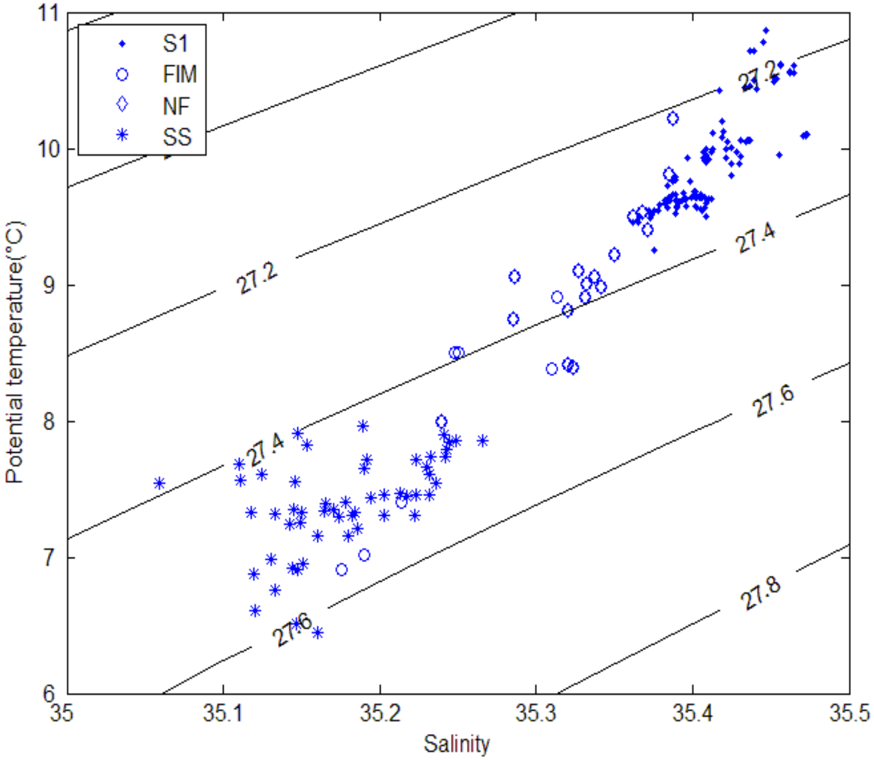
Hydrographic Data



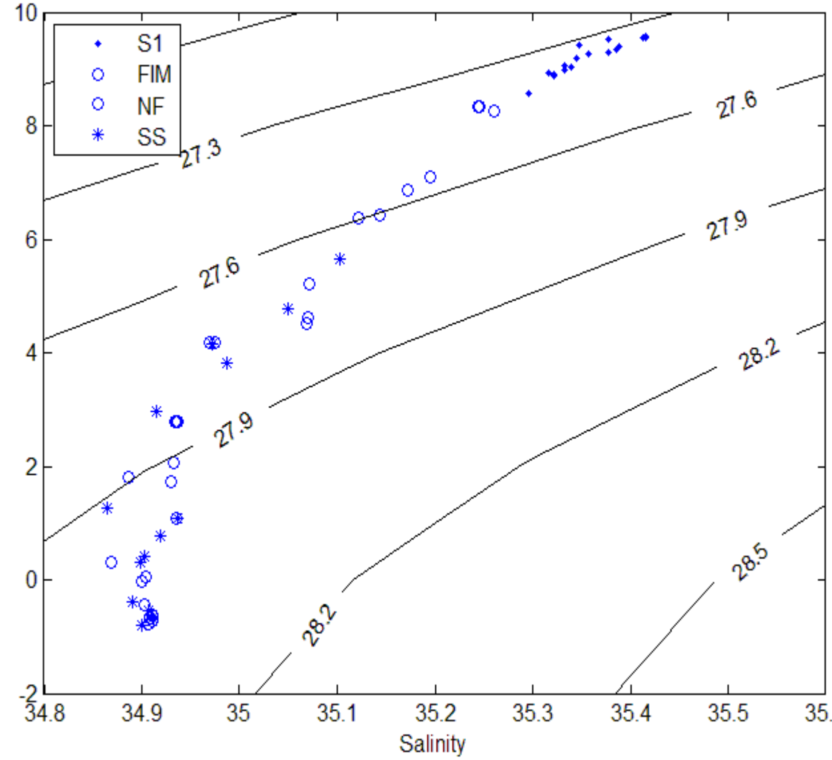
Spatialtemporal distribution of near-bottom data

- CTD data at approximately the same period of four sections across the slope are from Hydrobase 2, ICES and BODC.
- The bottom observation is defined as an observation with instrumental depth less than 20 meters above the floor.

Water mass properties along the slope

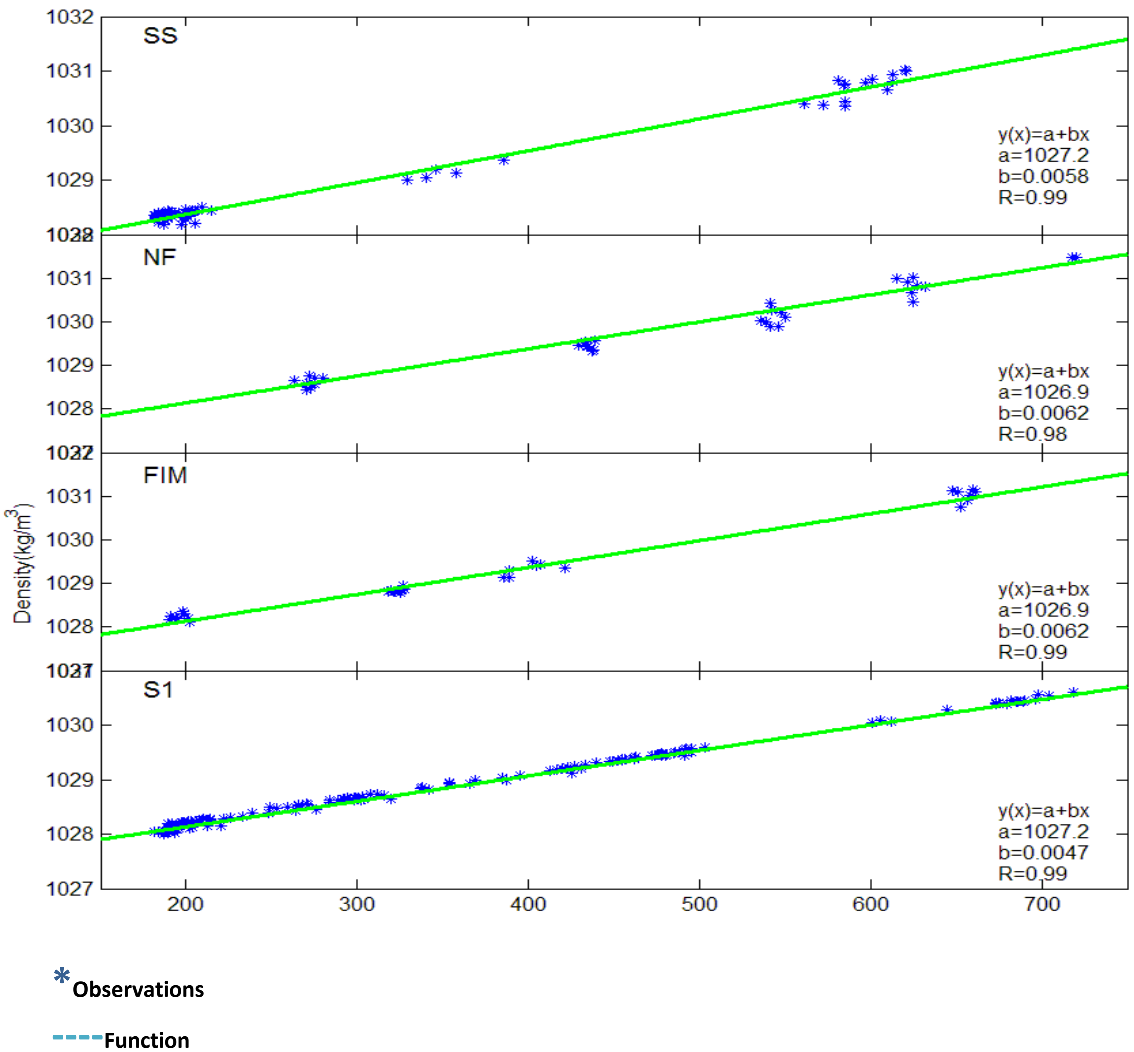


200-500m



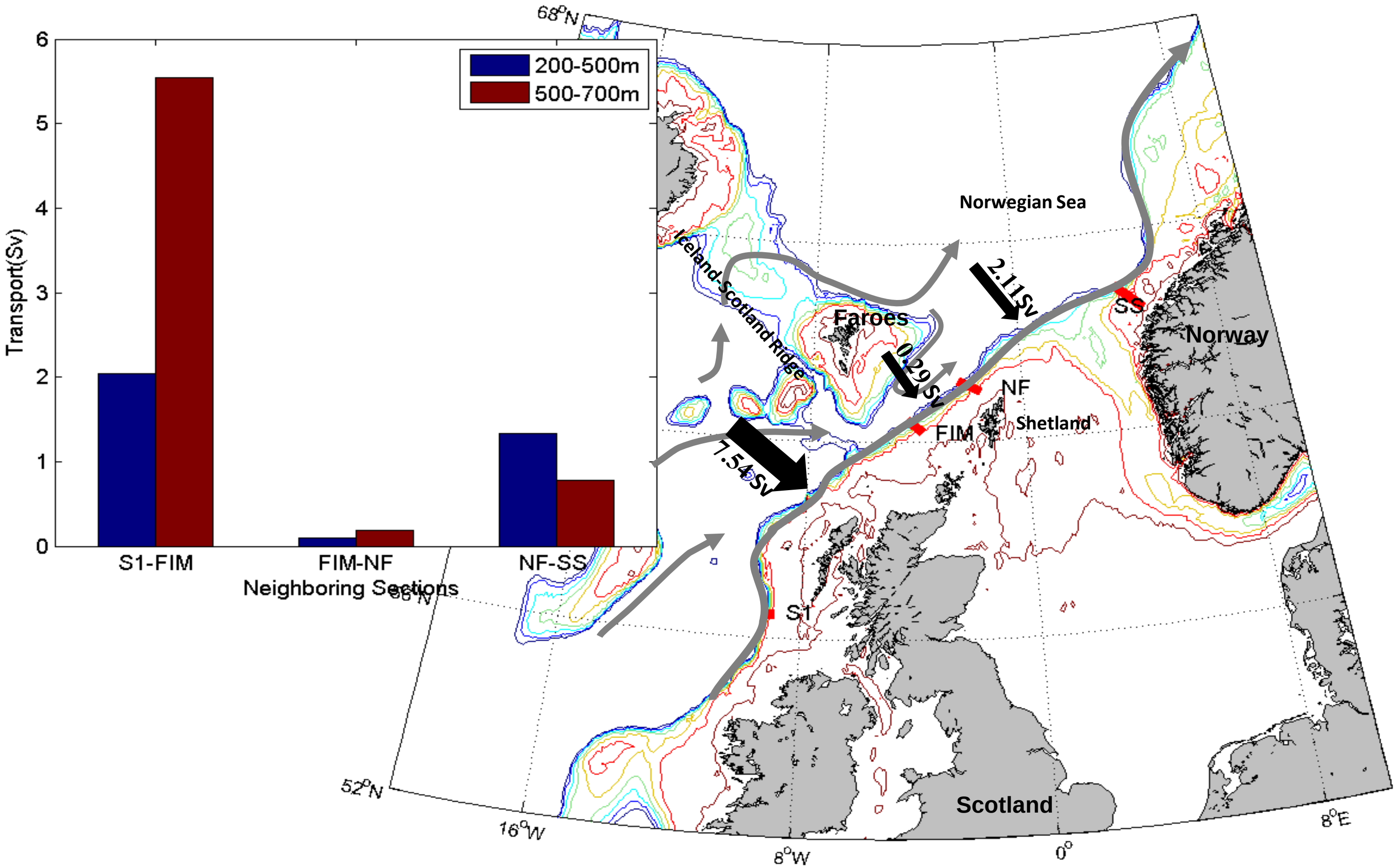
500-700m

Bottom densities across the slope



- Bottom density in each section is assumed as a linear function of water depth.
- The function slope is different at the four sections.
- Transport change between two neighboring sections are calculated from the fitted data.

Barotropic transport change between two neighboring sections



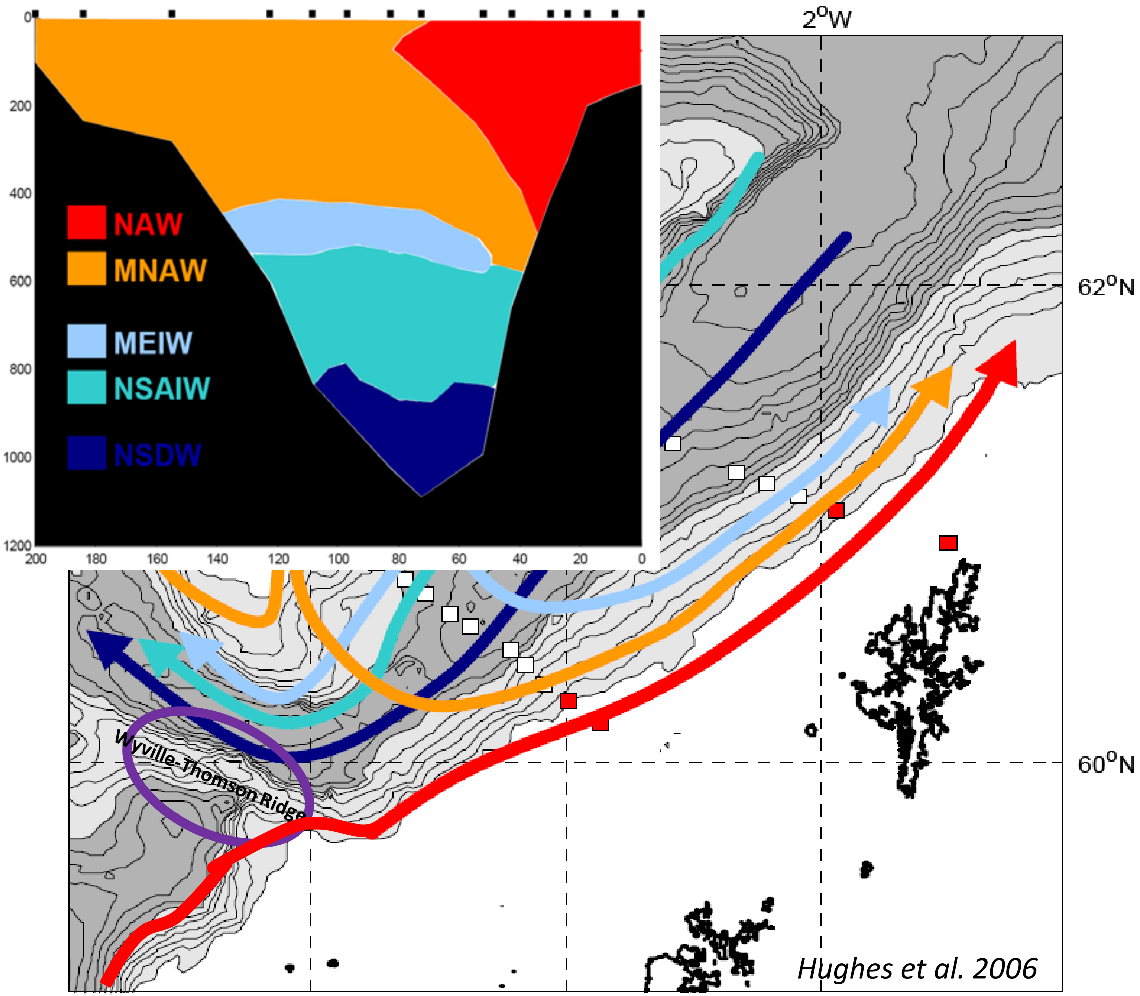
Barotropic transport change between two neighboring sections

	ΔT(Sv)		
	S1-FIM	**FIM-NF**	**NF-SS**
300m-500m	**2.04**	**0.10**	**1.33**
500m-700m	**5.54(?)**	**0.19**	**0.78**

- Barotropic transport increases along the slope, qualitively illustrating the Atlantic inflow structure along the slope.

- The results are comparable with observations, except on the slope of 500m-700m from S1-FIM.

Where does the geostrophy break?



- Along 700m and 600m isobath before and after the Wyville-Thomson Ridge,

$$\Delta U = O(10^{-1}), \Delta L = O(10^{4})$$

$$R = \frac{\Delta U}{f \Delta L} = O(10^{-1})$$

Conclusion

- Geostrophy can describe the dynamics of Atlantic inflow along the slope shallower than around 500m. The simple linear theory explains well why both the speed and transport of the inflow increases along the slope.

- Geostrophy breaks down at the slope deeper than around 600m at the area of Wyville-Thomson Ridge .