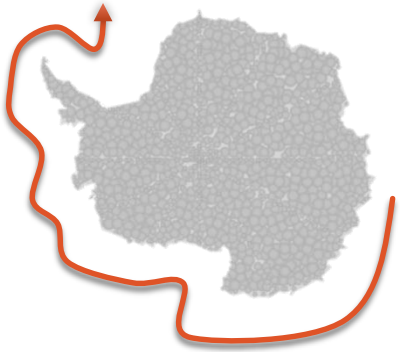

SCOTIA SEA PATHWAYS AS DEDUCED FROM ARGO FLOATS

7th EURO-ARGO SCIENCE MEETING

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BACKGROUND AND OBJECTIVES

The meridional overturning circulation depends directly on physical processes in the **Southern Ocean.**

Antarctic Circumpolar Current: Subantarctic front (SAF), Polar Front (PF), Southern Antarctic Circumpolar Current Front (SACCF) and Southern Boundary (SB).

- **SCOTIA SEA** → conditions and modifies the water properties.
  - Drake Passage
  - 54-54 Passage
  - Shag Rock Passage
  - Black Rocks Passage
  - Georgia Passage

- **OBJECTIVE**

- To quantify the geostrophic water transports into and out of the Scotia Sea, the contribution of the different water masses, and the temporal evolution.

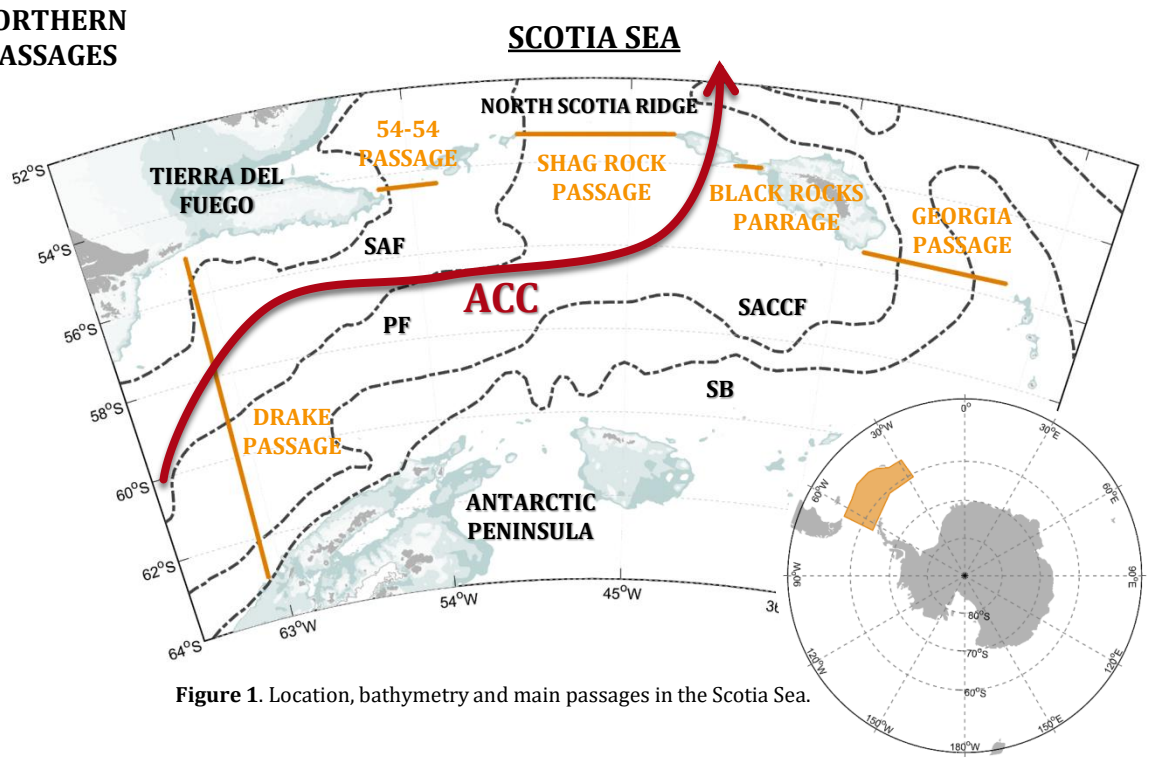


Figure 1. Location, bathymetry and main passages in the Scotia Sea.

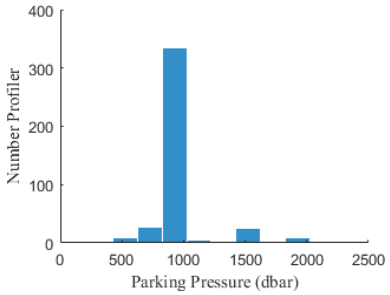
METHODS

- **ARGO FLOATS DATABASE**

  http://www.coriolis.eu.org

  - **JANUARY 2002 – OCTOBER 2018**
  - 78% between 950-1050 m parking depth
  - 169 floats through the Drake Passage
  - 156 floats through the NSR + Georgia Passages
  - Moving pentads (series of 5 years) between 2004 – 2016.

Figure 2. Parking Pressure of Scotia Sea floats.



- **TRAJECTORY** data ► float speeds at the parking depth ► Reference velocities

  Velocity at 1000 m parking depth ➔ YoMaHa & ANDRO

$$\hat{U}^n_{deep} = \left(X^n_{first} - X^{n-1}_{last}\right) cos\left(\pi\, Y^n_{deep}/180\right)/\Delta T$$

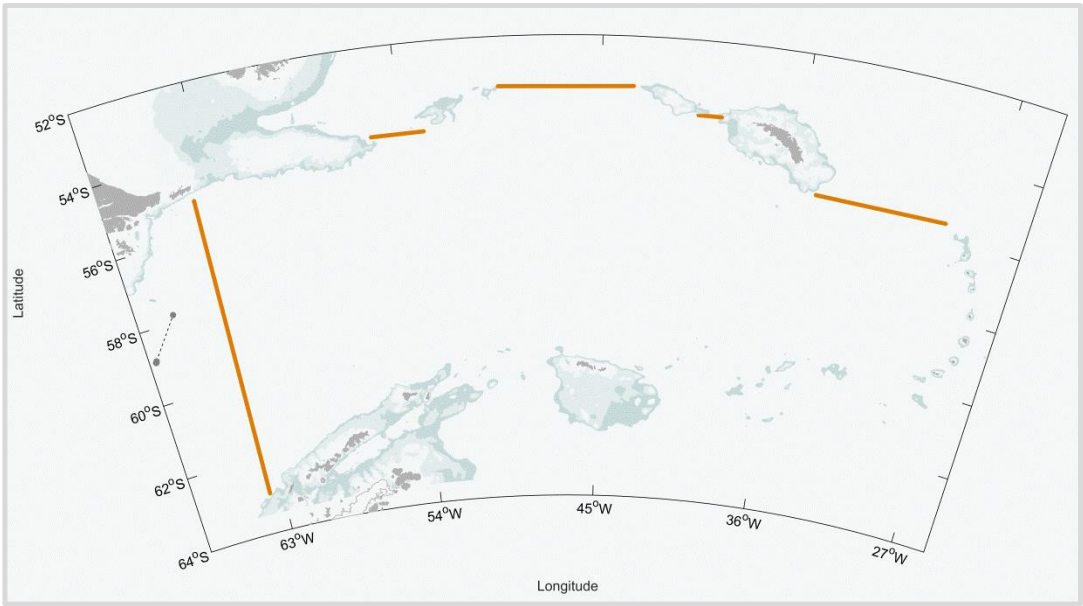
$$\hat{V}^n_{deep} = \left(Y^n_{first} - Y^{n-1}_{last}\right)/\Delta T$$

- **PROFILES** data ► Hydrography ► Relative geostrophic velocities

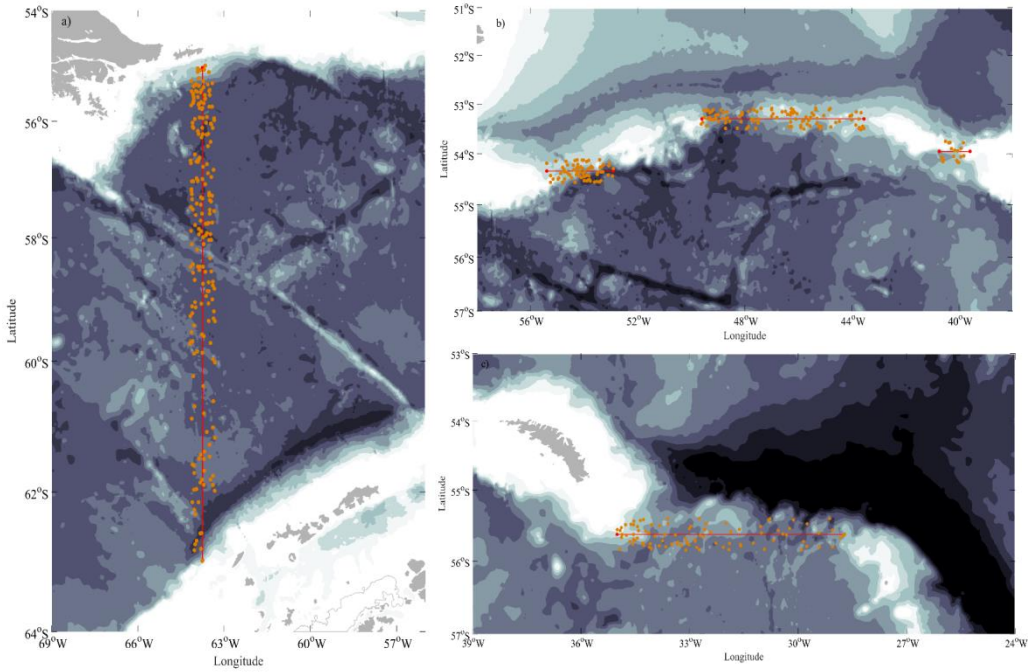
  Thermal wind equation ➔ Hydrostatic balance and steady state

$$v_g(x,z) = -\frac{g}{p_0 f}\int_{z_0}^{z}\frac{\partial \rho}{\partial x}\mathrm{dz} + \mathrm{b(x)}$$

Figure 3. Floats trajectory across the Scotia Sea.



HYDROGRAPHY



VERTICAL SECTIONS

- Temperature, salinity and neutral density:
  - ✓ 0 to 2000 m with 10-m vertical resolution.
  - ✓ 25-km horizontal resolution.
- The properties have similar structures in both passages

Figure 4. Profilers distribution along the passages

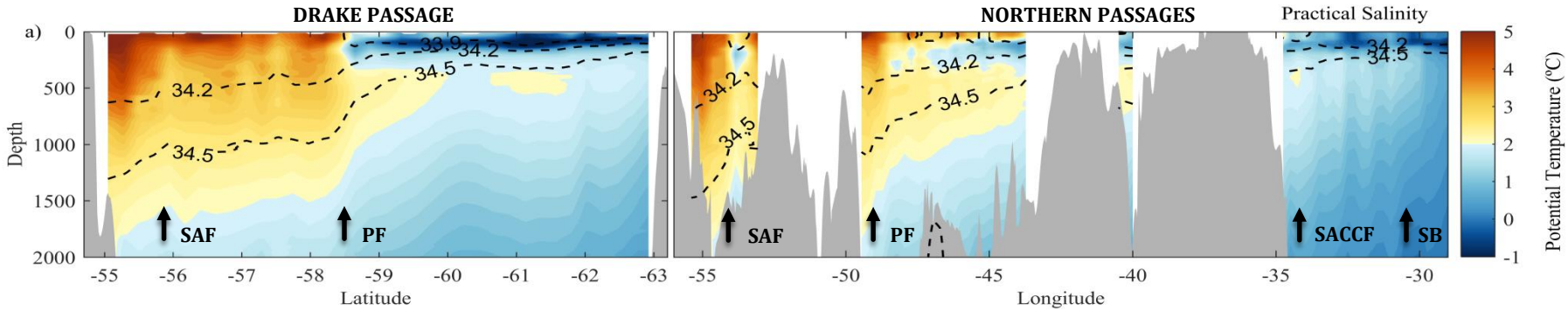
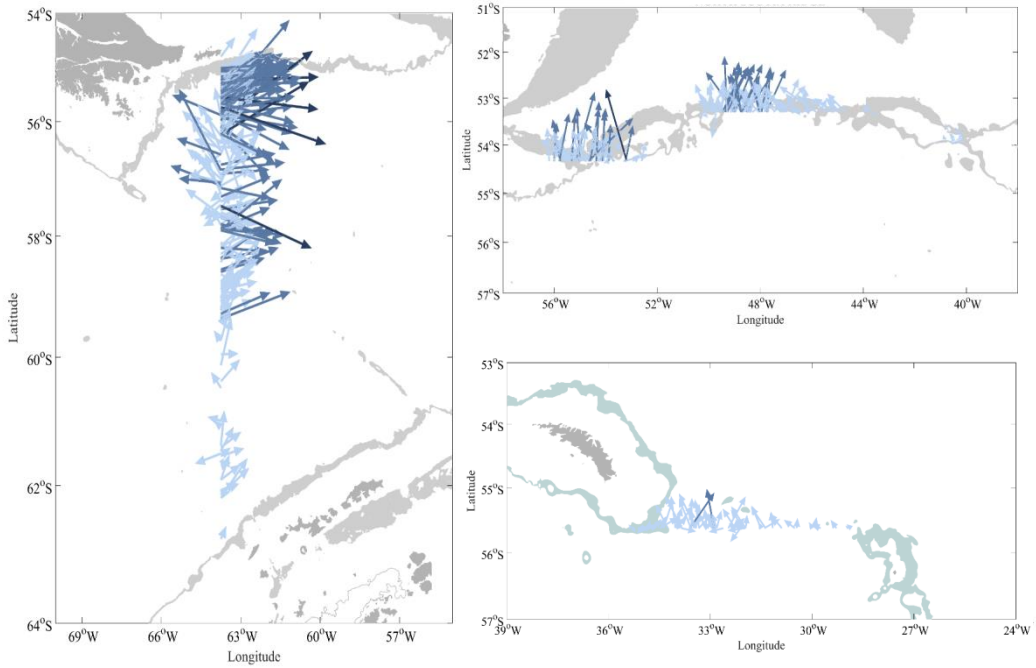


Figure 5. Potential temperature with practical salinity white contours.

The horizontal gradients indicates the position of the frontal systems (SAF, PF, SACCF and SB) as defined by Orsi et al. (1995).

REFERENCE VELOCITY

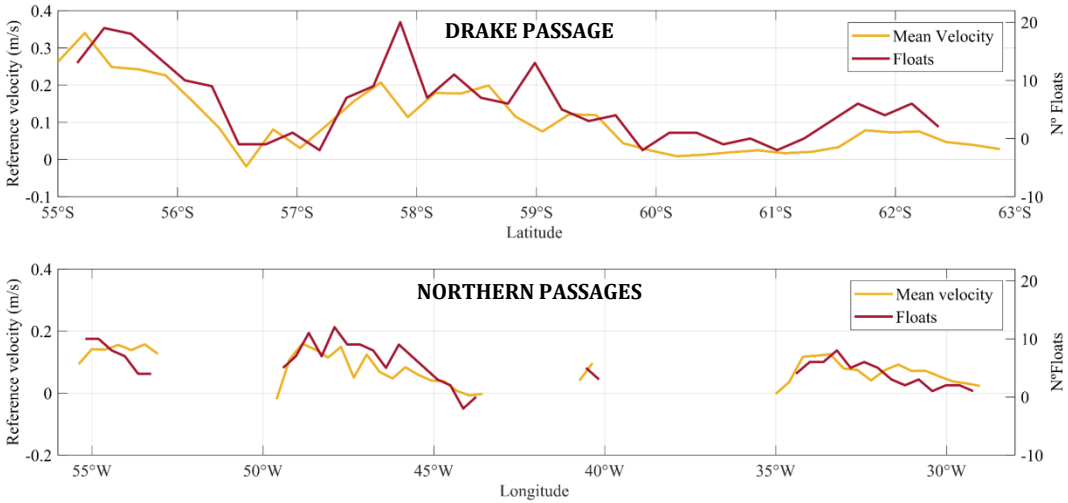


FLOAT SPEEDS

0-0.2m/s 0.2-0.4m/s 0.4-0.6m/s

- Most floats drift through the northern portion of the Drake Passage, and the western parts of the northern passages, typically exhibiting the highest speeds.
- Many floats recirculate along eddies and meanders as they cross the passages.

Figure 6. Floats direction and velocity at 1000 m on the different passages.

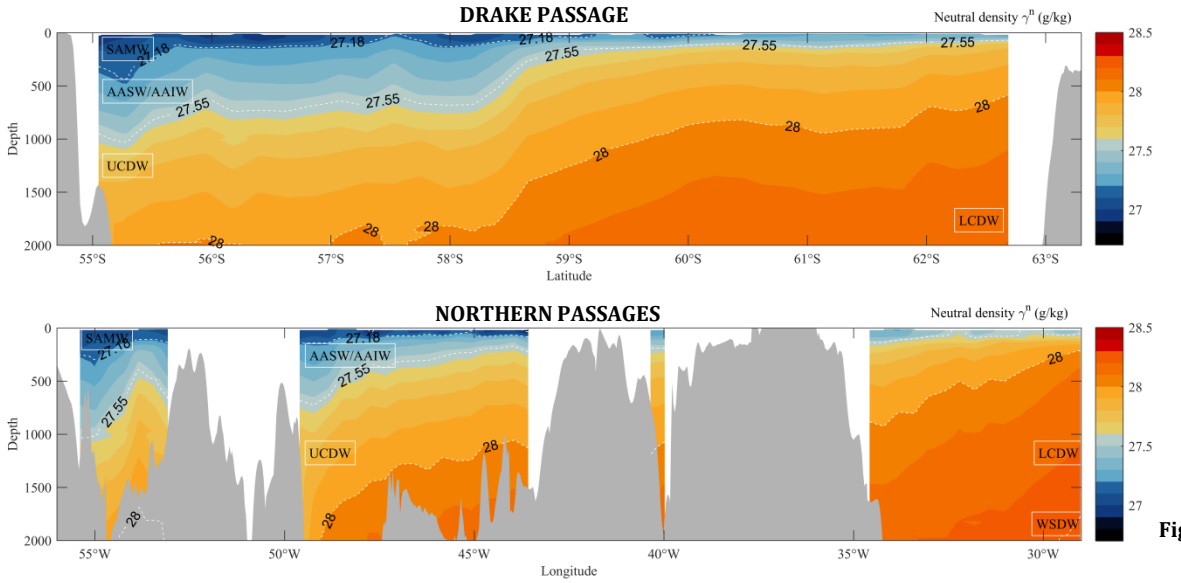


- The number of floats and reference velocity are well correlated.

CORRELATION	MEAN DATA
Drake Passage	R= 0.86
54-54 Passage	R= -0.55
Shag Rocks Passage	R= 0.87
Black Rocks Passage	R ≅ -1
Georgia Passage	R= 0.65

Figure 7. Reference velocity and number of floats through the passages.

ABSOLUTE VELOCITY



WATER MASS	NEUTRAL DENSITY
SASW	$\gamma_n < 26.90$
SAMW	$26.90 < \gamma_n < 27.18$
AASW/AAIW	$27.18 < \gamma_n < 27.55$
UCDW	$27.55 < \gamma_n < 28.00$
LCDW	$28.00 < \gamma_n < 28.26$
SPDW	-
WSDW	$28.26 < \gamma_n < 28.40$

Figure 8. Water masses distribution along the different passages.

- Absolute velocities once adjusted with reference velocities.
- Largest velocities are associated to the frontal systems.

- 165 Sv in Drake Passage ► Barotropic: 109 Sv
- 172 Sv NSR Passages + Georgia ► Barotropic: 98 Sv

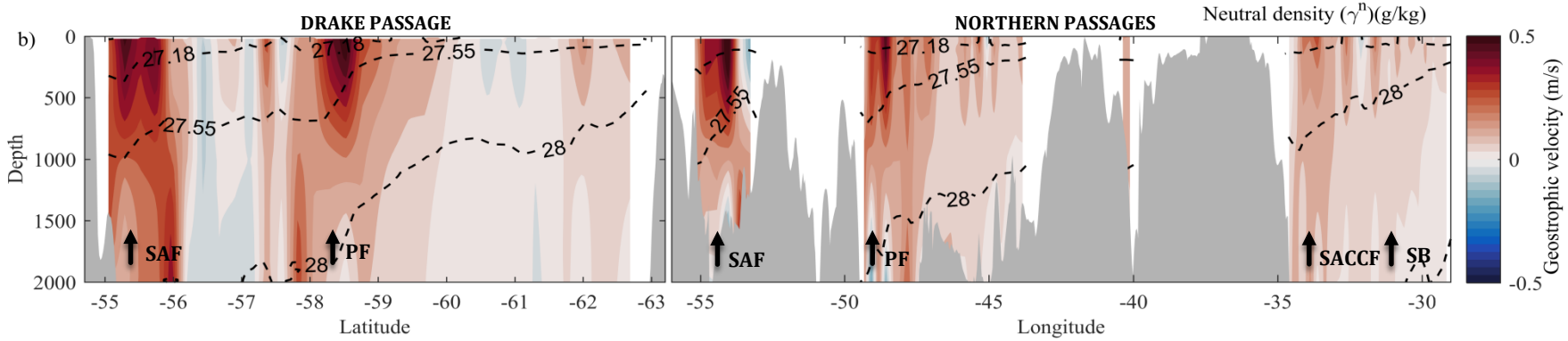
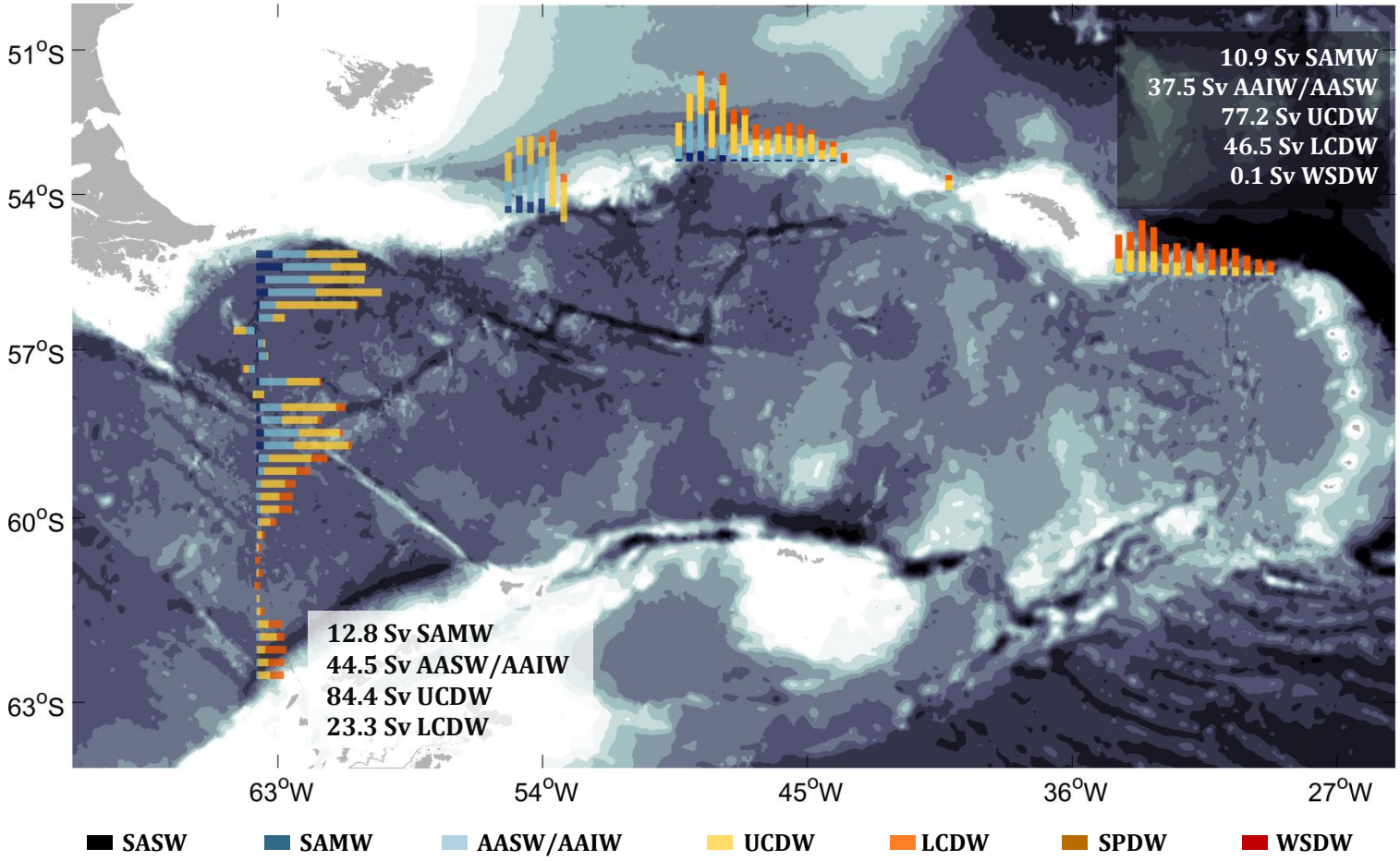


Figure 9. Geostrophic velocity (m/s) with neutral density (g/kg) black contours

TRANSPORTS: MEAN VALUES

Figure 10. Transports per water mass each 25 km for the several passages which limit the Scotia Sea.



AASW/AAIW and UCDW dominated in Drake Passage whereas in NSR + Georgia Passages dominates UCDW and LCDW.

Transport imbalances: 1.8 Sv in SAMW, 6.9 Sv for AASW/AAIW and 7.2 Sv for UCDW.

TRANSPORTS: TEMPORAL EVOLUTION

YEARS	DRAKE		54-54		SHAG ROCK		BLACK ROCKS		GEORGIA	
	Nº	TRANSPORT	Nº	TRANSPORT	Nº	TRANSPORT	Nº	TRANSPORT	Nº	TRANSPORT
2002-2006	12	41.9	4	11.3	4	27.0	1	0	2	4.3
2003-2007	32	84.5	12	32.8	9	26.8	2	0	4	23.4
2004-2008	56	149.5	20	35.0	14	63.3	6	0	7	34.4
2005-2009	71	167.7	24	31.0	25	64.6	6	0	12	30.4
2006-2010	85	185.1	31	31.3	28	64.6	6	0	11	30.9
2007-2011	85	191.9	31	42.0	29	63.8	5	0	12	31.3
2008-2012	80	181.1	26	38.2	33	63.3	6	3.6	12	33.4
2009-2013	63	160.8	22	30.8	30	62.0	6	0	10	28.7
2010-2014	53	158.4	19	32.5	20	49.4	3	2.09	7	27.54
2011-2015	57	160.5	14	37.6	22	58.5	6	2.5	9	36.11
2012-2016	61	171.2	14	32.8	25	53.2	10	2.7	13	40.01
2013-2017	63	172.5	13	31.2	27	59.6	10	2.0	18	54.29
2014-2018	58	188.2	11	18.7	29	59.8	9	0	20	53.27

Table 1. Total geostrophic transport obtained for each passage clustering the years in different pentads, respectively.

- Lack of data to establish the transport in Black Rocks passage.
- Minimums between 2010-14 period.
- Maximums in sparse pentads.
- Pentads variability 22% - 55% on passages.

TRANSPORTS: TEMPORAL EVOLUTION

DRAKE PASSAGE ► stable Antarctic waters transport.

54-54 PASSAGE ► AAIW/AASW and UCDW have a similar transport.

SHAG ROCKS PASSAGE ► LCDW decreases.

GEORGIA PASSAGE ► rise of WSDW presence.

- The fronts position depends on interannual variabilities ➔ SAF and PF maximum variations of 0.19 m/s.

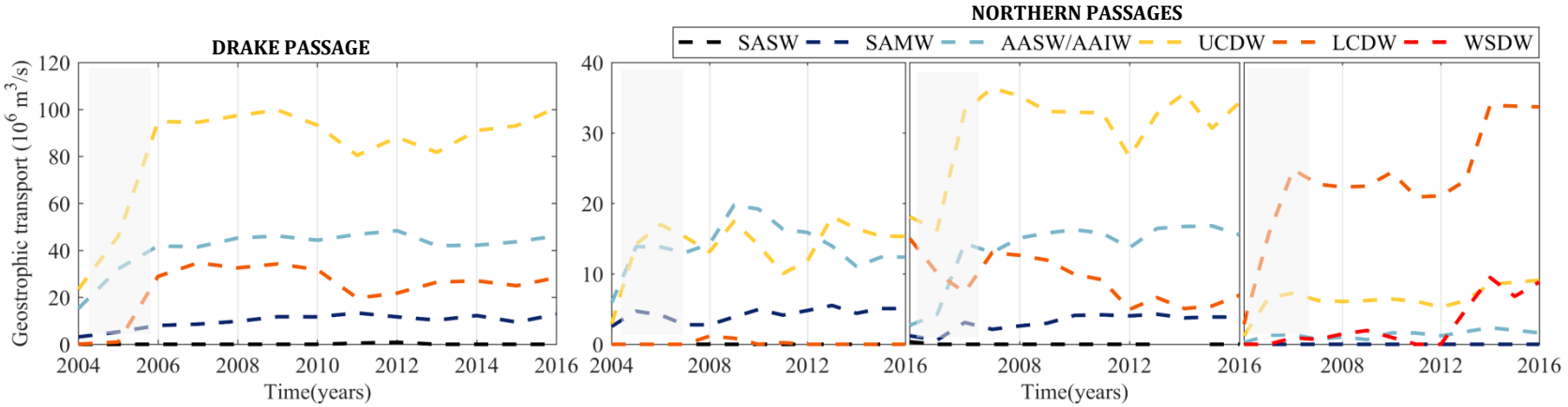


Figure11. Temporal variations in the ACC transports, as determined using 5-year (pentad) data.

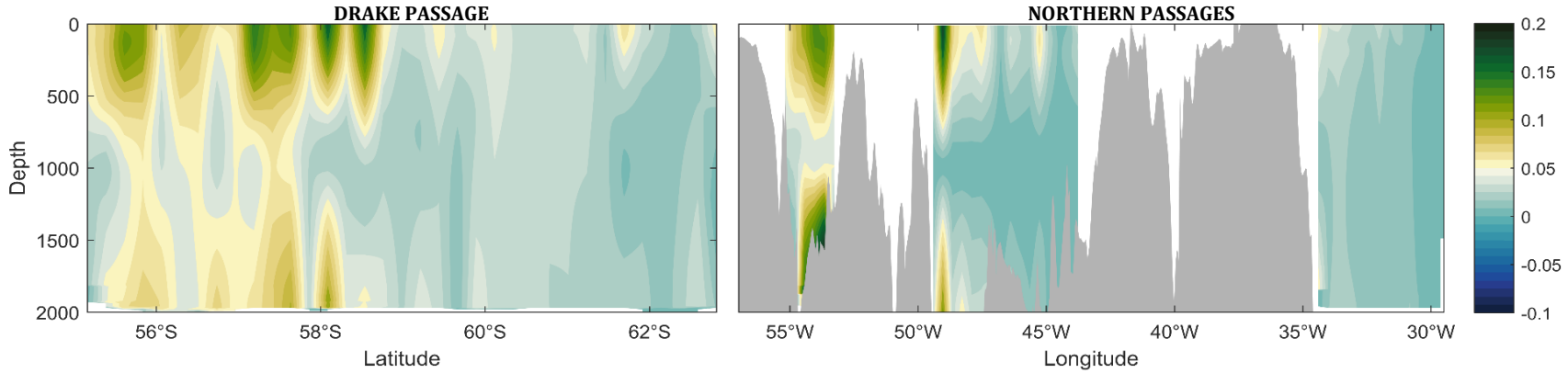
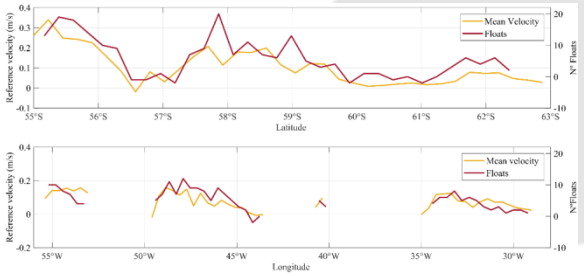


Figure 12. Standard deviation of the geostrophic velocity as calculated using the pentad data.

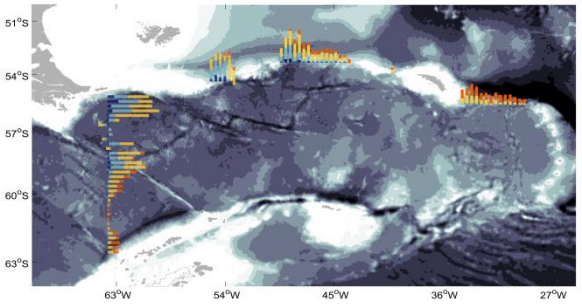
DISCUSSION & PRELIMINAR CONCLUSIONS

- Lack of data | Bathymetry presence
- Overestimate of geostrophic transports.

✓ The Argo floats reveal the main transports for ACC through the Scotia Sea. For a selected group of sections enclosing the Scotia Sea, the reference velocities are inferred from the floats surface positions and the absolute geostrophic velocities are calculated from the floats cast.

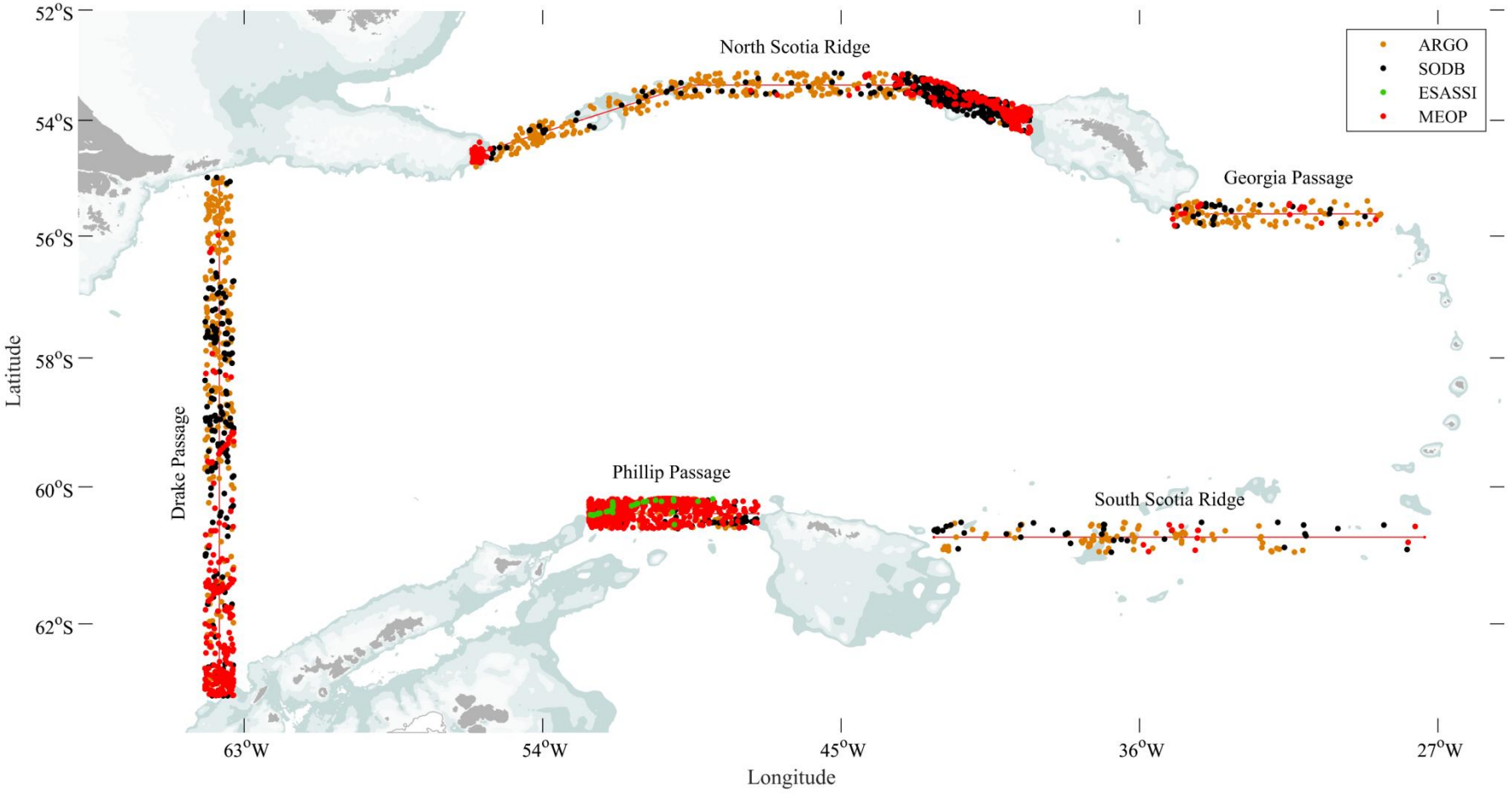


✓ In the upper 2000 m and for the 2002-2018 period, the mean absolute transports are 165 Sv along the Drake Passage, 53 Sv in the 54-54 Passage, 59 Sv in the Shag Rocks Passage, 5 Sv in Black Rocks Passage and is transported 55 Sv on Georgia. Drake, 54-54 and Georgia exhibit mainly a high barotropic behavior.



✓ Our analysis of the temporal variability displays substantial variability in the total and water-mass transports.

FUTURE WORK



- Apply an Inverse Model adding SODB, ESASSI cruise and MEOP to the Argo float data.

THANKS FOR YOUR ATTENTION!