Structure and transport of the North Atlantic Current in the eastern subpolar gyre from glider observations

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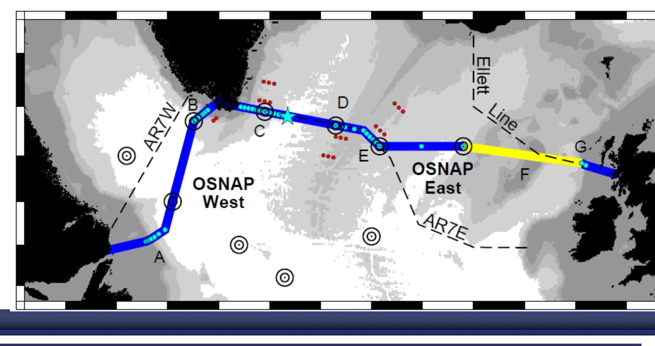
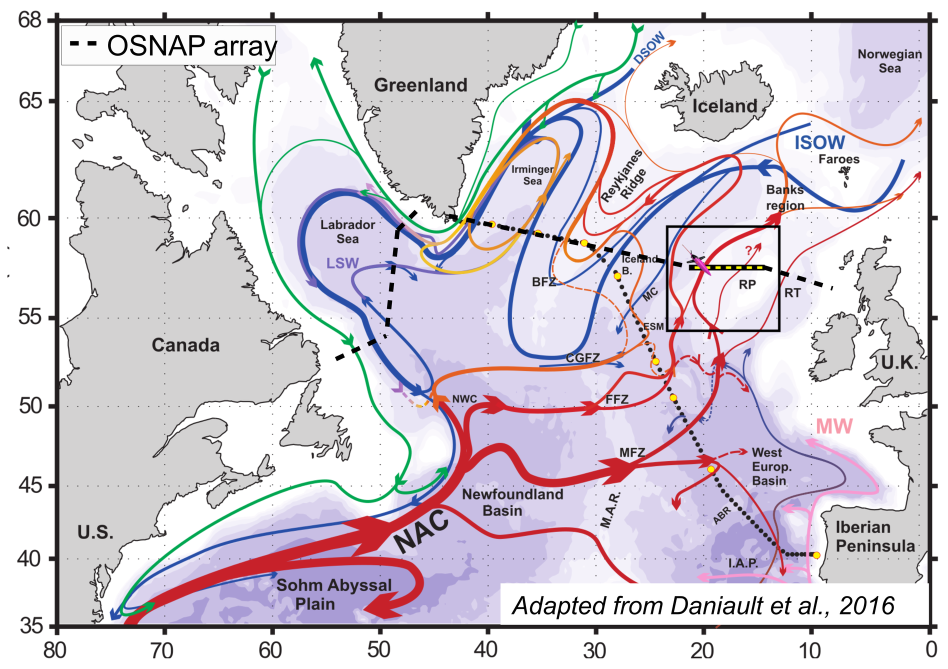


Key Points:

- Two branches of the North Atlantic Current (the Hatton Bank Jet and the Rockall Bank Jet) are revealed by repeated glider sections
- 6.3 Sv are carried out by the Hatton Bank Jet in summer
- The small scale current bands over the Rockall Plateau are not resolved by satellite altimetry.

1) Circulation and upper-ocean transport in the North Atlantic



The AMOC (northward flux of warm upper-ocean waters and compensating southward flux of cold deep waters) plays a fundamental role in the global climate system and its variability

About 60% (12.7Sv) of the upper-ocean water recirculates in the North Atlantic Subpolar Gyre (SPG). The other 40% (7.5/8.5 Sv) is carried poleward by the NAC between Greenland and Scotland.

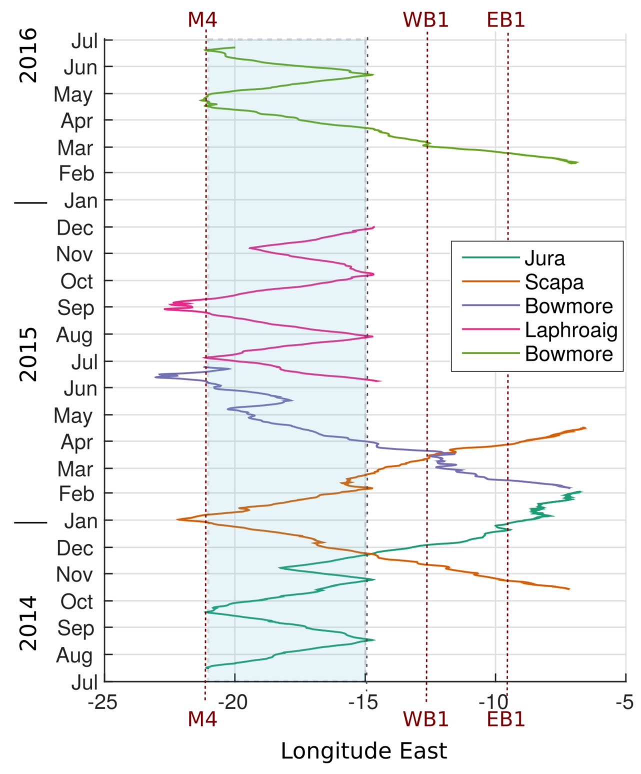
The Rockall Plateau (RP) is composed by the Hatton Bank (HB), the Hatton Rockall Basin (HRB) and the Rockall Bank (RB).

With typical depths of 200-1500m, the RP is unobserved by Argo floats. Station-spacing (30-50km) from past ship occupations is too large correctly resolve the mesoscale field over RP → **uncertainties on the circulation over RP**

2) UK-OSNAP glider programme

→ Permanent monthly occupation of RP from 2014 to 2018
→ Quantify the transport associated with the NAC over the RP

OSNAP main objectives:
i) continuous record of trans-basin mass, heat and freshwater fluxes in the SPG
ii) quantify the AMOC and its variabiliy (from seasonal to interannual)
iii) understand the link of the AMOC variability with deep water formation and wind forcing



3) Absolute geostrophic current from glider

Data quality control

Spikes removed, thermistor lag and thermal-inertia of the conductivity sensor corrections; comparison to climatological data ; manual QC

Absolute geostrophic current

Over each dive cycle, the depth-average current (DAC) can be deduced from the Seaglider dead reckoning navigation and GPS fixes at surface. Density sections and DAC time series are filtered with a gaussian moving average to filter out small-scale isopycnal oscillations (full width at half max. of 18.8km).

Absolute geostrophic velocities $v_n(z)$ are obtained by vertically integrating the thermal wind balance along the glider path, from the max. diving depth (*-H*) to the depth *z* :

$$\rho_0 f \frac{\partial v_n}{\partial z} = -g\frac{\partial \rho}{\partial s} \quad \xrightarrow{\int_{-H}^{z} \dots} \quad v_n(z) = v_n(-H) \underbrace{- \frac{g}{\rho_0 f}\int_{-H}^{z}\frac{\partial \rho}{\partial s}dz}_{v_{BC}(z)}$$

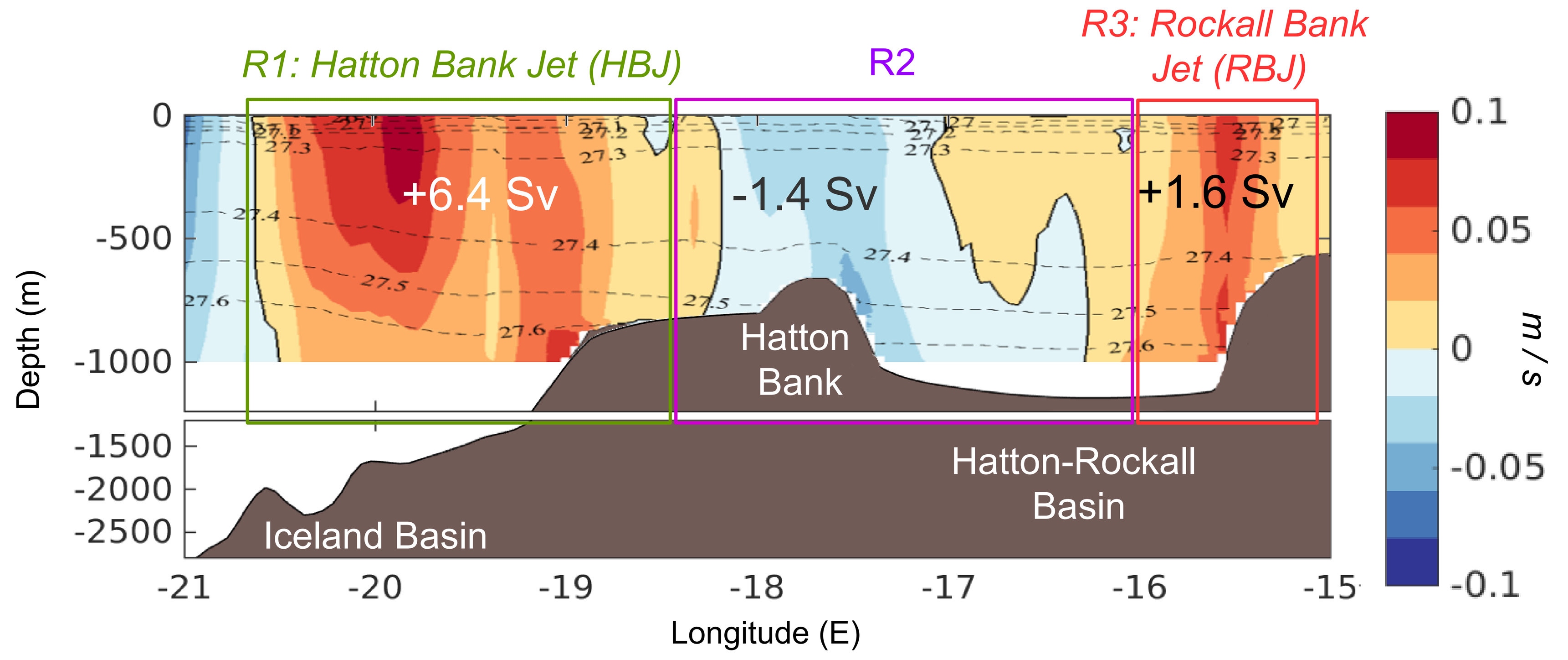
Reference velocity at the maximum diving depth $v_n(-H)$ is deduced from the DAC:

$$DAC = \bar{v}_n(z) = v_{-H} + \bar{v}_{BC}(z) \quad \rightarrow \quad v_{-H} = DAC - \bar{v}_{BC}(z)$$

Then, the along-path geostrophic velocity fields are projected onto a regular longitudinal grid along 58N .

4) Vertical structure of the NAC branches over Rockall Plateau

Mean absolute meridional geostrophic velocity



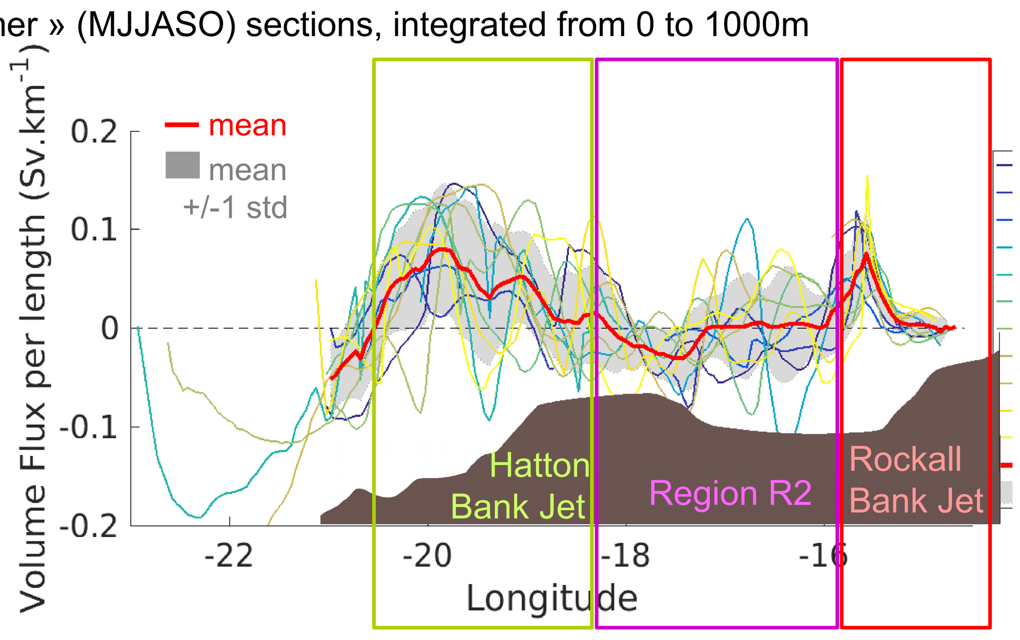
Mean flow seem separated into:
→ 2 semi-permanent northward flows: the Hatton Bank Jet (in R1) and the Rockall Bank Jet (in R3)
→ 1 southward flow in R2

Cores appear located on bathymetric features (steep slopes)
Standard deviation:
15W-19W: σ<8 cm/s, 19W-21W: σ<12 cm/s

5) Meridional absolute geostrophic transport

Absolute transport as a function of longitude

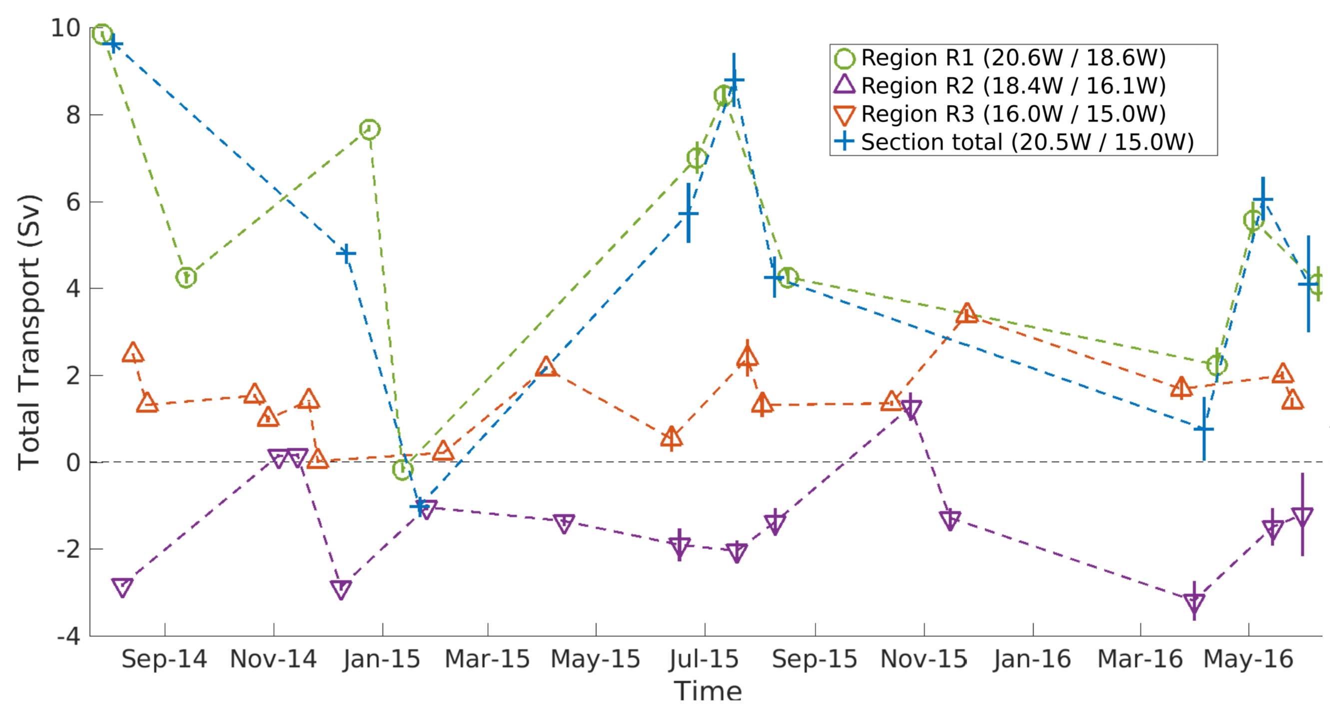
« Summer » (MJJASO) sections, integrated from 0 to 1000m



Two semi-permanent northward branches of the NAC: the Hatton Bank Jet and the Rockall Bank Jet

Not enough sections in NDJFMA (4) to distinguish a clear longitudinal structure

Total transport over the layer 0-1000m for each glider section



$$\phi_{abs} = \iint_{section} v_n(z)dxdz$$

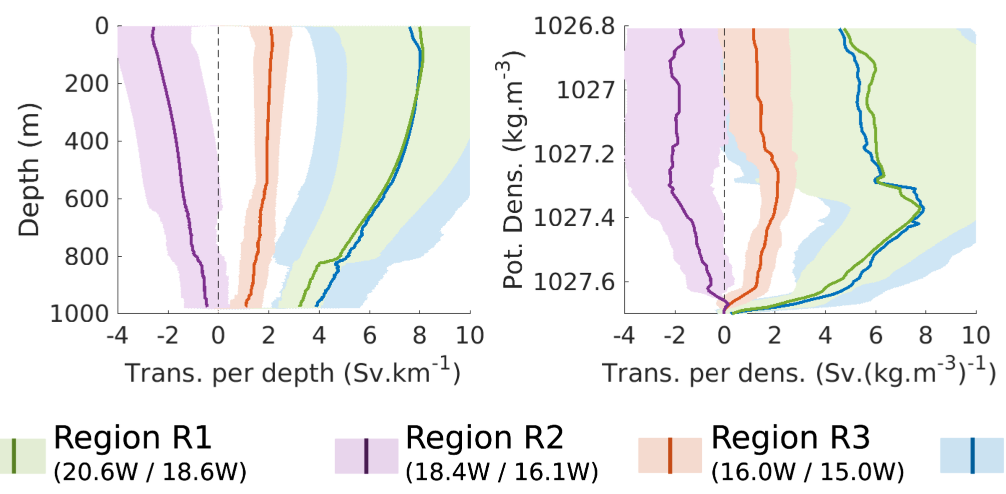
Mean and standard deviation:

Period	Area	μ	σ
Summer	Hatton Bank Jet	6.3	2.1
	Region R2	-1.1	1.4
	Rockall Bank Jet	1.5	0.7
	All	7.1	1.6

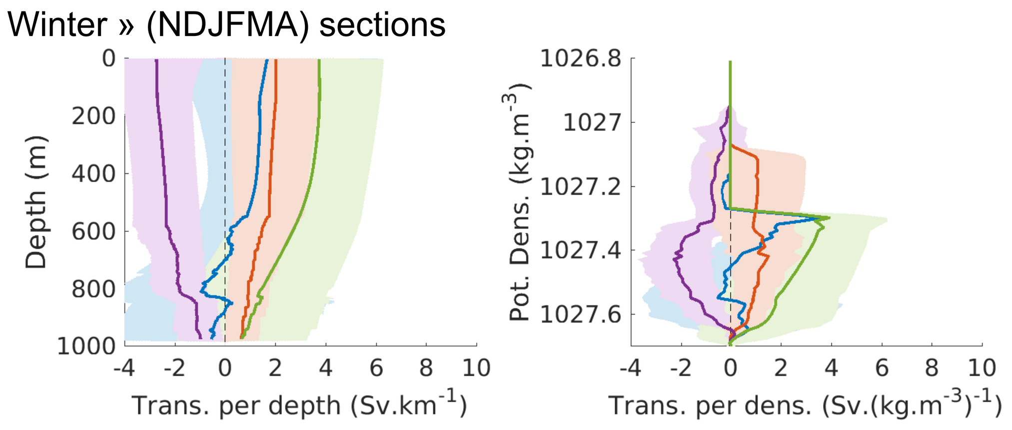
Mean uncertainties on the absolute transport is less than 0.5 Sv : Each glider section is described by an ensemble of 100 randomly perturbed sections (perturbations on the DAC and density field associated with the GPS accuracy, compass calibration and CT sensors drift). Φ_{abs} = mean of the 100 ensemble members; uncertainty on Φ_{abs} = 1 std

Transport per depth and per density class (mean and std)

« Summer » (MJJASO) sections



« Winter » (NDJFMA) sections



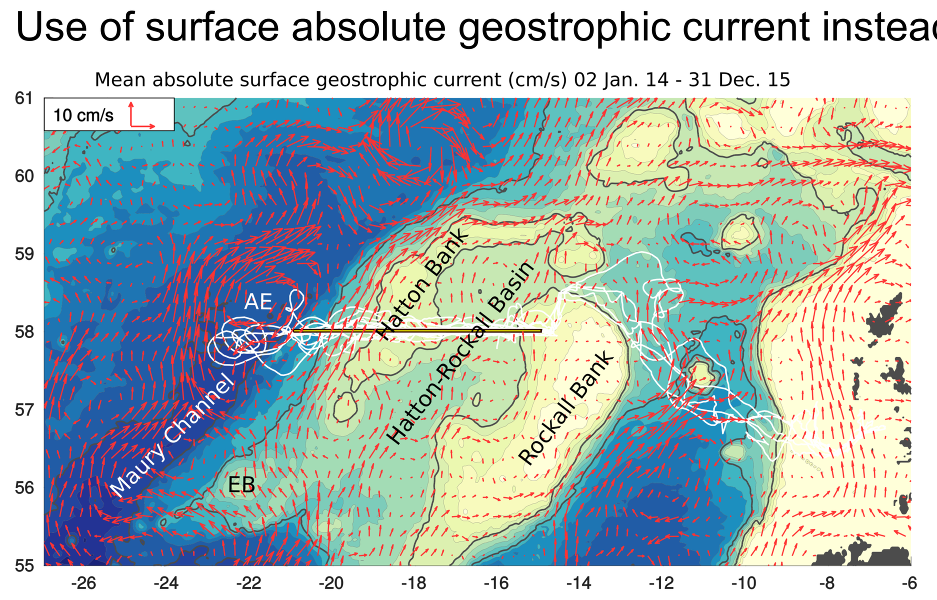
- Transport over R2 approx. equal to R3
- Mean transport is maximum for 27.3-27.4 kg.m^{-3} -> mode water (SPMW)
- 2.5Sv decrease of the transport by the Hatton Bank Jet (R1) in winter
- In winter, less transport for ρ <27.3 kg.m^{-3} -> SPMW formation

Conclusion

- Gliders used to estimate absolute geostrophic transport associated over the Rockall Plateau
- 2 semi-permanent northward flowing branches of the North Atlantic Current are found: **the Hatton Bank Jet** (6.3 ± 2.1 Sv) and **the Rockall Bank Jet** (1.5 ± 0.7 Sv); a southward flow of 1.1 ± 1.4 Sv can be observed along the western flank of the Hatton-Rockall Basin
- Theses branches appear bathymetrically steered
- Altimetry is unable to resolve the small mesoscale current bands in the Hatton-Rockall Basin

6) Comparison with altimetry-based estimates

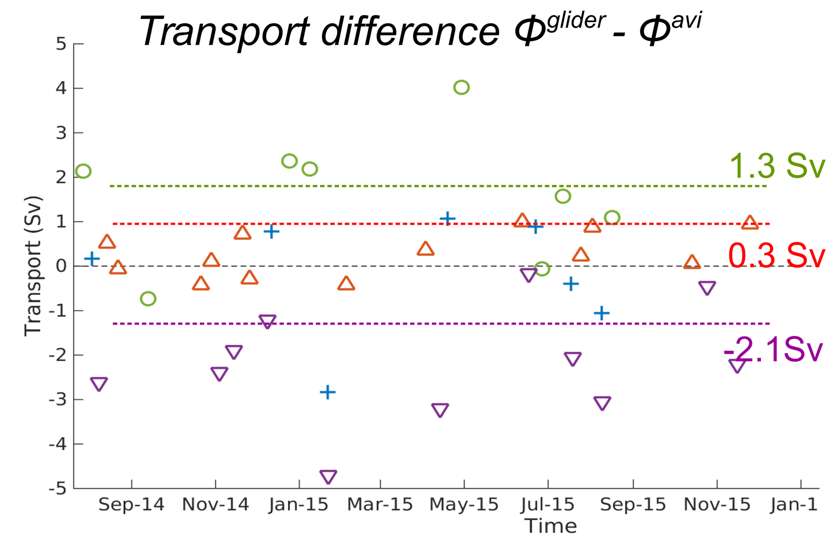
Use of surface absolute geostrophic current instead of glider DAC



$$v_n^{avi}(z) = \underbrace{V_{surf}^{avi}} + \frac{g}{\rho_0 f}\int_{z}^{0}\frac{\partial \rho}{\partial s}dz$$

from AVISO interpolated on glider track

Transport difference $\Phi^{glider} - \Phi^{avi}$



"Systematic biases" don't depend on the glider mission or orientation of glider section (east/west)
→ altimeter constellation sampling capability & mapping methodology

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