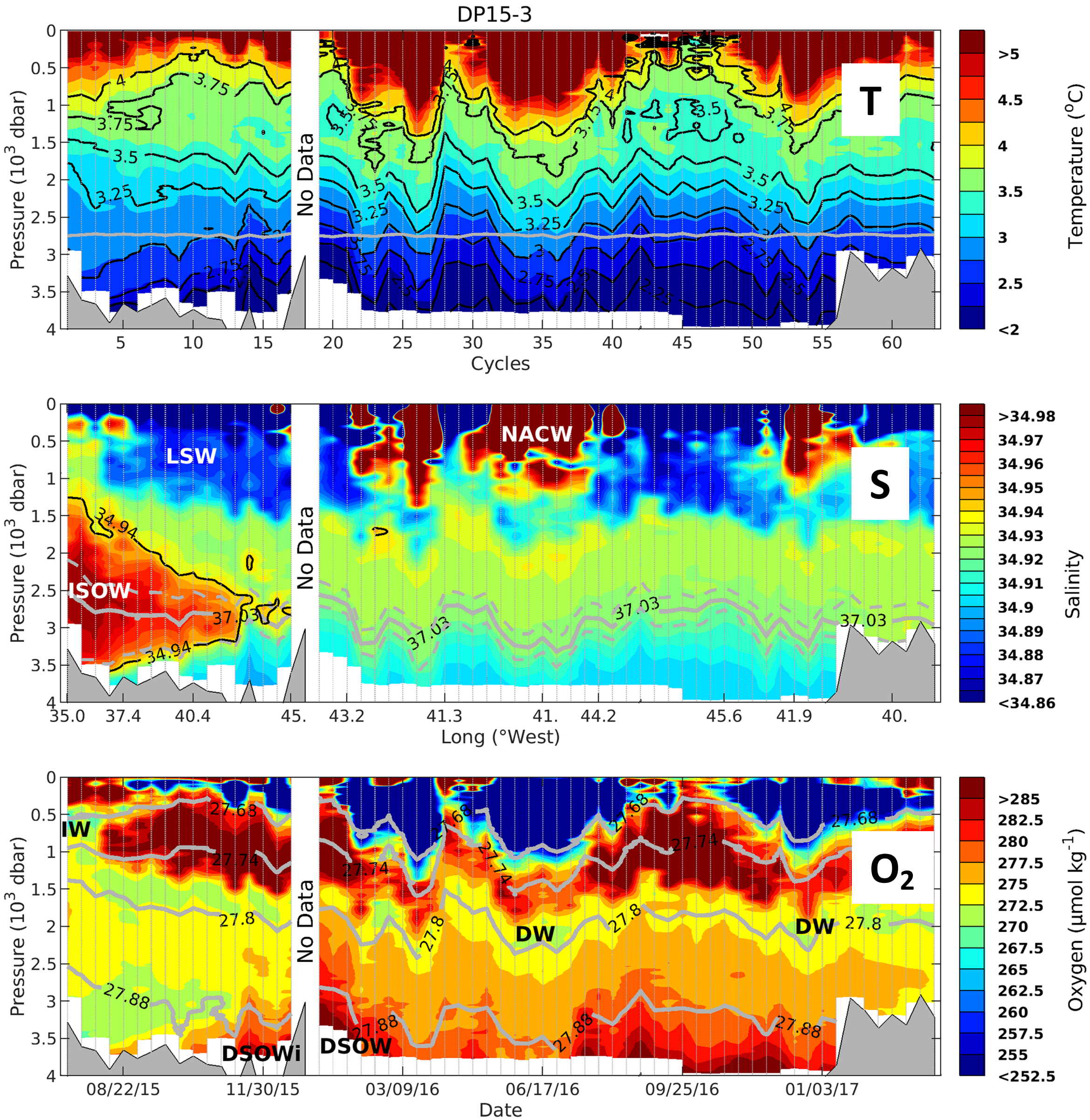
Deep-Arvor floats Science aspects

V. Thierry, LOPS, Coriolis Deployment, RDT, NKE teams

Ifremer, France

Deep-Arvor float

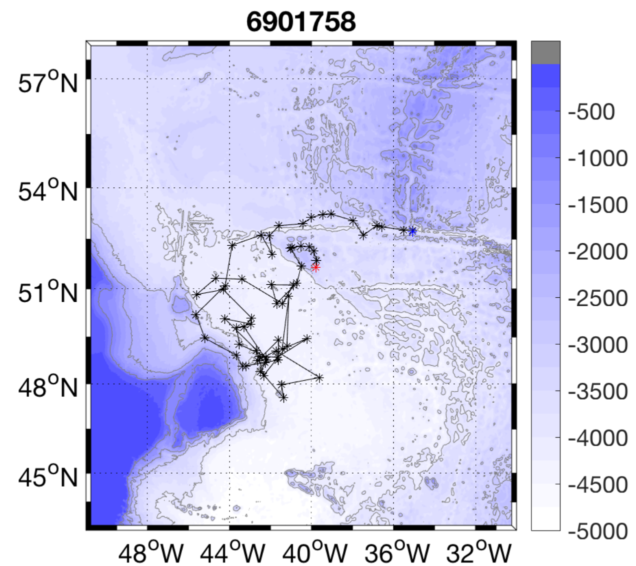


4000 dbar Deep-Argo floats

T, S, O_2 parameters

Grounding procedure management

More details in Xavier's presentaion



Objectives of the Deep Argo program

Operational application:

•Improve global ocean reanalysis and coupled ocean-atmosphere forecasting systems below 2000m

Climate change:

•Improvement of global heat and freshwater budget

•Improvement of regional sea level budget and quantification of the causes of sea level changes

•Track planetary energy budget in real time

Other research topics

•Quantify mean state and variability of deep ocean circulation

•Investigate relationship between circulation and topography

•Deep mixing and convection

•….

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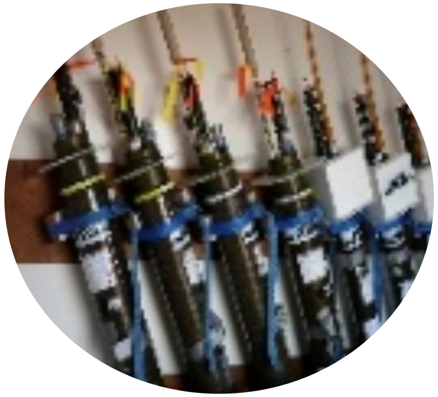


ISOW spreading and mixing from the Charlie Gibbs Fracture Zone as revealed by Deep-Arvor floats

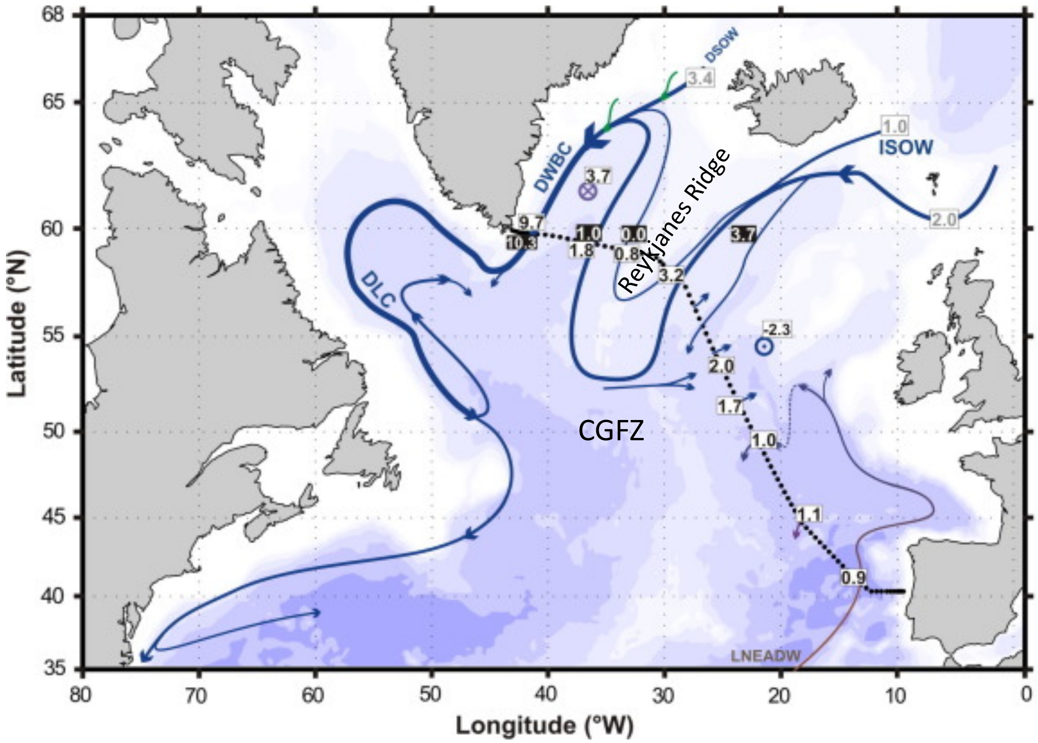
(Racapé et al., JGR, 2019)

Virginie Racapé, Virginie Thierry, Herlé Mercier, Cécile Cabanes, Cathy Lagadec, Guillaume Maze, Damien Desbruyères

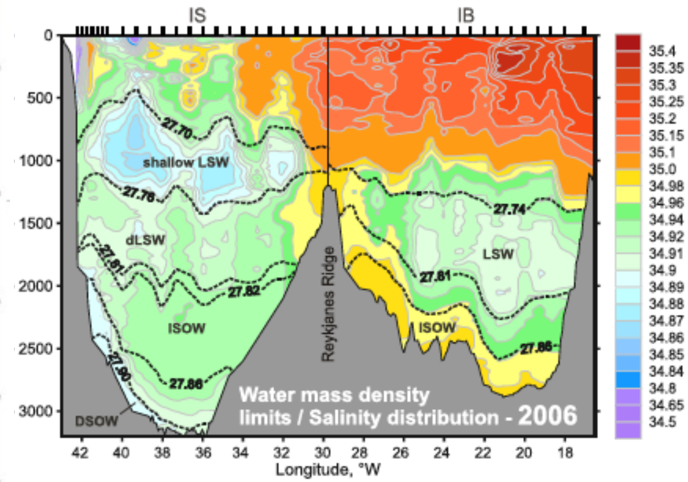
Laboratoire d'Océanographie Physique et Spatiale, Plouzané - France

The Iceland Scotland Overflow Water (ISOW)

Deep Circulation ($\sigma_0 > 27.80$)

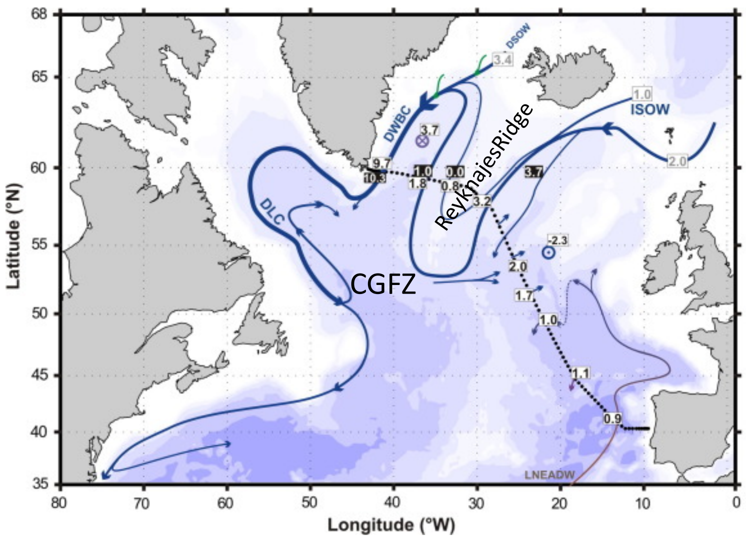


Salinity along 60°N

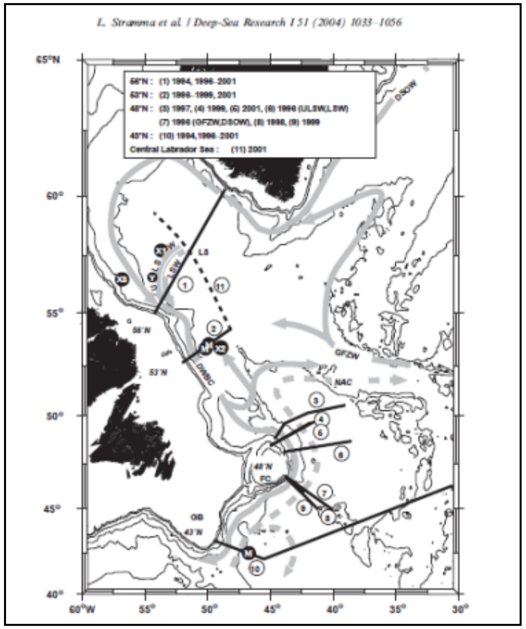


Daniault et al., 2016

Large uncertainties on ISOW pathway

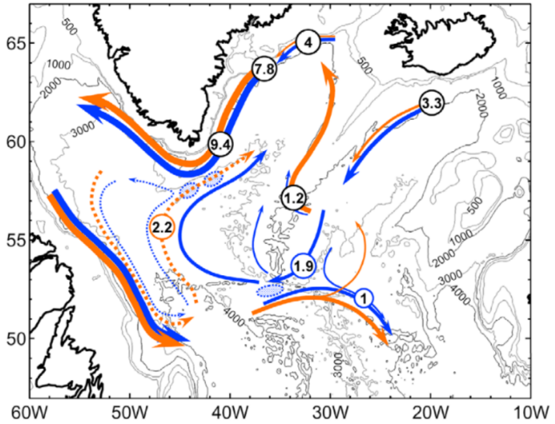


Daniault et al., 2016.
$\sigma_0 > 27.80$



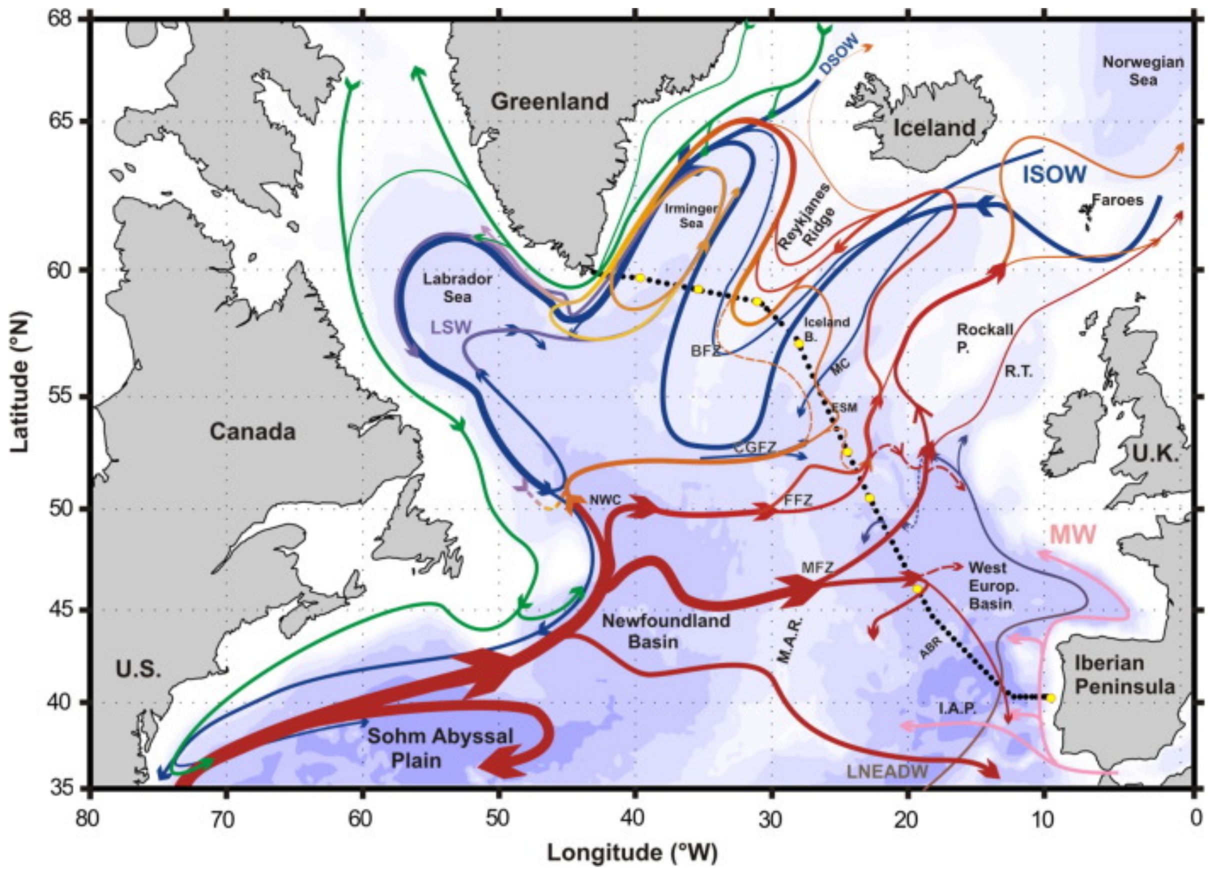
Stramma et al., 2004

Xu et al., 2010
orange: $27.80 < \sigma_0 < 27.85$
blue $\sigma_0 > 27.85$



Better understanding of ISOW pathways are necessary as ISOW contributes to the storage and transport of climate anomalies into the ocean interior

Surface/deep circulation interactions



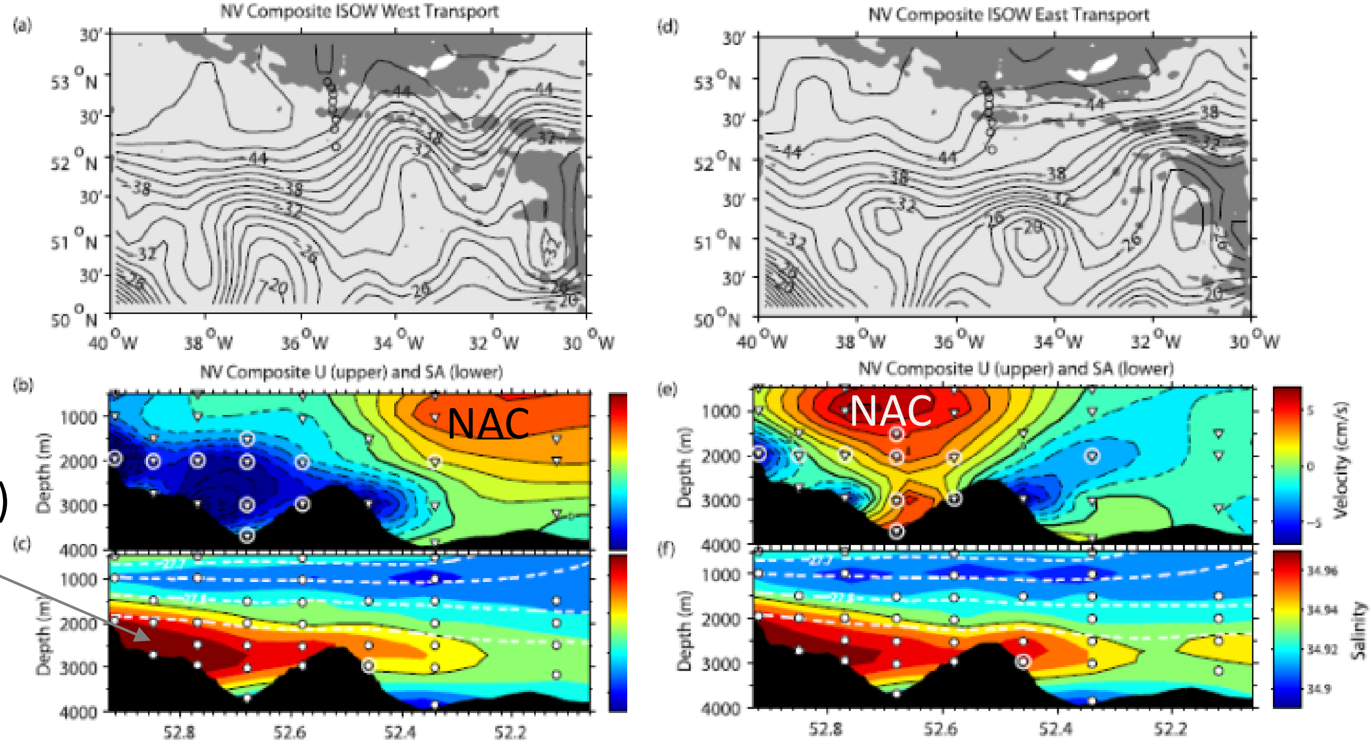
[Daniault et al, 2016]

Surface/deep circulation interactions

Strong variability of ISOW transport throughout the CGFZ due to the NAC meandering
[e.g. Saunders, 1994; Schott et al., 1999]

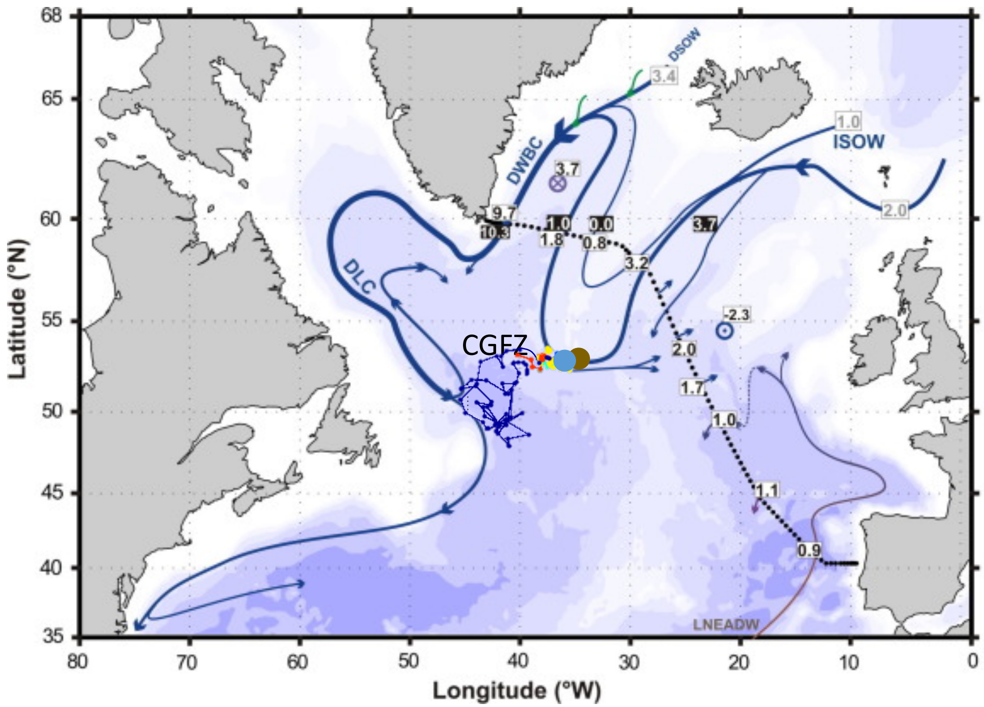
[Bower and Furey, 2017]

ISOW
(S > 34.94
below σ_0 = 27.80)



<u>Hypothesis</u> : the westward deep flow is blocked by the NAC when its eastward surface velocity exceeds 15 cm s^{-1} [Bower and Von Appen, 2008]

Deployment of Deep-Arvor floats in the ISOW layer at the CGFZ

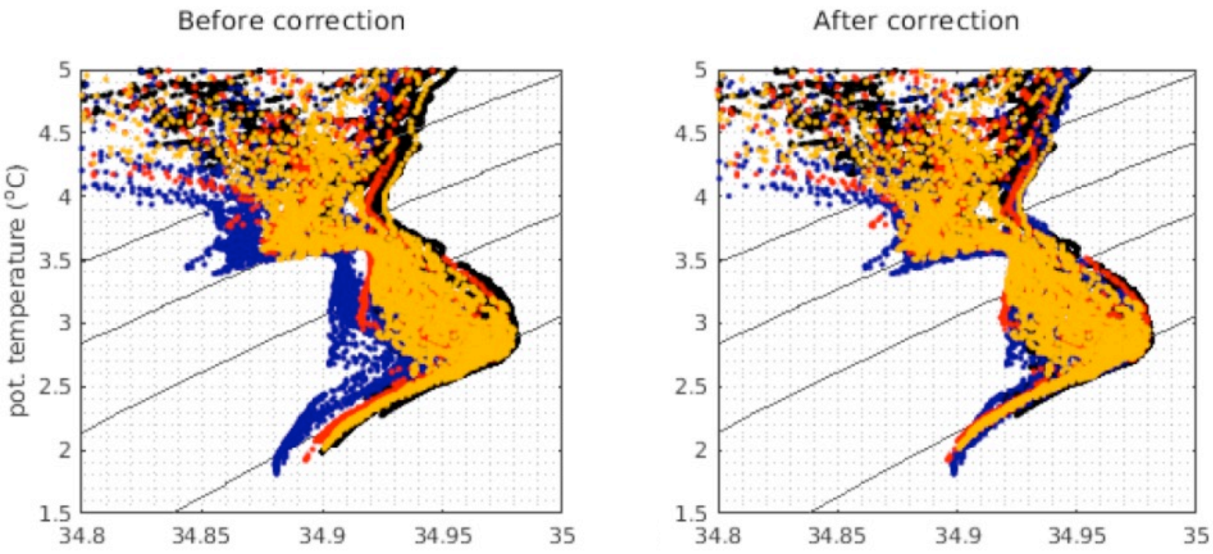


Daniault et al., 2016. Deep circulation (σ_0> 27.80)

Simultaneous deployments
Parking depth : 2750 dbar
Sensors : T, S, O_2

- 3 in July 2015 (RREX15)
- 2 in Aug. 2017 (RREX17)

Deep-Argo data set : **Fresh bias correction**



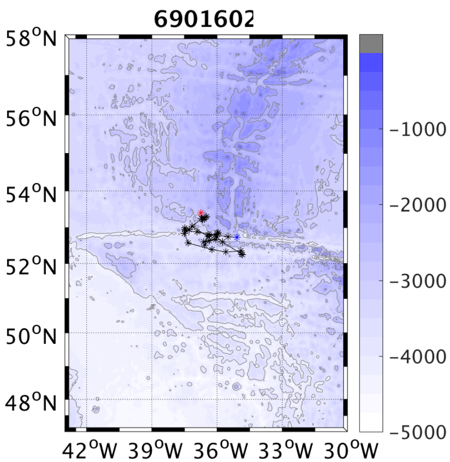
- Correction based on Owens and Wong [2009] modified by Cabanes et al. [2016]
- Validation by comparison to a calibrated ship-based CTD profile

0.017±0.008 (cy. 1 to 18) / -0.007 yr^{-1} (cy. 19 to 63)

0.004±0.013

0.000±0.010

Deep-Argo data set : **Oxygen correction**

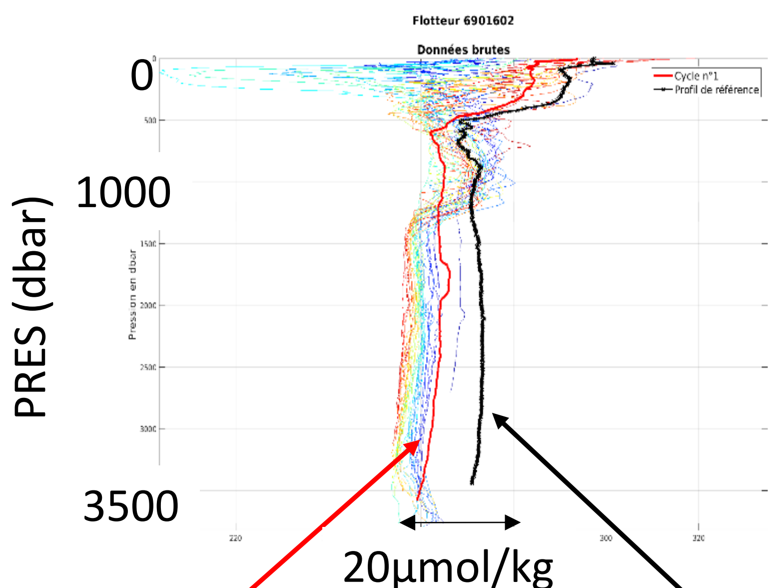


Exemple for float 6901602

After correction following Takeshita et al. 2013:

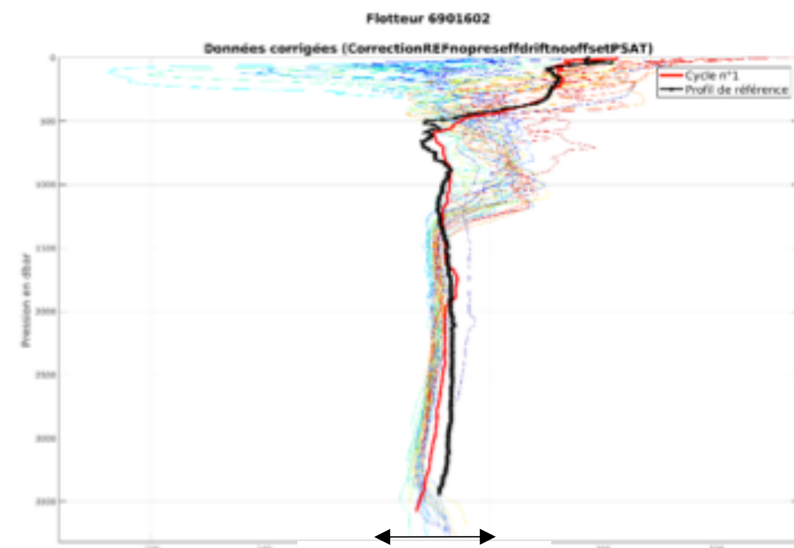
- Time drift
- PSAT_adjusted=a*PSAT

Before correction



Argo profile to be compared to the reference profile

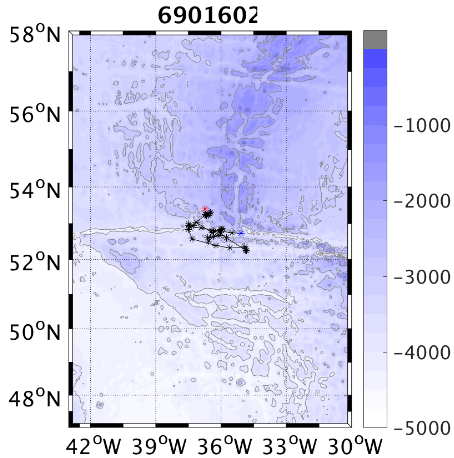
Reference profile



20µmol/kg

After correction

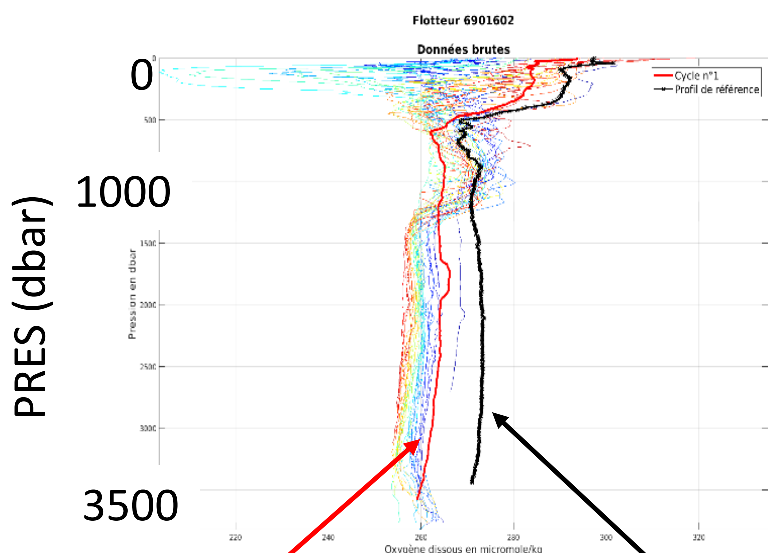
Deep-Argo data set : **Oxygen correction**



Exemple for float 6901602

After correction following Takeshita et al. 2013:
- A pressure effect remains
- Although pressure correction proposed by Bittig et al, 2015 taken into account

Before correction

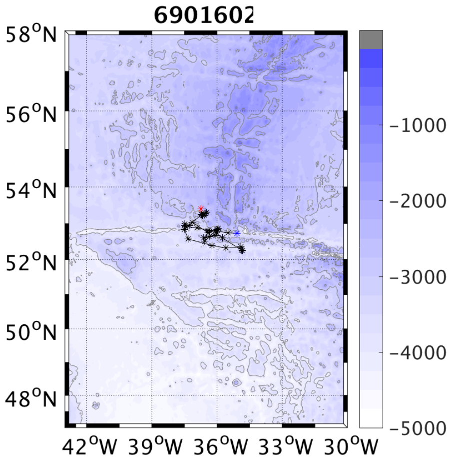


Argo profile to be compared to the refrence profile

Reference profile

After correction

Deep-Argo data set : **Oxygen correction**



Exemple for float 6901602

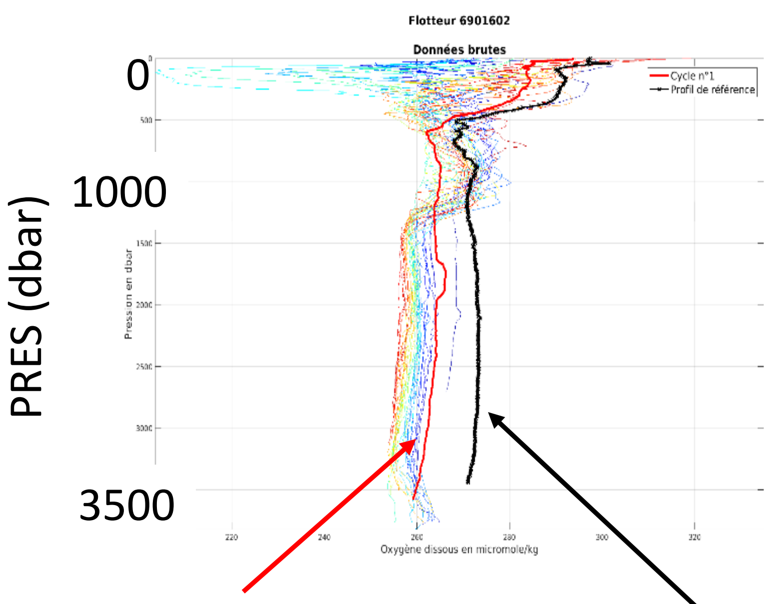
We applied an additional pressure correction on the raw data

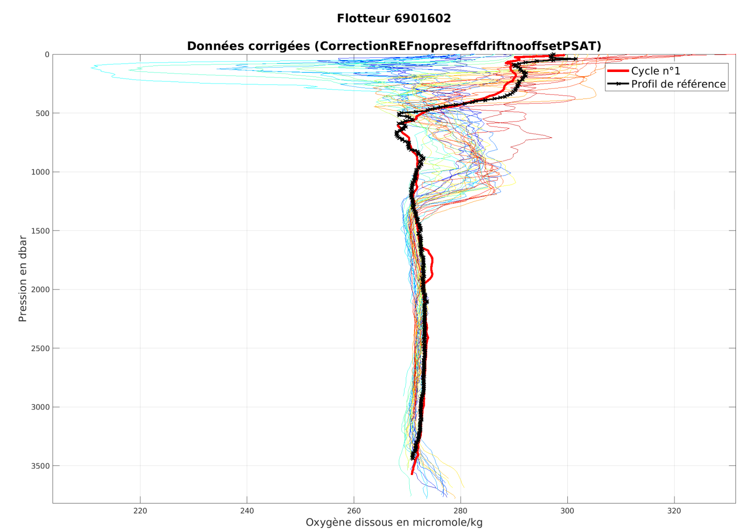
DOXY_corr=DOXY*(1+0.007*PRES/1000)

Time drift

PSAT_adjusted=a*PSAT

Before correction



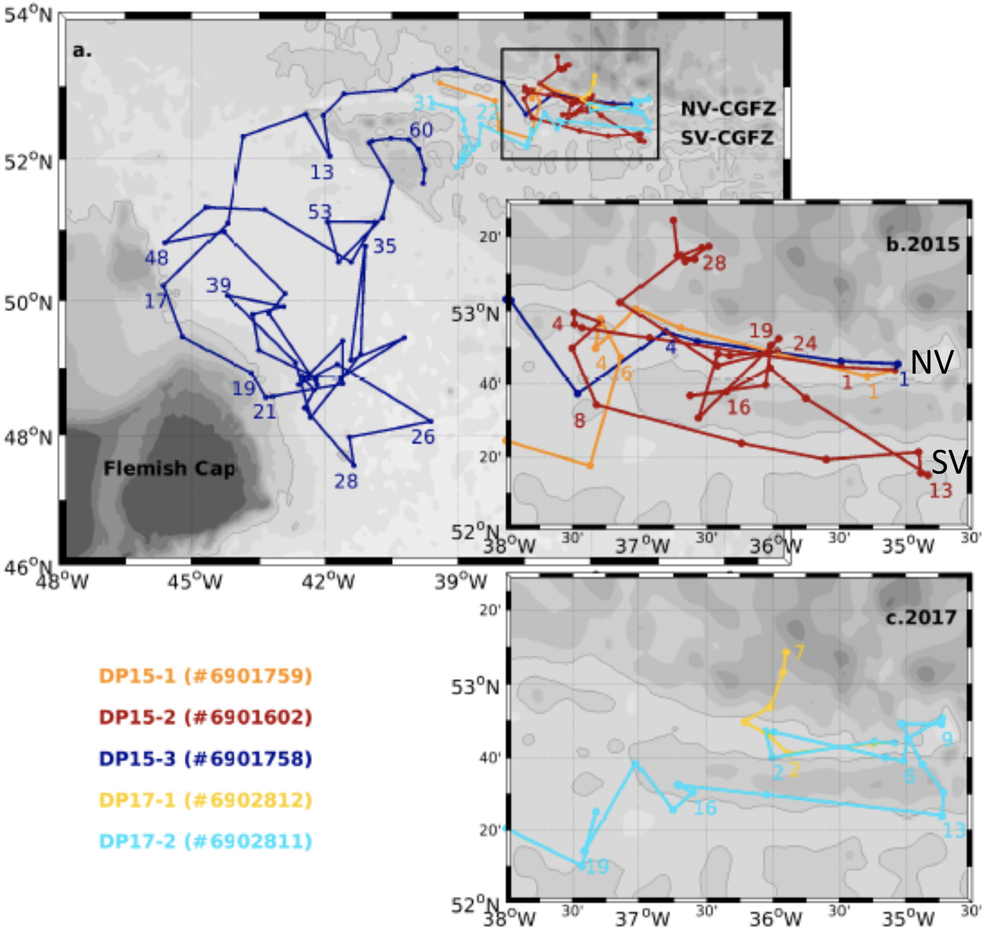


Argo profile to be compared to the refrence profile

Reference profile

After correction

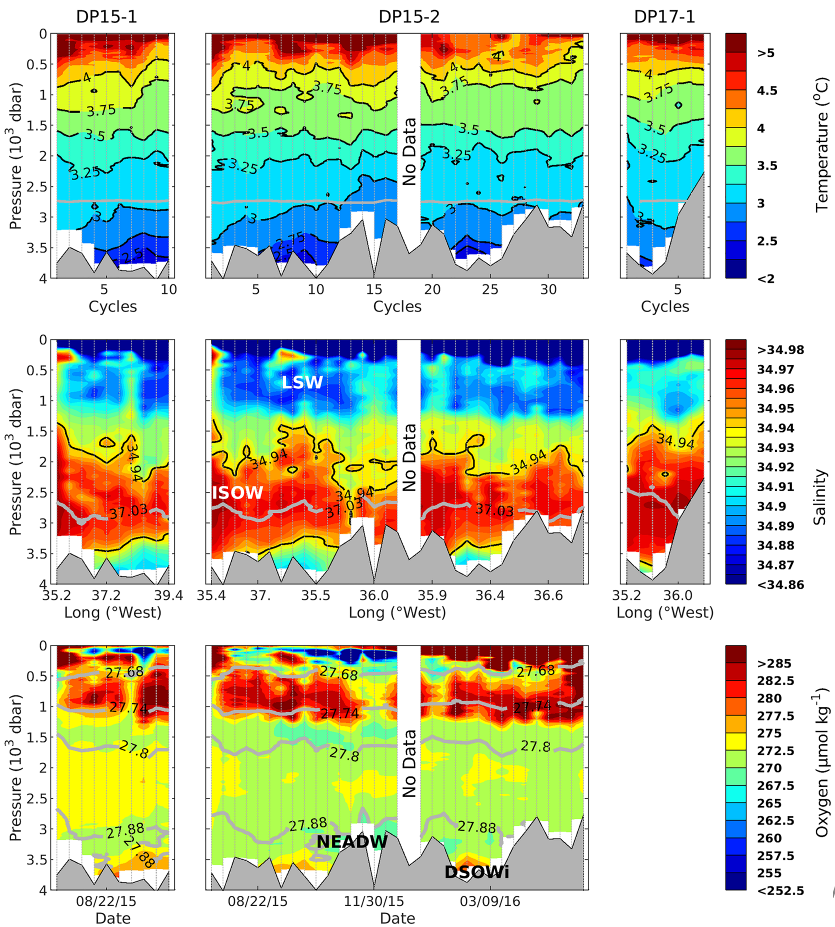
Floats trajectories

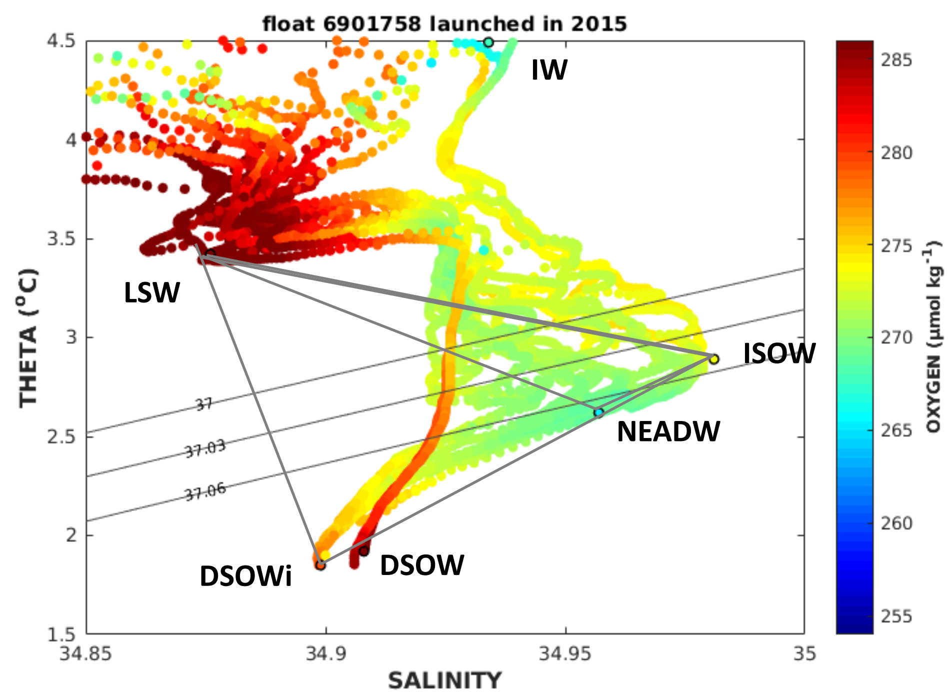


- As expected, all floats initially moved westward in the northern valley (NV) of the CGFZ.
- The floats generally moved westward during they stay in the CGFZ
- Pathway perturbed between 36°W and 38°W,
  - either they continued westward,
  - or northward,
  - or they recirculated (NV or SV)
- Only one float (dark blue) moved beyond the CGFZ toward the Newfoundland Basin
- All floats followed the 3500 isobath

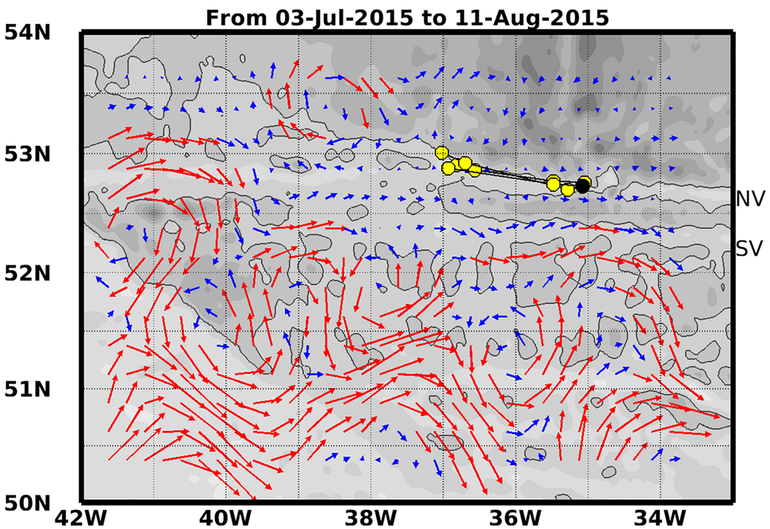
Optimum Multi-Parameter Analysis [Tomczak, 1981]

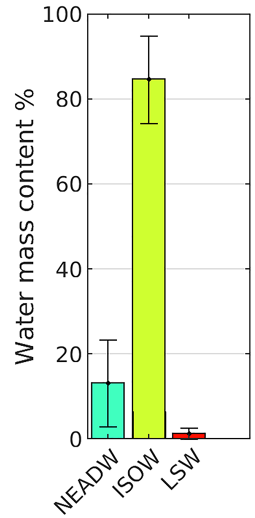
- identify the water masses (LWT) that mix together, and their fraction, to explain θ, S and O_2 measured at the ISOW layer
- LWT = Local Water Type → defined from Deep-Argo data set
- 3 parameters (θ, S, O_2) → 3 LWTs maximum → 4 equations



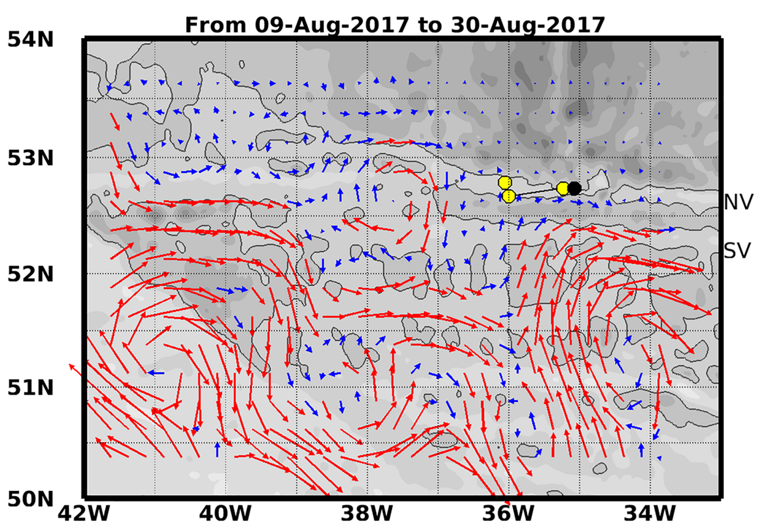


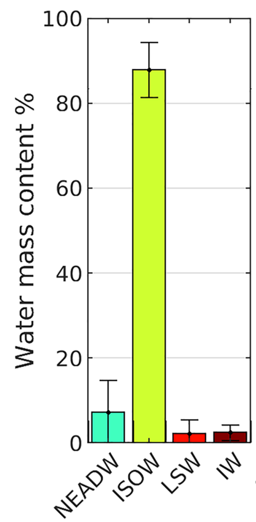
Result 1 : Composition of deep flow in the CGFZ = OMP results on σ2 = 37.03 kg/m3





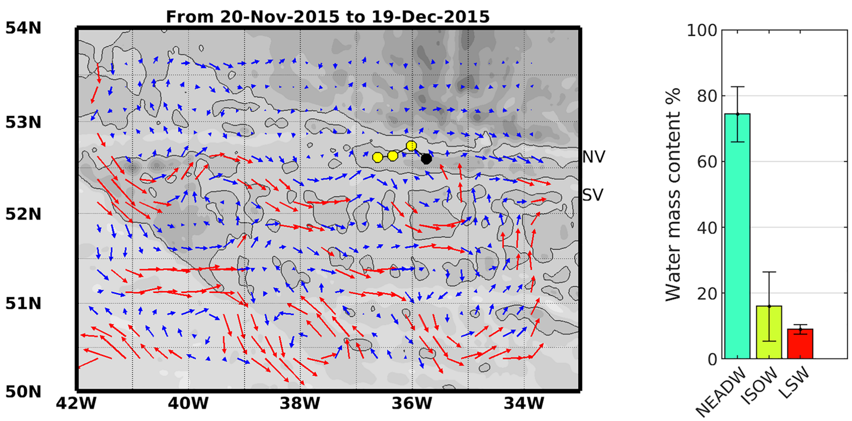
The expected case: ISOW is the main contributing water mass

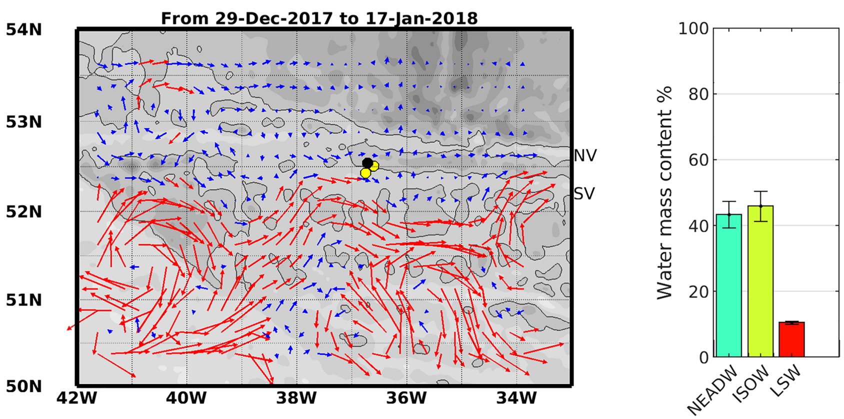


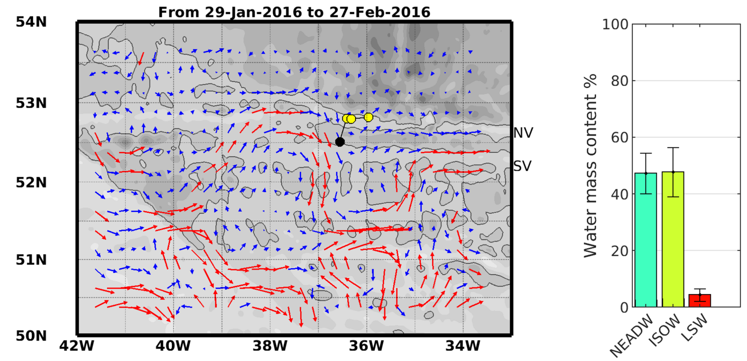


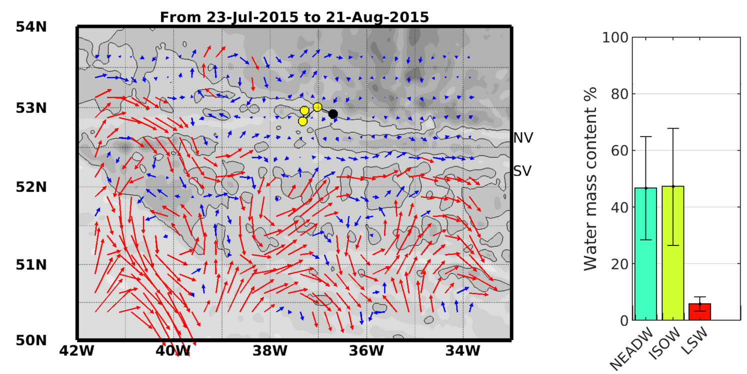
Red arrows = NAC with eastward surface velocity > 15 cm s^{-1}

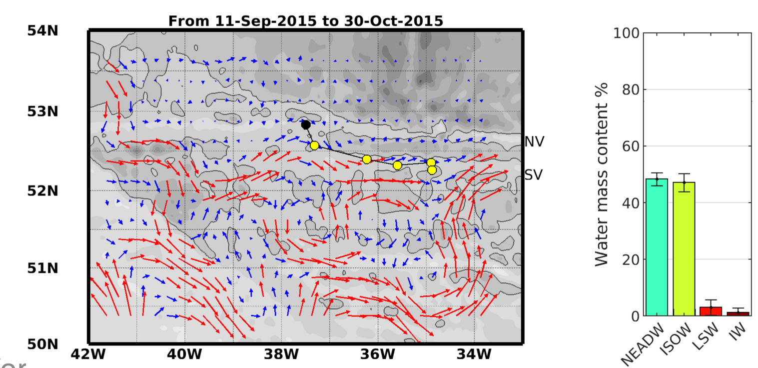
Result 1 : Composition of deep flow in the CGFZ = OMP results on σ2 = 37.03 kg/m3









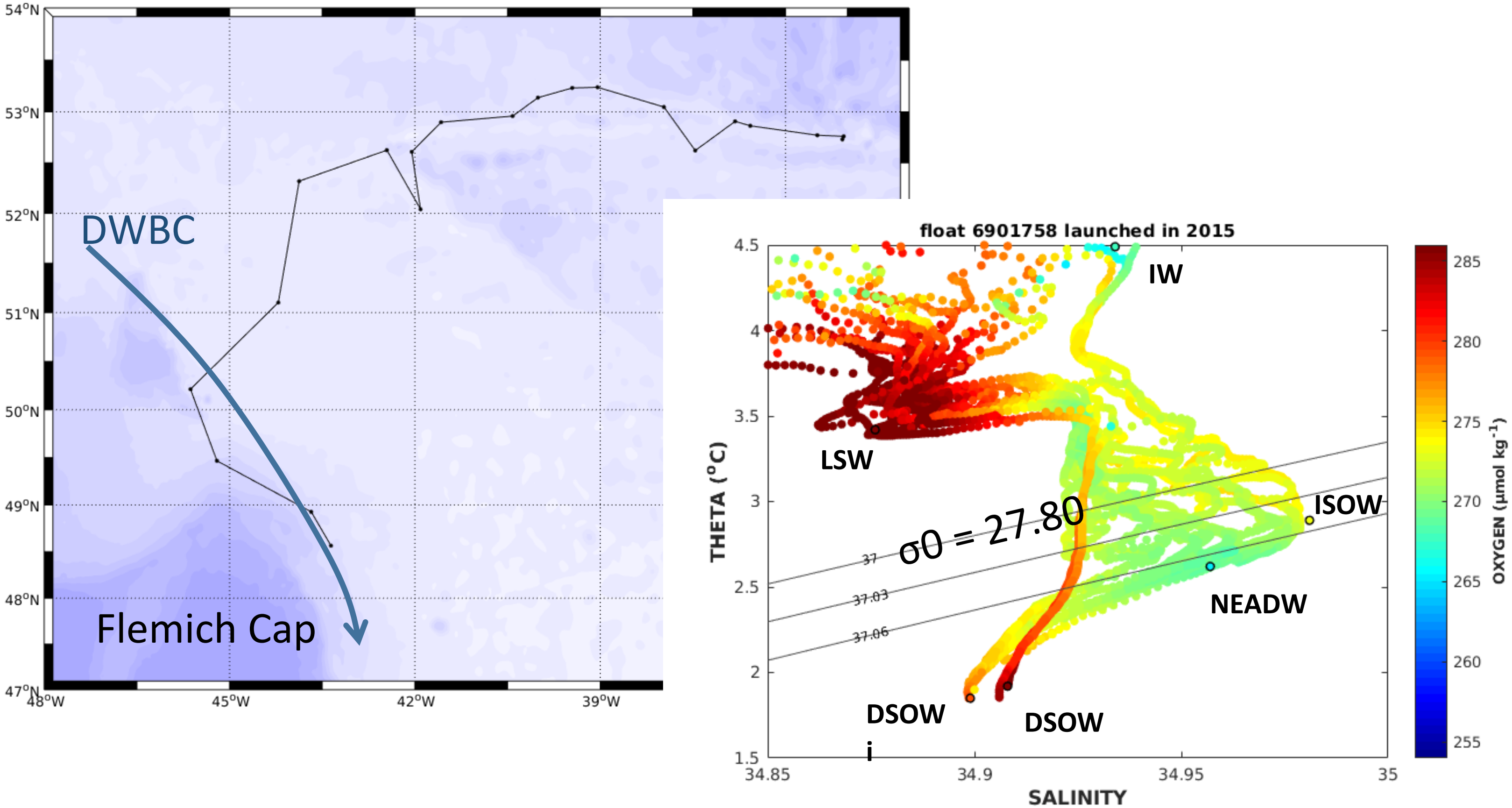


Range of various other configuration with larger contribution of NEADW.

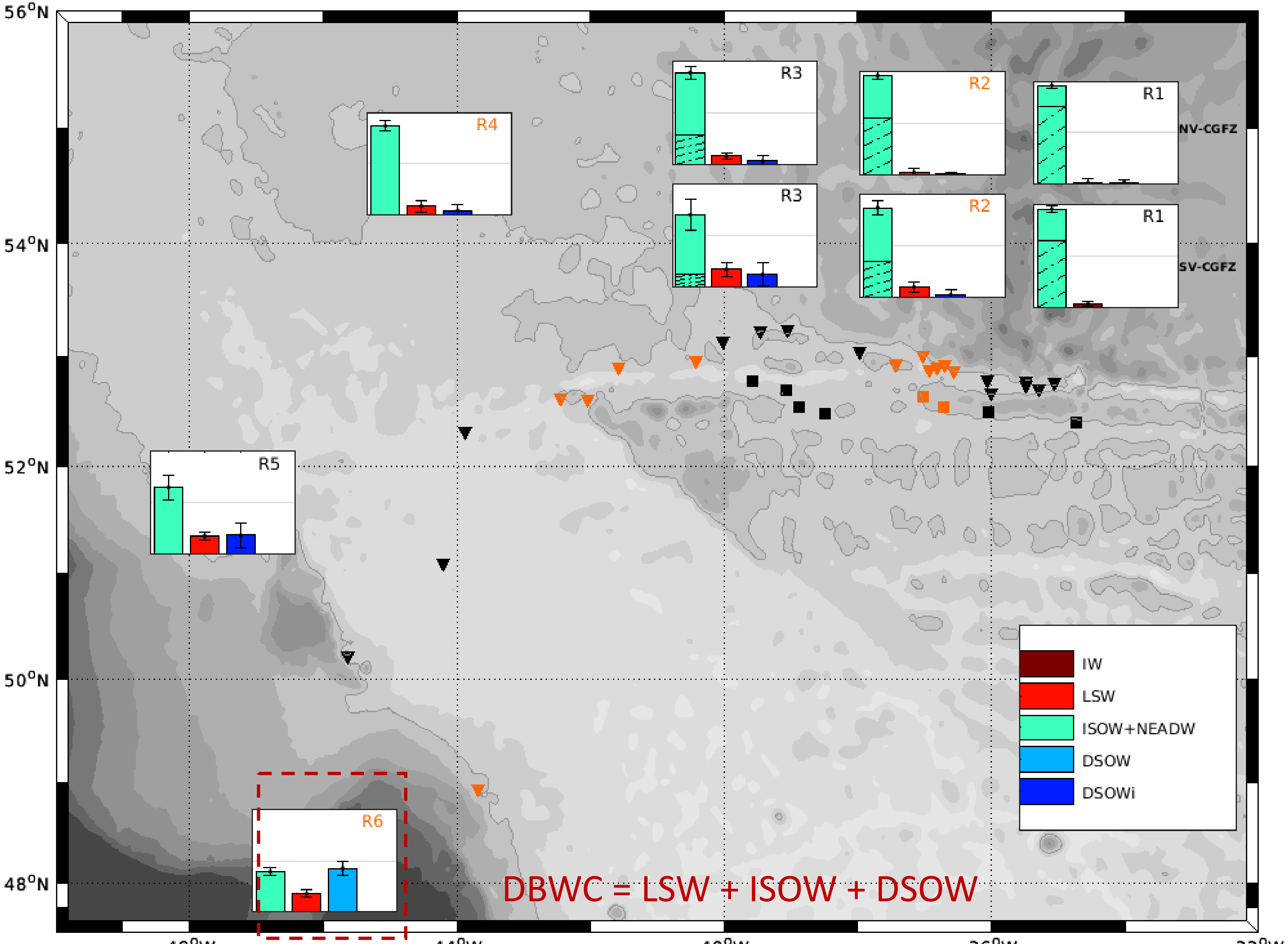
Result 2 : Westward deep flow from the CGFZ

ISOW at CGFZ : S > 34.94 below σ0 = 27.80 kg/m³ [Saunders, 1996]

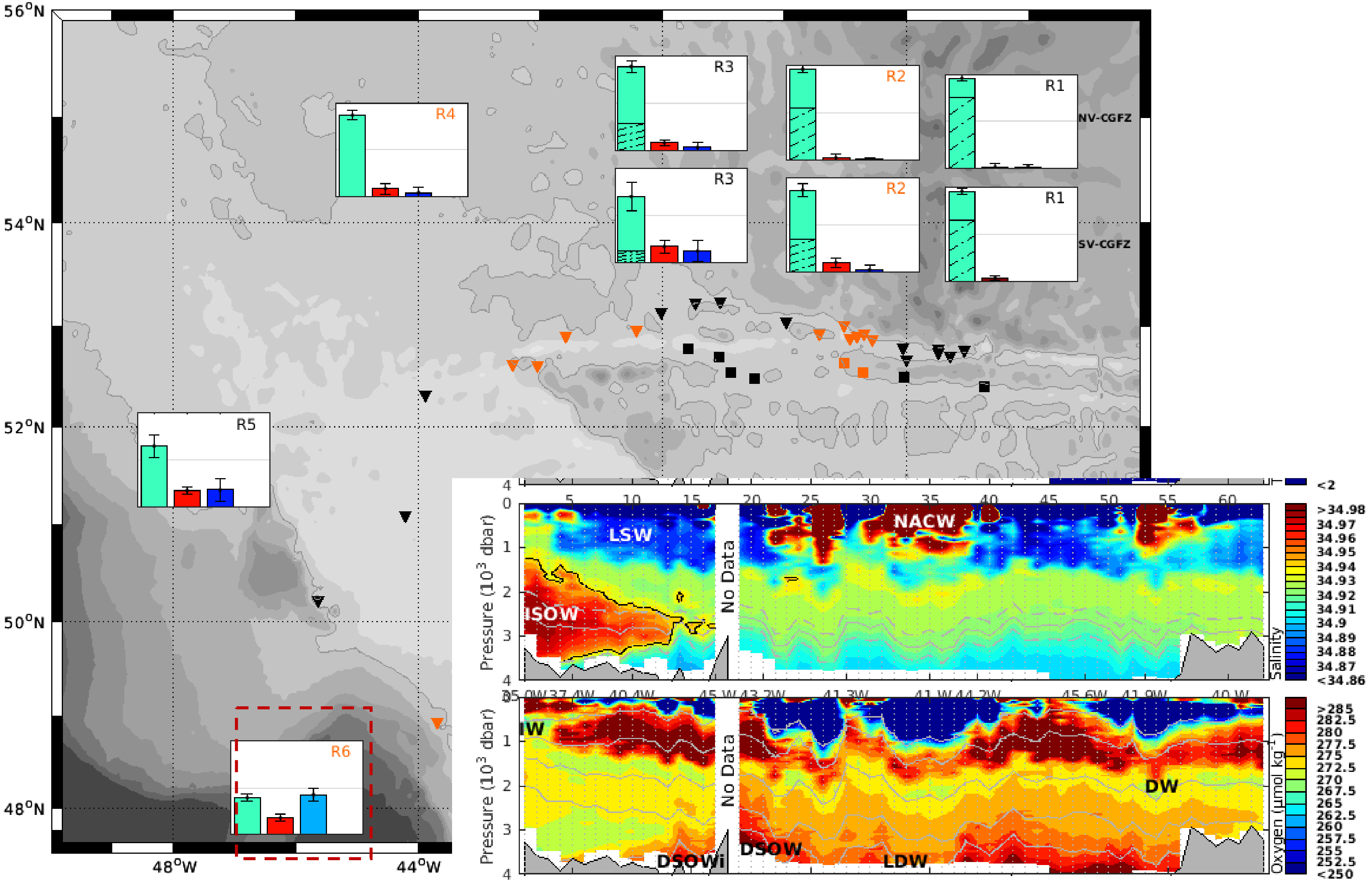
→ In this study, this definition corresponds at two LWTs : ISOW and NEADW



Result 2 : Westward deep flow from the CGFZ



Result 2 : Westward deep flow from the CGFZ



Conclusions

- The five Deep-Argo floats drifted in the ISOW layer and generally moved westward in the CGFZ.
- Northward pathway and recirculation were observed due to NAC interactions with westward deep flow in the ISOW layer.
- One deep-Argo float revealed a direct route for ISOW from the Charlie Gibbs Fracture Zone to the Deep Western Boundary Current
- The two main water masses that contributed to the θ-S-O2 properties on the 37.03 $\sigma 2$ isopycnal in the CGFZ were ISOW and NEADW. The third contributing water mass was LSW (less than 10%). ISOW was prevailing (more than 85%) iin the northern valley of CGFZ when the NAC was south of this valley. ISOW is more diluted by NEADW in the southern valley of CGFZ than in the northern valley and when the NAC moves north
- Mixing between ISOW, NEADW, LSW and DSOW is observed in the western basin
- Biogeochemical sensors are essential to better identify water masses and understand mechanisms involved.