PIRATA et SNO PIRATA : évolution des observations en Atlantique Tropical Est et perspectives

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- [2] *IRD/IMAGO, Brest, France*
- [3] *UFPE/LOFEC, Recife, Brazil*
- [4] *Météo-France/CNRM, Toulouse, France*
- [5] *IRD/LOCEAN, Paris, France*

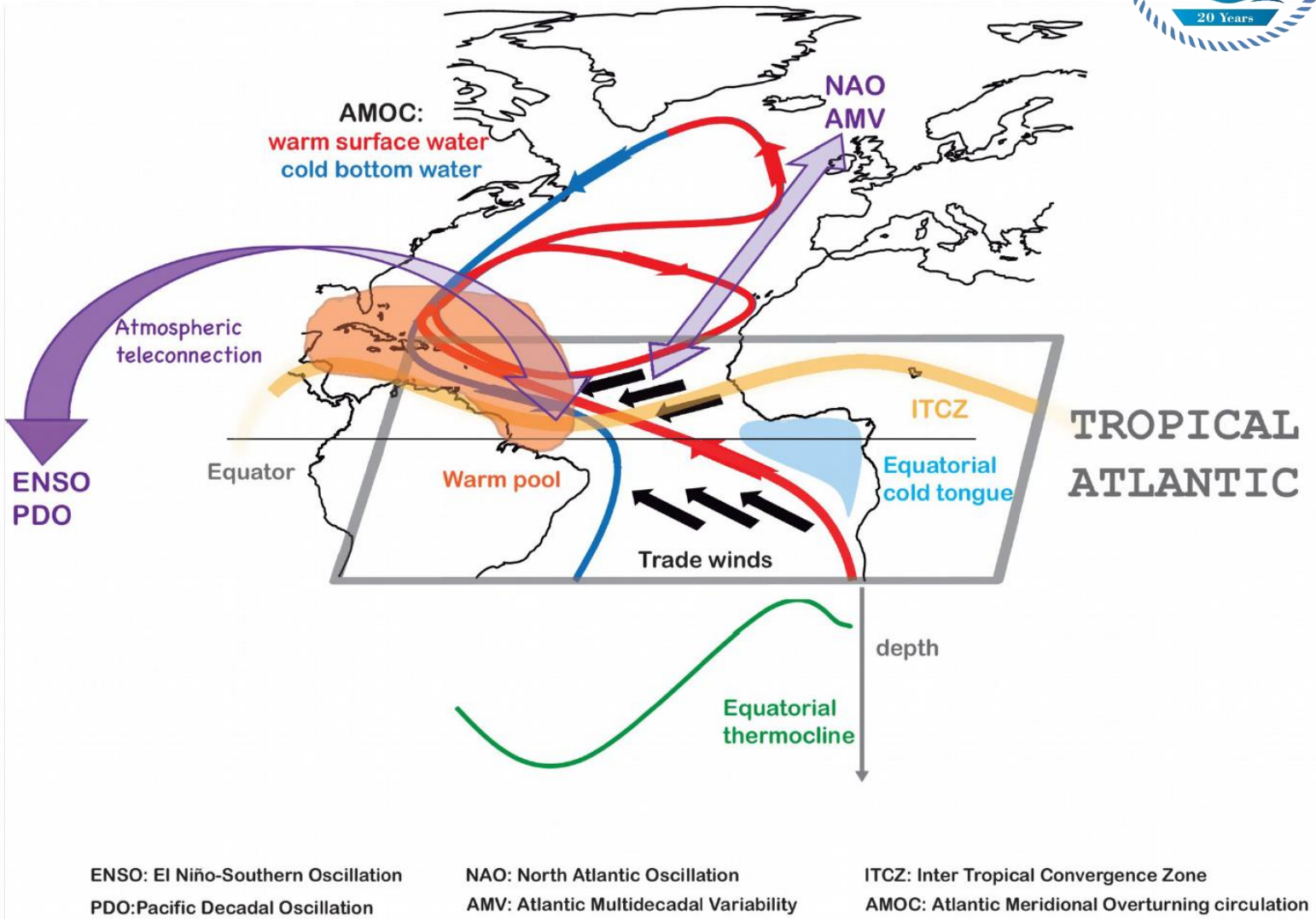
GMMC 2019, Toulon, France, 12-14 juin 2019

PIRATA in the Tropical Atlantic : why ?

Science & societal drivers:

- Rainfall
- Tropical cyclones
- Biogeochemistry, carbon, OMZ
- Ecosystems and pollution

→ Environmental and societal impacts in Northeastern Brazil



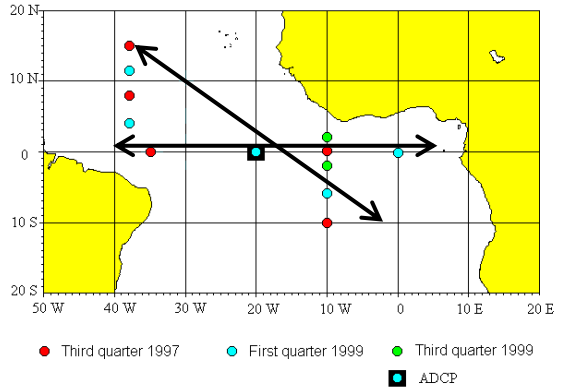
ENSO: El Niño-Southern Oscillation
PDO:Pacific Decadal Oscillation
NAO: North Atlantic Oscillation
AMV: Atlantic Multidecadal Variability
ITCZ: Inter Tropical Convergence Zone
AMOC: Atlantic Meridional Overturning circulation

Foltz et al., 2019

PIRATA in the Tropical Atlantic : why ?

→ **Fundamental scientific issues**

→ **Societal needs for improved prediction of the climatic variability and its impact on the regional hydroclimates**



PIRATA network as drawn initially

Main objectives :

1- Improve the description of the intra-seasonal to inter-annual variability in the atmospheric and oceanic boundary layers in the tropical Atlantic

2- Provide a set of data useful for developing and improving the predictive models of the ocean-atmosphere coupled system

Short/Long term Forecasts:
Continuous and long term observations are needed

10 ATLAS buoys

11 T + 4 C
2 press.
1 ADCP (2001 ...)

CLIVAR-WCRP (1st PIRATA Review)

17 ATLAS buoys

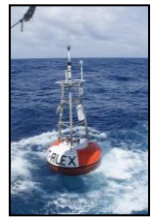
+NEE: 4 buoys
+SWE: 3 buoys
(6 flux ref. sites)
+ 2 ADCPs and CMs (Eq.)

18 ATLAS buoys

+1 buoy (Off Congo)
+ 18 OTNs (All sites)
+ 10 χpods (2 sites Eq.)

TAOS Review *underway*
(2nd PIRATA Review)

11 T-FLEX + **7** ATLAS



O_2
(2 OMZ sites 23°W)

1997 — 2004 — 2005 2006 2007 — 2008 — 2011 — 2013 2014 — 2015 — 2017 — 2018 — 2019 ●●●

Pilot Phase (MoU-1)

Consolidation Phase (MoU-2)

(MoU-3)

(MoU-4)

+ 2 fCO_2
(2 sites - ARP)

+ Bar. Press. (1 site)
+ 9 T/C (2 sites 10°W)

+10 CMs TACOS (1 site 23°W)
+ O2 (2 OMZ sites 23°W)
+ 1 fCO2 (Off Congo)

Short/Long term Forecasts:
Continuous and long term observations are needed

10 ATLAS buoys

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1 ADCP (2001 ...

1997 — 200

Pilot Phase (MoU-1)

PIRATA ATLAS buoys:

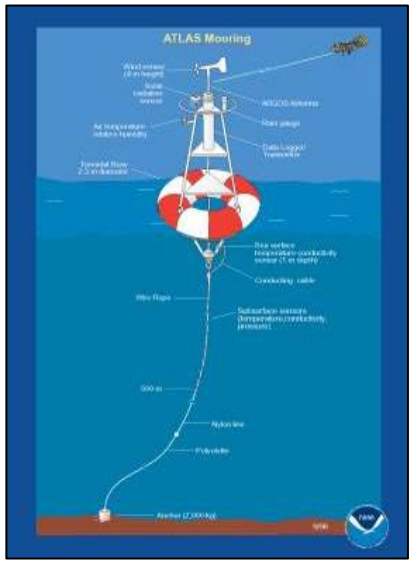
Measured Parameters :

Atmosphere:
- wind (direction, speed)
- relative humidity
- air temperature
- precipitation
- incident radiation

Ocean:
- temperature

(11 levels from surface to 500m)
- salinity

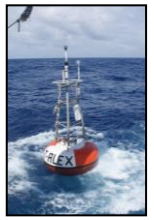
(4 to 9 levels between 0 & 120m)
- pressure (at 300 & 500m)
- surface currents at 4 sites



- Daily averaged data transmitted in real time by Argos;
- High frequency data (10mn) available after servicing operations

TAOS Review *underway*
(2nd PIRATA Review)

11 T-FLEX + **7** ATLAS



7 — 2018 — 2019 ●●●

(MoU-4)

Ms TACOS (1 site 23°W)
OMZ sites 23°W)
02 (Off Congo)

Short/Long term Forecasts:
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CLIVAR-WCRP (1st PIRATA Review)

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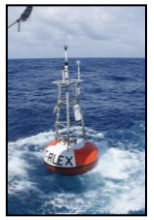

O_2
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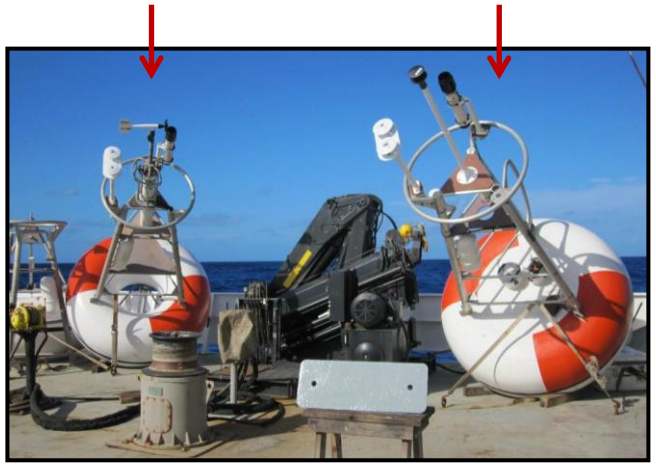
+10 CMs TACOS (1 site 23°W)
+ O2 (2 OMZ sites 23°W)
+ 1 fCO2 (Off Congo)

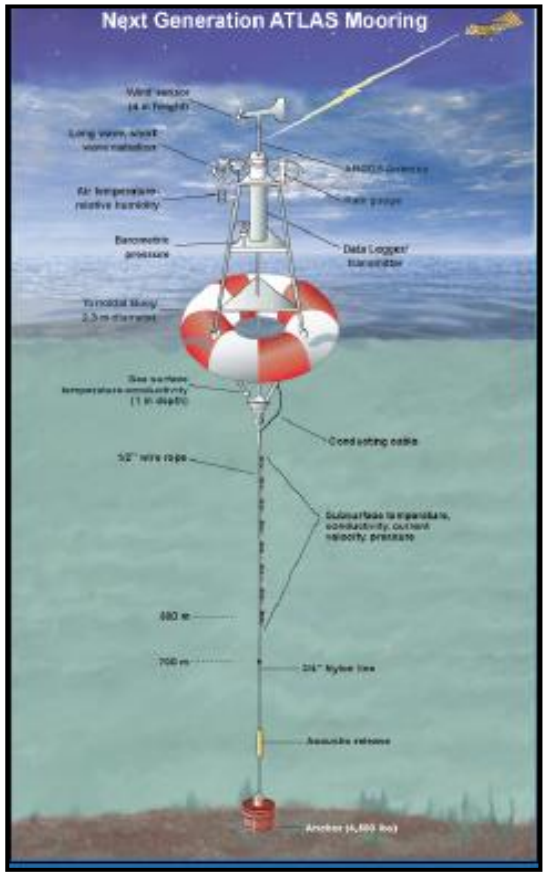
Improving PIRATA network

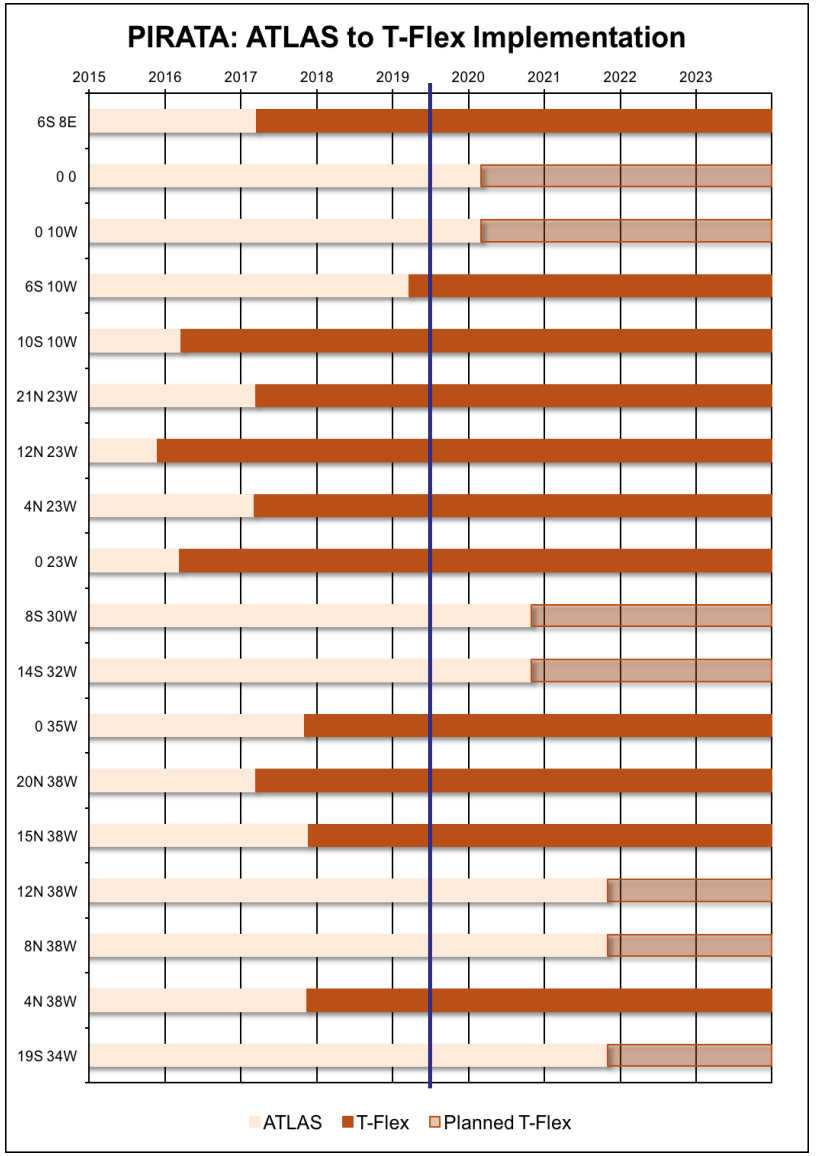
T-FLEX implementation is underway ...

From 2015 : 11 T-FLEX buoys

ATLAS T-FLEX

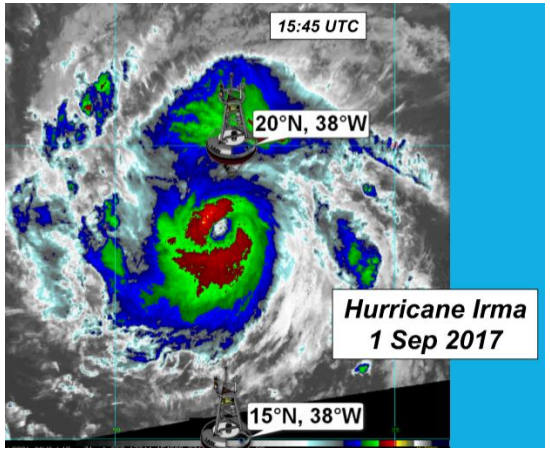


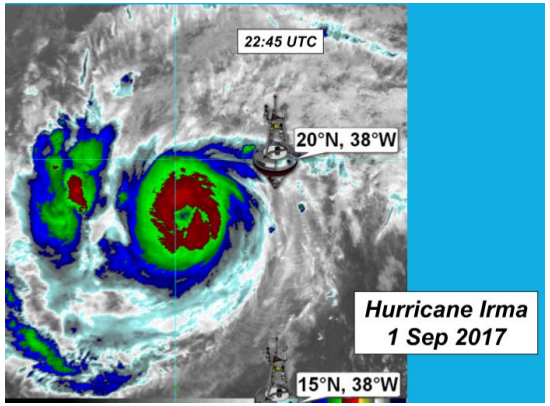


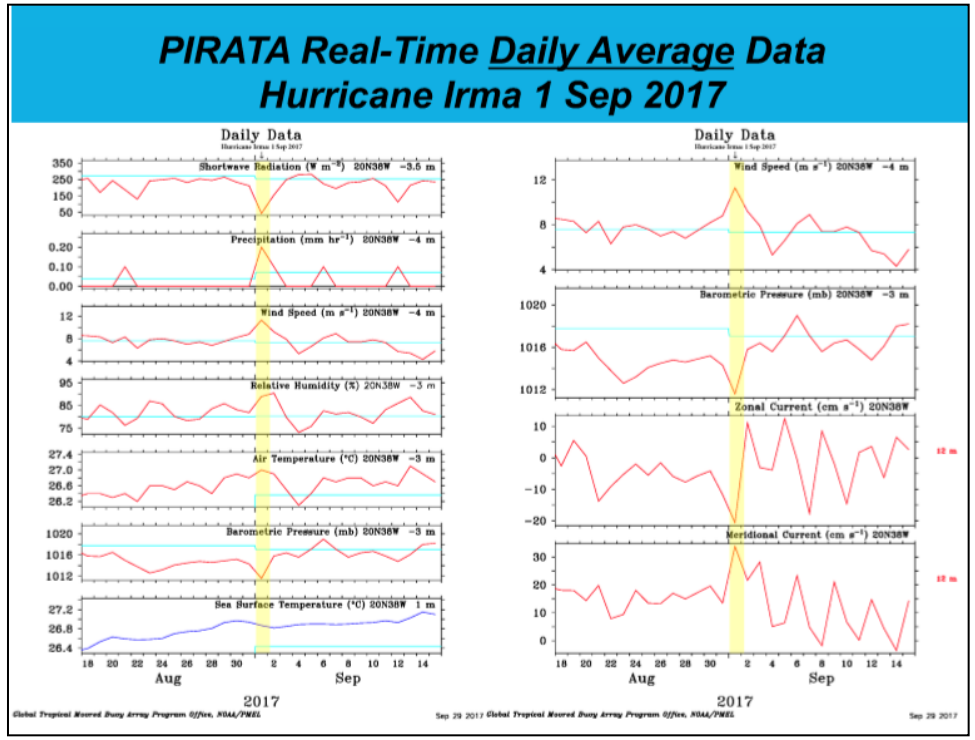


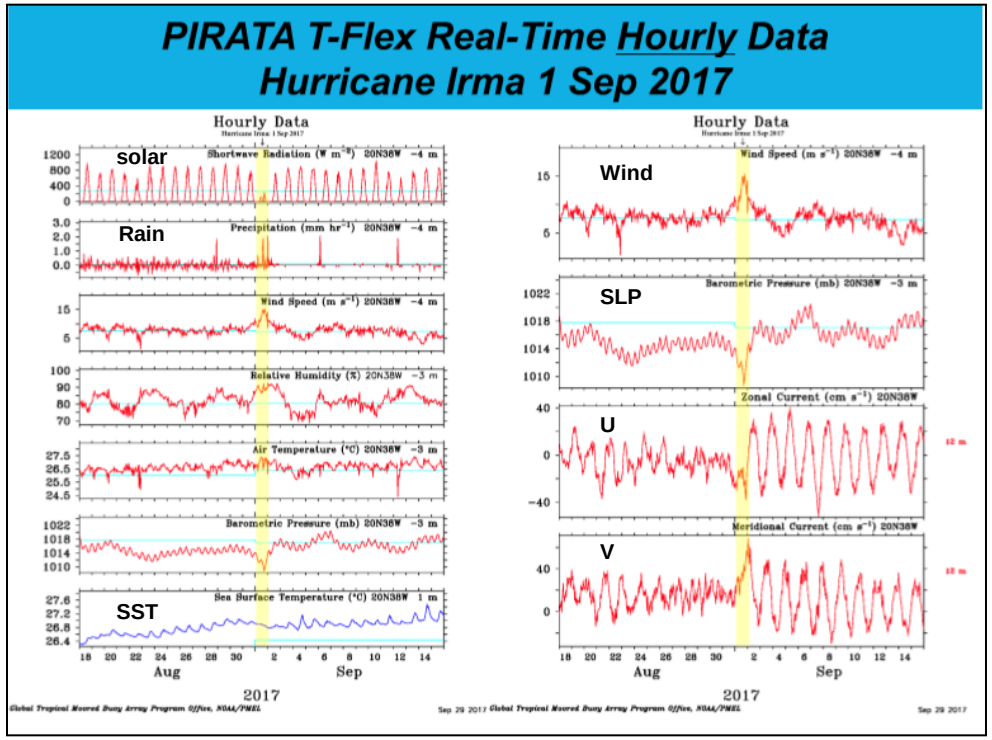
Real time monitoring enhancement with T-Flex

Predictability of Extreme Events (hurricanes, droughts/floods)
Impacts on Human Security & Health



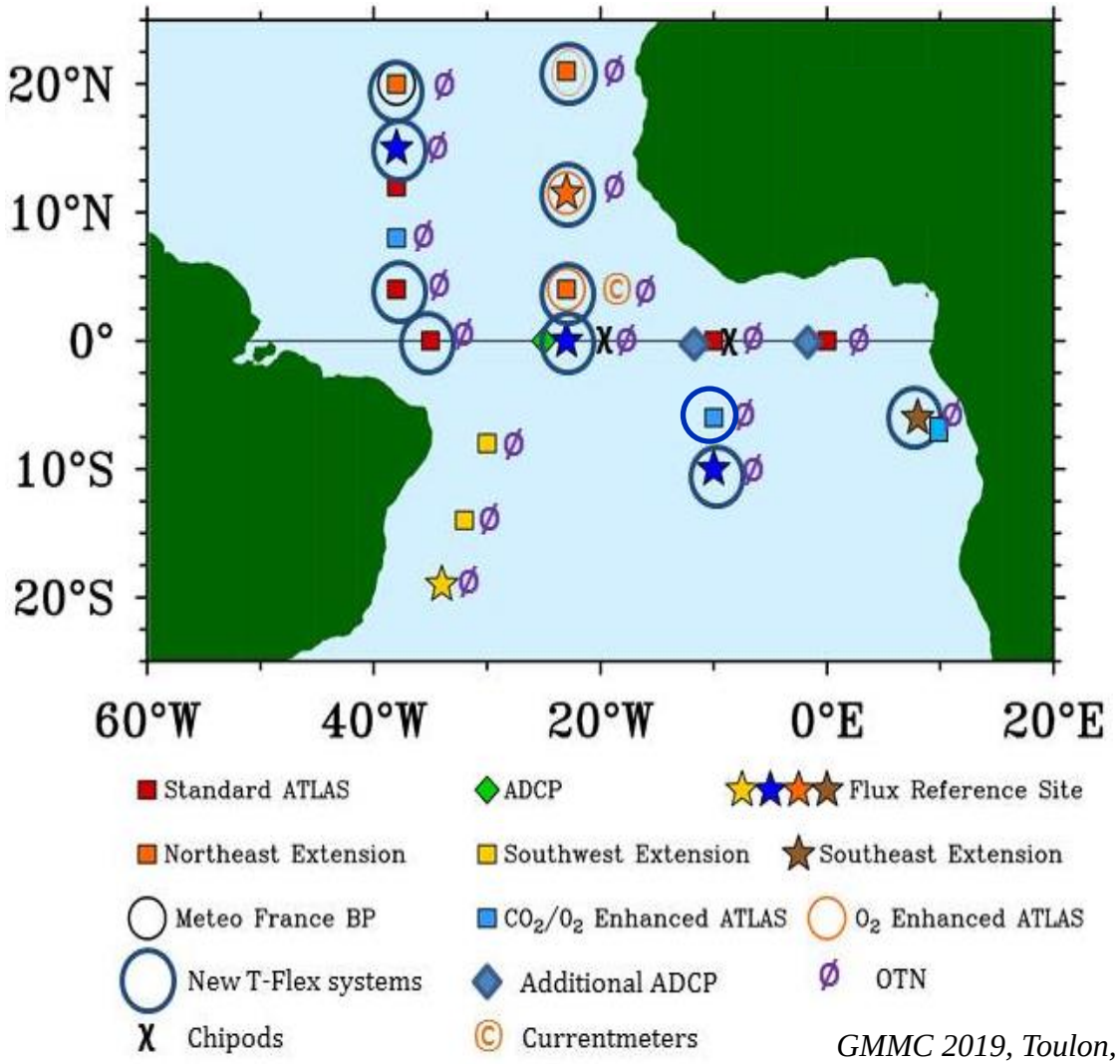






Courtesy: M. McPhaden (NOAA)

Prediction and Research moored Array in the Tropical Atlantic – PIRATA network



<u>18 meteo-oceanic buoys : ATLAS & T-Flex</u>
atmospheric parameters + EOV (T, S, + currents on some sites)

- OTN (acoustic sensors) at 200 m

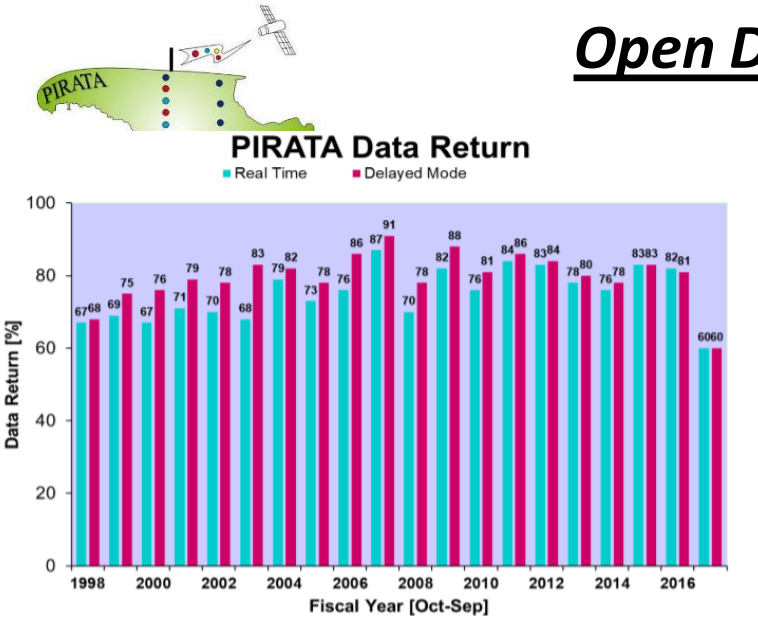
- Xpods (turbulence) at 23W-0N & 10W-0N

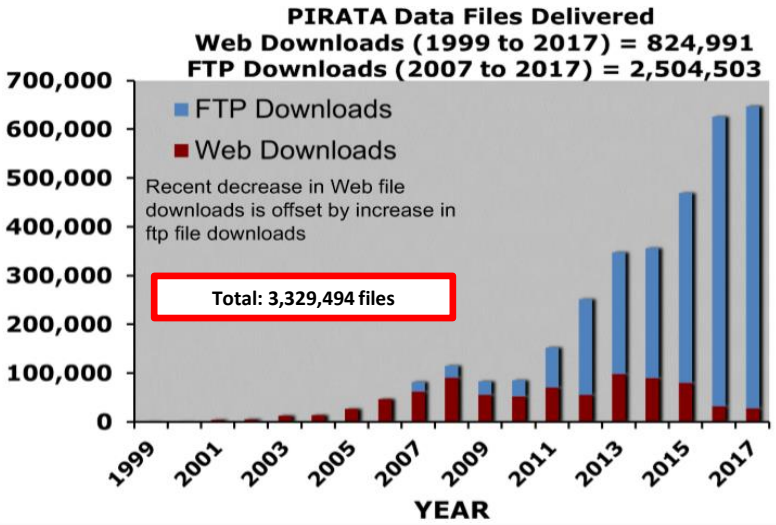
- 3 surface CO_2 sensors 38W-8N, 10W-6S, 8E-6S

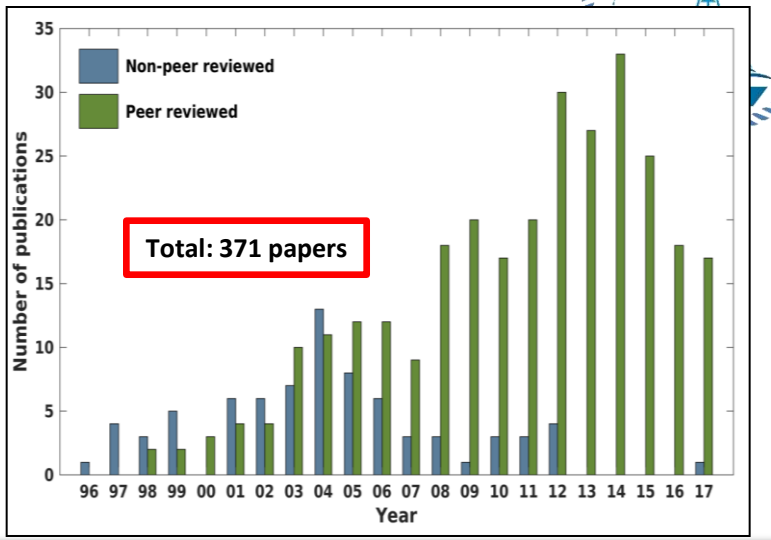
- 2 O_2 subsurface sensors at 23W-4N & 23W-11.5N

- 3 ADCP moorings (0-300 m) along the equator at 23W, 10W & 0E

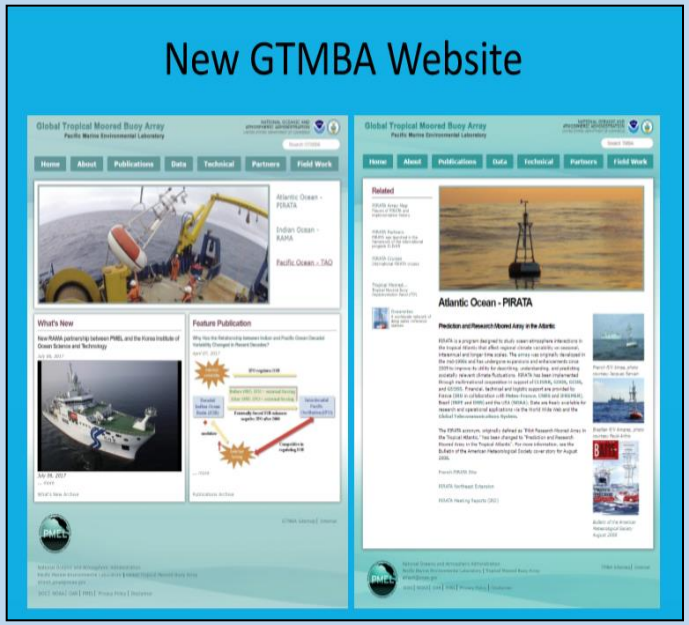
Open Data Policy





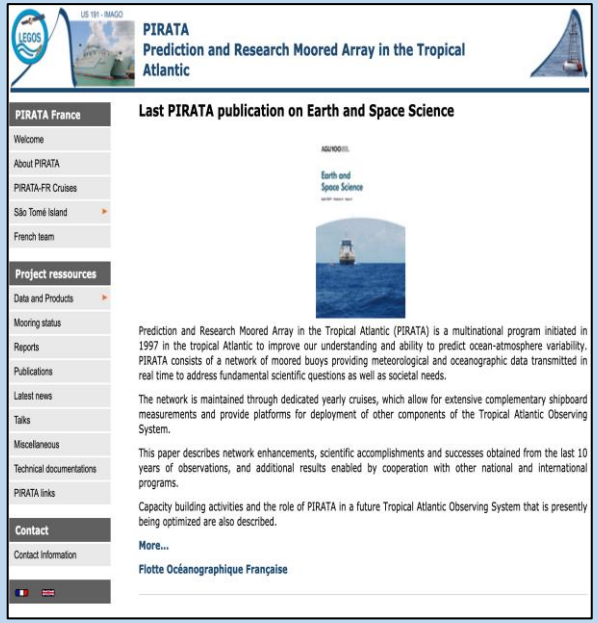


- BUOYS DATA:



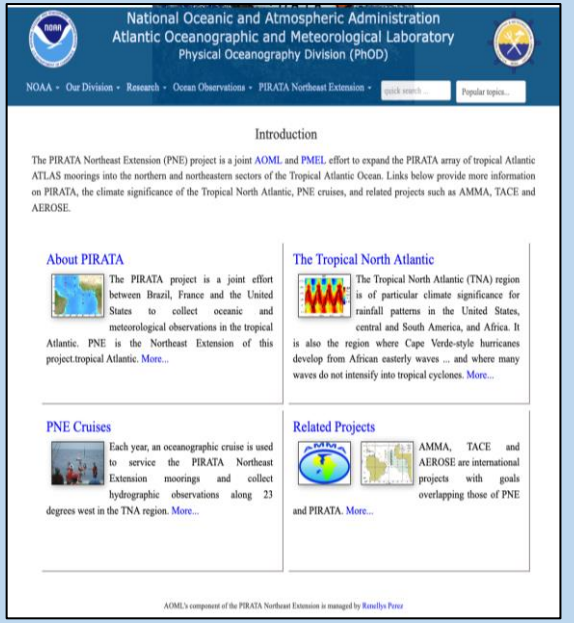
www.pmel.noaa.gov/gtmba/

- FR, BR & US CRUISES DATA:



www.brest.ird.fr/pirata/

pirata.ccst.inpe.br/



www.aoml.noaa.gov/

Prediction and Research moored Array in the Tropical Atlantic – PIRATA – Servicing Cruises

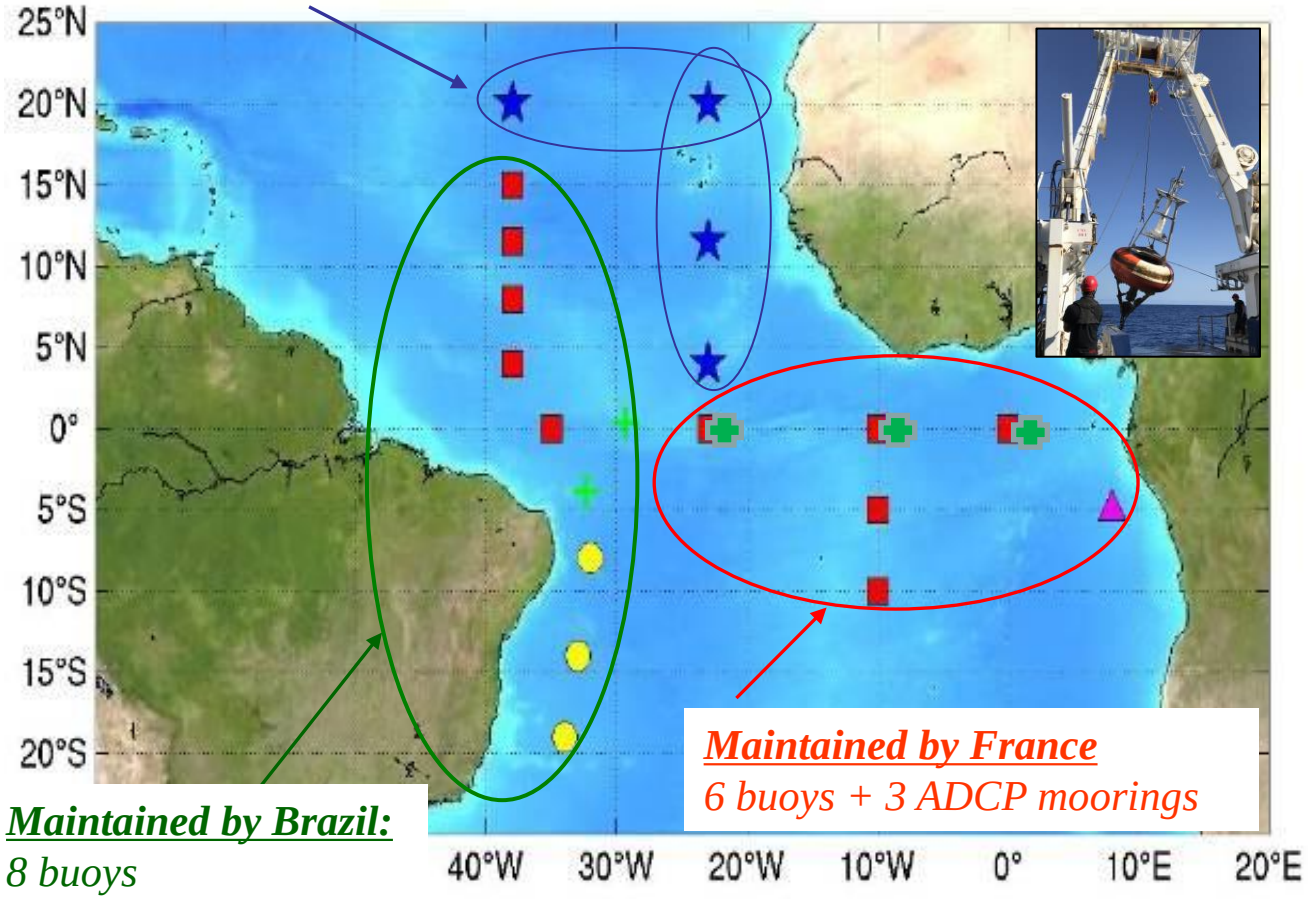
Typical sea work year:

T-FLEX/ATLAS moorings deployed: 18

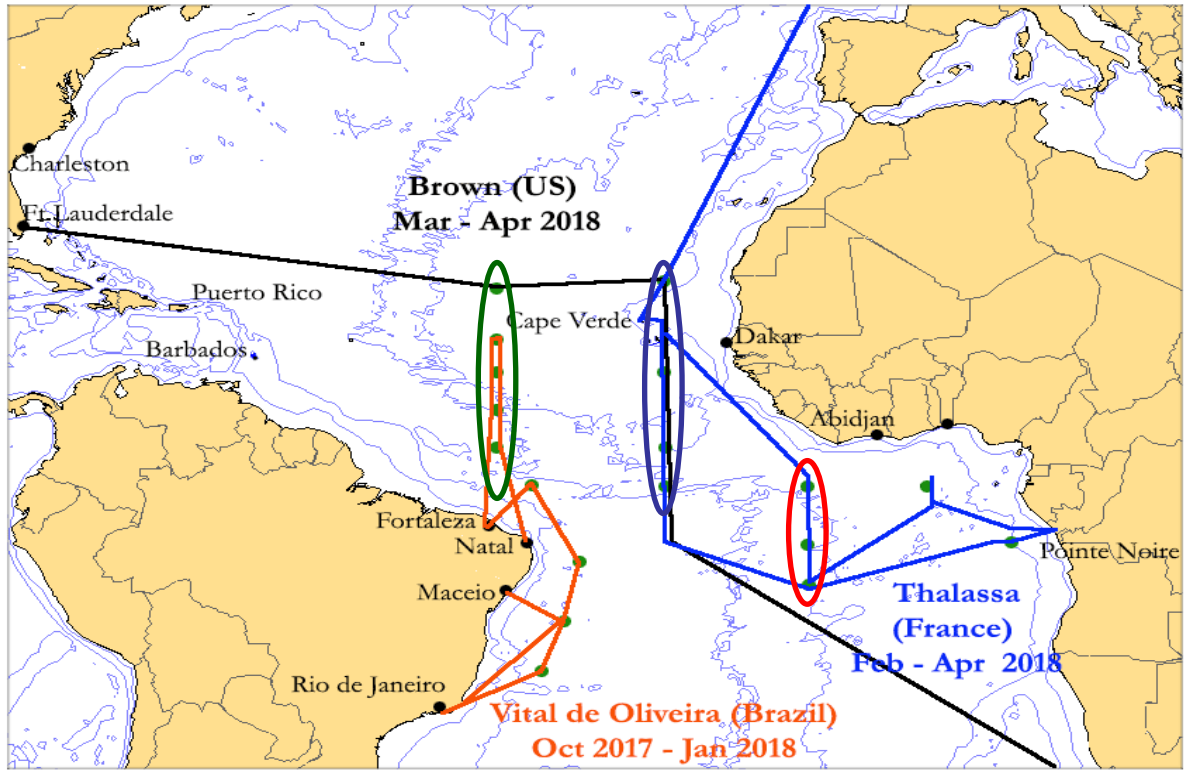
Shiptime: ~ 120 days

Maintained by USA:

4 buoys + sensors calibration

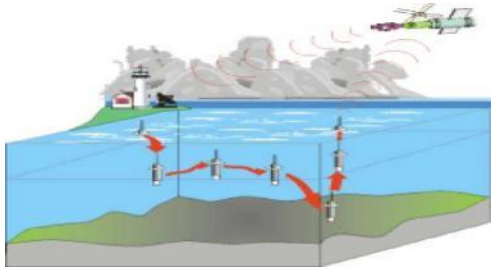


PIRATA Cruises Oct 2017 - Sep 2018



Yearly cruises ➡ repeated sections with CTD profiles at 38°W(*BR*), 23°W (*US*), 10°W (*FR*)

From 2003 : deployment of ARGO profilers in the eastern tropical Atlantic



Contribution to ARGO, through CORIOLIS

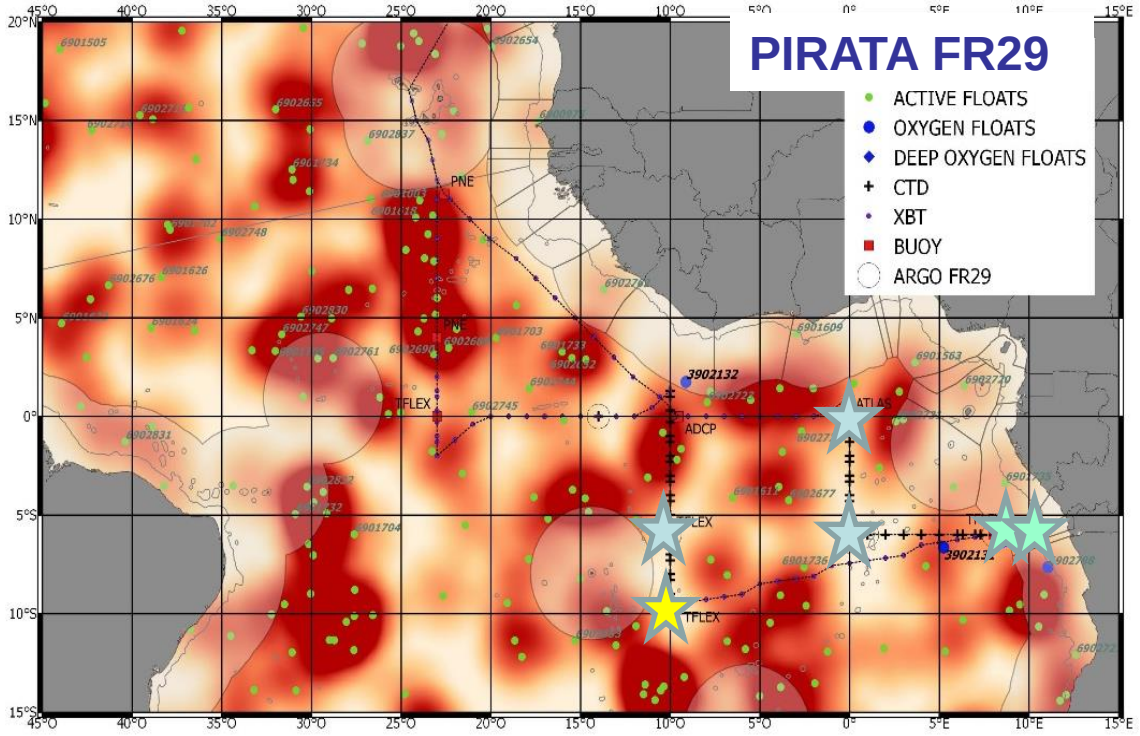
About 6-8 deployments during yearly French cruise :
142 profilers deployed from 2003 → Data in poorly documented regions (southeast)

Vertical resolution:
0-100m = 1m
100-200m = 5m
200-2000m = 25m

Iridium

Iridium O2

Argos



From 2013 : profilers with enhanced vertical resolution (1m)

From 2016 : profilers with "double" programmation

From 2017 : profilers with O_2 sensors

In 2018: 2 deep-ARGO profilers (T, S, O_2)

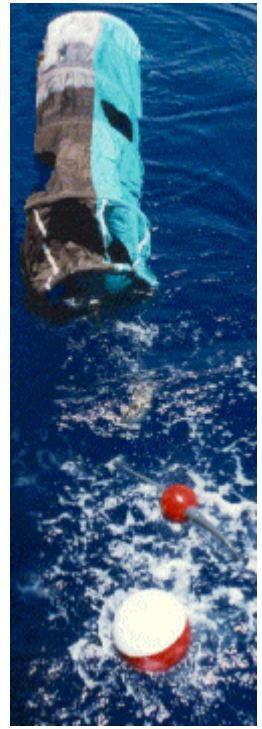
Courtesy: N. Poffa

=> need of T/C measurements for ARGO profiles validation down to 2000 m (or 4000 m for Deep-ARGO).
⇒ All CTD-O_2 profiles are down to 2000m depth during all PIRATA-FR cruises.

From 2005 : deployment of surface drifters in the eastern Tropical Atlantic

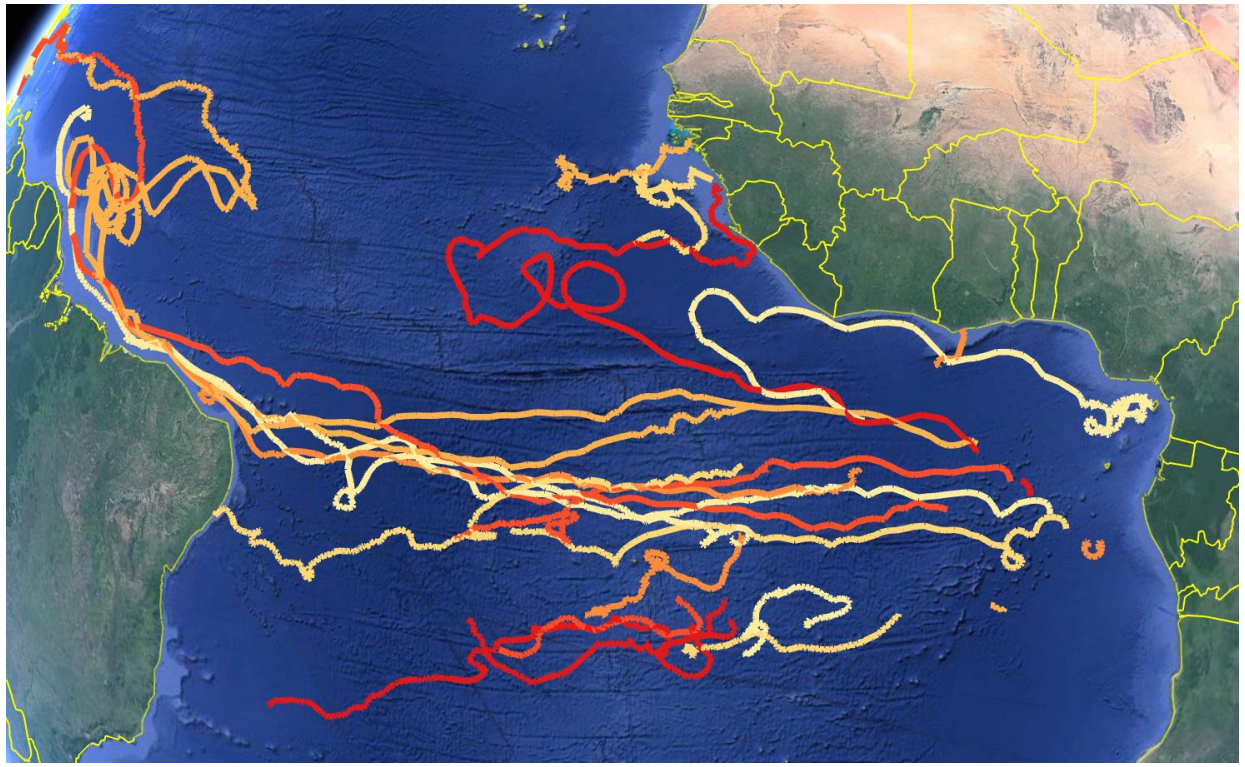
(SVP, SVP-B, SVP-BS)

Contribution to Global Drifter Program (GDP/DBCP)



From 5 to 25 deployments during yearly French cruise :
136 drifters deployed from 2005

Through Meteo-France, NOAA/AOML & contribution to AtlantOS

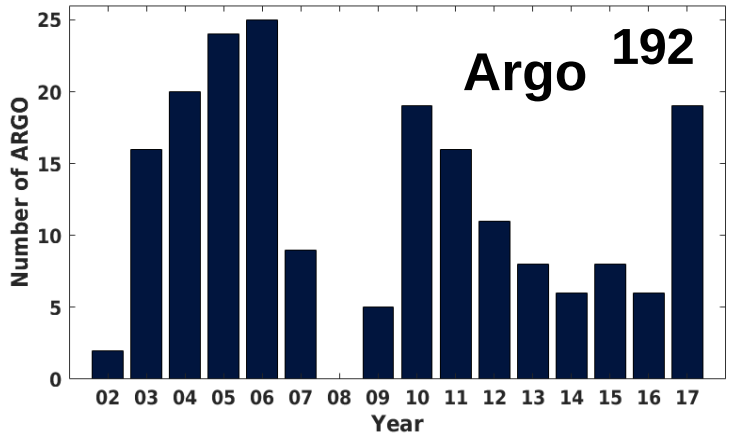


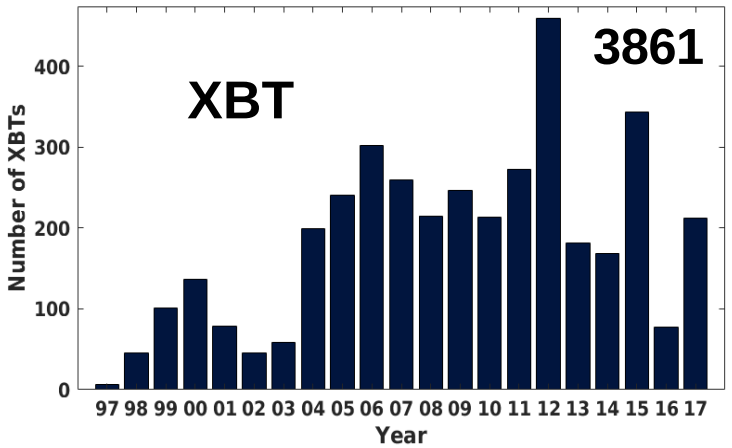
Example:
Trajectories of the SVP deployed during PIRATA-FR cruises between 2016 to 2018 as contribution to AtlantOS & NOAA GDP
(M. Le Garrec, pers. comm.)

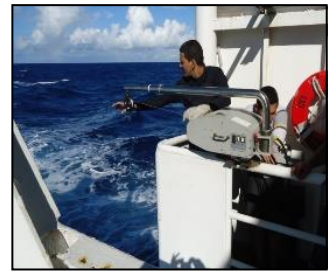
Prediction and Research moored Array in the Tropical Atlantic - PIRATA

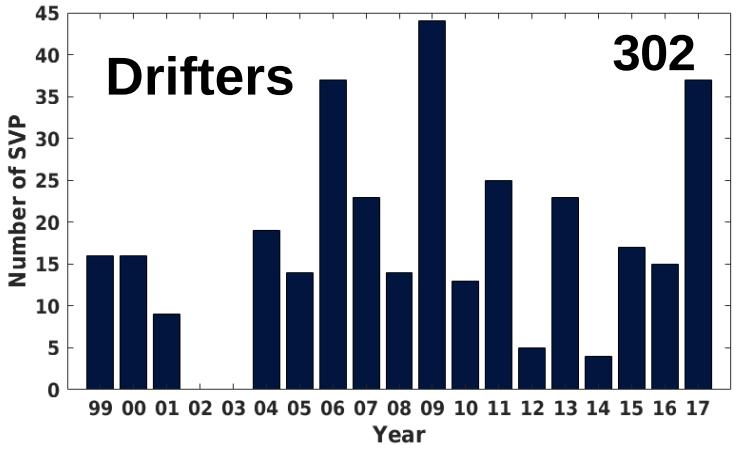
Network integration: *by cooperating/supporting different networks*

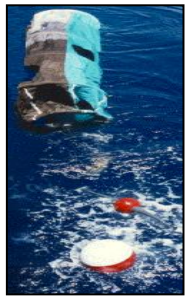
Number of deployed Argo profilers, XBT, SVP, Radiosondes and Ozone sondes during PIRATA cruises (1997-2017)



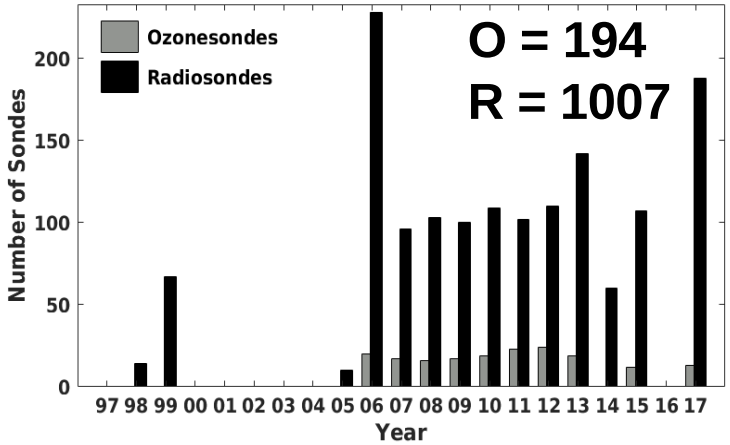








Bourlès et al. (2019)



From 2006 : acquisition of CO_2 parameters

Contribution to ICOS-Ocean

1) CARIOCA systems added at the buoys located :

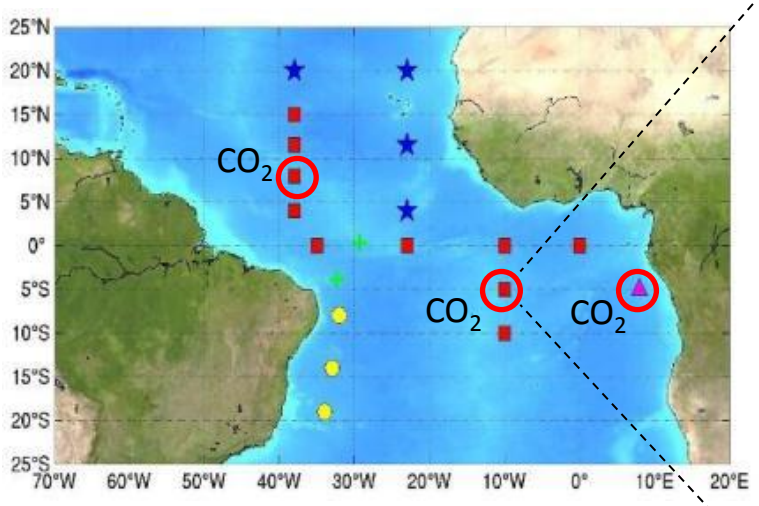
- **at 6°S-10°W (from 2006)**
- **at 8°N-38°W (from 2008)**
- **at 6°S-8°E (from 2017; AtlantOS).**

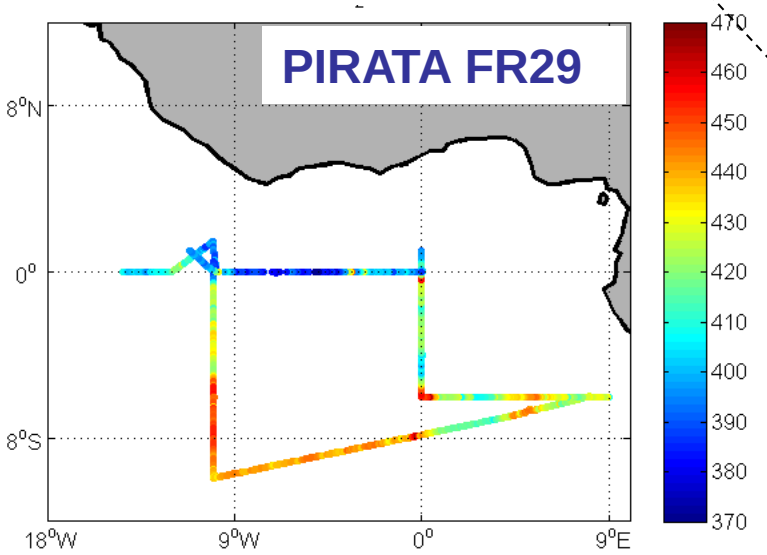
2) Continuous pCO2 measurements and surface samplings along the tracklines (every 1°- 2°) for DIC, TA

Samplings along the vertical (0-100m) during CTD-O_2 casts at the buoys

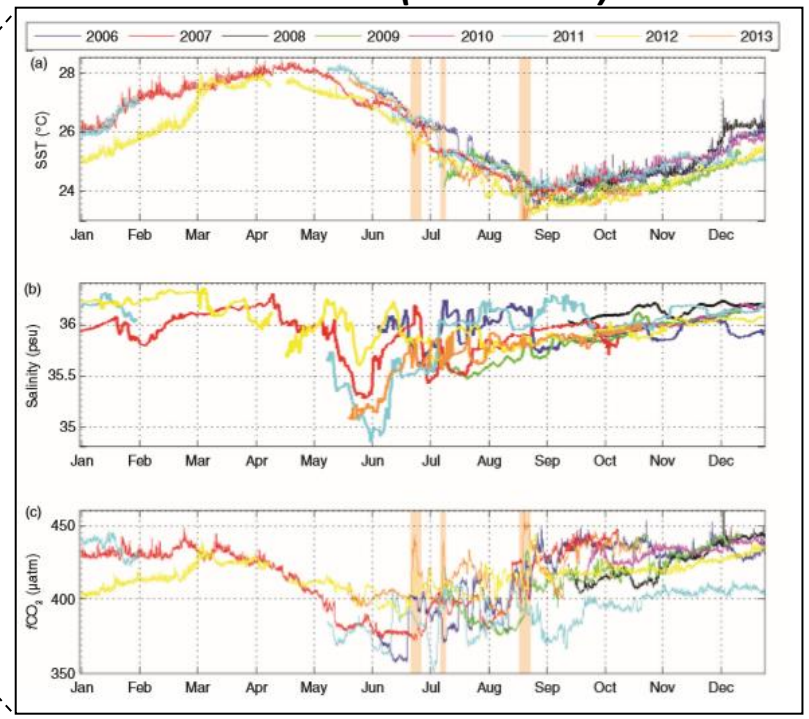
=> Amazon & Congo influences ?

PI: N. Lefèvre (IRD, Paris)





6°S-10°W (2006-2019)



(Lefèvre et al., 2016)

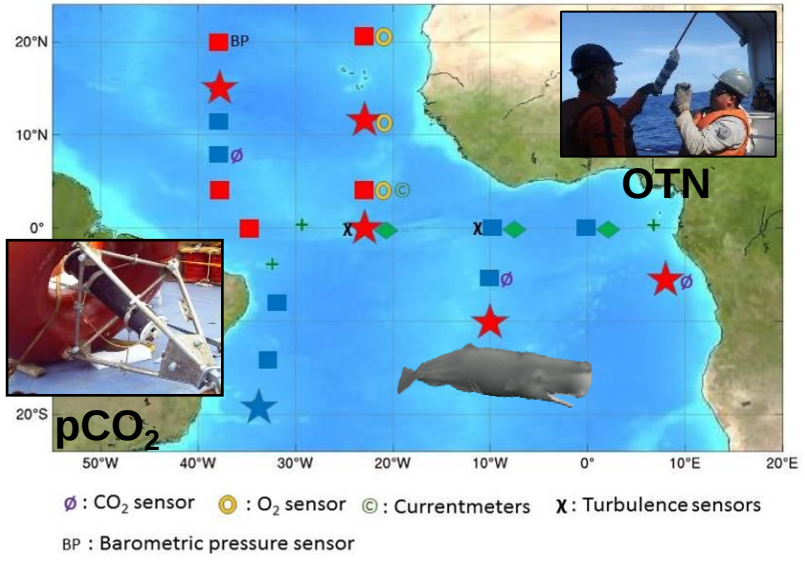
New CO_2 sensor

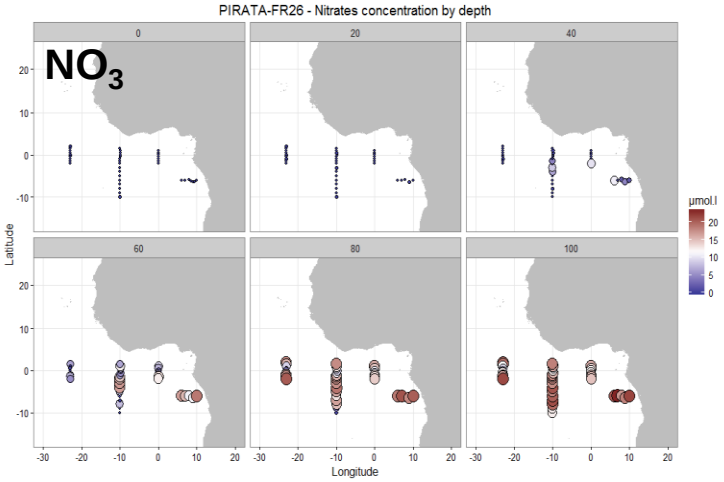
⇒ Moored and ship-based CO2 data are available through the *Surface Ocean CO2 Atlas* (SOCAT, www.socat.info)

Prediction and Research moored Array in the Tropical Atlantic - PIRATA

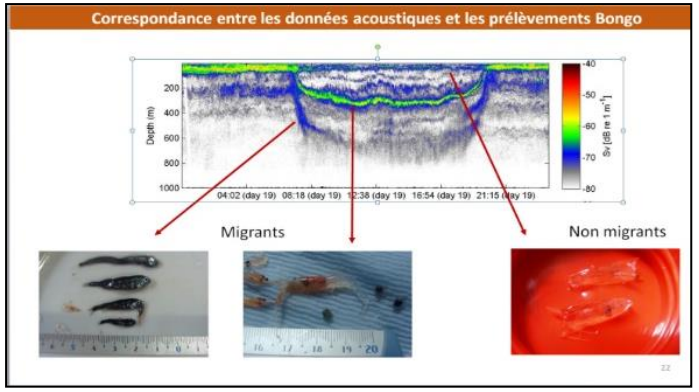
EOVs integration: *by integrating physical-biogeochemical-biological measurements*

Nutrients, pCO_2 (underway and fixed moorings), O_2 (OMZ), Chlorophyll pigments, Plankton, Acoustics, Mammals (OTN), Tuna Hg contamination

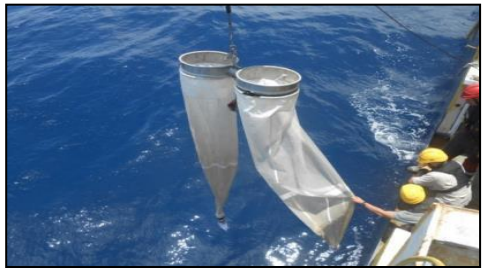




Link with **Acoustic data**
(and T/S/O2/ADCP/nutrients/Chl pigments…)

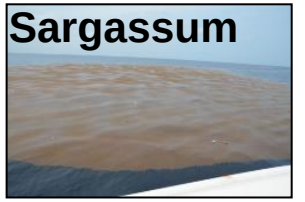


Plankton

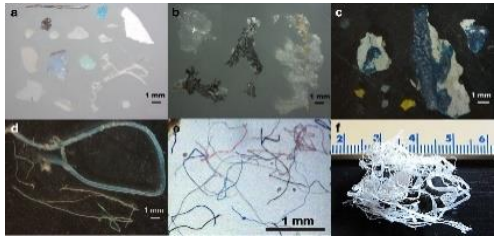


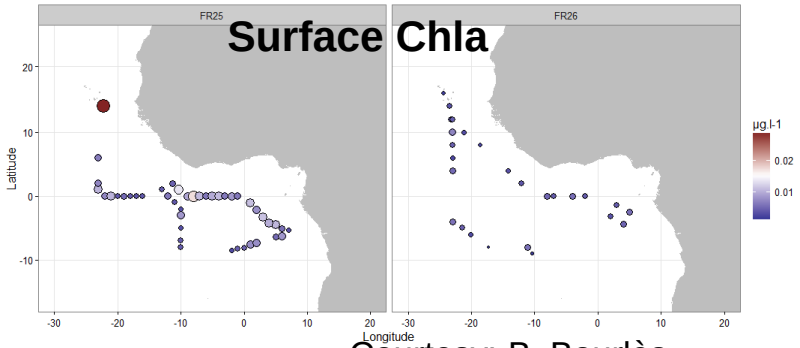
New !

Sargassum



Microplastics



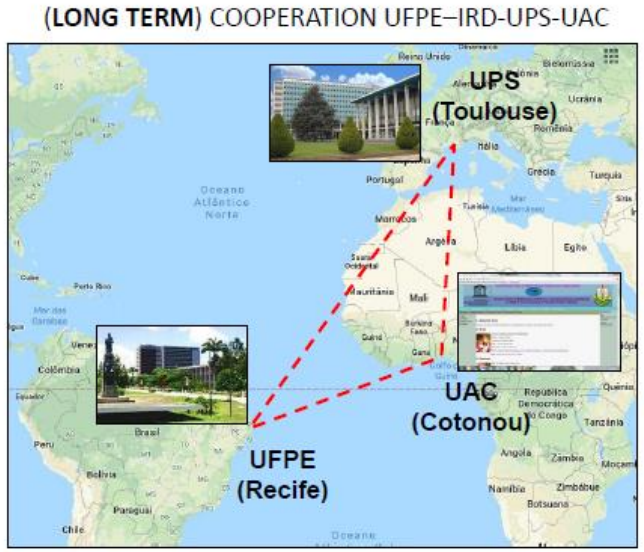


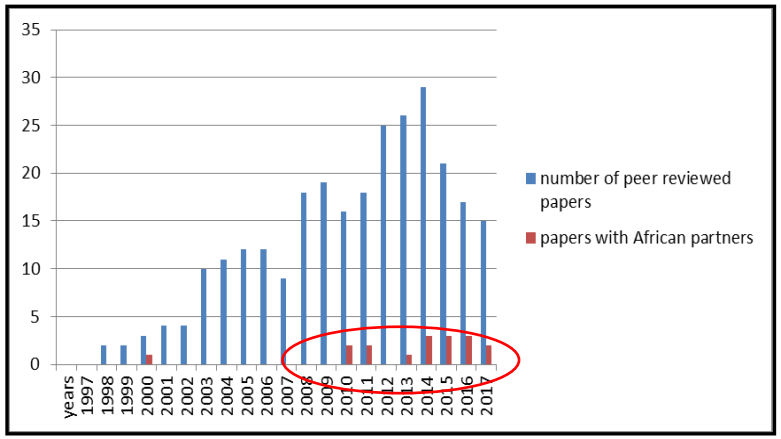
Courtesy: B. Bourlès

How beneficial PIRATA is ?

Capacity Building

Master in Physical Oceanography and Application - *M2 OPA* (Cotonou, Benin)





Institut de Recherche pour le Développement FRANCE

UNIVERSITÉ TOULOUSE III PAUL SABATIER

UFPE

- Students from all over West Africa to study the physics, chemistry and biology of the ocean;
- Lecturers from: France (UPS, LEGOS, ...), Benin (UAC) and Brazil (UFPE);
- >100 students formed from 2008 (Benin, Ivory Coast, Cameroon, Togo, Ghana, Senegal, Nigeria);
- >43 Continued in PhD: in France, Brazil, South Africa, Germany, Canada, Cameroon, Benin, ...

Conclusions and prospective

⇒ **PIRATA is a platform for several additional measurements**

⇒ **PIRATA servicing cruises offer repeat section sampling and additional experiments**

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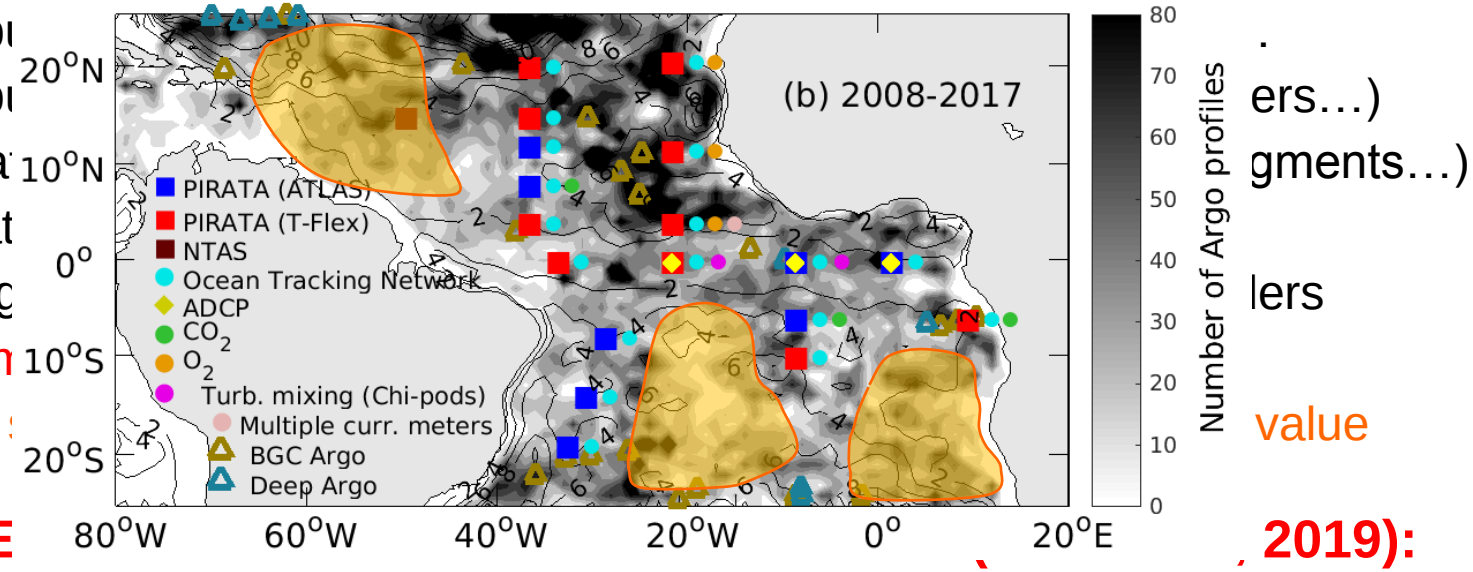
- Impact



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⇒ **IN THE FUTURE** **2019):**

- **Sustain the existing network** to carry on long term time series
- **Increase T/S sensors in the mixed layer**, add **surface currents** and **fluxes** measurements
- Upper **ocean mixing sensors** at few sites
- Expand **biogeochemical measurements at every site**
- Extend PIRATA array (new moorings) in the **South Atlantic, and in the North Atlantic warm pool**

Earth and Space Science

Research Article | Open Access

PIRATA: A Sustained Observing System for Tropical Atlantic Climate Research and Forecasting

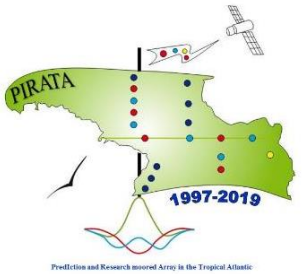
Bernard Bourlès, Moacyr Araujo, Michael J. McPhaden, Peter Brandt, Gregory R. Foltz, Rick Lumpkin, Hervé Giordani, Fabrice Hernandez, Nathalie Lefèvre, Paulo Nobre, Edmo Campos, Ramalingam Saravanan, Janice Trotte-Duhà, Marcus Dengler, Johannes Hahn, Rebecca Hummels, Joke F. Lübbecke, Mathieu Rouault, Leticia Cotrim, Adrienne Sutton, Markus Jochum, Renellys C. Perez

https://doi.org/10.1029/2018EA000428

AGU100

Earth and Space Science

April 2019 · Volume 6 · Issue 4



frontiers in Marine Science

REVIEW
published: 10 May 2019
doi: 10.3389/fmars.2019.00206

The Tropical Atlantic Observing System

G. R. Foltz[1]*, P. Brandt[2,3], I. Richter[4], B. Rodriguez-Fonseca[5,6], F. Hernandez[7,8], M. Dengler[2], R. R. Rodrigues[9], J. O. Schmidt[10], L. Yu[11], N. Lefevre[12], L. Cotrim Da Cunha[13], M. J. McPhaden[14], M. Araujo[9], J. Karstensen[2], J. Hahn[2], M. Martin-Rey[15], C. M. Patricola[16], P. Poli[17], P. Zuidema[18], R. Hummels[2], R. C. Perez[1], V. Hatje[19], J. F. Lübbecke[2,3], I. Polo[5], R. Lumpkin[1], B. Bourlès[20], F. E. Asuquo[21], P. Lehodey[22], A. Conchon[22], P. Chang[23,24], P. Dandin[25], C. Schmid[1], A. Sutton[14], H. Giordani[25], Y. Xue[26], S. Illig[27,28], T. Losada[5], S. A. Grodsky[29], F. Gasparin[30], T. Lee[31], E. Mohino[5], P. Nobre[32], R. Wanninkhof[1], N. Keenlyside[33,34], V. Garcon[27], E. Sánchez-Gómez[15], H. C. Nnamchi[2], M. Drévillon[30], A. Storto[35,36], E. Remy[30], A. Lazar[37], S. Speich[38], M. Goes[1,39], T. Dorrington[40], W. E. Johns[18], J. N. Moum[41], C. Robinson[42], C. Perruche[30], R. B. de Souza[32], A. T. Gaye[43], J. López-Parages[5], P.-A. Monerie[44], P. Castellanos[45], N. U. Benson[46], M. N. Hounkonnou[47], J. Trotte Duhá[48], R. Laxenaire[38] and N. Reul[49]

https://doi.org/10.3389/fmars.2019.00206

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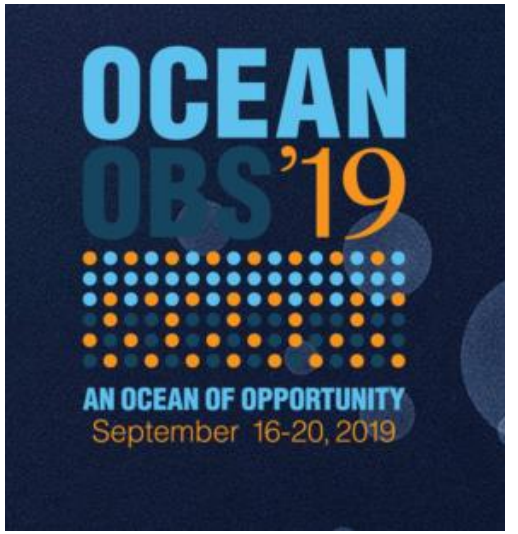

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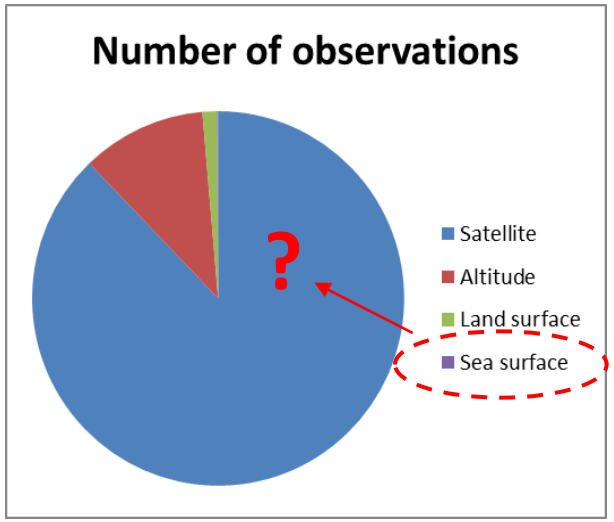
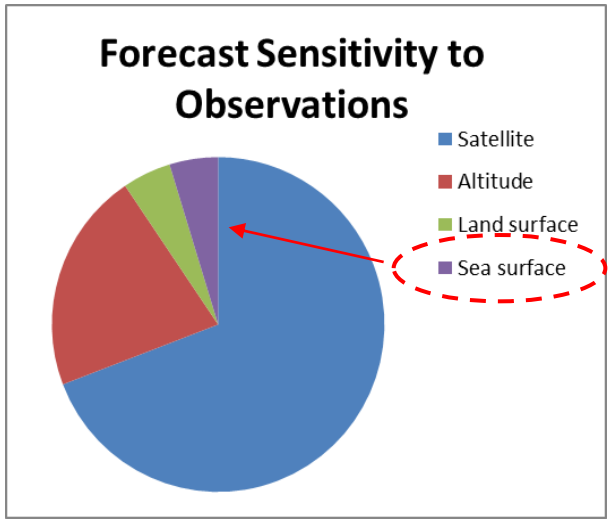
How beneficial PIRATA is ?

OSEs and OSSEs

- ***Observing System Experiments (OSEs) – EUMETNET/Météo-France/ECMWF (*)***



(a)



(b)

IF = (b)/(a)

Impact Factor

For PIRATA moored buoys:

(a) = 0.000055% of the total number of observations assimilated;

(b) = 0.006076 % of the total 24-hour global error forecast reduction.

IF (PIRATA moored buoys) ≅ 110

IF (drifting buoys in the tropics) ≅ 128

IF (drifting buoys on the surface of the globe) ≅ 400

IF (other surface marine observations) ≅ 5

IF (surface land-based observing systems) ≅ 4

IF (upper-air observing systems, including aircraft and radiosondes) ≅ 2

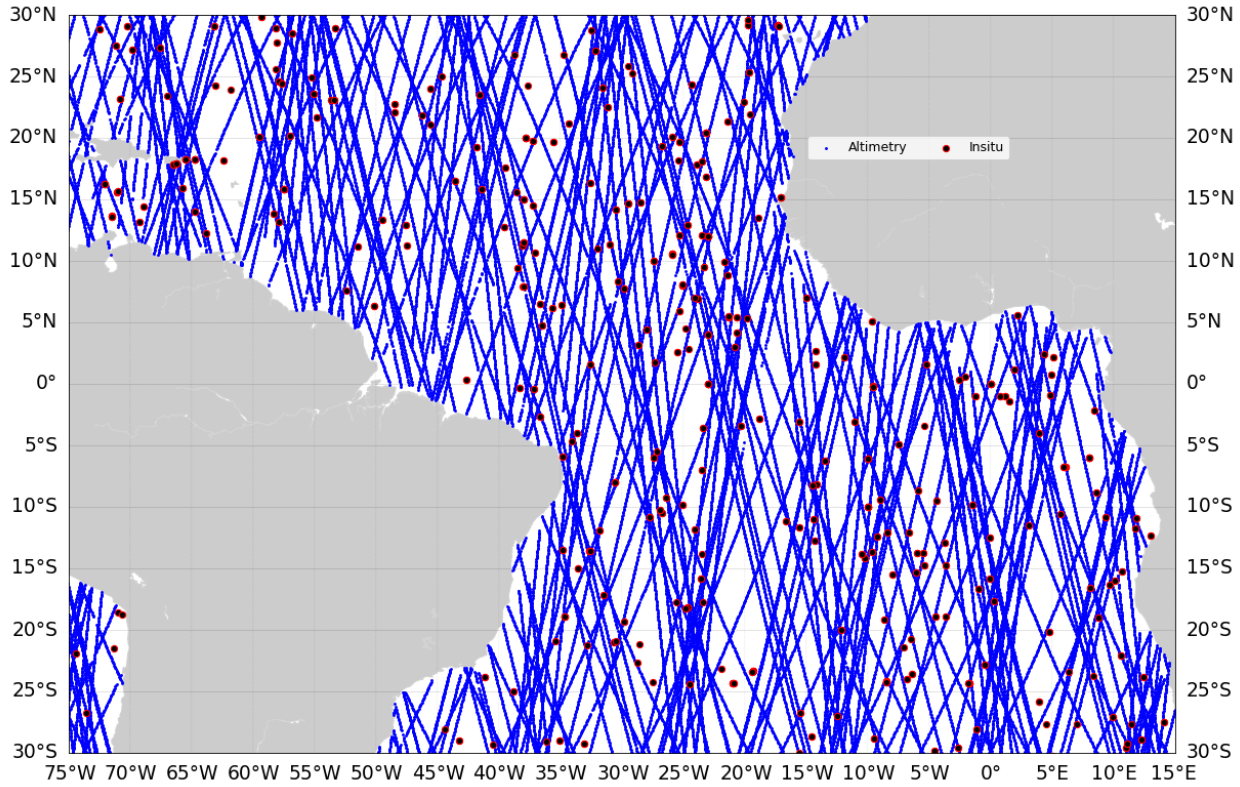
IF (satellites) ≅ 0.8

(*) P. Poli et al. (2018). *How useful are PIRATA mooring surface pressure data to improve the weather forecasts ?* doi:10.5281/zenodo.1164620. EUMETNET and Météo-France.

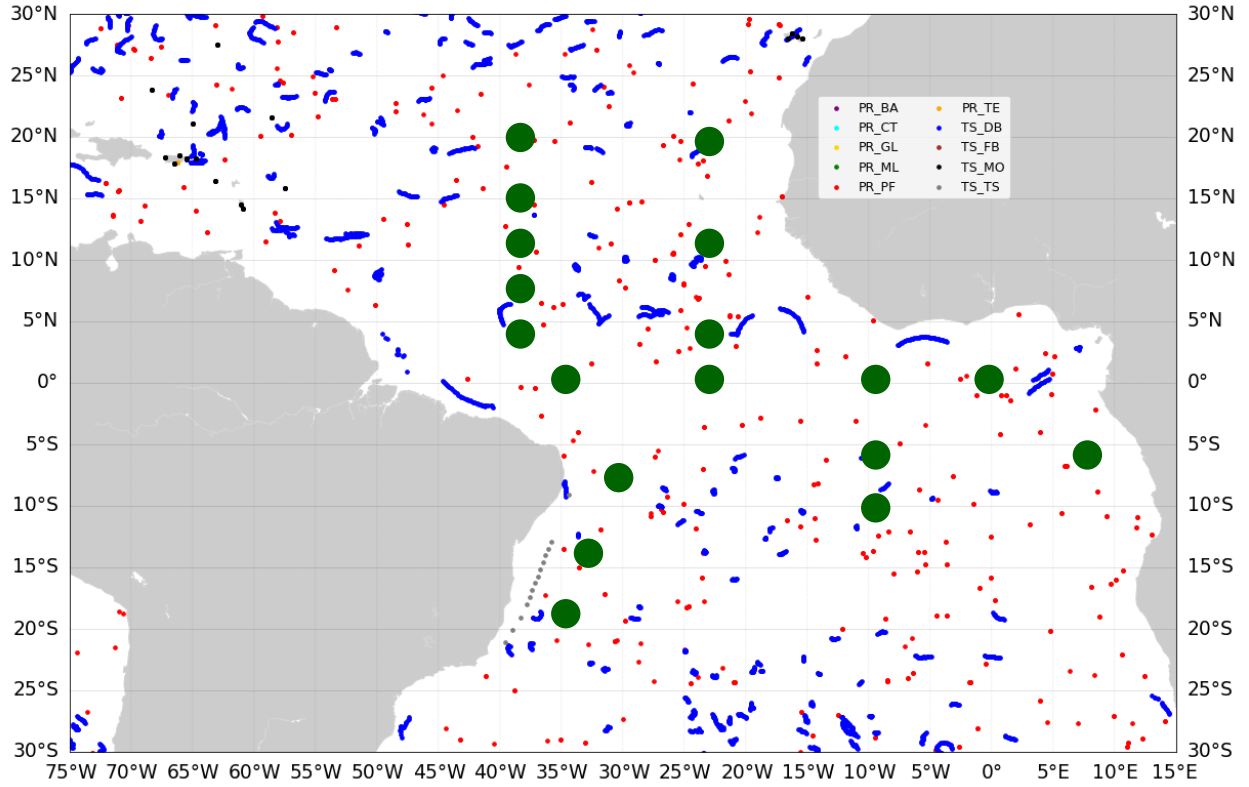
Open Data Policy:

Tropical Atlantic real-time transmitted data are ingested into operational systems

1 week positions of Assimilated data in MERCATOR 1/12



Positions of in situ data in CMEMS 20180704-20180711

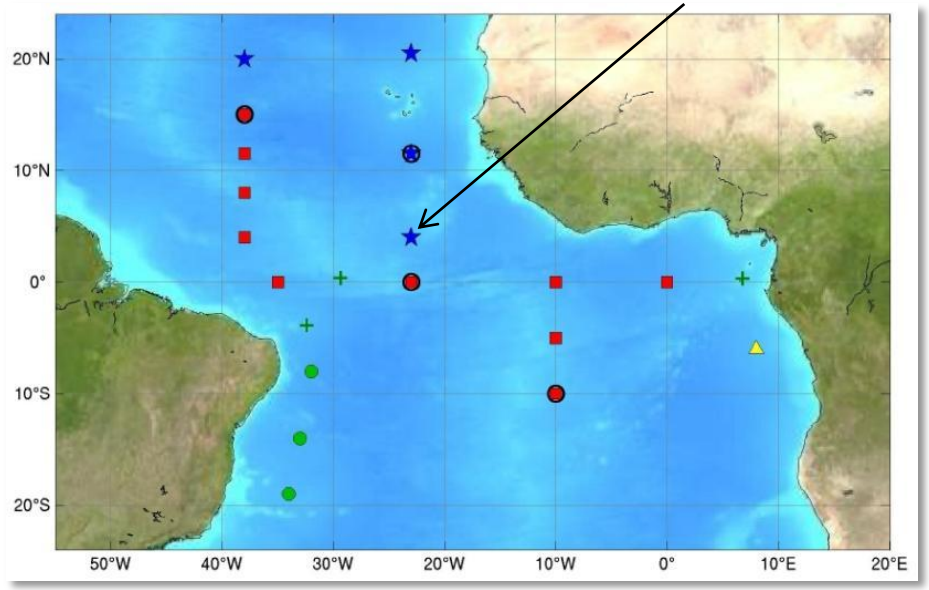


Data assimilated by Mercator 1/12° operational system, 4-11 july 2018 (courtesy of C. Regnier, Foltz et al., 2019)

Prediction and Research moored Array in the Tropical Atlantic - PIRATA

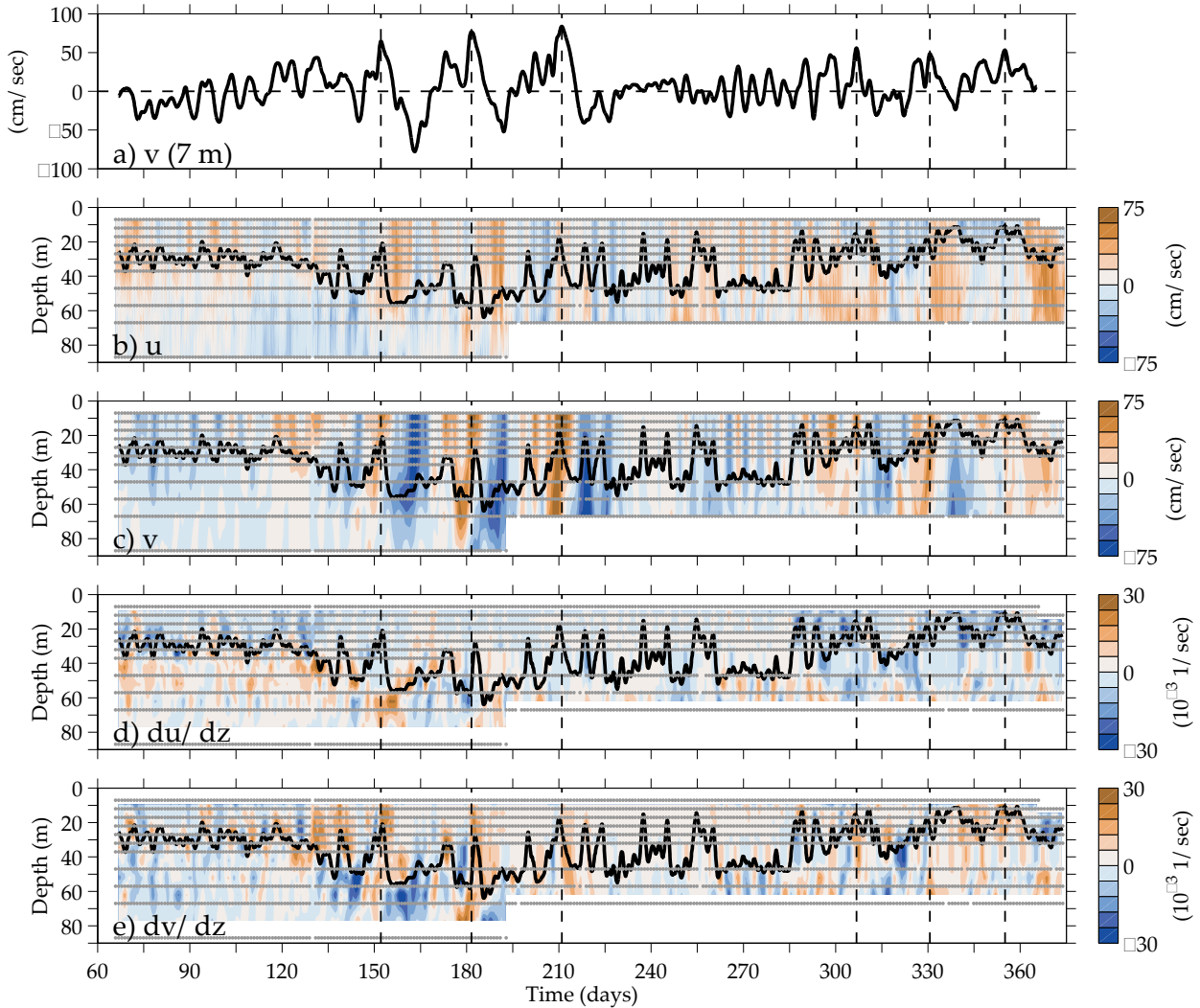
Tropical Atlantic Currents Observations Study (TACOS, R. Perez)

TACOS deployed in March 2017



11 current meters deployed at 4N, 23W mooring

Velocity and vertical shear

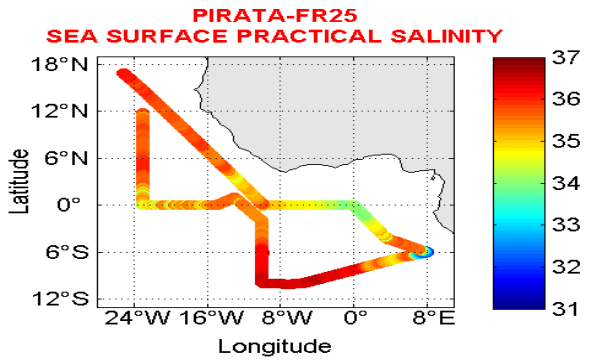


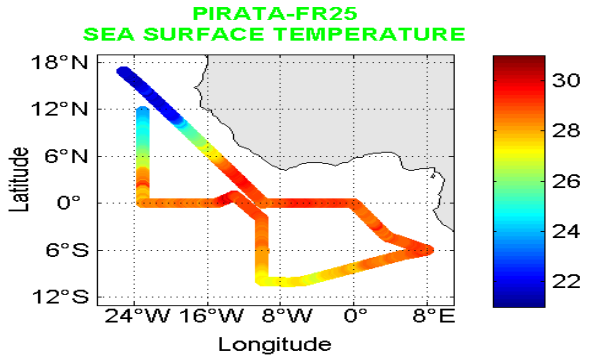
From 2011: Acquisition of Chl pigments (HPLC) in the eastern Tropical Atlantic

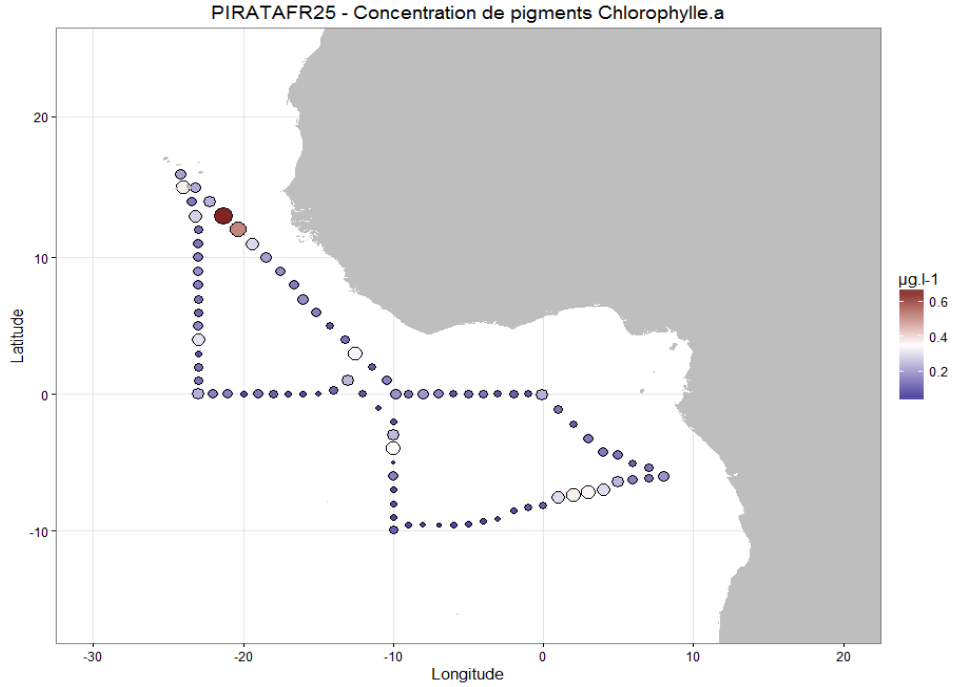
Surface samplings along the trackline (every 2°)

Samplings along the vertical during $CTDO_2$ casts

(S. Hillion, IRD-Brest)







Examples:

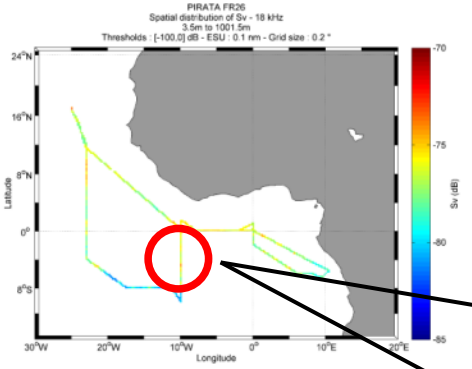
Up: Surface Chl pigments concentation during the PIRATA FR25 cruise -March/April 2015- (J.Habasque, IRD-Brest)

Left: surface SSS & SST along the PIRATA FR25 trackline (J.Grelet, IRD-Brest)

From 2015 *(but depending upon the research vessel equipment):*

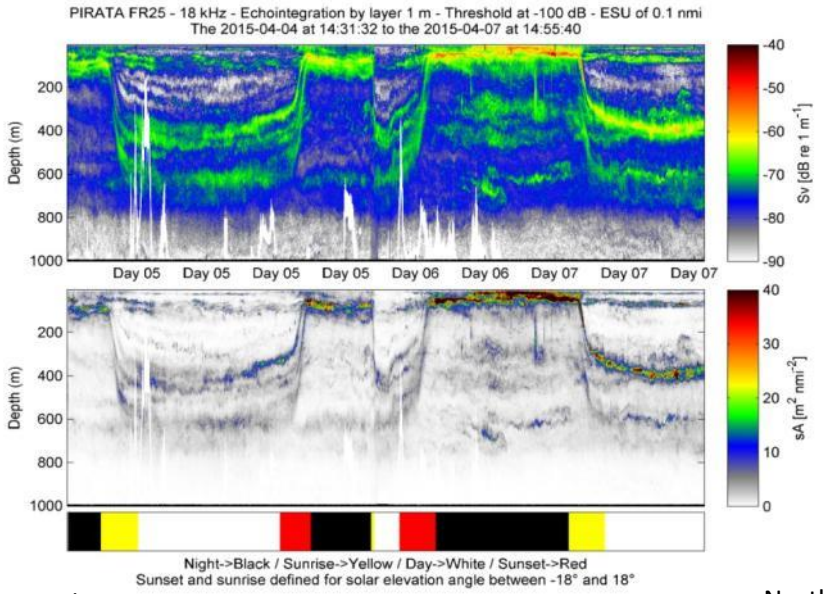
Acoustic measurements

R/V Thalassa => Multifrequency acoustic data (18, 38, 70, 120, 200 and 333 kHz)
=> information on biotic and abiotic ecosystem components.

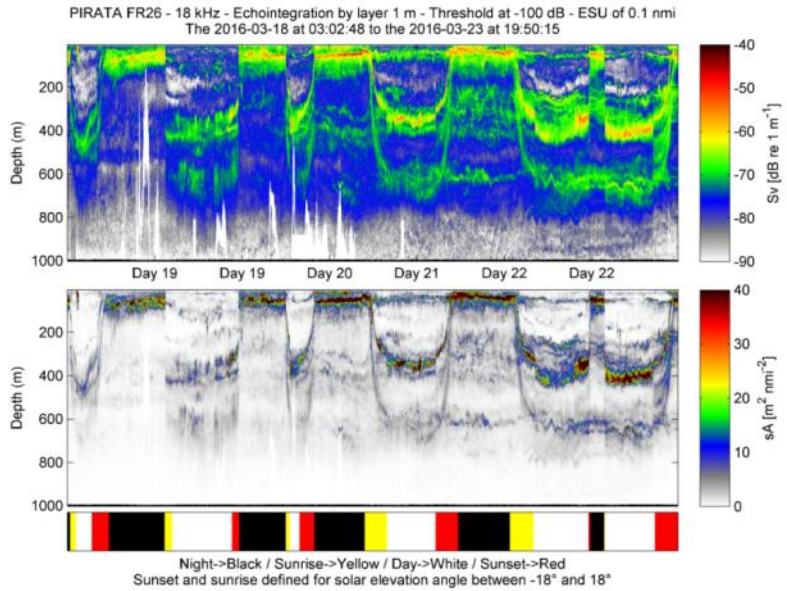


⇒ Analysis of the pelagic organism spatial organization, the planktonic biodiversity, as well as upper trophic level marine organisms in relation with ocean conditions in contrasted regions (fronts, upwellings, currents shear…) + diel vertical migration.

2015



2016



South → North

(J.Habasque, IRD-Brest)

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