Mooring Networks

Session 2: Tropical Atlantic Observing System Networks: Current Status and plans to 2030

PIRATA SSG and contributors

1st TAOS Review Workshop
Portland, USA, 8-9 Feb. 2018
Mooring Networks

Outline:

- PIRATA: PIRATA SSG and contributors
- TMA-MOVE: Uwe Send and Matthias Lankhorst
- TMA-RACE/SACUS: Rebecca Hummels and Peter Brandt
- CVOO: Björn Fiedler and Johannes Karstensen

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Prediction and Research moored array in the Tropical Atlantic – PIRATA´s contributions to:

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PIRATA mooring timeline

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

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.)

10 T-FLEX + 8 ATLAS
+ 10 CMs TACOS (1 site 23°W)
+ O2 (2 OMZ sites 23°W)
+ 1 fCO2 (Off Congo)

CLIVAR-WCRP (1st PIRATA Review)

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

Pilot Phase (MoU-1)
Consolidation Phase (MoU-2)

2013
(MoU-3)

2015

2017
(MoU-4)

2018

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

TAOS Review underway
(2nd PIRATA Review)

+ 2 fCO2 (2 sites - ARP)
+ Bar. Press. (1 site )
+ 9 T/C (2 sites 10°W)
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**Status in 2007:**

- PIRATA Array

**Status in 2017:**

- ATLAS buoys only; NE-SW-SE extensions.

- [Legend for symbols and markers]
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T-FLEX Implementation is underway ...

PIRATA: ATLAS to T-Flex Implementation
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T-FLEX Implementation Underway

PIRATA Real-Time Daily Average Data
Hurricane Irma 1 Sep 2017

PIRATA T-Flex Real-Time Hourly Data
Hurricane Irma 1 Sep 2017

Courtesy: M. McPhaden (NOAA)
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Data Return

PIRATA Mooring Data Return
1997 - 2017

PIRATA Mooring Survival
September 1997 - September 2017

All sites: 81%

Fishing vandalism

All sites: 238.5/254

Fishing vandalism

Moorings Intact / Moorings Deployed
96% - 100% Intact  81% - 95% Intact  51% - 80% Intact  0% - 50% Intact

(Intact: Not lost, significantly damaged, or impaired in any way)
Real Time: Daily mean (hourly with T-FLEX) subsurface data and hourly meteorological data at the times of satellite overpasses are placed on the GTS by Service Argos for real-time distribution to operational centers.

Delayed Mode: Measurements carried out at high frequency (from 1 min to 1 h, depending on the parameters) are stored internally and recovered during maintenance operations before being processed, calibrated, and made available to the community.

Note: 2016-2017 particular year due to vessel time issues; Better in Delayed Mode, after last cruises & sensors retrieved in November 2017-January 2018.
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Open Data Delivering

- Buoys Data:

New GTMBA Website

www.pmel.noaa.gov/gtmba/

- FR, BR & US Cruises Data:

www.brest.ird.fr/pirata/

pirata.ccst.inpe.br/

www.aoml.noaa.gov/
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**ADCP moorings**

All data (0-300m) available for the 0°S23°W and 0°S10°W moorings (doi: [http://doi.org/10.17882/51557](http://doi.org/10.17882/51557))
- 0°S23°W from 2002 ...
- 0°S10°W from 2006 ... (EGEE/AMMA&PIRATA)
- New 0°S0°W (PREFACE&PIRATA) from 2016 ... (will be serviced in 2018).
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T-Flex 2017: Real-Time Dissolved Oxygen

- 8 subsurface O2 Sensors were deployed at 3 sites along 23W (IFM/GEOMAR):
  - 21N, 23W at Depths: 80m, 150m, 300m (all real-time)
  - 12N, 23W at Depths: 80m, 300m, 500m (all real-time)
  - 4N, 23W at Depths: 300m, 500m
  - 4 new time series and one new site initiated (in bold above)
Moored and ship-based CO₂ data are available through the Surface Ocean CO₂ Atlas (SOCAT, www.socat.info).

(Lefèvre et al., 2016)

(Bruto et al., 2017)
**Ocean Tracking Network (OTN) Data**

PI: F. Whoriskey (Dalhousie U, CAN)

OTN sensors at 200m depth on each PIRATA buoy from 2014 ...
(acoustic receivers for monitoring sea mammals)

[Map of Currently Active Receivers]

//members.oceantrack.org
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**Turbulence/mixing Data**

PI: J. Moun (Oregon SU, USA)
- 5 years NSF project: 2015-2020;
- Along the equator: at 0°S23°W & 0°S10°W;
- Pilot experiment (2014-2015): 1 χpods at 30m depth on each site;
- From 2015 ... : 5 χpods at 21, 35, 50, 65 and 81m depth on each site.

ADCP currents at 1 hour sampling interval and χpod T°C and dissipation (ε) as 10-minute averages (from 100 Hz data).

Figure 1 – Time series of wind stress, temperature (sea surface and 30 m), u and v currents at 30 m depth and the dissipation rate, ε at 0, 10W - 04 May 2014 to 23 March 2015. TROPFLUX wind stress replaces buoy wind stress after sensor failure.
New product: Enhanced PIRATA (ePIRATA)

All original PIRATA measurements are retained, after removal of questionable data and correction for biases.

Temperature and salinity mapped to 5m vertical grid using PIRATA and Argo data, gaps filled.

Mixed layer heat budgets with error bars

Foltz et al. (2018), J. of Climate, doi.org/10.1175/JCLI-D-16-0816.1
TACOS deployed in March 2017

- 11 current meters deployed at 4N, 23W mooring
- Hurricane activity and rainfall over neighboring continents impacted by air-sea interactions
- Few observations exist of upper ocean velocity in tropical North Atlantic and these currents can impact temperature, salinity, and air-sea fluxes
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MOVE – Meridional Overturning Variability Experiment
*Uwe Send and Matthias Lankhorst*

Mooring array with presently 3 sites in NW tropical Atlantic (16°N):

- Objective is to monitor Atlantic Meridional Overturning Circulation
- Started 2000 in German CLIVAR
- Since 2008, a US project, presently integrated in US AMOC program
- Moorings measure high-accuracy temperature and salinity throughout water column, in the west also current meters
- Ship cruises to retrieve data annually, major mooring service with CTD casts every other year
- Mooring data are available at OceanSITES

*Figure credit: Send et al., GRL 2011*
Moored observations within BMBF projects “RACE”/”SACUS”

Rebecca Hummels and Peter Brandt

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**Western Boundary Current Array**

**Time period** | **Funding**
---|---
2013-2015 | BMBF RACE
2015-2018 | BMBF RACE II
2018-2019 | GEOMAR
2019- | ?

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**Eastern Boundary Current Array**

**Time period** | **Funding**
---|---
2013-2018 | BMBF SACUS
2018-2021 | BMBF SPACES
2021- | ?

➢ Additionally, bottom pressure sensors/PIES are installed on both sides of the basin at 300m/500m depth.
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Cape Verde Ocean Observatory – CVOO

Ship program [0 – 500 m]
- Temperature, Salinity
- $O_2$
- (In)organic Carbon
- Nutrients
- Fluorescence/Turbidity
- Chlorophyll a
- Light

Mooring program [0 – 3600 m]
- Temperature
- Salinity
- Current
- $O_2$
- $pCO_2$
- Particle Flux

Glider program [0 – 1000 m]
- Temperature
- Salinity
- $O_2$
- Fluorescence/Turbidity
- (Nitrate)
- $pCO_2$
- biomass

Field campaigns
- Oceanographic side campaigns (biol./phys/chem.)
- Atmospheric campaigns
- Instrumentation testing
Cape Verde Ocean Observatory – CVOO

Biogeochemical shipboard time series site
- Off West Africa, in EEZ of Cape Verde Archipelago
- Located 60 nm offshore, 3600 m water depth
- Labs etc. hosted by the Ocean Science Centre Mindelo (OSCM)

Focus region 1 (West Africa)
- Local research vessel can operate within entire region
- Student exchange between Cape Verdean and West African students planned (WASCAL Master Program)

Focus region 2 (North-South)
- Coordinate activities
- Plan future joint campaigns
- Using autonomous assets to connect observatories
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PIRATA Enhancements/Collaborations

- 6 Flux Reference Sites (15N38W, 19S34W, 12N23W, 0-23W, 10S10W, 6S8E):
  LWR, BP, 10m CM, 2 add’l. subsurface T (5m, 10m), 4 add’l. S (5m, 10m 60m, 80m)
- Continued enhancement of EU AtlantOS funded sensors (T/C and Vel.) on additional moorings
- 3 Surface CO$_2$/O$_2$ (LOCEAN)
- 8 Subsurface O$_2$ (IFM/GEOMAR); 6 in real-time; Plans for 8 real-time in 2018
- 1 Surface Pressure (BP) at 20°N, 38°W (Meteo France)
- 2 Sites w/$5$ Thermal microstructure sensors (10 total) (ChiPods, OSU)
- 18 Acoustic monitors (OTN, Dalhousie University)
- AEROSE (Aerosols and Ocean Science Expeditions, NCAS)
- 10 additional current meters at 4°N, 23°W (AOML)
- 9 new T/C sensors planned for each of 3 sites (FUNCEME) at:
  8N38W, 4N38W, and 0-35W

Courtesy: M. McPhaden (NOAA)
**T-Flex Implementation Underway**

- T-Flex and ATLAS systems provide equivalent data and T-Flex performance (real-time & delayed-mode data return, record length) equal to or better than ATLAS.
- Standalone T-Flex systems currently in RAMA (8 sites) and PIRATA (7 sites + 3 more sites in Nov 2017)
- No new T-Flex sites scheduled for PIRATA in 2018. Additional sites to be converted in 2019.

**Courtesy:** M. McPhaden (NOAA)