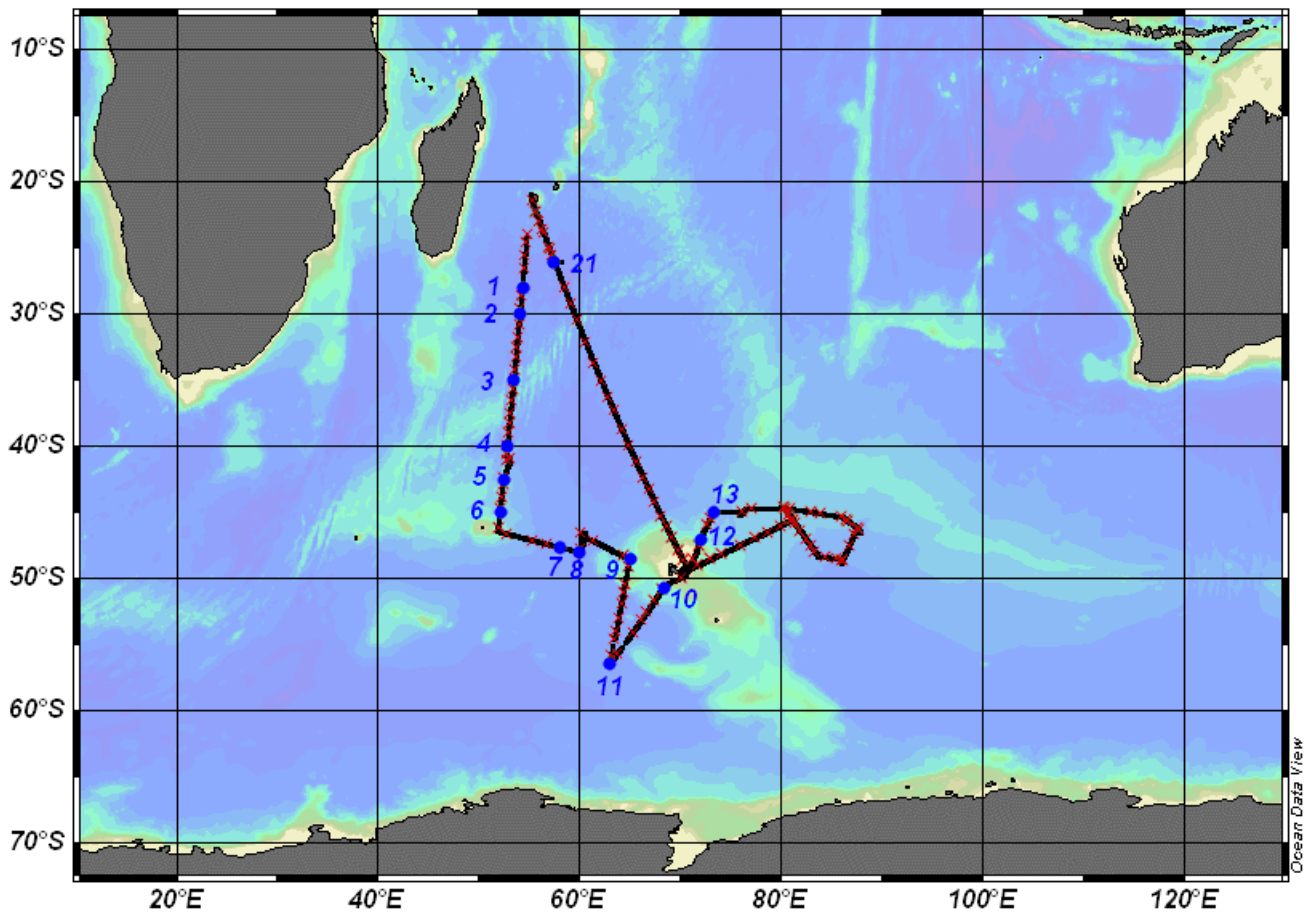# OISO19 cruise

conducted in Jan./Feb.2011

on board *R.V. Marion Dufresne*

Map locating the observations collected during the OISO19 cruise conducted in 2011 during austral summer (Jan./Feb.). Water column samples were collected at 14 CTD stations (shown as blue dots). Also indicated are the surface underway measurements of CO_2 and related parameters (continuous measurements in black, water sampling in red).

OISO19 - Metadata for water column observations

Principal Investigators

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Cruise Info

Project Name:	Océan Indien Service d'Observation (OISO)
Objectives:	The OISO program, started in 1998, aims at monitoring observations of the CO_2 system and associated properties (hydrology, biogeochemistry) in both sea surface and water column in the Southern Indian Ocean.
Cruise Name :	OISO19
Expocode:	35MF20110114
Region:	South Indian Ocean
Spatial Coverage:	28°S-58°S, 52°E-84°E
Temporal Coverage:	14 Jan. 2011 - 20 Feb. 2011
Ports of Call:	Le Port, Reunion Island
Vessel, Country:	Marion Dufresne (IPEV), France

Dataset Info

Submission Date: 2013, May

- Temperature CTD:

      Units : Degree Celsius

      Method: Temperature sensor Sea-Bird SBE3, calibrated in Dec. 2010.

      Quality Control: Temperature data are in good agreement with previous observations collected at the same locations (INDIGO, WOCE and OISO data).

- Salinity CTD:

      Method: Conductivity sensor Sea-Bird SBE4, calibrated in Dec. 2010.

      Quality Control: Salinity CTD data are in good agreement with bottle measurements (mean overall difference : bottle - CTD = 0.004 ± 0.006). A larger offset is found for stations 1 to 4 (0.012 ± 0.005) and station 9 (0.008 ± 0.002).

- Measured Salinity:

      Method: Water samples were collected from the Niskin bottles in 150 ml salinity bottles (Ocean Scientific International Ltd) and properly stored. Measurements were performed at LOCEAN using a Salinometer Guidline AUTOSAL 8400.

      Standardization: IAPSO standards were used (Ocean Scientific International Ltd).

      Accuracy: ±0.005, based on the analysis of replicate samples.

      Quality Control: A good agreement is obtained with previous observations collected at the same locations (INDIGO, WOCE and OISO data).

- Measured Oxygen

      Units: µmol/kg

      Method: Water samples were collected from the Niskin bottles in calibrated glass bottles (150-200ml). Measurements were performed onboard following Winkler's titration technique (Williams and Jenkinson,1982).

      Standardization: Iodate standards were used (Ocean Scientific International Ltd).

      Field Replicate: Deep replicate samples were collected from two different Niskin bottles (1000m or bottom). The mean difference between two deep replicates was 2.1 ± 2.3 µmol/kg (n=12).

      Accuracy: ±2 µmol/kg based on the analysis of deep replicate samples.

Quality Control: Deep oxygen data are in good agreement with previous observations collected at the same locations (INDIGO, WOCE and OISO data).

Method References:

Williams, P. J. LeB, and N. W. Jenkinson, 1982. A transportable microprocessor-controlled precise Winkler titration suitable for field station and shipboard use. *Limnol. Oceanogr,. 27*, 576-585.

- Total CO_2 and Alkalinity

Units: µmol/kg

Method: Water samples were collected from the Niskin bottles in 500 ml glass bottles for the simultaneous analysis of total CO_2 and total alkalinity. Measurements were performed onboard following a potentiometric titration method (Edmond, 1970), using an automated system with a closed cell described by Goyet et al. (1991). The equivalence point is determined using a non-linear regression method (D.O.E., 1994).

Standardization: We used Certified Referenced Materials (CRMs), batch #104, provided by Dr. A. Dickson (SIO, University of California). The precision of the titration system, based on the analysis of CRMs, was ±3.7 µmol/kg for total CO_2 and ±2.7 µmol/kg for total alkalinity.

Field Replicate: Deep replicate samples were collected from two different Niskin bottles (usually 1000m or bottom). The mean difference between two deep replicates was 2.1 ±0.9 µmol/kg for total CO_2 and 2.5±2.1 µmol/kg for alkalinity (n=11).

Accuracy: ±3 µmol/kg for both total CO_2 and alkalinity based on CRMs analysis.

Quality Control: High concentrations of total CO_2 and alkalinity measured in circumpolar deep waters are supported by low $\delta^{13}C$ values. We also found high total CO_2 concentrations in subtropical deep waters (station 21) compared to WOCE and INDIGO data, which was associated with high nitrate concentrations. Consequently, we attributed these anomalies to natural variability, in good agreement with observations collected the previous year (OISO18).

Method References:

D.O.E., 1994. Handbook of methods for analysis of the various parameters of the carbon dioxide system in sea water; version 2, A.G. Dickson and C.Goyet, eds. ORNL/CDIAC-74.

Edmond J. M., 1970. High precision determination of titration of alkalinity and total CO_2 of seawater by potentiometric titration, Deep-Sea Research, 17, 737-750.

Goyet C., C. Beauverger, C. Brunet and A. Poisson, 1991. Distribution of carbon dioxide partial pressure in surface waters of the southwest Indian Ocean, Tellus, 43B, 1-11.

- Silicate and Nitrate+Nitrite

Units: µmol/kg

Method: Water samples collected from Niskin bottles were filtered (0.2 µm) and poisoned with 0.1ml of saturated $HgCl_2$ solution. Two samples were collected from each Niskin bottle, and stored in two plastic bottles of 20ml in a cold and dark environment. Measurements were performed at LOCEAN using an automated system (AA3, Bran+Luebbe), following the segmented flow method described by Aminot and Kérouel (2007) and Coverly et al. (2009).

Standardization: Nutrients standard solutions (Ocean Scientific International Ltd) were diluted and used as reference samples.

Field Replicate: Deep replicate samples were collected from two different Niskin bottles (usually 1000m or bottom). The mean difference between two deep replicates was 0.4 ±0.6 µmol/kg for silicate and 0.2±0.2 µmol/kg for nitrate+nitrite (n=14).

Accuracy: ±0.2 µmol/kg for silicate and nitrate+nitrite, based on the analysis of 40 reference samples.

Quality Control: Nutrients data are in good agreement with previous observations collected at the same locations, with the exception of deep measurements at station 21 where high concentrations of nitrate are found compared to historical cruises (INDIGO and WOCE). However, because it was associated with higher total CO_2 concentrations, we attributed this anomaly to natural variability rather than a bias in the data.

Method References:

Aminot, A., and R. Kérouel, 2007. Dosage automatique des nutriments dans les eaux marines : Méthodes en flux continu. Ed. Quae / Ifremer, 2007, 188pp.

Coverly, S. C., Aminot, A., and R. Kérouel, 2009. Nutrients in Seawater Using Segmented Flow Analysis, In *Practical Guidelines for the Analysis of Seawater*, Ed. Oliver Wurl, CRC Press, June 2009, doi: 10.1201/9781420073072.ch8.

- Phosphate

  PI : Dr. C. Ridame (LOCEAN-IPSL)

  Units: µmol/kg

  Method: Water samples collected from Niskin bottles were filtered (0.2 µm) in plastic
  bottles of 20 ml, and stored at -60°C. Measurements were performed at LOCEAN
  by use of the colorimetric method of Murphy and Riley (1962) by manual
  spectrophotometry;

  Standardization: Phosphate solutions were used as reference samples.

  Field Replicate: The difference between two deep replicates was lower than 0.2 µmol/kg.

  Accuracy: the reproducibility was ±5%

  Detection limit = 0.02 µM

  Quality Control: Phosphate data are in good agreement with previous observations
  collected at the same locations, with the exception of deep measurements at
  station 21 (associated with high nitrate and total CO_2 concentrations) and in
  circumpolar deep waters (associated with high total CO_2 and alkalinity
  concentrations). These anomalies are attributed to natural variability.

  Method References:

  Murphy, J., and J. P. Riley. 1962. A modified single solution method for the
  determination of phosphate in natural waters. *Anal. Chim. Acta 27*: 31–36.

- Carbon isotope $\delta^{13}C_{DIC}$

  PI : Dr. C. Pierre (LOCEAN-IPSL)

  Units: ‰ (vs. Vienna-Pee Dee Belemnite)

  Method: Water samples were collected from the Niskin bottles in 125 ml glass bottles
  and poisoned with 1 ml of saturated $HgCl_2$ solution for storage. Measurements
  were performed at LOCEAN using a dual inlet-isotopic ratio mass spectrometer
  (SIRA9-VG), following the method described by Racapé et al. (2010), adapted
  from Kroopnick (1974). The precision and the reproducibility of this method are
  respectively close to ± 0.01 ‰ and 0.02‰ (Vangriesheim et al., 2009; Racapé et
  al., 2010).

  Standardization: The isotopic composition is expressed in the δ-unit defined by Craig
  (1957) by comparing the $^{13}C/^{12}C$ ratio of the sample (R) to the $^{13}C/^{12}C$ ratio of a
  reference material (R*), the Vienna-Pee Dee Belemnite (V-PDB), as follows:
  $\delta^{13}C_{DIC} = [(R/R^*) -1]$ x 1000.

Accuracy: ± 0.01‰ based on the analysis of replicate samples.

Quality Control: $\delta^{13}C_{DIC}$ data are in good agreement with previous observations collected at the same locations, with the exception of low values measured in circumpolar deep waters. We attributed this anomaly to natural variability because it was associated with high total CO_2 and alkalinity concentrations.

Method References:

Craig, H. 1957. Isotopic standards for carbon and oxygen and correction factor for mass-spectrometric analysis of carbon dioxide. *Geochimica Cosmochimica Acta, 12*, 133-149.

Kroopnick, P. 1985. The distribution of ^{13}C of ΣCO_2 in the world oceans. *Deep-Sea Research, 32 (1)*, 57-84.

Racapé, V., C. Lo Monaco, N. Metzl, and C. Pierre, 2010. Summer and winter distribution of $\delta^{13}C_{DIC}$ in surface waters of the South Indian Ocean (20°S-60°S). *Tellus B, 62 (5)*, 660-673, doi: 10.1111/j.1600-0889.2010.00504.x

Vangriesheim, A., Pierre, C., Aminot, A., Metzl, N., Baurand, F. and co-authors. 2009. The influence of Congo river discharges in the surface and deep layers of the Gulf of Guinea. *Deep-Sea Res. II*, doi:10.1016/j.dsr2.2009.04.002.

Additional information:

Other data: More parameters were measured during the OISO19 cruise: (contact PIs above)

- Water column measurements of $\delta^{18}O_{H2O}$, chlorophyll-a, light attenuation (PAR).

- Incubation for measurements of primary production and N_2 fixation.

- Underway surface pCO_2 and related physical and biogeochemical parameters.

- Atmospheric pCO_2 and meteorological observations

- Underway Current Profiler (ADCP)

Project URL: http://caraus.ipsl.jussieu.fr/oiso-accueil.html