Current and Oxygen Variability in the Tropical North East Atlantic

J. Hahn, P. Brandt, R. J. Greatbatch, G. Krahmann, A. Körtzinger

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1. Motivation

2. Data

3. Results
   3.1 $O_2$ mooring time series / dominant time scales of $O_2$ fluctuations
   3.2 Seasonal cycle
   3.3 Velocity and $O_2$ fluctuations / $O_2$ flux

4. Summary
1. Motivation

Oxygen Distribution in the Tropical Atlantic

O$_2$ distribution, top view (depth 300m - 500m)

Brandt et al. (2010)

O$_2$ cross section

Brandt et al. (2010)
1. Motivation

Analysis of repeated ship sections

Mean $O_2$

$O_2$ variance

sources for $O_2$ variance?

- stirring by mesoscale eddies / diapycnal mixing

- (zonal) current variability
1. Motivation

Lumpkin and Garzoli (2005)

Zonal currents

characteristic mean field (surface and near surface currents)

Brandt et al. (2010)

Zonal speed, 23-33°W

seasonal cycle of surface currents (shaded regimes: eastward velocity)

Lumpkin and Garzoli (2005)
Seasonal cycle of oxygen from CTD/O$_2$ data

Stramma et al. (2008)
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Goals

Goal I: Identify characteristic time scales of oxygen variability.

• Is there pronounced variability at defined time scales, e.g. seasonal or intraseasonal variability?

Goal II: Identify the physical processes that are responsible for the ventilation of the Tropical North East Atlantic.

• Does a seasonal cycle in zonal velocity contribute to the $O_2$ flux / $O_2$ supply?
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Moored observations along 23°W

background: $O_2$ distribution at 400m depth from *World Ocean Atlas 2009*
2. Data

Moored observations along 23°W

(O$_2$ distribution: update from Brandt et al. (2010))

Moored observations along 23°W (O$_2$ distribution: update from Brandt et al. (2010))
2. Data

Moored observations along 23°W

(O₂ distribution: update from Brandt et al. (2010))

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3. Results

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Moored observations
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O₂ time series

300m
11.5°N

8°N

5°N

4°N

500m
11.5°N

8°N

5°N

4°N

[σ²(O₂)] = μmol² kg⁻²
3. Results

$O_2$ time series, lowpass $>90d$

300m

$[\sigma^2(O_2)] = \mu\text{mol}^2\text{kg}^{-2}$ (% total $\sigma^2$)

$87.8\ \mu\text{mol}^2\text{kg}^{-2}$ (67%)

500m

$3.0\ \mu\text{mol}^2\text{kg}^{-2}$ (35%)

$64.3\ \mu\text{mol}^2\text{kg}^{-2}$ (42%)

$34.6\ \mu\text{mol}^2\text{kg}^{-2}$ (52%)

$56.1\ \mu\text{mol}^2\text{kg}^{-2}$ (33%)

$92.1\ \mu\text{mol}^2\text{kg}^{-2}$ (64%)

$42.2\ \mu\text{mol}^2\text{kg}^{-2}$ (51%)
**O₂ time series, bandpass (10d – 90d)**

**300m**

- **11.5°N**
- 2009 | 2010 | 2011 | 2012
- [24.1 µmol² kg⁻² (18%)]

**500m**

- **11.5°N**
- 2009 | 2010 | 2011 | 2012
- [1.9 µmol² kg⁻² (23%)]

**8°N**

- 2009 | 2010 | 2011 | 2012
- [44.6 µmol² kg⁻² (29%)]

**8°N**

- 2009 | 2010 | 2011 | 2012
- [19.0 µmol² kg⁻² (29%)]

**5°N**

- 2009 | 2010 | 2011 | 2012
- [45.1 µmol² kg⁻² (31%)]

**5°N**

- 2009 | 2010 | 2011 | 2012
- [45.1 µmol² kg⁻² (31%)]

**4°N**

- 2009 | 2010 | 2011 | 2012
- [44.7 µmol² kg⁻² (26%)]

**4°N**

- 2009 | 2010 | 2011 | 2012
- [19.7 µmol² kg⁻² (24%)]
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O$_2$ seasonal cycle at 300m along 23°W

4°N

5°N

8°N

11.5°N
3. Results

$O_2$ seasonal cycle at 300m along 23°W

4°N

$O_2$ [μmol kg$^{-1}$]

5°N

$O_2$ [μmol kg$^{-1}$]

8°N

$O_2$ [μmol kg$^{-1}$]

11.5°N

$O_2$ [μmol kg$^{-1}$]

blue/red:
monthly means of individual years

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3. Results

O$_2$ seasonal cycle at 300m along 23°W

4°N

5°N

8°N

11.5°N

blue/red:
monthly means of individual years

black:
monthly means of all years

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3. Results

O$_2$ seasonal cycle at 500m along 23°W

4°N

5°N

8°N

11.5°N

blue/red: monthly means of individual years
3. Results

\( O_2 \) seasonal cycle at 500m along 23°W

\[ 4°N \]

\[ 5°N \]

\[ 8°N \]

\[ 11.5°N \]

\( O_2 \) [\( \mu \text{mol kg}^{-1} \)]

\begin{align*}
\text{month} & : 2 & 4 & 6 & 8 & 10 & 12 \\
\end{align*}

\text{blue/red: monthly means of individual years}
3. Results

O₂ seasonal cycle at 500m along 23°W

*indication for persistent seasonal variability*

**blue/red:** monthly means of individual years

**black:** monthly means of all years
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O₂ time series
O₂ and velocity time series at 5°N, 500m, lowpass >90 days

O₂ and u

O₂ and v

u, v leading O₂
3. Results

O₂ flux at 5°N

O₂ and v, lowpass > 10d (500m)

Analysis from Hahn et al. (subm.)

Meridional O₂ flux based on time series anomalies

F = \langle v' O₂' \rangle

Hahn et al. (subm.)

O₂ and u, lowpass > 90d (500m)

Zonal O₂ flux based on annual harmonic: of order O(F) = 1 \cdot 10^6 \text{μmol kg}^{-1} \text{m yr}^{-1}
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Summary

- O\textsubscript{2} mooring time series provide a reliable data set to manifest the complexity of O\textsubscript{2} fluctuations.

- The Tropical Atlantic is rich of O\textsubscript{2} variability on seasonal (30% - 60%) and intraseasonal (up to 30% of total O\textsubscript{2} variance) time scales.

- No well-defined seasonal cycle at 300m / some indication for a seasonal cycle at 500m.

- Seasonal variability of zonal currents might contribute to O\textsubscript{2} supply of the southern OMZ boundary.
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Thank you for your attention!