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A multi-platform approach to investigate hidden biogeochemical processes off West Africa

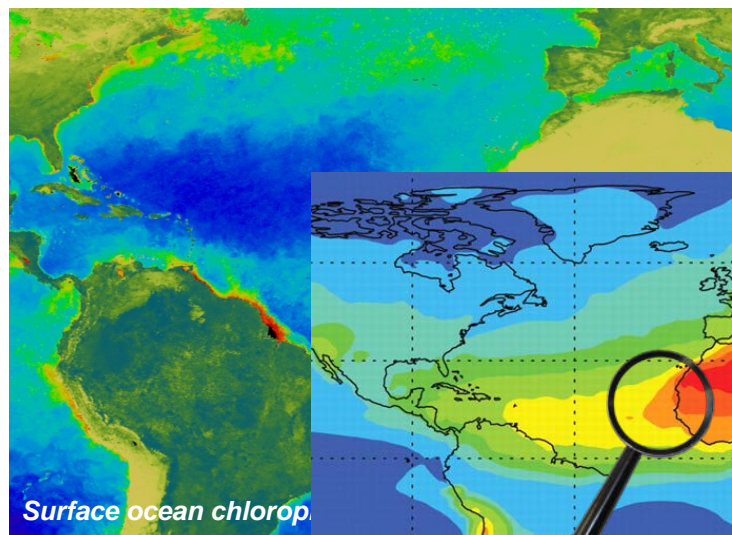
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GEOMAR Kiel, Germany

F. Schütte, P. Silva,
I. Monteiro, N. Vieira,
D. Grundle, C. Löscher,
J. Karstensen, C. Santos,
A. Körtzinger

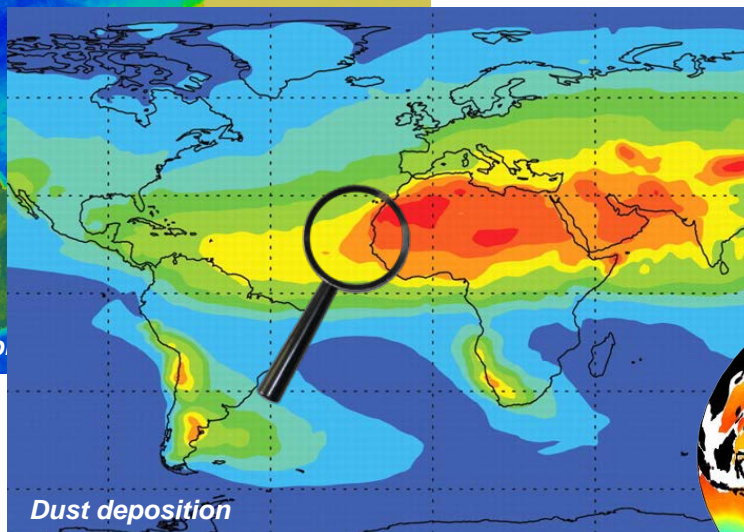
Aqua MODIS – Feb 07, 2012



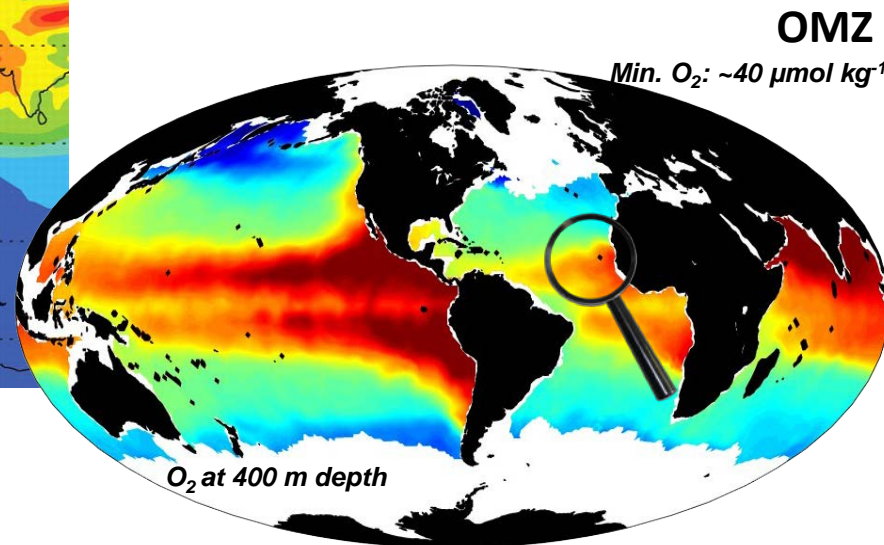
Study Area



Coastal
Upwelling



Dust
Deposition



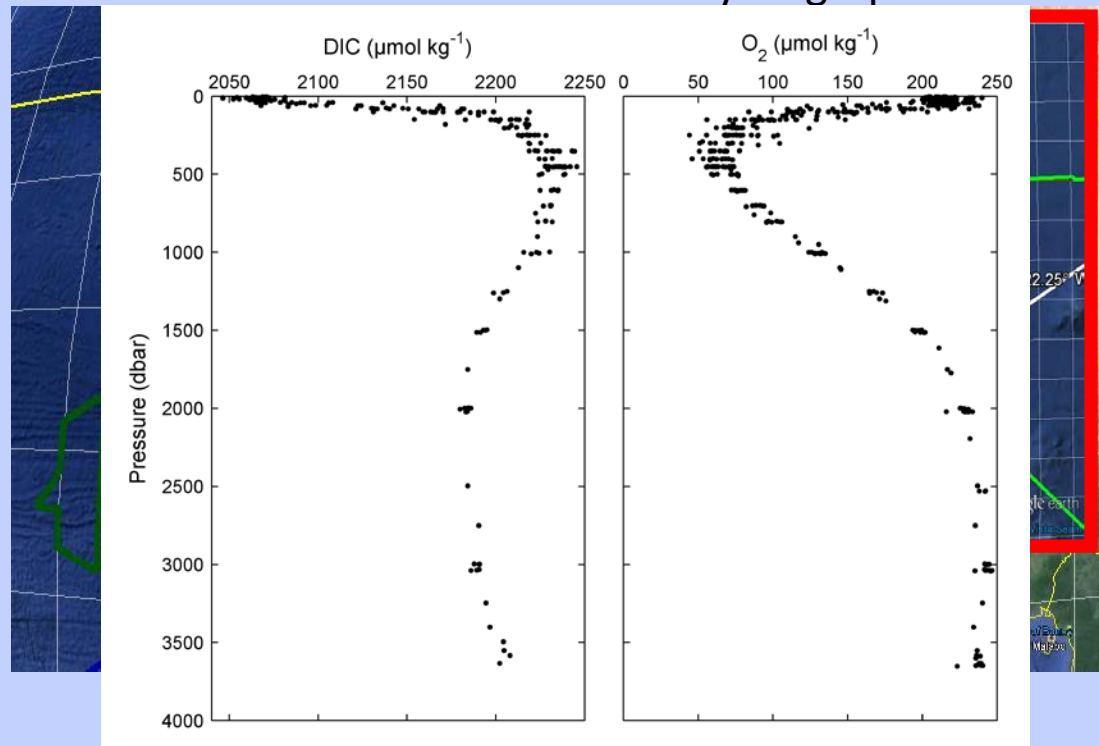
Mind the Gap: The Resolution “Issue”

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Hydrographic cruises

Resolution: Monthly/seasonal, stationary

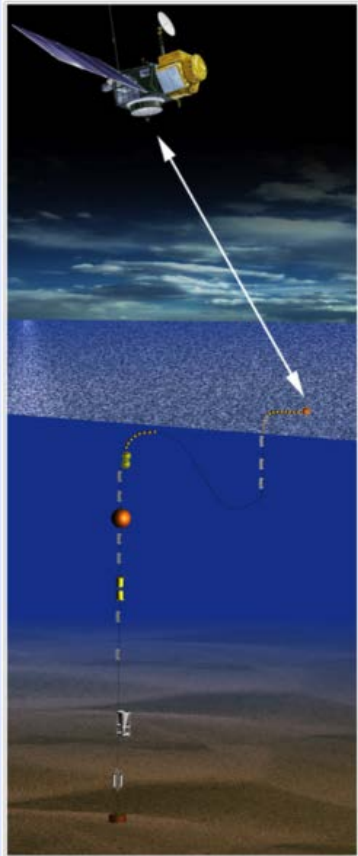


Mind the Gap: The Resolution “Issue”

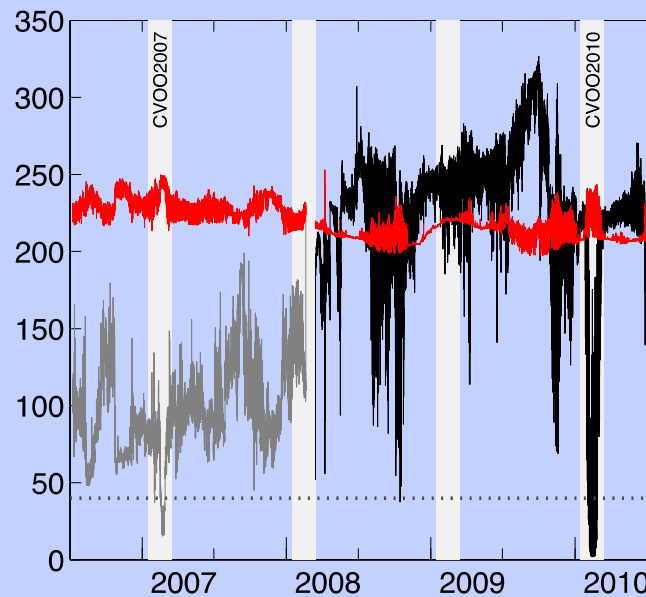
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Resolution: Monthly/seasonal, stationary

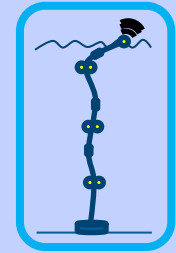
Resolution: Minutes, stationary



Long-term mooring, O₂ @ ~50 m



Karstensen et al., BG, 2015



Mind the Gap: The Resolution “Issue”

Resolution: Monthly/seasonal, stationary

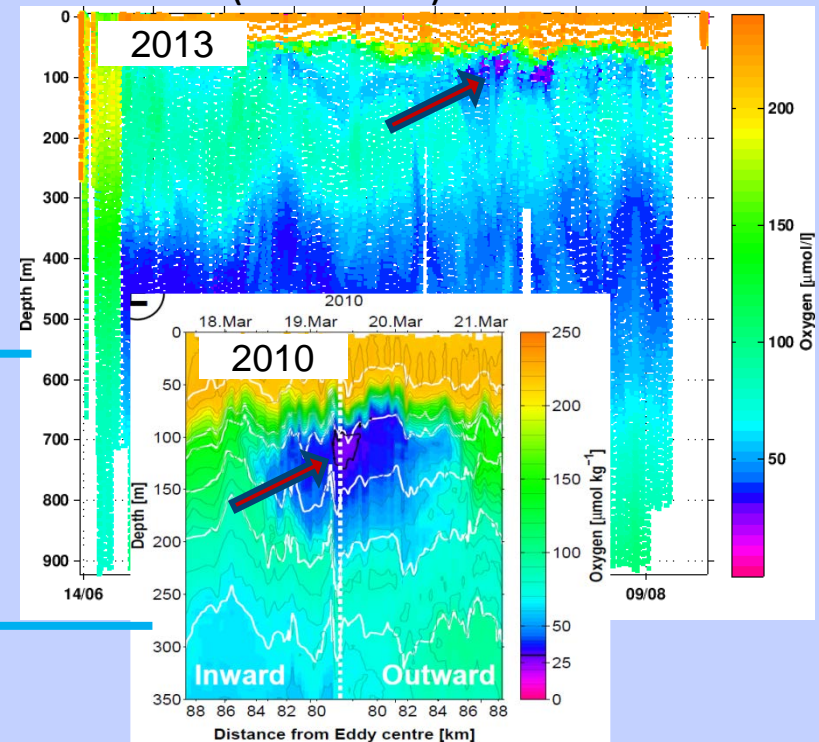
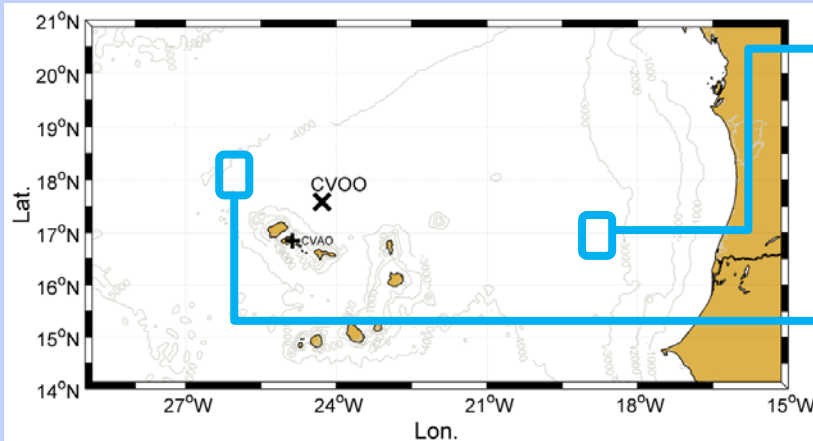
Resolution: Minutes, stationary

Resolution: Seconds, high spatial resolution, mobile

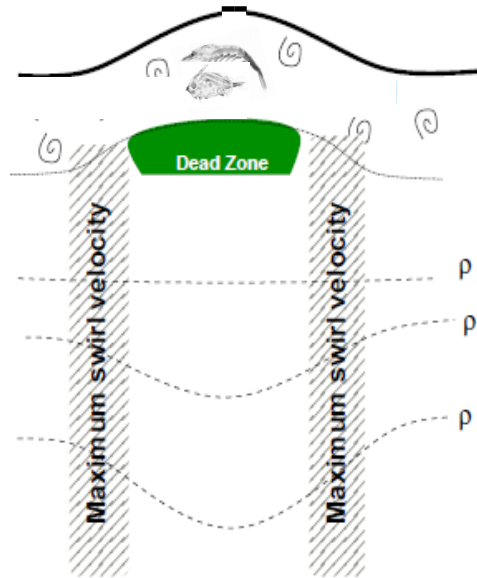


Photo: Teledyne Webb Research

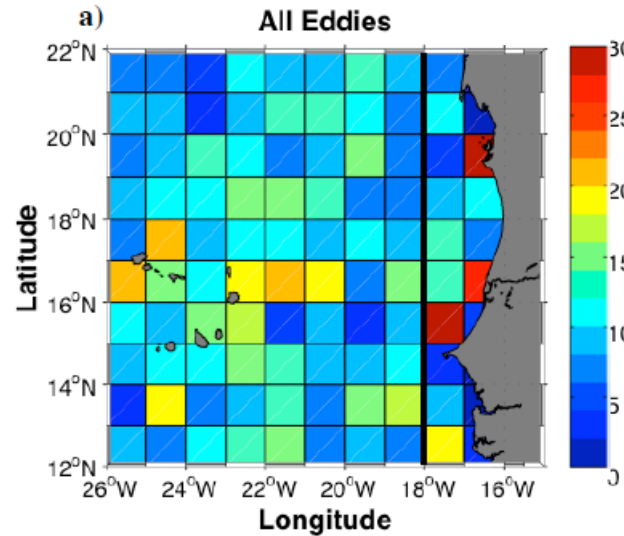
Measurements throughout the water column (0-1000 m)



Mesoscale Eddies



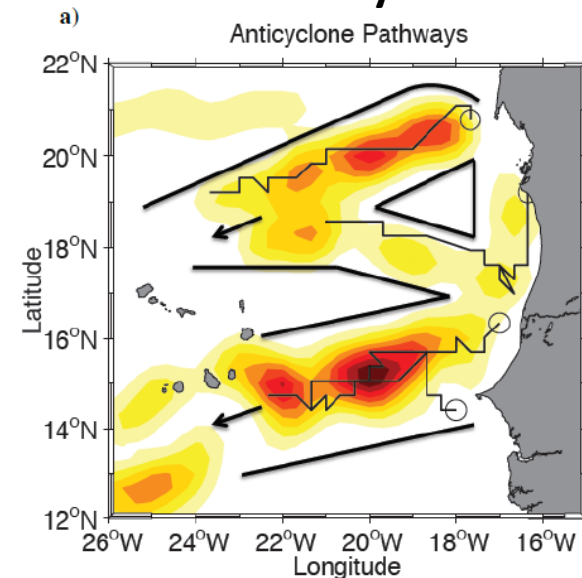
Anticyclonic Mode Water Eddy (ACME)



Schütte et al., *in prep.*

Eddy generating locations

Eddy corridors



Anticyclonic Mode-Water Eddies:

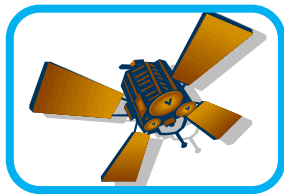
- Origin: Mauritanian Upwelling
- highly isolated water bodies, high organic matter payload
- intensive subsurface respiration

Dedicated Study: Hunting Eddies

Biogeochemistry and Ecology of Oxygen Depleted Eddies in the Eastern Tropical Atlantic:

Objectives:

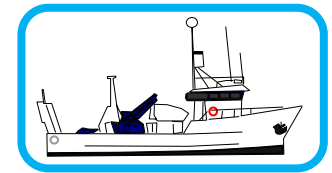
- locating and surveying a low- O_2 eddy
- identifying key biogeochemical processes + magnitudes
- ecosystem response (e.g., vertical + horizontal zooplankton distribution)
- building capacity



Remote Sensing:



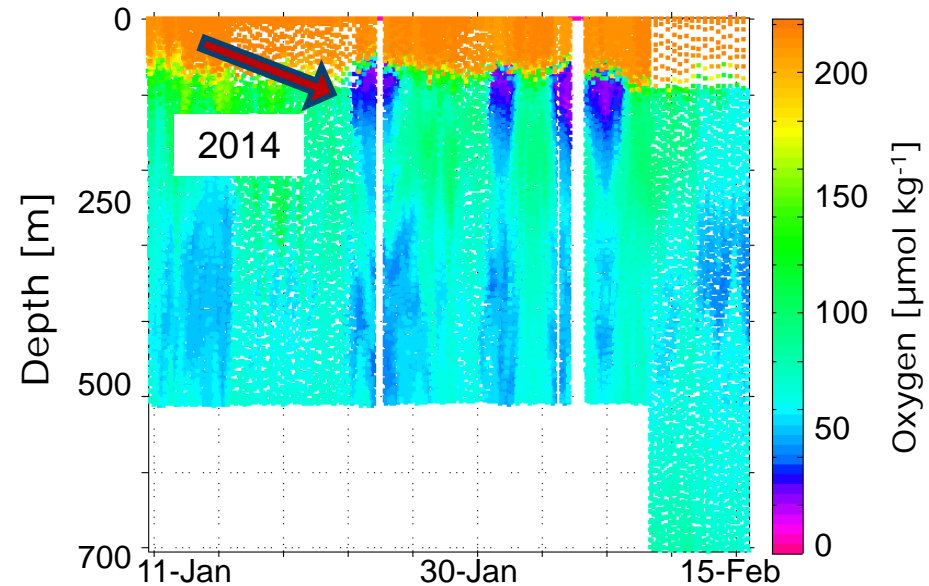
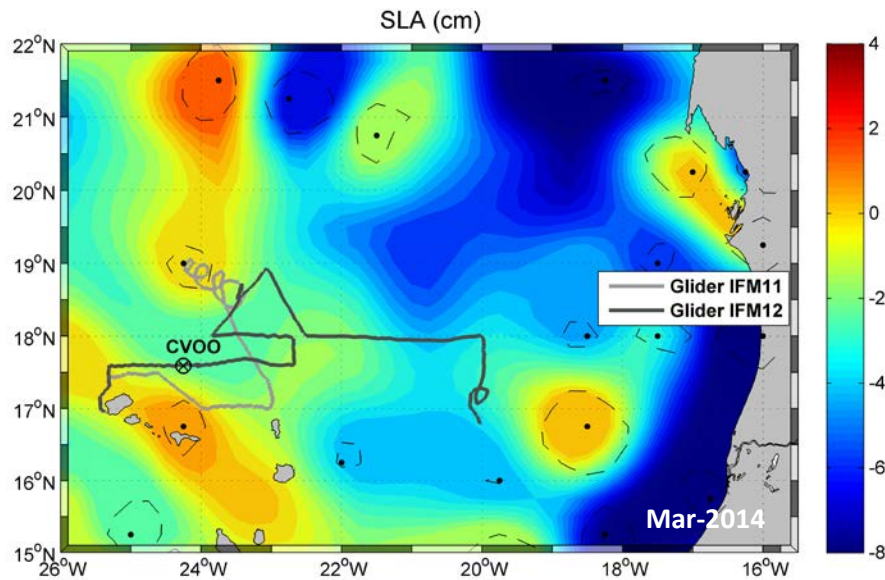
Glider survey:



Islandia survey:

- near-Realtime satellite maps for Sea Level Anomaly data (SLA) on cvo0.geomar.de
- Mission planning for glider survey
- detection of eddy candidates
- Mission planning for Islandia survey
- Full biogeochemical mapping of an eddy
- Obtaining first-time in situ data for: O_2 , Nutrients, DIC/TA, N_2/Ar , N_2O (+isotopes), TOC, DNA, Zooplankton

Eddy Hunt – Glider Survey



Glider surveys:

- 2 Gliders in Jan/Feb/Mar 2014
- 1 Glider in Mar/Apr 2014 (incl. NO_3^- sensor)

Eddy Hunt – Ship Surveys

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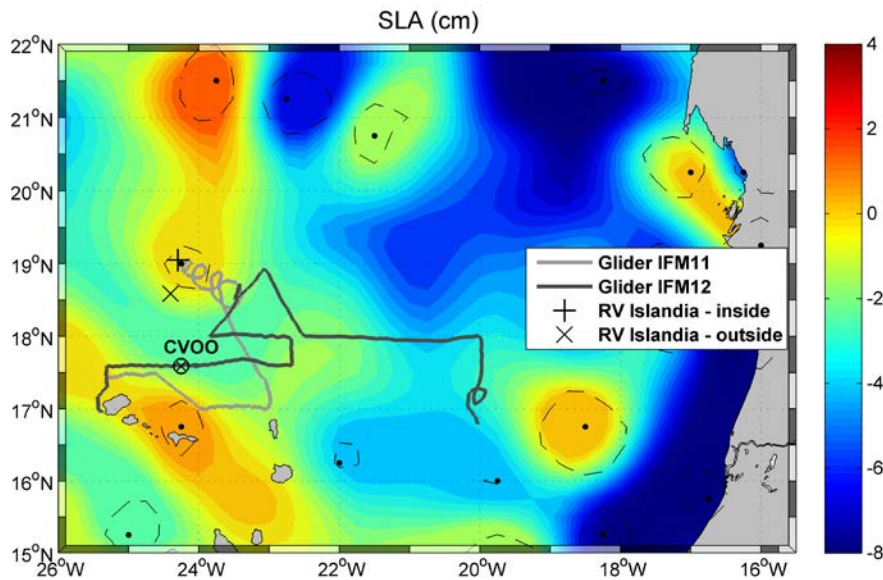


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Fiedler et al., *in prep.*

RV Islandia & Meteor surveys:

- Biogeochemical sampling in- & outside of the eddy
- Min. O₂ concentration at 100 m: **4.8 $\mu\text{mol kg}^{-1}$**

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Grundle et al., *in prep.*

- Exceptional high N₂O values in O₂ Minimum

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Nitrification

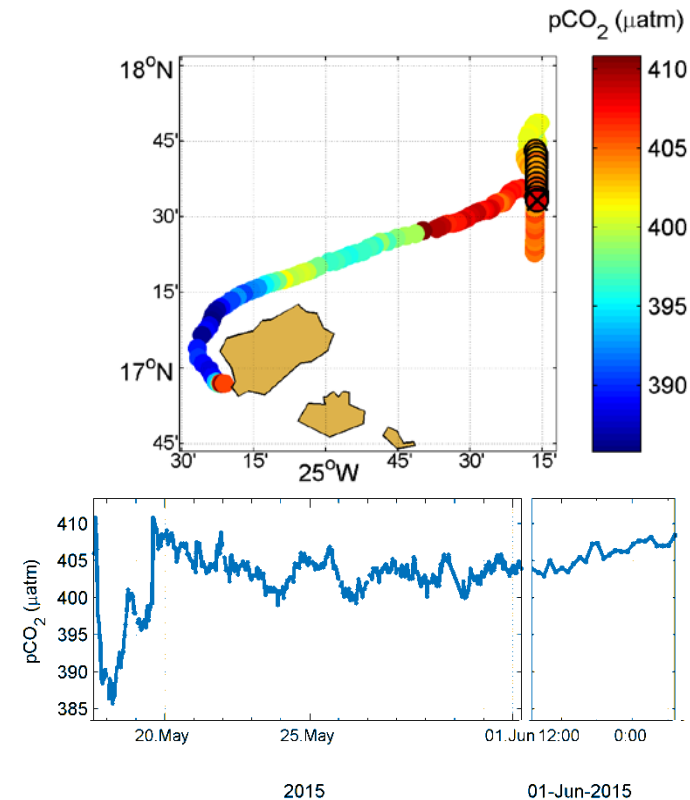
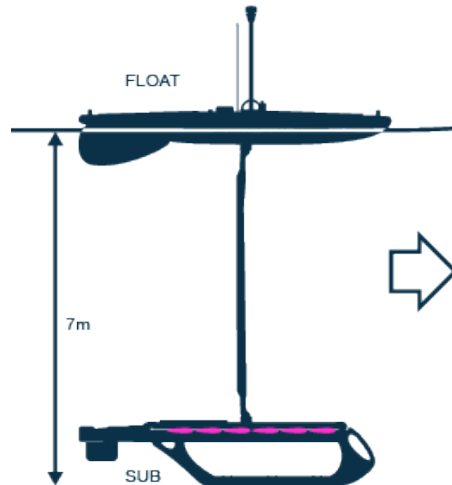
Denitrification

- Clear signatures of active denitrification!

Grundle et al., *in prep.*

Löscher et al., *in prep.*

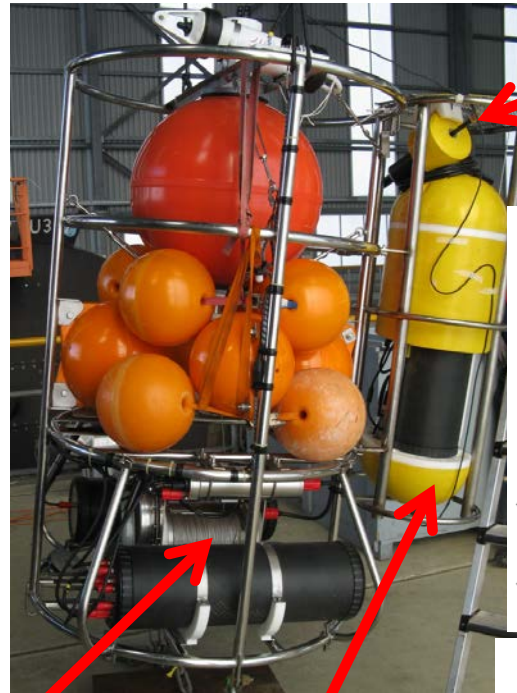
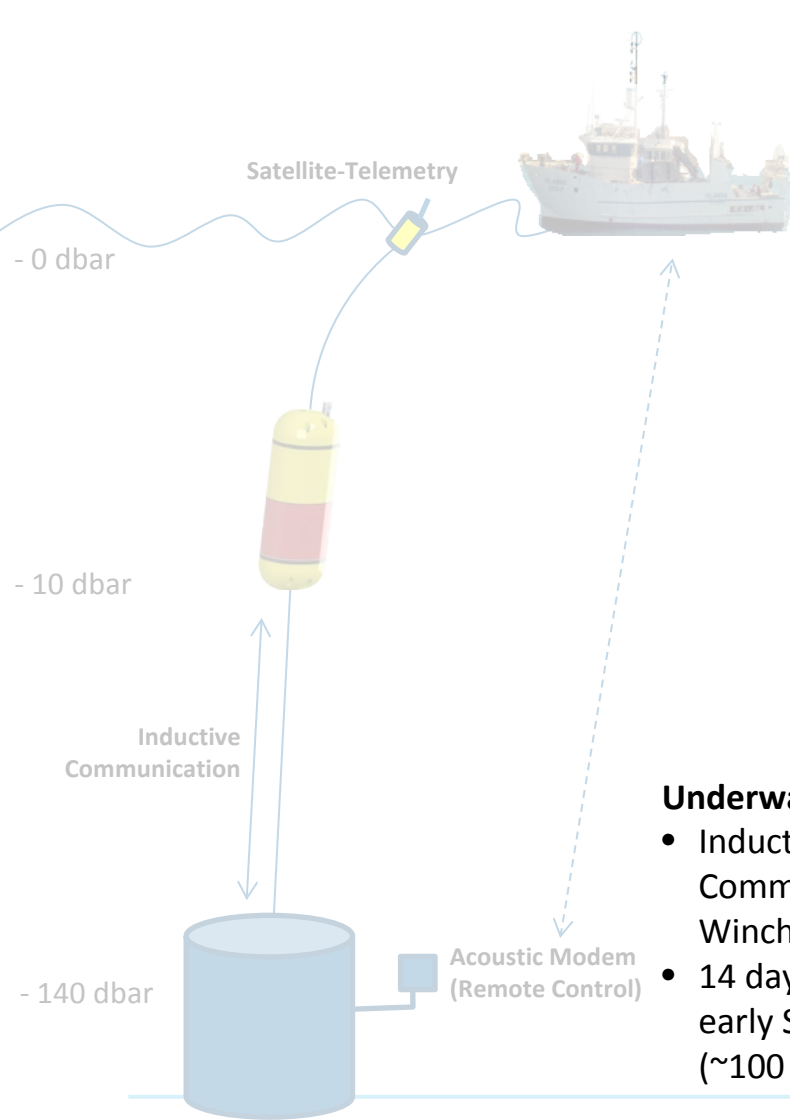
Wave Glider (enhancing horizontal resolution)



- Unmanned surface vehicle, realtime control via satellite
- Forward thrust by wave motion
- solar power for operating scientific sensors
- Rapid response: Eddies, dust events, volcanic eruptions

- CTD
- Fluor./Turb.
- $p\text{CO}_2$
- O_2
- Gas Tension/ N_2
- Wind, air press. & temp.

Moored Winch/Profiler (enhancing vertical resolution)



Sat-Telemetry:

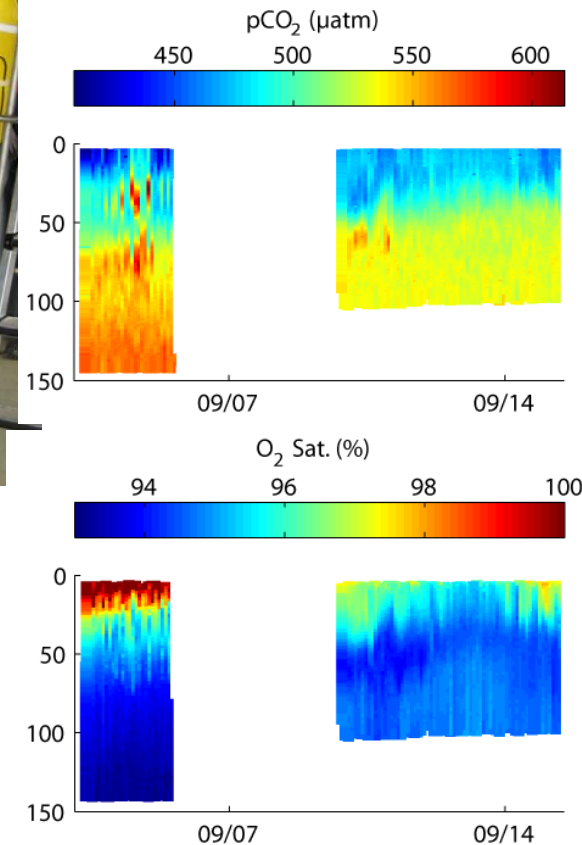
- Iridium
- GPS
- Remote Control

Underwater Winch:

- Inductive Communication Winch ↔ Profiler
- 14 days of profiling in early September 2014 (~100 profiles)

Profiler:

- CTD
- Fluor./Turb.
- $p\text{CO}_2$
- O_2



Summary

- Observation of several **open ocean O₂ anomalies** in the vicinity of CVOO, missed by shipborne time series samplings
- Features only detected by **synergetic autonomous observations** (mooring + glider)
- remote sensing + glider surveys used to guide a **comprehensive ship survey**

Eddy results:

- highly **isolated water body** (“mesocosm”)
- very **low pH** and **high nutrient** content in the core of the eddy
- **highest N₂O conc.** in the Atlantic Ocean
- evidence for open-ocean water column **denitrification in the Atlantic**
- hindrance of diurnal **zooplankton migration**

Next

- Extend autonomous observational capabilities (winch, wave glider)
- sample eddy at more (earlier) life stages
- Next Eddy Hunt in spring 2016

