Diapycnal diffusivity at the upper boundary of the North Tropical Atlantic oxygen minimum zone

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- Vertical mixing can contribute up to 30% of the ventilation in the regions of weak circulation [1].
- Tracer release experiment is the most accurate way to estimate time and space integrated diapycnal mixing rate, D.

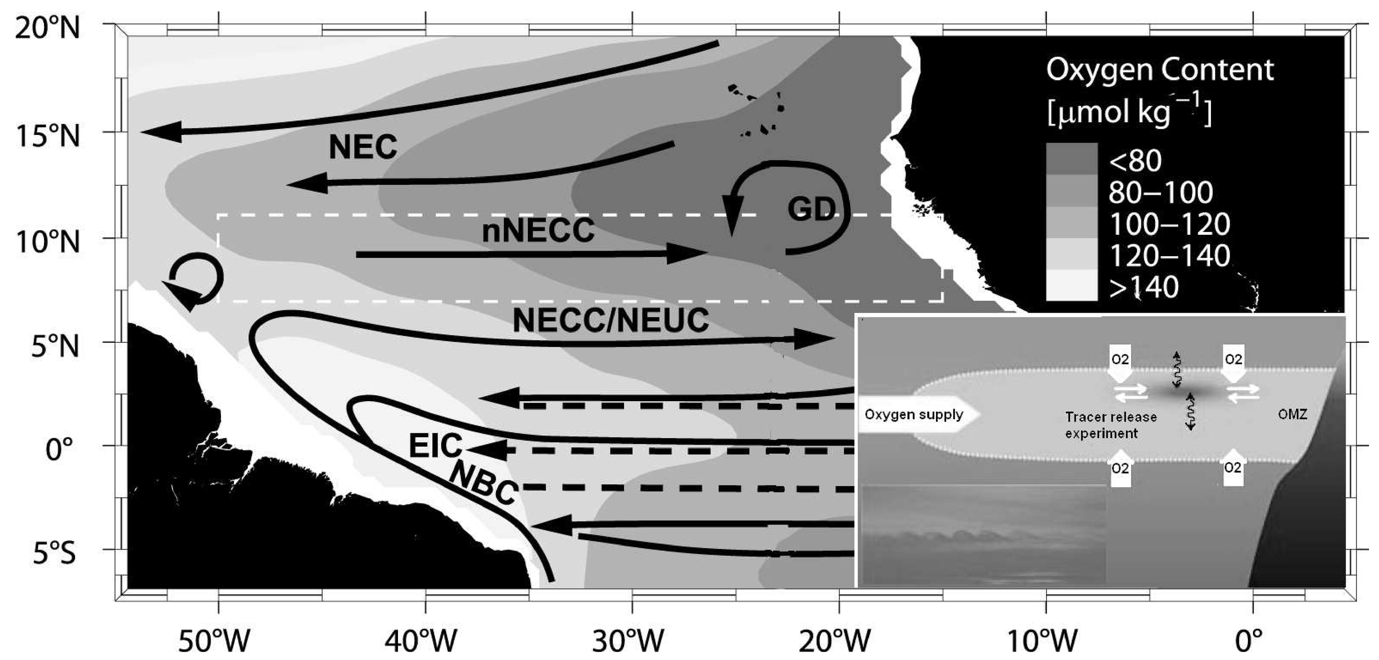

Figure 1: Oxygen distribution at 400 m depth with superimposed tropical Atlantic mean circulation (Fig. from [2], modified). Oxygen minimum zone (OMZ) is outlined by 80μmol kg^{-1} contour. Figure on the lower right corner show the sketch of the oxygen supply pathways to the OMZ. A circle at 8°N, 23°W marks the tracer injection position.

- The Guinea Upwelling Tracer Release Experiment (GUTRE) started in April 2008 by tracer, CF_3SF_5, injection on an isopycnal surface $\sigma_\Theta = 26.88$ kg m^{-3}, at about 350 m depth.
- Three surveys, performed 7 months, 20 months and 30 months after the tracer release, sampled the laterally and vertically expanding tracer patch.

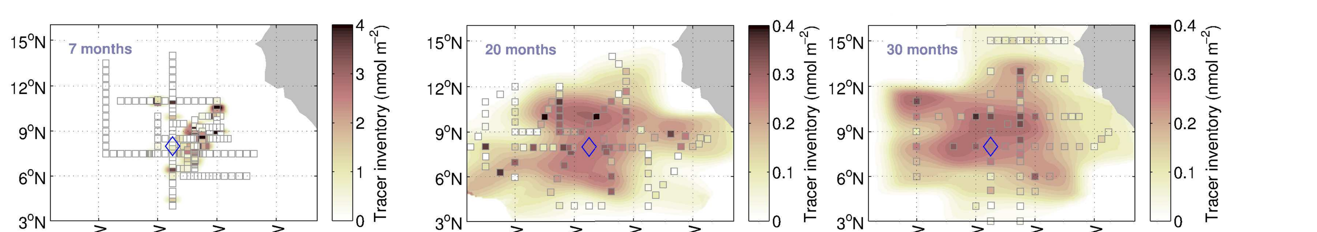

Figure 2: Lateral tracer patch distribution during three surveys. Squares mark the location of the tracer casts.

- According to simple diffusion model, D can be estimated directly from the time series of the squared widths of the Gaussian distribution.

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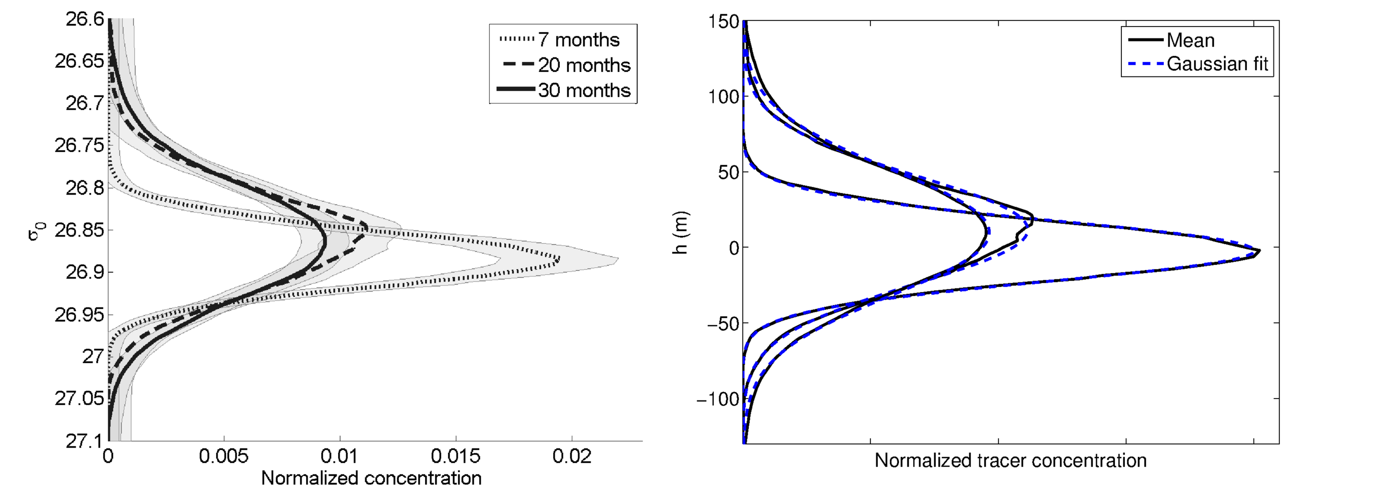
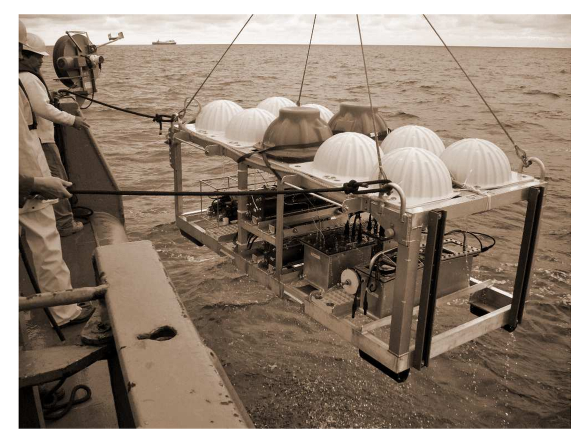
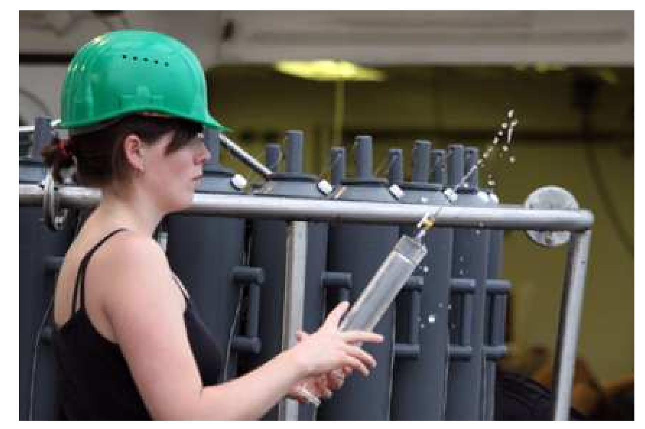


Figure 3: Normalized mean vertical tracer profiles for each survey plotted versus density (left) and height above the tracer injection density (right). Uncertainty is computed using Monte Carlo method and represents the variability in the shapes of the inidividual tracer profiles and the detection limit.

Result 1: D estimate for the whole period is $(1.2 \pm 0.1) \times 10^{-5}$ m^2s^{-1} in depth units, or $(3.1 \pm 0.2) \times 10^{-11}$ (kg $m^{-3})^2$ s^{-1} in density units.





- The vertical depth coordinates were transformed from density coordinates through the mean density-depth relation. Hence, result expressed in depth units is dependent on stratification.
- In the higher stratification region the isopycnals are squeezed and the tracer patch looks thinner than in the low stratification region. Hence, D appears smaller in high stratification region.

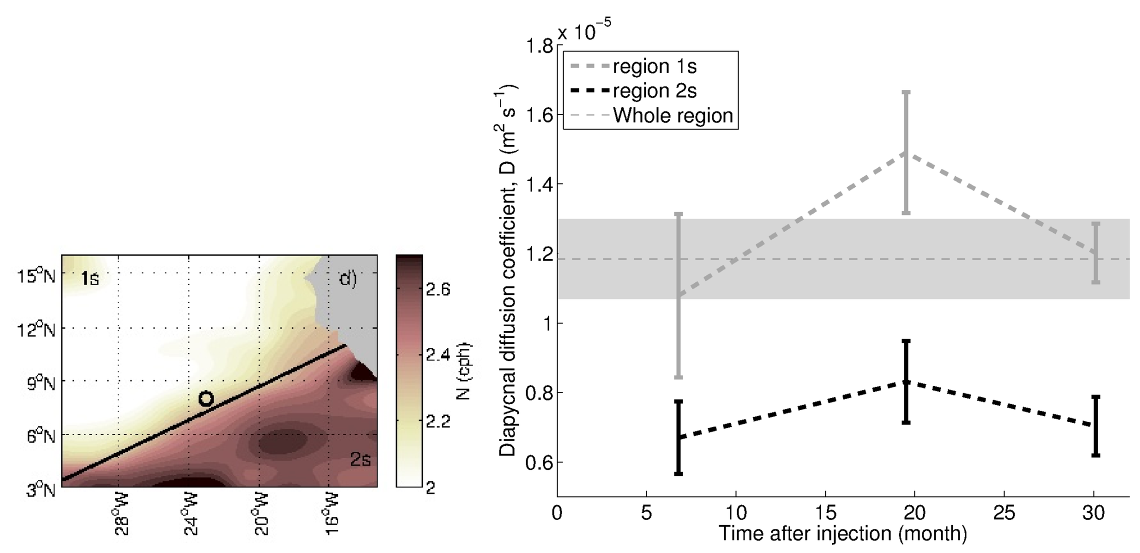


Figure 4: Figure on the left: two regions outlined in the site of experiment: low stratification ($N = 2.1$ cph) region (region 1s), and high stratification ($N = 2.7$ cph) region (region 2s). Figure on the right: D estimated for each survey using local density-depth profile.

Result 2: D in depth units was about 30% smaller in high stratification region (region 2s).

- Diapycnal diffusivity enhances in the proximity of the rough topography (e.g. [3]).

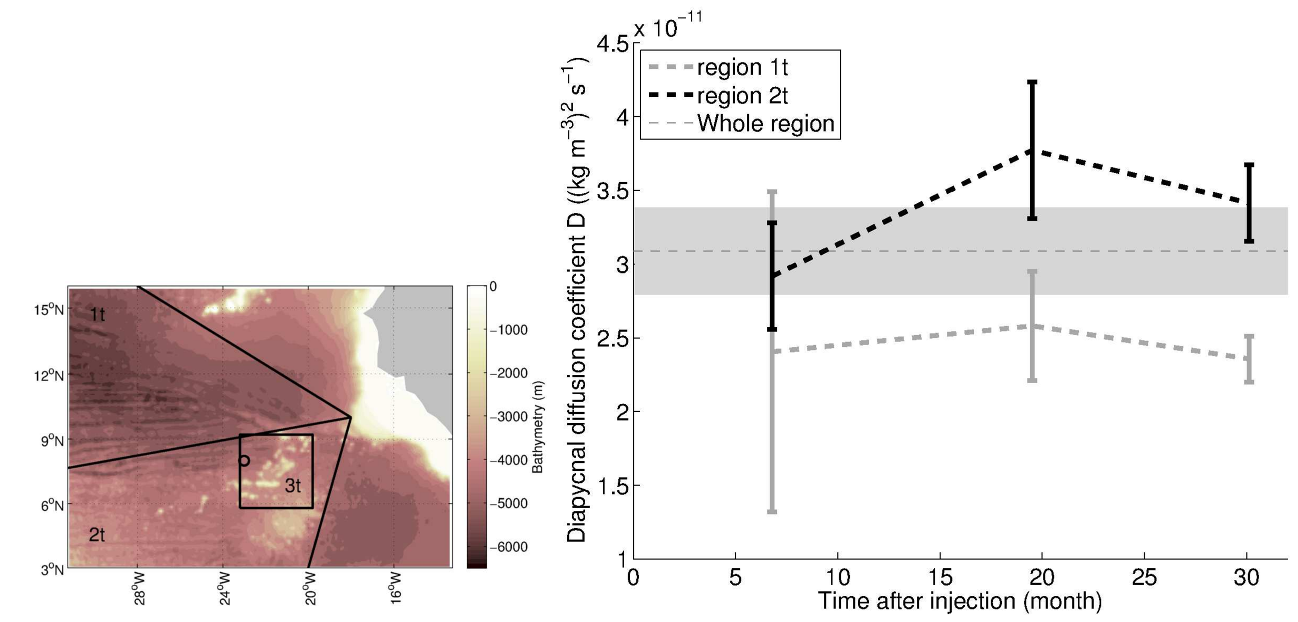


Figure 5: Figure on the left: three regions outlined in the site of experiment: abyssal plain region (region 1t), elevated topography region (region 2t), and seamount region (region 3t). Figure on the right: D in density units, estimated for each survey over region 1t and 2t. Seamount region (region 3t) yielded similar results to region 2t.

Result 3: D in density units was about 30% larger in elevated topography region as compared to the abyssal plane region.

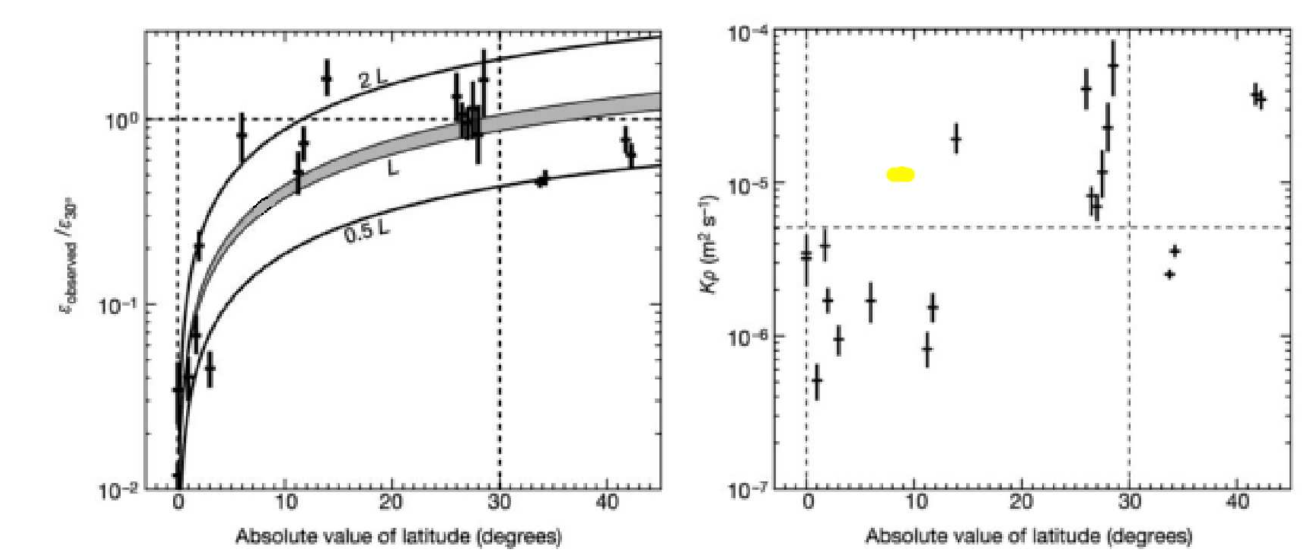


Figure 6: Figures from *Gregg et al. 2003* [4], were GUTRE results are marked with the yellow dot. D was about 30% smaller than the NATRE estimate ($D = 1.7 \times 10^{-5}$ m^2 s^{-1}) performed at 23°N. According to *Gregg et al. 2003* [4], latitude effect on internal wave induced mixing implies reduction by about 50% at 8°N as compared to NATRE. The larger than expected D in GUTRE could be the effect of topography.

Conclusion

- D was found larger by about 30% over the rough topography, but only when calculated in density units (kg $m^{-3})^2$ s^{-1}.
- D at about 8°N was not as small as projected by strong latitude dependence of dissipation [*Gregg et al. 2003* [4]].

References

[1] Brandt, P., V. Hormann, A. Körtzinger, M. Visbeck, G. Krahmann, and L. Stramma (2010), Changes in the ventilation of the oxygen minimum zone of the tropical North Atlantic, *J. Phys. Oceanogr.* (40), 1784-1801

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