Supplement of Ocean Sci., 17, 833–847, 2021
https://doi.org/10.5194/os-17-833-2021-supplement

Ocean Science Open Access EGU

Supplement of

Tropical deoxygenation sites revisited to investigate oxygen and nutrient trends

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Additional method information

The data base for the manuscript is similar low as it was for the investigation of Stramma et al. (2008). Hence for the results in this manuscript there is a possible uncertainty in some results, similar to the earlier paper. Following the publication of the 2008 paper additional measurements were performed and follow up literature by several authors confirmed the decreasing oxygen trends. This in mind, we think that it is worth discussing possible trends even with small data sets and only few statistically significant trends. A main focus of this manuscript is to compare the long-term trends in respect to the trends of the 2008-paper that had nearly 2 decades less data. To add additional areas it would be required to find a region with measurements covering a large part of the 1950 to present period. We are not aware of any such area, as in the tropics there are very limited regions with a sufficient large data spread. Due to spatially varying oxygen a horizontal extension of the areas analyzed would include larger uncertainties. Hence, we sticked to the identical areas as analyzed by Stramma et al. (2008).

Most CTD data are available in 1 dbar vertical resolution. CTD values were subsampled 5 dbar apart to reduce the amount of data and the vertical gridding was made on 5 dbar steps. Since CTD oxygen measurements have a higher vertical resolution compared to historic bottle data the computed year to year variability is significantly reduced for recent years. This is mainly due to the fact that large vertical spacing of bottle data does not capture all oxygen gradients accurately. The mapping scheme assumes a gaussian transition between data points. Nutrient trend computations could be improved if future nutrient measurements are made on defined standard depth levels to improve the comparability of results with only limited vertical measurements or the use of an in-situ nutrient measuring system that can provide profiles similar to CTD-oxygen data.

For some areas lower oxygen values are observed after the year 2000. This can not fully be explained, but A possible bias could result from the temporal heterogenous amount of CTD data, with more data in recent years. However, even before the year 2000 CTD profiles were used as the main source for oxygen measurements and the reduced oxygen values are not observed in all areas. As the climate signal for all three tropical oceans changed slightly before the year 2000 and also the nitrate measurements from bottle data indicate different trends before and after the year 2000 we expect the major source for the changes around the year 2000 to be caused by the climate signals.

As the annual data were computed independent of the season due to the lack of available data, a seasonal influence in the upper ocean layers might be possible. However, as the seasonal cycle in the tropics is weaker than in most subtropical and subpolar regions (Louanchi and Najjar, 2000) we chose the upper boundary at 50 m and we expect no major influence in the results of the 50 to 300 m layer. The same holds true to the vicinity of the thermocline, oxycline and nutricline to the 50m layer, in both cases we cannot rule out a certain impact on the noise but do not expect major differences.

Supplementary figures

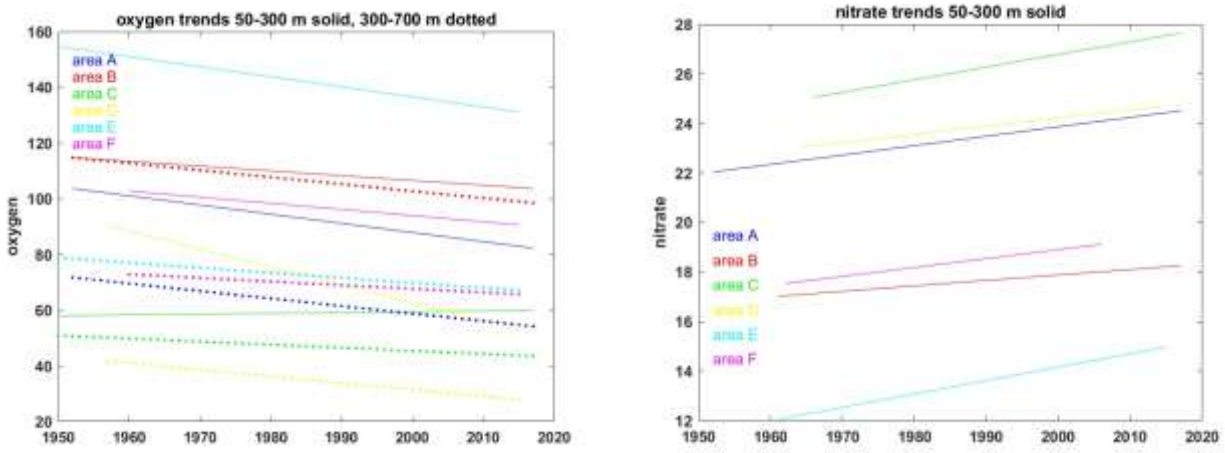

Figure S1. Oxygen trend lines (left figure) for the period of measurements for the 50 to 300 m layer and the 300 to 700 m layer (dotted) and nitrate trend lines (right figure) for the 50 to 300 m layer. The areas A through F are color-coded.