Spatial and Temporal Occurrence of Preformed Nitrate Anomalies in the Subtropical Ocean

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Introduction

- Preformed nitrate($PreNO_3$) is a theoretically conservative tracer derived to account for biochemical transformations of nitrate (NO_3^-).
- The stoichiometry of marine biochemical reactions typically follow the Redfield Ratio,106 C:16 N:1 P:138O_2.

$$PreNO_3 = NO_{3meas} - \frac{f_{POM} \cdot AOU}{r_{POM}} - \frac{f_{DOM} \cdot AOU}{r_{DOM}}$$

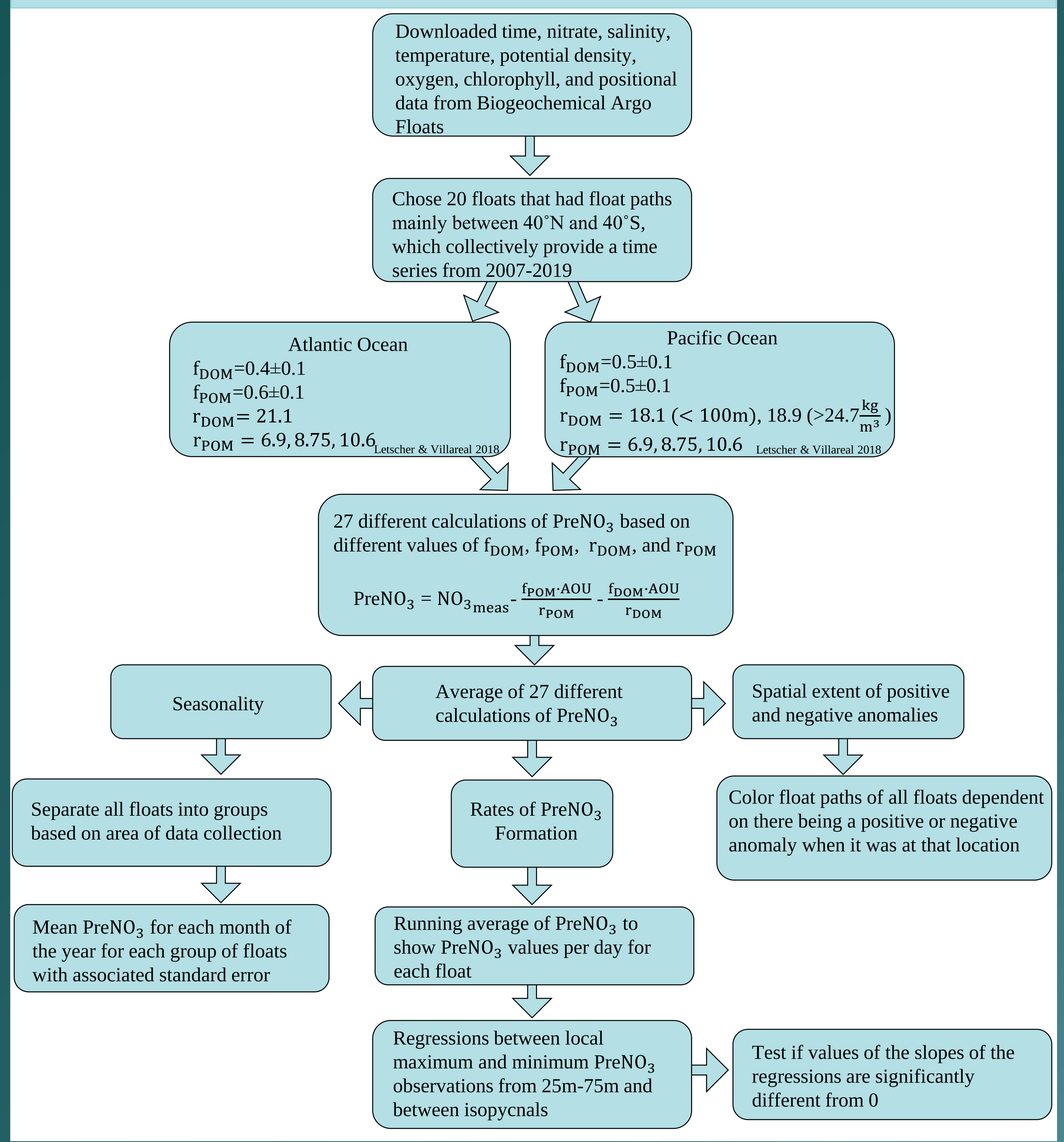
- f_{POM} and f_{DOM} are the ratios between oxygen use and Particulate Organic Matter(POM) and Dissolved Organic Matter(DOM) remineralization, respectively.
- POM and DOM differ based on the size of organic matter.
- r_{POM} and r_{DOM} are the ratios of oxygen used per mole of POM and DOM remineralization, respectively.
- Apparent Oxygen Utilization(AOU) is the biological use or production of oxygen.
- Positive $PreNO_3$ Anomaly: Indicates a process that produces oxygen without stoichiometric nitrate consumption.
- Negative $PreNO_3$ Anomaly : Indicates a process that consumes oxygen without stoichiometric nitrate accumulation.

Questions

1.) Are subsurface negative $PreNO_3$ anomalies and euphotic zone positive $PreNO_3$ anomalies recurrent in the global subtropical ocean?

2.) What are the spatial extents and seasonality of $PreNO_3$ anomaly formation?

Methods



Biogeochemical Argo Floats

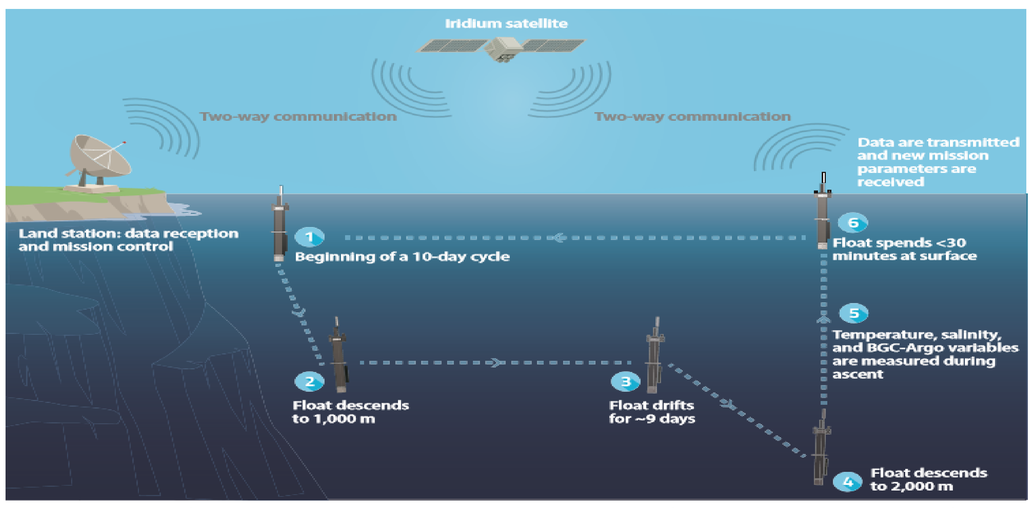
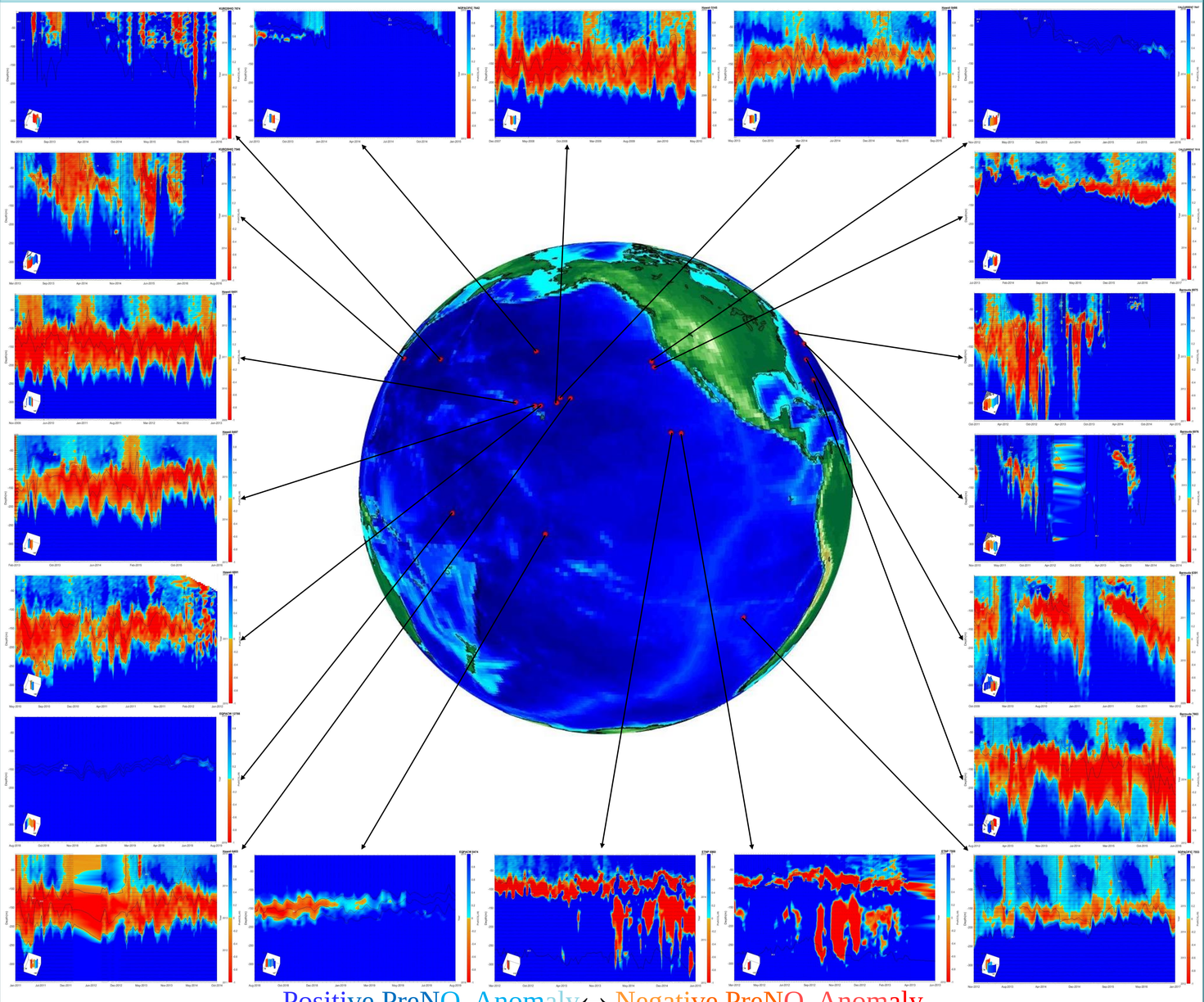


Figure 1. Figure 1 from Claustre et al. 2019. Diagram depicting cycle of Biogeochemical Argo Floats for data acquisition and transmission.

Occurrence of $PreNO_3$



Positive $PreNO_3$ Anomaly ↔ Negative $PreNO_3$ Anomaly

Figure 2. Globe with mean latitude and longitude of all floats (red dots). Each figure connected to a red dot is the $PreNO_3$ (μM) (colorbar right side) vs depth(y-axis) over time(x-axis) for the first 350m of the water column. Black lines represent isopycnals chosen to outline anomalies. Black dots are locations of float observations. Bottom left figure inside each connected figure is the float path colored by time (colorbar left side).

Seasonality

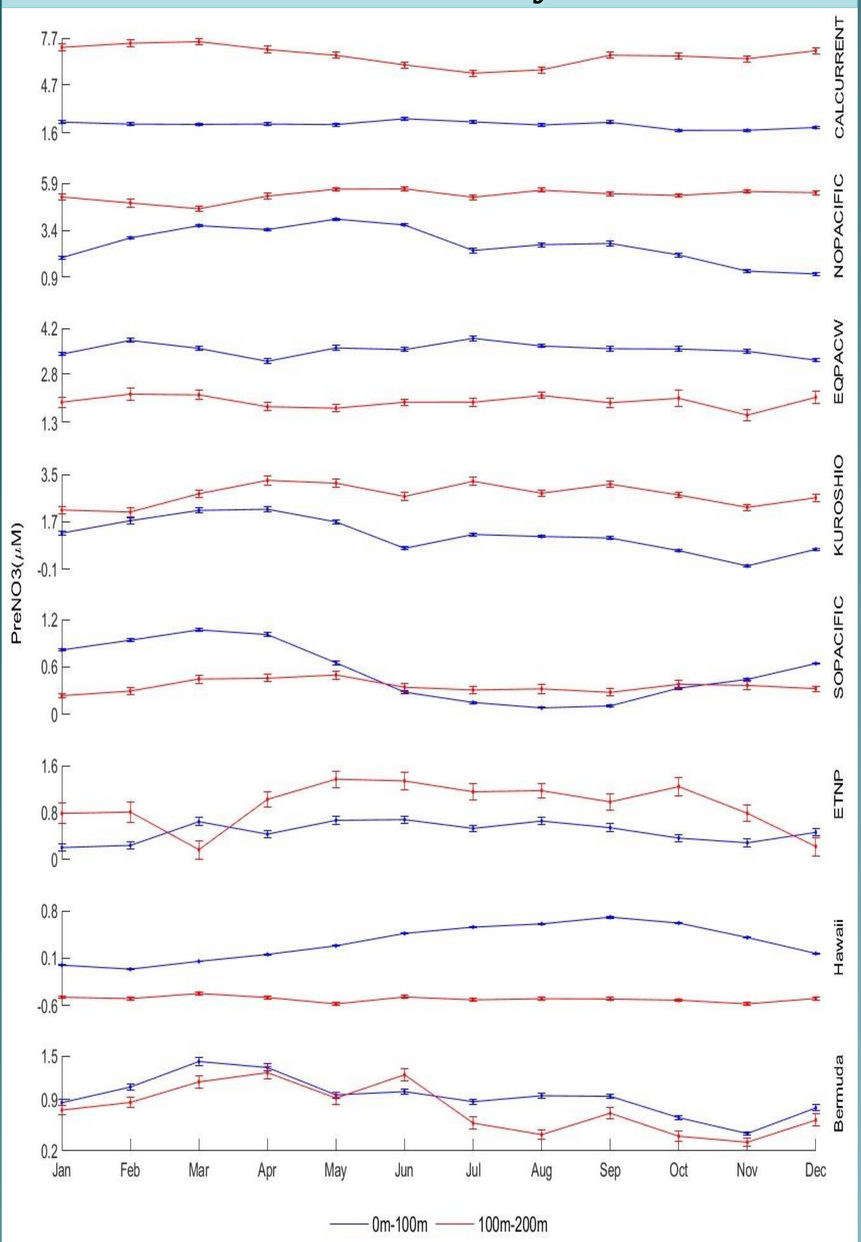


Figure 3. Monthly averaged $PreNO_3$ (μM) observations from 0m-100m (Blue) and from 100m-200m(Red) for groups of floats based on float names. Error bars are standard error.

Discussion

- The not yet fully explained mechanisms of $PreNO_3$ anomaly formation could influence the efficiency of the biological carbon pump, as the subtropical ocean expands[3].
- Negative $PreNO_3$ anomalies were seasonally persistent at 100m-200m in Hawaii.
- $PreNO_3$ values from 0m-100m are all positive except for the January and February values for the Hawaii floats.
- Except for a few floats in the North Pacific and at the equator, the occurrence of negative $PreNO_3$ anomalies at 100m-200m are relatively consistent for the 2007-2019 time series
- Further analysis is required to shed light on the mechanisms likely responsible for the formation of negative $PreNO_3$ anomalies

Future Work

- Look into sea surface height anomalies, chlorophyll, and temperature data overlapping with vertical mixing seen in float data to determine if a physical mechanism is responsible.
- Investigate relationships between changes in $PreNO_3$, NO_3^-, Oxygen, and AOU.
- Compare floats that show different $PreNO_3$ trends, to see if they were in the same locations at the same time.

References

1.) Claustre, Herve, Kenneth S. Johnson, and Yuichiro Takeshita, 2019, Observing the Global Ocean with Biogeochemical-Argo, Annual Review of Marine Science,v.12, p.23-48.

2.) Letscher, Robert T., and Tracey A. Villareal, 2018, Evaluation of the seasonal formation of subsurface negative preformed nitrate anomalies in the subtropical North Pacific and North Atlantic, Biogeosciences, v.15, p.6461-6480.

3.) Polovina, Jeffery J., John P. Dunne, Phoebe A. Woodworth, and Evan A. Howell, 2011, Projected expansion of the subtropical biome and contraction of the temperate and equatorial upwelling biomes in the North Pacific under global warming, ICES Journal of Marine Science, doi:10.1093/icesjms/fsq198.

Acknowledgements

These data were collected and made freely available by the International Argo Program and the national programs that contribute to it. (http://www.argo.ucsd.edu, http://argo.jcommops.org). The Argo Program is part of the Global Ocean Observing System. Argo (2000). Argo float data and metadata from Global Data Assembly Centre (Argo GDAC). SEANOE. http://doi.org/10.17882/42182