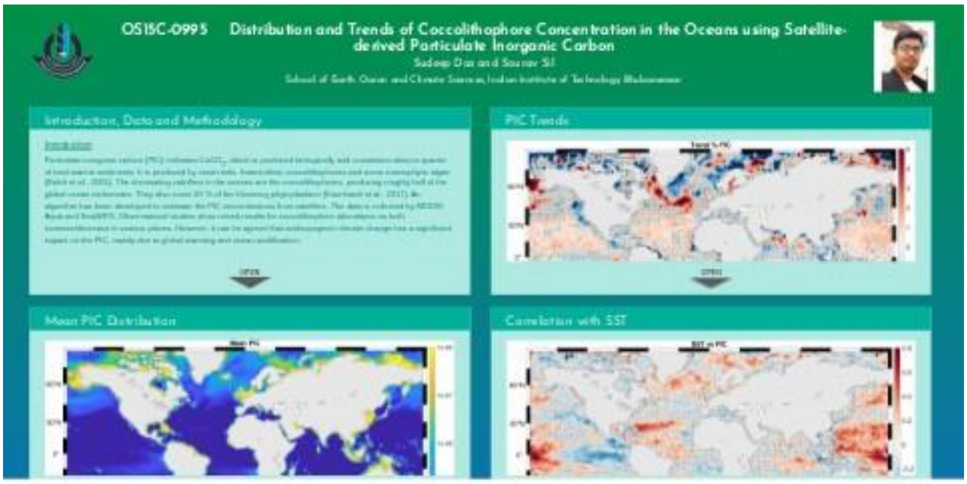
# OS15C-0995 Distribution and Trends of Coccolithophore Concentration in the Oceans using Satellite-derived Particulate Inorganic Carbon






Sudeep Das and Sourav Sil

School of Earth Ocean and Climate Sciences, Indian Institute of Technology Bhubaneswar

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# INTRODUCTION, DATA AND METHODOLOGY

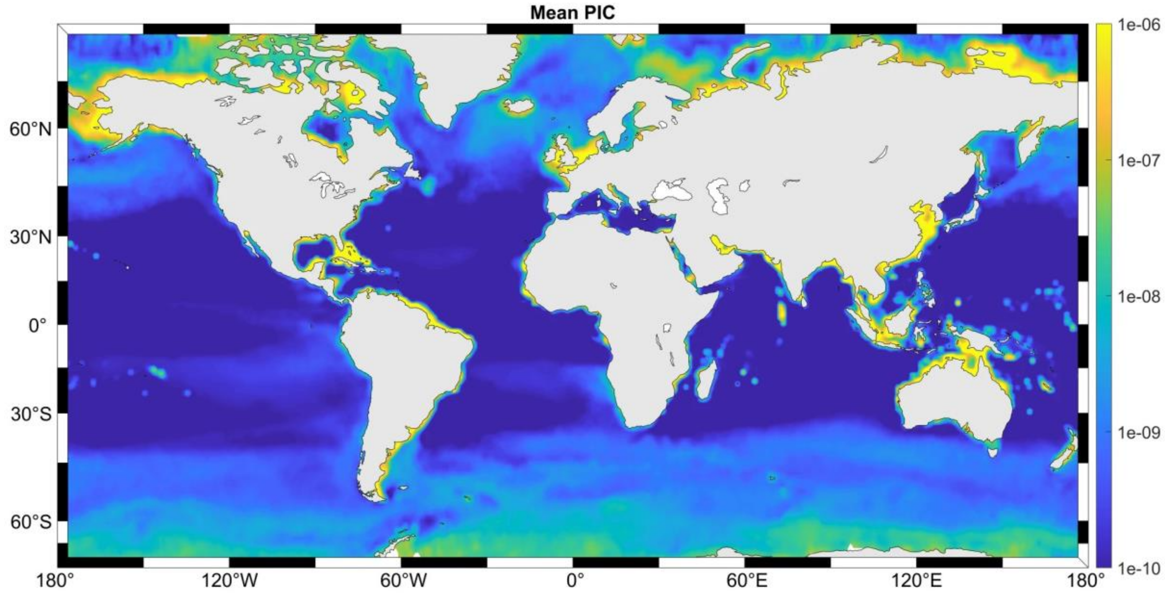
## Introduction

Particulate inorganic carbon (PIC) indicates $CaCO_3$, which is produced biologically and constitutes about a quarter of total marine sediments. It is produced by coral reefs, foraminifera, coccolithophores and some macrophytic algae (Balch et al., 2005). The dominating calcifiers in the oceans are the coccolithophores, producing roughly half of the global ocean carbonates. They also cover 20 % of the blooming phytoplankton (Krumhardt et al., 2017). An algorithm has been developed to estimate the PIC concentrations from satellites. The data is collected by MODIS Aqua and SeaWiFS. Observational studies show mixed results for coccolithophore abundance as both increase/decrease in various places. However, it can be agreed that anthropogenic climate change has a significant impact on the PIC, mainly due to global warming and ocean acidification.

## Data and Methodology

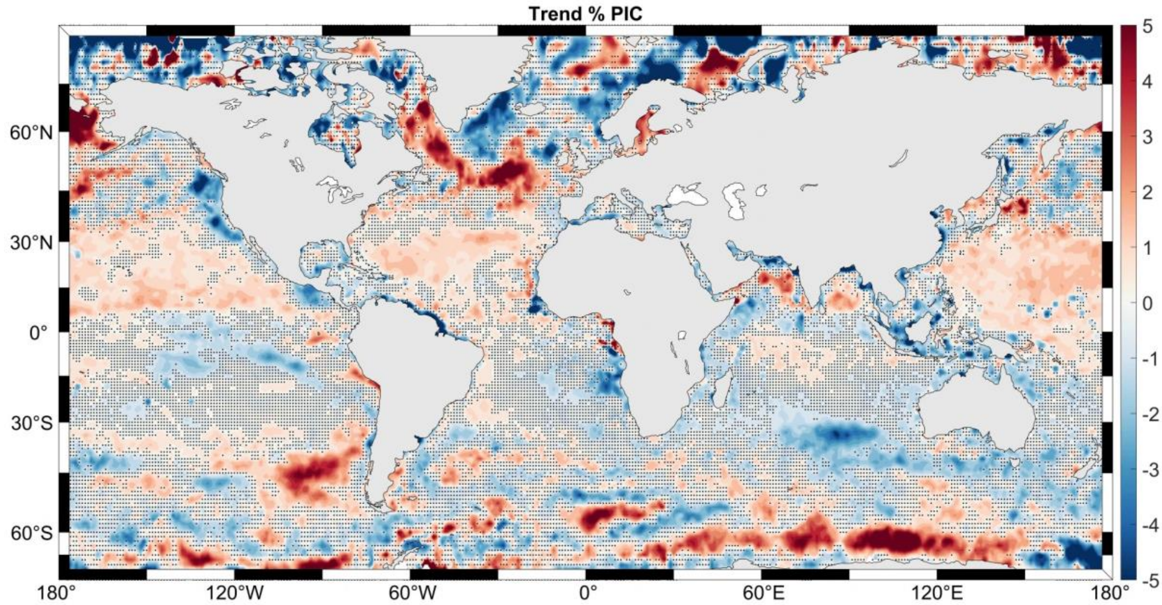
- The level 3 PIC data was downloaded from the NASA web color website. The MODIS Aqua sensor provides a 4km spatial resolution of data from 2002-21. The values are given in moles/$m^3$. Daytime SST (sea surface temperature) used in the study was also collected by MODIS Aqua at the same time and grid, making it easy for comparison.
- The PIC algorithm based on water-leaving radiance at two bands (440 and 550 nm) was given by Gordon et al. (1988) and validated in various environments by Balch et al. (2005).
- To reduce the computational pressure for further analysis, we averaged the data to a $1^o$ resolution. Outliers outside mean ± 3std and data points on land were removed, which may be due to instrument errors. For trends and correlation, the data was also deseasonalized. Trend percentage was calculated based on the mean value at that location. Places where the trend was insignificant ($p>0.05$) are marked as little dots.

# MEAN PIC DISTRIBUTION



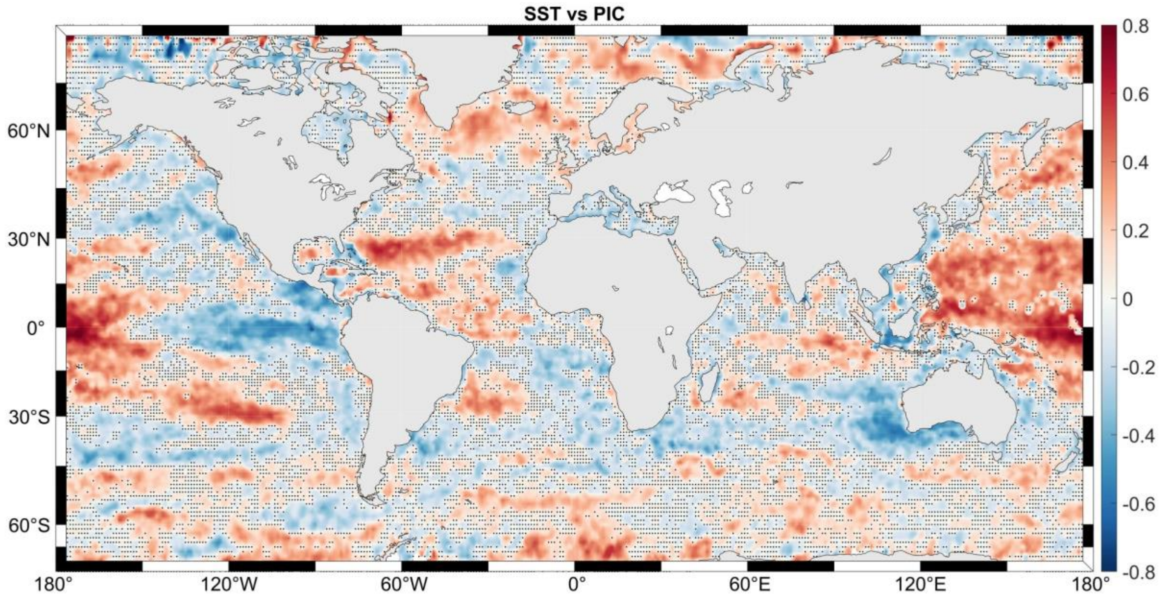

- The distribution pattern for PIC is similar to that of chl-a. Coccolithophores, being autotrophs, tend to bloom at eutrophic regions.
- The open oceans near tropics scarcely show coccolith blooms, except when close to the coast. Near the coast, shallow bathymetry of the continental shelf allows the formation of calcite organisms and deposition of calcite sediments. Even the volcanic islands in Hawaii and Polynesia show prominent PIC spots.
- The cold nutrient-rich regions of the Arctic and Southern Ocean show a high density of these calcite based organisms. One can easily identify the Great Calcite Belt, which is known for trapping alkalinity and being a dominant carbon sink. In the Southern Ocean, the highest concentration is seen near the South American continent tip, and decreases away from it.

# PIC TRENDS




- There is an overall decreasing trend of 1.11% for the available time period.
- There is a strong decreasing trend near the coast and generally a positive trend in the open oceans.
- In the oligotrophic regions, we can observe an asymmetry between the north and south tropics.
- A decreasing trend in The North Atlantic Ocean seems to be an effect of the weakening of the AMOC (Atlantic meridional overturning circulation).
- A strong positive trend around the Antarctic Ocean may indicate the effect of increasing CO2 on the alkalinity trapping phenomenon.

## CORRELATION WITH SST




- Correlation of SST with PIC shows some exciting results and explains the oligotrophic asymmetry in hemispheres and North Atlantic decreasing trend as a function of SST.
- Higher temperature seems to enhance metabolism and cause a positive correlation in the open oceans. However, the negative correlation near the equator might be due to unbearably high SST.
- There is a negative correlation along the coasts, which is maybe due to the effect of ocean acidification or increasing anthropogenic activities.

## DISCLOSURES

The authors gratefully acknowledge the infrastructure provided by IIT Bhubaneswar and financial support provided by CSIR (Council of Scientific & Industrial Research).

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# ABSTRACT

Coccolithophores are a group of important and dominant microscopic species in the oceans. Their calcareous shells are essential to the ocean carbon cycle and also affect the planetary albedo. Furthermore, being autotrophs, they also contribute to global productivity and oxygen release. The Particulate Inorganic Carbon (PIC) product from MODIS is established to depict coccolithophore concentration in the oceans, using backscattering radiation from their shells. Mean PIC distribution indicates the deficit of concentration of coccolithophores in the open oceans of the oligotrophic areas. However, in areas near the coast and in semi-closed seas, the concentration is very high due to the effect of both bathymetry and nutrient availability. We also identified the Great Calcite Belt in the Southern Ocean and a similar belt near the northern latitudes (north of 50° N). The value is even higher close to the coast around the Arctic Ocean. The trends in seasonal PIC during 2002-2020 showed a decreasing trend at a rate of 1.11 % per year over the mean value. Further spatial plots show a decreasing trend of 3 to 10 % at the highly productive coastal areas of all the oceans, and large patches in the southern Arctic Ocean (around 60° N). The oligotrophic regions, in general, have a slightly increasing trend (up to 1 %), except a decrease trend (up to 2 %) in the latitude belt of 0-10° S. A strong positive trend (5-10 %) is observed around the Antarctic coast in the Southern Ocean and may indicate the trend of the alkalinity trapping effect. Some positive trend patches are identified near the Bering Strait and off the Chilean coast.

# REFERENCES

- Balch, W. M., Gordon, H. R., Bowler, B. C., Drapeau, D. T., & Booth, E. S. (2005). Calcium carbonate measurements in the surface global ocean based on Moderate-Resolution Imaging Spectroradiometer data. Journal of Geophysical Research: Oceans, 110(C7).
- Krumhardt, K. M., Lovenduski, N. S., Iglesias-Rodriguez, M. D., & Kleypas, J. A. (2017). Coccolithophore growth and calcification in a changing ocean. Progress in oceanography, 159, 276-295.
- Trnovsky, D., Stoltenberg, L., Cyronak, T., & Eyre, B. D. (2016). Antagonistic effects of ocean acidification and rising sea surface temperature on the dissolution of coral reef carbonate sediments. Frontiers in Marine Science, 3, 211.
- Gordon, H. R., Brown, O. B., Evans, R. H., Brown, J. W., Smith, R. C., Baker, K. S., & Clark, D. K. (1988). A semianalytic radiance model of ocean color. Journal of Geophysical Research: Atmospheres, 93(D9), 10909-10924.