A Multiple Linear Regression of pCO_2 against Sea Surface Temperature, Salinity, and *Chlorophyll a* at Station BATS and its Potential for Estimate pCO2 from Satellite Data

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Ocean is one of the major reservoirs of carbon and can be a major sink of anthropogenic carbon dioxide. Together with pH, alkalinity, and total dissolved inorganic carbon (DIC), partial pressure of carbon dioxide (pCO_2) is one of the four essential parameters for determining aquatic CO_2 system. These four CO_2 parameters are interrelated through chemical equilibrium and the determination of any two is sufficient for calculating the other two parameters. Ship-based oceanographic research cruise, that is expensive to operate and inefficient to provide global coverage, has long been the main source of data for characterizing oceanic CO_2 system. Recently, Lohrenz and Cai (2006) conducted a field study of partial pressure of carbon dioxide, temperature, salinity, and *Chlorophyll a* in surface waters of the Northern Gulf of Mexico and developed a correlation method for estimating carbon dioxide distribution from the Moderate Resolution Imaging Spectroradiometer (MODIS) remote sensing data. Although it showed great potential, the correlation is based on field data with a small temperature variation and atypical salinity for open ocean waters, and it is not clear whether it can be applied elsewhere in the ocean. Here, we propose to extend the applicability of the method by conducting a data analysis study of field observations conducted at station BATS (Bermuda Atlantic Time-Series)

Specifically, we: (1) Obtain field data of alkalinity, DIC, temperature, salinity, and Chlorophyll a determined at BATS station in the last two decades; (2) Calculate pCO2 from alkalinity and DIC; (3) Apply the correlation method to test the applicability of the method in the central Atlantic Ocean;

I. Introduction

Ocean is both a source and sink of anthropogenic carbon dioxide. In order to quantify the size of this source and sink, one needs systematic measurement of CO_2 in the ocean. Pressure of carbon dioxide (pCO2) is a parameter in determining measurements of carbon dioxide. The measurement of sea - surface CO_2 in the field is just about attainable, and the remote sensing algorithm for CO_2 has not been reported yet. Satellite remote sensing is a promising alternative method for measuring pCO2. Although satellite measurements have been proposed [Lohrenz and Cai 2006] on the Mississippi shelf, its application in the other ocean regions is questionable.

The Research cruise has been the routine of choice for many decades. Cruises are exceptionally pricey to perform and time consuming, resulting in scientists working on substitute methods. We set out to expand that

method on other parts of the ocean. Our research will be based on monthly measurements of temperature, salinity, chlorophyll a, PC, DOC, and pCO2 measurements at

II. Methodology

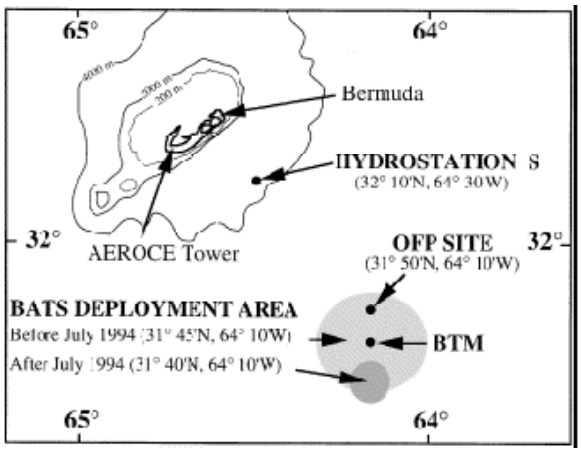

Figure 1. The primary station is located at 31°50'N, 64°10'W approximately 82 km SE of St. David's Light, Bermuda in 4500 m of water. The Bermuda Atlantic Time-series Study (BATS) station operates since October 1988 and is representative of the western North Atlantic subtropical gyre (Sargasso Sea)

Their Methods

Previous researches used diverse methods for the different parameters. Total Alkalinity (TAlk), dissolved inorganic carbon (DIC), temperature, salinity and chl *a* were obtained by field measurements. Surface water samples were obtained with a CTD rosette system equipped with 10-L Niskin bottles. Wang and Cai [2004] provided the formulas to calculate DIC, Talk, and pH, and also to calculate pCO_2 from DIC and Talk. They filtered surface water samples with GF/F filter and fluorometric assay of 90% acetone extracts to get Chlorophyll measurements.

Remote sensing methods for sea-surface temperature have been in routine use for two decades [*McClain et al.,1985*]. Sea-surface chlorophyll *a* is determined using OC4 algorithms [*O'Reilly et al., 1998],* dissolved organic carbon (DOC) and particular organic carbon (POC) together with sea surface chlorophyll *a* can also be estimated with a algorithm proposed recently [*Maritorena et al., 2002]*. Lohrenz and Cai [2006] proposed a new method to calculate pCO_2 from satellite. Their method was a multiple linear correlation using parameters that can be measured with satellite. The correlation was developed using ship-based measurements.

Our Methods

We used field data of Temperature, Salinity, TAlk, Dissolved Organic Carbon (DOC), Dissolved Inorganic Carbon (DIC), Chlorophyll *a*, particular carbon (PC), and pH collected from Bermuda Atlantic Time-Series. Station (Figure 1) from the past two decades. Raw data were sorted and all unused measurements (i.e. incomplete) were removed. The remaining data were put into the data analysis software in Microsoft Excel. That information was then used to formulate the regression. The results of the regression analysis allowed us to compare original pCO2 data and pCO2 predicted to calculate the multiple linear regression equation.

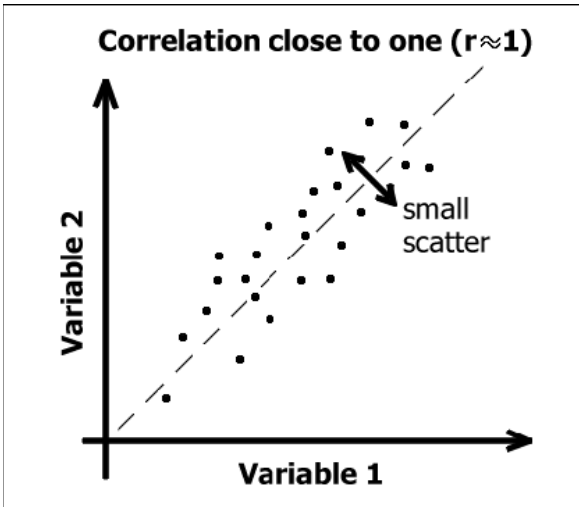

Figure 2. A plot of variable 2 vs. variable 1 with a correlation coefficient between the two variables

approx. equals to one.

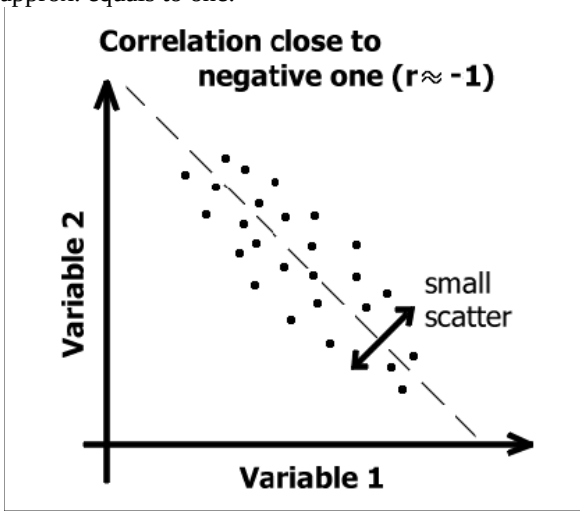

Figure 3. A plot of variable 2 vs. variable 1 with a correlation coefficient between the two variables approx. equals to negative one.

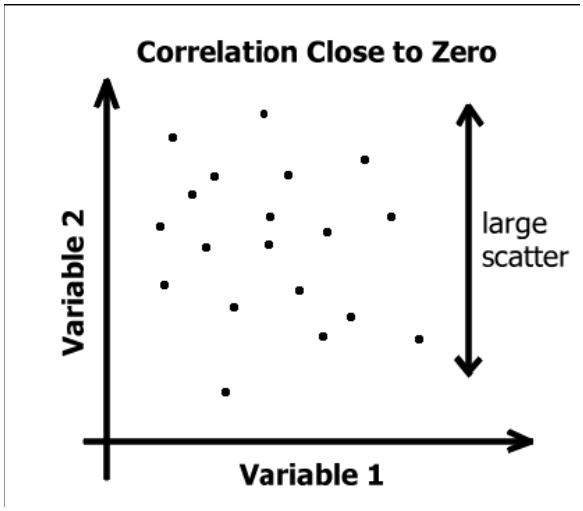

Figure 4. A plot of variable 2 vs. variable 1 with a correlation coefficient between the two variables approx. equals to zero.

P-value allows us to know the significance of the parameters we obtained in the correlation. The closer the P-value is to 0, the more significant the parameter is to the correlation.

- *Software*

  Microsoft Excel
  Microsoft Word
  BATS station data

- *Hardware*

  Desktop Computer

III. Results

the 2008 Oceanography Team results included two graphs

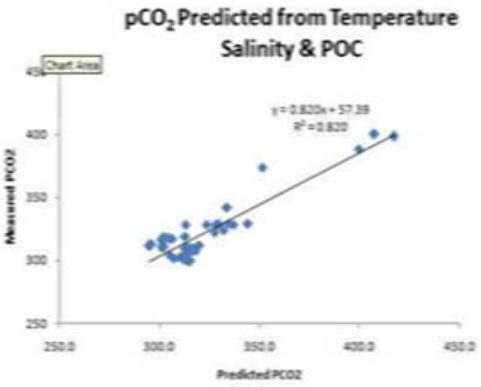

Chart 1. Comparison between the Predicted, and Measured pCO2 with POC. Temperature, Salinity, and Chlorophyll a were used to calculate pCO2.

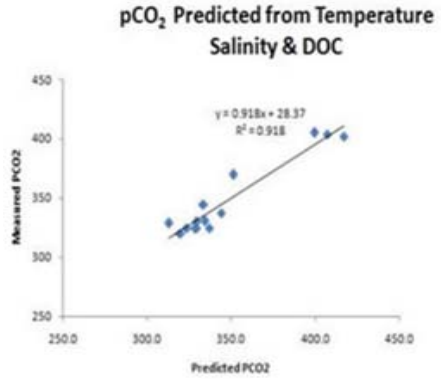

Chart 2. Comparison between the Predicted, and Measured pCO2 with DOC. Temperature, Salinity, and Chlorophyll a were used to calculate pCO2.

IV. Conclusion

A multiple linear correlation between pCO_2, temperature, salinity, and chlorophyll *a* was obtained from sea-surface water in western North Atlantic subtropical gyre. All three independent variables are significant in the correlation. The correlation can be used to approximate pCO_2 from parameters that can be determined from satellite remote sensing. We used P-values to confirm that temperature, salinity and chlorophyll a were significant factors in calculating pCO_2.

VI. References

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