YOUR FACULTY

Volume 1 of 1

YOUR THESIS TITLE

by

YOUR NAME

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Abstract

Shelf seas are regions of high biological activity, contributing 15-30% of global oceanic primary production, with temperate shelf seas as an important global carbon sink. To understand how shelf seas will respond to environmental changes it is important to fully understand phytoplankton dynamics and inter-annual variability of phytoplankton production in these areas. Previous modelling works have shown that meteorology can affect phytoplankton seasonal dynamics but there is still debate in the literature about the direct mechanisms that affect long-term phytoplankton productivity.

1 Introduction

Shelf seas are ocean regions where water depth is less than a few hundred metres (~ 200 m). They are separated from the deep ocean by a shelf break, where the seabed inclination generally increases rapidly from the top of the continental slope to the abyssal ocean. In these regions, the effects of friction and boundaries play a crucial role in determining ocean dynamics, experiencing a physical regime which is distinct from that of the abyssal ocean where depths are measured in kilometres.

The rest of this paper is organized as follows. In section 2, we describe the methodology used. In section 3, we conclude.

2 Method

The following institutions' radiocarbon measurements ($\Delta^{14}C$ and/or FM) were compared with the GNS Rafter Radiocarbon Laboratory in turn, each elaborated upon in the following sections. Each intercomparison is tailored specifically to the type of data available between each institution.

2.1 Rafter Radiocarbon Lab

The rafter lab operates the longest runnnig record of atmospheric 14CO2...

2.2 Heidelberg University

2.2.1 Available Data

The Heidelberg University Institute of Environmental Physics in affiliation with the ICOS Central Radiocarbon Laboratory operates a network of time-series stations measuring $\Delta^{14}CO_2$. One of these stations, Cape Grim, Tasmania (CGO; 40.68S, 144.68E, 94 m a.s.l; Levin et al., 2010), is a reasonable candidate through which to compare Heidelberg University to Rafter Radiocarbon Lab $\Delta^{14}CO_2$. Cape Grim and Baring Head observe a similar mixture of air from the Southern Ocean and Austrailia (Ziehn et al., 2014, Law et al, 2010), and a short initial time-series indicates no measurable differnece between the sites from 2017-2019 (**??**). What method was used for sampling? (NaOH)

While the BHD record extends from 1950 to the present, the CGO record includes available data from 1987 to 2016, resulting in 30 years of overlapping data for intercomparison. Two intervals will are ignored: 1995-2006 and 2009-2012. Variability in BHD exists between 1995 and 2005 as 1) the Rafter measurement method was changed from gas counting to AMS and 2) an online ^{13}C measurement allowed for approporiate fractionation correction (Turnbull et al, 2017; Zondervan et al., 2015), therefore this interval is ignored in the intercomparison. Additionally, the interval of 2009-2012 is ignored as the BHD record sees increasing noise in this period related to a temporary change in NaOH sampling protocol. Further details on the decision to remove these data can be found in the Supplementary Information. The remaining overlapping intervals are parsed into 4 sections: 1987 - 1991; 1991 - 1994; 2006 - 2009; 2012 - 2016. Each of these data intervals are non-stationary time-series containing seasonality.

2.2.2 Curve Smoothing

To extract long-term systematic offsets between institutions, and remove seasonality, the CCGCRV curve fitting procedure (Thoning et al., 1989; www.esrl.noaa.gov/gmd/ccgg/mbl/crvfit/) is implemented similar to (Turnbull et al., 2017). We employ the "smooth" and "trend" functions of the CCGCRV algoritm. "Smoothed" data includes the results of the polynomial and harmonic fits of the data, and a long-term low-pass filter of 667 days. "Trended" data is similar; but retains the polynomial fit to the function and ignores harmonic components. Since the BHD and CGO data were not sampled on the same dates (i.e., they have an unequal number and value of x-components which impairs direct comparison of fitted data), the CCGCRV algorithm is programmed to output each smoothed/trended curve in 348 equal steps from 1987 to 2016 (12 samples/year), slightly underestimating the average sampling resolution of each dataset (CGO: 17 samples/year; BHD: 12.25 samples/year). By controlling the x-values of smoothed/trended data output from CCGCRV, the datasets can be compared. Error-estimates from the curve smoothing processes are obtained via a Monte-Carlo simulation, run to 10,000 iterations.

The following process occurs during each iteration for both BHD and CGO data:

- For each x-value, the y-value is randomly re-assigned, weighted about its normal distribution (1-σ error).
- This randomized time-series is smoothed/trended with CCGCRV algoritm
- The generated data (in 348 equal steps from 1987 to 2016) is appended to a growing dataframe of smoothed/trended data.

When the loop is complete, the mean and standard deviation of y each 348 x-values is calculated for BHD and CGO. These computed values are used to assess the intercomparability of BHD and CGO, and thus, Rafter Radiocarbon Lab and Heidelberg University over time. This Monte-Carlo simulation is shown on a small scale in Figure **??**

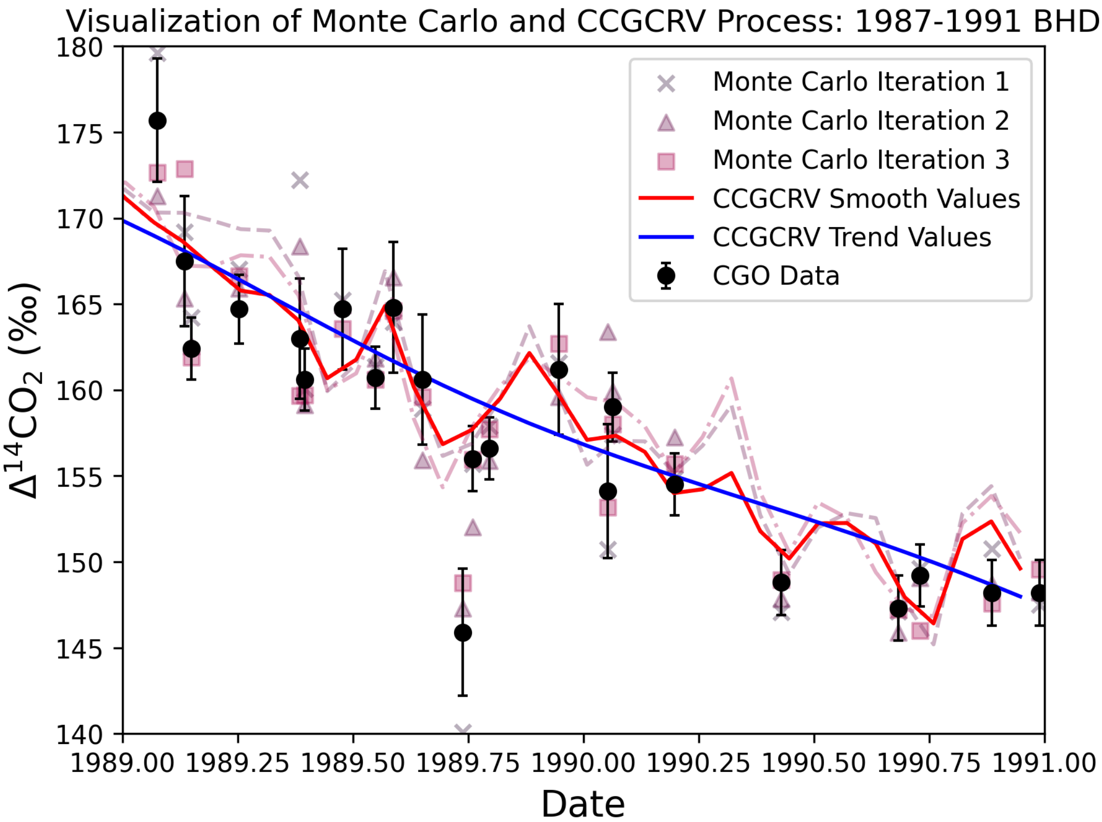


Figure 1: Vizualization of the Monte Carlo simulation to generate an uncertainty estimate about the CCGCRV curve smoothing algoritm.

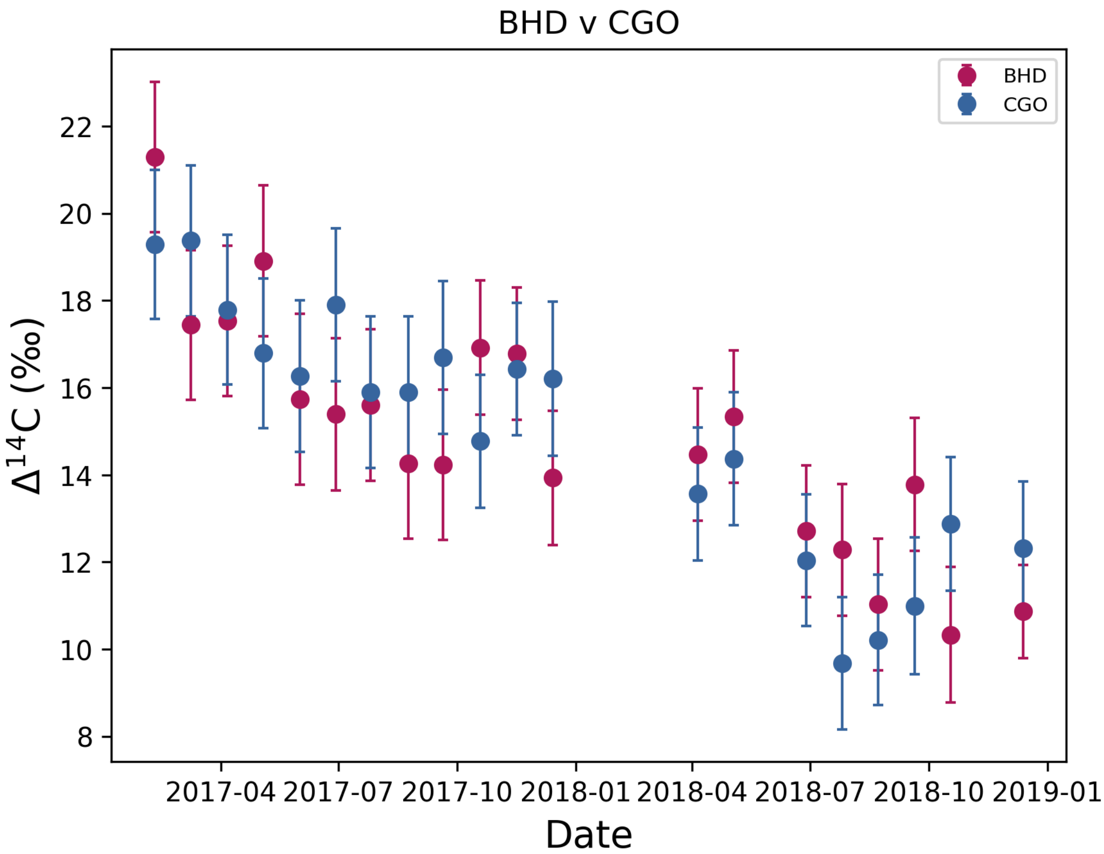
3 Conclusions

There are different ways to study shelf seas including using research vessels and remote, autonomous vehicles. Water samples are needed to understand the ecology and biogeochemistry of the system. However, data from research vessels is limited as it is not synoptic, i.e. it is not sampled at different locations simultaneously and, because of this, remote sensing plays an important role in the study of shelf seas. With satellite data it is possible to obtain information about the distribution of net phytoplankton production in the ocean, but other phenomena such as the SCM are difficult to observe. Besides, suspended sediments and dissolved organic material can influence this data. To complement the available data from research vessels and remote sensing, ocean models are used to study and understand marine biogeochemistry.

4 Supplementary Information

4.1 Site Intercomparison of Baring Head and Cape Grim

Figure 2: Intercomparison of $\Delta^{14}CO_2$ measurements at Cape Grim, Tasmania (CGO), and Baring Head, New Zealand (BHD) collected by NIWA and measured at Rafter Radiocarbon Laboratory. Dates represent the middle of the sampling period, which differ no more than one day between sites. These data show that during the time in which data are available, no measureable difference is found between the two sites. This provides some evidence that the two sites may be considered equivalent for this intercomparability study.



4.2 Removal of data interval 2009 - 2012 in Rafter vs. Heidelberg University Intercomparison