

## ***Interactive comment on “Volcano impacts on climate and biogeochemistry in a coupled carbon-climate model” by D. Rothenberg et al.***

### **Anonymous Referee #2**

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In the manuscript of “Volcano impacts on climate and biogeochemistry in a coupled carbon-climate model” by Rothenberg et al. the authors used the model of CCSM3 to investigate the physical and biogeochemical response of the Earth system to volcanic eruptions in the last two hundred years. The authors reported that the modeled climate and carbon cycle response to the eruption of Mount Pinatubo is in fair agreement with available observations. In addition, the authors found that the test of climate model using simulated response to volcano can be done without performing a ‘no volcano’ control simulation. This study makes a useful contribution to the climate modeling community by providing new results on the Earth system response to volcanic eruptions from a coupled climate-carbon cycle model. I would recommend its publication after the following comments are addressed.

## Abstract

“In addition, a method for computing the volcanic response in model output without using a control ensemble is tested against a traditional methodology using two separate ensembles of runs; the method is found to produce similar results”

It should be emphasized here that the similarity between the results from ‘volcanic-control’ and ‘no control’ only holds for global-mean results. As the authors presented in the main text, the results between these two methods differ substantially on regional scales.

### 1. Introduction

“The strength of land and ocean sinks of CO<sub>2</sub> are not increasing along with rising anthropogenic emissions (Le Quere et al., 2009; Sarmiento et al., 2010) as evidenced by an increase in atmospheric CO<sub>2</sub> levels.”

The meaning of this sentence is not clear. Please rephrase.

### 2. Methods

#### 2.1 Model description

“Ammann et al. (2003) scaled the peak aerosol depth for 20th century eruptions by looking at previous estimates of peak aerosol loading . . . .”

This paragraph does not seem belong to Model description.

#### 2.3 Model and data analysis

“This mean anomaly between volcanic runs and control runs was compared to the set of anomaly time series for each individual eruption, averaged over the three pairs (volcano-control) of ensemble members.”

Please explain what is the purpose of comparing the mean anomaly with the anomaly of each individual eruption? If I understand correctly, the mean anomaly is calculated

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from the four-year anomaly mean starting from the month of each eruption. Is there any particular reason to choose four years as the averaging periods?

“For each month in the years following the eruption, an anomaly is computed based on the two years previous to the eruption to compute the deviation from the average seasonal cycle”.

Is there any particular reason to choose the previous two years as the periods to calculate anomaly? How will the results change if the previous one or three years were used?

### 3. Results

#### 3.1 Physical climate response to volcanic forcing

The authors used the study of Shindell et al. (2004) as a benchmark to compare modeled temperature with observations. Is it possible to reproduce and show the results of Shindell et al. (2004) in the temperature figure? Otherwise, the readers will have no clue of how ‘observed’ temperature anomaly looks like. Likewise, it would be useful to reproduce the precipitation results of Trenberth and Dai (2007), which is used as a benchmark for the comparison of modeled precipitation.

#### 3.2 Biogeochemical responses to the Pinatubo eruption

“These changes in uptake of atmospheric CO<sub>2</sub> motivate an analysis of the modeled carbon cycle and terrestrial biosphere”

What is the role of the ocean carbon cycle here?

“The decreases in the modeled gross primary production are associated with anomalous decreases in both surface temperature and precipitation, and potentially increases in diffuse radiation (Fig. 5b) in both the global average and in the Amazon.”

I have two questions here: First, how are the interactions between diffuse radiation, plant growth, and volcanic eruption treated in the model? Second, how does an in-

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crease in diffuse radiation lead to a decrease in gross primary production?

### 3.3 Average responses to volcanic eruptions

I am not sure what the main purpose is to examine the averaged responses to volcanic eruptions. What can we learn from the averaged responses that cannot be learned from the response to individual volcano eruptions? For example, as the authors noticed, these eruptions occur at different times of the year, which would impact growing season differently. Therefore, the averaged response in the land carbon cycle is damped compared to the response to individual eruptions. Do we learn anything new here?

Figures:

Fig. 1: Legend “While prescribed CO<sub>2</sub> is used for radiation in the model, the CO<sub>2</sub> in the runs plotted here is fully interactive.”

If the model calculates atmospheric CO<sub>2</sub> interactively, why does the model use prescribed CO<sub>2</sub> in the radiation calculation?

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