

## ***Interactive comment on “Impact of Icebergs on Net Primary Productivity in the Southern Ocean” by S.-Y. Wu and S. Hou***

**S.-Y. Wu and S. Hou**

swu001@udayton.edu

Received and published: 4 November 2016

Dear Editor,

We would like to thank you and the reviewers for the helpful comments. Based on these comments, we have significantly changed our approach, and included many additional analyses. A brief description of the new methodology and results is provided below. We will address each reviewer's questions in details in a separate file attached to this email. Reviewers' original questions/comments are in blue, and our answers are in black. Owing to the extensive changes made to the original manuscript, some comments on specific wording and styles may no longer be applicable. We will response to them accordingly.

Synopsis of the new methodology and results This study aims to examine whether

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icebergs have a significant impact on the ocean net primary productivity (NPP) at the scale of the entire Southern Ocean (SO). We examine both large and small icebergs based on two separate datasets and determine if similar impacts can be observed. We first divided the SO into four ecological zones based on their different nutrient source and profile: the continental shelf zone (CSZ), the seasonal ice zone (SIZ), the permanent open ocean zone (POOZ), and the polar front zone (PFZ). Within each zone we compared NPP for grids with and without iceberg presence. For small icebergs, we found that grids with iceberg presence in general have higher NPP than those without icebergs. However, the impact is not uniform. In the CSZ where high level of iron is supplied through glacial meltwater and sediment input from the continent and continental shelf, and phytoplankton growth is largely limited by macronutrients, the presence of icebergs does not seem to have any impact on the ocean NPP. On the other hand, Iceberg presence could significantly increase NPP in the high-nutrient low-chlorophyll (HNLC) regions. The NPP of grids with icebergs is 21% higher than those without in the SIZ, and 16% higher in the POOZ. The difference is slightly less (12%) for the PFZ where upwelling and eddy mixing could provide additional iron to the surface water, hence iron limitation is not as severe. Direct correlation between iceberg frequency and NPP is weak although statistically significant. The strongest correlation is found at the SIZ which contains over 70% of the icebergs by volume. For large icebergs, we found that the mean NPP for iceberg grids and their immediately adjacent grids are on average 10% higher than NPP of the nearby grids further away. However, the zonal response is different. The enhancement of NPP is the greatest in the high latitude zone of the CSZ and SIZ, which contains the majority of the large iceberg occurrences. Finally, we examined the secular trend of iceberg occurrence in the SO under the current climate change. For the entire period of the iceberg data, 1992-2014, both iceberg volume and frequency have shown significant increasing trends. The increasing trend is most significant for the Pacific and Indian sections of the SO, whereas the Atlantic section of the SO shows no statistically significant trend. This could be related to the greater mass loss of the West Antarctica Ice Shelf, and the

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relative stability of the East Antarctica Ice Shelf under present climate change. As the climate continues to warm, the Antarctic Ice Sheet is expected to experience increased mass loss as a whole, which could lead to more icebergs in the region. Based on our study, this could result in higher level of NPP in the SO as a whole, providing a negative feedback for global warming.

Thank you for your consideration.

Best regards, Shuang-Ye Wu

Please also note the supplement to this comment:

<http://www.the-cryosphere-discuss.net/tc-2016-166/tc-2016-166-AC1-supplement.pdf>

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Interactive comment on The Cryosphere Discuss., doi:10.5194/tc-2016-166, 2016.