Combining bio-optical glider observations and biogeochemical modeling to examine potential Ross Sea phytoplankton changes in the 21st century

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INTRODUCTION

The Ross Sea, a highly productive coastal bay of Antarctica, is dominated by the phytoplankton Phaeocystis antarctica and diatoms (Kaufman et al. 2014).

In the Ross Sea, projected climate-induced physical changes over the next century include (Smith et al. 2014):
- increased summer mixed layer temperatures,
- shallower mean mixed layer depths (MLDs),
- earlier melting of sea ice.

How will phytoplankton productivity and carbon export in the Ross Sea be affected by future climate-induced changes in temperature, mixing, and sea ice?

METHODS

Model

The Model of Ecosystem Dynamics, nutrient Utilisation, Sequestration and Acidification was adapted for the Ross Sea (MEDUSA-RS) to include both solitary and colonial P. antarctica as well as diatoms (Kaufman et al. 2017a).

Data

- Physical forcings were generated from glider measurements and other available dataset.
- Boundary conditions at 200m were set to climatological means for nitrate and silicate, and means of available data for dissolved iron (Kaufman et al. 2017b).

RESULTS

Primary productivity and carbon export are greater in both mid- and late-century scenarios compared to the contemporary estimate.

Climate Scenarios

Scenario experiments with MEDUSA-RS examined the response of phytoplankton to projected physical conditions (Table 1).

<table>
<thead>
<tr>
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<th>2050</th>
<th>2100</th>
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<tbody>
<tr>
<td>Increased Temp</td>
<td>0.3 °C</td>
<td>0.8 °C</td>
</tr>
<tr>
<td>Shallower MLDs</td>
<td>6%</td>
<td>29%</td>
</tr>
<tr>
<td>Earlier Melting of Sea Ice</td>
<td>5 days</td>
<td>11 days</td>
</tr>
</tbody>
</table>

Table 1 (above): Simulations with a Ross Sea implementation of the Regional Ocean Modeling System (ROMS) were conducted to quantify projected physical changes for 2050 and 2100 for this area.

CONCLUSIONS

- Climate model scenarios for the mid-21st and late-21st century indicate increases of primary productivity and carbon export flux.
- Increased production over the next century is primarily driven by increased light availability as a result of melting sea ice. Other changes (temperature and changes in surface iron input) produce minor independent effects.
- Combined light and MLD changes modify the phytoplankton assemblage composition over the next century. Until 2050, increased production is largely a result of increased diatom production as they outcompete P. antarctica under higher light conditions. By 2100, availability of low light early in the season allows productivity of P. antarctica to rebound to its contemporary level.

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References


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