MODELING STUDY OF THE ARCTIC SEA ICE AND OCEAN PRIMARY PRODUCTION AND MODEL VALIDATION THE WESTERN ARCTIC

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ABSTRACT

In the Arctic Ocean, both phytoplankton and sea ice algae are important contributors to primary production and the arctic food web. An ice algal ecosyst em model, which has been lacking in previous arctic ecosystem models, was add ed to fully couple with the global physical model POP-CICE (Parallel Ocean Pro gram- Los Alamos Sea Ice Model) and the open-ocean pelagic ecosystem model. The physical model captured the seasonal and interannual variations of northern hemispheric sea ice extent and area measured by satellite remote sensing for the model period of 1992 to 2007. The model results showed a reasonable mean sea sonal cycle of ice algal production from March to May and subsequent ocean pr oduction from May to September in the Arctic. The ice algal production, although smaller than that of the ocean, is of ecological importance as a food source for higher trophic levels during the long arctic winter before ice melt. The simulated mean open-ocean upper 100m primary production within the Arctic Circle was $413 \pm 88\ Tg\ C\ yr^{-1}$ in the years 1998 to 2006, close to the remote sensing derived estimate of $419 \pm 33\ Tg\ C\ yr^{-1}$ but with higher interannual variations. The mean sea ice algal production in the Northern Hemisphere from 1998 to 2007 was 21.3 $Tg\ C\ yr^{-1}$, which is in the range of multi-observational estimations of 9 to 73 $Tg\ C\ yr^{-1}$ based on in situ measurements. Model-data comparisons were conducted with various regional observations and the observed trend of temporal and spatial variation of the primary production. The model results compared well with the following observations and observed trends: 1) a similar increase of ocean primary production from 2003 to 2007 in the arctic open water areas as derived from remote sensing data; 2) regional annual ice and ocean primary production measured in the Bering and Chukchi seas, and Canadian Basin; 3) primary production rate with phytoplankton size composition and Chl a concentration along an arctic cruise track in the Chukchi Sea and Canadian Basin from August 2 to September 7, 2008; 4) observed decadal changes of ocean primary production from the 1990s to 2007 due to rising temperature and increased open-ocean area in the western Arctic. The changes were shown as a trend of a northward shift of production with a decrease in the Bering Sea and an increase in the arctic shelf. The in clusion of the ice-ocean ecosystem model in the physical climate model in this s tudy was successful in the simulation of the coupled ice and ocean primary prod uction in the Arctic. This will improve our estimates of deep ocean carbon expo rt and air-sea CO_2 fluxes and increase our understanding of past and future ecol ogical and biogeochemical changes in the Arctic.