

Bo Qu

**The Impact of Melting
Ice on the Ecosystems
in Greenland Sea**
Correlations on Ice
Cover, Phytoplankton
Biomass, AOD and PAR



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Correlations on Ice Cover, Phytoplankton
Biomass, AOD and PAR



Springer

Bo Qu
School of Science
Nantong University
Nantong, Jiangsu
China

ISSN 2191-5547

ISBN 978-3-642-54497-2

DOI 10.1007/978-3-642-54498-9

ISSN 2191-5555 (electronic)

ISBN 978-3-642-54498-9 (eBook)

Library of Congress Control Number: 2014949369

Springer Heidelberg New York Dordrecht London

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This work was supported by the National Science Foundation of China (Grant No. 41276097).

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Preface

It has been argued that the Arctic is a sensitive indicator of global change. The ice cover in Arctic Ocean provides a control not only on the surface heat and mass budgets of the Arctic Ocean but also on the global heat sink. It has also been suggested that an enhanced pool of Arctic and freshwater on the ocean surface coming from melting ice may significantly affect the global ocean thermohaline circulation. Changes in sea-ice cover will affect not only the physical Arctic Ocean, but also result in chemical, biological, and ecosystem changes. The impact of melting ice on oceanic phytoplankton and climate forcings in the Arctic Ocean has attracted increasing attention due to its special geographical position and potential susceptibility to global warming.

Salty sea smell near the ocean does not result from the salt alone. Gases diffuse across the air-sea interface, many of which are synthesized and emitted by microalgae. One of these gases is a sulfur-based compound that has a strong characteristic odor. It has been suggested that variations in algal production of these natural gases play an important role in moderating our climate through their aerosol effect on backscattering solar radiation and in cloud formation. Scientists have identified the sulfurous gas as dimethylsulfide (DMS). DMS is a naturally produced biogenic gas essential for the Earth's biogeochemical cycles.

In the ocean, DMS is produced through a web of biological interactions. Certain species of phytoplankton, microscopic algae in the upper ocean synthesize the molecule dimethylsulfoniopropionate (DMSP), which is a precursor to DMS. When phytoplankton cells are damaged, they release their contents into the seawater. Bacteria and phytoplankton are involved in degrading the released algal sulfurous compound DMSP to DMS and other products. A portion of the DMS diffuses from saltwater to the atmosphere. Once it is transferred to the atmosphere the gaseous DMS is oxidized to sulfate aerosols, and these particulate aerosols act as cloud condensation nuclei (CCN) attracting molecules of water. Water vapor condenses on these CCN particles forming the water droplets that make up clouds. Clouds affect the Earth's radiation balance and greatly influence regional temperature and climate. DMS represents 95 % of the natural marine flux of sulfur gases to the atmosphere, and scientists estimate that the flux of marine DMS supplies

about 50 % of the global biogenic source of sulfur to the atmosphere. Greenhouse gases have well-constrained positive forcings (creating a warming). In contrast, DMS air-sea fluxes have negative forces creating a cooling effect.

At its maximal extent, sea-ice covers over 80 % of the Arctic Ocean. Sea-ice plays a dominant role in determining the intensity of the DMS fluxes in the Arctic and the Antarctic and to a large extent determines the climate sensitivity of both regions. The decline in sea-ice cover would have an effect on phytoplankton dynamics and ocean circulation systems and hence have a significant impact on the global climate.

Here I studied the sea-ice impact on the Greenland Sea ecosystem. Greenland Sea is located on the west of the Arctic Ocean and east of Greenland where the world's second largest glaciers are located. The sea-ice has great impact on the local phytoplankton communities. The correlation study is essential for the overview of the local ecosystem. The analysis results and methods provided here not only give an outline of the ecosystem in Greenland Sea in the recent decade and how the ice impacts the local ecosystems, but also provide valuable statistical methods on analyzing correlations and predicting the future ecosystems.

As a research fellow, I worked in Griffith University, Brisbane from 2003 to 2006. I worked for a project of the biogeochemistry research in Arctic Ocean undertaken by Prof. Albert Gabric, a well-known DMS modeling expert in the world. We carried out ecosystem research in Barents Sea. It is found that temporal and spatial distribution of phytoplankton biomass (measured using chlorophyll-a (CHL)) is strongly influenced by sea-ice cover, light regime, mixed layer depth, and wind speed in Barents Sea. Later, we used genetic algorithms to calibrate a DMS model in the Arctic Ocean. The general circulation model (CSIRO Mk3) was applied to calibrate DMS model to predict the zonal mean sea-to-air flux of DMS for contemporary and enhanced greenhouse conditions at 70 °N–80 °N. We found that significant ice cover decrease, sea surface temperature increase, and mixed layer depth decrease could lead to annual DMS flux increases by more than 100 % by the time of equivalent CO₂ tripling (the year 2080). This significant perturbation in the aerosol climate could have a large impact on the regional Arctic heat budget and consequences for global warming. Leon Rotstayn, the Principal Research Scientist from Marine and Atmospheric Research Centre in CSIRO supervised the GCM batch system running.

The cooperation research with Australia has been carried on since then. My Chinese national natural science funding entitled “The Impact of Arctic Ecosystem and DMS to its Climate” provided us with further research possibilities.

Sincere thanks should first go to Prof. Albert Gabric for his opening the door and leading to the further study of this project. Huge thanks to my four students: Li Hehe, Gu PeiJuan, Dong LiHua, and Wang ZaQin, for their hard work on processing regional satellite data. Great thanks to Chinese national natural science funding for providing the possibilities on carrying work on the project.

Acknowledgments

Huge thanks should go to my four students: Li HeHe, Gu PeiJuan, Dong LiHua and Wang ZaQin. Thanks for their hard work on getting those regional satellite data and processing them as well. Sincere thanks to my previous supervisor Prof. Albert Gabric in Griffith University, Australia, for his guidance and leading me to this Arctic ecosystem research area. Thanks to NASA's Ocean Biology Processing Group for providing MODIS aqua, Level 3 (4-km equi-rectangular projection) 8-day mapped data for chlorophyll-*a* (CHL) and aerosol optical depth (AOD). Thanks to NASA Goddard Space Flight Centre of SeaWiFS Project group for providing 8-day mapped Photosynthetically Active Radiation data. Thanks to NASA Web SeaDAS development group for providing Ocean Colour SeaDAS Software (SeaWiFS Data Analysis System) for processing CHL, AOD, and PAR data. Thanks to NOAA NCEP EMC CMB GLOBAL Reyn-SmithOIv2 for providing weekly and monthly sea-ice concentration. Thanks to NASA for providing Wind Data and Sea Surface Temperature data. WindSat data are produced by Remote Sensing Systems and sponsored by the NASA Earth Science MEASURES DISCOVER Project and the NASA Earth Science Physical Oceanography Program. Thanks to NASA <http://gdata1.sci.gsfc.nasa.gov> for providing cloud cover data.

Thanks to the Chinese National Natural Science Funding (Funding No. 41276097) for providing funding for this project. Thanks to the Chief Editor Lisa Fan and other editors, for all the initiation and hard work toward getting this book organized until publishing.

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