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Recent increase of natural sulfur emission from the North Atlantic seasonal sea ice area reconstructed from the SE-Dome ice core, southeastern Greenland

Content

Under the warming climate, the primary production of the ocean has been changing. The strengthening of the ocean stratification in spring and summer and the weakening of the vertical mixing in winter owing to the warming of air temperature can decrease the production. On the other hand, reduced sea ice extent can improve the light environment in the ocean and increase production. Dimethyl sulfite (DMS), which originated from the ocean phytoplankton, plays an important role in water and material circulation such as cloud formation above the ocean. However, there are many unclear points about the behaviors of DMS between the ocean and atmosphere. We provided a profile of methane sulfonic acid (MSA), which is produced by oxidation of DMS, with a high temporal resolution in an ice core drilled at a southeastern dome (SE-Dome) of the Greenland Ice Sheet. Due to the high accumulation rate (1.01 m w.eq. yr^{-1}), MSA is well preserved without post-depositional loss. The 90.45-m ice core covers from 1960 to 2014. The number of samples is 395 from 1960 to 2014, corresponding to approximately 7-samples per year on average. The annual flux of MSA (MSA_{flux}) decreased from 1960 to 2001 and remarkably increased after 2002. The seasonal variation of MSA_{flux} showed a bimodal pattern with peaks of spring (April–June) and summer (July–September). The spring MSA_{flux} highly correlated with the chlorophyll-a (Chl-a) concentration in the northern part of the North Atlantic ($r = -0.873$, $p < 0.01$). The spring MSA_{flux} decreased from 1960 to 2005 and was relatively high after the late 2000s. We conclude that the spring phytoplankton bloom has been enhanced and then the natural sulfur emission from ocean to atmosphere increased after the late 2000s. The summer MSA_{flux} in 2002–2014 was 3–6 times higher than that in 1972–2001. Backward trajectory analysis showed that possible source of MSA was the southeastern coast of Greenland. In the southeastern coast of Greenland, a retreat of sea ice in 2002–2014 was earlier than that before 2001, and almost all sea ice in the region disappeared until June in 2002–2014. The earlier retreat of sea ice improves the light environment at the surface and sub-surface of the ocean and enhances the production of phytoplankton. Satellite data showed that the Chl-a concentration in the southeastern coast of Greenland in 2002–2014 was higher than that in 1998–2001. Therefore, the recent increase in summer MSA_{flux} indicates the increase of DMS emission from enhanced phytoplankton growth by the early retreat of sea ice in the southeastern coast of Greenland.

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