Reconsideration of upward growth processes of sea ice contributed by snow cover

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Landfast sea ice has shown quasi-periodic breakups in Lützow-Holm Bay, East Antarctica, since 1980. Based on satellite imagery and wintering reports, it is found that each unstable regime with a large-scale breakup and stable without disintegration have been continuing for several years, respectively. In the austral autumn of 2016, landfast sea ice collapsed extensively in multi-year ice as well as young ice region since 2006. The field observation just before the 2016 event revealed that multi-year landfast ice has grown to maximum thickness of 6 m with snow cover of 1.0 m or more. Thus, extremely thick ice field was much stable against strong wind and ocean swell, then severe ice conditions prevented the icebreaker SHIRASE from approaching Syowa Station during the first half of 2010s. This study aims to elucidate a mechanism for landfast sea ice breakup under heavy snow condition in the Antarctic coastal region, and to provide scientific knowledge for planning field operation including ice navigation.

According to the sea-ice core analysis, formation of sea ice originating from snow has been confirmed, that is, sea ice is found to grow upward as snow ice or superimposed ice. Note that deep snow gives opposite effects on preservation of sea ice; one is mechanically reinforcement due to upward growth through formation of snow ice or superimposed ice and having high albedo; the other is weakening due to lowering flexural strength by gradually increasing the ratio of snow-origin ice. Time series data on snow depth has suggested that snow cover controls stability of landfast ice. During the period of several-year continuation of heavy snow contributes to the stabilization of multi-year ice, then snow cover on the ice brings about ice thickening and strengthening effect. Though a trend of heavy-snow years has been recognized since 2009, the degree of snow-origin ice increase for each year is dull. This suggests that when the sea ice becomes extremely thick, the sea ice cannot be sunk under the water surface in ordinary snow accumulation alone, and the snow ice formation will be suppressed.

Furthermore, when the ice thickness and the snow depth are large, the temperature drop of the sea ice layer (the ice body near the boundary with the snow layer) is also suppressed, making it difficult to maintain the condition of the superimposed ice formation. From these facts, it is suggested that there is an upper limit to the upward growth of sea ice under heavy snow condition. In this study, effects of snow on multi-year ice growth and decay have been reconsidered and some results will be discussed.