2012 年晩冬季に東南極域で観測された海氷上の異常積雪深の成因について

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What caused the significant snow depth observed off east Antarctica in late winter 2012?

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In late winter 2012, the SIPEXII expedition was conducted off East Antarctica onboard RV Aurora Australis. The sea ice conditions during this expedition were characterized by significantly thick ice and snow, trapping the ship for about 10 days near the coastal region off Wilkes Land. The deep snow overlying sea ice was particularly remarkable, in that its average value of 0.45 m was more than twice that observed on past cruises to the region. To reveal what caused such significant amount of snow, we examined the meteorological conditions using the ERA-interim dataset. Analysis of moisture budget and precipitation minus evaporation (P-E) data over the entire Antarctic sea ice region and for the period of 1990 to 2012 reveals no significant evidence for much higher snow accumulation there in the winter of 2012. Given that snow ice fraction was shown to be limited from ice core analysis, it is provisionally concluded that there was limited conversion of snow to snow ice due to significant ice thickness, and that this might be responsible for the significant amount of snow on sea ice in 2012.

Introduction The SIPEXII (Sea-Ice Physics and Ecosystem eXperiment II) expedition was conducted in late September to early November 2012 off Wilkes Land in East Antarctica. During the expedition, the measurements were obtained of snow depth along 11 transect lines of 100 m length, and snow properties in 19 pits on 5 ice floe stations. While observation was relatively limited, the results showed unprecedentedly greater snow depth (0.45±0.26 m on average) compared with the past data (0.13 to 0.21 m on average) obtained in this region in 1992, 1994, 1995, 2003, and 2007. Since snow affects the growth of the underlying sea ice through its thermal insulation effect and/or its conversion into sea ice by flooding of seawater, monitoring snow depth is very important to understand the thickness trend of Antarctic sea ice and its likely future trajectory. According to the analysis using satellite passive microwave sensor by Maksym and Markus (2008), our study region is characterized by thick snow ice. Given these factors, it is important to clarify what causes the interannual variation of snow accumulation in this region. The purpose of this study is to examine the reason for such significantly deep snow in 2012 from the analysis of meteorological dataset.

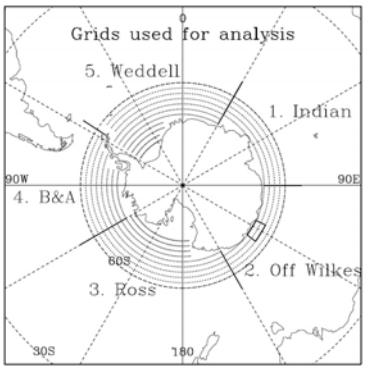

Figure. 1 Grids and sectors used for analysis. Square area denotes the study region.

Data & Methods For the analysis of meteorological conditions, we used ERA-interim upper and surface data for the period 1990 to 2012. Due to lack of direct measurement, snow accumulation rates were calculated from moisture budget data by the following equation, for the study region and 5 sectors surrounding the Antarctica (Fig.1): $P - E = -\partial PW/\partial t - \nabla \cdot \langle q\vec{V} \rangle$, where PW is precipitable water and $\langle q\vec{V} \rangle$ is a vertical integration of moisture flux.

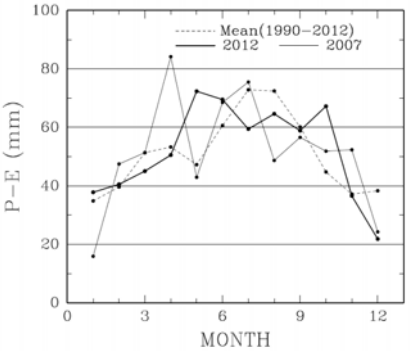

Figure. 2 Monthly integrated P-E for 2012, 2007 and total period.

Results The time series of monthly-integrated P-E in 2012 is shown in Fig.2, with that in 2007 and mean values for the total period included for comparison. This figure shows no significant evidence for higher P-E in 2012, which is almost the case for other sectors in Fig.1. Considering the much thicker sea ice (2.33±1.63 m), larger freeboard (0.12±0.18 m) and lower fraction (~7%) of snow ice in 2012, it is more likely that the limitation of snow to snow ice conversion might have resulted in significantly deeper snow on sea ice in 2012.

Reference

Maksym, T. and T. Markus, Antarctic sea ice thickness and snow-to-ice conversion from atmospheric reanalysis and passive microwave snow depth, *J. Geophys. Res.*, Vol.113, C02S12, doi:10.1029/2006JC004085, 2008.