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Variability and Anomalous Trends in the Global Sea Ice Cover

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Abstract

The advent of satellite data came fortuitously at a time when the global sea ice cover has been changing rapidly and new techniques are needed to accurately assess the true state and characteristics of the global sea ice cover. The extent of the sea ice in the Northern Hemisphere has been declining by about -4% per decade for the period 1979 to 2011 but for the period from 1996 to 2010, the rate of decline became even more negative at -8% per decade, indicating an acceleration in the decline. More intriguing is the drastically declining perennial sea ice area, which is the ice that survives the summer melt and observed to be retreating at the rate of -14% per decade during the 1979 to 2012 period. Although a slight recovery occurred in the last three years from an abrupt decline in 2007, the perennial ice extent was almost as low as in 2007 in 2011. The multiyear ice, which is the thick component of the perennial ice and regarded as the mainstay of the Arctic sea ice cover is declining at an even higher rate of -19% per decade. The more rapid decline of the extent of this thicker ice type means that the volume of the ice is also declining making the survival of the Arctic ice in summer highly questionable. The slight recovery in 2008, 2009 and 2010 for the perennial ice in summer was likely associated with an apparent cycle in the time series with a period of about 8 years. Results of analysis of concurrent MODIS and AMSR-E data in summer also provide some evidence of more extensive summer melt and meltponding in 2007 and 2011 than in other years.

Meanwhile, the Antarctic sea ice cover, as observed by the same set of satellite data, is showing an unexpected and counter intuitive increase of about 1 % per decade over the same period. Although a strong decline in ice extent is apparent in the Bellingshausen/ Amundsen Seas region, such decline is more than compensated by increases in the extent of the sea ice cover in the Ross Sea region. The results of analysis of MODIS, AMSR-E and SSM/I data reveal that the sea ice production rate at the coastal polynyas along the Ross Ice Shelf has been increasing since 1992. This also means that the salinization rate and the formation of bottom water in the region are going up as well. Simulation studies indicate that the stronger production rate is likely associated with the ozone hole that has caused a deepening of the lows in the West Antarctic region and therefore stronger winds off the Ross Ice Shelf. Stronger winds causes larger coastal polynyas near the shelf and hence an enhanced ice production in the region during the autumn and winter period.

Results of analysis of temperature data from MODIS and AMSR-E shows that the area and concentration of the sea ice cover are highly correlated with surface temperature for both the Arctic and Antarctic, especially in the seasonal regions where the correlation coefficients are about 0.9. Abnormally high sea surface temperatures (SSTs) and surface ice temperatures (SITs) were also observed in

2007 and 2011when drastic reductions in the summer ice cover occurred. This phenomenon is consistent with the expected warming of the upper layer of the Arctic Ocean on account of ice-albedo feedback. Changes in atmospheric circulation are also expected to have a strong influence on the sea ice cover but the results of direct correlation analyses of the sea ice cover with the Northern and the Southern Annular Mode indices show relatively weak correlations. This might be due in part to the complexity of the dynamics of the system that can be further altered by some phenomena like the Antarctic Circumpolar Wave and extra polar processes like the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO).