IMPACTS OF ARCTIC SEA ICE CHANGE ON ICE-ALBEDO FEEDBACK AND SURFACE ENERGY BALANCE

Donald. K. Perovich
ERDC – CRREL
72 Lyme Road
Hanover NH 03755 USA

Since the start of the observational satellite record in 1979, a general decline in the areal extent [1, 2] of the Arctic sea ice cover has been observed. Sea ice thickness data from submarine surveys and satellite observations have shown a decline in thickness [3]. These changes impact, and are impacted by, the partitioning of solar radiation and the surface heat budget. Estimates of solar heat absorbed in the ocean and in the ice have been calculated from 1979 to 2008 on a 25 x 25 km Equal Area Scalable Earth Grid for the area covered by both seasonal and perennial ice [4, 5]. Input parameters for these calculations include incident solar irradiance (from reanalysis products), ice concentration (from satellites), onset dates of melt and freezeup (from satellites), and ocean and ice albedo (from in situ observations). Albedos were obtained by generalizing surface based observations of the albedo of open ocean [6] and the seasonal evolution of sea ice albedo [7]. The seasonal evolution sea ice albedo was defined in terms of the onset dates of melt and freezeup. Results show a general increase of solar heat into the ice – ocean system due primarily to a decrease in summer ice area. There was an increase of solar heating of the ocean during the past few decades in over 85% of the area studied, with maximum increases of 5% per year. The increase in solar heat input to the ice has been more modest and is more sensitive to the onset date of summer melt than the freezeup date. In situ measurements of sea ice mass balance have established a linear correlation between increased solar heat input to the upper ocean and bottom melting of the ice. For example, the Beaufort Sea in 2007 had a 500% positive anomaly in solar heat input to the upper ocean. This is consistent with in situ ice mass balance observations in that area that showed an extraordinary amount of bottom melting (roughly 2 m) [8]. Further thinning of the ice will lead to more solar heat input to the ocean and enhanced bottom melting and continued decline of the ice cover. This is a classic of the ice – albedo feedback. Synthesizing mass balance observations with calculated estimates of solar heating indicate a strong correlation between solar heat to the ocean and bottom melting, but only a modest correlation between solar input to the ice and surface melting.

Bibliography

[1] J. C. Comiso, , Parkinson, C. L., Gersten, R. & Stock, L. Accelerated decline in the Arctic sea ice cover, *Geophys. Res. Lett.* 35, LO1703, doi:10.1029/2007GL031972, 2008

[2] M.C. Serreze, M.M. Holland, and J. Stroeve, Perspectives on the Arctic's Shrinking Sea-Ice Cover. Science, 315, 1533, doi: 10.1126/science.1139426, 2007.

[3] R. Kwok, G. F. Cunningham, M. Wensnahan, I. Rigor, H. J. Zwally, and D. Yi, Thinning and volume loss of the Arctic Ocean sea ice cover: 2003–2008, *J. Geophys. Res.*, 114, C07005, doi:10.1029/2009JC005312, 2009.

[4] D. K. Perovich, B. Light, H. Eicken, K. F. Jones, K. Runciman, and S. V. Nghiem, Increasing solar heating of the Arctic Ocean and adjacent seas, 1979–2005: Attribution and role in the ice- albedo feedback, *Geophys. Res. Lett., 34*,L19505, doi:10.1029/2007GL031480, 2007.

[5] S.V. Nghiem, , I. G. Rigor, D. K. Perovich, P. Clemente-Colon, J. W. Weatherly, and G. Neumann, Rapid reduction of Arctic perennial sea ice, *Geophys. Res. Lett*., 34, L19504, doi:10.1029/2007GL031138, 2007.

[6] W. S. Pegau and C.A. Paulson, The albedo of Arctic leads in summer, *Ann. Glaciol.*, 33, 221–224, 2001.

[7] D.K. Perovich, T.C. Grenfell, B. Light, and P.V. Hobbs, The seasonal evolution of Arctic sea ice albedo, *J.Geophys. Res.*, 10.1029/2000JC000438, 2002.

[8] D. K. Perovich , J. A. Richter-Menge, K. F. Jones, and B. Light, Sunlight, water, and ice: Extreme Arctic sea ice melt during the summer of 2007, *Geophys. Res. Lett.*, 35, L11501, doi:10.1029/2008GL034007, 2008.