Observations of Arctic Sea Ice and River Discharge with Multiple Satellite Sensors

S. V. Nghiem[1,2], D. K. Hall[3], I. G. Rigor[4], P. Li[1], and G. Neumann[1]

[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA
[2]Joint Institute for Regional Earth System Science and Engineering, University of California at Los Angeles, Los Angeles, CA 90095, USA
[3]NASA Goddard Space Flight Center, Greenbelt, Maryland, USA
[4]University of Washington, Seattle, Washington, USA

Arctic sea ice has declined rapidly. A record low of sea ice extent occurred in summer 2012 as observed over three decades of satellite data. The regime of the Arctic ice cover has shifted to a new state dominated by seasonal sea ice, as perennial sea ice has diminished drastically. Changes in the distribution of sea ice classes can precondition summer melt, alter the surface albedo, upset the Bowen ratio, and impact atmospheric photochemical processes. To investigate Arctic sea ice, environmental, and chemical changes, we conducted the Bromine, Ozone, and Mercury Experiment (BROMEX) around Barrow, Alaska, in March-April 2012, together with continuous measurements through the present. We used satellite active microwave scatterometer (AMS) and passive microwave radiometer (PMR) to observe the change in sea ice extent (SIE). A problem for sea ice observations in summer is that surface melt can impact PMR signatures of sea ice, causing large uncertainties in the measurement of SIE. We developed an AMS algorithm to determine SIE, primarily based on a quadruplet combination of relative AMS values rather than the absolute magnitudes of the signature and thus improving SIE accuracy. Then we took the SIE product from AMS in 2000-2009 to calibrate PMR results and reconstruct a SIE time series over three decades (1979-2013). To monitor sea surface temperature change caused by river discharge, we obtain results from two different algorithms using data acquired from the Moderate-resolution Imaging Spectroradiometer (MODIS) instruments that are currently in orbit on both the Terra and Aqua satellites, launched in 1999 and 2002, respectively. We present results from spring-summer 2012 over the Beaufort Sea where warm waters from the Mackenzie River surged onto the sea surface layer thereby accelerating sea ice melt. Additionally, we estimated the total annual heating power carried by 72 rivers into the Arctic Ocean. We found that Arctic rivers could provide an enormous amount of energy to melt sea ice. With their immense watersheds (several million square kilometers), the Arctic rivers are effective conduits that transport heat from the warm continents in summer to the Arctic Ocean, thus contributing to sea ice melt, and enhancing the sensitivity of Arctic sea ice to climate change. In stark contrast, Antarctica is a frozen continent without any warm rivers to affect sea ice in the Southern Ocean. Using satellite observations, we directly address the question: Why has Arctic sea ice decreased precipitously while Antarctic sea ice has been relatively stable? This topic draws tremendous attention from the cryospheric science community, and has been a challenging riddle in climate change research. The influence of river discharge into the Arctic Ocean helps to answer that puzzle.

978-1-4673-5225-3/14/$31.00 ©2014 IEEE