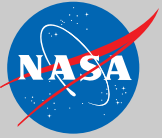


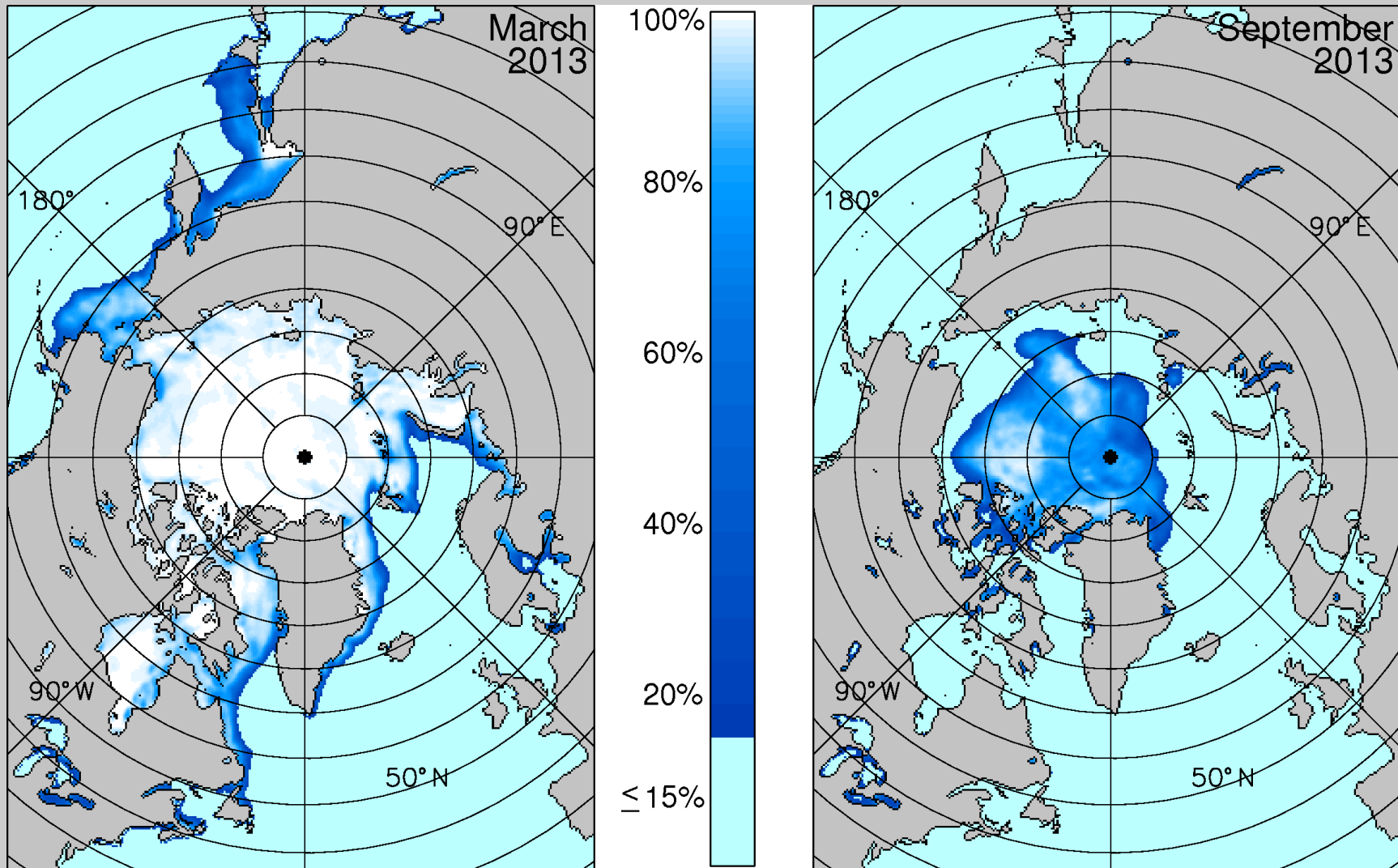
Satellite Observations of the Decreasing Arctic Ice Cover

Claire L. Parkinson
NASA Goddard Space Flight Center

Presentation at the Secure World Foundation, Washington,
D.C., January 27, 2015



Winter and Summer Arctic Sea Ice Coverages as determined from satellite data

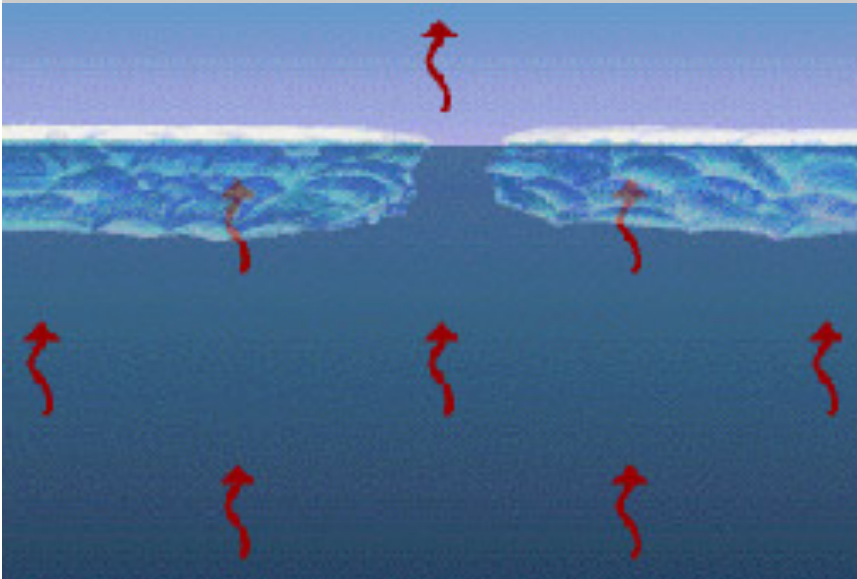


The values mapped are sea ice concentrations (percent areal coverages of ice).

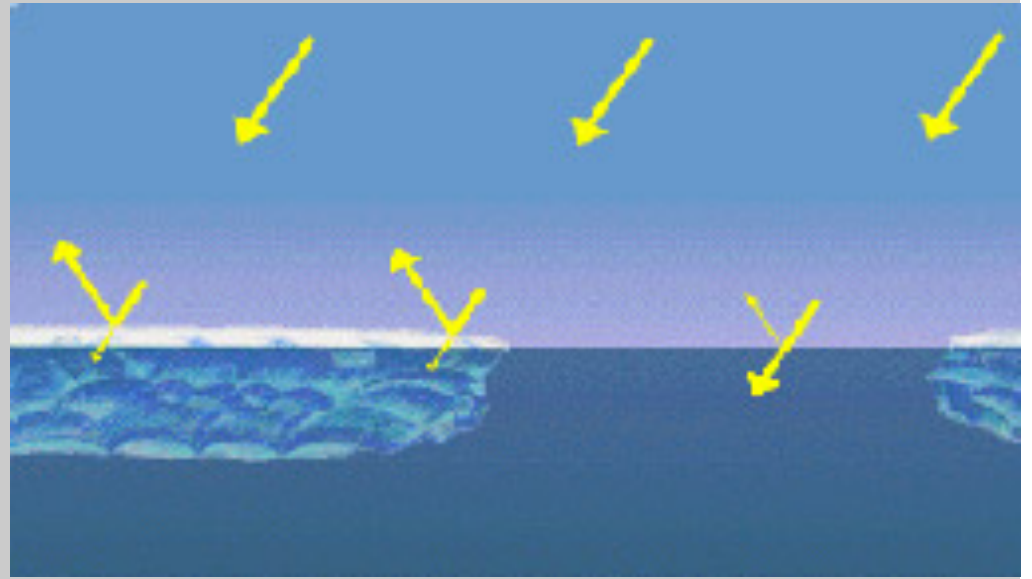


Sea Ice Impacts

Insulation



Reflectivity



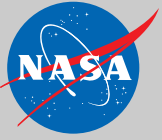
Impacts on plant and animal life



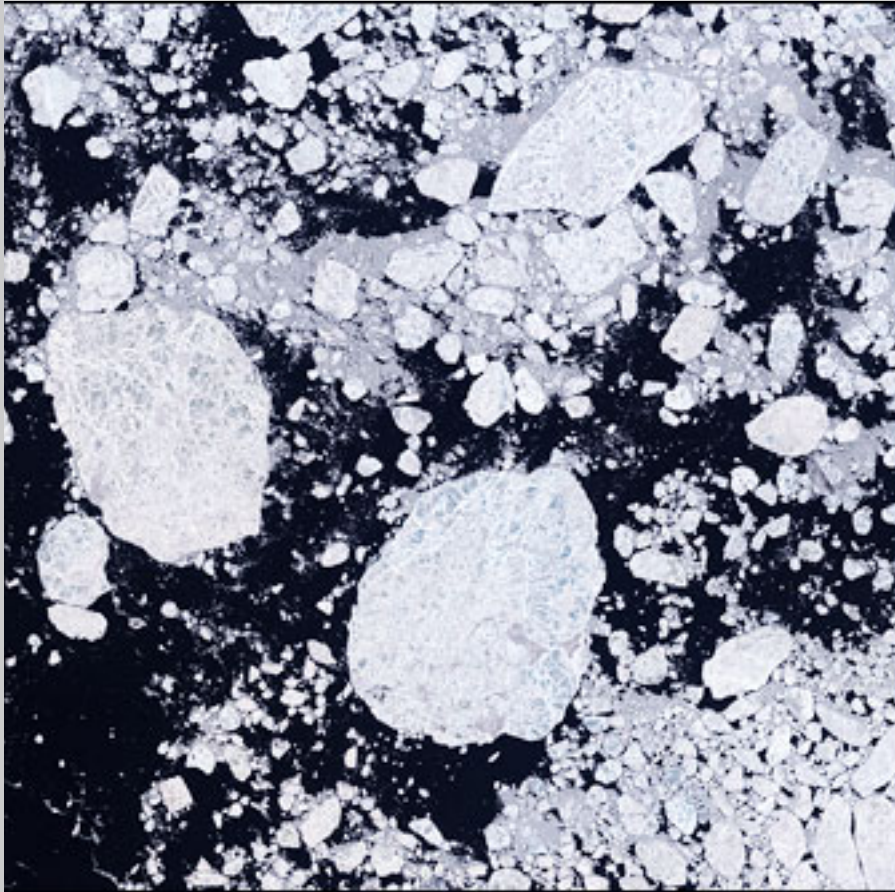
(photo by Robert Taylor)

Impacts on human activities

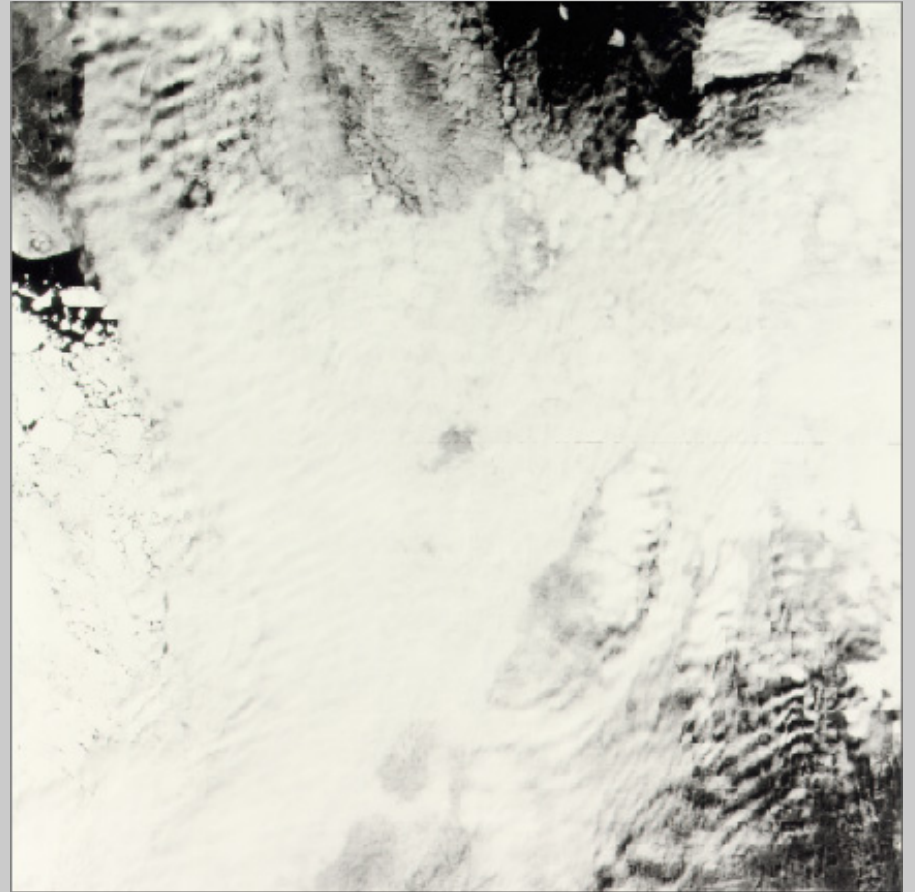




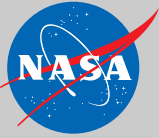
Arctic Sea Ice from Landsat Visible Imagery



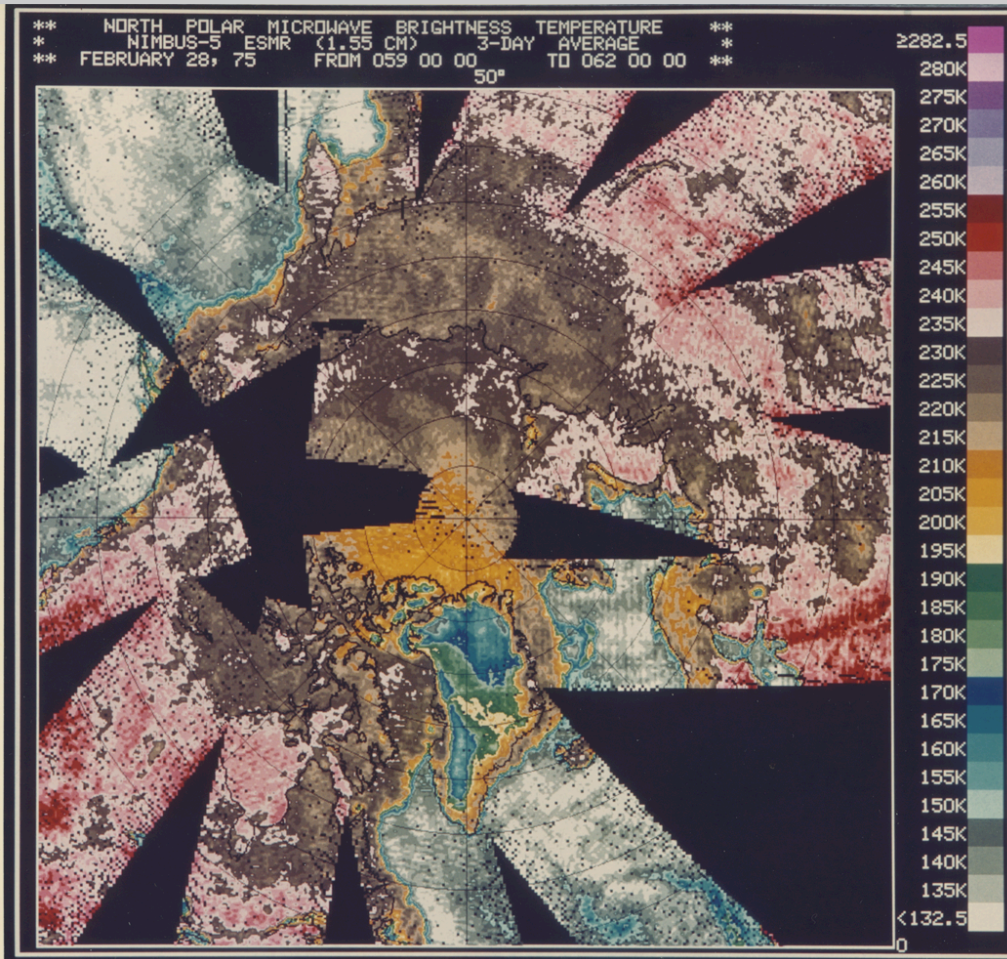
June 1, 2001, from Landsat 7



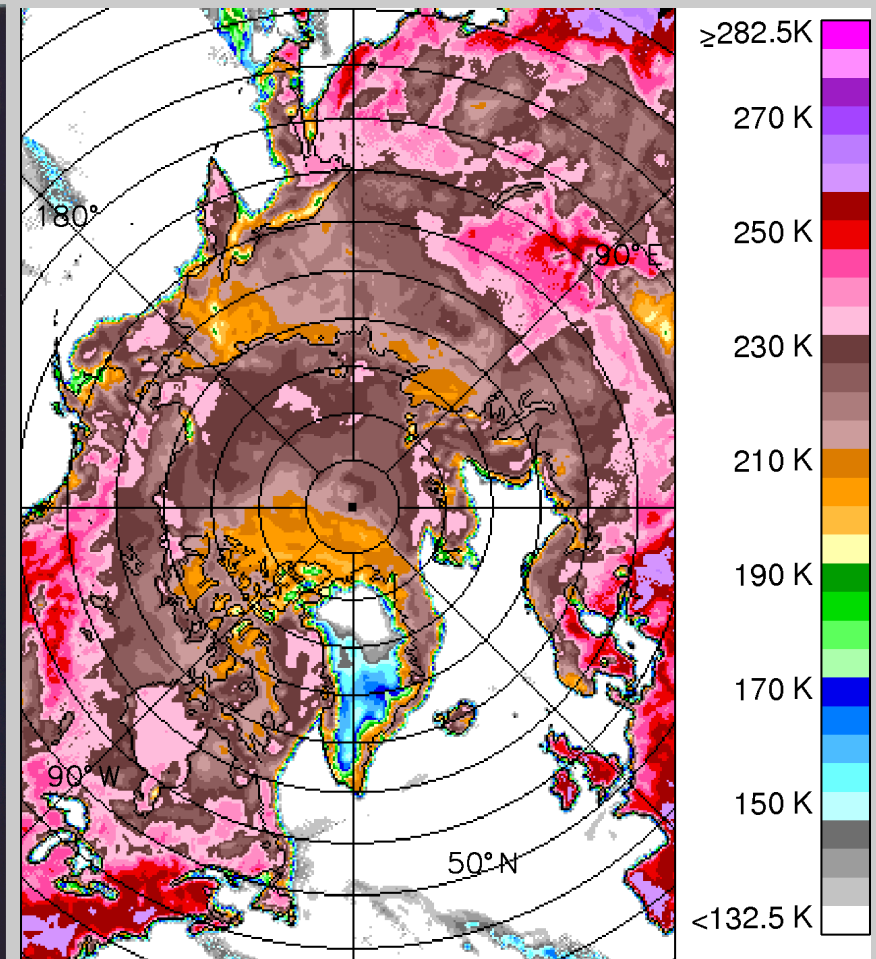
Sea ice obscured by clouds,
Sept. 5, 1972, from Landsat 1



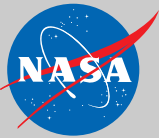
Sample 3-Day Arctic Image from NASA's Nimbus 5 Microwave Imager, Feb. 28 – March 2, 1975



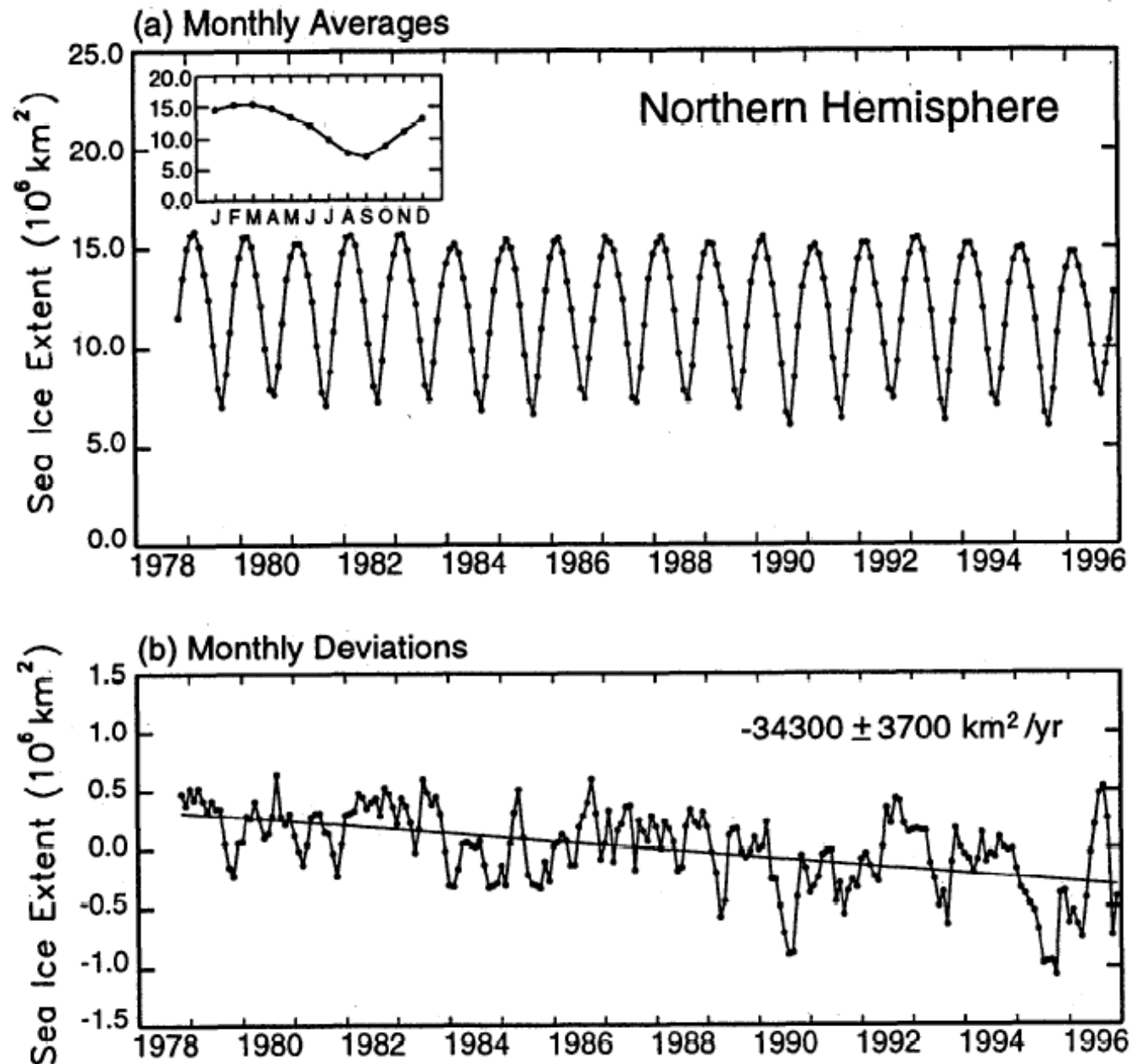
Sample 1-Day Arctic Image from the Defense Meteorological Satellite Program's Microwave Imager, March 1, 2013



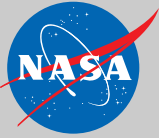
Instrument's used: (Left) Electrically Scanning Microwave Radiometer (ESMR);
(Right) Special Sensor Microwave Imager/Sounder (SSMIS)



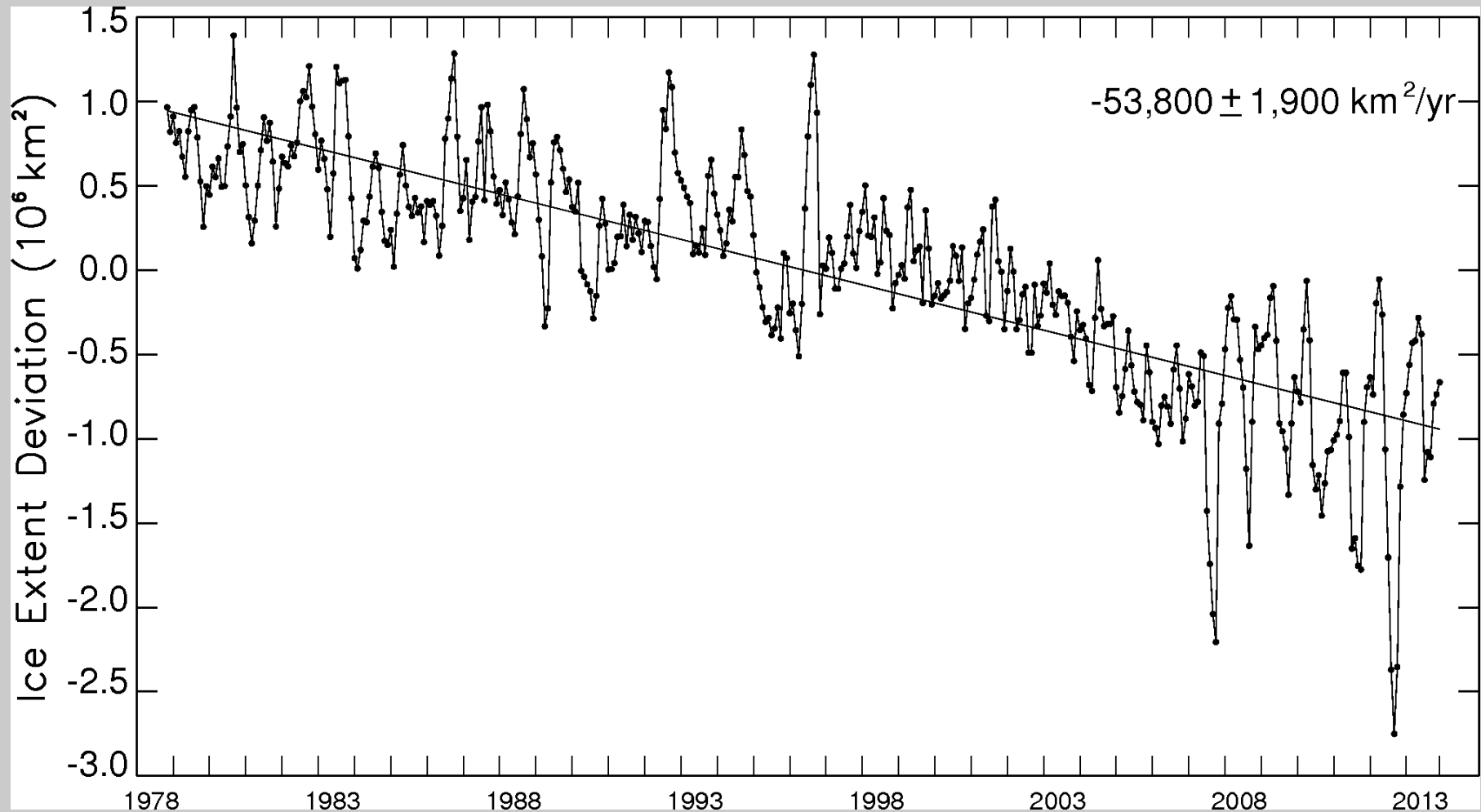
Arctic Sea Ice Extents, 1978-1996



(plots from Parkinson et al., 1999, *J. Geophys. Res.*, based on Nimbus 7 and DMSP satellite microwave imager data)

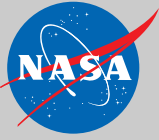


Arctic Sea Ice Extent Monthly Deviations, 11/1978 – 12/2013, from satellite microwave data

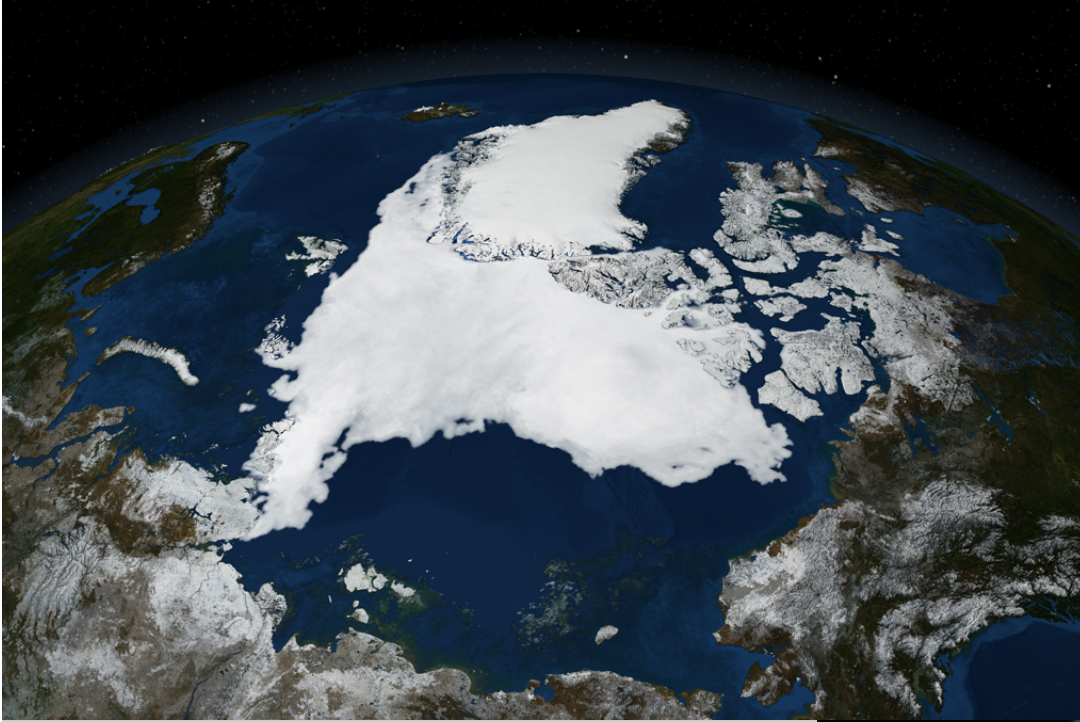


(from Parkinson, 2014, *J. Wash. Acad. Sci.*)

Instruments used: Nimbus 7 Scanning Multichannel Microwave Radiometer (SMMR),
DMSP Special Sensor Microwave Imager (SSM/I), and SSM/I/Sounder (SSMIS)

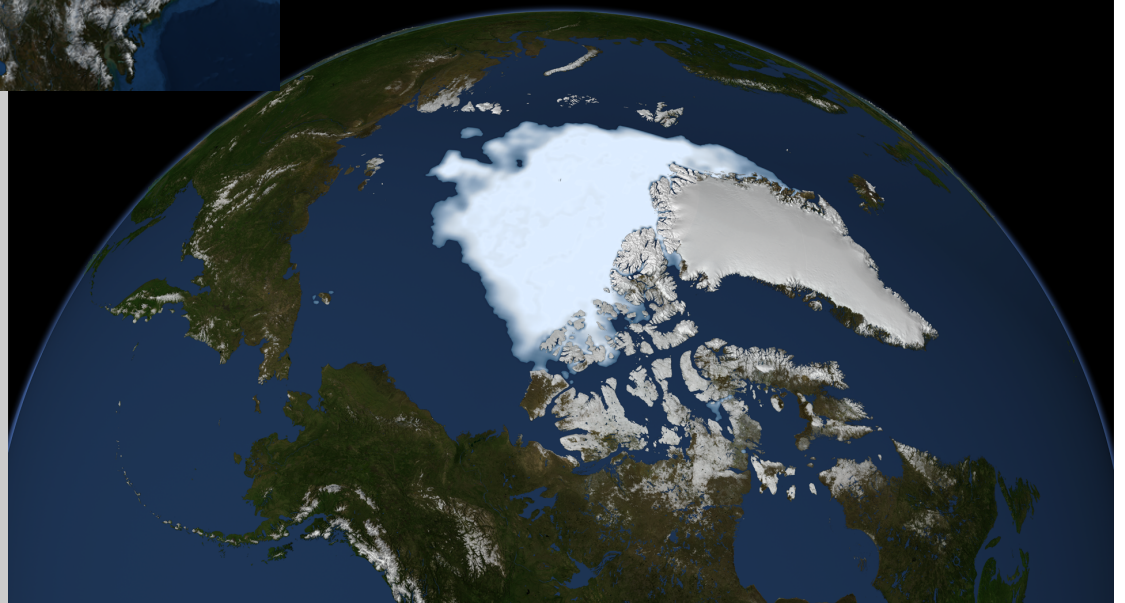


Arctic Record Low Sea Ice Coverages, September 14, 2007 and September 13, 2012



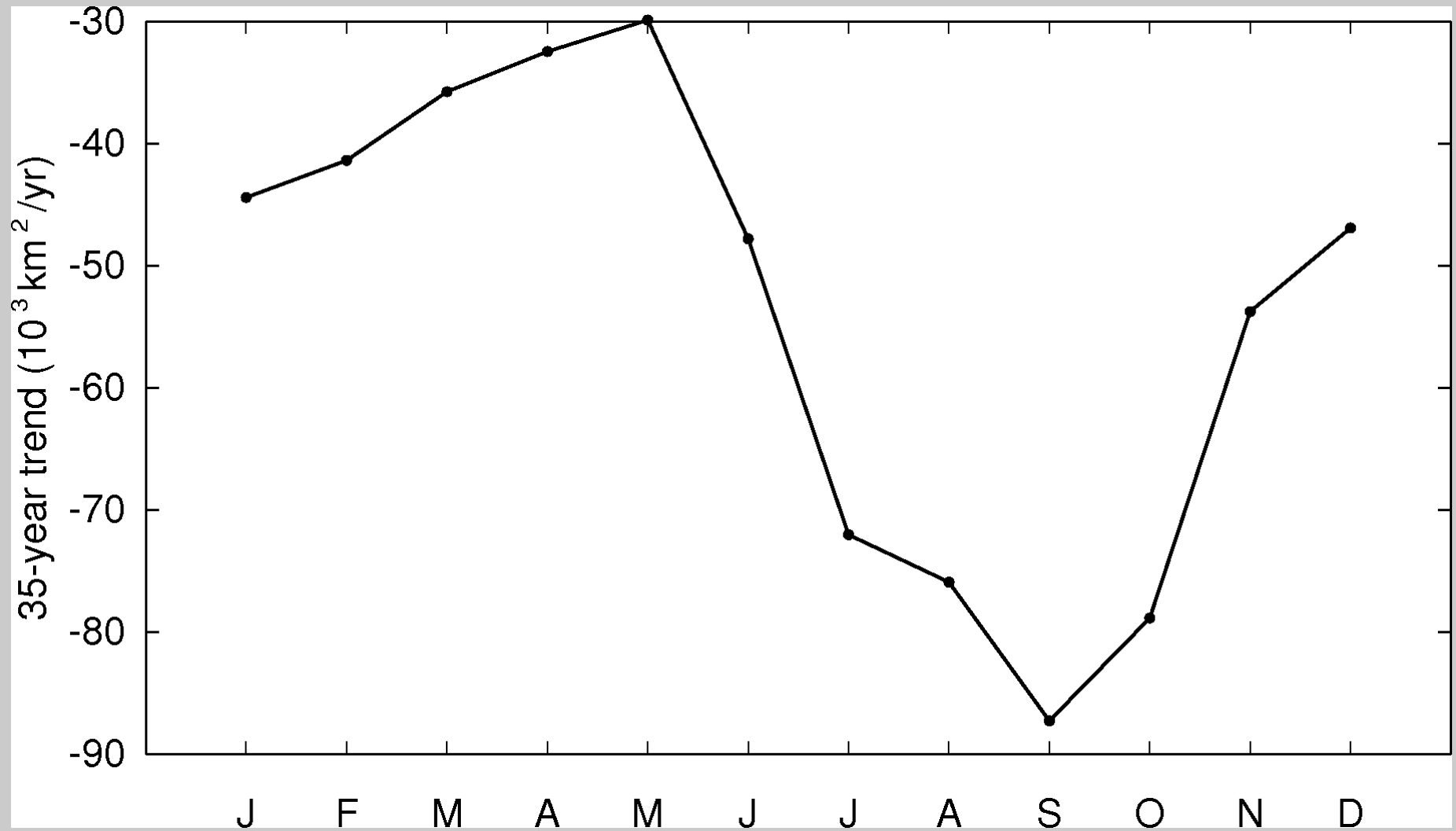
September 14, 2007 ice coverage,
from the Japan Aerospace Exploration
Agency's (JAXA's) Advanced Micro-
wave Scanning Radiometer for the
Earth Observing System (AMSR-E) on
NASA's Aqua satellite

September 13, 2012 ice coverage,
from the AMSR2 instrument on
Japan's Shizuku satellite

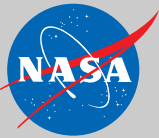




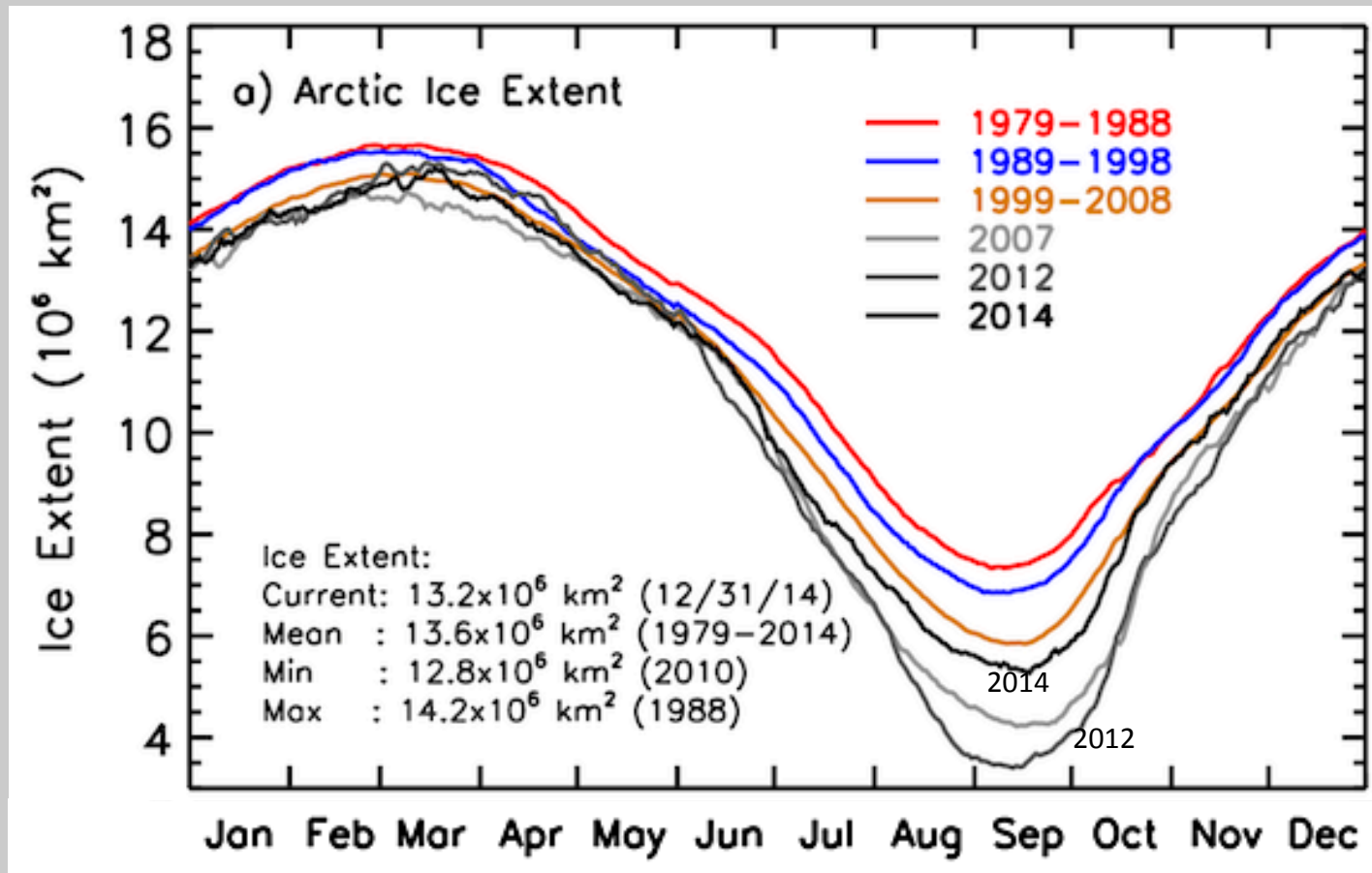
Arctic Sea Ice Extent Trends by Month, 1979-2013



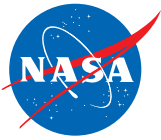
(updated from Parkinson and Cavalieri, 2008, *J. Geophys. Res.*)



2014 Arctic Sea Ice Coverage (in black) in comparison with earlier satellite data

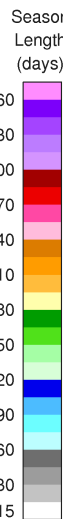
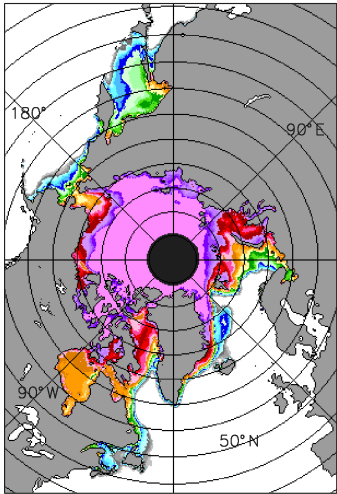


(plot from J. Comiso, C. Parkinson, T. Markus, D. Cavalieri, and R. Gersten, updated weekly on the NASA GSFC Cryospheric Sciences website, at neptune.gsfc.nasa.gov/csb/)

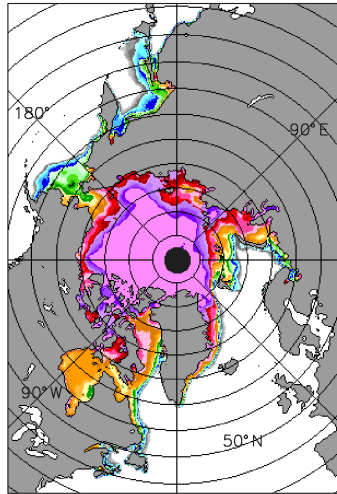


Changes in the Length of the Sea Ice Season Throughout the Arctic, 1979-2013

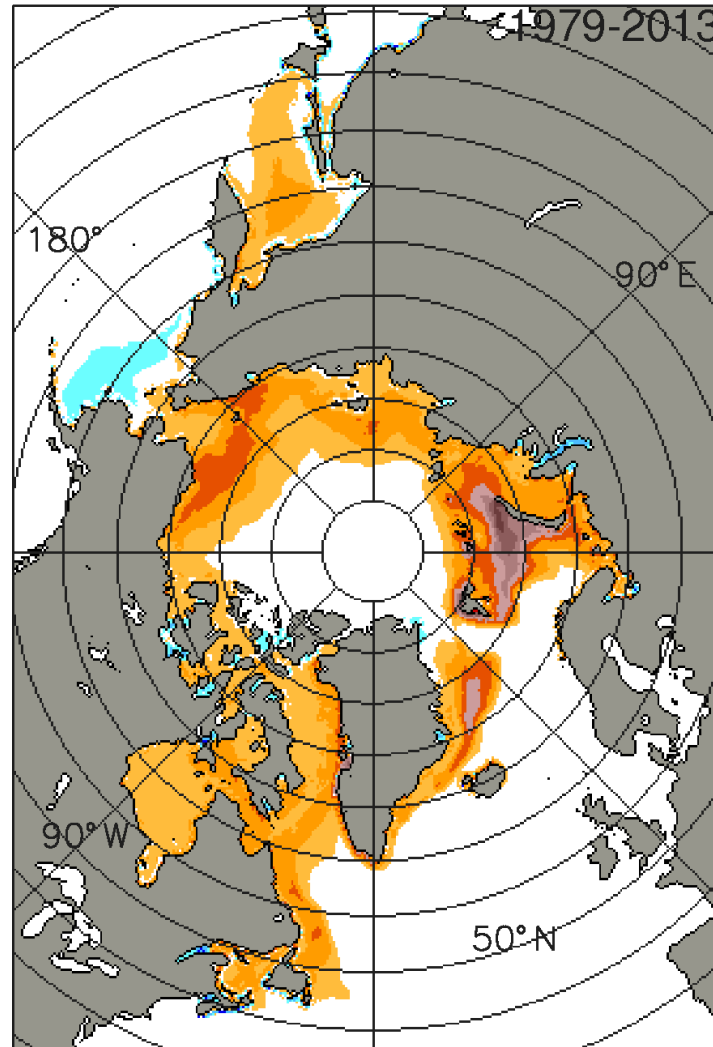
(a) 1979 Season Length



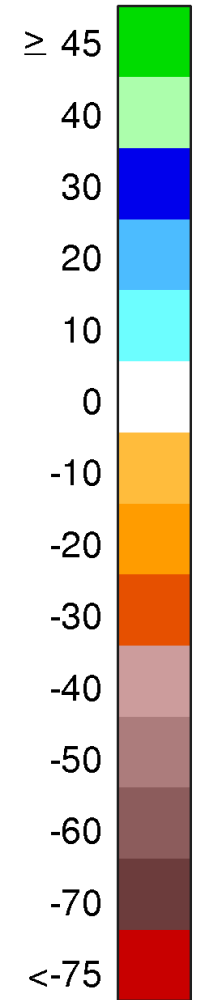
(b) 2013 Season Length



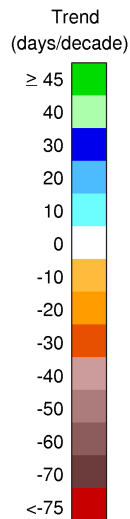
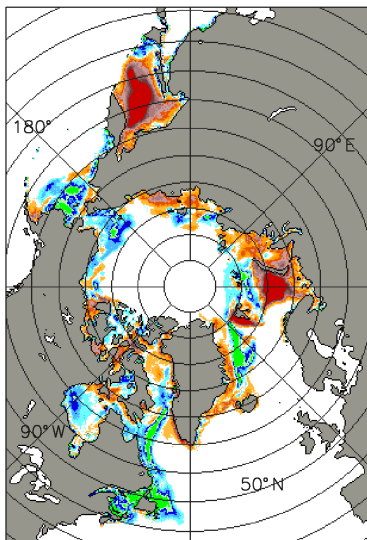
Trends in the length of the sea ice season for the full 35-year record



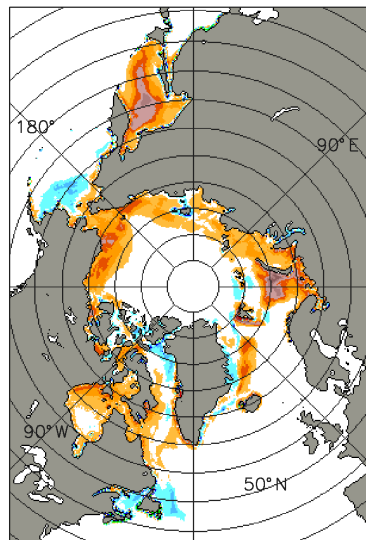
Trend (days/decade)



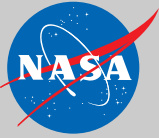
10-Year trends, 1979-1988



20-Year trends, 1979-1998

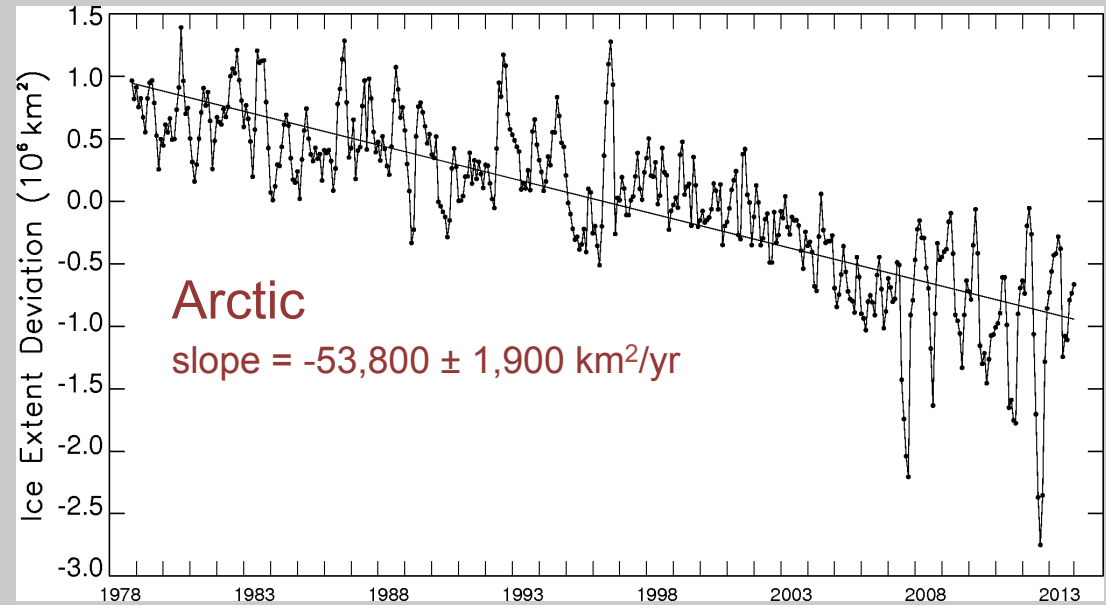


(from Parkinson 2014, *Geophys. Res. Lett.*)

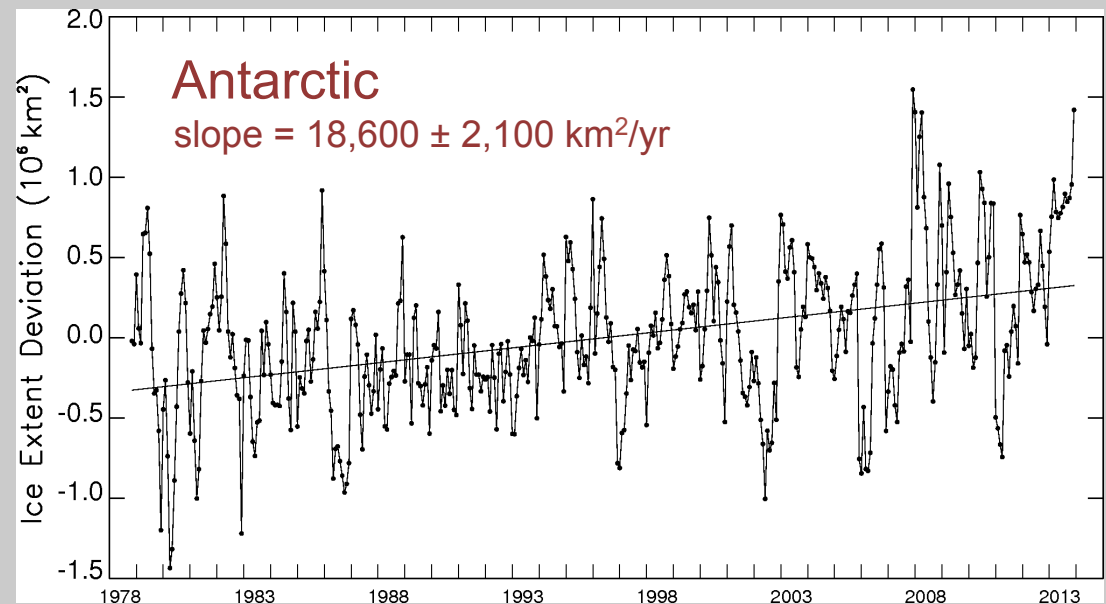


Comparison of Arctic and Antarctic Sea Ice Extent Monthly Deviations, November 1978 – December 2013

Strong Arctic sea ice decreases, tied to widespread Arctic warming.



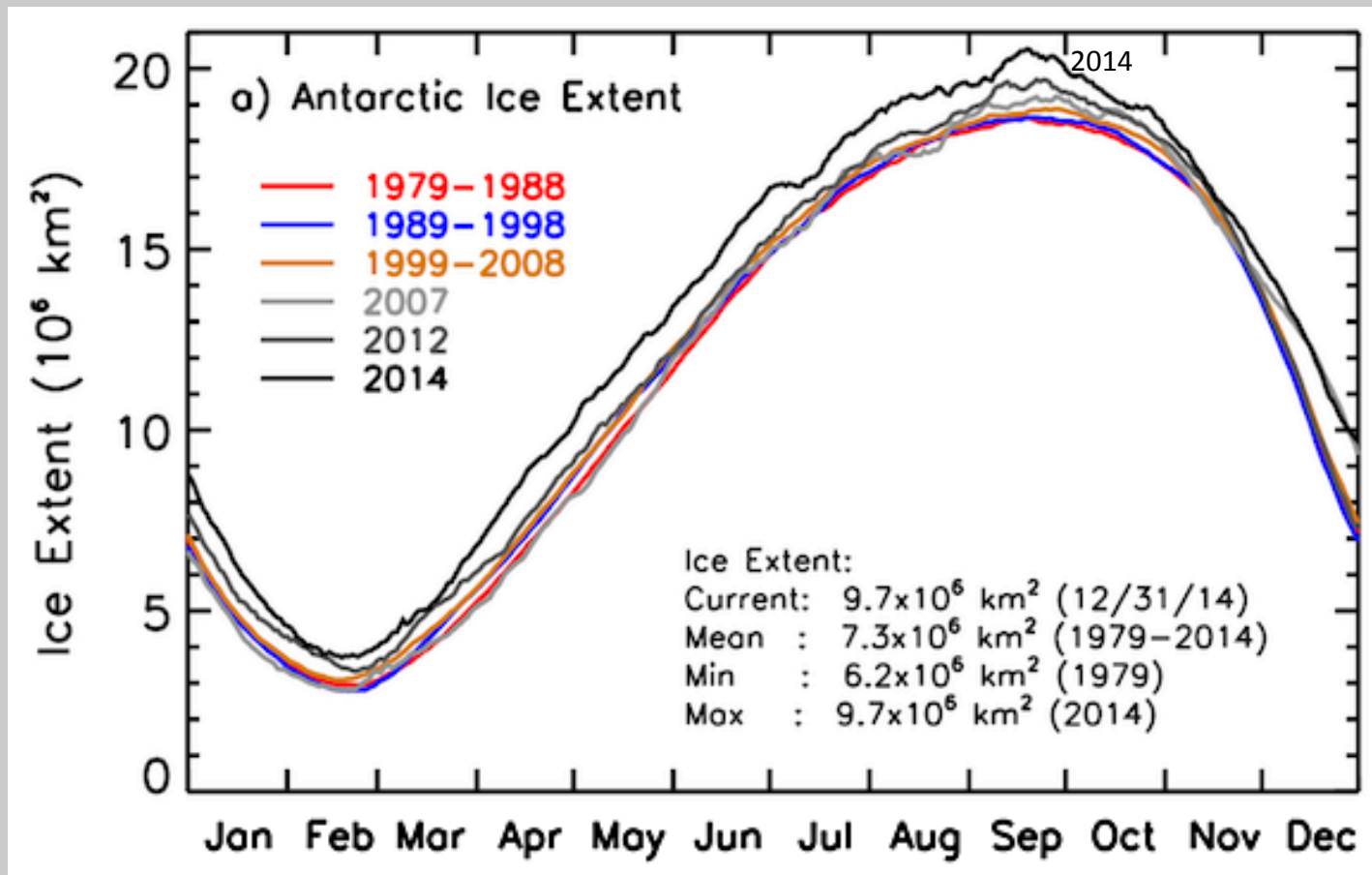
Weaker Antarctic sea ice increases, perhaps tied to changes in atmospheric circulation.



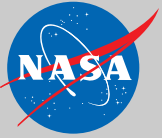
(plots updated through 2013 from Parkinson et al., 1999 and Zwally et al., 2002, *J. Geophys. Res.*)



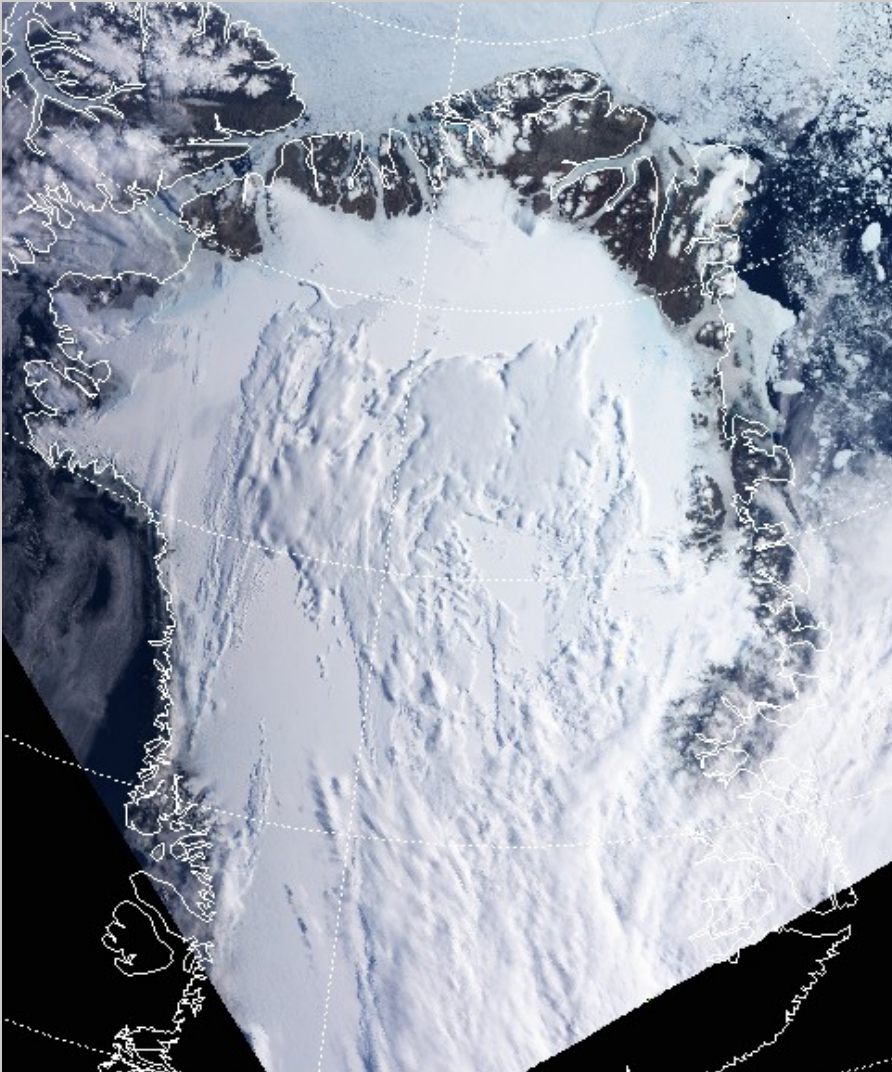
2014 Antarctic Sea Ice Coverage (in black), in comparison with earlier satellite data



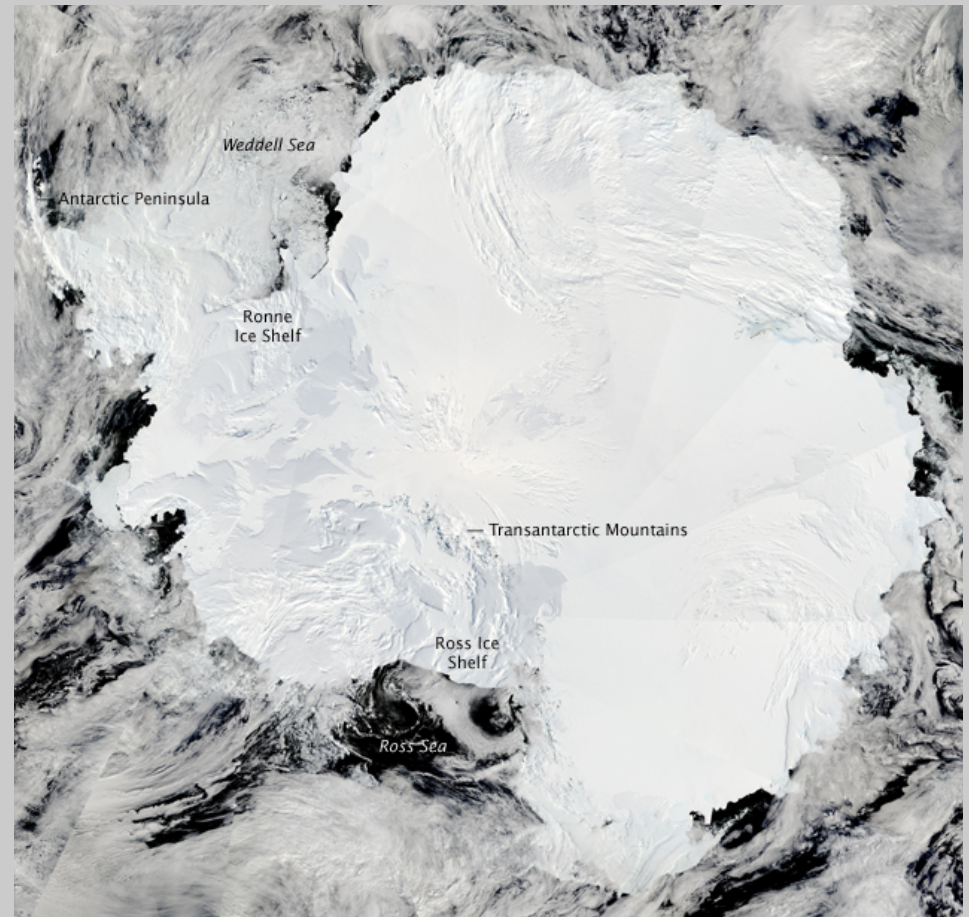
(plot from J. Comiso, C. Parkinson, T. Markus, D. Cavalieri, and R. Gersten, updated weekly on the NASA GSFC Cryospheric Sciences website, at neptune.gsfc.nasa.gov/csb/)



The Greenland and Antarctic Ice Sheets, from Aqua Visible Data

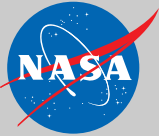


Greenland on July 13, 2002



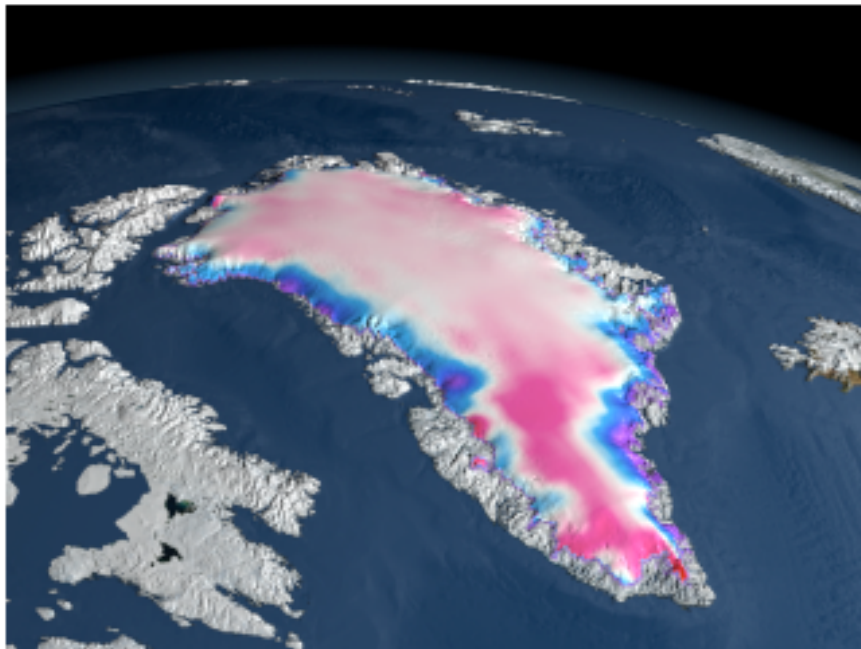
Composite image of Antarctica

Instrument used: Moderate-resolution Imaging Spectroradiometer (MODIS)



Early 21st Century Changes in the Greenland Ice Sheet

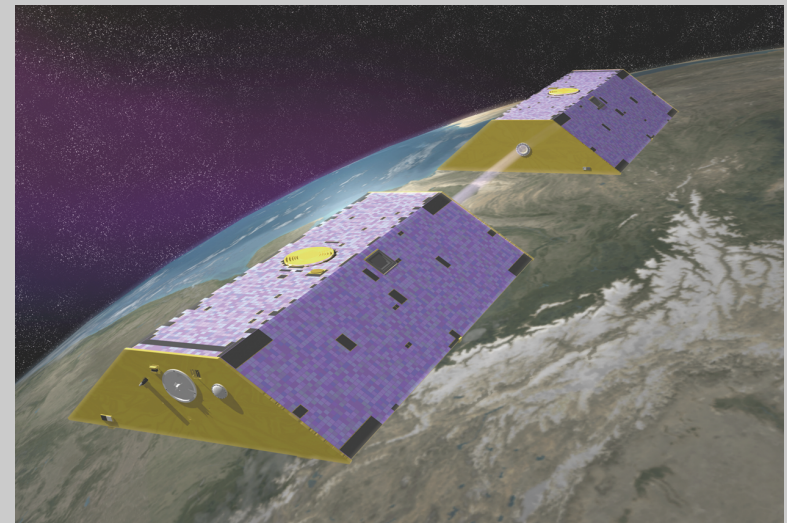
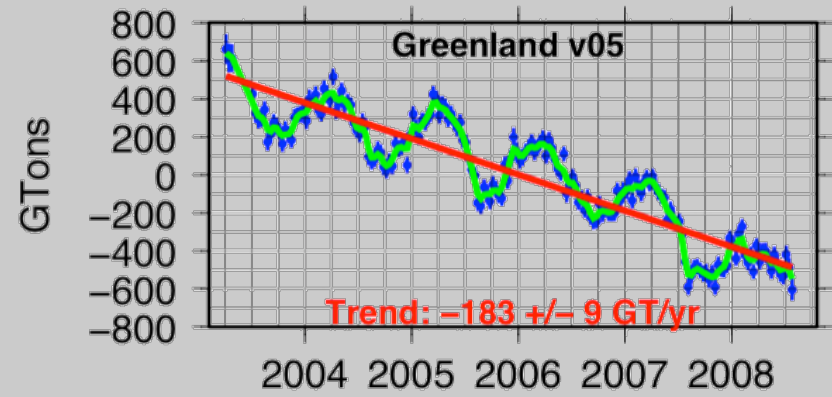
Elevation changes, 2003-2006, derived from ICESat data



(from J. Zwally and the ICESat Science Team)

ICESat = Ice, Clouds, and land Elevation Satellite

Changes in ice mass, 2003-2008, derived from GRACE satellite data



(from S. Luthcke and the GRACE Science Team)

GRACE = Gravity Recovery and Climate Experiment