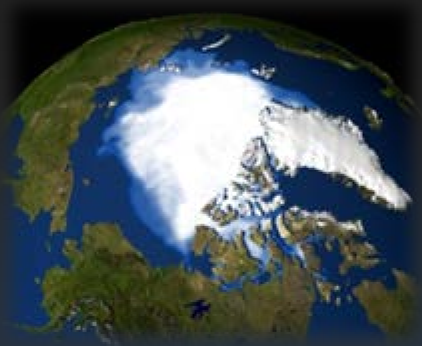
JPSS Snow and Ice Products



Jeff Key

NOAA Satellite and Information Services, Madison, Wisconsin USA

JPSS-CPO TIM, 30 January 2017

JPSS Snow and Ice Products

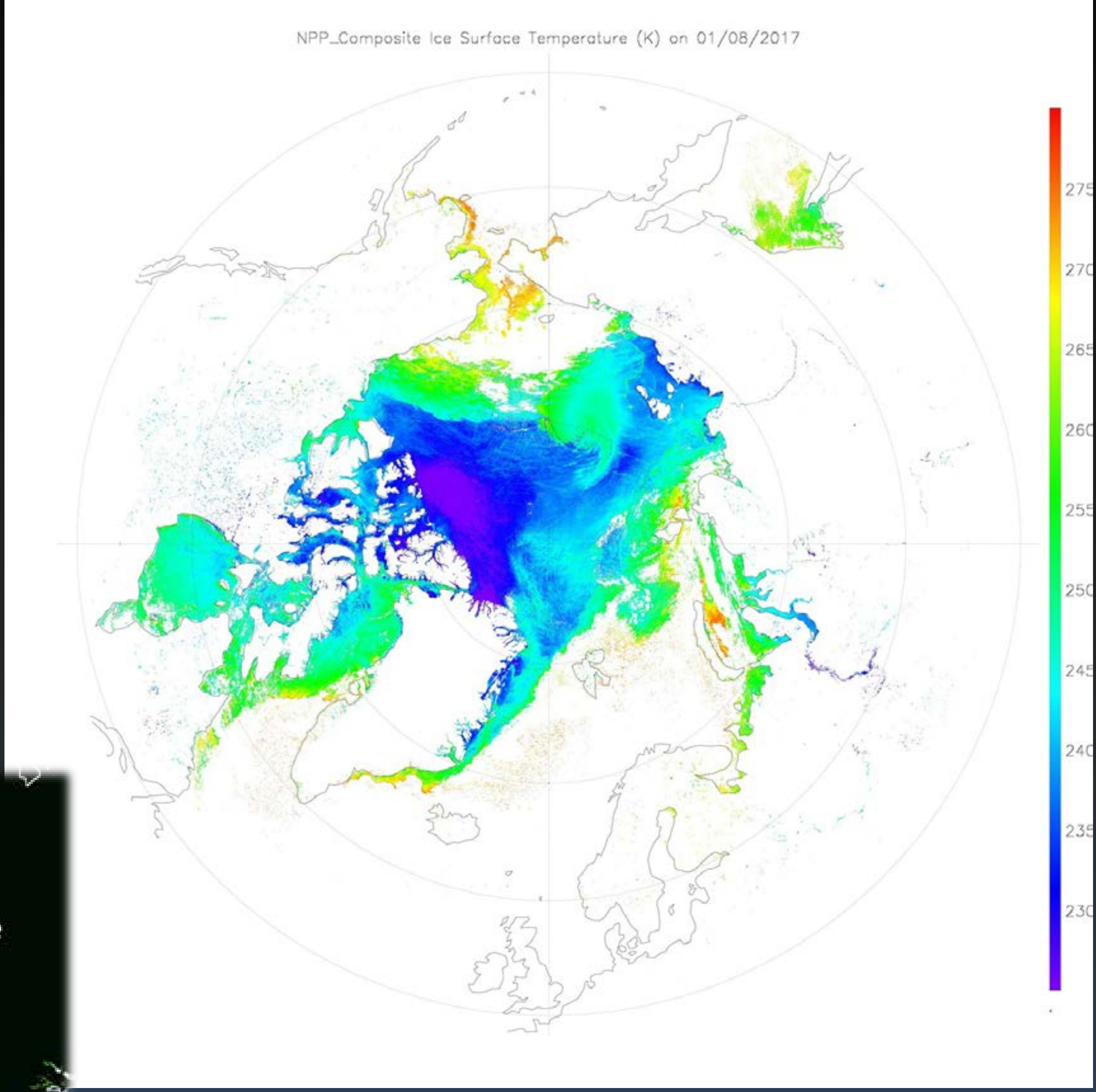
NPP/JPSS VIIRS

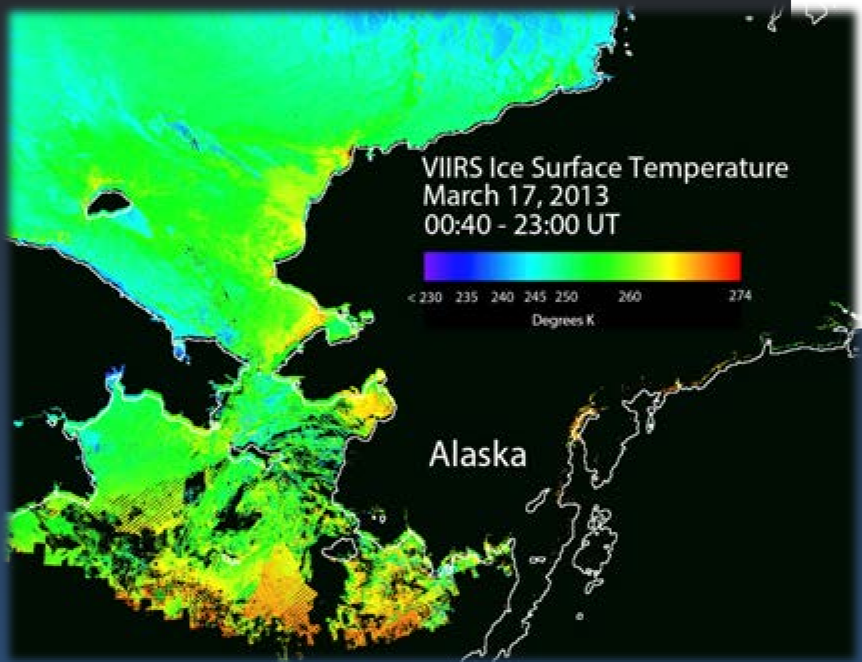
- Snow cover (binary)
- Snow fraction
- Ice thickness and age
- Ice concentration
- Ice surface temperature
- Ice motion (experimental)
- Sea ice leads (future)

AMSR-2 on GCOM-W1

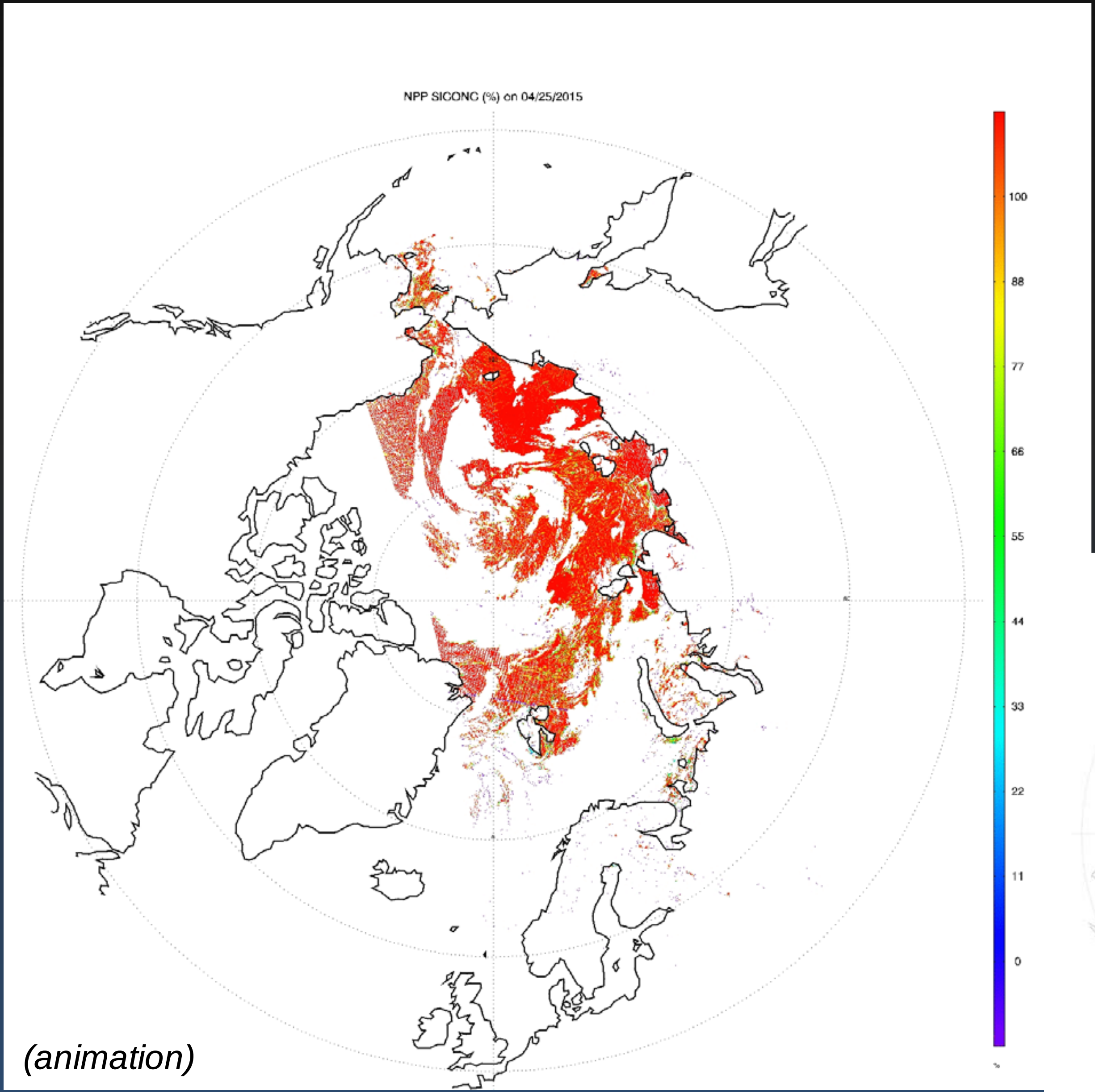
- Snow cover
- Snow depth
- Snow water equivalent (SWE)
- Ice characterization
  - Ice age class (first-, multi-year)
  - Ice concentration
- Ice motion (experimental)

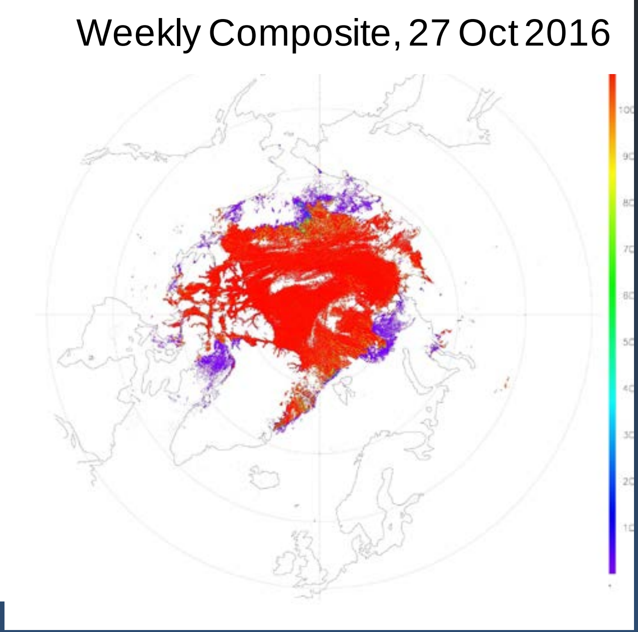
VIIRS Ice Surface Temperature



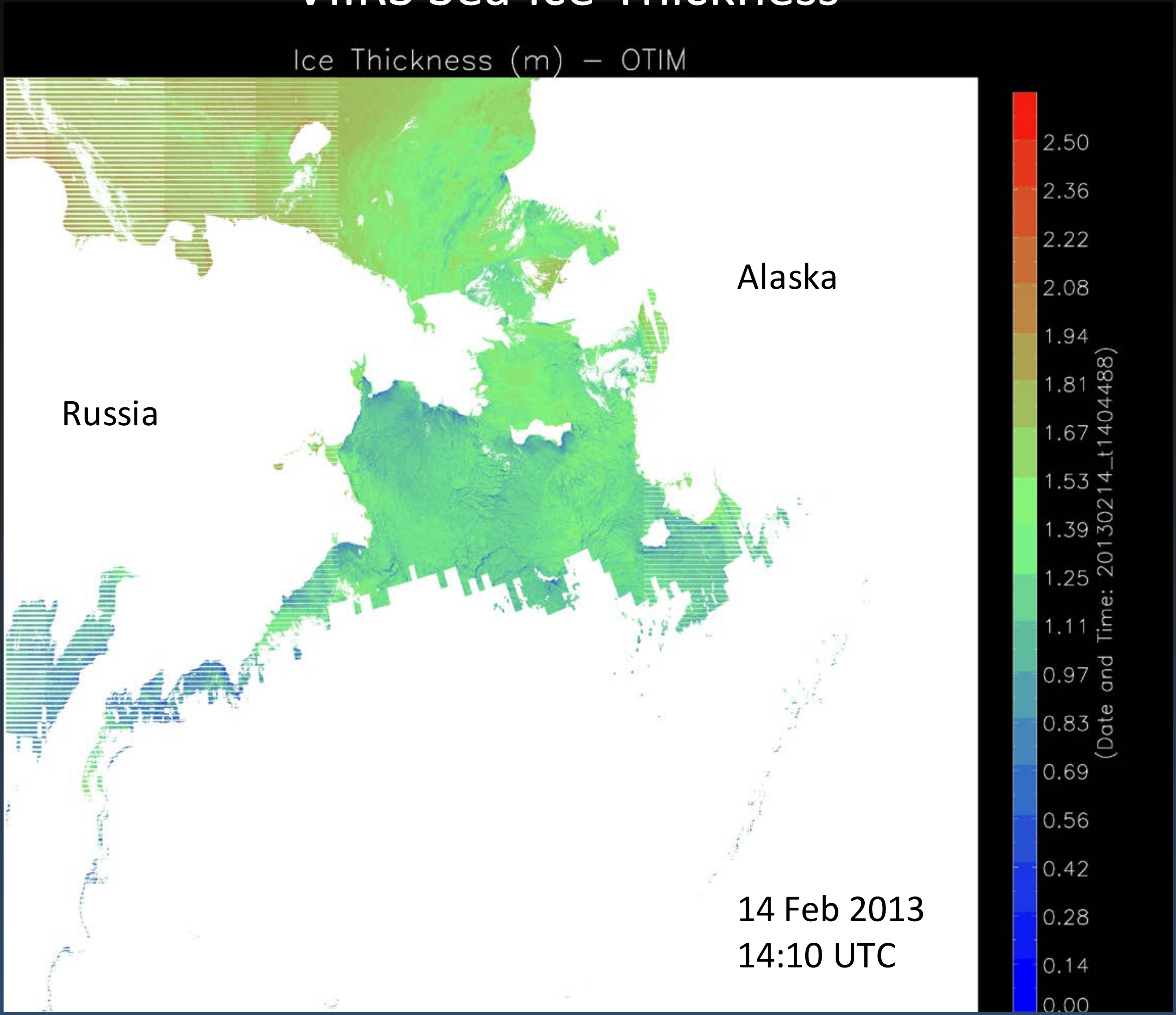


VIIRS Ice Concentration

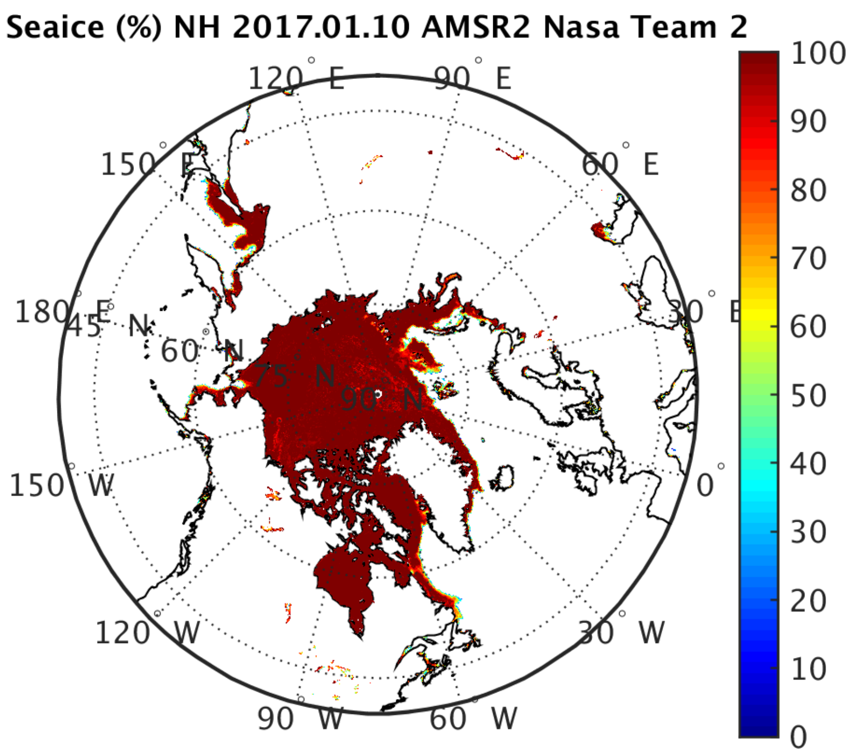


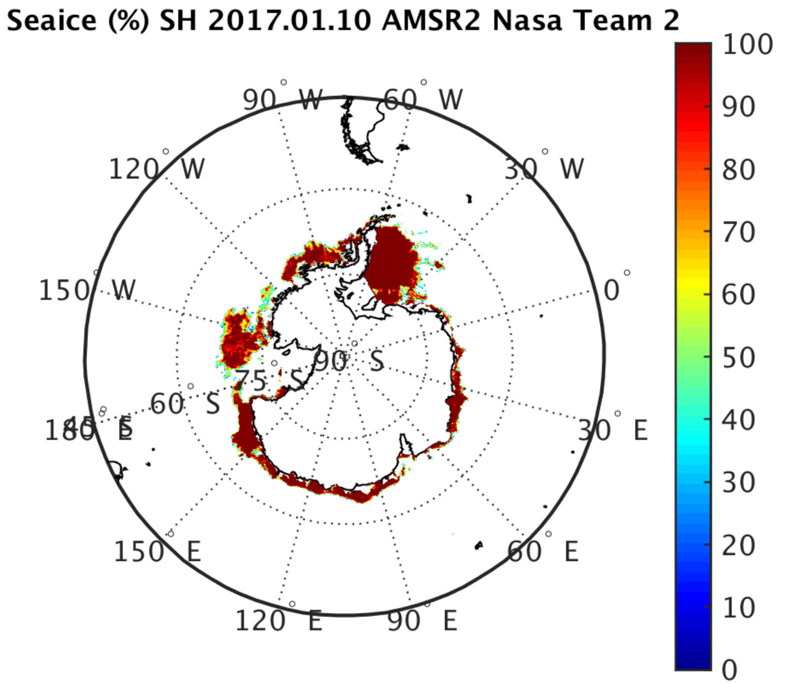


VIIRS Sea Ice Thickness



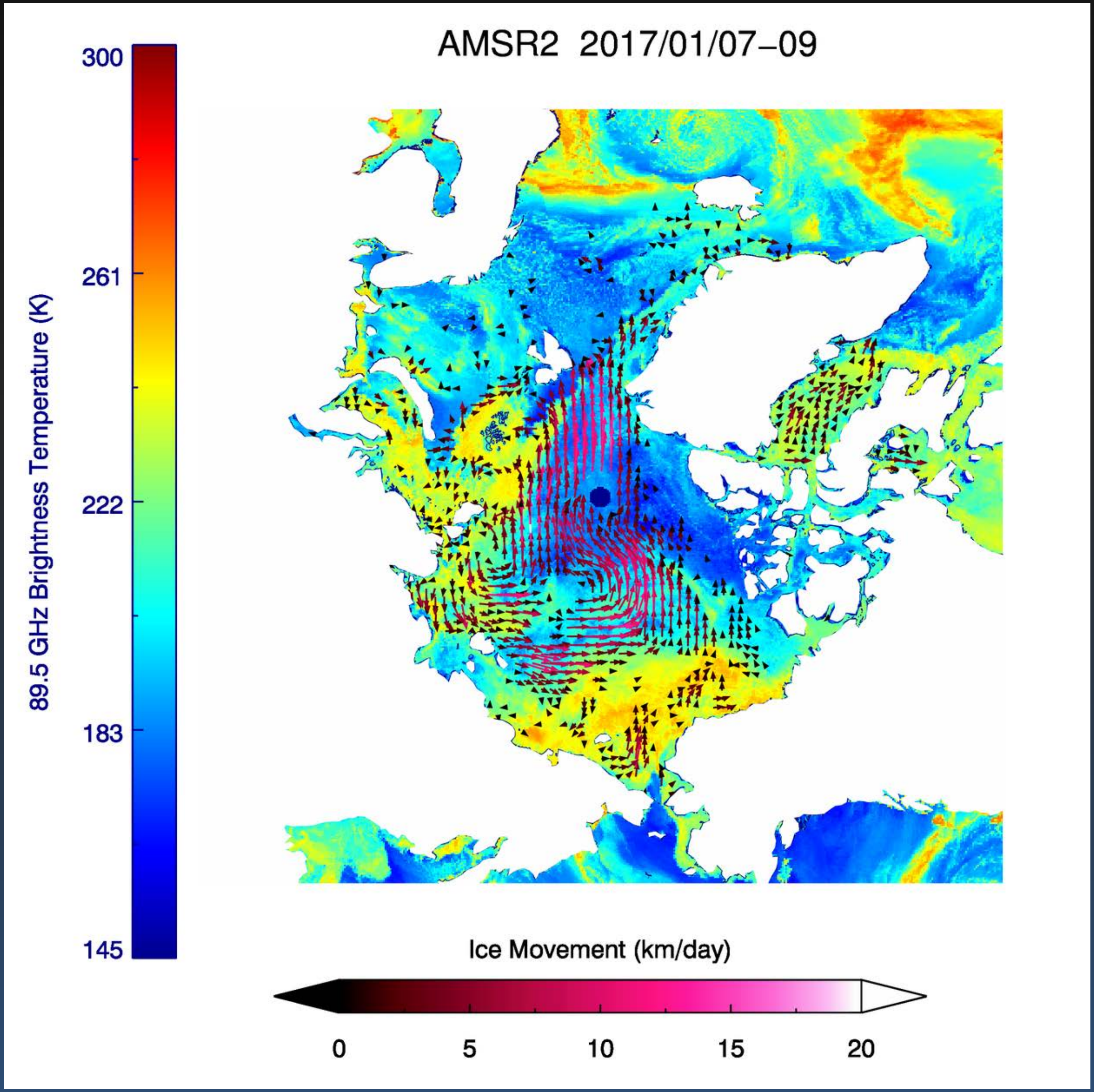
AMSR2 Ice Concentration



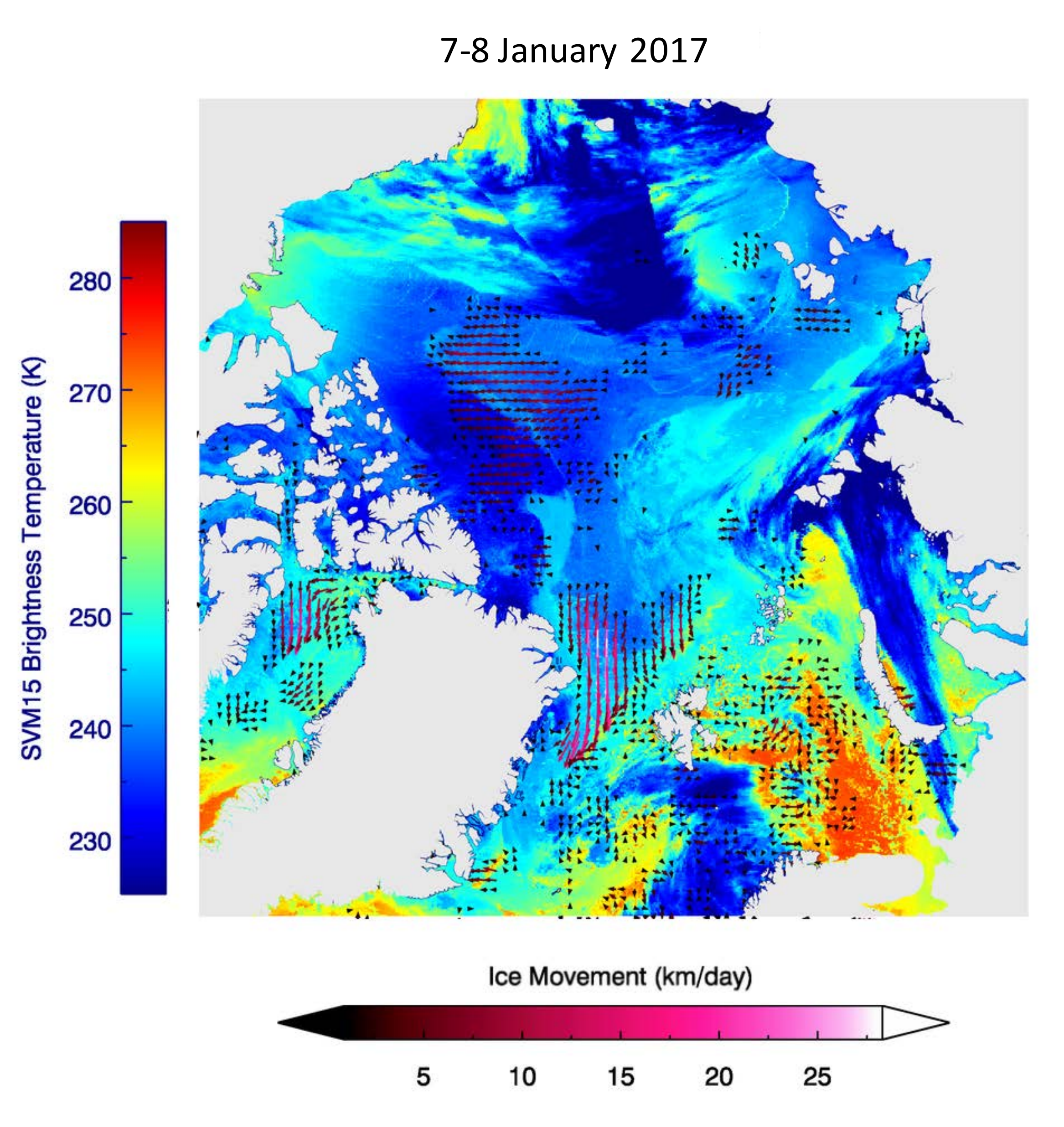


AMSR2 snow and ice products are running daily at CIMSS
(http://stratus.ssec.wisc.edu/gcom/rtproducts)

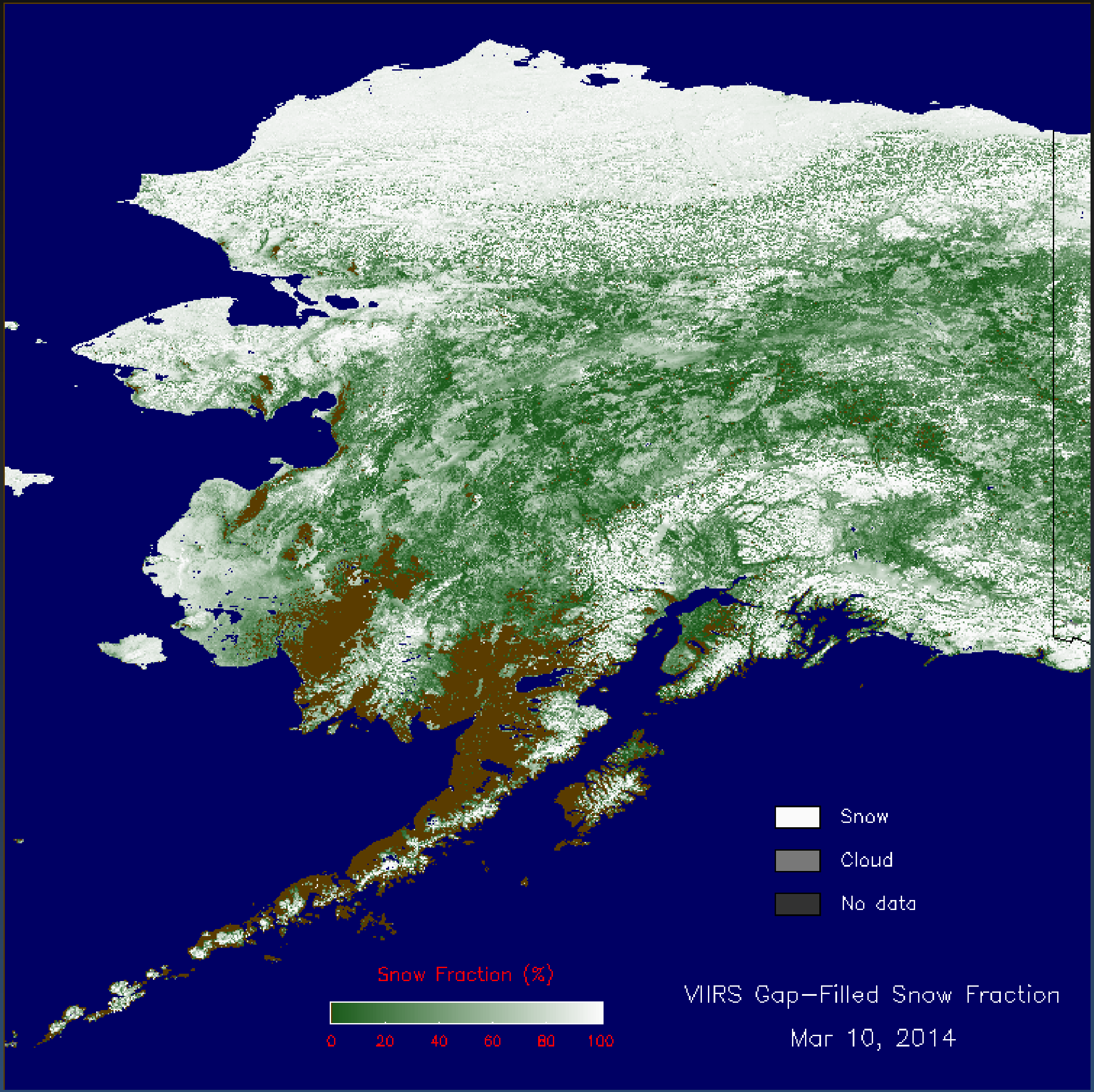
AMSR2 Ice Motion



VIIRS Ice Motion



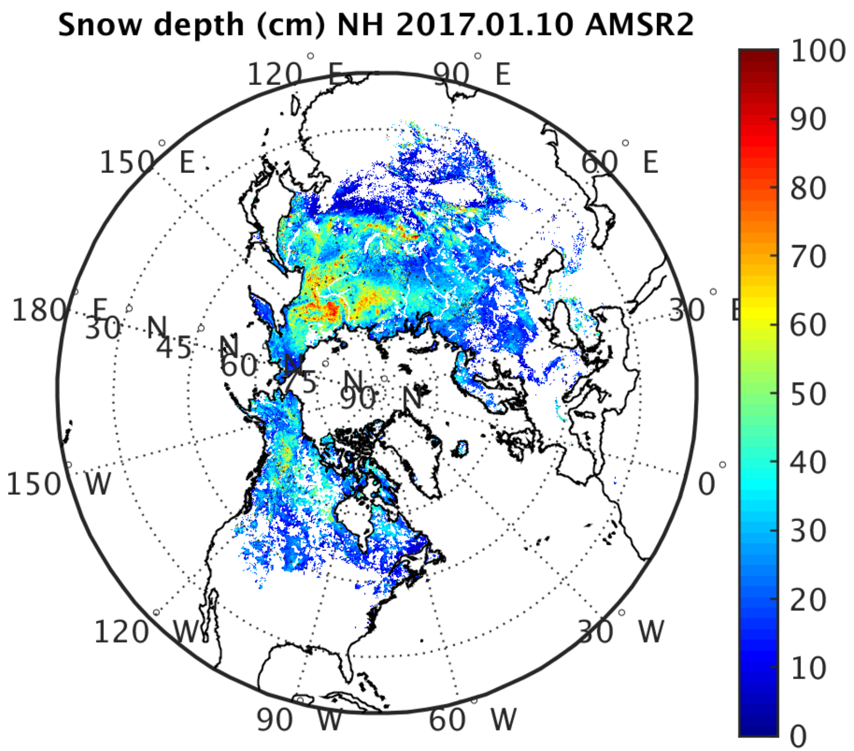
VIIRS Snow Fraction

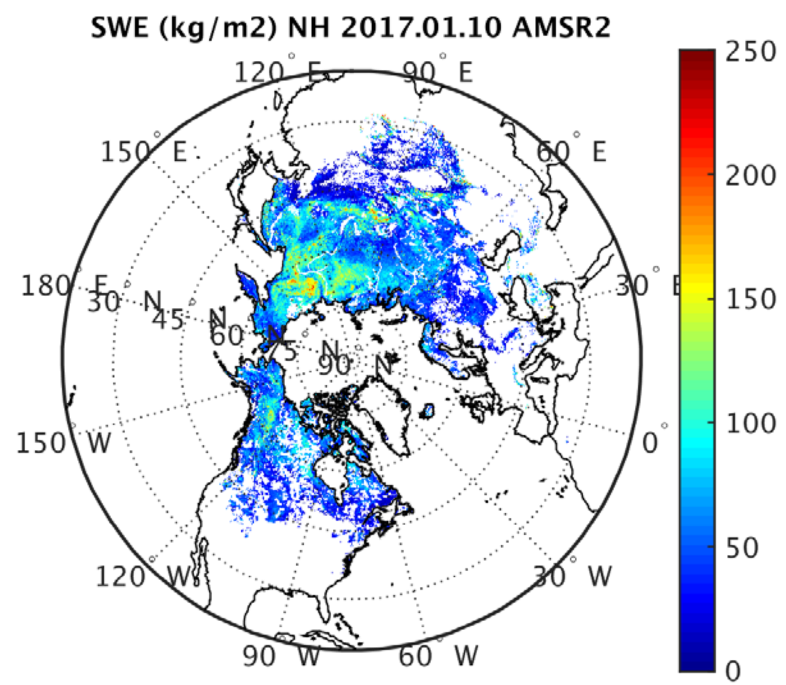


Some artifacts exist due to the cloud mask

(animation)

AMSR2 Snow Depth and Snow Water Equivalent (SWE)





AVHRR Polar Pathfinder-Extended (APP-x)

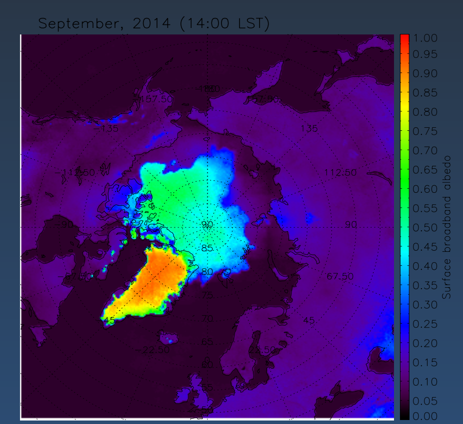
A Climate Data Record

APP-x contains 19 variables:

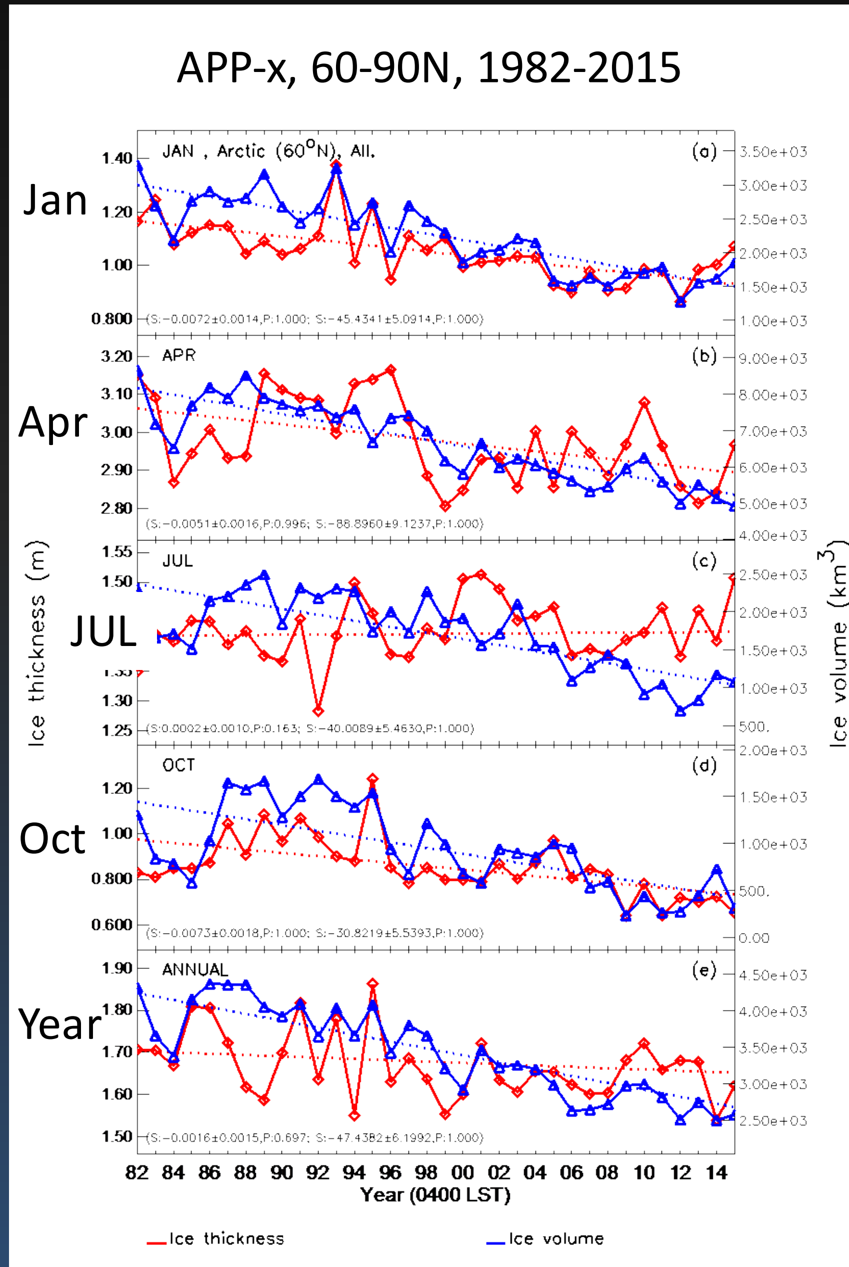
- Surface skin temperature, snow, ice, land
- Surface broadband albedo, all-sky
- Sea ice thickness
- Surface type
- Cloud mask
- Cloud particle thermodynamic phase
- Cloud optical depth
- Cloud particle effective radius
- Cloud top temperature
- Cloud top pressure
- Cloud type
- Up/down shortwave radiation at the surface
- Up/down longwave radiation at the surface
- Up/down shortwave radiation at the TOA
- Upwelling longwave radiation at the TOA
- Shortwave cloud radiative forcing at the surface
- Longwave cloud radiative forcing at the surface

APP-x characteristics:

- 1982 – present, updated daily
- Arctic and Antarctic
- 25 km resolution , EASE grid
- Twice daily centered on 04:00/02:00 (Arctic/Antarctic) and 14:00 <u>local solar time</u>
- Available from NCEI



APP-x: Arctic sea ice thickness and volume trends

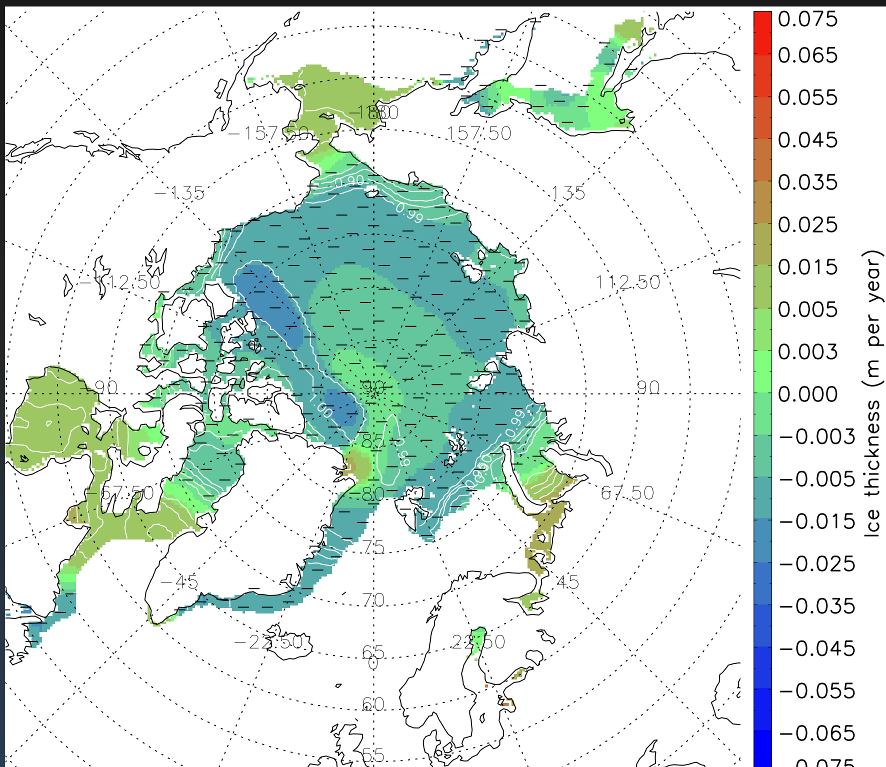


The first and second pairs of (S,P) in each panel are the trend and statistical significance level for ice thickness (red line) and ice volume (blue line).

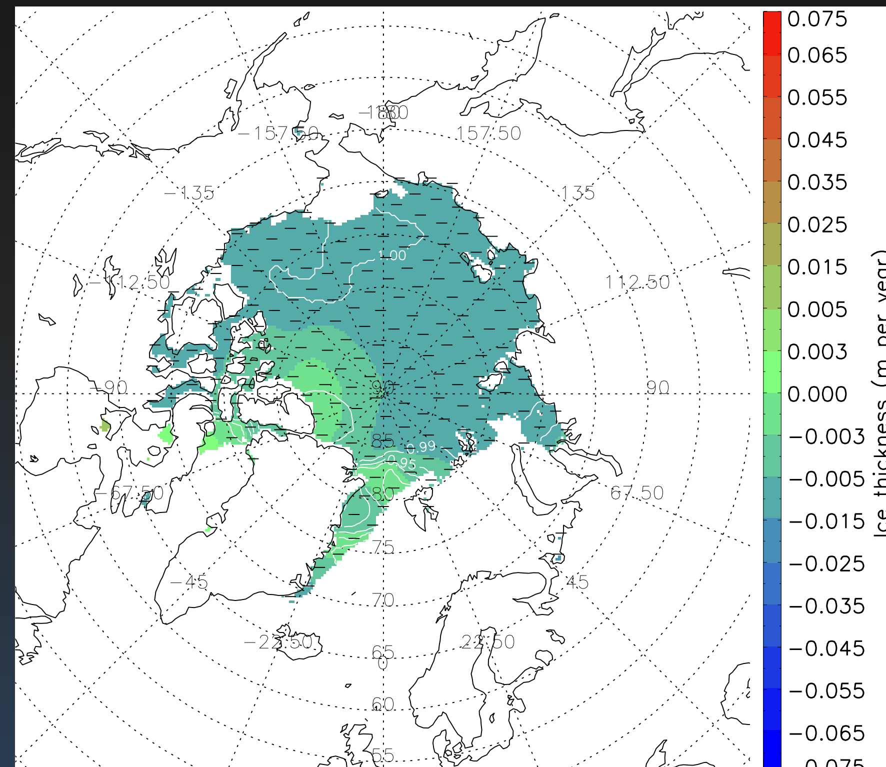
JAN=January, APR=April, JUL=July, OCT=October, ANN=Annual, S=Slope (trend in per year), P=Statistical significance level

Arctic Sea Ice Thickness Trends, 1982-2015

April

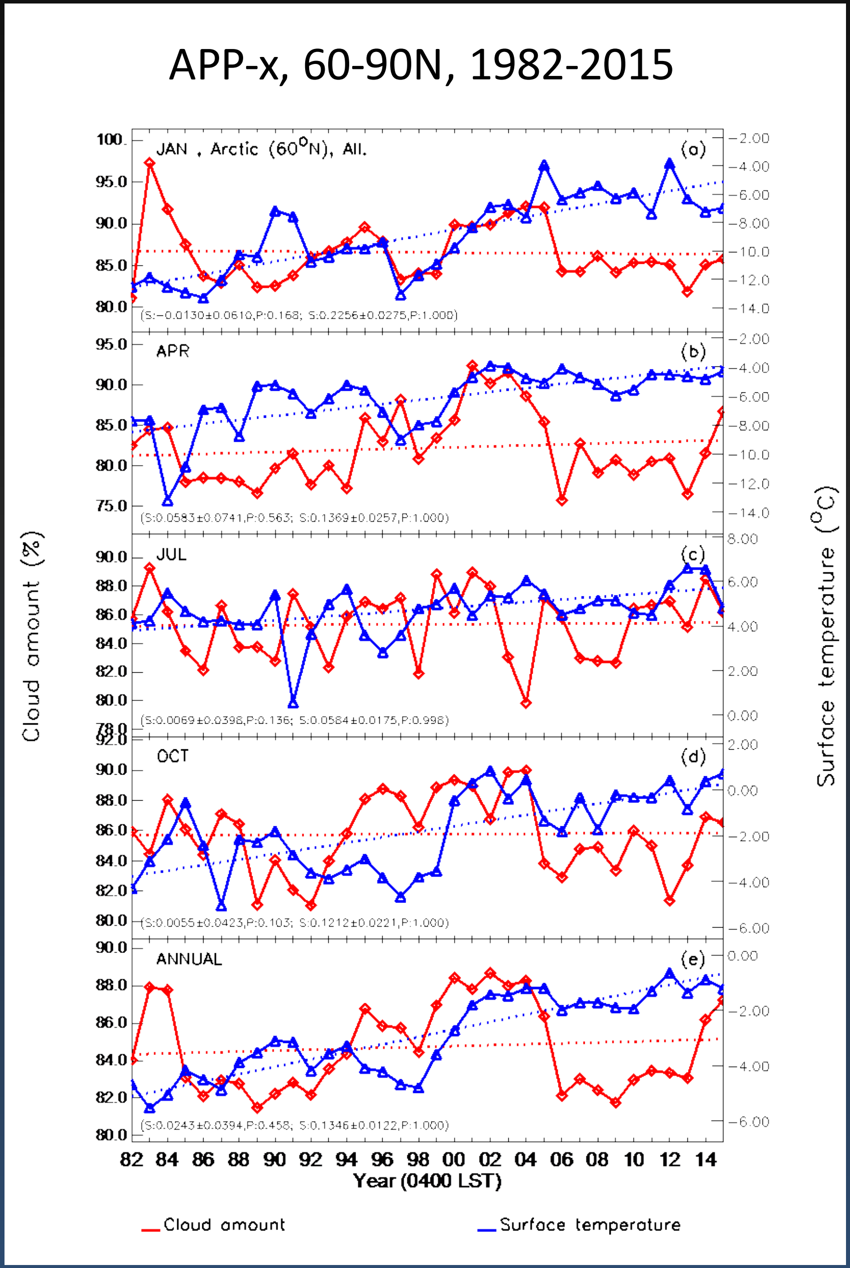


October



Arctic sea ice thickness trends in April (left) and October (right), 60-90N, 1982-2015. The dashed areas indicate declining trends in sea ice thickness. The white contour lines indicate the statistical significance level.

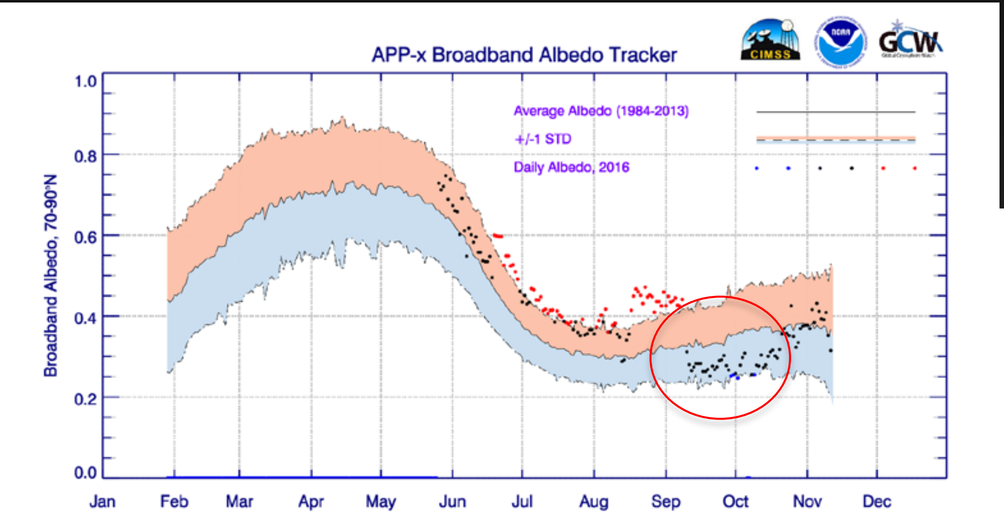
Arctic cloud fraction and surface temperature trends

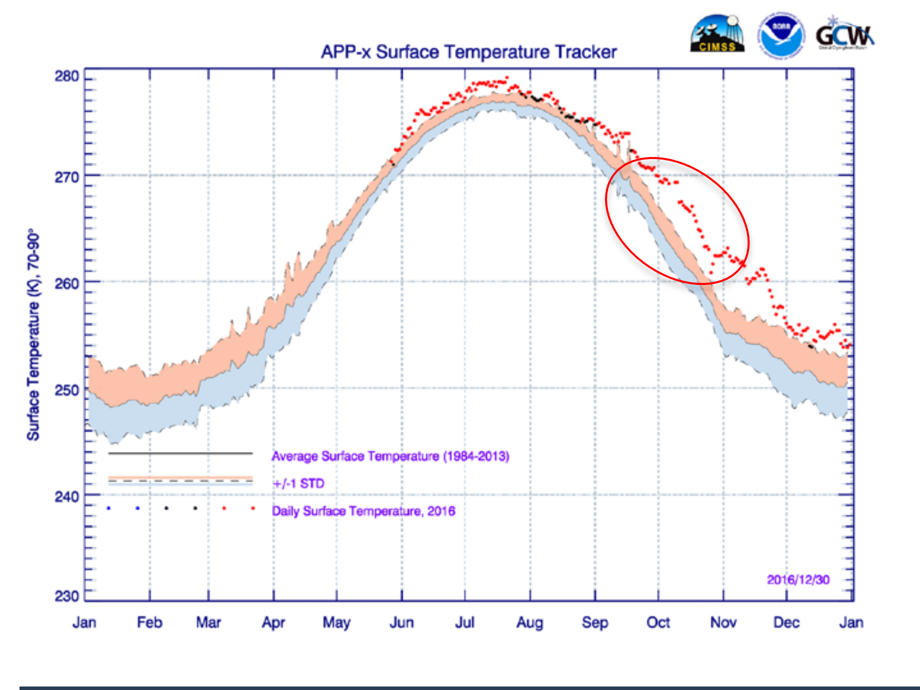


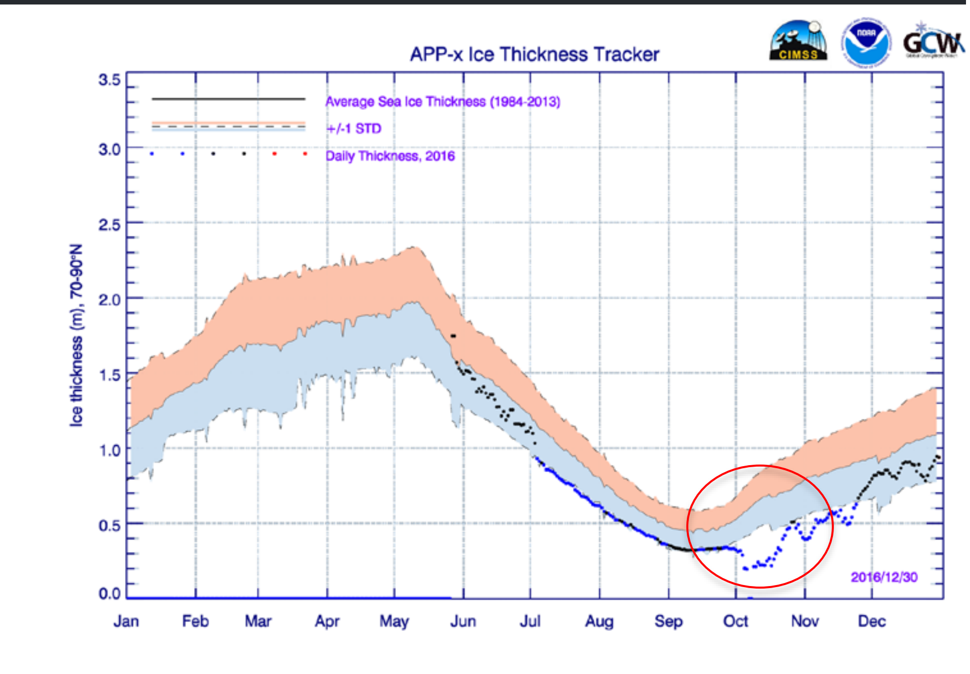
The first and second pairs of (S,P) in each panel are the trend and statistical significance level for the first parameter (red line) and second parameter (blue line).

JAN=January, APR=April, JUL=July, OCT=October, ANN=Annual, S=Slope (trend in per year), P=Statistical significance level

APP-x "Trackers"



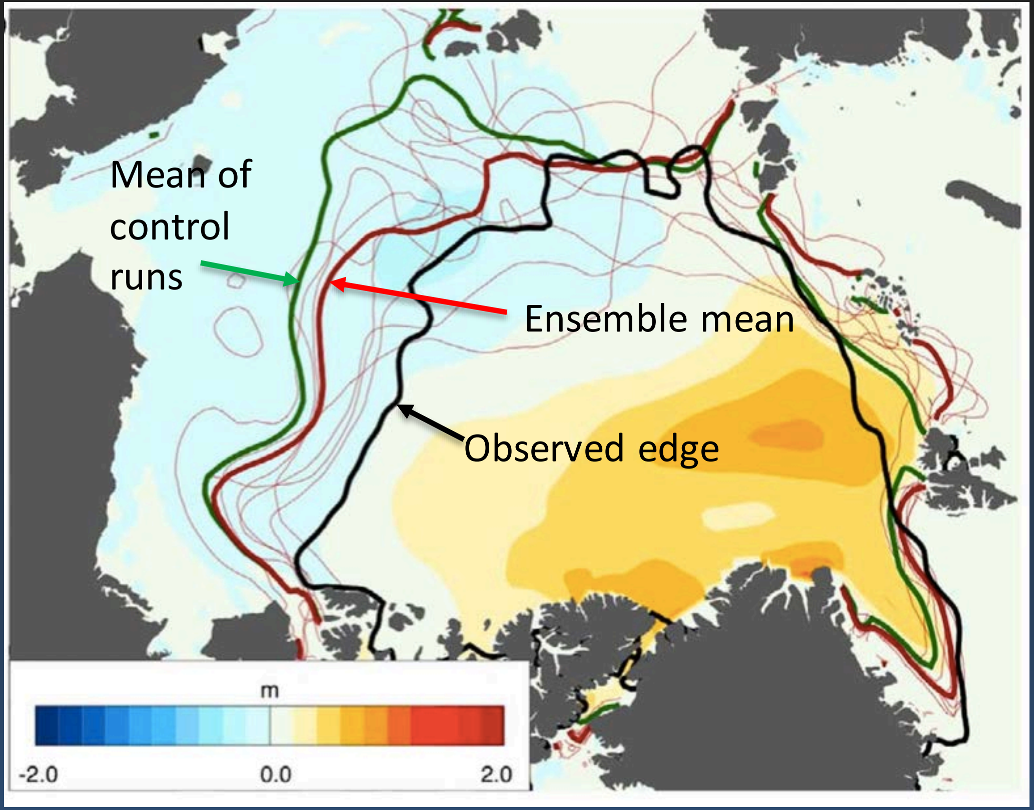




Importance of Ice Thickness

Thermodynamically and dynamically it is ice thickness, not ice extent, that is important. Thickness provides an integrated measure of changes in the energy balance. It is critical to navigation.

While little work has been done on assimilating ice thickness in models, indications are that doing so would improve ice forecasts.



The difference in mean ice thickness for September between the corrected and the control runs of the PIOMAS model, where corrected runs use IceBridge and SIZONet ice thicknesses to correct the initial thickness field. The thin red lines are the ice extent (0.15 ice concentration) lines for each of the corrected ensemble members and the thick red line is the mean for the ensemble. The thick green line is the mean of the ensemble of control runs and the black line is the observed September mean ice extent. From Lindsay et al. (2012)

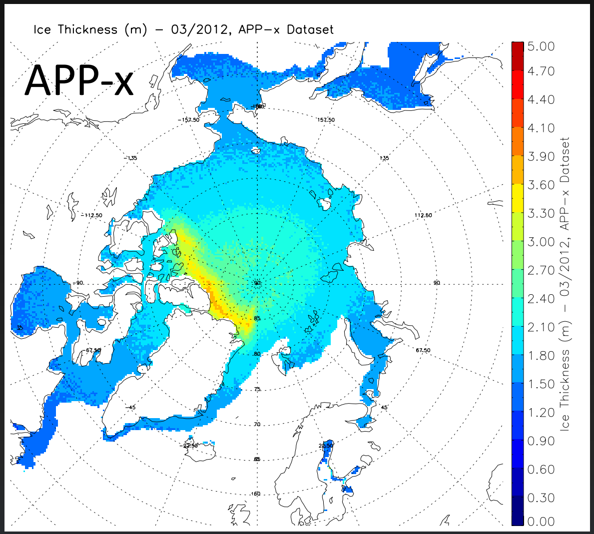
Satellite-Derived Ice Thickness Products

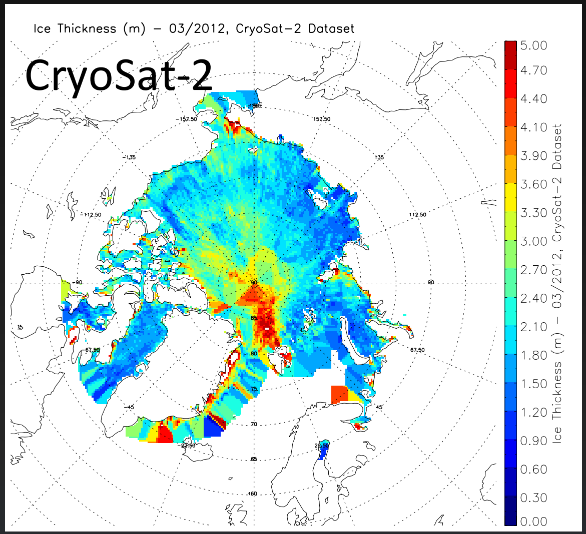
- The One-dimensional Thermodynamic Ice Model (OTIM) is an energy budget approach for estimating sea and lake ice thickness using various satellite products from sensors such as the Advanced Very High Resolution Radiometer (AVHRR), the Moderate Resolution Imaging Spectroradiometer (MODIS), and the Visible Infrared Imaging Radiometer Suite (VIIRS). OTIM is used for ice thickness in the AVHRR Polar Pathfinder-Extended (APP-x) product. (*Wang et al., 2010*).
- Laser and radar altimeter data from the ICESat and CryoSat-2 satellites estimate ice thickness from ice elevation (freeboard) – ICESat, CryoSat-2, and IceBridge (*Kwok et al., 2009; Laxon et al., 2013; Kurtz et al., 2013*).
- Another method employs low-frequency passive microwave data from the Soil Moisture and Ocean Salinity (SMOS) mission (*Tian-Kunze et al., 2014*).

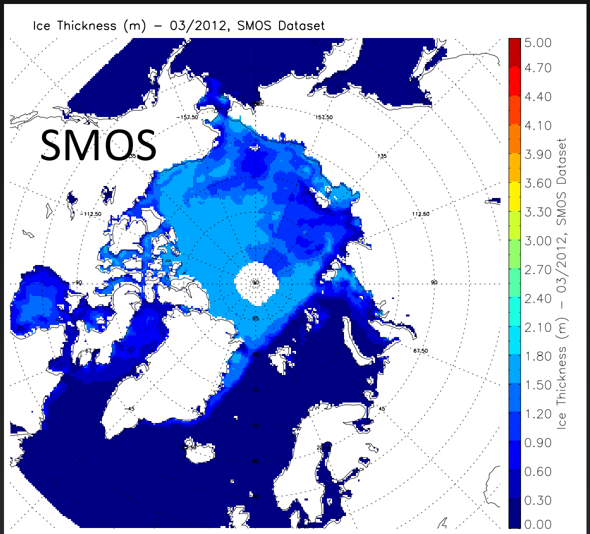
Non-satellite:

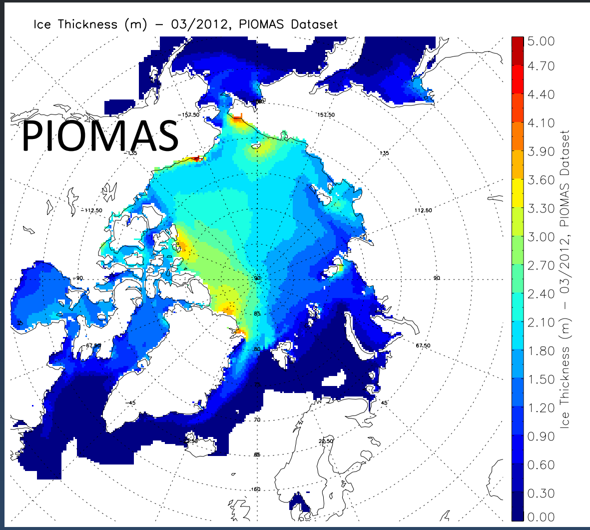
- NASA's Operation IceBridge is an aircraft campaign carrying a laser altimeter and a snow radar for the thickness of snow on ice.

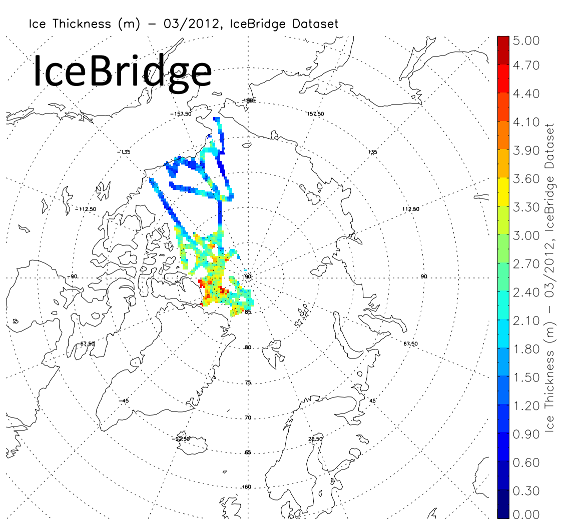
Satellite-Derived Ice Thickness Products

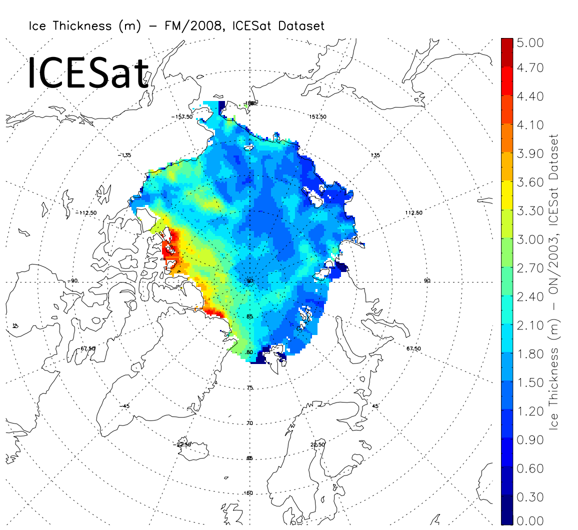












These are the monthly mean results for March 2012, except for ICESat sea ice thickness, which is a 34-day average from 2 February to 31 March 2008.

Ice Thickness Product Characteristics

Product	APP-x	ICESat	Cryosat-2	IceBridge	SMOS
Time Period	1982-present	2003–2008	2011–present	2009–present	2010–present
Days for Full Arctic Coverage	Daily	91 days	28 days	None	Daily
Spatial resolution	25 km	25 km	25 km	40-300 m	25 km
Clear or all sky	All	Clear	All	Clear	All
Direct measurement of	Surface temperature, albedo, clouds	Surface elevation	Near-surface elevation	Surface elevation and snow depth	Brightness temperatures
Measurement range	0~5 m	unlimited	unlimited	unlimited	0~0.5 m
Accuracy	0.20 m	0.14	0.10 m	0.18 m	0.10 m
Uncertainty (RMS)	0.54 m	0.63	0.62 m	0.78 m	0.16 m