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Assessment of the Stability of a Satellite Snow Extent CDR from Station Snow Depth Observations

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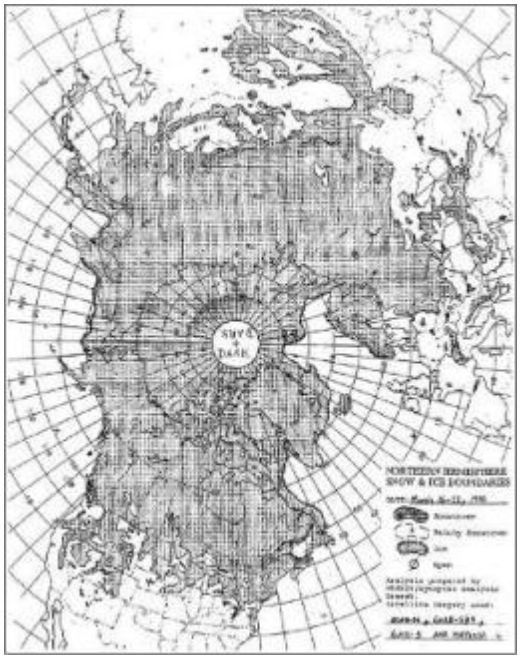
2nd International Satellite Snow Products Intercomparison Workshop
Boulder, Colorado: September 14, 2015

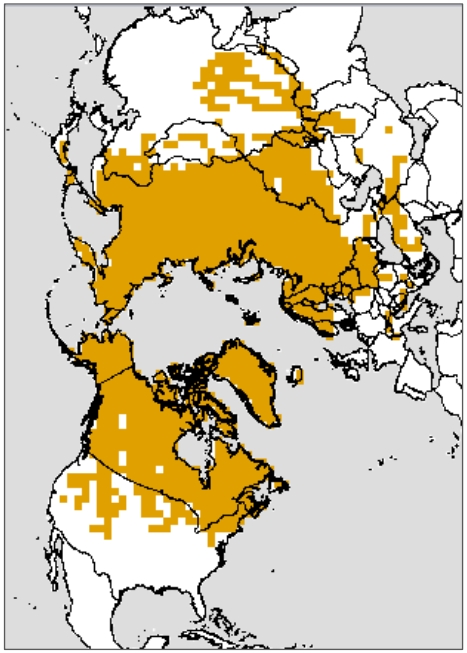
Research supported by
Global Science and Technology, Inc.
at NOAA NCEI

- **NOAA visible snow product**
- **How reliable are NOAA snow map trends?**

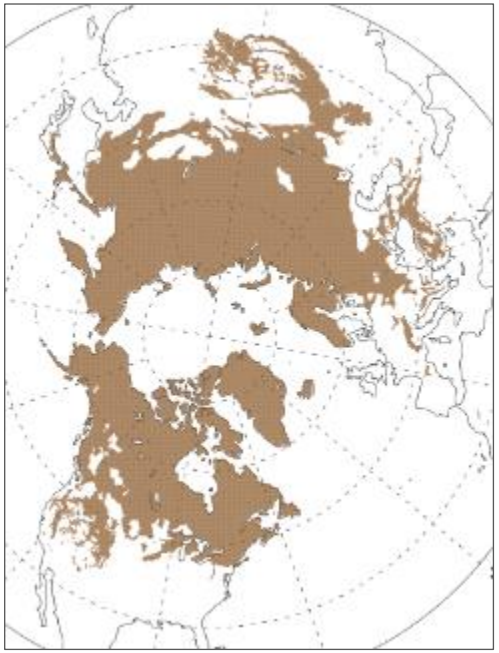
NOAA Visible Weekly SCE Climate Data Record



Weekly charts



Digitization



Daily IMS

Nov 1966 | Oct 1972 | May 1975 | 1980-81 | 1988-89 | 1990s May 1999

ESSA, NOAA, GOES Series | Weekly 190 km Digitized | METEOSAT & GMS added | Reanalysis of 1966-71

Feb 1997 | Feb 2004 | Dec 2014

Interactive Multisensor Snow & Ice Mapping System

IMS 24 km | IMS 4 km | IMS 1 km

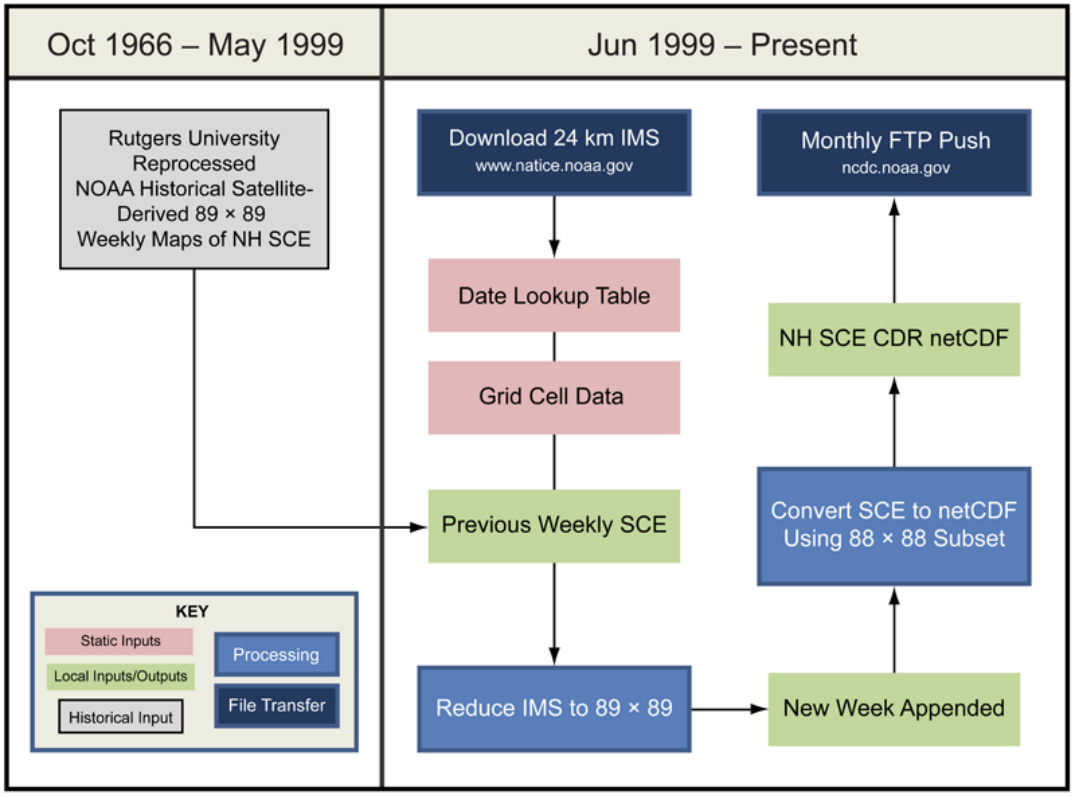
NOAA Visible Weekly SCE Climate Data Record

Specifications

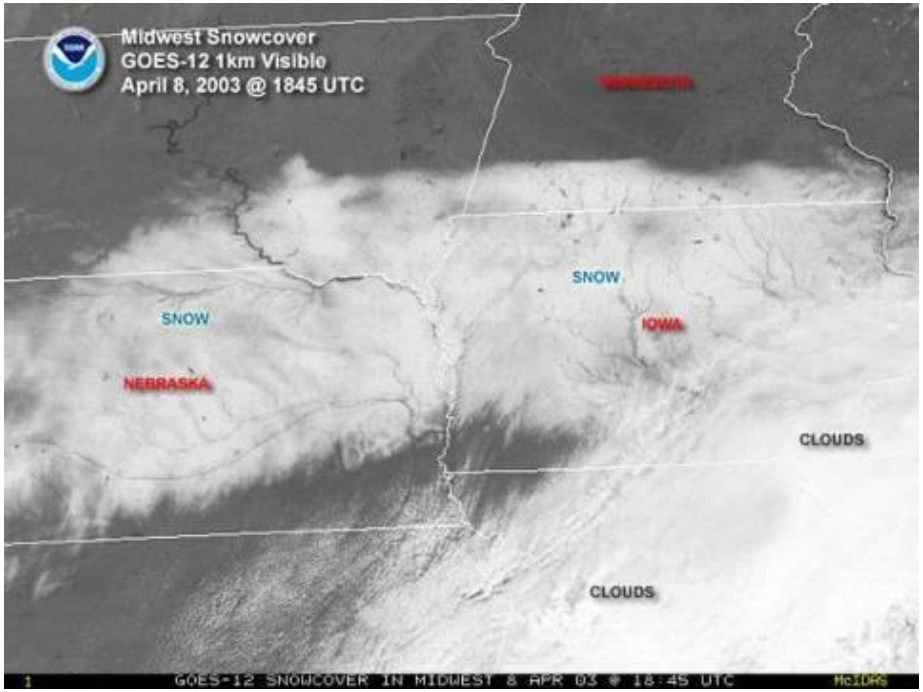
- Binary (snow / no snow) over NH land surface
- 88 × 88 Cartesian grid on polar stereographic projection
- 190.6 km resolution at 60°N
- Weekly temporal resolution
- October 4, 1966–present

Inputs to CDR

- October 1966–May 1999: primarily visible satellite imagery from multiple instruments
- After May 1999: Interactive Multisensor Snow and Ice Mapping System (IMS)
- SCE derived from multiple sources by trained analysts

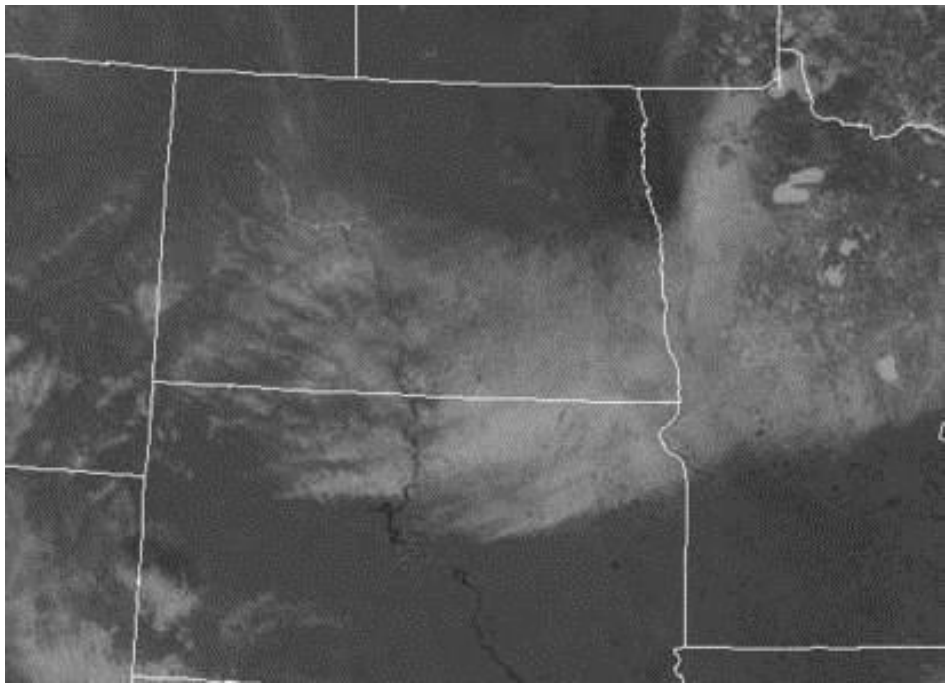


NH SCE CDR simplified processing flow diagram

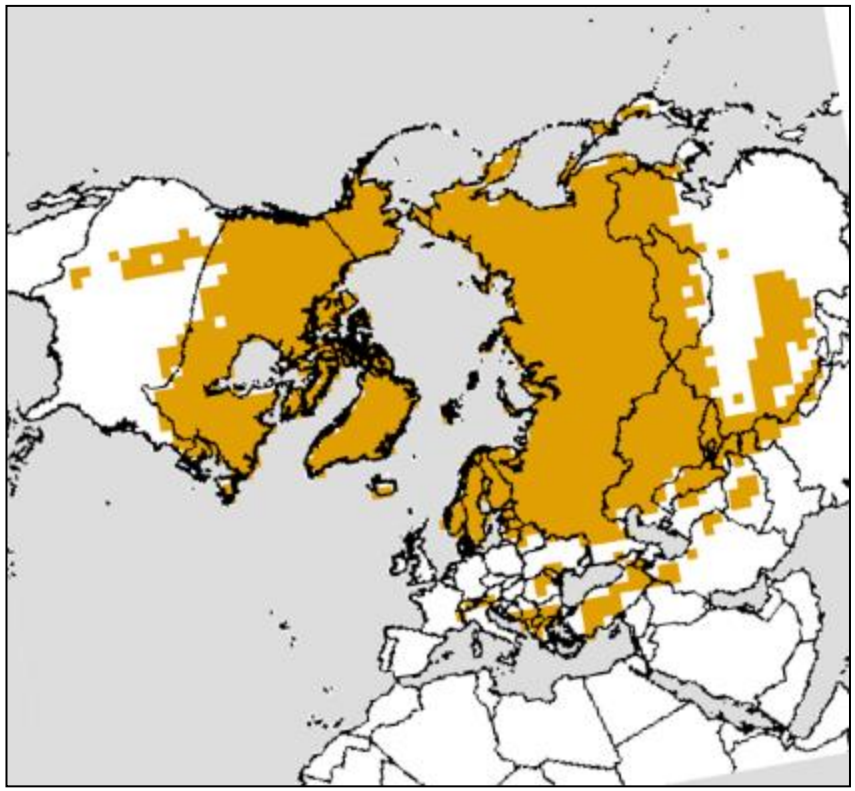


April 8, 2003

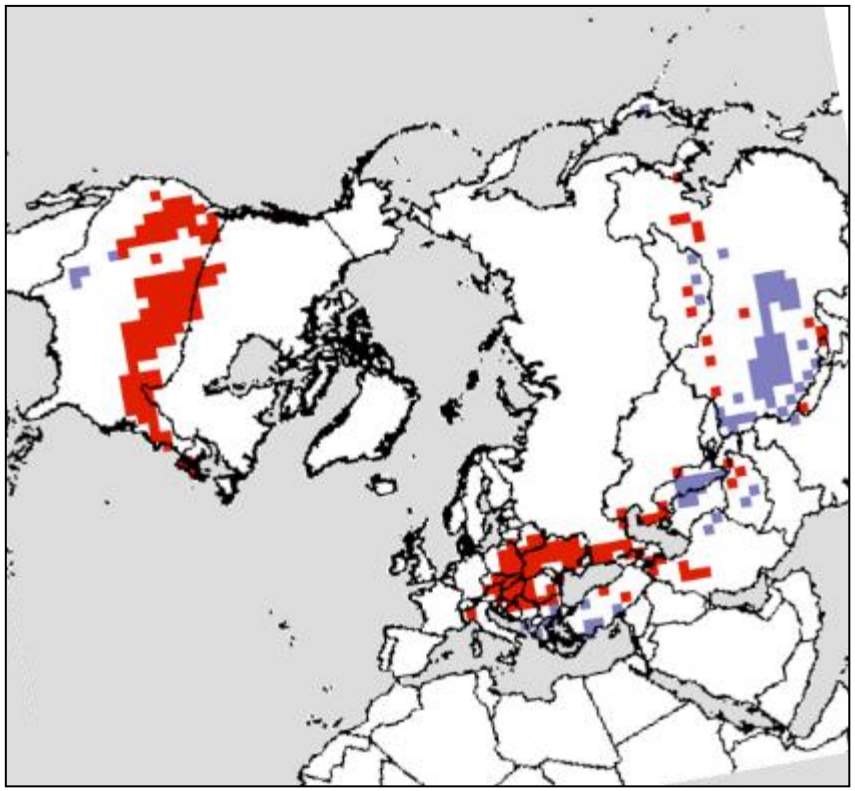
April 8, 2007



Northern Hemisphere Continental Snow Cover
10 January 2012

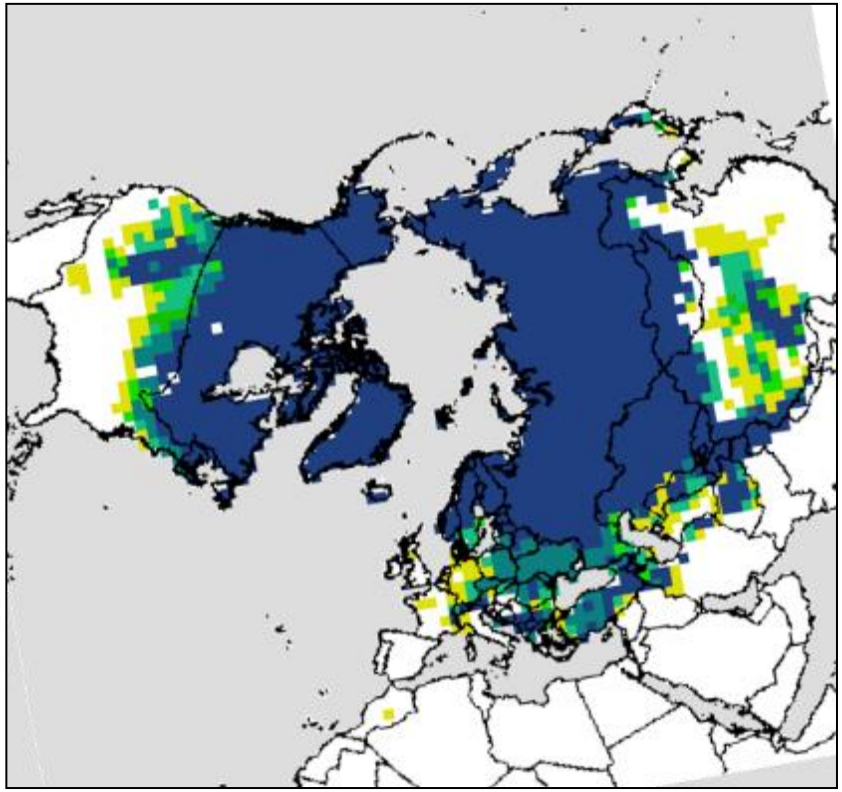


Extent

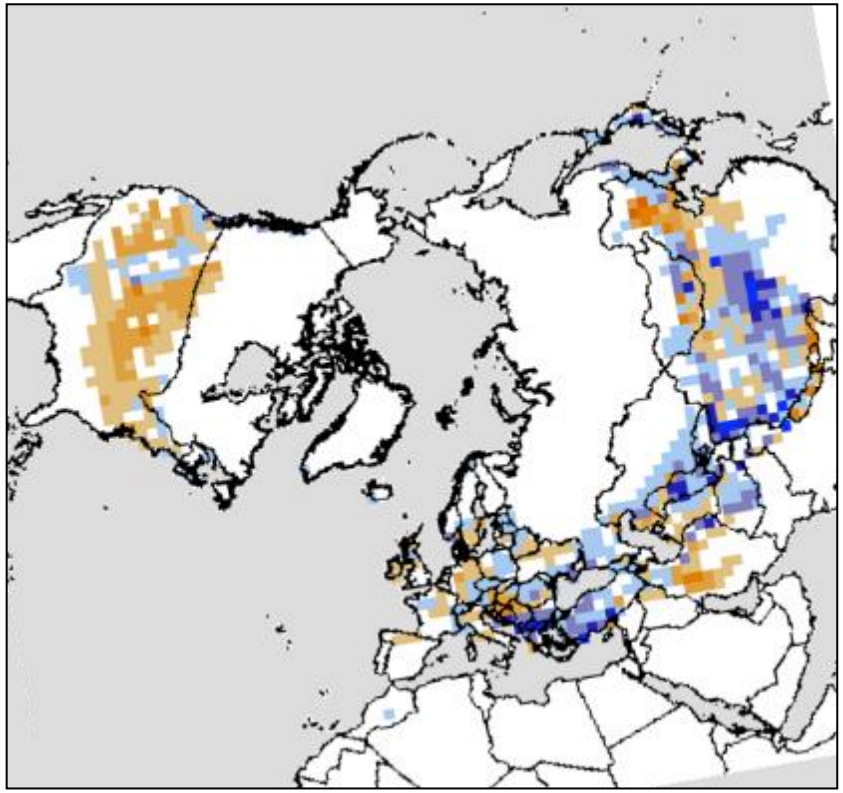


Departure
(blue: positive; red: negative)

Northern Hemisphere Continental Snow Cover
January 2012



Extent

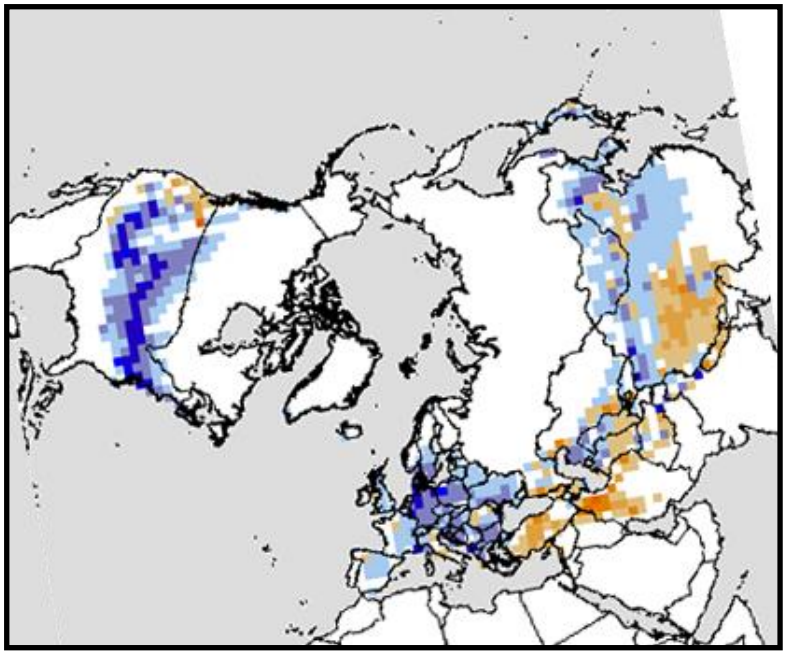


Departure
(blue: positive; tan: negative)

Swings from most to least extensive SCEs occurring within months

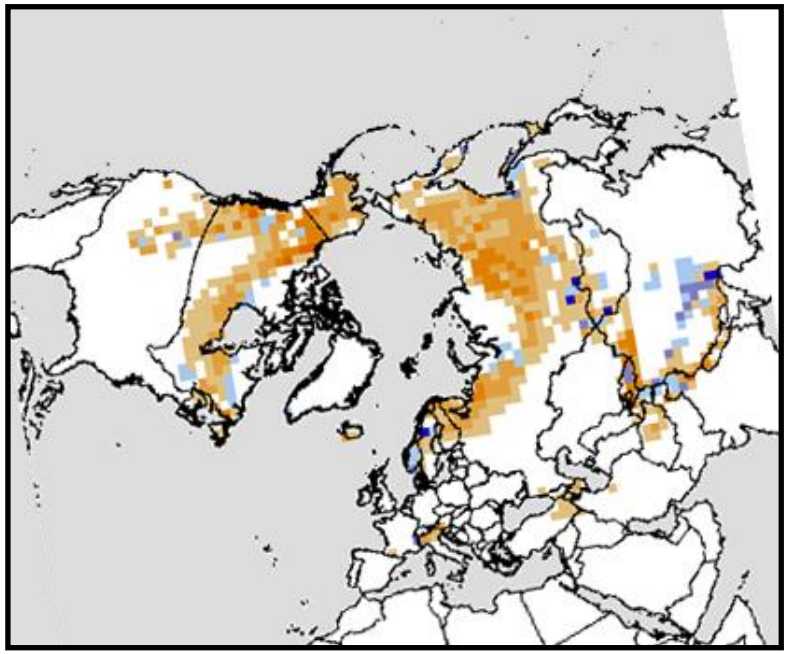
Departures

Feb 2010



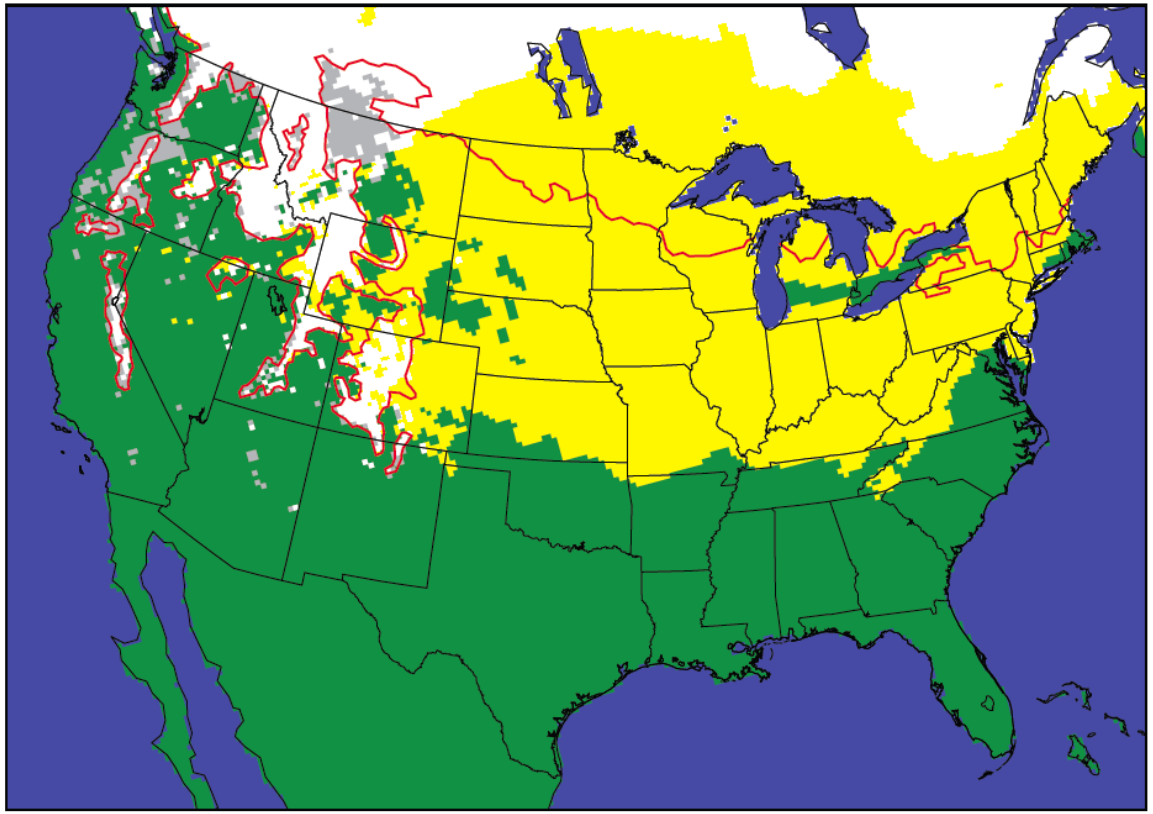
3rd most extensive

May 2010



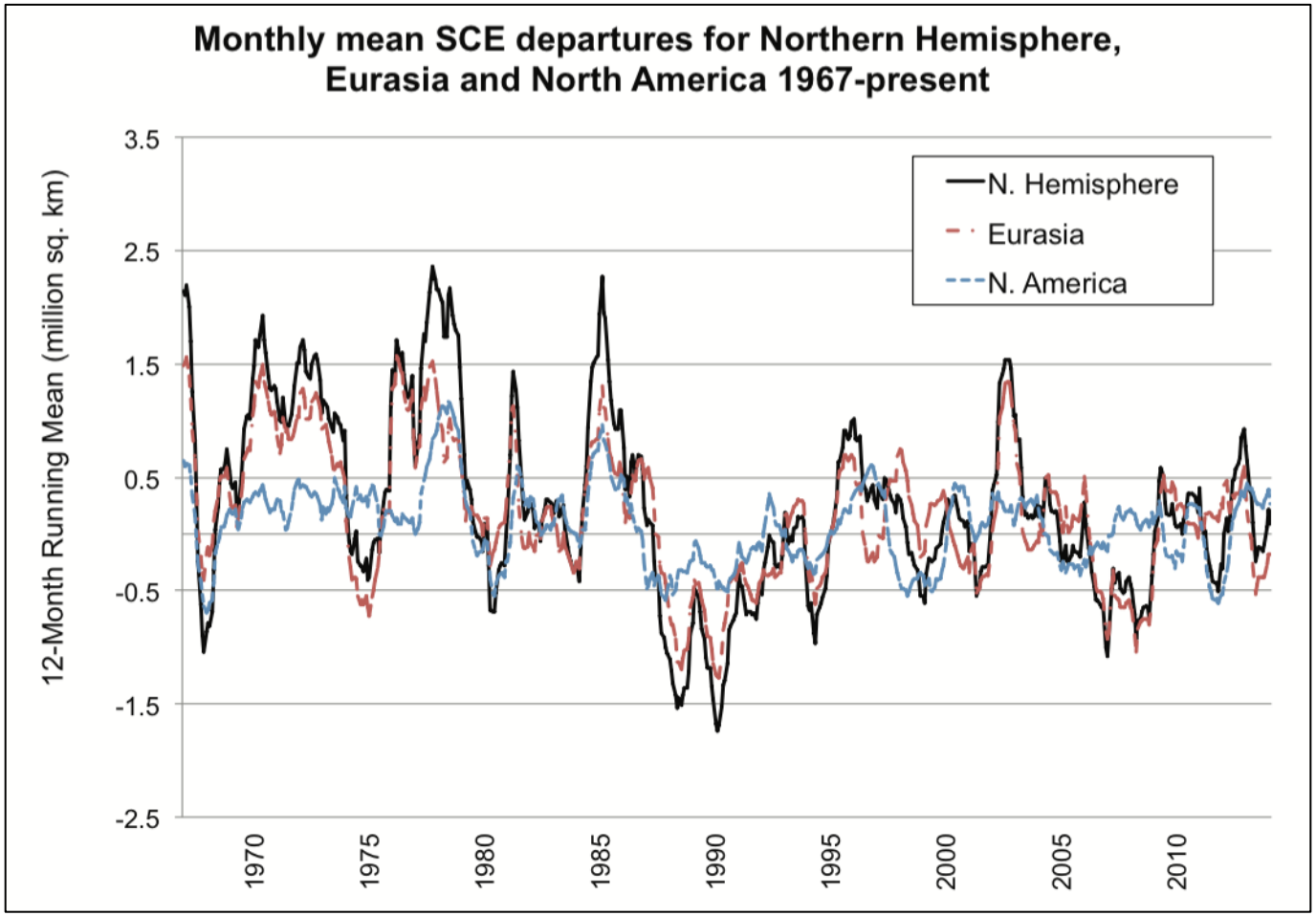
1st least extensive

Interannual variability:
SCE: 25 March 2012 versus 2013



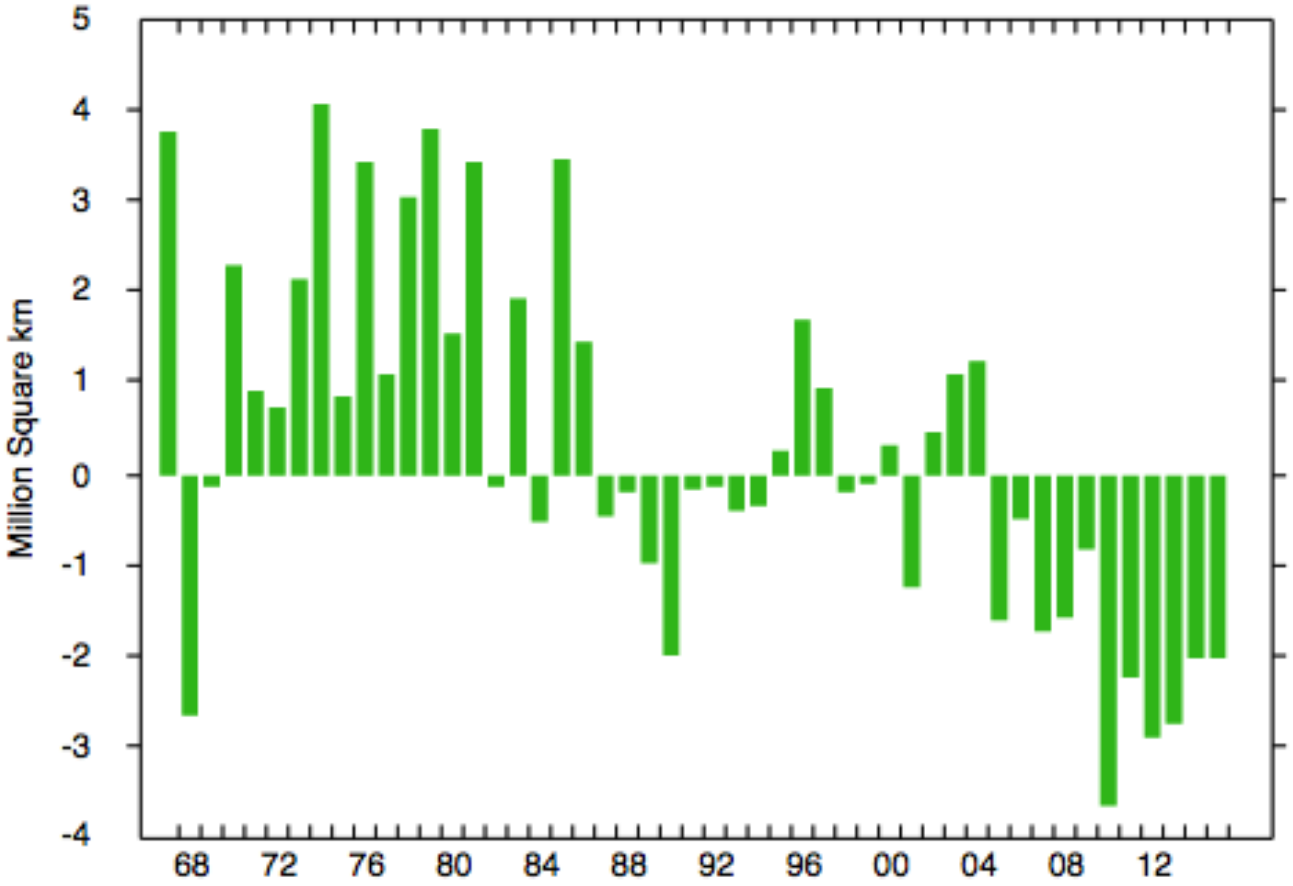
Extent of snow cover across the U.S. and southern Canada on March 25, 2012 and March 25, 2013, showing exceedingly more snow cover on this date in 2012. Areas in white were snow covered on this date in both years. Those in yellow were snow covered in 2012 but not in 2013. Grey areas were snow covered in 2013 but not in 2013. Also shown (red line) is the average extent of snow cover on this date for the period 1999-2013. Data are gleaned from NOAA Interactive Multisensor Snow and Ice Mapping System maps.

NH Snow Cover Extent: 1966-2015



Departures derived from 1981-2010 mean

May NH SCE Departures: 1967-2015

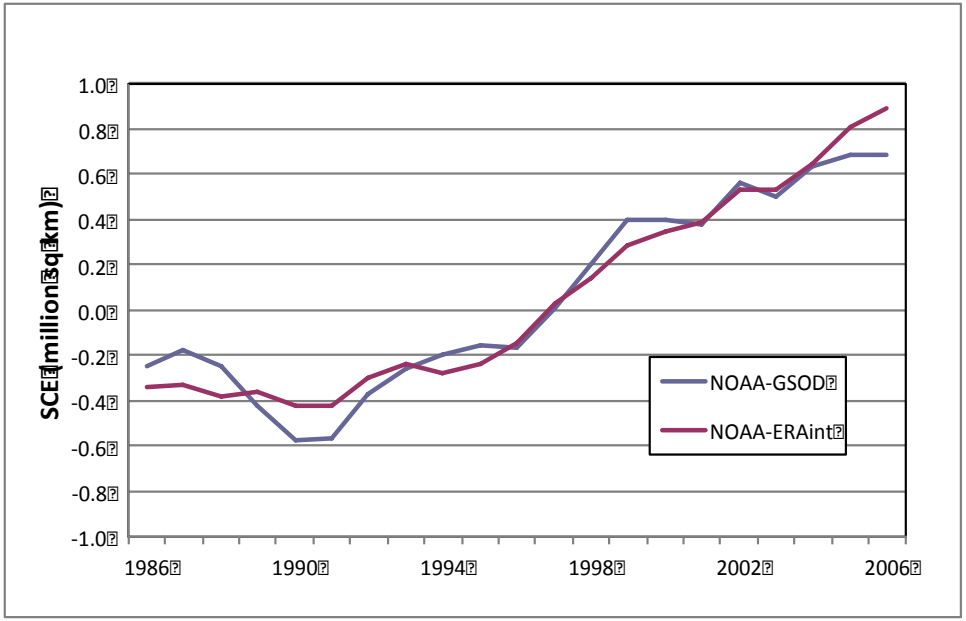


How reliable are the NOAA snow map CDR trends?

Fall

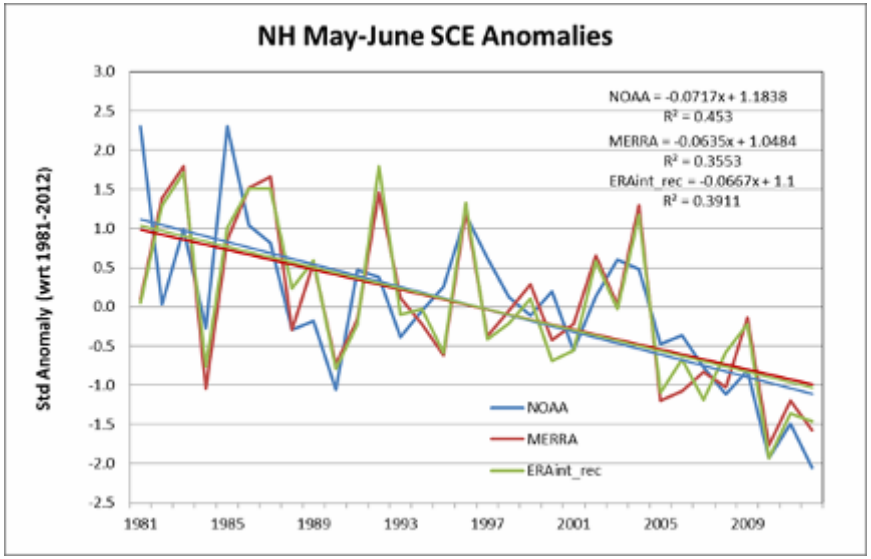
Difference between NOAA snow chart CDR and other independent SCE datasets, 1986-2006

There is evidence of a tendency in the NOAA snow chart data record to map relatively more snow over Eurasia in the snow onset period than other datasets since ~1997, ***which results in an artificial trend (~+0.5 million km² per decade) October snow cover.***

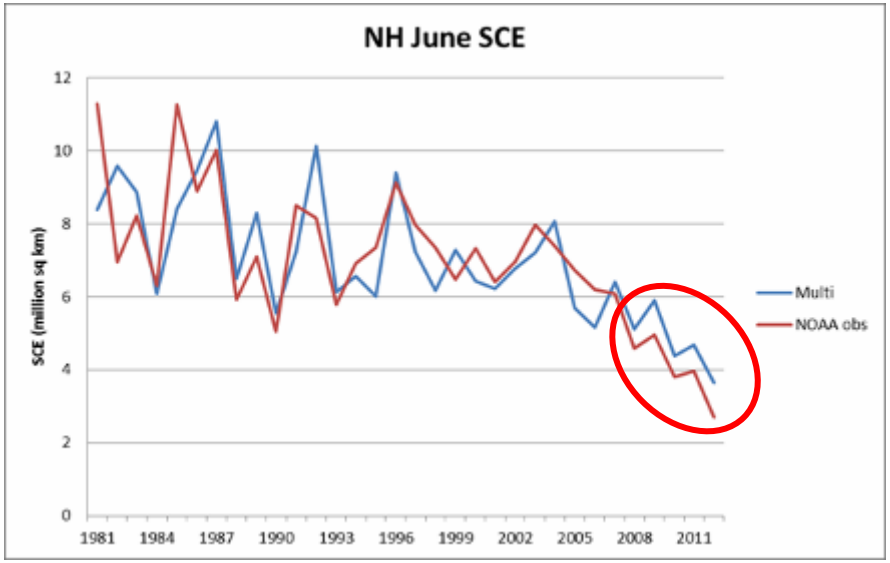


From: Derksen & Brown: AGU 2012

Spring



Standardized anomaly time series of Northern Hemisphere SCE, 1981-2012, from the NOAA snow chart CDR (blue), MERRA (red) and ERAint (green)

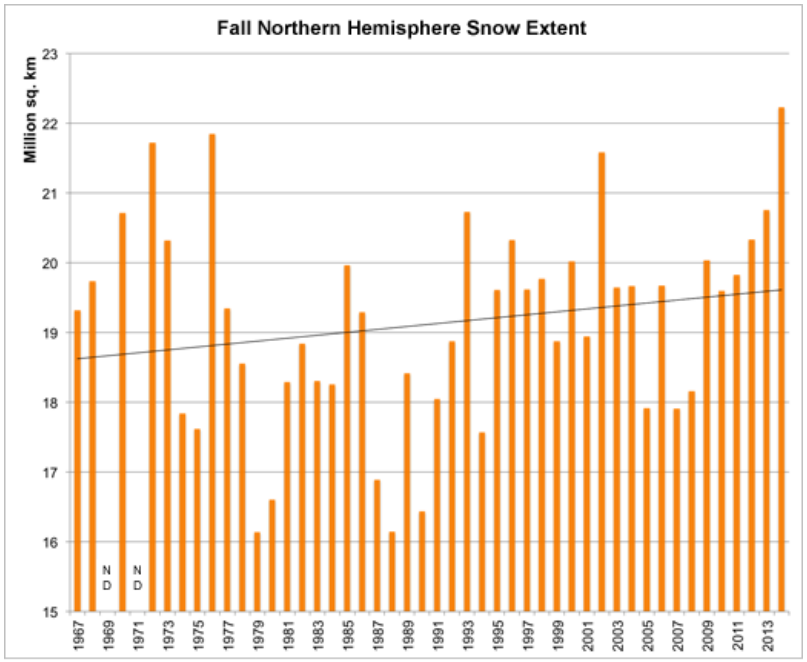


Northern Hemisphere SCE time series, 1981-2012, for the NOAA snow chart CDR (red) and average of NOAA+MERRA+ERAint (blue)

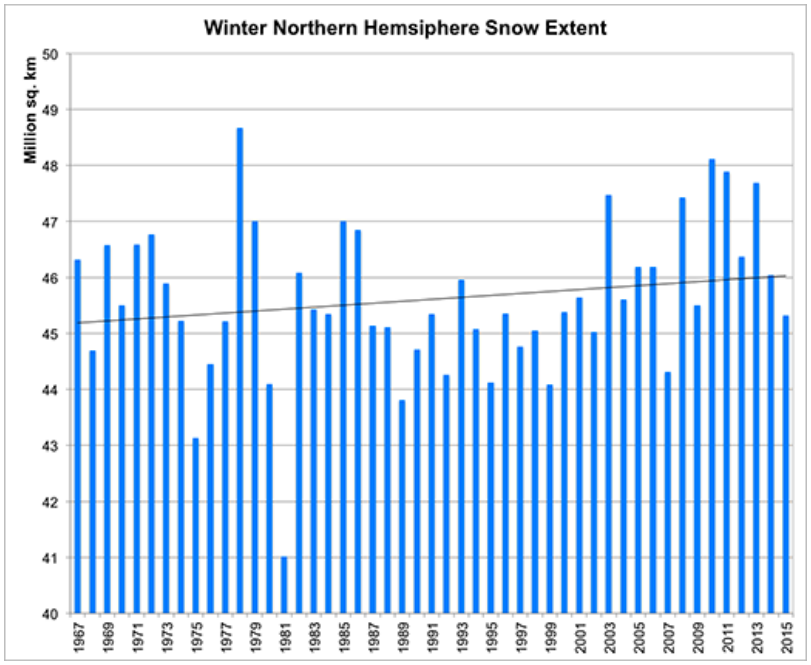
- Similar anomaly trend results obtained with three independent datasets.

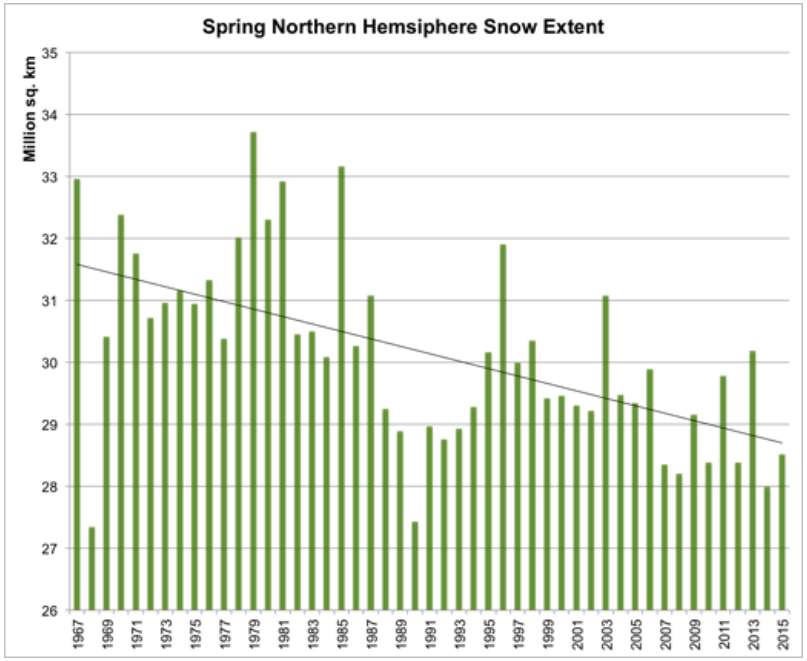
- Tendency for NOAA to consistently map less spring snow (~0.5 to 1 million km^2) than the multi-dataset average since 2007.
- Accounting for this difference reduces the June SCE trend to -15.0% per decade.

Derksen & Brown: AGU 2012



ND indicates no data for a given year





So……
do these findings remove any upward trend in fall and perhaps even winter? And what about a spring downward trend?

There are no definitive answers in the following slides, but some food for thought.

The study only covers the winter over North America.

We will look to expand this, given the availability of sufficient Eurasian in situ observations (winter) and again, with adequate in situ data attempt this over both continents in fall and spring.

North American Winter Study

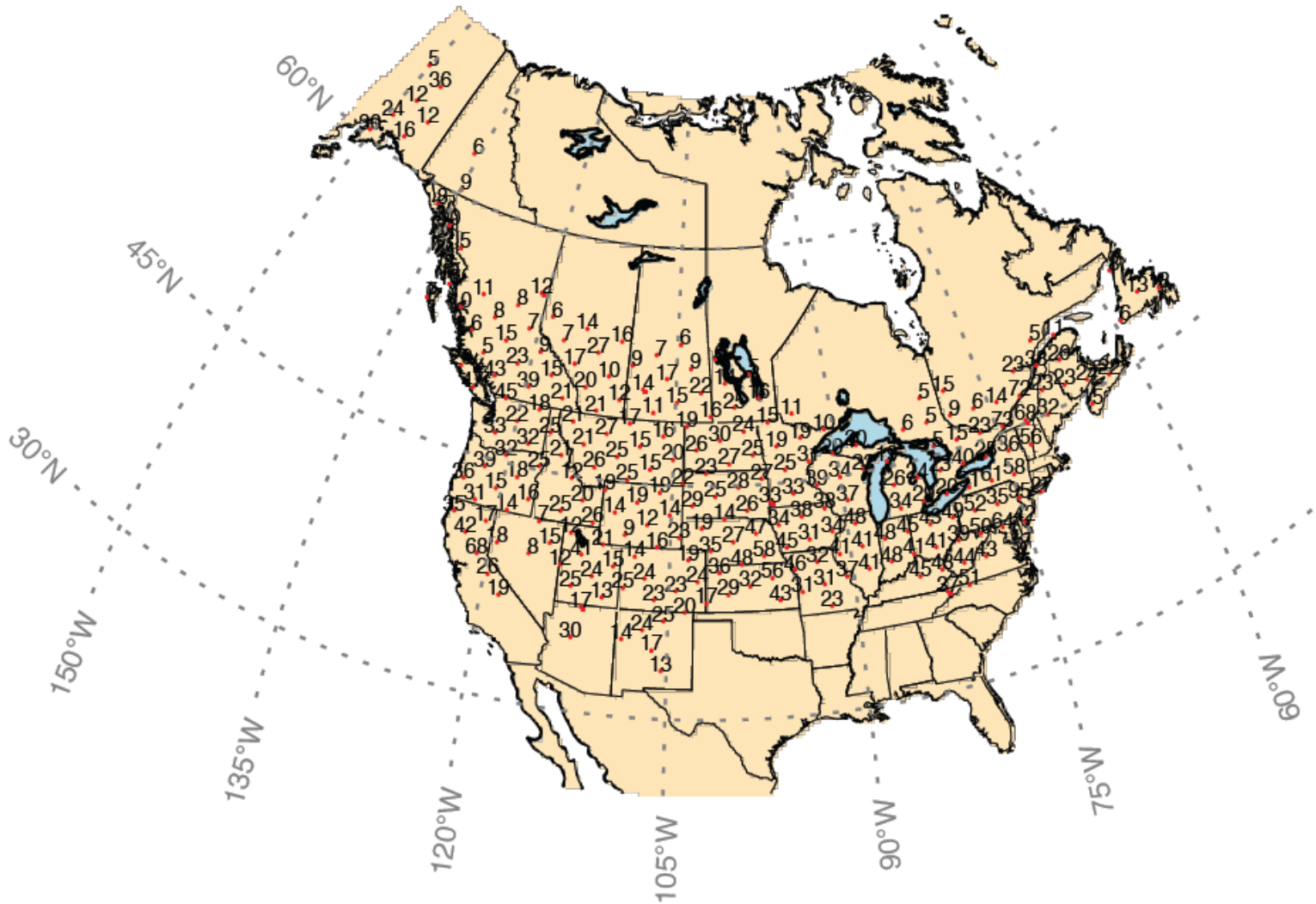
Logistic regression modeled the probability of snow cover detection in any NOAA cell based on average depth and fraction of stations reporting measurable depth.

Dependent variable: presence or absence of snow in the satellite product.
Independent variable: average snow depth in the grid cell.

Three time periods:

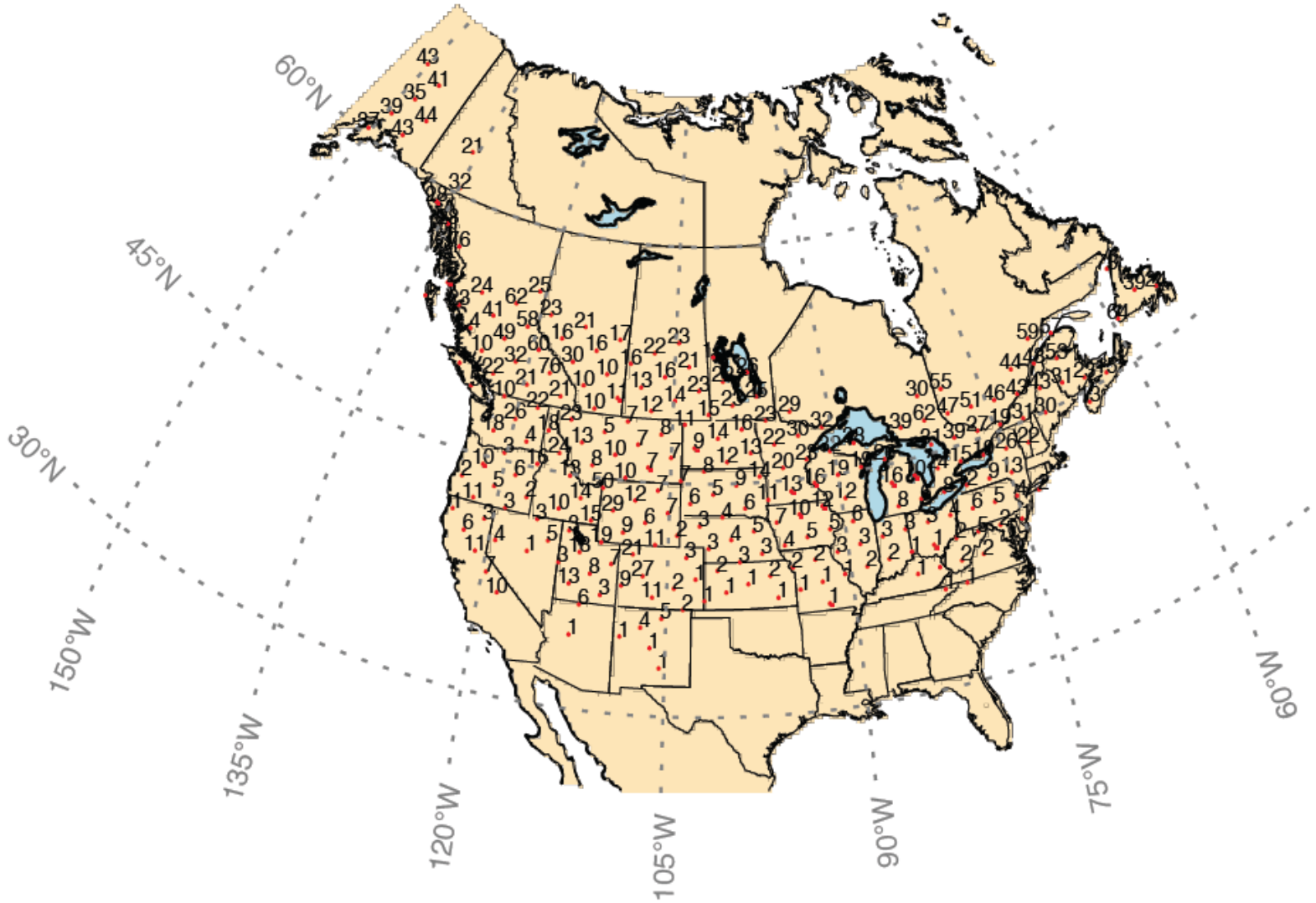
1. 1967-1980
2. 1981-1998
3. 1999-2009

Median number of stations reporting snow cover



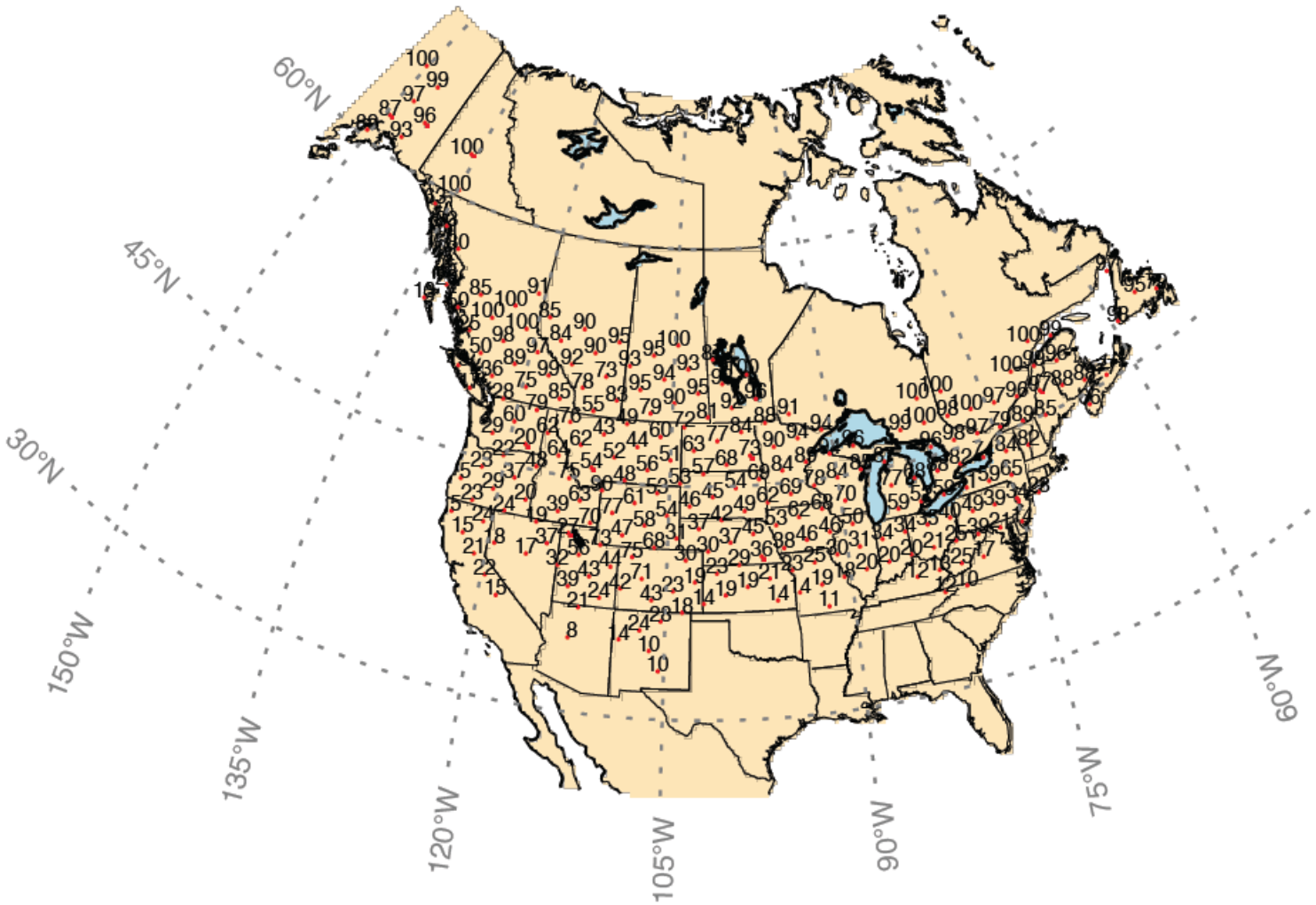
Average depth of 1 cm or greater and at least 5 stations recording snow depth: D-F

Average snow depth (cm)



Average depth of 1 cm or greater and at least 5 stations recording snow depth: D-F

Median percentage of stations with a measurable snow depth



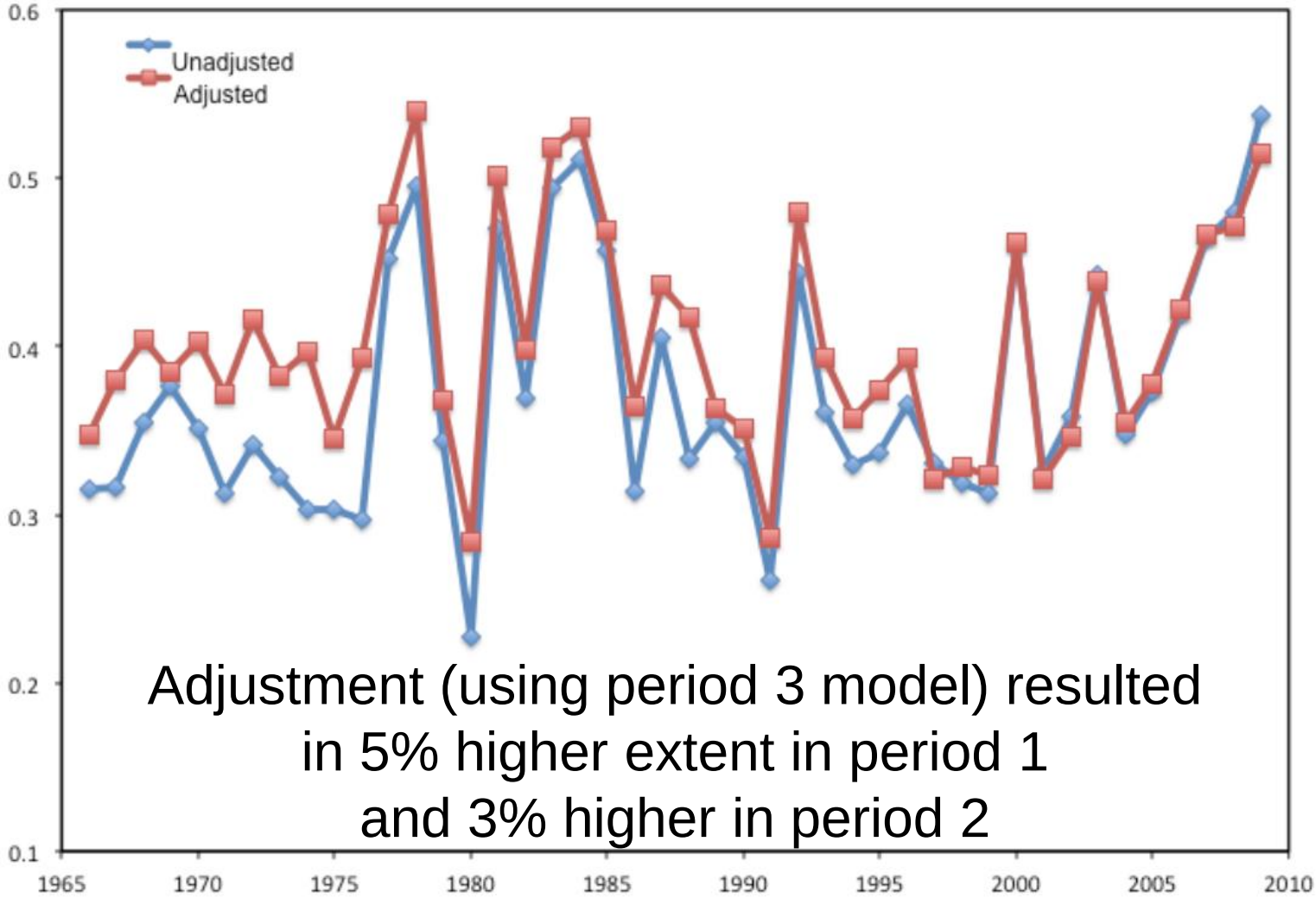
Average depth of 1 cm or greater and at least 5 stations recording snow depth: D-F

Only cells with in situ snow in one or more stations analyzed

Model predicted 80% correct in period 1
84% in period 2 and 87% in period 3.

More likely to predict cover based on in situ data when absent in satellite than predict no snow based on in situ when present in satellite

Unadjusted and adjusted average fraction of snow cover by year within the study area



Adjustment (using period 3 model) resulted in 5% higher extent in period 1 and 3% higher in period 2

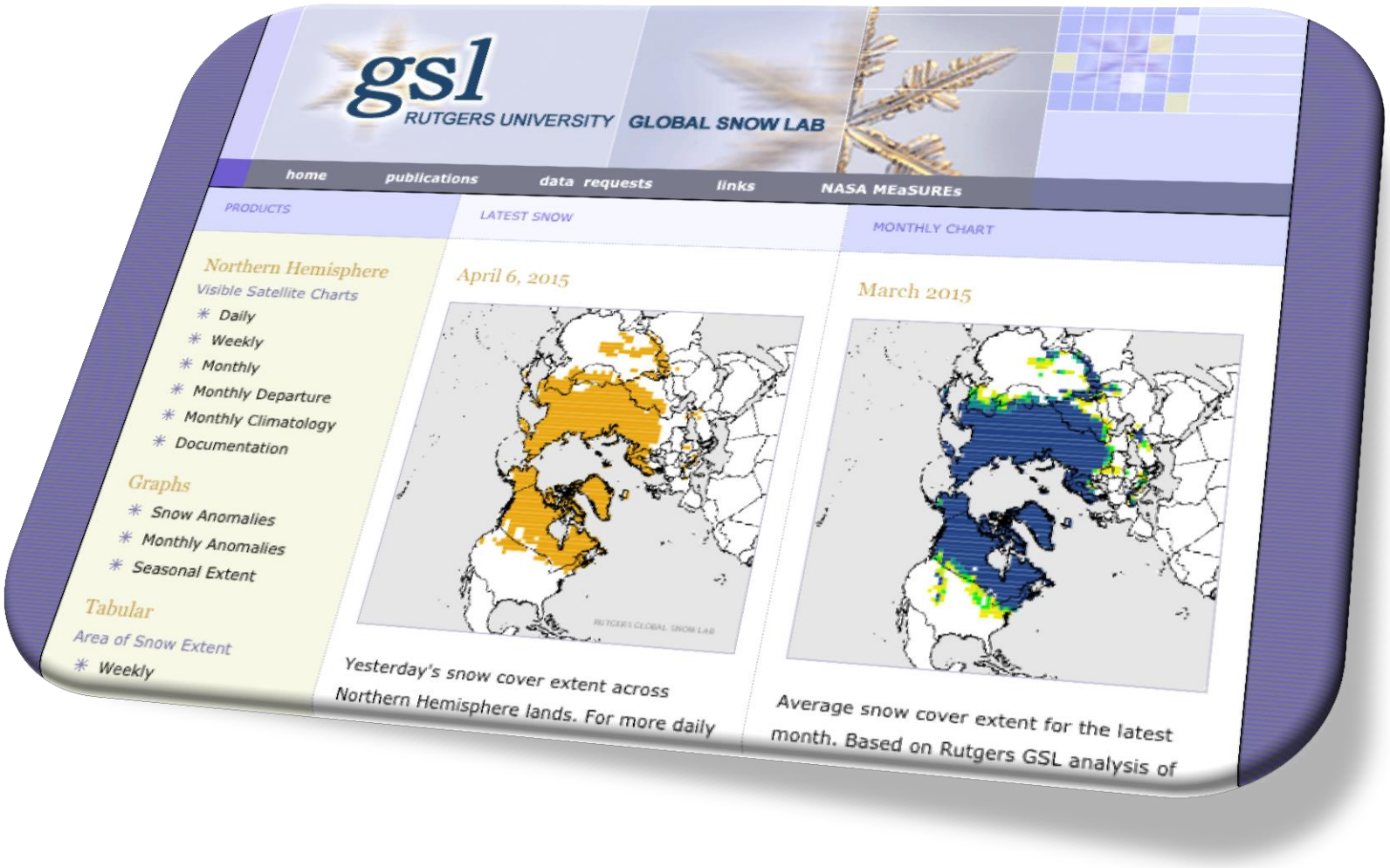
Remember:

1. Limited region
2. Cells with 5 or more stations
3. Only December to February evaluated

Summing up…

- NOAA satellite-era weekly SCE maps have been the work horse in understanding where snow lies over NH continents and how SCE has trended with time.
- Questions have long surrounded the accuracy of the weekly SCE product. Not to a first order, rather more subtle variations that may be the result of mapping methodologies over time.
- An analysis of NOAA SCE data with that from in situ station observations of snow on ground has been performed over North America during winter (D-F)
- Results show an improvement in snow recognition in the SCE product relative to in situ observations over time.
- This suggests that a NA trend toward more extensive winter SCE may be a partial or complete result of improved mapping.
- Further study is required over the NA swing seasons and over Eurasia in all seasons.

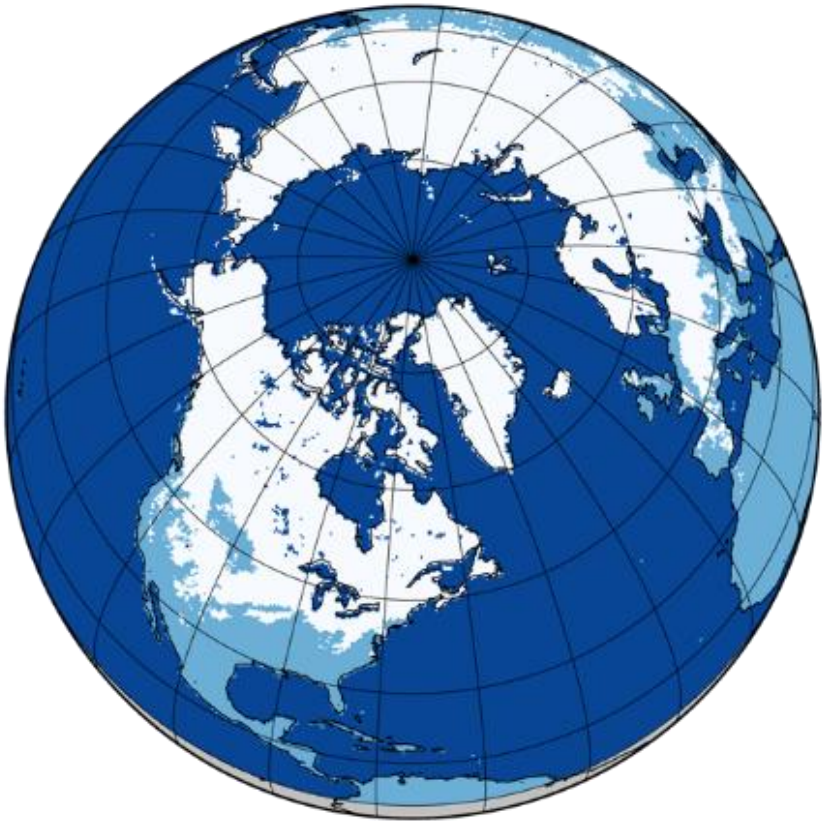
Rutgers Global Snow Lab: snowcover.org



17 years of operational IMS output

- Operational since November 1998
- 24 km resolution at 60°N
- Daily temporal resolution

- Bring IMS SCE output up to CDR standards



Thanks

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- snowcover.org

NASA/GSFC/Suomi NPP
White Marble
26 May 2012