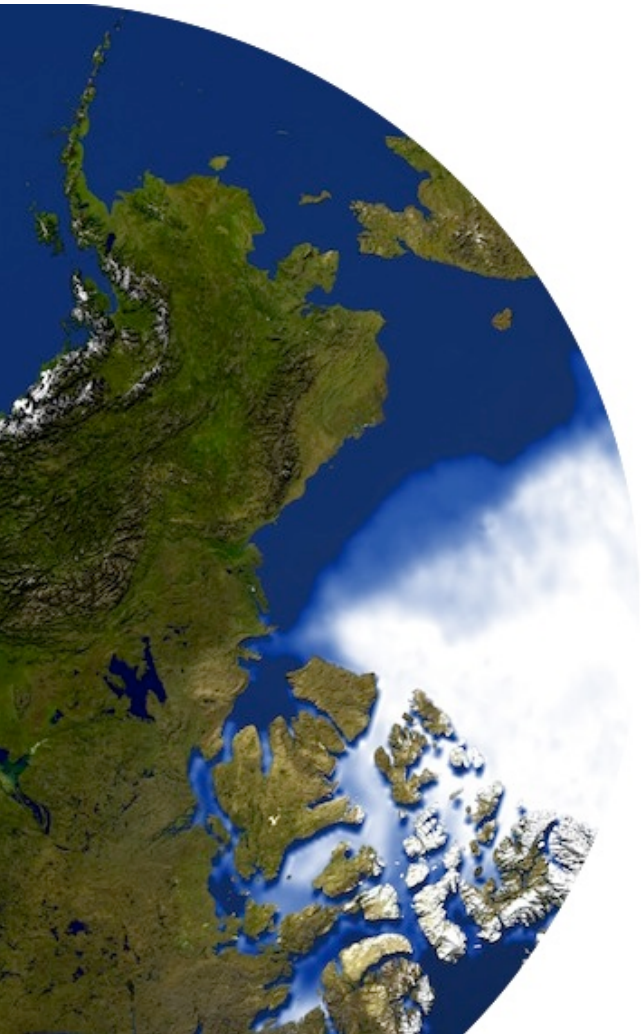
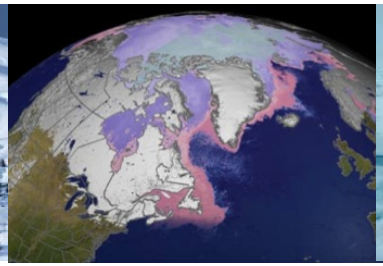
Ice, Snow, Winds, and Other Products for the High Latitude Proving Ground



Jeff Key
NOAA/NESDIS
Madison, Wisconsin USA

Alaska Proving Ground Meeting, June 2013, Anchorage

Snow and Ice Properties

Snow

- snow water equivalent (SWE), depth, extent, density, grain size, albedo

There are at least 30 cryosphere properties that, ideally, would be measured. Of those, measurement techniques from space can be considered mature for only 8.

- freeze/thaw/melt/dp, thickness, snow on ice

Sea Ice

- extent, concentration, type (age), thickness, motion, temperature, leads, snow on ice

Glaciers, Ice Caps, Ice sheets

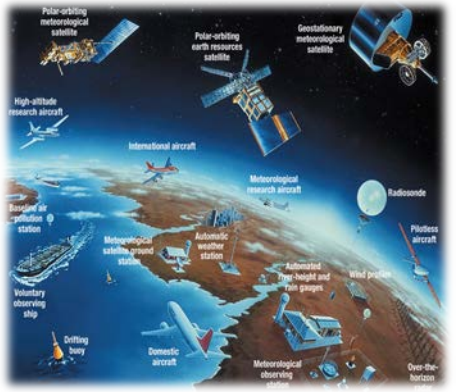
- mass balance (accumulation/ablation), thickness, area, length (geometry), firn temperature, velocity, snowline/equilibrium line, icebergs, snow on ice

Frozen Ground/Permafrost

- soil temperature/thermal state, active layer thickness, borehole temperature, extent, snow cover

(Green: mature capability; Blue: moderate/developing capability; Red: little or no capability)

Products



NPP/JPSS VIIRS

- Snow cover
- Ice characterization
  - Ice age
  - Ice concentration
- Ice surface temperature

GOES-R ABI

- Fractional snow cover (baseline)
- Snow depth - plains only*
- Ice cover**
- Ice concentration**
- Ice thickness/age**
- Ice motion*

*Future capabilities

**Future capabilities - NDE

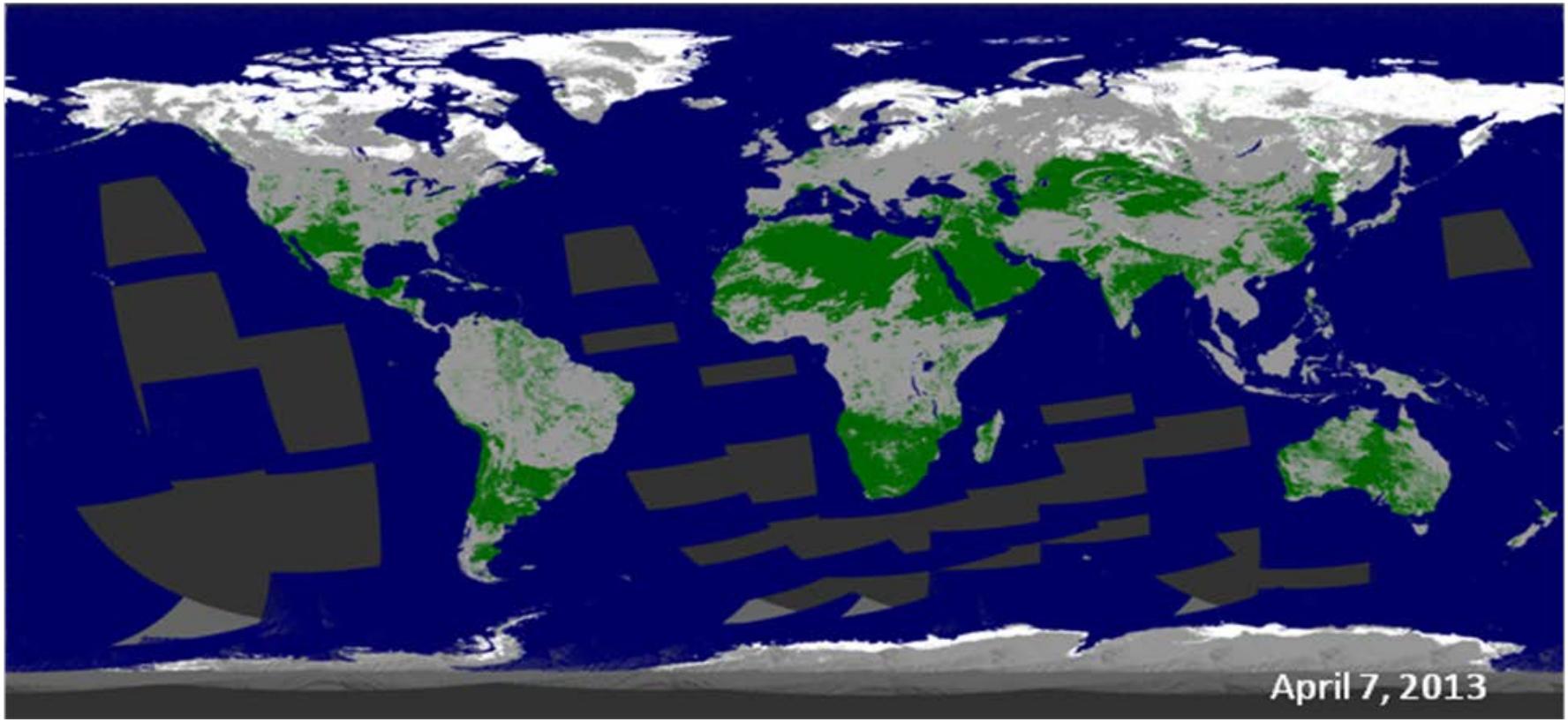
AMSR-2 on GCOM-W1

- Snow cover
- Snow depth
- Snow water equivalent (SWE)
- Ice characterization
  - Ice age
  - Ice concentration

Other

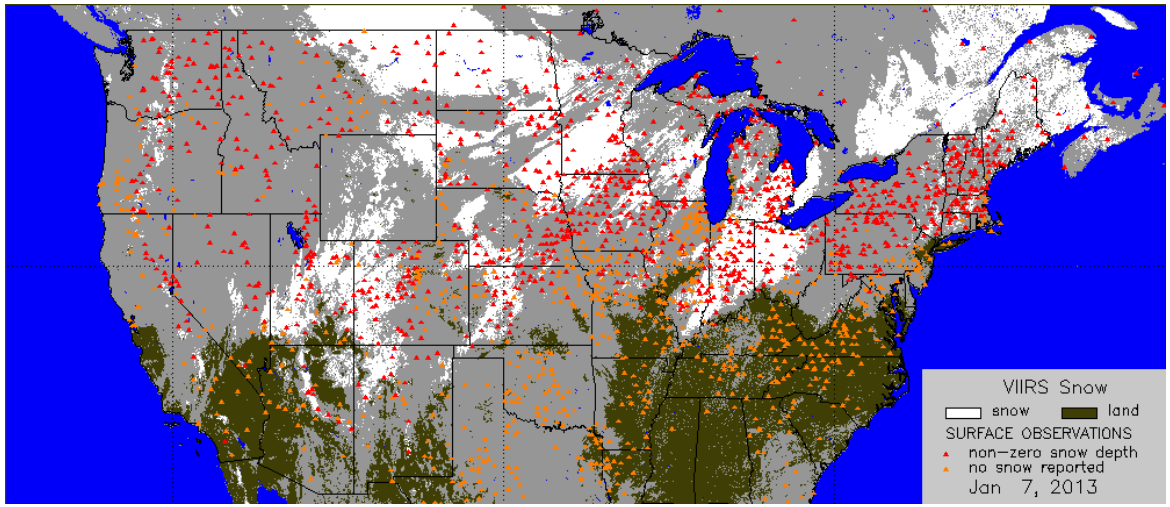
- Polar winds
- Arctic composites
- Sea ice leads (VIIRS)

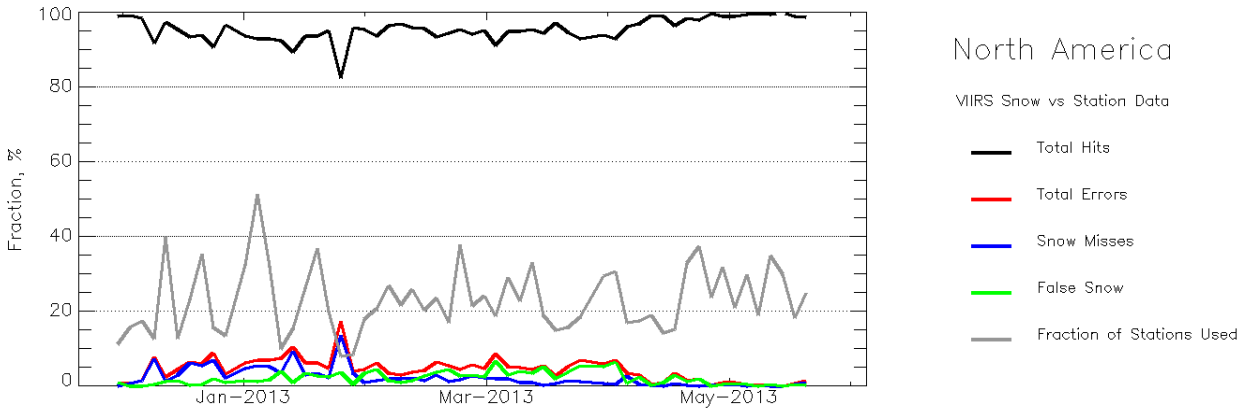
VIIRS Snow Cover



Daily global snow cover map derived from VIIRS data. Granules containing no “land” pixels are not processed by the VIIRS snow algorithm.

VIIRS Snow Cover Validation

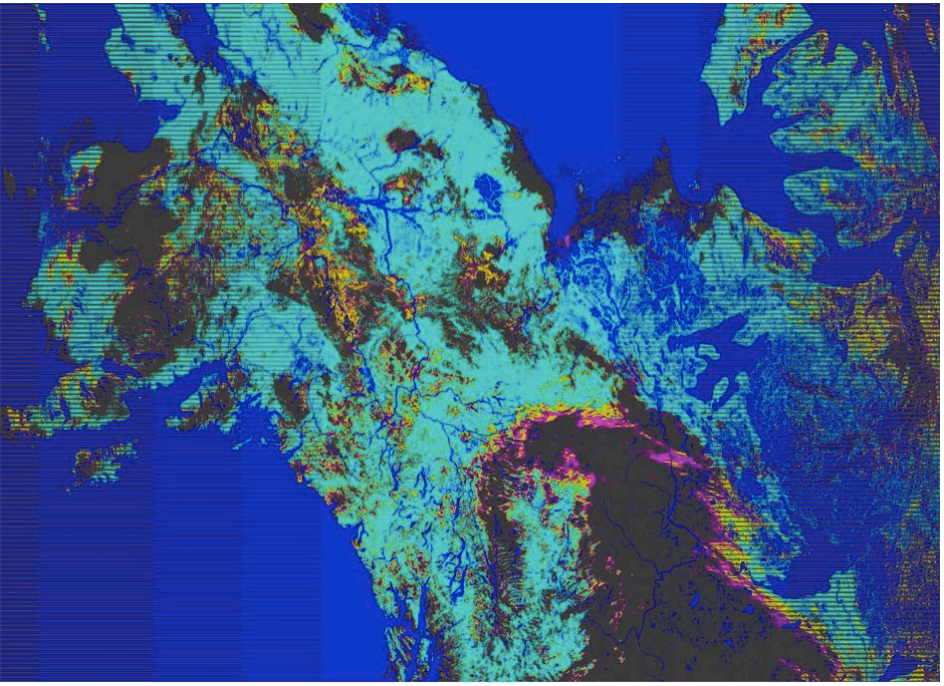




Top: VIIRS binary snow cover map over Continental U.S. (CONUS) area with surface snow cover observation data overlaid. Bottom: Statistics of errors and agreement between the VIIRS daily snow cover map and station data during the time period from December 2012 to May 2013.

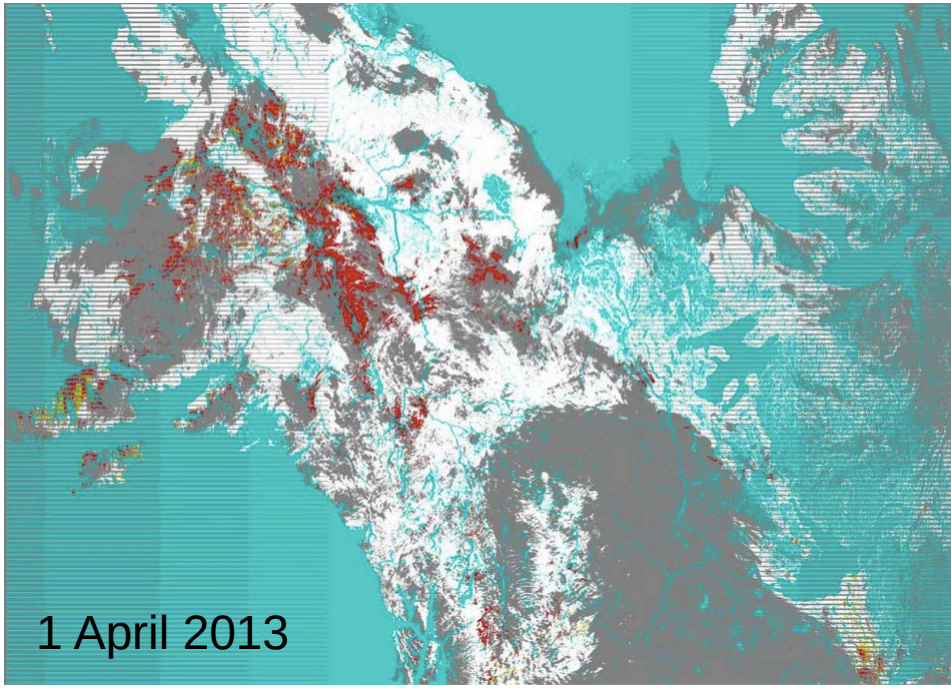
Binary Snow Cover: Use “Confidently Clear” Only

Cloud Detection Confidence



Cyan - confidently clear, yellow - probably clear, magenta - probably cloudy, dark grey - confidently cloudy

Snow and Snow Omission Errors

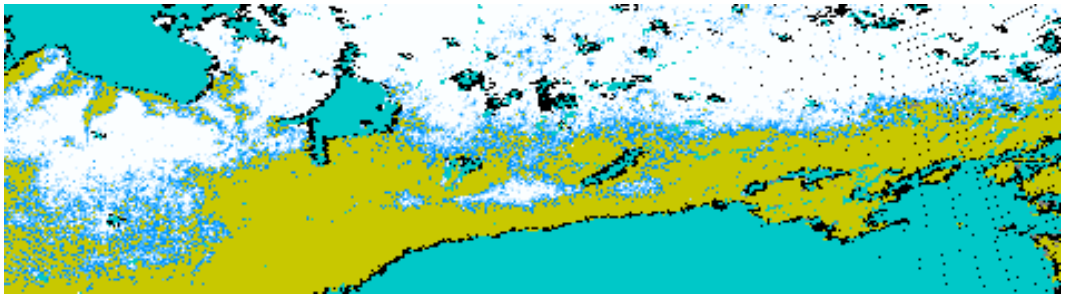


White – snow, yellow – missed snow when cloud mask is confidently clear, red – missed snow when probably clear and probably cloudy

Areas of Alaska that are probably clear and probably cloudy in the left image are actually snow-covered, but are not labeled as snow- (red areas on the right).

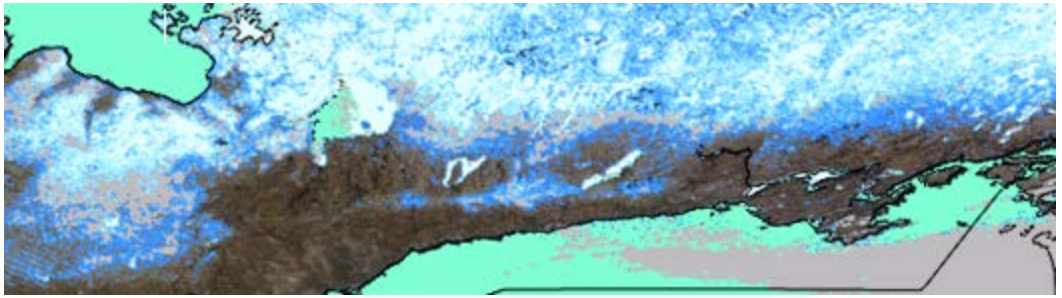
VIIRS Snow Fraction

VIIRS fraction



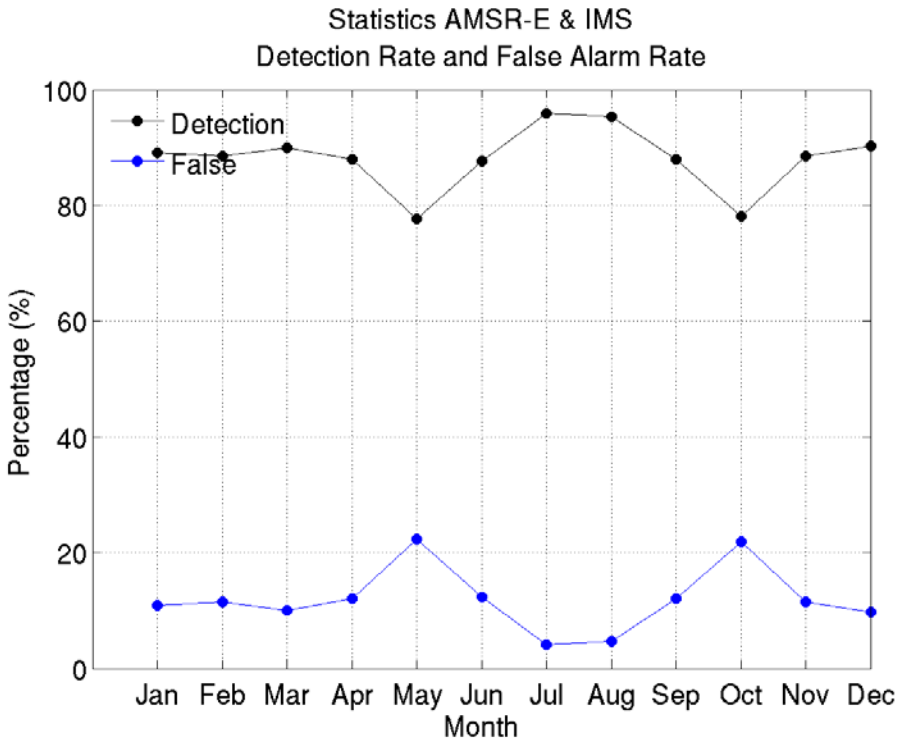
Image

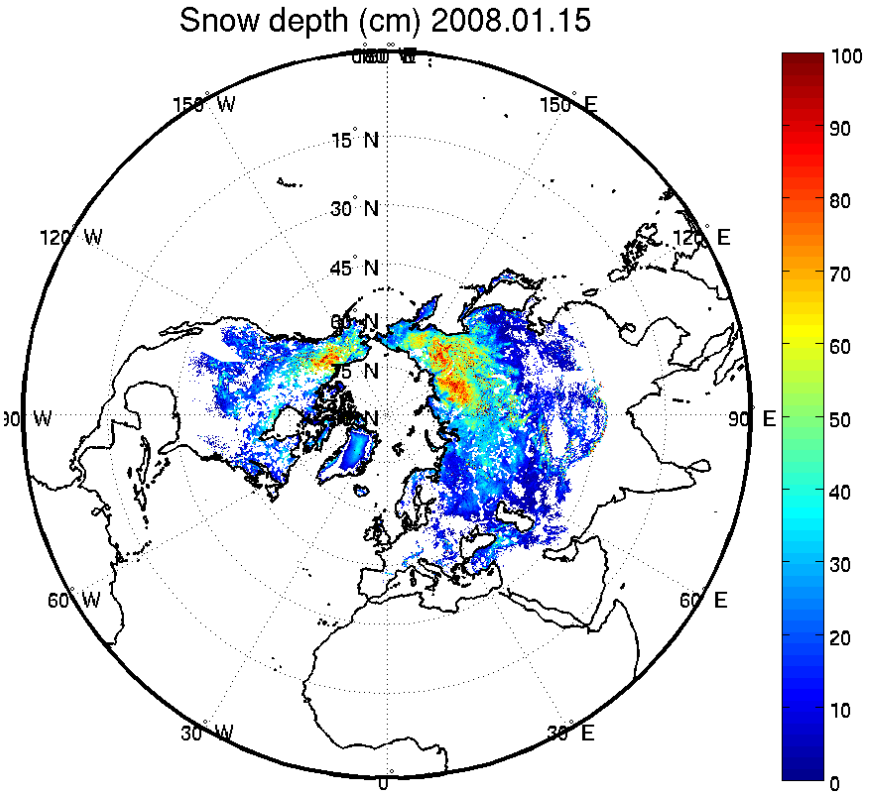
MODIS fraction



Snow fraction is a 2x2 pixel average of the binary snow map, so only 5 values are possible. Therefore, transition zones from snow-covered to snow-free are narrow.

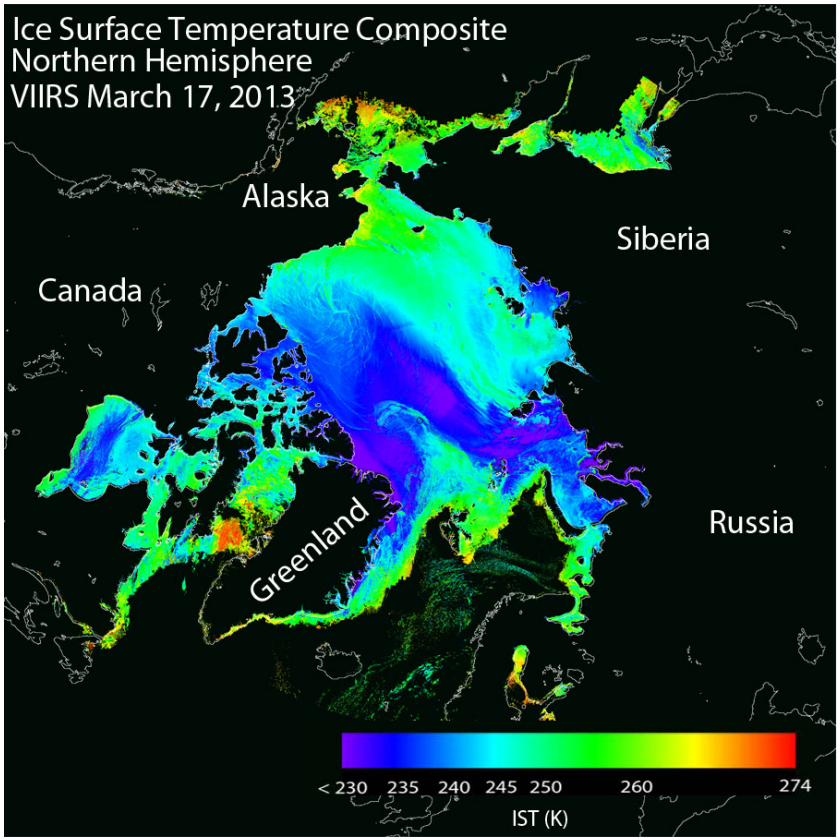
AMSR-E (AMSR2) Snow Cover

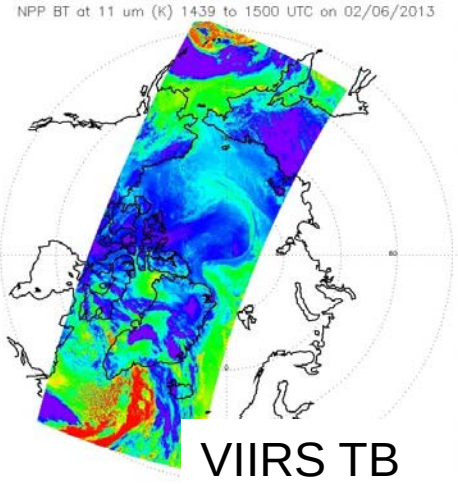




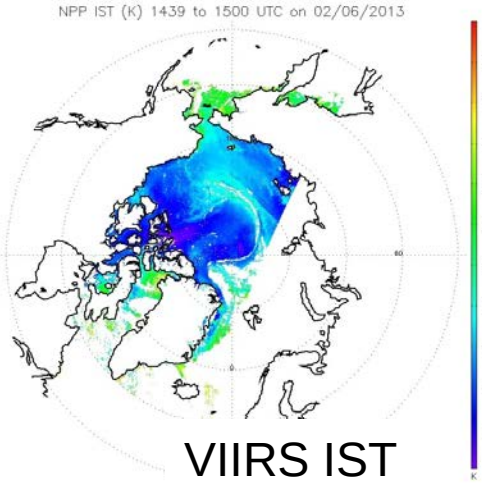
Left: AMSR-E (AMSR2 algorithm) snow cover (binary mask) accuracy vs IMS snow cover.
Right: Snow depth from AMSR-E (AMSR2 algorithm). Snow water equivalent (SWE) is coming soon.

VIIRS Ice Surface Temperature

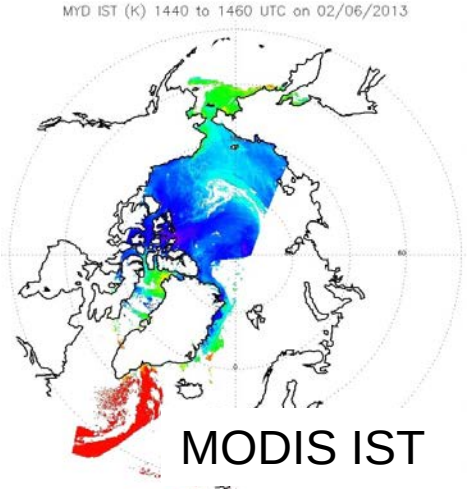




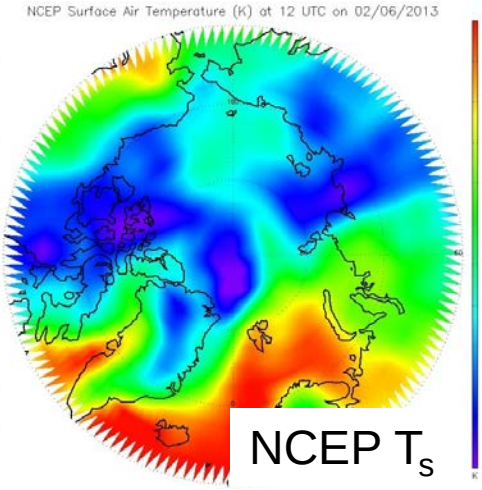
VIIRS TB



VIIRS IST

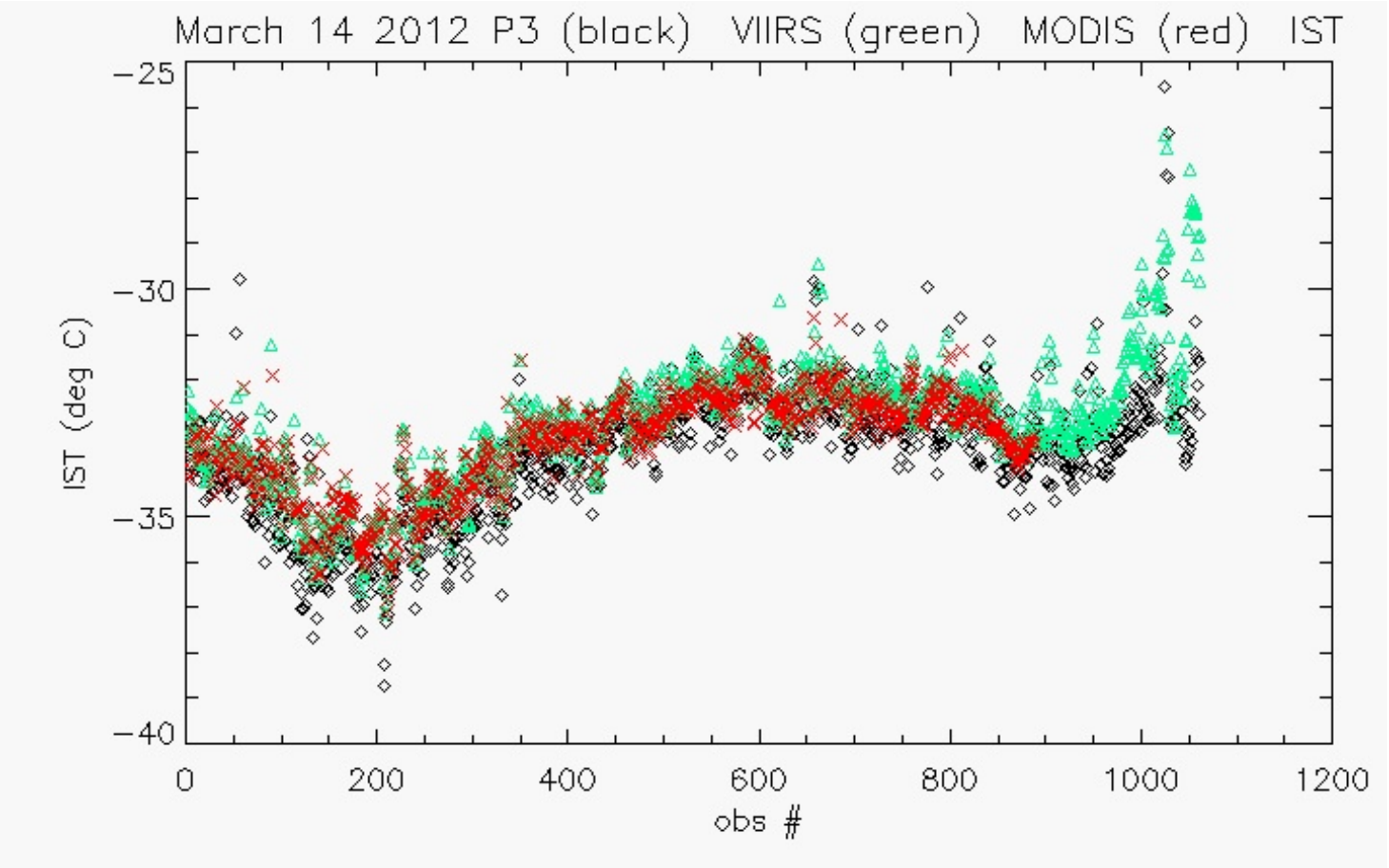


MODIS IST



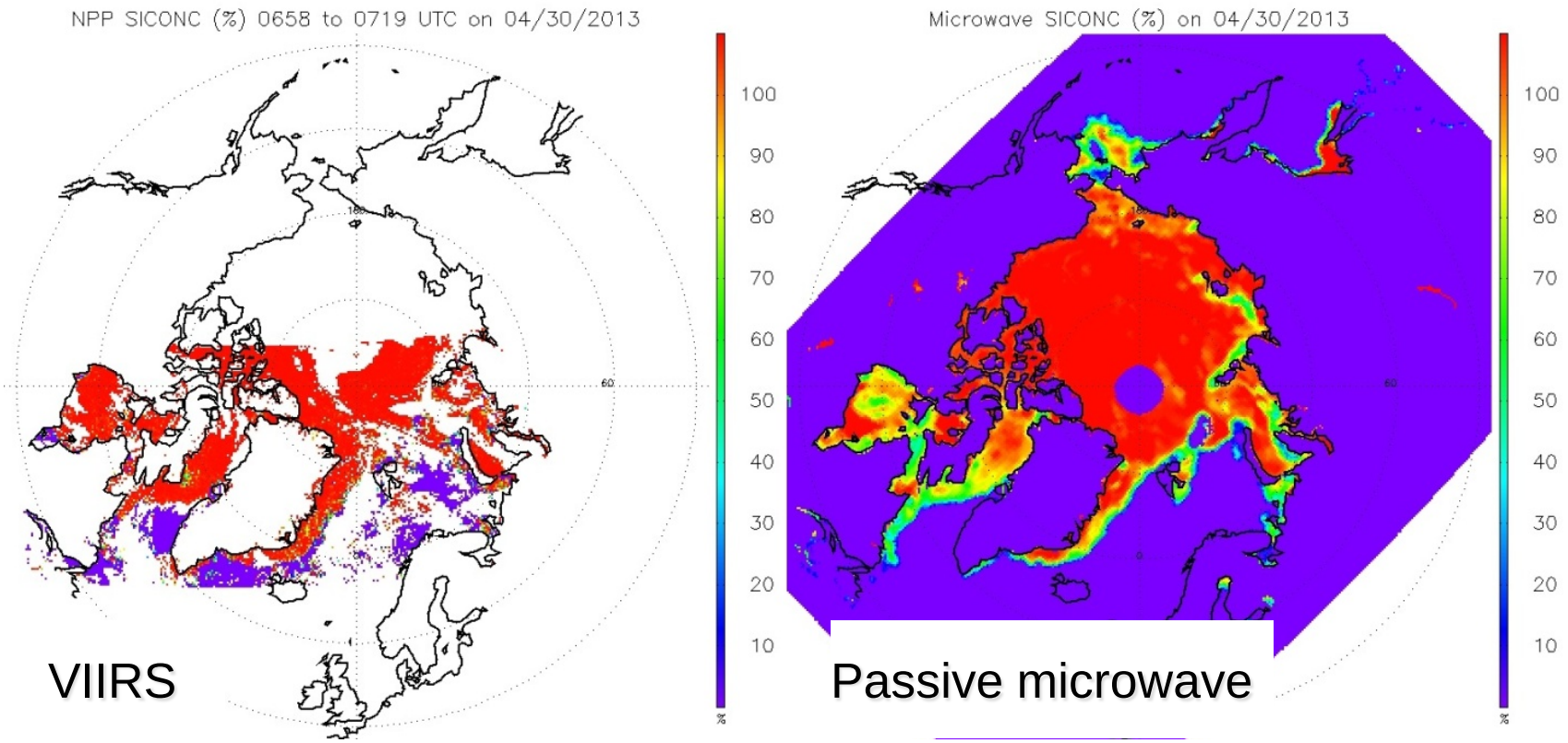
NCEP T_s

VIIRS Ice Surface Temperature Validation



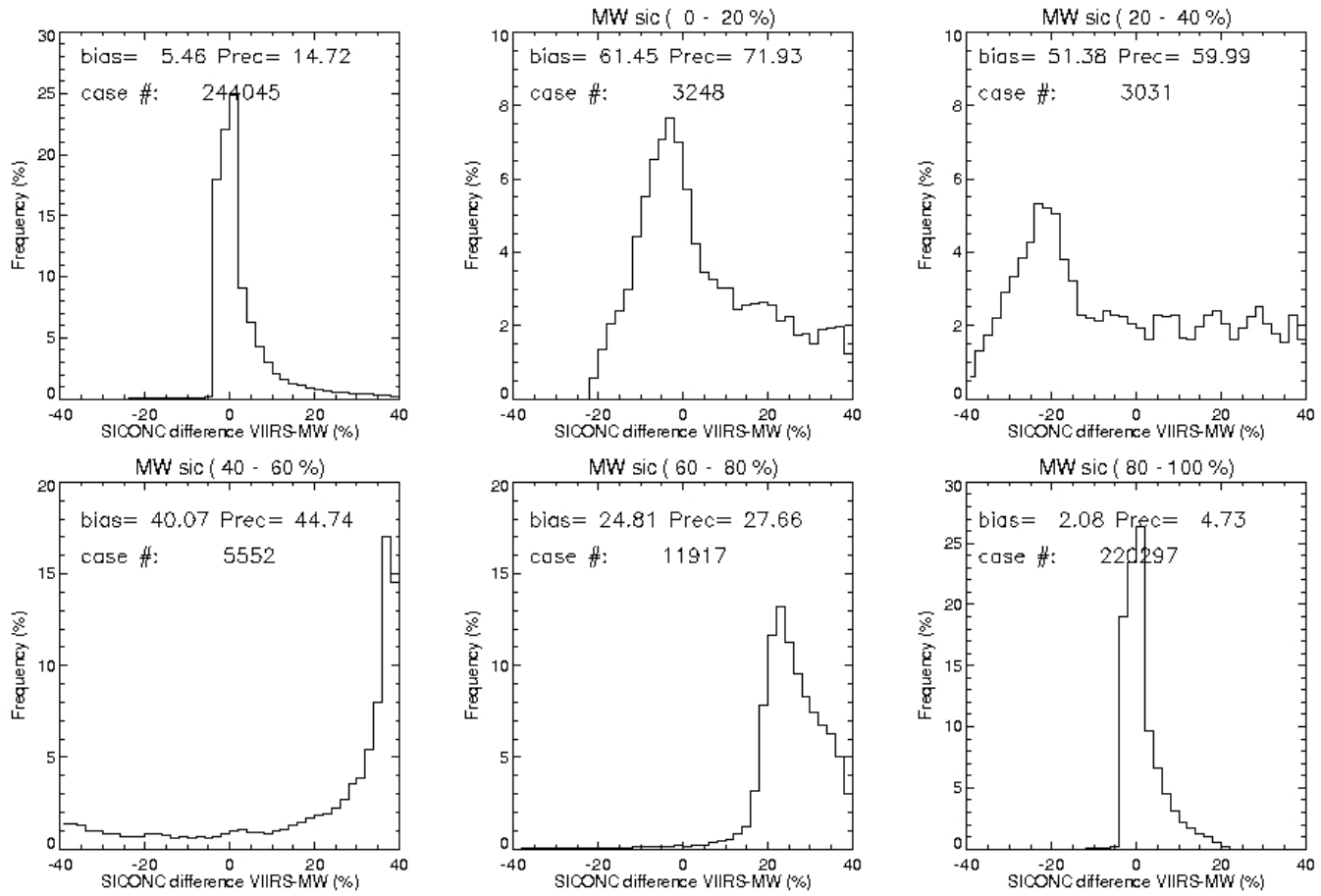
	VIIRS / KT-19	MODIS / KT-19	VIIRS / MODIS
RMS difference (˚C)	+0.60	+ 1.19	+ 1.12

Ice Cover and Concentration



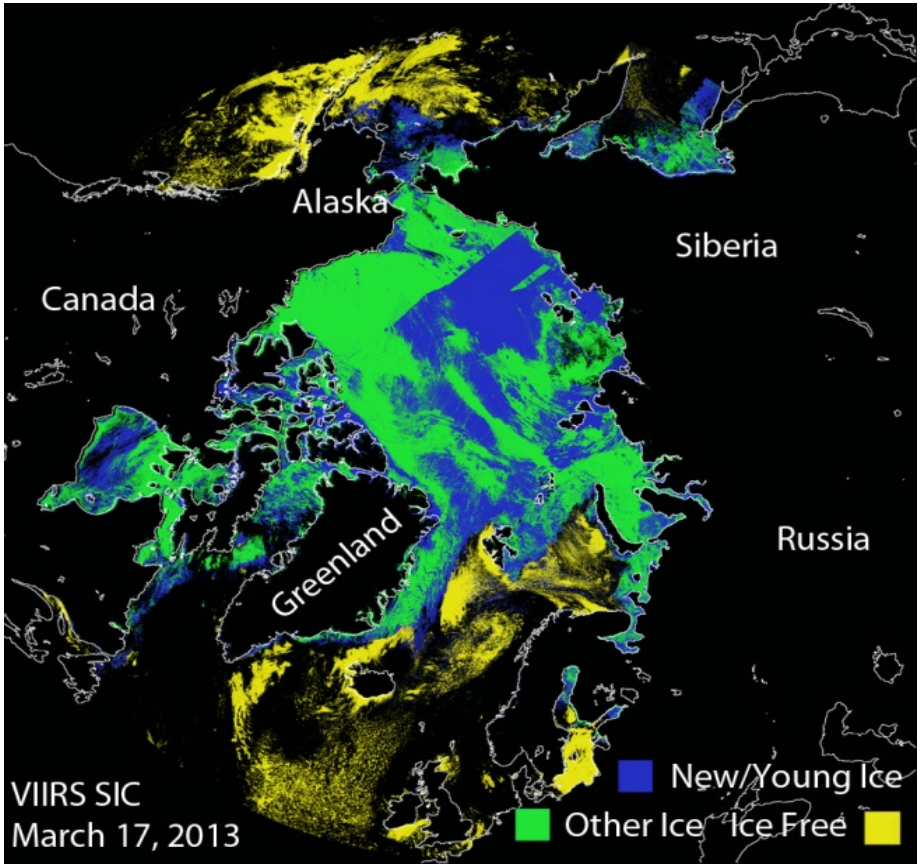
Sea ice concentration from NPP VIIRS IP (left) and from microwave using NASA team algorithm (right) on April 30, 2013.

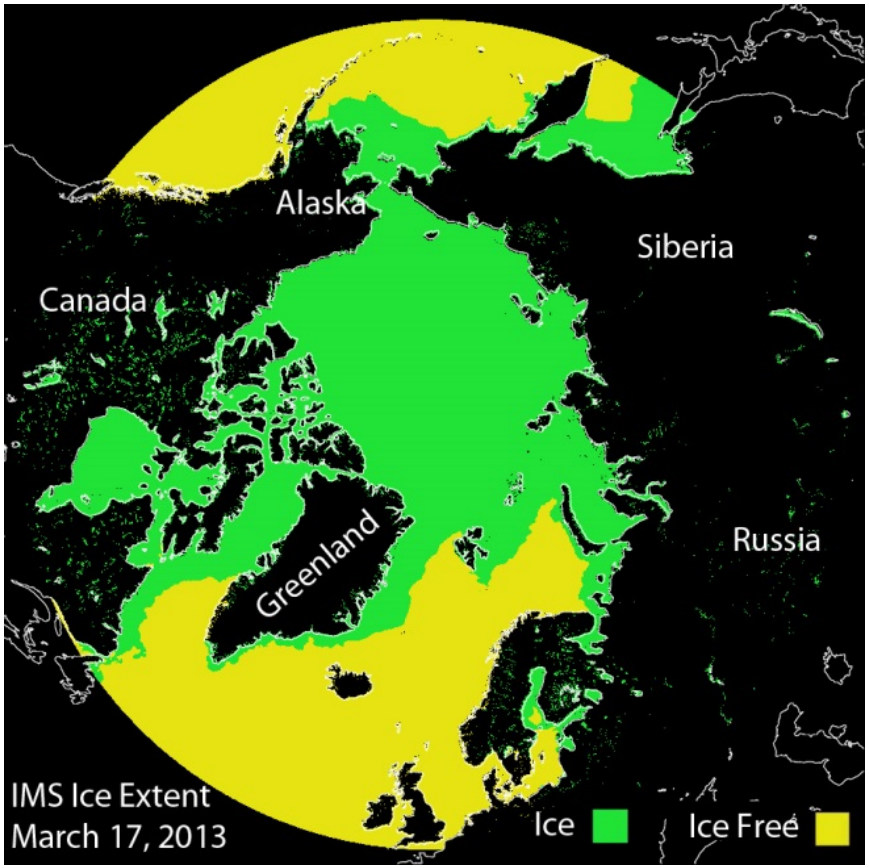
VIIRS Ice Cover Concentration Validation



Histogram of sea ice concentration differences of NPP VIIRS and Microwave using NASA team algorithm in February 2013 in the Arctic for all cases (upper left), and cases with Microwave sea ice concentration in the ranges 0-20%, 20-40%, 40-60%, 60-80%, and 80-100%. Measurement accuracy (bias) and measurement uncertainty (Prec) are indicated for each bin.

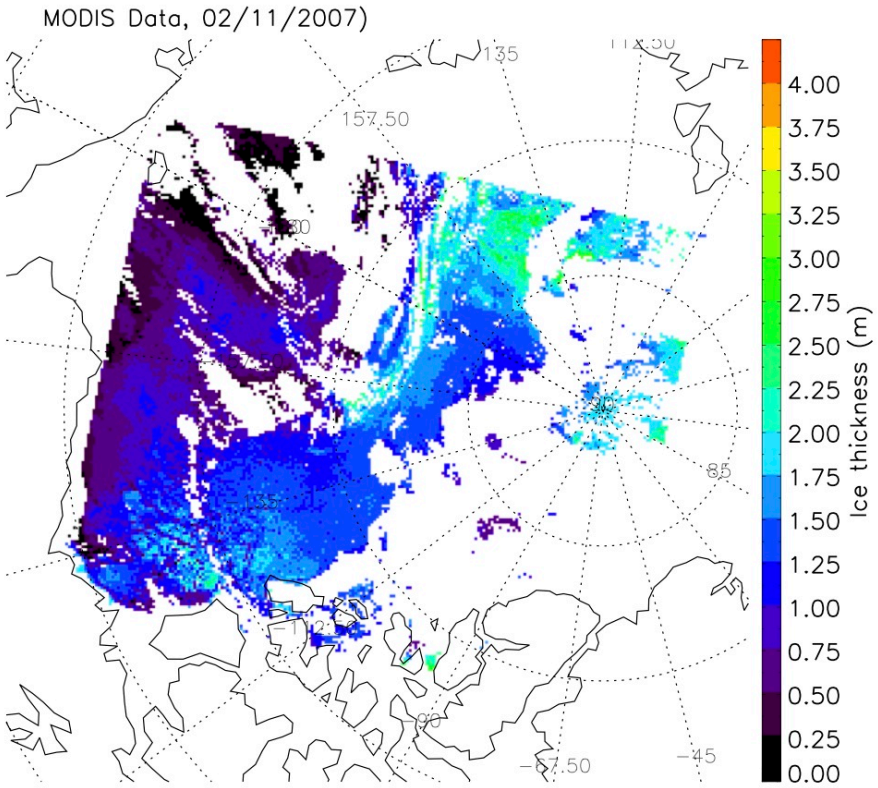
VIIRS Ice Characterization (Age)



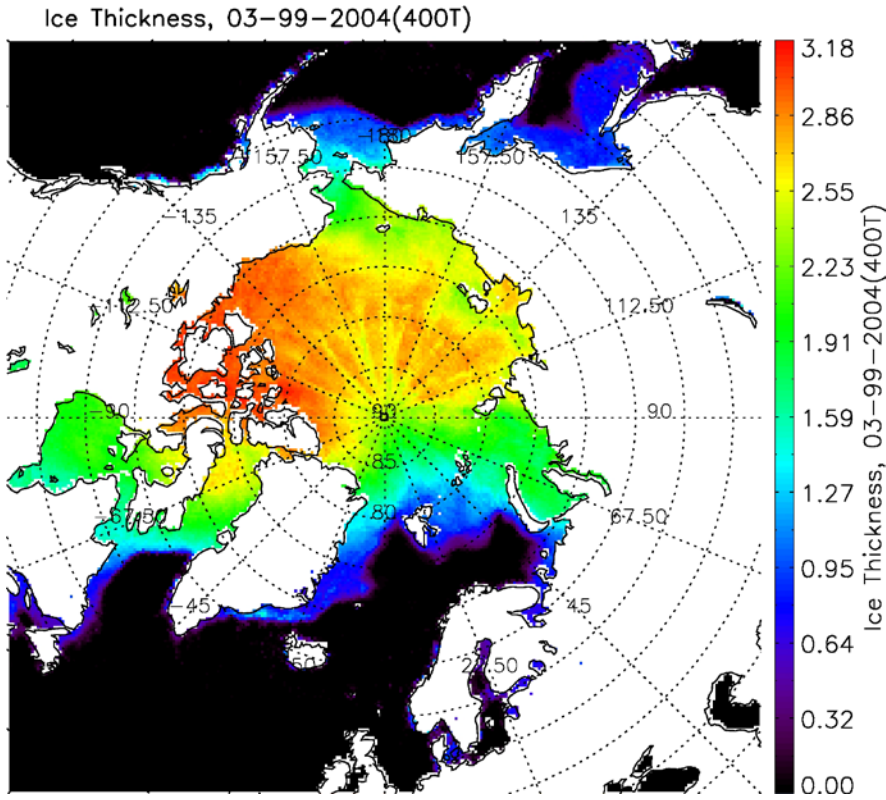


VIIRS Sea Ice Characterization EDR (left) and IMS Sea Ice Extent (right) during March17, 2013. VIIRS SIC provides “new/young” ice (< 30 cm) and “other ice” categories.

Ice Thickness from MODIS, AVHRR (and soon VIIRS)



MODIS

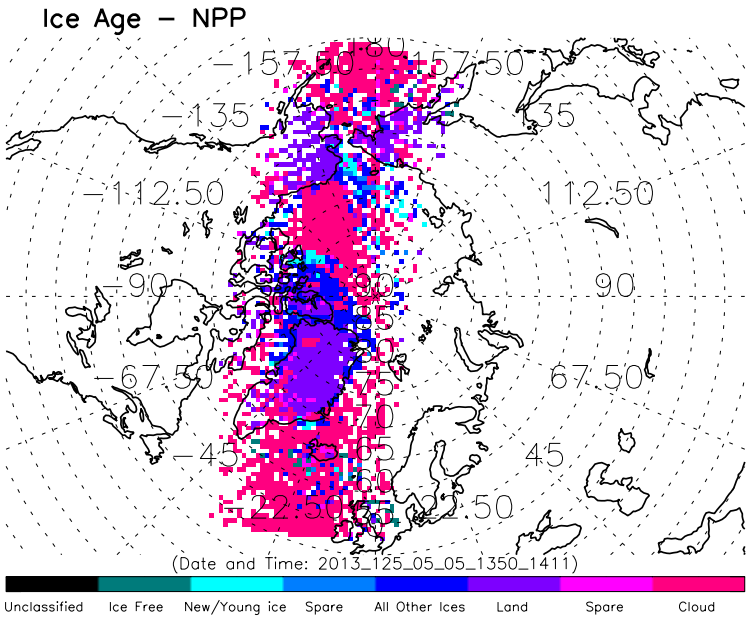


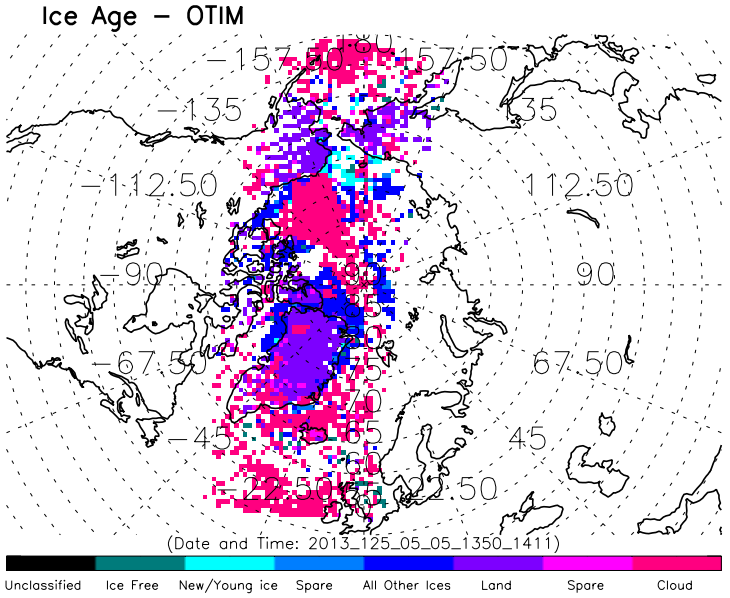
AVHRR composite

Ice Age Validation

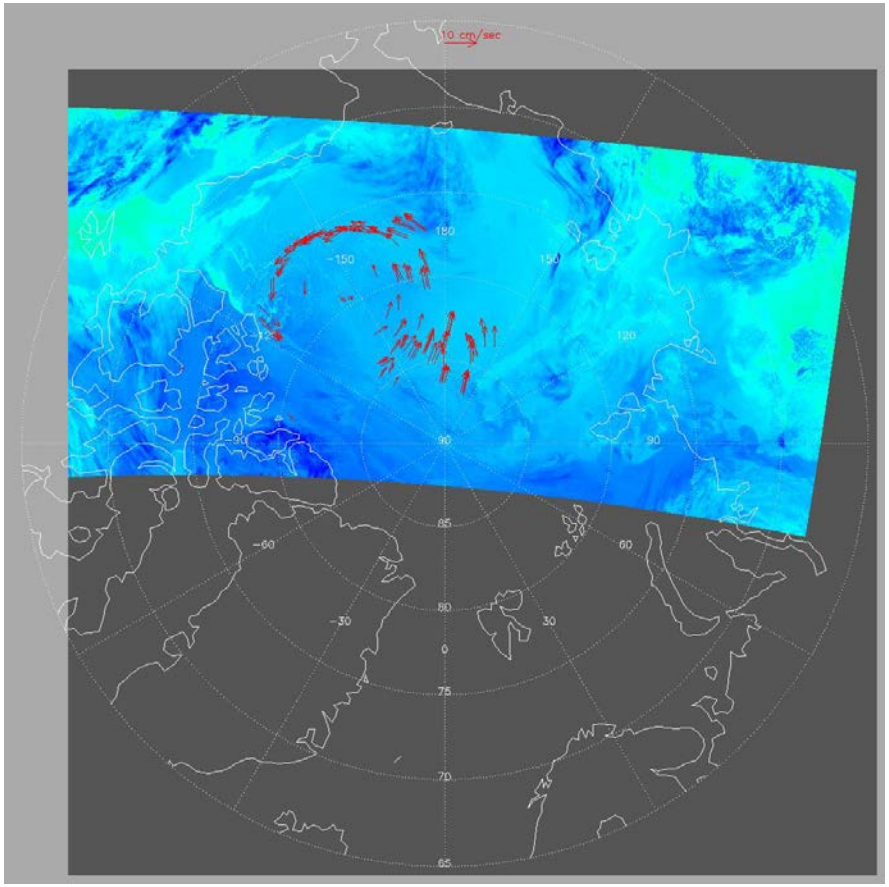
Percentage in each ice age category from VIIRS and OTIM

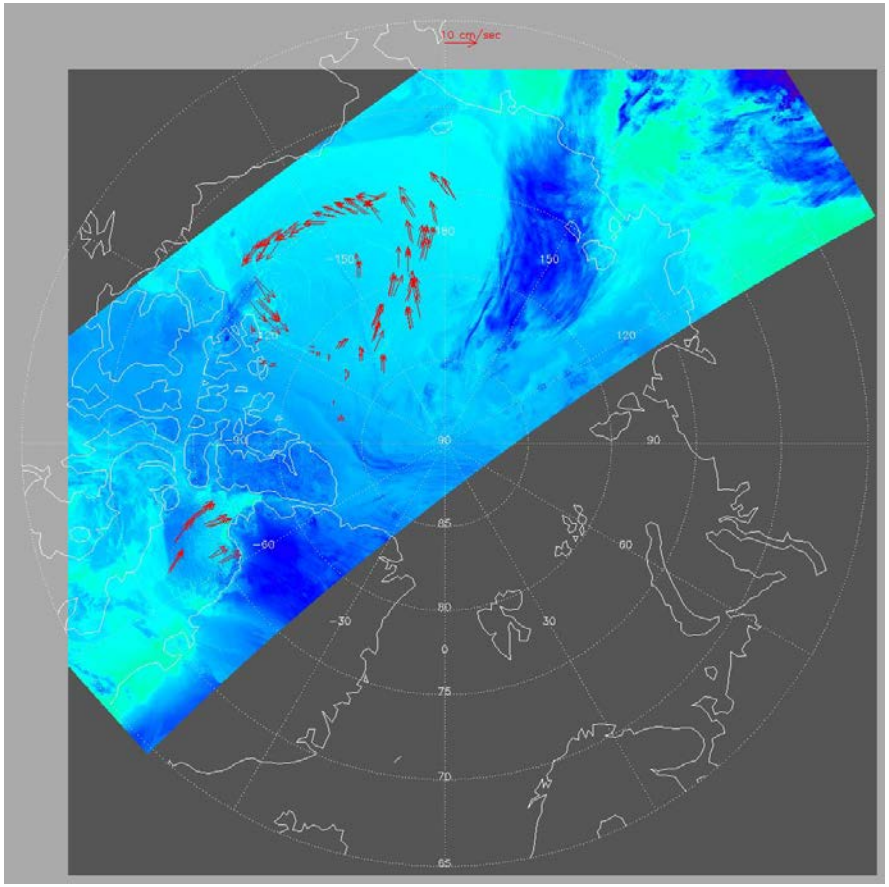
Categories	VIIRS ice age	OTIM ice age	Difference (VIIRS-OTIM)
Day and night time:			
Ice free	17	25	-8
New/Young ice	29	11	18
Other ice	54	64	-10
Daytime:			
Ice free	14	24	-10
New/Young ice	24	5	9
Other ice	62	71	-9
Nighttime:			
Ice free	26	29	-3
New/Young ice	50	25	25
Other ice	24	46	-22





Ice Motion

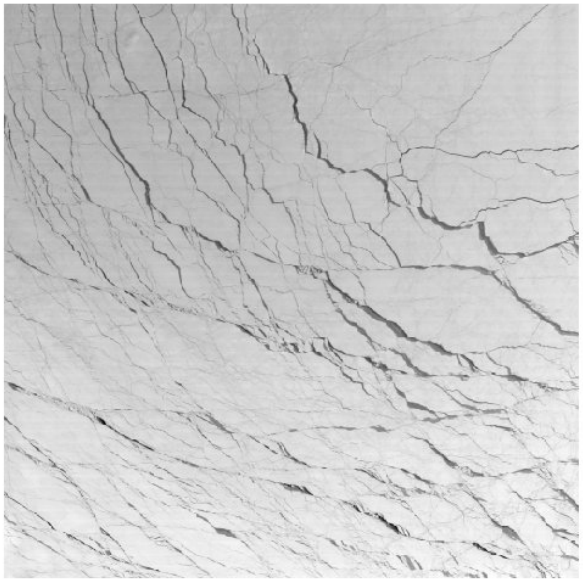


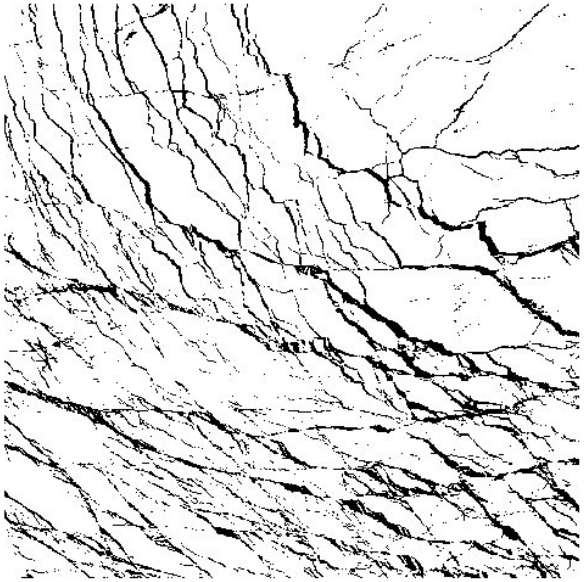


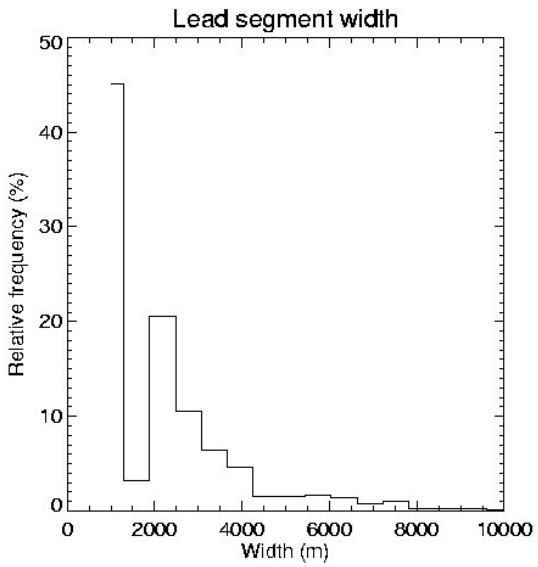
From MODIS (ideally this would be a blended microwave/vis-IR product)

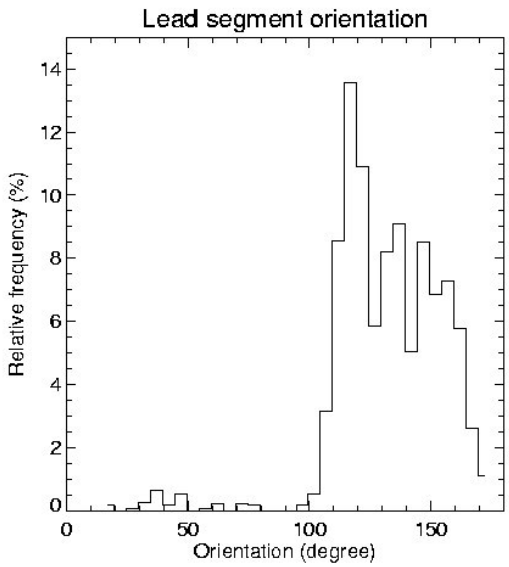
(Investigator: Yinghui Liu)

VIIRS Proving Ground Effort: Sea Ice Leads







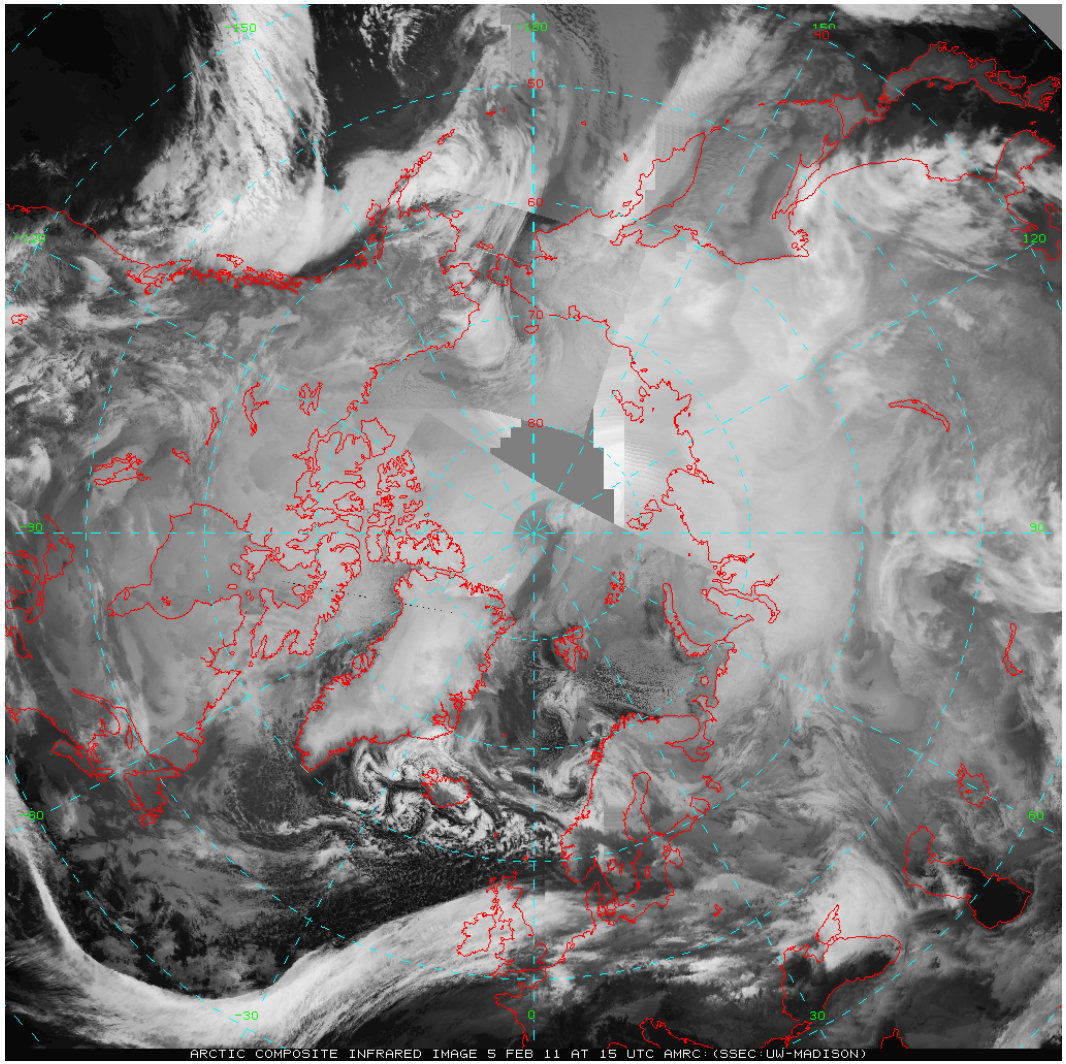


The reflectance at 0.64 μm from MODIS (upper left), mask of leads derived using group thresholds method (upper right), distributions of lead segment width (lower left), and lead segment orientation (lower right) based on the mask of leads. The scene is over the Beaufort and Chukchi Seas on March 11, 2009.

Arctic Composite Imagery

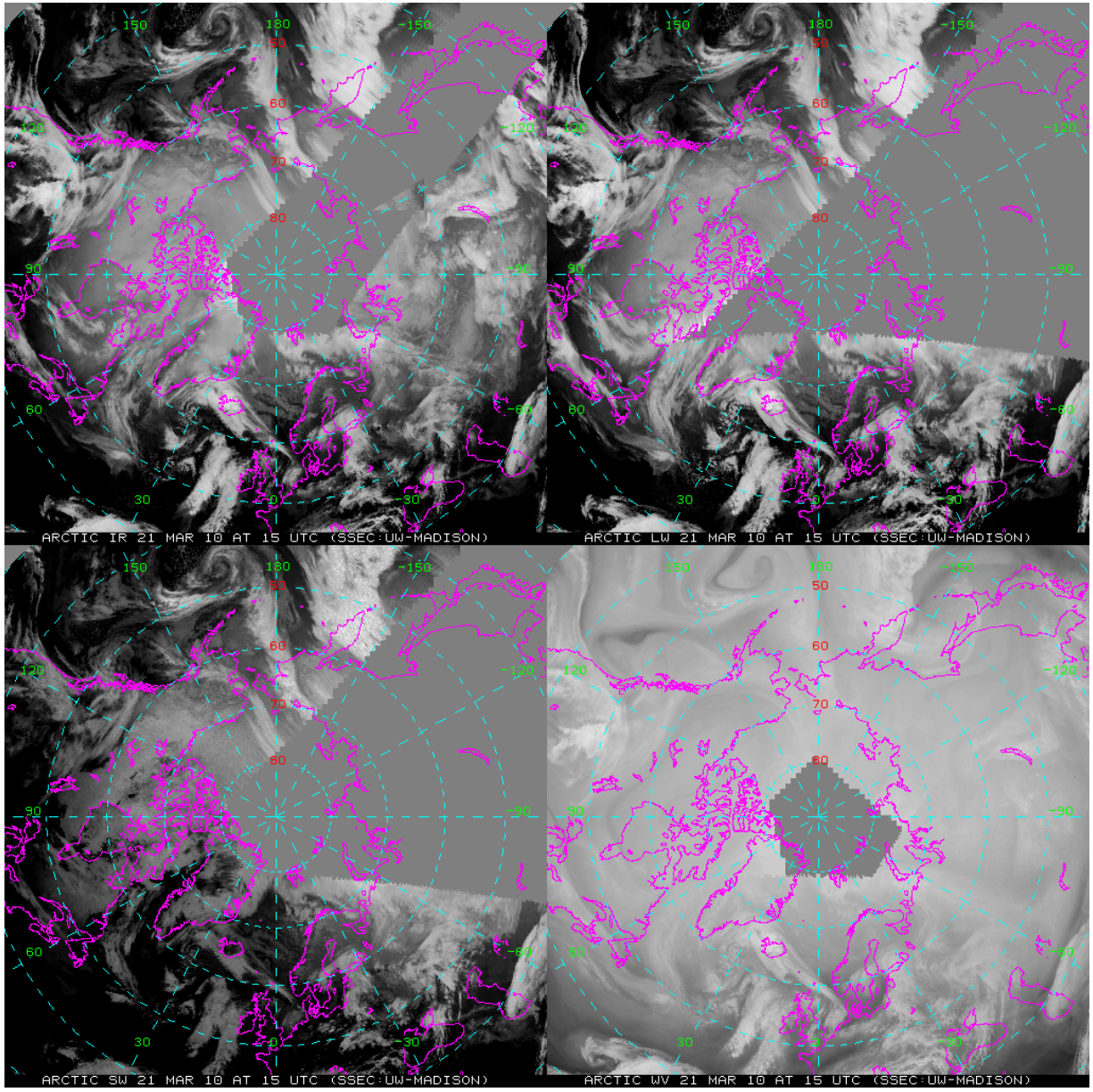
The product is an hourly mosaic of geostationary and polar-orbiting satellite data over the Arctic and Antarctic. A time series of images provides for animations, which can be used to examine the evolution of weather phenomena.

Arctic composites are currently generated with GOES, Meteosat, MTSAT, FY-2; NOAA, Aqua/Terra, Metop-A, and Metop-B. S-NPP will be added soon.



(animation)

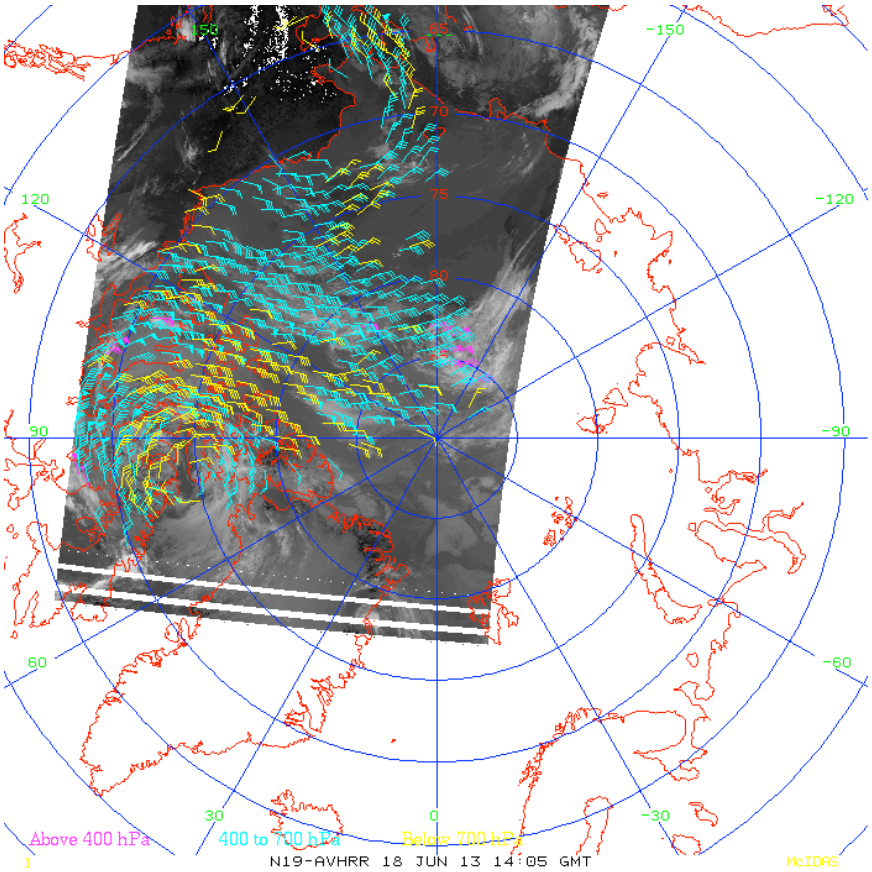
Investigator: Matthew Lazzara (SSEC)



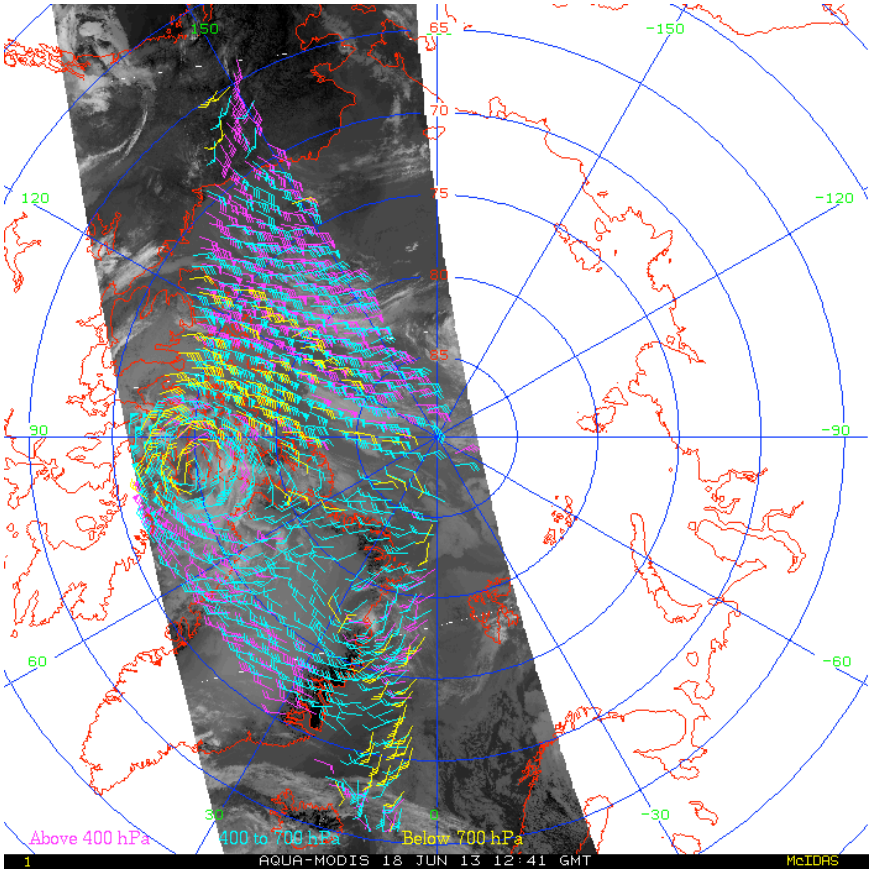
Output Channels	
Visible	~0.65 **µm**
Shortwave Infrared	~3.8 **µm**
Water Vapor	~6.7 **µm**
Infrared Window	~11.0 **µm**
Longwave Infrared	12.0 **µm**

(not all are shown)

Polar Winds



AVHRR winds from Barrow

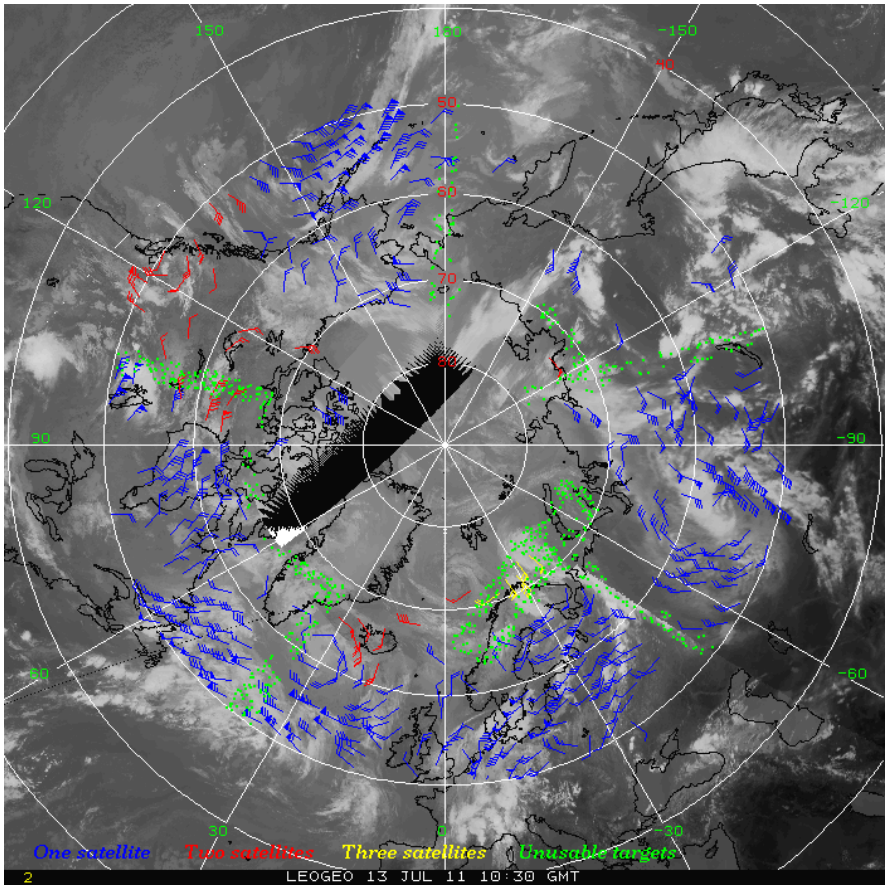


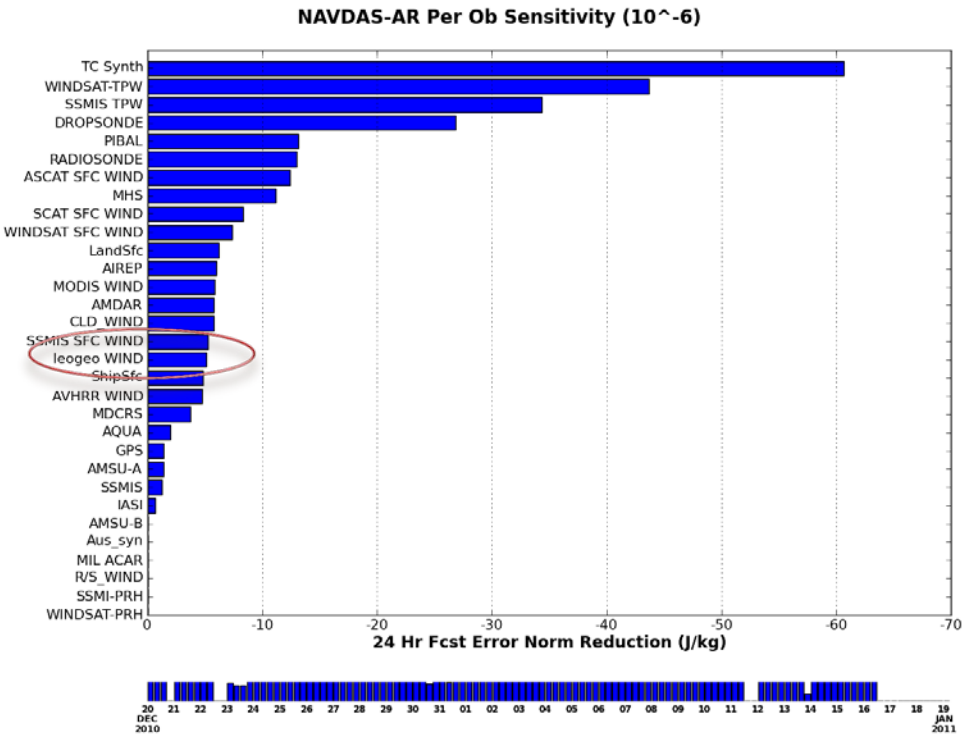
Terra MODIS winds

Polar winds products are from AVHRR (NOAA-15, -16, -18, -19, Metop-A, Metop-B), MODIS (Terra, Aqua, Terra+Aqua), LEO-GEO. Direct broadcast from NOAA AVHRR and MODIS.

LEO-GEO Polar Winds

A combined polar-orbiting and geostationary polar winds product has been developed in the GOES-R Risk Reduction program.





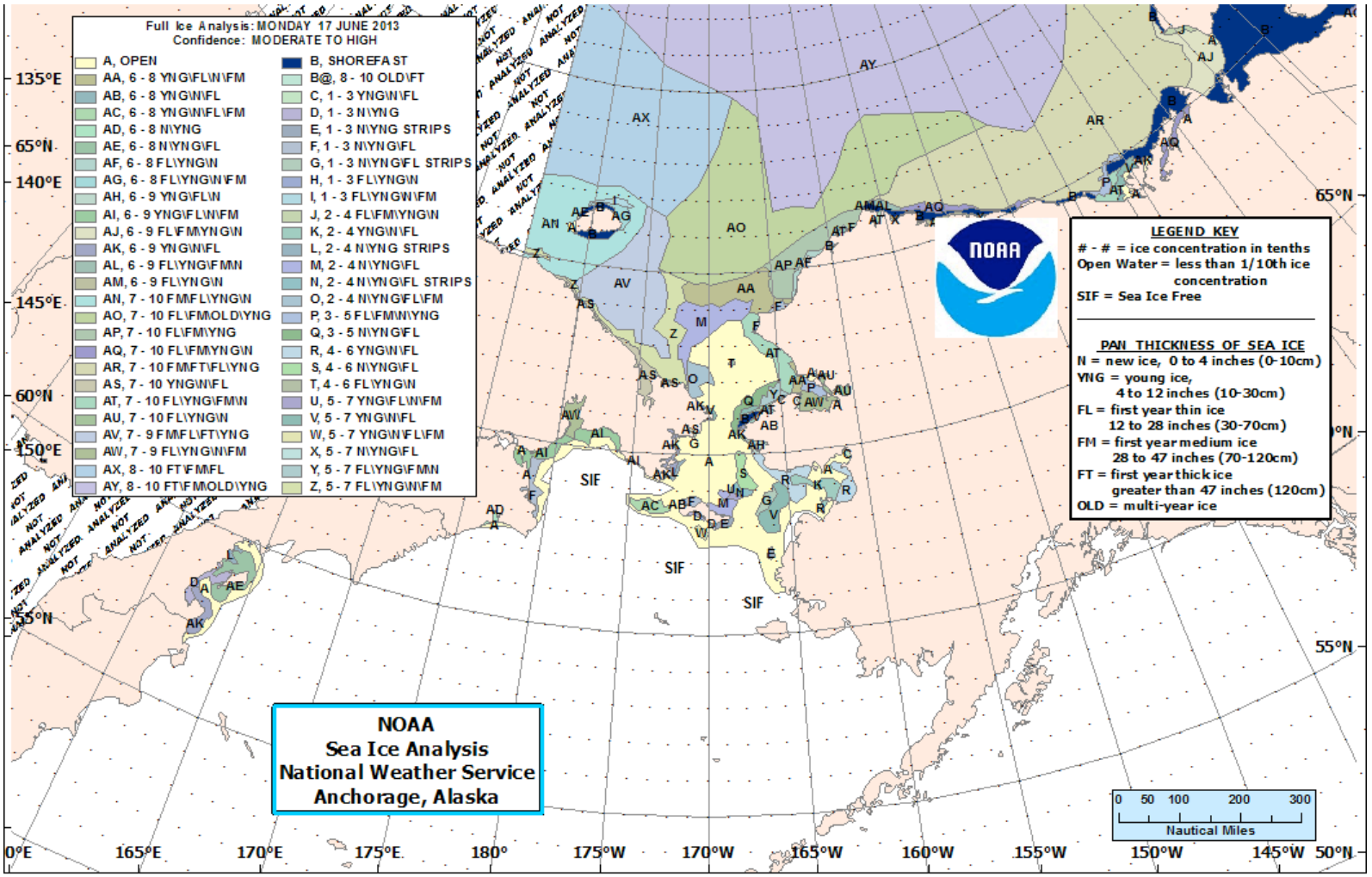
24-hr forecast error reduction in the FNMOC model for various observation types. The reduction in error resulting from the incorporation of the LEO-GEO wind product is circled. This wind product will be incorporated into FNMOC's operational system after further testing.

Investigators: Matthew Lazzara – PI (SSEC), Dave Santek (CIMSS), Chris Velden (CIMSS), Jeff Key (STAR), Randy Pauley (FNMOC)

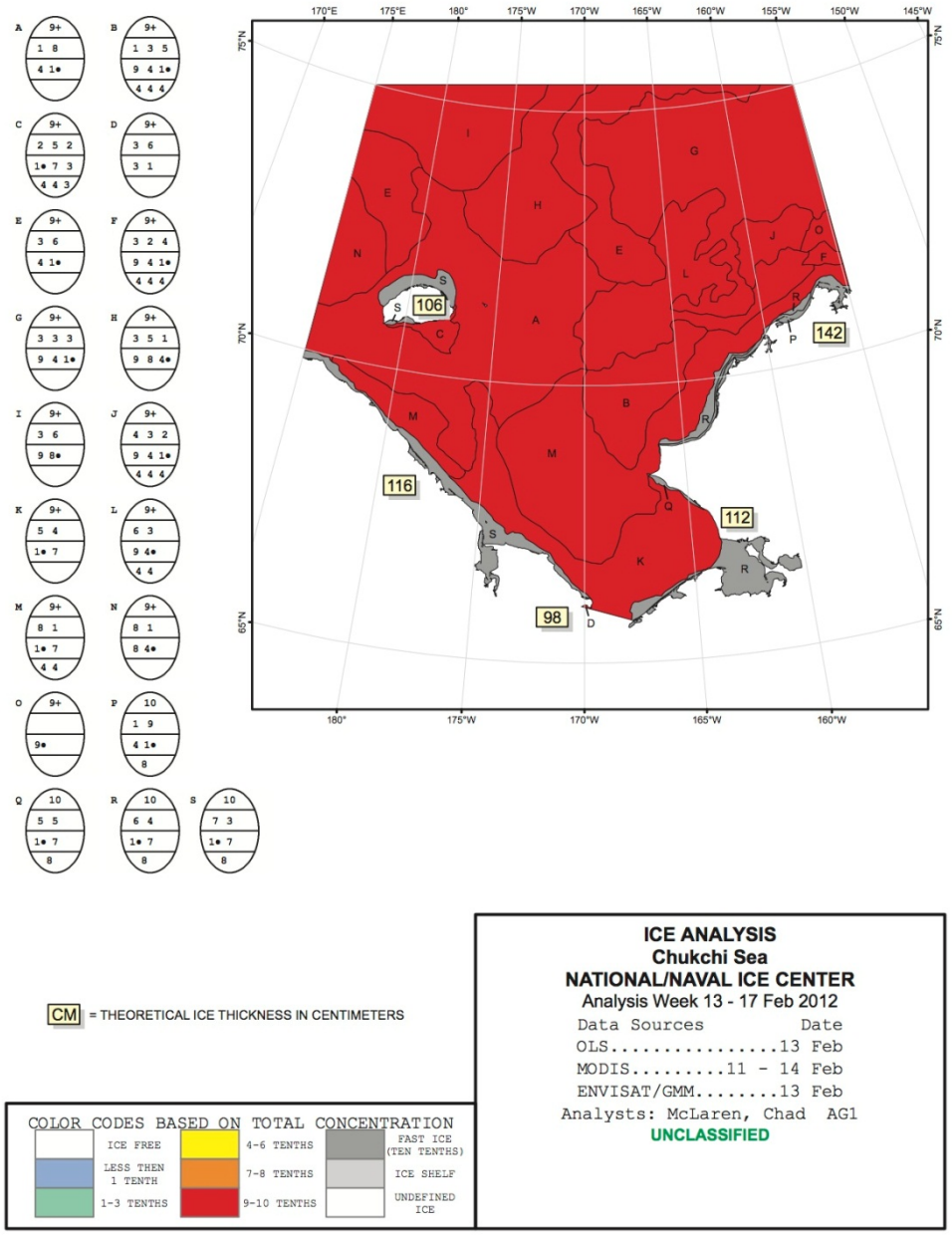
Uses and Users

- Numerical Weather Prediction (NWP centers)
  - Snow and ice cover are commonly used.
  - Ice thickness is used in some applications; should be used universally!
- Navigation and Transportation (National Ice Center, Navy, USCG, Alaska Ice Desk, local services)
  - Shipping, national security
  - Highway, railroad, municipal, and commercial snow removal services
- Hydrologic Modeling (NOHRSC, local services)
  - River flood forecasters – the protection of life, property, and commerce
  - Emergency managers and responders
  - Water supply forecasters
  - Soil moisture forecasters and agriculture, forestry, and wildfire managers
  - Recreation industry
- Climate Modeling, Monitoring, and Analysis

Sea ice analysis from the Alaska Ice Desk (NWS)



Ice chart from the National Ice Center



Status and Usage Notes

Product	Status/Usage Notes	Application
VIIRS binary snow map	Good, but use “confidently clear” pixels only	Hydrology, model assimilation
VIIRS snow fraction (2x2 pixel average of binary snow map)	Limited utility because there only 5 possible values (0, 25, 50, 75, 100%)	---
VIIRS ice surface temperature	Meets requirement (or nearly so)	Model verification, other?
VIIRS ice concentration	Good	Ice analysis
VIIRS ice characterization	Daytime ok, nighttime not. Use ice thickness instead.	Ice analysis
AVHRR, MODIS, VIIRS ice thickness	AVHRR available; others coming soon	Ice analysis
AMSR2 snow and ice	Coming soon	Ice analysis, hydrology, model assimilation
Polar winds (various satellites)	Used by 13 NWP centers in 9 countries	Model assimilation
Arctic composite imagery	Available now; operational later	Visual applications

Global Cryosphere Watch

Global Cryosphere Watch

WMO OMM

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Highlights

GCW held its first CryoNet workshop to define its surface observing network.

Participants are helping define measurement standards and practices, measurement types, and requirements for station inclusion in CryoNet.

(Photograph courtesy of FMI)

First CryoNet Workshop, Vienna, Nov 2012

Cryosphere In the News

How does internal variability influence the ability of CMIP5 models to reproduce the recent trend in Southern Ocean sea ice extent?
2013-03-12
the-cryosphere.net

Brief communication "The aerophotogrammetric map of Greenland ice masses"
2013-03-11
the-cryosphere.net

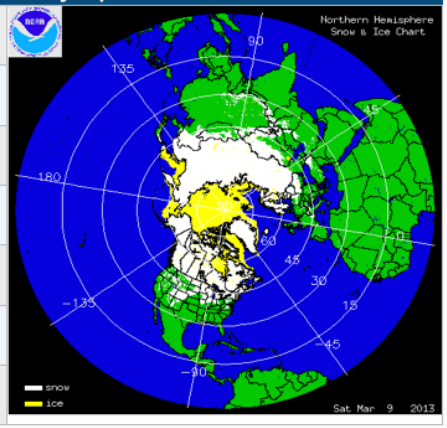
Sea ice dynamics influence halogen deposition to Svalbard
2013-03-08
the-cryosphere-discuss.net

Data assimilation and prognostic whole ice-sheet modelling with the variationally derived, higher-order, open source, and fully parallel ice sheet model VarGlaS
2013-03-08
the-cryosphere-discuss.net

More Cryosphere in the News »

The Cryosphere Now

- Sea and Freshwater Ice
- Snow
- Glaciers & Ice Caps
- Ice Sheets
- Permafrost
- Atmosphere
- Satellite Products



GCW News and Activities

Third Meeting of the WMO Polar Space Task Group, 22-23 May 2013, Paris, France

Fourth Meeting of the WMO Panel on Polar Observations, Research, and Services, 13-15 March 2013, Lanzhou, China

The GCW Implementation Plan is now available.

First Snow Watch Workshop lays the groundwork for assessing current snow products and providing new services.

First CryoNet Workshop helps define the path forward for the GCW surface observation network.

GCW News | Meetings | Calendar »

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globalcryospherewatch.org