

New Generation Weather Satellite Readiness: Marine and Arctic Applications



Jordan Gerth, Cooperative Institute for Meteorological Satellite Studies

Contributors

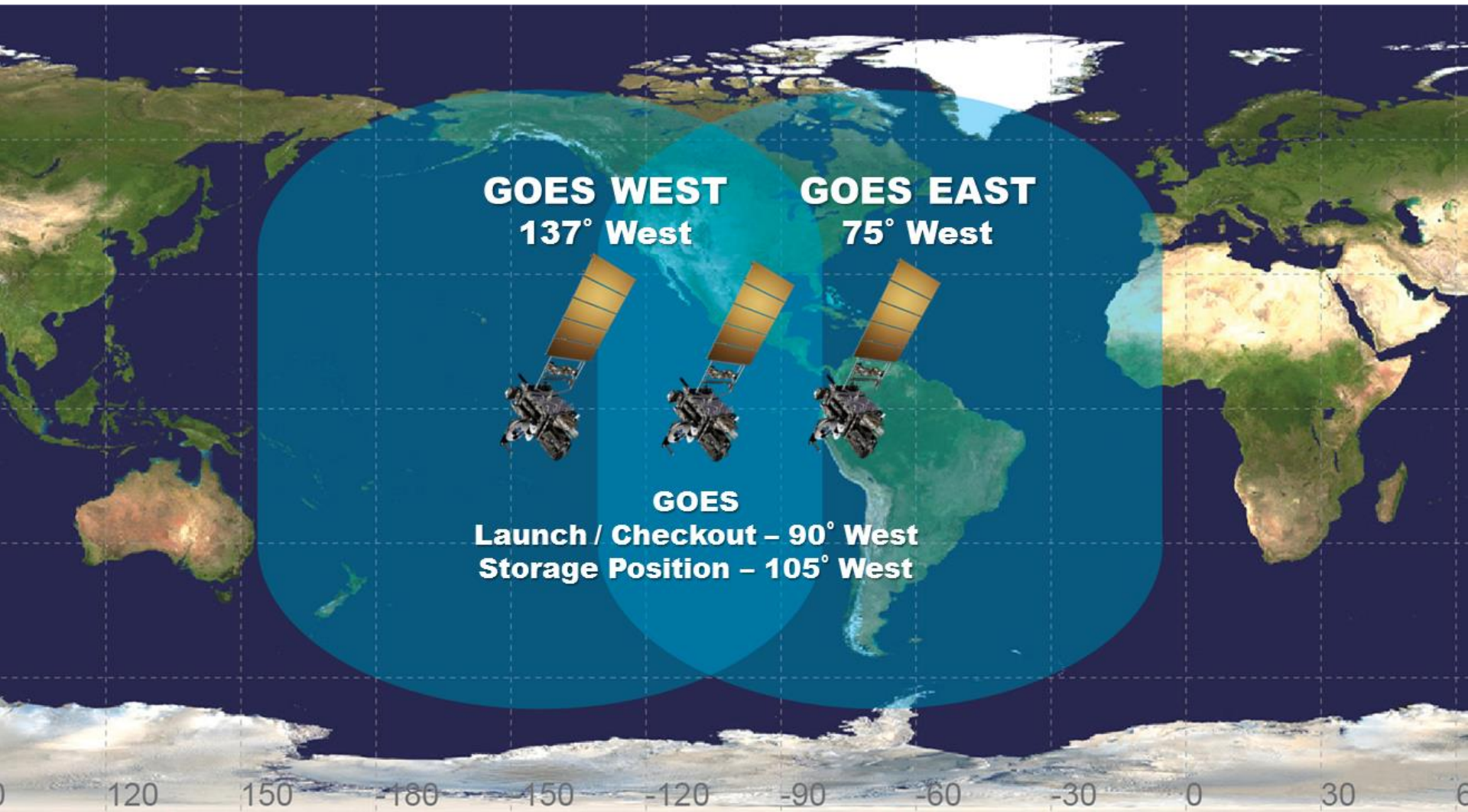


- CIMSS Satellite Blog
 - Scott Bachmeier
 - Scott Lindstrom
 - <http://cimss.ssec.wisc.edu/goes/blog/>
- Tim Schmit (NOAA)
- Jeffrey Key (NOAA)

Upcoming GOES-R/S Launch

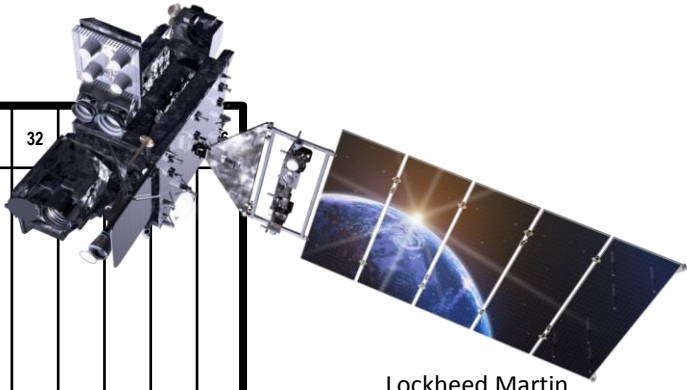
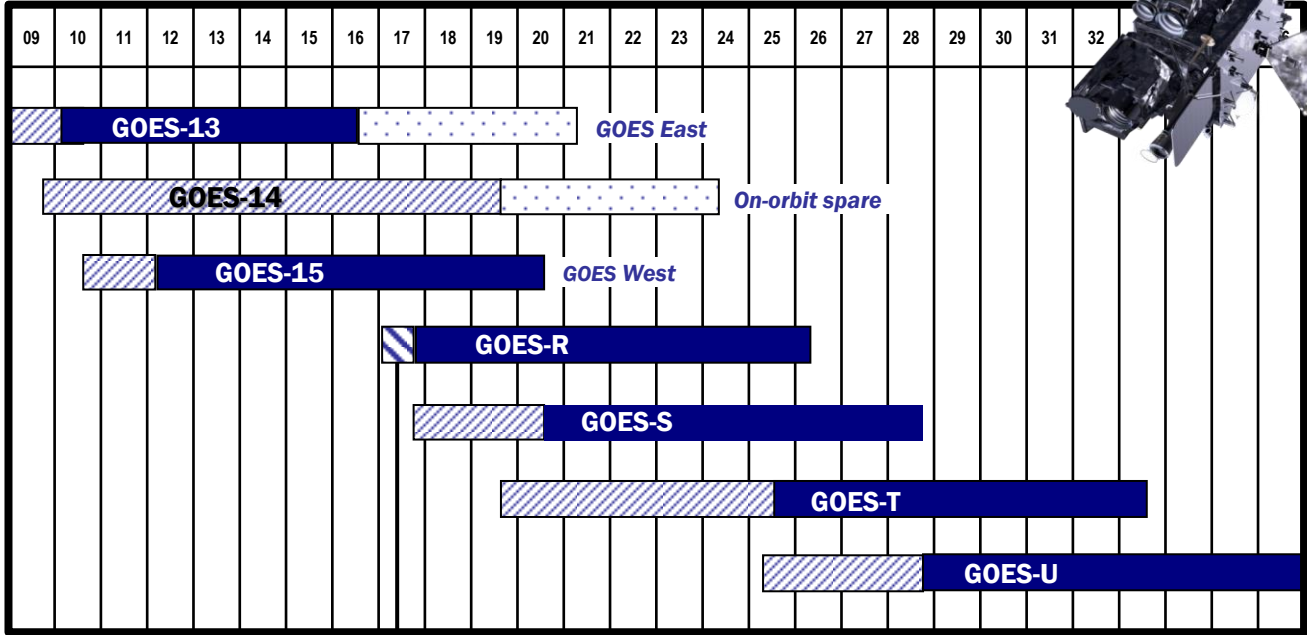
- GOES-R is tentatively scheduled to launch on October 13, 2016, in Cape Canaveral, Florida
- GOES-S will launch approximately one year after GOES-R
- GOES-R post-launch testing will occur with the satellite at 89.5 degrees West
 - GOES-R will be there for approximately one year
- Operational location of GOES-R will depend on NWS priorities and the health of the existing GOES satellites

Future GOES-R/S Constellation



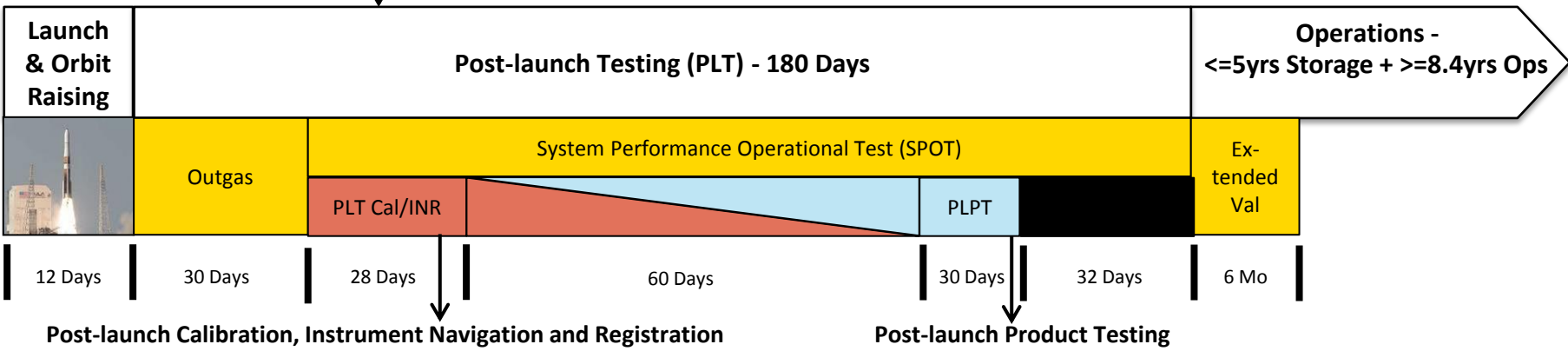
Continuity of GOES through 2036

Fiscal Year



Lockheed Martin

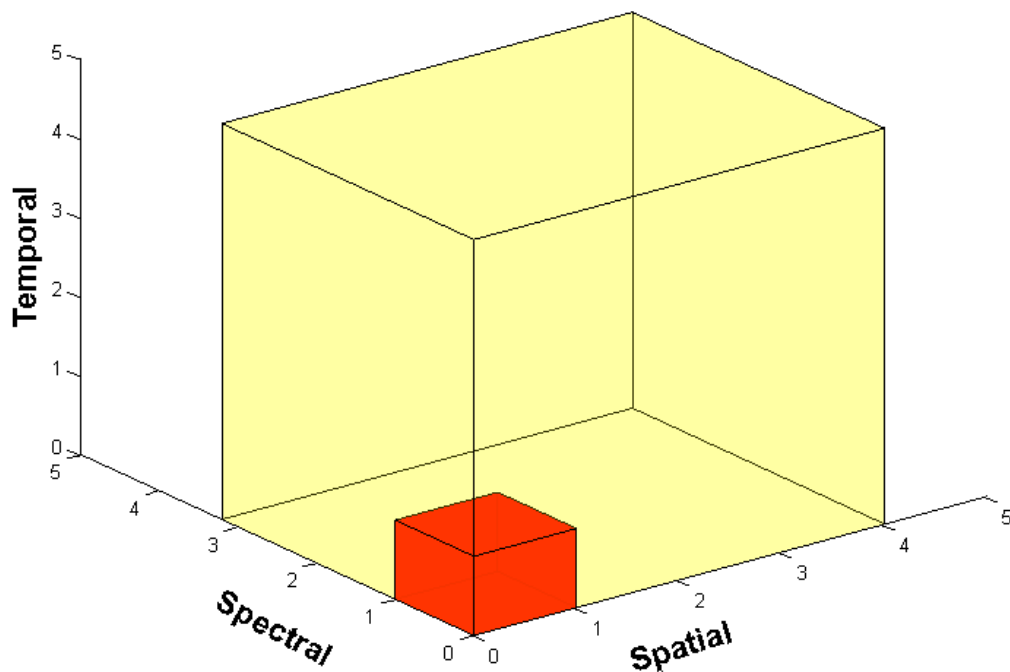
	On-orbit storage
	Test & Checkout
	Operational
	Fuel-Limited Lifetime



Post-launch Calibration, Instrument Navigation and Registration

Post-launch Product Testing

Advanced Baseline Imager (ABI)



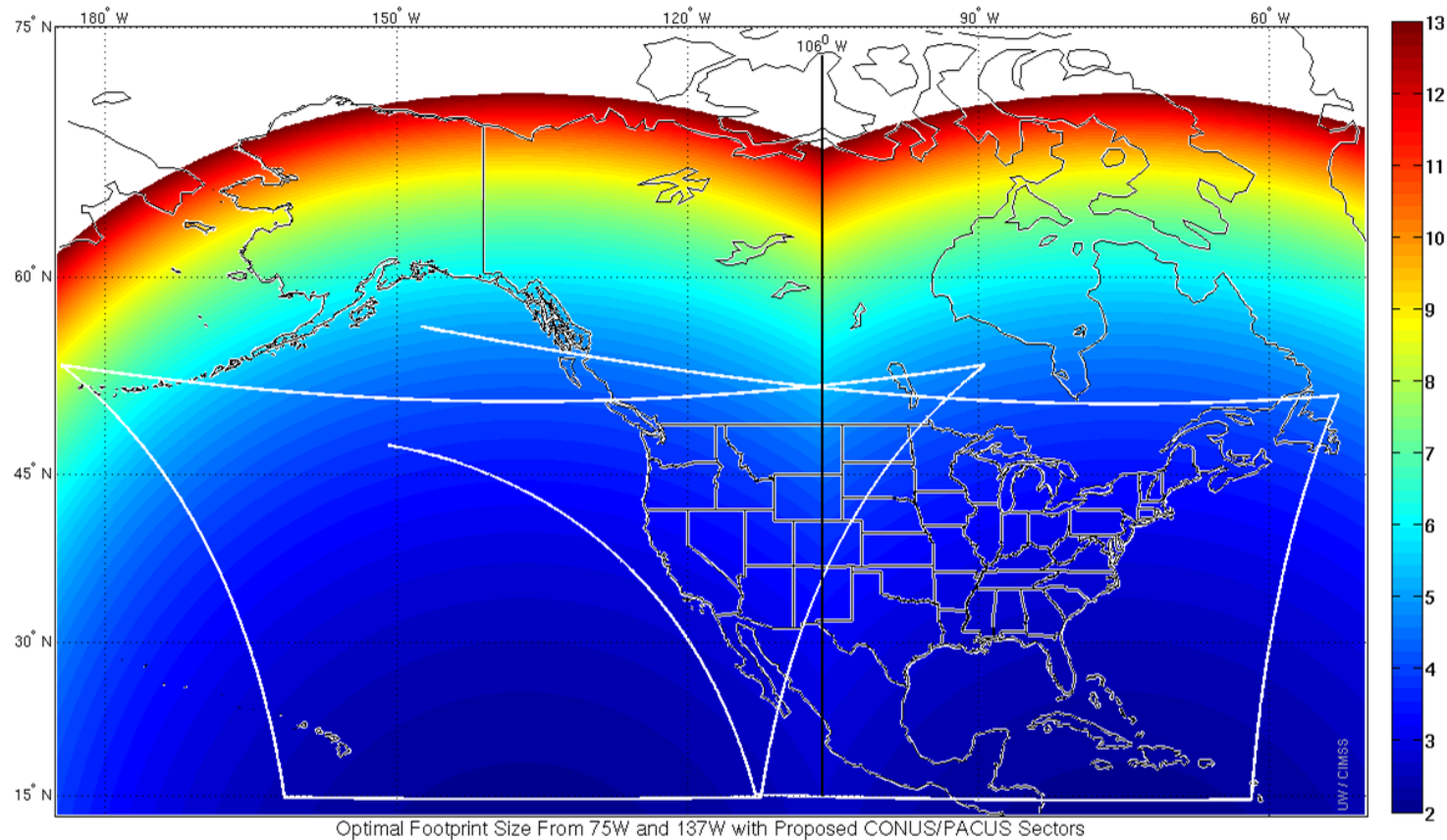
5x
Faster scanning
(5-minute full disk
vs. 25-minute)

4x
Improved spatial
resolution (2 km IR
vs. 4 km)

NOAA/NESDIS ASPB

3x
More spectral bands
(16 on ABI vs. 5)

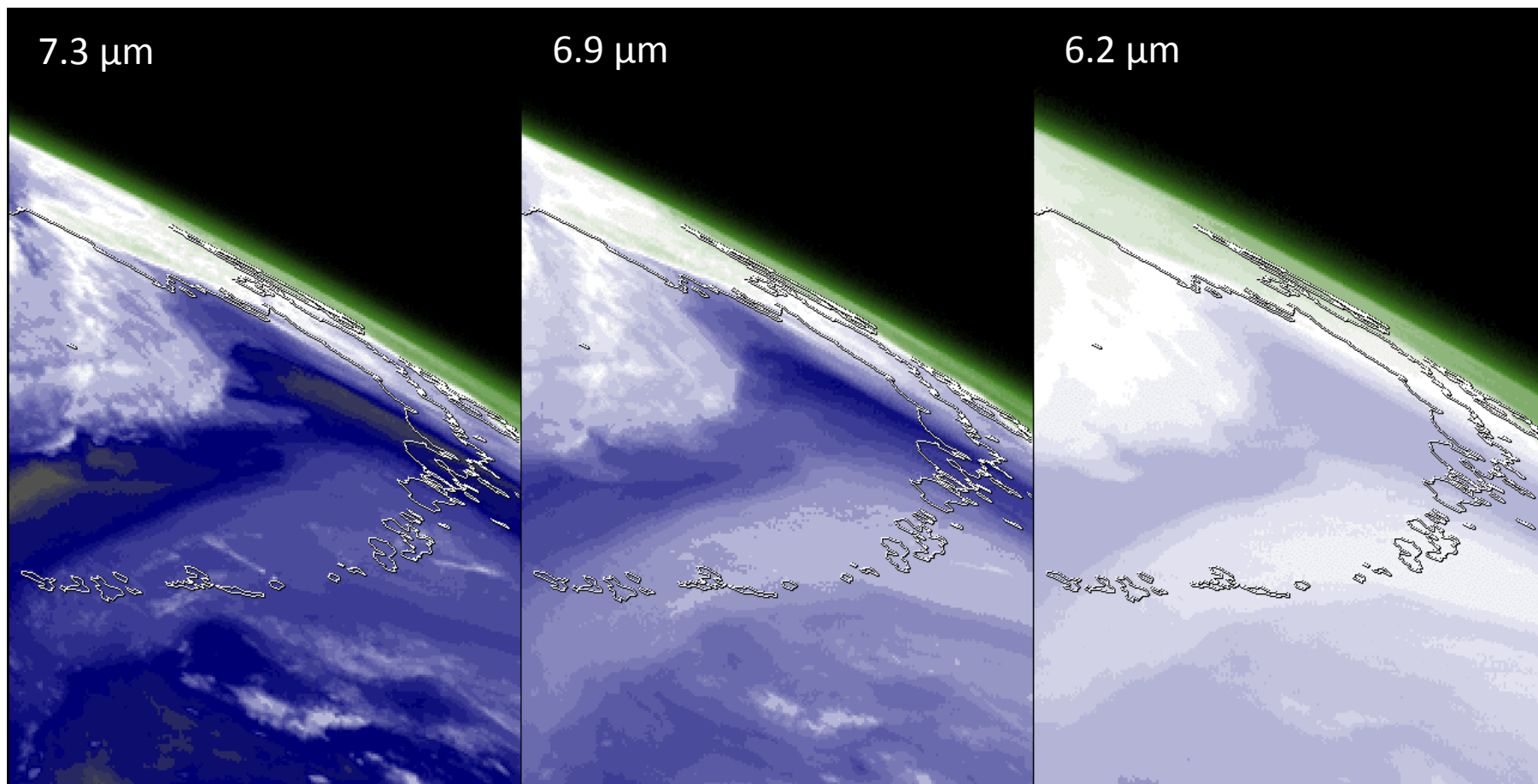
Improved Spatial Resolution



Highest infrared window spatial resolution from two GOES-R series satellite constellation

List of ABI Spectral Bands

ABI Band	Wavelength (μm)	Wavelength range (μm)	Sub-point pixel spacing (km)	Descriptive Name
1	0.47	0.45 - 0.49	1	"Blue"
2	0.64	0.60 - 0.68	0.5	"Red"
3	0.864	0.847 - 0.882	1	"Veggie"
4	1.373	1.366 - 1.380	2	"Cirrus"
5	1.61	1.59 - 1.63	1	"Snow/Ice"
6	2.24	2.22 - 2.27	2	"Cloud Particle Size"
7	3.90	3.80 - 3.99	2	"Shortwave window"
8	6.19	5.79 - 6.59	2	"Upper-level Water Vapor"
9	6.93	6.72 - 7.14	2	"Mid-Level Water Vapor"
10	7.34	7.24 - 7.43	2	"Lower/Mid-level Water Vapor"
11	8.44	8.23 - 8.66	2	"Cloud-top Phase"
12	9.61	9.42 - 9.80	2	"Ozone"
13	10.33	10.18 - 10.48	2	"Clean longwave window"
14	11.21	10.82 - 11.60	2	"Longwave window"
15	12.29	11.83 - 12.75	2	"Dirty longwave window"
16	13.28	12.99 - 13.56	2	"CO ₂ "



Himawari-8 view of Mount Pavlof eruption

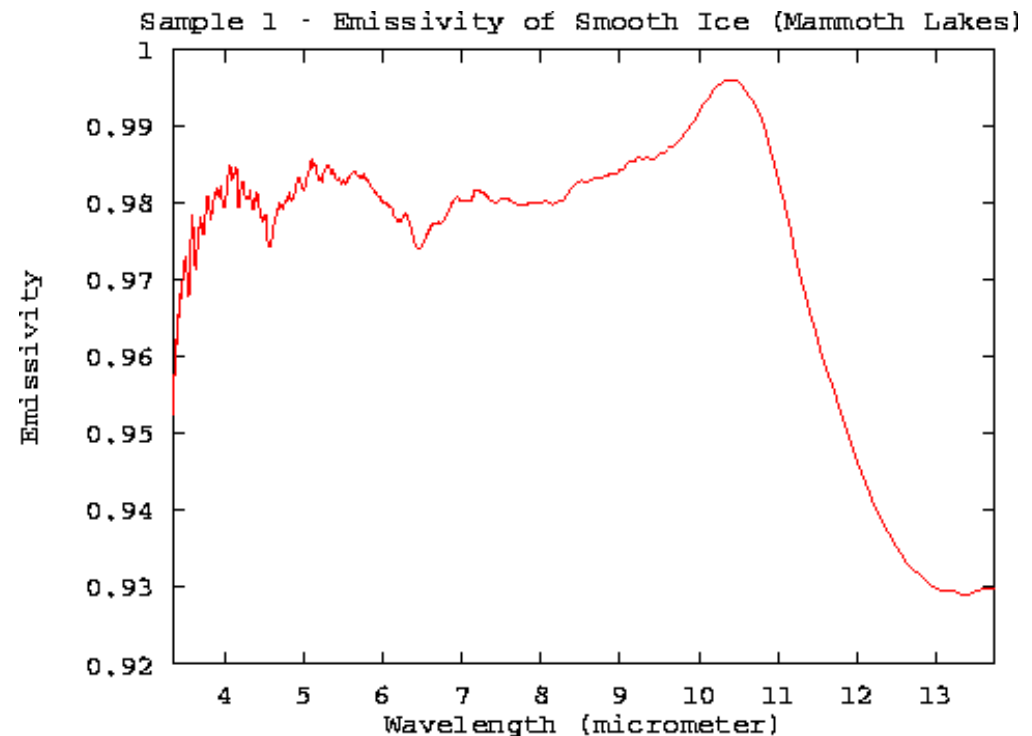
Alaska Peninsula, 28 March 2016, Starting 0:00 UTC

Source: CIMSS Satellite Blog (<http://cimss.ssec.wisc.edu/goes/blog/>)

ABI Bands of Interest to Marine and Arctic Weather Community

- Reflectance: ABI Bands 2, 3, and 5
- Brightness Temperature: ABI Bands 14 and 15

New ABI bands collectively enable better discrimination between land, sea, ice, water cloud, and ice cloud.



ABI and AHI Band Fact Sheets



GOES-R ABI Fact Sheet Band 1 ("Blue")

The "need to know" Advanced Baseline Imager reference guide for the NWS forecaster



Above: Simulated image of ABI Band 1 for Hurricane Katrina. This image was simulated via a combination of high spatial resolution numerical model runs and advanced "forward" radiative transfer models. (Credit: CIMSS)

The 0.47 μm , or "blue" band, one of the two visible bands on the Himawari-8 for monitoring aerosols. Included on NASA's GOES-R series, there are a number of well-established blue μm band will provide nearly continuous day clouds. Measurements of aerosol optical depth and tracking. This blue band, combined with other bands and/or sensors) and a "red" natural color" imagery of the Earth. Measure estimates of visibility. The 0.47 μm band will improve numerous products that rely on clear sky products. Other potential uses are related to a natural "true color" RGB. See the *Weather Event Simulator (WES) Guide by CIMSS*.

In a nutshell

GOES-R ABI Band 1 (0.47 μm central, 0.45 μm to 0.49 μm)

Also Himawari-8/9 AHI Band 1, Suomi NPP VIIRS Band M2

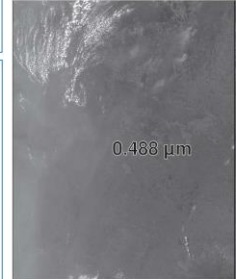
New for GOES-R Series, not available on current GOES

Nickname: "Blue" visible band

Availability: Daytime only

Primary purpose: Aerosols

Uses similar to: GOES-R ABI Band 2



Suomi NPP images of similar blue (left-hand side) and red (right) appearing in the 0.488 μm band. The image is over part of South America.

Did You Know? There are two baselines in the "flex" mode that are used to monitor aerosols every minute. The second mode, continuous full disk scan every 5 minutes.



Himawari AHI Fact Sheet

The "need to know" Advanced Himawari reference guide for the NWS forecaster



The next-generation geostationary meteorological satellite of the Japan Meteorological Agency, Himawari-8, was successfully launched on October 7, 2014 from the Tanegashima Space Center in Kagoshima, Japan. Photo and caption source: Japan Meteorological Agency.

The 0.51 μm , or "green" band, is visible bands on the Himawari-8. The longitude for Himawari-8 is 140 degrees East. The Japan Meteorological Agency launched this satellite with the Himawari Imager (AHI) as a very similar band, 0.55 μm band, is used for monitoring aerosols. This band will provide information related to the land, sea, and atmosphere. This green band, combined with other bands, provides a "natural color" image of the Earth. This band is used for air pollution monitoring.

In a nutshell

Himawari AHI Band 2 (0.51 μm central, 0.50 μm to 0.53 μm)

Also similar to the Suomi NPP VIIRS Band M4

Not available on current GOES or with the GOES-R series ABI

Nickname: "Green" visible band

Availability: Daytime only

Primary purpose: Solar Insolation estimates

Uses similar to: GOES-R ABI Band 1, Band 2



Suomi NPP image of a similar green band, which is a key component of the natural color image from CIMSS.

Did You Know? The 0.51 μm band, which is a key component of the natural color image from CIMSS.



GOES-R ABI Fact Sheet Band 2 ("Red" visible)

The "need to know" Advanced Baseline Imager reference guide for the NWS forecaster



Above: Simulated image of ABI Band 2 for Hurricane Katrina. This image was simulated via a combination of high spatial resolution numerical model runs and advanced "forward" radiative transfer models. Credit: CIMSS

The second ABI visible band is the 0.6 μm (or "red" band). During the daytime, it will assist in the detection of fog, estimation of solar insolation and depiction of diurnal aspects of clouds. It is called the red band because the center frequency of this band is near the red part of the visible spectrum. The 0.6 μm visible band is also used for daytime snow and ice cover, detection of severe weather, low-level cloud-drift winds, smoke, volcanic ash, hurricane analysis, and winter storm analysis. A similar band on the current GOES imager has demonstrated many of these applications, although the ABI will offer improved spatial and temporal resolutions. This band is essential for a natural color RGB. Since there is no "green" ABI band on the GOES-R series, this band will be approximated from other spectral bands for use in generating "true color" imagery. In the case of the ABI, this approach will be a look-up table using the "blue" (0.47 μm), red (0.64 μm) and "veggie" (0.86 μm) bands. Source: Schmit et al., 2005 in BAMS, Miller et al. 2012 and the ABI Weather Event Simulator (WES) Guide by CIMSS.

In a nutshell

GOES-R ABI Band 2 (approximately: 0.64 μm central, 0.60 μm to 0.68 μm)

Also similar to the Suomi NPP VIIRS Band I1

Similar band available on current GOES imager

Nickname: "Red" visible band

Availability: Daytime only

Primary purpose: Clouds

Uses similar to: GOES-R ABI Band 1



True color with blue, synthetic green and red bands from ABI simulated data (from CIMSS). Image from Don Hillger, BAMS.

Did You Know? While many think that the visible band on the first geostationary imager on ATS-1 in December 1966 was a band centered at approximately 0.64 μm , the band on ATS-1 actually peaked at approximately 0.52 μm . The approximate resolution for this sensor was between 3 and 4 km. It was this imager that took the first full-disk Earth images from geosynchronous orbit and the first image of Earth and the moon together.



<http://www.goes-r.gov/>

State of NWS Training Efforts

- Foundational course
 - Introduction to enhanced spatial, spectral, and temporal resolution of ABI (and GLM) with general applications to common weather analysis/forecast scenarios
 - Approximately eight hours of self-paced, pre-recorded teletraining content
 - Interactive elements
 - Available in October 2016
- Specific applications
 - Many marine and arctic applications are not part of the foundational course; may be available later

Training Paradigm

Foundation

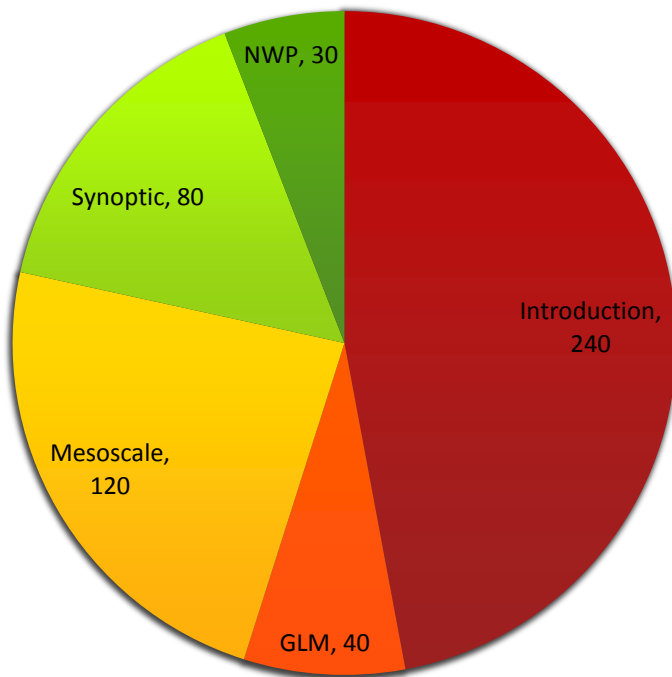
General

Specialized

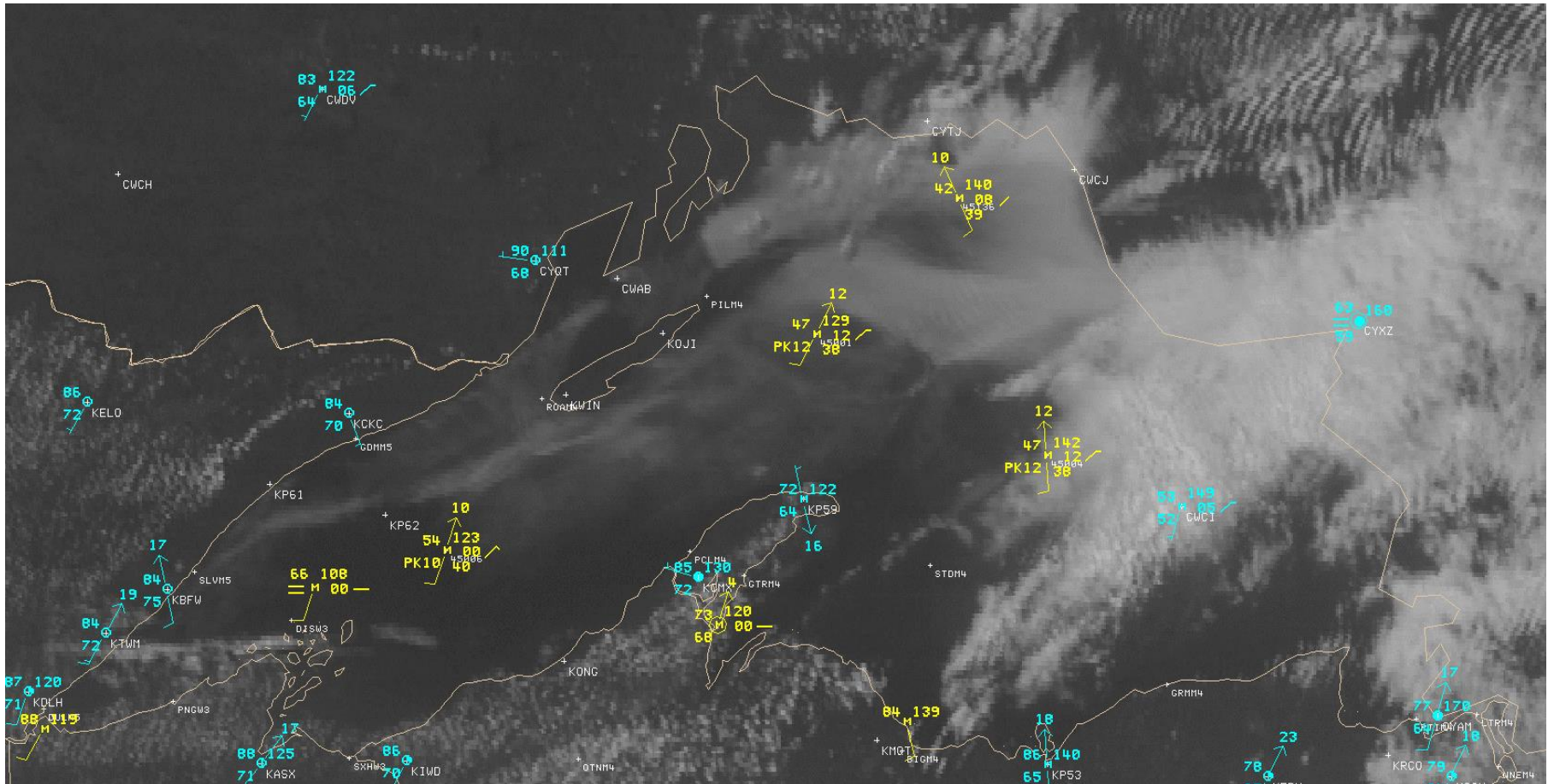


Foundational Training Distribution

for all NWS (US NMHS) meteorologists



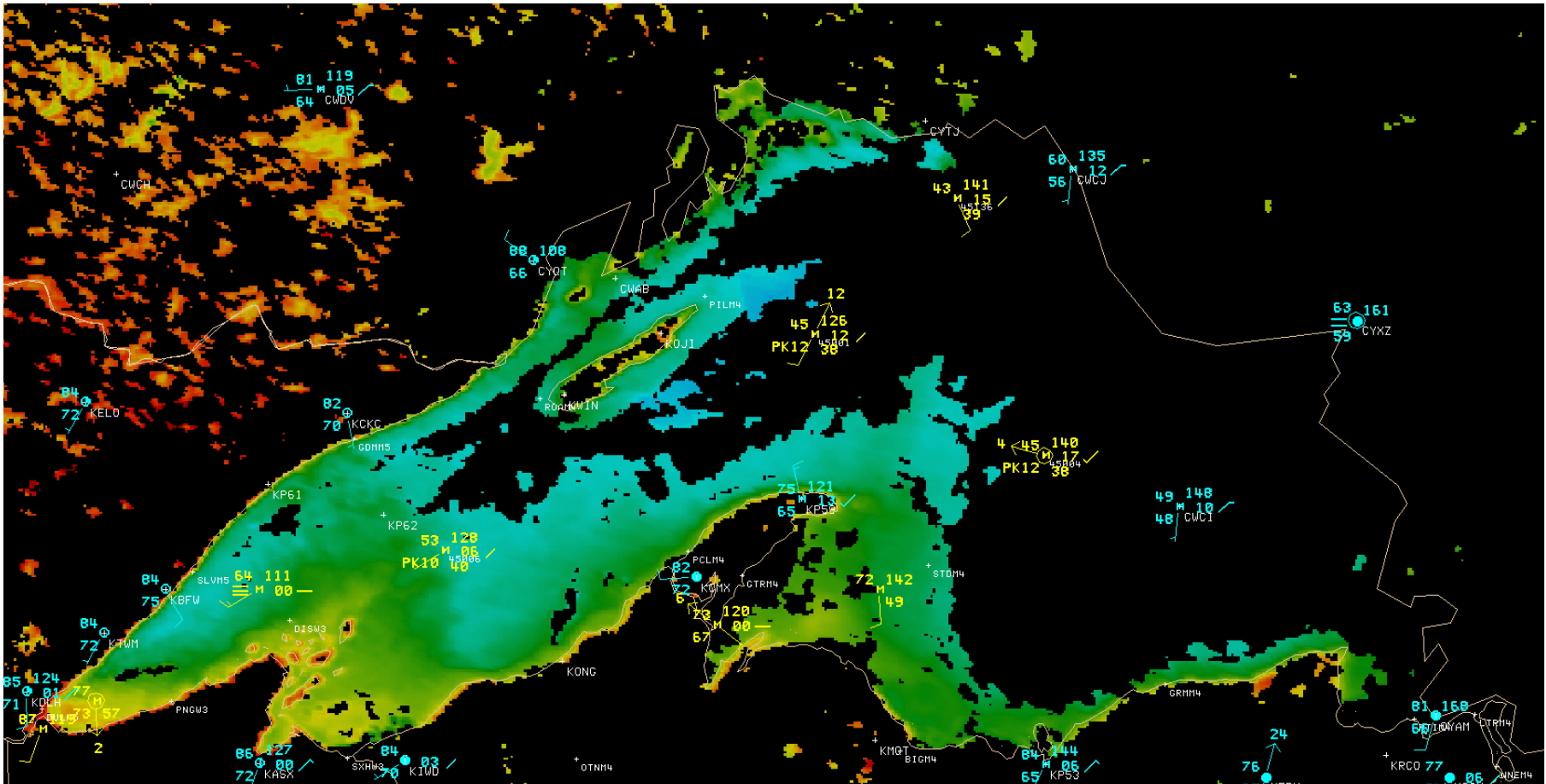
- GOES-R Introduction and SatMet Background Track (240 minutes)
- Geostationary Lightning Mapper Track (40 minutes)
- Mesoscale/Convection Track (120 minutes)
- Synoptic Scale Track (80 minutes)
- Numerical Weather Prediction and Data Assimilation Track (30 minutes)



Characterizing marine advection fog with GOES

Lake Superior, 21 July 2014, 19:00 UTC (to 1:00 UTC)

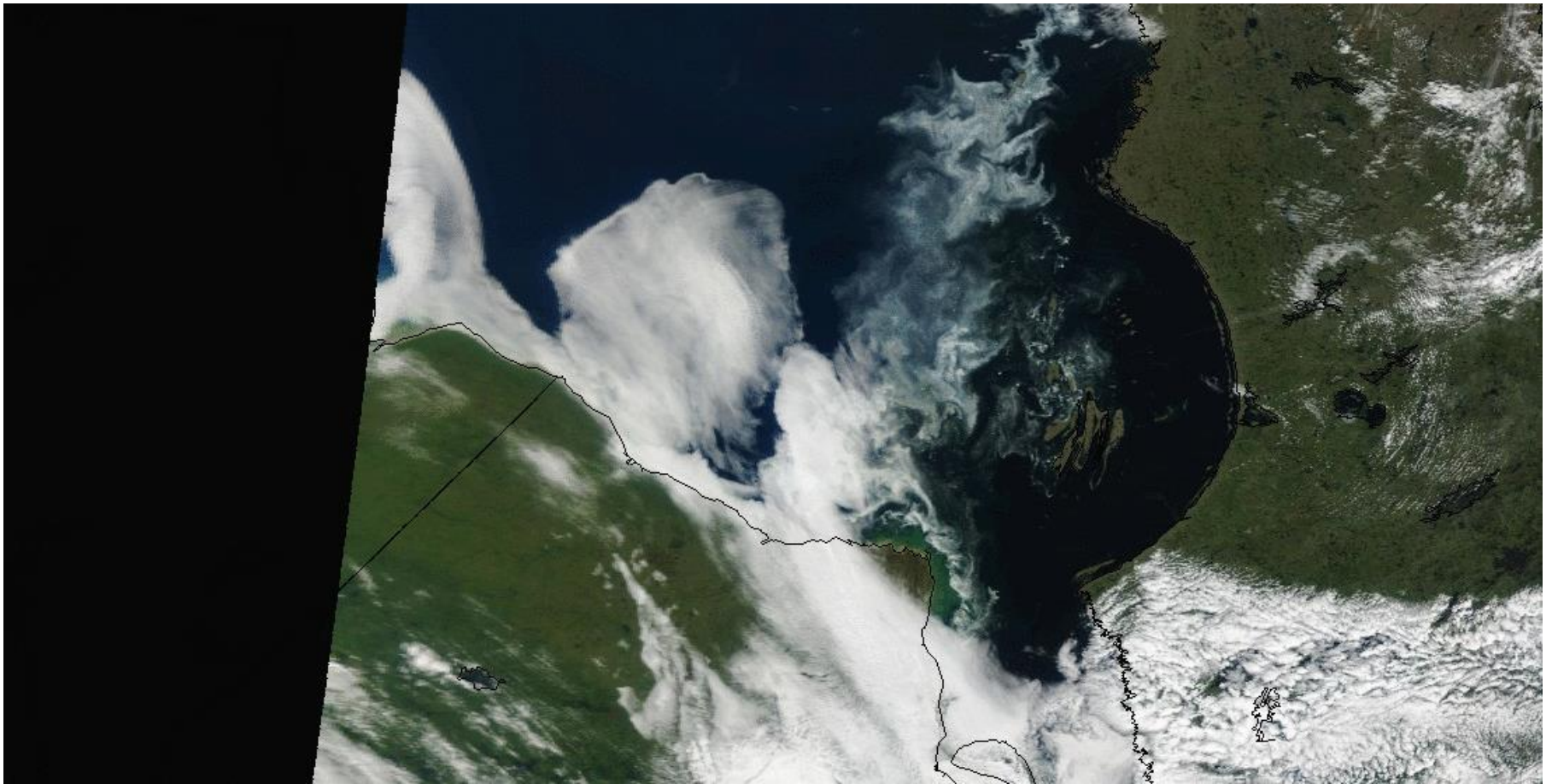
Source: CIMSS Satellite Blog (<http://cimss.ssec.wisc.edu/goes/blog/>)



Assessing fog potential with skin temperatures

MODIS, Lake Superior, 21 July 2014, 17:37 UTC

Source: CIMSS Satellite Blog (<http://cimss.ssec.wisc.edu/goes/blog/>)

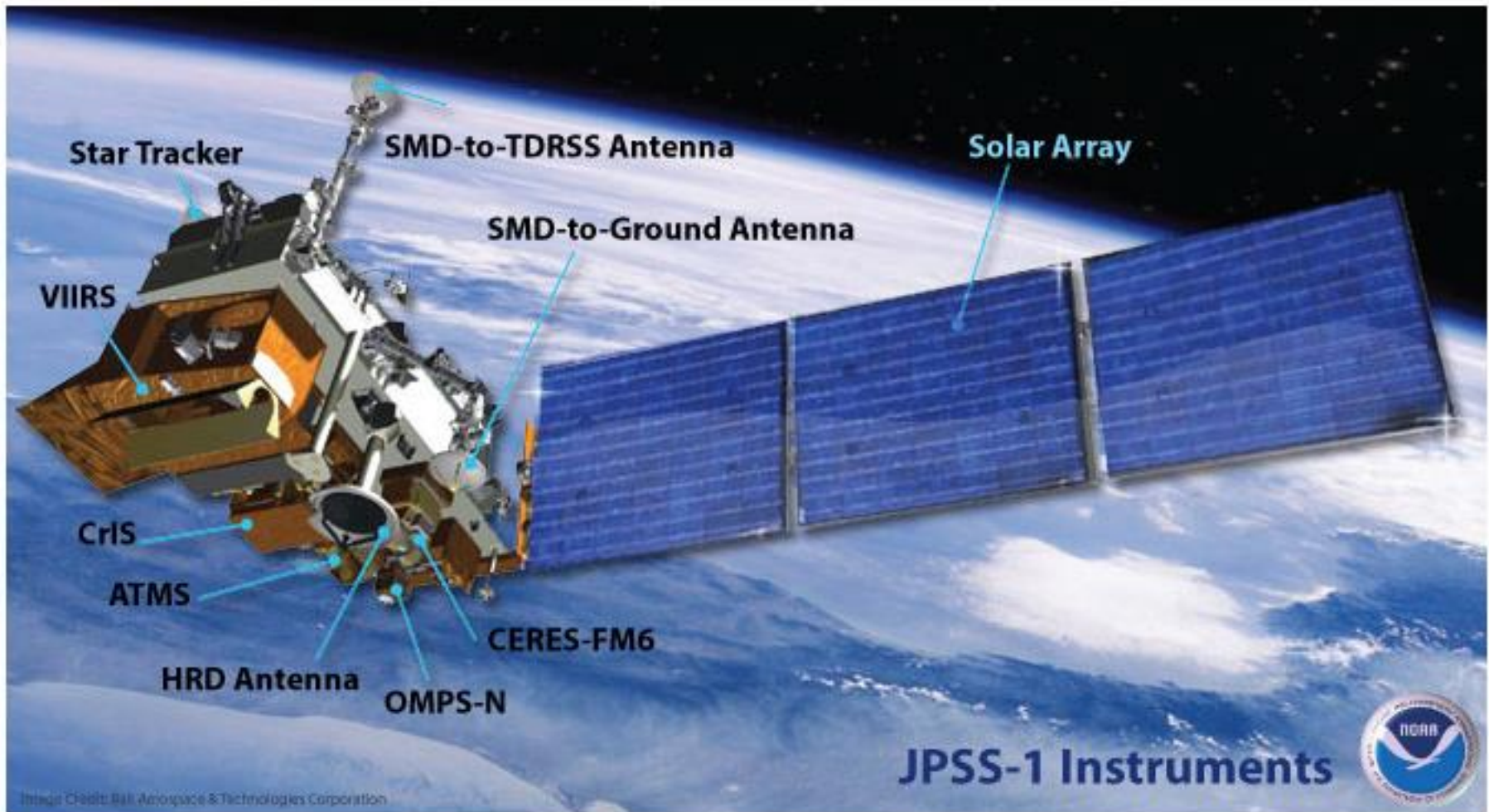


Discriminating ice from supercooled water cloud

MODIS, Hudson Bay, 7 August 2015, 16:11 UTC

Source: CIMSS Satellite Blog (<http://cimss.ssec.wisc.edu/goes/blog/>)

Joint Polar Satellite System (JPSS)



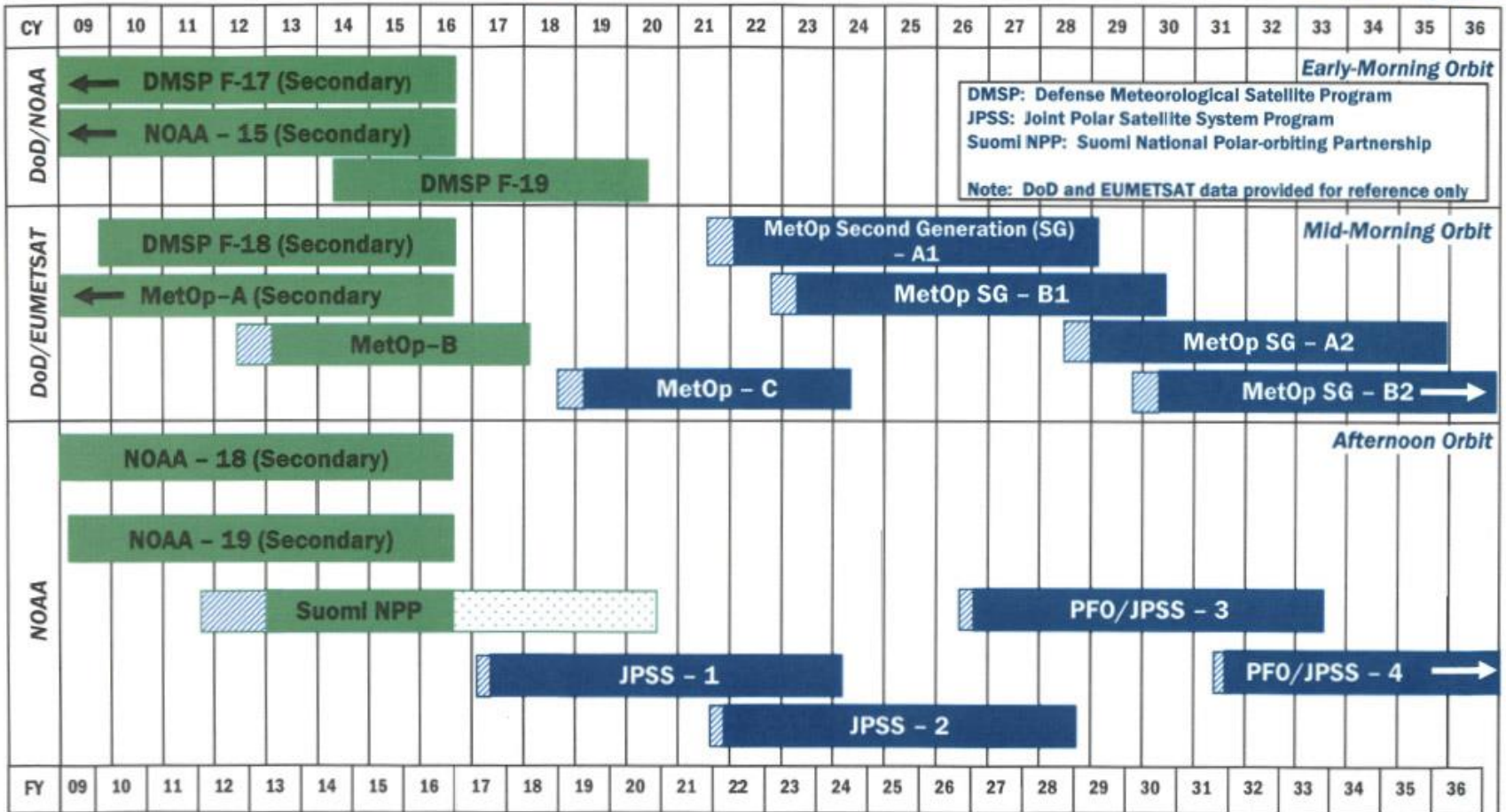


NOAA & Partner Polar Satellite Programs

Continuity of Weather Observations



As of January 2016



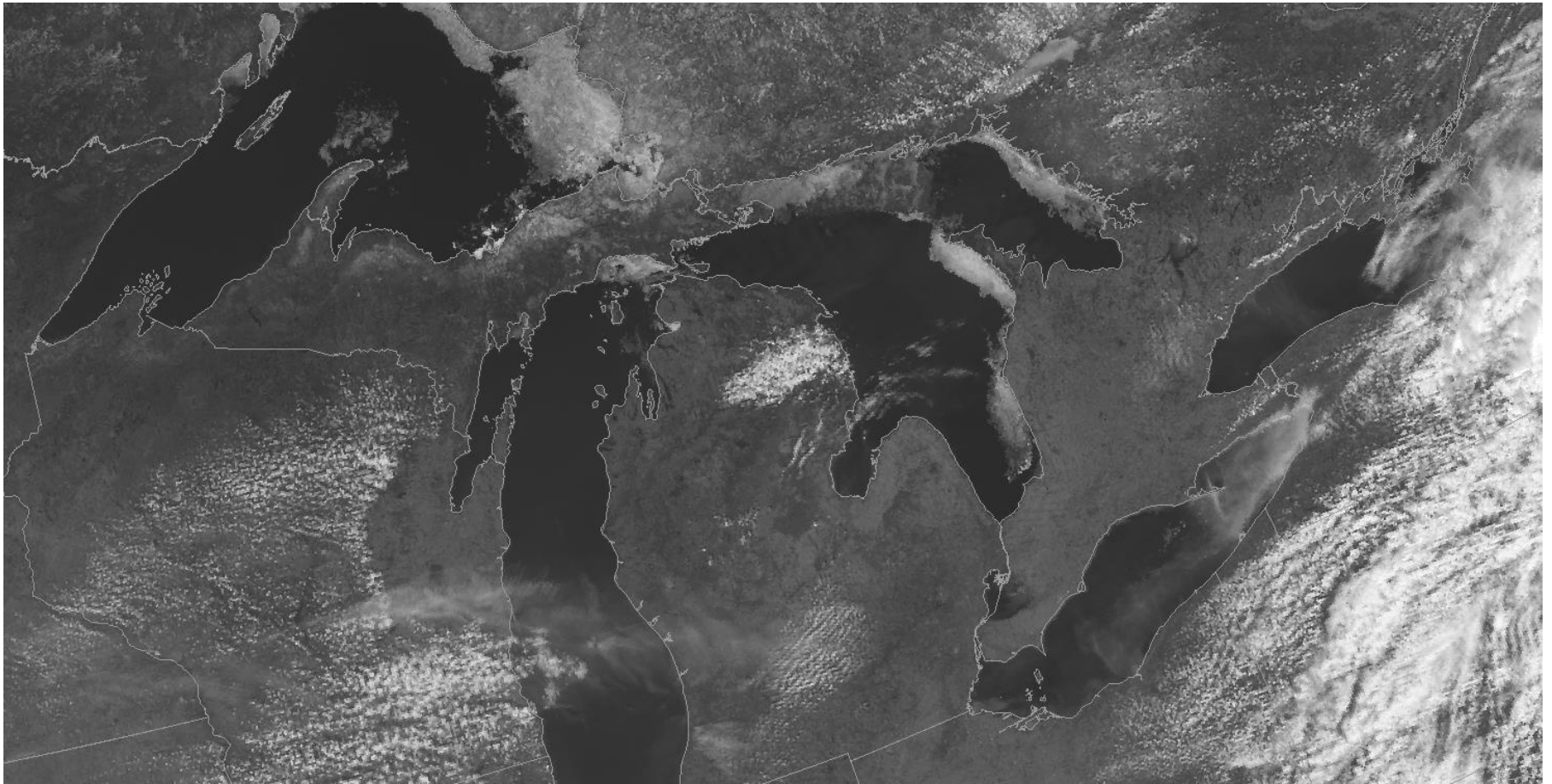
DMSP: Defense Meteorological Satellite Program
 JPSS: Joint Polar Satellite System Program
 Suomi NPP: Suomi National Polar-orbiting Partnership

Note: DoD and EUMETSAT data provided for reference only

Approved: Stephen [Signature]
 Assistant Administrator for Satellite and Information Services

Note: Extended operations are reflected through the current FY, based on current operating health.

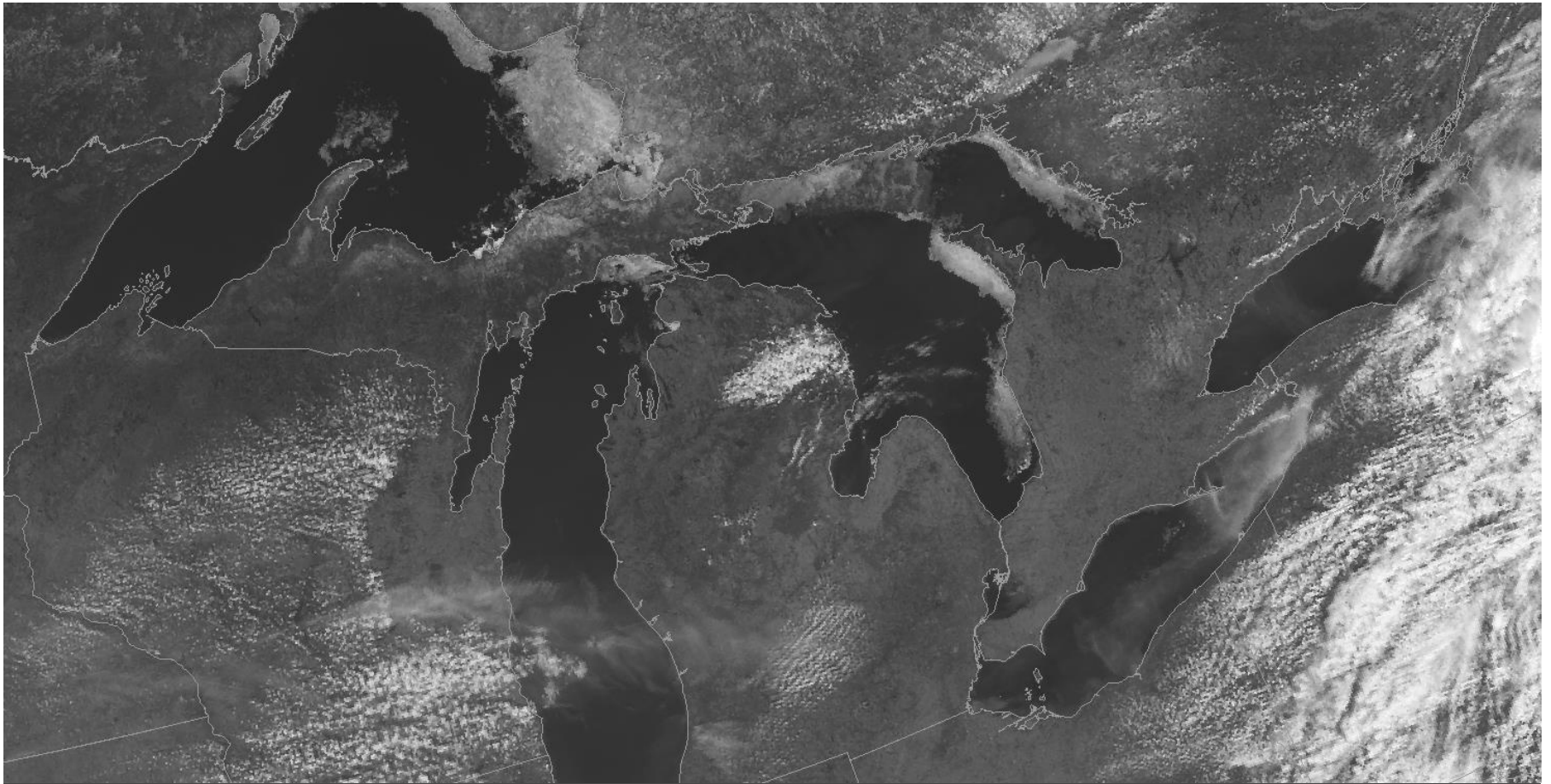
	In orbit		Post Launch Test
	Fuel-Limited Lifetime Estimate		Planned Mission Life, from Launch Readiness Date
	Launched before Oct 2008		Operational beyond Dec 2036



Suomi NPP VIIRS (0.86 μm , 0.64 μm , DNB)

Great Lakes, 17 April 2015, 18:02 UTC

Source: CIMSS Satellite Blog (<http://cimss.ssec.wisc.edu/goes/blog/>)



Suomi NPP VIIRS (1.61 μm , 0.64 μm)

Great Lakes, 17 April 2015, 18:02 UTC

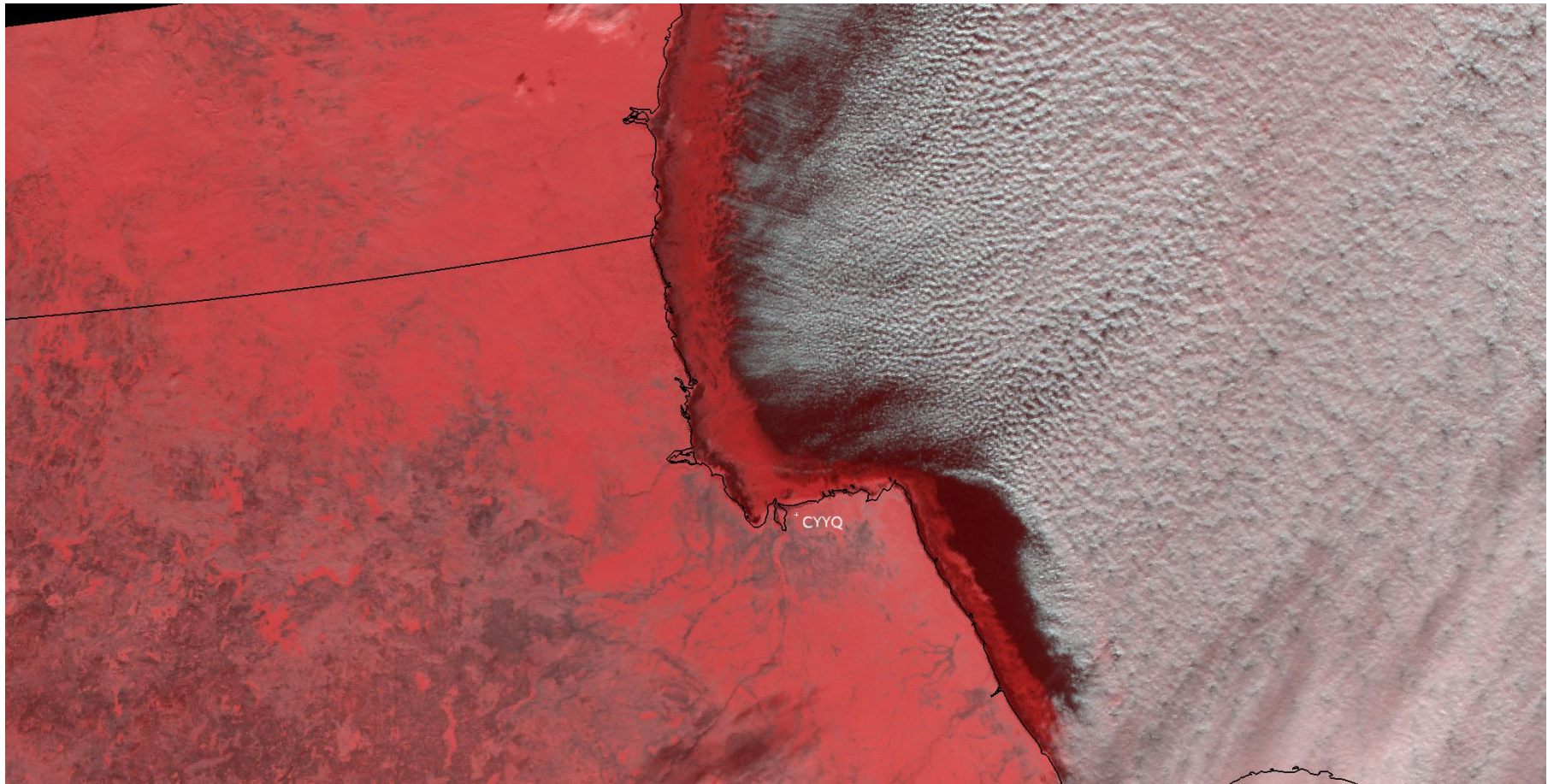
Source: CIMSS Satellite Blog (<http://cimss.ssec.wisc.edu/goes/blog/>)



Suomi NPP VIIRS (3.74 μm)

Great Lakes, 17 April 2015, 18:02 UTC

Source: CIMSS Satellite Blog (<http://cimss.ssec.wisc.edu/goes/blog/>)



Discriminating ice from supercooled water cloud

VIIRS, Churchill Airport, 17-18-19 November 2013, 19 UTC

Source: CIMSS Satellite Blog (<http://cimss.ssec.wisc.edu/goes/blog/>)

Snow and Ice Products

NPP/JPSS VIIRS

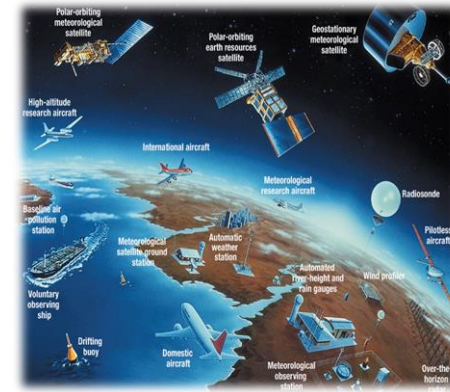
- Snow cover (binary)
- Snow fraction
- Ice thickness and age
- Ice concentration
- Ice surface temperature

GOES-R ABI, Himawari-8 AHI

- Ice thickness/age¹
- Ice cover²
- Ice concentration²
- Ice motion²
- Fractional snow cover (baseline)
- Snow depth – prairie only²

¹Future capabilities

²Future capabilities, NOAT Top 5



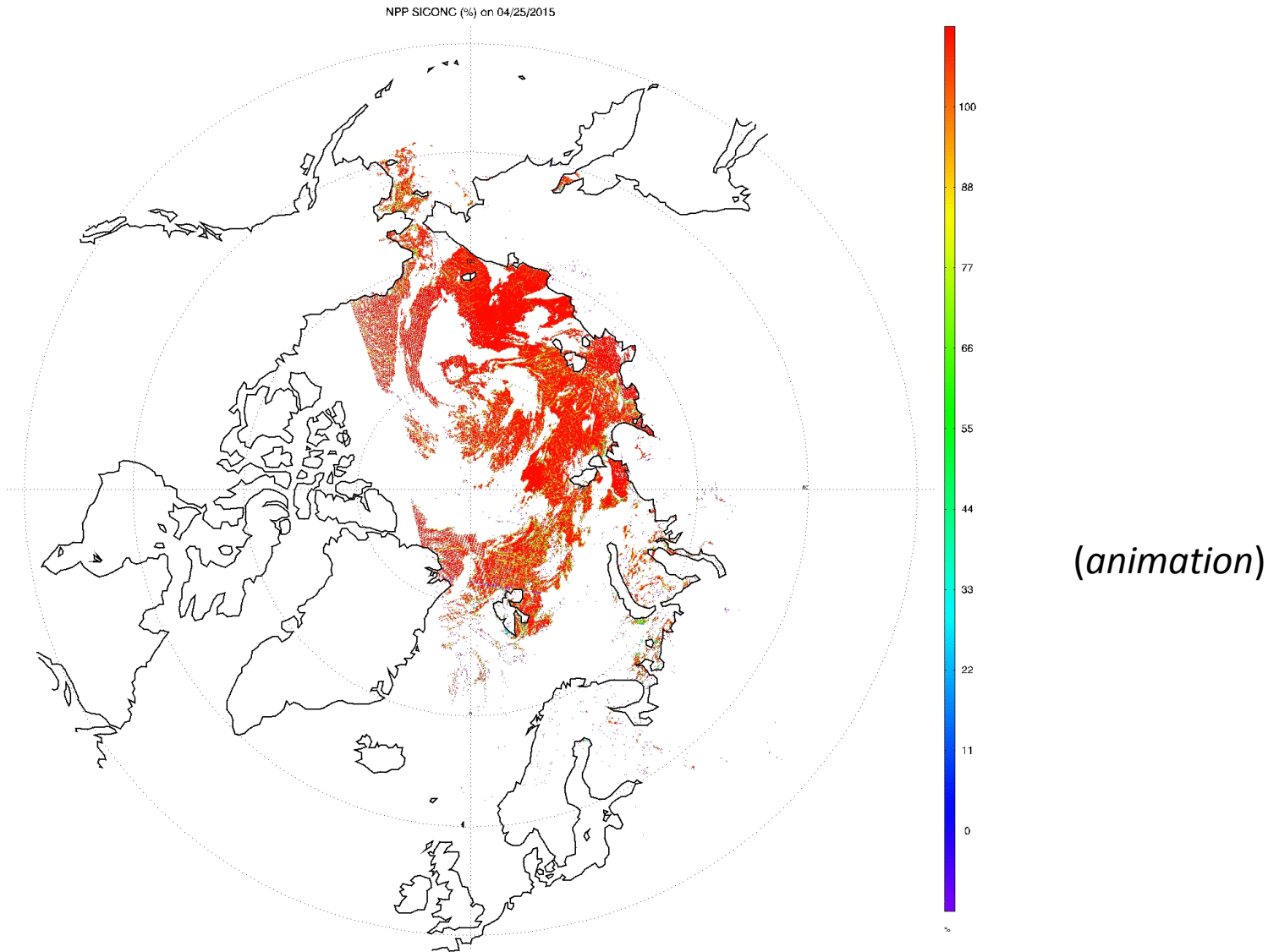
AMSR-2 on GCOM-W1

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

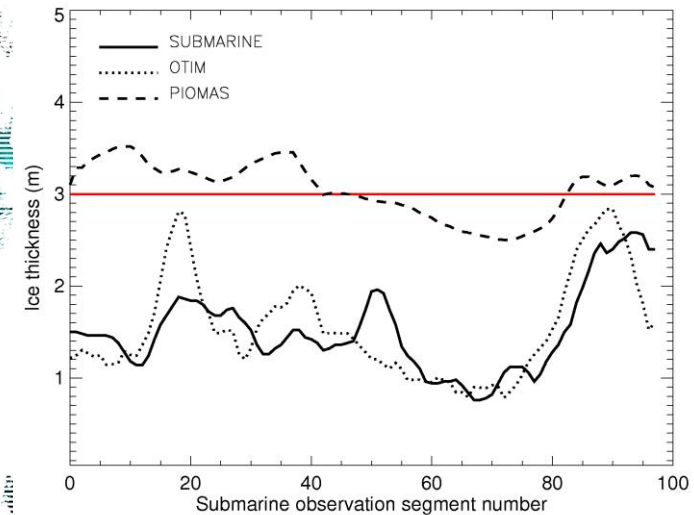
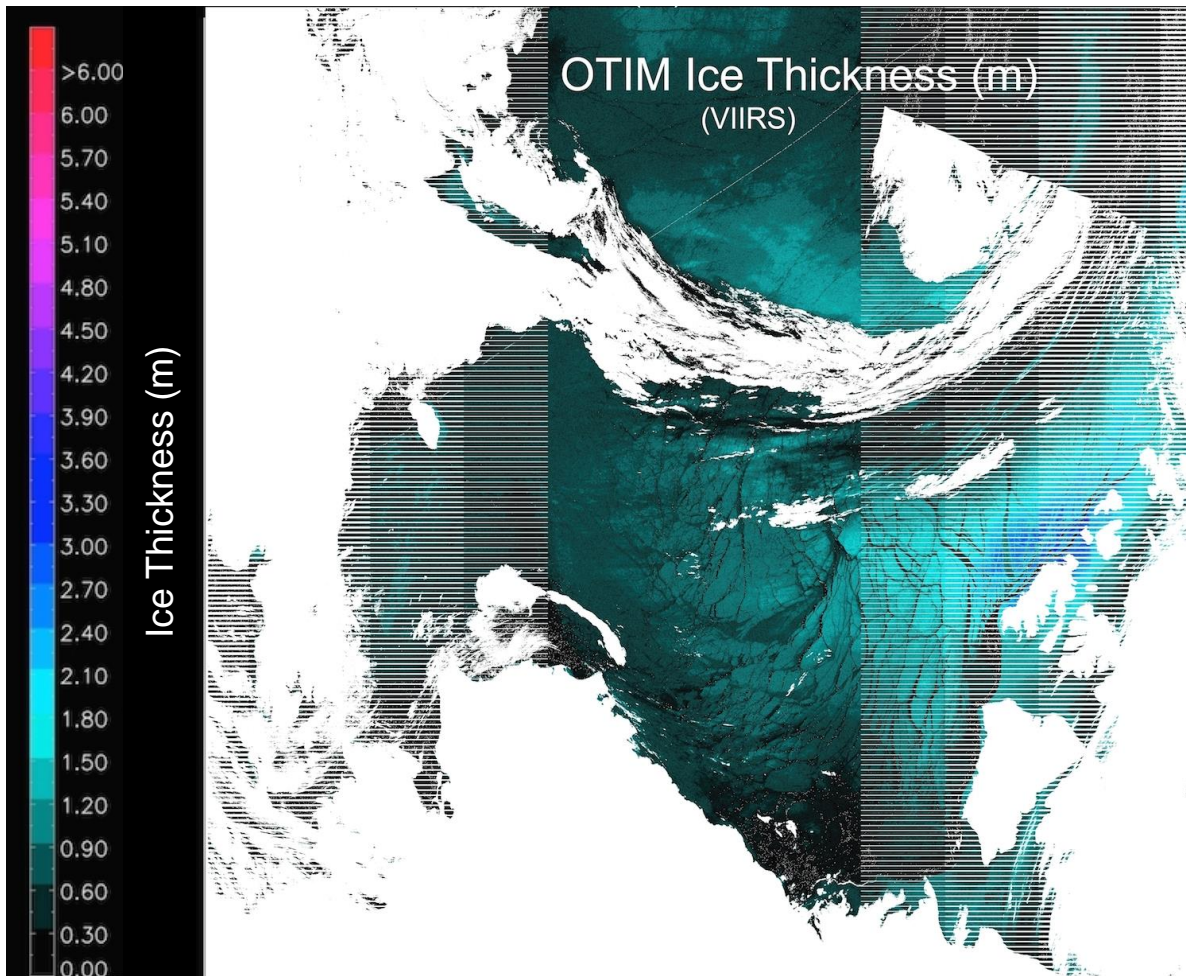
Other

- Sea ice leads (VIIRS)

VIIRS Ice Concentration



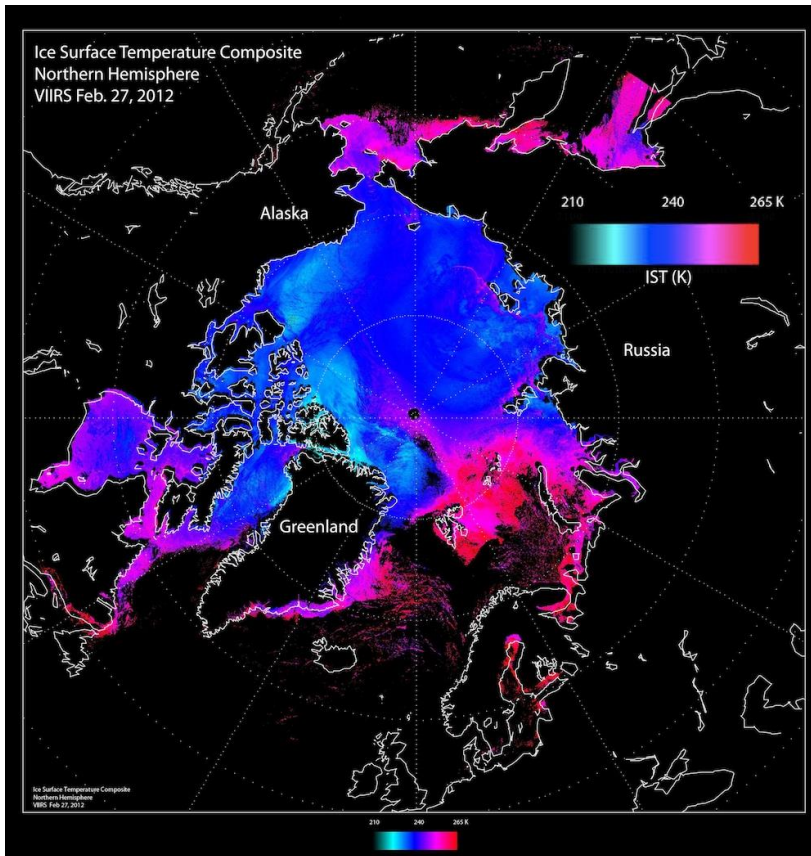
VIIRS Sea Ice Thickness



Validation with submarine sonar
and modeled ice thicknesses.

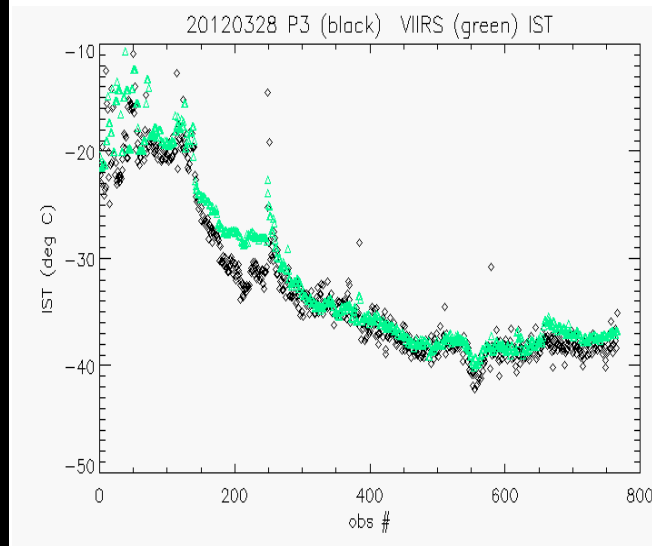
VIIRS Ice Surface Temperature

The Ice Surface Temperature (IST) is the surface skin, or radiating, temperature of sea ice.



Composite of VIIRS Ice Surface Temperature, 27 Feb 2012

IceBridge KT19 vs. VIIRS IST, 2012



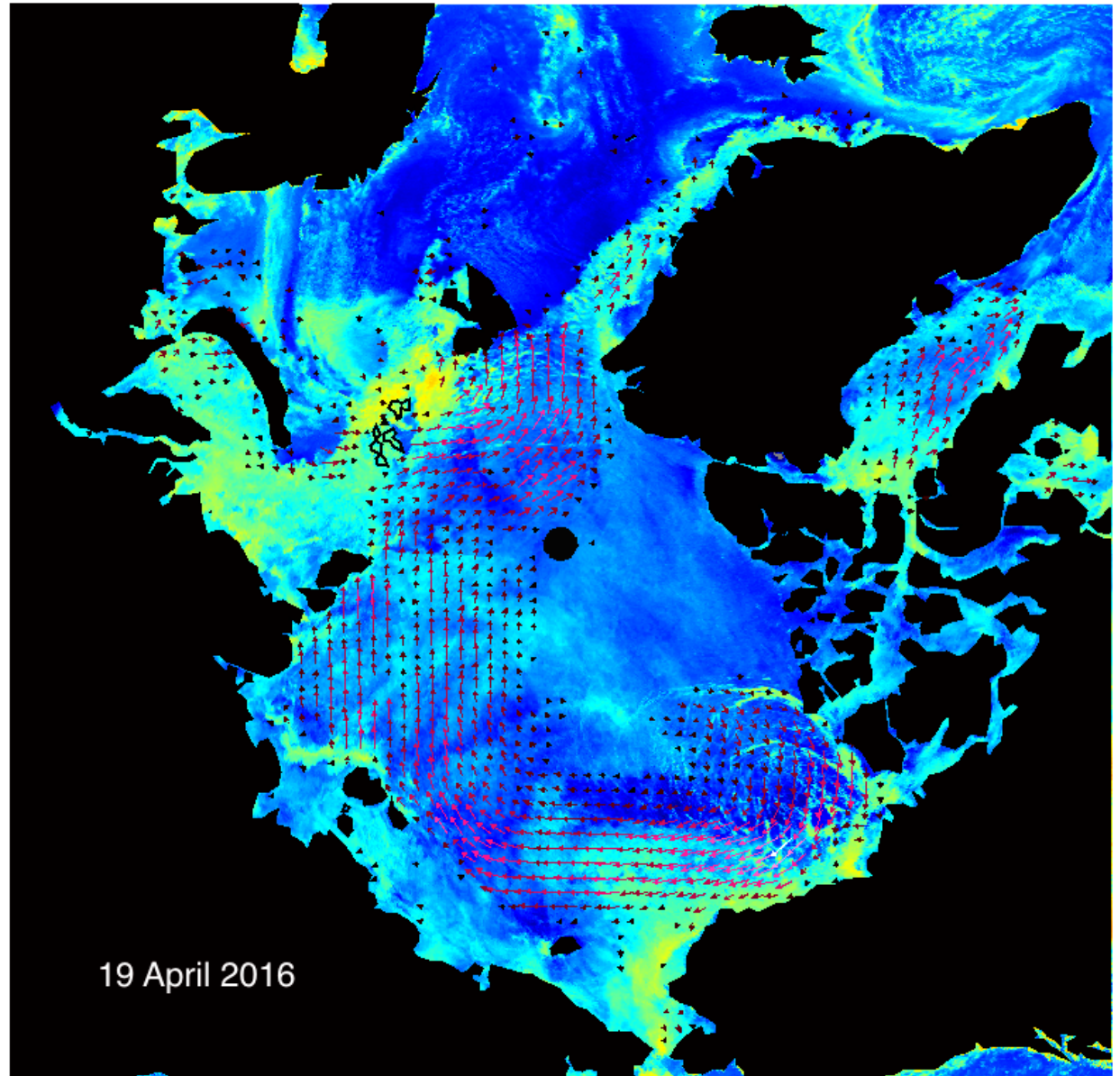
DATE	BIAS	RMS
3/14	0.56	0.08
3/15	-0.84	0.63
3/16	1.01	0.71
3/21	-0.55	0.41
3/22	-0.21	0.14
3/27	0.12	0.21
3/28	1.12	0.53
3/29	0.46	0.10
4/02	0.66	0.19

$BIAS = VIIRS - KT19$

AMSR2 Ice Motion

Ice motion from
Advanced Microwave
Scanning Radiometer 2
(AMSR2) over the Arctic
on 19 April 2016

Source: Jeff Key



Uses and Users

- Numerical Weather Prediction (NWP centers)
 - Snow and ice cover are commonly used.
 - Ice thickness is not yet utilized; should be used universally!
- Navigation and Transportation (National Ice Center, NWS Anchorage Ice Desk, Navy, USCG, 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

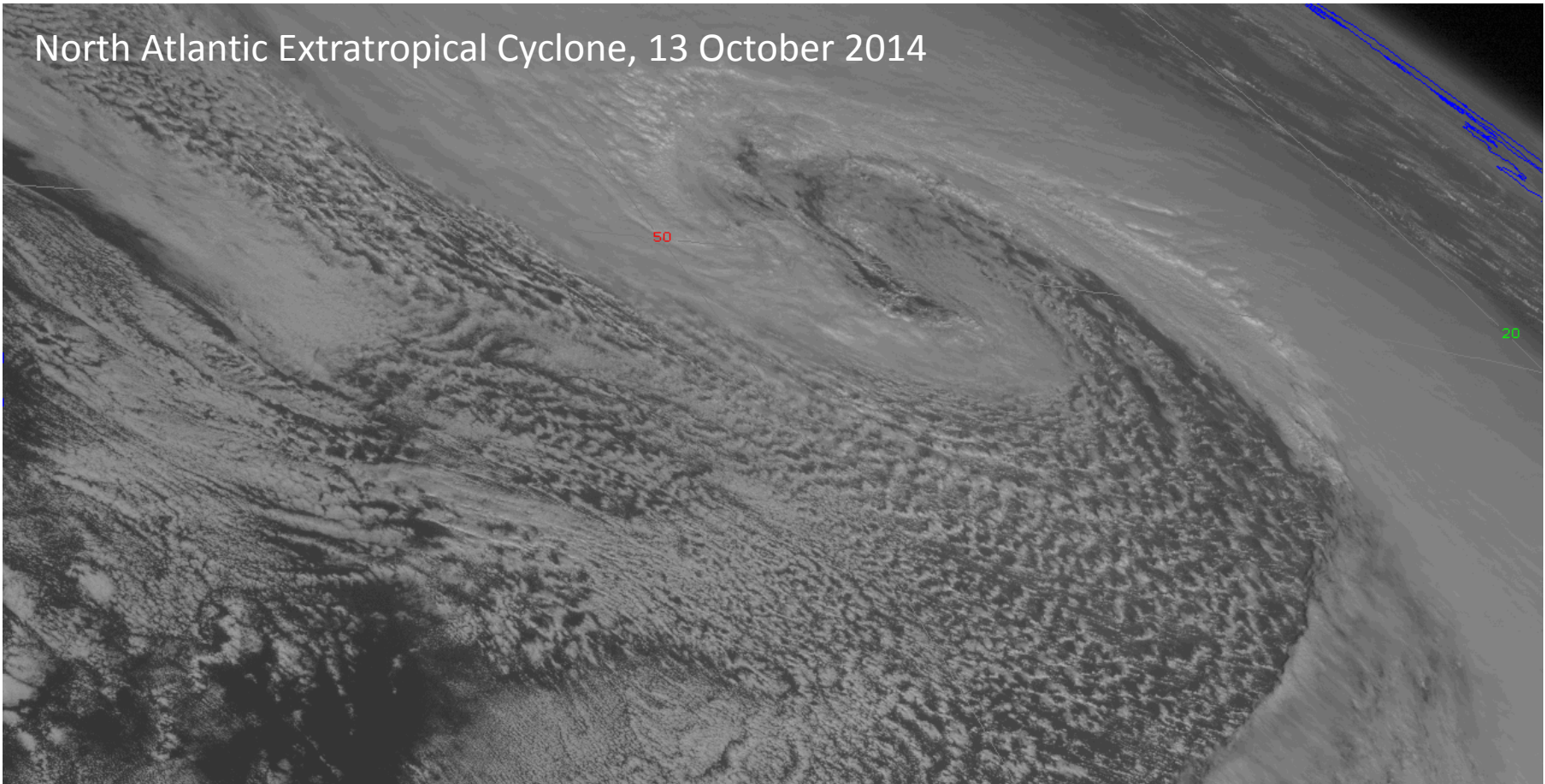
Potential Areas of Collaborations

- Applications-based training and workflows for applying new generation satellite imagery and products to operational decisions related to arctic and marine forecasts
- Assuring availability and awareness of GOES-R mesoscale sectors to Canadian counterparts when cross-border coverage exists
- Standardization of derived satellite products available to customers and stakeholders

Summary

- This is an exciting time for the United States operational environmental satellites with new geostationary and polar-orbiting satellites launching in the upcoming year.
- These new satellites will positively impact marine and arctic operational weather analysis/forecast capabilities as a result of improved specifications for spectral, spatial, and temporal resolution.
- We can and should work together!

North Atlantic Extratropical Cyclone, 13 October 2014

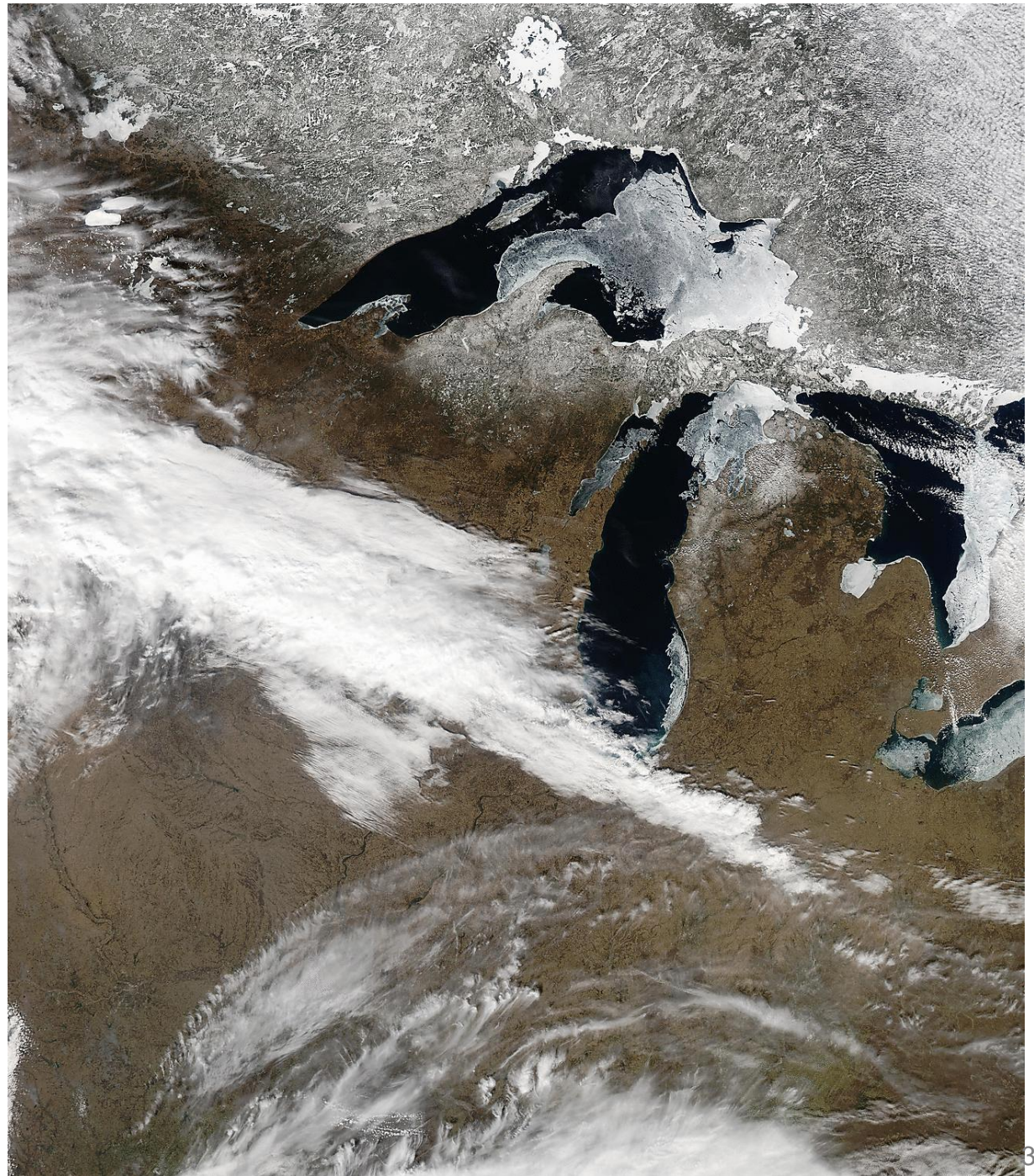


Questions? Comments?

Jordan Gerth, Cooperative Institute for Meteorological Satellite Studies

E-mail: Jordan.Gerth@noaa.gov

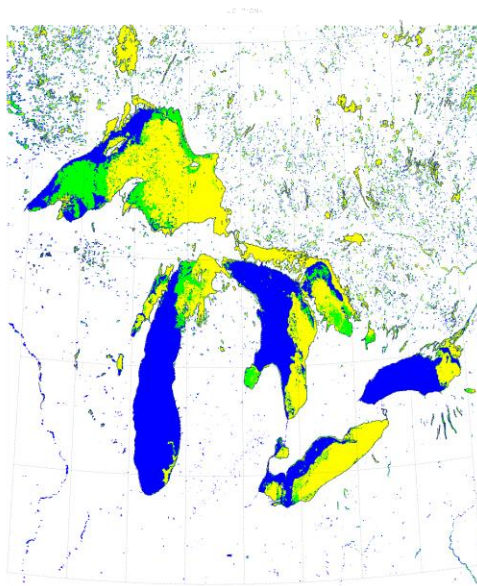
Great Lakes Examples



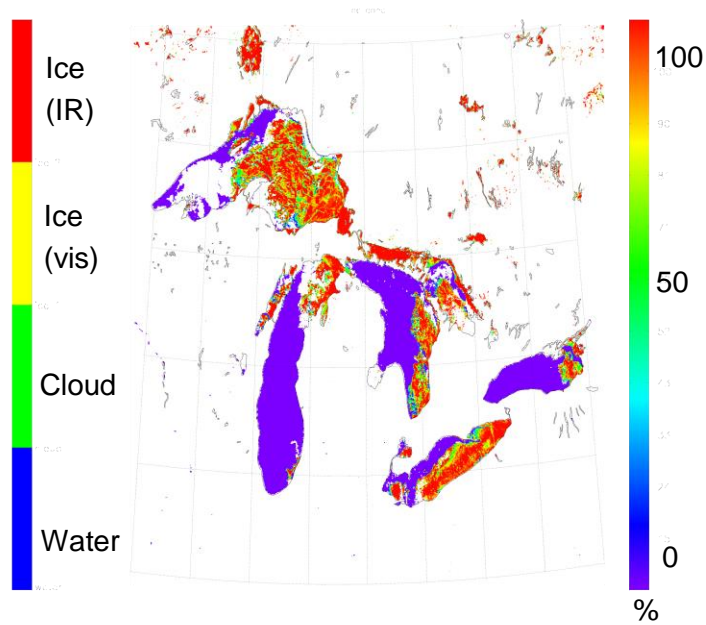
MODIS, March 23-28, 2015
(with 2-day gap)

Great Lakes Ice

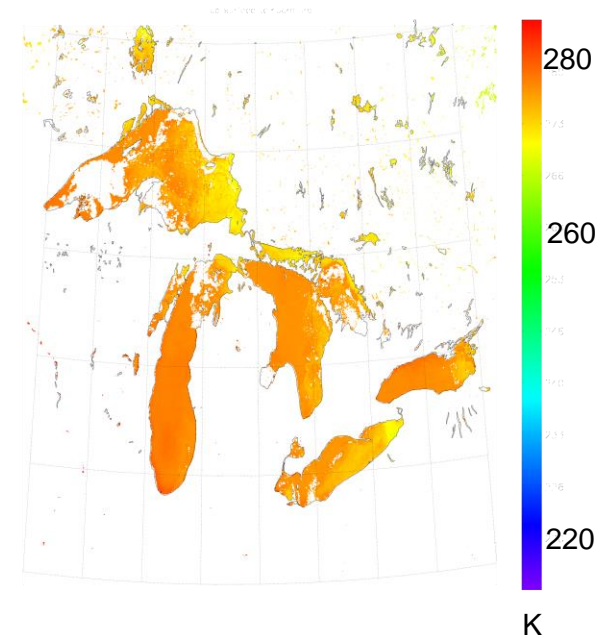
Ice Cover



Ice Concentration



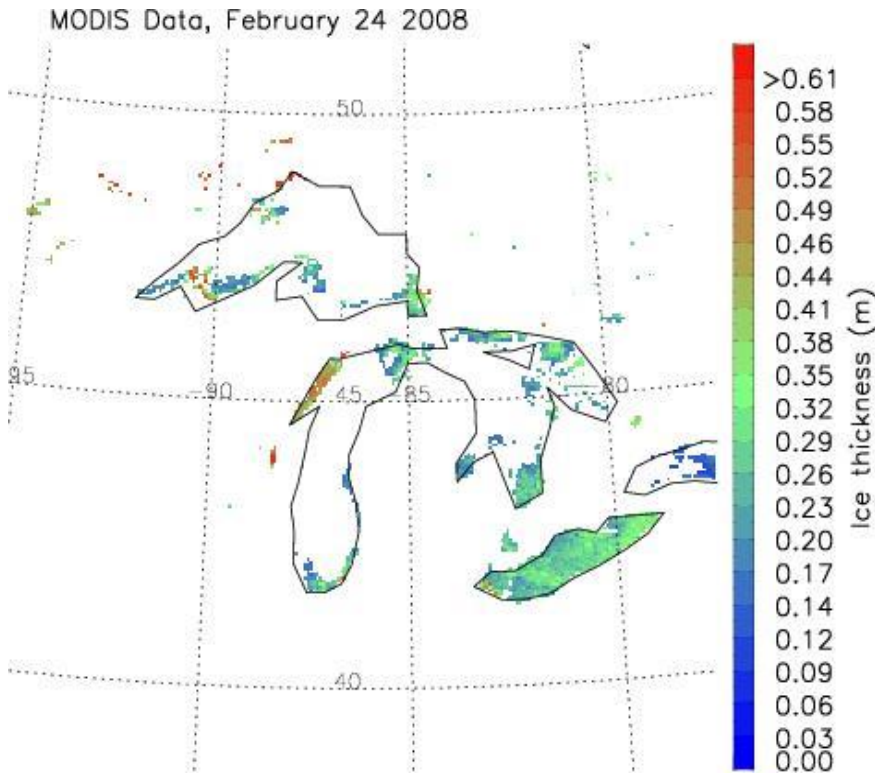
Ice Surface Temperature



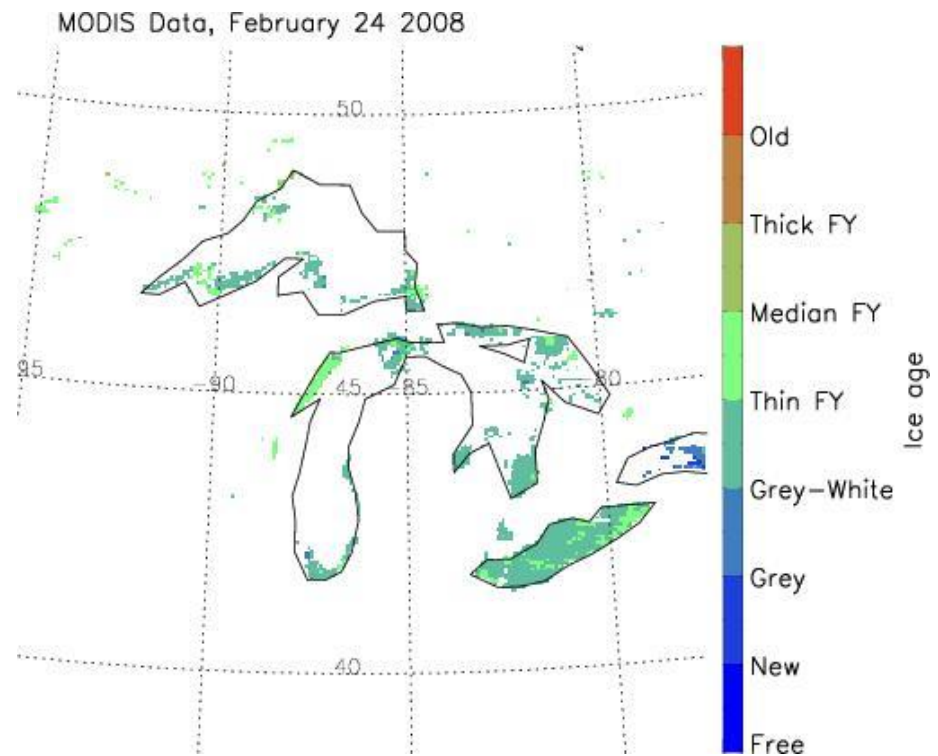
Based on MODIS data, March 28, 2015

Ice Thickness and Age

Ice Thickness



Ice Age



Estimated ice thickness (left) and ice age categories (right) based on MODIS data on February 24, 2008.