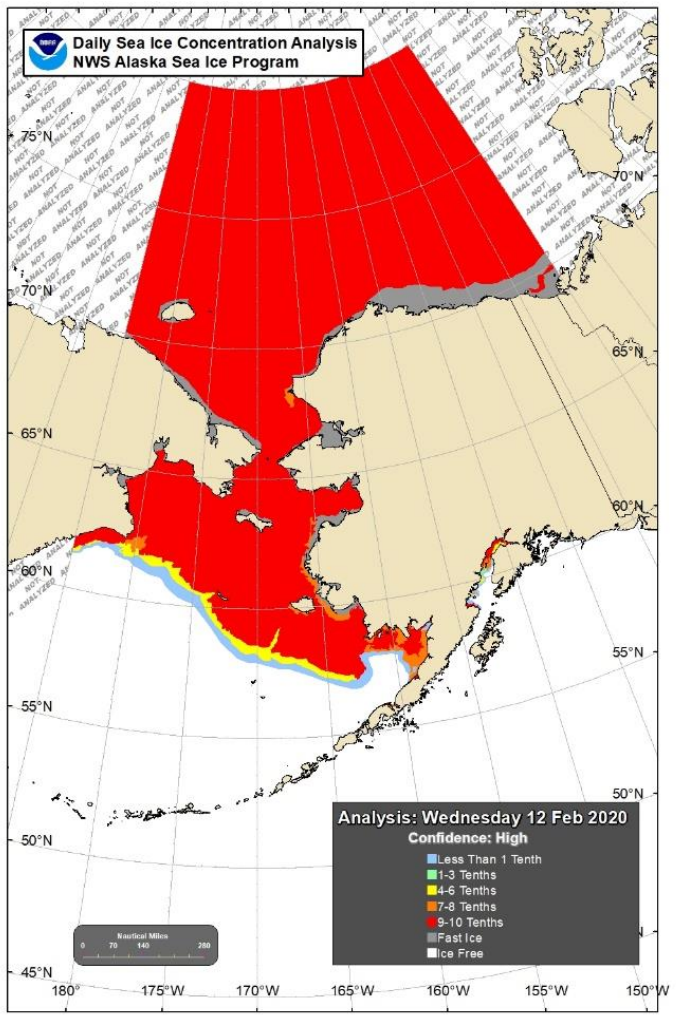
Alaska Sea Ice Program Operations

JPSS/GOES-R PG RR Summit

Michael Lawson 2/27/20

End Products



FZAK80 PAFC 130038
ICEAFC

Sea Ice Advisory for Western and Arctic Alaskan Coastal Waters
National Weather Service Anchorage Alaska
335 PM AKST Wednesday 12 February 2020

FORECAST VALID...Monday 17 February 2020

ANALYSIS CONFIDENCE...High

SYNOPSIS...Low pressure will move north into the central Bering Sea through Sunday, then move off to the east Monday.

-Beaufort Sea-
-Chukchi Sea-
-Bering Sea-
PKZ180-Kuskokwim Delta and Etolin Strait-
PKZ181-North and West of Nunivak Island-
PKZ200-Norton Sound-
PKZ210-Dall Point to Wales-
PKZ215-Kotzebue Sound-
PKZ220-Wales to Cape Thompson-
PKZ225-Cape Thompson to Cape Beaufort-
PKZ230-Cape Beaufort to Point Franklin-
PKZ235-Point Franklin to Cape Halkett-
PKZ240-Cape Halkett to Flaxman Island-
PKZ245-Flaxman Island to Demarcation Point-
PKZ500-Western U.S. Arctic Offshore-
PKZ505-Central U.s. Arctic Offshore-
PKZ510-Eastern U.S. Arctic Offshore-

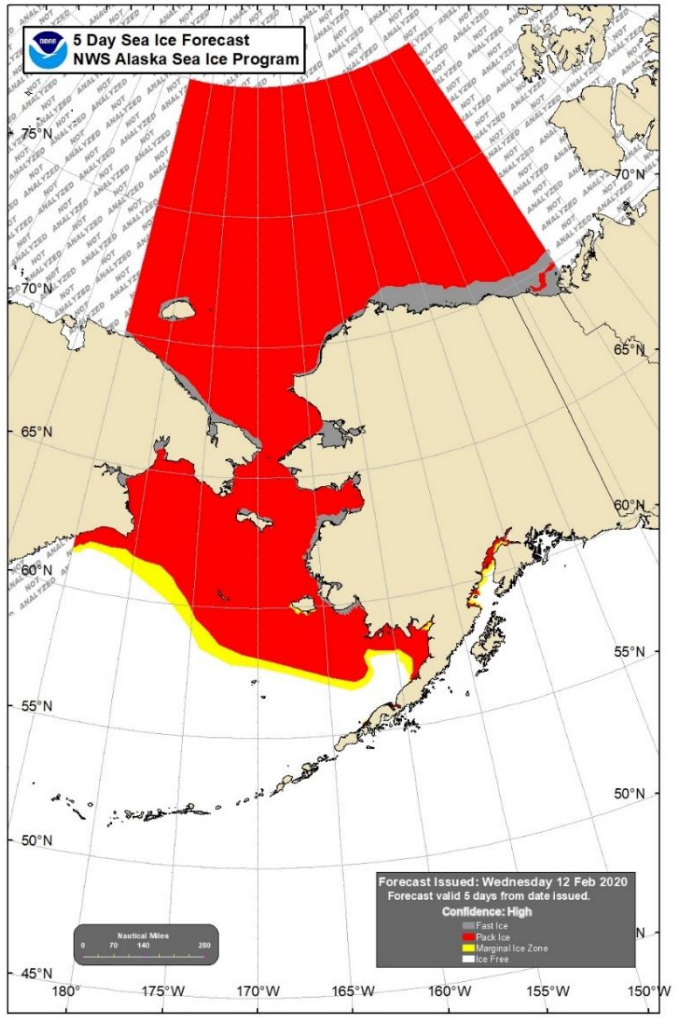
Ice covered.

-Bering Sea-
PKZ160-Bristol Bay-
PKZ165-Port Heiden to Cape Sarichef-
PKZ185-Saint Matthew Island-
PKZ412-Bering Sea Offshore 171W to 180 and N of 56N-
PKZ414-Bering Sea Offshore East of 171W-

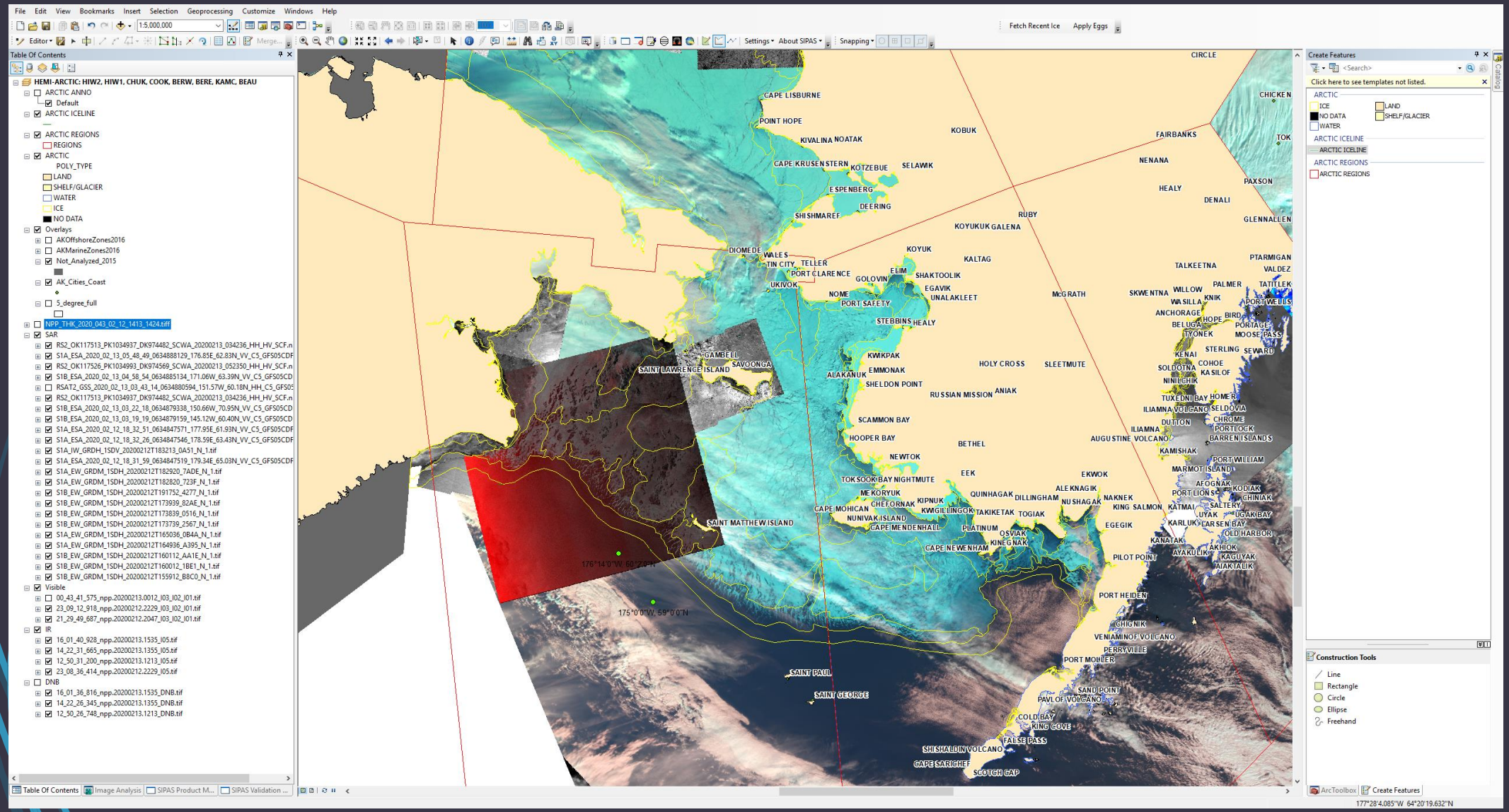
The main sea ice edge extends from near 56.6N 159.6W to 57.8N 159.8W to 57.8N 162W to 56.7N 162.7W to 57.9N 170.7W to 60.1N 175W to 61N 177.8W to 61.8N 177.7W and continues in Russian waters. The ice edge is open water. There is approximately 10 nm of open water before the low concentration strip ice begins. There is roughly 10 to 15 nm of 4-6 tenths coverage of strip ice from roughly St. Paul Island westward, with the main pack north and east of the strips of ice.

FORECAST FOR THE BERING SEA (Days 1 through 5)...Moderate easterly to southeasterly winds will continue through Saturday, then winds will become northerly through Monday. Expect the ice edge to move to the west 30 to 45 nm through Monday, with strips of ice being pulled westward off the main pack and slowly melting as it reaches warmer waters.

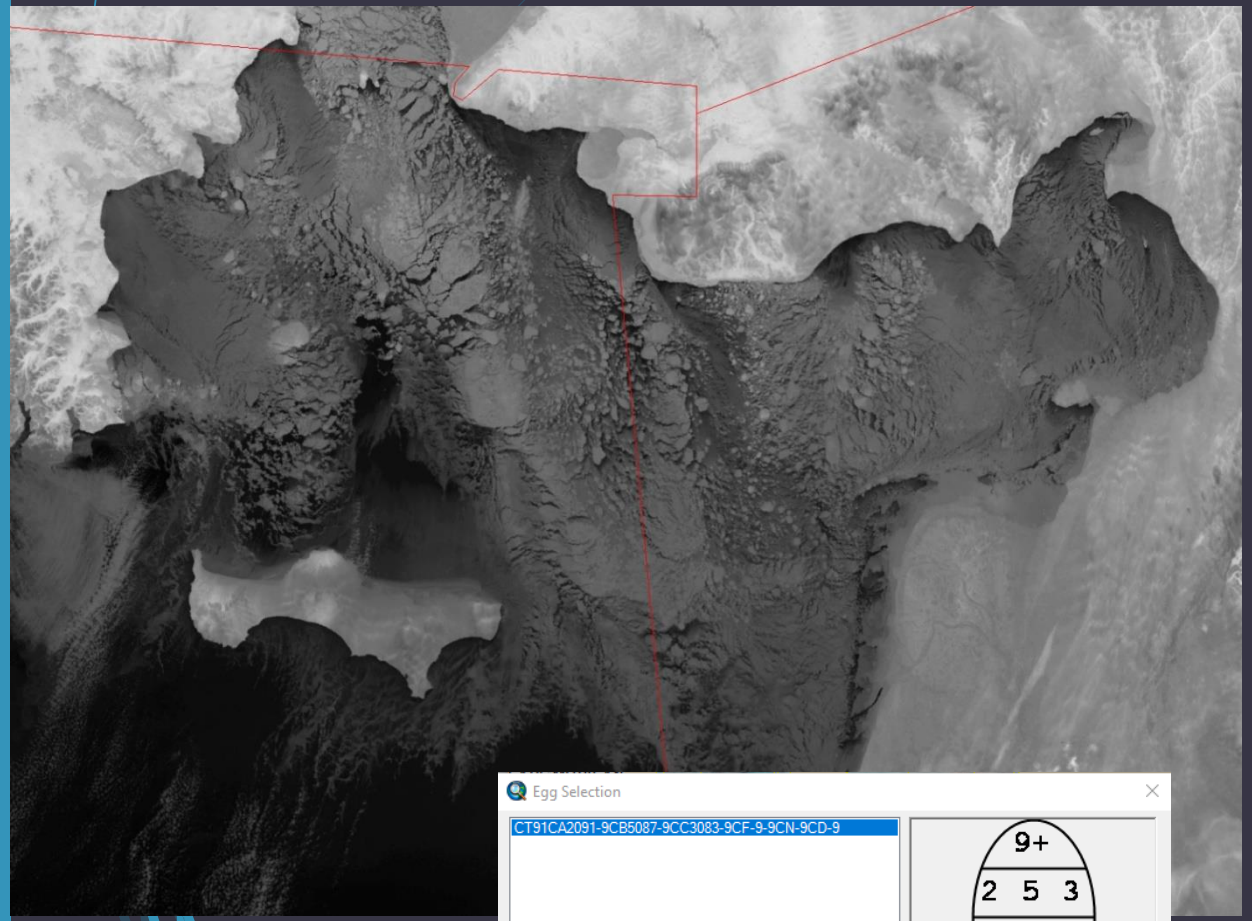
Looking ahead...Another period of colder air and northerly to northeasterly winds will likely continue into early next week. At this time this looks to be fairly brief, but please continue to watch the forecasts through this week for updates.

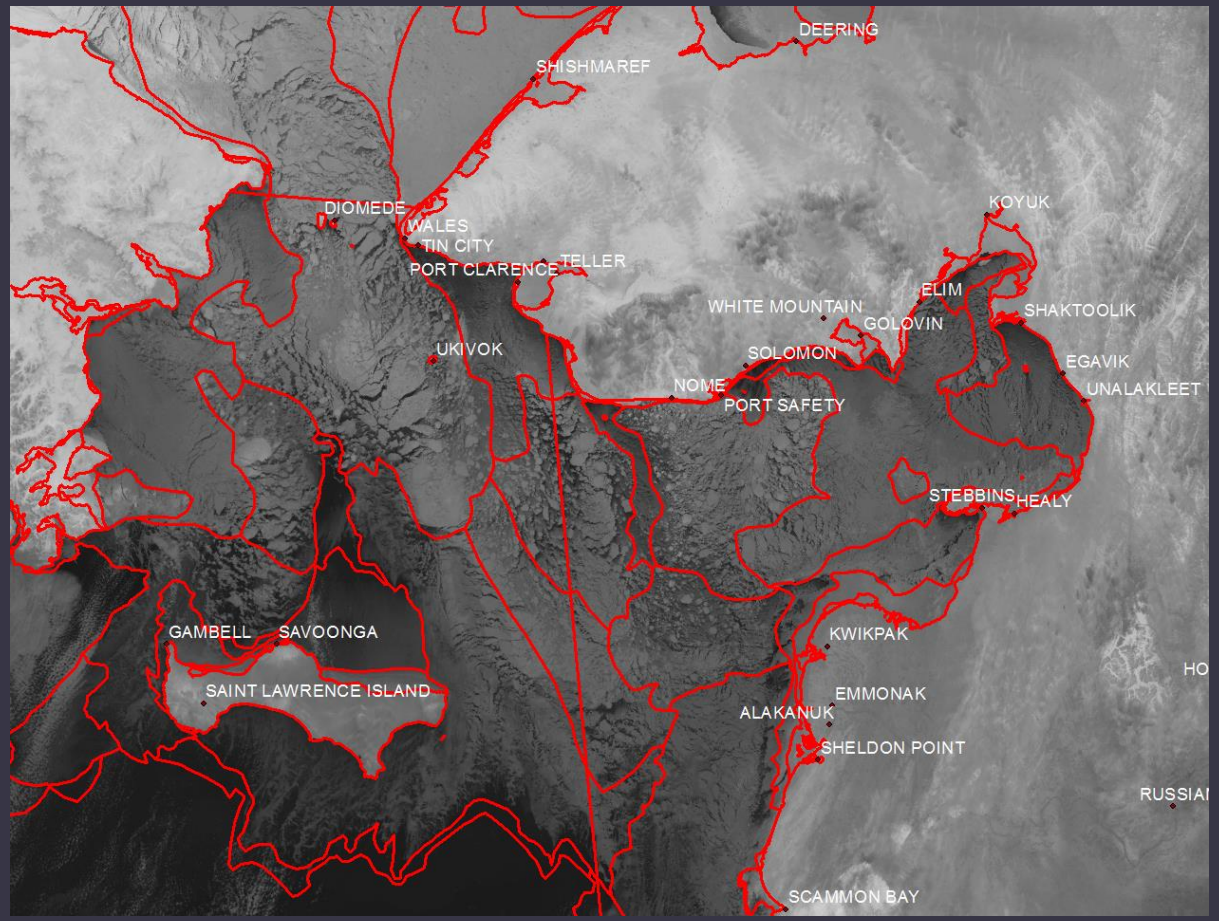


Format/What we use



Starting Image------> End Goal

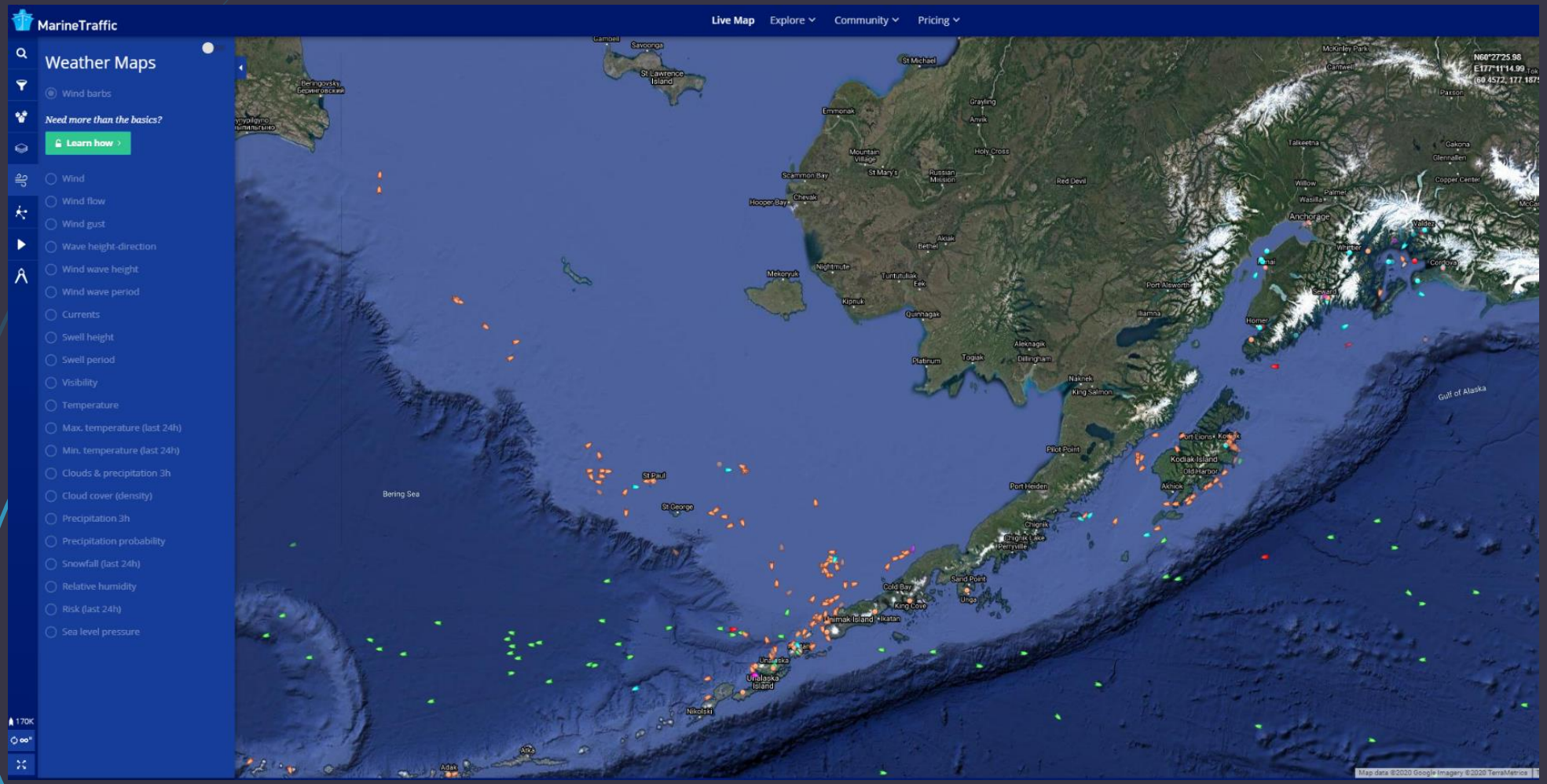




What is important to us?

- Ice edge (position of marginal ice zone/pack ice zone)
- Shorefast ice (Public safety: subsistence hunting/travel)
- Identification of old ice (Summertime navigational waters)

Fishing fleet DSS

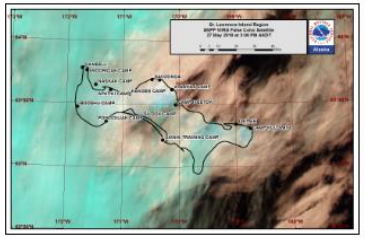
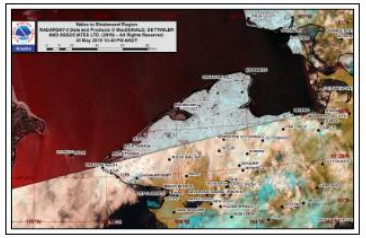
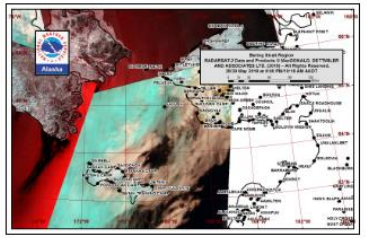


Additional resources

Sea Ice for Walrus Outlook:

Satellite Images

St. Lawrence Island | Wales to Shishmaref | Bering Strait

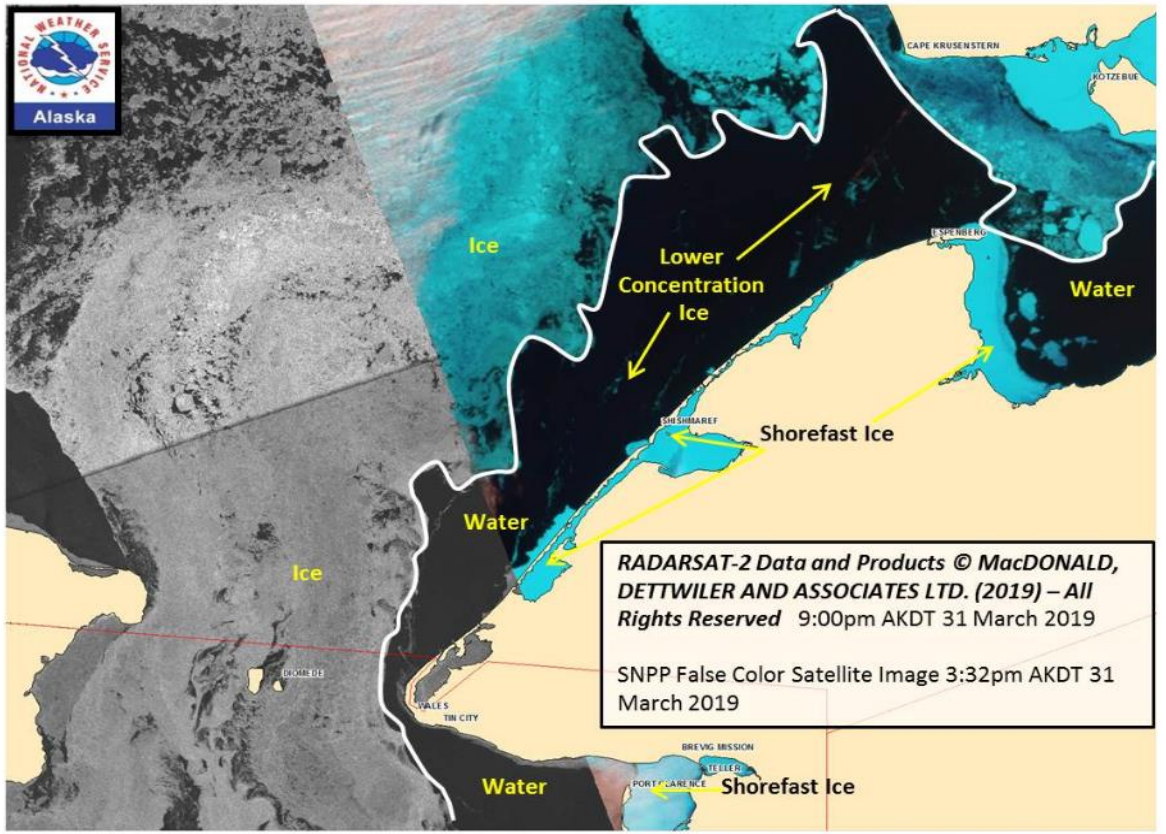




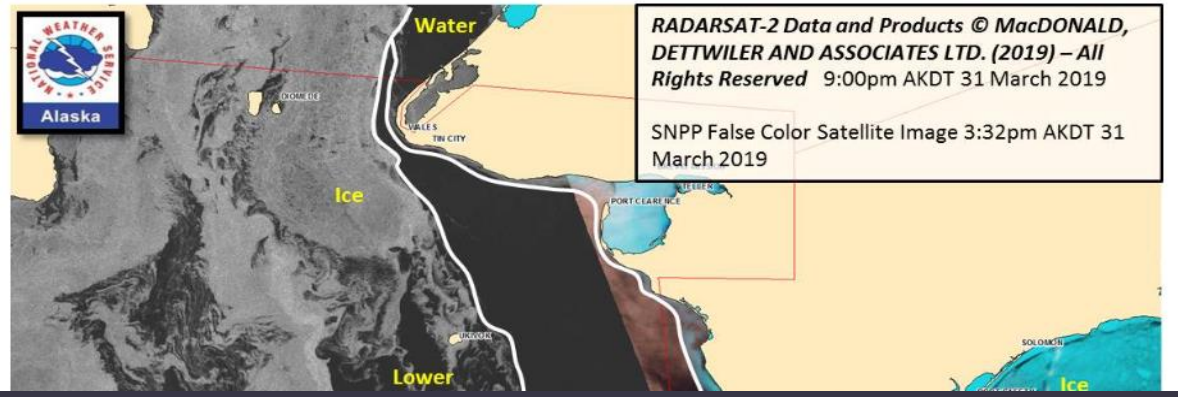
Alaska Sea Ice Program: Satellite Resource Info

Weather.gov > Anchorage, AK > Alaska Sea Ice Program: Satellite Resource Info

Anchorage, AK
Weather Forecast Office

4/1/19: Satellite imagery showing the current location and condition of the sea ice through the northern Bering Sea and southern Chukchi Sea. The satellite imagery is from the afternoon and evening of 31 March 2019.





U.S. National Ice Center

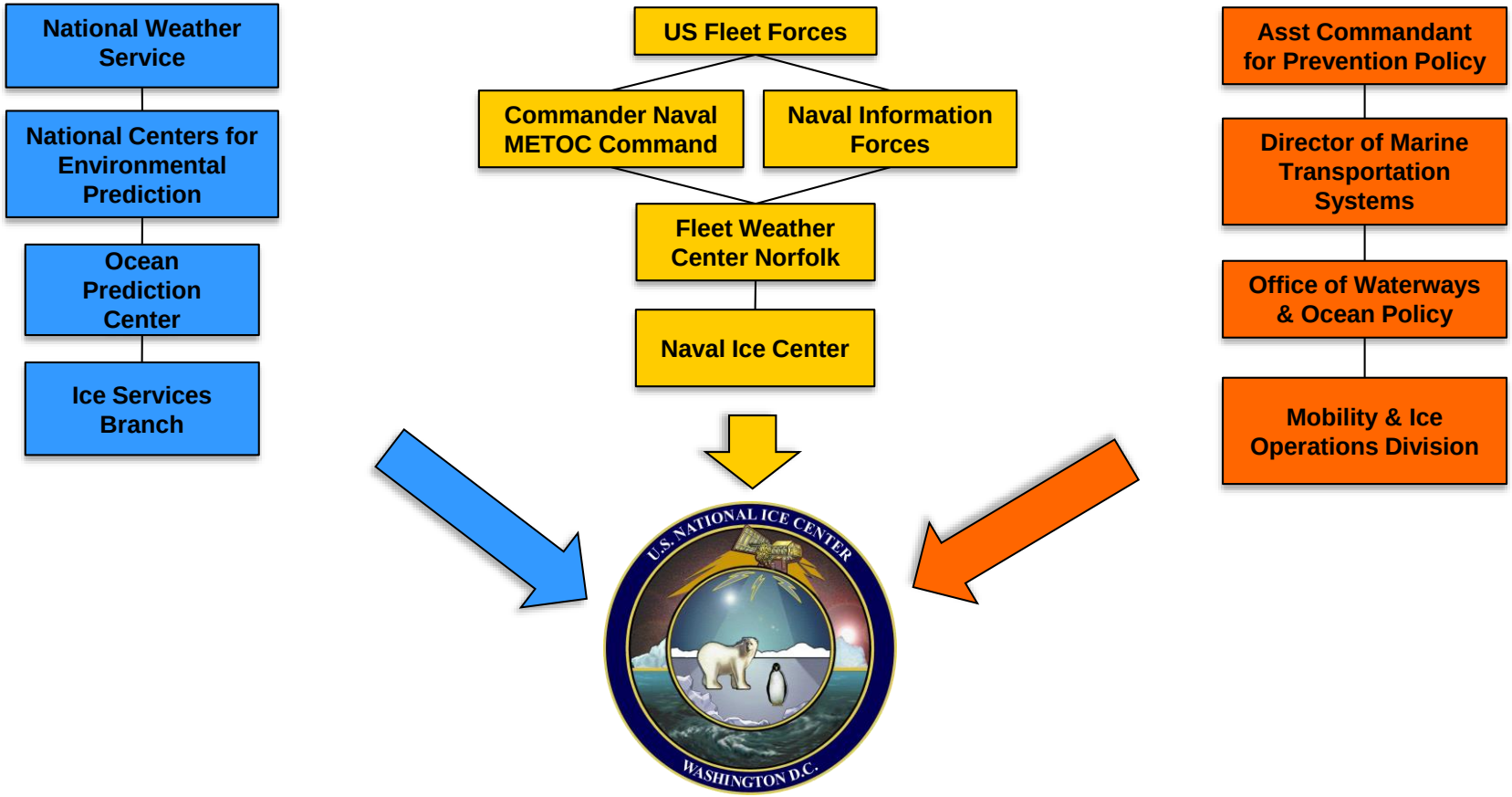
Providing Domain Awareness at High Latitudes

USN **USCG** **NOAA**

Director: CDR Heather Quilenderino, USN
Deputy Director: Mr. Kevin Berberich, NOAA
27 February 2020

JPSS/GOES Joint Proving Ground/Risk Reduction Summit
Application Area: Arctic/Cryosphere

Organizational Alignment & Mission



Mission: The U.S. National Ice Center provides global to tactical scale ice and snow products, ice forecasting, and related environmental intelligence services for the United States government.

High-Latitude Domain Awareness

Global Area of Responsibility

Characterization: Observation, Analysis, and Prediction

Satellites

Buoys

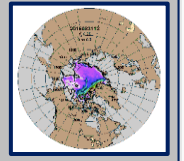
Ship Observations

Aircraft

Webcam

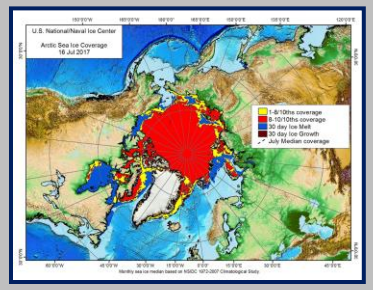
Radar

Surface Observations

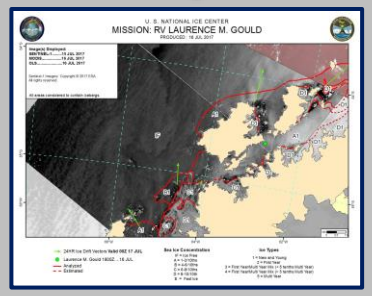


Models

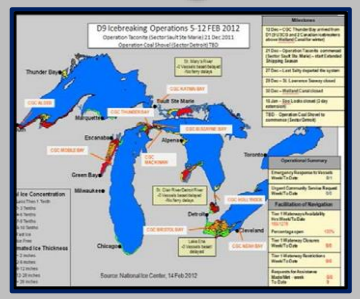
Exploitation: Tailoring and Integration



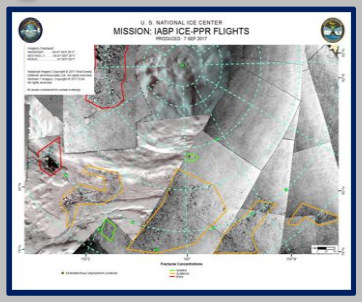
Weekly Hemispheric



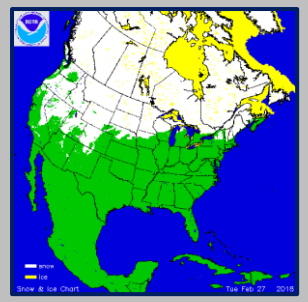
Annotated Imagery



Asset Management



Fractures, Leads & Polynyas



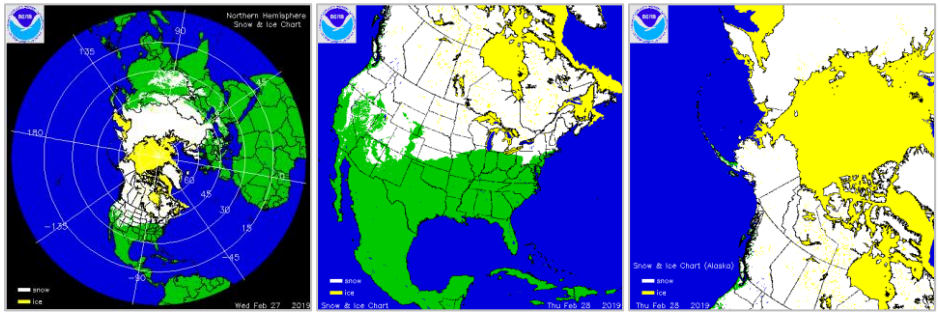
Daily Snow & Ice Charts

Accurate… Timely… Relevant… Consistent

Snow and Ice Operations

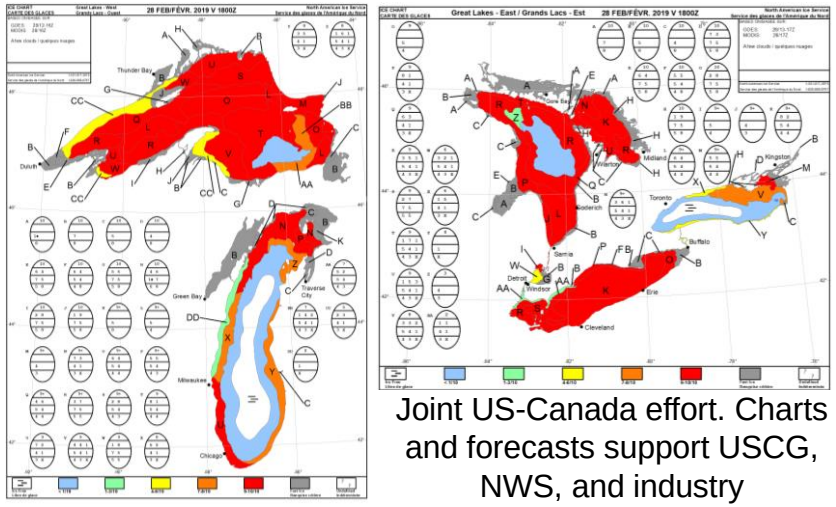
Sample Products

Interactive Multi-sensor Snow and Ice Mapping System (IMS)



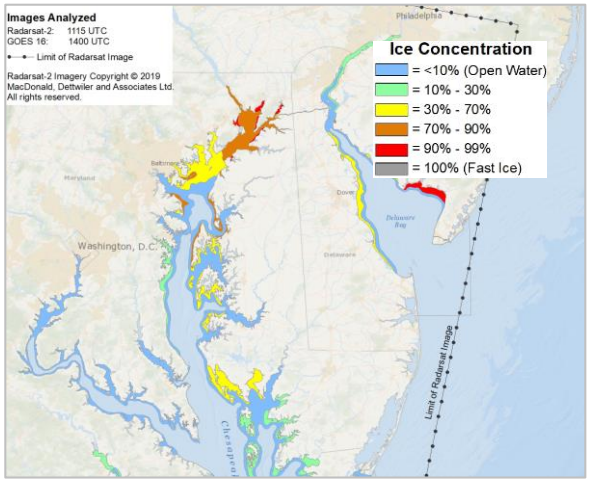
Serves as snow and ice initialization for most numerical weather prediction models

Great Lakes



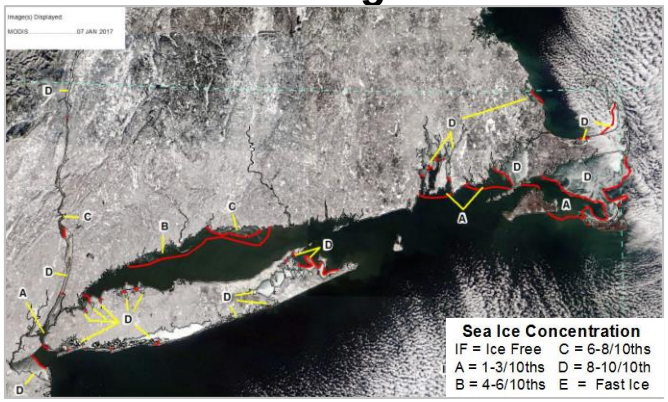
Joint US-Canada effort. Charts and forecasts support USCG, NWS, and industry

Chesapeake and Delaware Bay



USNIC forecasts and analyses are considered by the USCG Captain of the Port when making decisions to impose hull restrictions or close regional ports.

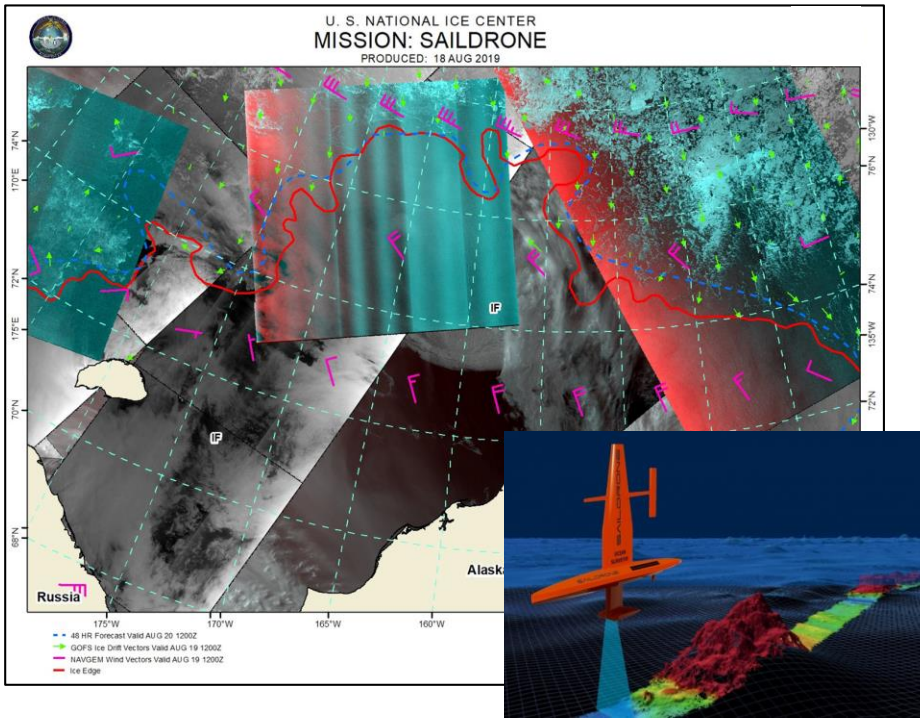
New England

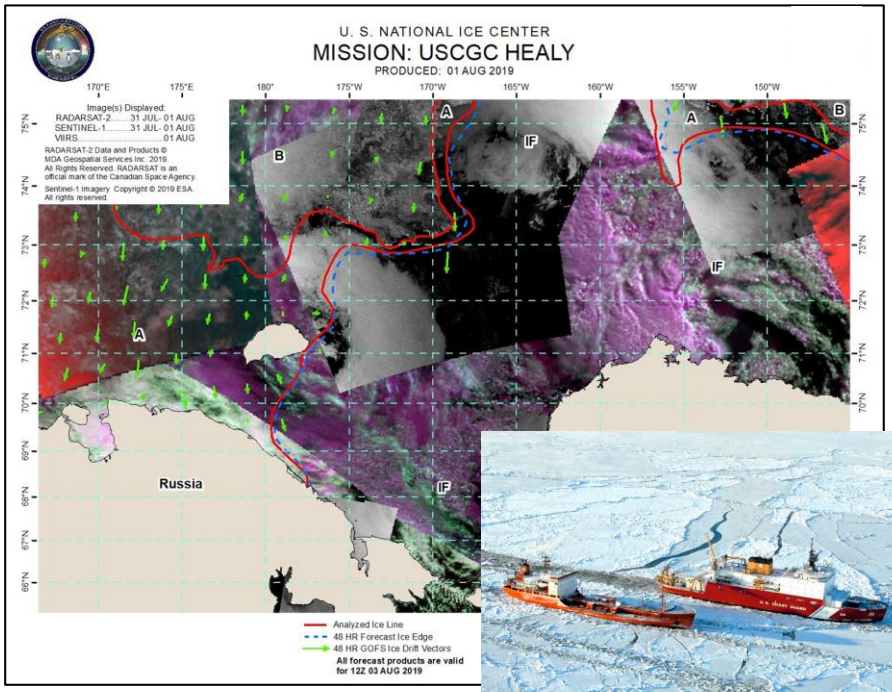


Though not as common as ice in the Great Lakes or the mid-Atlantic, USNIC supports operators in the critical hubs of New York City and Boston

Tailored Support Program

Sample Products





Mission Dates: June – Sep 2019

Agency: NOAA Pacific Marine and Environmental Lab (PMEL)

USNIC supported PMEL's use of autonomous systems in its development of improved sea ice prediction

Mission Dates: Sep – Oct 2019

Agencies: U.S. Coast Guard, National Science Foundation

USNIC supported USCG maritime awareness and NSF ocean exploration and research efforts

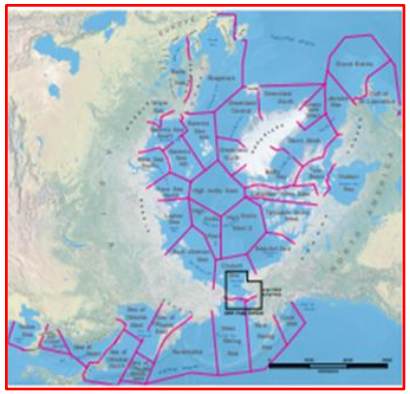
Tailored Support Program provides critical situational awareness to U.S. interests (national defense, resupply, R&D) in or near sea-ice.

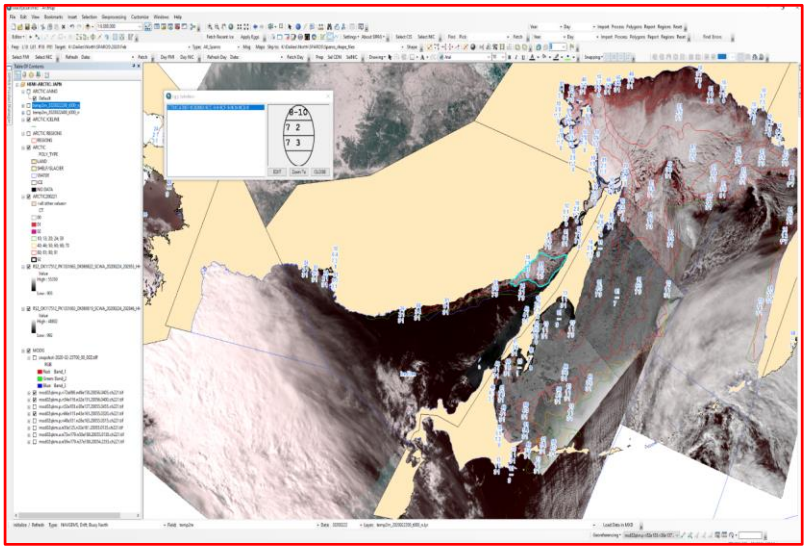
Ice Analysis Process

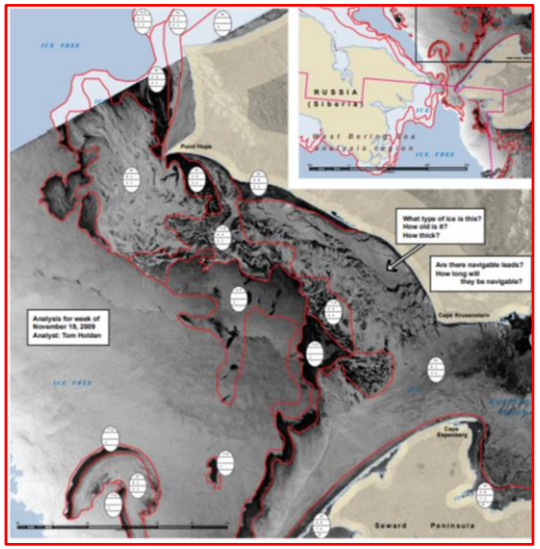
1) Identify Area of Analysis
- Check out region within operational software (Satellite Image Processing and Analysis System – SIPAS)
- Northern Hemisphere: 39 Regions
- Southern Hemisphere: 13 Regions

2) Import Available Data
- Identify and select most recent, highest resolution imagery covering assigned region
- Import any ancillary data such as buoy data, weather, models, etc.

3) Perform Ice Analysis
- Characterize ice, both concentration and stage of development. Complete task by performing polygon analysis
- Use customized tools within SIPAS to assign attributes in WMO global sea ice code standards







4) Perform Quality Control (QC)
- QC will check for consistency, correlation with weather factors, degree of ice accretion or melt based on environmental factors, historical ice coverage, ice typing consistent with imagery signature, general pattern as compared to ice drift or other information in area

Process Limitations and Inefficiencies

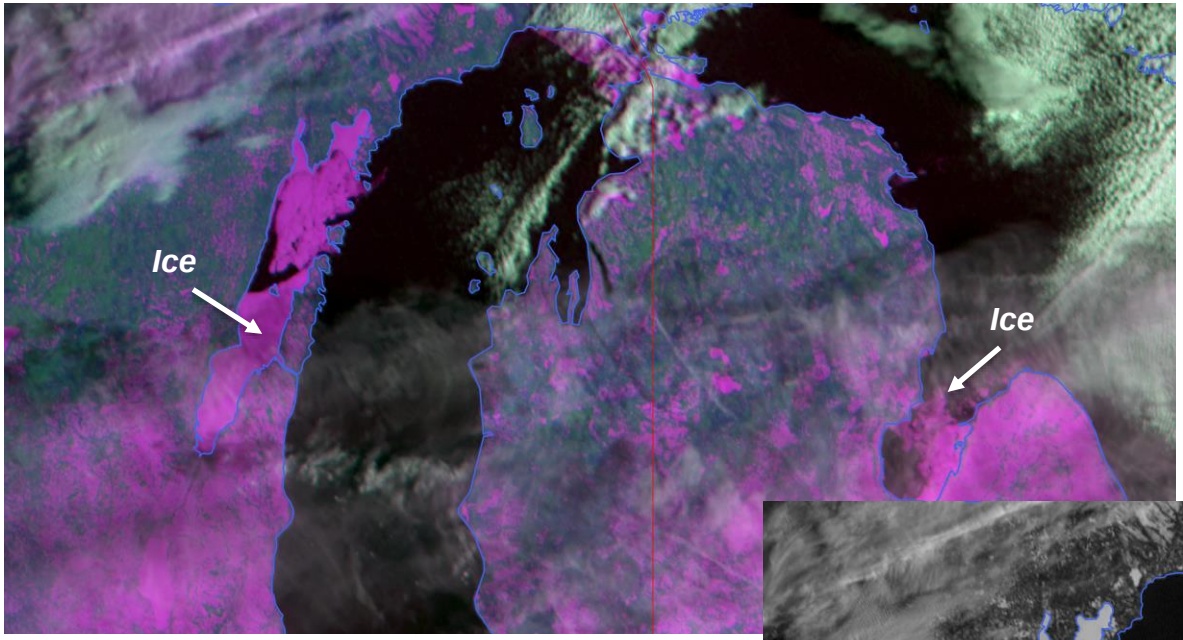
- Data latency to the operations floor
- Data formatting
- Imagery and derived products - obscuration from clouds
- File sizes/system lags
- Time to produce daily hemispheric marginal ice zone products
- Time to produce weekly hemispheric analysis – Arctic and Antarctic

Illustrations of GOES and JPSS Satellite Data used within USNIC Production Workflow

GOES-R Series Satellite Observations

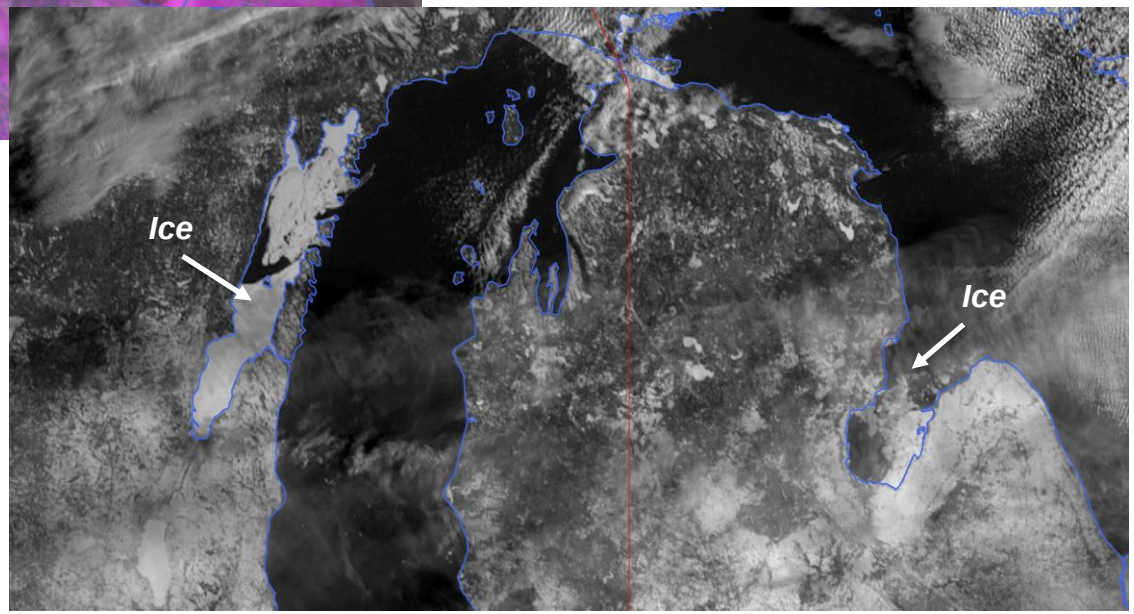
Illustrations from USNIC's SIPAS ice analysis system

Great Lakes, Northern Michigan



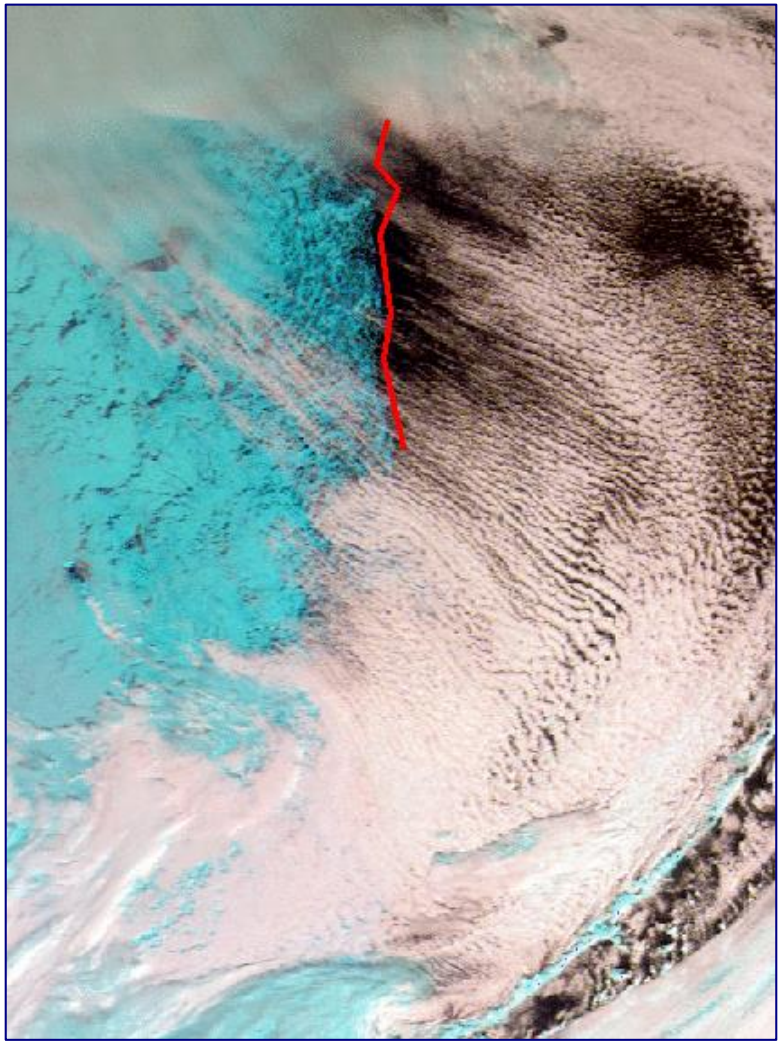
12 Feb 2020: GOES-16 ABI Multiband composite of the Red Band (Band 02), near-IR snow/ice band (Band 05), near-IR 'Veggie' band (Band 03)

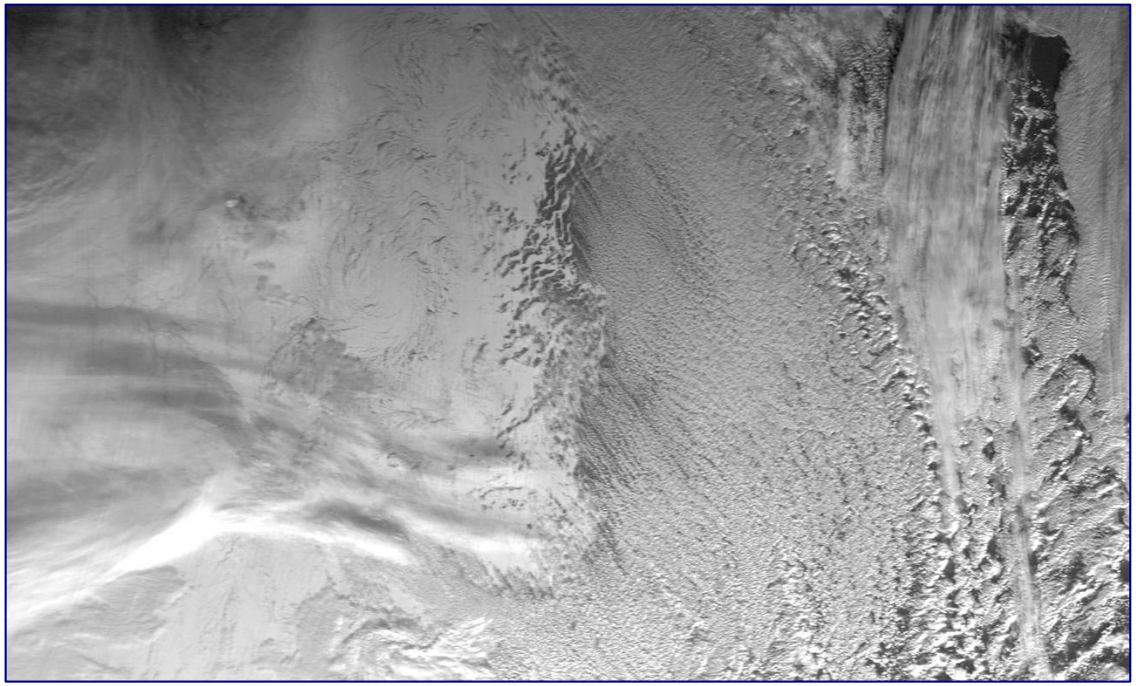
12 Feb 2020: GOES-16 ABI CH 2



GOES-R Series Satellite Observations

Animations of data within SIPAS/ArcGIS environment



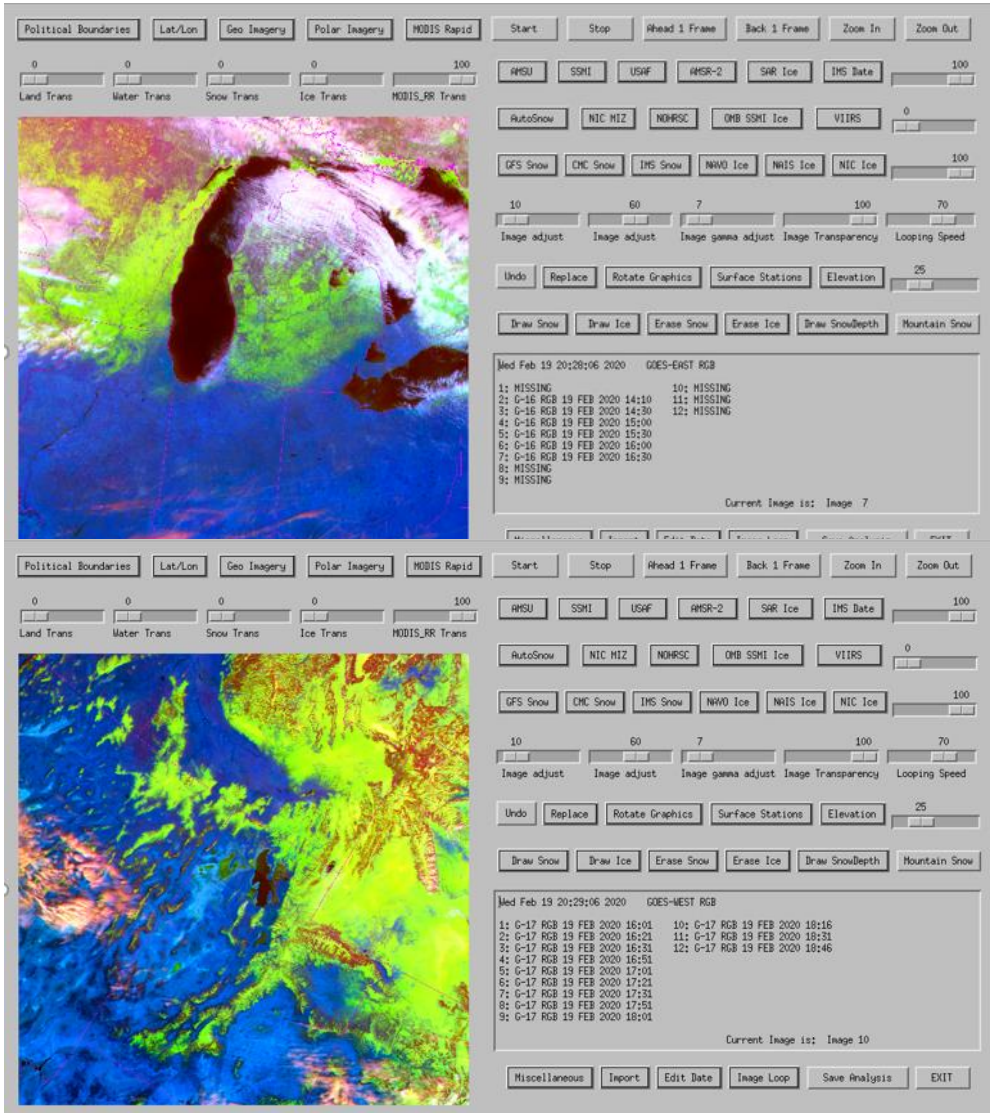


GOES-16 ABI channel 2 on Sep 12, 2017 (10hr loop)

GOES-16 ABI Image using channels 5, 3, and 2. The red line traces the overall ice edge not fully seen in any individual still image, demonstrating the utility of time animations not only for ice motion but for the mapping and characterization of sea ice.

GOES-R Series Satellite Observations

Illustrations from USNIC's IMS snow and ice analysis system

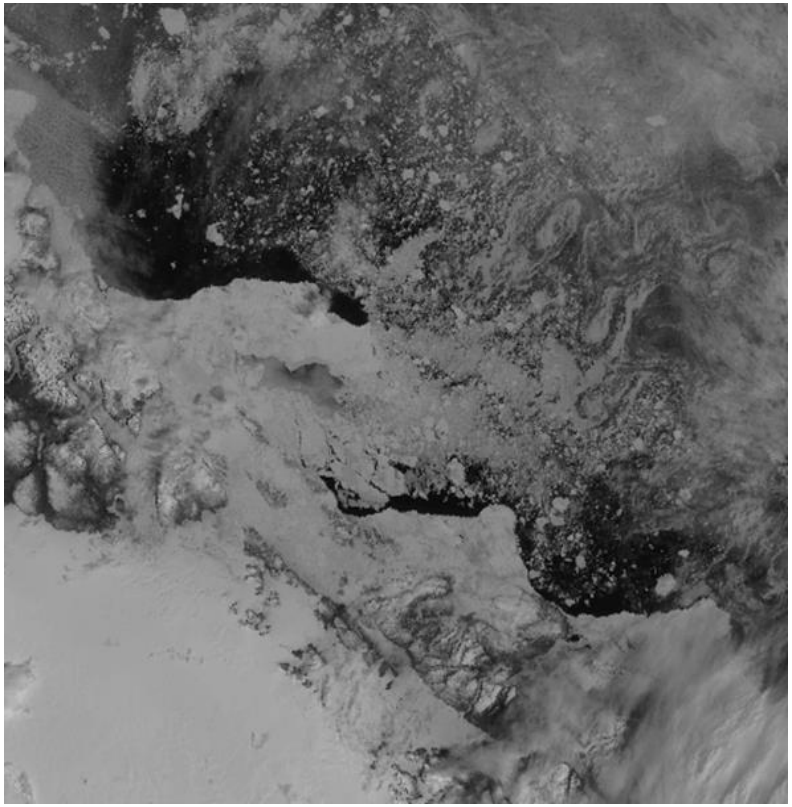


- ***Feb 19th: GOES-16 ABI RGB Multiband composite***
- ***Used for Snow/No Snow classification by Analyst***
- ***Location: Midwest U.S./Lake Michigan***

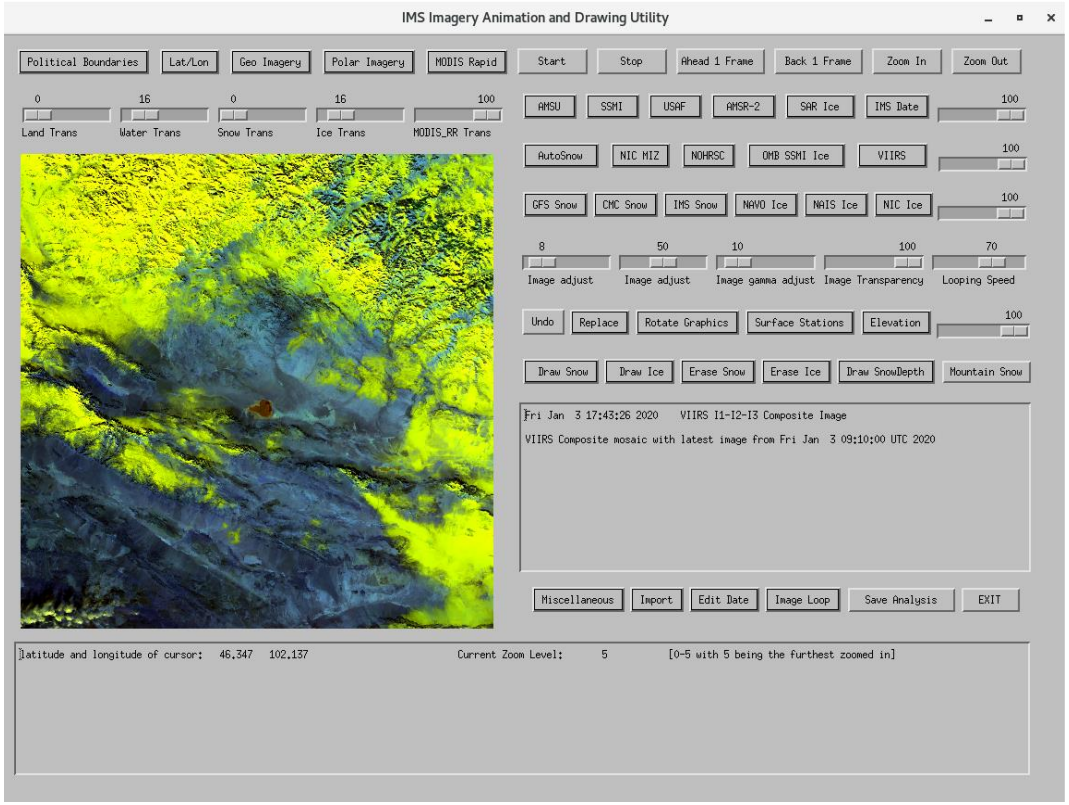
- ***Feb 19th: GOES-17 ABI RGB Multiband composite***
- ***Used for Snow/No Snow classification by Analyst***
- ***Location: Western U.S.***

JPSS Satellite Observations

Illustrations from USNIC's IMS snow and ice analysis system



System: IMS
NOAA-20 VIIRS Imagery, Band I5

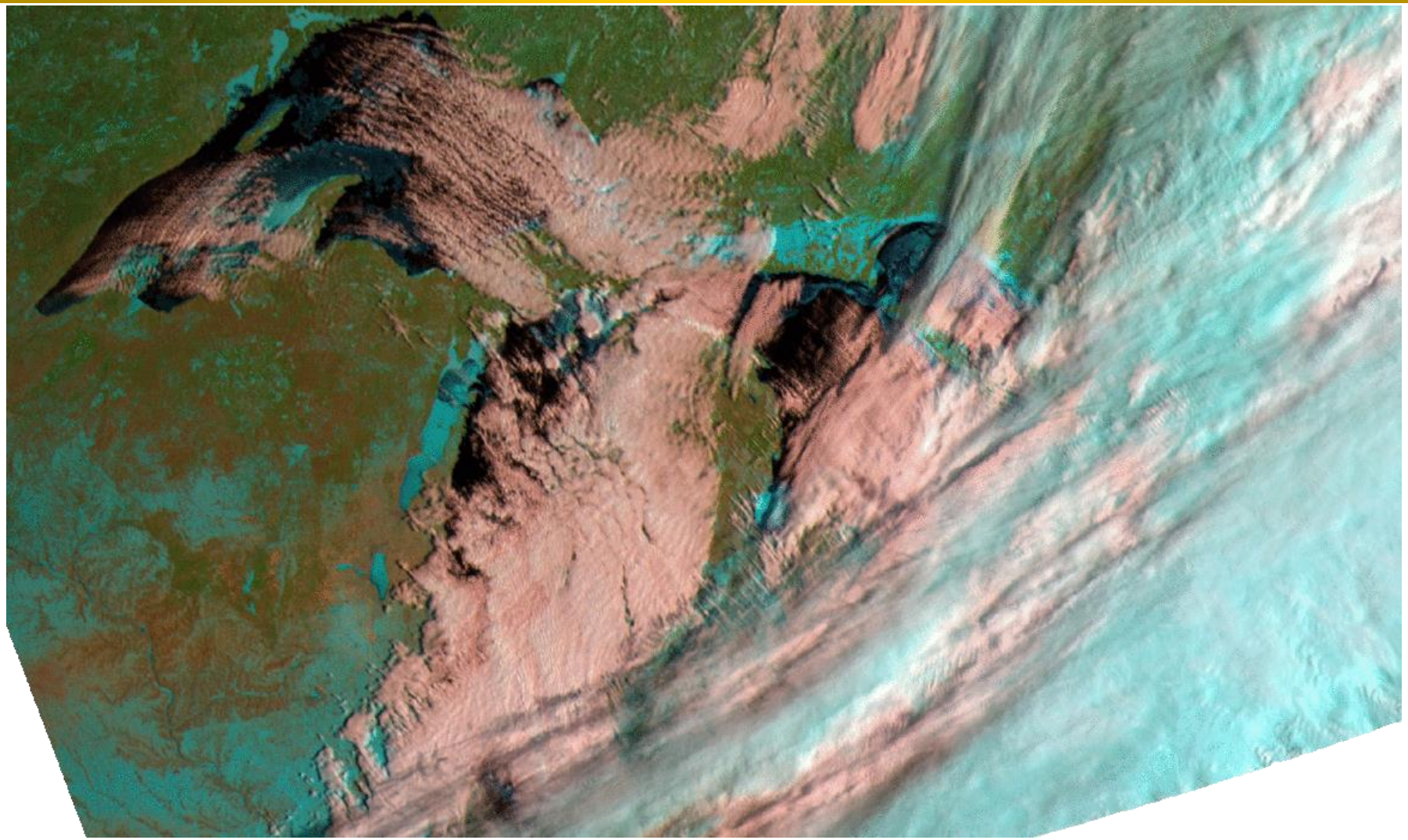


System: IMS
NOAA-20 VIIRS Imagery, Band I1, I2 and I3 Composite Image composite

Ideas for Satellite Data Improvements for Snow and Ice Analysis

- **Continued timely access to not only NOAA data, but also to non-NOAA datasets *(hosting global operations means dependencies on domestic and international data)***
- **Incorporate GOES West animation into operations *(will support NWS Alaska Sea Ice Program)***
- **Incorporate VIIRS imagery loops near poles for ice detection**
- **Explore more satellite derived products for operational value/use**
- **Continue to explore use of automation within operations**
- **Exploit and capitalize on recent ice forecast modeling *(lots of new science – pros and cons to this from operational perspective)***

Questions and Comments



Command Duty Officer: nic.cdo@noaa.gov | www.natice.noaa.gov | www.facebook.com/nationalnavalicecenter

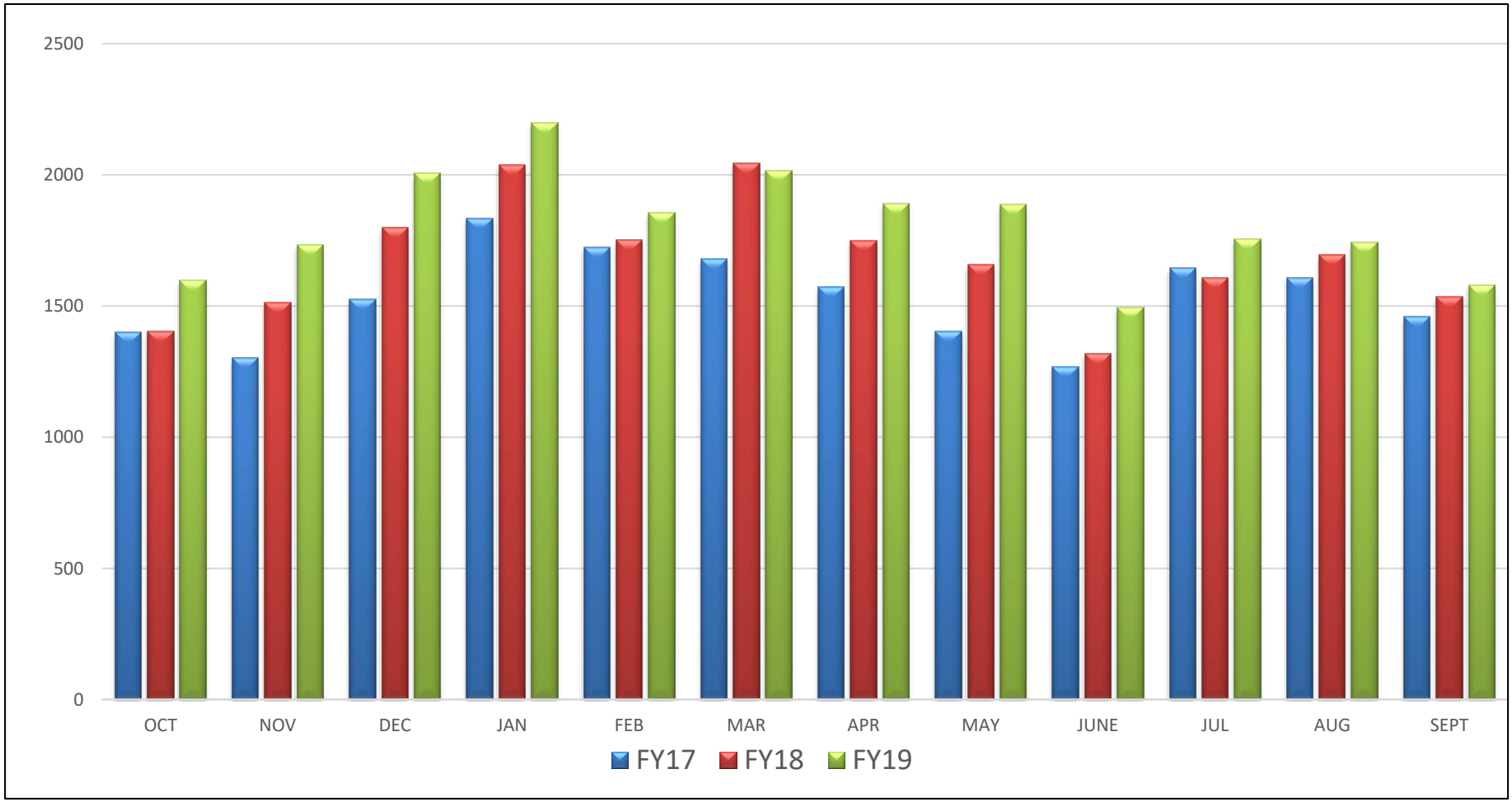
Backup

Hierarchy of Satellites/Sensors at USNIC

SIPAS Ice Analysis

Satellite	*Sensor*	*Sensor Type*	*Resolution at Nadir*	*Swath Width*	*Received From*	*Satellite Owner*	*Orbit Type*	*Repeat Cycle*
RADARSAT-2	C-Band; 5.405GHz	SAR	100 - 3m	500km - 50km	MDA	MDA	Sun-synchronous	24 days
Sentinel 1A/1B	C-Band; 5.405GHz	SAR	40 - 5m	400 - 80km	NOAA/STAR	ESA	Sun-synchronous	6 days
Terra/Aqua	MODIS	Visible; IR	500 - 250m	2330km	NOAA/NESDIS	NASA	Sun-synchronous	16 days
NOAA-20 (JPSS-1)	**VIIRS**	**Visible; IR**	**750 - 375m**	**3000km**	**NOAA/NESDIS**	**NOAA**	**Sun-synchronous**	**16 days**
GOES-E/W	**ABI**	**Visible; IR**	**2000 - 500m**	**40km**	**NOAA/NESDIS**	**NOAA**	**Geostationary**	**Cont.**
METOP-A/B	AVHRR	Visible; IR	1090m	2000km	NOAA/NESDIS	NOAA	Near-polar	29 days
METOP-A/B	ASCAT	Active microwave	50 - 25km	500km	NOAA/NESDIS	EUMETSAT	Sun-synchronous	29 days
GCOM-W1	AMSR-2	Passive microwave	10 - 5km	1450km	NOAA/NESDIS	JAXA	Sun-synchronous	2 days

U.S. National Ice Center
Increasing Demand Year Round



21% growth in operational support since 2017

Arctic Cryosphere Satellite Needs

JPSS/GOES-R PG/RR Summit

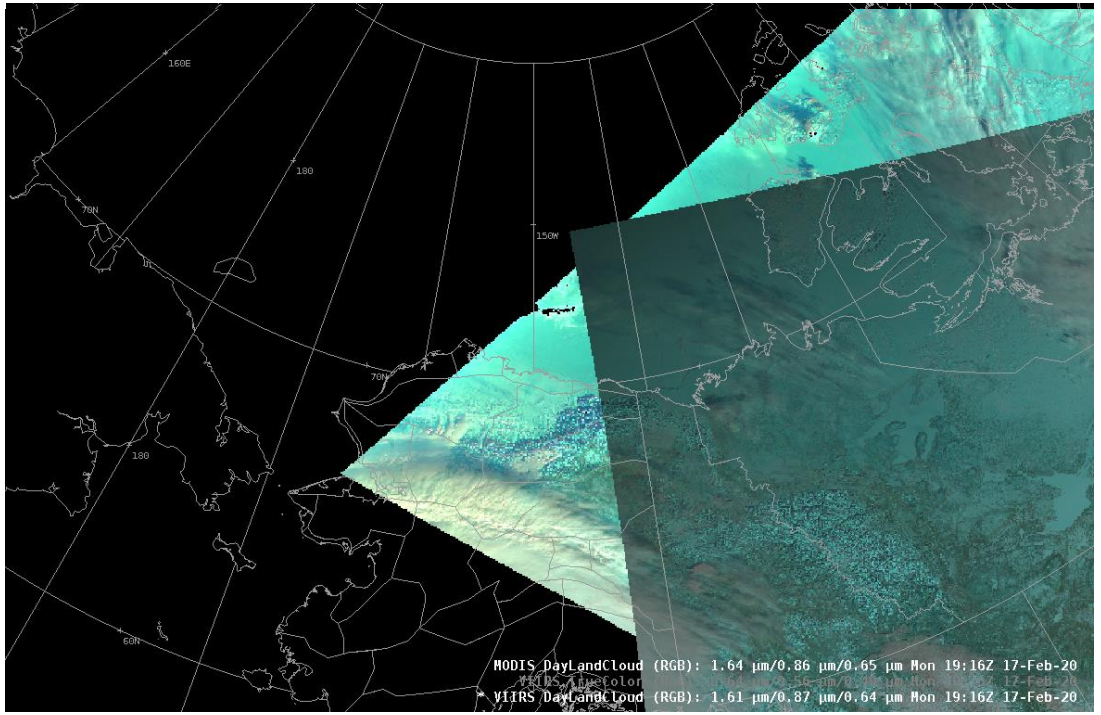
Carl Dierking

UAF/GINA

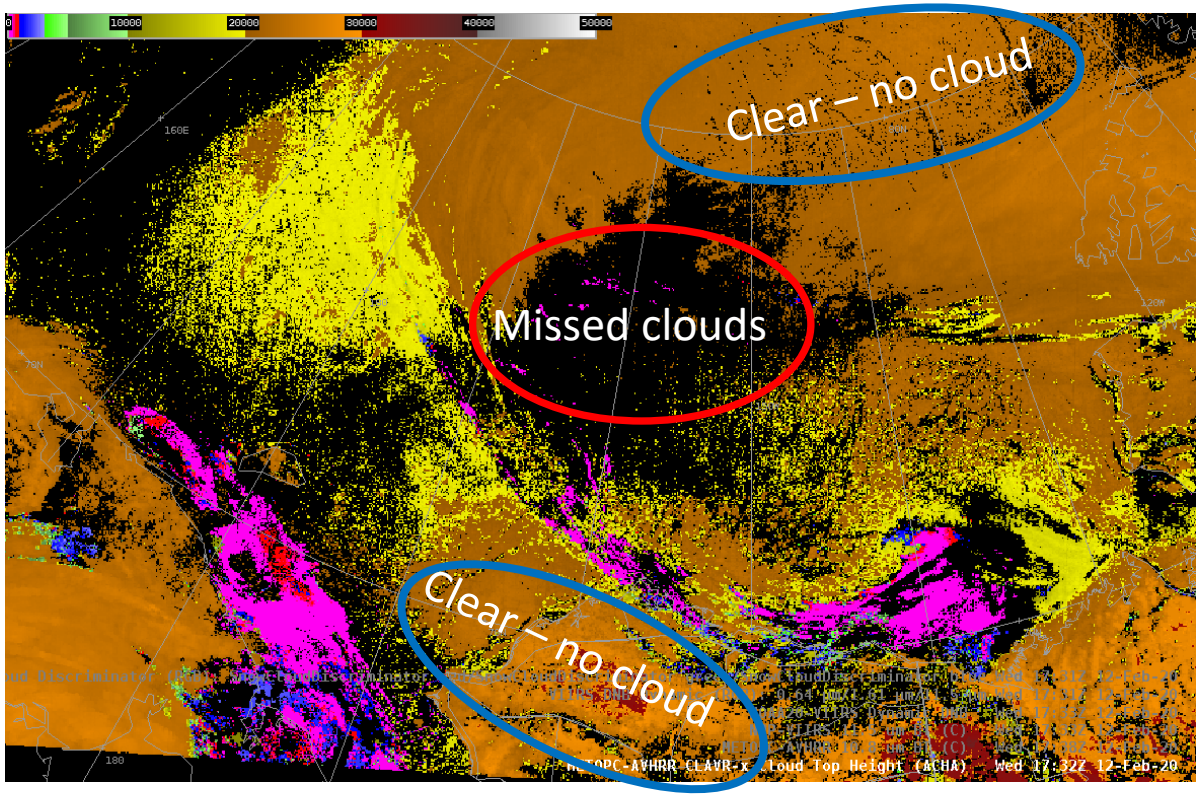
The Arctic is a very active place

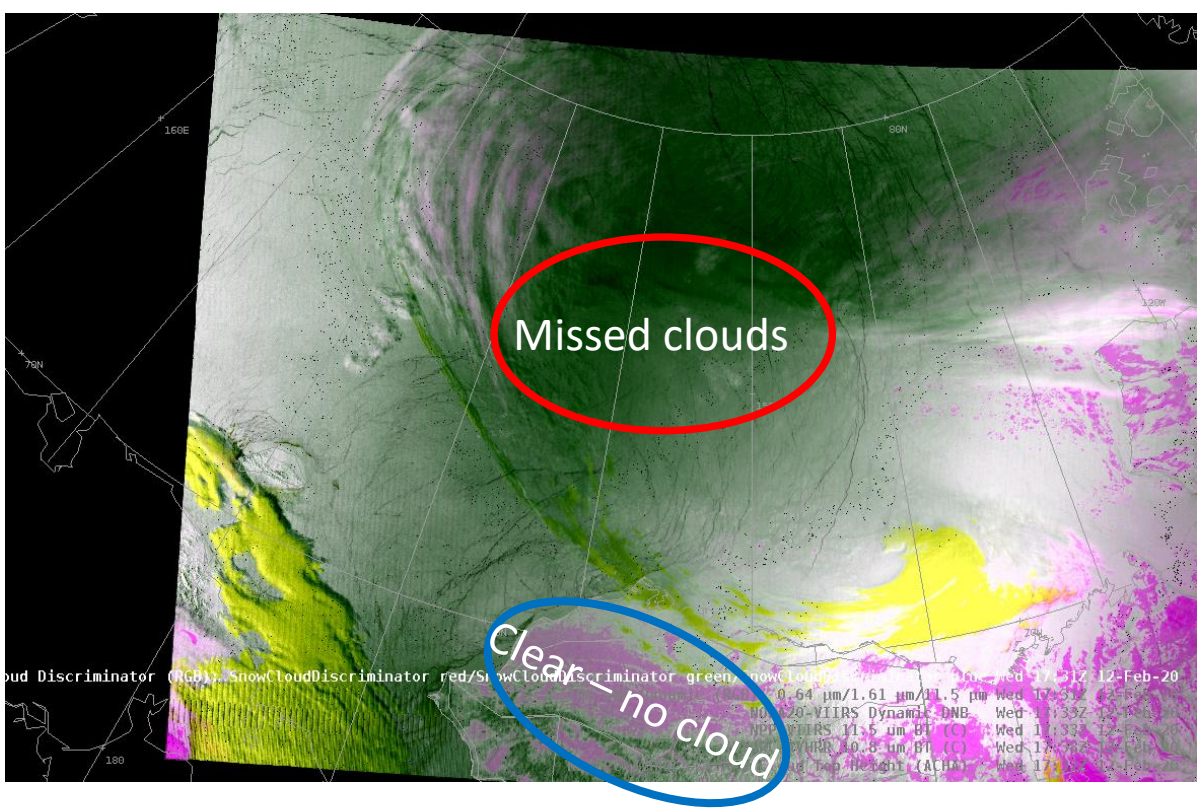
Winter Challenges

- Dark – Visible & Reflectance bands not available
- White - snow/ice cover much of land/sea
- Different – LEO satellites vary in instrument configurations & capabilities
- Intense – changes more dramatic (snow/ice, temperature, wind, etc)



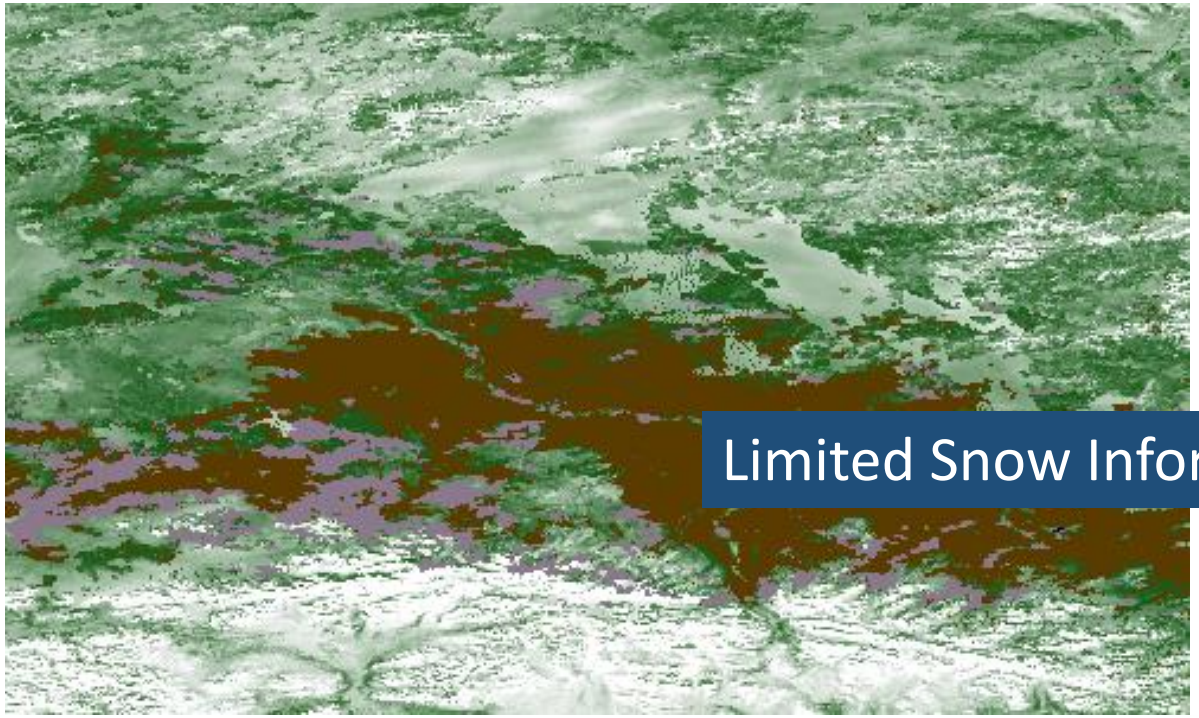
Cloud Identification (Mask)



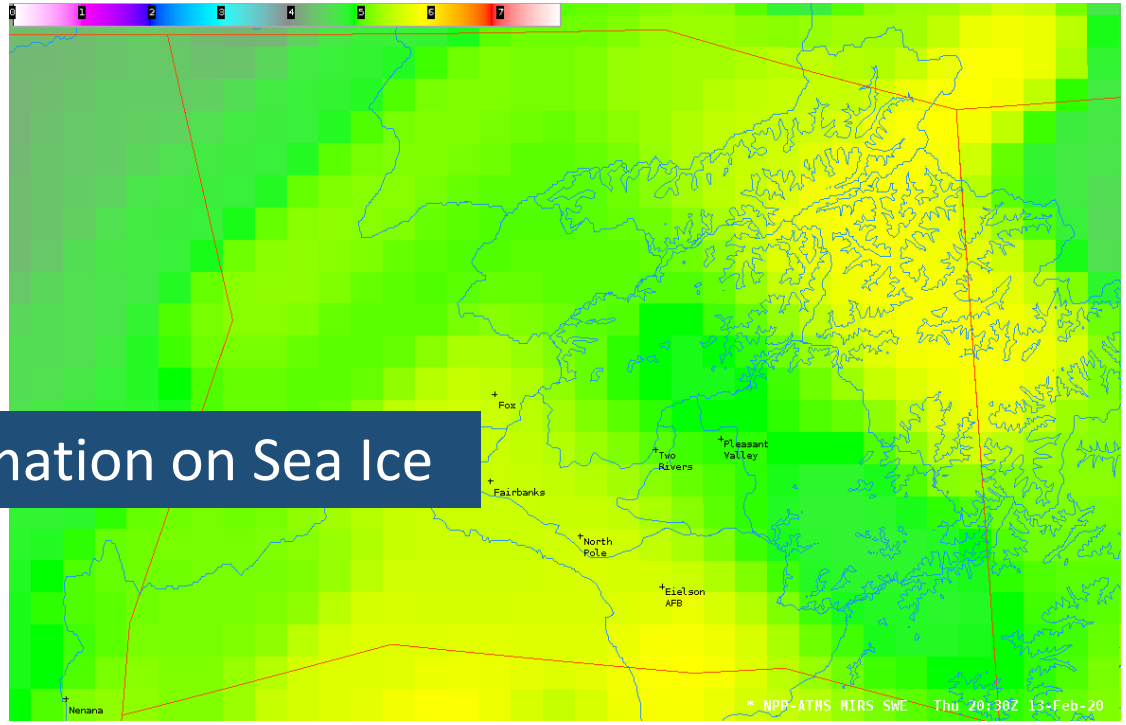


Difficult to Differentiate Cloud from Ice/Snow in Winter

Snow/Ice Characterization & Quantification



Limited Snow Information on Sea Ice



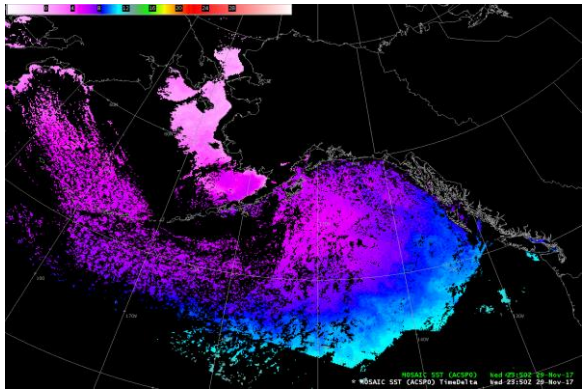
VIIRS Snow Cover Fraction

- Day only (requires visible & reflectance bands)
- Affected by land cover & terrain steepness
- Clear Sky only, dependent on cloud mask, some issues with shadows
- No Quantity or Characterization

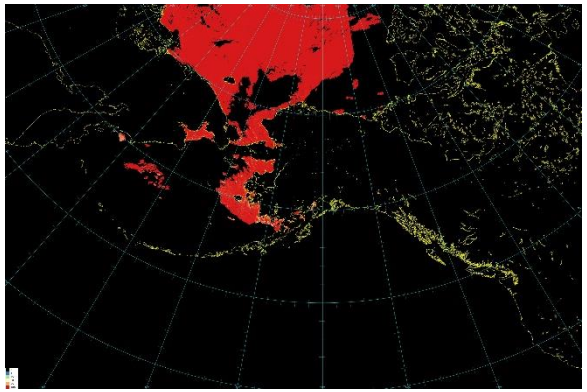
Microwave Snow Depth & SWE (MIRS, AMSR2)

- Coarse resolution
- Affected by land cover & terrain steepness
- Issues with ponding or melting snow, rain on snow, etc.
- Limits on max depth

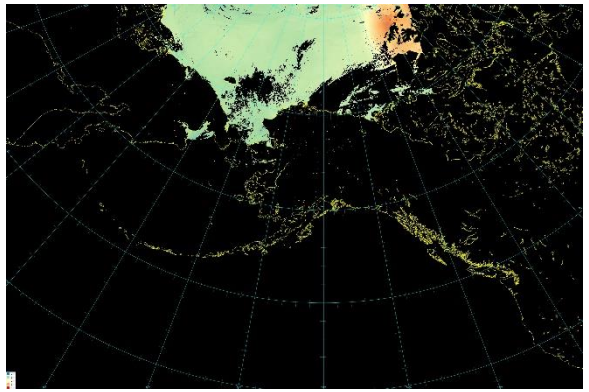
Many Products Depend on Cloud/Snow Input



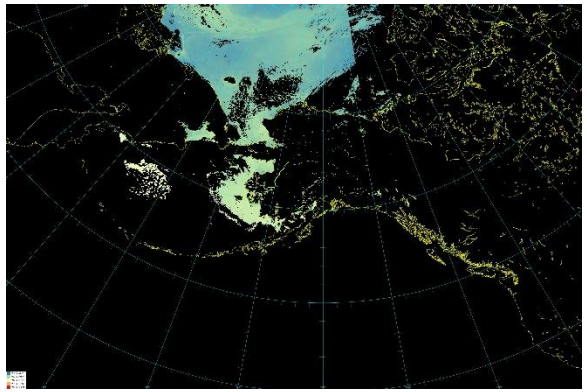
ACSPO SST



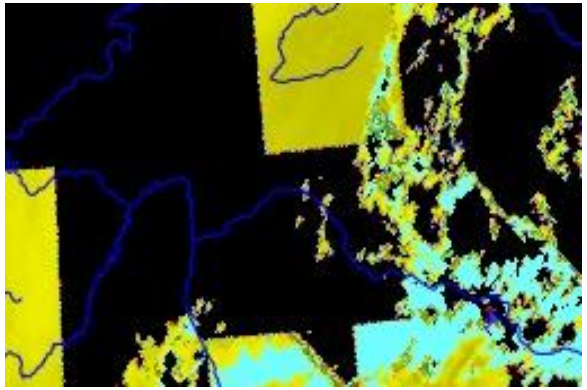
Sea Ice Concentration



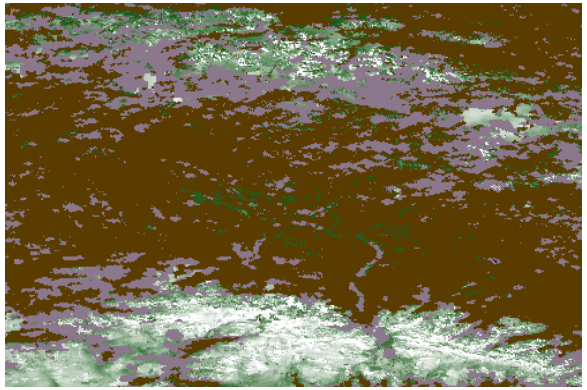
Sea Ice Temperature



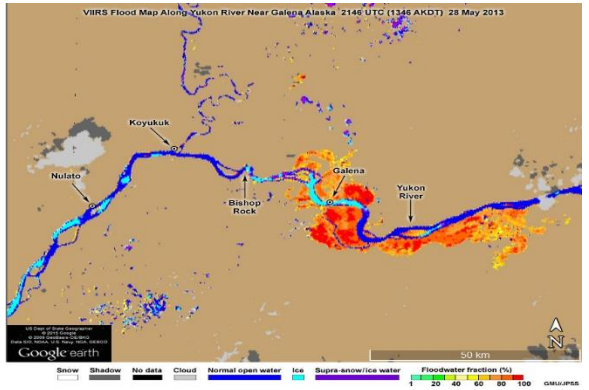
Sea Ice Thickness



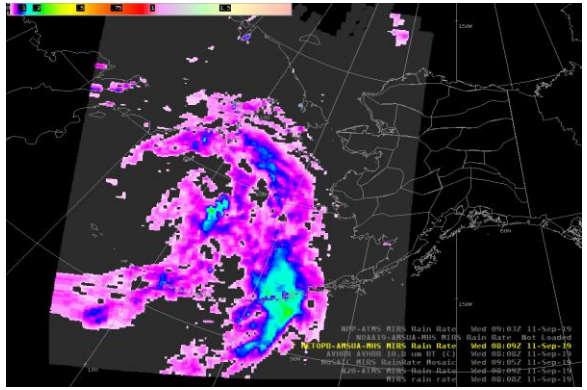
Cloud Base Height



Snow Fraction



River Flood Areal Extent



Microwave Rain Rates

Challenges and Questions…

- What, if anything, can be done to improve cloud mask and snow mask input during artic winter to cryosphere product algorithms?
- Are there current and future sensors that can be utilized to improve cloud and snow analysis?
- Are there calibration issues over the Arctic that are different?

Role of SAR in Operational Cryospheric Monitoring

Sean Helfrich, sean.helfrich@noaa.gov

Frank Monaldo

Chris Jackson

Tyler Ruff

Xiaofeng Li

SAR Based Measurements and Products

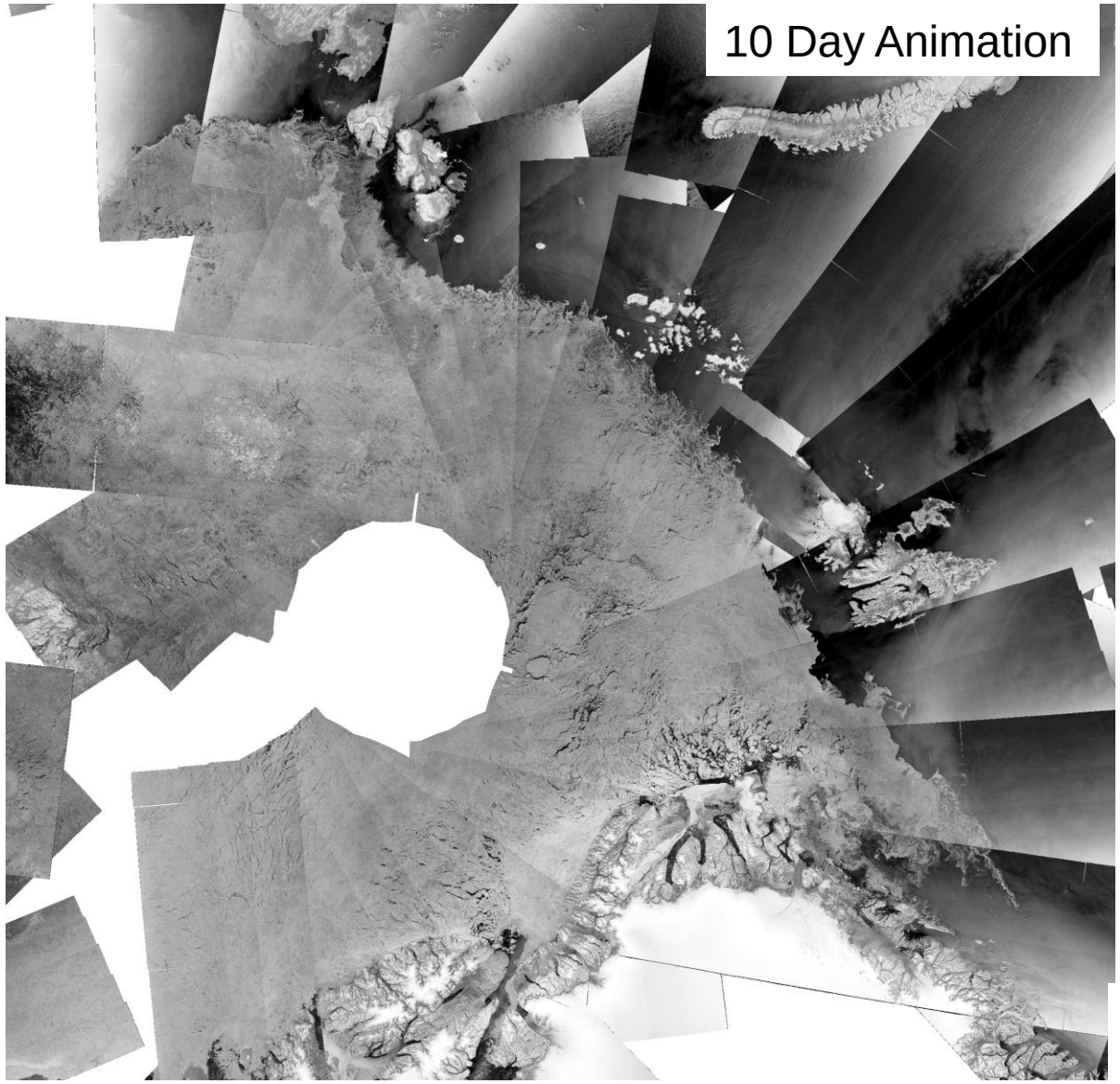
General SAR parameters

- Active microwave – Day-Night Independent
  - **L-band (23 cm)**
  - **C-band (5 cm)**
  - **X-band (2 cm)**
- Not obscured my clouds and rain
- Swath widths from 240 to 400 km
- Resolutions from **10** to **50** m.
- NOAA acquires ~ **450** SAR images
- Geolocation to within a pixel for modern SARs

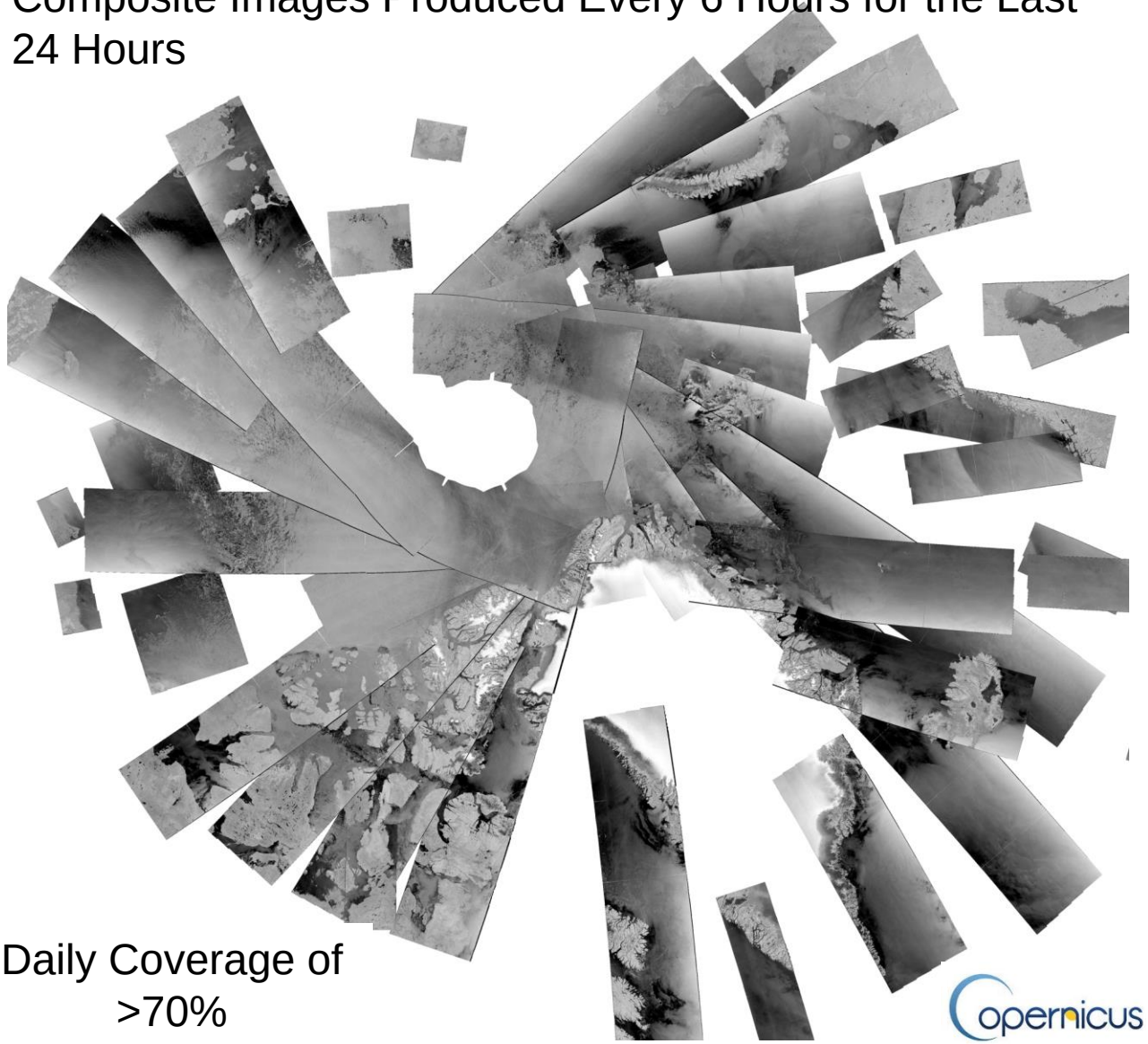
Current SAR Products

- **Imagery :** Uses by ice, oil, and ocean analysis and forecasters
- **Ice:** Radar cross section is affected by surface roughness and volume scattering.
- **Winds**: The higher the wind the higher the roughness and the higher the cross section.
- **Waves**: Roughness higher at the wave crests.
- **Oil**: Oil smooths the surface and decreases radar cross section.
- **Flooding**: Smooth water has a lower cross section than the surrounding land.
- **Objects**: Direct specular reflection – Ships, Icebergs, and Platforms

SAR Mosaics (RadarSat 2 + Sentinel 1)

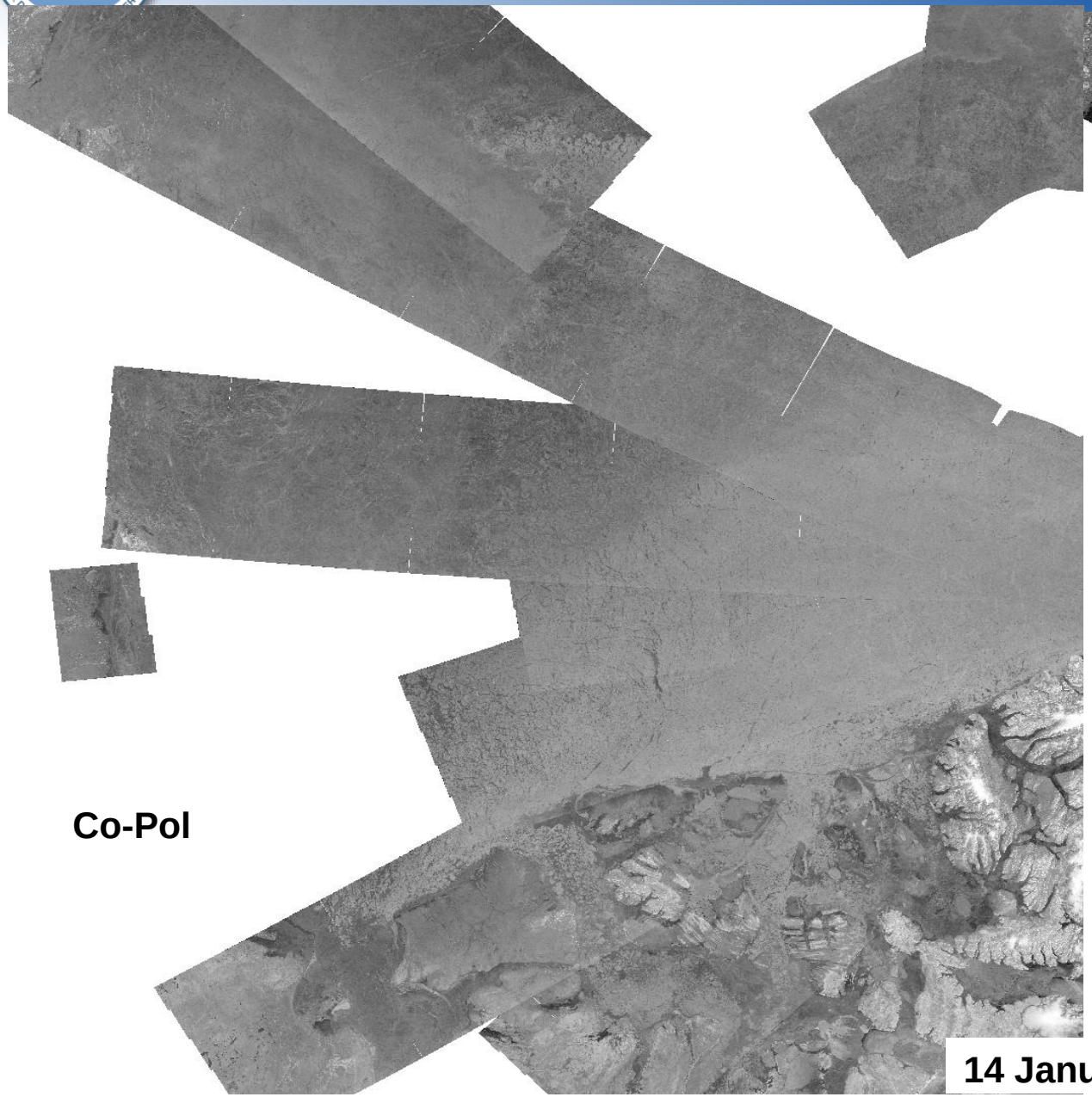


Composite Images Produced Every 6 Hours for the Last 24 Hours

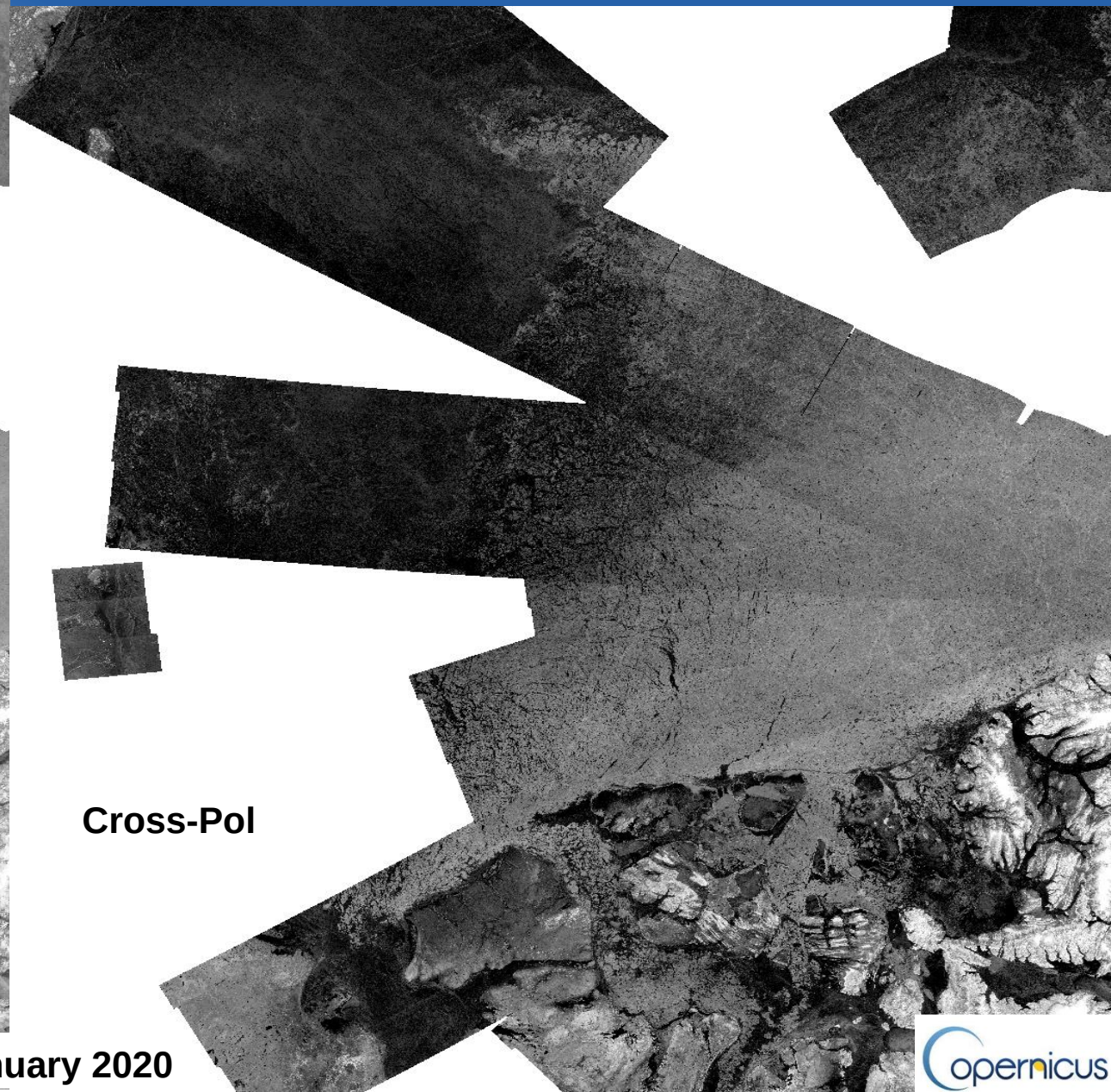


Daily Coverage of >70%

Co-Polarization and Cross-Polarization



Co-Pol

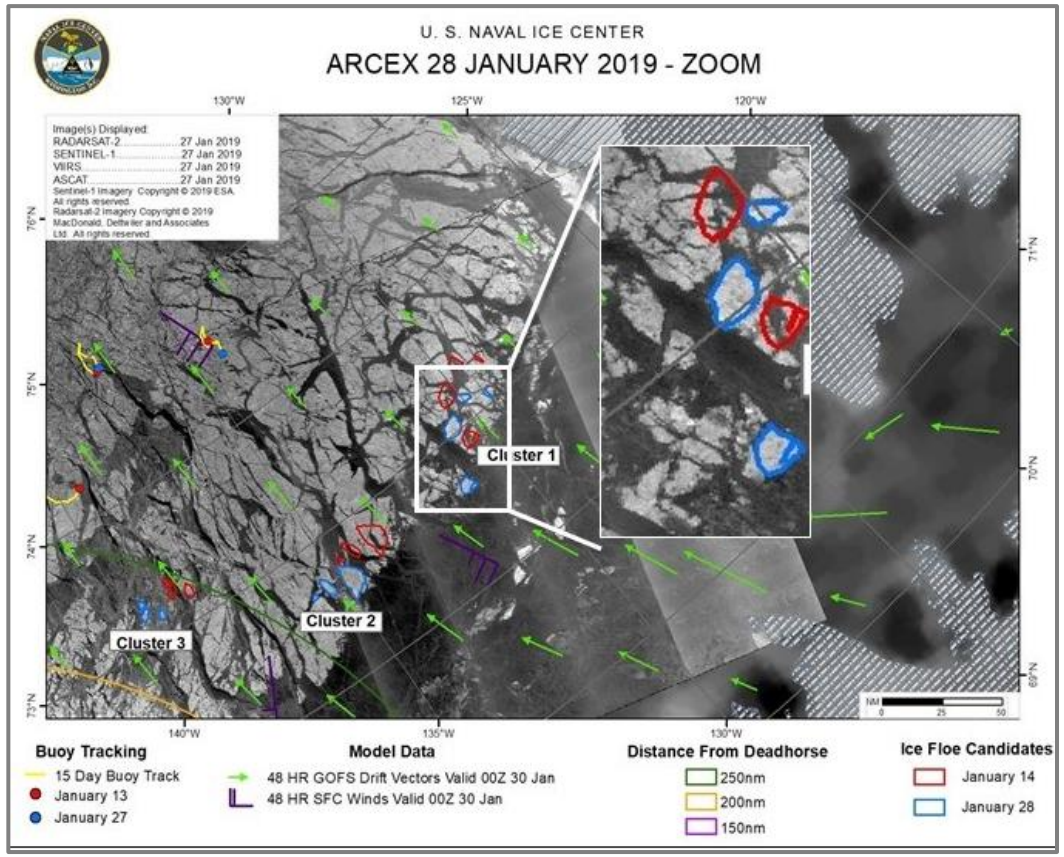


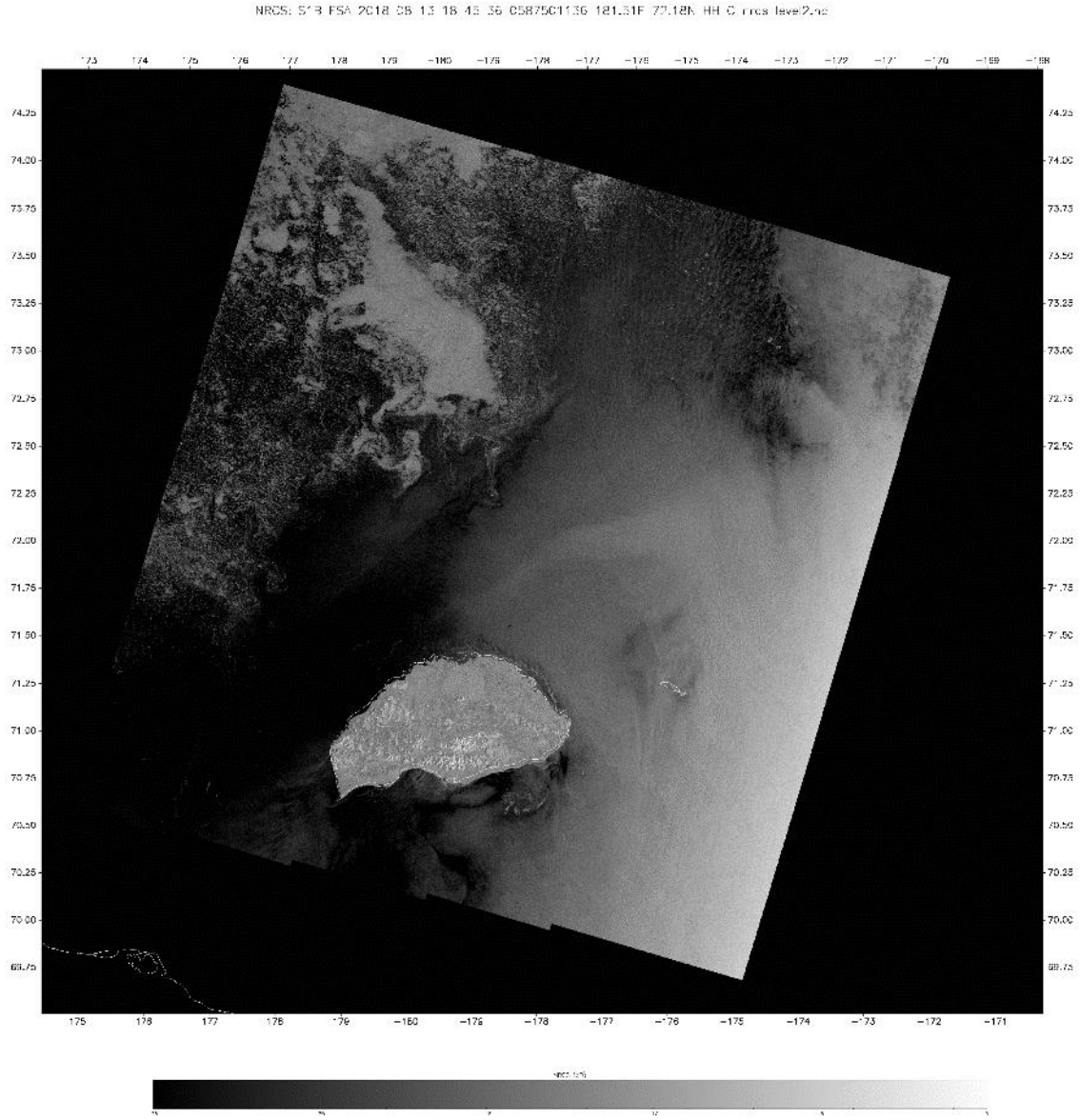
Cross-Pol

14 January 2020

Operational Use of Higher Resolution SAR Imagery

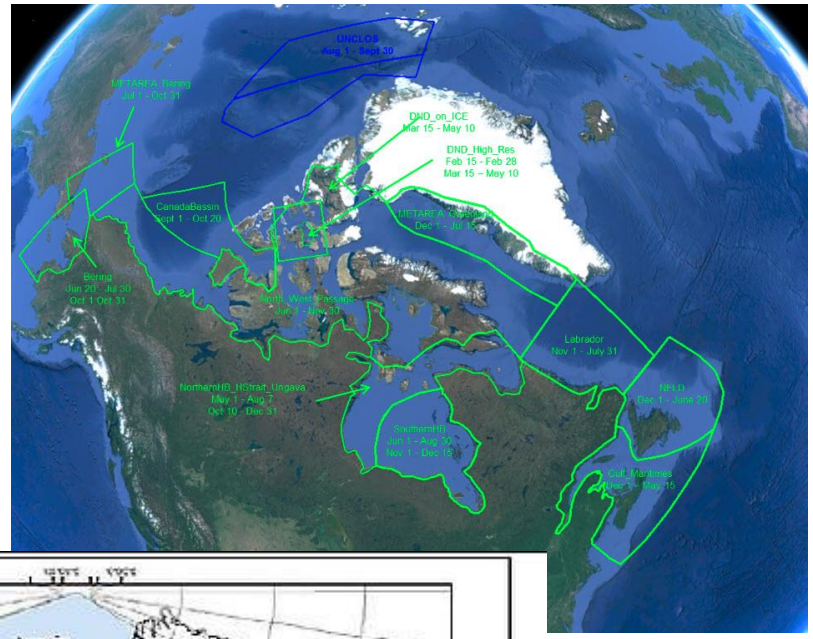
Normalized Radar Cross Section (NRCS): The NRCS provides analysts the ability to generate products from the image

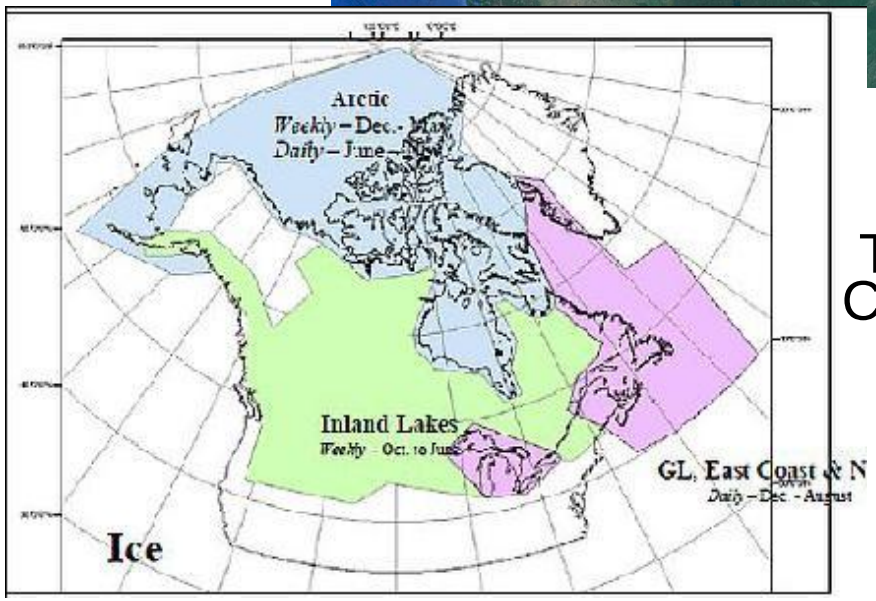




CSA RadarSat Constellation Mission

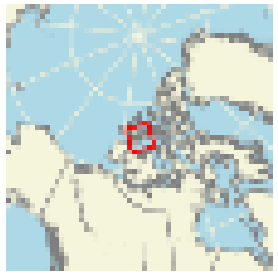
Ice Daily

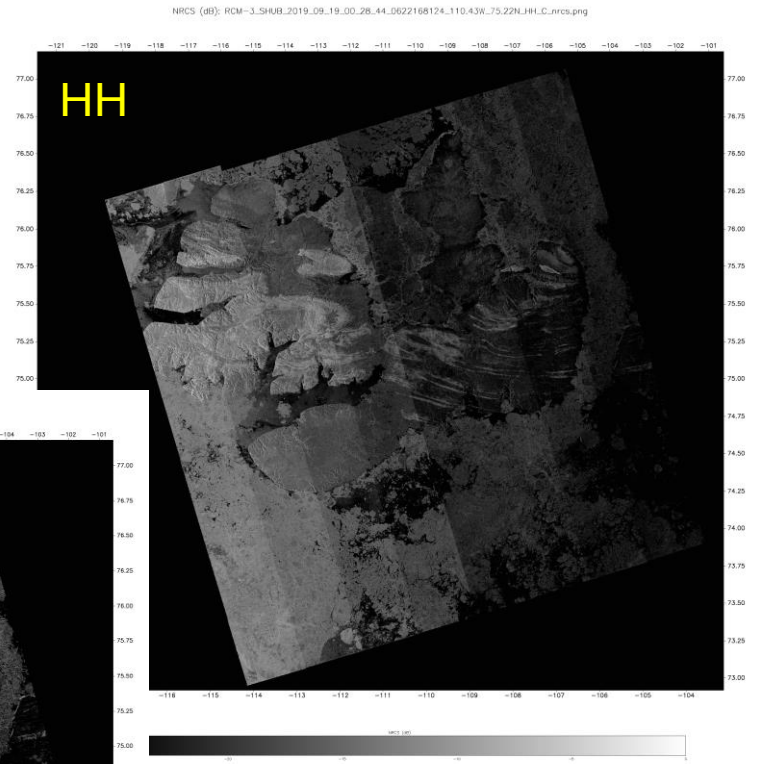


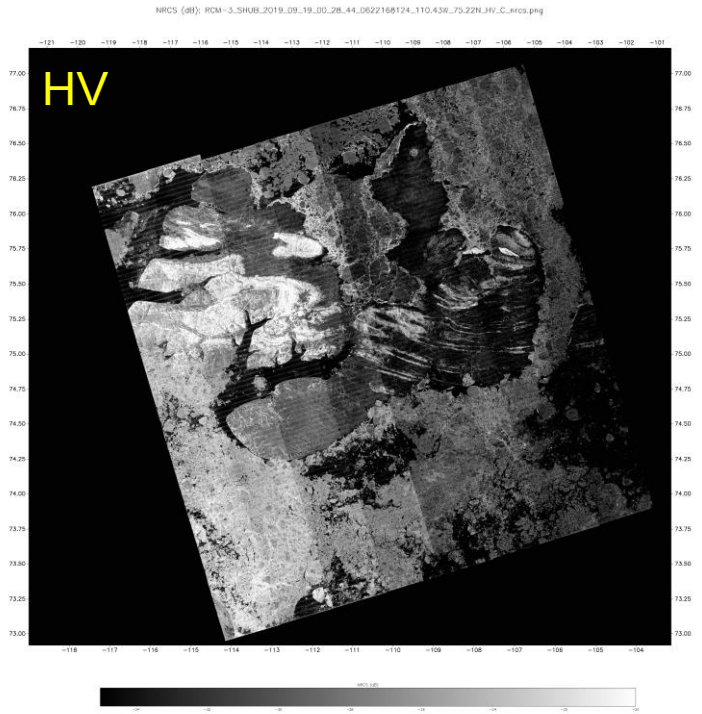


Total Ice Coverage

RCM-3 Image over Ice

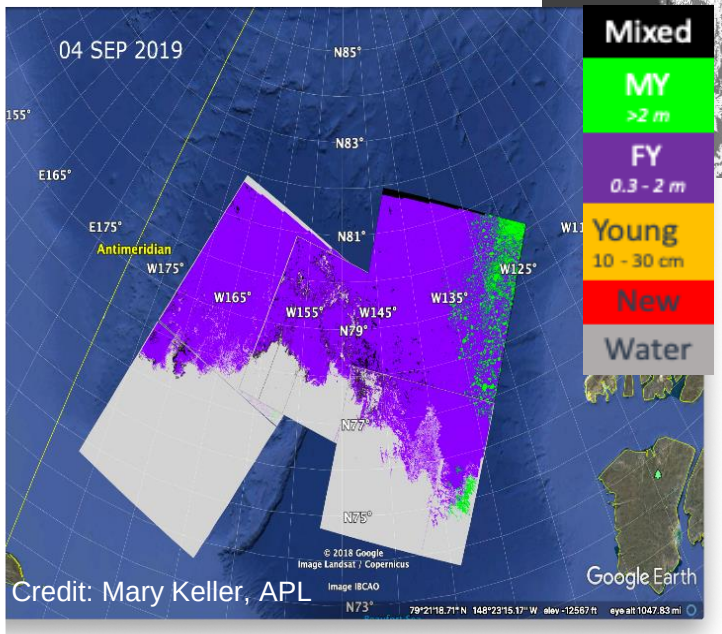






Role of Automation in STAR SAR Development

SAR Auto Ice Extent
20 - 22 April 2019



Auto Stage of Development

Objectives

- **Explore how to effectively apply the growing availability of SAR data**
- **Seek path to reduced time needed to generate ice and snow analysis**
- **Reduce human bias into ice and snow analysis**
- **Generate multisensor solutions to automated ice and snow charting**

Date: 14-Feb-2019
Day: 045

RSAT2 11:0

Classes SAR Wind | Class_tif Wind_Diff | Class_IceM

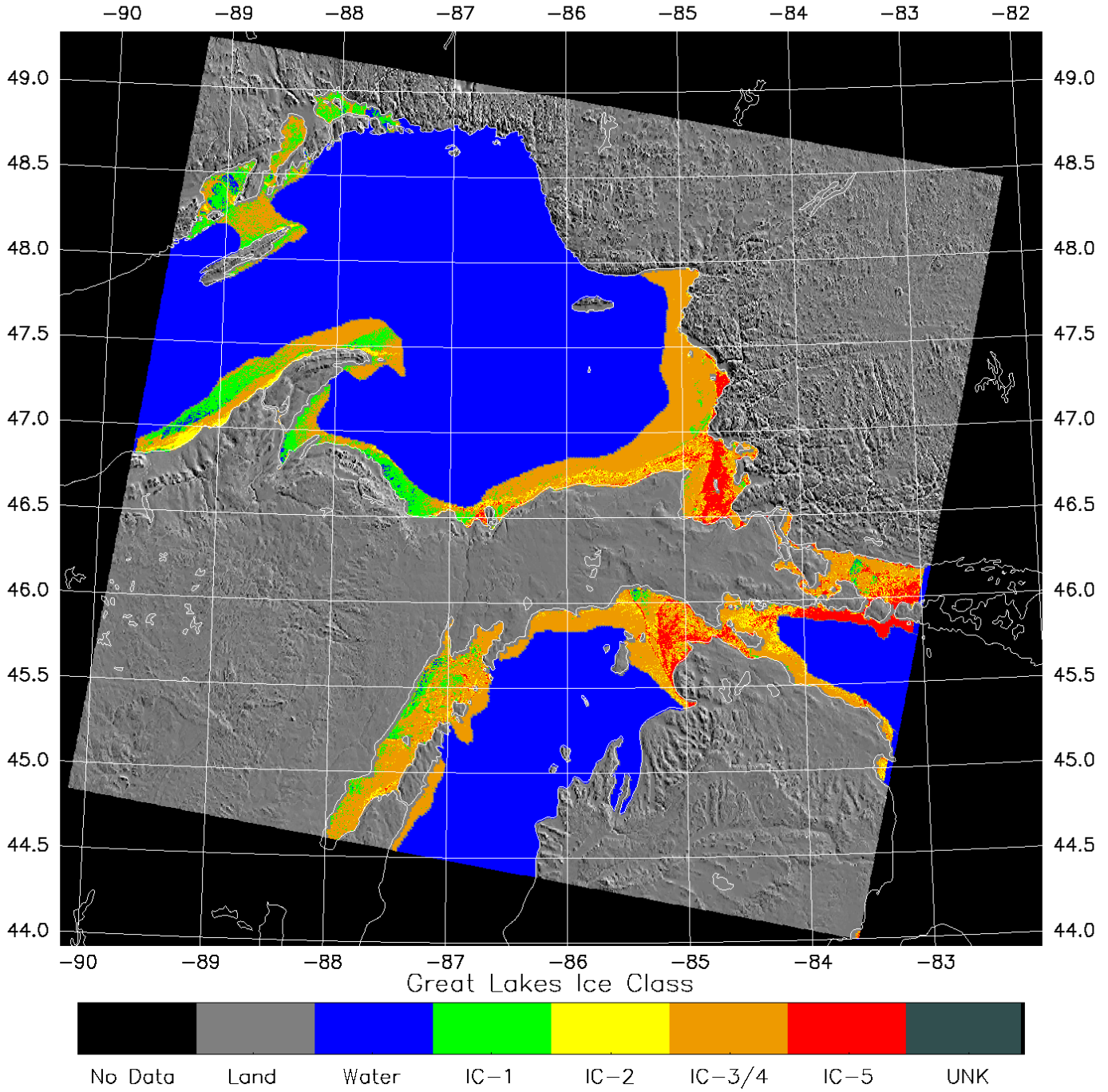
S1B 23:3

Classes SAR Wind | Class_tif Wind_Diff | Class_IceM

S1B 23:3

Classes | Class_tif | Class_

Ice Class: RSAT2_CSS_2020_02_21_11_54_05_0635601245_86.26W_46.69N_HH_C5_CFS05CDF_glice_level2.nc

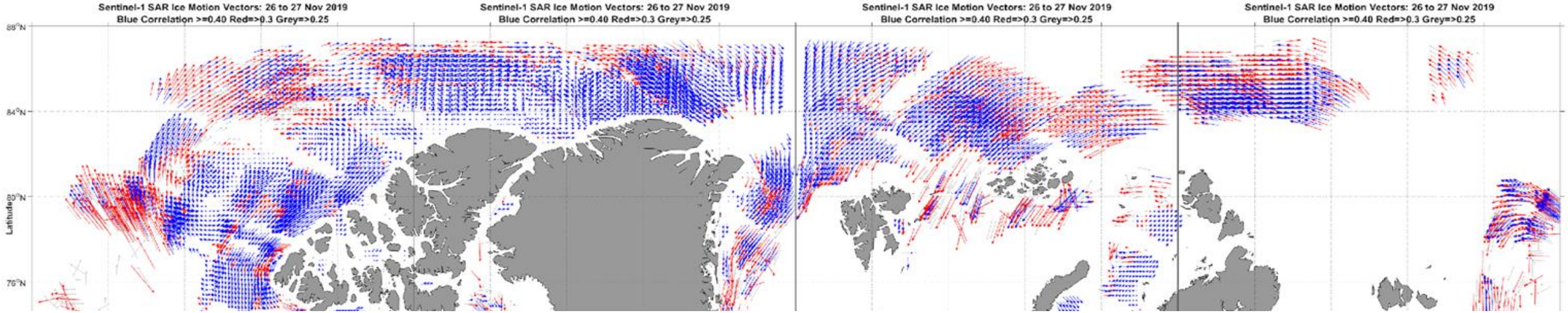


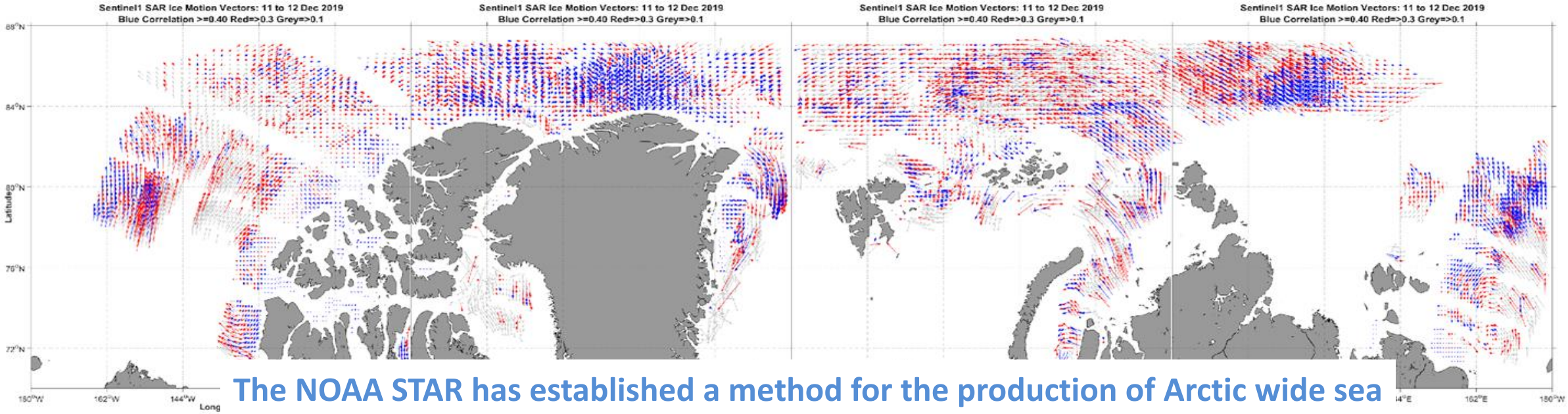
t: 500 m
d ICECON
ased on
alues

n:

s ICECON based 500m
s for the Great Lakes.
oe working with GLERL
astWatch to improve

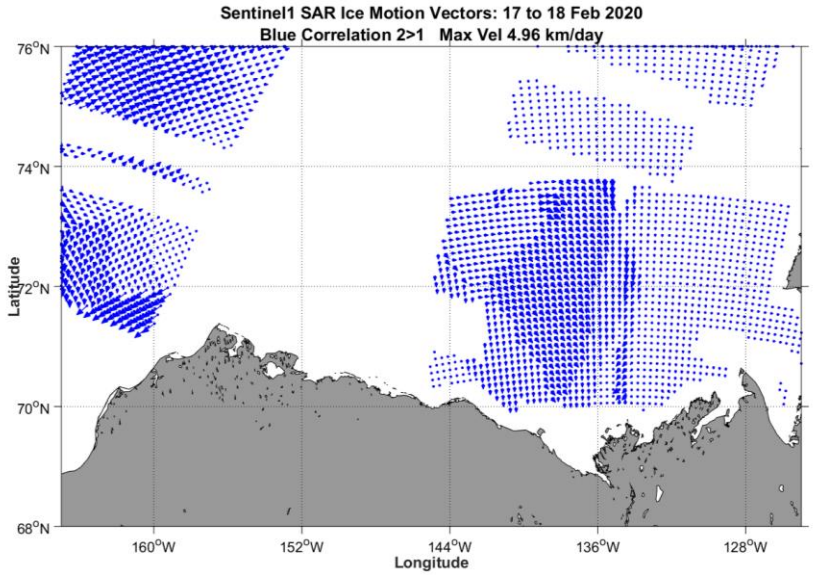
SAR Ice Motions

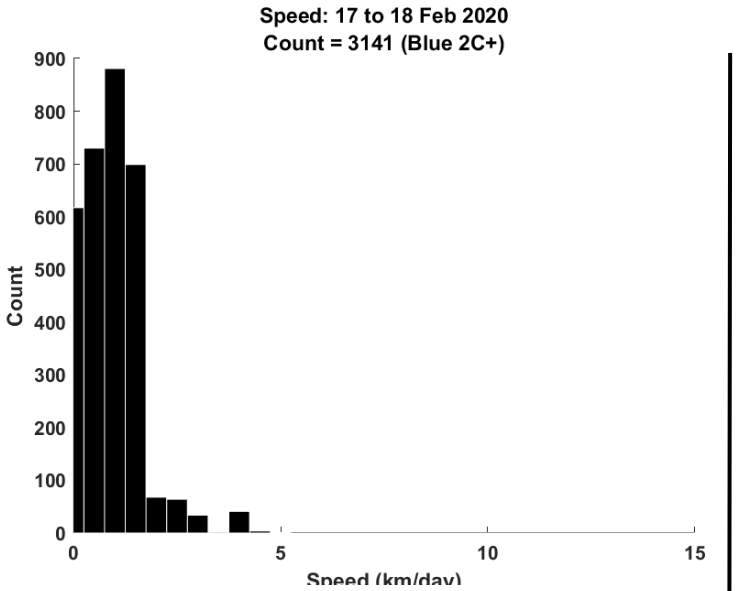


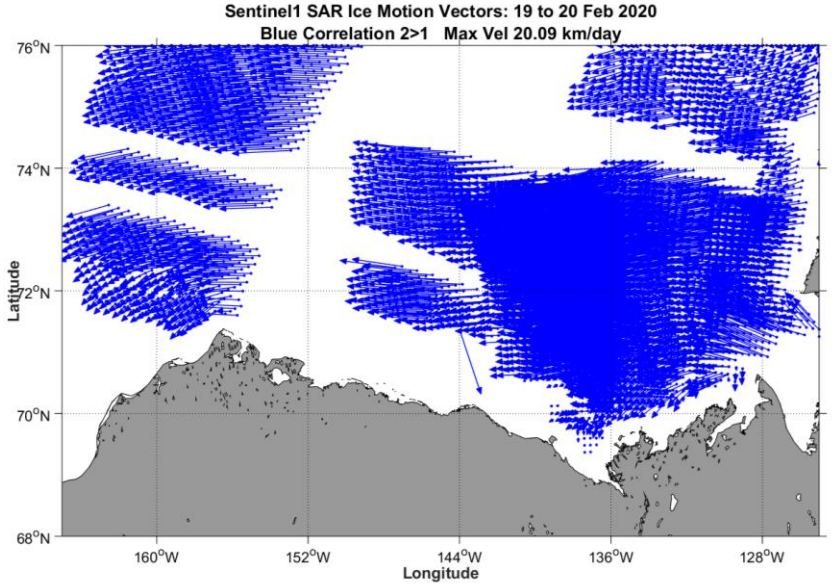


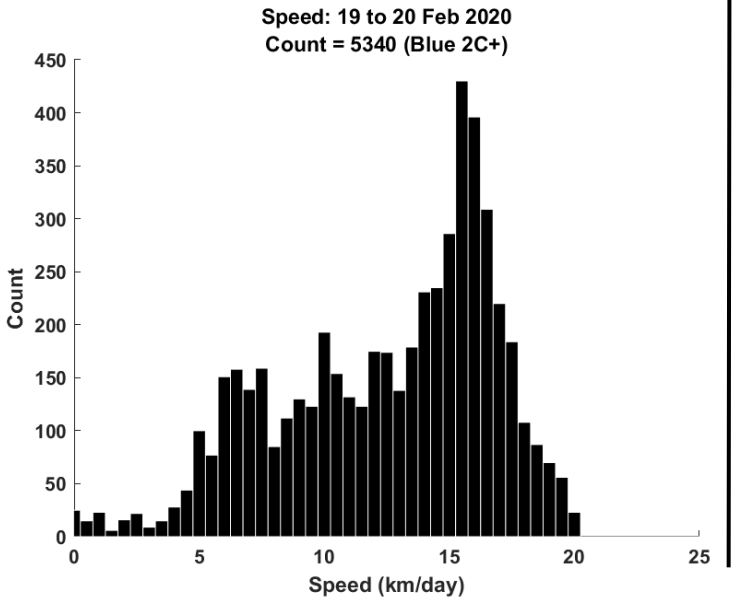
The NOAA STAR has established a method for the production of Arctic wide sea ice motion vectors (using S1 and R2 SAR)

SAR Ice Motions









Objectives

- Direct SAR Motions to support Ice Services
- Integration with JPSS Blended Ice Motions
- Assimilation into Models
- Add to CoastWatch
- Use for Fast Ice Detection
- Customize products to meet customer needs

Fit for Purpose SAR Ice Products

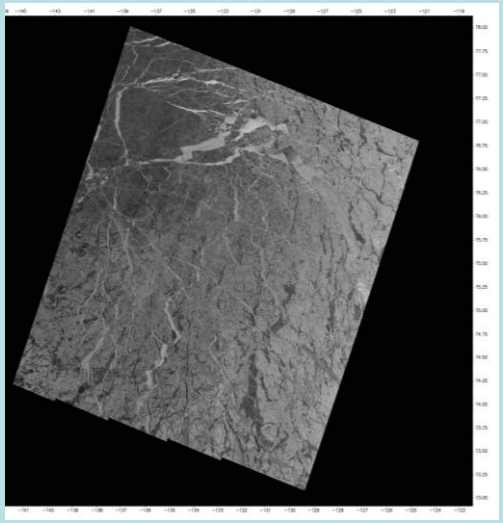
Imagery

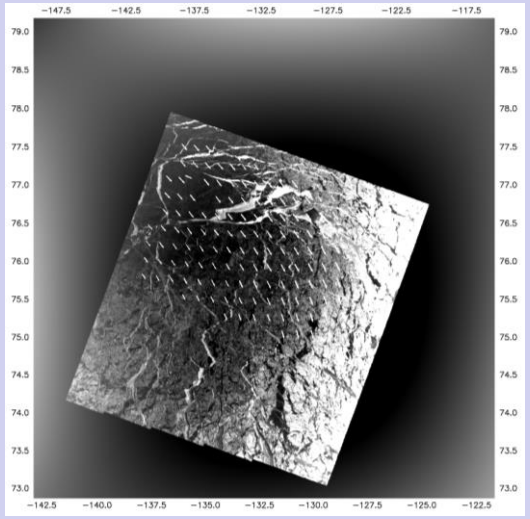
Product Generation

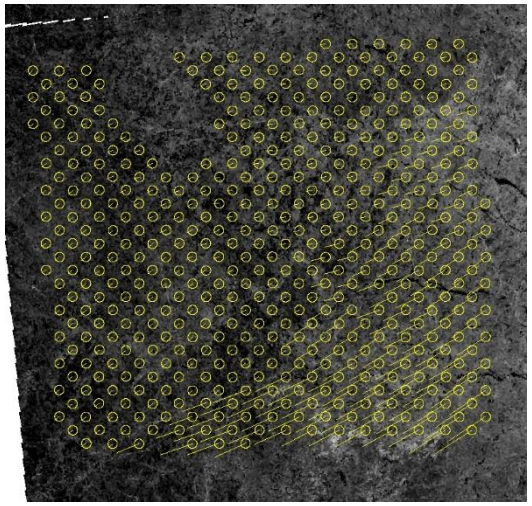
Customization

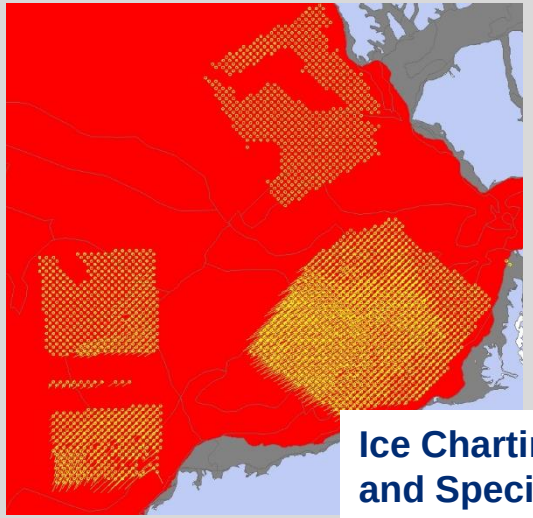
Integrate into Production

Ice Motions



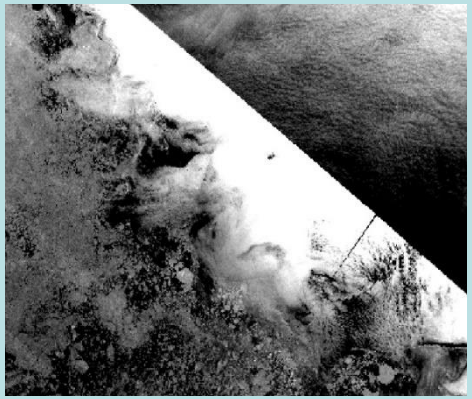


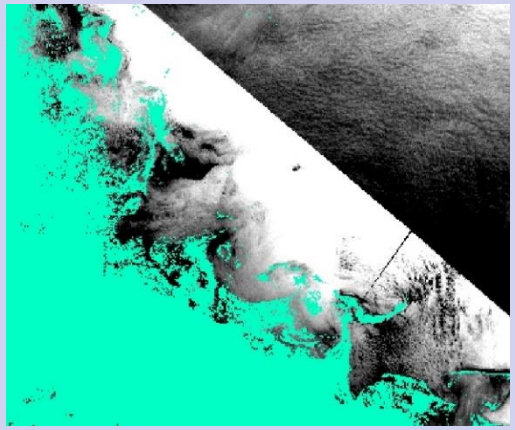


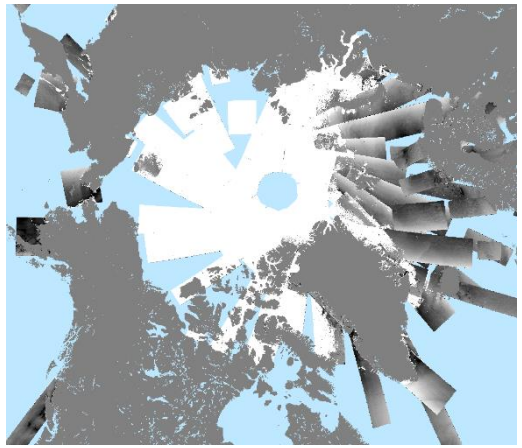


Ice Charting and Special Support

Ice Extent







IMS integration

Potential SAR Measurements

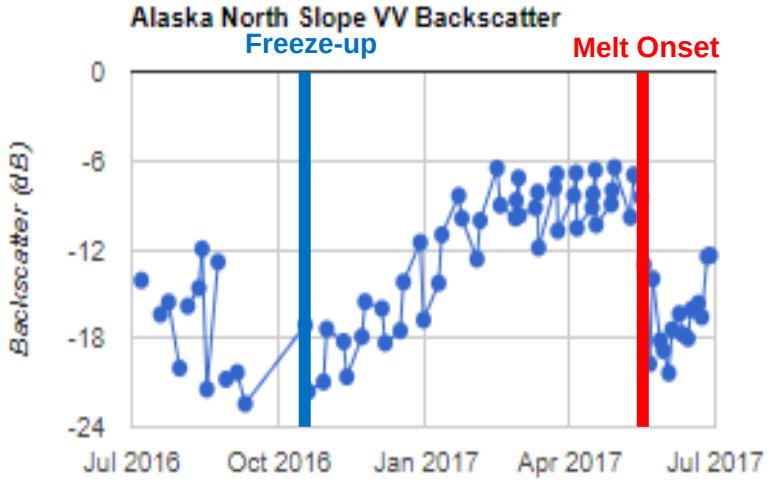
- burn scar mapping
- backscatter
- coastal land use ±
- convergent/divergent fronts
- flood/standing water ±
- **glaciers ±**
- **ice extent ±**
- **ice motion: direction and speed ±**
- **ice origin ±**
- **ice sheet topography**
- hurricane morphology ±
- **lake ice age w ±**
- land topography
- ocean and lake surface wind speed ±
- oil platform positions and change detection
- oil spill location
- **sea and lake ice thickness w ±**
- **sea ice age w ±**
- **sea & lake ice concentration w ±**
- shoreline mapping ±
- significant wave height ±
- **snow cover w ±**
- **snow water equivalent w ±**
- soil moisture w ±
- swell direction ±
- swell height
- swell period
- vessel positions w
- wave direction ±
- wave height ±
- wave period ±
- wave spectra

w = JPSS Level 1 Requirement

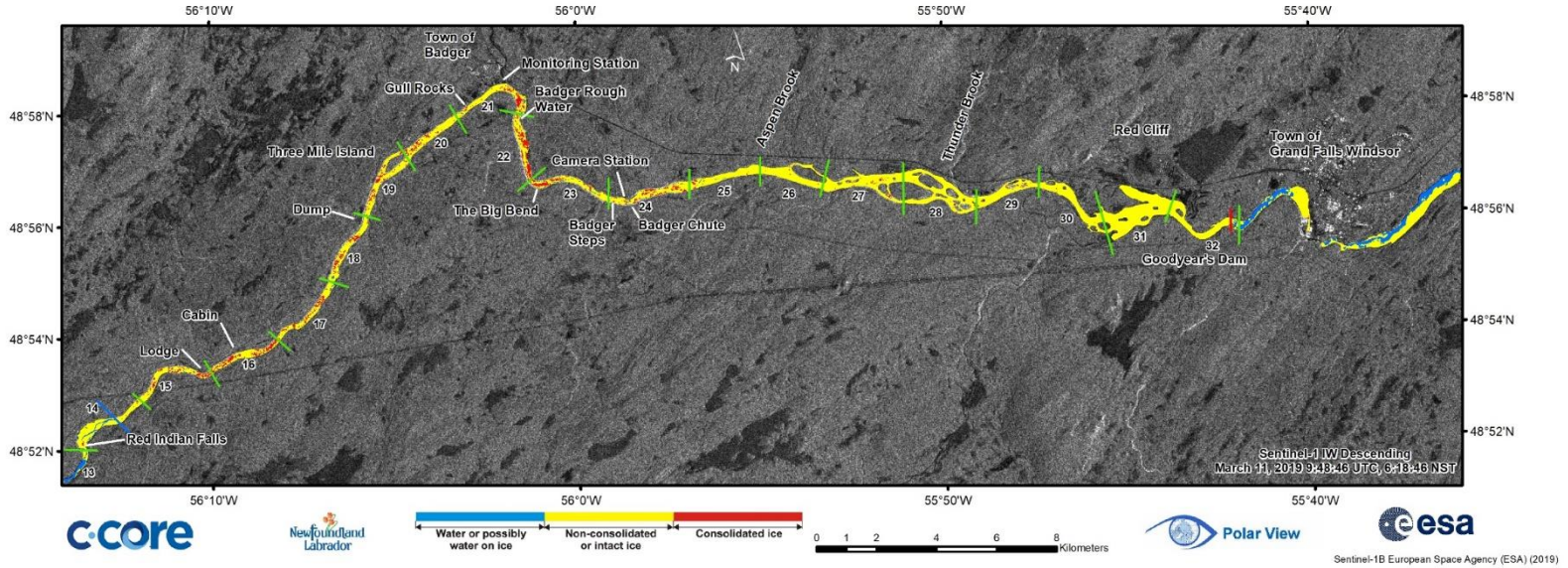
± = Mission Critical (P1) NOAA PORD Requirements (TPIO)

Development Lake and River Ice Monitoring with SAR

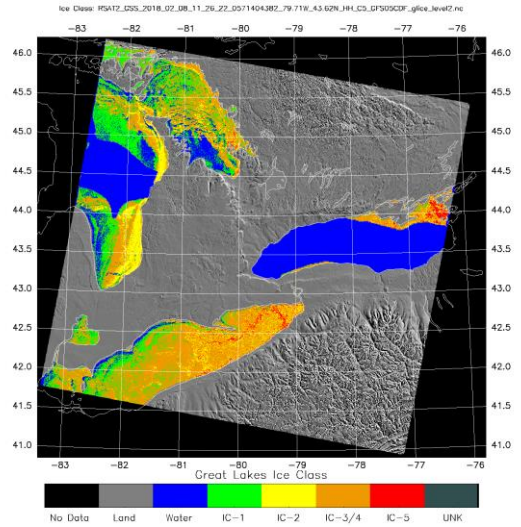
Lake Ice Phenology Monitoring



Exploits River - Ice Classification

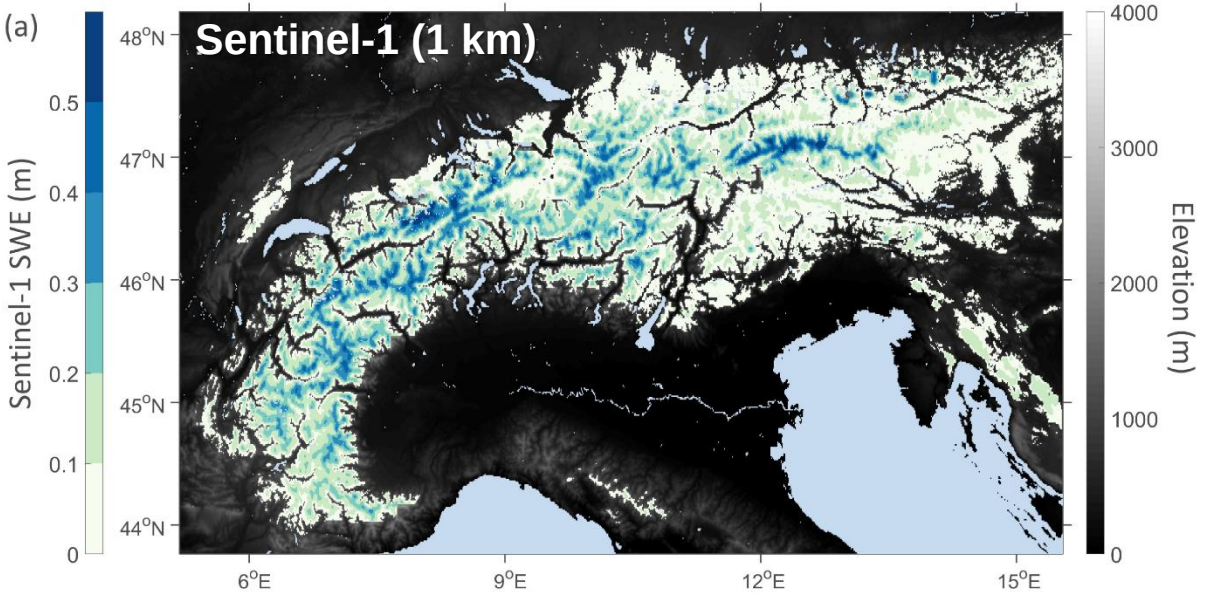


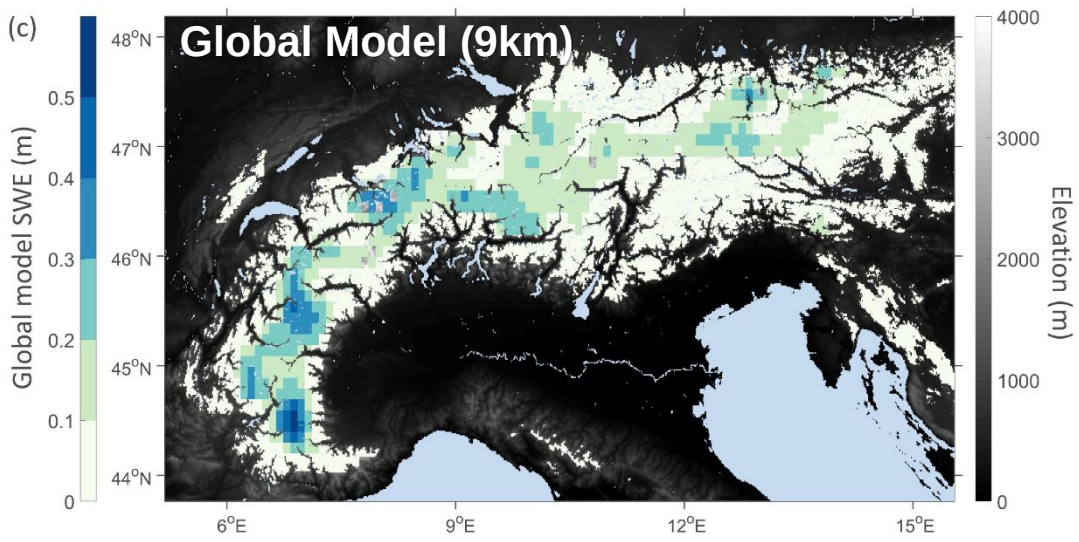
SAR can be used to map lake ice coverage, ice type, and river ice break up during all seasons and under any weather conditions

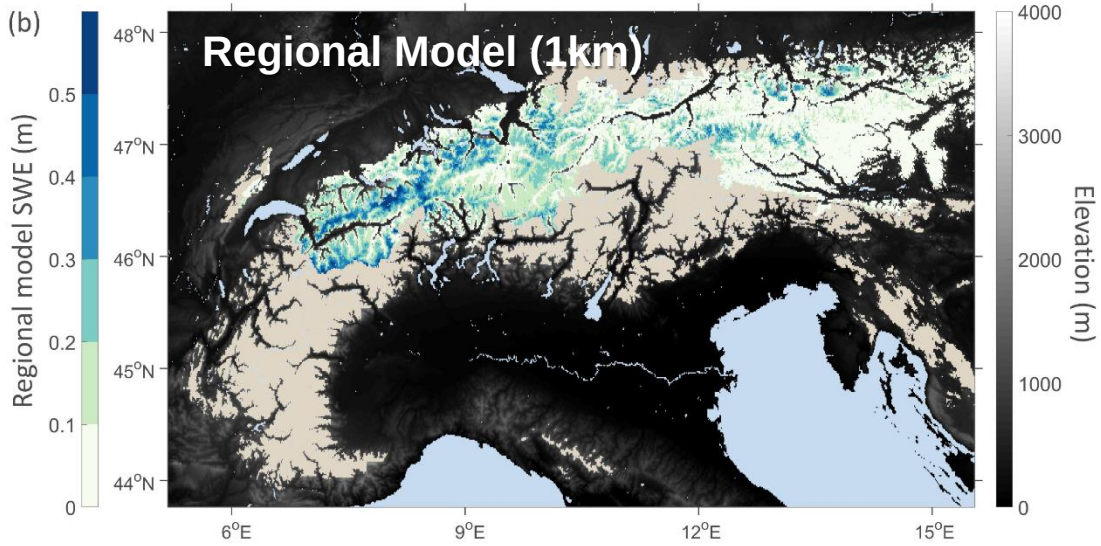


Lake Ice Type from SAR. Red = Brash Ice

Development SAR Snow Water Equivalent (March 1, 2017)







Sentinel-1 cross-pol ratio is sensitive to SWE even during the dry snow season.

Sensitivity persists even in relatively deep snow (SWE ~ 0.5m).

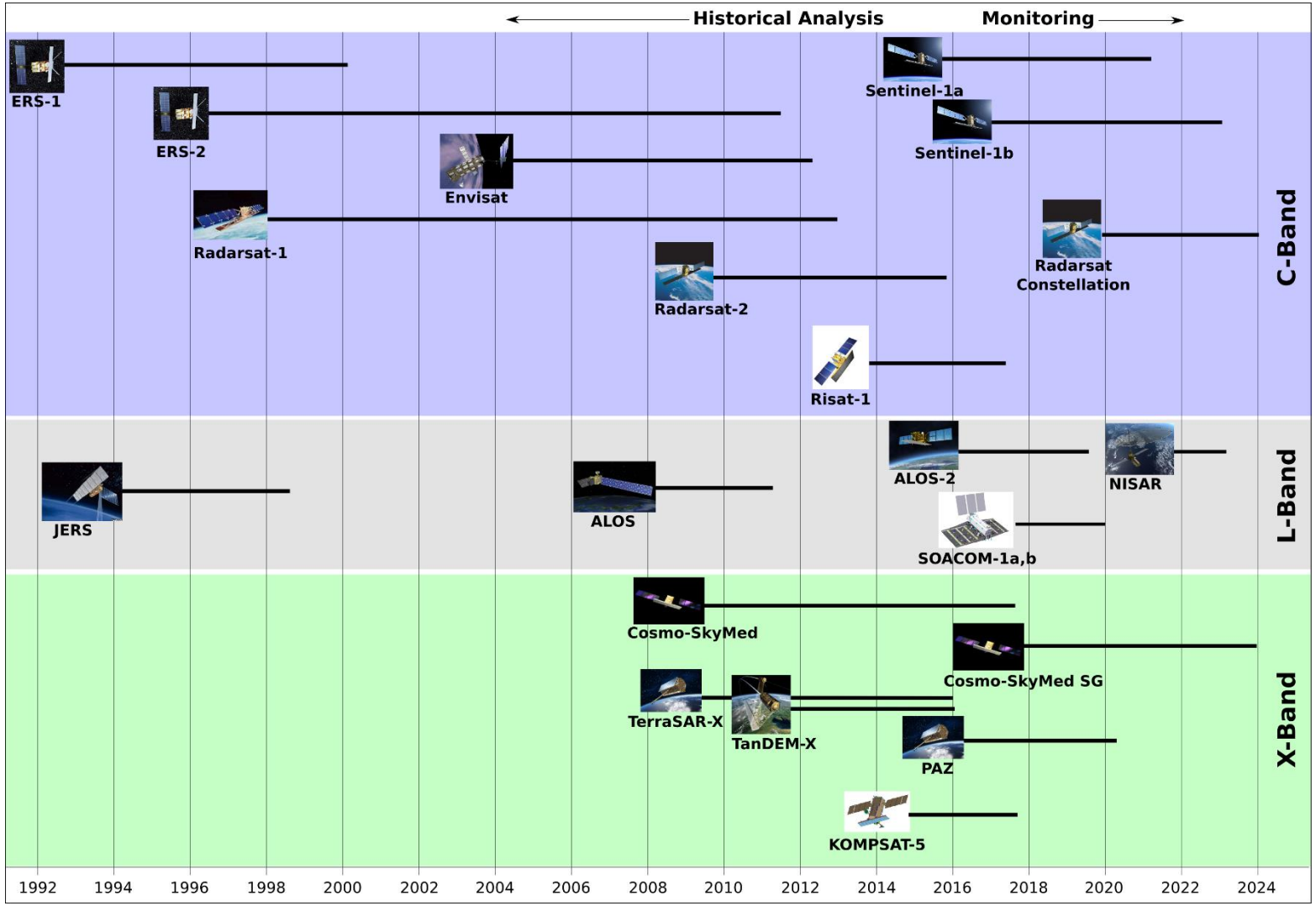
High resolution (1-km) enables SWE retrieval in mountainous regions.

Sentinel-1 SWE retrievals for the entire season

- **outperform global model simulations when validated vs. in situ measurements and**
- **approach the skill of regional model simulations that use lots of local information.**

Source: H. Lievens, R. Reichle, M. Girotto, L. Brucker, E. Kim, C. Marty, T. Jonas, M. Olefs, M. Dumont, D. Verfaillie, J. Schoeber and G. De Lannoy. Mapping Snow Mass in the European Alps Using Sentinel-1 Radar Observations. Eastern Snow Conf. 2018

Entering the Golden Age of SAR



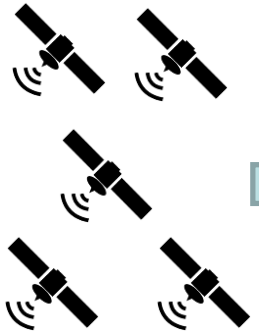
Only Sentinel-1 and NISAR are free and open in operationally useful quantities. Other data must be purchased, need user agreements with foreign agency, or are available in more limited amounts.

By 2022, SAR Coverage over the Arctic should provide coverage nearly 3-6 times per day just with open access data.

Moving Forward

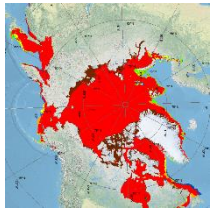
- Preoperational Ice Motions — 2020
- Test and add Radarsat Constellation Mission (RCM) data. — 2020
- Restore Blended Ice Concentrations for IMS — 2020
- Add NIC IMS and Hemispheric Ice Chart products into CoastWatch / PolarWatch — 2020
- Test SAR-based ice concentration products. — 2020-21
- Generate Automates Marginal Ice Zone / Ice Edge — 2021
- Operational Ice Motions — 2021
- Research new ICECON algorithm with GLERL — 2021
- Refine AI Based ice classification algorithm — 2021
- Blended Ice Cons, ice thickness / ice type (SAR, VIIRS, AMSR2, CryoSat, IceSAT2) — 2021-24
- Test and add NISAR and Sentinel 1c — 2022-23
- Automated ice charting — 2023-25
- Test and Develop SAR Snow Products — 2023-25

Semi-Automated Ice Analysis Products

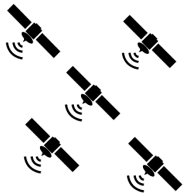


Current Hours Spent by Operational Ice Centers

Training, Testing,
Program Management,
Projects



Desired Hours Spent by Operational Ice Centers?



JPSS/GOES-R Snow Products

Peter Romanov
NOAA-CREST, City University of New York

Review of NESDIS snow products from

- JPSS VIIRS
- GOES-R ABI
- GCOM-W1 AMSR2

Binary snow, Snow fraction, Snow depth/SWE

Properties, performance, issues, remedies…

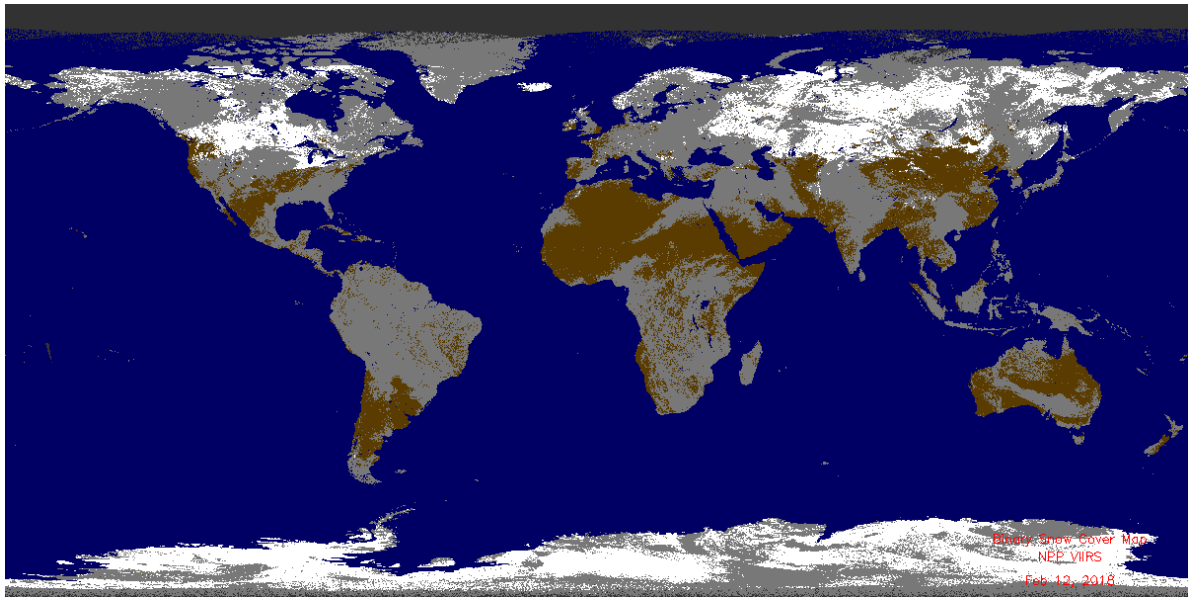
Advanced snow products

Binary Snow Cover

Properties
Identifies snow on the ground (yes/no)
Operational from **VIIRS SNPP, NOAA-20**
Accuracy: > 90%
Coverage: Global
Gridded maps produced offline at ~ 1 km

Limitations
Gaps in the coverage due to clouds, polar night
Critically dependent on the cloud mask accuracy

Applications
Snow analysis
Models
Other satellite products (albedo, LST, VH, precipitation, etc.)



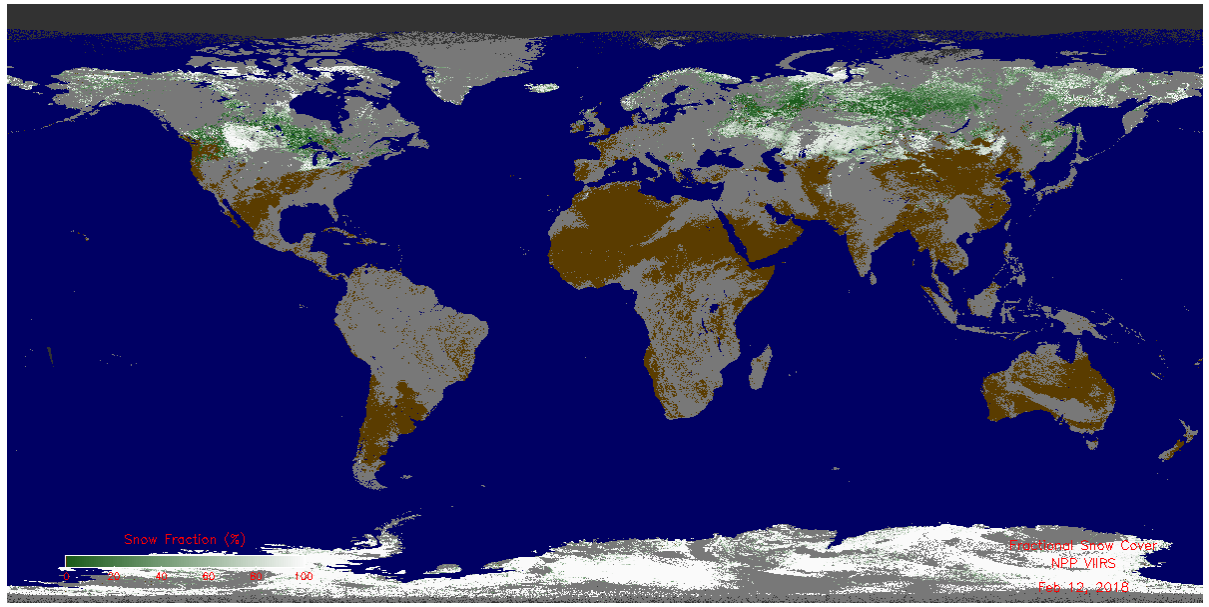
Binary Snow Map

Fractional Snow Cover (FSC)

Properties
Fraction of pixel covered with snow as “seen” by satellite
Accuracy: ~20%
Operational from VIIRS SNPP, NOAA-20
VIIRS gridded maps produced offline at ~ 1 km

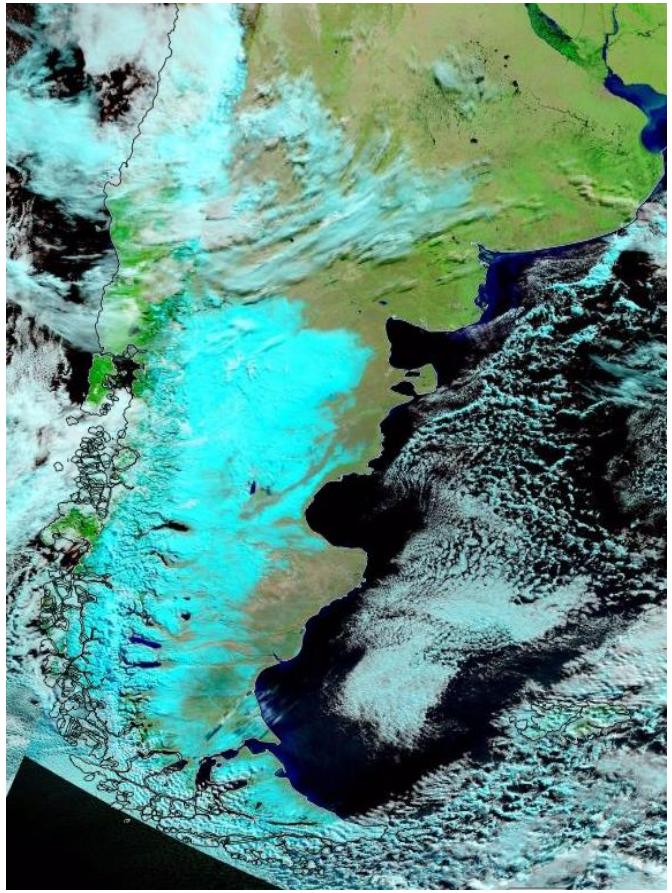
Limitations
Gaps in the coverage due to clouds, polar night
Critically dependent on the cloud mask accuracy

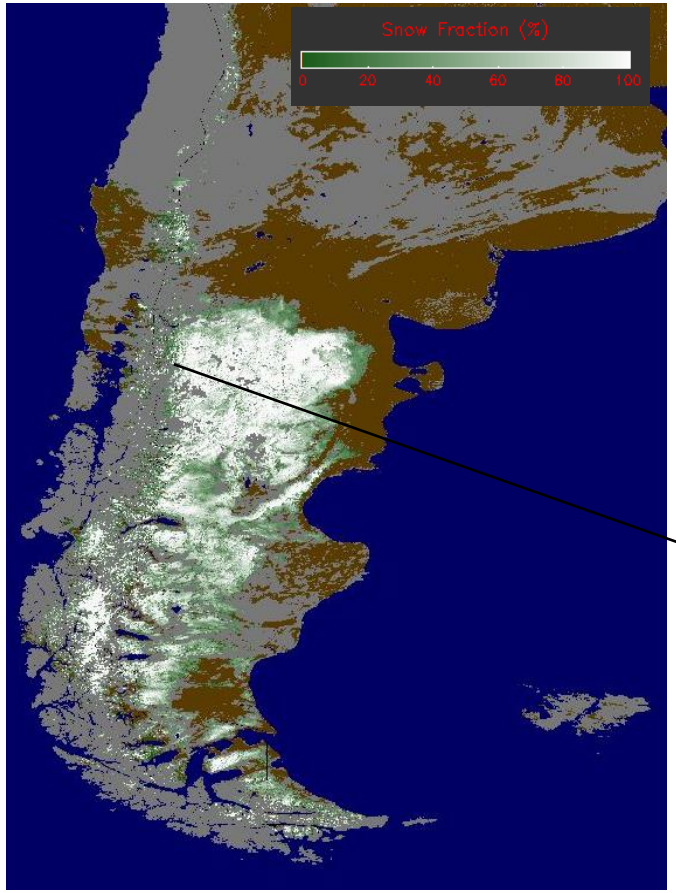
Applications
Models (FSC is directly related to albedo)
Land cover change (forest cover)
Other satellite products



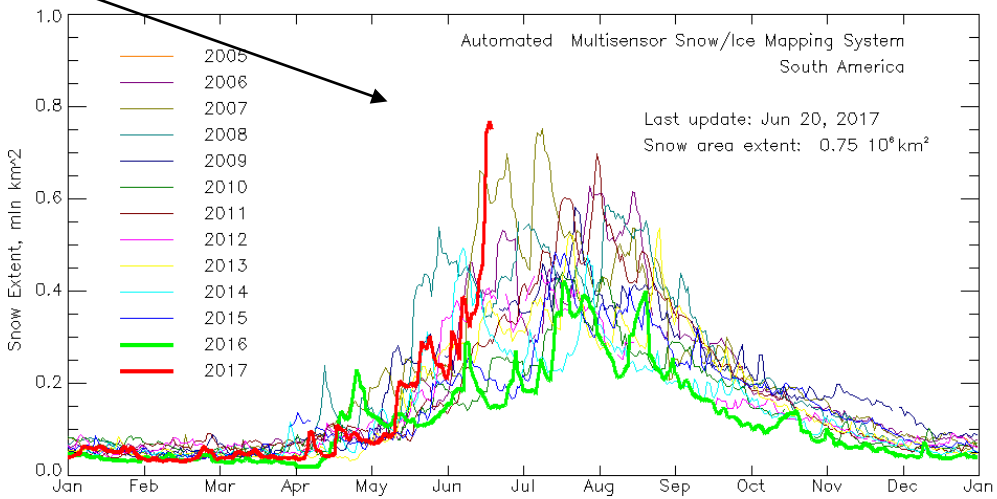
VIIRS Snow Fraction

VIIRS Snow Fraction: South America





Record large snow extent in South America in June 2017

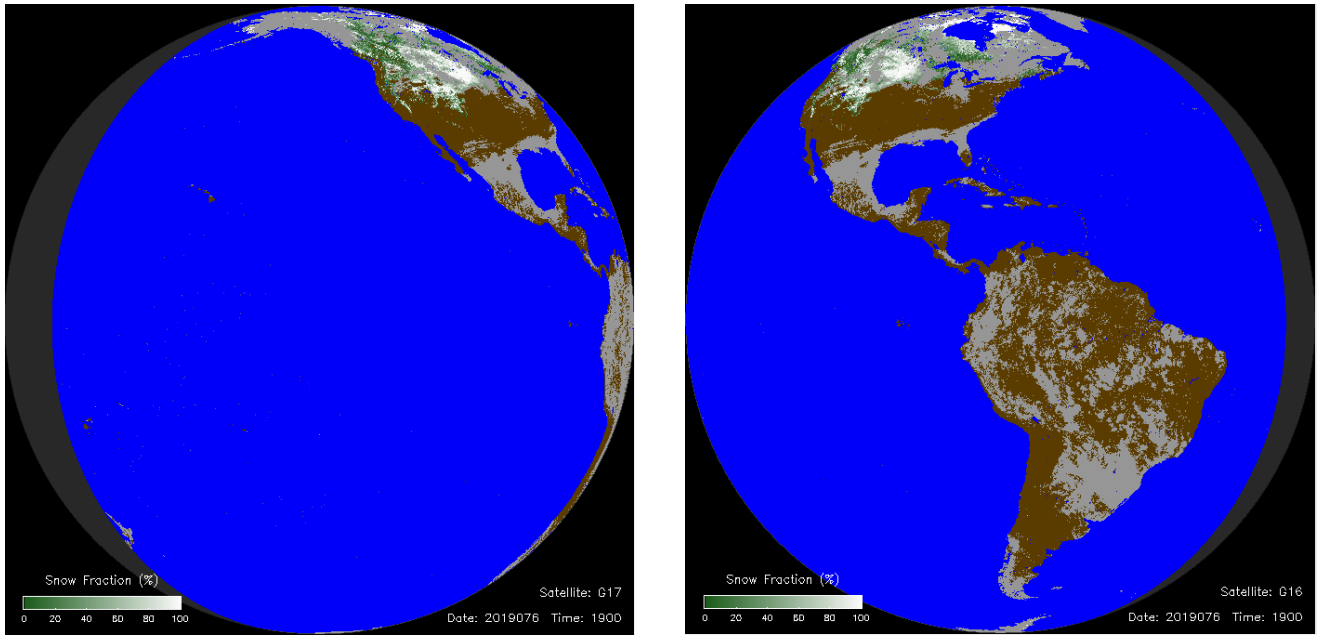


Fractional Snow Cover from GOES-R ABI

Properties
Viewable snow fraction (same as VIIRS)
30 min update period
Not yet operational

Advantages vs VIIRS
Better daily area coverage (compositing)
Intraday snow cover change

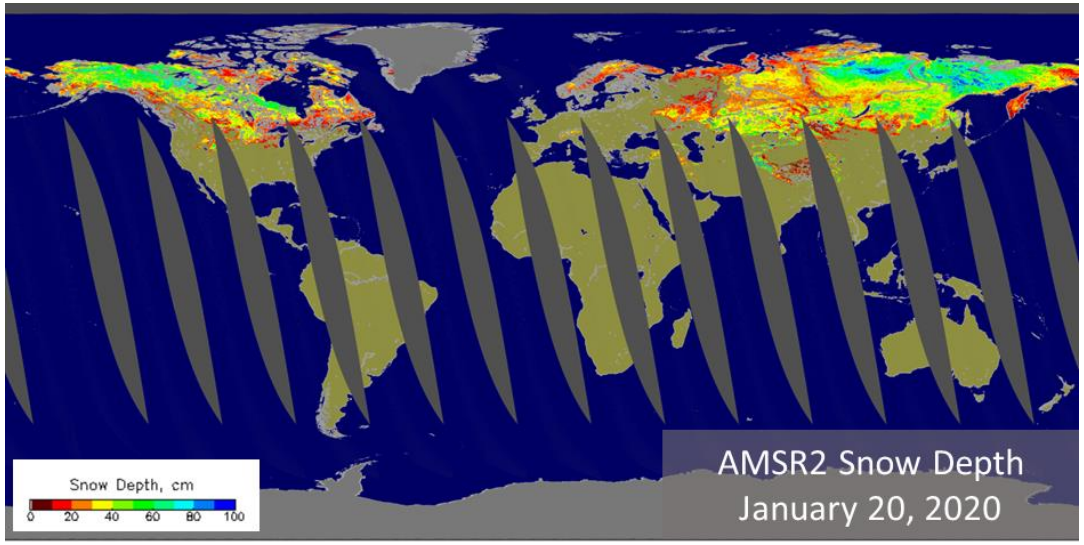
Applications
Models
Snow cover analysis
Other satellite products



ABI Snow fraction, Enterprise algorithm

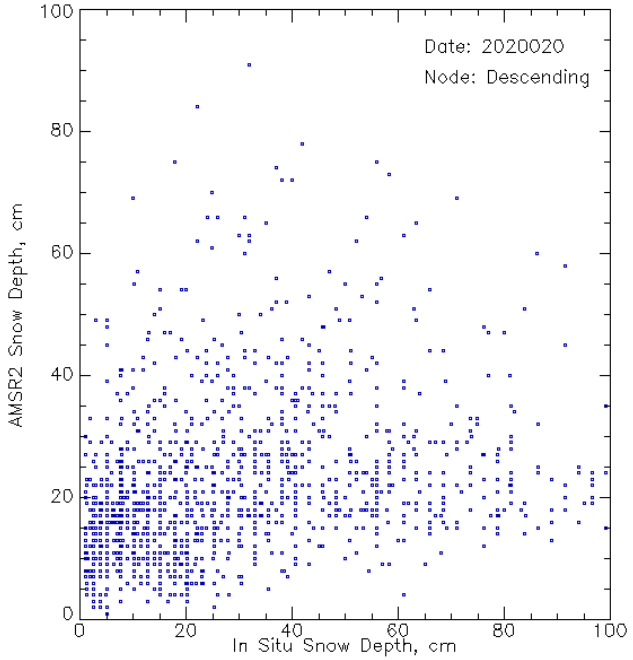
GCOM-AMSR2 (Passive Microwave) Snow Products

Parameters: Snow Depth, SWE,
State of Snow Pack (melting, frozen)
Status: Operational
Resolution: ~10 km
Gridded Maps: Produced offline



No retrievals over mixed land/water scenes
Other issues: Alpine areas, melting/shallow snow cover

Performance:
Snow Depth accuracy: ~ 20 cm (50-80%)
SWE accuracy: 10-20mm (20-25%)
Correlation vs in situ: 0.3-0.4



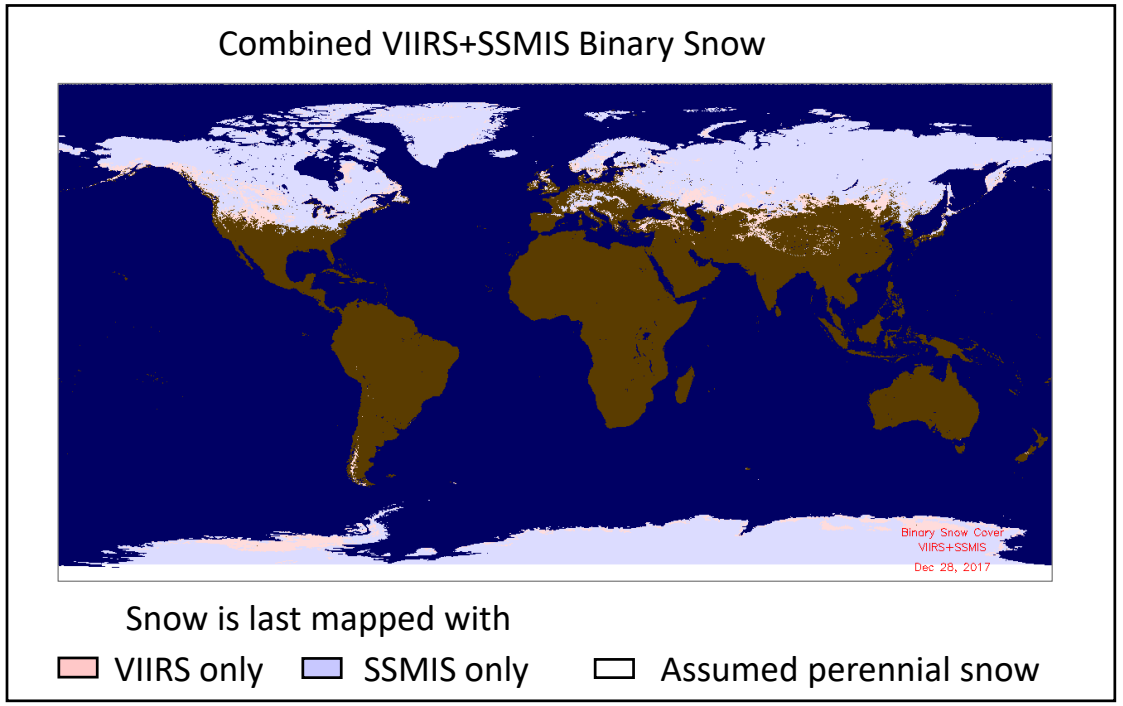
Some improvement is possible via blending microwave retrievals with in situ observations

Advanced Products: Blended VIIRS/AMSR2(SSMIS) snow cover

Provides spatially continuous (gap-free) daily map (similar to IMS)

Status: Being tested, Generated offline
Algorithm: GMASI (AVHRR+SSMIS)

Advantages:
- Better suits model and remote sensing applications.
- Applicable in climate monitoring and climate change studies



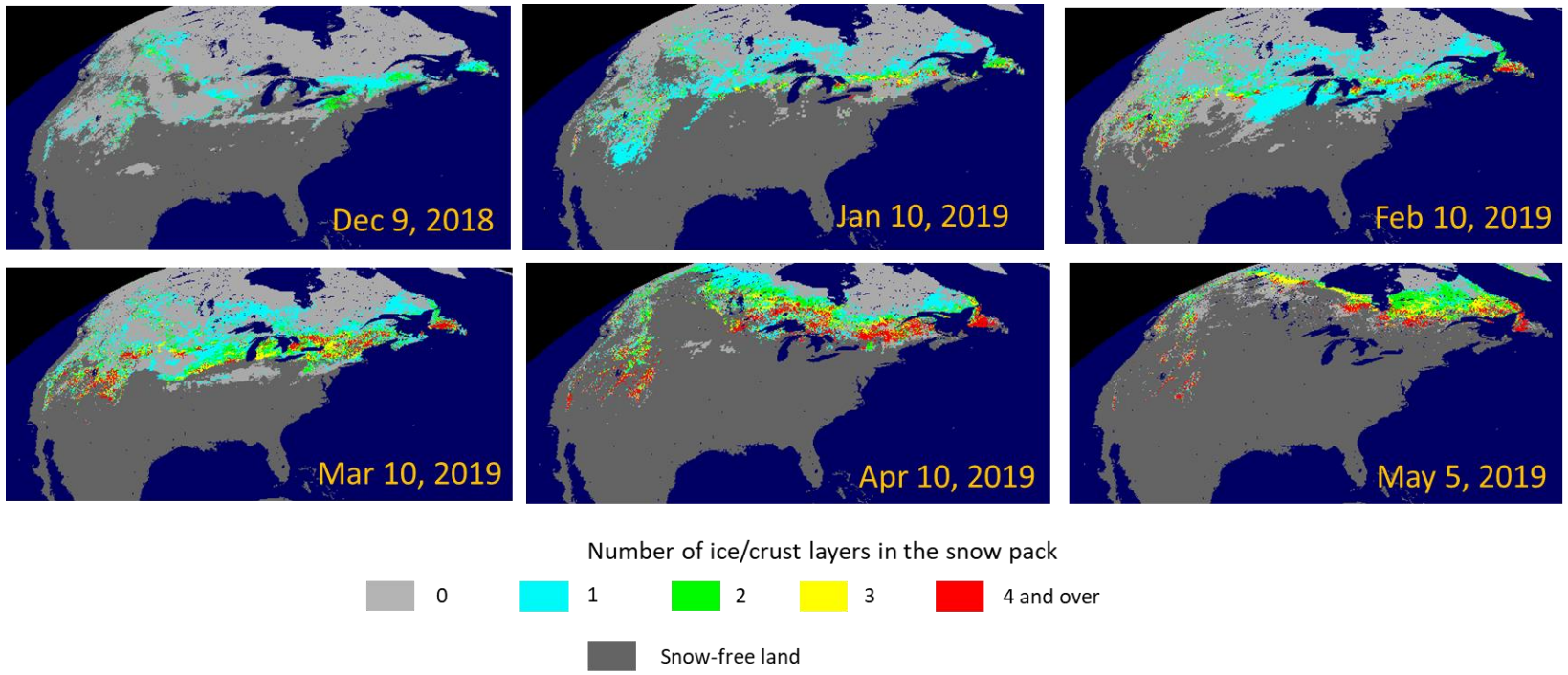
Advanced Products: Snow Pack Properties (ABI & AMSR2)

Characterizes ice and crust layers in the snow pack
Based on continuous monitoring of snow pack throughout winter season

Reports:
- Instantaneous/Daily state of the snow pack (melting/frozen/refrozen)
- Ice/crust layers in the snow pack (presence, thickness, number count) Identifies

Applications:
Hydrology
Climatology
Microwave Remote Sensing

Ice/crust layers in the snow pack: 2018-2019 winter season. GOES ABI data



Summary

Global snow cover is being monitored with JPSS/GOES-R optical and microwave satellite sensors

Information provided: Binary/fractional snow cover, Snow depth/SWE

Most product weaknesses are due to physical limitations of techniques involved

Synergy of optical and microwave observations is the way towards improved snow products

(More) Ice Products at NESDIS

Jeff Key
NESDIS/STAR
Madison, WI

and Yinghui Liu, Sean Helfrich, Peter Romanov, Xuanji Wang, Aaron Letterly, Rich Dworak, Mark Tschudi, Chris Jackson

JPSS/GOES-R Proving Ground/Risk Reduction Summit
College Park, MD, 24-28 February 2020

The NESDIS Cryosphere

River and lake ice ✓

Sea ice ✓

Snow ✓

✗ Ice sheets, ice caps, ice shelves

✗ Permafrost and seasonally-frozen ground

✗ Glaciers

Ice Concentration

What it provides – Fraction of ice in each pixel

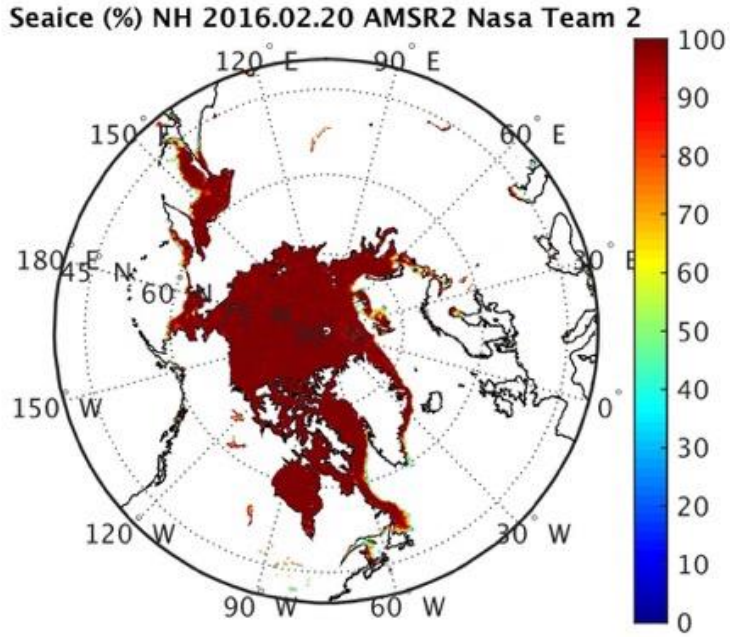
Why it should be used - Improve model thermodynamics; navigation

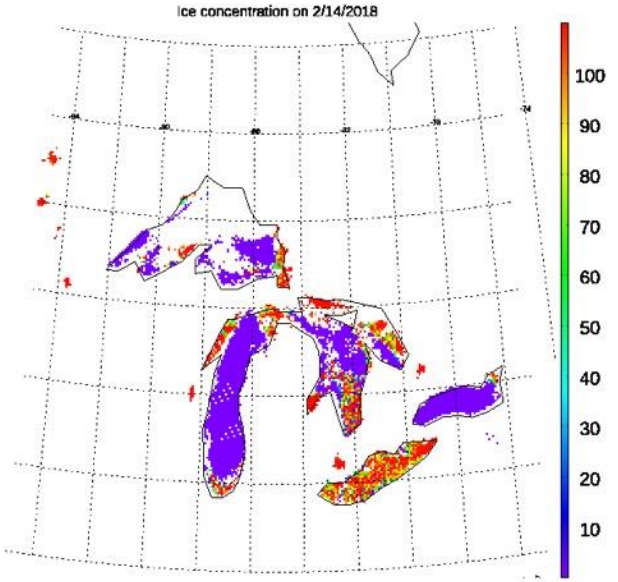
Status – VIIRS and AMSR2 products are operational

Who should use it* - Ice analysts, models; climate monitoring

**User types:*

1. *Modelers (NWP, ice models)*
2. *Operational personnel (ice analysts),*
3. *R&D for environmental understanding*
4. *Downstream value-added product providers (NCEI)*





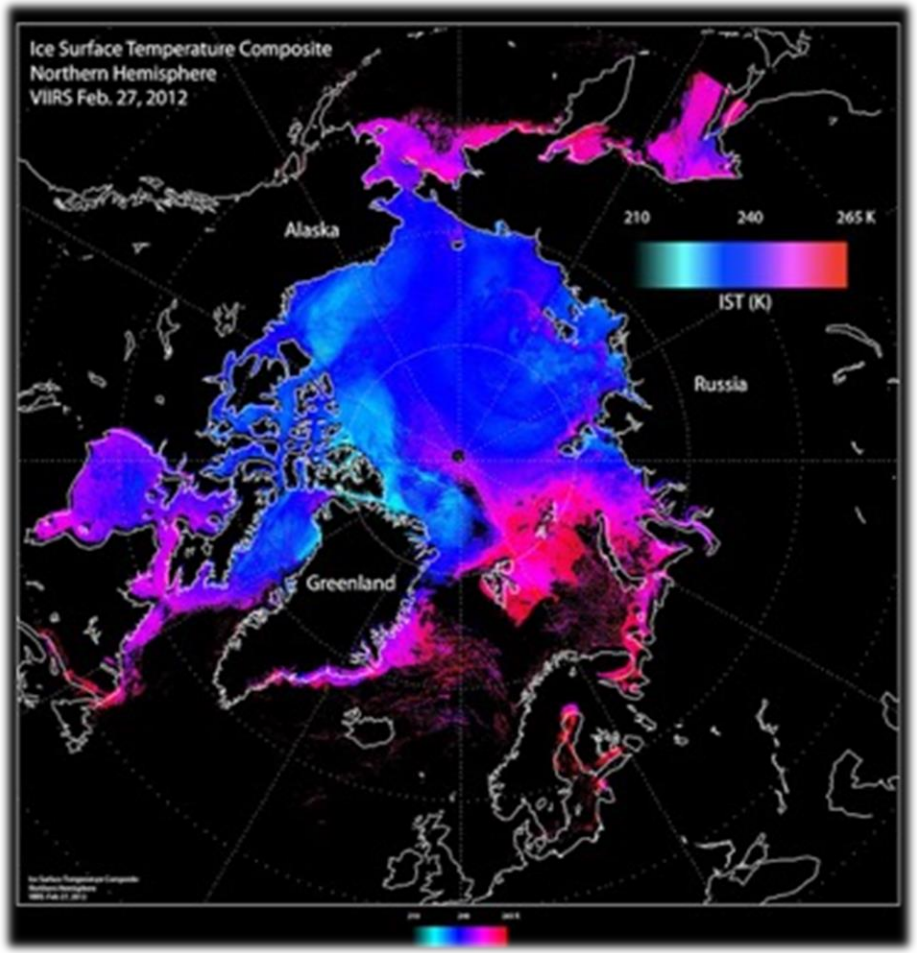
Ice Surface Temperature (IST)

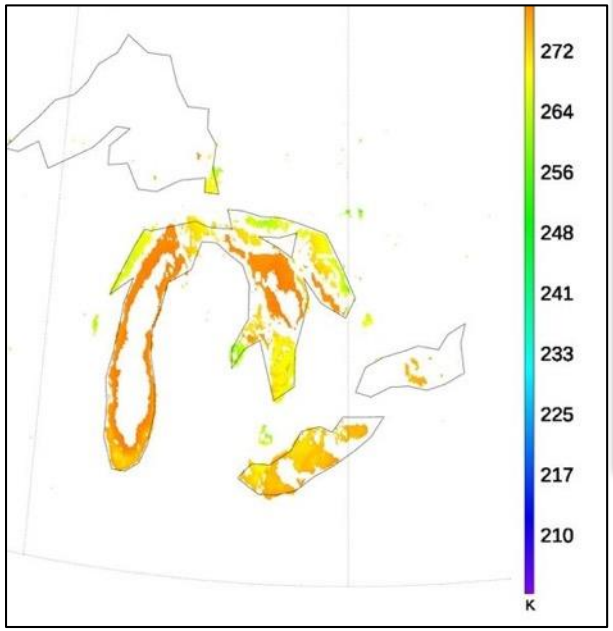
What it provides – The radiating (skin) temperature of the surface of the sea and lake ice cover

Why it should be used - Drifting ice buoys do not provide accurate temperatures. IST should be assimilated, not calculated.

Status – VIIRS is operational; ABI is transitioning to operations

Who should use it - NWP models, climate monitoring





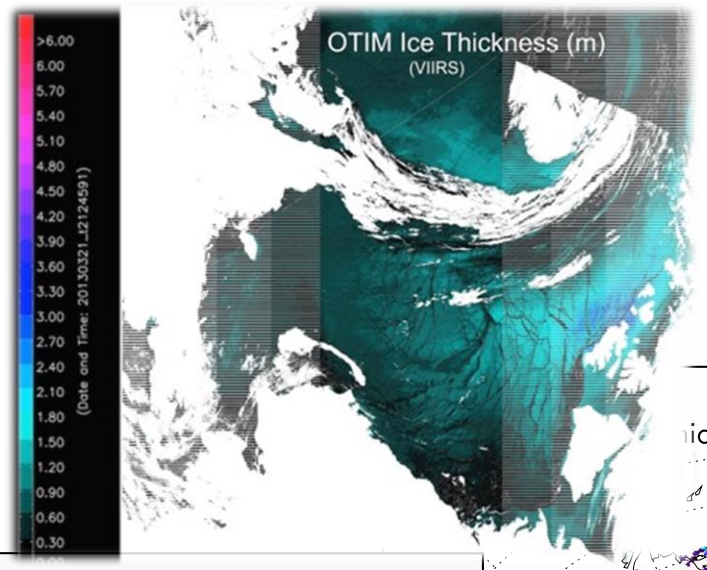
Ice Thickness

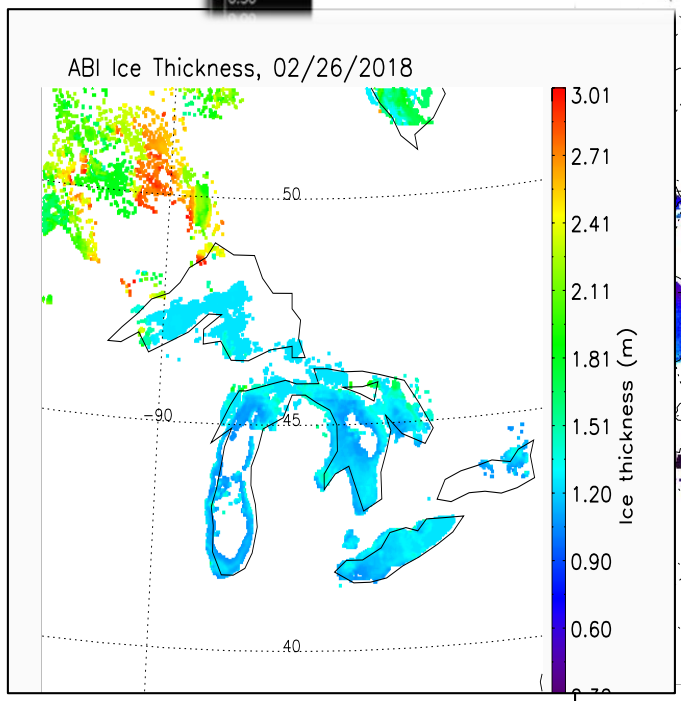
What it provides – Thickness of sea, lake, and river ice; age categories based on thickness

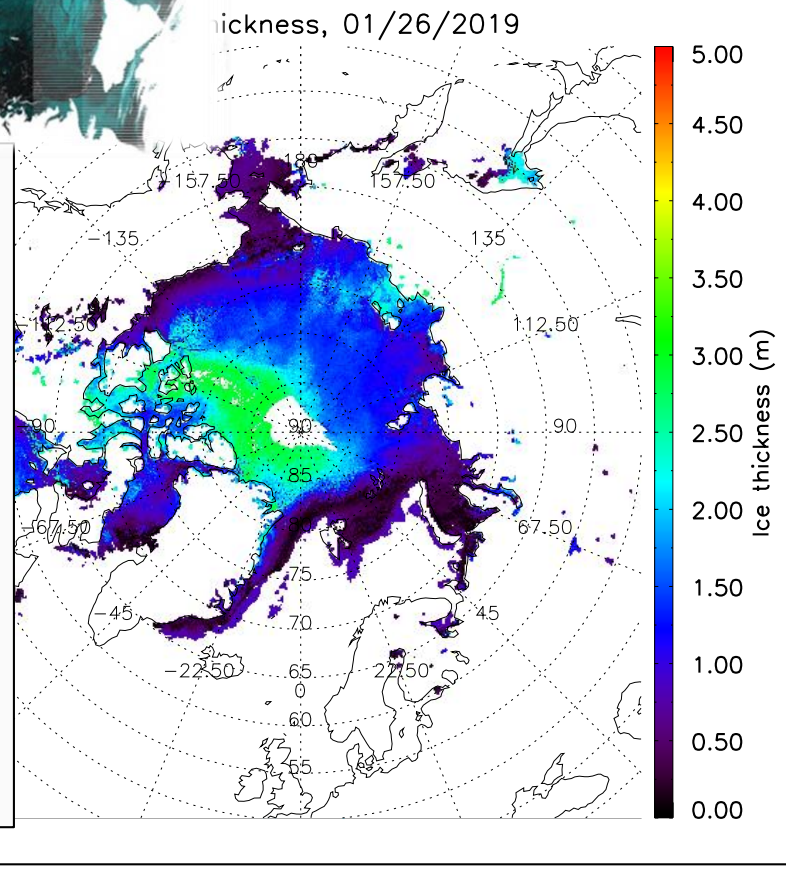
Why it should be used – Ice thickness is the single most important property, essential for thermodynamics and ice operations

Status – VIIRS is operational; ABI is transitioning to operations. CryoSat-2 and ICESat-2 are under development.

Who should use it – Ice analysts, NWP models, climate analysis







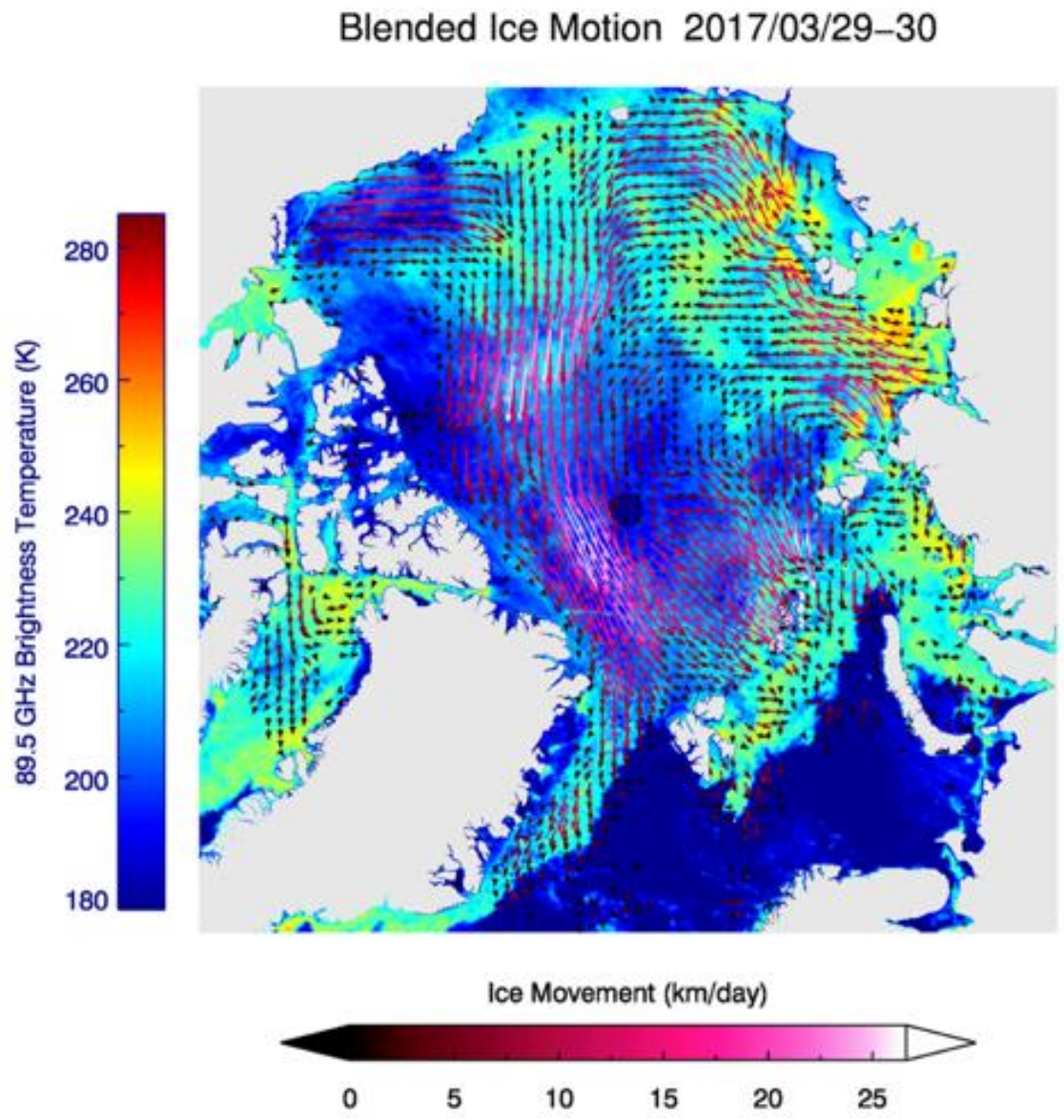
Ice Motion

What it provides – Motion of ice over 24 hrs, speed, direction, and vector

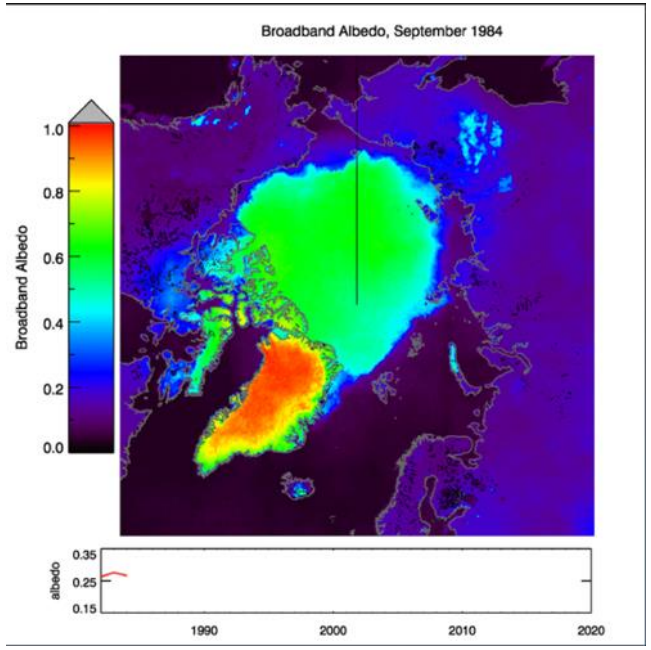
Why it should be used - Drifting ice buoys do not provide complete coverage. Models cannot accurately estimate ice motion based on the surface wind.

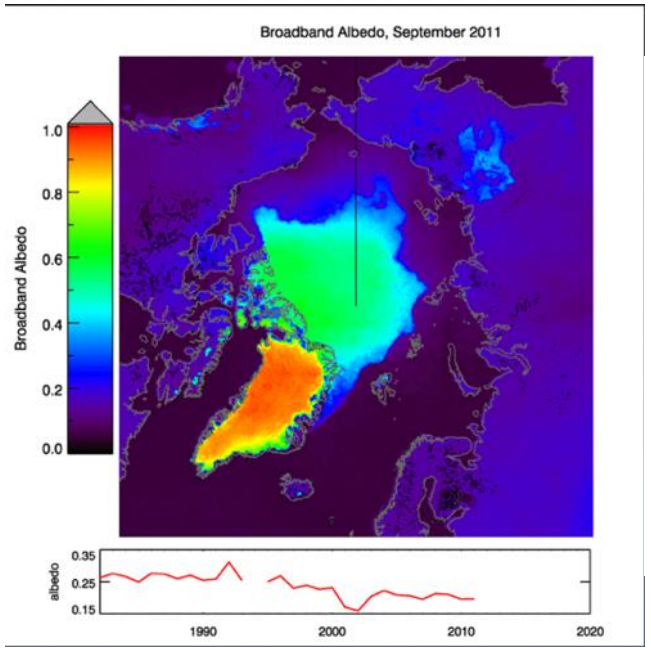
Status – VIIRS, AMSR2, SAR are under development; running routinely

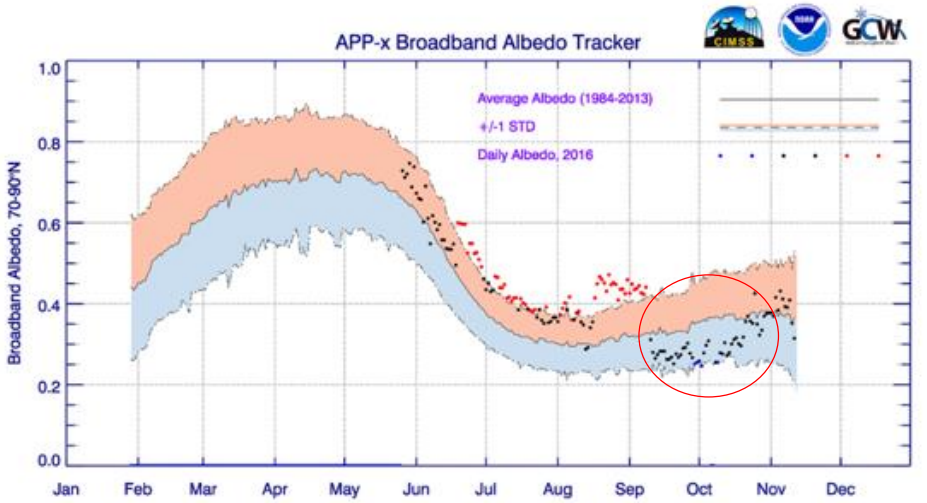
Who should use it - NWP models, ice operations

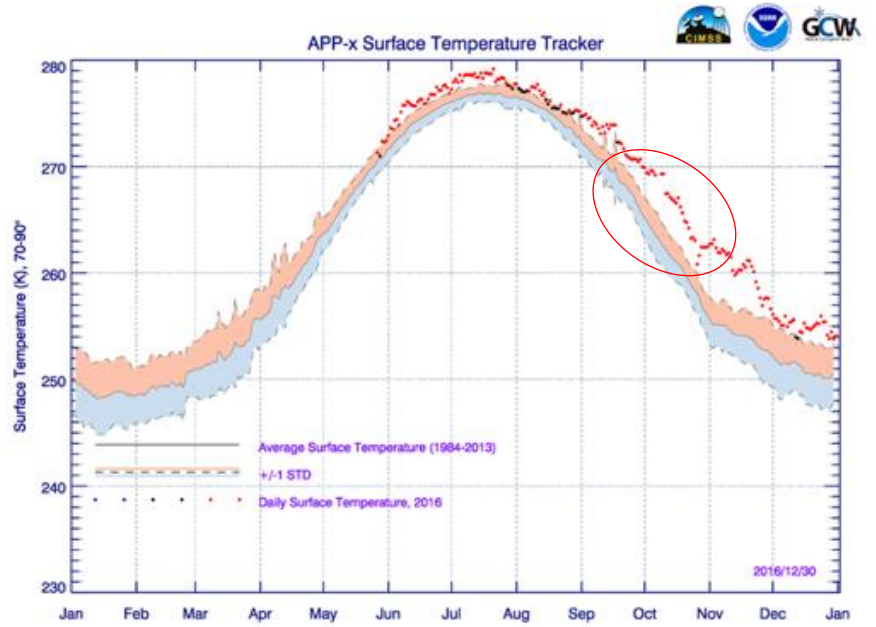


Climate: AVHRR Polar Pathfinder-Extended (APP-x)









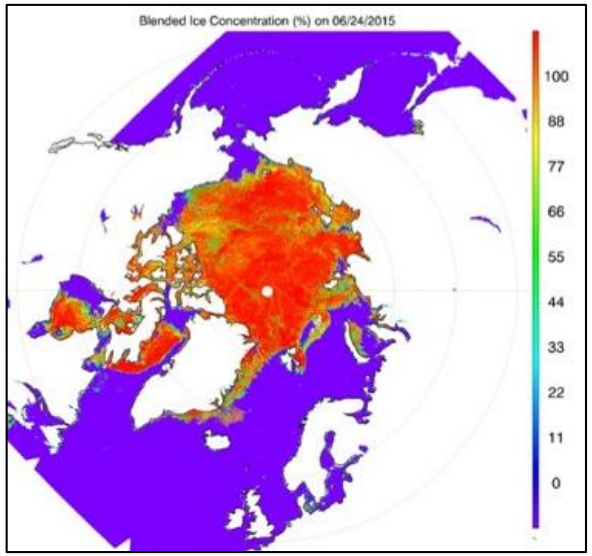
Why it should be used – Provides a robust, consistent observational record of the some of the most important surface and atmosphere properties.

Status – Distributed by NCEI; 1982 to present minus 4 days.

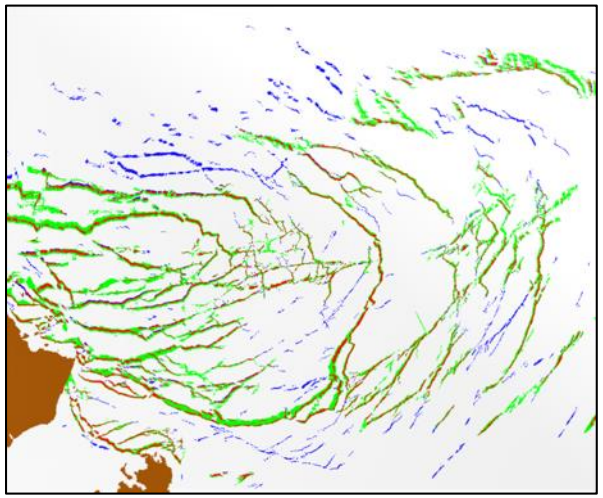
Who should use it – Climate analysis, reanalysis verification

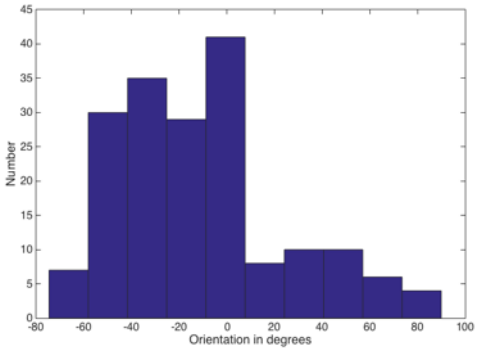
Other Needs and Some Products to Address Them

1. **Improved year-round sea ice concentration and thickness accuracy**
   - Application: models, navigation
   - Solution: Blended AMSR2/VIIRS ice concentration
   - Status: Blended ice concentration is generated routinely. Blended ice thickness (with altimeter data) is under development



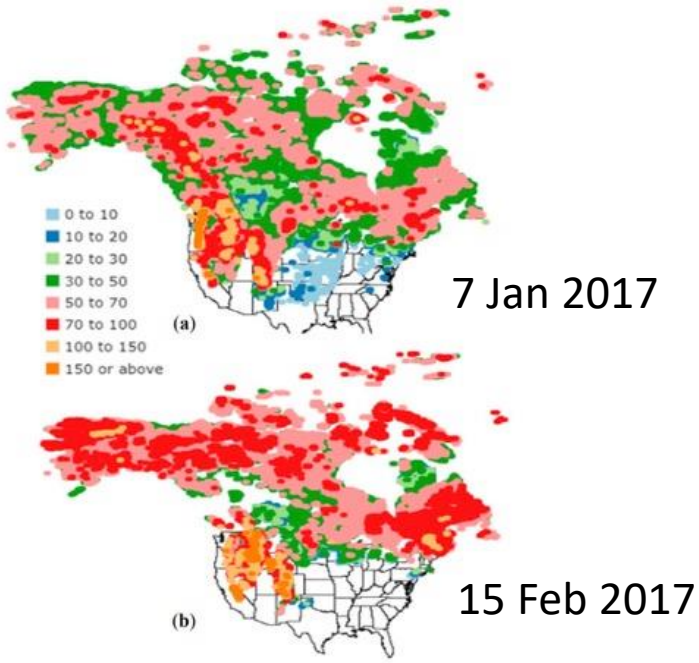
2. **Information on sea ice leads (fractures)**
   - Applications: navigation, meteorology
   - Solution: Lead detection and characterization product
   - Status: Generated routinely





Other Needs and Some Products to Address Them

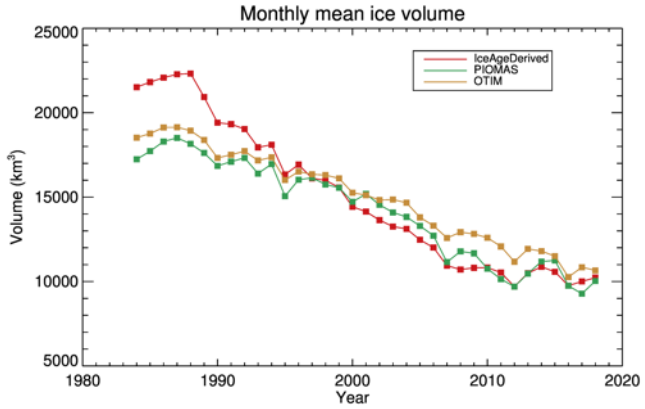
3. **Improved snow water equivalent (SWE)**
   - Application: models
   - Solution: Blended AMSR2/in situ SWE
   - Status: Under development, paper published (C. Kongoli)



7 Jan 2017

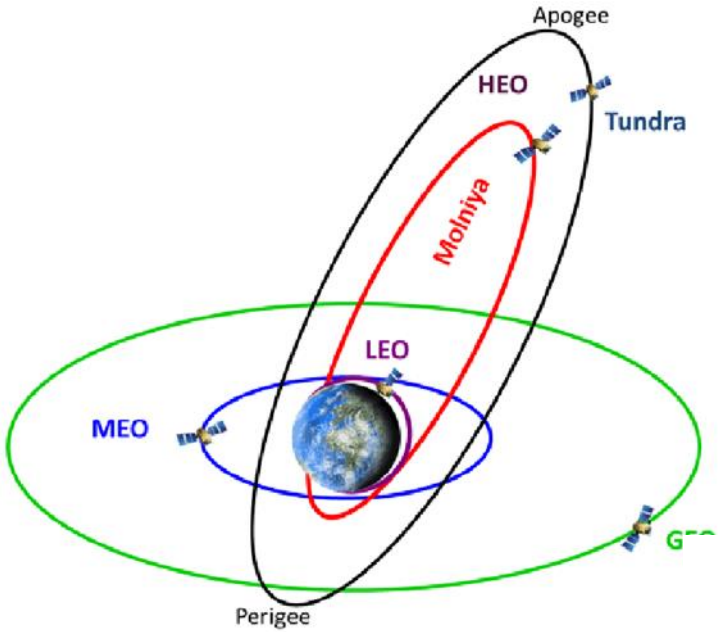
15 Feb 2017

4. **More consistent time series of sea ice thickness and volume**
   - Application: climate studies
   - Solution: Ice thickness based on ice age
   - Status: Available, paper accepted (Y. Liu)



Other Needs and Some Products to Address Them

5. **Higher frequency of obs over the poles**
   - Applications: All
   - Solution: Highly elliptical orbit
   - Status: Canada, US, Russia are planning



6. **More product distribution options**
   - Applications: All
   - Solution: PolarWatch

https://polarwatch.noaa.gov/