INTERACTIVE AND AUTOMATED BLENDED SNOW AND ICE PRODUCTS

Sean Helfrich, NOAA/NESDIS/STAR—5830 University Research Ct., Suite 3233 College Park, MD 20740, USA; sean.Helfrich@noaa.gov

Collaborators: Peter Romanov, John Woods, Edmond Rodriguez, Chris Jackson, Frank Monaldo

Blended and Snow and Ice Products

Blended Products = Fusion of Multi Sourced, Multisensor, and multiple time observations into a single product

Why?

The basic objective of blended remote sensing products is to leverage the strengths of multiple sensors and multiple time observations to fill gaps in time and space that are not observable or have weaknesses from a single source or time interval observation. The data synthetize allows users and forecasters to need less analysis time to apply the data for their applications.

Current / Future Blended Snow and Ice Products

Interactive Multisensor Snow and Ice Mapping System (IMS)

Automated Blended Snow and Ice Cover (GMASI)

Blended Snow Depth (IMS)

Blended Ice Concentrations: 2018/19

Blended Ice Motions: Future

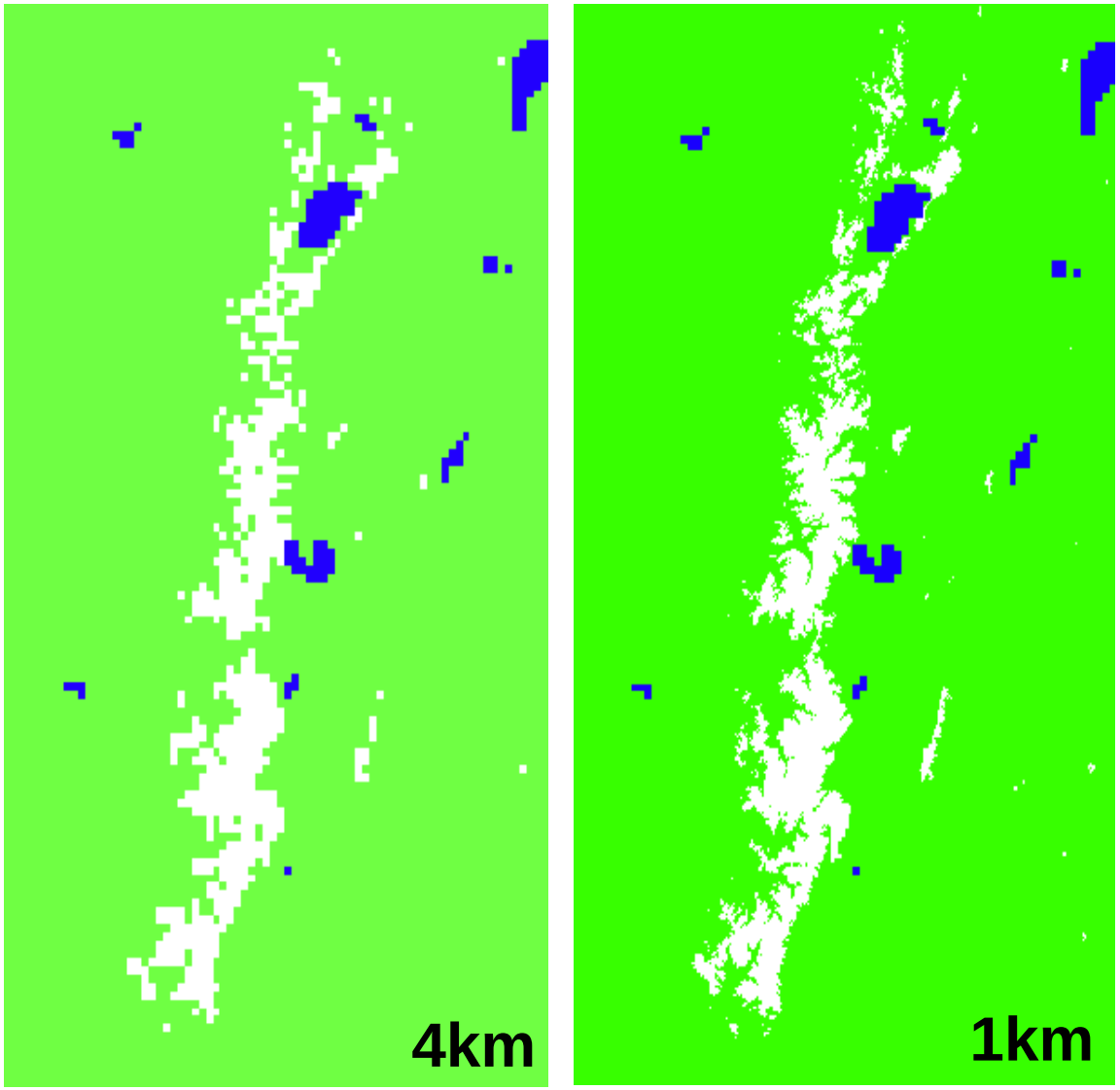
Blended Ice Thickeness: Future

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

- 1, 4, & 24km Northern Hemisphere Analysis
- Snow & Ice Cover
- ASCII, BIN, GeoTiff, Grib2
- 2x day production
- Automated 2km Southern Hemisphere Analysis
- Snow Depth (with uncertainty values)
- VIIRS, SAR, MODELS, More Surface obs,
- Ability to import derived data sources
- Same underlying Snow & Ice cover resample algorithms - *Vital to keeping consistent record*

www.natice.noaa.gov/ims/

Sierra Nevada Snow Cover – March 18, 2015



IMS Input Data Addition Timeline

1997: AVHRR (24km) NOHRSC (24km), USAF, SSMI, Joint Ice Center (NIC) Ice Edge

1998: AVHRR (4km), GOES (E) – Current Day, GOES(W) – Past Day

1999: GMS, INDOEX (MeteoSat 5), MeteoSat 7, NOHRSC (4km), AutoSnow V1, GOES W

2000: AMSU (snow, ice , rain), COOP obs

2001: Ch. 3a AVHRR (4km), INDOEX – Direct Import), NIC Ice Edge, AMSU B

2002: North American AutoSnow

2003: MSG (1km)

2004: MODIS (1km), MODIS animations, AutoSnow V2 (4km), NOHRSC (1km), MMAB Sea Ice (1km)

2005: METAR ob

2006: AMSR-E 89ghz & SIC

2008: NIC MIZ, CoCoRaHS

2009: ENVISAT GMM, NIC&Foreign Ice Charts

2010: RadarSat, WebCams

2011: AutoSnow V3, ASCAT

2014: AVHRR (Channels 1,2,3) MODIS (Channels 1,2,7,8), MeteoSat (MSG (ch 1,2,3) & 7), VIIRS (ice, snow, I1, I2, I3, I5, DNB), ATMS SWE, ACNFS Model, SYNOP obs, US Radar

2015: Himawari 8

2017: GOES ABI, Meteosat 8/10

Changes to IMS in FY18

New OSPO Product Lead : John Woods

New STAR IMS Development Lead : Sean Helfrich

Additional products available for input (SAR, SAR ice detection, Polar Composite loops) and restoration of broken links to input sources

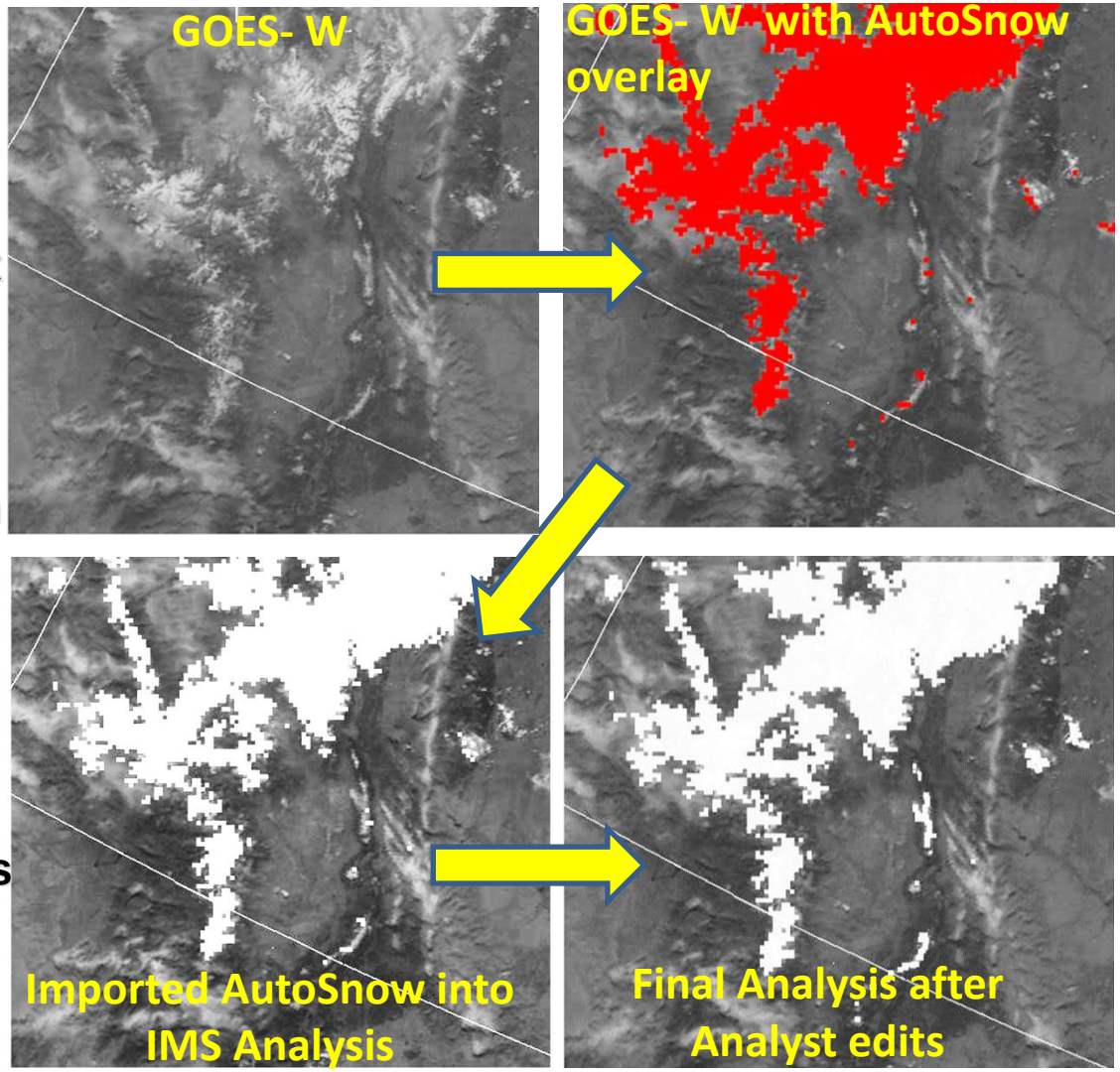
New Southern Hemisphere Snow Depth (2 km SH AutoSnow + ATMS/AMSR2)

Code adjustments for Blended Snow Depth

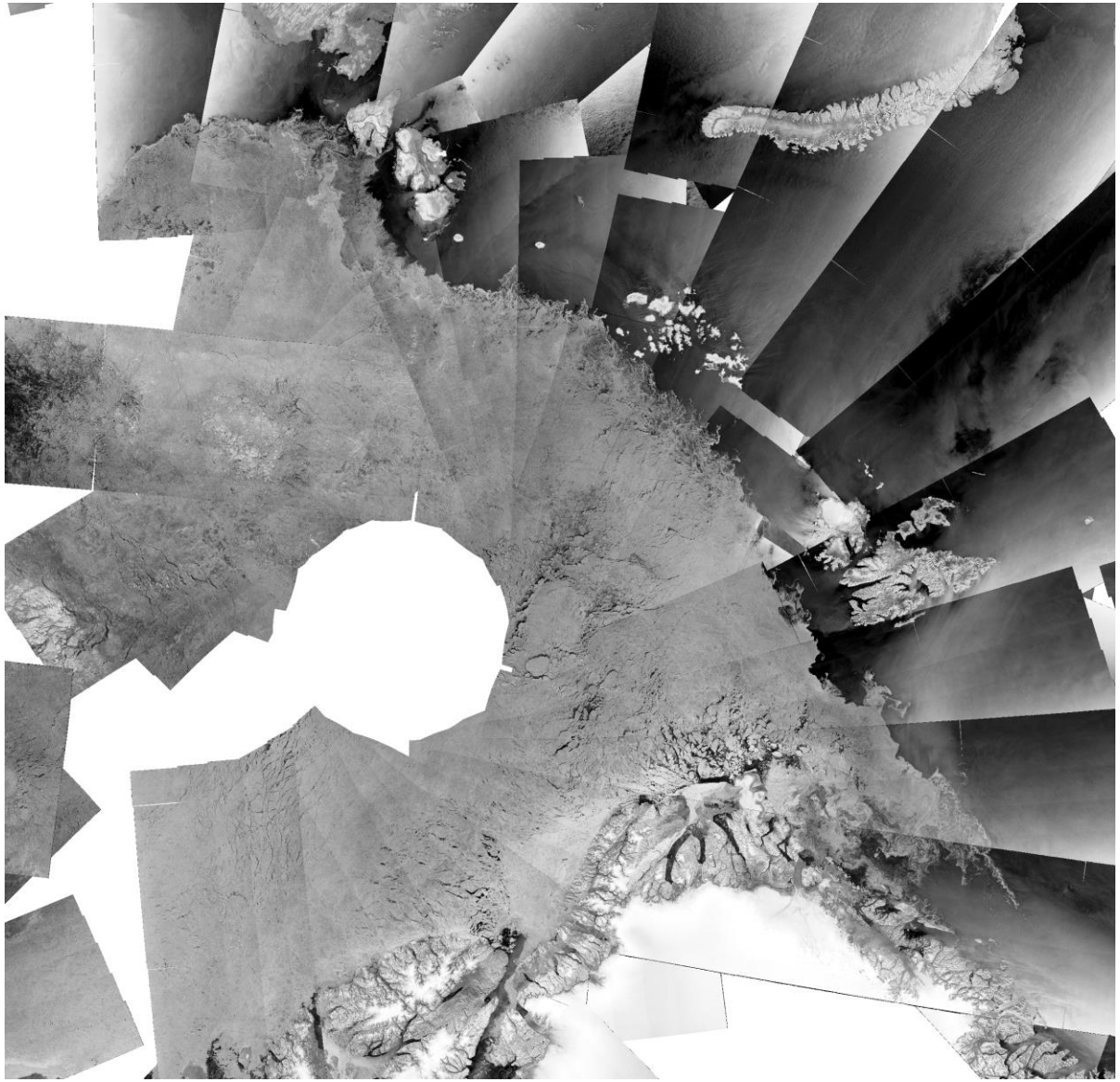
Delayed role out of the blended ice concentration

Direct Import of Automated Snow & Ice Cover

- Analysts will be able to selectively import the data from satellite derived products directly into the IMS analysis
- Analysis will have selection box to select snow cover and ice cover from the VIIRS, NOHRSC (2017), and NH AutoSnowIce, Blended Ice Concentrations (2018/19), SAR ice classification (2018), and GOES 16 (2018).
- Human data selection to optimize product use based on expert knowledge and imagery interpretation
- Combines the speed and reliability of automated products with the QC and flexibility of Human Analysts



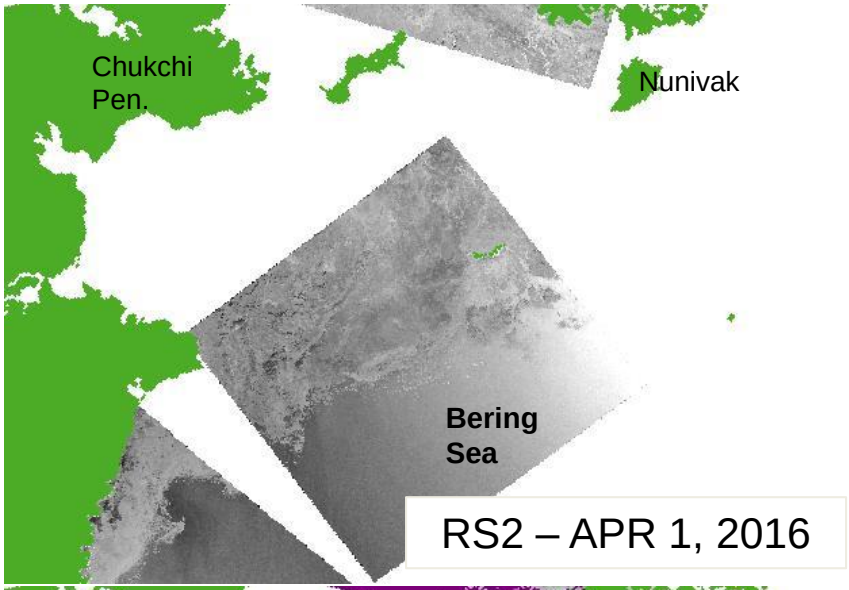
Ice Tracking and SAR Ice Motions



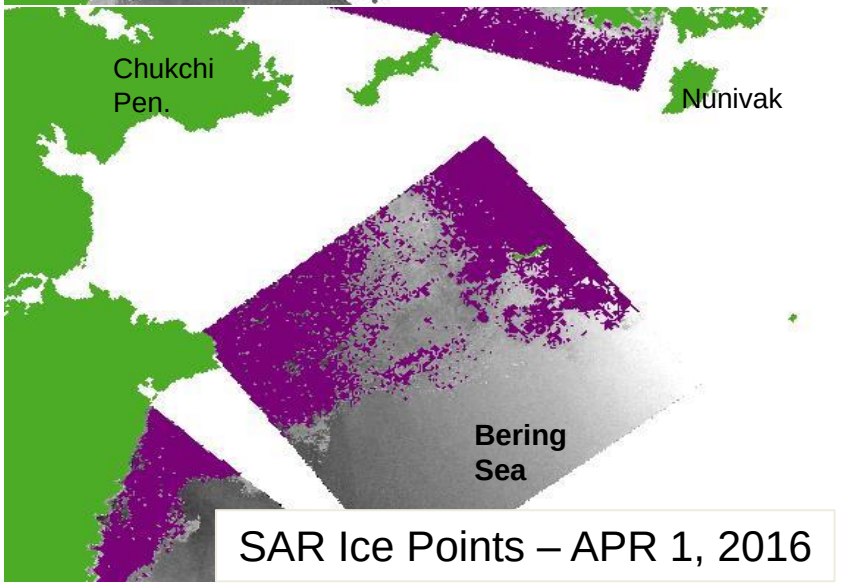
SAR Program Ice Product Objectives

2017-2018

- Automated Sea-Ice Mask Using Multiple Inputs: Winds, IMS, Variance: Research mode - Evaluation phase
- Research implementation of sea-ice motion using feature tracking. Limited area with frequent coverage – Begun Test Phase
- Beta implementation of routine Great Lakes sea-ice classification - Complete
- Beta implementation of routine ship/iceberg detection – Starting Coding Phase
- SAROPS software upgrade and maintenance: improved configuration management – Complete

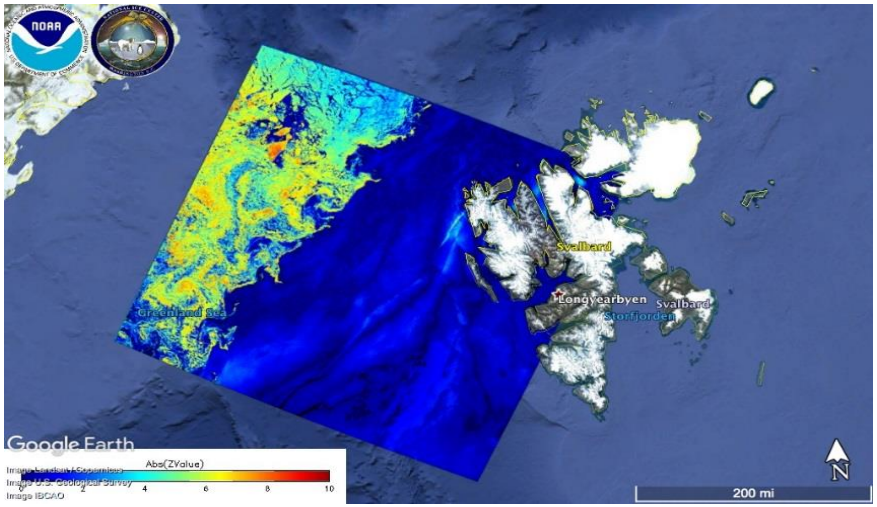


RS2 – APR 1, 2016

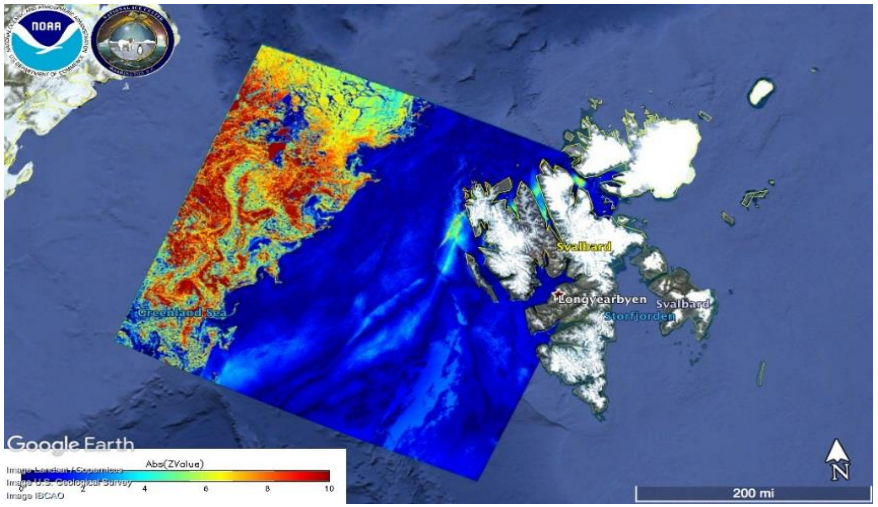


SAR Ice Points – APR 1, 2016

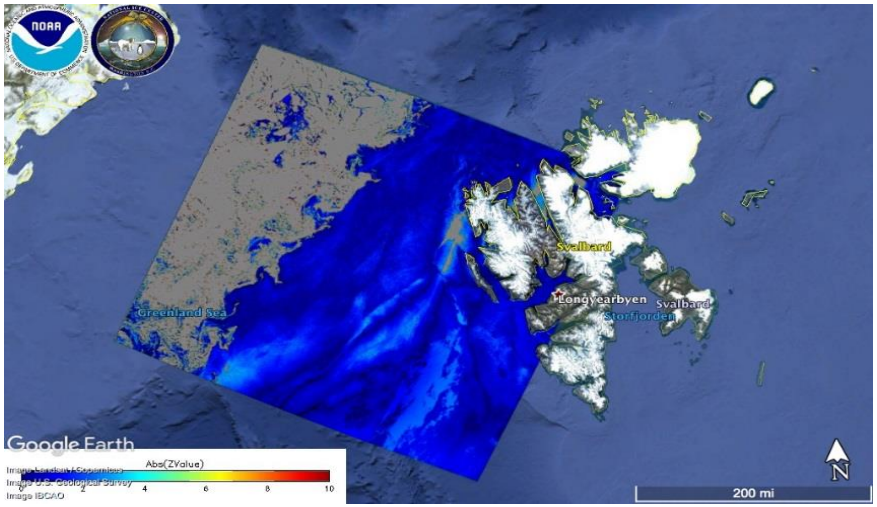
SAR Ice Mask



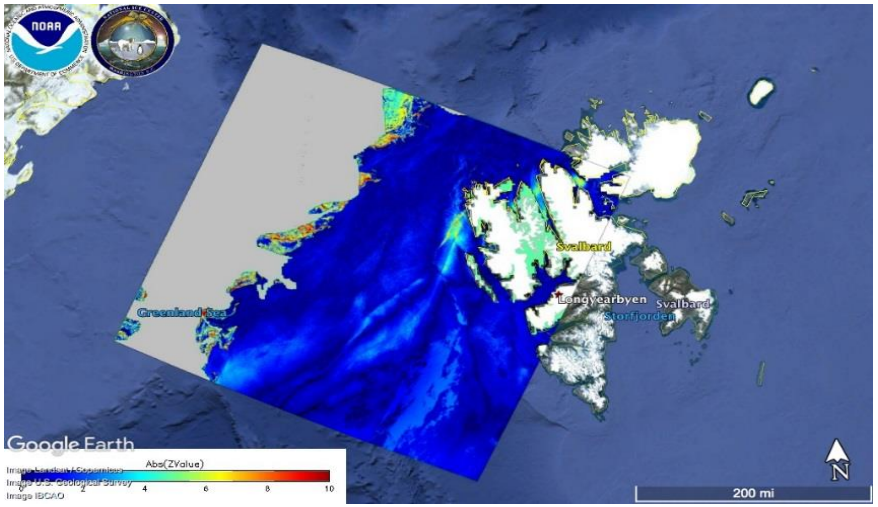
SAR-Derived Wind



SAR-Derived Wind – Model Wind



SAR-Derived Ice Mask



IMS Ice Mask

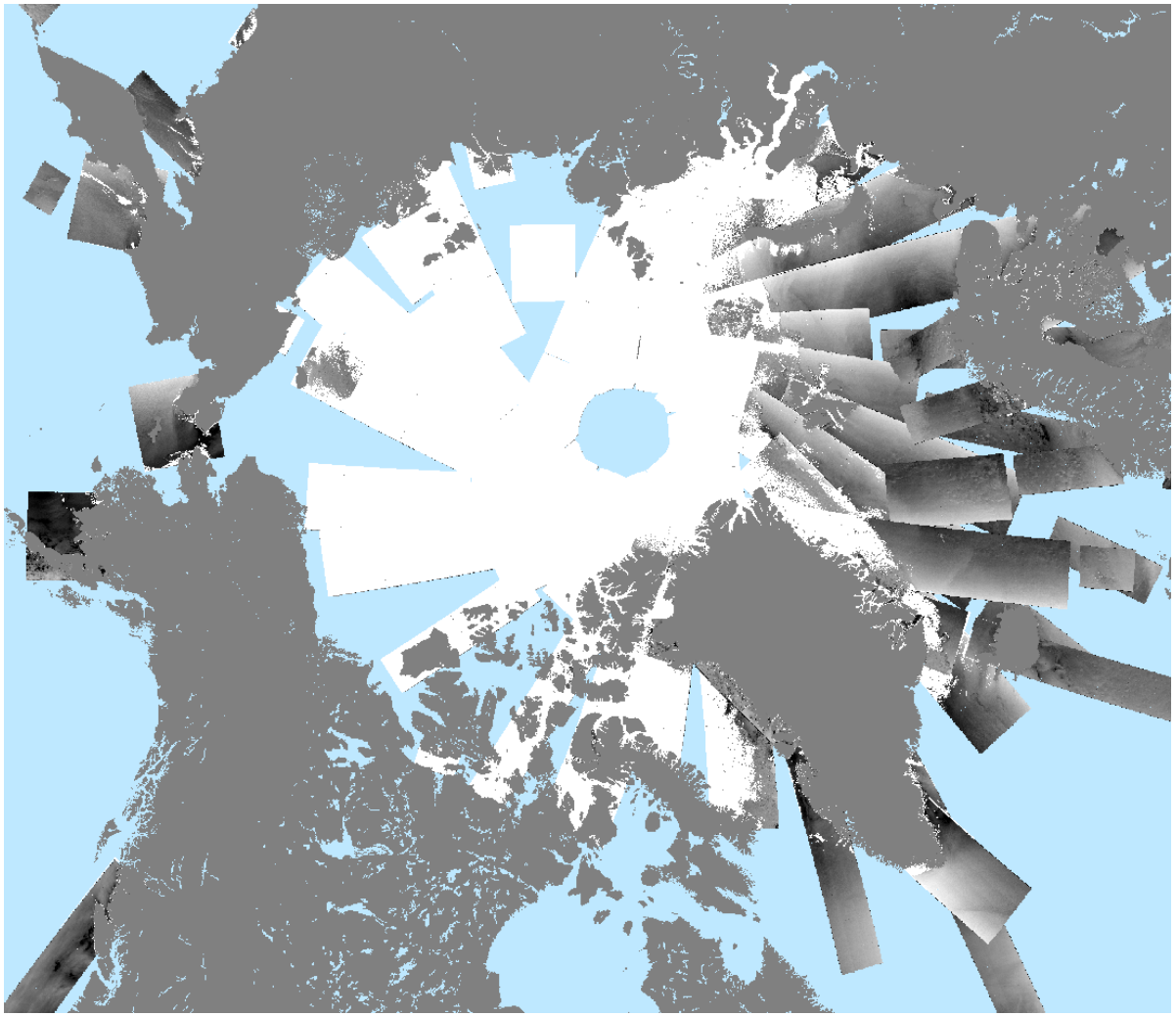
Radarsat-2 2015-09-23 07:00:58 UTC 4.81E 78.81N

Current SAR Ice Mask

Input parameters:

- Difference between SAR and GFS model wind speed,
- Wind speed variance

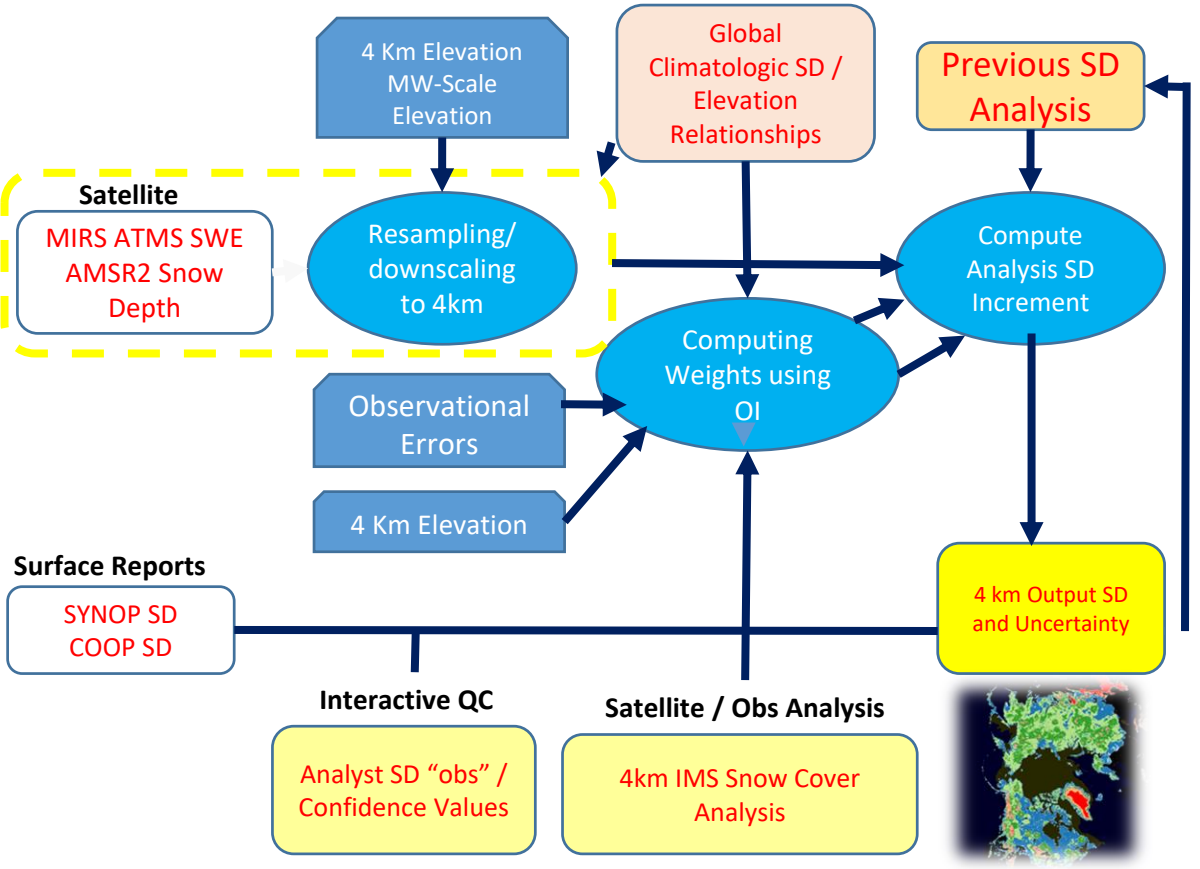
- Polar Stereographic projection sampled at 250m
- Run 2x daily using the latest 24 hours of data
- Currently input to IMS
- geotiff format



IMS Blended Snow Depth

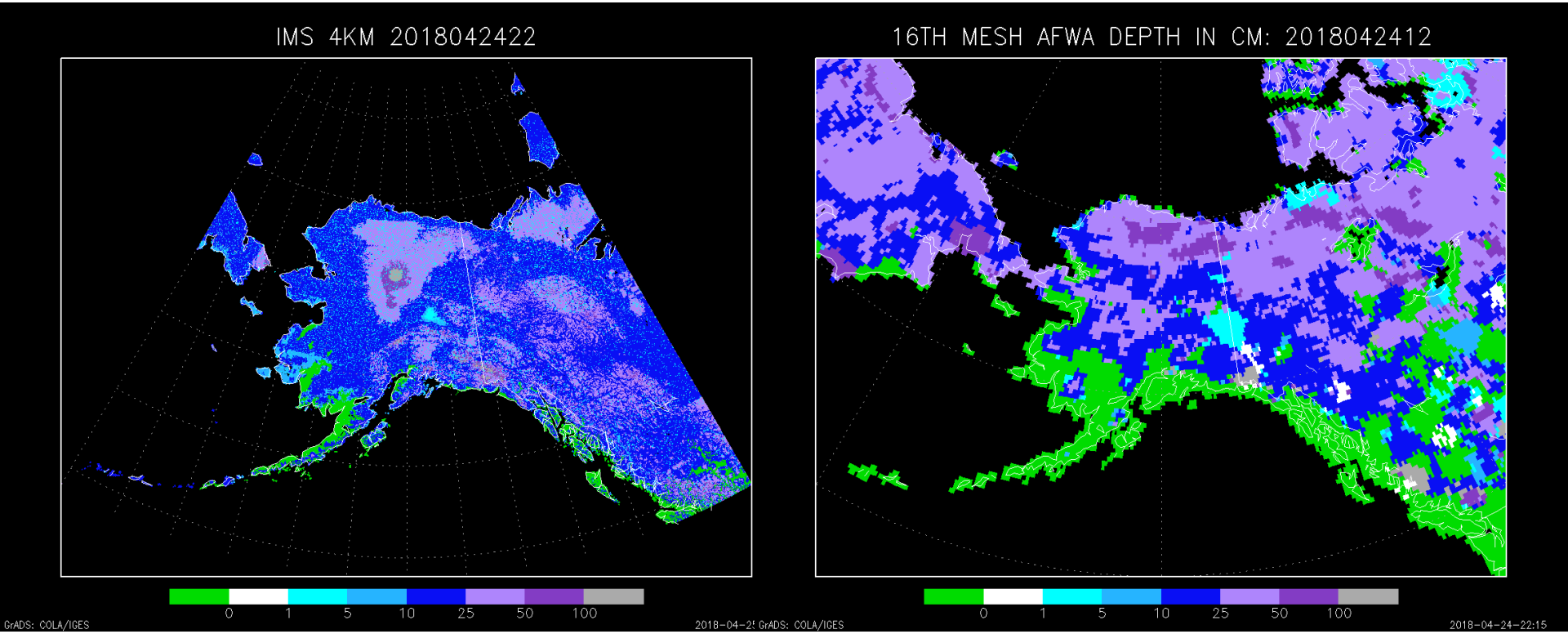
Key features:

- 2-D OI Analysis integrated into IMS V3
- Multi-Source Scheme: MW+in-situ + Climatology + Analyst Updates
- IMS Analyst SD and Uncertainty estimates are also ingested into OI as independent data stream
- MW Downscaling based on elevation
- Applies previous day as initial guess

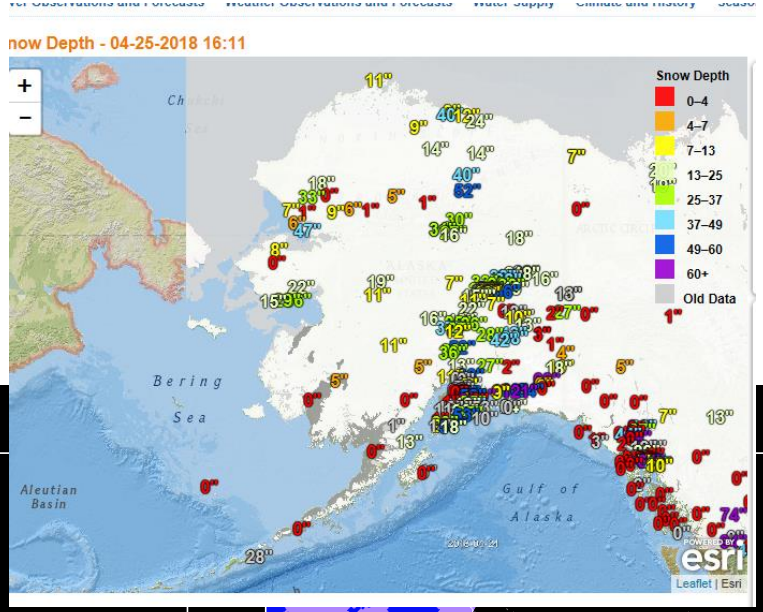


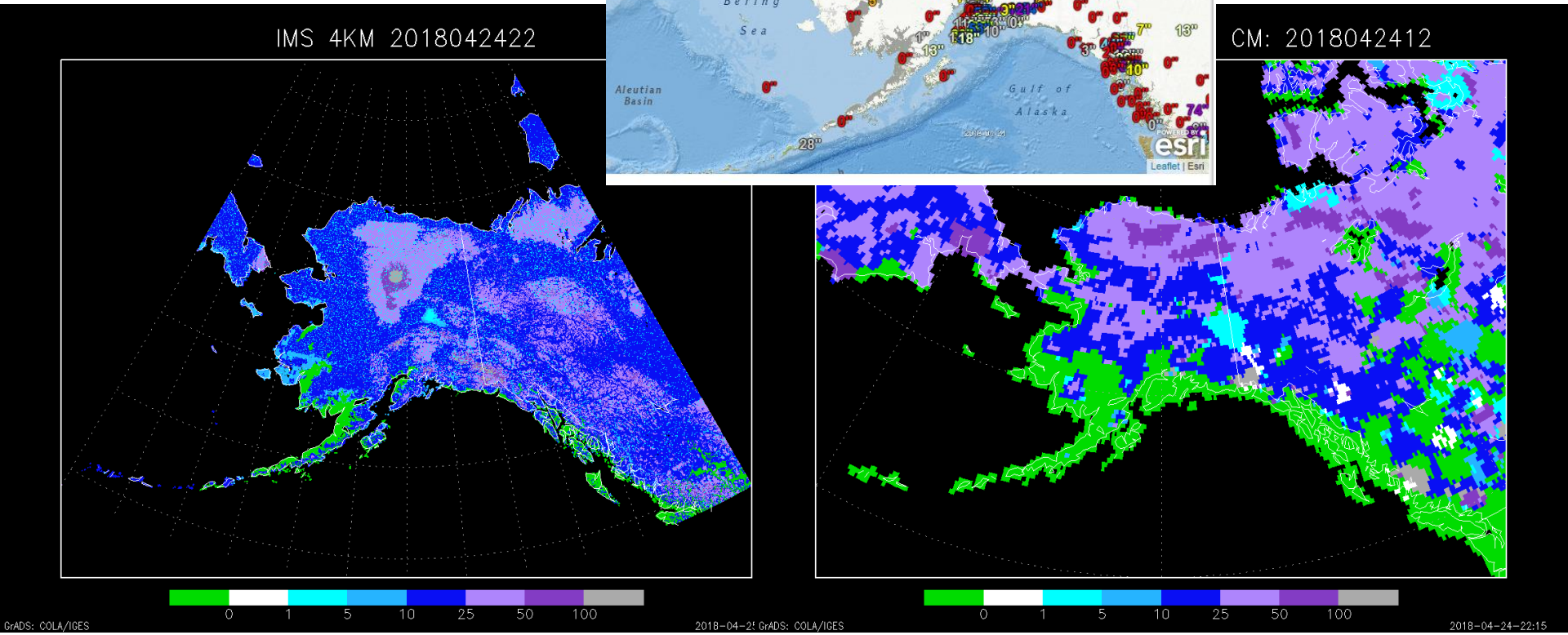
** JAXA's Global Change Observation Mission (GCOM) AMSR2 data is used to generate Snow Depth via NOAA Algorithm, ATMS data uses the NOAA MIRS SWE to convert to SD. Both are applied in the algorithm*

IMS Blended Snow Depth

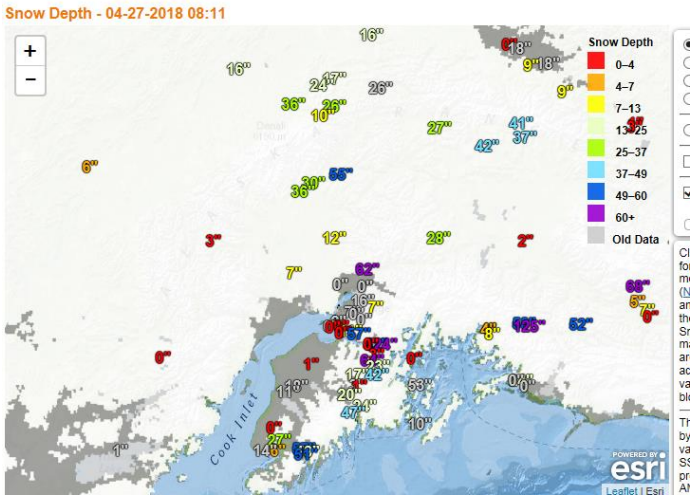


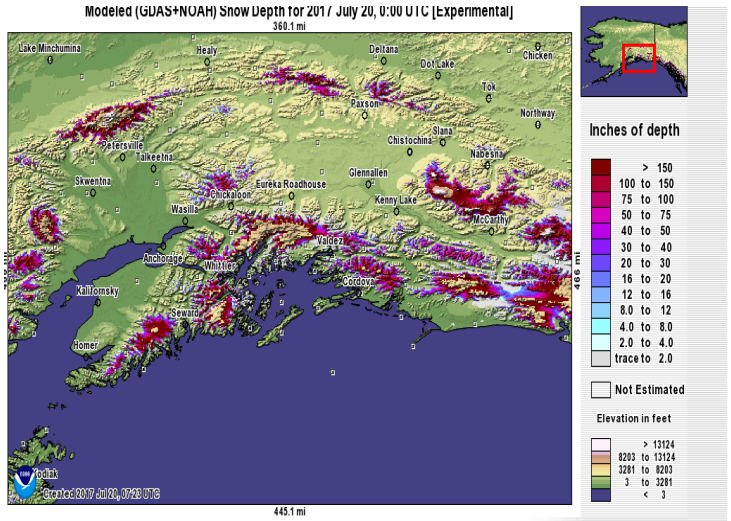
IMS Blended Snow Depth

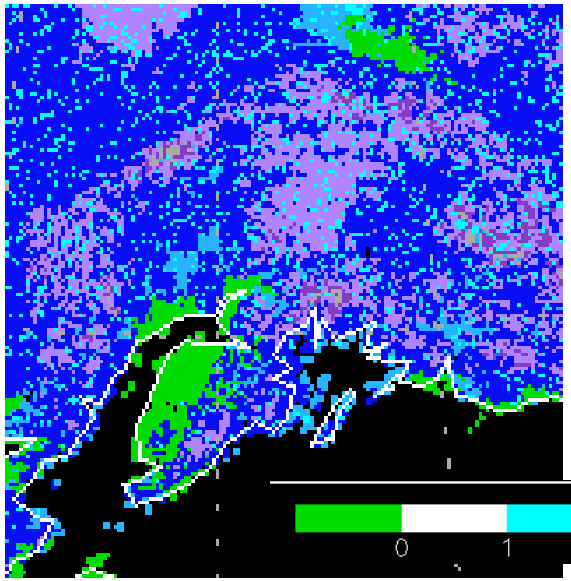




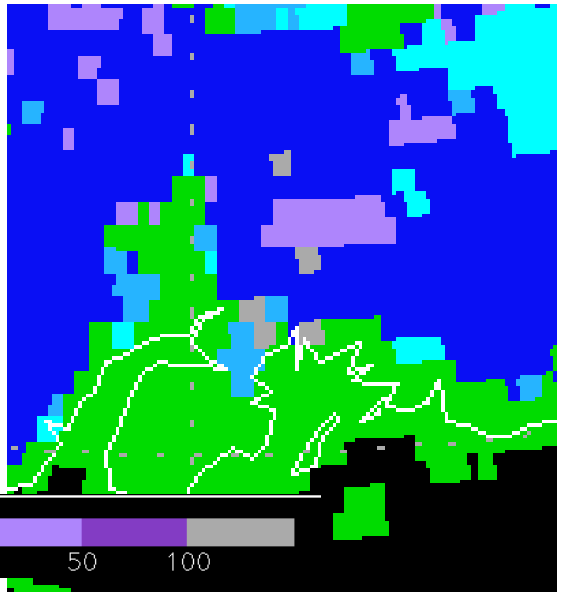
IMS Blended Snow Depth







IMS 4KM 2018042622

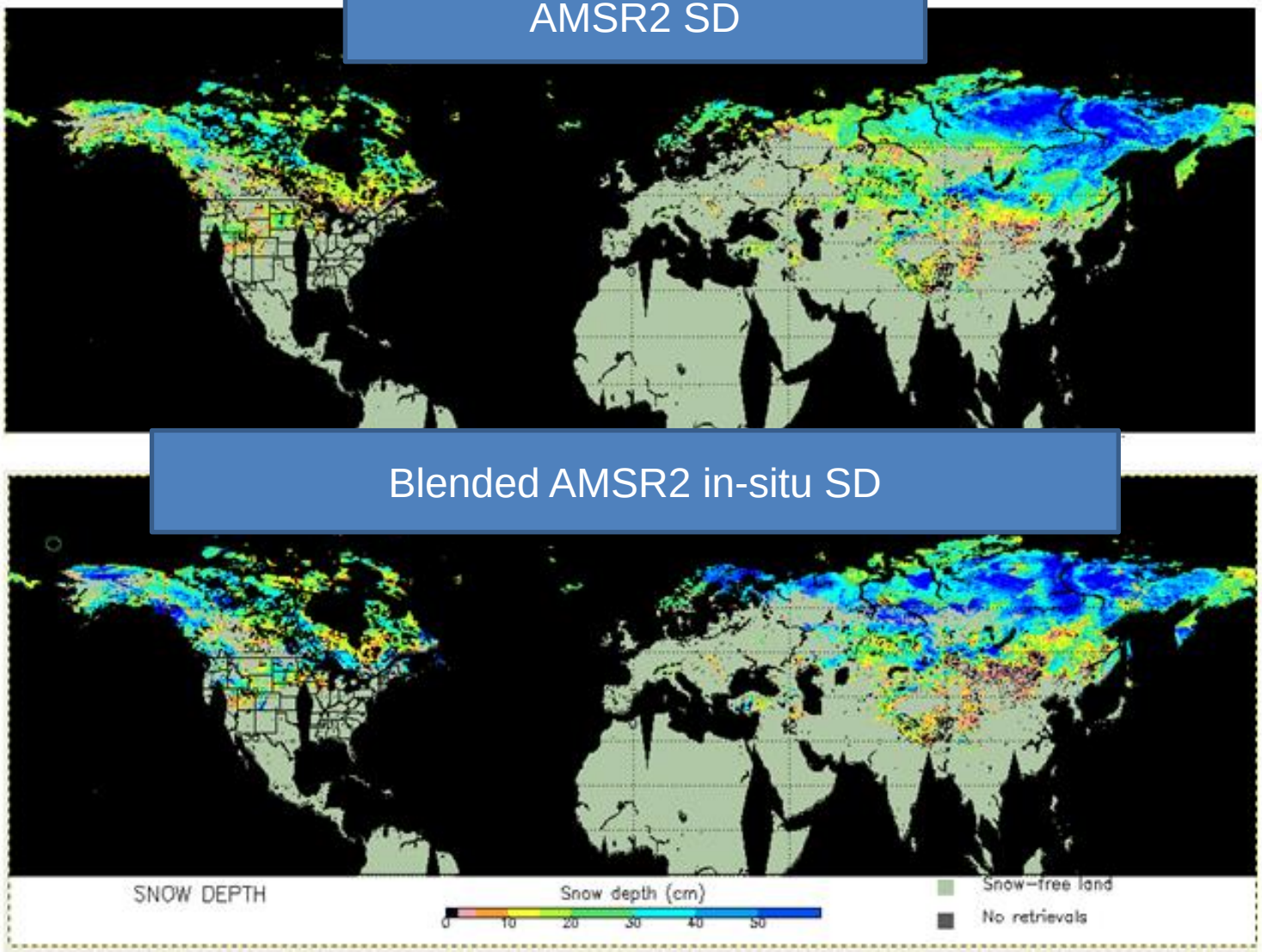


16TH MESH AFWA DEPTH IN CM: 2018042612

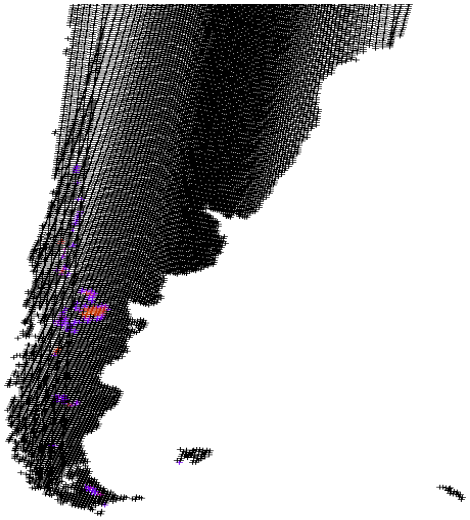
IMS Blended Snow Depth

AMSR2 SD

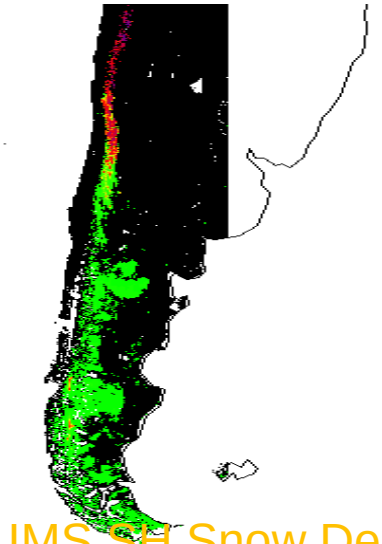
Blended AMSR2 in-situ SD



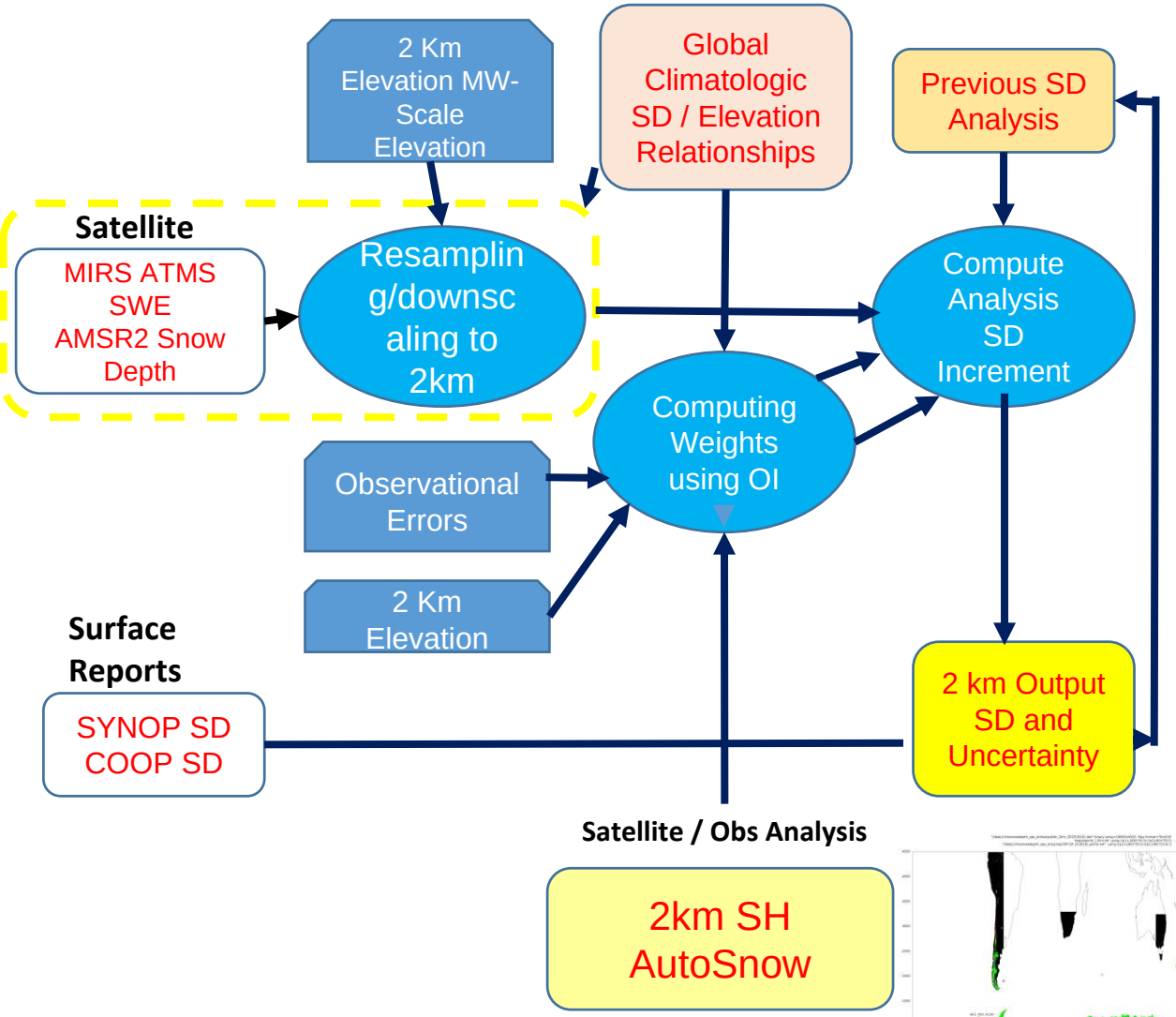
Southern Hemisphere Blended Snow Depth



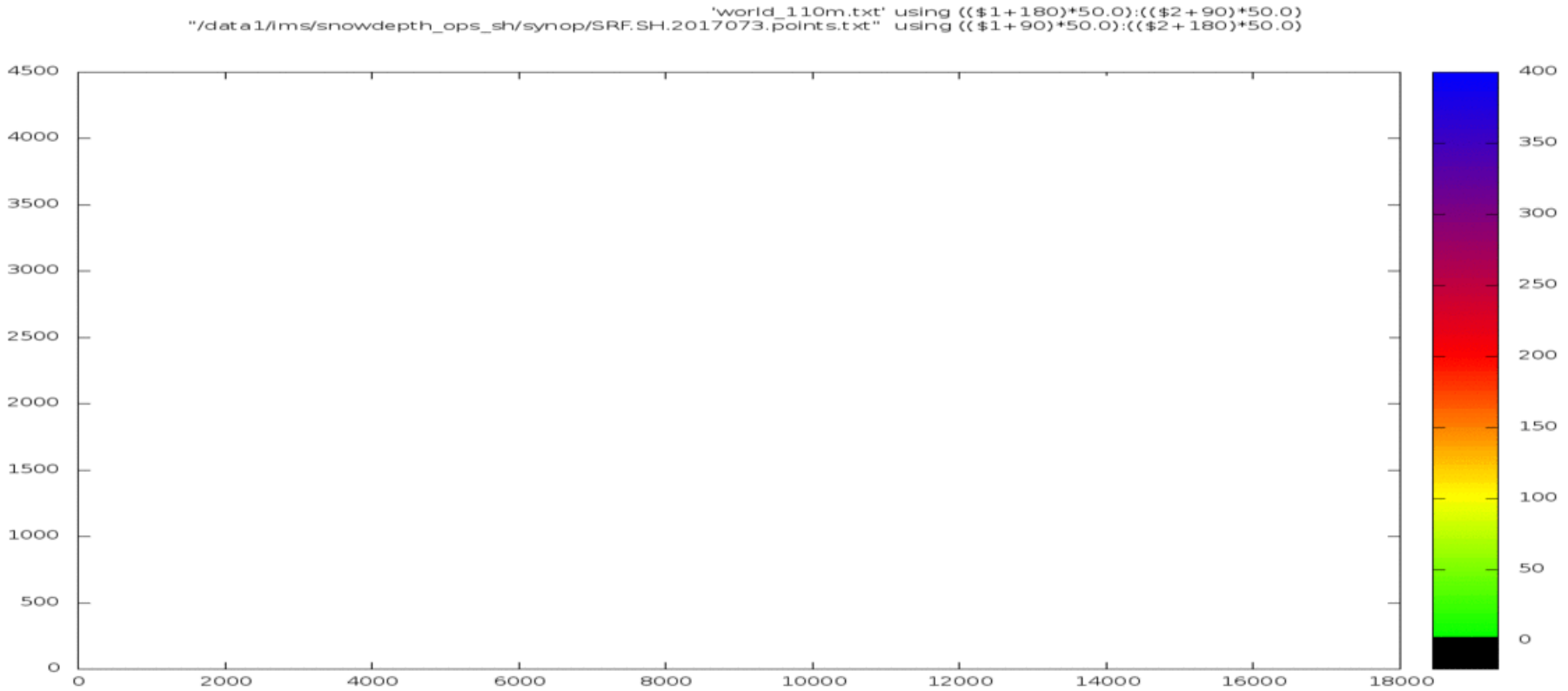
ATMS SWE



IMS SH Snow Depth

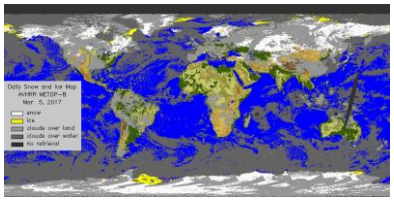


Southern Hemisphere Blended Snow Depth

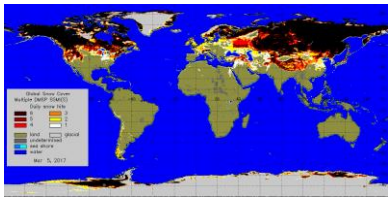


Approach

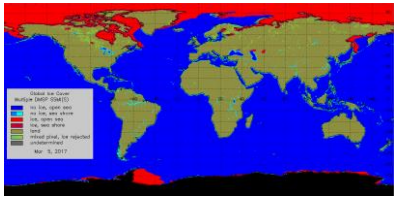
: - Snow/ice maps are derived for each sensor data individually and then combined
- Blending algorithm accounts for snow/ice and temperature climo, surface topography and surface type
- Previous day product is used to fill in remaining gaps in the current day snow/ice map



Optical snow/ice



Microwave snow



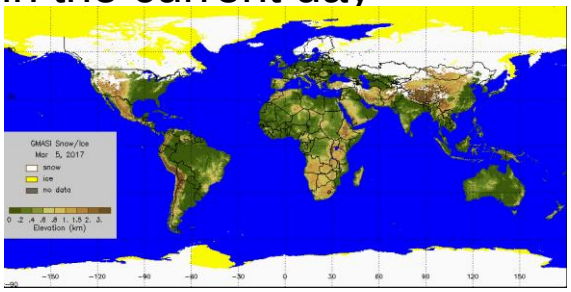
Microwave ice

Blendin g

Climate datasets (snow, ice, LST, SST), elevation, surface type

Final gap-filling

First guess (previous day blended snow/ice map)



Blended daily snow/ice map

Generates daily continuous (gap-free) maps of snow and ice from combined satellite observations in the visible/infrared and in the microwave

Current GMASI Input and Product Features

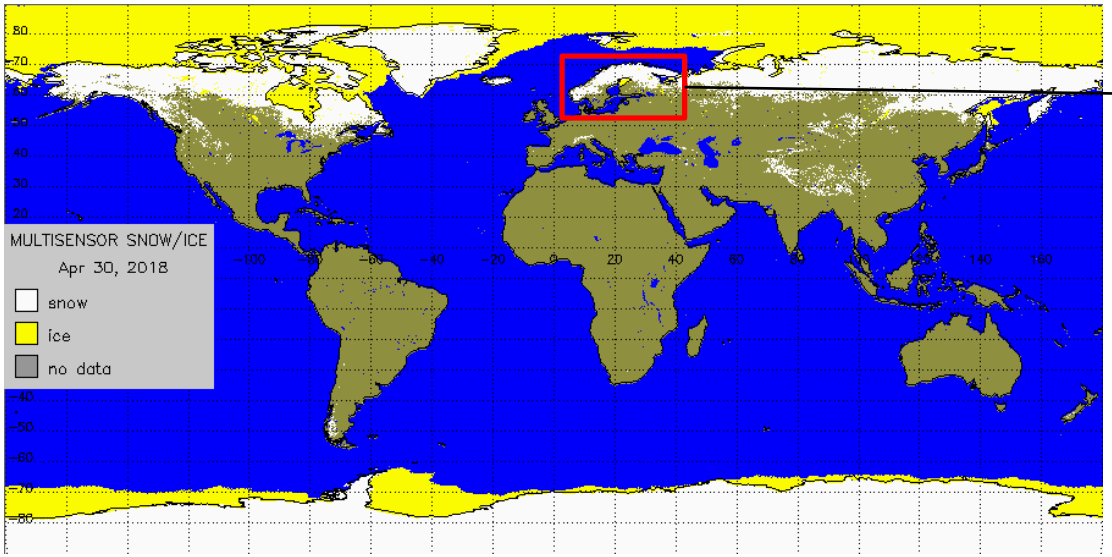
Input:

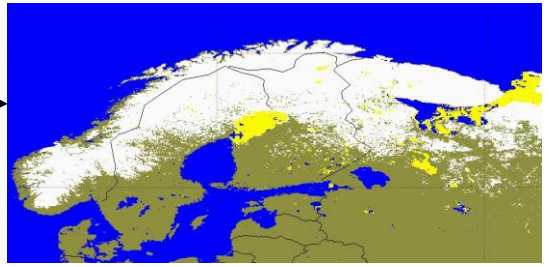
- AVHRR METOP-B
- DMSP SSMI/SSMIS F-15, -16, -17, -18

Output

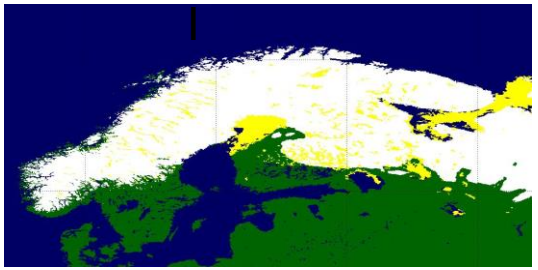
:

- Global daily gap-free map of snow and ice cover
- 0.04^0 (~4 km) resolution, global geographical projection, 0.02^0 (~2 km SH) Operational at OSPO since 2006, reprocessed daily data available since 1988
- > 92% agreement to IMS, over 88% agreement to in situ station data in





GMAS



IMS

In Near Term (2019)

Blended Ice Concentration

Blended Snow Depth improvements

SAR Ice Mask – Algorithm Improvement

SAR Ice Motions

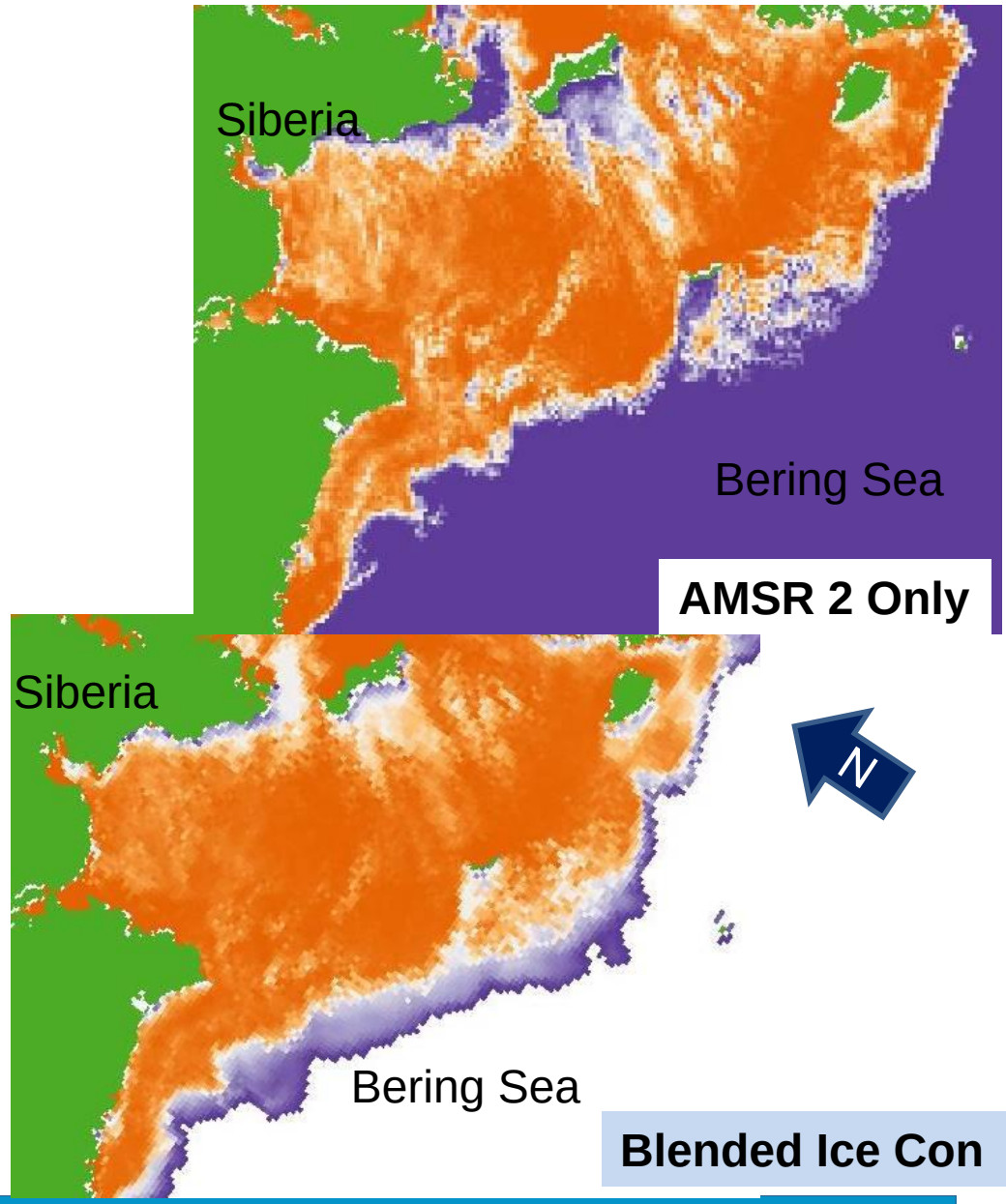
Improvements in IMS production environment

Blended Ice Conc. AMSR2+VIIRS+SAR+Model+Charts

BLENDED ICE CONCENTRATIONS:

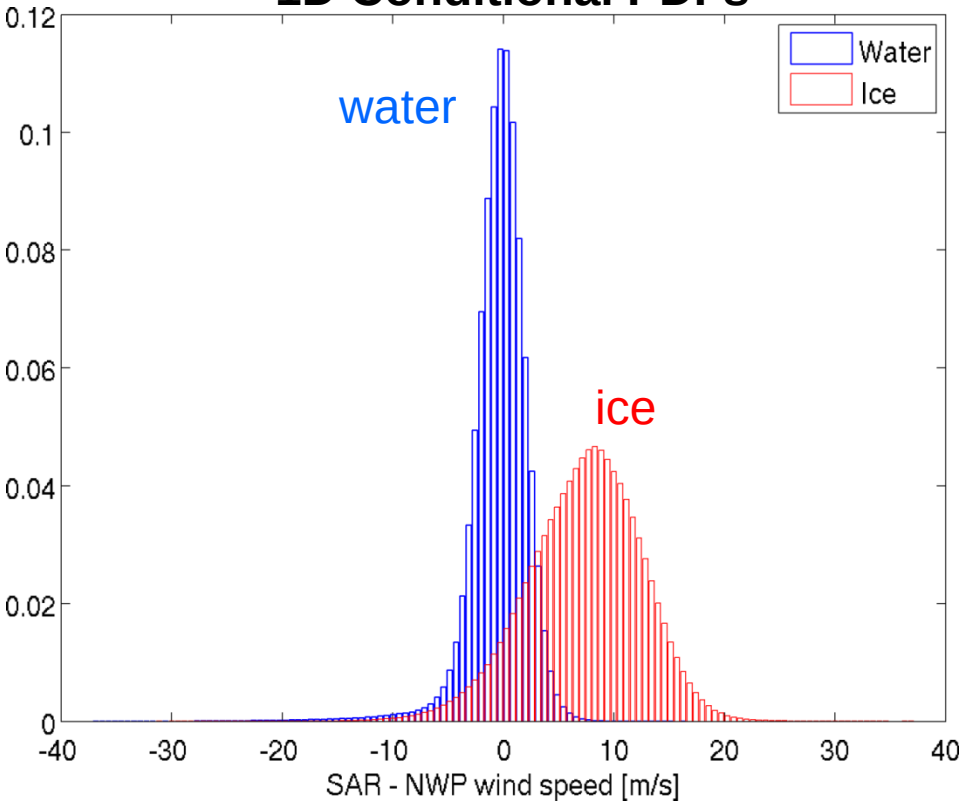
STAR and NIC are developing a Blended Ice Concentration primarily for modeling

- **Using Differential Weighting and Interpolation to blend ice concentrations**
- **Ice Concentrations determined from:**
  - ***IMS Ice Cover***
  - ***AMSR 2***
  - ***SAR Ice Points***
  - ***VIIRS Ice Con***
  - ***Ice Charts (NIC and NWS Alaska*** *with CIS, DMI, MetNo under consideration)*
  - ***NWP model SST***
- **Late 2018/Early 2019 Release**

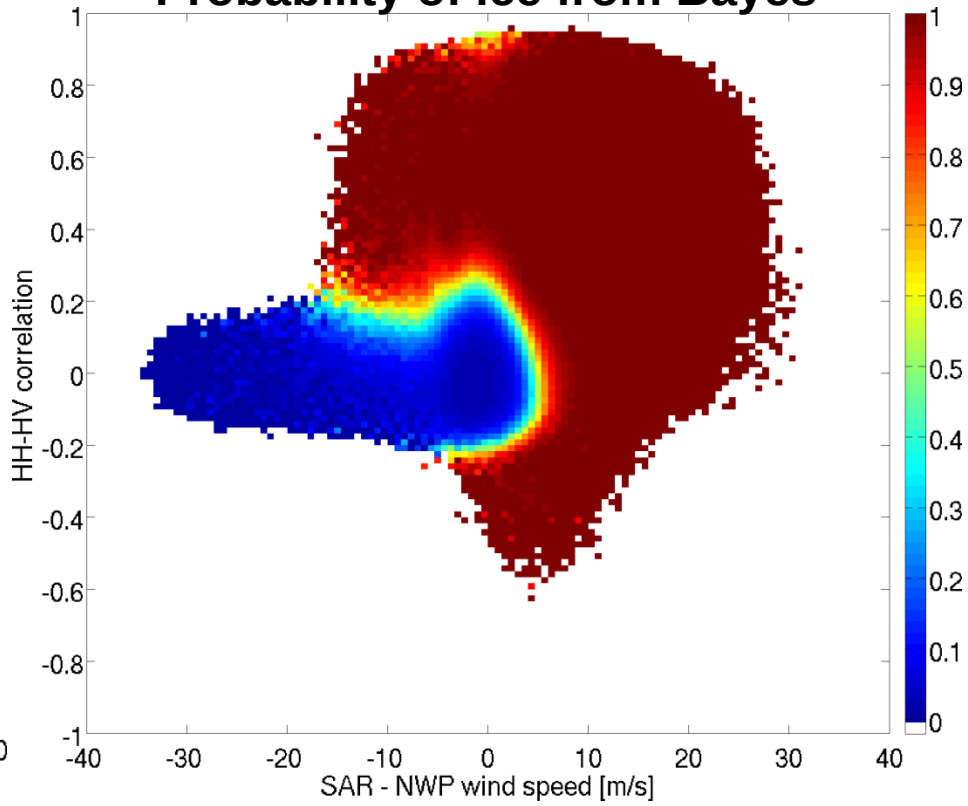


Adding probabilistic threshold for SAR Auto Ice Extent

1D Conditional PDFs



Probability of ice from Bayes

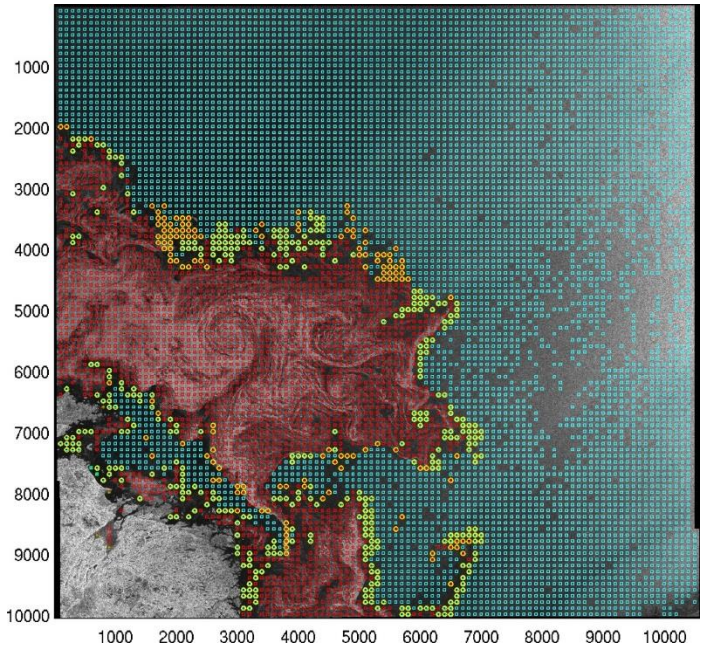


Presence of ice and open water is obtained from CIS image analyses

ECCC Verification against IMS

7411 RADARSAT-2 images in 2013

	Number of samples	Classified [%]	Misclassified [%]	Unknown [%]	Accuracy [%] Nc / (Nc + Nm)
Ice	24,719,977	75.81	2.58	21.61	96.71
Water	12,813,635	55.53	2.90	41.57	95.04
Ice & Water	37,533,612	68.89	2.69	28.43	96.24



Labrador Sea, May 3, 2013

Ice/water retrievals at 5 km spacing

Ice agrees with IMS

Water agrees with IMS

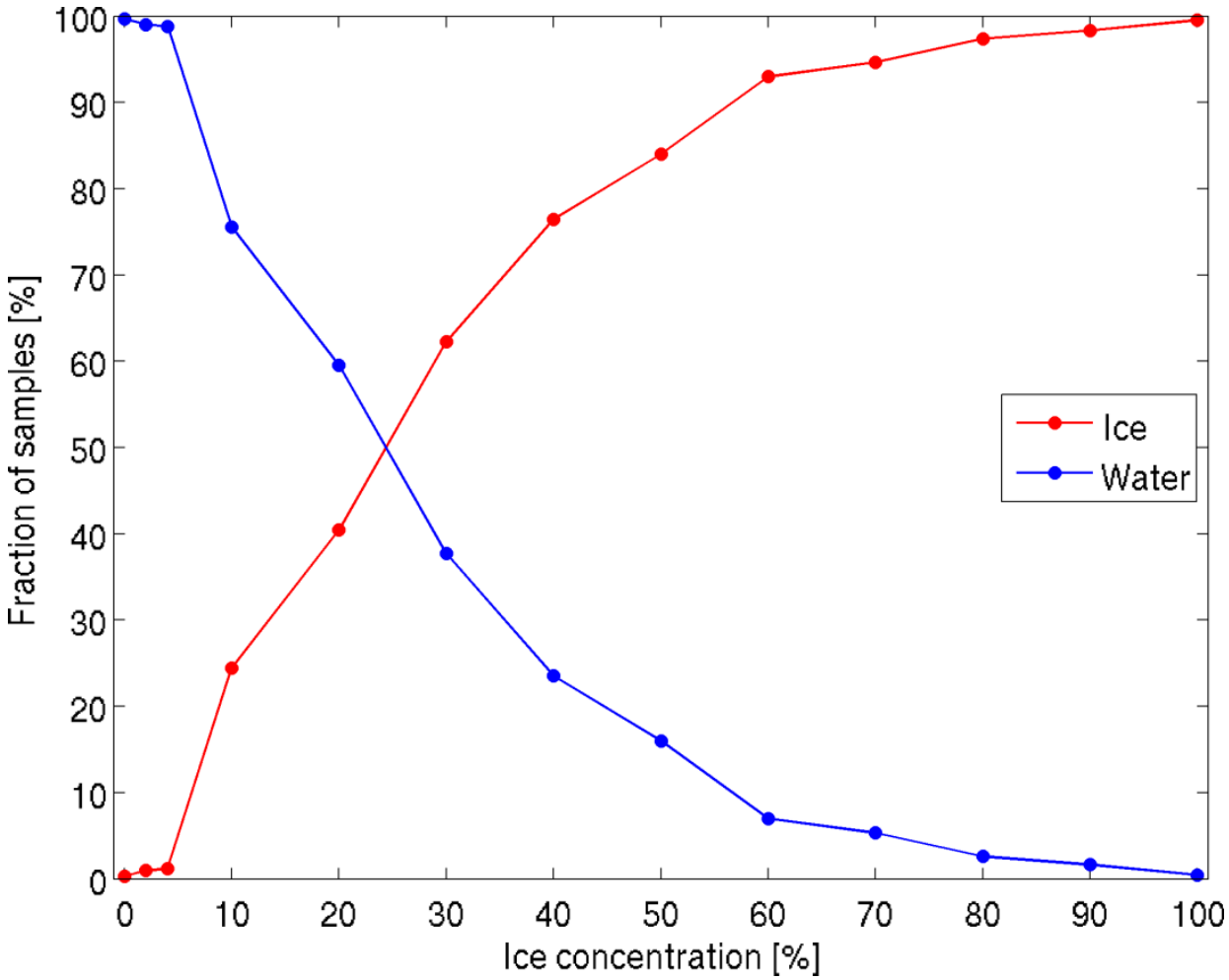
Ice disagrees with IMS

Water disagrees with IMS

Many disagreements likely due to low temporal resolution of IMS

Acknowledgement: Mark Buehner, Alex Komarov, and Alain Caya (ECCC)

Potentiel SAR Ice Concentration



Fraction of ice/water samples

$$F_i = N_i / (N_i + N_w)$$

$$F_w = 1 - F_i$$

Based on estimation of different scales of CIS image analysis and 2x2 km composites of ice points

Same examination is planned by STAR to examine the

Acknowledgement: Mark Buehner, Alex Komarov, and Alain Caya (ECCC)

Outlook for 2020

NIC formally moved to Ocean Prediction Center (OPC), so NIC is no longer a JPSS Blended Products provider but a customer of the products

IMS not part of the enterprise migration since it will be a part of the NWS environment, not NESDIS'. It appears that GMASI (AutoSnowIce) products will remain in the OSPO enterprise environment

GMASI improvements (add SNPP/NOAA-20 VIIRS and GCOM-W1 snow and ice products, 1km resolution, and new formats (netCDF, HDF, geotiff) will be implemented during FY 2019-2020

Greater integration of Passive Microwave (ATMS, AMSR) + VIIRS + SAR + Scatterometry + GEO + Altimetry products to improve accuracy and customer support.

IMS moving more towards a semi-automated analysis due to the improved input data sources and allowing more time for analysts to forecast ice.

Thank you for your attention

For more information contact
NOAA/NESDIS/STAR/SOCD/MECB
Email: sean.helfrich@noaa.gov