



# ***Naval Oceanographic Office Cryosphere Session***

***STAR JPSS 2017 Annual Science Team Meeting  
14 – 18 August 2017 NCWCP College Park, MD***

***NAVOCEANO  
NRL-DC  
NRL-SSC***

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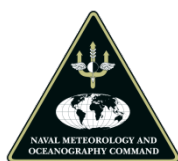


# ***Naval Oceanographic Office***



## ***Outline***

- ***Naval Research Lab-Stennis Space Center (NRL-SSC)***
  - ***Arctic Cap Nowcast/Forecast System (ACNFS)***
  - ***Global Ocean Forecast System (GOFS)***
  - ***Assimilating Ice***
- ***NRL- Washington, DC (NRL-DC)***
  - ***VIIRS Ice concentration***
  - ***Blended AMSR2/VIIRS***
- ***NAVOCEANO***
  - ***Operational Sea Ice for assimilation***
- ***Questions and contacts***



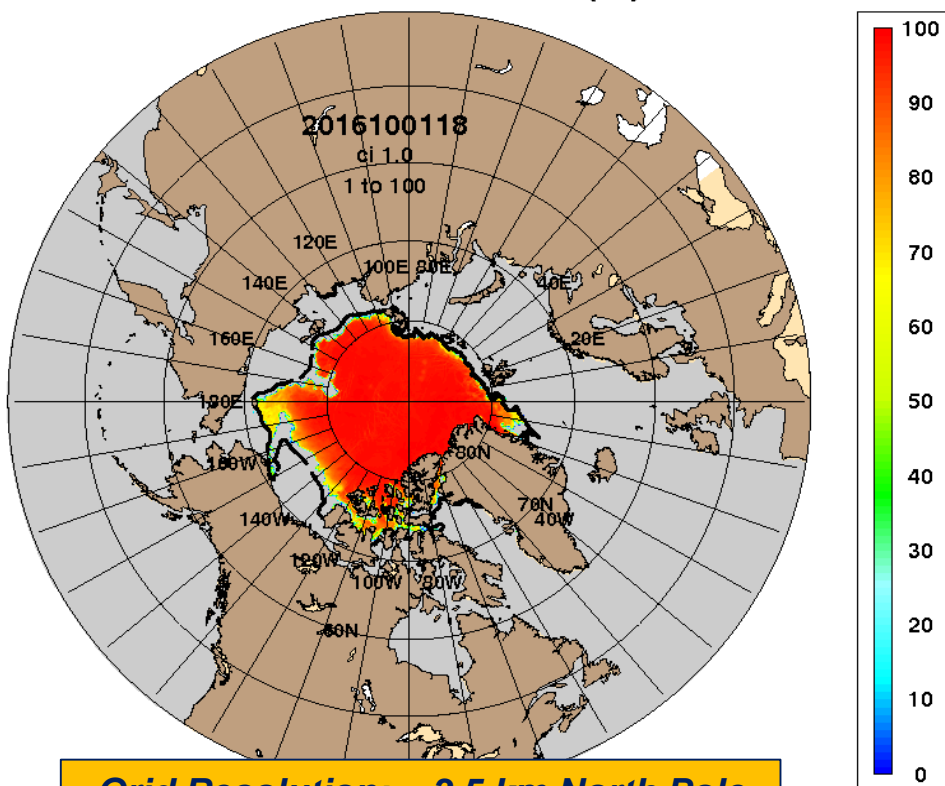
# Arctic Cap Nowcast/Forecast System (ACNFS)



- **ACNFS consists of 3 components:**
  - Ice Model:** Community Ice CodE (CICE) v4
  - Ocean Model:** HYbrid Coordinate Ocean Model (HYCOM)
  - Data assimilation:** Navy Coupled Ocean Data Assimilation (NCODA)
- **Prescribed atmospheric forcing from NAVy's Global Environmental Model (NAVGEN)**
- **Declared operational Sept 2013**
- **Runs daily at the Naval Oceanographic Office (NAVOCEANO)**
- **ACNFS produces nowcast/7-day forecasts of ice concentration, ice thickness, ice drift, SST, SSS, and ocean currents for the Northern Hemisphere**
- **Products pushed daily to the U.S. National Ice Center (NIC) and NOAA**

Daily graphics can be found:  
[www7320.nrlssc.navy.mil/hycomARC](http://www7320.nrlssc.navy.mil/hycomARC)

ARCc0.08-04.6 Ice Concentration (%): 20160929



Grid Resolution: ~3.5 km North Pole  
Black line is the independent ice edge location (NIC). Animation spans Sept – Oct 2016



# Global Ocean Forecast System (GOFS) 3.1

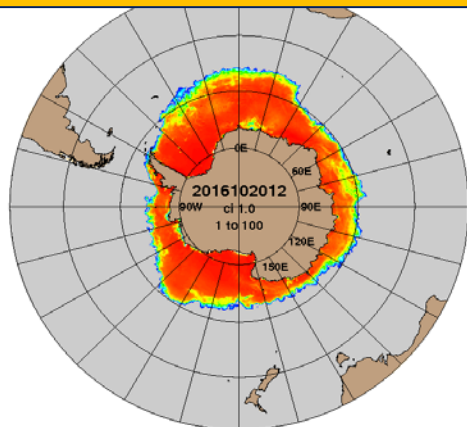


- **Similar to ACNFS, GOFS 3.1 produces ice forecasts in the Northern Hemisphere and also has the added capability of forecasting ice conditions in the southern hemisphere.**
- **OPTEST is underway, scheduled to be completed by end of summer 2017**
- **Once declared operational, GOFS 3.1 will replace ACNFS**

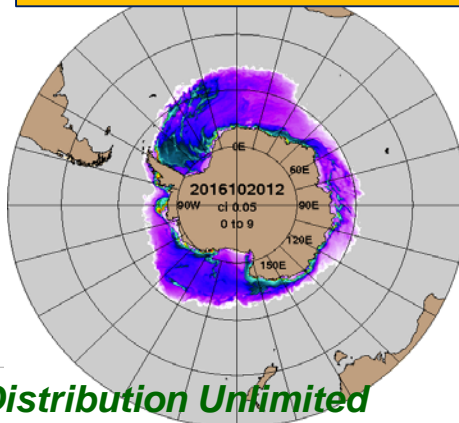
**Daily graphics available:**

**<http://www7320.nrlssc.navy.mil/GLBhycomcice1-12>**

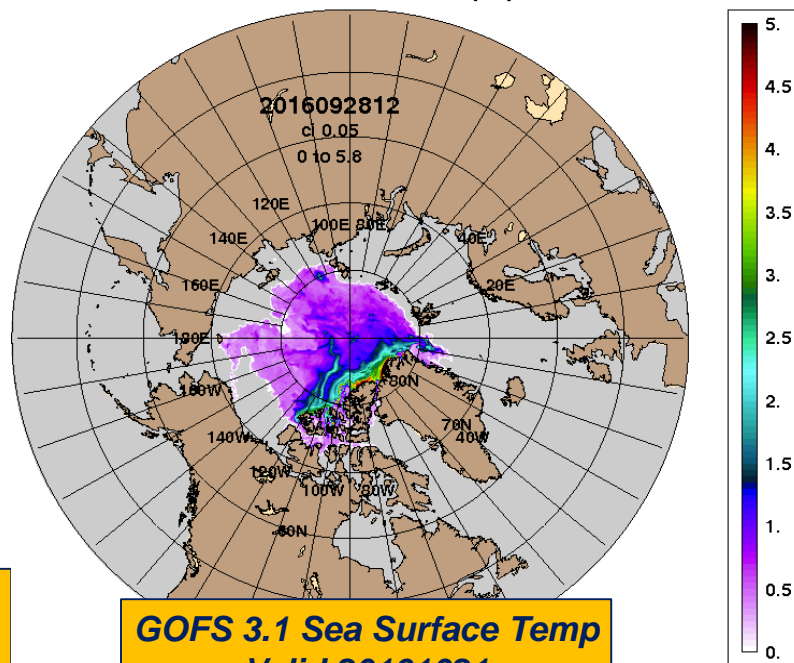
**GOFS 3.1 Ice Concentration  
Valid 20161021**



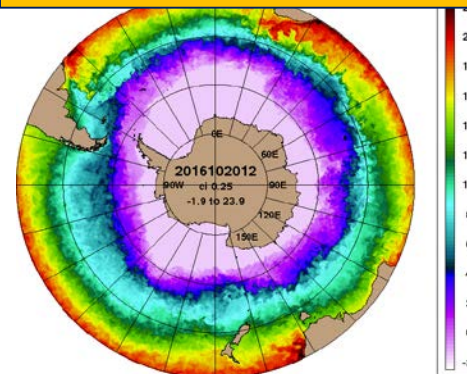
**GOFS 3.1 Ice Thickness  
Valid 20161021**



**GLBb0.08-92.7 Ice Thickness (m): 20160929**



**GOFS 3.1 Sea Surface Temp  
Valid 20161021**





# ***Assimilating ice observations***



- Since the late 1990's, DMSP SSMI and then SSMIS ice concentration (~25km) have been assimilated in the Navy's ice forecast systems***
- Since Feb 2015, implemented AMSR2 ice concentration into operational ACNFS and pre-operational GOFS 3.1***
- NRL will be implementing VIIRS ice concentration into GOFS 3.1 by the end of calendar year 2017***
  - Performed sensitivity tests assimilating new data source VIIRS ice concentration (NOAA – U of Wisconsin) in ACNFS for May – Sept 2016***

## ***IMPORTANT:***

***For operational systems, observations must be available in near real-time (within 12 hrs).***

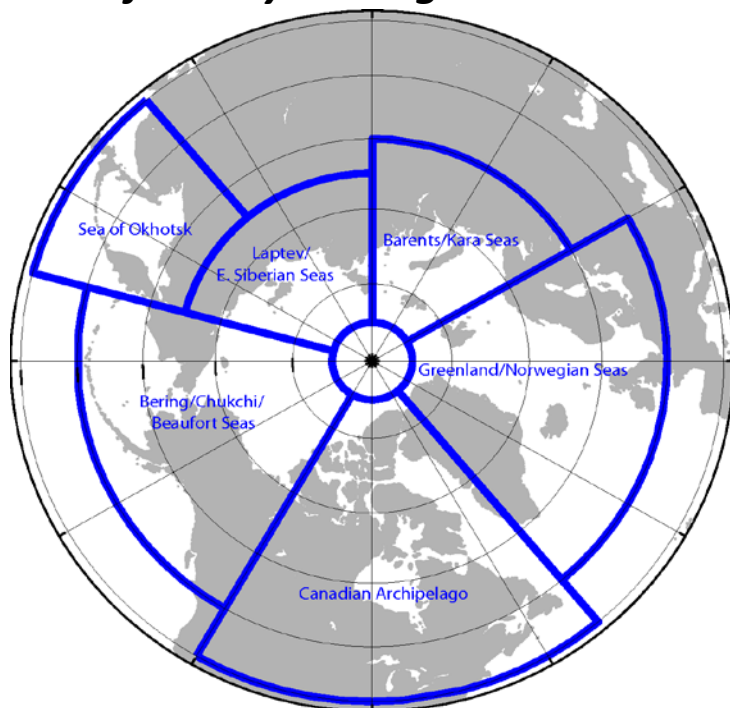




# Ongoing Efforts:



*Arctic ice validation analysis regions defined by the regional seas*



*Mean ice edge errors (km) between the observed ice edge and 6 hr ACNFS for the time period of May – Sept 2016*

Region	Op ACNFS SSMI/AMSR2	ACNFS SSMI/AMSR2/VIIRS
Arctic	41 km	27 km
Greenland	38 km	26 km
Barents	34 km	24 km
Sea of O	31 km	23 km
Can Arch	54 km	31 km
Total improvement		34%

**Improvement of 34% over current operational capability along the ice edge location**

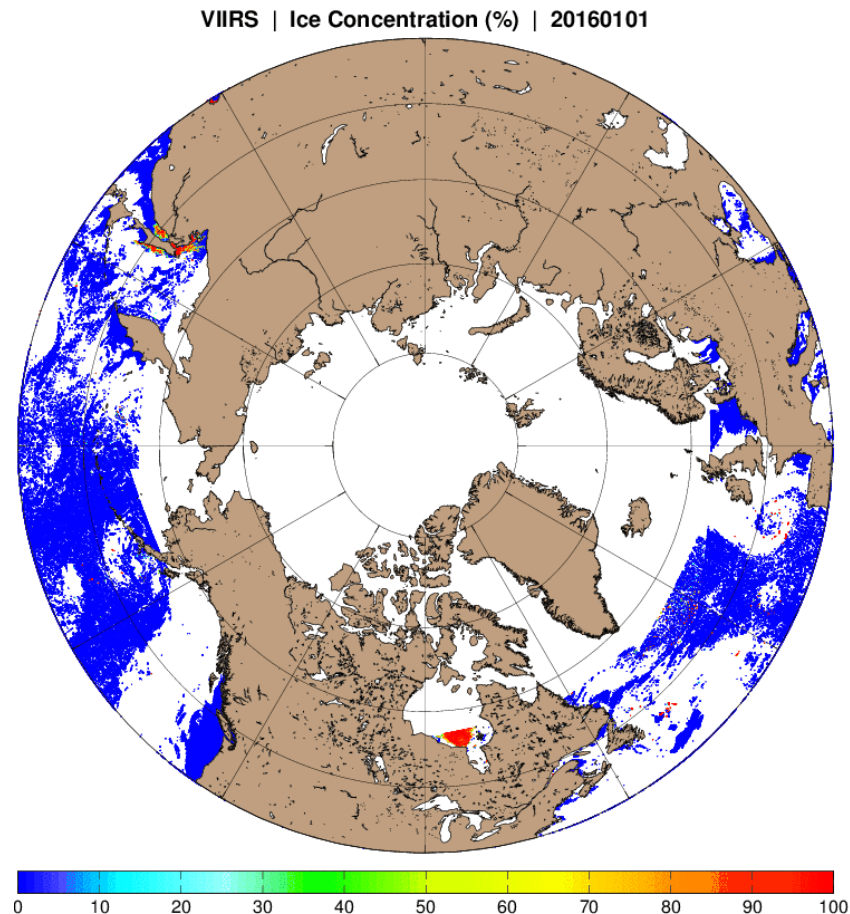
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# VIIRS Operational Satellite Sea Ice Concentration Algorithm



- **Adopted from the AMSR-E/MODIS algorithm to blend AMSR2/VIIRS sea ice data for data assimilation.**
- **VIIRS standalone algorithm doesn't require inputs data from AMSR2 and other VIIRS EDRs**
  - **Inputs: VIIRS visible & near IR data**
  - **Outputs: surface/cloud classification and sea ice concentration**
- **Daytime retrievals only**
- **Good coverage of Marginal Ice Zone**
- **Less affected by summer melt**



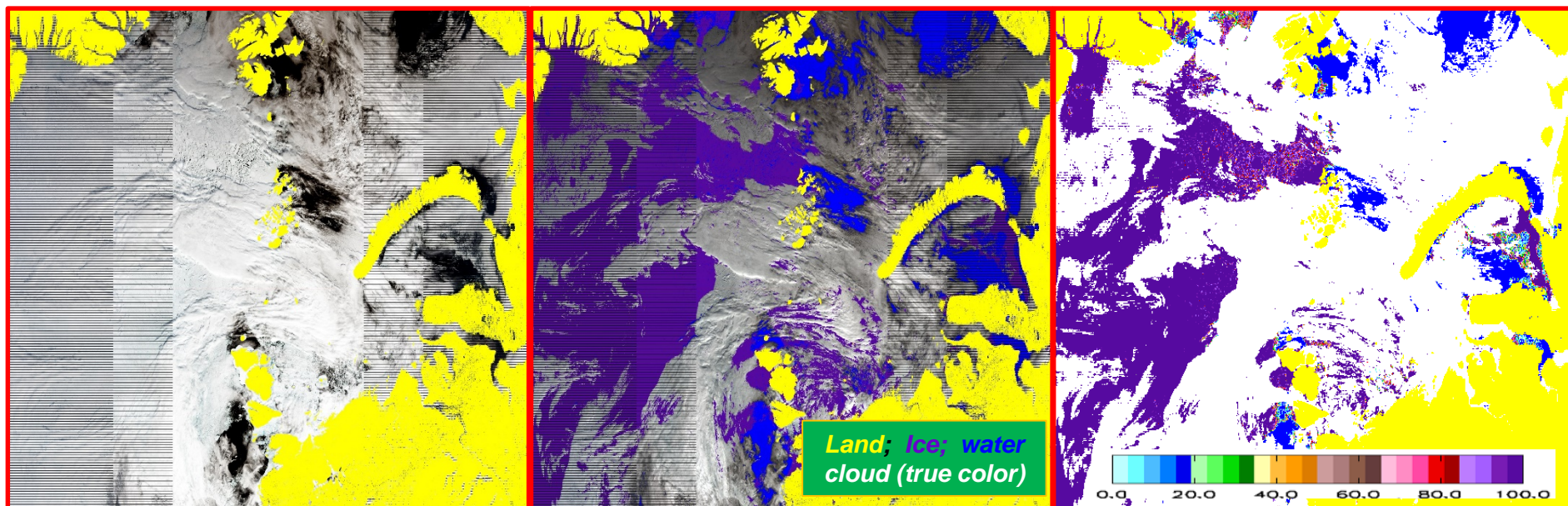
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# VIIRS Algorithm Procedure



- 1) **Surface classification at 375m resolution water/sea ice/snow-on-ice/cloud/land**
- 2) **Ice concentration is then calculated at a degraded 4km resolution to match the Arctic ice model resolution**
- 3) **Retrieval is performed on swath data then projected to the 4km EASE grid**



True Color

Surface Classification

Sea Ice Concentration

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# Blended AMSR2 and VIIRS Daily Sea Ice Concentration (SIC) Data

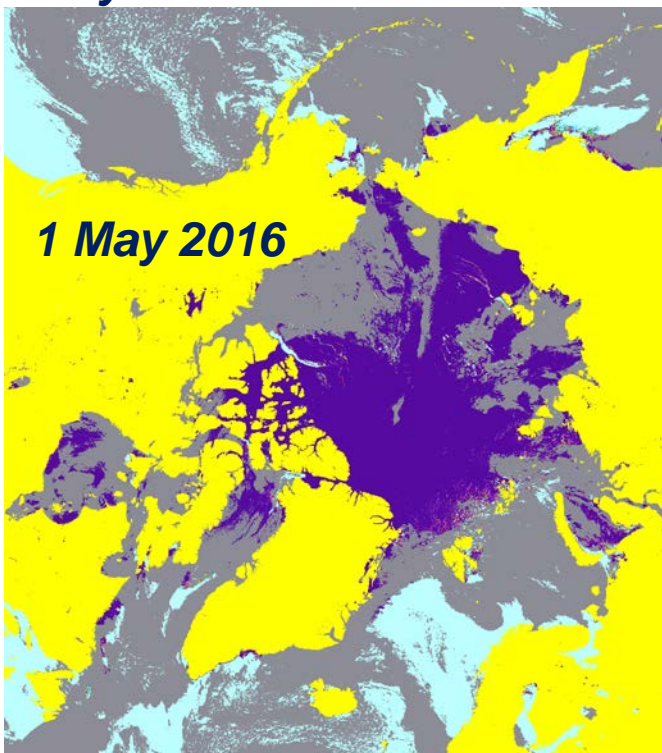


*Combined AMSR2/VIIRS information provide the best resolution, accuracy and data coverage available.*

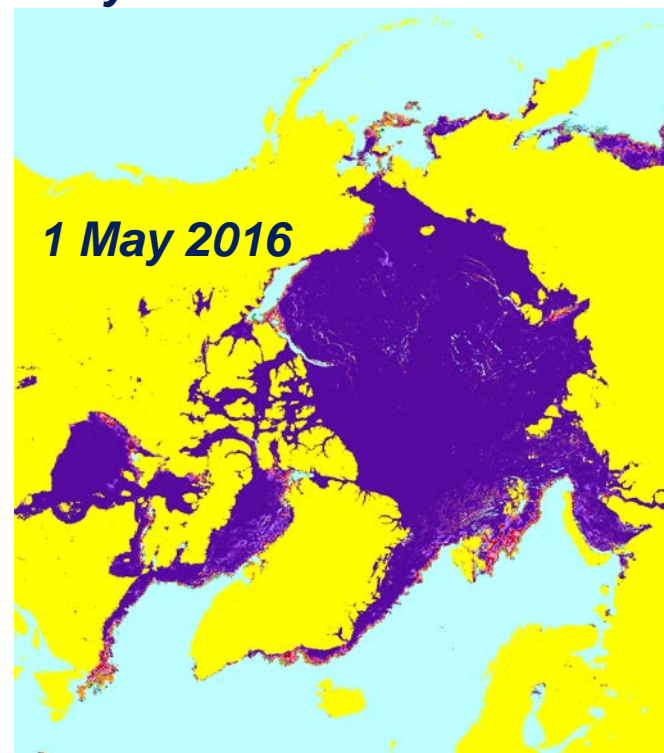
Cloud &  
No Data

Clear  
Sky & No  
Ice

**Daily VIIRS SIC**



**Daily AMSR2/VIIRS SIC data**



**Ice Concentration (%)**

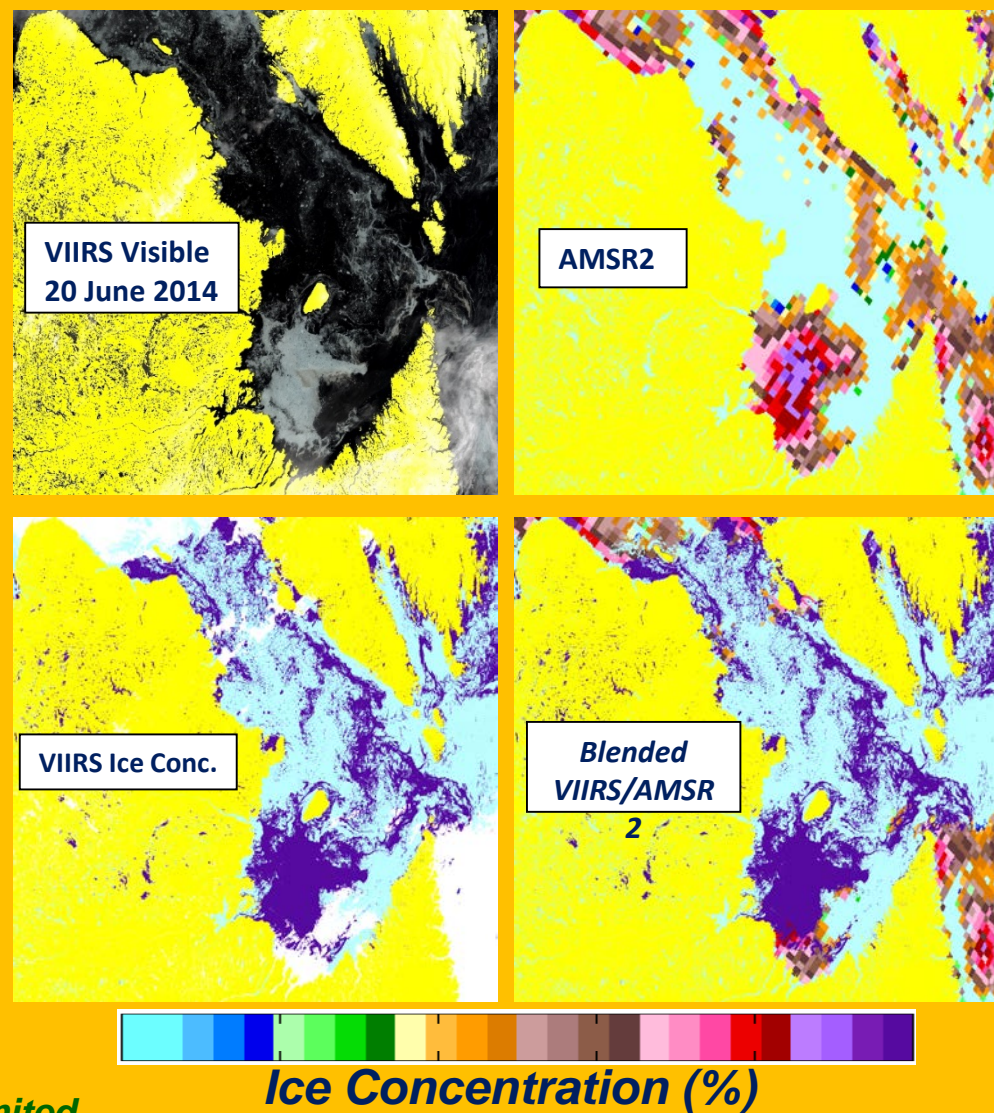
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# Blended AMSR2 and VIIRS Sea Ice Concentration Data in MIZ



- *Better accuracy for the low ice concentration conditions in the MIZ for clear sky region*
- *Better ice edge information than AMSR2 alone due to the improvements in data resolution*



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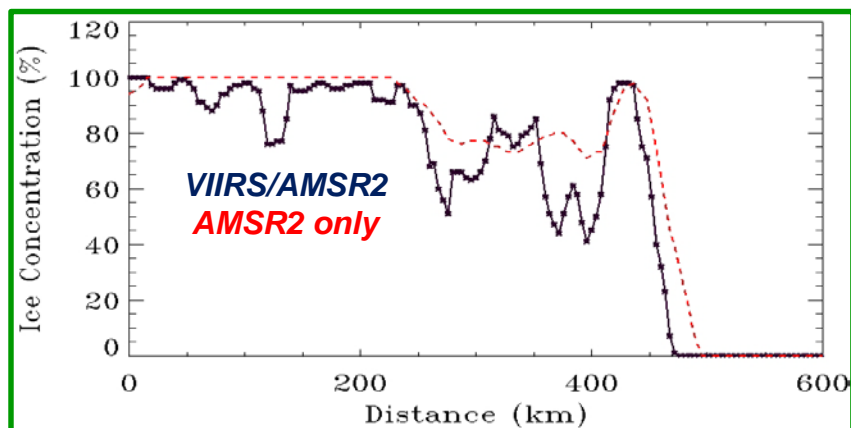




# Assimilation of the NPP VIIRS Sea Ice Concentration (SIC) Data for Arctic forecasts



## Sea ice concentration observations



## Mean ice edge errors (km) between the observed and forecasts

Region	Assimilation without VIIRS data	Assimilation including VIIRS data
Pan-Arctic	45.8	33.4
Greenland	43.8	34.6
Barents	37.7	25.3
Laptev	64.8	51.6
Sea of Okhotsk	40.1	35.8
Bering/Beaufort	43.0	35.6
Canadian Arch	57.6	33.3

AMSR2 SIC

VIIRS/AMSR2 SIC

7 July 2016

7 July 2016

- Average errors for the time period of Jan – Dec 2016.
- Adding VIIRS SIC products into the operational sea ice forecast reduces ice edge error by an average of 25%

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Naval Oceanography

Ready Fleet, Global Reach



# NAVOCEANO Operational Sea Ice data for ACNFS/GOFS Assimilation



**FY19**

**NAVO NPP VIIRS Ice  
Concentration**

**NAVO J-1 VIIRS Ice  
Concentration**

**NAVO AMSR2 Ice  
Concentration**

**FNMOCC SSMIS Ice  
Concentration**

**NIC 4km IMS**

**NIC Ice  
concentration**

**Ice Thickness**

**FY18**

**NAVO NPP VIIRS Ice  
Concentration**

**NAVO AMSR2 Ice  
Concentration**

**FNMOCC SSMIS Ice  
Concentration**

**NIC 4km IMS**

**Current**

**JAXA AMSR2 Ice  
Concentration**

**FNMOCC SSMIS Ice  
Concentration**

**NIC 4km IMS**

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**Naval Oceanography**

**Ready Fleet, Global Reach**

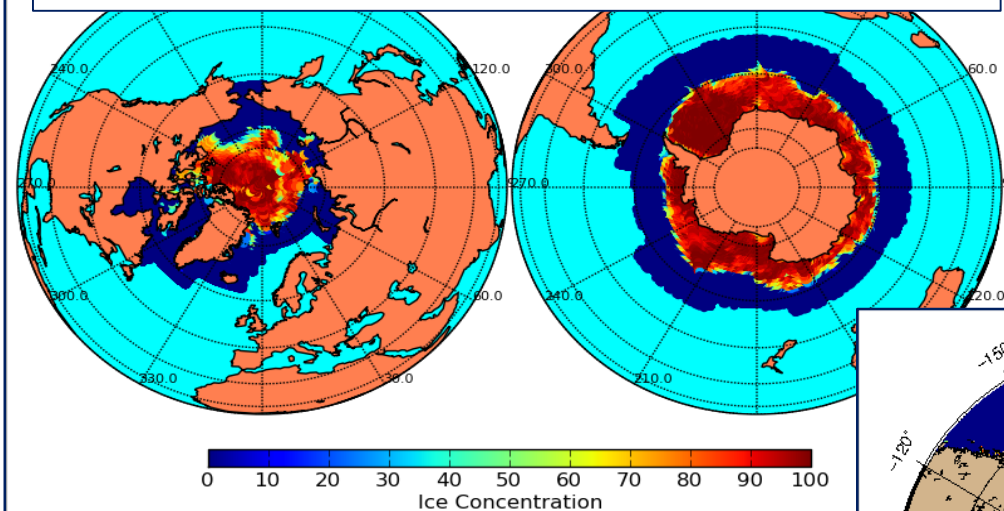




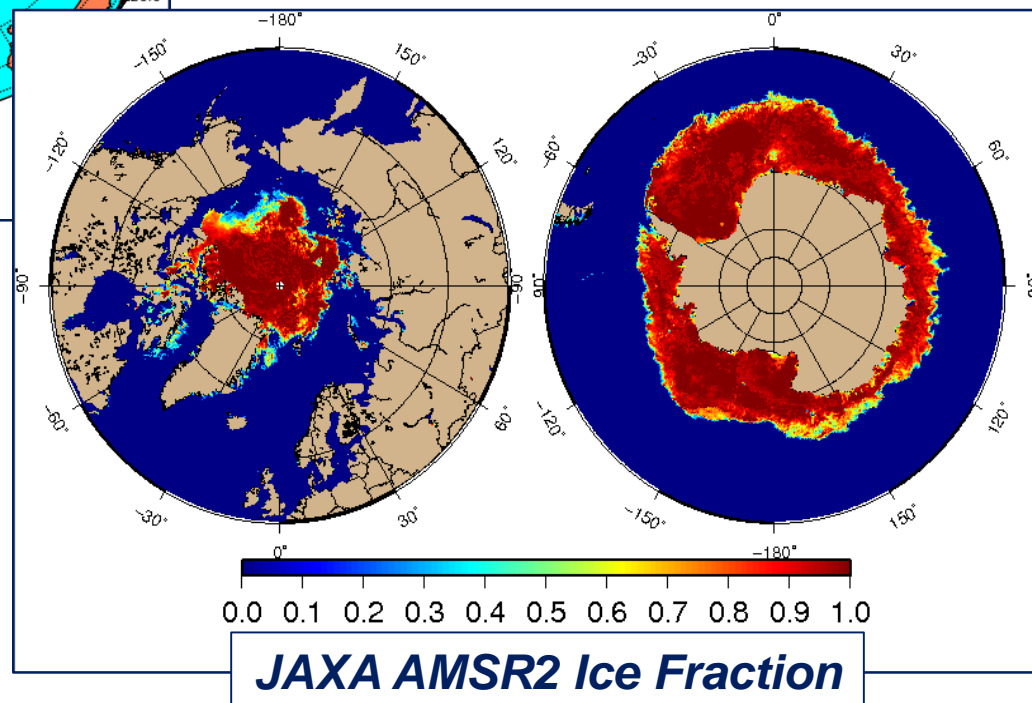
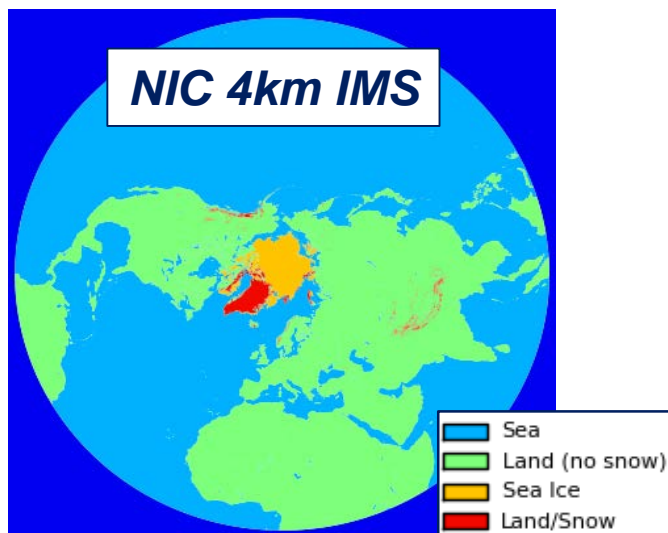
# NAVOCEANO Operational Sea Ice data for ACNFS/GOFS Assimilation



## FNMOC SSMIS F16/18 Ice Concentration



## NIC 4km IMS



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# Questions ?

## ***Points of Contact:***

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