

Improving Arctic sea ice edge forecasts by assimilating high resolution VIIRS sea ice concentration data into the U.S. Navy's ice forecast systems

R. Allard¹, D.A. Hebert¹, W. Johnston³, L. Li¹, J. May¹, M.W. Phelps⁴, P.G. Posey², and O.M. Smedstad²
¹Naval Research Laboratory, ²Vencore Services and Solutions, Inc., ³Computational Physics, Inc., ⁴Jacobs Technology Inc.



Abstract

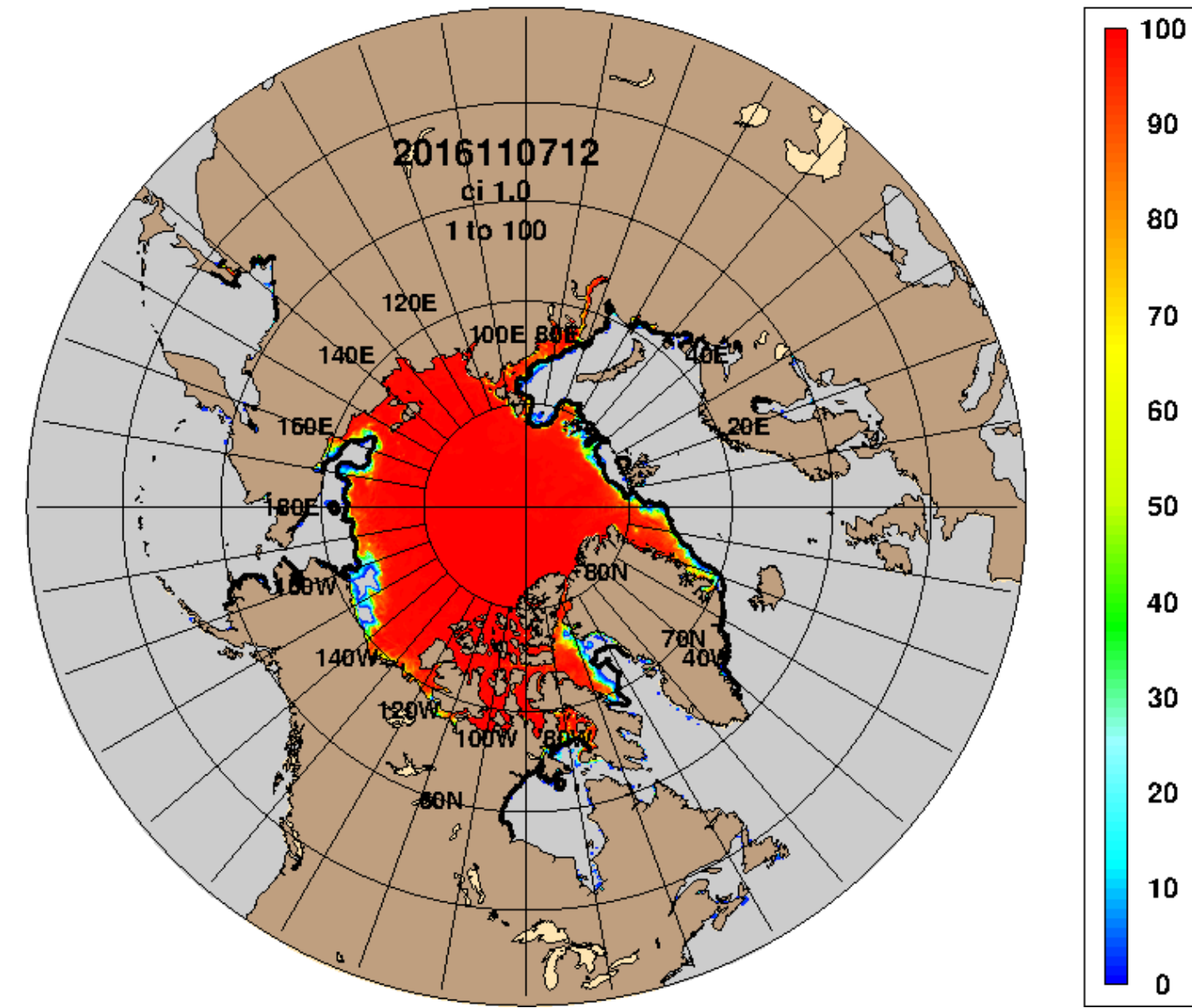
This study presents the improvement in ice edge error within the U.S. Navy's sea ice forecast system gained by assimilating the high horizontal resolution visible/infrared satellite-derived VIIRS ice concentration products. A hindcast study is performed for the period of 1 November 2016 - 31 October 2017 using the Global Ocean Forecast System (GOFS 3.1), a 1/12° Hybrid Coordinate Ocean Model (HYCOM) that is two-way coupled to the Community Ice CodE (CICE) in a daily update cycle with the Navy Coupled Ocean Data Assimilation (NCODA). Comparisons using the Visible Infrared Imaging Radiometer Suite (VIIRS) ice concentration products (< 1km resolution) show lower ice edge location errors than the current system, which assimilates near real-time passive microwave data from the Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave/Imager (SSMIS) and the Advanced Microwave Scanning Radiometer (AMSR2) ice concentration products (25 and 12.5 km resolution respectively). The daily ice edge locations from the model simulations are compared against independent observed ice edge locations. Results from the Arctic and Antarctic regional areas are presented.

Global Ocean Forecast System (GOFS 3.1)

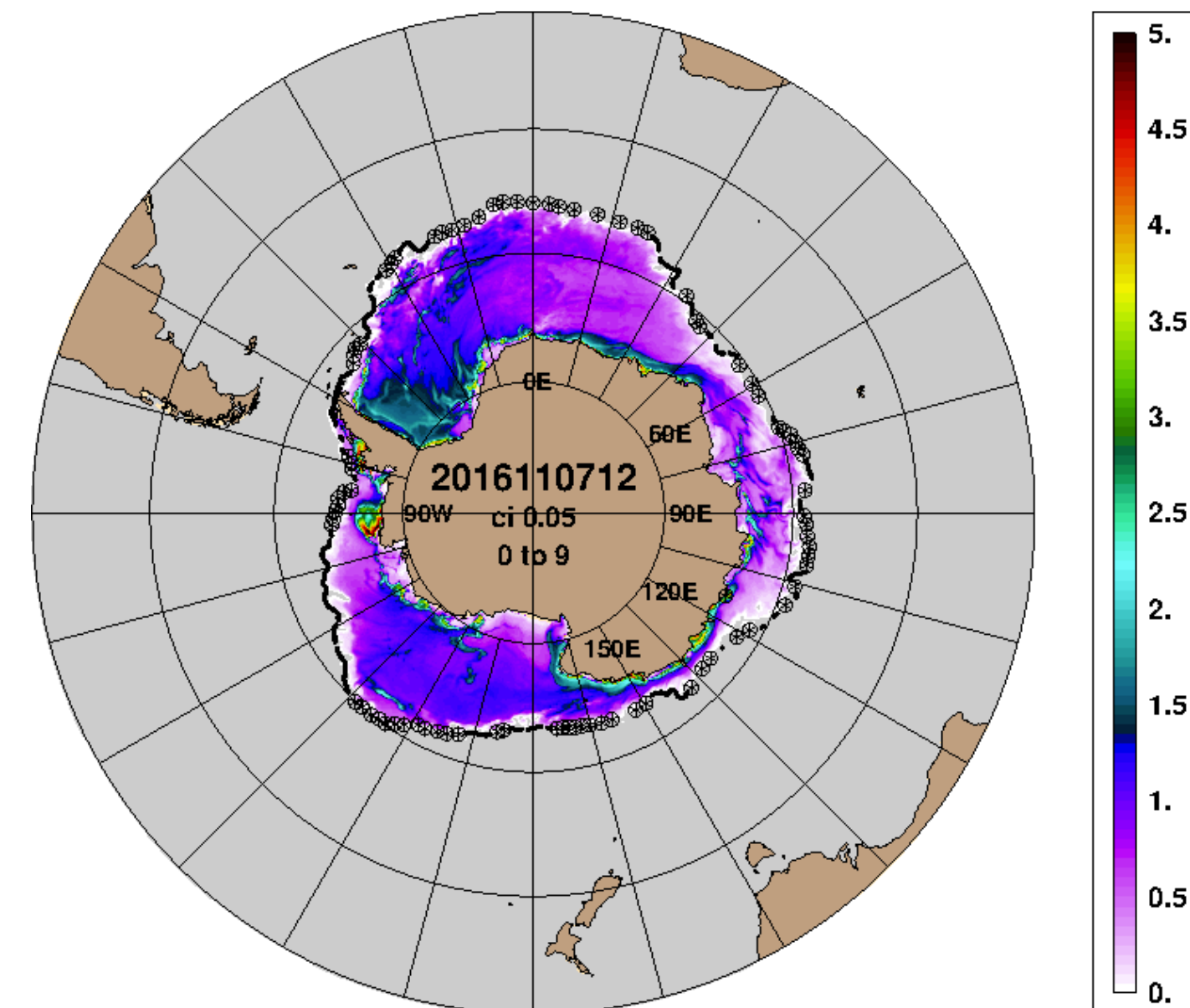
1/12° (3.5 km at Pole) global two-way coupled HYCOM-CICE modeling system with data assimilation (NCODA)

- Produces daily 7-day forecast of ice drift, ice thickness, ice concentration, lead-opening rate, sea surface temperature, sea surface salinity, ocean currents, etc.
- Undergoing operational testing by the Fleet Numerical Meteorology and Oceanography Center

GLBb0.08-92.7 Ice Concentration (%): 20161108



GLBb0.08-92.7 Ice Thickness (m): 20161108

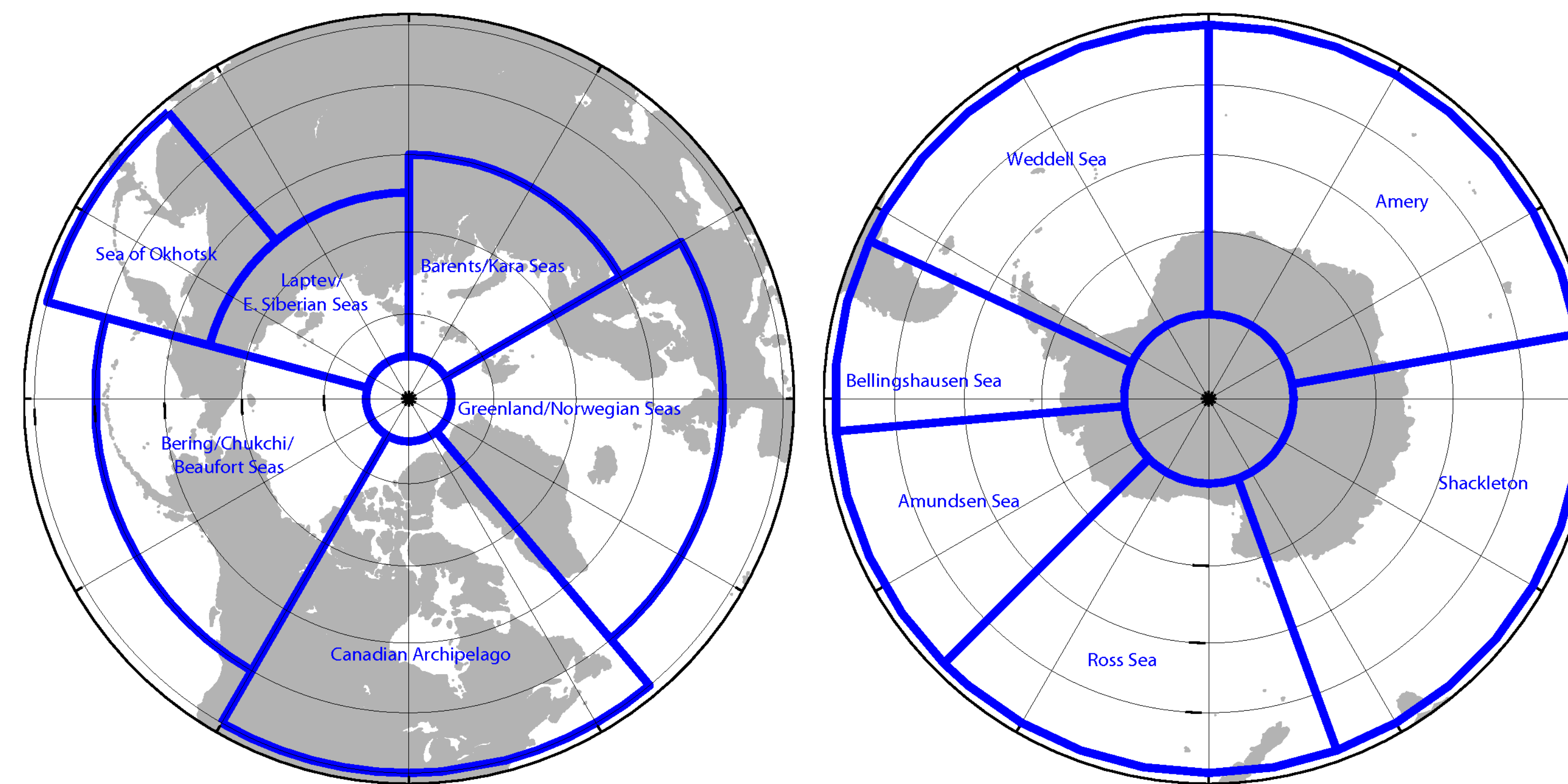


Daily GOFS 3.1 products:

www7320.nrlssc.navy.mil/GLBhycomcice1-12

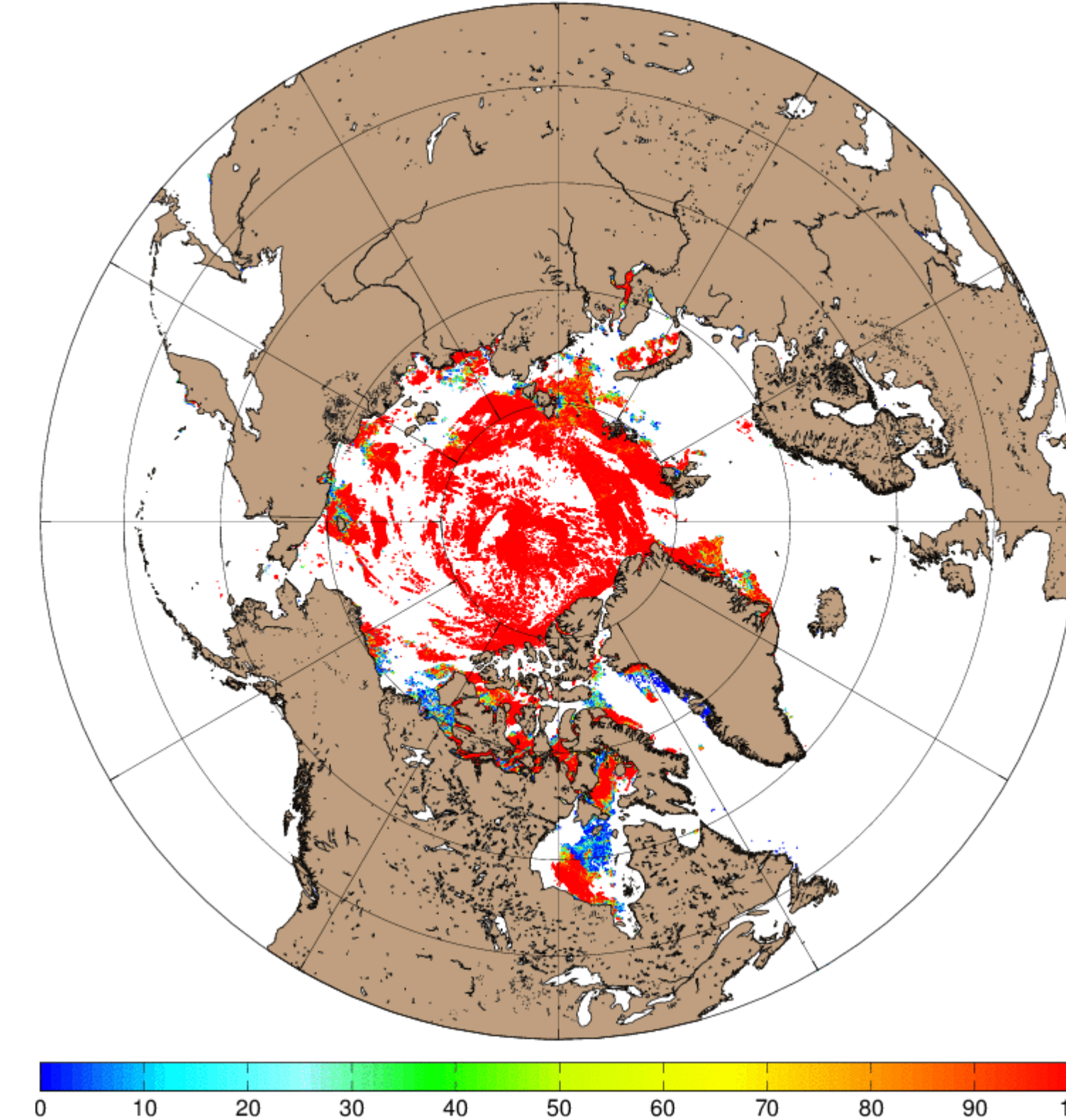
GOFS 3.1 Hindcast Study

A year-long GOFS 3.1 hindcast study is performed for the period of 1 November 2016 – 31 October 2017 to quantify the improvement of the ice edge location by assimilating VIIRS ice concentration. An issue with passive microwave sensors during the summer is that they can not easily distinguish between melt ponds and open water. The addition of a visible ice concentration product helps to mitigate this problem. The modeling system is forced with the NAVy Global Environmental Model (NAVEM). Ice edge error distance (km) between the U.S. National/Naval Ice Center (NIC) observed ice edge and GOFS 3.1 forecasts are calculated for several regional seas. Analysis regions used for the NIC ice edge comparison are shown below.

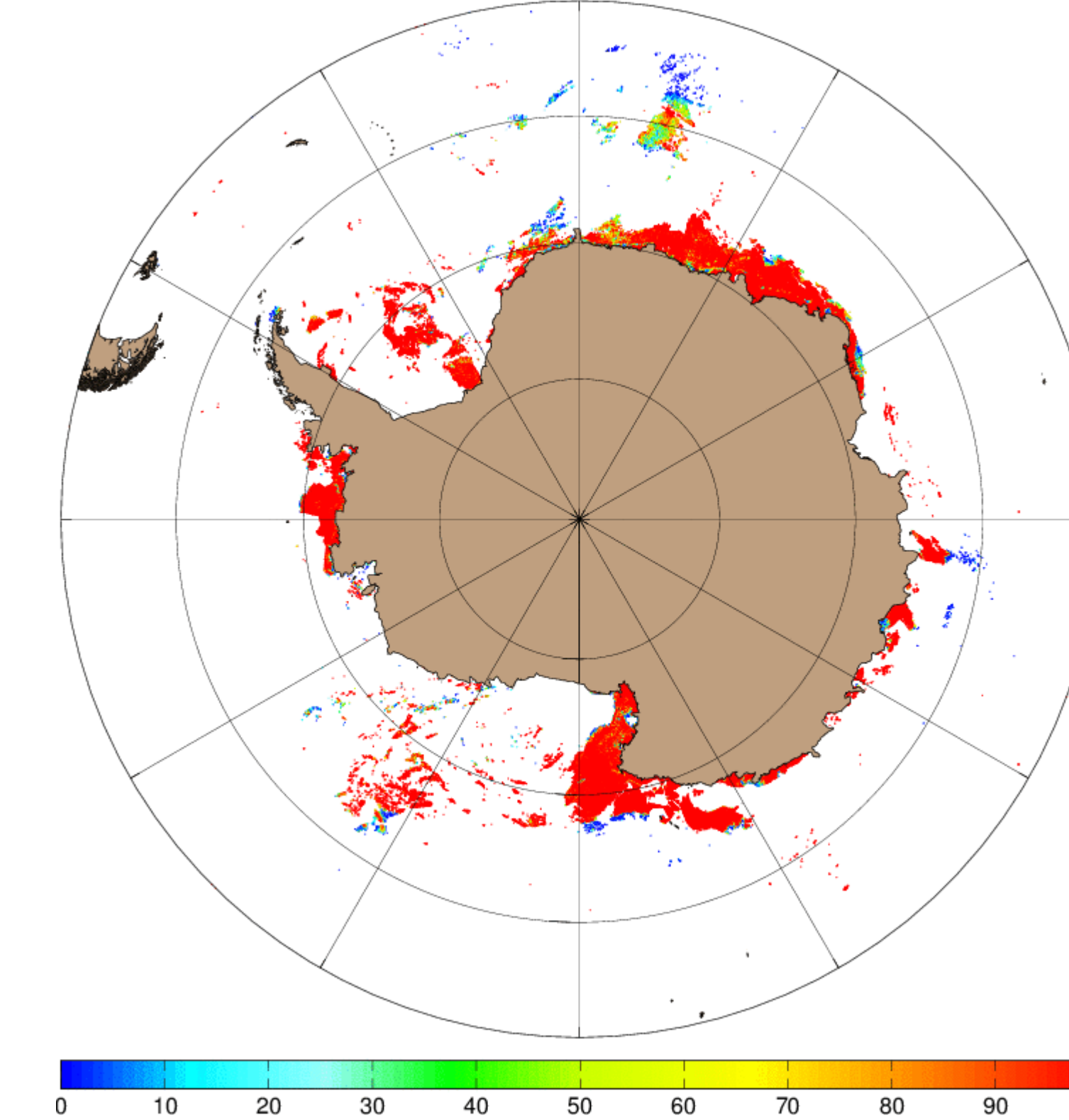


Analysis regions for Arctic (left) and Antarctic (right)

VIIRS | Ice Concentration (%) | 20170626



VIIRS | Ice Concentration (%) | 20161210



VIIRS ice concentration (%) for left) 26 June 2017, and right) 10 December, 2016.

Results

The tables below show the regional mean distance differences (km) between the NIC ice edge and the 12 hour GOFS 3.1 forecast for time period of 1 November 2016 – 31 October 2017 for the Arctic and Antarctic regions.

Arctic	Pre-operational GOFS 3.1 SSMI/AMSR2	GOFS 3.1 SSMI/AMSR2/VIIRS	Total improvement over pre-operational GOFS 3.1
Greenland	31 km	21 km	31%
Barents	24 km	22 km	8%
Laptev	28 km	23 km	16%
Sea of Okhotsk	20 km	18 km	8%
Bering/Beaufort/Chukchi	24 km	22 km	9%
Canadian Archipelago	31 km	25 km	21%
Pan-Arctic	27 km	22 km	19%

Pan-Arctic improvement of 19% over current operational capability by adding VIIRS ice concentration data.

Antarctic	Pre-operational GOFS 3.1 SSMI/AMSR2	GOFS 3.1 SSMI/AMSR2/VIIRS	Total improvement over pre-operational GOFS 3.1
Amery	39 km	33 km	15%
Shackleton	32 km	29 km	8%
Ross	42 km	38 km	9%
Amundsen	37 km	34 km	9%
Bellingshausen	28 km	25 km	9%
Weddell	46 km	41 km	12%
Pan-Antarctic	38 km	34 km	11%

Pan-Antarctic improvement of 11% over current operational capability by adding VIIRS ice concentration data.

Conclusion

This study demonstrates the improvement in the ice edge location for both the Arctic and Antarctic regional seas by assimilating the high resolution VIIRS ice concentration products. This new data source is scheduled to be implemented into the pre-operational GOFS 3.1 job stream in Spring 2018.