# NRL-SSC Transitions New Ice Model to Navy

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The Coast Guard Cutter *Healy* escorts the Russian-flagged tanker vessel *Renda* 250 miles south of Nome, Alaska, Jan. 6, 2012. The vessels are transiting through ice up to five feet thick in this area. *(Photo: U.S. Coast Guard - Petty Officer 1st Class Sara Francis)*

Scientists from the Naval Research Laboratory at Stennis Space Center (NRL-SSC) have played a key role in the development and transition of the Arctic Cap Nowcast Forecast System (ACNFS) from research to operational Navy use. The ACNFS replaces the Polar Ice Prediction System (PIPS 2.0).

**The Cutting Edge**

ACNFS provides real-time nowcast/forecasts at 1/12-degree horizontal resolution, including snapshots and animations of Arctic ice conditions that include ice thickness, ice concentration, ice speed and drift, sea surface temperature, and sea surface salinity.

"Over the years, computer resources have improved in speed and capabilities," said Pam Posey. "As a direct result, computer models have also improved using higher grid resolutions, more sophisticated ocean/ice models and improved data assimilation methods. These improvements, included in ACNFS, provide the Navy with better forecasts of ice conditions."

Validation testing determined that ACNFS performs significantly better than PIPS 2.0 for the ice edge location and performs similarly in estimating ice thickness and ice drift. Similar to PIPS 2.0, ACNFS provides five-day forecasts of ice drift and ice thickness and concentration, along with new fields (areas of convergence/divergence and snow thickness).

ACNFS uses the Hybrid Coordinate Ocean Model (HYCOM) for ocean conditions, is coupled with the Los Alamos National Laboratory Community Ice Code (CICE), and assimilates in situ and satellite-derived data using the Navy Coupled Ocean Data Assimilation (NCODA) system. ACNFS nowcasts and forecasts conditions in all sea ice covered areas in the northern hemisphere (poleward of 40° N).

All the data available via ACNFS will allow ice analysts at the Naval Oceanographic Office and the National/Naval Ice Center (NIC) to better understand the changing ice conditions in the Arctic and provide the Navy Fleet with more accurate daily (1-5 day) ice forecasts.

The Arctic community already benefitted from the ACNFS in an operational setting beginning in October

2011 when the National Weather Service (NWS) Alaska Region Ice Program integrated output from the modeling system within their forecast process.

**A Cold Winter in Nome**

An unseasonably strong extra-tropical cyclone affected a large part of western Alaska in November 2011. The storm caused one death and an estimated $30 million in damage. Forty-foot waves were generated in the Bering Sea, wind speeds exceeded 80 mph along the coast, blizzards occurred inland and on St. Lawrence Island, and two coastal storm surge episodes reached nearly 10 feet above high tide. The ACNFS provided critical insight to Alaska forecasters on the potential movement of early season sea ice because of the winds and on the potential impact of the storm on coastal communities.

Just 100 miles south of the Arctic Circle, on the southwest side of the Seward Peninsula on the Bering Sea, sits the port town of Nome, Alaska--a commerce, transportation, and government hub for its nearly 4,000 residents, more than half of whom are Alaska Native Yupik or Inupiaq descent.

Accessible only by plane, private boat, or dogsled trail, Nome is the only incorporated town within 250 miles where one can purchase supplies or groceries. For the difficulty of getting items to remote Nome, residents pay a premium price on every product--$7.29 for a gallon of milk, $9.49 for a six-pack of soda, $5.94 for a gallon of unleaded gasoline and $6.19 for diesel fuel.

In the fall of 2011, Nome was expecting a delivery of more than 1 million gallons of gasoline, diesel, and heating fuel, but the fuel supplier missed the delivery due to a severe early winter storm that froze the ports and harbors earlier than anticipated. More storms, followed by severe sea and ice conditions, led officials to predict fuel barges wouldn't be available to supply the town until spring. That meant the town would need to consider how to cope with a fuel shortage during the most severe weather months of the year.

The local fuel distributor--and intended local purchaser of the fuel from the supplier--chartered T/V *Renda*, a heavy-duty, ice-breaking Russian fuel-tanker to deliver 1.4 million gallons of fuel in January 2012.

The U.S. Coast Guard Cutter *Healy*, a medium-duty polar ice breaker, was tasked with breaking the 300 miles of ice extending from the shore--as much as 5 feet thick in many places--for *Renda*'s passage to Nome.

Once *Healy* and *Renda* reached an area near Nome harbor, a hose at least a mile off shore delivered the fuel from the tanker to the shore-based tanks. This was the first time petroleum products were delivered by sea to a western Alaskan community in winter and at a cost substantially lower than the standard winter delivery air tanker method.

**A Model Resupply Mission**

More than 5,000 miles southeast, oceanographers Pam Posey and Rick Allard at NRL-SSC were watching the resupply mission.

*Healy* was relying upon detailed, real-time ice information provided by the NIC, NWS, and the Fleet Weather Center in San Diego, Calif.

And they were all using model output from Posey and Allard's new coupled ice/ocean model, ACNFS.

Carven Scott, with the NOAA NWS Alaska Region in Anchorage, provided frequent updates to the NRL-SSC team.

"The ACNFS proved to be a critical piece of information for the NWS operations supporting the Nome resupply mission," said Scott. "Ice and weather forecasters utilized the output routinely, integrated the ice and ocean current data into forecast operations to help provide *Healy* and *Renda* with the safest path into Nome as well as the return voyage."

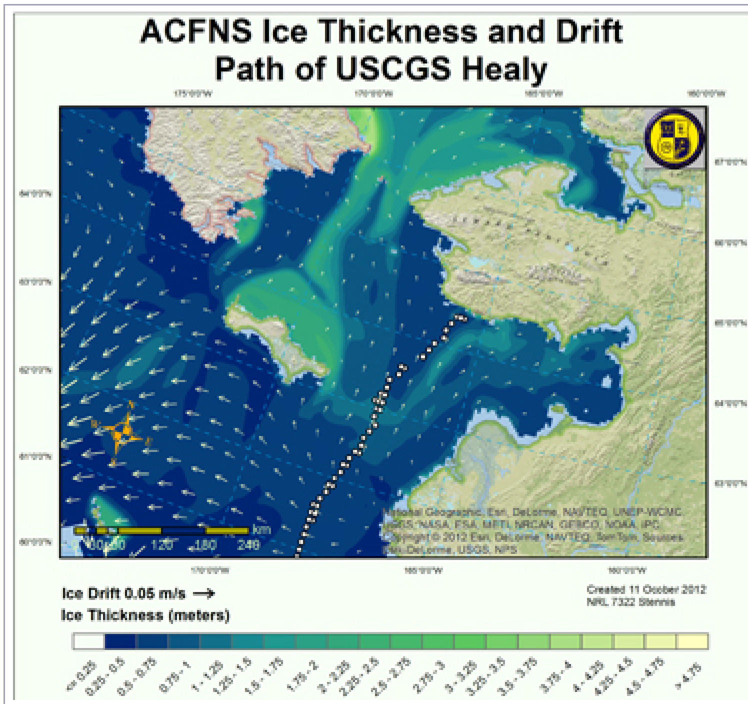
On January 6, Nome recorded a 13-year low of -40 degrees Fahrenheit. Every link in the chain had to work to ensure the people of Nome would not be left in the cold. Although validation testing was positive, ACNFS had not been approved for operational use.

The old ice/ocean model--PIPS 2.0--had been the operational Navy ice forecasting system since 1996. But Pam and Rick knew the increase in grid resolution (approximately 3.5 km near the North Pole for ACNFS vs the 27 km resolution of PIPS), improvements in both the ice and ocean model physics, and data assimilation scheme made the ACNFS better.

"Forecasters were a little hesitant with ACNFS in the beginning, not having routine access to sea ice or ocean model data sets," said Scott. "However, confidence in the model increased with time as predicted trends in the ice edge tracked closely with subjective forecast tools and the eventual verification."

ACNFS performed without fail, a welcome informal validation for Posey and Allard.

"Any time someone uses your forecast, we hope that it will be a useful tool. After the mission is completed and feedback is supplied back to us, further improvements in the model can be made," said Posey.




ACNFS ice thickness product overlaid with ice drift, valid 13 Jan 2012. Circles indicate daily positions of the *Healy*. *(Photo: U.S. Naval Research Laboratory - James Dykes)*

**The Arctic: the New Hotspot?**

Similar to the National Hurricane Center's annual storm predictions, a consortium of scientific organizations composed of government and academia, including Posey and Allard, annually predict the minimum sea ice extent using various ice models. As real-world observations are collected, the data are fed into the models and new predictions are made.

The ACNFS was designed primarily for short-term forecasts, but made its first ever long-term (120 days) forecast in 2012 as part of the Study of Environmental Arctic Change (SEARCH) Sea Ice Outlook annual call for ice extent predictions.

"The ACNFS estimate of the 2012 minimum sea ice extent was consistent with the other submitted computer model predicted values," said Posey.

The minimum sea ice extent, which typically occurs each September, is indicative of the amount of atmospheric heating absorbed by the ocean and prevailing weather patterns as winds affect the transport of ice. As summer ebbs into fall, Arctic sea ice begins to grow back, and by March of each year, the ice extent recovers, although for the past several years the thickness of the ice has been reduced. Ice that survives the summer melt season is called multi-year ice. There has been less Arctic multi-year ice during the past several years, allowing the thinner ice to melt during summer, resulting in more areas of open water resulting lower minimum ice extents. Since 1980, the lowest observed sea extent occurred in 2007. However, a new record low of 3.41 M $km^2$ was set on September 16, 2012.

The melting of sea ice is providing new opportunities for commercial transit, drilling, and potential geopolitical conflict as previously unnavigable sea lanes open up. As these viable economic opportunities become available in the Arctic, interest in the Arctic will increase.

Now proven as a reliable ice/ocean model, the NIC has begun using the ACNFS forecasts as one source of information in determining daily products. The center is operated by the U.S. Navy, NOAA, and the U.S. Coast Guard, and provides timely, accurate, and relevant snow and ice products and services to those protecting and supporting U.S. interests.

**The Future of Navy Ice Prediction**

Ice modelers like Posey and Allard at NRL-SSC are developing the science and technology that gives Naval warfighters the advantage they need to maintain a technological advantage over other countries.

NRL oceanographers are presently implementing the latest version of the CICE model in the Navy's 1/12-degree global forecasting system (GOFS 3.1) HYCOM/NCODA. A full transition is slated for 2013. Being fully global, CICE will allow the Navy to have the capability to provide ice forecasting in not only the Northern Hemisphere area but also for the Southern Hemisphere.

"We presently have a 6.1 NRL Core Accelerated Research Option [basic research project] for fiscal years 2012-2016 with NRL's Remote Sensing, Oceanography and Marine Geosciences Divisions, in which where we are developing new algorithms based on in situ, airborne, and satellite measurements to derive estimates of Arctic-wide snow and ice thickness in near real-time," said Allard. "These data will be assimilated into our ice model to provide much improved initial conditions that will increase our forecast accuracy."

Allard also noted a fiscal year 2013 applied research (6.2) new start joint project between the Oceanography and Marine Meteorology Divisions, in which scientists will extend the Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS) by coupling it to the CICE model.

"This will provide the Navy with a high-resolution relocatable modeling system which will be used for areas such as the Beaufort and Chukchi Seas," said Allard. "We envision running CICE at resolutions of 1 km forced with COAMPS surface forcing on the order of 3-4 km."

The present ACNFS is forced with the Navy Operational Global Atmospheric Prediction System (NOGAPS), which has a 50-km resolution.

"We're only going to get better," said Allard.

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**About the U.S. Naval Research Laboratory**

The U.S. Naval Research Laboratory is the Navy's full-spectrum corporate laboratory, conducting a broadly based multidisciplinary program of scientific research and advanced technological development. The Laboratory, with a total complement of approximately 2,500 personnel, is located in southwest Washington, D.C., with other major sites at the Stennis Space Center, Miss., and Monterey, Calif. NRL has served the Navy and the nation for over 90 years and continues to meet the complex technological challenges of today's world. For more information, visit the NRL homepage or join the conversation on Twitter, Facebook, and YouTube.