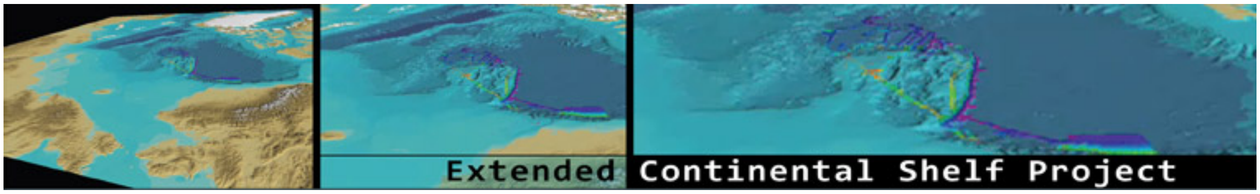
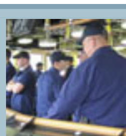
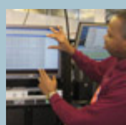
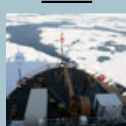


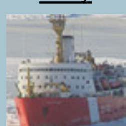

2010 Mission

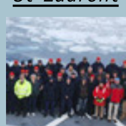

Mission Plan

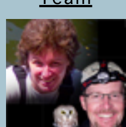

Law of the Sea


Continental Shelf


USCGC *Healy*


CCGS *Louis S. St-Laurent*


Healy's Science Team

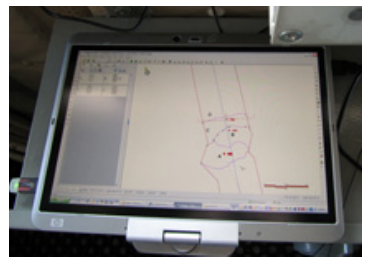

Teachers

Back to the Ice, Part 2
Using Ice Observation and Satellite Imagery to Find a Way Through the Floes

August 18, 2010

By Helen Gibbons, Web Coordinator, ECS Project

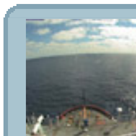
Date: August 18, 2010
Time: 1500 hours Pacific Daylight Time
Latitude: 74°45.4'N
Longitude: -150°12.3'W
Air temperature: 1.7°C (35°F)
Sea temperature: -1.1°C (30°F)
Wind speed and direction: 25 knots from the east-southeast
Ship's speed over the ground: 4.4 knots
Water depth: 3800 m


Tablet computer used to record sea-ice observations in the program ICEggs. An onlooker remarked that it looked like an Etch-a-Sketch, and Canadian ice specialist Erin Clark said, "If you shake it hard enough, everything really does disappear." Don't shake it! Click image for larger view. Credit: Helen Gibbons, USGS/ECS Project

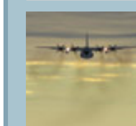
On Tuesday, August 17, we rejoined *Louis* at the edge of the ice pack and resumed our joint mapping operations, with *Healy* in the lead. (See log for August 17.) While we approached and moved into the ice, MST1 Josh Miller (ice analyst with the National Ice Center [NIC]) was on the bridge, observing the ice floes and recording the ice concentration (the fraction of sea surface covered by ice, usually recorded in tenths), ice type (first-year, multi-year, and so on), ice-floe size, stage of melt, and any ridging or other topographic features on the ice. He entered these data into a Canadian program called ICEggs on a tablet computer brought onboard by Erin Clark, Ice Services Specialist with the Canadian Ice Service, Environment Canada. As an ice analyst, Josh works mainly with satellite imagery; during this mission, he is being trained in ice observation by Erin, who has had 4 years of experience observing ice in the field and comparing satellite images with what she sees out the window.

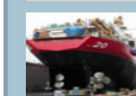
Soon Erin joined Josh on the bridge, and they observed the ice together, Erin giving Josh guidance on visual observing techniques and using the ICEggs program. Some days ago, when *Healy* and *Louis* exchanged personnel on August 10, Operations Technical Advisor Caryn Panowicz of NIC moved from *Healy* onto *Louis*, and Erin transferred to *Healy*. Now, by working together, the U.S. and Canadian observers and analysts aboard both ships are learning from each other and from the approaches taken by their respective agencies. Additionally, having both U.S. and Canadian ice specialists and analysts aboard both vessels gives each vessel access to a greater number of the most recent satellite images.

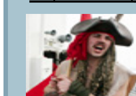
Erin and Josh are using a combination of satellite-imagery analysis and sea-ice observations to help chief scientists Brian Edwards (on *Healy*) and David Mosher (on *Louis*) plan routes through the ice. The challenge is to find paths that minimize icebreaking (thus minimizing the risk of

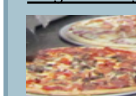

Hourly Photos from *Healy's* Aloft Conn


USCG Logs


Photos of the Day


Sep 05 Log


Aug 29 Log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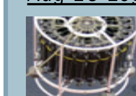
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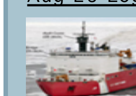
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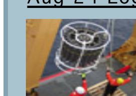
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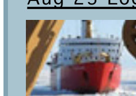
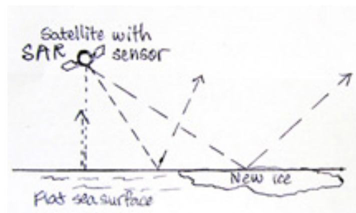

Aug 22b Log

Erin watches as Josh enters ice observations into the ICEggs program used by Erin's agency, Canadian Ice Service. Click image for larger view. **Credit:** Helen Gibbons, USGS/ECS Project

damage to gear towed by *Louis*) and maintain reasonably straight lines while the ice shifts in response to currents and winds. Ice analysts and observers are essential to successful and efficient data acquisition in ice-covered regions.

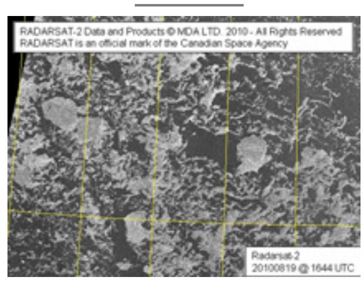
Traditionally, analysis of satellite images for planning routes through ice has taken place onshore and the analyses sent to ice observers aboard vessels. This practice continues, but increasingly—as on this mission—satellite images are delivered directly to vessels through download from FTP sites, and field personnel on the vessels work as both imagery analysts and ice observers.



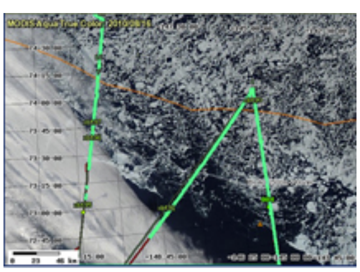
Highly simplified diagrams illustrating how flat surfaces, such as new ice or a calm sea surface (top), reflect most of the microwaves away from the SAR sensor, whereas irregular surfaces, typical of multi-year ice (bottom), reflect many beams back to the sensor. Click images for larger view. **Credit:** Helen Gibbons, USGS/ECS Project

The images that Josh and Erin use come from polar orbiting satellites. These satellites move in orbits that pass over the North and South Poles, carrying sensors that collect swaths of imagery as the Earth spins beneath them. The higher the resolution, the narrower the "footprint," or swath of Earth's surface imaged by the sensor.

Erin and Josh rely most heavily on SAR (synthetic aperture radar) imagery. SAR sensors on the Radarsat-2 and Envisat satellites beam microwaves at the Earth and receive the echoes, also known as "backscatter." The stronger the return, the brighter the pixel on the image. Flat surfaces, such as seawater on a calm day or the surface of new ice, reflect most of the microwaves away from the sensor, and so those features appear nearly black in SAR images. Some older ice floes, in contrast, contain numerous topographic features with just the right angles to reflect incoming beams back to the sensor, making such ice appear bright in the imagery. Josh and Erin are using SAR images with 100-m resolution (1 pixel = 100 m on a side on the ground; for comparison, *Healy* is 128 m long). SAR sensors can "see" during dark (night) hours and through clouds and fog, making this imagery particularly useful.

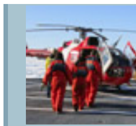


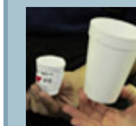
Screenshot of SAR (synthetic aperture radar) image from the Radarsat-2 satellite, collected August 19, 2010. Multi-year floes with irregular topography return much of the microbeam energy back to the SAR sensor, making them appear bright in SAR images. Courtesy of Erin Clark, Canadian Ice Service. Click image for larger view. **Credit:** Helen Gibbons, USGS/ECS Project



MODIS image collected August 16, 2010. During daylight hours where clouds are thin or absent, these visible-light images provide a good view of the ice. Click image for larger view. **Credit:** *Healy* Map Server/Steve Roberts, National Center for Atmospheric Research.

If recent SAR imagery is not available for our area of operation, Erin and Josh turn to visible-light imagery, of which several kinds are available. One example is the Moderate Resolution Imaging Spectroradiometer (MODIS) carried on NASA's Aqua and Terra satellites. This sensor collects visible-light imagery at a resolution of 250 m (each pixel


Aug 22a Log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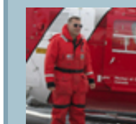
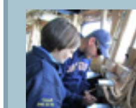

Aug 20 Log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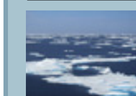
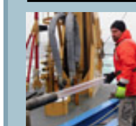

Aug 17 Log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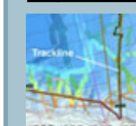
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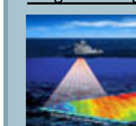
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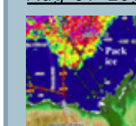
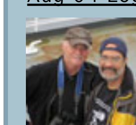

Aug 06 Log


Aug 04 Log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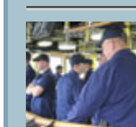
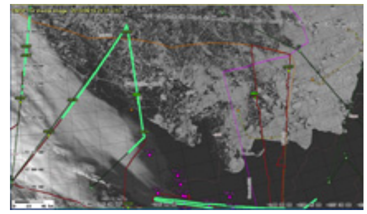


Photo Log

= 250 m on a side). The images provide valuable information during daylight hours if clouds are thin or absent.

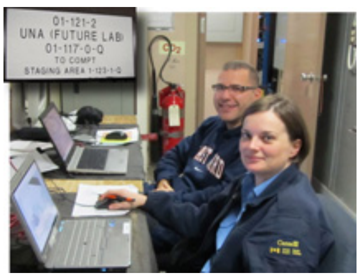
Other types of visible-light imagery available to Josh and Erin during this mission are:

- Advanced Very High Resolution Radiometer (AVHRR) imagery with 1-km resolution. AVHRR sensors measure the reflectance of the Earth in five spectral bands, including red and infrared light, and thermal radiation. The images have a resolution of 1 km and are affected by precipitation, fog, and clouds. They can be used for ice analysis if cloud cover is thin or absent, but are more useful for analyzing large-scale weather systems.
- Defense Meteorological Satellite Program (DMSP) imagery with 500-m resolution. DMSP satellites carry a sensor that provides visual and infrared imagery. Like AVHRR images, DMSP images can be used for ice analysis if cloud cover is thin or absent but are generally more useful for analyzing weather patterns.



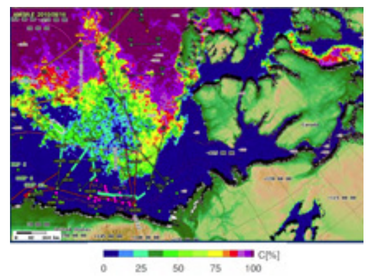
DMSP visible-light image collected at about 0924 hrs (Pacific Daylight Time) on August 16, 2010. Cloud cover is absent and sea ice visible in the righthand two-thirds of the image. Click image for larger view. **Credit**: *Healy* Map Server/Steve Roberts, National Center for Atmospheric Research.

For an overall view of ice position and concentration, Erin and Josh turn to imagery from the Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-E) carried on the NASA's Aqua satellite. With a resolution of 6 km, AMSR-E images cannot be used to pick paths through ice floes.



Fittingly, Erin and Josh, who help *Healy* and *Louis* anticipate upcoming ice conditions, analyze their satellite imagery in a room called the Future Lab. Click image for larger view. **Credit**: Helen Gibbons, USGS/ECS Project.

Erin and Josh look for the best combination of recent imagery, high resolution, good visibility, and coverage in the satellite images they use. They prefer the most recent images, which can be as little as 1 hour old, but will work with whatever they have. With all images, but especially the older ones, they incorporate weather conditions and surface currents into their forecasts of ice positions. SAR images provide the best resolution and visibility, but a more recent visible-light image might be preferable if it provides a good view of the ice. Because the satellites cover different swaths during different orbits, the choice of imagery is also constrained by coverage; imagery of a certain type simply may not be available for the area of operation during a given time frame. The higher the resolution, the narrower the swath of Earth's surface imaged by the sensor, and so the desired coverage can be more difficult to obtain in higher resolution imagery, such as SAR imagery.



Sea-ice concentration map from the Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-E) for August 16, 2010. Concentration (C) expressed as percentage of sea surface covered by ice. Click image for larger view or here for a high resolution image. **Credit**: *Healy* Map Server/Steve Roberts, National Center for Atmospheric Research.

To be continued...