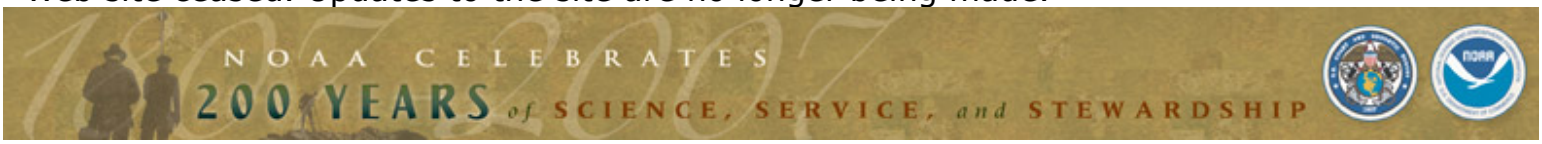
With the NOAA 200th Celebration coming to a close at the end of 2007, maintenance of this Web site ceased. Updates to the site are no longer being made.



Transformations: National Ice Center

The Evolution of Operations at the U. S. National Ice Center: From Paper to Pixel

The National Ice Center (NIC) is a multi-agency operational center operated by NOAA, the U.S. Navy, and the U.S. Coast Guard. NIC monitors, analyzes, and forecasts sea ice, to ensure safe navigation of vessels traveling in potentially perilous waters. Data collected by NIC are also used in scientific studies.

Most of us are probably familiar with the story of the *Titantic*—that "unsinkable" ship who met her demise after striking an iceberg while transiting the Atlantic. Icebergs and other forms of sea ice pose a significant threat to navigation. The National Ice Center has the responsibility of providing high-quality ice analysis services tailored to meet the operational requirements of U.S. national interests.

The Center produces literally hundreds of ice-related products, including weekly ice analyses, ice forecasts, daily ice edge products, tactical scale ice analyses, and annotated satellite imagery. While other countries possess agencies whose purpose is monitoring regional ice conditions, NIC is the only agency in the world that monitors and analyzes ice conditions *across the entire globe*.

Since the early 1980s, technological advances have vastly altered the way the National Ice Center creates ice analysis products. Powerful computer workstations have replaced grease pencils and light tables. Synthetic Aperture Radar (SAR) has superseded visible/infrared imagery as the preferred data source for ice analysis. Digital products have replaced paper charts, and the Internet has replaced the U.S. mail and fax machines as the preferred method of product dissemination. Evolving technology has produced rapid, sometimes dramatic, changes in the way NOAA does business, as is evident in the daily operation of the National Ice Center.

The National Ice Center is a multi-agency operational center operated by NOAA, the U.S. Navy, and the U.S. Coast Guard.

Background: A Brief History

Beginning in the 1960s with the launch of the first Earth-observing satellites, the value of using satellite imagery to monitor global ice was quickly recognized. Both NOAA and the U.S. Navy recognized the importance of analyzing and monitoring global ice conditions, for use in any daily marine operations and from a climatological standpoint.

In 1976, analysts from NOAA and the Navy joined forces to form the Joint Ice Center (JIC), with a mission to monitor and analyze global ice conditions.

After nearly 20 years of joint NOAA-Navy ice analysis operations, the JIC expanded in 1994 to include the U.S. Coast Guard. The new organization, renamed the United States National Ice Center (NIC), became a tri-agency government organization, building on the strengths of each of the

Graphic displaying the National Ice Center logo, along with the logos of the participating agencies. *Click image for*

agencies involved in this partnership.

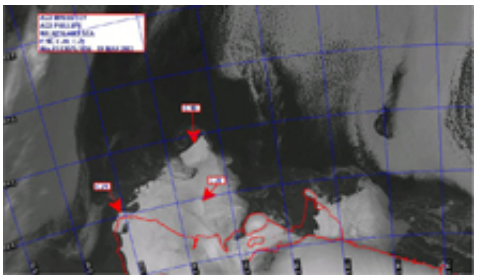
larger view.

Improvements in NIC analysis capabilities over the years can be attributed to three primary factors: the ability to process, enhance, and analyze remotely sensed data in a digital format; an increase in volume and resolution of incoming remotely sensed data; and the ability to disseminate products in a digital format.

That Was Then: Working by Hand

Prior to developing the capability to ingest and analyze remotely sensed data in a digital environment, NIC analysts made use of hardcopy satellite imagery. Although satellite data were, in fact, available in a digital format prior to NIC receiving them digitally, it took time for NIC to develop the computer capabilities to ingest, enhance, and analyze this imagery in a digital environment.

Through most of the 1980s, the analysis process at NIC was relatively primitive. Ice analysis products were created using hardcopy cartographic (mapping) techniques. An analyst taped a paper copy of a satellite image to a light table, overlaid the image with a sheet of Mylar containing a latitude/longitude grid to reference points on the image to the real-world coordinates, and traced analysis lines with a grease pencil. The grease pencil analyses were then joined together to form a draft analysis, which was quality controlled by a senior ice analyst and then traced (again) onto a final analysis chart with an ink pen.



In March 2003, the NIC confirmed an iceberg broke off from the Shackleton Ice Shelf, a large sheet of glacial ice and snow extending from the Antarctic mainland into the western Wilkesland Sea. This image of the iceberg was taken by the NOAA Advanced Very High Resolution Radiometer infrared sensor on March 19, 2003. *Click image for larger view.*

Visible and infrared satellite imagery from NOAA's Advanced Very High Resolution Radiometer (AVHRR) was the most widely used imagery at NIC through the 1980s. The AVHRR is a radiation-detection imager that can be used for remotely determining cloud cover and surface temperature. This imagery arrived in long paper strips that were manually sliced prior to analysis. Imagery was processed using pre-defined enhancement techniques, limiting the individual analyst's interpretation capability. Unlike today where the analyst has the ability to use a computer workstation to digitally enhance imagery onscreen, analysts had to "make due" with whatever pre-enhanced imagery they received.

Entering the Computer Age

The purchase of NIC's first personal computer in 1984 officially brought NIC into the "computer age." Although it was a gradual process at first, the advantages of computer technology soon transformed NIC operations. Over the next decade, there were dramatic changes in the technology employed in day-to-day operations.

NIC began its first effort to use digital satellite data with the installation of a new, computerized analysis system called the Digital Ice Forecasting and Analysis System (DIFAS), developed by the Naval Research Laboratory. This new system allowed analysts to view AVHRR imagery in digital format and use analysis tools that closely mimicked manual analysis methods.

One significant improvement provided by digital analysis was the ability to have user-defined enhancements applied to satellite imagery. Prior to this advancement, analysts were at the mercy of pre-determined enhancement look-up tables. Now, analysts are able to enhance digital imagery on the spot. The switch to a digital environment also allowed analysts to overlay several data layers onto satellite imagery. For example, an analyst can now overlay latitude/longitude grids and shorelines onto imagery.

A Gradual Transition

Despite the advantages of "going digital," the transfer of NIC operations to a completely digital environment occurred gradually. Through the early 1990s, some data sources continued to be received by NIC in hardcopy format. For example, visible imagery from the Defense Meteorological Satellite Program (DMSP) continued to arrive at NIC in hardcopy "flats" into the early 1990s. Analysis of this data still required traditional hardcopy cartographic techniques. It was not until 1993 that data from DMSP was integrated into a digital environment at NIC.

Going Fully Digital

In the early 1990s, NIC began generating its first fully digital analysis products using DIFAS. AVHRR imagery was ingested and combined with shore station reports and aerial photography to produce a digital data field. Analysis information (ice lines and attributes) was then transferred to a workstation where it was edited using an early Geographic Information System (GIS) called the Geographic Resources Analysis Support System, or GRASS.

Although the technology now existed for processing and analyzing satellite imagery in a digital environment, it took two more years to transfer all NIC analysis products into a completely digital environment. Therefore, although some NIC products were now being generated digitally, analysts were still required to print their imagery and use light tables to manually trace lines for other products.

By 1996, however, NIC began to produce all of their ice analyses, from start to finish, in a digital format. In addition to imagery from AVHRR and the Canadian Space Agency's new SAR satellite, RADARSAT-1, DMSP optical and microwave imagery was also available to analysts in a digital format. However, the analysis of DMSP imagery required the use of a second computer workstation equipped with an analysis software package called Terascan.

A series of UNIX commands were necessary for the analyst to merge their lines showing the location of ice from the two different NIC analysis systems (including Terascan and the Navy Satellite Image Processing System). The ice lines and attributes were then pulled into GRASS where they were checked. Once the product went through the quality-control process, a digital graphics product could be generated. The ability to produce a digital product was a major advance for NIC, as this eliminated the need for paper products and the time-consuming process of hand-tracing analysis lines.

Example of one of the first digital ice analysis products produced by NIC. *Click image for larger view.*

The NIC of Today

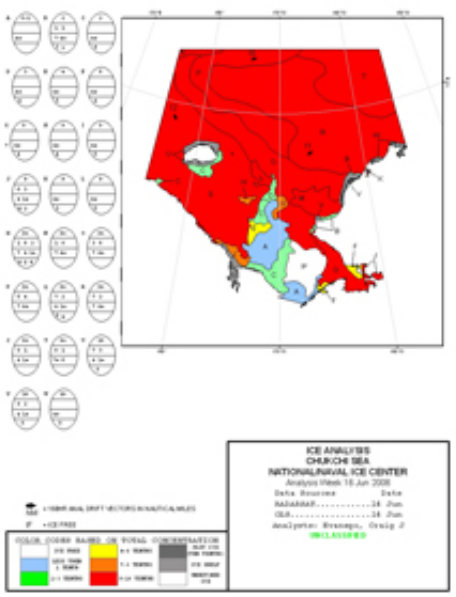
As time passed, paper products gradually became obsolete, and the U.S. mail was no longer used to disseminate NIC products, although the autopolling fax system continued to be popular among NIC customers. In 1996, NIC launched its first Web site and began disseminating products on the Internet. Customers were weaned off of the autopolling fax system and soon the Internet became the single source of NIC analysis products.

Working with ESRI

By 1998, NIC's GRASS GIS was replaced with the Environmental Systems Research Institute's (ESRI) ArcInfo/ArcView software package. In addition to being more user-friendly, the ESRI-based system allowed NIC to generate products that were more compatible with other users' systems. In 1999, Lockheed Martin

received a contract to produce a complete analysis and chart production system, based around ESRI software. The new system, called Carterra, wrapped several analysis packages (including ArcView, ArcInfo, Remote View, and ERDAS Imagine) neatly into one system.

Continuing to advance its ice analysis capabilities, in 2003, NIC contracted with ESRI to develop the current NIC analysis system, called SIPAS (Sea Ice Prediction and Analysis System). SIPAS is built around two shared databases—one for the Arctic and one for the Antarctic. This system enables NIC analysts to produce an analysis, from start to finish, using only ESRI products, allowing NIC to shed costly software licenses for numerous other software products.



A recent analysis produced by NIC using SIPAS. *Click image for larger view.*

Looking Ahead

Because the NIC's new analysis system is a shared geodatabase, it allows the ice analyst to analyze one particular region of the hemispheric database (Arctic or Antarctic) while other analysts are simultaneously analyzing other regions of the hemisphere. Any changes made to the database are seen by all of the analysts, making the matching of adjoining analyses much easier than in the past. Eventually, NIC plans to use the database concept to allow users to define their own area of interest (AOI) and create their own analysis graphics by tapping into the NIC database and providing their own AOI.

Today, NIC is expanding its scope from strictly sea and lake ice to a more comprehensive cryospheric vision. NIC plans to assume responsibility for several NOAA global snow cover products. The snow cover products, in addition to NIC's existing global ice analyses, will allow NIC to provide a more complete picture of the Earth's cryosphere.

In October 2006, NIC moved its operations into the new NOAA Satellite Operations Facility (NSOF) at the Suitland Federal Complex in Maryland. The new facility at NSOF provides NIC with nearly twice as much space as it had previously occupied. This spacious new operations center also gives NIC room to grow as it prepares for a busy and exciting future.

Contributed by Craig J. Evanego, NOAA's National Environmental Satellite, Data, and Information Service

Works Consulted

Benner, D., Bertoia, C., Dedrick, K., Partington, K. & Van Woert, M. (2001). U.S. National/Naval Ice Center Digital Sea Ice and Climatology Data. Canadian Journal of Remote Sensing: Vol. 27, No. 5, October, pp. 457-475.

Bertoia, C. & Carrieres, T. (1994). Operational Use of Satellite Data for Sea Ice Analysis at the U.S. and Canadian National Ice Centers. Proceedings International Geoscience and Remote Sensing Symposium IGARSS '94, August 8-12, Pasadena, California, pp. 1228-1230.

Benner, D. & Bertoia, C. (1992). Operational Satellite Sea Ice Analysis at the Navy/NOAA Joint Ice Center. Preprint of 6th Conference on Satellite Meteorology and Oceanography, January 5-10, 1992, Atlanta, Georgia, American Meteorological Society, Boston, pp. 395-398.

Wohl, G. (1995). Operational Sea Ice Classification from Synthetic Aperture Radar Imagery. Photogrammetric Engineering and Remote Sensing: Vol. 61, No. 12, pp. 1455-1462.

Interview with Mr. David Benner, former National Ice Center Deputy Director. July 7, 2006.

Phone interview with Mr. Jim Rodgers, former National Ice Center employee. July 7, 2006.

Interview with Mr. Paul Seymour, National Ice Center Operations Technical Advisor. June 29, 2006.

Interview with Mr. Christopher Szorc, National Ice Center Senior Analyst. June 28, 2006.
