Missile Warning Data in Use for Arctic Sea Ice Monitoring

A military/academic partnership has potential to develop new capabilities and products and reduce costs.

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For Your Consideration

- How does your organization encourage "outside-the-box" thinking and problem solving?
- What partnerships exist between your organization and others (civil, military and commercial), and how can these partnerships be leveraged to improve processes and capabilities?
- What are you doing to expand existing technologies and capabilities to enhance warfighter lethality through improved battlefield capabilities or situational awareness?

As the Arctic becomes seasonably ice-free, increased international commercial and military activity in the region is anticipated. This development will require that geographic combatant commands with responsibility in the Arctic (U.S. Pacific Command, Northern Command and European Command) re-assess their Arctic capabilities and response preparedness. A military/academic project is exploring the feasibility of using data from missile-warning satellites to develop an ice characterization algorithm for charting and eventually tracking sea ice in the high Arctic.

The partnership between the Air Force Space and Missile Systems Center (SMC) and the National Snow and Ice Data Center (NSIDC) represents a type of unorthodox relationship that academics and defense personnel are beginning to embrace in order to achieve their individual goals. For the Department of Defense these partnerships provide access to experts in fields that are difficult to source internally, while reducing cost by less reliance on defense contractors. Similarly, as research funding declines across all disciplines (National Science Foundation, NASA, etc.), academics are warming to DOD as potential funding sources for research. Often the research is directly applicable to the researcher's interests and has additional applicability in a national security or intelligence role. It may also have tangential implications for defense organizations, providing both researcher and customer with purpose.

Common Ground

Located in sunny Los Angeles, the SMC Remote Sensing Systems Directorate's top priority is to support warfighter operations. Conversely, the federally funded NSIDC in Boulder, Colo., home to research scientists and big-data managers, considers sea ice its "bread-and-butter." The common ground between these organizations is the belief that the Air Force's remote sensing data can be exploited in new, innovative and unprecedented ways.

Only a few products exist that provide situational awareness in the remote Arctic, and none of them is at a temporal or spatial scale to which most commanders are accustomed. SMC currently provides data that support characterizing and researching sea ice through passive microwave sensors on Defense Meteorological Satellite Program satellites. The new partnership

has NSIDC attempting similar operations with data from the Space-Based Infrared System (SBIRS) in highly elliptical orbit.

This effort provides an opportunity for the Air Force to assess the potential of the SBIRS constellation to support new missions, leveraging the expertise of a team of academics with impressive credentials. If the ice product has utility, that is a bonus for geographic combatant commands and civil users (as the products will remain classified). More significantly, success demonstrates the vast capability of the SBIRS constellation and challenges the DOD and intelligence community to exploit this constellation to its full potential.

For NSIDC the project represents a potential fire-hose of data that could fuel scientific exploration for many years and develop products to increase user base and fuse the data with other sources to enhance existing or emerging products. Further, by demonstrating the scientific potential of this abundant data, there is an increased emphasis on storing all of the collected data, not just that deemed interesting in the near term by the DOD and intelligence agencies.

This archival data could then provide context for future operations as well as scientific context for continued scientific monitoring of the Arctic. The combination of well-regarded research institutes (like NSIDC) with trusted data (from Overhead Persistent Infrared systems) creates a winning combination with regard to product credibility for DOD and intelligence users.

Noise is Good

In most circumstances, the SBIRS data that NSIDC is interested in constitutes noise for the rest of the user base. In fact, NSIDC is only concerned with the data that does not have national security purposes, as these types of scenes would likely disrupt processing due to anomalous events. The potential of this "noise" from OPIR is understood to a limited extent by both Air Force Space Command and Army Space and Missile Defense Command, but demonstration of ice characterization capability with the OPIR constellations dramatically increases the potential for this data.

The design for a SBIRS-based ice product (termed ICARTA–Ice Characterization of the Arctic for Transportation Applications) leverages the persistent nature of the constellation. Ice and water can be identified based on their unique spectral signatures in the short-wave infrared frequencies, although images are complicated by the prevalence of clouds in the scenes. This is where the unique structure of SBIRS/OPIR is most beneficial. Because clouds move faster than ice, using a temporal approach, clouds can be filtered out of images by their relative motion to the background (ice/water). This distinction is available because of SBIRS' persistence and allows for near real time/short delay reporting. During processing, as the ice/water is determined, any pixels obscured by clouds will default back to their most recent cloud-free value (ice or water) given a six-day cache of images.

Most existing ice products are developed using passive microwave, which determines the brightness temperature of the surface at different microwave band frequencies (10-89+ GHz). These products rely upon the DMSP series of satellites for the passive microwave data, but because of the low power of these emissions they have to aggregate over a large area to derive a meaningful signal. This aggregation results in 25-kilometer pixels for standard ice products covering the entire Arctic.

Regional products supplement this data with visible and near infrared data to increase resolution but have limited utility during times of polar darkness and under cloudy conditions;

the Arctic is often cloudy. With the congressional cancellation of DMSP-20, the future of the passive microwave sea ice record, continuously dating back to October 1978, is in jeopardy with no easy or foreseeable backfill.

The research team working on ICARTA includes a former NASA International Space Station program manager, a physical scientist from the NASA Goddard Space Flight Center and an Oceanographer and Remote Sensing Applications expert at the Naval Research Laboratory, among other scientists and researchers with noteworthy contributions to Arctic sciences and big-data management. In this group, three scientists already possess active security clearances while four others previously held clearances based upon prior employment, enabling access to the restricted data. These scientists are accustomed to proposing innovative research, as they are almost exclusively reliant upon research grants to pay their salaries.

In fact, the idea for ICARTA was derived from an SMC call for proposals that said little more than "if given 'x' data, what would you do with it and how much would that cost?" This $400,000 and 15-month investment into the NSIDC team of researchers/scientists funds the salaries of these professionals and nets SMC rights to all of the data, algorithms and products developed by the team.

Think Beyond the Threat

The space warfighter community needs to continue to think beyond the threat fan with the instruments available and leverage the talents of those with institutional expertise to pull new signal from the noise. The SMC/NSIDC sea ice project is an excellent example of defense/academic collaboration to explore the true utility of existing (and expensive) satellite systems, forge unorthodox relationships that are mutually beneficial and achieve results on short timelines and with limited budgets. While a near-real-time sea ice product would be unprecedented in its utility to the Arctic's continued development, the model sought by SMC to employ experts and get results is one that could enhance warfighter capability dramatically and on expedited timelines.

Air Force SMC is able to leverage the expertise of gifted academics to test the bounds of the SBIRS data. NSIDC can then potentially incorporate a new data source and create products necessary to support increased military, civil and commercial operations as the Arctic becomes more navigable. While Overhead Persistent Infrared was designed to detect high-intensity heat events, showing its ability to similarly capture significant events in some of the coldest water on Earth would challenge the Defense Department and intelligence community to further exploit the sensors at their disposal.