U.S. NAVAL RESEARCH LABORATORY

Remote Sensing of the Cryosphere

Remote Sensing Division (Code 7200)

AT A GLANCE

Why the cryosphere?

The U.S. Navy needs snow depth and sea ice forecasting capabilities that meet stringent year-round spatial resolution and coverage requirements for polar operations.

What are we doing?

Understanding the physics behind how snow and ice are viewed by active and passive microwave and visible/infrared sensors (e.g. AMSR, VIIRS, PACE, WSF-M, ICEYE and SMAP satellites, drone- and ship-based sensors) and modeling these phenomena.

What are our research goals?

(1) Operational algorithms exploiting satellite data with the ultimate goal of operational sea ice concentration and sea ice thickness forecasting algorithms in the polar regions

(2) Sensors for increased Arctic battlespace awareness

R&D Sponsor

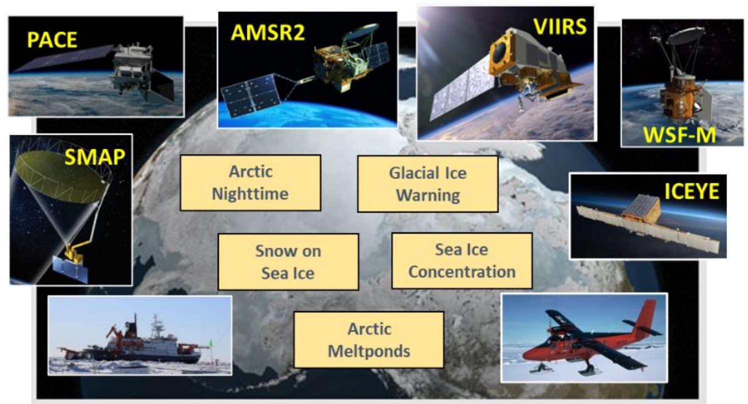
Office of Naval Research (ONR)

Points of Contact

Dr. Elizabeth Twarog
202.767.9130
elizabeth.m.twarog.civ@us.navy.mil

Dr. Li Li
202.767.0849
li.li4.civ@us.navy.mil

Dr. Wesley Moses
202.767.5187
wesley.j.moses.civ@us.navy.mil



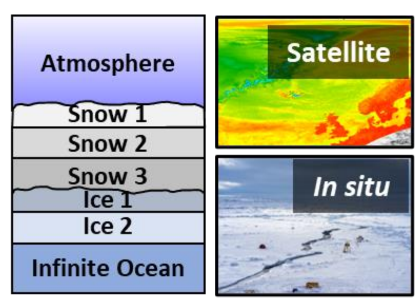
Cryosphere Programs and Spaceborne Cryosphere-Imaging Sensors

The Remote Sensing Division at NRL has a cryosphere research focus on understanding and utilizing the phenomenology of passive and active microwave and visible/infrared (Vis/IR) signatures of snow and sea ice in the Arctic. Radiative transfer modeling and satellite-based spectral analysis are vital tools for this research. The programs highlighted here build the theoretical basis for future operational algorithms and sensors.

Snow depth and snow water equivalent on both land and sea ice are vitally important to cold weather tactical mobility and gap-crossing capabilities, as well as for numerical weather prediction. Accurate sea ice prediction is critically important for the Navy's mission, operations, and preparedness for the changing Arctic. High-resolution Arctic sea ice concentration data are vital for the safe transport of ships and submarines year round. Knowledge of iceberg location increases battlespace awareness in the Arctic Ocean and provides greater operational flexibility for non-ice-hardened vessels.

Snow on Sea Ice

Objective: Develop a radiative transfer model to accurately characterize upwelling passive microwave emissions from snow on sea ice.

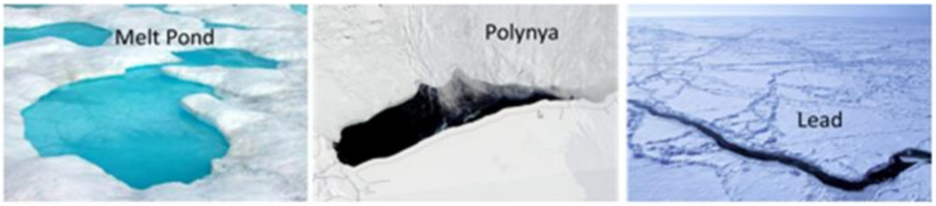


Snow and ice modeling / validation

Uncertainty in the depth of snow on sea ice is one of the largest sources of error in sea ice forecast models and is also the largest source of error in satellite estimates of sea ice thickness. The goal is to provide accurate global retrievals of snow in order to improve satellite-based sea ice thickness measurements and medium/long term sea ice forecasting. We aim to build a physically-based dense media radiative transfer model to investigate and accurately characterize upwelling microwave emission signatures from bulk properties (e.g. depth, salinity, density, grain size) of sea ice and the snowpack.

Integrated Remote Sensing and Modeling of Arctic Melt Ponds

Objective: Characterize Arctic melt pond formation, evolution, and refreezing and their impacts on sea ice characteristics (i.e. thickness and extent), through modeling and a multi-sensor, multi-modal remote sensing approach involving active and passive technologies.



Melt ponds, Polynyas, and Leads in Arctic Sea Ice

Melt pond formation and dynamics affect and are affected by sea ice properties. Observational melt pond information is not incorporated in current sea ice models, thereby leading to inaccuracies in model predictions of sea ice extent.

We will examine how melt pond processes affect sea ice thickness, extent, and distribution; how the ponds affect thermal conductivity and salinity gradients in sea ice; and how multi-modal (optical, synthetic aperture radar, and lidar) remote sensing data can be used synergistically to detect melt pond characteristics. This project will lay the foundation for an integrated remote sensing capability to retrieve observational melt pond data and feed them into models, which promises to improve sea ice modeling and forecasting via satellite data assimilation.

Glacial Ice Warning System

Objective: Design a shipboard passive microwave radiometric system to enhance tactical awareness during near-ice navigation for Navy vessels with emphasis on small iceberg detection (< 60 m length).

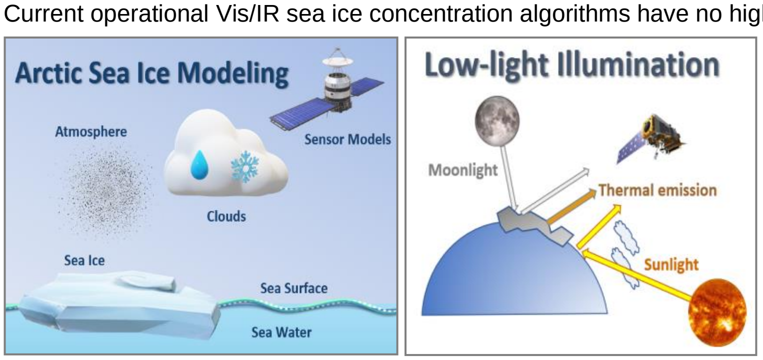
Passive microwave shipboard small iceberg detection sensor

Arctic icebergs are usually freshwater remnants of the Greenland ice sheet and are hazardous due to their high density and the large proportion of mass below the sea surface. They have low radar cross sections and are difficult to detect from space. We will combine established models into a simulation tool to evaluate radiometric sensitivity in polar conditions from a ship-board geometry, incorporate empirical data, quantify system performance metrics and design a radiometric system for ice navigation.

Arctic Nighttime Sea Ice Remote Sensing

Objective: Investigate the spectral signatures of visible to long-wave IR of the Arctic sea ice under the previously-unstudied low-light conditions of twilight, moonlight, and cloud shadow.

Current operational Vis/IR sea ice concentration algorithms have no high-resolution forecast capability during the Arctic winter due to the lack of understanding of the physics of the input satellite data acquired under low-light conditions.



3D radiative transfer modeling of low-light Arctic illumination

This project investigates and models the physical processes observed by satellites in Arctic low-light conditions using 3D radiative transfer modeling of clouds and below-horizon twilight illumination. This will result in an understanding of both the physical processes associated with the interaction between twilight illumination and sea ice and clouds as well as the phenomenology of Vis/IR sensors that produce high resolution sea ice observations during the Arctic winter.