NRL scientists optimize arctic sea ice data products

March 26 2012

The NRL team, using a specially equipped de Havilland DHC-6 Twin Otter aircraft (similar to aircraft shown), collect data to aid in the validation and calibration of data captured by the ESA Cryosat-2 satellite. Credit: NASA Glenn Research Center

Scientists from the U.S. Naval Research Laboratory (NRL) Marine Geosciences Division are assisting NASA, the US Army Cold Regions Research and Engineering Laboratory (CRREL) and the European Space Agency (ESA) in developing more accurate monitoring and sustainable forecasting of Arctic sea ice.

Recent dramatic changes in the characteristics of the Arctic sea ice cover have sparked interest and concern from a wide range of disciplines. The demand for an improved ability to monitor and forecast changes in sea ice cover is driven by diverse and varying priorities to include socioeconomics, maritime safety and security, and resource management, as well as basic research science.

Satellites provide an important and cost effective platform for instruments designed to monitor basin-wide changes in the volume of ice cover and snow pack depths. The primary focus of NRL and NASA is to collect data to aid in the validation and calibration of these data sets to further optimize instrument suites and the development of predictive sea ice models.

"Our project takes direct aim at this issue by targeting the largest identified contributors to errors in sea ice thickness measurements from airborne and satellite-based instruments," said Joan Gardner, NRL geologist. "Central to our work is the rare opportunity for a multi-scale approach to mapping the snow depth and sea ice thickness distribution using the most comprehensive set of in situ data collected to date."

In March 2011, a nine kilometer-long survey line was established on the sea ice cover by CRREL and NRL near the U.S. Navy Arctic Submarine Laboratory ICEX2011 ice camp. It was strategically located to cover a wide range of ice types, including refrozen leads, deformed and un-deformed first year ice, and multiyear ice. A highly concentrated set of in situ measurements of snow depth and ice thickness were taken along the survey line.

The first of its kind ICEX survey has proved to be of great value to both NASA and NRL in terms of better understanding the capabilities of airborne and satellite based instruments to measure varying ice types. This will aid in achieving a resolution that is adequate to minimize the degree of uncertainty in models that forecast future conditions and for monitoring decadal variability.

Once the survey line was in place, NASA IceBridge — a six-year NASA mission, and largest airborne survey of Earth's polar ice ever flown — flew a dedicated mission along the survey line, collecting data with an instrument suite that included the Airborne Topographic Mapper (ATM), a high precision, airborne scanning laser altimeter; the Digital Mapping System (DMS), a nadir viewing digital camera; and the University of Kansas ultra-wideband Frequency Modulated Continuous Wave (FMCW) snow radar. The IceBridge measurements were further leveraged by complementary airborne measurements taken by NRL and submarine ice draft measurements.

"We plan to use this set of data to characterize the error on the IceBridge snow depth and sea ice thickness data products as a function of ice type," adds Gardner. "These results will also be applied to improve understanding of new sensors." Sensors to include the IceBridge snow radar, NRL radar altimeter and the European Space Agency CryoSat-2 satellite carrying a state-of-the-art Synthetic Aperture Radar (SAR) Interferometer Radar Altimeter, or SIRAL.

Improved understanding of these measurements and their accuracies will allow scientists to develop new algorithms to incorporate this information into regional sea ice models used by the research community. The error estimates will also help tie the Ice, Cloud, and land Elevation Satellite (ICESat) and future ICESat-2 records together.

Remote techniques to monitor sea ice extent in all seasons are well developed — these observations reveal a dramatic decline in summer sea ice extent since 1979, when satellite records became available. Further, they indicate that the decline has been facilitated by a dramatic decrease in the extent of perennial or multiyear ice.

Combined estimates of ice thickness derived from submarine records between 1958 and 2000, and ICESat laser altimetry from 2003 to 2008, provided the longest-term record of sea ice thickness observations. These data suggest a decrease in the mean overall thickness of the sea ice over a region covering about 38 percent of the Arctic Ocean.

The ICESat satellite has been critical to meeting the goals of NASA's Cryospheric Science Program by providing ice elevation information at continental scales with high spatial resolution. As of October 11, 2009, ICESat stopped collecting science data — increasing the urgency of continued observations during IceBridge missions. ICESat-2 is planned to launch no sooner than 2016.

This work directly addresses priorities to improve the utility of IceBridge data to estimate ice thickness and snow accumulation on Arctic sea ice. Because of its fundamental nature, the results from this research will also contribute to the priorities of improved understanding of the mechanisms controlling sea ice cover. These include quantification of the connections between sea ice, ocean and the atmosphere, and validated and improved predictive models of changes in sea ice cover, especially in the coming century, as well as, implications of these changes to the ocean, atmosphere, surrounding land areas and global system. The proposed work also addresses Arctic-related objectives of the US Navy, the Study of Environmental Arctic Change (SEARCH), and the U.S. Global Climate Change Research Program (USGCRP).

Provided by Naval Research Laboratory