NRL Use of IceBridge Sea Ice Products

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IceBridge Science Team Meeting
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NRL 6.1 Program: Determining the Impact of Sea Ice Thickness on the Arctic’s Naturally Changing Environment (DISTANCE)

Strategy

Remote Sensing Synergism
- Collect in situ data (ice/snow thickness)
- Develop airborne algorithm from in situ data
- Utilize airborne data to derive satellite algorithm

Ice-Ocean Modeling Scheme
- Validate model ice thickness against new satellite/airborne data
- Simulate snow forcing on ice distribution

Leverage existing Arctic programs
NRL Use of IceBridge Sea Ice Products

- NRL Arctic Cap Nowcast/Forecast System (ACNFS) ice model validation and IceBridge data assimilation (Rick Allard, Pamela Posey)
  - Injected the IceBridge snow depth and ice thickness data into the data subsystem
  - Preliminary ACNFS and IceBridge data comparisons are encouraging
  - Working on assimilation of IceBridge ice thickness and snow data into ACNFS ice model

- Coordinated airborne campaigns with OIB (John Brozena, Joan Gardner)
  - Use combined Lidar/Radar approach
  - Acquiring a snow radar from U Kansas (similar to what is flown on IceBridge)

- Coordinated filed work with OIB (Jackie Richter-Menge, Don Perovich)
  - ICEX 2011, 2014
  - Snow depth and ice thickness, and Snow/ice surface roughness
  - Characterization of snow and ice vertical profiles

- Sensor physics and snow/ice retrievals (Li Li, David Truesdale)
  - Impacts of snow/ice/lead properties on radar/radiometer signatures
    - EM Model development and validation using NRL/CRREL and IceBridge data sets (ATM, Ku-band radar altimeter, DMS, CAMBOT, and snow depth).
  - Model up-scaling from airborne (NRL/IceBridge) to satellite (CryoSat-2/AMSR-2/WindSat) platforms

Leveraging IceBridge Data is Essential for the Success of the DISTANCE Program
NRL Arctic Cap Nowcast /Forecast System (ACNFS)

- **A Coupled Sea Ice & Ocean Model**
  - 1/12° (3.5 km at Pole) horizontal resolution
  - Ice Model (CICE)
  - Ocean Model (HYCOM)
    » Receives boundary conditions from 1/12° global model

- **Navy Coupled Ocean Data Assimilation (NCODA) System**

- **Data Products:**
  - Ice thickness, ice concentration, ice speed and drift, sea surface height (SSH), sea surface temperature (SST) and sea surface salinity (SSS)

http://www7320.nrlssc.navy.mil/hycomARC/
Preliminary Examination of 2012 NASA IceBridge Data

Long Term Goal: Ability to assimilate remotely sensed ice thickness and snow data into ice model
NRL has developed a preliminary combined laser/radar altimeter algorithm for retrieving sea ice thickness and snow-on-ice depth.

First CryoSat-2 underflight flown by NASA IceBridge on 20 April 2010.

Top right panel shows snow surface elevation measured by Airborne Topographic Mapper (ATM) LiDAR at 500m altitude.

Second panel shows ku-band radar altimeter ecogram data at lower resolution (~16x10 m) to detect snow and ice surfaces.

Bottom panels depict derived sea ice thickness and snow depth; ACNFS data shown as dashed line.
CryoSat-2 Underflight by NRL & IceBridge (Mar 23, 2011)

Geolocation derived from DMS data using Google Earth. Estimation error: 700m

- **Goal**: Sensor signatures and their up-scaling from airborne to satellite.
- **NRL LiDAR**: Snow surface roughness.
- **CRREL In Situ**: Validation
- **OIB LiDAR/Radar**: Data synergism.
- **OIB DMS/CAMBOT**: Snow/ice characterization, geolocation.
RMS Height

RMS Slope

NRL ICEX 2011 Lidar Data

RMS Height

RMS Slope
IceBridge Combined Ku-Band Radar + ATM Data

Snow Surface Elevation from Lidar (m)

ATM Data Derived Surface Roughness

RMS Height (m)

IceBridge Ku-Band Radar Echo

Radar Pulse Width Index

Radar Echo Strength

Radar Ecogram and Snow/Ice Surfaces

Along Track Distance (km)

Cross Track (km)

Elevation (m)

Along Track Distance (km)