CReSIS OIB Planning Meeting

June 29 – July 1, 2010

Prasad Gogineni, Chris Allen, Carl Leuschen,
John Paden, and William Blake

NATIONAL SCIENCE FOUNDATION :: KANSAS TECHNOLOGY ENTERPRISE CORPORATION :: NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The University of Kansas | The Ohio State University | Pennsylvania State University
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Centre for Polar Observation and Modelling | University of Copenhagen
Technical University of Denmark | Antarctic Climate & Ecosystems CRC

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People

Aerospace:	**Rick Hale, Emily Arnold, John Hunter, Wanbo Liu**
Radar System:	**Prasad Gogineni, Chris Allen, Carl Leuschen, Sarah Seguin, Fernando Rodriguez-Morales, John Ledford, Lei Shi, Ben Panzer, Aqsa Patel, Kyle Byers, Reid Crowe, Dennis Sundermeyer**
Data Processing:	**Ken Jezek, John Paden, Lei Shi, William Blake, Keith Lehigh, Josh Meisel, Deepananthan Dhanasekaran**

Sensors

Instrument	Measurement	Frequency (Bandwidth)	Platform	Deployment
MCoRDS	• Ice Thickness • Bed Characteristics • Bed Imaging • Internal Layering	195 MHz (30 MHz)	• DC-8 • P-3 • Twin Otter	• Fall 2009 (DC-8) • Spring 2010 (DC-8 and P-3)
Accumulation	• Internal Layering	750 MHz (300 MHz)	• P-3 • Twin Otter	• Spring 2010 (P-3)
Snow Radar	• Snow Cover • Internal Layering • Topography	4.5 MHz (4 MHz)	• DC-8 • P-3	• Spring 2009 (P-3) • Fall 2009 (DC-8) • Spring 2010 (DC-8 and P-3)
Ku-Band	• Snow Cover • Topography	14 MHz (4 MHz)	• DC-8 • P-3 • Twin Otter	• Fall 2009 (DC-8) • Spring 2010 (DC-8 and P-3)
TIDSOR	• Ice Thickness	13.5 MHz (1 MHz)	• Surface	• N/A

Presentations

- Snow and Ku-Band Status and Results
- MCoRDS Status and Results
- MCoRDS Processing
- FMCW Processing
- MCoRDS Tomography Results
- Dual-Frequency HF Radar Sounder

Snow and Ku-band Radars

Operation Ice Bridge: 06/29/10

Ben Panzer, Aqsa Patel, Reid Crowe, and Carl Leuschen

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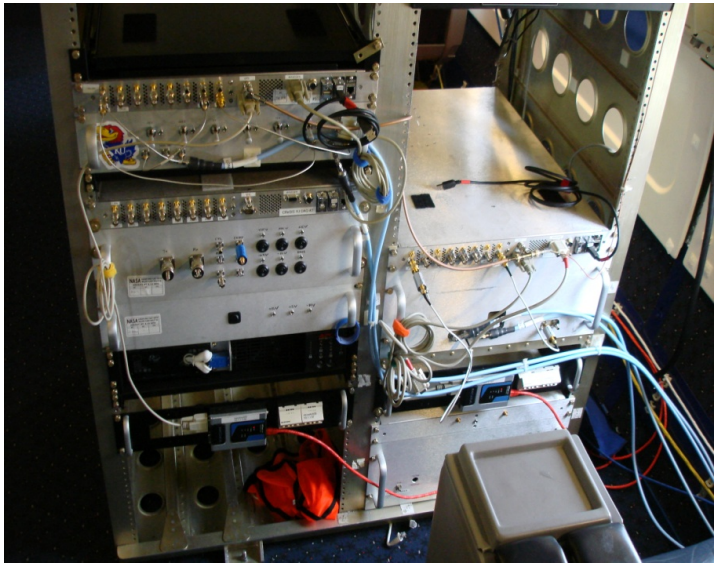

Snow Radar description

	Greenland 2009	Antarctica 2009	Greenland 2010
Bandwidth	2.5 to 7 GHz	4 to 6 GHz	2.0 to 6.5 GHz
Pulse Length	270 us	100 us to 240 us	250 us
PRF	2 kHz	2 or 3 kHz	2 kHz
Transmit Power	20 dBm	20 dBm	20 dBm
IF Frequency Range	41-58 MHz	31-62 MHz	31-62 MHz
Sampling Frequency	58.32 MHz	62.5 MHz	62.5 MHz
Range Resolution*	~2.5 cm	~5.5 cm	~2.5 cm

*In snow, assuming a snow density of 0.5

Ku-band altimeter description

	Antarctica 2009	Greenland 2010
Bandwidth	14 to 16 GHz	12.5 to 13.5 GHz
Pulse Length	170 to 240 us	240 us
PRF	3 kHz	3 kHz
Transmit Power	20 dBm	20 dBm
IF Frequency Range	5-31 MHz	5-31 MHz
Sampling Frequency	62.5 MHz	62.5 MHz
Range Resolution*	~5.3 cm	~10.6 cm

*In snow, assuming a snow density of 0.5

Data collected: Greenland 2009

- 18 hours processing time, 6 seconds/file

DATE	MISSION NAME	TYPE	DURATION	DATA RECORDED [GB]
03/31/09	Svalbard Sea Ice	Sea Ice	4:20	234
04/01/09	East Central Gap Filler	Land Ice	4:04	227
04/02/09	Thule to Fairbanks Sea Ice	Sea Ice	5:06	289
04/05/09	Fairbanks to Thule Sea Ice	Sea Ice	5:28	293
04/06/09	Northwest Gap Filler	Land Ice	4:30	242
04/17/09	Thule 04	Land Ice	6:52	373
04/20/09	Thule 02	Land Ice	8:31	457
04/21/09	Sea Ice Science 01	Sea Ice	6:07	271
04/22/09	Thule 01	Land Ice	7:25	395
04/23/09	Thule 03	Land Ice	7:16	381
04/24/09	Northeast Gap Filler	Land Ice	7:31	380
04/25/09	Ice Camp Mission	Sea Ice	4:48	247
04/27/09	Thule 05	Land Ice	7:03	359
04/28/09	Sondy 04	Land Ice	6:54	370
05/01/09	Sondy 03	Land Ice	6:35	356
05/02/09	Sondy 02	Land Ice	5:55	316
05/05/09	UAVSAR Flight	Land Ice	3:28	160
		Sea Ice	**25 hrs. 49 min.**	**1334**
		Land Ice	**76 hrs. 4 min.**	**4016**
		Total	**101 hrs. 53 min.**	**5350**

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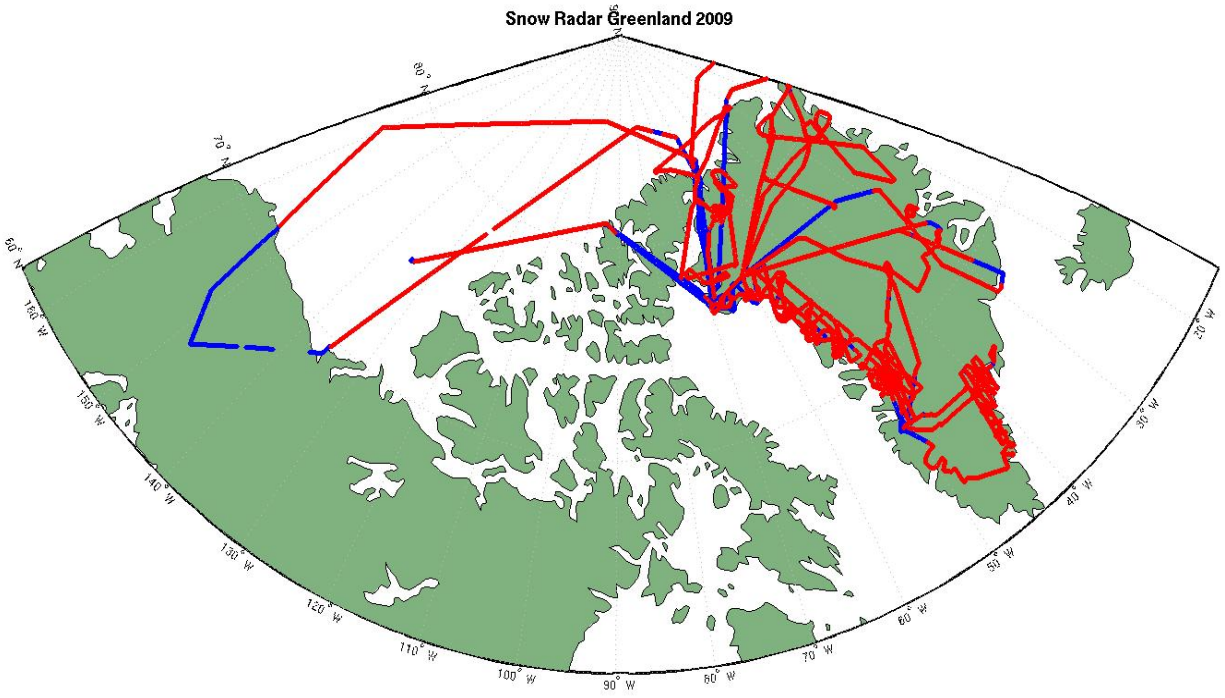
Data collected: Greenland 2009



DATE	% COLLECTED
03/31/09	100.00%
04/01/09	87.61%
04/02/09	95.00%
04/05/09	77.75%
04/06/09	89.93%
04/17/09	96.36%
04/20/09	98.50%
04/21/09	81.04%
04/22/09	97.89%
04/23/09	97.07%
04/24/09	93.75%
04/25/09	95.35%
04/27/09	100.00%
04/28/09	100.00%
05/01/09	94.51%
05/02/09	98.61%
05/05/09	99.07%

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Data collected: Antarctica 2009

- 12 hours processing time, 5 seconds/file

DATE	MISSION NAME	TYPE	SNOW DATA [GB]	Ku-BAND DATA [GB]
10/16/09	Getz Island	Land Ice	172	40
10/18/09	TSK2	Land Ice	181	185
10/20/09	Pine Island High Altitude	Land Ice	**	**
10/21/09	Amundsen & Bellingshausen Seas	Sea Ice	253	226
10/24/09	Weddell Sea (Sea ice #2)	Sea Ice	329	440
10/25/09	86 degree Arc High Altitude	Land Ice	**	**
10/27/09	Pine Island Glacier 2	Land Ice	*	191
10/28/09	TSK3	Land Ice	184	306
10/29/09	Pine Island Glacier 1	Land Ice	270	402
10/30/09	Weddell Sea (Sea ice #3)	Sea Ice	353	400
10/31/09	PEN2	Land Ice	220	325
11/02/09	TSK1	Land Ice	222	320
11/03/09	PEN1	Land Ice	*	378
11/04/09	PEN3	Land Ice	-	444
11/05/09	LVIS PEN	Land Ice	**	**
11/07/09	PIG Modified Grid	Land Ice	366	391
11/09/09	PIG4	Land Ice	326	328
11/12/09	Abbot Ice Shelf	Land Ice	295	312
11/15/09	Evans Glacier	Land Ice	346	346
11/16/09	PEN5	Land Ice	308	310
11/18/09	TSK4	Land Ice	277	274
		Total	**4102**	**5618**

* - Data overwritten in backup
** - High altitude flight

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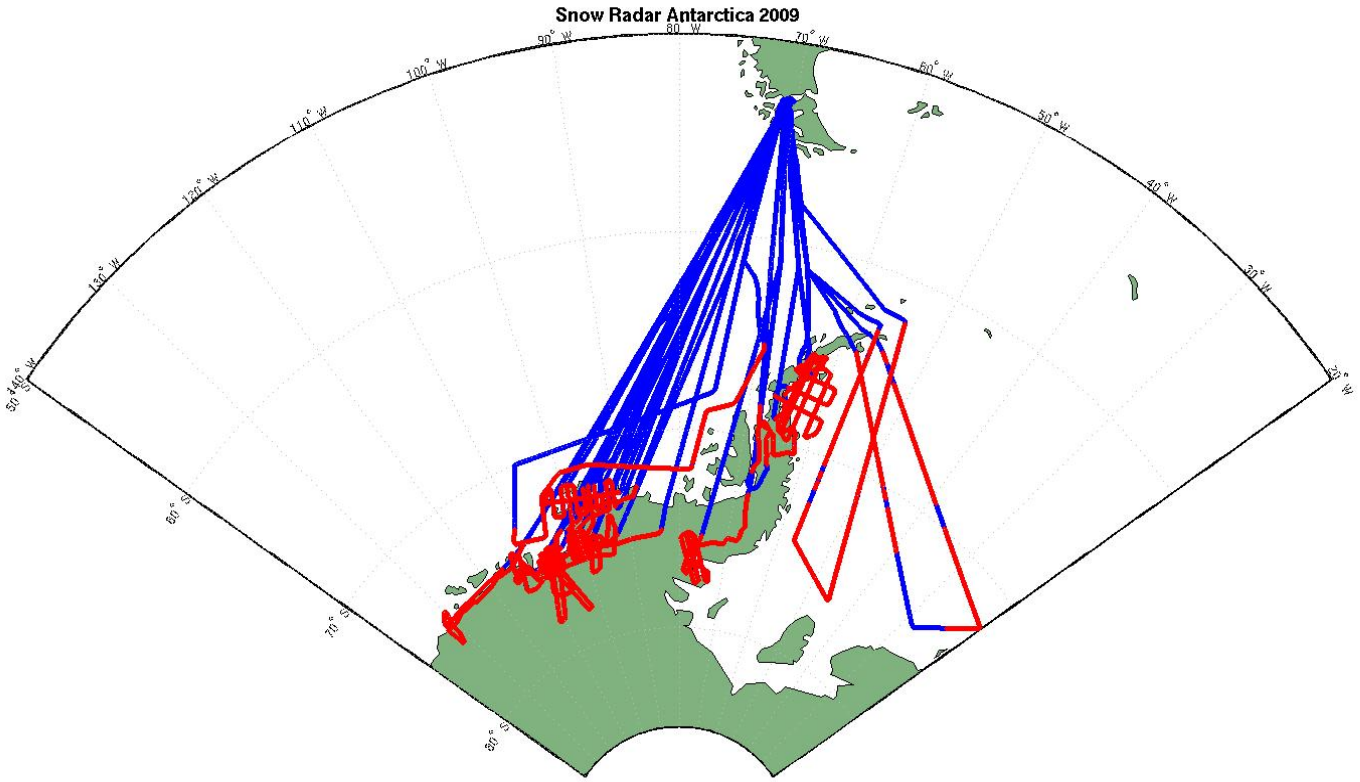
Data collected: Antarctica 2009



DATE	% COLLECTED
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10/18/09	97.96%
10/21/09	98.76%
10/24/09	72.89%
10/28/09	87.60%
10/29/09	99.67%
10/30/09	92.83%
10/31/09	82.68%
11/02/09	98.13%
11/07/09	97.64%
11/09/09	98.44%
11/12/09	91.16%
11/15/09	99.74%
11/16/09	96.89%
11/18/09	100.00%

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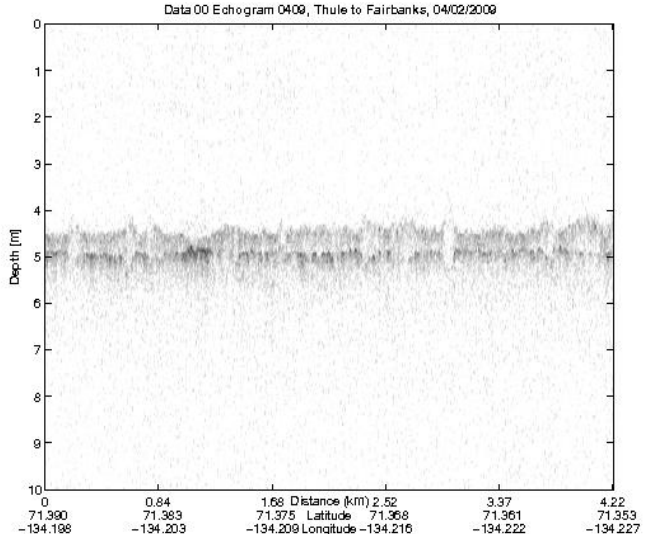
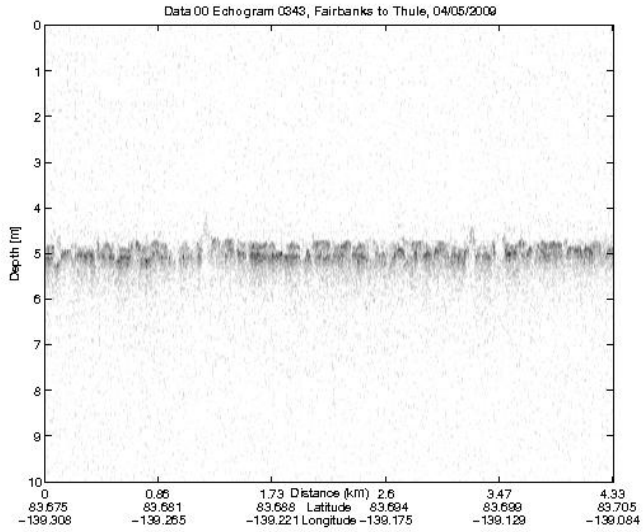
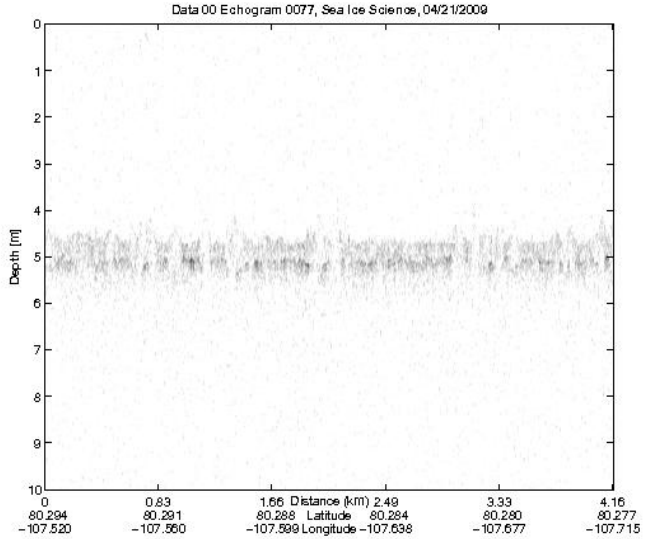
Processing

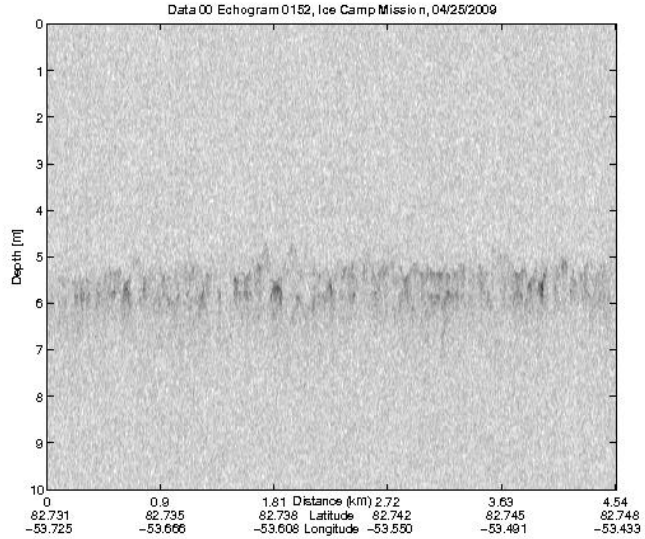
- Both radars follow the same processing routine
- Subtract the fast-time mean
- Coherent integration
- Hanning window data in fast-time
- Fast Fourier Transform
- Altitude correction
- Incoherent integration

Greenland 2009 sea ice images

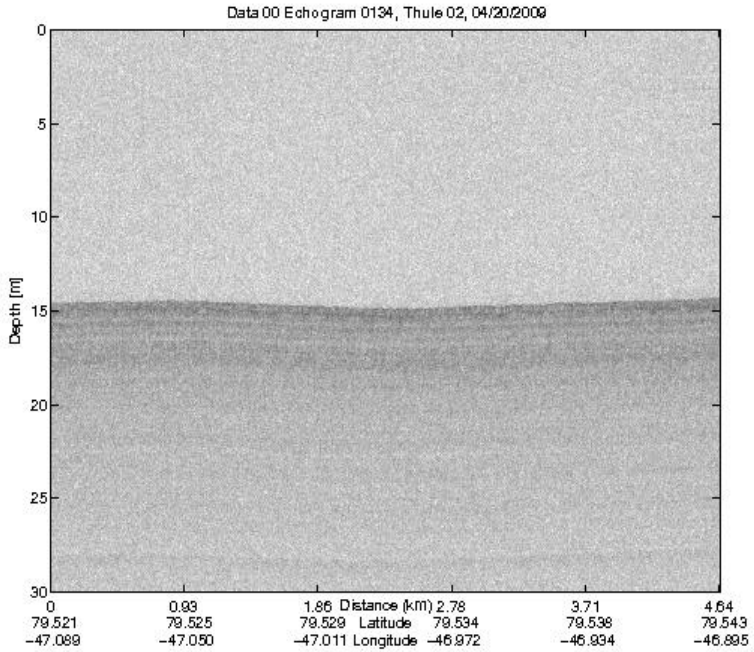


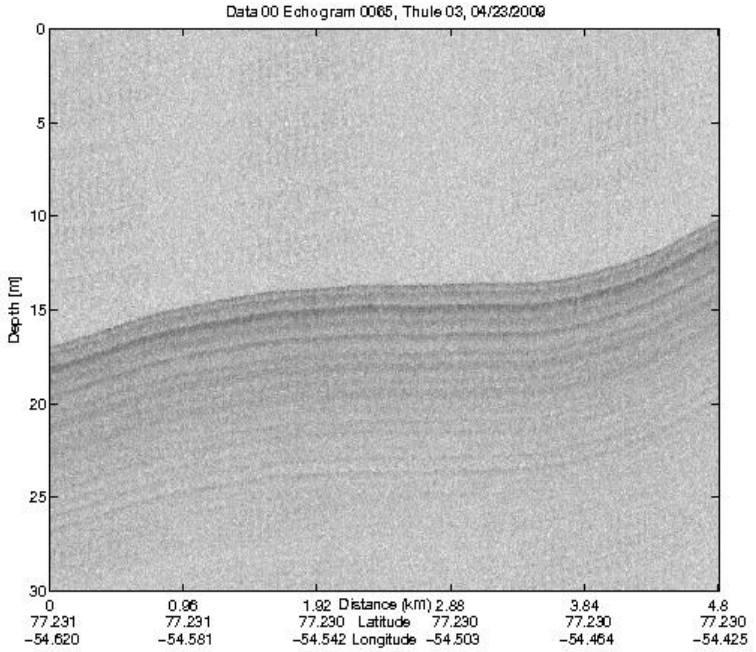






Greenland 2009 ice sheet





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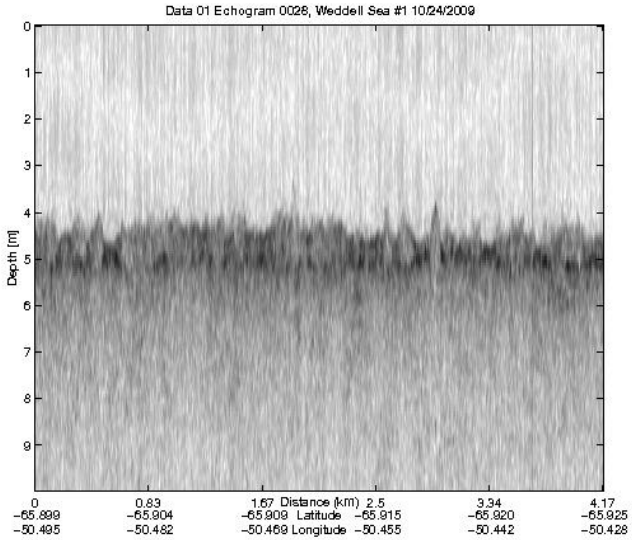
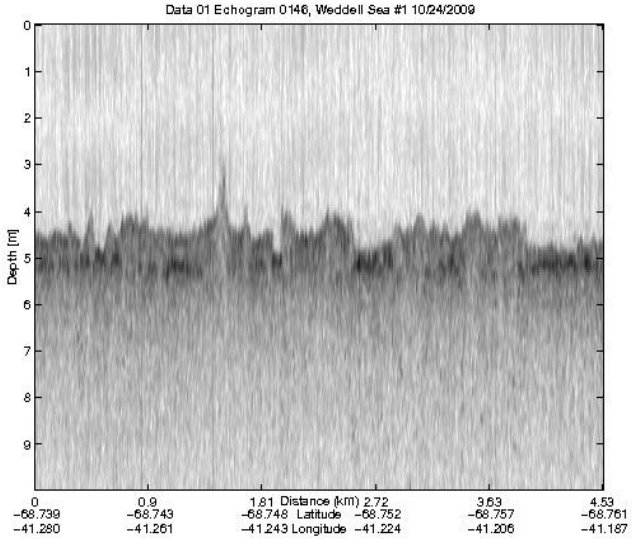
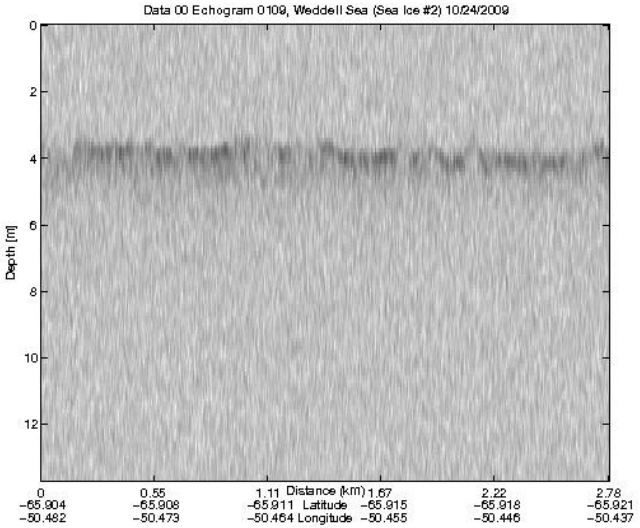
Antarctica 2009 sea ice images

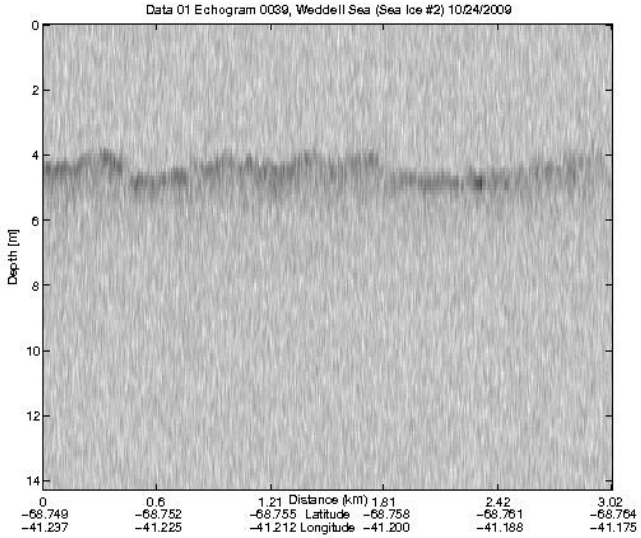
Snow Radar





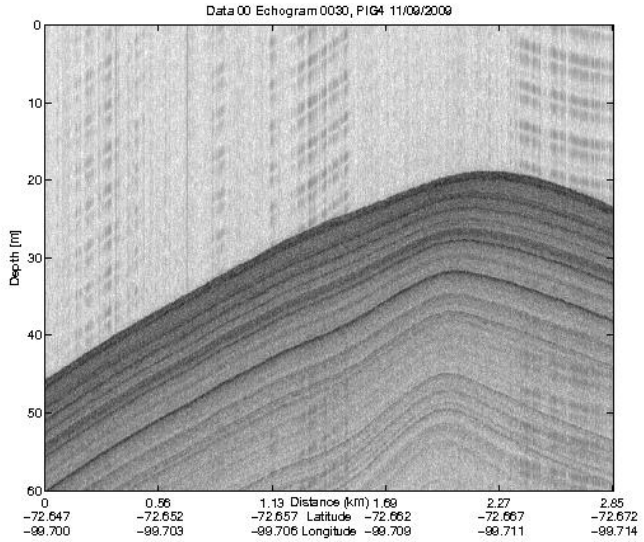
Ku-band Radar

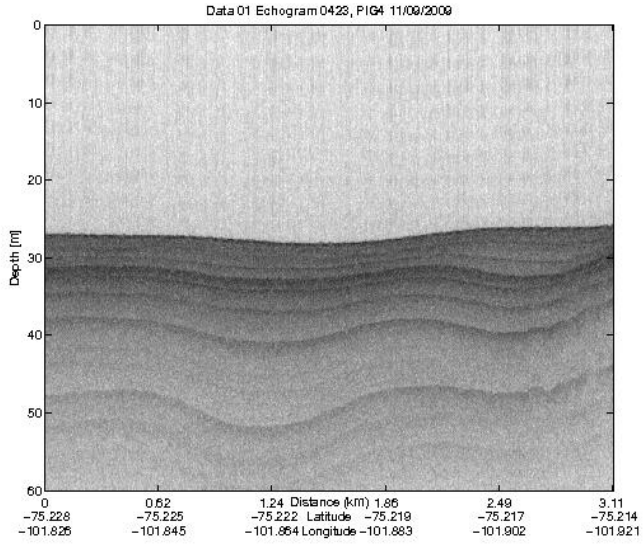




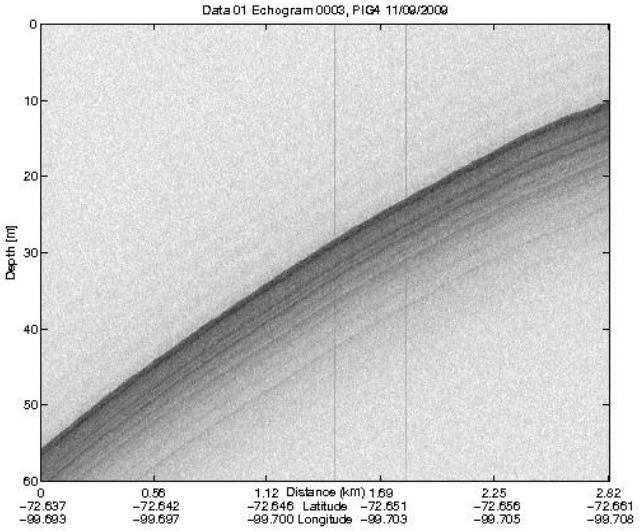
Antarctica 2009 land ice images

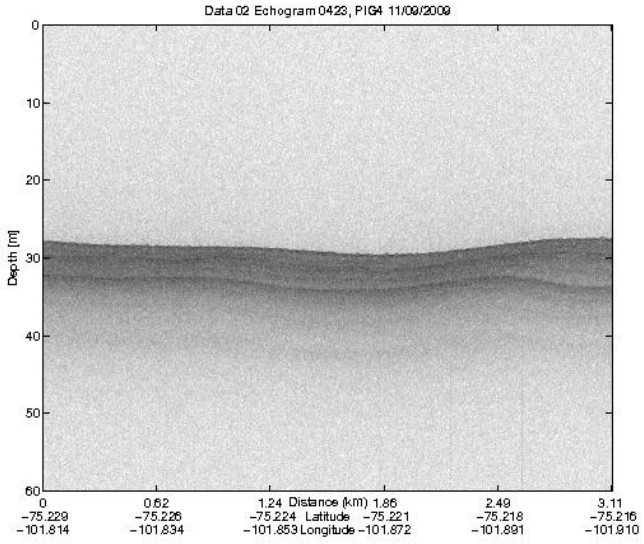
Snow Radar





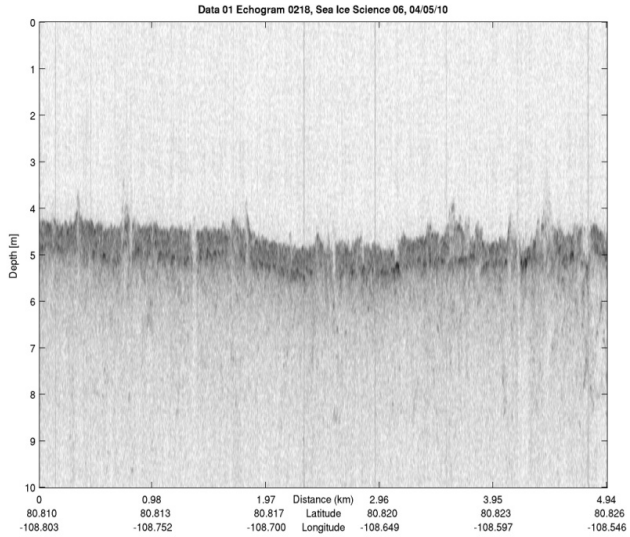
Ku-band Radar

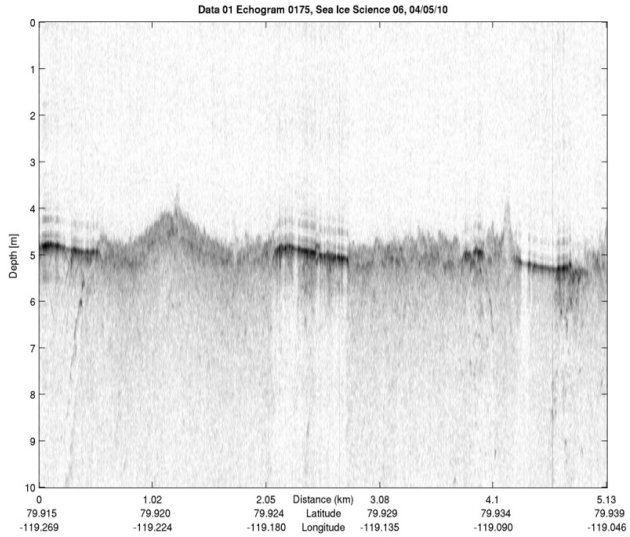




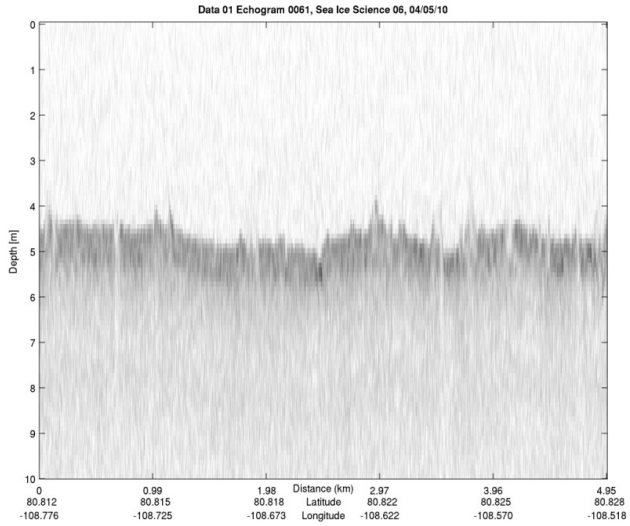
Greenland 2010 prelim results

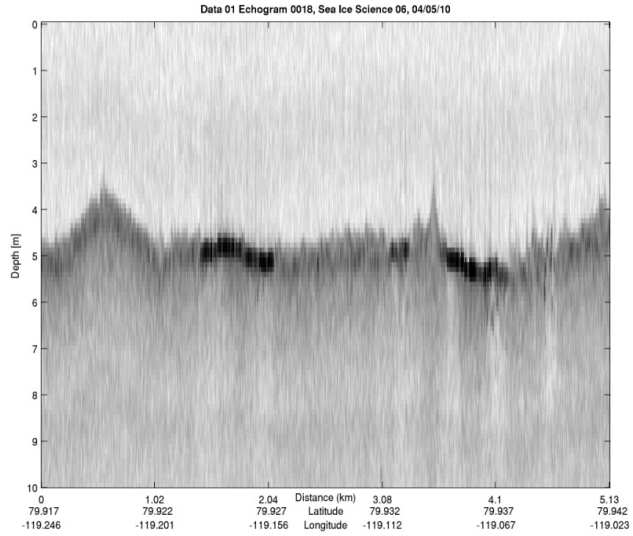
Snow Radar





Ku-band Radar





Current limitations

- Transmit/Receive Antenna Isolation (DC-8)
  - Limits transmit power of radar to avoid receiver saturation
    - Limits altitude or depth of penetration due to degradation of signal-to-noise ratio
  - Coherent noise raises the noise floor of the radar

Desired improvements

- Re-location of antennas to DC-8 wing roots
  - Provides better isolation
  - Allows for higher altitude/deeper penetration
- Reconfiguration of P-3 Snow Radar to multi-channel system

Future processing

- Implementation of the CReSIS Automatic Thickness Estimator (CRATE)
  - Interface picking – sea ice, Layer picking – land ice
- Implemention of Multiple Signal Classification (MuSiC) algorithm
  - Pseudo-spectrum estimation for interface/layer picking