

CRYOVEx 2011

AIRBORNE SEA ICE VALIDATION CAMPAIGN

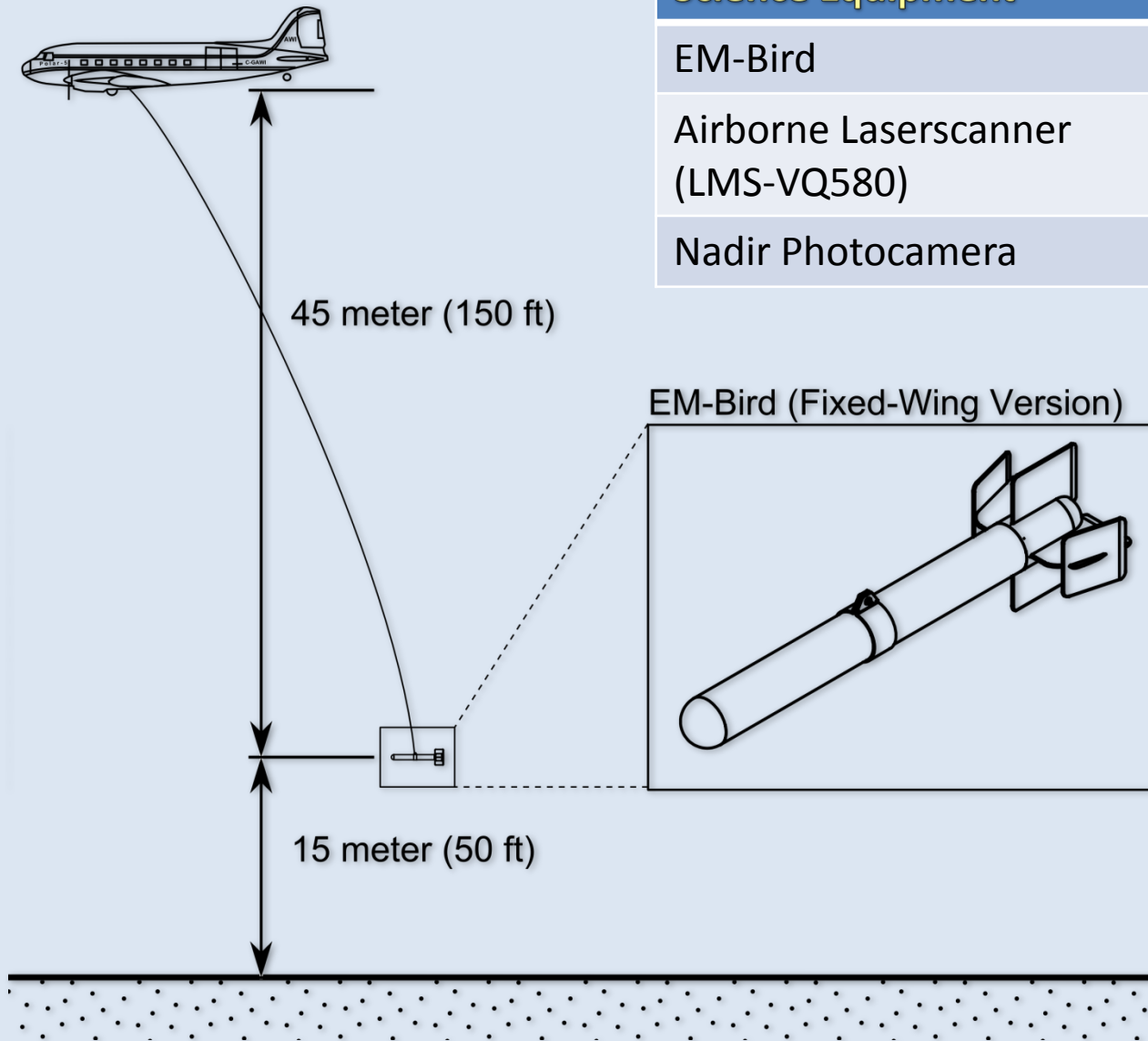


AWI
University of Alberta

Stefan Hendricks, Veit Helm, Andreas Herber
Christian Haas



Platform Polar-5



Science Equipment

EM-Bird

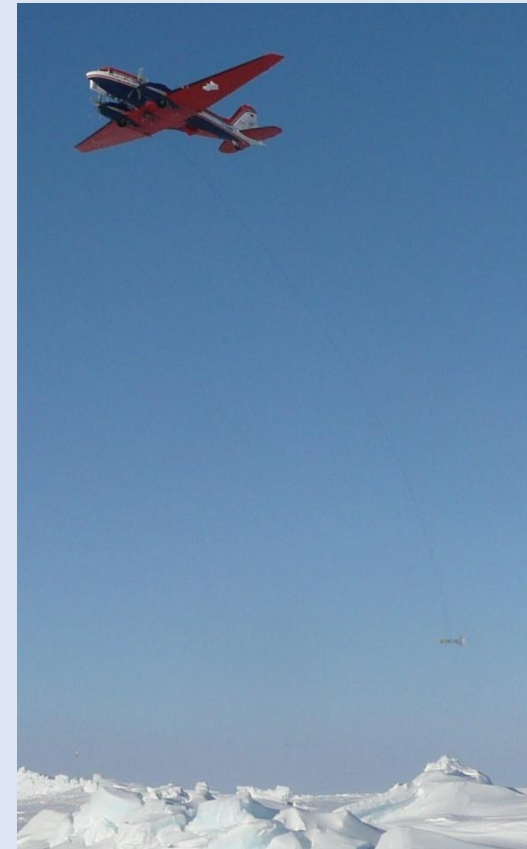
Ice + Snow Thickness

Airborne Laserscanner
(LMS-VQ580)

Digital Elevation Model

Nadir Photocamera

Aerial Imagery

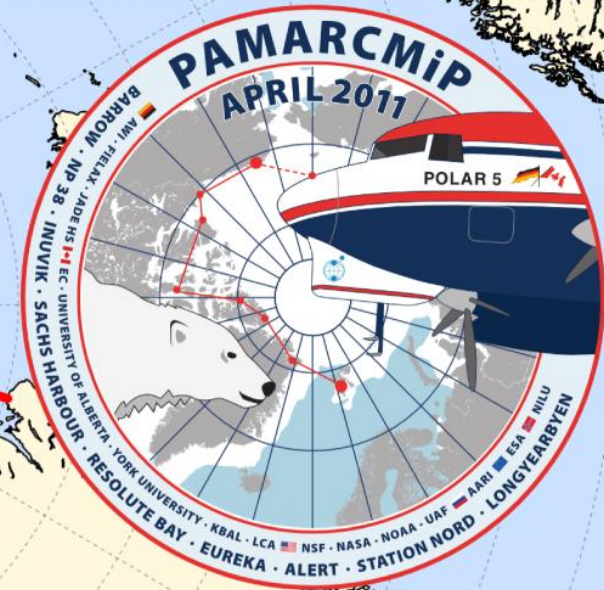


Overview Airborne Activities

Airborne EM Sea Ice Thickness PAMARCMIP 2011

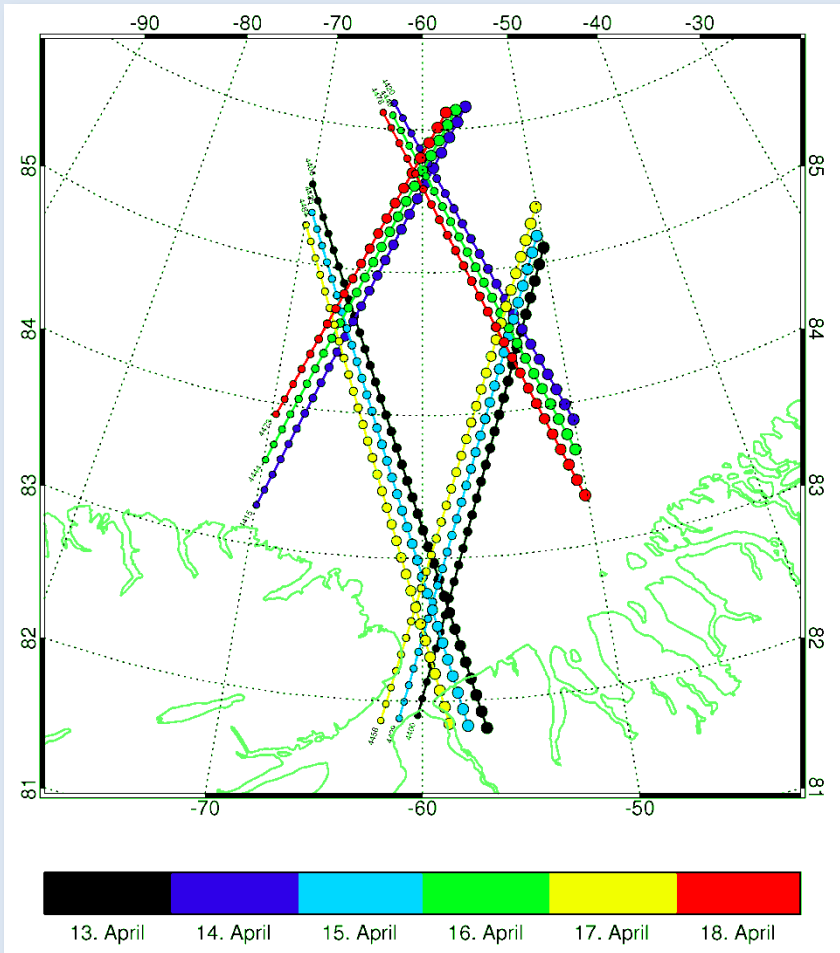
Airborne EM profiles

CryoVEx 2011
CryoSat-2 Orbit 4400
CryoSat-2 Orbit 4435
CryoSat-2 Orbit 4464



CryoSat-2 Validation Activities embedded in AWI PAMARCMIP sea ice campaign

CryoSat-2 Underpasses

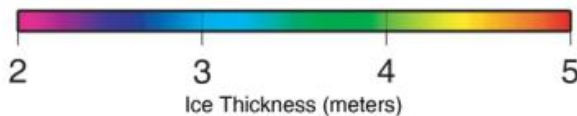
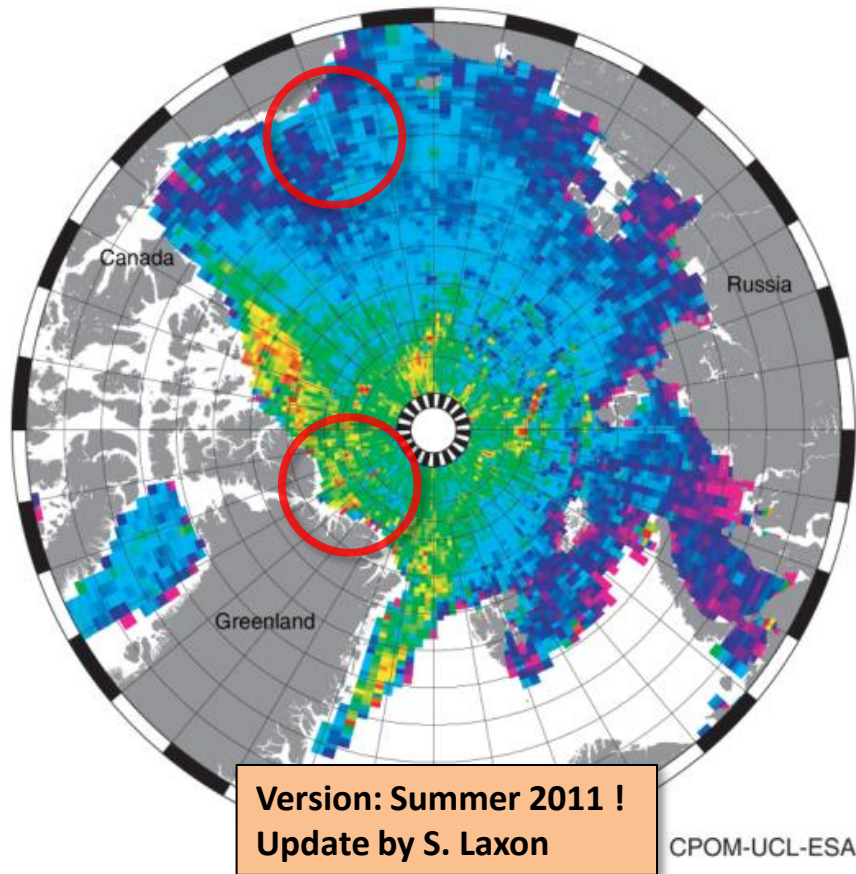


CryoSat-2 Target Orbits for CryoVEx 2011
for airborne validation activities

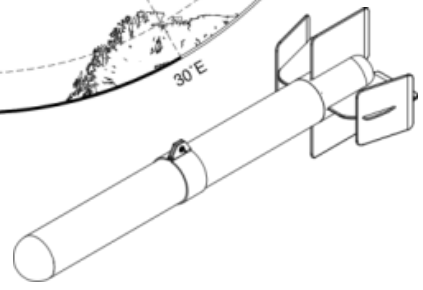
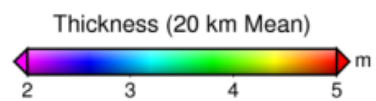
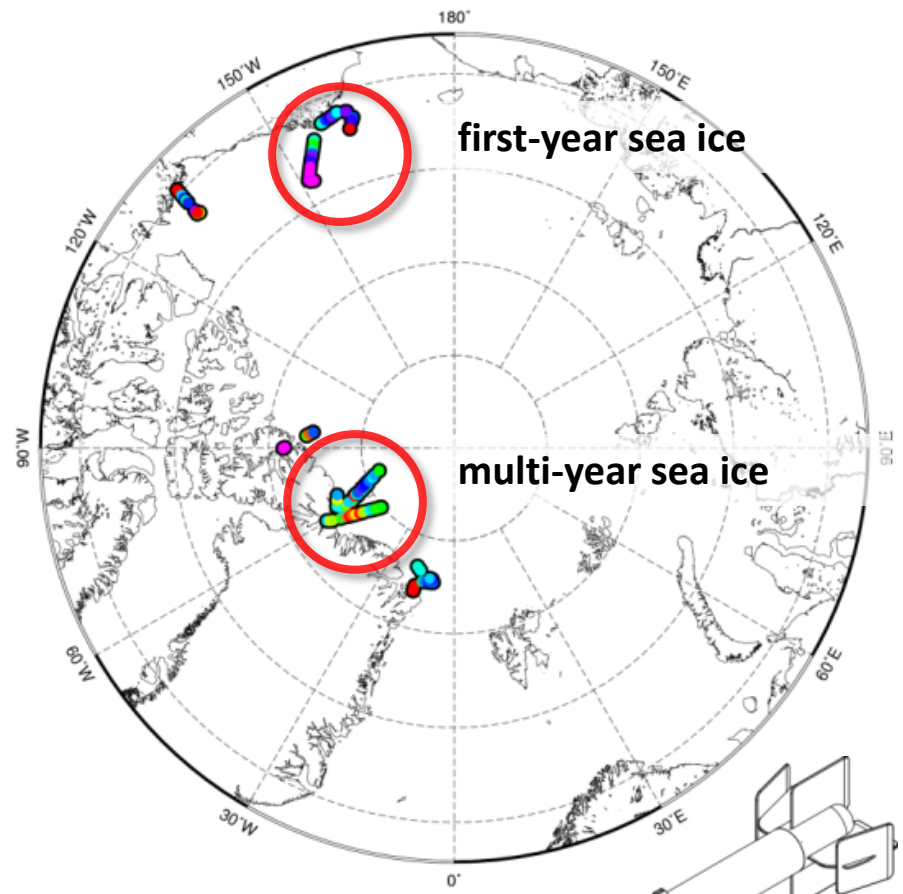
- **Three CryoSat-2 underpasses with Polar-5**
 - **14. April 2011:**
CryoSat-2 Orbit 4400
Time offset of 1 day (low ice drift)
 - **15. April 2011:**
CryoSat-2 Orbit 4435
Coincident with ASIRAS
 - **17. April 2011:**
CryoSat-2 Orbit 4467
Coincident with ASIRAS

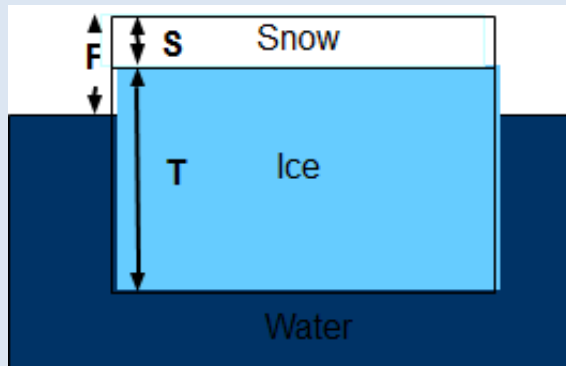
CryoSat-2 vs. EM-Bird (Spring 2011)

Sea ice thickness in the Arctic ocean
(January/February 2011)



April 2011





$$h_i = f \frac{\rho_w}{(\rho_w - \rho_i)} + \frac{h_s \rho_s}{(\rho_w - \rho_i)}$$

Objectives:

- Large scale validation of satellite freeboard (ASIRAS) and thickness (+AEM/LASER) – CryoSat+ aircraft
- Validation of ice freeboard (as measured by Cryosat) to thickness conversion –
 - Ice/snow interface level to thickness conversion aircraft + in situ data.
 - Average radar reflection horizon relationship to ice/snow interface.
- In-situ data for forward modeling of AEM, ASIRAS, CryoSat-2 data

The Plan

- Establish three ground validation sites; on fast ice, on thick multiyear ice, on thin multiyear ice or first-year ice; to describe general regional variability
- Perform overflights of ground validation sites with 1. ASIRAS, 2. EM Bird, 3. IceBridge sensors
- Extrapolate results to coincident, simultaneous CryoSat underflights



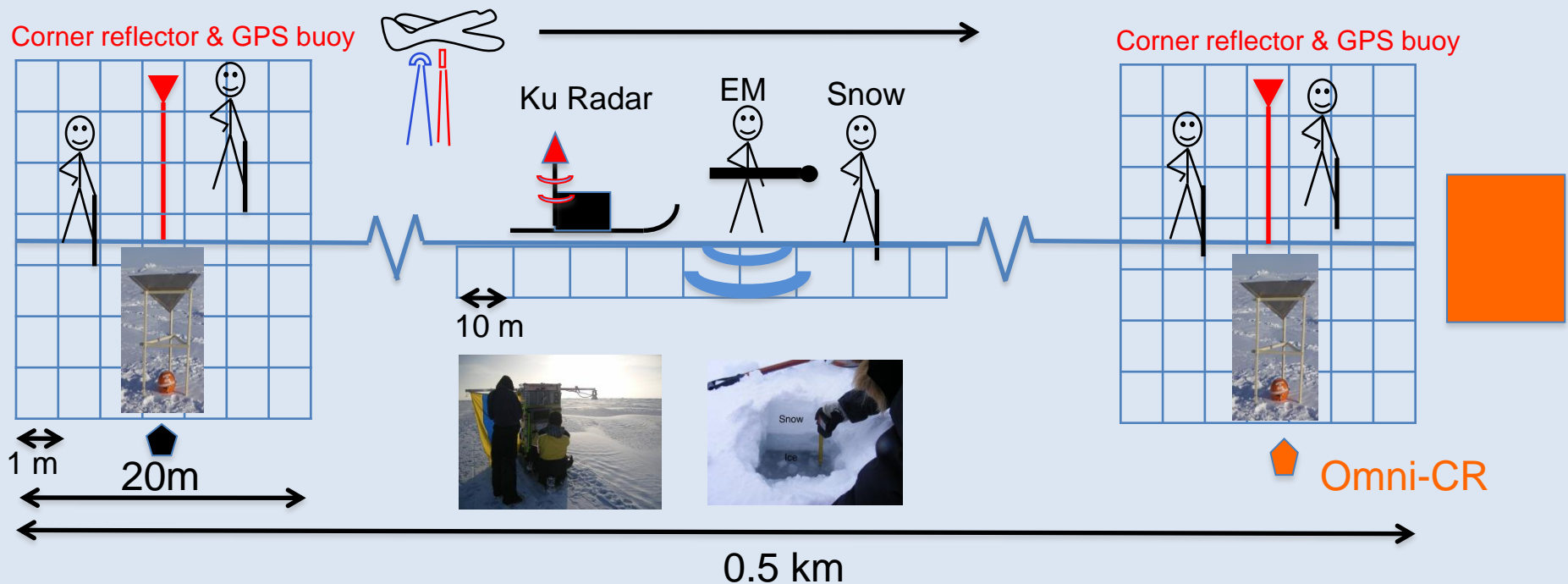
In-situ measurements at ground validation sites

Line survey

- 10 m: snow depth, ground EM31, snow freeboard measured by rotating laser. Few drill-holes.

Grid survey around corner reflector:

- Snow depth grid 20x20m, every 1 m (ASIRAS across track footprint)
- ~5 Snow pits at selected locations in grid
- Ku-band snow radar (GPR) at snow pits



Validation Line

Radiometry Pod

Bird Tow Cable

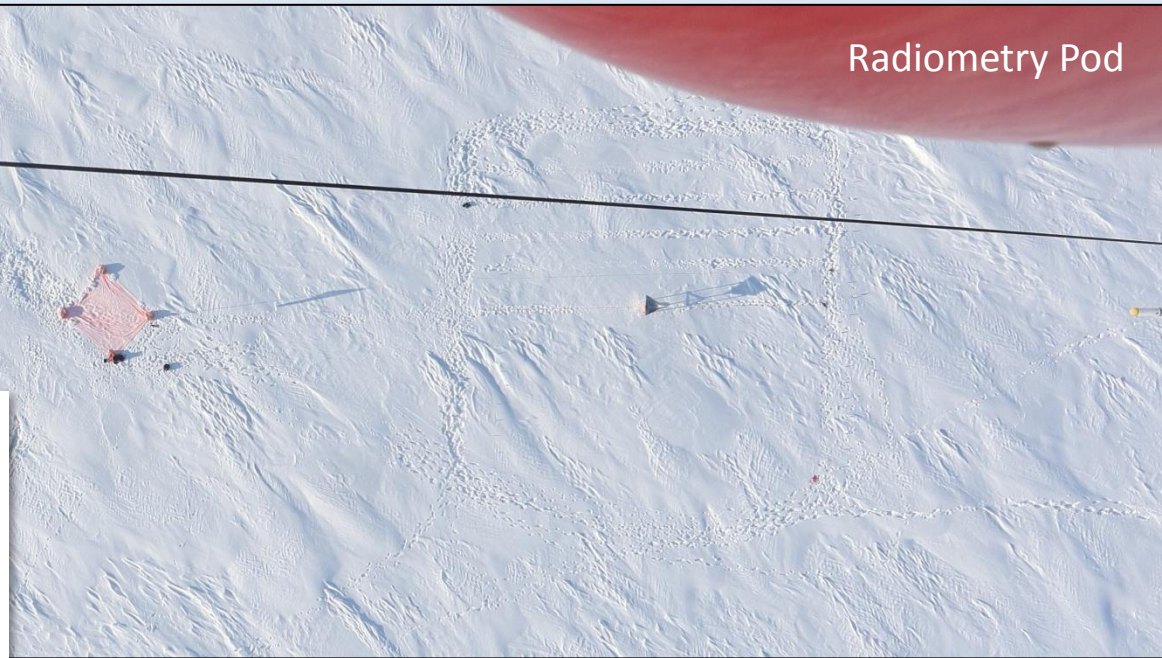
CryoVEx 2011 Airborne EM Survey
(Southern Validation Site)

2 Overpasses



GPS Altitude (m)

0 100 200 300 400 500 600 700 800 900 1000



Example of Polar-5 Nadir-Image

- **Two Polar-5 overpasses over southern validation line (April 16.)**
- **Available**
 - EM-Bird thickness
 - High-resolution Laser DEM
 - Aerial Photography

South Site

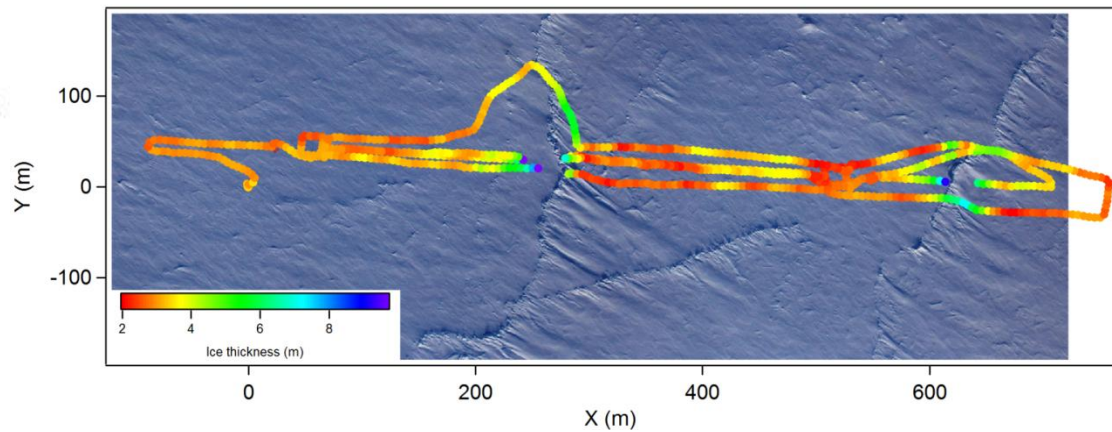
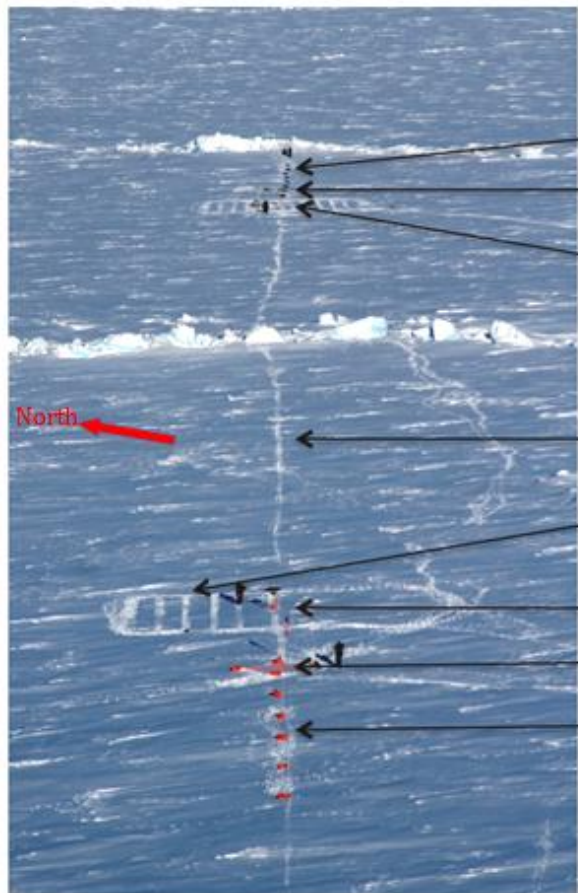
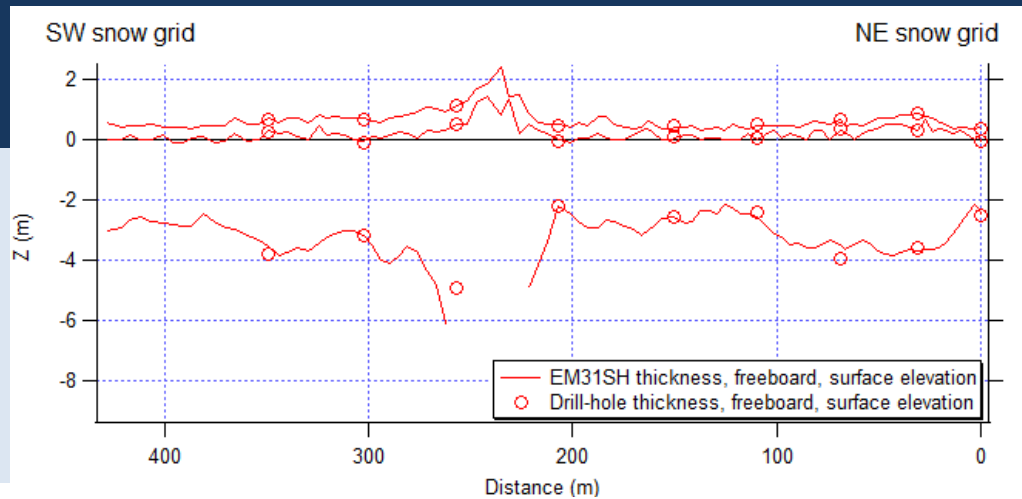
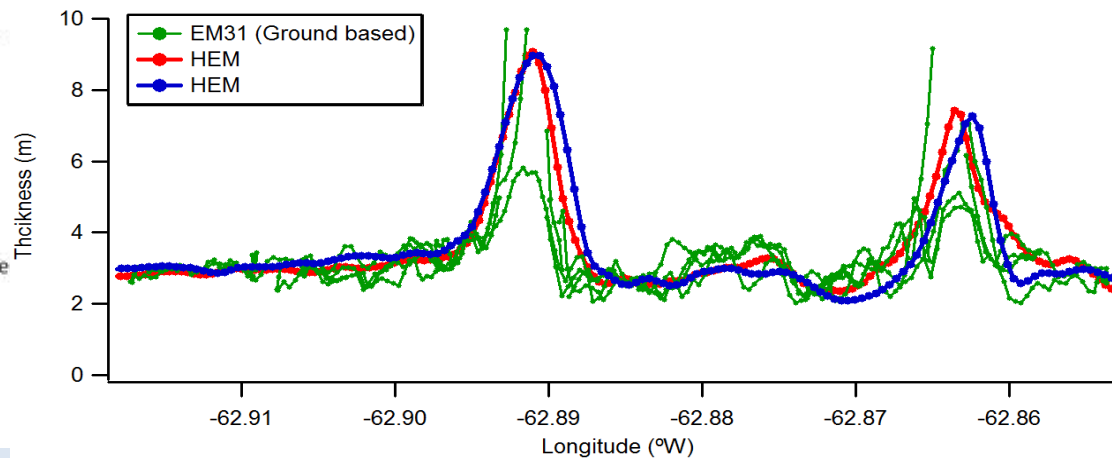
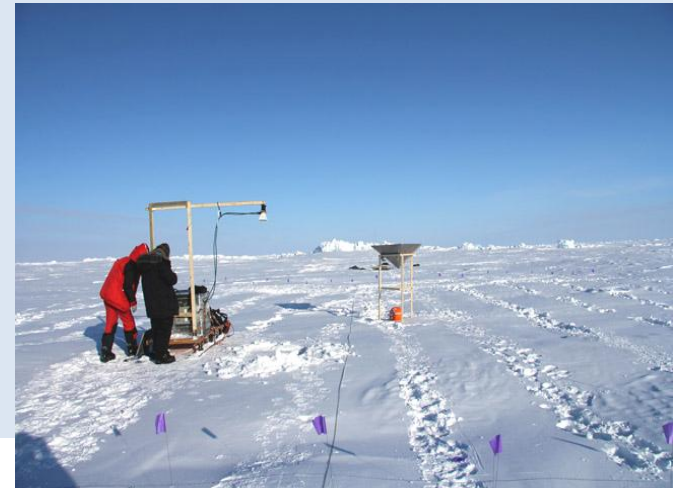


Photo © IceBridge

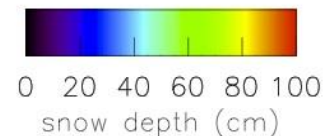
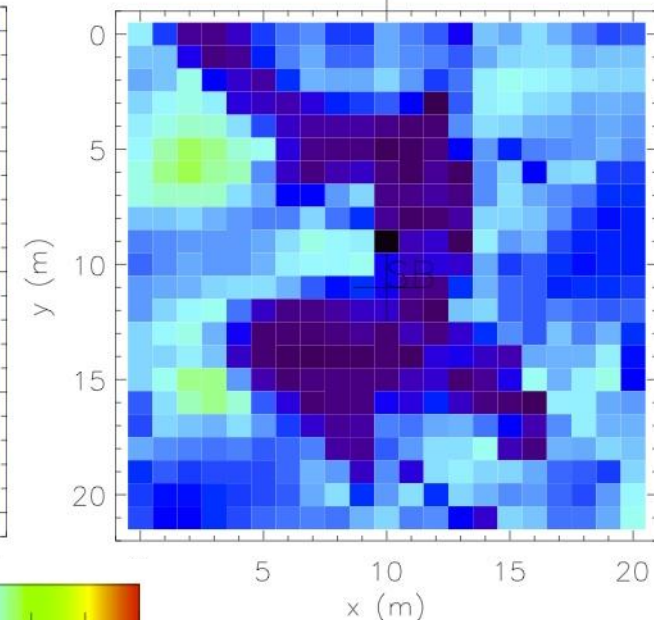
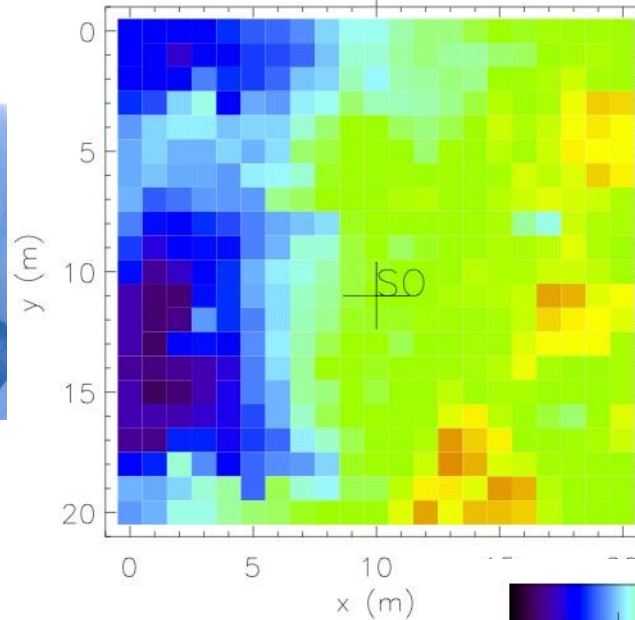
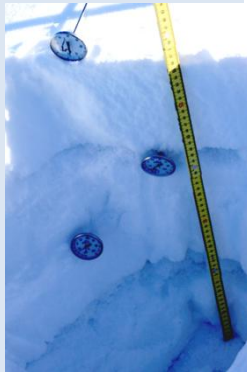


South Site Snow Grids & Pits

SO1 (site 4) #3: (Christian 16/4/2011)
 Depth Temperature



45	Soft new snow	-29.8
44	Hard wind blown slab grain size < 1 mm	-25.2
33	Medium hard wind blown slab grain size 1 mm	-22.2
20	Depth hoar grain size < 5 mm	-18.6
0		-14.5

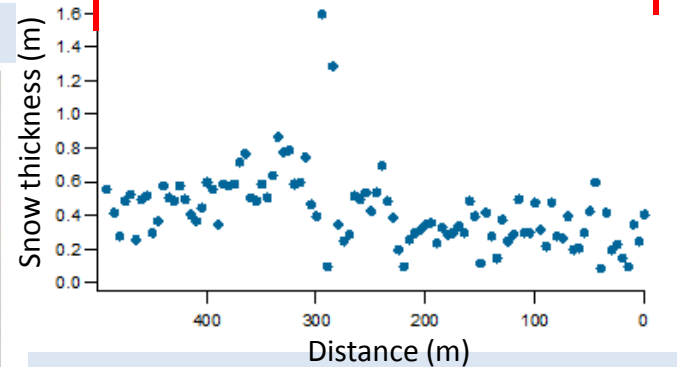
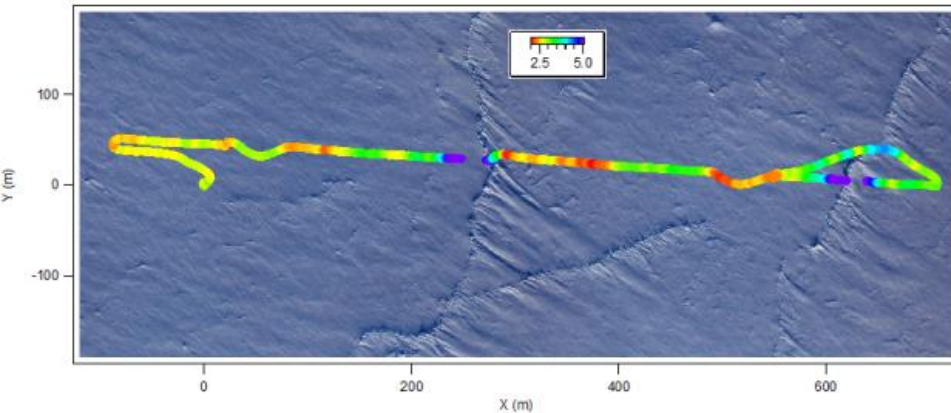
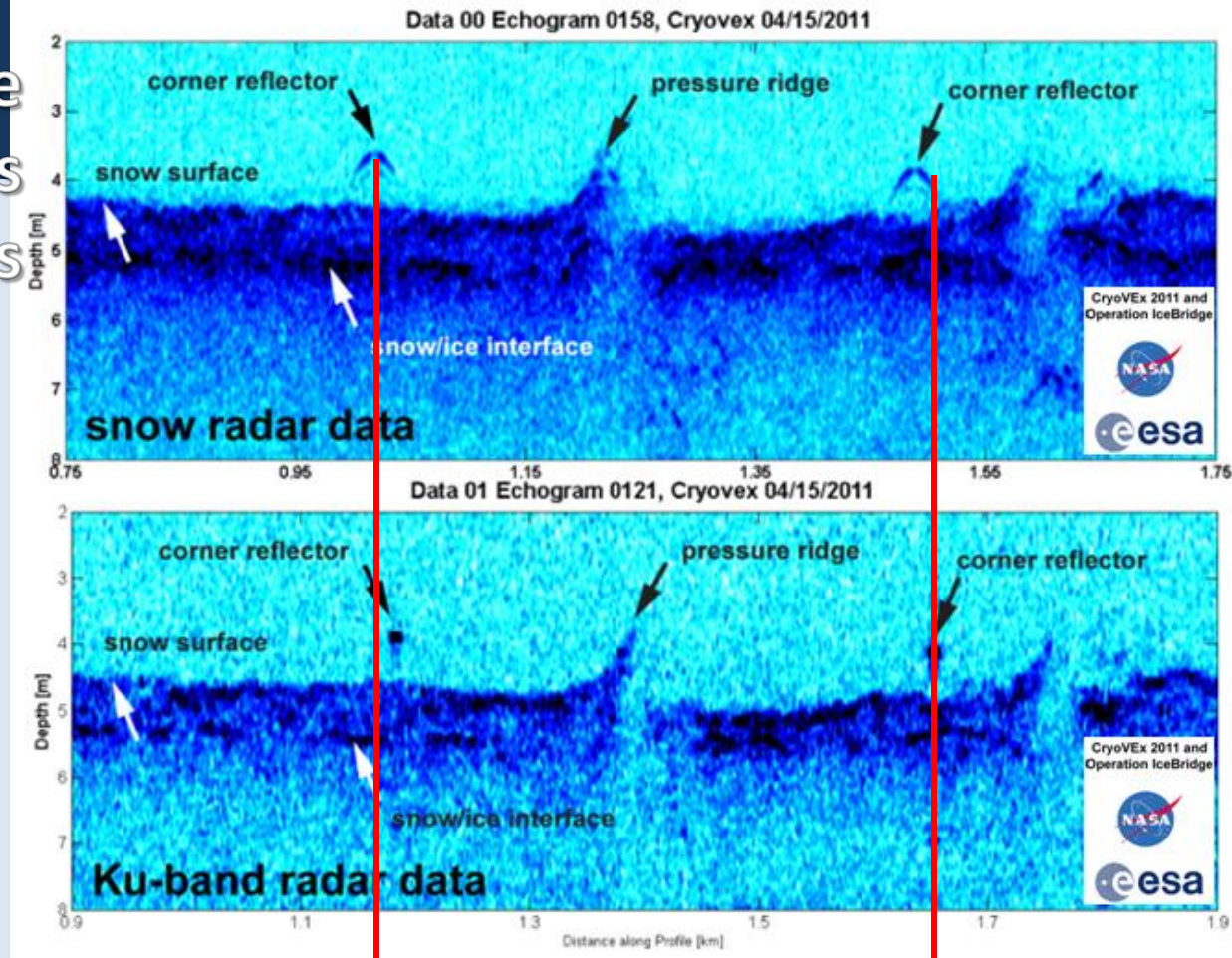


Summary of in-situ snow and ice measurements along transects

	North Site	South Site	Fast Ice
Mean EM thickness (snow plus ice; m)	2.37 ± 0.53 (N = 82)	3.18 ± 0.65 (N = 92)	4.25 ± 1.29 (N = 101)
Modal EM thickness (m; bin width 0.1 m)	2.1	3.4	3.6
Mean snow thickness (m)	0.41 ± 0.13 (N = 82)	0.43 ± 0.22 (N = 99)	0.29 ± 0.16 (N = 101)
Modal snow thickness (m; bin width 0.05 m)	0.30 & 0.40 (bimodal)	0.25 & 0.50 (bimodal)	0.35
Mean freeboard (m)	ND	0.20 ± 0.27 (N = 99)	0.58 ± 0.44 (N = 92)
Modal freeboard (m; bin width 0.05 m)	ND	0.00 & 0.25 (bimodal)	0.60

CryoVEx & IceBridge snow thickness measurements

- Comparison of in-situ and airborne measurements between corner reflectors
- Good qualitative agreement



Conclusions

- All goals achieved
- Great luck with weather
- Report soon available
- Need better methods for snow property measurements

CryoVEx 2011 Alert Sea Ice Campaign Ground Team Report



Ground Team Operating out of Alert base, April 11th-18th 2011:
Christian Haas (PI) & Justin Beckers, University of Alberta;
Seymour Laxon, Katharine Giles & Rosemary Willatt, UCL;
Malcolm Davidson, ESA

Report compiled by Rosemary Willatt: rcw@cpom.ucl.ac.uk



AWI Airborne Dataset

Sea ice thickness data available in first-year and multi-year sea ice regions

CryoVEx Lincoln Sea: 3 CryoSat-2 Underpasses, 2 Overflights Validation Line

High-resolution laser DEM due to low flight altitude (200 ft)

Aircraft Coordination

Polar-5 and **Twin-Otter:** > 400 km of coincident EM and ASIRAS data

Very short temporal offset between aircraft, exact match: TBD

Processing Status

- EM-Bird Sea Ice Thickness
- Laserscanner DEM
- Nadir Imagery