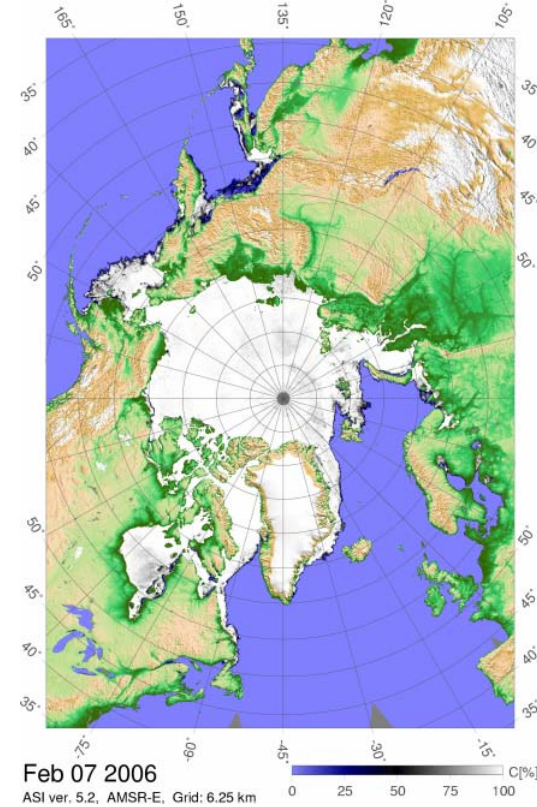
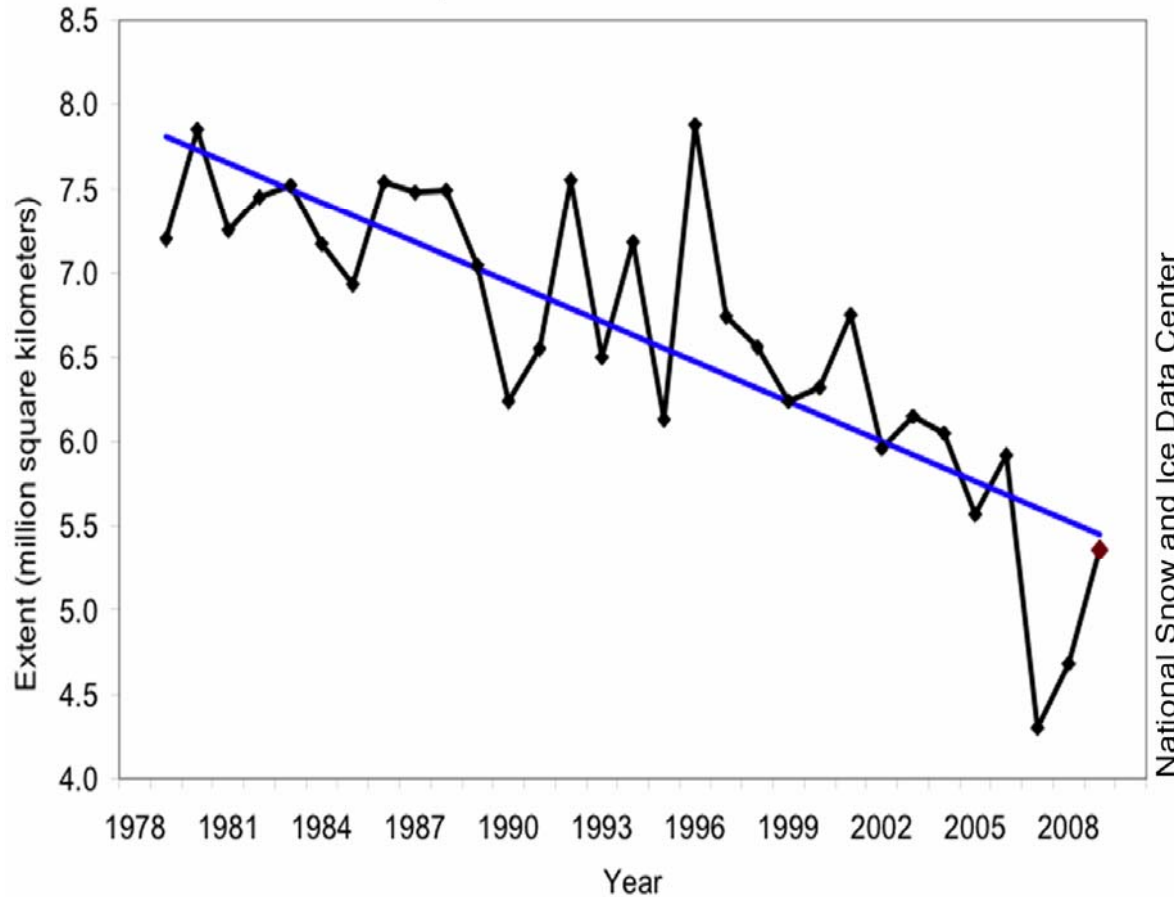


# Airborne measurements for the validation of satellite sea ice products



*Christian Haas et al., University of Alberta*

## Average Monthly Arctic Sea Ice Extent September 1979 to 2009



- Ice extent has declined at a rate of 11.2 percent per decade during September
- Thickness changes largely unknown

**Ice-albedo-feedback; Polar amplification;  
Ocean circulation; Ice as platform**

- Shipping and offshore operations in ice
- North-West Passage, Beaufort Sea



November 2007,  
Antarctic Peninsula

- Exploration activities rely on sea ice information, in particular ice thickness, to increase safety and reduce environmental impact





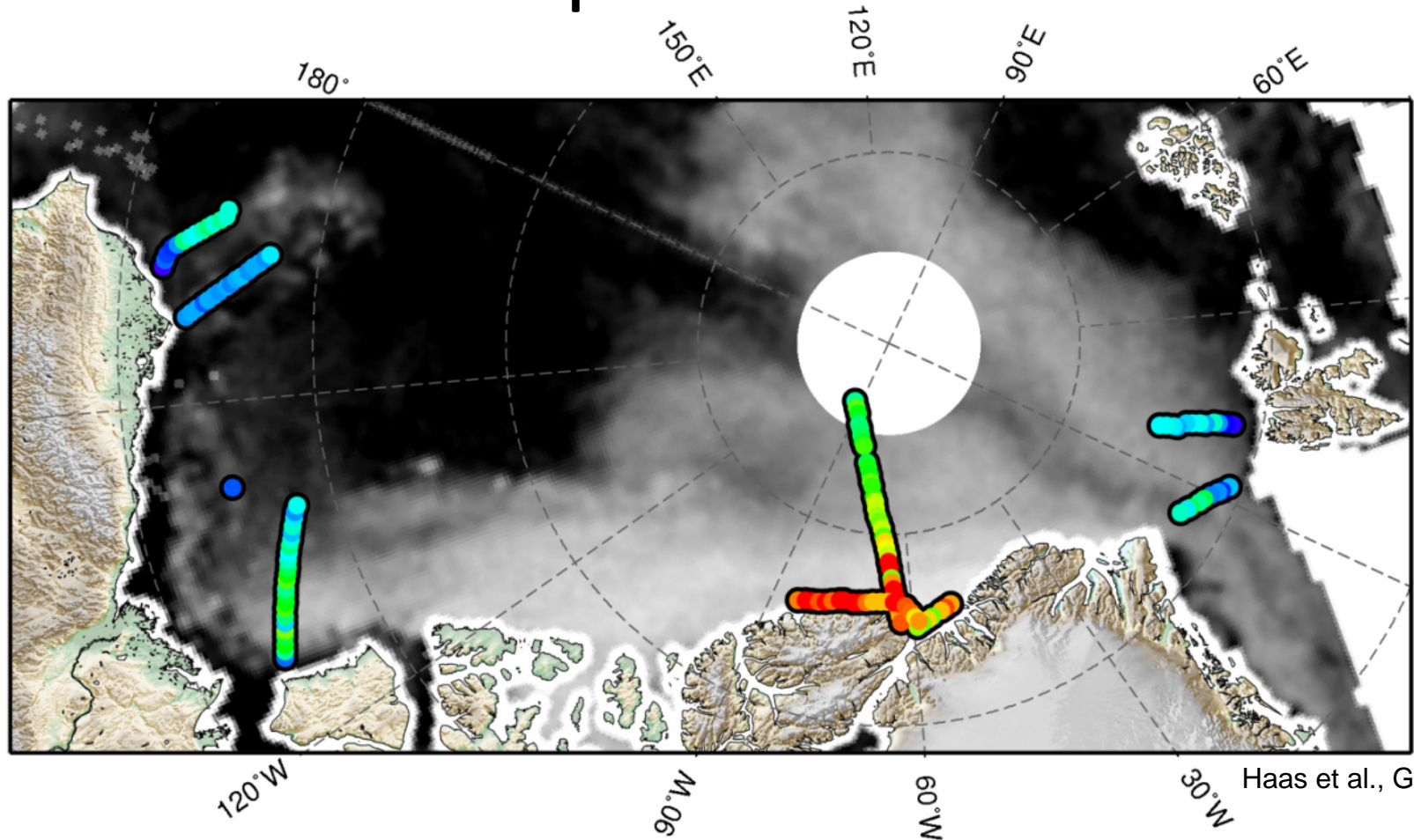
# Electromagnetic (EM) thickness sounding



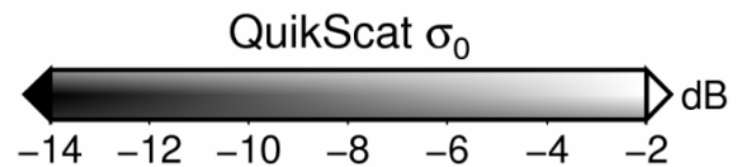
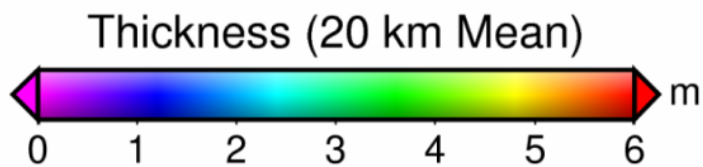




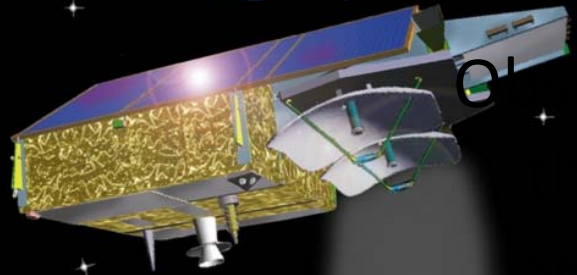
# Pan-Arctic ice thickness snapshot April 2009



Haas et al., GRL 2010



# CryoSat goals



Objective: Measure changes of the thickness of the Arctic ice cover and Antarctica's and Greenland's ice sheets



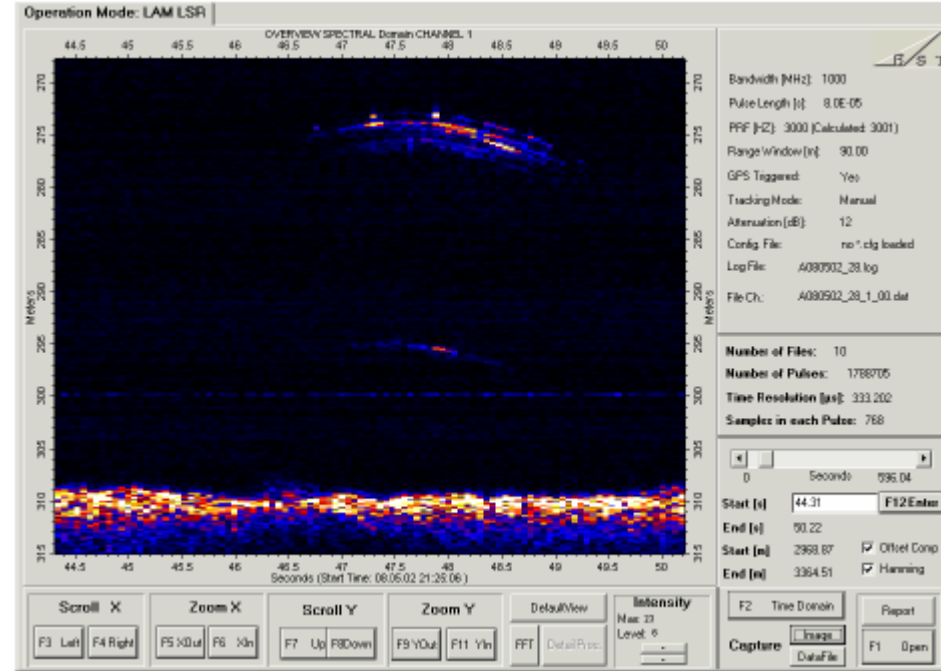
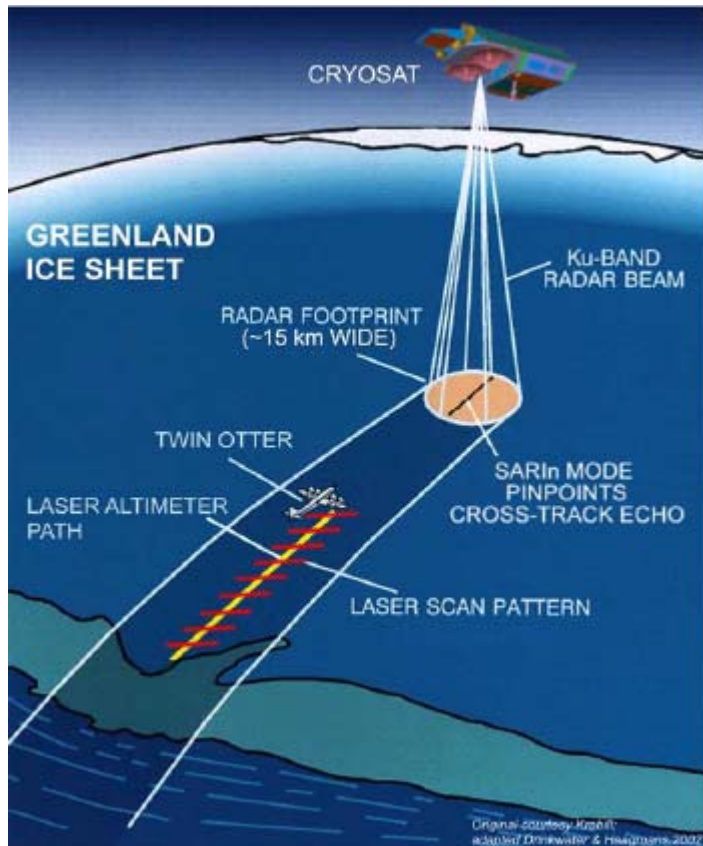
<http://news.bbc.co.uk/2/hi/science/natu>

Launch on April 8, 2010, 15:57 CEST

© 2009 by Airbus Space & Defense



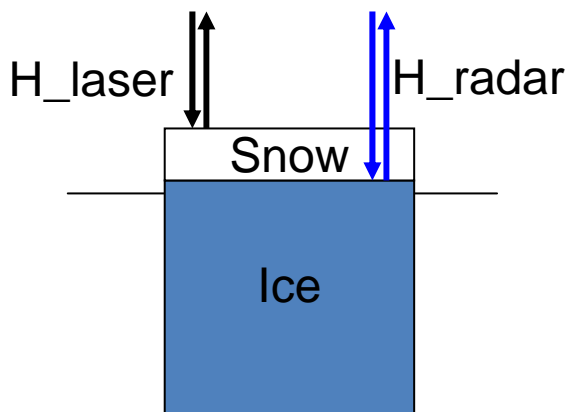
# CryoSat Cal/Val



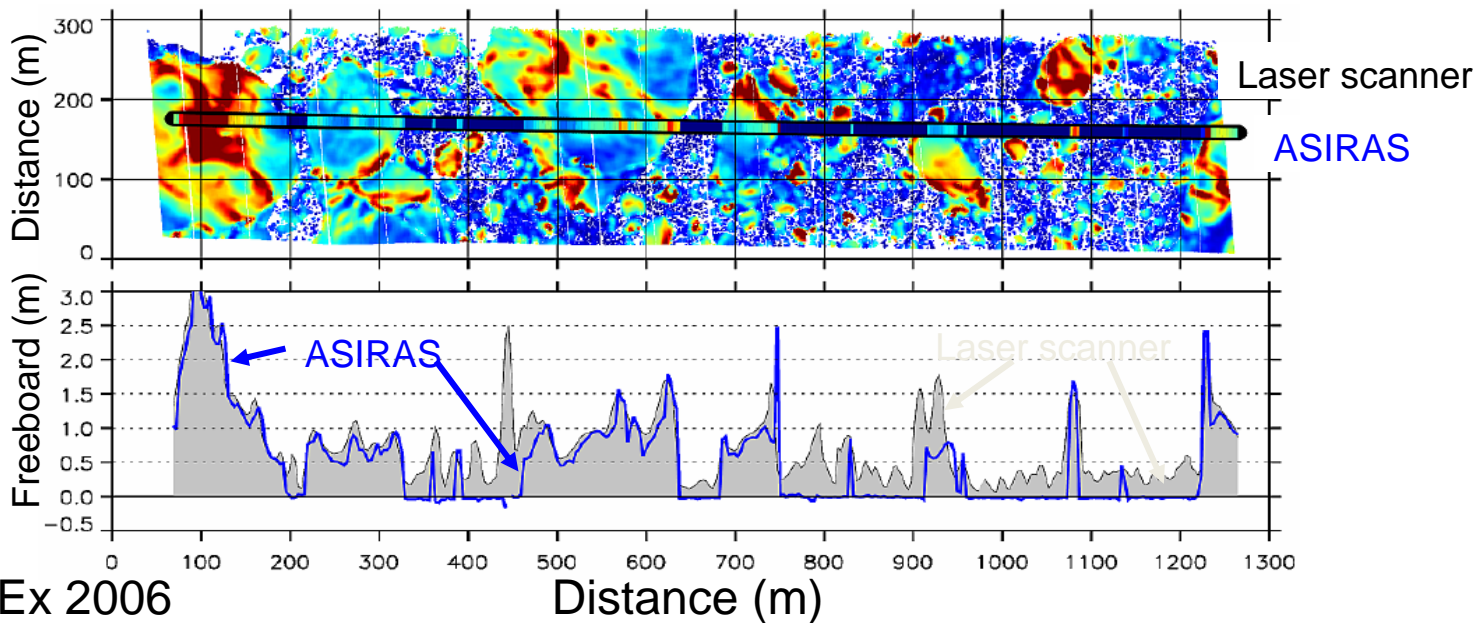
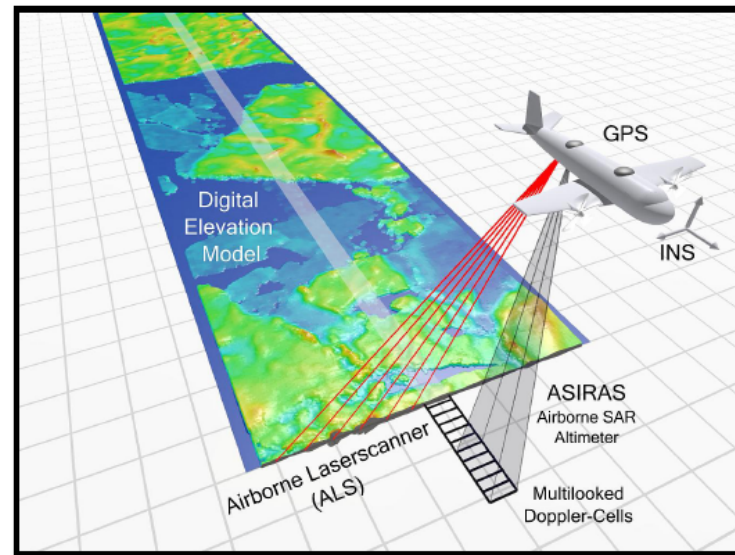
- Addressing major satellite retrieval uncertainties
- Coincident aircraft, helicopter and ground surveys
- Campaigns in 2003, 2004, 2006, 2008, planned 2011, 2012

# Airborne Synthetic–Aperture Interferometric Radar System (ASIRAS)

- snow penetration uncertainty

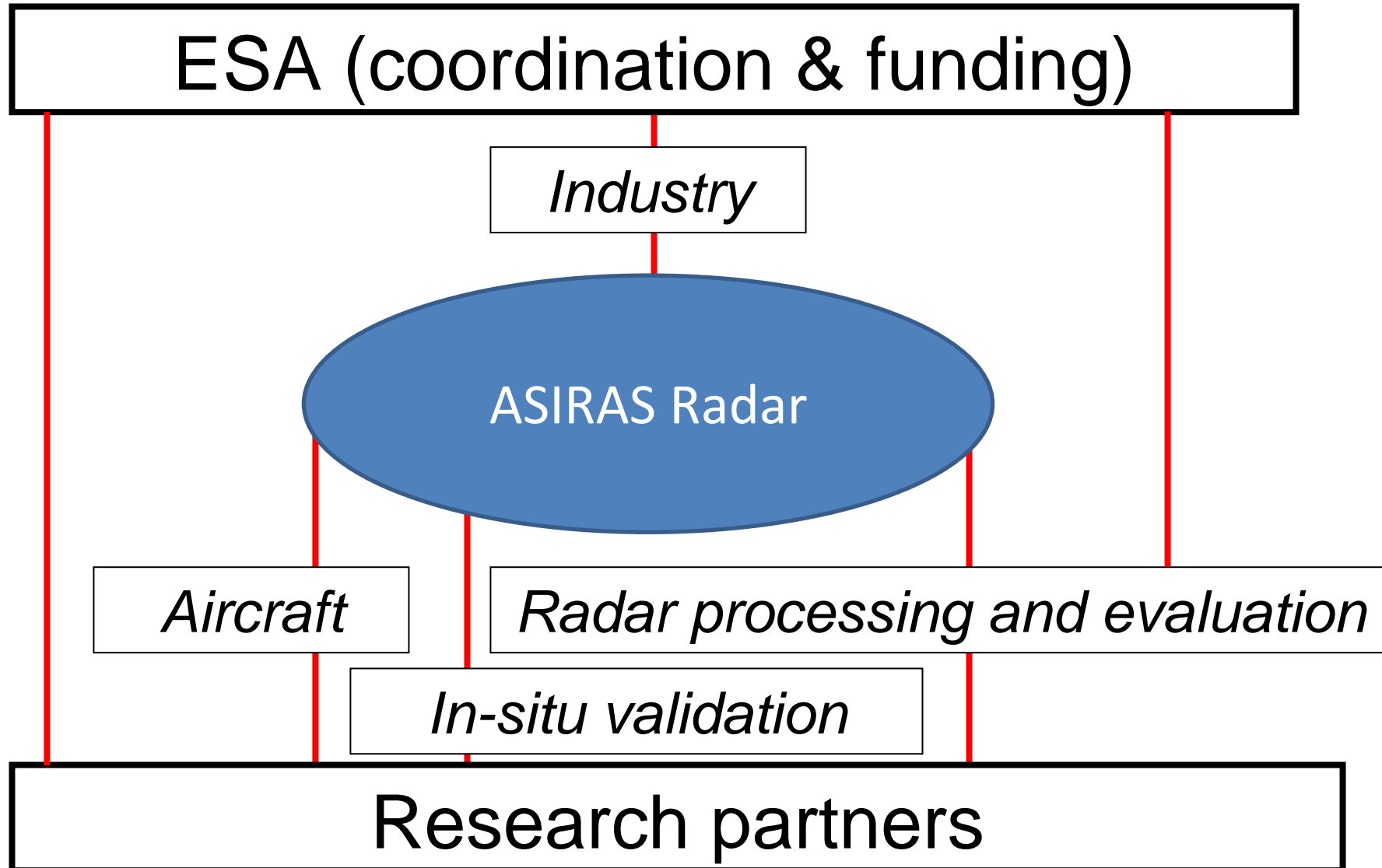


Snow thickness =  $H_{\text{radar}} - H_{\text{laser}}$



CryoVEx 2006

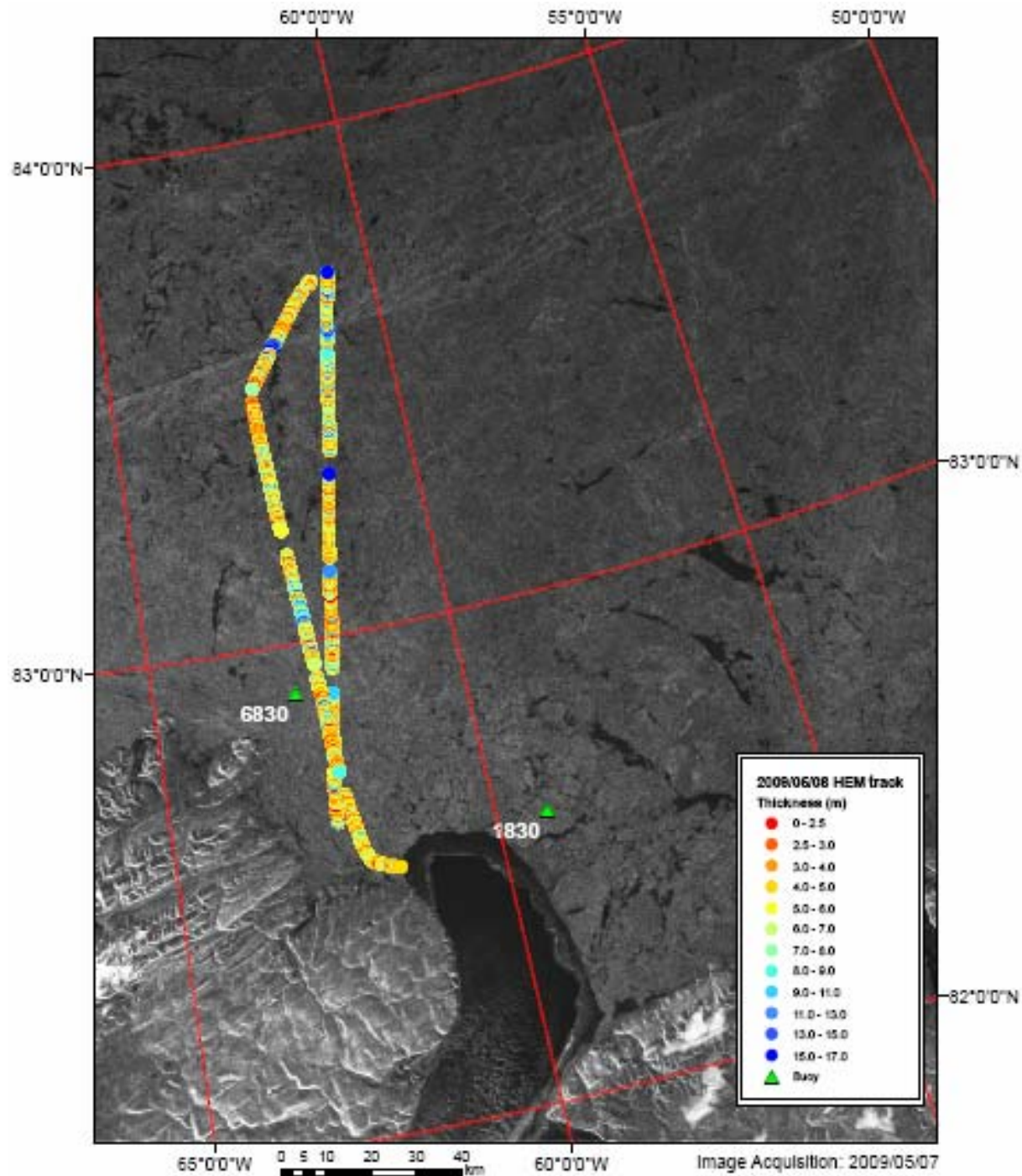
# CryoSat Cal/Val organizational structure





# SAR

- Envisat, TerraSAR-X, ALOS
- Validation of SAR signatures by means of EM and laser profiling

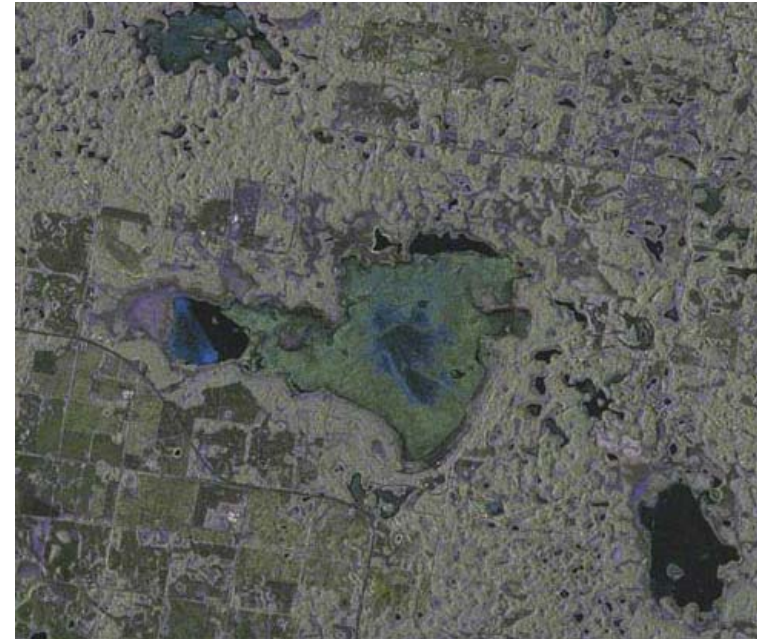
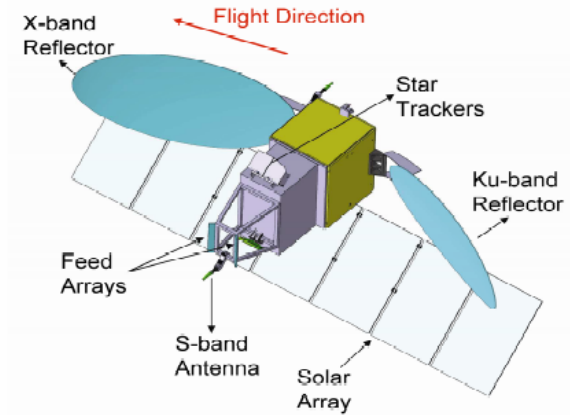


# CoReH2O

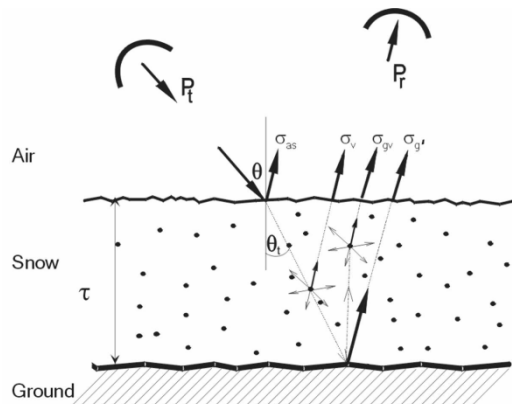


## Cold Regions High-Resolution Hydrology Observatory

- Snow as an essential part of the sea ice mass balance
- Snow as important water resource in western Canada
- Collaboration with Env. Canada microwave radiometers & U. Waterloo Scat.



Validation with TerraSAR-X & in-situ on Miquelon Lake, Alberta



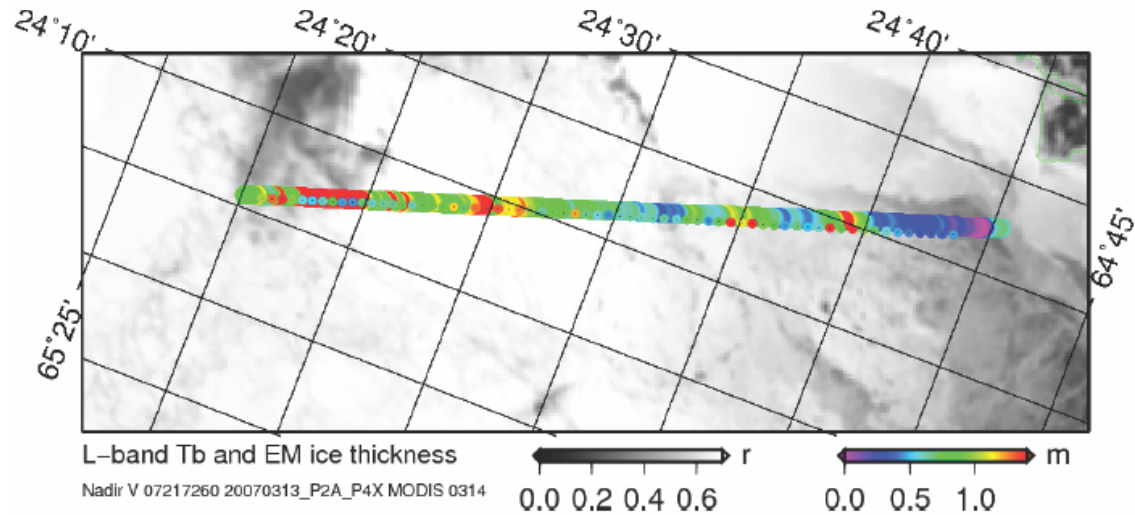
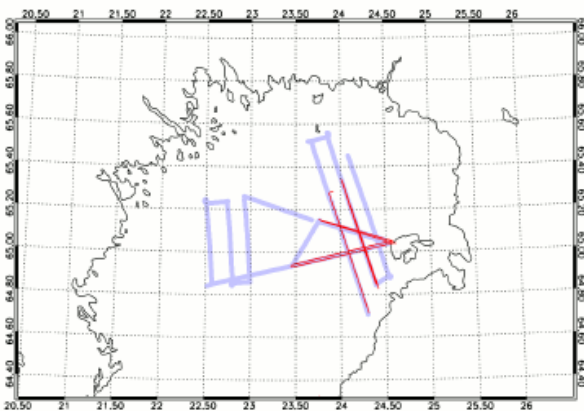
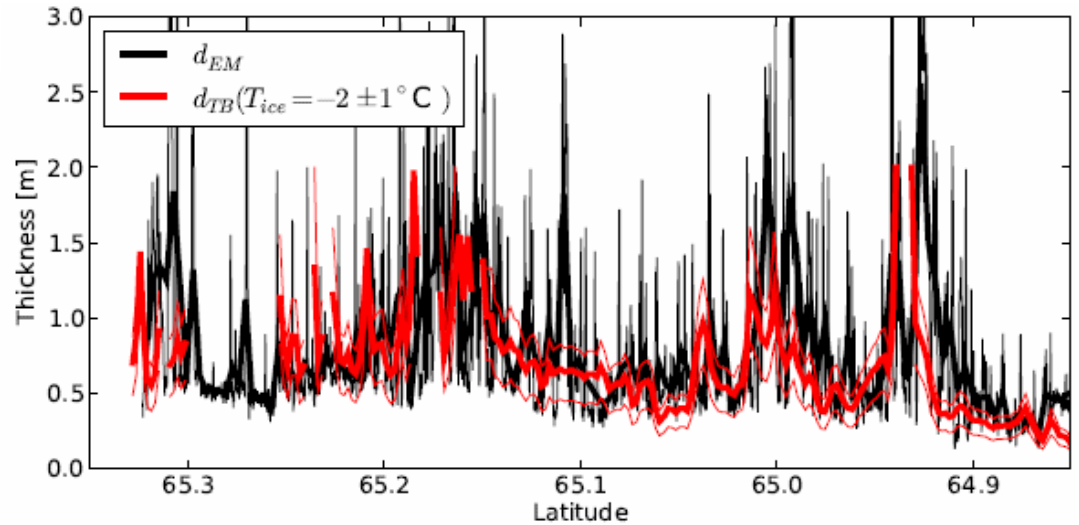
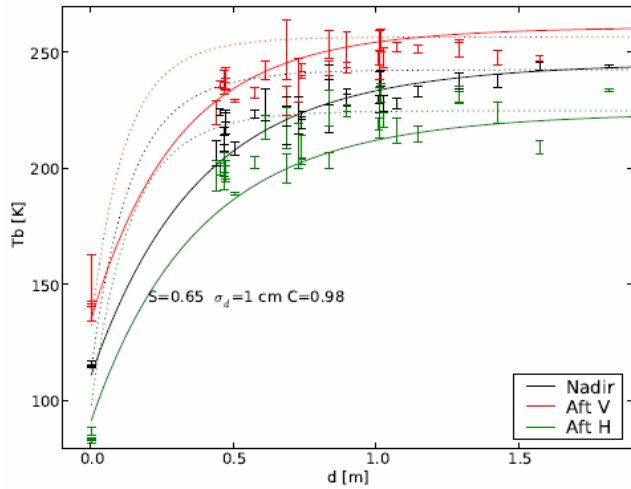
X- and Ku-band SAR

# SMOS



Soil Moisture and Ocean Salinity Mission

- Coincident airborne L-band radiometer & EM thickness





# Basler BT67 (DC-3): the optimum research platform

- Large payload
- Long endurance; Safe operations
- Many aircraft modifications for science instruments
- Canadian aircraft; already routinely used by NSF in the Arctic and Antarctic
- Most experienced aircraft operator; ready to fly for Canada! 🇨🇦

McMurdo Ice Shelf, Antarctica, Nov. 2009



# DC3-Basler can land on unprepared sea ice to support in-situ ice & ocean measurements



March 26, 2010, 89°23'N, 76°08'W

Courtesy [underthepole.com](http://underthepole.com) / Kenn Borek

# Future scenario in Canada

CSA (Earth Observation)

*Provision of air time*

Basler BT67 (DC-3)

*Instrumentation*

*Satellite missions*

*Validation*

Research partners







UNIVERSITY OF  
**ALBERTA**  
EDMONTON, ALBERTA, CANADA