Overview of CryoSat Validation Activities: 2003 - 2006

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Validation Context

he CryoSat system was designed by requiring that the measurement uncertainty at en
f mission adds no more than 10% to the limit of total uncertainty imposed by natural
ariability:

$$\bar{\sigma}_r^2 = \bar{\sigma}_n^2 + \bar{\sigma}_m^2$$

The CryoSat Science and Measurement Requirements.

Requirement	Arctic Sea Ice 10^5 km^2	Ice Sheets 10^4 km^2	Ice Sheets 13.8 x 10^6 km^2
$\bar{\sigma}_r(\eta_r)$	3.5 cm yr^{-1} i.e.	8.3 cm yr^{-1} i.e.	0.76 cm yr^{-1} i.e. (92 Gt yr^{-1})
$\bar{\sigma}_m$	1.6 cm yr^{-1}	3.3 cm yr^{-1}	0.17 cm^{-1}

he purpose of validation is to quantify and verify the uncertainties in CryoSat product
sing independent measurements.

he mission requirements of CryoSat place considerable demands on the nature and
uantity of the independent measurements

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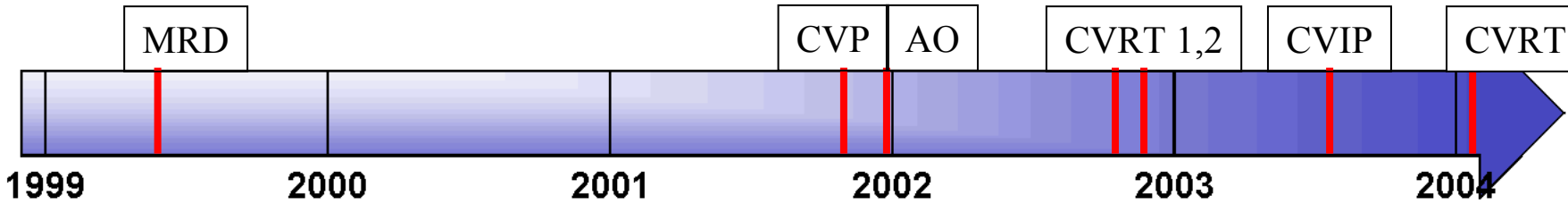
Validation – Programmatic Context



Mission Requirements Document (MRD): Scientific Objectives and Context of Miss

CryoSat Calibration and Validation Concept (CVP): Provides evaluation of sources uncertainties and potential methods available to estimate them

Announcement of Opportunity (AO): Announcement of Opportunity in calibration, validation and retrieval for the CryoSat mission

Cryosat Validation and Retrieval Team (CVRT) Meetings: working meetings to plan calibration and validation experimental activities. Third meeting (*CVRT3*) planned in January 2004 to finalise planning

Cryosat Validation Implementation Plan (CVIP): draft plan of experimental activitie for the validation of CryoSat Products

Key Elements for CryoSat Validation Planning

Various sources of error requiring validation experiments identified in the *CryoSat Calibration and Validation Concept (CVP)*

- Time-varying penetration of electromagnetic wave (sea, land)
- Preferential sampling of large ice floes (sea)
- Snow loading and ice density (sea)
- Fluctuations in snowfall and near surface density (land)
- etc…

Main guidelines from initial CVRT meetings

- Coordinated ground and aircraft experiments
  - ➢ bridge spatial scales from local in-situ measurements to satellite base products
- Repeated Experiments
  - ➢ time-variant errors in retrieved heights due to variations in snow cover over annual cycle
- Prelaunch Validation activities
  - ➢ Several coordinated ground and aircraft experiments have not previously been performed, ne for prelaunch trials to validate experimental concept

Main tools for field experiments

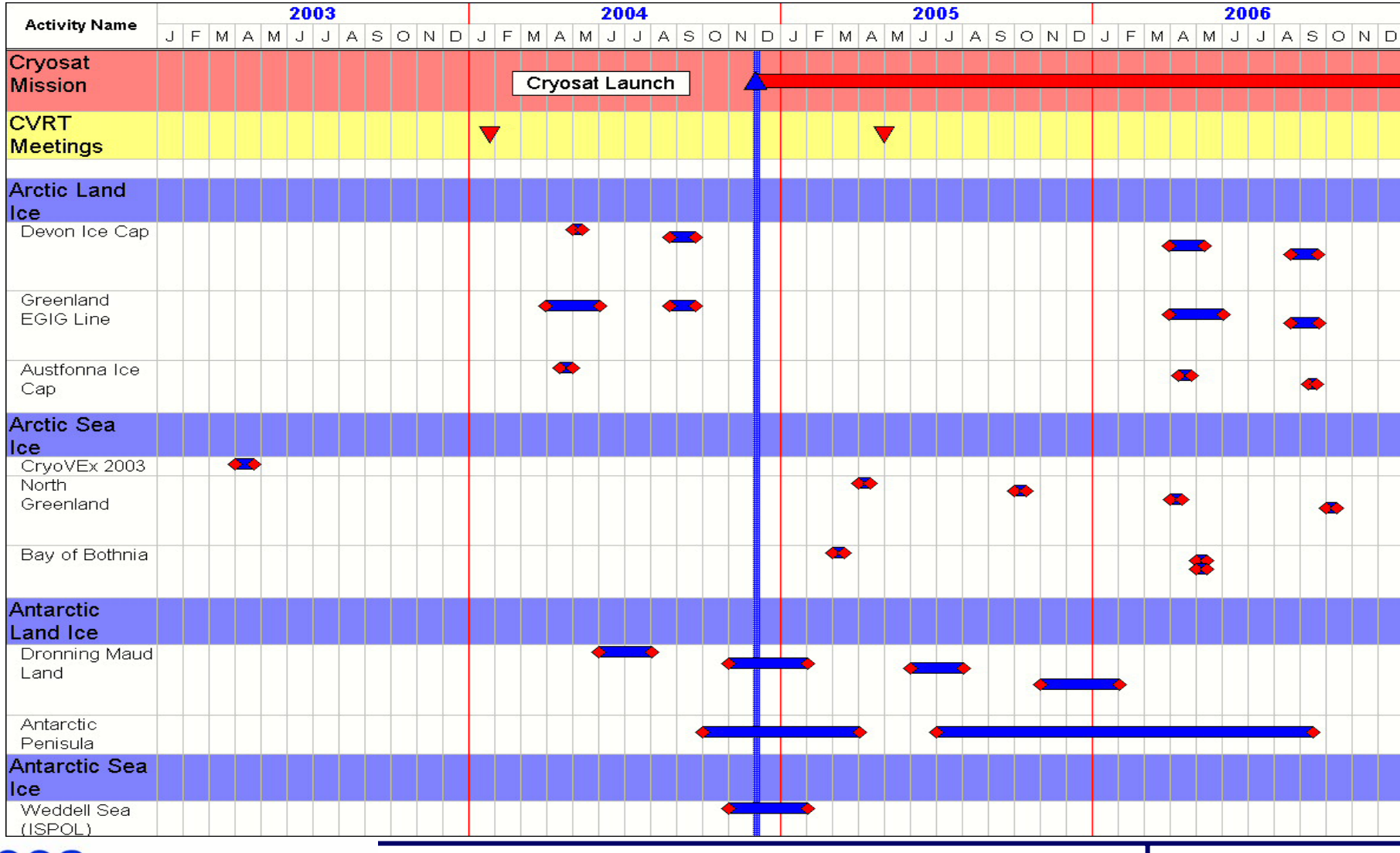
rborne

228	AWI	Laser Scanner ASIRAS	H. Miller U. Nixdorf	
eenair Twin ter	KMS	Laser Scanner D2P Radar altimeter ASIRAS	R. Forsberg	
3B	NASA	ATM Laser Scanner D2P Radar Altimeter	W. Krabill K. Raney	
per Navaho	GSC	ALTM Laser Altimeter	M. Demuth	
WI Helicopter	AWI	EM Boom	C. Haas	

-Situ

GPS, Neutron Probe, Coring, Coffee Can, gamma profiling, roughness profiling (Land)
re holes, ice/snow density, wetness, grain size, salinity, upward looking sonar (Sea)

Validation Activities Schedule



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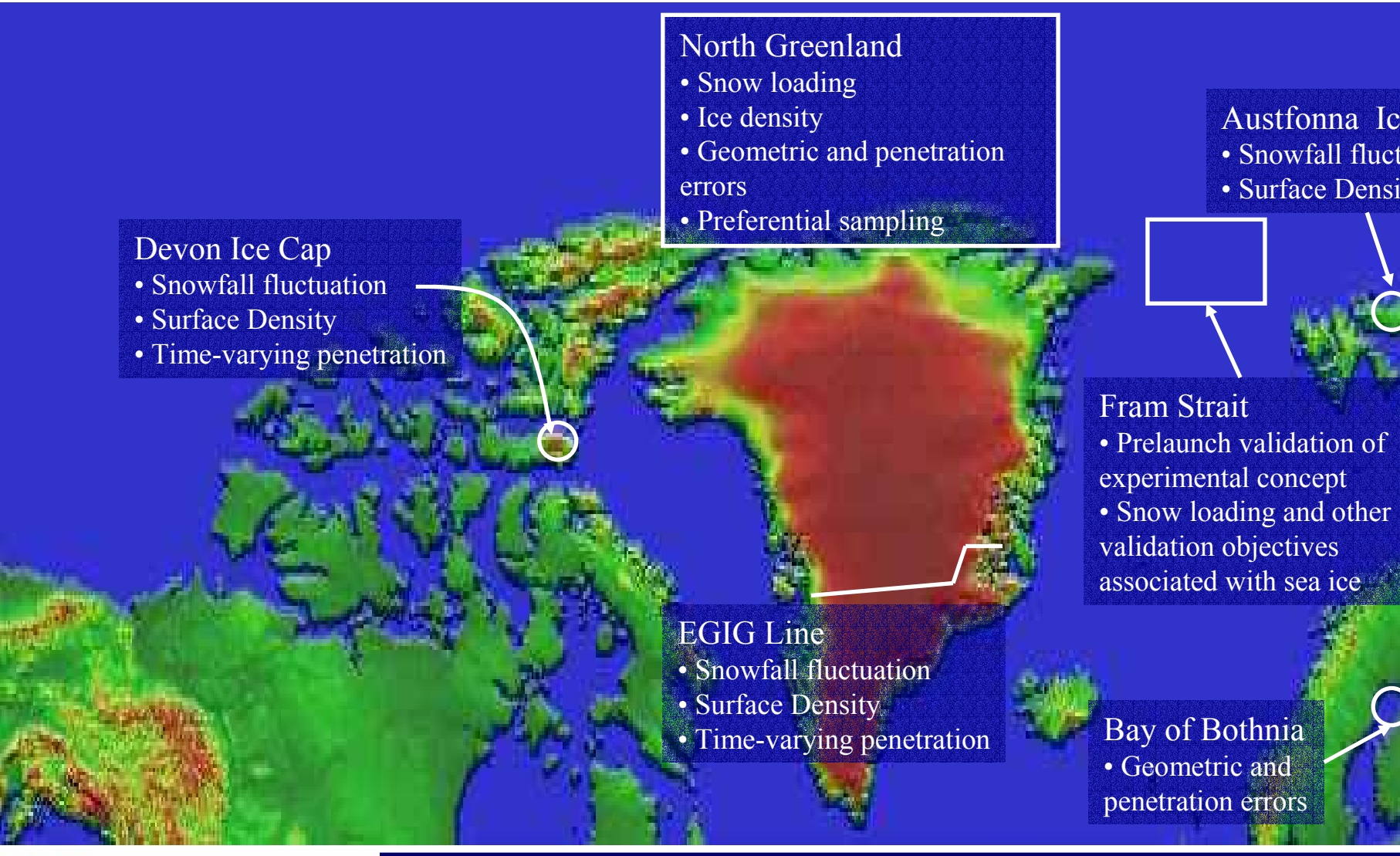
Principal Arctic Validation Sites



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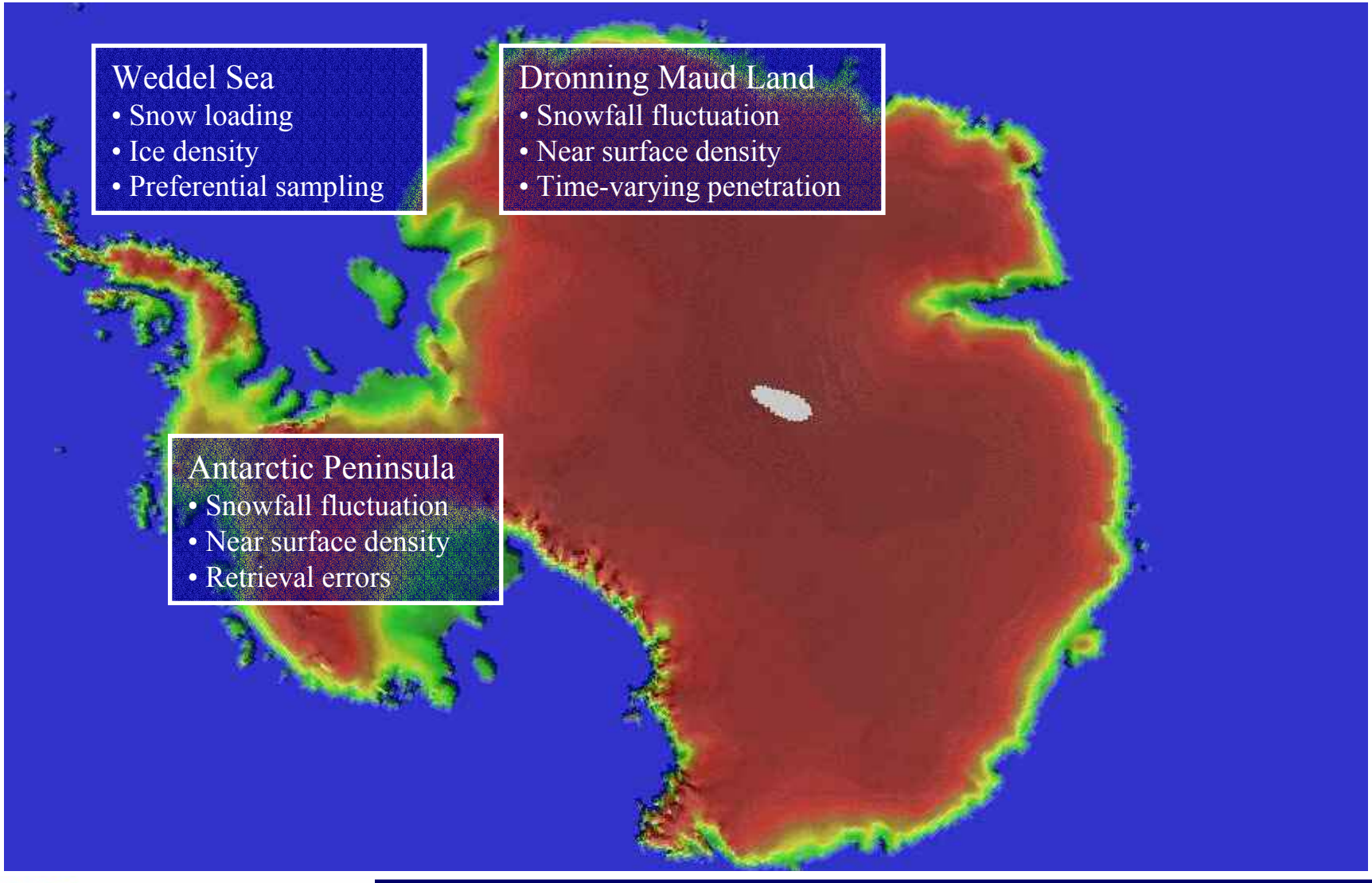
Principal Antarctic Validation Sites



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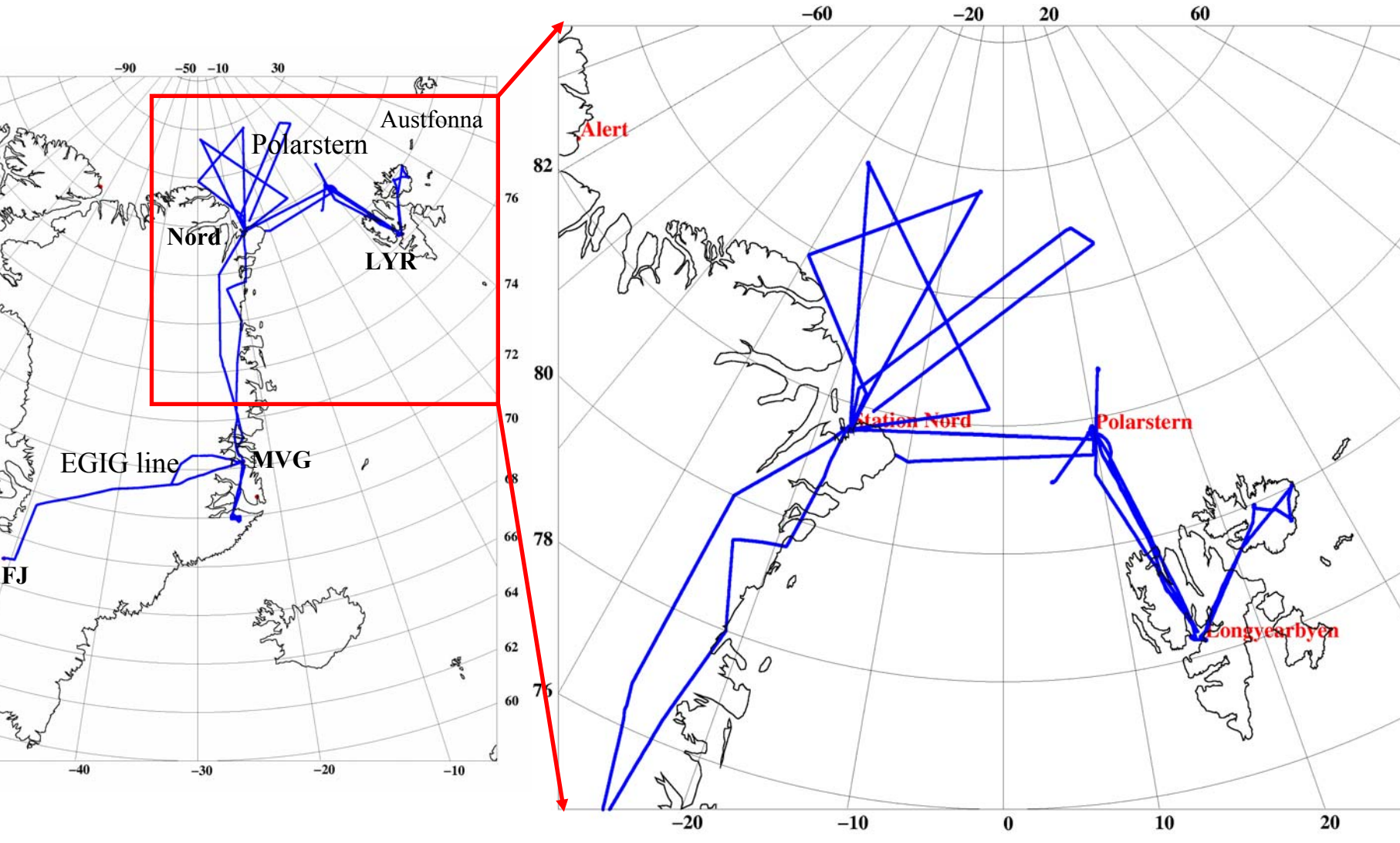
Cryovex 2003 Pre-launch Campaign

- **Experiment dates: April 03 – 19, 2003**
- **Aims:**
  - Collection of simultaneous, colocated airborne laser and radar altimeter data, helicopter borne ice thickness measured using electromagnetic probe and borehole data
  - Prelaunch validation of campaign concept to address Cryosat sea ice retrieval errors
- **Instrumentation**
  - AWI Polarstern icebreaker
  - KMS Twin Otter aircraft
    - D2P radar altimeter
    - Scanning laser altimeter
  - AWI Helicopter housed on Polarstern
    - Electromagnetic (EM) boom

Cryovex 2003: Flight Tracks



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Cryovex 2003:Instrument Installation

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Cryovex 2003:Ice Examples

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nd Ice

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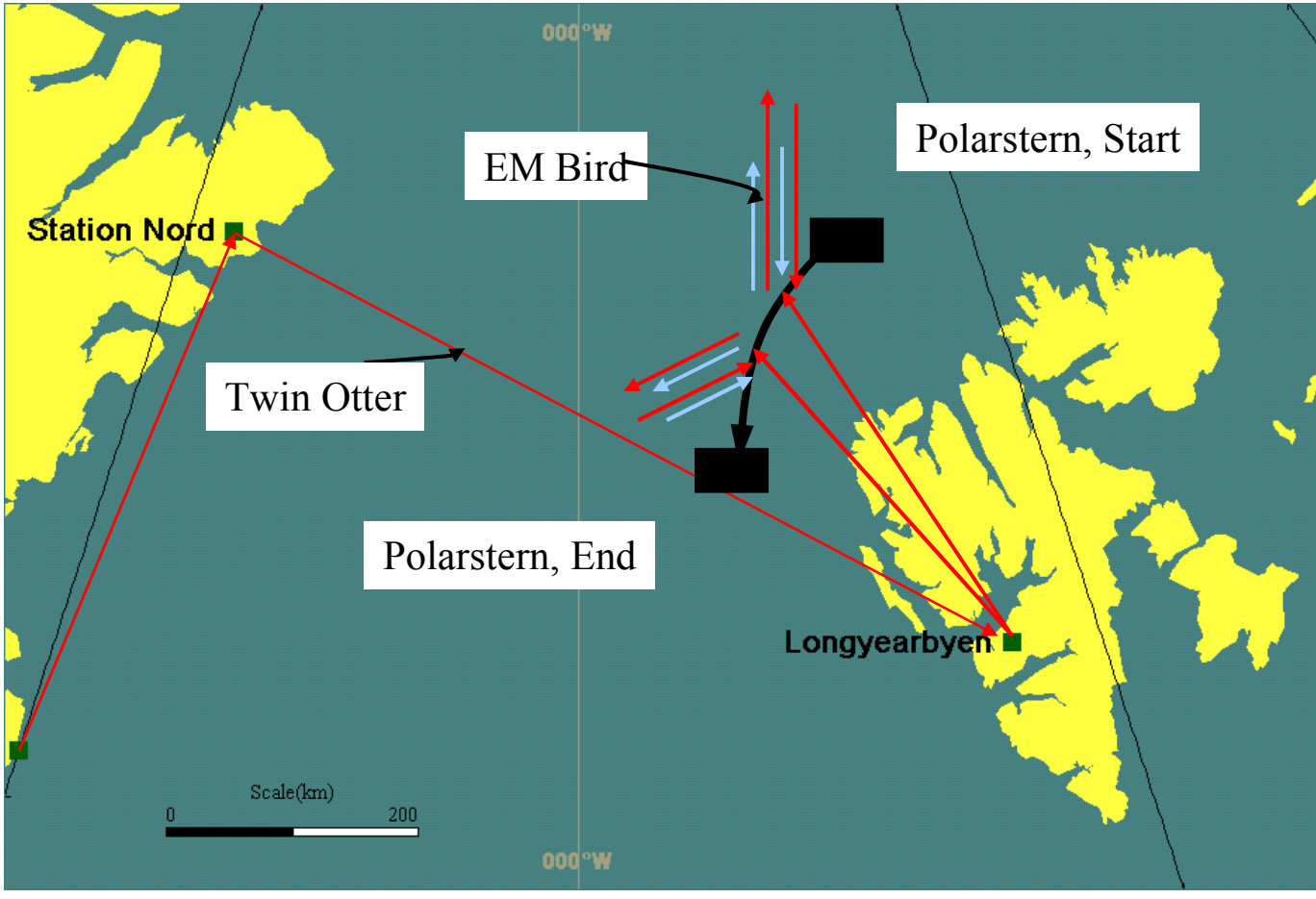
Cryovex 2003: Coordinated EM Bird – Twin Otter flights



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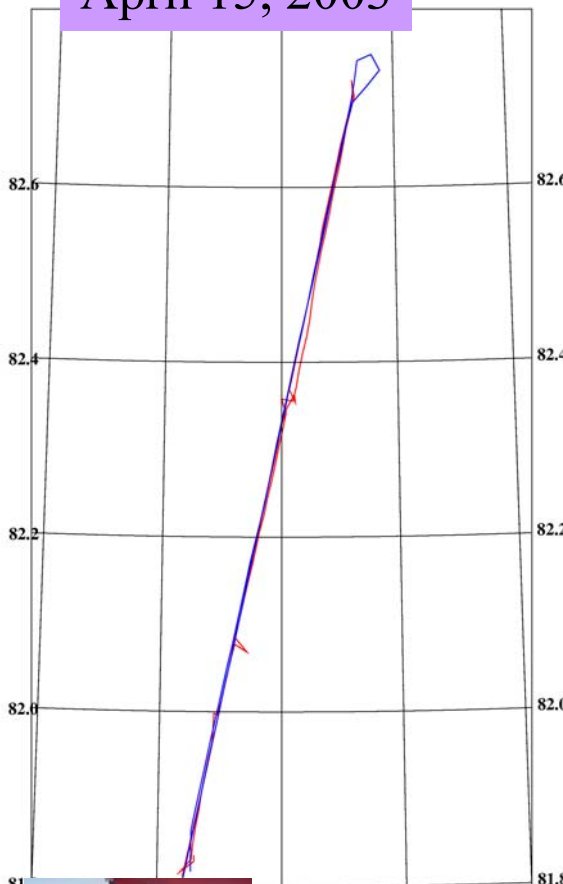
Cryovex 2003: Coordinated Airplane – Helicopter acquisition

EM Bird

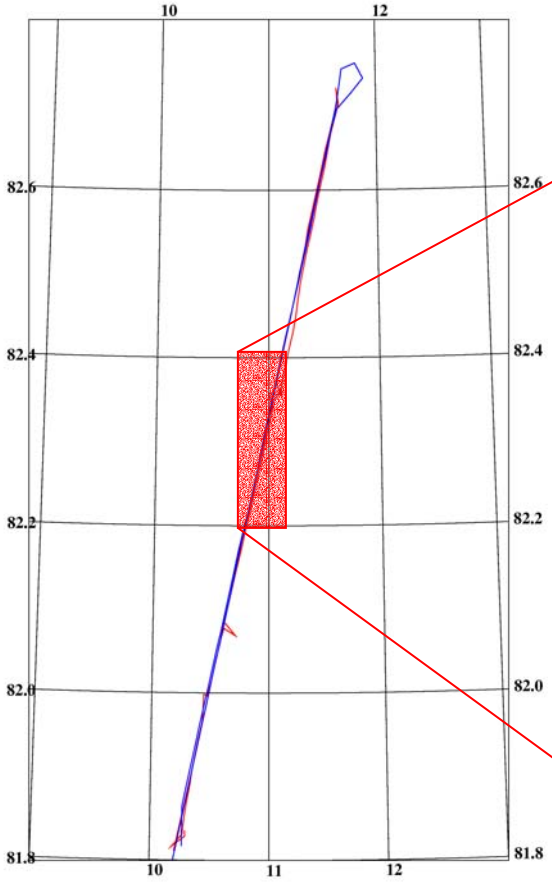
Twin Otter

April 11, 2003

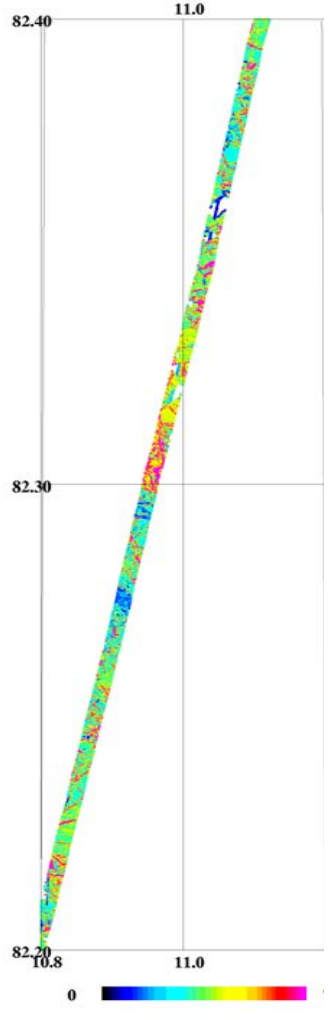
April 15, 2003

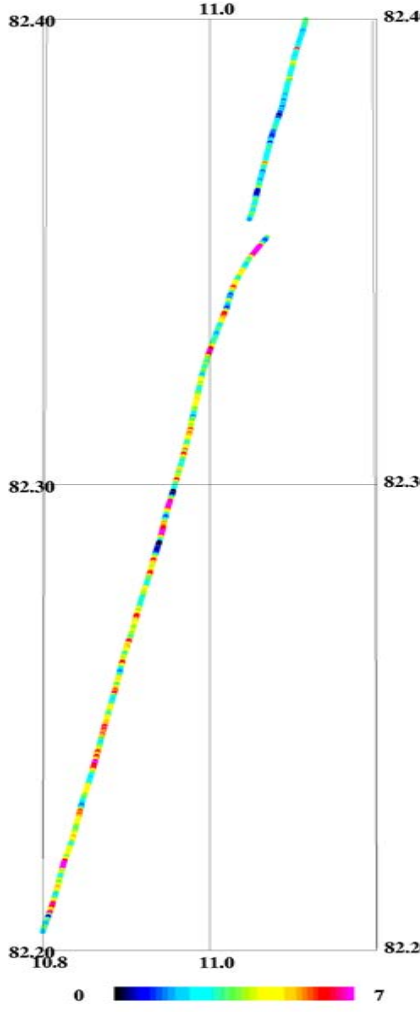


Cryovex 2003: Initial Results for Colocation



April 15, 2003





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Conclusions on Validation Activities

Draft *Cryosat Validation Implementation Plan* (CVIP) issued

- inputs provided by the AO Responses/CVRT meetings
- outlines coordinated validation strategy
- identifies common set of validation experiments agreed to by ESA and CVRT members
- plan to be finalised early 2004 at 3rd CVRT meeting
- confirmation of national funding sought by end of 2003

Pre-launch validation activities initiated

- feedback provided on feasibility of key elements of validation strategy (e.g. coordination of in-situ, helicopter, airborne and satellite acquisitions)
- initial feedback on error estimation

Validation experiments represent collaboration between ESA and cryosphere scientific community