



# Report on CEOS WGCV SAR Subgroup Activities

Presented at

**CEOS WGCV 29<sup>th</sup> Plenary**  
**Avignon, France**  
**September 30 – October 03, 2008**

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**Canadian Space Agency**



## CEOS WGCV SAR Subgroup (1)

- Mission: to foster high-quality synthetic aperture radar imagery from airborne and space borne SAR systems through precision calibration in radiometry, phase, and geometry, and validation of high level products.
- Objectives:
  - Act as a forum for international technical interchange on the evolving methodologies, techniques, and equipment of SAR data processing, calibration and validation,
  - To determine standard definitions and calibration-validation requirements for SAR systems.
  - To support changes in CEOS formats and user products as appropriate,
  - To facilitate international cooperative programs in the calibration and validation of SAR systems,
  - To educate the SAR community.

## CEOS WGCV SAR Subgroup (2)

- Action Plan:
  - Annual Workshop/Meeting
  - Set up, characterize standard CAL/VAL sites – inter-sensor comparison
  - Calibration specification, requirements and techniques for Polarimetry, Interferrometry, POLInSAR
  - Support **GEO Task: DA-06-02**
- Recent Annual Workshop/Meeting
  - 2007 – 7<sup>th</sup> Advanced SAR Workshop, hosted jointly by CSA and CEOS WGCV SAR Subgroup in Vancouver, Canada
  - 2006 – Hosted by University of Edinburgh in Edinburgh, UK
  - 2005 – Hosted jointly by DSTO and University of Adelaide in Adelaide, Australia
  - 2004 - Hosted by ESA in Ulm, Germany
  - 2003 – 5<sup>th</sup> Advanced SAR Workshop, hosted jointly by CSA and CEOS WGCV SAR Subgroup in Saint-Hubert, Canada

# Next CEOS SAR CAL/VAL Workshop/Meeting (1)

- Will be hosted by DLR
- A 2-day Workshop to be held at DLR facilities in Oberpfaffenhofen, Germany on November 27-28, 2008
- Back to back with TerraSAR-X/TanDEM-X Science Meeting on November 24-26, 2008
- Important Dates:
  - Deadline for abstract submissions (**Extended!**): **September 30, 2008**
  - Notification of paper acceptance: October 20, 2008
  - Deadline for workshop registration: October 31, 2008
  - Deadline for final paper or pdf presentation submission: November 28, 2008
  - Delivery of Workshop Proceedings: February, 2009

## Next CEOS SAR CAL/VAL Workshop/Meeting (2)

### ➤ Suggested Topics:

- Performance and calibration of new SAR missions
- Performance and calibration of running missions
- Calibration methodology
- Calibration targets and sites
- Calibration requirements (polarimetric calibration)
- Innovative SAR concepts
- Emerging SAR applications
- Processing algorithms

### ➤ Visit:

[http://www.dlr.de/hr/desktopdefault.aspx/tabid-4729/7824\\_read-12203/](http://www.dlr.de/hr/desktopdefault.aspx/tabid-4729/7824_read-12203/)

## ➤ International Amazon Rainforest Site

- A CEOS radiometric calibration reference site
- Data routinely collected and analyzed for calibration monitoring of SAR satellites including RADARSATs
- Radiometry of the site remains stable

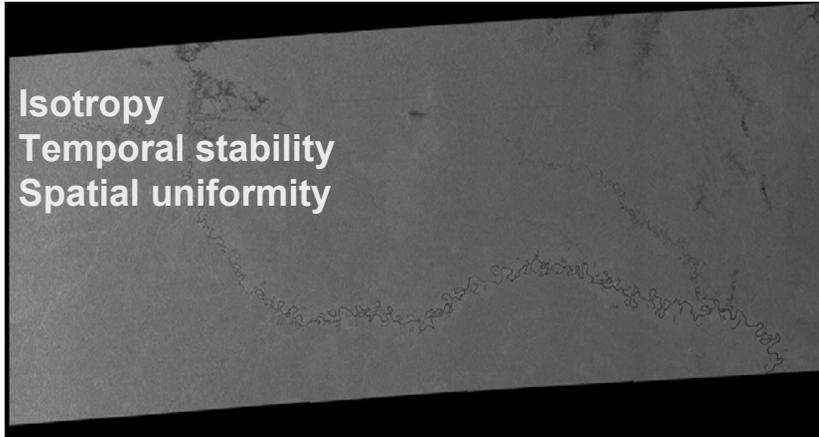


## ➤ Canadian Boreal Forest Site

- Radiometric characterization completed at C-band using RADARSAT-1 data
- Site seasonally dependent
- Can be used as a complimentary site to the Amazon but with reduced radiometric accuracy



## Rainforest Properties

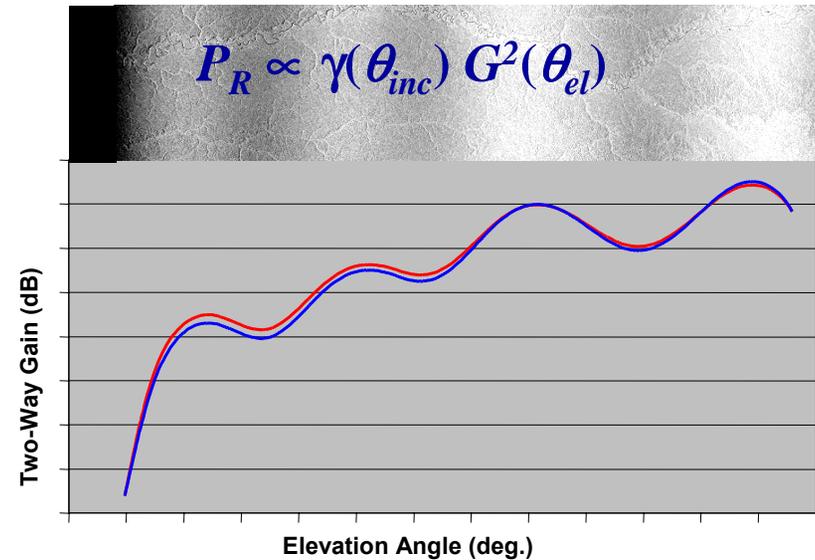


## Well characterized radiometrically

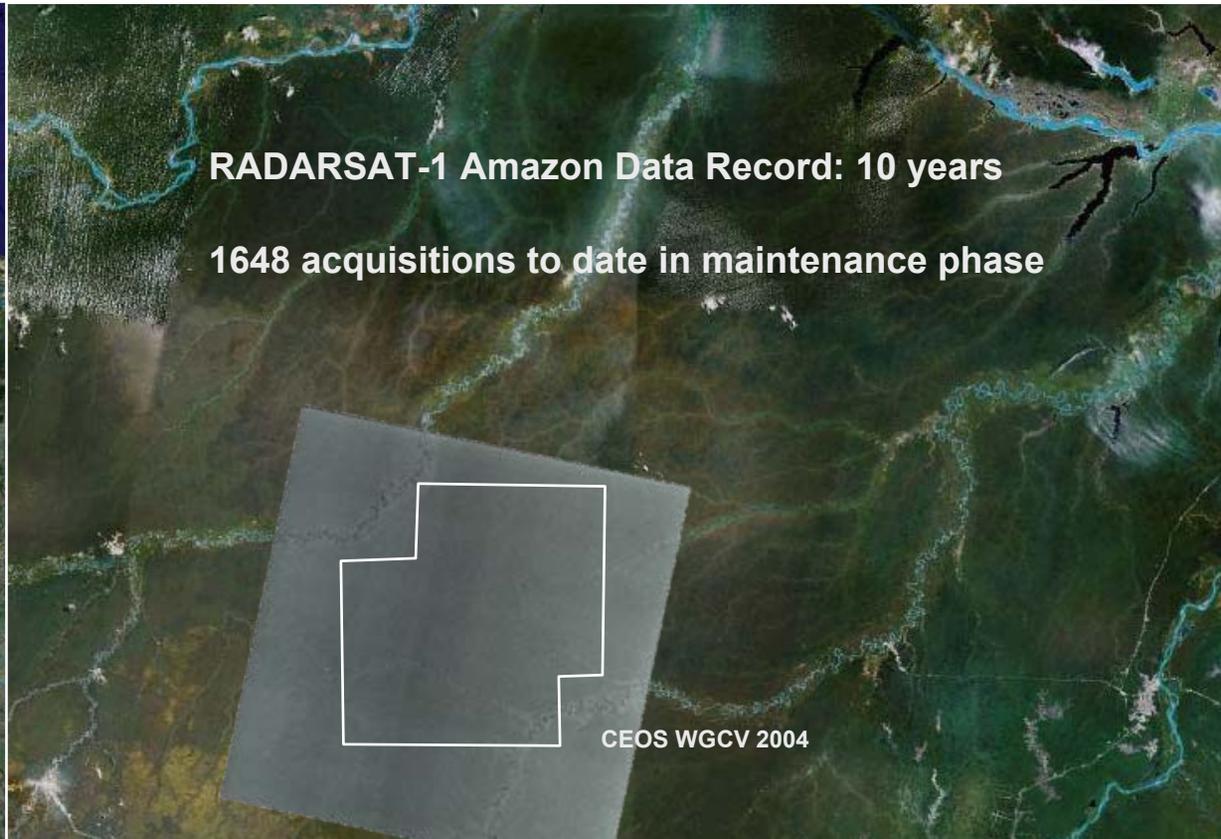
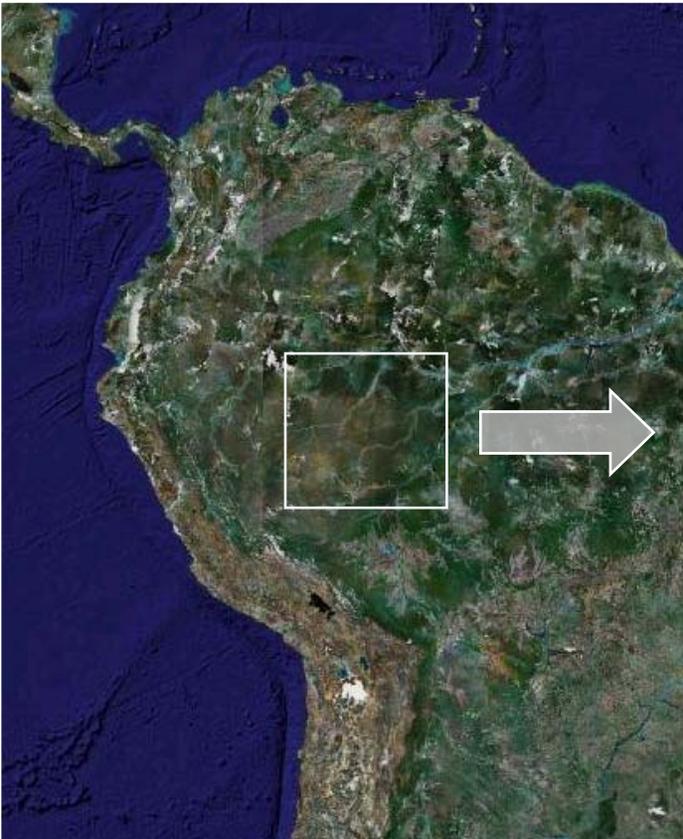
## Recognized distributed target reference

- 1978 Seasat (L)
- 1985 SIR-B (L)
- 1991 ERS-1 (C)
- 1992 ERS-2 Scatterometer (C)
- 1994 SIR-C (X)
- 1992 JERS-1 (L)
- 1996 RADARSAT-1 (C)
- 2002 ENVISAT (C)
- 2008 RADARSAT-2 (C)

## Use of Amazon imagery (uncorrected )



- Extraction of In-Flight Elevation Beam Pattern from Amazon Rainforest images (Antenna pattern correction off)
- Range averaging → Elevation beam pattern
- Comparison against Calibrated Pattern (reference stored in processing)
- Calculate pk-pk deviation: 1 dB tolerance



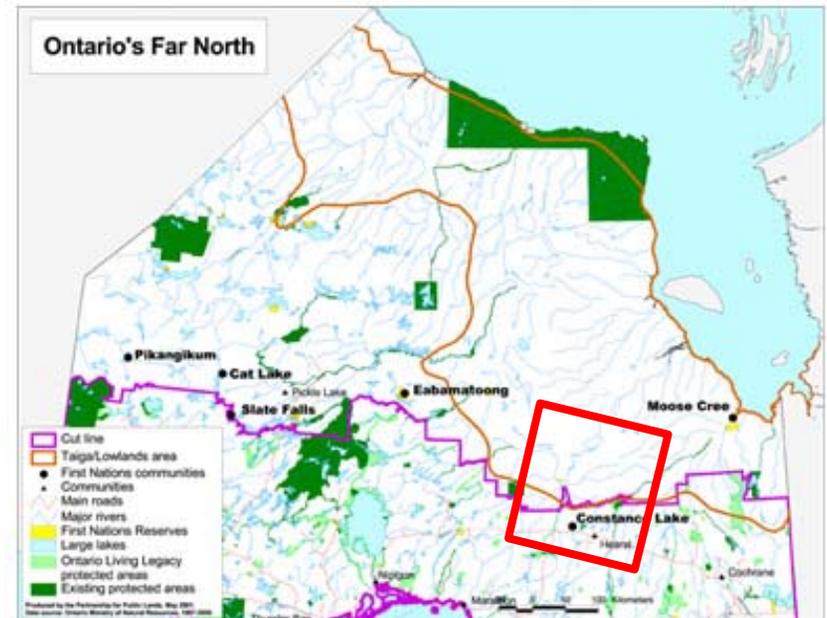
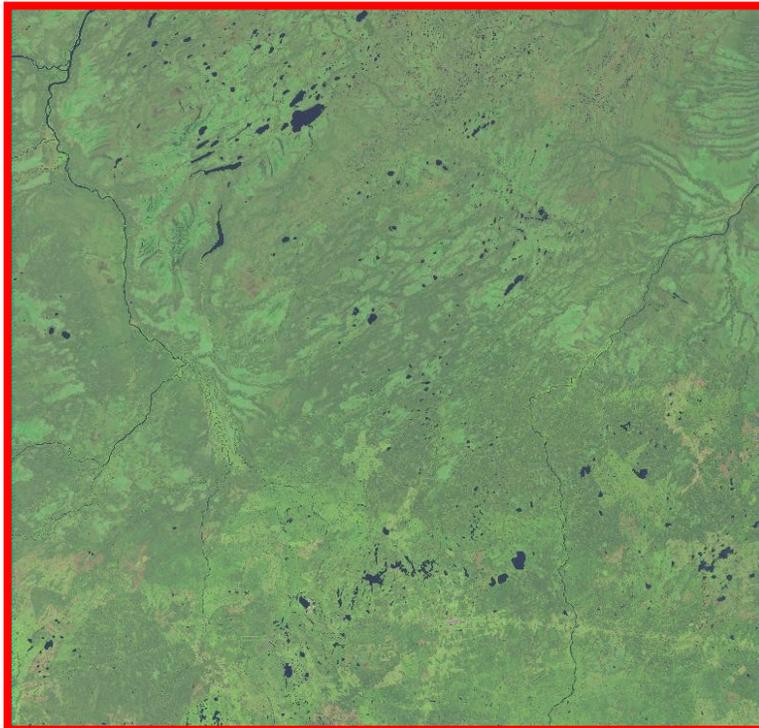
**RADARSAT-1 Amazon Data Record: 10 years**

**1648 acquisitions to date in maintenance phase**

CEOS WGCV 2004

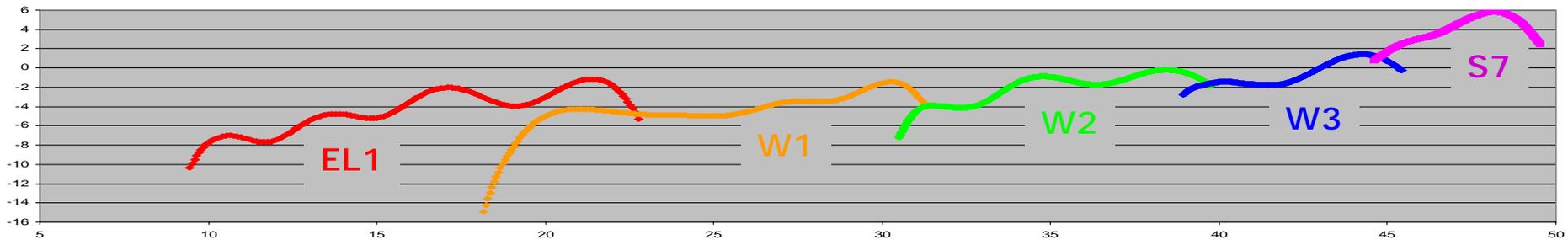
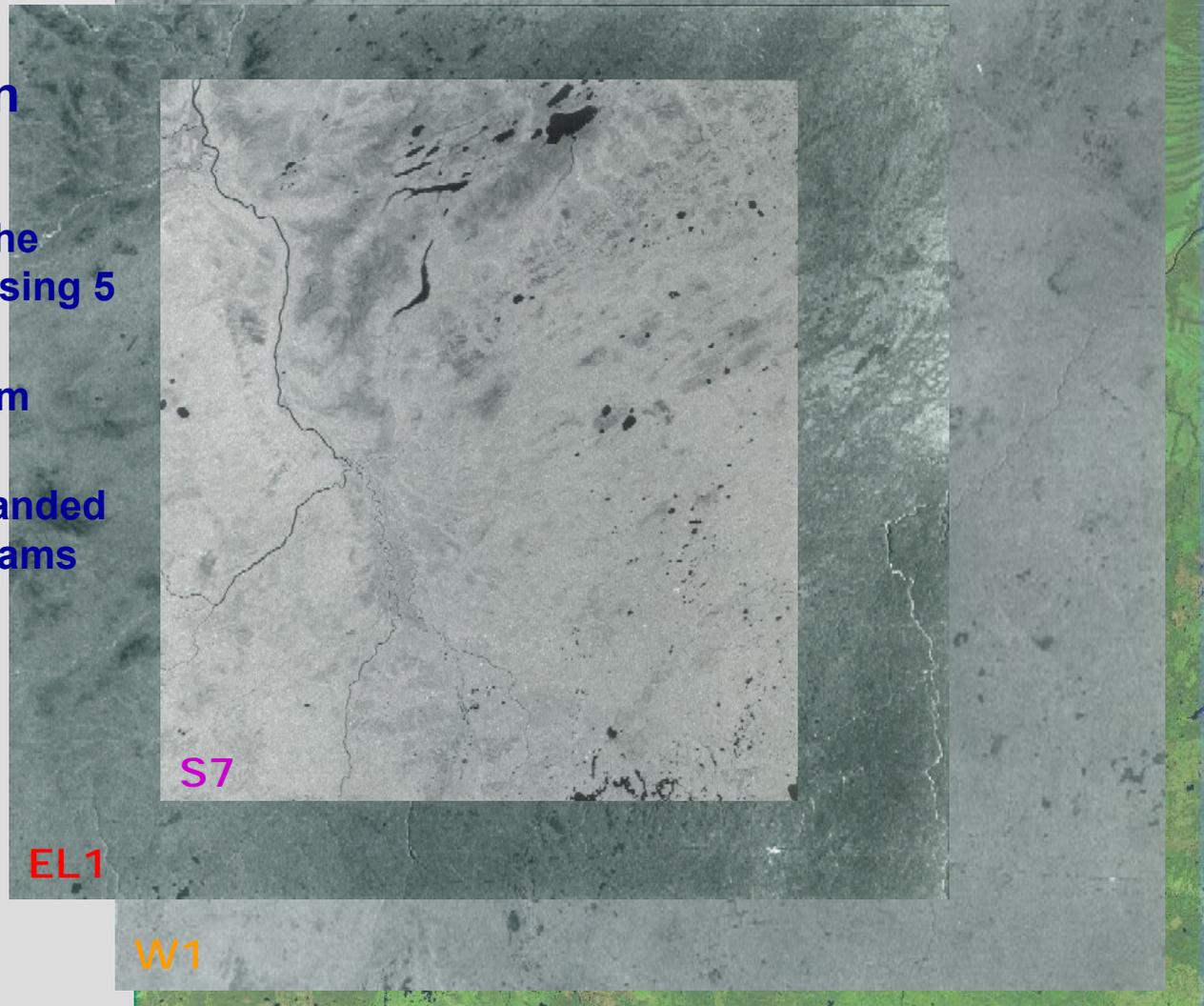
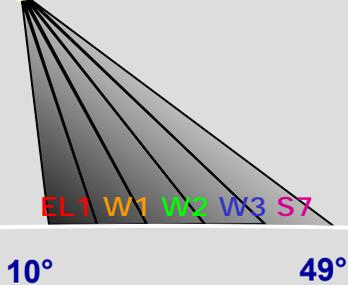
- In July 2008, latest performance assessment of the remaining RADARSAT-1 On-Board Recorder (OBR) led to a new policy for preserving the life of the OBR, restricting its usage
- Starting August 2008, Amazon datasets for calibration monitoring are acquired on an 'as-needed' basis
- Use of the Boreal Forest, within reach of the Canadian receiving facilities, site was increased

- **Northwestern Ontario landmass (Hudson Bay basin)**
- **Boreal Forest-Barrens transition**  
boreal spruce, balsam fir, jack pine, poplar, birch, tamarack, cedar
- **Seasonal Variations**

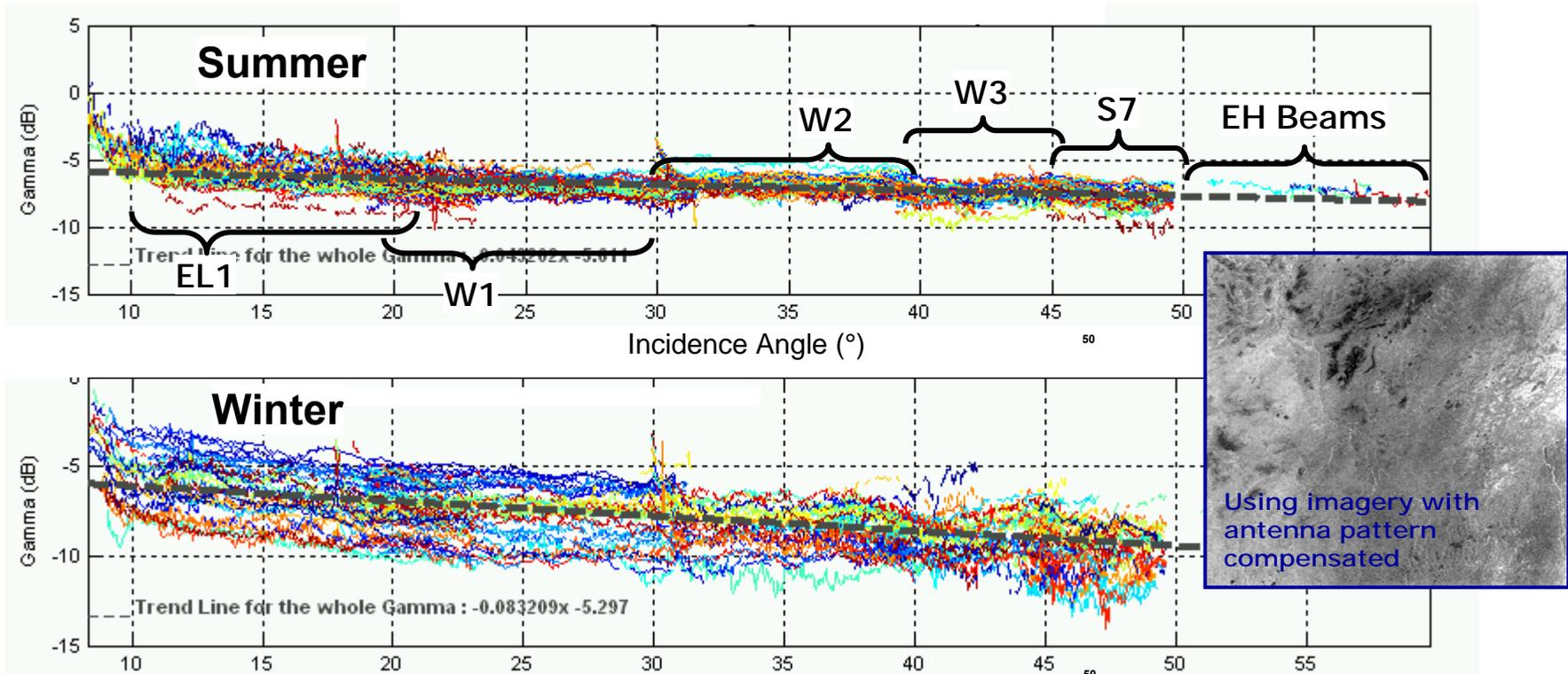


# RADARSAT-1 Measurement Campaign

- Started in January 2003
- Site was studied covering the entire R1 incidence range using 5 beams
- 2 to 4 products of each beam every 24-day cycle
- Acquisition policy was expanded to include all 7 Standard beams (S1-S7) in summer 2008
- 935 acquisitions to date



## Gamma measurements from Boreal Forest images as of Aug. 2008



- Gamma centred around Rainforest value (-6.5 dB)
- Linear dependence conforms to clutter models
- Large spread of reflectivity levels in winter, but first degree dependence (slope) remains

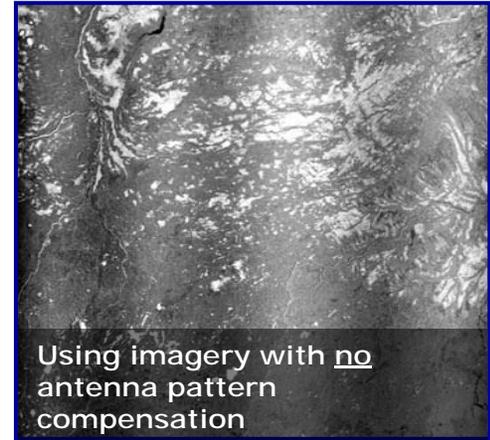
For each beam monitored, a linear reflectivity estimate was derived for both summer and winter reference periods

$$G^2(\theta_{el}) \propto P_R / \gamma(\hat{\theta}_{inc})$$

Seasonal measurements started in June 2004

Procedure (as with Amazon imagery):

1. Extract beam pattern by subtracting seasonal reflectivity estimate of the area
2. Compare with calibrated pattern in Payload Parameters File
3. **Measure radiometric deviation: peak-peak of pattern difference (dB)**



Summer results outperform Winter:

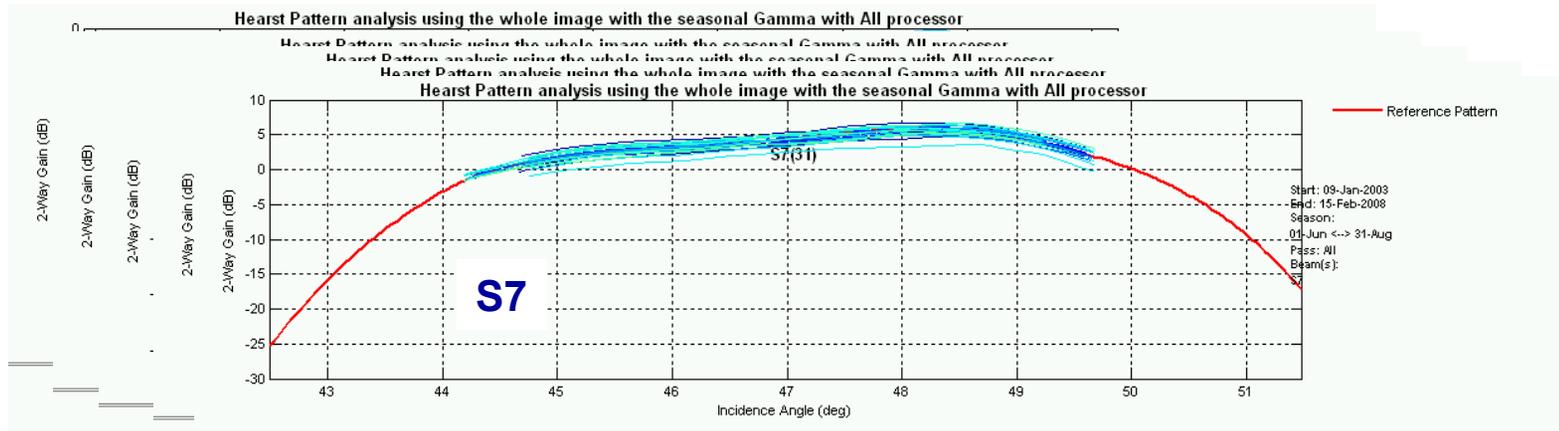
- by 0.3 dB on average for entire swath results
- by 0.2 dB when excluding beam pattern edges

Summer results (excluding edges) commensurate within 0.3 dB of Amazon measurements

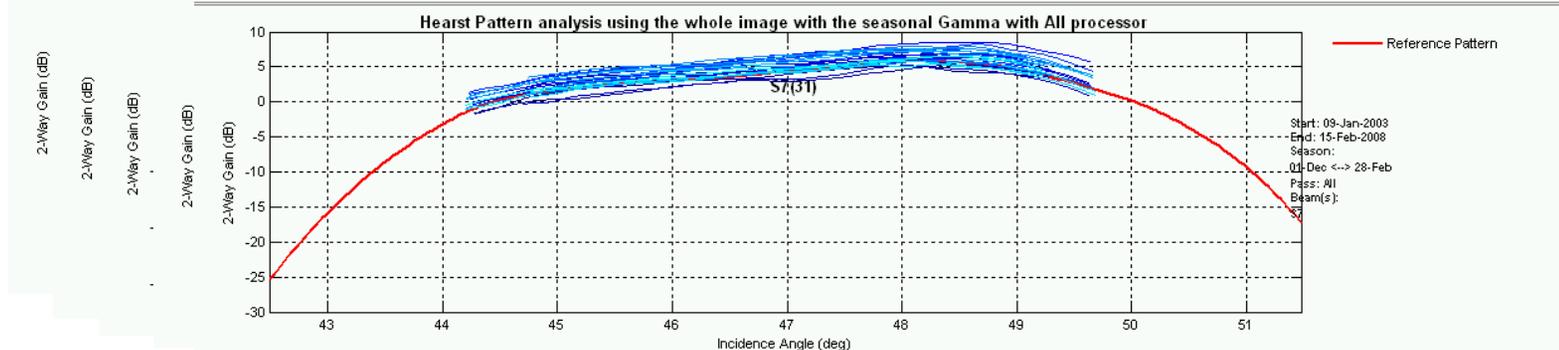
	Average peak-peak pattern difference (dB)			
	'Summer'		'Winter'	
	Entire Swath	Excluding Edges	Entire Swath	Excluding Edges
EL1	1.6	1.2	1.9	1.2
W1	1.4	1.0	1.5	0.9
W2	1.0	0.8	1.4	1.1
W3	0.8	0.7	1.3	1.1
S7	0.8	0.7	1.2	1.1

- Use of Boreal Forest data to monitor central part of the elevation beam pattern to within 1.2 dB for EL1, W1-W3, and S7 beams
- Campaign being extended to S1 - S6 (100 km coverage)
- Smaller swath beams excluded due to terrain non-uniformities
- Transitional seasons were discarded due to local backscatter variations induced by freeze-thaw periods

Summer



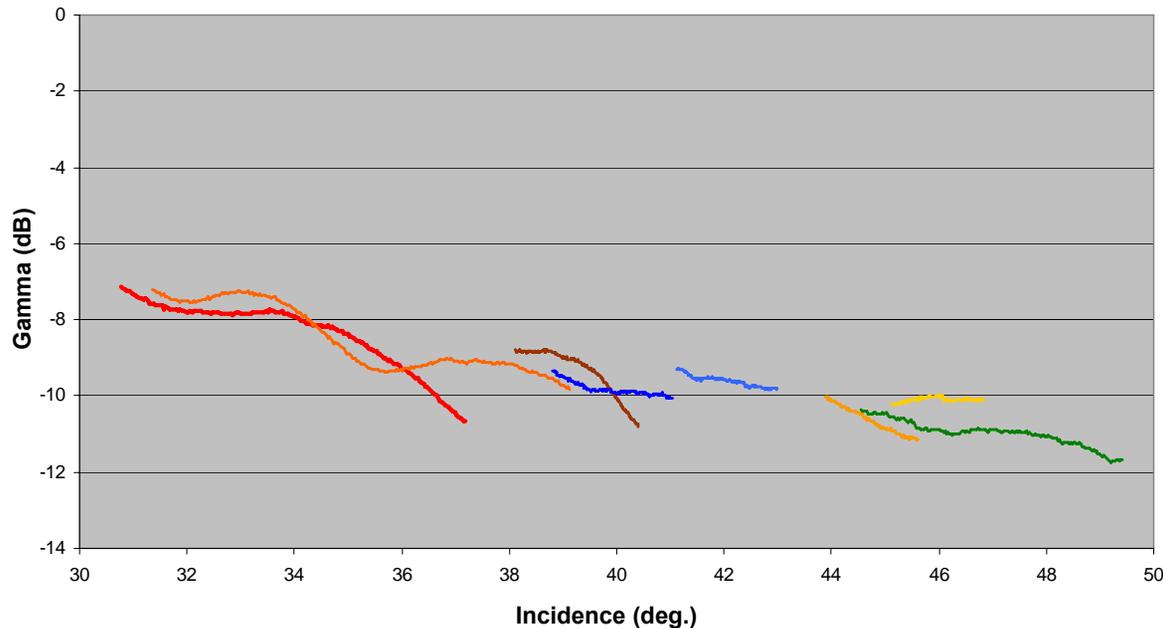
Winter



## RADARSAT-1 Campaign (March 2008)

### Extraction of Gamma reflectivity profiles

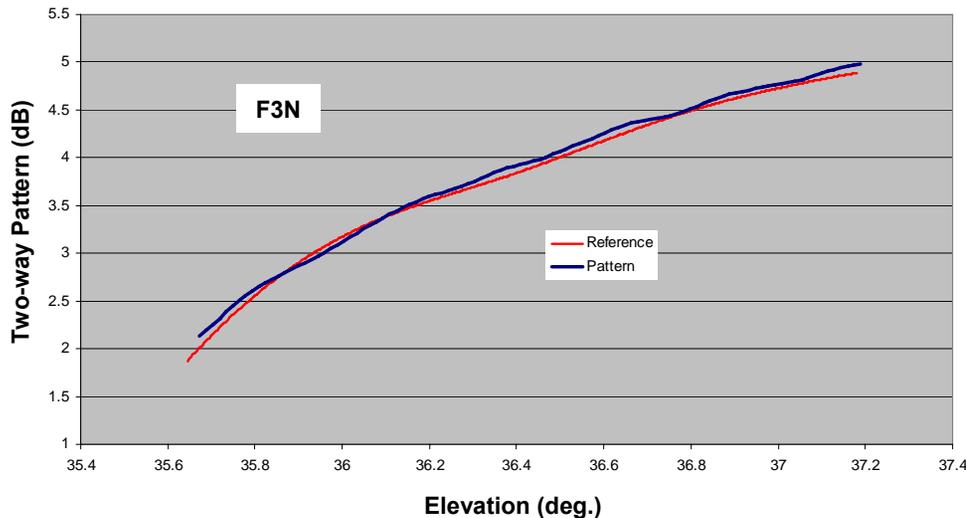
- Smooth profiles compared to Boreal Forest and Amazon
- With increasing incidence, Gamma level at C-band appears to decrease more markedly than with the Boreal Forest (-0.25 dB/deg. vs -0.05 dB/deg.)
- Terrain height variations within the selected area impaired larger swath measurements



## RADARSAT-1 Campaign (March 2008)

### Preliminary beam pattern extraction trials

- For smaller swath beams (Fine beams: 40 km coverage), results seem to indicate radiometric accuracy to be commensurate with the Amazon
- Encouraging preliminary results



Beam	Peak-peak difference between extracted and reference (calibrated) pattern (dB)	
	Dome-C	Amazon
	Entire Swath	Entire Swath
F1F	0.85	0.50
F2N	0.36	0.37
F3N	0.19	0.33
F4	0.12	0.37
F5N	0.24	0.40

## RADARSAT-2 Campaign (ongoing)

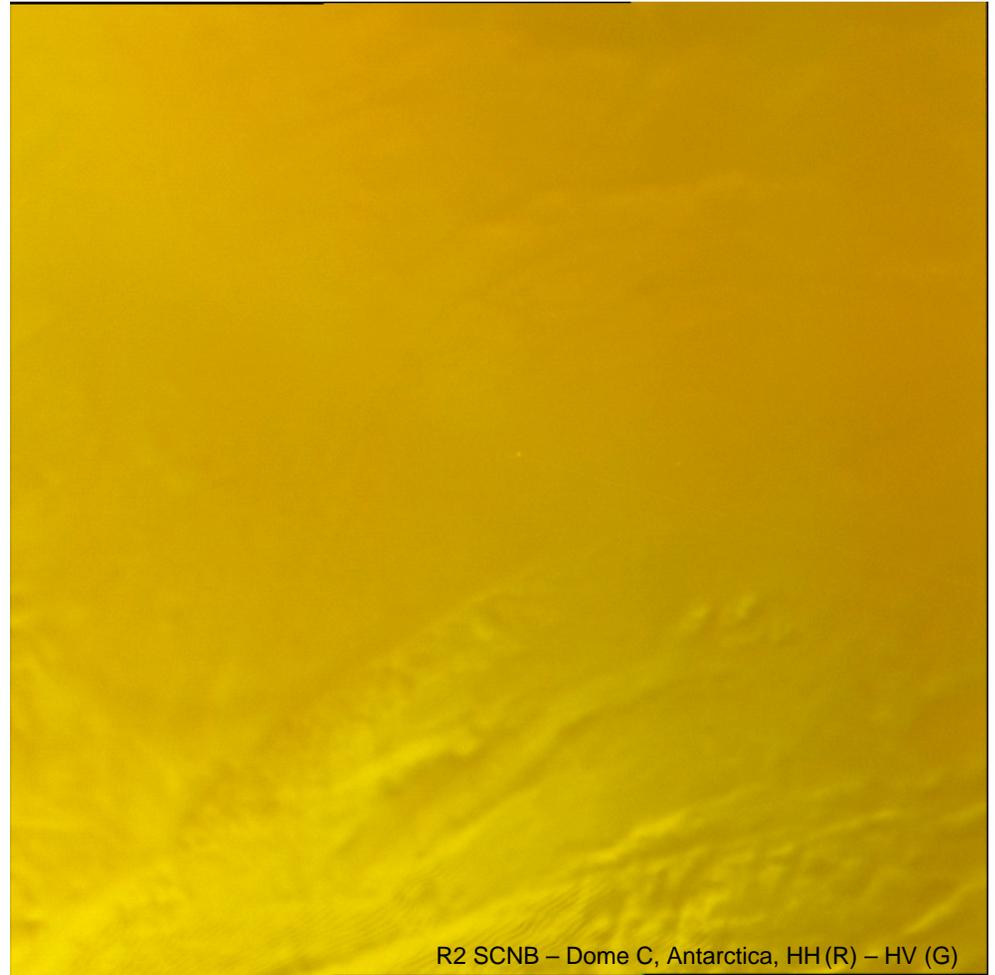
Planning larger swath acquisitions to assess regional non-uniformities in C-band:

- Local height variations
- Snow texture: dunes, sastrugi

## Objectives:

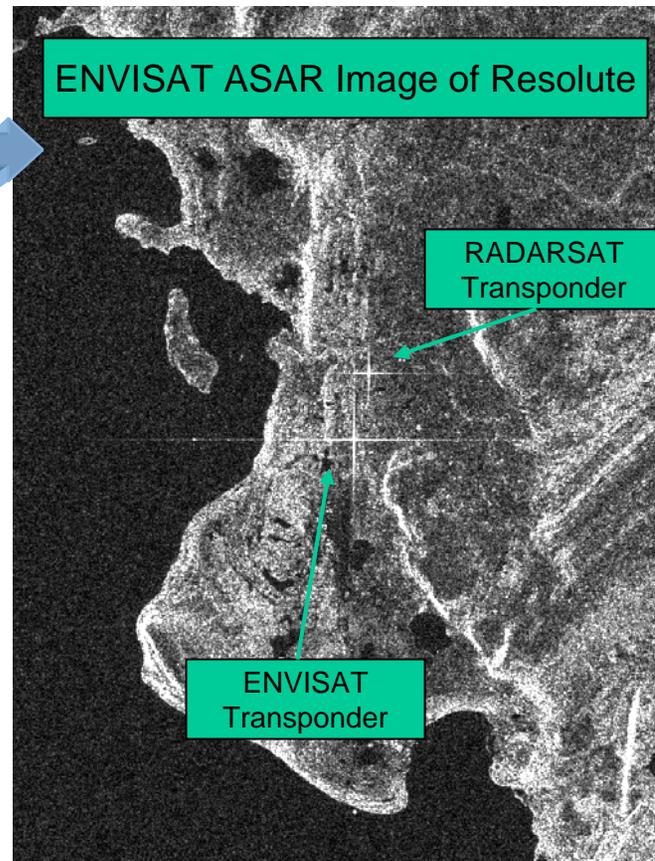
- Identify physically uniform areas
- Identify temporally stable areas in terms of backscatter

## Multipolarimetric campaign



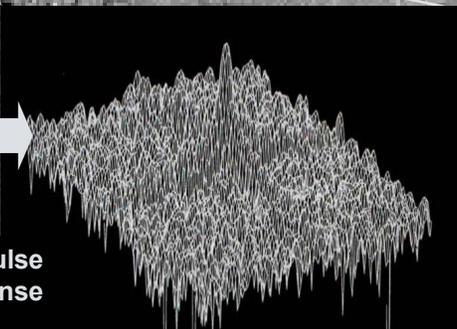
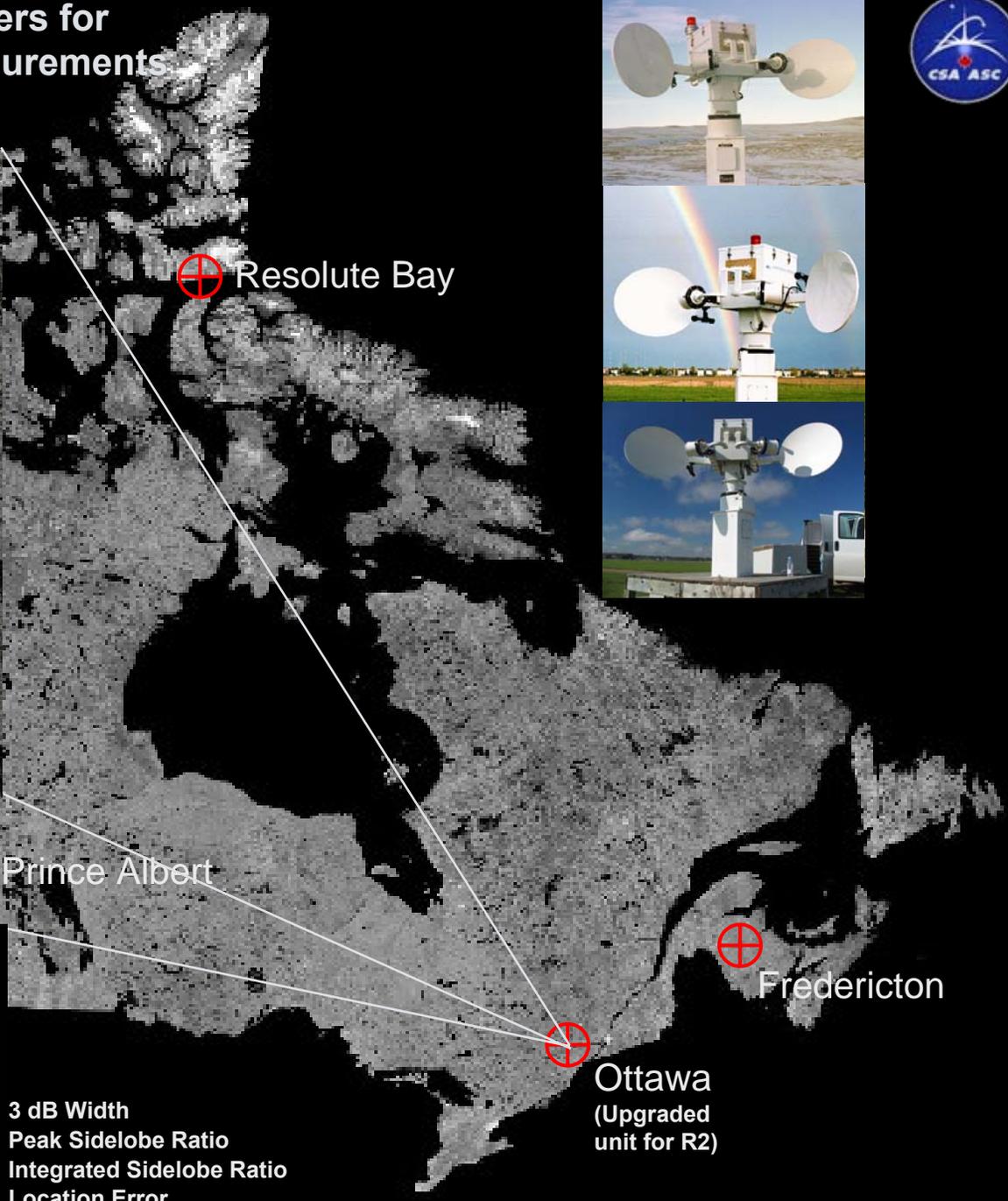
## Multi-Transponder Sites in Canada

- In Fall 2006, ESA relocated an ENVISAT ASAR Transponder in Resolute Bay in vicinity of a RADARSAT Transponder
- Both transponders can be used simultaneously by ENVISAT
- In 2007 another ENVISAT ASAR Transponder was relocated in Ottawa, again in vicinity of another RADARSAT Transponder



- Two potential sites in Canada for inter-sensor comparisons for C-band SARs (e.g., RADARSAT-1, RADARSAT-2, ENVISAT)

# RADARSAT-1 Precision Transponders for Image Quality and Calibration Measurements



SAR Impulse Response

- 3 dB Width
- Peak Sidelobe Ratio
- Integrated Sidelobe Ratio
- Location Error