CSA Report on Earth Observation

Presented at
CEOS WGCV 31st Plenary
Washington, DC
March 2 – 4, 2010

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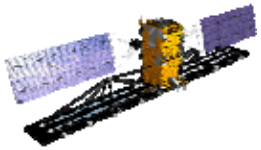
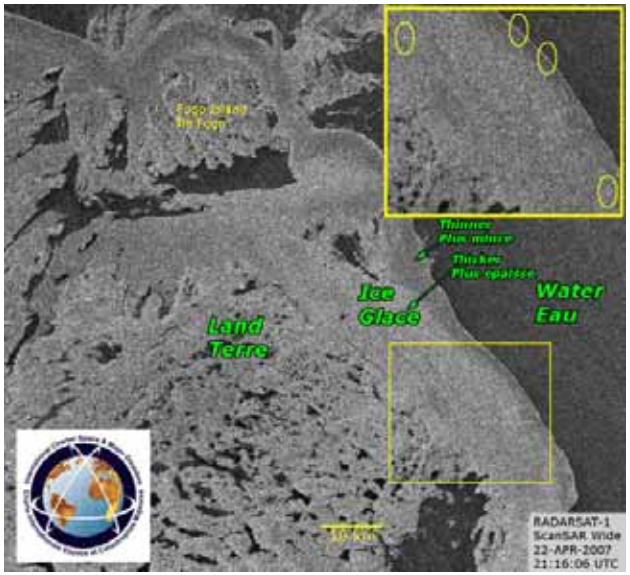
CSA Member of WGCV
Canadian Space Agency

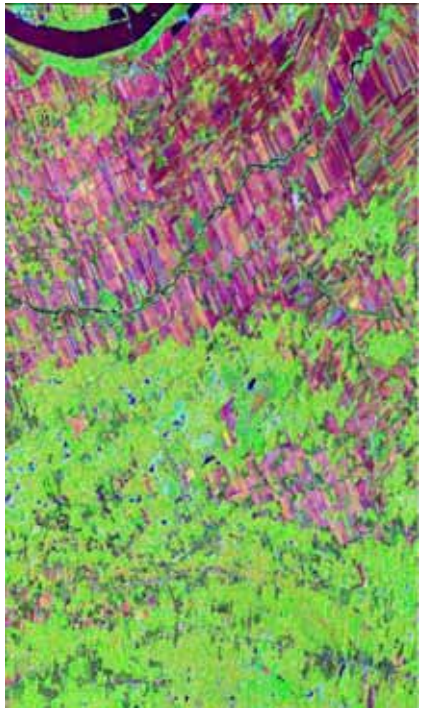
CSA Committed to Provide RADARSAT Data Continuity

1995: RADARSAT-1

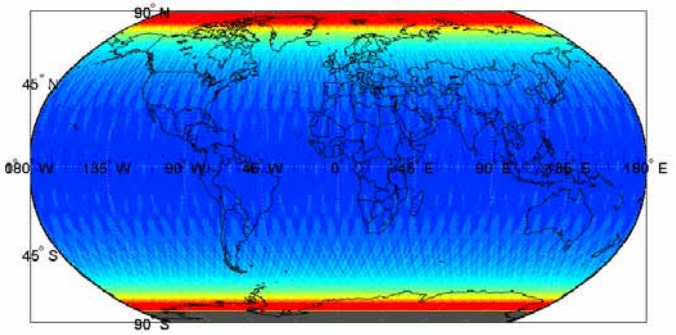


2007: RADARSAT-2





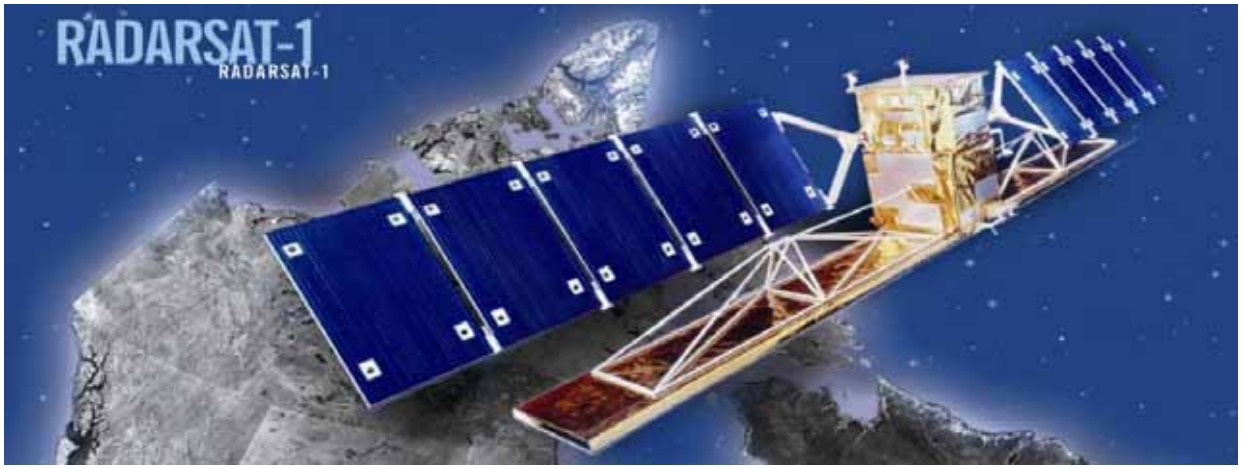
2014:
2015:
2015: RCM



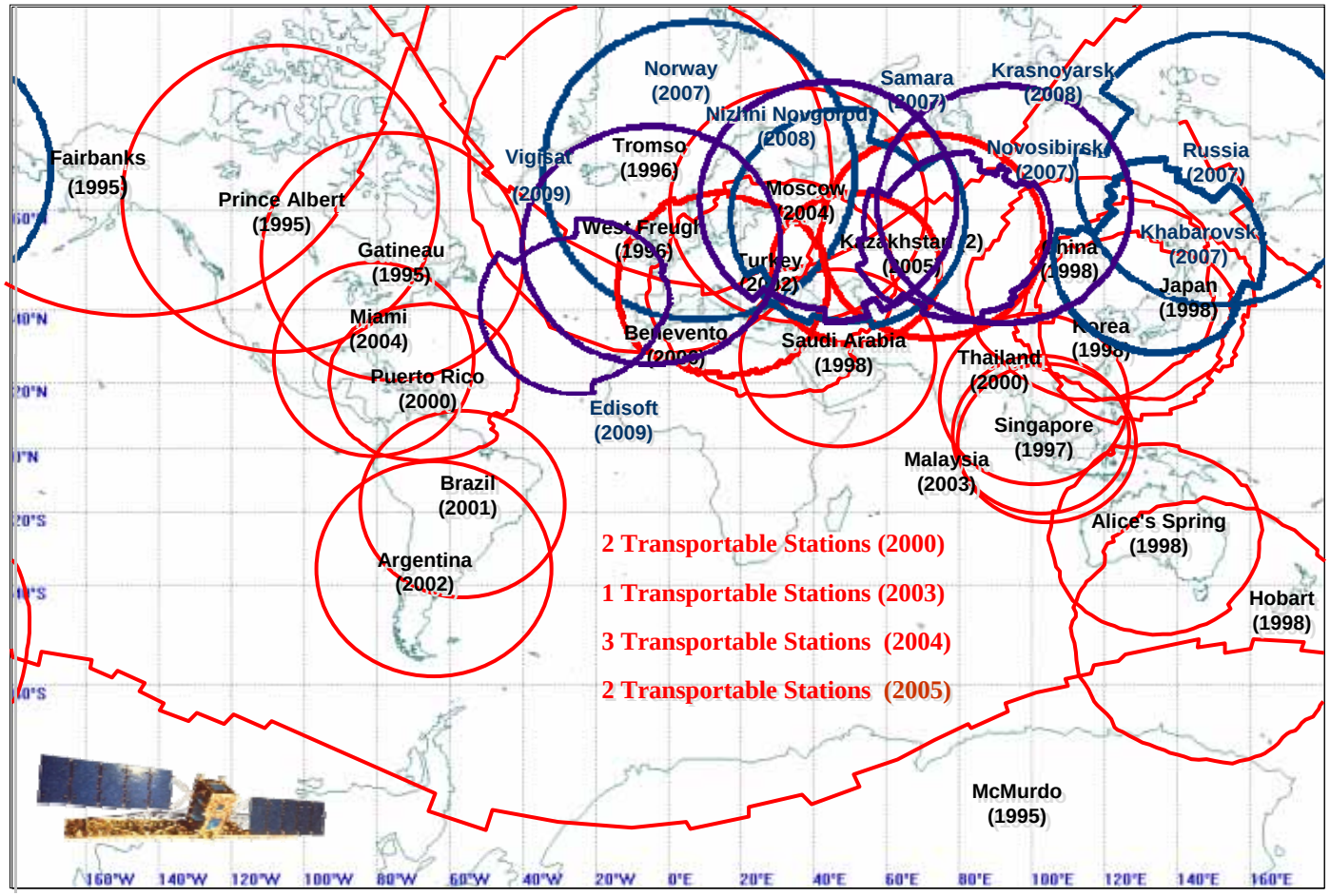
Agence spatiale Canadienne | Canadian Space Agency

RADARSAT-1 Program Status (1)

- CSA has approved continuation of RADARSAT-1 operation for three more years (until March 31, 2012)
- Running in 14th year of operation
- Data received and processed at 42 ground stations with 28 archive facilities globally. One ground station is presently under certification.
- As of January 25 2010, completed 74,263 orbits, planned 326,853 user requests corresponding to a total acquisition of 620,293 minutes of SAR data
- Average system performance maintained better than 93%



RADARSAT-1 Reception Coverage



2010
2009
2008
2007
2006
2005
2004
2003
2002
2001
2000
1999
1998
1997
1996
1995

- Data Reception Facilities: 42 (including 8 transportable stations)
- Data Archiving Facilities: 29
- Stations actually under certification: 1

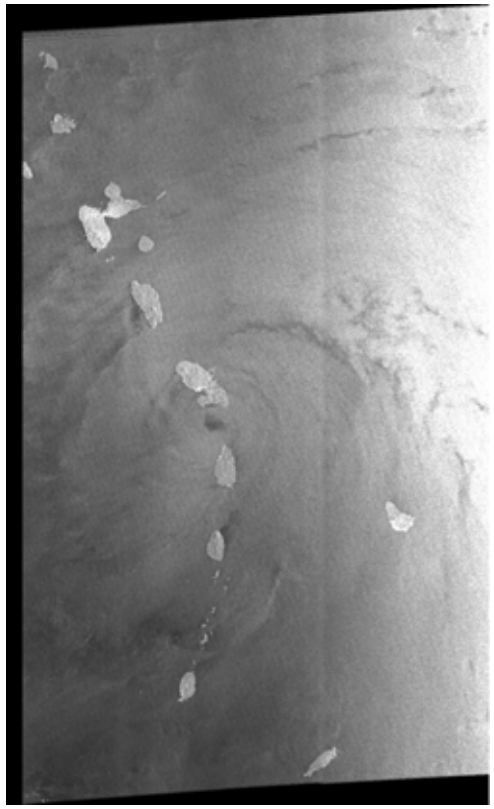
RADARSAT-1 Program Status (2)

- In January 2009 On Board Recorder (OBR) started showing severe degradation in performance resulting in data drop outs and processing failures and thus recoded data was not considered reliable. As a result, OBR utilization was terminated by CSA on February 20, 2009. However, many Network Stations are available globally to receive and process data for clients.

- As a member of International Charter Space and Major Disasters, provided **619 frames of RADARSAT-1 image data** for **286** Charter emergencies to date

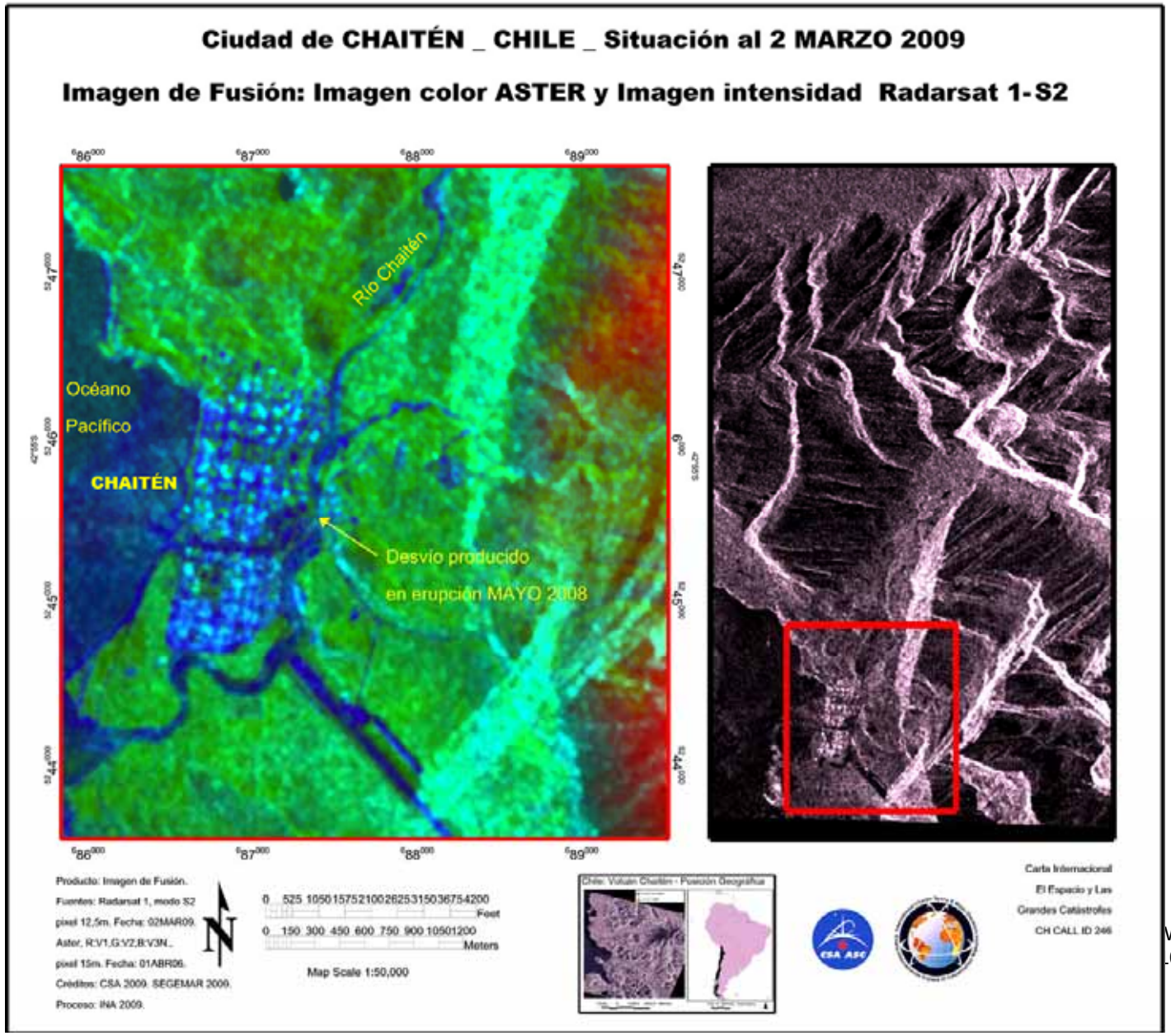
- Image quality and calibration maintained better than system specification

- Plans for Background Mission: Multiple coverage campaigns (using RADARSAT-1 and –2);
  - Focus on site and application-specific acquisitions:
    - Natural Hazards
      - Disaster Watch
      - Hurricane Watch
    - Polar Regions
      - 4-Season coverage of Arctic Basin
      - IPY

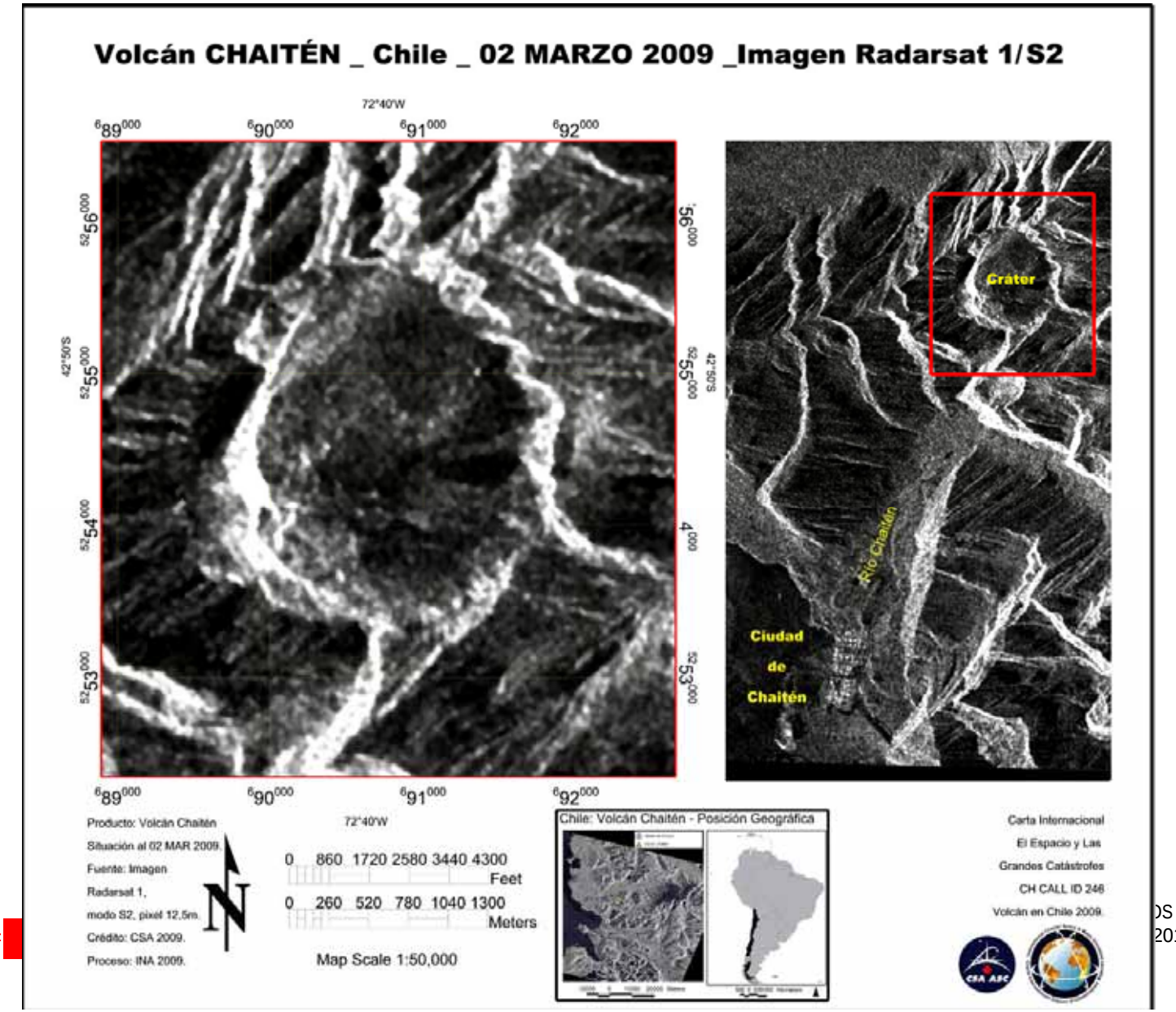


Hurricane Dean 17 Aug 2007, 09:53 UTC, Lesser Antilles, Caribbean

International Charter: RADARSAT-1 Image Product from 2009 Eruption of Chaiten Volcano, Chile (1)



International Charter: RADARSAT-1 Image Product from 2009 Eruption of Chaiten Volcano, Chile (2)



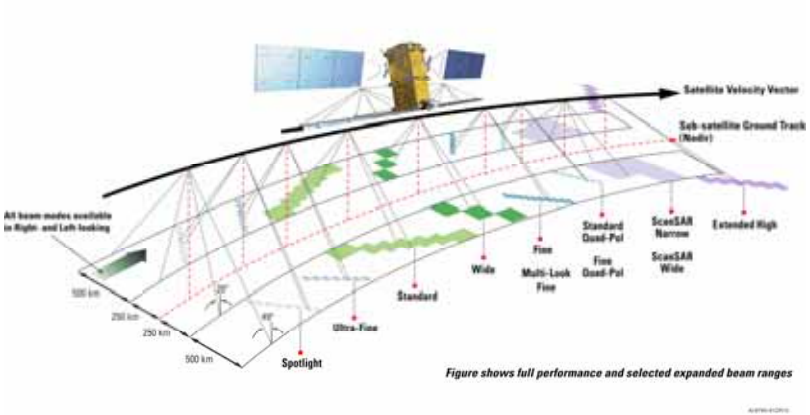
RADARSAT-2 Mission Overview

Co-funded by Canadian Space Agency (CSA) and MacDonald Dettwiler (MDA)

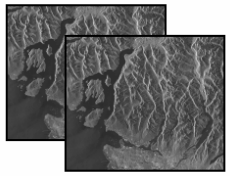
- MDA is the owner and operator of RADARSAT-2 and holds the the worldwide distribution rights for all products
- MDA has the copyright of all RADARSAT-2 products
- Data continuity from RADARSAT-1
  - all RADARSAT-1 imaging modes supported
  - plus many additional capabilities
- Mission optimizes to support long-term data supply through 2014
- Launched: December 14, 2007
- Operational: April 25, 2008

RADARSAT-2 Features

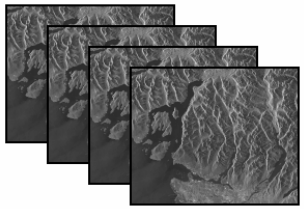
- High resolution:
  - 3 m
  - multi-look 10 m
  - SpotLight
- Polarimetric modes
  - single/dual polarization
  - quad-pol
- Right and left-looking capability
- Enhanced ground system providing:
  - efficient satellite tasking (12 - 24 hours routine)
  - faster data processing
  - data encryption



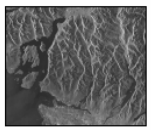
RADARSAT-2 Imaging Parameters



HH + HV
VV +VH



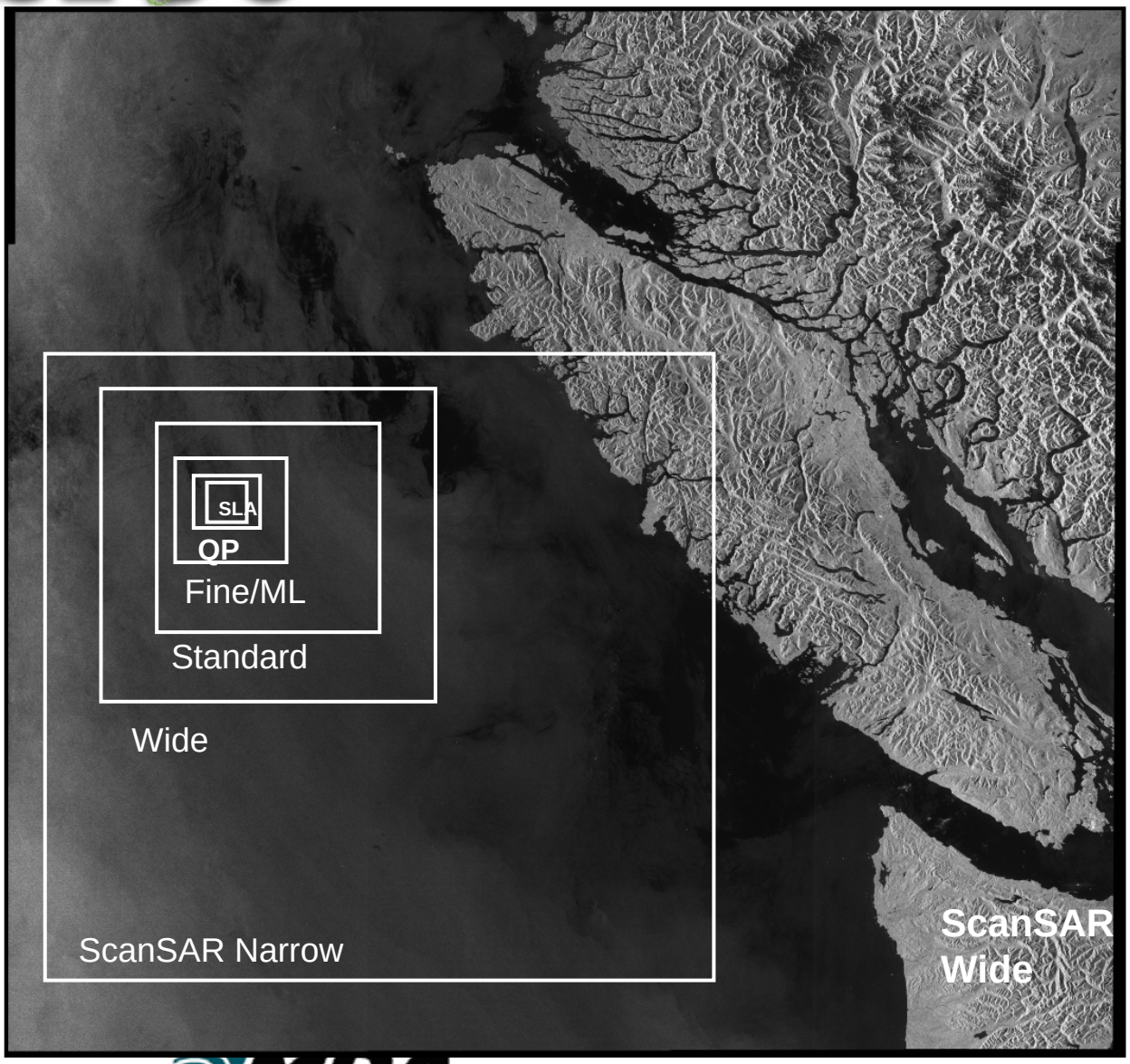
HH + VH + HV + VV



HH or VV or HV or VH

Beam Mode		Approximate Incidence Angle	Nominal Swath Width	Approximate Resolution Gnd Rg x Az	Number of looks Rg x Az
Selective Polarization transmit H or V receive H and / or V	Fine	30° - 49°	50 km	10 x 9 m	1 x 1
	Standard	20° - 49°	100 km	25 x 28 m	1 x 4
	Low Incidence	*10° - 23°*	*170 km*	*40 x 28 m*	*1 x 4*
	High Incidence	49° - 59°	70 km	20 x 28 m	1 x 4
	Wide	20° - 44°	150 km	25 x 28 m	1 x 4
	ScanSAR Narrow	20° - 46°	300 km	50 x 50 m	2 x 2
	ScanSAR Wide	20° - 49°	500 km	100 x 100 m	4 x 4
Polarimetric transmit H and V on alternate pulses receive H and V simultaneously	Fine Quad-Pol	20° - 41°	25 km	11 x 9 m	1 x 1
	Standard Quad-Pol	20° - 41°	25 km	25 x 28 m	1 x 4
Selective Single Polarization transmit H or V receive H or V	Ultra-fine	30° - 49°	20 km	3 x 3 m	1 x 1
	Multi-Look Fine	30° - 49°	50 km	11 x 9 m	2 x 2
	SpotLight	20° - 49°	8 x 20 km	2.2 x 0.7 m	1 x 1

RADARSAT-2 Beam Mode Coverage



- ScanSAR Wide
  - 500 km x 500 km
  - 100 m res
- ScanSAR Narrow
  - 300 km x 300 km
  - 50 m res
- Wide
  - 140 km x 140 km
  - 30 m res
- Standard
  - 100 km x 100 km
  - 25 m res
- Fine/ML
  - 50 km x 50 km
  - 10 m res
- Quad Standard
  - 25 km x 25 km
  - 25 m res
- Quad Fine
  - 25 km x 25 km
  - 10 m (nom)
- SpotLight
  - 10 km x 20 km
  - .8m x 2.5 m res

(Nominal values)

Multi-look Fine

MultiLook Fine 1:1
10 m resolution
50 km swath width

Vancouver airport

Ultra Fine

Ultrafine 1:1
3 m resolution
20 swath width

Vancouver airport

Spot Light

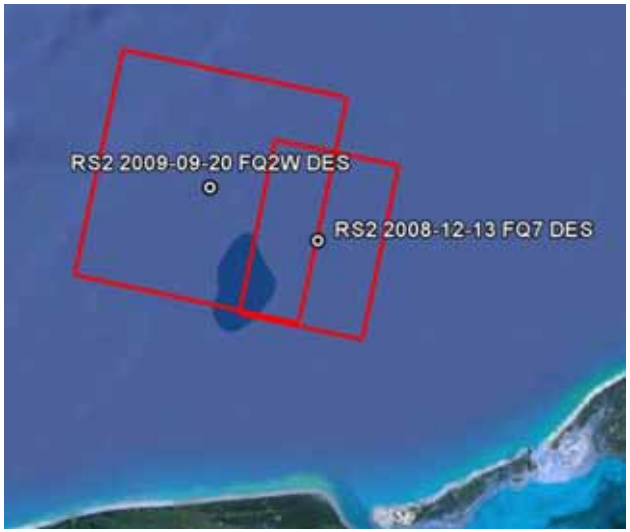
Spotlight 1:1
.8 m x 2.3 m
resolution
20 km swath width

Vancouver airport

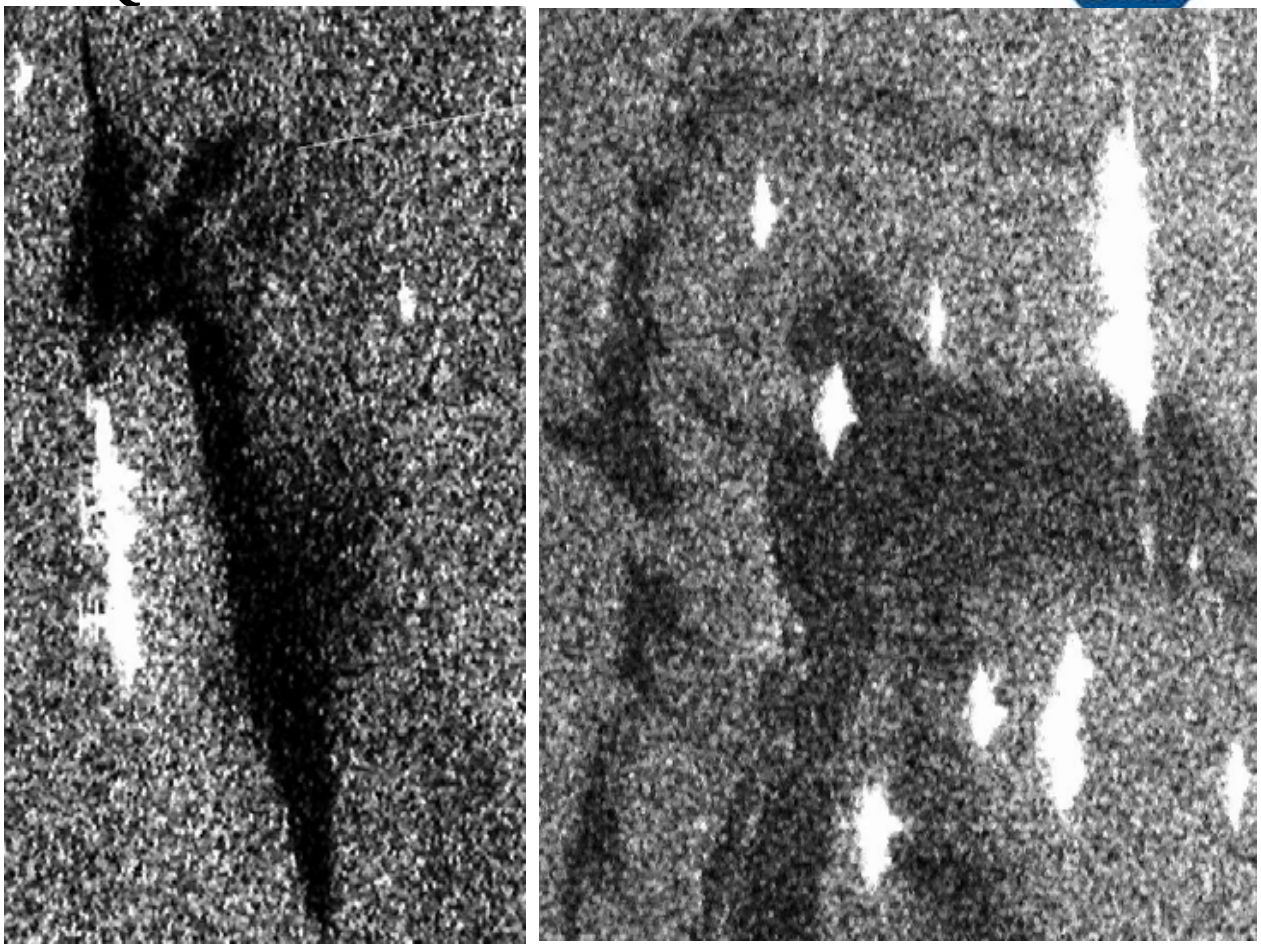
RADARSAT-2 New Modes

- Modes available operationally:
  - MF SLC
  - SQ22-31 and FQ22-31 (extending the incidence angle range out to near 50 degs from the previous limit of about 41 or 42 degs)
- Modes that are ready, but waiting for approval:
  - 50 km swath SQ and FQ
  - Wide Swath Fine Resolution: similar to the Fine Mode, but cover swaths from 110 - 170 km

Fine Quad Wide-Swath Mode



Comparison of new 50 km swath-width Fine quad pol Wide (FQ2W) and 25 km swath-width Fine quad (FQ7).



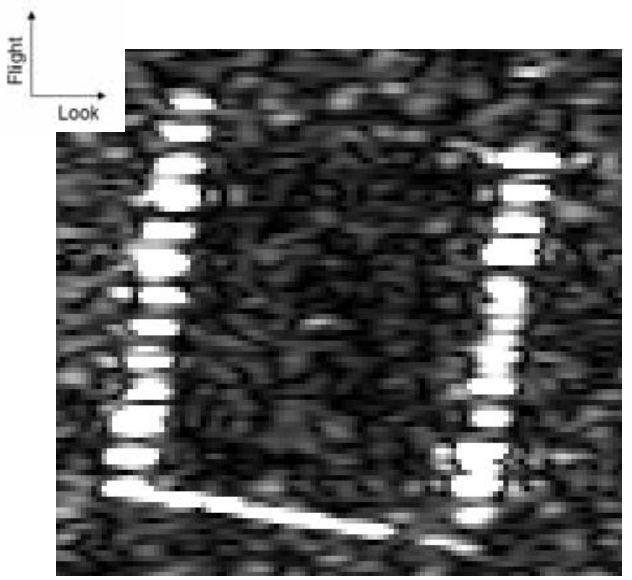
Cantarell oil seep (Gulf of Mexico) subregion.
FQ7 (left) and FQ2W (right). Images are VV polarization.

Spot Light

- At launch, Canadian government regulations restricted SpotLight design resolution:
  - 3 m range
  - 1 m azimuth
- Regulations have been relaxed, so the full capability of SpotLight can be utilized:
  - 2.2 m range
  - 0.7 m azimuth

Azimuth (N-S orientation)

Range (E-W orientation)

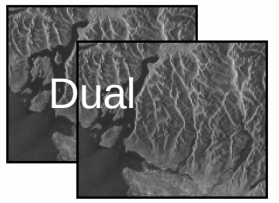


HH polarization
Resolution: 0.7 m az x 2.2 m rg
Ascending
43° incidence angle (nominal)

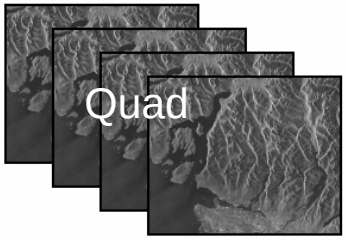
Polarization Modes Summary

Beam Mode	Polarization			Product						
	S	D	Q	SLC	SGX	SGF	ScN	ScW	SSG	SPG
SpotLight	✓			✓	✓	✓			✓	✓
UltraFine	✓			✓	✓	✓			✓	✓
MultiLook Fine	✓				✓	✓			✓	✓
Fine		✓		✓	✓	✓			✓	✓
Standard		✓		✓	✓	✓			✓	✓
Wide		✓		✓	✓	✓			✓	✓
Ex Low	✓			✓	✓	✓			✓	✓
Ex High	✓			✓	✓	✓			✓	✓
Fine Quad			✓	✓	✓				✓	✓
Standard Quad			✓	✓	✓				✓	✓
ScanSAR Narrow		✓					✓			
ScanSAR Wide		✓						✓		

HH or VV or HV or VH



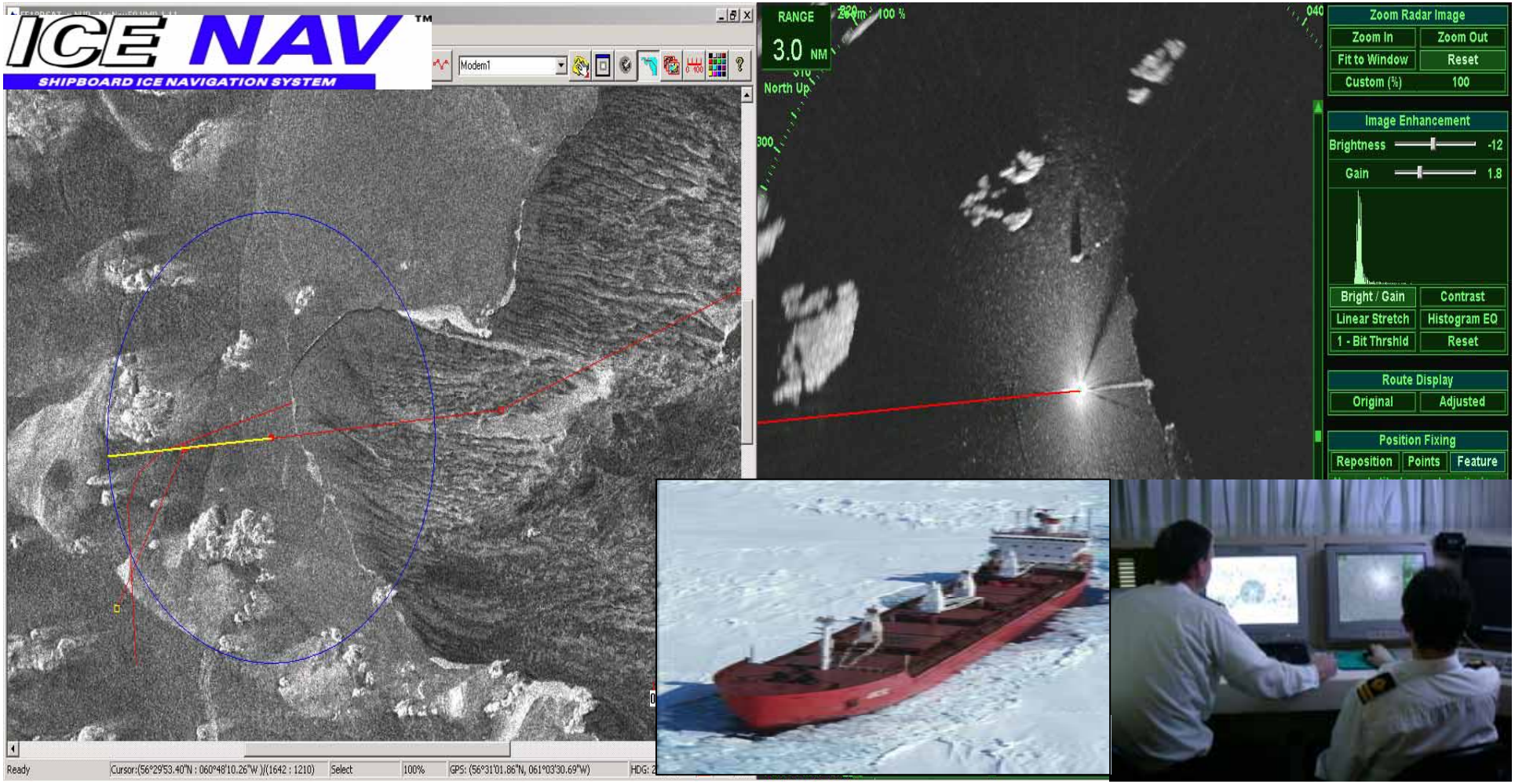
HH + HV
VV +VH



HH + VH + HV + VV

Products		Abbreviation	Processing Level	Product Descriptive Name
Slant Range	Single Look Complex	SLC	Georeferenced	Single Look Complex
Ground Range	SAR Georeferenced Extra	SGX	Georeferenced	Path Image Plus
	SAR Georeferenced Fine	SGF	Georeferenced	Path Image
	ScanSAR Narrow Beam	SCN	Georeferenced	Path Image
	ScanSAR Wide Beam	SCW	Georeferenced	Path Image
Geocorrected	SAR Systematic Geocorrected	SSG	Systematic Geocoded	Map Image
	SAR Precision Geocorrected	SPG	Precision Geocoded	Precision Map Image

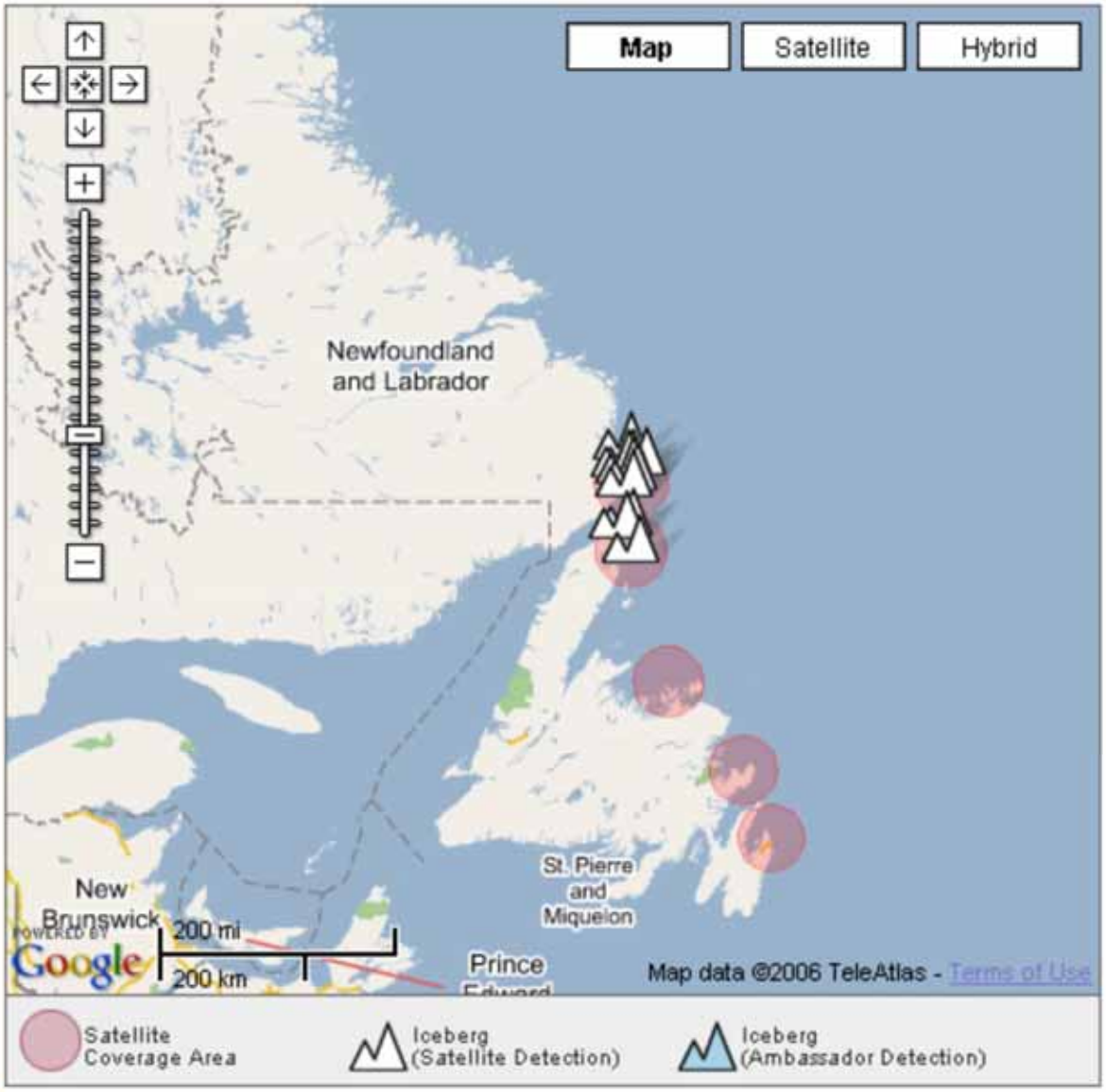
NAVIGATION IN ICE INFESTED WATERS



Reduced fuel consumption and greenhouse gas emissions; Reduced risk of pollution

ICEBERG FINDER.COM

IcebergFinder.com is the place to find information on viewing icebergs in Newfoundland and Labrador, Canada.



Active Icebergs

id	detected	region	
10240	8/8/2006 1:45 PM	Western	
10239	8/8/2006 1:45 PM	Western	
10238	8/8/2006 1:45 PM	Western	
10237	8/8/2006 12:44 PM	Labrador	
10236	8/8/2006 12:44 PM	Labrador	
10235	8/8/2006 12:44 PM	Labrador	
10234	8/8/2006 12:44 PM	Labrador	
10233	8/8/2006 12:44 PM	Labrador	
10232	8/8/2006 12:44 PM	Labrador	
10231	8/8/2006 12:44 PM	Labrador	

NEED HELP?

Double click on the map to center it on a specific area.

Click the [+] to zoom in, click the [−] to zoom out.

Click on an iceberg to get more info.

Click and hold on blank part of the map to drag it around.

PIPELINE GEOHAZARD MONITORING

ENVIRONMENT AND PUBLIC SAFETY

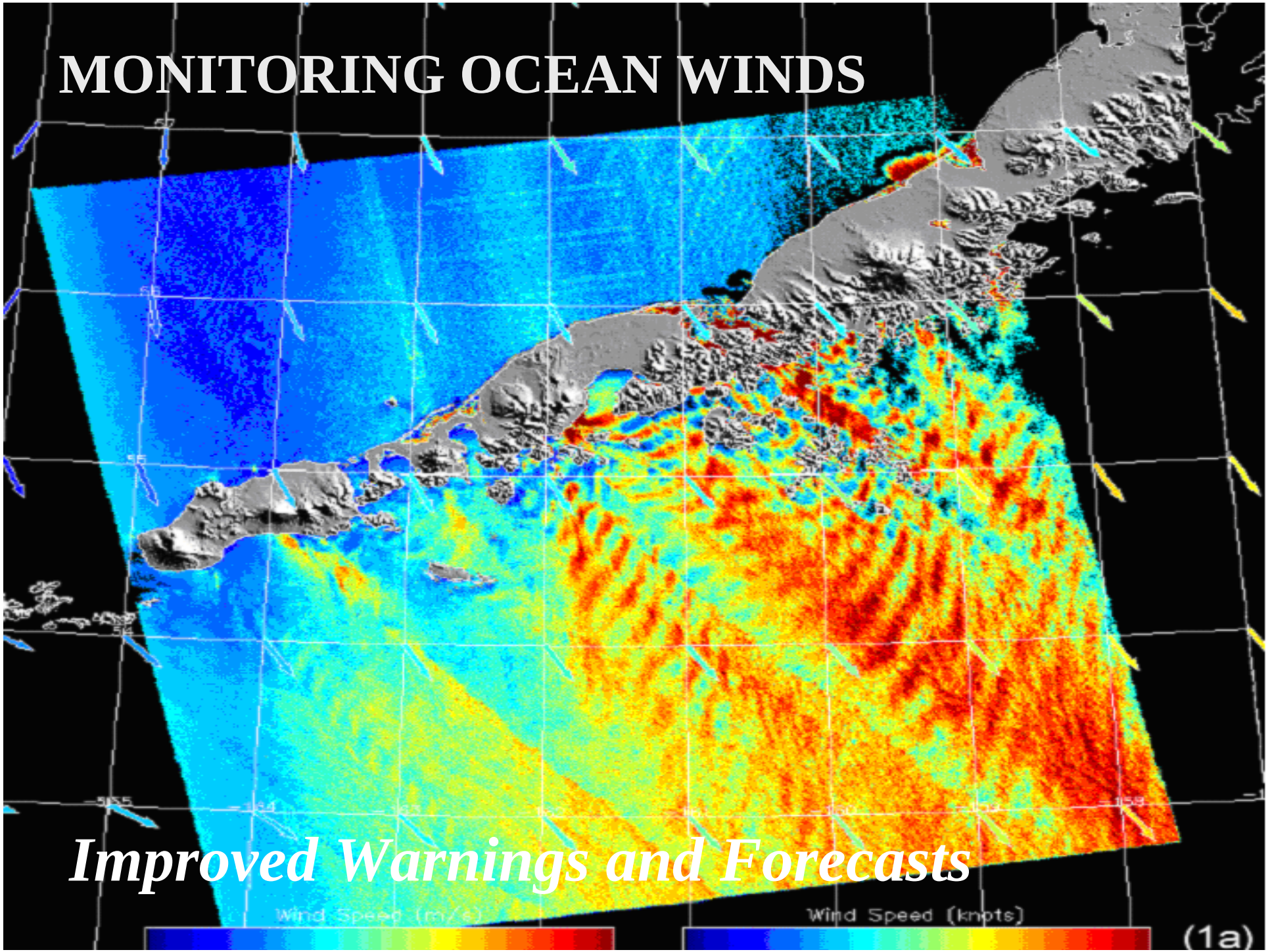
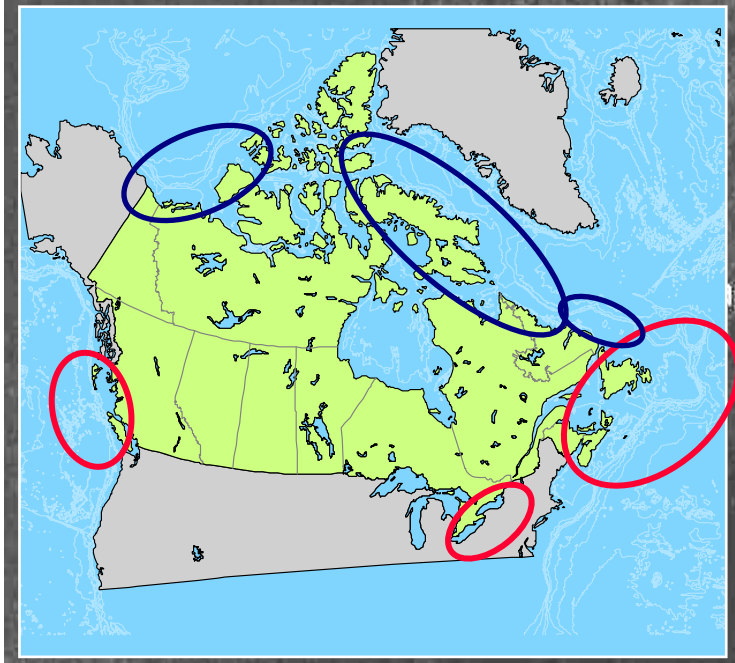

MONITORING OCEAN WINDS
Improved Warnings and Forecasts
Wind Speed (m/s)
Wind Speed (knots)
(1a)

image acquired at 10:01:24 UTC

46°03.82N
58°19.40W

Integrated Satellite Tracking of Polluters (ISTOP)



45°44.73N
57°07.90W

approx. heading = 297°

45°35.32N
56°45.33W

approx. heading = 277°

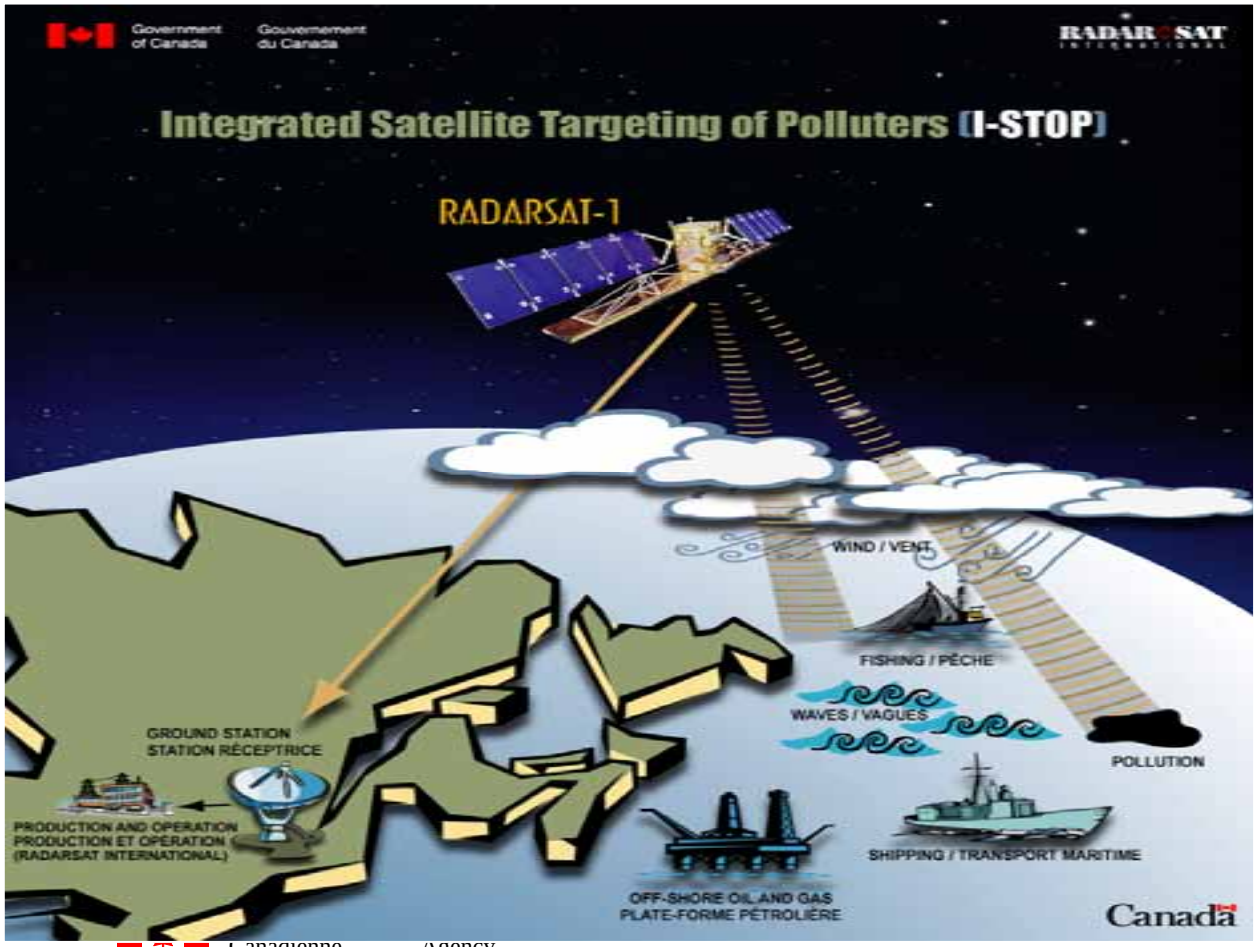
10000 0 10000 20000 Meters

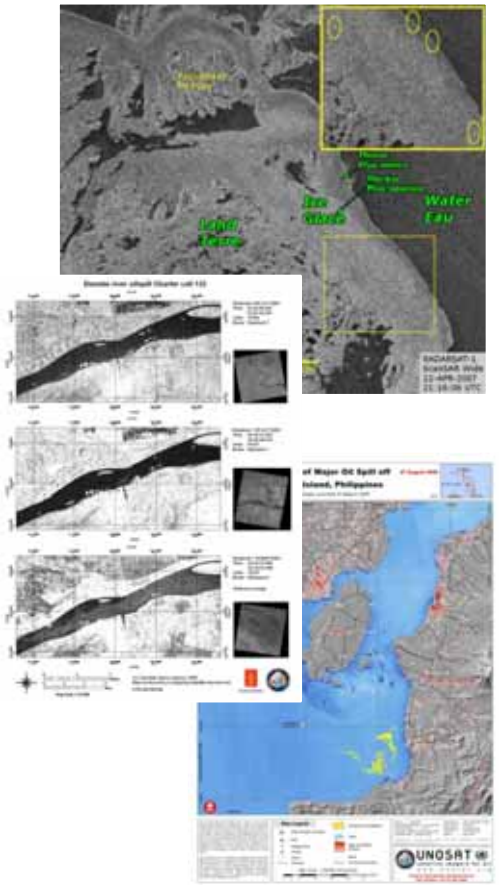
45°27.22N
56°17.02W

Monitoring illegal oil discharges in Canadian waters

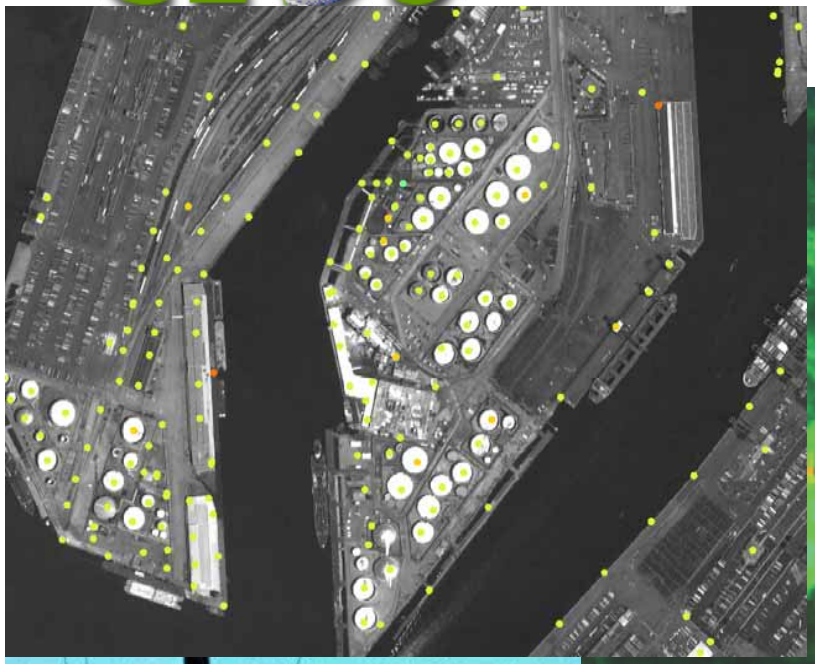
EOAU Security Initiatives / Socio-Economic Areas

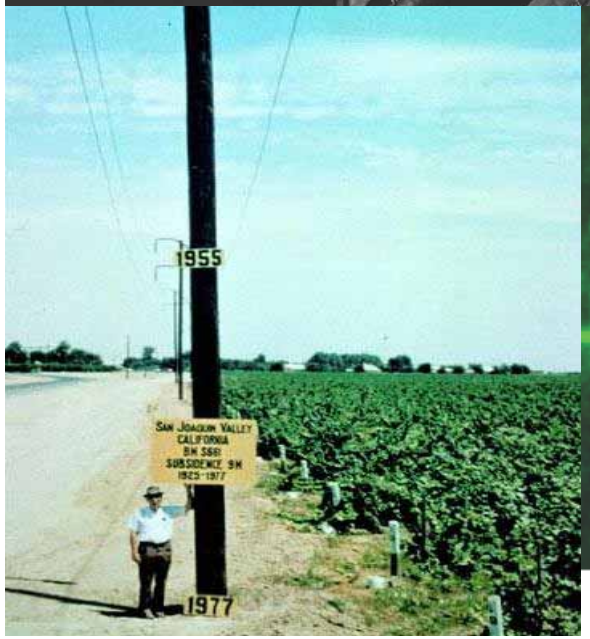
Disasters /Oil Spills

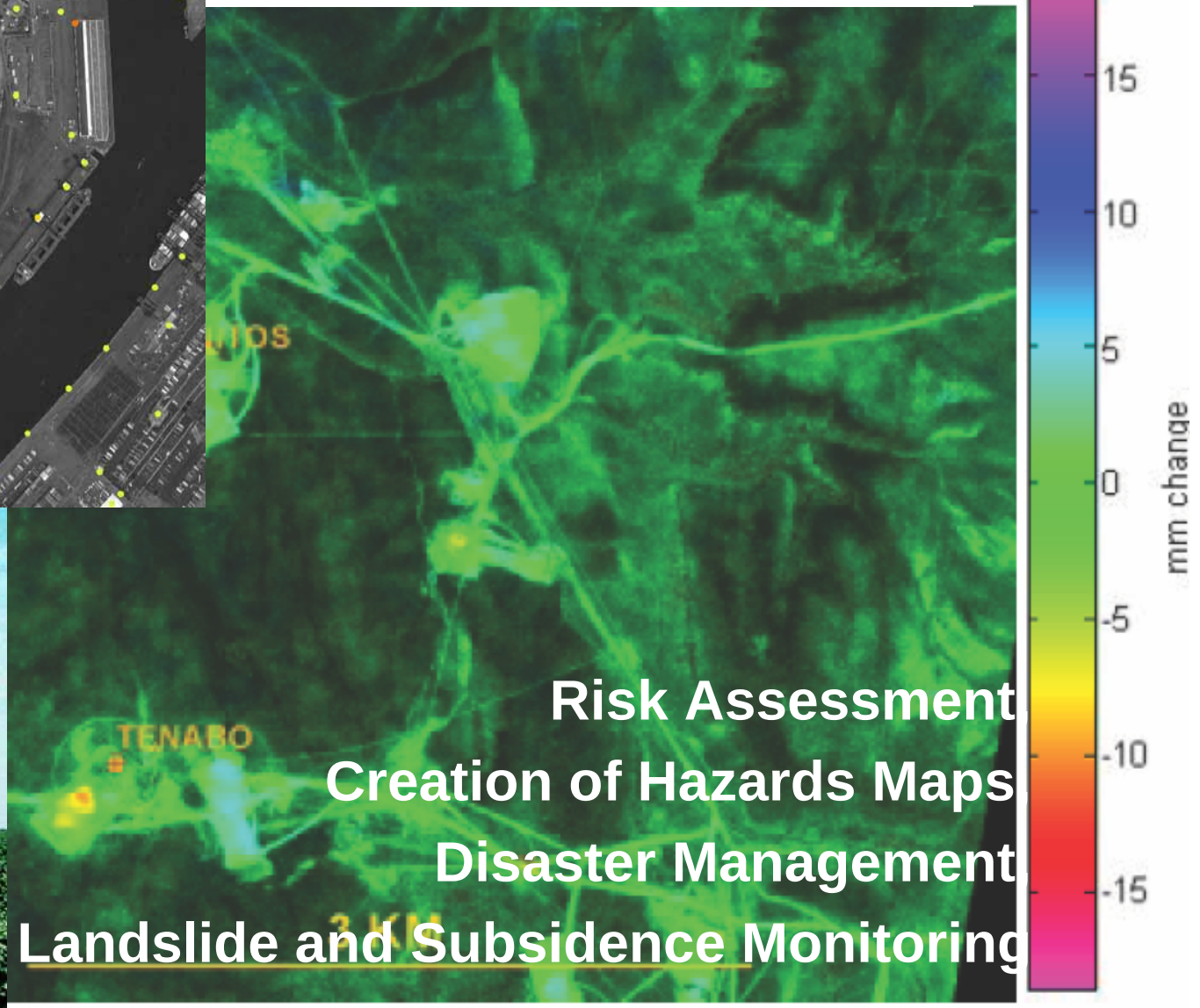




SUBSIDENCE MONITORING







Risk Assessment

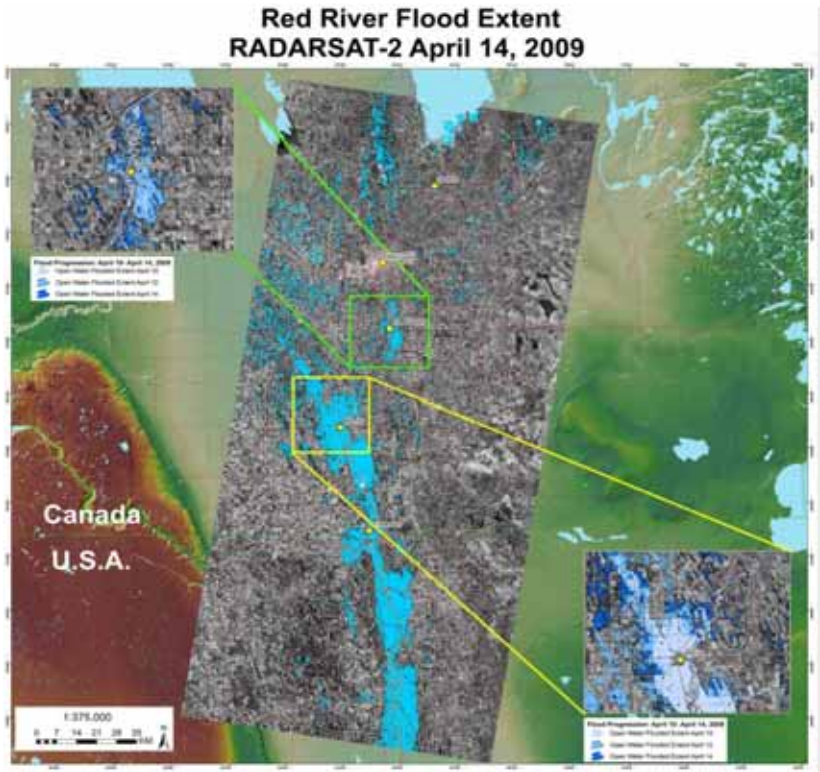
Creation of Hazards Maps

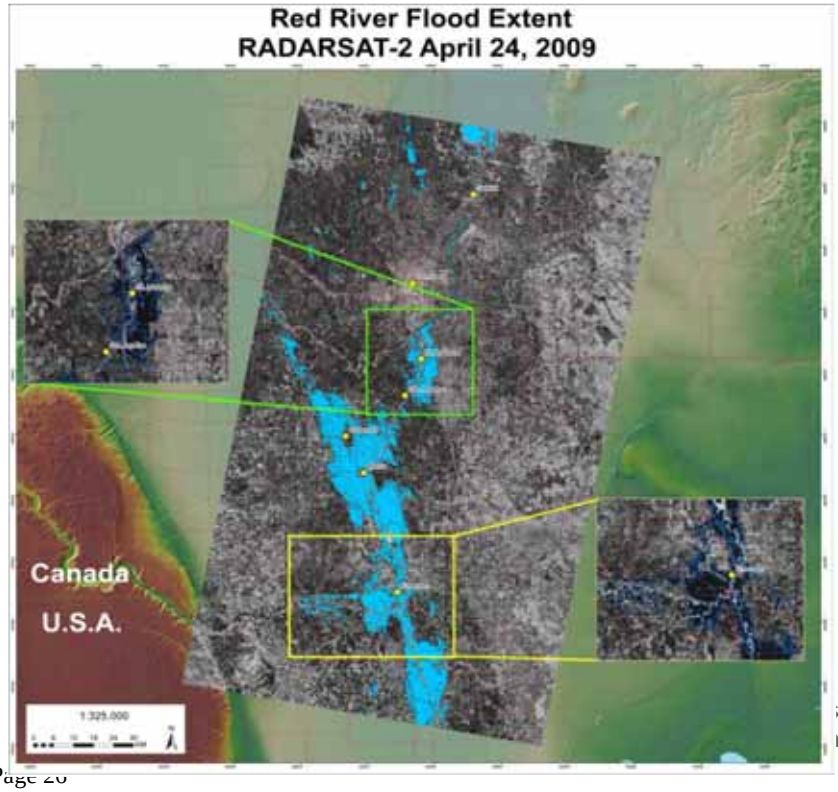
Disaster Management

Landslide and Subsidence Monitoring

CSA GRIP / Forest Sector

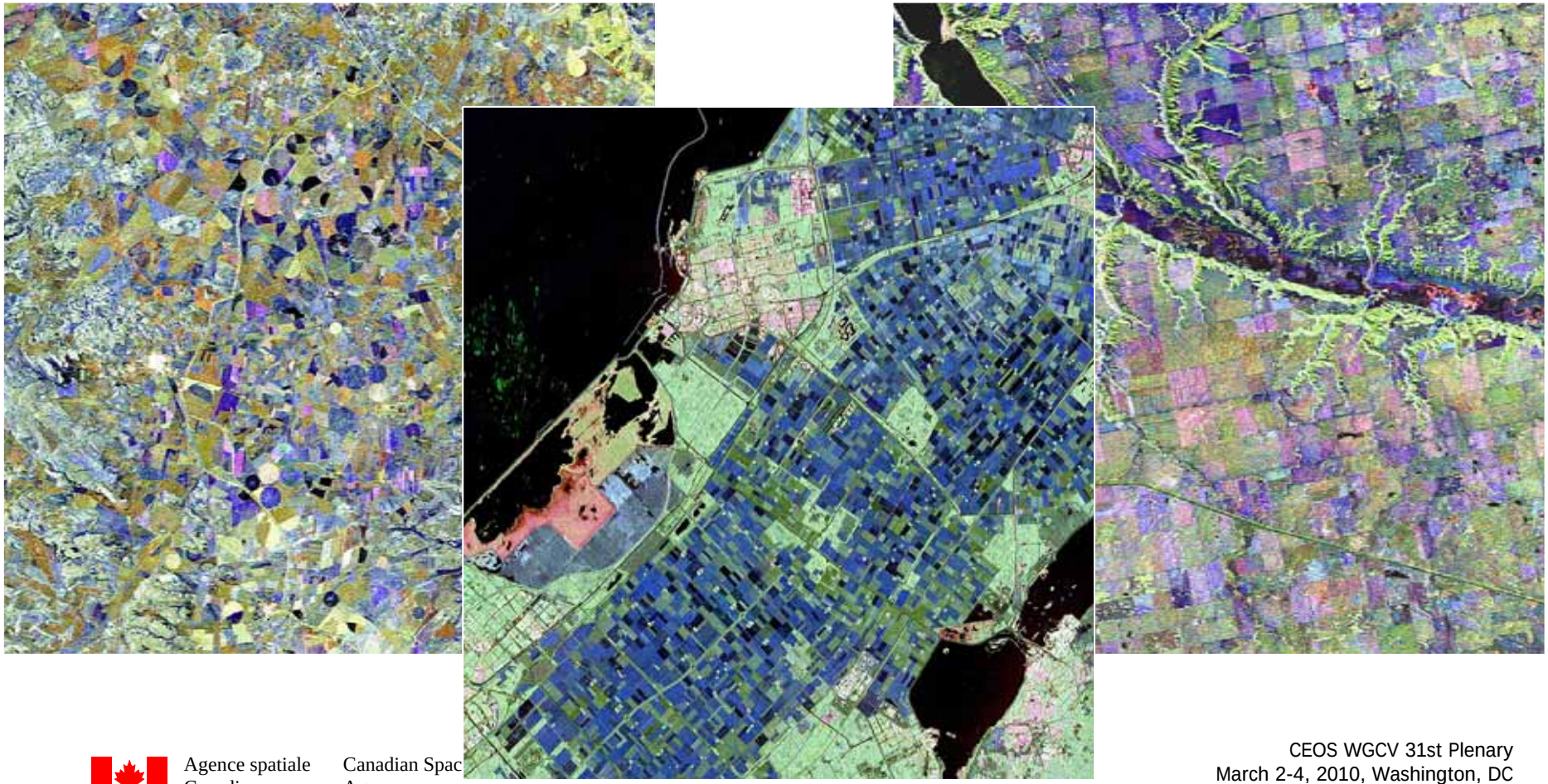
Risks (flood)





CSA EOAU Security Initiatives

Agriculture / Food Security



RADARSAT-2 polarimetric radar images acquired on April 4, 2009

Landslides:
MacKenzie Valley Pipeline

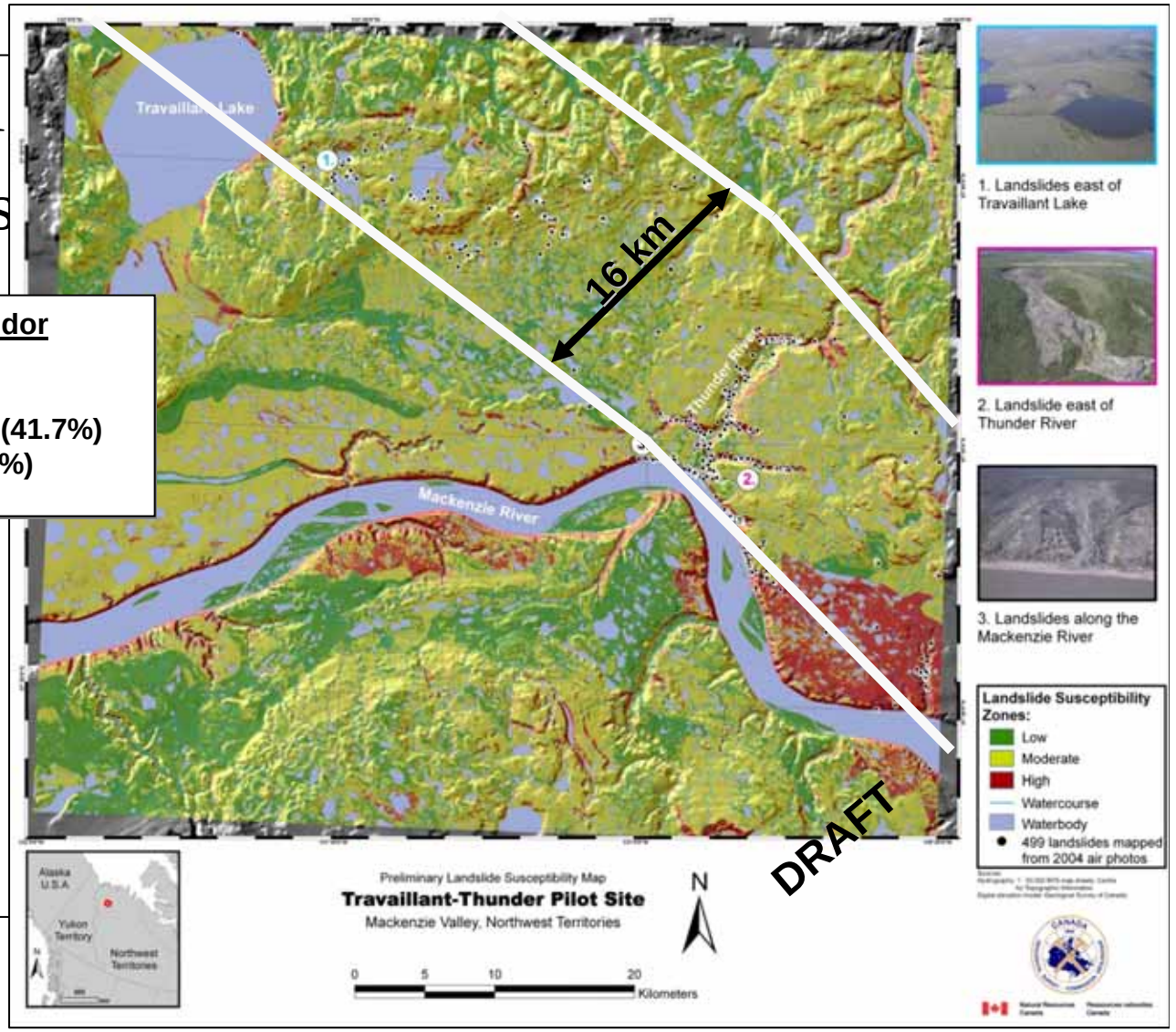
- Landslides tri
- by Permafros

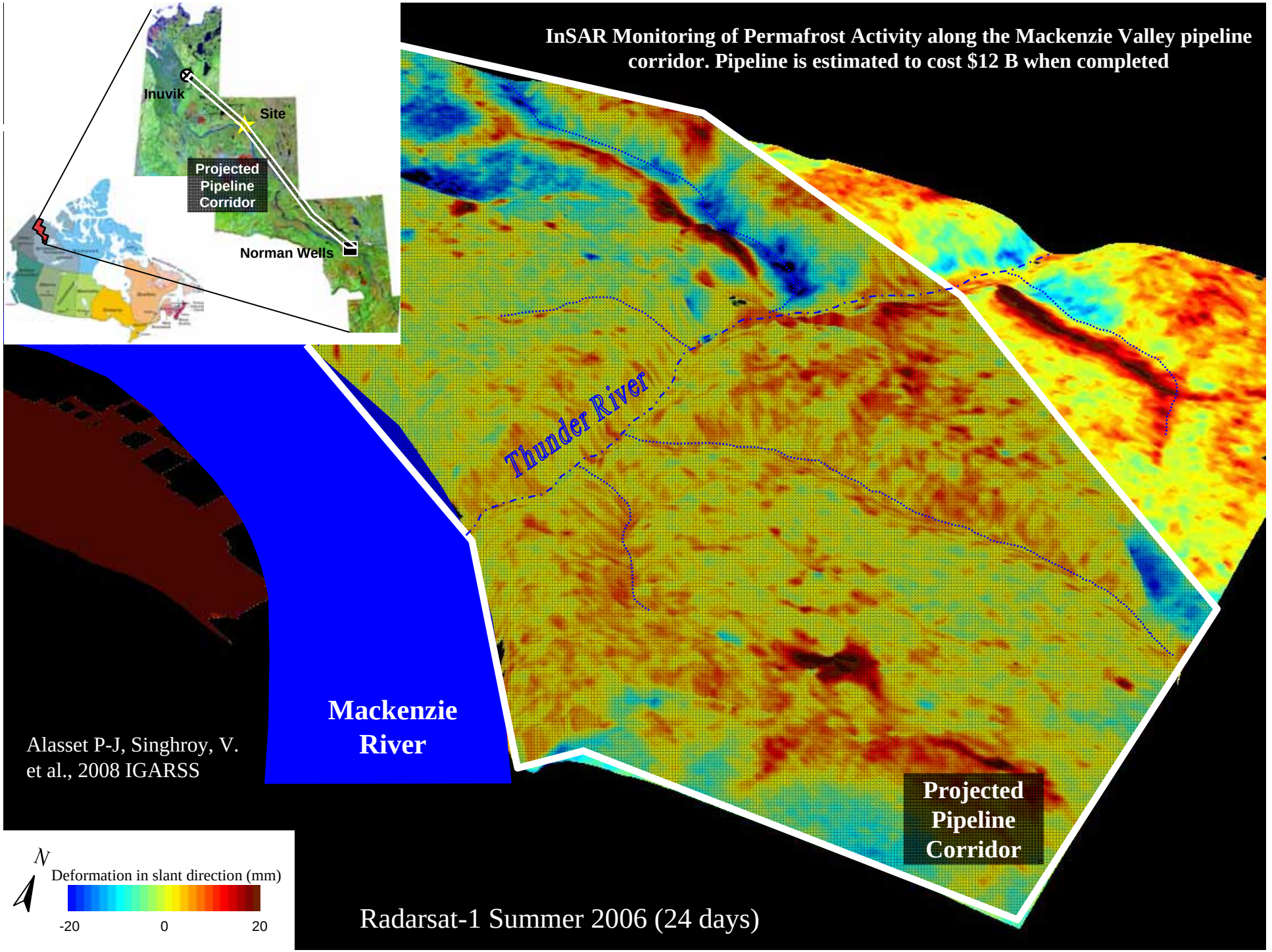
499 landslides in the pipeline corridor

- **18 landslides fall in the low LSZ (3.6%)**
- **208 landslides fall in the moderate LSZ (41.7%)**
- **273 landslides fall in the high LSZ (54.7%)**

Landslide Susceptibility Zone (LSZ)

- **Low** LSZ (20% of TTPS area)
- **Moderate** LSZ (56%)
- **High** LSZ (8%)
- **Hydrography** (16%)

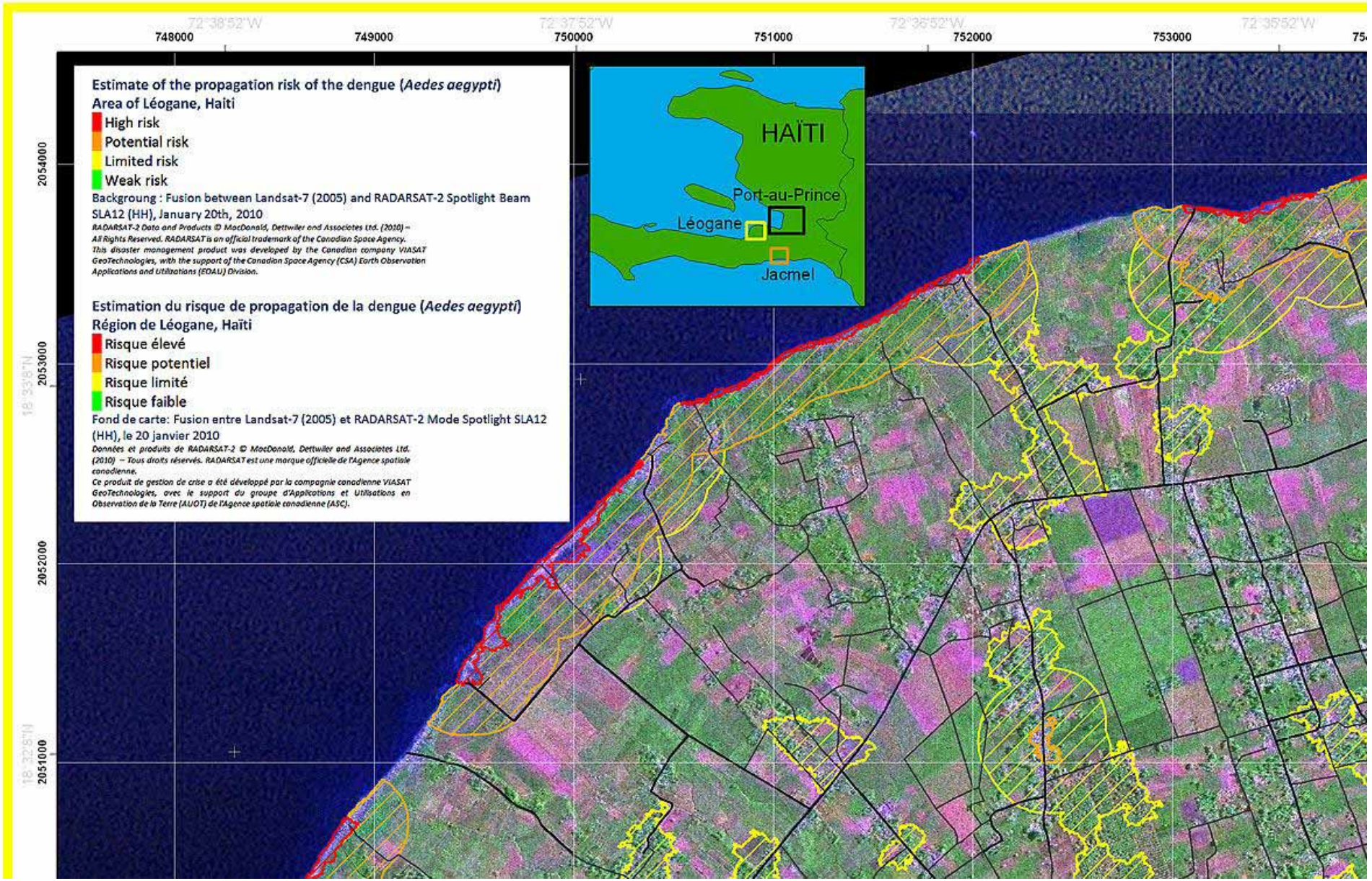



InSAR Monitoring of Permafrost Activity along the Mackenzie Valley pipeline corridor. Pipeline is estimated to cost $12 B when completed
Inuvik
Site
Projected Pipeline Corridor
Norman Wells
Thunder River
Mackenzie River
Alasset P-J, Singhroy, V. et al., 2008 IGARSS
Projected Pipeline Corridor
N
Deformation in slant direction (mm)
-20
0
20
Radarsat-1 Summer 2006 (24 days)

Northern Needs: from a Floe Edge Service Perspective

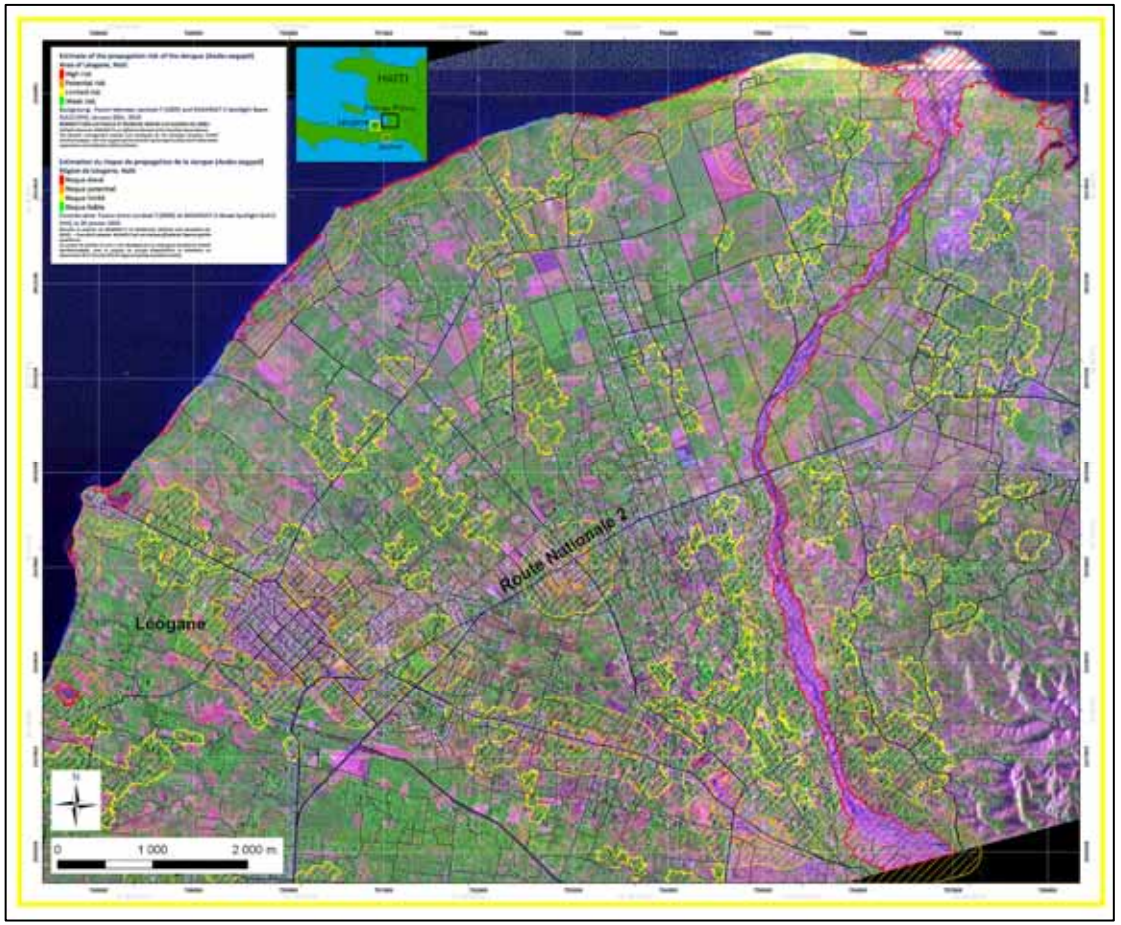
Tom Hirose (Noetix Research)

International Charter: RADARSAT-2 Image Product from 2010 Haiti Earthquake



Earthquake in Haiti

Risk estimate of the propagation of mosquitoes (Aedes aegypti) spreading the dengue fever in the Léogane region.

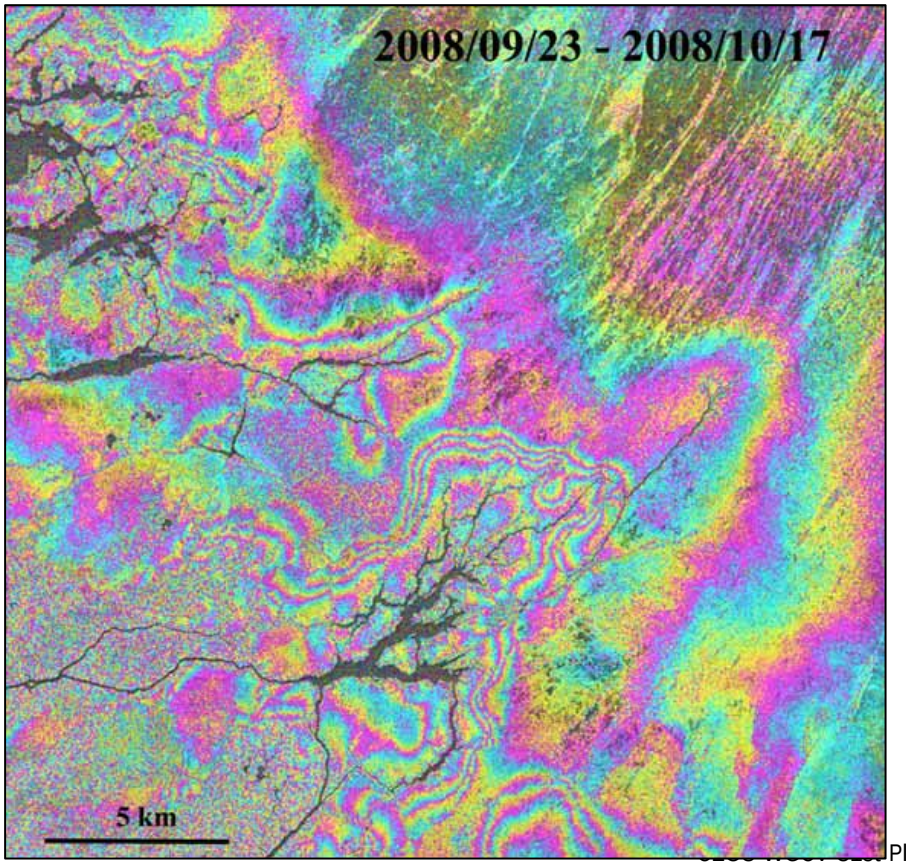


Science and Operational Applications Research (SOAR)

More than 250 projects supported, and currently being developed. Principal Investigators have an obligation to publish.

Wetland InSAR over the Everglades from space observed polarimetric data

RADARSAT-2 interferogram of western south Florida showing tide-induce water level changes along the transition between the saltwater mangrove marsh in the southwest and freshwater swamp in the northeast.

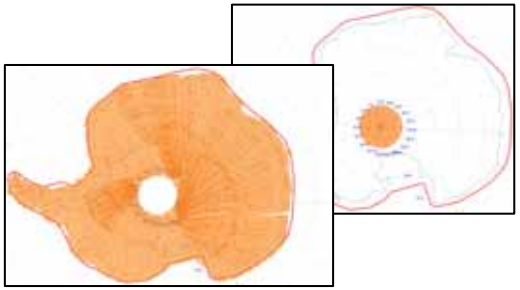


Sang-Hoon Hong and Shimon Wdowinski (U of Miami) and Sang-Wan Kim (Sejong University)

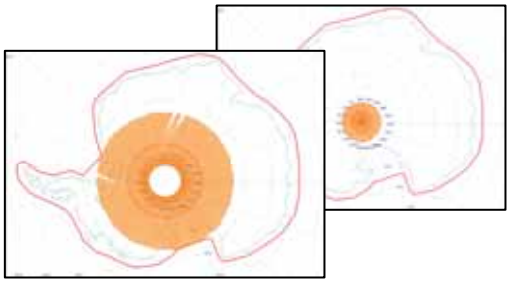
Antarctic Mapping: Background Mission

RADARSAT-2, an exceptional contribution to IPY!

- Following on the successful 1997 RADARSAT-1 campaign, RADARSAT-2 was used to capture the 2nd completed Antarctic Mosaic.
- An Antarctica Interferometric Coverage campaign was also successfully completed.

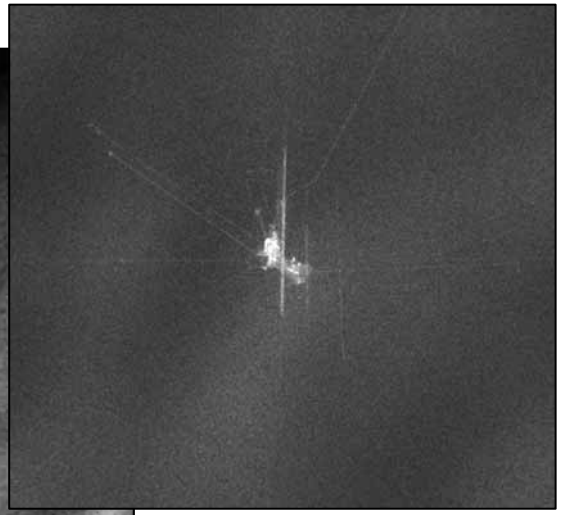


Mosaic: Wide 2 and Extended High 4



InSAR: Standard 5 and Extended High 4

Partnership with MDA and GIIPSY



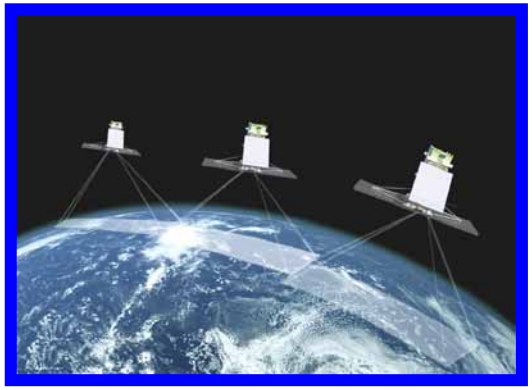
RADARSAT-2 (HH)

Extended High 4

2008-11-01

Agence spatiale Canadienne / Canadian Space Agency

RADARSAT Constellation Mission (RCM)

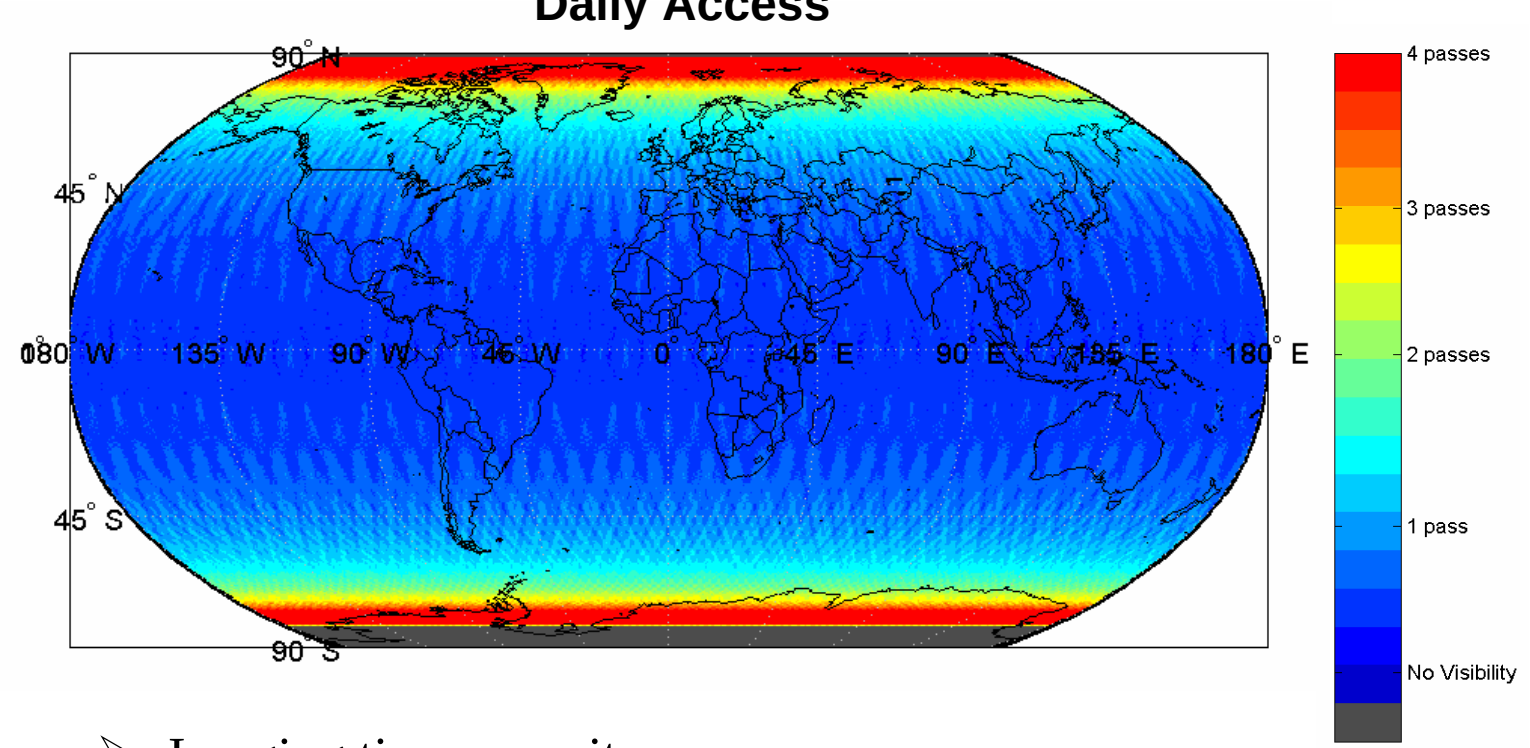


- Follow on to the RADARSAT-2 program
- Evolution toward wider operational use and higher reliability
- Provide increased coverage with daily revisit of Canada and daily access to 90% of the world
- Canadian Government owned and operated

- Three satellites with a potential of six
- Minimum daily coverage of Canadian waters and regular land coverage
- Data analyzed in near real time for operational applications
- 4-day Coherent Change Detection using SAR interferometry in between satellite
- Dual polarization data capability, with experimental quad pol and compact pol

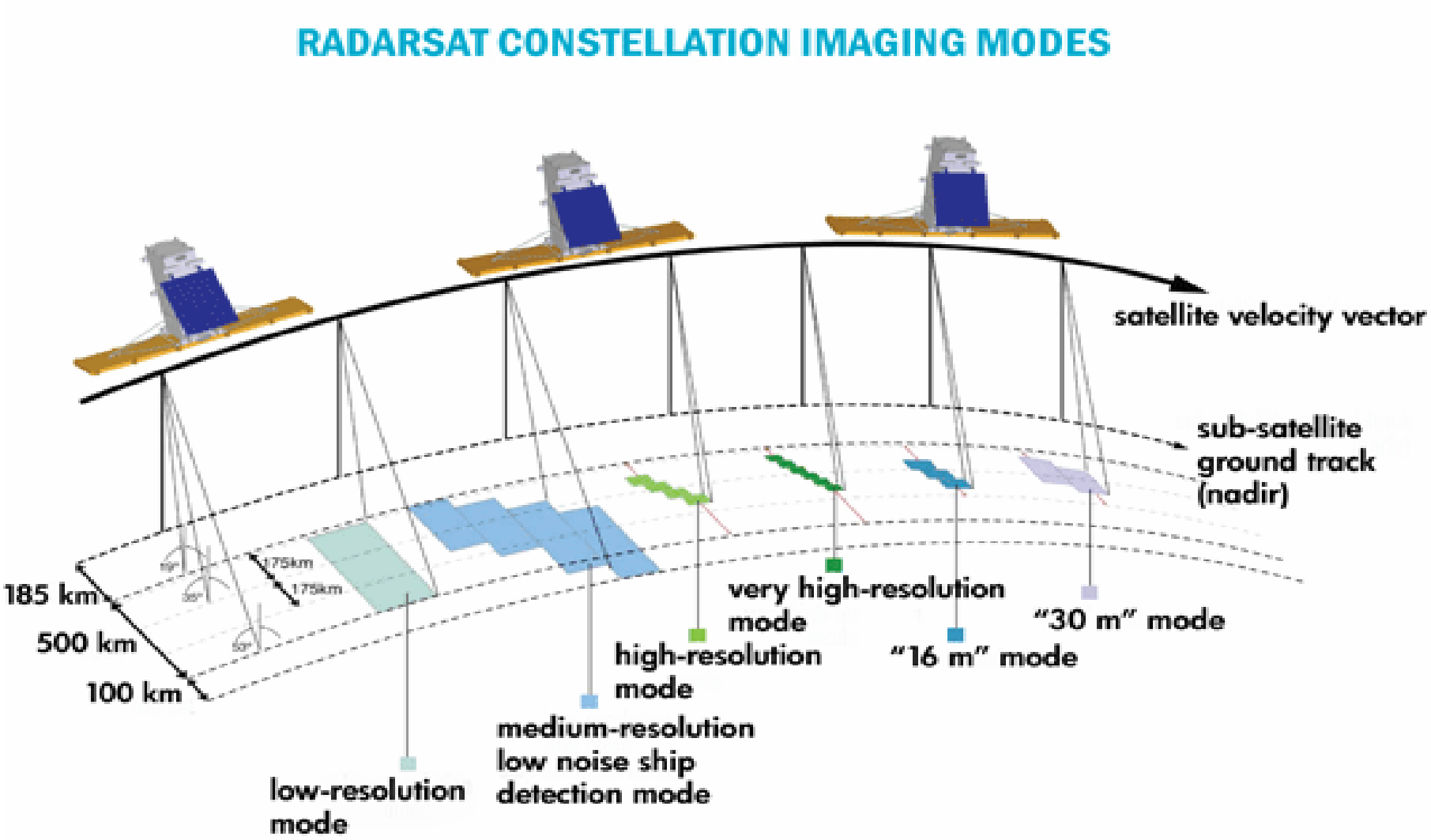
Imaging Capacity

Daily Access



- Imaging time capacity
  - 12 minutes per orbit per satellite on average
- Coverage requirements
  - Average daily coverage of marine stakeholders areas above 42 degree of latitude

Imaging Modes



Imaging Modes

Imaging Mode	Nom. Res. m	Num Looks rng x az	Nominal Swath Width (accessible) km	Min Along Track Length km	Nom-inal NESZ dB	Polarization Options								
						Single Pol				Dual Pol				Quad Pol
						HH	VV	HV	VH	HH+HV	VV+VH	HH+VV[2]	Compact	HH+VV+HV+VH
Low Resolution 100m	100	8x1	500 (500)	10	-22	✓	✓	✓	✓	✓	✓	✓	✓	
Medium Resolution 50m	50	4x1	350 (500)	10	-22	✓	✓	✓	✓	✓	✓	✓	✓	
Medium Resolution 16m	16	1x4	30 (350)	10	-25	✓	✓	✓	✓	✓	✓		✓	
Medium Resolution 30m	30	2x2	125 (350)	10	-24	✓	✓	✓	✓	✓	✓		✓	
High Resolution 5m	5	1	30 (500)	10	-19	✓	✓	✓	✓	✓	✓	✓	✓	
Very High Resolution 3m	3 @35°	1	20 (500)	10	-17	✓	✓	✓	✓	✓	✓	✓	✓	
Low Noise	100	4x2	350 (500)	10	-25	✓	✓	✓	✓	✓	✓		✓	
Ship Detection	var.	var.	350 (600)	10	var.	✓	✓	✓	✓	✓	✓		✓	
Quad-Polarization	NR[1]	NR[1]	> 20 (NR[1])	10	NR[1]									✓
Spotlight	1 (az) x 3 (grd) @35°	1	5 (350) *Goal*: 8 (350)	5	-17	✓	✓	✓	✓	✓	✓		✓	

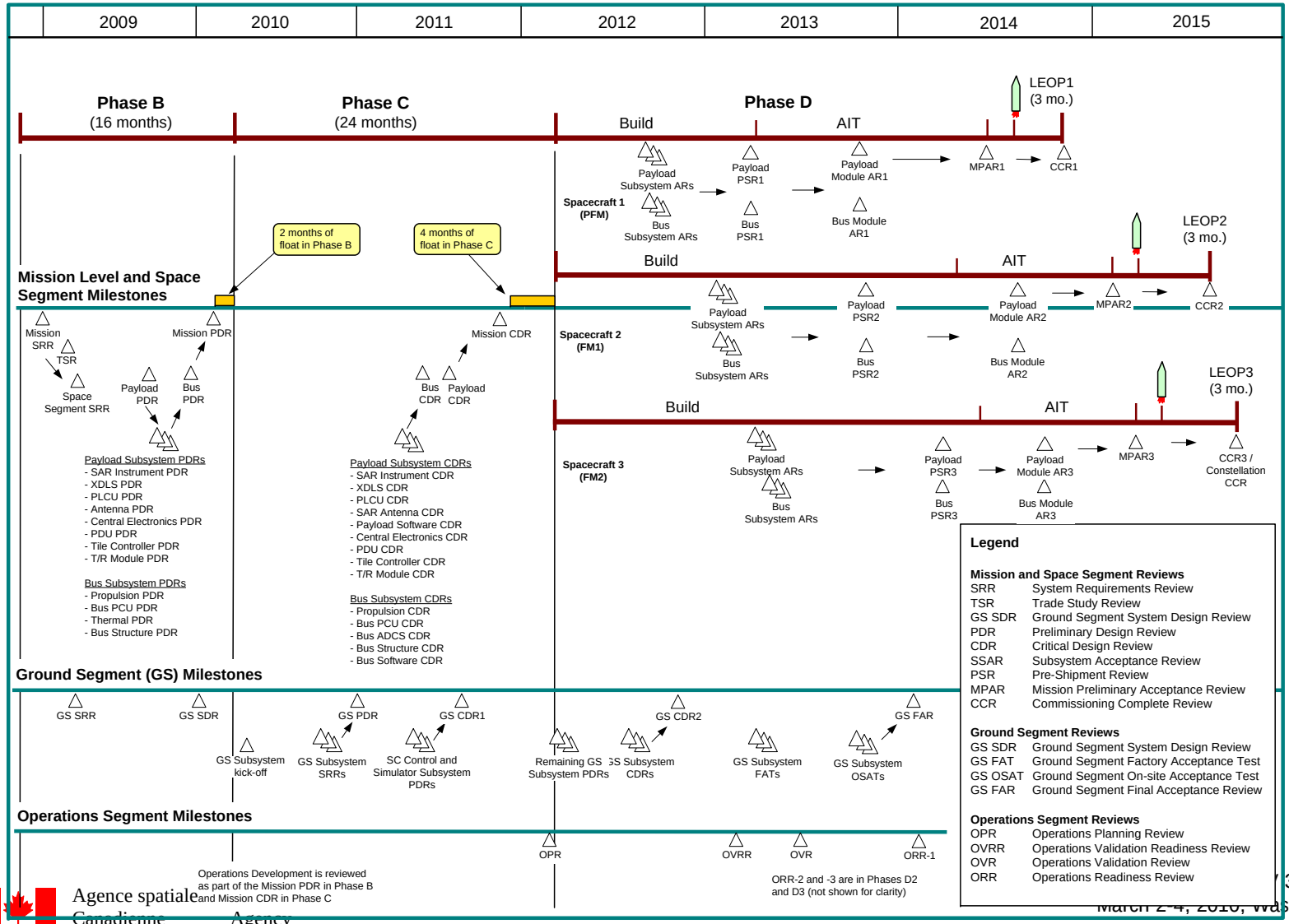
[1] Quad-Pol: No requirement specified

[2] HH-VV: The resolution, swath, or number of looks in dual HH-VV polarization modes will be degraded compared to single-polarization acquisitions

Benefits to Canadian Users

- **C-band continuity**
  - Critical for current operational SAR-based applications like ice and oil pollution
- **Redundancy**
  - Marine apps no longer dependent on one SAR in orbit → multiple satellites adds robustness
- **Complete coverage of Canadian coastal waters**
  - More complete monitoring – ice, oil, ships, and wind
  - Reduction in aircraft hours currently used to fill daily satellite coverage gaps
- **High frequency of coverage in Arctic**
  - Supports better estimation of ice dynamics, marine winds, and ship movements
- **Fast turnaround of imagery**
  - Improve ship detection and oil pollution monitoring for enforcement
- **Standard Coverage approach**
  - Reduce planning overhead associated with swath-based ordering
  - Decrease conflicts amongst users
- **New polarization capabilities (i.e. Compact Polarimetry)**
  - Potential to provide new and more reliable information over large regional areas

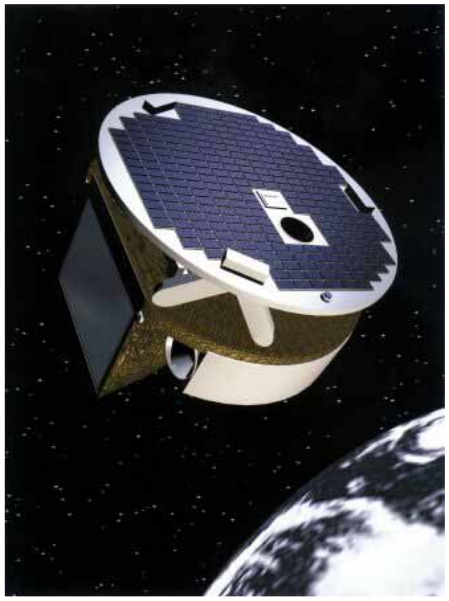
RCM Master Schedule



SCISAT Program Status (1)

- Launched in August 2003, SCISAT satellite measures numerous trace gases, thin clouds and aerosols in the stratosphere, thereby enabling a more comprehensive understanding of the several chemical processes that play a role in stratospheric ozone depletion

- CSA has approved continuation of SCISAT operation for three more years (until March 31, 2012)



SCISAT

SCISAT Program Status (2)

- Capacity to receive science data was augmented from 1.1 GB (GBytes) to 3.0 GB per day by employing two Canadian stations and those of US and European partners
- Since the beginning of this fiscal year alone, i.e., for the period: Apr. 1, 2009 – Dec 30, 2009, amount of science data collected was more than 790 GB and will exceed 1 TB for the complete fiscal year
- Data routinely being provided to the science team. Intensive data analyses by scientists have produced a number of new results that have been disseminated at international scientific conferences and through the publication of peer-reviewed scientific papers