CSA Report on Earth Observation

Presented at
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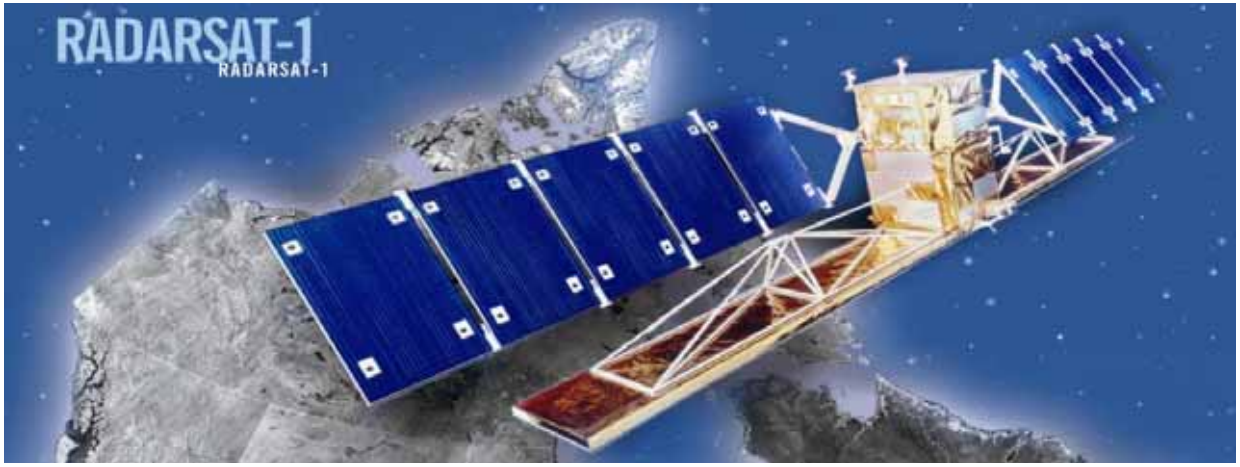
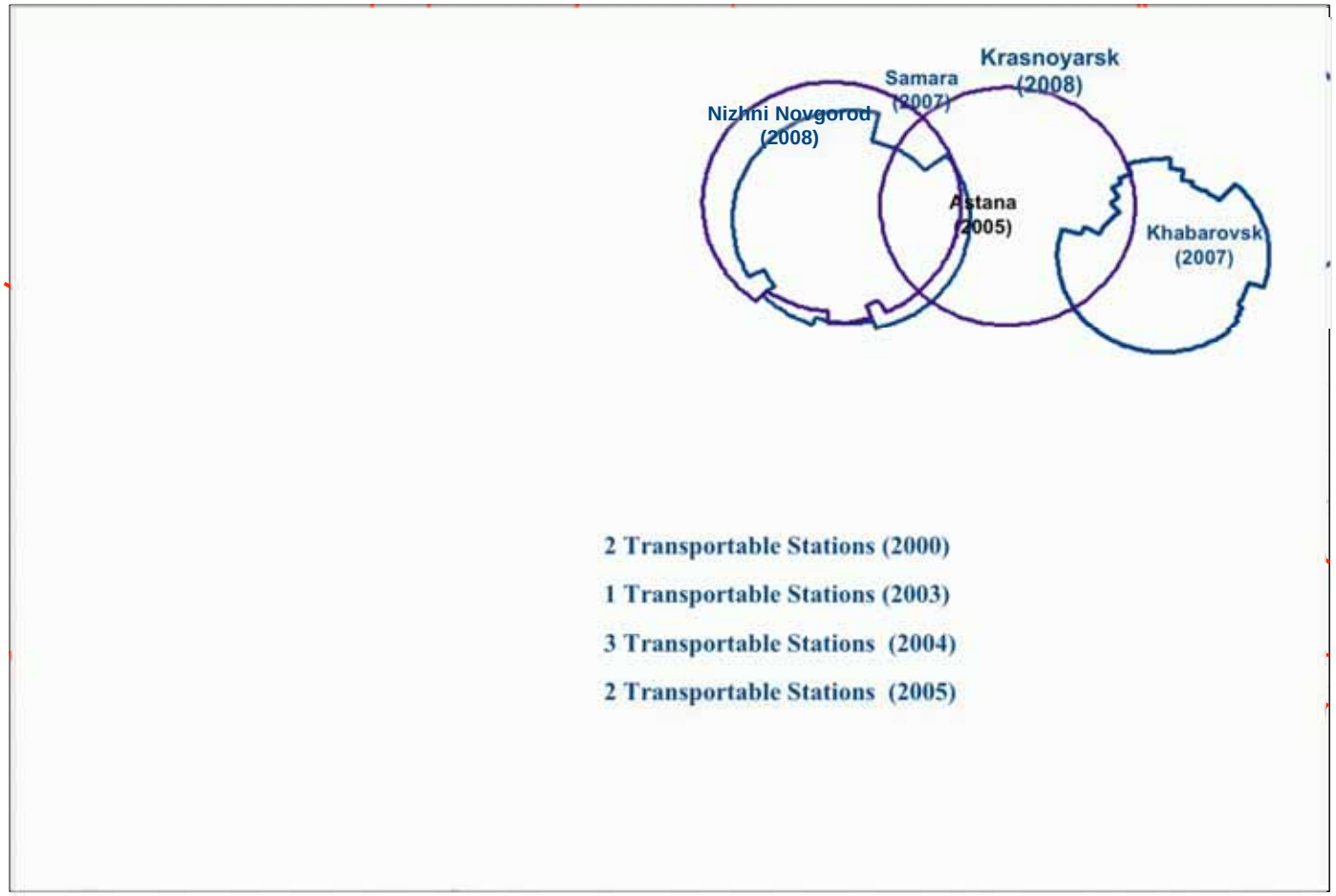
Canadian Space Agency

RADARSAT-1 Program Status (1)

- Running in 13th year of operation
- Data received and processed at 40 ground stations with 27 archive facilities globally
- As of September 1, 2008, completed 66,960 orbits, planned 311,436 user requests corresponding to a total acquisition of 601,439 minutes of SAR data
- Average system performance maintained better than 95%



RADARSAT-1 Reception Coverage



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

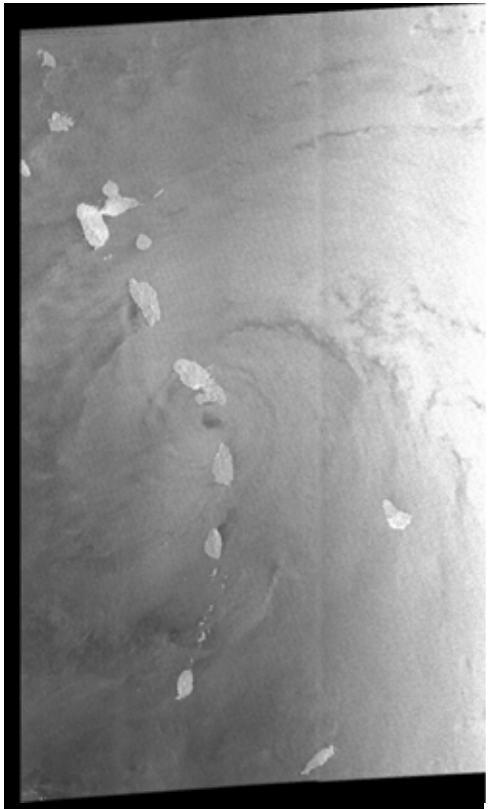
- Data Reception Facilities: 40 (including 8 transportable stations)
- Data Archiving Facilities: 27
- Under certification: 1

RADARSAT-1 Program Status (2)

- As a member of International Charter Space and Major Disasters, provided **493** RADARSAT-1 images for **141** 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 Canadian site-specific acquisitions:
    - Natural Hazards
    - Environment
  - Polar Regions
    - Seasonal coverage of Arctic Basin
    - Effects of climate changes
  - Environmental Watch
    - Disaster Watch
    - Hurricane Watch

RADARSAT-1 Program Status (3)
Special projects: Hurricane Watch

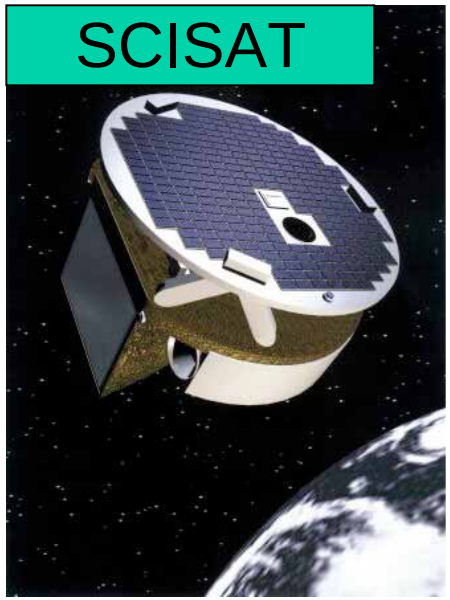
- Program started in 1999, operates from June 1st to November 30th
- Hurricane Watch monitors North Eastern Atlantic, North Eastern & North Western Pacific regions to acquire RADARSAT-1 data of tropical cyclones
- Unique archives: 598 Hurricane Watch images submitted, 221 images captured eye or edge of cyclones
- ***Innovative research and development of applications using RADARSAT-1 Hurricane SAR data:*** Letters of Interest submitted to CSA by Investigators currently being reviewed by CSA for the CSA Announcement of Opportunity (AO) to give access to 160 images from archives to the scientific community



Hurricane Dean 17 Aug 07, 09:53 UTC, Lesser Antilles, Caribbean

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

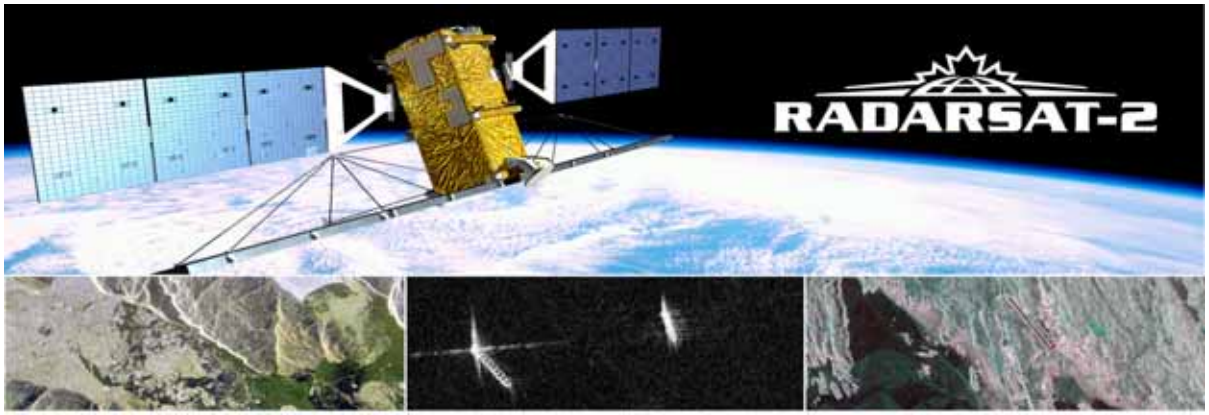


SCISAT Program Status (2)

- Capacity to receive science data was augmented from 1.1 GB (GBytes) to 2.9 GB per day by employing two Canadian stations and those of US and European partners
- In present fiscal year alone for the period: Apr. 1, 2008 – Aug. 31, 2008, amounts of science data collected were: FTS: 292.3 GB, Imager: 42.5 GB, MAESTRO: 10.9 GB
- 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

RADARSAT-1 and SCISAT Programs

- Funding in place to continue operations of both RADARSAT-1 and SCISAT until 31st March 2009
- A submission has been made to the CSA Executive Committee to fund the two operations for three more years
- CSA's decision is expected in October, 2008

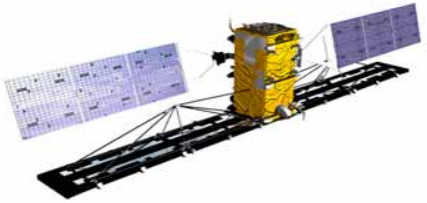


RADARSAT-2 Program

RADARSAT-2 Program Overview

- MDA is the owner and operator of RADARSAT-2 and holds the the worldwide distribution rights for all products
- Co-funded by the Canadian Space Agency (CSA) against pre-purchase of data for use by departments of the Government of Canada and for their joint or sponsored projects with university, industry and other institutions
- Data continuity from RADARSAT-1
  - all RADARSAT-1 imaging modes supported
  - plus many additional capabilities
- Designed Mission Life: 7 Years
- Launched: December 14, 2007
- Operational: April 25, 2008

System Capabilities Comparison



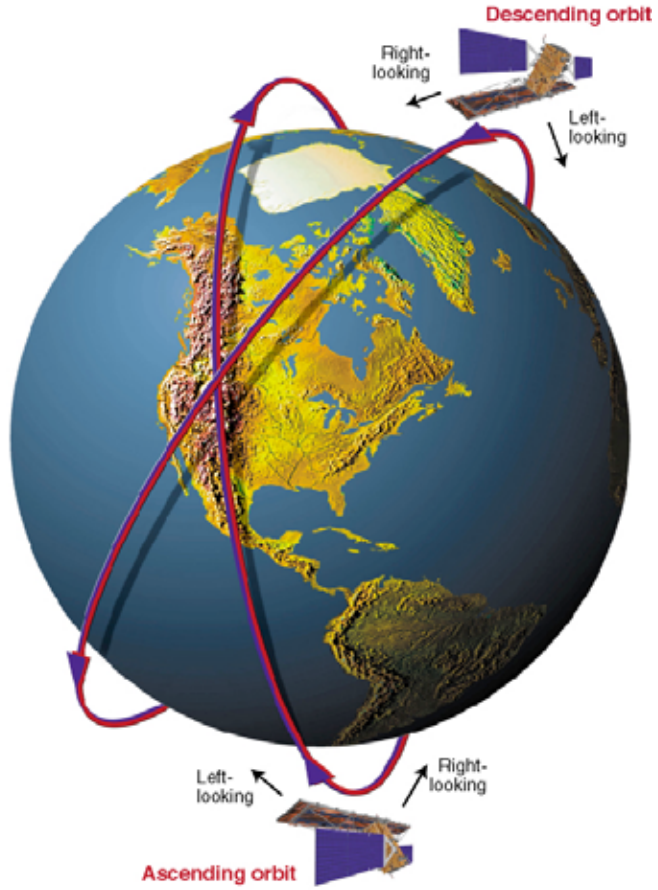
	RADARSAT-1	RADARSAT-2
Mass at Launch	2750 kg	2280 kg
Design Life	5 years	7 years
On-board Recording	Tape recorder	Solid-state recorder
Spacecraft Location	S/C ranging	GPS on-board
Imaging Frequency	C-Band, 5.3 GHz	C-Band, 5.405 GHz
Spatial Resolution	10 to 100 metres	1 to 100 metres
Polarization	HH	HH, HV, VV and VH
Look Direction	Right-looking	Routine left-and right-looking

Orbit Parameters

RADARSAT-2 operates in an orbit identical as RADARSAT-1 except for a 180º offset in time

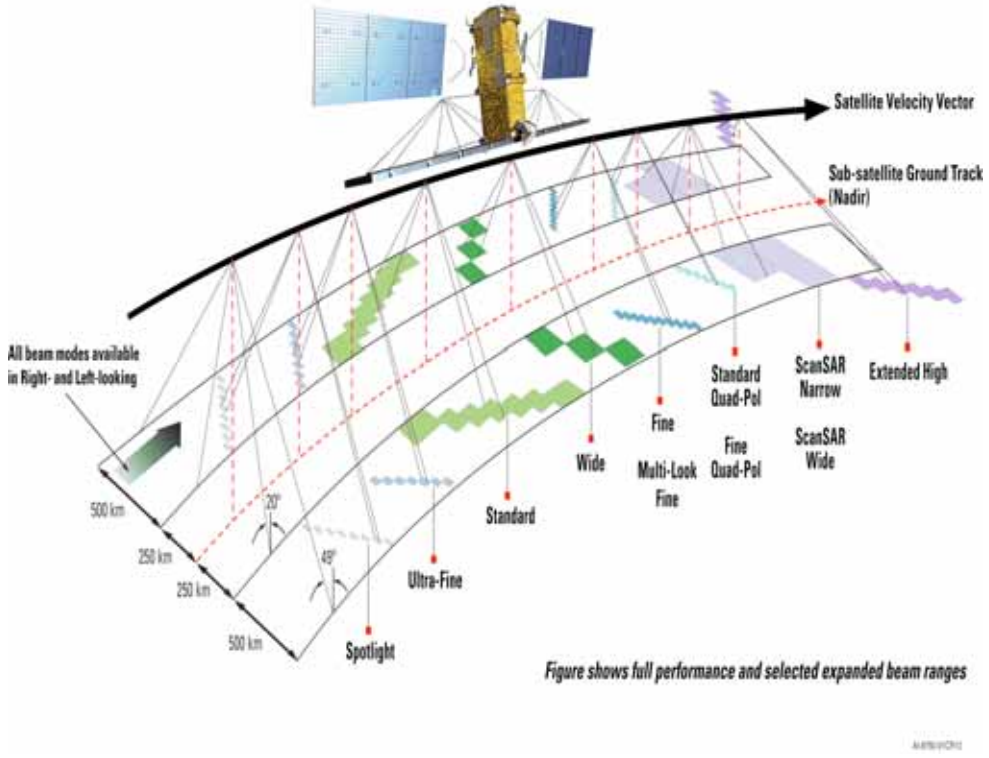
ORBIT CHARACTERISTICS	
Altitude (average)	798 km
Inclination	98.6 degrees
Period	100.7 minutes
Ascending node	18 hrs (± 15 min)
Sun-synchronous	14 orbits per day
Repeat cycle	24 days

COVERAGE ACCESS USING 500 KM SWATH WIDTH	
North of 70°	Daily
North of 48°	Every 1-2 days
Equator	Every 2-3 days

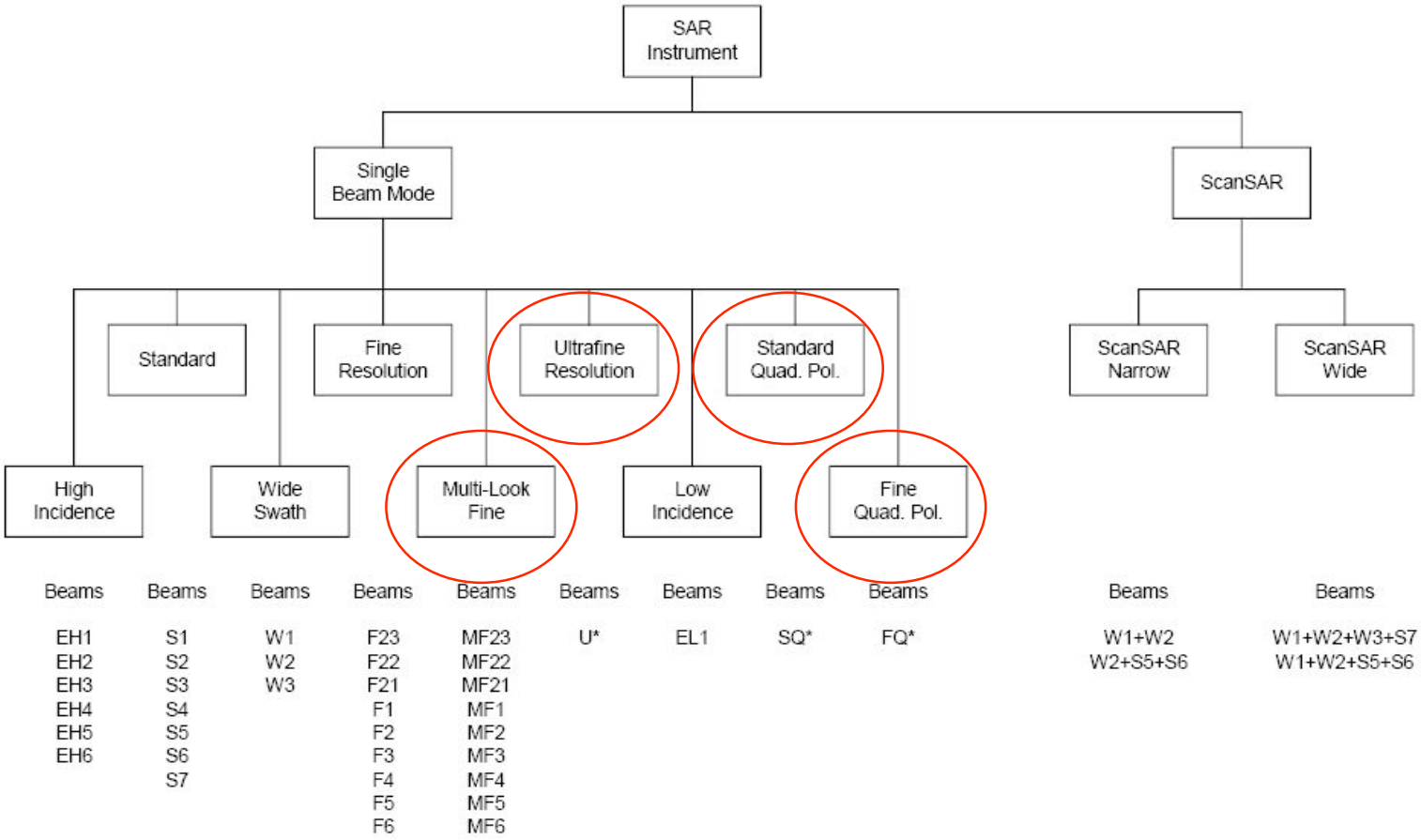


RADARSAT-2 Features

- 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 Modes

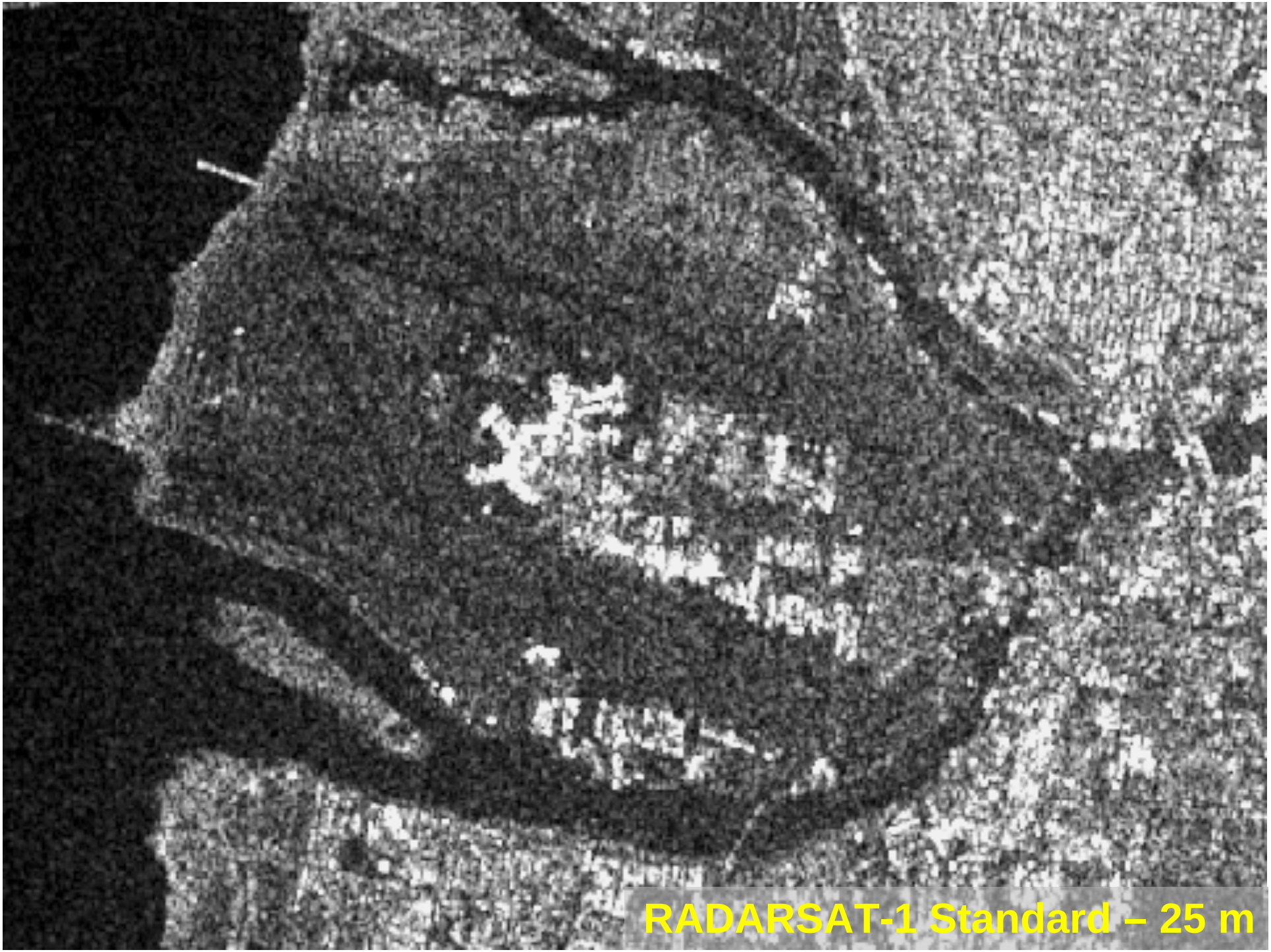


RADARSAT-2 Imaging Parameters

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

Image Quality Status

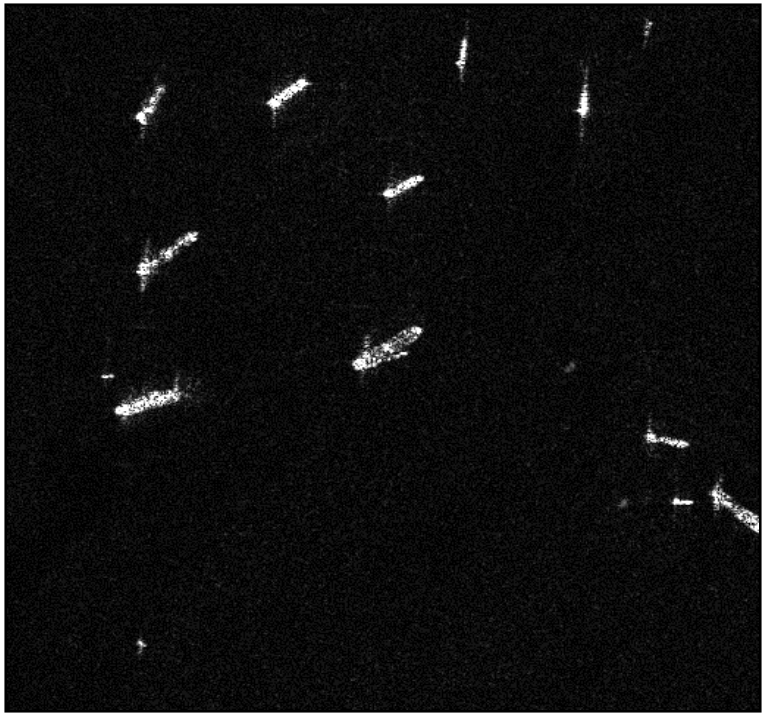
- All imaging modes except Spotlight are available for operational use
- Geo-location accuracy for all single beam modes is better than 50m
- Dual-Pol
  - All these modes are radiometrically calibrated for both left- and right-looking imaging
  - All impulse response measures (including resolution) are better than specification
  - The noise floor is several dB lower than for equivalent RADARSAT-1 modes
  - ScanSAR images essentially free of visible beam boundaries and “scalloping”
- Quad-Pol
  - Channel registration checks consistently show registration to better than 1% of a pixel in each dimension after correction
  - Largest cross-pol leakage term (after correction) <-35dB
  - Relative inter-channel phase error after correction <4º
  - Relative inter-channel amplitude error after correction <0.4dB


RADARSAT-1 Standard – 25 m

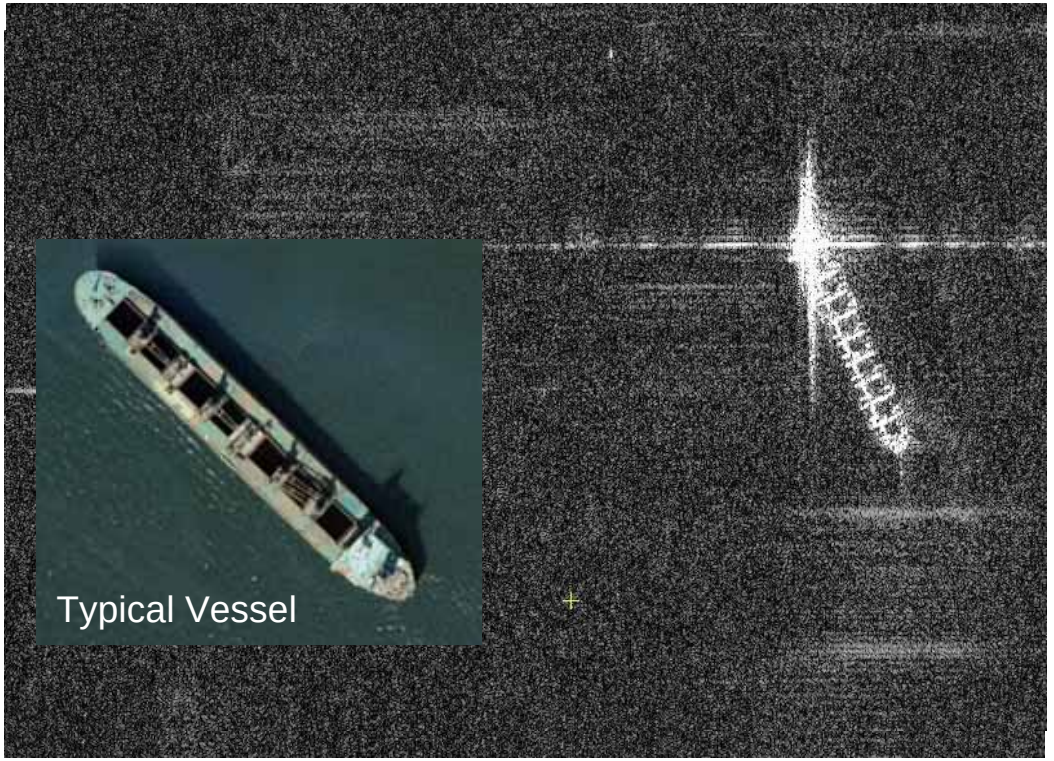
RADARSAT-1 Fine – 10 m

RADARSAT-2 Multi-look Fine – 10 m

RADARSAT-2 Ultra- Fine – 3 m

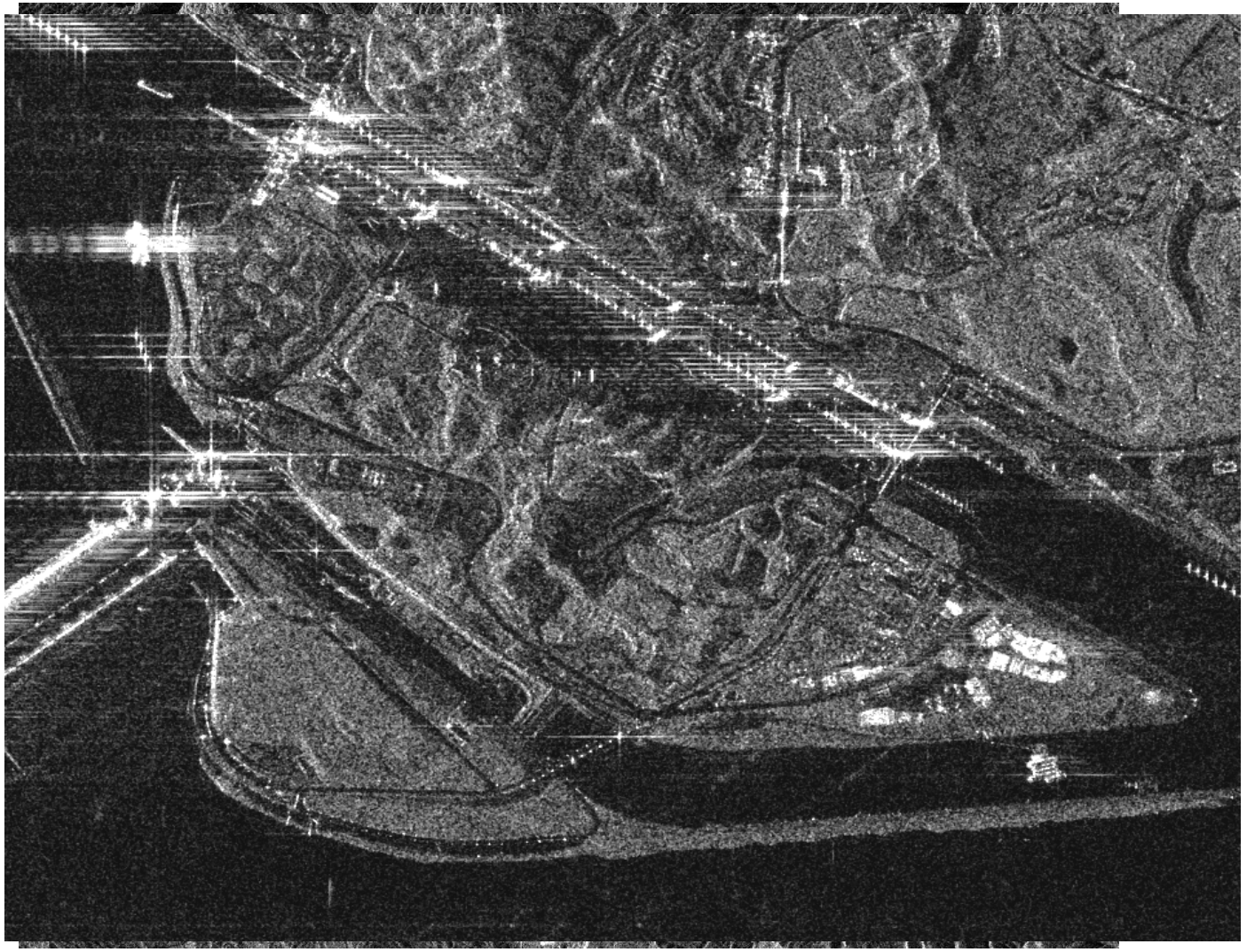


RADARSAT-1 Fine
January 8, 1996
Singapore harbour



RADARSAT-2 UltraFine, January 8, 2008
Vancouver harbour

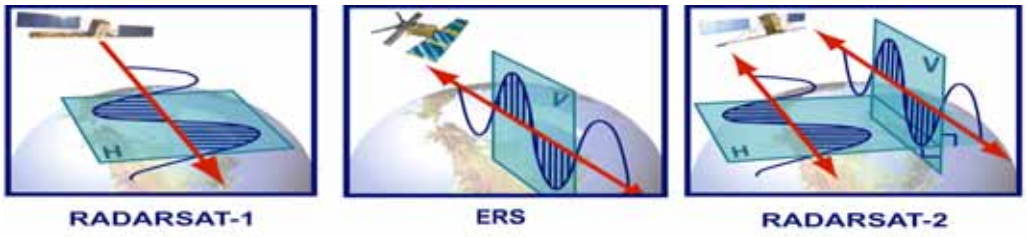
Dam Good Imagery



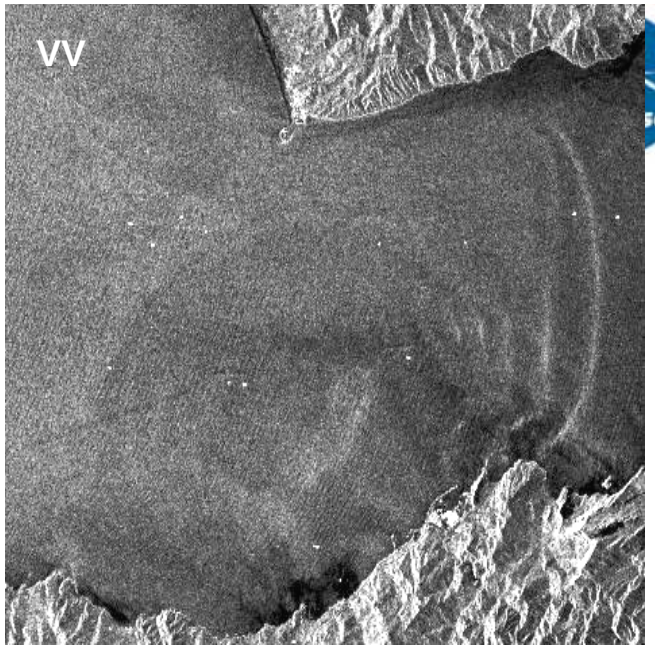
Three Gorges Dam, May 2008, UF 22

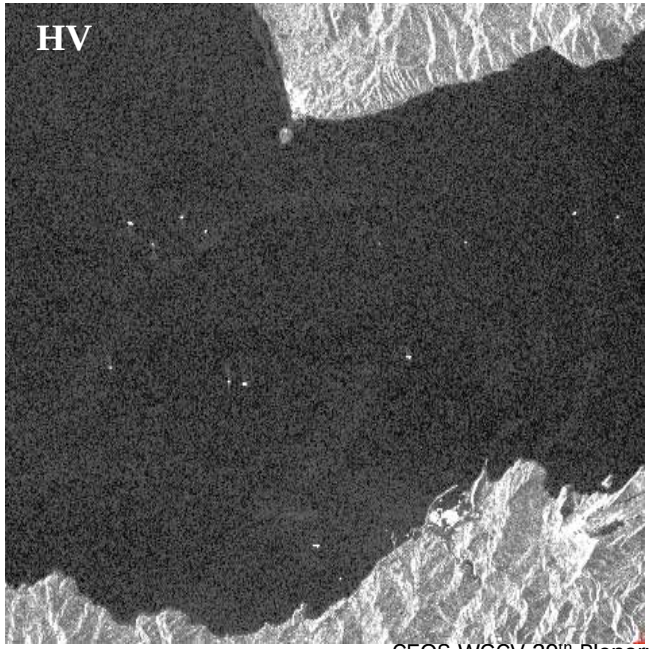
Polarization Concept

- For imaging radar applications, the polarization state of the radar wave is defined with-respect-to the Earth's surface
- Co-polarized: transmit/receive **horizontal** or **vertical** (HH or VV)
- Cross-polarized:
  - transmit **horizontal**, receive **vertical** (HV)
  - transmit **vertical**, receive **horizontal** (VH)



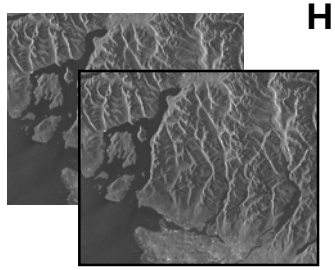
RADARSAT-1 ERS RADARSAT-2





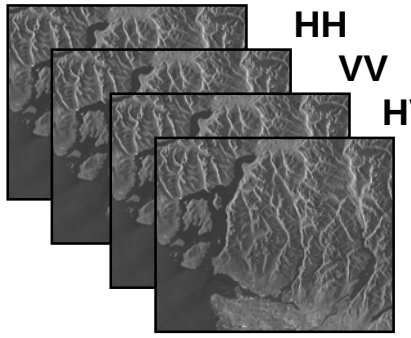
RADARSAT-2 Image Products

Beam Mode	
Selective Polarization transmit H or V receive H and / or V	Fine Standard Low Incidence High Incidence Wide ScanSAR Narrow ScanSAR Wide
Polarimetric transmit H and V on alternate pulses receive H and V simultaneously	Fine Quad-Pol Standard Quad-Pol
Selective Single Polarization transmit H or V receive H or V	Ultra-fine Multi-Look Fine



HH + HV

VV + VH

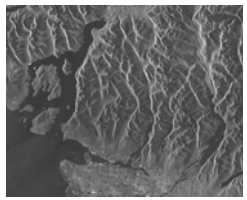


HH

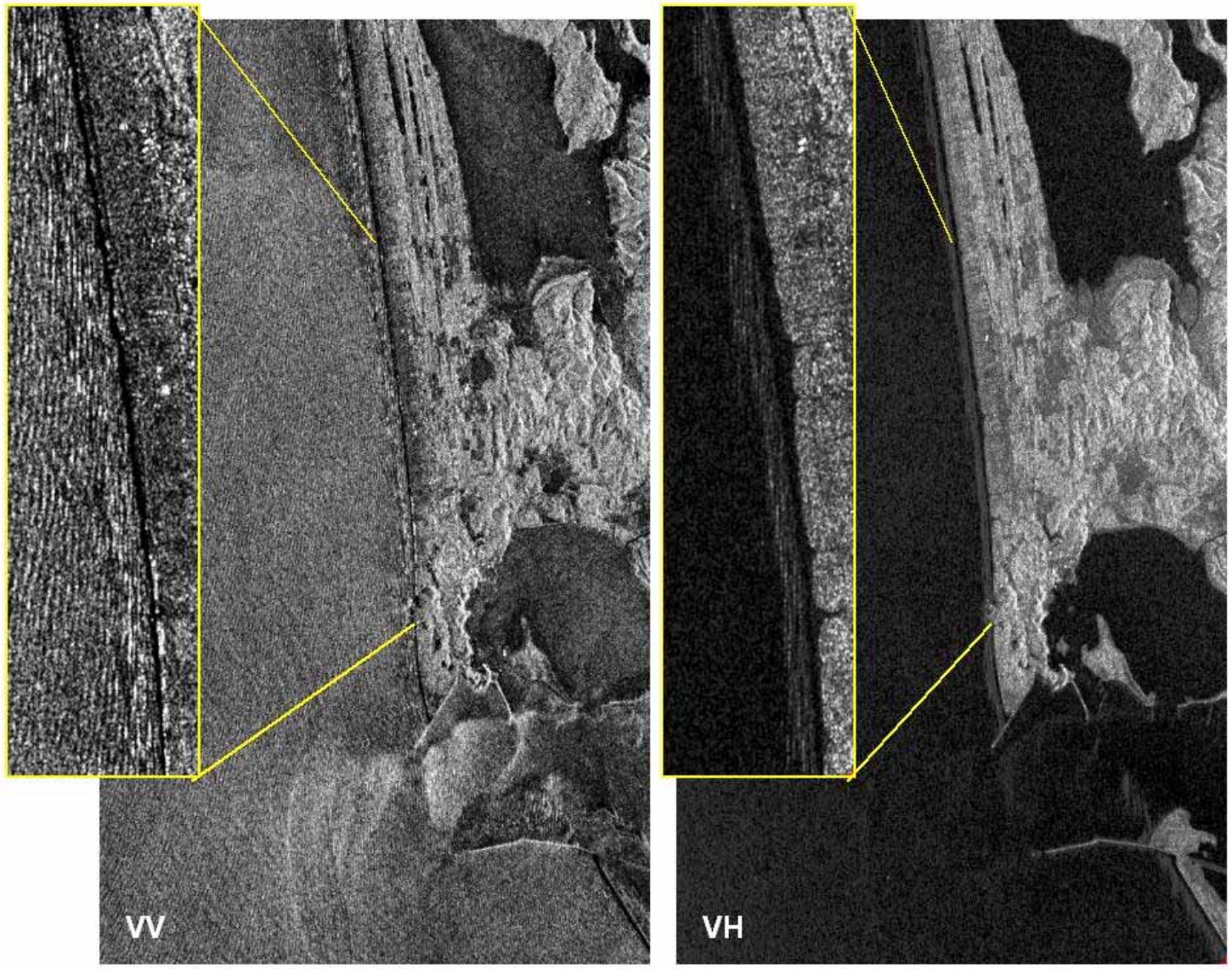
VV

HV

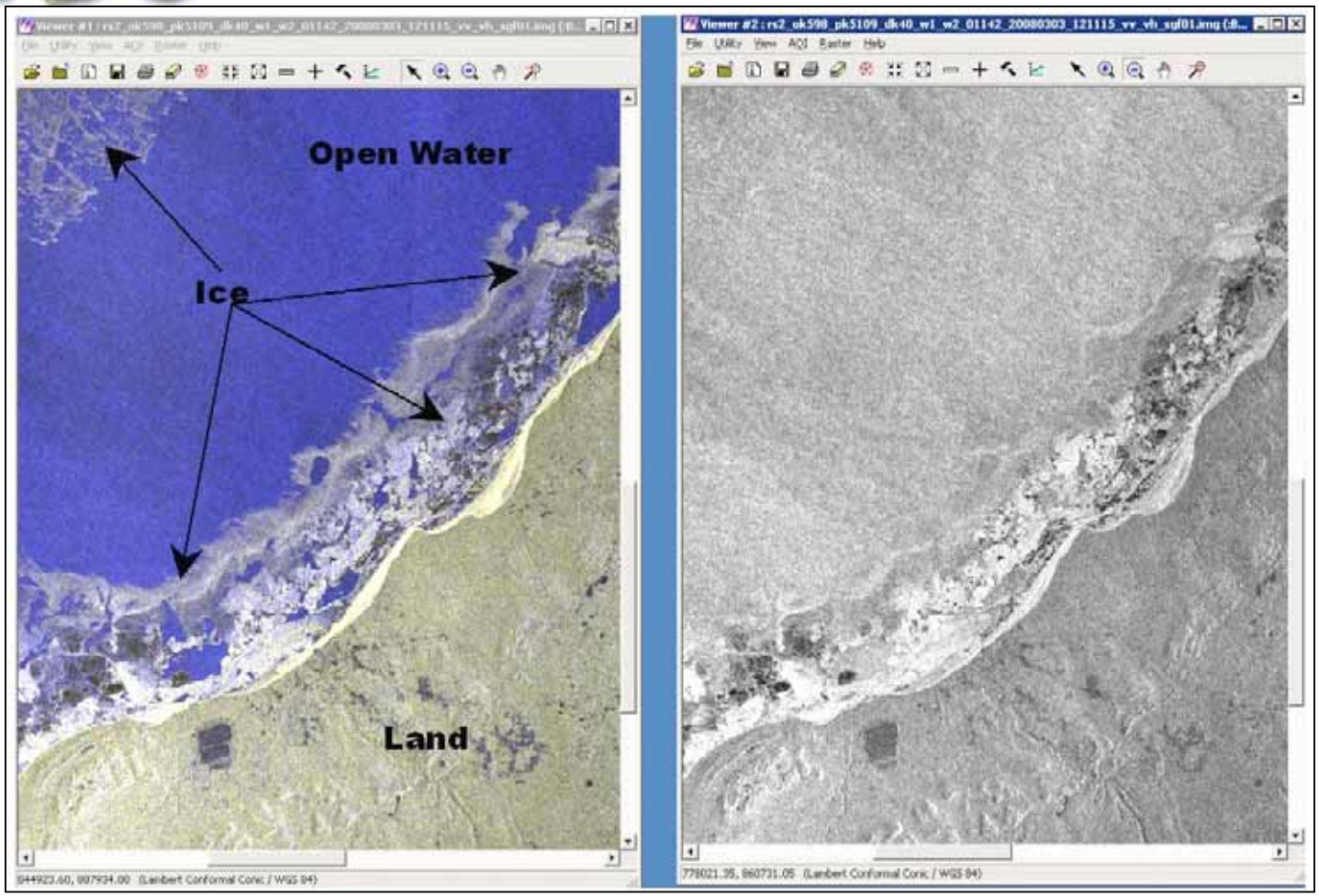
VH



HH or VV or HV

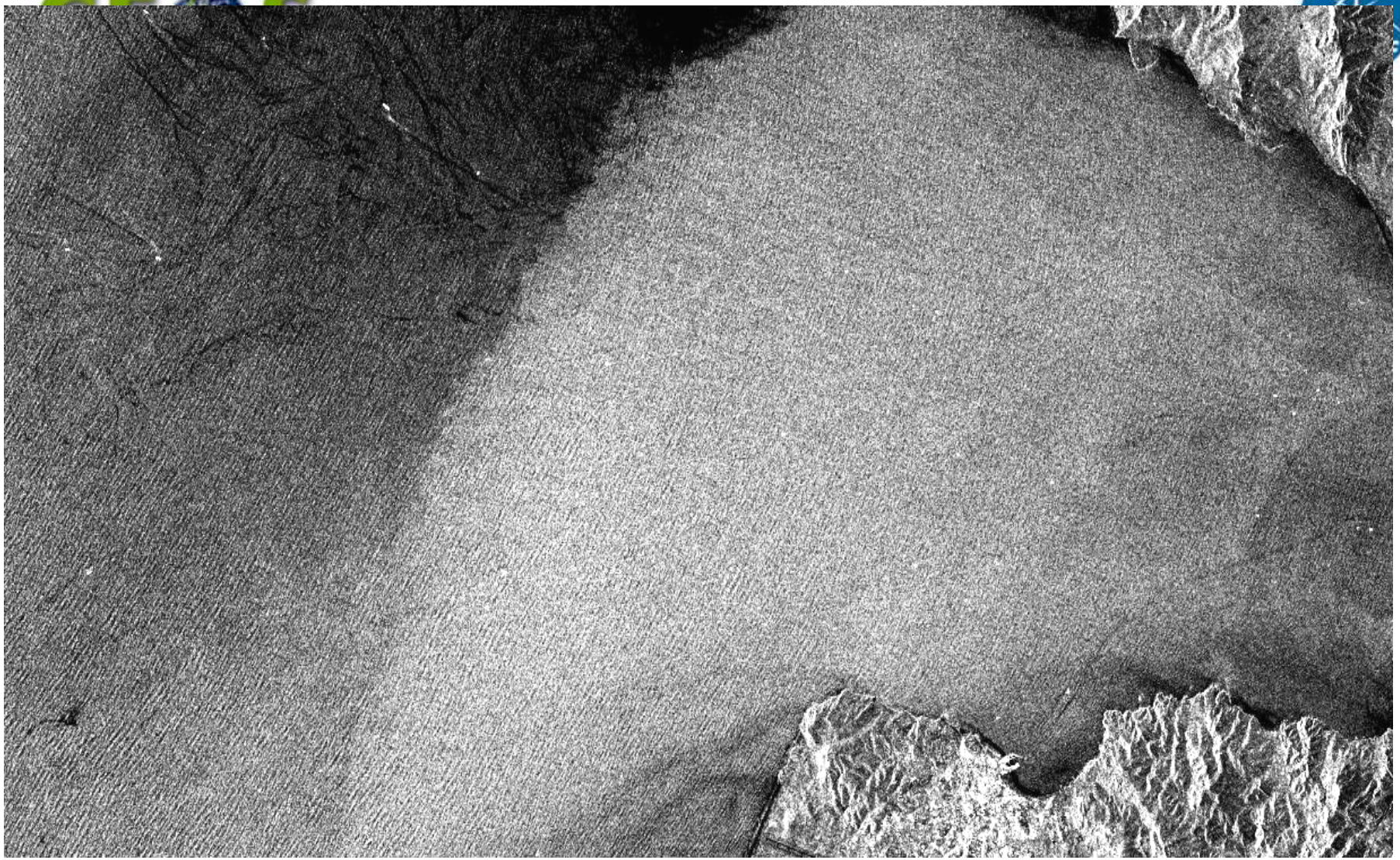


Comparison of VV and HV polarization showing ocean-surface waves. In the offshore area, the wave crests are visible in the VV image, but not the VH. At the shoreline, the waves break and are visible in both the VV and VH images. S1, Columbia River, OR, May 2008

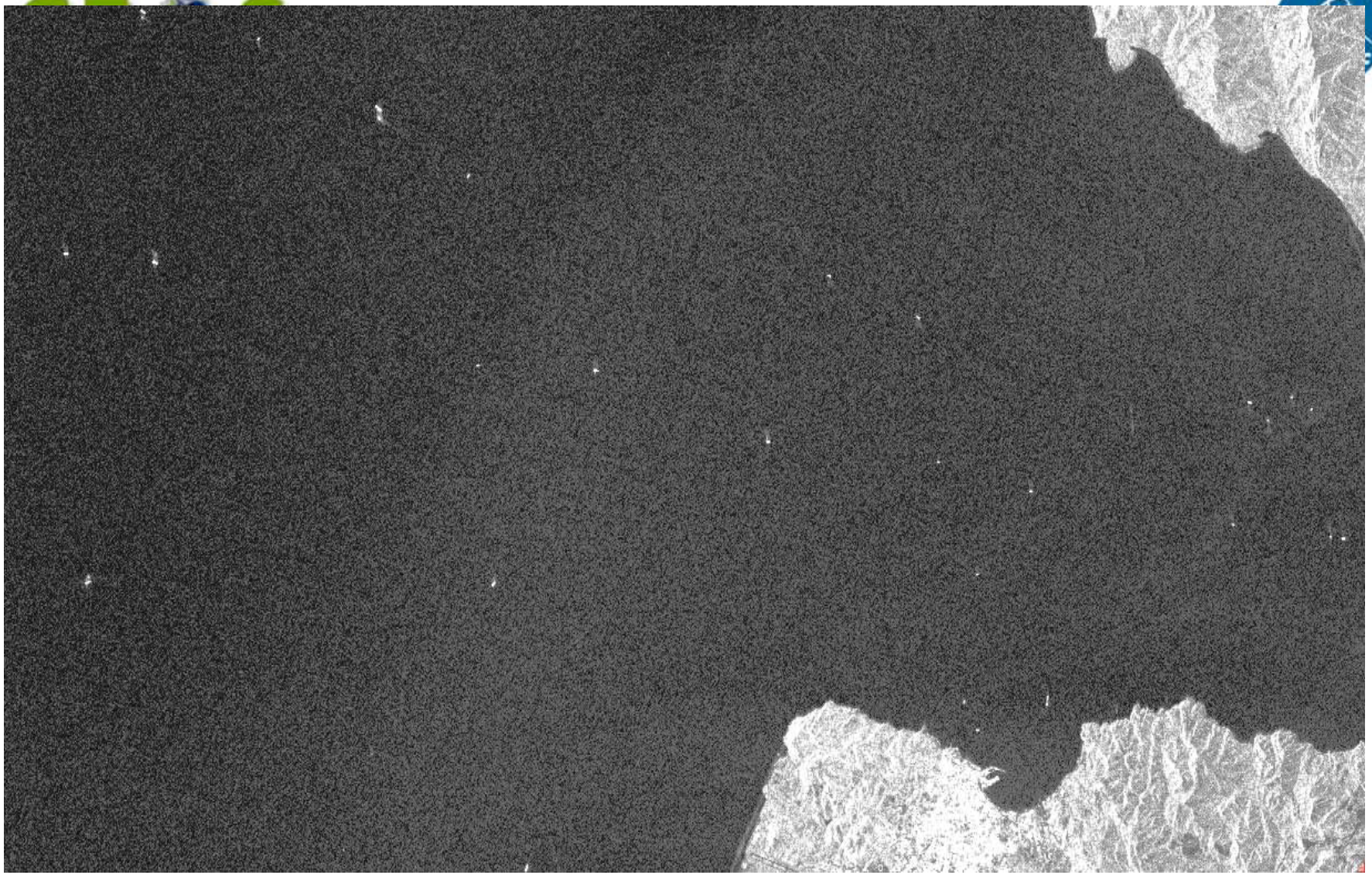


Flett and De Abreu, ASTRO'08.

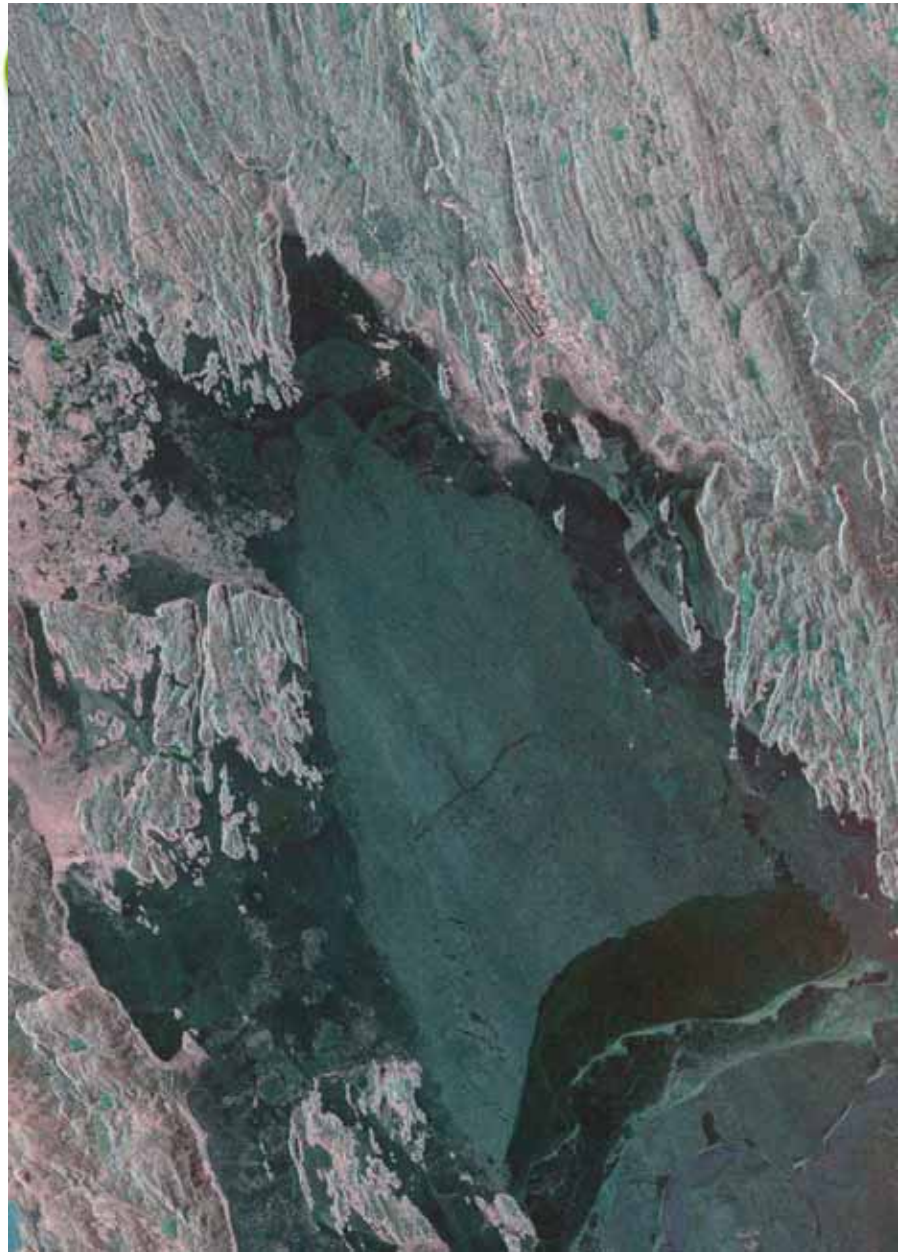
Subarea of a RADARSAT-2 ScanSAR Narrow VV/VH image of Lake Superior. The VV/VH image provides impoved ice-water discrimination versus the VV image.



Strait of Gibraltar, Wide 1 VV, Feb 5, 2008
5x5 filter



Strait of Gibraltar, Wide 1 VH, Feb 5, 2008
5x5 filter



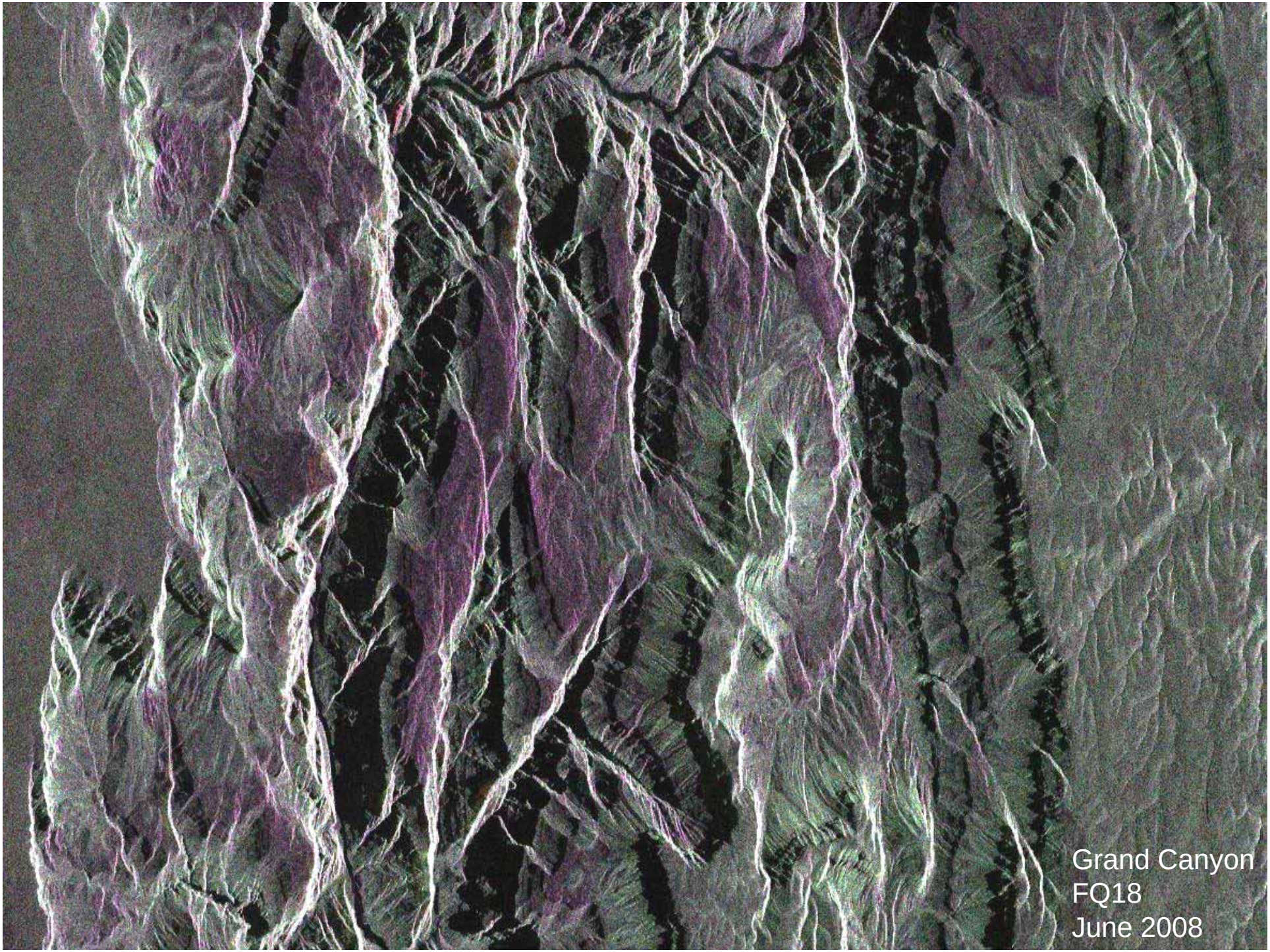
RADARSAT-2 Fine Quad-Pol, Iqaluit, NU

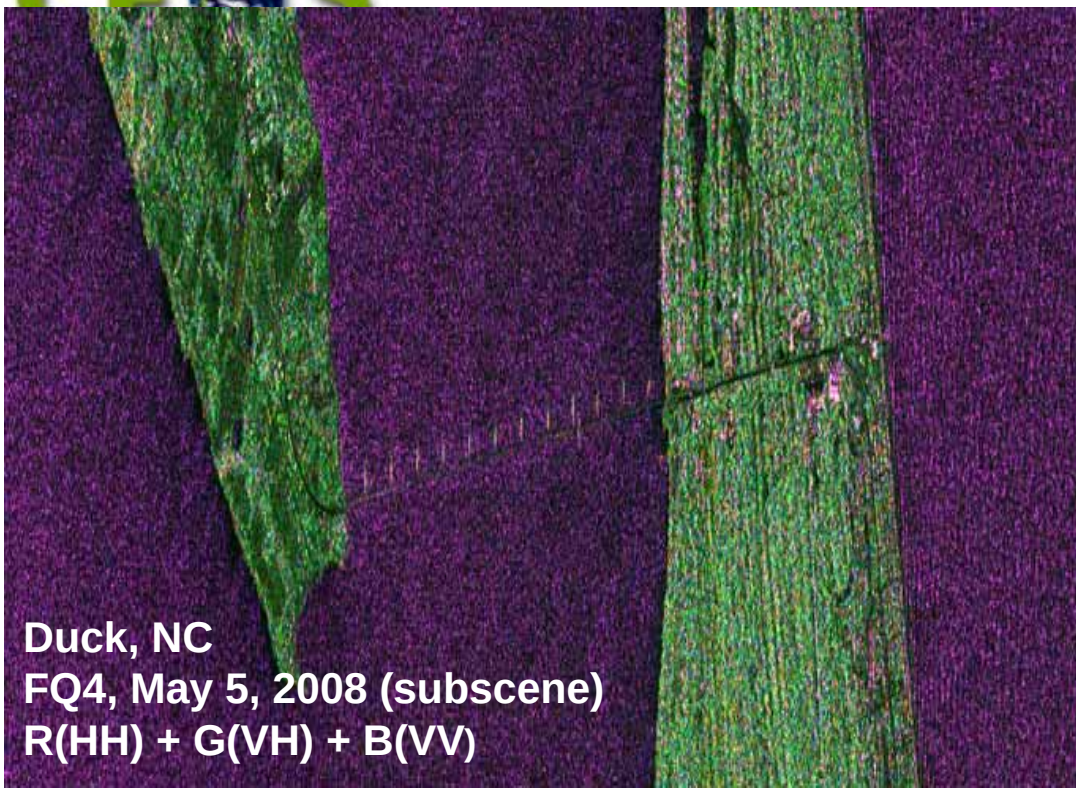
RADARSAT-2 Quad Polarization

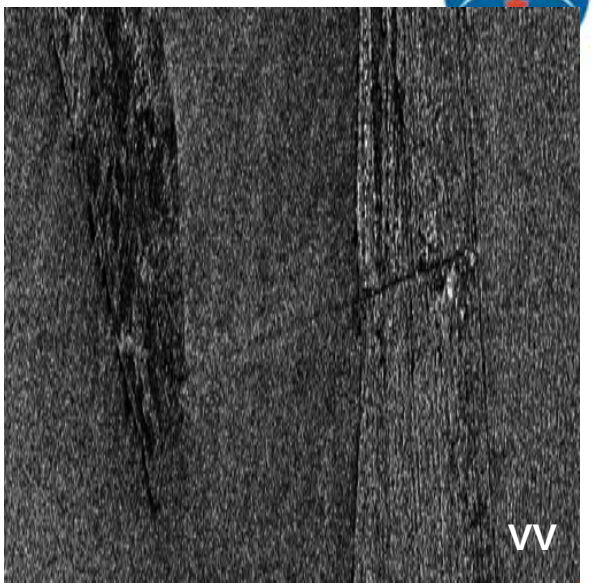
San Francisco
Fine Quad 9
April 2008

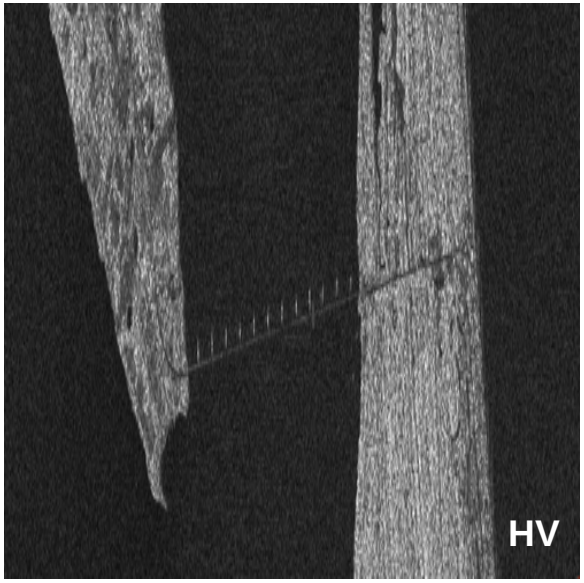
28° nominal incidence angle

12 m (rg x az) nominal resolution

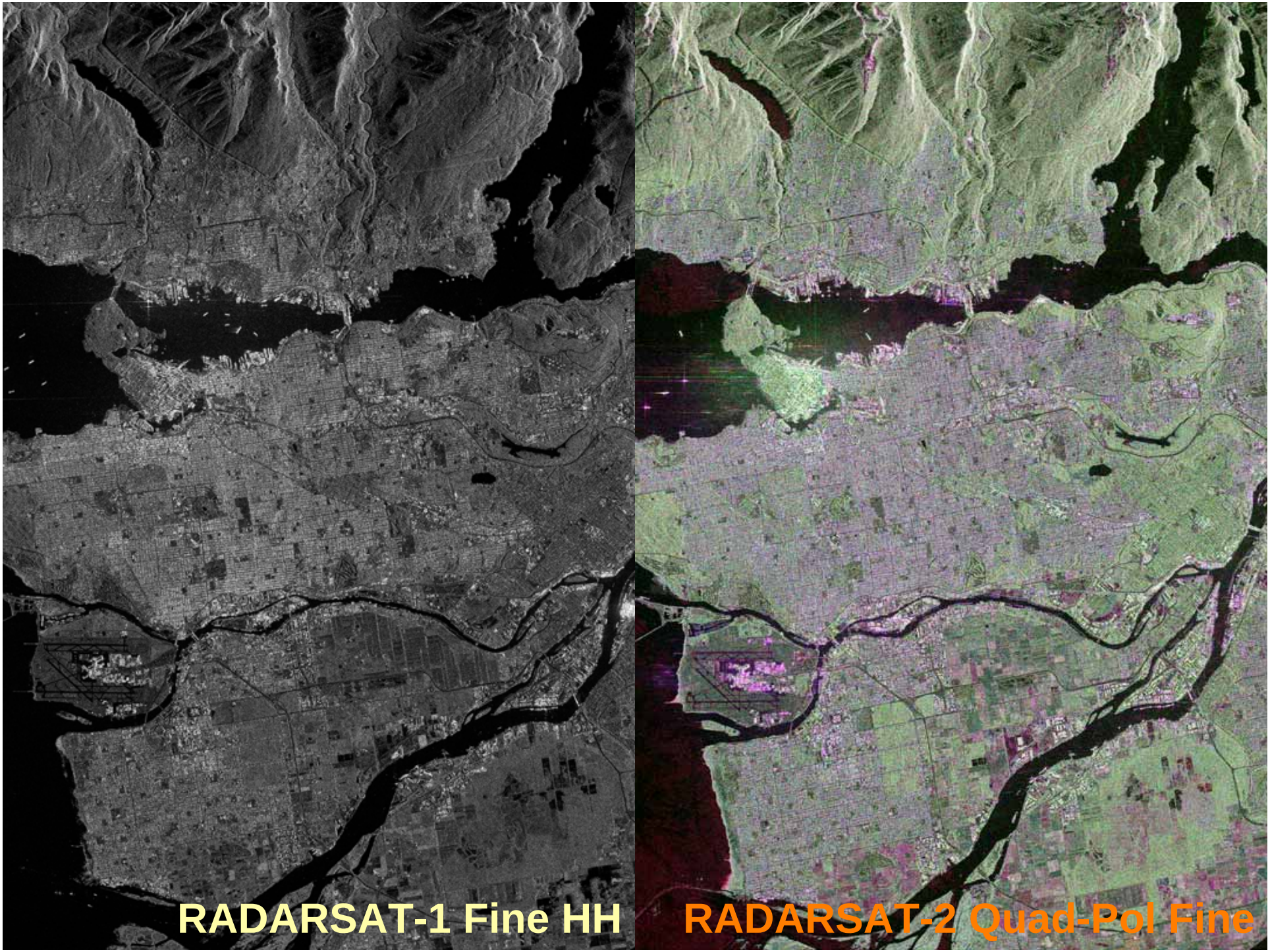

Grand Canyon
FQ18
June 2008

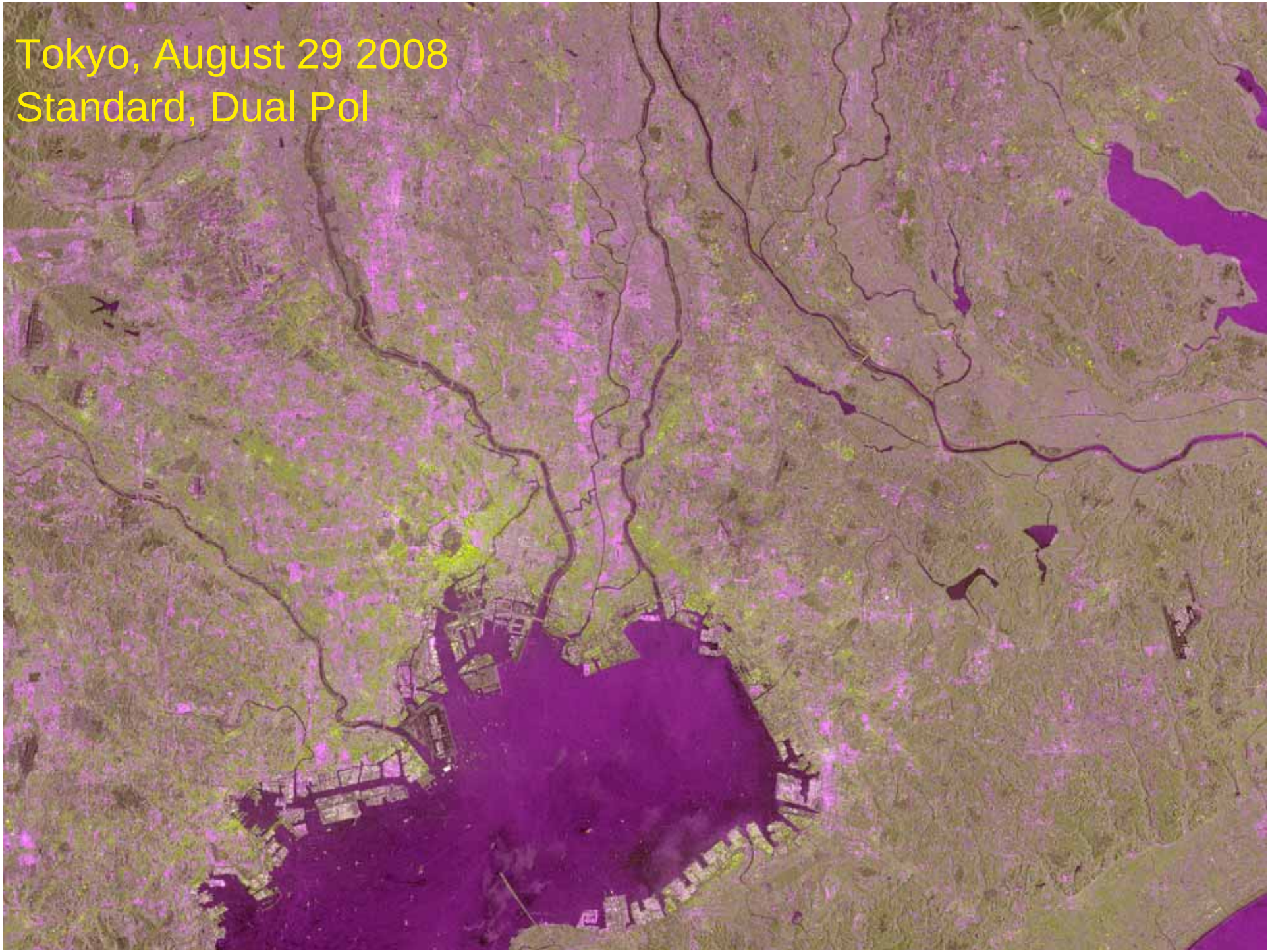


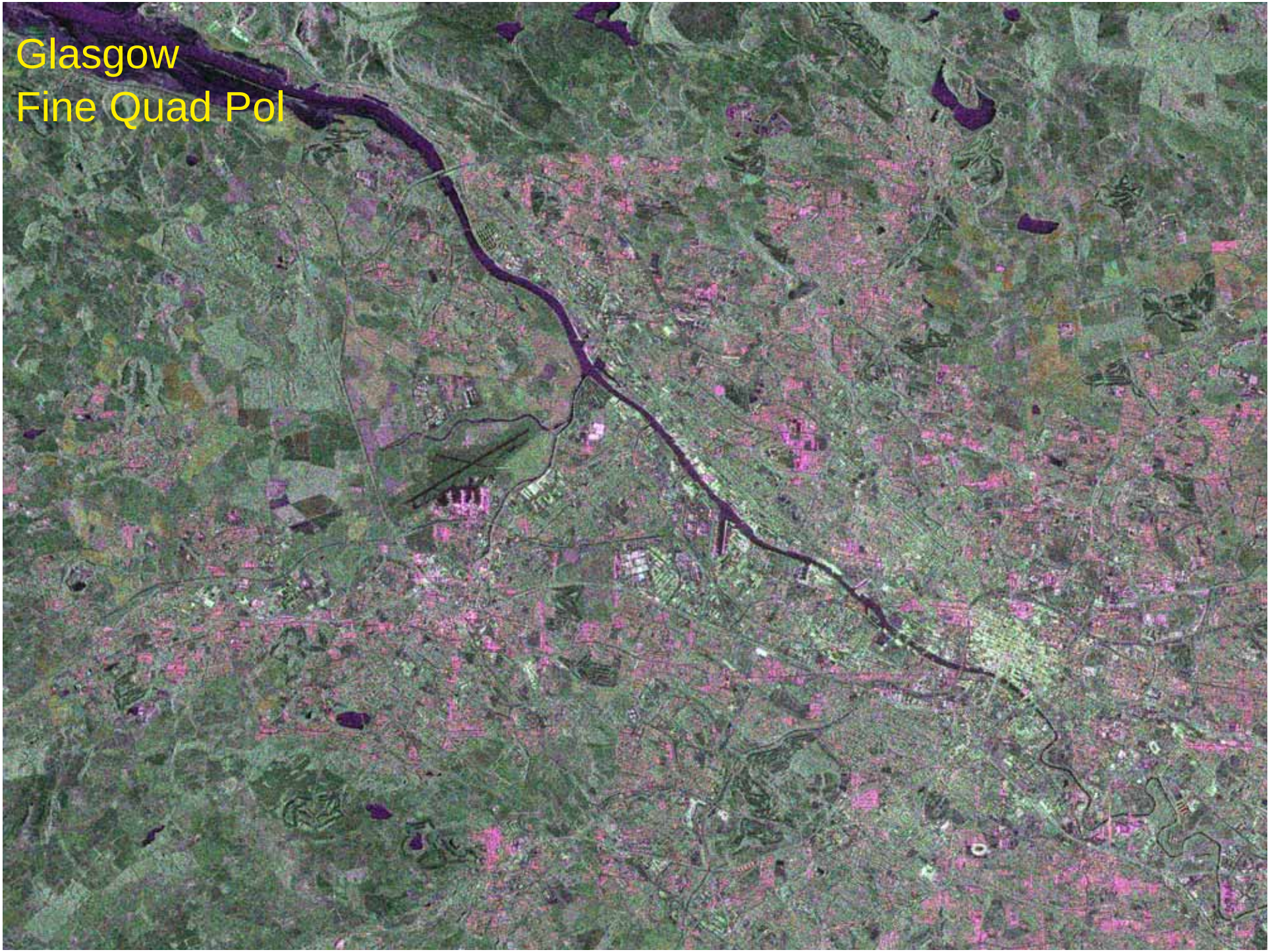




VV polarization provides ocean surface information.
HV polarization provides good discrimination between surface (ocean) and volume scattering (land).

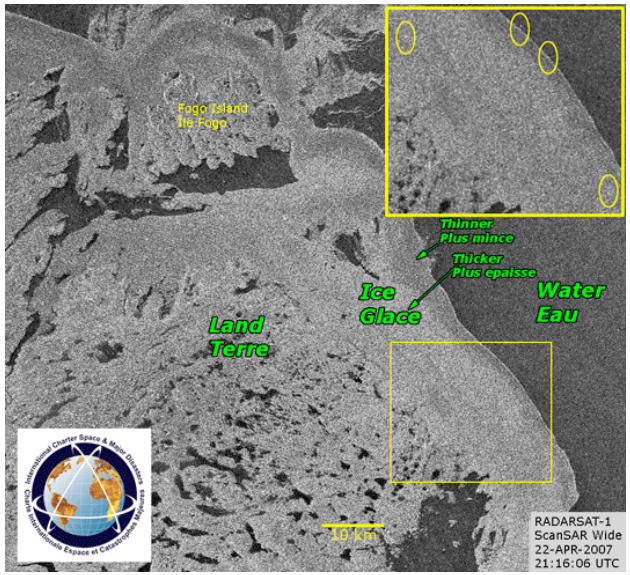

RADARSAT-1 Fine HH
RADARSAT-2 Quad-Pol Fine


Tokyo, August 29 2008
Standard, Dual Pol


Glasgow
Fine Quad Pol

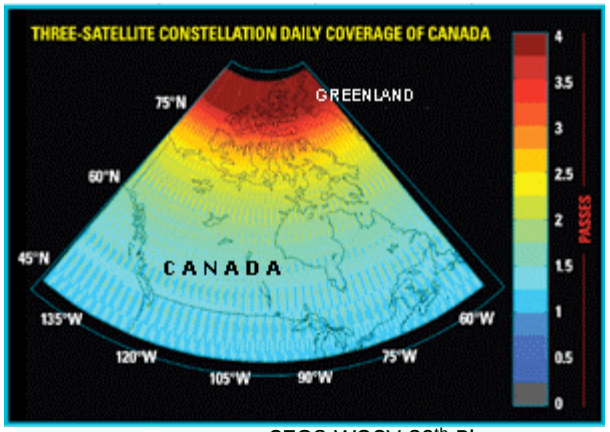
CSA Committed to Providing RADARSAT Data Continuity

1995: RADARSAT-1

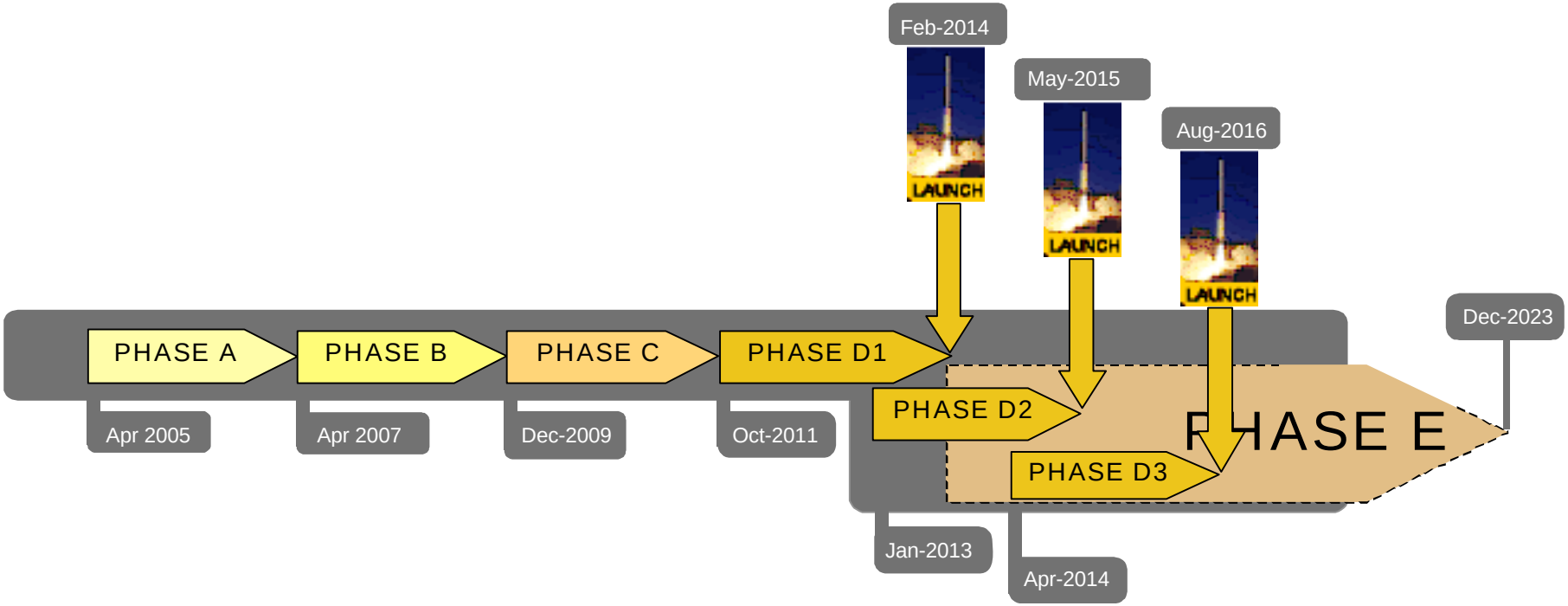


2007: RADARSAT-2

2014: RCM
2015:
2015:



RADARSAT Constellation Mission (RCM) Project Schedule



Phase	Description	Milestones
A	*Concept Development*	*Mission and System Requirements*
B	*Initial Design*	*Preliminary Design*
C	*Critical Design*	*Critical Design*
D1	*Manufacturing Satellite 1*	*Launch Satellite 1*
D2	*Manufacturing Satellite 2*	*Launch Satellite 2*
D3	*Manufacturing Satellite 3*	*Launch Satellite 3*
E	*Commissioning & Operations*	