

‘Very’ High resolution imagery

= higher than Landsat etc..

First Soviet ‘high-res’
unmanned spy satellite

Zenit 2

camera ports visible

resolution 10m

>500 launched 1961-94

zenit 2-8



CORONA 1959-72 (CIA-USA)

America's reconnaissance satellite program was designed to take photos of the Soviet bloc, officially top secret until 1992

- Photos declassified Feb 22, 1995
- 144 Corona satellites launched
- 860,000 images of the earth's surface collected 1960 -1972
- * Most photos 2-8m resolution



The Israeli Dimona nuclear reactor complex.
Photographed by Corona satellite
Nov 11th, 1968.

Corona DEM: Himalayas, 1960s



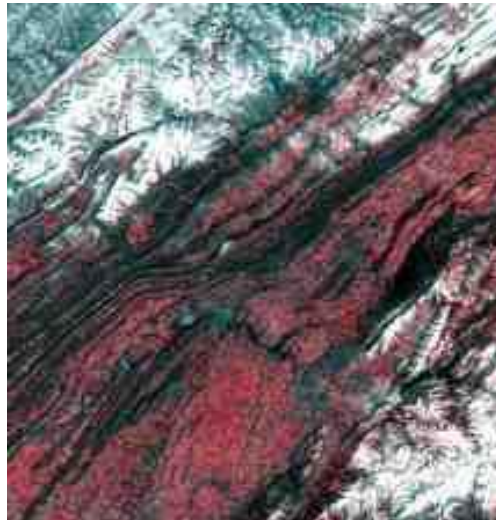
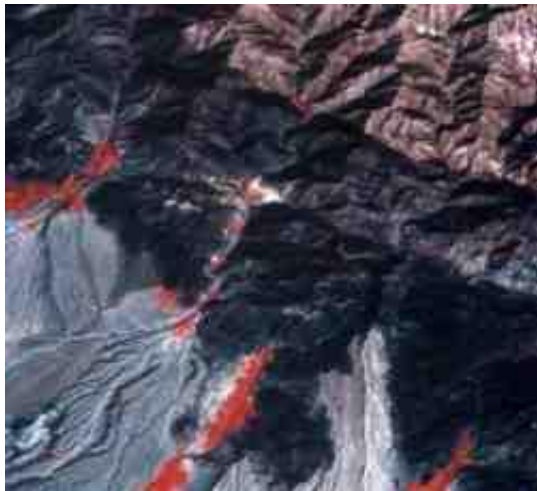
JC-130 recovery aircraft, U.S. Air Force retrieves a Corona satellite film-return capsule, using a "bucket," over the Pacific.



Highest resolution imagery in the old millennium

1959-72	Corona spy photos:	2 – 8 m
1972	Landsat 1-3 MSS:	80m
1984	Landsat 4/5 TM:	30m
1986:	SPOT1 PAN/MS:	10/20m
1995:	IRS-1C Pan/MS:	6/24m (see images)

Indian Remote Sensing (IRS)



a. Panchromatic (PAN) camera of 6 m resolution. (right)

b. Linear Imaging Self Scanner (LISS-3) 23.6m (left)

c. Wide Field Sensor (WiFS) 189m centre

High resolution **corporate** satellites 2000->
security issues approved by Clinton administration
Ikonos: launched September 1999; image data Jan 1, 2000 -> 2015
Resolution: Pan 1m Multispectral (BGRN) 4m





There was excitement on the use of high resolution Ikonos imagery for forestry classifications.

Ikonos facilitated shift in thinking. Rather than pixels as the medium of analysis, object-oriented classification could be possible, such as individual tree crown analysis (ITC).

Carleer and Wolff. 2004. Exploitation of very high resolution satellite data for tree species identification. *Photogrammetric Engineering & Remote Sensing*. 70: 135-140.

Gougeon and Leckie. 2006. The individual tree crown approach applied to Ikonos images of a coniferous plantation area. *Photogrammetric Engineering & Remote Sensing*. 72: 1287-1297.

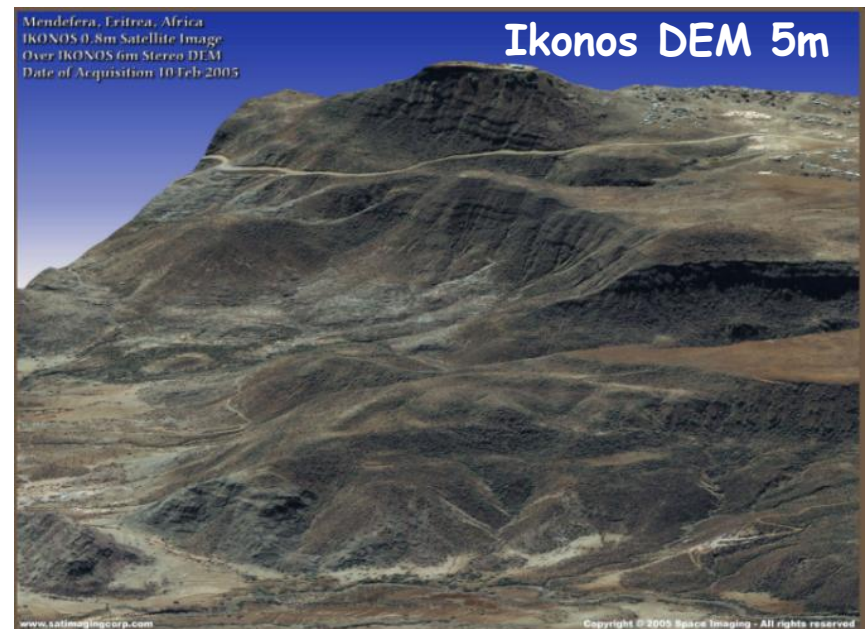
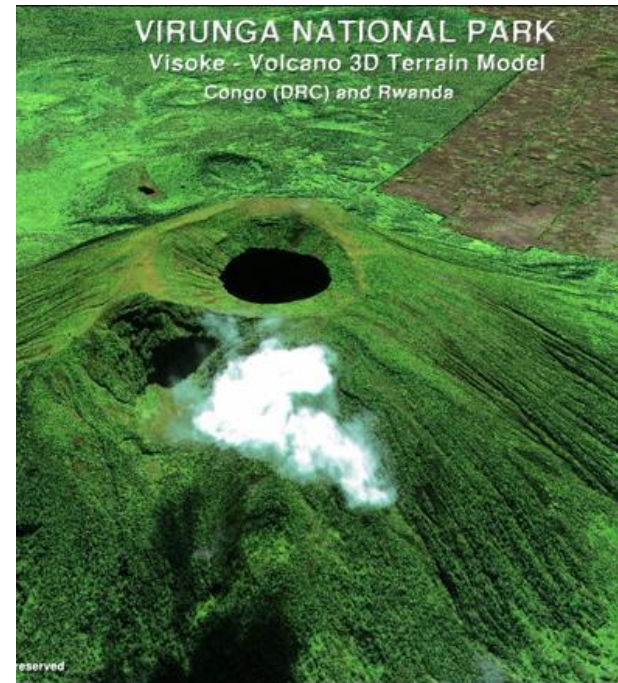
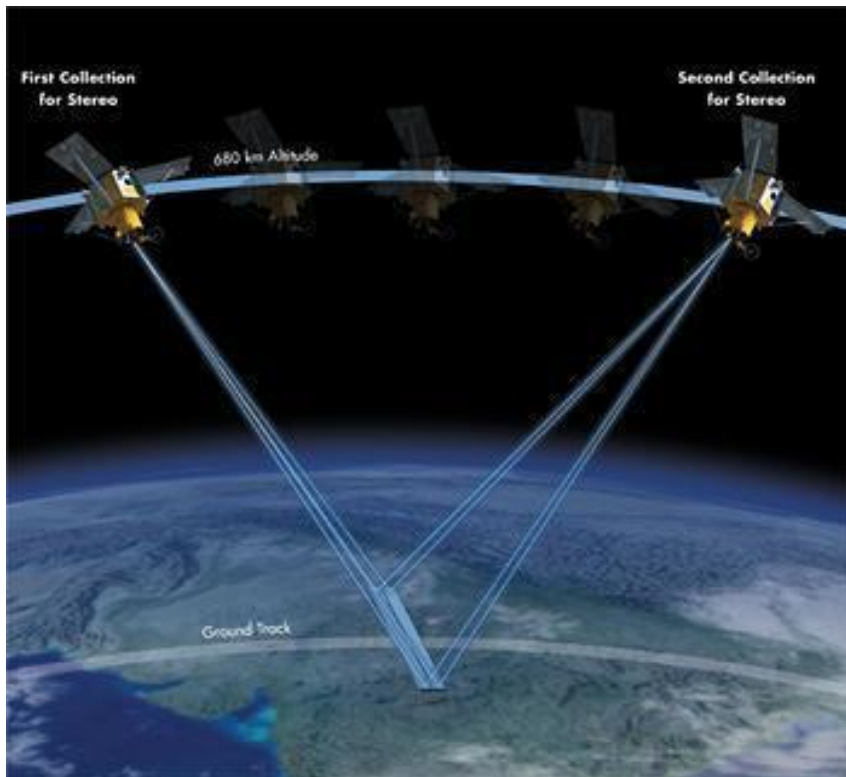
Ikonos (from Greek *eikōn* → *image*)

Owner	GeoEye → now part of DigitalGlobe
Resolutions	4m multispectral 1 panchromatic
Bands	Blue (445-516nm) Green (506-595nm) Red (632-698nm) NIR (770-888nm) PAN (450-900nm)
Operational Dates	Jan 2000 to 2015
Data Cost	\$10 to \$45 per km ² (from landinfo.com)
equatorial time	10:30 am
Revisit time	11 days but can be as little as 3 days with 45 degree viewing angle
Viewing angle	Can be rotated up to 45 degrees off nadir
Individual Image coverage	11km x 11km = 121km ²
Altitude	681 km sun synchronous

Can be used to create DEMs by viewing from 2 different angles

DEMs from high resolution imagery

Ikonos imagery can be available in stereo due to maneuverability of viewing angle. Stereo pairs are captured on same swath ... moments apart to create DEM



Ikonos 1m pixels: Whistler Olympic park (Jan 16, 2010)



(For 2010 Winter Olympics)

Quickbird, 2001

Pan 60cm
Multispectral 2.4m



Country : North Korea
Area : Taepodong Missile Complex

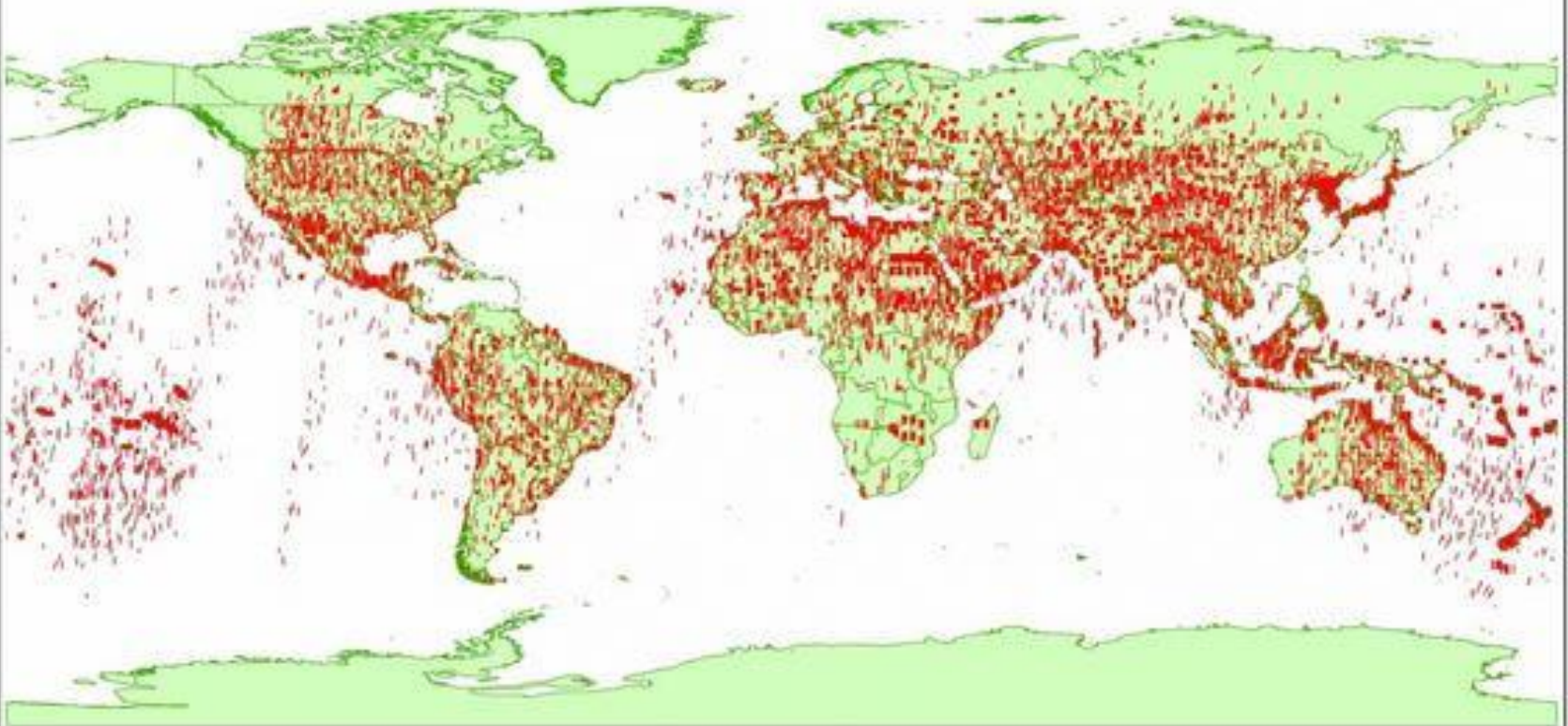
Satellite Sensor : QuickBird
Acquisition Date : March 26, 2009
Resolution (GSD) : 0.6m

Launch Pad with Rocket

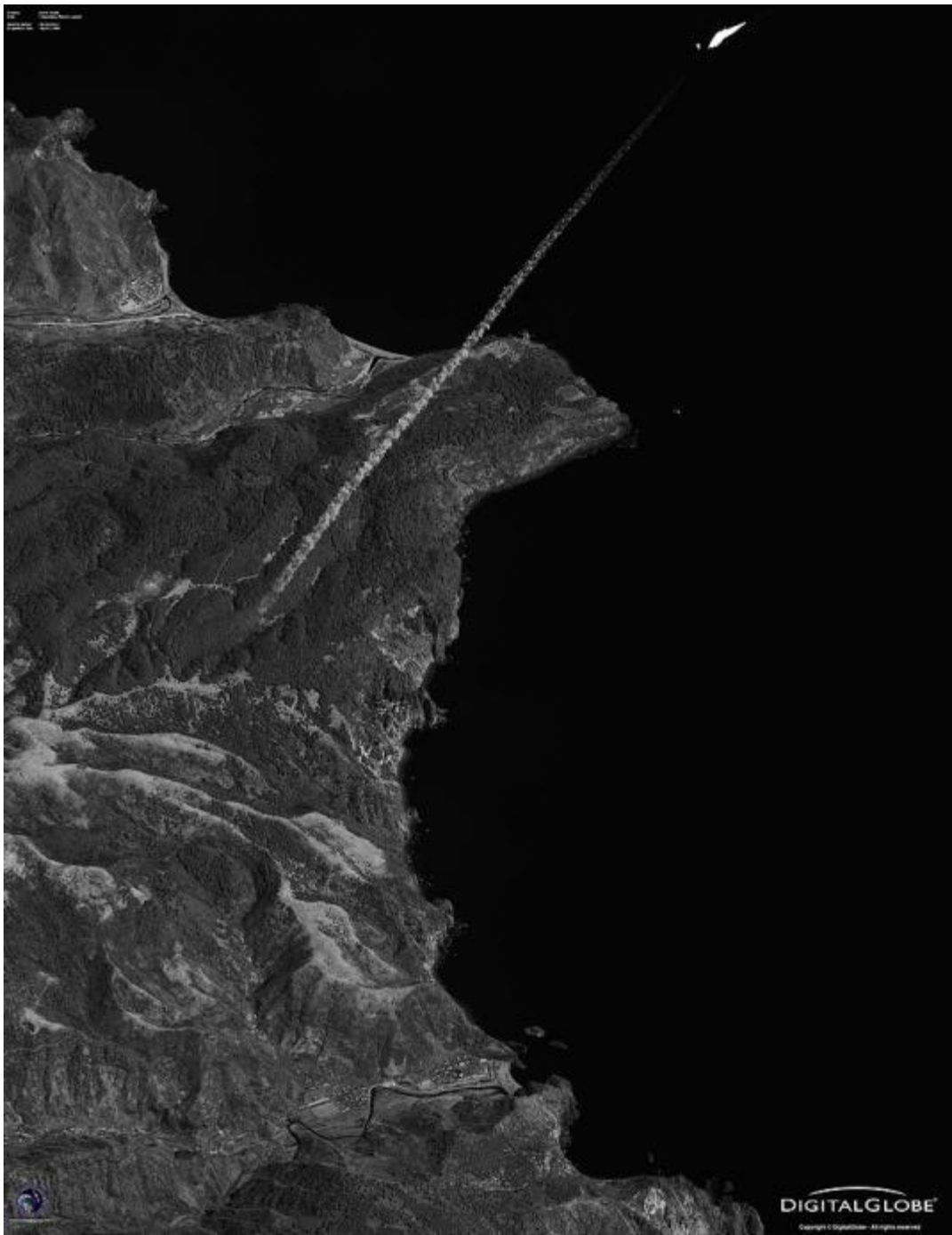


Orbview 3, 2003- same bands/resolution as Ikonos

USGS OrbView 3 Coverage



Orbview (high res.) image data on EarthExplorer; Ikonos 3 samples also available
Most high res. Image data are NOT freely downloadable



Worldview 1, 2007
Pan 50cm RGBN 2m

*April 5, 2009 WorldView-1
Satellite Image of Missile
Launch in North Korea*

RapidEye 2008 ->

(Germany)

5 identical satellites: 5m pixels

Tachys (rapid)

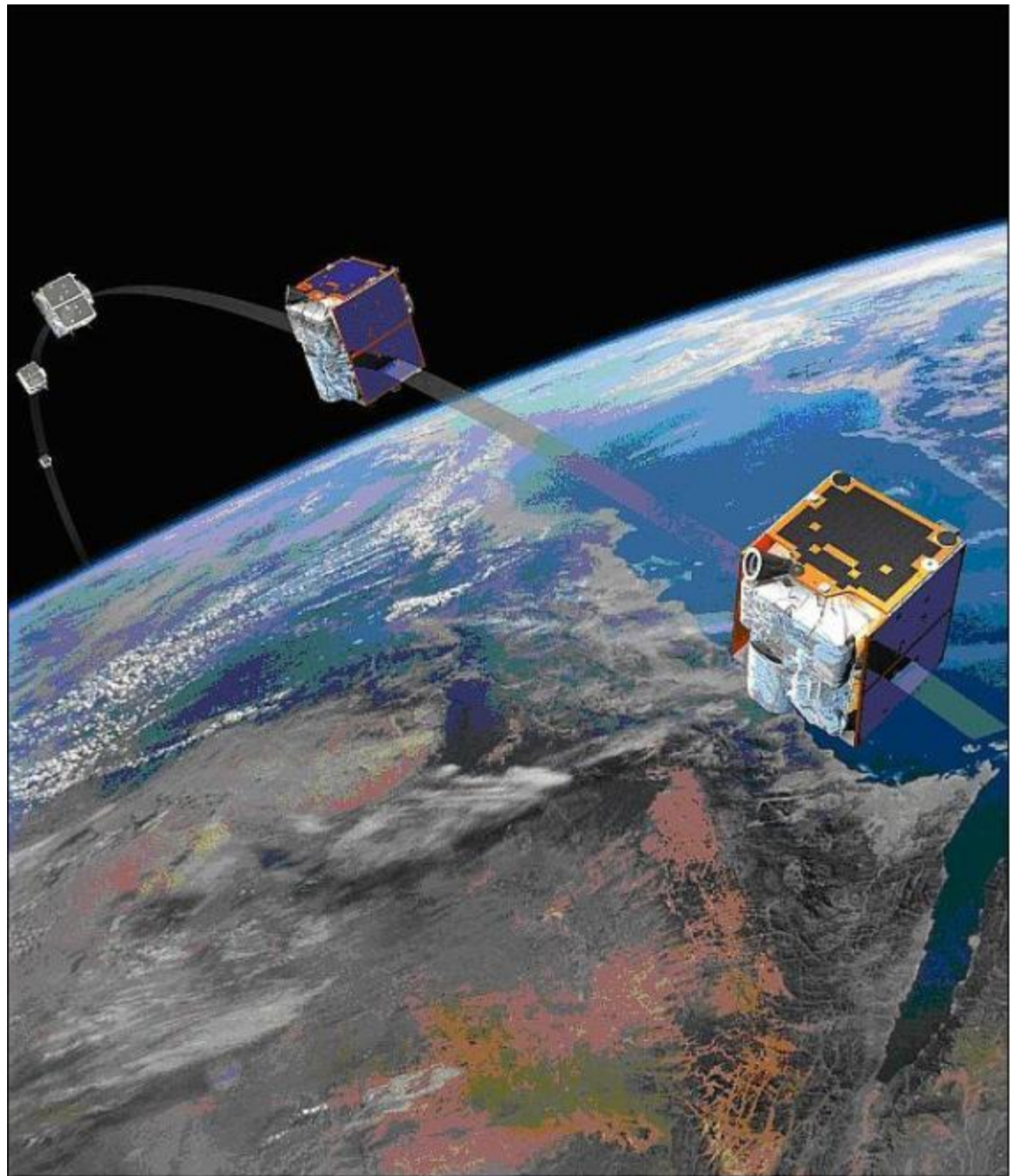
Mati (eye)

Choma (earth)

Choros (space)

Trochia (orbit)

Price: \$1.40 / sq km (\$2.50 rectified)



RapidEye: first satellite(s) capturing the Red Edge

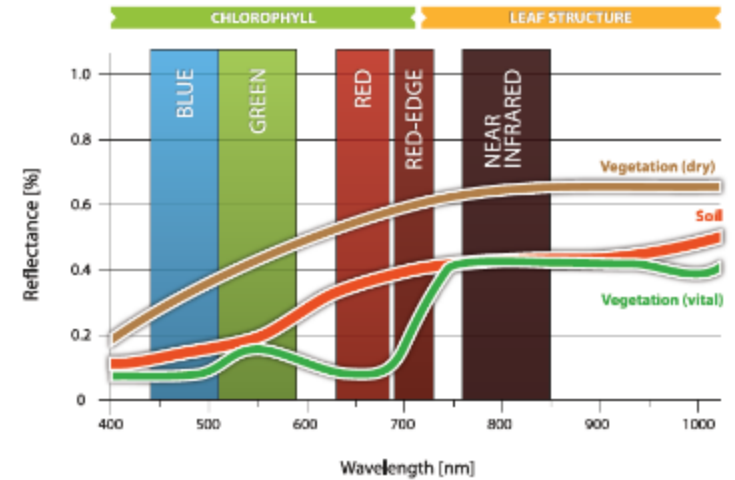


Figure 1: Typical spectral reflectance curves of selected surfaces in relation to the RapidEye spectral bands

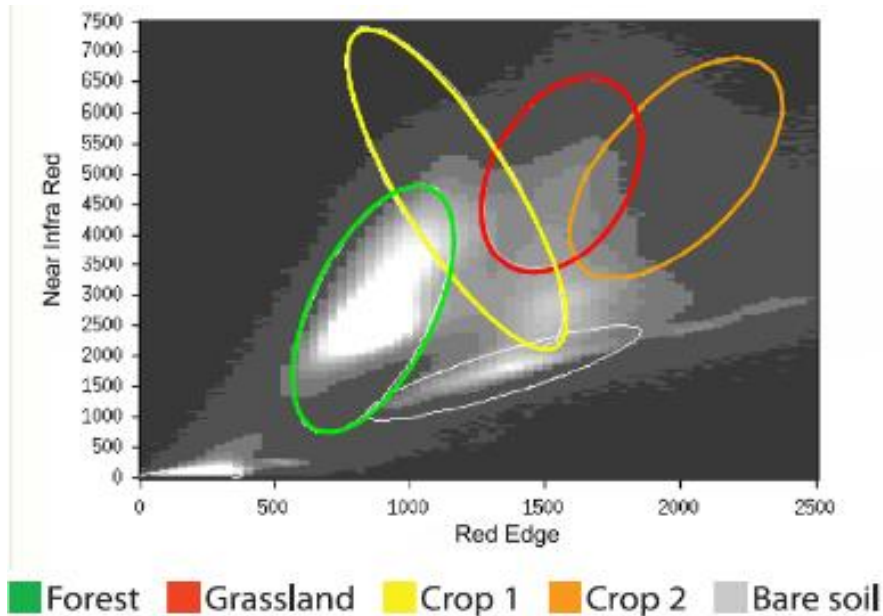
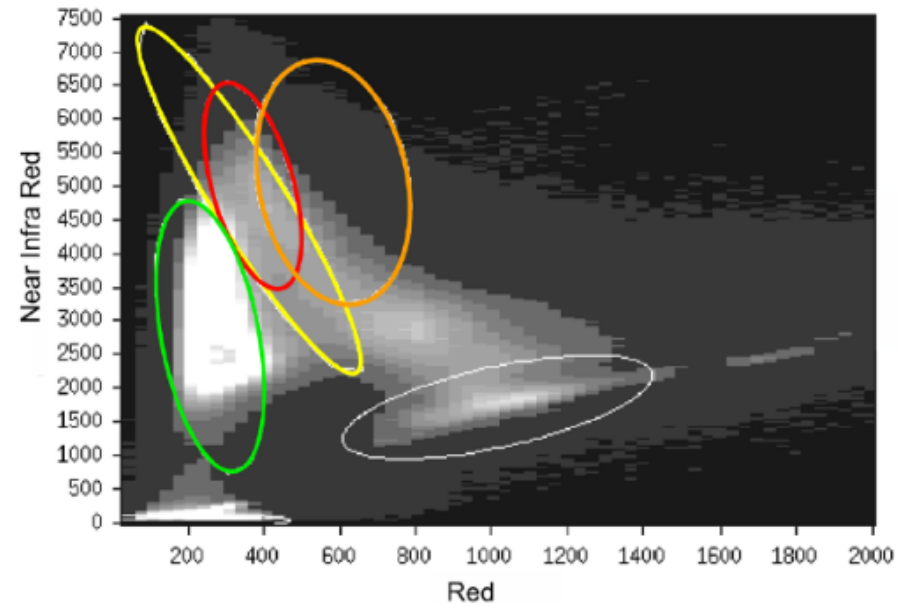
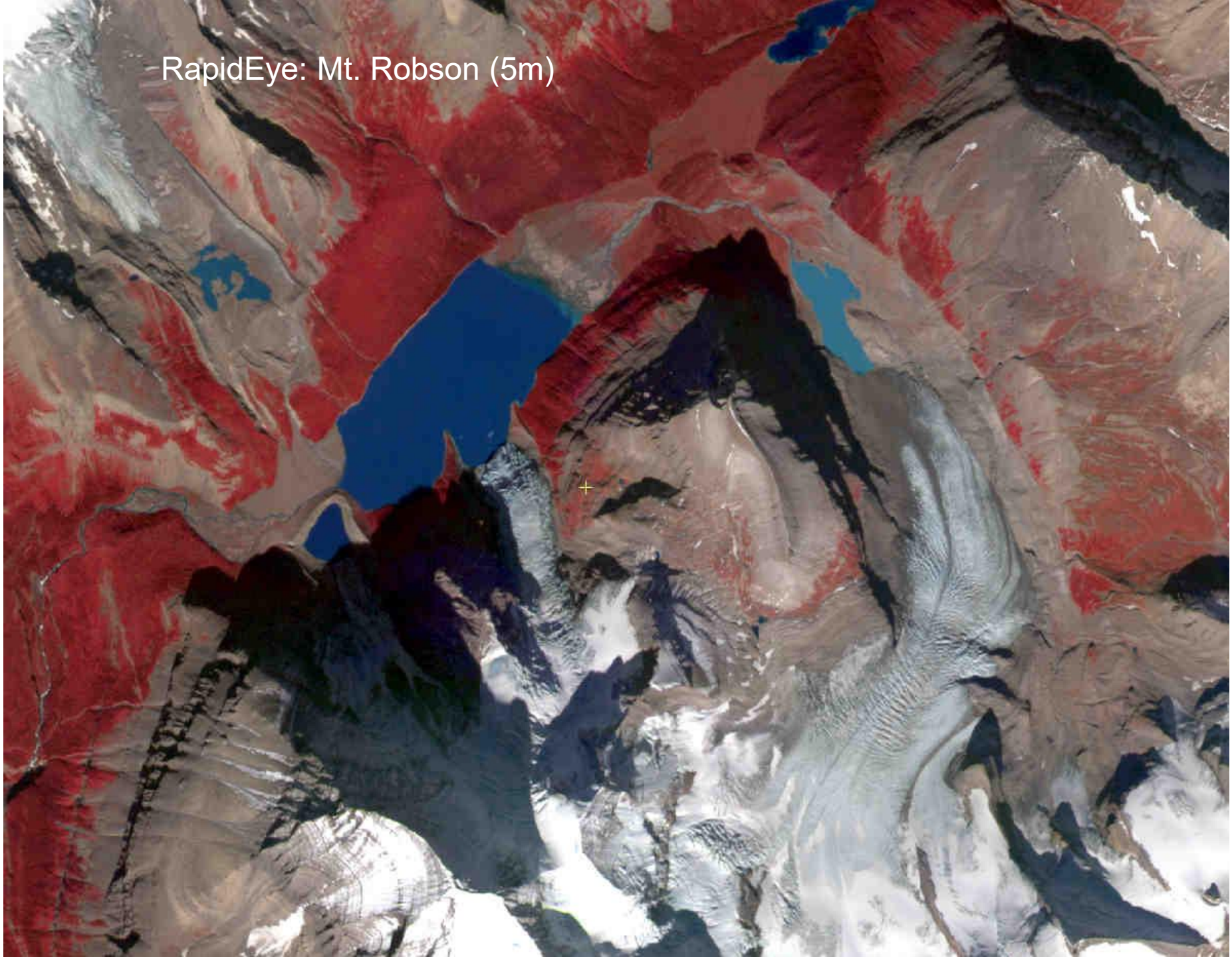


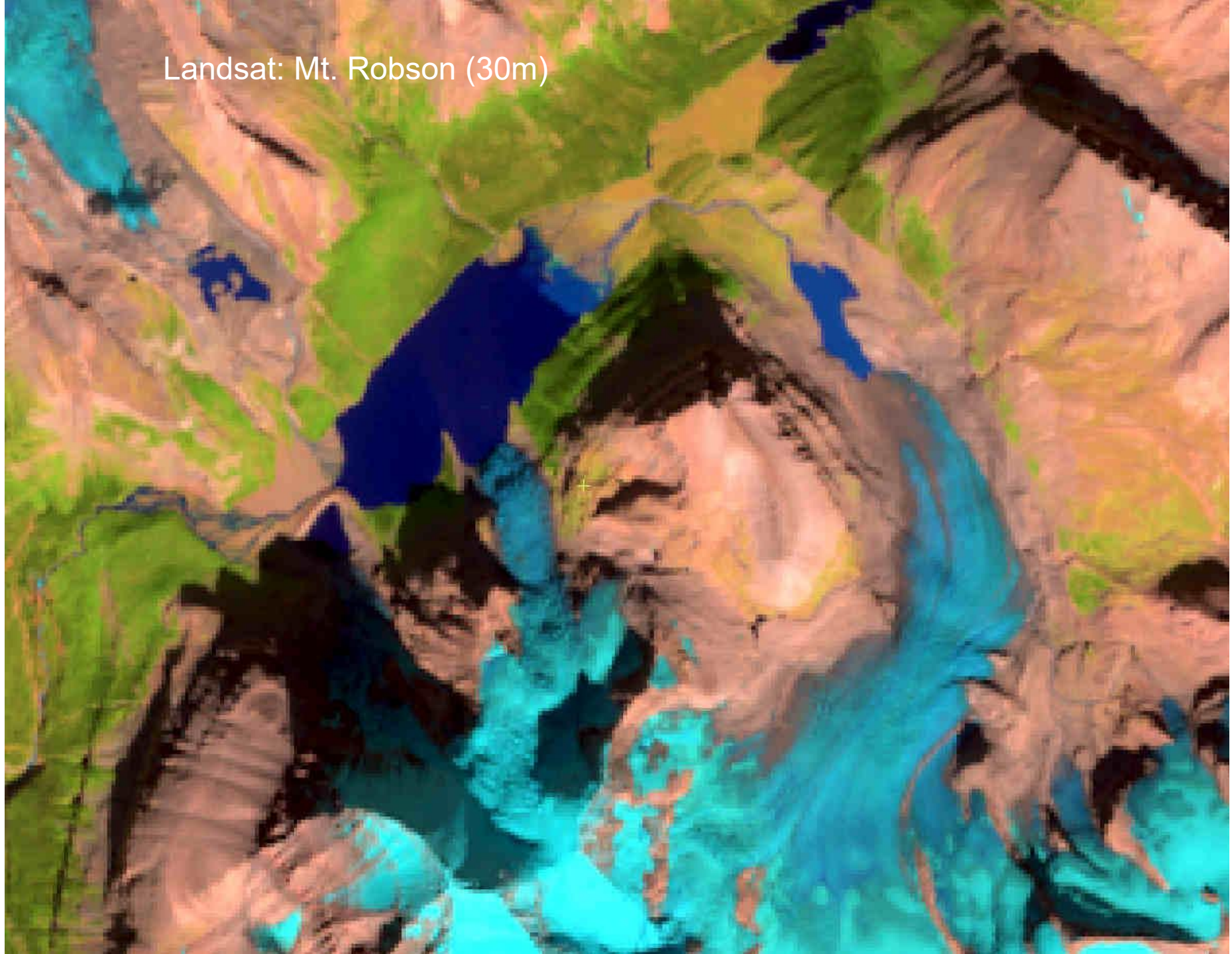
Figure 3: (a, b, c) Scatterplots of different combinations of two RapidEye bands including the representation of selected land cover classes. a:



RapidEye: Mt. Robson (5m)



Landsat: Mt. Robson (30m)



Sept 5 2011: Iunctus Geomatics Corp. of Lethbridge, Alberta, Canada's exclusive distributor of French SPOT optical satellite data, purchased Germany-based RapidEye for ~13 million euros (\$19m)



Ryan Johnson, President

<http://www.rapideye.de/gallery/index.htm>



GeoEye 1 (launched by Google) 2008

41 / 46cm PAN 1.65m MS

Obama Inauguration (Jan 2009)



→ GeoEye 2 - PAN 31cm 2016 (Trump inauguration ?)

Worldview II, October 2009: 0.46 / 1.84 metre pixels

Panchromatic

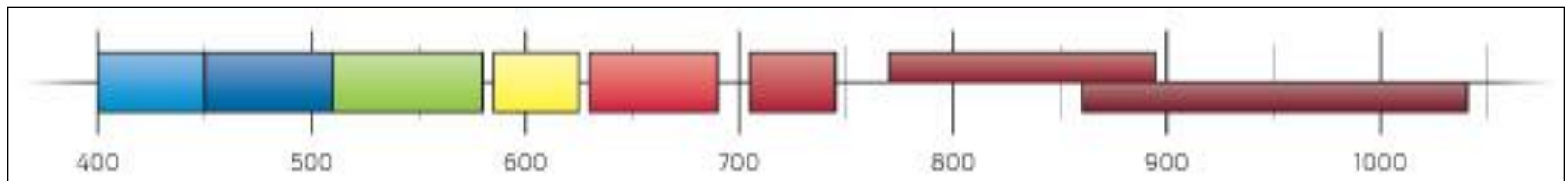
- 46 cm at nadir
- 52 cm at 20° off-nadir

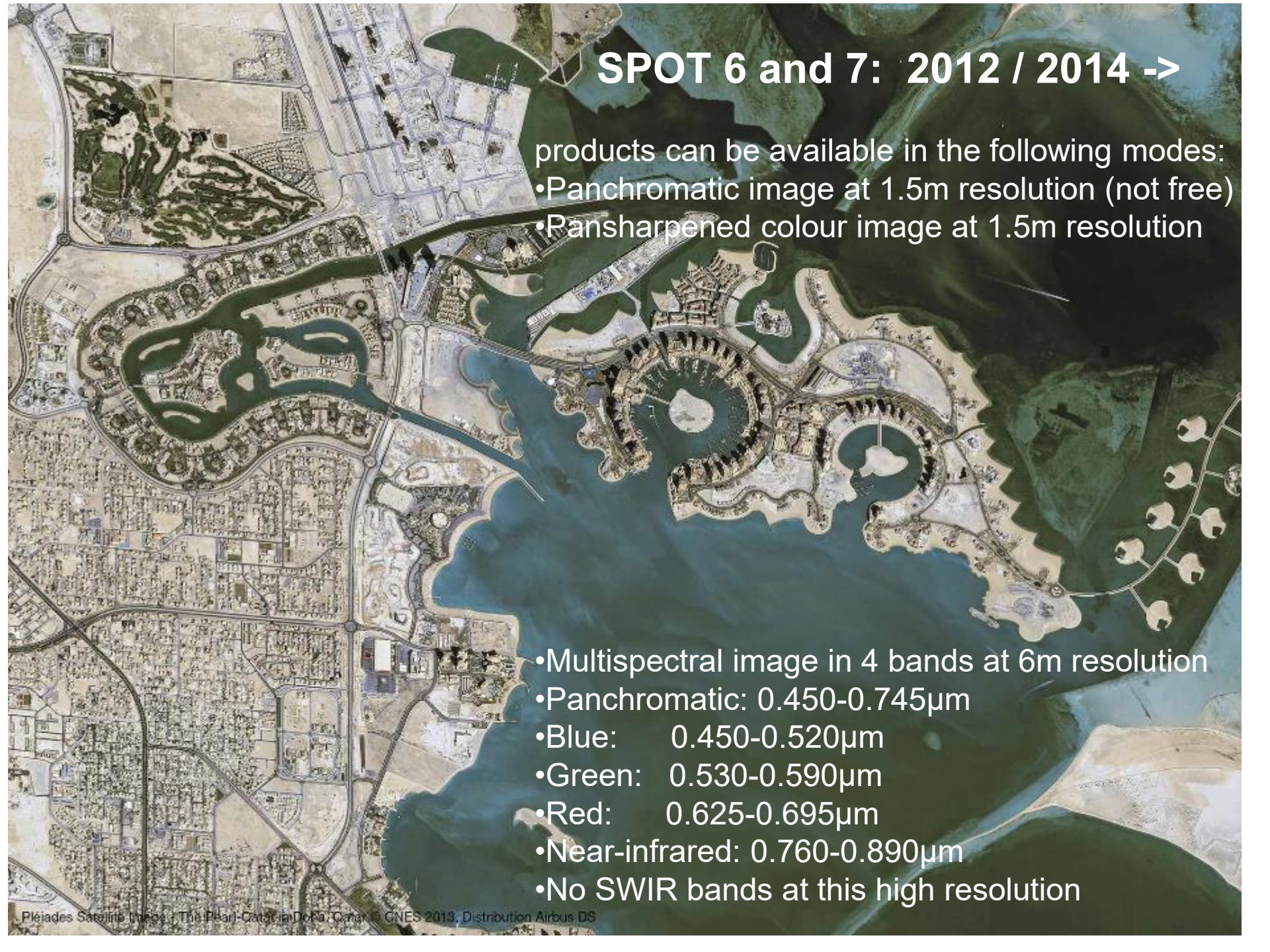
Multispectral:

- 4 standard bands: blue, green, red, near-IR1
- 4 new bands: coastal blue, yellow, red edge, near-IR2
- 1.84 m at nadir
- 2.08 m at 20° off-nadir



Sydney Opera house, Australia;
October 20, 2009 (12 days after launch)



A high-resolution satellite image of The Pearl-Qatar, a large artificial island in Doha, Qatar. The island features a complex network of roads, buildings, and green spaces, surrounded by water. The image is a mosaic of several smaller images, showing the island's layout and its connection to the mainland.

SPOT 6 and 7: 2012 / 2014 ->

products can be available in the following modes:

- Panchromatic image at 1.5m resolution (not free)
- Pansharpened colour image at 1.5m resolution

- Multispectral image in 4 bands at 6m resolution
- Panchromatic: 0.450-0.745 μ m
- Blue: 0.450-0.520 μ m
- Green: 0.530-0.590 μ m
- Red: 0.625-0.695 μ m
- Near-infrared: 0.760-0.890 μ m
- No SWIR bands at this high resolution

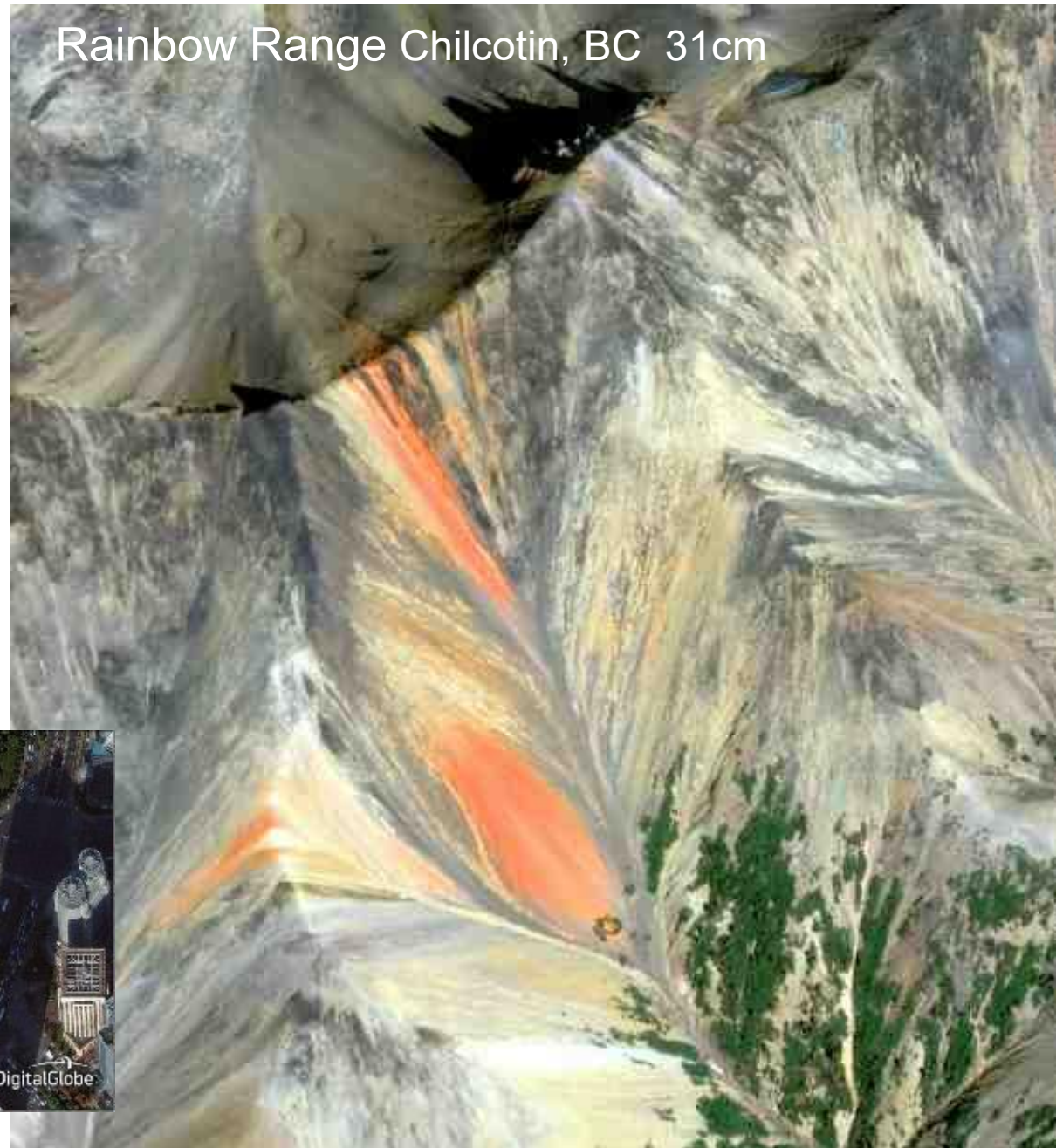
Worldview 3 2014

'superspectral' (10-50 bands)

PAN: 31cm

VNIR: 1.24m – 8 bands

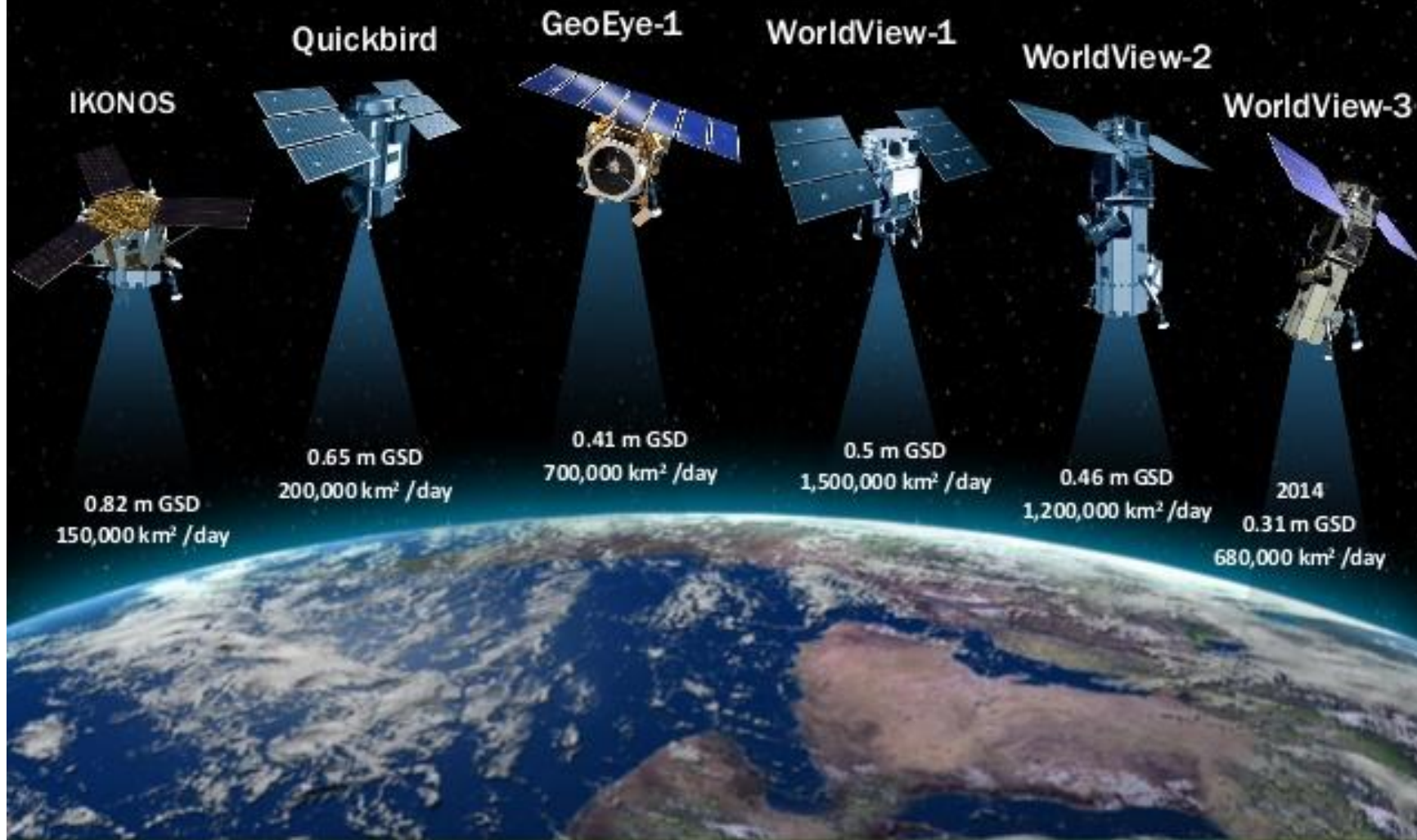
SWIR: 3.72m – 8 bands



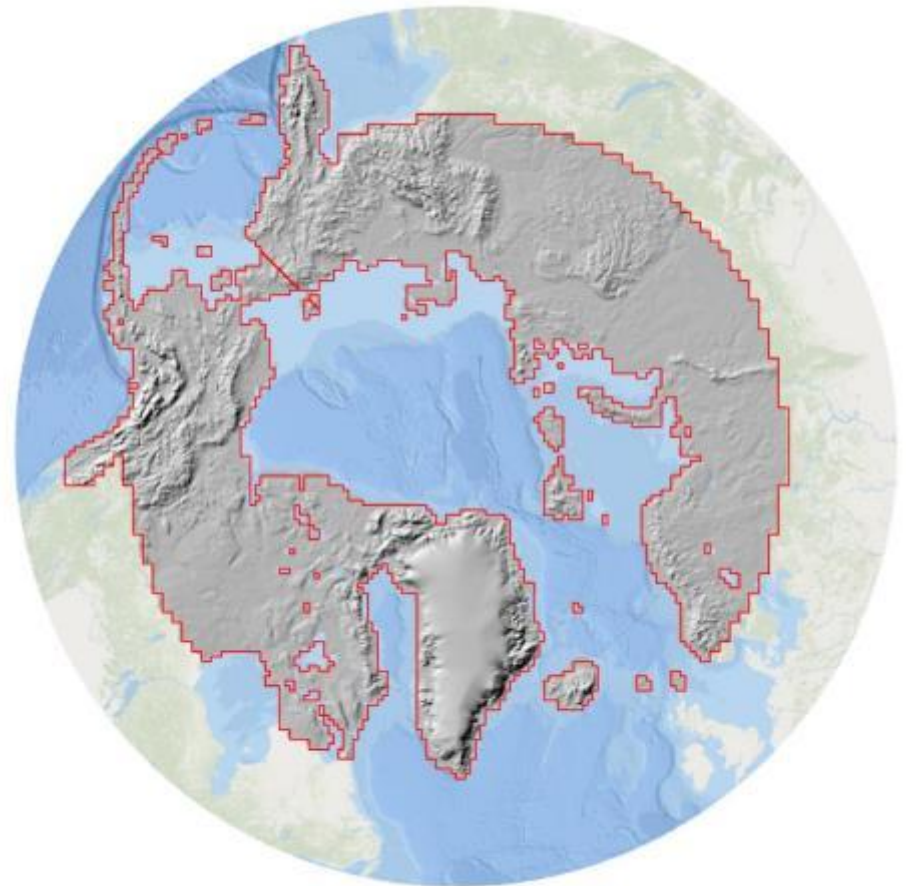
Pudong, Shanghai

DigitalGlobe Constellation (MAXAR)

Data cost ~ \$10-25 per km; arrangements made with Universities and researchers for projects, humanitarian applications



ArcticDEM is constructed from individual stereoscopic DEMs extracted from pairs of submetre (0.32 to 0.5 m) resolution Maxar satellite imagery, including data from WorldView-1, WorldView-2, and WorldView-3, and a small number from GeoEye-1, acquired between 2007 and 2022 over the summer seasons.



Fusion / Merge / Pansharpening

PAN band has 2-4 x resolution of MS bands

Satellite sensor	PAN	MS (metres)
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Landsat 7 ETM+	15	30
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Landsat 8 / 9 OLI	15	30
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SPOT 1-4	10	20
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SPOT 5	5	10
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SPOT 6-7	1.5	6
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High-resolution

Ikonos	1	4
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Quickbird	0.6	2.4
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Worldview	0.31	1.24
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Selected New millennium High resolution sensors

Launched by corporations, not always countries

Date	Sensor	Bands*	Pixel (m)	Swath (km)	Orbit (km)	Data
1999	Ikonos	RGBN	1 / 4	11.3	681	11 bit
2001	Quickbird	RGBN	0.6 / 2.4	16.5	450	11
2003	Orbview3	RGBN	1 / 4	8	470	11
2007	Worldview1	RGBN	0.5 / 2	17.6	496	11
2008	GeoEye1	RGBN	.41 / 1.65	15	681	11
2009	Worldview2	8 bands	.46 / 1.85	16.4	770	11
2014	Worldview3	VNIR/SWIR	.31 / 1.24	13.1	617	11
2016	Worldview4 = GeoEye2 = same as Worldview 3				617	11

* plus higher resolution Panchromatic band

Even more New millennium High resolution sensors

Date	Sensor	Bands	Pixel (m)	data	Country
		(+Pan)			
2011	Pleiades	RGBN	0.5/2.0	14 bit	France
2012	Kompsat	RGBN	0.7/2.8	14 bit	S.Korea
2014	Gaofen-2	RGBN	0.8/3.2	14 bit	China
2017	Formosat	RGBN	0.5/2.0	14 bit	Taiwan
2019	Cartosat-3	RGBN	0.25/1.0	11 bit	India
2025	Albedo	RGBN	0.12 / 0.48	+thermal	USA VLEO: 320km alt.

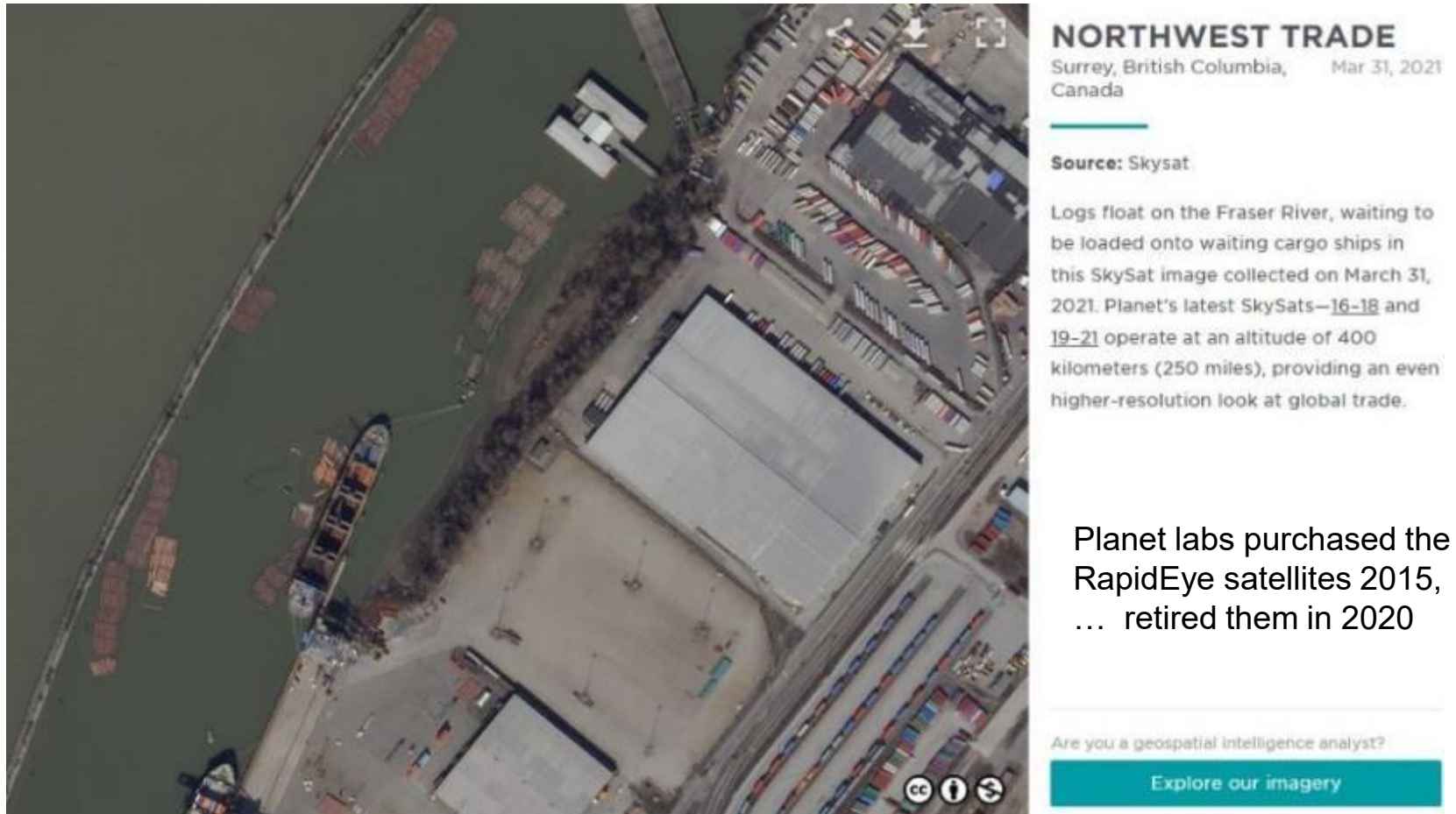
Also: Gokturk, DubaiSat, KoreaSat, KazeoSat, etc

<https://www.satimagingcorp.com/satellite-sensors/other-satellite-sensors>

<https://www.eoportal.org/satellite-missions>

https://en.wikipedia.org/wiki/List_of_Earth_observation_satellites

Planet Labs – constellation of nanosatellites mapping the planet



<https://www.planet.com/> Map the planet every day at 1-5m resolution

“Maxar Technologies and Planet Labs are the Key Players in the Remote Sensing Services Market [2022-2027]”
Image classification now requires Artificial Intelligence (AI) and Machine Learning (ML)

India successfully launches 104 satellites

Launch sets a record for most satellites launched at once

The Associated Press | Posted: Feb 15, 2017 9:18 AM ET | Last Updated: Feb 15, 2017 11:54 AM ET



This photograph released by Indian Space Research Organisation shows its polar satellite launch vehicle lifting off from a launch pad at the Satish Dhawan Space Centre in Sriharikota, India, Wednesday, Feb. 15, 2017. (Indian Space Research Organization)

The launcher placed the satellites into Sun-synchronous orbits after a flight of 17 minutes.

nanosatellites: two from India, +Cartosat 3; one each from Kazakhstan, Israel, Netherlands, Switzerland, United Arab Emirates, and 96 USA.

Of these 96, 88 CubeSats (doves) were owned by Planet Labs, a private Earth imaging company based in San Francisco



Gunter's space page: https://space.skyrocket.de/doc_chr/lau2025.htm