New millennium sensors: Earth Observation (EO)

- Landsat (NASA) 1970s-> 1999-> 2013->
- ASTER and MODIS (NASA) 2000 ->
- Sentinel (ESA) 2015 ->
- High resolution satellites 2000->

- RADAR
- LiDAR

Landsat 8 (OLI) 2013->

Highest settlement in the world, Peru

Landsat 8 OLI 432 composite plus mid-IR (band 6) for fires
Landsat 7 continuing but without Scan Line Calibration
Swath ~180km, L7 central stripe free ~ 20km

Remote sensing, Fall 2020: project

The general goal is essentially to apply the lessons learned from the labs and using an area of interest to classify or threshold, generate clean and meaningful polygon vectors for selected features, and present these with the satellite image, and/or DEM layers. The class features might be land cover that you can identify without extensive ground knowledge.

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Week 2 (Nov 26): channel creation / classification

Week 3 (Dec 3): vectors /analysis /write-up

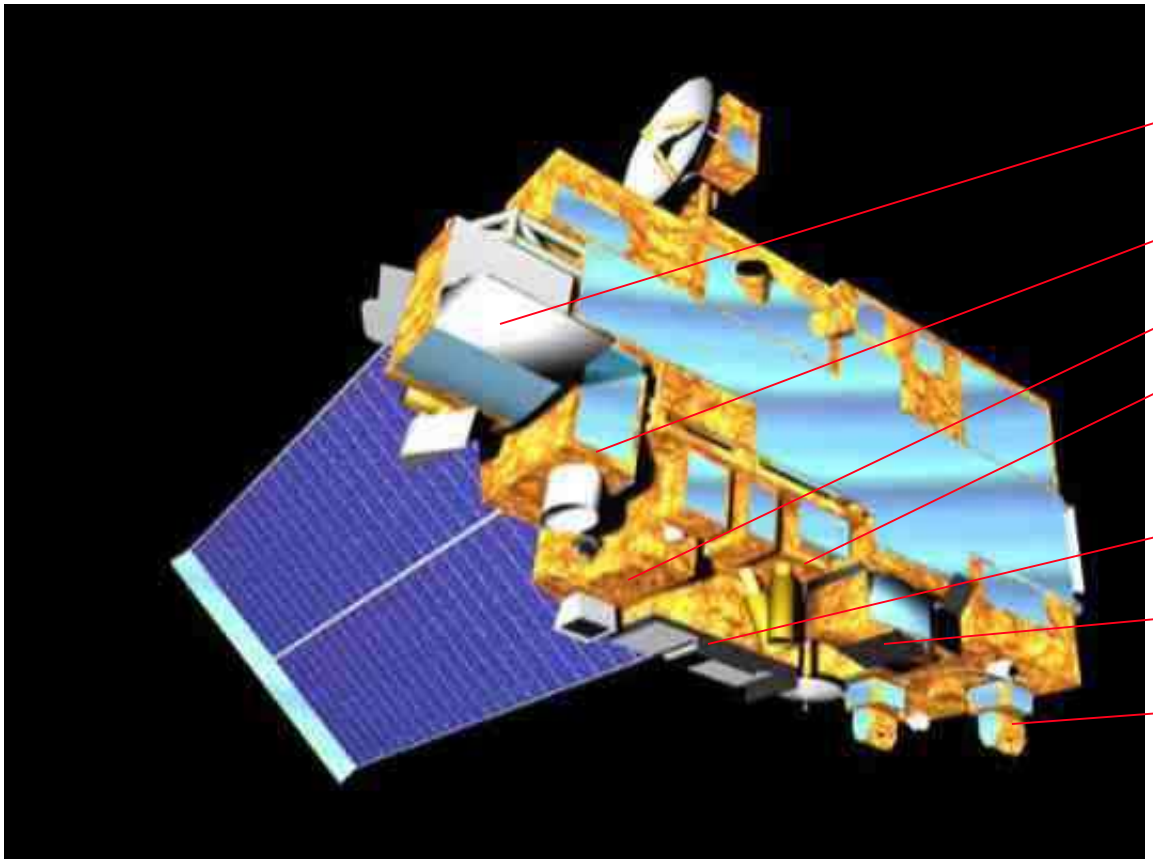
Due date: Tuesday 8 December

Terra Satellite

data since Feb 24, 2000 (launched 18 Dec 1999)

Terra is the flagship of NASA's Earth Science Enterprise.

ASTER is the 'zoom lens' of Terra..



TERRA: THE EARTH OBSERVING SYSTEM (EOS) AM-1

http://www.gsfc.nasa.gov/gsfc/service/gallery/fact_sheets/earthsci/terra/terra_eos_am.htm

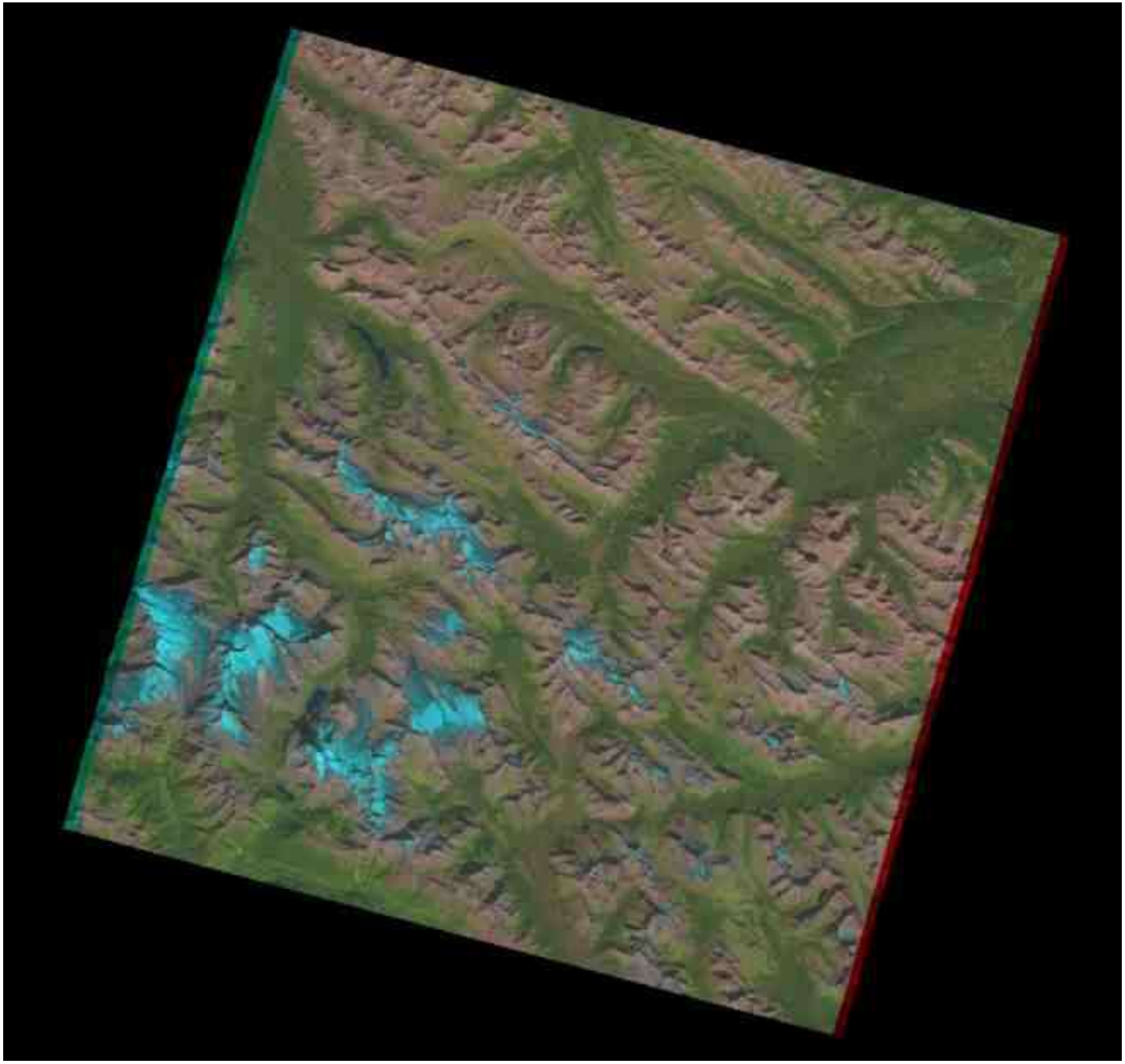
ASTER **Advanced Spaceborne Thermal Emission and Reflection Radiometer** JAPAN

MODIS **Moderate-resolution Imaging Spectroradiometer**

CERES **Clouds and the Earth's Radiant Energy System** (thermal)

MISR **Multi-angle Imaging Spectro-Radiometer**
VNIR at 26, 46 60, 70 degrees

MOPITT **Measurement of Pollution in the Troposphere** (CO, CH4)
http://www.atmosp.physics.utoronto.ca/MOPITT/home.html CANADA



ASTER

Landsat-like

Sept 2007

Mt. Robson

15/30m

SWIR
failed
April 2008

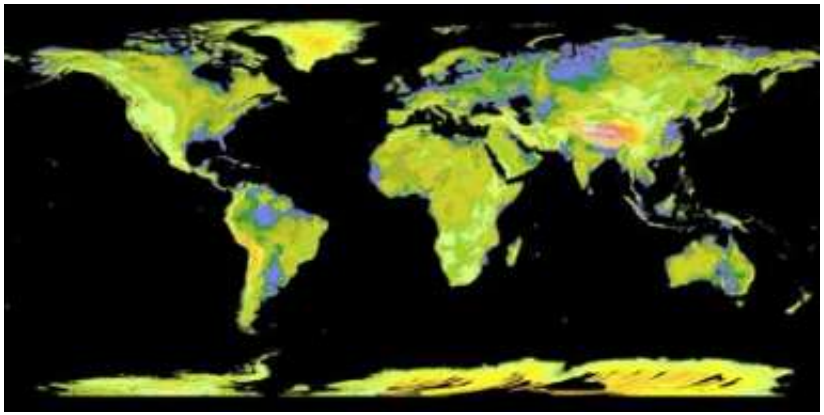
ASTER bands – band 3 has two modes: 3N and 3B

Band	Wavelength (microns)	Spatial Resolution (m)
	Visible to Near-Infrared Bands	
1	0.52 – 0.60	15
2	0.63 – 0.69	15
3	0.76 – 0.86	15
	Shortwave Infrared Bands	
4	1.60 – 1.70	30
5	2.145 – 2.185	30
6	2.185 – 2.225	30
7	2.235 – 2.285	30
8	2.295 – 2.365	30
9	2.360 – 2.430	30
	Mid-infrared (Thermal) Bands	
10	8.125 – 8.475	90
11	8.475 – 8.825	90
12	8.925 – 9.275	90
13	10.25 – 10.95	90
14	10.95 – 11.65	90

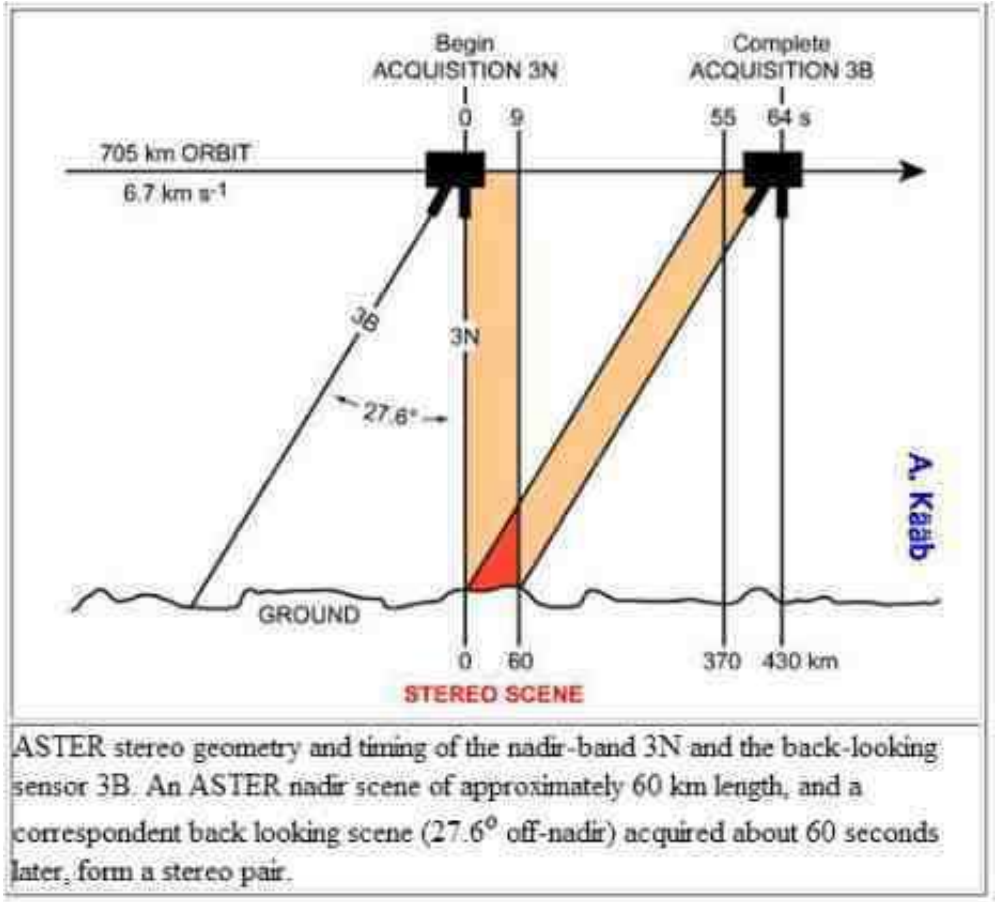
Failed 2008

ASTER – imagery and DEMs 2000-

Global DEM to 83 degrees latitude



Sample ASTER draped image



ASTER stereo geometry and timing of the nadir-band 3N and the back-looking sensor 3B. An ASTER nadir scene of approximately 60 km length, and a correspondent back looking scene (27.6° off-nadir) acquired about 60 seconds later, form a stereo pair.

https://asterweb.jpl.nasa.gov/gallery.asp

ASTER

Advanced Spaceborne Thermal Emission and Reflection Radiometer

SEARCH ASTER

GO

- HOME
- MISSION
- GALLERY
- Archaeology
- Cities
- Geology
- Glaciers
- Hydrology
- Land Use
- Natural Hazards
- Volcanoes

ASTER's Satellite Image Gallery

20 Most Recent Additions to the Gallery

"Image of the Week"

Sea of Galilee, Israel

Gravity Wave Detectors

Aldan, Siberia, Russia

Tao-Rusyr Volcano, Kuril Islands

Lake Fitri, Chad

Nishinoshima Volcano, Japan

Mount Whaleback Iron Ore Mine, Australia

2020 Al Jowf

MODIS (Moderate-resolution Imaging Spectroradiometer)

MODIS SPECIAL THEMES

MODIS Team Member	MODIS Product
E. Vermote	Surface Reflectance
Z. Wan	Land Surface Temperature
A. Strahler/J.-P. Muller	BRDF/Albedo
A. R. Huete/C. O. Justice	Vegetation Indexes
R. B. Myneni/S. W. Running	LAI/FPAR
C. O. Justice/Y. J. Kaufman	Fires/Burned Area
D. Hall	Snow/Ice/Sea Ice
J. R. G. Townshend/A. Strahler	Land Cover/Land Cover Change
S. W. Running	PSN/NPP

EarthExplorer datasets

Launched by NASA in 1999 on the Terra (EOS AM) satellite, and in 2002 on the Aqua (EOS PM) satellite.
Terra: 10.30am descending
Aqua: 1.30pm ascending

MODIS: MODerate-resolution Imaging Spectroradiometer

36 spectral bands ranging in wavelength from 0.4 μm to 14.4 μm and at spatial resolutions between 250m and 1km. Swath: 2330 km Earth covered 1-2 days
Designed to combine some of the characteristics of AVHRR and Landsat TM
'Superspectral' (vs Multispectral)
MODIS is THE main medium resolution EO satellite sensor

Reflected Solar Bands			Emissive Bands
Aggregated 250 m	*Aggregated 500 m*	*1 km*	*1 km*
Band 1 (620-670 nm)	Band 3 (459-479 nm)	Band 8 (405-420 nm)	Band 20 (3.660-3.840 μm)
Band 2 (841-876 nm)	Band 4 (545-565 nm)	Band 9 (438-448 nm)	Band 21 (3.929-3.989 μm)
	Band 5 (1230-1250 nm)	Band 10 (483-493 nm)	Band 22 (3.939-3.989 μm)
	Band 6 (1628-1652 nm)	Band 11 (526-536 nm)	Band 23 (4.020-4.080 μm)
	Band 7 (2105-2155 nm)	Band 12 (546-556 nm)	Band 24 (4.433-4.498 μm)
		Band 13L (662-672 nm)	Band 25 (4.482-4.549 μm)
		Band 13H (662-672 nm)	Band 27 (6.535-6.895 μm)
		Band 14L (673-683 nm)	Band 28 (7.175-7.475 μm)
		Band 14H (673-683 nm)	Band 29 (8.400-8.700 μm)
		Band 15 (743-753 nm)	Band 30 (9.580-9.880 μm)
		Band 16 (862-877 nm)	Band 31 (10.780-11.280 μm)
		Band 17 (890-920 nm)	Band 32 (11.770-12.270 μm)
		Band 18 (931-941 nm)	Band 33 (13.185-13.485 μm)
		Band 19 (915-965 nm)	Band 34 (13.485-13.785 μm)
		Band 26 (1.360-1.390 μm)	Band 35 (13.785-14.085 μm)
			Band 36 (14.085-14.385 μm)


MODIS 13 Nov 2018

Attu

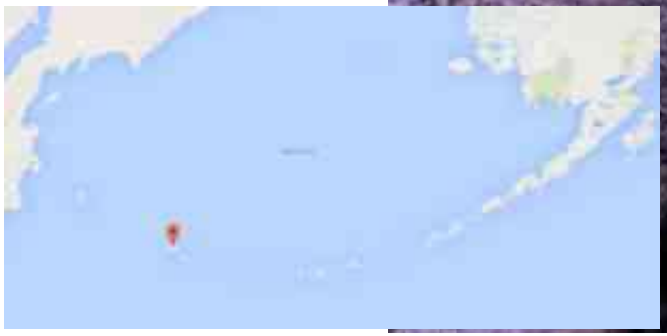
Aleutian Islands

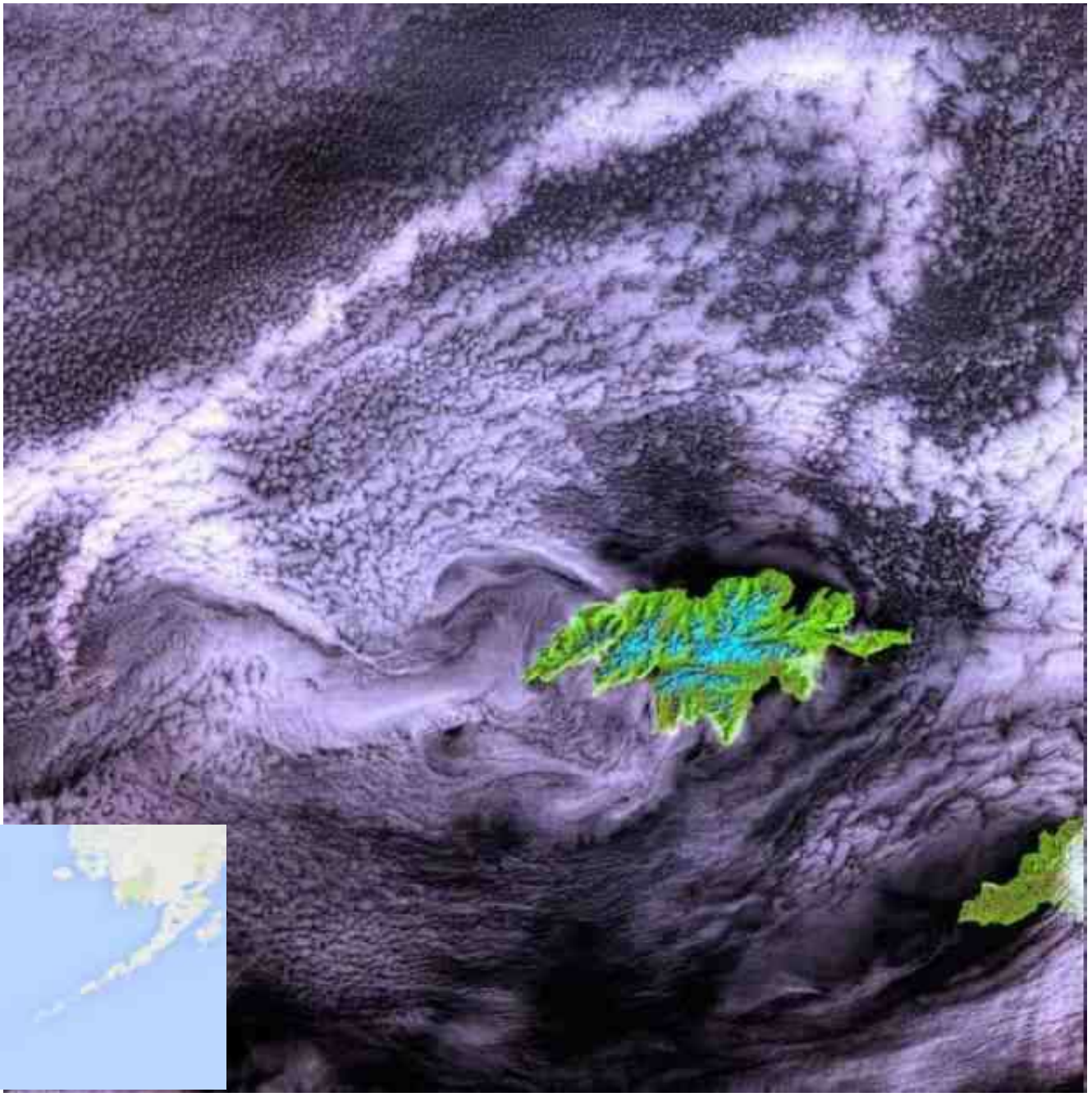
(MODIS image)

Westernmost

(and easternmost?) point of North America

50 km





Sentinel Program 2015->

European Space Agency (ESA)
Heimay, Iceland
Nov 1, 2018

This week

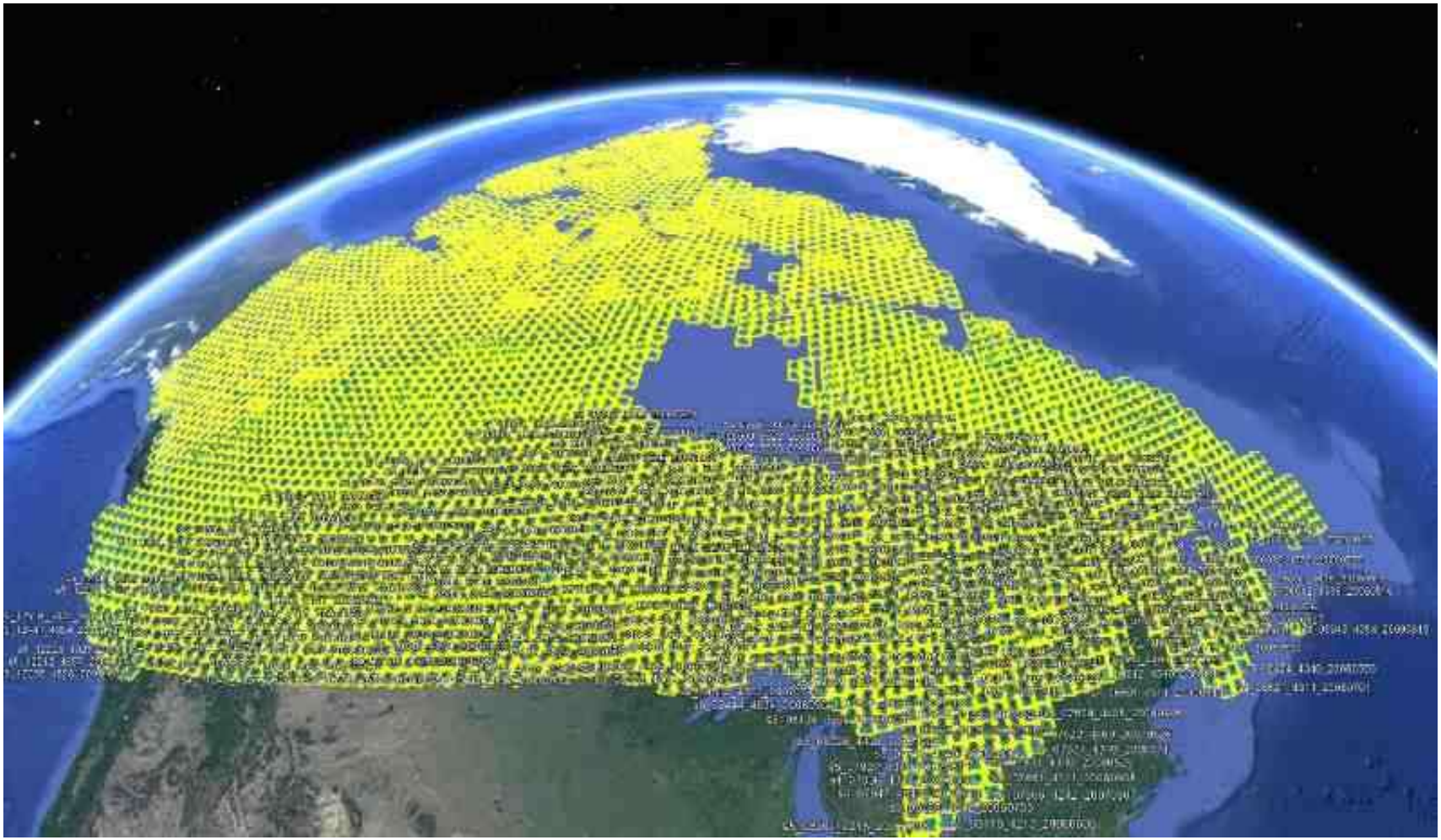
ESA Copernicus program: Sentinel – all free data

1a / b: April 2014 / 2016 RADAR 10m res.

2a / b: June 2015 / March 2017 Optical 290 km swath

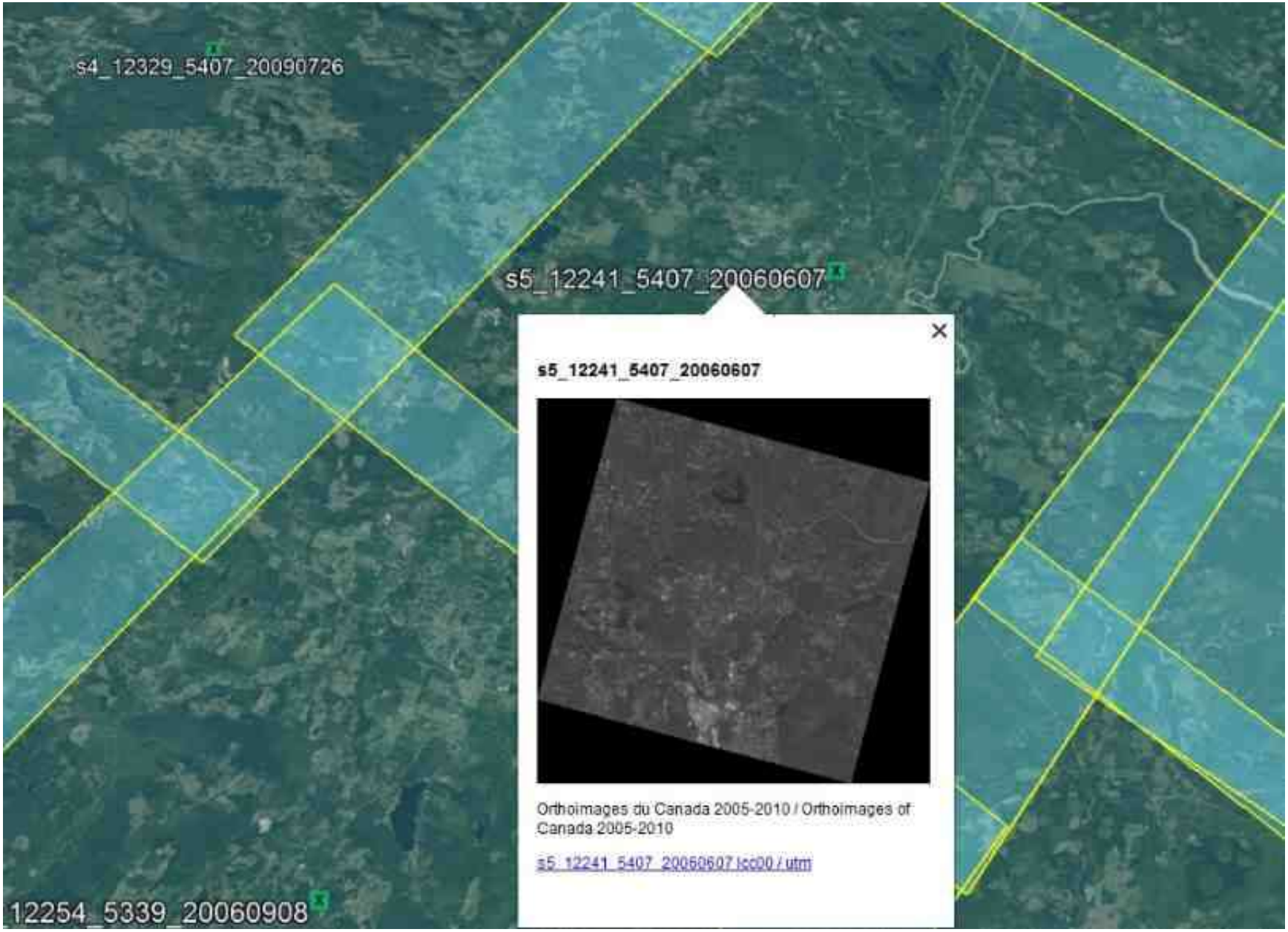
Sentinel-2 Bands	Central Wavelength (µm)	Resolution (m)	Bandwidth (nm)
Band 1 – Coastal aerosol	0.443	60	20
Band 2 – Blue	0.490	10	65
Band 3 – Green	0.560	10	35
Band 4 – Red	0.665	10	30
Band 5 – Vegetation Red Edge	0.705	20	15
Band 6 – Vegetation Red Edge	0.740	20	15
Band 7 – Vegetation Red Edge	0.783	20	20
Band 8 – NIR	0.842	10	115
Band 8A – Narrow NIR	0.865	20	20
Band 9 – Water vapour	0.945	60	20
Band 10 – SWIR – Cirrus	1.375	60	20
Band 11 – SWIR	1.610	20	90
Band 12 – SWIR	2.190	20	180

GEOBASE SPOT 4/5: Canada/France agreed to cover Canada 2005-2010 at 10/20m resolution; cloud free is not always guaranteed



https://ftp.maps.canada.ca/pub/nrcan_rncan/image/spot/geobase_orthoimages

Zoom into your area, click on x and see the file name–coded by Lat/long

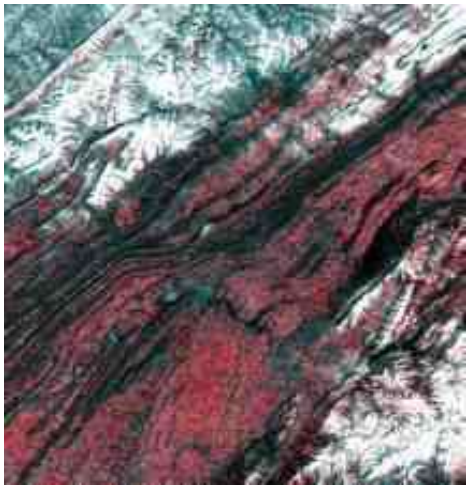


Highest resolution imagery in the old millennium

1959-72 Corona spy photos: 1.8 – 7.5 m resolution

1986: SPOT 1 PAN 10m Multi 20m

Indian Remote Sensing IRS-1C 1995:
Panchromatic (PAN) camera of **6 m** res. (right)
Linear Imaging Self Scanner (LISS-3) 23.6m (left)
Wide Field Sensor (WiFS)189m centre



Toronto

High resolution **corporate** satellites 2000->

Ikonos: launched late 1999; first data sold Jan 1, 2000

Resolution: Pan 1m Multispectral 4m

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

(For 2010 Winter Olympics)

Quickbird 2001

Pan 60cm MS 2.4m

GeoEye (launched by Google) 2008

41 / 46cm PAN 1.65m MS

Obama Inauguration (Jan 2009)

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

Worldview3 2014

Rainbow Range

Chilcotin, BC 31cm

PAN: 31cm

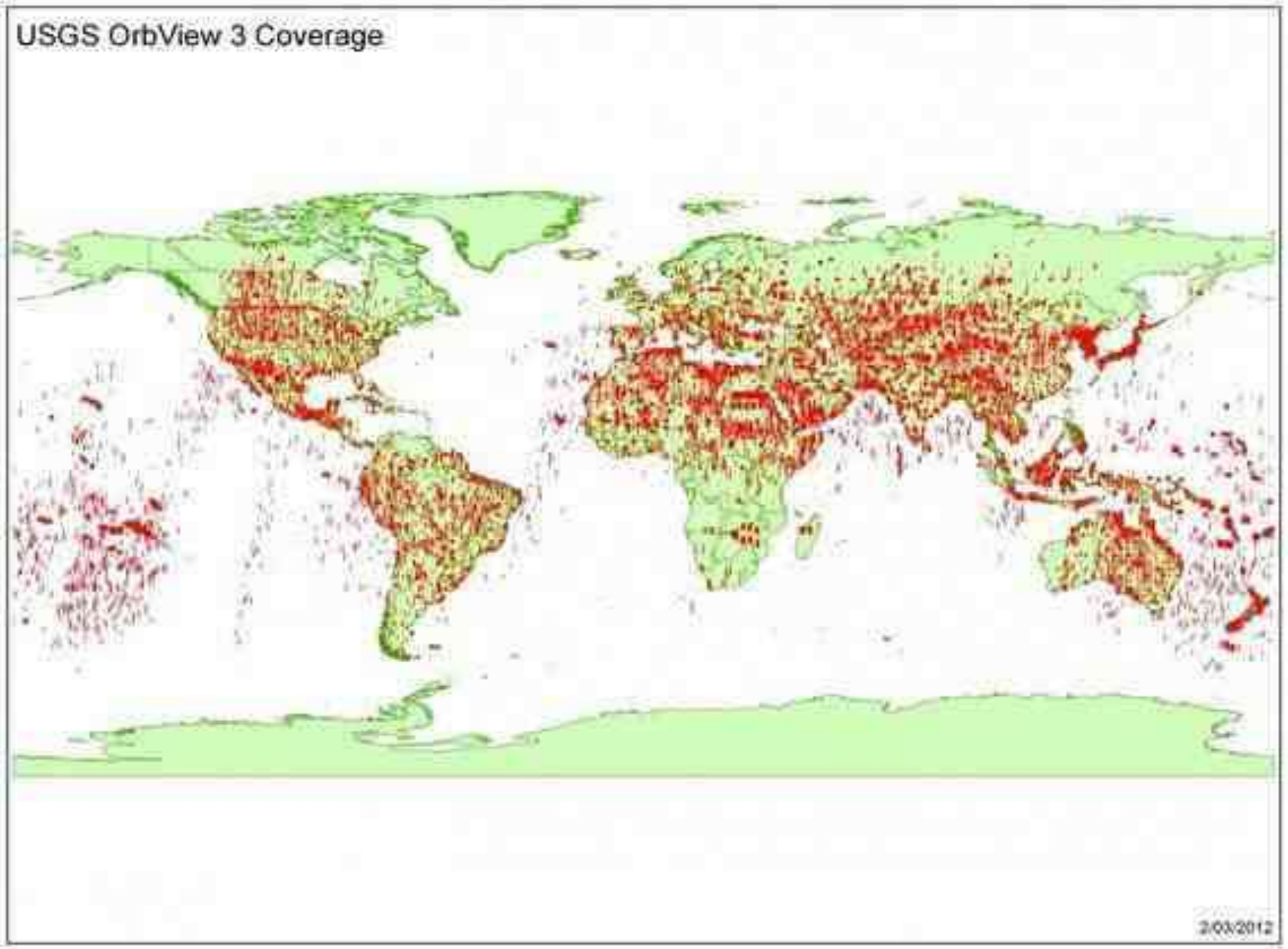
VNIR: 1.24m

SWIR: 3.72m

(8 bands)

EarthExplorer datasets

Ikonos – for government departments only
Orbview (high res.) image data on EarthExplorer



Fusion / Merge /Pansharpening

Satellite sensor	PAN	MS (metres)
Landsat 7 ETM+	**15**	**30**
Landsat 8 OLI	**15**	**30**
SPOT 1-4	**10**	**20**
SPOT 5	**5**	**10**
SPOT 6-7	**1.5**	**6**
<u>High-resolution</u>		
Ikonos	**1**	**4**
Quickbird	**0.6**	**2.4**
Worldview	**0.31**	**1.24**

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	Orbview 3	RGBN	1 / 4	8	470	11
2007	Worldview 1	RGBN	0.5 / 2	17.6	496	11
2008	GeoEye 1	RGBN	.41 / 1.65	15	681	11
2009	Worldview 2	8 bands	.46 / 1.85	16.4	770	11
2014	Worldview 3	Vis-MIR	.31 / 1.24	13.1	617	11
2016	Worldview 4 = GeoEye2 = same as Worldview 3				617	11

* and higher resolution Panchromatic band

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

Remote sensing, Fall 2020: project

The general goal is essentially to apply the lessons learned from the labs and using an area of interest to classify or threshold, generate clean and meaningful polygon vectors for selected features, and present these with the satellite image, and/or DEM layers. The class features might be land cover that you can identify without extensive ground knowledge.

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For next week:

Nov 15: Article review (Sunday)

Nov 18: RADAR (think about project,
based on your interests/experience)

Geographic area: BC / Canada / World

Application: forests, water, ice, urban etc**..**

Data source: Landsat 5/7/8, SPOT, ASTER

Nov 19: Lab: download and prepare data (clip)

Nov 20: LiDAR