Remote sensing: review The Electromagnetic Spectrum



Visible: **reflected** 'natural colour' – what we see

Near/mid-IR: <u>reflected</u> from earth = vegetation; moisture

Thermal IR: <u>emitted</u> from earth = temperature

Microwave: unaffected by clouds – includes RADAR RADAR and LiDAR are ACTIVE systems; the rest are PASSIVE

Earth from Space: Earth Observation (EO) satellites



Total number: ~15,000 satellites

Myth #1: Most satellite images are not photos; they are scanned except for...



ISS orbit: 400km, 51 degree angle

Satellites have two types of orbit

1. Geostationary: 36,000 km above equator, stay vertically above the same spot, rotate with earth - mostly weather images

e.g. GOES (Geostat. Operational Env. Satellite)



2. Sun-synchronous satellites: Earth Observation

650-900 km altitude, orbit at ~ 81-82 degree angle to the equator (= near polar): captures imagery ~ same time each day (~ 10 - 11am)



Landsat:

http://earthnow.usgs.gov

Earth from Space Satellite Images for mapping

from low resolution 10km (weather satellites) to very high

capable of detecting objects <1 metre

Hurricane Katrina (2005)



Geostationary satellite orbit



New Orleans, before and during Hurricane Katrina



Myth #2: "...its so big you can see it from space"



Russian tank convoy Ukraine invasion 'special military operation'

High resolution satellite imagery (Maxar), 15-30cm Feb 28, 2022



Spatial Resolution (pixel size) <1 metre to >10 kilometres

Low resolution (free)

Medium resolution (free)

High resolution (mostly free)

Very High resolution (costs \$\$)

Landsat – 30m pixels

1km - 10km (international) -small scale

100m - 500m (national) - < 1:250,000

10 -50 m (regional) - 1:50,000

25cm - 5m (Local) - > 1:20,000

McBride, BC Air photo: <1m pixels





Small scale satellite images (10km pixels) http://www.goes.noaa.gov/~70% cloudsGOES Alaska SECTOR IR Image



Low resolution imagery (~10km pixels)

Daily sea surface temperatures using Microwave wavelengths - cloud free



'Isarithmic thematic map'

Medium resolution: MODIS (since 2000)

500m - 1km

'national scale coverage'



Medium - High resolution: Landsat (NASA-1972)

Satellites 1,2,3 had a Multi-Spectral Sensor (MSS) with a pixel size 80 metres in resolution.

Bands (layers): Visible / Near-IR

First Landsat image: San Francisco 1972



And Africa and Annual America and Annual America and





EOSD Image 15/22 (15 June 2001



Reservoirs in Quebec 1975-2000

High resolution (the Next Generation) Landsat 5 Thematic Mapper (TM): 1984 Pixel size: 30 metres; mid-IR/Near-IR/Red (Moisture/dryness-Vegetation-Visible)



Bowron Lakes -Landsat natural colour composite RGB (e.g. Google maps / Earth)



Google Maps / Earth was based on Landsat 7 (1999-2003) with updates from later air photos/high-res imagery

Landsat 5 bands (1982-2011), followed by Landsat 7 (1999), 8 (2013), 9 (2021)

Band No.	Wavelength Interval (µm)	Spectral Response	Resolution (m)
1	0.45 - 0.52	Blue-Green	30
2	0.52 - 0.60	Green	30
3	0.63 - 0.69	Red	30
4	0.76 - 0.90	Near IR	30
5	1.55 - 1.75	Mid-IR	30
6	10.40 - 12.50	Thermal IR	120
7	2.08 - 2.35	Mid-IR	30

Think of these as different 'GIS / mapping' layers

Google Earth Time Lapse 1984-2021

38 years of Landsat images; 65,000 images - >1 petabytes of data https://earthengine.google.com/timelapse/

Note: mountain areas comparison are less effective due to seasonal snow



Ft. MacMurray: https://www.smithsonianmag.com/smart-news/google-earths-new-tools-shows-32-years-changing-planet-180961251/

Landsat 1984 – composite images Mid-IR/Near-IR/Red











European Space Agency -ESA Sentinel 2 2015-> 10m pixels

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Oak Island, NS

RADAR ... As it is not affected by darkness or weather, it is especially useful in **arctic regions for mapping ice**; and tropical areas, which are often **cloud covered** and other areas



Ireland, 1991: Radar and Landsat (Visible / Optical image)

RADARSAT 1-2 1995/2007

Radarsat 1 - 2 are the only <u>Canadian</u> satellite systems in space for mapping

Built by MacDonald-Dettwiler, Richmond, BC

John MacDonald, UNBC Chancellor 2010-15









RADARSAT-2 Data and Products @ MacDONALD, DETTIMLER AND ASSOCIATES LTD, (2008) - All Rights Reserved - RADARSAT is an official mark of the Canadian Space Agenc

Canada produces the first complete image of Antarctica RADARSAT launched by NASA in exchange for complete map image

Radarsat was driven by the need to know and map sea ice extents in the **Canadian** Arctic





TOPOGRAPHIC DATA BASE PRODUCTION

Figure 12 illustrates the evolution of the Northern mapping project that began in 2004 up to 2010 (light green to dark green). Complete map coverage will be achieved with the 2011-2012 production plan utilizing SPOT5/HRS and Radarsat-2 data sources (Figure 13)



Figure 12 Northern Mapping project

SRTM (Shuttle RADAR Topographic Mission)Feb 200030/90 metre pixels, 56°S - 60°N latitudee.g. Google Earth DEM



http://www.cgiar-csi.org/data/elevation/item/45-srtm-90m-digital-elevation-database-v41

Very high resolution satellites

First corporate satellites **2000** Ikonos: 1m image resolution Quickbird: 60cm (2001)







Worldview3 2014 Rainbow Range Chilcotin, BC 31cm





Myth #2: "...its so big you can see it from space"

India successfully launches 104 satellites

Launch sets a record for most satellites launched at once

'doves'

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

Planet and Maxar (15-30cm pixels)

Review: Remote sensing developments from wars

- US Civil War: Photography from Pigeons and kites 1860s
- **World War I:** Aerial photography photogrammetry 1910s
- World War II: RADAR- RAdio Detection And Ranging 1940s
- Korean War: Infra-red photography 1950s
- **Cold War:** Satellite imagery originally for espionage 1960s
- Gulf Wars: 3D imagery -> Google Earth (2005)

'War on Terrorism': Unmanned Aerial Vehicles (drones) 2010s