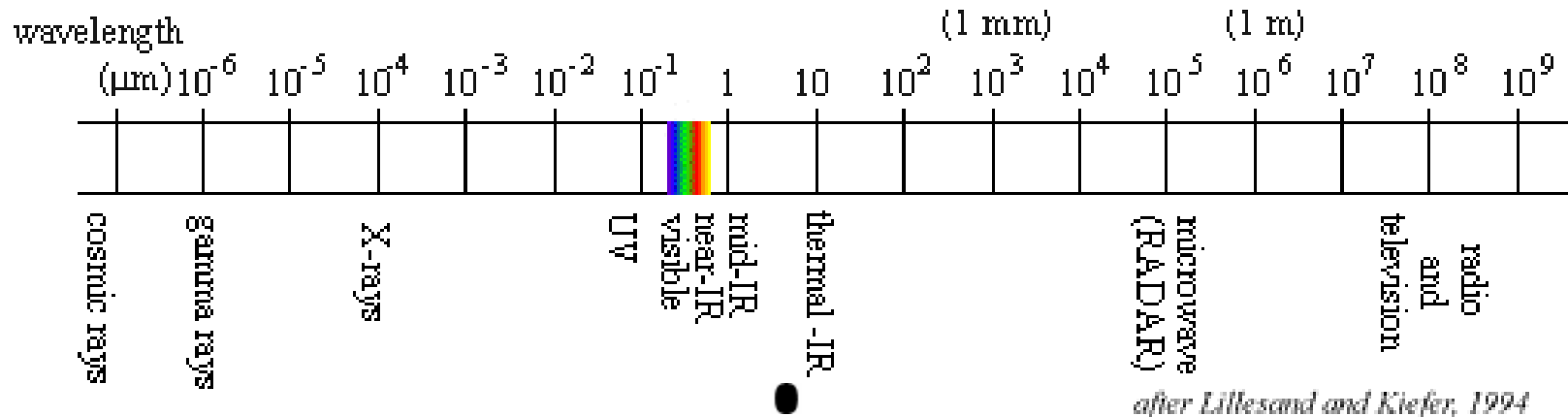


# Remote sensing: review

## The Electromagnetic Spectrum



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

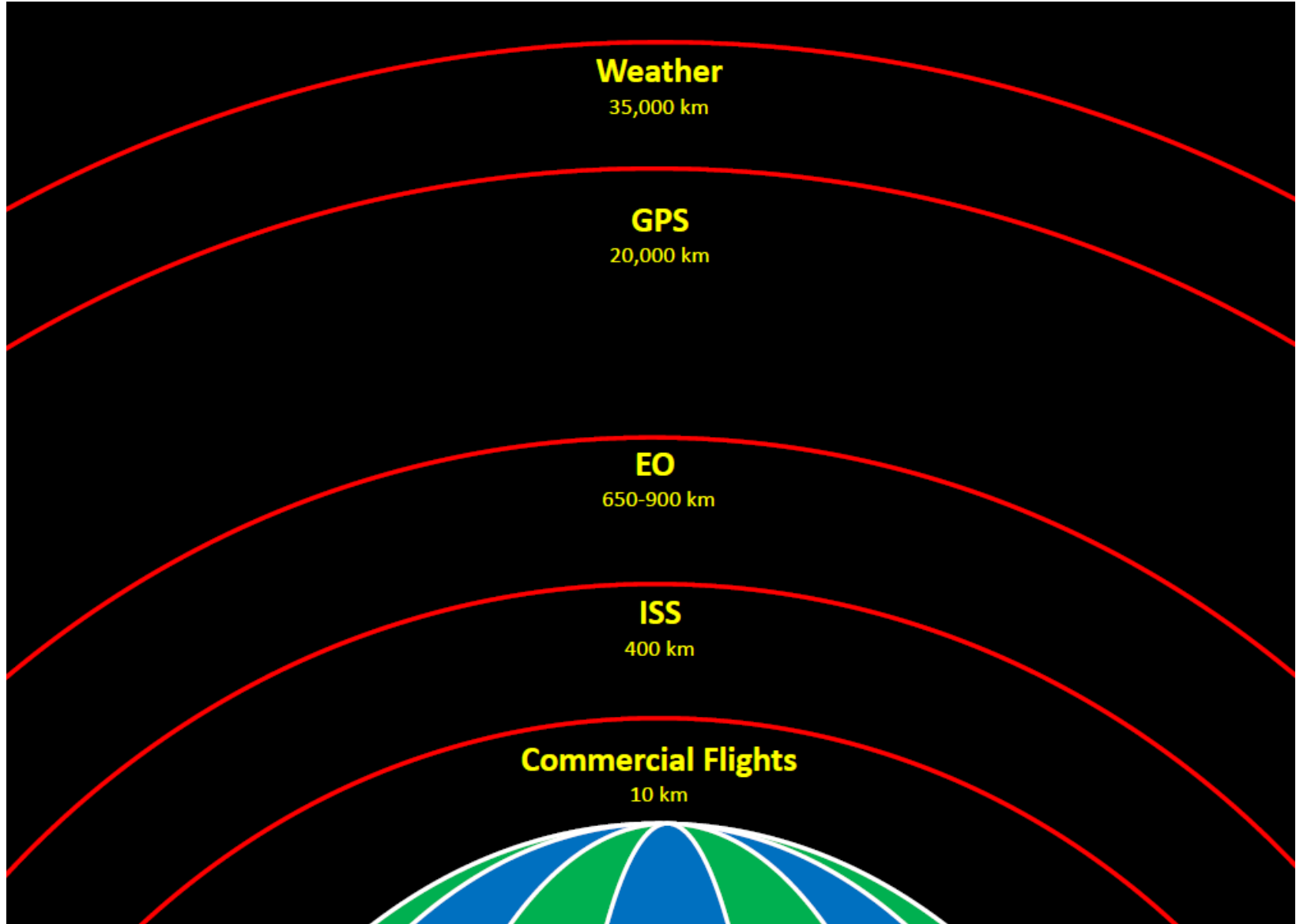
**Near-IR/SWIR:** reflected from earth = vegetation; moisture

**Thermal IR:** emitted 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...

**Alberta, BC and Rocky Mountain Trench, from International Space Station, Sept 06, 2014**



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), some GPS

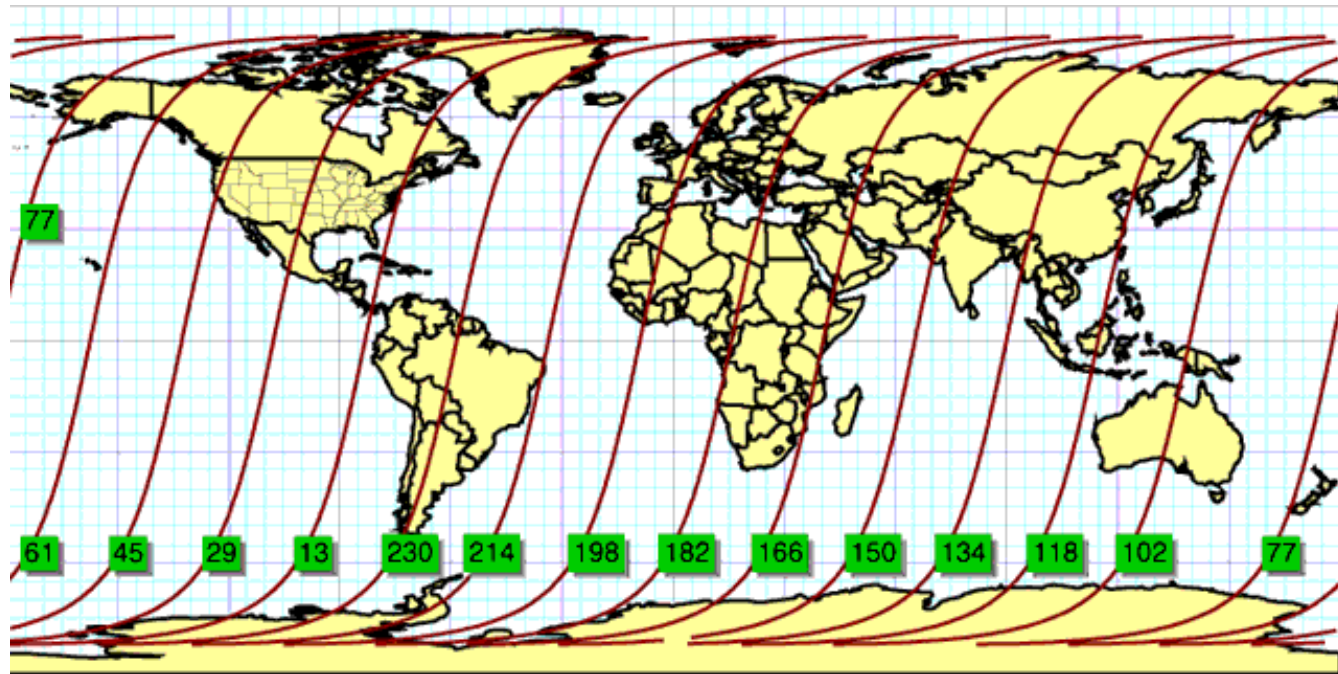
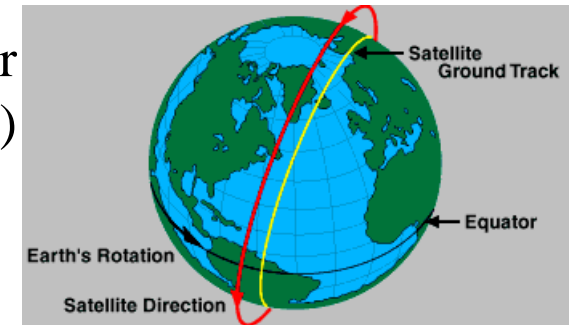




## 2. Sun-synchronous satellites: Earth Observation

650-900 km altitude, orbit at  $\sim 81\text{-}82^\circ$  angle to the equator (near polar):  $\sim$  images same time each day ( $\sim 10.30\text{-}11\text{am}$ )

These satellites map/monitor the world



<https://svs.gsfc.nasa.gov/11481>

: <http://earthnow.usgs.gov>

Satellite scanners image the same swath / area every  $\sim 7\text{-}10$  days  
Good images for mapping are limited by:  
Cloud cover (except for RADAR) and snow cover (winter)

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

Low resolution (free)                      1km - 10km (international) -small scale

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

High resolution (mostly free)            10 -50 m (regional) - 1:50,000

Very High resolution (costs \$\$)        25cm - 5m (Local) - > 1:20,000

Landsat – 30m pixels



McBride, BC

Air photo: <1m pixels



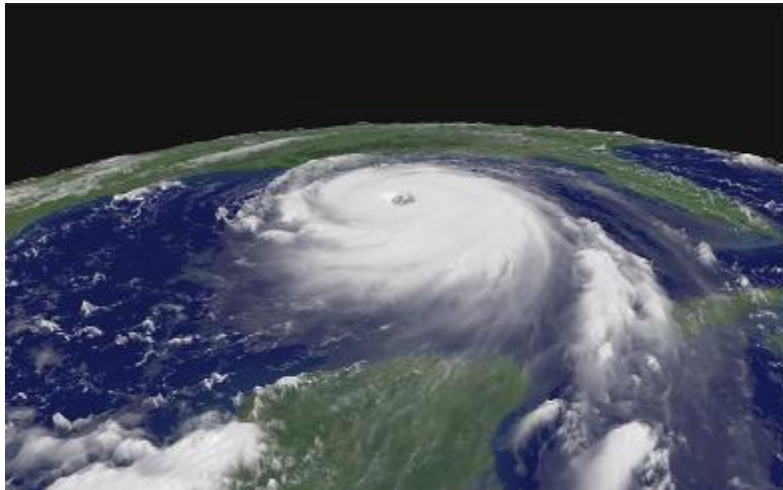


# Earth from Space

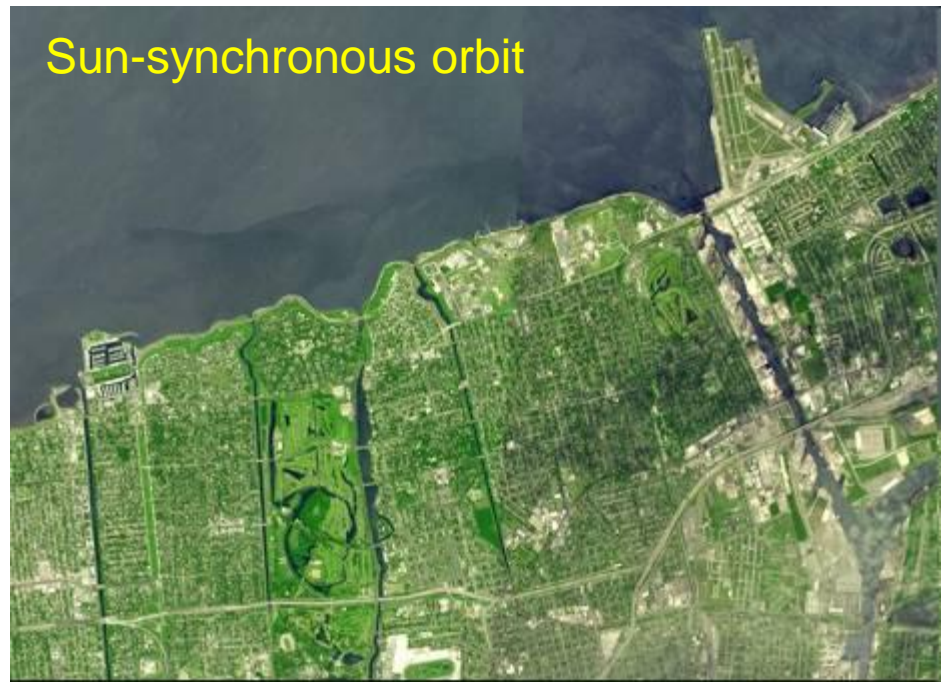
Satellite Images for mapping

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

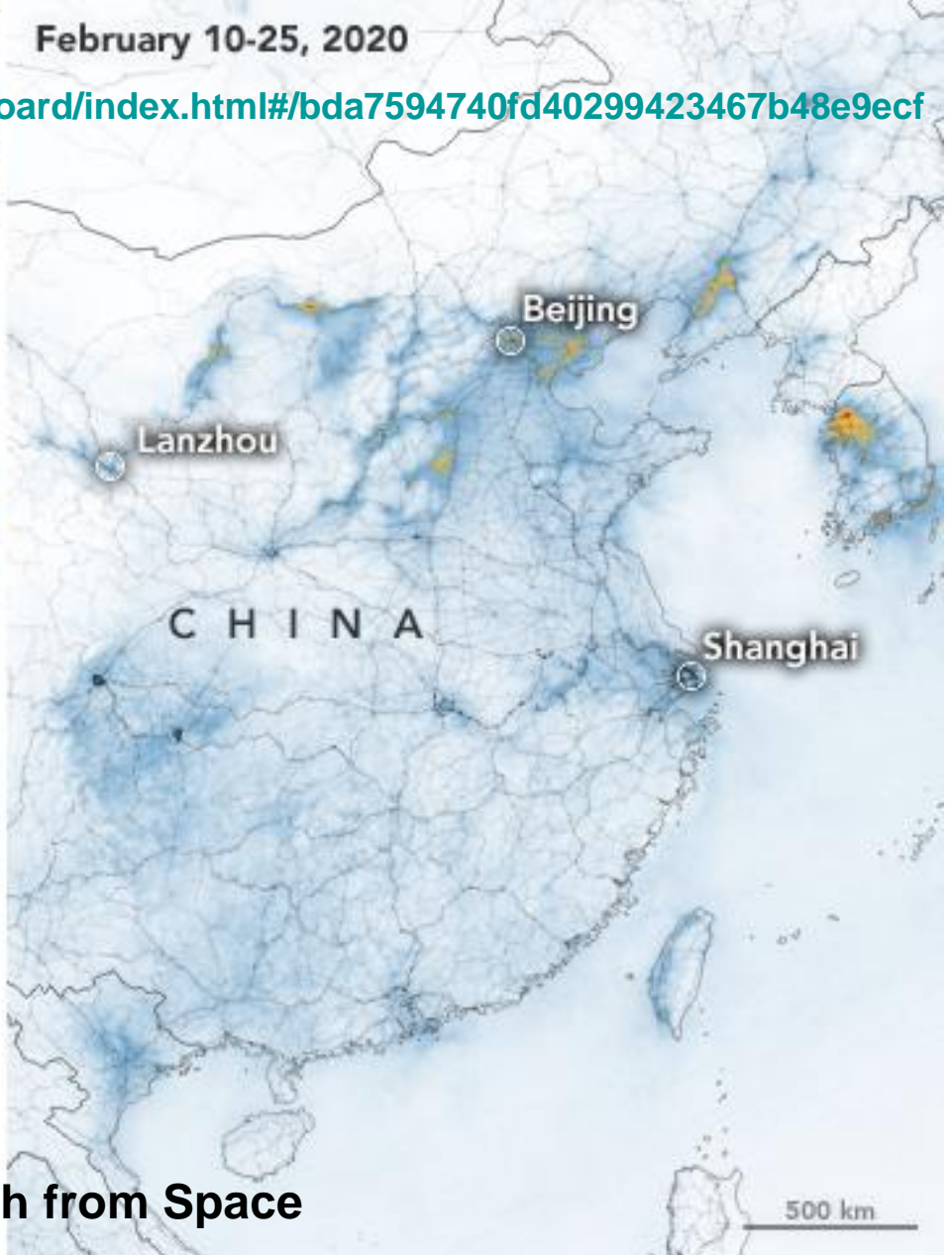
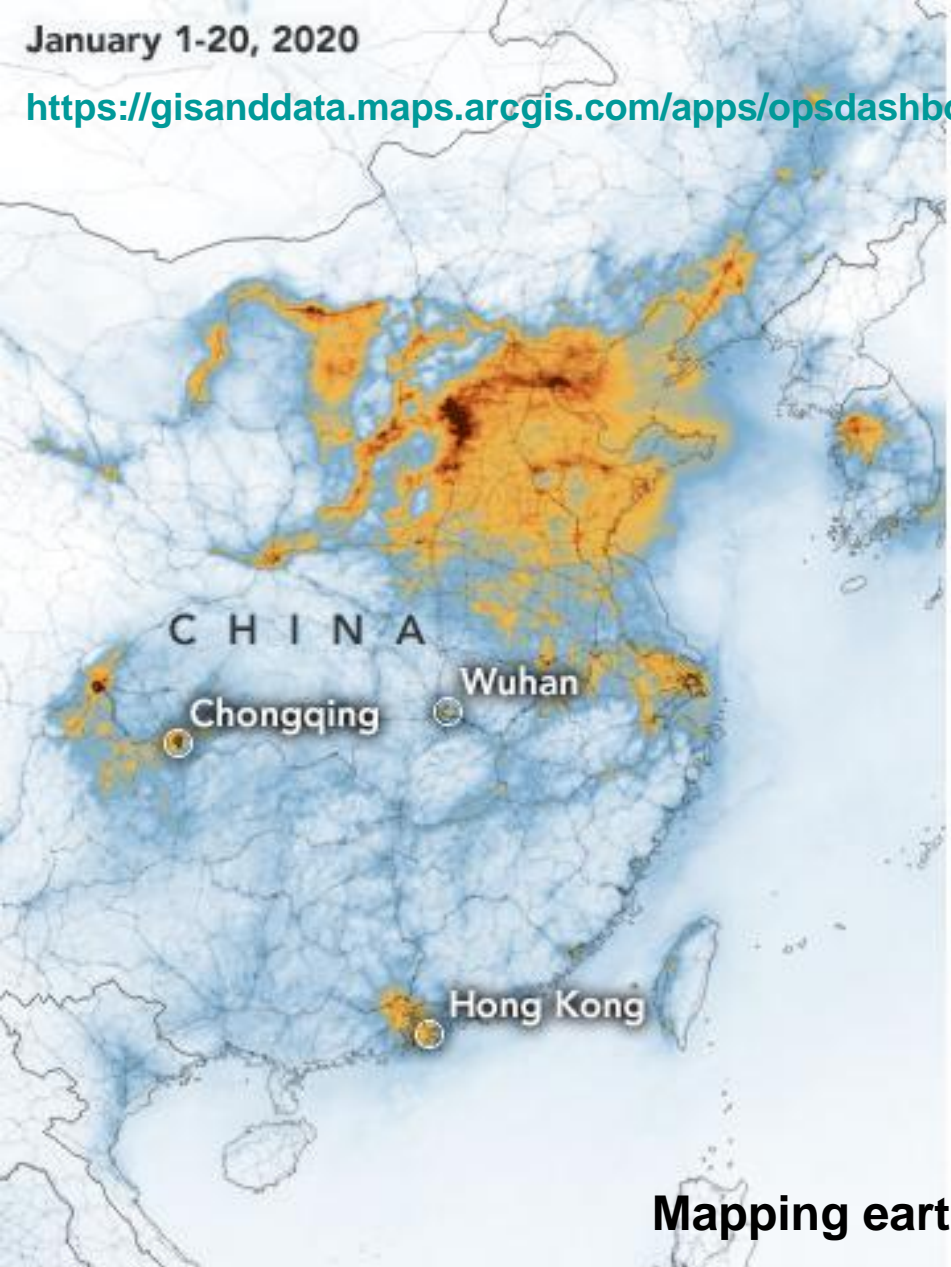




January 1-20, 2020

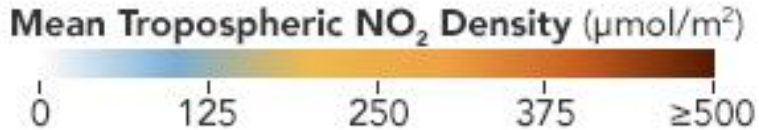
February 10-25, 2020

<https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf>



### Mapping earth from Space

**Airborne Nitrogen Dioxide  
Plummets Over China**

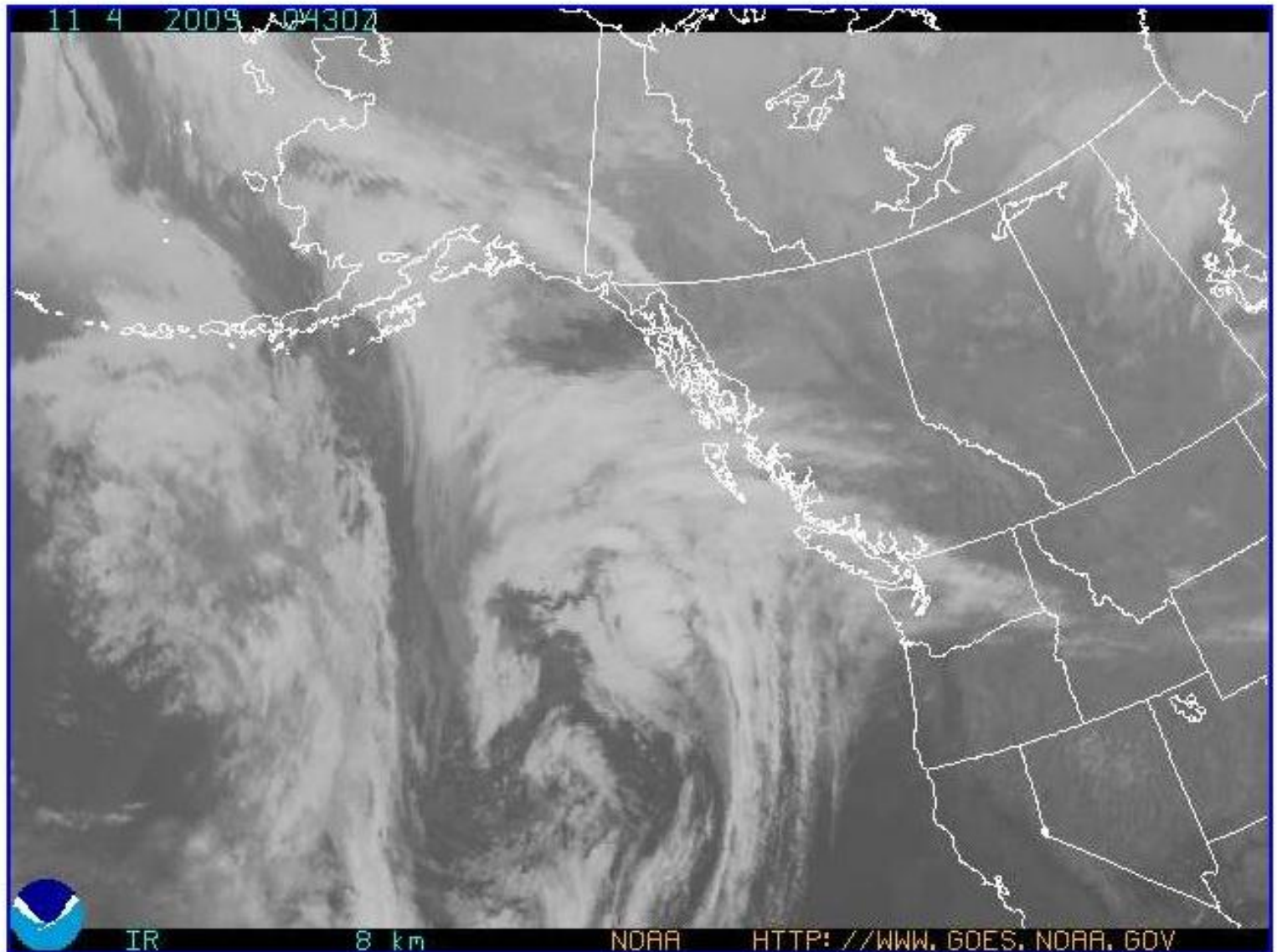


from industrial reduction  
Post-coronavirus

# Small scale satellite images (10km pixels) <http://www.goes.noaa.gov/>

~70% clouds

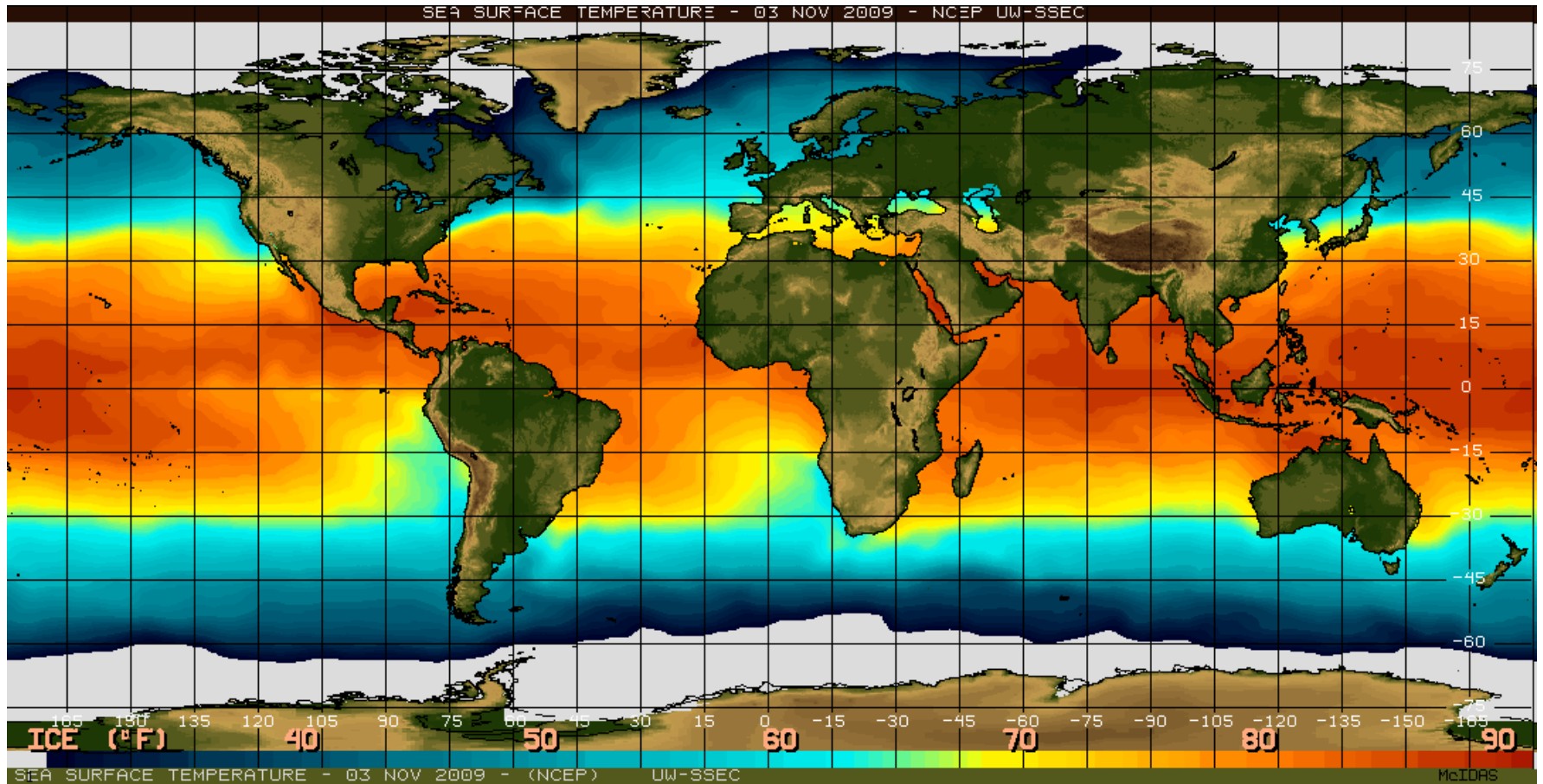
GOES Alaska SECTOR IR Image





## 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: Landsat 1-3 (NASA-1972)

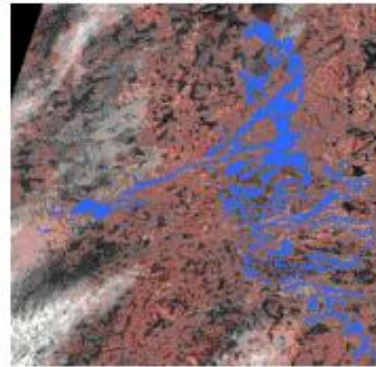
Satellites 1,2,3 had a Multi-Spectral Sensor (MSS) with a pixel size 80 metres in resolution.

Bands (layers): Visible / Near-IR

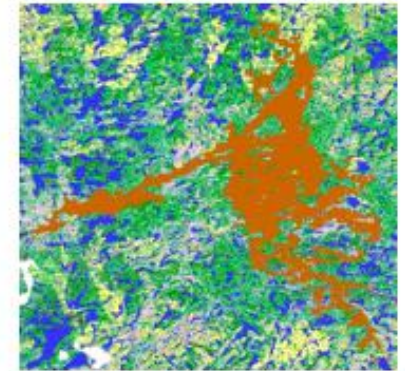
First Landsat image: San Francisco 1972



Good for 1:250,000 mapping



MSS Image 16/22 (09 Jul 1978)



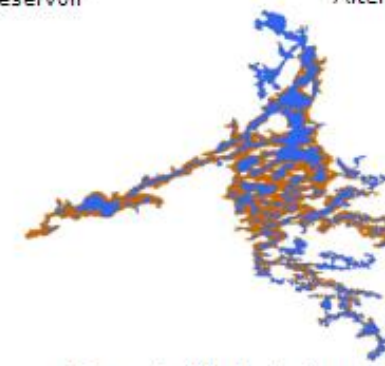
EOSD Image 15/22 (15 June 2001)



Before flooding of reservoir



After flooding of reservoir



Difference highlighted in brown

Reservoirs in Quebec 1975-2000



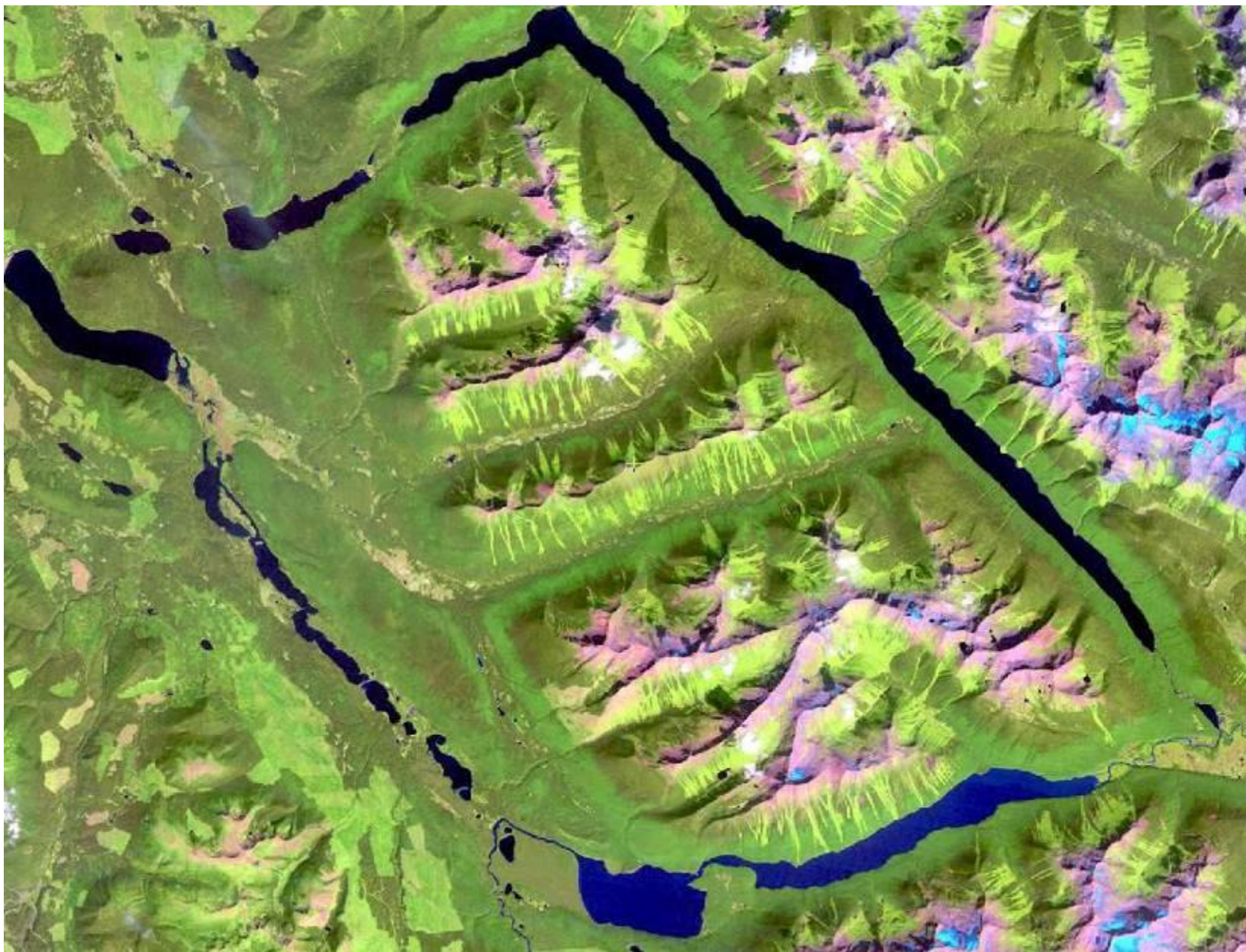
Bowron Lakes -Landsat natural colour composite RGB (e.g. Google maps / Earth )



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



**High resolution: Landsat 4,5 Thematic Mapper (TM): 1982, 1984**  
**Pixel size: 30 metres; SWIR/Near-IR/Visible (Moisture-Vegetation-Visible)**





# Google Earth Time Lapse 1984-2022

39 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**

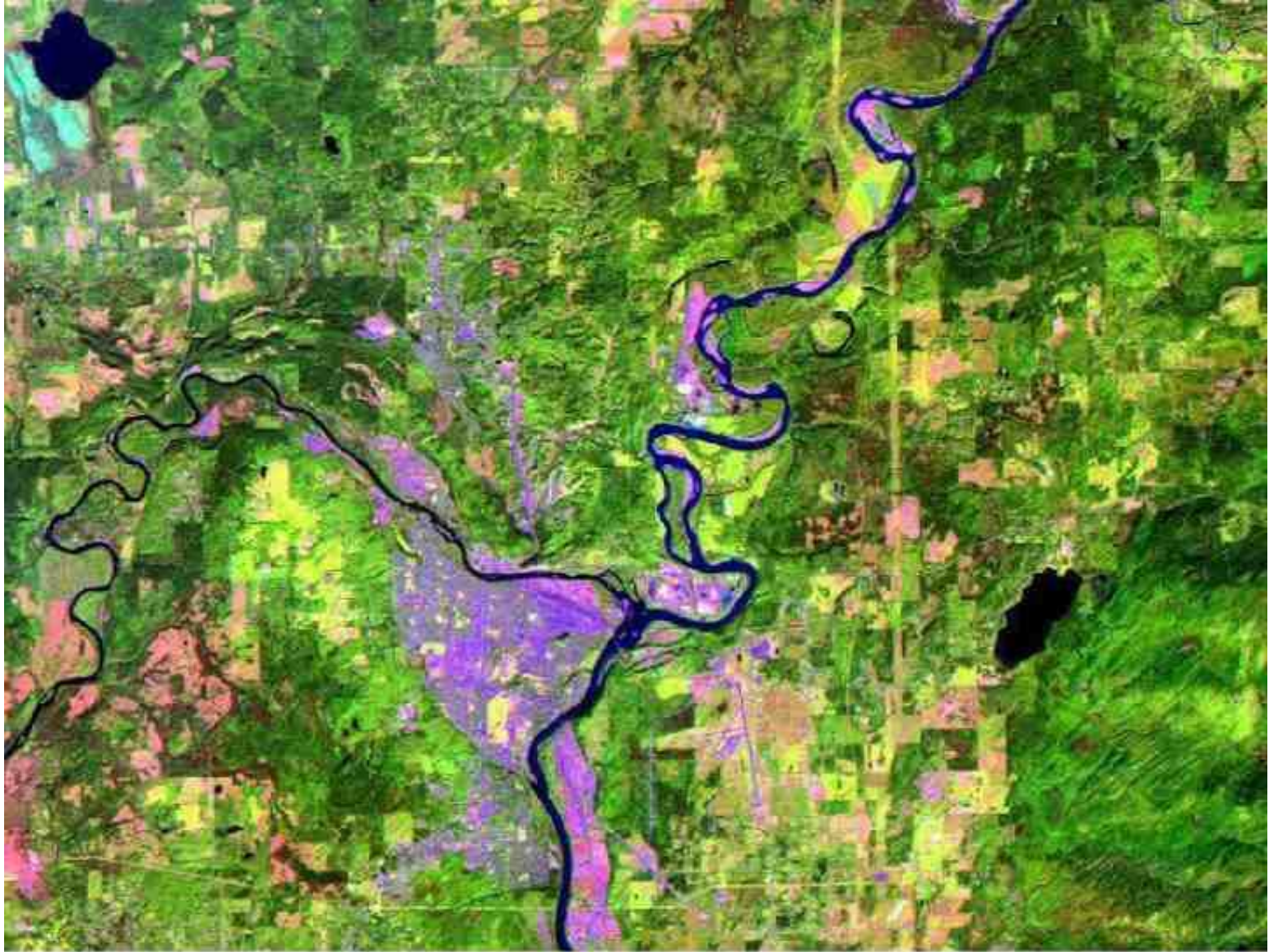


1996





2011



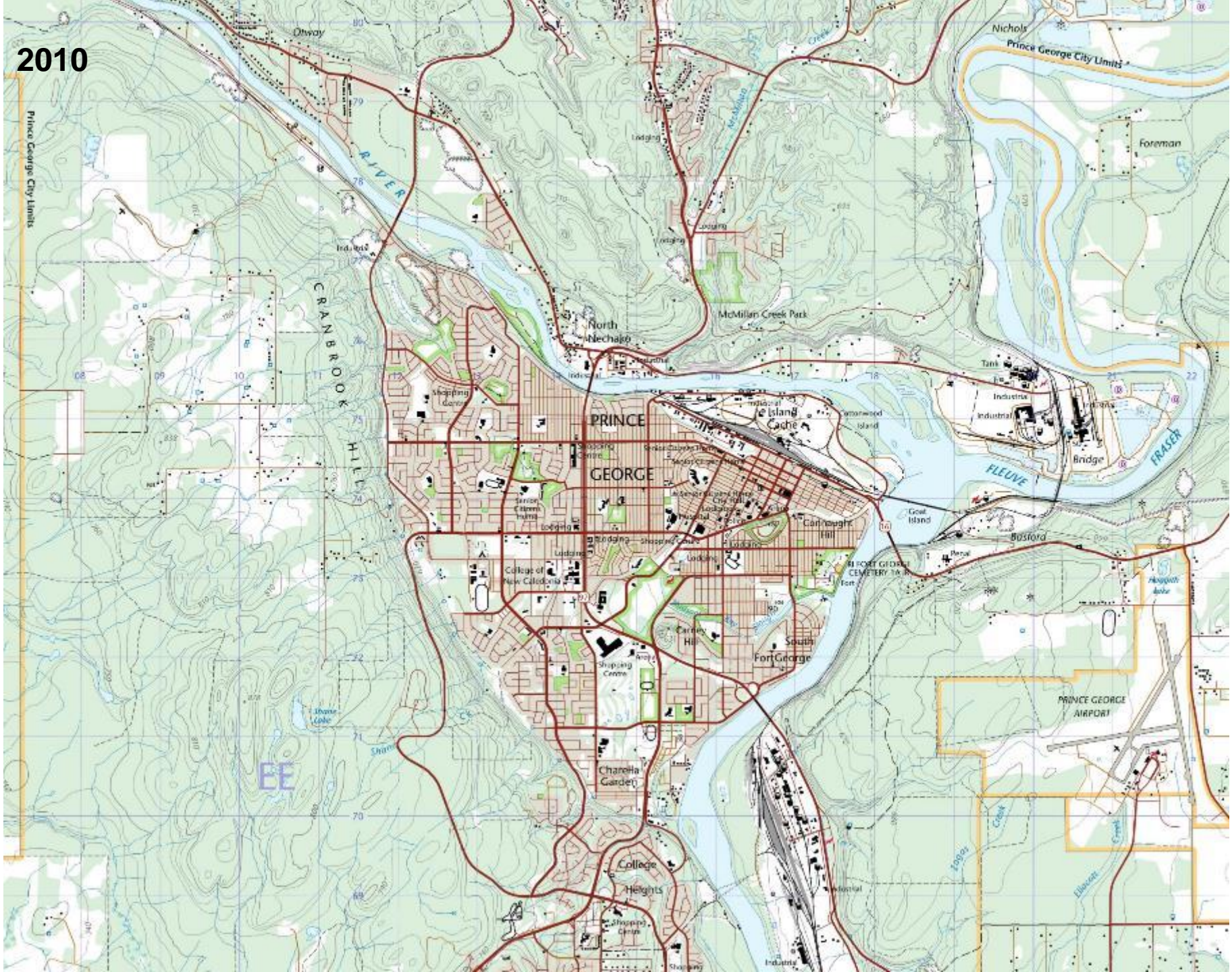


2013





2010





**European  
Space Agency  
(ESA)**

**Copernicus  
Program  
Sentinel 2A/B  
2015 / 17**

free download

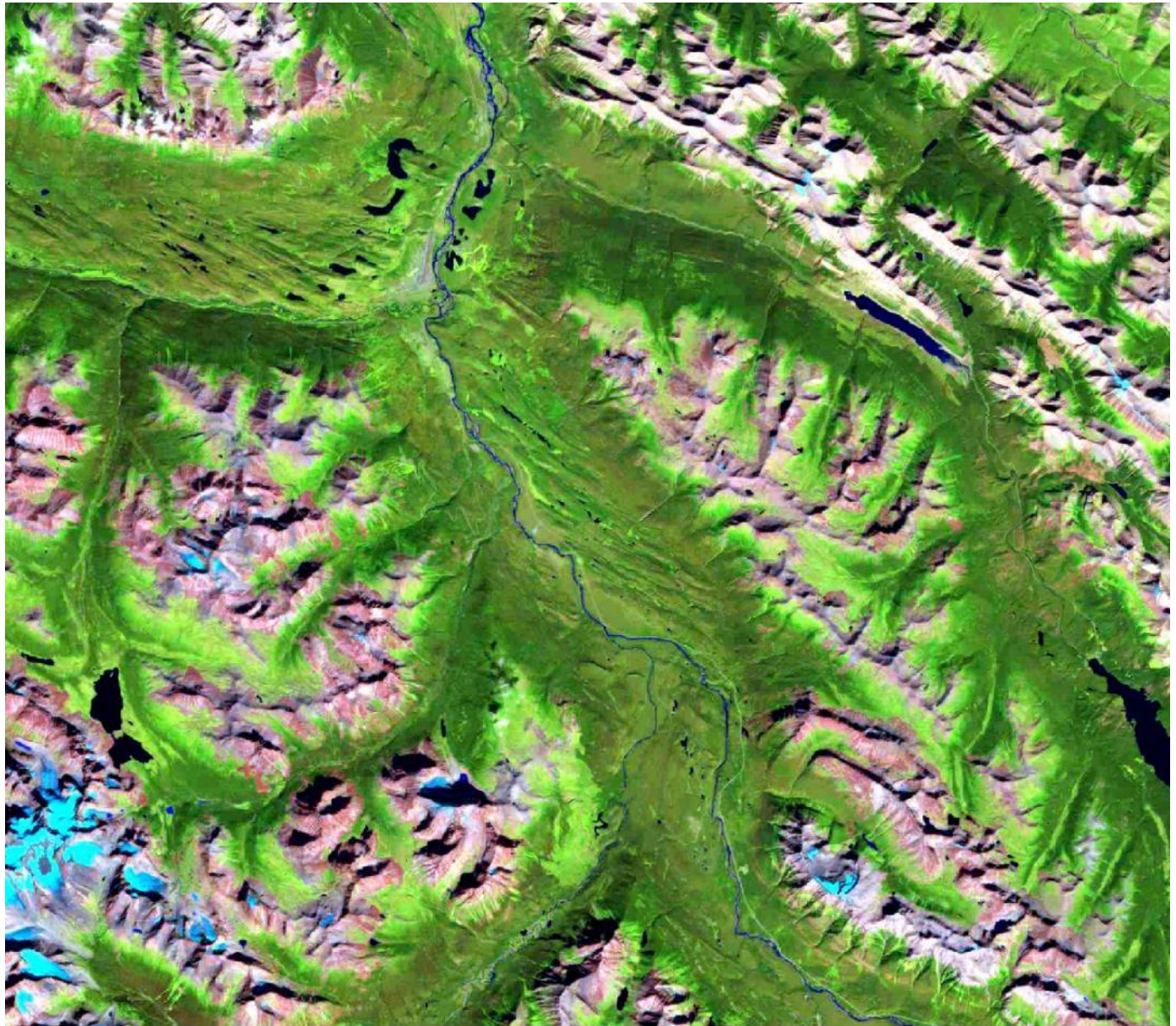
10 / 20m pixels





Jasper  
Sept 2, 2023

Red: SWIR  
Green: NIR  
Blue: Visible

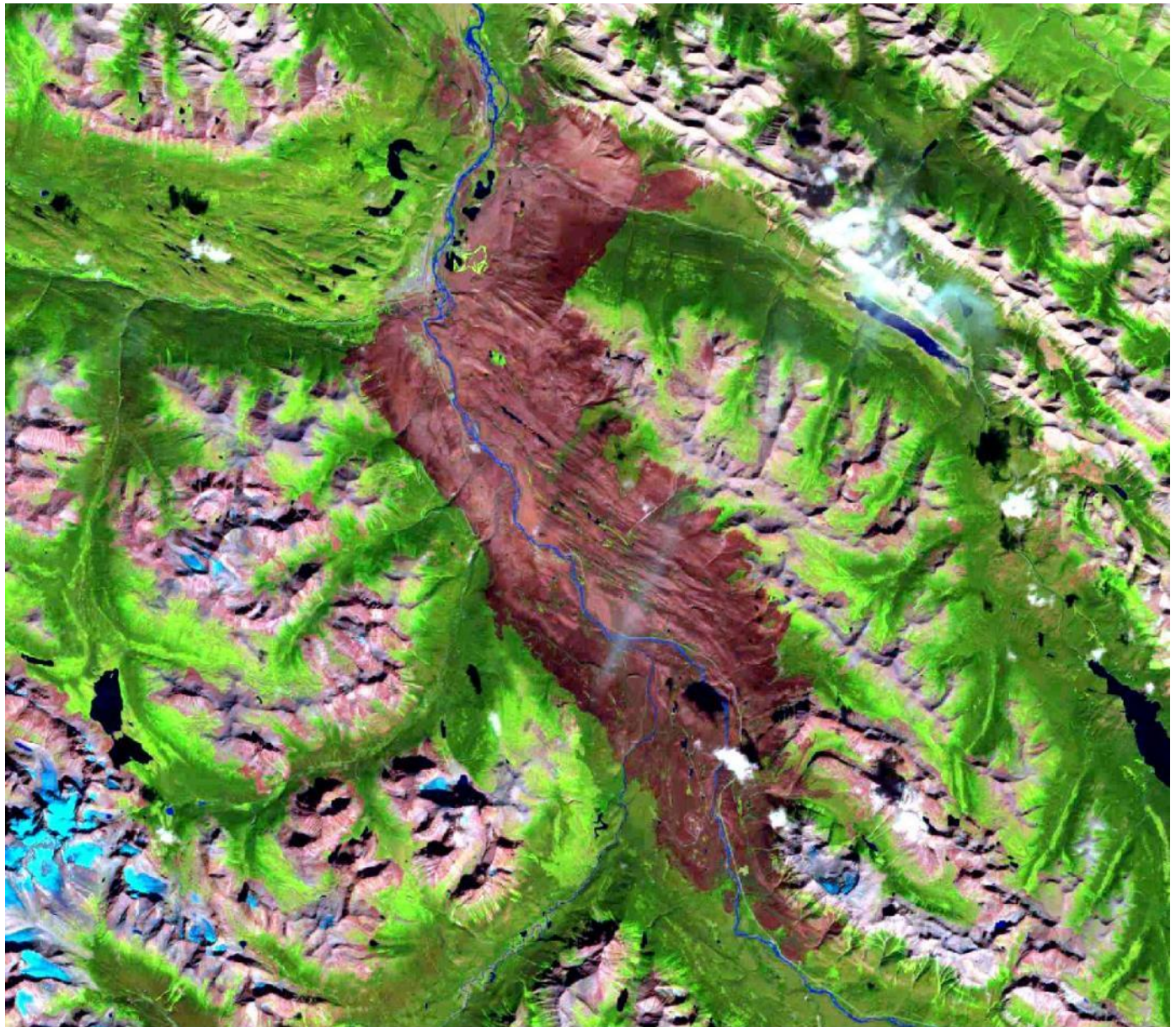




Jasper  
Aug 19, 2024

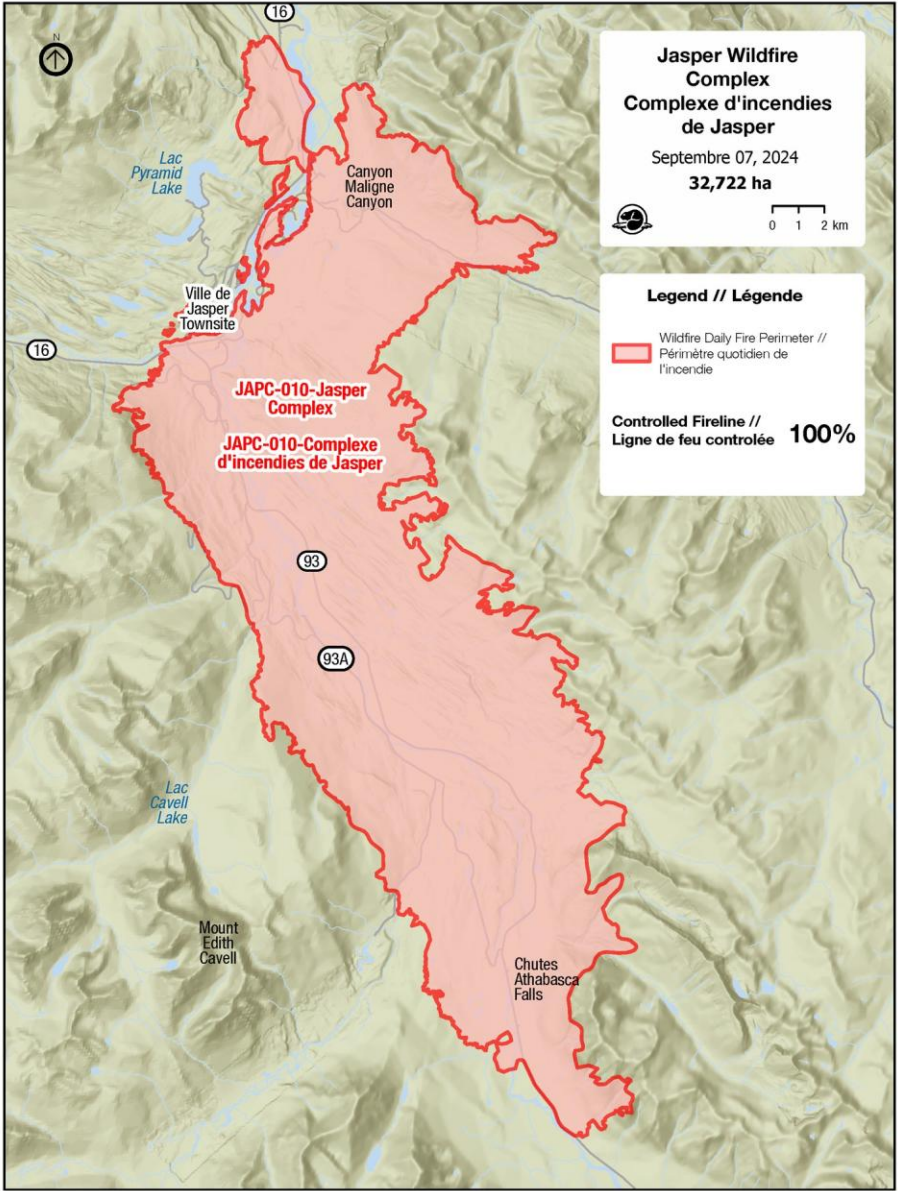
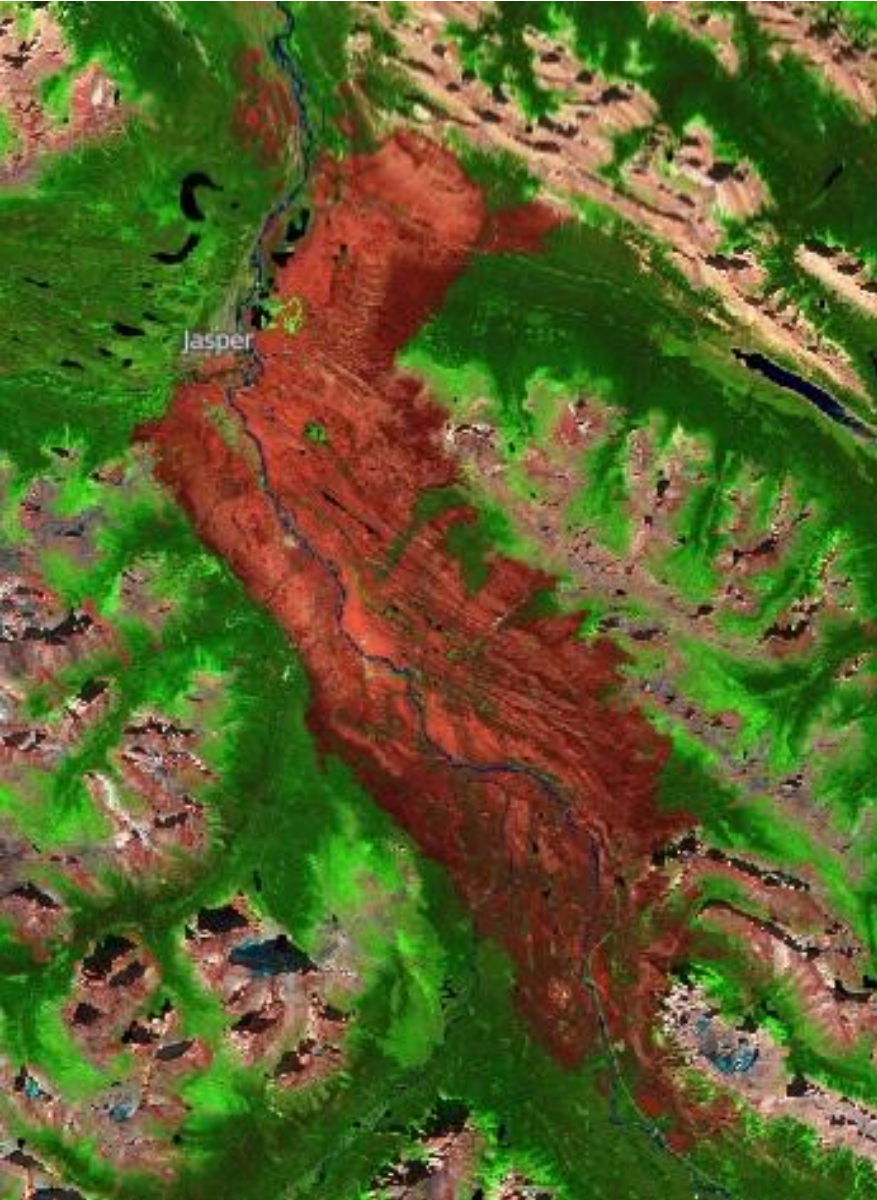
Post-fire  
July 23-24

Red: SWIR  
Green: NIR  
Blue: Visible

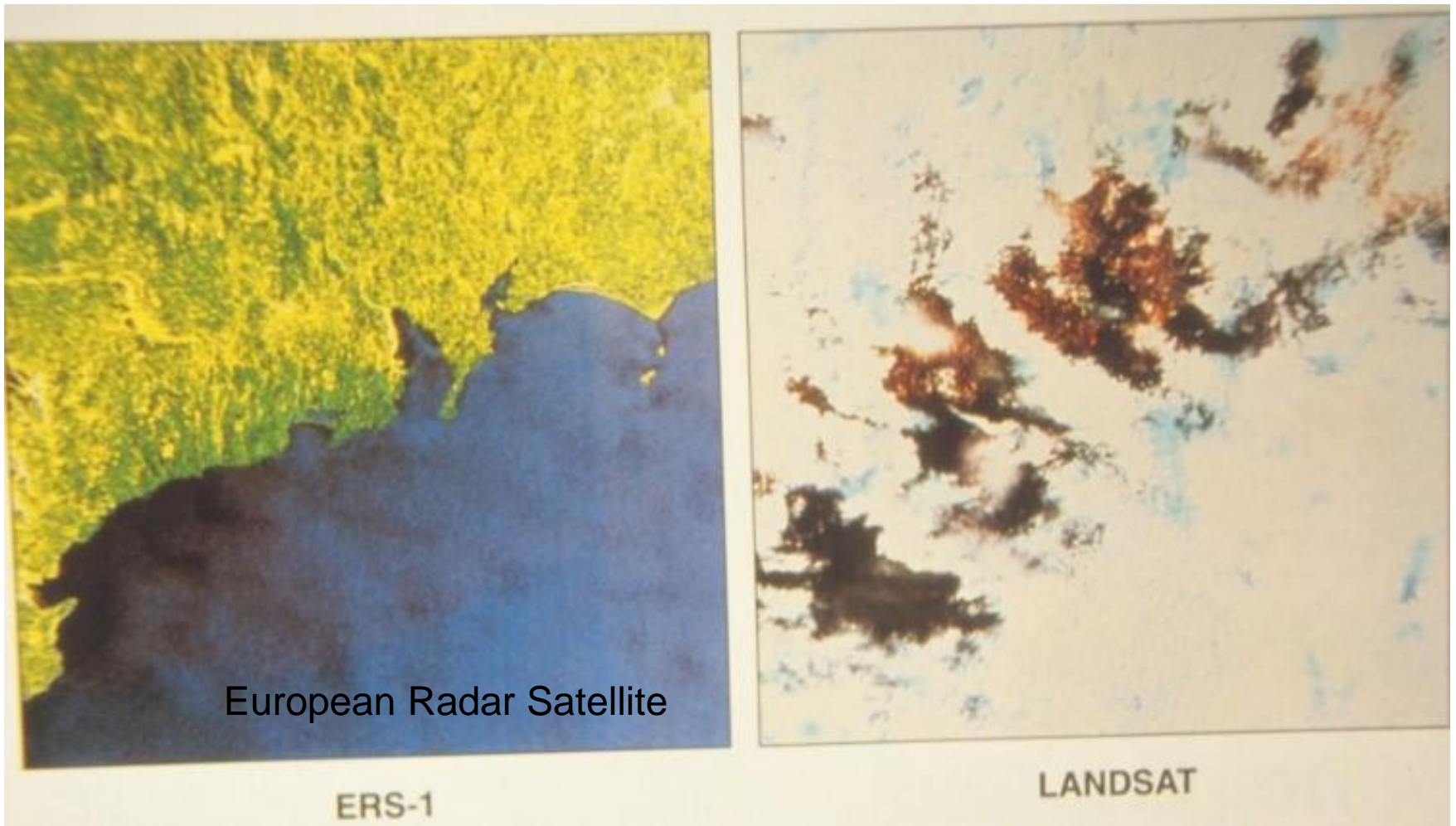




# Jasper: ESA Sentinel image 5 September; and map 7 September



**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 vs Landsat (Visible / Optical image)

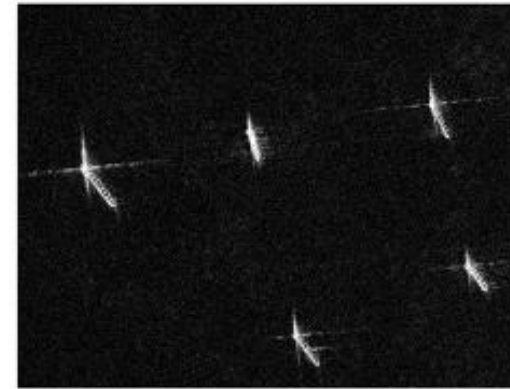
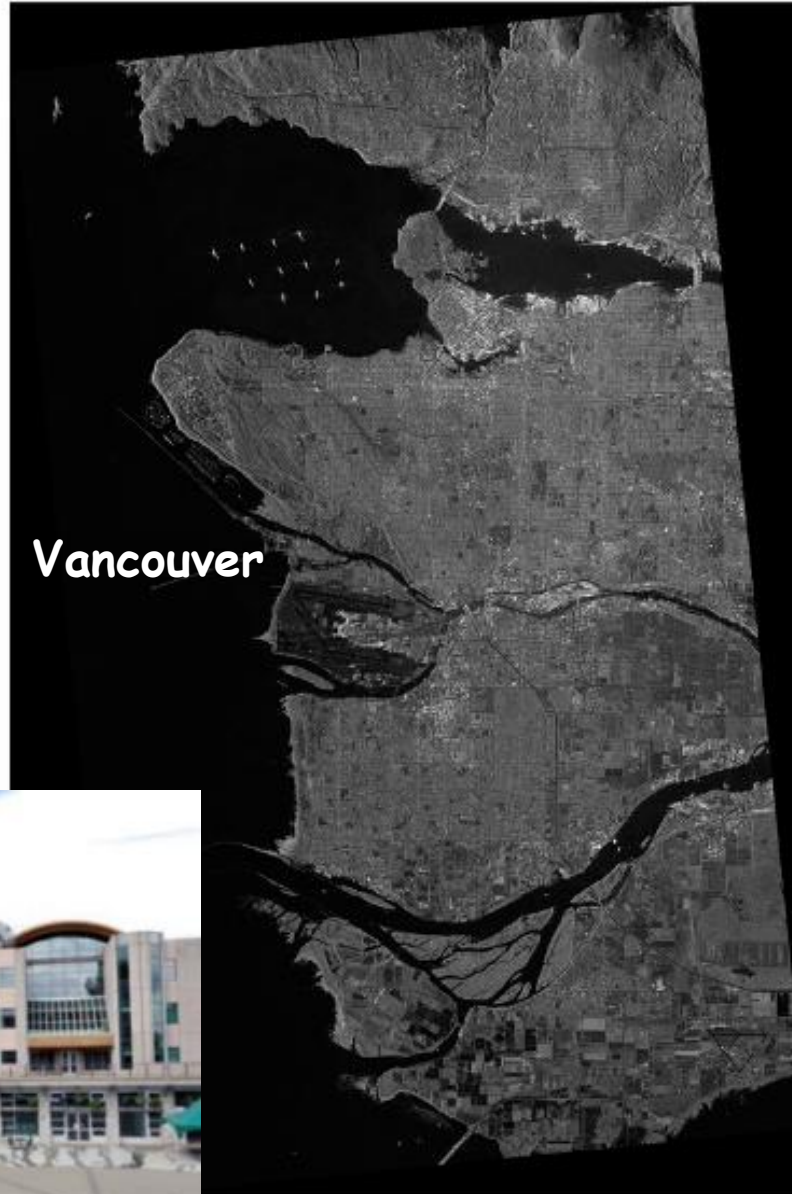


# RADARSAT 1-2 1995/2007

Radarsat 1 - 2 are the only Canadian satellite systems in space for mapping

Built by MacDonald-Dettwiler, Richmond, BC

John MacDonald, UNBC Chancellor 2010-15

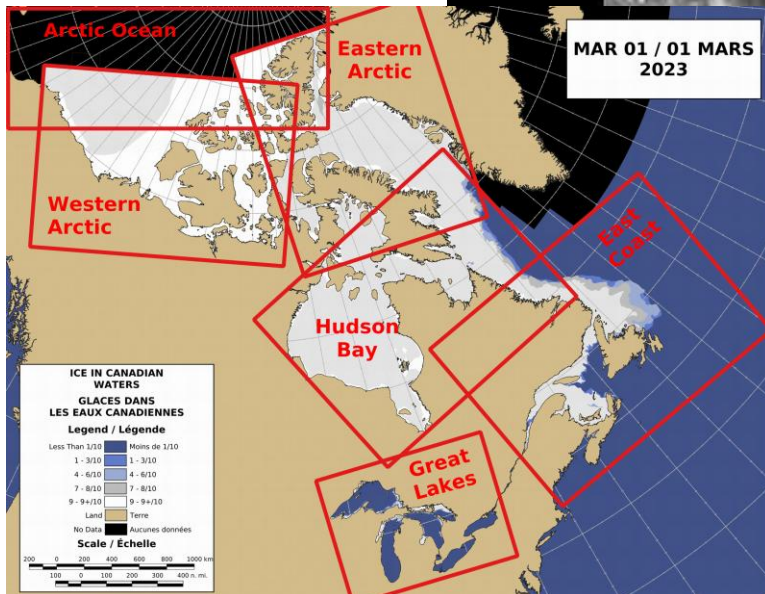
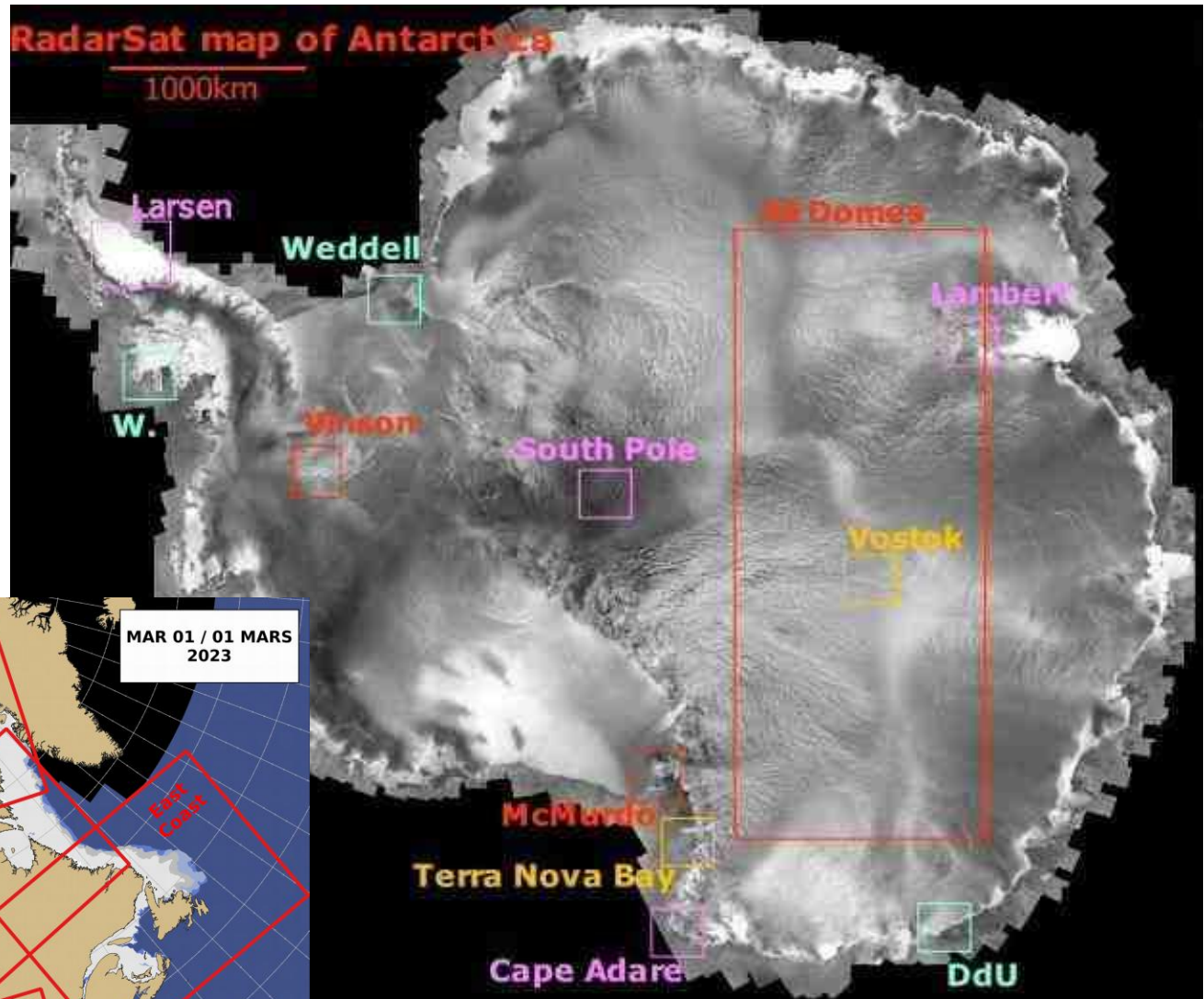


Tone = texture e.g.  
Dark = smooth

# 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





# SRTM (Shuttle RADAR Topographic Mission)

Feb 2000

30/90 metre pixels, 56°S - 60°N latitude

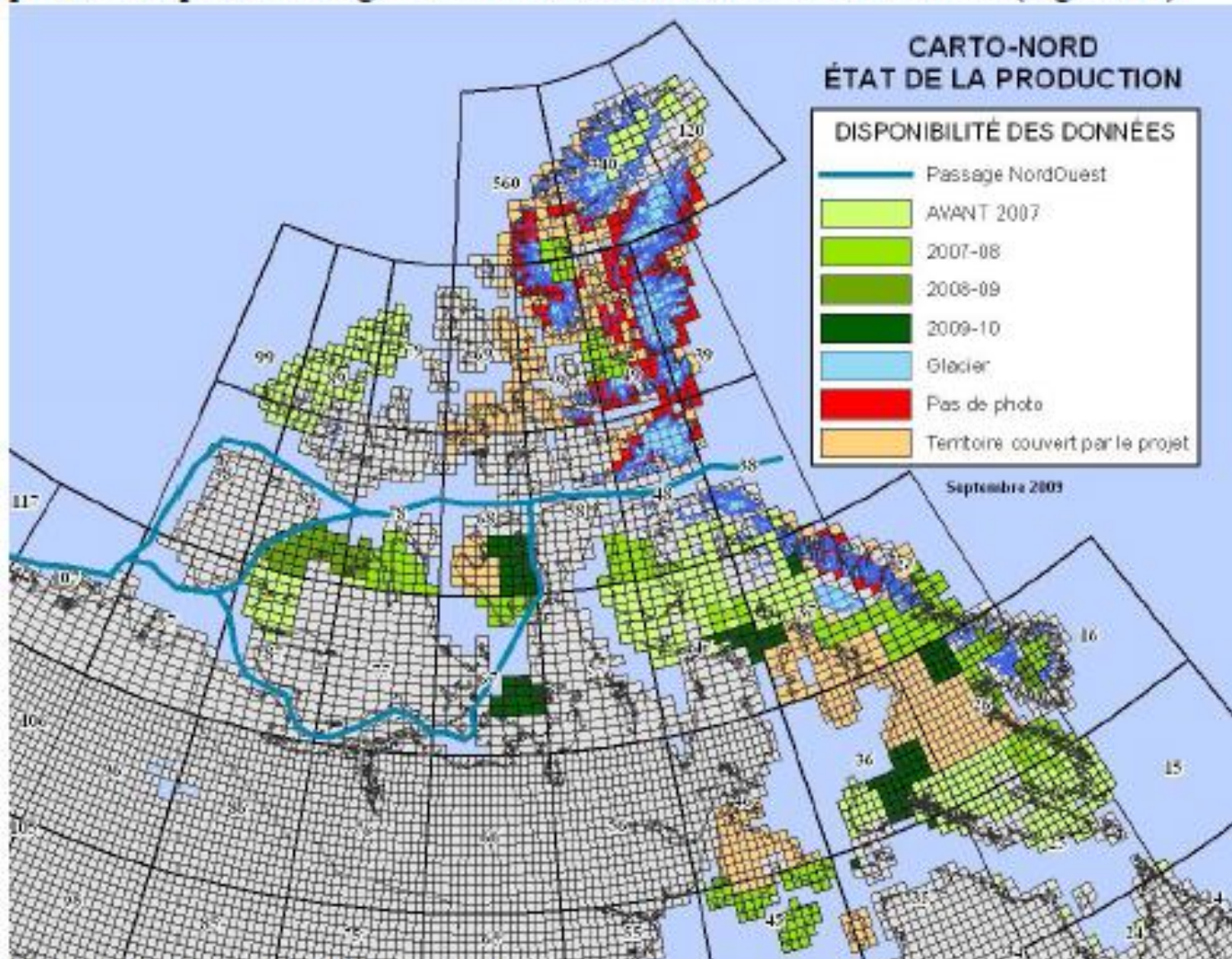
e.g. Google Earth DEM





# 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)



GEOG 357 project  
Use of satellite  
imagery for Digital  
mapping of Glaciers  
(Purple), Water (green)  
and Vegetation (blue)

Figure 12 Northern Mapping project



# Very high resolution satellites 2000->

First corporate satellites 2000

Ikonos: 1m resolution (2000)

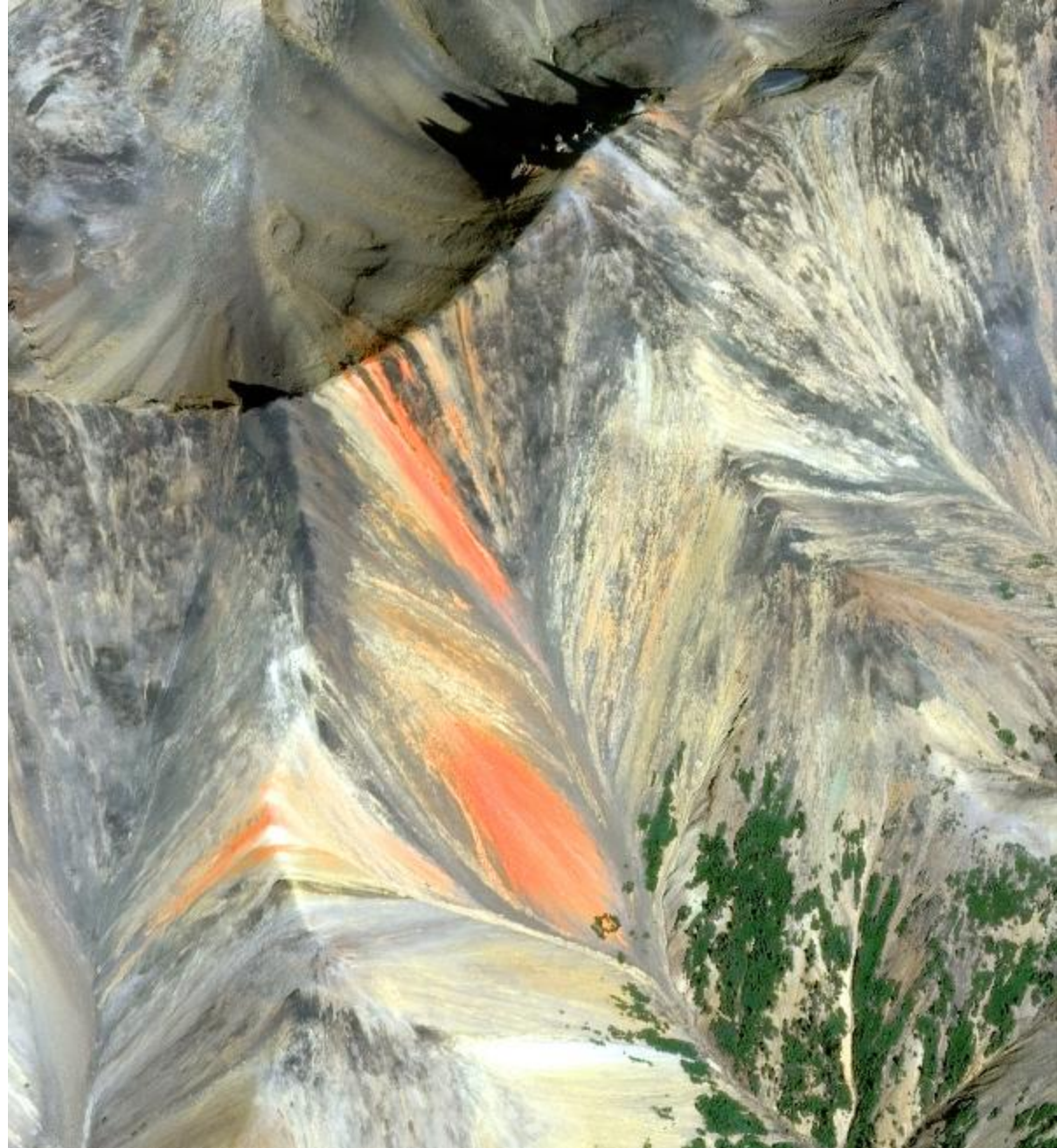
Quickbird: 60cm (2001)





**Worldview3 (2014)**

Rainbow Range  
Chilcotin, BC 31cm





# 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

'doves'



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) – map the planet every day, apart from clouds