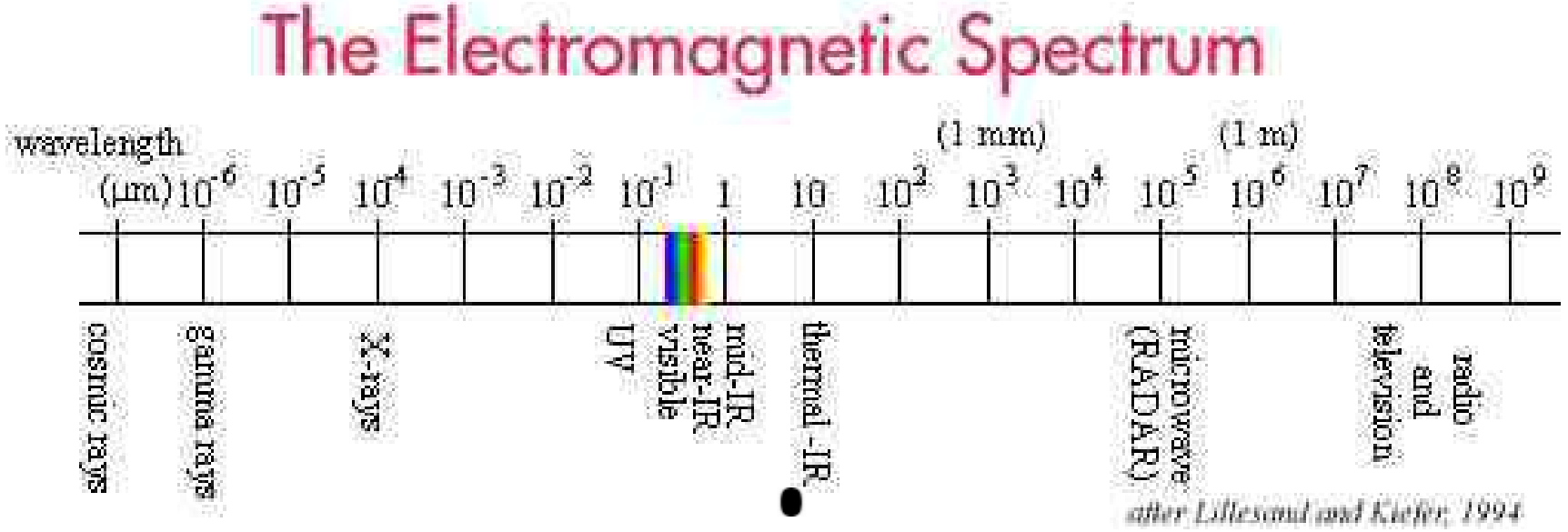
Remote sensing: review

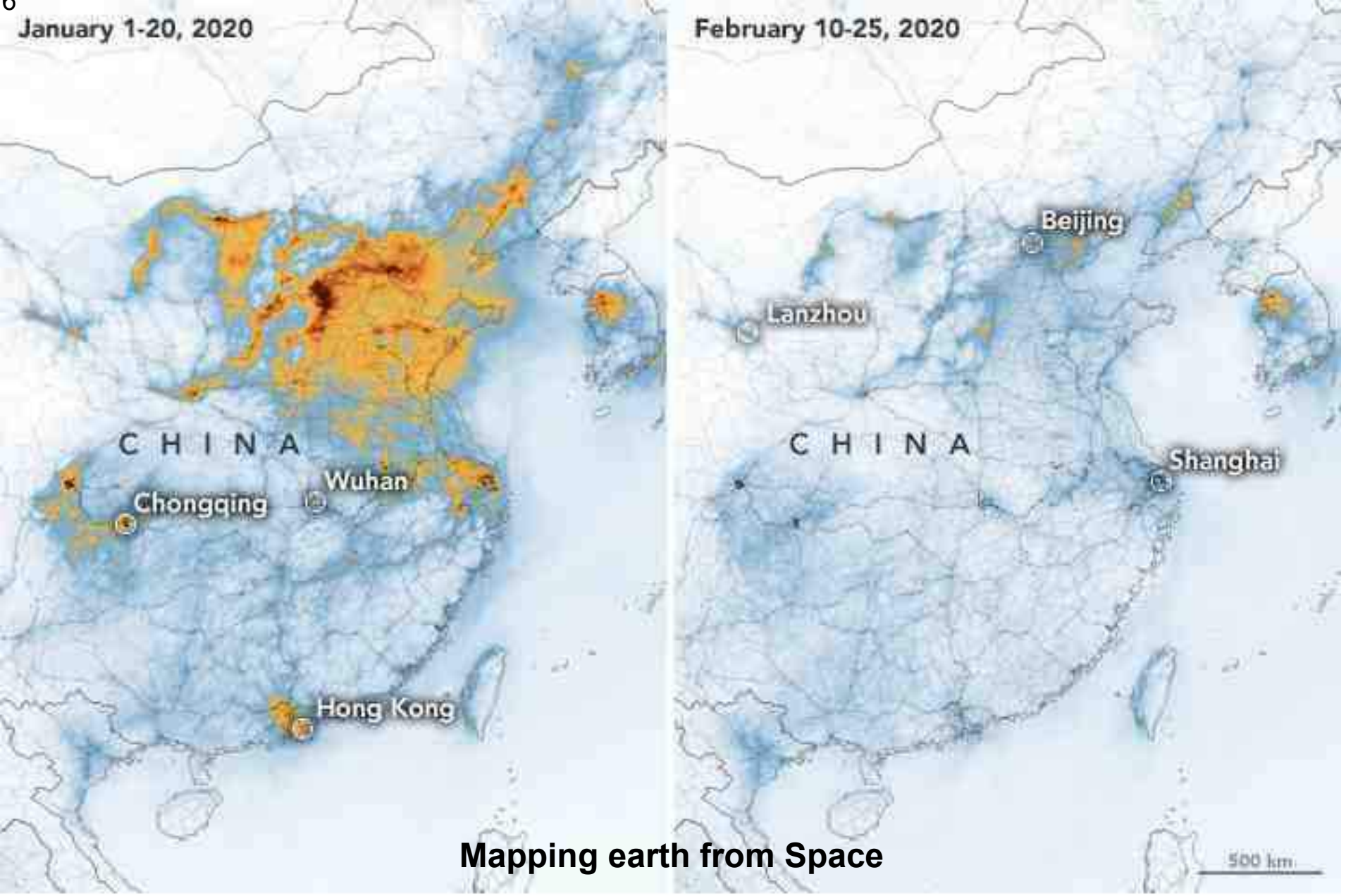


Visible: **reflected** 'natural colour' – what we see

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

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

Microwave: unaffected by clouds – includes RADAR



Mapping earth from Space

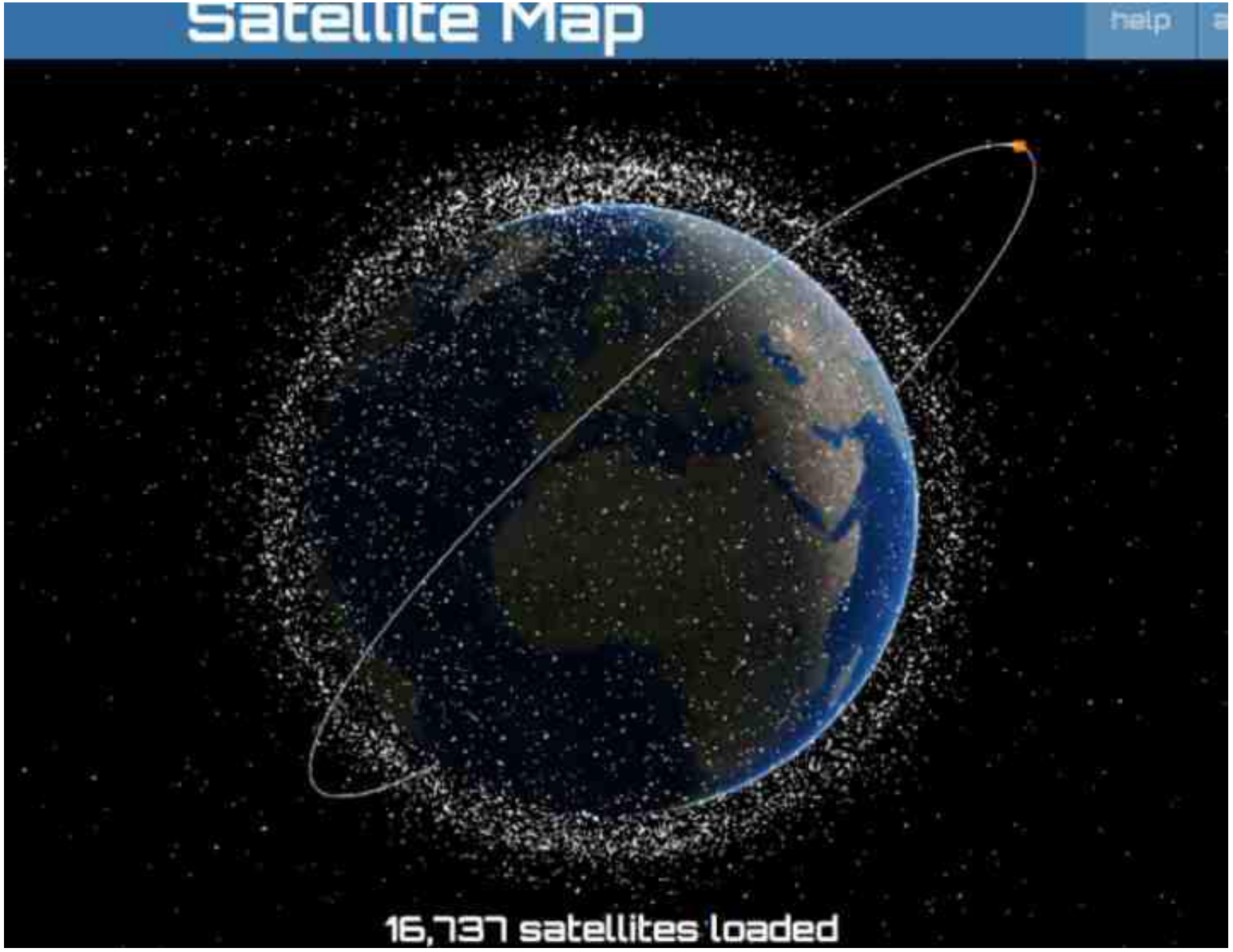
Airborne Nitrogen Dioxide Plummets Over China

from industrial reduction Post-coronavirus

Deforestation in Papua

https://earthobservatory.nasa.gov/images/148021/deforestation-in-papua

Earth from Space: satellite images



https://www.youtube.com/watch?v=cfSaztUiw5s

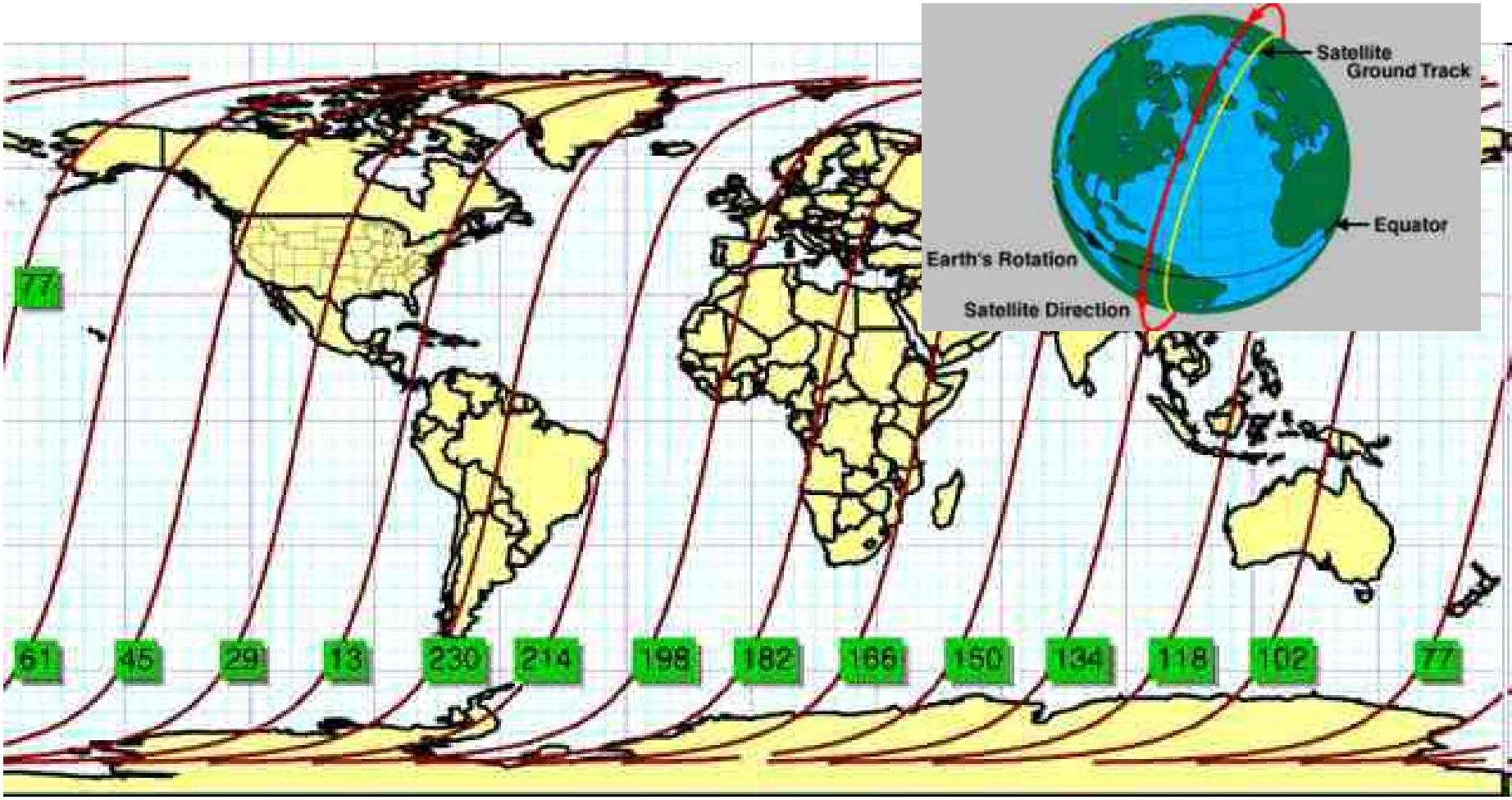
Satellites have two types of orbit (GPS satellites include both types):

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

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

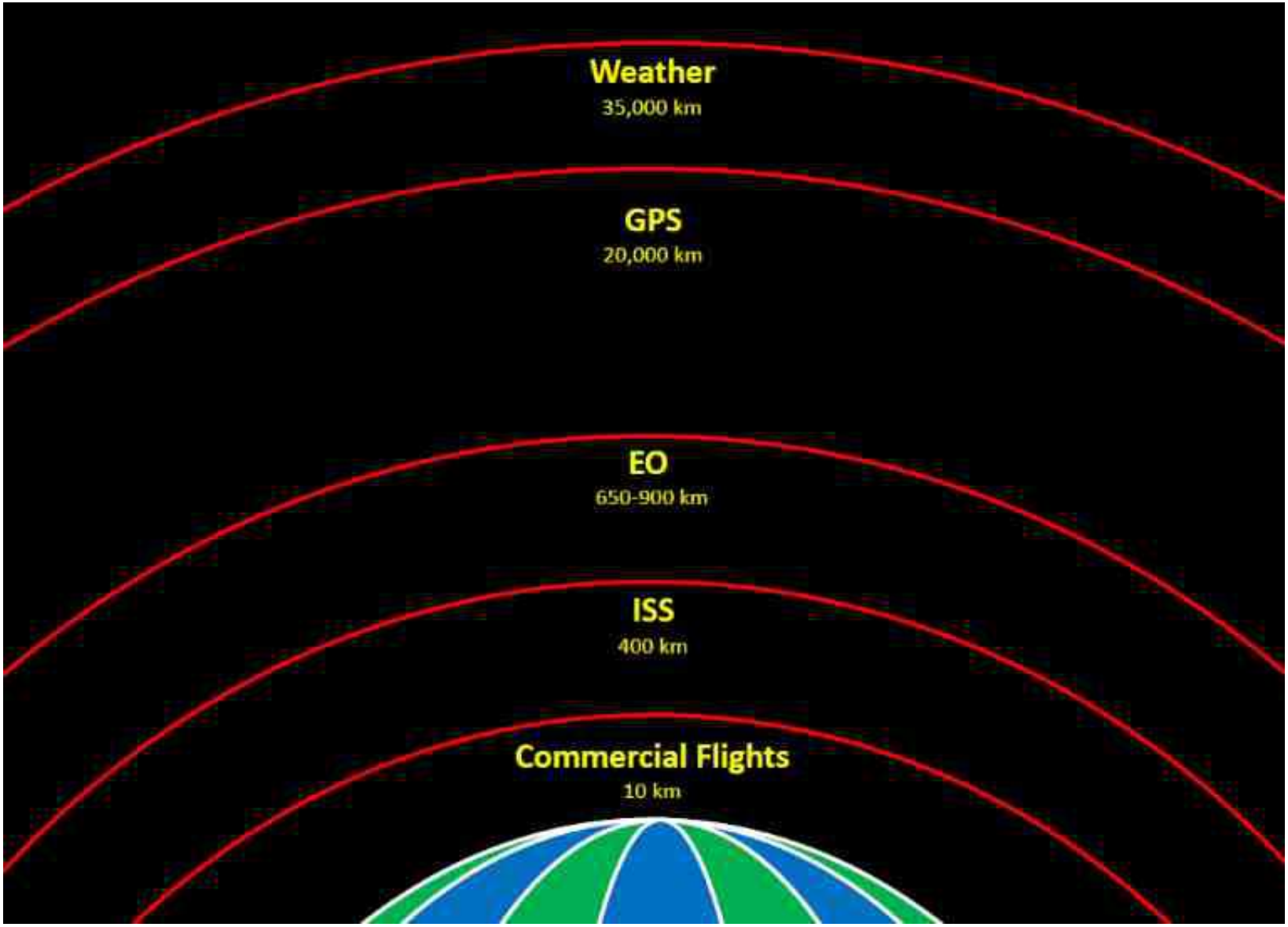
2. **Sun-synchronous satellites: all mapping satellites**

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: Earth Observation (EO) satellites



Myth #1: Most satellite **images** are **not** photos; they are scanned except…

ISS orbit: 400km, 51 degree angle

Earth from Space

Satellite Images for mapping

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

capable of detecting objects <1 metre

Hurricane Katrina

Geostationary satellite orbit

New Orleans, before and during Hurricane Katrina

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*

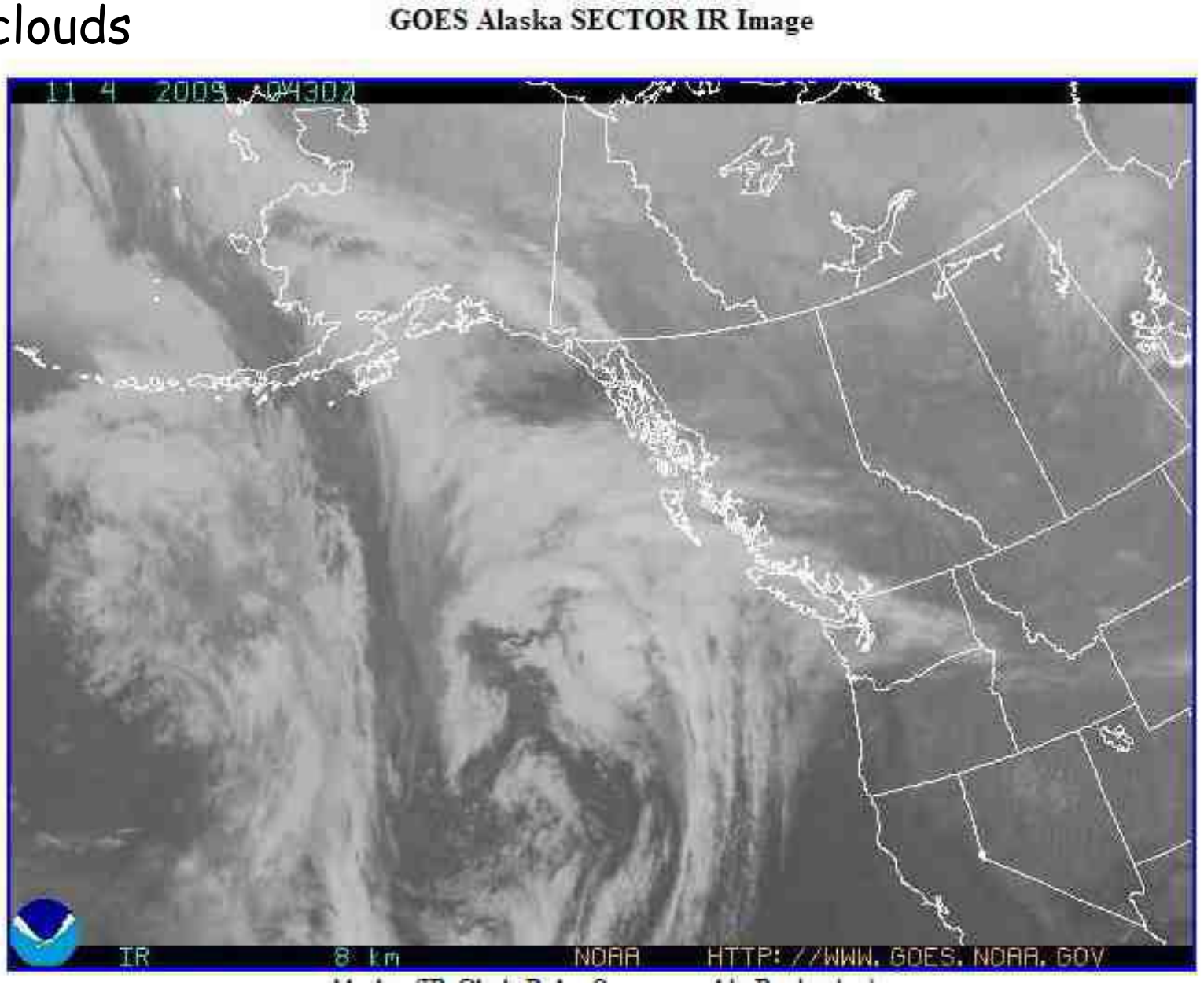
High resolution (mostly free) *10 -100 m (regional) - 1:50,000*

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

Landsat – 30m pixels

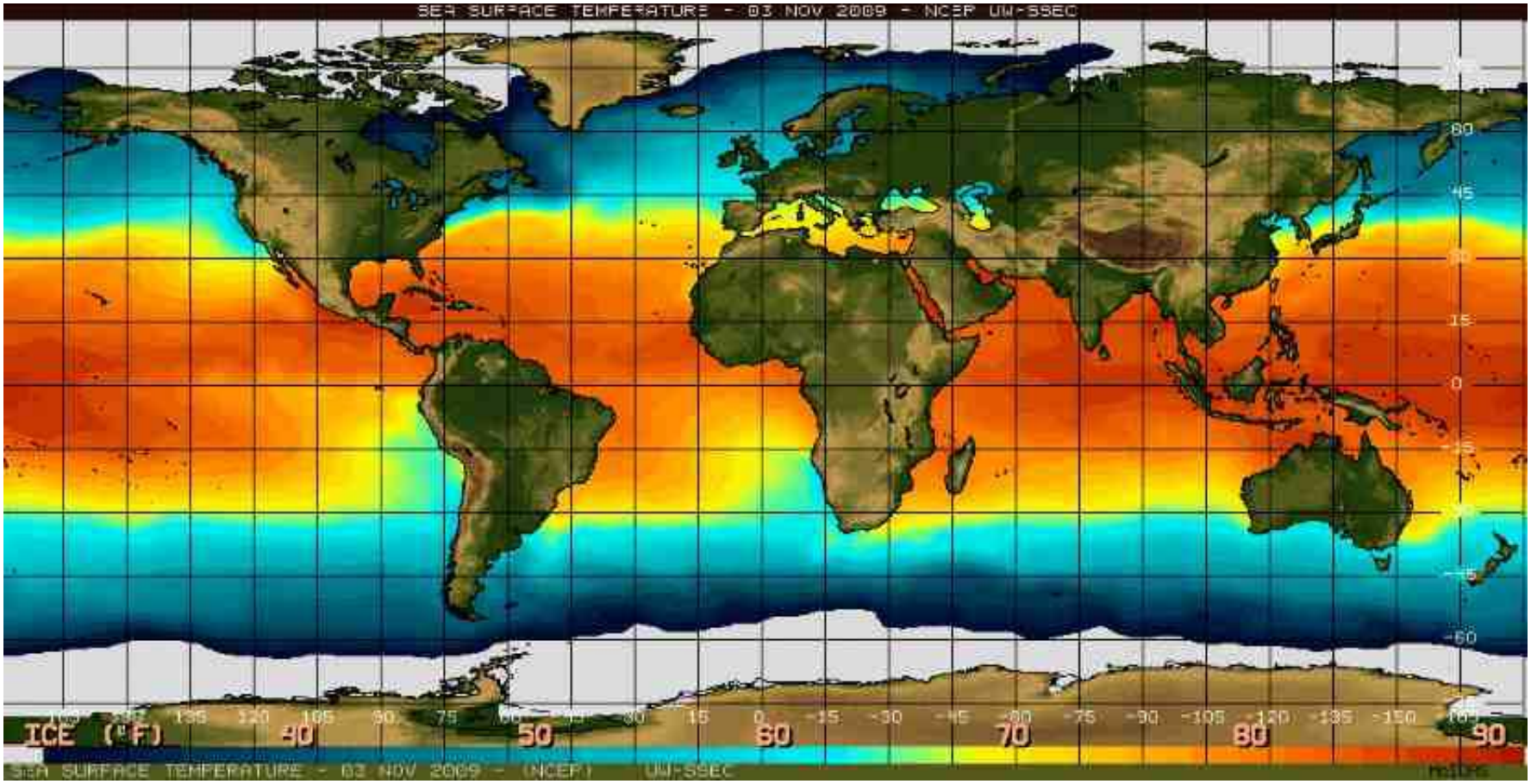
Air photo: <1m pixels

Small scale satellite images (10km pixels) http://www.goes.noaa.gov/
~70% clouds



Low resolution imagery (~10km pixels)

Daily sea surface temperatures using **Microwave** wavelengths – cloud free



'Isarithmic thematic map'

Medium resolution:

MODIS

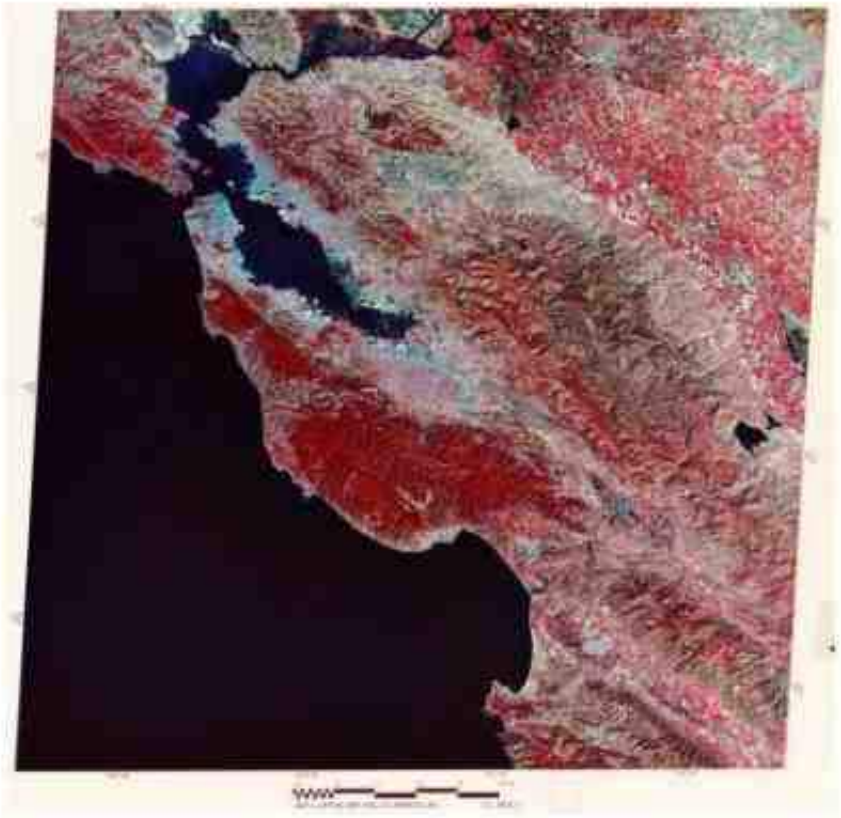
(since 2000)

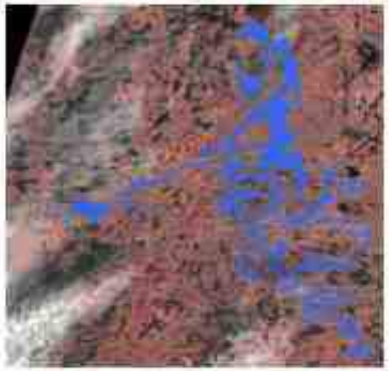
500m – 1km

Medium -High resolution: Landsat (NASA-1972)

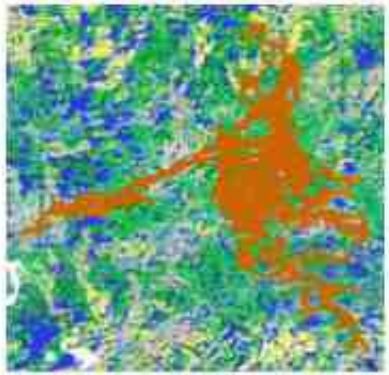
Satellites 1,2,3 had a Multi-Spectral Sensor (MSS) with a pixel size 80 metres in resolution.

First Landsat image: San Francisco 1972





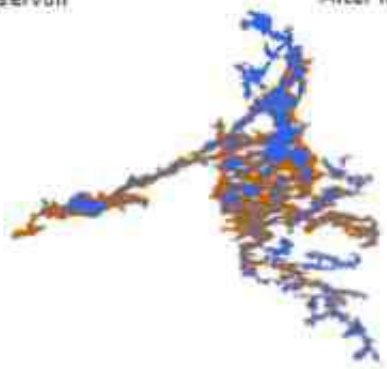
MSS Image 16/22 (09 Jul 1978)



EOSD Image 15/22 (15 June 2001)

Before flooding of reservoir

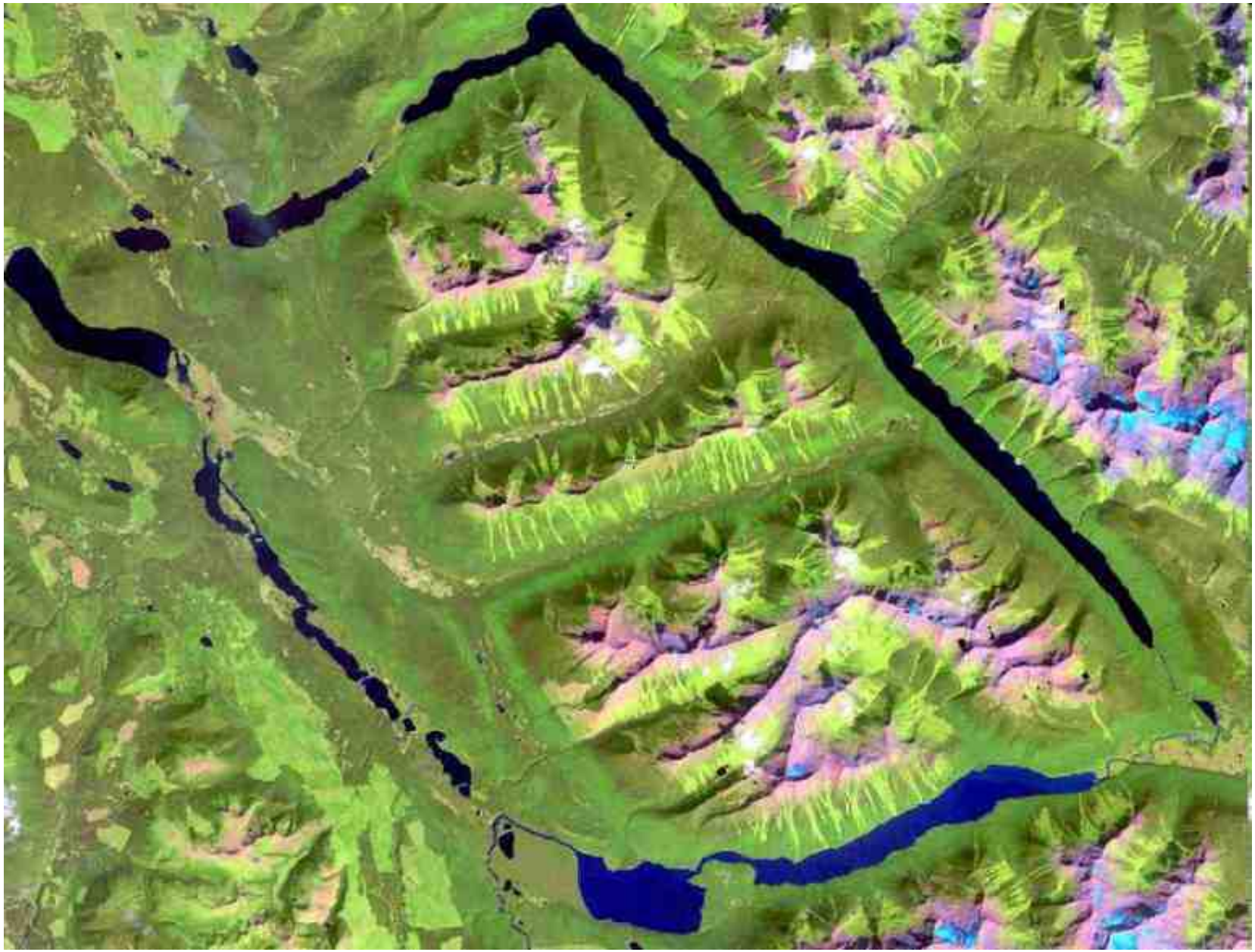
After flooding of reservoir



Difference highlighted in brown

Reservoirs in Quebec 1975-2000

High resolution (the Next generation) Landsat 5 Thematic Mapper (TM): 1984
Pixel size: **30 metres; display is Red band - Near IR – mid IR**



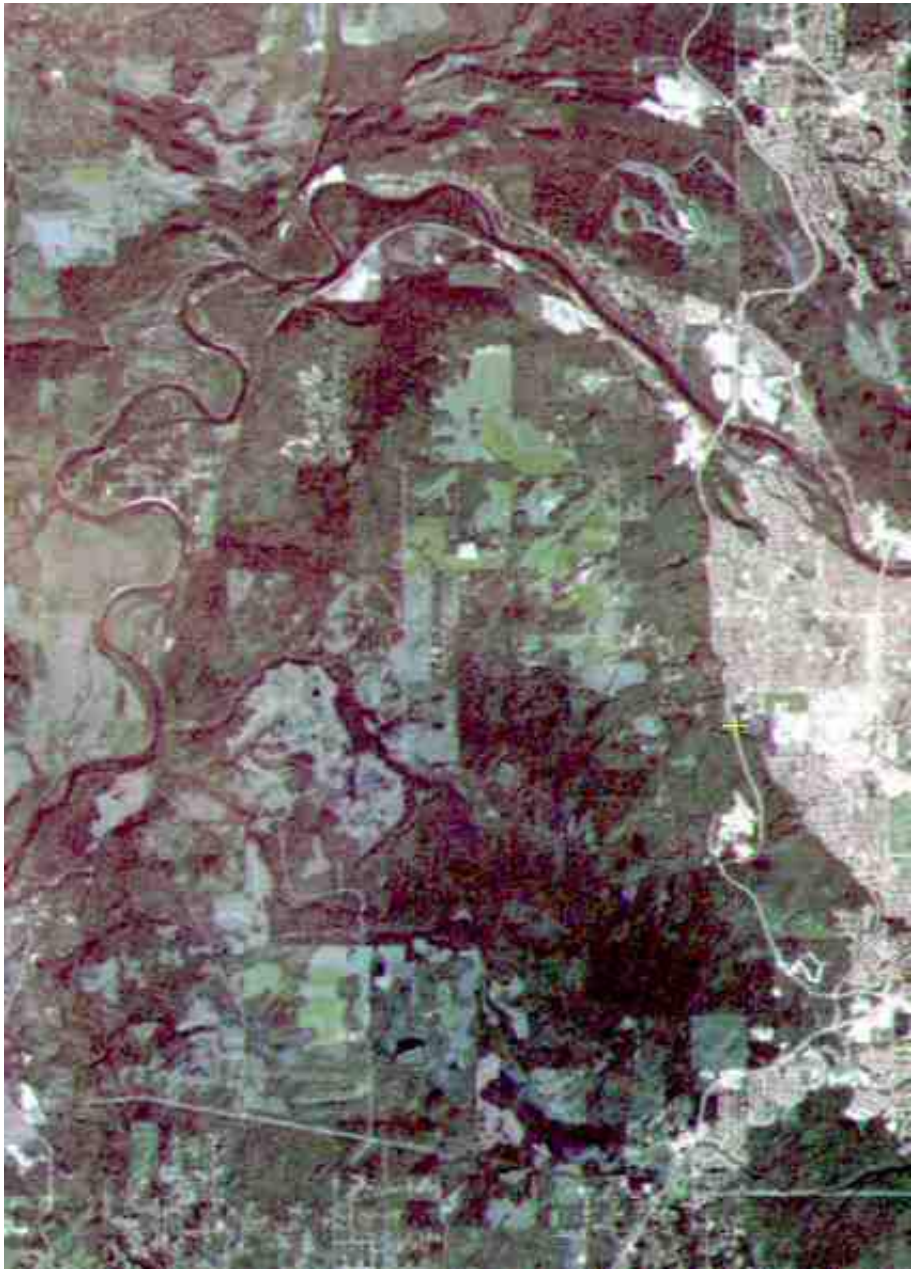
Bowron Lakes -Landsat natural colour composite RGB (e.g. Google maps / Earth)

Launched 1999 2013

Landsat-7 ETM+ Bands (μm)			Landsat-8 OLI and *TIRS* Bands (μm)		
			30 m Coastal/Aerosol	0.435 - 0.451	Band 1
Band 1	30 m Blue	0.441 - 0.514	30 m Blue	0.452 - 0.512	Band 2
Band 2	30 m Green	0.519 - 0.601	30 m Green	0.533 - 0.590	Band 3
Band 3	30 m Red	0.631 - 0.692	30 m Red	0.636 - 0.673	Band 4
Band 4	30 m NIR	0.772 - 0.898	30 m NIR	0.851 - 0.879	Band 5
Band 5	30 m SWIR-1	1.547 - 1.749	30 m SWIR-1	1.566 - 1.651	Band 6
Band 6	60 m TIR	10.31 - 12.36	*100 m TIR-1*	*10.60 – 11.19*	Band 10
			100 m TIR-2	*11.50 – 12.51*	Band 11
Band 7	30 m SWIR-2	2.064 - 2.345	30 m SWIR-2	2.107 - 2.294	Band 7
Band 8	15 m Pan	0.515 - 0.896	15 m Pan	0.503 - 0.676	Band 8
			30 m Cirrus	1.363 - 1.384	Band 9

Base for Google Earth 1999-2002 images

PG: normal colour RGB and ‘red-nearIR-midIR’

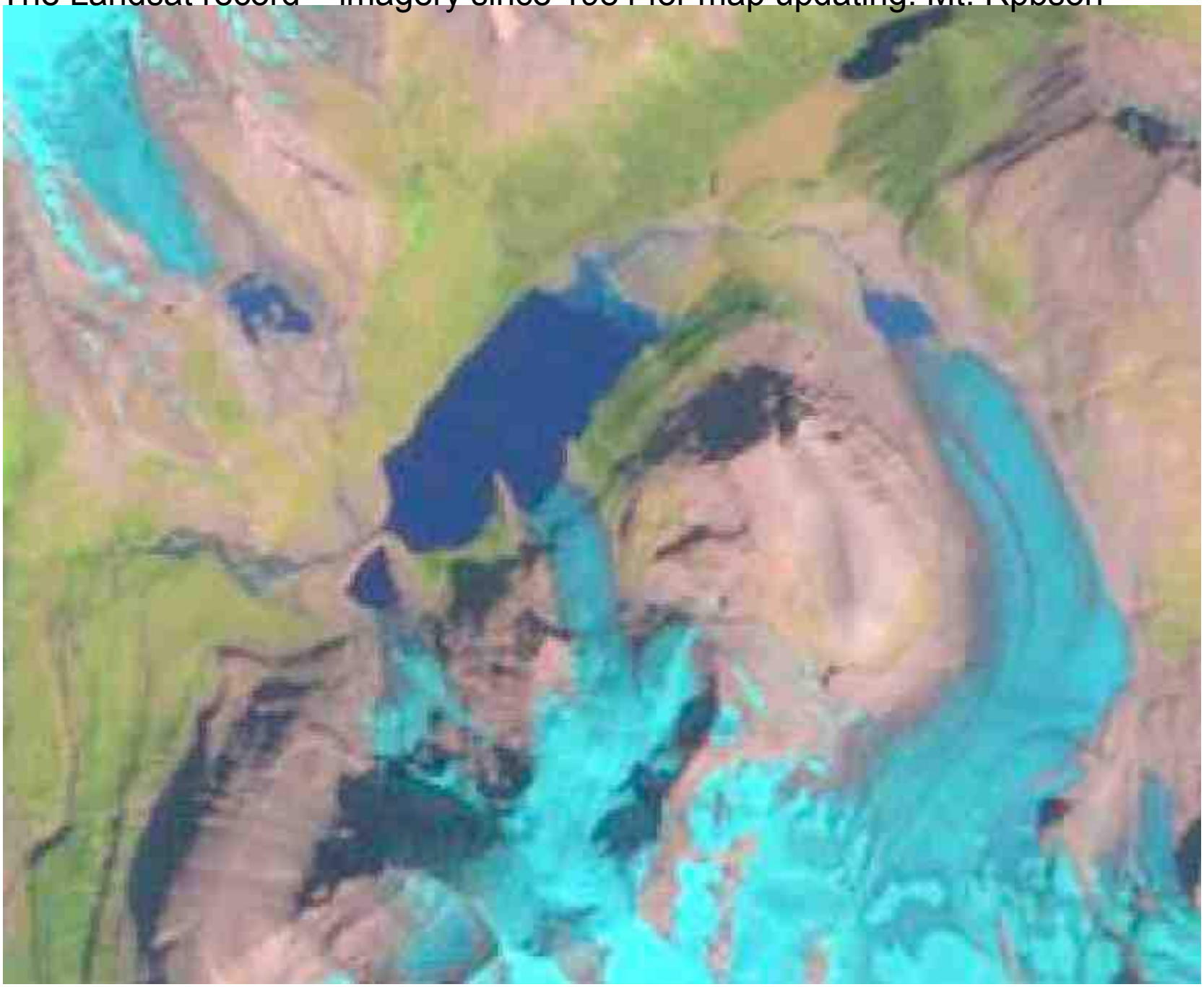


Google Earth: aerial photography and satellite images

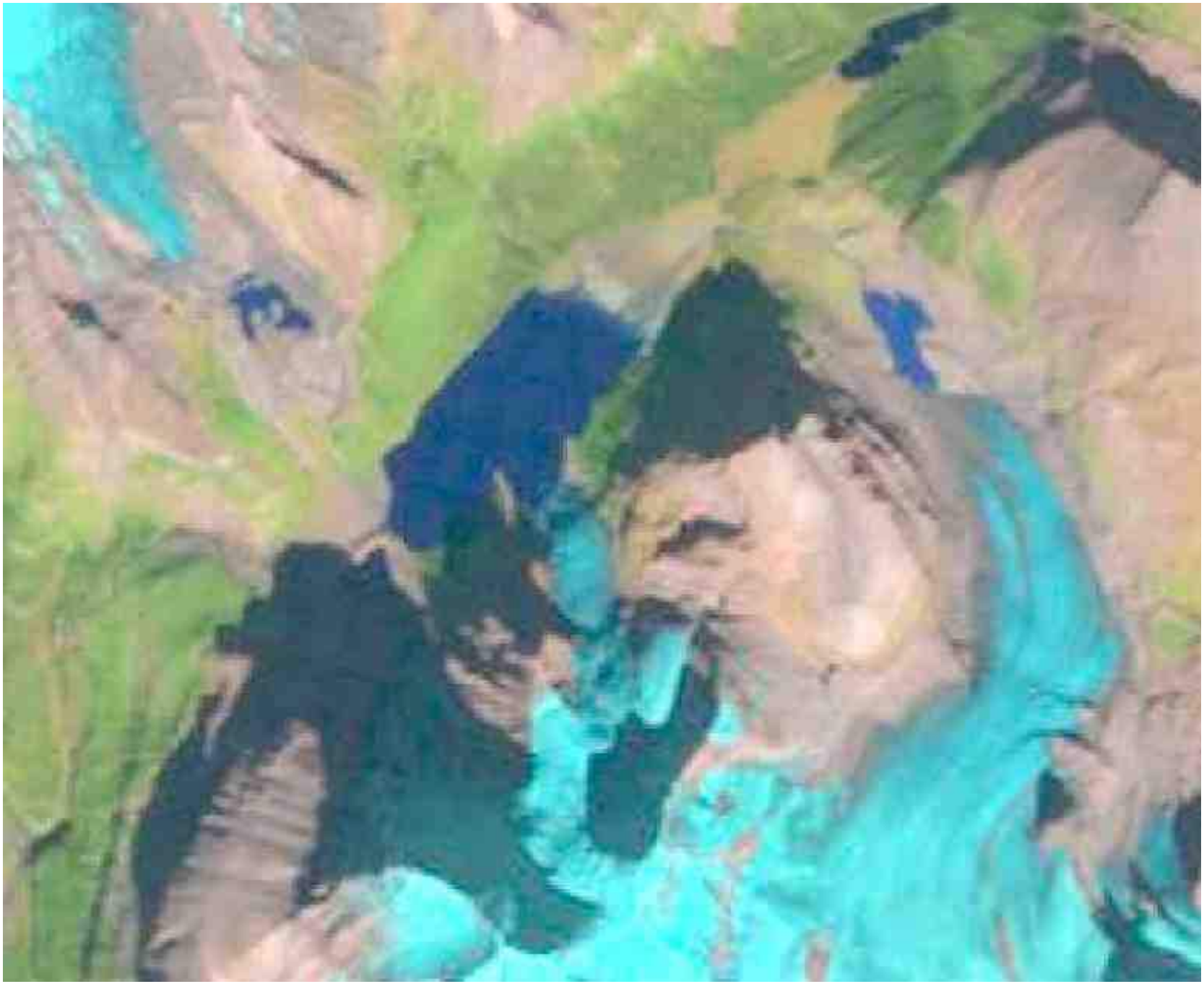
Mosaic of Landsat 7, high-resolution images and air photos

The Landsat record – imagery since 1984 for map updating: Mt. Rpbson

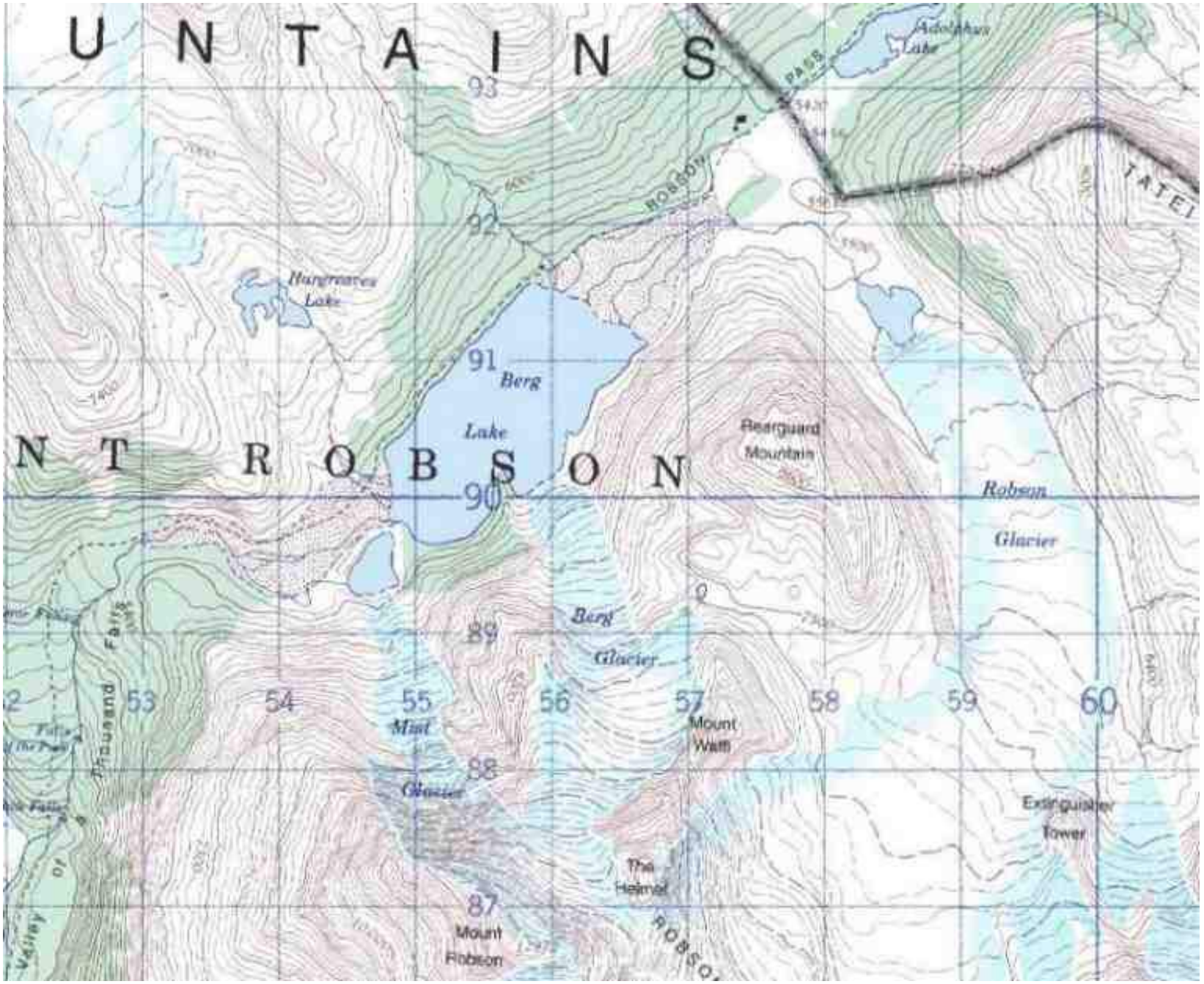
1985



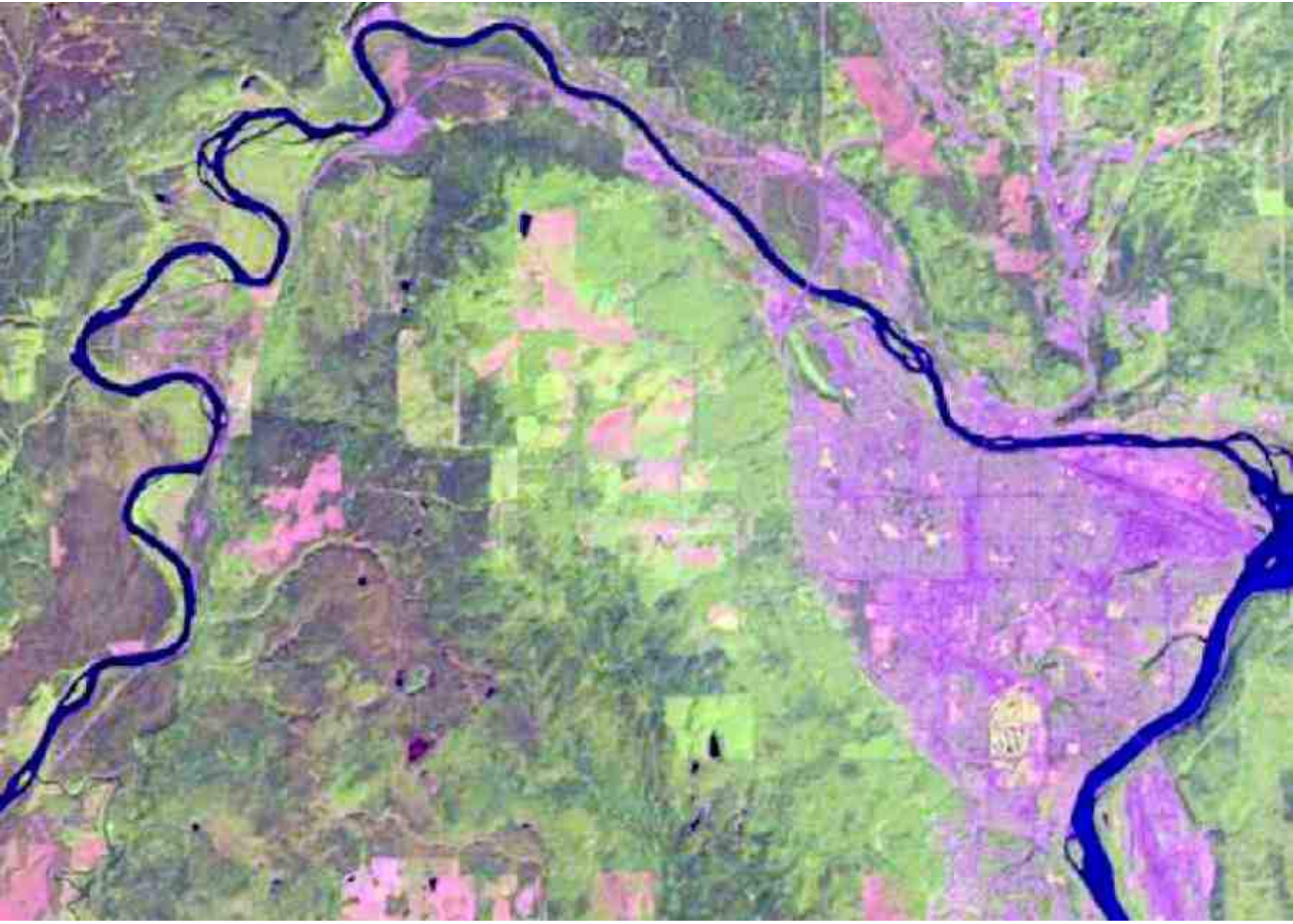
2007

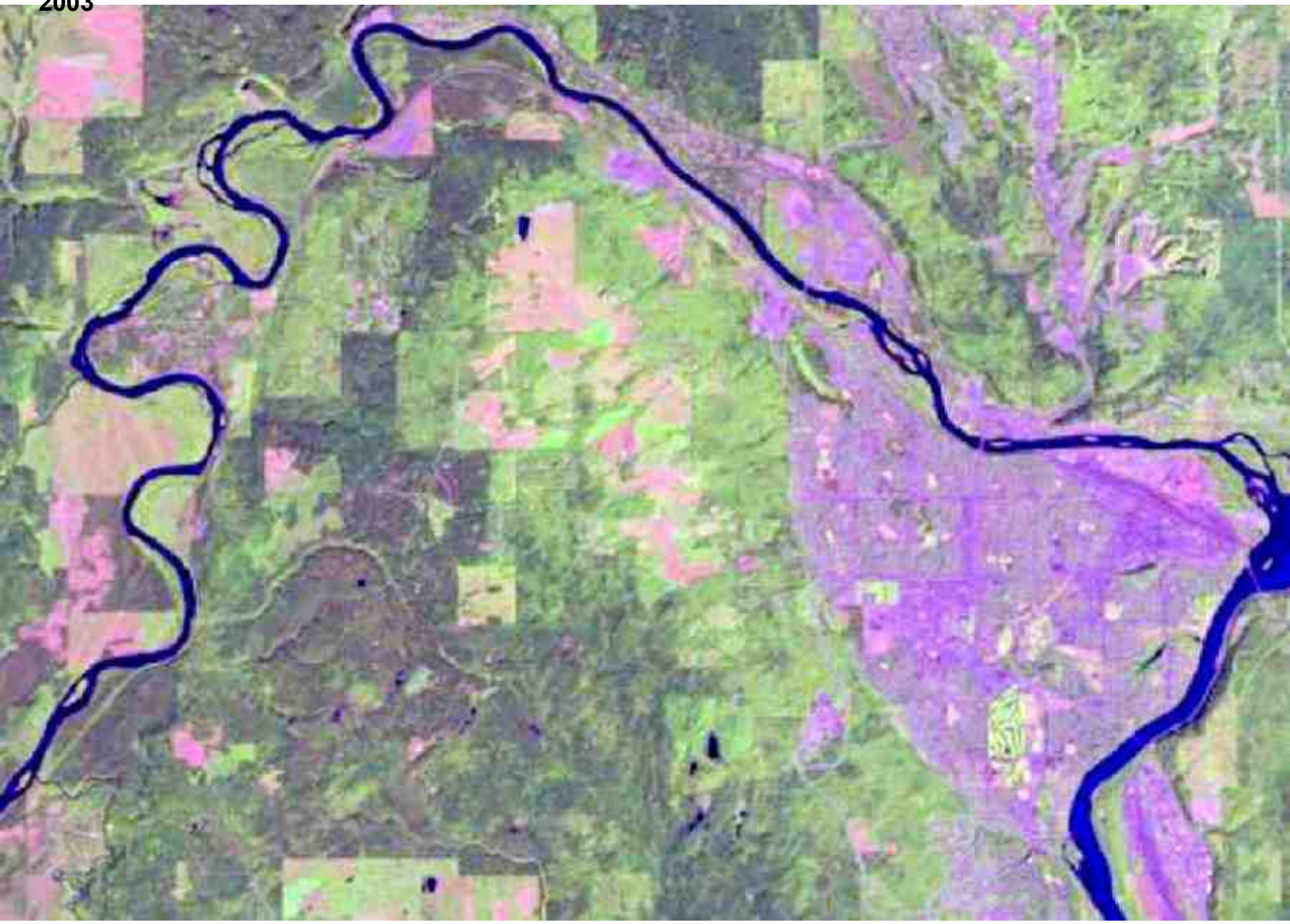


1995 NTS map sheet – glaciers from 1975

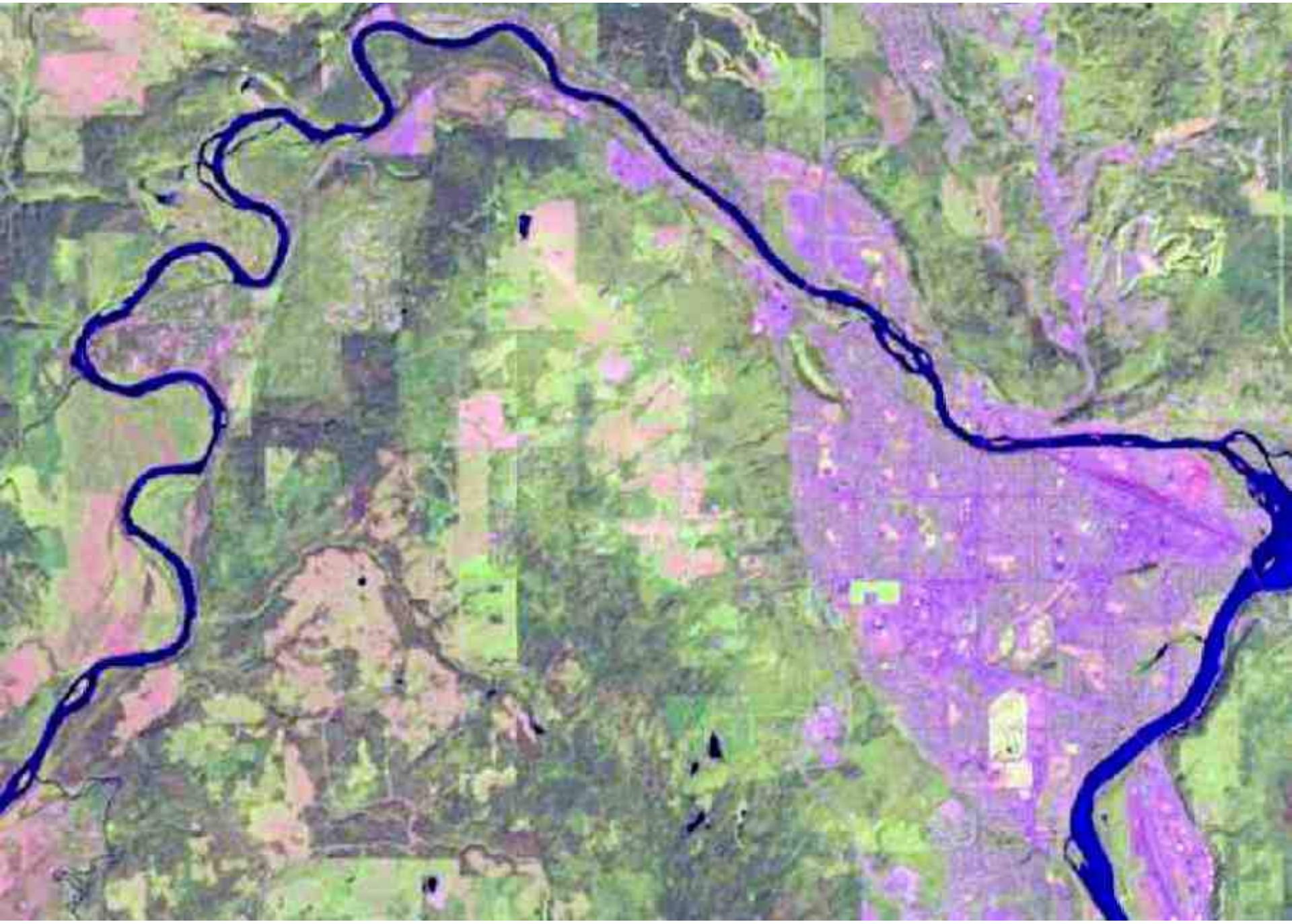


1984

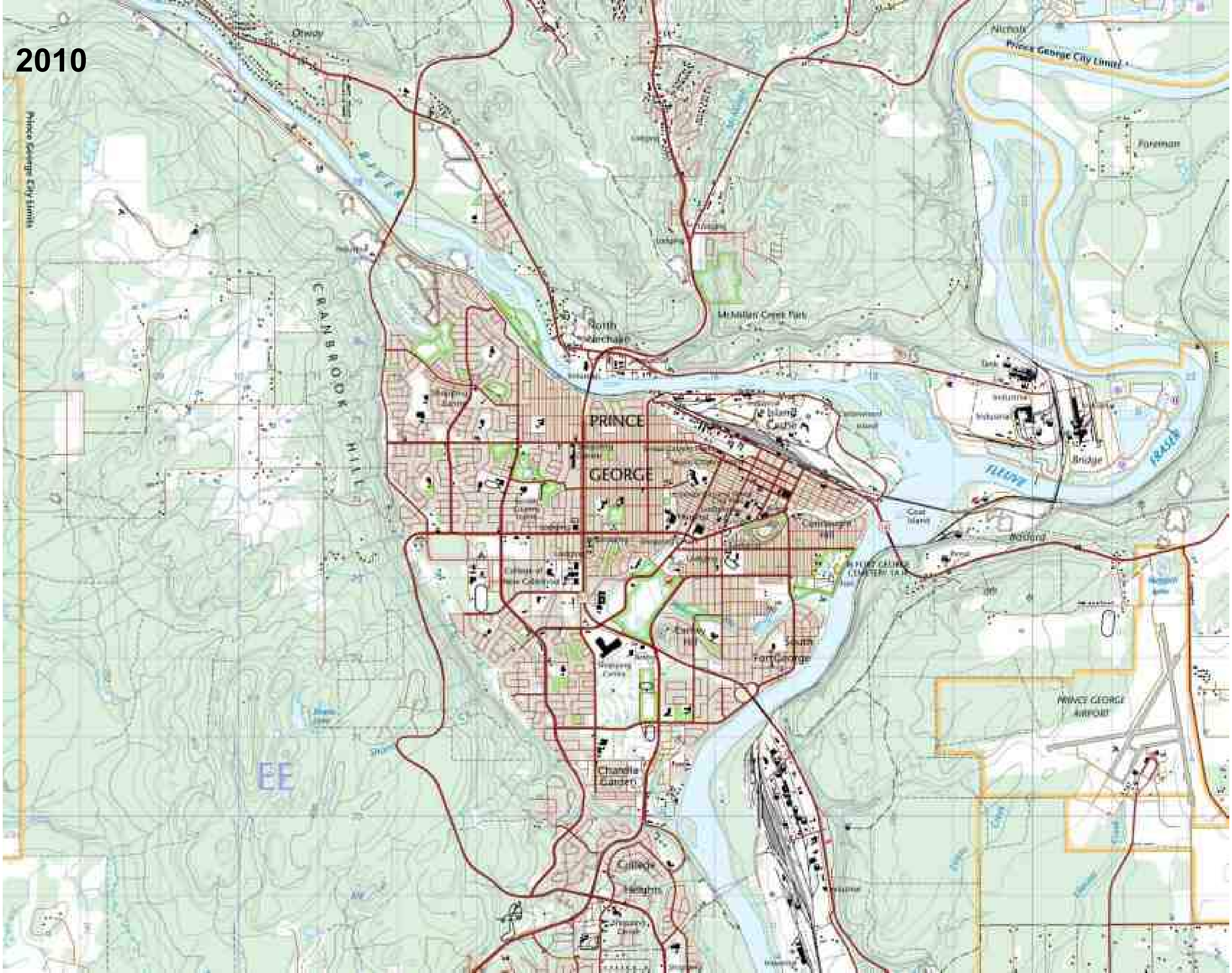



2003

2013 – Landsat 8




2013



2010
PRINCE
GEORGE
Prince George City Limit
Prince George City Limits
Otway
Nicholls
Foreman
CRANBROOK HILL
RIVER
North Nechako
McMillan Creek Park
Island Cache
Coal Island
Connaught Hill
Bridge
FRASER
South Fort George
College of New Caledonia
PRINCE GEORGE AIRPORT
Charella Garden
College
Heights

Google Earth Time Lapse 1984-2016

33 years of Landsat images; 55,000 images - 1 petabytes of data

https://earthengine.google.com/timelapse/

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

Ft. MacMurray:

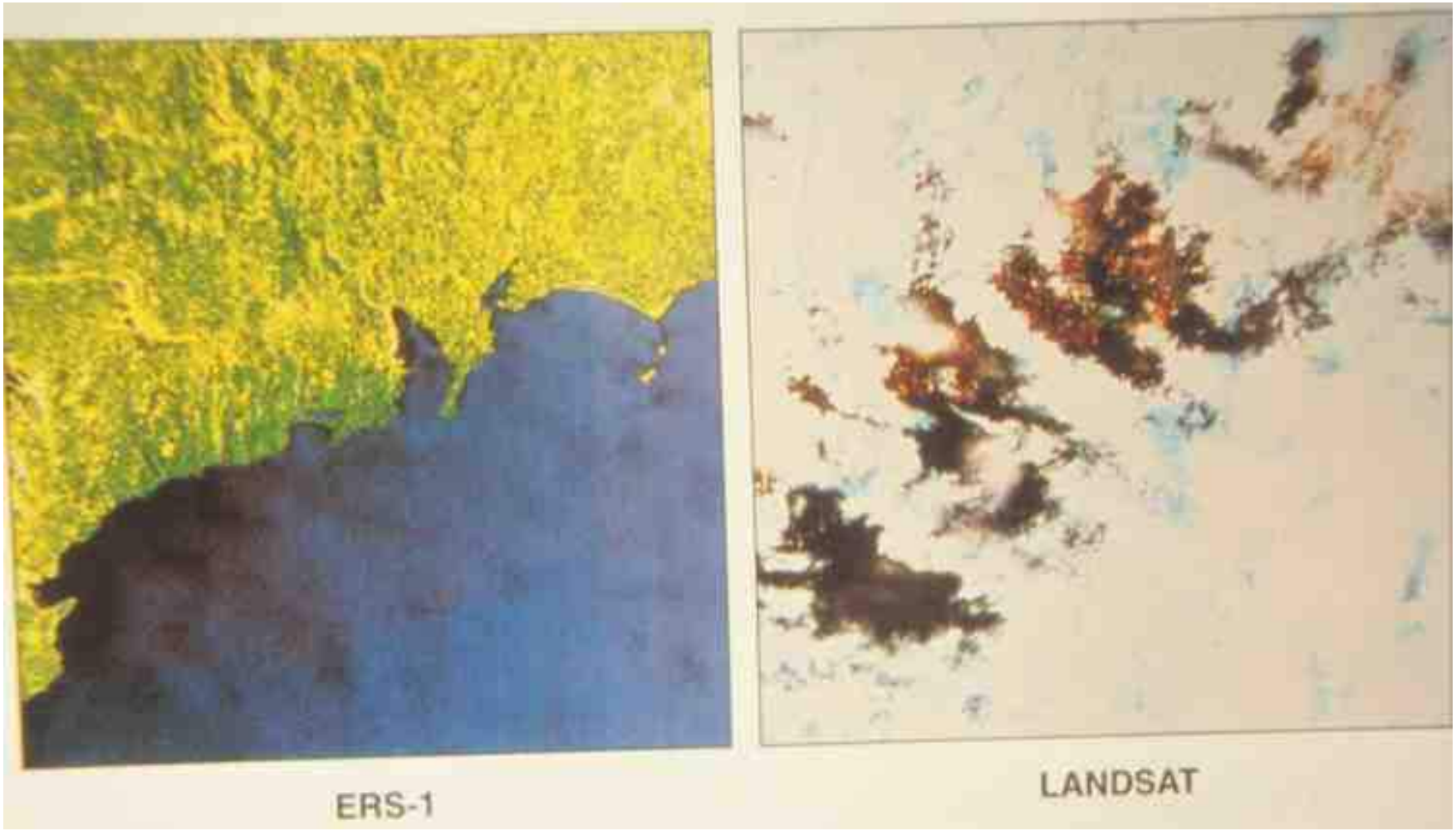
https://www.smithsonianmag.com/smart-news/google-earths-new-tools-shows-32-years-changing-planet-180961251/


ESA Sentinel 2
2015->
Oak Island, NS

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

This week's labs use Sentinel-2 images

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



European Radar Satellite

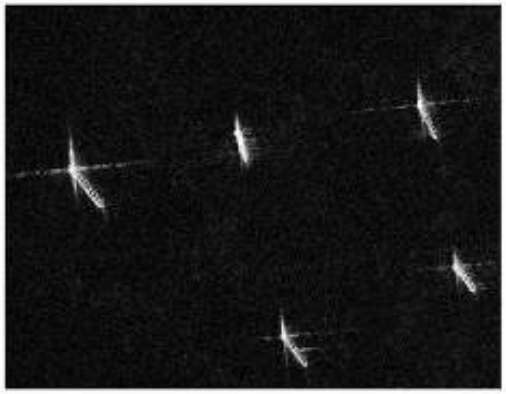
Ireland, 1991: Radar and Visible/ Optical image

Radar image, Vancouver RADARSAT 2

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



RADARSAT-2 Data and Products © MacDONALD, DETTWILER AND ASSOCIATES LTD. (2008) – All Rights Reserved - RADARSAT is an official mark of the Canadian Space Agency

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)

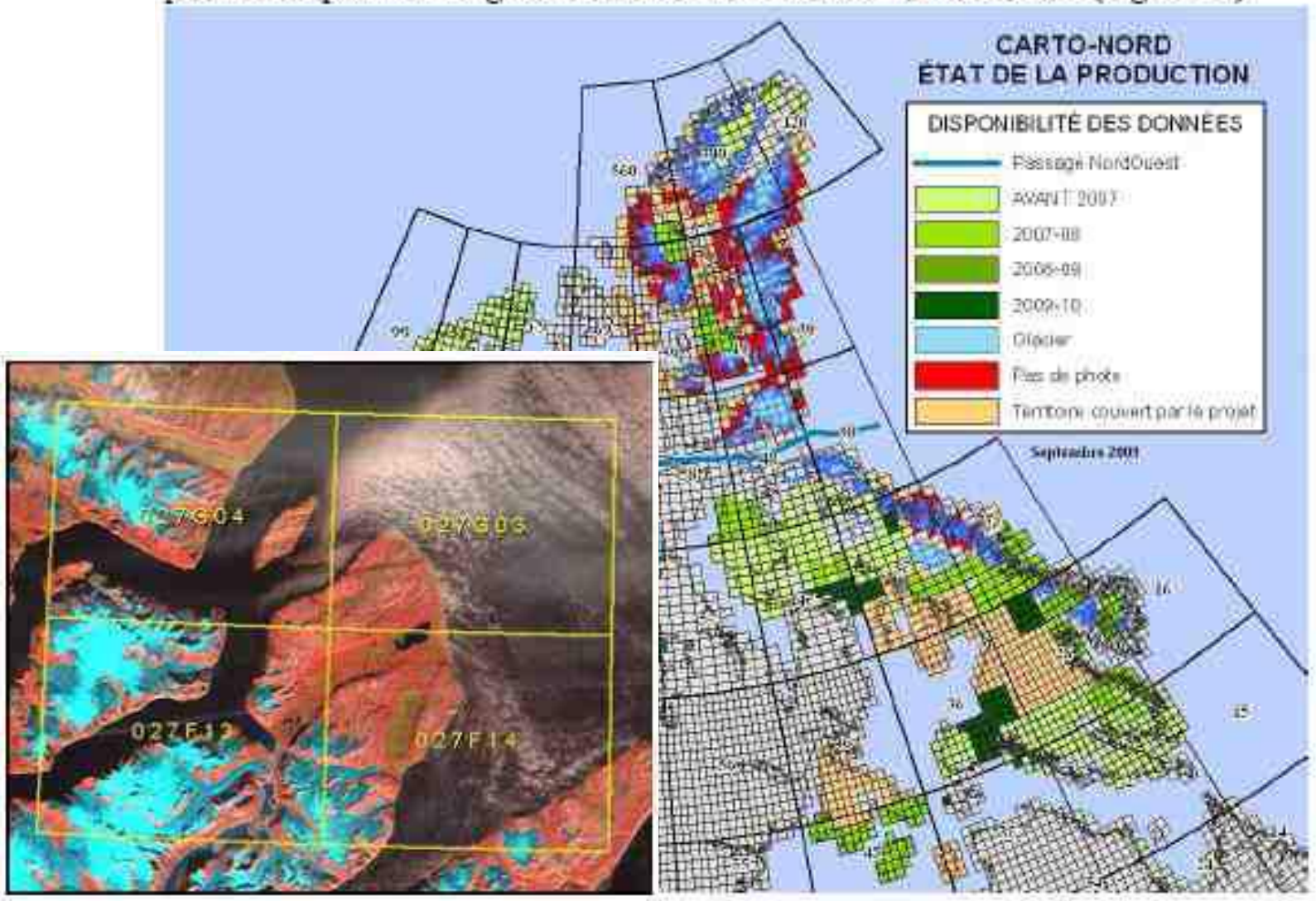
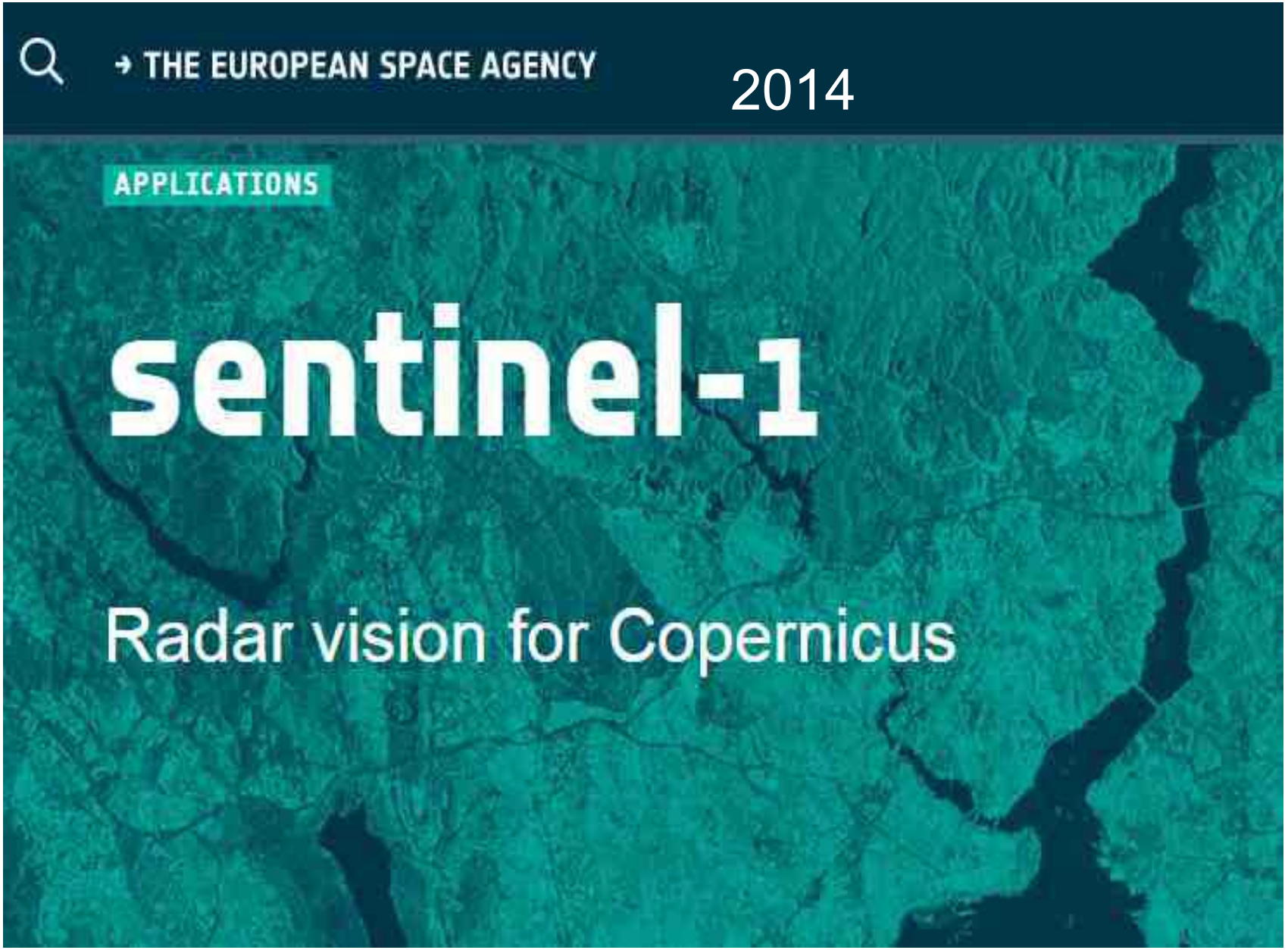


Figure 12 Northern Mapping project

SRTM (Shuttle RADAR Topographic Mission) Feb 2000

30/90 metre pixels, 56°S - 60°N latitude e.g. Google Earth

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


→ THE EUROPEAN SPACE AGENCY
2014
APPLICATIONS
sentinel-1
Radar vision for Copernicus

Very high resolution satellites

First corporate satellites 2000

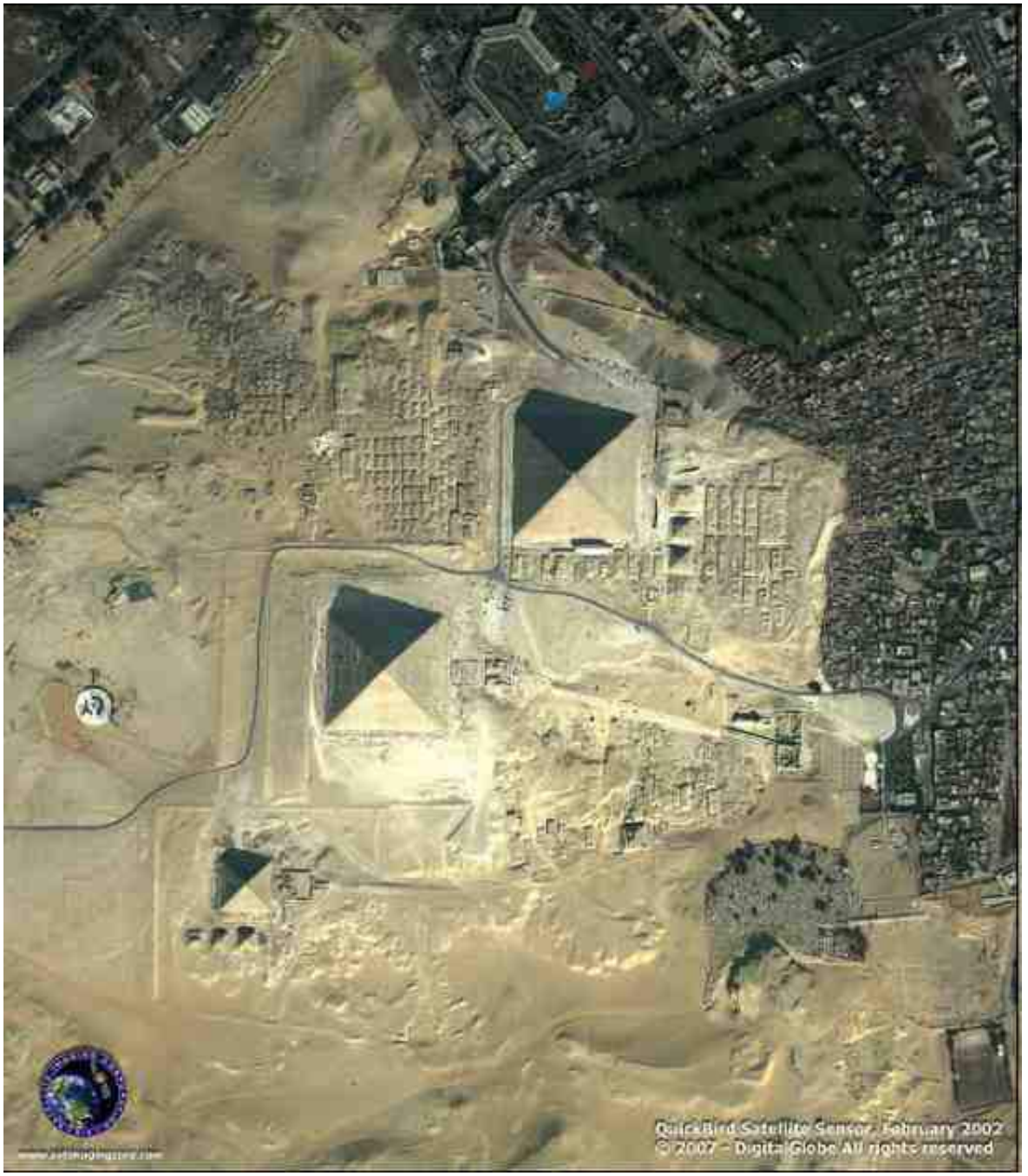
Ikonos: 1m image resolution

Whistler, 2012

Quickbird, 2001

60 cm pixels

- from 800km in space



GeoEye – 1: Obama inauguration,
Jan 20, 2009; Resolution: 40 cm

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

Worldview3
2014 Rainbow Range Chilcotin, BC 31cm

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

The giant dog you can see from space

Monday, June 9, 2008 BORIS the bull mastiff is so big that he can be seen lounging in his favourite position in the garden - from space. The 89kg dog has been captured on Google Earth's satellite images. 'He was in his favourite place,' said Fran Milner, from Bournemouth. We knew he was big but didn't think he was big enough to be seen from space.'

India successfully launches 104 satellites

Launch sets a record for most satellites launched at once

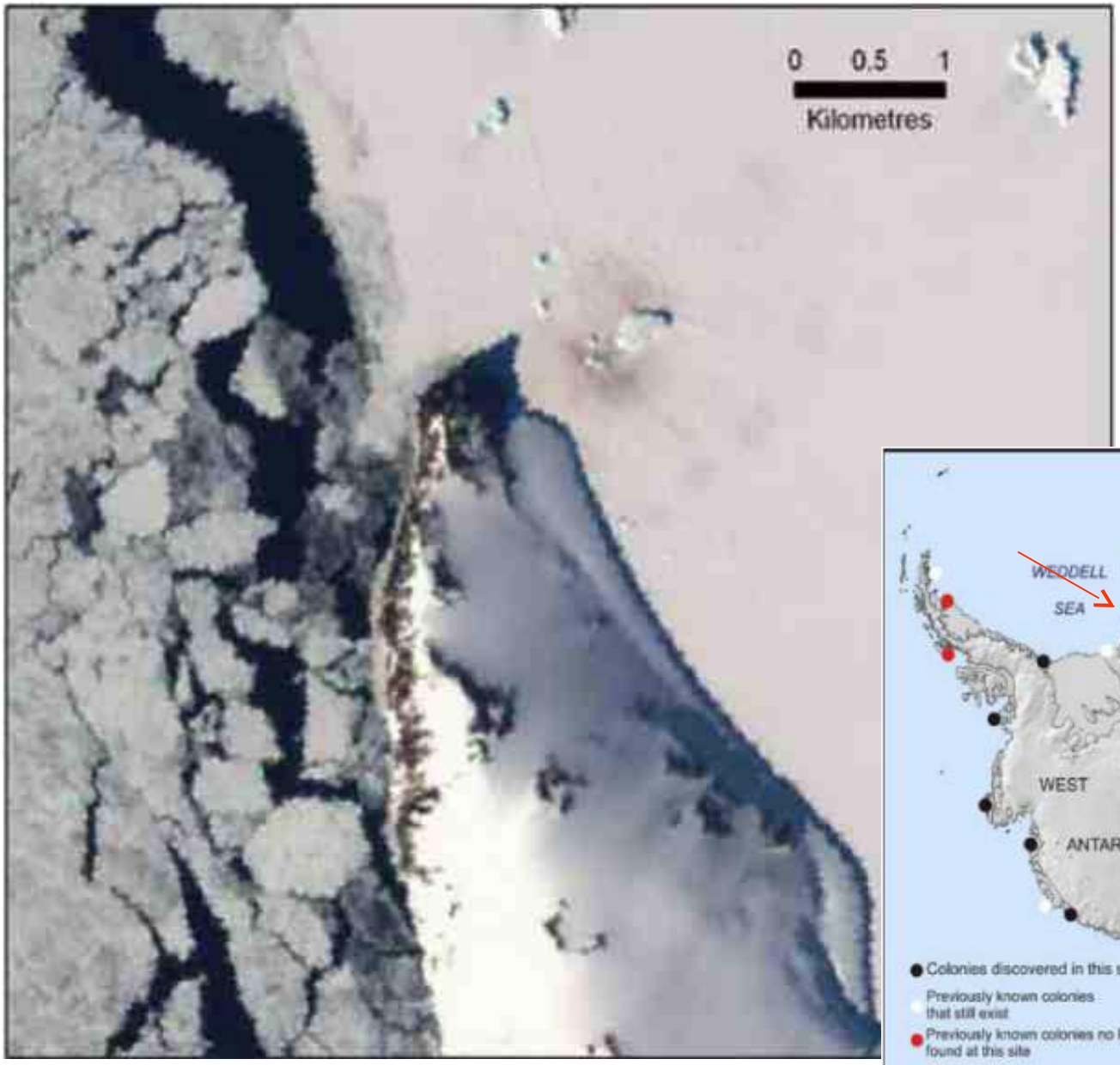
'doves'

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

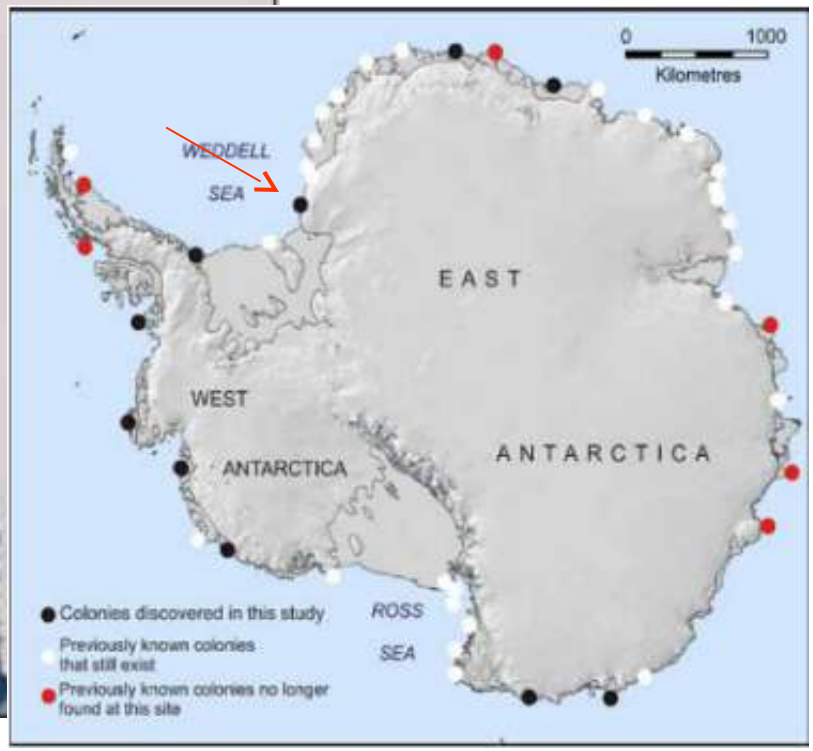
This photograph released by Indian Space Research Organisation shows its polar satellite launch vehicle lifting off from a launch pad at the Satish Dhawan Space Centre in Sriharikota, India, Wednesday, Feb.15, 2017. (Indian Space Research Organization

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

Mapping Penguins from space – using penguin poop



Pan-sharpened Landsat TM image showing guano stains of an emperor penguin colony in Halley Bay, Antarctica



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