



The History of Observing The Earth from Space and Canada's role.

Learning Objectives

- In this lecture you will learn...
 - History of observing the Earth from space
 - The major Earth observing systems in space
 - Why Canada is a leader and has a key role in Earth observation systems



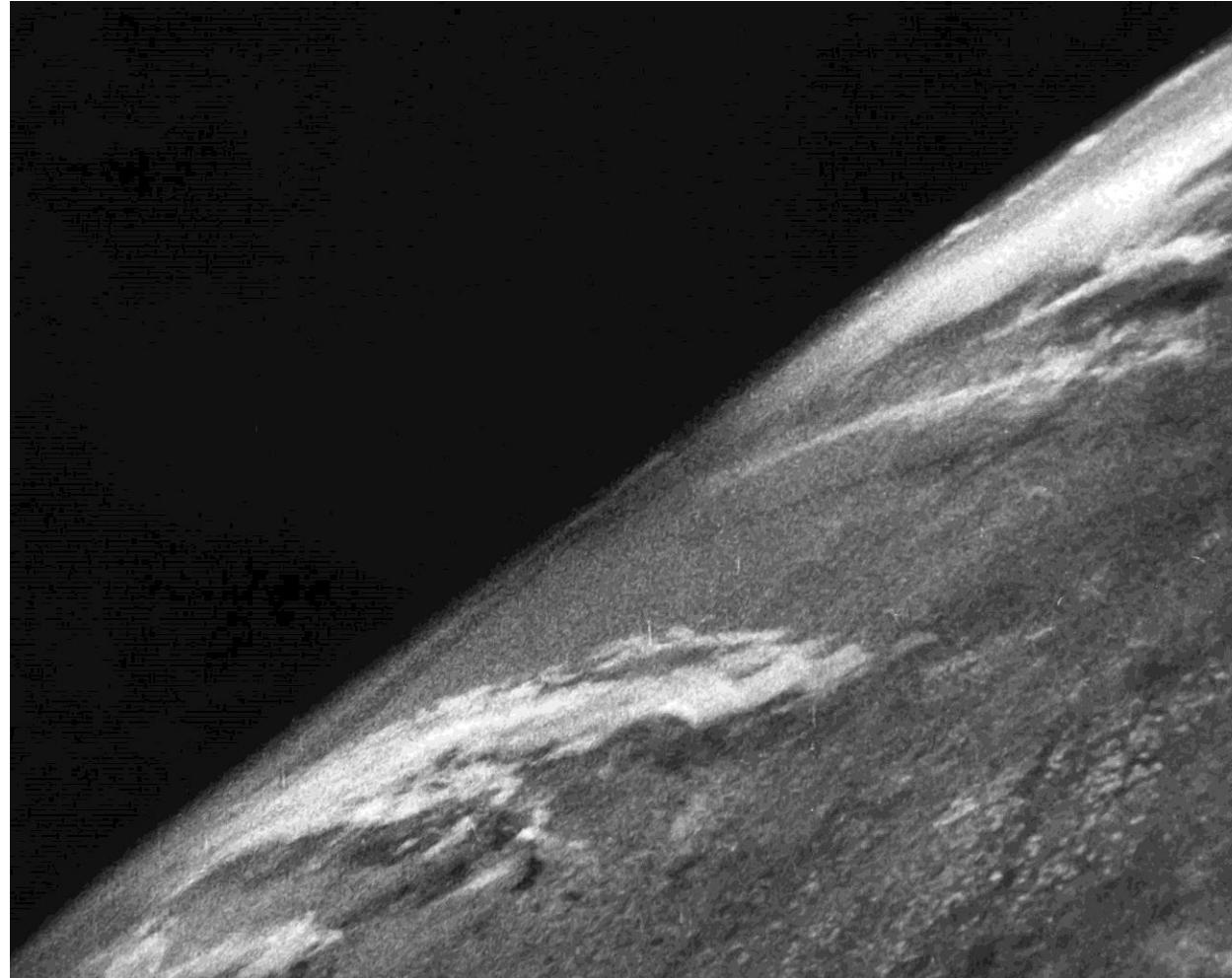
History of Observing Earth from Space

- Cameras were initially fixed to unmanned rockets
- First images from space came from American V2 rocket in 1946
- Images show New Mexico and Gulf of California



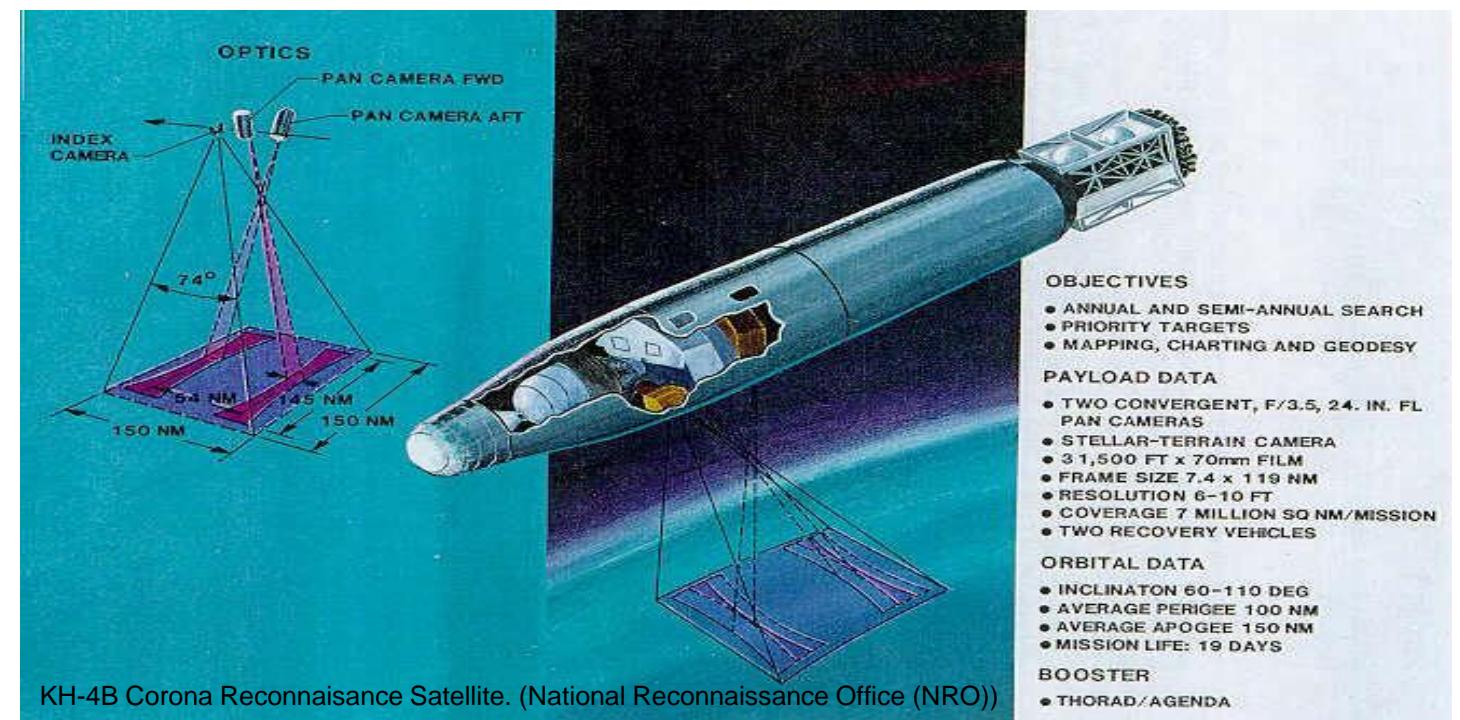
First Earth Observations from Space

- V-2 Rocket



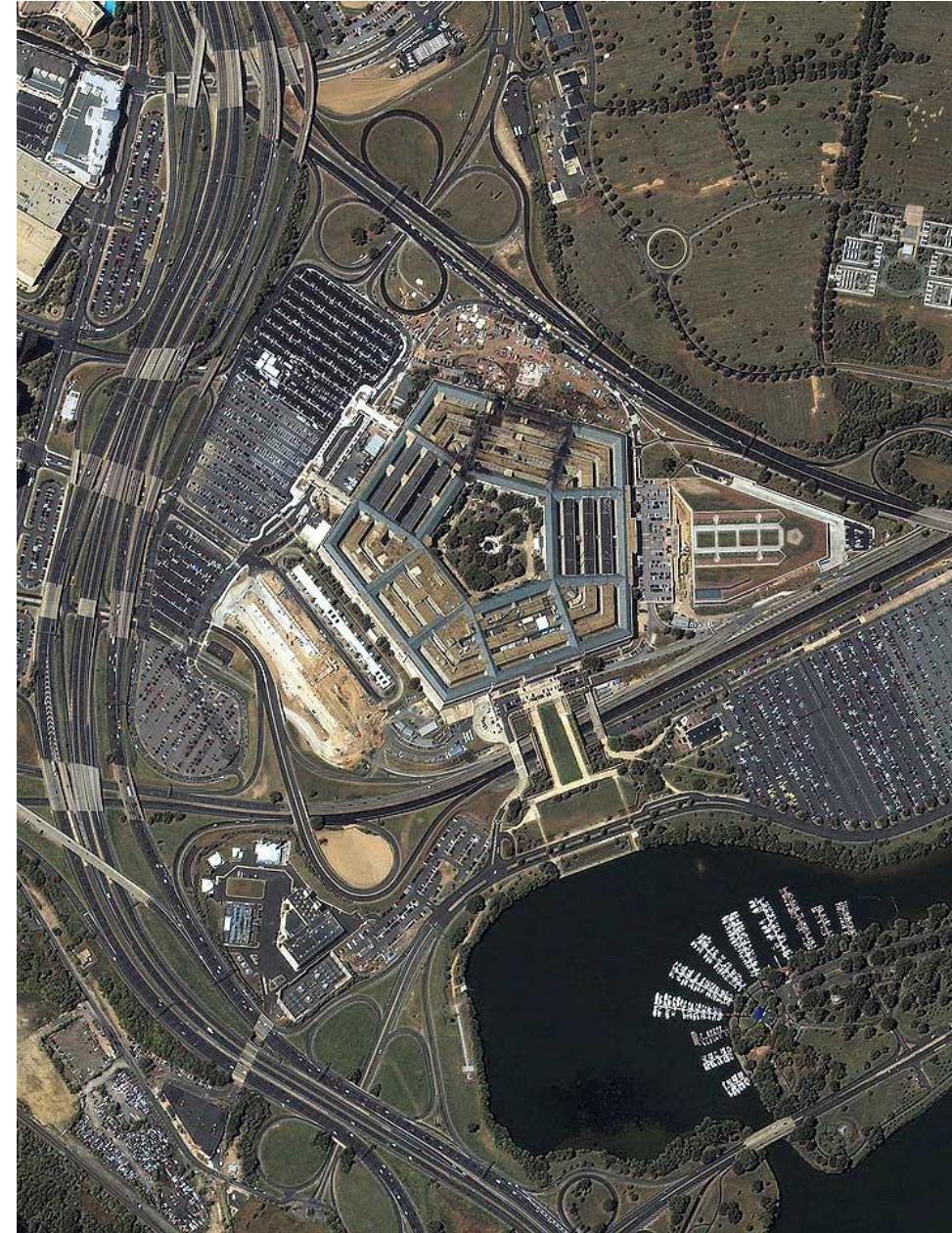
History of Observing Earth from Space

- Following the successful launch of rockets with a camera, systems specifically designed for cameras were developed by the military.
- CORONA, ARGON, LANYARD are three such programs which provided space photo reconnaissance satellite (1959-72).





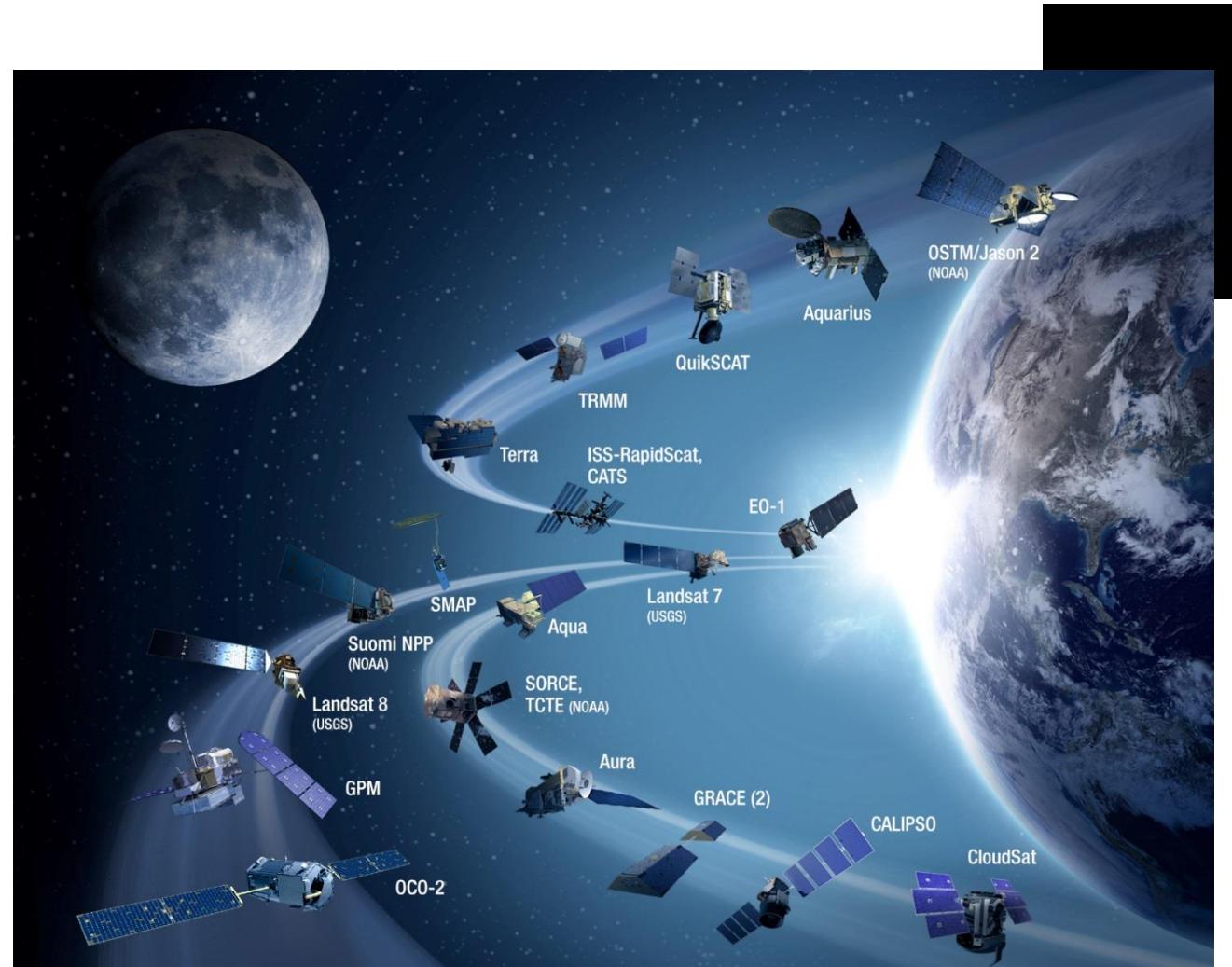
Corona image of the Pentagon, 25 Sep 1967 Source: <http://www.nro.gov/corona/corona7.jpg> Status: PD-USGov {{PD-USGov}})



QuickBird image of the Pentagon 2008.

What are Earth observing systems?

- Continuous data streams that provide observations of Earth
- For monitoring the major systems of Earth (atmosphere, biosphere, cryosphere, lithosphere, etc.)
- Important to have repeat, stable, and consistent observations for monitoring



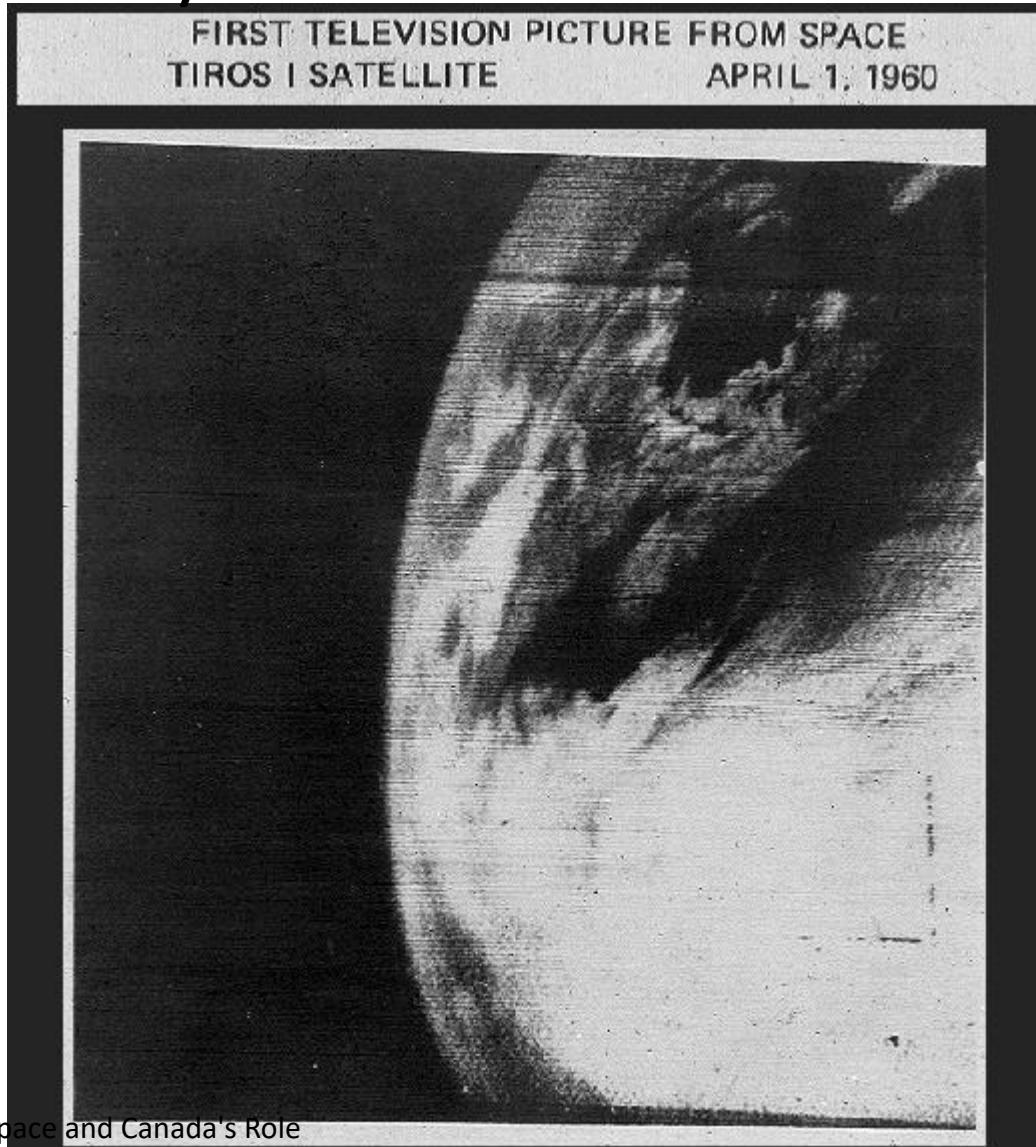
Observing Systems in Space and Canada's Role

What was the first Environmental Application of images from Space ?



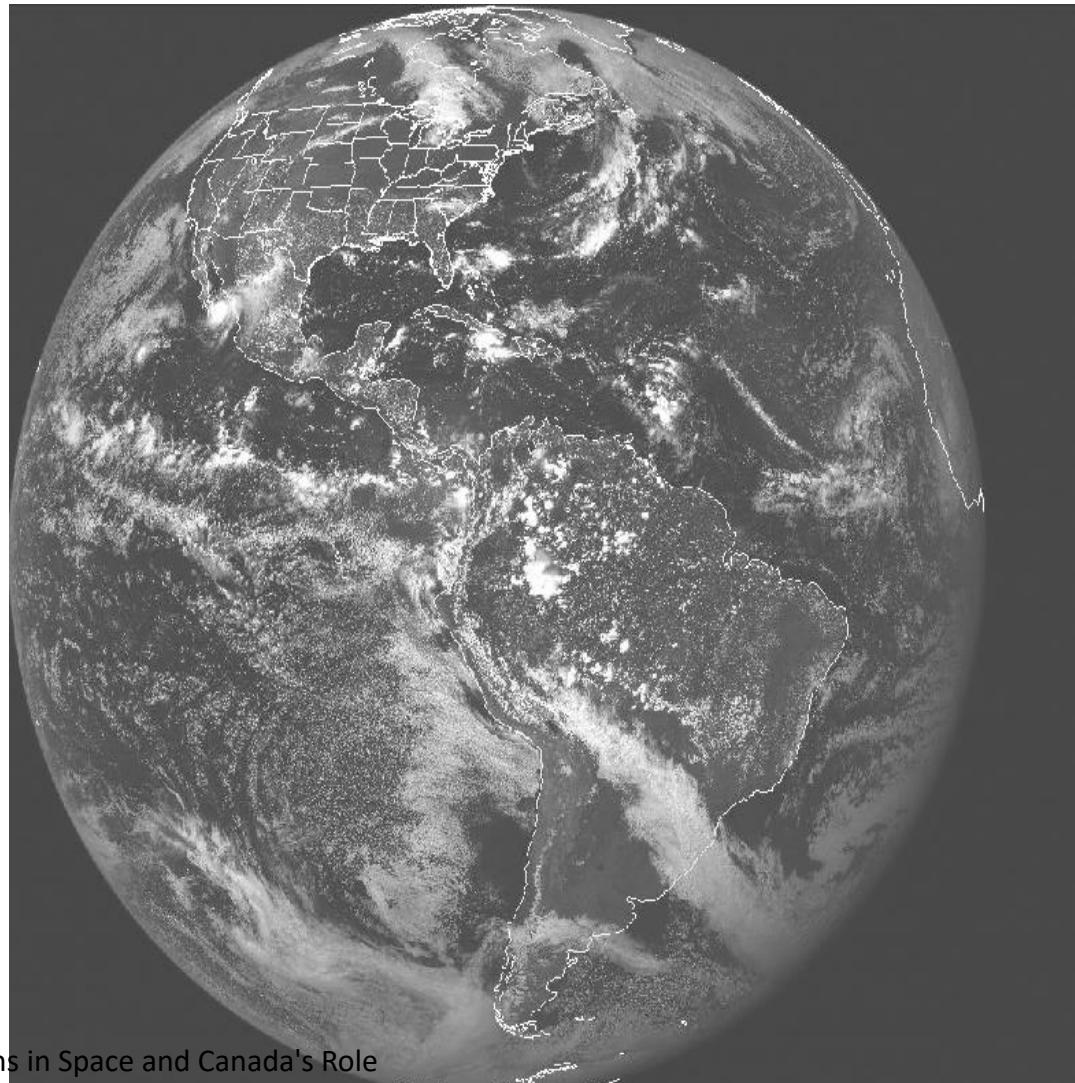
The first Earth Observation Systems

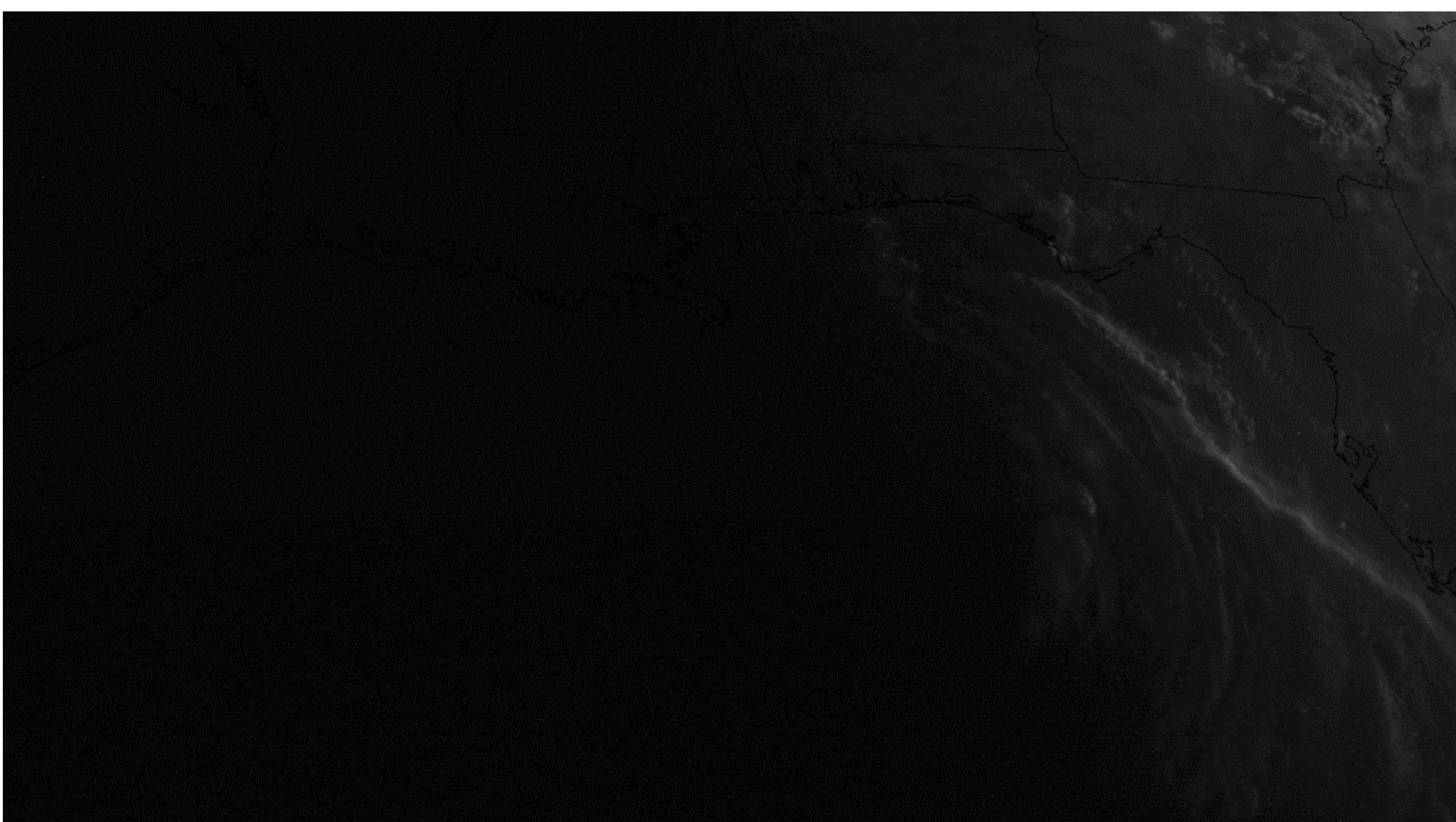
- First Earth observing systems in space for environmental applications
 - Weather satellites
- Practical need to monitor weather patterns, systems, and storms
- First televised picture from space was aboard the TIROS weather satellite in 1960



The first Earth observation systems

- Geostationary Operational Environmental Satellite (GOES) series
- Geostationary orbits provide 24/7 coverage for a hemispherical side of Earth





In CONS 127 we will learn of FOUR Earth Observation Programs

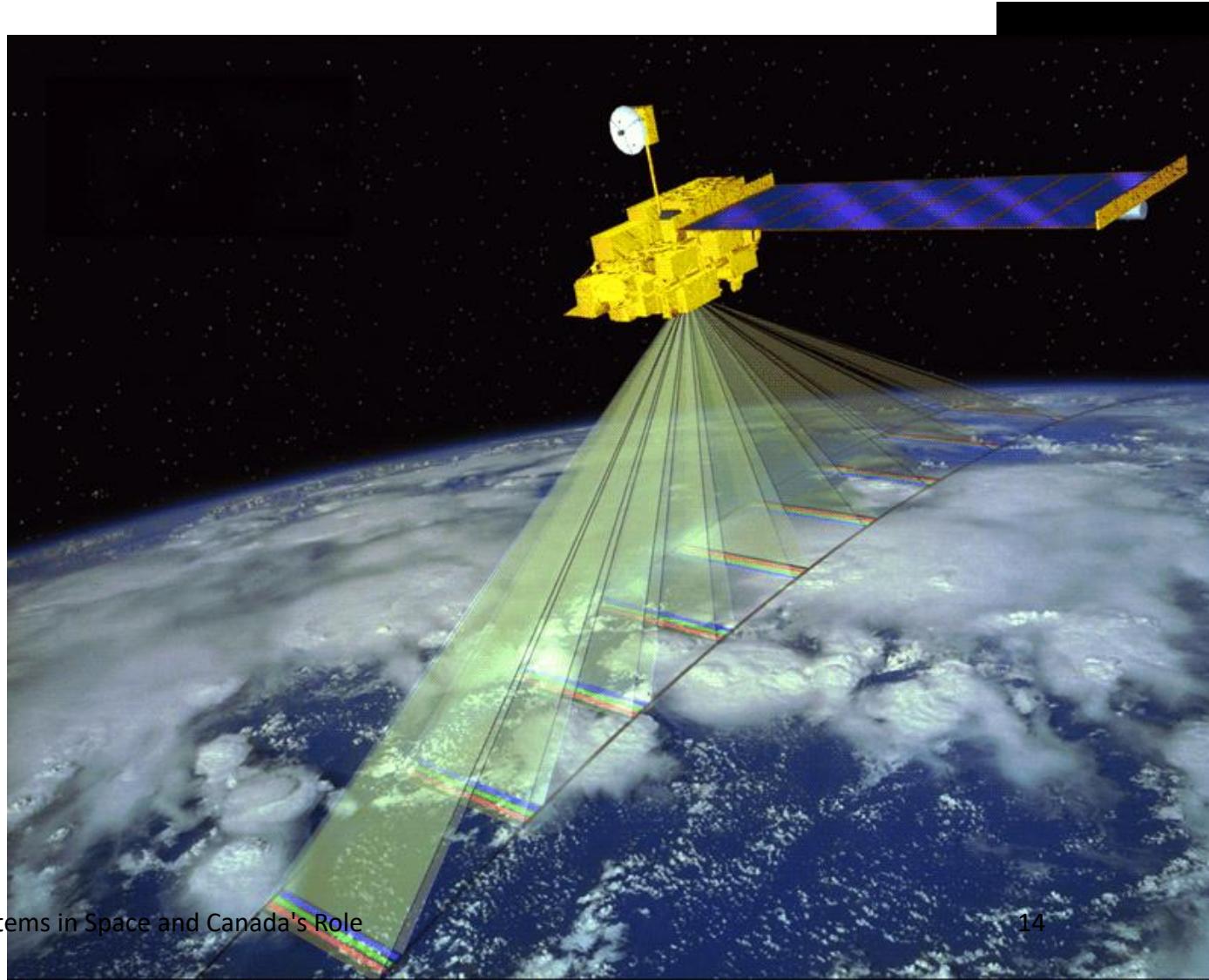
- MODIS (onboard TERRA/AQUA)
- Landsat
- WorldView
- ICESat
 - Lidar



Earth observation systems: Terra and Aqua

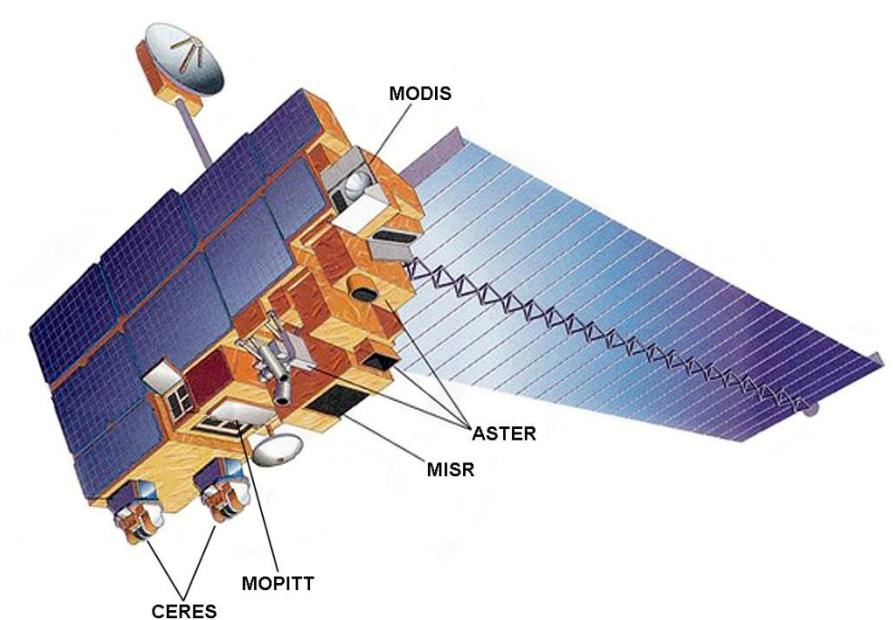
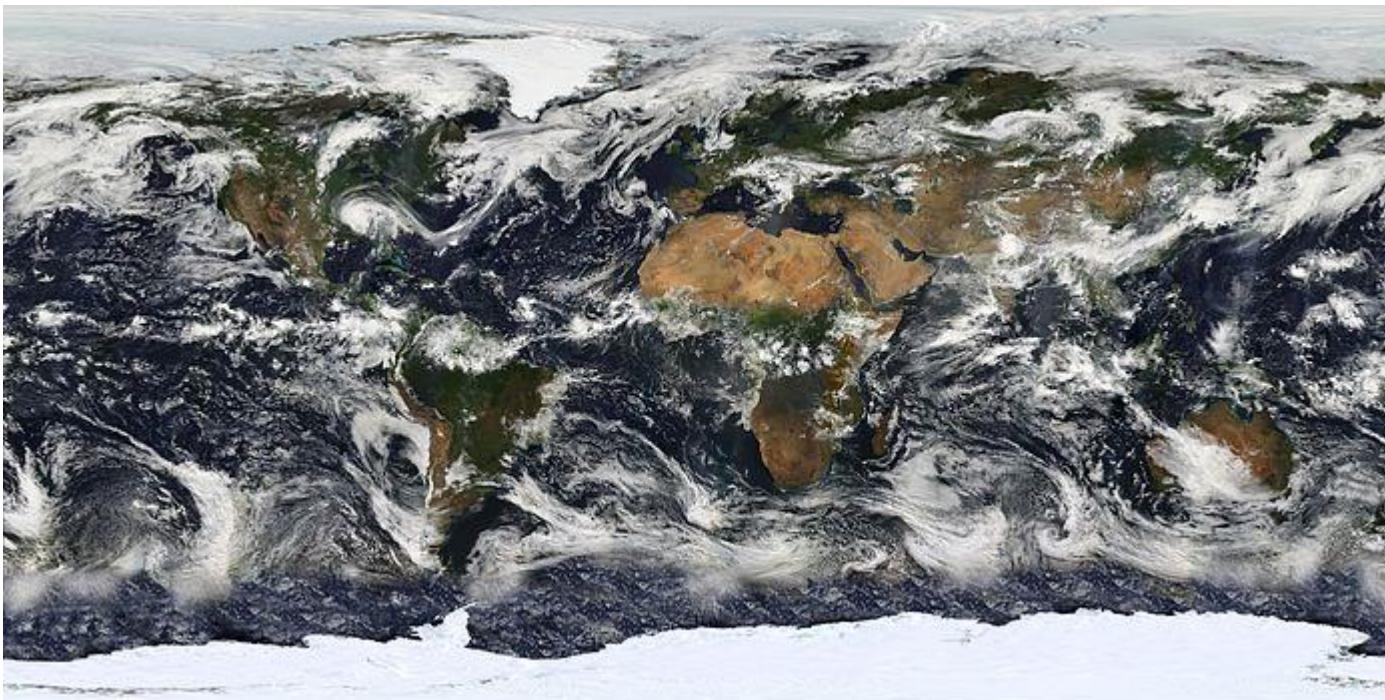
Moderate Resolution Imaging Spectroradiometer (MODIS)

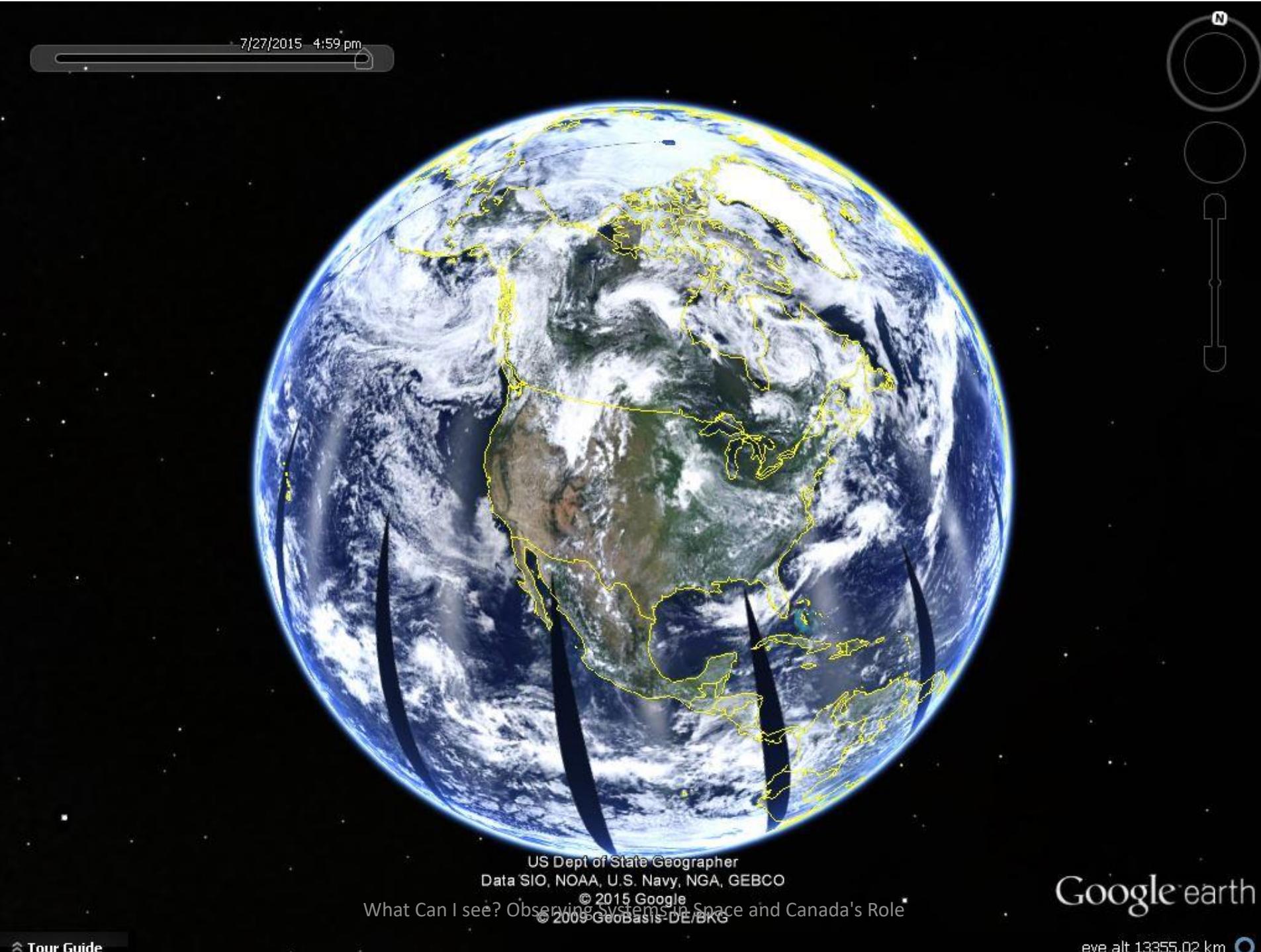
- 250-500m pixel for land research
- 1000m pixel for ocean and atmosphere research
- 1 – 2 day return period



MODIS (Onboard Terra/Aqua)

- Daily imagery
- Coarse scale of spatial information, fine scale temporal info (1-2 days)





Google earth

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US Dept of State Geographer
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

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What Can I see? Observing Systems in Space and Canada's Role

Earth observation systems: Landsat

Landsat

- 30m pixel
- 16-day return period
- Series of 8 satellites comprised of 4 different sensors

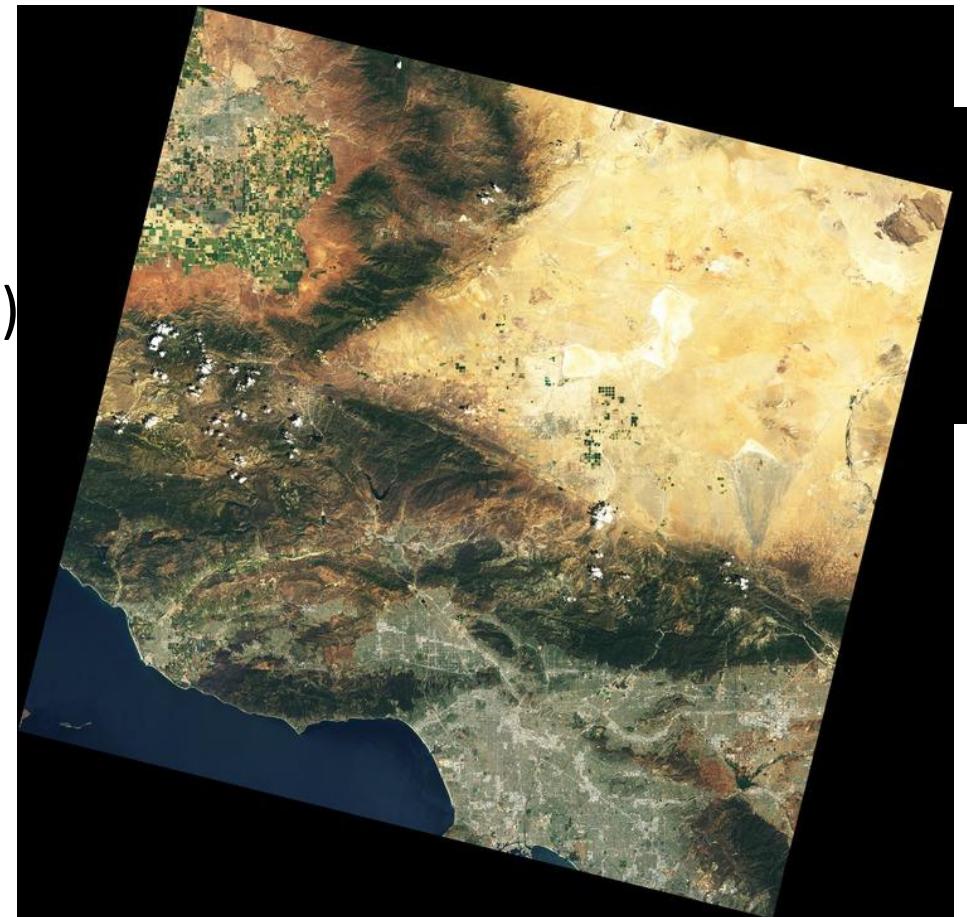


Landsat Missions: Imaging the Earth Since 1972



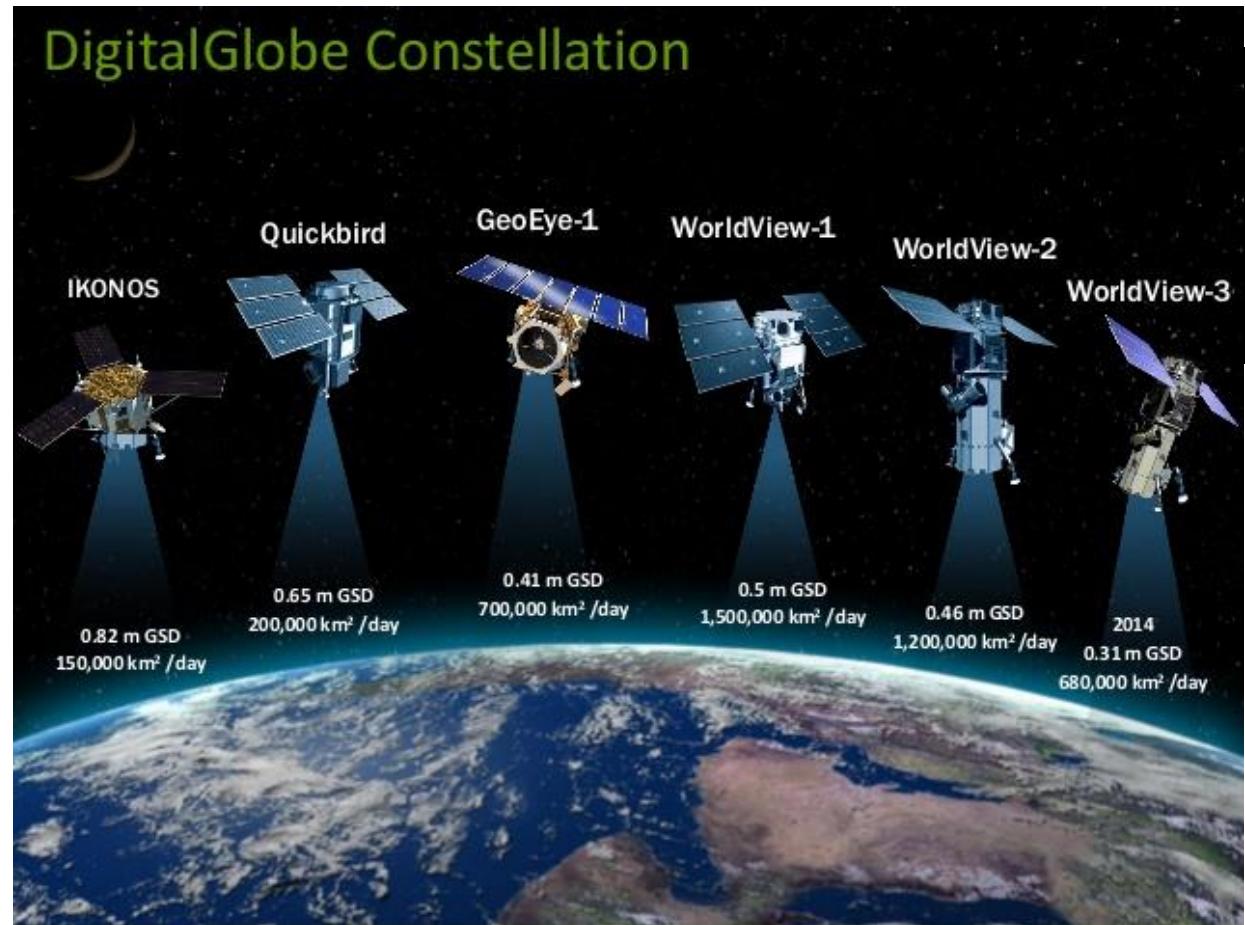
Landsat

- Oldest program
 - Dating back to 1972 (TM dates back to '82/'84)
- Moderate scale of spatial information
- Fine/moderate temporal info (16 days)



Commercial Satellite Companies: World View 1 - 4

- DigitalGlobe is one of the largest and most successful private satellite companies which has launched 6 high spatial resolution satellites since 1999
- Most recently they launched the World View series of satellites of which there are now 4
- They are the highest spatial resolution available from a space platform, in some cases as low as 30cm



WorldView

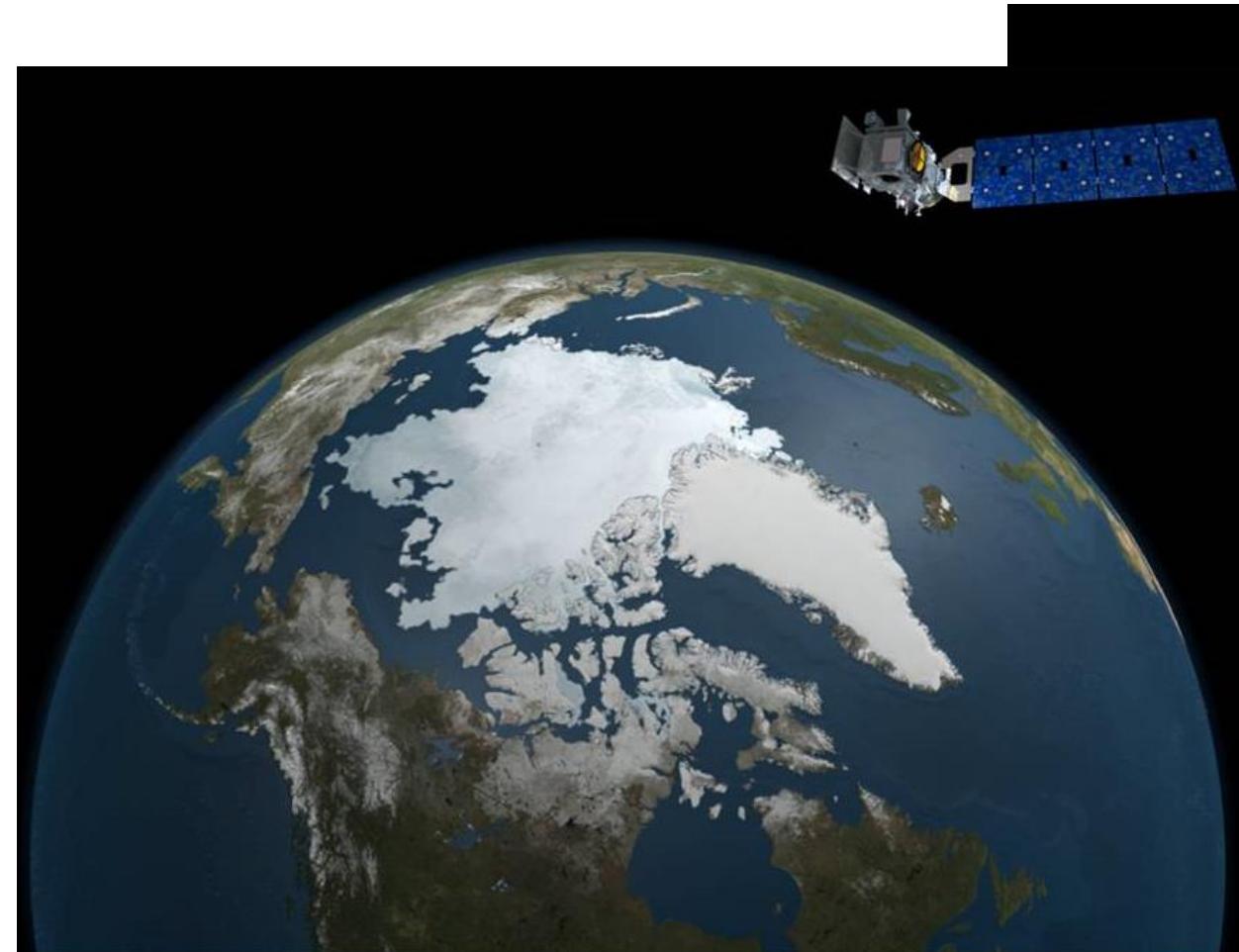
- Finest scale of spatial information
- Private



Earth observation systems: ICESat

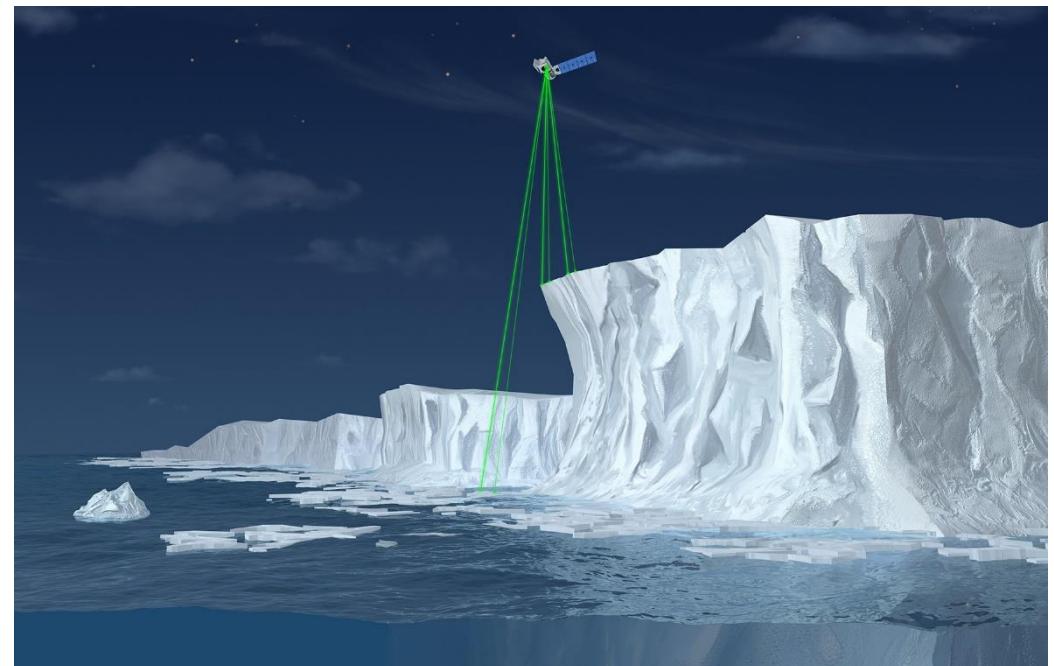
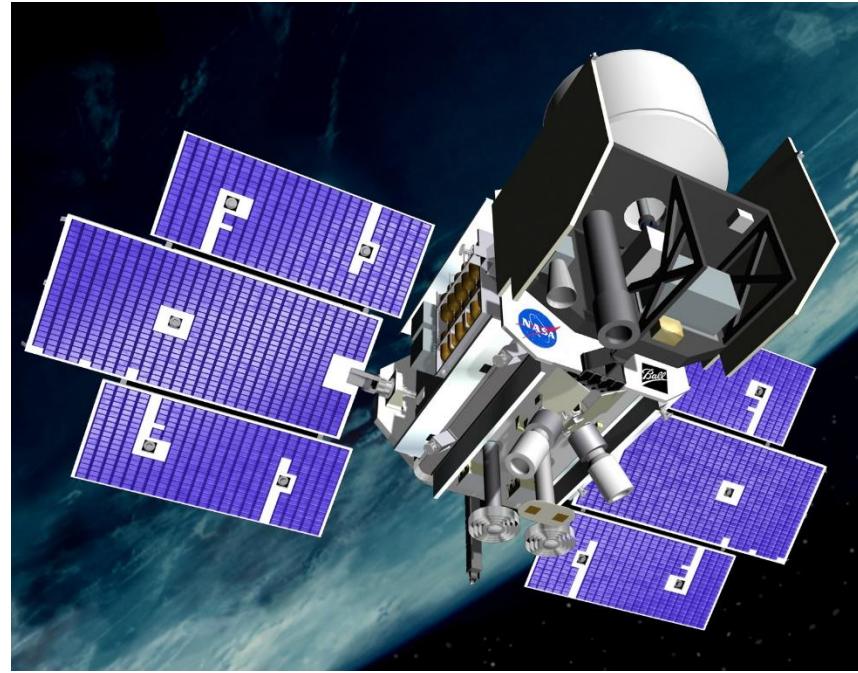
Ice, Cloud and land Elevation Satellite (ICESat)

- 70m “footprint”
- Space-borne laser-ranging
- Monitoring ice, cloud and land elevation



ICESat

- Uses Lidar
 - We will talk later about what Lidar is
- For now, just know it images:
 - Ice
 - Clouds
 - Elevation



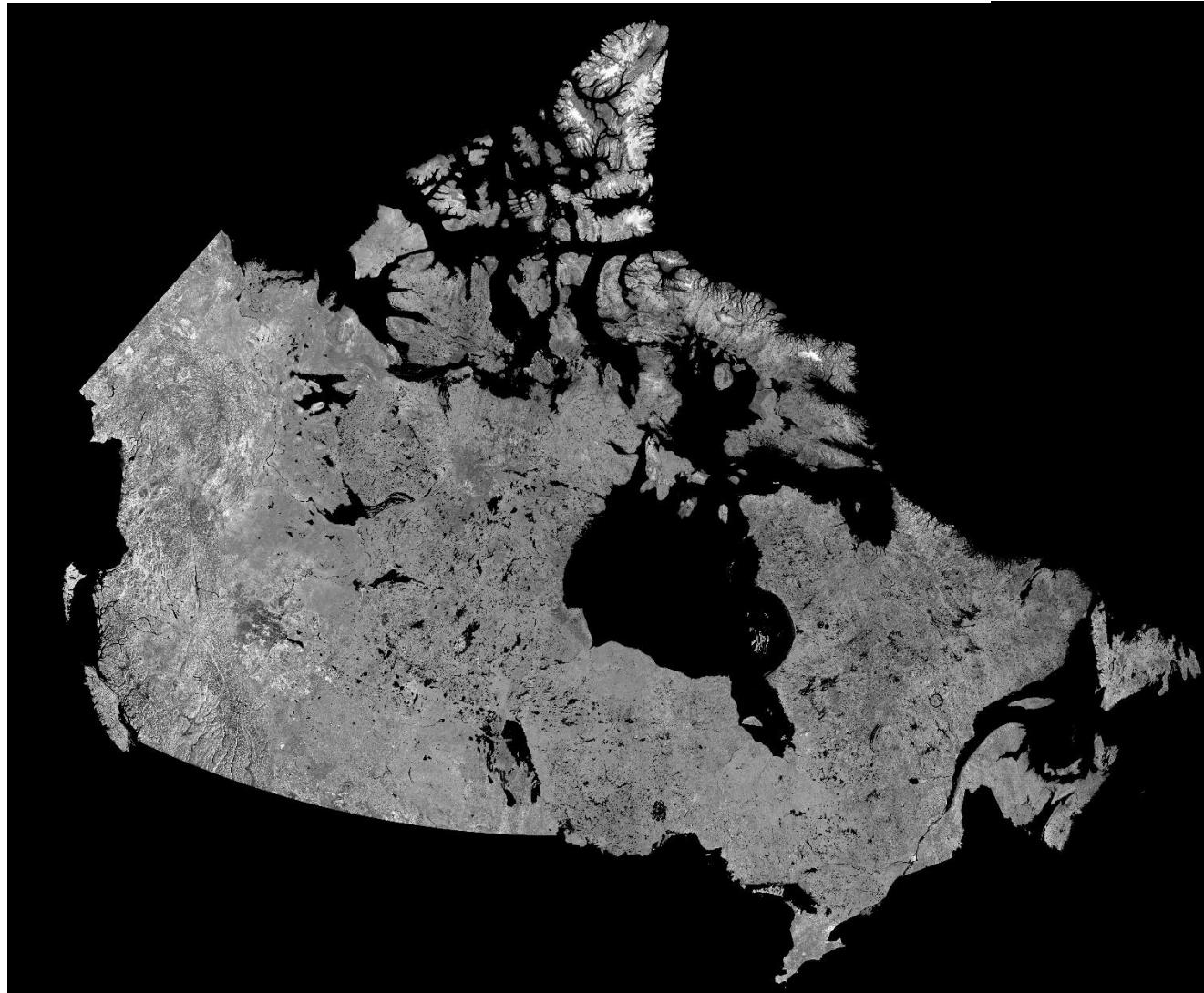
Terminology

- Pixels
 - MODIS has different sized pixels?
- Footprints
 - ICESat
 - Lidar
- Hold off for when we discuss...
 - Resolutions



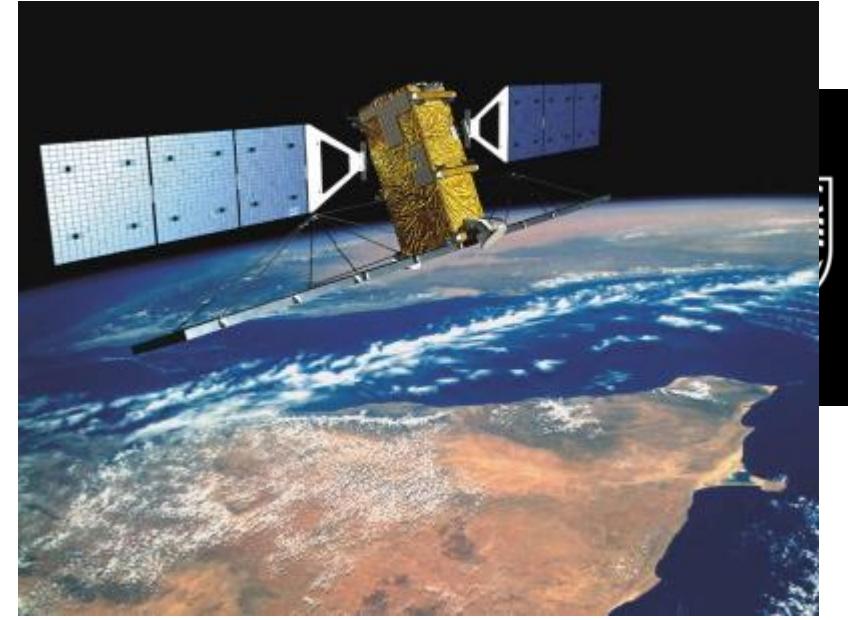
Earth Observing Systems: Canada's role

- Canada is large and vast with lots of resources to monitor
- Canada contains 7% of the Earth's renewable freshwater supply
- Need to monitor these resources efficiently, repeatedly, and constantly



Canada's Contributions to Earth Observation from Space

- Astronauts
 - Chris Hadfield
 - Roberta Bondar
- RADARSat
- Candarm
- UrtheCast



- Dr Chris Hadfield took over on the ISS in 2012 and became the first Canadian to command the ISS.
- He returned home in May 2013
- Chris Hadfield took over 45,000 images while in space.



Earth Observing Systems: Canada's role

- Chris Hadfield was first Canadian to walk in space
- On his first space walk in 2001, he installed Canadarm2 to the International Space Station



Earth Observing Systems: Canada's Role

- Dr. Roberta Bondar was Canada's first female astronaut
- Also the first neuroscientist to launch into space
 - Main research focus was health sciences
 - Studying effects of microgravity on human body



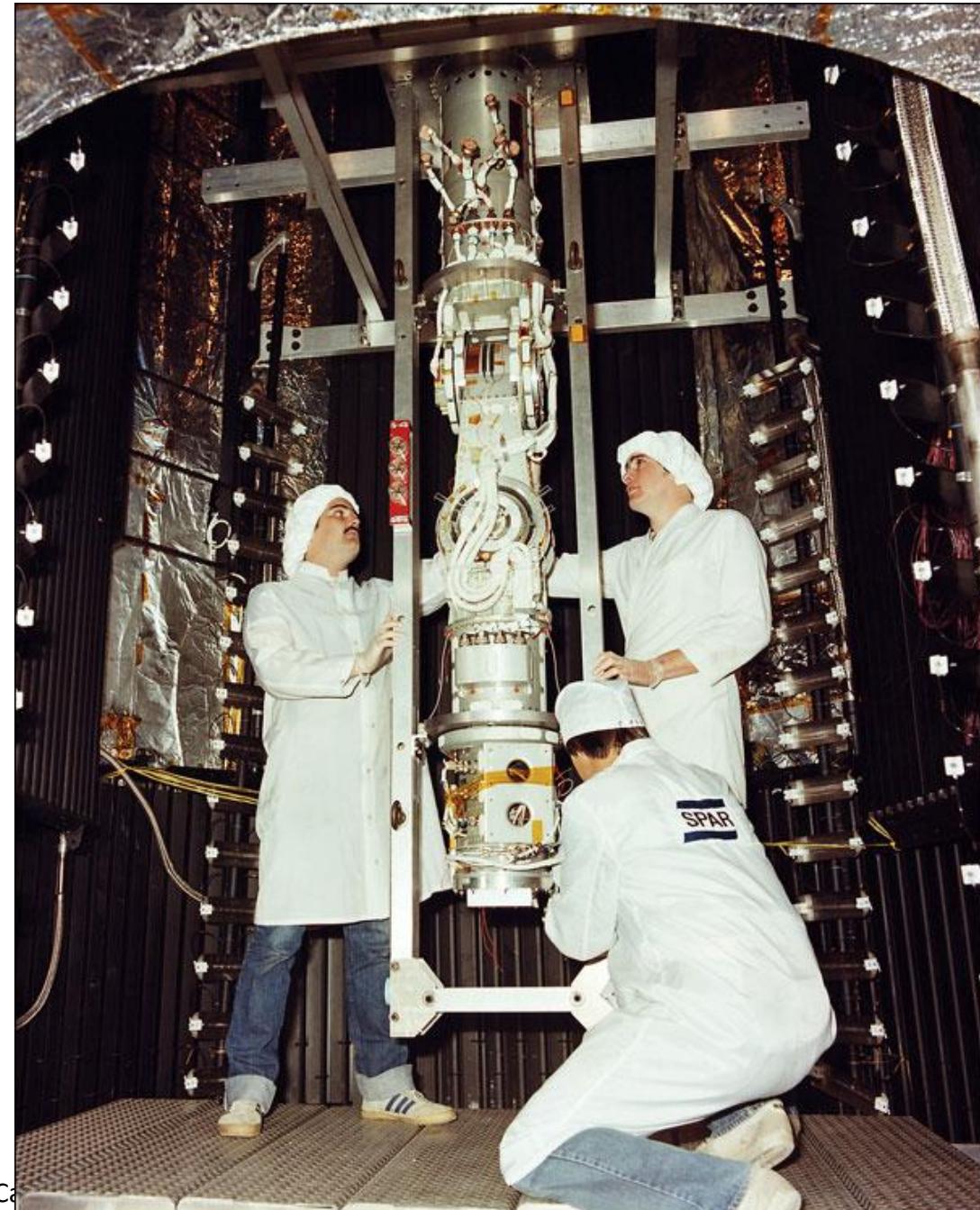
Earth Observing Systems: Canada's role

Canadarm1 on Space Shuttle in 1981

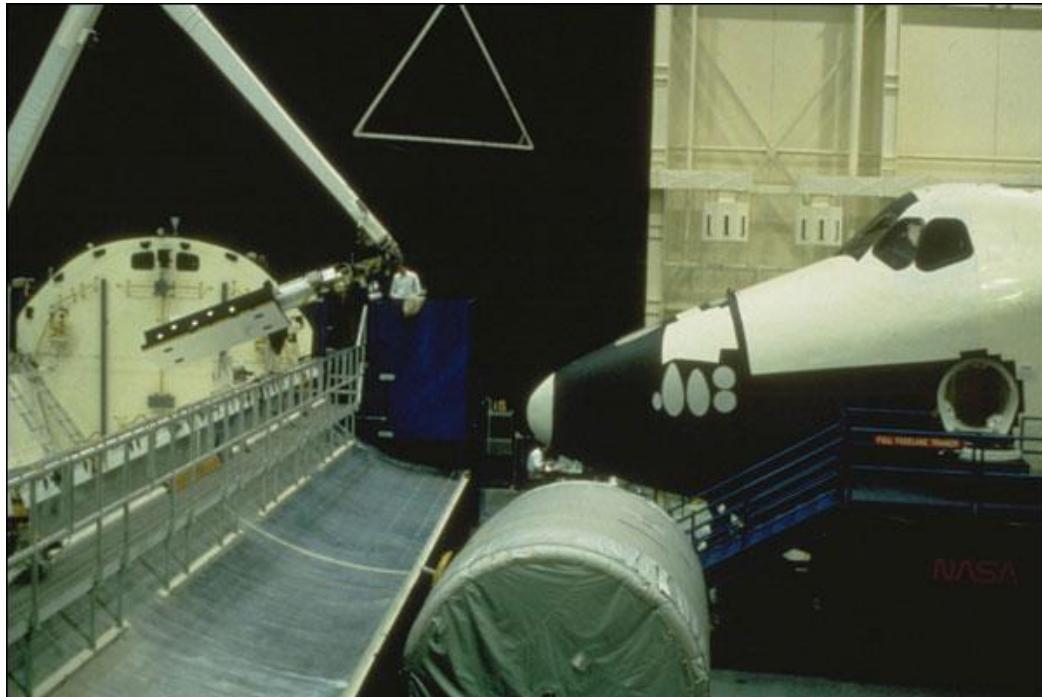
Canadarm2 on ISS in 2001



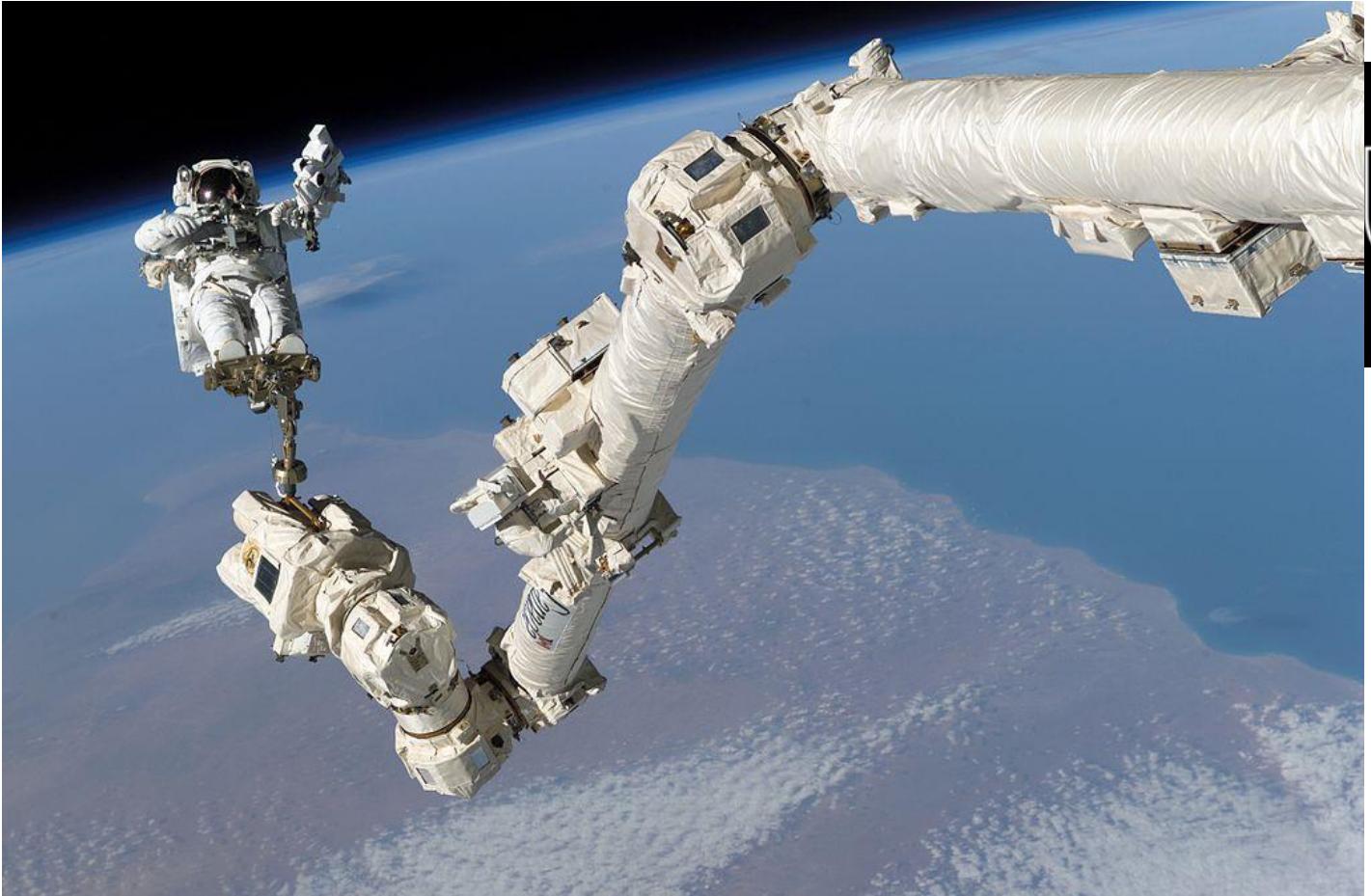
- Canada had an agreement with NASA in 1969 to help contribute to the NASA Space Shuttle Mission
- It was agreed that Canada would provide a robotic arm
- The name “Canadarm” was given in 1981 at the first delivery.
- In all 5 Canadarms were delivered, each cost around \$100 million CAD
- The last Canadarm 1 left the space station in 2011



The Canadarm is deployed for the first time in space during Mission STS-2 in 1981.



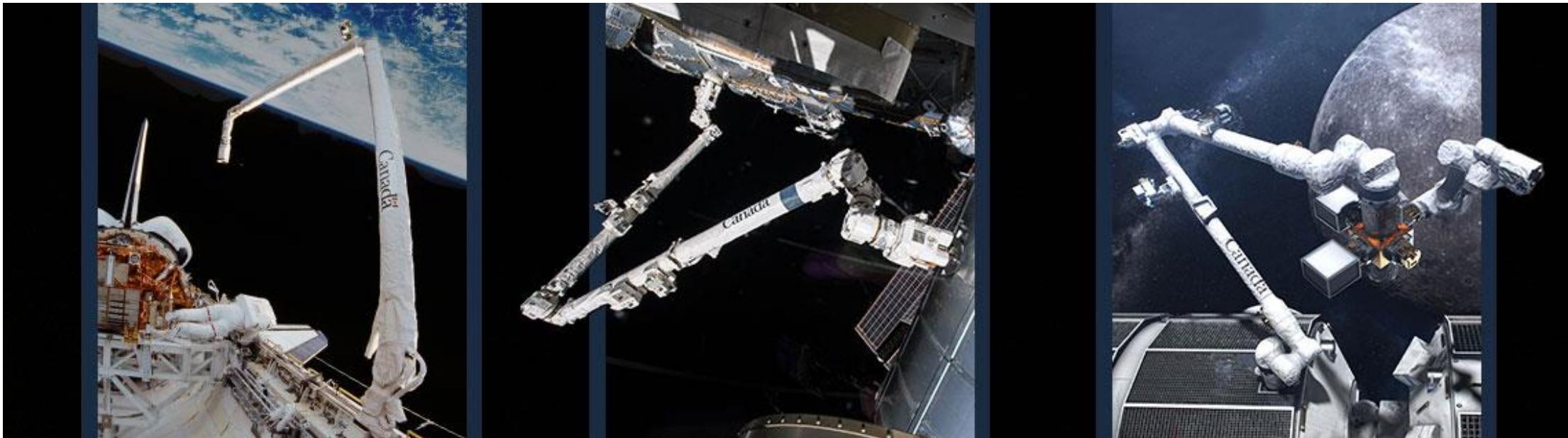
- Canadarm-2 was a second generation arm put on the space station in 2001



Canadarm

Some clarifications about the Canadarm:

- There were several Canadarm-1 iterations
 - These were fixed to NASA's space shuttles
 - The last Canadarm-1 left the space station in 2011
- There is one Canadarm-2
 - It has been permanently mounted on the ISS since 2001



Earth observing systems: Canada's role

RADARSAT

Designed to monitor:

- Ice
- Surface wind
- Oil pollution
- Ships
- Disasters
- Ecosystems

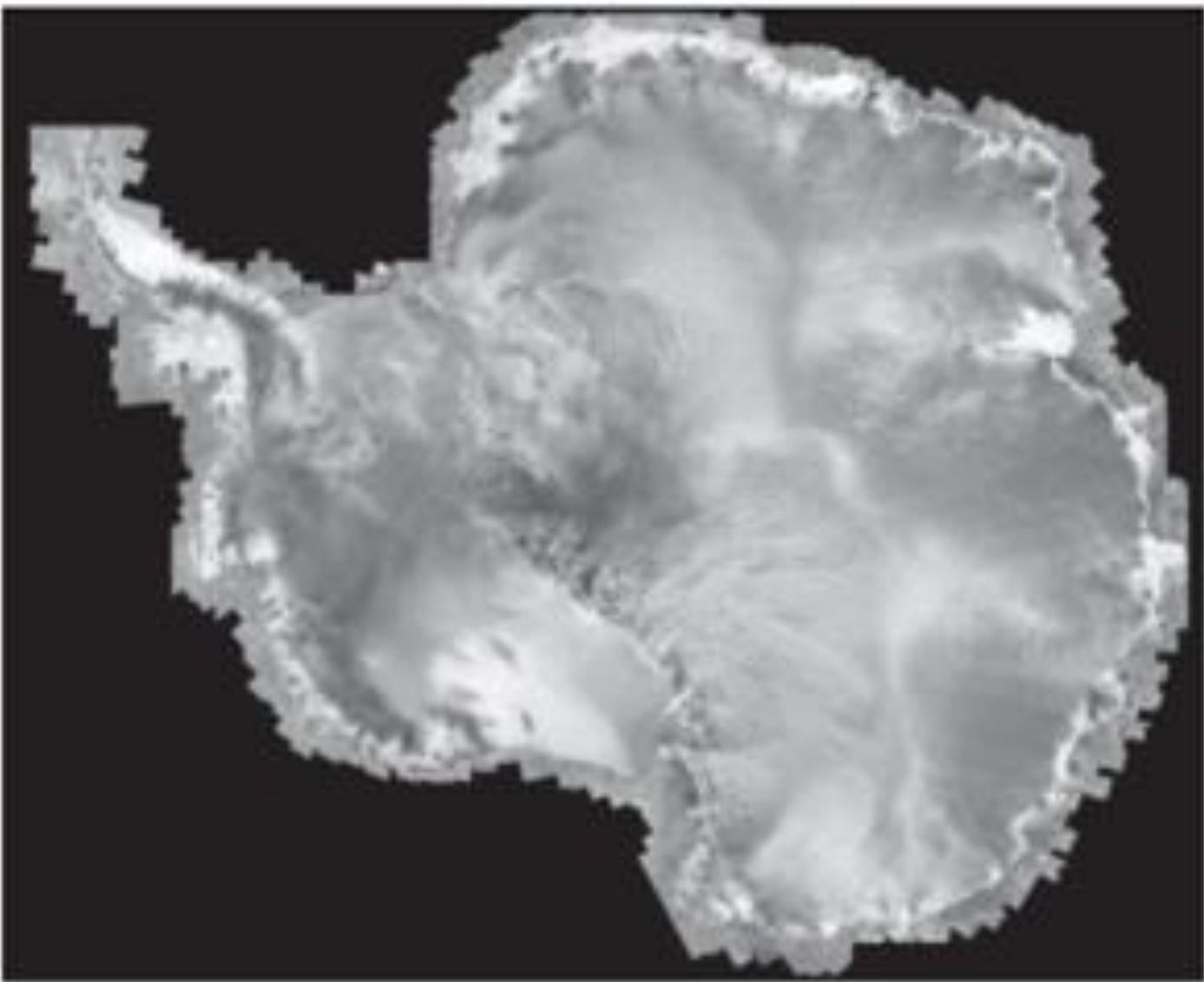


RADARSAT 1 and 2

- First operational civilian RADAR satellite launched in November 1995
- RADARSAT 2 Launched In Dec 2007
- C-band
- Spatial resolution from 8 - 100m
- Can see through clouds and very good at detecting sea ice and snow



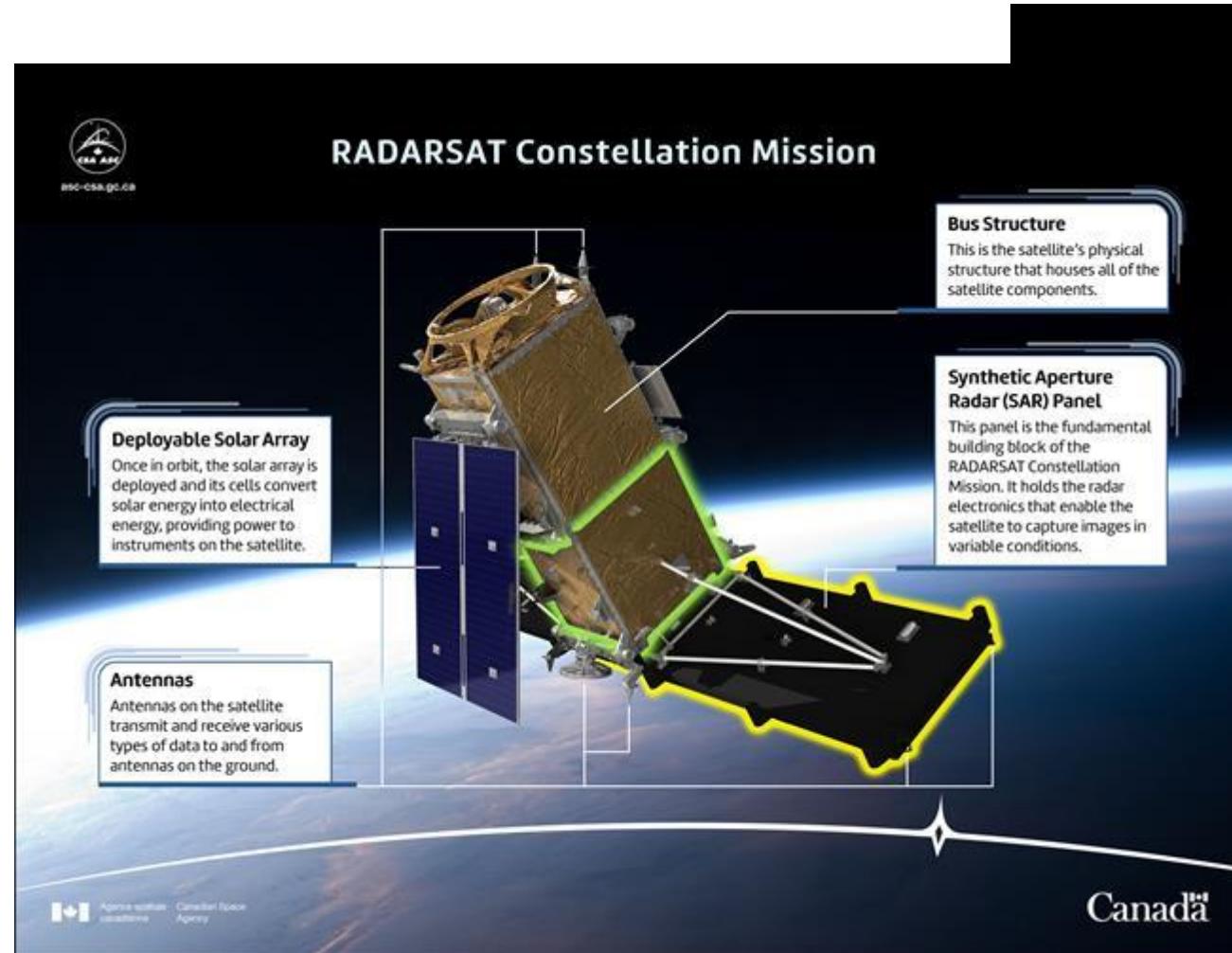




Earth Observing Systems: Canada's role

3rd RADARSAT is the RADARSAT Constellation

- 3 Identical smaller satellites
- 3-8m pixel



RADARSAT Constellation

- Launched by SPACE-X from California
- February 2019

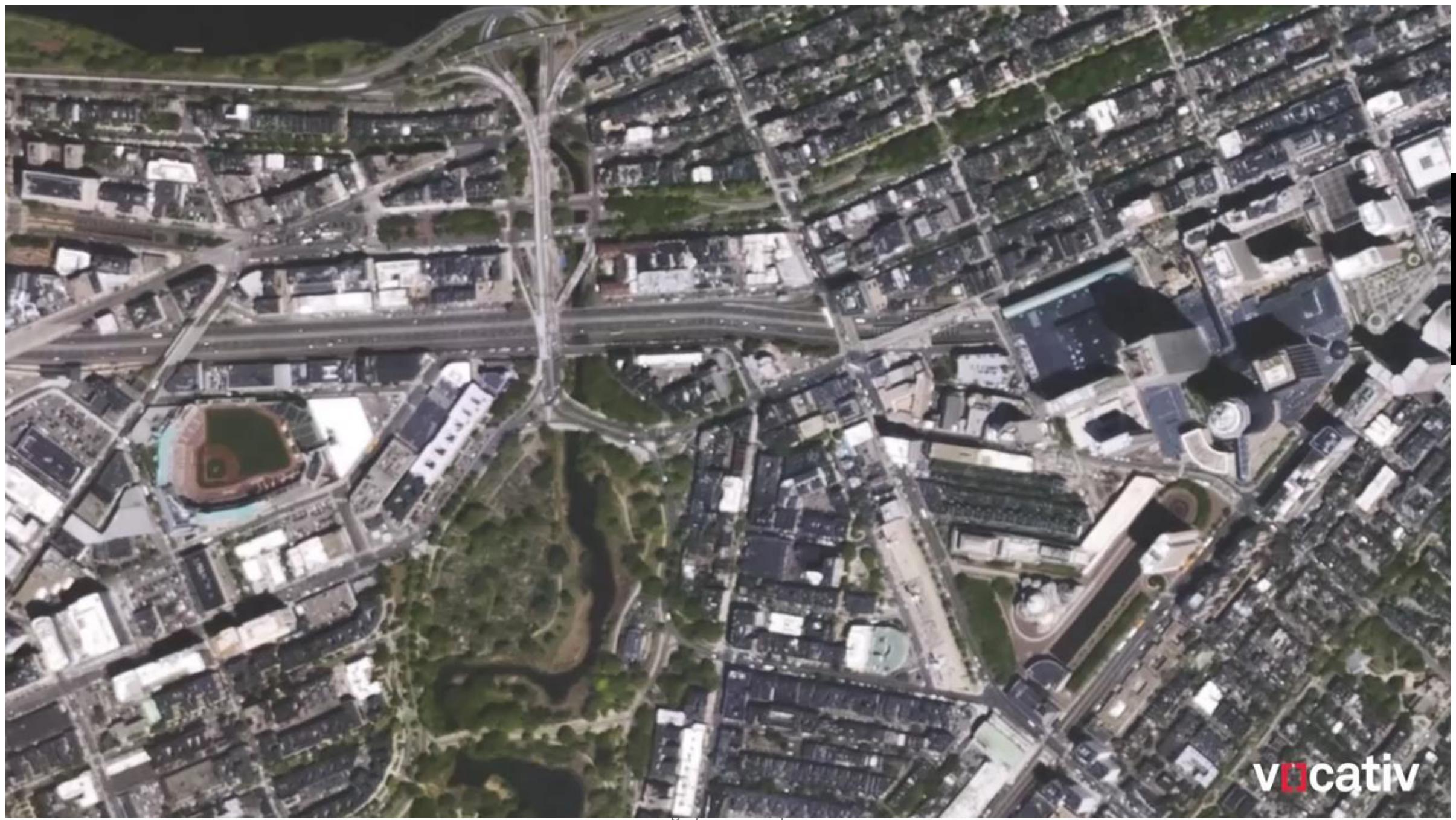




UrtheCast

- UrtheCast has launched a video camera that operates on the ISS
 - First high res HD videos from space
- The camera allows tracking of objects on the Earth's Surface as the ISS orbits the Earth
- Vancouver-based Canadian earth observation company
 - Now called EarthDaily after recent insolvency





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URTHECAST

Important Topics

- What is the significance of the V2 Rocket?
- What was the first environmental application of earth observing satellites?
- How often does MODIS image the Earth?
- What is the longest operating earth observation satellite mission?
- What is UrtheCast and why are they significant to Canada's contributions to Earth Observation from Space?



<http://www.drroyspencer.com/2014/10/make-your-own-big-blue-marble/>

<https://earthdata.nasa.gov/labs/worldview/>

<https://www.urthecast.com>

https://weather.gc.ca/satellite/index_e.html

