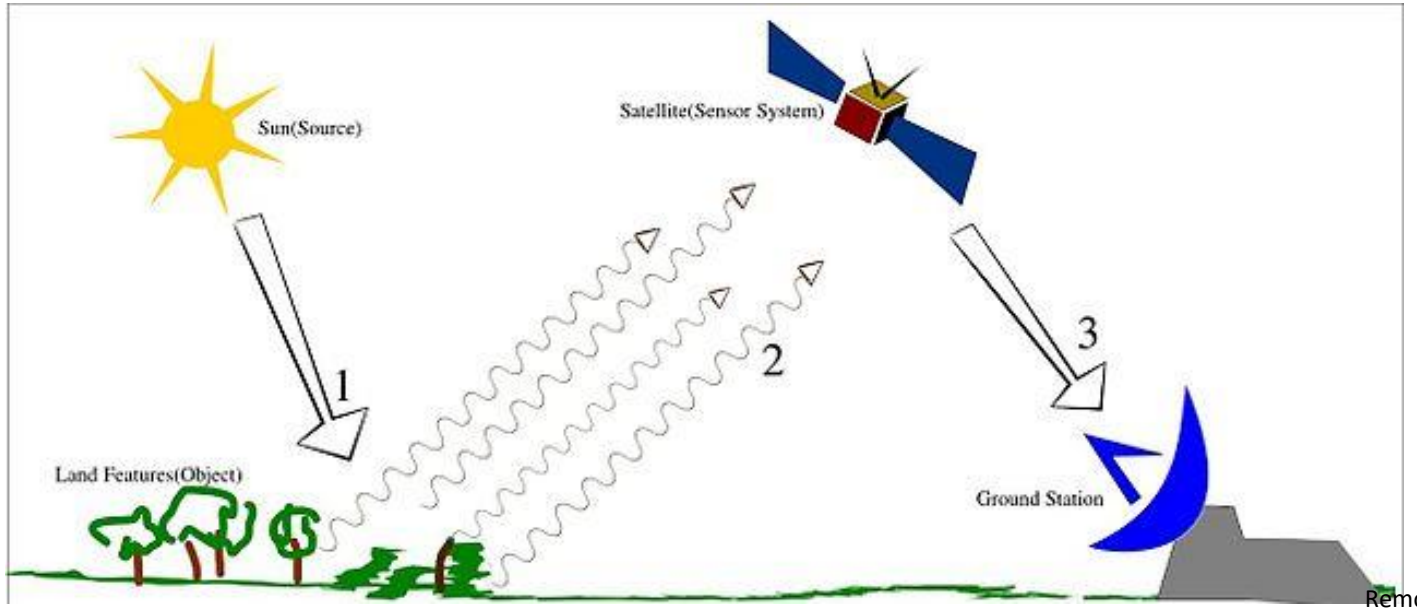
# Earth Observations from Space: Active Remote Sensing Systems Part 1

# Learning Objectives

- Understand active remote sensing and how it differs from passive systems
- Understand how LiDAR, RADAR and SONAR work
- Applications of each active remote sensing technology

# Passive Remote Sensing

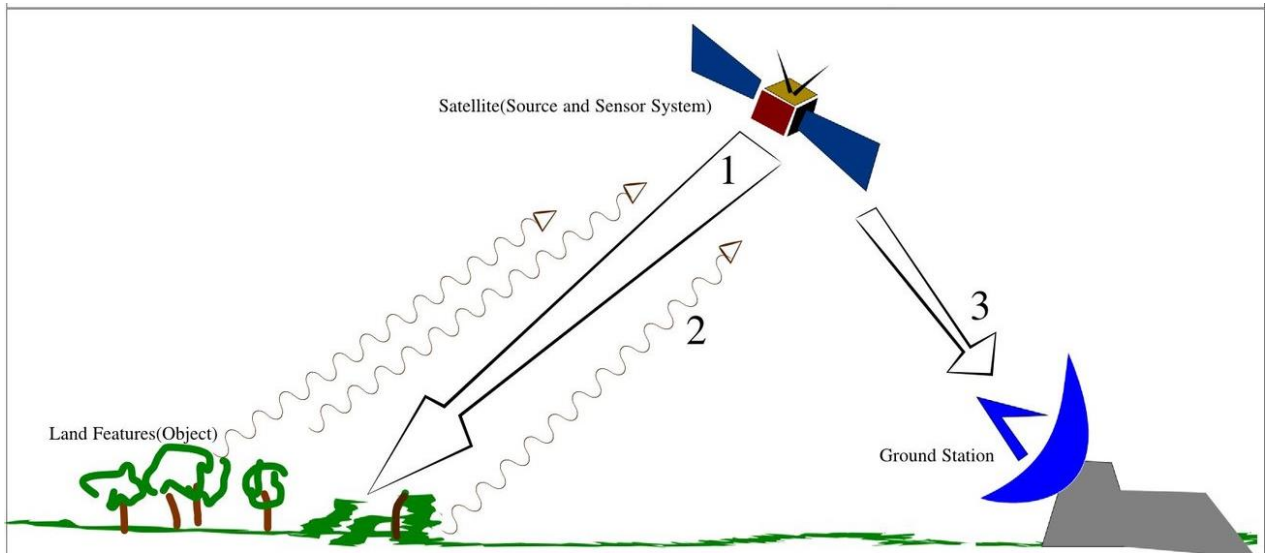
- Passive remote sensing measures energy that is naturally emitted
  - Typically from the sun
  - And reflected off of targets/surfaces




Remote Sensing Illustration (Source: Wikimedia Commons)

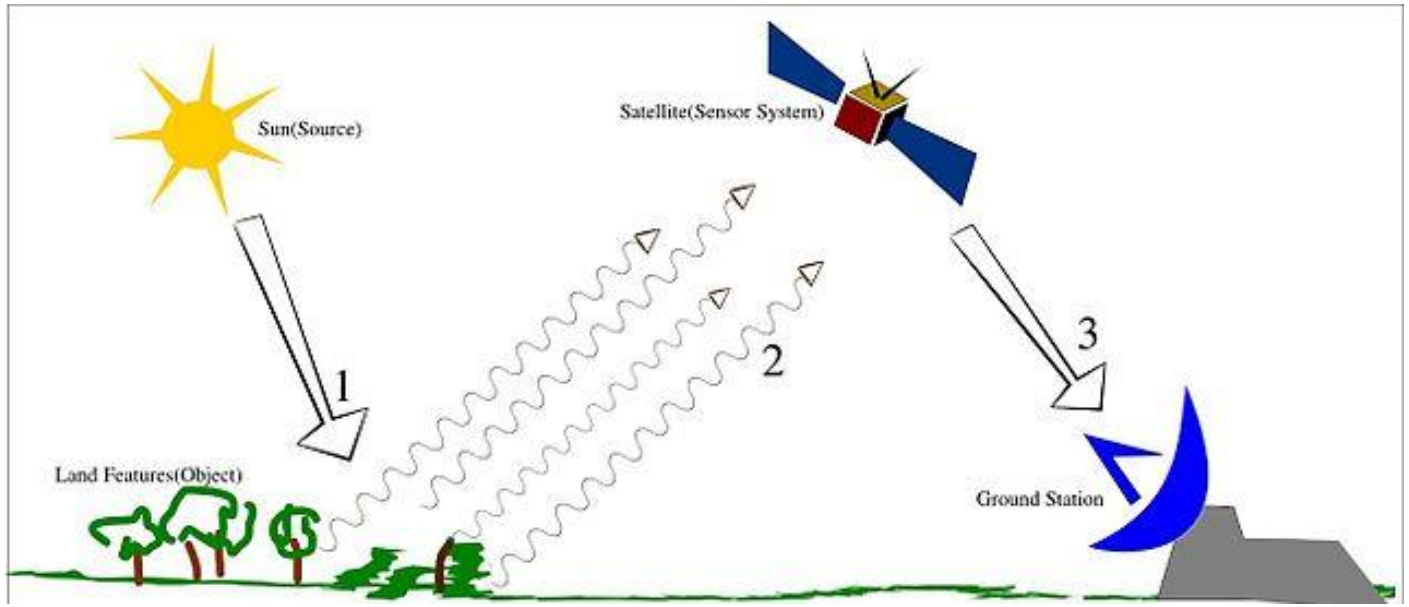
# Active Remote Sensing

- Active sensors provide their own energy source for illumination
- A sensor emits a form of radiation that is directed towards a target in a particular area
- The radiation that is reflected back from the target is then detected and measured by the sensor

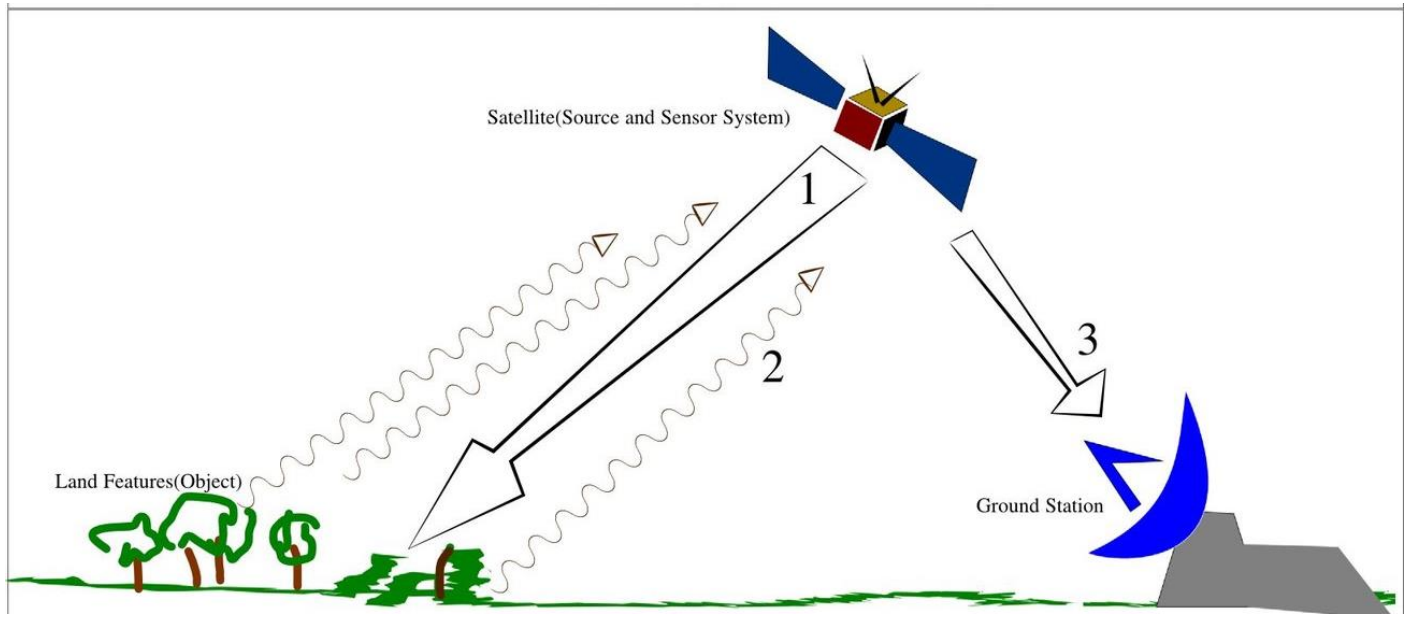



Remote Sensing Illustration (Source: Wikimedia Commons)

Passive




Active



# Passive vs. Active Remote Sensing

**Passive**

- Energy is naturally emitted from the sun
- This energy is reflected off the surface of the Earth
- Reflection of this energy is measured by a sensor

**Active**

- Instruments produce their own energy (radiation)
- Energy travels towards a target and is reflected
- Sensor detects and measures this reflected radiation

# Active Remote Sensing

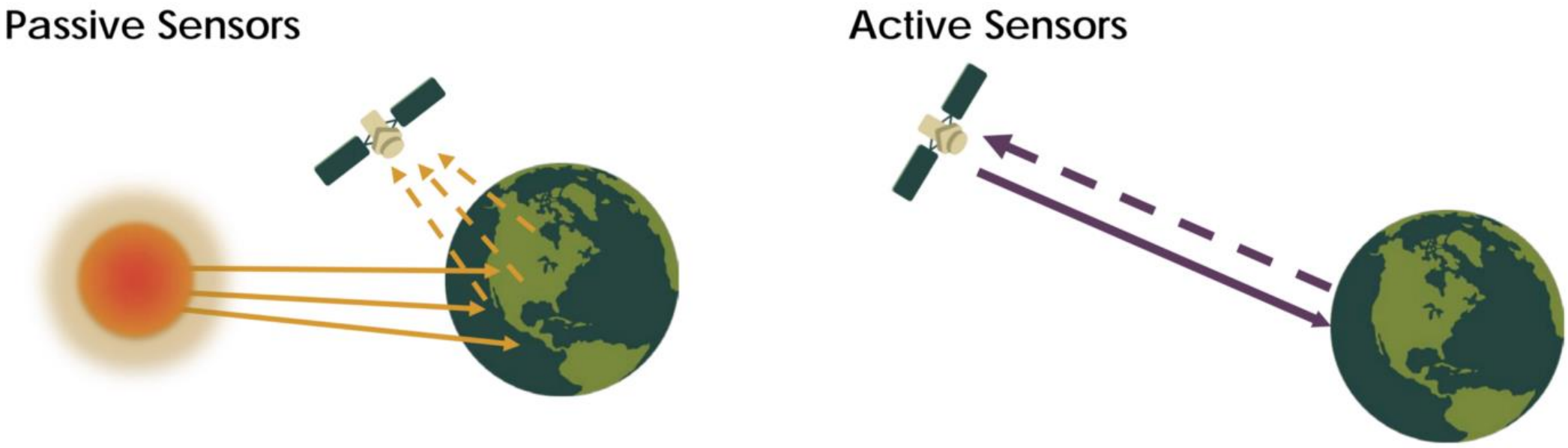
**Advantages**

- Weather independent (for RADAR)
- Sunlight independent
  - Survey at anytime of day
  - Control energy emitted
- Can penetrate vegetation, soil, ice and snow
  - Information on surface layers and structure

**Disadvantages**

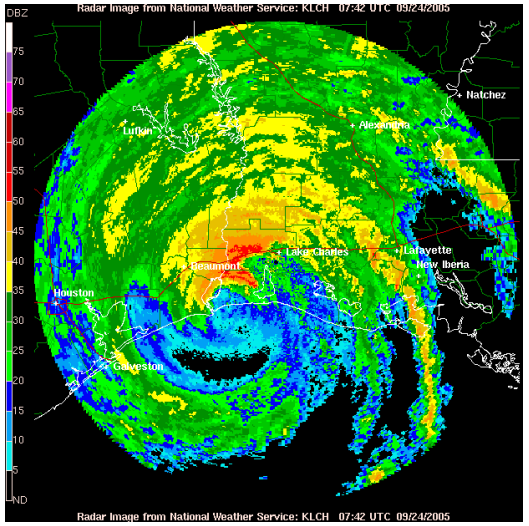
- Limited spectral information
- Complicated analysis
- Costly

# Why would active remote sensing have limited spectral information?

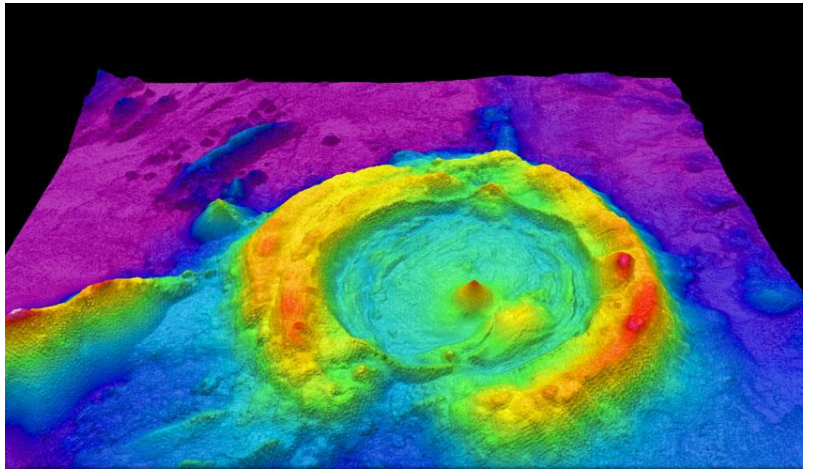


# Three Types of Active Remote Sensing

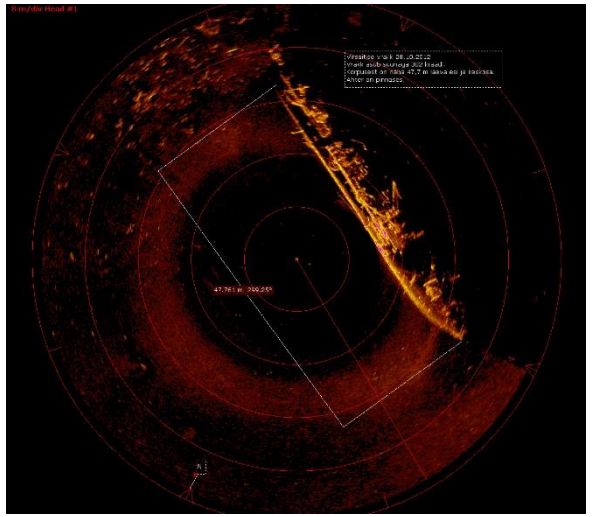
1. RADAR – uses high frequency radio / microwaves
2. LiDAR – uses a laser light beam (often VIS or NIR)
3. SONAR – uses sound waves




Hurricane Rita Lake Charles radar



Airborne Lidar Bathymetric Technology



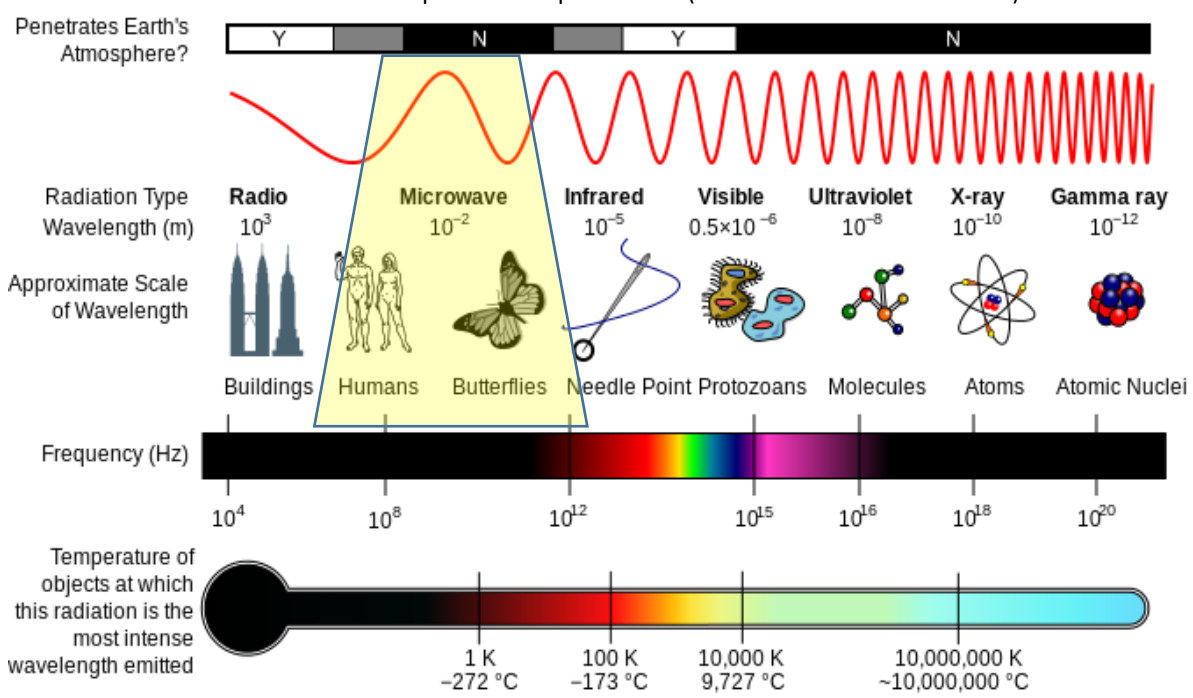
SONAR; Miinitraaleri "Virsaitis" vrakk (Source: Wikimedia Commons)

# RADAR (**RA**dio **D**etection **A**nd **R**anging)

Radar works with different wavelengths in the microwave part of the spectrum, by:

1. Transmitting a microwave (or radio) signal towards a scene
2. Receiving the portion of transmitted energy backscattered from the scene
3. Observing the strength (**detection**), orientation and time delay (ranging) of the return signals
   - We mostly discuss detection in this class

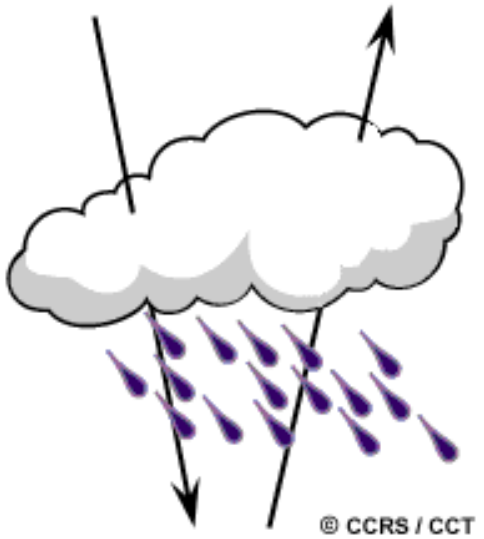
EM Spectrum Properties edit (Source: Wikimedia Commons)

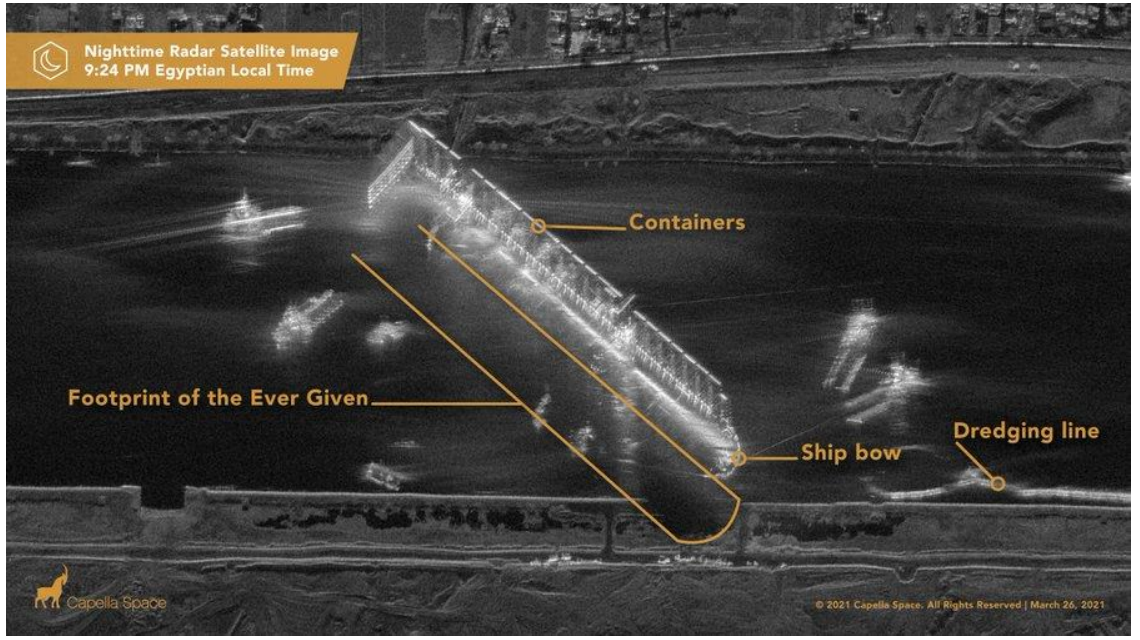


# Why Use RADAR?

- Active microwave energy penetrates clouds and serves as an all-weather remote sensing system

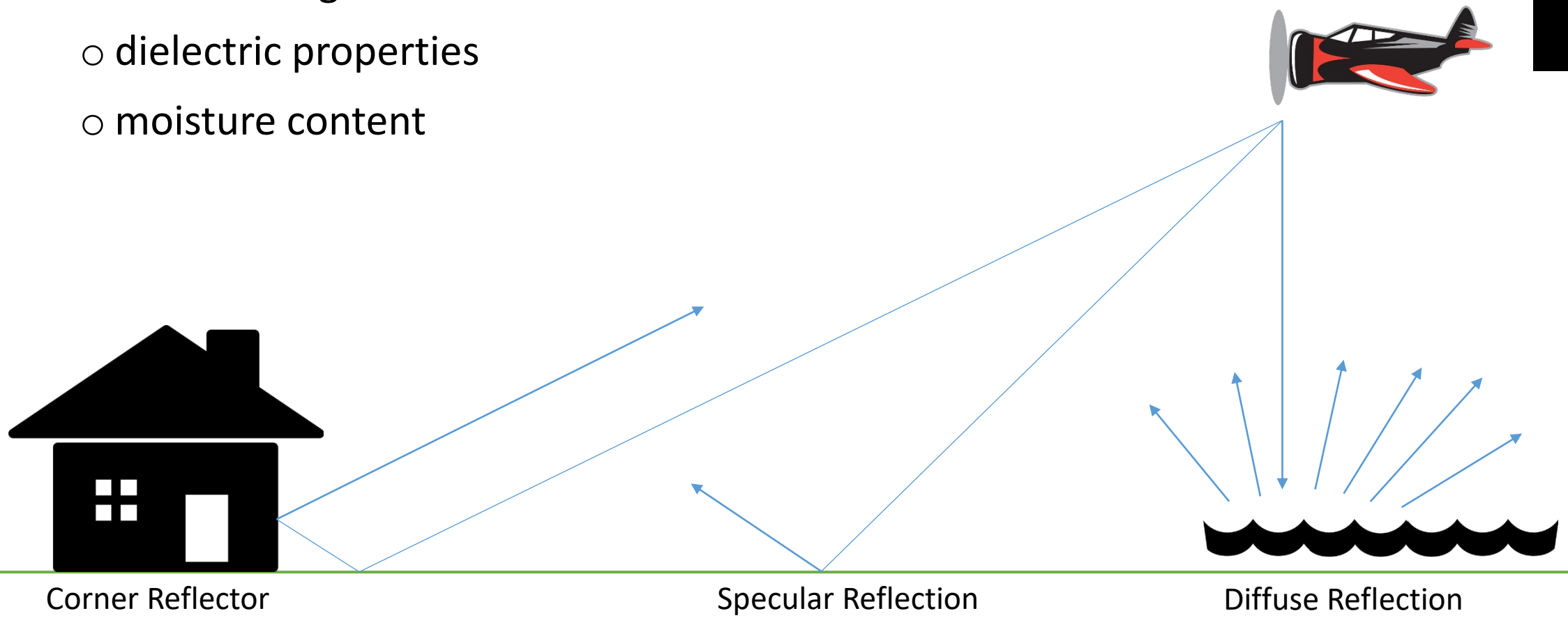
- Coverage can be obtained at user-specified times, even at night



# RADAR

- Three factors govern the response of the backscatter:
  - surface roughness
  - dielectric properties
  - moisture content



| Frequency of Wavelengths of Commonly Used Radar Remote Sensing Bands | | | |
|---|---|---|---|
| Band | Frequency | Wavelength | Key Characteristics |
| X | 12.5 – 8 GHz | 2.4 – 3.75 cm | Used for military reconnaissance, mapping and surveillance |
| C | 8 – 4 GHz | 3.75 – 7.5 cm | Penetration capability of vegetation or solids is limited and restricted to the top layers. Useful for sea-ice surveillance |
| L | 2 – 1 GHz | 15 – 30 cm | Penetrates vegetation to support observation applications over vegetated surfaces and for monitoring ice sheet an glacier dynamics |
| P | 1 – 0.3 GHz | 30 – 100 cm | Used for research and experimental applications. Significant penetration capabilities regarding vegetation canopy (estimation of vegetation biomass), sea ice, soil, glaciers |

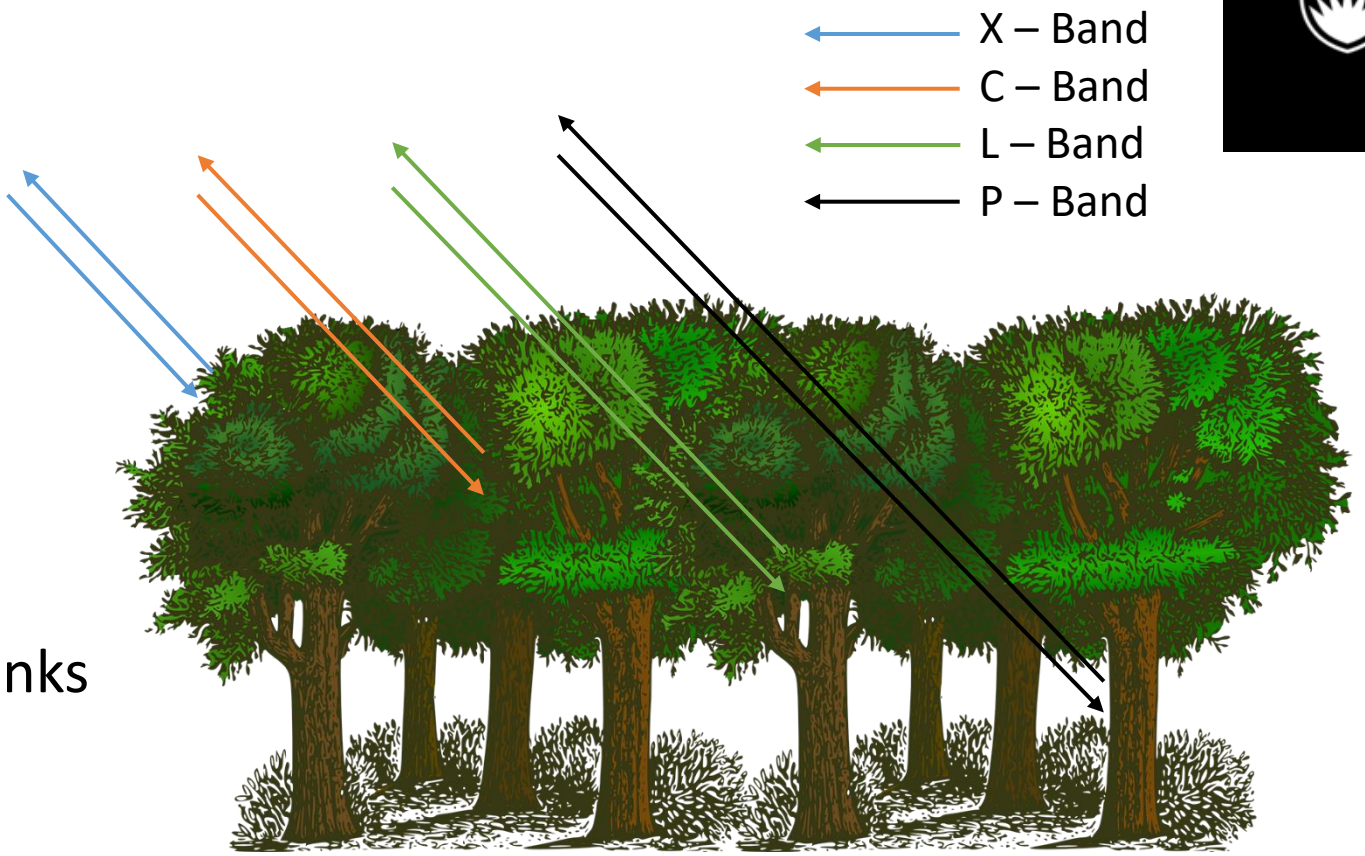
# RADAR Bands

| Band | Wavelength Size | Applications | Ground Penetration |
|---|---|---|---|
| X | Smallest | - Military reconnaissance<br>- Mapping and surveillance | Smallest |
| C | | - Limited vegetation penetration<br>- Sea-ice surveillance | |
| L | | - Penetrates vegetation<br>- Observing vegetated surfaces<br>- Ice sheet and glacier dynamics | |
| P | Largest | - Research and experimental applications<br>- Significant penetration in vegetation canopy<br>- Estimation of biomass<br>- Observing sea-ice, soil, glaciers | Largest |

# Scattering

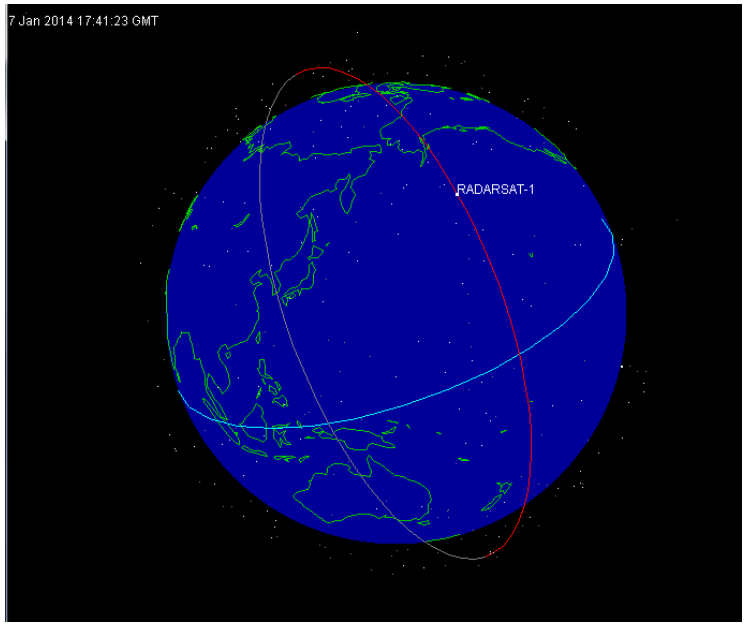
**General Rule**: choose the wavelength that approximates the objects of interest

- Smaller target: X-band
  - Example: rain droplets
- Medium target: C-band
  - Example: leaves
- Larger target: L & P-band
  - Example: branches and tree trunks



# RADARSAT 1 and 2

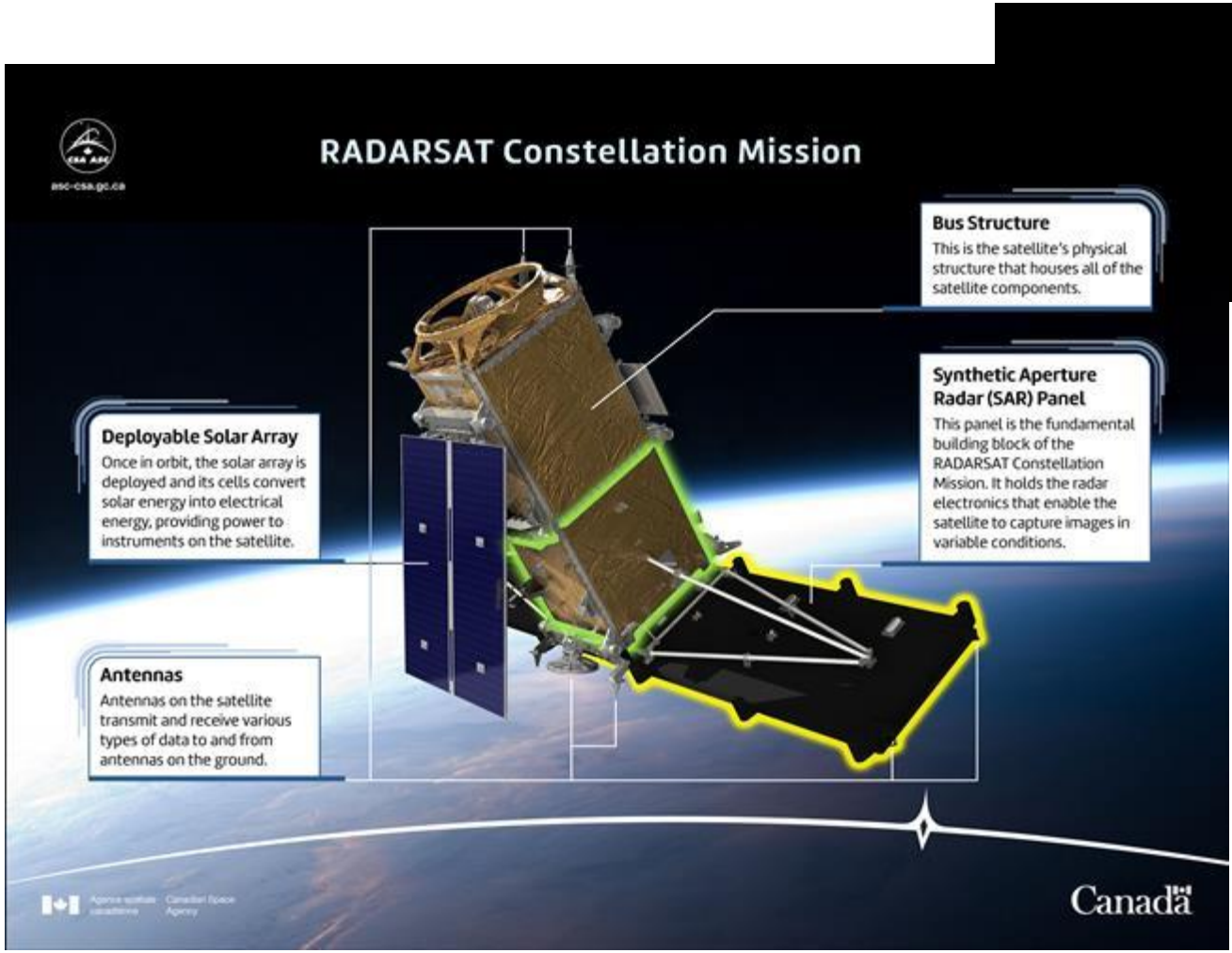
- First operational civilian RADAR satellite launched in November 1995
- RADARSAT 2 Launched In Dec 2007
- C-band
- Spatial resolution from 8 - 100m
- Can see through clouds and very good at detecting sea ice and snow
- Covers polar regions daily
- Temperate zones every 3 days; Tropical zones every 5 days



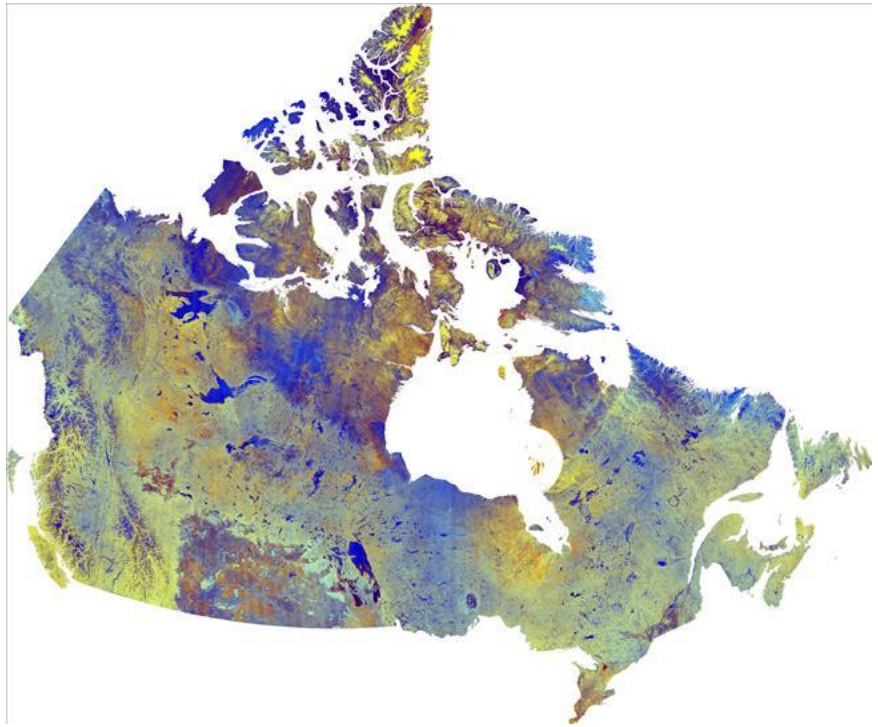
# Earth Observing Systems: Canada's role

**3rd RADARSAT is the RADARSAT Constellation**

- 3 Identical smaller satellites
- 3-8m pixel

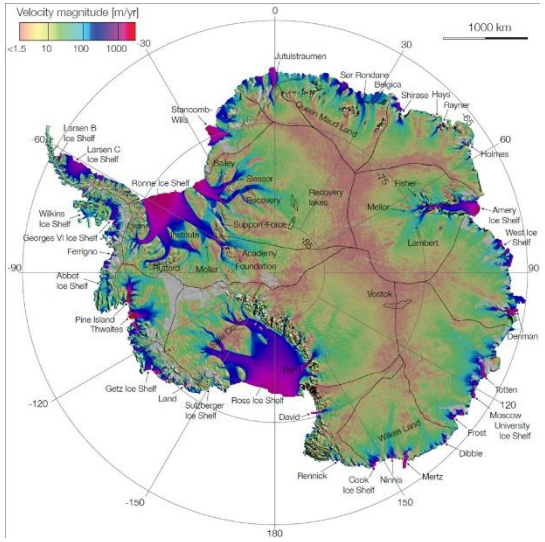


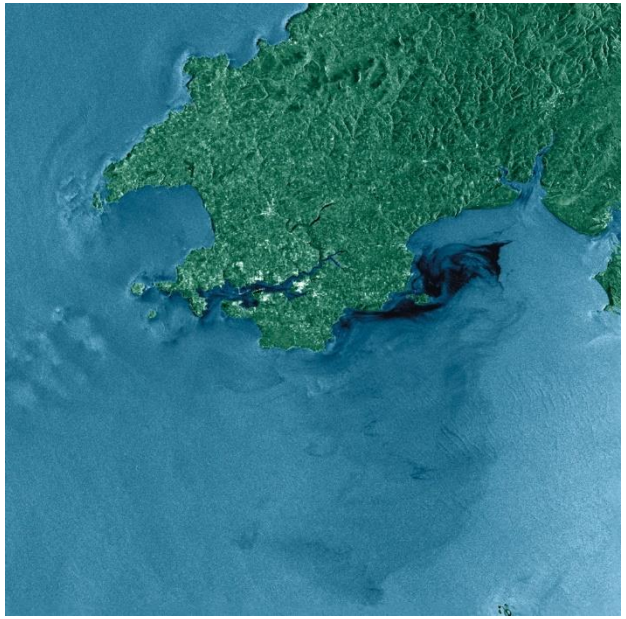
- Why is RADAR particularly suitable for a country like Canada?
- Hint:
  - Think about Canada's geographic location



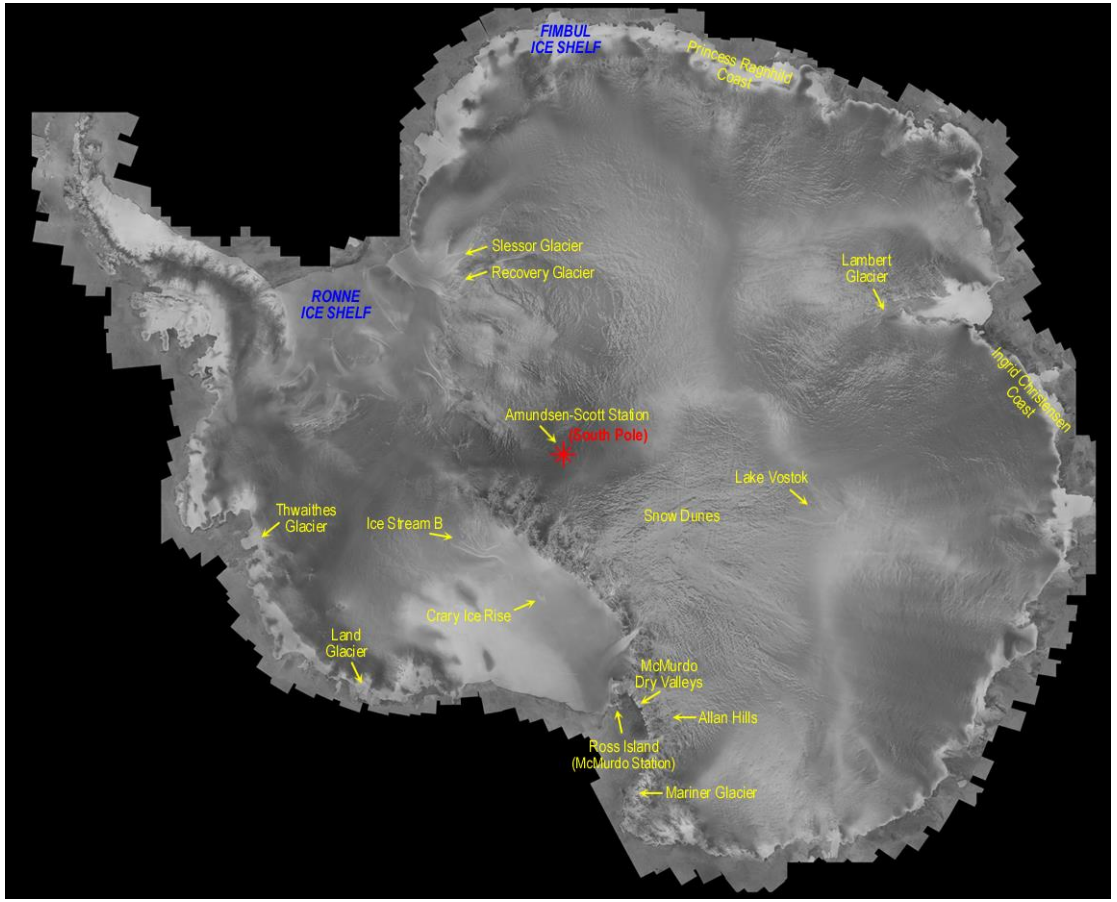
# RADAR Applications

- Ice mapping
- Oil spills
- Ground penetrating RADAR for archaeology

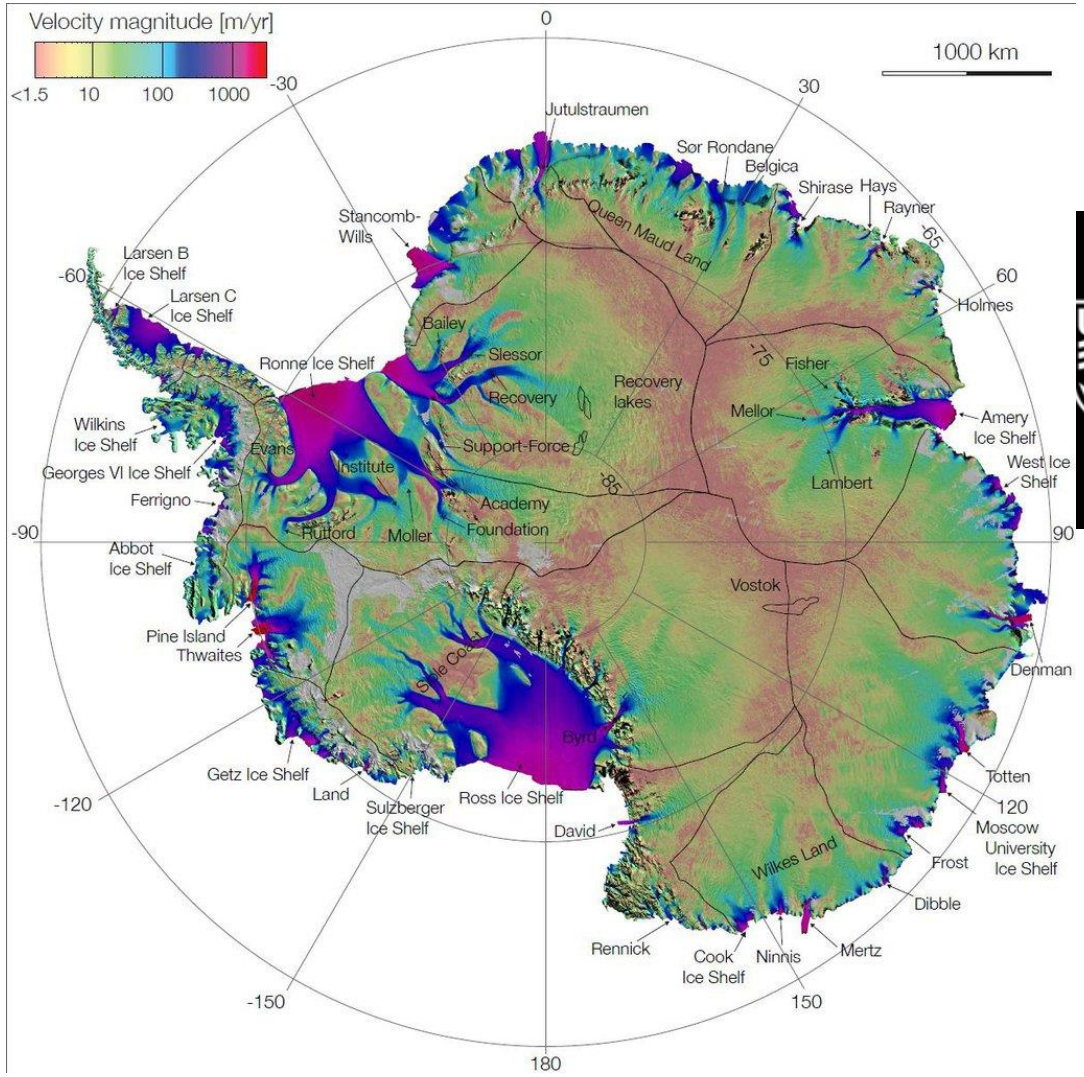


# RADAR Applications



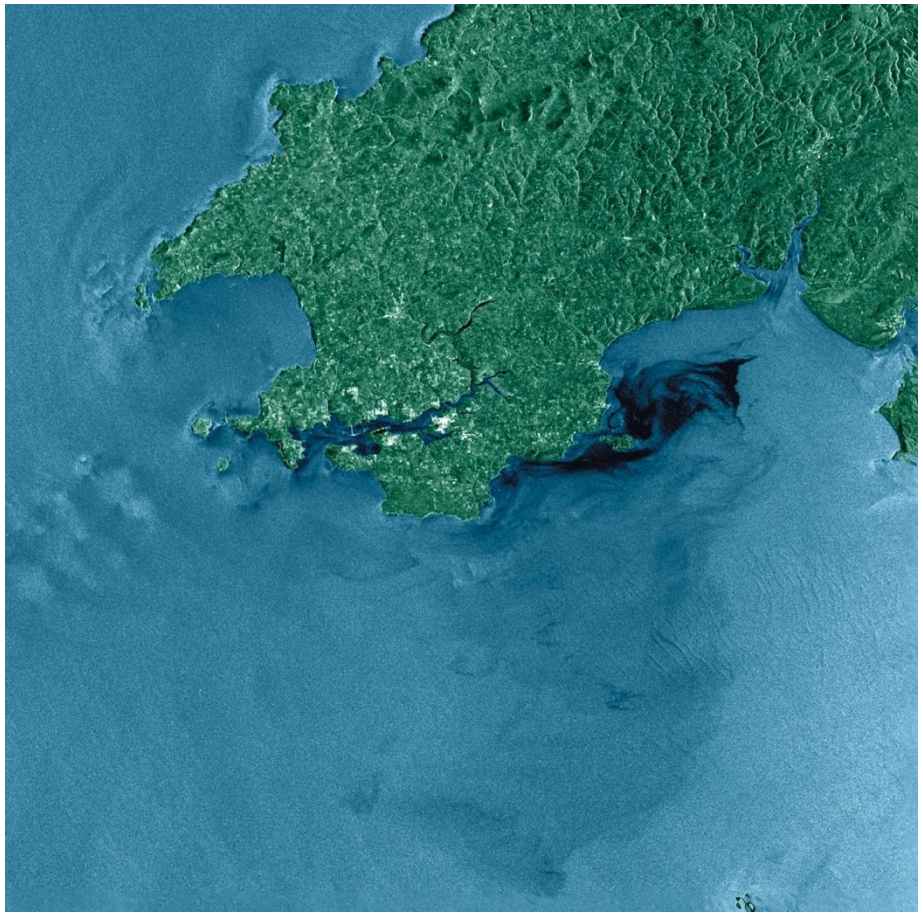

First seamless mosaic of Antarctica which was compiled by RADARSAT-1 between September and October 1997




First complete map of the speed and direction of ice flow on Antarctica derived from RADARSAT-2 (and two other Japanese and European satellites)

# RADAR Applications

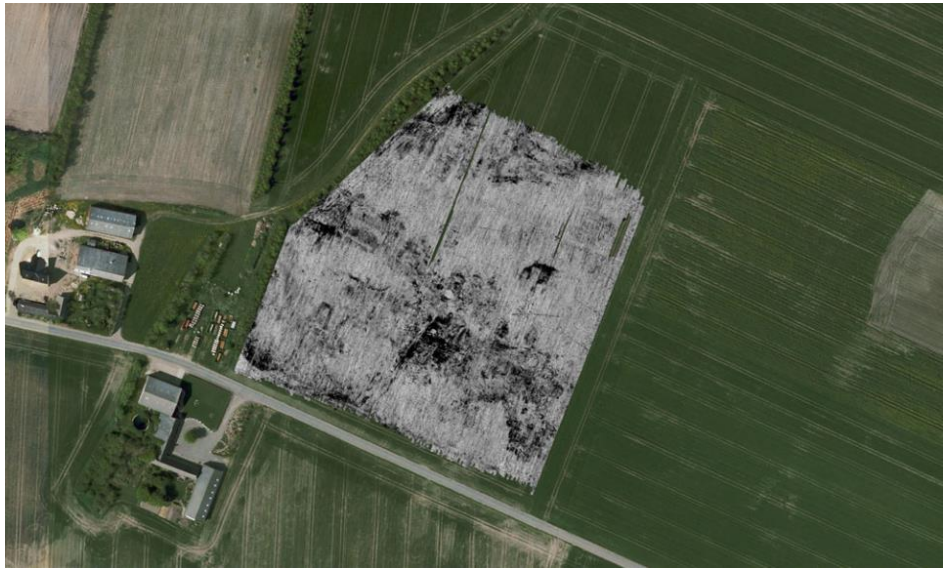
- Camarthen Bay, Wales, a super tanker, ran aground on rocks on February 15, 1996, releasing crude oil
- Oil floats on water, suppressing oceanic capillary waves, and creating a surface that is smoother than the surrounding water
  - Easily detectable day or night by RADAR



Camarthen Bay, Wales (Source: Canada Centre for Remote Sensing, Natural Resources Canada)

# Ground Penetrating RADAR

- Geophysical archaeological study at several Viking Age and medieval sites in West Jutland, Denmark



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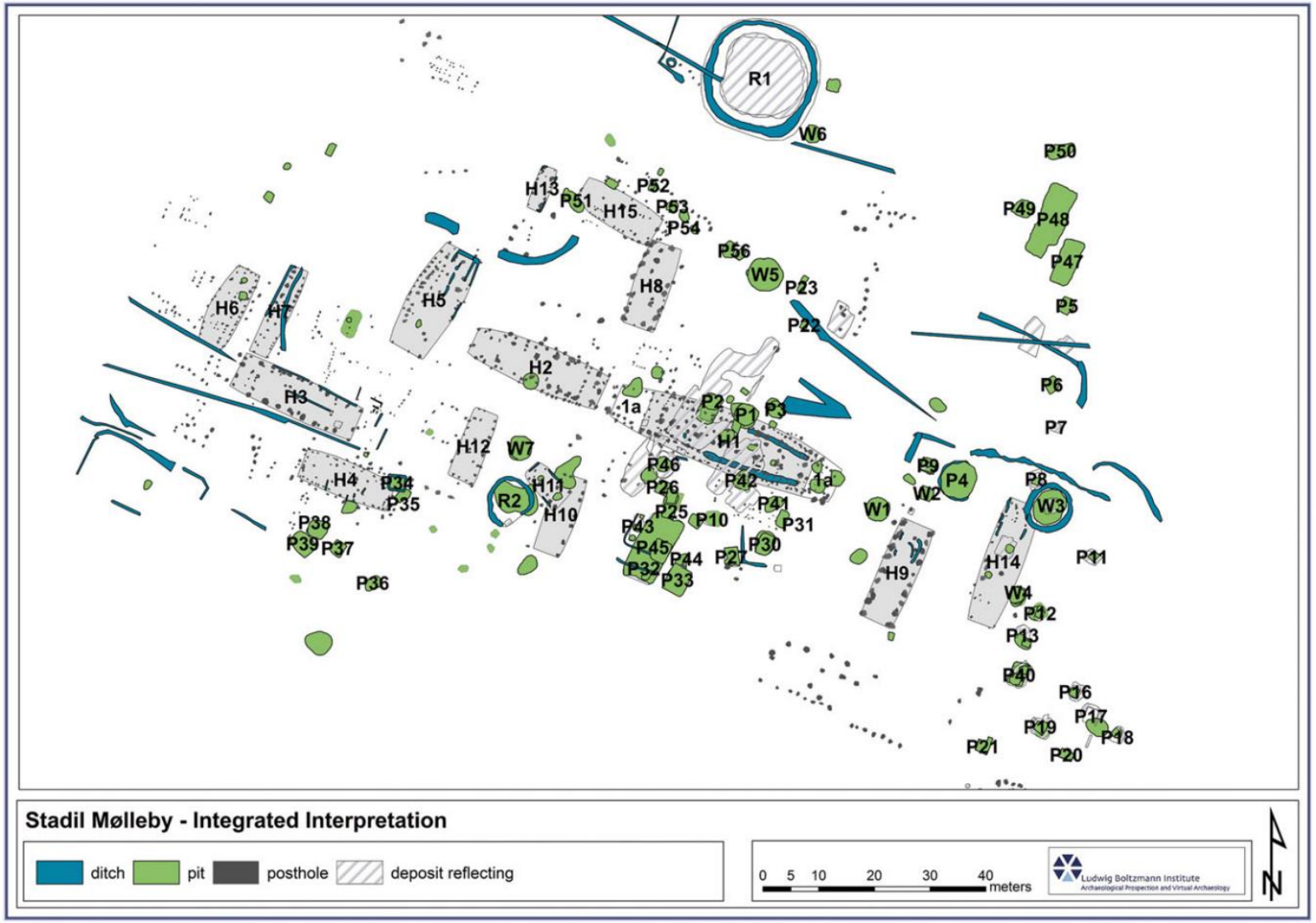


Interpreted mosaic of ground-penetrating RADAR, identifying medieval Viking buildings

# Ground Penetrating RADAR


Imagery of ground penetrating RADAR showing building H1

# Important Topics

- How does an active remote sensing instrument differ from a passive one?
- What are two advantages of using RADAR?
- What are the common RADAR bands used in practice that we discussed in class?
  - Which has the largest wavelength size?
- What types of waves do RADAR, LiDAR, and SONAR use?
- Name what you think is the most interesting application of RADAR from what we discussed in class