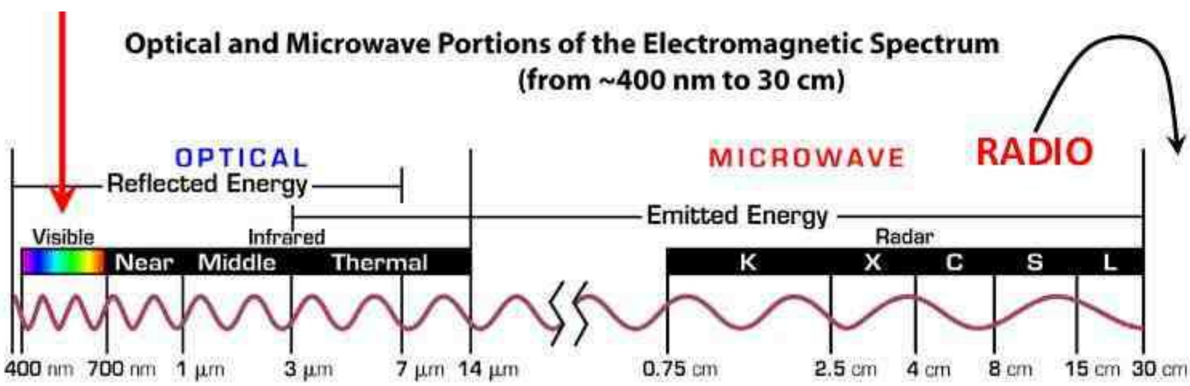
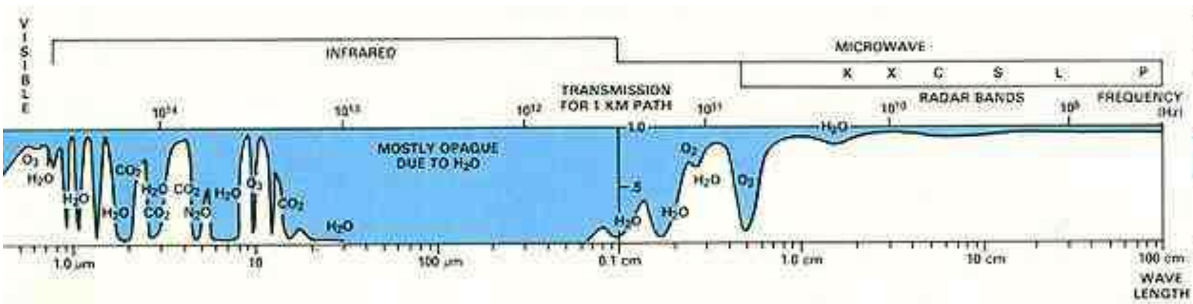
GEOG 357

LECTURE 17



Microwave Sensing: 1mm to 1 metre (mostly 1cm-30cm)



Microwave Sensing: 1mm to 1 metre (mostly 1cm-30cm)

3

Microwave Sensing

- Microwave sensing encompasses both active and passive forms
- Because of their long wavelengths, microwaves penetrate through cloud cover, haze, dust, light rain, snow
  - And are used in communications
- Like thermal RS, all objects emit microwave energy but the amounts are low.
- Emitted microwaves are related to the temperature and moisture properties of the object

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- Passive microwave RS is used to monitor oceans, sea ice cover and atmospheric ozone
- Because there is limited natural energy in microwave wavelengths, so the field view is large and hence the pixel size needs to be large

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Like thermal RS…

Passive microwave sensing is a continuation of recording thermal energy in the microwave wavelengths. The signal is a **brightness temperature** but there is less terrestrial energy to sense, so a large pixel, ca. 10-25km is needed for radiometric resolution.

brightness temperature = temperature x emissivity

Remote sensing at microwave wavelengths is effective because …

the insignificant atmospheric attenuation for microwave windows

= **unaffected by clouds**

Microwave sensors: SMMR TMI-TRMM AMSR SSM/I ESMR

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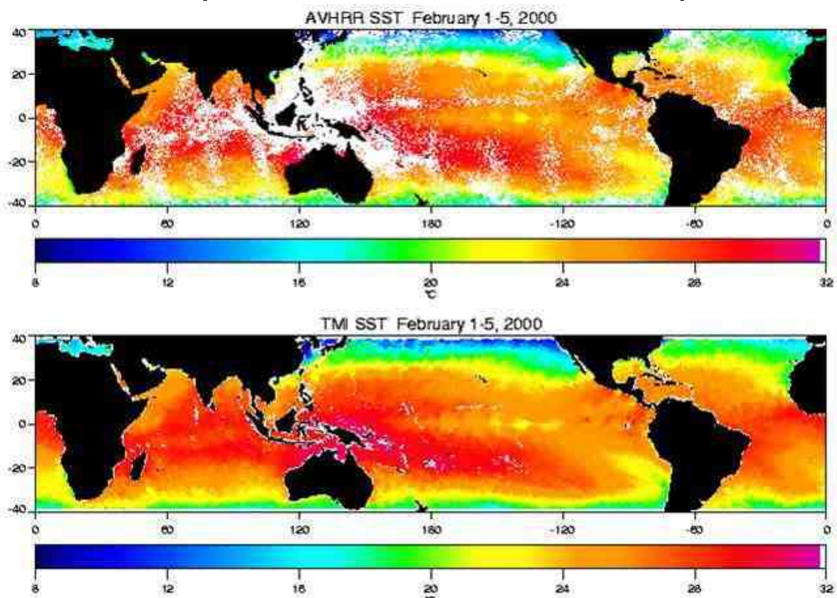
Sea Surface Temperature a. Thermal IR, b. Microwave passive



Thermal IR: higher resolution and accuracy; affected by clouds

Microwave: sensitive to precipitation and surface roughness

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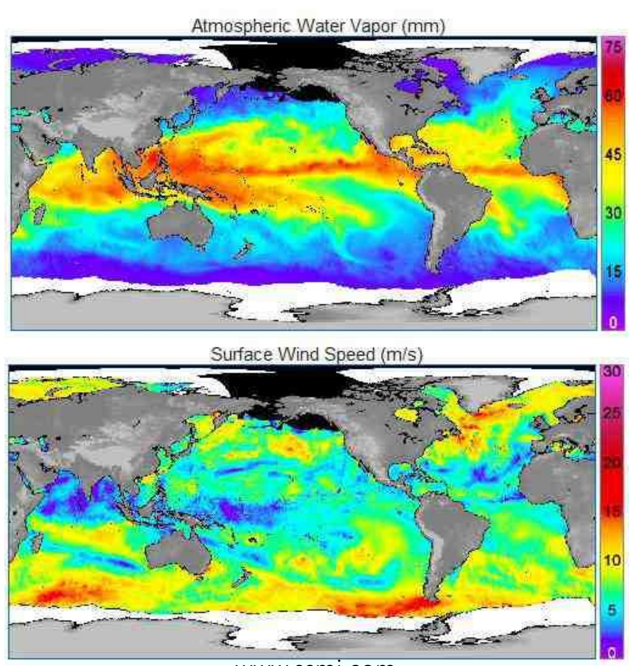
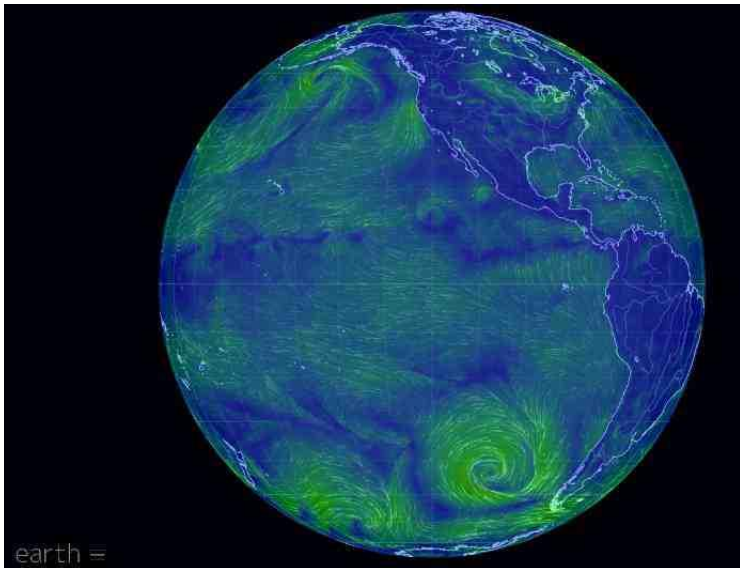


www.ssmi.com

8

https://earth.nullschool.net



Wind measurement, using microwaves

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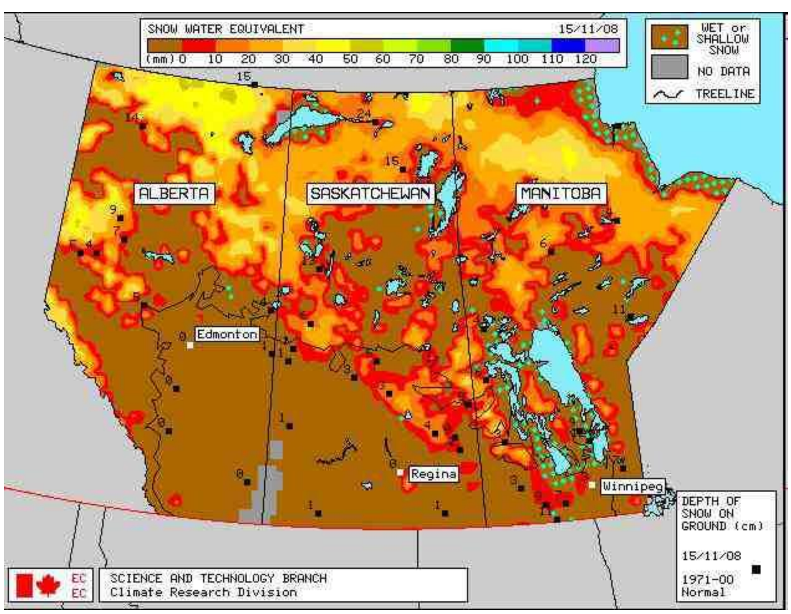
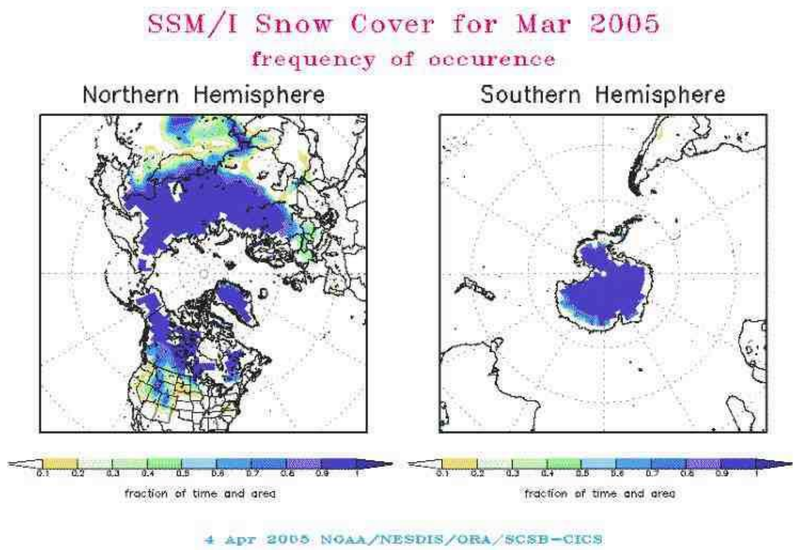
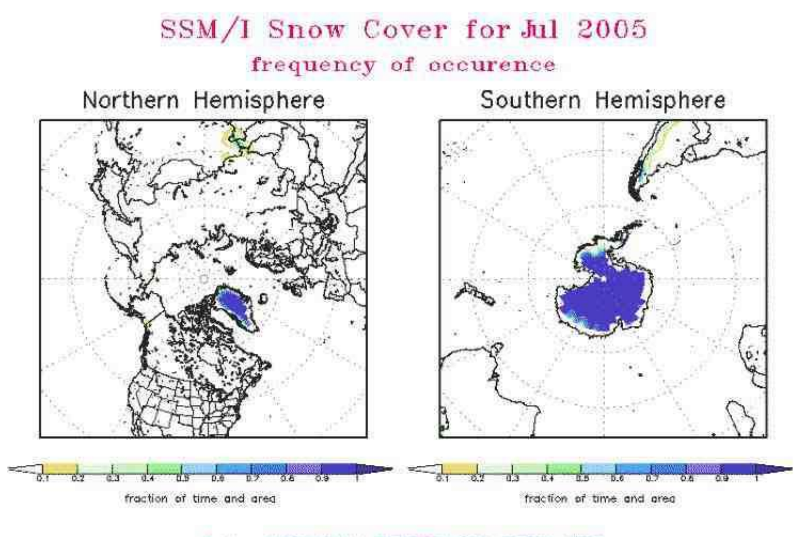
Snow Water Equivalent Map for Canadian Prairies: AMSR-E



10


SSM/I Snow Cover for Mar 2005
frequency of occurence
Northern Hemisphere
Southern Hemisphere
fraction of time and area
fraction of time and area
4 Apr 2005 NOAA/NESDIS/ORA/SCSB-CICS

11


SSM/I Snow Cover for Jul 2005
frequency of occurence
Northern Hemisphere
Southern Hemisphere
fraction of time and area
fraction of time and area
3 Aug 2005 NOAA/NESDIS/ORA/SCSB-CICS

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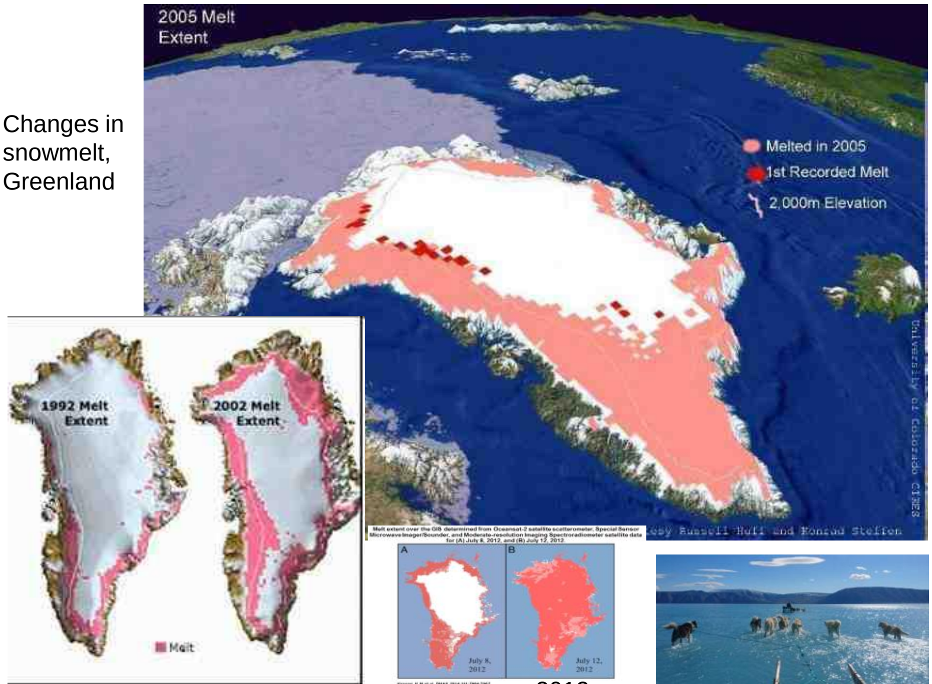
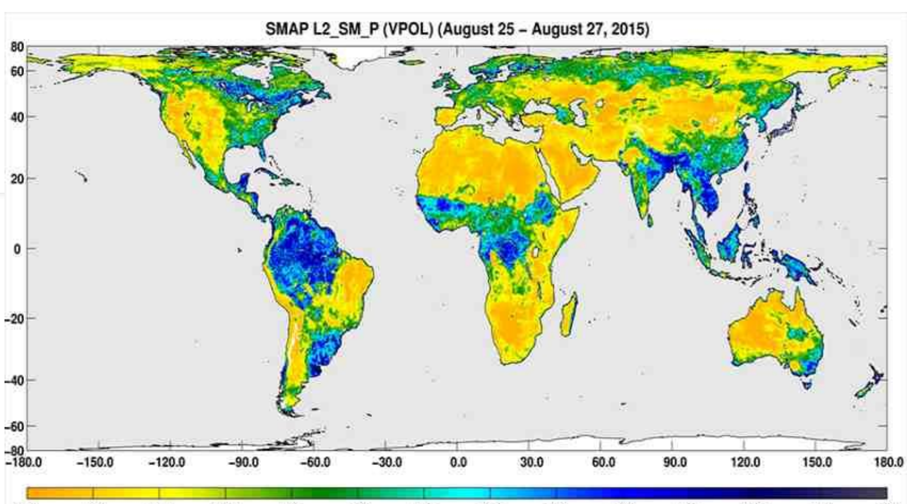
Changes in snowmelt, Greenland



2012

13



A three-day composite global map of surface soil moisture as retrieved from SMAP's radiometer instrument between Aug. 25-27, 2015. Wetter areas are blue and drier areas are yellow. *Image Credit: NASA*

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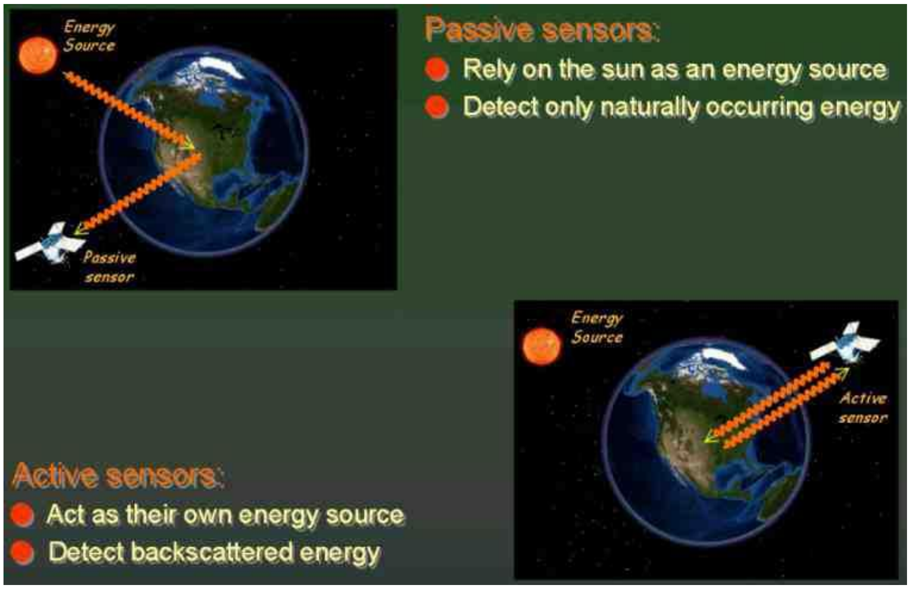
So far, we have mostly looked at 'passive' remote sensing systems.
As **passive** microwave sensors deal with very low resolution, more applications in these wavelengths use **active** sensors:



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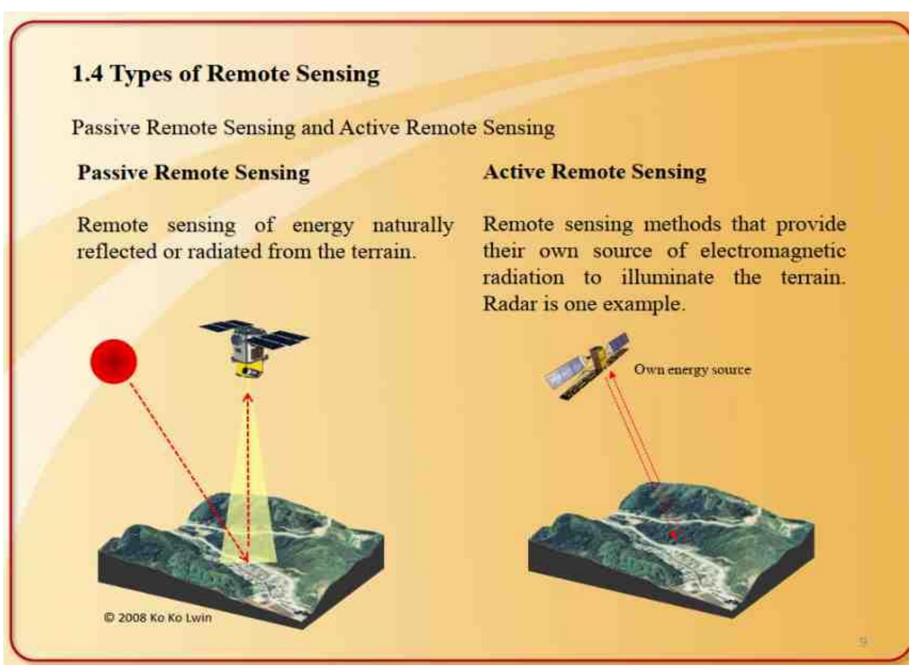

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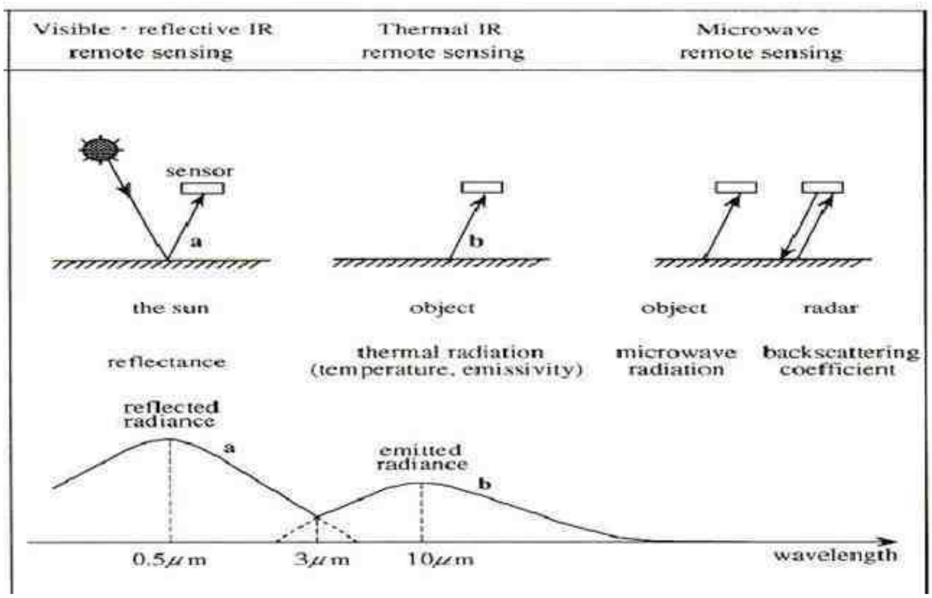
RADAR is the most commonly used space-based *active* sensing system.

It is an acronym for ***RAdio Detection And Ranging***.



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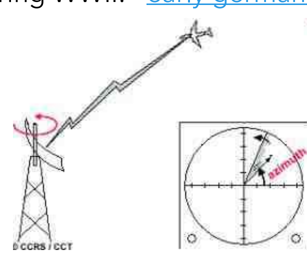
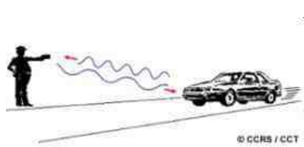
Radar systems were first implemented in the 1930s to detect ships on water and to measure their proximity, and later airplanes.

Imaging radar systems have been in use since the 1950s.

The original technology was developed during WWII: early german radar.



Non-imaging radar



Plan position indicators (PPI) produce a type of image. These radars use a circular display screen to indicate objects surrounding the rotating antenna. They are commonly used for weather monitoring, air traffic control and navigational systems.

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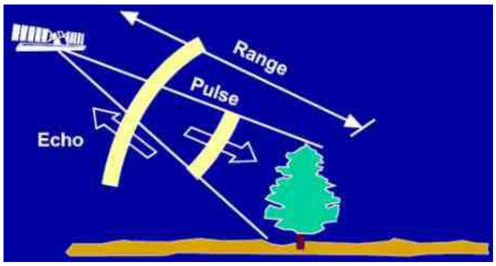
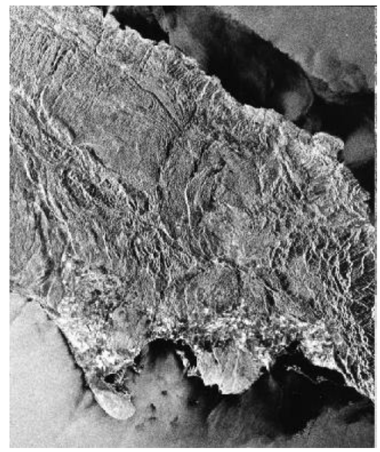
The RADAR device transmits energy, a portion of which is returned to the sensor. The time taken gives the distance (location) of the target, the strength of the return describes its characteristics.

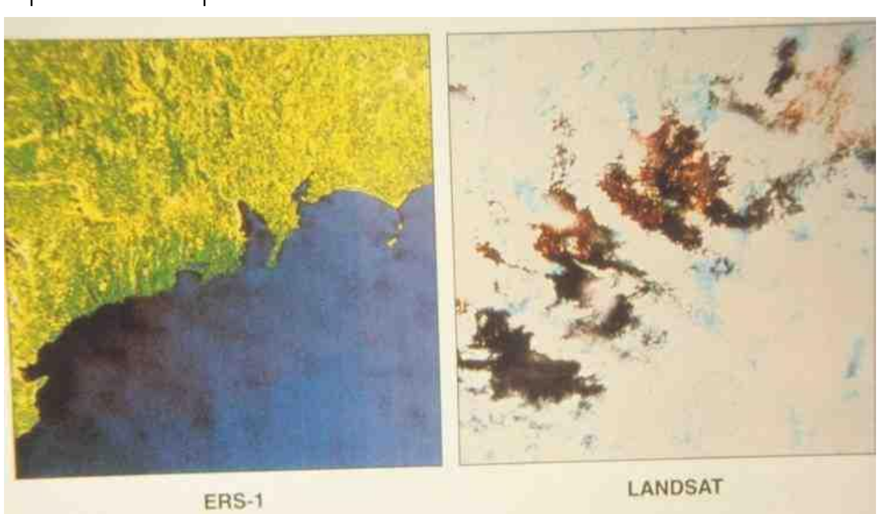




Satellite imaging radar started with SEASAT, launched in 1978.

20

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



Ireland, 1991: Radar and Visible image

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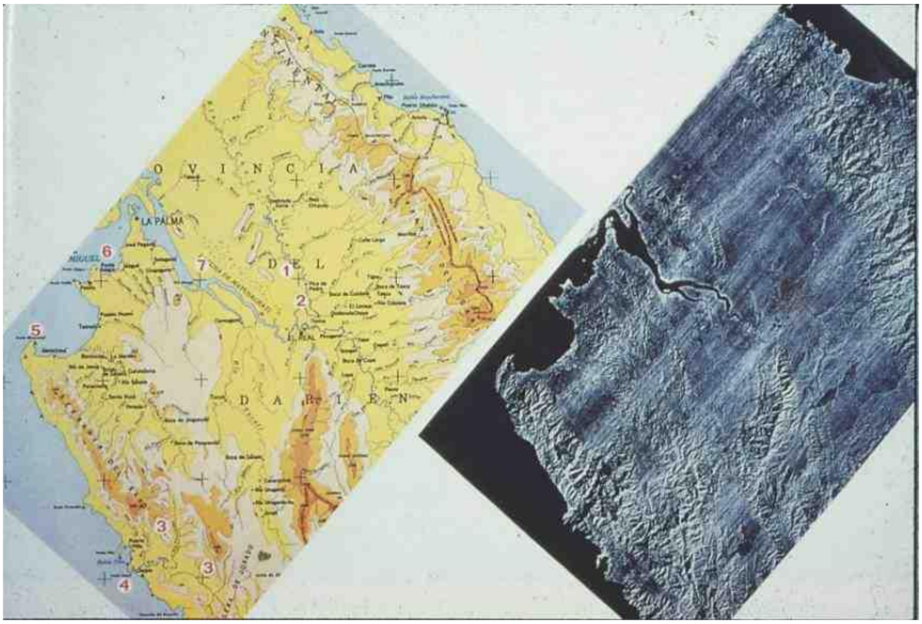
Most early imaging RADAR was airborne, e.g. Calgary Intera technologies: Panama



Tropical areas are often cloud-covered and poorly mapped without RADAR

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Selected RADAR satellite systems (Date launched, Wavelength, Resolution)

Satellite	Launch date	Wavelength	Pixel size
SEASAT (USA)	1978	L	25m
SIR- A,B,C (USA) JPL	1981	L	40m (Shuttle Imaging Radar)
ERS (EUROPE)	1991, 1995	C	30m
JERS (JAPAN)	1992	L	25m
RADARSAT (CANADA)	1995	C	10-100m CCRS - Radar
ENVISAT (EUROPE)	2002		multiple

RADARSAT 2 (Canada) 2007 C 3-100m

Sentinel-1 (ESA) 2014 C 10m

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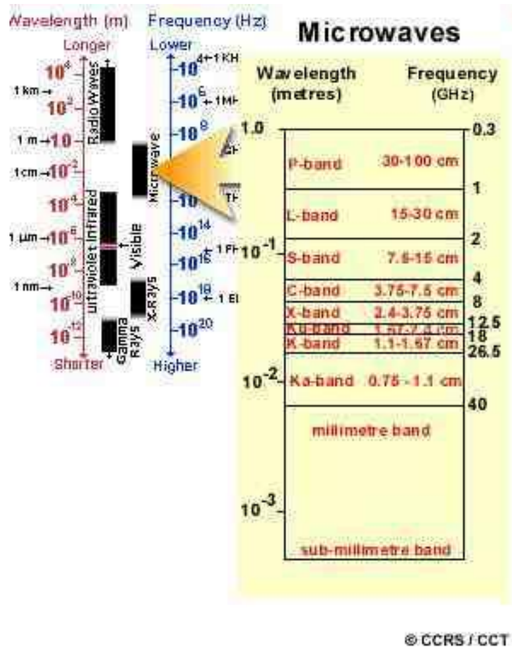
In the microwave, it is more usual to refer to bands by frequency in Gigahertz (waves/second) than wavelength, especially for RADAR

Frequency is inversely proportional to wavelengths

e.g. 1cm to 10cm = 30 to 3 GHz

L=Longwave
S= shortwave
C=compromise
X= Cross(hairs) as in WWII



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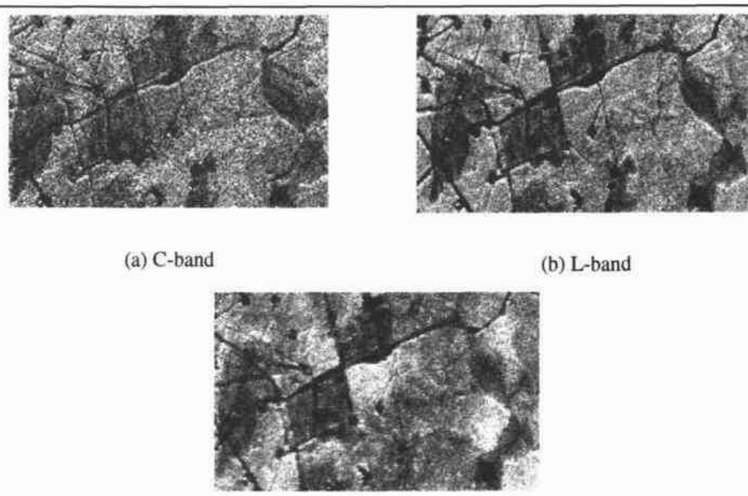

(a) C-band

(b) L-band

(c) P-band

Fig. 3. Comparison between HH-polarized *SAR* images acquired with the *JPL-AIRSAR* in three bands (C, L and P), on the same harvested area near Whitecourt, Alberta, in May 1991.

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multiband – CPL (multifrequency) image of San Francisco

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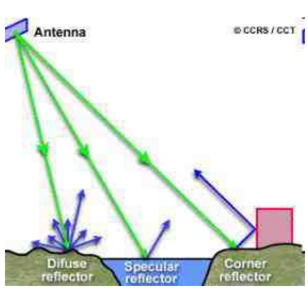
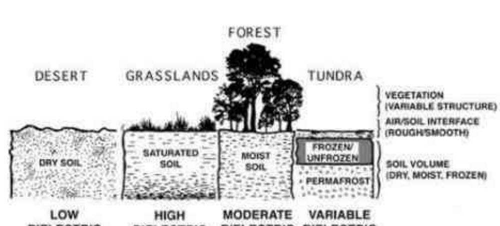
Radar image interpretation: Digital Numbers

The response to radar energy by the target depends on three factors:

- **Surface structure and roughness**
- **Moisture content: electrical properties (dielectric constant)**
- **Radar - surface geometry relationship**

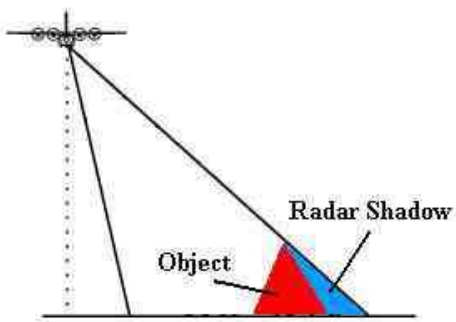




http://www.geog.ucsb.edu/~jeff/115a/remote_sensing/radar/radarroughness.jpg

27

Radar - surface geometry relationship: shadows



http://hosting.soonet.ca/eliris/remotesensing/bl130lec13.html

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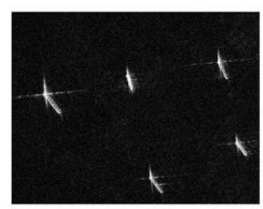
RADARSAT 2 – Canadian Space Agency 2007

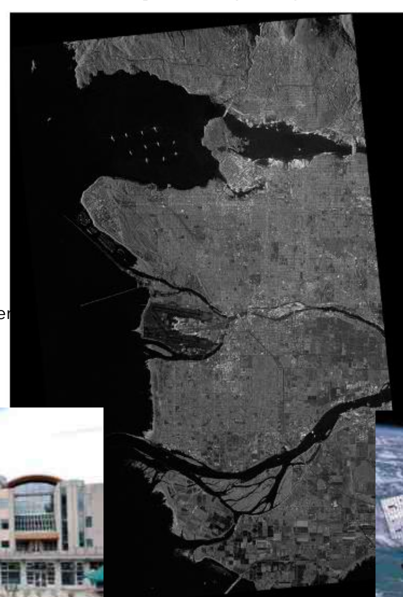
Bright = texture

Low = low dielectric constant (low texture)

Highest – corner reflectors

John S. MacDonald
Co-founder MacDonald-Dettwiler Associates /
UNBC Chancellor. 2008-15





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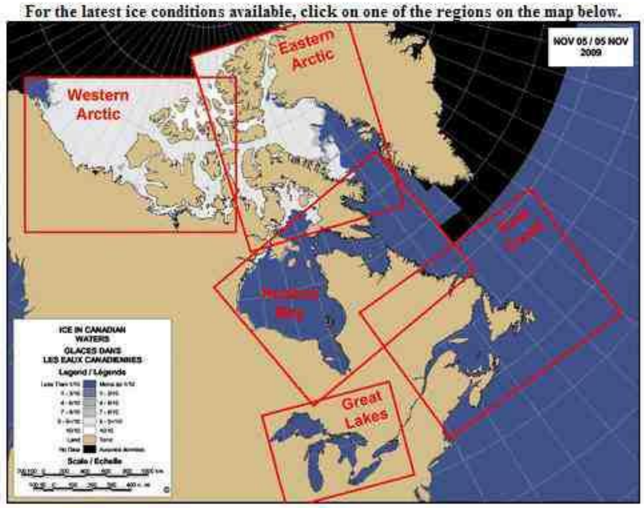
Canadian Ice Service

Please click View to view a full resolution version of "Ice in Canadian Waters" or Animate to view a recent daily animation.

For the latest ice conditions available, click on one of the regions on the map below.



http://ice-glaces.ec.gc.ca/App/WsvPageDsp.cfm?ID=1&Lang=eng

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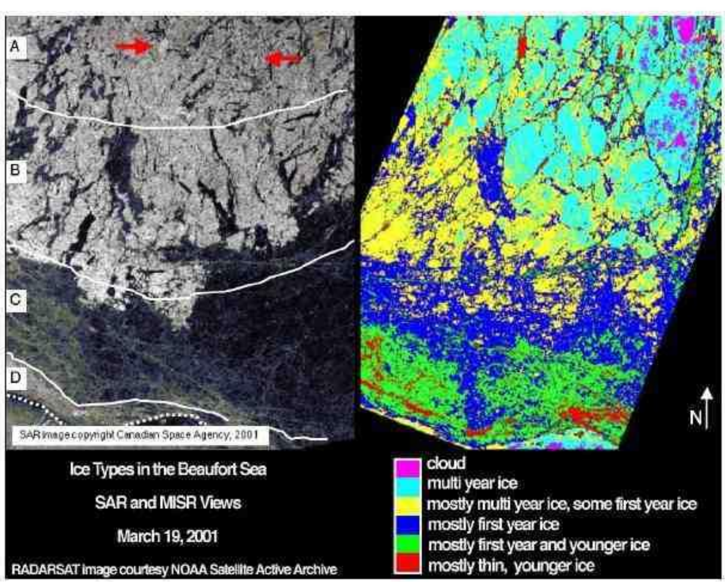
Ice Types in the Beaufort Sea, Alaska



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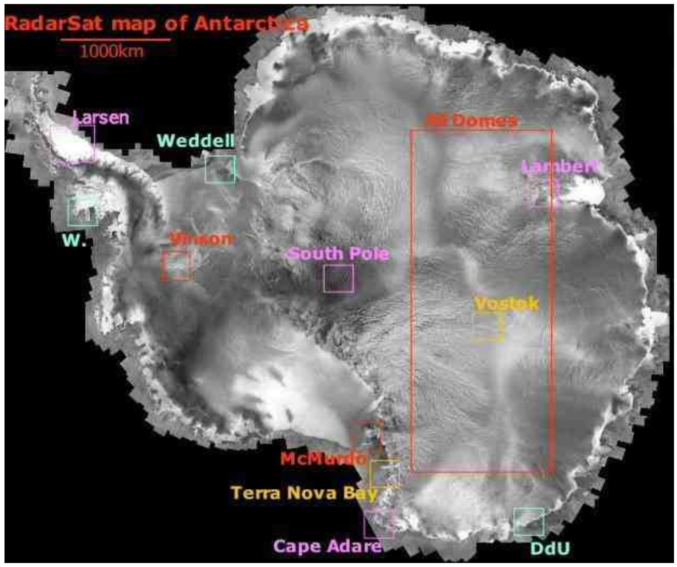
Canada produces the first complete image of Antarctica – we rock
RADARSAT launched by NASA in exchange for complete map image



http://ice-glaces.ec.gc.ca/App/WsvPageDsp.cfm?ID=1&Lang=eng

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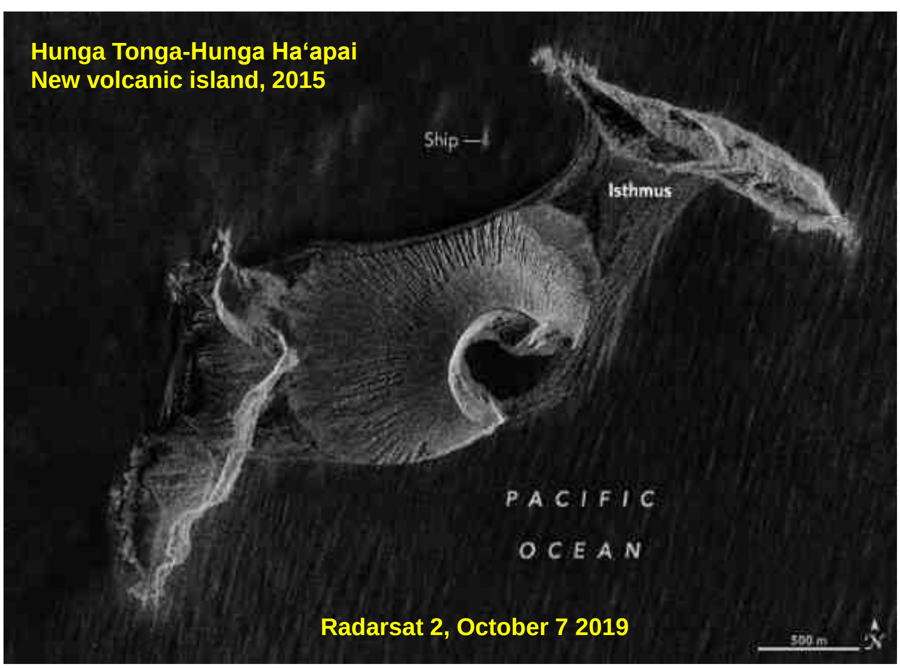

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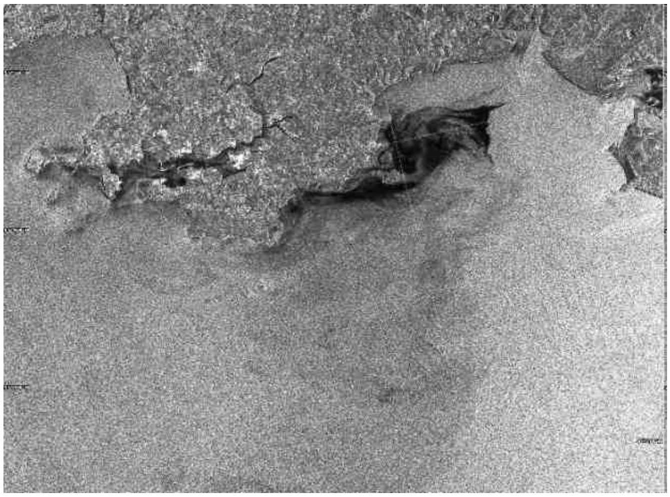
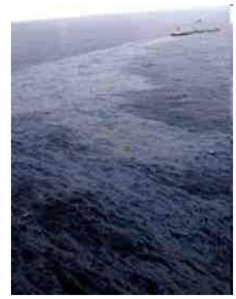
Oceanography – oil spills

http://earth.esa.int/ew/oil_slicks/wales_gb_96/





http://www.mms.gov/tarprojectcategories/remote.htm

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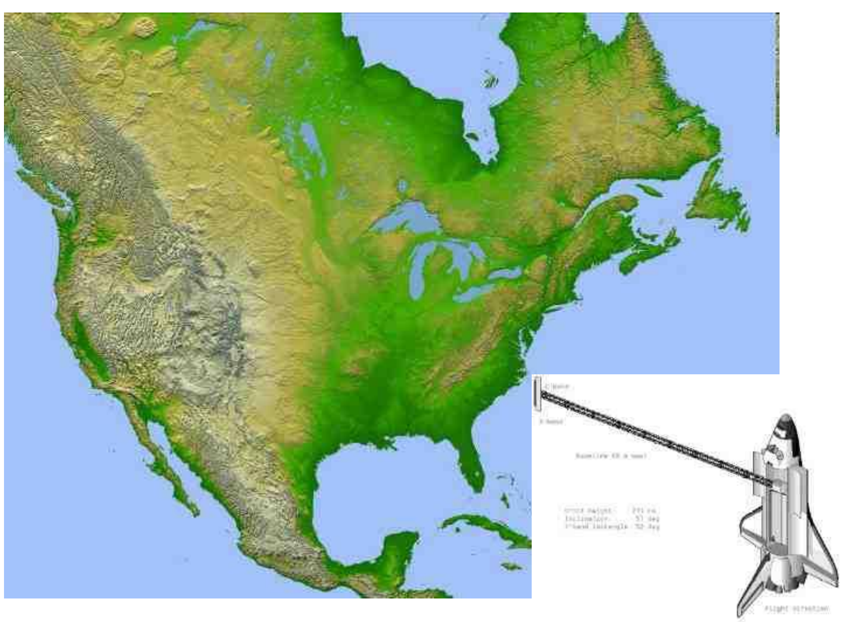
DEMs from RADAR e.g. Shuttle Radar Topographic Mission, 2000



The first ‘near-global’ high-res DEM (30-90m)

Drawing of the SRTM Configuration with the Secondary Antennas mounted on the Mast.

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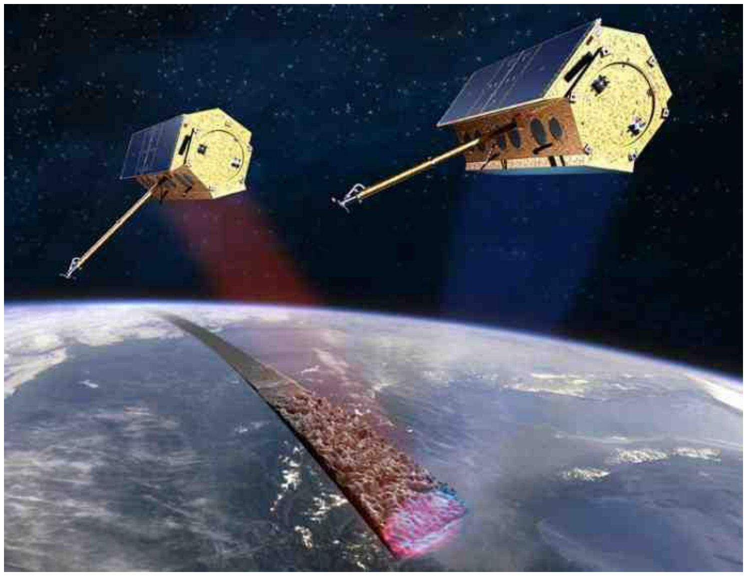
TerraSAR-X (2007) and TanDEM-X (2010)

High resolution Global DEM (2016) – 10 m pixels

German Aerospace Centre



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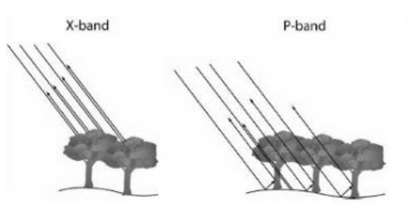
SIR-A in November, 1981. The color scene is a Landsat subimage of the Selma Sand Sheet in the Sahara Desert within northwestern Sudan.

Because dry sand has a low dielectric constant, long P radar waves penetrate these small particles by several metres



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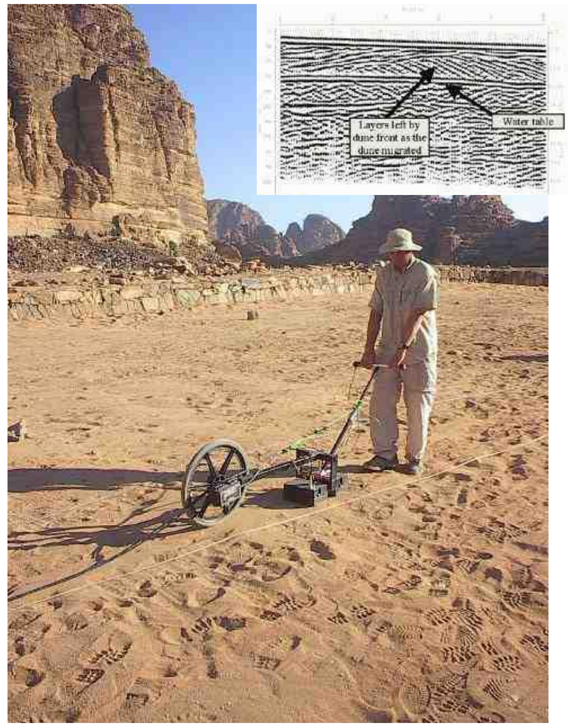
Ground penetrating radar (GPR) is a tool for analysing underground objects (such as graves), gravel and sand layers, and other underground features e.g. buried tombs and archaeological structures

… but is this remote sensing ?



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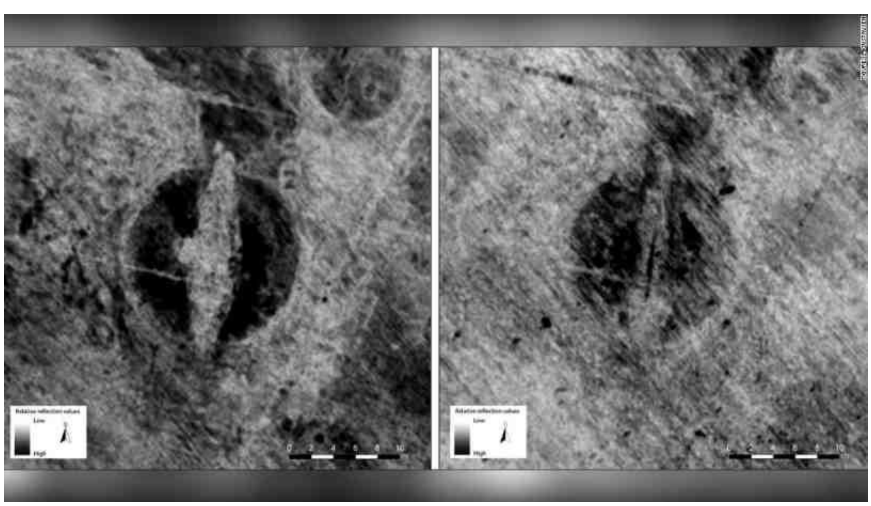
Nov 11, 2020: GPR discovers buried Viking ship Late Nordic Iron Age, 550 to 1050



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