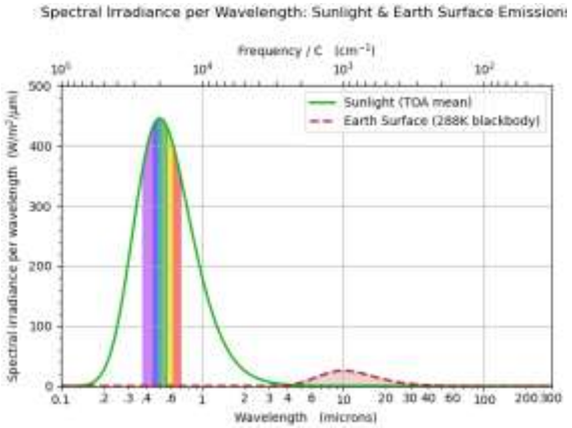
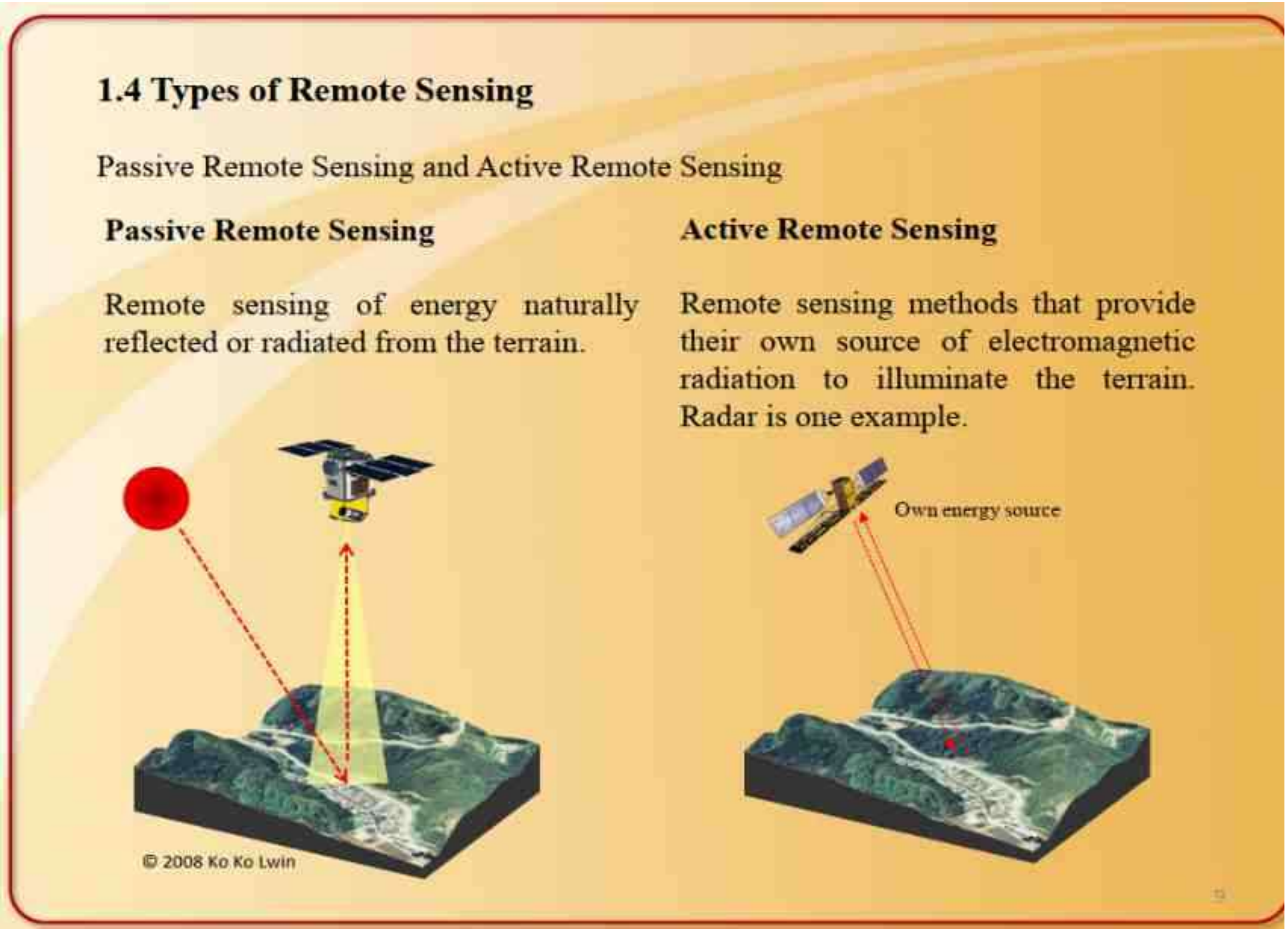
RADAR

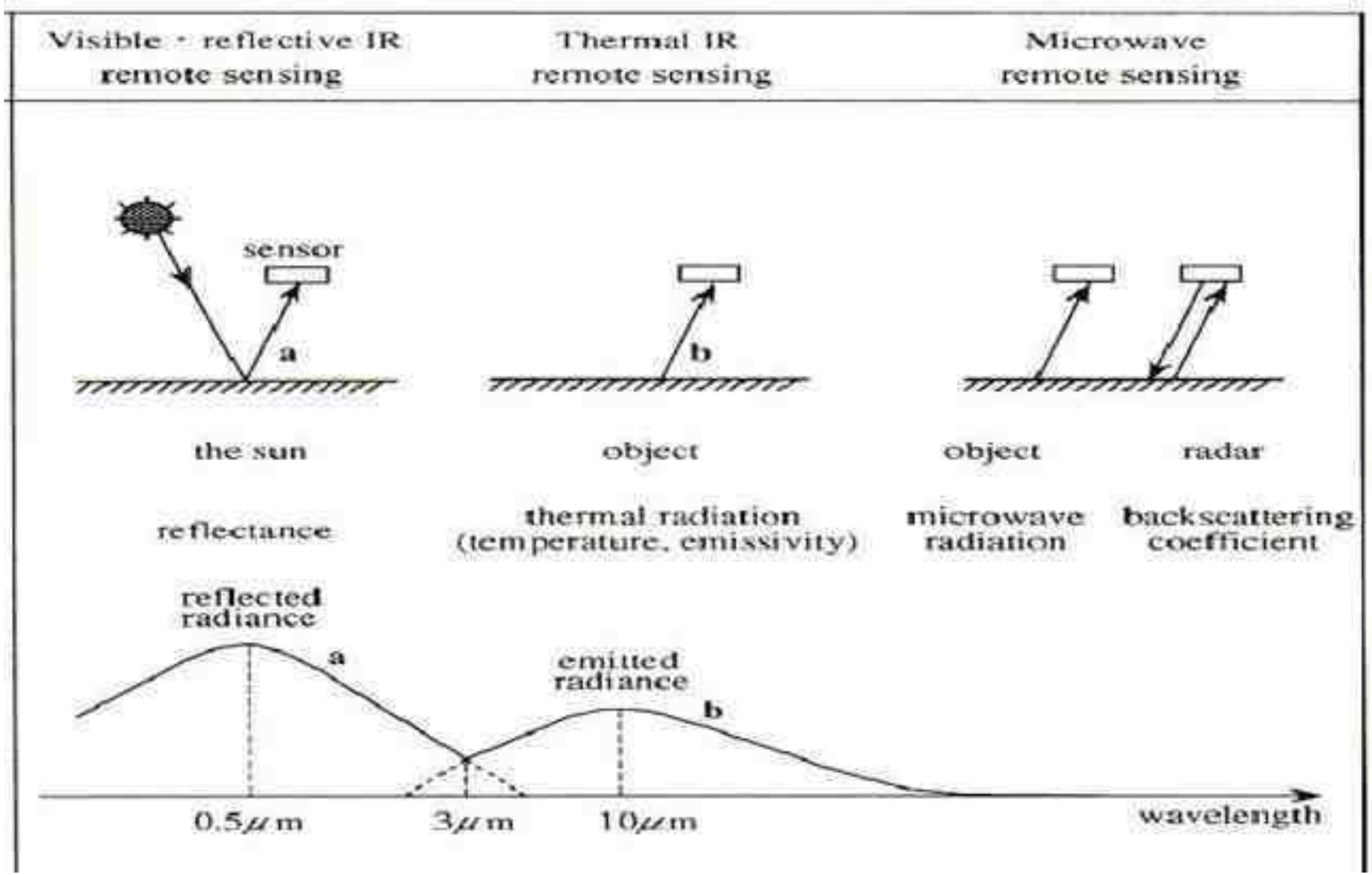
Microwave passive remote sensing: low resolution e.g. 10km pixels: limited earth emissions





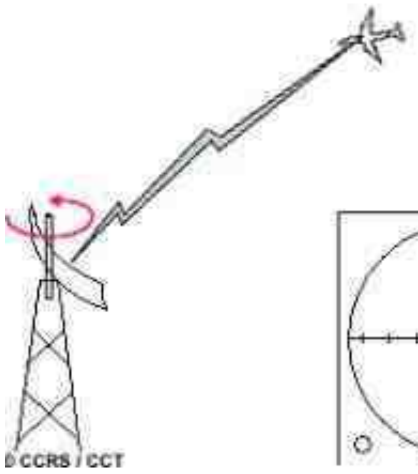
As **passive** microwave sensors deal with very low resolution, more applications in these wavelengths use **active** sensors

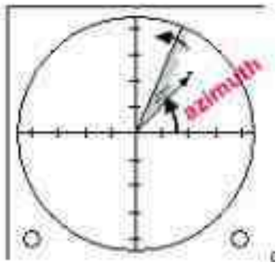
RADAR is the most commonly used space-based *active* sensing system.
It is an acronym for **RA*dio* De*tection* And Ra*nging***.



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.

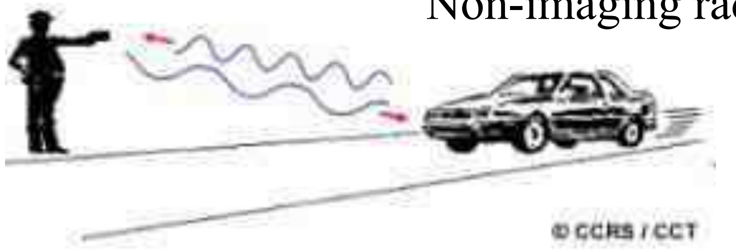
The original technology was developed during WWII: https://www.radarworld.org/germany3.html





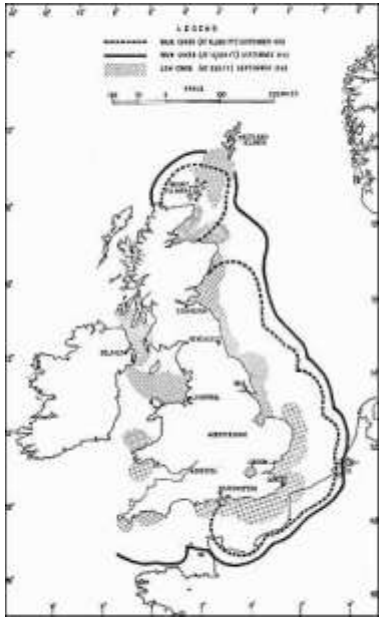
Plan position indicators (PPI) produce a type of image. These radars use a circular display screen to indicate objects surrounding the rotating antenna. They are commonly used for weather monitoring, air traffic control and navigational systems.

Non-imaging radar



Invention/development of RADAR: Robert Watson-Watt (1935)

Use of transmitting Radio waves to detect enemy aircraft in World War II

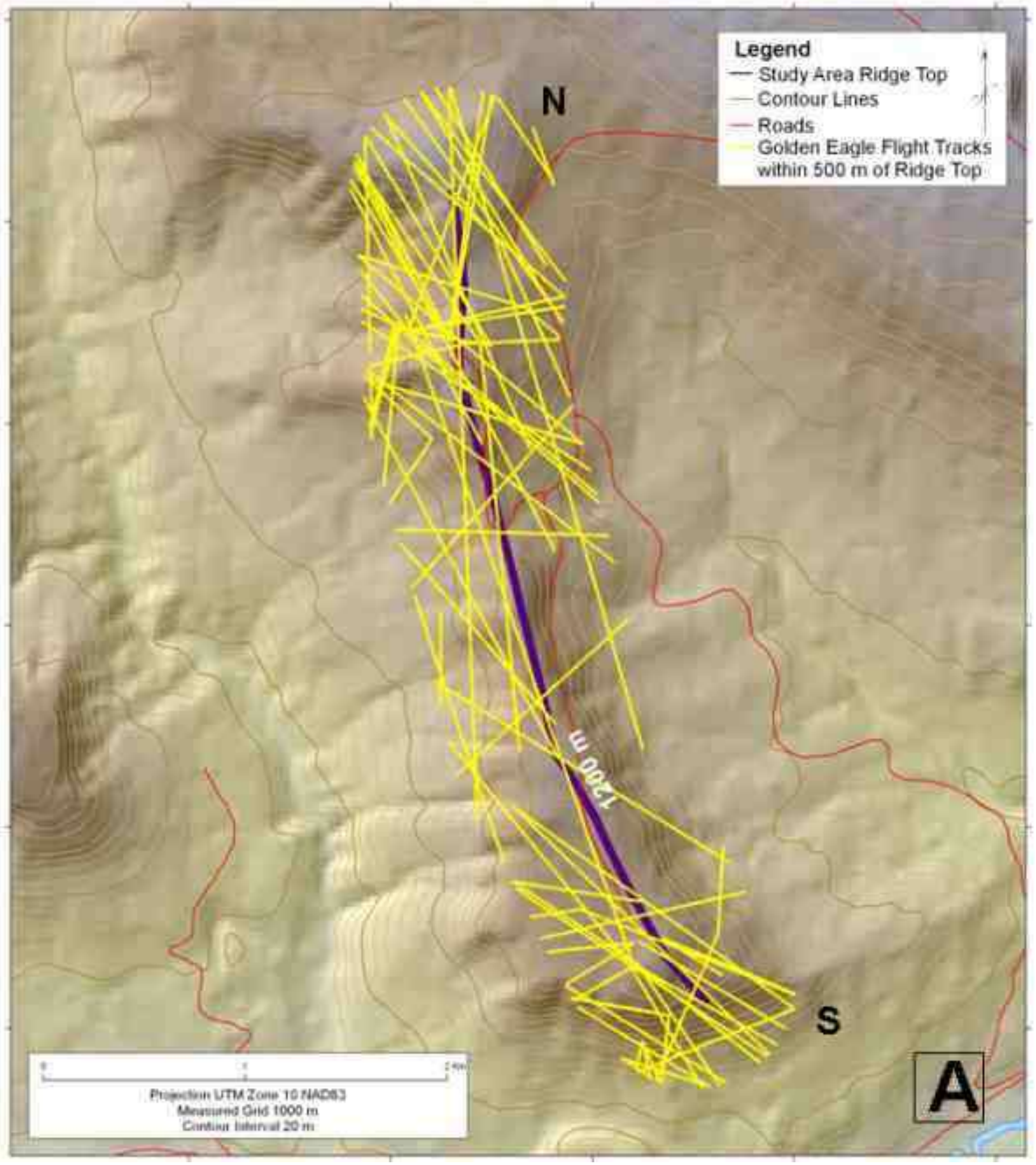


In 1956, he moved to Canada where Watson-Watt reportedly was pulled over for speeding by a radar gun - toting policeman (his own invention).

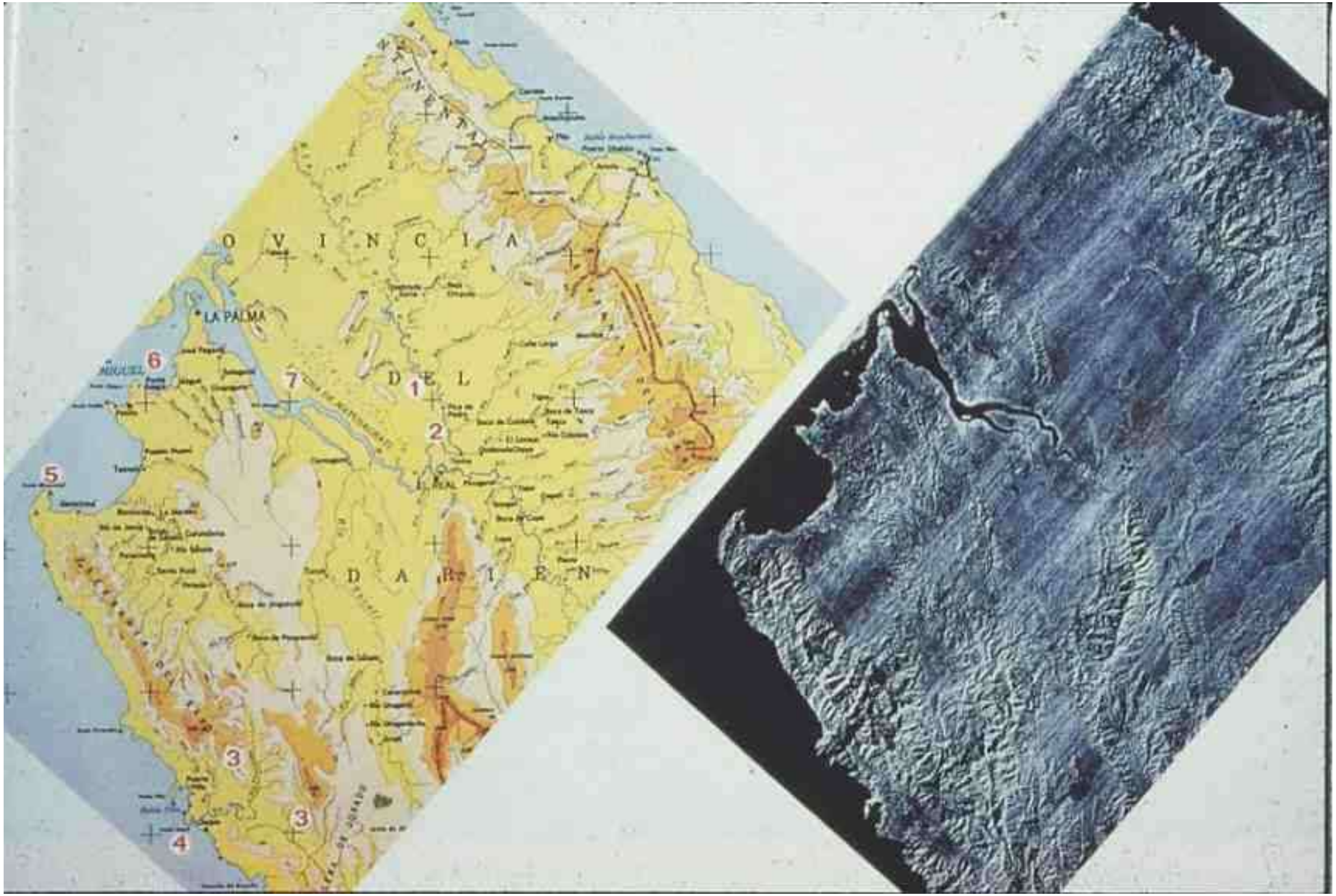
Then: Massachusetts-based Raytheon in 1947 named the original **microwave "Radarange"** because it cooked food using the same radio-wave-producing magnetron tubes the company manufactured for use in military radar.

Raytheon credits the discovery of microwave cooking to an engineer named Percy L. Spencer. One day in 1945, Spencer was walking through a radar test room with a chocolate bar in his pocket, and the candy began to melt.

Now: UNBC bird study using RADAR – near Chetwynd (Dr. Ken Otter) Dokie Ridge: site of wind turbines

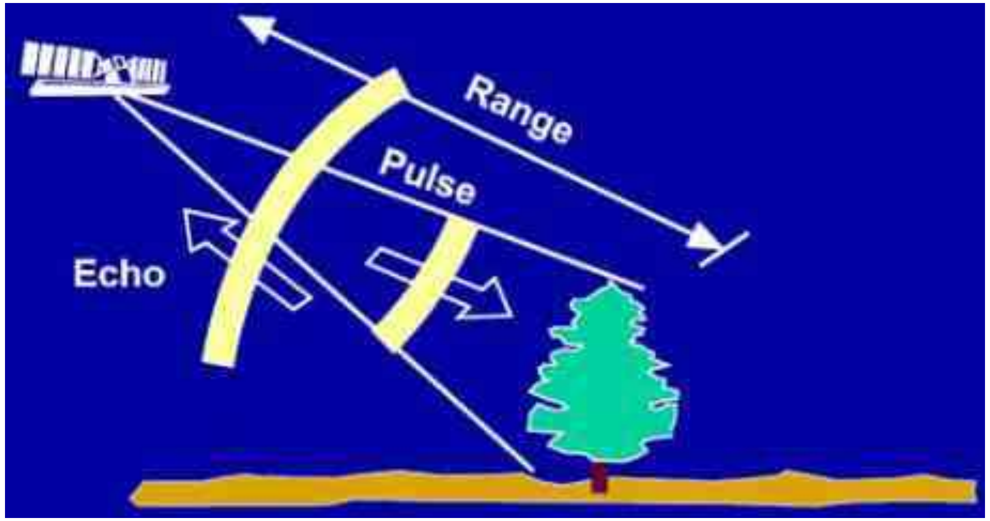


1970s-80s: Most early imaging RADAR was airborne, e.g. Calgary Intera technologies: Panama



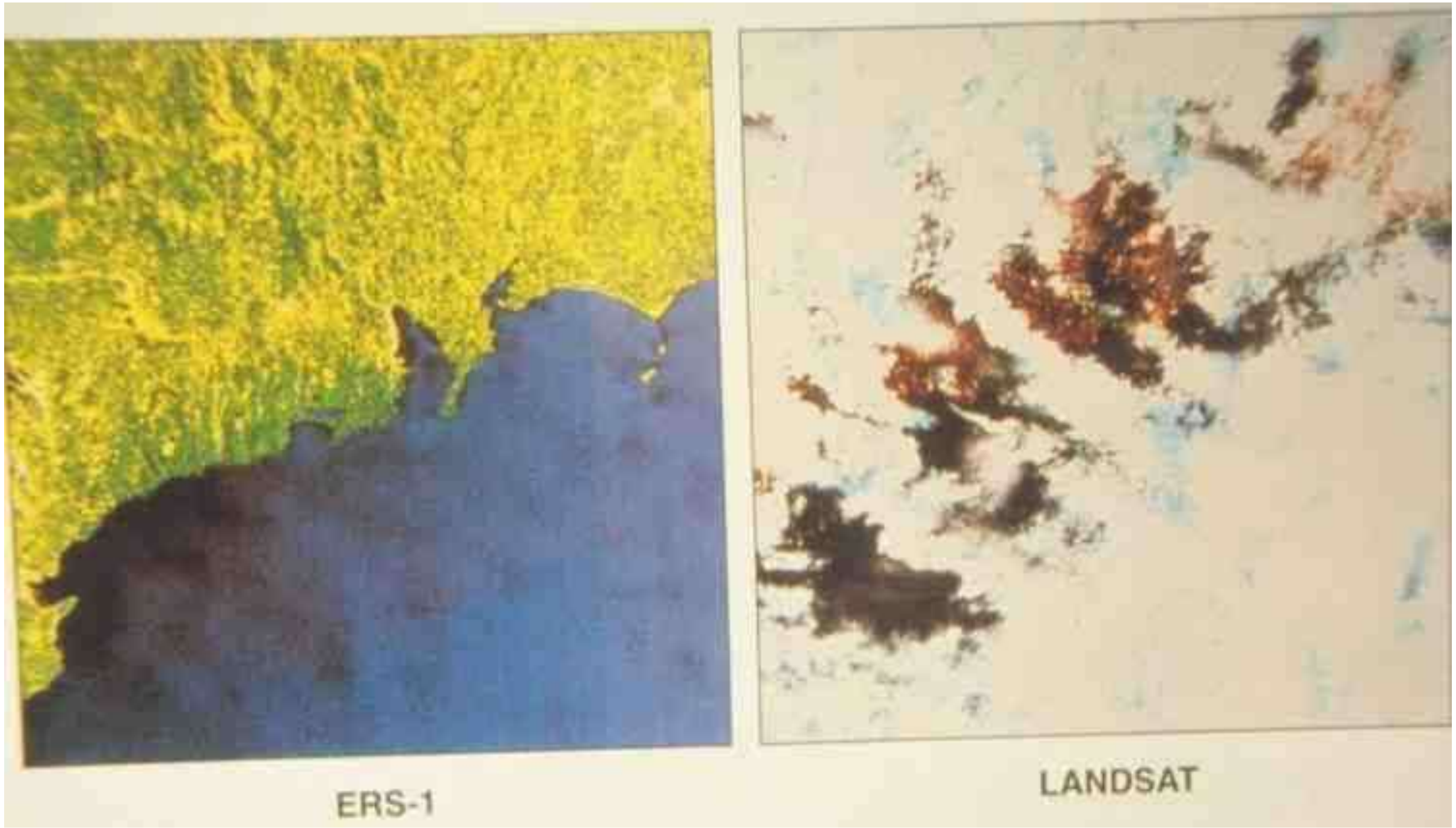
Tropical areas are often cloud-covered and poorly mapped without RADAR

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.

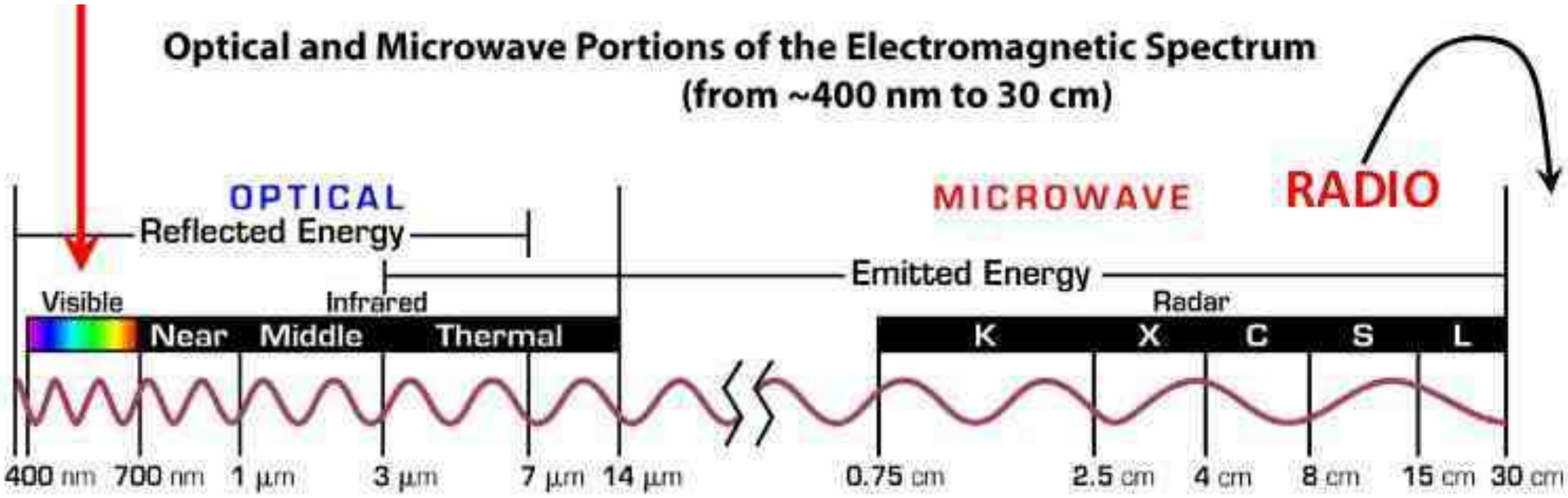


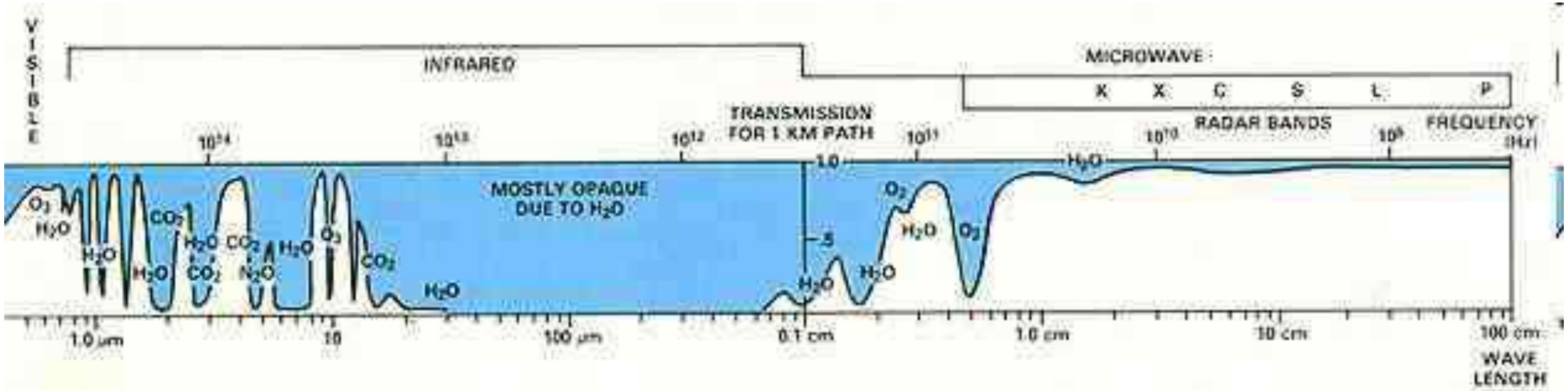
Satellite imaging radar started with SEASAT, launched in 1978.

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


Optical and Microwave Portions of the Electromagnetic Spectrum
(from ~400 nm to 30 cm)
OPTICAL
Reflected Energy
MICROWAVE
RADIO
Emitted Energy
Visible
Infrared
Radar
Near
Middle
Thermal
K
X
C
S
L
400 nm
700 nm
1 µm
3 µm
7 µm
14 µm
0.75 cm
2.5 cm
4 cm
8 cm
15 cm
30 cm

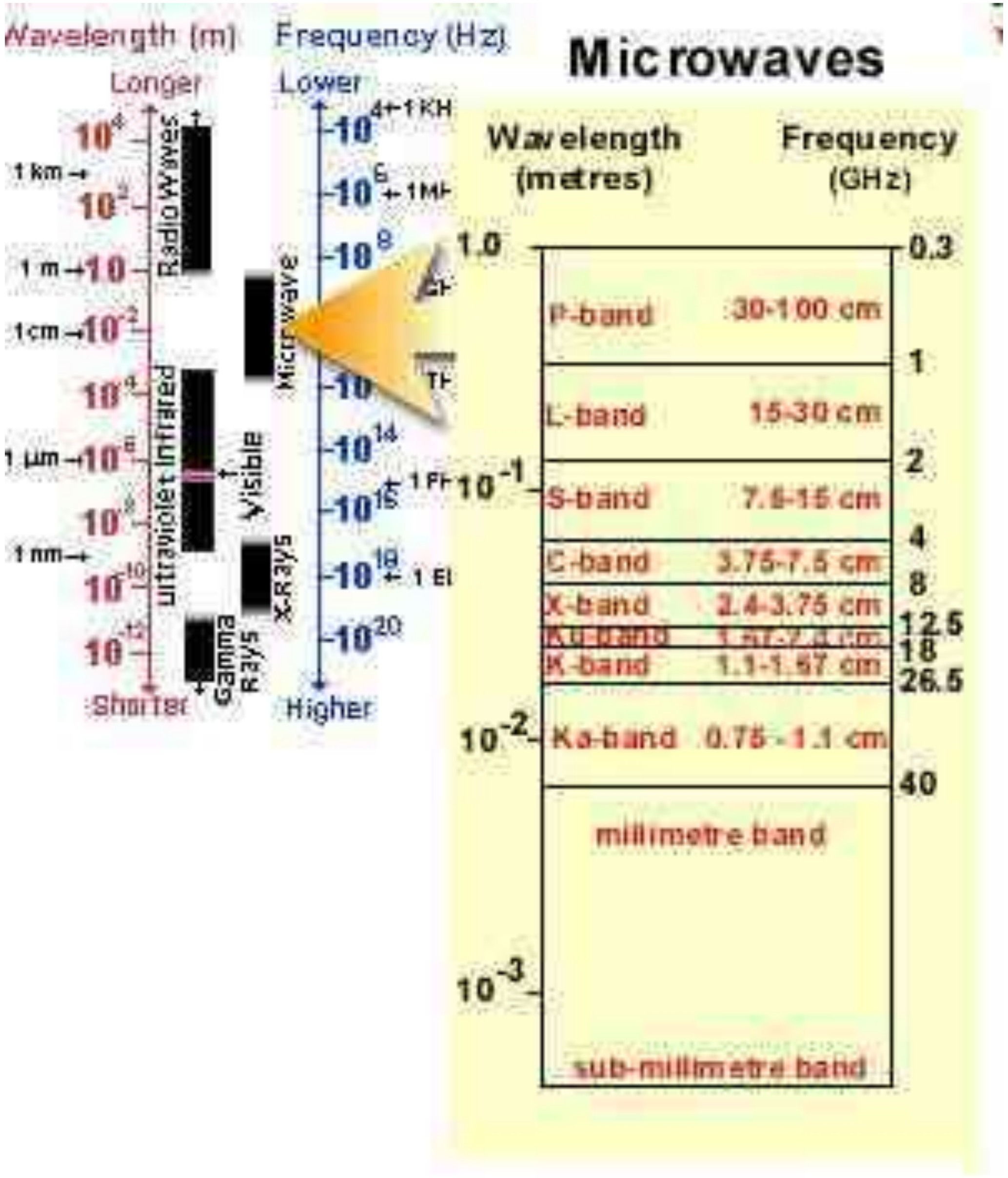

VISIBLE
INFRARED
MICROWAVE
K
X
C
S
L
P
RADAR BANDS
TRANSMISSION
FOR 1 KM PATH
FREQUENCY
MOSTLY OPAQUE
DUE TO H2O
1.0 µm
10
100 µm
0.1 cm
1.0 cm
10 cm
100 cm
WAVE
LENGTH

In RADAR microwave, it as usual to refer to bands by frequency in Gigahertz (waves/second) as in wavelength

Frequency is inversely proportional to wavelengths

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

P = penetration
L= Longwave
S= Shortwave
C=compromise
X= Cross(hairs) as in WWII
K = Kurtz (short in german)



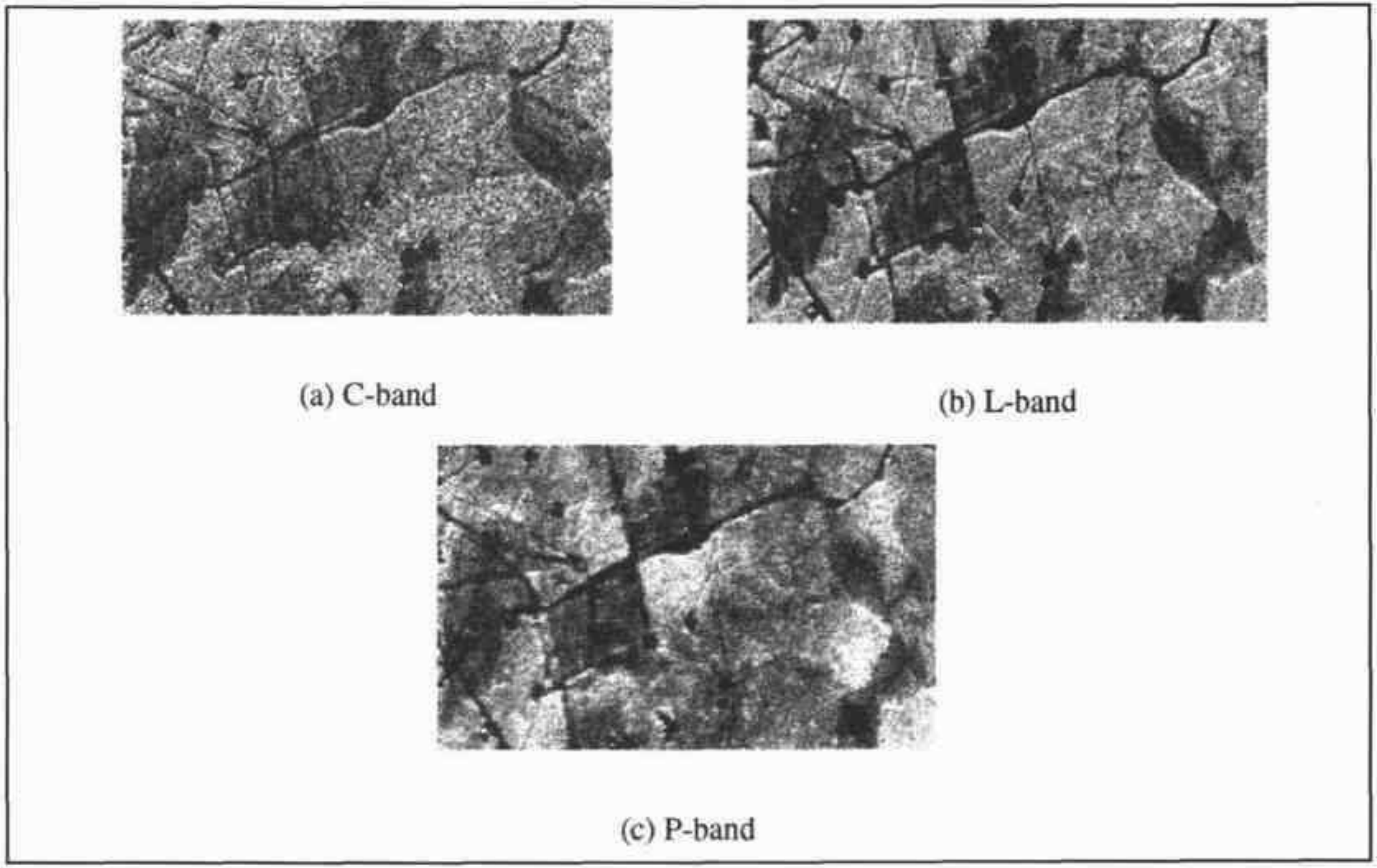


Fig. 3. Comparison between HH-polarized *SAR* images acquired with the *JPL-AIRSAR* in three bands (C, L and P), on the same harvested area near Whitecourt, Alberta, in May 1991.

multiband – CPL (multifrequency) image of San Francisco

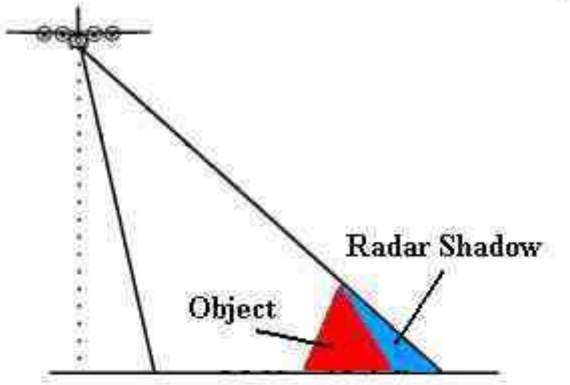
Radar image interpretation: Digital Numbers

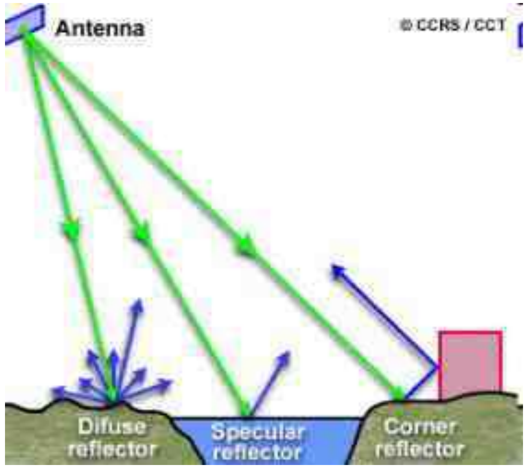
Radar - surface geometry relationship: shadows

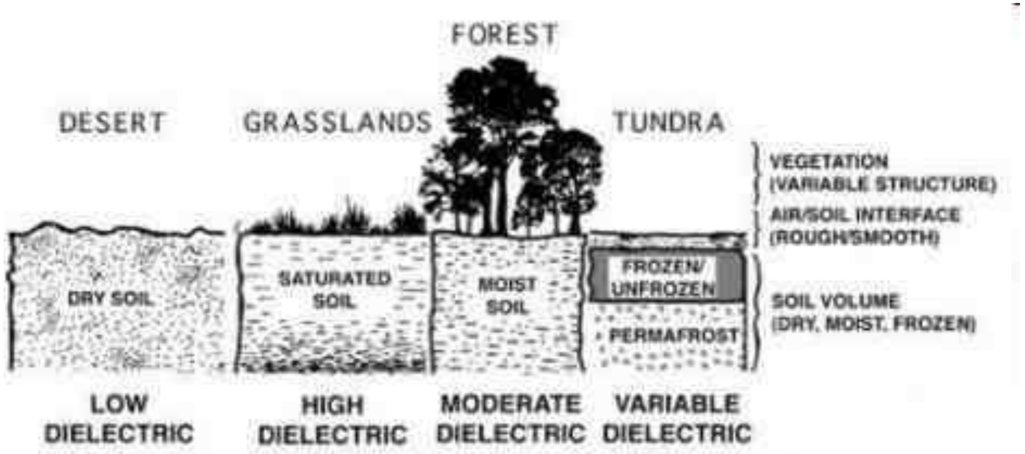
Most imaging RADAR is 'side-looking'

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**



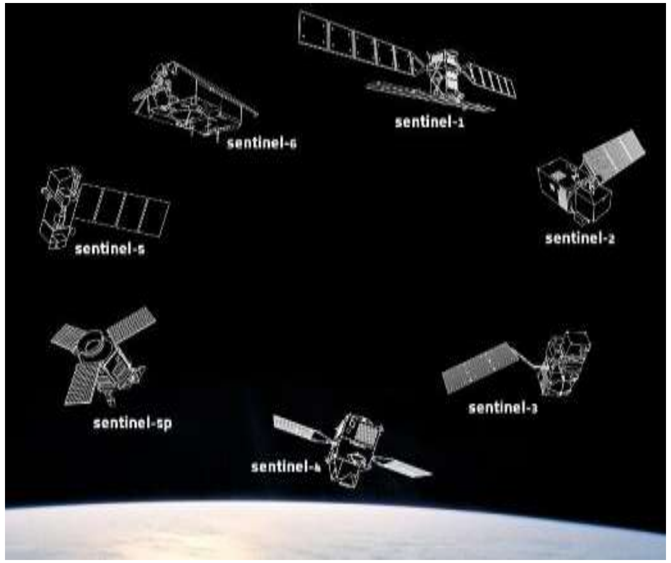




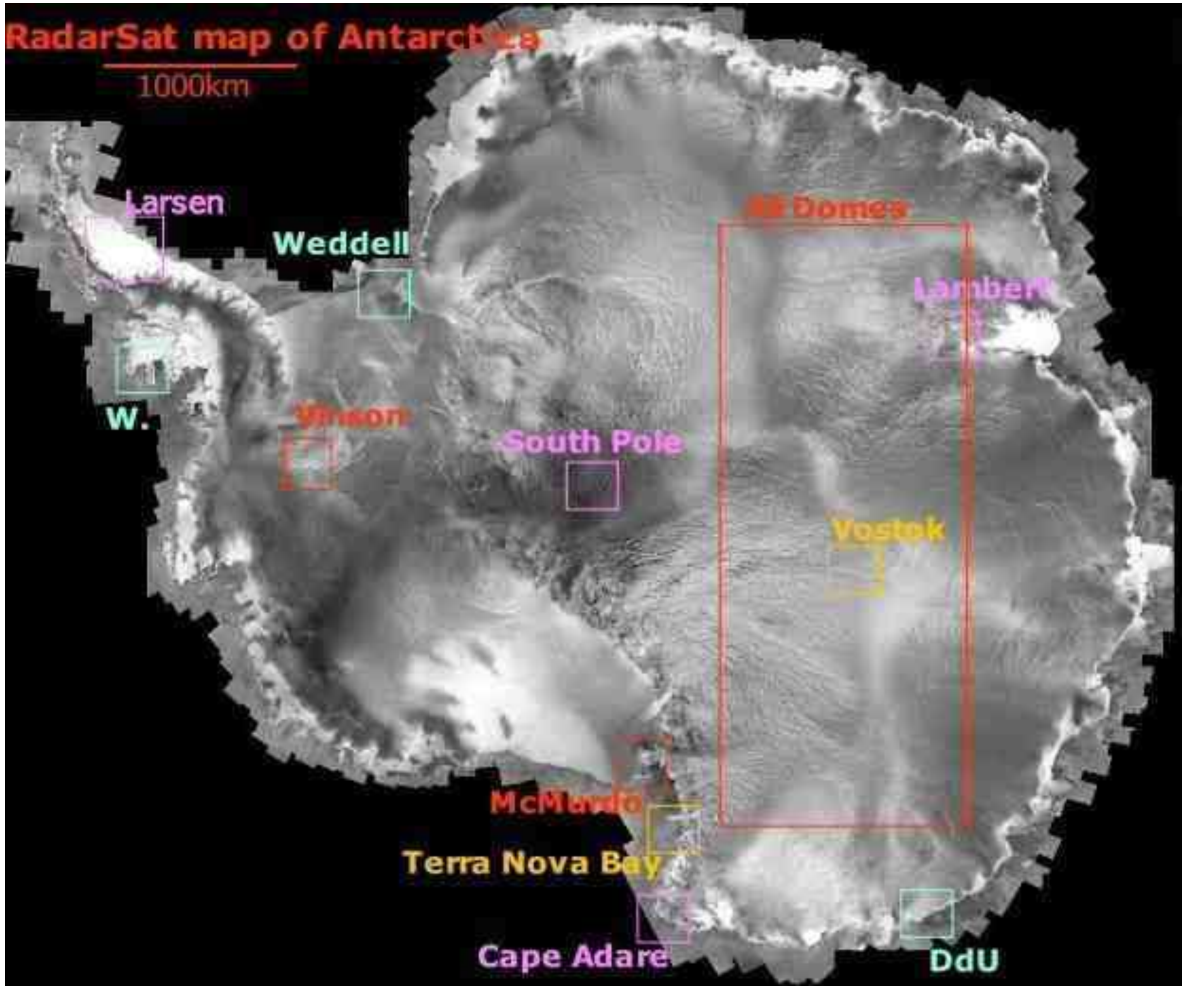
http://www.geog.ucsb.edu/~jeff/115a/remote_sensing/radar/radarroughness.jpg

Some early RADAR satellite systems (Date launched, Wavelength, Resolution)

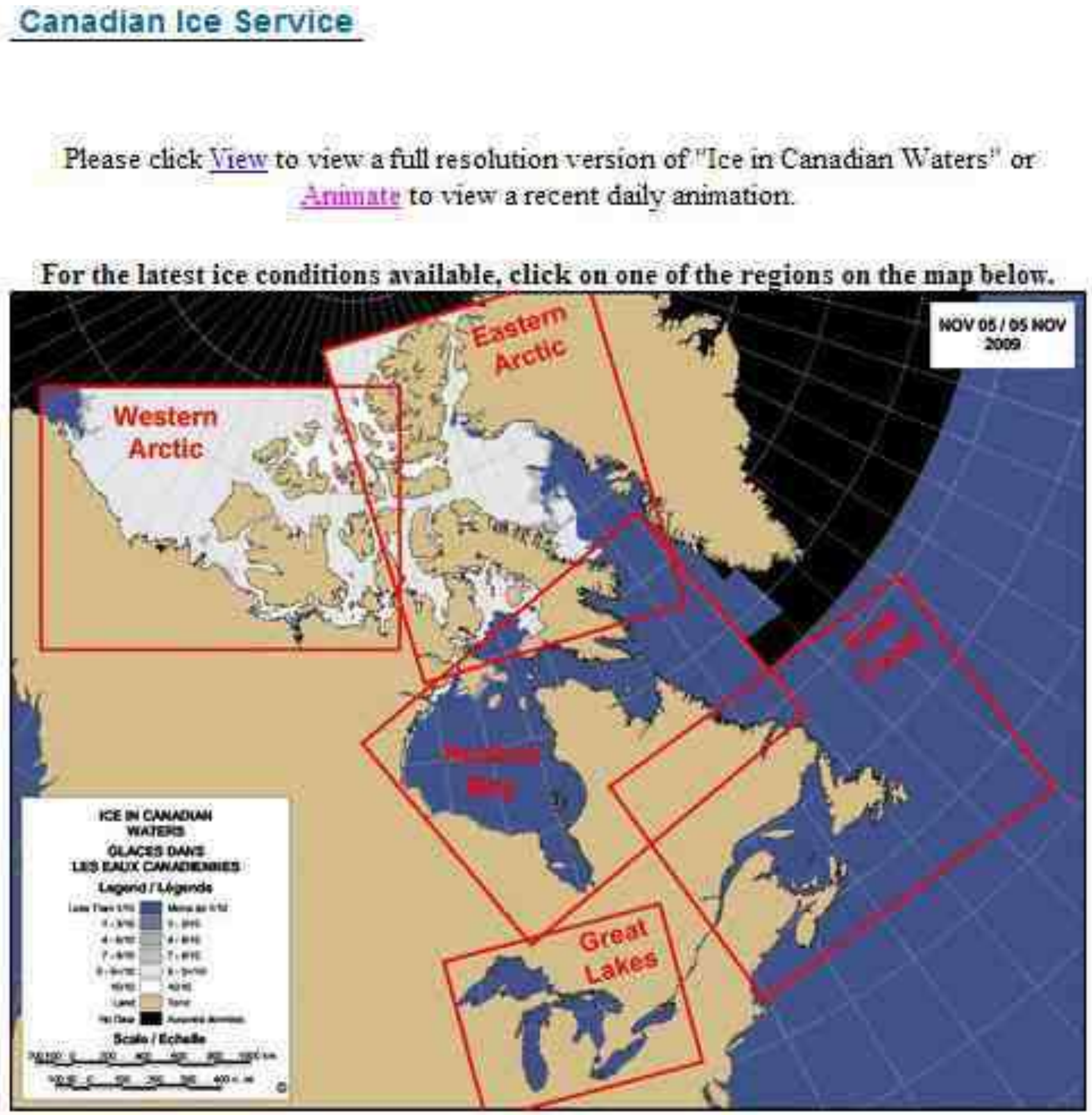
SEASAT (USA)	1978	L	25m
SIR- A,B,C (USA) JPL	1981	L	40m (Shuttle Imaging Radar)
ERS (EUROPE)	1991, 1995	C	30m
JERS (JAPAN)	1992	L	25m
RADARSAT (CANADA)	1995	C	10-100m CCRS - Radar
ENVISAT (EUROPE)	2002		multiple
RADARSAT 2 (Canada)	2007	C	3-100m
Sentinel-1 (ESA) A/B	2014 / 2016	C	10m (Free)



Canada produces the first complete image of Antarctica
RADARSAT launched by NASA in 1995 in exchange for complete map image of Antarctica

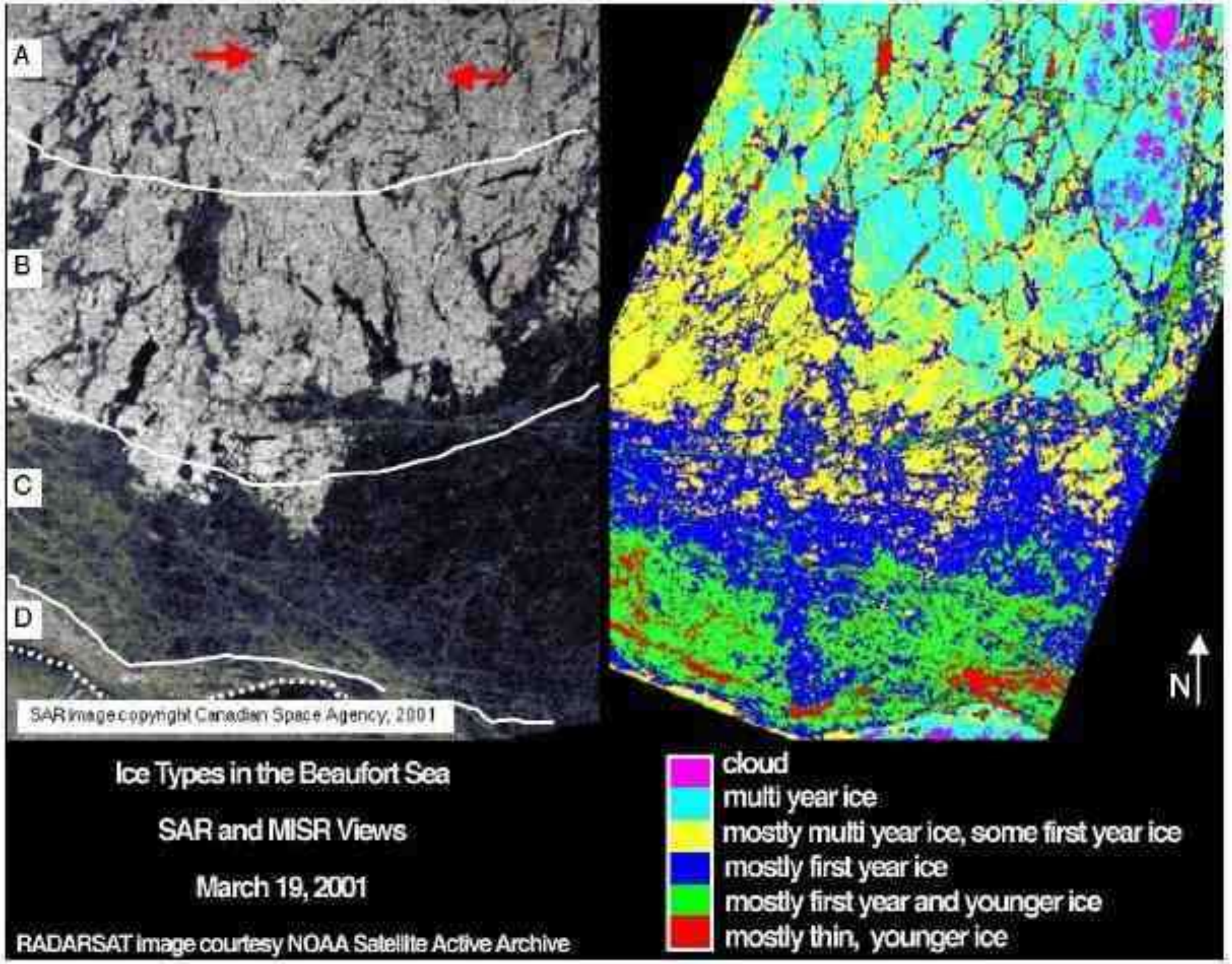


https://www.asc-csa.gc.ca/eng/satellites/radarsat1/antarctic.asp



https://natural-resources.canada.ca/maps-tools-publications/satellite-elevation-air-photos/sea-ice-applications

Ice Types in the Beaufort Sea, Alaska



RADARSAT – Canadian Space Agency (CSA)

RADARSAT1: 1995-2013, RADARSAT2: 2007 ->

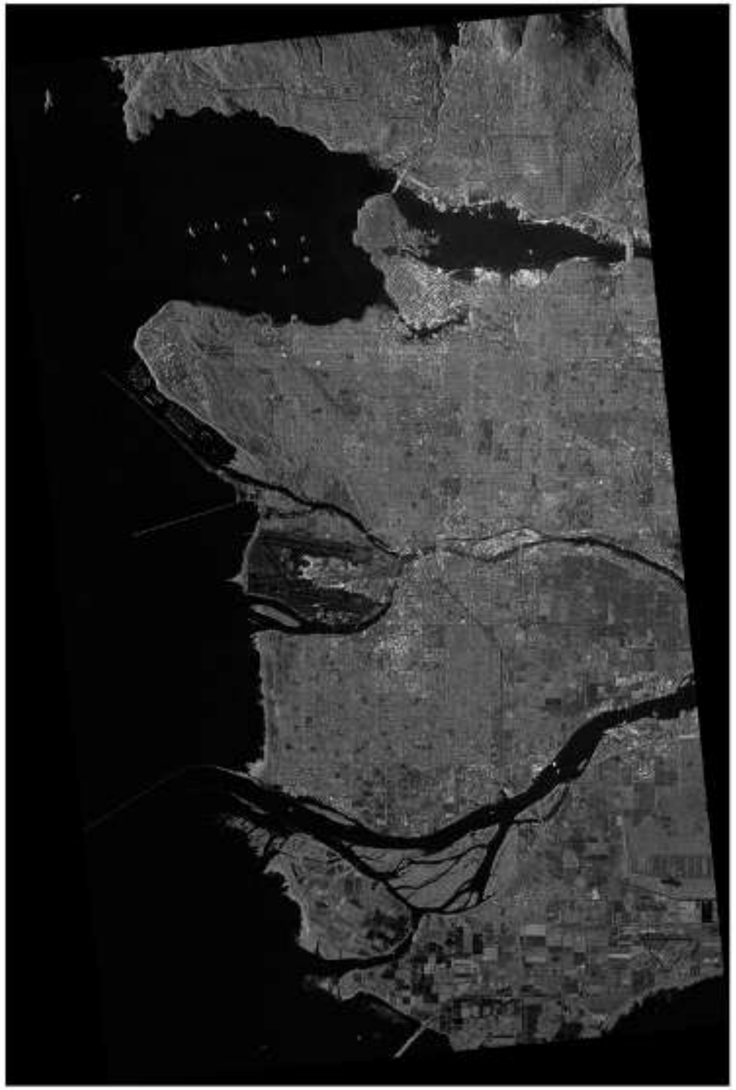
Bright = texture

Low = low dielectric constant (low texture)

Highest – corner reflectors

John S. MacDonald
Co-founder MacDonald-Dettwiler Associates

UNBC Chancellor, 2008-15



Oceanography – oil spills

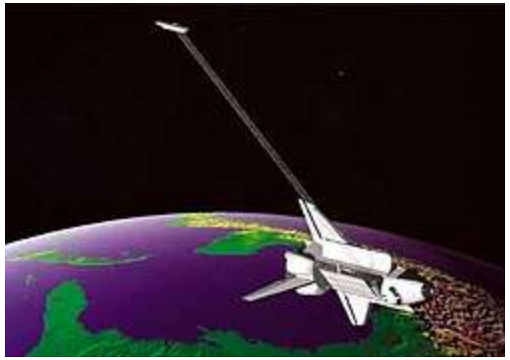
http://earth.esa.int/ew/oil_slicks/wales_gb_96/

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

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

The Shuttle Radar Topography Mission (**SRTM**) was an **international research effort** that obtained digital elevation models on a near-global scale from 56°S to 60°N.

Resolution was 1 arcsecond (~90m)



The first 'near-global' high-res DEM (30-90m) – C / X bands used to create Google Earth

2011-15
GLO-30 DEM

Best current global DEM

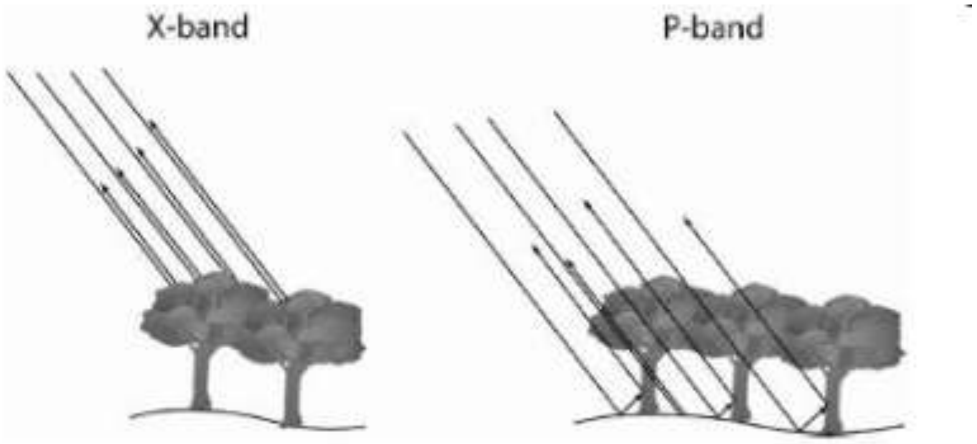
https://spacedata.copernicus.eu/collections/copernicus-digital-elevation-model

https://dataspace.copernicus.eu/explore-data/data-collections/copernicus-contributing-missions/collections-description/COP-DEM

Longest RADAR P waves – penetrate sand

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

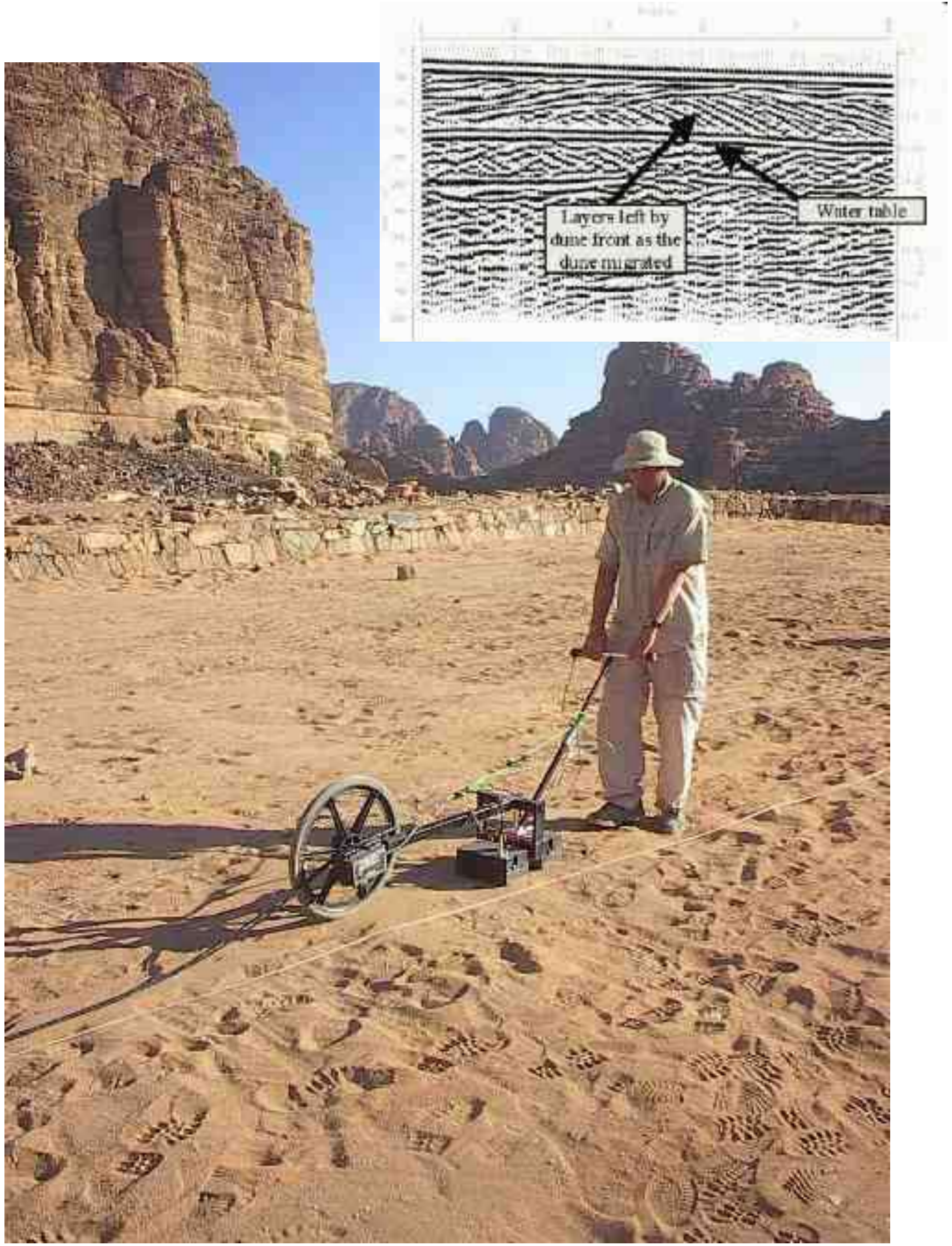
Because dry sand has a low dielectric constant, very long P radar waves penetrate these small particles by several metres



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

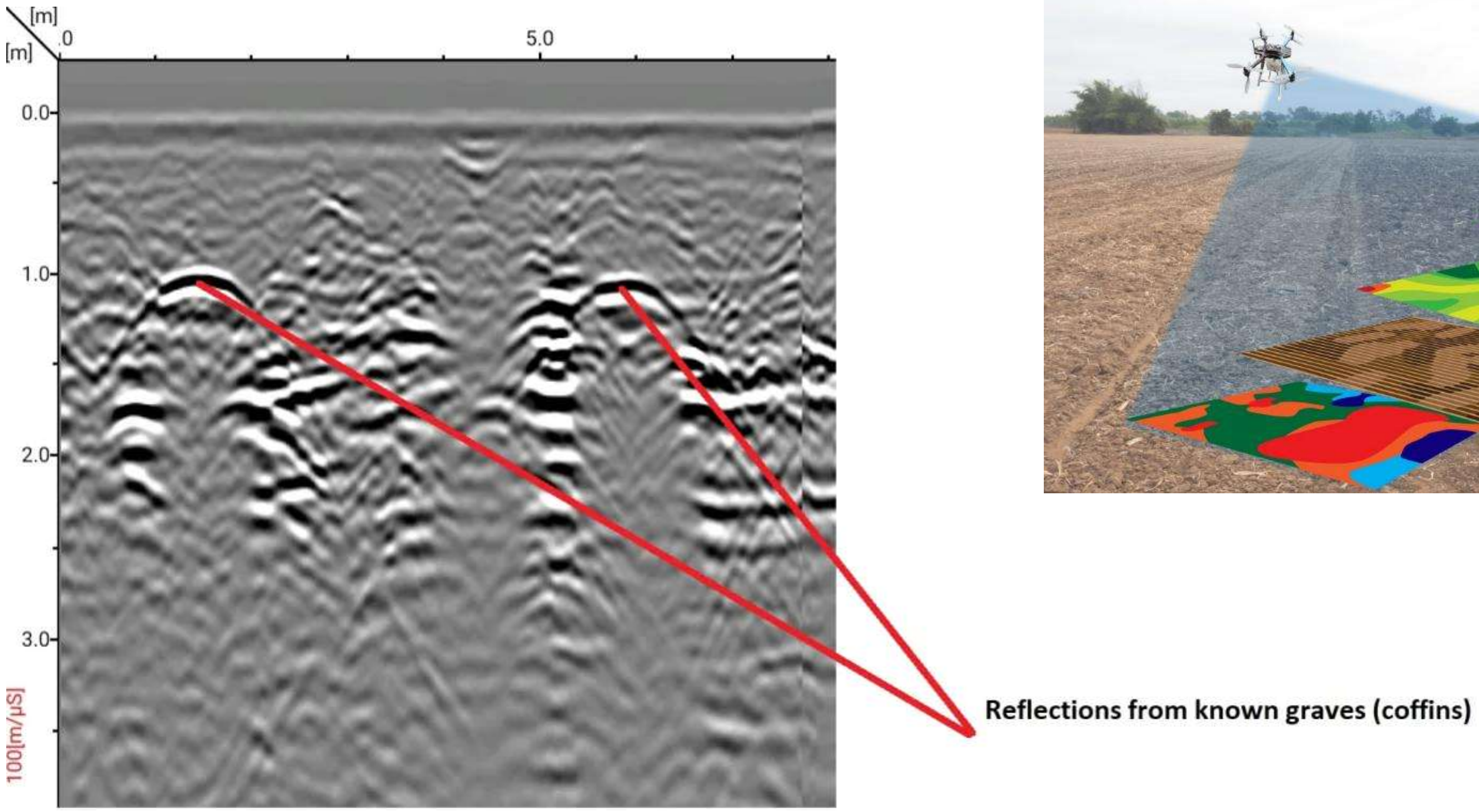
… is this then still remote sensing ?

Also possible from aircraft / drones – surface penetration not as good

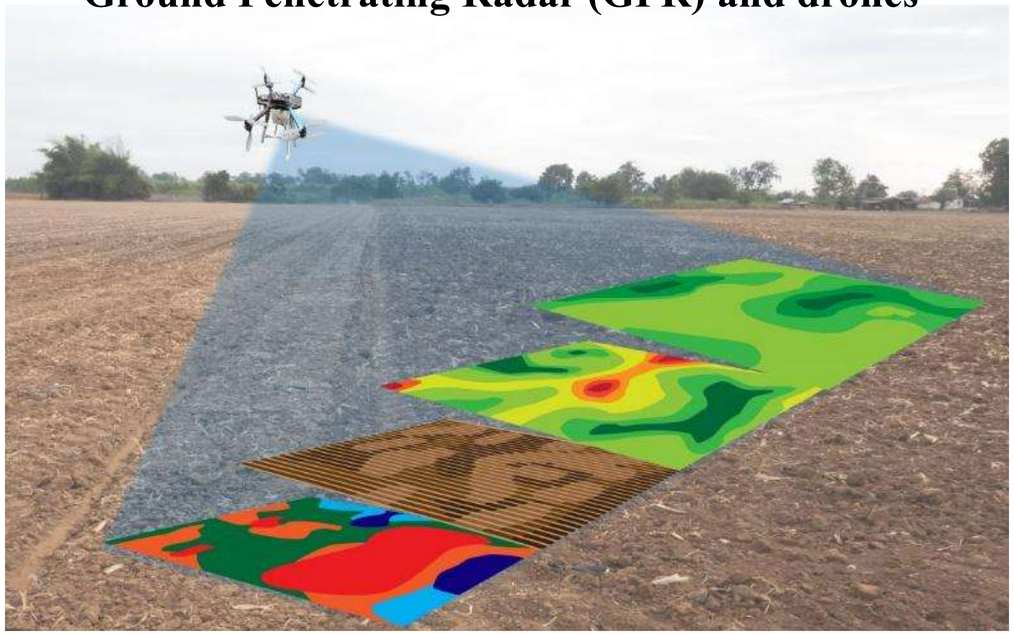


Ground Penetrating Radar (GPR) discovers unmarked graves in residential schools: Canada 2021-22

https://www.cbc.ca/news/canada/ground-radar-technology-residential-school-remains-1.6049776



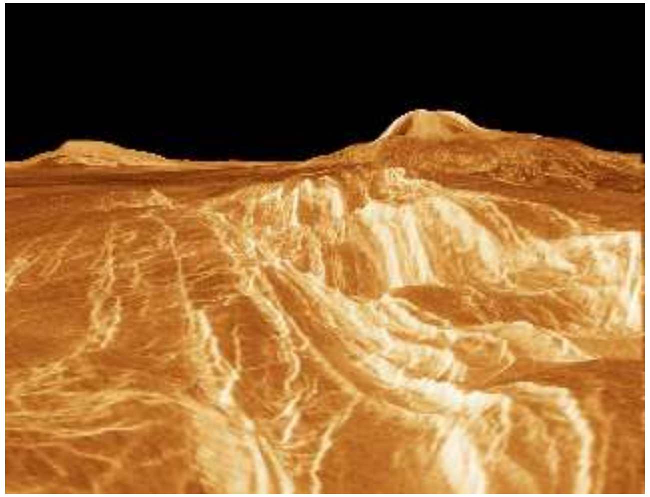
Ground Penetrating Radar (GPR) and drones



Venus: Magellan mission: sensor system launched from Shuttle 1989 (11 years before SRTM): Radar 100m resolution

Planet is perpetually Cloud covered

Composite colours based on elevations – DEM data



RADAR DEM and perspective flights
http://www.solarviews.com/eng/venus.htm