Lesson 6

- Sensors in Remote Sensing (Contd)
(Lidar and Microwave sensors)

An active optical remote sensing instrument

Non-imaging instrument

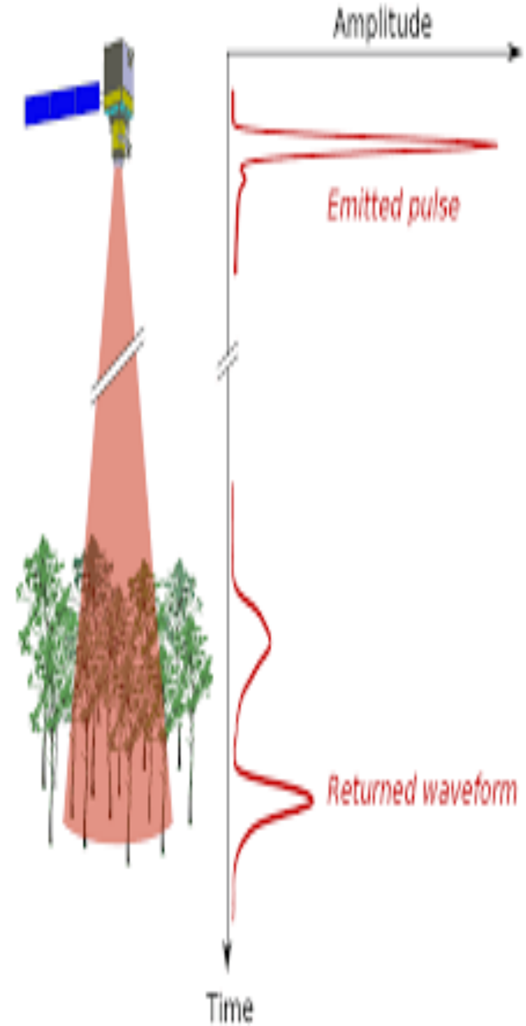
Instruments sends several pulses on ground and receive it in time domain.

- Each time the laser is pulsed:
  - Laser generates an optical pulse
  - Pulse is reflected off an object and returns

    to the system receiver
  - Time measurement is converted to a distance (the distance to the target and the

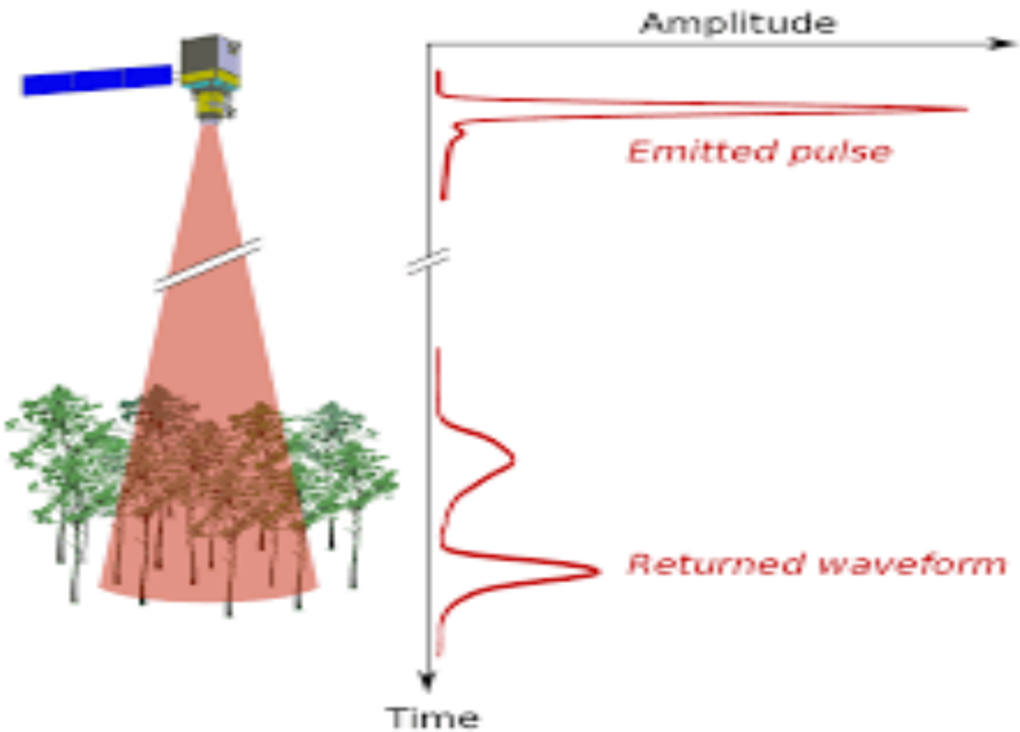
    position of the airplane is then used to determine

    the elevation and location)
  - Multiple returns can be measured for each pulse
- Up to 200,000+ pulses/second



ACTIVE SENSOR: LIDAR

LIDAR



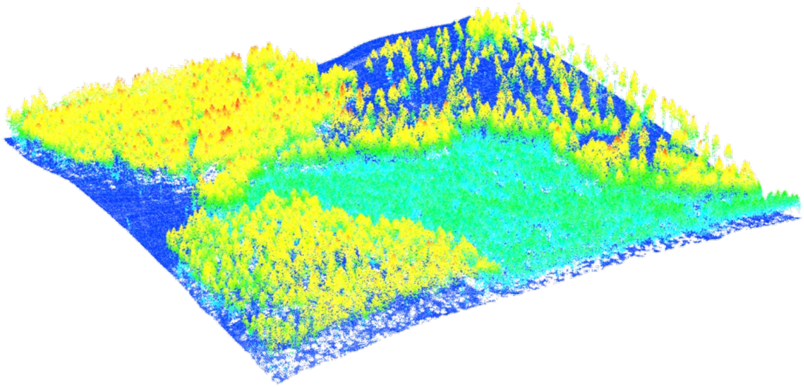
Distance = (Speed of Light x Time of Flight) / 2

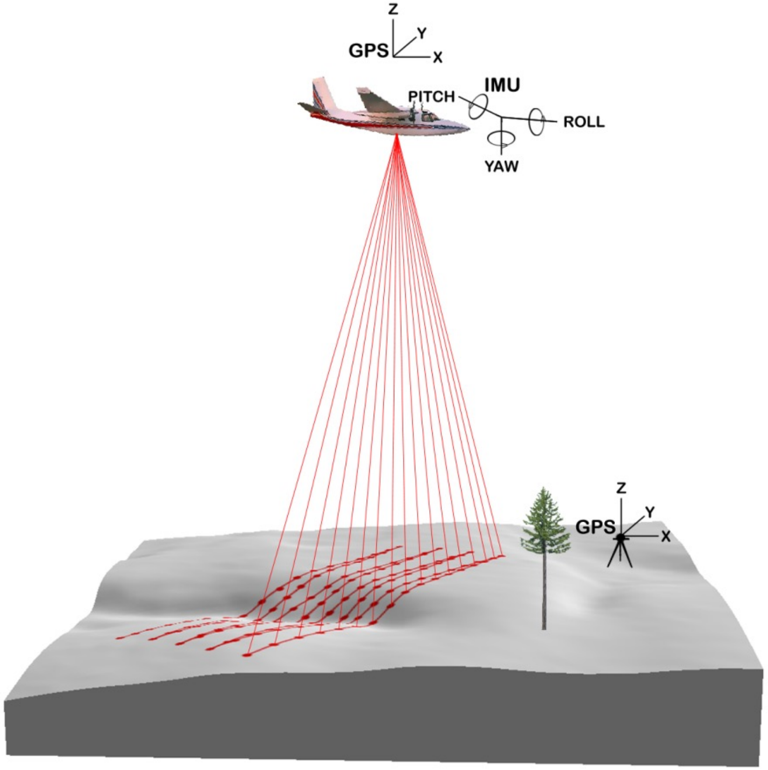
https://www.earthdatascience.org/courses/use-data-open-source-python/data-stories/what-is-lidar-data/

Aerial LiDAR System Components*

- Aircraft
- Scanning laser emitter-receiver unit
- Differentially-corrected GPS
- Computer

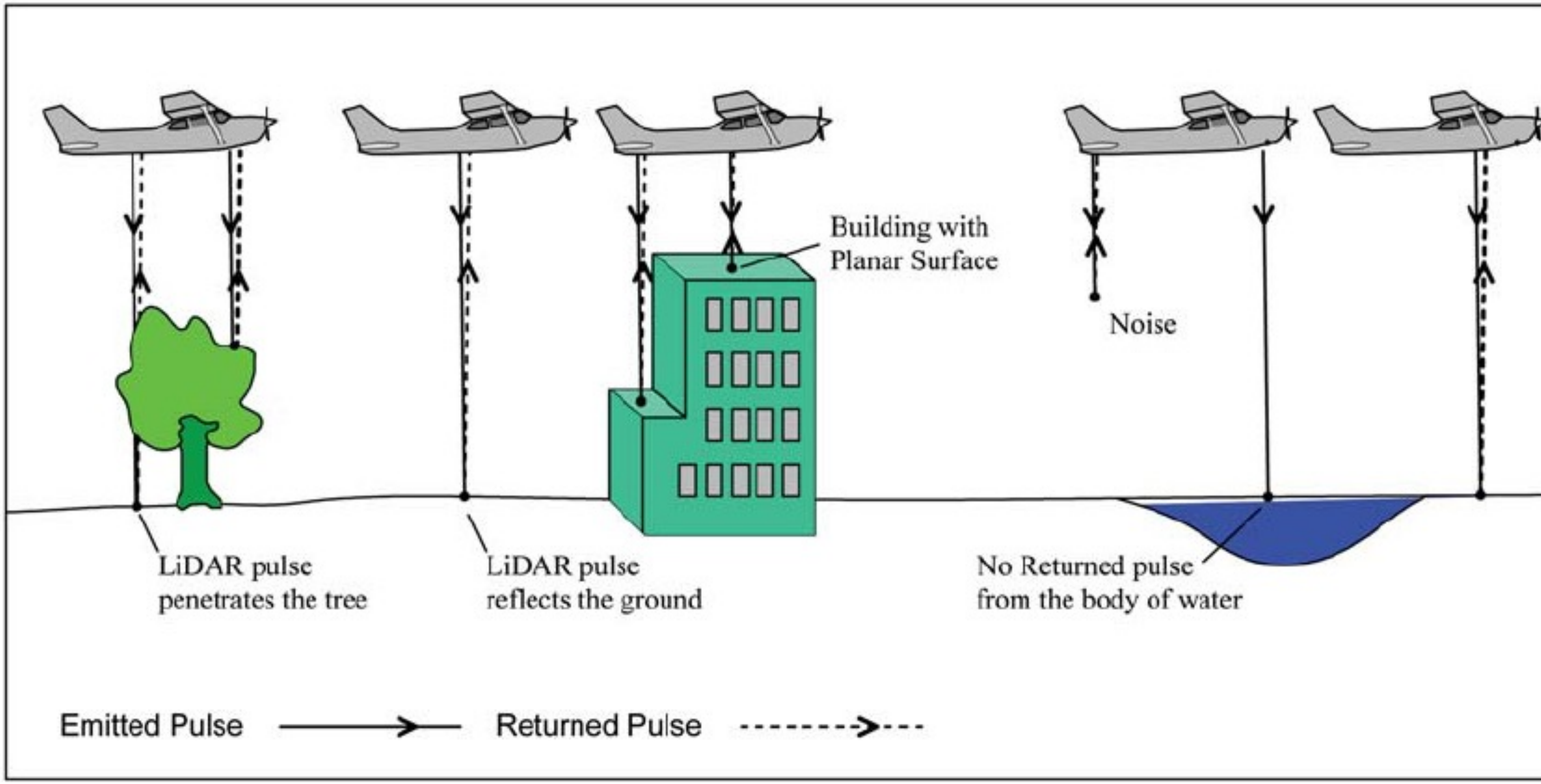
LiDAR point data colored by height



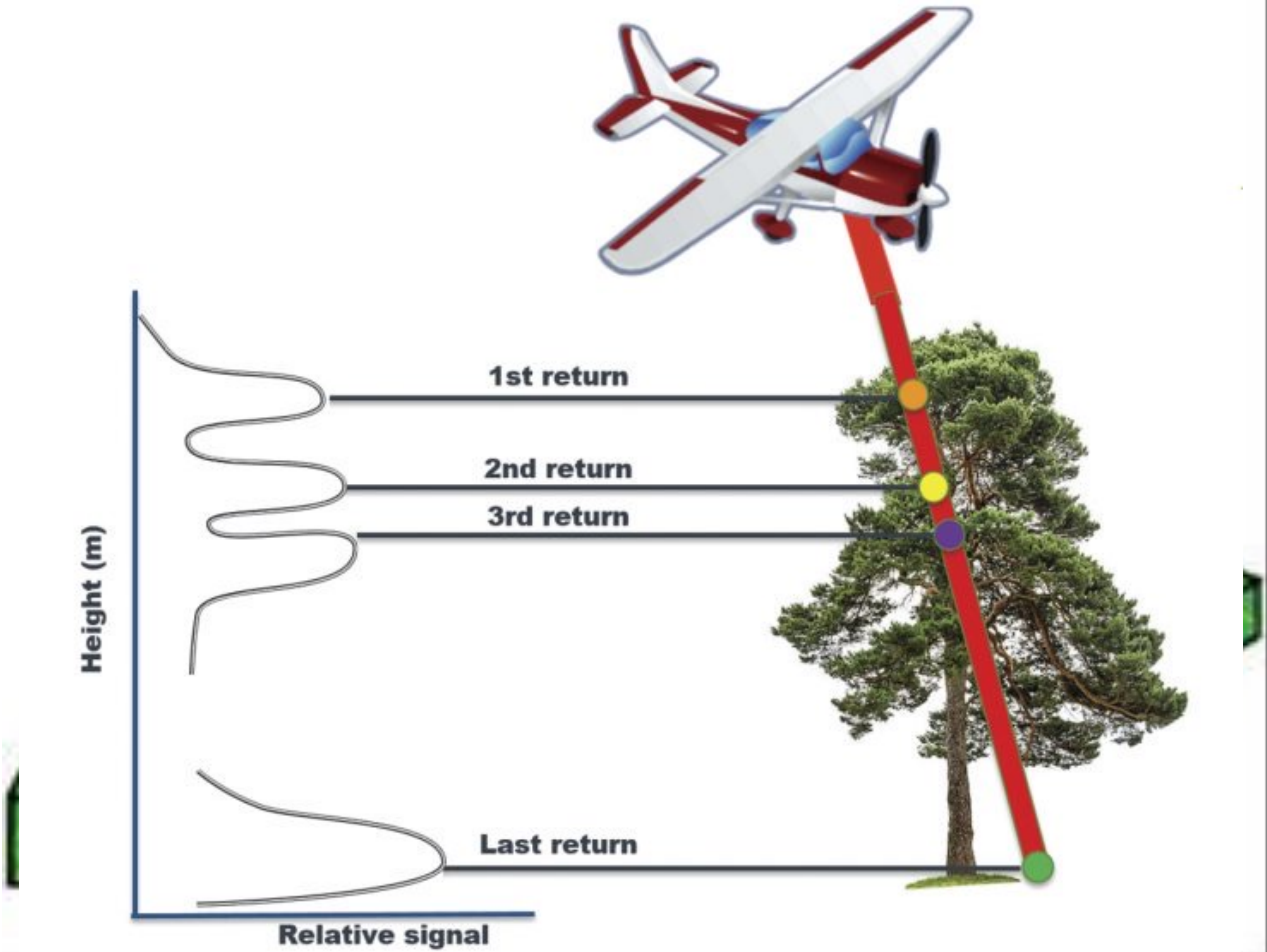


* *components can be sources of error…more on this in Part II*

Figures from McMcGaughey
USDA Forest Service--PNW Research Station

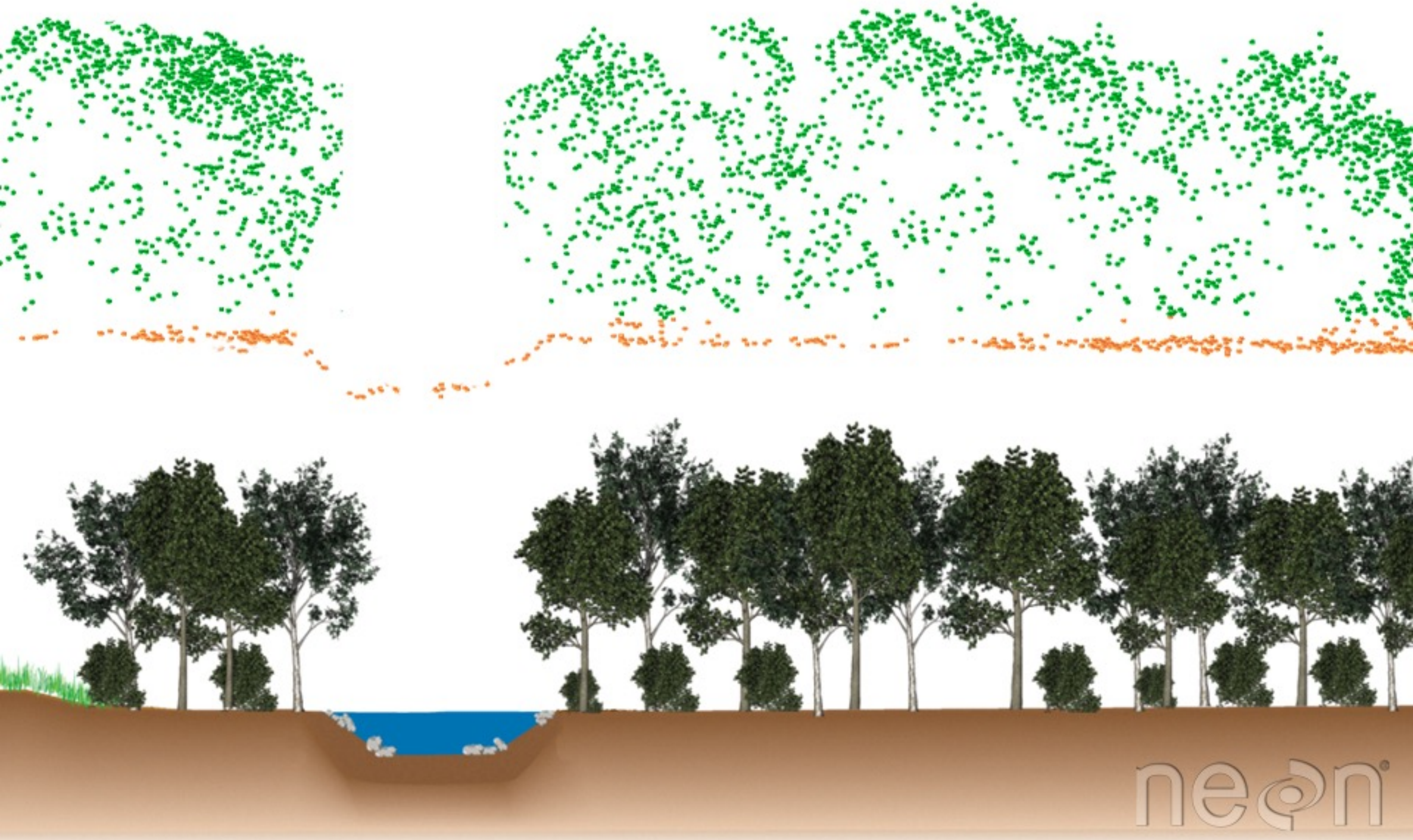


Distance = (Speed of Light x Time of Flight) / 2


1st return
2nd return
3rd return
Last return
Height (m)
Relative signal


neon

TREE STRUCTURE

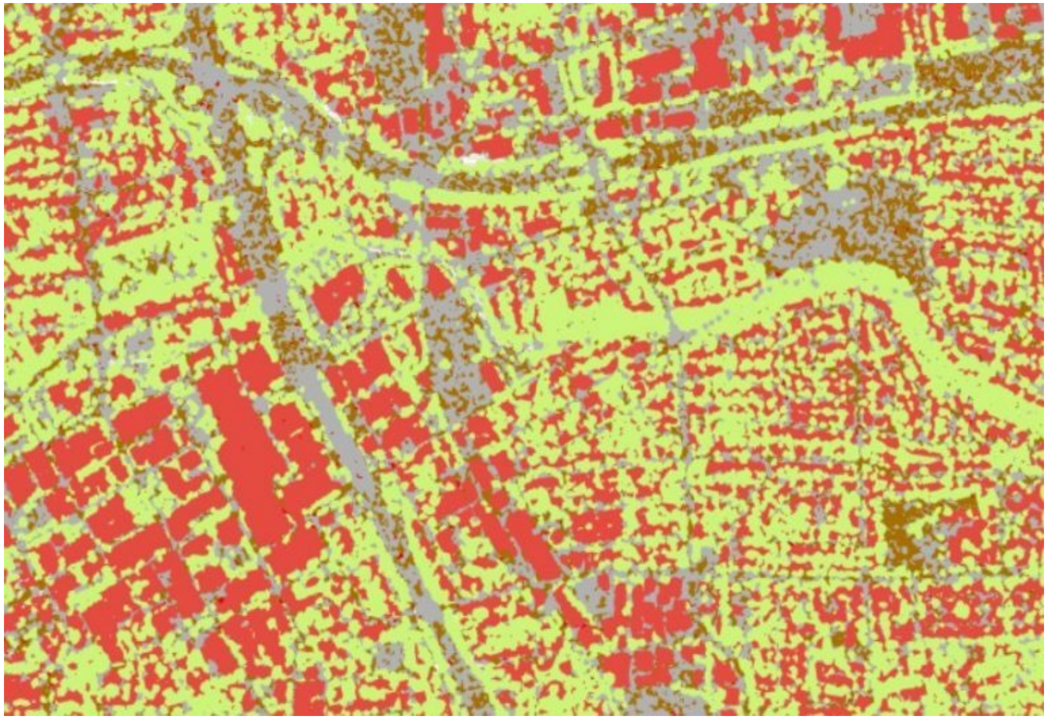


LIDAR APPLICATIONS tree structure and height

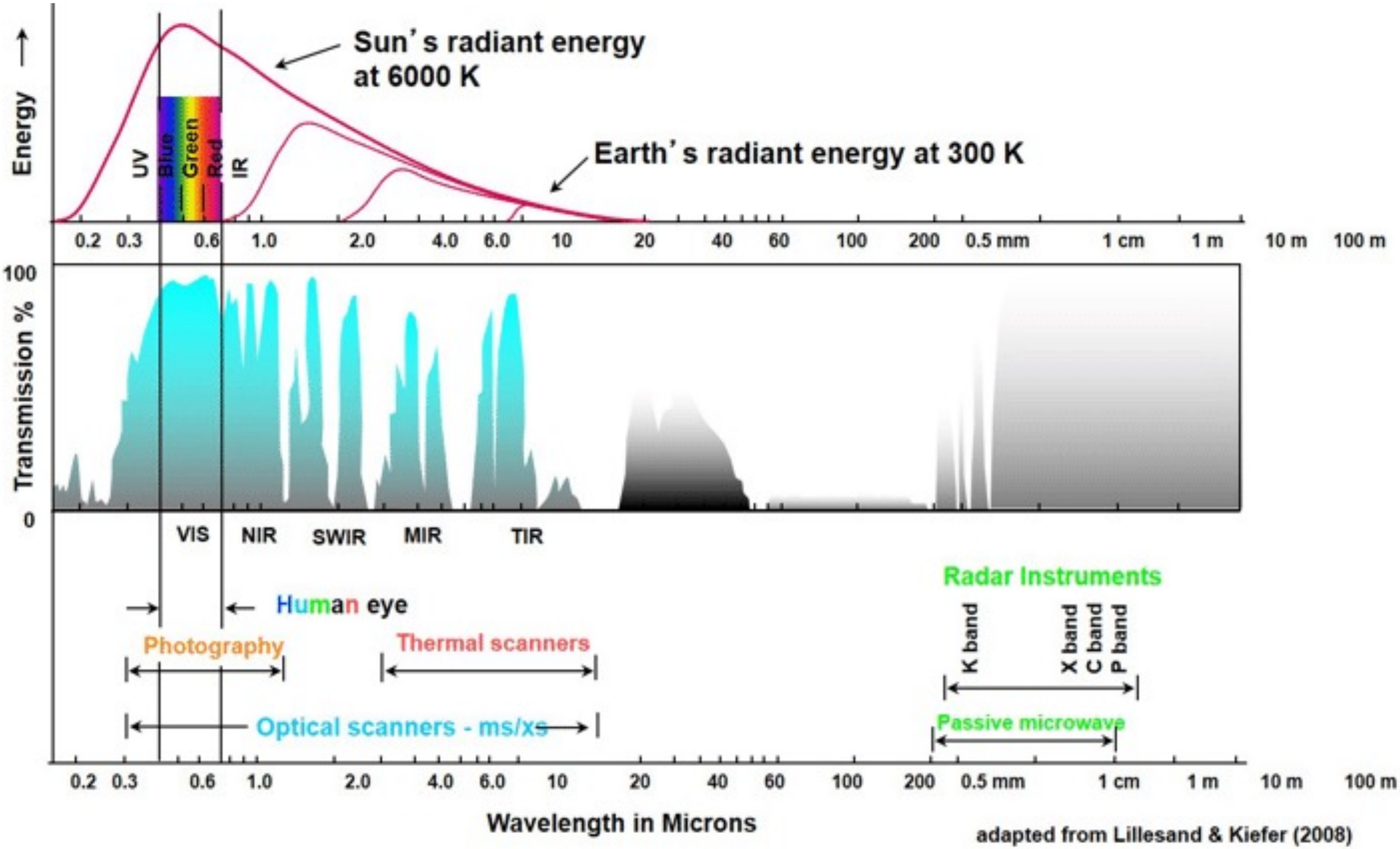
digital elevation models.

Land cover

topographic contours,i



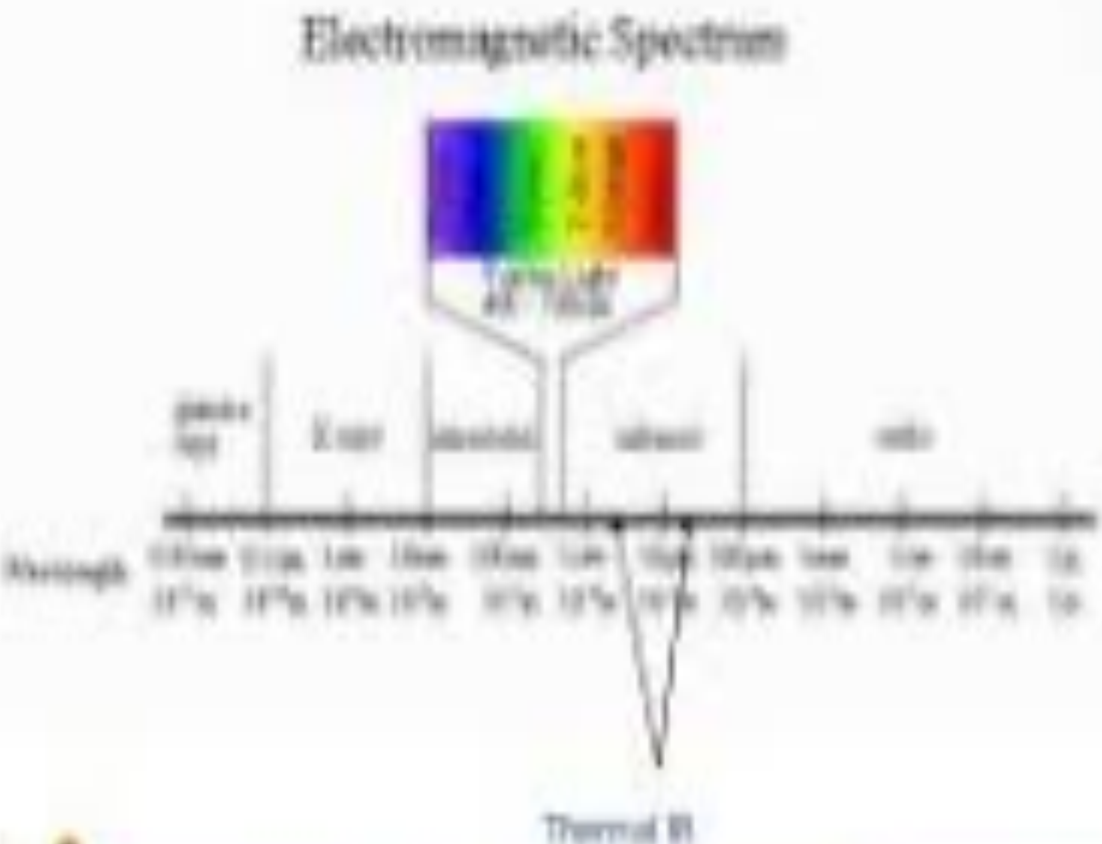
Atmospheric gases (industrial poluutants So2, No2,etc) , aerosol, land surface



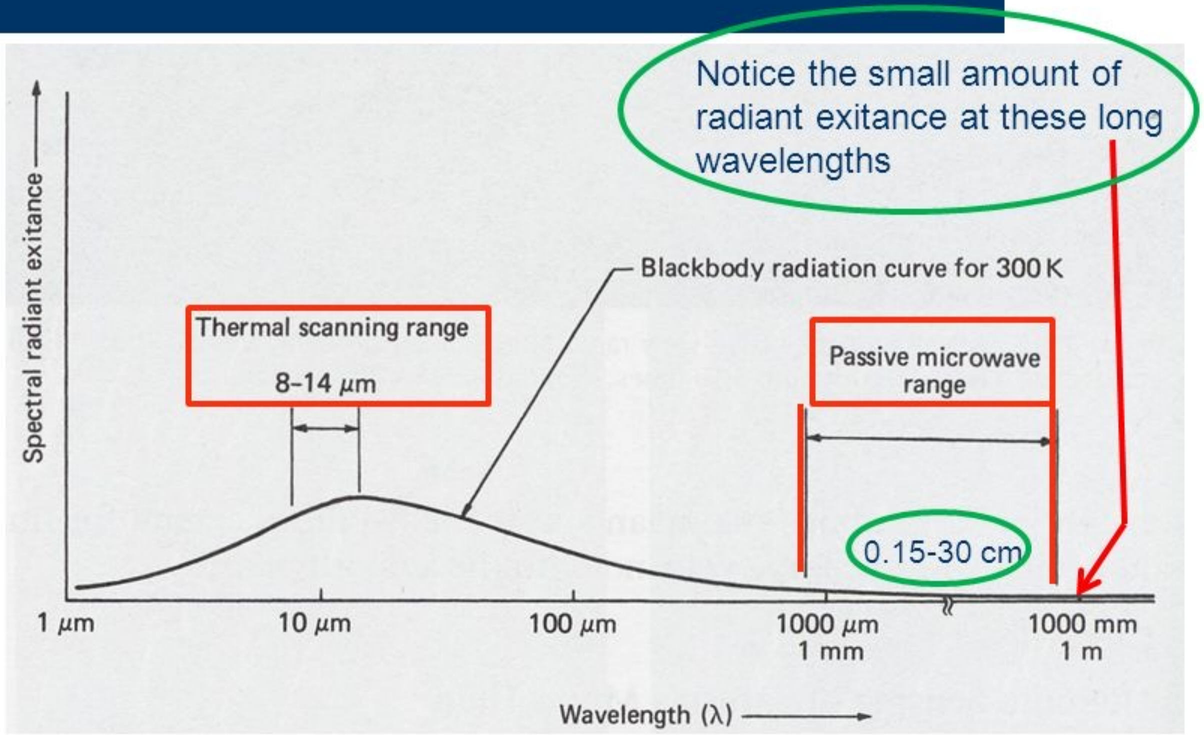
Sun's radiant energy at 6000 K
Earth's radiant energy at 300 K
Energy
UV
Blue
Green
Red
IR
0.2
0.3
0.6
1.0
2.0
4.0
6.0
10
20
40
60
100
200
0.5 mm
1 cm
1 m
10 m
100 m
Transmission %
100
0
VIS
NIR
SWIR
MIR
TIR
Radar Instruments
K band
X band
C band
P band
Human eye
Photography
Thermal scanners
Optical scanners - ms/xs
Passive microwave
Wavelength in Microns
adapted from Lillesand & Kiefer (2008)

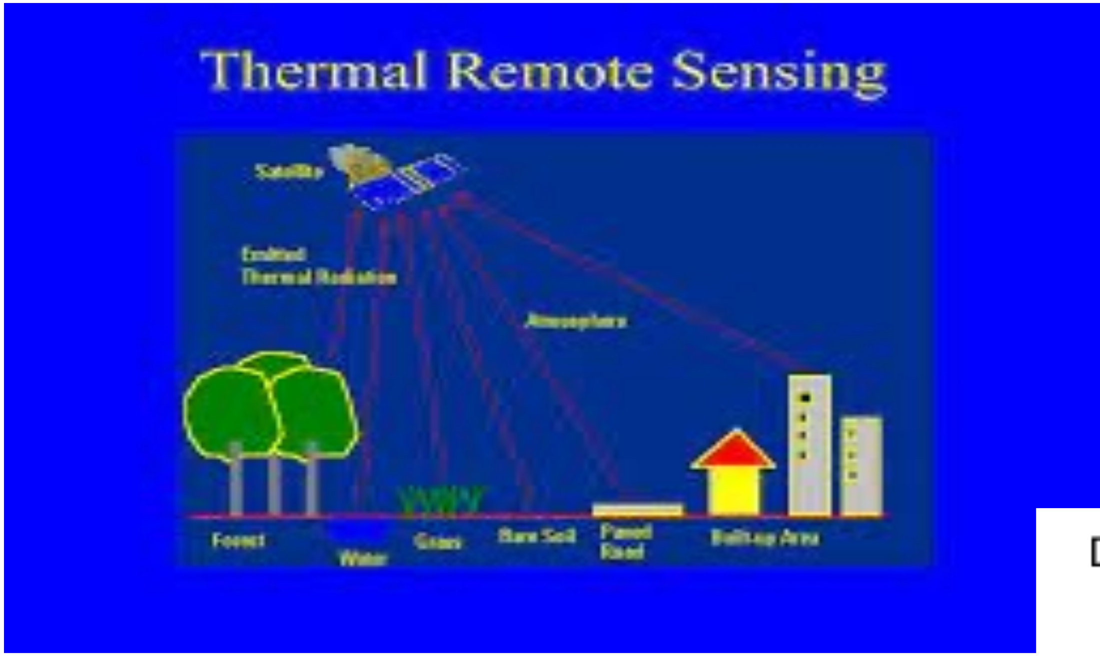
Thermal Infrared Spectrum:

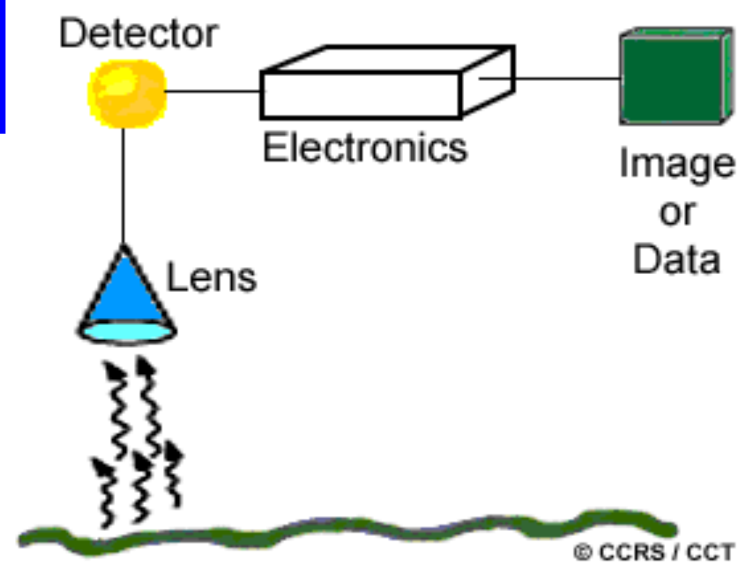
- Near IR: 0.7-1.3 µm
- Mid IR: 1.3 - 3.0 µm
- Thermal IR: 3 - 14 µm



Wavelength Range for Passive Microwave

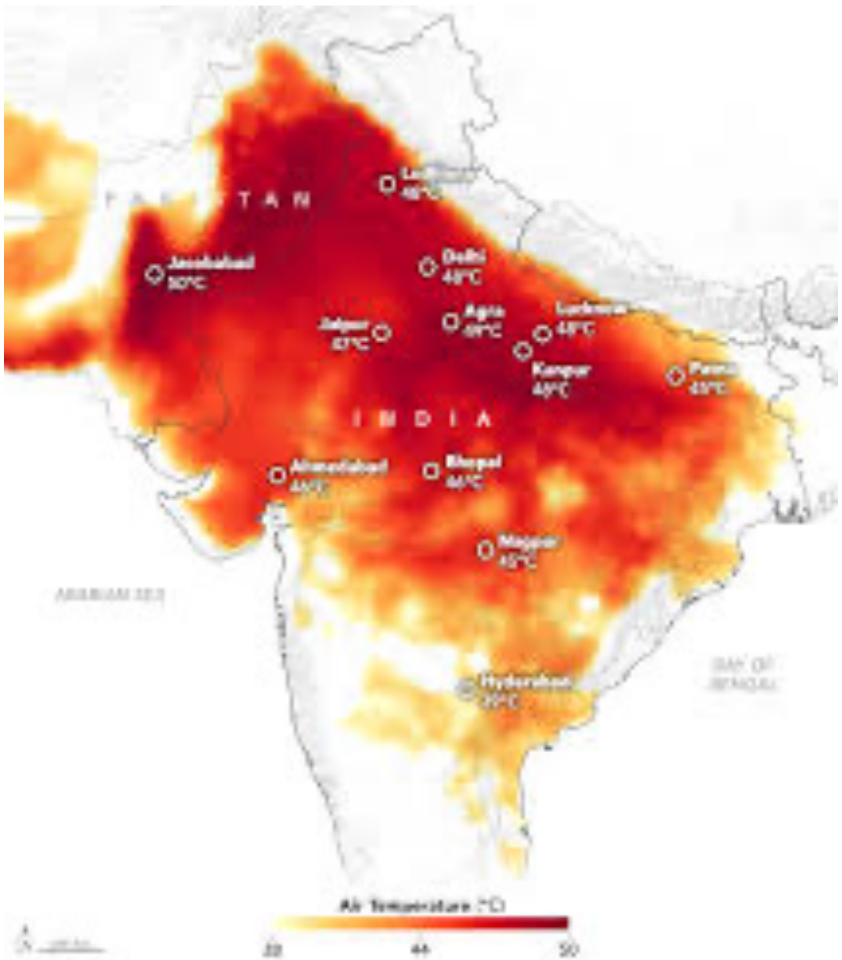




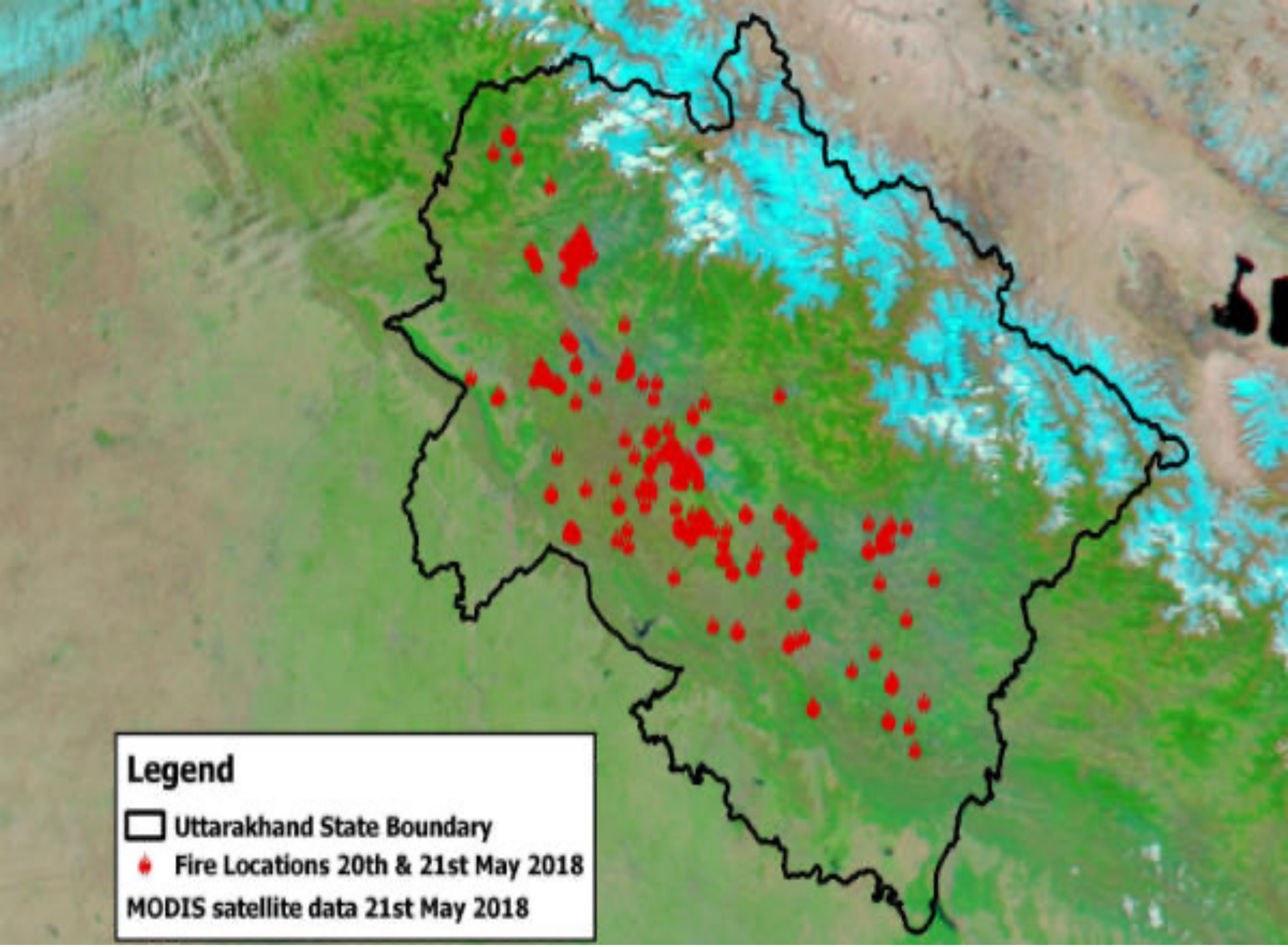


A *bolometer* is a device for measuring radiant heat by means of a material having a temperature-dependent electrical resistance
It absorbs radiation by which its temp increases

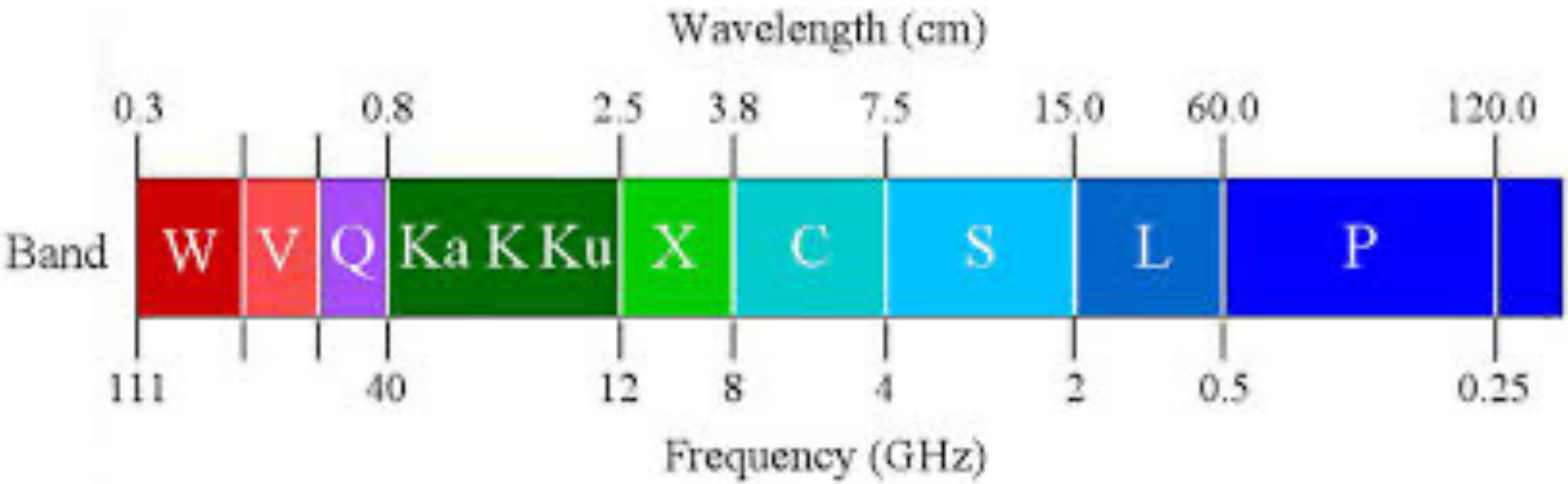
Heat wave



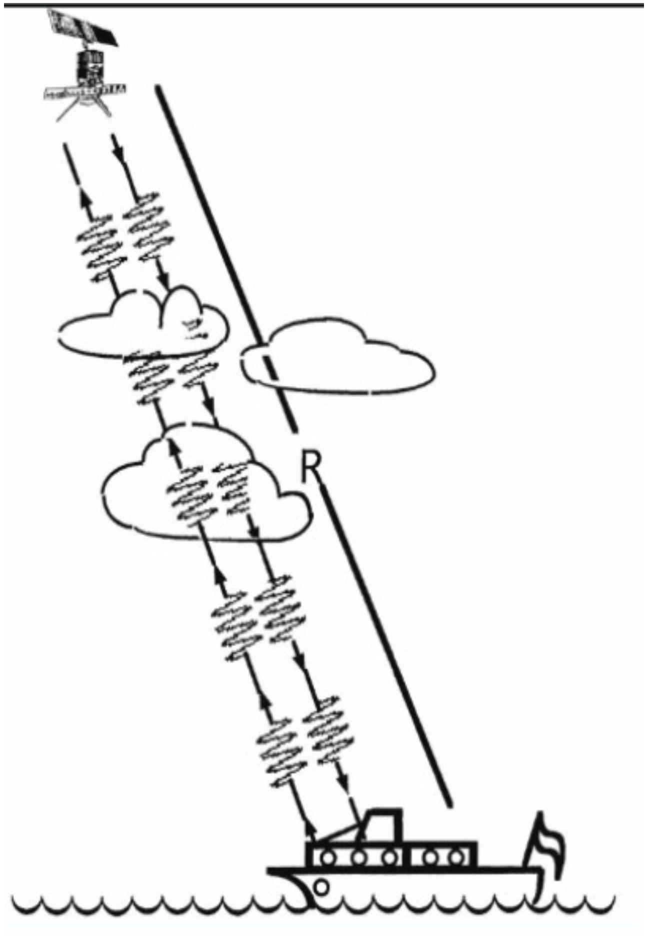
Jacobabad
50°C
Delhi
Agra
Jaipur
Lucknow
Kanpur
INDIA
Ahmedabad
Bhopal
Nagpur
Hyderabad
Air Temperature (°C)
44
50

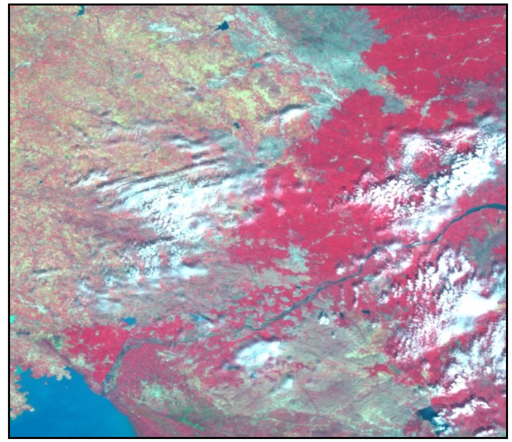

Legend
Uttarakhand State Boundary
Fire Locations 20th & 21st May 2018
MODIS satellite data 21st May 2018

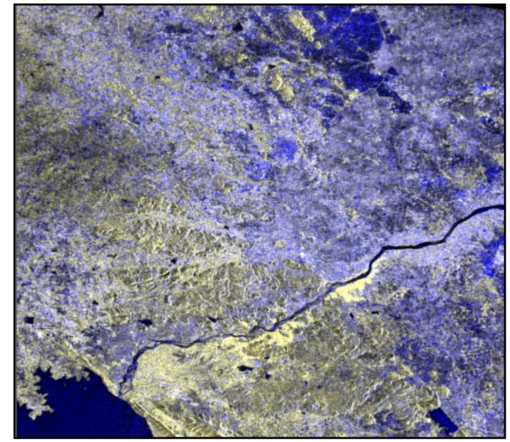
MICROWAVE SENSORS

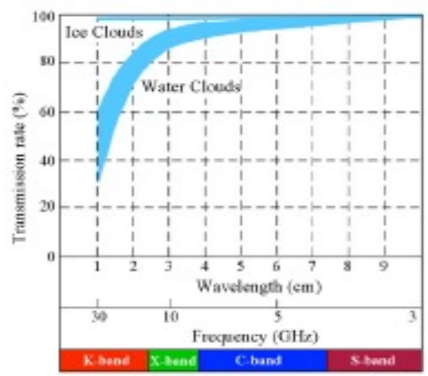

Wavelength (cm)
0.3
0.8
2.5
3.8
7.5
15.0
60.0
120.0
Band
W
V
Q
Ka K Ku
X
C
S
L
P
111
40
12
8
4
2
0.5
0.25
Frequency (GHz)

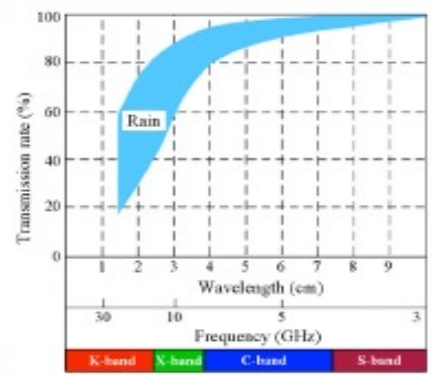
Why- IMAGING UNDER CLOUDY CONDITION







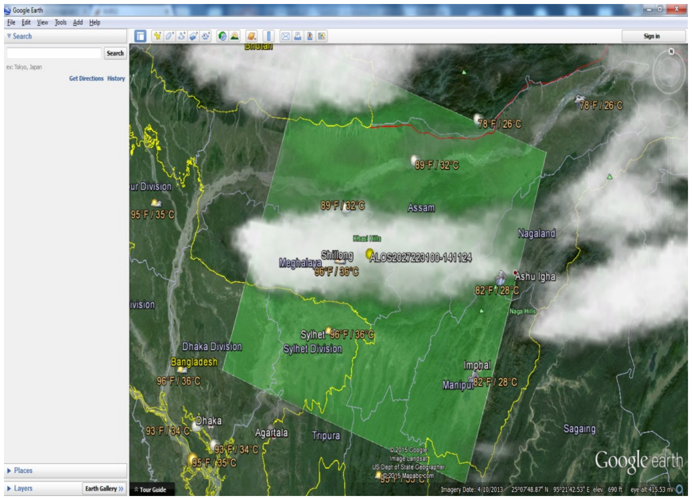




Data consistency

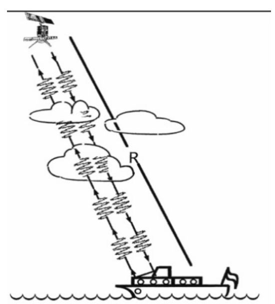
Temporal data

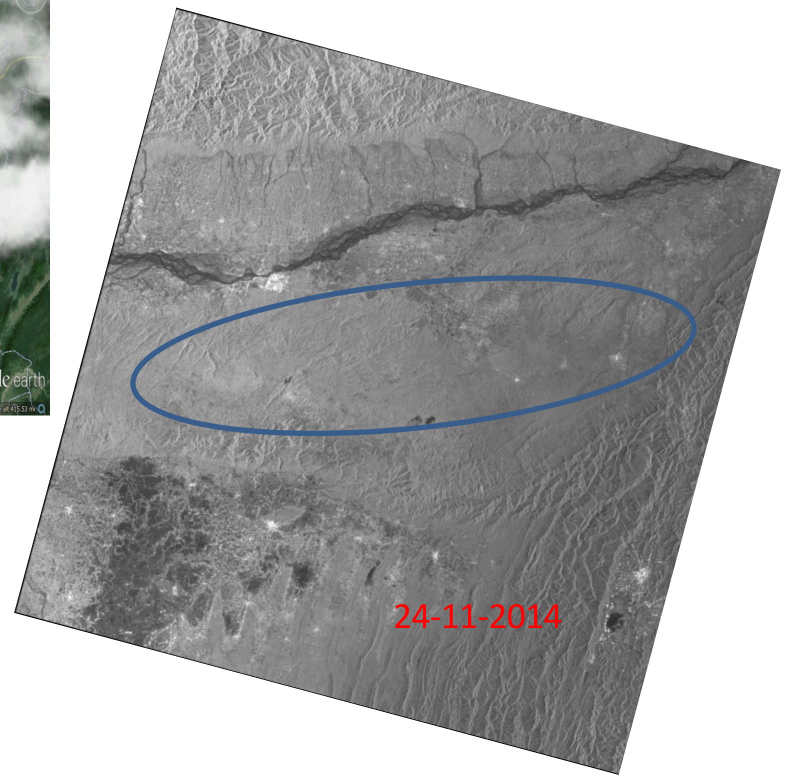
Penetration:



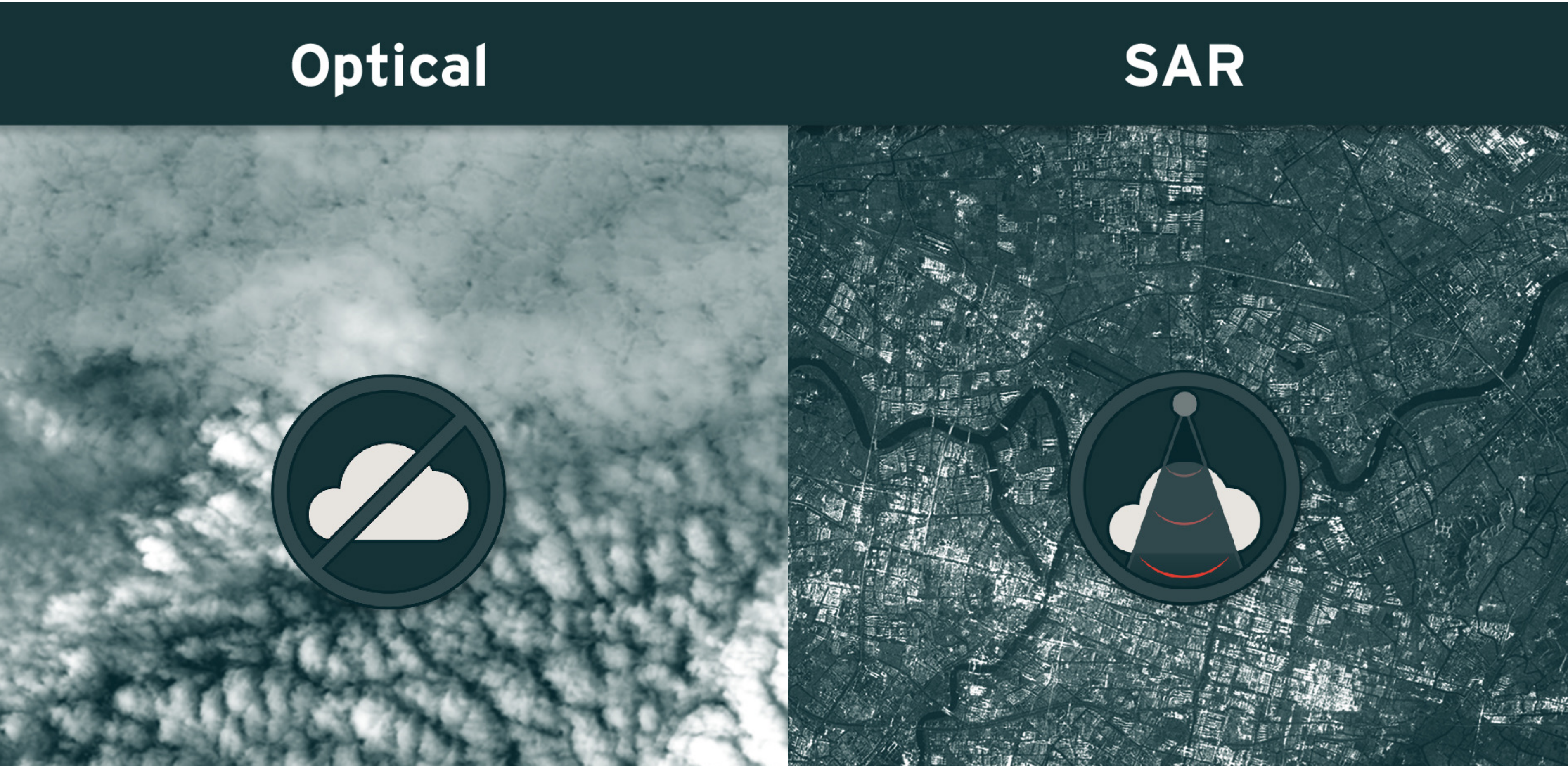
ALOS2027223100-141124

Satellite	ALOS2
Sensor	PALSAR-2
Scene ID	ALOS2027223100-141124
Product ID	WBDR1.5RUD
Observation Date	2014-11-24
Path No	44
Frame(center)	3100
SceneShift	0
Offnadir Angle	45.2
Scene Time(Center)	05:46:45.086
Scene Time(Start)	05:46:19.087
Scene Time(End)	05:47:11.085
Lat/Long(center)	25.678/92.301
Lat/Long(Left Upper)	27.507/91.073
Lat/Long(Right Upper)	26.938/94.601
Lat/Long(Left Lower)	24.329/90.478
Lat/Long(Right Lower)	23.753/93.909

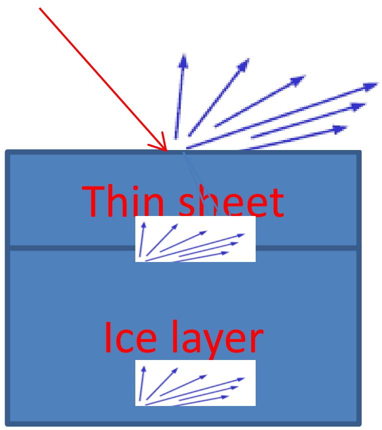


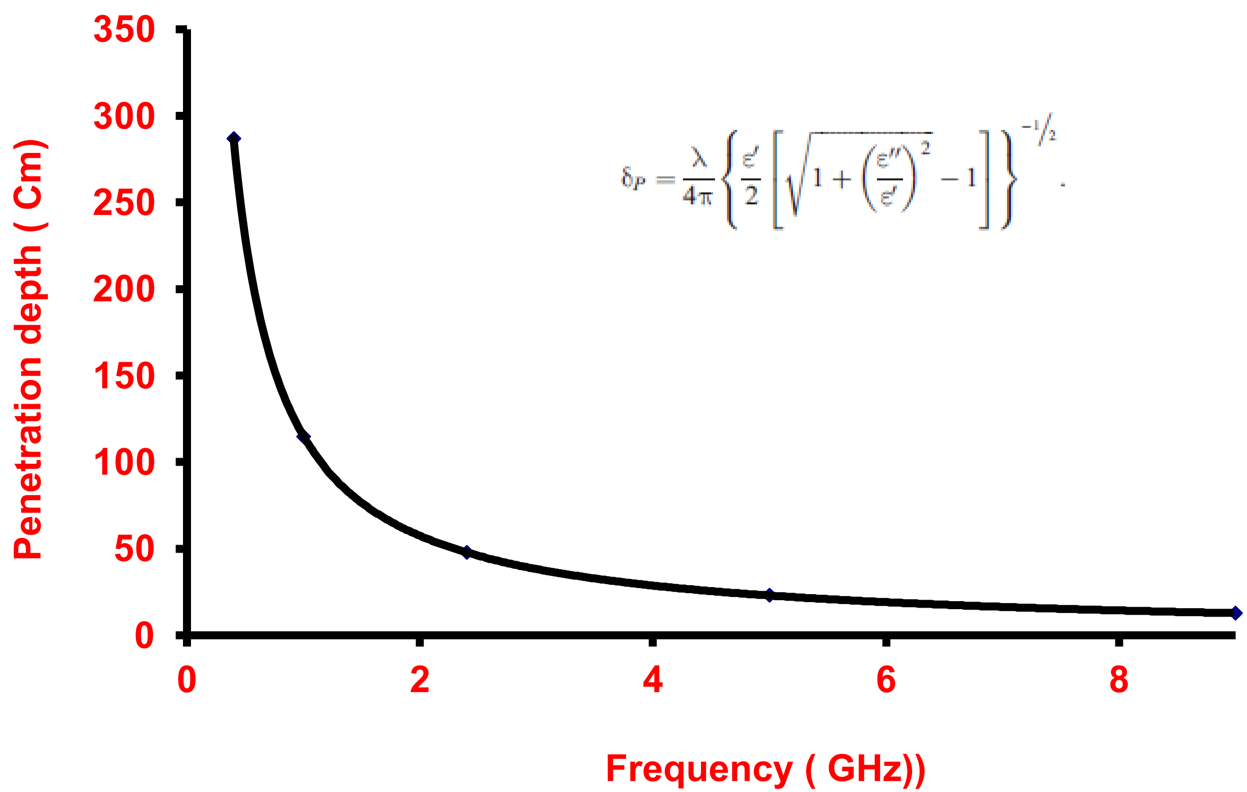


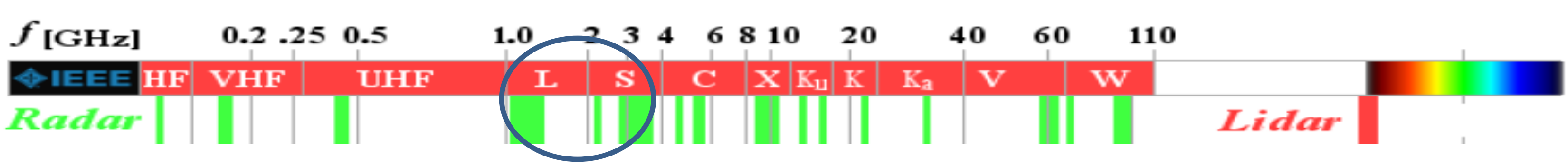
Helps in long term data set

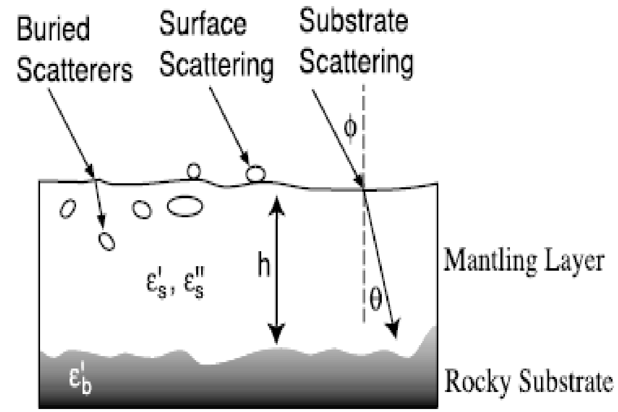

Optical
SAR

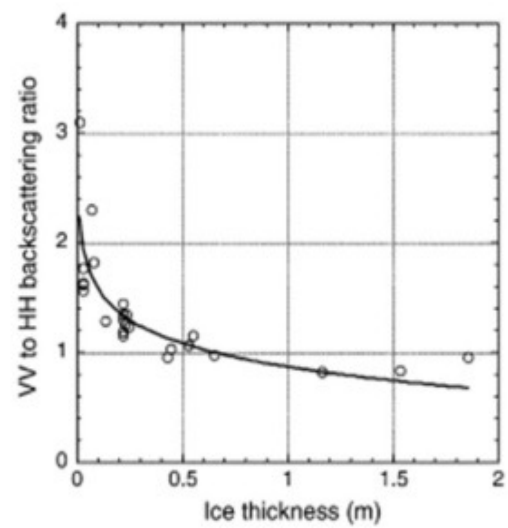
Penetration capability;



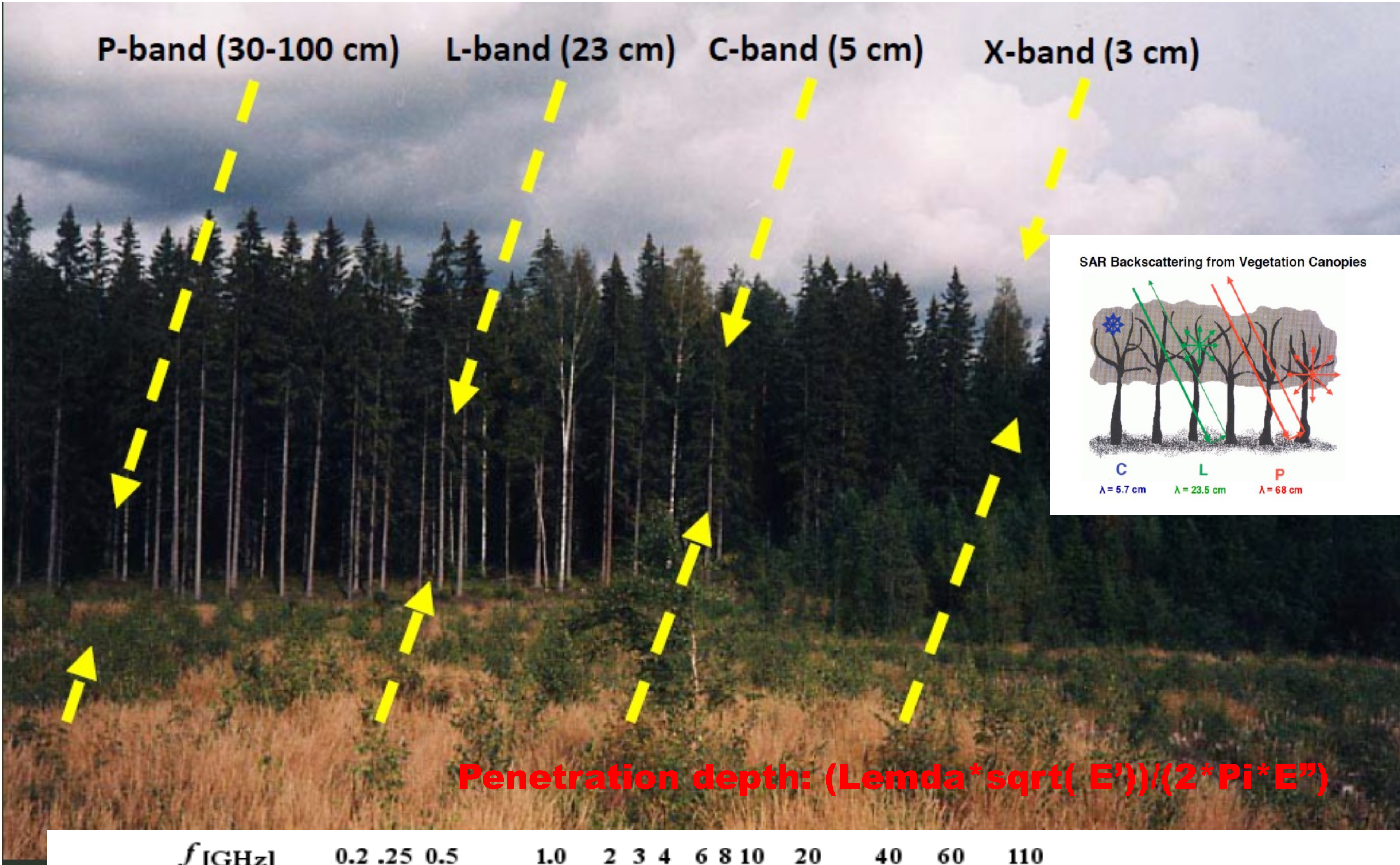





Buried Scatterers
Surface Scattering
Substrate Scattering
ϕ
h
ε'_s, ε''_s
θ
Mantling Layer
ε'_b
Rocky Substrate

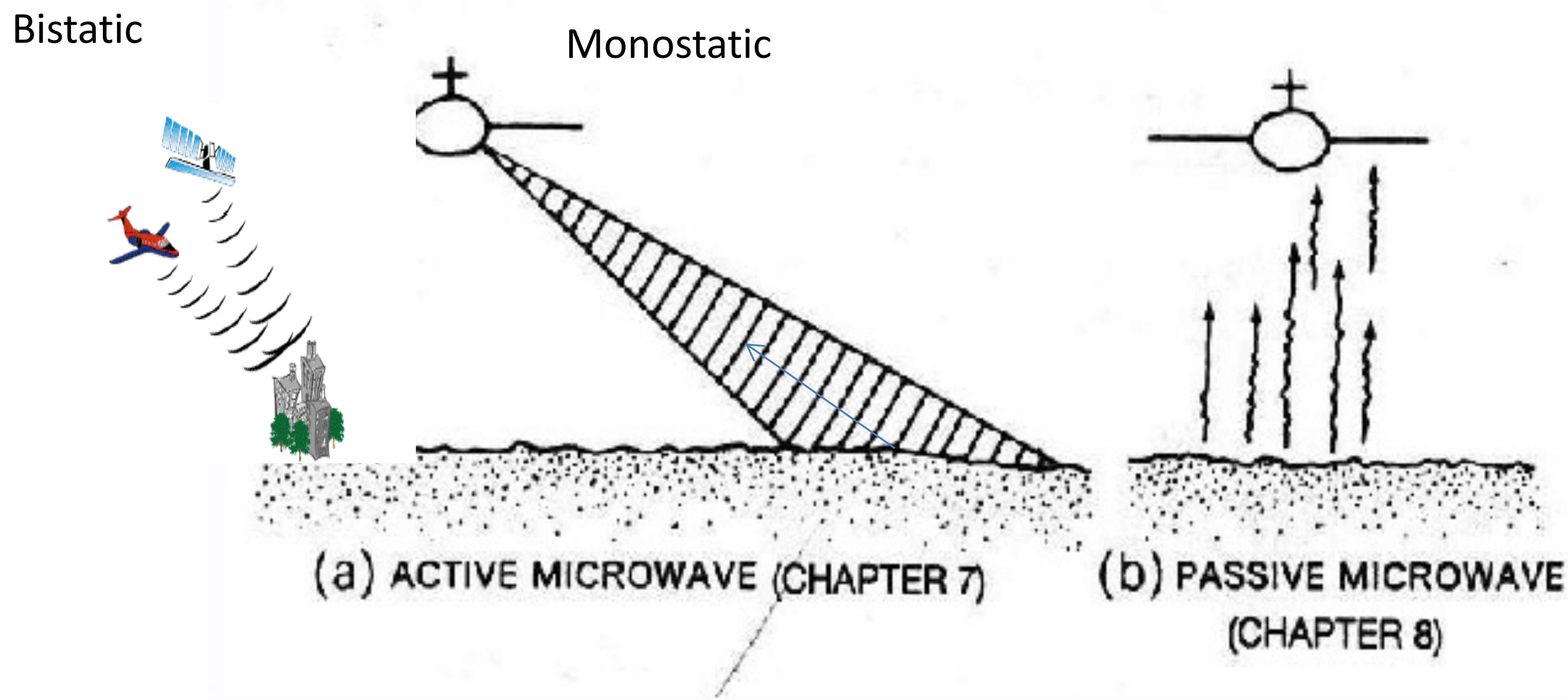

VV to HH backscattering ratio
Ice thickness (m)
0
1
2
3
4
0
0.5
1
1.5
2

INTERACTION WITH DIFFERENT PART OF VEGETATION



Commonly Used Frequency Bands

Frequency band	*Frequency range*	*Application Example*
• VHF	300 KHz - 300 MHz	Foliage/Ground penetration, biomass
• P-Band	300 MHz - 1 GHz	biomass, soil moisture, penetration
• L-Band	1 GHz - 2 GHz	agriculture, forestry, soil moisture
• C-Band	4 GHz - 8 GHz	ocean, agriculture
• X-Band	8 GHz - 12 GHz	agriculture, ocean, high resolution radar
• Ku-Band	14 GHz - 18 GHz	glaciology (snow cover mapping)
• Ka-Band	27 GHz - 47 GHz	high resolution radars



Active and Passive microwave remote sensing. (a). Active microwave Sensing, (b) Passive microwave sensing

ACTIVE => **RADAR* (SLAR/SAR, SCATTEROMETER, ALTIMETER)**
PASSIVE=> **RADIOMETER**

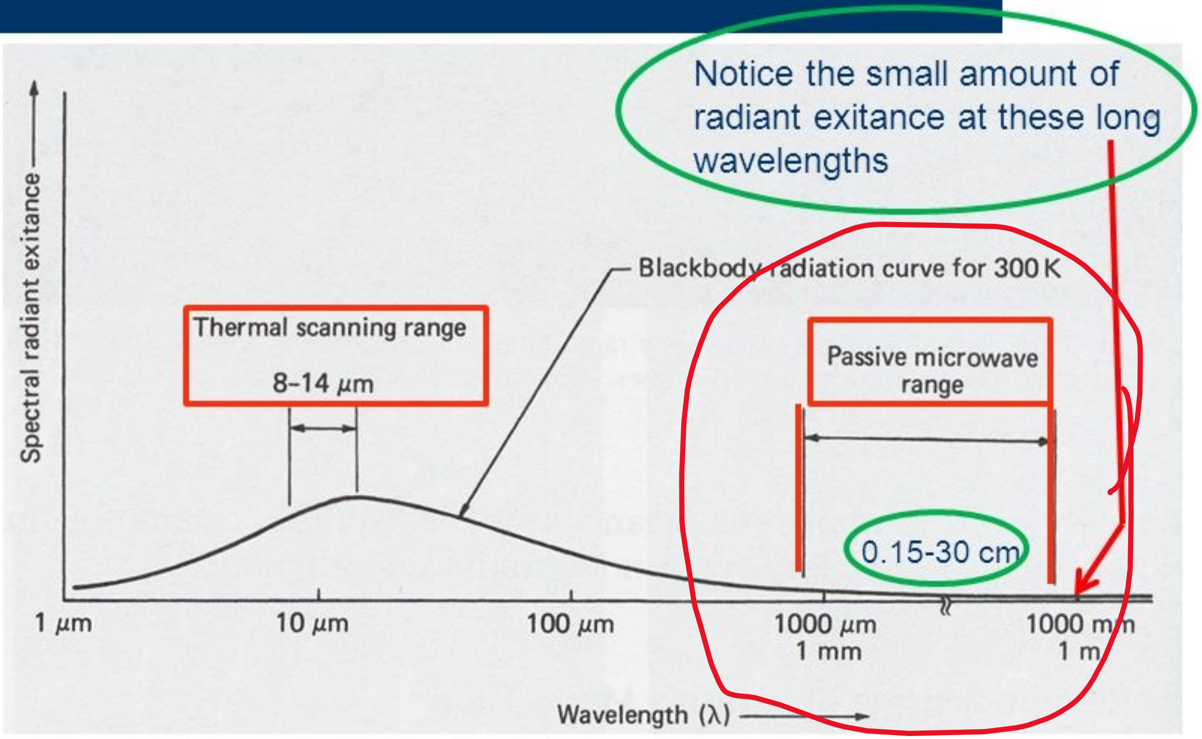
ACTIVE- MODE OF OPERATION: **BISTATIC MODE, MONOSTATIC MODE**

TODAYS CONTEXT: **MONOSTATIC MODE ONLY**

- *Acronym: RAdio Detection And Ranging

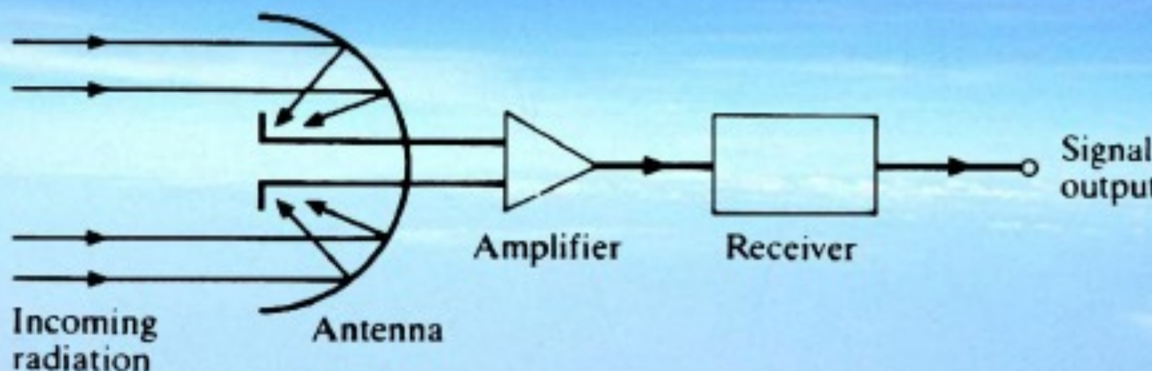
STRATIGN

Wavelength Range for Passive Microwave



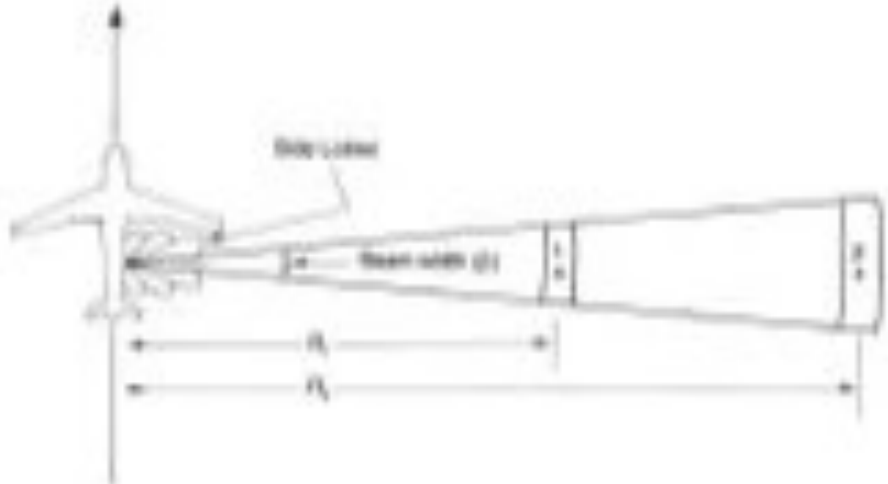
Passive Microwave Radiometry

- Passive microwave sensors use an antenna to detect photons which are then converted to voltages in a circuit



- Scanning microwave radiometers
  - mechanical rotation of antenna,
  - fixed antenna and oscillating mirror
  - fixed parabolic and oscillating antenna

Spatial Resolution



Azimuth resolution. *For real aperture radar, the ability of the system to acquire fine detail in the along-track axis derives from its ability to focus the radar beam to illuminate a small area.*

Beam width, in relation to range (R), determines detail—region 1 at range R_1 will be imaged in greater detail than region 2 at greater range R_2

The most common form of **imaging active microwave sensors is RADAR**

Non-imaging microwave sensors include **Altimeters** and **scatterometers.**

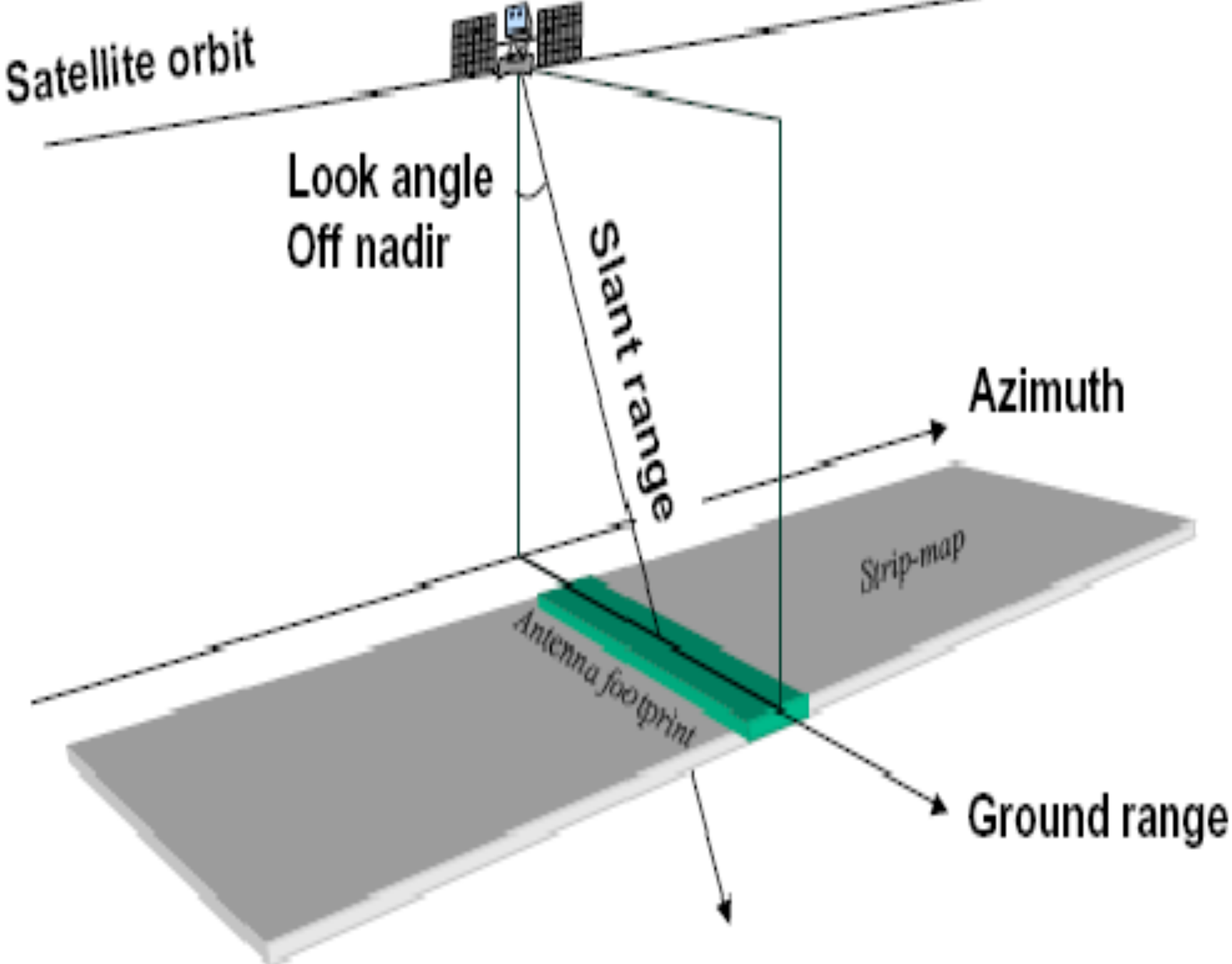
imaging radars (side-looking) used to acquire images (~1m - 1km)

altimeters (nadir-looking) to derive **surface height variations**

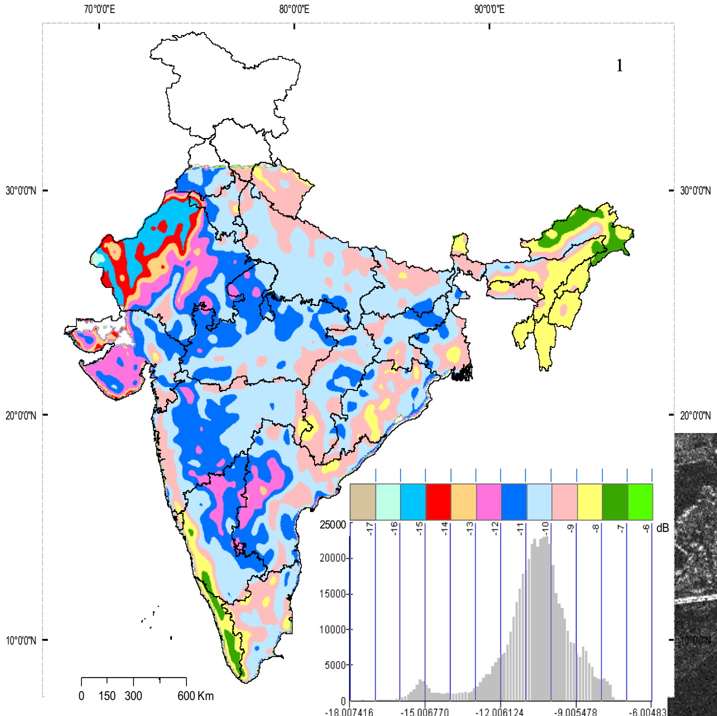
scatterometers to derive **reflectivity** as a function of incident angle, illumination direction, polarisation, etc

http://ecoursesonline.iasri.res.in/mod/page/view.php?id=124951

Sensor	SAR	Multi-Spectral
Classification basis	Backscatter coefficient	Illumination reflectance
Primary sensing factor	Surface roughness Surface dielectric property	Bands' reflectance differences Imagery calibration
Possible noise source	Winds, flooding, soil moisture, vegetation, ice, and snow cover	Cloud, mist, floating vegetation, turbidity, highly eutrophicated waters, high sediment load, ice, and snow cover
Advantage	All-weather and illumination-independent sensing ability Cloud penetration	Straightforward to interpret The abundance of openly accessible sensors and images less sensitive to soil moisture and usable during wet season
Disadvantage	Affected by wind, flooding, soil moisture	Affected by cloud and illumination conditions



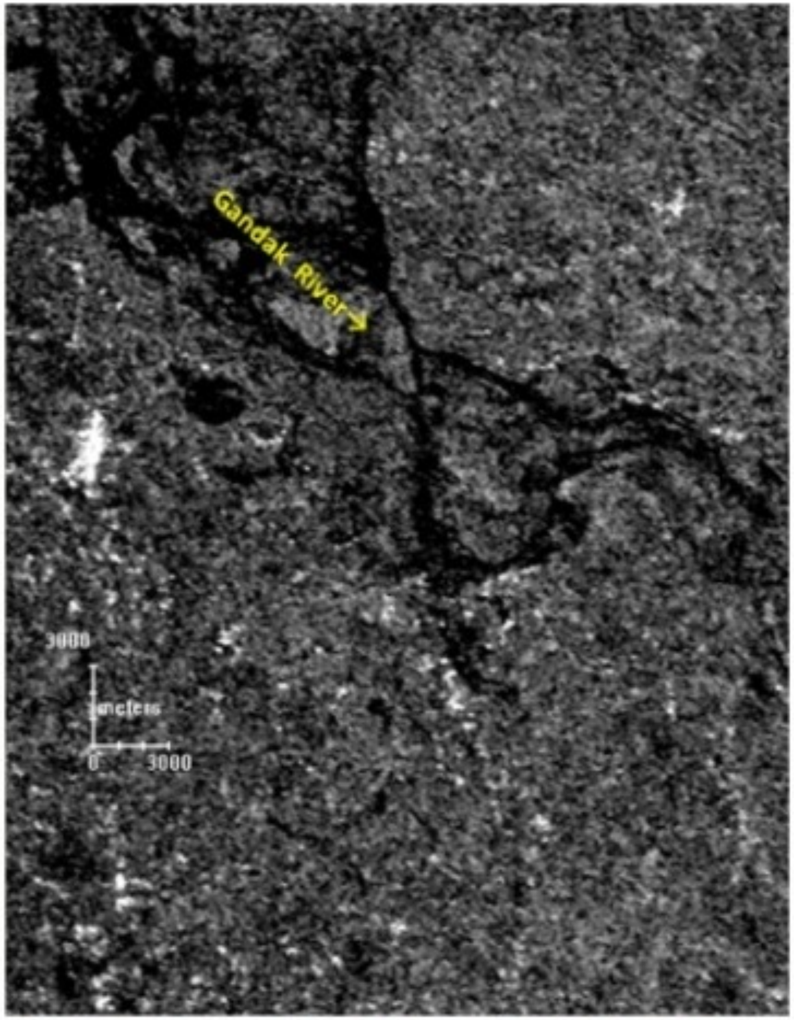
https://crisp.nus.edu.sg/~research/tutorial/mw.htm



Response to surface material properties

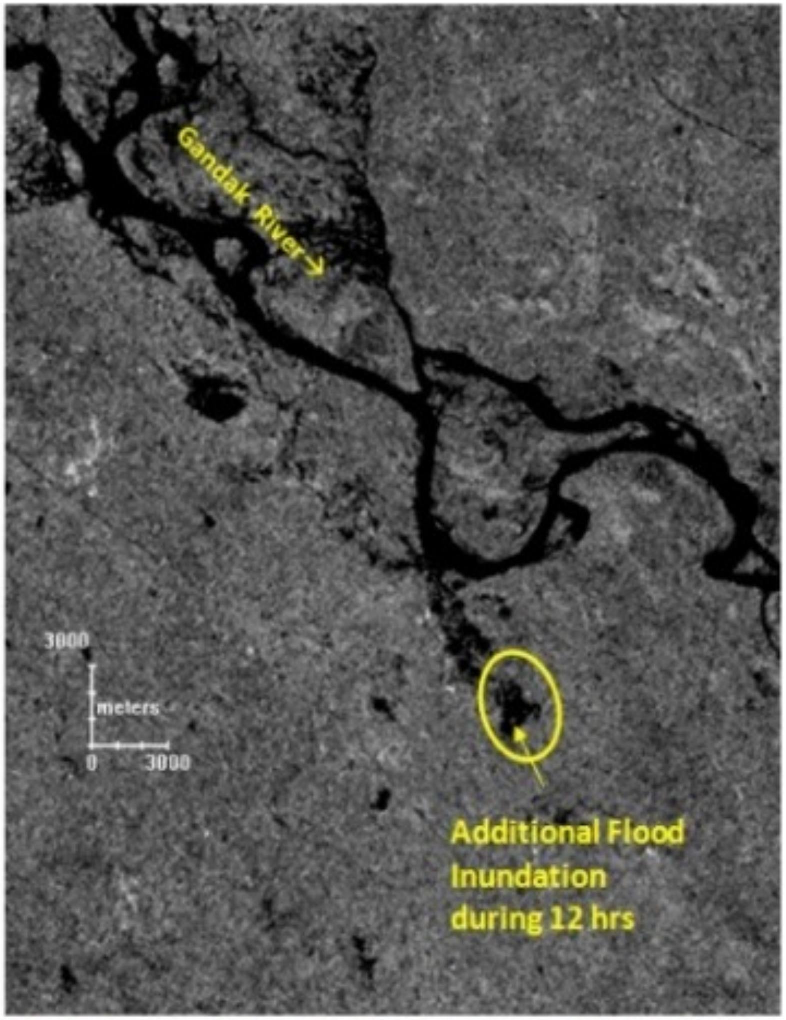
Sliced image map of ERS-2,
C – band Sigma-0 at 40^{o} of incidence angle.

Morning



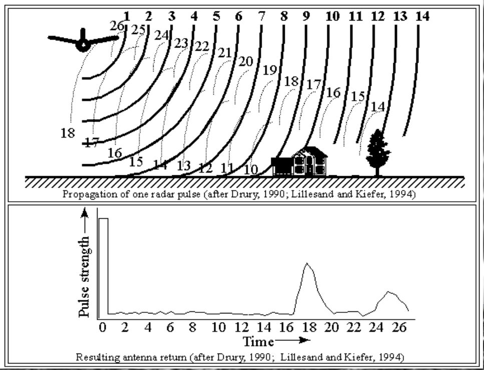
RADARSAT Microwave Image of 20-September-2010 at 6.00 A.M

Evening

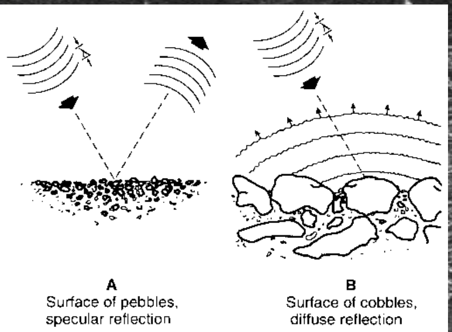


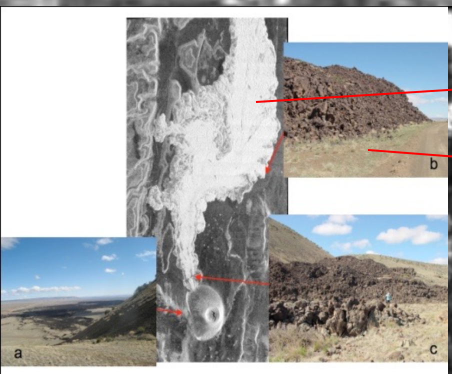
RADARSAT Microwave Image of 20-September-2010 at 6.00 P.M

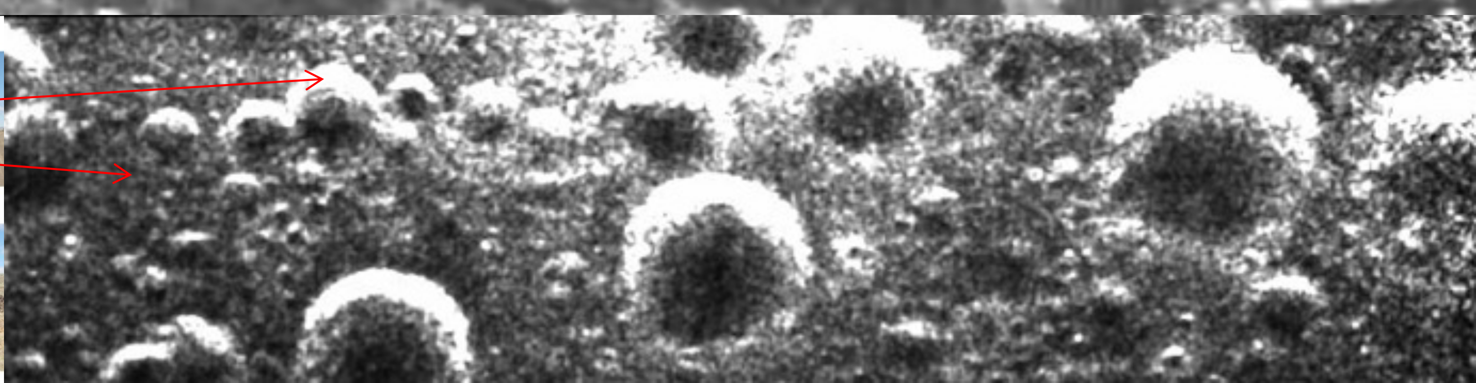
North Bihar: Gopal ganj – 20-9-2010



- Connect to Industry
- Connect to Global Experts
- Knowledge dissemination
- Virtual laboratory
- Participation in International Program
- Members benefit







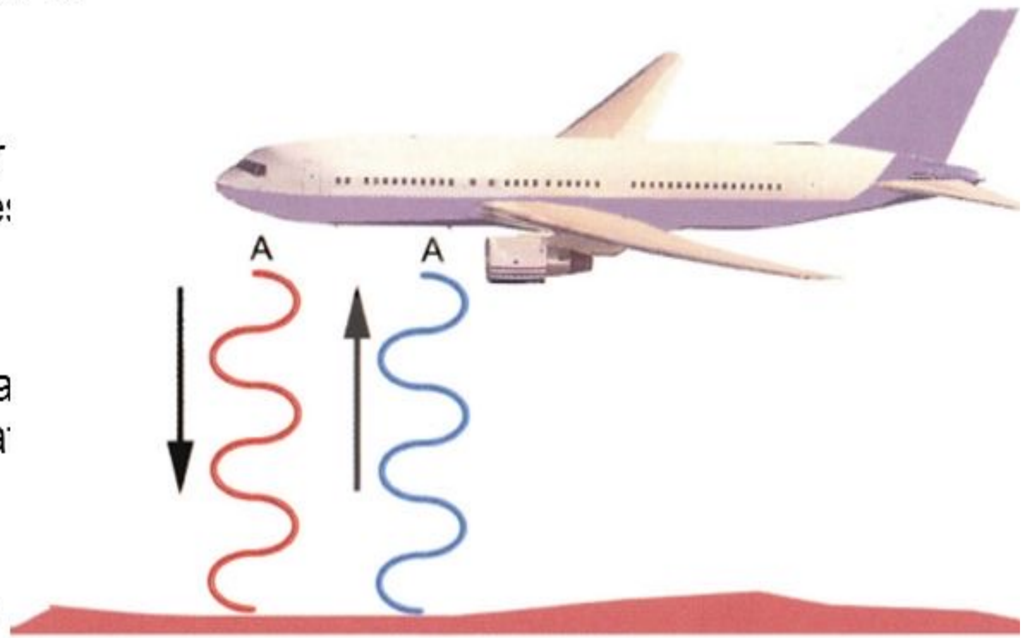
Radio Altimeter Operation

The airplane is shown over a point on the ground.

At this instant, the radar altimeter transmitting the carrier at its lowe frequency (A).

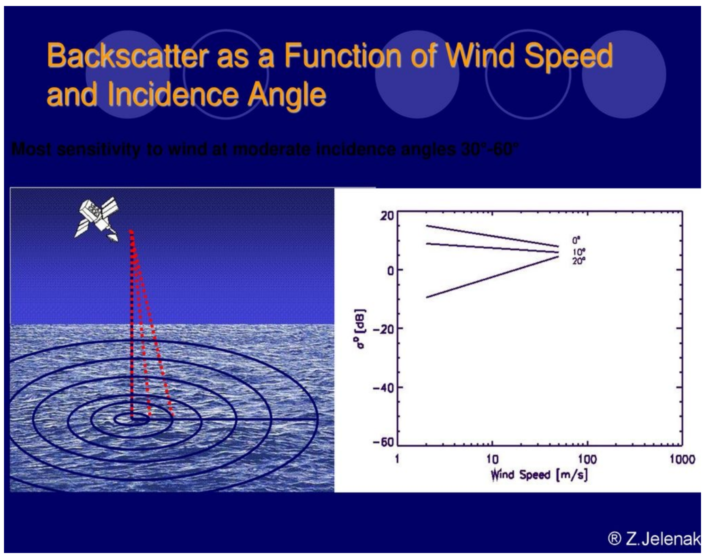
The signal travels to the ground a is reflected back to the airplane a same frequency (A).

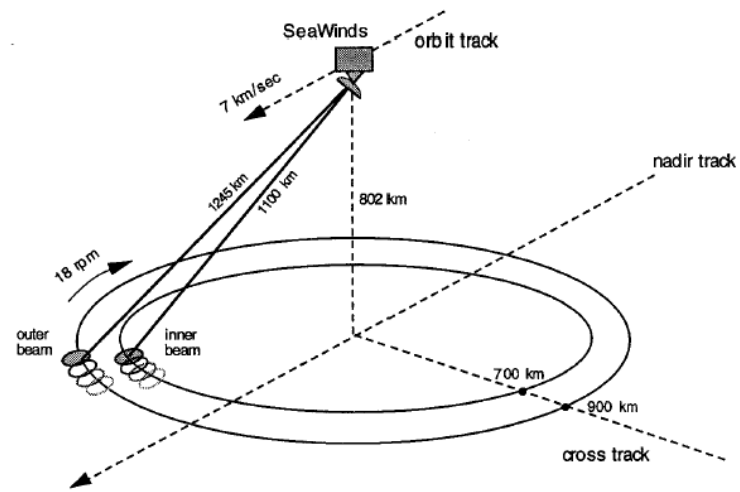
The returning signal reaches the airplane after an interval of time, the number of microseconds it takes for the round trip.

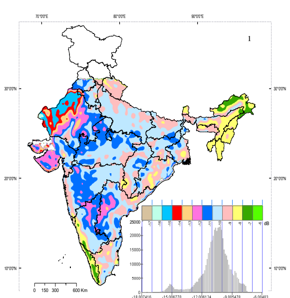


$$\text{Delay} = \frac{2 * \text{altitude}}{\text{Speed-of-light}}$$

A scatterometer is a microwave radar sensor used to measure the reflection or scattering effect produced while scanning the surface of the earth from an aircraft or a satellite.







- Agriculture. Differences in surface roughness are indicative of field ploughing, soil tillage, and crop harvesting.
- Floods. ...
- Land subsidence. ...
- Snow cover. ...
- Wildfires. ...
- Wetlands.

MAJOR ADVANTAGE: PENERATION THROUGH CLOUDS

Question bank

1. **Explain working principle of Lidar**
2. **What are advantages of Thermal remote sensing**
3. **What are advantages of microwave remote sensing**