Introduction of Spectroradiometer and Determination of Spectral Reflectance of different ground features

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2018

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Part 1:

- Introduction of EM Waves, Spectroscopy

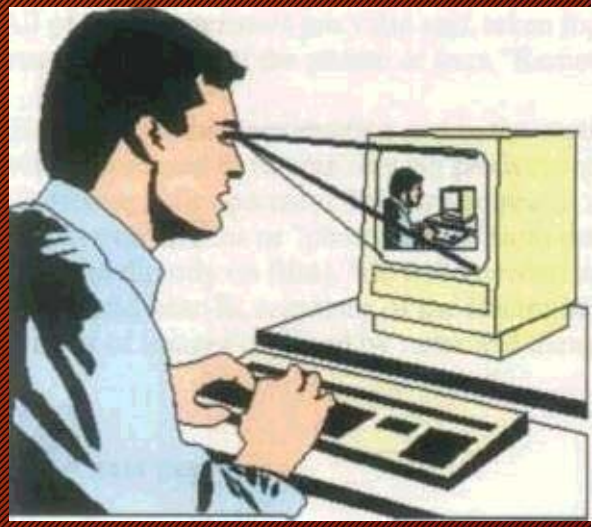
Part 2:

- Use of Spectroradiometer for measurement of Reflectance Spectrum

Basics

- Have you ever used RS??

- Types of RS
- PLATFORMS of RS



Significance of RS

- Environment
- Hydrology
- Developers and Planners
- Oil / Gas Industry
- Forestry
- Agriculture
- Geology
- Military

Cost Effective

Time Effective

Technological Assisted Remote Sensing

- Force Field
  - (Gravitational and Magnetic)
    NASA's Gravity Recovery and Climate Experiment (GRACE)
- Acoustical Energy
  - For Sonar Survey
- Electromagnetic Energy
  - Pass through free space
  - Pass through atmosphere
  - Variety in Behaviour
  - Can be exploited in different ways

Spectroscopy

- Branch of science which deals will interaction of matter with light or electromagnetic energy

Or

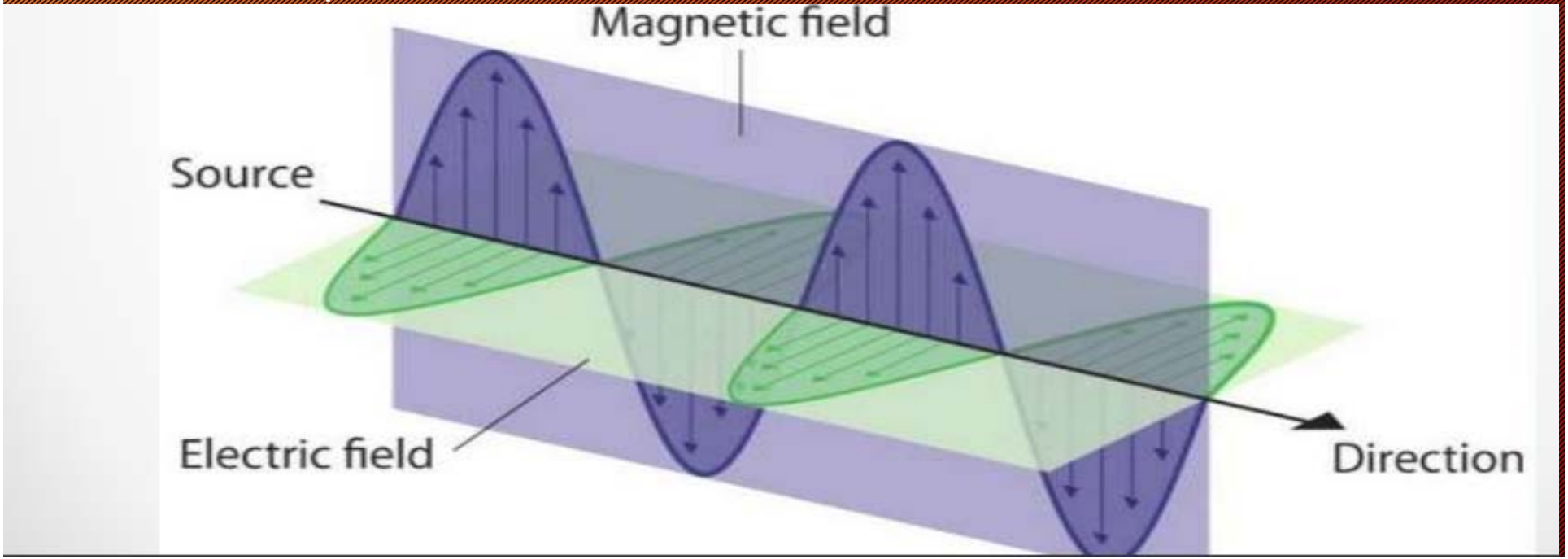
- It is branch of science in which electromagnetic radiation of particular wave length or range of wave length is used for qualitative and quantitative analysis of matter

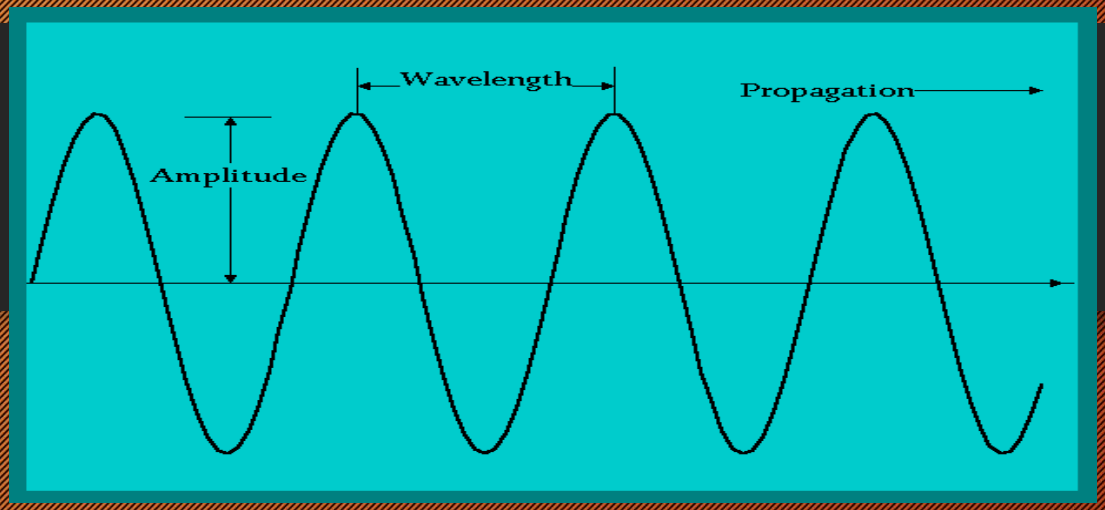
Ref: https://www.slideshare.net/niralimodha3/fundamentals-of-spectroscopy

Electromagnetic radiation

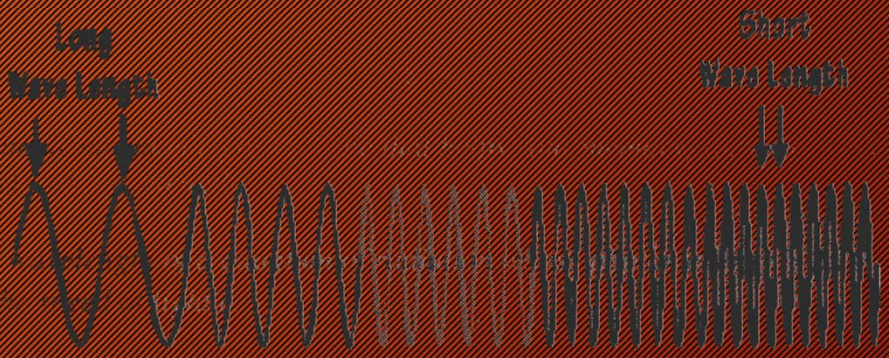
Waves produced by motion of electrically charged particles (photons)

- Wave Length
- Frequency
- Speed





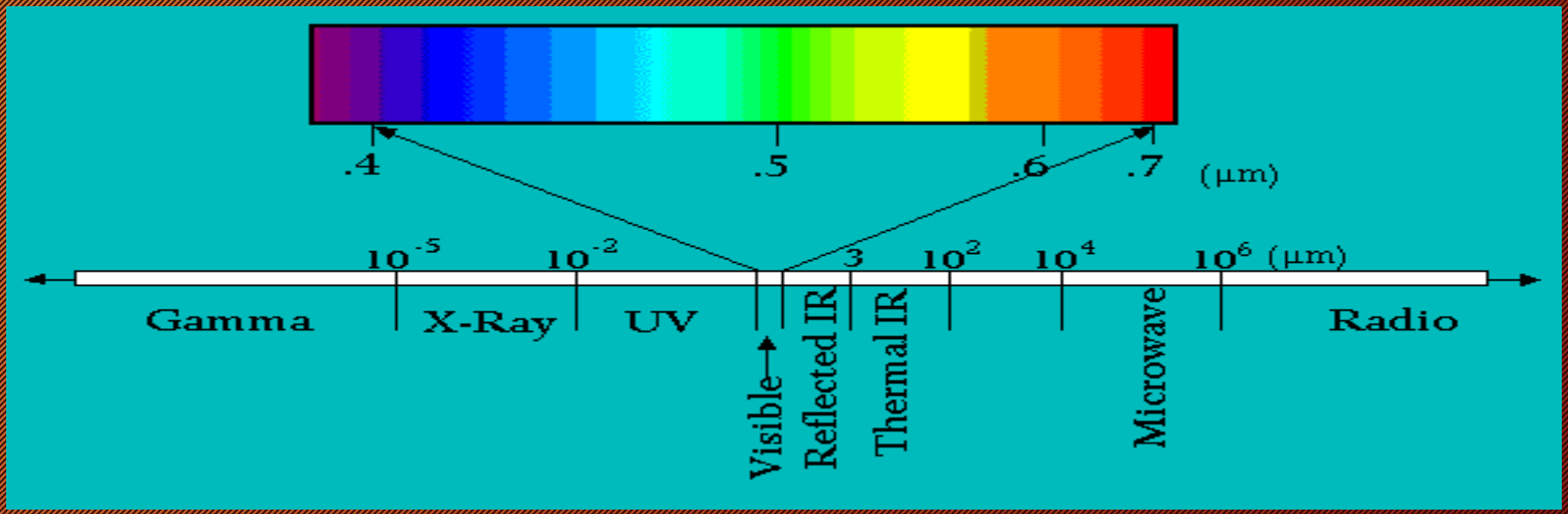
Frequency
Wavelength
Transmission direction
Amplitude
Plane of polarization



Low Frequency,
Low Energy

High Frequency,
High Energy

EM Waves and their nomenclature



Speed of EM Wave

$$c = f \lambda$$

c = Speed of Light
= 3×10^8 m/Sec

Energy of a Particle

$$E = h f$$

h = Planck's Constant
= 6.626×10^{-34} Joule Sec

$$E = h c / \lambda$$

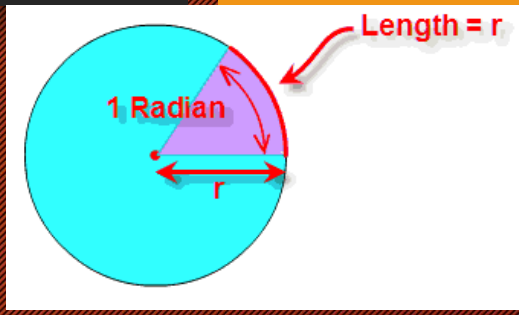
Principles of SPECTROSCOPY

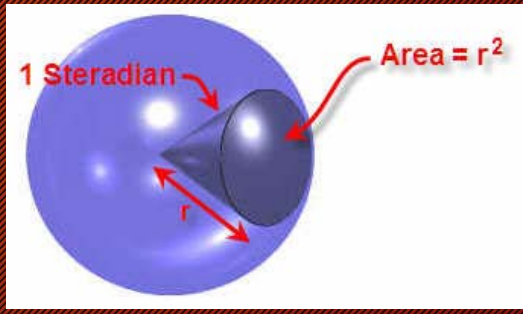
- **PRINCIPLE:** based on measurement of spectrum
- **SPECTRUM:** Graph or plot of intensity of absorbed/emitted/reflected/transmitted **radiation** by a sample vs. wave length or frequency of EM wave
- **SPECTROMETER:** The instrument to measure the spectrum of a sample

Ref: https://www.slideshare.net/niralimodha3/fundamentals-of-spectroscopy

EM Radiation & its Characteristics

- Energy
- Radiant Energy (E)
- Flux of Energy (Φ)
  (similar to Power)
- Radiant Flux Density W (Φ/area)
  - Irradiance (incoming)
  - Radiant Exitance (outgoing)
- Radiance (L) (Φ area^{-1} st^{-1})
- Spectral Radiance W_λ (L / λ)





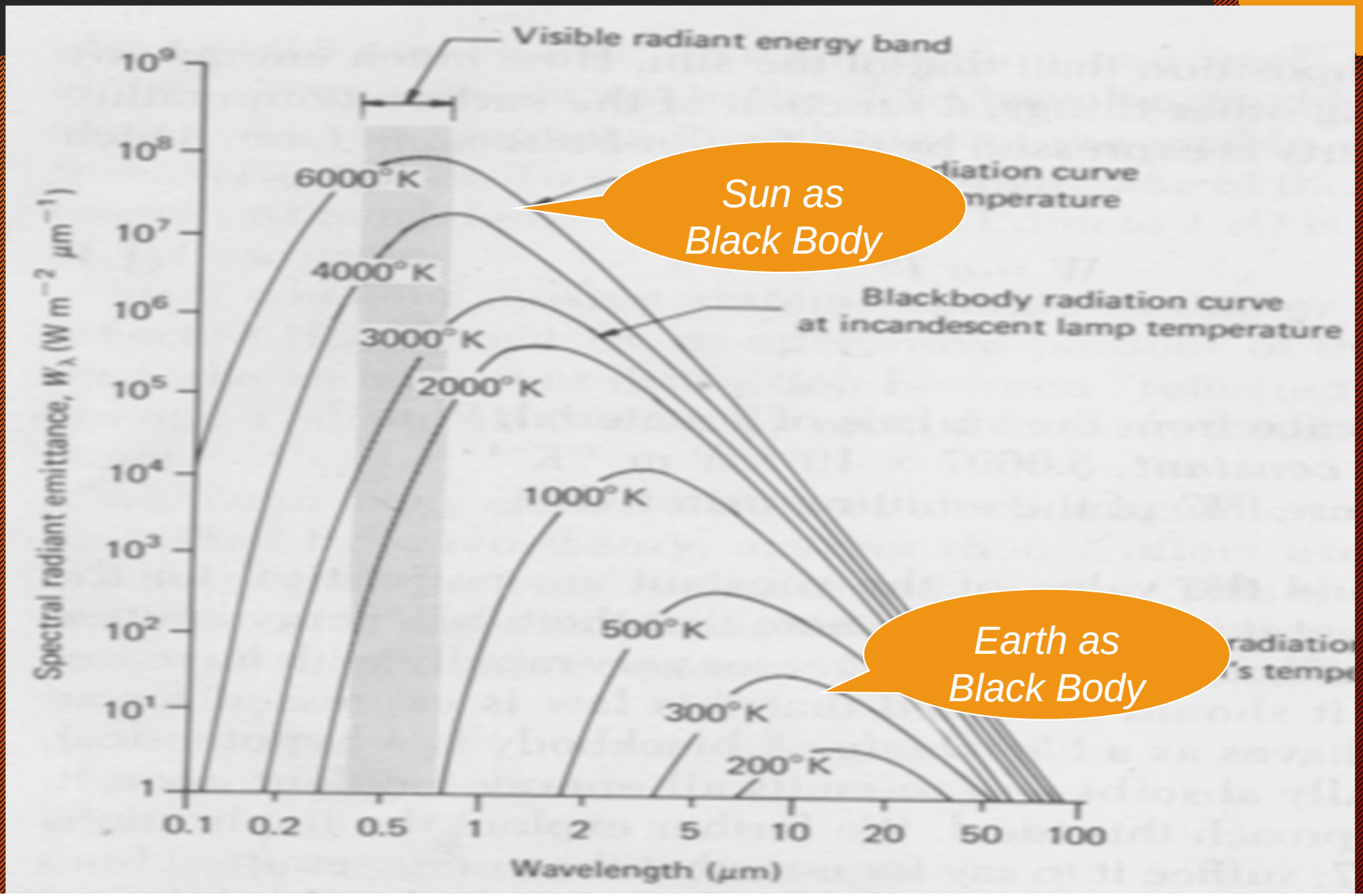
Ref:http://www.matematikaria.com/geometri/steradian.html

Concepts of Radiations

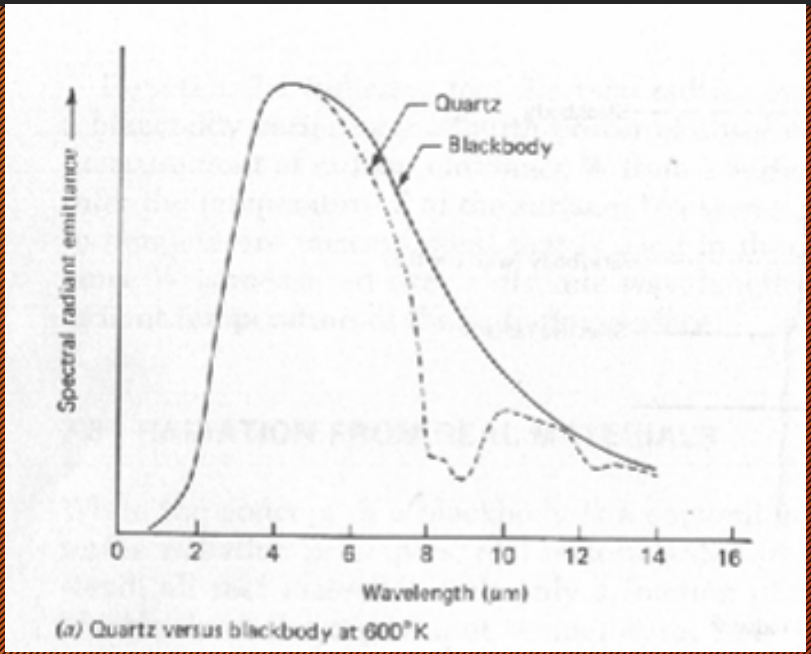
- Black Body ?
  (perfect absorber, perfect radiator)

  An object that absorbs all the radiations incident upon it, and emits maximum amount of radiation at all temperatures.
- Gray Bodies (Constant Emissivity)
- Selected Radiator (Variable Emissivity)
- White Body (perfect Reflector)

Black Bodies Emission

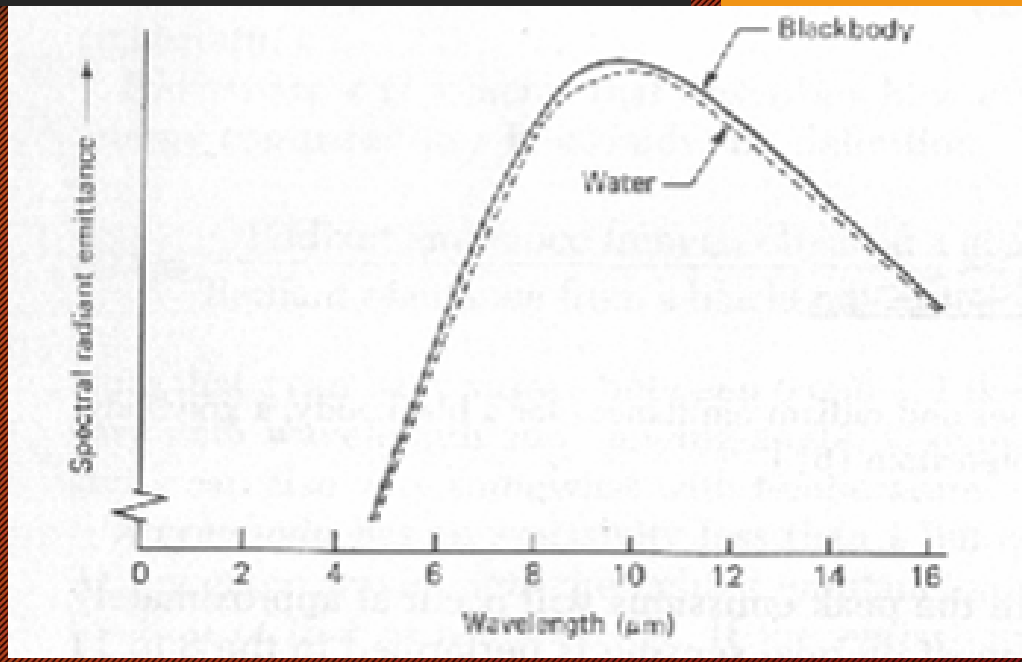


Emittance from Real Bodies



(a) Quartz versus blackbody at 600°K

QUARTZ



WATER

Interaction with Atmosphere

- Scattering
  - Selective
    - Rayleigh Scattering

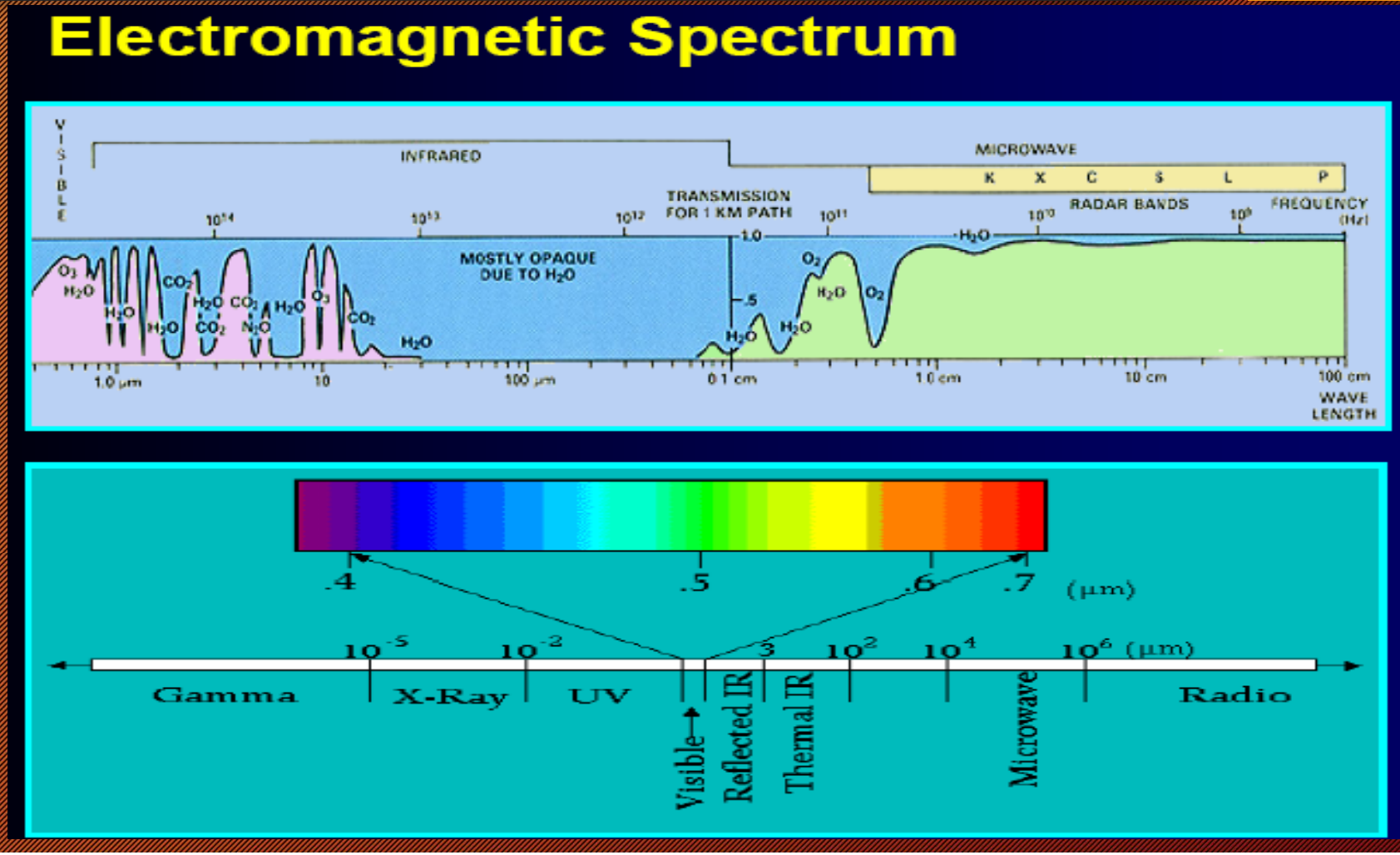
    Because of particles dia <0.1 micrometer (e.g. Gas molecules)
    It is inversely proportional to Wave length^4
    Smaller wave lengths are more affected
    - Mie Scattering

    Because of particles dia >0.1 to 10 micrometer (smoke, dust and salts)
    inversely prop to Wave length^1~2
    Not much diff. for wave lengths
  - Nonselective

    wavelength independent
    because of larger molecules (ice, water droplets, etc) >10 micrometer
- Absorption

  (Water, O_2, O_3, C_2O, etc)
- Atmospheric Windows

Atmospheric Interaction with EM Spectrum



Interaction b/w EM Energy & Earth Features

Incoming Energy

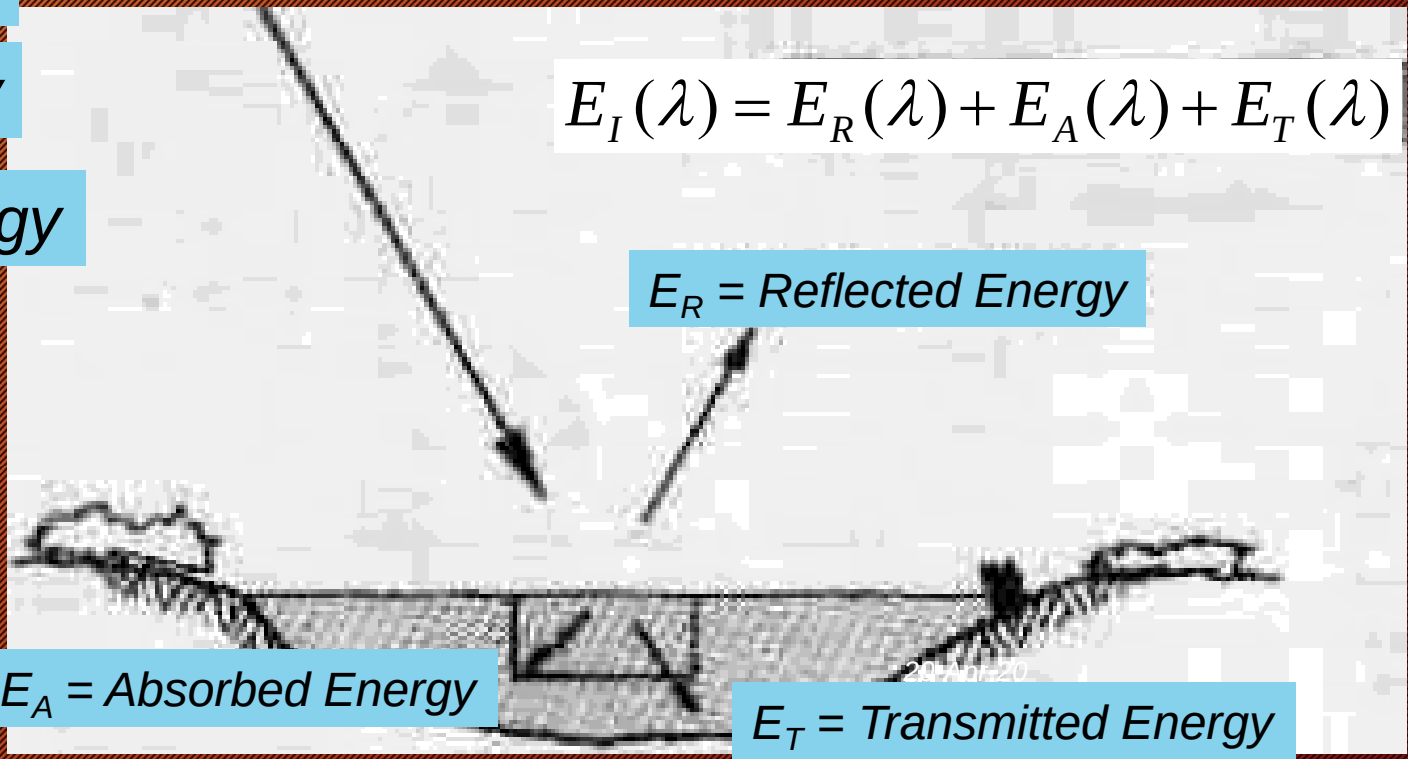
Reflected Energy

Absorbed Energy

Transmitted Energy

E_I = *Incoming Energy*

$$E_I(\lambda) = E_R(\lambda) + E_A(\lambda) + E_T(\lambda)$$



E_R = *Reflected Energy*

E_A = *Absorbed Energy*

E_T = *Transmitted Energy*

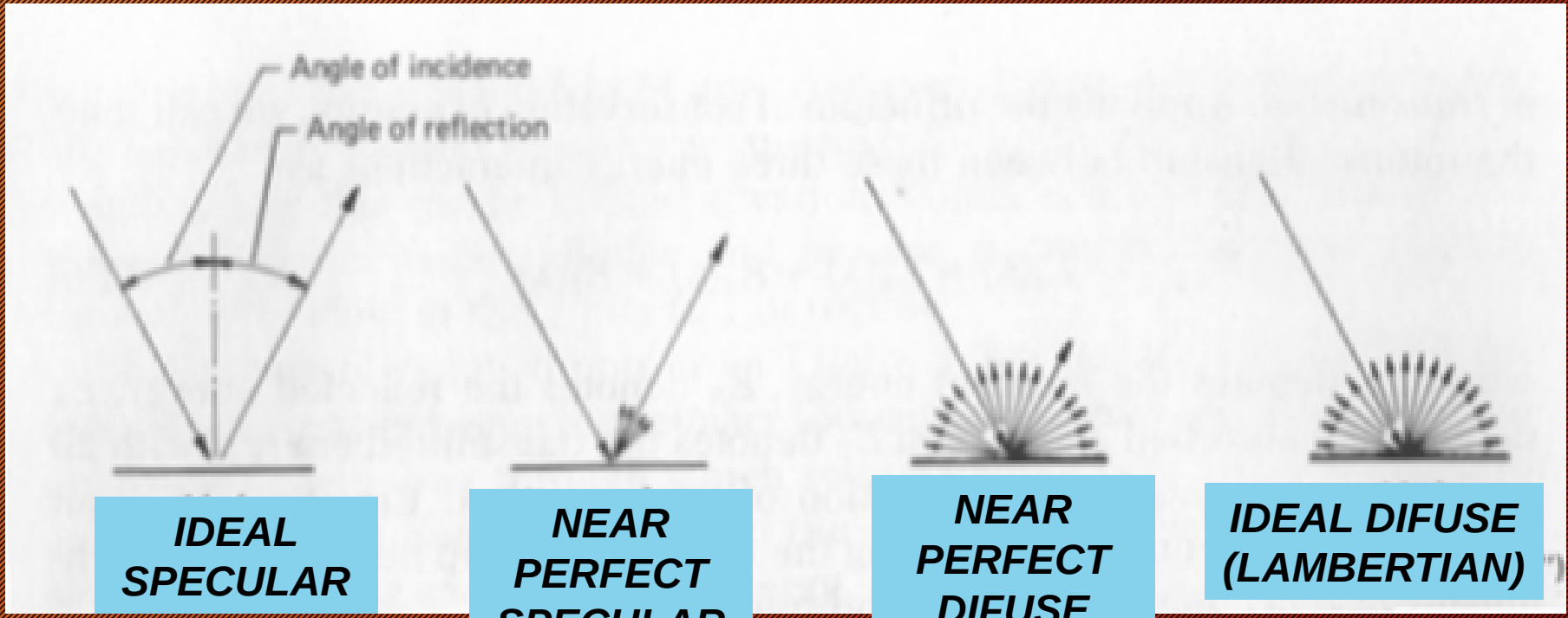
Energy Balance Equation

- Er, Et, Ea not necessarily same
- There variation from object to object help us distinguish different objects.

$$E_I(\lambda) = E_R(\lambda) + E_A(\lambda) + E_T(\lambda)$$

$$E_R(\lambda) = E_I(\lambda) - \left[E_A(\lambda) + E_T(\lambda)\right]$$

Reflectors



IDEAL SPECULAR

NEAR PERFECT SPECULAR

NEAR PERFECT DIFUSE

IDEAL DIFUSE (LAMBERTIAN)

Spectral Reflectance

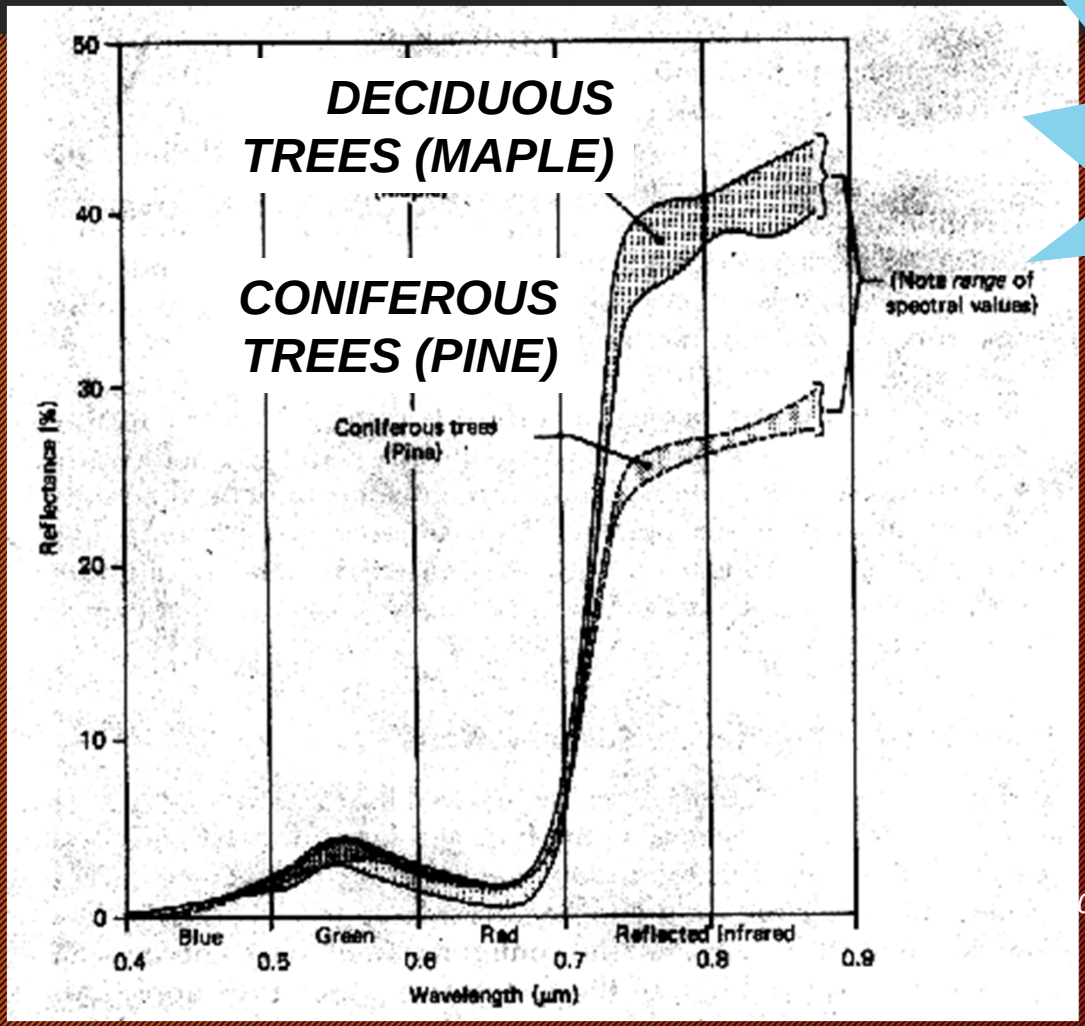
$$R_\lambda = \frac{E_R(\lambda)}{E_I(\lambda)}$$

$$= \frac{Energy of Wave Length \lambda reflected from Object}{Energy of Wave Length \lambda incident upon Objet}$$

%age Reflectance as Recorded by MSS of Landsat

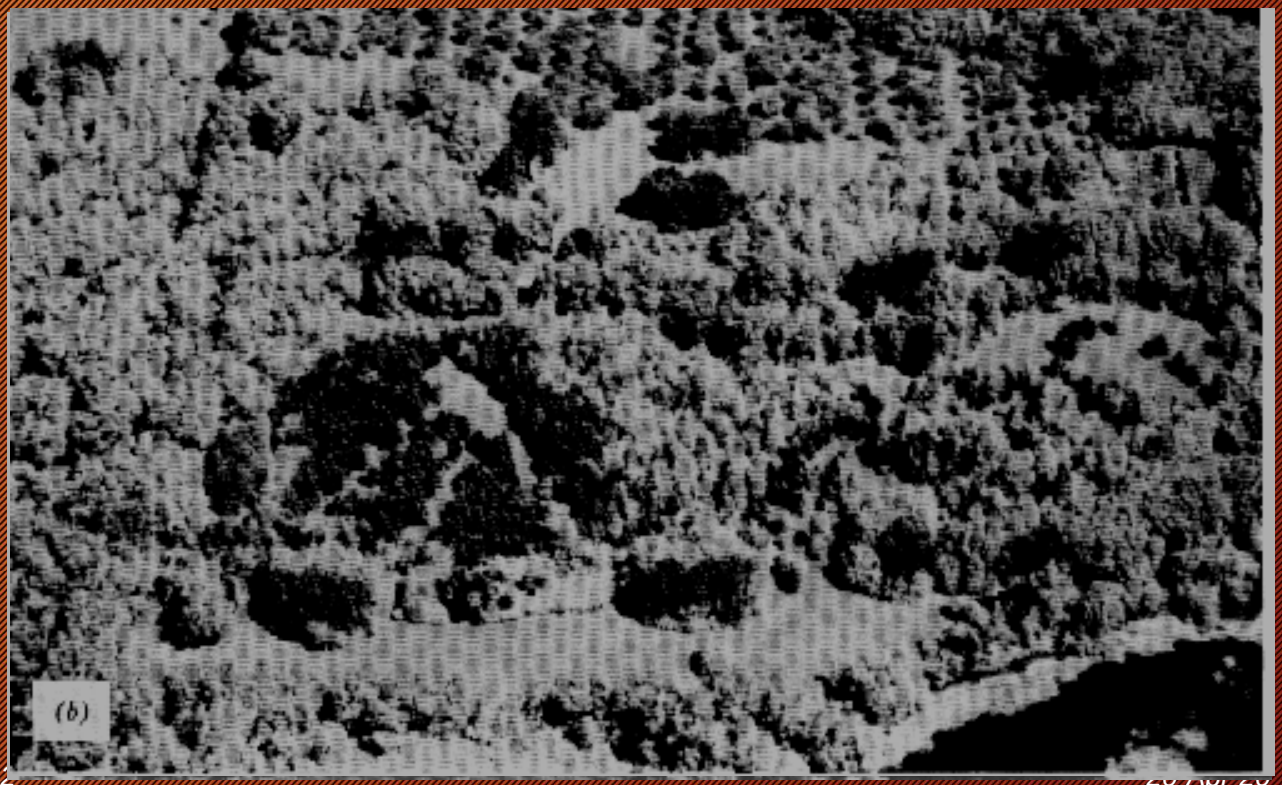
	Reflectance (%)			
	Band 1 (0.5–0.6 μm)	Band 2 (0.6–0.7 μm)	Band 3 (0.7–0.8 μm)	Band 4 (0.8–1.1 μm)
Rock and soil materials and covers				
Sand	5.19	4.32	3.46	6.71
Loam 1% H_2O	6.70	6.79	6.10	14.01
Loam 20% H_2O	4.21	4.02	3.38	7.57
Ice	18.30	16.10	12.20	11.00
Snow	19.10	15.00	10.90	9.20
Cultivated land	3.27	2.39	1.58	(not given)
Clay	14.34	14.40	11.99	(not given)
Gneiss	7.02	6.54	5.37	10.70
Loose soil	7.40	6.91	5.68	(not given)
Vegetation				
Wheat (low fertilizers)	3.44	2.27	3.56	8.95
Wheat (high fertilizers)	3.69	2.58	3.67	9.29
Water	3.75	2.24	1.20	1.89
Barley (healthy)	3.96	4.07	4.47	9.29
Barley (mildewed)	4.42	4.07	5.16	11.60
Oats	4.02	2.25	3.50	9.64
Oats	3.21	2.20	3.27	9.46
Soybean (high H_2O)	3.29	2.78	4.11	8.67
Soybean (low H_2O)	3.35	2.60	3.92	11.01

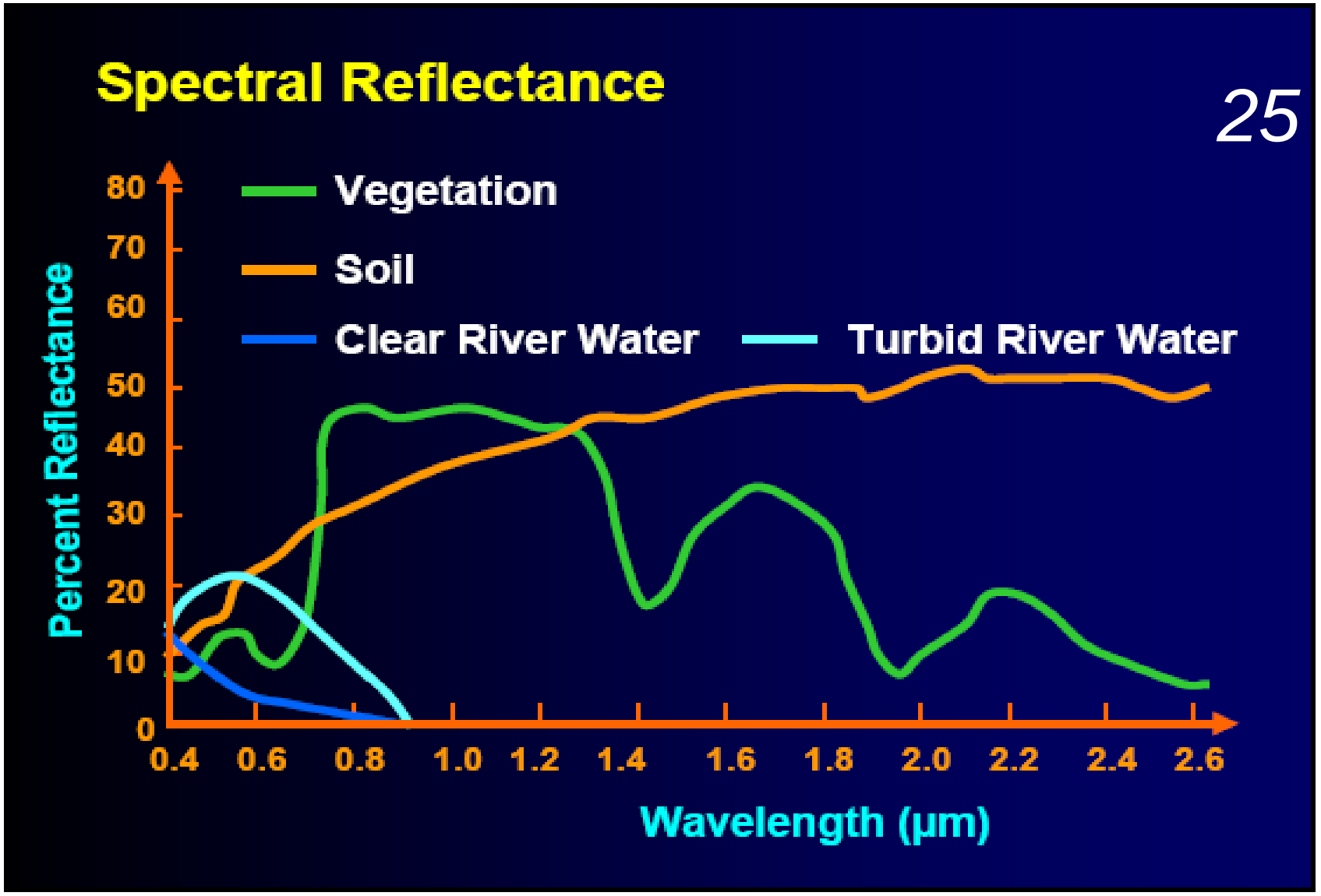
Spectral Reflectance Curve



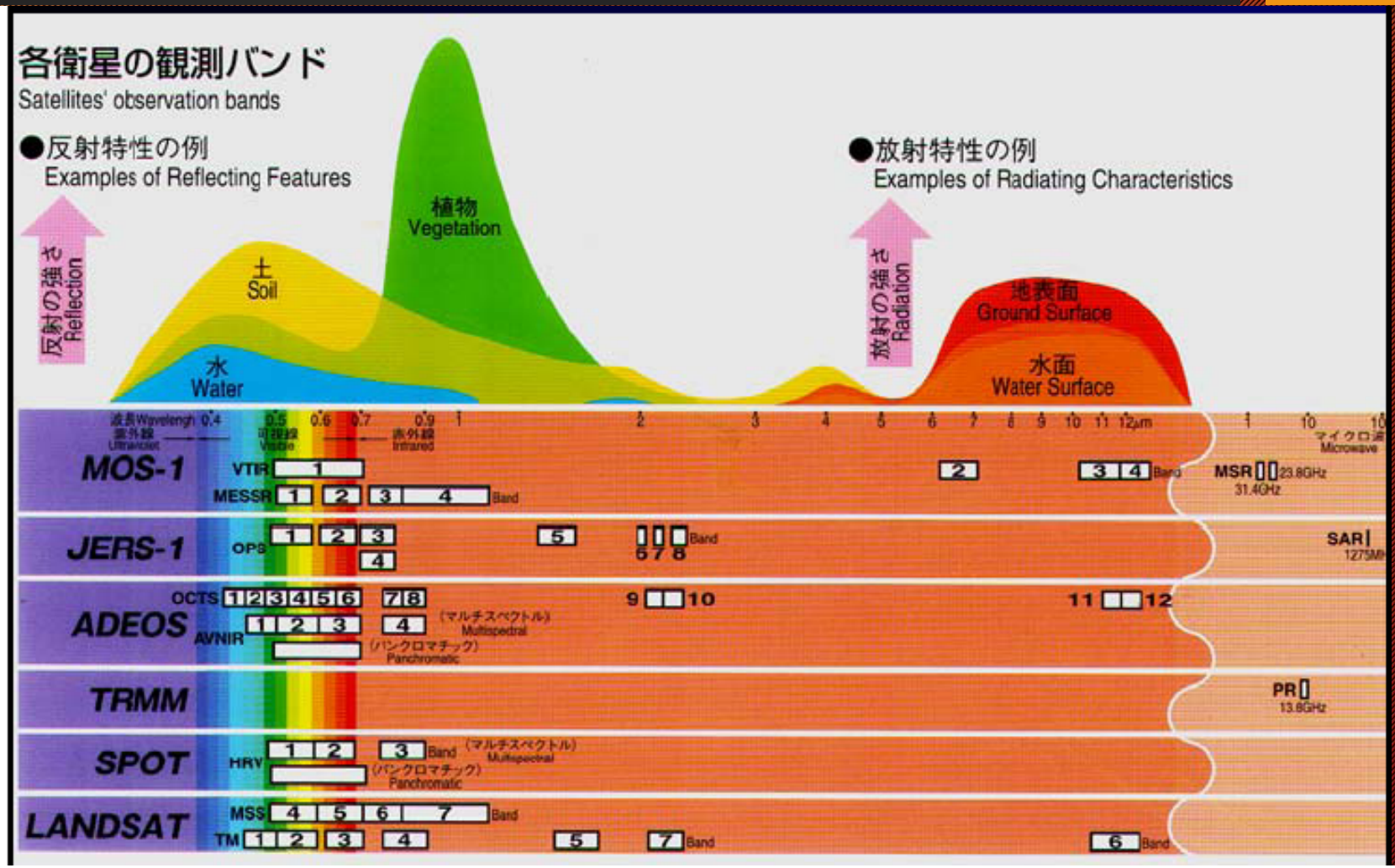
Which Wave Length is Best to Differentiate?

Panchromatic
vs
Reflected Infra Red




Spectral Reflectance
Vegetation
Soil
Clear River Water
Turbid River Water
Percent Reflectance
80
70
60
50
40
30
20
10
0
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
Wavelength (μm)

What sattelite/bands are suitable

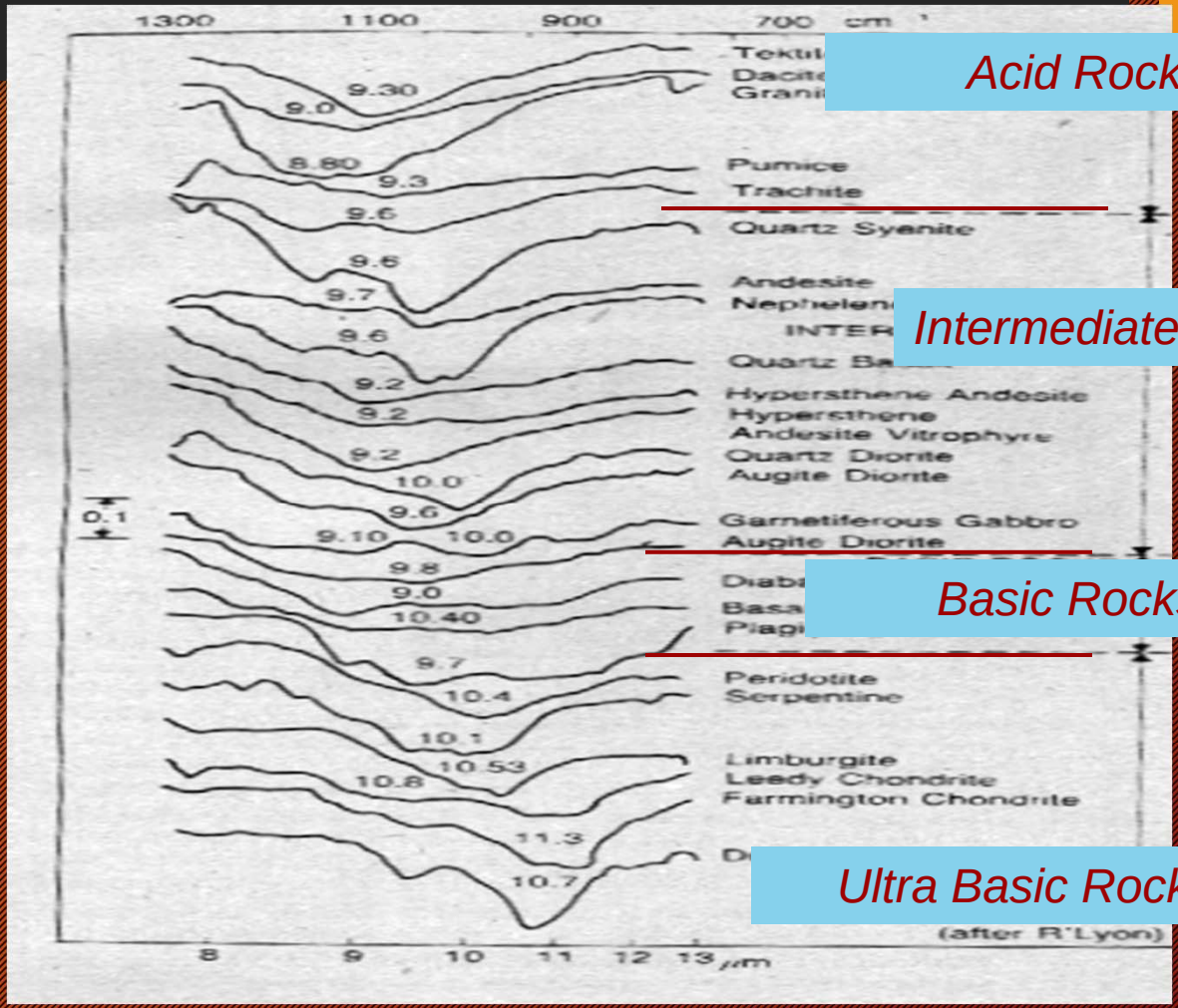


Landsat Thematic Mapper (TM)

Band No.	Wavelength Interval (μ m)	Spectral Response	Resolution (m)
1	0.45-0.52	Blue-Green	30
2	0.52-0.60	Green	30
3	0.63-0.69	Red	30
4	0.76-0.90	Near-IR	30
5	1.55-1.75	Mid-IR	30
6	10.40-12.50	Thermal-IR	120
7	2.08-2.35	Mid-IR	30

(TM) has been added to Landsats 4 (1982), 5 (1984), 6 (failed to attain orbit during launch and thus has never returned data) and 7 (1999).

Spectral Response Pattern / Signature
IR Emission



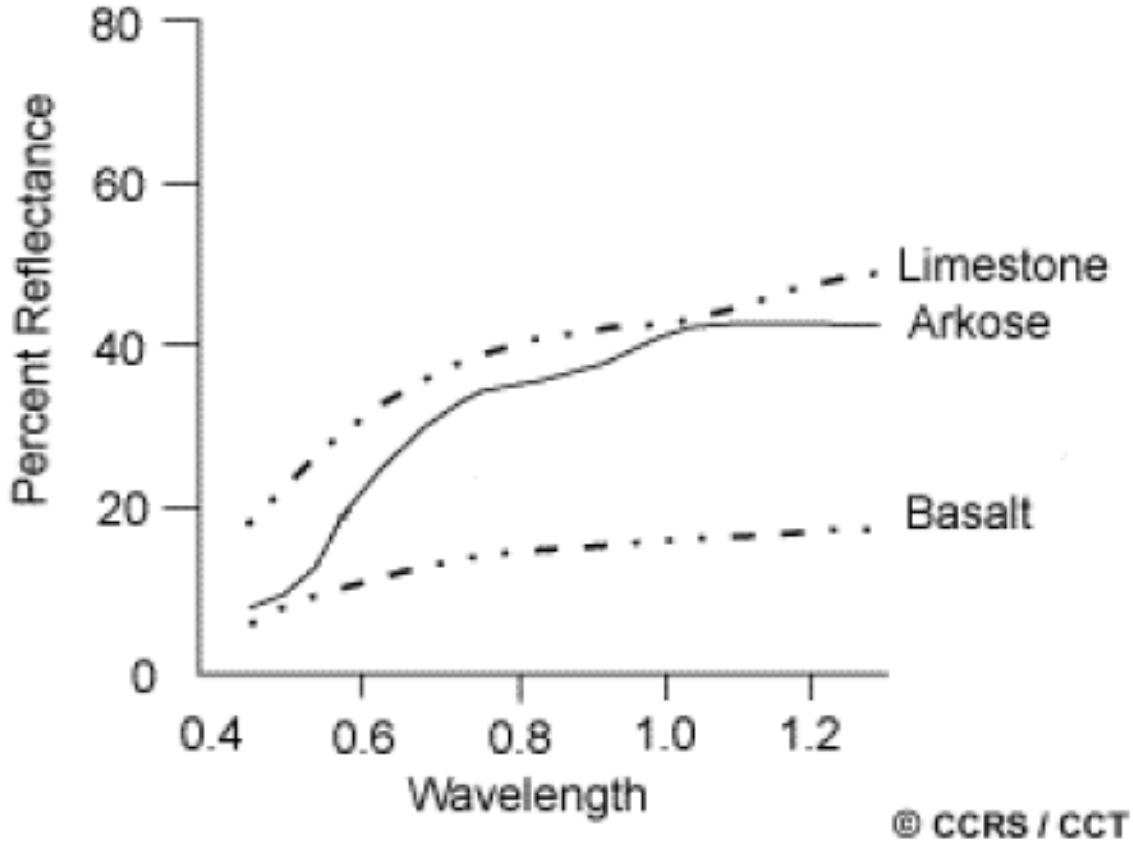
Acid Rocks

Intermediate Rocks

Basic Rocks

Ultra Basic Rocks

Spectral Response of few Rocks



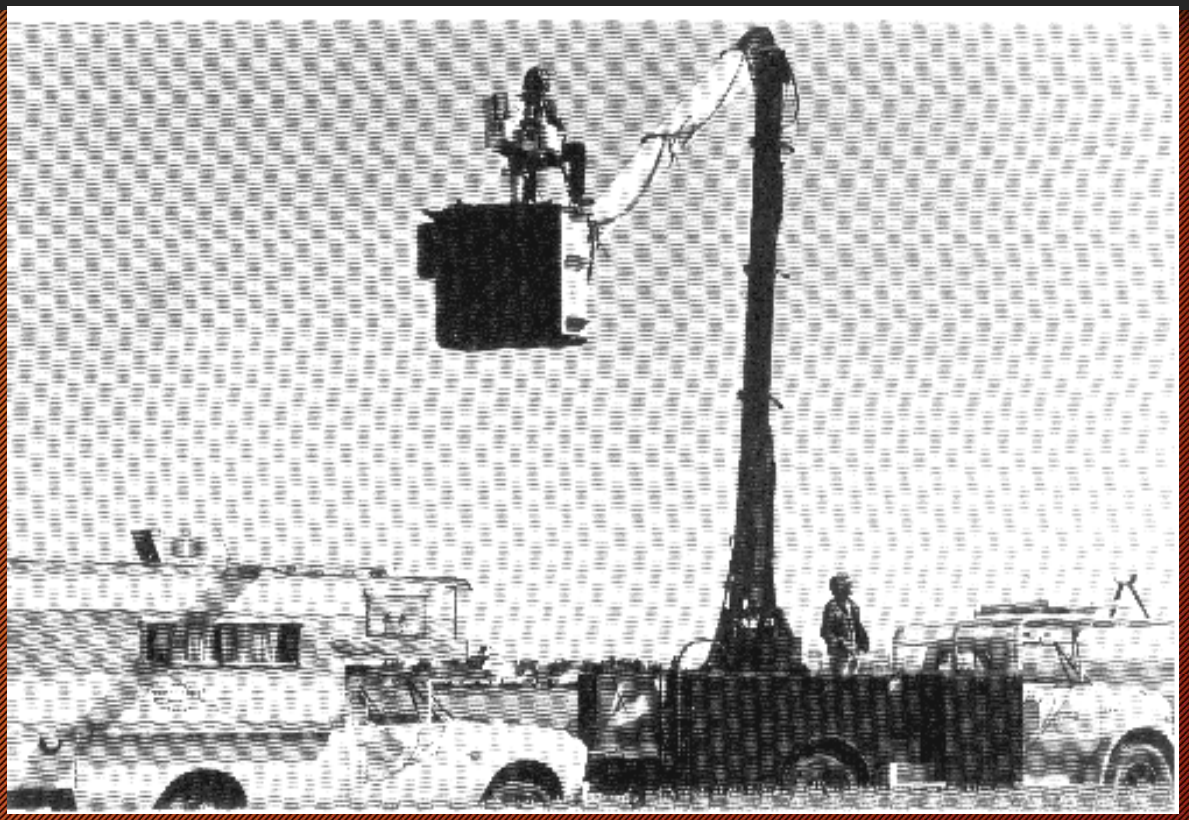
Typical Albedo/Reflectance Values

Type of surface	Surface	Albedo % of incident shortwave radiation
Soils	Fine sand	37
	Dry black soil	14
	Moist ploughed field	14
	Moist black soil	8
Water surfaces	Dense, clean and dry snow	86–95
	Woody farm, snow-covered	33–40
	Sea ice	36
	Ice sheet with water covering	26
Vegetation	Desert shrubland	20–29
	Winter wheat	16–23
	Oaks	18
	Deciduous forest	17
	Pine forest	14
	Prairie	12–13
	Swamp	10–14
	Heather	10
Geographic locations	Yuma, Arizona	20
	Winnipeg (July)	13–16
	Washington, DC (September)	12–13
	Great Salt Lake, Utah	3

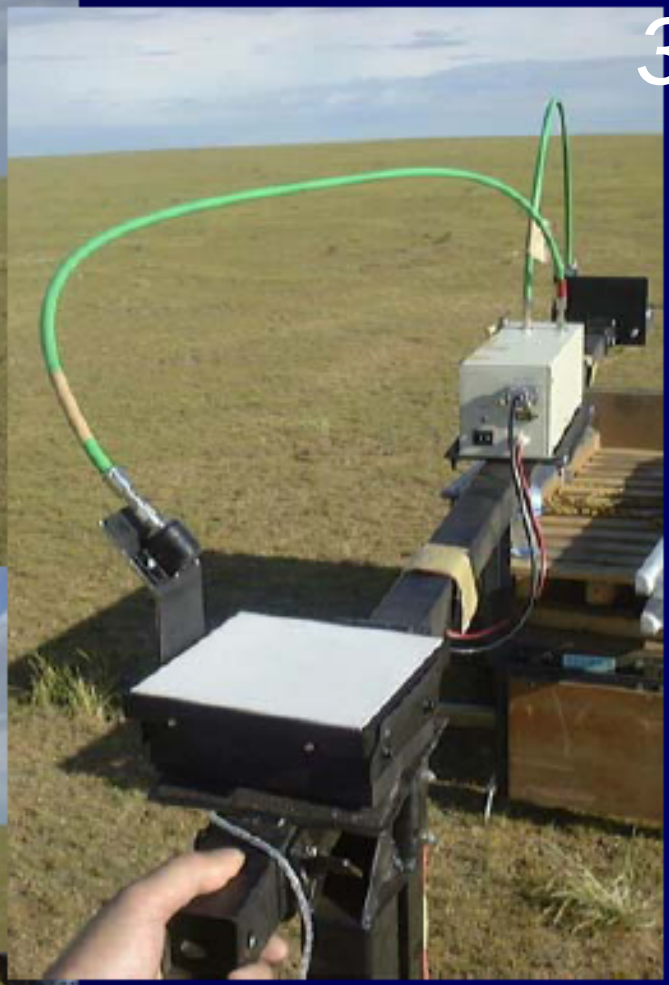
Reference Data

- To Aid in analysis and Interpretation of RS Data
- To Calibrate Sensor
- To Verify Information extracted form RS

Reference Data / Ground Truth



Mobile Spectrometer Unit

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Thanks