Remote Sensing: refers most often to

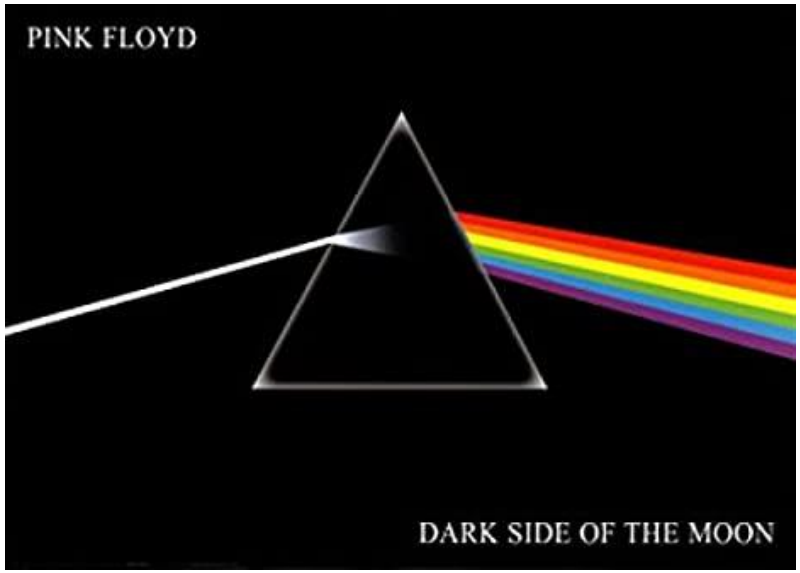
… the acquisition and analysis of aerial and satellite images

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact. (Wikipedia)

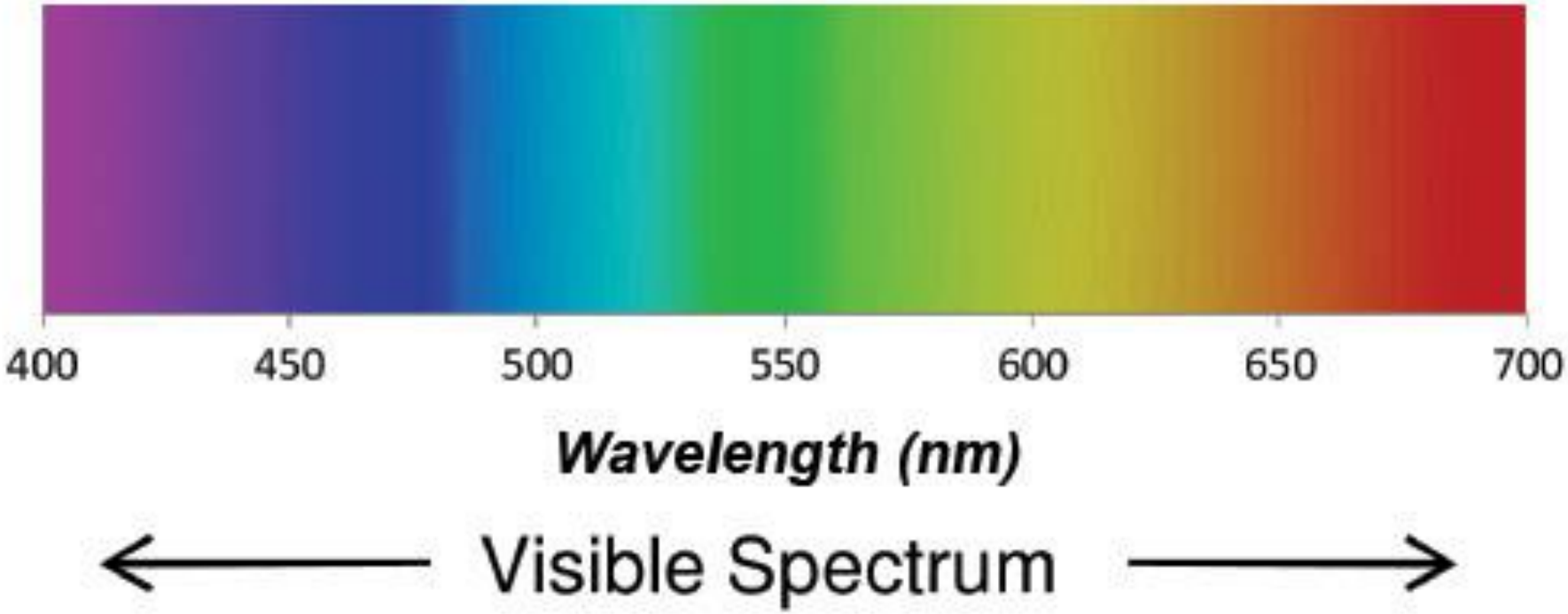
Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft). (USGS)

Remote sensing is the acquisition of information about a surface without actually being in contact with it. (NRCan)

Remote sensing and the electromagnetic spectrum



The spectrum provides the 'layers' in RS



Here are the 7 rainbow colours from shortest to longest wavelength.

- Violet - shortest wavelength, ~ 400-420 nanometers
- Indigo - 420 - 440 nm.
- Blue - 440 - 490 nm.
- Green - 490 - 570 nm.
- Yellow - 570 - 585 nm.
- Orange - 585 - 620 nm.
- Red - longest wavelength, ~ 620 -700nm

•1 nm = 1 billionth of a metre

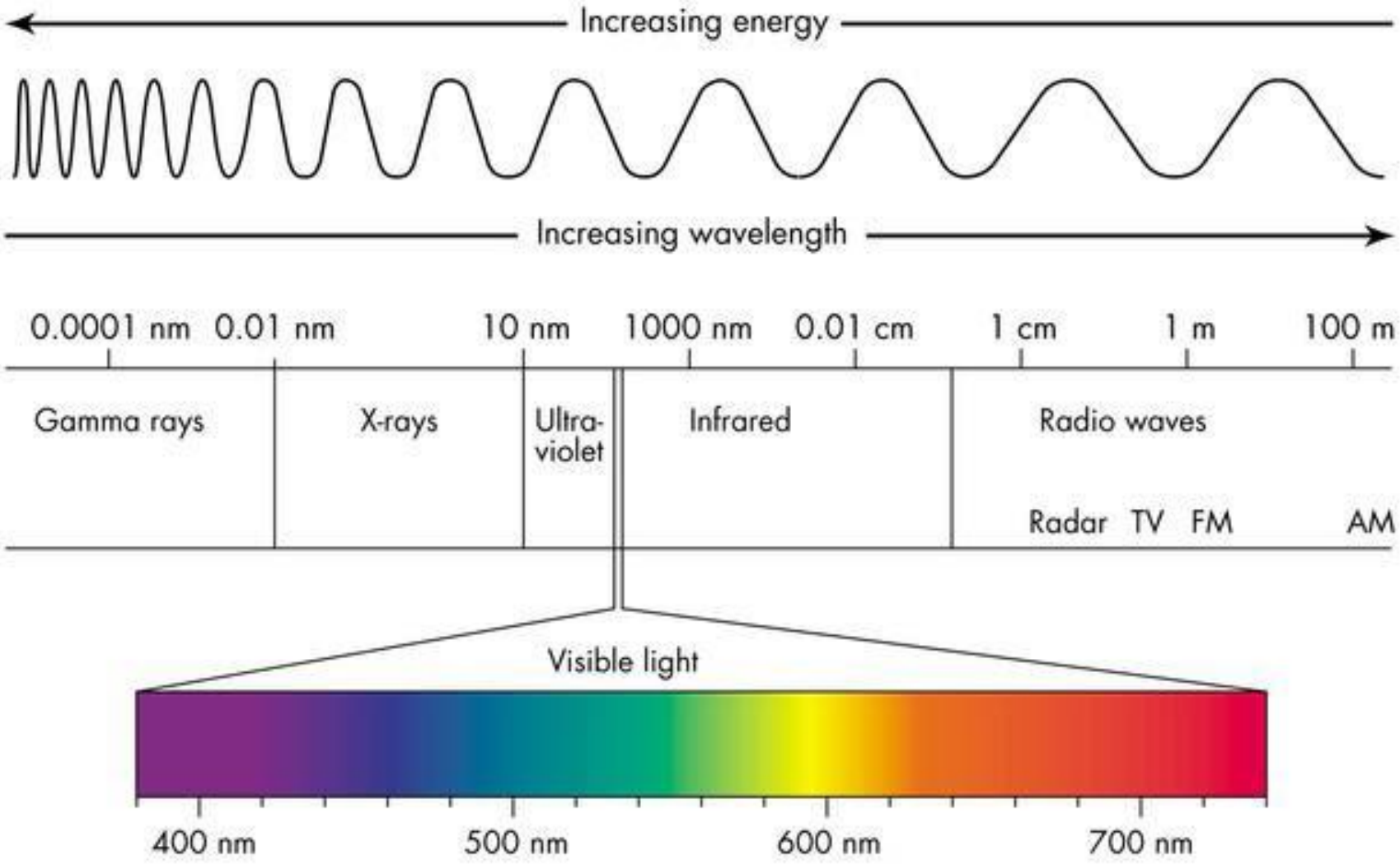
Units of wavelength measurement

1kilometre = 1000 metres		m
Millimetres:	thousands of a metre	mm
micrometres 'microns' :	millionths of a metre	μm
nanometres:	billionths of a metre	nm
Picometres	trillionth of a metre	pm

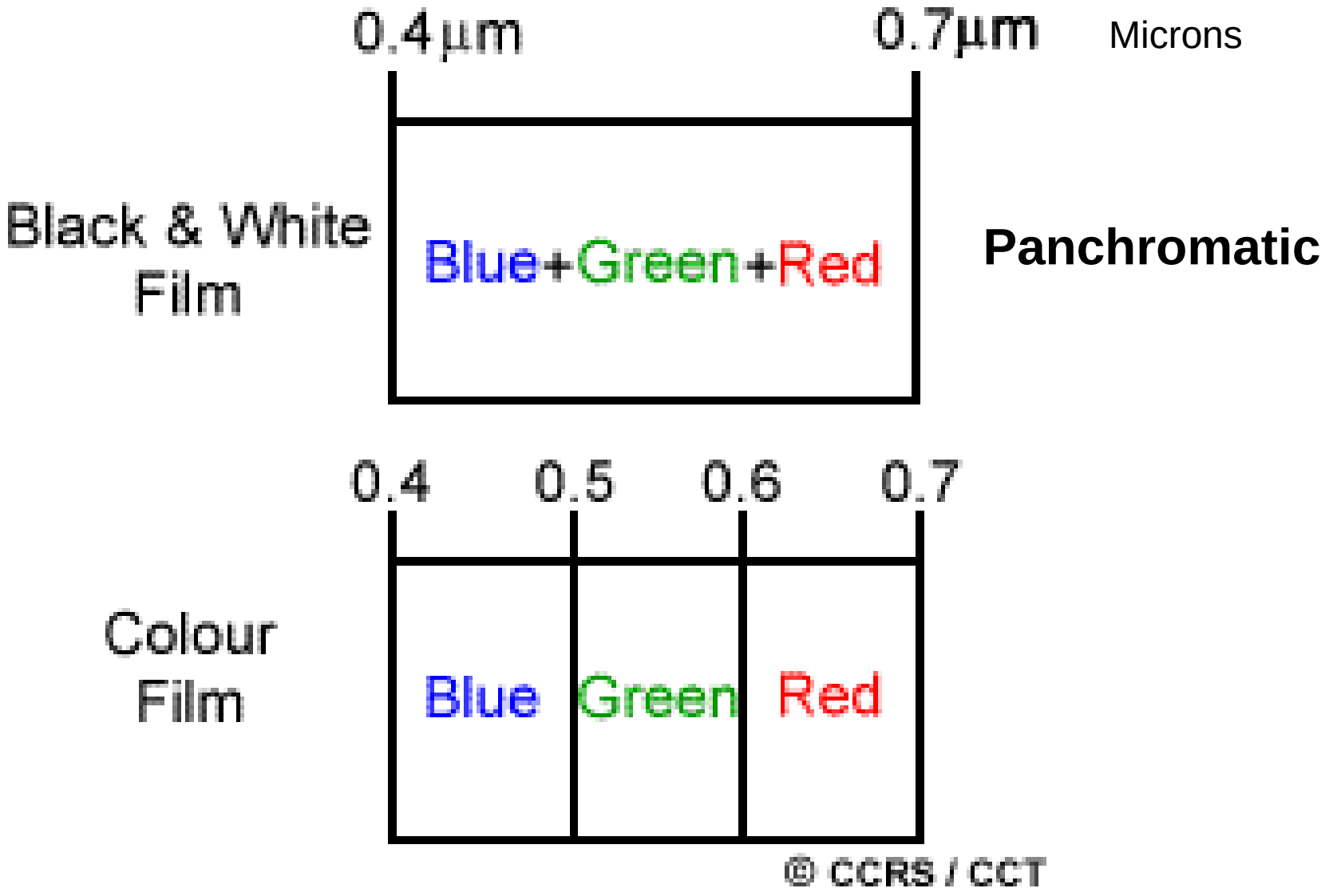
[1 nanometre = 10 angstroms **Å**]

e.g. visible wavelengths

Blue	**0.4 - 0.5 μm (microns)**	**= 400 to 500 nm**
Green	**0.5 - 0.6 μm**	**= 500 to 600 nm**
Red	**0.6 - 0.7 μm**	**= 600 to 700 nm**



Wavelengths and Frequencies:
Shorter Waves – Higher Frequency
Longer Waves – Lower Frequency


0.4 µm
0.7µm
Microns
Black & White Film
Blue+Green+Red
Panchromatic
0.4
0.5
0.6
0.7
Colour Film
Blue
Green
Red
© CCRS / CCT

Panchromatic air photo: 15th / University Way

Colour air photo: 15th / University Way

COMMON ANIMALS AND THE COLORS THEY CAN SEE

ANIMAL	THE COLORS THEY SEE	RELATIVE TO HUMANS
SPIDERS (jumping spiders)	ULTRAVIOLET AND GREEN	Different
INSECTS (bees)	ULTRAVIOLET, BLUE, YELLOW	Different
CRUSTACEANS (crayfish)	BLUE AND RED	Less
CEPHALOPODS (octopi and squids)	BLUE ONLY	Less
FISH	MOST SEE JUST TWO COLORS	Less
AMPHIBIANS (frogs)	MOST SEE SOME COLOR	Less
REPTILES (snakes*)	SOME COLOR AND INFRARED	Different
BIRDS	FIVE TO SEVEN COLORS	More
MAMMALS (cats)	TWO COLORS BUT WEAKLY	Less
MAMMALS (dogs)	TWO COLORS BUT WEAKLY	Less
MAMMALS (rabbit)	BLUE AND GREEN	Less
MAMMALS (rats)	ULTRAVIOLET, BLUE, GREEN	Different
MAMMALS (squirrels)	BLUES AND YELLOWS	Less
MAMMALS (primates-apes and chimps)	SAME AS HUMANS	Same
MAMMALS (African monkeys)	SAME AS HUMANS	Same
MAMMALS (South American monkeys)	CAN'T SEE RED WELL	Less
* pit vipers, some boas and some pythons		

1800-01: discovery of IR and UV by William Herschel and Johann Ritter

1950s: Infra-red (IR) photography

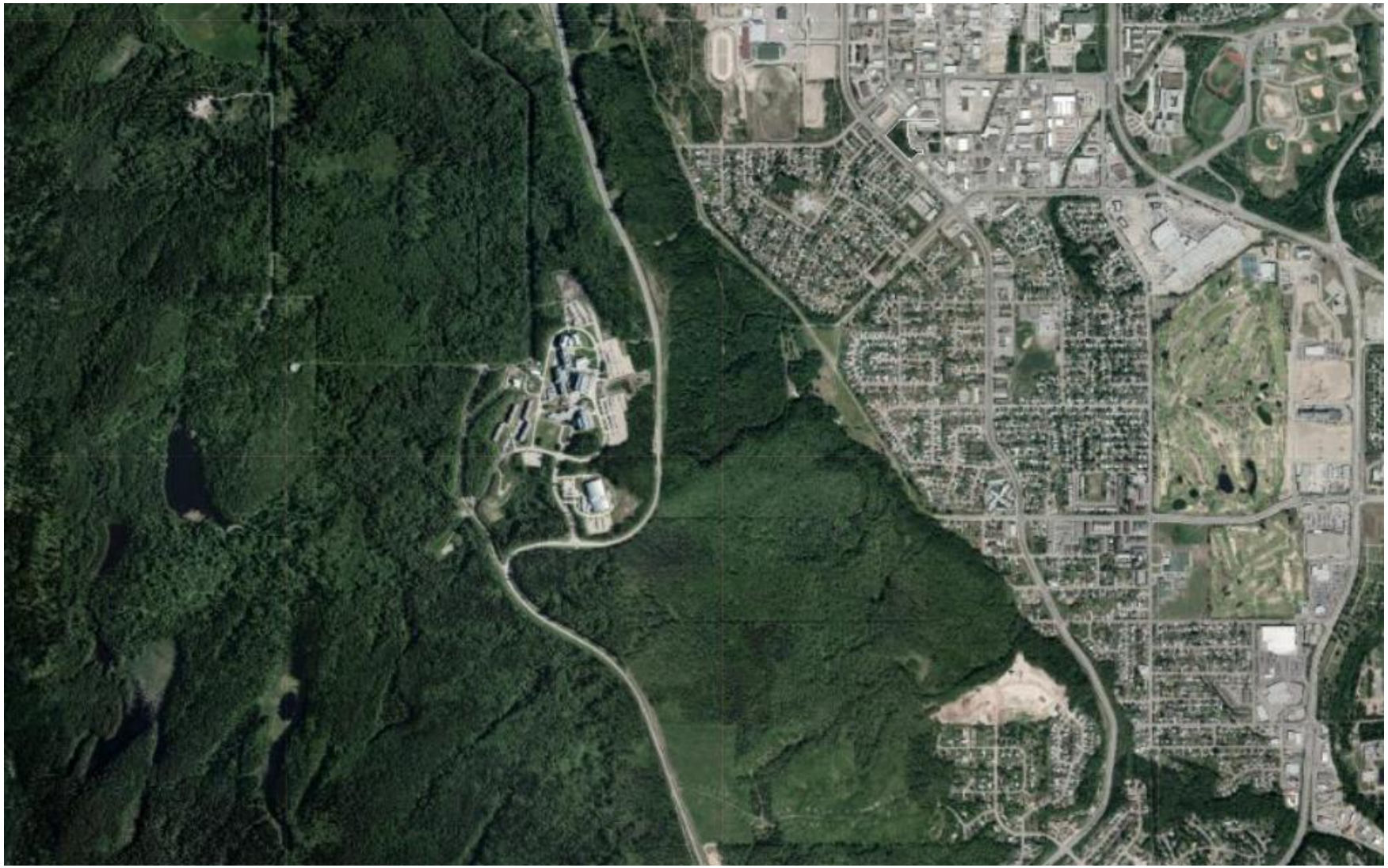
IR was developed during the Korean War to distinguish between healthy vegetation (refelecting IR) and camouflage. Hence it was known as 'camouflage detection' film or 'false colour'.

Table 2 : Characteristics of normal colour and false colour film

Normal colour film (Energy captured by film)	IR film (Energy captured by film)	Colour that results on film
B	G	Blue
G	R	Green
R	IR	Red

Digital Display
B
G
R

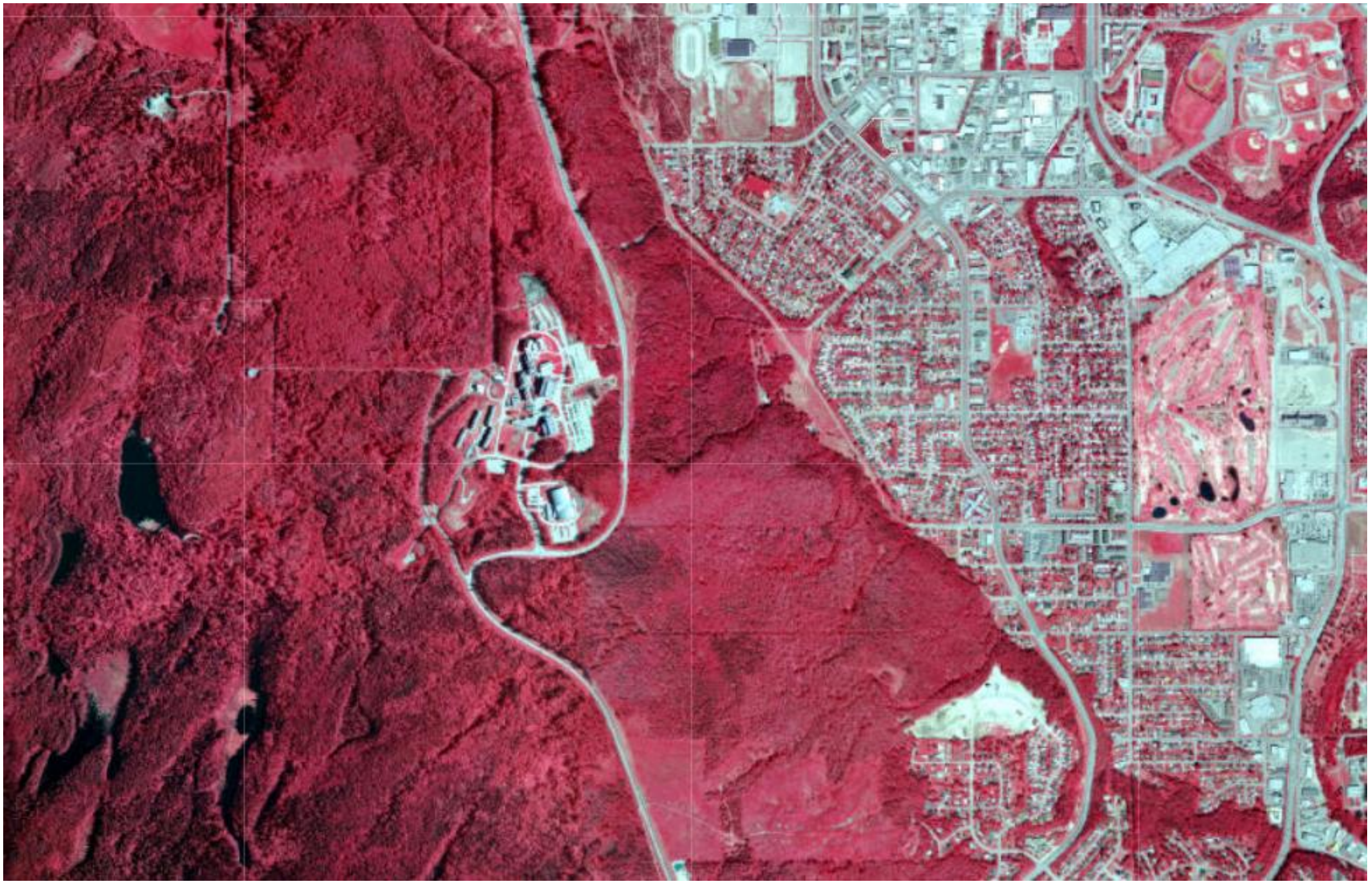
PGmap spring 2014 natural colour



Advantages of natural colour:

1. What most interpreters are familiar with
2. Matches online mosaics e.g. Google Maps/Earth, Bing maps

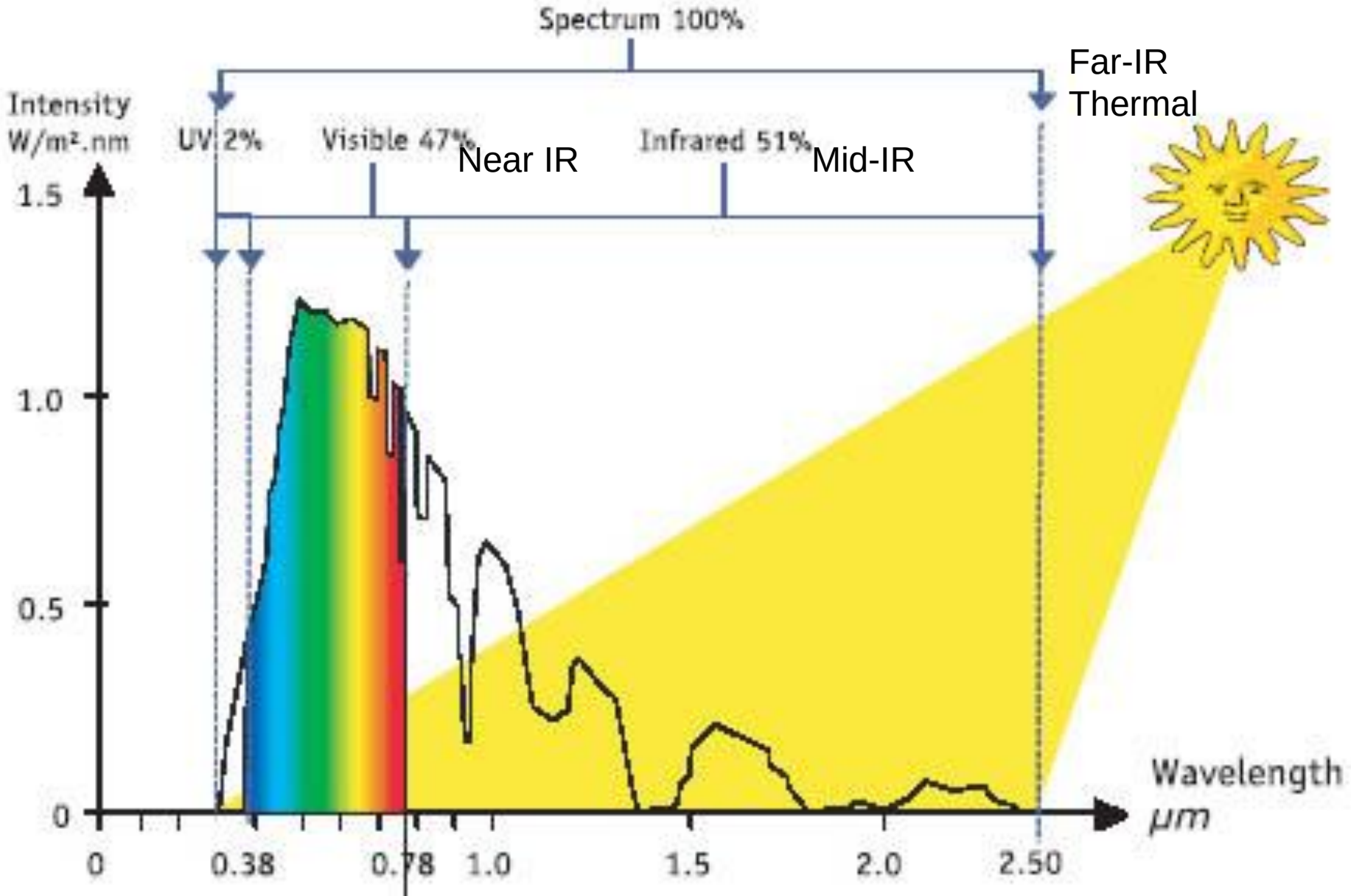
PGmap spring 2014 IR image: https://pgmappub.princegeorge.ca/Html5Viewer/?viewer=PGMapMobile



Summary of advantages of (near) Infra-Red wavelengths:

1. Vegetation differences are enhanced e.g. coniferous v deciduous etc..
2. Land-water distinctions are enhanced
3. Blue -most susceptible to haze- is removed

SOLAR SPECTRUM



The Infra-red portion of the EM spectrum

0.7 – 1.5 microns: near IR – vegetation biomass /health

1.3 – 3.0 microns: mid-IR - moisture content (inverse)
Also referred to as ShortWave IR (SWIR)

Visible / Near and Mid-IR are **reflected** energy from the Sun

3.0- 15.0 microns: far IR – thermal (temperature)
Some sources extend far-IR to 1000 microns (1 mm)
Note: most of this energy is not reflected solar energy, but is **emitted** terrestrial energy

Landsat TM band combinations: Visible versus IR combination

Visible wavelengths image

e.g. Google maps, earth (3-2-1)

Including Infrared (NIR / SWIR)

e.g. BC imap / GEOG357 labs (5-4-3)

The best displays include one band each from the visible, near-IR and mid-IR

Landsat 5 Thematic Mapper bands (1984-2011)

Band No.	Wavelength Interval (μm)	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

Landsat satellites 4,5,7 bands

Band	Wavelength	Useful for mapping
Band 1 - blue	0.45-0.52	Bathymetric mapping, distinguishing soil from vegetation and deciduous from coniferous vegetation
Band 2 - green	0.52-0.60	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 3 - red	0.63-0.69	Discriminates vegetation slopes
Band 4 - Near Infrared	0.77-0.90	Emphasizes biomass content and shorelines
Band 5 - Short-wave Infrared	1.55-1.75	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 6 - Thermal Infrared	10.40-12.50	Thermal mapping and estimated soil moisture
Band 7 - Short-wave Infrared	2.09-2.35	Hydrothermally altered rocks associated with mineral deposits
Band 8 - Panchromatic (Landsat 7 only)	.52-.90	15 meter resolution, sharper image definition

Spatial versus spectral resolution

Spatial resolution = physical size of the pixel (picture element) e.g. 30m, 120m

Spectral resolution = band width e.g. 10nm, 20nm

There is a relationship between these: more available energy = finer spatial and spectral resolution (see Landsat TM example) = more precise analysis potential

Visible bands: < 10nm width

Near IR: ~ 15nm

Mid-IR: 20-30nm

Thermal IR: > 2000nm (2 microns) and 120m pixels

Panchromatic: higher spatial resolution due to pooling of visible / NIR reflection

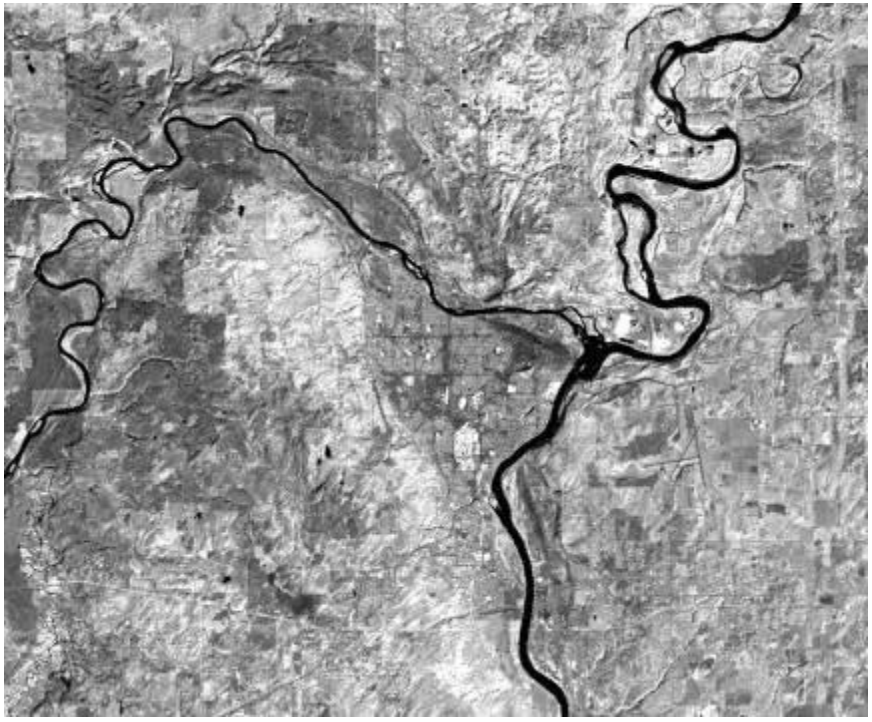
(but lower ‘spectral’ resolution)

The **near IR** (0.7-1.3 microns) records energy related to **vegetation vigour** (health), while the **mid- IR** (1.3-3.0 microns) is (soil) **moisture**.

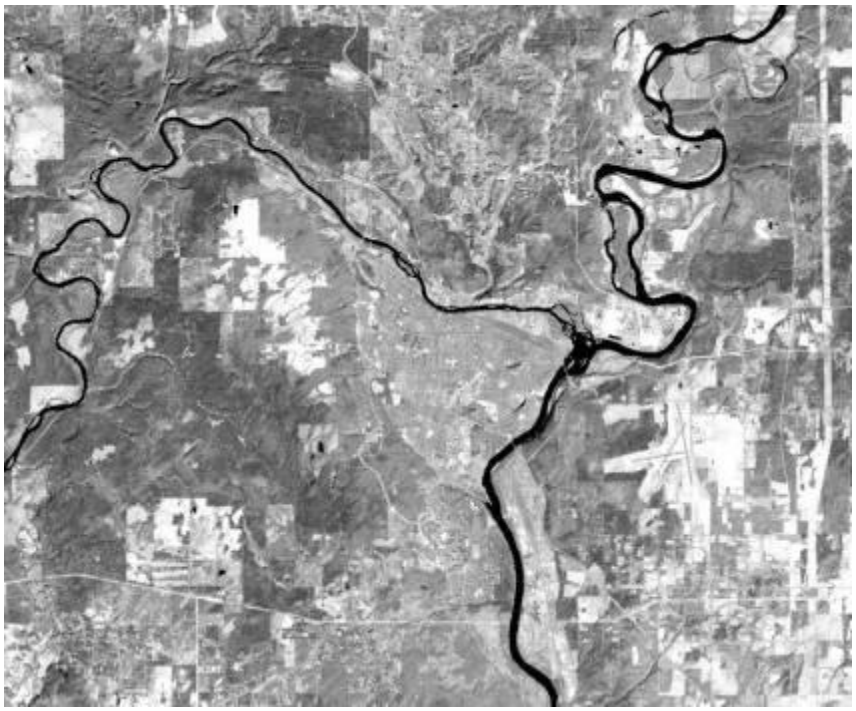
Neither have much to do with temperature

normal colour and Mid-IR/NIR/Red composites ->

Near-IR

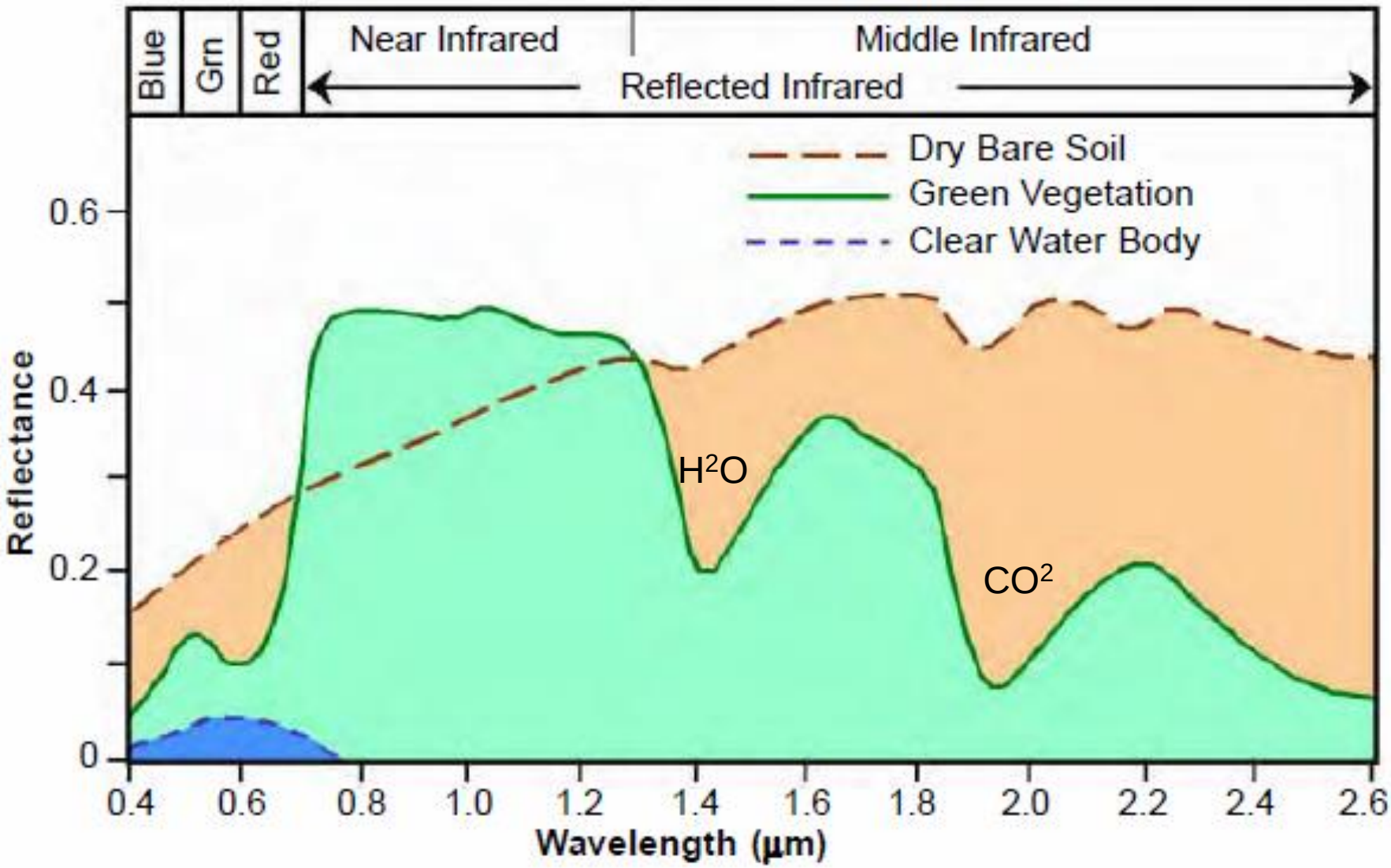


Mid-IR

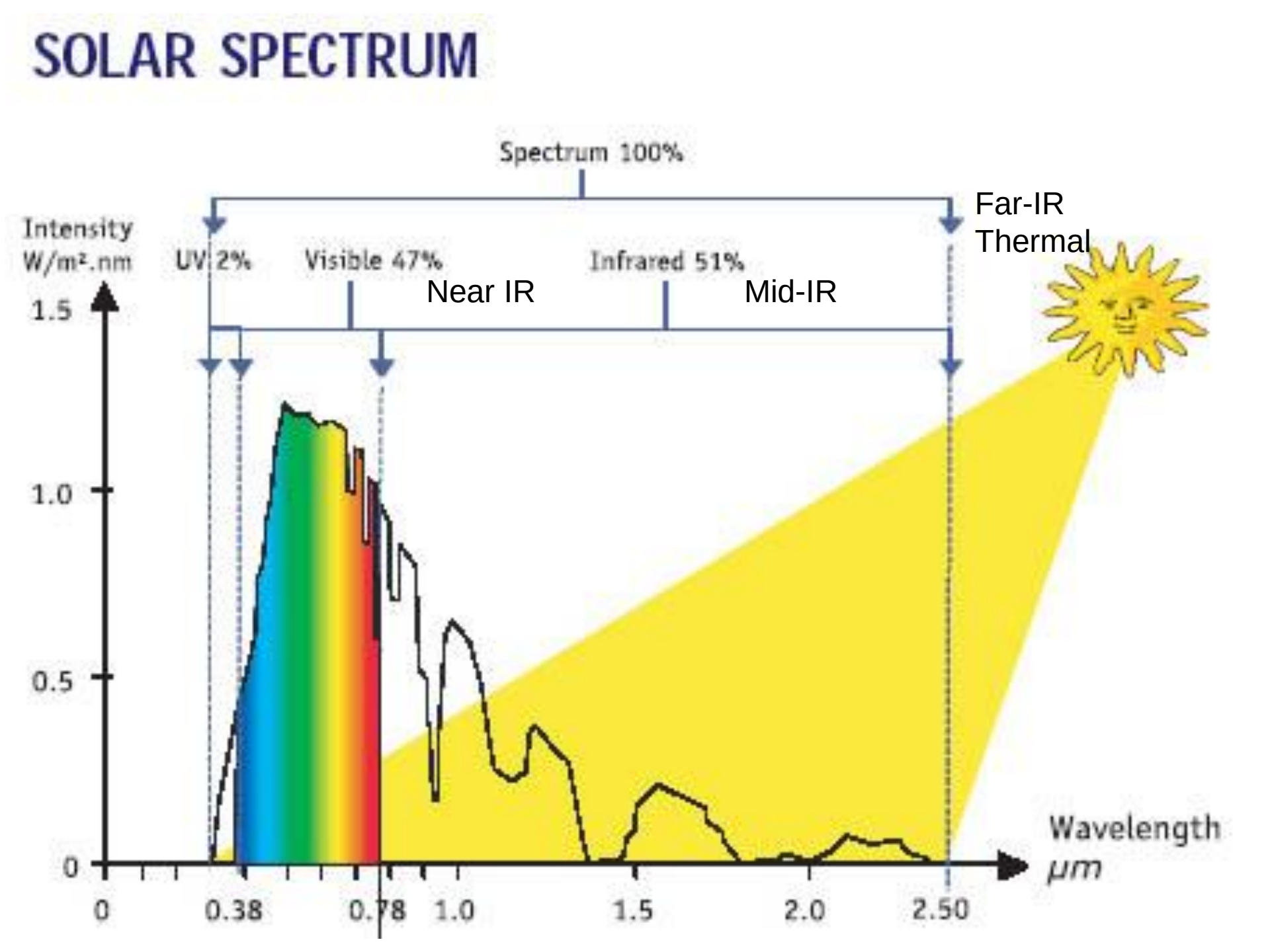


advantages of Infra-Red wavelengths: contrast

Spectral Reflectance Curves

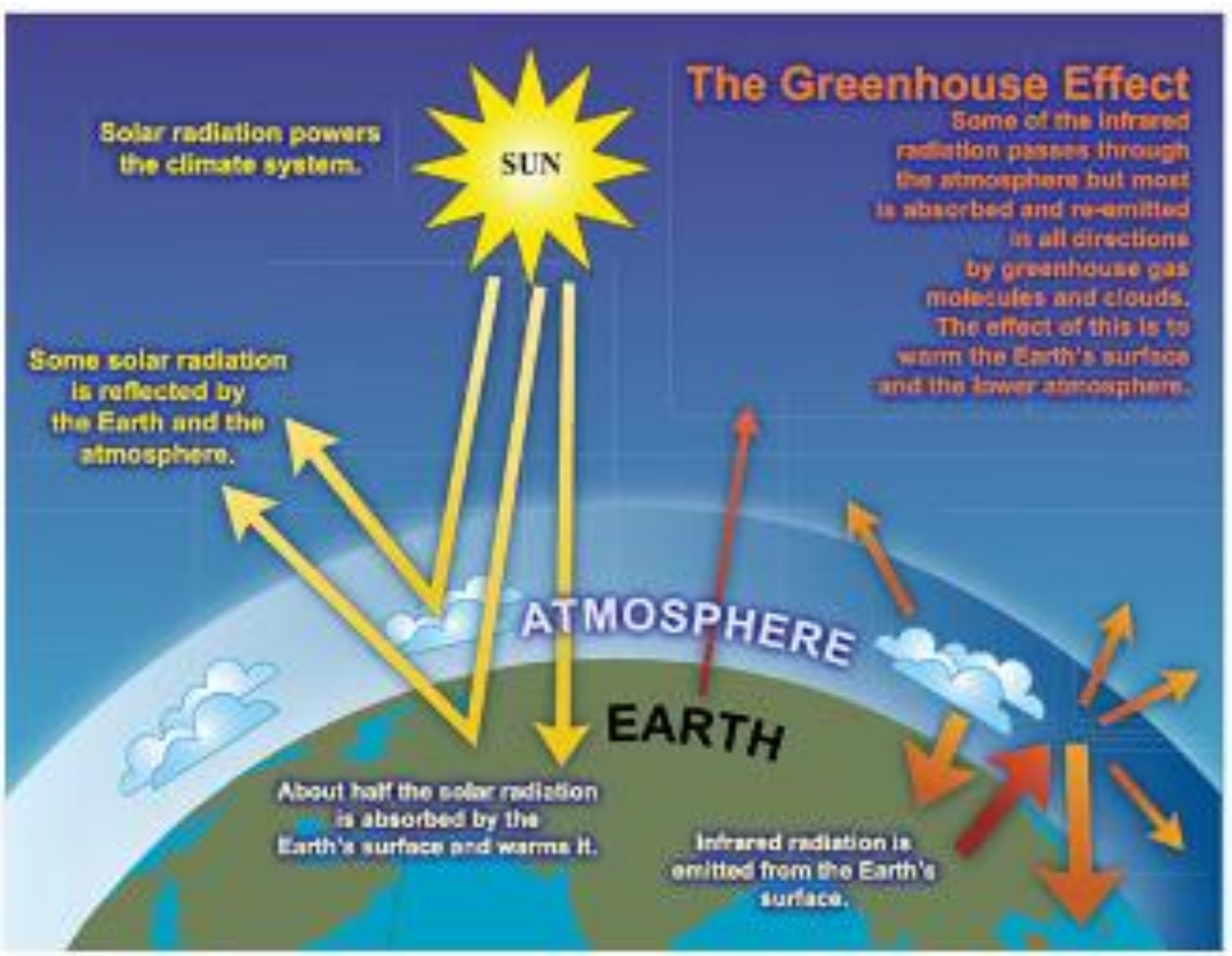


SOLAR SPECTRUM



Thermal Infrared (3-15 microns)

This records longer wavelengths (shown in orange) and a measure of temperature as it is emitted **NOT** reflected IR - Works day / night

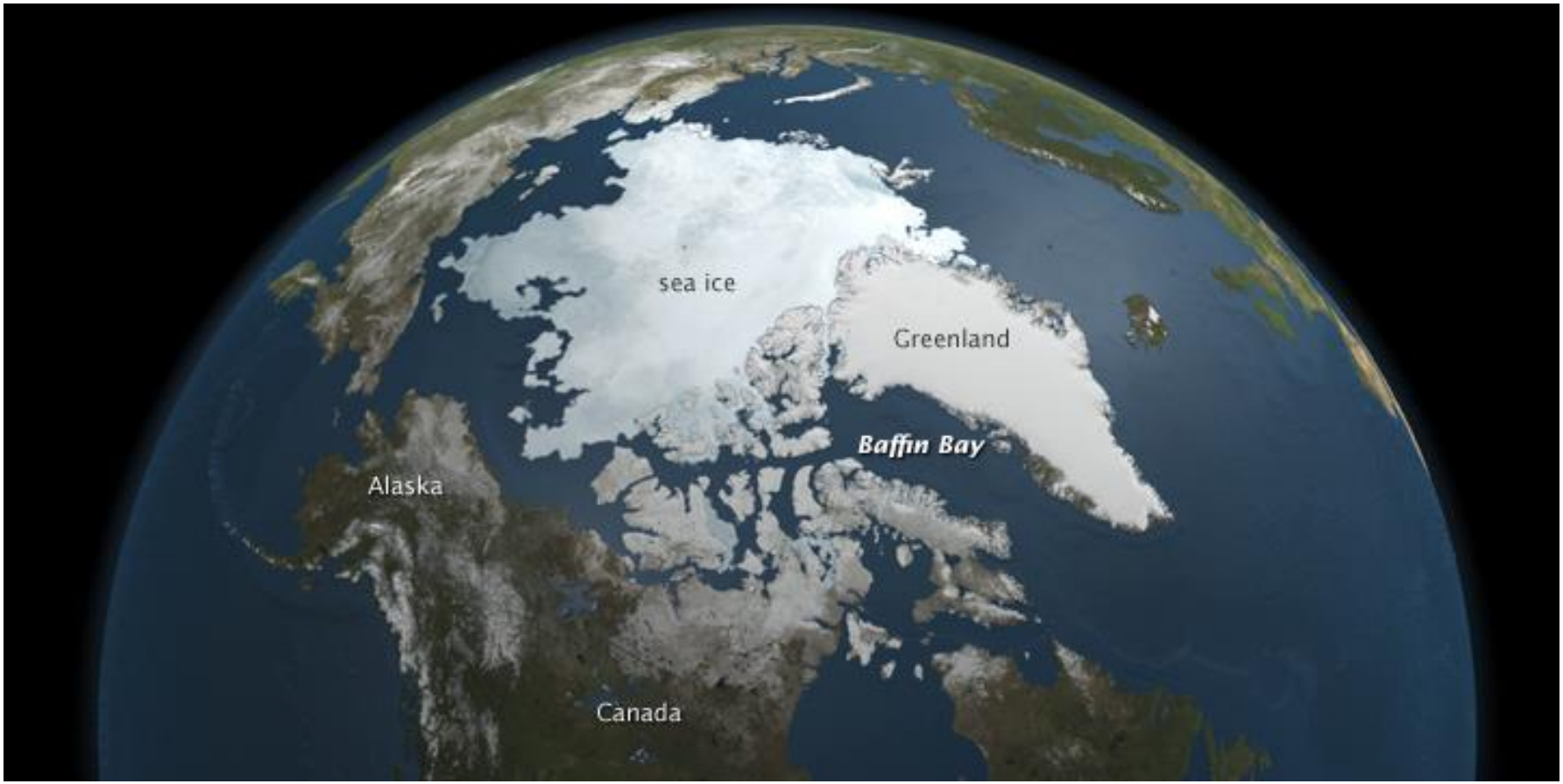


Prince George Landsat 5 Band 6 - thermal-IR

‘Brightness temperature’ – related to surface thermal qualities

Microwave: 1mm – 1 metre wavelength

These wavelengths beyond the infra-red can 'see through' clouds, light rain, and snow, but there is a low amount of it
… why we use these wavelengths for communications



As wavelength increases, so does atmospheric penetration ….

Gamma rays: **most don't reach earth**

Table: penetration by energy wavelengths

Ultra-violet	Cannot get through glass
Visible	Can penetrate through glass
Infra-Red	Penetrates through haze
Thermal Infra-Red	Penetrates through smoke
Microwave	Gets through clouds, snow, and even sand

Summary

Remote Sensing activity is classified into three groups based on the wavelengths used, and type/source of data:

1. Visible and Near/Mid Infrared (reflected) = 'optical'

2. Thermal Infrared (emitted from earth)

3. Microwave (= cloud-free … includes Radar)