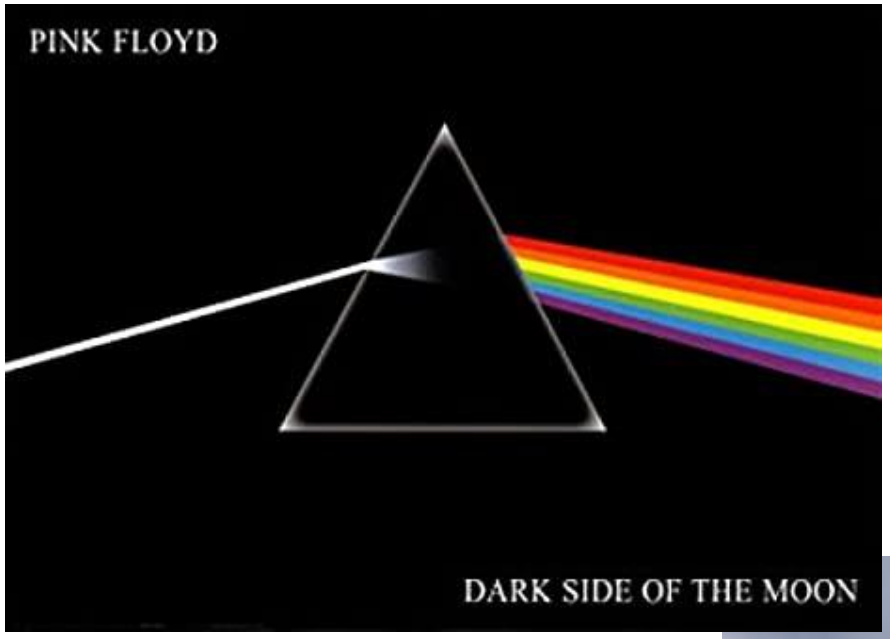
Remote sensing and the electromagnetic spectrum



The EM spectrum provides the 'layers' in RS and is key to the data collected.

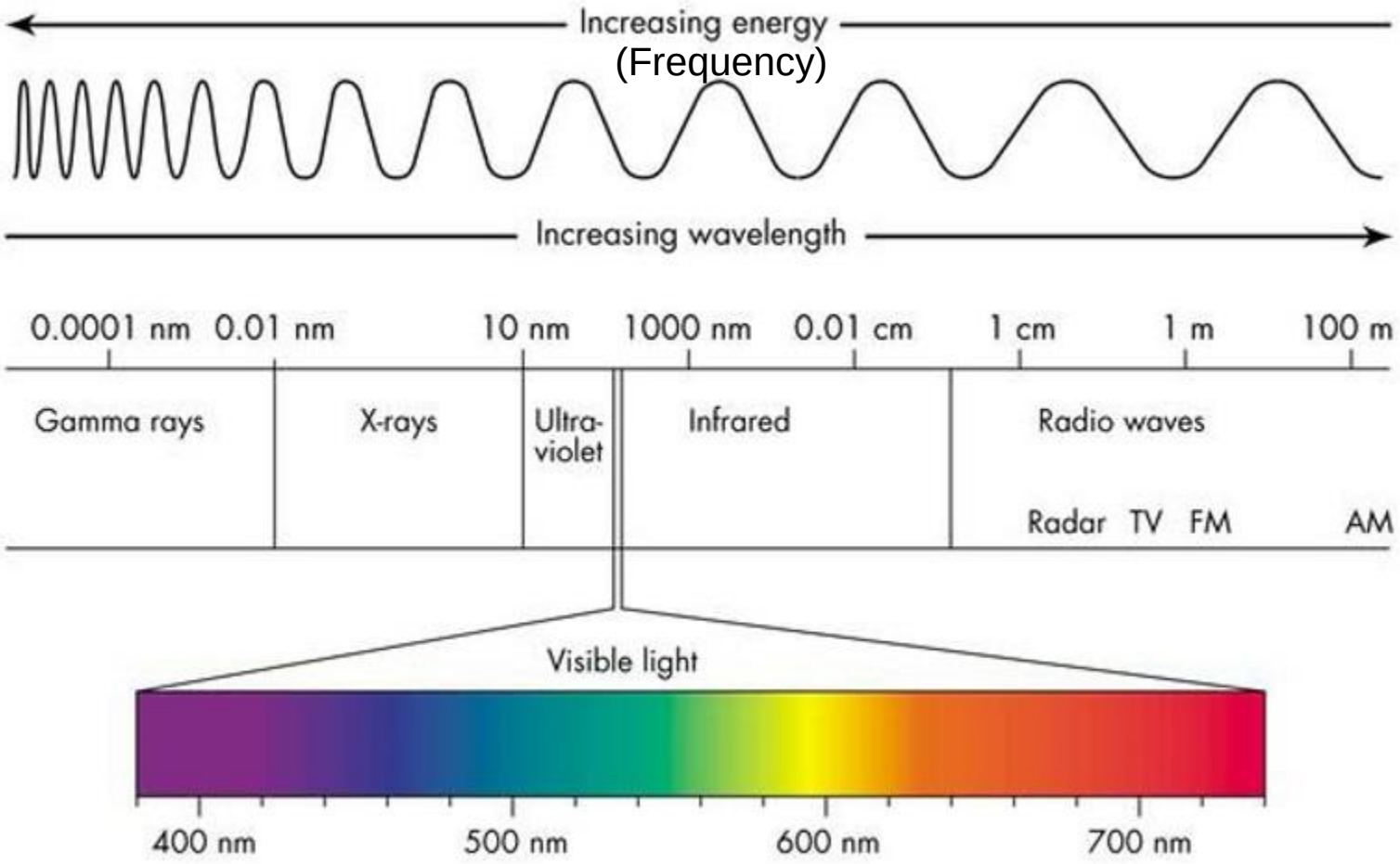
Units of wavelength measurement

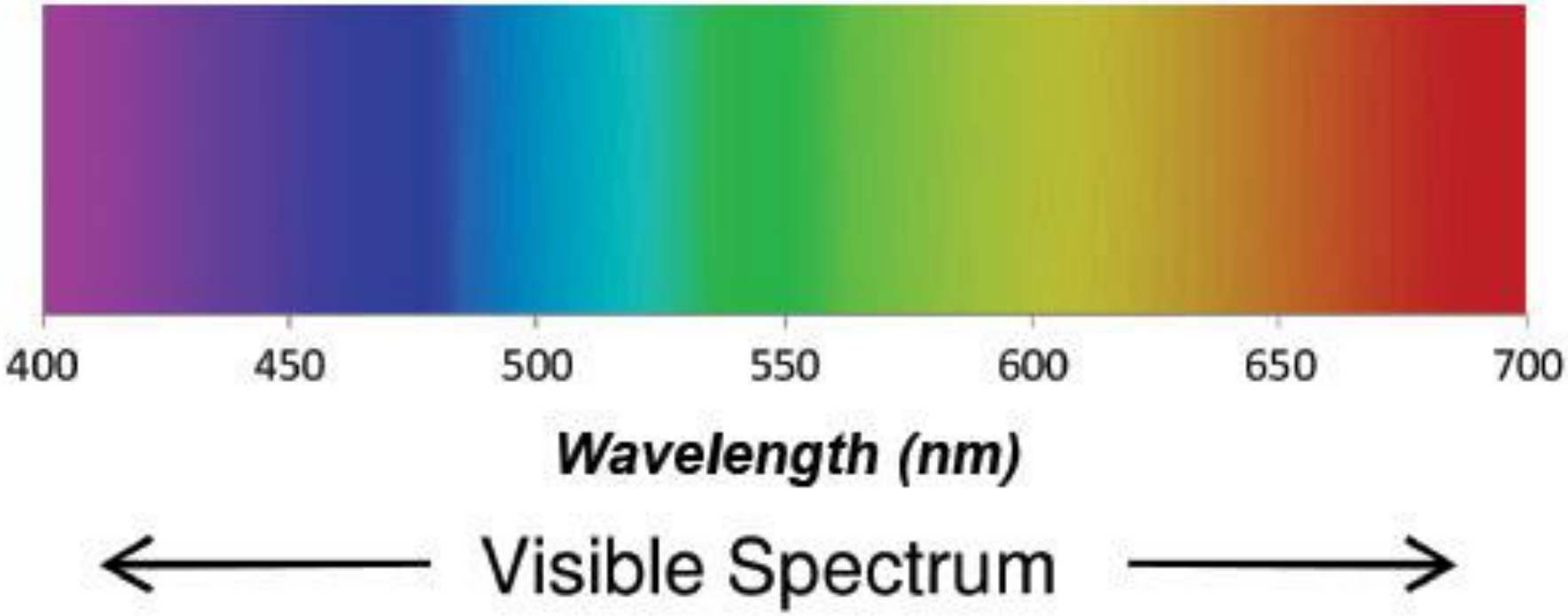
Metres: thousandths of a km

Millimetres: thousandths of a metre

micrometres: millionths of a metre (microns)

nanometres: billionths of a metre

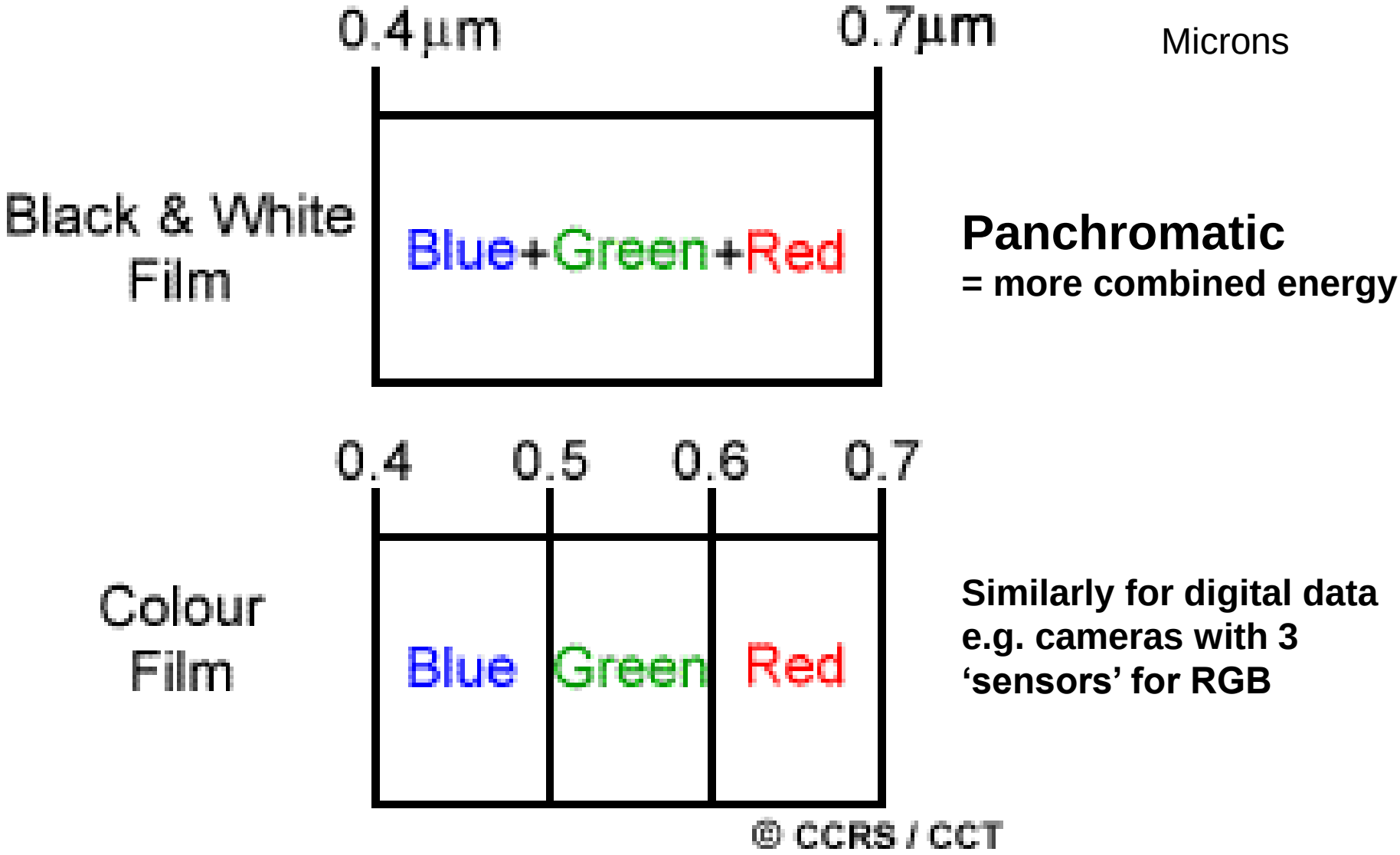




Here are the 7 rainbow colours from shortest to longest wavelength.

- 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 620 - 700nm = longest visible wavelength

Visible wavelengths range from 0.4- 0.7 microns (400-700nm)


0.4µm
0.7µm
Microns
Black & White Film
Blue+Green+Red
Panchromatic
= more combined energy
0.4
0.5
0.6
0.7
Colour Film
Blue
Green
Red
Similarly for digital data e.g. cameras with 3 'sensors' for RGB
© CCRS / CCT

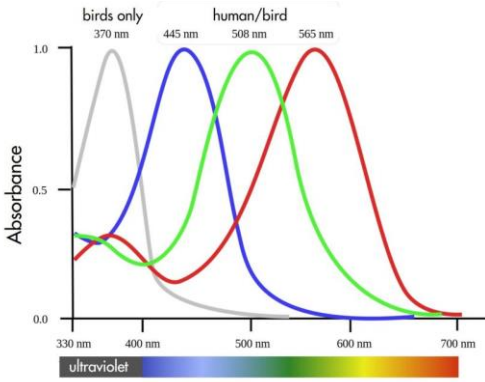
Panchromatic air photo: 15th / University Way

Colour air photo: 15th / University Way

There is limited ‘extra information’ compared to PAN

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		



1950s: Infra-red (IR) photography

IR was developed during the Korean War to distinguish between healthy vegetation (reflecting 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

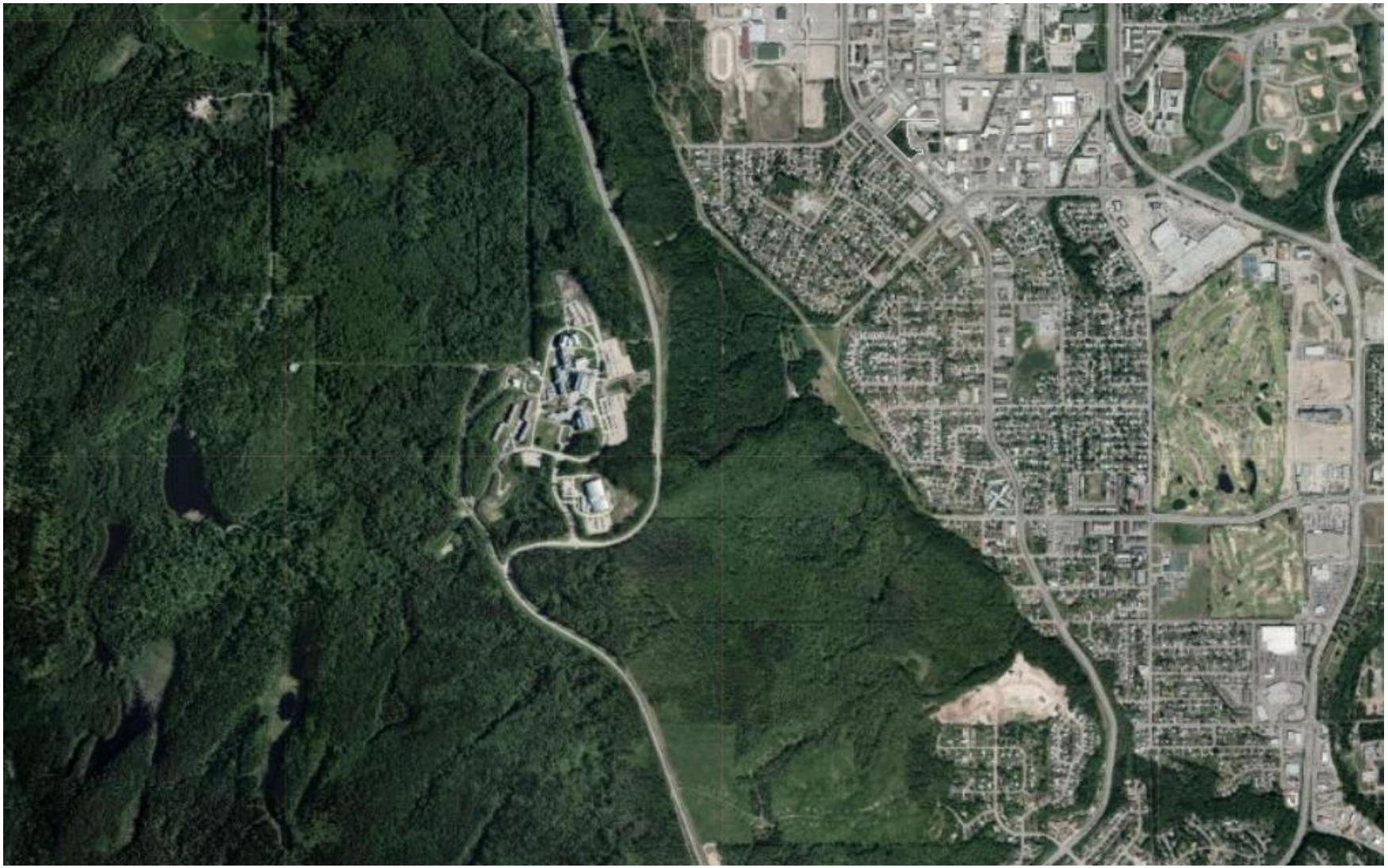
/ screen display

B

G

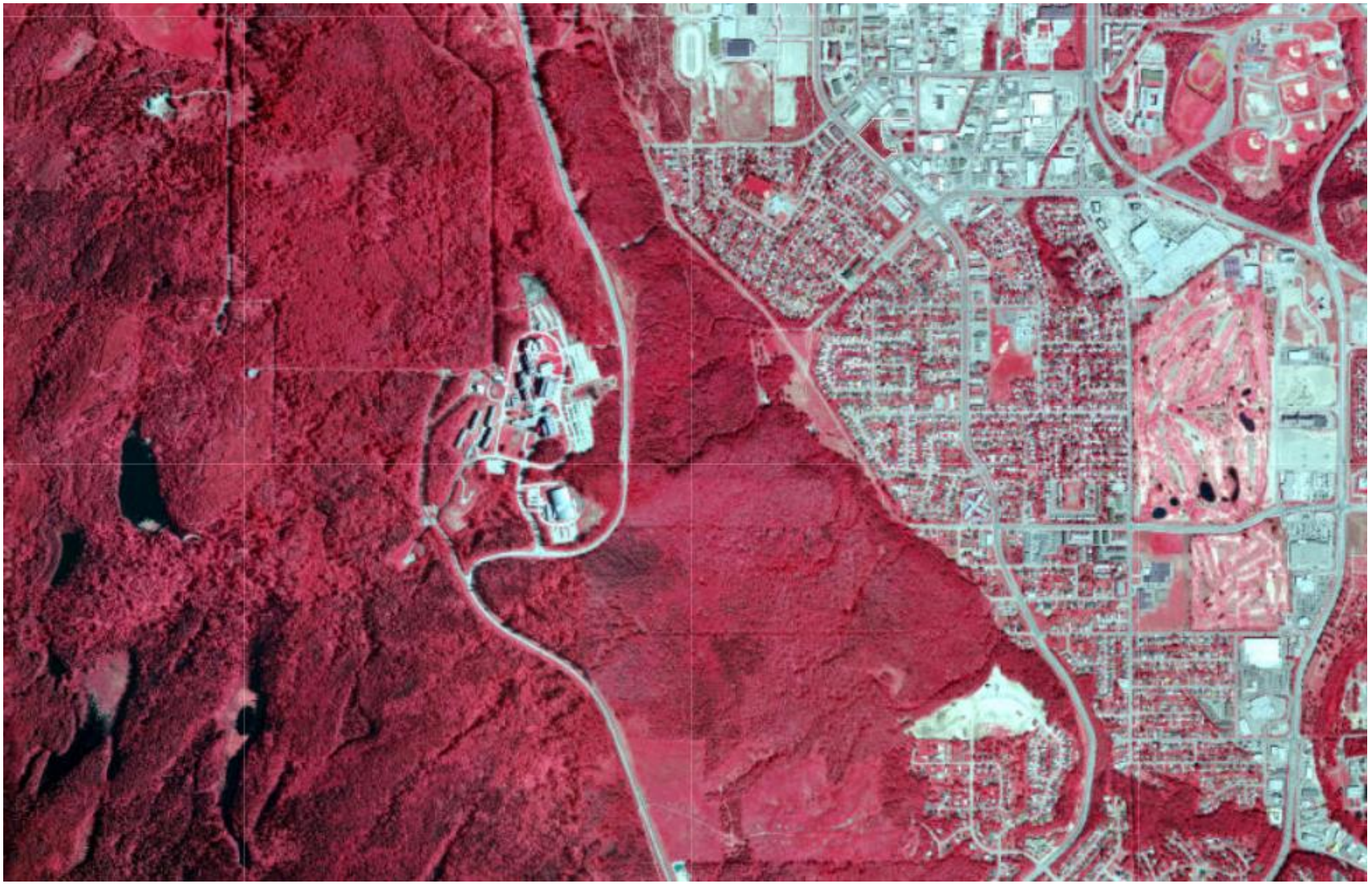
R

PGmap spring 2014 natural colour



https://pgmap.princegeorge.ca/Html5Viewer/index.html?viewer=PGMap

PGmap spring 2014 IR image:



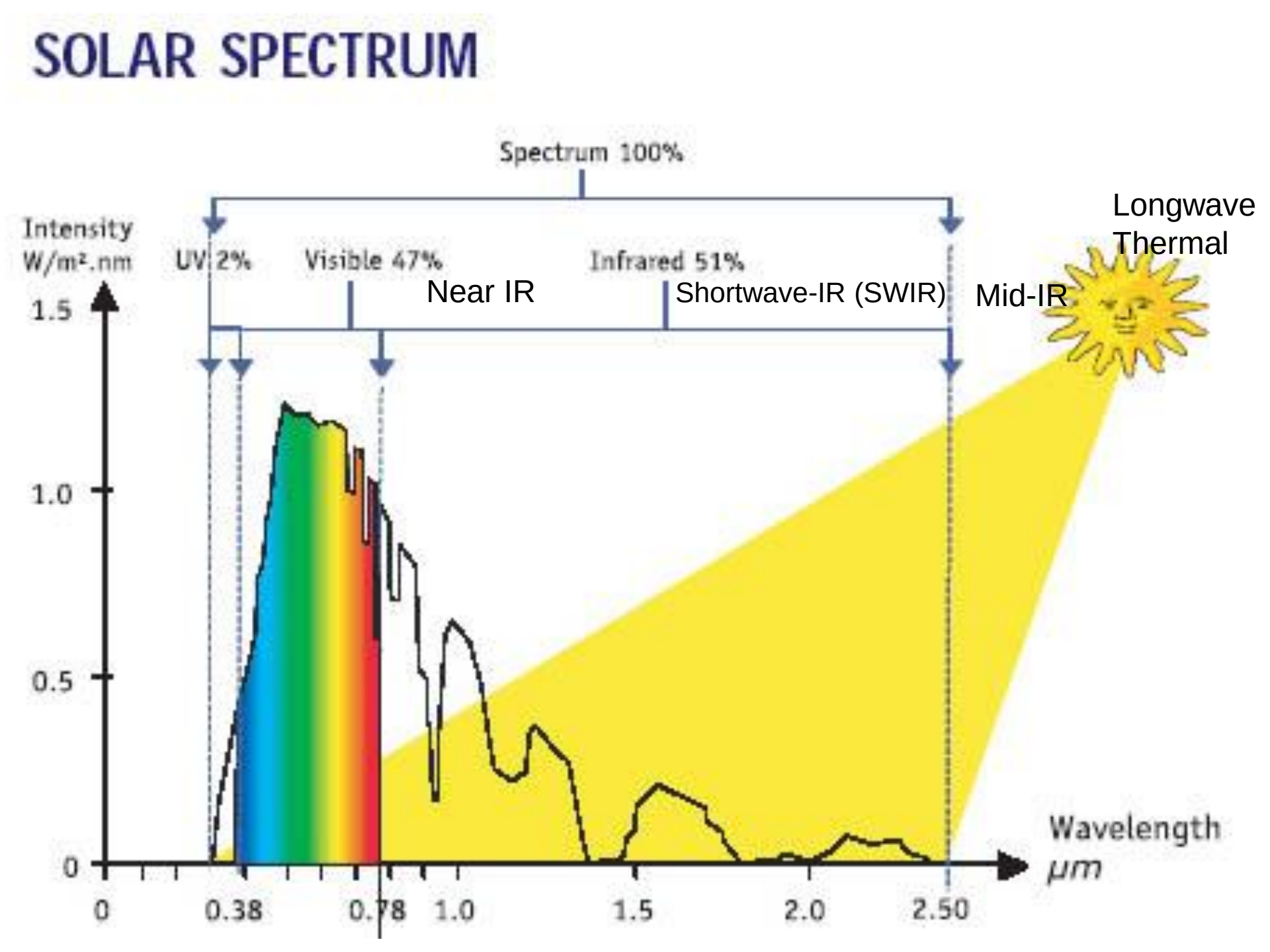
Summary of advantages of (near) Infra-Red wavelengths:

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: SWIR - **moisture content** (inverse= dryness)
SWIR= ShortWave IR
Visible, Near and SWIR are **reflected** energy from the Sun

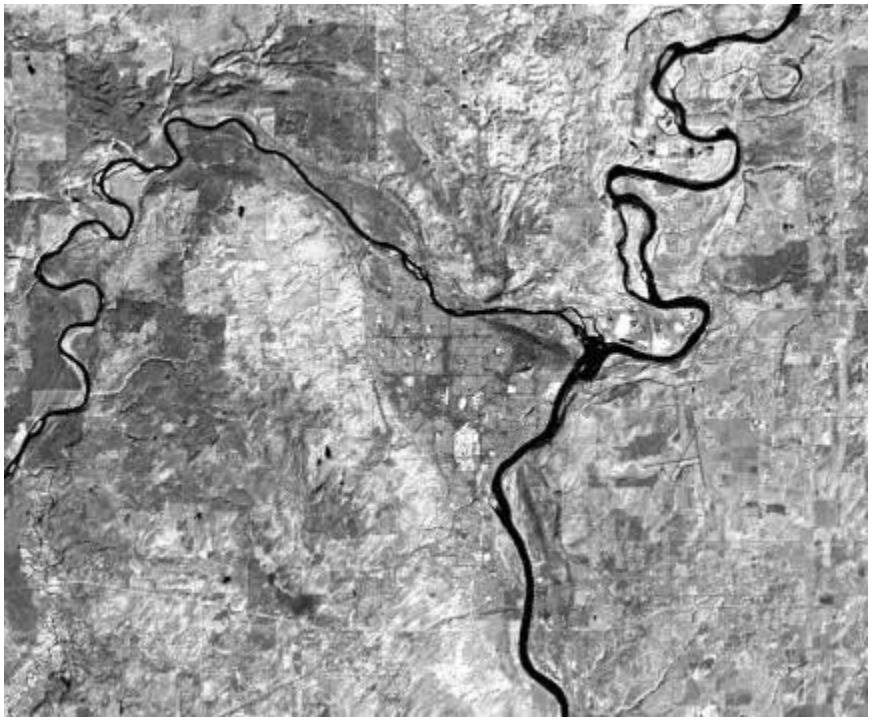
3.0- 15.0 microns: far IR – thermal (temperature)
Some sources extend far IR to 1000 microns (1 mm)

Note: most of this energy is not reflected solar energy, but is **emitted** terrestrial energy (see previous slide)

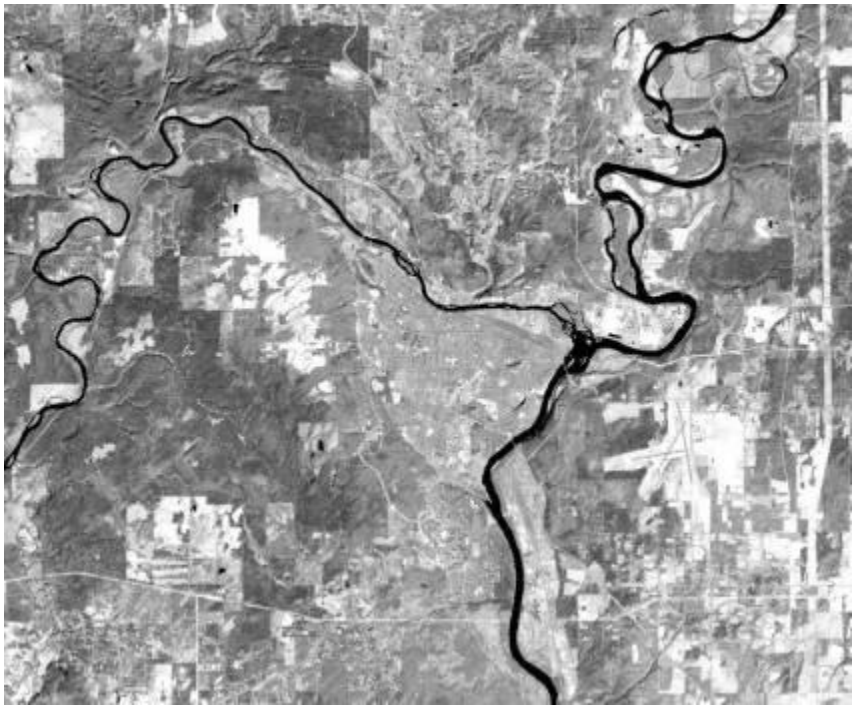
The **near IR** (0.7-1.3 microns) records energy related to **vegetation vigour** (health), while the **SWIR** (1.3-3.0 microns) is (soil) **moisture**.

Neither have to do with temperature (or not much)

Near-IR



SWIR



Landsat TM band combinations: Visible versus IR combination

RGB are not too different

Visible wavelengths image

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

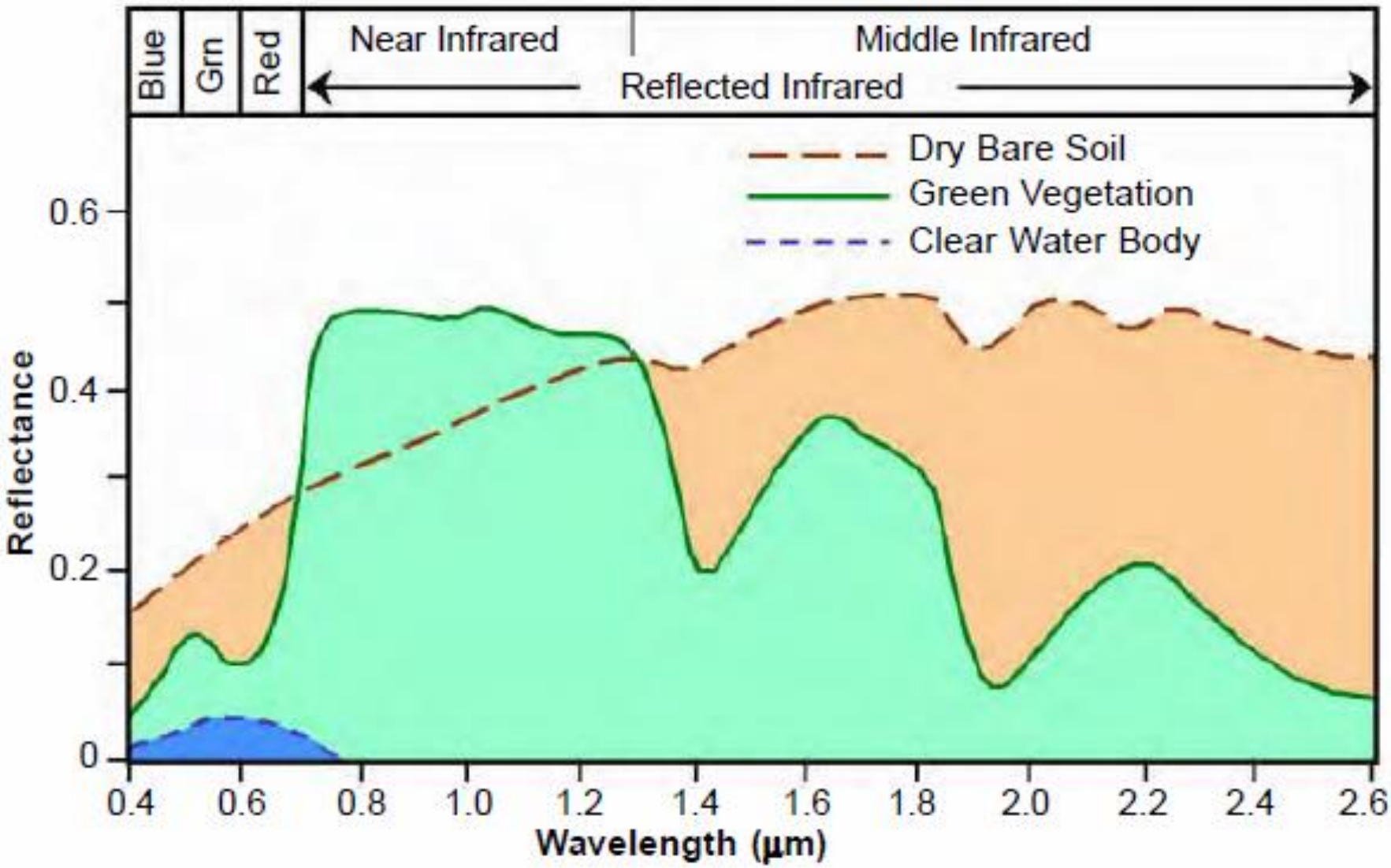
Including Infrared (NIR / SWIR)

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

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

advantages of Infra-Red wavelengths: contrast

Spectral Reflectance Curves



The various wavelengths are captured as ‘Bands’ or layers e.g. Landsat satellites 4, 5 and 7 (below)

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

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

Note previous confusion of ‘SWIR with Mid-IR

A note on divisions within Infrared

Thermal

Division name	Abbreviation	Wavelength	Frequency
Near-infrared	NIR, IR-A *DIN*	0.75–1.4 μm	214–400 THz
Short-wavelength infrared	SWIR, IR-B *DIN*	1.4–3 μm	100–214 THz
Mid-wavelength infrared	MWIR, IR-C *DIN*; MidIR.[19] Also called intermediate infrared (IIR)	3–8 μm	37–100 THz
Long-wavelength infrared	LWIR, IR-C *DIN*	8–15 μm	20–37 THz
Far infrared	FIR	15–1,000 μm	0.3–20 THz

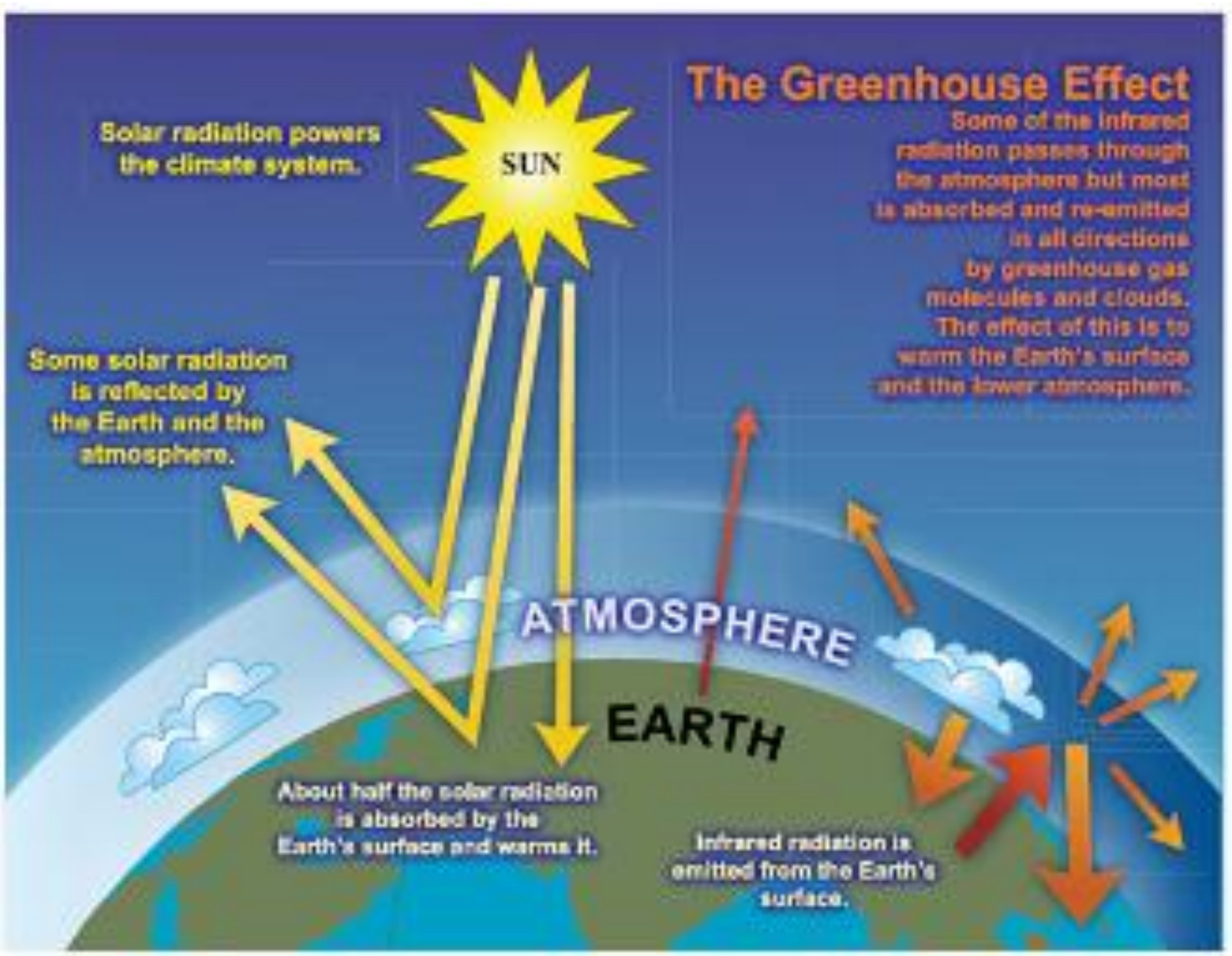
https://en.wikipedia.org/wiki/Infrared

Prince George Landsat 5 Band 6 - thermal-IR

‘Brightness temperature’ – related to surface thermal qualities

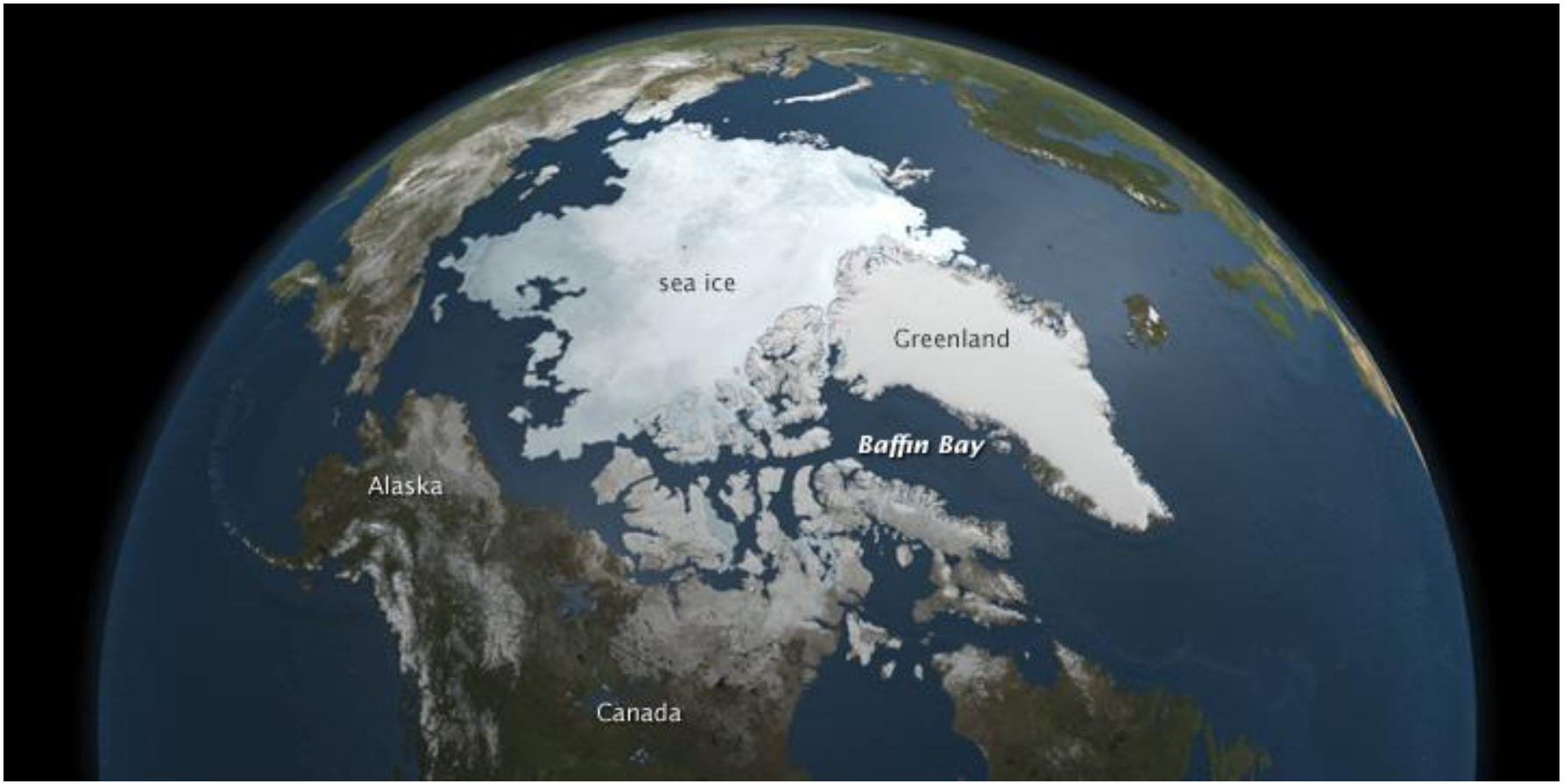
Thermal Infrared (3-15 microns)

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



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/Shortwave Infrared (reflected) = 'optical'

2. Thermal Infrared (emitted from earth)

3. Microwave (emitted and cloud-free … includes Radar)