GEOG 357

LECTURE 14

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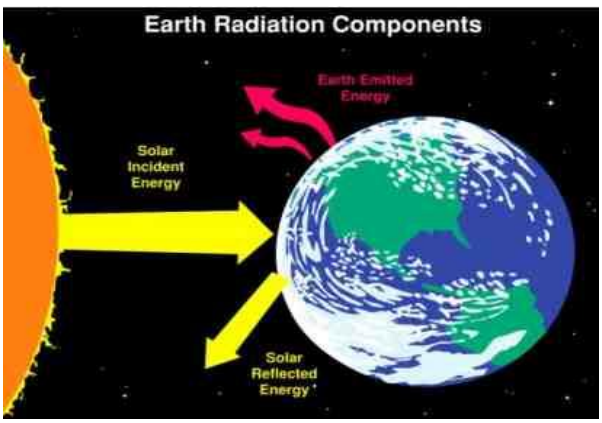
Thermal Infrared (3-14 microns)

Features of thermal RS:



records longer wavelengths and a measure of temperature as it is emitted **NOT** reflected IR

- Works day / night (temperatures above 0 K = -273 Celsius)

Usually, lower pixel resolution as there is less energy to capture

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Thermal Infrared (3-14 microns)

Thermal IR can 'see' through haze and smoke - but not clouds

A comparison of a thermal image and an ordinary photograph. The plastic bag is mostly transparent to long-wavelength infrared, but the man's glasses are opaque.

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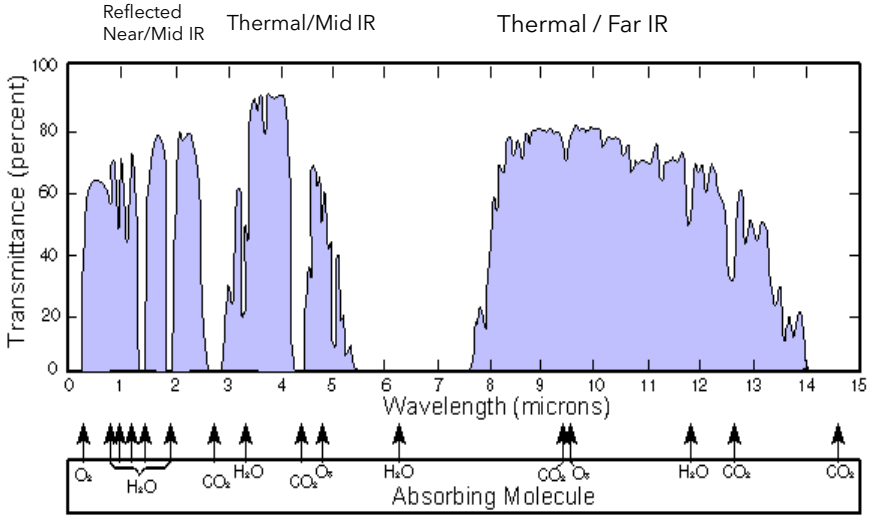
1. Thermal Wavelengths (3-14 μm) windows:3-5,8-14

In 5 - 8 micrometres, energy is **absorbed by water vapour** in the atmosphere.



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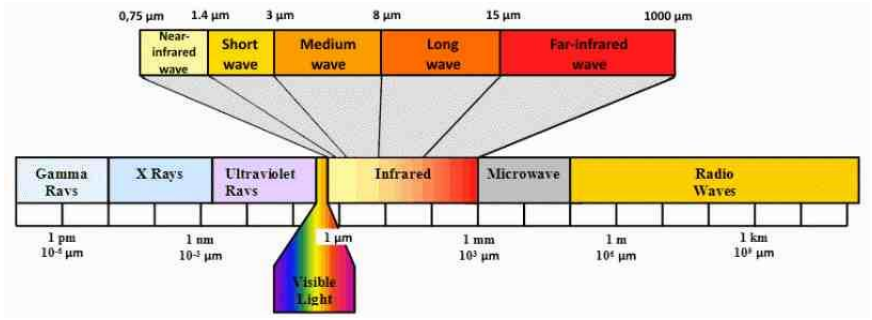
There is some confusing naming of IR sections of the spectrum

Bands NIR SWIR / MIR TIR



Different scientific areas use different terms

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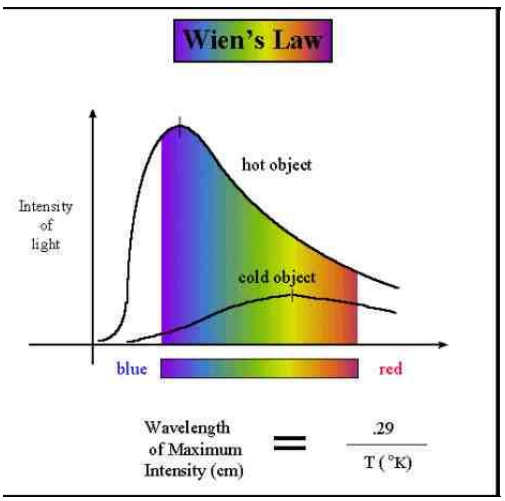
2. Wavelength & Temperature

- Thermal IR is emitted terrestrial energy
  - received from the sun and absorbed.
- All objects emit some energy if their temperature is above 0 Kelvin (= -273C)

Wien's Law: the maximum emission of energy from a body occurs at a wavelength **inversely** proportional to its temperature



Wavelength = 2898 /temp K (microns)

-> so earth radiates energy at longer wavelengths than the sun

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Wien's Equation: max energy wavelength (micrometres)
= **2898 / Temperature (K)**

Earth (temp = 27°C = 300K) = 2898 / 300 = 9.5
(thermal IR/long)

Forest fire (temp = 600K) = 2898 / 600 = 4.8
(thermal IR / mid)

SUN (temp= 6000K) = 2898 / 6000 = 0.5
(green)

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3. Brightness Temperature (DN) & Emissivity

Emissivity = the relative power of a surface to emit heat by radiation.

It is the ratio of energy radiated by a particular material to the energy radiated by a black body at the same temperature.

Brightness Temperature = emissivity x temperature ^{4}

(DN converted back to radiance)

i.e. Actual temperature = $\sqrt[4]{\text{DN /emissivity}}$

Sample emissivity values:

Water	0.99
Wet soil	0.95
Dry soil	0.92
Snow	0.85
Sand	0.76

Result: features with similar DNs may have different temperatures and vice versa ; we use an infrared thermal radiometer to 'ground truth' e.g. sea buoys

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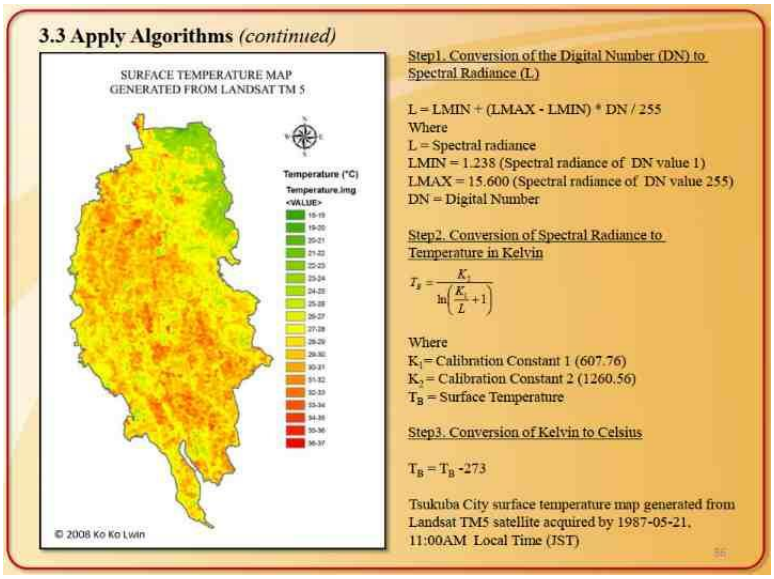
Converting thermal DN values to radiance → temperatures



This could be a topic for advanced RS

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4. Thermal Capacity of Surfaces: the role of water

Thermal capacity determines how well a material stores heat.
Water has a very high capacity

water heats up and cools down slowly, as it absorbs Visible / IR during the day and releases energy at night as thermal IR

In temperate climates, water is warmer in winter than land surfaces and cooler in summer; and may be warmer at night than land and cooler during the day.

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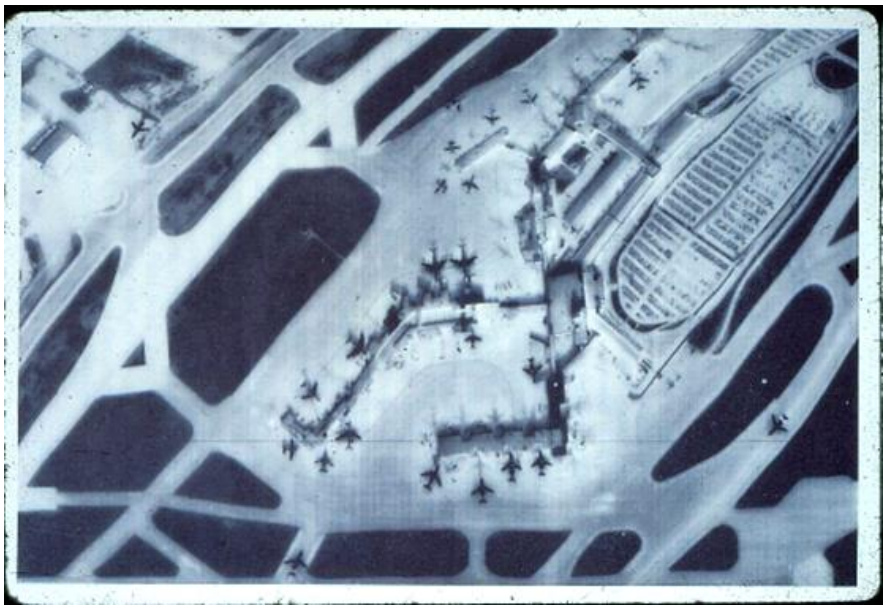
Dusseldorf airport thermal image



Daytime image - – note the 'ghost' plane shadows

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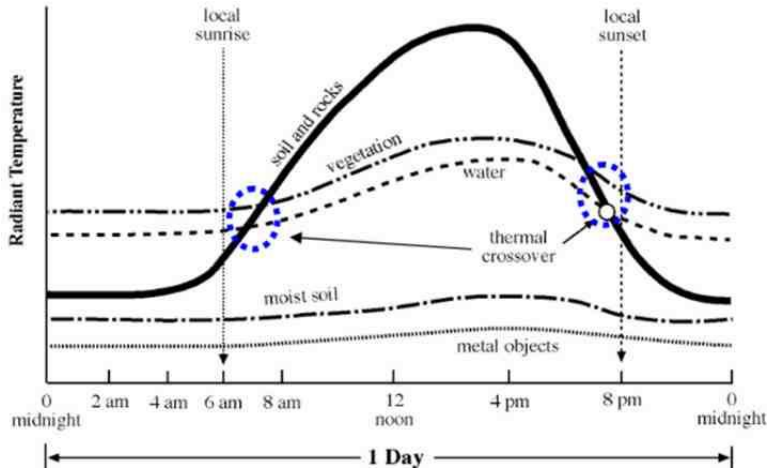
Diurnal variation – and thermal crossovers

The diurnal or seasonal times when land and water are equal in temperature and scanned images show least contrast. Such '**crossover** periods ' should be avoided in thermal sensing.



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Practical considerations in thermal remote sensing

➢Lower thermal wavelengths can get mixed with reflected solar energy (3-5 microns).

➢Night time is preferred to avoid shadowing (topographic / clouds) and solar heating.

➢The larger the pixel area, the finer temperature differences can be detected. …. Temperature resolution can be as fine as 0.1° C.

➢pixel size is larger (courser resolution), than for reflected bands …. as there is less energy to capture

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Landsat thermal bands

Landsat thermal bands are affected by:

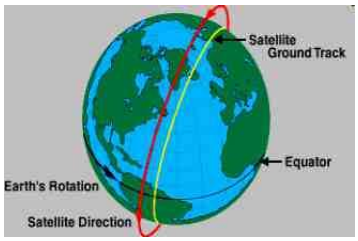
➢low radiance = reduced DN range (60-120m pixels)
➢shadows (10.30am)
➢recent moisture
➢it is mostly daytime so not ideal for thermal remote sensing
– except for 'ascending orbit' 'dark side of the earth'

Sensors, wavelength, resolution:

Landsat 4/5 TM: 10.45-12.4 120m

Landsat 7 ETM+: 10.31-12.46 60m

Landsat 8 (2013): 10.3-11.3; 11.5-12.5 100m



Sun-synchronous orbit

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Prince George Landsat 5 Band 6 - thermal-IR

'Brightness temperature' – related to surface thermal qualities

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(Landsat) thermal applications (short list)

- Urban heat island effects
- Volcanic hazard assessment
- Mapping lake thermal plumes from power plants
- Burnt area mapping and active fires
- Glaciers ????

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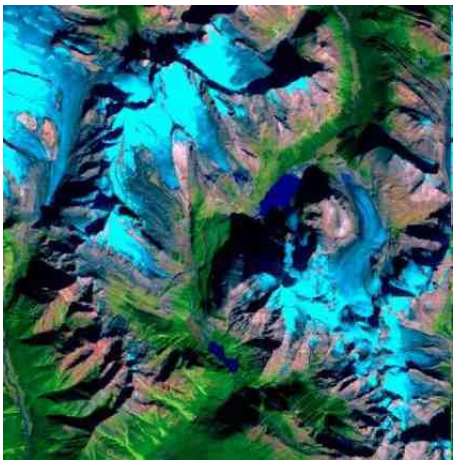
Thermal characteristics Mt. Robson, TM 543 composite/ thermal band 6

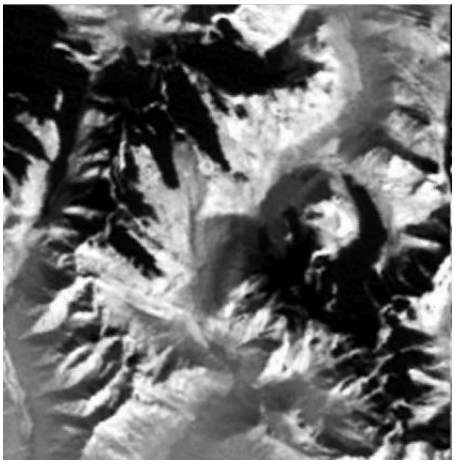
Water is cooler (darker) during day, but reversed at night .. due to heat transfer;

Vegetation is cooler than surroundings in day, warmer at night (leaves have moisture).

Grass is warmer during day than forest, cooler-darker at night

Damp ground: Effect of absorbed water: cooler in day, warmer at night





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Fires burned along the coast of Queensland, Australia on October 17, 2009. The MODIS on NASA's Aqua satellite captured this true-color image the same day.

Fires – MODIS

Fires in the Bahamas, Florida and Cuba (03 April 2004, 18:30 UTC) identified using MODIS Aqua and outlined in red on the MODIS 1km active fire map (MODIS)
http://activefiremaps.fs.fed.us/

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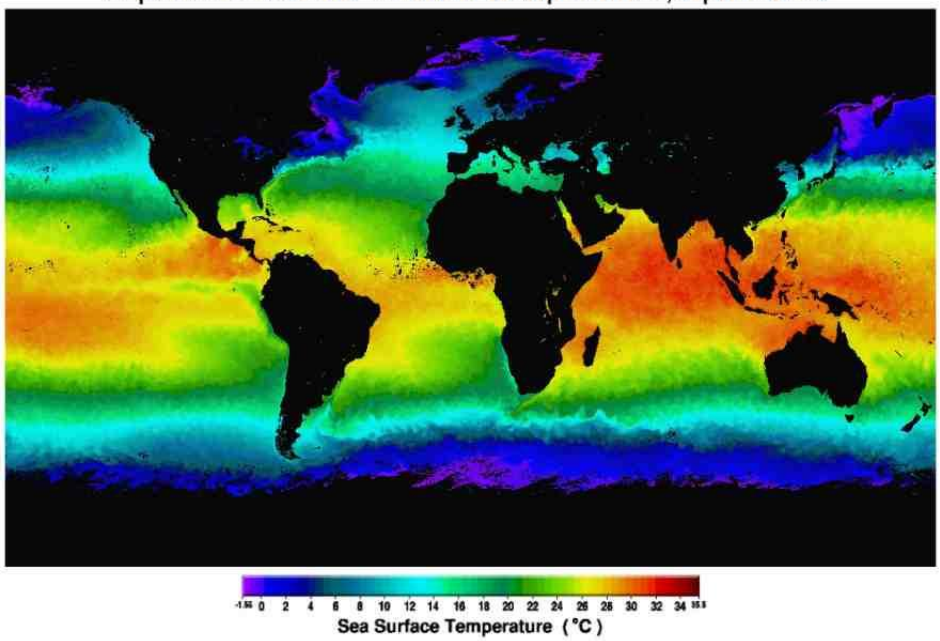
Aqua MODIS Sea Surface Temperature, April 2004



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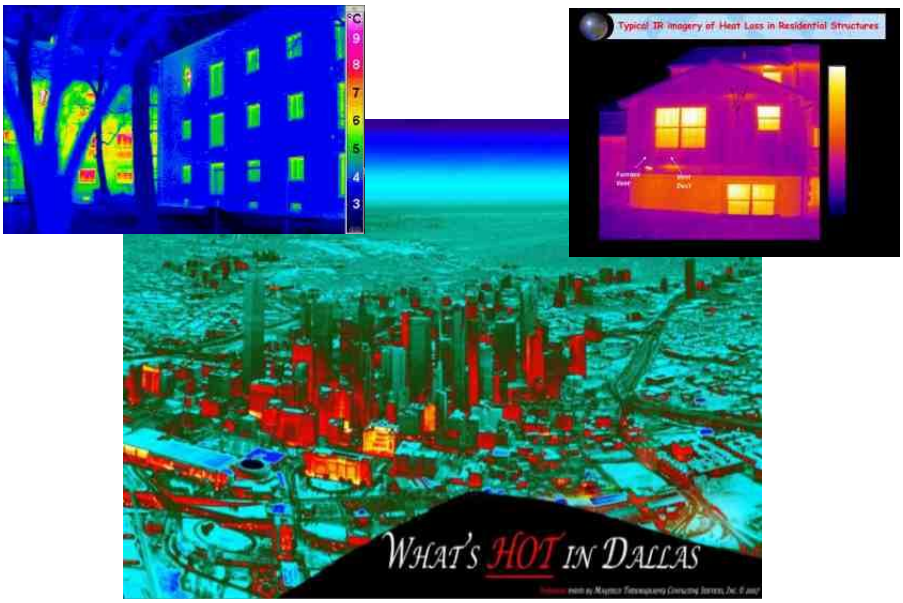
Thermography- Building heat loss



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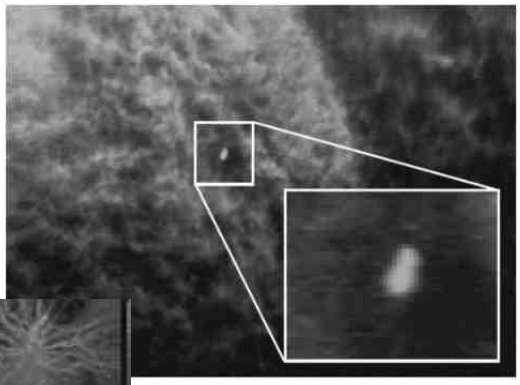
Wildlife:

http://idahohelicopters.com/flir.htm **x**



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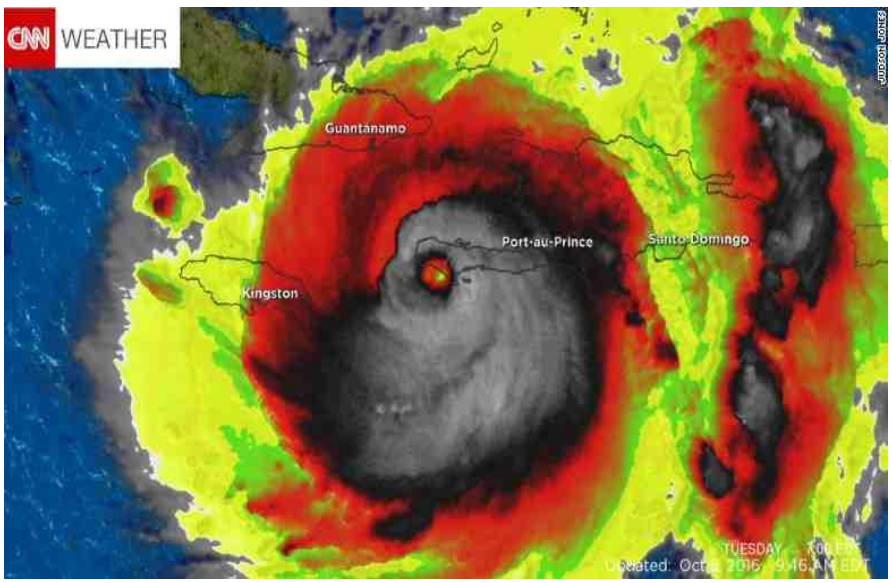

Hurricane Matthew, October 2016

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