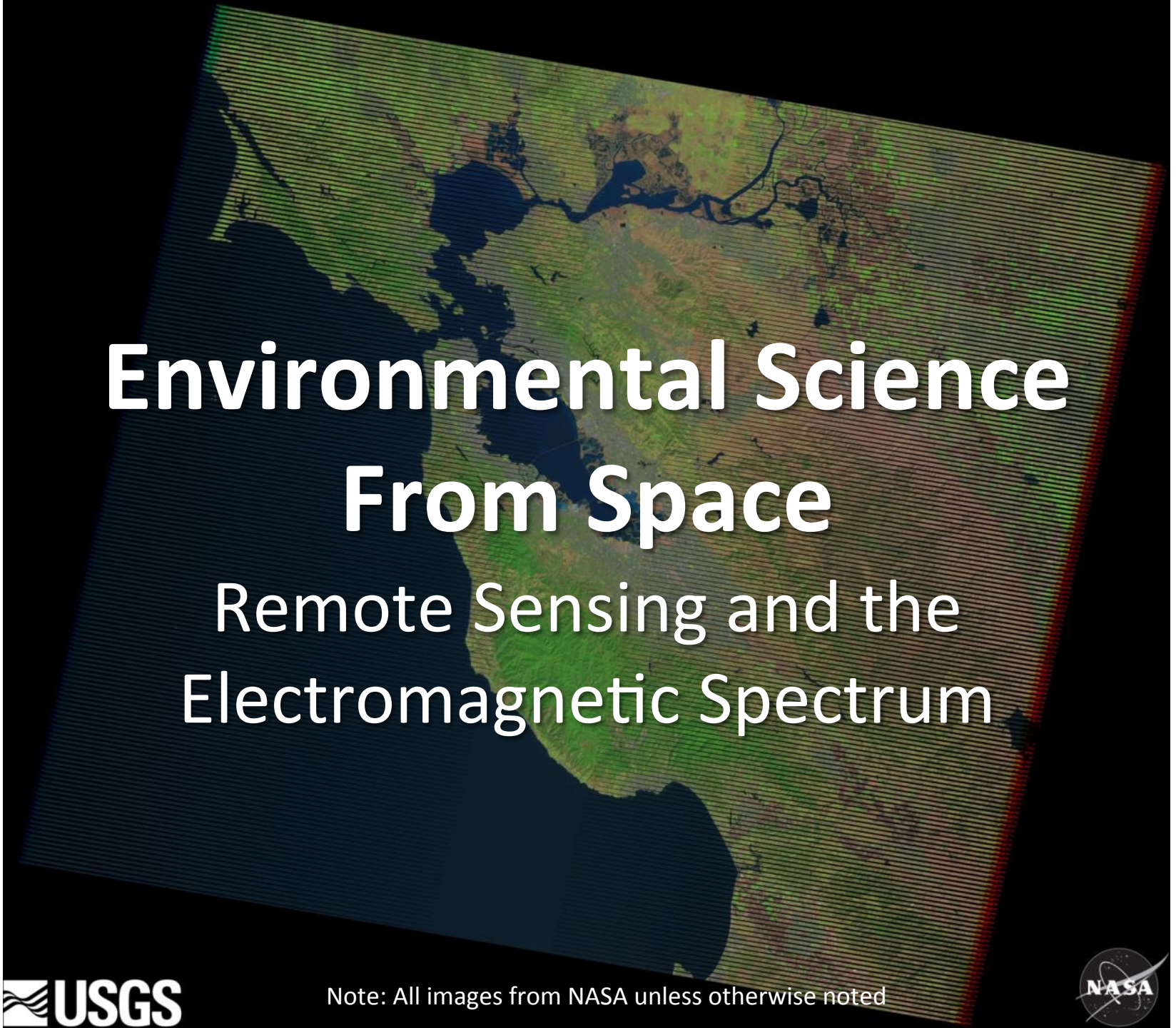


Environmental Science From Space

Remote Sensing and the Electromagnetic Spectrum

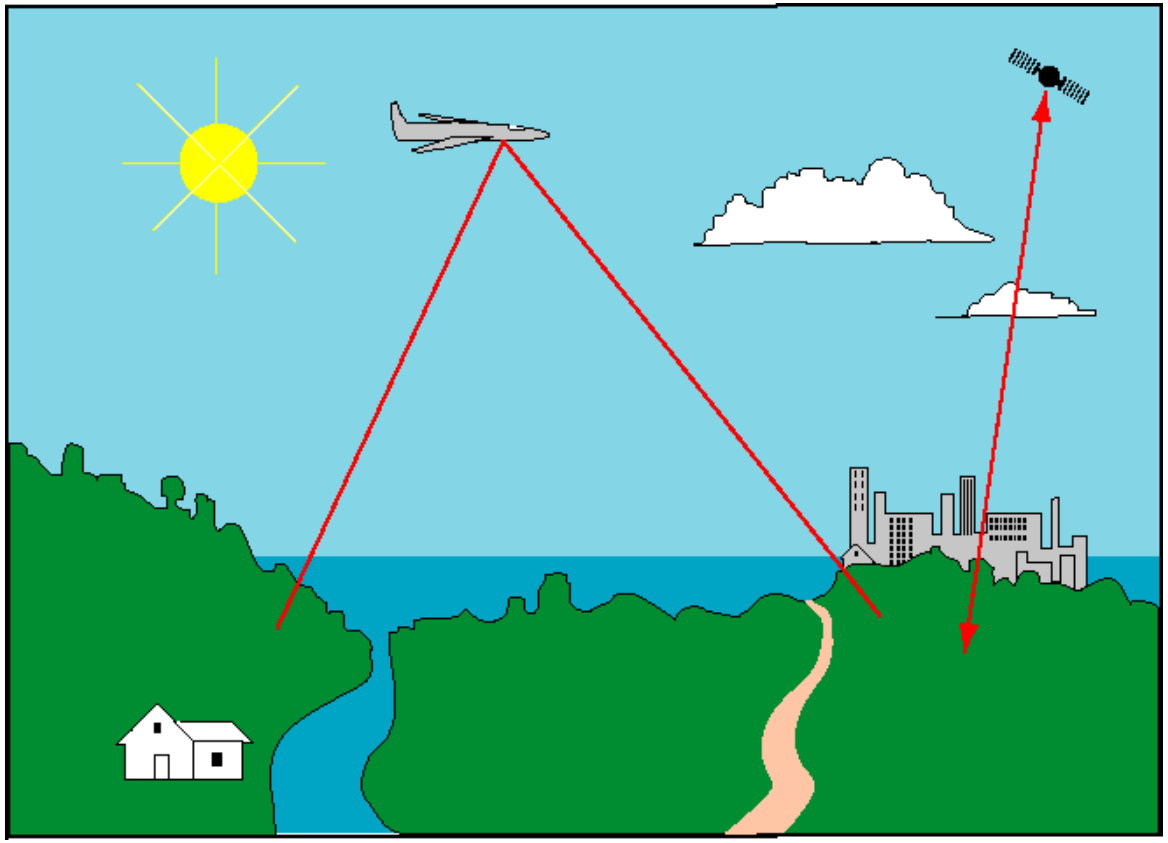
USGS

Note: All images from NASA unless otherwise noted

NASA

Remote Sensing

= learning about an object or phenomenon without touching, usually using satellites or airplanes

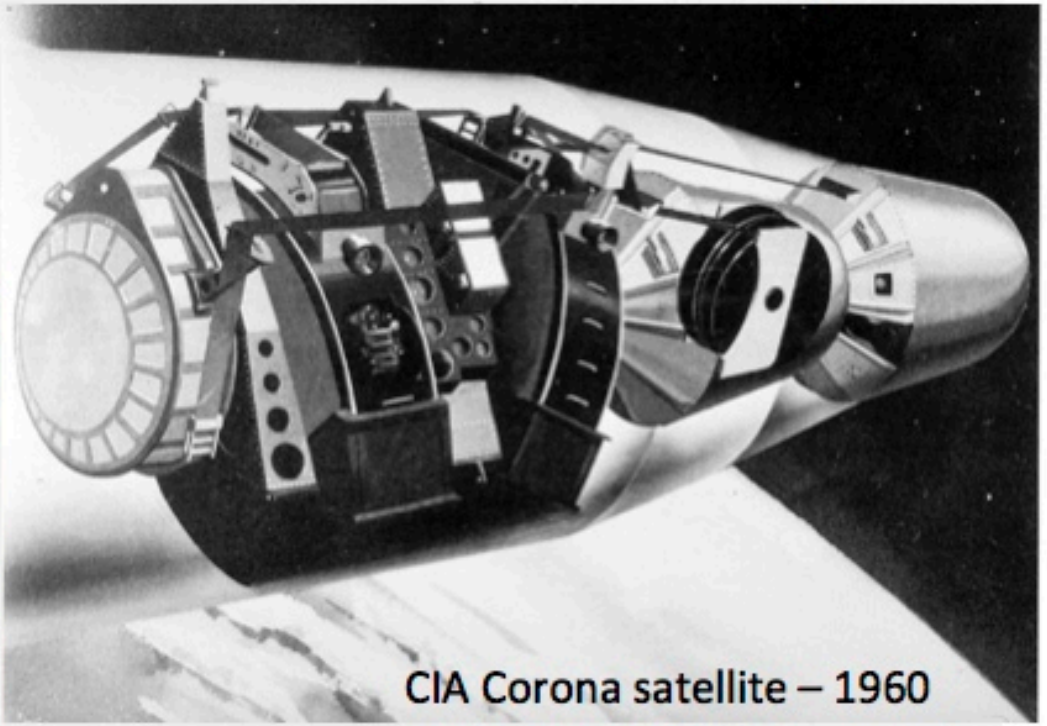


http://www.nasa.gov/centers/langley/news/factsheets/RemoteSensing.html

1830s

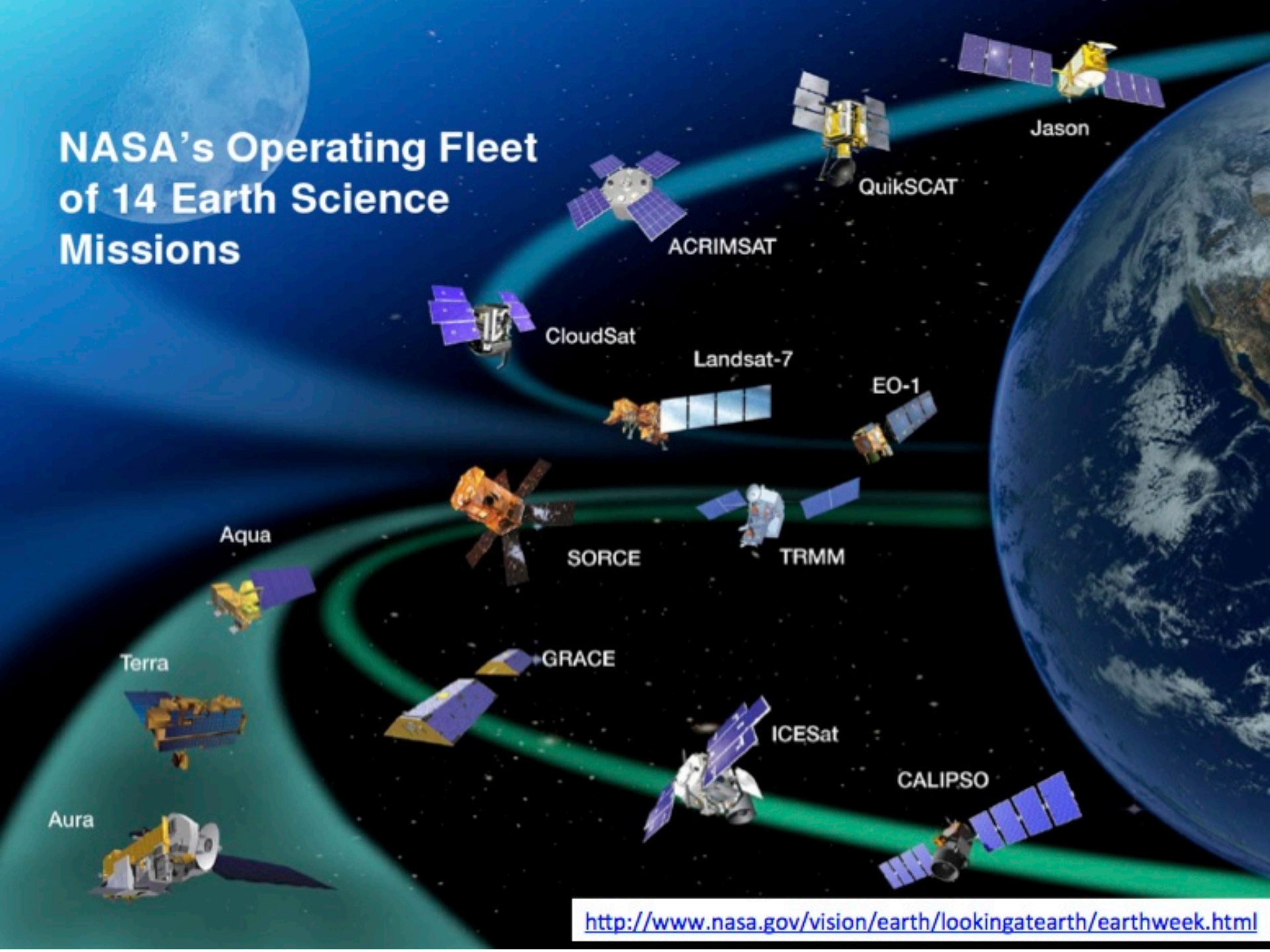
Early 1900s

U-2 Spyplane at
70,000 ft – 1950s

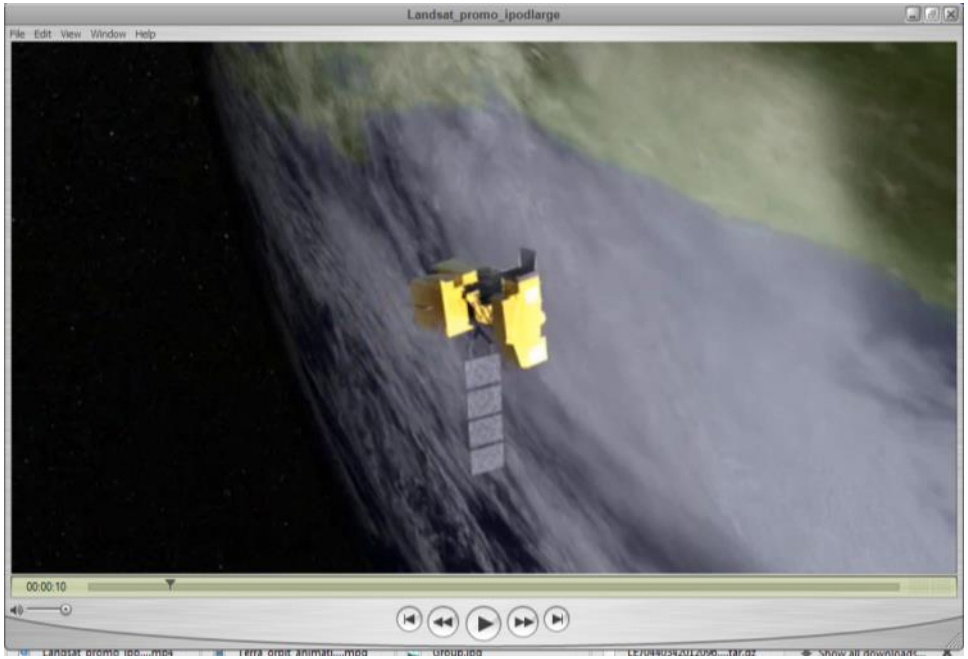


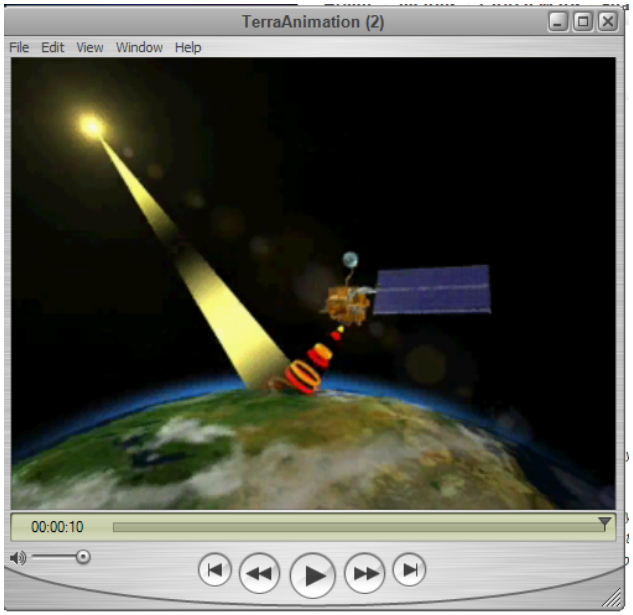
CIA Corona satellite – 1960

http://earthobservatory.nasa.gov/Experiments/ICE/Channel_Islands/tg_channelislands.php

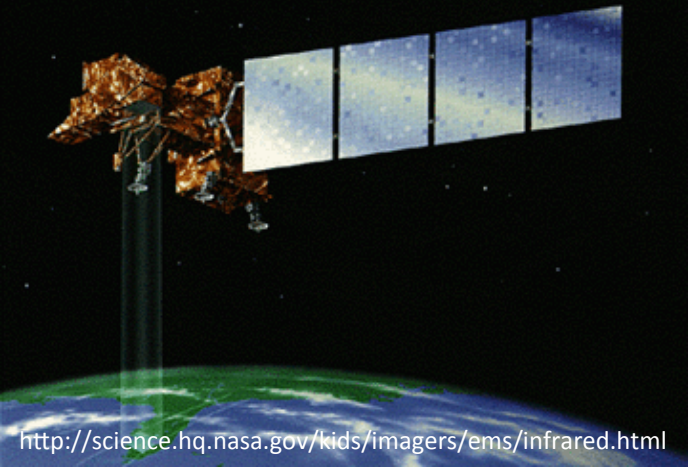

NASA's Operating Fleet of 14 Earth Science Missions
Jason
QuikSCAT
ACRIMSAT
CloudSat
Landsat-7
EO-1
Aqua
SORCE
TRMM
Terra
GRACE
ICESat
CALIPSO
Aura
http://www.nasa.gov/vision/earth/lookingatearth/earthweek.html

Videos

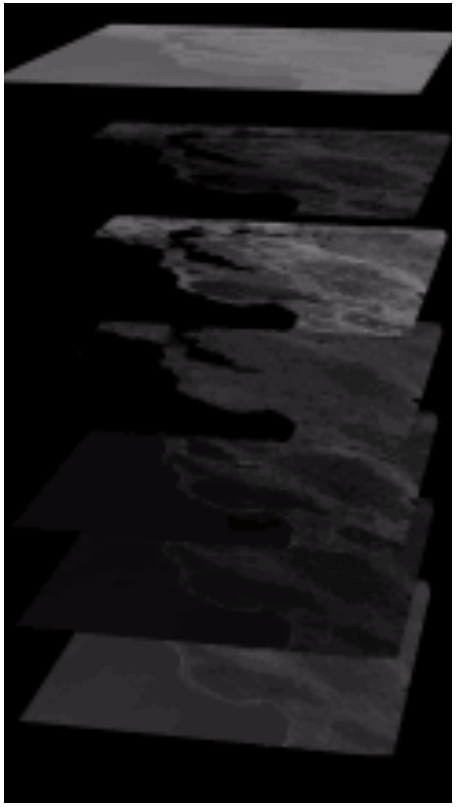




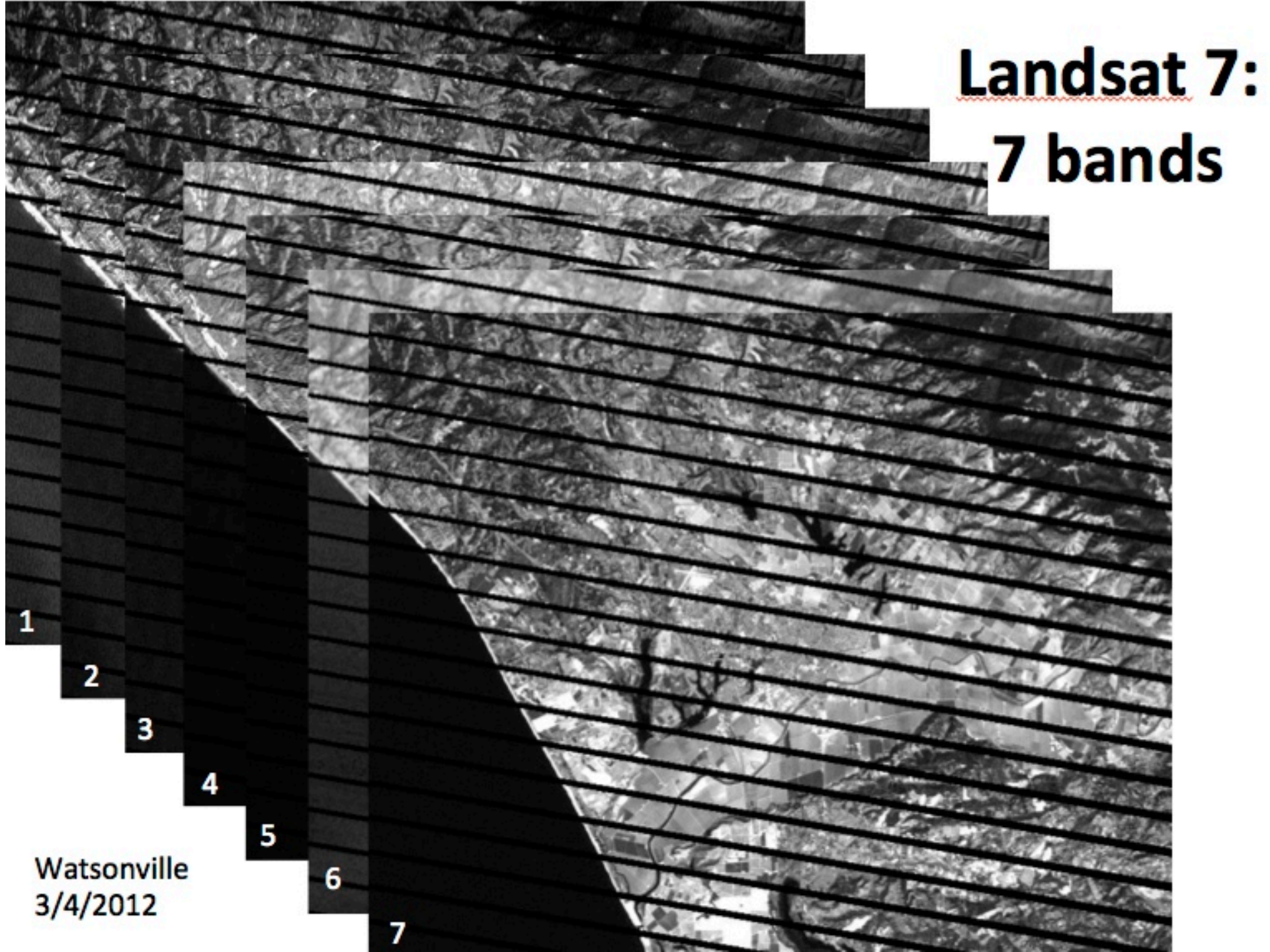
LandSat video: http://landsat.gsfc.nasa.gov/about/
Terra orbit animation:
http://earthobservatory.nasa.gov/Experiments/ICE/panama/panama_mov2.php
Watch live broadcast of LandSat: http://earthnow.usgs.gov/

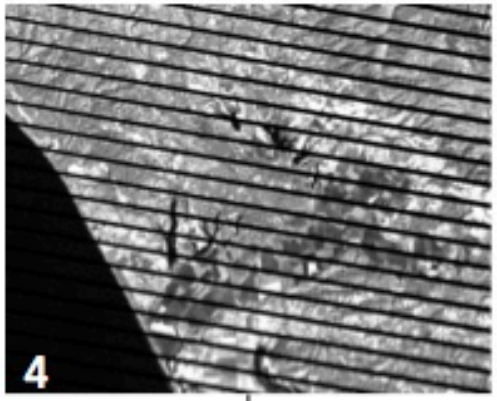


Landsat 7



Band	Bandwidth (nm)	Radiation
1	450-515	Blue
2	525-605	Green
3	630-690	Red
4	750-900	Near Infrared
5	1,550-1,750	Shortwave Infrared
6	10,400-12,500	Thermal Infrared
7	2,090-2,350	Shortwave Infrared


Landsat 7:
7 bands
1
2
3
4
5
6
7
Watsonville
3/4/2012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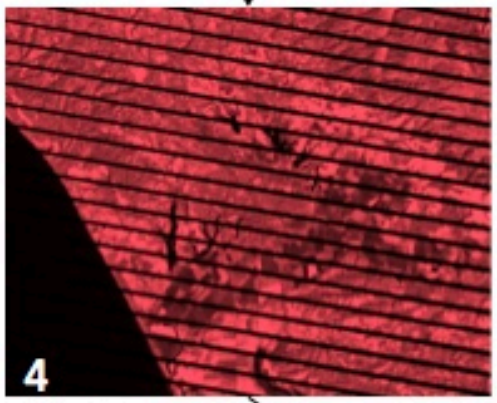
3

2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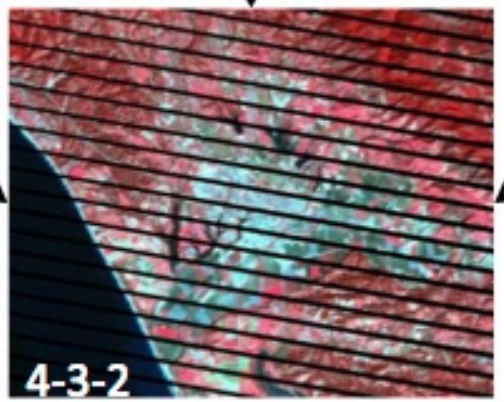
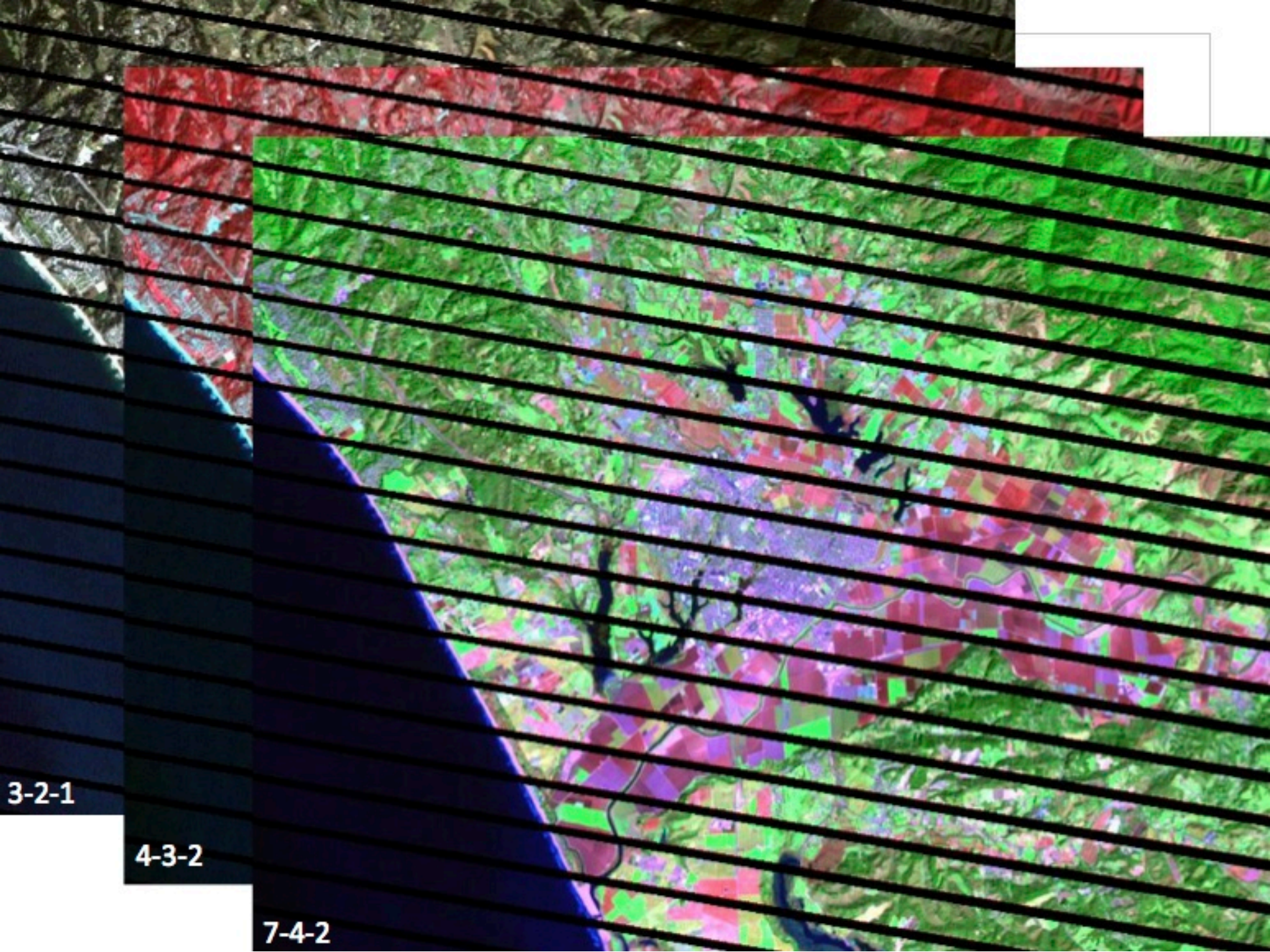
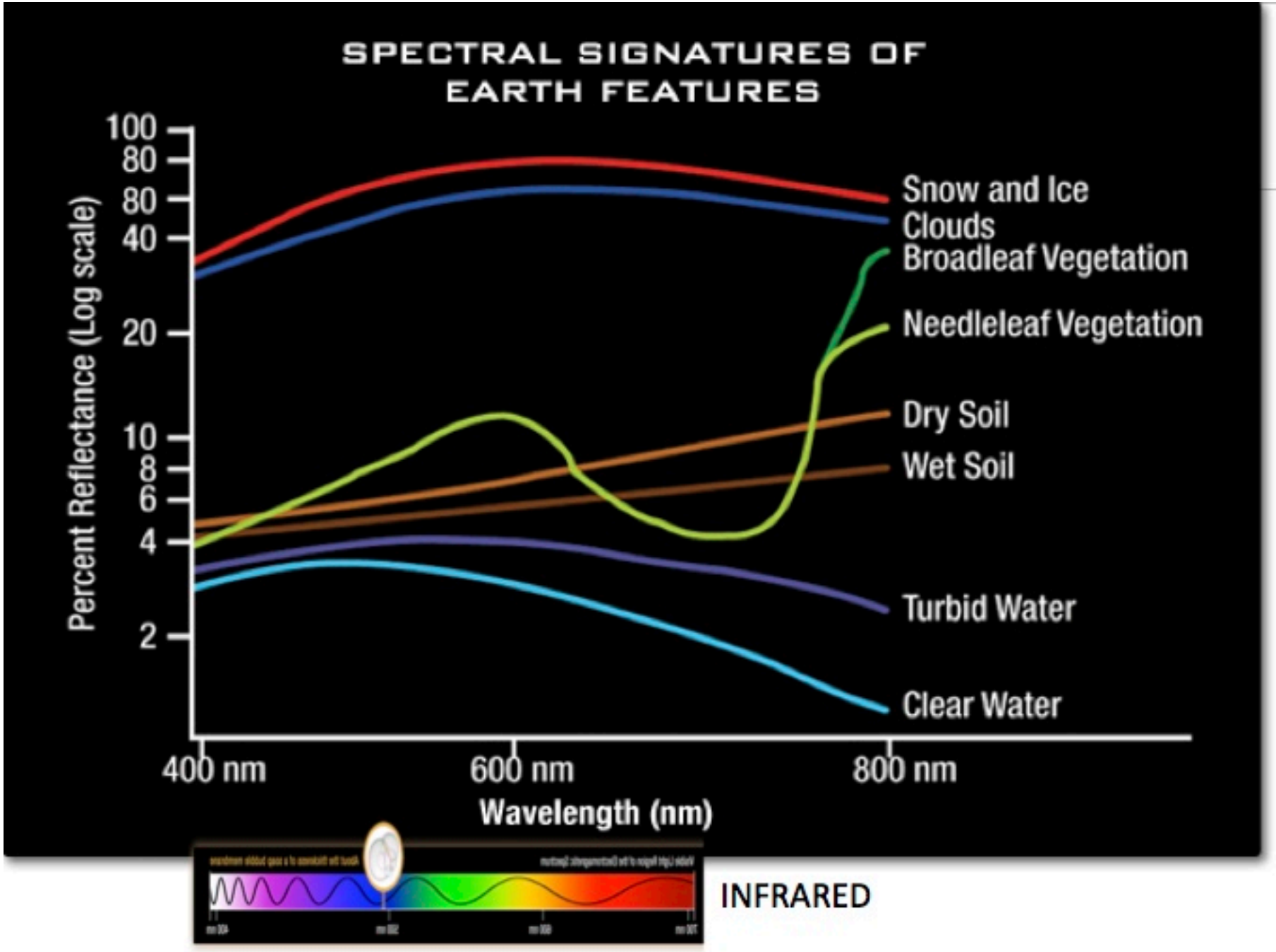
3

2


4-3-2

http://landsat.gsfc.nasa.gov/


3-2-1
4-3-2
7-4-2

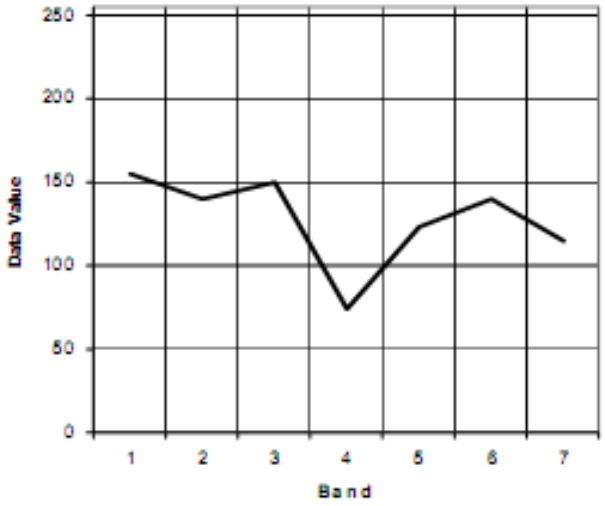


http://missionscience.nasa.gov/ems/09_visiblelight.html

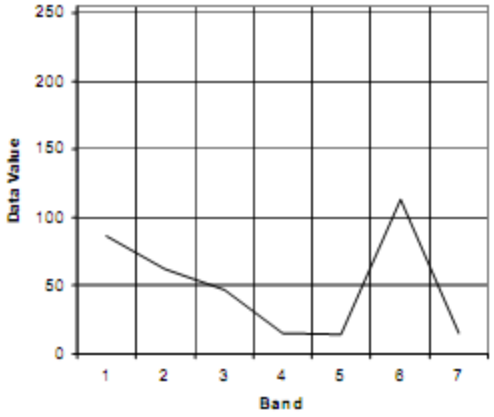
LandSat Spectral Signatures

Band	Bandwidth (nm)	Radiation
1	450-515	Blue
2	525-605	Green
3	630-690	Red
4	750-900	Near Infrared
5	1,550-1,750	Shortwave Infrared
6	10,400-12,500	Thermal Infrared
7	2,090-2,350	Shortwave Infrared

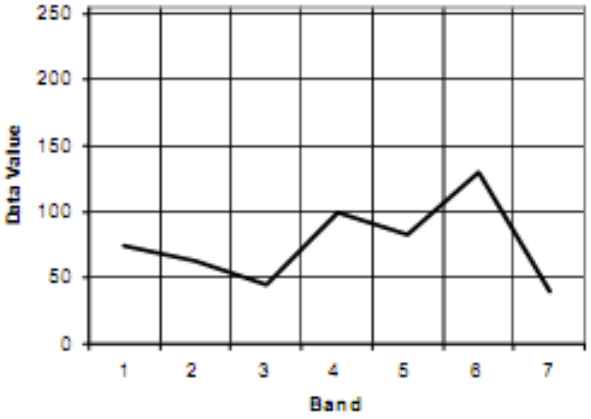
BUILDINGS



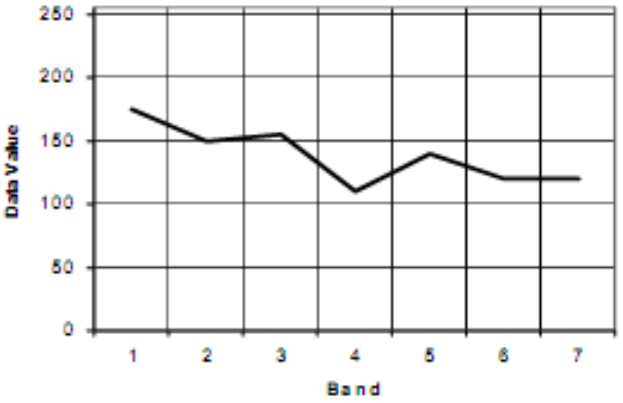
WATER



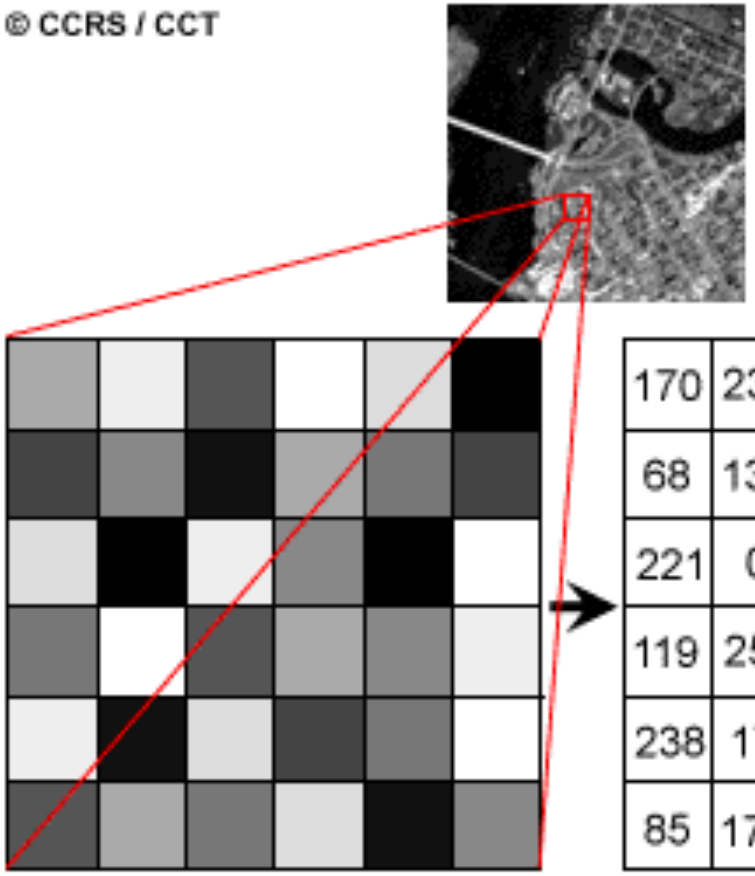
TREES



ROCKS



Pixels & RGB Codes



170	238	85	255	221	0
68	136	17	170	119	68
221	0	238	136	0	255
119	255	85	170	136	238
238	17	221	68	119	255
85	170	119	221	17	136

= 255,0,0

= 0,255,0

= 0,0,255

=255,255,255

= 0,0,0

= 255,0,255

= 0,255,255

ACTIVITY:

Creating & Interpreting Remote Sensing Images

(Derived from NASA's Remote Sensing Math)

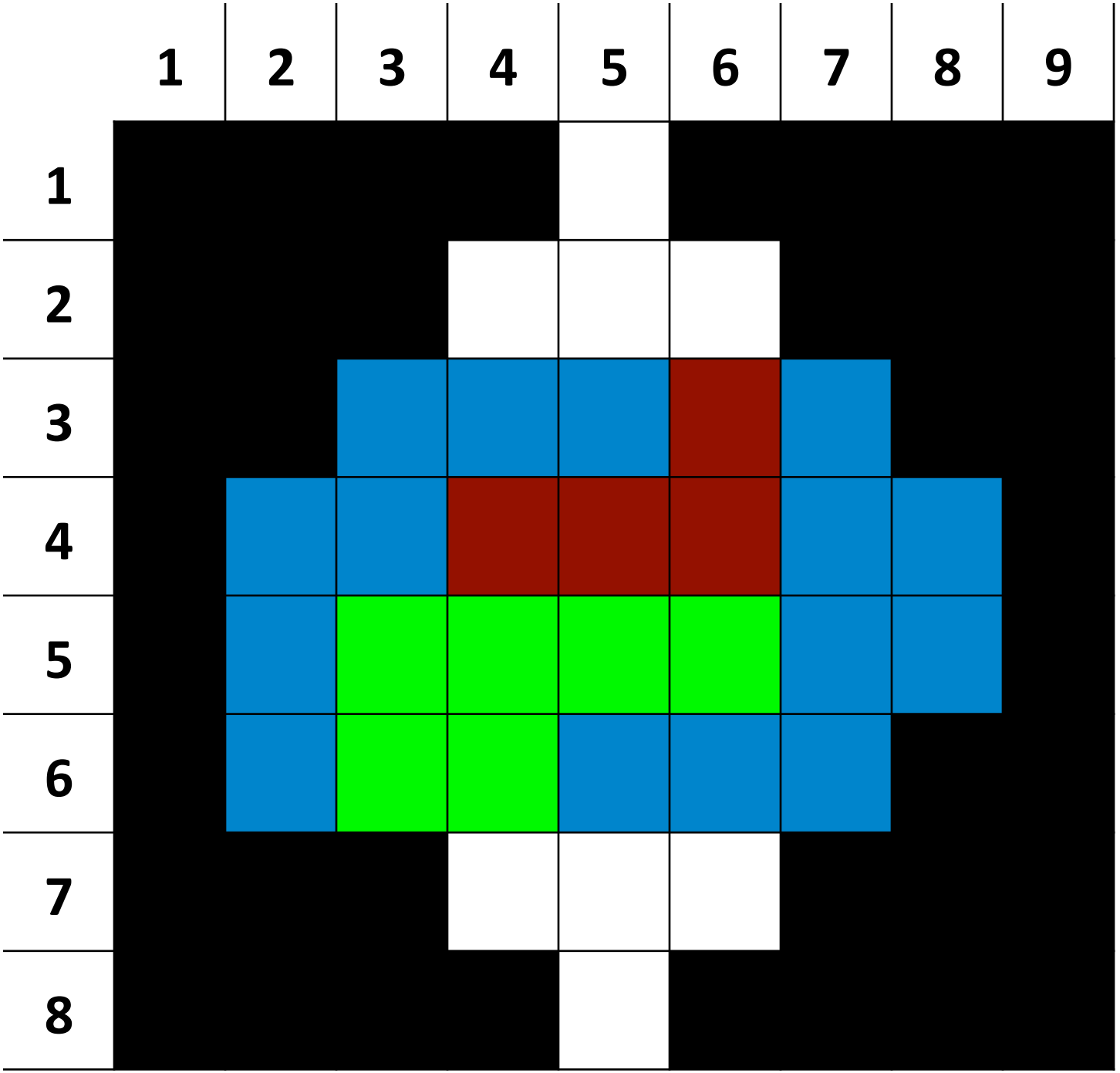
Key to Pixels

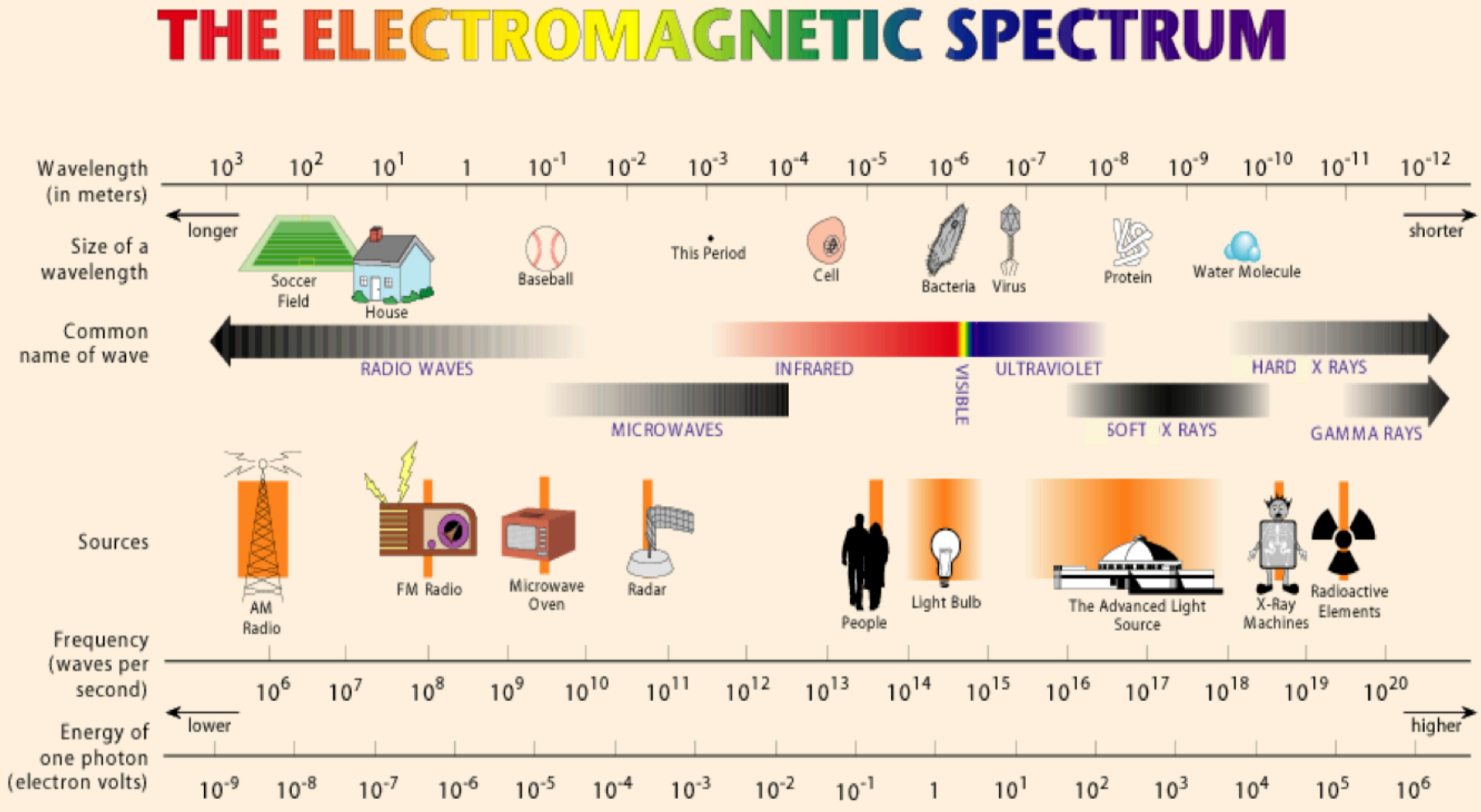
Feature	Symbol	Color	RGB Code
Sky			
Water			
Ice			
Land			
Plants			

Key to Pixels

Feature	Symbol	Color	RGB Code
Sky	S	Black	0,0,0
Water	W	Blue	0,0,1
Ice	I	White	1,1,1
Land	L	Brown	1,1,0
Plants	P	Green	0,1,0

	1	2	3	4	5	6	7	8	9
1									
2									
3									
4									
5									
6									
7									
8									

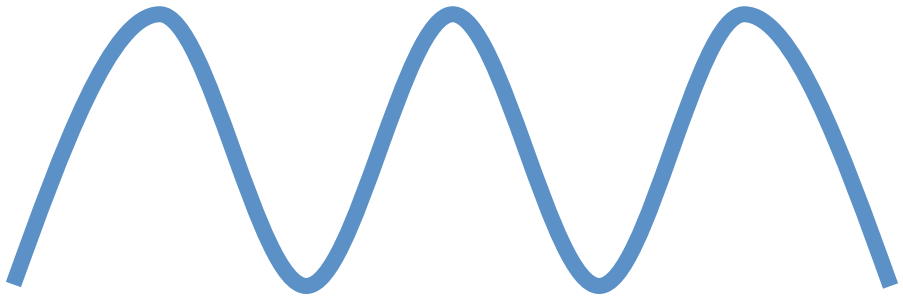

1 2 3 4 5 6 7 8 9
1
2
3
4
5
6
7
8



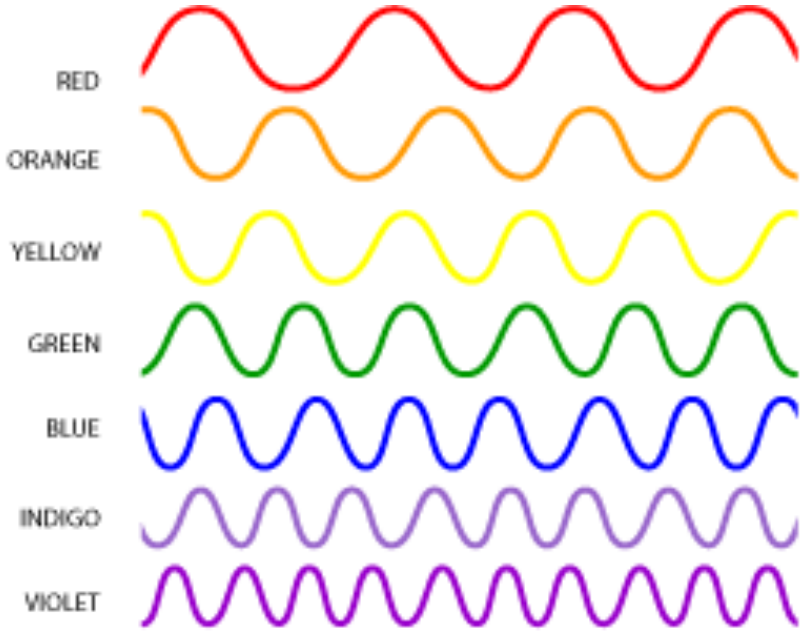
http://science.hq.nasa.gov/kids/imagers/ems/index.html

Reviewing Waves

- _____ (λ) = distance from any point on a wave to an identical point on the next wave
- _____ (f) = number of cycles or vibrations per unit of time (1 Hz = 1/s)
- _____ (v) = distance/time
- _____ = _____ * _____
- Speed of light (c) in vacuum = 3.8×10^8 m/s (186,000 miles/second)



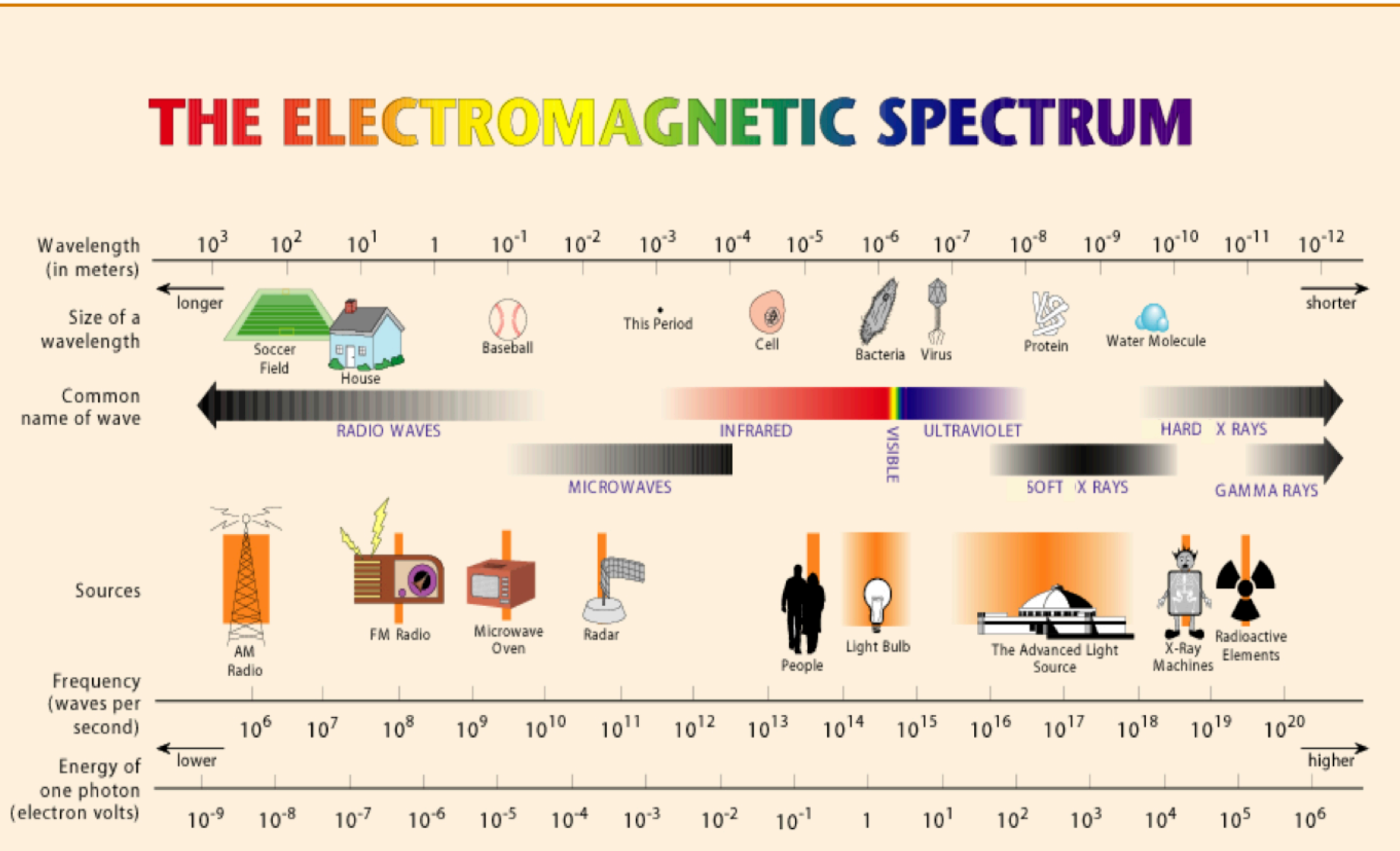
Problem #1: Visible Light



- Which color has the longest wavelength?
- Which color has the highest frequency?
- Which color has the highest speed?

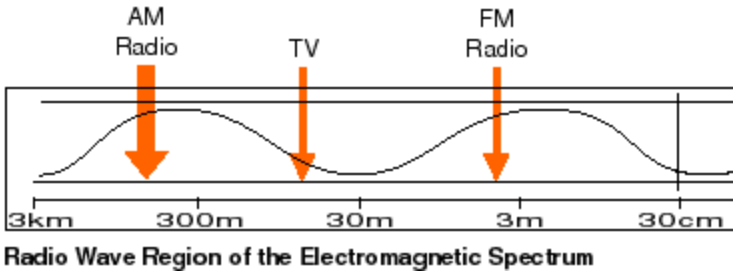
http://science.hq.nasa.gov/kids/imagers/ems/index.html

We can only see a small amount of the light that surrounds us all the time.

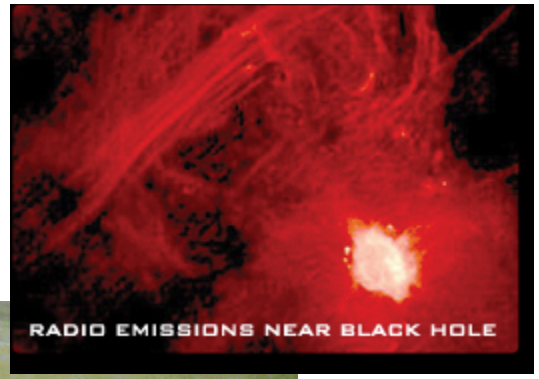


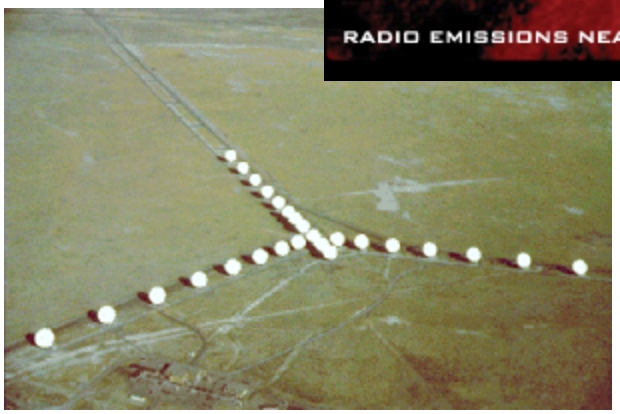
http://science.hq.nasa.gov/kids/imagers/ems/index.html

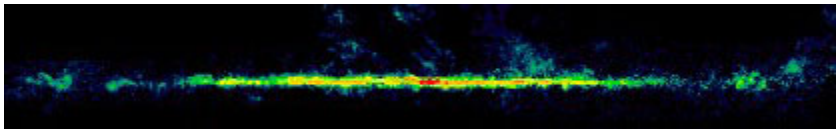
Radio Waves

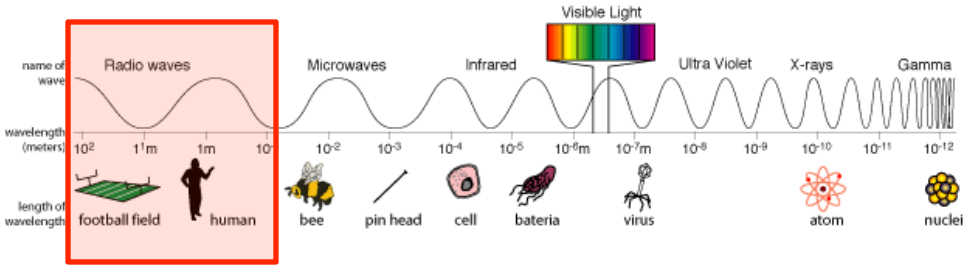


Radio Wave Region of the Electromagnetic Spectrum







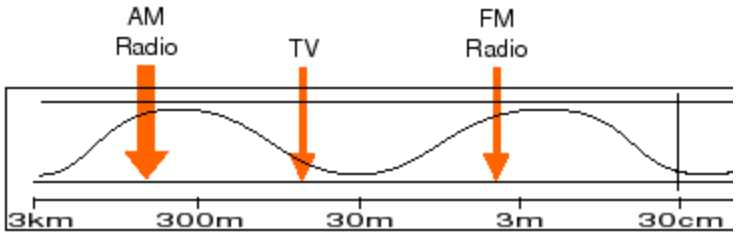


- Carry TV, AM & FM radio, cell phone, & other communication signals
- Used by radio telescopes to study radiation emitted by objects in space

Carbon Monoxide (CO) gases in our Milky Way galaxy

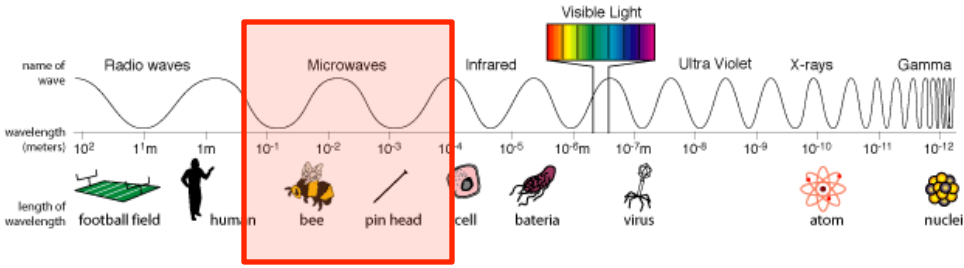
Problem #2: Radio

- What's the frequency of your favorite radio station?
- Calculate its wavelength.



Radio Wave Region of the Electromagnetic Spectrum

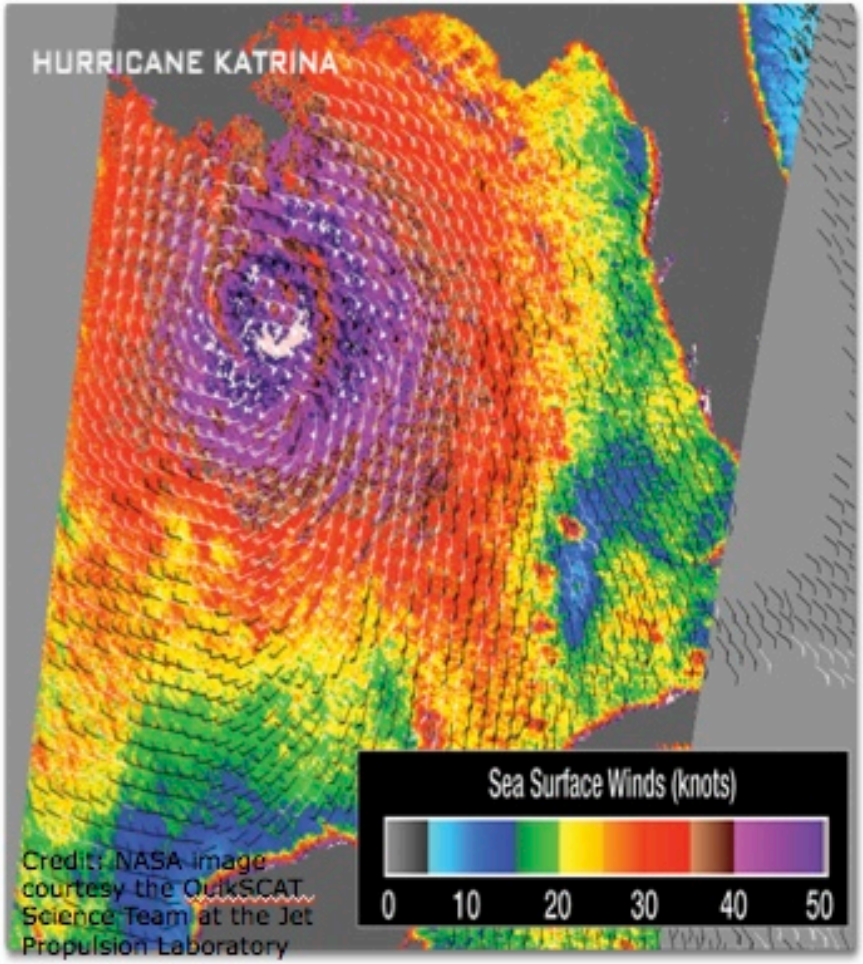
Microwaves

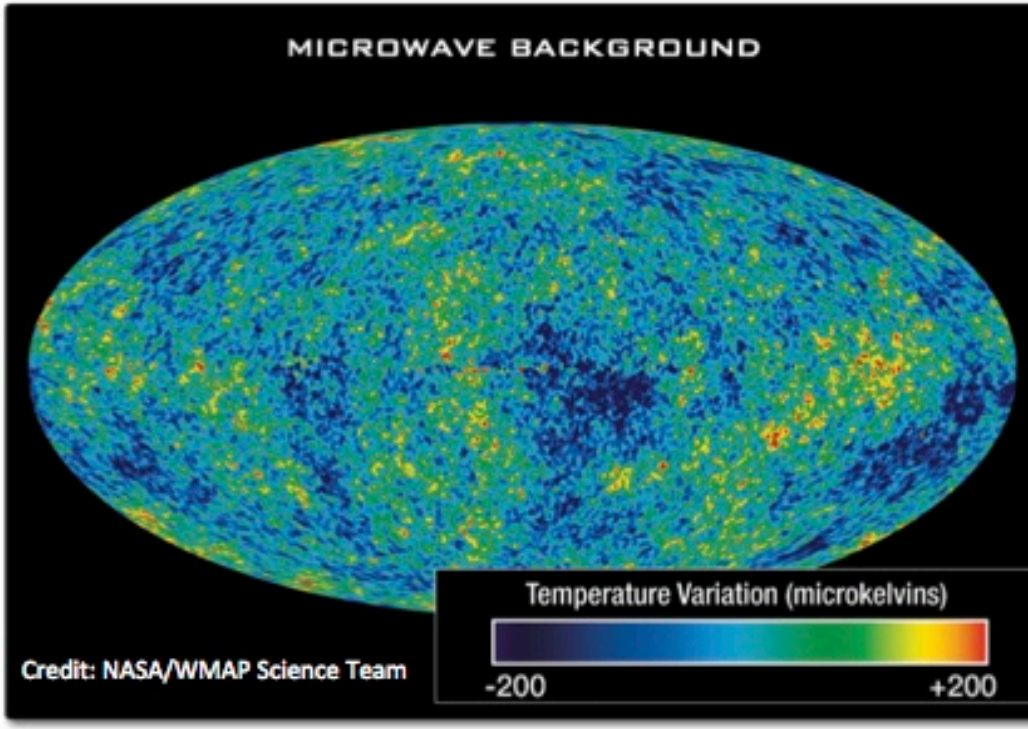


- Heat food by making molecules rotate fast
- Used to detect & measure distance to objects, such as airplanes & weather, with radar

http://science.hq.nasa.gov/kids/imagers/ems/micro.html

Microwaves





Background radiation in the universe gives clues to the Big Bang

http://missionscience.nasa.gov/ems/06_microwaves.html

Infrared Waves

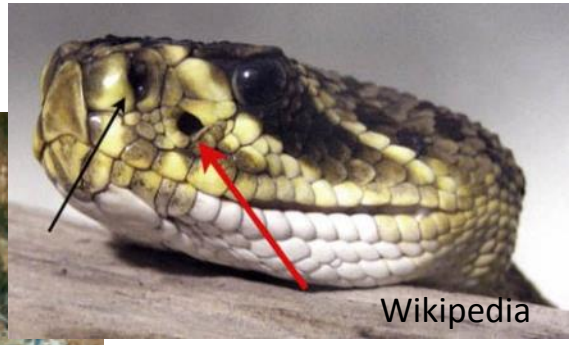
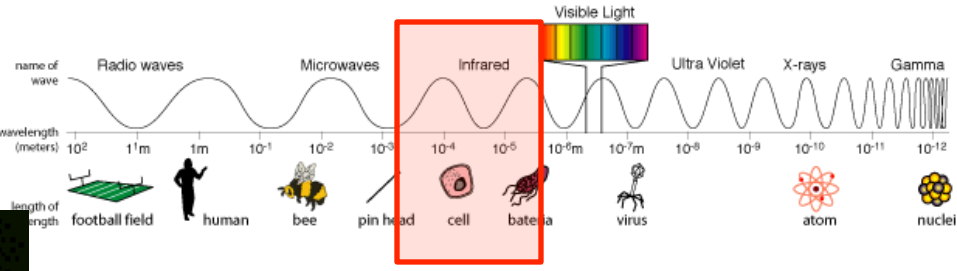
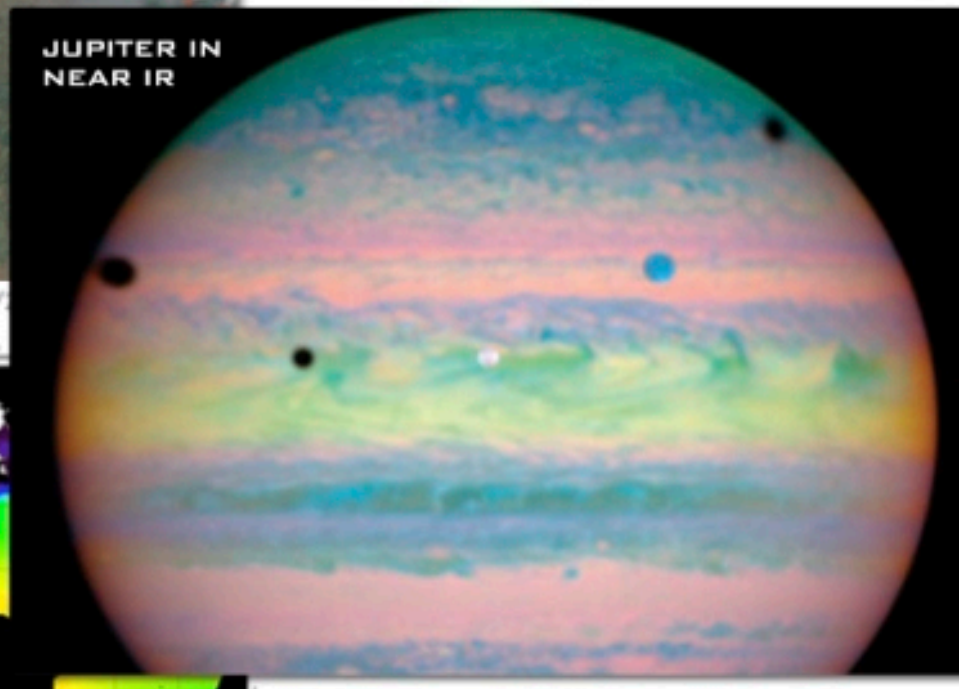
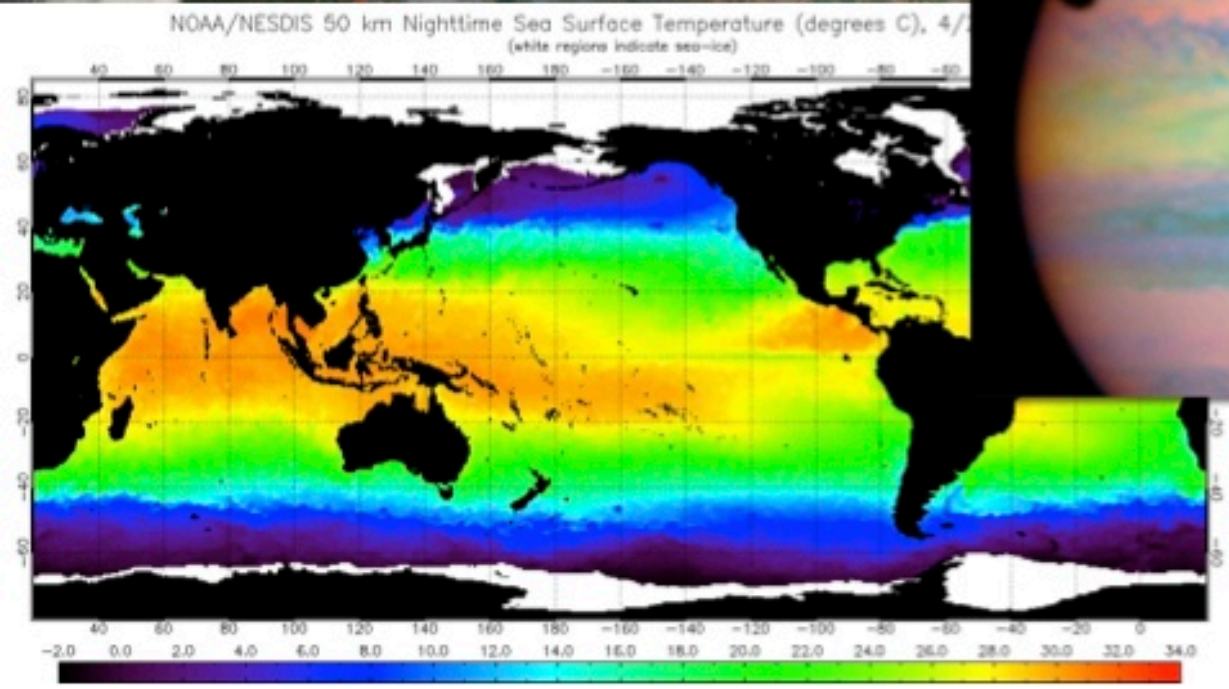


Image of Phoenix (AZ) with near infrared as red



- Heat – used to determine temperature of objects
- Uses
  - Keeping food, spaces, animals warm (heat lamps)
  - TV remote signal
  - Firefighting
  - Rattlesnakes use to detect warm-blooded animals
  - Remote sensing
    - Determine temperature of land, water
    - Map clouds, vegetation

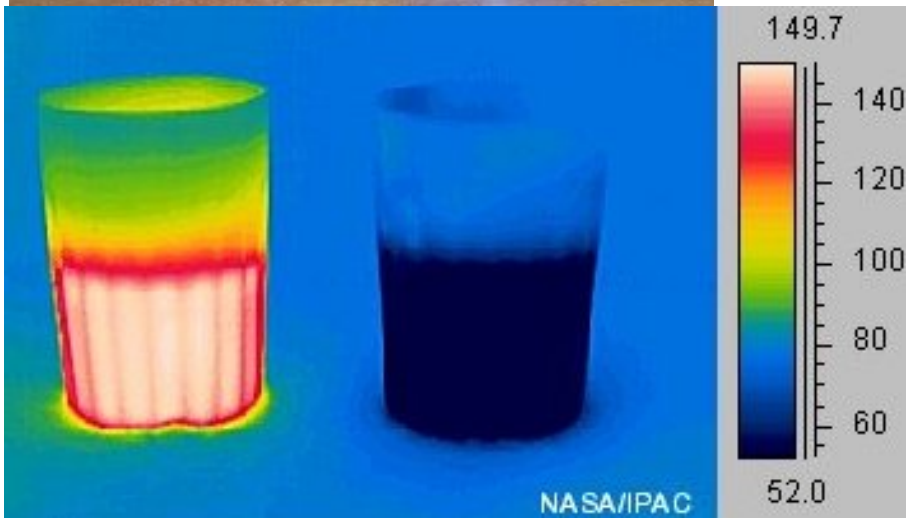




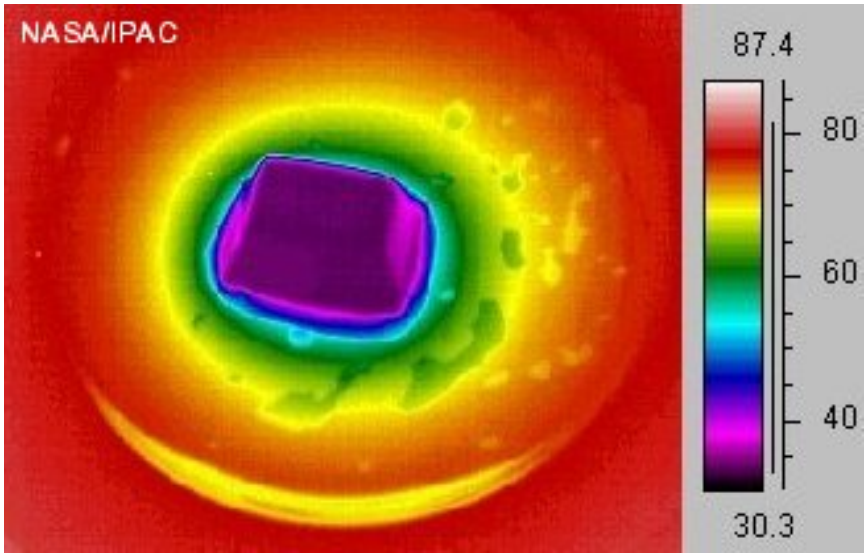
http://www.osdpd.noaa.gov/ml/ocean/sst/sst_50km.html

http://missionscience.nasa.gov/ems/07_infraredwaves.html

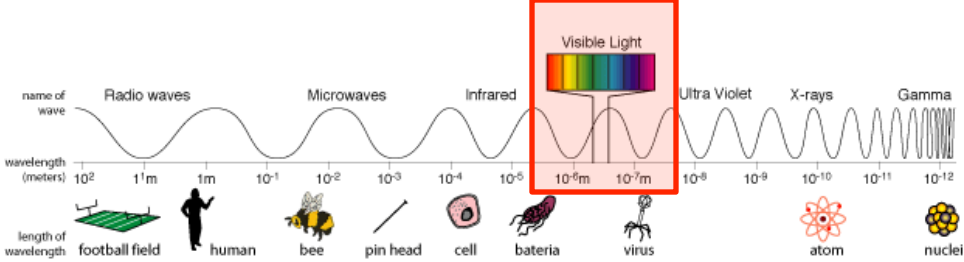
Infrared Imaging

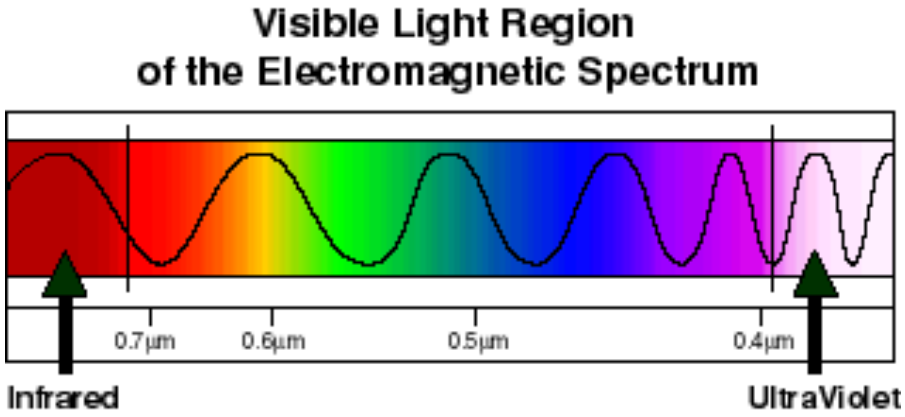


- What object is in the image below?



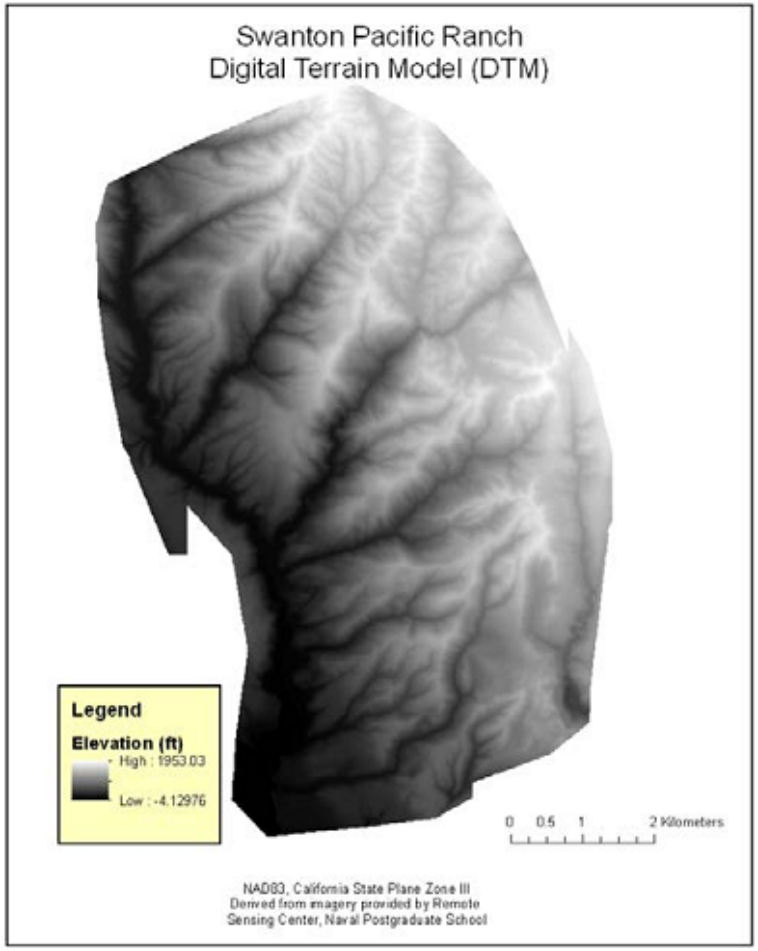
Visible Light



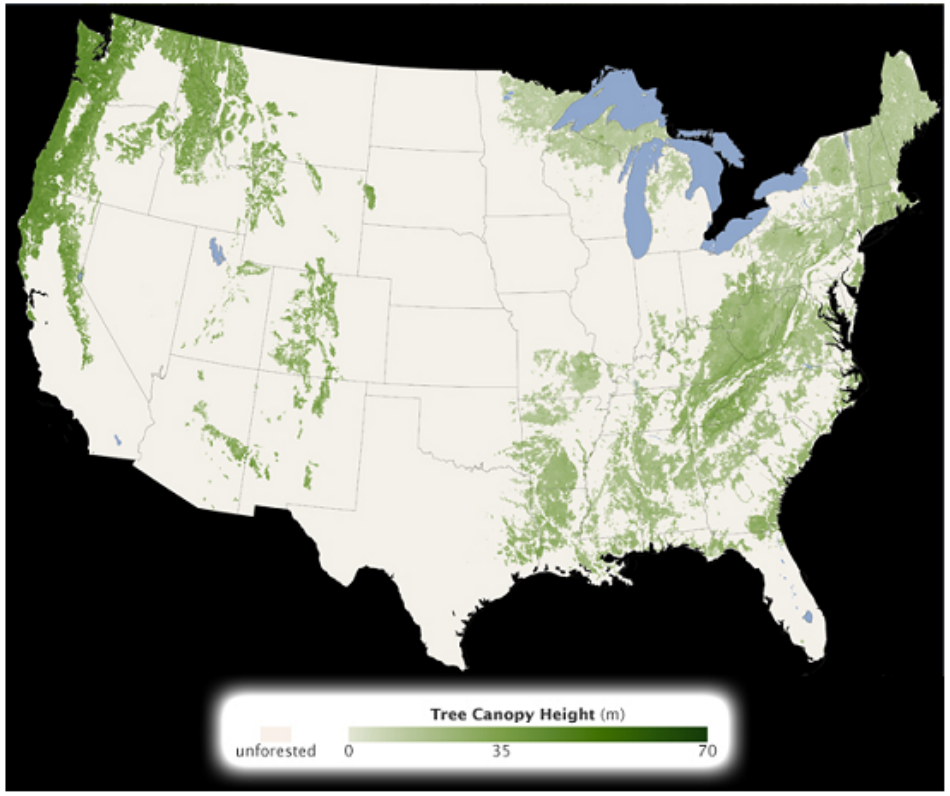


- Only wavelengths we can see
- Sources: sun, light bulbs
- Uses
  - Human vision
  - Photosynthesis of plants
  - Remote sensing: map height of mountains, trees, clouds, etc.

Laser Altimetry (LiDAR)



Outside Davenport, north of Santa Cruz
www.nps.edu/Faculty/Olsen/Student_theses/11Sep_Harmon.pdf



Where are the tallest trees?

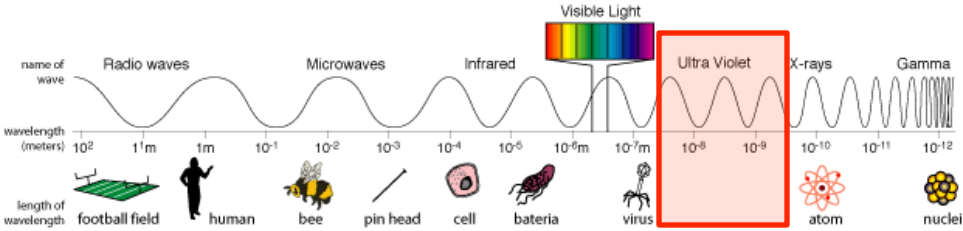
Credit: NASA Earth Observatory/Image by Jesse Allen and Robert Simmon/Based on data from Michael Lefsky.
http://www.nasa.gov/topics/earth/features/forest-height-map.html

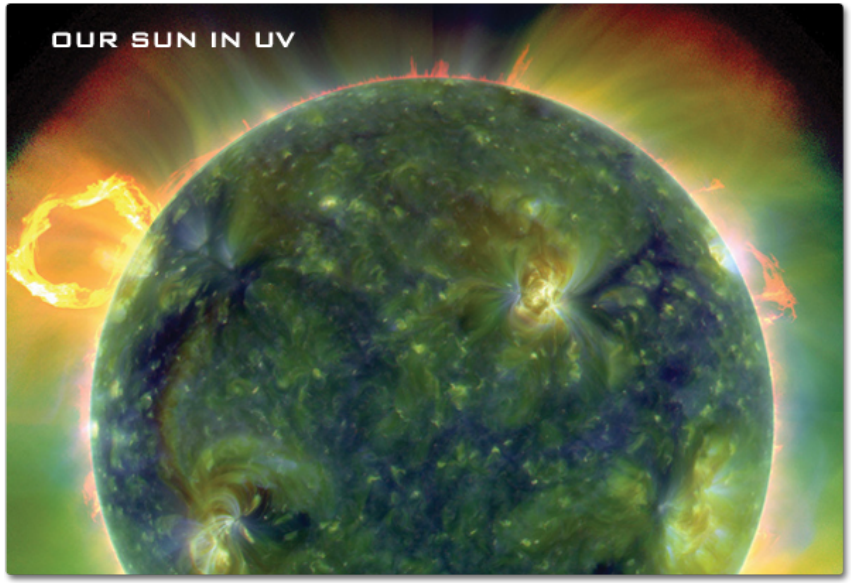
Problem #3: Technology

- Choose one of the following devices
  - Bluetooth (2400 MHz)
  - GPS (1575.42 MHz)
  - Wi-Fi (5 GHz)
- What wavelength is this?
- What type of radiation is this?

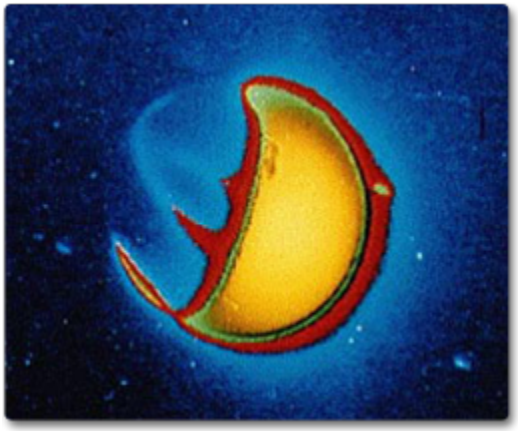
Wikipedia

Ultraviolet Light





- Causes sunburn
- Partially blocked by ozone in atmosphere
- Astronomers use to study stars

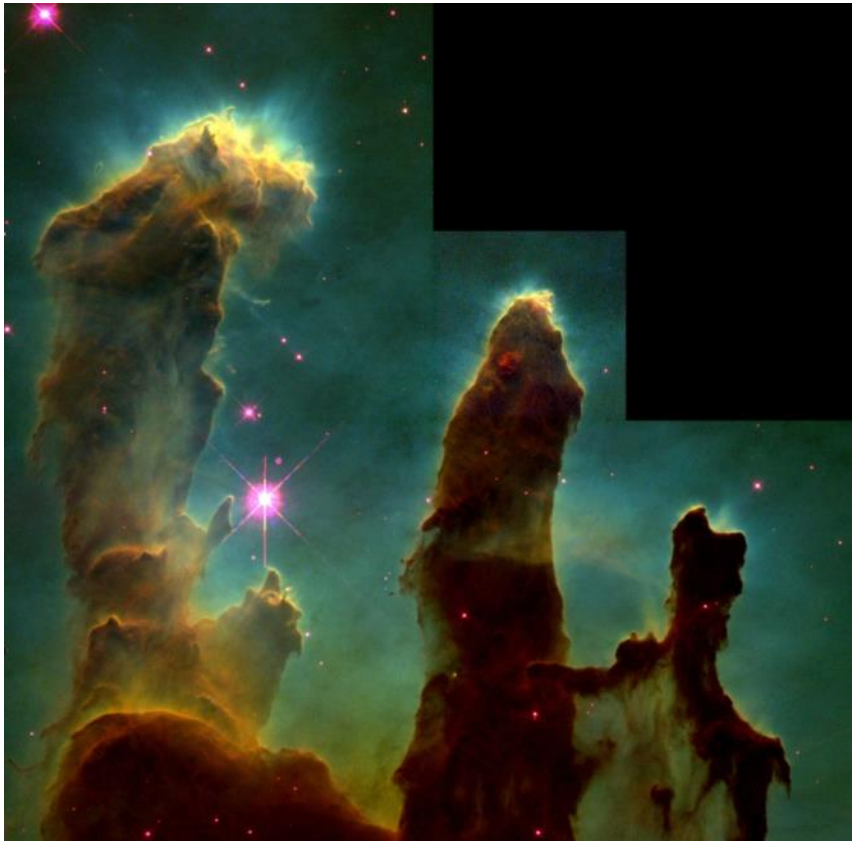


UV image of Earth taken from Moon

Bees can see UV!

Hubble Space Telescope

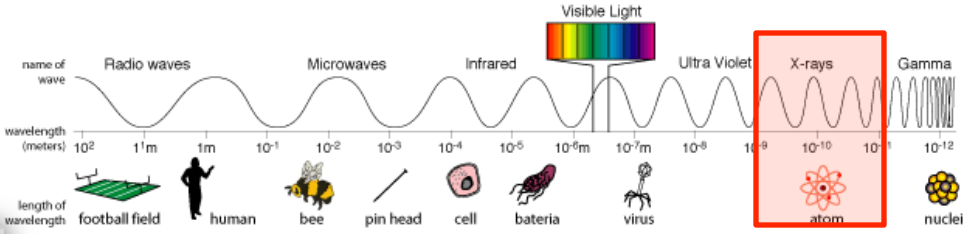
spiral galaxy
Messier_100



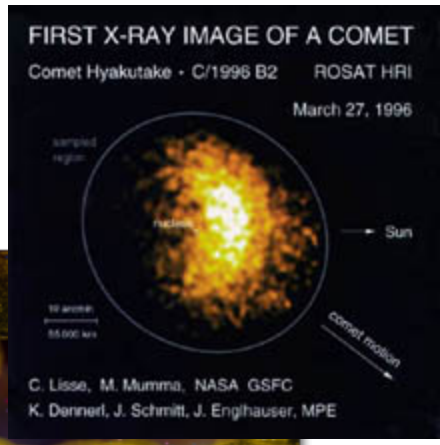
stars forming in the Eagle Nebula

Wikipedia

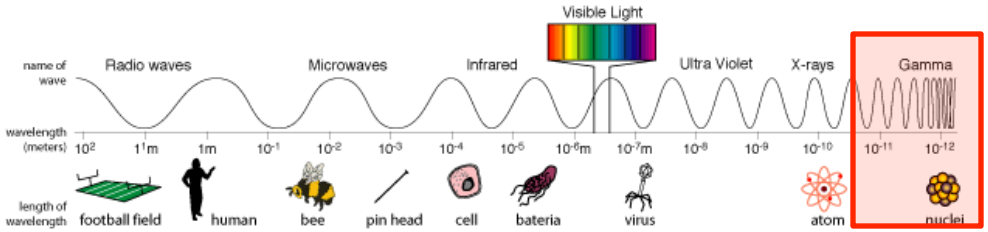
X-Rays

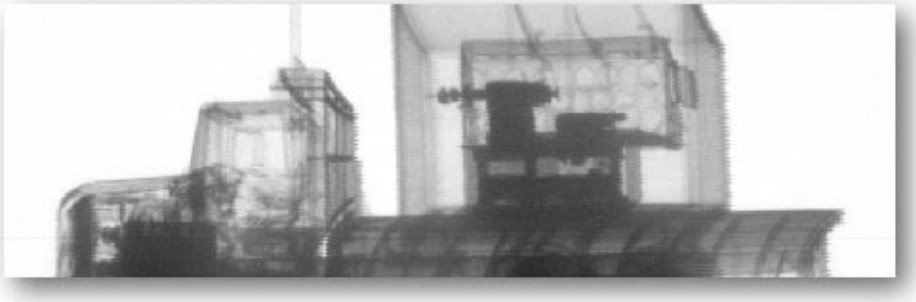


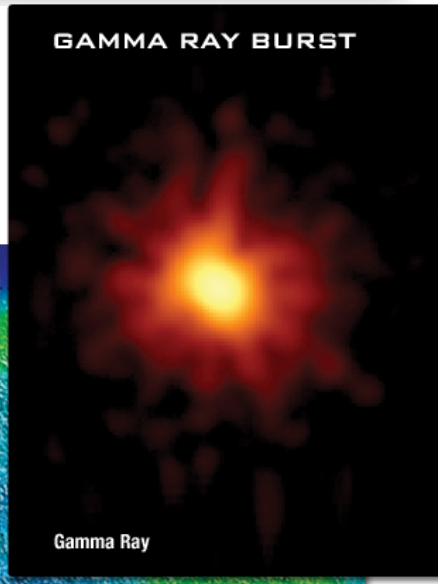
- Image bones & teeth for medicine
- Astronomers use to study very hot objects such as stars, supernova & black holes

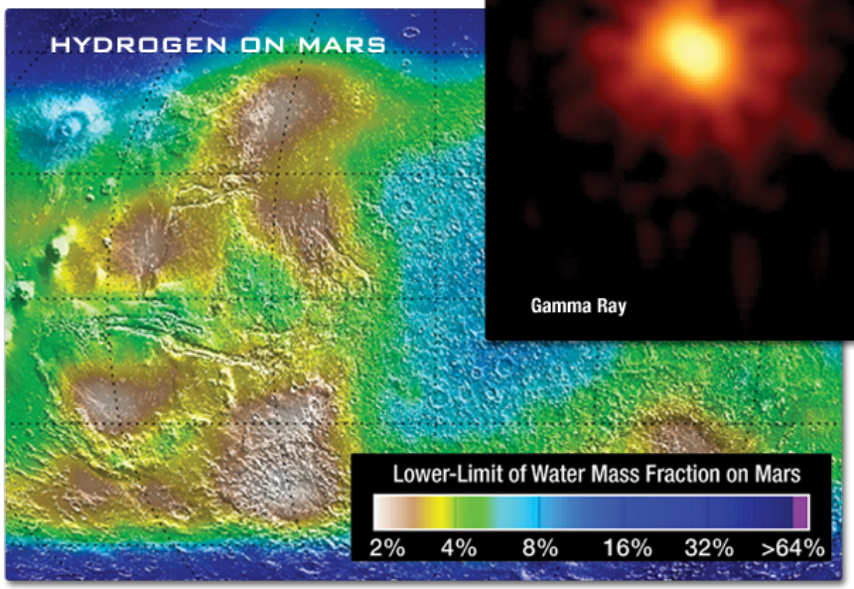


Gamma Rays





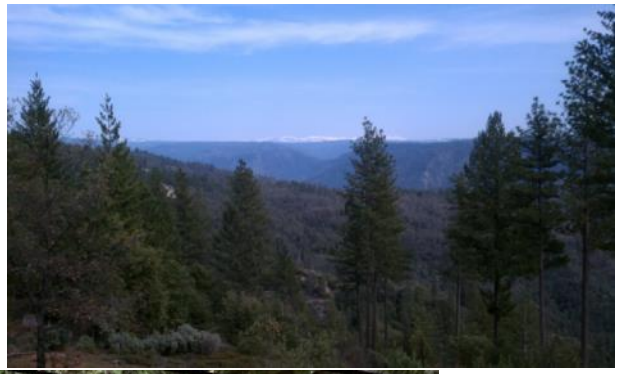


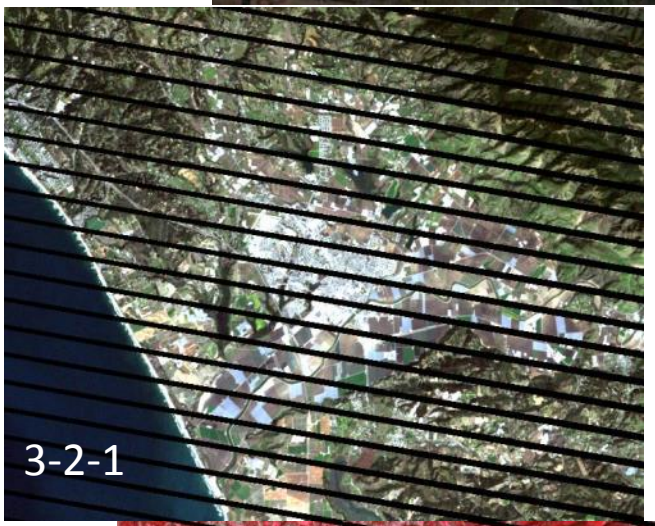


- Sources:
  - Radioactive atoms
  - Nuclear explosions
  - Lightning strikes
  - Supernova explosions (death of star)
  - Black holes
- Uses:
  - Detect spread of cancer
  - Kill cancer cells
  - Scan shipping containers for security
  - Detect elements on other planets

Mapping Vegetation

North America seasonal NDVI animation:
http://www.nasa.gov/topics/earth/features/obscure_data.html

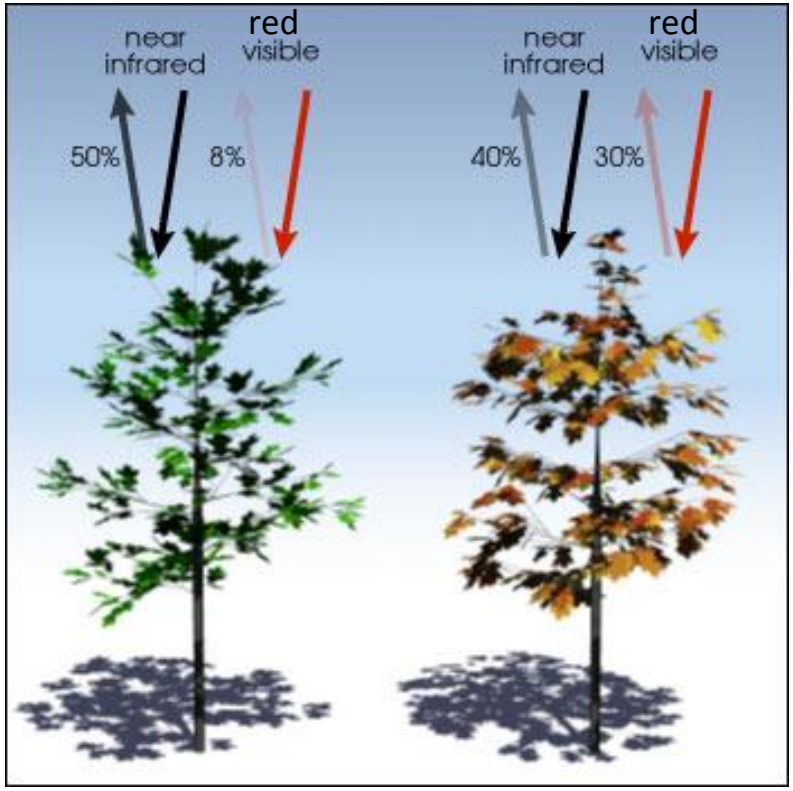




Normalized Difference Vegetation Index

NDVI = (NIR – Red) / (NIR + Red)

Problem #4: Mapping Vegetation



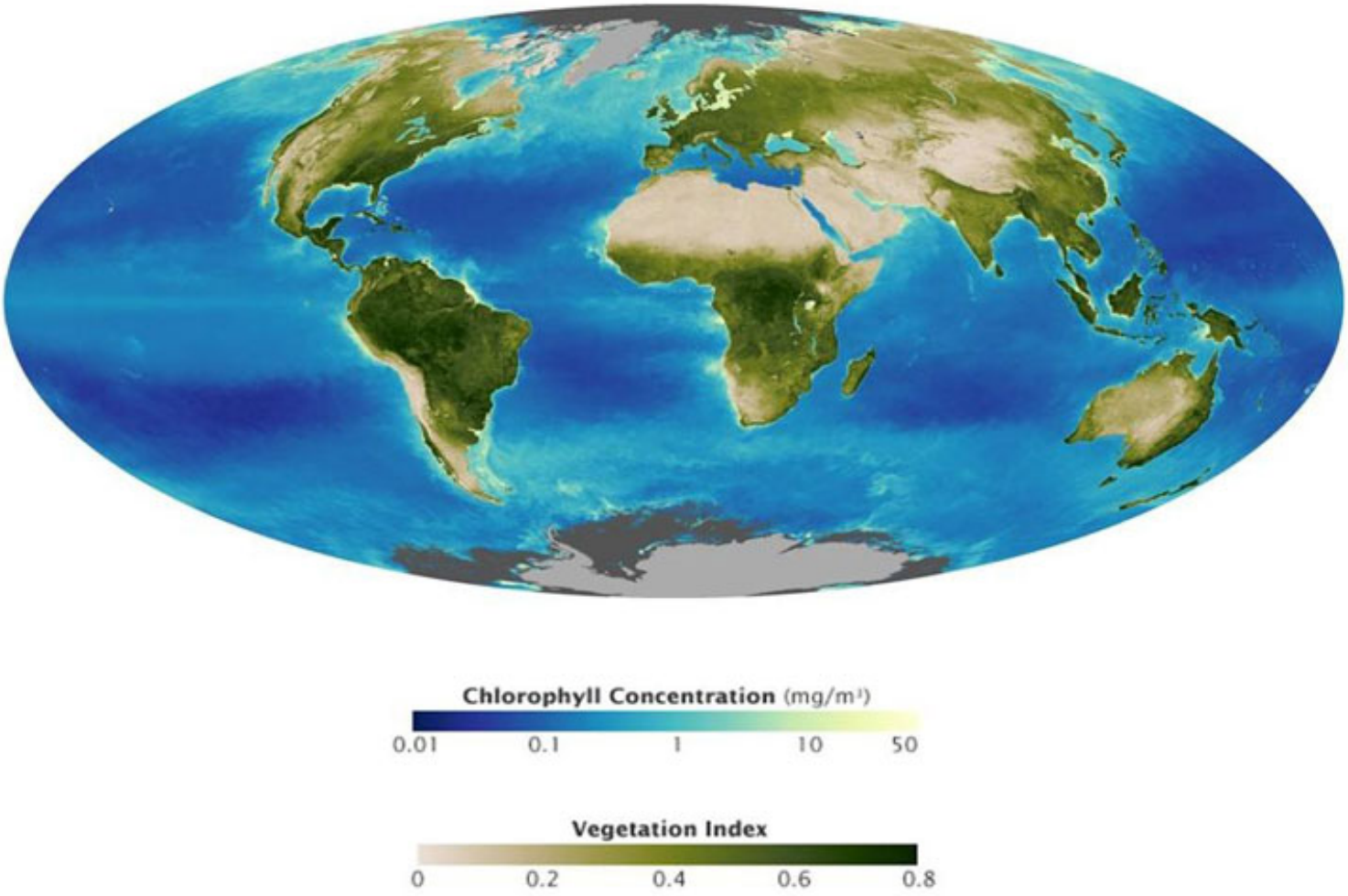
- Calculate NDVI for the healthy tree.
- Calculate NDVI for the stressed tree.

Normalized Difference Vegetation Index

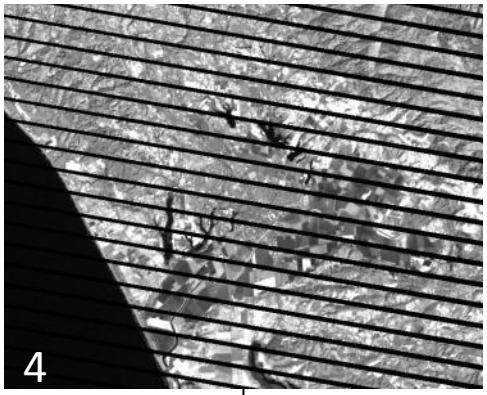
NDVI = (NIR – Red) / (NIR + Red)

http://earthobservatory.nasa.gov/Experiments/ICE/panama/panama_ex2.php

Vegetation Index Products



NASA Earth Observatory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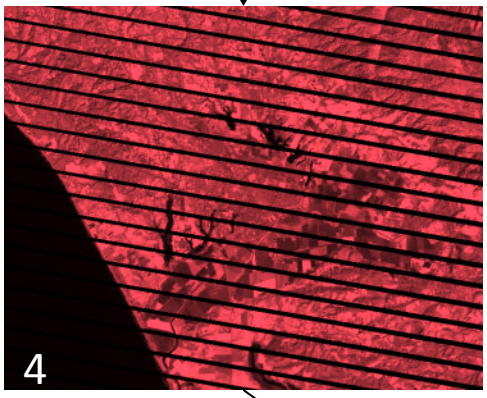
3

2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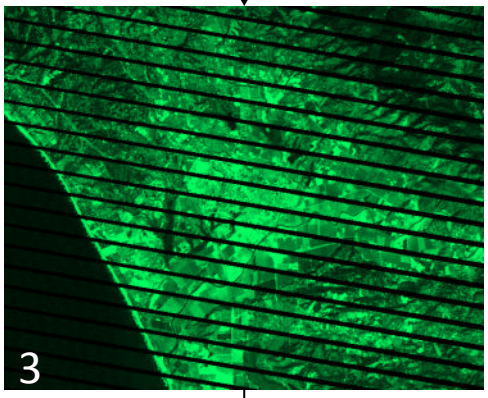
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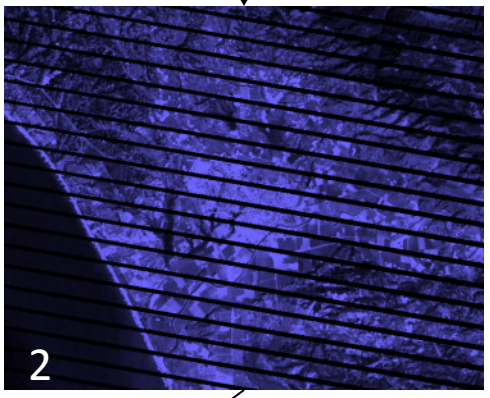
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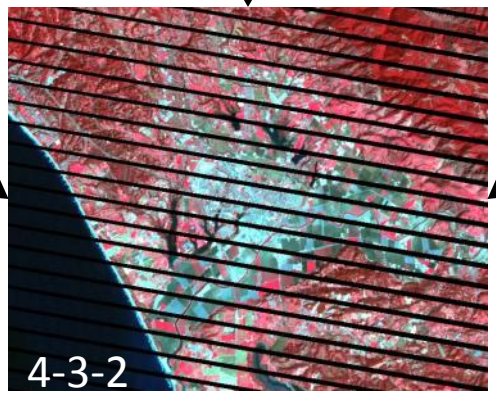
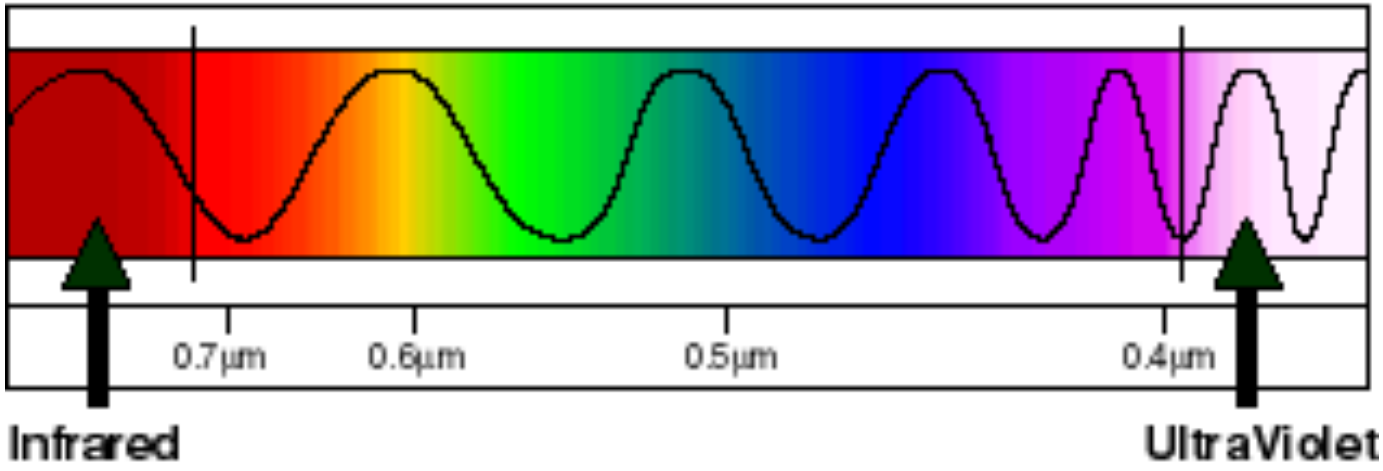

4-3-2

http://landsat.gsfc.nasa.gov/

Activity:
Remote Sensing of Barro Colorado Island

NASA's Rainforest at the Crossroads
http://earthobservatory.nasa.gov/Experiments/ICE/panama/

Visible Light Region of the Electromagnetic Spectrum