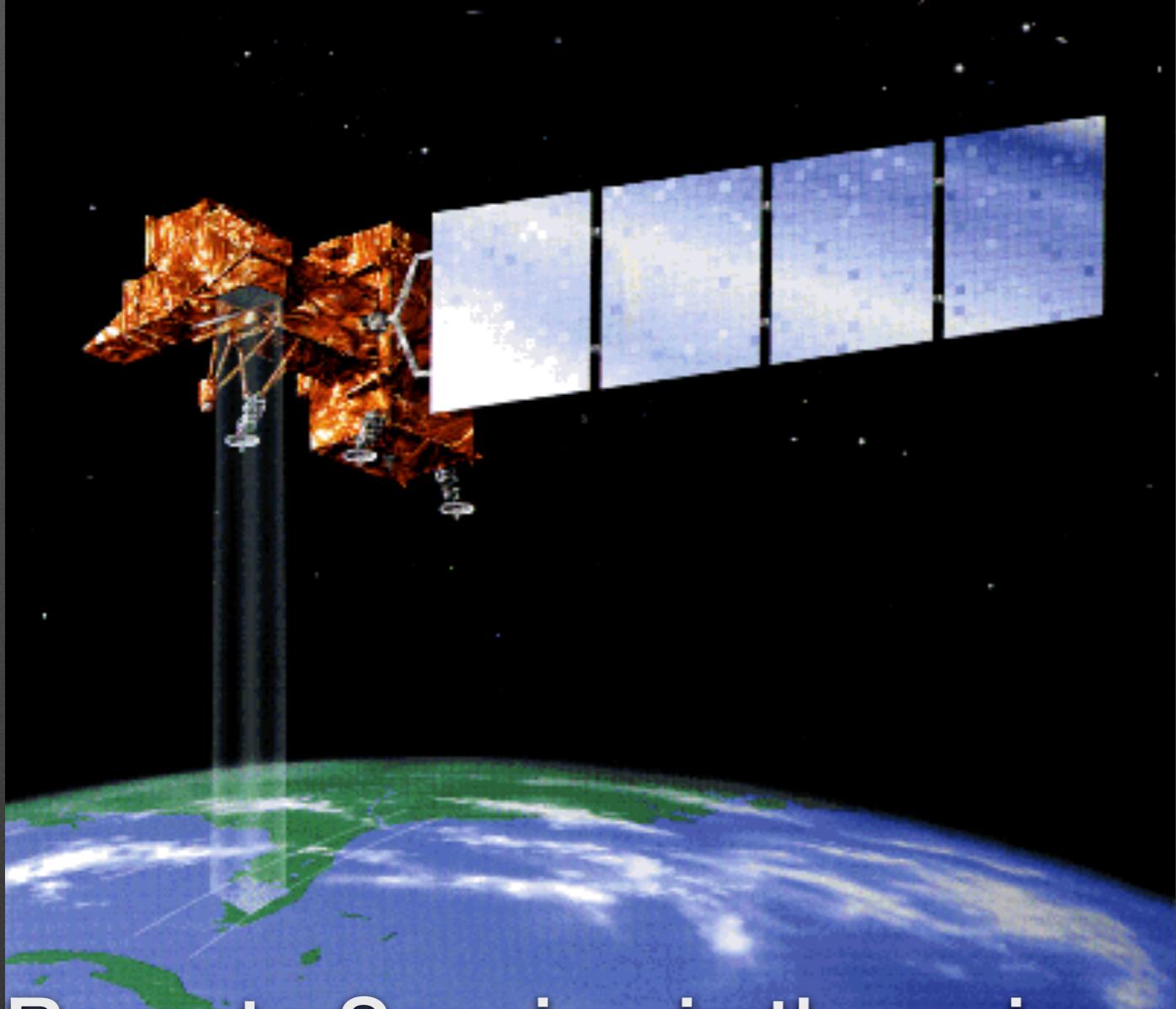


Remote Sensing

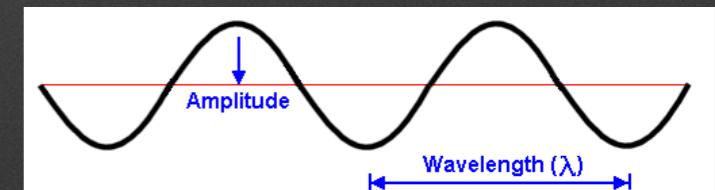
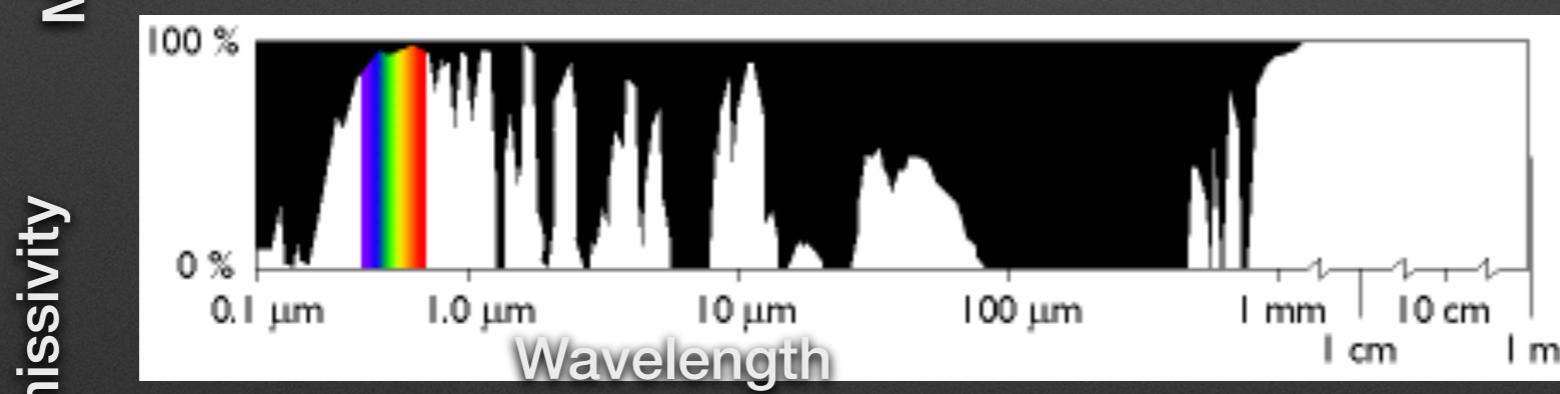
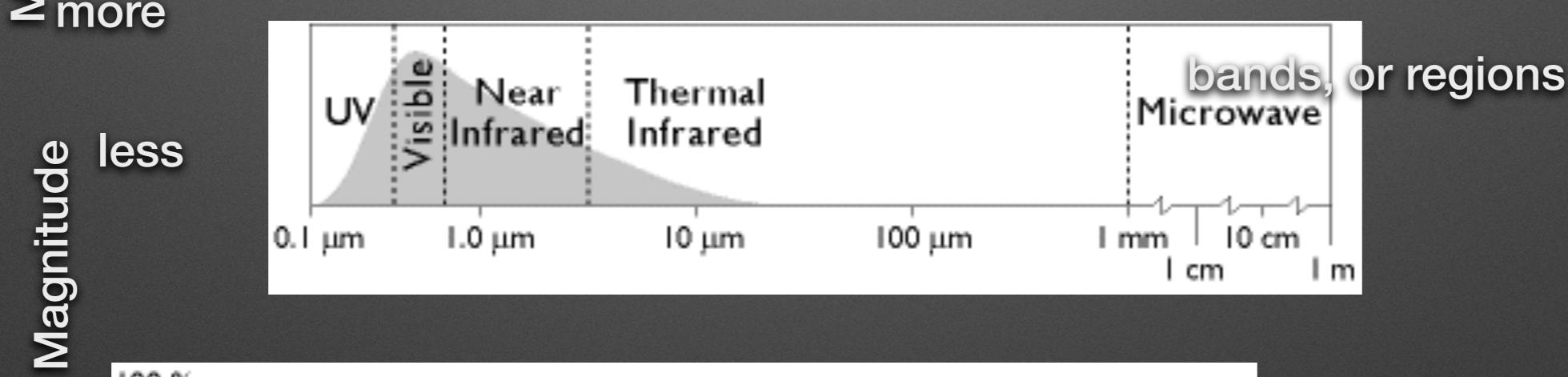
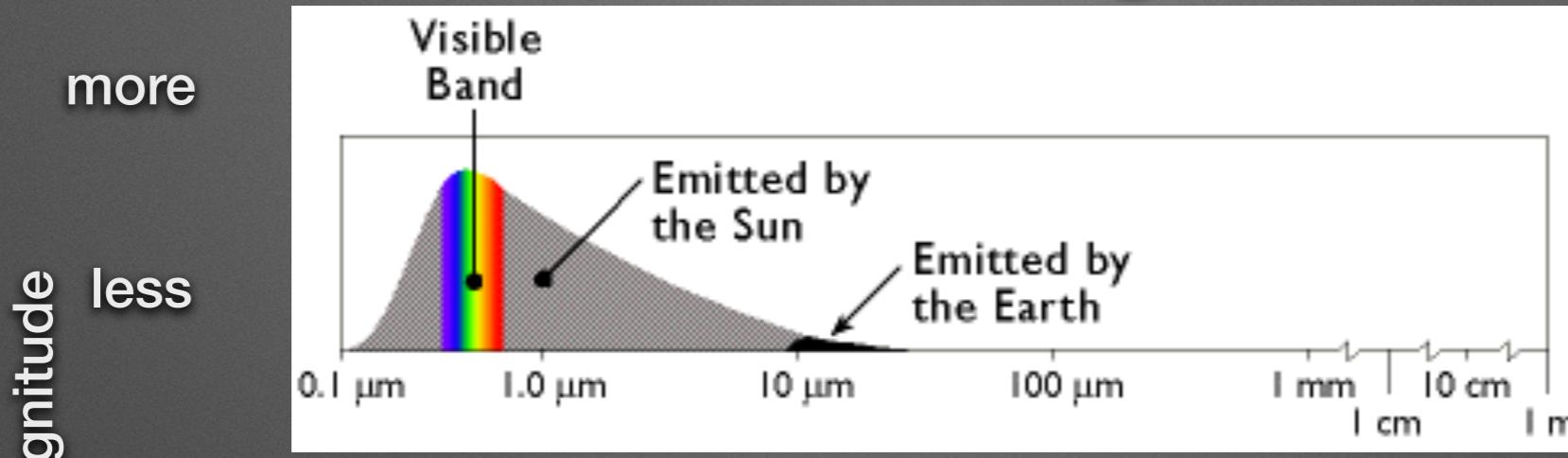
What is remote sensing?



Remote Sensing is the acquisition of information about an object without being in physical contact with it.

Remote Sensing is the science of acquiring, processing and interpreting images that record the interaction between electromagnetic energy and matter

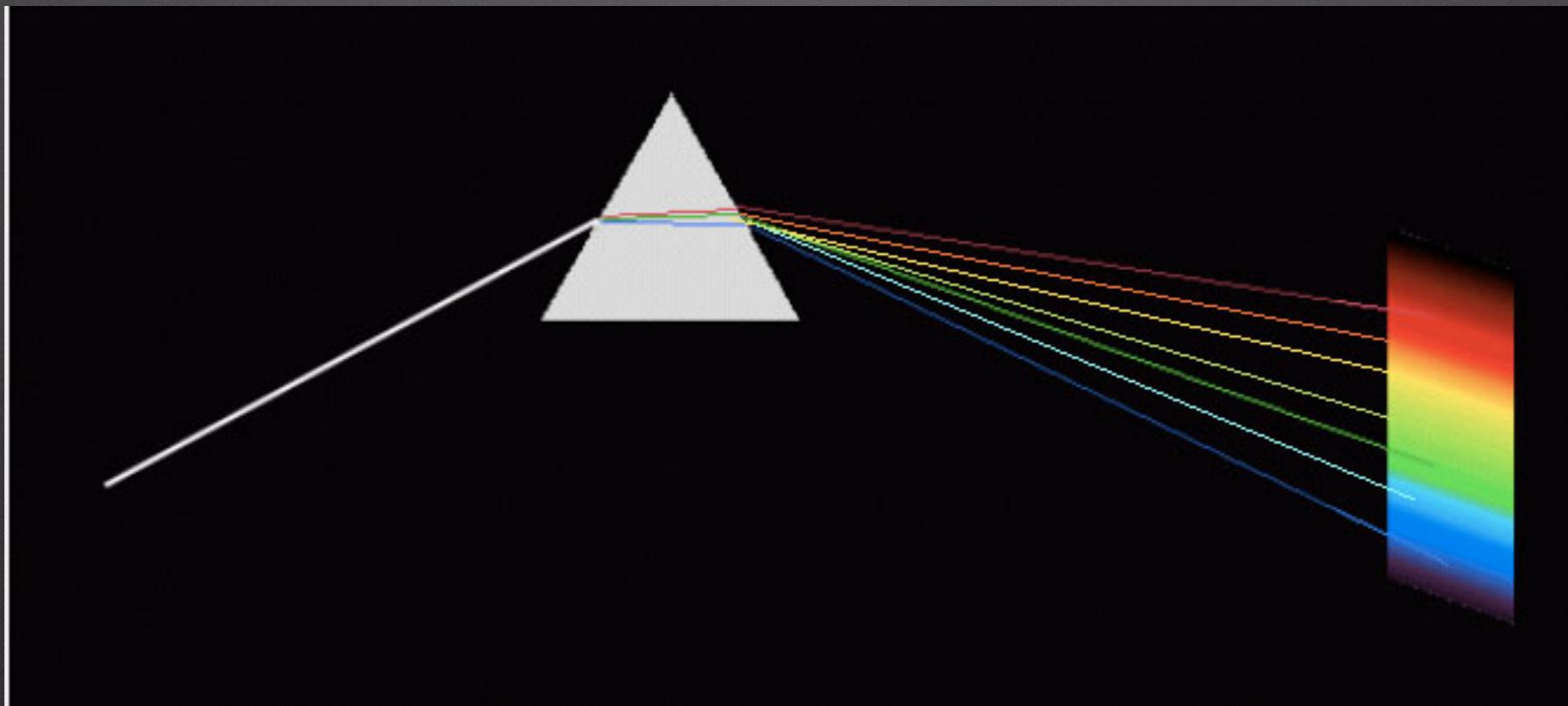
What is electromagnetic energy?

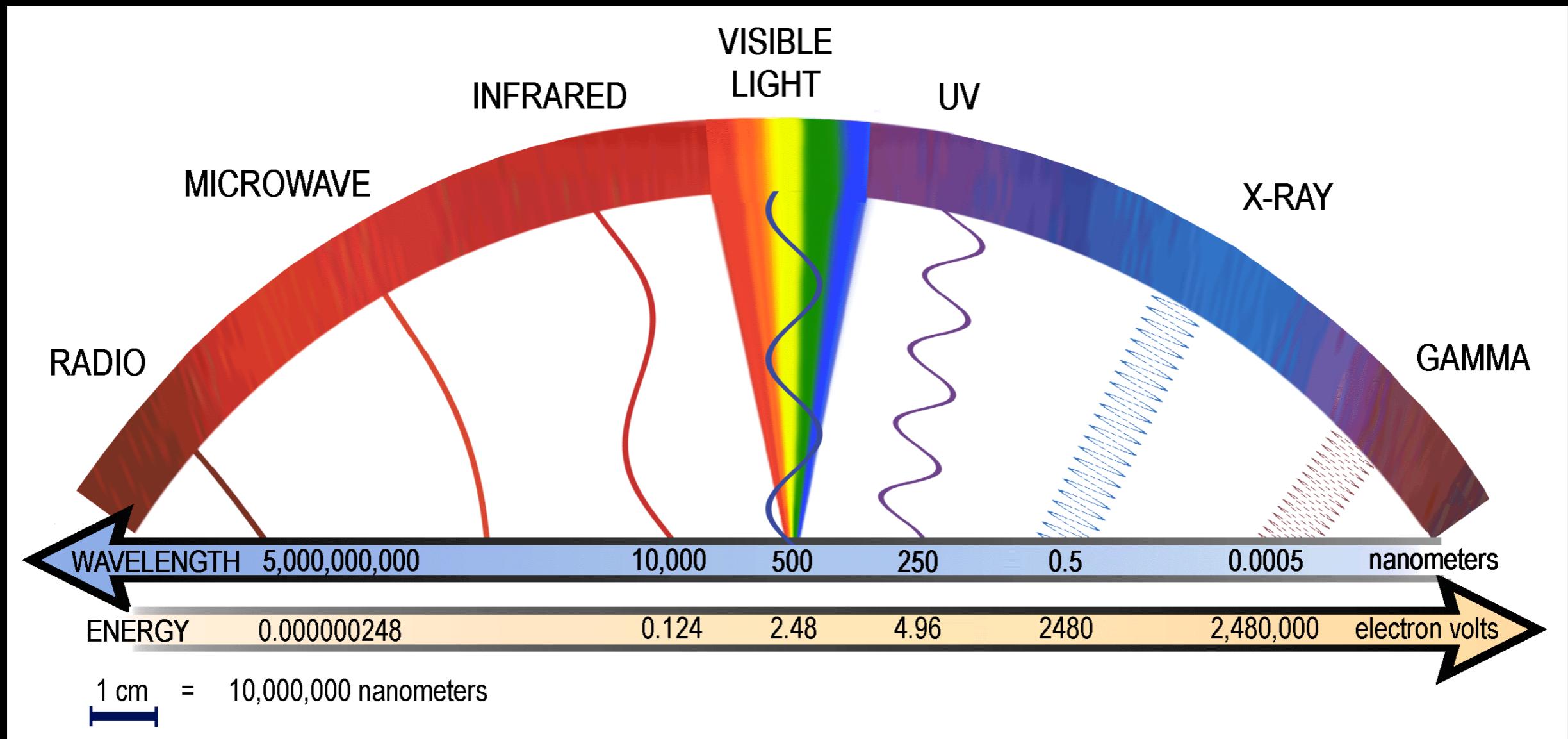


Transmissivity - a measure of the ability of a material or medium to transmit electromagnetic energy, as light. (dictionary.com)

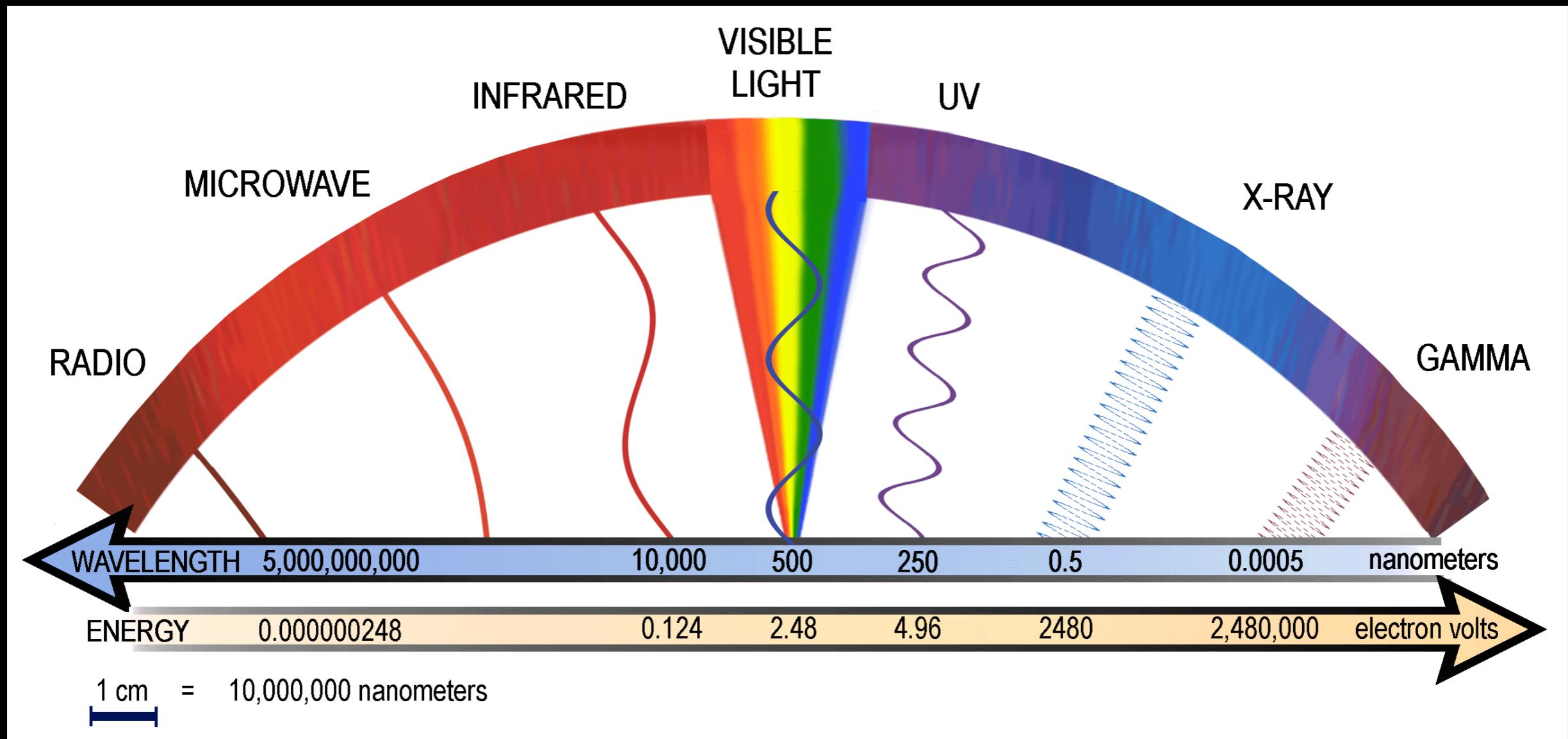
Light

- In 1676, Isaac Newton demonstrated that white light is composed of a spectrum of many colors

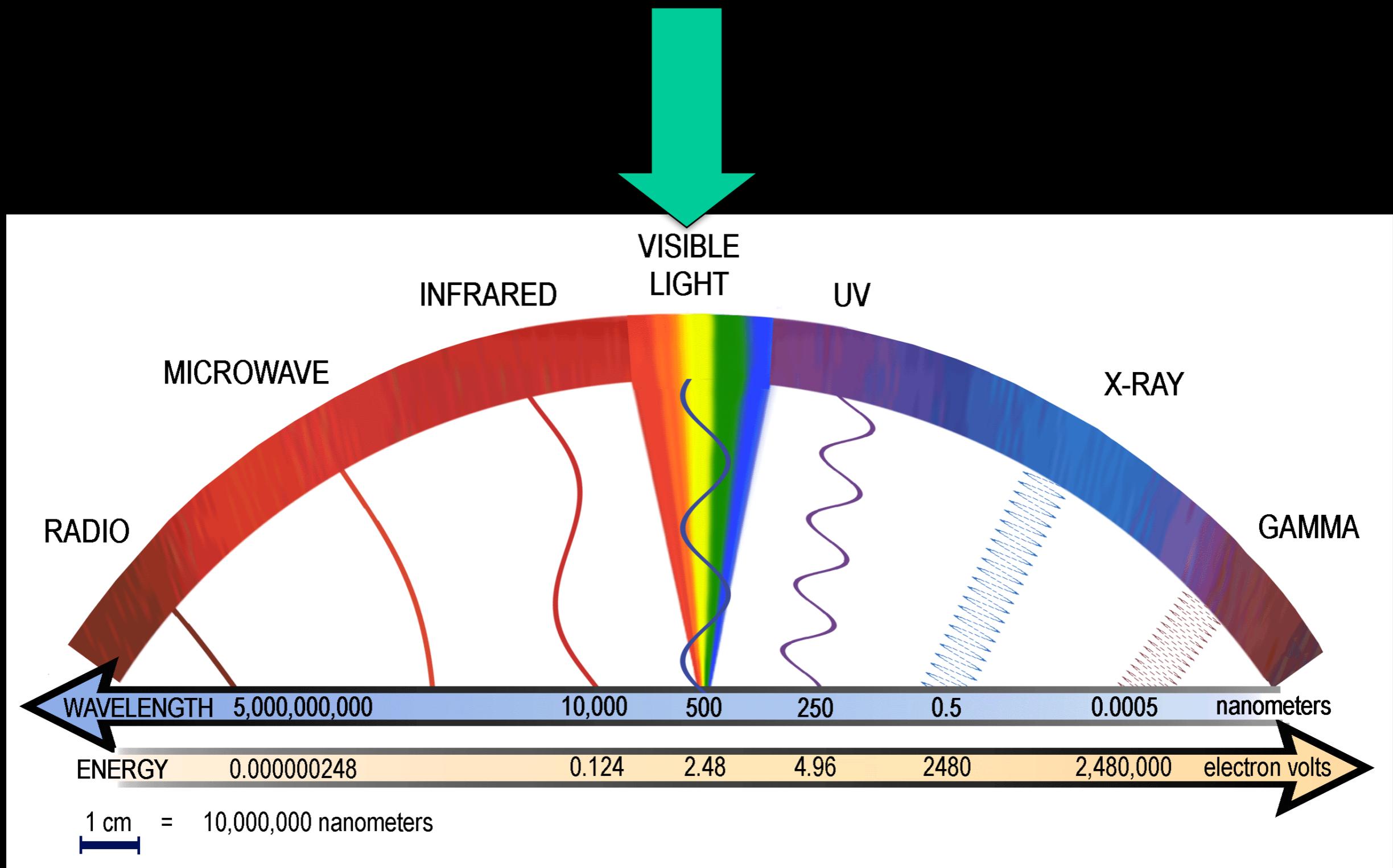


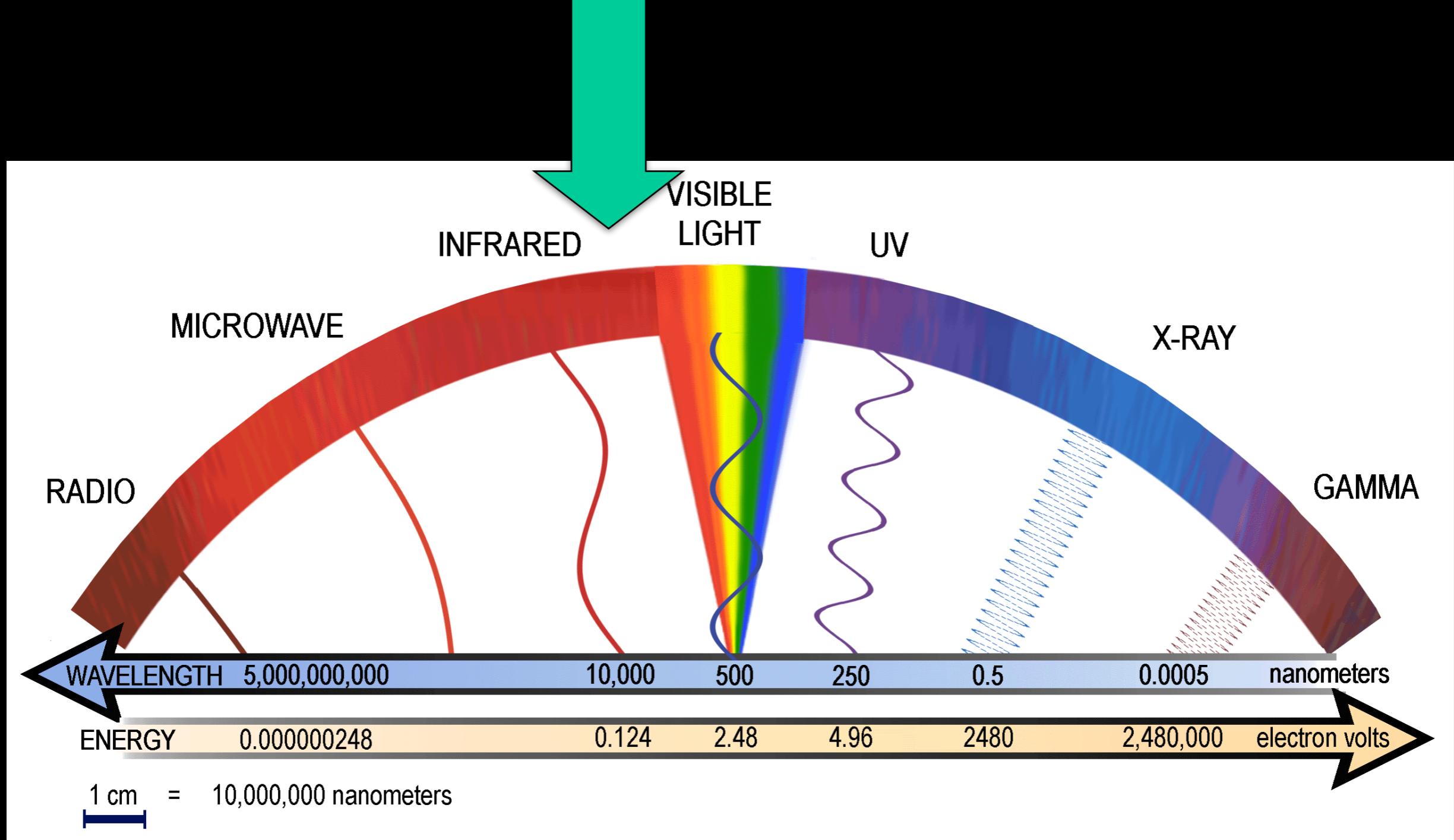


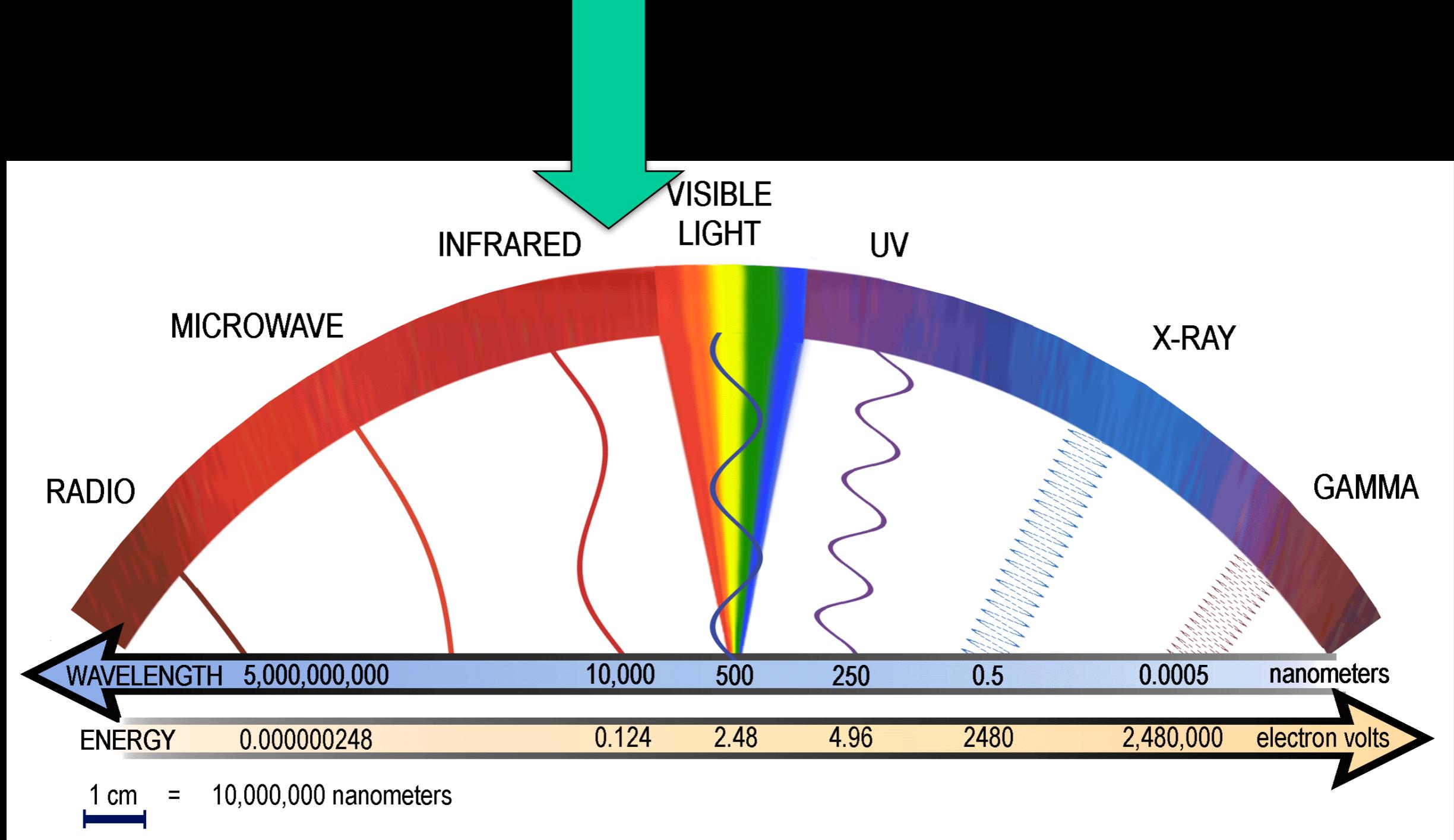


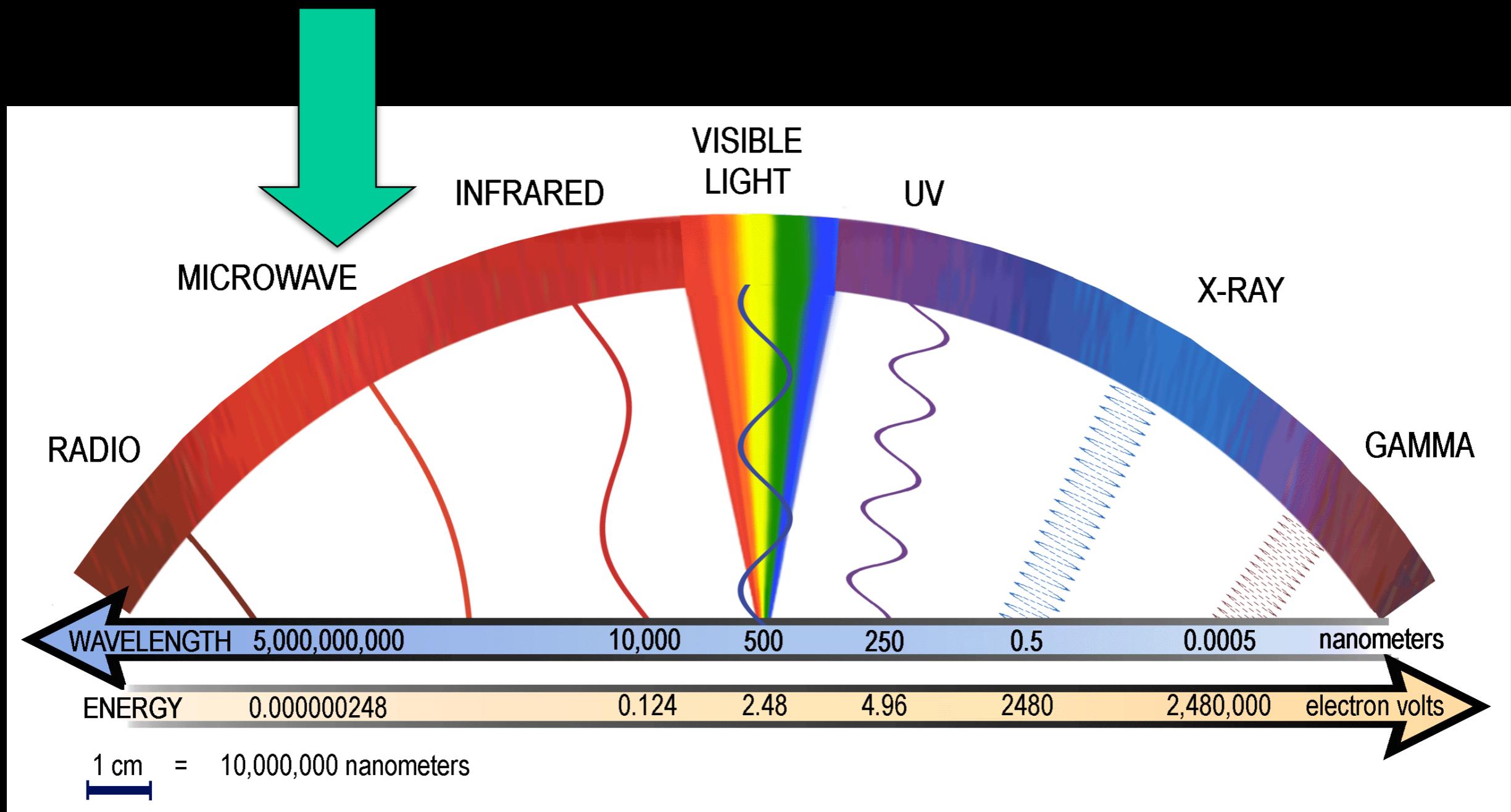




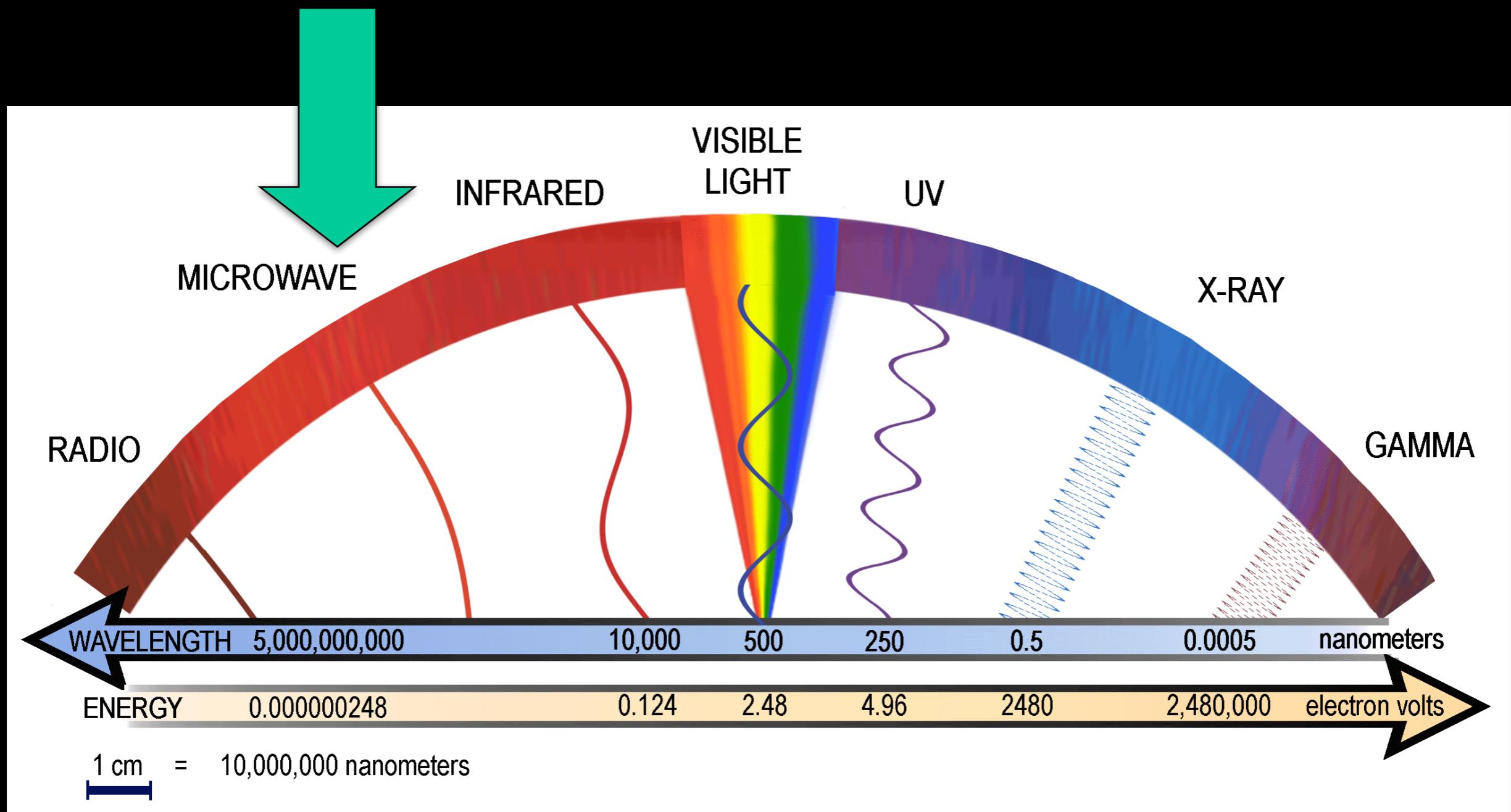


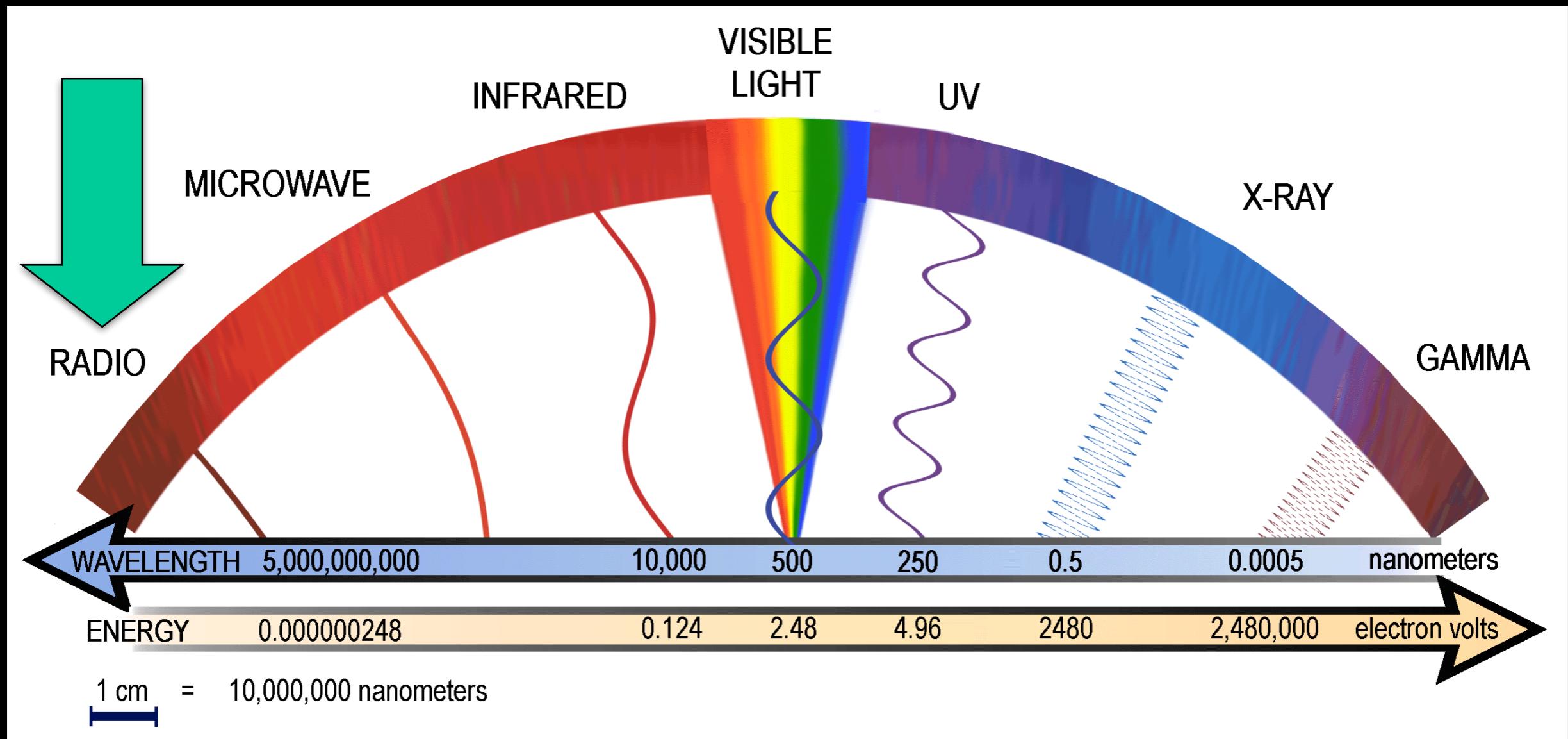


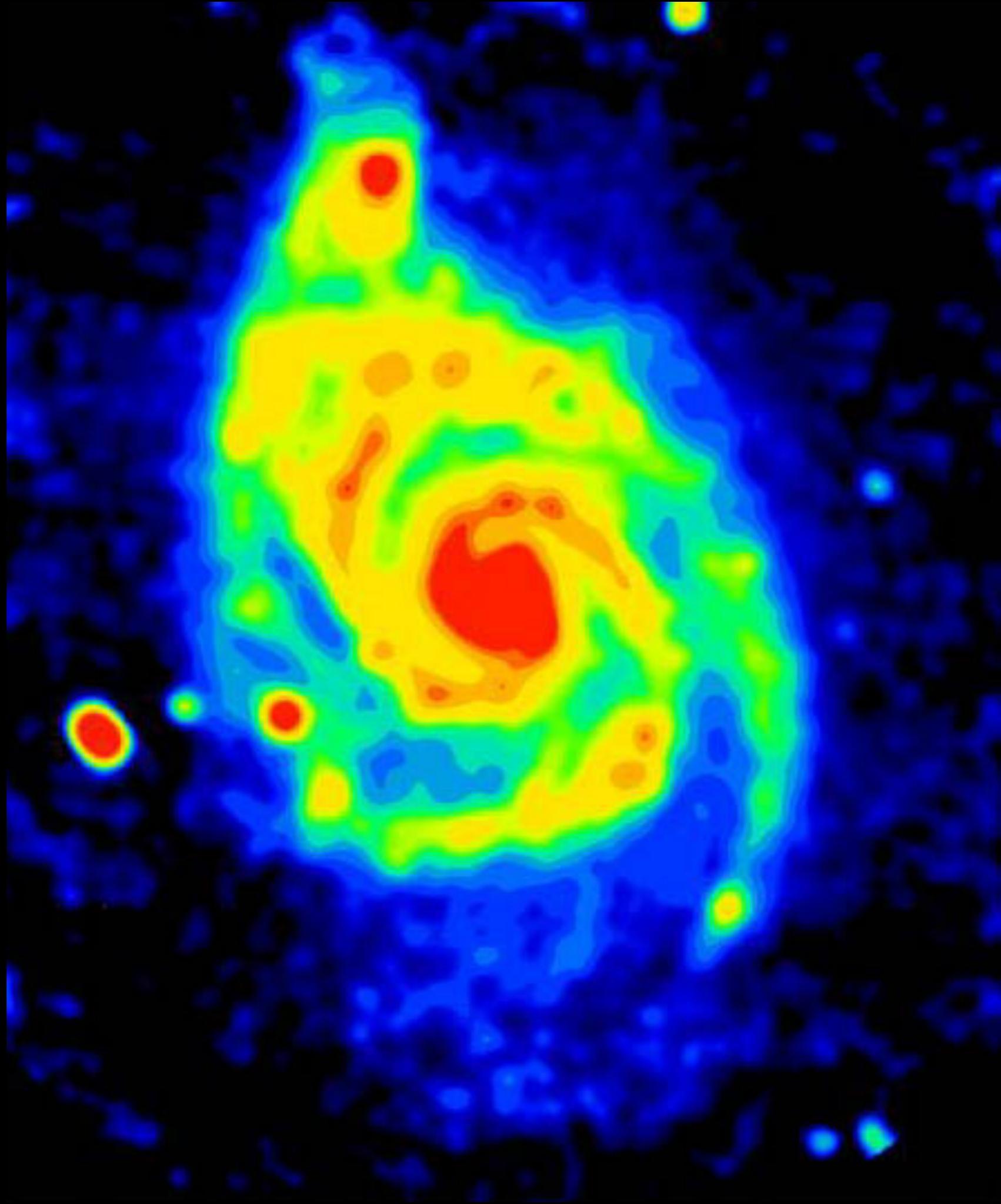


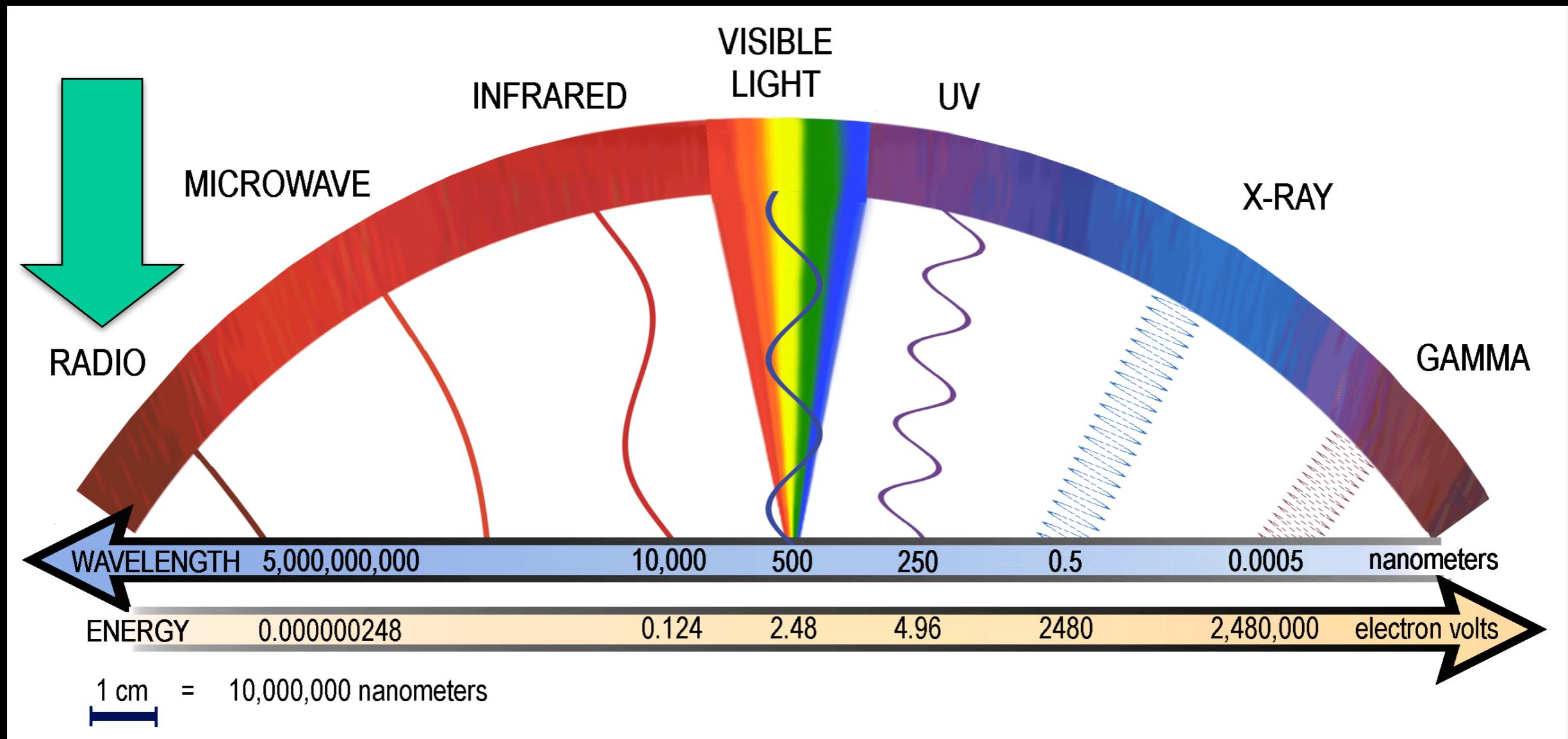


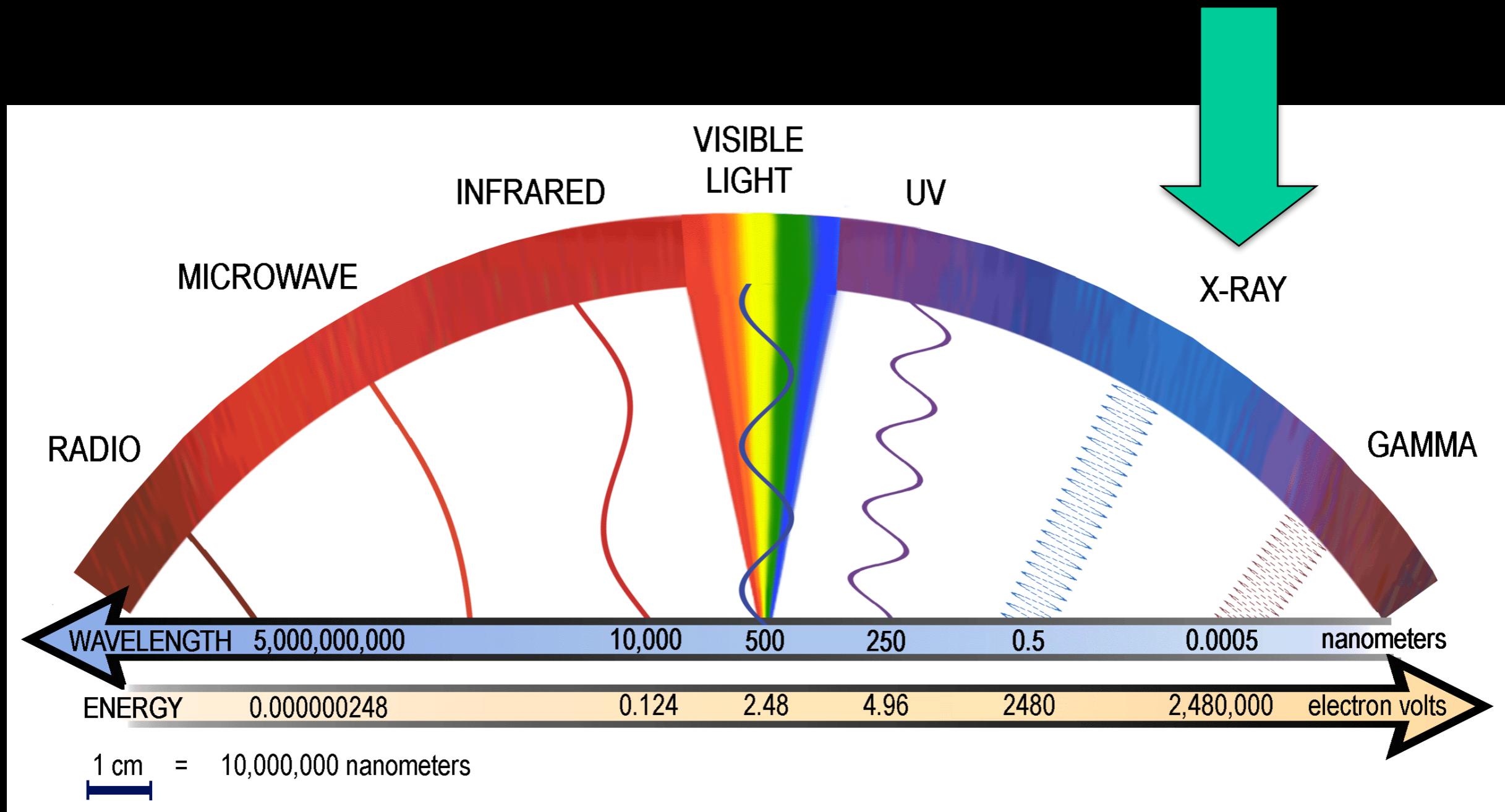






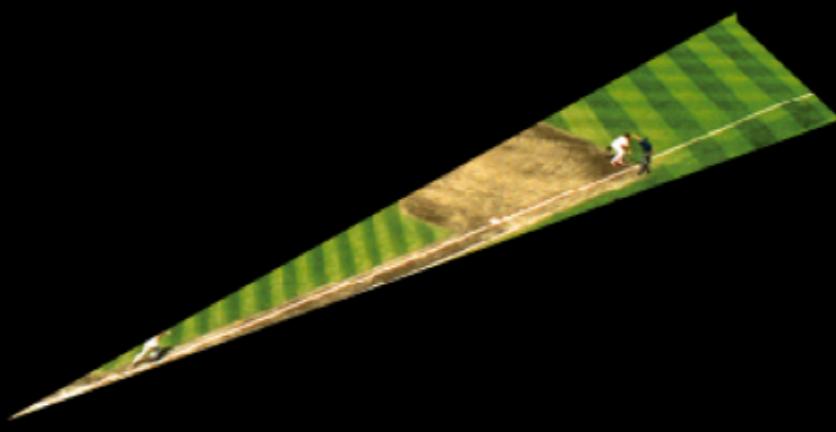






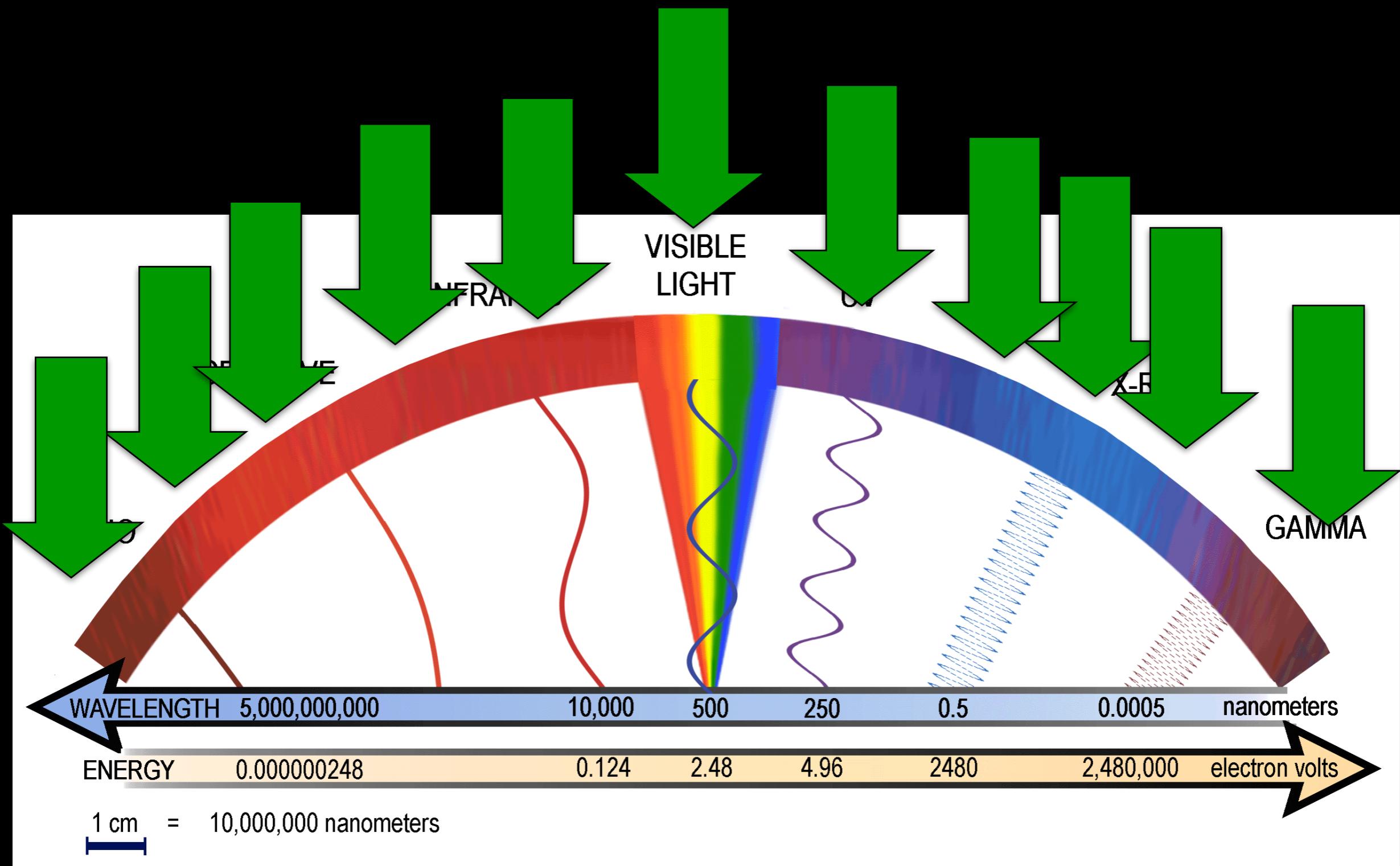




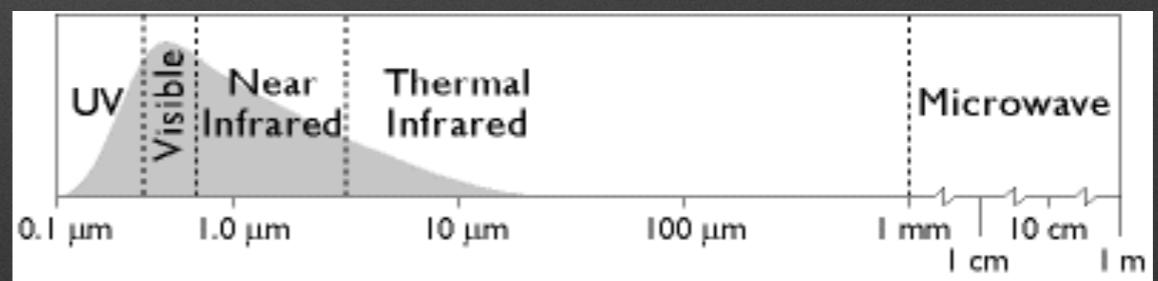






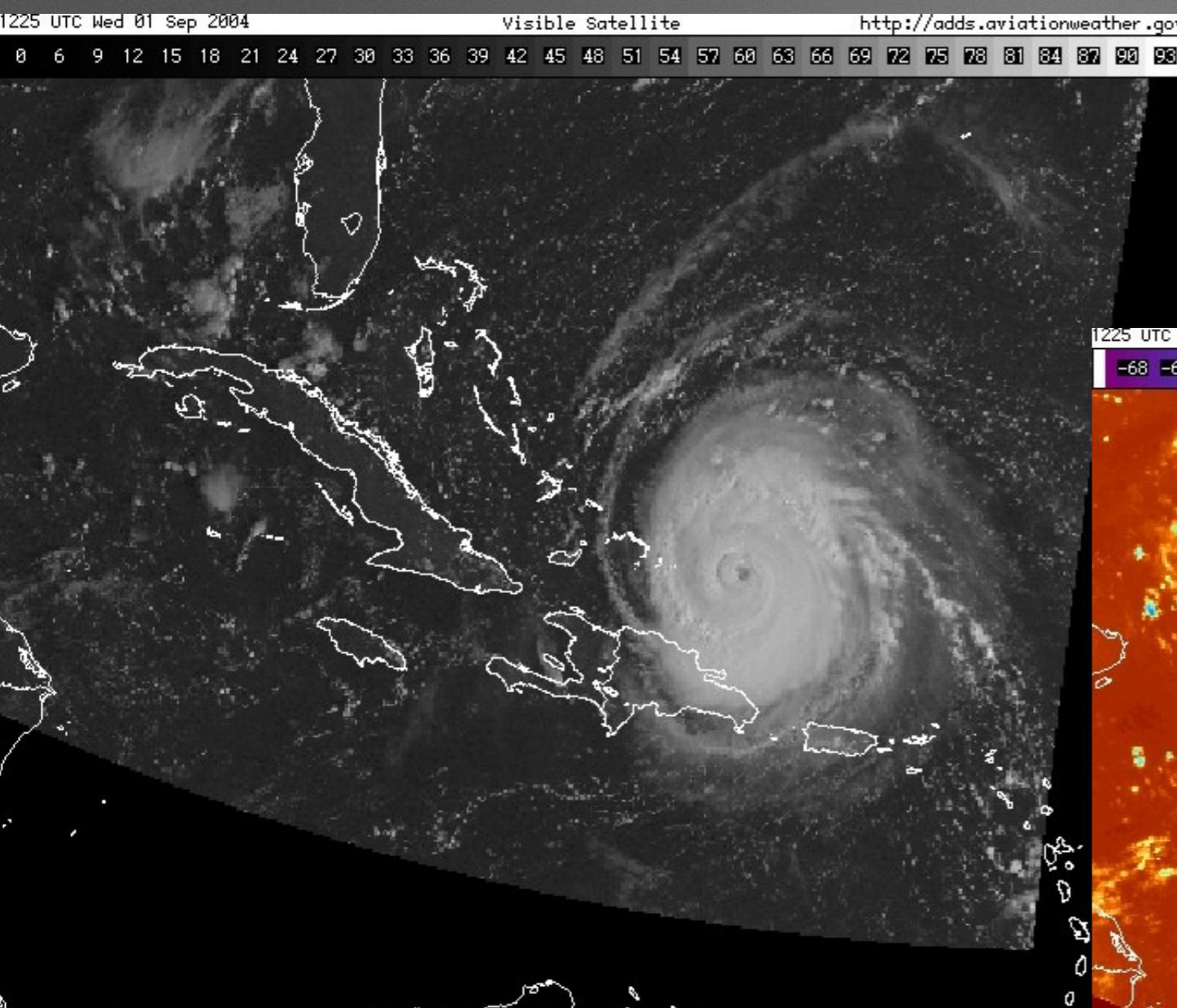


What are remotely sensed image data?

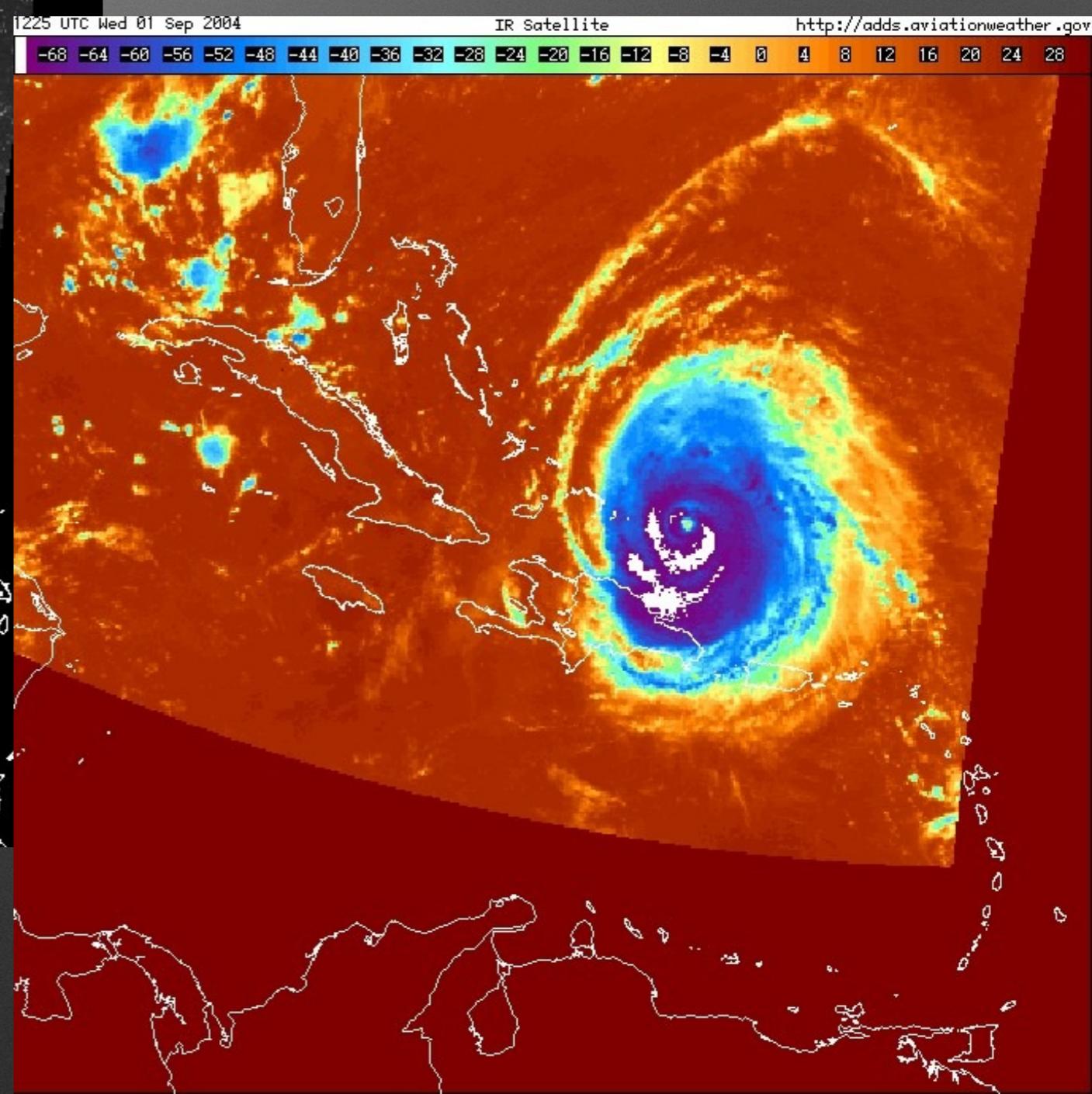


Digital data, Binary values, Raster

**POES (Polar orbiting environmental satellite)
visible channel: 12 UTC
9/1/04**



**POES thermal infrared
channel: 12 UTC 9/1/04**

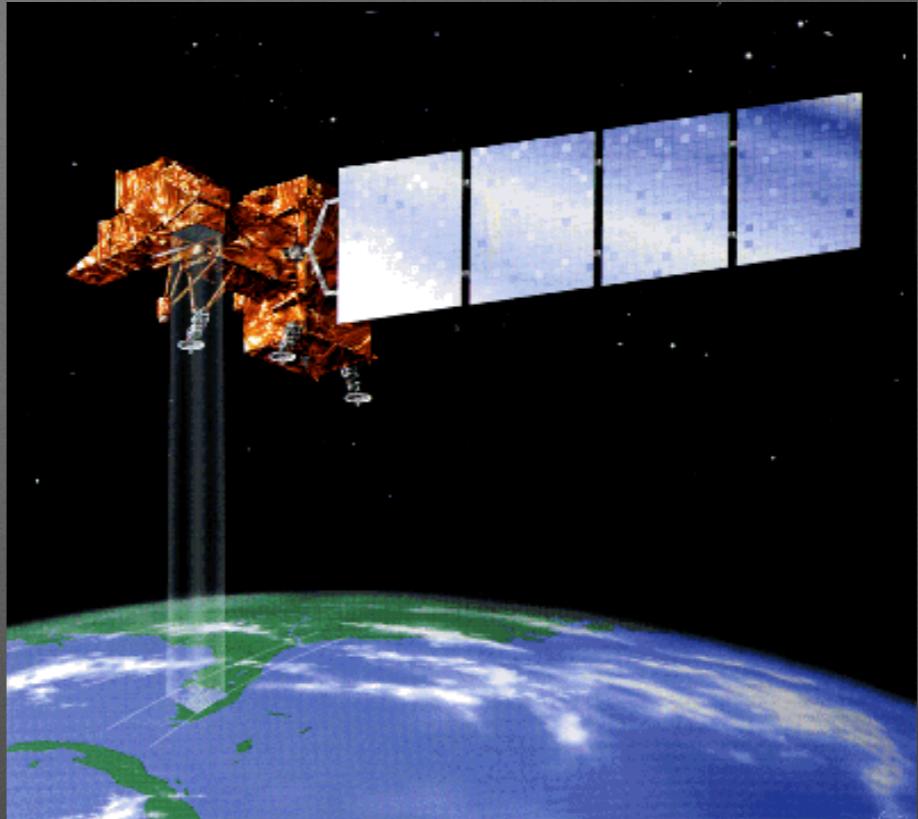


sensor = scanner = instrument

How do sensors record e.m. energy?



- energy source: reflected/ emitted
 - rows (raster)
- convert to electrical charge
 - convert to digital data

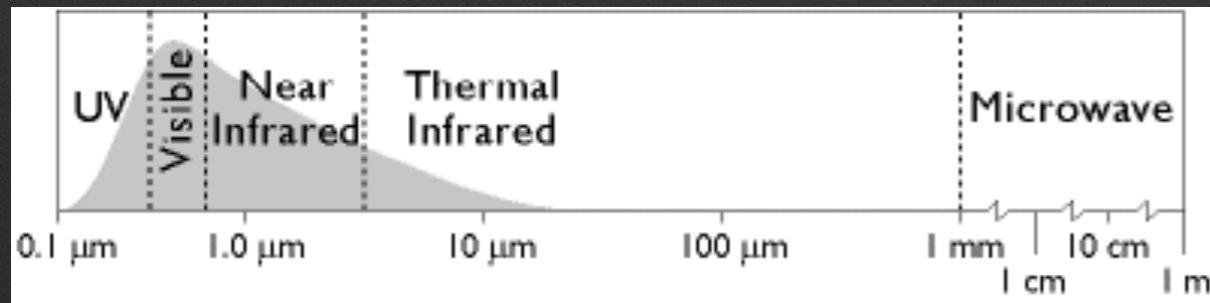
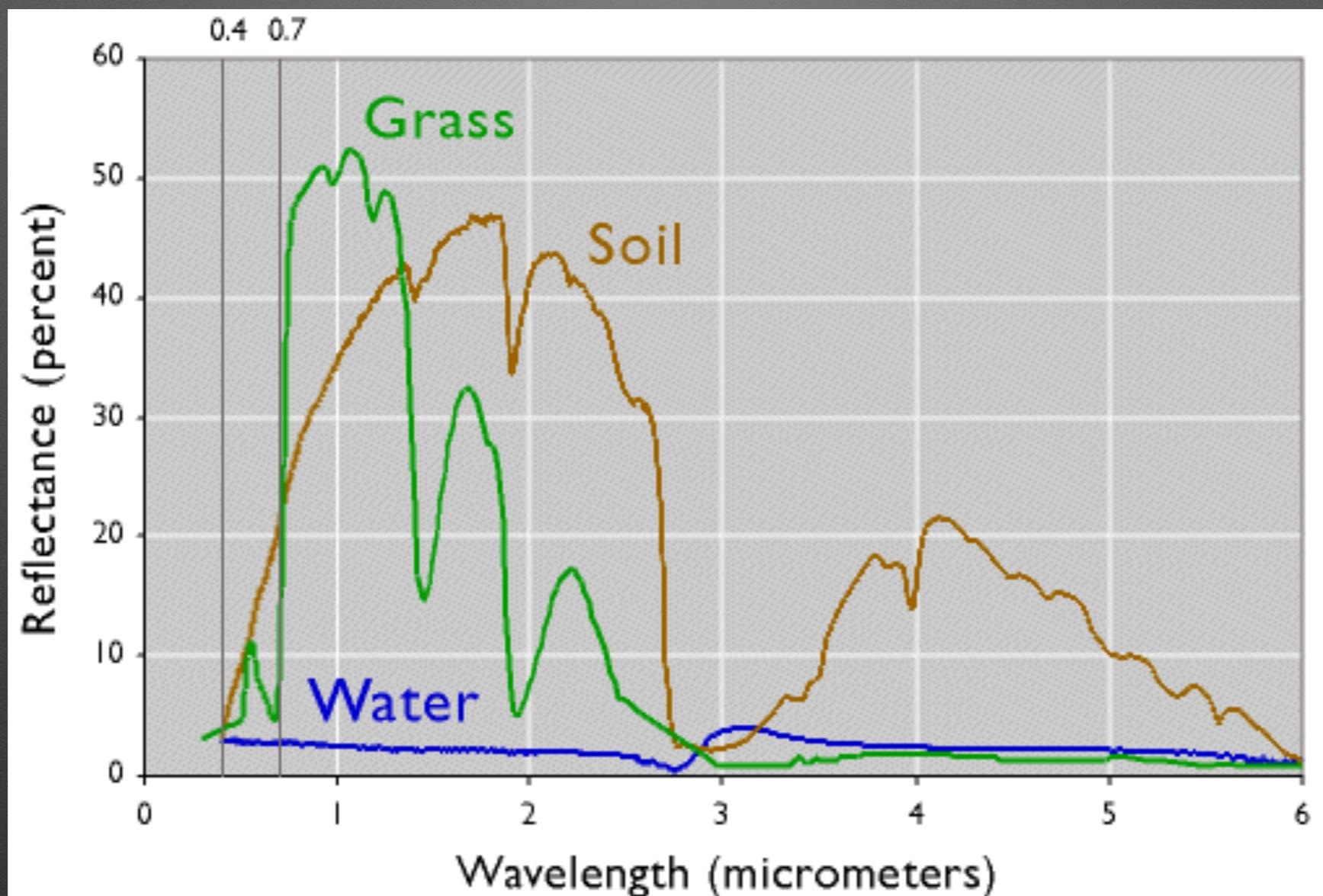


Earth is big, curved, moving, has an atmosphere.

Distance, latitude, season (axis tilt), time of day (rotation) all have an effect.

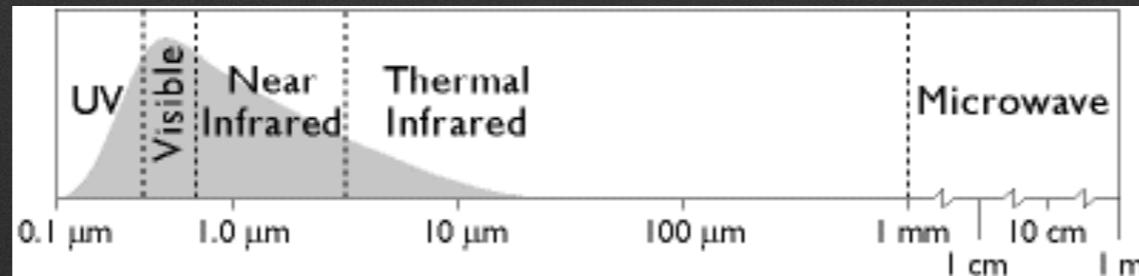
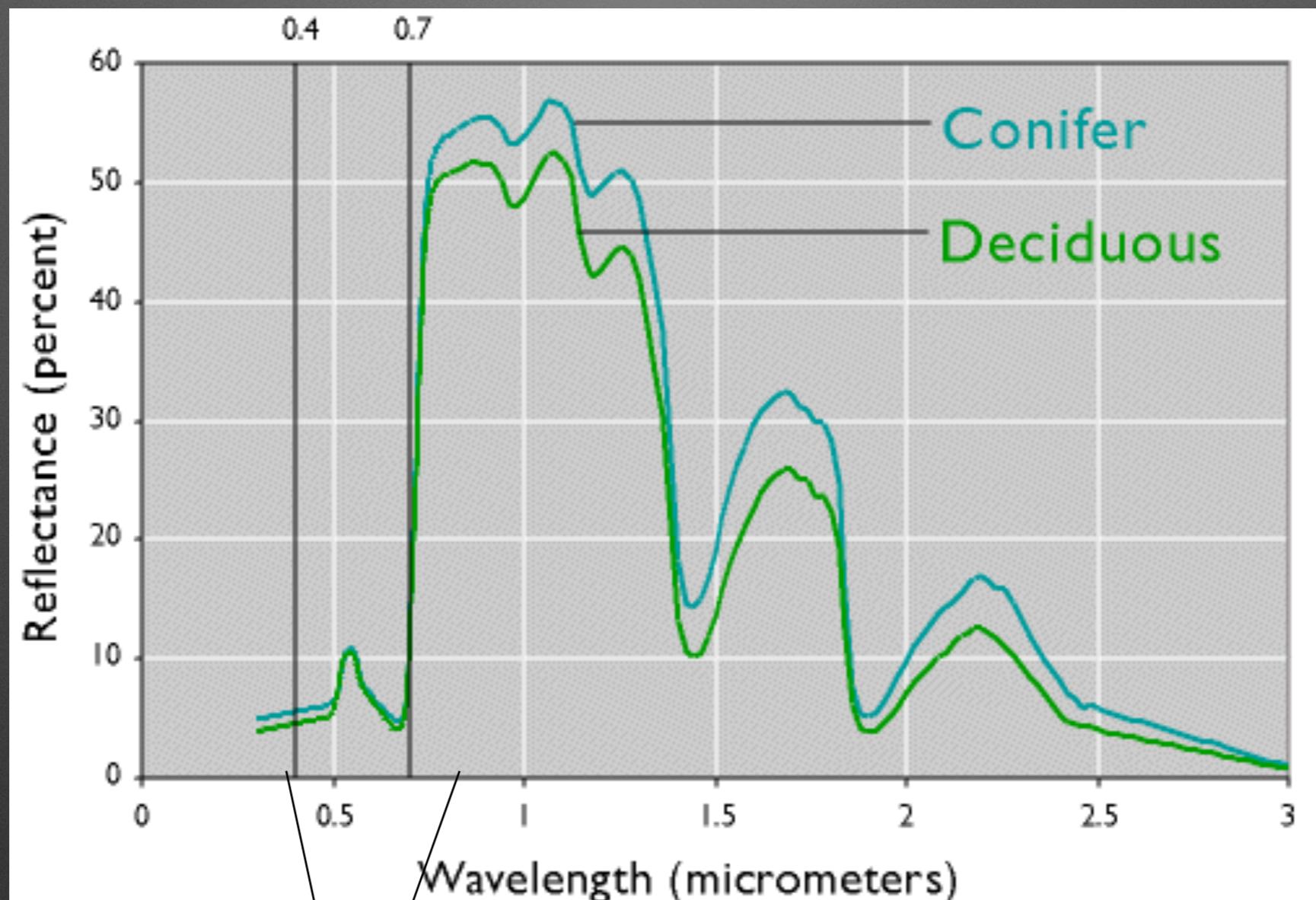
Image Processing is required

What are spectral response patterns?



(Signatures)

What are spectral response patterns? (Signatures)



What's important about all this?

- Ability to visualize and analyze invisible as well as visible electromagnetic energy wavelengths
- Ability to differentiate between visually (to our eyes) similar features
- Ability to map larger areas of the Earth's surface more frequently

What is resolution?

- Spatial
- Spectral
- Radiometric
- Temporal

What is spatial resolution?



- Measure of the fineness of detail visible in a remote sensing image
- Determines size of the smallest area that can be resolved by the sensor.
- Higher resolution images = sharper more detailed.
- Commonly expressed as pixel size in meters.

Think Raster Data cell size

Spatial Resolution Example



Coarse Resolution

AVHRR-1.1km-MODERATE

GOES-25km-VERY COURSE

Fine Resolution

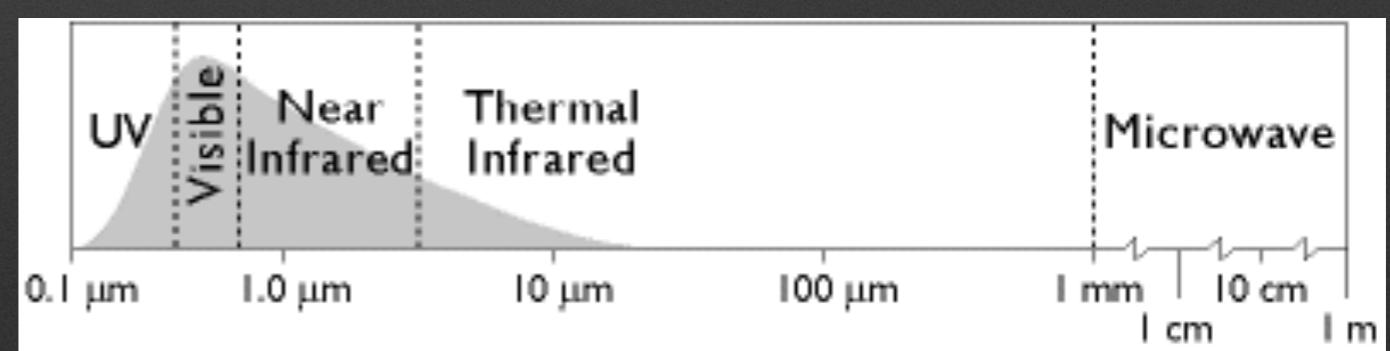
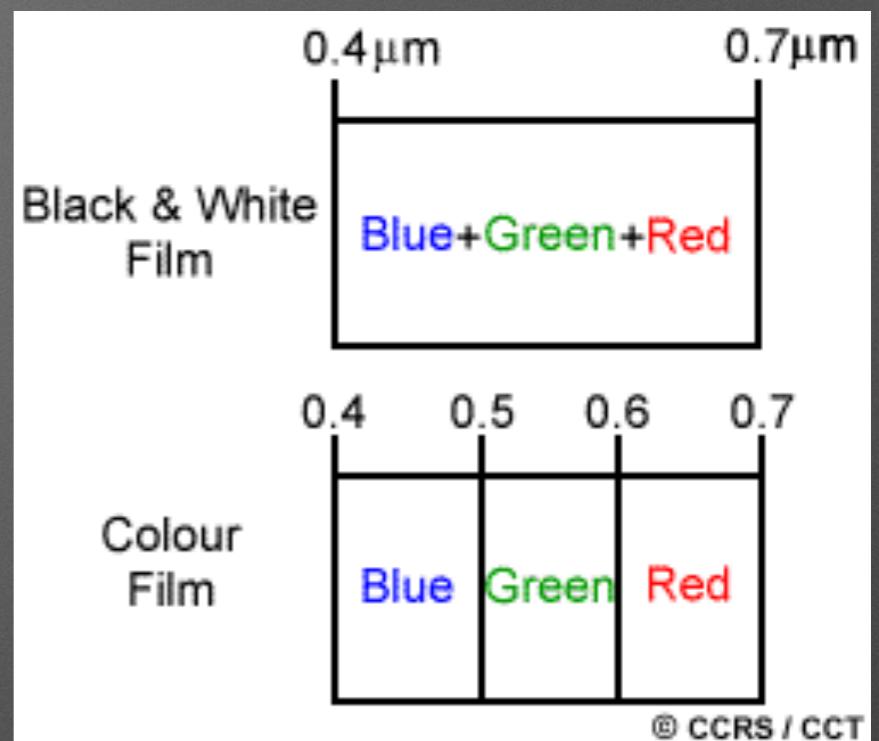
SPOT Panchromatic -10m

LANDSAT -30m



What is spectral resolution?

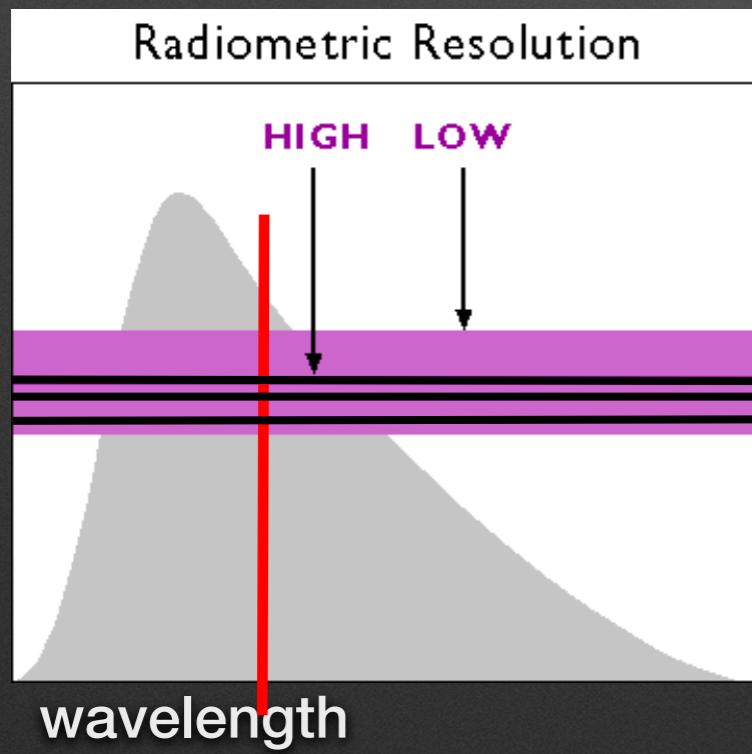
- Spectral resolution or spectral sensitivity is :
- Description of a sensors ability to discriminate fine spectral differences.
- Smallest band or portion of the electromagnetic spectrum in which objects are discernable.
- Specific wavelength intervals detected by a sensor



What is radiometric resolution?



magnitude



- How good is the instrument at measuring small differences in the magnitude, or brightness, of radiation within the ground area corresponding to a single raster cell.
- Radiometric resolution determines how fine the sensor can distinguish between objects of similar reflection. The higher the radiometric resolution, the better we can distinguish between even subtle differences in reflection.
- The number of possible data values in each band.

Another illustration of radiometric resolution

2-bit image



22 or 4
Shades
of Gray

8-bit image



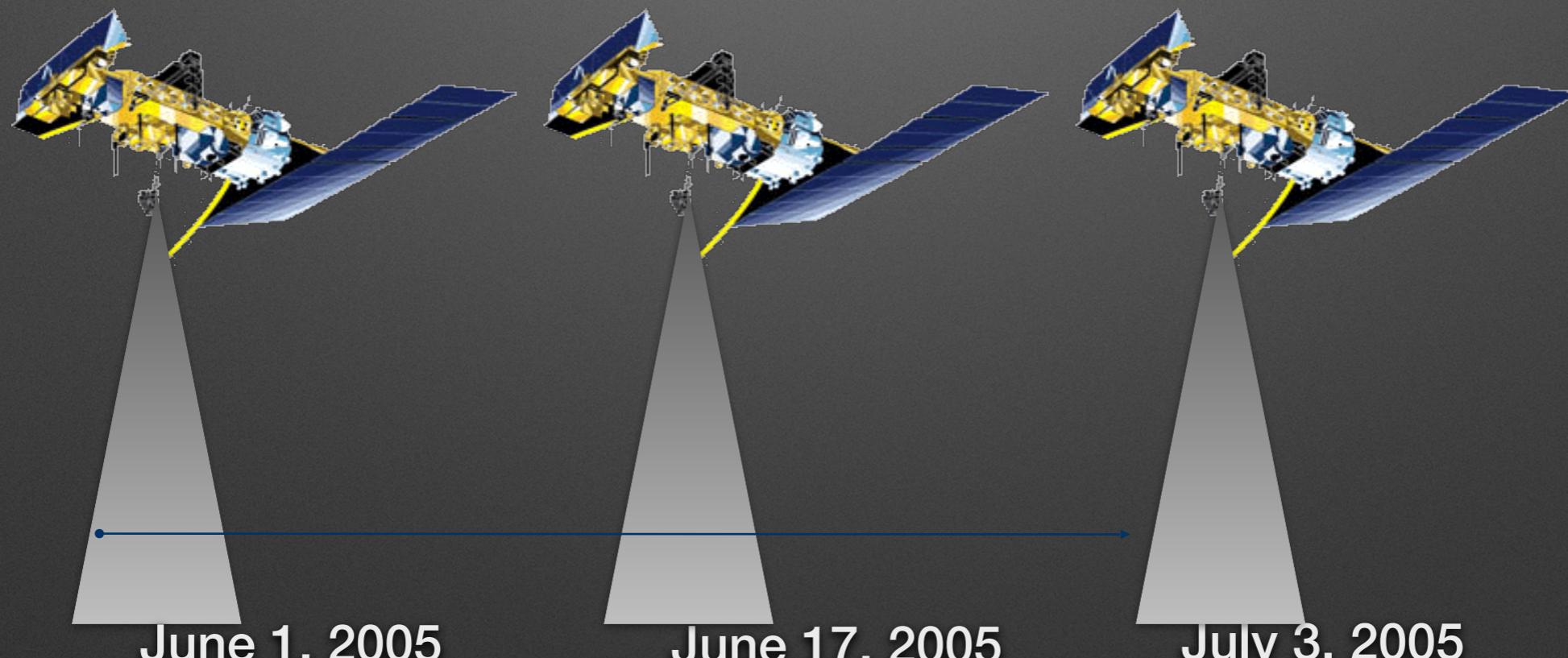
28 or
256
Shades
of Gray

Temporal Resolution

How often the satellite system collects data of a particular area
(repeat time)

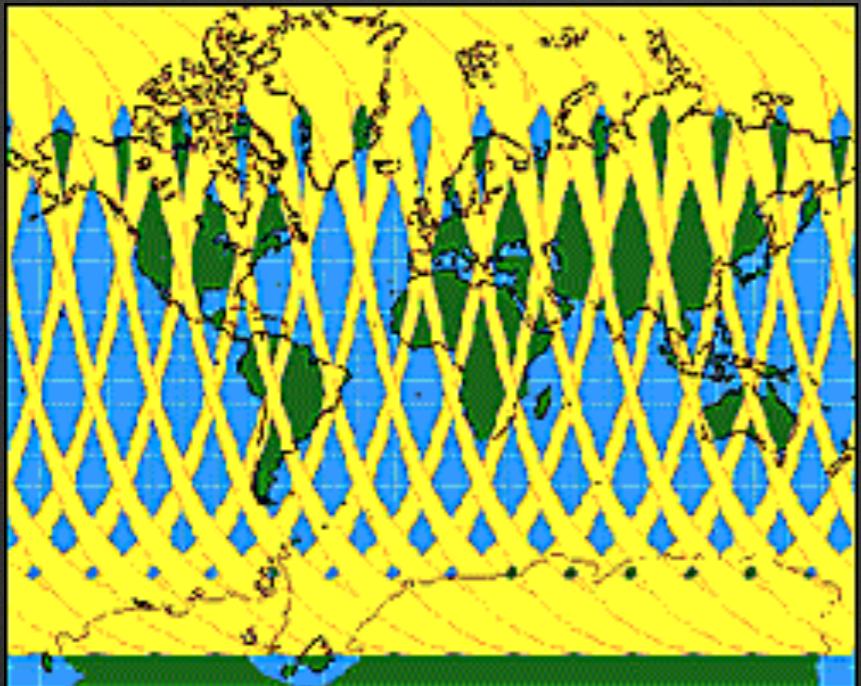
Temporal Resolution

Every 16 Days



What is temporal resolution?

- How frequently imagery is obtained for the same area.
- Ability to collect imagery of the same area of the Earth's surface at different periods is critical
- Spectral characteristics of features may change over time
- Changes can be detected by collecting and comparing multi-temporal imagery.



- The time factor in imaging is important when:
- persistent clouds offer limited clear views of the Earth's surface (often in the tropics)
- short-lived phenomena (floods, oil slicks, etc.) need to be imaged
- multi-temporal comparisons are required (e.g. the spread of a forest disease from one year to the next)
- the changing appearance of a feature over time can be used to distinguish it from near-similar features (wheat / maize)

Let's look at both Spatial and Spectral resolution

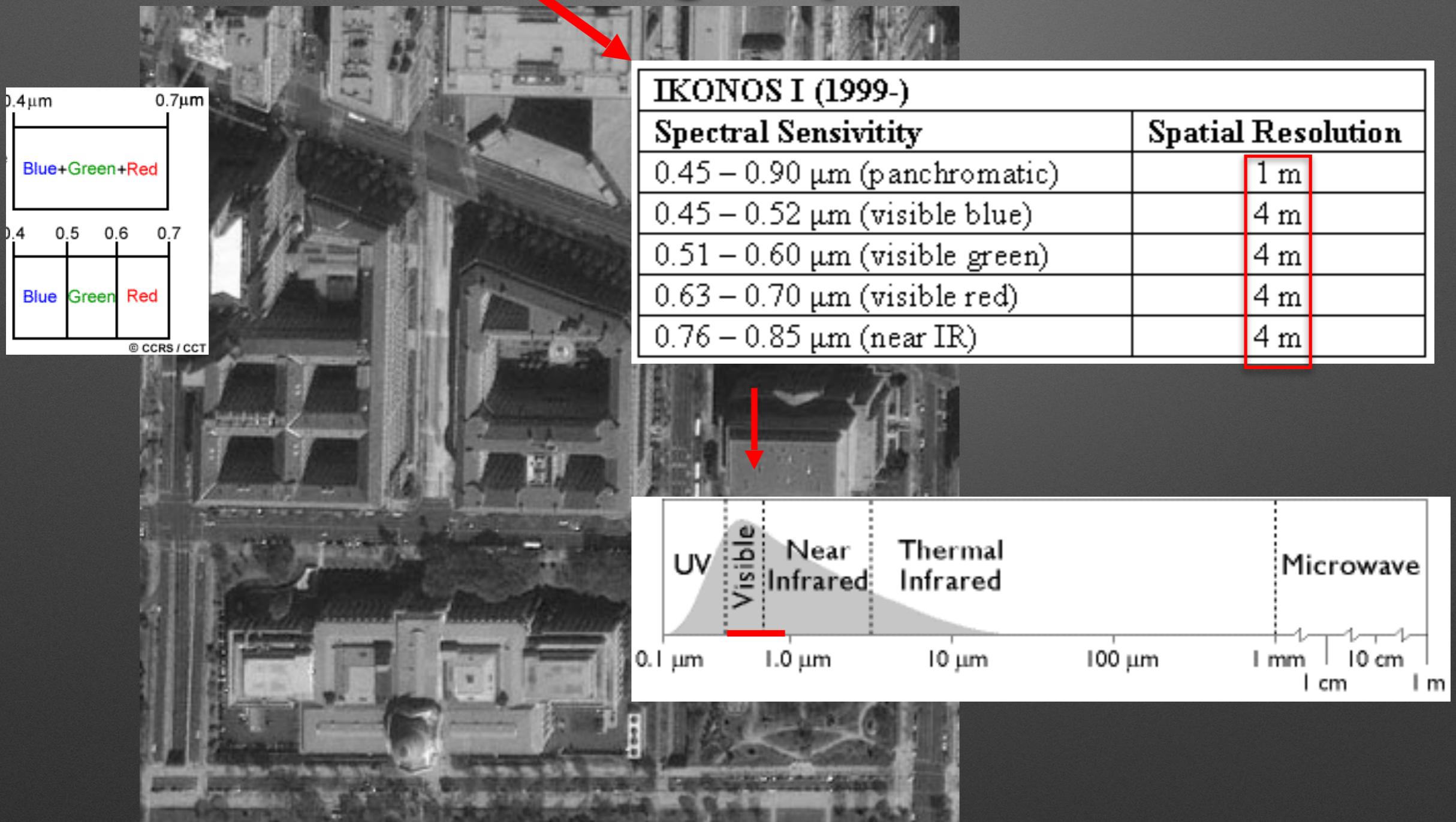


Next five slides describe 3 Multispectral scanning systems: IKONOS, AVHRR, and Landsat.

A multispectral system collects data over a variety of different wavelengths, or bands.

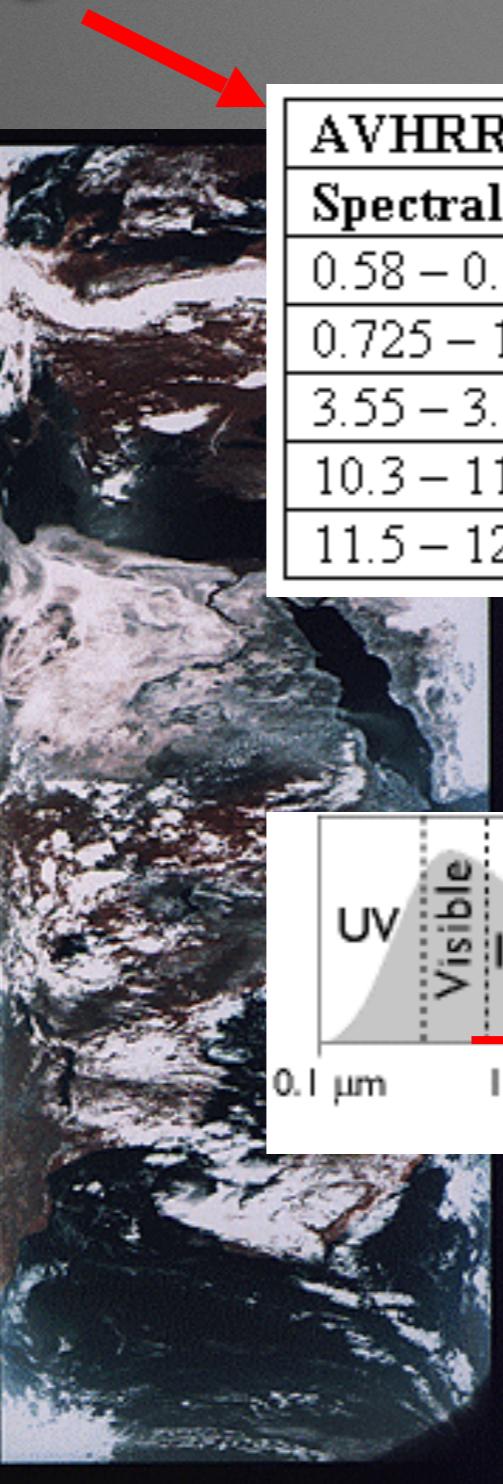
Take note of both the spatial resolution and the spectral resolution of each.

What is “high” spatial resolution?

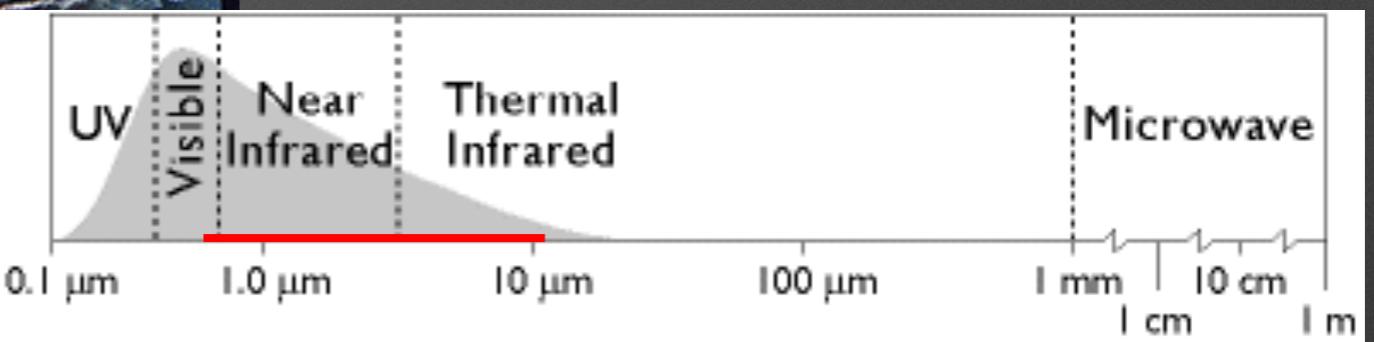


What is “low” spatial resolution?

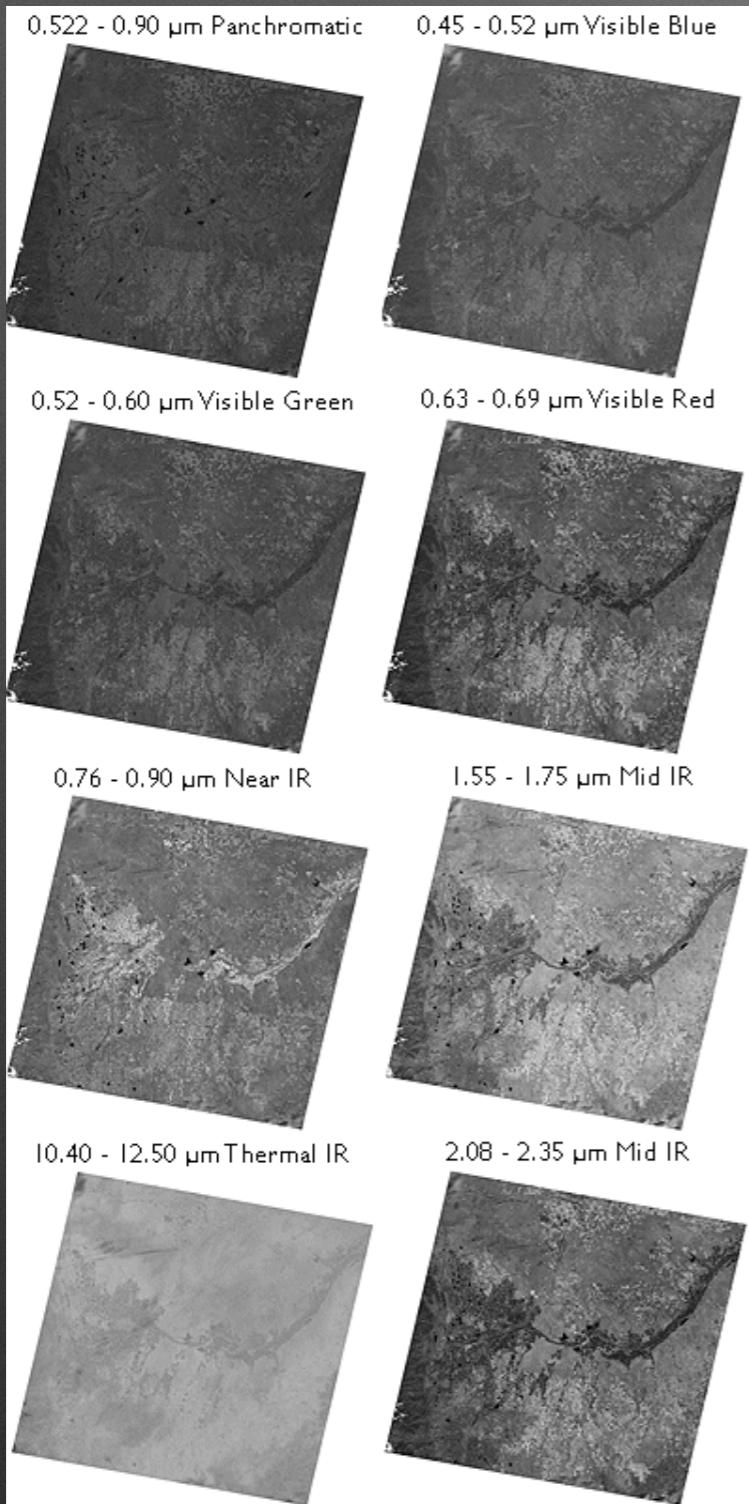
Advanced Very High Resolution Radiometer



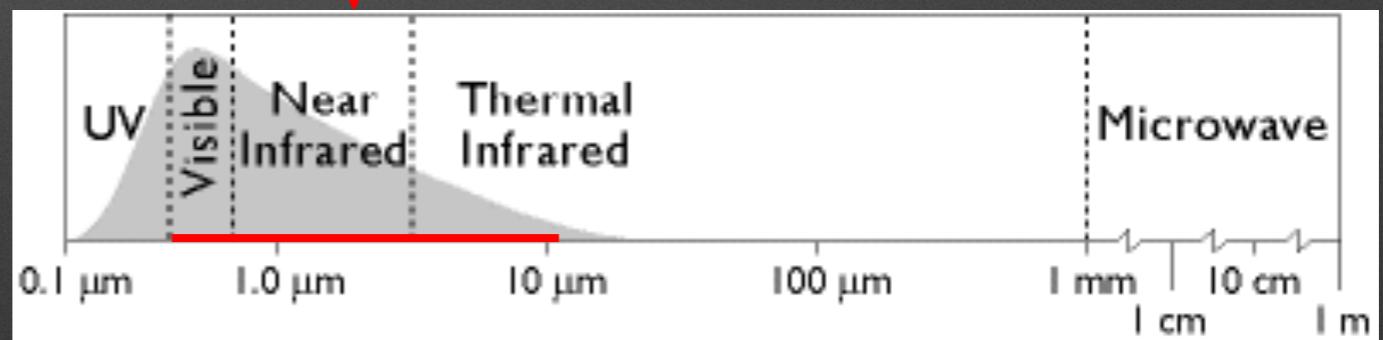
AVHRR (1979-)	
Spectral Sensitivity	Spatial Resolution
0.58 – 0.68 µm (visible red)	1-4 km*
0.725 – 1.10 µm (near IR)	1-4 km*
3.55 – 3.93 µm (thermal IR)	1-4 km*
10.3 – 11.3 µm (thermal IR)	1-4 km*
11.5 – 12.5 µm (thermal IR)	1-4 km*



What is Landsat?

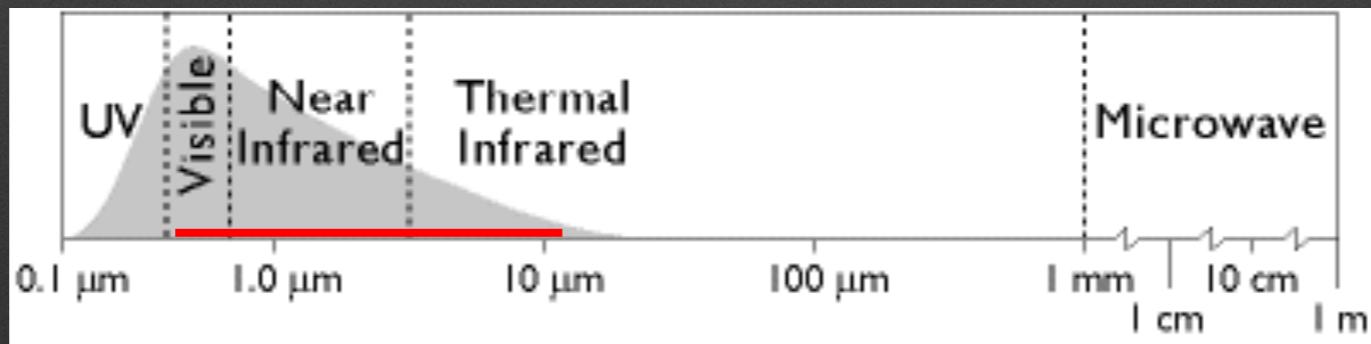


Landsat TM & ETM+ (1982-)	
Spectral Sensitivity	Spatial Resolution
0.522 – 0.90 μm (panchromatic)*	15 m*
0.45 – 0.52 μm (visible blue)	30 m
0.52 – 0.60 μm (visible green)	30 m
0.63 – 0.69 μm (visible red)	30 m
0.76 – 0.90 μm (near IR)	30 m
1.55 – 1.75 μm (mid IR)	30 m
10.40 – 12.50 μm (thermal IR)	120 m
2.08 – 2.35 μm (mid IR)	30 m



Why so many bands?

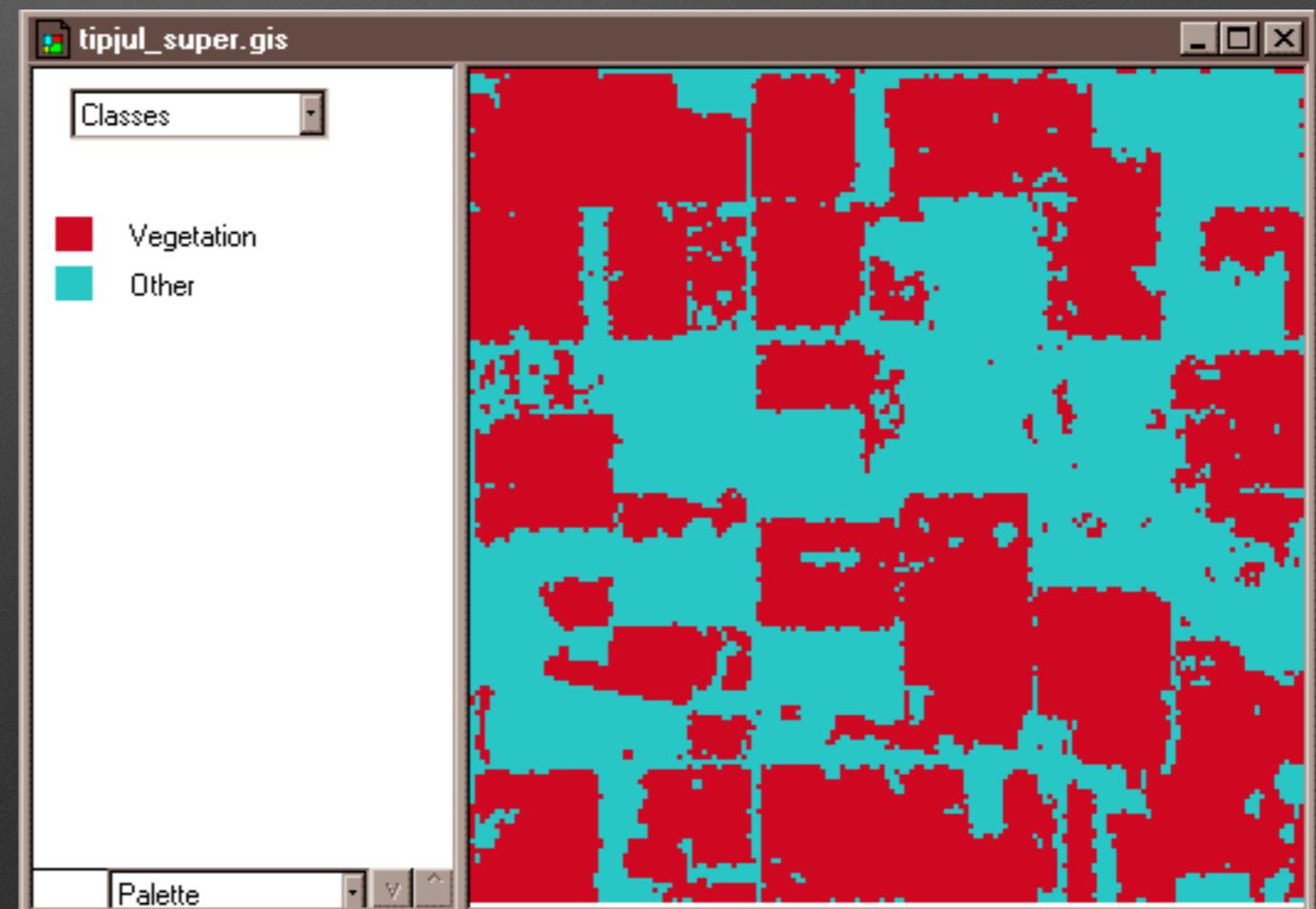
Phenomena revealed by different bands of Landsat TM/ETM data	
Band	Phenomena revealed
0.45 – 0.52 µm (visible blue)	Shorelines and water depths (these wavelengths <u>penetrate</u> water)
0.52 – 0.60 µm (visible green)	Plant types and vigor (peak vegetation <u>reflects</u> these wavelengths strongly)
0.63 – 0.69 µm (visible red)	Photosynthetic activity (plants <u>absorb</u> these wavelengths during photosynthesis)
0.76 – 0.90 µm (near IR)	Plant vigor (healthy plant tissue <u>reflects</u> these wavelengths strongly)
1.55 – 1.75 µm (mid IR)	Plant water stress, soil moisture, rock types, cloud cover vs. snow
10.40 – 12.50 µm (<u>thermal IR</u>)	Relative amounts of heat, soil moisture
2.08 – 2.35 µm (mid IR)	Plant water stress, mineral and rock types



What is image data classification?

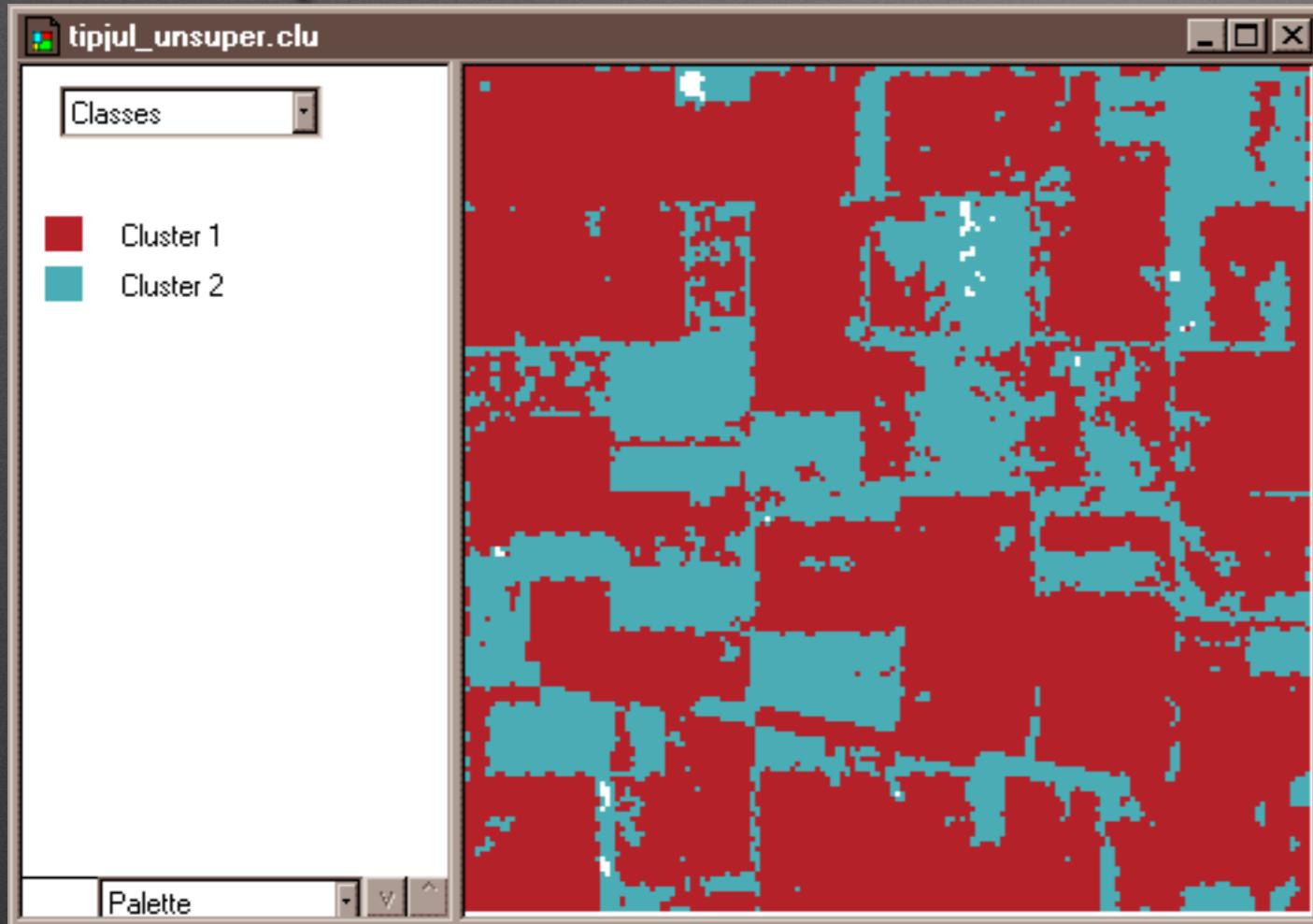
“Supervised” classification

The analyst specifies, in advance, the reflectance values typical of each landuse/cover type or class.



What is image data classification?

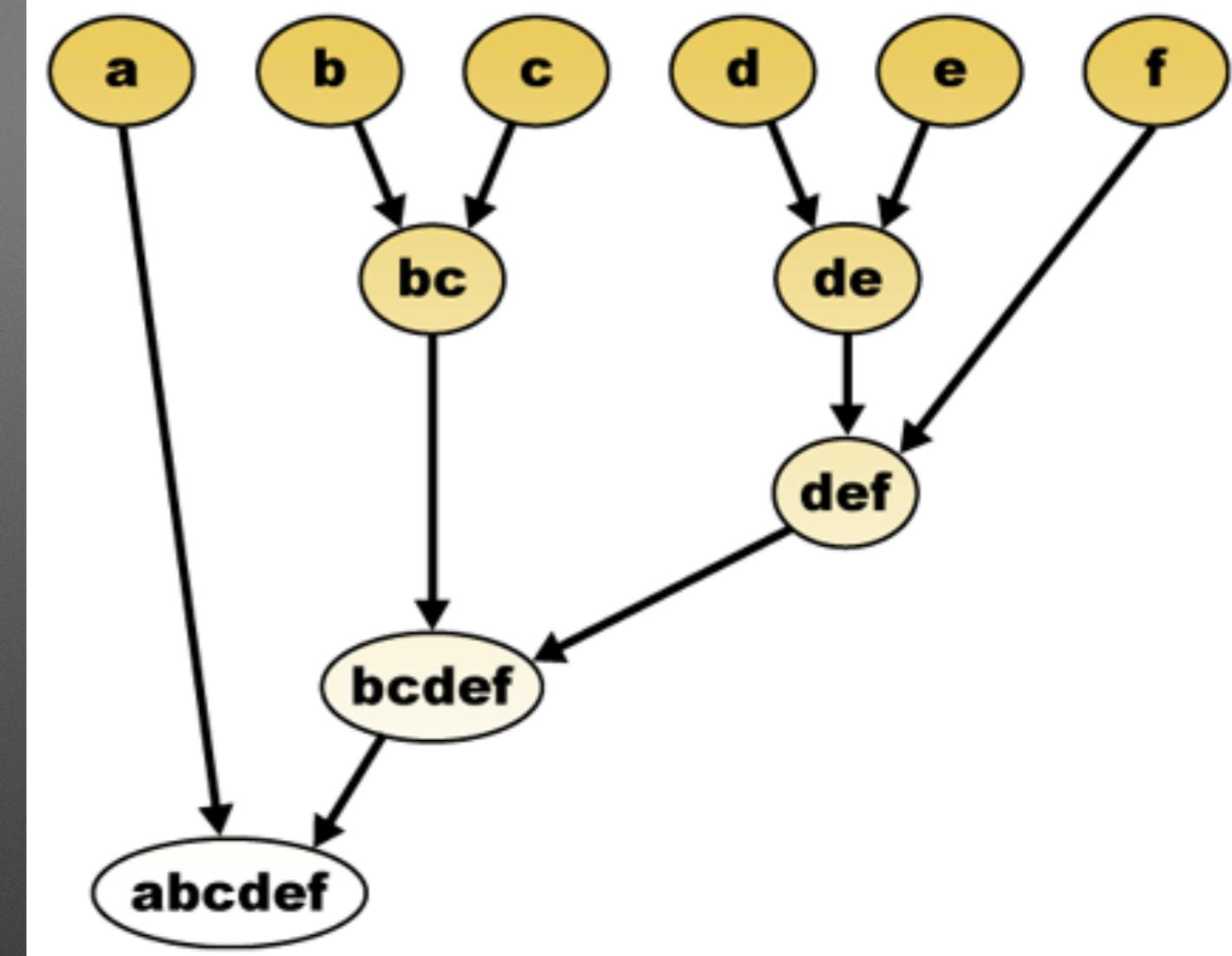
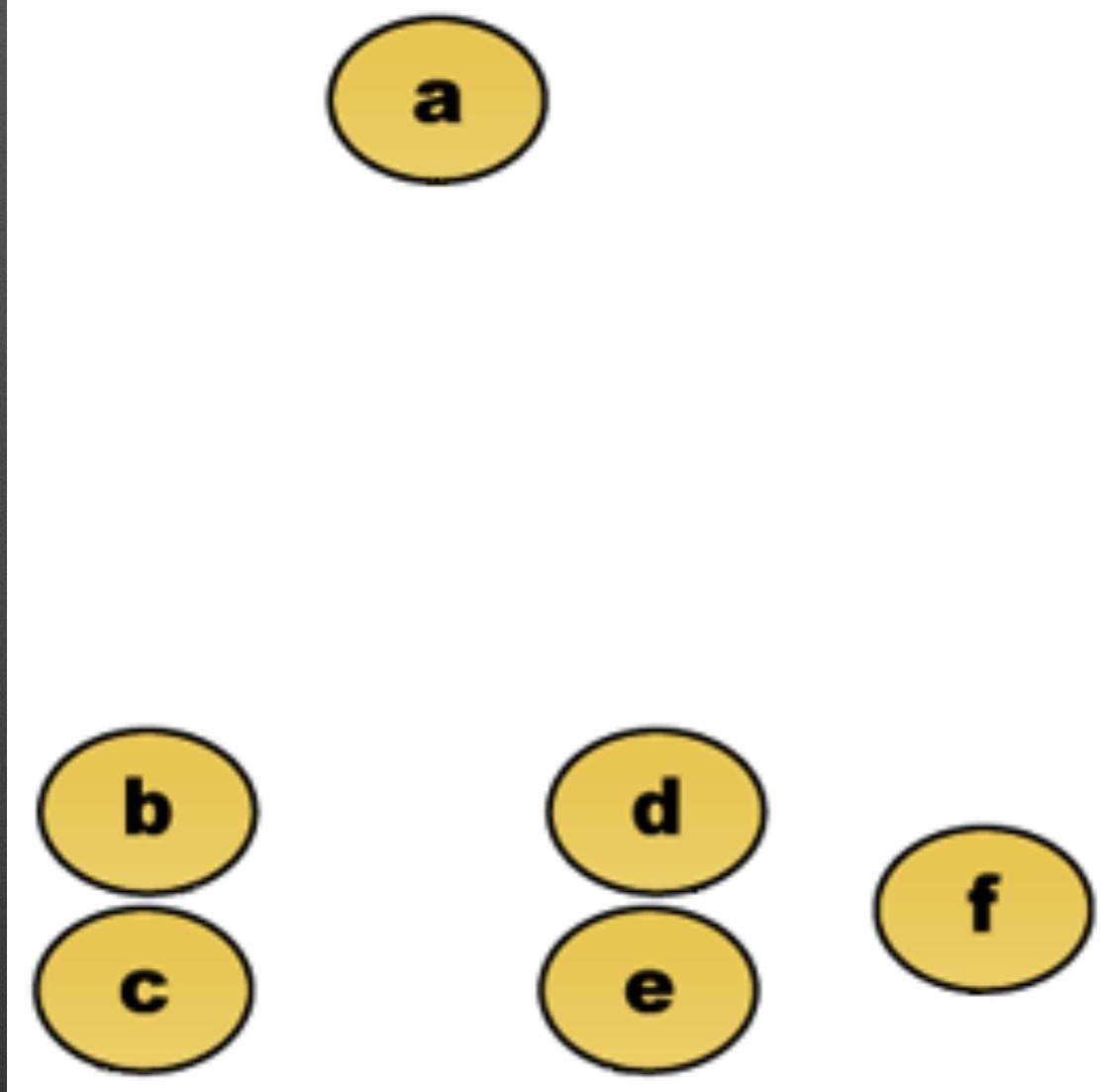
“Unsupervised” classification



Classes of reflectance values are first created by statistical software.

Then the analyst determines how the spectral classes correspond to landuse/cover categories.

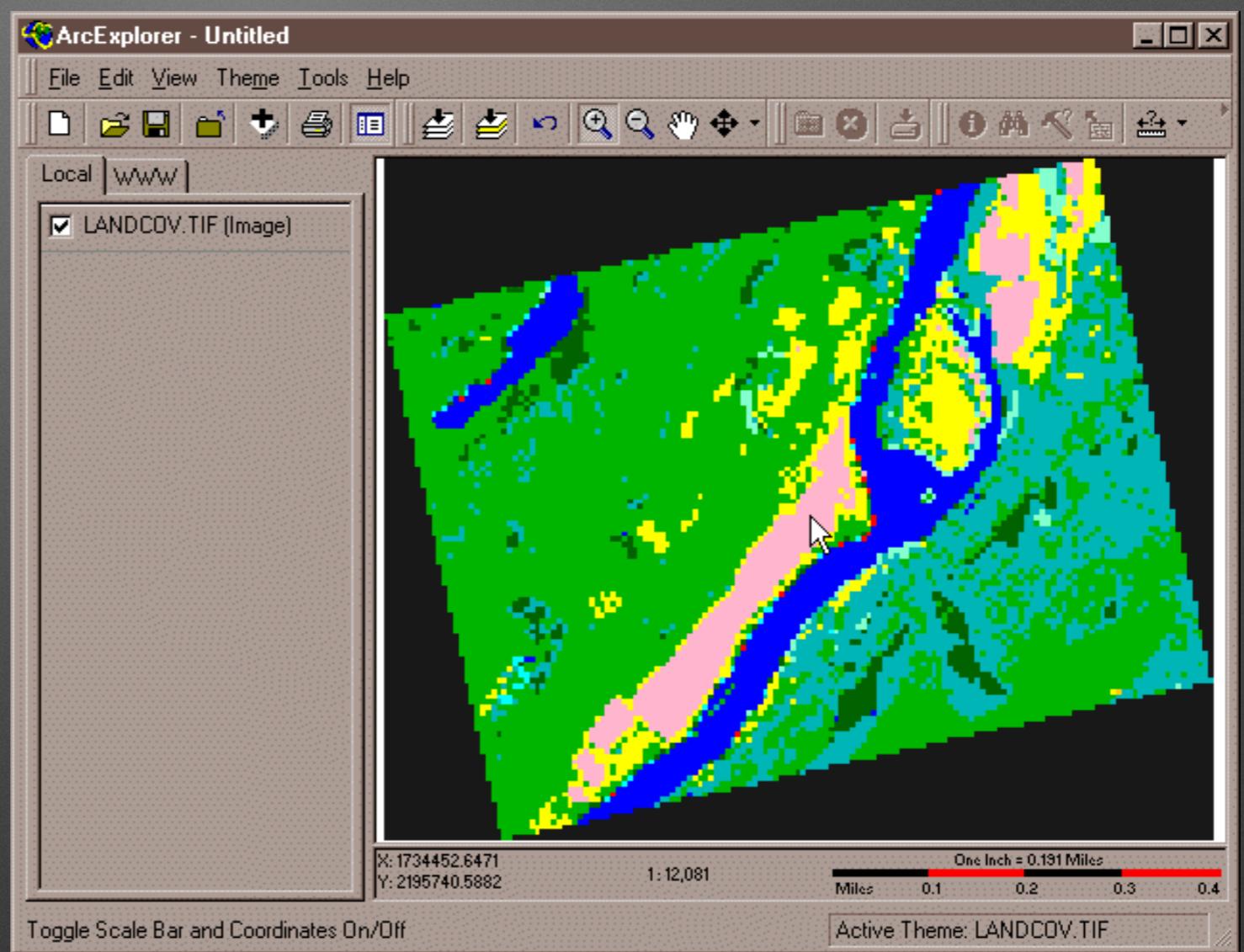
Clustering Basics



This example uses Euclidian distance

What is the National Land Cover Dataset?

National Land Cover Dataset Classification System Legend		
Color Key	RGB Value	Class Number and Name
[Blue]	0,0,255	11 Open Water
[White]	255,255,255	12 Perennial Ice/Snow
[Yellow]	255,204,0	21 Low Intensity Residential
[Orange]	255,153,0	22 High Intensity Residential
[Red]	255,0,0	23 Commercial/Industrial/Transportation
[Dotted]	229,229,204	31 Bare Rock/Sand/Clay
[Brown]	128,77,51	32 Quarries/Strip Mines/Gravel Pits
[Pink]	255,0,255	33 Transitional
[Green]	0,178,0	41 Deciduous Forest
[Dark Green]	0,102,0	42 Evergreen Forest
[Teal]	0,178,178	43 Mixed Forest
[Yellow-Green]	178,178,0	51 Shrubland
[Purple]	153,25,229	61 Orchards/Vineyards
[Brown]	229,204,153	71 Grasslands/Herbaceous
[Yellow]	255,255,0	81 Pasture/Hay
[Pink]	255,179,204	82 Row Crops
[Maroon]	204,77,128	83 Small Grains
[Grey]	178,178,178	84 Fallow
[Light Green]	128,255,0	85 Urban/Recreational Grasses
[Light Blue]	128,255,204	91 Woody Wetlands
[Cyan]	0,255,255	92 Emergent Herbaceous Wetlands



<http://nationalmap.gov/>

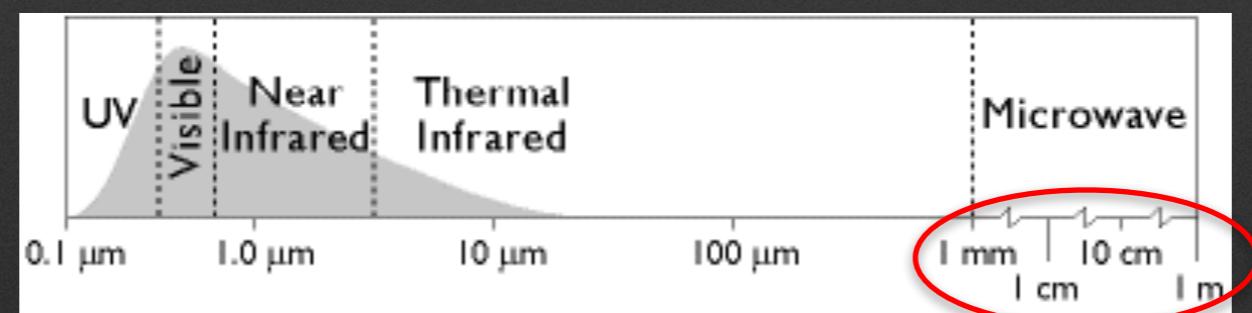
What is the National Land Cover Dataset?

Anderson Land Use / Land Cover Classification

LEVEL I CLASSES	LEVEL II CLASSES
Water	11 Open Water 12 Perennial Ice/Snow
Developed	21 Low Intensity Residential 22 High Intensity Residential 23 Commercial/Industrial/Transportation
Barren	31 Bare Rock/Sand/Clay 32 Quarries/Strip Mines/Gravel Pits 33 Transitional
Forested Upland	41 Deciduous Forest 42 Evergreen Forest 43 Mixed Forest
Shrubland	51 Shrubland
Non-Natural Woody	61 Orchards/Vineyards/Other
Herbaceous Upland Natural/Semi-natural Vegetation	71 Grasslands/Herbaceous
Herbaceous Planted/Cultivated	81 Pasture/Hay 82 Row Crops 83 Small Grains 84 Fallow 85 Urban/Recreational Grasses
Wetlands	91 Woody Wetlands 92 Emergent Herbaceous Wetlands

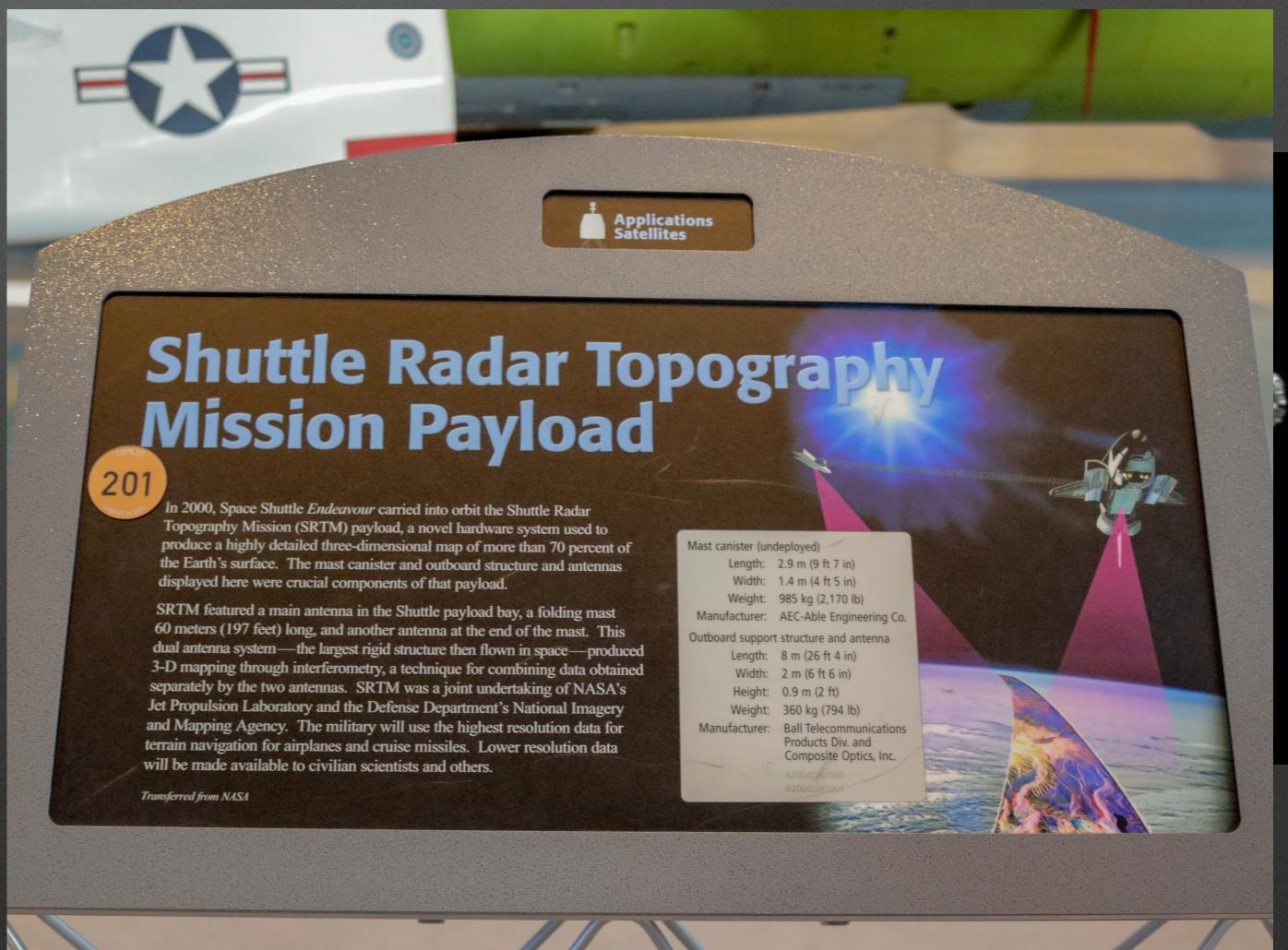
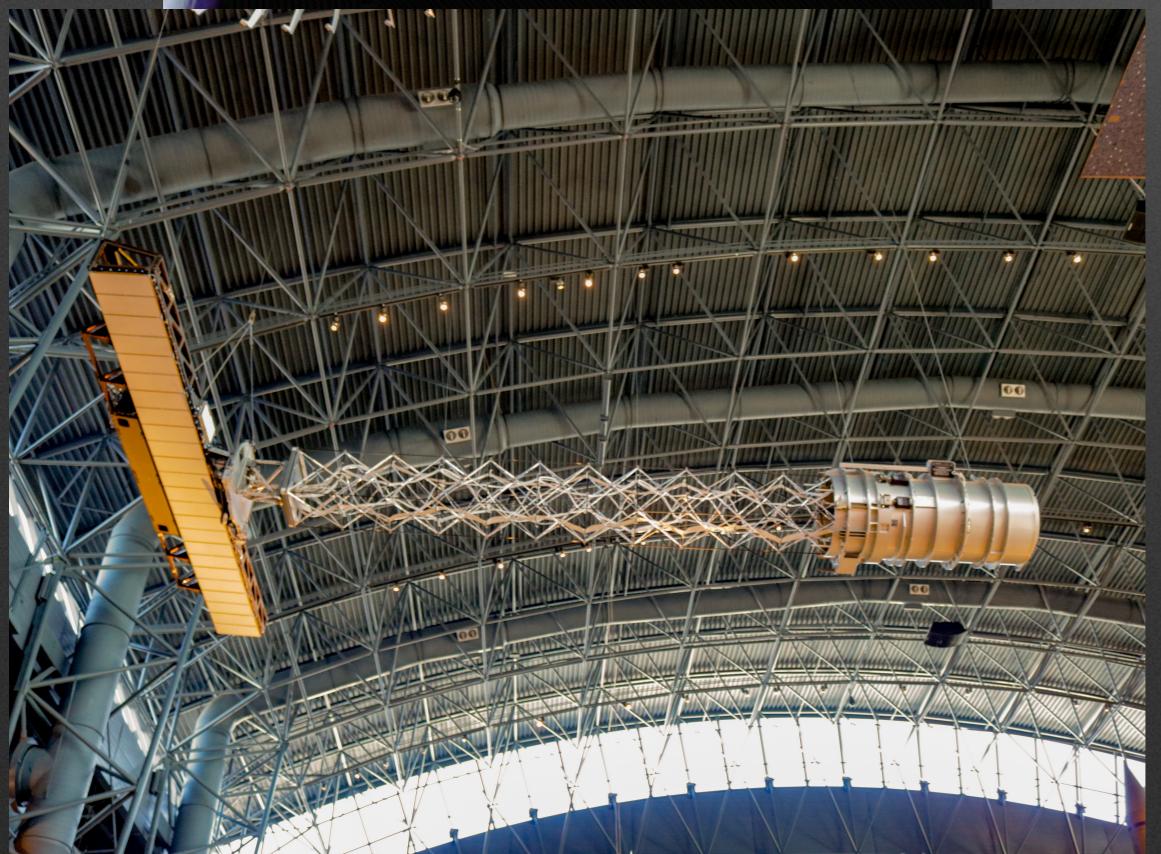
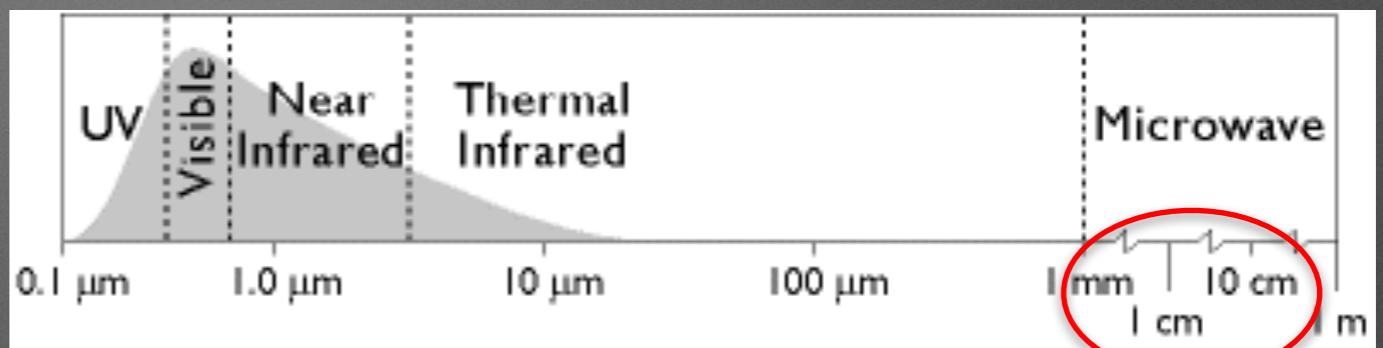
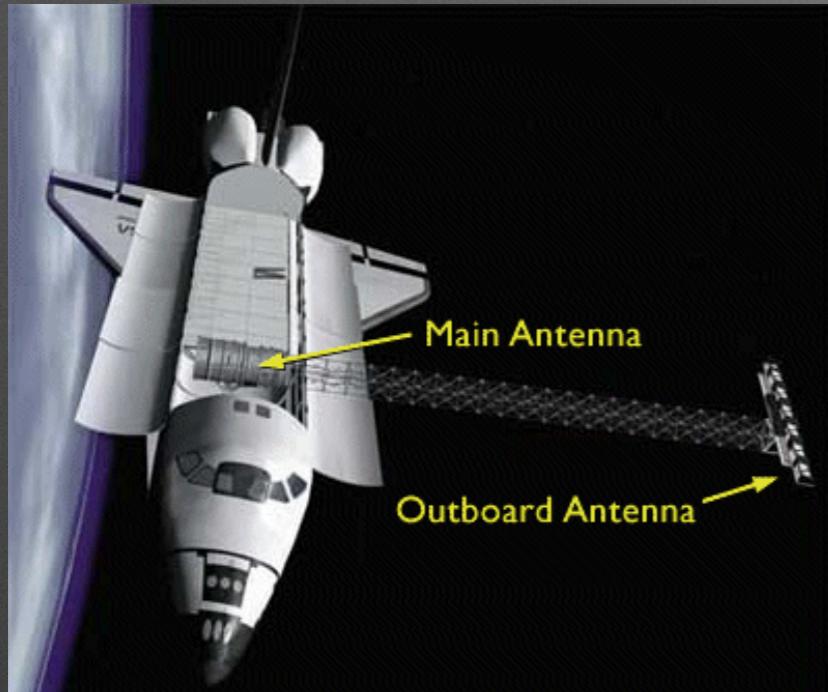
Types of Sensors

- Passive sensors: measure ‘naturally occurring’ radiation
- Active sensors: emit their own radiation and measure the reflection
- Passive sensors have two main shortcomings
 - Cloud cover blocks these wavelengths
 - Only measurable in daylight hours
- Active sensors use Longwave radiation (e.g., microwaves) that can penetrate clouds.
- But objects on the surface of Earth do not emit enough microwaves to be easily detectable from space.



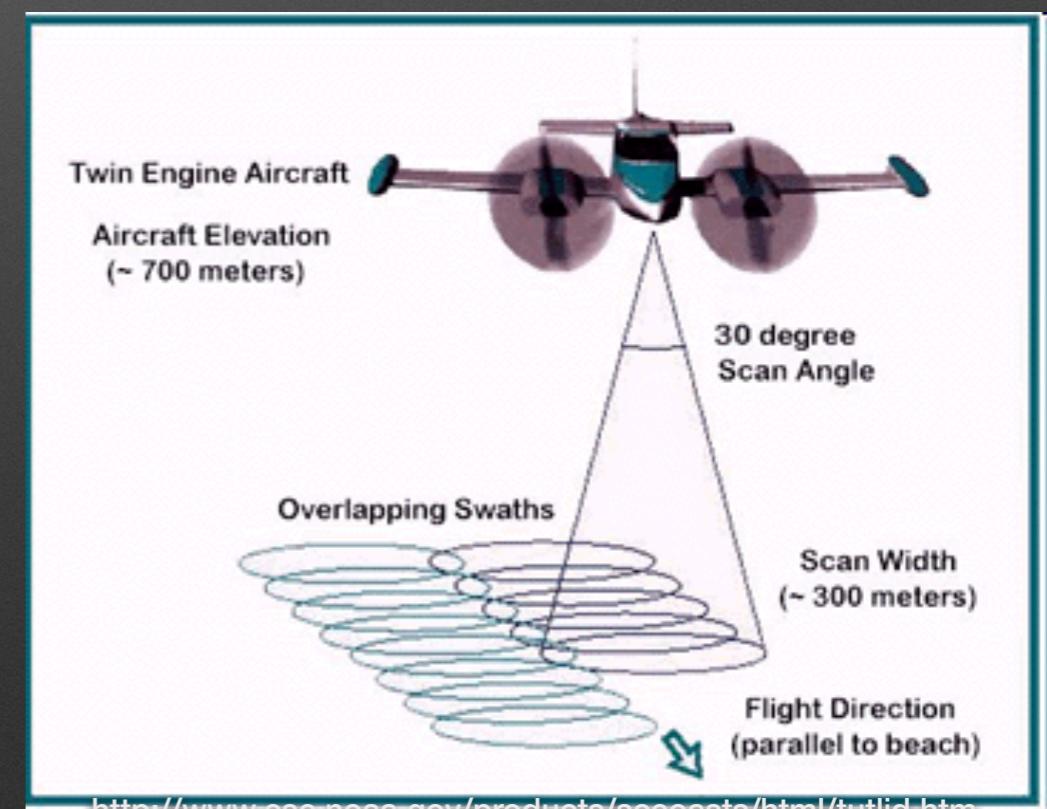
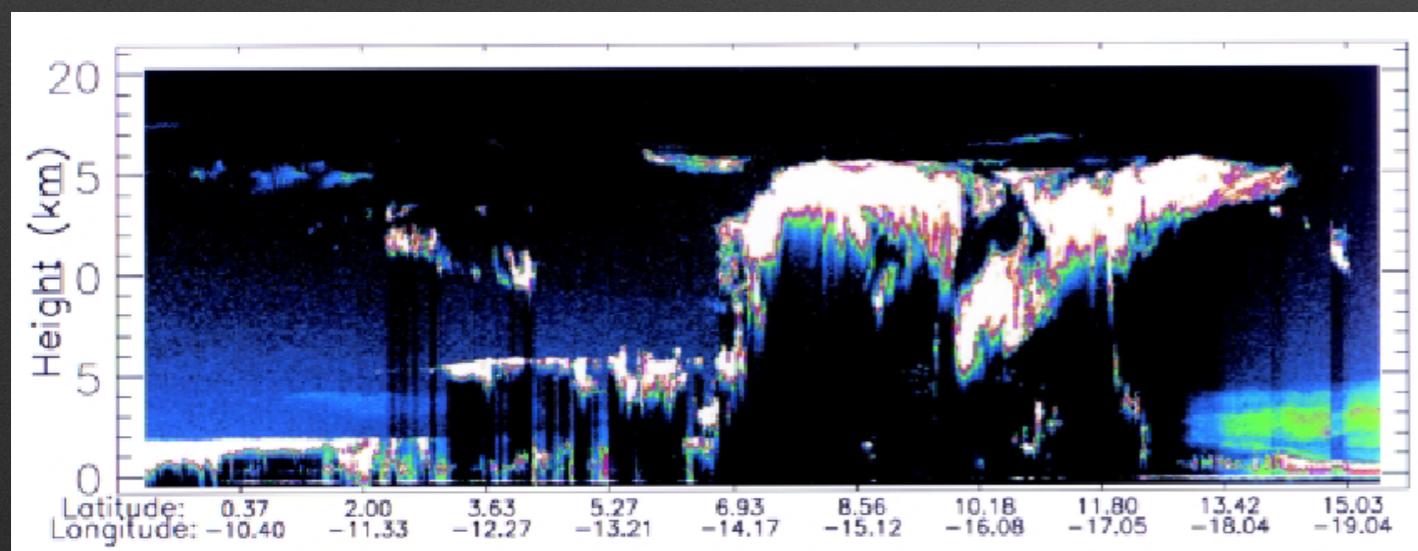
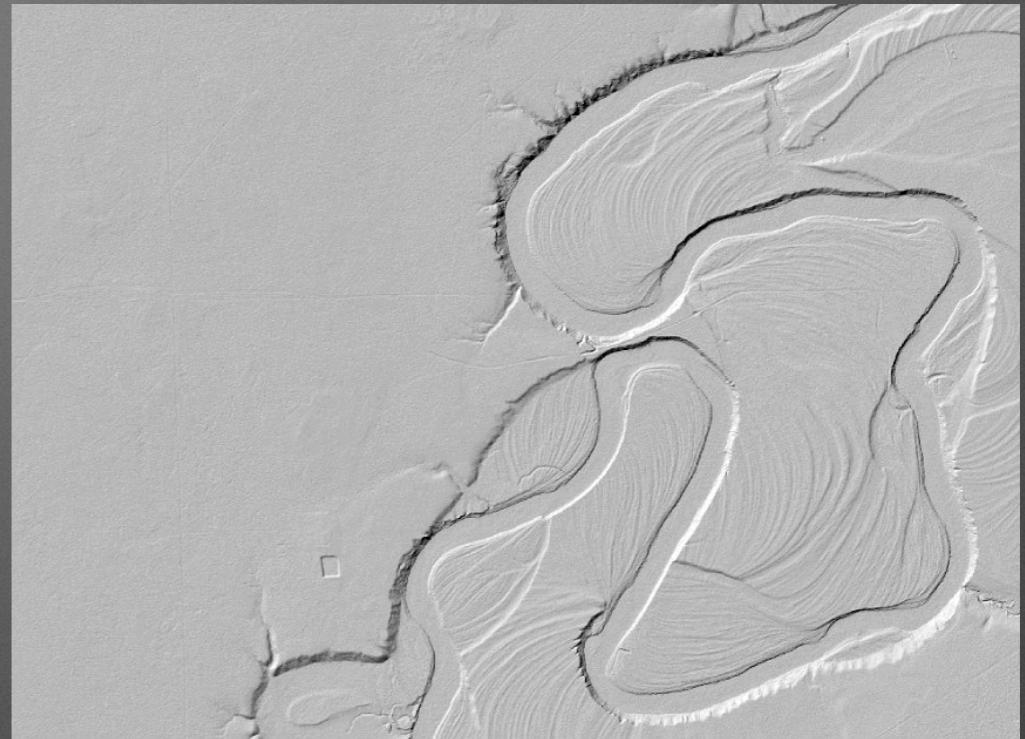
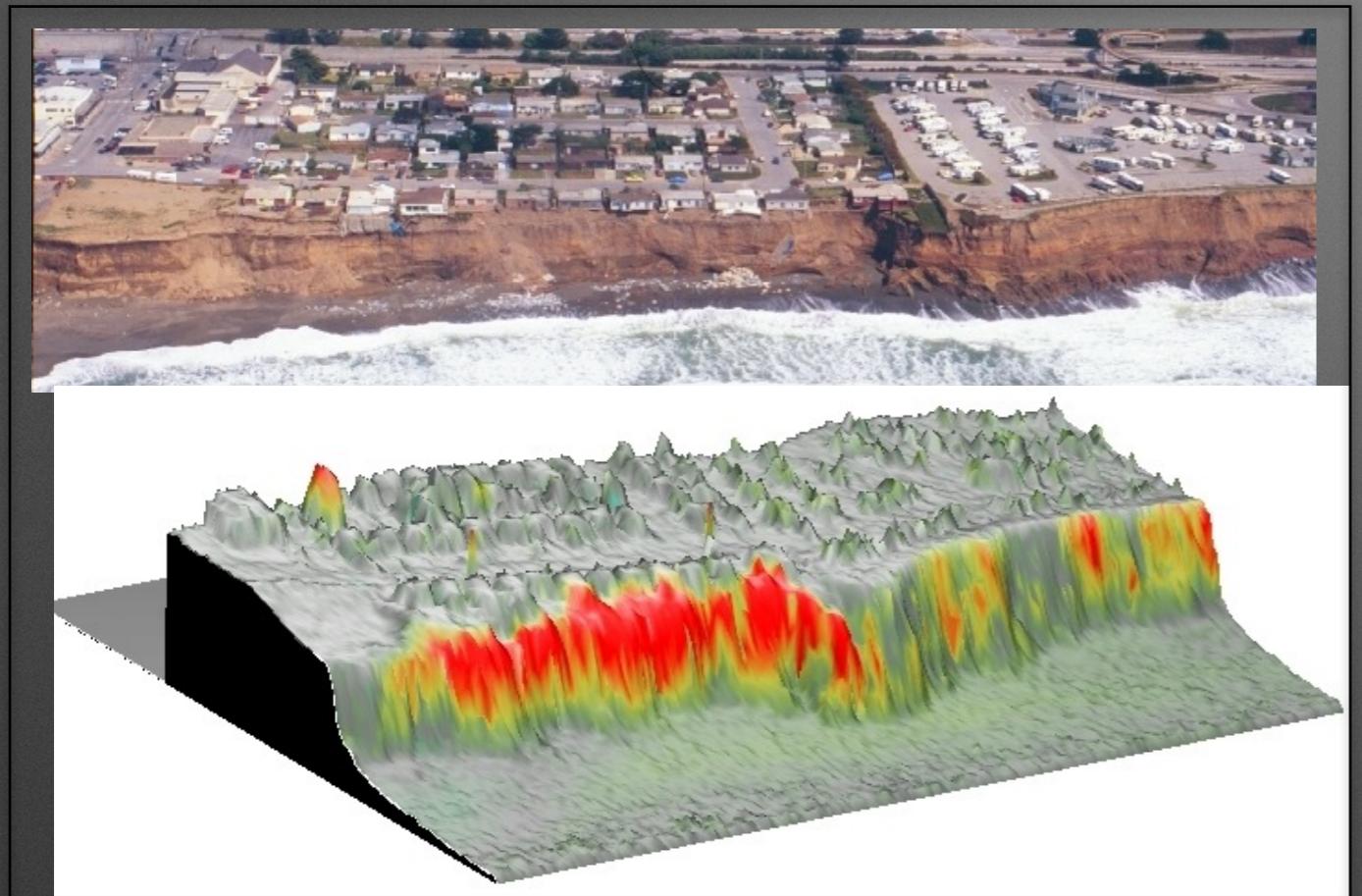
What is “active” remote sensing?

SRTM - Shuttle Radar Topography Mission



What is “active” remote sensing?

LiDAR - Light Detection And Ranging



<http://www.csc.noaa.gov/products/sccoasts/html/tutlid.htm>

Hands on

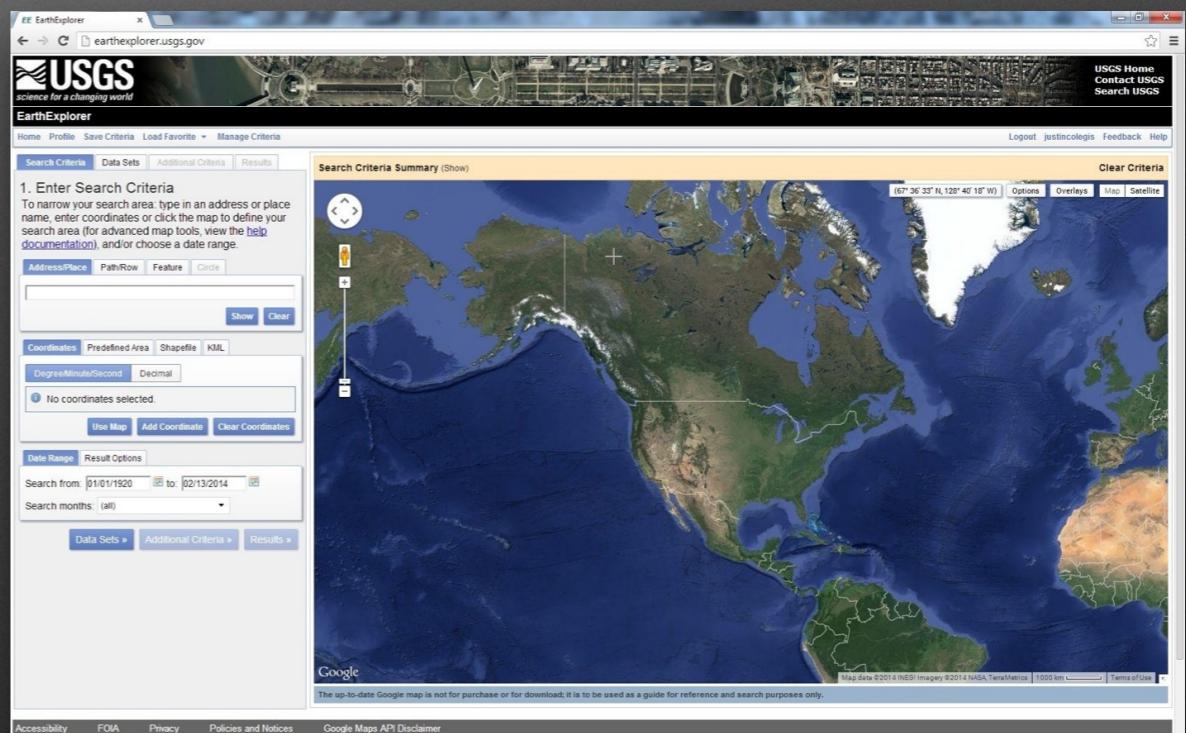
- Downloading Landsat 8 Scene and a Supervised Classification using ArcGIS Pro

Getting the Data

- USGS provides the data through two different viewers
 - Earth Explorer provides a direct link to the data including the raw data
 - Landsat Look is an ArcGIS Server Application which accesses the data and allows you to see it in a map display
- Both have good and bad aspects to using them

Earth Explorer

- earthexplorer.usgs.gov
- Basic interface using google maps
- You can either define your location manually, import a kml, shape file
- Then you can set the date range



Earth Explorer

- earthexplorer.usgs.gov
- Basic interface using google maps
- You can either define your location manually, import a kml, shape file
- Then you can set the date range

Search Criteria Data Sets Additional Criteria Results

1. Enter Search Criteria
To narrow your search area: type in an address or place name, enter coordinates or click the map to define your search area (for advanced map tools, view the [help documentation](#)), and/or choose a date range.

Address/Place Path/Row Feature Circle

Show Clear

Coordinates Predefined Area Shapefile KML

Degree/Minute/Second Decimal

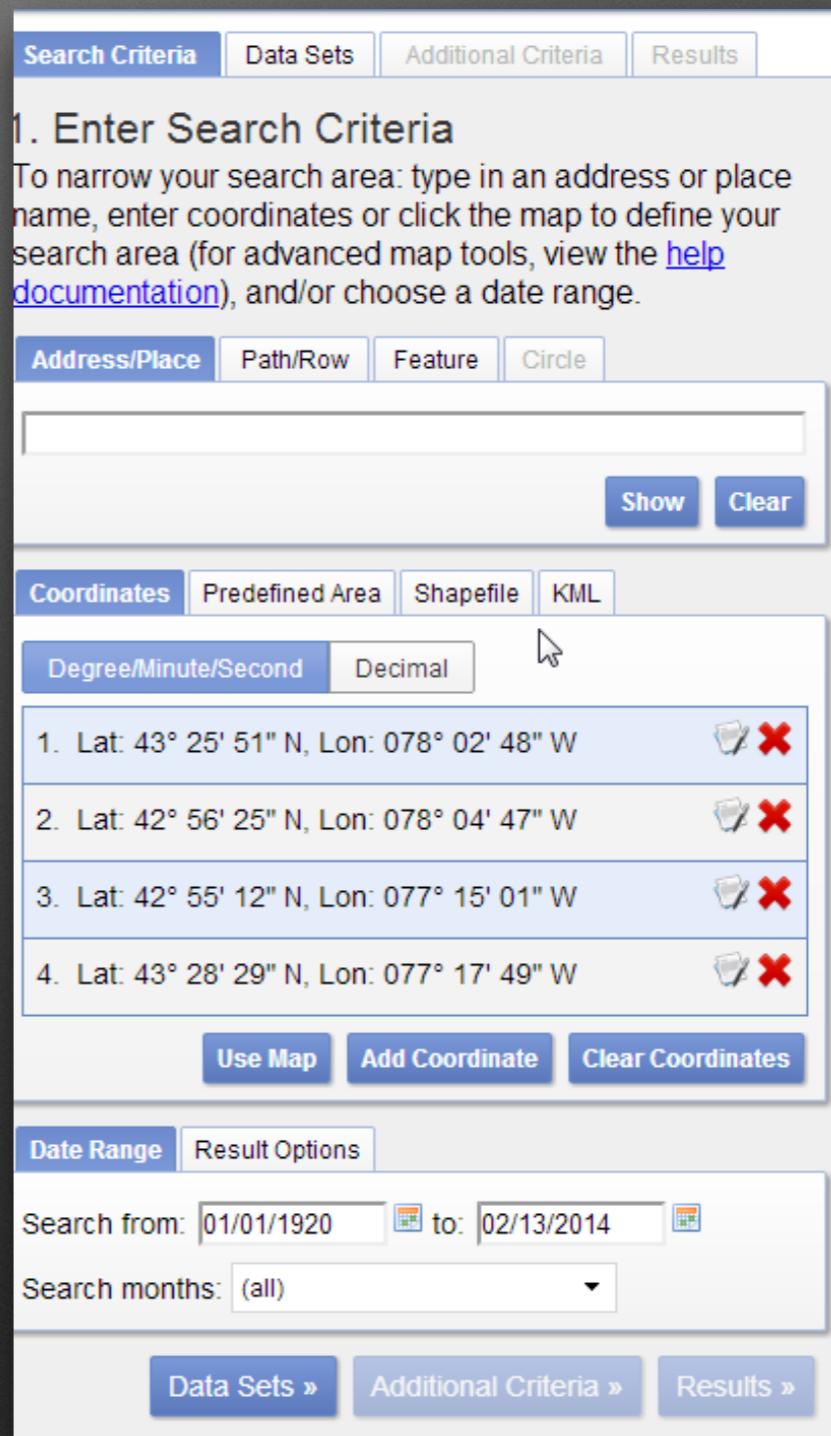
1. Lat: 43° 25' 51" N, Lon: 078° 02' 48" W  
2. Lat: 42° 56' 25" N, Lon: 078° 04' 47" W  
3. Lat: 42° 55' 12" N, Lon: 077° 15' 01" W  
4. Lat: 43° 28' 29" N, Lon: 077° 17' 49" W  

Use Map Add Coordinate Clear Coordinates

Date Range Result Options

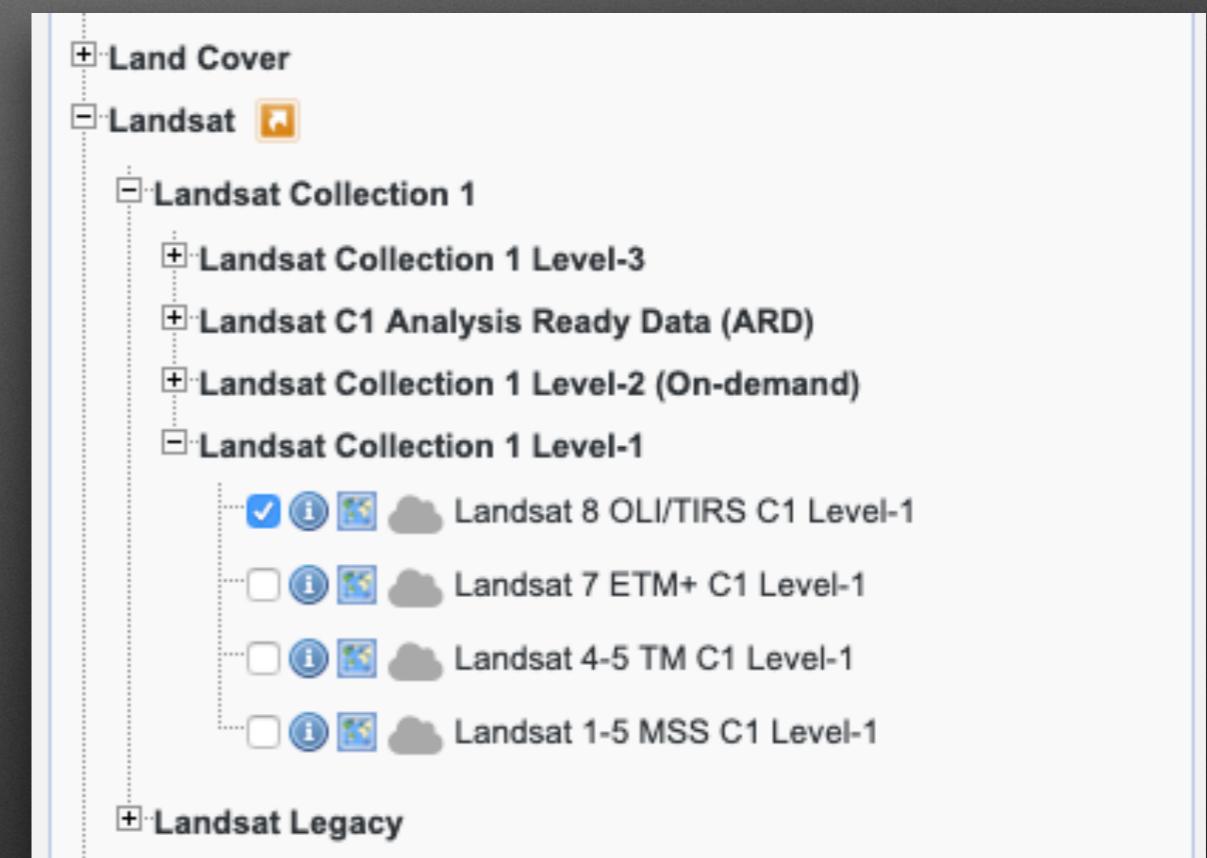
Search from: to:
Search months:

Data Sets » Additional Criteria » Results »



Earth Explorer

- Then you can select which dataset
- Select Landsat -> Landsat Collection 1 -> Landsat Collection 1 Level 1 -> Landsat 8 OLI/TRIS C1 Level 1
- In the Earth Explorer you have access to all of the previous Landsat Scenes as well as the latest images
- For the most part there is 2-3 scenes per month for an area
- Once you select the data you will then be given the ability to look at each dataset



Earth Explorer

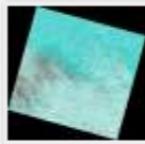
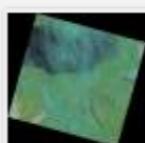
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Show Result Controls ▾

Data Set L8 OLI/TIRS Click here to export your results » ↗

« First < Previous 1 Next > Last »

Displaying 1 - 10 of 36 ⓘ

1		Entity ID: LC80160302013102LGN01 Coordinates: 43.18475,-77.00847 Acquisition Date: 12-APR-13 Path: 16 Row: 30	
2		Entity ID: LC80160302013118LGN02 Coordinates: 43.18473,-77.00299 Acquisition Date: 28-APR-13 Path: 16 Row: 30	
3		Entity ID: LC80160302013134LGN03 Coordinates: 43.1847,-77.04259 Acquisition Date: 14-MAY-13 Path: 16 Row: 30	
4		Entity ID: LC80160302013150LGN00 Coordinates: 43.18483,-77.05735 Acquisition Date: 30-MAY-13 Path: 16 Row: 30	

Earth Explorer



- As you work with the different datasets you will be able to see the footprint of the scene, the metadata, and then a few options for downloading
- This is the found in the toolbar under each dataset
- To download you can either download the scene processed, add to cart, or use the bulk data application to download

Show Result Controls

Data Set [Click here to export your results »](#)

L8 OLI/TIRS

« First < Previous 1 Next > Last »

Displaying 1 - 10 of 36 ⓘ

	Entity ID:	Coordinates:	Acquisition Date:	Path:	Row:	Actions
1	LC80160302013102LGN01	43.18475,-77.00847	12-APR-13	16	30	
2	LC80160302013118LGN02	43.18473,-77.00299	28-APR-13	16	30	
3	LC80160302013134LGN03	43.1847,-77.04259	14-MAY-13	16	30	
4	LC80160302013150LGN00	43.18483,-77.05735	30-MAY-13	16	30	

Earth Explorer Metadata

Data Set Attribute	Attribute Value
Landsat Scene Identifier	LC80160302013134LGN03
WRS Path	016
WRS Row	030
Target WRS Path	016
Target WRS Row	030
Nadir Off Nadir	NADIR
Full or Partial Scene	FULL
Data Category	NOMINAL
Roll Angle	
Station Identifier	LGN
Day/Night	DAY
Data Type Level 1	Level 1T
Sensor Identifier	OLI_TIRS
Date Acquired	2013/05/14
Start Time	2013:134:15:53:08.5718808
Stop Time	2013:134:15:53:38.5721838
Image Quality	9
Scene Cloud Cover	81.95
Sun Elevation	61.51028523
Sun Azimuth	142.69953242
Geometric RMSE Model X	5.316
Geometric RMSE Model Y	6.114
Browse Exists	Yes
Center Latitude	43°11'04.92"N

Full Display of LC80160302013134LGN03

LandsatLook "Natural Color" Preview Image

< >

1 / 3

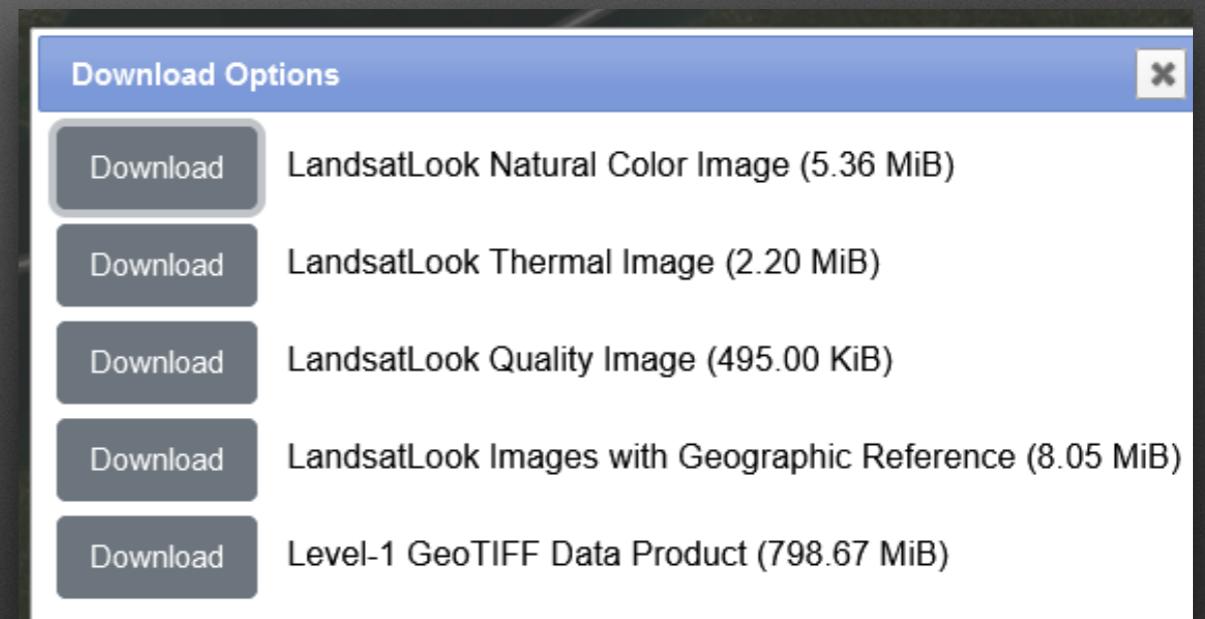
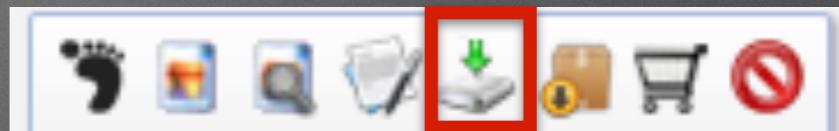
Data Set Attribute Attribute Value

Landsat Scene Identifier LC80160302013134LGN03

Open New Window Close

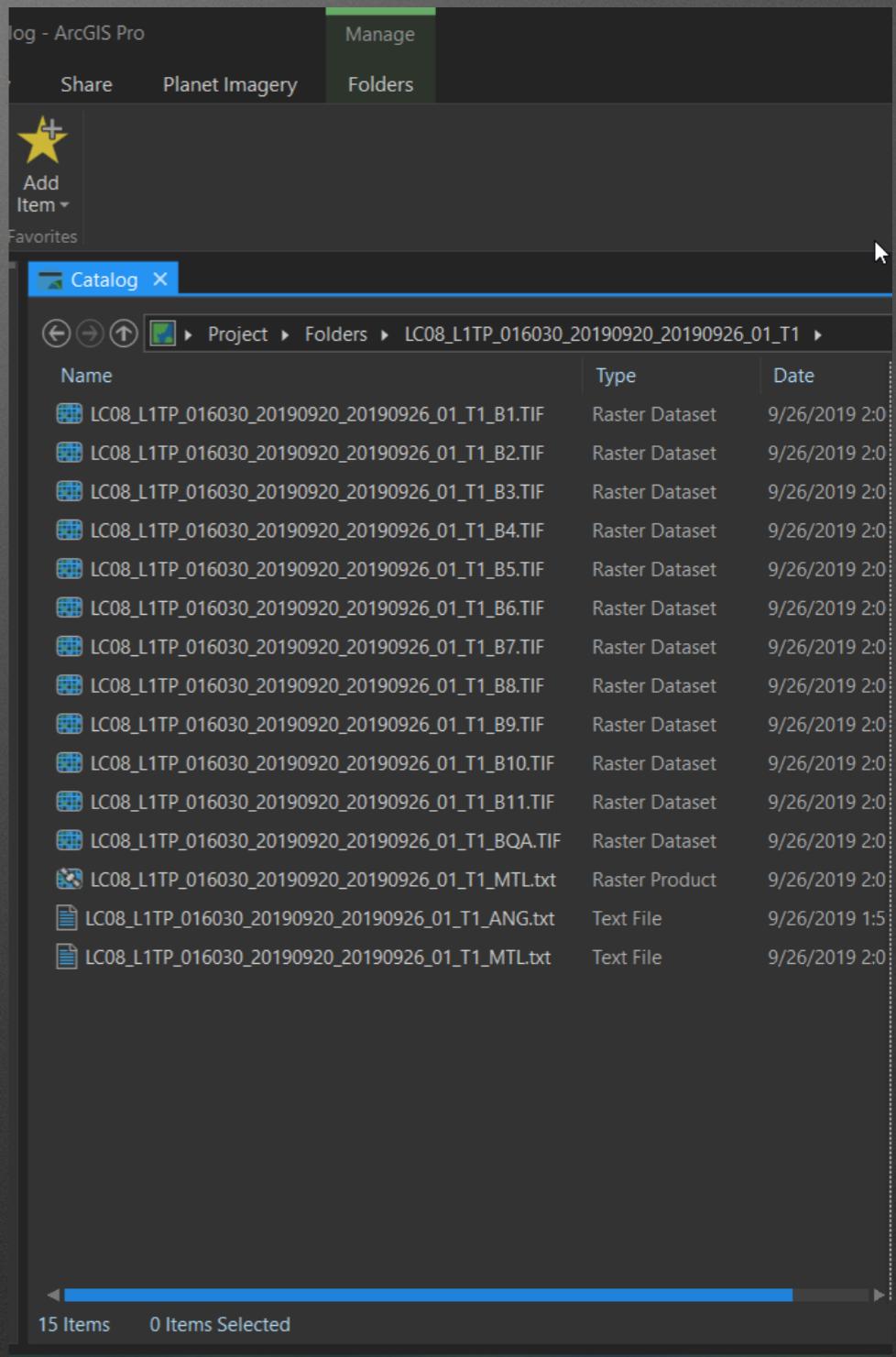
Download the Data

- Click the download icon for your desired scene
- Look for the Level-1 GeoTIFF Data Product and click download that
- The download will be around 700 megabytes
- Once you download it use 7zip and extract the file twice
 - Once for the .GZ and then for the .TAR files



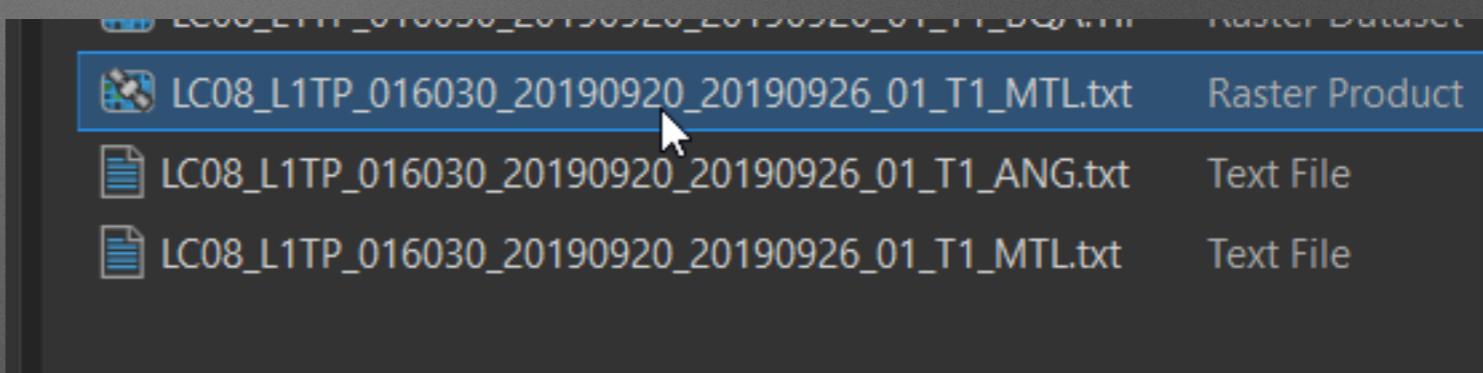
ArcGIS

- Now we have the GeoTIFFs and we can start to use the data
- If you are working without the need to post process the images you can add in the images or a special file type which does do some of the processing for you
- For processing the images ArcGIS has a few good tools



Catalog

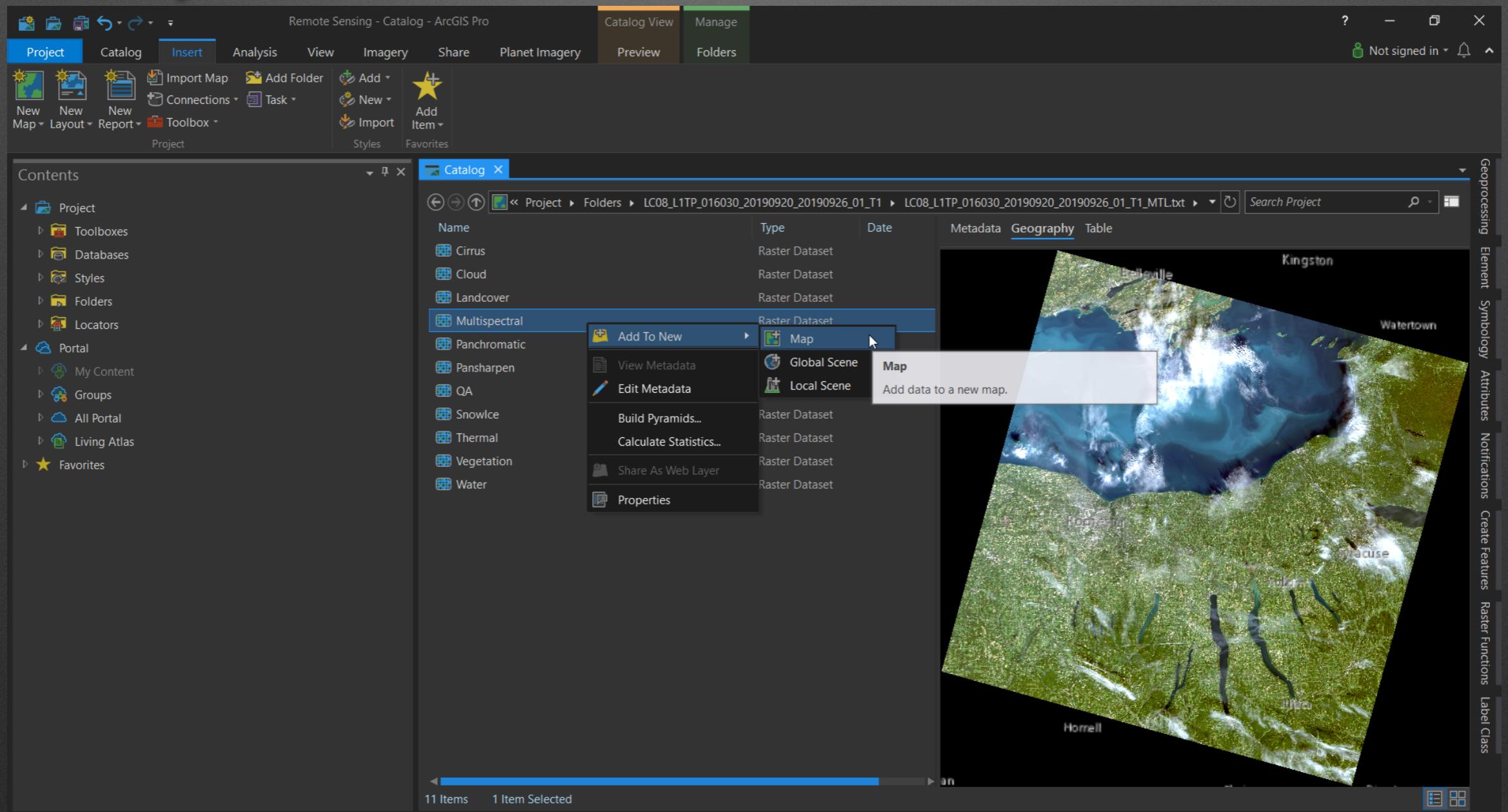
- Once you have unzipped all of the files you will be able to explore the data in Catalog View
- You will see each band as a separate tiff image and a MLT.txt
- The MLT.txt is the metadata as well as a raster product which can have different ways of viewing the data
- This is helpful so you do not have to process the data



Name	Type
Cirrus	Raster Dataset
Cloud	Raster Dataset
Landcover	Raster Dataset
Multispectral	Raster Dataset
Panchromatic	Raster Dataset
Pansharpen	Raster Dataset
QA	Raster Dataset
SnowIce	Raster Dataset
Thermal	Raster Dataset
Vegetation	Raster Dataset
Water	Raster Dataset

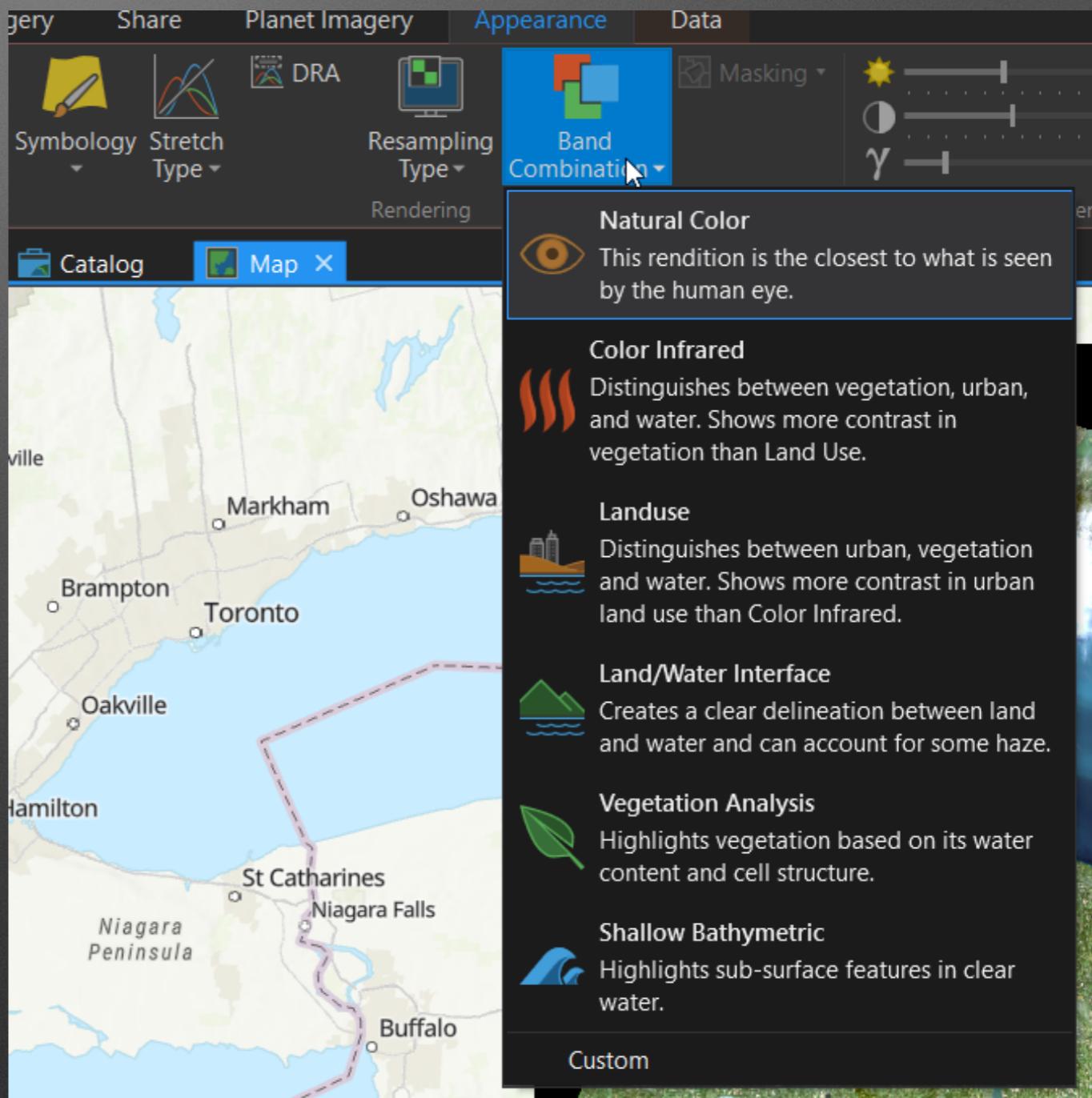
Supervised Classification

- Right click on your Multispectral Band and add to New Map



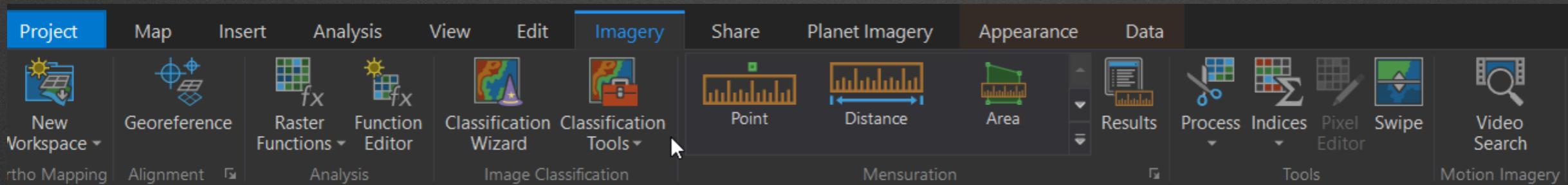
Supervised Classification

- Add Your Multispectral Raster Dataset to you map (Located in the MTL Raster Product Feature Class)
- Explore Your Band Combinations using the Appearance Ribbon



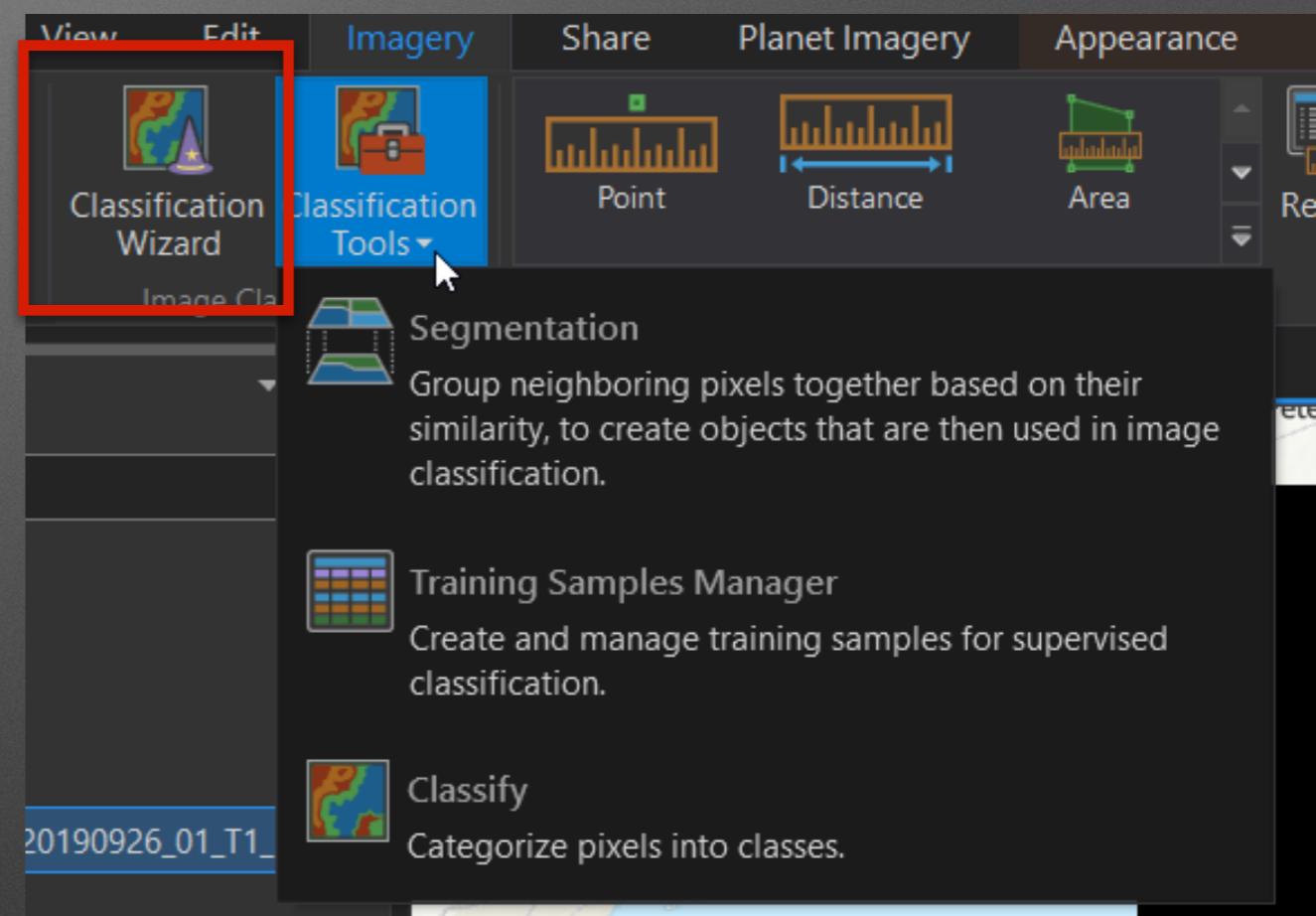
Supervised Classification

- Add Your Multispectral Raster Dataset to you map (Located in the MTL Raster Product Feature Class)
- Explore Your Band Combinations using the Layer Properties and Symbology
- Click on the Imagery Ribbon to see the different Image Processing Tools



Supervised Classification

- Add Your Multispectral Raster Dataset to you map (Located in the MTL Raster Product Feature Class)
- Explore Your Band Combinations using the Layer Properties and Symbology
- Add your Image Classification Toolbar to your workspace
- We are going to use the Classification Wizard to Classify our image



Supervised Classification

Image Classification Wizard

Configure

Classification Method

Supervised

Classification Type

Object based

Classification Schema

NLCD2011

Output Location

C:\Users\Justin D. Cole GISP\Documents\Arc

Optional

Segmented Image

Training Samples

Reference Dataset

Image Classification Wizard

Configure

Classification Method

Supervised

Classification Type

Object based

Classification Schema

NLCD2011

Output Location

C:\Users\Justin D. Cole GISP\Documents\Arc

Optional

Segmented Image

Training Samples

Reference Dataset

Image Classification Wizard

Segmentation

Segmentation will be performed on the rendered output of the layer 'Multispectral_LC08_L1TP_016030_20190926_01_T1_MTL'. Adjust disp...

Spectral detail

15.50

Spatial detail

15

Minimum segment size in pixels

20

Show Segment Boundaries Only

Reset

Next >

Preview

< Previous

Next >

The image displays three sequential screenshots of the ArcGIS Image Classification Wizard. The first screenshot shows the initial configuration step with 'Supervised' classification method, 'Object based' type, and 'NLCD2011' schema. The second screenshot shows the detailed configuration for supervised classification, including training samples and reference datasets. The third screenshot shows the segmentation step, where the user has selected the 'Segmentation' method and specified parameters like spectral and spatial detail, minimum segment size, and boundary visibility. A note in the third screenshot indicates that segmentation will be performed on the rendered output of a specific multispectral layer.

Supervised Classification

Image Classification Wizard

Training Samples Manager

Select a class to start drawing shapes

NLCD2011

- Water
- Developed
- Barren
- Forest
- Shrubland
- Herbaceous
- Planted / Cultivated
- Wetlands

Class # Samples Pixels (%)

Class	# Samples	Pixels (%)
Water	1	98.76
Developed	1	0.27
Wetlands	1	0.05
Water	1	0.03
Water	1	0.01
Mixed Forest	1	0.04
Wetlands	1	0.07
Planted / Cu	1	0.12
Mixed Fores	1	0.04
Developed	1	0.03

Remote Sensing - Map - ArcGIS Pro

Raster Layer

Analysis View Edit Imagery Share Planet Imagery Appearance Data

Effects

Catalog Map

16030_20190920_20190926_01_T1_MTL

1:88,106 296,743.49E 4,785,268.44N m

Selected Features: 0

Image Classification Wizard

Training Samples Manager

NLCD2011

- Water
- Developed
- Barren
- Forest
 - Deciduous Forest
 - Evergreen Forest
 - Mixed Forest
 - Shrubland

< Previous Next >

Supervised Classification

Image Classification Wizard

Remote Sensing - Map - ArcGIS Pro

Raster Layer

Imagery

Share

Planet Imagery

Appearance

Data

Point

Distance

Area

Results

Process

Indices

Pixel Editor

Swipe

Video Search

Mensuration

Tools

Motion Imagery

New Workspace

Georeference

Raster Functions

Function Editor

Classification Wizard

Classification Tools

Ortho Mapping

Alignment

Analysis

Project

Map

Insert

Analysis

View

Edit

Classification

Image Classification

Contents

Catalog

Map

Search

Drawing Order

Map

Preview_Classified_SVM_500_COLOR_MEAN_1432

Class_name

- Water
- Developed
- Barren
- Deciduous Forest
- Mixed Forest
- Shrubland
- Planted / Cultivated
- Wetlands

Segmented_2019061432357761952

RGB

- Red: Band_1
- Green: Band_2
- Blue: Band_3

Preview_Segmented

RGB

- Red: NearInfrared
- Green: Red
- Blue: Green

Multispectral_LC08_L1TP_016030_20190920_20190926_01_T1_MTL

RGB

- Red: Red
- Green: Green

Image Classification Wizard

Train

Press the "L" key to toggle transparency of the preview layer.

Classifier: Support Vector Machine

Maximum Number of Samples per Class: 500

Segment Attributes:

- Active chromaticity color (checked)
- Mean digital number (checked)
- Standard deviation
- Count of pixels
- Compactness
- Rectangularity

< Previous | Next >

Train : Multispectral_LC08_L1TP_016030_20190920_20190926_01_T1_MTL
Completed with warnings

< Previous | Run | Next >

Supervised Classification

Remote Sensing - Map - ArcGIS Pro

Raster Layer

Project Map Insert Analysis View Edit Imagery Share Planet Imagery Appearance Data

New Workspace Georeference Raster Functions Function Editor Classification Wizard Classification Tools

Ortho Mapping Alignment Analysis Image Classification Mensuration Tools Motion Imagery

Not signed in

Contents Catalog Map

Search

Drawing Order

Map

Classified_201910061442196137672

Class_name

- Water
- Developed
- Barren
- Deciduous Forest
- Mixed Forest
- Shrubland
- Planted / Cultivated
- Wetlands

Preview_Classified_SVM_500_COLOR_MEAN_1432

Class_name

- Water
- Developed
- Barren
- Deciduous Forest
- Mixed Forest
- Shrubland
- Planted / Cultivated
- Wetlands

Segmented_201910061432357761952

RGB

- Red: Band_1
- Green: Band_2
- Blue: Band_3

Generating Classified Dataset...

Image Classification Wizard

Classify

Output Classified Dataset
Classified_201910061442196137672

Use Classifier From (optional)

Output Classifier Definition File (.ecd) (optional)

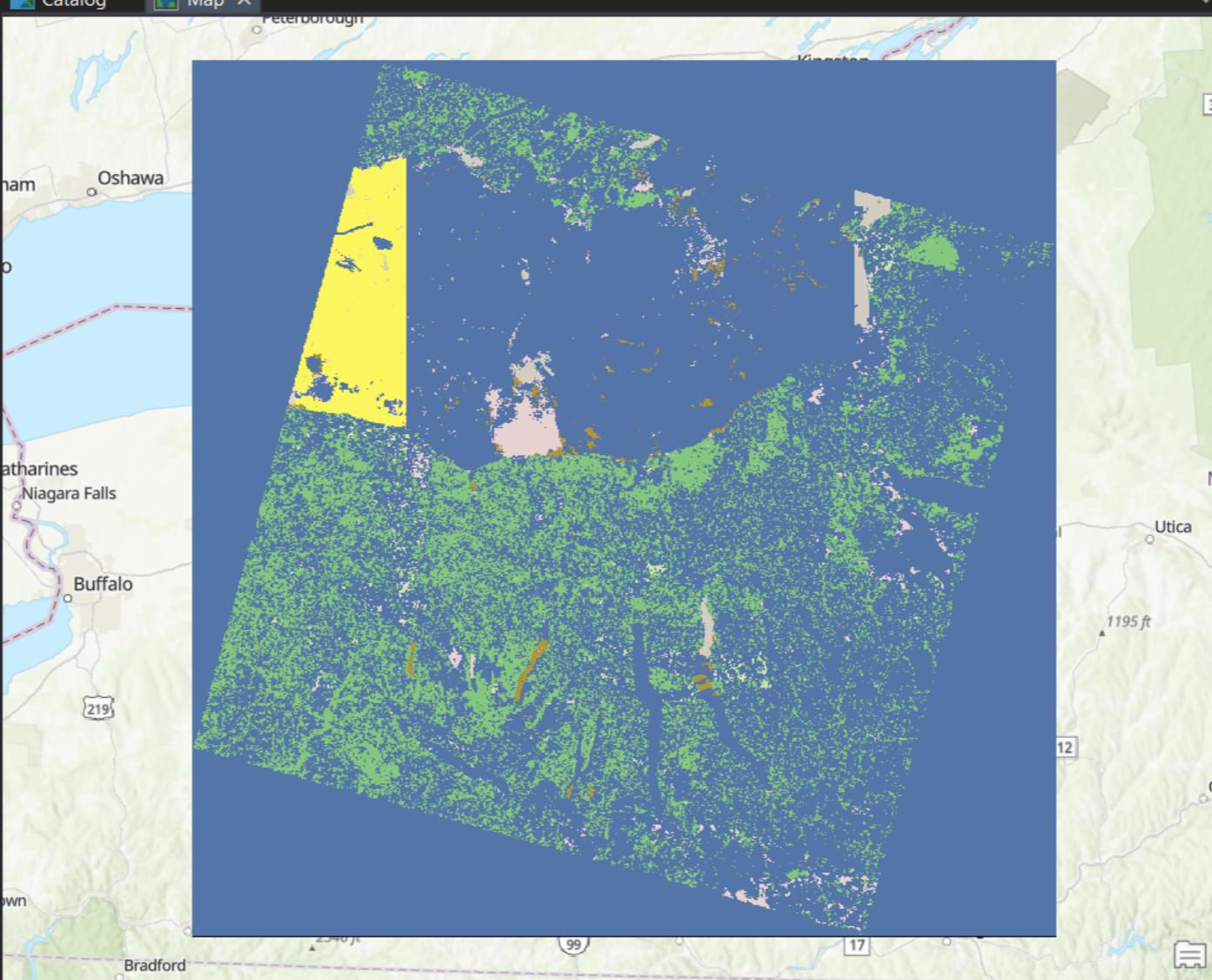
Output Segmented Image (optional)

< Previous Next >

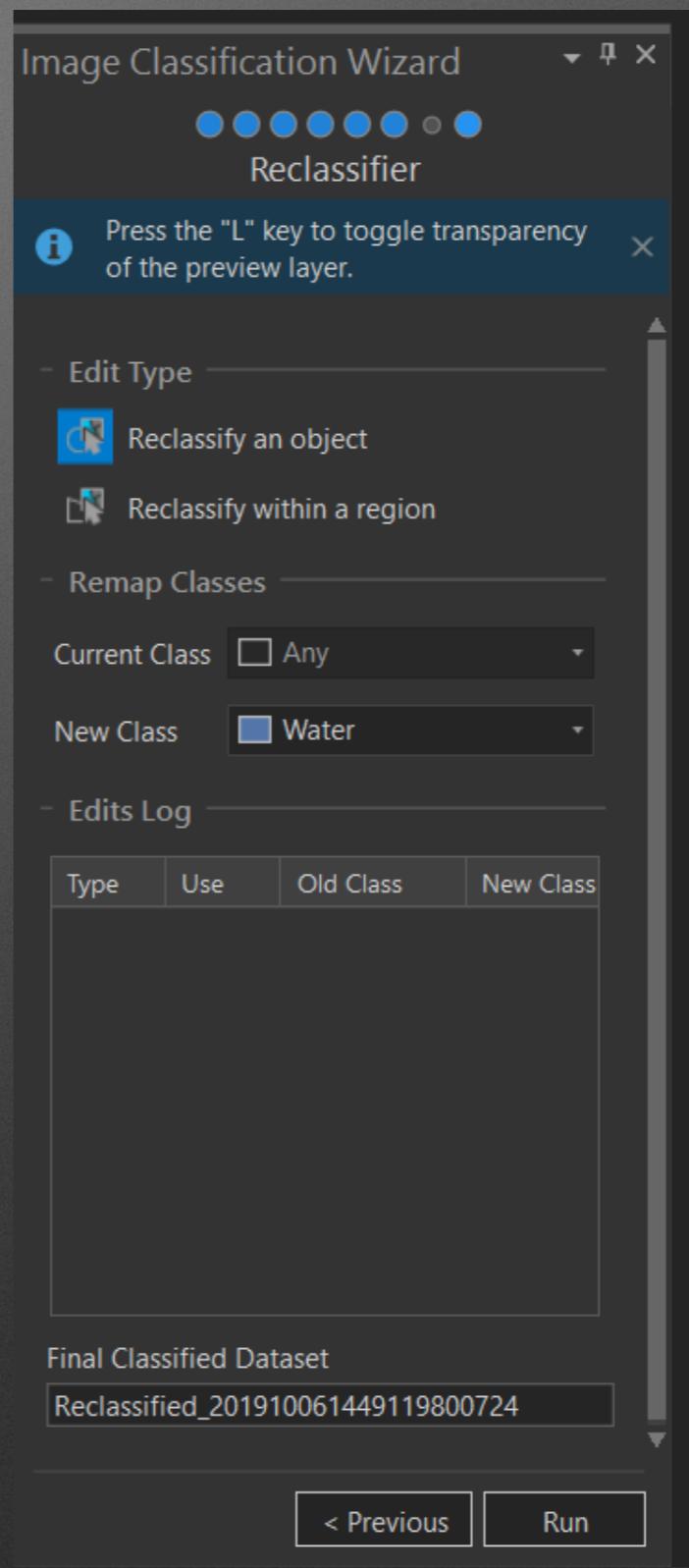
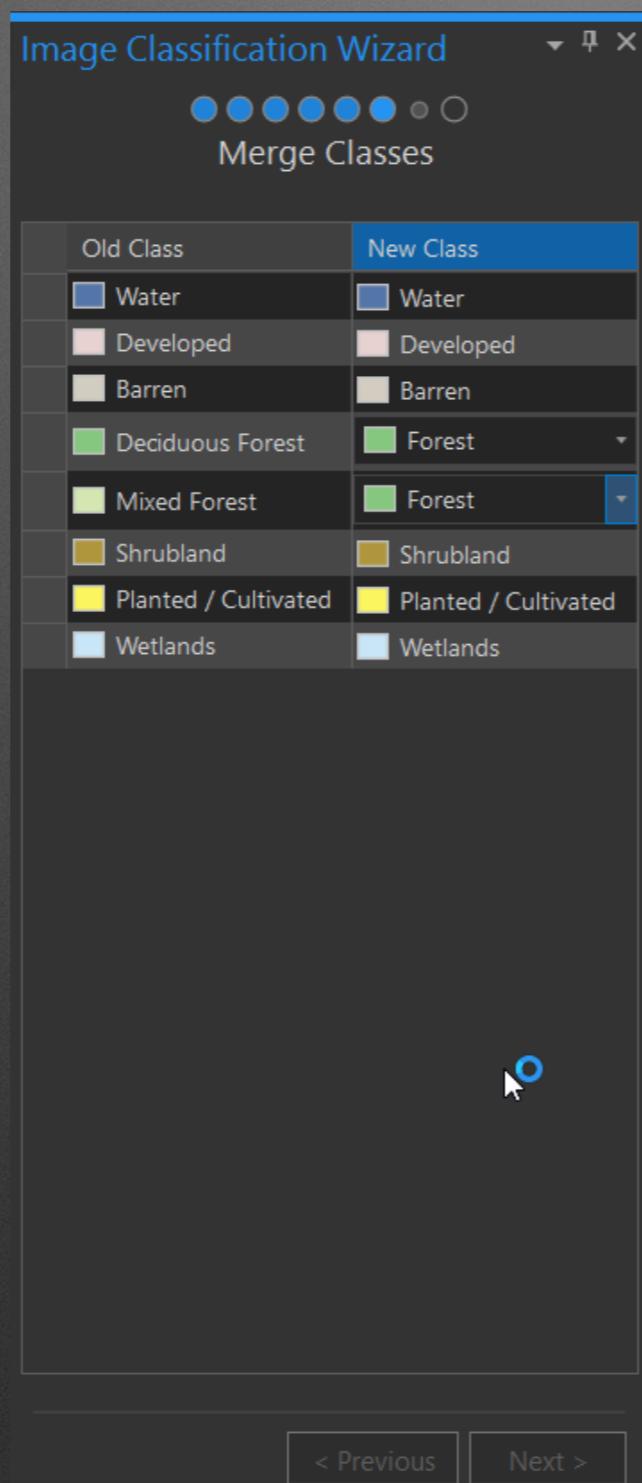
Classify : Multispectral_LC08_L1TP_016030_20190614_20190614_00000000000000000000000000000000

Completed successfully

Geoprocessing Element Symbology Attributes Notifications Create Features Raster Functions Label Class



Supervised Classification



UAV - Regulations

Part 107

- FAA Part 107 opened up the possibility of flying UAVs commercially in the US
 - Authorized September 2016
- Before that companies had to submit for a 333 exception which was a long process
- The goal of both is to make the US Airspace safe for all traffic
- Hobbyists have been able to fly under the model airplane regulations which have been around for quite some time
 - They were not able to make money doing it
- Students are exempt from 107 for classwork but teachers are required to have the certification
- YouTube is a grey area but posting videos can generate money so it is best to have the license.

Basic Regulations Part 107

- Unmanned Aerial Vehicle or System (UAV or UAS) is regulated from .55lbs to 55lbs
- Anyone over 13 must register their unit if it meets those requirements
- Maximum Altitude is 400 Average Ground Level (AGL)
 - Can fly 400ft around a structure for inspections
- Maximum Speed is 100 miles per hour
- No Flying within 5 miles of an airport without Air Traffic Control Approval (ATC)

Basic Regulations

- No Flying Over People
- No Flying after consuming Alcohol within 8 hours or with a .04BAC
- Must keep visual line of sight to the aircraft (VLOS)
- Cannot pose a safety risk to other aircraft or people

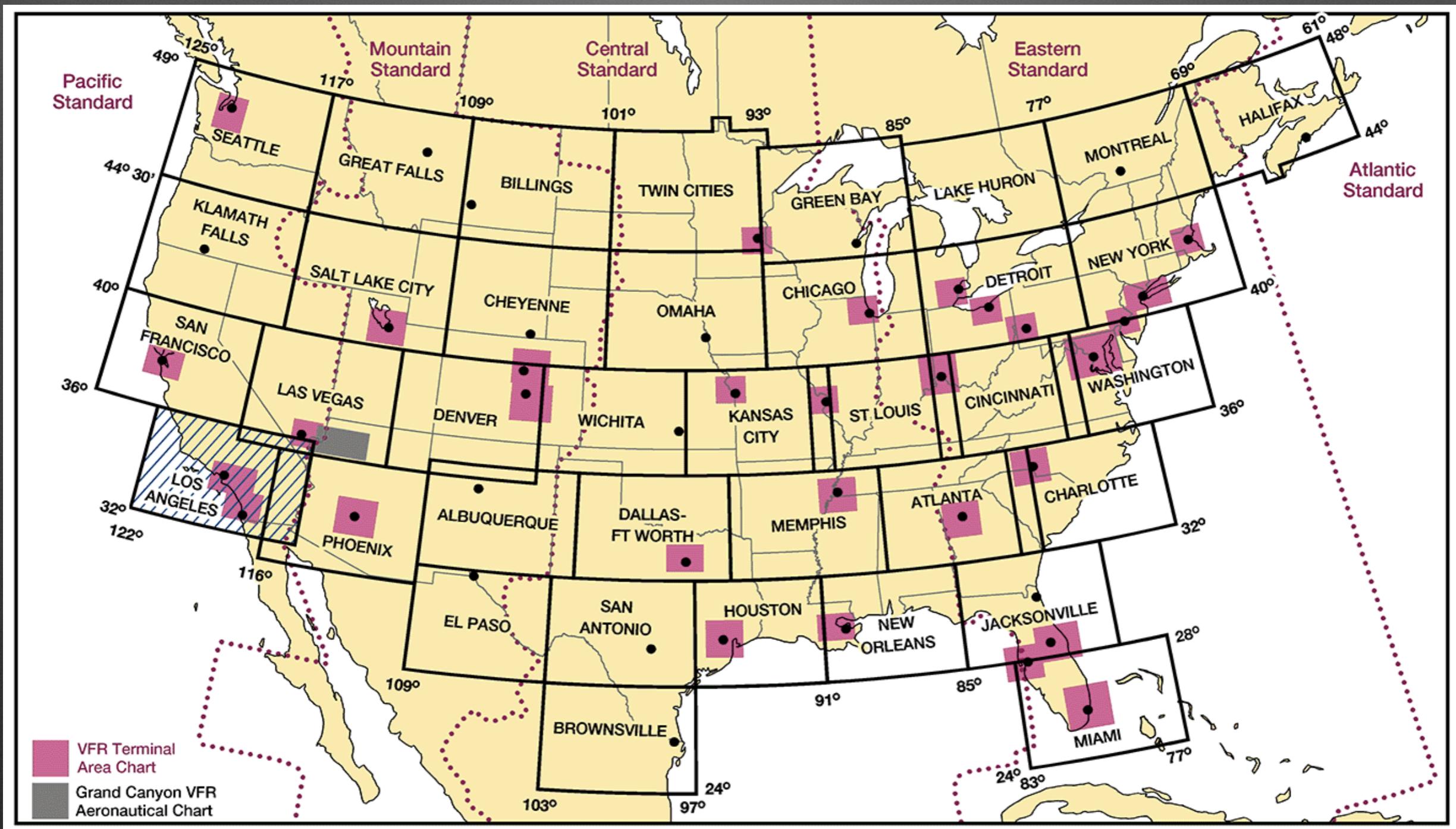
Where is it OK to Fly

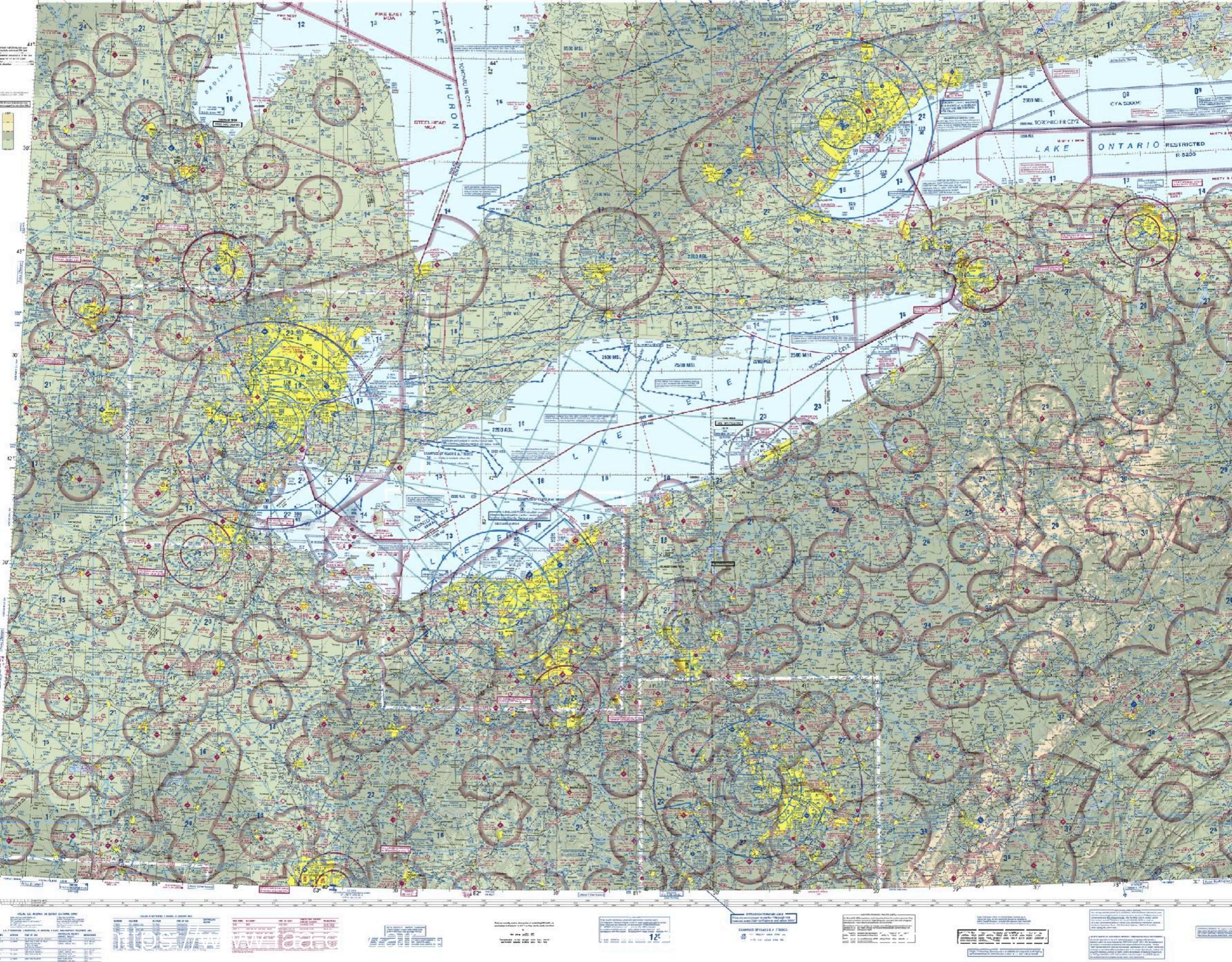


Airspace

Airspace	Think	Airport Traffic Control Permission
Class A	High Up	Prohibited
Class B	Biggest Airports	Yes (Check for altitude notation)
Class C	Large Airports	Yes (Check for altitude notation)
Class D	Medium Airport	Yes (Always starts at the surface)
Class E with an airport	Small Airport	Yes (Check for altitude symbol)
Class E without an airport	Almost everywhere but at the surface	No
Class G	Good to Go!	No (ATC doesn't exist!)

Sectional Charts





SECTIONAL AERONAUTICAL CHART

SCALE 1:500,000

LEGEND

Airports having Control Towers are shown in Blue, all others in Magenta. Consult Airport/Facility Directory (A/FD) for details involving airport lighting, navigation aids, and services. For additional symbol information refer to the Chart User's Guide.

AIRPORTS	AIRPORT DATA	AIRPORT TRAFFIC SERVICE AND AIRSPACE INFORMATION	TOPOGRAPHIC INFORMATION								
AIRPORTS <ul style="list-style-type: none"> Other than hard-surfaced runways Hard-surfaced runways 1500 ft. to 8069 ft. in length Hard-surfaced runways greater than 8069 ft., or same multiple runways less than 8069 ft. Open dot within hard-surfaced runway configuration indicates approximate VOR, VOR-DME, or VORTAC location. <p>All recognizable hard-surfaced runways, including those closed, are shown for visual identification. Airports may be public or private</p>	AIRPORT DATA <p>Box indicators FAR 93 Special Air Traffic Rules & Airport Traffic Patterns</p> <p>FSS NO SVFR FAR 91 Location Identifier NAME (NAM) (PNAM) CT - 118.3 * ATIS 123.8 285 L 72 122.95 RP 23, 34 ICAO Location Indicator shown outside contiguous U.S. VFR Advry 125.0 AOE UNICOM Runways with Right Traffic Patterns (public use) RP - Special conditions exist - see A/FD Airport of Entry</p>	AIRPORT TRAFFIC SERVICE AND AIRSPACE INFORMATION <p>Only the controlled and reserved airspace effective below 18,000 ft. MSL are shown on this chart. All times are local.</p> <p>Class B Airspace</p> <p>Class C Airspace (mode C See FAR 91.215(AIM))</p> <p>Class D Airspace Ceiling of Class D Airspace in hundreds of feet. (A minus ceiling value indicates surface up to but not including that value).</p> <p>Class E (atc) Airspace</p> <p>Class E Airspace with floor 700 ft. above surface.</p> <p>Class E Airspace with floor 1200 ft. or greater above surface that abuts Class G Airspace.</p> <p>2400 MSL Differentiates floors of Class E Airspace greater than 700 ft. above surface.</p> <p>4500 MSL Class E Airspace exists at 1200 AGL unless otherwise designated as shown above.</p> <p>Class E Airspace low altitude Federal Airways are indicated by center line.</p> <p>Intersection - Arrows are directed towards facilities which establish intersection.</p> <p>132° E - Isogonic Line (2010 VALUE)</p> <p>132° V 69 Total mileage between NAVAID, on direct Airways</p> <p>169 Between NAVAID, on direct Airways Class E Airspace low altitude RNAV routes are indicated by center line.</p> <p>T319 TK313 RNAV (helicopter only) waypoint</p>	TOPOGRAPHIC INFORMATION <p>Roads & Road Markers</p> <p>Railroad</p> <p>Power Transmission Lines</p> <p>Aerial Cable</p> <p>Landmark Feature - stadium, factory, school, golf course, etc.</p> <p>Outdoor Theatre</p> <p>Lookout Tower Elevation Base of Tower</p> <p>CG Coast Guard Station</p> <p>Race Track</p> <p>Tank-water, oil or gas</p> <p>Oil Well Water Well</p> <p>Mine or Quarry</p> <p>Mountain Pass Elevation of Pass</p>								
ADDITIONAL AIRPORT INFORMATION <p>(R) Private "(Pvt)" - Non-public use having emergency or landmark value.</p> <p>Military - Other than hard-surfaced. All military airports are identified by abbreviations AFB, NAS, AAF, etc. For complete airport information consult DOD FLIP</p> <table border="1"> <tr> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> </tr> </table> <p>Services-fuel available and field attended during normal working hours depicted by use of ticks around basic airport symbol. (Normal working hours are Mon thru Fri 10:00 A.M. to 4:00 P.M. local time. Consult A/FD for service availability at airports with hard-surfaced runways greater than 8069 ft.)</p> <p>★ Rotating airport beacon in operation Sunset to Sunrise</p>									<p>FSS - Flight Service Station NO SVFR - Fixed wing special VFR flight is prohibited. CT - 118.3 - Control Tower (CT) primary frequency * - Star Indicates operation part-time (see tower frequencies) tabulation for hours of operation. G - Indicates Common Traffic Advisory Frequencies (CTAF) ATIS 123.8 - Automatic Terminal Information Service ASOS/AWOS 135.42 - Automated Surface Weather Observing Systems (shown where full-time ATIS is not available). Some ASOS/AWOS facilities may not be located at airports. UNICOM - Aerotronics advisory station VFR Advry - VFR Advisory Service shown where full-time ATIS not available and frequency is other than primary CT frequency. 285 - Elevation in feet L - Lighting in operation sunset to sunrise *L - Lighting limitations exist, refer to Airport/Facility Directory. 72 - Length of longest runway in hundreds of feet; usable length may be less.</p> <p>When information is lacking, the respective character is replaced by a dash. Lighting codes refer to runway edge lights and may not represent the longest runway or full length lighting.</p>	<p>2400 MSL Differentiates floors of Class E Airspace greater than 700 ft. above surface.</p> <p>4500 MSL Class E Airspace exists at 1200 AGL unless otherwise designated as shown above.</p> <p>Class E Airspace low altitude Federal Airways are indicated by center line.</p> <p>Intersection - Arrows are directed towards facilities which establish intersection.</p> <p>132° E - Isogonic Line (2010 VALUE)</p> <p>132° V 69 Total mileage between NAVAID, on direct Airways</p> <p>169 Between NAVAID, on direct Airways Class E Airspace low altitude RNAV routes are indicated by center line.</p> <p>T319 TK313 RNAV (helicopter only) waypoint</p>	<p>Ultralight Activity</p> <p>Hang Glider Activity</p> <p>Glider Operations</p> <p>Unmanned Aircraft Activity</p> <p>Parachute Jumping Area (See Airport/Facility Directory).</p> <p>Marine Light</p> <p>NAME (VPXYZ)</p> <p>VFR Waypoints (See Airport/Facility Directory for latitude/longitude).</p> <p>Perennial Lake</p> <p>Non-Perennial Lake</p> <p>Pier</p> <p>Rock</p> <p>Dams</p> <p>Bridges and Viaducts</p>
RADIO AIDS TO NAVIGATION <ul style="list-style-type: none"> VHF OMNI RANGE (VOR) VORTAC VOR-DME Non-Directional Radio Beacon (NDB) NDB-DME Other facilities, i.e., FSS Outlet, RCO, etc. 	COMMUNICATION BOXES <p>122.1R 122.6 123.8</p> <p>OAKDALE 382 * OAK</p> <p>Underline indicates no voice on this frequency. Crosshatch indicates Shutdown Status.</p> <p>* Operates less than continuous or On-Request. ASOS/AWOS HIWAS</p> <p>FSS radio providing voice communication</p> <p>122.1R MIAMI</p> <p>Heavy line box indicates Flight Service Station (FSS). Frequencies 121.5, 122.2, 243.0 and 255.4 (Canada - 121.5, 126.7 and 243.0) are available at many FSSs and are not shown above boxes. All other frequencies are shown.</p> <p>Certain FSSs provide Airport Advisory Service, see A/FD.</p> <p>R - Receive Only.</p> <p>Frequencies above this line box are remote to NAVAID site. Other FSS frequencies providing voice communication may be available as determined by altitude and terrain. Consult Airport/Facility Directory for complete information.</p>	OBSTRUCTIONS <p>1000 ft. and higher AGL</p> <p>below 1000 ft. AGL</p> <p>or Group Obstruction</p> <p>Obstruction with high-intensity lights May operate part-time</p> <p>Elevation of the top above mean sea level</p> <p>2049 Height above ground (1149) Under construction or UC reported; position and elevation unverified.</p> <p>NOTICE: Guy wires may extend outward from structures.</p>	<p>122.1R CHICAGO CHI</p> <p>Heavy line box indicates Flight Service Station (FSS). Frequencies 121.5, 122.2, 243.0 and 255.4 (Canada - 121.5, 126.7 and 243.0) are available at many FSSs and are not shown above boxes. All other frequencies are shown.</p> <p>Certain FSSs provide Airport Advisory Service, see A/FD.</p> <p>R - Receive Only.</p> <p>Frequencies above this line box are remote to NAVAID site. Other FSS frequencies providing voice communication may be available as determined by altitude and terrain. Consult Airport/Facility Directory for complete information.</p>								

LEGEND 1.—Sectional Aeronautical Chart.

Aviation Weather

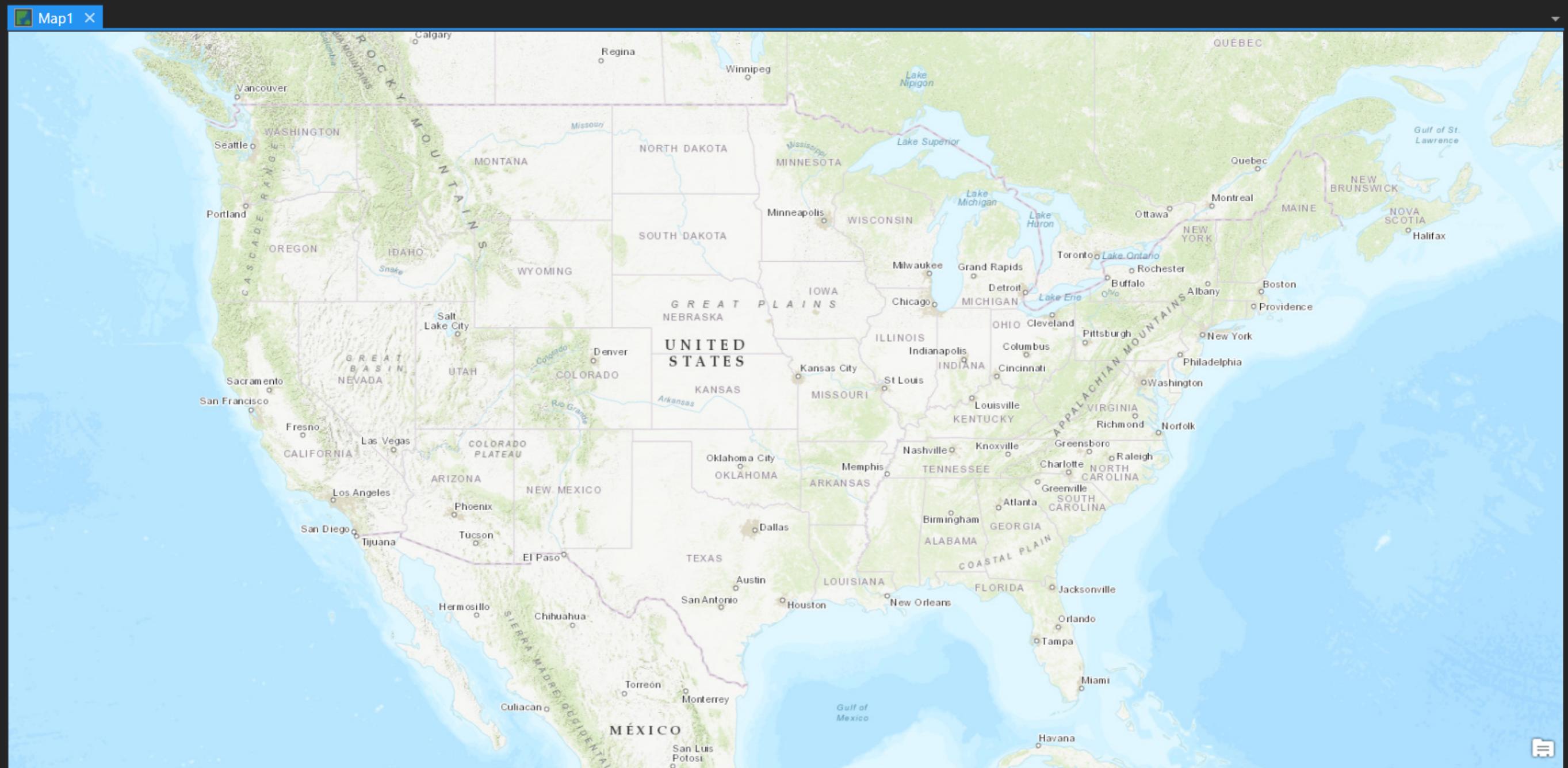
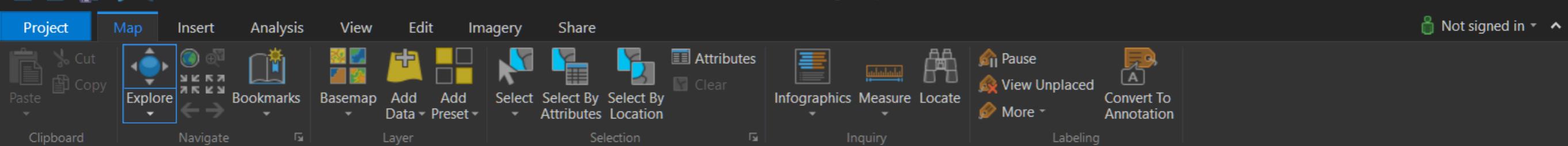
- METAR
 - KROC 061554Z 32013G20KT 10SM FEW025 OVC032
09/03 A3002 RMK AO2 SLP171 T0089003
- TAF
 - TAF AMD KROC 061519Z 0615/0712 32016G21KT
P6SM BKN020 FM062000 30015KT P6SM BKN035
FM070200 31010KT P6SM FEW130 FM070900
33006KT P6SM SCT100

Aviation Weather

- Outside of knowing your unit's performance there are regulations when you can fly
- Minimum Visibility 3 SM
- Minimum 500 ft below the clouds and 2000 ft horizontally from clouds

Notice to Airmen and TFR

- A Notice to Airmen (NOTAM) is a notice filed with an aviation authority to alert aircraft pilots of potential hazards along a flight route or at a location that could affect the safety of the flight. - notams.aim.faa.gov
- Temporary flight restrictions - A TFR is a geographically-limited, short-term, airspace restriction, typically in the United States.



1:25,014,874 | + | Selected Features: 0 |

ArcGIS Pro - UAV Planning - Map1

Project Map Insert Analysis View Edit Imagery Share

Cut Copy Paste Explore Bookmarks Basemap Add Data Preset Select Select By Attributes Select By Location Attributes Infographics Measure Locate Pause View Unplaced More Convert To Annotation Clipboard Navigate Layer Selection Inquiry Labeling

Map1 X

Add Data

« All Portal Search Result for 'FAA' » FAA

Project Databases Folders

Portal My Content Groups All Portal Living Atlas

Computer Desktop

National Security UAS Flight Restrictions

UAS Facility Map Data

Drone_No_Fly_Zones_USA_story_map_airport_buffers_solid

Drone_No_Fly_Zones_USA_story_map_airports_stadiums

USA Airports

FAA Sectional Charts - Map Service

Light Gray Canvas

Drone_No_Fly_Zones_USA_story_map_airport_buffers

Name FAA Sectional Charts - Map Service Default

OK Cancel

1:25,014,874 | Selected Features: 0

127.2343068°W 50.4422733°N

The screenshot displays the ArcGIS Pro interface with a map titled "Map1" showing a regional view of North America. A modal dialog box titled "Add Data" is open, showing search results for "FAA". The results list several items, with "Drone_No_Fly_Zones_USA_story_map_airport_buffers_solid" currently selected. The "Name" field in the dialog is set to "FAA Sectional Charts - Map Service". The bottom right of the dialog has "OK" and "Cancel" buttons. The ArcGIS ribbon at the top includes tabs for Project, Map, Insert, Analysis, View, Edit, Imagery, and Share, along with various toolbars for navigation, selection, and labeling.

UAV Image Capture and Processing

UAV Types

- There are two main types of UAVs
 - Fixed Wings
 - Multi-Rotors
- They have each have their own purposes

Examples of Fixed Wing UAVs



Uses of Fixed Wing UAVs

- Large Scale Mapping Projects
 - Precision Agriculture
 - Elevation Models
- Large flying area with low battery usage.
- They need larger areas for landing and taking off
- Not good for developing 3D models of a building

EXAMPLES OF MULTI-ROTORS



Multi-Rotor

- Multi-rotor is what most people now think UAVs are
- These are fairly easy to fly with vertical take off and landing
- They can do a lot of different task such as mapping large areas, but also are great for inspections
- They are limited in flight time because of the power needed to maintain flight

Capture Software

- For the most part you do not even need to know how to fly, as many UAV's are setup with autopilots
- Using a software like Drone Deploy, Pix4D, Drone2Map, you pick what type of mission you want to do
- Then draw your box and it does the rest

Sensor Packages

- The UAV is only a mechanism for flying a sensor
- Like we talked about in the Remote Sensing lectures, there are both passive and active sensors
- You can put on LiDAR, Multi Spectral, and Thermal Images

Passive Sensors



Active Sensors



RIT's UAV Has Both Types Sensors Onboard



Recommended Videos To Watch

- Fixed Wing UAV Flight Procedures - <https://youtu.be/RVPkibtxwKw>
- 3D Model of a Castle with multiple types of UAVs - <https://youtu.be/j7PGgrMSi5o>
- One of My Favorites Frozen in Time - <https://youtu.be/Zhk5ZDzjiQg>
 - This video uses UAVs, Other Types of Remote Sensing, and Fabel the Archeology Dog



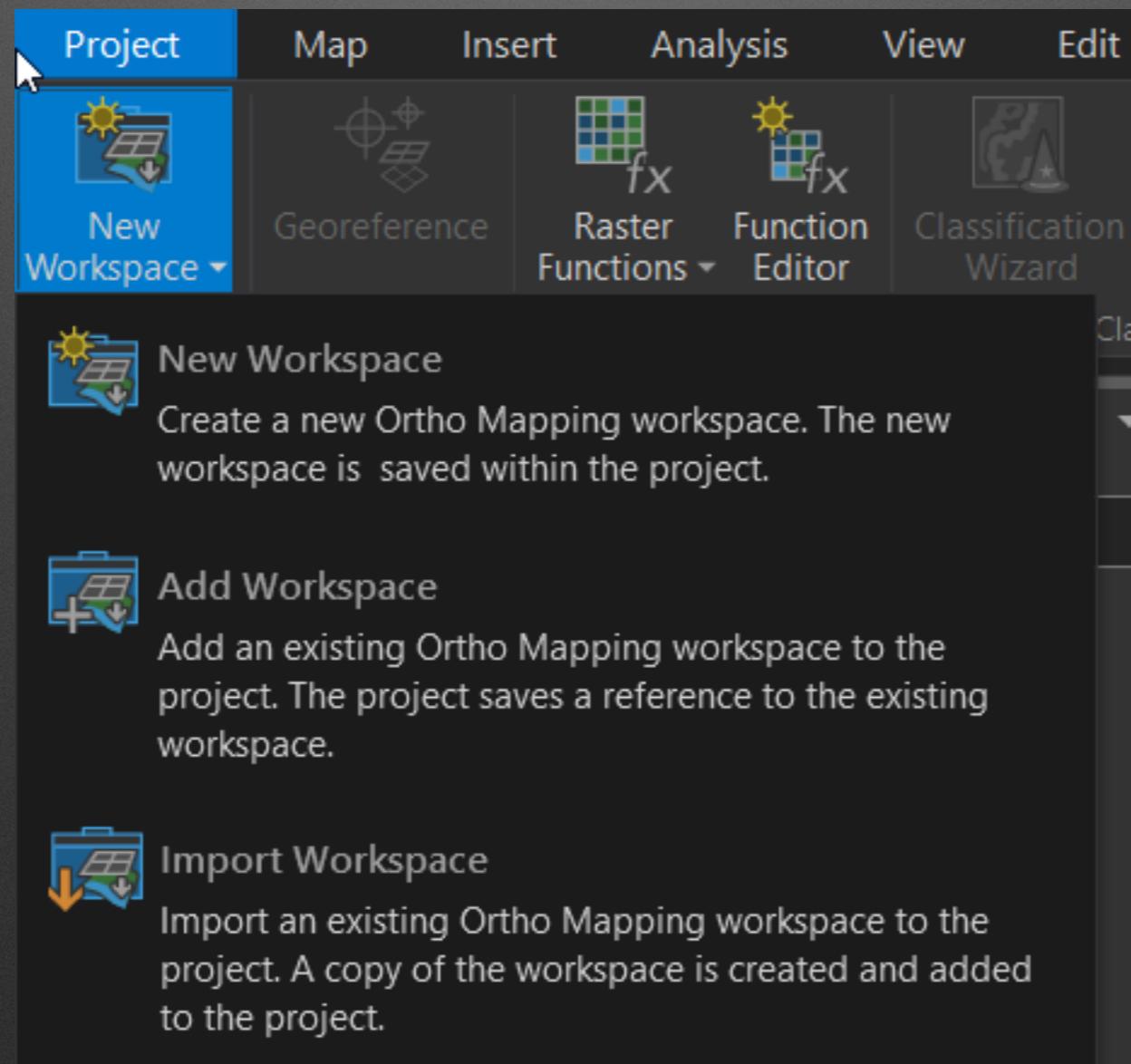
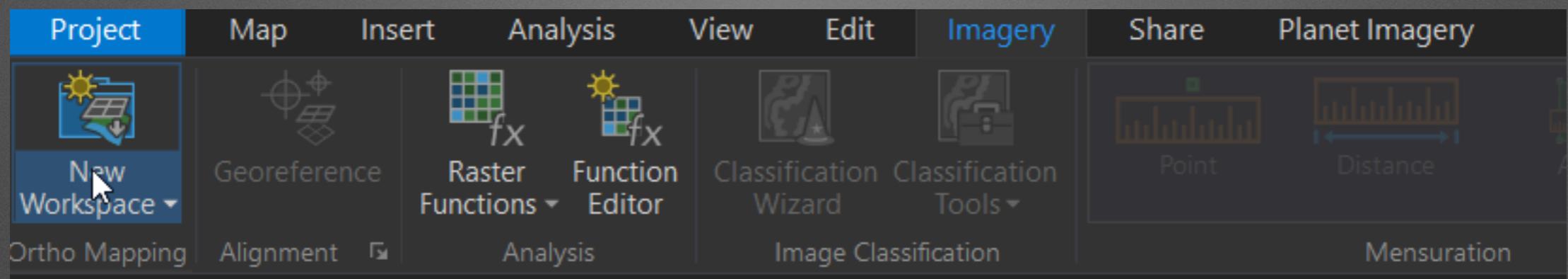
What to Look for in a Trainer Drone

- The Trainer Drones that I like are Parrot Mini Drones because they fly very similarly to my Parrot Anafi and the DJI Phantoms
 - They have been discontinued so they are hard to come by now
- DJI has a Tello drone which is very similar to the mini drones and has a camera
- There are a lot of other options out there. When looking for one that will fly just like many of the professional ones look for altitude hold using either optical or ultrasonic sensors
- Some you will find require you to trim the power to maintain altitude, these while good for learning on handle different than the others but may also be even cheaper
- I recommend also getting blade guards to protect the drone and things in your home and extra propellers because you will go through them while learning

Activity

- Process a set of UAV images using ArcGIS Pro
- Download the data [http://downloads.esri.com/
learnarcgis/estimate-storage-capacity-with-drone-
imagery/yvwd-images.zip](http://downloads.esri.com/learnarcgis/estimate-storage-capacity-with-drone-imagery/yvwd-images.zip)
- Open a new Map project

Ortho Mapping Project



Orthomapping Project Wizard

Workspace Configuration

The ArcGIS Ortho Mapping suite can process a variety of aerial and satellite imagery to produce digital orthoimage products for mapping and GIS applications. An ortho mapping workspace is a sub-project within your ArcGIS Pro project, and can be opened in a workflow-centric environment.

Name: Storage

Description:

Type:

Next >

Image Collection

Sensor Type: Generic

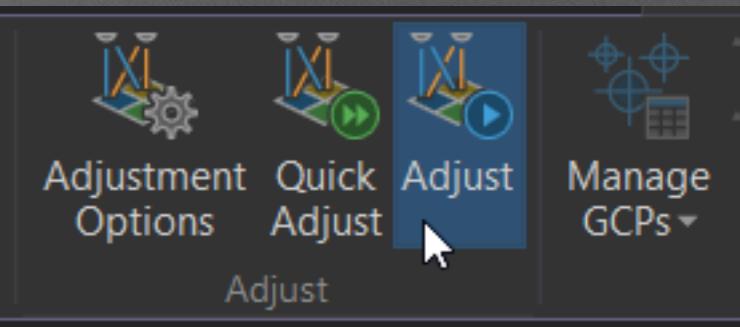
Add Remove Remove All

	Image	Lat [Y]	Long [X]	Alt [Z]
<input checked="" type="checkbox"/>	DJI_0953.jpg	34.007	-117.0	699.76
<input checked="" type="checkbox"/>	DJI_0954.jpg	34.007	-117.0	699.76
<input checked="" type="checkbox"/>	DJI_0955.jpg	34.007	-117.0	699.76
<input checked="" type="checkbox"/>	DJI_0956.jpg	34.007	-117.0	699.76
<input checked="" type="checkbox"/>	DJI_0957.jpg	34.007	-117.0	699.66
<input checked="" type="checkbox"/>	DJI_0958.jpg	34.007	-117.0	699.66
<input checked="" type="checkbox"/>	DJI_0959.jpg	34.007	-117.0	699.76
<input checked="" type="checkbox"/>	DJI_0960.jpg	34.007	-117.0	699.76
<input checked="" type="checkbox"/>	DJI_0961.jpg	34.007	-117.0	699.76
<input checked="" type="checkbox"/>	DJI_0980.jpg	34.007	-117.0	699.76
<input checked="" type="checkbox"/>	DJI_0981.jpg	34.007	-117.0	699.76
<input checked="" type="checkbox"/>	DJI_0982.jpg	34.007	-117.0	699.76
<input checked="" type="checkbox"/>	DJI_0983.jpg	34.007	-117.0	699.66
<input checked="" type="checkbox"/>	DJI_0984.jpg	34.007	-117.0	699.76

Geolocation Set elevation source

< Previous Finish

Orthomapping



Remote Sensing - Storage - ArcGIS Pro

Map Ortho Mapping

Project Map Insert Analysis View Edit Imagery Share Planet Imagery Ortho Mapping

Cut Copy Copy Path Paste Select Measure Bookmarks Refine Interior Orientation Adjustment Options Quick Adjust Manage GCPs Analyze Tie Points Recompute Tie Points DEMs Orthomosaic Custom Logs Adjustment Report Product Review

Contents Catalog Map1 Storage

Search

Ortho Mapping

- Storage
 - Data Products
 - Solution Data
 - QA/QC Data
 - Control Points
- Flight Data
 - Camera Locations
 - location
 - Flight Path
 - path
- Source Data
 - Image Collection
 - Boundary
 - Footprint
 - Image
 - RGB
 - Red: Band_1
 - Green: Band_2
 - Blue: Band_3
- Reference Data

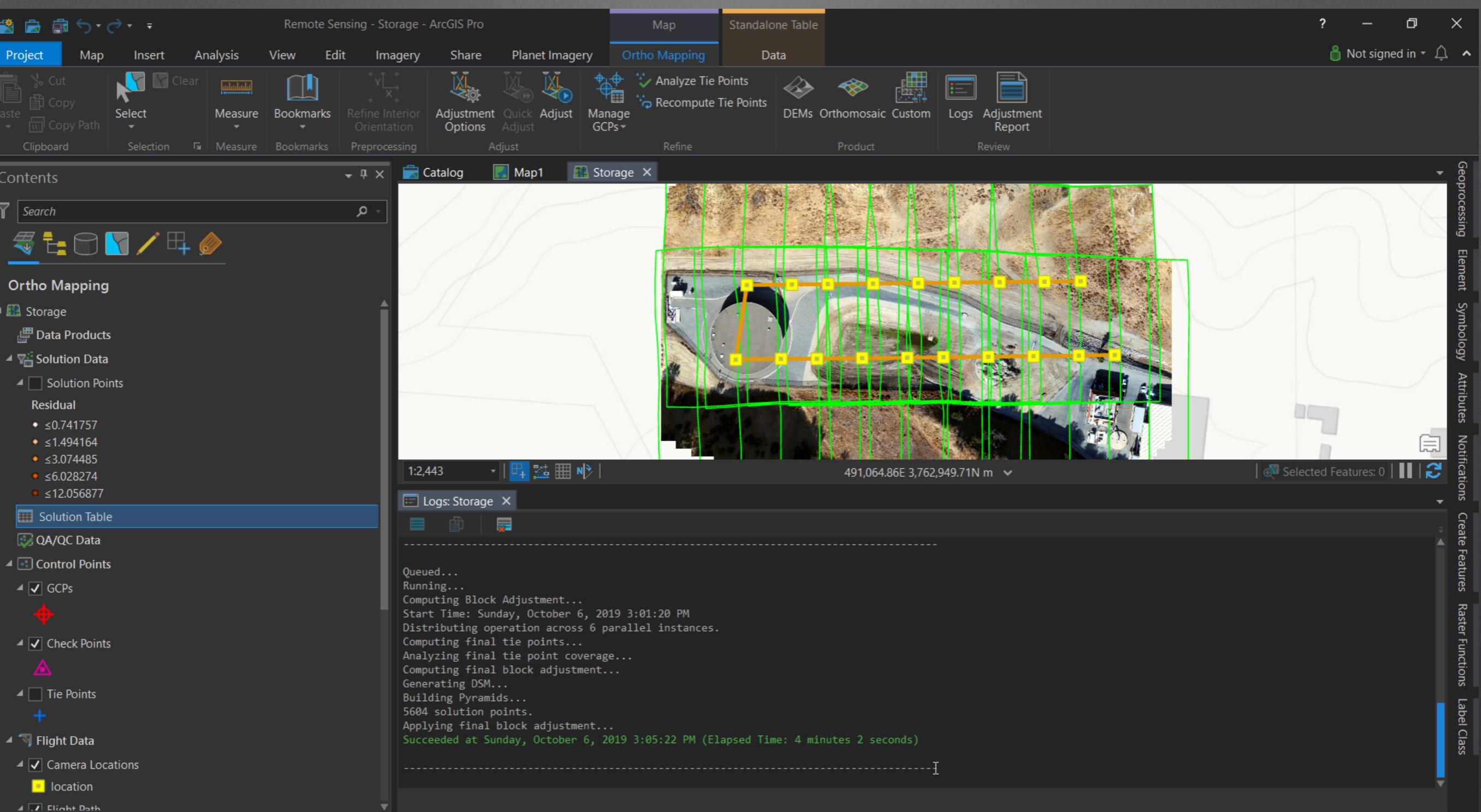
1:2,443 491,067.45E 3,763,217.06N m

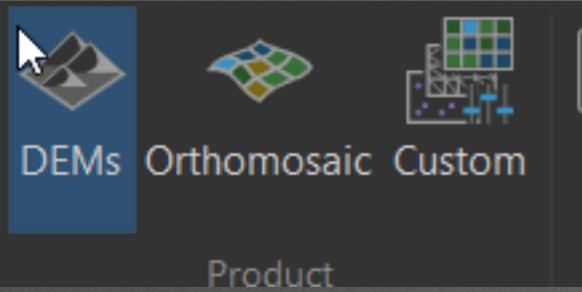
Selected Features: 0

Logs: Storage

2019-10-06T14:57:05.028: Loading raster datasets
2019-10-06T14:57:05.622: Completed crawling 19 data source items. Added 19 mosaic dataset items.
2019-10-06T14:57:05.624: Synchronizing crawled data source items
2019-10-06T14:57:05.758: Synchronizing items associated with raster type instance 'UAV/UAS' [ID: 1].
2019-10-06T14:57:08.156: Estimating raster statistics for mosaic dataset.
2019-10-06T14:57:09.637: Completed synchronization: 19 items selected, 19 items synchronized.
2019-10-06T14:57:10.006: Computing cell size levels
2019-10-06T14:57:10.007: Computing unique cell size values
2019-10-06T14:57:10.418: Computing maximum cell size values
2019-10-06T14:57:10.478: Computing minimum cell size values
2019-10-06T14:57:10.486: Updating visibility values of selected items
2019-10-06T14:57:10.567: Computing maximum cell size for mosaic dataset
2019-10-06T14:57:10.577: Completed computing cell size ranges.
2019-10-06T14:57:10.774: Completed building boundary.
Succeeded at Sunday, October 6, 2019 2:57:12 PM (Elapsed Time: 18.57 seconds)

Orthomapping





Orthomapping

Ortho Mapping Products Wizard

The Custom Products Wizard provides a guided workflow for creating all Ortho Mapping products. You can create a single product or many products with this wizard. All products consist of DTM, DSM, and a photogrammetrically corrected image.

Digital Elevation Model

Interpolate DEM from Solution Points

Orthomosaic

Color Balance

Generate Seamlines

Generate Orthomosaic

[Next >](#)

DEM Interpolation Settings

Surface Type: Digital Surface Model

Cell Size: 5 x GSD (0.028€)

Format: Cloud Raster Format

Compression: None

Interpolation Method: TIN Linear Interpolation

Smoothing Method: Gaussian 5 by 5

Fill Missing Pixels Using:

Orthorectify images using this DEM

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Color Balance Settings

Select Mosaic Candidates

Maximum Area Overlap: 0.6

Maximum Area Loss Allowed: 0.05

Balance Method: Dodging

Color Surface Type: Second Order

Target Raster:

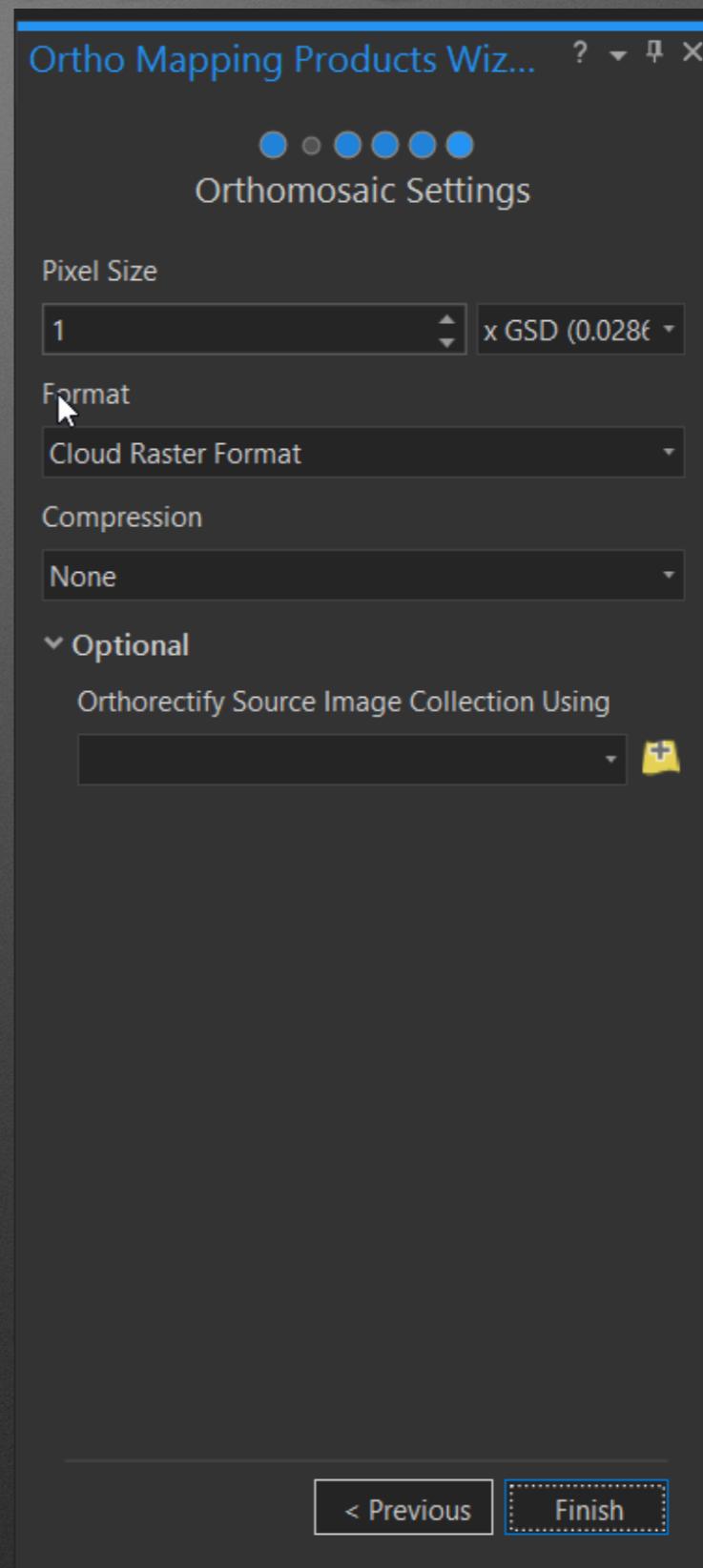
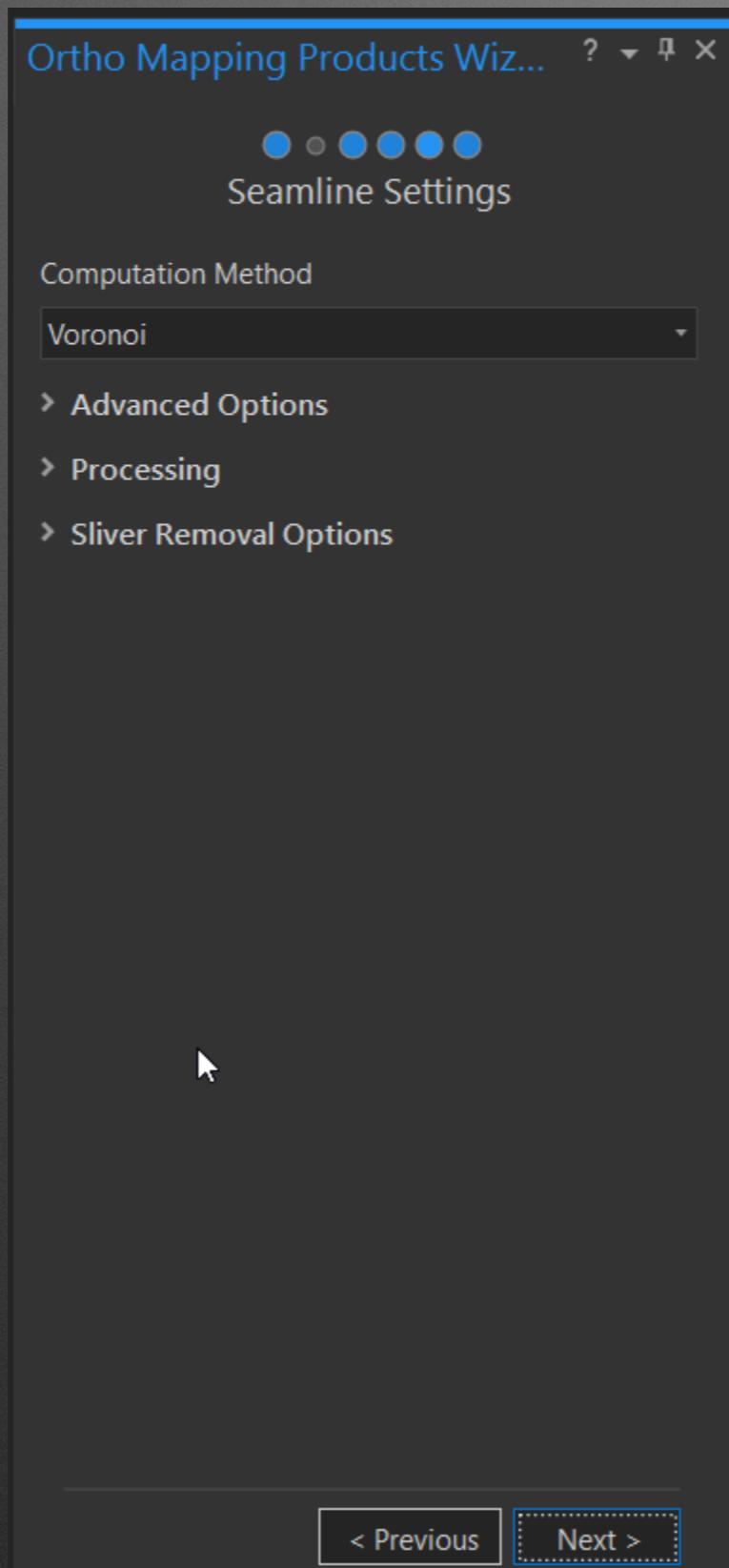
Recalculate Statistics

Number of Columns to Skip: 10

Number of Rows to Skip: 10

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Orthomapping



Orthomapping

Remote Sensing - Storage - ArcGIS Pro

Project Map Insert Analysis View Edit Imagery Share Planet Imagery Ortho Mapping Appearance Data

Cut Copy Copy Path Paste Select Clear Measure Bookmarks Refine Interior Orientation Adjustment Options Quick Adjust Manage GCPs Analyze Tie Points Recompute Tie Points DEMs Orthomosaic Custom Logs Adjustment Report Product Review

Not signed in

Contents Catalog Map1 Storage

Search

Ortho Mapping

- Tie Points
- + Flight Data
- Camera Locations
 - location
- Flight Path
 - path

Source Data

- Image Collection
 - Boundary
 - Footprint
 - Seamline
 - Image
 - RGB
 - Red: Band_1
 - Green: Band_2
 - Blue: Band_3

Reference Data

- Topographic

Map1

1:2,443 490,920.59E 3,762,999.36N m

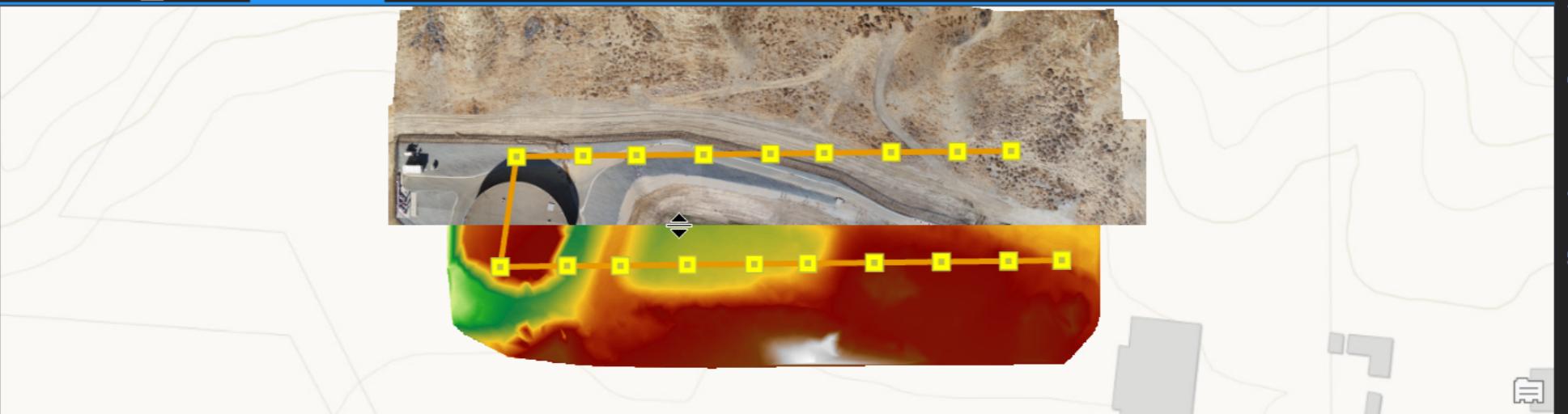
Logs: Storage

Succeeded at Sunday, October 6, 2019 3:08:02 PM (Elapsed Time: 4.63 seconds)

Updating Image Collection Properties...
Start Time: Sunday, October 6, 2019 3:08:09 PM
Succeeded at Sunday, October 6, 2019 3:08:11 PM (Elapsed Time: 2.66 seconds)

Generating Orthomosaic...
Start Time: Sunday, October 6, 2019 3:08:14 PM
Building Pyramids...
Calculating Statistics...
Succeeded at Sunday, October 6, 2019 3:09:07 PM (Elapsed Time: 52.60 seconds)

Geoprocessing Element Symbology Attributes Notifications Create Features Raster Functions Label Class



UAV Readings

- [https://www.faa.gov/uas/getting started/part 107/](https://www.faa.gov/uas/getting_started/part_107/)
- [https://www.faa.gov/uas/getting started/part 107/remote pilot cert/](https://www.faa.gov/uas/getting_started/part_107/remote_pilot_cert/)
- (Optional but recommended if you want your certification <https://www.asa2fly.com/Test-Prep-2020-Remote-Pilot-P4124C738.aspx>)

Assignment

- On the Sectional Chart that we created in class look up your own address or area.
 - Explain if you are authorized to fly in your area and what is the airspace. Include an exported map of your area in your write up.
- Write up an explanation of a possible project that you could use an UAS. Include the area that you would be flying, what possible authorizations you would need, and what type of UAS would you choose and why.
- The sectional charts are in either ArcGIS Online or ArcGIS Pro. Search for Sectional or FAA
- Or you can go to the FAA's website on the sectional charts https://www.faa.gov/air_traffic/flight_info/aeronav/productcatalog/vfrcharts/sectional/