INTTERRA
REMOTE SENSING 101

AGENDA

- What is Remote Sensing?
- How does the Intterra auto-processor work?
- How can I view remotely sensed image data in **SituationAnalyst (SA)**?

WHAT IS REMOTE SENSING?

BEFORE WE BEGIN… REVIEW KEY TERMS

- Remote Sensing
- Electromagnetic spectrum
- Spectral signatures
- Band combinations
- Resolutions
  - Spatial
  - Spectral
  - Temporal
  - Radiometric
- Sensor types
  - Passive
  - Active
- PAN vs. MSI vs. HSI
- LiDAR

INTERRA

REMOTE SENSING

The American Society of Photogrammetry and Remote Sensing (ASPRS) combined definition of Remote Sensing and Photogrammetry:

> *"… the art, science, and technology of obtaining reliable information about physical objects and the environment, through the process of recording, measuring, and interpreting imagery and digital representations of energy patterns derived from noncontact sensor systems." (Colwell, 1997)*

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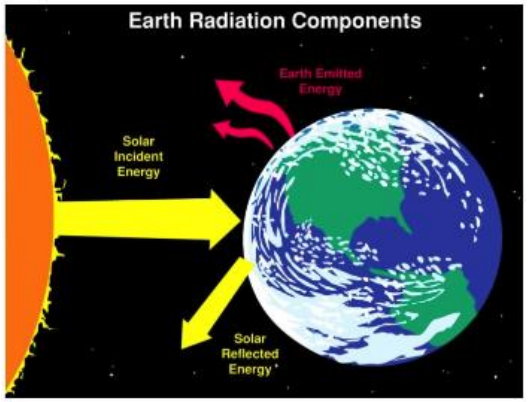
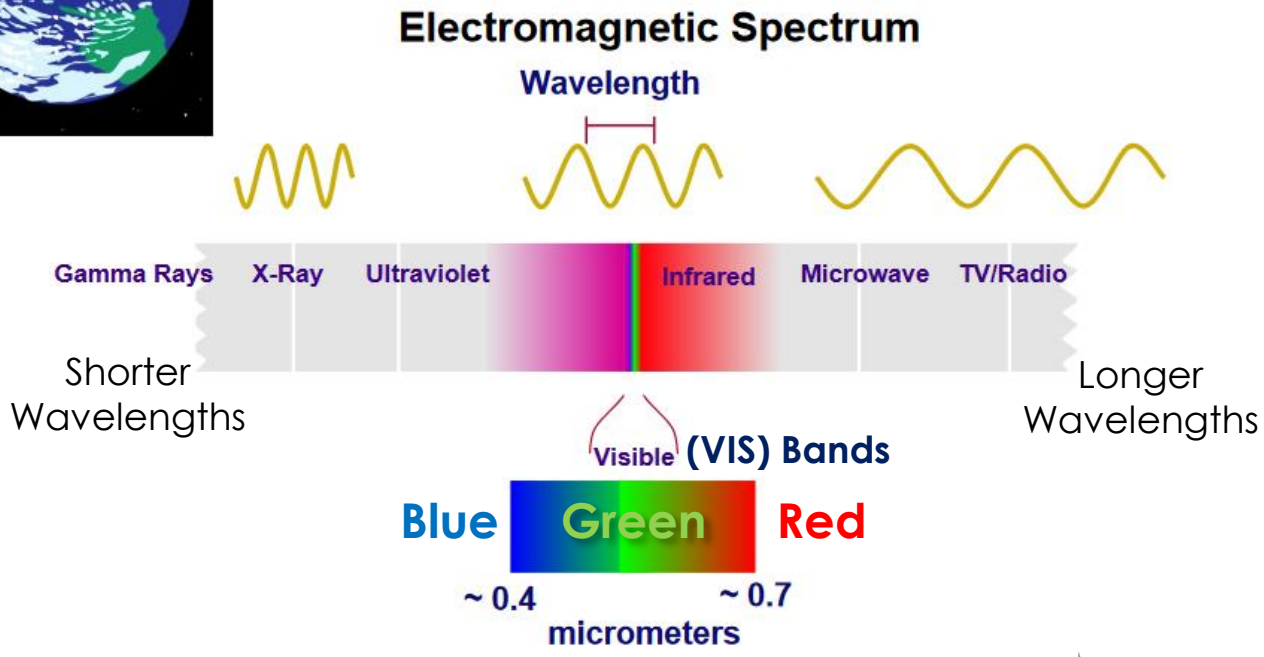
ELECTROMAGNETIC SPECTRUM



Earth-Ocean-Land-Atmosphere System :
- Reflects solar radiation back to space
- Emits Infrared and Microwave radiation to space

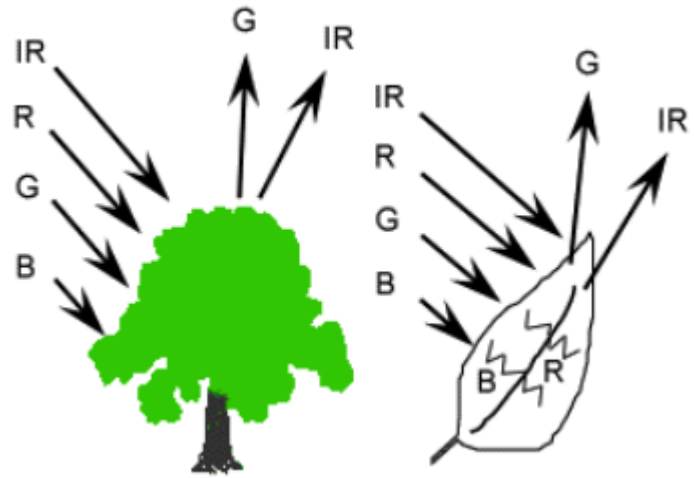
- The Sun produces a continuous spectrum of energy from gamma rays (very small) to radio waves (very large).
- The visible portion of the spectrum may be measured using wavelength (400 – 700 nanometers or 0.4 – 0.7 micrometers).



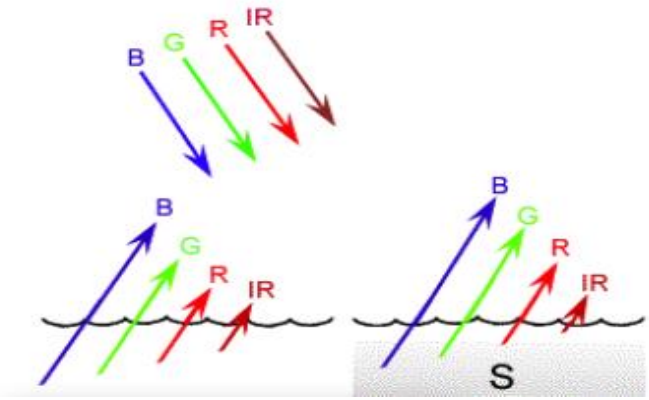
SPECTRAL SIGNATURES

Every surface type has its own spectral signature, which is based on absorption and reflection of bands in the electromagnetic spectrum.

- Vegetation
  - Healthy vegetation absorbs blue and red wavelengths, and reflects green and near infrared (NIR).
  - Since we cannot see NIR radiation, we see healthy vegetation as green.

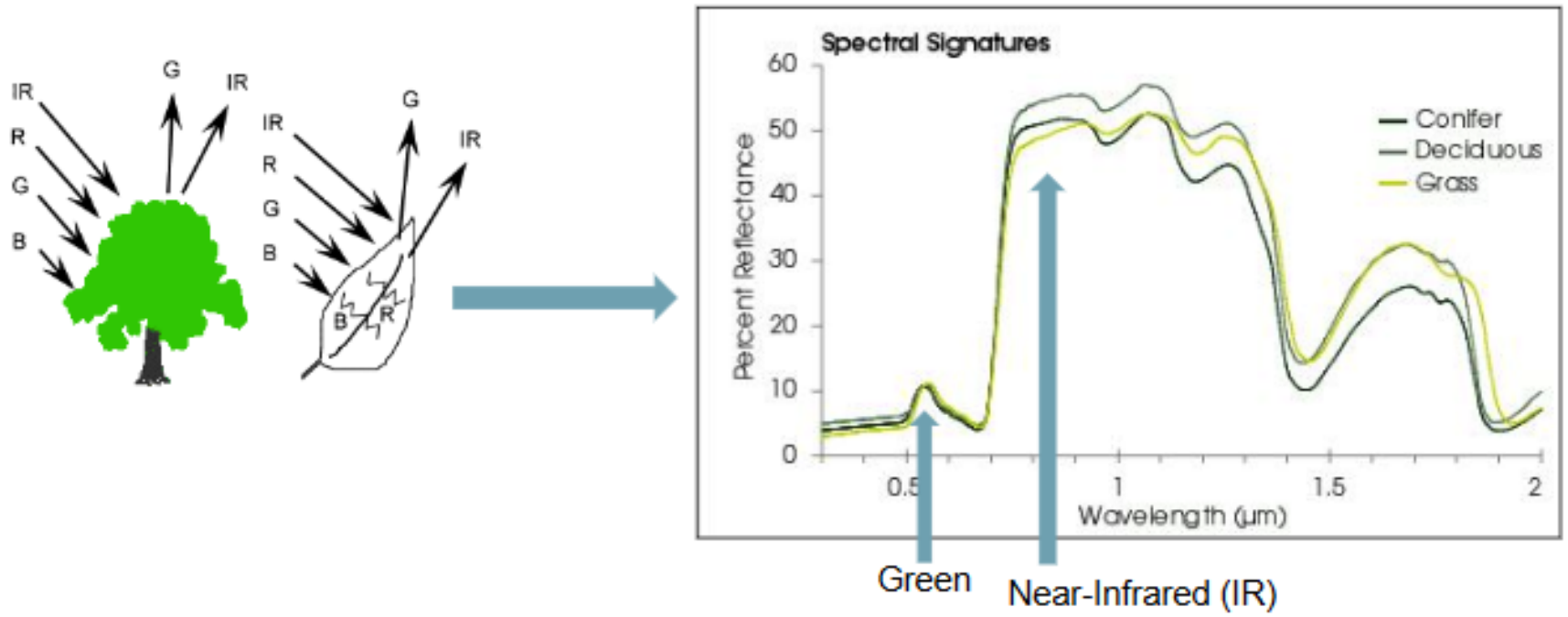


- Water
  - Longer visible wavelengths (green and red) and NIR radiation are absorbed more by water than shorter visible wavelengths (blue). Therefore, water usually looks blue or blue-green.
  - Sediment (S) present in upper layers of the water column will result in more red reflectance (and will appear brighter).



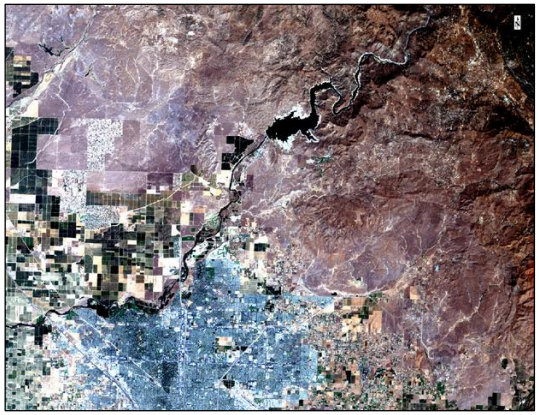
SPECTRAL SIGNATURES

- X-axis: Perfect reflectance
- Y-axis: Wavelength value
- A signature graphically represents the x- and y-values

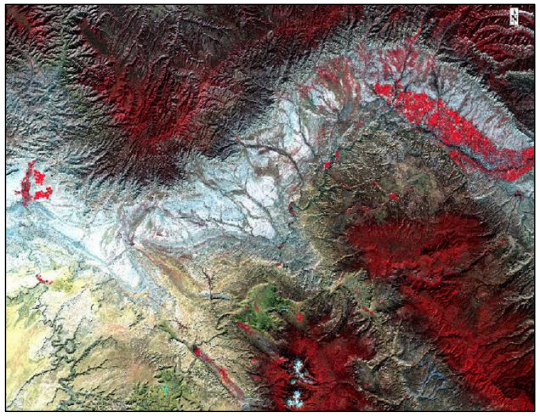


BAND COMBINATIONS

Different band combinations produce images that can "highlight" specific features.

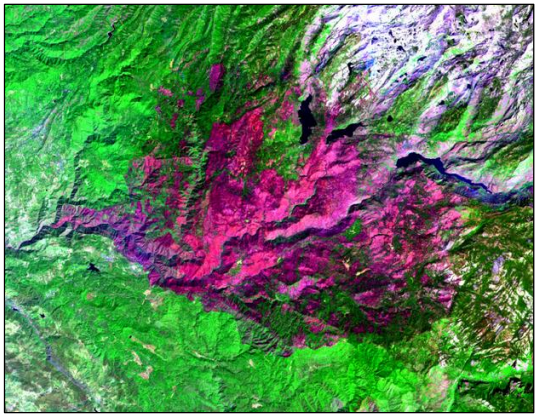


True Color
Bands: Red, Green, Blue



False Color
Bands: NIR, Red, Green

Useful for detecting healthy vegetation



False Color
Bands: SWIR, Red, Green

Useful for detecting burn scars

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RESOLUTIONS

- **Spatial:** A 1 meter pixel vs. a 30 meter pixel.

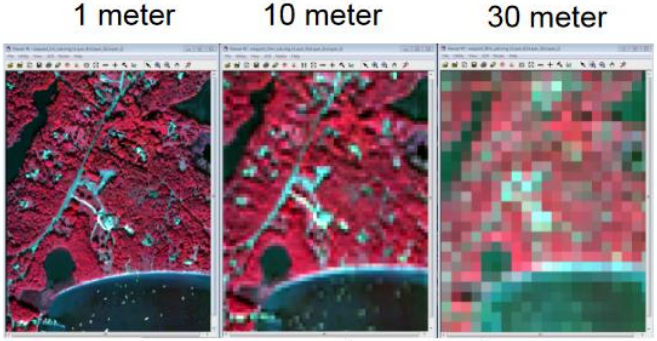
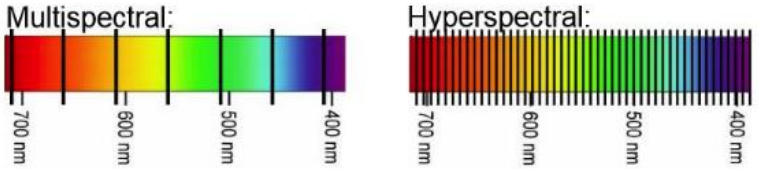
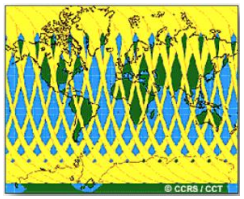


Image courtesy of www.csc.noaa.gov

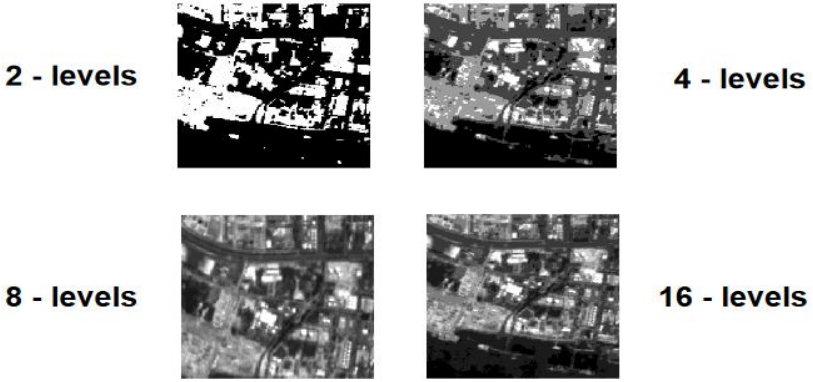
- **Spectral:** The ability of a sensor to define wavelength intervals. Example: An image acquired by a sensor with 7 bands vs. 256 bands.



- **Temporal:** How frequently a satellite observes the same geographic location. Example: An image acquired every 2 days vs. every 16 days. (Also called "revisit time.")



- **Radiometric:** The maximum number of brightness levels available depends on the number of bits used in representing the energy recorded. Example: 8-bit sensor = 2^8 or 256 levels (0-255).



- Note: When resolutions are discussed, there are always tradeoffs. Example: Higher spatial resolution (lower spatial extent), but lower temporal resolution. The sensor you choose to use will depend on the problem you are attempting to solve.

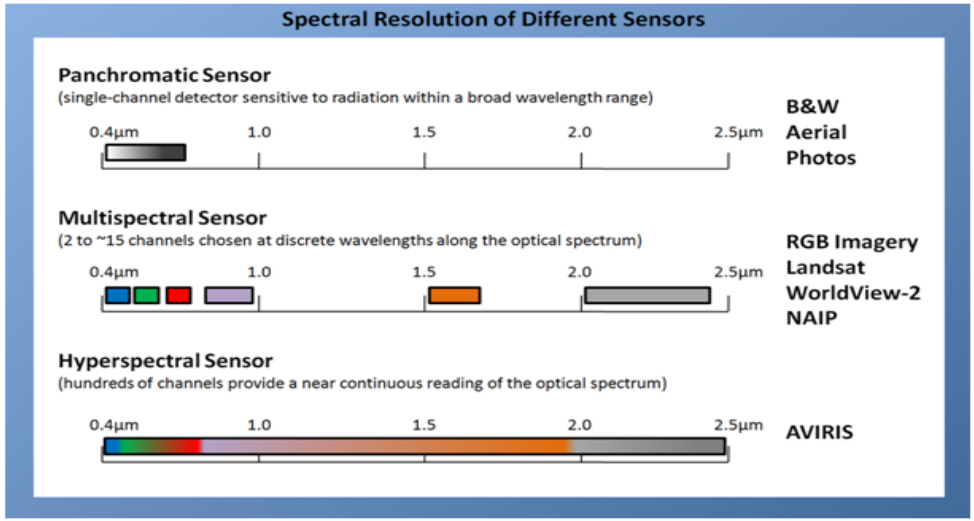
SENSOR TYPES

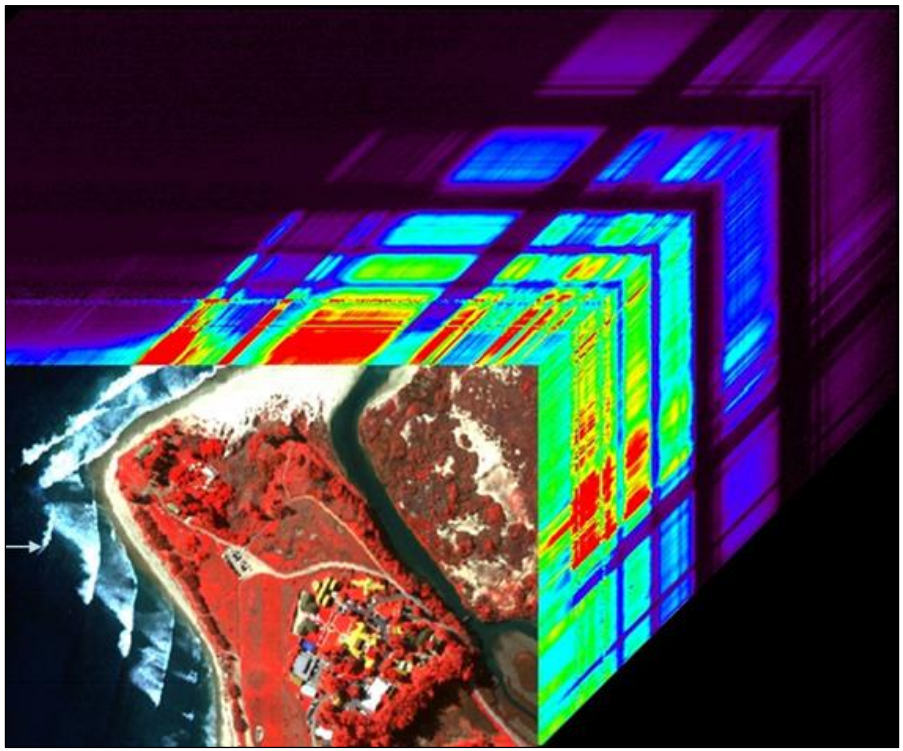
- **Passive:** Sensors measure radiant energy reflected or emitted by the Earth-atmosphere system. This means these sensors rely on sunlight for their light source.
  - Examples: Multispectral, Hyperspectral
  - Pros: Often easier to process and more readily available
- **Active:** Sensors send beams of radiation on the Earth-atmosphere system and measure "back-scattered" radiation. This means these sensors create their own light source.
  - Examples: RAdio Detection and Ranging (RADAR), Light Detection and Ranging (LiDAR)
  - Pros: Can image day or night, and some sensors can penetrate cloud cover

PAN VS. MSI VS. HSI

- Like panchromatic (PAN) and multispectral imagery (MSI), hyperspectral imagery (HSI) relies on sunlight for its light source → **Passive** sensor.
- MSI and HSI both break apart the light spectrum to reveal information about a target that is not visible to PAN sensors.
- An HSI sensor is characterized by several hundred narrow, contiguous bands. By placing so many channels so close together, you can sample the spectrum with much greater detail. The high **spectral resolution** is what allows you to tell the difference between specific materials.

PAN VS. MSI VS. HSI (SPECTRAL RESOLUTION)





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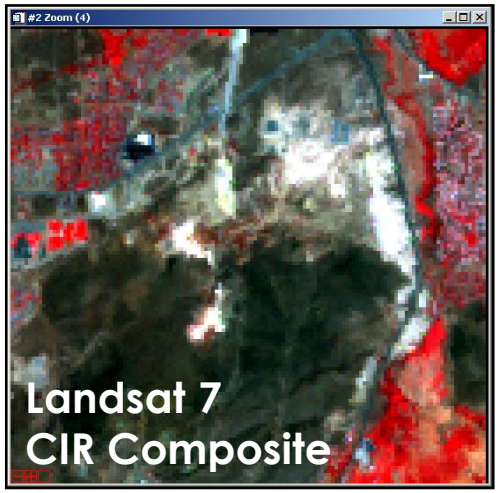
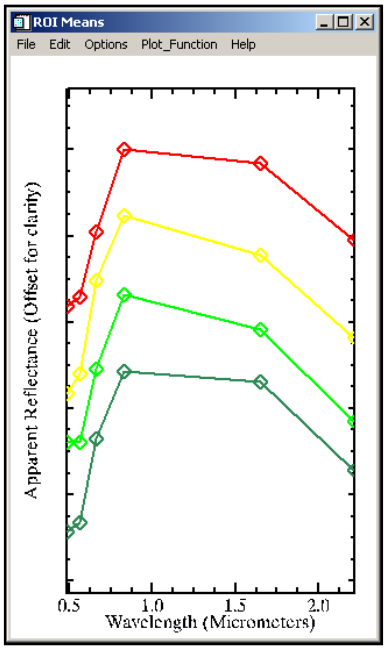
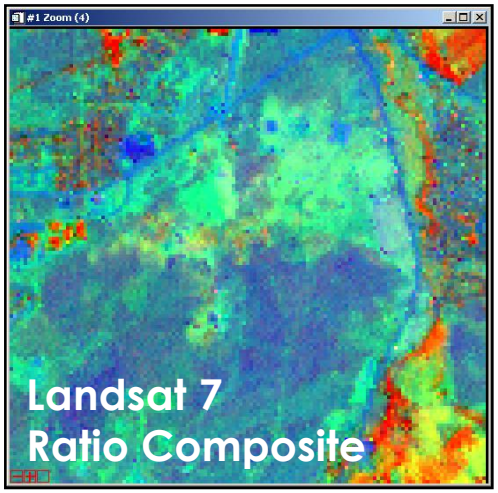
MSI: Landsat 7

- MSI data are undersampled (not enough spectral bands)
- Band ratios and classification allow for discrimination of different materials

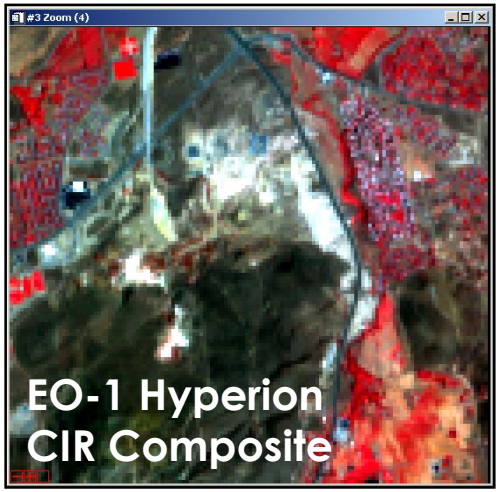


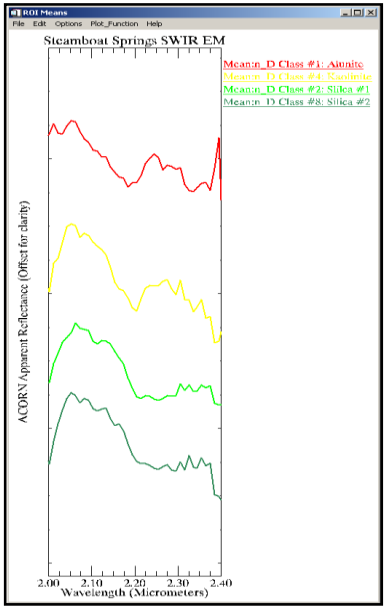


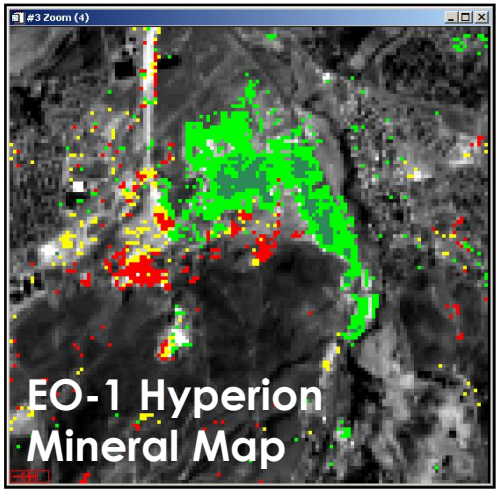


HSI: EO-1 Hyperion

- HSI data are, by definition, oversampled (more spectral channels than inherent data dimensions)
- Detailed spectral analysis allows for identification of specific materials

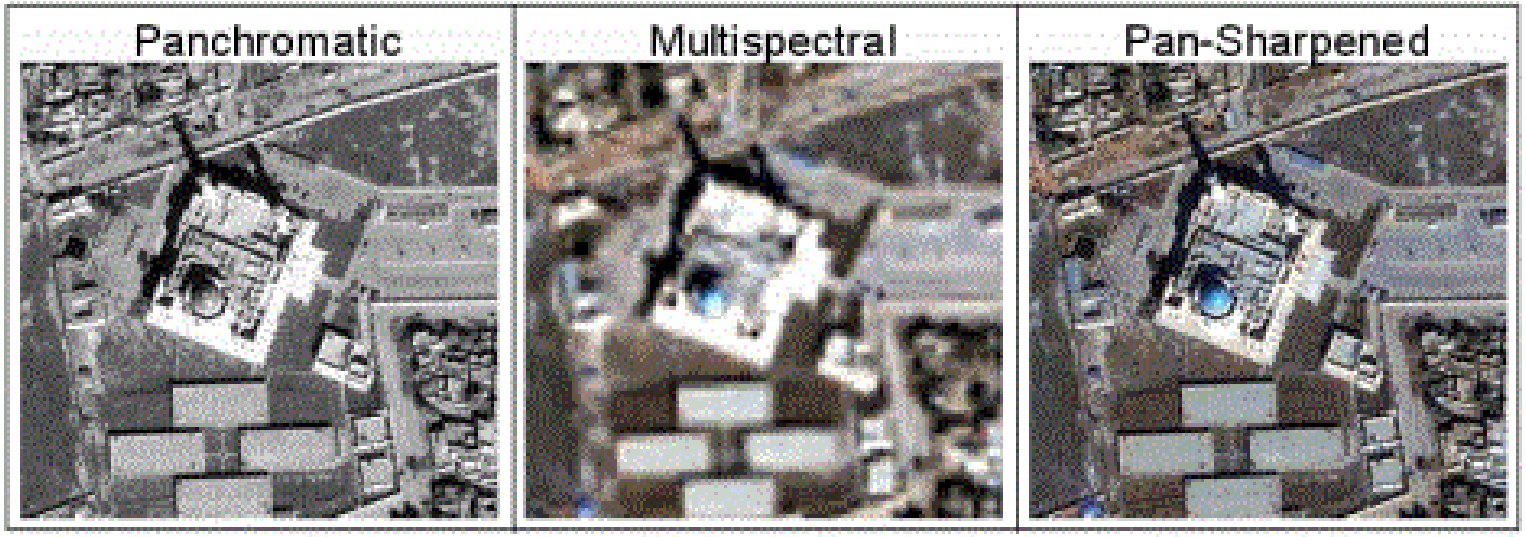






PAN-SHARPENING

- Pan-sharpening is a technique that merges high-resolution PAN data with medium-resolution MSI data to create a multispectral image with higher-resolution features.



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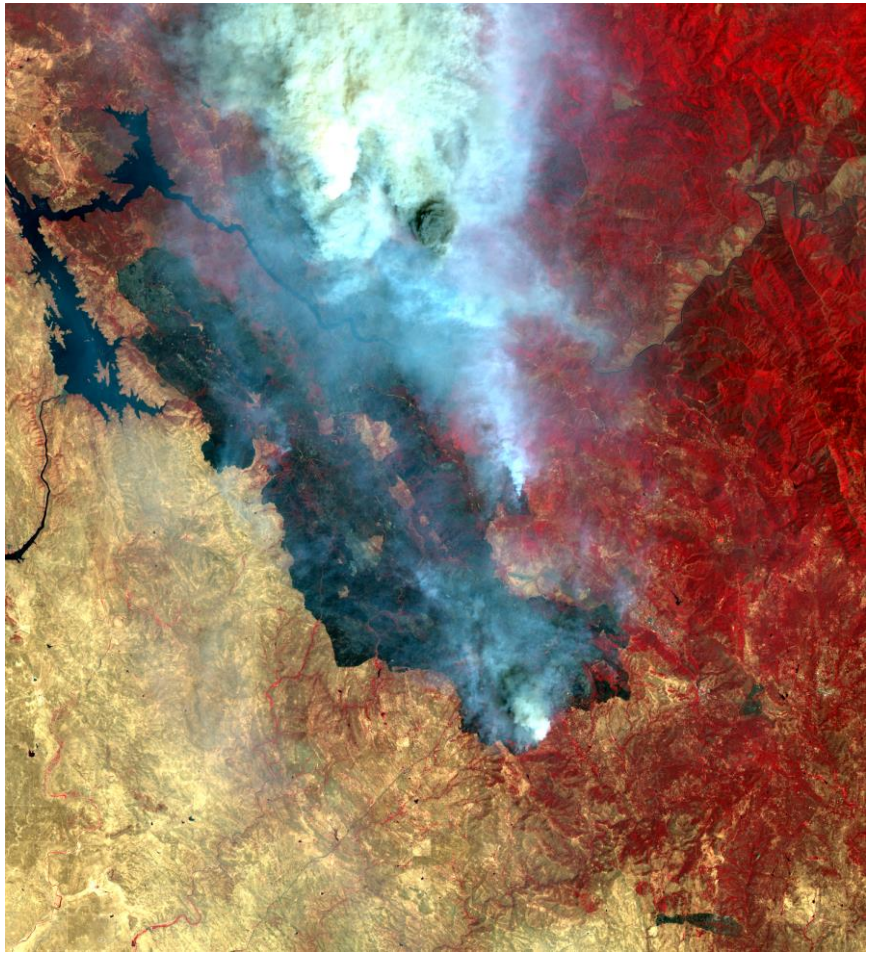
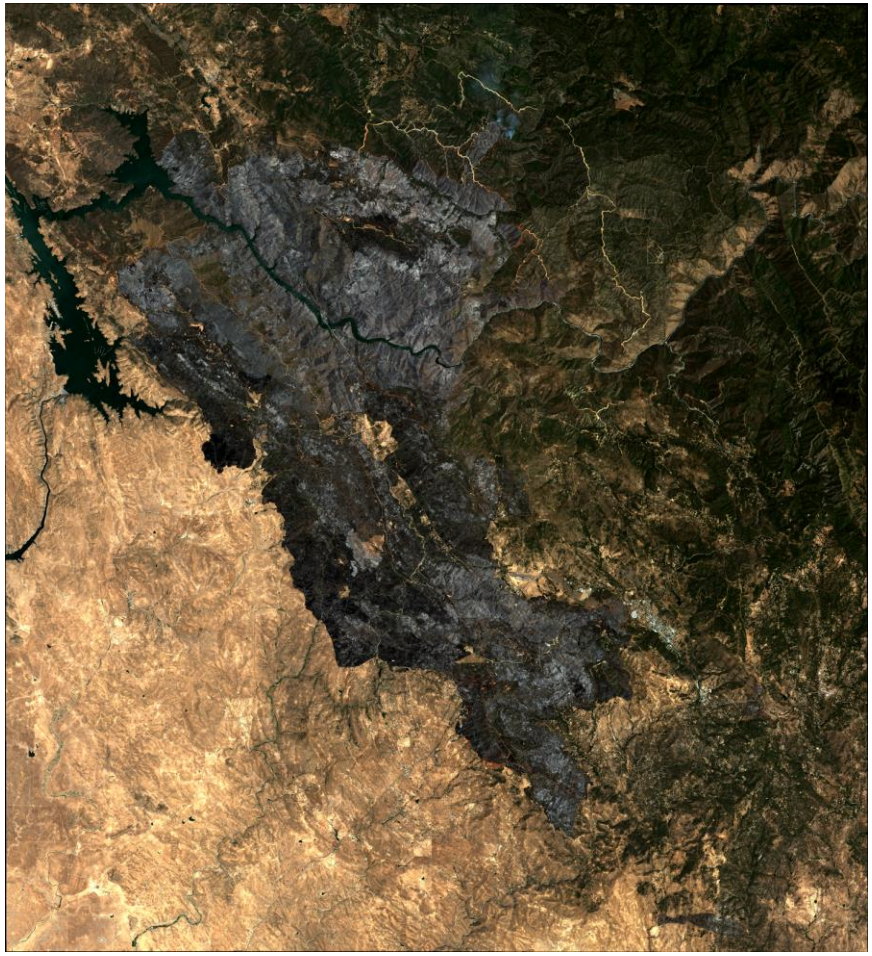
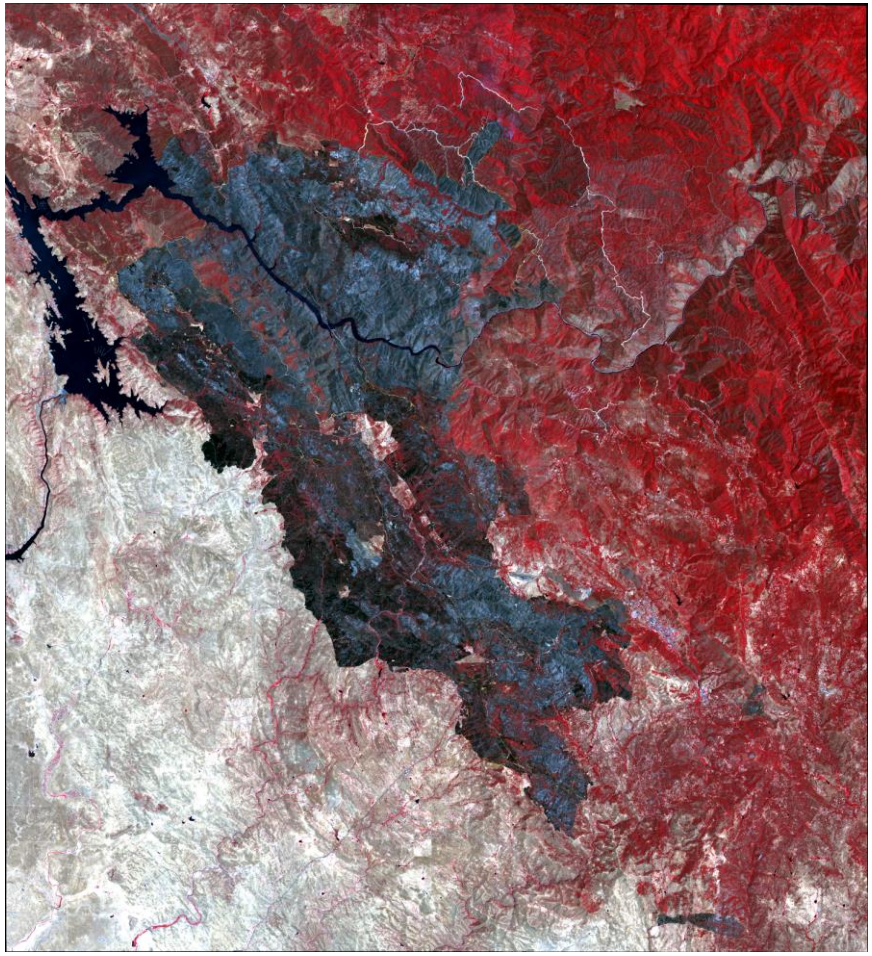
Images of Fires and Burn Scars



19 July 2017 - Detwiler Fire - SPOT 6
RGB: “True Color” (left) vs. NIR: “False Color” (right)

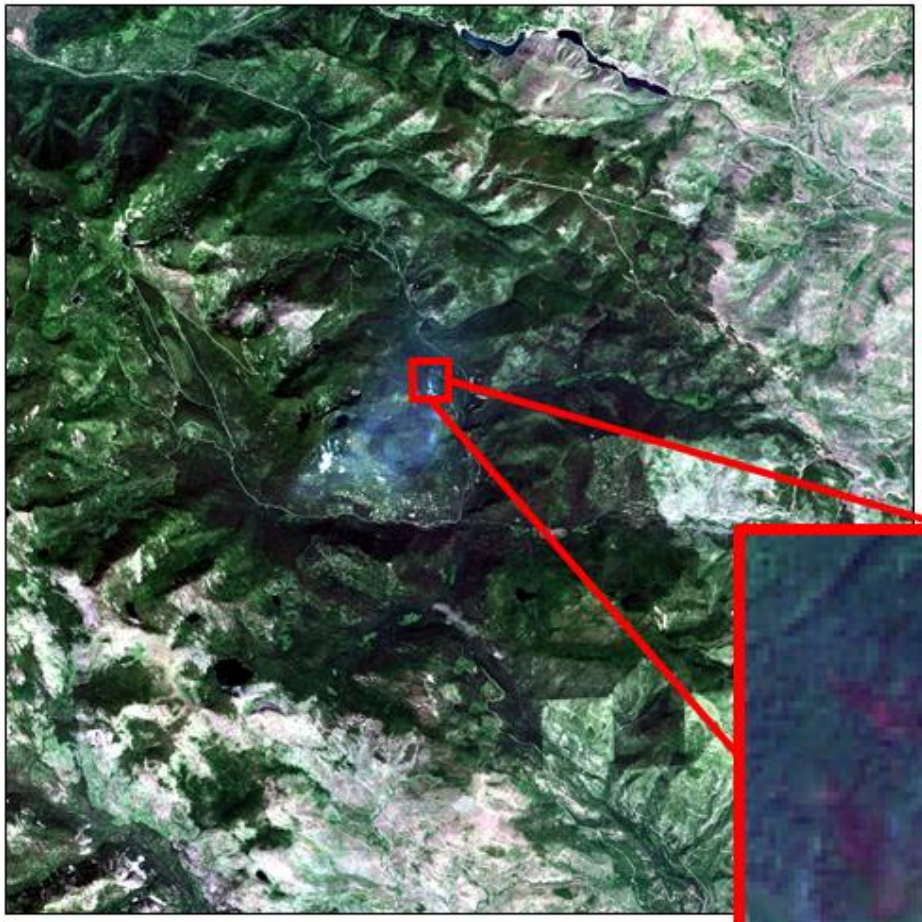
INTERRA





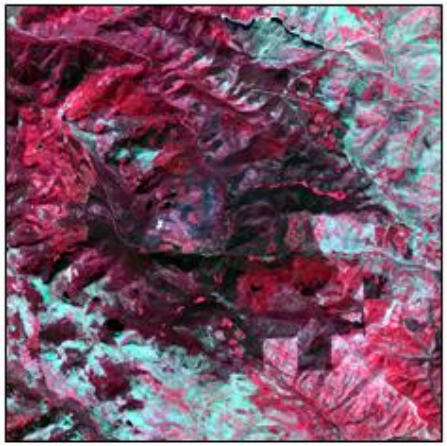
25 July 2017 - Detwiler Fire - SPOT 7
RGB: “True Color” (left) vs. NIR: “False Color” (right)

INTERRA

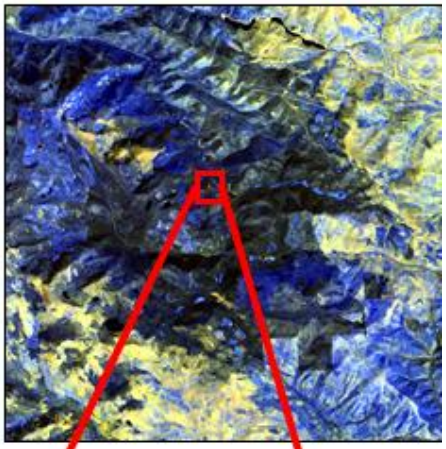


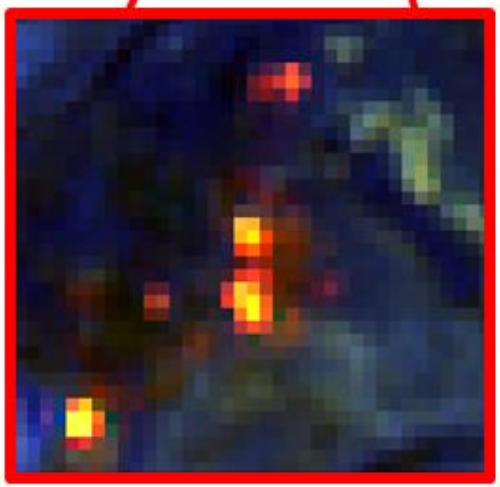
"True Color"

"False Color"



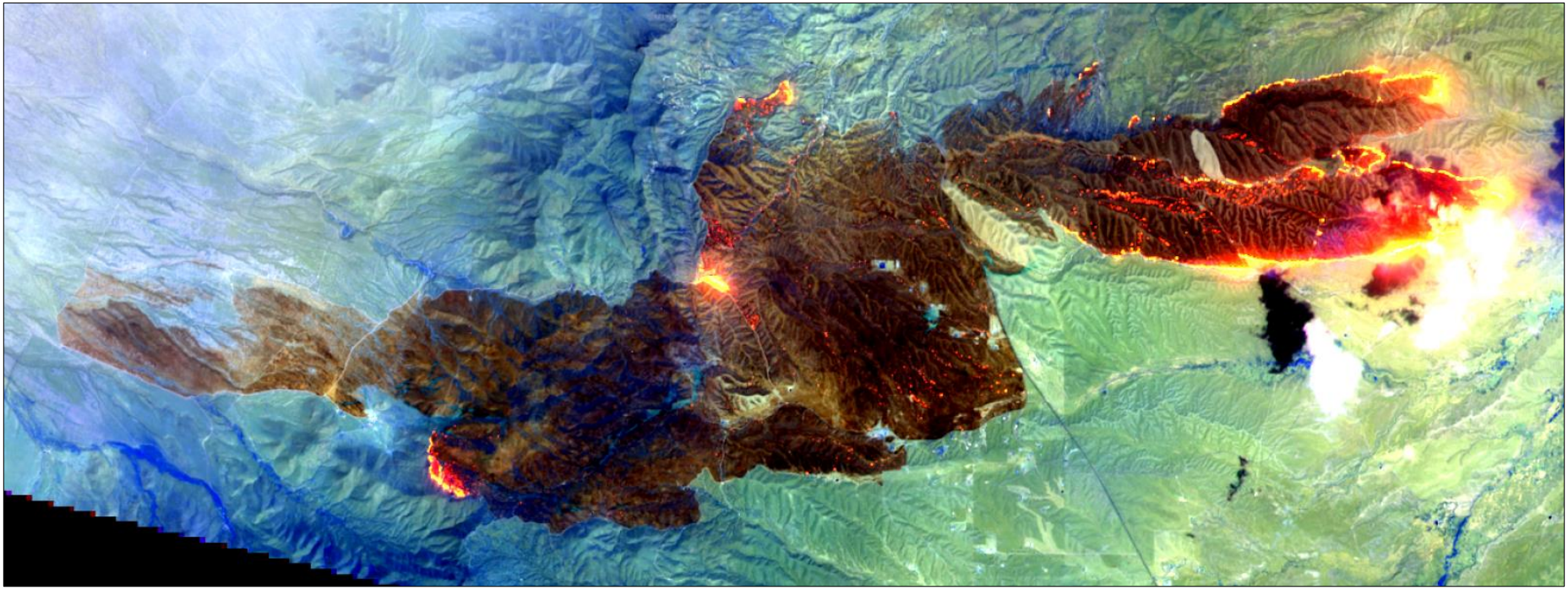
"False Color"





23 July 2017 - Liberty Fire - Sentinel-2A

INTERRA



25 April 2017 - Sawmill Fire - Sentinel-2A - SWIR: “False Color”

17 August 2017 - Eclipse Complex Fire
Multi-Mission Aircraft Collections - Infrared Imagery

INTERRA

LIDAR

- Similar to RADAR, Light Detection and Ranging (LiDAR) sensors transmit their own energy, and then receive the backscattered energy to form an image.
  - Both LiDAR and RADAR, therefore, are **active** sensors.
- LiDAR technology uses lasers to exploit the focused, coherent nature of a laser beam to produce detailed imagery. Most LiDARs use wavelengths in a specific portion of the electromagnetic spectrum for different tasks:
  - For penetration of water bodies: 0.532 micrometers (green band)
  - For sensitivity to vegetation, ability to detect open water, and freedom from atmospheric scattering: 1.64 micrometers (NIR band)
- Different designs of LiDAR instruments include:
  - Waveform LiDAR
  - Discrete Return LiDAR
  - Pulsed LiDAR

Oregon LiDAR Consortium

Aircraft computer records pulse return data.

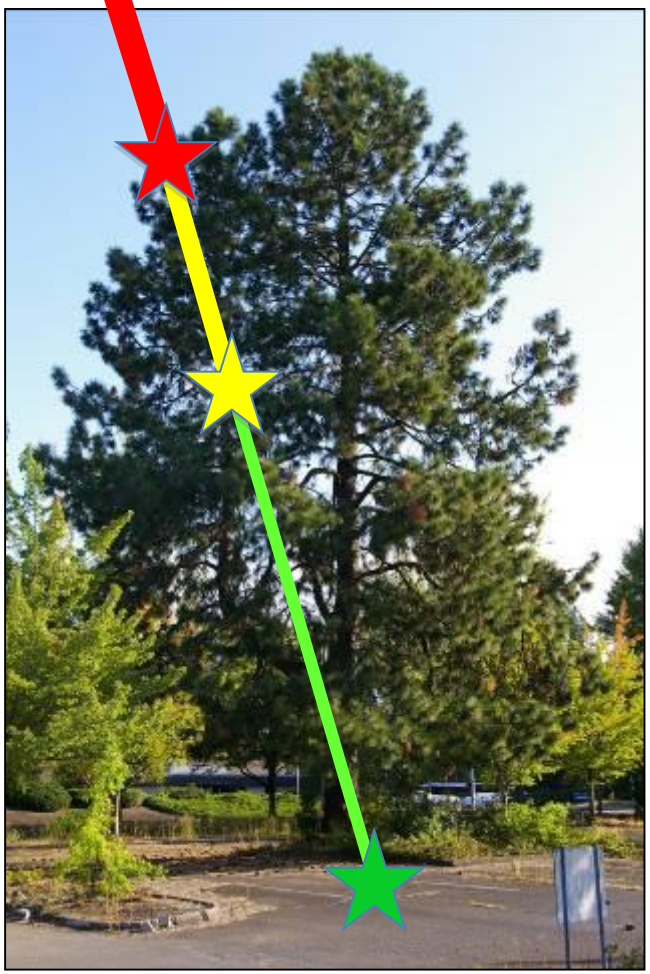
- Travel time, combined with known location and attitude of laser platform plus scan angle allows for calculation of precise locations of each return point.

The laser can scan the surface at ~30,000 pulses per second.

Aircraft ***attitude*** is determined by Inertial Measurement Unit (IMU).

Aircraft ***location*** is known to within a few cm using GPS base stations.

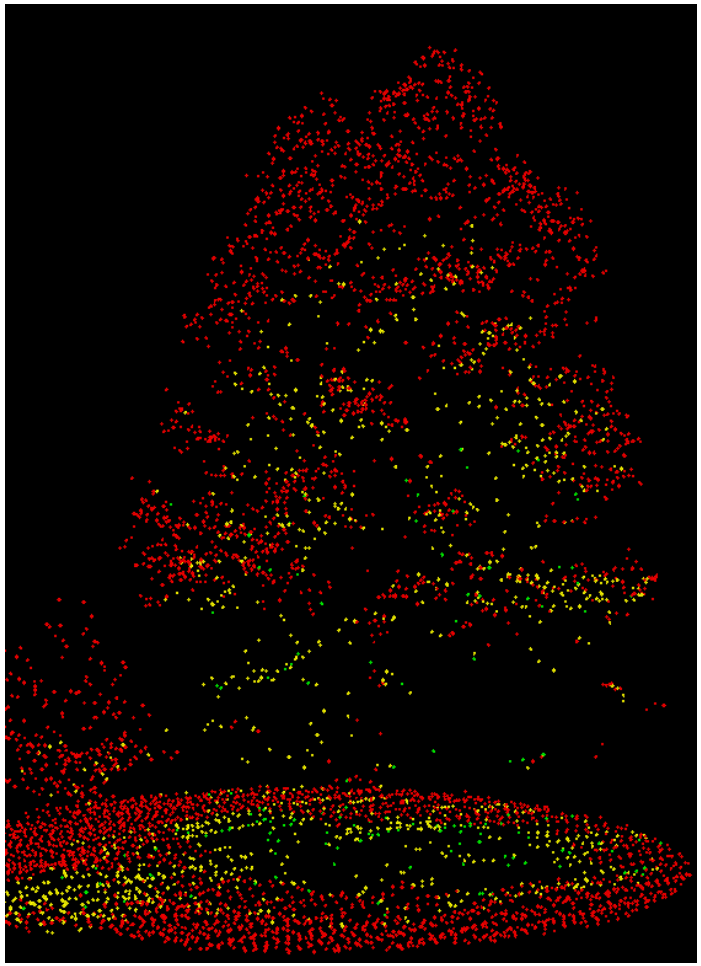
Each laser pulse can produce multiple returns by reflecting off several surfaces in its path.



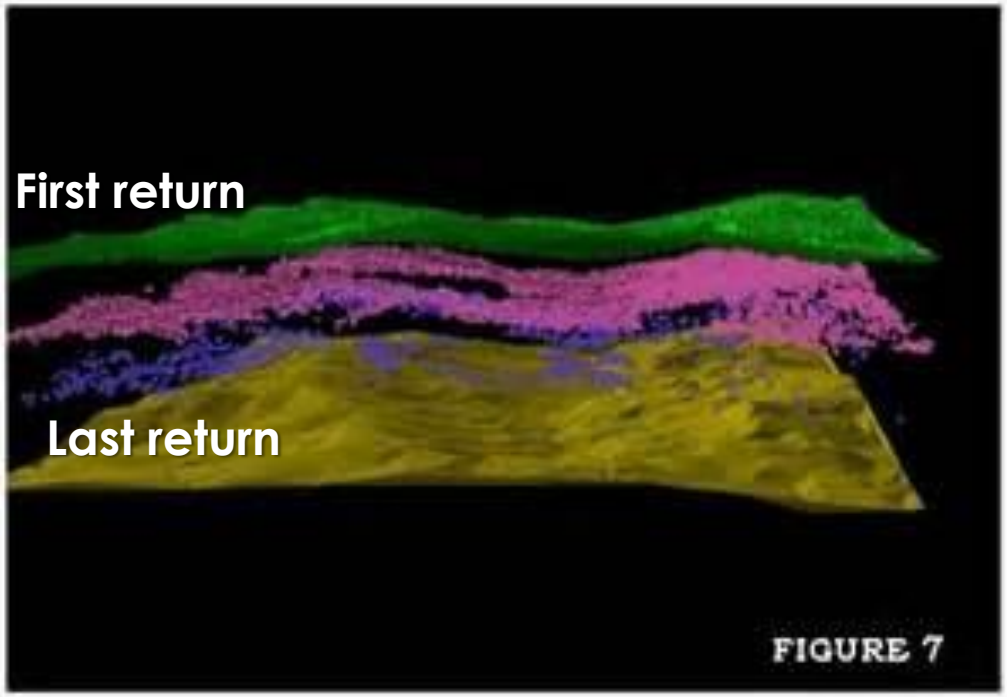
Left: Each return defines a point in space with a unique set of X-Y-Z coordinates

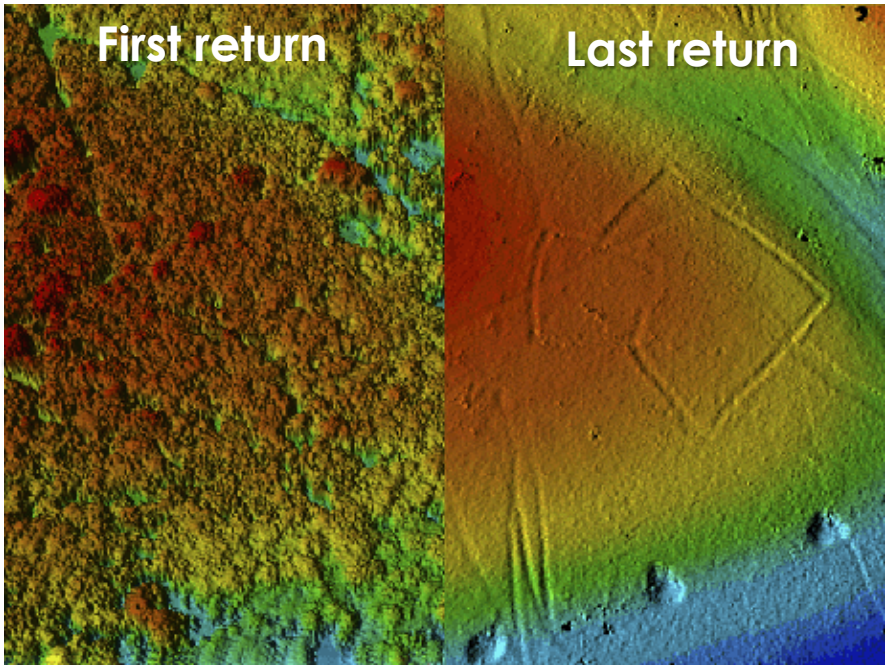
Right: Point cloud view of tree (right), colorized by LiDAR return:

- Red = 1st return
- Yellow = 2nd return
- Green = 3rd (last) return



LIDAR: FIRST VS. LAST RETURNS





LIDAR VIDEOS

How LIDAR Scans Reveal Angkor's Hidden City

Visualization of LIDAR data

Radiohead – House of Cards

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BENEFITS OF HSI & LIDAR

- MSI & HSI
  - MSI & HSI: Teaches users about areas of healthy vs. dying/dead vegetation
  - HSI: Successfully maps tree species
  - MSI & HSI: Allows us to identify areas with fire retardant
  - Con: Restricted to horizontal plane, meaning it provides limited insight to vertical distribution of forest structure

- LiDAR
  - Powerful technology for determining terrain elevations and vertical distributions

INTERRA

HOW DOES THE INTTERRA AUTO-PROCESSOR WORK?

- Code – Intterra Auto-Processor
  - Data search and discovery → Sensor/Template matching → Atmospherics, Algorithm, Products.
  - Currently written for: Quickbird, WorldView-2, Landsat 7 and 8, Spot 5 and 6/7, and a variety of HSI systems (AISA, Terra, many DoD systems)
    - Currently working to update for: WorldView-3, Sentinel-2, Planet
  - Several processing chains but, in summary:
    1. Performs atmospheric correction
    2. Chips imagery to a specified area of interest
    3. Performs target detection
       - Hot spots
       - Fire retardant
    4. Creates a file that summarizes product output/results

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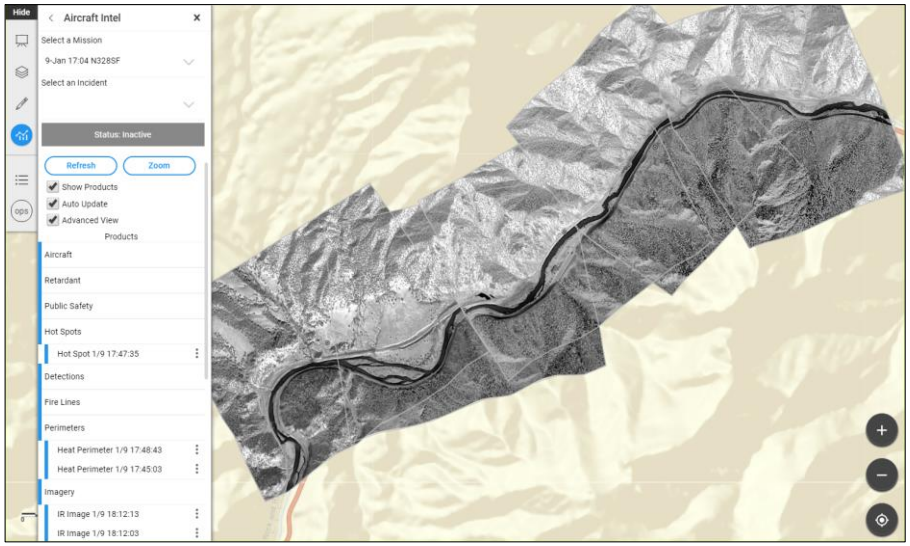
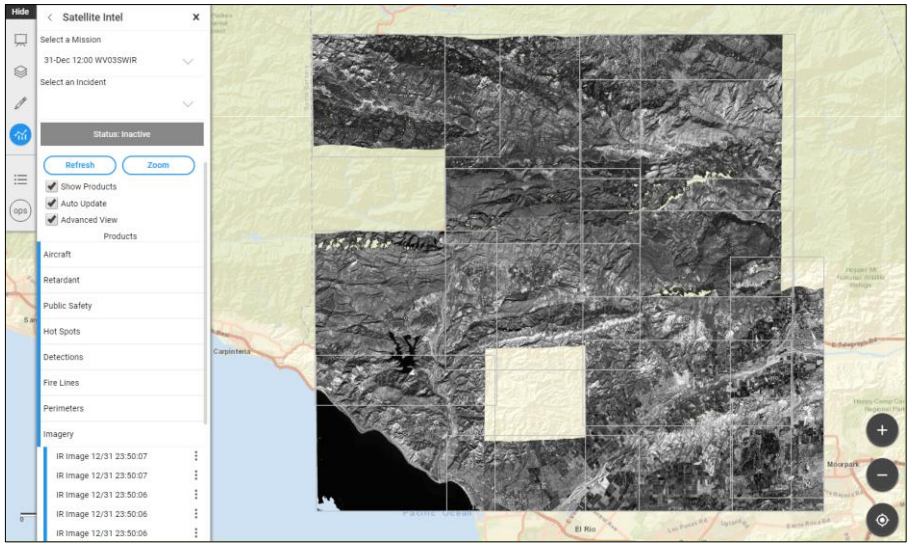
HOW CAN I VIEW REMOTELY SENSED IMAGE DATA IN SITUATIONANALYST (SA)?

AIR & SATELLITE INTEL TOOLS

Air Intel Tool



Satellite Intel Tool



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DATA SHARED BY INTEL TOOLS

- Depending on the airborne (specific drone or UAV) or spaceborne (satellite sensor) platform utilized, the following information may be available:
  - Aircraft
  - Retardant
  - Public Safety
  - Hot Spots
  - Detections
  - Fire Lines
  - Perimeters
  - Imagery
  - Videos
- Can search based on mission or incident

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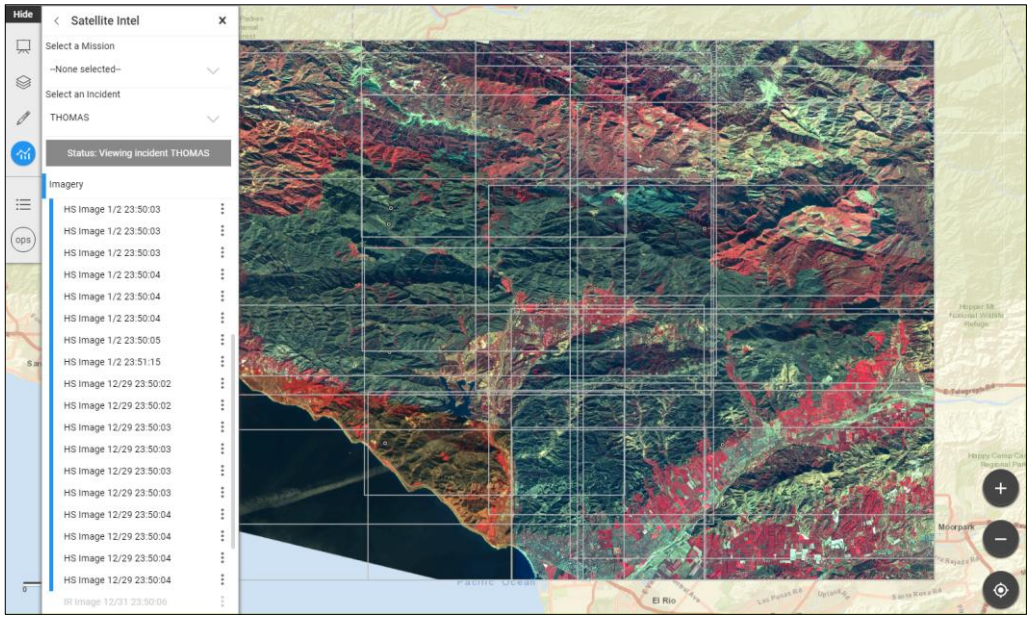
Example (right): Satellite Intel Tool displaying infrared imagery.



Example (left): Air Intel Tool with video captured by the Multi-Mission Aircraft (MMA).
Intterra is continuing work to ingest other UAV and drone data as well.

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QUESTIONS?

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EXTRA SLIDES

USEFUL LINKS

- HSI:
  - USGS Spectral Viewer

- LiDAR:
  - http://gisgeography.com/lidar-light-detection-and-ranging/
  - http://www.opentopography.org/index.php/resources/educators
  - http://www.lidarbasemaps.org/
  - http://lidar.cr.usgs.gov/
  - http://www.neoninc.org/data-resources/get-data/airborne-data
  - How Does LiDAR Remote Sensing Work?
  - Introduction to LiDAR
  - This Technology Could Transform Life in Cities

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APPLICATIONS OF LIDAR

- General:
  - Precise 3D mapping of natural and human-made objects
  - Object height determination
  - Emergency response
  - Temporal change comparison/change detection
- Environmental:
  - Vegetation density/biomass and cover estimation
  - Topographic mapping
  - Modeling of areas affected by inundation and storm surges
  - Hydrodynamic modeling
  - Shoreline mapping
  - Hydrographic surveying
  - Coastal vulnerability analysis
  - Floodplain mapping
  - Atmospheric studies
- Urban:
  - Determination of building densities
  - Highway planning
  - Building footprint determination
  - Route planning

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