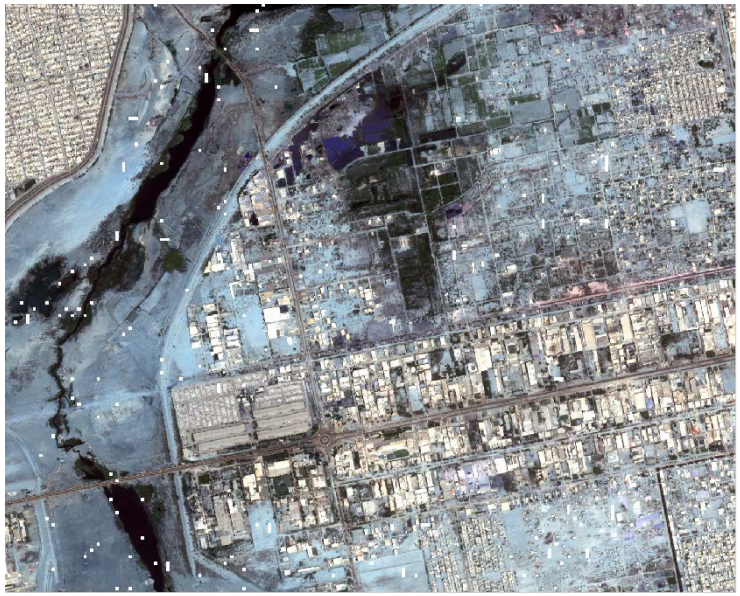
Remote Sensing

Use of Remotely Sensed Imagery

- Satellite imagery and aerial photography can be powerful datasets
- An understanding of some basic terms and differences between the two will allow you to make better decisions about when and how to use remotely sensed imagery
- The ability to automatically extract objects from imagery, whether point or linear, is appealing but is also a considerable technical challenge

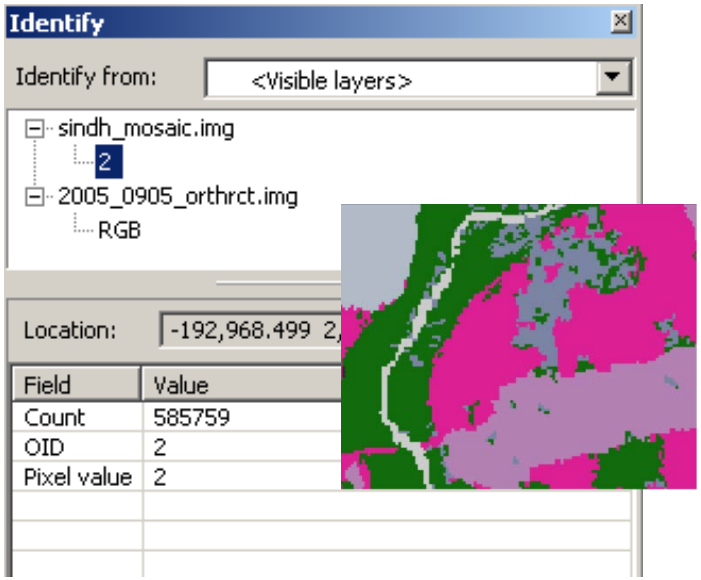
Raster Concepts

- All raster data types are tessellations (i.e. divisions of geographic space)
- Raster tessellation divides the space into a series of discrete chunks within which to represent geographic data (i.e. quantizing space)

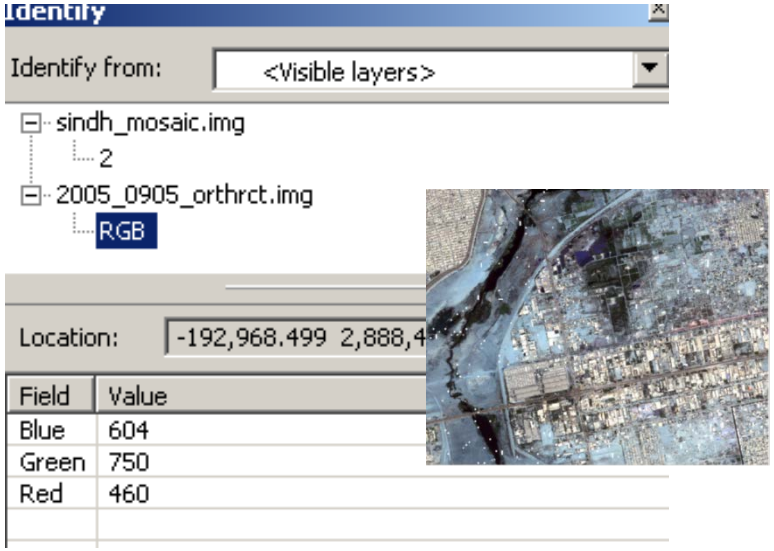


Raster Representation

The images show the same area in a categorical and image-like raster.



Categories represented by a number.



3 band combination that may be integer or continuous (floating point).

Remote Sensing Terminology

- **Satellite Image:** Data based on reflected or emitted electromagnetic radiation collected from orbit that can be used to create photograph-like representations.
- **Aerial Image:** Data based on reflected or emitted electromagnetic radiation collected from a sub-orbital platform, most commonly an airplane, which can be used to create photograph-like representations.
- **Sensor:** A particular instrument used to collect either satellite images or aerial photographs with a set resolution and sensitive to particular bands.

Remote Sensing Terminology

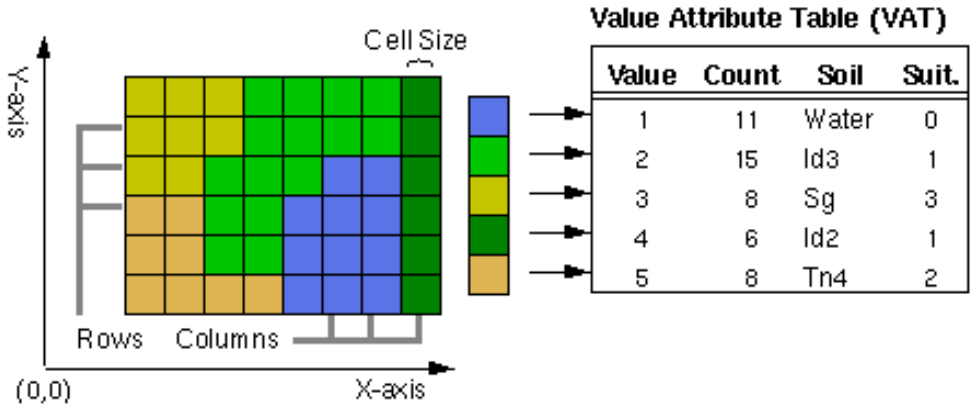
- **Band:** A range of values in the electromagnetic spectrum (e.g., visible light) to which a sensor is sensitive.
- **Color Composite:** An image created from a combination of bands using the Red, Green, and Blue channels. If the red, green, and blue bands are in the red, green, and blue channels the image is referred to as a true-color composite.
- **Pixel:** The lowest resolvable unit in any remotely sensed image, the dimensions of which are referred to as the resolution of the image.

Raster Formats

- There are several types of raster formats.
  - Ex: BMP, GIF, ERS, MrSID, NITF, IMG.
- Most commonly used: TIFs, IMGs, JPGs, Binary files, GRIDS.
- We will be using IMGs for all of our outputs.
- What is a GRID file?
  - A grid is a raster data storage format native to ESRI. There are two types of grids: integer and floating point.
    - Integer grids are used to represent discrete data
    - Floating-point grids represent continuous data.

Raster Data Structure

- Integer grids (discrete data) store pixel or cell values in a Value Attribute Table (VAT).



- Floating point grids (continuous data) do not store pixel or cell values in a Value Attribute Table (VAT).

Discrete and Continuous Data

- **Discrete:** A geographic feature with a discernible boundary. For example a house, road, or tree stand. Represented by a vector or raster.
- **Continuous:** A geographic field that varies over space without a clear defined boundary. For example elevation, population density, or rainfall. Nearly always represented by a raster, or contour lines.

Integer and Floating Data

- **Integer:** Always used when representing discrete data in raster format (categories). Can also be used to represent continuous data on a compressed histogram.
- **Floating Point:** Each pixel can have a positive or negative real number value. Processor intensive during analysis. Files can be large.

Integer Datasets

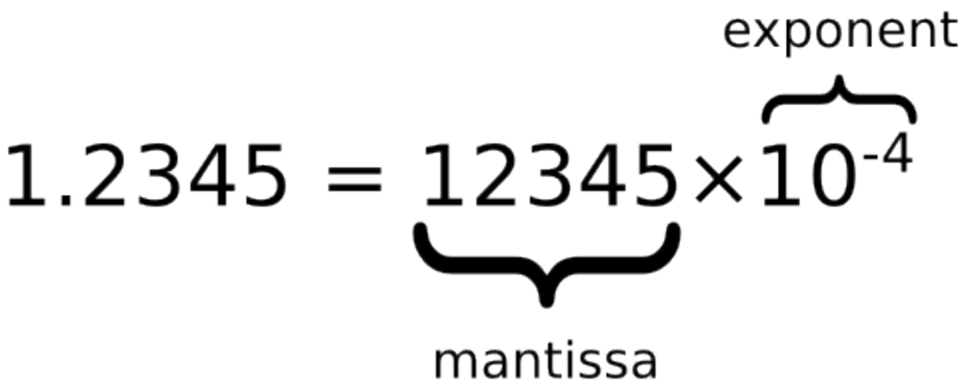
- Categorical rasters are stored as discrete integer values.
- Image like rasters (combinations of colored bands) rasters may also have discrete values.

Bit Value	Possible Integer Values
1	0 - 1
8	0 - 255
16	0 - 6,535
32	0 - 4,294,967,295

Halved for signed values.

Floating Points Datasets

- Also called floating point
- Often the format in which satellite data are received
- Software may list the type as “continuous”



Why do Rasters Matter?

- Native format for satellite imagery
- Allow for fast processing of large amounts of data
- Algorithms can be modeled more simply using raster and the built-in operators and functions contained in Commercial Off The Shelf software (frequently referred to as COTS in IT/management jargon)

Other Raster Data Formats

- **Imagine Image File (.img):** a proprietary format but easily convertible between software. Geographic information, VAT, and color map all stored in single file. Larger files will split data into a .ige file.
- **GeoTIFF:** A standard digital image format with an embedded header that stores geographic information.

Requirements for Working with Remotely Sensed Imagery

- Remote sensing software
  - Spatial analyst in ArcGIS, ERDAS Imagine, ENVI, GRASS/QGIS (open-sources)
- Imagery
  - Multi-band – Classification and analysis
  - Photography – Manual interpretation and adjustment only

Storage and Retrieval

- Storage
  - Remotely-sensed datasets tend to be large
  - 500 MB-3 GB for high-resolution (QB, 18 km x 16.4 km)
  - 1 GB Landsat-8 (170 km x 183 km)
- Retrieval
  - Image catalogs can be confusing, staff time often lost trying to find correct image
- ERDAS Apollo (Hexagon), ArcGIS Image Extension for ArcGIS Server (esri)

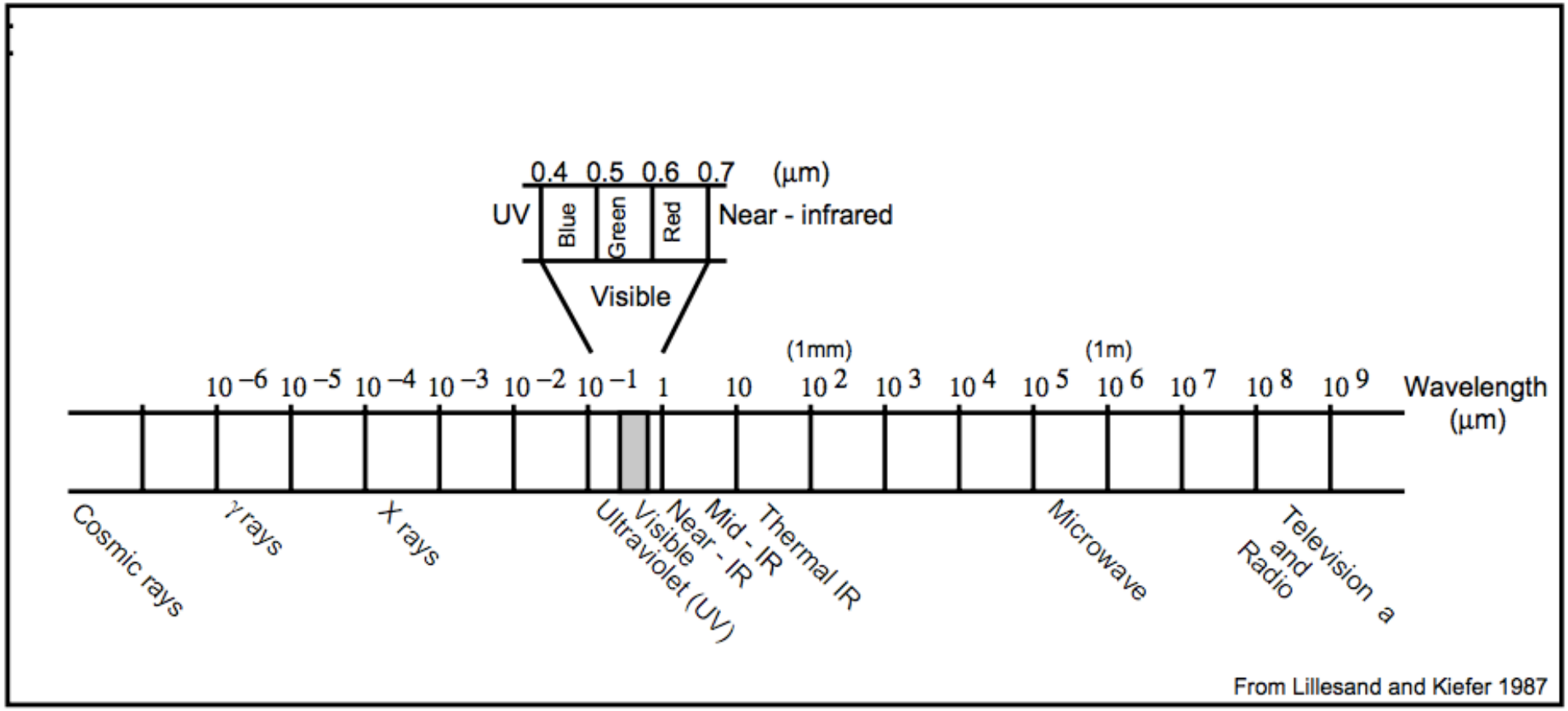
Group Discussion

- Which type of raster would you expect to receive from a remotely sensed source?
- Which data model does that raster represent?
- How might you want to transform remotely sensed data at an NSO and which data model would the transformed data represent?

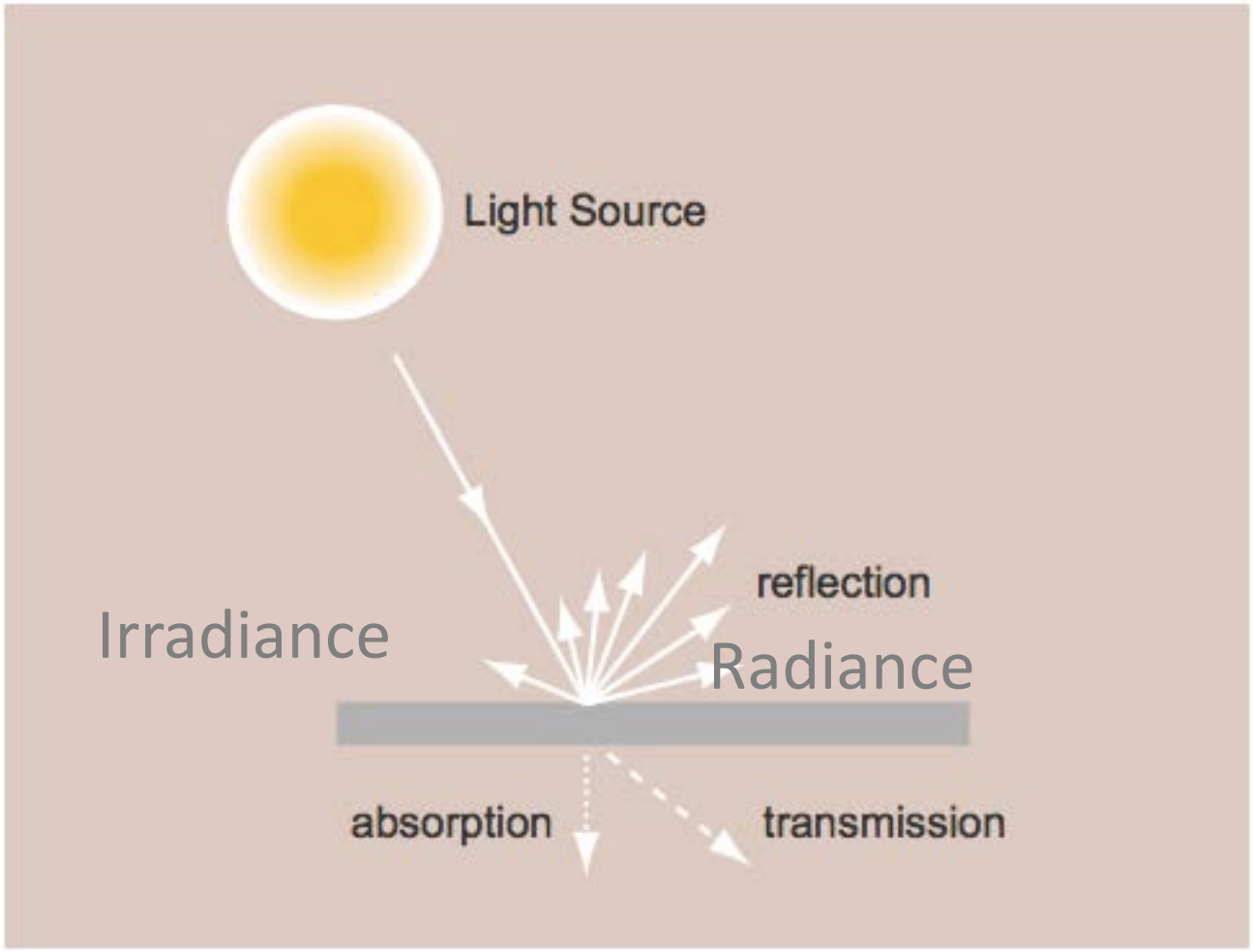
Remotely Sensed Data and Sources

Wavelengths

- Electromagnetic spectrum



Spectral Response



Types of Sensors

- Active
  - RADAR
  - LiDAR
- Passive (optical)
  - ASTER
  - AWiFS
  - CBERS
  - IKONOS
  - Landsat
  - MODIS
  - SPOT
  - Quickbird
  - WorldView

Landsat 8 – OLI **Launched February, 2013**

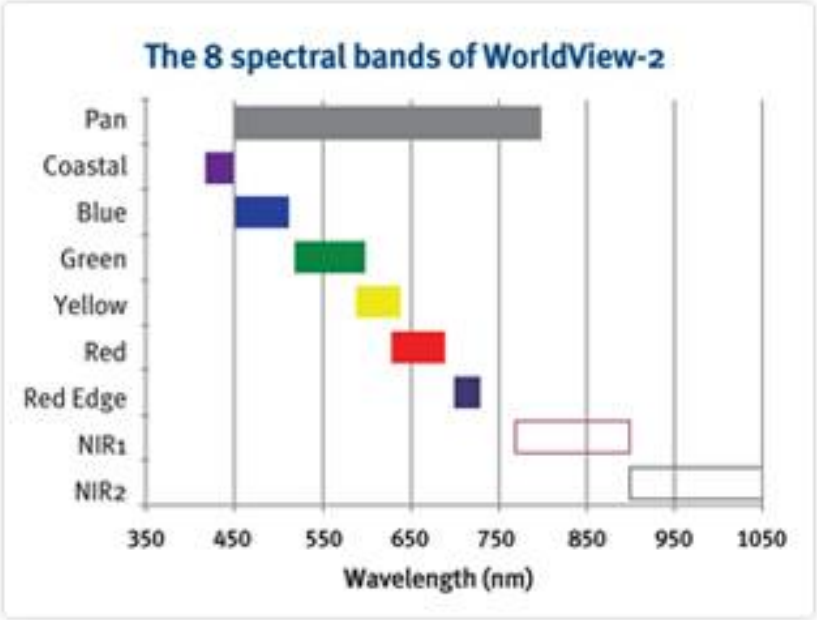
- Operational Land Imager

Spectral Band	Wavelength	Resolution
Band 1 - Coastal / Aerosol	0.433 - 0.453 µm	30 m
Band 2 - Blue	0.450 - 0.515 µm	30 m
Band 3 - Green	0.525 - 0.600 µm	30 m
Band 4 - Red	0.630 - 0.680 µm	30 m
Band 5 - Near Infrared	0.845 - 0.885 µm	30 m
Band 6 - MIR	1.560 - 1.660 µm	30 m
Band 7 - MIR	2.100 - 2.300 µm	30 m
Band 8 - Panchromatic	0.500 - 0.680 µm	15 m
Band 9 - Cirrus	1.360 - 1.390 µm	30 m

- 12 Bit Radiometric Resolution
- Pushbroom vs. Whiskbroom sensor

WorldView 2 – Digital Globe

- Launched October 8th 2009
- 1.8 m Multispectral
  - 8 Bands
- .46 m panchromatic
- 11 bit
- 16.4 km swath width
- 1.1 day repeat



Ikonos

- Spectral/Spatial resolutions:
  - 4 Multispectral bands (4m)
    - Blue, Green, Red, NIR
  - 1 panchromatic band (1m)
  - Swath 11 km
- Temporal resolution: < 3 days
- Radiometric resolution: 11-bits

QuickBird

- Spatial/Spectral Resolution
  - 0.6m, Panchromatic
  - 2.4m, multi-spectral (1-B, 2-G, 3-R, 4-NIR)
  - 16.5 km swath width
- Radiometric
  - 11 bit
- Temporal
  - 1-3.5 day Revisit Frequency

Integrating Satellite Data

- Multi-Spectral Classification
  - Based on how light reflects off of different surfaces
- Object-based classification
  - Based on reflecting light and geometric properties of objects
- Photo-interpretation
  - Human interpretation (digitization) of features

Storage and Retrieval

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Others

- Formosat 2
  - Taiwan's National Space Organization
    - 2 meter pan, 8 m vis-NIR
- Cosmos KVR-1000
  - 2 m pan - Russian
- Eros
  - Earth Resources Observation Satellite, Israel
  - 1.8 m pan
- Indian Remote Sensing (IRS)
  - 5.8 m pan, 23 m vis-NIR
- Kompsat 2
  - KOrean MultiPurpose SATellite
  - Panchromatic : 1 m
    Multispectral (B, G, R, NIR) : 4 m
- Worldview 1, 2, 3
- Geoeye 1, 2
- Rapid Eye

http://www.satimagingcorp.com/satellite-sensors.html