Session 8: Image Analysis and Remote Sensing

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Class Schedule

Monday	Tuesday	Wednesday	Thursday	Friday
08/05/19 **Introduction to Geographical Information Systems** 10:45 am–12:15 am	08/06/19 **Cartography and Spatial Data Display** 8:30am – 11:00pm	08/07/19 **Querying Data for Spatial & Attribute Selections** 8:30am – 11:00pm	08/08/19 **Data Formats and Open-Source GIS** 8:30am – 11:00pm	08/09/19 **Map Projections and Coordinate Systems** 8:30am – 11:00pm
08/12/19 **Spatial Analysis Tools** 8:30am – 11:00pm	08/13/19 **Raster and Terrain Analysis** 8:30 am – 10:00 am **Scripps Institution of Oceanography** 1:00pm – 4:00pm	08/14/19 **Image Analysis & Remote Sensing** 8:30am – 11:00pm	08/15/19 **Editing Spatial Data and Geocoding** 8:30am – 11:00pm	08/16/19 **Web Mapping/ Wrap up** 8:30am – 11:30am

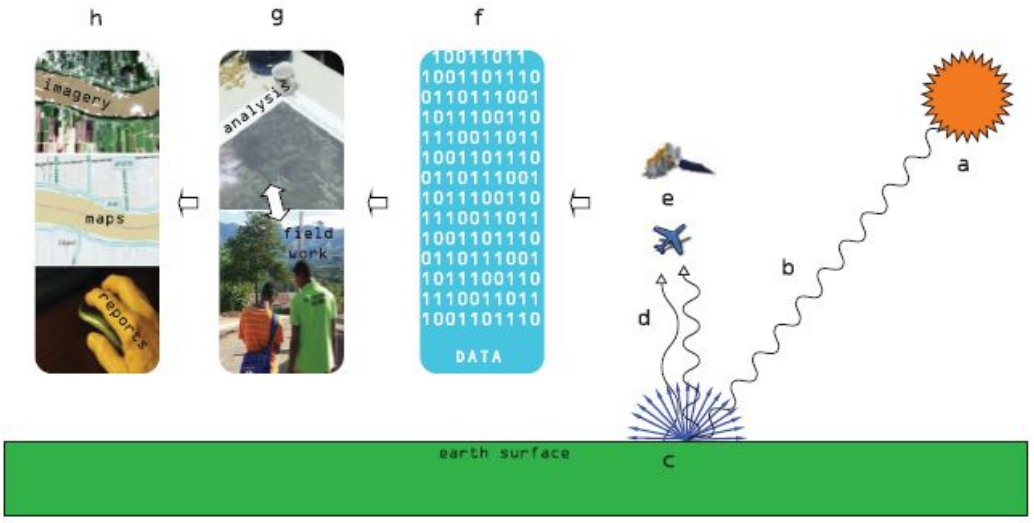
Outline: Imagery and Remote Sensing

- Introduction
- Available Imagery
- ArcGIS Pro Tools
- Displaying Image Data
- Demonstration

Introduction

- Remote sensing:
  - data collected using devices not in contact with target
- Many different types of remote sensing
  - Aerial Imagery
  - Satellite Imagery
  - Radar Imagery
- Used in multiple applications

Remote Sensing



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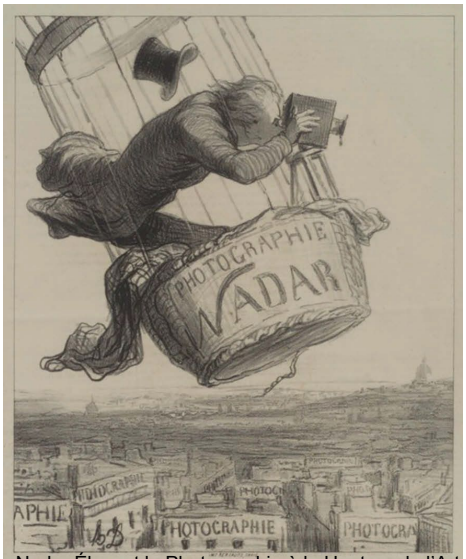
Instrument emits electromagnetic radiation (EMR)
EMR is either reflected, transmitted, or absorbed
Two types of remote sensing:
Passive
Active

Types of Remote Sensing

- Aerial photography
- Satellite imagery
- Multispectral imagery
- Radar
- LiDAR



Nadar Élevant la Photographie à la Hauteur de l'Art, Daumier; Honoré-Victorin Daumier, 25 May 1862

Many Platforms

Geosynchronous — 22,236 miles

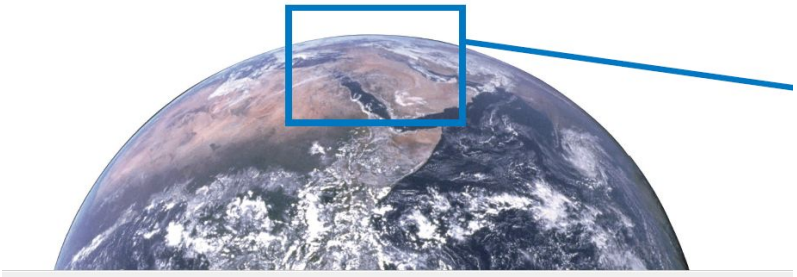
Satellites that match Earth's rotation appear stationary in the sky to ground observers. While most commonly used for communications, geosynchronous orbiting satellites like the hyperspectral *GIFTS* imager are also useful for monitoring changing phenomena such as weather conditions. NASA's Syncom, launched in the early 1960s, was the first successful "high flyer."

Sun synchronous — 375–500 miles

Satellites in this orbit keep the angle of sunlight on the surface of the earth as consistent as possible, which means that scientists can compare images from the same season over several years, as with Landsat imagery. This is the bread-and-butter zone for earth observing sensors.

Atmospheric satellite — 100,000 feet

Also known as pseudo-satellites, these unmanned vehicles skim the highest edges of detectable atmosphere. NASA's experimental Helios craft measured solar flares before crashing in the Pacific Ocean near Kauai.



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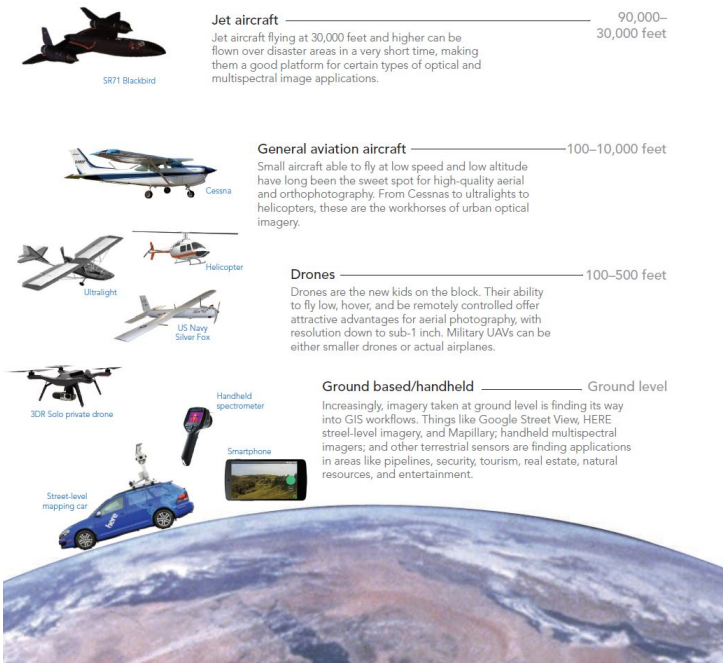

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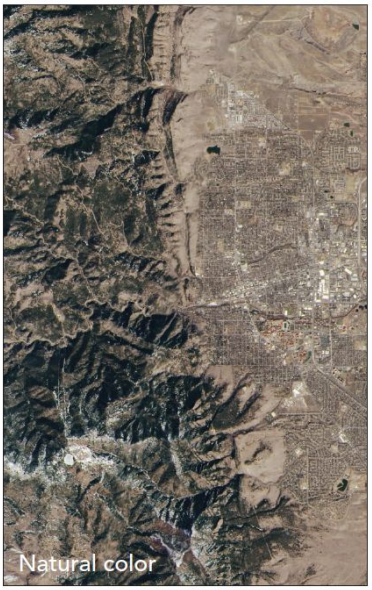
Jet aircraft
Jet aircraft flying at 30,000 feet and higher can be flown over disaster areas in a very short time, making them a good platform for certain types of optical and multispectral image applications.

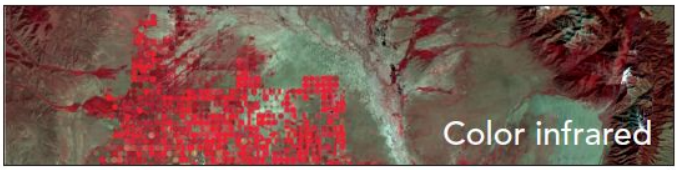
General aviation aircraft
Small aircraft able to fly at low speed and low altitude have long been the sweet spot for high-quality aerial and orthophotography. From Cessnas to ultralights to helicopters, these are the workhorses of urban optical imagery.

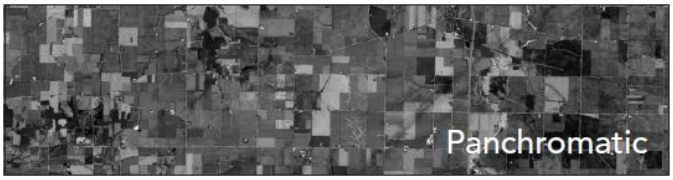
Drones
Drones are the new kids on the block. Their ability to fly low, hover, and be remotely controlled offer attractive advantages for aerial photography, with resolution down to sub-1 inch. Military UAVs can be either smaller drones or actual airplanes.

Ground based/handheld
Increasingly, imagery taken at ground level is finding its way into GIS workflows. Things like Google Street View, HERE streel-level imagery, and Mapillary; handheld multispectral imagers; and other terrestrial sensors are finding applications in areas like pipelines, security, tourism, real estate, natural resources, and entertainment.

Imagery Types



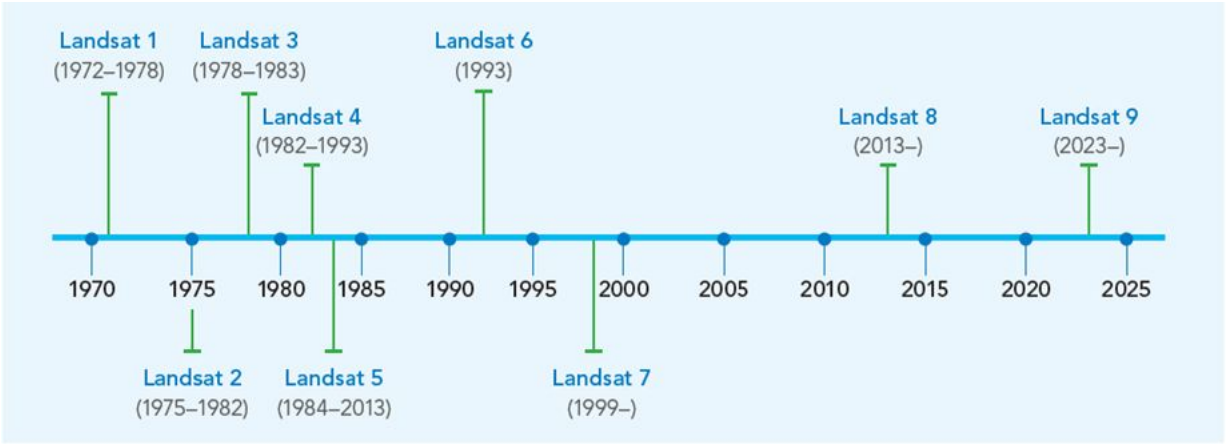




Source: The ArcGIS Imagery Book

Landsat Satellite Data

First satellites to provide continuous global observation



Source: The ArcGIS Imagery Book

Landsat Satellite Imagery can be viewed as a time machine
They are/were the first satellites to provide continuous global observation.

Landsat sees Earth in a unique way. It takes images of every location in the world to reveal Earth's secrets, from deforestation patterns, to agricultural trends, to volcanic activity, to urban sprawl. The Landsat program started collection with early sensors in the 1970s and continues with the current Landsat 8 mission. Since every part of the earth is captured every couple of weeks, this enables us to see and analyze how places change over time. Publicly shared imagery

The USGS manages the Landsat data program and makes the imagery freely available for everyone. This collection has been continuously updated with new scenes from various Landsat sensors for over four decades, resulting in an amazing, historical earth imagery resource. New Landsat scenes are being collected daily. As new scenes are generated, they are added to a dynamically growing image mosaic containing millions of existing Landsat scenes in the shared database, providing extraordinarily useful information for historical comparisons.

Multispectral Imagery

Band 1	Coastal Aerosol
Band 2	Blue
Band 3	Green

Band 4	Red
Band 5	Near Infrared
Band 6	Shortwave Infrared 1

Band 7	Shortwave Infrared 2
Band 8	Panchromatic
Band 9	Cirrus

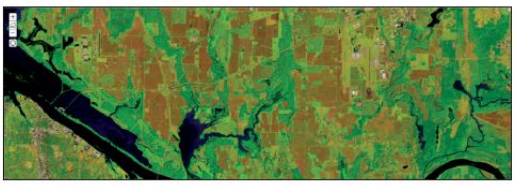
Band 10	Thermal Infrared
Band 11	Thermal Infrared

Natural color

Color infrared

Land and water interface

Vegetation analysis



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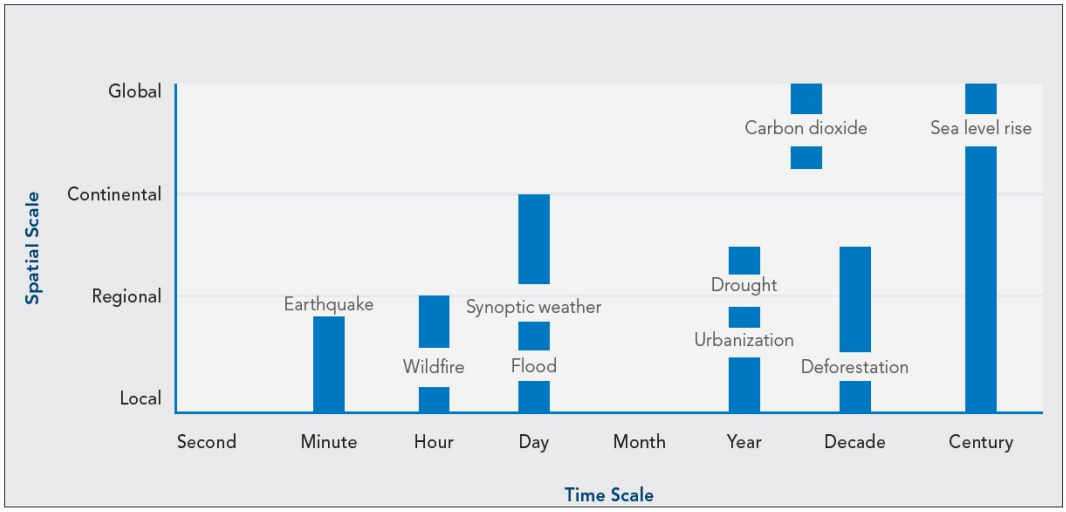
Source: The ArcGIS Imagery Book

One of the most extraordinary types of imagery collected by remote sensing is multispectral imagery. Each image is composed of data from a series of onboard sensors that collect small slices (or bands) across the electromagnetic spectrum. The table below shows the complete list of wavelengths (expressed as bands) that are collected by the Landsat 8 imagery according to what they capture. The images below are examples of what you “see” by combining different bands into red, green, and blue electronic displays or hard-copy prints.

Space-Time Scales



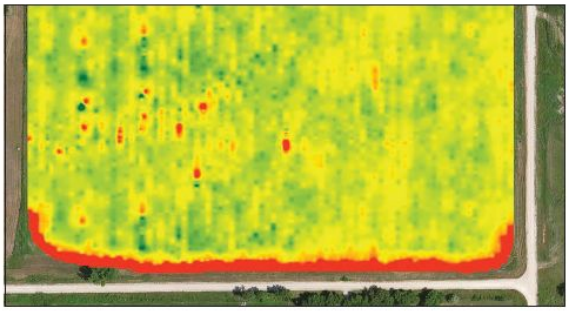
Critical challenges to our planet occur at various space-time scales.

Source: The ArcGIS Imagery Book

Explore information throughout time:
Visualize the past, understand the present, and help predict the future
For example, earth scientists use a time series of satellite observations to track monthly precipitation patterns such as snowpack coverage and extent as it descends from the higher latitudes and the poles during the winter months and then recedes in summer. Scientists use satellite time series observations to monitor droughts. And climatologists apply models to forecast climate trends for future points in time.
Continuous global satellite remote sensing
There is an ongoing explosion of continuously observing satellite platforms—both government and commercial—all contributing to our collections of earth observations. A number of satellites are designed for continuous observation, revisiting the same areas over repeating time periods—Landsat, MODIS, GLDAS, Sentinel, SPOT, and RapidEye, to name just a few.
New time-based capabilities are being developed
As computing and GIS continue to grow, new time-based capabilities are being developed and applied. Along with this trend, there is a growing appreciation for the critical importance of imagery's temporal aspects.

Applications

Precision agriculture



Information gathered during harvest, including yield at any given location, helps growers track their results and provides valuable input for calculating seeding and soil amendment rates for the following year.

Humanitarian aid

Access to up-to-date imagery shows the creation of the Zaatari refugee camp over a nine-day period in July 2012. Designed to hold over 60,000 people, its population skyrocketed to over 150,000 before new camps relieved some of the pressure. The story map The Uprooted tells the tale.

Source: The ArcGIS Imagery Book

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Story Map: Humanitarian aid
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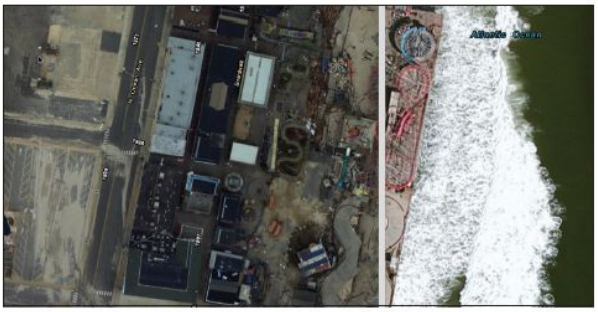
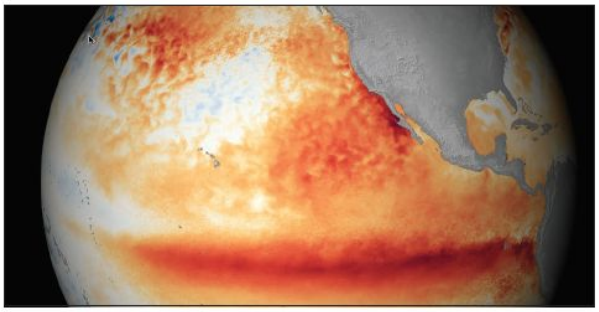
Applications

Natural disaster assessment



This scene shows the destruction of Hurricane Sandy's storm surge in Seaside, New Jersey. The active swipe map compares pre- and postevent imagery from the National Oceanic and Atmospheric Administration (NOAA).

Climate and weather study



This short map presentation from NOAA answers many of the questions about the effects of El Niño. Scroll down to learn more about this climate feature and its characteristics.

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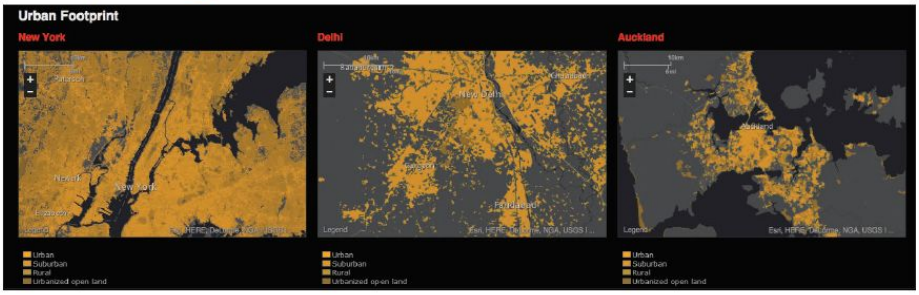
Applications

Urban Planning: Urban Observatory



The Urban Observatory is an ambitious project led by TED founder Richard Saul Wurman to compile data that allows comparision of metro areas at common scales.

Source: The ArcGIS Imagery Book

Urban Planning

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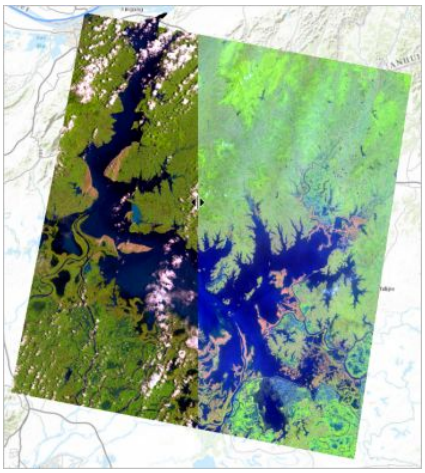
ArcGIS Pro Imagery Tools

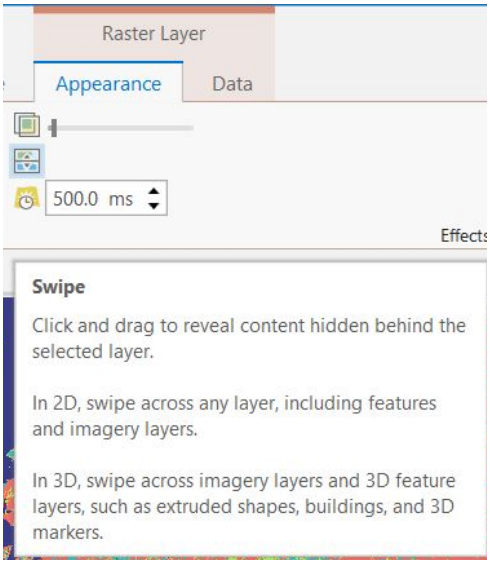
- Swipe tool
- Classification
  - Unsupervised
  - Supervised
- Majority Filter
- Boundary Clean

These are a small sample of the tools in ArcGIS Pro that you will use when working with imagery.

Swipe Tool

- Select Layer
- Appearance > Effects > Swipe

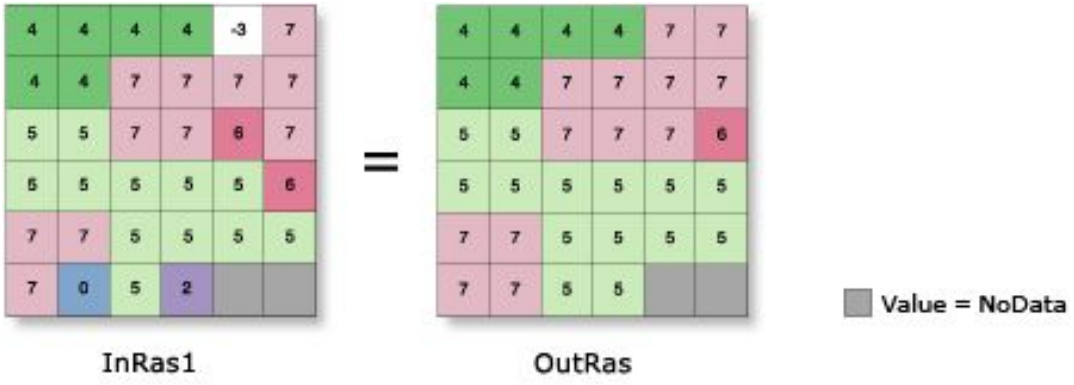




The Majority Filter tool is a data generalization tool. It replaces cells in an image or raster layer based on the value of the majority of the neighboring cells. If a cell has a value of 1 but three of its four neighboring cells have a value of 2, the tool will change the 1 value to fit the surrounding values.

Majority Filter

- Data generalization tool
- Replaces cells with value of majority of neighbors



Source: [Smoothing zone edges with boundary clean and majority filter]

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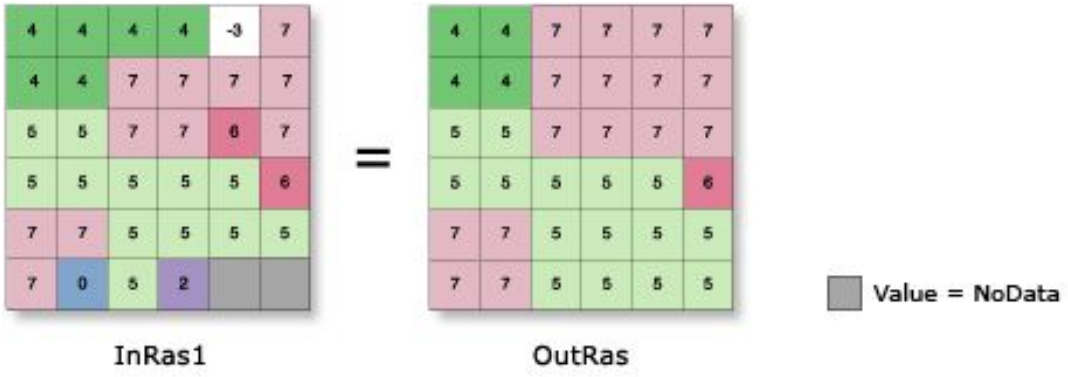
Boundary Clean

- Cleaning ragged edges between zones
- Uses an expand and shrink method



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Source: [Smoothing zone edges with boundary clean and majority filter]

The Boundary Clean tool is primarily used for cleaning ragged edges between zones. It uses an expand and shrink method that cleans boundaries on a relatively large scale. Initially, zones of higher priority invade their neighboring zones of lower priority by one cell in all eight directions. Then they shrink back to those cells that are not completely surrounded by the cells of the same value. Any cells that are not internal cells (that is, they can't be viewed as a center to eight nearest neighbors of the same value) may be replaced. For the default method where there is no sorting by size (Do not sort), larger values have a higher priority. In the image above, Boundary Clean was applied to the input raster with no sorting of the zones. Zones with larger values have a higher priority to expand into zones with smaller values. Notice that cells with the value 7 expand into the lower value cells.