Imagery and Remote Sensing in ArcGIS

Vinay Viswambharan

Mark Romero

esri

ESRI PETROLEUM GIS CONFERENCE

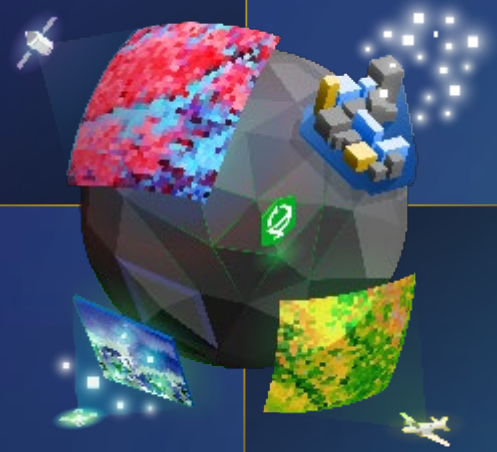
Agenda

- Introduction to the Imagery Platform
- Imagery content on the living Atlas (Landsat/Sentinel/Naip….)
- Image Management – Mosaic Dataset, Image server
- Map Production
  - -Ortho Mapping in ArcGIS Pro, Drone2Map, Ortho Maker
- Image Processing in ArcGIS
  - Raster functions, Raster Analytics
  - Deep dive (optional)
- Image Analyst Extension
  - Stereo, ICS, Mensuration, Full Motion Video
  - Deep Learning
- App Templates
- Oriented Imagery (optional)

5 Key Imagery Capabilities of ArcGIS

Visualization

Management



Content

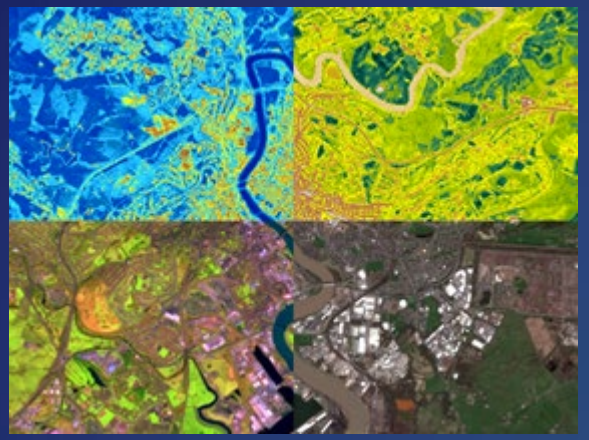
Analysis

Map Production

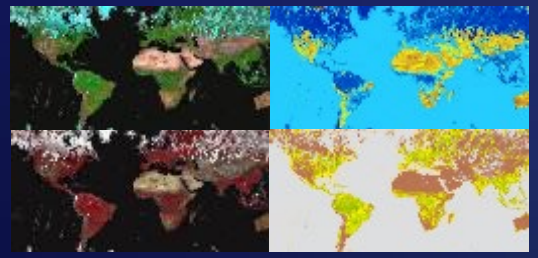
Imagery Content

ArcGIS Online and The Living Atlas of the World

Word Imagery

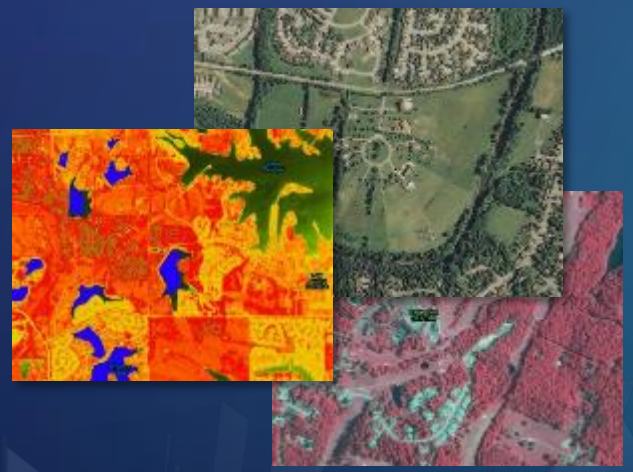


Sentinel 2



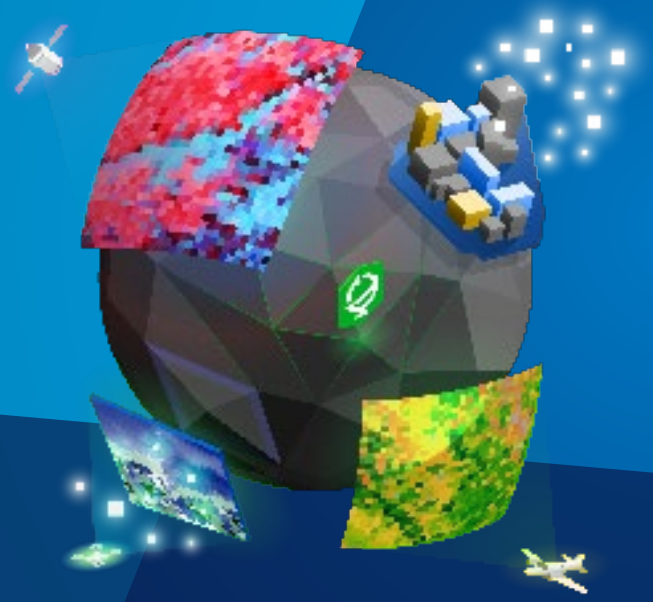
Landsat

World Terrain



NAIP

Partners



Imagery Content on the Living Atlas

Naip
Landsat
Sentinel
Elevation
…

Image Management

Making Imagery Accessible

Working with Imagery in ArcGIS Pro

Sensors and format support

Mosaic Datasets

ArcGIS Image Server

Image Services

- On-The-Fly Processing
- Dynamic Image Services
- Persisting Products using Raster Analytics

Image Management Workflows

On Premise and Cloud

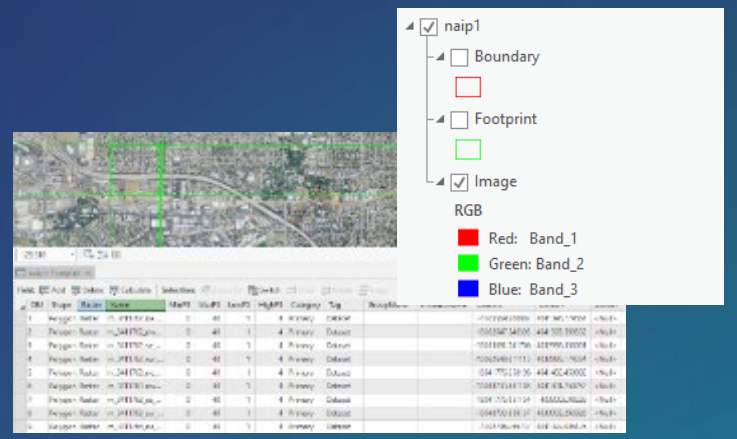
- Support for AWS, Azure
- Many Cloud Storage Options

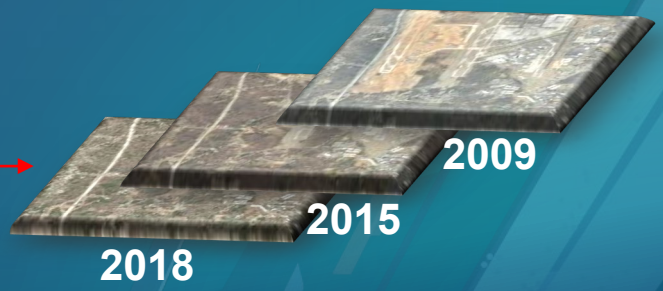
System of Record

Image Management Using Mosaic Datasets

ArcGIS Imagery Information Model

- Catalog of
  - Imagery
  - Associated metadata
  - Processing to be applied
- Support multiple sources and modalities
- Support multiple metadata formats
- Support multiple formats
- Maintain Image quality
- Handle overlapping and disparate datasets
- Support over 50 Raster (Sensor) Types
- Support Rich Web services (Image Services)
- Enables
  - Dynamic Mosaicking
  - On-the-fly processing

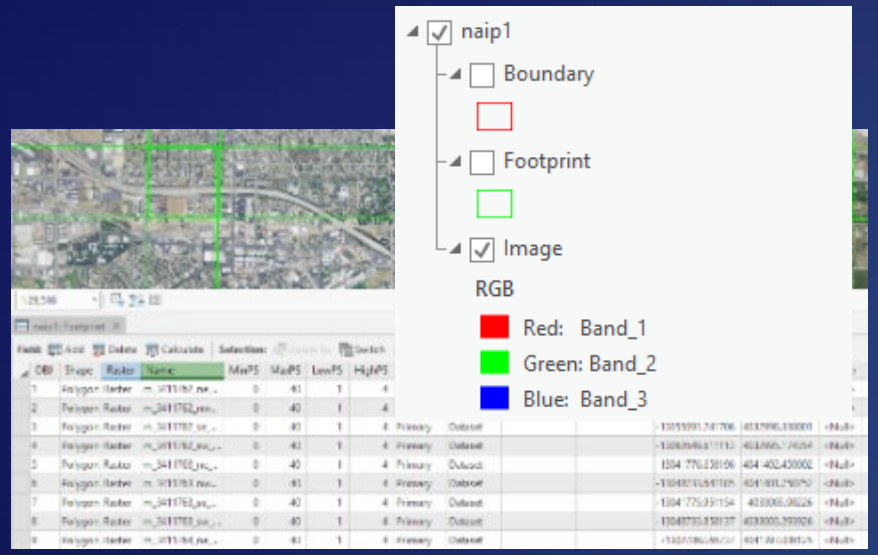




Scalable from 1 to Millions of records

ArcGIS Image Server

- Dynamic Image Services
  - Providing Access
  - Dynamic Mosaicking and On-The-Fly Processing
- Raster Analytics
  - Persisting Products using Distributed Compute and Storage
- Ortho Mapping
  - Creating imagery products from Satellite, Aerial and Drones



Demo

Building a Mosaic Dataset
Image Services

MAP PRODUCTION

Creating precise imagery derived products

Satellite, Aerial, Drones

Orthophoto production

Block Adjustment

Digital Elevation Model Generation

Drone2Map, Ortho Mapping, Ortho Maker

OrthoMosaics, DTM, DSM

Tile Cache Generation

Dynamic Image Services

Stereo Display and Feature Extraction

Satellite, Frame Camera, ADS

System of Record

Ortho Mapping

Drone2Map
Stand Alone App for Windows

ArcGIS Pro
Ortho Mapping Workflow

Ortho Maker
WebApp on
ArcGIS Image Server

Drone2Map in ArcGIS

Generate 2D and 3D Products from Drone Imagery

- Orthorectified mosaics
- Terrain models
- Point clouds
- 3D meshes
- Process in the field or in the office (laptop)
- Batch processing of multiple collects
- Share flight data and derivative products

  to ArcGIS Online or ArcGIS Enterprise

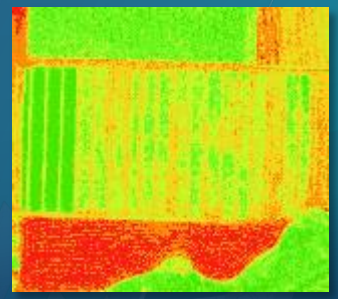
Drone2Map

orthomosaics

DSM & DTM

point clouds &
3D meshes

smart inspection
& 3D PDF



more…

Version 1.3.1

- Better multispectral camera support
- Point cloud improvements
- Automated point cloud classification
- Improved DTM generation
- OSGB mesh output (in addition to I3S)
- Processing speed improvements

Demo

Drone2Map

ANALYSIS

Extracting Information from Imagery

ArcGIS Pro Image Analyst Extension

Machine Learning, Prediction, Classification, Deep Learning

Tools built into ArcGIS

Integration with External Toolkits

Scaling using Raster Analytics

System of Insight

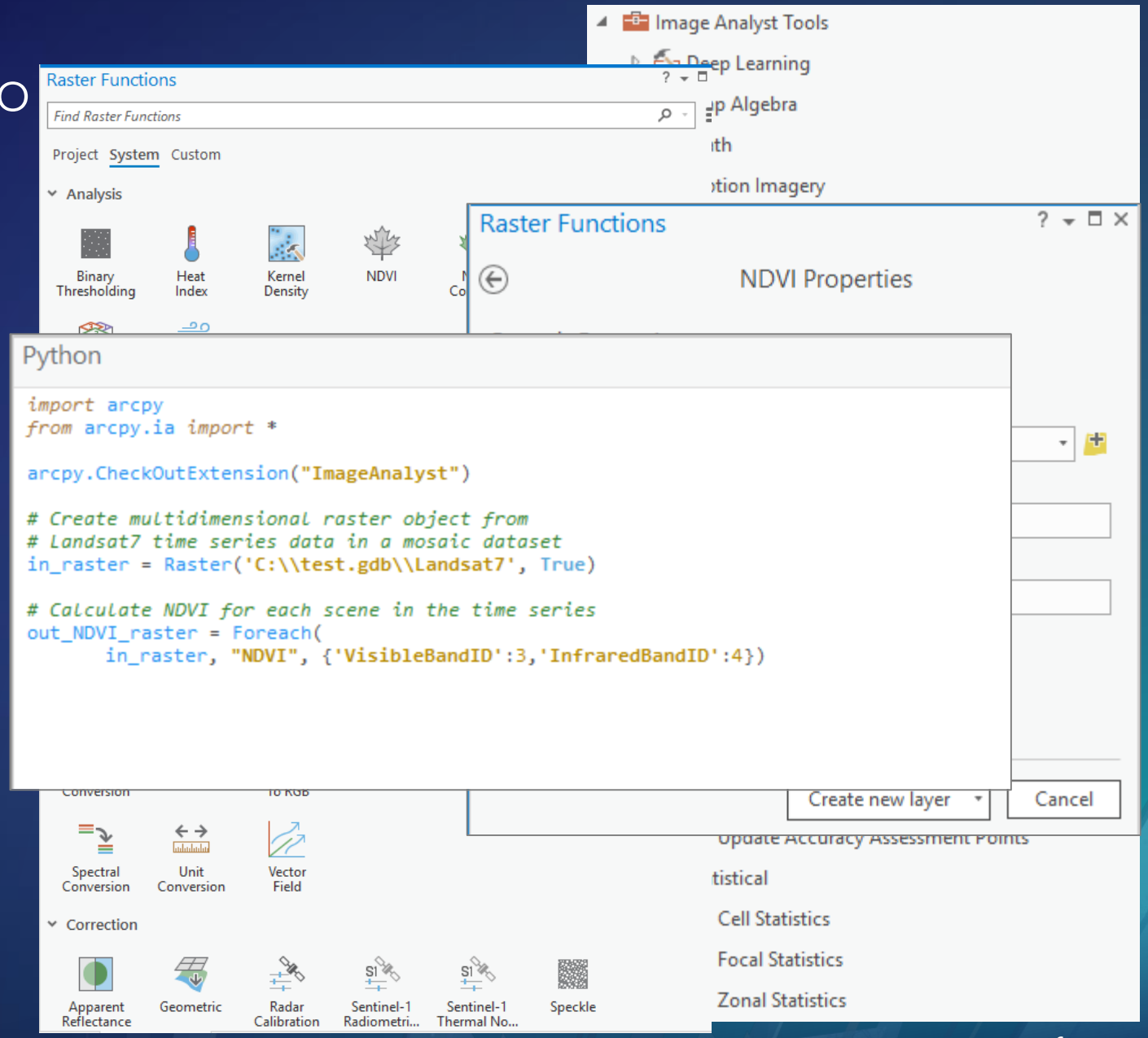
Image Analysis in ArcGIS Pro

3 main ways to accomplish image analysis in ArcGIS Pro

Raster Functions

Python

Geoprocessing tools



System of Insight

Image Processing and Analysis in ArcGIS

- **Process images to create new images (traditional image processing)**
- **Process images on-the-fly to create dynamic virtual products**
- **Process images to create tiled image maps**
  - Georeferencing and Orthorectification
  - Color Balancing
  - Seam line generation
  - Caching to tiles
- **Geoprocessing tools**
  - More than 80 tools for image management and processing
- **Raster Functions**
  - Can be applied to Raster Datasets, Mosaic Datasets, and Image Services

Raster Function

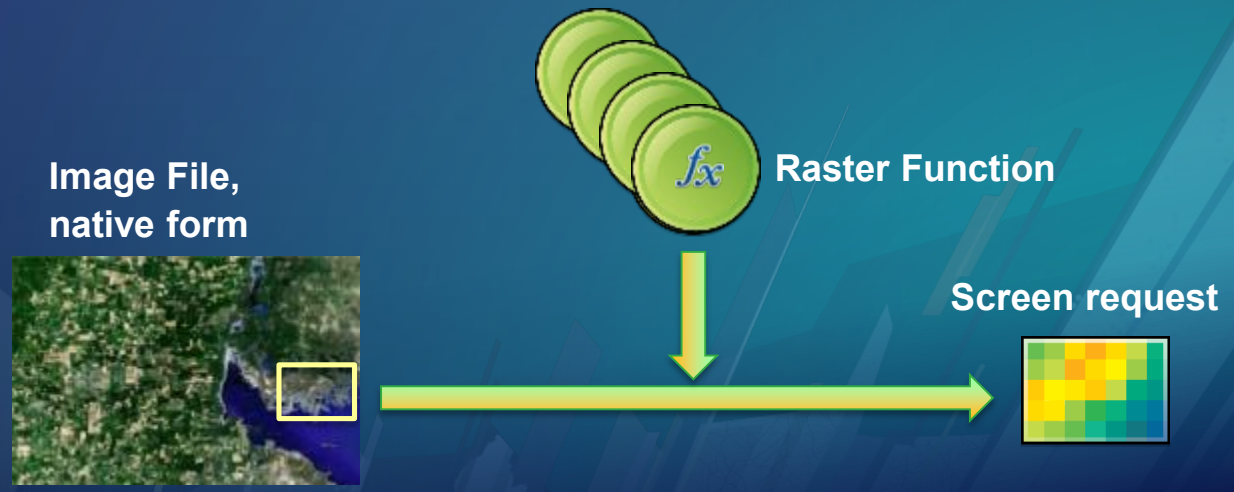
Geoprocessing

Distributed Raster Analysis

Raster Functions

Processing imagery in ArcGIS

- Primary information model component which processes raster data
- Takes input pixels and transform output pixels into meaningful products
- Raster functions to process:
  - Pixels/block of pixels
  - Raster datasets or a collection of raster datasets
  - Mosaic datasets
- Geometric or Radiometric
- 100+ out-of-the box
- Chained together to create “processing chains”
- Extensible https://github.com/Esri/raster-functions



Raster Functions

ArcGIS Pro
~50 Raster Functions

Multiband Math

Arithmetic
Band Arithmetic

Analysis: Band Math & Indices

NDVI / NDVI Colorized
SAVI / MSAVI / TSAVI
GEMI
GVI (Landsat TM)
PVI
Tasseled Cap (Kauth-Thomas)
Binary Thresholding
Heat Index
Wind Chill

Statistics

ArgStatistics

Visualization & Appearance

Contrast and Brightness
Convolution
Pansharpening
Resample
Statistics and Histogram
Stretch

Correction

Apparent Reflectance
Geometric Correction
Speckle Filtering (Lee,Frost,Kuan)
Thermal noise
Radiometric Calibration

Data Management & Conversion

Raster to Vector
Vector to Raster
Colormap
Colormap To RGB
Complex
Grayscale
Remap / Reclass
Spectral Conversion
Unit Conversion
Vector Field
LAS to Raster
LAS Dataset to Raster
Clip
Composite
Extract Bands
Mask
Mosaic Rasters
Rasterize Features
Reproject

Interpolation

Interpolate Irregular Data
- Nearest Neighbor
- IDW
- EBK
Swath

Surface Generation & Analysis

Aspect
Curvature
Elevation Void Fill
Hillshade
Shaded Relief
Slope
Contour

Python

Custom Algorithms

Image Analyst
~60 Raster Functions

Analysis: Image Segmentation & Classification

Segmentation (Mean Shift)
Training (ISO, SVM, ML, Random trees)
Supervised Classification

Analysis: Overlay

Weighted Sum

Statistics:

Zonal Statistics
Cell Statistics

Math

Calculator
Abs
Divide
Exp
Exp10
Exp2
Float
Int
Ln, Log10
Log2
Minus
Mod
Negate
Plus
Power
Round Down
Round Up
Square
Square Root
Times
ACos
ACosH
ASin
ASinH
ATan
ATan2
ATanH
Cos
CosH
Sin
SinH
Tan
TanH
Con
Set Null
Bitwise
And
Left Shift
Not
Or
Right Shift
Xor
Boolean
And
Not
Or
Xor
Equal To
Greater Than
Greater Than Equal
Is Null
Less Than
Less Than Equal
Not Equal

Spatial Analyst
~13 Raster Functions

Analysis: Distance & Density

Euclidean Distance
Cost Distance
Least Cost Path
Kernel Density

Analysis: Hydrology

Fill
Flow Accumulation
Flow Direction
Flow Distance
Stream Link
Watershed

Analysis: Overlay

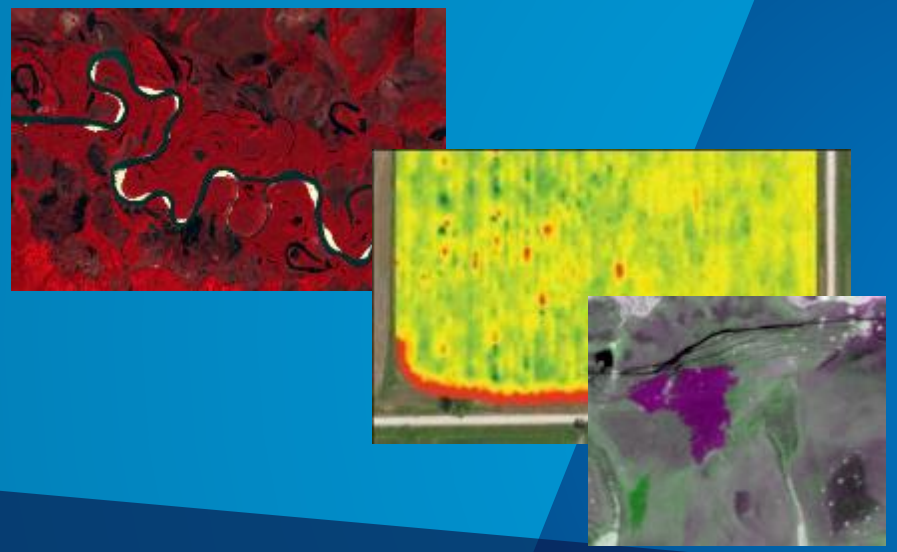
Weighted Overlay

Surface Generation & Analysis

Viewshed

Data Management

Nibble



Raster functions for Image Processing in ArcGIS

Raster Functions
Client Side Processing
Server Side Processing

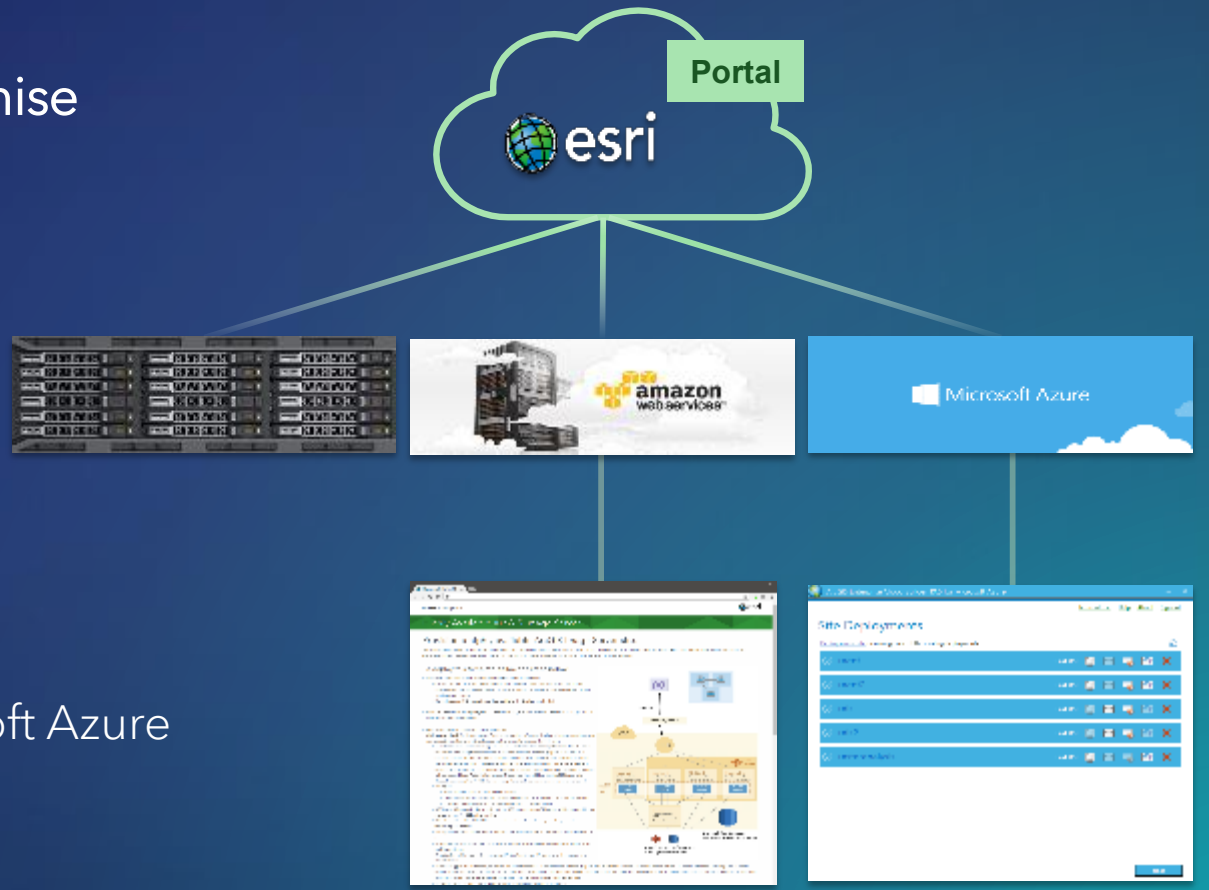
Enterprise Image Server with Distributed Raster Analysis

- ***ArcGIS can create and execute spatial analysis models and image processing chains which leverage distributed storage and analytics***
  - ***Raster Analysis works with your existing GIS data and imagery***
    - *register your data with Image Server without converting*
  - ***Raster Analysis can optimize your data for distributed analytics***
    - *result imagery is written into distributed raster storage for improved scalability*
  - ***Raster Analysis is designed to scale with your organization's demands***
    - *scale up to get the job done quicker, scale down when resources are not needed*

Raster Analytics

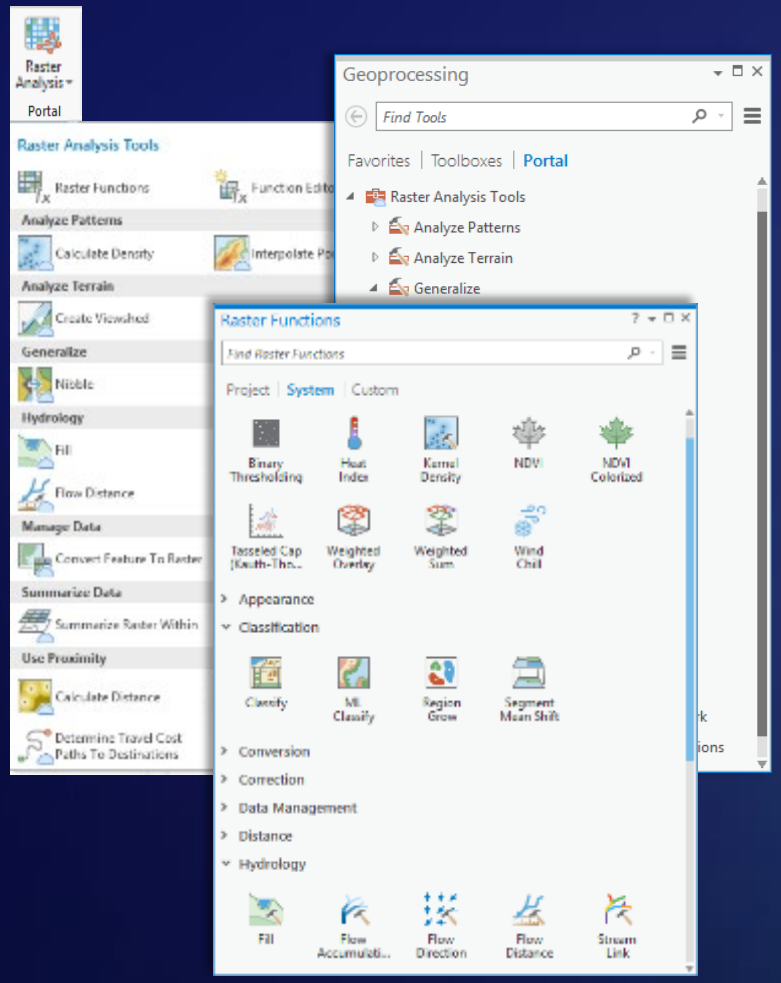
In your infrastructure

- deployed as Enterprise / Web GIS on-premise
- your infrastructure can be…
  - your hardware
  - your Amazon
  - your Azure
- deployment tools
  - Amazon CloudFormation Templates
  - ArcGIS Enterprise Cloud Builder for Microsoft Azure

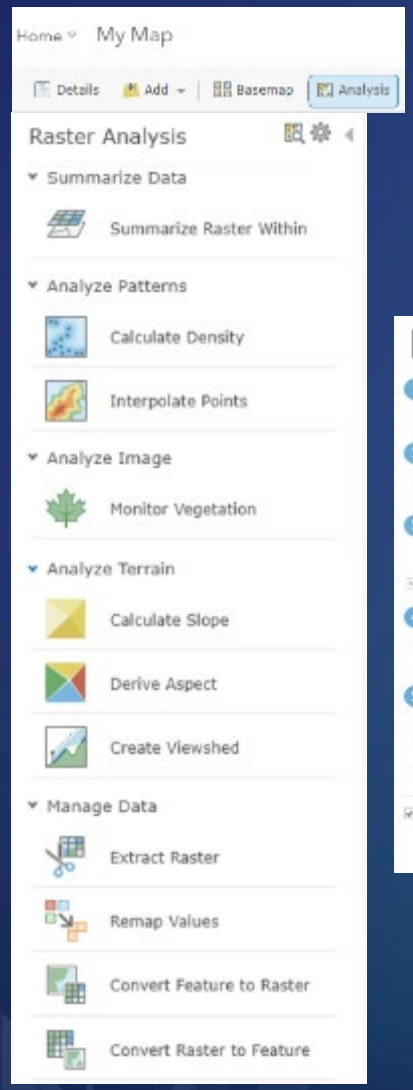


Raster Analytics Clients

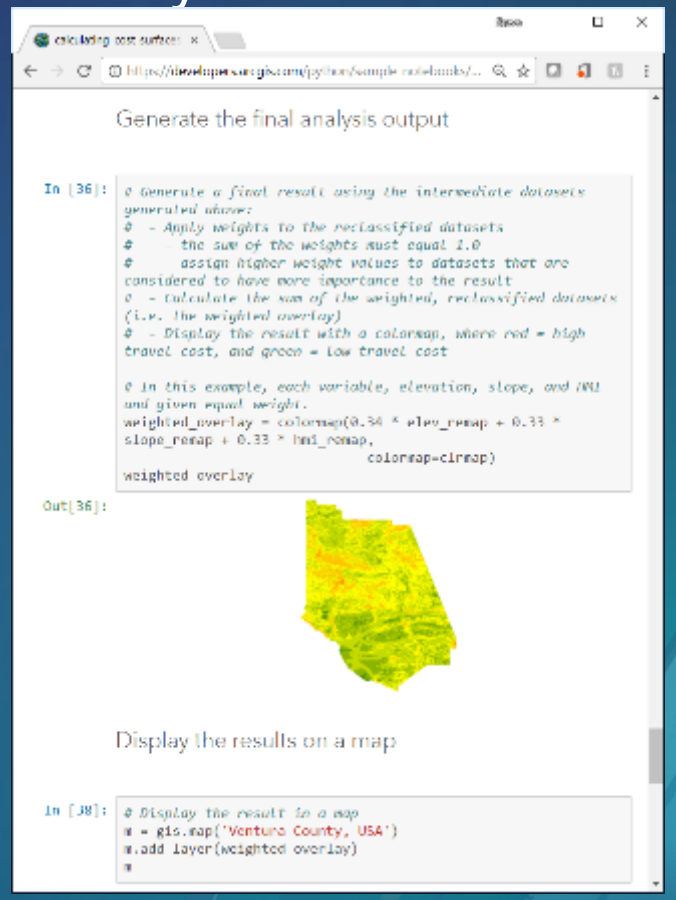
Pro



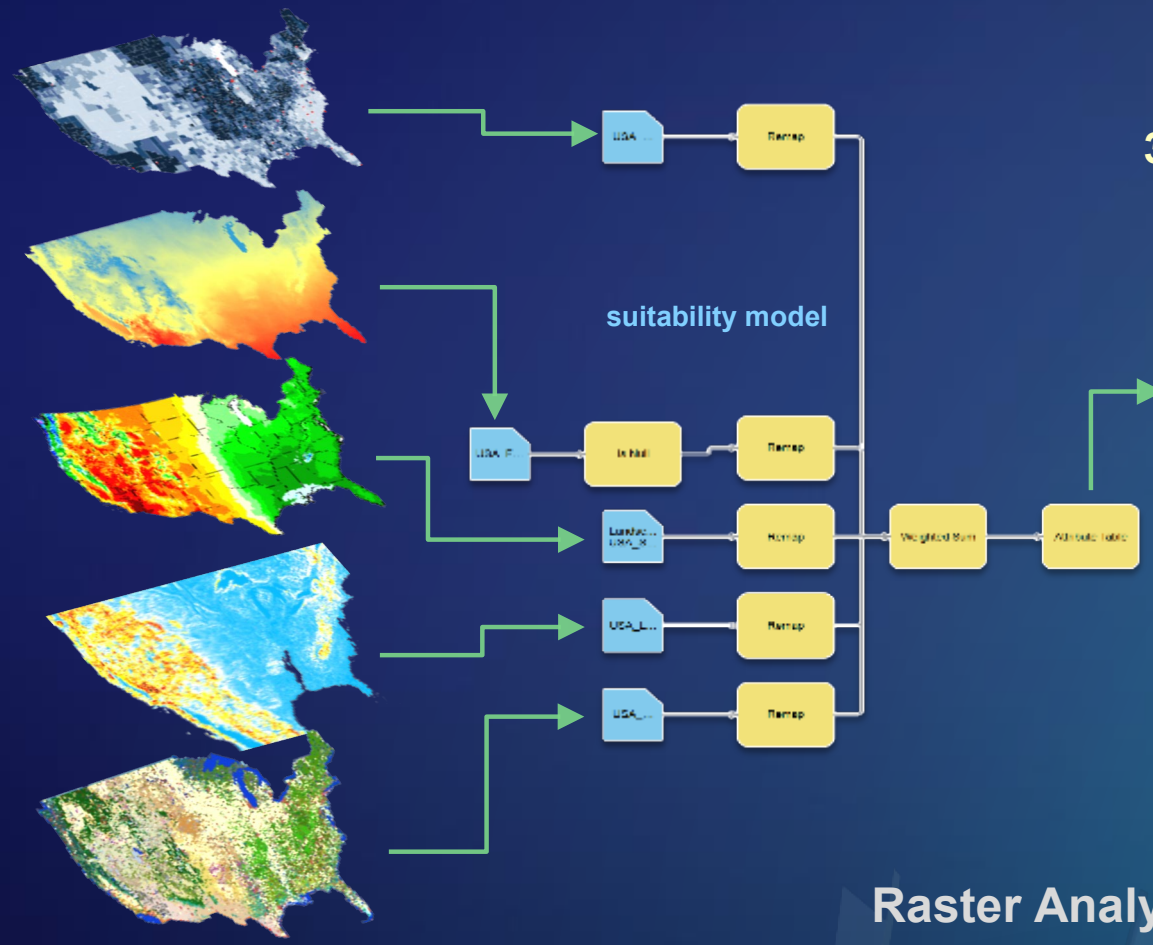
Web



Python API



Raster Analytics Test Case: Solar Power Plant Suitability



30m National Solar Plant Suitability Raster

ArcGIS Desktop (ArcMap or ArcGIS Pro)

5 hours 45 minutes

Raster Analytics (6 Raster Analytics Processors)

16 minutes

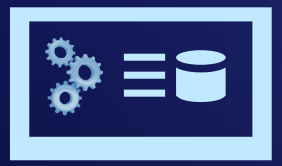
esri virtual machine

- 16GB RAM, 8 cores, NAS storage

Raster Analytics Test Case: Landsat Processing

Infrastructure

Esri Web GIS on AWS



Distributed Raster Analytics Cluster

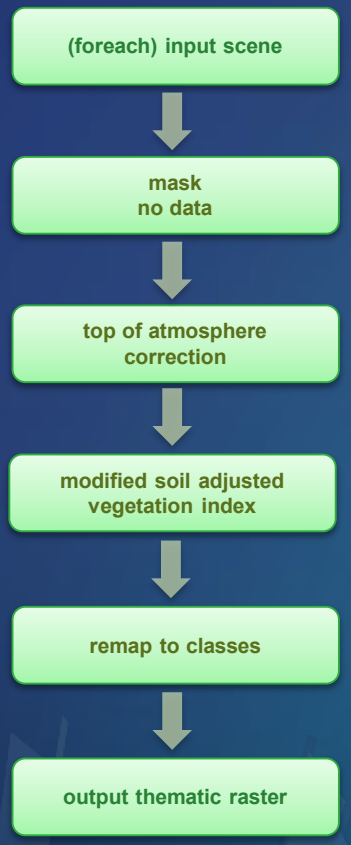
- single node
- AWS c3.8xlarge
- 60GB RAM, 32 cores, 500GB SSD
- 200 Raster Analytics Processors

Input Collection

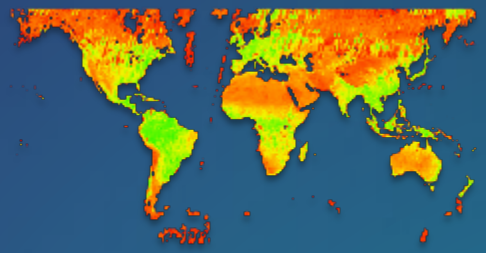
Landsat GLS 1990

- 7422 Multispectral Scenes
- S3 storage

Processing



Output



Thematic Rasters

- 7422 Thematic Rasters
- Distributed Raster Datastore

2 hours 48 minutes

44 scenes per minute

¾ scene per second

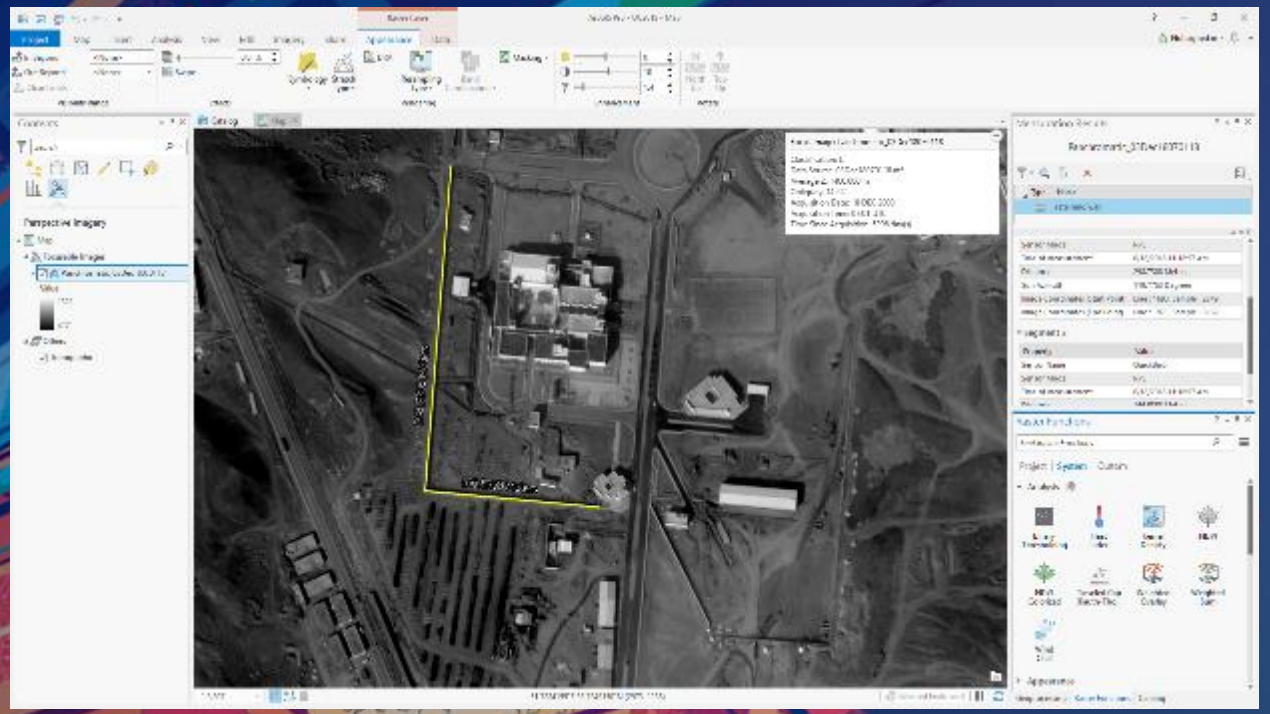
Demo
Raster Analytics

Introduction to ArcGIS Image Analyst Extension

Stereo Mapping	Image Space Analysis	Full Motion Video	Image Classification	Raster Functions and Geoprocessing
- Stereo visualization and data capture capabilities - Enables detailed and accurate elevations and height measurements	- View imagery undistorted, with vectors transformed to the image - View imagery from the sensor perspective - Mensuration in Image space - Improved UX for oblique imagery	- Work with spatially enabled video in a map - Create features that display in video and map - Export frames and metadata for deliverable information	- Workflows and tools for image classification and machine learning - These include the classification tools that previously required Spatial Analyst Extension	- Some of the raster functions that currently require the SA extension, are also available through the Image Analyst extension (review appendix) - Segmentation Classification - Math: Algebra - Math: General, con, Logical, Trig - Statistical and Overlay

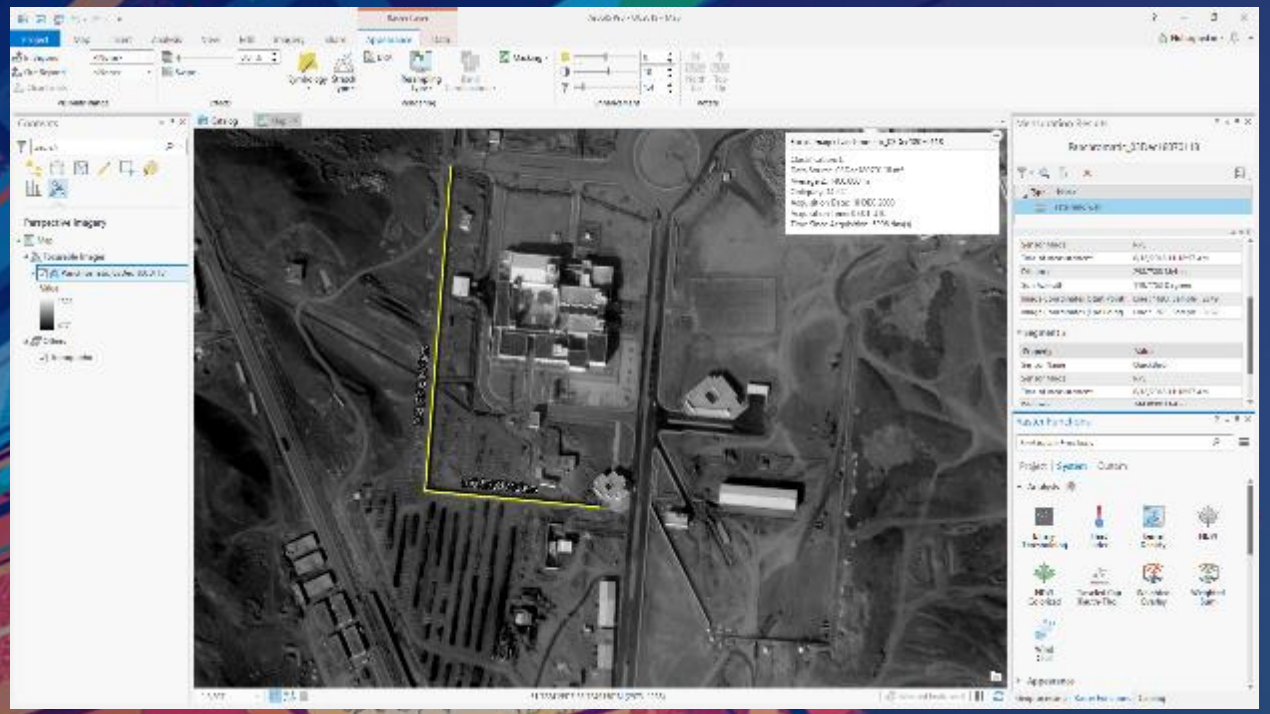
- Extends ArcGIS Pro with advanced tools and user experiences for Image Analysts
- Designed for Image Analysts and Geospatial Analysts who <u>focus</u> on:
    - Image interpretation and exploitation of imagery
    - Creation of information products from imagery
    - Advanced feature interpretation and measurements from imagery
    - Detailed data capture and measurement on stereo imagery
    - Advanced raster and image analysis workflows for machine learning and feature extraction

ArcGIS Pro 2.1+



Demo

Image Analyst extension



Demo
Image Classification

Machine Learning Tools in ArcGIS

Classification

- Pixel & Object Based
- Image Segmentation
- Maximum Likelihood
- Random Trees
- Support Vector Machine

Deep Learning

- Generate training samples
- Detect objects
- Classify pixels

Clustering

- Spatially Constrained Multivariate Clustering
- Multivariate Clustering
- Density-based Clustering
- Hot Spot Analysis
- Cluster and Outlier Analysis
- Space Time Pattern Mining

Prediction

- Empirical Bayesian Kriging
- Areal Interpolation
- EBK Regression Prediction
- Ordinary Least Squares Regression and Exploratory Regression
- Geographically Weighted Regression

Machine Learning/Deep Learning

Pro + Image Analyst

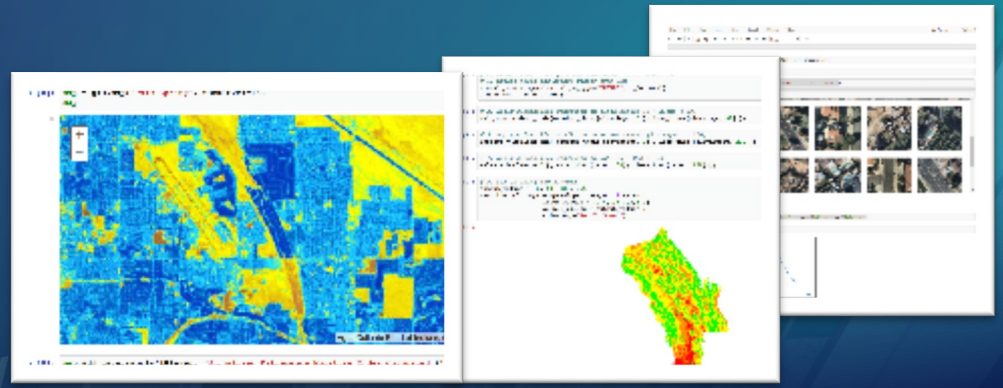
- Deep learning training data extraction tools
- Deep learning Inferencing Tools
  - Object detection
  - Pixel classification
- Support for multiple deep learning frameworks

Enterprise

- Deep learning service tools

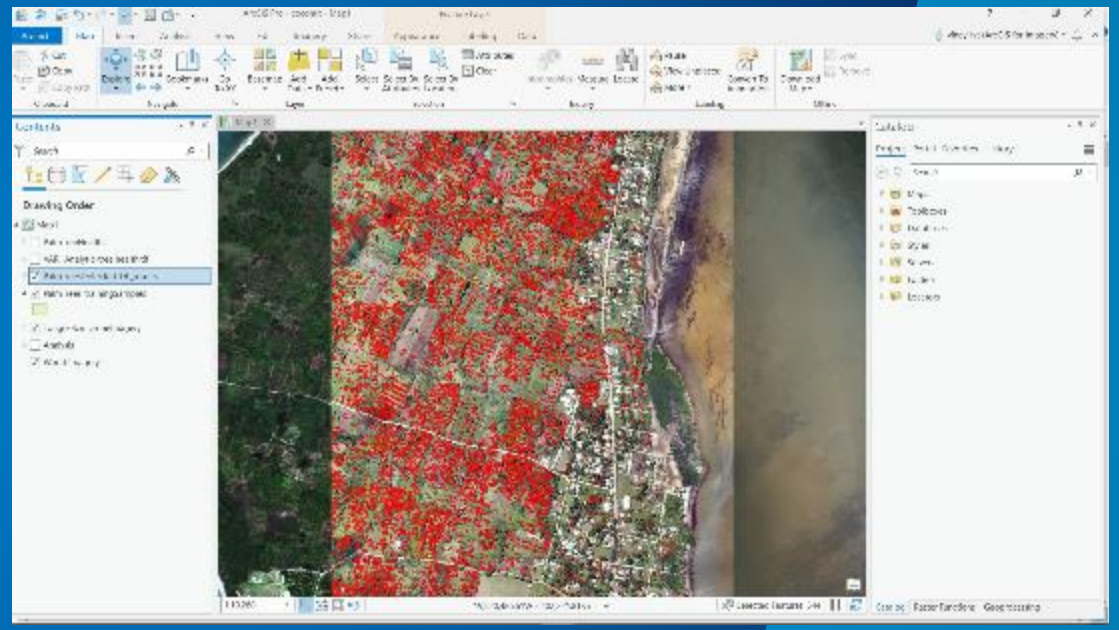
ArcGIS API for Python - arcgis.learn module

- Data Store APIs
- Data Prep APIs
- Model Training APIs
- Model Management APIs
- Inference APIs
- export_training_data() for exporting image chips
- SingleShotDetector for training object detection models
- detect_objects() and classify_pixels() for inferencing

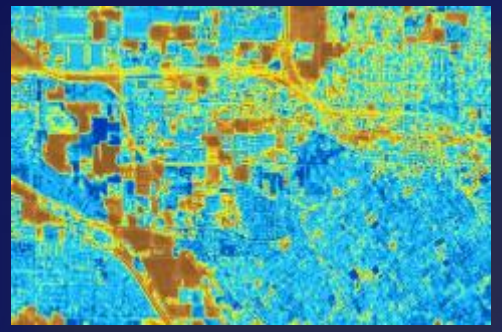


Demo

Object detection using ArcGIS

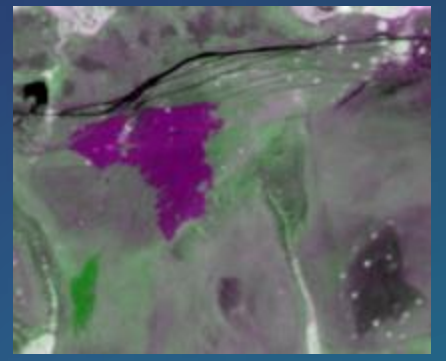


Machine Learning Examples

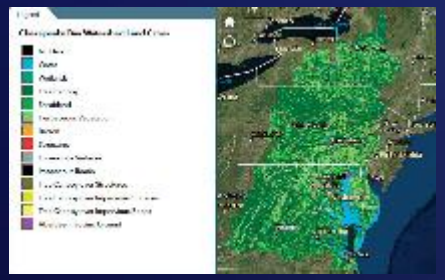


Regional Planning

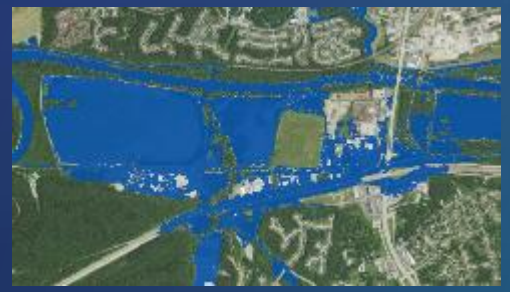
Impervious Mapping



Change Detection



Landcover Classification

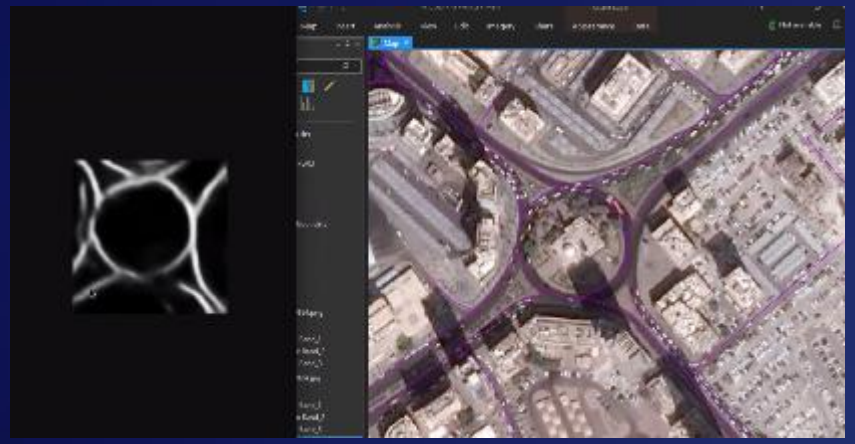


Flood Planning

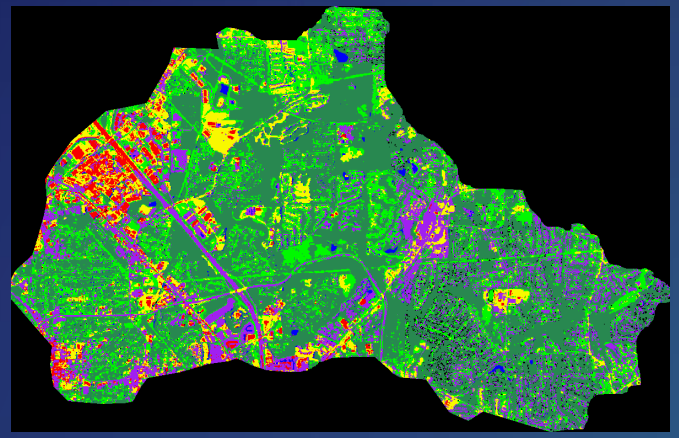
Riparian Corridors

and more…

Deep Learning Examples



Transportation Networks



Landcover Classification

Environment Compliance

Legal Compliance

Emergency Management

Retail Predictions

and more…

Image Visualization and Exploitation

Integrating imagery into dynamic applications to aid understanding

Desktop

ArcGIS Pro + Image Analyst Extension

Image Space, Mensuration

Stereo

Motion Video

Web

Map Viewer enhancements

Image Configuration Apps

WABIS

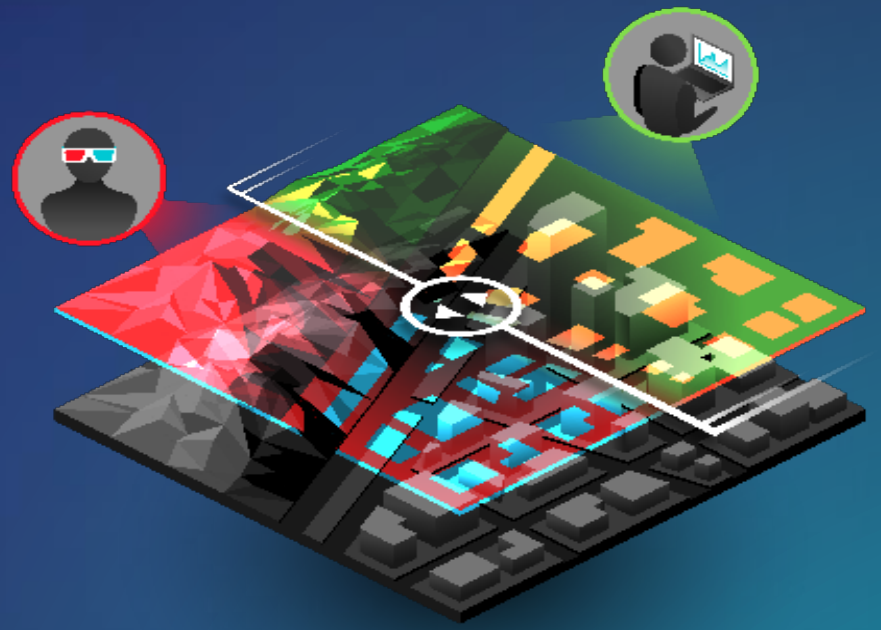
Engaging Visualization Tools

Interpretation tools

Mobile

Focused Apps

LT Mosaic Dataset in RunTime



ArcGIS Pro

Image Analyst Extension

ArcGIS Enterprise + Image Server

ArcGIS Online

System of Engagement

Visualization and Exploitation on the Web

Prior

- WAB – Templates
- WABIS
- Oriented imagery 1.1
- JS 4.x
- - Image layer support
    - Rendering
    - Mosaic methods
    - Client side pixel filtering
    - Supported in scene viewer

New

- JS 4.x API
    - Support for renderers
- Image catalog viewer
- Imagery application templates
    - Image visit
    - Image mask
    - Image viewer
- Oriented imagery 1.1
- Excalibur

ArcGIS Excalibur

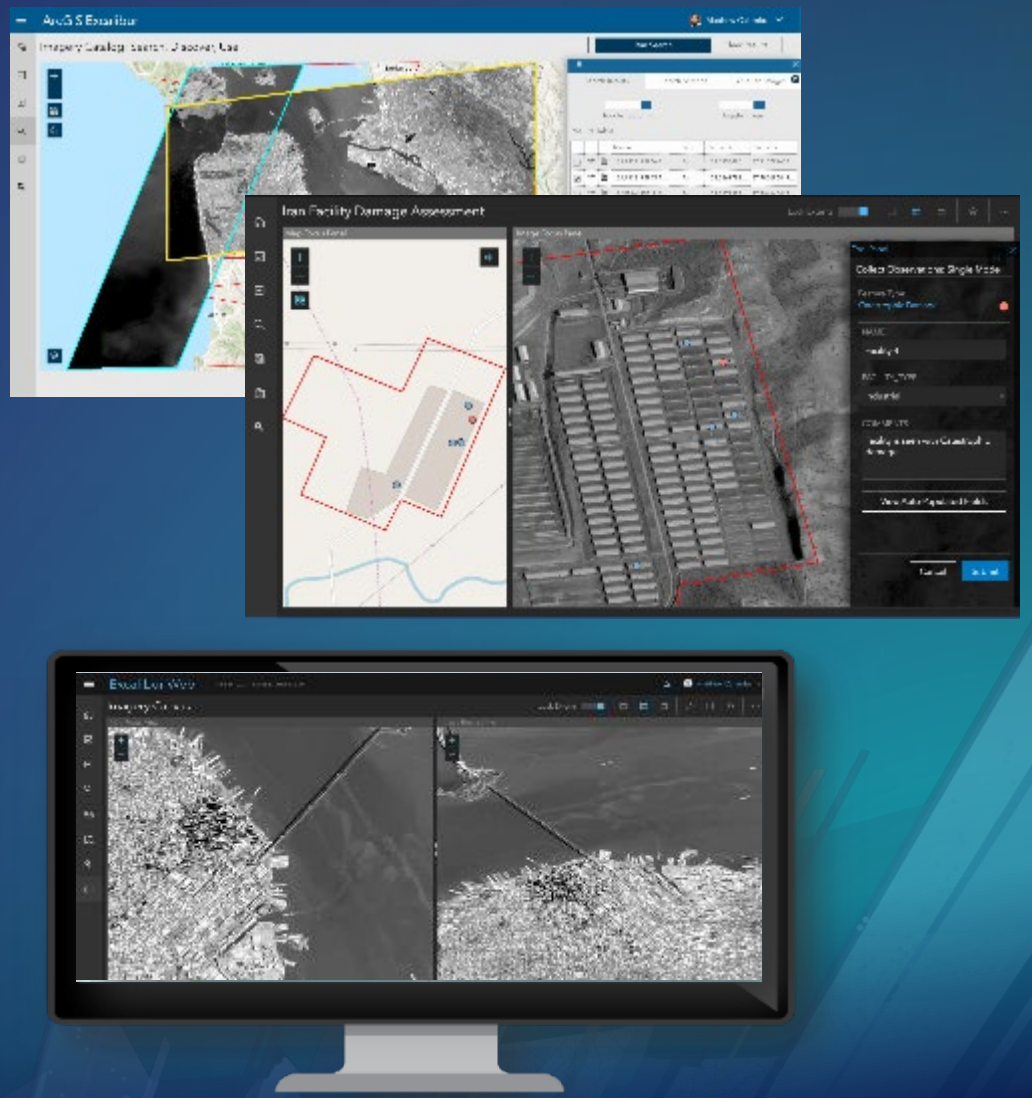
Integrating Imagery Exploitation and Observation Management

A new, modern *web* experience for ArcGIS Enterprise v10.7

For: Analysts, Imagery Specialists, and Imagery/GIS Managers

Who: Need to discover, analyze, report and efficiently disseminate information derived from imagery analysis and workflows.

That provides: a focused, simple, and intuitive design for working with oblique and ortho-rectified imagery that introduces a project-based workflow to provide focused workflows to organizations to assign, track, measure and manage imagery work related efforts.



ArcGIS Excalibur

Integrating Imagery Exploitation and Observation Management

Focused on Image Analysts

Project Management

Task Based Workflows
Dashboards

Image Access Management

Integrated Search

Exploitation

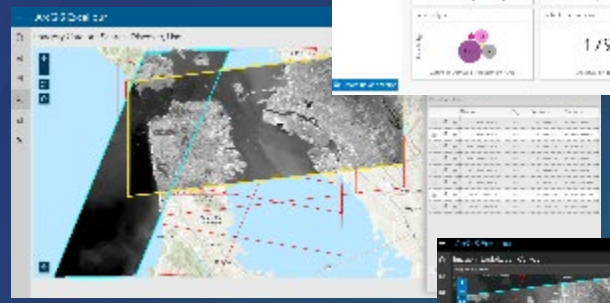
On-the-Fly Processing
Raster Analysis
Image Space

Derived Products

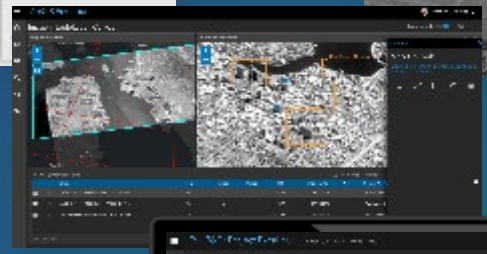
Analytic Assessments
Change Monitoring
PPTs/Story Maps

ArcGIS Excalibur

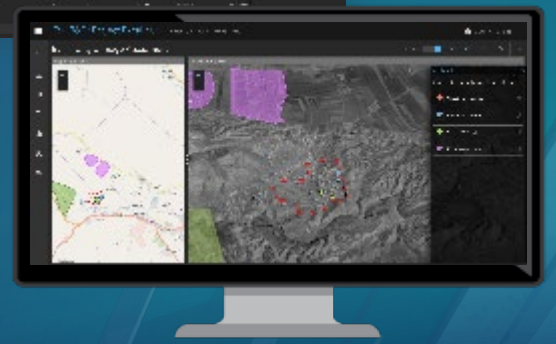
Observation and Activity Based Analysis



Search, Discover, and Exploit



Imagery Derived Reporting and Dissemination

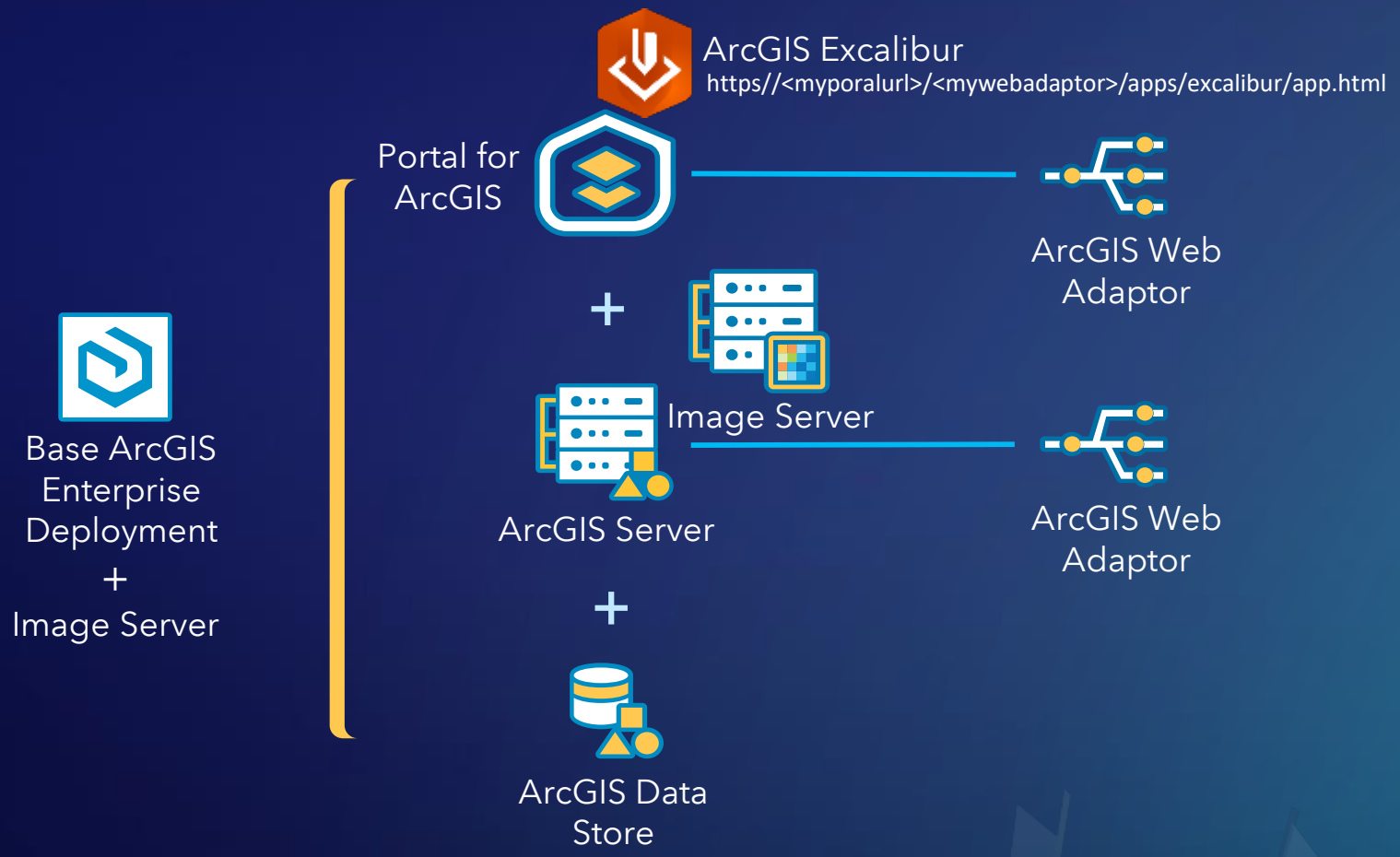


Browser-Based App

Delivering the Next Generation Imagery Workflows

ArcGIS Excalibur

Integrating Imagery Exploitation and Observation Management



- Licensed Web App for ArcGIS Enterprise v10.7
- Separate Installer at v10.7 via My Esri
- *Creator* or *GIS Professional* User Type
- Utilizes ArcGIS Image Server Services at v1.0
- ***Introduces***:
  - New Excalibur Imagery Project Item Type
  - Create and Persist Personal App Level Settings

Demo

ArcGIS Excalibur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