

Web GIS Enabled Spatial Analysis & Data Science with ArcGIS

Aki Kaapro

Course Goals

- Understand the ArcGIS platform as a Web GIS system
- Reach familiarity with vector, raster and point cloud data in ArcGIS
- Get to know ArcGIS' spatial data science and spatial analytics possibilities and frameworks: pattern detection, clustering and prediction tools

Agenda, day 1.

- 09 AM -12.15 PM
 - Lesson 1. 9.10 AM – 11 AM
 - Introduction to Web GIS and ArcGIS platform (30 min)
 - ArcGIS Pro desktop software
 - Hands-on: the ArcGIS Pro UI (30 min)
 - Get Started With ArcGIS Pro –exercise
 - Lesson 2. 11 AM - 12.15 PM “Nose-dive to Analytics”
 - Introduction to Spatial Science and Spatial Analysis on ArcGIS
 - Hands-on: Cluster and Outlier Analysis and Regression tools

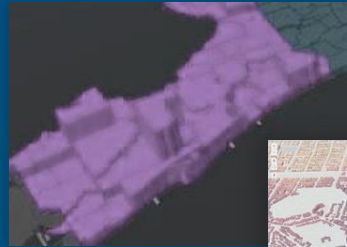
Agenda, day 2.

- 09 AM -12.15 PM
 - Left-overs from day 1.
 - Lesson 3. 9.10 AM – 10.15 AM
 - Short Introduction to Point Clouds in ArcGIS Pro
 - Hands-on: Point clouds and derivatives
 - Hands-on: Raster Functions (altogether)
 - Lesson 4. 10.30 AM – 10.50 AM “GeoAI”
 - Introduction to Deep Learning workflows on ArcGIS platform
 - Instructor demo
 - Lesson 5. 10.50 AM – 11.30 AM
 - Multidimensional Datasets & Rasters (ArcGIS Notebook exercise!)
 - Temporal Charts
 - Lesson 6. 11.30 AM – 12 PM
 - Collaboration and Communication
 - Demo introduction to Dashboards, Story Maps, Sentinel-2 Explorer etc. and other configurable app templates
 - Configuring Web Apps with WebApp Builder
 - Wrap-up & Summary 12 PM – 12.15 PM

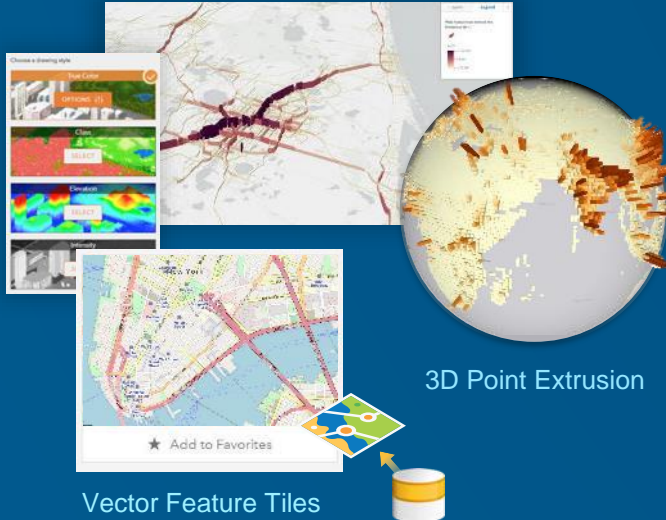
Introduction to Web GIS and ArcGIS platform



Today: Smart, Data-Driven Mapping and Visualization



Data-Driven 3D

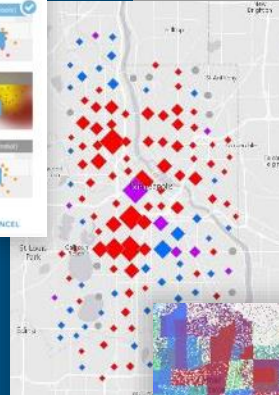


3D Point Extrusion

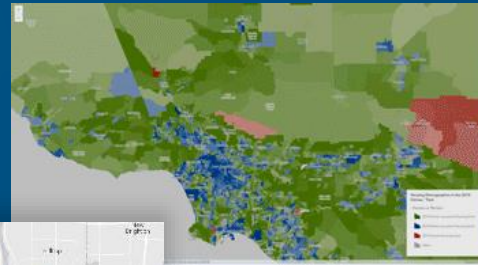
Vector Feature Tiles



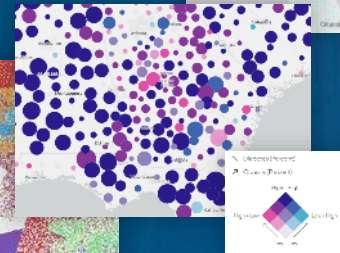
Dynamic Clustering



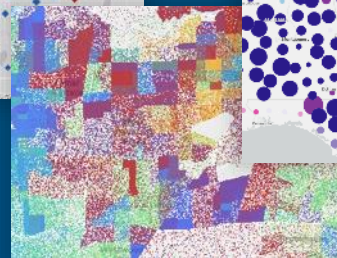
Fast Performance WebGL



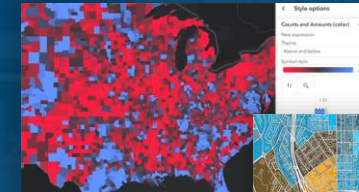
Multivariate



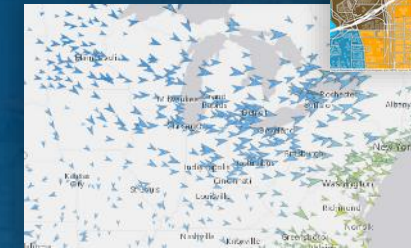
Dot Density



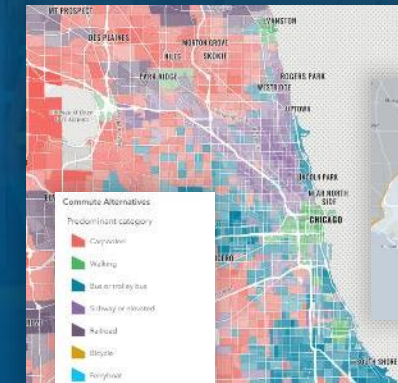
Exploratory Mapping



Directional Mapping



Predominance Mapping



Graduated Symbols



ArcGIS is Advancing Rapidly . . .

Integrating Many Innovations



A New Pattern for Delivering GIS Capabilities

Leveraging Common Computing Architecture



File Based



Database Centric



Server Centric



Web Centric

Web GIS Is Driving Digital Transformation

Interconnected Information, Processes, and Workflows . . .
. . . All Happening at the Same Time



Using the Power of Location to Integrate Everything

The Esri Geospatial Cloud

Expands the Reach of the Geospatial Community

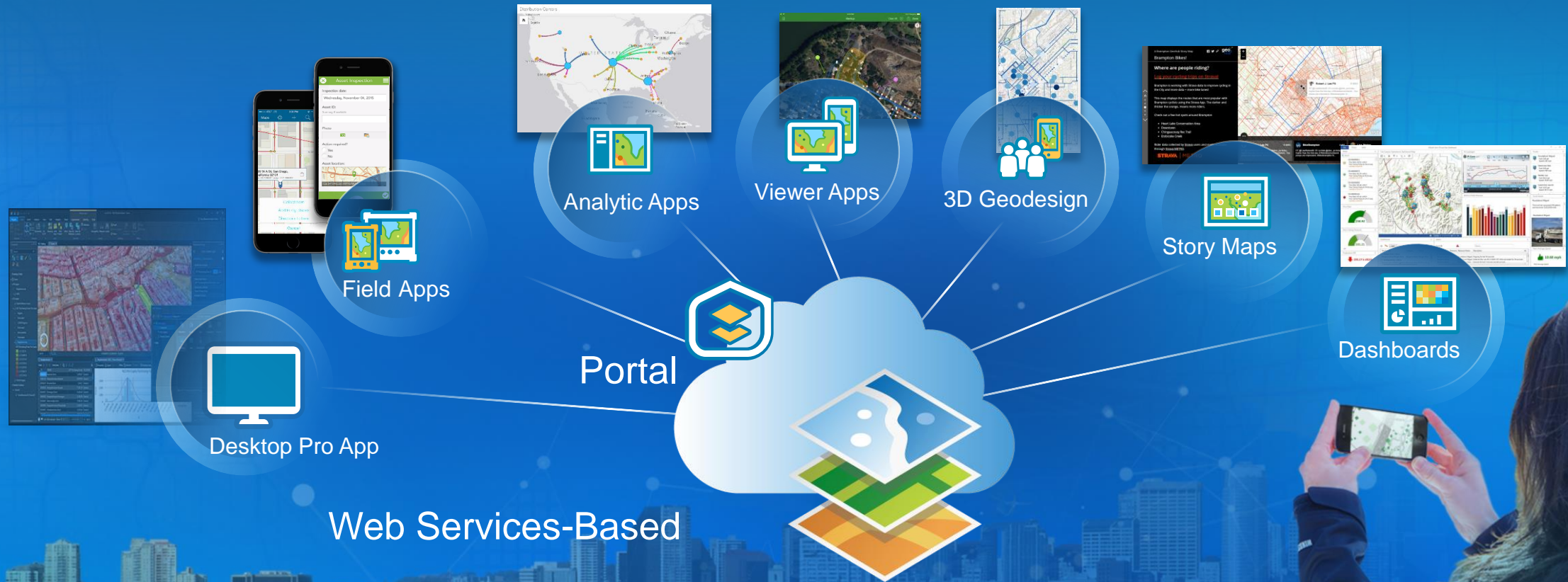
“Portal” =

ArcGIS Enterprise (on-premises)
ArcGIS Online (www.arcgis.com)



ArcGIS Apps

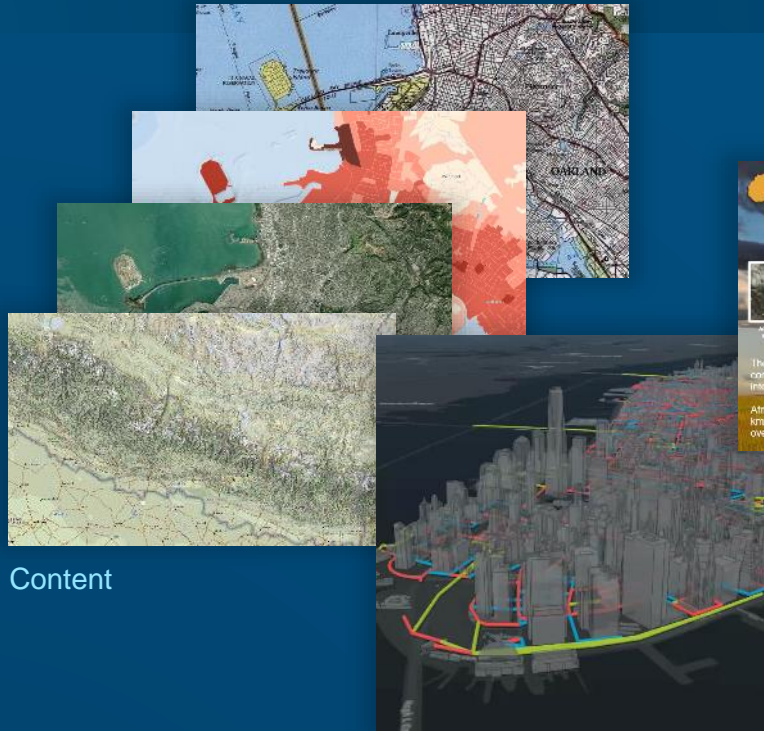
Extend the Reach of GIS to Everyone



Across Organizations and Beyond

ArcGIS Online Complete Mapping and Location Platform

www.arcgis.com



Content

2D / 3D



Configurable

- 7+ Million Users
- Billions of Maps
- 25 Million Items
- 150k Open Datasets

World's Largest Mapping
and Data-Sharing Ecosystem

New and Improved

- User Types
- Search
- Large Organization Administration
- Configurable Basemaps (Vector Feature Tiles)
- Smart Mapping Styles
- 3D
- New StoryMaps

Coming

- New Map Viewer
- Bulk User & Item Management
- Org-to-Org Collaboration
- Tracking
- Notebooks
- Hosted Imagery
- IoT Integration



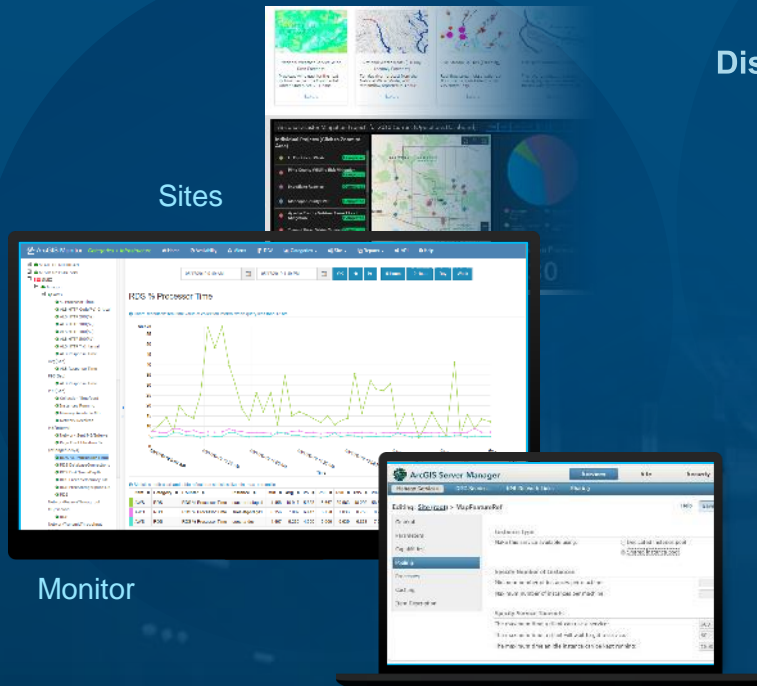
ArcGIS Enterprise Comprehensive GIS for Your Organization

New and Improved - 10.7.1 & 10.8

- Bulk Publishing
- Webhook Events
- Notebook Server Manager
- Sites Editor
- Templates and Apps
- Machine Learning & AI
- Feature Service Drawing Performance

Coming - ArcGIS Enterprise on Kubernetes

- Cloud-Native Deployment Option
- Microservices
- Supports Distributed Applications
- Better Security
- Dynamic Scaling, Streamlined Installation, Easier Maintenance, and Faster Updates
- Initial Release Q1-2021



Enterprise Data Management,
Mapping, Analysis, and Collaboration



ArcGIS Integrates All Types of Data

Data Management ... Editing and Updating ... Visualization Analytics



ArcGIS Content: Living Atlas

A Fundamental Part of the Platform

<https://livingatlas.arcgis.com/>

Thousands of Ready-to-Use Maps
and Datasets from Esri

Basemaps

Soils

Agriculture Topo Maps Addressing

Ecology Sentinel Earthquakes Traffic Rainfall

Geology Vegetation Roads

Imagery Land Cover Scientific

Stream Gauges Landsat Species NAIP Planes

Water MODIS Biology Elevation Lifestyle POIs

Demographics

Protected Areas

Distribution

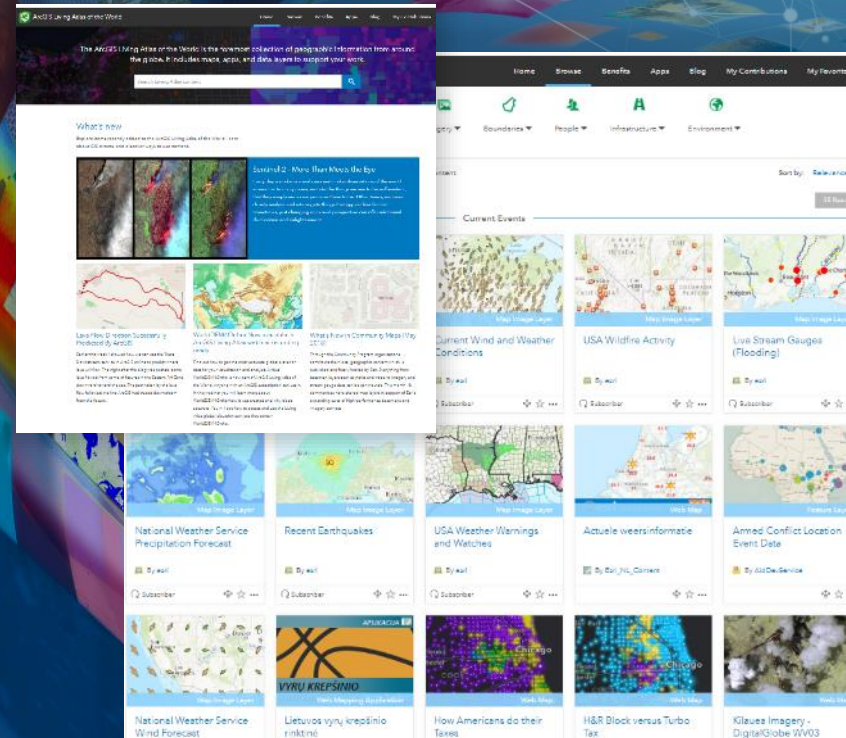
Hazards Climate DigitalGlobe Floodplains

Weather Historical Maps Landscape Oceans Stream Forecasts

Population Boundaries

OSM

Sea Temperature Wildfires Railroads



New

- Vector Basemaps
- Dynamic OSM
- Sentinel-2
- Imagery Styles
- Clarity & Firefly
- Wayback

Millions of Maps, Layers, and Data Sets
Shared by Users

The Foremost Collection of Digital Geographic Information . . .
. . . a Living Atlas of the World

3D Mapping and Visualization

New and Improved

- Smart Mapping
- Mobile Apps
- Point Clouds
- ArcGIS Earth
- Revit Support
- Symbology
- Standards



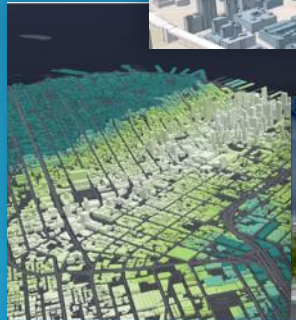
BIM



Edge Rendering



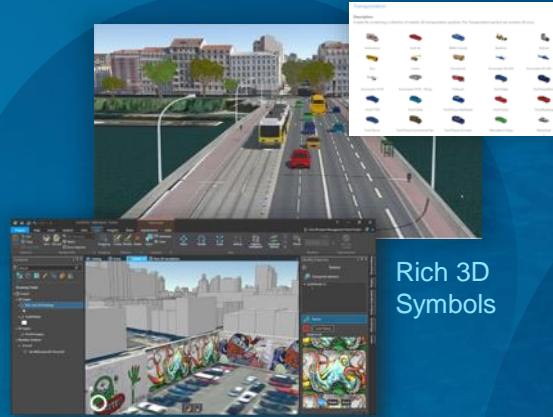
Visual Variables



Smart Mapping



Urban



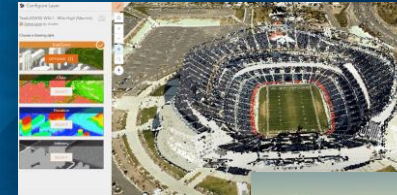
Rich 3D Symbols

Textures

3D Mobile Apps



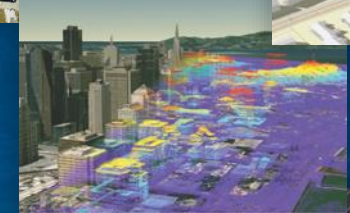
Global Scenes



Massive Point Clouds



I3S OGC Community Standard



Lidar



3D Mesh

Augmented Reality / VR



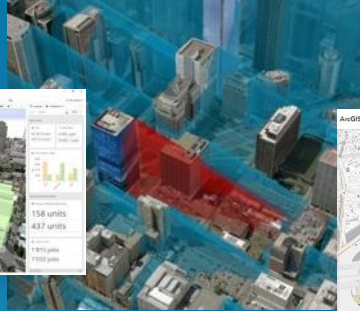
Mobile

3D Analysis

Analytics



Scenarios
and Dashboards

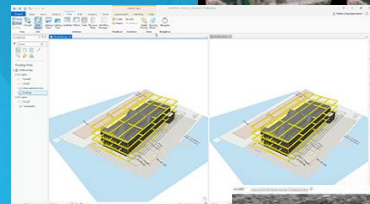


Shadow Analysis



3D Measurement

Stereo Display



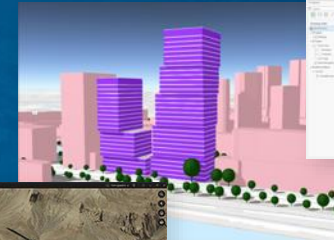
Isometric
Views



Line of Sight

Apps

CityEngine



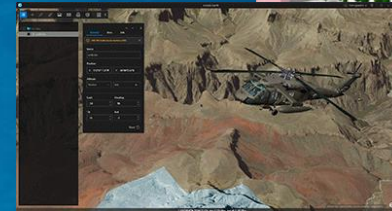
Pro



Scene Viewer



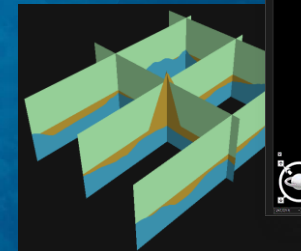
Earth



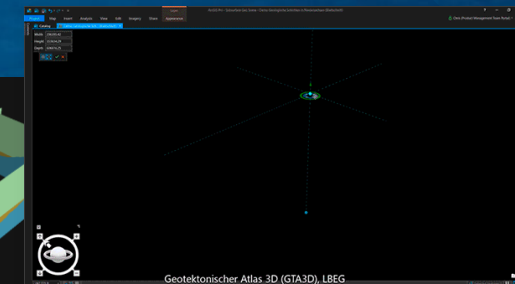
3D Objects and Analytics

Procedural
Modeling

Volumetrics



3D Fences



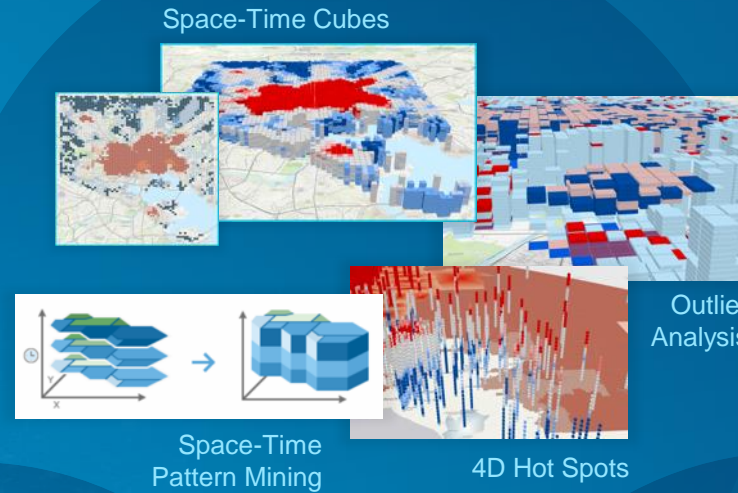
Interactive Slice

Comprehensive Spatial Analysis | Enabling Geospatial Data Science

New and Improved

- 60+ New Tools (1,200+ total)
- Charting
- ModelBuilder
- Space-Time
- VRP Solver
- Hydrologic Analysis
- Python API

Spatial Statistics



Raster Analysis

Hydrologic Tools



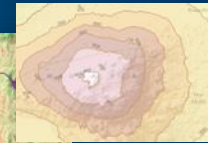
Flood Modeling



Big Datasets (230 Billion)



Contour Polygons



Corridor Analysis



Charting



Improved Processing

Batch Geoprocessing



Improved ModelBuilder



Integrated Analytic Notebooks

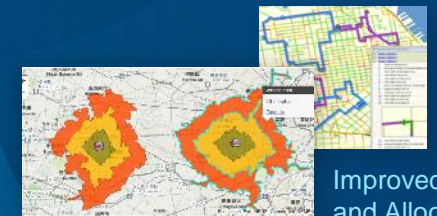


Big Data Computation



API for Python

Network Analysis



Improved VRP and Allocation

Artificial Intelligence, Machine Learning, & Data Science

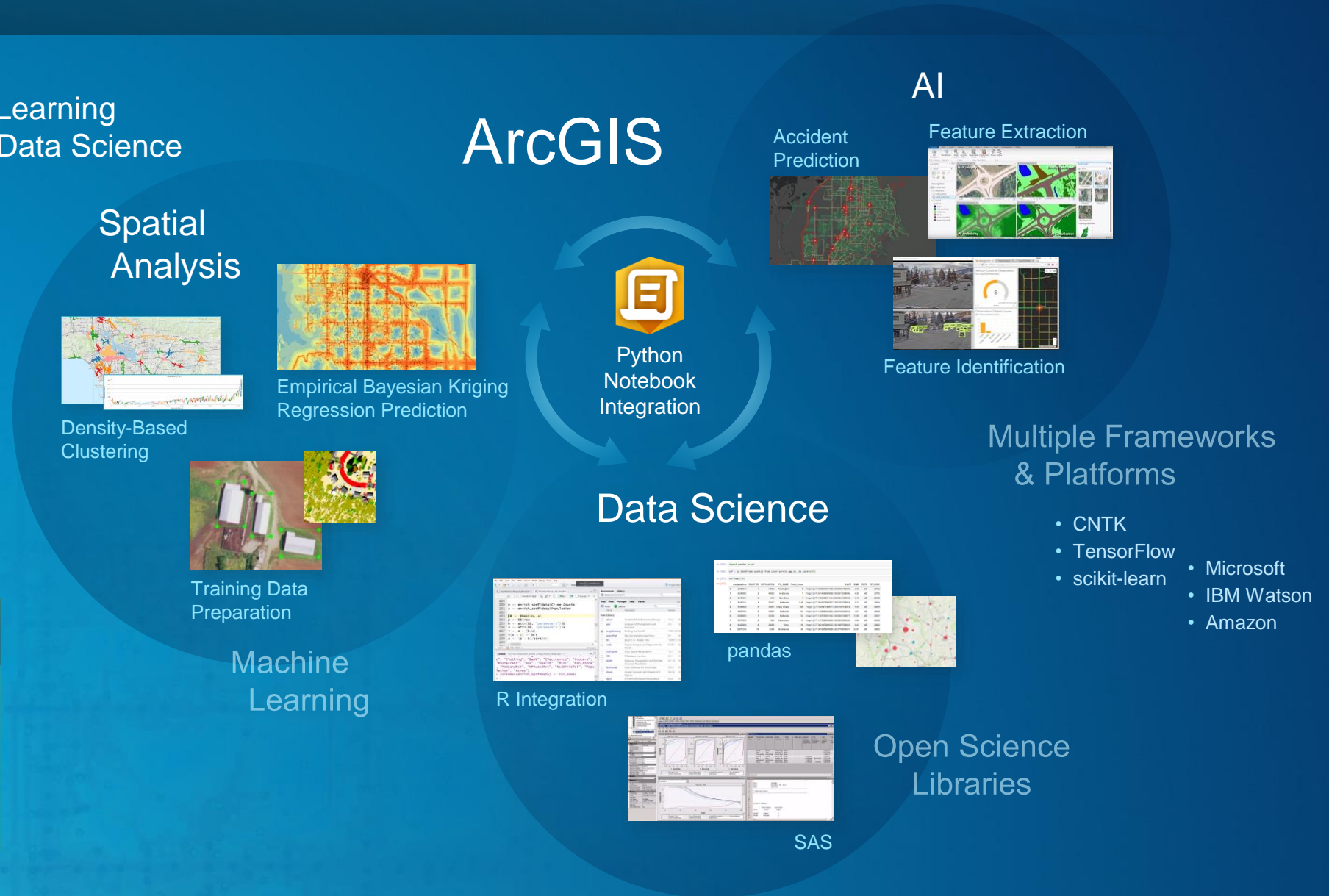
ArcGIS Includes Machine Learning
... and Integrates AI & Data Science

New and Improved

- Clustering
- Prediction
 - Classification
 - Regression
 - Interpolation
- Object Identification

Coming

- Feature Extraction
- Site Selection
- Event Prediction
- Image Analysis



Imagery | A Comprehensive System for Imagery and Remote Sensing



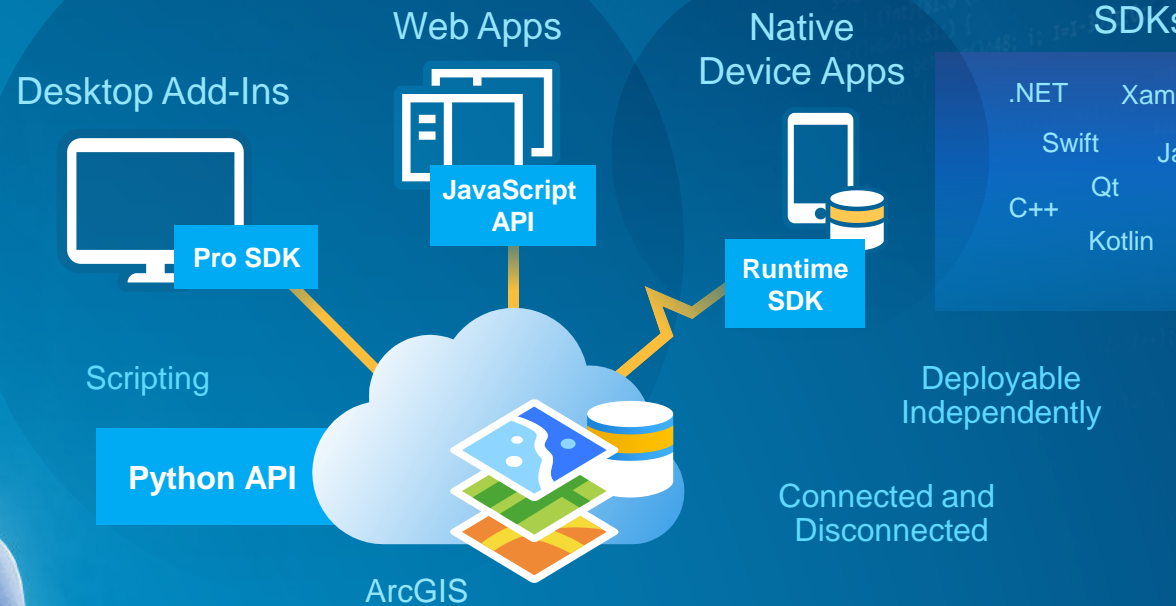
ArcGIS Developer Platform

Extending the Platform and Creating New Apps

Build Apps & Solutions

Supporting Multiple Types of Developers

- Mapping and Location Apps
- Geocentric Apps



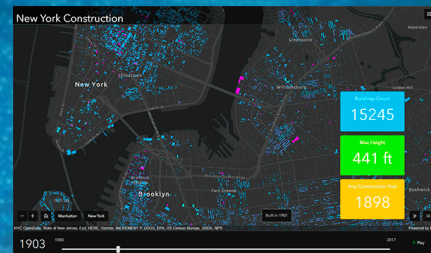
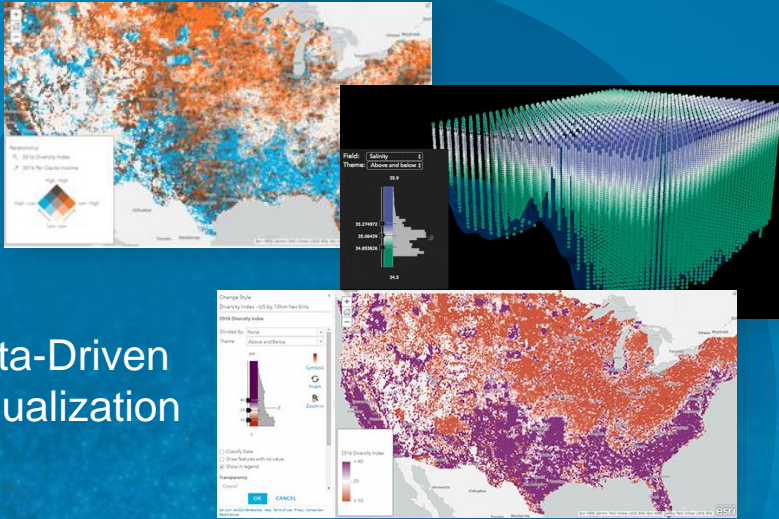
For Devices,
Web, and Desktop

Improved Developer Program

Supports Flexible Development and Deployment

JavaScript API | Enabling Powerful and Modern Web GIS Apps

Data-Driven
Visualization



Fast Interaction with
Large Datasets (WebGL)

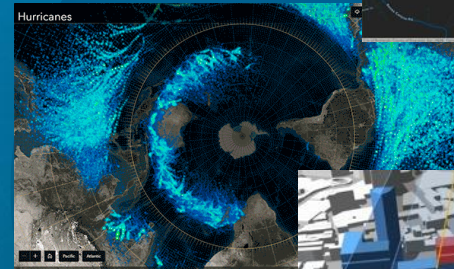
3D Measurement



Widgets and Tools

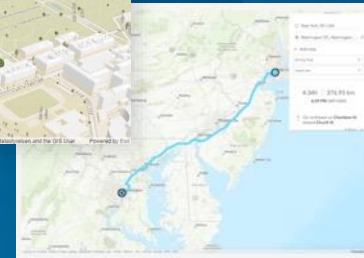
Client-Side Mapping
and Analytics

Client-Side Projection



Fast Display of
Large Datasets

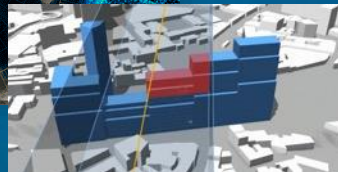
Directions



Drawing Tools

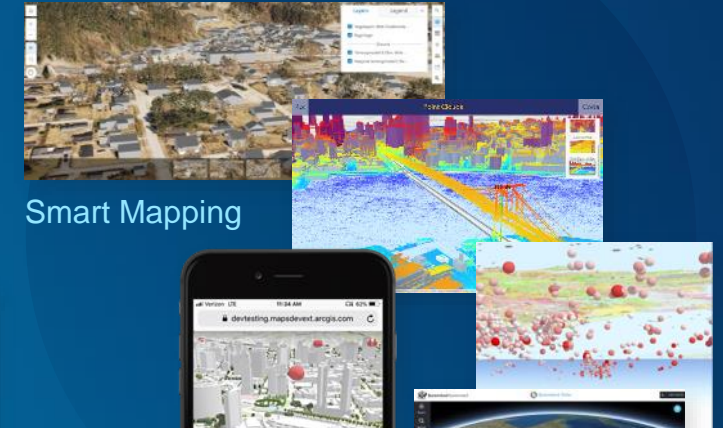


Real-Time
Geometric Analytics



Interactive Analysis

3D Scenes



Smart Mapping

3D Mobile
Web



ArcGIS App Builders | Enable *Everyone* to Build Apps

Simple and Powerful

Web

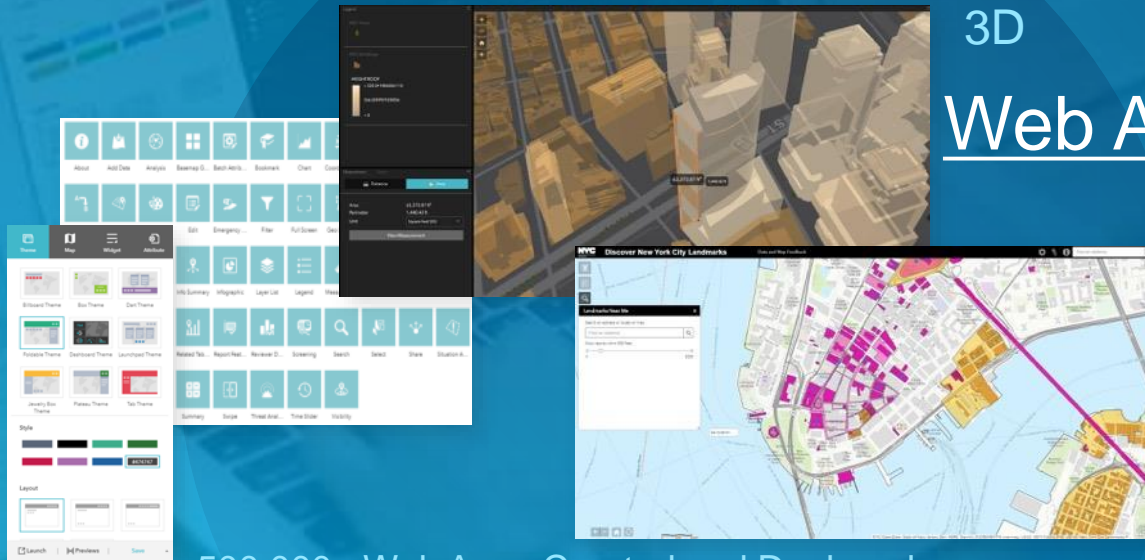
Expanding Capabilities

Online/Offline

3D

Web AppBuilder

Native Devices



500,000+ Web Apps Created and Deployed



AppStudio

Experience Builder

Build Once, Deploy on Any Device

No Programming Required



Field Operations | Empowering Mobile Workers

Integrated Apps for the Field

Connected and Disconnected

Smart Forms

Field Maps

Workforce

Navigator

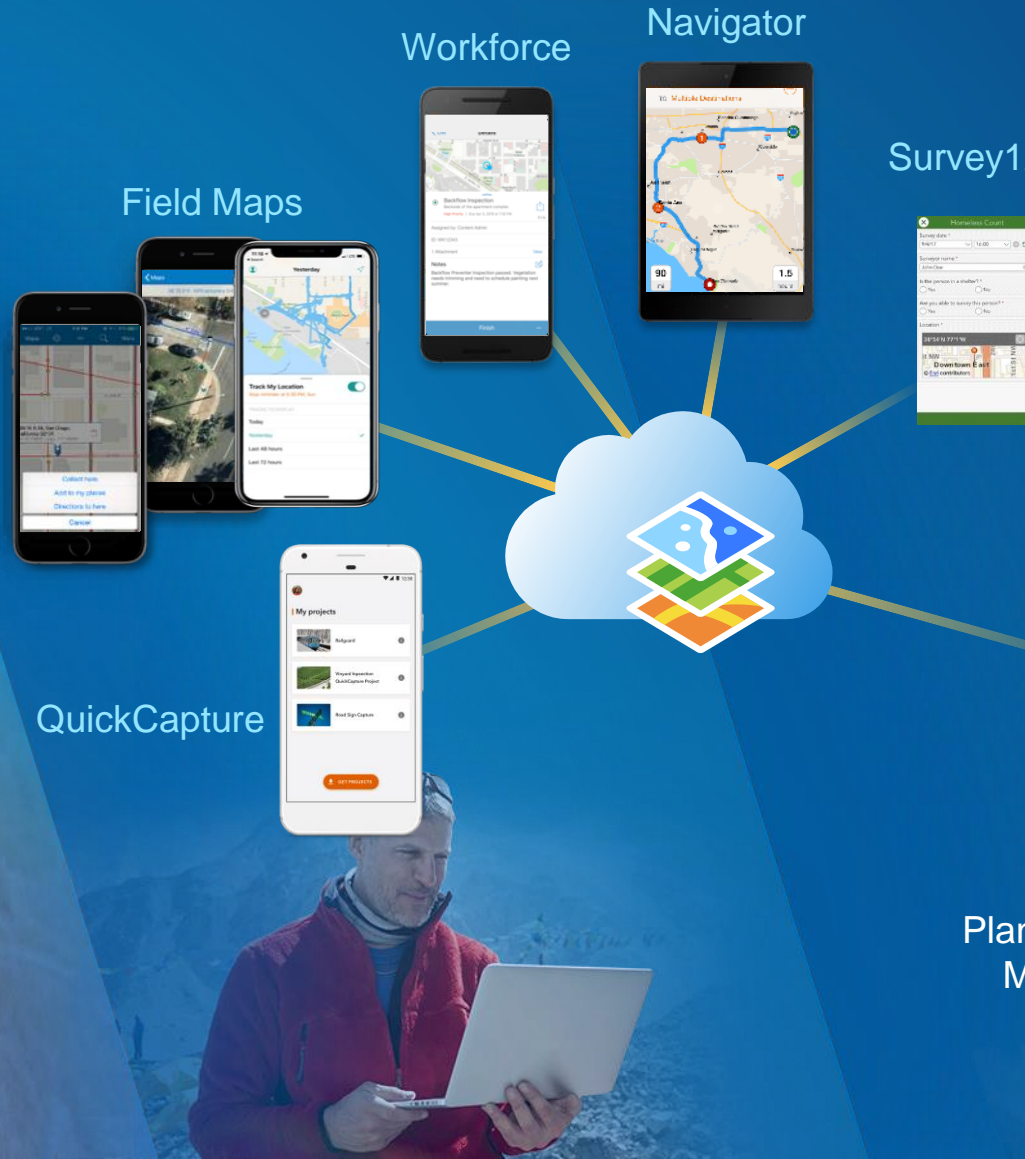
Survey123

QuickCapture

Dashboard

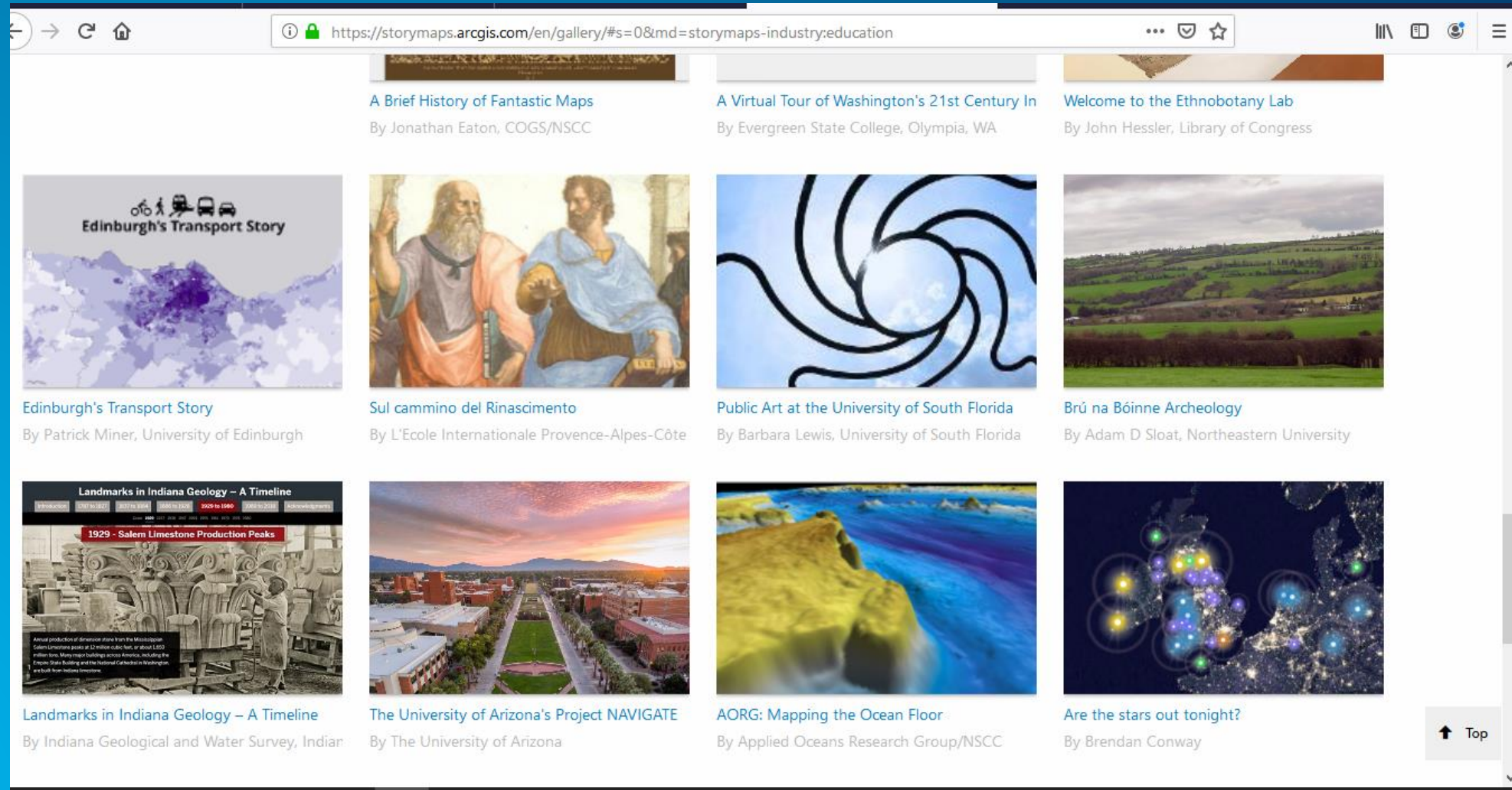
Plan & Monitor

- Data Capture
- Coordinating Work
- Navigation
- Mapping & Markup
- Location Tracking



StoryMaps: Publish your Results to the Rest of the World

... or just for colleagues and stakeholders...



The screenshot displays the StoryMaps gallery website, which features a grid of interactive map stories. Each story includes a thumbnail image, a title, and the author's name. The stories are as follows:

- A Brief History of Fantastic Maps** By Jonathan Eaton, COGS/NSCC
- A Virtual Tour of Washington's 21st Century In** By Evergreen State College, Olympia, WA
- Welcome to the Ethnobotany Lab** By John Hessler, Library of Congress
- Edinburgh's Transport Story** By Patrick Miner, University of Edinburgh
- Sul cammino del Rinascimento** By L'Ecole Internationale Provence-Alpes-Côte
- Public Art at the University of South Florida** By Barbara Lewis, University of South Florida
- Brú na Bóinne Archeology** By Adam D Sloat, Northeastern University
- Landmarks in Indiana Geology – A Timeline** By Indiana Geological and Water Survey, Indiana
- The University of Arizona's Project NAVIGATE** By The University of Arizona
- AORG: Mapping the Ocean Floor** By Applied Oceans Research Group/NSCC
- Are the stars out tonight?** By Brendan Conway

The website interface includes a browser address bar showing the URL <https://storymaps.arcgis.com/en/gallery/#s=0&md=storymaps-industry:education> and a sidebar with navigation options like Home, My StoryMaps, and Search.

Esri Geo-Enabled Systems – directly supporting focused workflows

Hub Engagement



Business Analyst Business Intelligence



Mission Awareness and Collaboration



Urban Urban Planning



Indoors Indoor Mapping

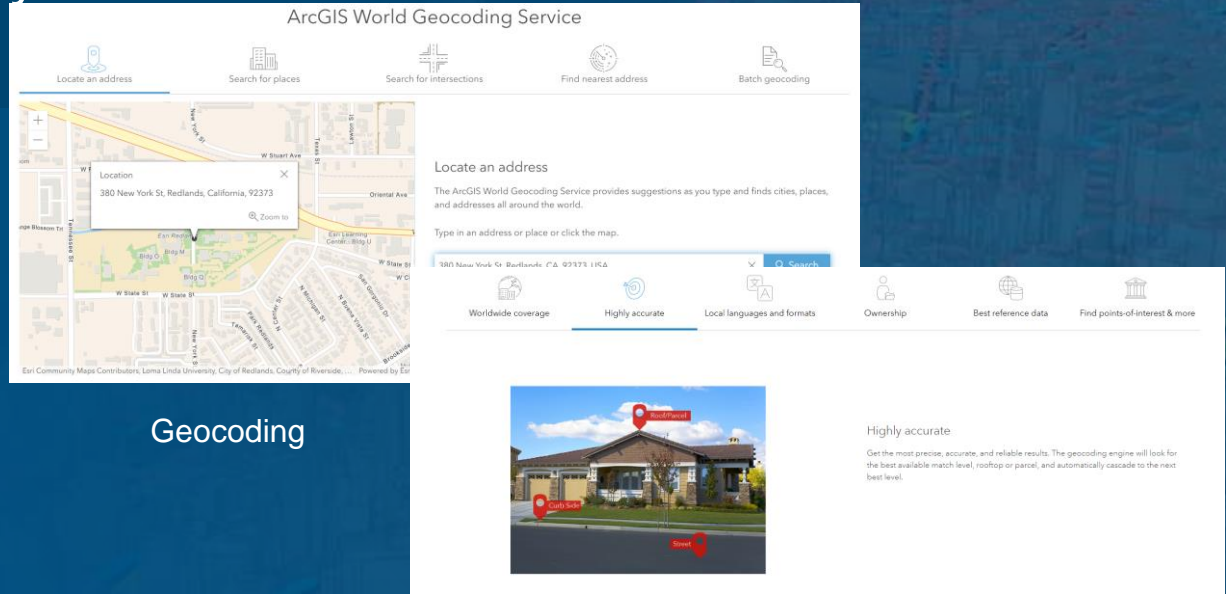
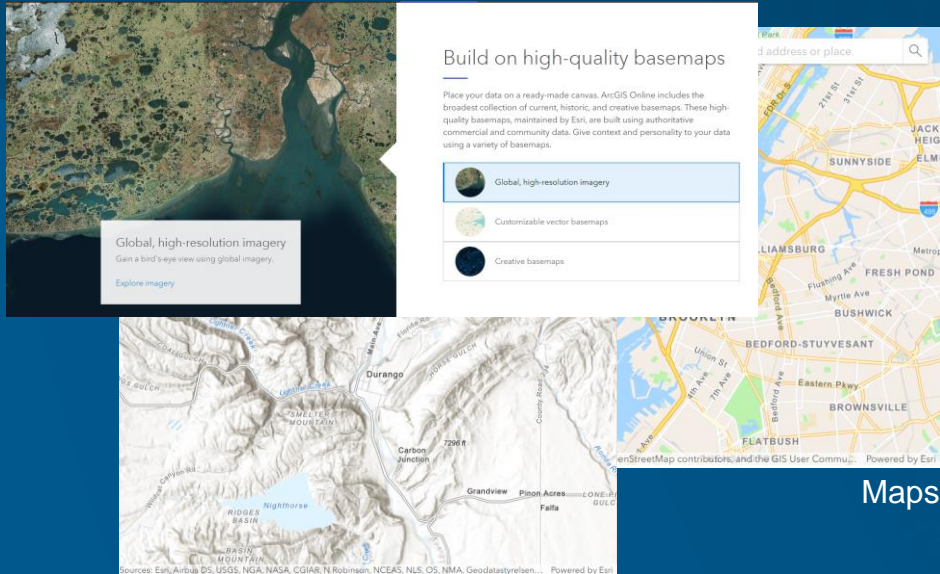


ArcGIS Insights GeoBI

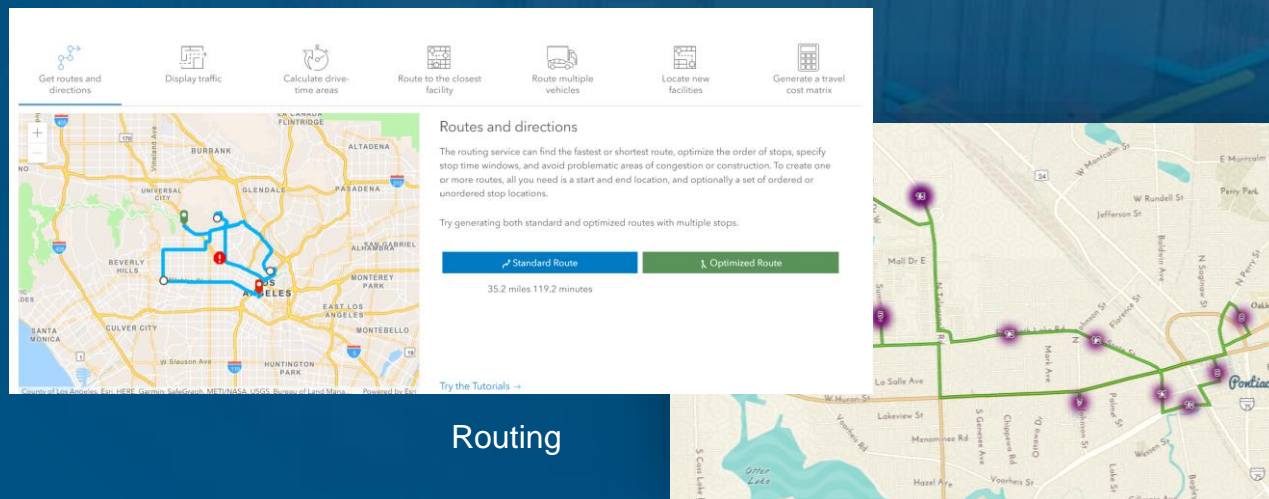
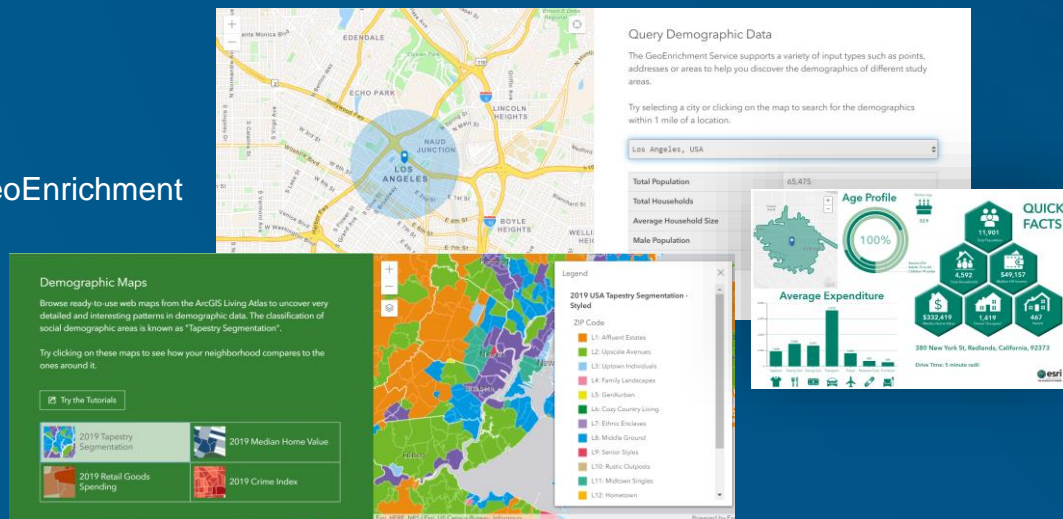


ArcGIS Platform (PaaS): Location Services

Provide spatial context and geo-enable your information

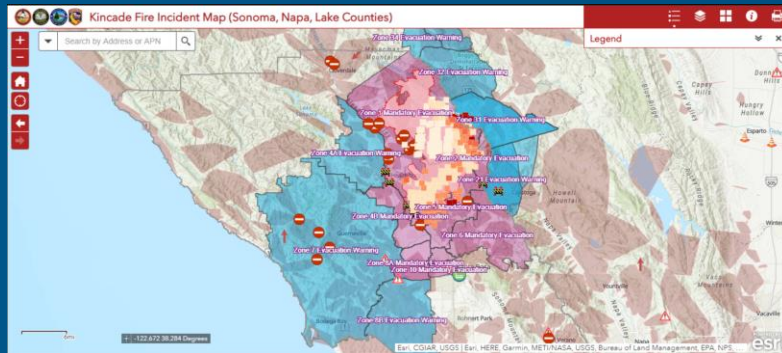


GeoEnrichment

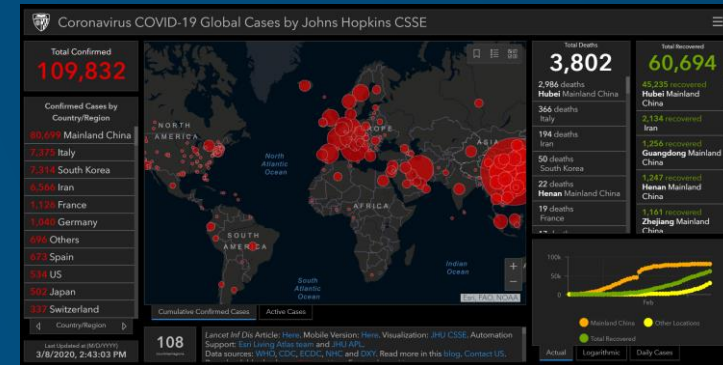


Routing

An online platform for sharing important information at scale

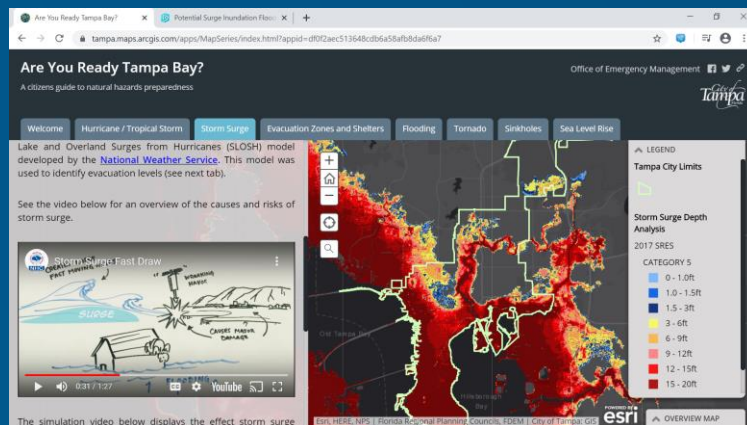


Sonoma County

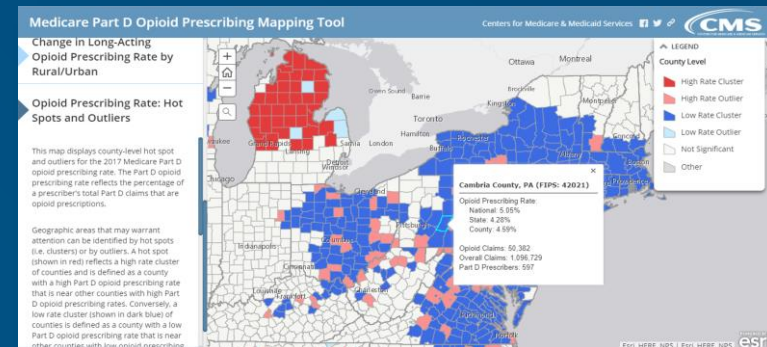


Johns Hopkins CSSE

A single trending map app may receive many thousands of requests/second and have millions of concurrent users



City of Tampa



Centers for Medicare and Medicaid Services US

Location Analytics

ArcGIS Insights

Self-Service

Mapping

Multiple Geometries
Flow Maps
Chart Symbology . . .

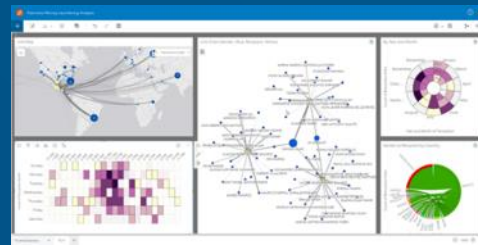
Analytics

Spatial
Temporal
Statistical
Predictive
Link/Graph . . .

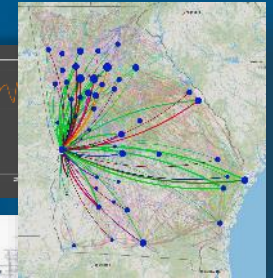
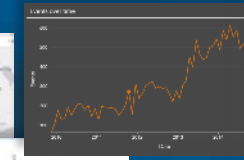
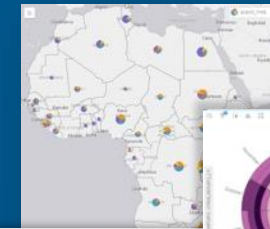
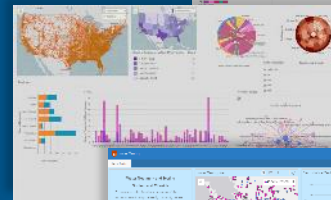
Charting

Distributions
Interactions
Measurement
Part to Whole
Relationships
Change . . .

Data Visualization and Analytics



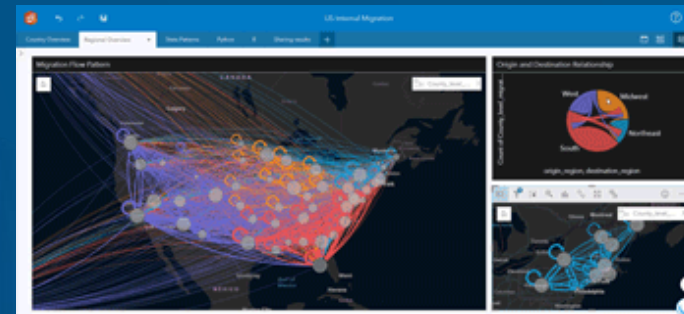
Charts



Link Charts

Spatial /
Temporal

Domains & Subtypes



New and Improved

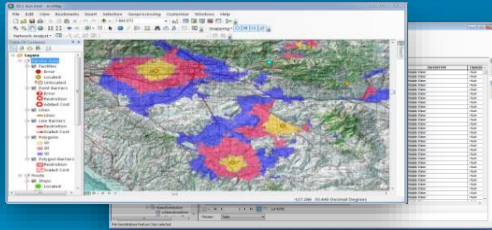
- Insights Desktop
- Subtypes and Domains
- New Visual Analytics
- Link Analysis
- Data Science Integration

Integrate spatial and traditional analysis across your organization . . .

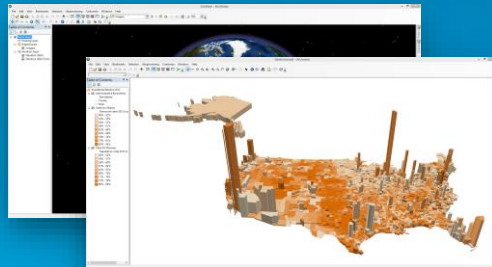
ArcGIS Pro desktop software

ArcGIS Pro

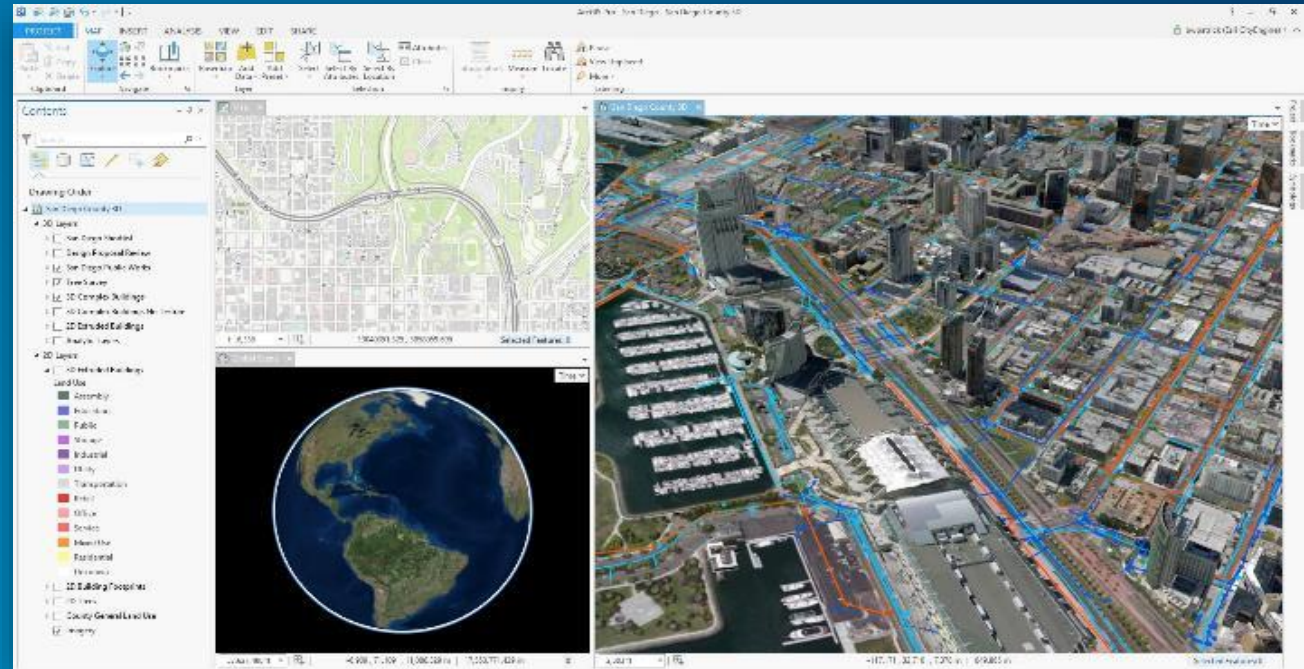
ArcMap / ArcCatalog



ArcGlobe / ArcScene



CityEngine

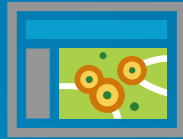


ArcGIS Pro 

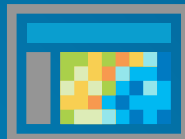
64-bit software...
Parallel Processing...
GPU computing...
Performance-wise, far superior to ArcMap

ArcGIS Pro: project

Maps, 3D-scenes and map layouts



Map 1



Map 2



3D-scene



Map layout

Tools, geoprocessing models, scripts, reports



Tool



GP model



Script



Report

Data Connections



Cloud



Server



Database

















Folder

Project folder

This PC > Documents > ArcGIS > Projects > Ensimmäinen_projekti

riige AB

Name	Date modified	Type
 Ensimmäinen_projekti.gdb	27/05/2019 17.00	File folder
 ImportLog	22/10/2018 14.57	File folder
 Index	28/10/2018 10.35	File folder
 LAS	24/10/2018 12.38	File folder
 Ajantasa-asemakaava on vantstarc1.esri-cloud.com	14/02/2018 13.46	Windows Media Player Skin File
 Ensimmäinen_projekti	28/10/2018 10.35	ArcGIS Project File
 Ensimmäinen_projekti.tbx	11/07/2018 14.05	TBX File
 image on vantstarc2.esri-cloud.com (user).ags	09/08/2018 10.56	AGS File
 mattikoulutus on vantstarc1.esri-cloud.com (user).ags	29/01/2018 15.20	AGS File
 server on vantstarc3.esri-cloud.com (user).ags	31/05/2018 14.36	AGS File
 Tekla Xcity WMS Server on kartta.pori.fi	11/07/2018 13.02	Windows Media Player Skin File
 testi_gdb.sde	03/05/2018 15.41	SDE File
 vandevarcdb1.esri-cloud.com.sde	22/10/2018 14.57	SDE File
 WMS on vantstarc1.esri-cloud.com	05/04/2018 15.54	Windows Media Player Skin File

User Interface

The screenshot displays the ArcGIS Pro interface with several key components highlighted by orange arrows:

- Top menu:** Points to the top ribbon menu containing tabs like 'Projekti', 'Kartta', 'Lisää', 'Analyysi', 'Näytä', 'Muokkaa', 'Kuva-aineisto', 'Jaa', 'Military Tools', 'Lisäosa', 'Ulkosa', 'Otsikointi', and 'Aineisto'.
- Contents-pane (TOC):** Points to the left pane showing the 'Piirtojärjestys' (Table of Contents) with layers like 'Asemakaava-alue' and 'World Topographic Map'.
- Active Map:** Points to the central map area displaying a red-outlined urban planning map.
- Attribute table:** Points to the bottom pane showing a table with columns: OBJECTID, Aloituspäivä, Budjetti, Kaavan nimi, Kaavan varsinaista nii, and As.
- Catalog Pane:** Points to the right pane showing the 'Hakemisto' (Catalog) with search results for 'Asemakaava-alue'.

The attribute table data is as follows:

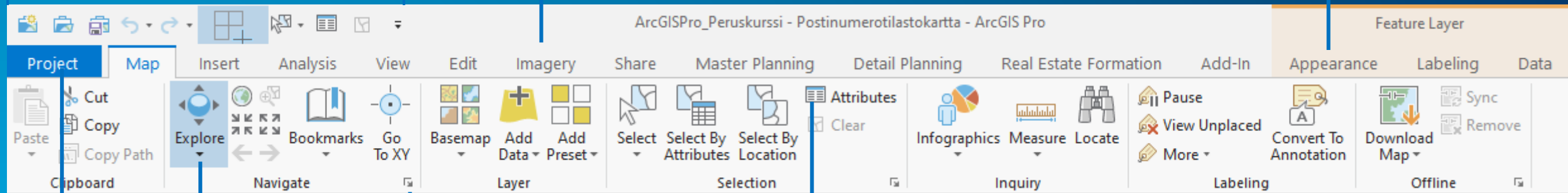
OBJECTID	Aloituspäivä	Budjetti	Kaavan nimi	Kaavan varsinaista nii	As
1	<Null>	<Null>	VAPAALA/13029	13/18.12.1997/K...	<N
	<Null>	<Null>	Varisto/14207 tontit...	14/10.9.2014/y	<N
	<Null>	<Null>	VIERTOLA,63113 OSA	63	<N
4	<Null>	<Null>	SIMONKYLÄ/65018/25	65	<N
5	<Null>	<Null>	KAIVOKSELA/16144,...	16/4.2.00/K...	<N

User Interface

Quick Access functionalities

Menu

Context-based menu



Project-menu
Project settings
and options

Hidden button
to open more
settings

Button/Functionality

Attributes

Show the Attributes pane. This allows you to view and edit the attributes of selected features.

Mouse pointer over
button shows pop-up
information

ArcGIS® Pro Roadmap

Near-term

- Upgrade Python Environment
- Knowledge Graphs
- Projects in the Enterprise
- Roof Editing in Stereo
- Dynamic Feature Clustering
- Animated Symbols
- Big Data Analytic Warehouses
- Indoor Positioning
- Presence-only Prediction
- Change Point Detection
- Geoprocessing Credit Estimator
- Suitability Modeler Sharing
- Parcel Fabric 3D Cadaster
- Voxel Layer Sharing
- Reality Mapping Extension
- Linear Referencing UI

Mid-term

- Catalog Layers
- Point Cloud Scene Layer Data Management
- Simulation Modeling
- Presentations
- Spatio-temporal Density Analysis
- Multiscale GWR
- Scientific Data Ingestion
- Parcel Lineage Visualization
- Parcel Fabric Coordinate Based Cadaster
- Managed Indoor Data Pipeline
- ENC Chart Viewing
- Enhanced Radar data support

Long-term

- Terrain Editing
- Materials Authoring
- High Fidelity Rendering
- 3D Mesh as Ground
- Integrated Mesh Scene Layer Data Management
- 64-Bit Object ID
- New Data Types (BigInteger, Timestamp with Time zone)

May 2021

Hands-on: the ArcGIS Pro UI

+ Environment Settings, Portal Login, File Geodatabase...

Hands-on: the ArcGIS Pro UI

- **Let's do a simple exercise from learn.arcgis.com website to learn the basics of the UI**
- **Open web browser and go to:**
 - <https://learn.arcgis.com/en/projects/get-started-with-arcgis-pro/>
- **Do the exercise.**

“Nose-dive to Analytics”

- Introduction to Spatial Science and Spatial Analysis on ArcGIS
- ArcGIS Pro desktop software
- Hands-on: Cluster and Outlier Analysis and Regression tools

What is Data Science, Spatial Analysis?

- Data science is an inter-disciplinary field that uses scientific methods, processes, algorithms and systems to extract knowledge and insights from many structural and unstructured data. Data science is related to data mining, deep learning and big data. (Wikipedia 2020)
 - In GIS context it is often understood for the use of supervised and unsupervised machine learning techniques and methods
 - clustering, classification and prediction techniques are some of the most widely used methods in machine learning
 - Machine Learning methods have been around GIS and spatial analysis for a long time...
- Spatial Analysis examines the topological, geometrical or geographical properties of given features or phenomenon. These properties include i.e. relationships and neighborhood properties.

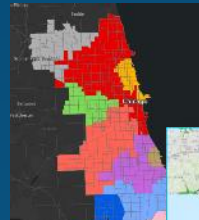
Spatial Analysis and Data Science

Many Improvements

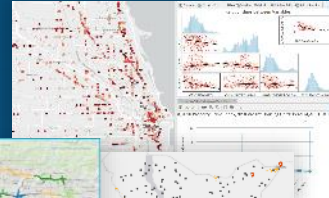
- Functionality
- Scalability
- Accessibility

Spatial Statistics

Balanced Zones



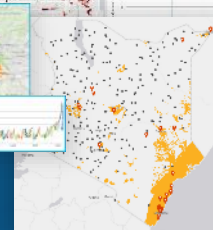
Logistical Regression



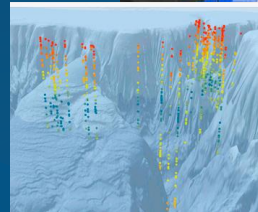
Density-Based Clustering



Forest-based Classification and Regression



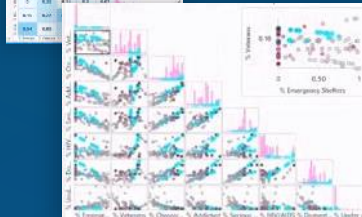
3D Interpolation (EBK)



Charting



Calendar Heat Map



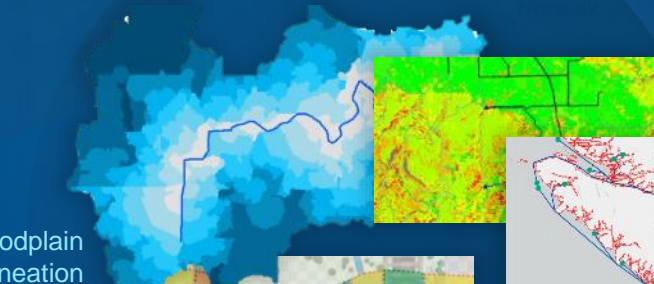
Scatter Plot Matrix



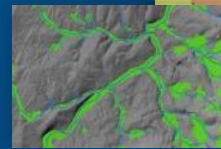
Data Clock

Raster Functions

Floodplain Delineation



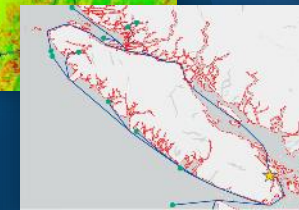
DEM Error



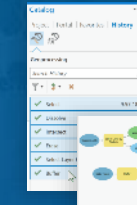
River Classification



Cost Distance



Improved Processing



Tool History to Models



Models to Python

Enterprise

Pro



Scalable GeoAnalytics



Deep Learning



Python Notebooks

AI, ML and Deep Learning Integrating Open Science



Current focus areas: multispectral imagery, feature extraction from 3D point clouds and meshes

Imagery

A Comprehensive System for Imagery and Remote Sensing

New

- Image Cube Support
- Deep Learning Tools
- NTM Support
- Drone Imagery in Cloud
- Flight Planning

Map Production



Analysis



Visualization & Exploitation

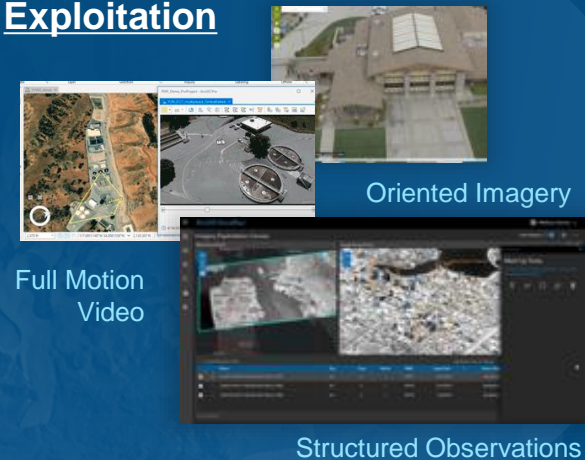
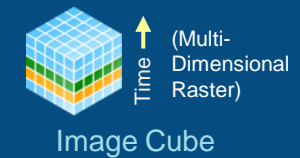


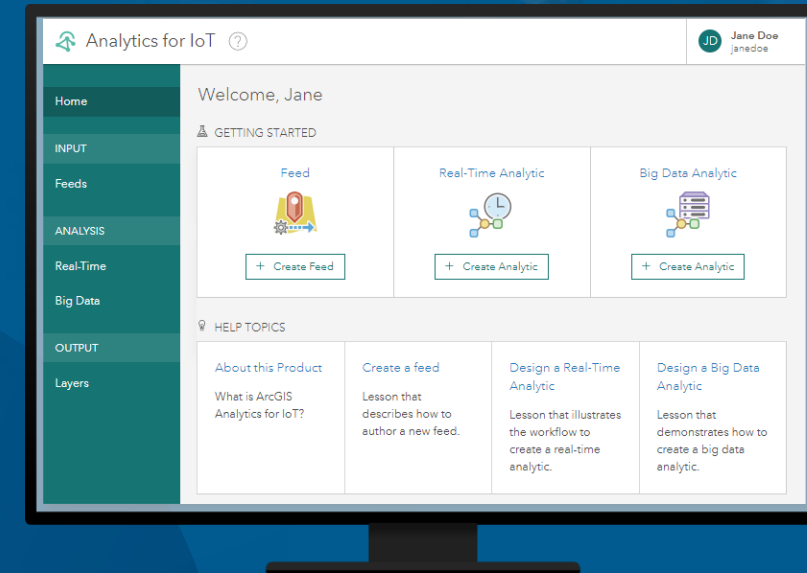
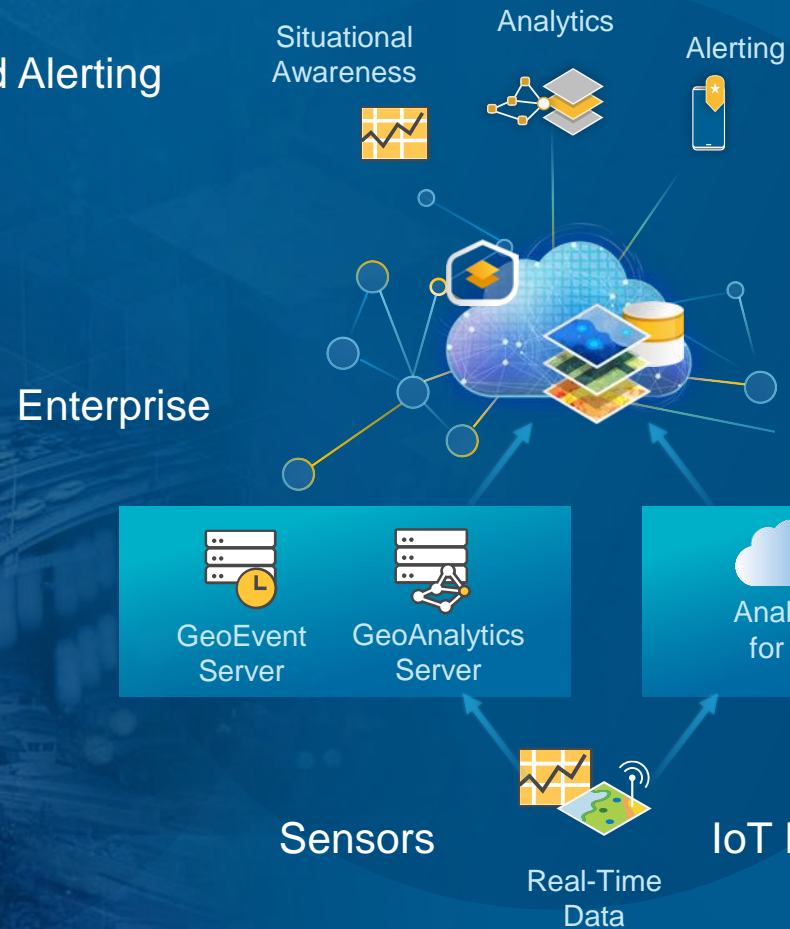
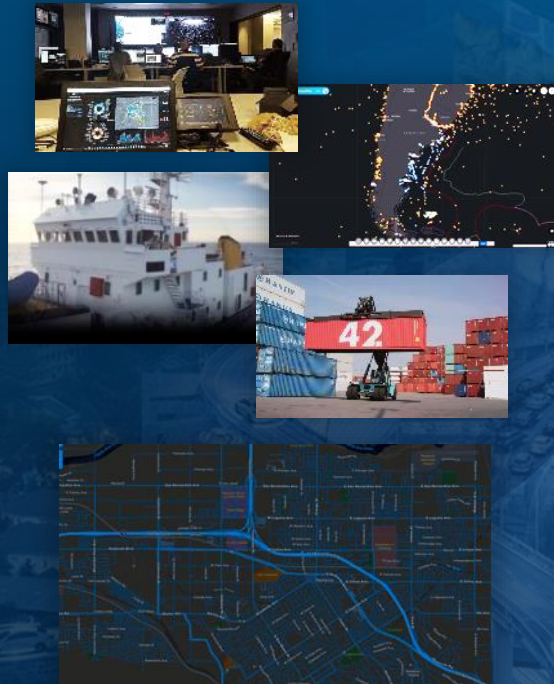
Image Management



Real-Time Analytics

Integrating Sensor Networks and IoT

Supporting High-Velocity Data Streams
Tracking, Monitoring and Alerting



- Cloud Native Service
- Very Fast
- High Volume
- SaaS

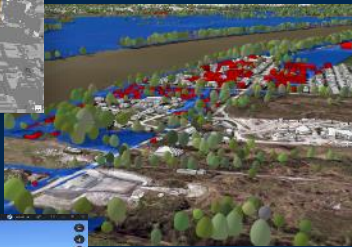
Collapsing the Time from Measurement to Decision Making

3D Analysis

Analytics



Shadow Analysis



Flood Impact



3D Measurement



Lidar to Buildings

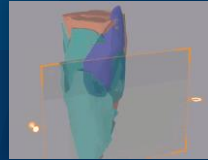


Line of Sight & Viewshed

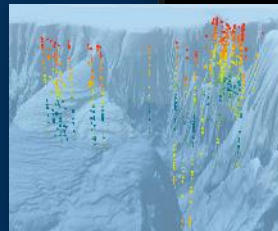


Elevation Profile

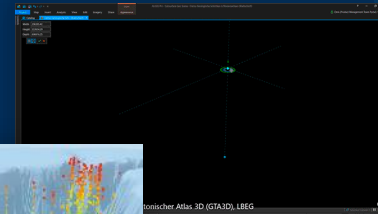
Volumetrics



Volumetric Slicing



3D Interpolation (EBK)



Interactive Slice

Apps

Pro



3D GIS

CityEngine



Procedural Modeling

Scene Viewer



Visualization

Earth



3D Visualization and Analytics



Mobile

ArcGIS Notebooks

Jupyter Notebook for Integration, Modeling and Automation

Data Engineering

Data frames
Geoenrichment
Geocoding
Create and edit layers

Spatial Analysis

Standard Analysis Tools
Geoprocessing (ArcPy)
GeoAnalytics
Raster Analytics

AI, ML, & Deep Learning

Spatial Machine Learning
Neural Networks
Natural Language Processing

Interactive Computing

ArcGIS Notebook



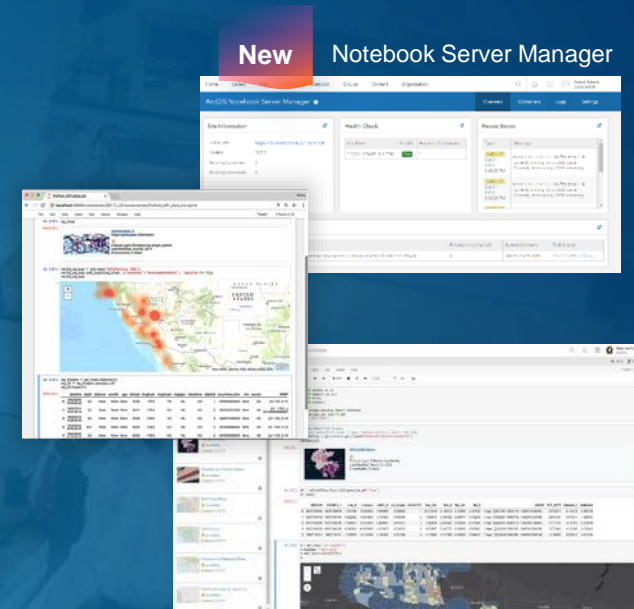
Pro
Enterprise
Online

Automation

ArcGIS API for Python
Built-in scheduling (coming)
Import existing notebooks

New

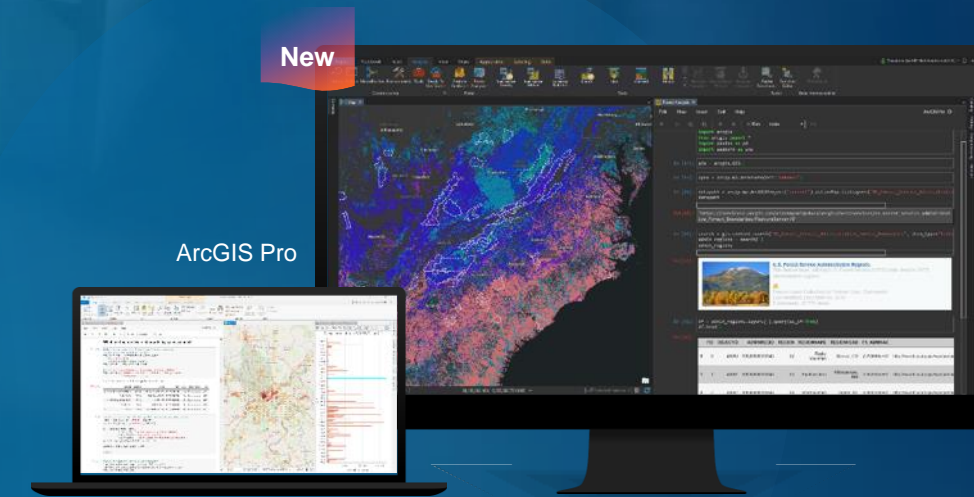
Notebook Server Manager



Hosted in ArcGIS Enterprise
and Coming to ArcGIS Online

New

ArcGIS Pro



Hands-on: Cluster and Outlier Analysis + Regression tools

Cluster and Outlier Analysis (Anselin Local Moran's I)

Optimized Hot Spot Analysis

Density Based Clustering

Multivariate Clustering

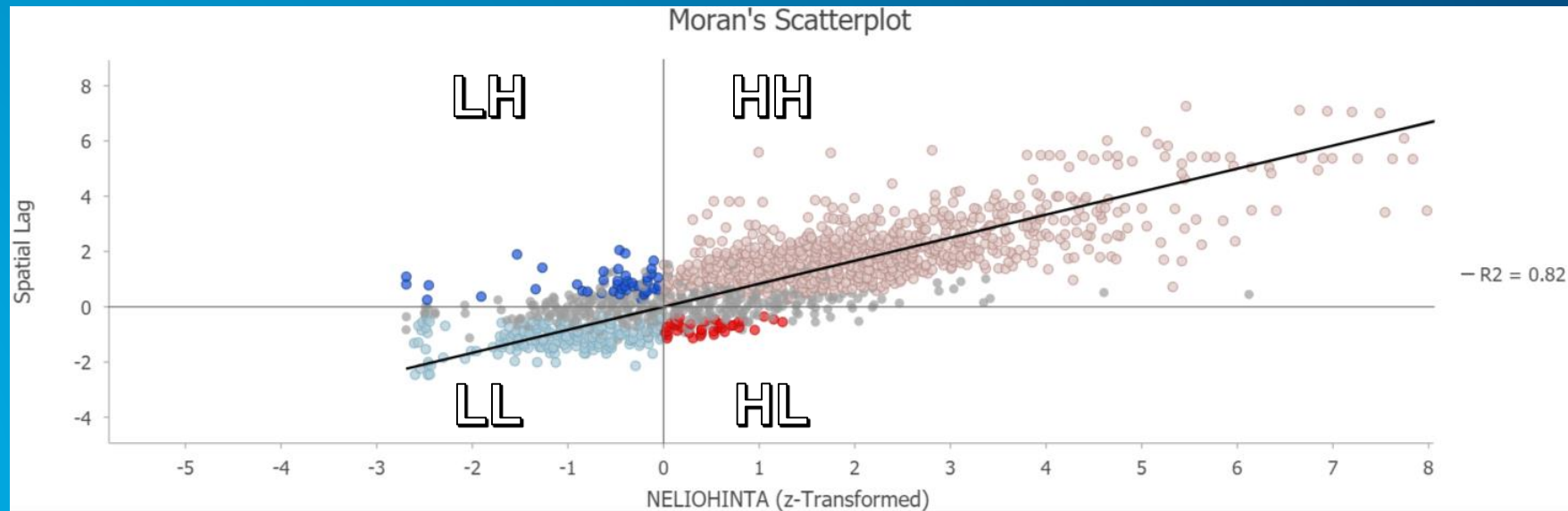
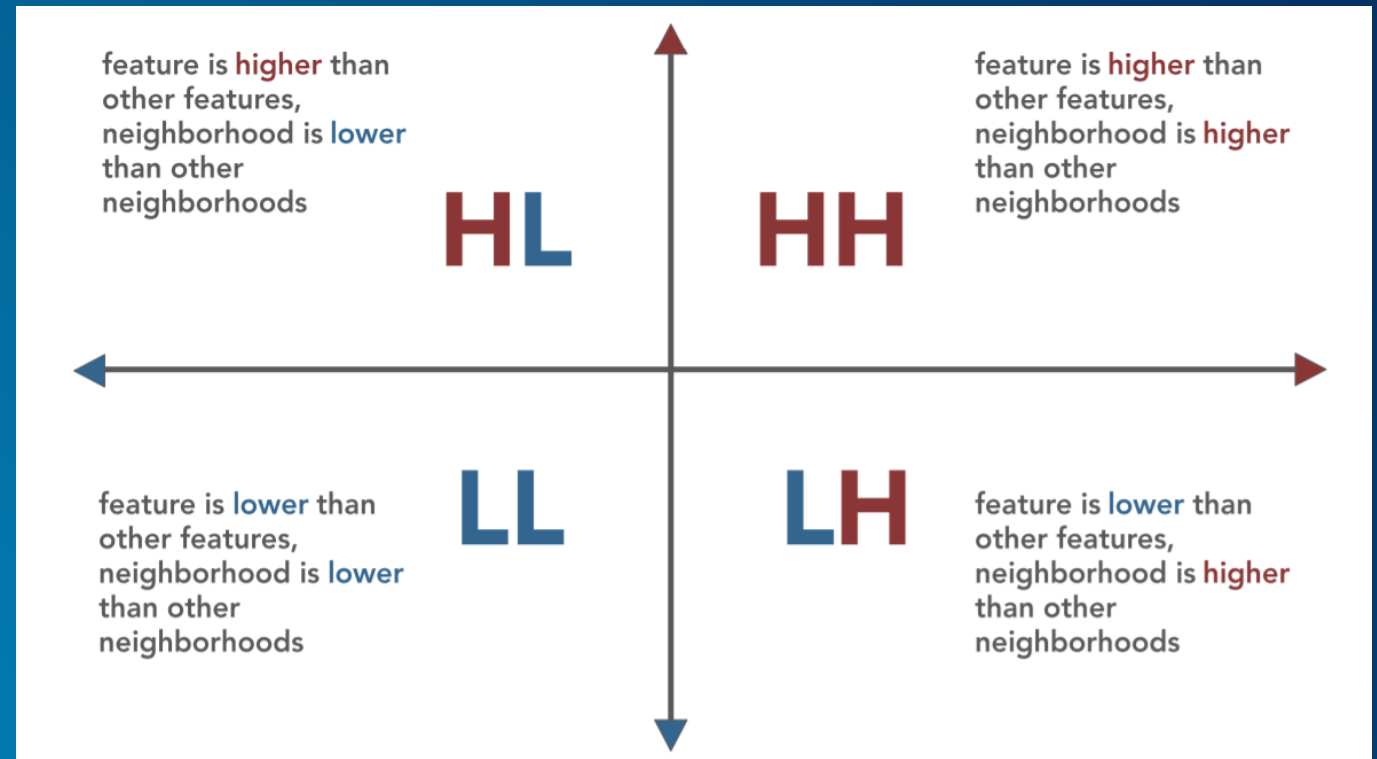
Regression tools for predictions

Hands-on: Cluster and Outlier Analysis

- In the next exercise we first examine for clusters and outlier anomalies of residence sales information in Helsinki Metropolitan area...
- ... then we determine density clusters of road traffic incident clusters
- ... and make demographic segmentation based on local demographic profile data
- Cluster and Outlier Analysis (Anselin Local Moran's I) tool to test clusters of features for statistical significance
- We use *Density-Based Clustering (DBC)*, *Multivariate Clustering (MVC)* utilize unsupervised machine learning methods to determine clusters from input data
 - These classification methods are considered unsupervised as they do not require a set of pre-classified features to guide or train on in order to find clusters in your data.

Cluster and Outlier Analysis

- Cluster and Outlier Analysis (Anselin Local Moran's I)



Speaking of Hot Spots...

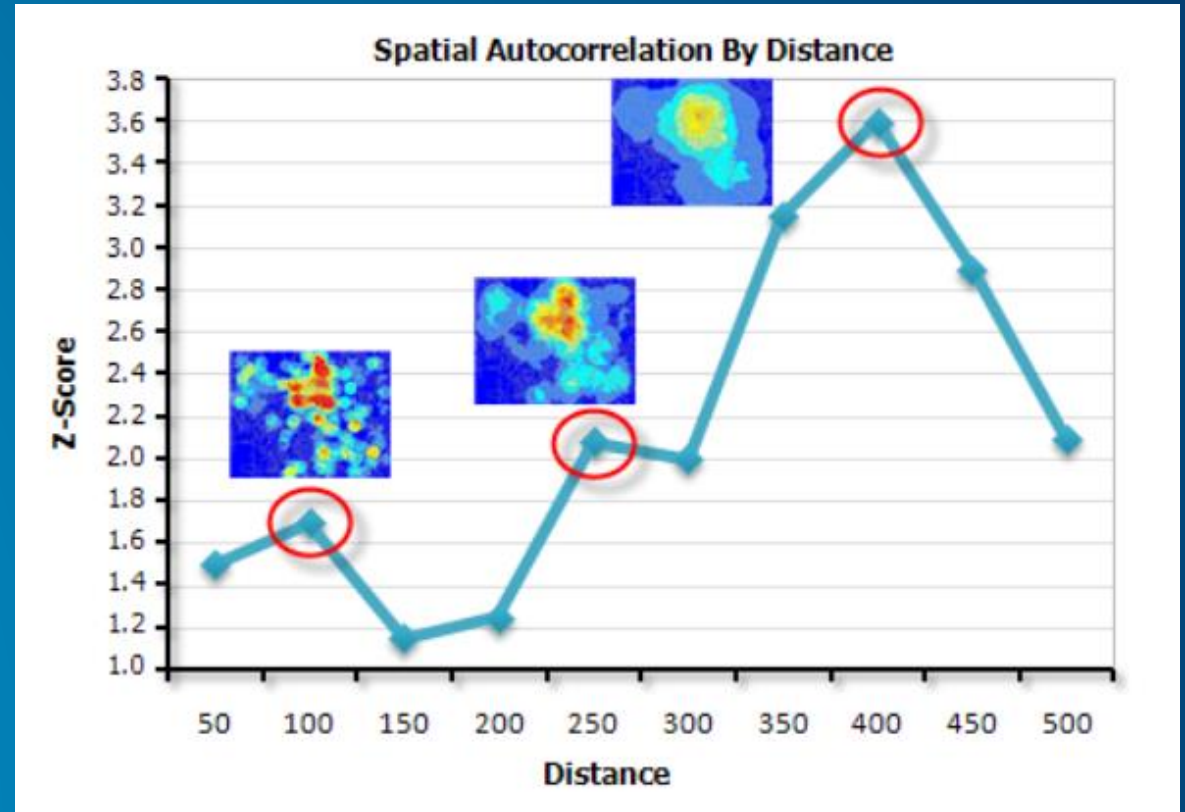
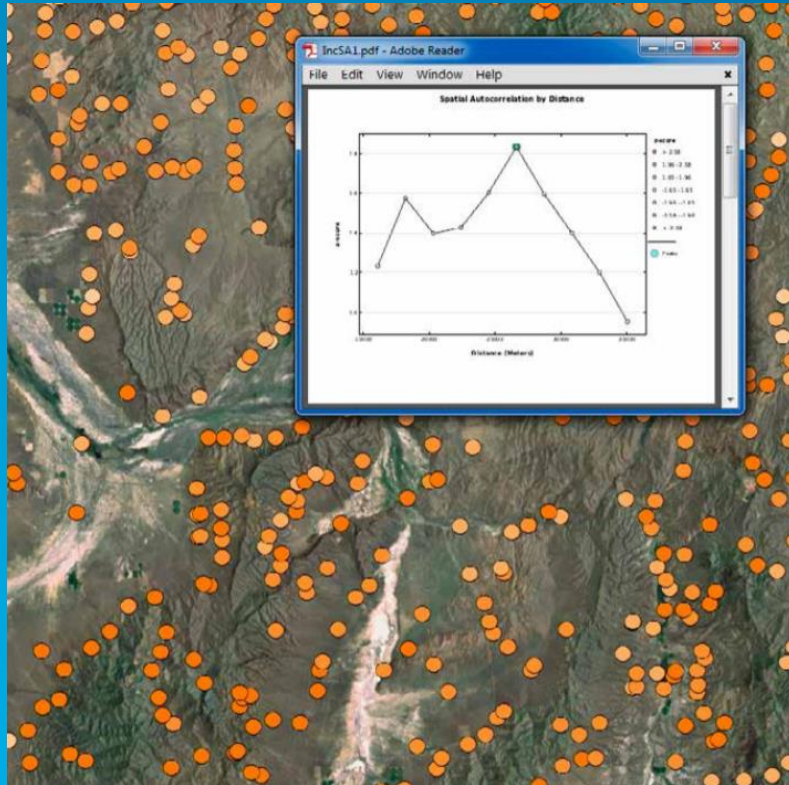
Detecting and Quantifying Patterns

Where are the significant hot spots, anomalies, and outliers?

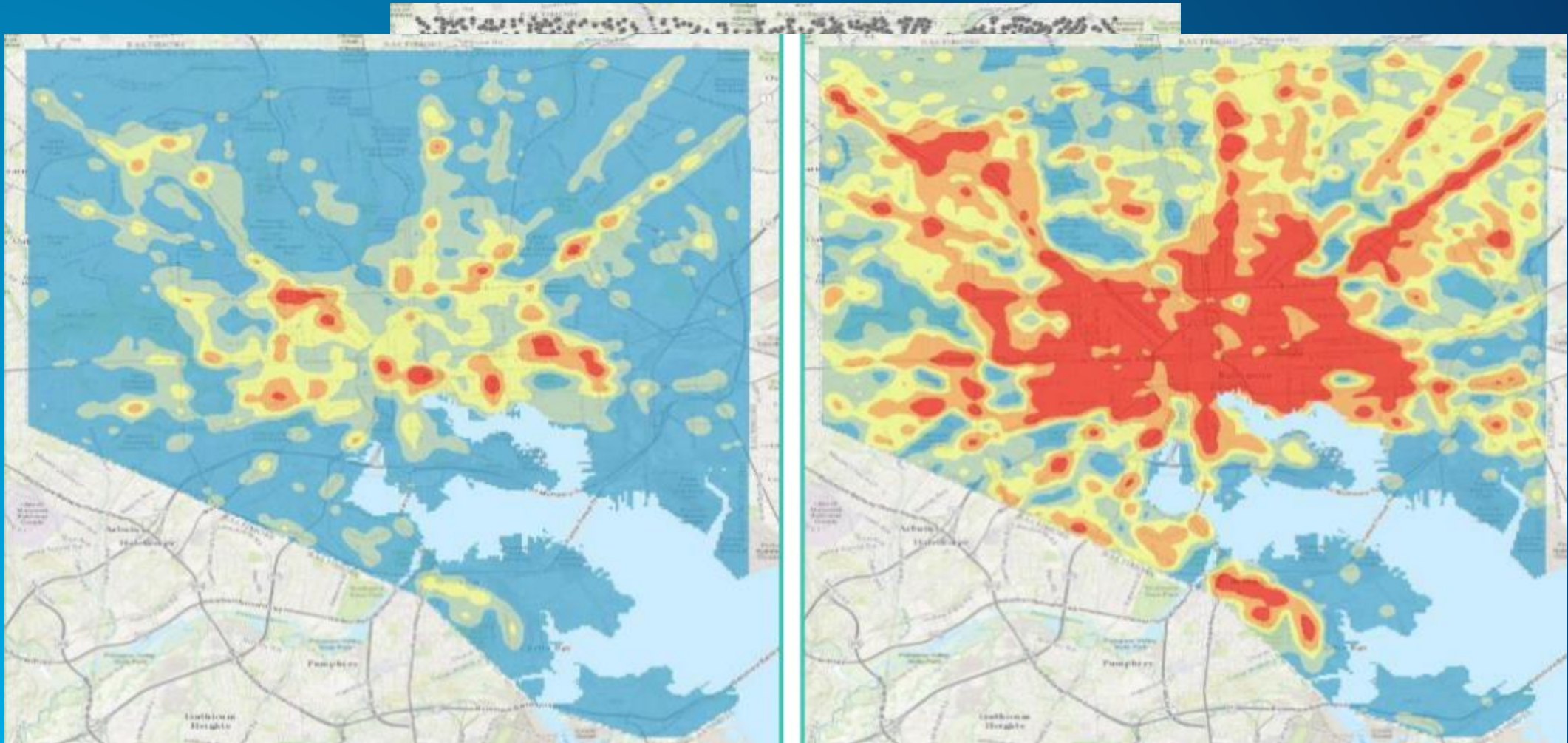
What are the local, regional, and global spatial trends?

Which features/pixels are similar, and how can they be grouped together?

Are spatial patterns changing over time?



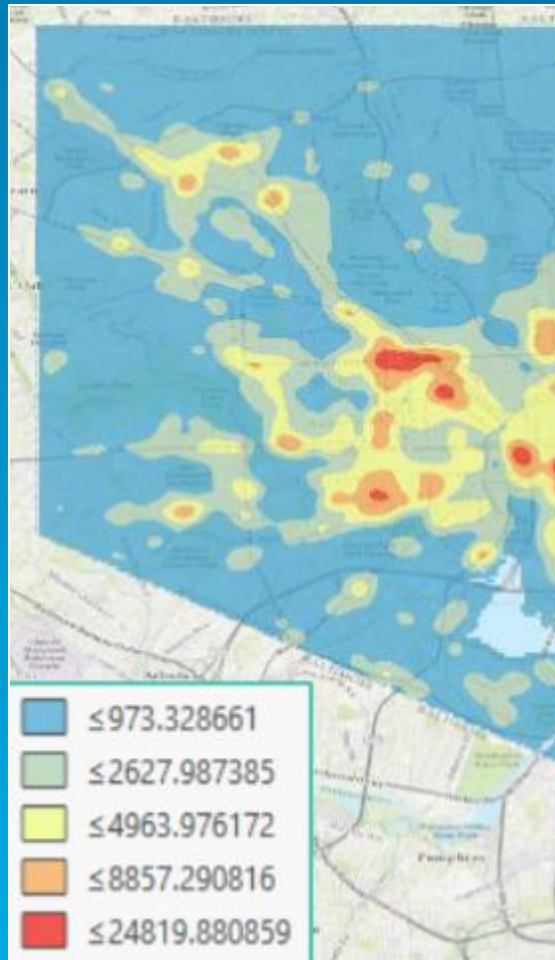
911 Calls in Baltimore



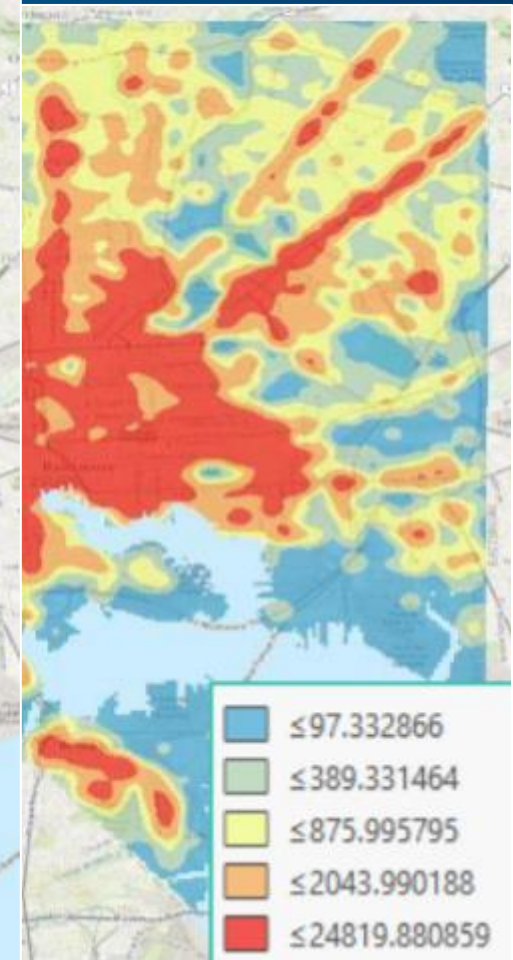
Where are the actual hot spots? Where is the variation higher?

911 Calls in Baltimore

Natural Breaks



Quantile

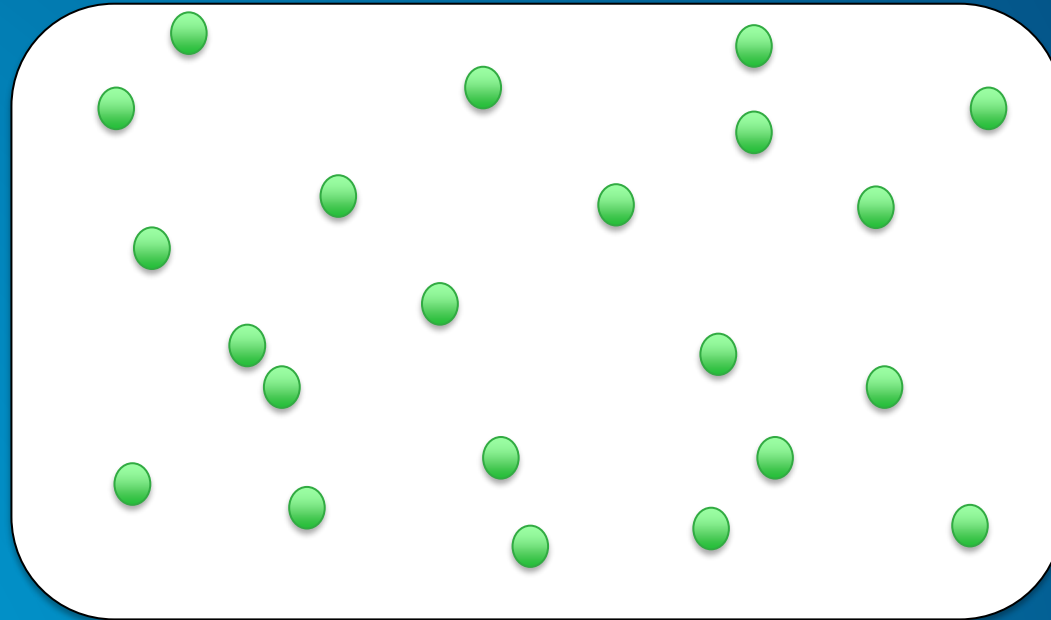


Heat maps vs. hot spots!

The subjectivity of visual pattern analysis is (sometimes) something we want to *minimize*.

Statistical Significance is tested vs.
Null Hypothesis of
Complete Spatial Randomness (CSR)

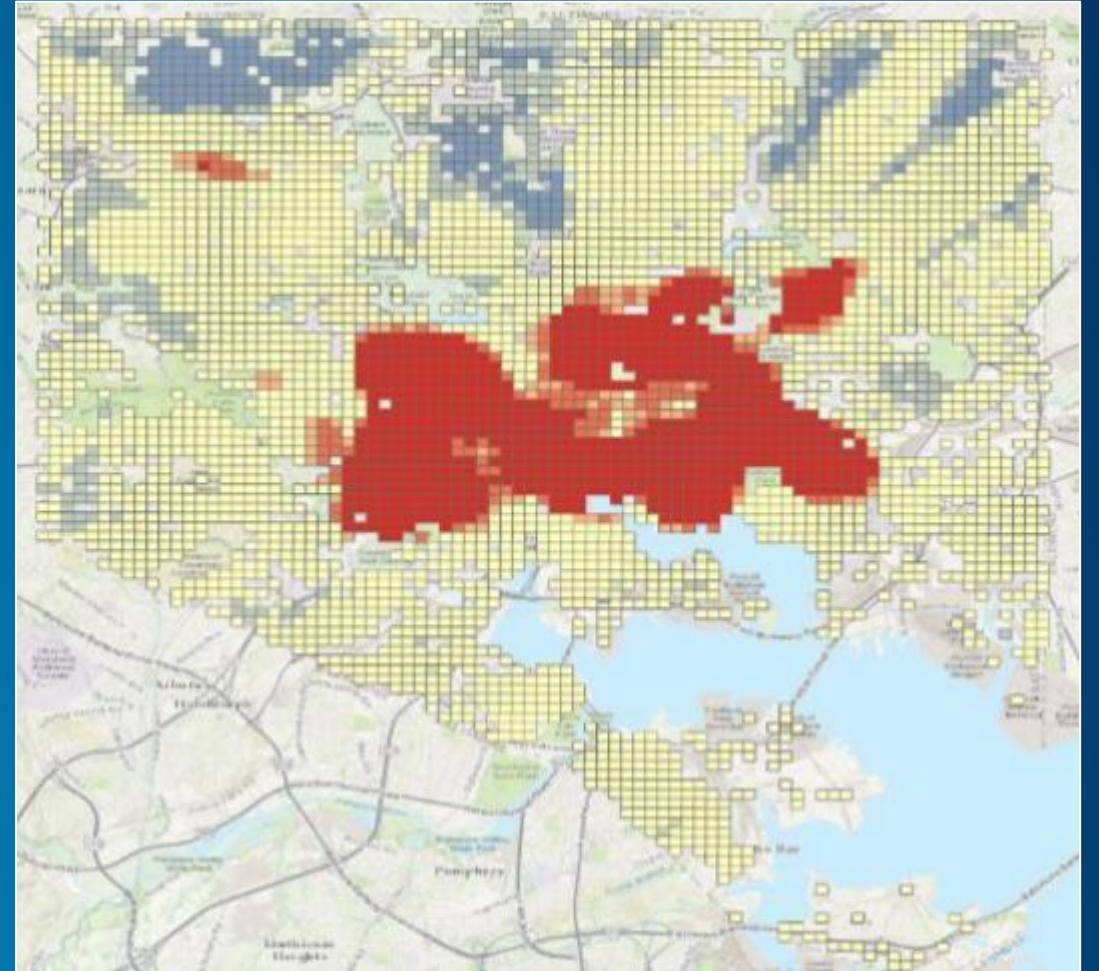
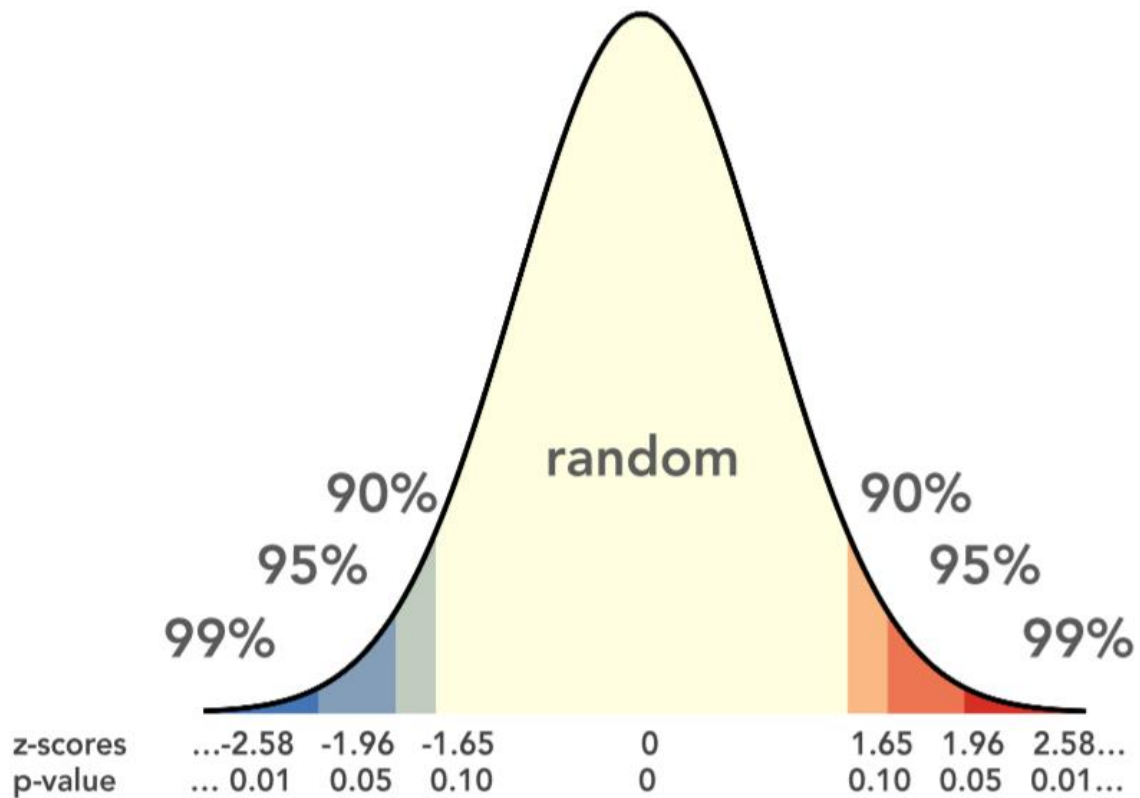
Is there a pattern?



We want to find patterns that are so distinctive, that
they could not have occurred by a random process

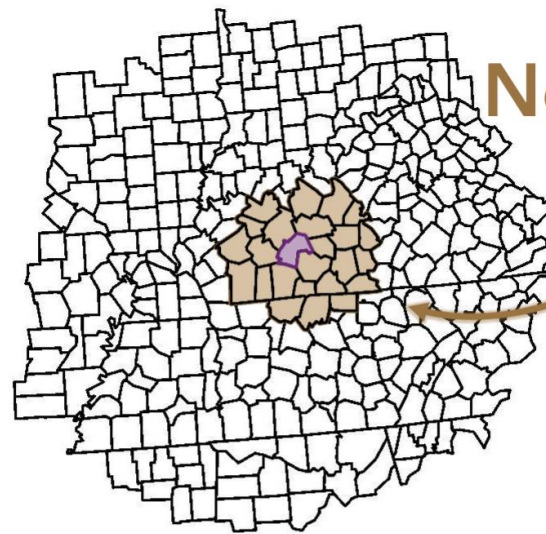
Z-scores and p-values are used to determine the chance the pattern occurred randomly

z-scores and p-values

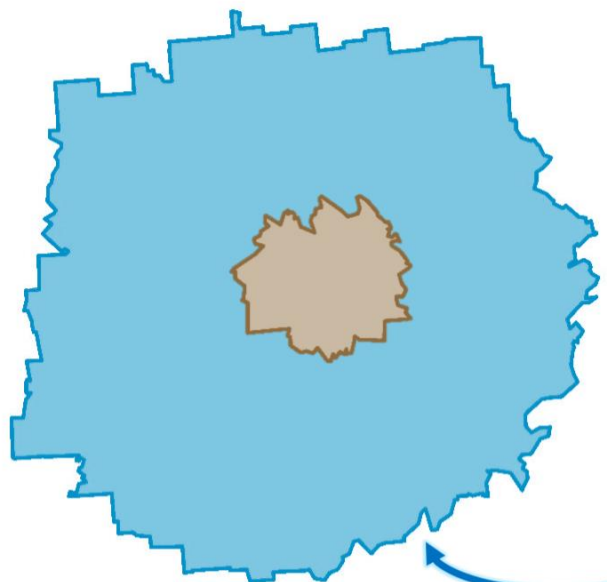




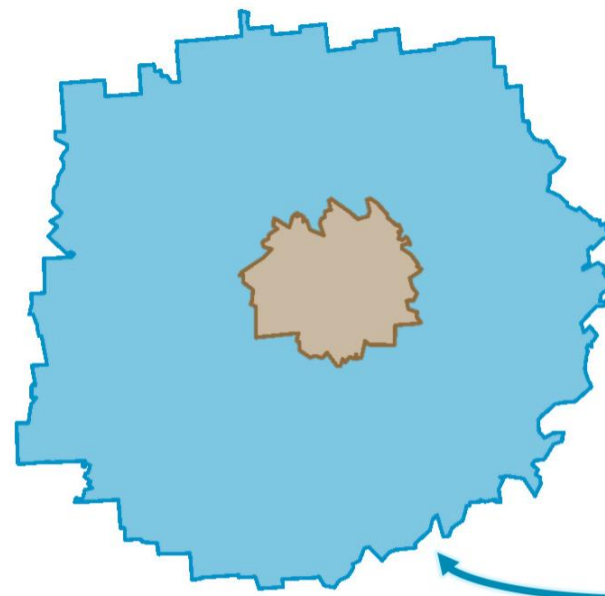
each
feature
has a
value



Neighborhood

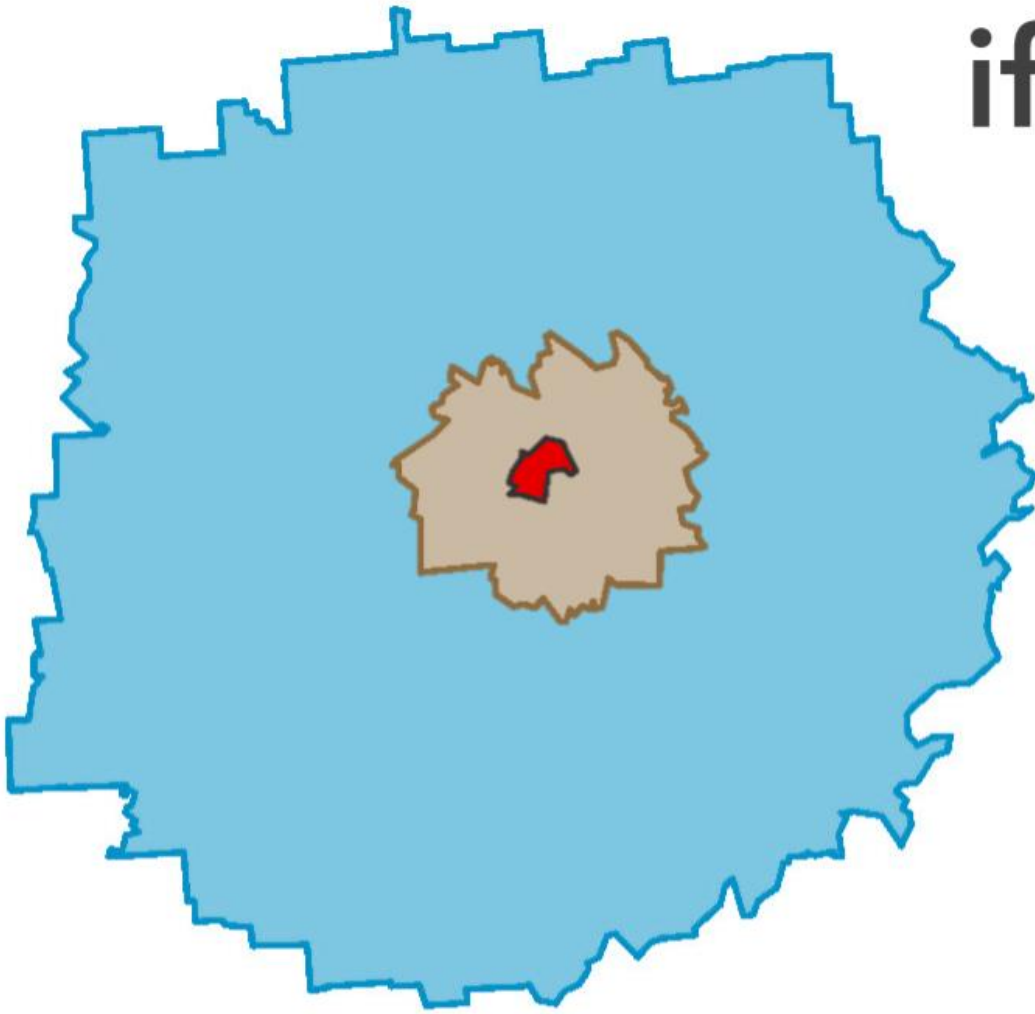


**Study
Area**



is this

significantly
different from
this?

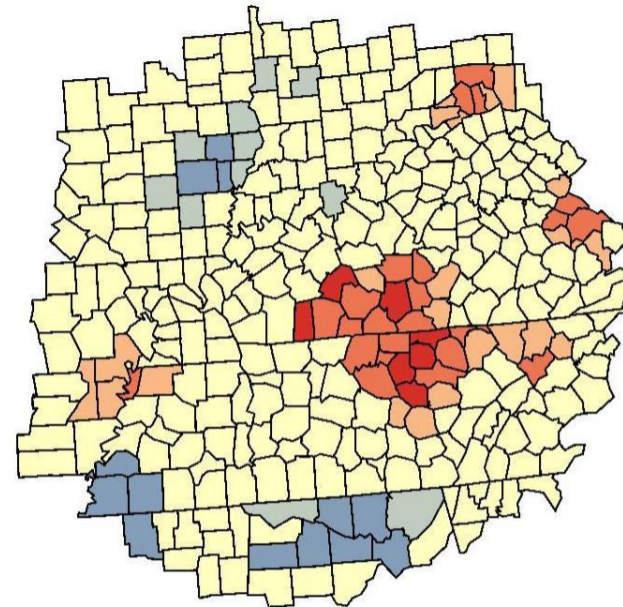


if significantly
higher...

feature is
marked as a
hot spot!



- Hot Spot - 90% Confidence
- Hot Spot - 95% Confidence
- Hot Spot - 99% Confidence



- Cold Spot - 99% Confidence
- Cold Spot - 95% Confidence
- Cold Spot - 90% Confidence
- Not Significant
- Hot Spot - 90% Confidence
- Hot Spot - 95% Confidence
- Hot Spot - 99% Confidence

Hands-on: Residence Sales Information

Clusters and Outliers

Clusters and Outliers

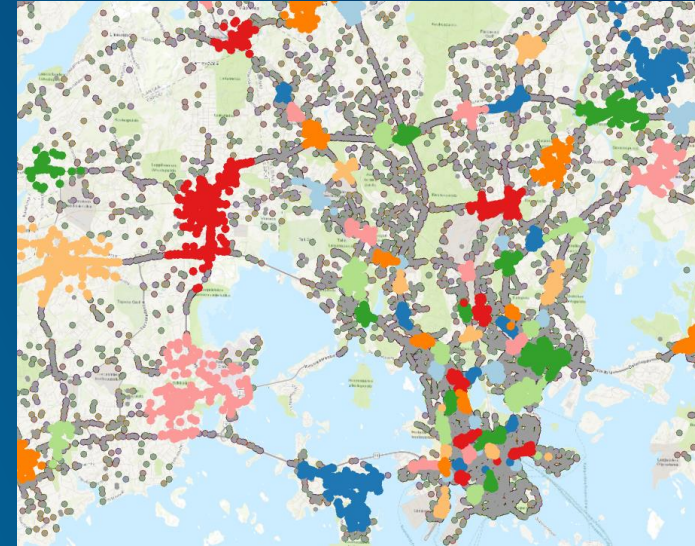
- Check the course page for Exercise 2.!

Hands-on: Density Based Clustering and Multivariate Clustering

Road Accident data, Statistical Grid data

Density Based Clustering

- Let's continue to analyze clustering on traffic accidents...
- The “Density Based Clustering” tool this tool creates clusters based on feature locations
 - detects areas where points are concentrated and where they are separated by areas that are empty or sparse
 - points that are not part of a cluster are labeled as *noise*
 - uses unsupervised machine learning clustering algorithms which automatically detect patterns based purely on spatial location and the distance to a specified number of neighbors.
 - Recommended reading: <https://pro.arcgis.com/en/pro-app/tool-reference/spatial-statistics/how-density-based-clustering-works.htm>



Density Based Clustering

- 3 clustering methods:

- DBSCAN:

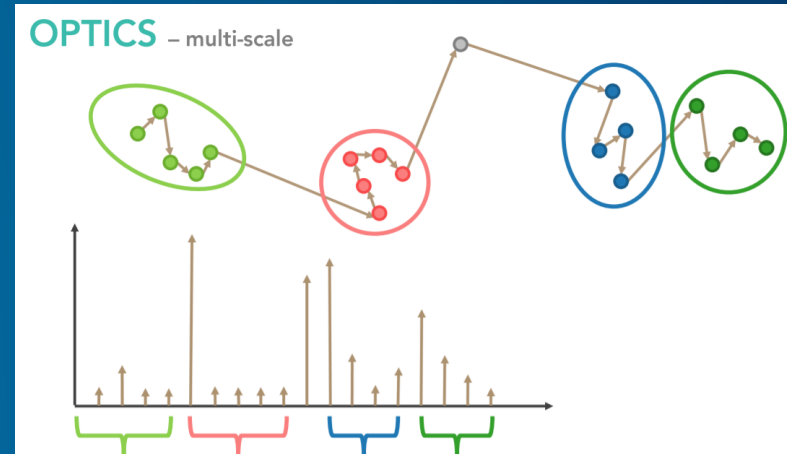
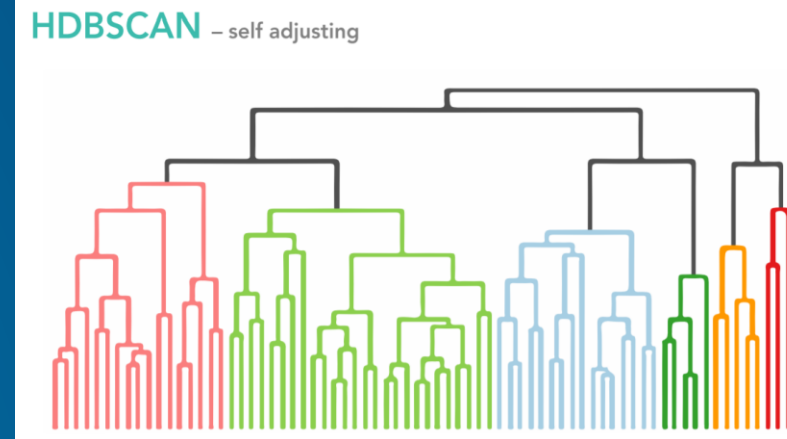
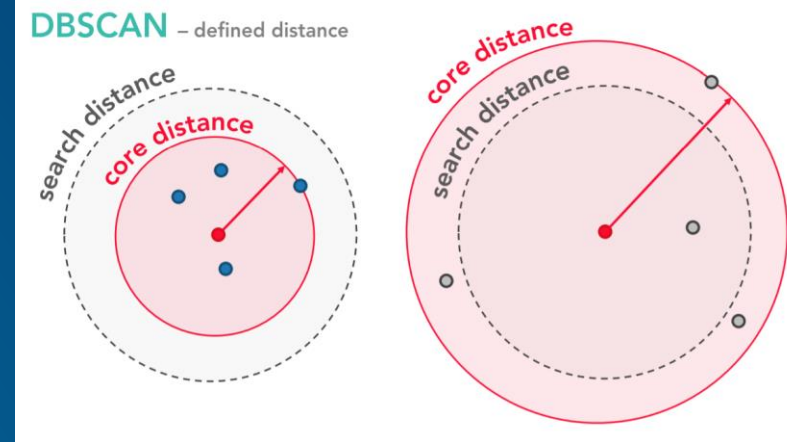
- uses fixed search distance
- clusters of similar densities
- fast

- HDBSCAN

- uses range of search distances to find clusters of varying densities
- data driven, requires least user input

- OPTICS

- uses neighbor distances to create reachability plot
- most flexibility for fine tuning
- can be computationally intensive



Density Based Clustering

- Road Accident Clusters:

- Pro's Catalog: search ArcGIS Online for “**tieliikenneonnettomuudet**” and add the “***tieliikenneonnettomuudet_2009_2017_pksLaaja***” feature service to ArcGIS Pro

- Right click -> Add To Current Map

- From Geoprocessing window, search for tool “***Density Based Clustering***” and execute it

- Create a Line Chart from observations (might take some time...):

- Right-click layer in Table of Contents -> Create Chart -> Line Chart

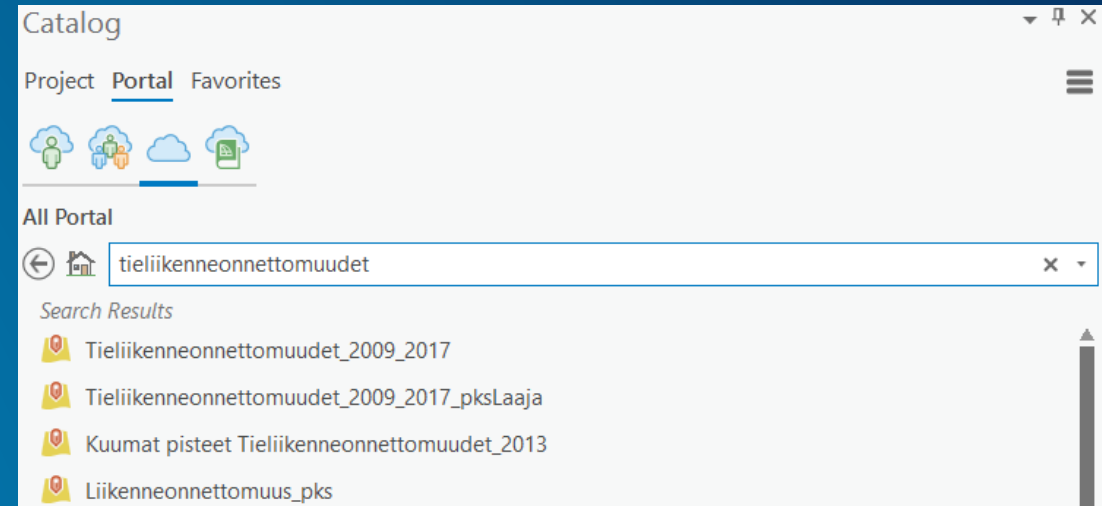
- Notice the “Chart Properties” window in right-side of UI

- Number or Data: “Tunti”

- Aggregation: Count

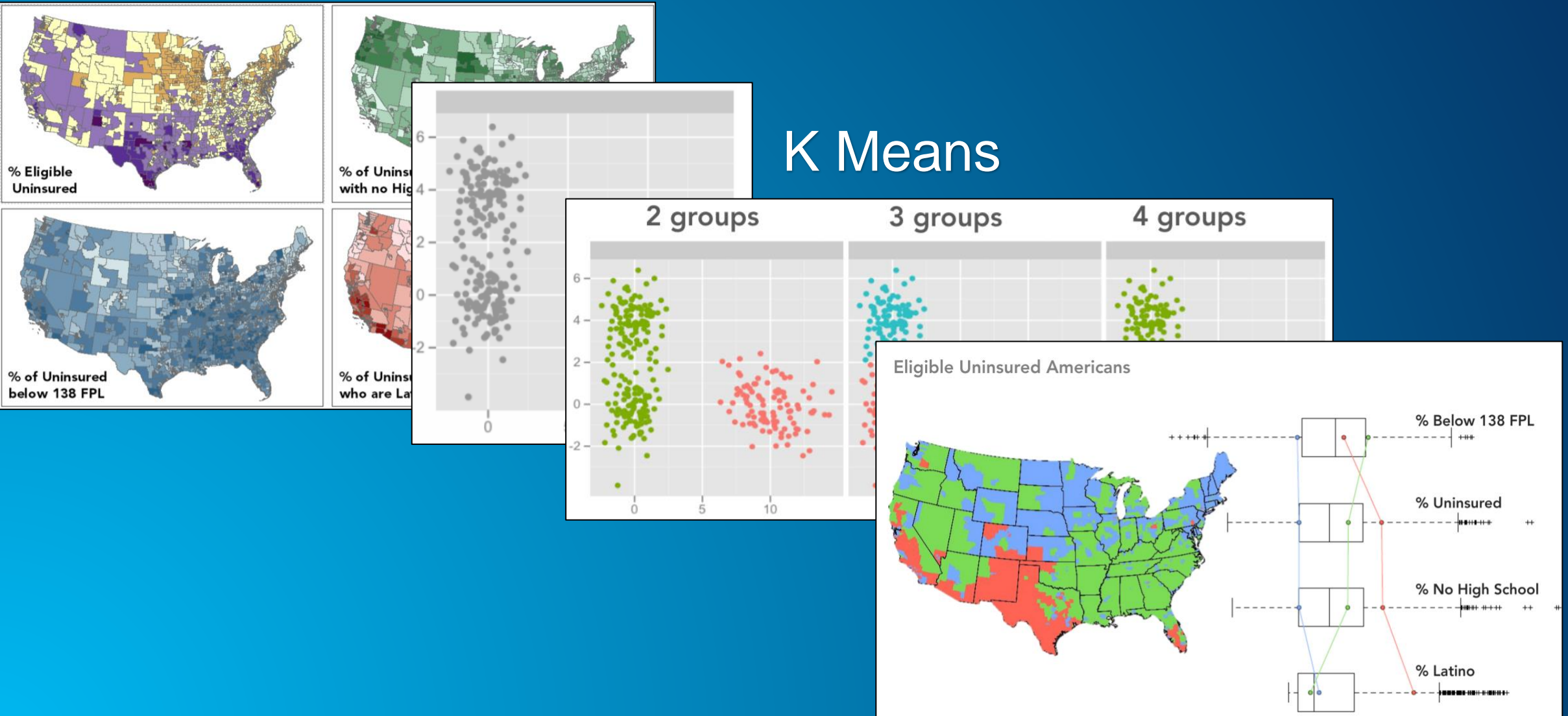
- Split By: “Weekday”

- Try also: Calendar Heat Chart, Data Clock



Multivariate Clustering

K Means



Multivariate Clustering tool

Which features/pixels are similar, and how can they be grouped together? What are the areas with similar characteristics based on socioeconomic status?

Search

Drawing Order

- Map
- ☒ MVC_KMeansSeeds
- 1
- 2
- 3
- 4
- 5
- 6
- 7

Charts

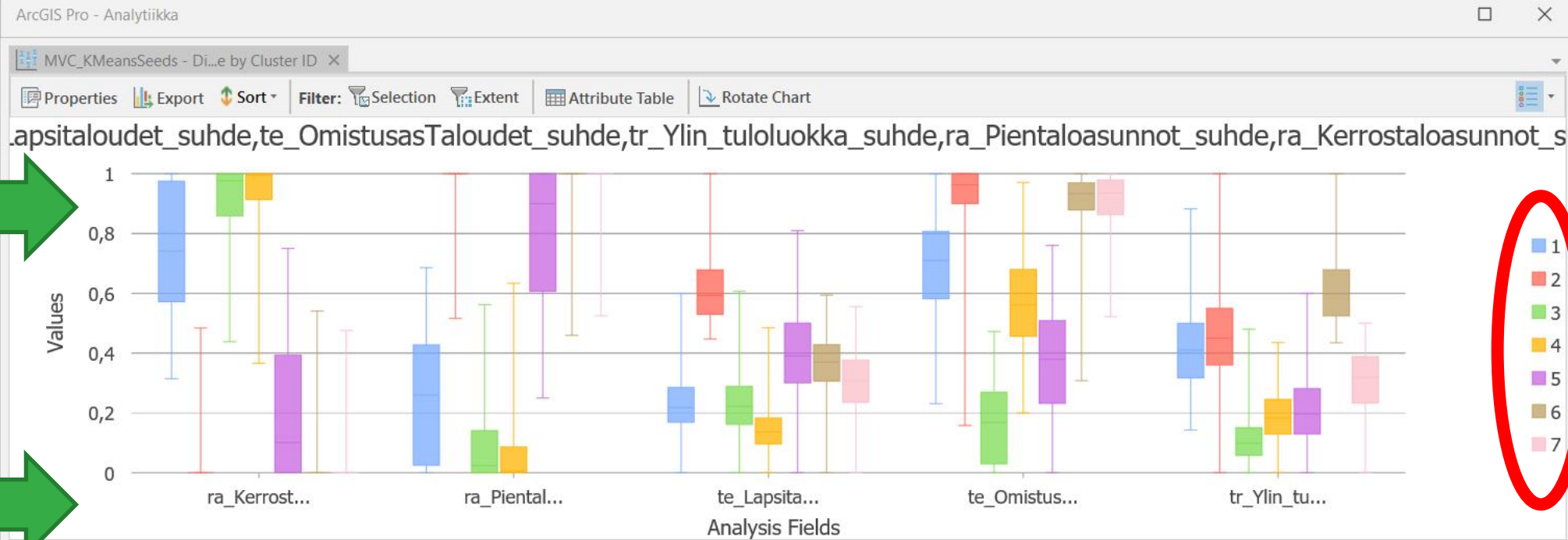
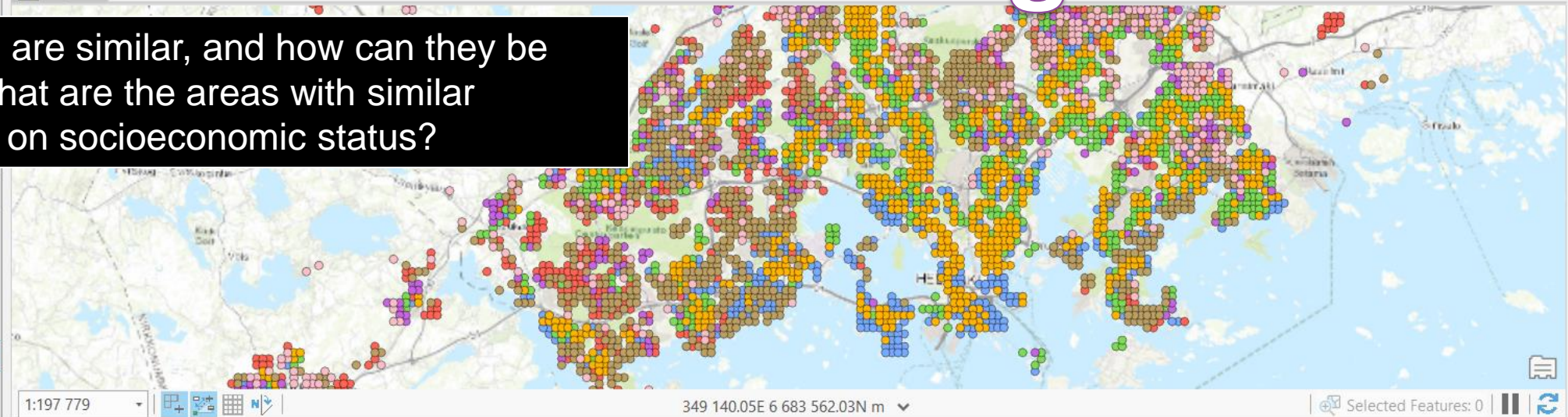
- ☒ Distribution of te_Lapsitaloudet_suhde,te_Omistus...
- ☐ Features Per Cluster Chart

rttk2014_250

SiemenHavainto

- ☒ 1
- ☐ 0

☒ World Topographic Map



% values

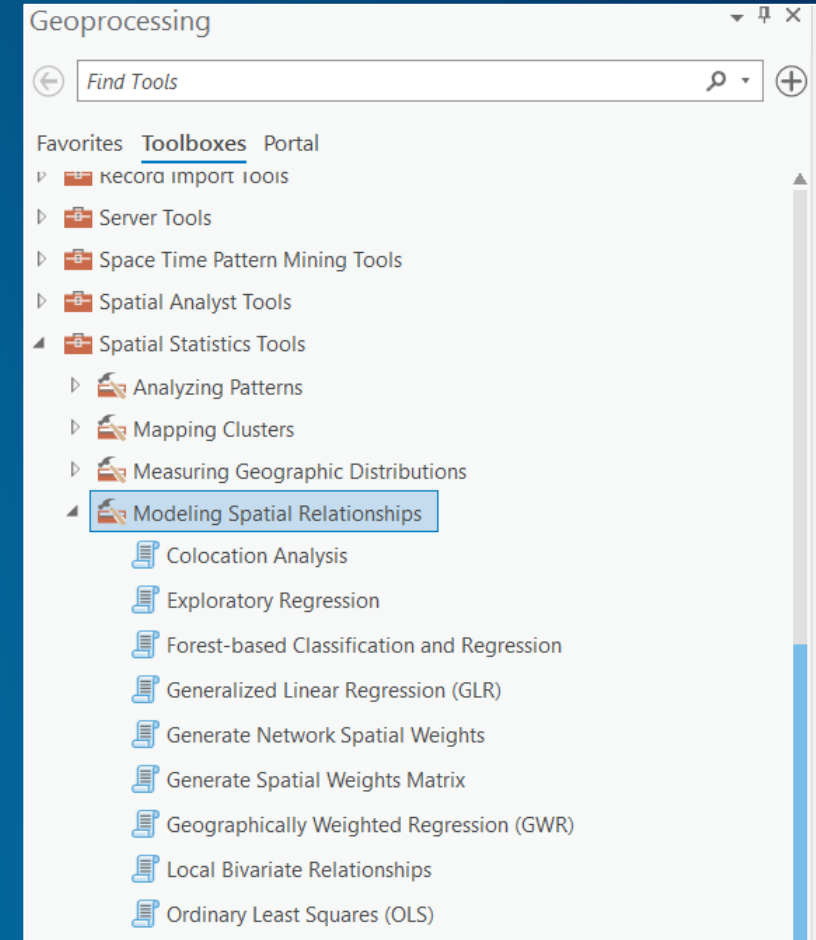
Variables

Multivariate Clustering

- From Pro's Catalog window, search for a dataset 'RTTK2014_Ratios' and add the "*RTTK2014_Ratios*" feature service to ArcGIS Pro
 - Right click -> Add To Current Map
- Open attribute table and familiarize yourself with attributes
 - almost all fields contain ratio values
 - null values exist, because of Finnish data privacy policies
 - you could calculate all nulls to zeros, but is it the same thing...? No.
 - the Multivariate Clustering tool runs with nulls, so we don't make any alterations to input data
 - notice at the end of attribute table the field 'SeedObservation'
 - seven 1s and the rest are zeros
 - the 1s are so-called *Seed Points* that can be used in MVC tool to determine the initial processing locations or calculation features (they have a pre-determined distinctive profile)
- Fill in the tool dialogue

Regression tools in ArcGIS Pro

- ArcGIS Pro has several good regression tools for prediction analysis
 - Exploratory Regression (OLS)
 - Forest-based Classification and Regression
 - uses random trees (ML algorithm)
 - Generalized Linear Regression (OLS, Poisson, Logistic)
 - Geographically Weighted Regression (GWR)
 - coefficients are locally calibrated
 - Ordinary Least Squares (OLS)
- These can be found from the Geoprocessing pane, under Spatial Statistics toolbox and Modeling Spatial Relationships



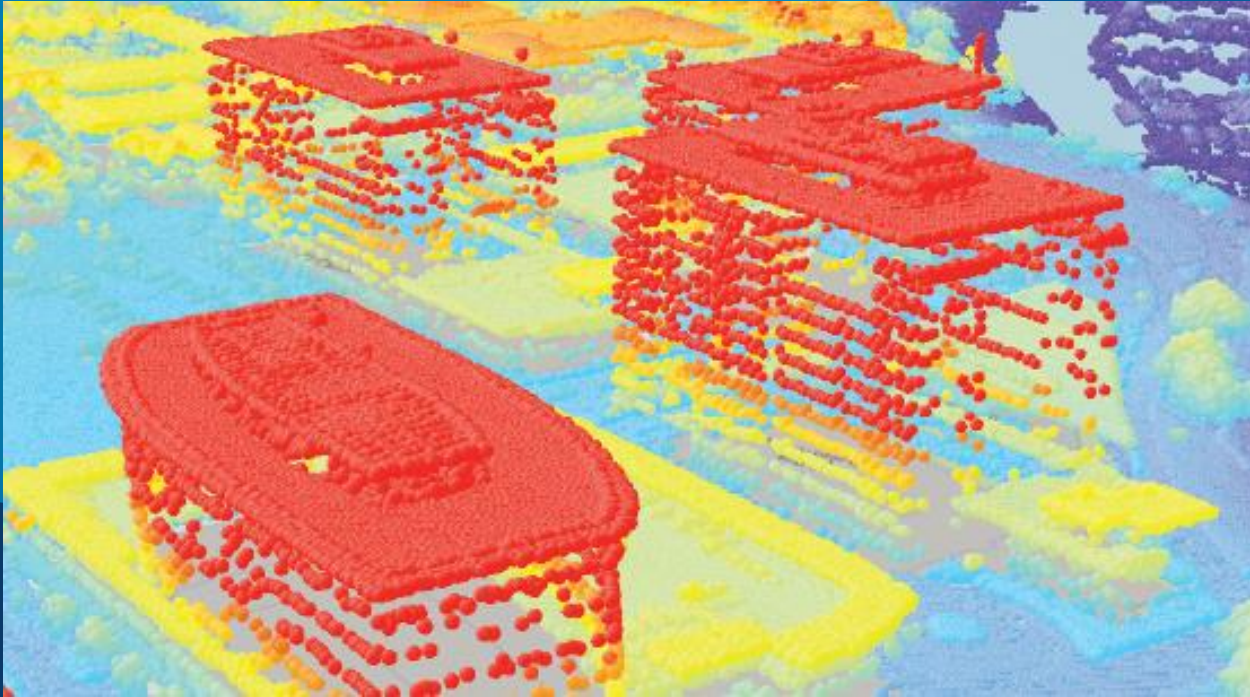
End of Day 1!

Start of Day 2!

Leftovers...

Regression tools, publishing datasets to Portal...

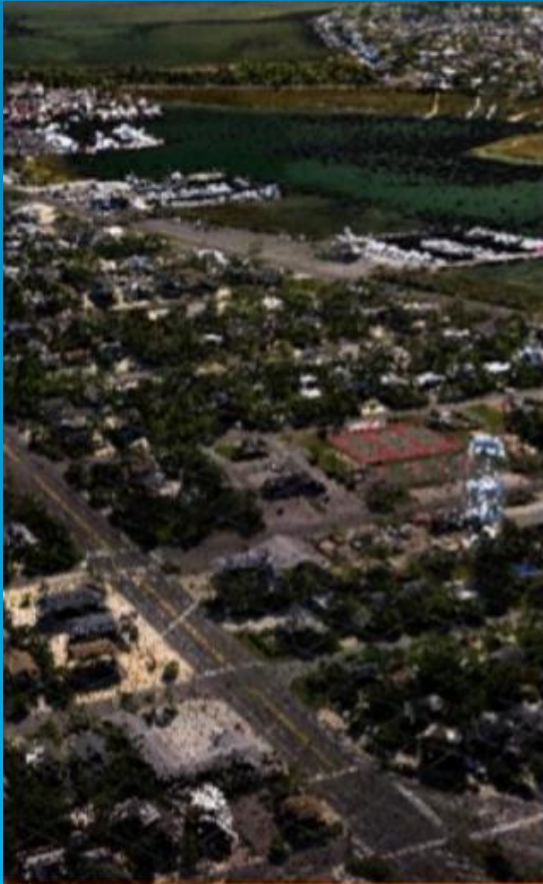
Short Introduction to Point Clouds in ArcGIS Pro



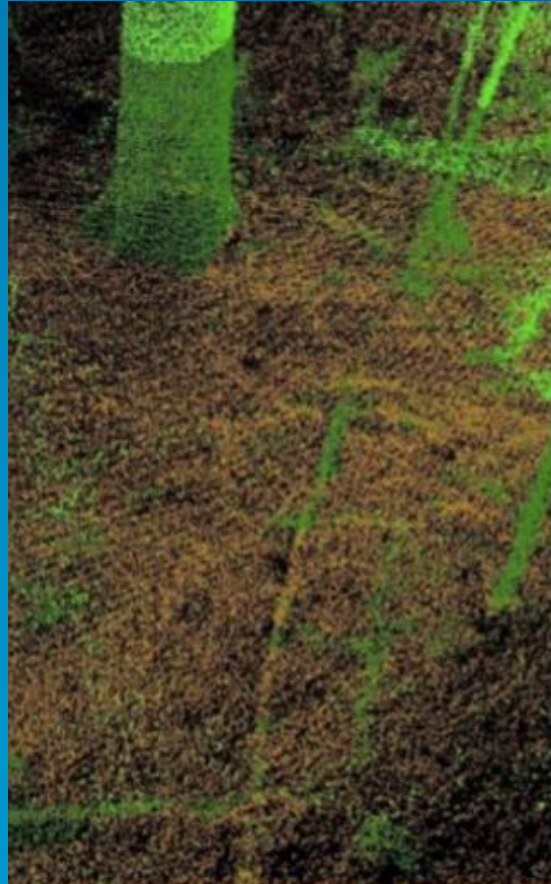
LAS Dataset

Lidar surveys in ArcGIS Pro

Aerial



Terrestrial



Mobile



Drone/UAV

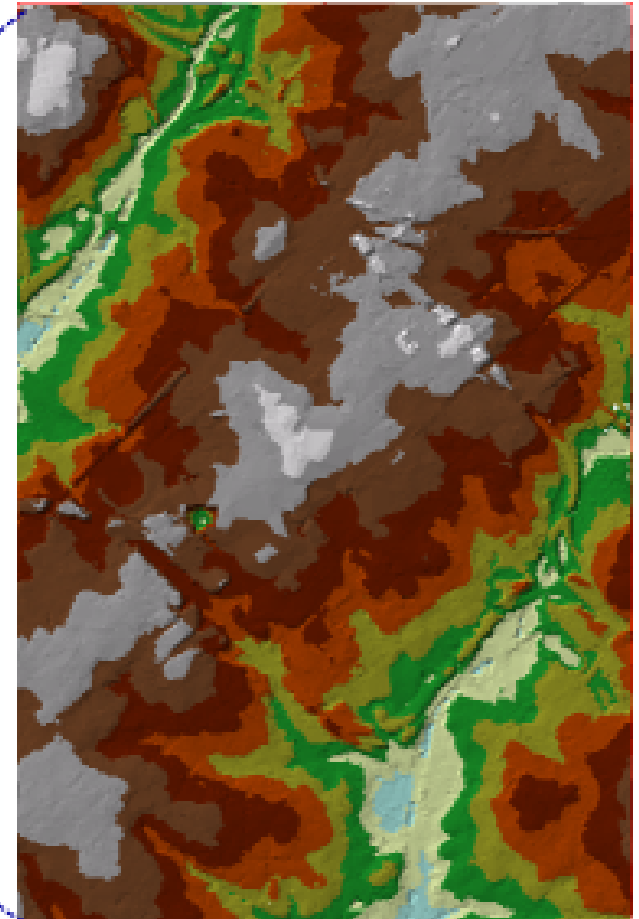
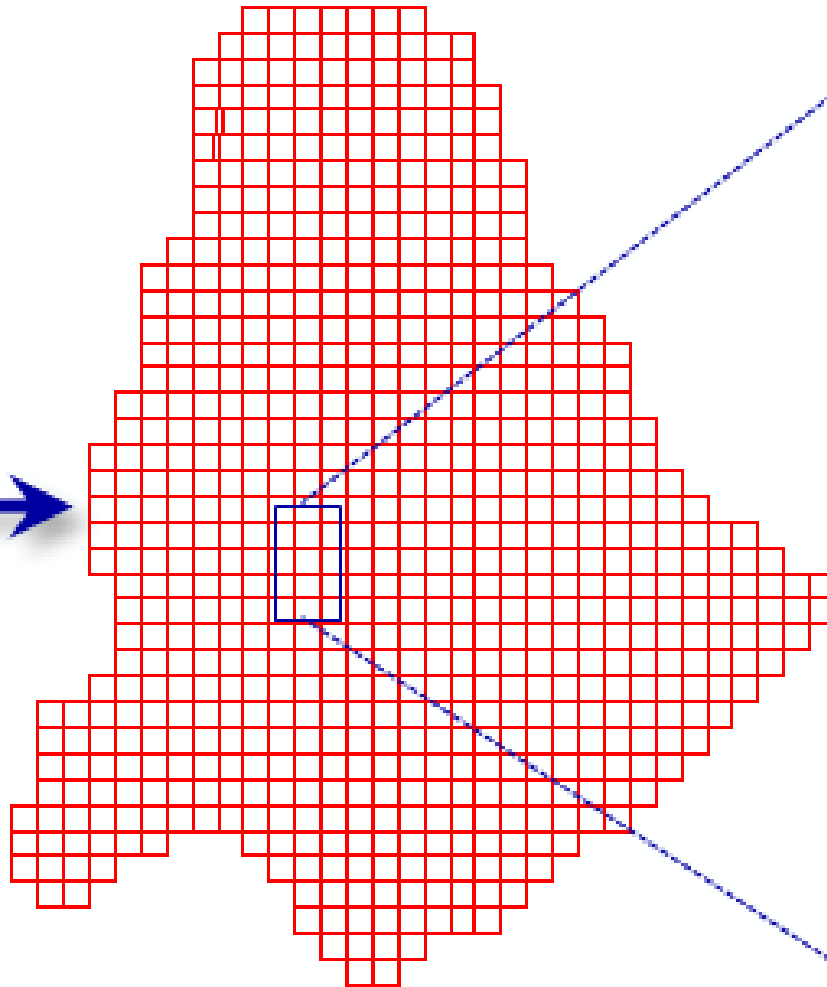


Data Structures for lidar support in ArcGIS

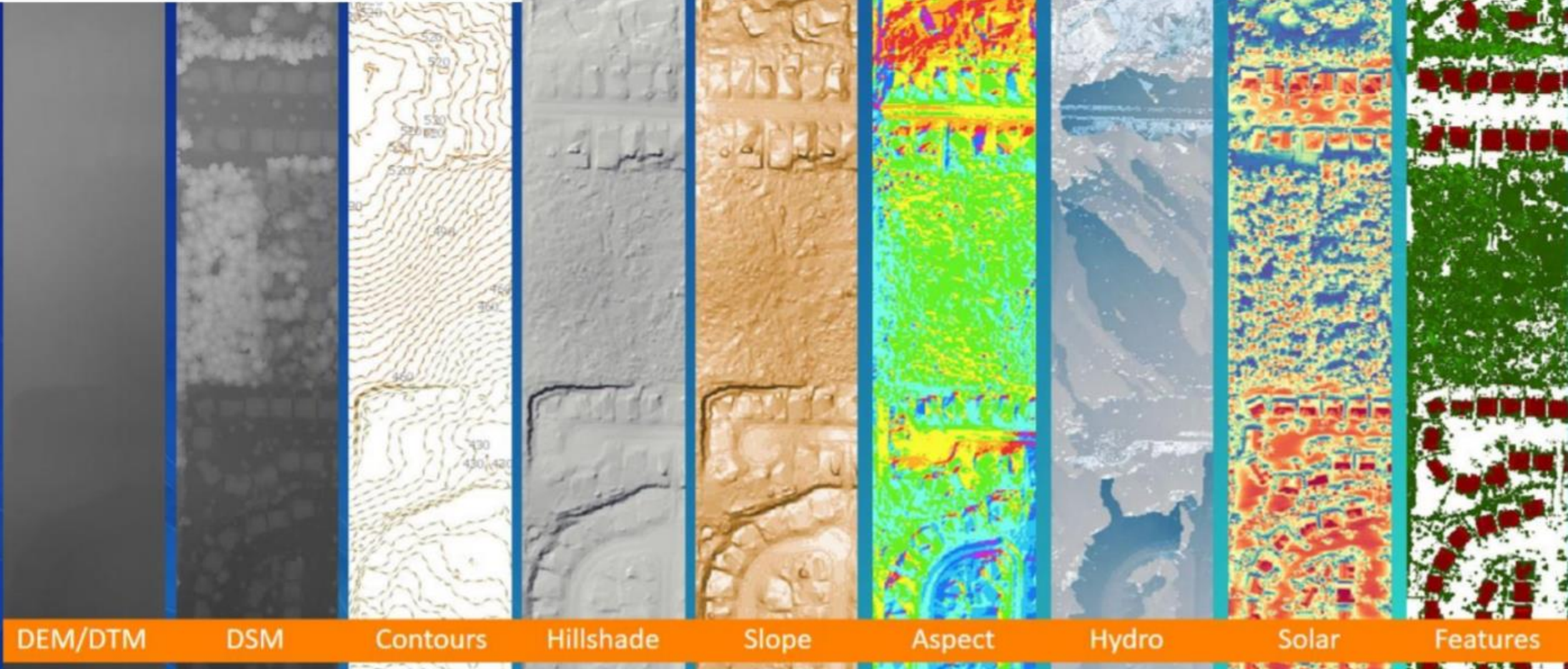


LAS Dataset

4458-03.las	4479-03.las
4458-04.las	4479-04.las
4459-01.las	4488-01.las
4459-02.las	4488-02.las
4459-03.las	4488-03.las
4459-04.las	4489-01.las
4467-01.las	4489-02.las
4467-02.las	4489-03.las
4467-03.las	4489-04.las



Elevation & Analytical Raster Data



Hands-on:

Point clouds and derivatives

Raster functions

Point Clouds and Raster Functions

- Let's do Exercise 3.!
- Remember to download point cloud file from course page and unzip it!
 - it's a .las file from National Land Survey of Finland
- Follow the instructions
- On Raster Functions, we'll check them together

GeoAI



Artificial Intelligence

Caffe

Object Tracking

CNTK

Object Detection

PyTorch

Computer Vision

scikit-learn

Random Forest

Machine Learning

Neural Networks

Natural Language Processing

Cognitive Computing

TensorFlow

Data Science

GeoAI

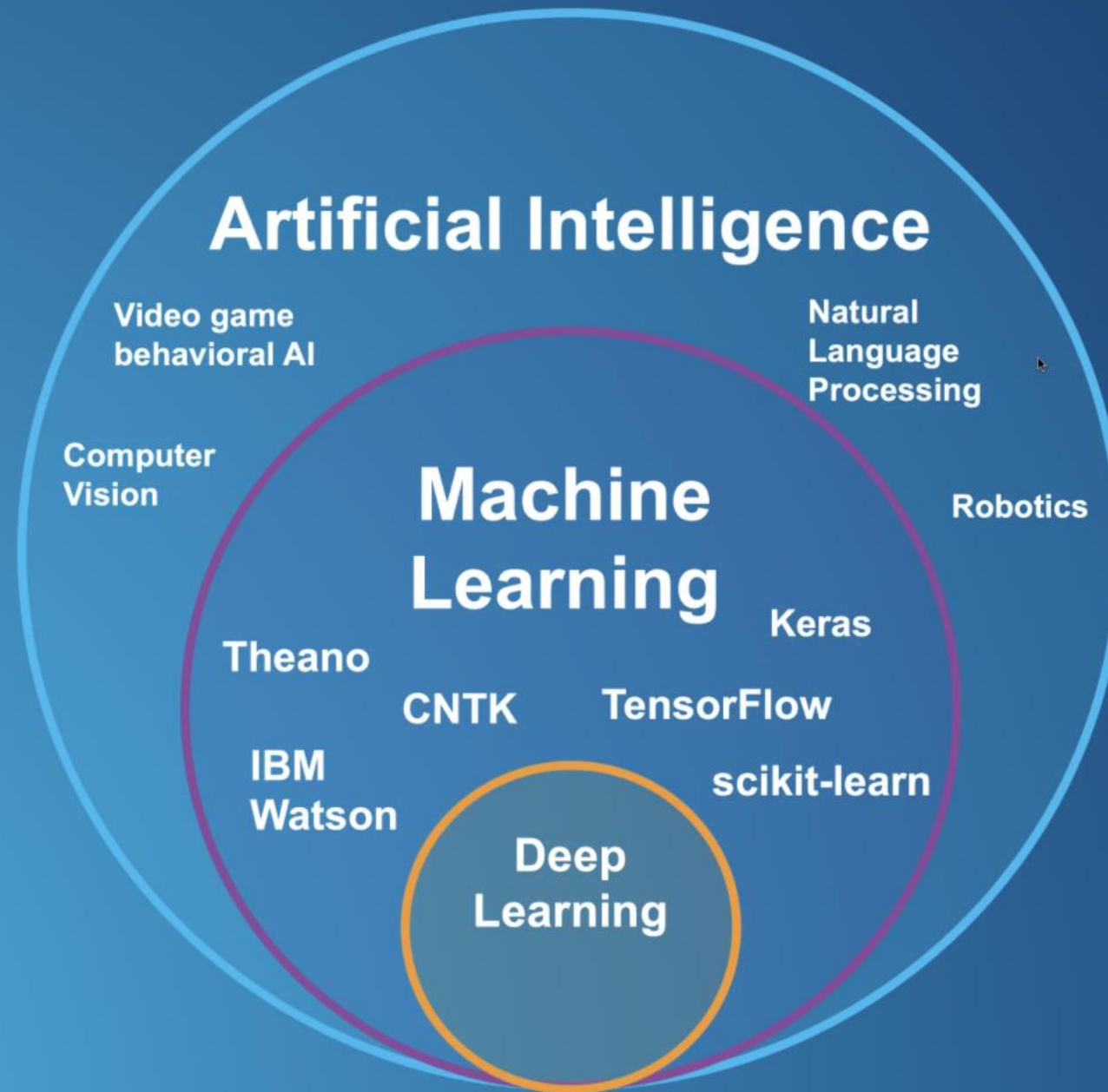
Deep Learning

fast.ai

Keras

Dimensionality Reduction

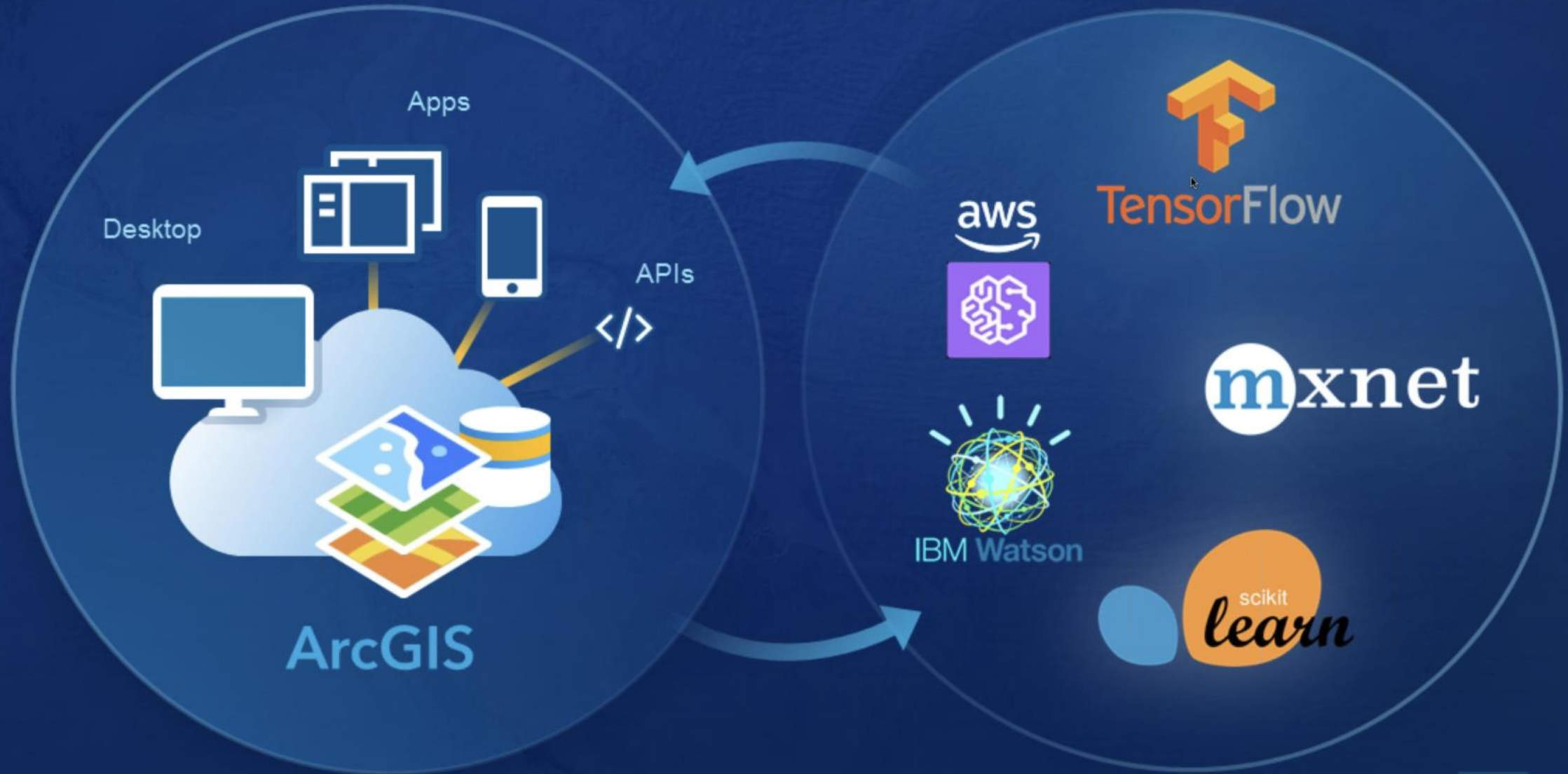
Support Vector Machines



ArcGIS Includes Machine Learning Tools



Machine Learning Integration with External Frameworks




Deep Learning workflows in ArcGIS integrate to open common deep learning frameworks. ArcGIS Pro version specific deep learning libraries are available in GitHub: <https://github.com/Esri/deep-learning-frameworks> Installer is ready-to-run, but read the instructions.

← → ↻

github.com/Esri/deep-learning-frameworks

☆ ⋮ 👤

 Why GitHub? ▾ Team Enterprise Explore ▾ Marketplace Pricing ▾

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Esri / deep-learning-frameworks


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<> Code ⓘ Issues 5 🔗 Pull requests 1 ⌚ Actions 📁 Projects 📖 Wiki ⚠ Security 📈 Insights

🔗 master ▾ 🌿 3 branches 🏷 4 tags

Go to file

📄 Code ▾

 cleebp Merge pull request #14 from sandeepgadhwal/update_doc ... dcf59d on Apr 5 ⌚ 33 commits

📁 ThirdPartyAcknowledgements	Add files via upload	4 months ago
📁 images	Add initial draft of README	10 months ago
📄 README.md	disconnected users	2 months ago
📄 install-deep-learning-frameworks-ma...	added 2.7 manual install instructions	4 months ago
📄 install-deep-learning-frameworks-ma...	added 2.7 manual install instructions	4 months ago

☰ README.md


Deep Learning Libraries Installers for ArcGIS

About

Installation support for Deep Learning Frameworks for the ArcGIS System

📖 Readme

Releases 4

 Deep Learning Libraries instal... Latest on Jan 11

+ 3 releases

Packages

No packages published

AI is not one product. It spans the ArcGIS platform.



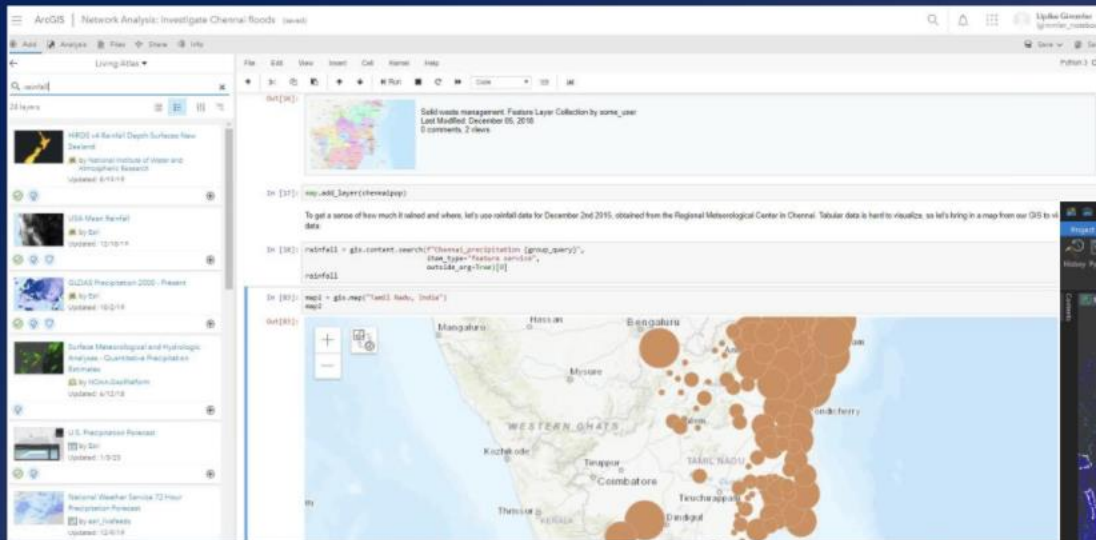
Where we offer machine learning integration.



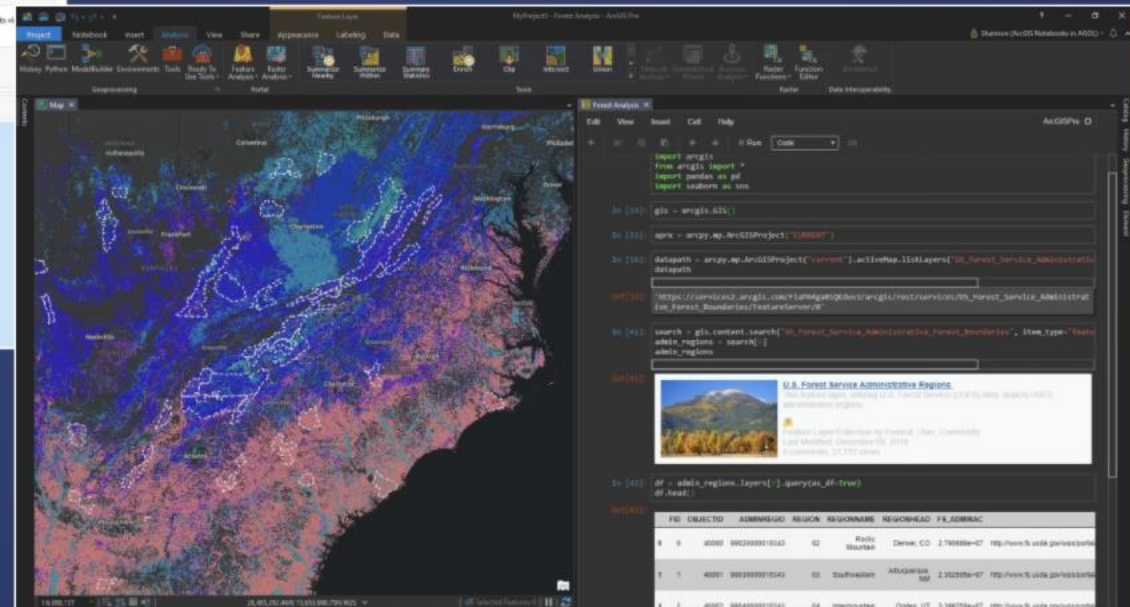
- ArcGIS API for Python
- ArcGIS Analytics for IoT - in R&D
- ArcGIS Notebooks
- ArcGIS Pro
- ArcGIS Online
- ArcGIS Enterprise
- ArcGIS Hub - Citizen Data Science
- ArcGIS QuickCapture - Edge AI (in R&D)
- ArcGIS Insights
- ArcGIS Pro for Intelligence

A Spatially Optimized Jupyter experience within ArcGIS

Integrated Python notebooks in ArcGIS Pro allow you to seamlessly move data and analysis results between both.



Hosted notebooks allow for easy searchability of datasets and to bring in analysis tools as code snippets.



Three main Patterns for GeoAI

Object Detection



Detecting Objects from Imagery/Videos, Land Cover, Change Detection..

Buildings, Road Segments, Swimming Pools, Blight, Graffiti, Overgrowth, Road Signs, Vehicles from CCTVs, and more

Prediction



Predicting Geospatial Events/Phenomena

Water Pipe Breaks, Asthma Rates, Diseases, Crimes, Crashes, Incidents, Fires, Congestion, 911 Calls,

Pattern Detection

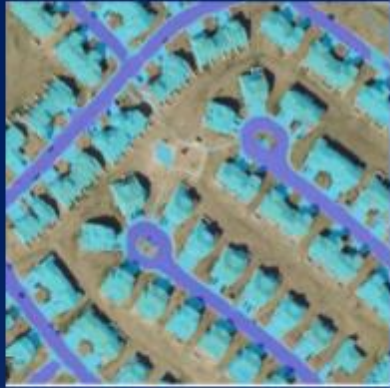


Finding Statistically Significant Clusters & Patterns

Top Risky Segments, Emerging Hotspots of 911 Calls, Disease Clusters, and more

Applications of Deep Learning to GIS

Impervious Surface
Classification



Coconut Tree
Detection



Building Footprint
Extraction



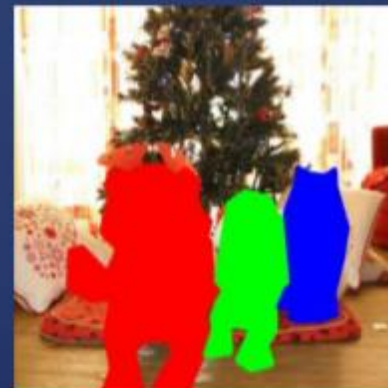
Damaged House
Classification



Pixel Classification



Object Detection



Instance Segmentation



Image Classification

Examples for Imagery AI Workflows

Object Detection, Instance Segmentation, Land Cover, Change Detection..

Damaged Structures



Building Footprints



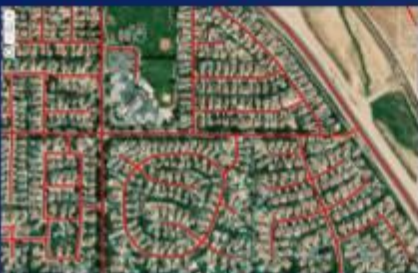
Land Cover



Pipeline Encroachment



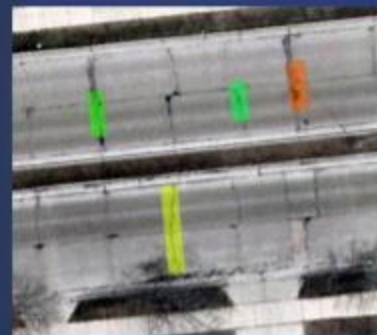
Roads



Oil Pads



Road Cracks



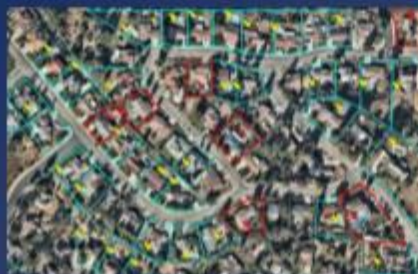
Cars



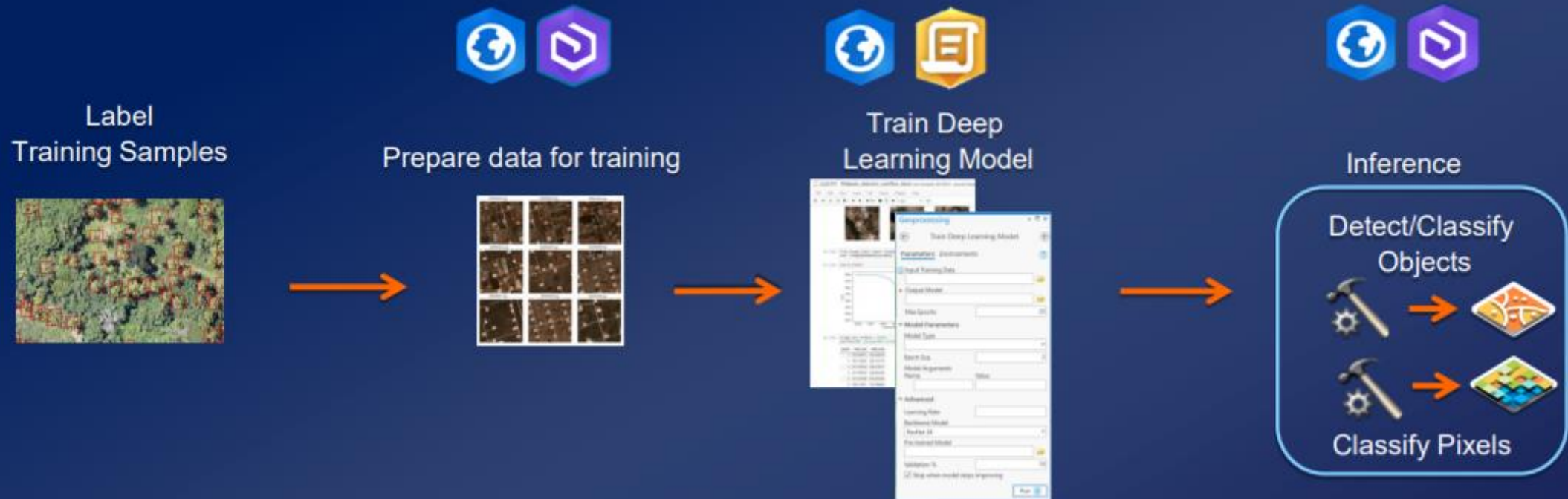
Palm Trees



Swimming Pools

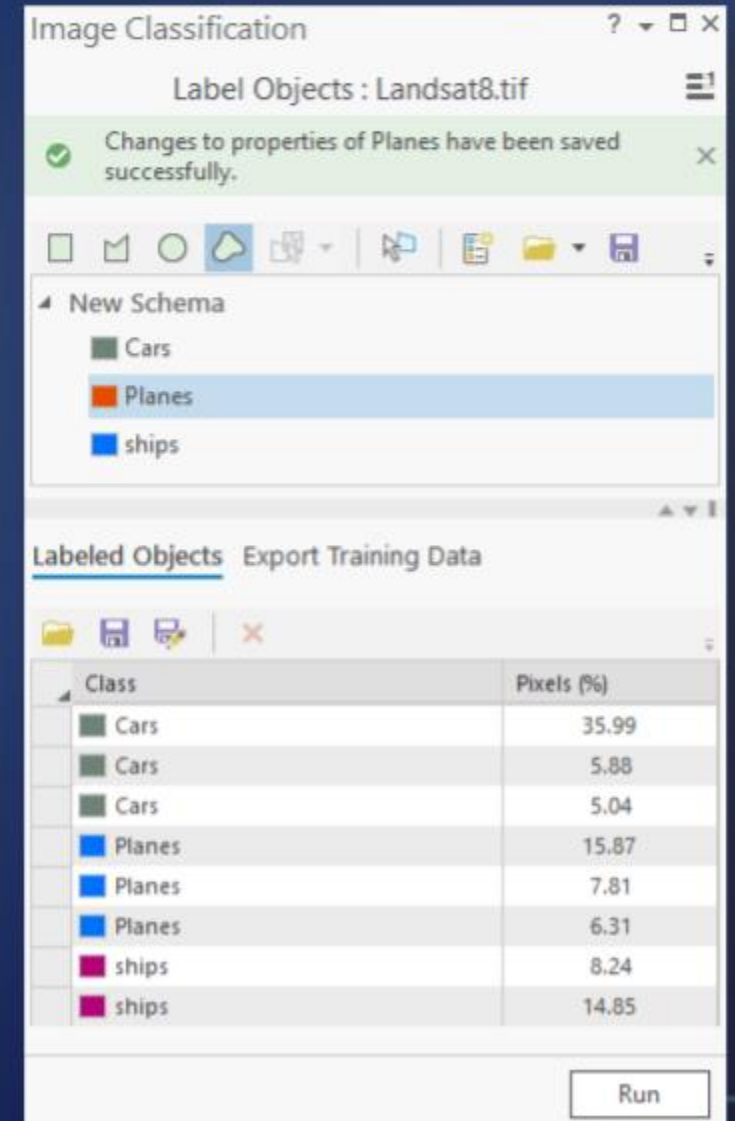


Deep Learning Workflow in ArcGIS



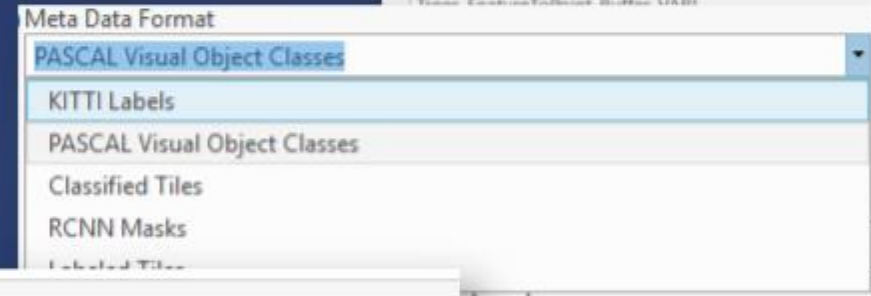
Collect Training Samples / Label data

- Different methods
 - **Label Objects for Deep Learning – ArcGIS Pro (2.5)**
 - Training sample manager – ArcGIS Pro
 - Feature editing
 - ArcGIS Pro
 - Map Viewer
 - JS Web Apps
- Different data models
 - Feature class (local single user)
 - Feature services (collaborative experience)
 - Classified thematic rasters

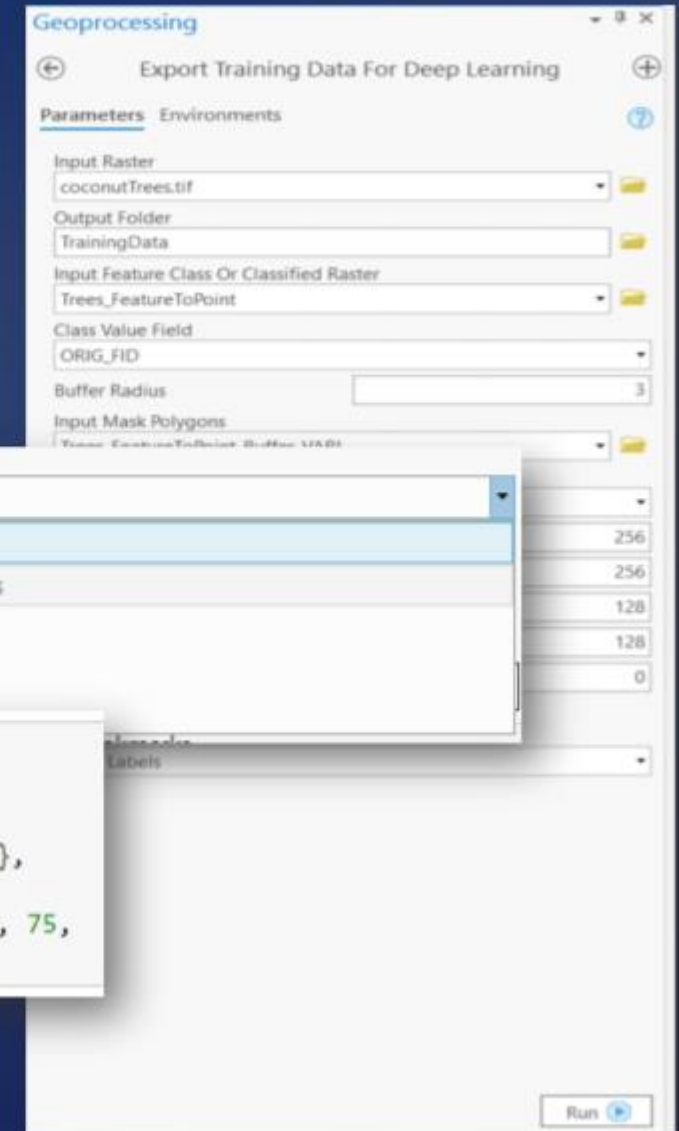


Export Training Data for Deep Learning

- Exports samples to training images
- Images have associated labels/metadata
- Writes out and ECD
- Used as inputs for model training
- Supports various formats



```
#Export training data
chips = export_training_data(sentinel_data,
                             well_pads,
                             "PNG", {"x":448,"y":448},
                             {"x":224,"y":224},
                             "PASCAL_VOC_rectangles", 75,
                             "well_pads")
```



Train Deep Learning Model

- ArcGIS Pro and ArcGIS API for Python supports training
- ArcGIS Pro “Train Deep Learning Model” tool
- arcgis.learn module in ArcGIS API for Python
- Supported Models:
 - Object Detection - SSD, RetinaNet, MaskRCNN
 - Object Classification – Feature classifier
 - Pixel Classification – UNET, PSPNet
- External Deep Learning Frameworks
 - TensorFlow
 - CNTK...



Geoprocessing

Train Deep Learning Model

Parameters Environments

* Input Training Data

* Output Model

Max Epochs 20

Model Parameters

Model Type

Batch Size 2

Model Arguments

Name Value

Train SingleShotDetector Model

```
from arcgis.learn import SingleShotDetector

ssd = SingleShotDetector(data, grids=[9], zooms=[1.0], ratios=[[1.0, 1.0]])

ssd.fit(10, lr=slice(1e-3, 1e-2))
```

Backbone Model

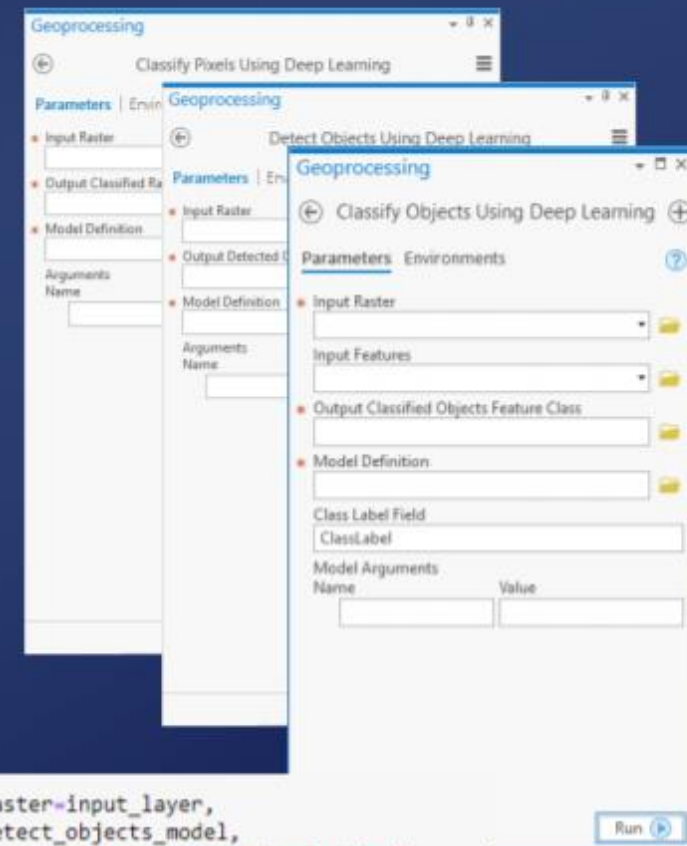
Validation % 10

☒ Stop when model stops improving

Run

Use Deep Learning Models

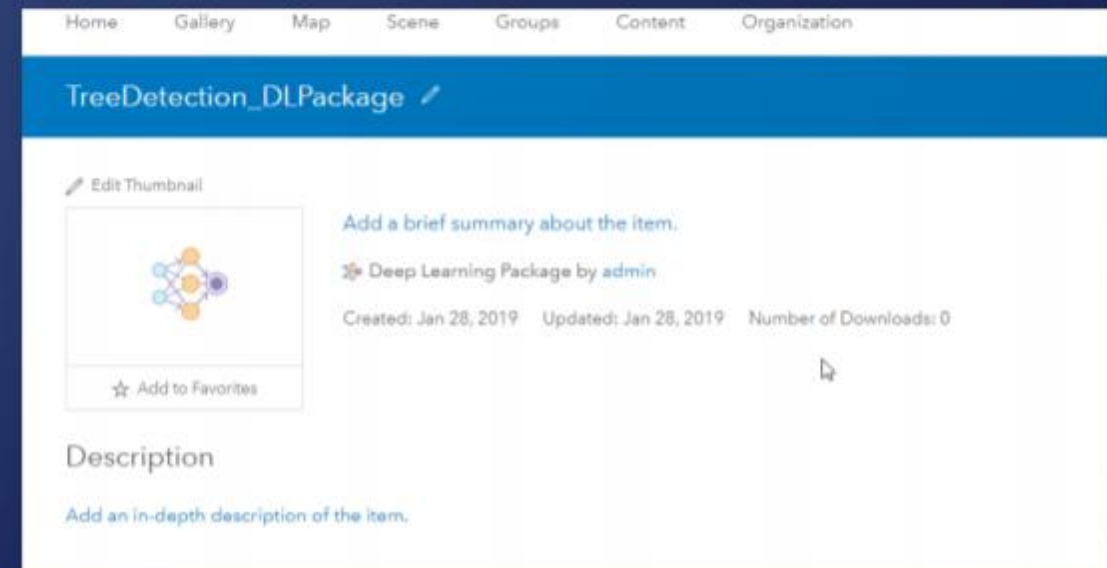
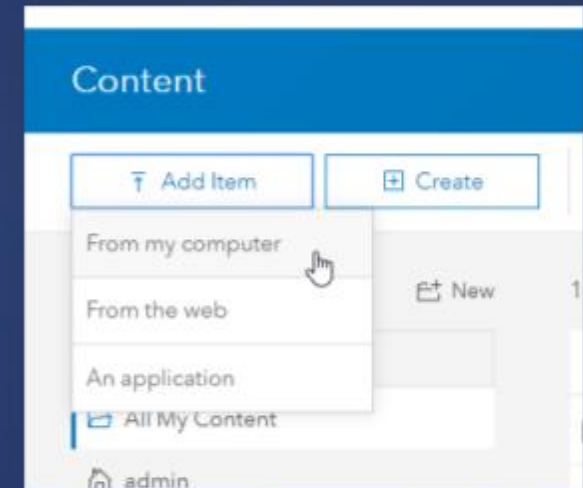
- Run on desktop and enterprise
- Parallel processing using enterprise
- Types of inferencing
 - Object detection
 - Classify objects
 - Pixel classification



```
detect_objects(input_raster=input_layer,  
               model=detect_objects_model,  
               output_name="Well_Pad_Detection_Sentinel",  
               context=context,  
               gis=gis)
```

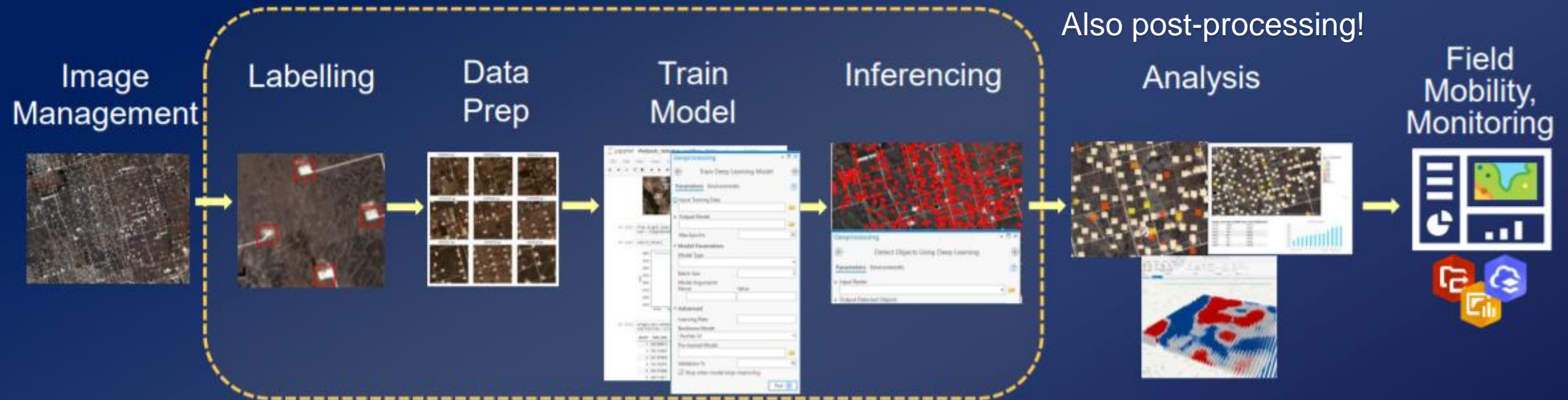
Deep Learning Package

- Zip with a .dlpk file extension
 - Created by Train Deep Learning Model tool and `arcgis.learn` (ArcGIS API for Python)
- Contents of the dlpk
 - Model definition file (.emd)
 - Deep learning model file (framework specific)
 - Python Raster Function (.py, optional if using an out-of-the-box model)
- Can be shared across your organization



Deep Learning Workflow in ArcGIS

End-to-end from raw imagery to structured information products



Also post-processing!

ArcGIS being used for each step of the deep learning workflow

ArcGIS uses common external deep learning frameworks for DL tasks.

An installer package is available in GitHub

<https://github.com/Esri/deep-learning-frameworks>


github.com/Esri/deep-learning-frameworks

install-deep-learning-frameworks-ma... added 2.7 manual install instructions 4 months ago

install-deep-learning-frameworks-ma... added 2.7 manual install instructions 4 months ago

README.md

Deep Learning Libraries Installers for ArcGIS



ArcGIS Pro, Server and the ArcGIS API for Python all include tools to use AI and Deep Learning to solve geospatial problems, such as feature extraction, pixel classification, and feature categorization. This installer includes a broad collection of components, such as PyTorch, TensorFlow, Fast.ai and scikit-learn, for performing deep learning and machine learning tasks, a total collection of 99 packages. These packages can be used with the [Deep Learning Training tools](#), [interactive object detection](#), by using the `arcgis.learn` module within the ArcGIS API for Python, and directly imported into your own scripts and tools. Most of the tools in this collection will work on any machine, but common deep learning workflows require a recent NVIDIA graphics processing unit (GPU), and problem sizes are bound by

livingatlas.arcgis.com/en/browse/#d=2&q=deep%20learning


deep learning

Search Examples

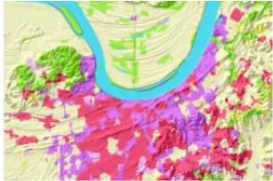
All Trending Basemaps Imagery Boundaries People Infrastructure Environment

All content types All time All regions ☐ Esri-only content ☐ Authoritative-only content Sort by: Relevance


23 Results




Building Footprint Extraction - USA
Deep Learning Package By [esri_analytics](#)
This deep learning model is used to extract building footprints from high-resolution aerial/satellite imagery. This model was trained using Esri's World Imagery.



Land Cover Classification (Sentinel-2)
Deep Learning Package By [esri_analytics](#)
This deep learning model is used to perform land cover classification using Sentinel-2 imagery. The imagery will be classified into 16 classes based on a modified CLC Class Level II classification system as used by the CORINE Land Cover inventory.



Tree Point Classification
Deep Learning Package By [esri_analytics](#)
Deep learning model to classify points representing trees in point cloud



Land Cover Classification (Landsat 8)
Deep Learning Package By [esri_analytics](#)
Deep learning model to perform land cover classification using Landsat 8

Esri's Living Atlas service provides ready-to-use deep learning models for inferencing on various topics.

<https://livingatlas.arcgis.com/en/home/>

GeoAI Examples

Road Features Extraction

- Road signs
- Guard rails
- Curbs
- Road cracks
- Pavement markings
- Other road features



ML Solution Covers:

- Detection of road signs
- Classification
- Optical Character Recognition
- Inferred lat/long of objects of interest using depth prediction neural network
- Outputs a feature layer



ArcGIS
Pro



ArcGIS
Online



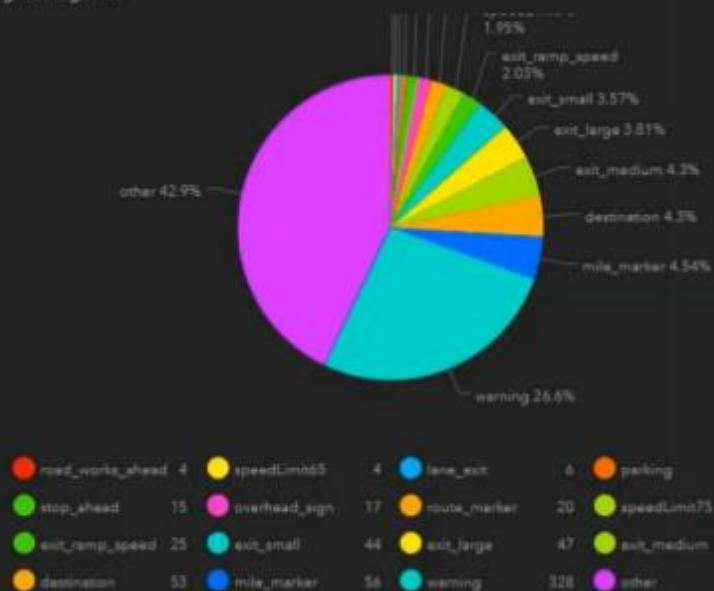
Road Sign Classification Demo

For IN 015 NB

Detections
1,233

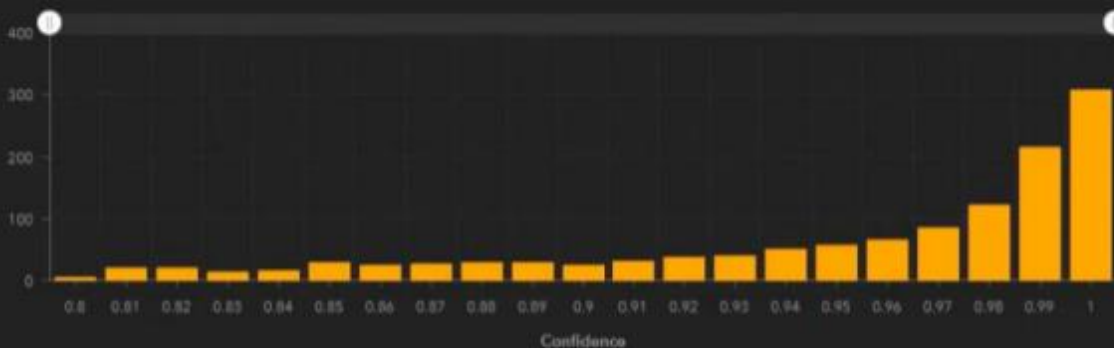
Last update: a minute ago

Sign Categories

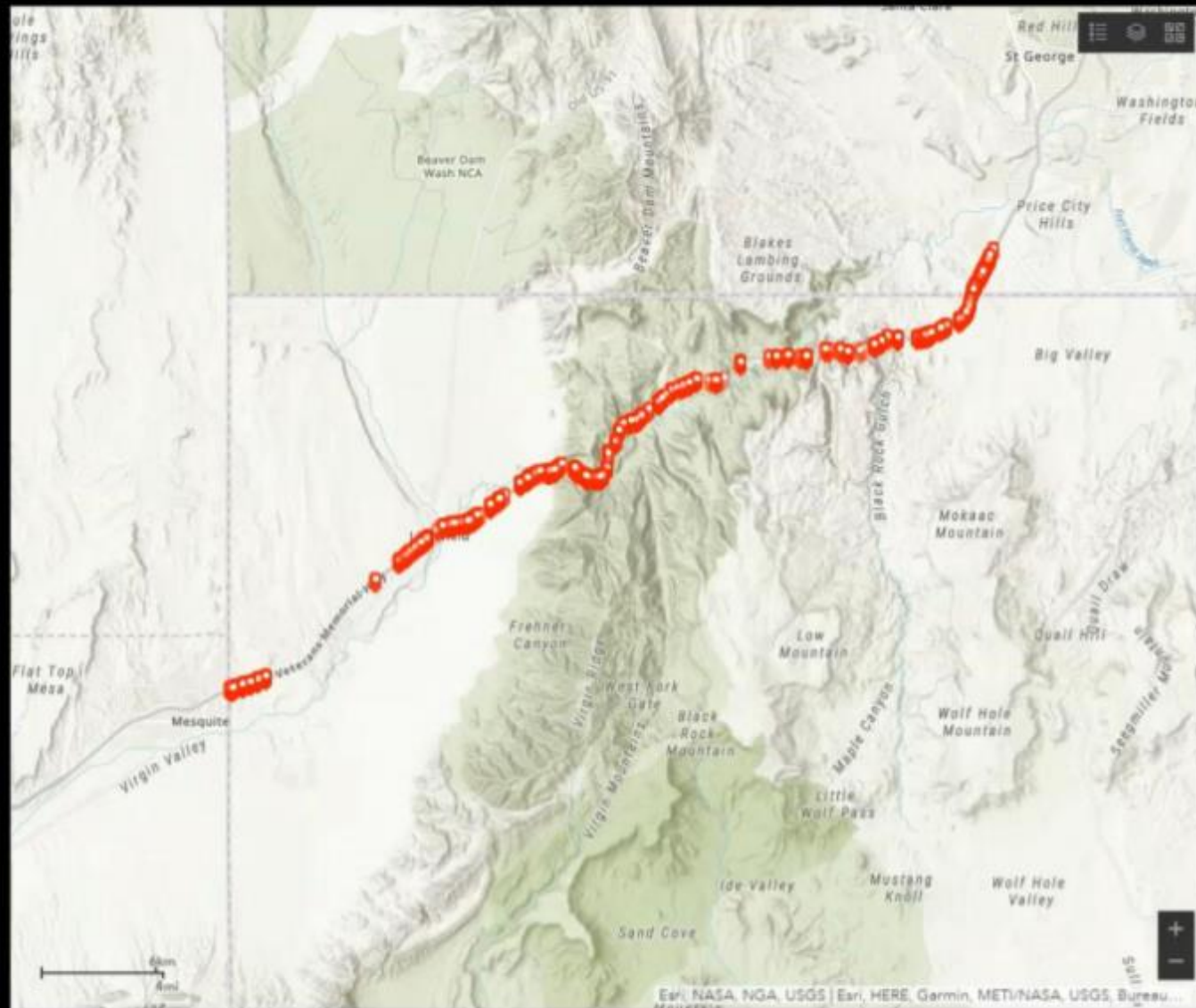


Last update: a minute ago

Detection Confidence

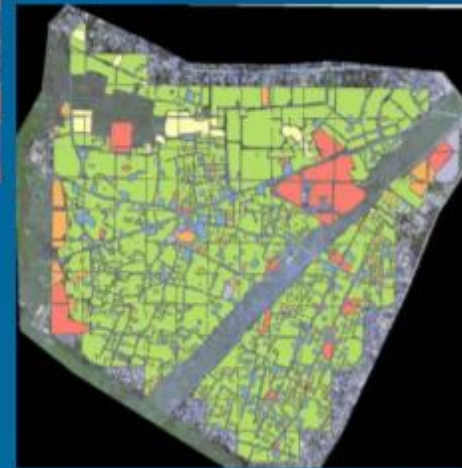


Last update: a minute ago



Parcel Boundary Extraction

- Detect Parcel Boundaries
- Detect Type: Agriculture, commercial, residential..

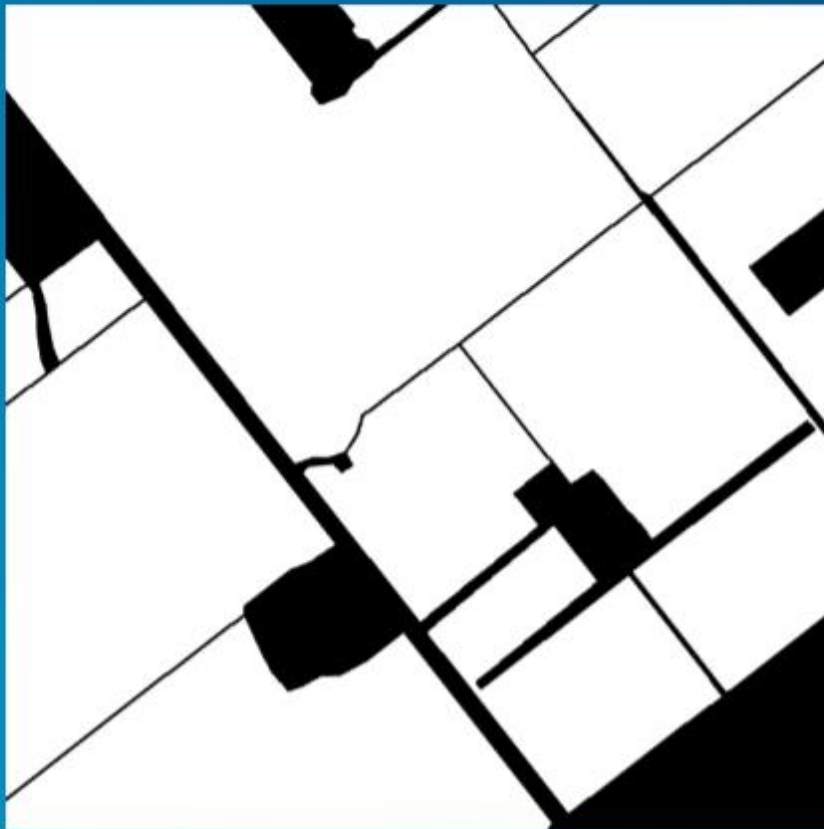


Field Boundary Delineation (Agriculture)

Image

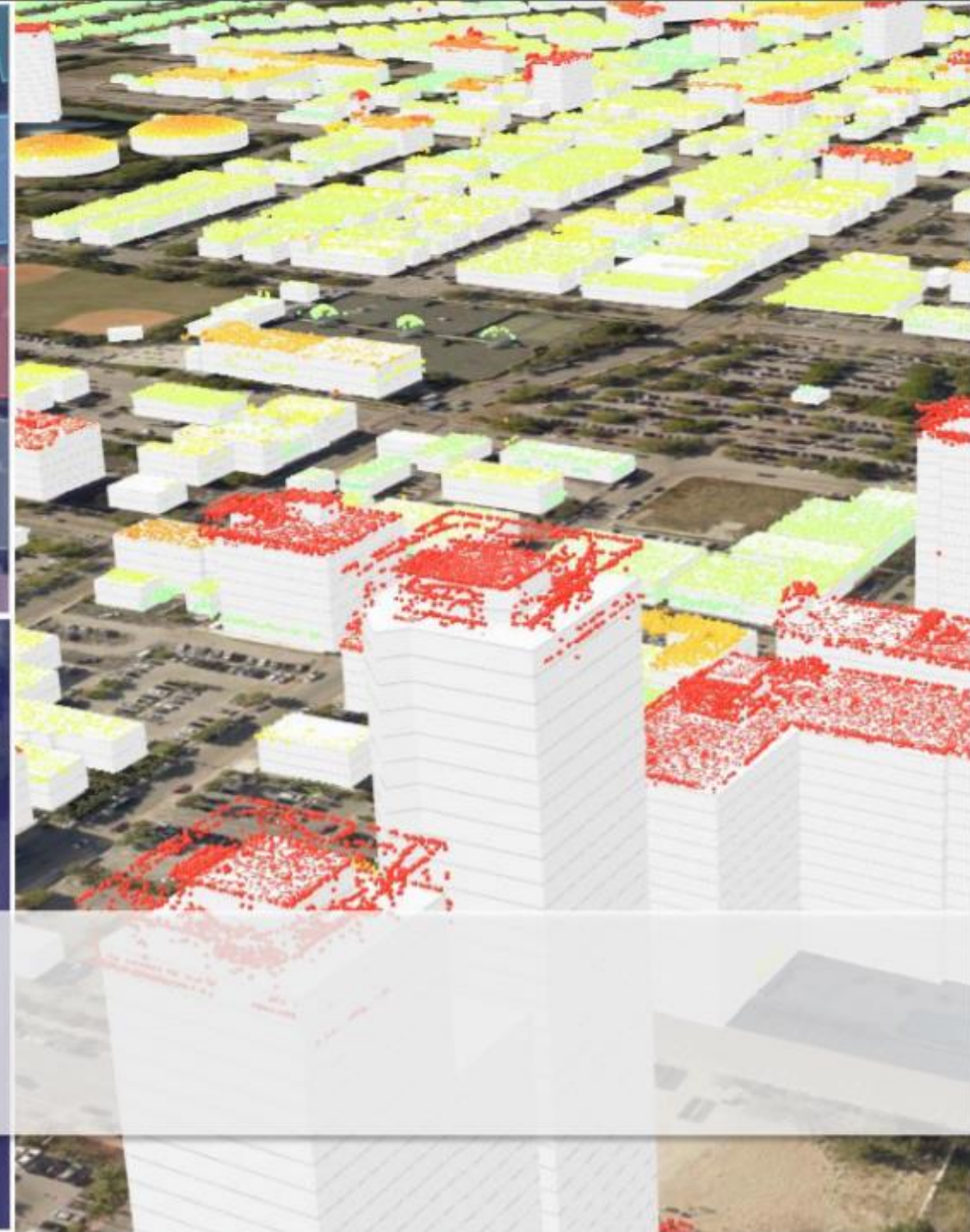


Label



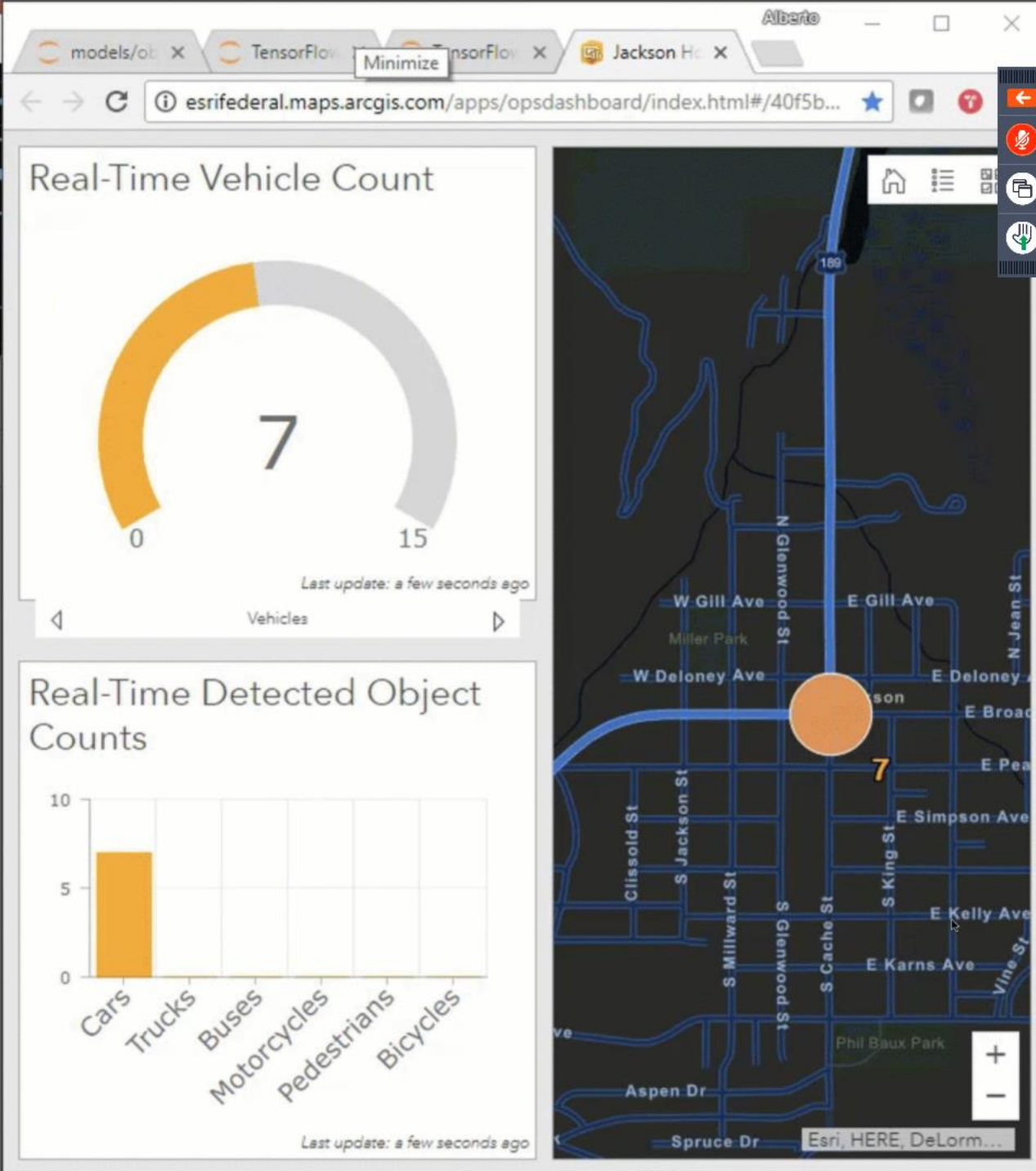
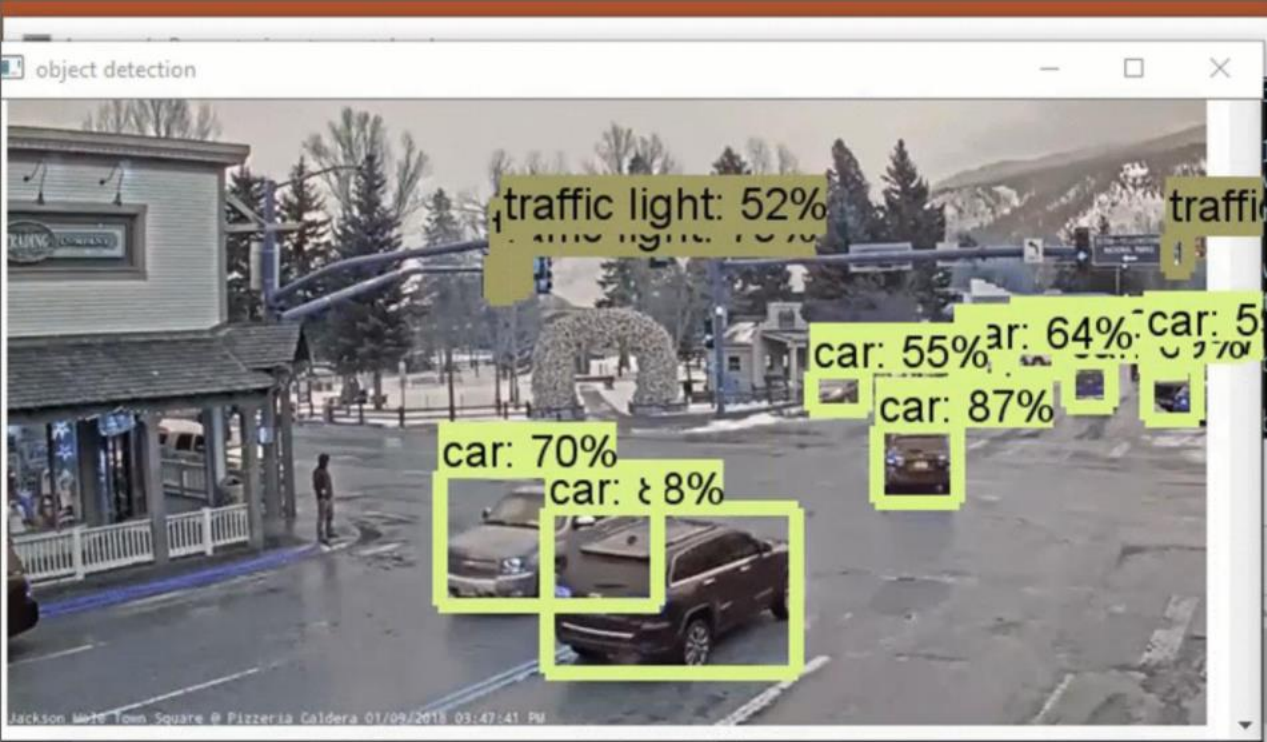
Model





3D Reconstruction from LiDar

Detect Buildings, Roof Type, Height, and More!



Activity Detection in Washington D.C. Machine Learning and ArcGIS

Constitution Ave @ 15th St
Last Detection: 5/28/2018, 2:43 PM

4 Cars Detected
8 Pedestrians Detected
0 Buses Detected
0 Trucks Detected

12th St @ Constitution Ave
Last Detection: 5/28/2018, 2:42 PM

1 Cars Detected
7 Pedestrians Detected
0 Buses Detected
0 Trucks Detected

Constitution Ave @ 17th St
Last Detection: 5/28/2018, 2:43 PM

3 Cars Detected
6 Pedestrians Detected
0 Buses Detected
0 Trucks Detected

15th St @ New York Ave & Pennsylvania Ave
Last Detection: 5/28/2018, 2:44 PM

6 Cars Detected
6 Pedestrians Detected
0 Buses Detected
1 Trucks Detected

Maryland Ave @ H St & Benning Rd
Last Detection: 5/28/2018, 2:45 PM

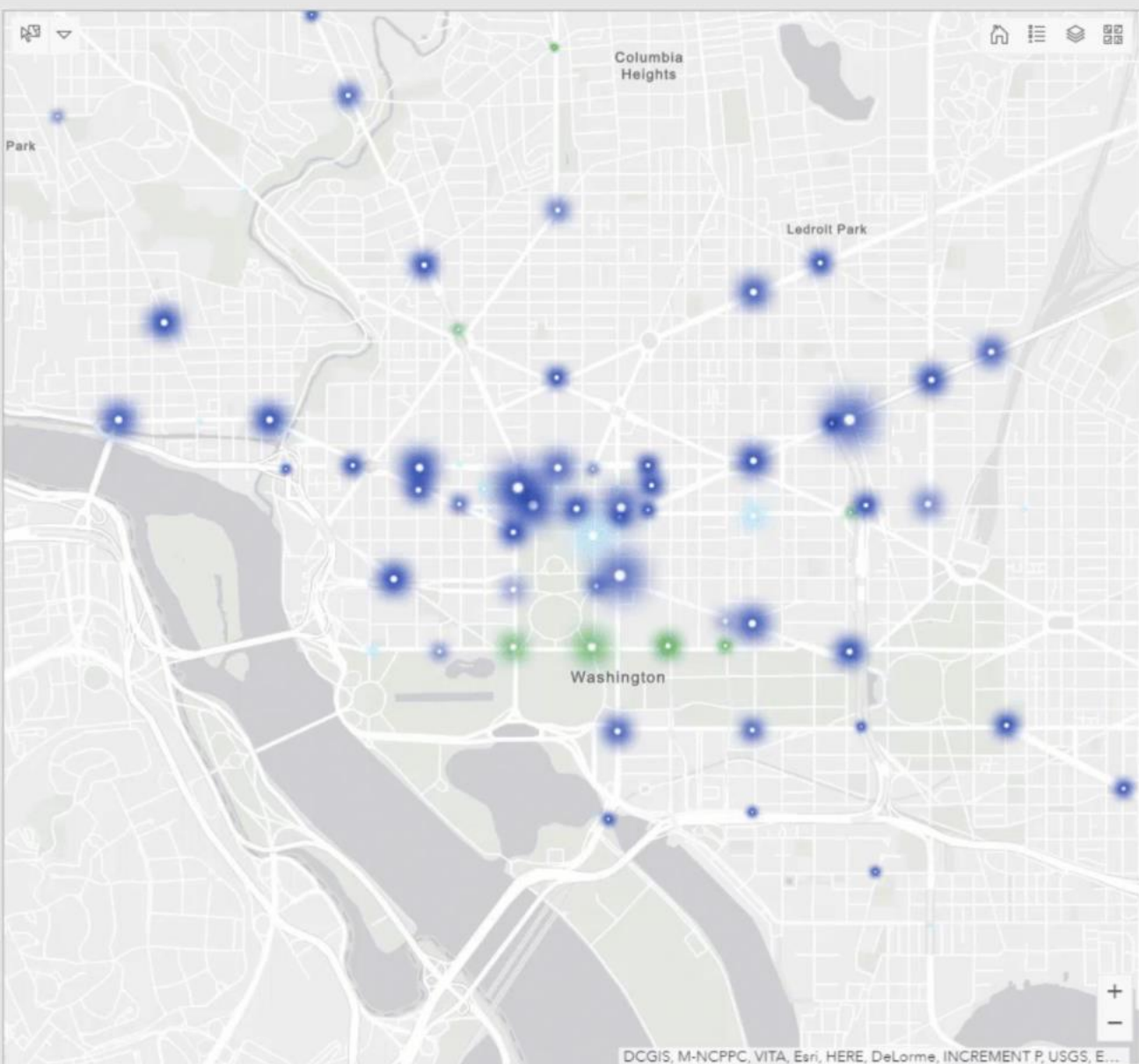
11 Cars Detected
4 Pedestrians Detected
0 Buses Detected
0 Trucks Detected

7th St @ H St
Last Detection: 5/28/2018, 2:42 PM

4 Cars Detected
4 Pedestrians Detected
0 Buses Detected
0 Trucks Detected

Last update: a few seconds ago

All Cars Pedestrians Buses Trucks Time













Detected Cars
365
in 69 Scanned Locations
Last update: a few seconds ago

Detected Pedestrians
71
in 69 Scanned Locations
Last update: a few seconds ago

Detected Buses
4
in 69 Scanned Locations
Last update: a few seconds ago

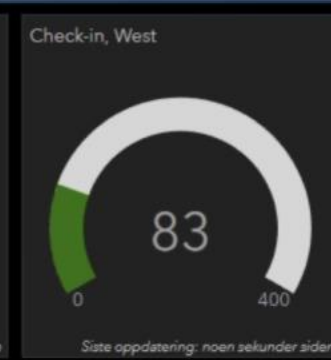
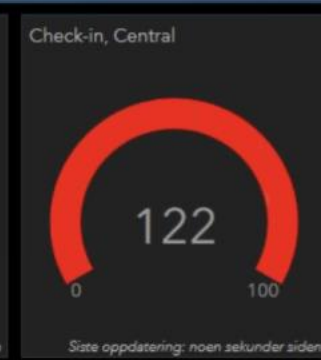
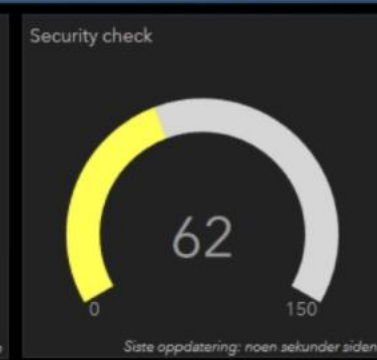
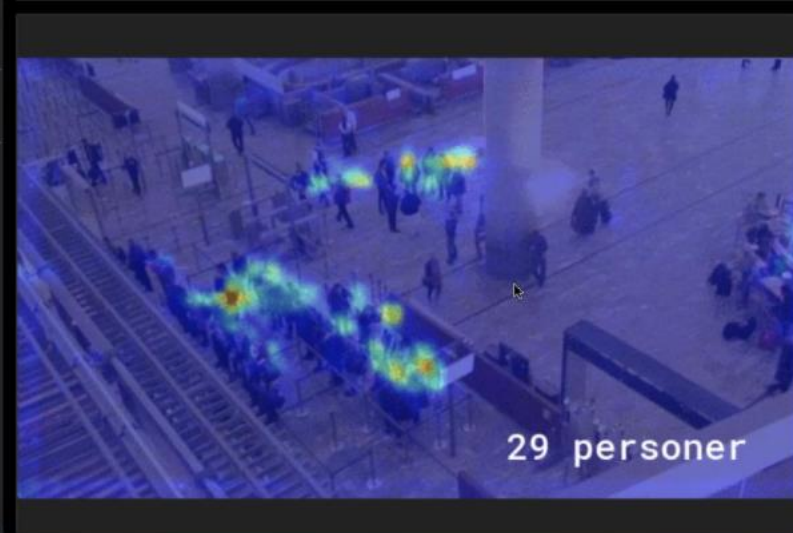
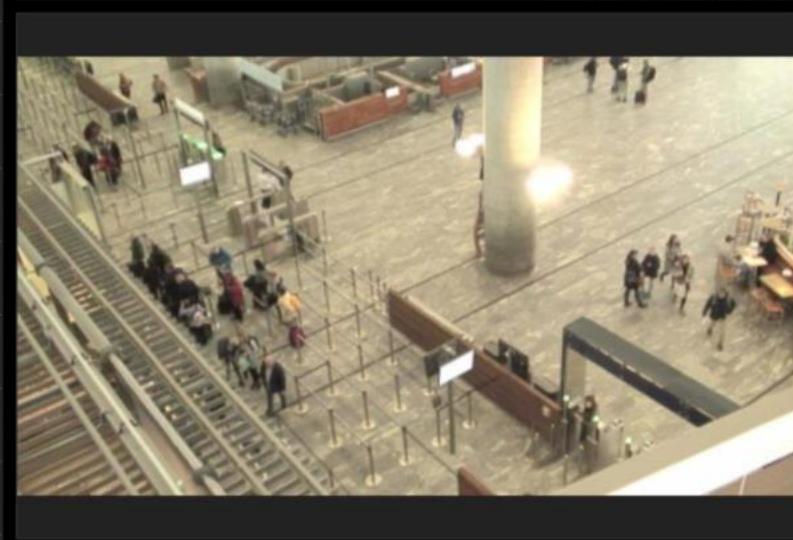
Detected Trucks
13
in 69 Scanned Locations
Last update: a few seconds ago

	Sikkerhetskontroll, S1	28
	Sikkerhetskontroll, S2	24
	Innsjekking, V3	25
	Sikkerhetskontroll, S4	10
	Innsjekking, S5	14
	Gate, D2	40
	Gate, D1	37
	Innsjekking, V8	15
	Innsjekking, S9	45
	Innsjekking, V10	0
	Innsjekking, V11	33
	Innsjekking, V12	10
	Innsjekking, S13	31
	Innsjekking, S14	32

Security check, S1

28

Siste oppdatering: noen sekunder siden



Road Cracks

372

Longitudinal Cracks Detected

Last update: a few seconds ago

1

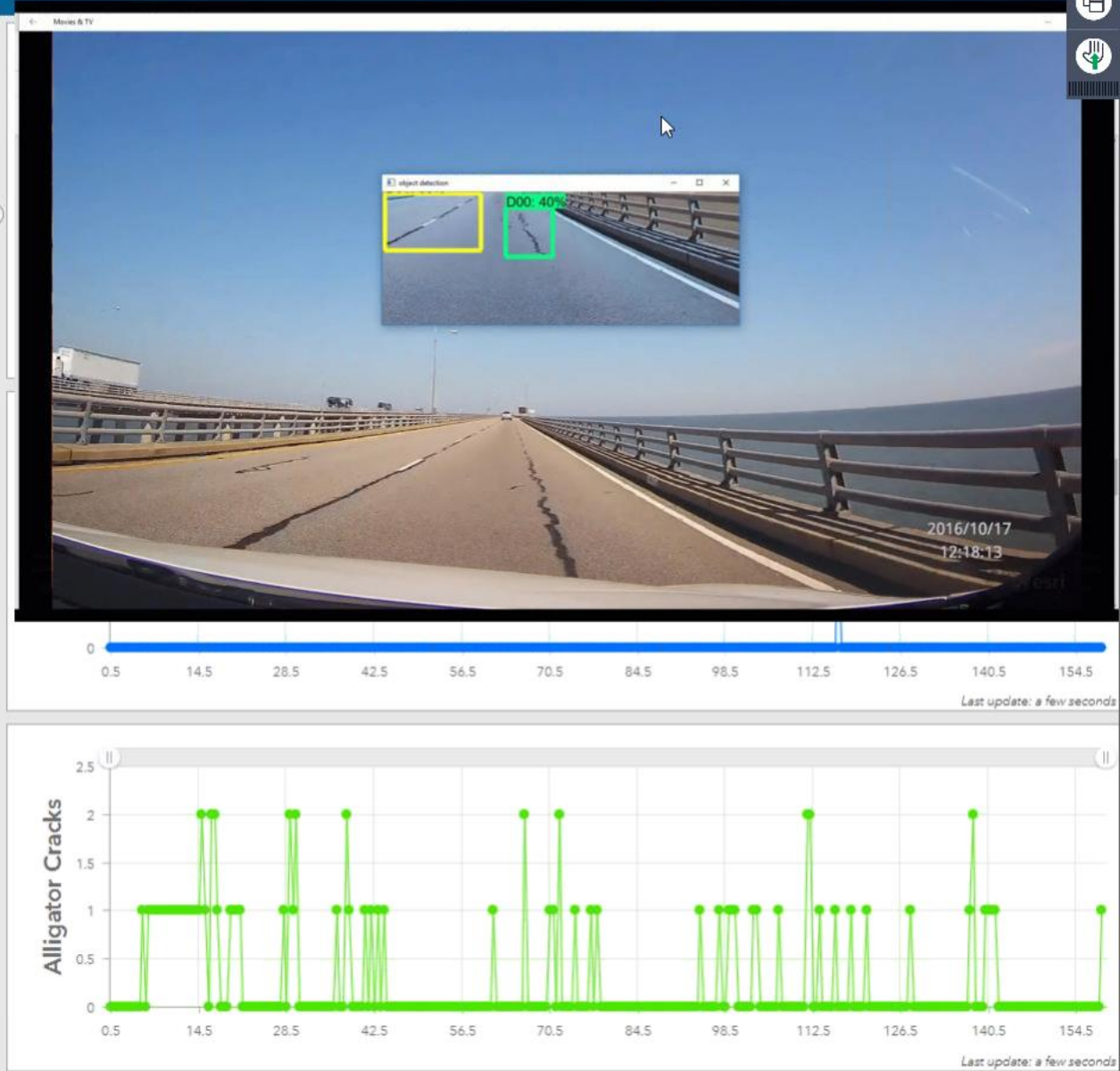
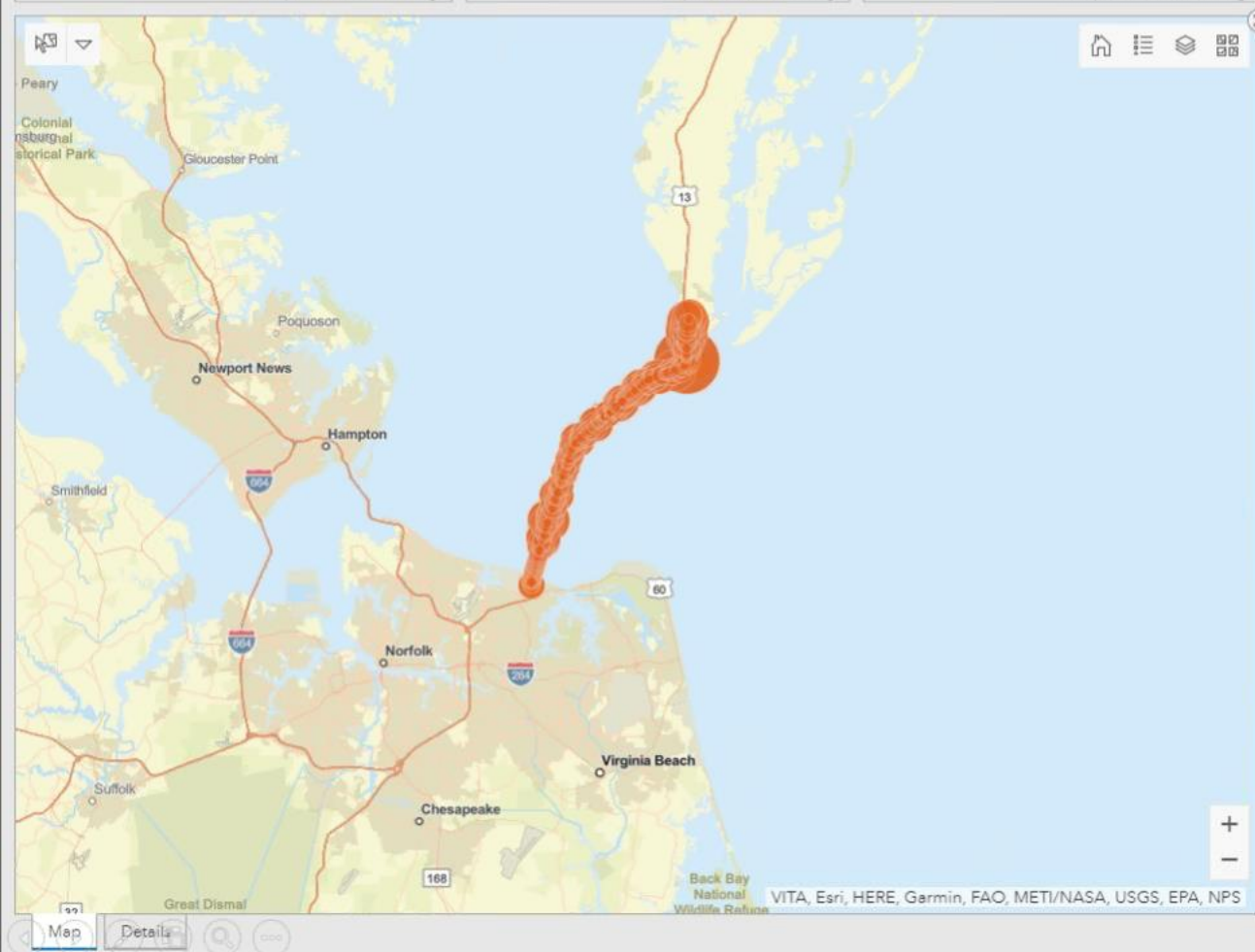
Lateral Cracks Detected

Last update: a few seconds ago

79

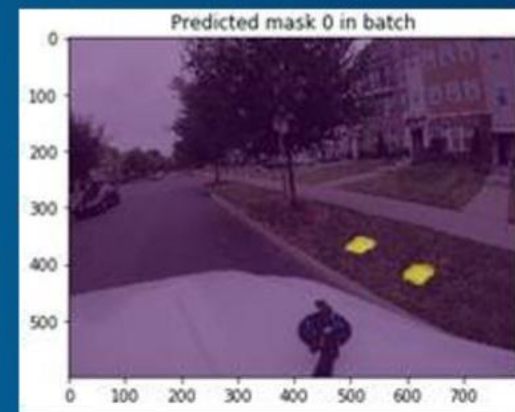
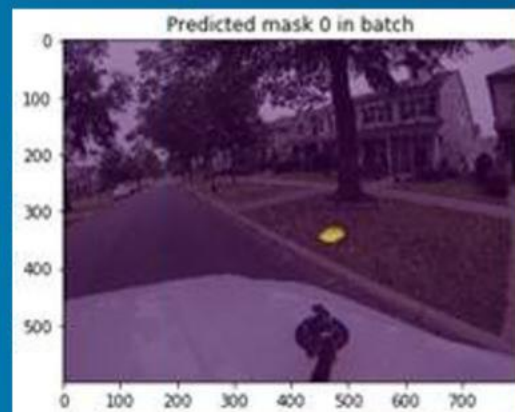
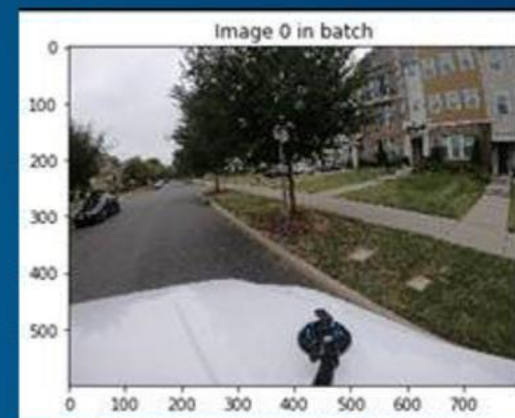
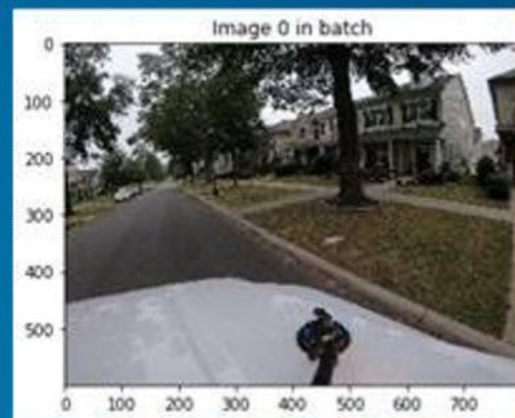
Alligator Cracks Detected

Last update: a few seconds ago



Water Meter Detection

- From 180 training images
- mIOU 0.9982 after imgaug

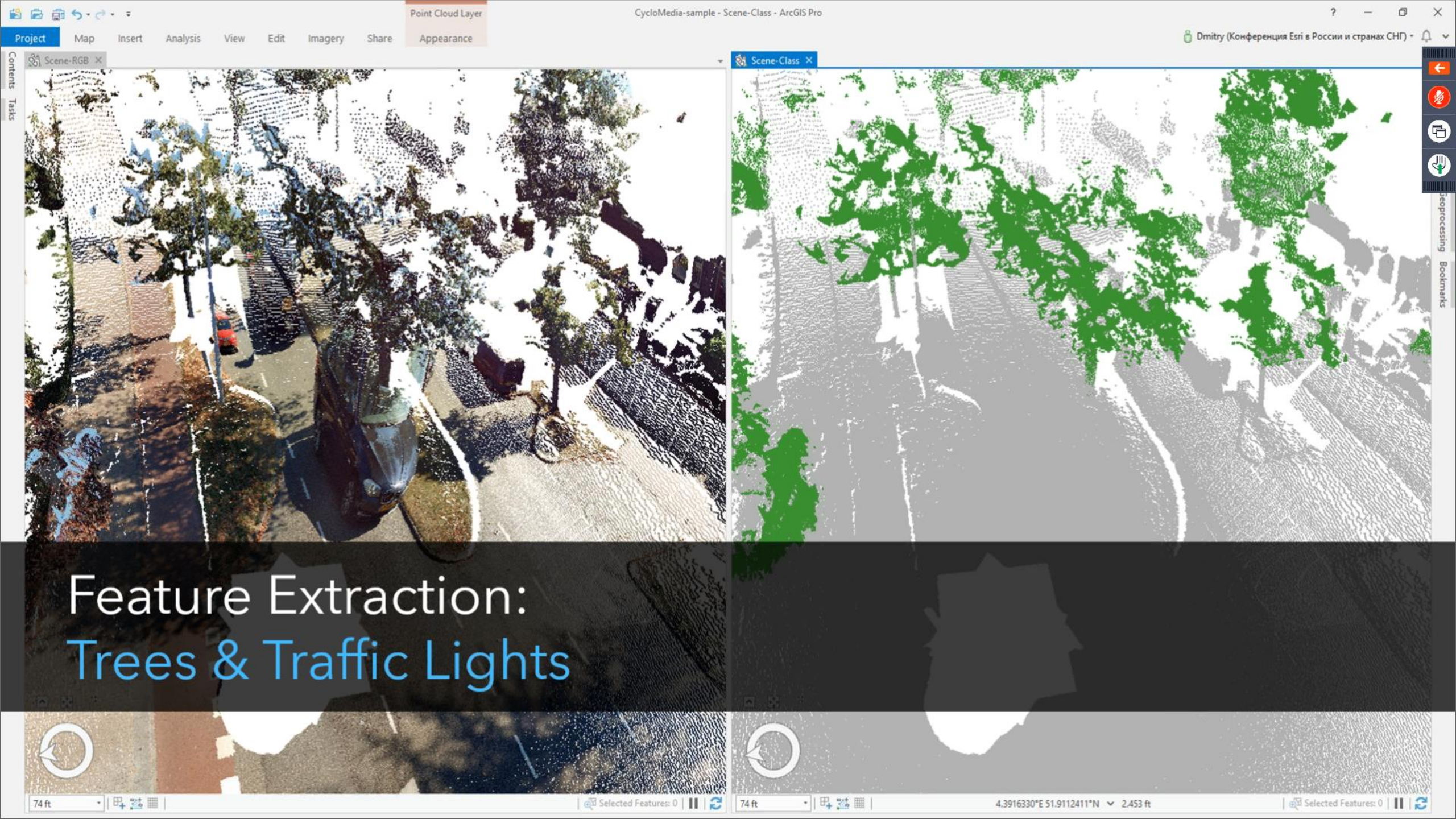


Winter Road Conditions

Automated classification of road conditions using dashcam images

- Cameras mounted on dash of snow plows
- Images collected at regular intervals
- Images stored in cloud; metadata in AGOL
- Train a residual neural network to classify:
 - Dry, wet, partial, or complete snow cover
- Model has very high performance ($F_1 = 0.8$)
- Results can be used in a variety of downstream applications:
 - Public-facing maps and apps
 - DOT resource routing





Feature Extraction: Trees & Traffic Lights

GeoAI Demo

Road Extraction

Multidimensional Datasets and Rasters

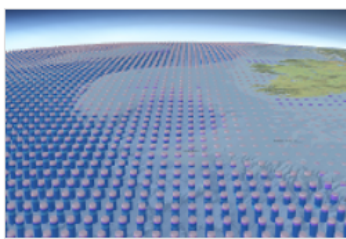
Multidimensional rasters

- **Multidimensional data represent data captured at multiple times and/or multiple depths or heights**
 - commonly used in atmospheric, oceanographic and earth sciences
- **Multidimensional raster data can be:**
 - captured by satellite observations where data are collected at certain time intervals
 - generated from numerical models where data are aggregated, interpolated or simulated from other data sources
- **Common storage formats for multidimensional raster data are netCDF, GRIB, and HDF**
 - Oceanographic data are often stored in netCDF format (.nc), weather data in GRIB format, and NASA often uses HDF format to store scientific data
- **ArcGIS Pro is capable of managing, visualizing, and processing multidimensional raster data, and publishing them as a web service**


Multidimensional rasters

- Multidimensional formats share common capabilities for storing multiple variables, with each variable being a multidimensional array
 - i.e. a netCDF file can store temperature, humidity, and wind speed for every month from the years 2010 to 2014, and at elevations of 0, 1, and 10 meters, respectively
- More information on multidimensional rasters:
 - <https://pro.arcgis.com/en/pro-app/help/data/imagery/an-overview-of-multidimensional-raster-data.htm>

i.e. NetCDF multidimensional datasets can be published to ArcGIS Online as Geoprocessing Samples (zip)... Download to use in ArcGIS Pro.



netCDF file with EMU variables for the entire globe.

 Geoprocessing Sample by [esri_oceans](#)

Created: Apr 3, 2020 Updated: May 20, 2020 Number of Downloads: 40

Description

The Group on Earth Observations (GEO), a consortium of over 100 nations with an intergovernmental protocol related to Earth observation, commissioned a global map of EMUs to support the wise use of ocean resources to gain environmental resilience. Rigorous statistical clustering produced 37 distinct 3D volumetric regions of ocean properties most likely to drive ecosystem responses. With this in hand, conservation-minded organizations, academic institutions, or citizen scientists can gauge positive or negative trends and use data to make informed decisions that preserve marine environments.




This netCDF file contains the EMU variables for the entire globe. The following blog was used to create the netCDF file in Python:
<https://www.esri.com/arcgis-blog/products/arcgis/data-management/creating-netcdf-files-for-analysis-and-visualization-in-arcgis/>

Download


Details

Size: 738 MB


★★★★★



Share



Owner

 [esri_oceans](#)

Hands-on: multidimensional rasters and ArcGIS Notebook

<https://www.esri.com/arcgis-blog/products/arcgis/imagery/precipitation-patterns-and-trends-predictions-multidimensional-data/>

Wrap-up & Summary

THE LANGUAGE OF SPATIAL ANALYTICS

Using *The Science of Where* to understand our world—mapping where things are, how they relate, what it all means, and what actions to take.



Understanding where

- 1 Understanding where things are (location maps).
- 2 Understanding where the variations and patterns in values are (comparative maps).
- 3 Understanding where and when locations and values change.



Measuring size, shape, and distribution

- 4 Calculating individual feature geometries.
- 5 Calculating geometries and distributions of feature collections.



Determining how places are related

- 6 Determining what is nearby or coincident.
- 7 Determining and summarizing what is within an area(s).
- 8 Determining what is closest.
- 9 Determining what is visible from a given location(s).
- 10 Determining overlapping relationships in space and time.



Finding the best locations and paths

- 11 Finding the best locations that satisfy a set of criteria.
- 12 Finding the best allocation of resources to geographic areas.
- 13 Finding the best route, path, or flow along a network.
- 14 Finding the best route, path, or corridor across open terrain.
- 15 Finding the best supply locations given known demand and a travel network.



Detecting and quantifying patterns

- 16 Where are the significant hot spots, anomalies, and outliers?
- 17 What are the local, regional, and global spatial trends?
- 18 Which features/pixels are similar, and how can they be clustered, classified, and identified?
- 19 Are spatial patterns changing over time?



Making predictions

- 20 Given a success case, identifying, ranking, and predicting similar locations.
- 21 Finding the factors that explain observed spatial patterns and making predictions.
- 22 Interpolating a continuous surface and trends from discrete sample observations.
- 23 Predicting how and where objects spatially interact (attraction and decay).
- 24 Predicting how and where objects affect wave propagation.
- 25 Predicting where phenomena will move, flow, or spread.
- 26 Predicting what-if.

A very Short **list of Esri terms**

Without explanations 😊

- **Common**

- Shapefile
- Feature Class
- Feature Layer
- File Geodatabase
- Enterprise Geodatabase
- LAS Dataset
- Mosaic Dataset
- ArcGIS Online
- ArcGIS Enterprise
- Portal
- Portal Items
- Map Viewer, Scene Viewer
- ArcGIS Pro, CityEngine...
- Solutions (ArcGIS Urban, ArcGIS Hub etc.)

- **Portal Items**

- Feature Service
- Imagery Layer
- Tile Layer
- Map Image Layer
- Scene Layer
- Building Scene Layer
- Point Cloud Scene Layer
- WebMap (2D map)
- WebScene (3D scene)
- Apps (Collector, Survey123, Quick Capture etc.)
- App Templates

More: <https://developers.arcgis.com/rest/users-groups-and-items/items-and-item-types.htm>

Wrap-up & Summary

- If using Esri's training license – please sign-out in ArcGIS Pro!
- Useful links:
 - Esri Spatial Statistics homepage: <https://spatialstats.github.io/>
 - lots of material, presentations, instructions to install ArcGIS-R bridge etc.
 - GeoAI:
 - medium.com/geoai (highly recommended reading; thoughts on where AI and GIS intersect)
 - ArcGIS Python API: <https://developers.arcgis.com/python/guide/geospatial-deep-learning/>
 - Deep Learning in ArcGIS Pro: <https://pro.arcgis.com/en/pro-app/help/analysis/image-analyst/deep-learning-in-arcgis-pro.htm>
 - learn.arcgis.com
 - guided lessons on real-world problems
 - <https://learn.arcgis.com/en/>
 - ArcGIS Pro roadmap May 2021 (most recent, updated after new versions)
 - <https://community.esri.com/t5/arcgis-pro-documents/arcgis-pro-roadmap-may-2021/ta-p/1060636>

Wrap-up & Summary

- **Questions & Comments:**
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 - licenses, activities etc.
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