Working with Temporal Data
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What is temporal data and why is it important?

**Moving features**
- Feature that move over space
  - Planes
  - Vehicles
  - Animals
  - Satellites
  - Storms

**Discrete events**
- Events that happen at various locations
  - Crimes
  - Lightning
  - Accidents

**Stationary recorders**
- Features stay in one place and record changes
  - Weather stations
  - Traffic sensors

**Change / growth**
- Change or growth over an area
  - Demographics
  - Fire perimeter
GIS integrates temporal data

**Temporal maps**

- **Real-time sensor network**
  - Mobile
  - Stationary

- **Analysis, simulation, & modeling**

**Data Sources**

- Fixed time temporal data
  - Time stamps / time extents
  - Multidimensional \((x, y, z, t)\)
ArcGIS built time into GIS

• Unified experience for time
  - Part of Desktop, Engine, and Server products
• Geoprocessing (GP) tools
  - Data management tools
  - Time-aware analysis tools
• Ability to share temporal data/maps
  - Packages, videos, images, temporal map books, map services, web maps, web map apps
ArcGIS terms

- **Time-enabled layer** – layer enabled to display time
- **Time Slider window** – tool to work with those layers
Time-stamps

- Single time field
- Start and end time fields
Working with time-enabled layers

• Two-step process
  1 Configure time properties on the layer
  2 Use Time Slider window to work with the layer
Time Properties on a layer

Example of a Time Properties window for a layer in GIS software. The options include:

- **Layer Time**: Choose if each feature has a start and end time field.
- **Start Time Field**: Specify the field containing the start time.
- **End Time Field**: Specify the field containing the end time.
- **Field Format**: Choose the format for the time fields (e.g., YYYY).
- **Time Step Interval**: Set the interval between time steps (e.g., Decades).
- **Layer Time Extent**: Set the start and end dates for the layer.
- **Advanced settings**: Options for time zone, offset, and cumulative display.

These properties allow for the visualization and analysis of data that changes over time.
Working with time-enabled layers

• Set additional display properties
  • Display data cumulatively
  • Time offset
  • Time window
  • Time text
  • Dynamic text
Time Slider window

- Enable/disable time on map
- Export to video
- Current time stamp
- Time step interval
- Decrease time extent
- Increase time extent
- Full time extent
- Live feed mode
Time Slider window – Playback controls

Options

Export to video

Current time stamp

Time step interval

Decrease time extent

Increase time extent

Enable/disable time on map

Previous time stamp

Scroll back in time

Start time of the display

Next time stamp

End time of the display

Scroll forward in time

Options

Export to video

Current time stamp

Time step interval

Decrease time extent

Increase time extent

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Dynamic nature of the data and display

- The temporal nature of the data is intuitively expressed in a dynamic map
- But it is more complex!
Dynamic versus animated maps

- **Dynamic maps** – show changes in feature shape/position and/or attributes over time
- **Animated maps** – a type of dynamic map but there are others
  - Change in perspective, like a fly-through
- Use Animation tools
Temporal graphs

- Create a graph that relates to a table or a layer
- The graph will animate if the table or layer it is created from is time-enabled
Managing temporal data
Supported data types

- Let’s look at each of these in detail in the next few slides:
  - Feature layers
  - Mosaic datasets
  - Raster catalogs
  - Tables
  - NetCDF layers
  - Tracking layers
  - Network dataset layers with traffic data
  - Video layers
Managing temporal data

- Supported data types
- Storing time stamps
- Tools to migrate and convert data
Feature layers – Separate features

• Feature shape/position change over time
• A new feature for each time stamp
• Attribute values can change over time
Feature layers – Features joined to a table

- Feature layers with one-to-one or one-to-many join
- Feature shape/position is constant
- Attribute values change over time
Mosaic datasets and raster catalogs

- Field containing time information
- Two primary ways to organize the data:
  - A single mosaic dataset for all imagery
  - Multiple mosaic datasets in a master mosaic dataset
NetCDF layers

• A file format for storing multidimensional data
  - X, Y, Z, T, temperature, pressure, salinity, wind speed,…
Tracking layers

• **Tracking Analyst extension**
  - View objects that move or change through time

• **Track objects in real time**

• **Temporal symbology**
Managing temporal data

- Supported data types
- Storing time stamps
- Tools to migrate and convert data
Date field type

- A field type that stores dates, times, or dates and times
- Most efficient format for query and display performance
  - Supports more sophisticated database queries
- Easiest to configure on the layer

Index the field for faster display and query performance
Number and Text field types

- Only “sortable” formats are supported
  - YYYYMMDD 20140709 > 20130709 = TRUE
  - MMDDYYYY 07092014 > 08092013 = FALSE

- Named month is not supported
  - AUG-09-2013 would come before JUL-09-2013

Index the field for faster display and query performance
Converting between time formats

- **Convert Time Field** GP tool
  - Converts custom Text/Number formats into a new Date field
  - “July 09, 2013” → 07/09/2013
Setting duration

• **Calculate End Time** GP tool
  - Populates an end time field with the next record’s start time

• The last record will not have a duration
  - The end time is calculated to be the same as the start time of the feature
Temporal data stored in multiple columns

- **Transpose Fields** GP tool
  - Shifts data entered in columns into rows
Working with time zones

- ArcGIS integrates data across different time zones
  - Layers in map can be in different time zones

- Data for same layer needs to be in the same time zone

- **Convert Time Zone** GP tool
  - Converts time values recorded in a date field from one time zone to another time zone

- Standardize on UTC\(^1\) or GMT\(^2\)
  \(^1\) Coordinated Universal Time, \(^2\) Greenwich Mean Time
Daylight savings time

• Problems with DST
  - Regional differences
  - Rules and boundaries change frequently
  - Some DST zones adjust less than an hour
    - 30 minute DST offset
    - 45 minute DST offset

Store temporal data as Standard Time (not DST)

Analyzing temporal data
Analyzing temporal data

- Geoprocessing tools for spatial/temporal data
- All GP tools honor time
- ArcPy site-package
Space-time cluster analysis

- ArcToolbox > Spatial Statistics > Mapping Clusters
  - Hot Spot Analysis GP tool
  - Cluster and Outlier Analysis GP tool
  - Grouping Analysis GP tool
Mapping Clusters

- **Hot Spot Analysis** GP tool
  - Creates a map of statistically significant hot and cold spots

- **Cluster and Outlier Analysis** GP tool
  - Identifies statistically significant hot spots, cold spots, and spatial outliers

- **Grouping Analysis** GP tool
  - Groups features based on feature attributes and optional spatial/temporal constraints
Conceptualization of Spatial Relationships

- A parameter in a number of Spatial Statistics tools in ArcToolbox
- **Generate Spatial Weights Matrix** GP tool – used to define neighbor relationships using both spatial and temporal parameters
All GP tools honor time

- At 10.1 service pack 1
  - GP tools honor temporal setting for time-enabled layers
  - Process only features within the time extent set in the Time Slider window
  - Similar to a selection or definition query
ArcPy site-package

- Provides classes and functions to work with time in the map and data
  - DataFrameTime class
  - UpdateLayerTime() function
- Arcpy.time
  - Python module for working with time in ArcGIS
Sharing temporal data
Sharing temporal data

- Time-enabled layer and map packages
- Temporal map books
- Export as video layer files (for ArcGlobe)

- Let’s look at each of these in detail in the next few slides:
  - Export as video (AVI)
  - Export as sequential images
  - Create web map services
  - Use in web map
  - Use in a web map app
Export as video

- In AVI format
- Works with maps and graphs
- Options for:
  - Off-screen recording
  - Custom extents
    - Web – 800 x 600
    - YouTube – 1280 x 720
  - Temporarily resizing window
  - Frame based export
Export to video

- Video file size is a function of:
  - Frame rate
  - Screen size
  - Compressor

For high quality videos, choose a codec that does not have lossy compression, e.g., Full Frames (Uncompressed)
Export as sequential images

- In BMP or JPG format
- Specify the number of images to be exported
Create web map services

- Map services preserve the time information from time-enabled layers
- Use to display or query the map services
Temporal Data in ArcGIS Pro
Thank you…

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