ArcGIS Pro: Working with Temporal Data

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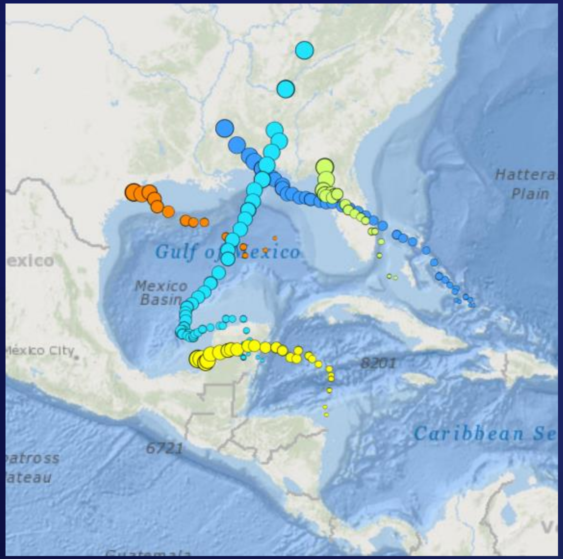
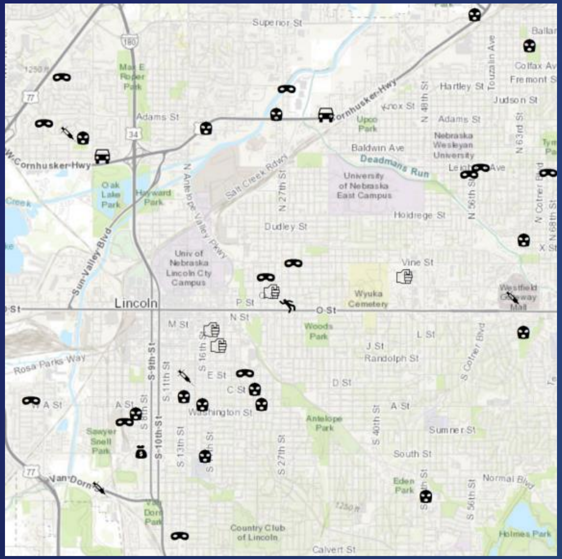
Types of Temporal Data

Moving Features



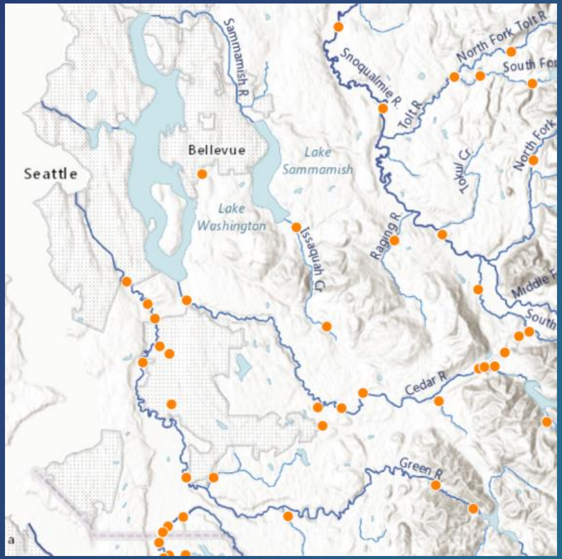
- Airplanes, boats, vehicles
- People, animals
- Storm centers

Discrete Events



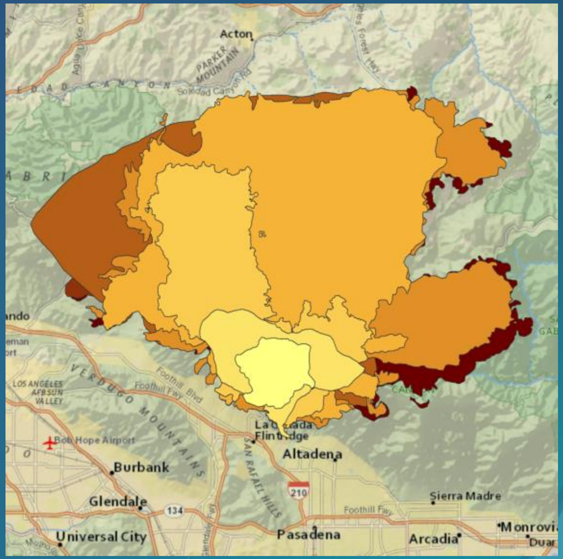
- Crimes
- Accidents
- Earthquakes, lightning strikes, volcanic events

Stationary Recorders



- Weather stations
- Traffic sensors
- Stream gauges

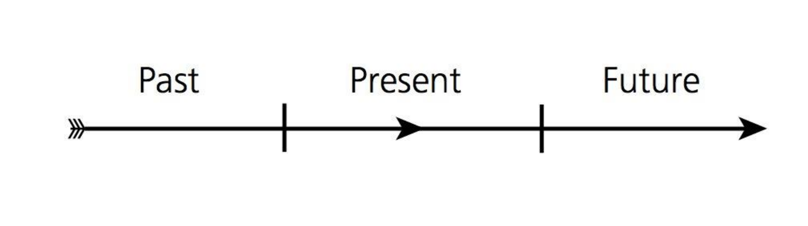
Change & Growth

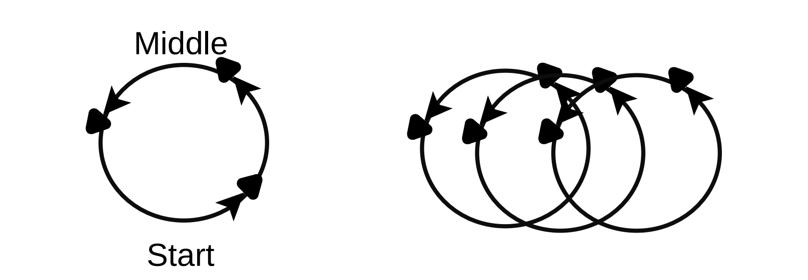


- Demographics
- Fire perimeters
- Flood extents
- Country Boundaries

The nature of temporal data

- Conceptualizations of time can vary
  - **Linear** (directional)
    - Each moment is unique, time moves forward
    - Eg: Purchase of a home
  - **Cyclic** (repeating)
    - Moments are repeated, time loops back around
    - Eg: Daily feeding schedule at a zoo





- ArcGIS assumes that time is **linear**

http://www.businessinsider.com/how-different-cultures-understand-time-2014-5

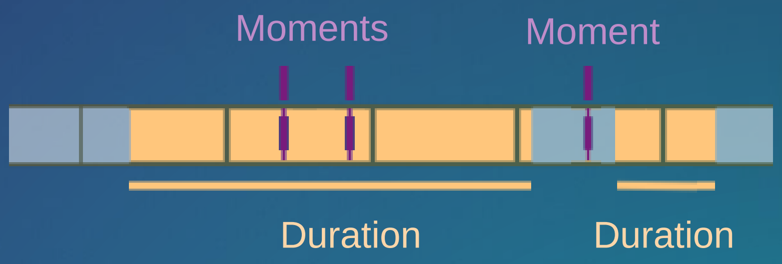
The nature of temporal data

- Time is relative to something
  - Clock-driven time
    - *"On Jan 10th, 1990, at 11.00am, …"* (Gregorian Calendar, UTC)
    - Hourly water temperatures
    - Crime occurrences
  - Event-driven time
    - *"At T-minus 10 minutes, …"*
    - Days since a specific earthquake
    - Planning / conducting a military exercise
  - State-driven time
    - *"2 seconds after the vehicle stops, …"*
    - Automated factory scheduling
    - Melting of ice sheets

http://www.businessinsider.com/how-different-cultures-understand-time-2014-5

The nature of temporal data

- Temporal data can be:
  - **A moment**
    - Information is captured / defined for a specific point in time
    - Described as a single time-value
    - Eg: *The exam starts at 9.00am*
  - **A duration**
    - Information is captured / defined for an interval of time
    - Can be described as either [start-time + length-of-time] or [start time + end-time]
      - ArcGIS Pro requires the latter storage format
    - Eg: *The exam lasts for 90 minutes*; or *The exam ends at 10.30am*



http://www.businessinsider.com/how-different-cultures-understand-time-2014-5

The nature of temporal data

- The frequency of data collection can be:
  - Regular
    - Data values are collected at a constant rate
    - Eg: Hourly GPS positions from a vehicle tracker
    - Eg: A 10-year census
  - Irregular
    - Data values are collected on indeterminate events, or whenever required
    - Eg: The occurrence of crimes
    - Eg: Changes in political boundaries

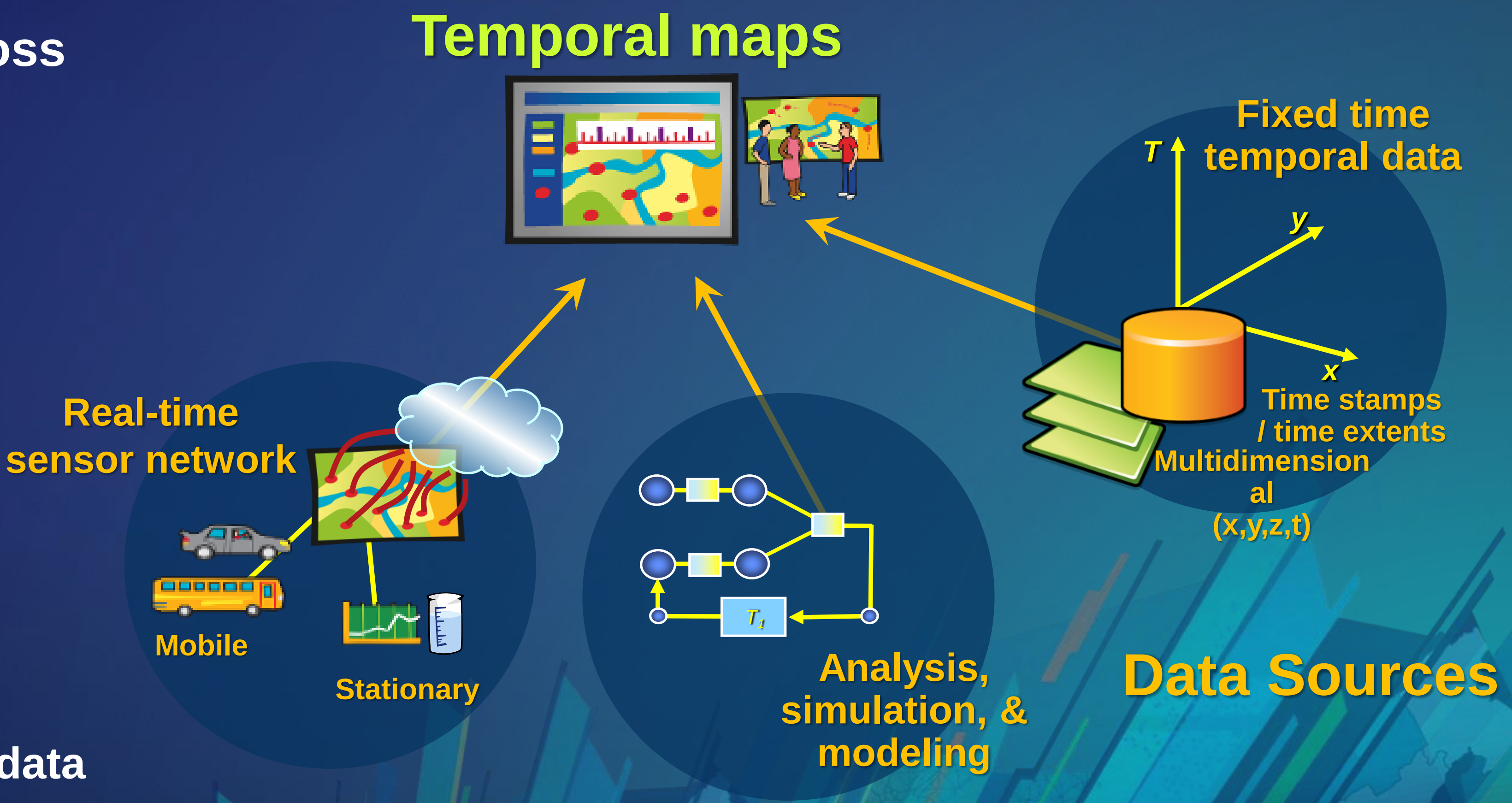
http://www.businessinsider.com/how-different-cultures-understand-time-2014-5

GIS integrates temporal data

- ArcGIS integrates time across the platform
  - ArcGIS for Desktop
  - ArcGIS Pro
  - ArcGIS Portal
  - ArcGIS Online
  - …

- ArcGIS can be used to:
  - Manage
  - Visualize
  - Analyze
  - Share

temporal data



A quick note

This session covers:

- Structuring…
- Visualizing…
- Sharing…

…Temporal Data in ArcGIS Pro

- Not:
  - Analyzing, Editing, Generating Space-Time Cubes, …

Structuring temporal data

Supported data storage types

- Data that can be presented as tabular rows
  - Feature layers
  - Mosaic datasets
  - NetCDF layers
  - Tables
  - Raster catalogs
  - Tracking layers / Stream layers
  - Network dataset layers with traffic data
- Plus service layers with historical content and updating data feeds

Storing temporal values – best practice

- **Store time values in a date field**
  - A field type that stores dates, times, or dates-and-times
  - Supports more sophisticated database queries
  - Easiest to configure on the layer
  - ** Note: we will cover using 'Range' (numbers) for time values later*
- **Store temporal data in row format**
  - Pro filters tabular content by rows
  - Each time-aware data entry should be a single record/row
- **Index the date field**
  - Interactively filtering rows means many database queries
- **Consider storing date values in UTC or GMT**
  - If your data covers multiple time zones, '10am' becomes unreliable

Supported string field formats

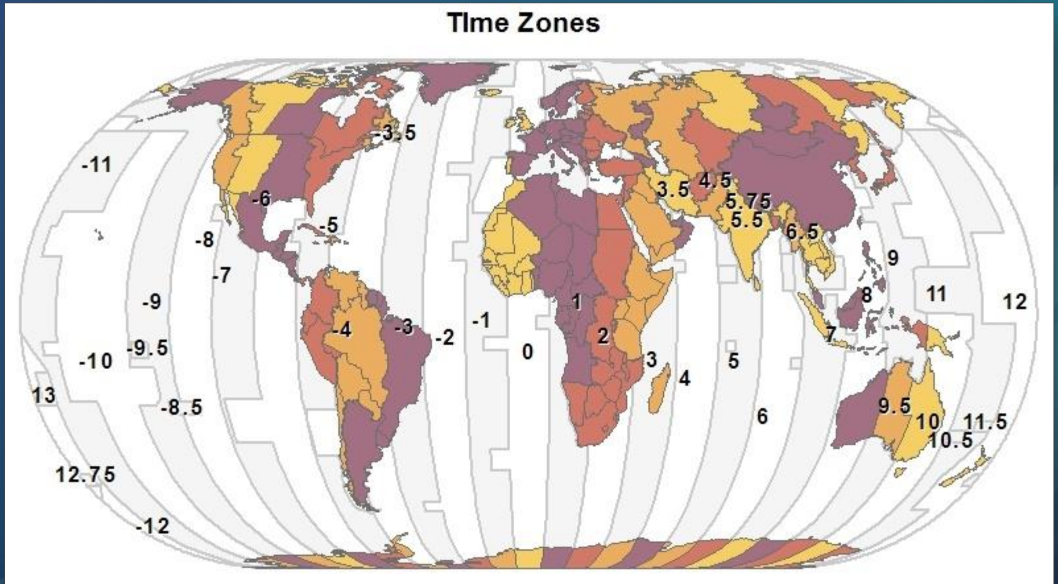
- YYYY
- YYYYMM
- YYYY/MM
- YYYY-MM
- YYYYMMDD
- YYYY/MM/DD
- YYYY-MM-DD
- YYYYMMDDhhmmss
- YYYY/MM/DD hh:mm:ss
- YYYY-MM-DD hh:mm:ss
- YYYYMMDDhhmmss.s
- YYYY/MM/DD hh:mm:ss.s
- YYYY-MM-DD hh:mm:ss.s
- YYYY-MM-DDThh:mm:ss.s

Supported numeric field formats

- YYYY
- YYYYMM
- YYYYMMDD
- YYYYMMDDhhmmss

When data comes from across multiple time zones…?

- Pro does integrate, and allow for, data across different time zones
  - The *map* has a time zone (values shown on the Time Slider)
  - A *layer* has a time zone, and all values must be for the *same time zone*
- Ensure all values in the *layer* are in the *same* time zone
  - Use the Convert Time Zone GP tool, as needed
  - Adjusts the rows' time values (in a date field) from one time zone to another



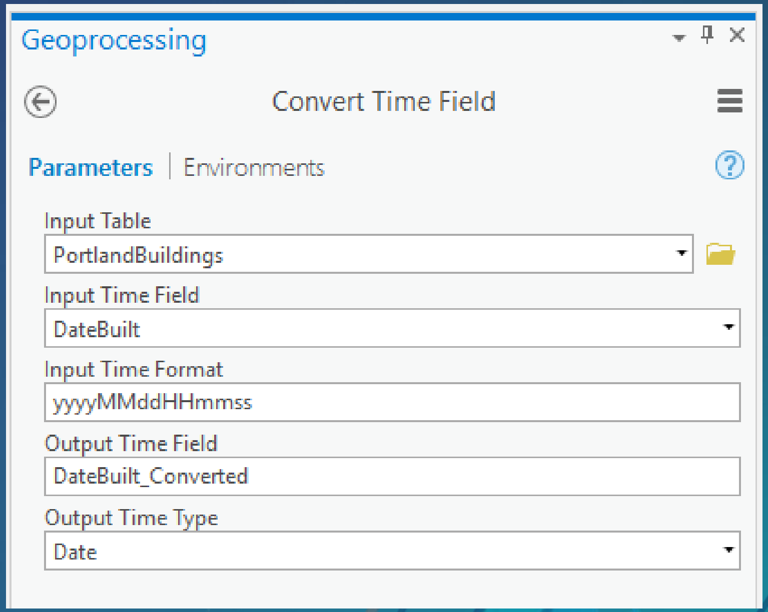
- Tip: Convert to standard time (UTC[1] or GMT[2])
  - Avoid issues with daylight savings time

[1] Coordinated Universal Time
[2] Greenwich Mean Time

When temporal values are not in Date format…?

- Convert values into a date field type
  - Use the Convert Time Field GP tool
  - Converts Text/Number fields into a new Date field
    - "July 09, 2016" ⇨ 07/09/2016 ⇨ MM/DD/YYYY
  - You can define a custom text format, if needed

- The tool allows other time conversions

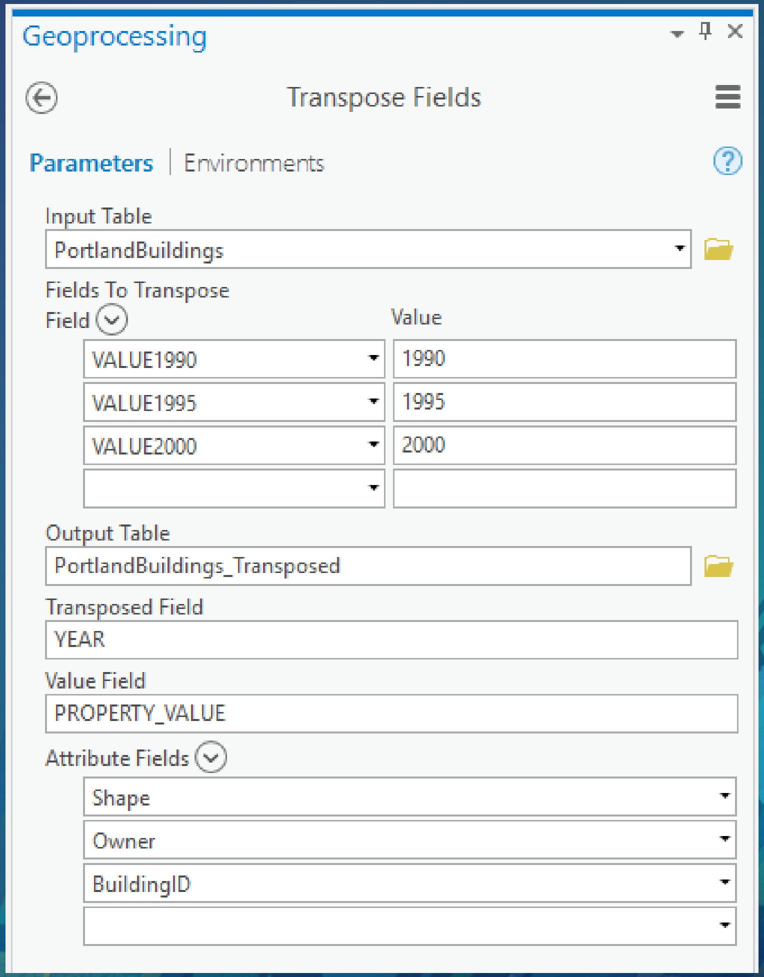


When temporal values are stored across multiple columns…?

- **Expand the data into one time-stamp per row**
  - Use the Transpose Fields GP tool
  - Shifts data stored in columns into individual rows
  - Geometry shapes are duplicated
  - Choose which other fields are brought across

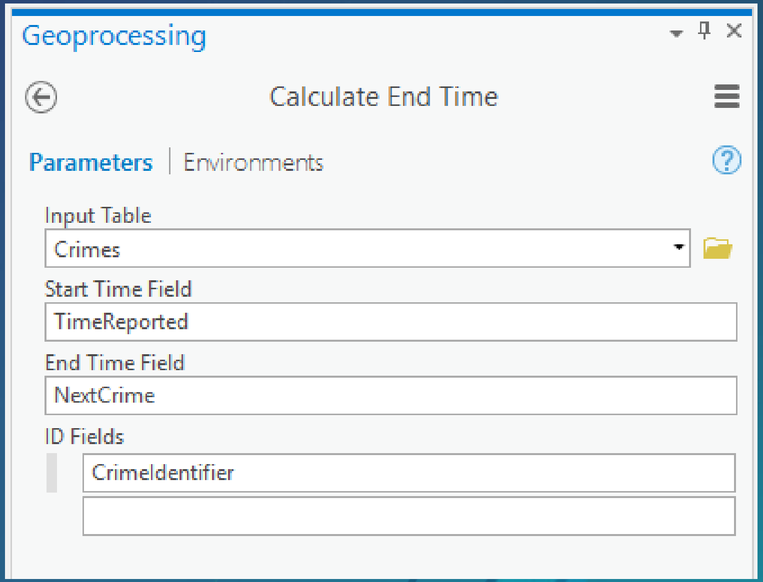
STATE_NAME	Y1980	Y1981	Y1982
Alabama	539	706	707
Alaska	180	215	274
Arizona	109	115	117
Arkansas	101	113	136
California	20	22	25
Colorado	0	0	0
Connecticut	106	105	115

STATE_NAME	DateField	Expense
Alabama	Y1980	539
Alaska	Y1980	180
Arizona	Y1980	109
Arkansas	Y1980	101
California	Y1980	20
Colorado	Y1980	0
Connecticut	Y1980	106
Alabama	Y1981	706
Alaska	Y1981	215
Arizona	Y1981	115
Arkansas	Y1981	113



When you need durations between events…?

- **Pull the next row's time-value into the current row**
  - Use the Calculate End Time GP tool
  - Populates an end time field with the next record's start time
  - The last record duplicates its start and end times



Result

Start_Time	End_Time
1/5/2010 6:00:00 AM	1/6/2010 1:00:00 PM
1/6/2010 1:00:00 PM	1/7/2010 4:00:00 PM
1/7/2010 4:00:00 PM	1/8/2010 11:00:00 AM
1/8/2010 11:00:00 AM	1/10/2010 2:00:00 PM
1/10/2010 2:00:00 PM	1/10/2010 2:00:00 PM

Modeling data… as separate rows (best general interaction)

- Each row contains all feature values, regardless of which ones change
  - Pros: anything can change per row (including shape), simple to configure, one table
  - Cons: potential for significant duplicated content
- Well-suited for:
  - Moving objects, like vehicle tracking
  - Changing polygonal areas, like fires boundaries

OBJECTID*	Shape*	Name	State_Name	POP	DATE_ST	DATE_END	Shape_Length	Shape_Area
2698	Polygon	Abbeville	South Carolina	33400	01/01/1900	01/01/1910	162402.504779	1339524251.7354
5944	Polygon	Abbeville	South Carolina	34804	01/01/1910	01/01/1920	162402.504779	1339524251.7354
8975	Polygon	Abbeville	South Carolina	27139	01/01/1920	01/01/1930	162402.504779	1339524251.7354
12185	Polygon	Abbeville	South Carolina	23323	01/01/1930	01/01/1940	162402.504779	1339524251.7354
15135	Polygon	Abbeville	South Carolina	22931	01/01/1940	01/01/1950	162402.504779	1339524251.7354
18243	Polygon	Abbeville	South Carolina	22456	01/01/1950	01/01/1960	162402.504779	1339524251.7354
21371	Polygon	Abbeville	South Carolina	21417	01/01/1960	01/01/1970	162402.504779	1339524251.7354
24464	Polygon	Abbeville	South Carolina	21112	01/01/1970	01/01/1980	162402.504779	1339524251.7354

Modeling data… using a joined table (optimal database method)

- A primary table, with a one-to-many join to a time-centric data table
  - Pros: optimized data storage, decide which values update, not hard to configure
  - Cons: multiple tables, slower general performance
- Well-suited for:
  - Stationary objects, like stream-gauge monitoring devices
  - Mostly-static polygonal areas, like parcels to a tax assessment table

Stations feature class

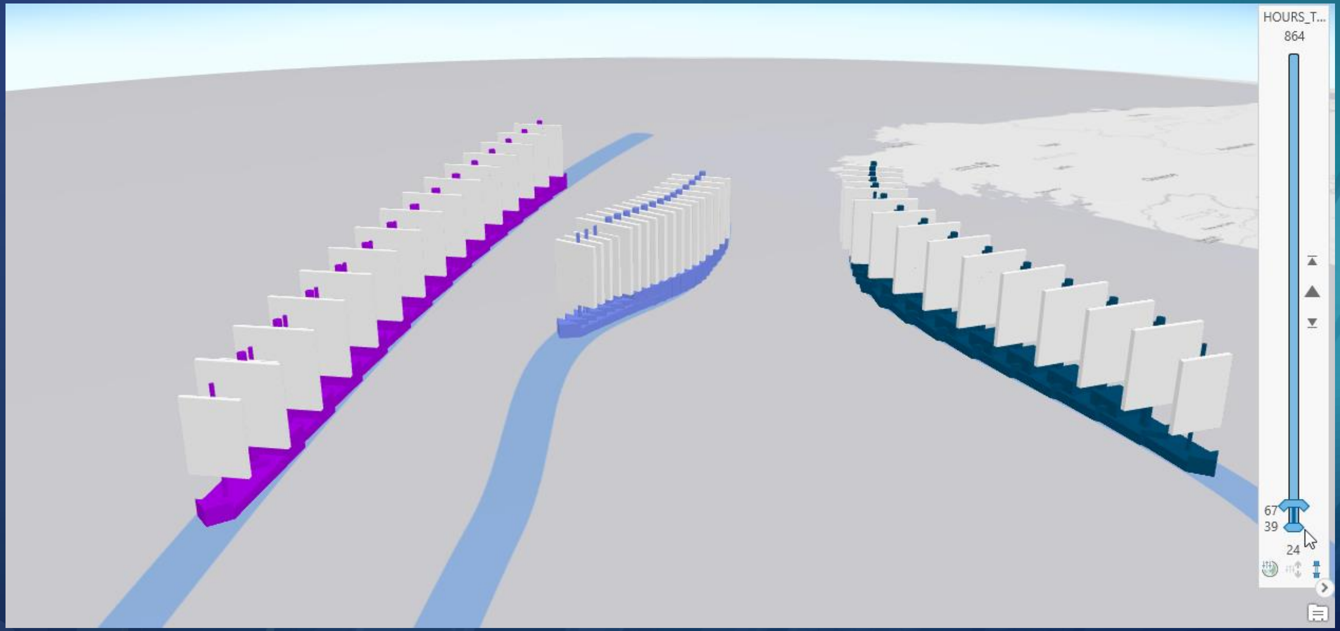
OBJECTID*	SHAPE*	StationID
1	Point	43
2	Point	55
3	Point	21
4	Point	15
5	Point	30

Temperature table

OBJECTID*	StationID	Date_1	Temp
1	43	1/1/2000	50
2	43	1/1/2001	53
3	43	1/1/2002	49
4	43	1/1/2003	58
5	43	1/1/2004	55
6	55	1/1/2000	65
7	55	1/1/2001	70

Modeling temporal data… using Range (for numeric values)

- Same rules as previous, but values are stored as numbers (instead of dates)
- Can save needless conversion to Date format
- Well-suited for:
  - Event-driven sequential data, like “contamination levels each hour after the spill”
  - Huge time extents, like “tectonic plate movement across 100 million years”
  - “Stop-motion” style animation (using interpolated positions)

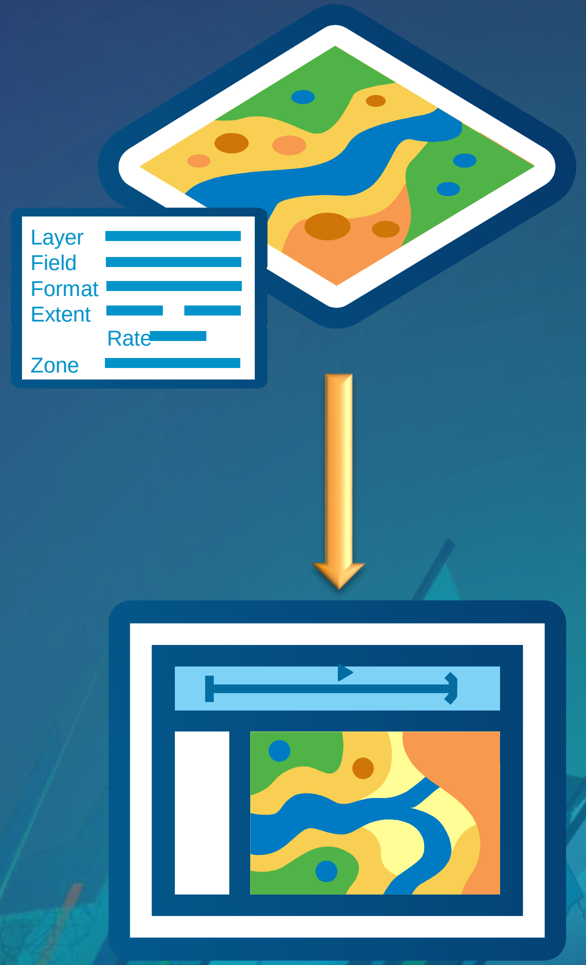


Visualizing temporal data

Visualizing temporal data in ArcGIS Pro – two steps

1. Configure time data properties **for each layer**
   - Specify which field/s drive time
   - Set the layer's full time extent
   - Indicate a refresh rate for live feed data
   - Set the time zone

2. Set the current time extent **for the map**
   - The map has a well-defined temporal extent (and timezone)
   - Use the interactive slider to change the map time
   - Use the time step for regularly-captured time data



The time slider automatically appears with time-enabled layers (and range)

Demo

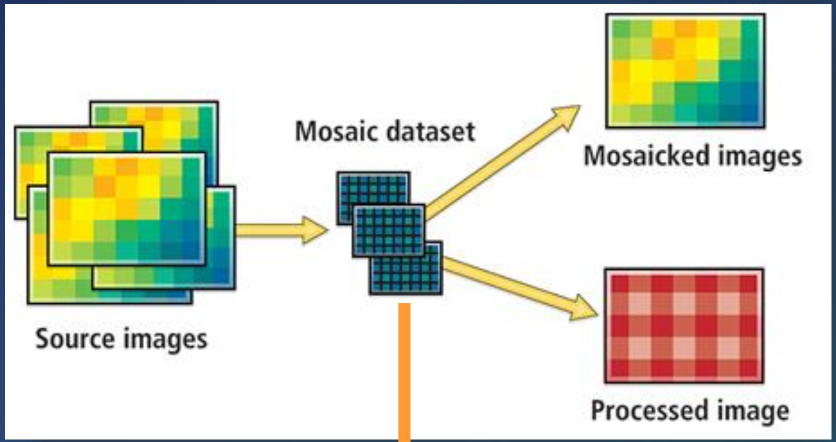
Temporal data in ArcGIS Pro

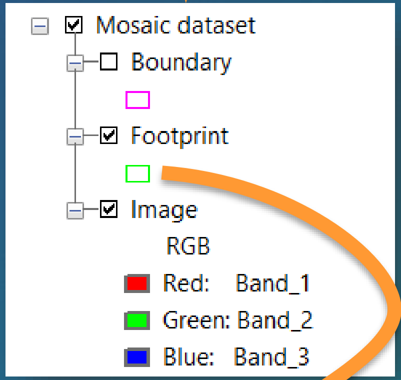
- Import MXD workflow
- Configuration of the time slider
- Using Range instead of Time

Modeling data in Mosaic Datasets

- Mosaic datasets are like a table of raster images
  - The table can contain date field/s
  - Common in long-term aerial imagery capture
  - Also common for storing analysis results through time
- They act just like feature data stored as separate rows

- Open the Mosaic dataset table from the Footprint layer



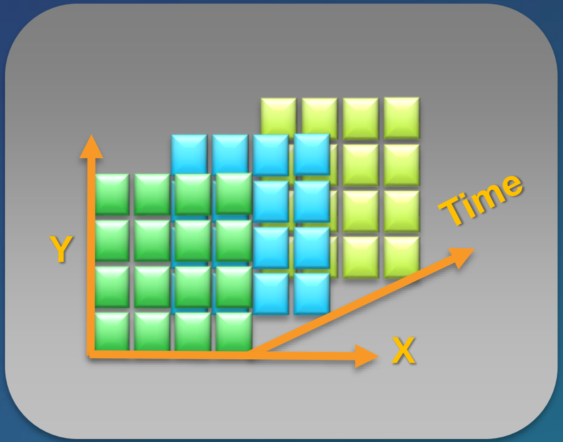


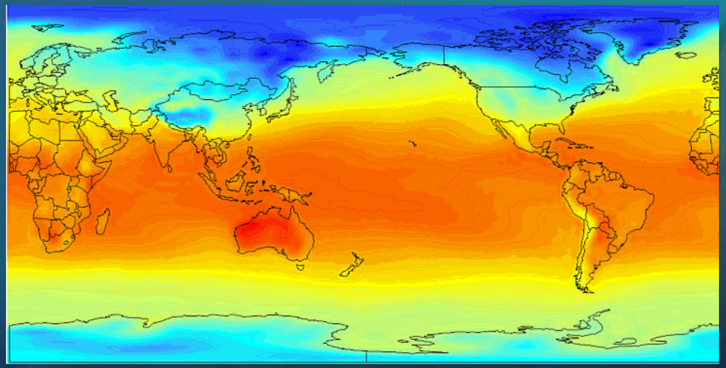
OBJECTID*	NAME	Shape*	Raster	Date_Time	SHAPE_Length	SHAPE_Area
1	Image1.gif	Polygon	Raster	1998-10-14 12:00:00	3068	522753
2	Image2.gif	Polygon	Raster	1998-10-15	3068	522753
3	Image3.gif	Polygon	Raster	1998-10-15 12:00:00	3068	522753
4	Image4.gif	Polygon	Raster	1998-10-16	3068	522753
5	Image5.gif	Polygon	Raster	1998-10-16 12:00:00	3068	522753
6	Image6.gif	Polygon	Raster	1998-10-17	3068	522753
7	Image7.gif	Polygon	Raster	1998-10-17 12:00:00	3068	522753

Modeling data from NetCDF layers

- NetCDF is a file format for spatio-temporal data
  - Contains multiple dimensions (x, y, z, t)
  - Often has many variables (temp, pressure, salinity, …)

- Time values are (often) available as a dimension
- Author the NetCDF Layers to include the time dimension
  - You can author feature or raster layers from NetCDF
- They act just like feature data stored as separate rows





Demo

NetCDF Data

Sharing temporal data

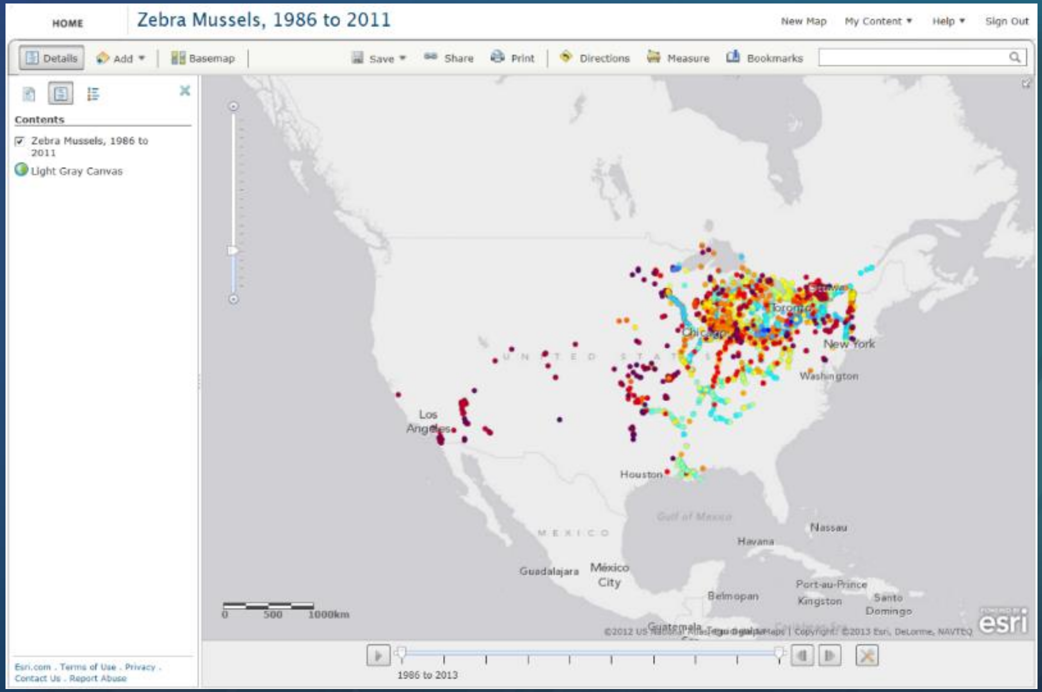
A variety of ways to share temporal visualizations

- As a time-enabled web map
  - TIP: Publish time-aware web maps from Pro (instead of per-layer in 10.x)
    - Open Pro, import an mxd, and publish the web map directly
    - *Extra tip*: Replace the basemap (to avoid group layers)
- As time-enabled image services (Portal only)
- As an animation / video
- As a series of exported images
- As a temporal map book
- As "small multiples" on a single layout
- As map or layer packages

Create web map services

- Map services preserve the time information from time-enabled layers
  - Used to query and display content (with the time slider)

- Example temporal web maps:
  - Atlantic Storms (1993-95)
    - Imported an MXD, updated the basemap, publish
  - One year of ice pack imagery (North Pole)
    - Time-aware aerial imagery



Demo

Time-aware web maps

Using Z for time (space-time cube)

Authoring Temporal Animations
- Introduction to keyframing

Demo

Authoring Temporal Animations

- Telling a GIS story
- Using time and range
- Adding information & overlays
- Using dynamic text elements

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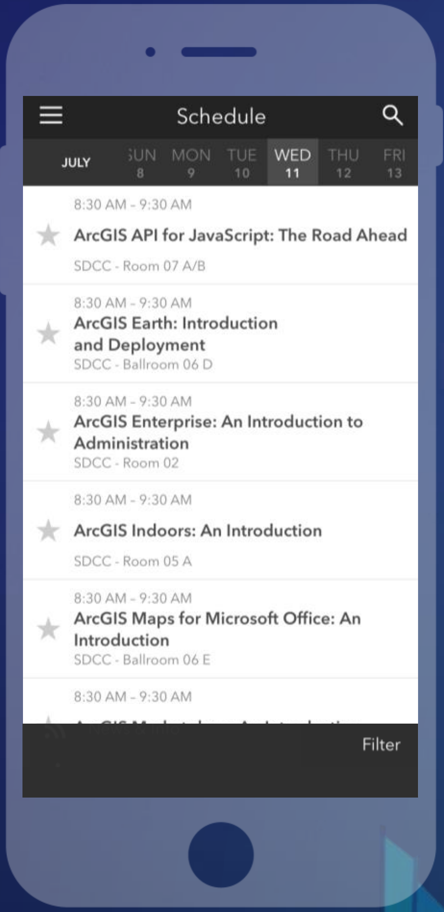
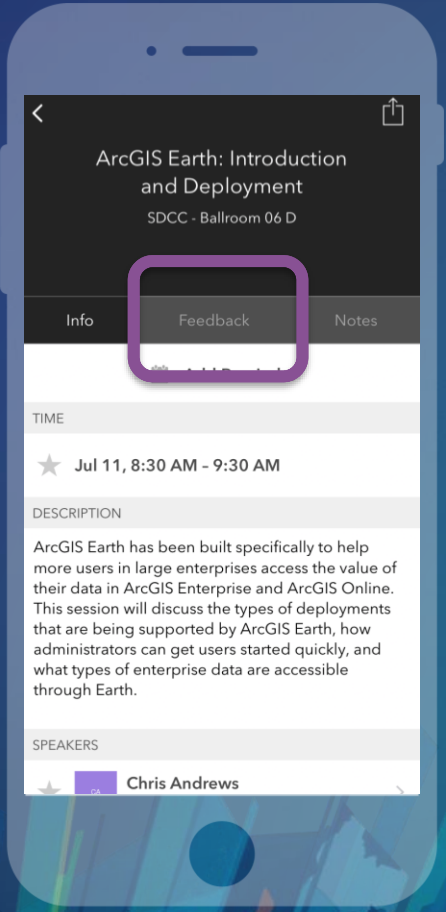
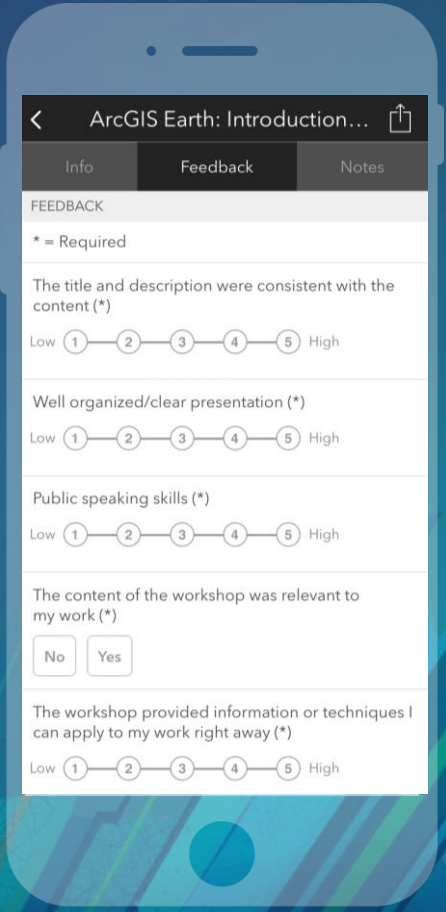


Scroll down to find the feedback section



Complete answers and select "Submit"



Questions???

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