Working with Temporal Data

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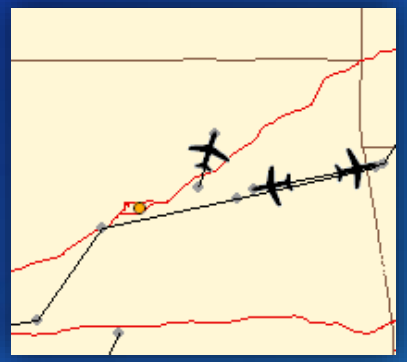
What is temporal data and why is it important?

Moving features

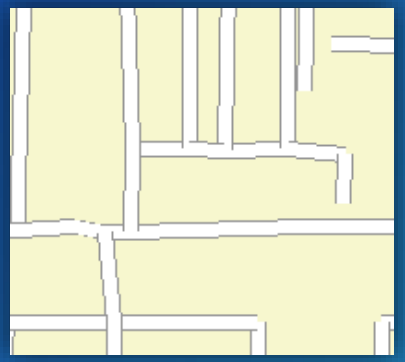
Feature that move over space



- Planes
- Vehicles
- Animals
- Satellites
- Storms

Discrete events

Events that happens at various locations



- Crimes
- Lightning
- Accidents

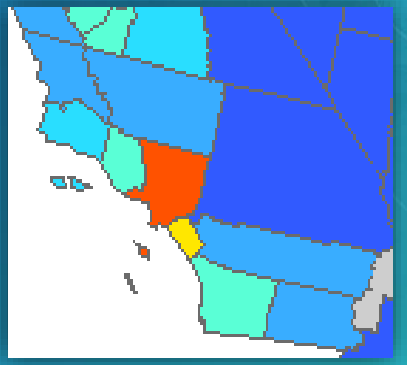
Stationary recorders

Features stay in one place and record changes

- Weather stations
- Traffic sensors

Change / growth

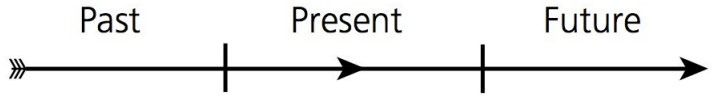
Change or growth over an area

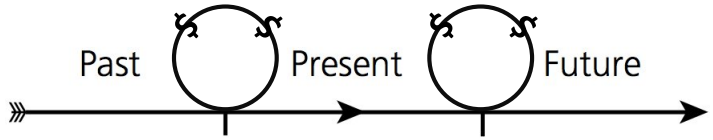


- Demographics
- Fire perimeter

The nature of temporal data

- Conceptualizations of time vary
  - Linear (unique, directional time periods)
  - Cyclic (repeating after a specific range in time)
  - Others
- Time is relative to something
  - Clock-driven time – synchronized to a specific clock
  - Event-driven time – synchronized to an event (e.g., BC, AD)
  - State-driven time – synchronized to a change in state
- Time data can be:
  - Point data – specific to point in time
  - Range data – accumulated over an interval of time





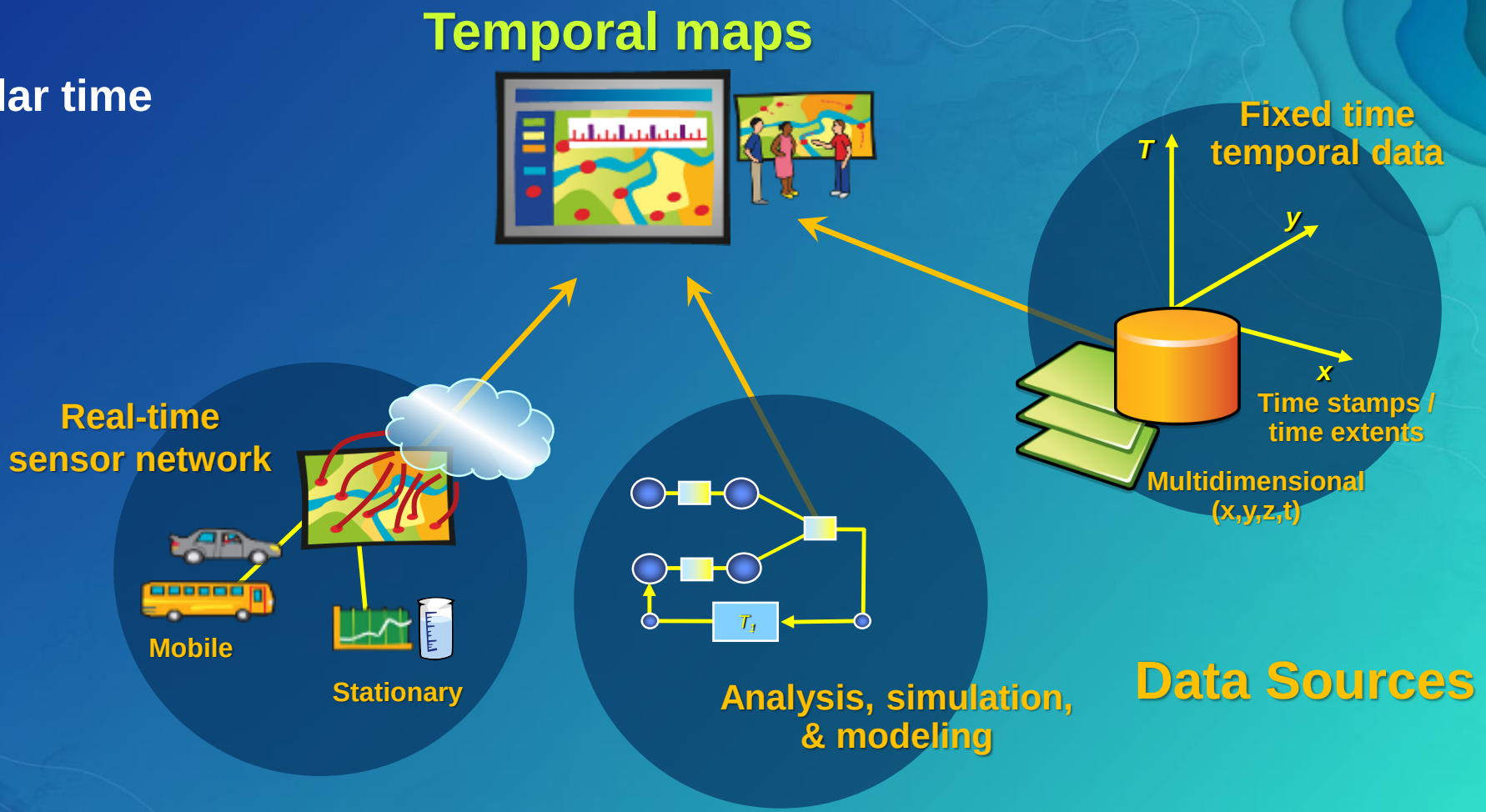
$T_1\ S_x,\ T_2\ S_x,\ T_3\ S_x,\ \ldots$
$T_1 - T_0,\ T_2 - T_0,\ T_3 - T_0,\ \ldots$
$S_1,\ S_2,\ S_3,\ \ldots$

where T = Time and S = State

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

ArcGIS integrates temporal data

- Regular or irregular time



Time is built into ArcGIS

- Unified experience for time
  - Part of Desktop, Pro, Runtime, and Portal products
- Geoprocessing (GP) tools
  - Managing time aware data
  - Analyzing through time, or space-and-time
- Ability to share temporal data/maps
  - Web layers and image services
  - Videos, images, map series, packages

Demo

Temporal data in
ArcGIS for Desktop

Demo

Temporal data in
ArcGIS Pro

This session…

- Data types
- Managing
- Analyzing
- Sharing

Data Types

for temporal data

Supported data types

- Feature layers
- Mosaic datasets
- NetCDF layers
- Tables
- Raster catalogs
- Tracking layers / Streaming layers
- Network dataset layers with traffic data

- Plus service layers with historical content and updating data feeds

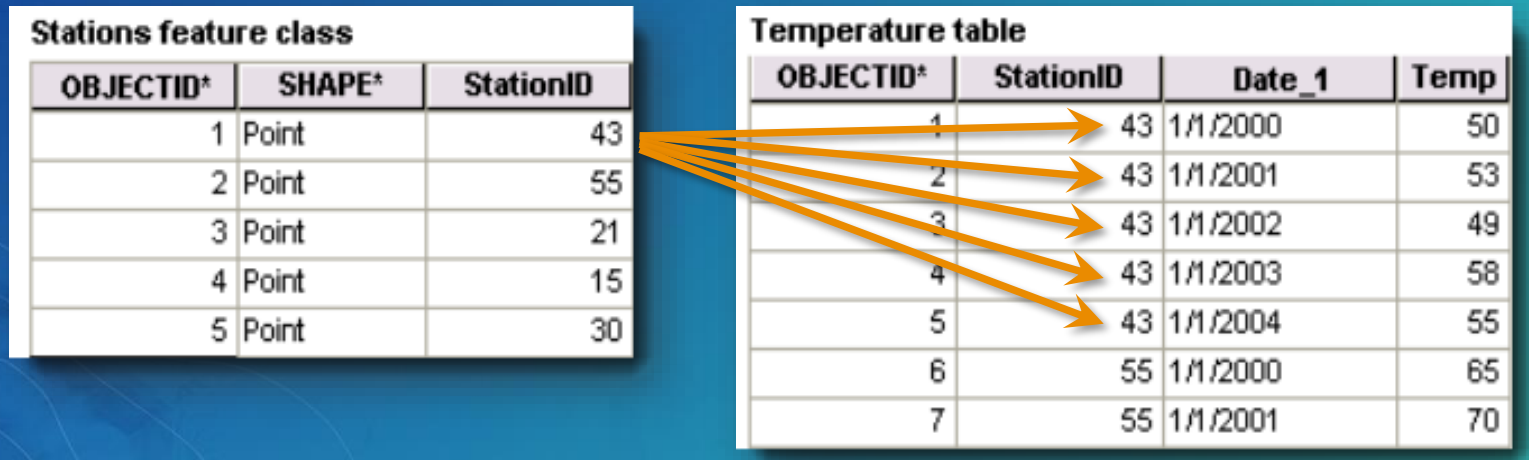
Feature layers – Separate features

- Enable time on the Time tab of the feature layer's Layer Properties dialog box
- With feature layers, features can be visualized over time in two ways:
  1. The shape and location of each feature changes over time
     - Store separate features

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

Feature layers – Features joined to a table

- Enable time on the Time tab of the feature layer's Layer Properties dialog box
- With feature layers, features can be visualized over time in two ways:
  1. The shape and location of each feature changes over time
     - Store separate features
  2. The shape and location of each feature is constant but attribute values change over time
     - You can represent the changing attributes in a separate (one-to-many) joined table



Stations feature class

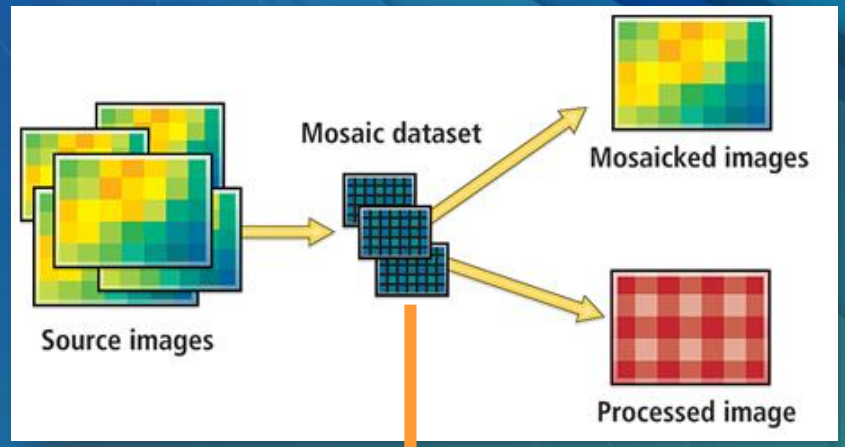
OBJECTID*	SHAPE*	StationID
1	Point	43
2	Point	55
3	Point	21
4	Point	15
5	Point	30

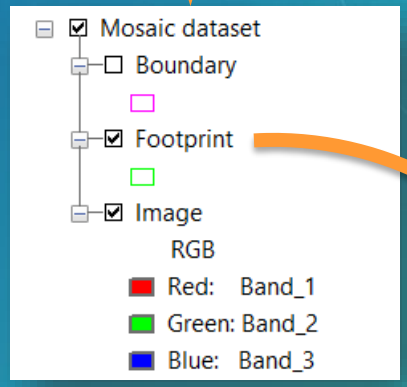
Temperature table

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

Mosaic datasets

- Enable time on the Time tab of the mosaic dataset's Layer Properties dialog box
- Mosaic datasets store rasters that represent change over time
- The time field is in the Footprint attribute table of the mosaic dataset





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

NetCDF layers

- NetCDF is a file format for storing spatiotemporal data
  - Multiple dimensions (x, y, z, t)
  - Multiple variables (temperature, pressure, salinity, wind speed)
- Time values are stored as one dimension of the netCDF layer
- Enable time on the Time tab of the Layer Properties dialog box
- For netCDF feature layers, specify the layer time using a time dimension or the attribute fields
- For netCDF raster layers, specify layer time using the time dimension

Demo

NetCDF Data

Managing

temporal data

Temporal data stored in multiple columns

- **Store temporal data in a row format**
  - Each feature in a row
- **Transpose Fields GP tool**
  - Shifts data entered in columns into rows

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

- **Best practices for managing temporal data**

Number and Text field types

- Only “sortable” formats are supported
  - YYYYMMDD 20160701 > 20150701 = TRUE
  - MMDDYYYY 07012016 > 08012015 = FALSE
- Named month is not supported
  - AUG-01-2016 would come before JUL-01-2016

✓ Index the field for faster display and query performance

Date field type

- **Store time values in a date field**
  - 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

yyyy/MM/dd HH:mm:ss.s
yyyy/MM/dd HH:mm:ss
yyyy/MM/dd HH:mm
yyyy/MM/dd HH
yyyy/MM/dd
yyyy/MM
yyyy-MM-dd HH:mm:ss.s
yyyy-MM-dd HH:mm:ss
yyyy-MM-dd HH:mm
yyyy-MM-dd HH
yyyy-MM-dd
yyyy-MM
yyyyMMddHHmmss.s
yyyyMMddHHmmss
yyyyMMddHHmm
yyyyMMddHH
yyyyMMdd
yyyyMM
yyyy
d/M/yy HH:mm:ss
d/M/yy h:m:s t
M/d/yy h:m:s t
M/d/yy HH:mm:ss
dd/MM/yy HH:mm:ss
dd/MM/yy hh:m:s t
MM/dd/yy hh:m:s t
MM/dd/yy HH:mm:ss

A wide range of standard formats

Converting to a Date field type

- **Use Data Management GP tools to convert to a date field type**
  - **Convert Time Field GP tool**
    - **Converts custom Text/Number formats into a new Date field**
      - **"July 09, 2016" ⇨ 07/09/2016 ⇨ MM/DD/YYYY**

Date	Date_Converted
January 21, 1988 17:12:57	1/21/1988 5:12:57 PM
August 28, 1998 00:01:01	8/28/1998 12:01:01 AM
August 10, 2001 19:56:30	8/10/2001 7:56:30 PM
September 7, 2002 5:00:00	9/7/2002 5:00:00 AM
July 31, 2003 13:45:00	7/31/2003 1:45:00 PM
August 23, 2009 17:30:00	8/23/2009 5:30:00 PM
July 18, 2010 11:00:00	7/18/2010 11:00:00 AM

The Date field can also have a custom format

MM dd, yyyy HH:mm:ss

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

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

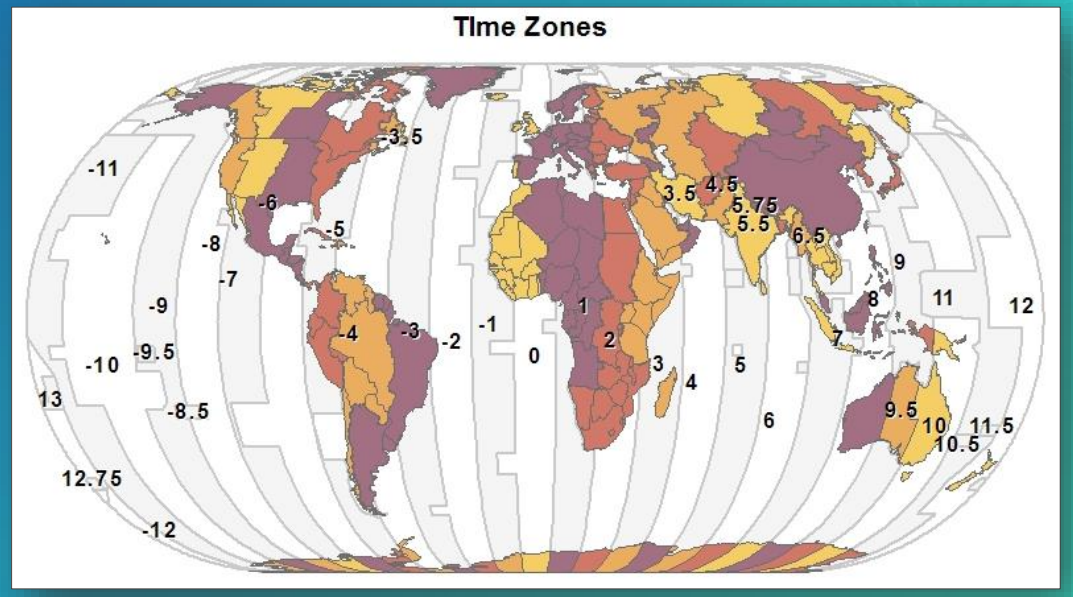
Working with time zones

- 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

Use standard time (UTC[1] or GMT[2])
- To avoid issues with daylight savings time

[1] Coordinated Universal Time

[2] Greenwich Mean Time



Demo

Managing Temporal Data

Analyzing

temporal data

Analyzing temporal data

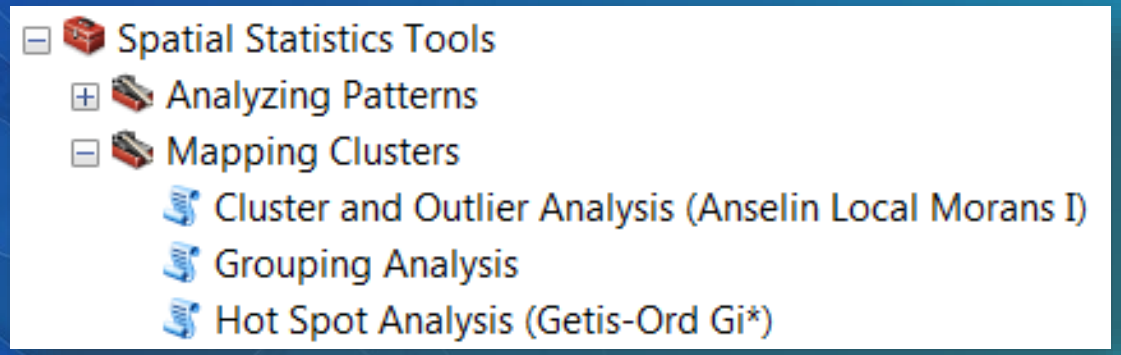
- Geoprocessing tools to manage temporal data – we have already seen these
- All GP tools honor time
- GP tools that analyze time and space
- ArcPy site-package

All GP tools honor time

- GP tools honor the temporal settings for time-enabled layers
- Tool process only those features within the time extent set in the Time Slider
- Similar to a selection or definition query

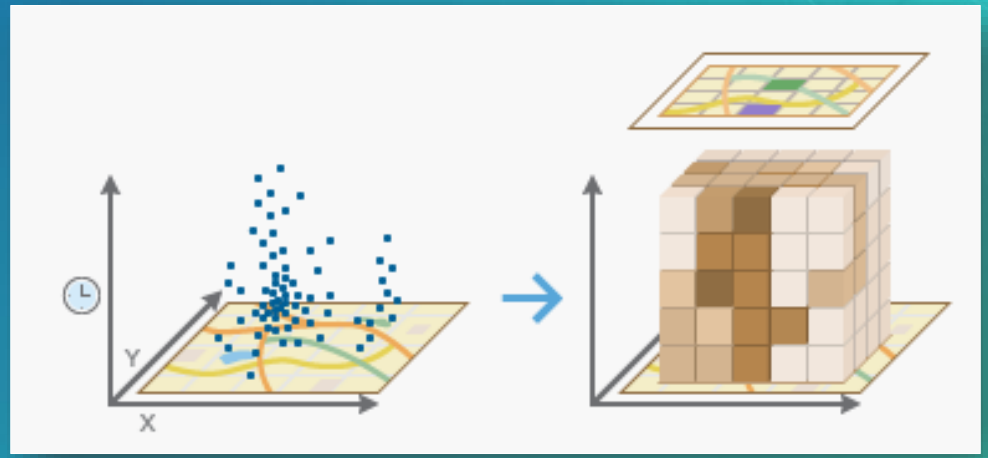
GP tools for space-time data: ArcGIS for Desktop and Pro

- ArcToolbox > Spatial Statistics > Mapping Clusters
- These use a spatial weights matrix that has a temporal constraint
  - 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



GP tools for space-time data: Pro

- **Space Time Pattern Mining toolbox**
  - **Create Space Time Cube GP tool**
    - Summarizes a set of points into a netCDF data structure by aggregating them into space-time bins
  - **Emerging Hot Spot Analysis GP tool**
    - Identifies trends in the clustering of point counts or attributes in a netCDF space-time cube
  - **Local Outlier Analysis GP tool**
    - Identifies statistically significant clusters of high or low values as well as outliers



Demo

Analyzing Temporal Data

GP tools for space-time data: Sessions

Tuesday, July 11th

- 10.15am	Desktop Mapping: Working with Temporal Data	Rm 31A
- 1.30pm	Spatial Data Mining: Essentials of Cluster Analysis	Ballroom 06 D
- 3.30pm	Methods for Mapping Temporal Data	Demo Theater 03

Wednesday, July 12th

- 8.30am	Spatial Data Mining II: Deep Dive into Space-Time	Ballroom 06 E
- 1.30pm	Spatial Data Mining: Essentials of Cluster Analysis	Ballroom 06 E

Thursday, July 13th

- 1.30pm	Desktop Mapping: Working with Temporal Data	Rm 05A
- 3.15pm	Spatial Data Mining II: Deep Dive into Space-Time	Ballroom 06 E

Sharing

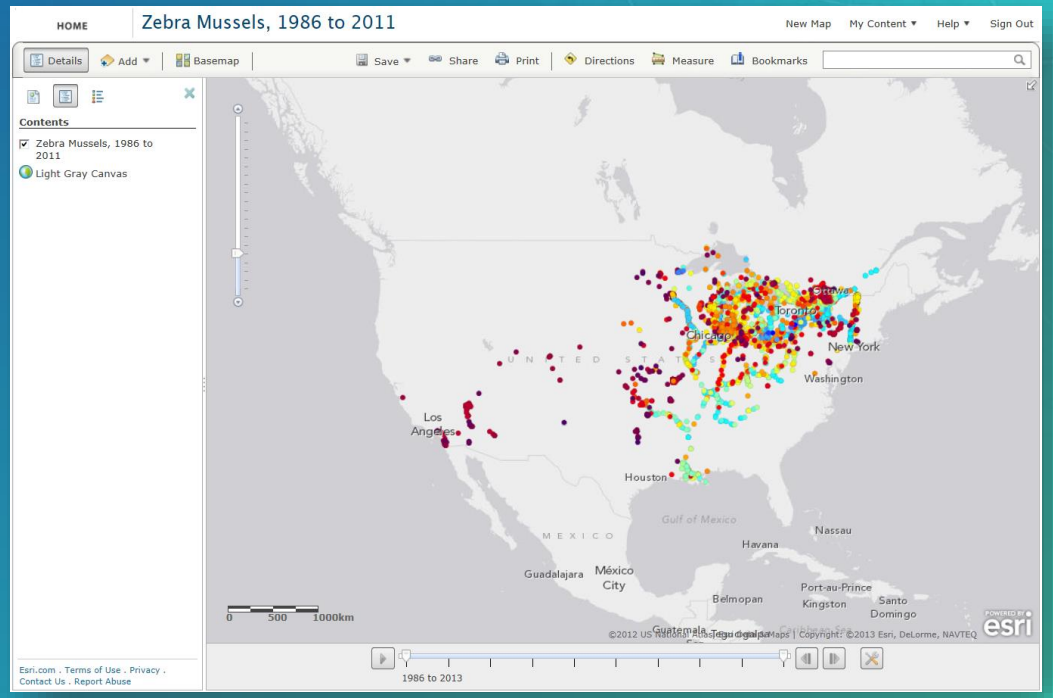
temporal visualizations

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
  - Known issues with current AGOL means two edits to an imported mxd before publishing:
    - [1] Replace the basemap (to avoid group layers)
    - [2] Do not use a definition query against a time field
- 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

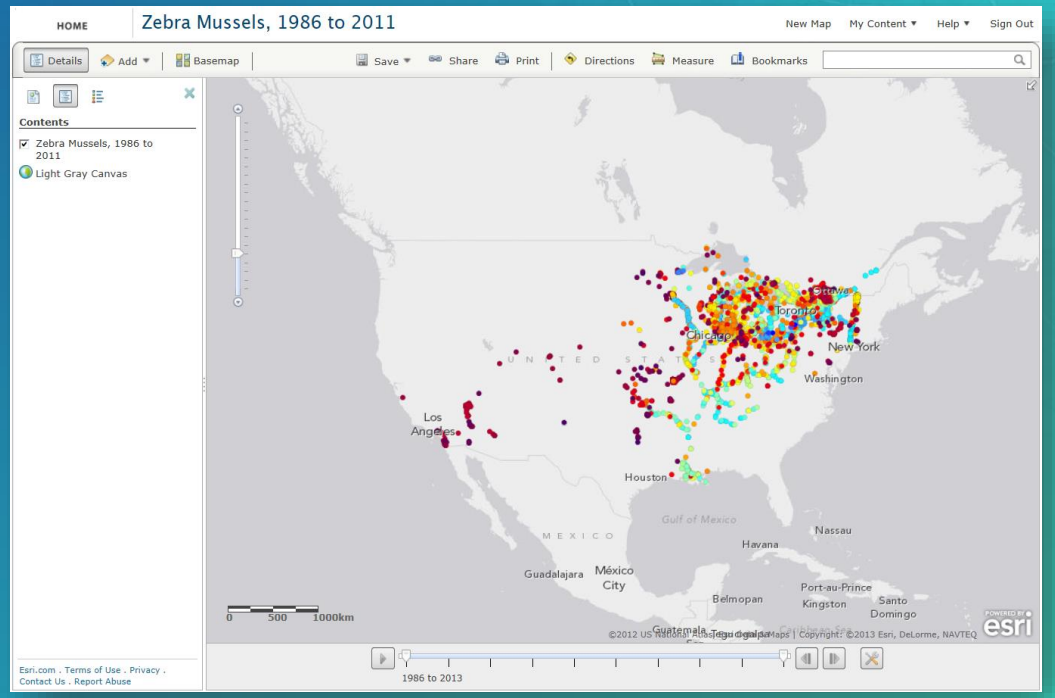
Create web map services

- Map services preserve the time information from time-enabled layers
  - Used to query and display content (with the time slider)
- Animated GIFs can be used for icons (eg: in the Living Atlas)
  - LINK - ArcGIS Online web map search for 'time'
- Example web maps:
  - TBD
  - TBD



Create web map services

- Map services preserve the time information from time-enabled layers
  - Used to query and display content (with the time slider)
- Animated GIFs can be used for icons (eg: in the Living Atlas)
  - LINK - ArcGIS Online web map search for 'time'
- 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



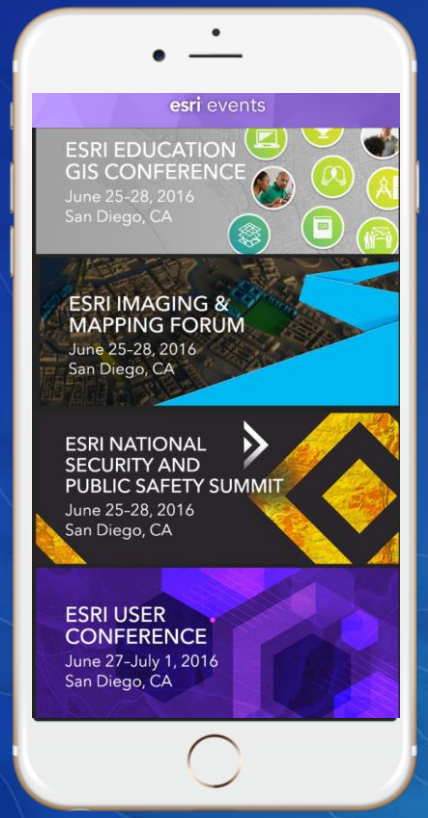
Demo

Sharing Temporal Data

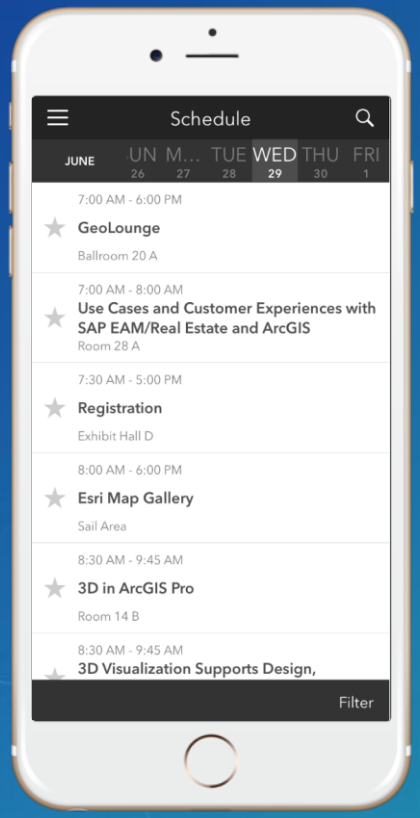
Please take our survey

Your feedback allows us to help maintain high standards and to help presenters

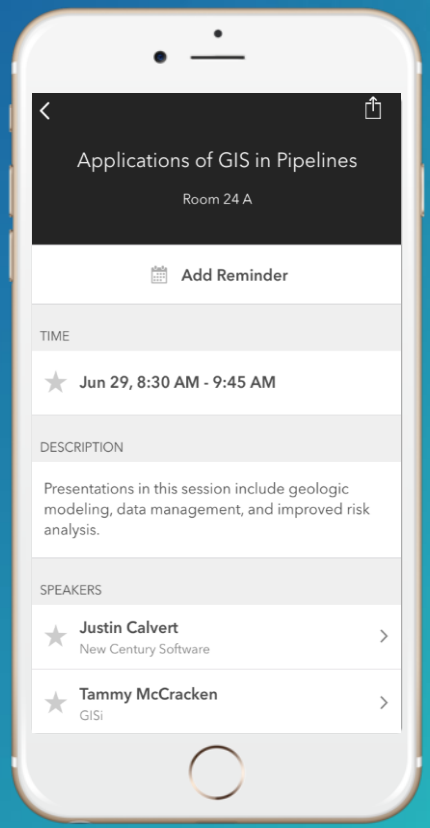
Find our event in the Esri Events App



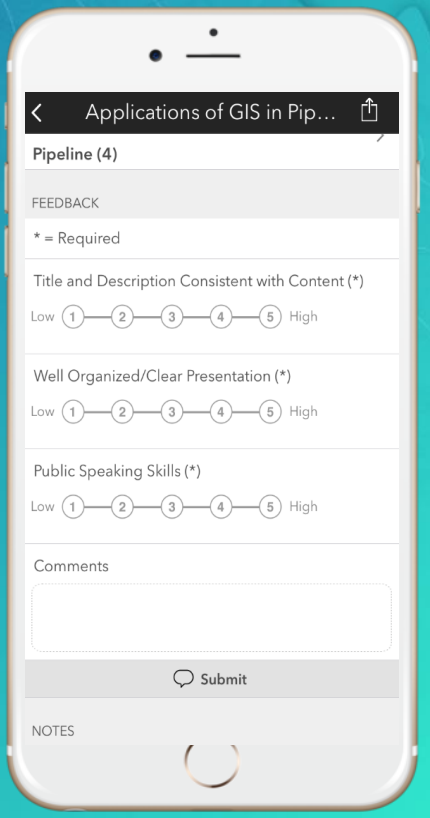
Find the session you want to review



Scroll down to the bottom of the session



Answer survey questions and submit

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