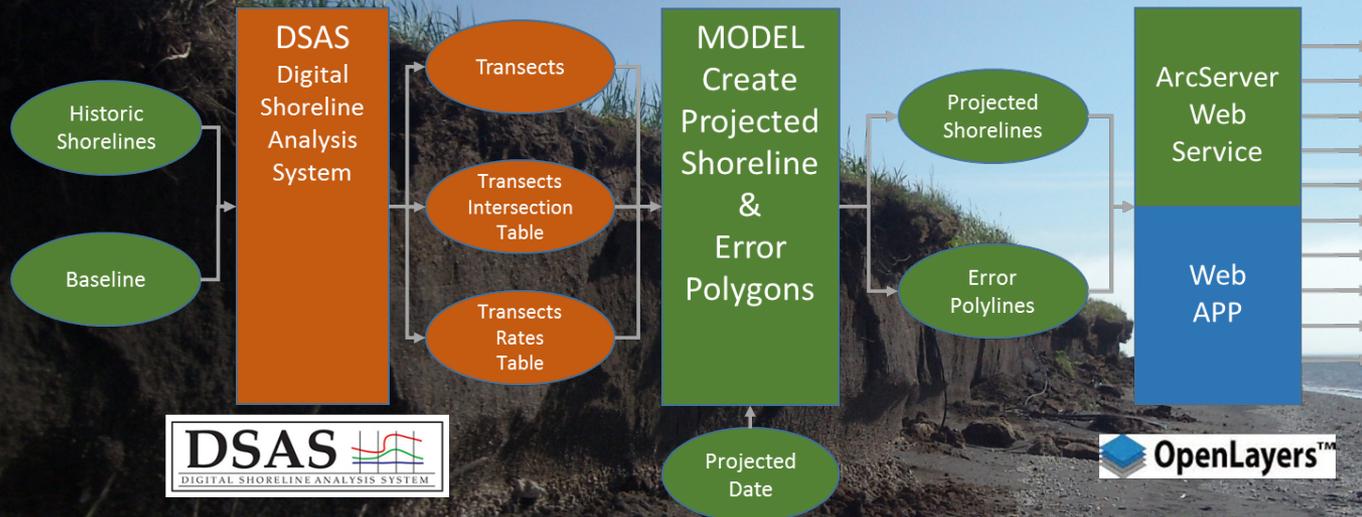


Creating and Serving Alaska Shoreline Change Predictions



Mike Hendricks
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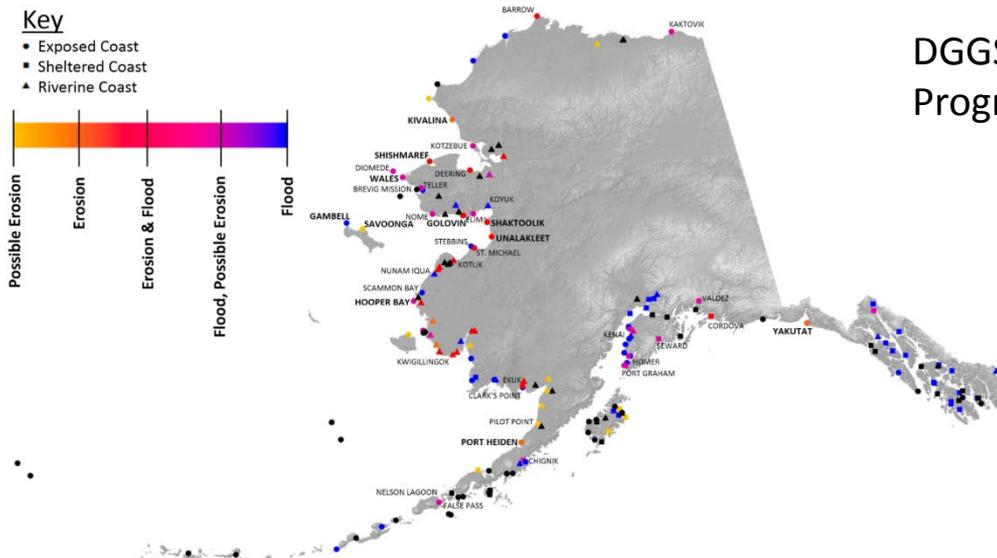
Agenda

- Coastal Program at DGGS
- Shoreline Change Prediction Requirements
- Model Builder & Python Scripting
- ArcGIS Models for Shoreline Change Prediction
- Creating GIS Web Services
- Creating Custom Web Applications

Coastal Program at DGGs

- Program launched in 2011 with seed funding from Coastal Impact Assistance Program
- Program objectives:
 - Increase quality/quantity of coastal baseline data
 - Provide shoreline change and coastal inundation tools
 - Encourage/develop coastal management resources for an Alaskan audience

Alaska Coastal Populations Vulnerable to Flooding and Erosion



DGGs Coastal Hazards Program - Fairbanks, AK
Program Manager: Nicole Kinsman

nicole.kinsman@alaska.gov

907-451-5026

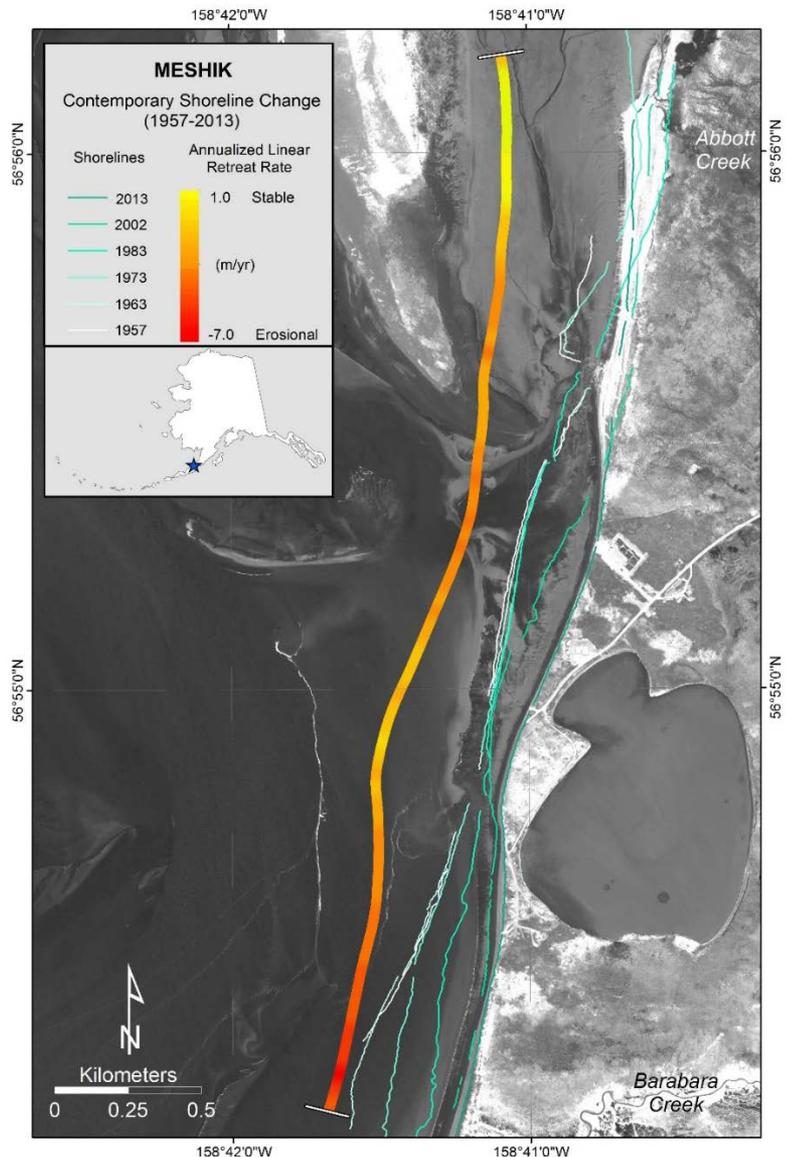


Prevailing Shoreline Change Prediction Display Methodology

- Collect Historical Shoreline Data

Proxy indicator of shoreline position typically bluff top/vegetation line

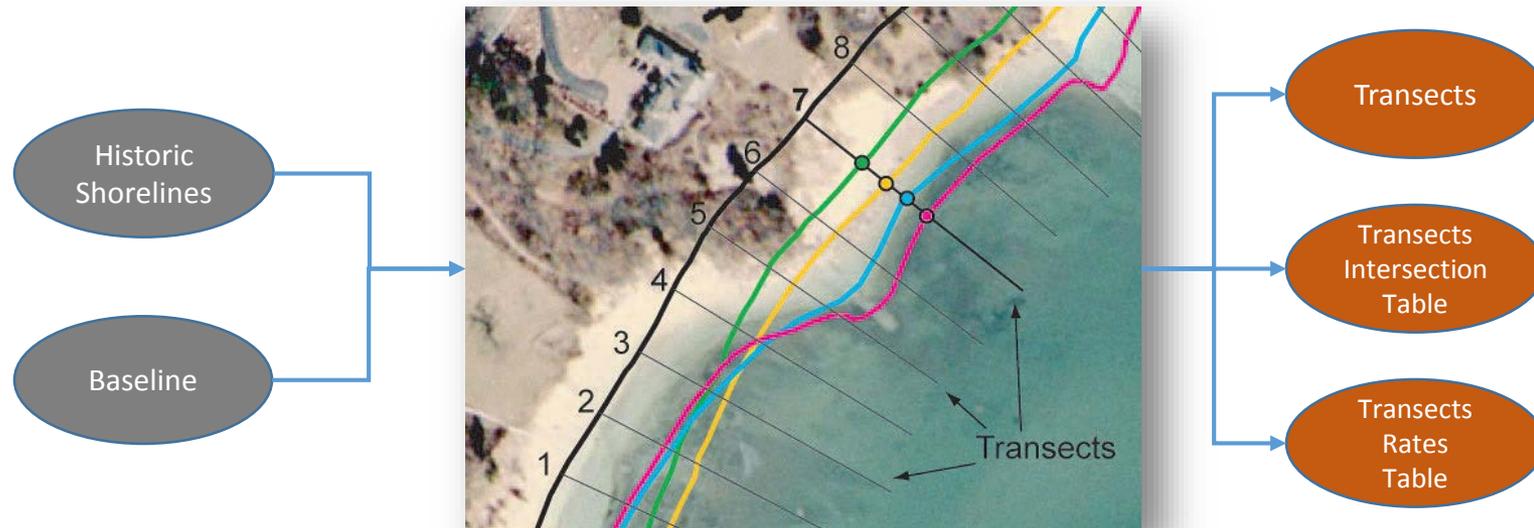
- Creation of change rates with Digital Shoreline Analysis System (DSAS) from USGS
- Display change rates along shoreline without explicitly mapping predicted shoreline at a future date.
- Difficult to effectively show prediction uncertainty along shoreline



Digital Shoreline Analysis System (DSAS)

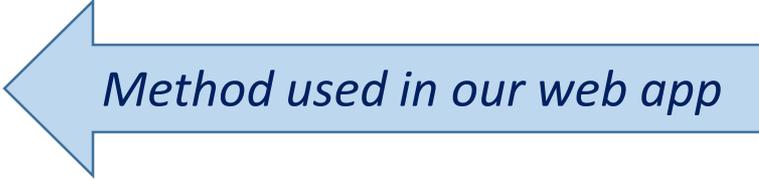
DSAS version 4.3.4730 for ArcGIS 10

“The Digital Shoreline Analysis System (DSAS) is computer software that computes rate-of-change statistics from multiple historic shoreline positions residing in a GIS”.



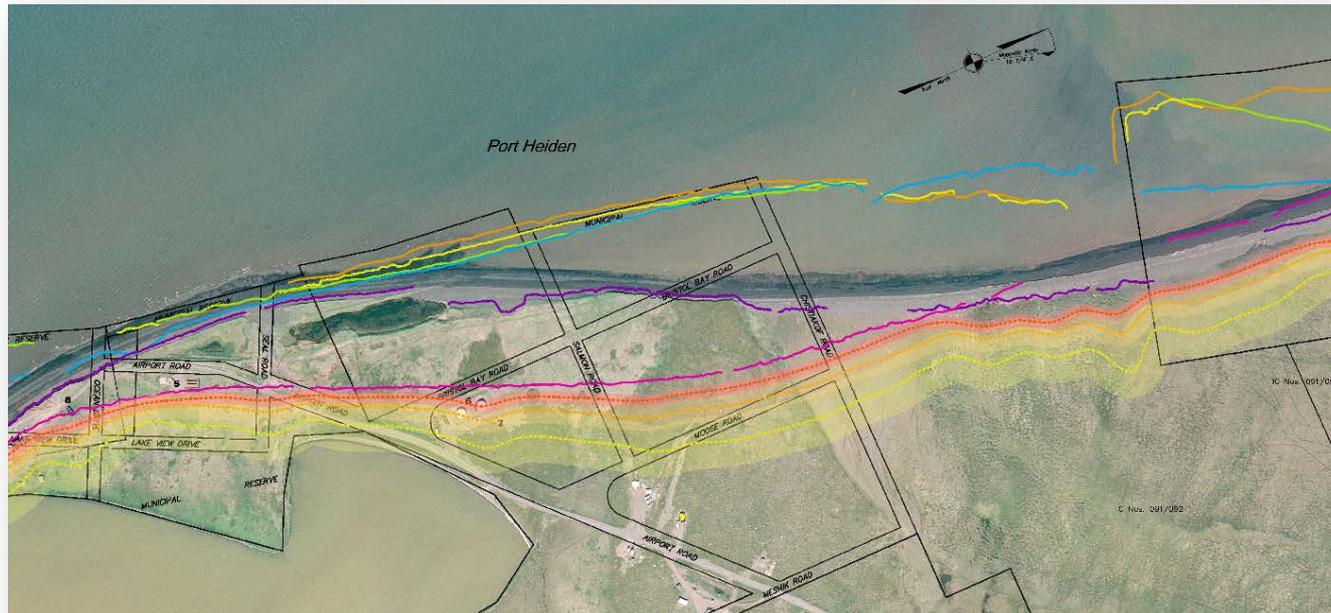
Rate of Change Statistics provided by DSAS

- Simple End Point Rate
- **Linear Regression Rate**
 - Standard Error
 - Confidence Interval
 - R-Squared
- **Weighted Linear Regression Rate**
 - Standard Error
 - Confidence Interval
 - R-Squared
- Least Median of Squares



Method used in our web app

Goal: A set of Tools and Technologies to Calculate, Display, & Disseminate Projected Long Range Shoreline Positions



Alaska Division of Geological & Geophysical Surveys
Preliminary Interpretive Report 2014-1
**Contemporary Shoreline Change
(1957-2013)**

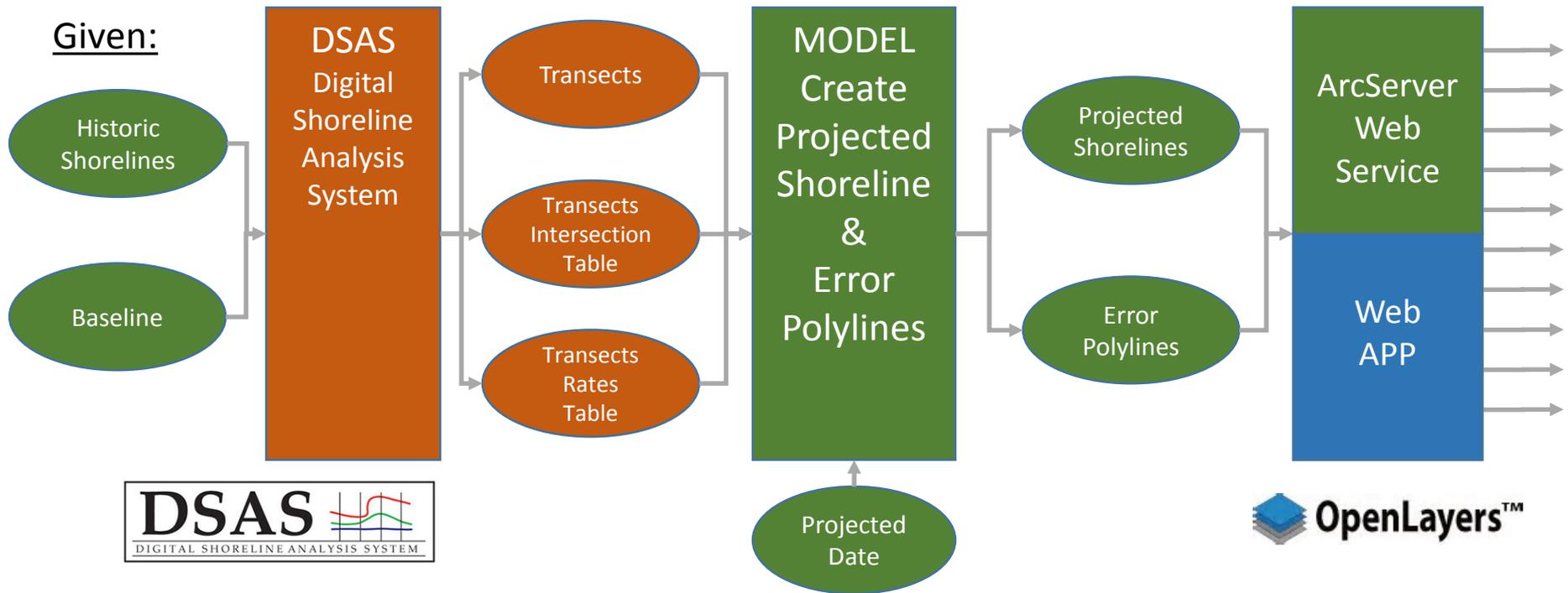


All projections are based on long-term rates. This calculation assumes that the rate of change has not significantly accelerated or decreased since 1957.

The previous manual GIS process to produce projected shorelines from DSAS rates of change output was labor intensive.

ArcGIS models and Python scripting allows automation and documentation of the process

The GIS based Task to Achieve Goal



Desired GIS based output:

- Predicted Shoreline for a user defined future date as a polyline
- Display variable location uncertainty along this predicted shoreline
- Deliver this information to the public with a web service & app



ArcGIS Model Builder

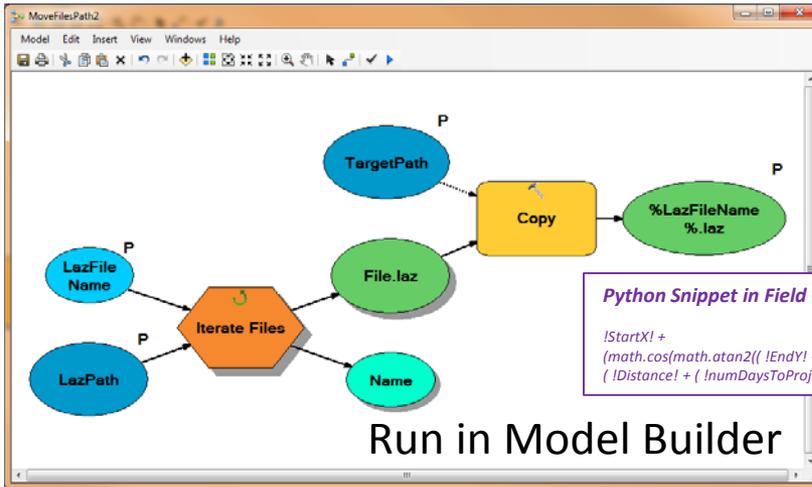
- Model Builder is an application you use to create, edit, and manage models.
- Models are workflows that string together sequences of geoprocessing tools, feeding the output of one tool into another tool as input.
- Model Builder can also be thought of as a visual programming language for building workflows.

ArcGIS Online Help

Models built in Model Builder are not meant to be the fast, efficient, or compact code, but... the visual process-flow interface is very compelling to many ArcGIS users.

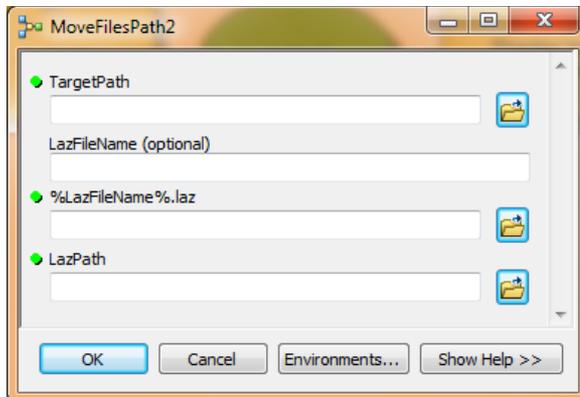
ArcGIS Model Builder & Python Basics

Design Process Flow in Model Builder



Run in Model Builder

or
Run from Dialog



Optionally: Export as Python Script

```
#!/usr/bin/env python
# coding: utf-8 -*-
# -----
# Created on: 2015-02-13 14:08:18.00000
# (generated by ArcGIS/ModelBuilder)
# Usage: test2 <TargetPath> <LazFileName> <v_LazFileName_laz> <LazPath>
# Description:
# -----
# Import arcpy module
import arcpy

# Load required toolboxes
arcpy.ImportToolbox("Model Functions")

# Script arguments
TargetPath = arcpy.GetParameterAsText(0)
if TargetPath == '#': or not TargetPath:
    TargetPath = "\\test" # provide a default value if unspecified

LazFileName = arcpy.GetParameterAsText(1)
if LazFileName == '#': or not LazFileName:
    LazFileName = "2009_000001" # provide a default value if unspecified

v_LazFileName_laz = arcpy.GetParameterAsText(2)
if v_LazFileName_laz == '#': or not v_LazFileName_laz:
    v_LazFileName_laz = "%TargetPath%\%LazFileName%.laz"

LazPath = arcpy.GetParameterAsText(3)
if LazPath == '#': or not LazPath:
    LazPath = "\\test" # provide a default value if unspecified

# Local variables:
File_laz = LazPath
Name = LazPath

# Process: Iterate Files
arcpy.IterateFiles_management(LazPath, LazFileName, "laz", "NOT_RECURSIVE")

# Process: Copy
arcpy.Copy_management(File_laz, v_LazFileName_laz, "File")
```

Alternate Work Flow:

- Use Python exclusively to build tool

Modeling Subtasks

1. Find Projected Shoreline Intersection for each Transect

Given DSAS rate of change output data, calculate the location along a transect at some given future date

2. Create Shoreline from these points

Given a set of predicted point locations along a set of transects, create a smoothed polyline representing the predicted shoreline at the given future date

3. Create Error Representation along Shoreline

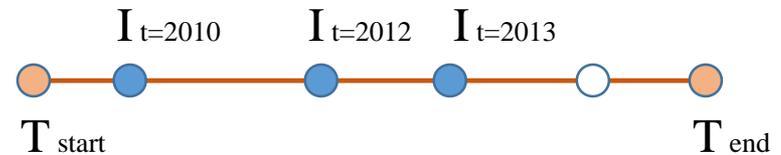
Given the location along the transect at some given future date and the Error Data from DSAS for each transect, create a geometric based error representation along the predicted shoreline

SubTask 1:

Calculate the location along a transect at some given future date

Given:

- transect 
- historic shoreline intersections 
- predicted rate of change along the transect from DSAS



Python Snippet Used in Model:

Calculate X Coordinate

```
!StartX! +  
(math.cos(math.atan2(( !EndY! - !StartY! ),  
( !EndX! - !StartX! ))) *  
( !Distance! + ( !numDaysToProjT! * !Rate!/360) ))
```

Calculate Y Coordinate

```
!StartY! +  
(math.sin(math.atan2(( !EndY! - !StartY! ),  
( !EndX! - !StartX! ))) *  
( !Distance! + ( !numDaysToProjT! * !Rate!/360) ))
```

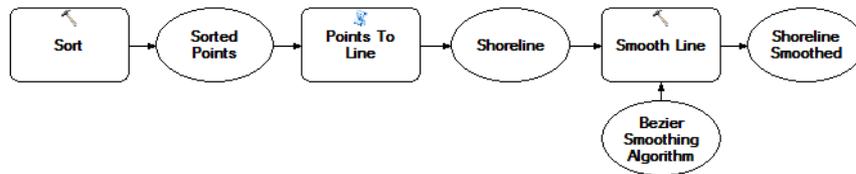
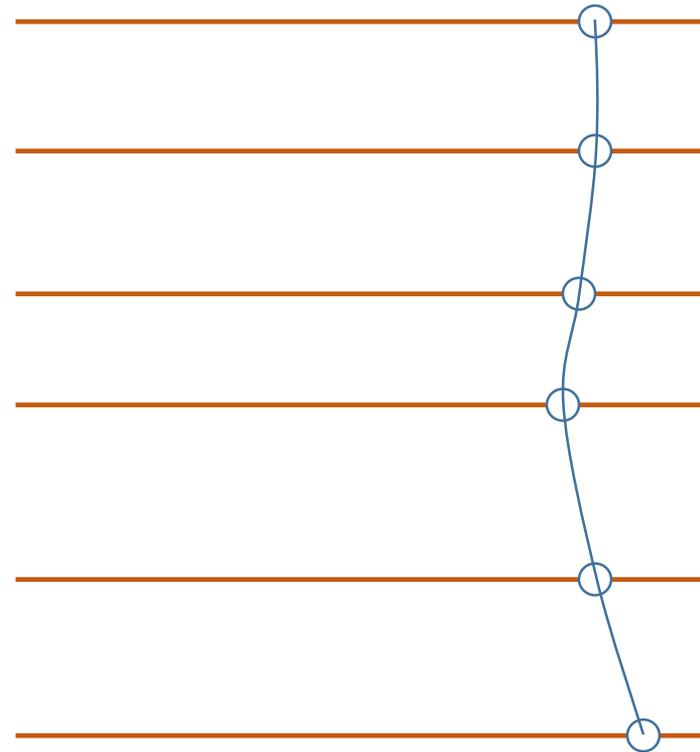
Create: The location along the transect at some given future date 

SubTask 2:

Create a smoothed polyline representing the predicted shoreline at the given future date

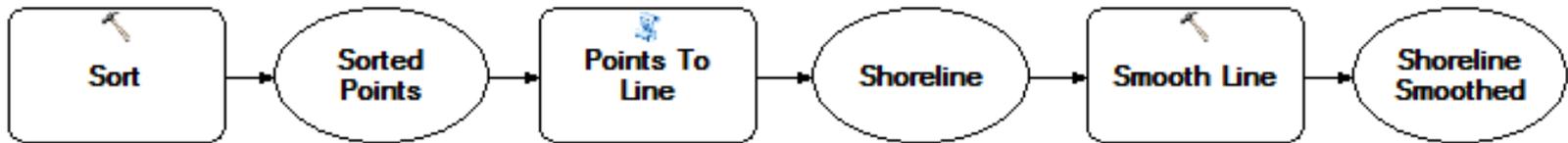
Given: The projected intersection points for a set of transects ○

Create: The smoothed polyline representing the predicted shoreline at the given future date

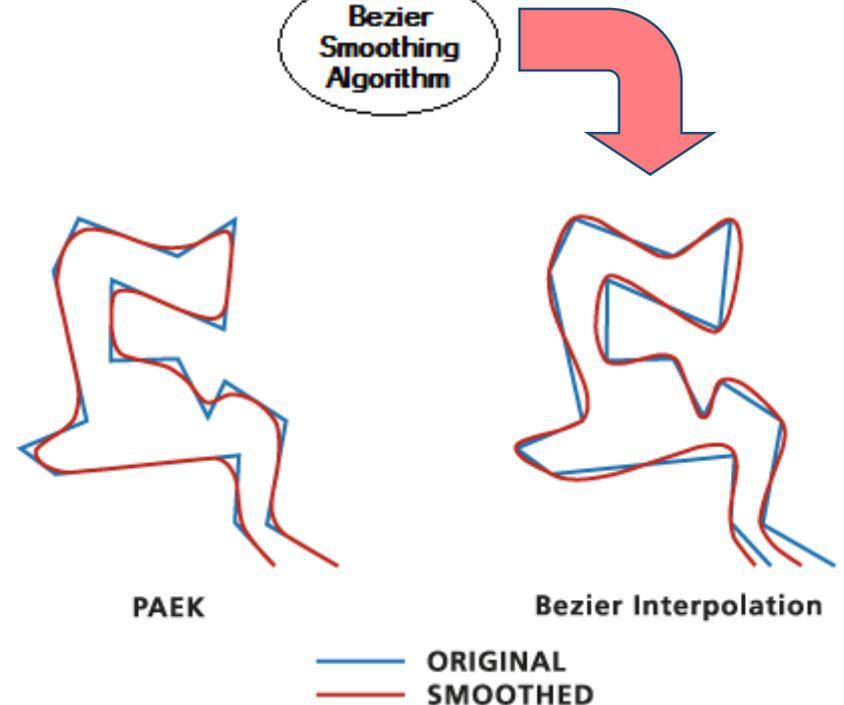
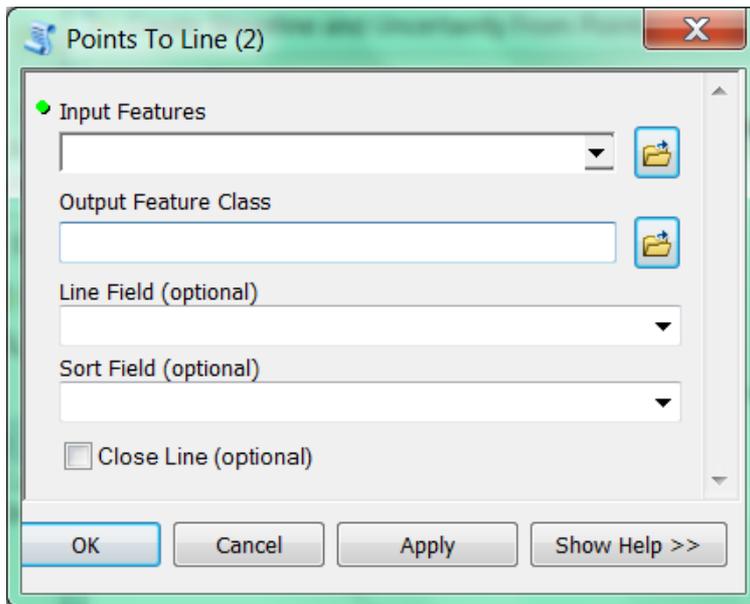


SubTask 2:

Create a smoothed polyline representing the predicted shoreline at the given future date



Note: this is a python script tool

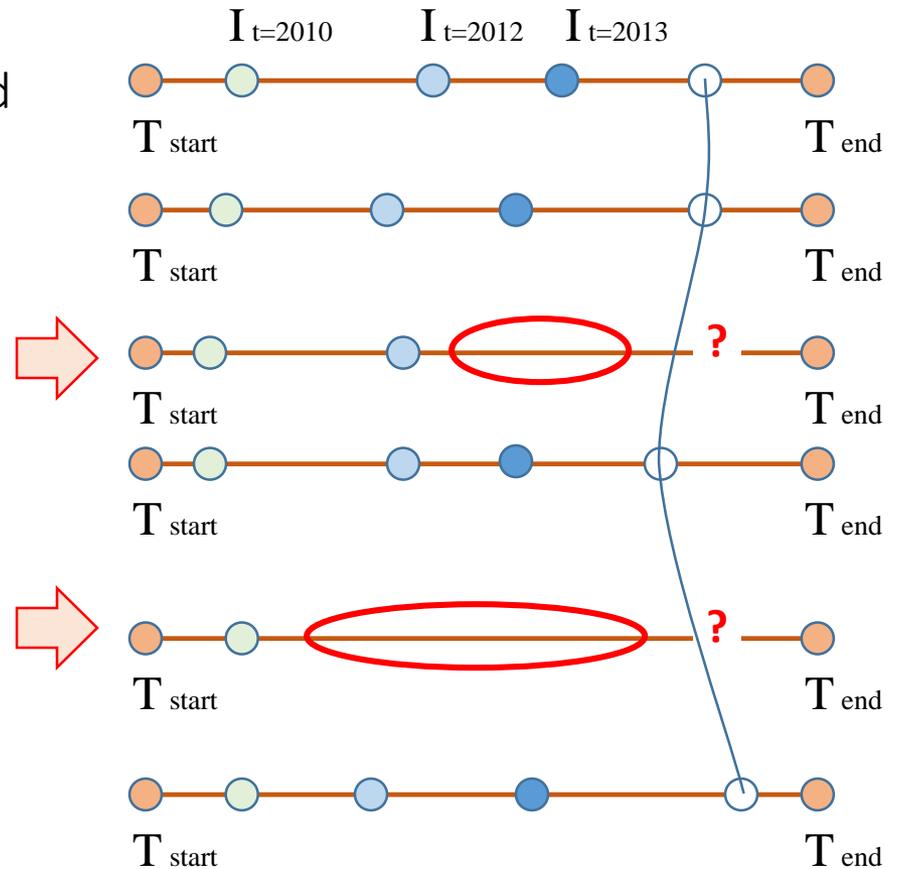


PAEK (Polynomial Approximation with Exponential Kernel)

Issue:

How should we project shoreline along a transect if recent historic shoreline data is not available?

- How current should the most recent shoreline be established to base calculated rate of change?
- Current Decision: We do not use projected points along a transect if the most recent date is older than user provided variable, but instead shoreline is smoothed over this transect



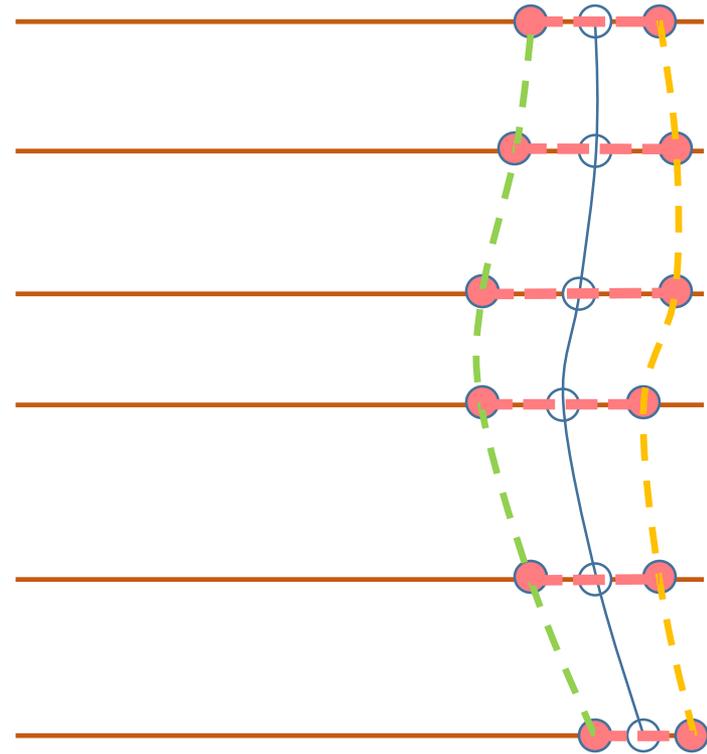
SubTask 3:

Create a geometric based error representation along the predicted shoreline

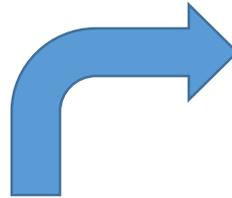
Given: The location along the transect at some given future date and the error data from DSAS for each transect

Create: A geometric based error representation along the predicted shoreline 

**Current Decision: Create Polyline
(as opposed to polygon)
representation of uncertainty**

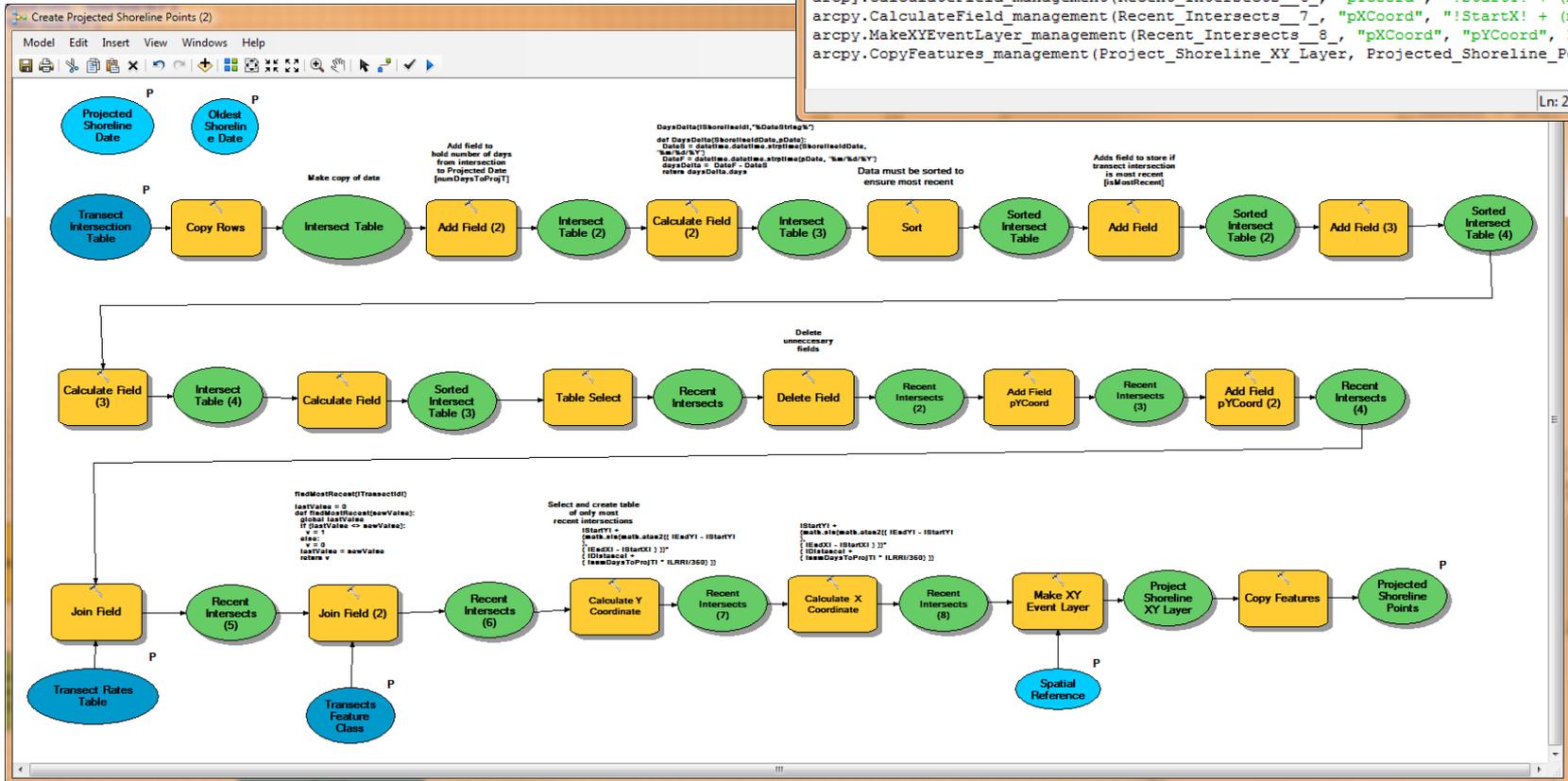


Key lines on Python Script exported from model

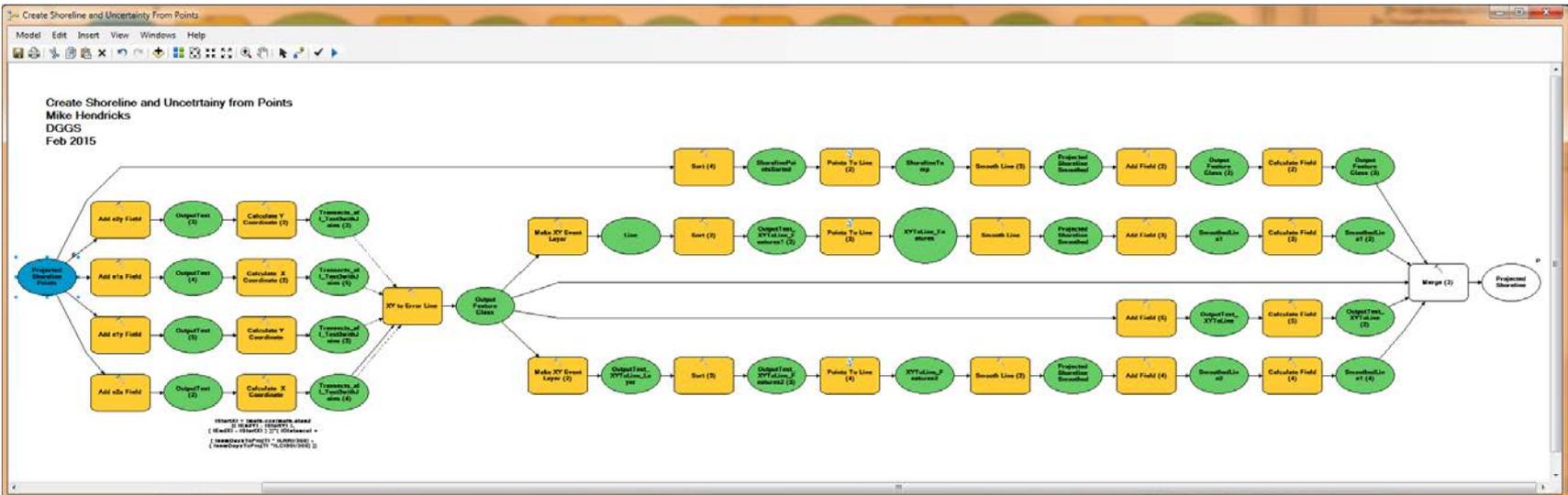
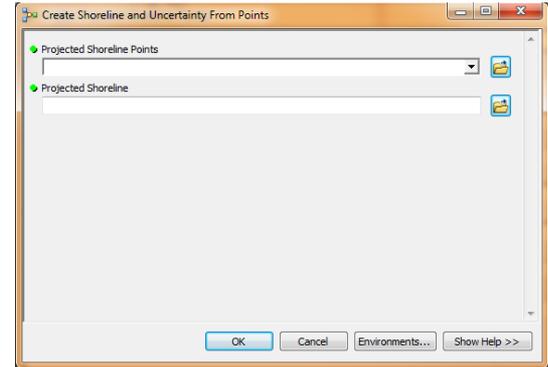


```

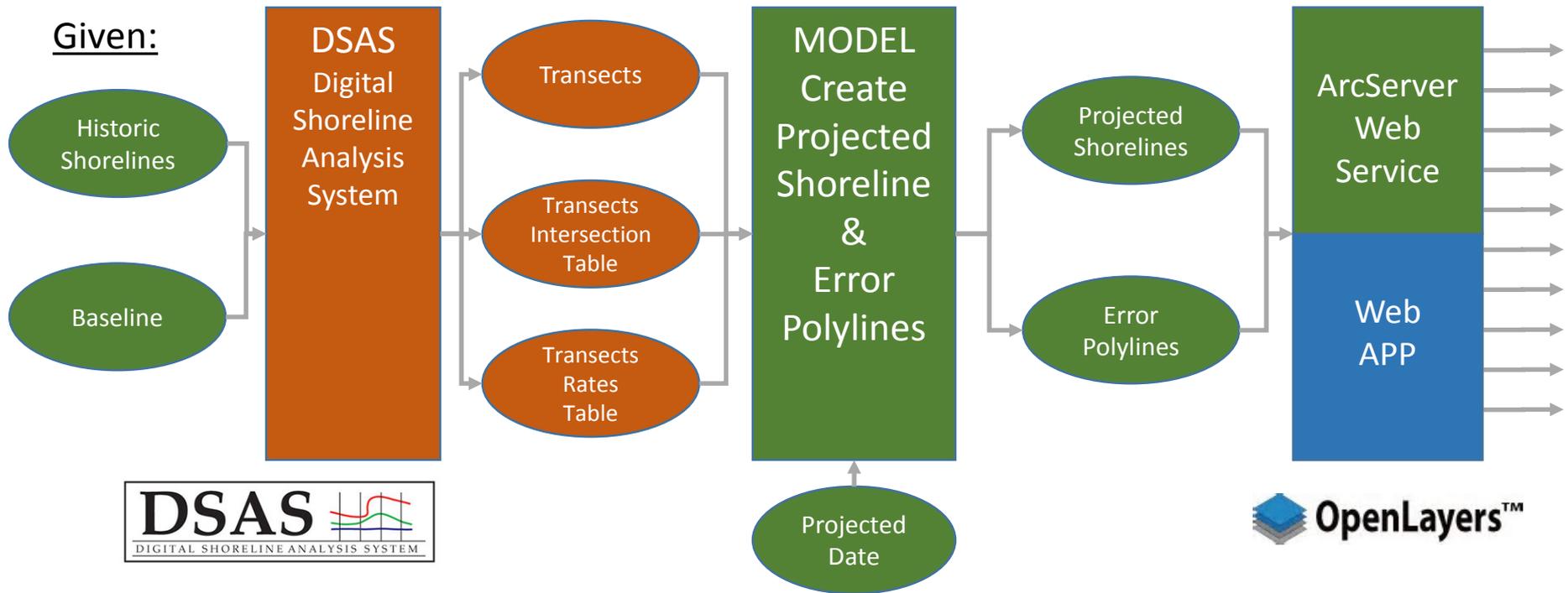
File Edit Format Run Options Windows Help
# Import arcpy module
import arcpy
# Script arguments REMOVED FOR DEMO
# Local variables REMOVED FOR DEMO
# Process: Copy Rows
arcpy.CopyRows_management(Transect_Intersection_Table, Intersect_Table, "")
arcpy.AddField_management(Intersect_Table, "numDaysToProjT", "LONG", "", "", "",
arcpy.CalculateField_management(Intersect_Table_2, "numDaysToProjT", "DaysDelta
arcpy.Sort_management(Intersect_Table_3, Sorted_Intersection_Table, "TransectId AS
arcpy.AddField_management(Sorted_Intersection_Table, "isMostRecent", "SHORT", "", "",
arcpy.AddField_management(Sorted_Intersection_Table_2, "DaysFromOldestShorelineDat
arcpy.CalculateField_management(Sorted_Intersection_Table_4, "DaysFromOldestShorel
arcpy.CalculateField_management(Intersect_Table_4, "isMostRecent", "findMostRec
arcpy.TableSelect_analysis(Sorted_Intersection_Table_3, Recent_Intersects, "isMost
arcpy.DeleteField_management(Recent_Intersects, "BaselineId;IntersectX;IntersectY
arcpy.AddField_management(Recent_Intersects_2, "pYCoord", "DOUBLE", "", "", "",
arcpy.AddField_management(Recent_Intersects_3, "pXCoord", "DOUBLE", "", "", "",
arcpy.JoinField_management(Recent_Intersects_4, "TransectId", Transect_Rates_Ta
arcpy.JoinField_management(Recent_Intersects_5, "TransectId", Transects_Feature
arcpy.CalculateField_management(Recent_Intersects_6, "pYCoord", "!StartY! + (ma
arcpy.CalculateField_management(Recent_Intersects_7, "pXCoord", "!StartX! + (ma
arcpy.MakeXYEventLayer_management(Recent_Intersects_8, "pXCoord", "pYCoord", Pr
arcpy.CopyFeatures_management(Project_Shoreline_XY_Layer, Projected_Shoreline_Poi
Ln: 2 Col: 0
    
```



Create Shoreline and Uncertainty From Points

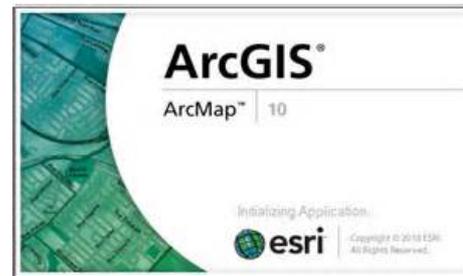


The GIS based Task to Achieve Goal



Desired GIS based output:

- Predicted Shoreline for a user defined future date as a polyline
- Display variable location uncertainty along this predicted shoreline
- Deliver this information to the public with a web service & app



Creating GIS Web Services

The image displays the ArcMap interface with a map titled "Shoreline Projections_3". The map shows a coastline with multiple colored lines representing different years of shoreline projections. The Table of Contents on the left lists the layers, including "Port Heiden" and "Shoreline Projections" for the years 1957, 1963, 1973, 1983, 2002, 2009, 2011, 2013, 2020 Projected, and 2025 Projected. The legend indicates different types of shoreline data: Implied, Measured, Projected, and Uncertainty.

The Service Editor dialog box is open, showing the configuration for a new web service. The connection is set to "arcgis on 204.90.103.41_6080 (admin)" and the service name is "Shoreline_Proje...". The service is configured as a "Map Service" on an "ArcGIS Server". The "Start service immediately" checkbox is checked.

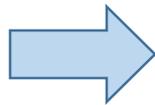
Service Editor
Connection: arcgis on 204.90.103.41_6080 (admin) Service Name: Shoreline_Proje... Import Analyze Preview Publish

General
Parameters
Capabilities
Mapping
WMS
Pooling
Processes
Caching
Item Description

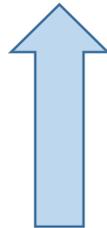
General
Service Name: apps/Shoreline_Projections
Connection: http://204.90.103.41:6080/arcgis/admin
Type of Server: ArcGIS Server
Type of Service: Map Service
 Start service immediately

Creating the Shoreline Web App

Overlay Shoreline WMS Service



 **OpenLayers™**



Basemap WMS Services

Base Layer

- Street Map
- Google Terrain
- Google Satellite
- GINA Satellite
- GINA Topographic
- GINA Shaded Relief



State of Alaska
myAlaska My Government Resident Business in Alaska Visiting Alaska State Employees

Shoreline

Alaska Division of Geological & Geophysical Surveys

State of Alaska - Natural Resources - Geological & Geophysical Surveys - Maps - Shoreline

Base Layer

- Street Map
- Google Terrain
- Google Satellite
- GINA Satellite
- GINA Topographic
- GINA Shaded Relief

Overlays

- Quadrangle Boundaries

1957
 1963
 1973
 1983
 2002
 2009
 2011
 2013
 2020 Projected
 2025 Projected
 2035 Projected

Unalakleet [Zoom to extent]
Wales [Zoom to extent]

1000
2000
Unknown
Google

This interactive tool displays historic and predicted shoreline position throughout Alaska. Users can explore the coasts of the state to see where shoreline has been in the past, and where it will be in the future. Historic shoreline positions were determined by looking at aerial photographs and satellite imagery dating back to the 1950s. Using the Digital Shoreline Assessment Tool (DSAS), rates of shoreline change were calculated. These rates were then used to project shoreline positions. Each predicted shoreline has an uncertainty, shown by a collar of dashed lines, that represents a 90 percent confidence that the shoreline will be within that area for that year. Currently, historic shoreline data are available for download but predicted shoreline positions are not.

In final development

Creating the Shoreline Web App

State of Alaska

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Shoreline

Alaska Division of Geological & Geophysical Surveys

State of Alaska > Natural Resources > Geological & Geophysical Surveys > Maps > Shoreline

30 m
100 ft
Unknown

Google

Base Layer

- Street Map
- Google Terrain
- Google Satellite
- GINA Satellite
- GINA Topographic
- GINA Shaded Relief

Overlays

- Quadrangle Boundaries

Port Heiden [Zoom to extent]

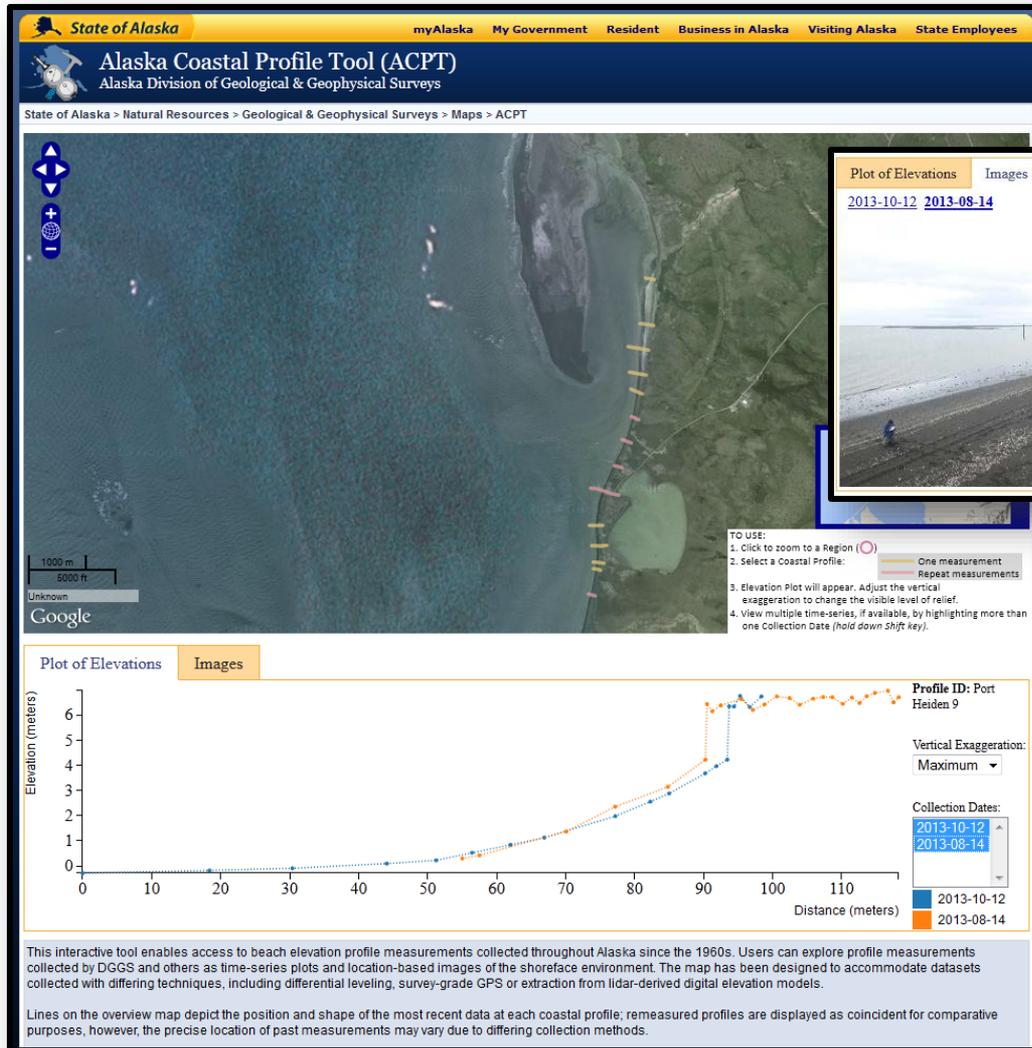
- 1957
- 1963
- 1973
- 1983
- 2002
- 2009
- 2011
- 2013
- 2020 Projected
- 2025 Projected
- 2035 Projected

Unalakleet [Zoom to extent]

Wales [Zoom to extent]

This interactive tool displays historic and predicted shoreline position throughout Alaska. Users can explore the coasts of the state to see where shoreline has been in the past, and where it will be in the future. Historic shoreline positions were determined by looking at aerial photographs and satellite imagery dating back to the 1950s. Using the Digital Shoreline Assessment Tool (DSAS), rates of shoreline change were calculated. These rates were then used to project shoreline positions. Each predicted shoreline has an uncertainty, shown by a collar of dashed lines, that represents a 90 percent confidence that the shoreline will be within that area for that year. Currently, historic shoreline data are available for download but predicted shoreline positions are not.

Related Coastal Web App



<http://maps.dggs.alaska.gov/acpt>

Other DGGS Web Apps

<http://maps.dggs.alaska.gov>

The screenshot shows the homepage of the Alaska Department of Natural Resources, Division of Geological & Geophysical Surveys. The navigation bar includes links for Home, About Us, Publications, Sections, STATEMAP, Geophysics, Geologic Materials Center, Contact Us, and Links. The main content area is titled "Interactive Maps" and features several map-based tools:

- Geologic Map Index of Alaska:** Provides outlines of DGGS and USGS geology-related maps of Alaska.
- Quaternary Faults and Folds (QFF):** Displays locations and relative activity of Alaska's faults and folds.
- Alaska Geologic Data Index (AGDI):** Includes information about industry reports and maps, field notes, drill logs, and other unpublished geology-related data.
- Alaska Coastal Profile Tool:** Enables access to beach elevation profile measurements collected throughout Alaska since the 1960s.
- LIDAR Datasets of Alaska:** Displays known public-domain LIDAR datasets of Alaska.
- Historically Active Volcanoes of Alaska:** Displays the location of historically active volcanoes of Alaska.
- Airborne GeophysWeb:** A compilation of publicly available airborne geophysical surveys conducted in Alaska since 1993 by DGGS and other cooperating agencies.

At the bottom, there is a link for "Available DGGS Data Feeds".

Example: Lidar Datasets of Alaska

The screenshot shows the "LiDAR Datasets in Alaska" web application. The interface includes a search bar, navigation links, and a main map area. A blue arrow points from the "LIDAR Datasets of Alaska" link in the previous screenshot to this application. The map displays a 3D point cloud of a landscape. A text box on the map states: "Multiple datasets are available in the area you've selected. Please choose one or more from the list below." Below this, there are checkboxes for "Infrastructure Corridors (All Points)", "Infrastructure Corridors (Ground Points)", and "Matsu - USGS (All Points)". A legend on the right side of the map lists various datasets, including "Matsu - USGS", "Nome Creek - USGS", "Totschunda Fault - Earthscope", "Unalakleet", "Valdez - USGS", "Whittier", and "Yukon Flats - USGS". A scale bar at the bottom left indicates 10 km and 10 mi. A small inset map at the bottom right shows the location of the dataset area within Alaska.

Over 9,123 square miles of point cloud data (and over 144,005,309,282 points) available!

This interactive map was designed to view known public-domain LiDAR datasets in Alaska. The map offers zoom and scroll options, and multiple base map layers. We provide an easy point and click interface to download the digital data. Explanation of icons on this page:

- Information Tool: Single click to get information about a survey area.
- Area of Interest Tool: Use this tool to define an area and download compressed point cloud data.
- Full screen mode: Toggles map using entire browser window.

For more download options, full citation information, WMS feed information, and metadata, go to: <http://www.dggs.alaska.gov/pubs/id/25239>

Please Note: The LAS files included in downloaded items have been compressed using [LASzip](#). [LASzip](#) is an open-source, lossless compression for LiDAR point-cloud data in the LAS format that provides significant file size reductions. To uncompressed the .laz files in your download package, you can download the latest version from laszip.org or download the tool (for

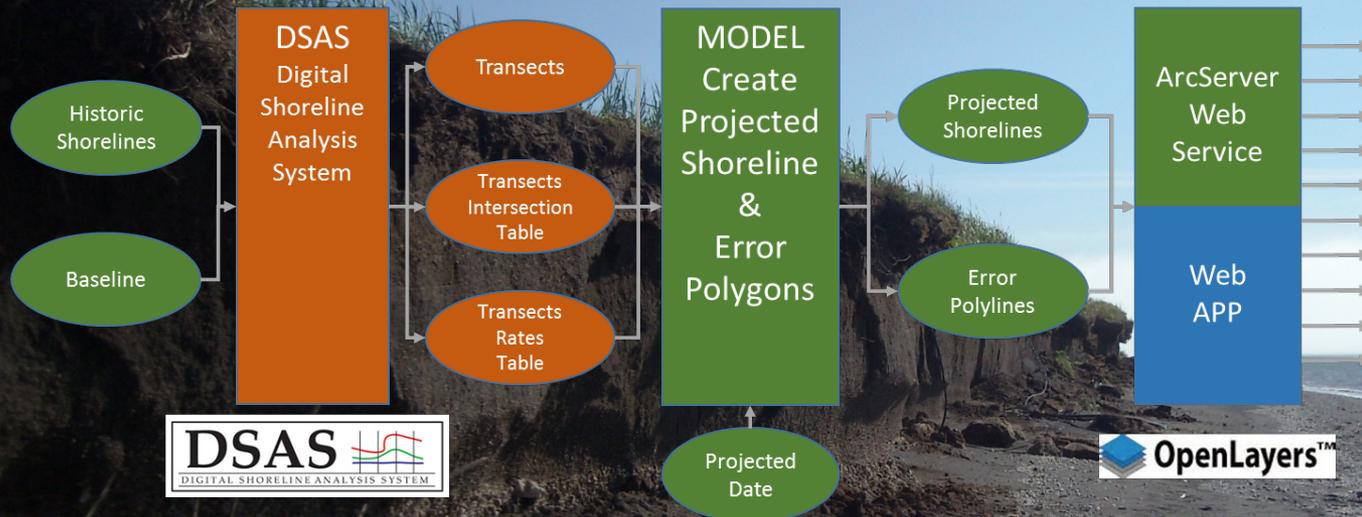
Click to zoom to each dataset:

- [Brooks Camp - USGS](#)
- [Eklutna Glacier - USGS](#)
- [Fairbanks - USGS](#)
- [Golovin](#)
- [Infrastructure Corridors](#)
- [Juneau 2012 - USGS](#)
- [Kotzebue Sound - NOAA](#)
- [Matsu - USGS](#)
- [Nome Creek - USGS](#)
- [Totschunda Fault - Earthscope](#)
- [Unalakleet](#)
- [Valdez - USGS](#)
- [Whittier](#)
- [Yukon Flats - USGS](#)

Future Work

- Develop more efficient tool in Python
- Develop tools and metrics to semiautomate the creation of baselines for use in DSAS
- Publish a geoprocessing service of this tool

Creating and Serving Alaska Shoreline Change Predictions



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