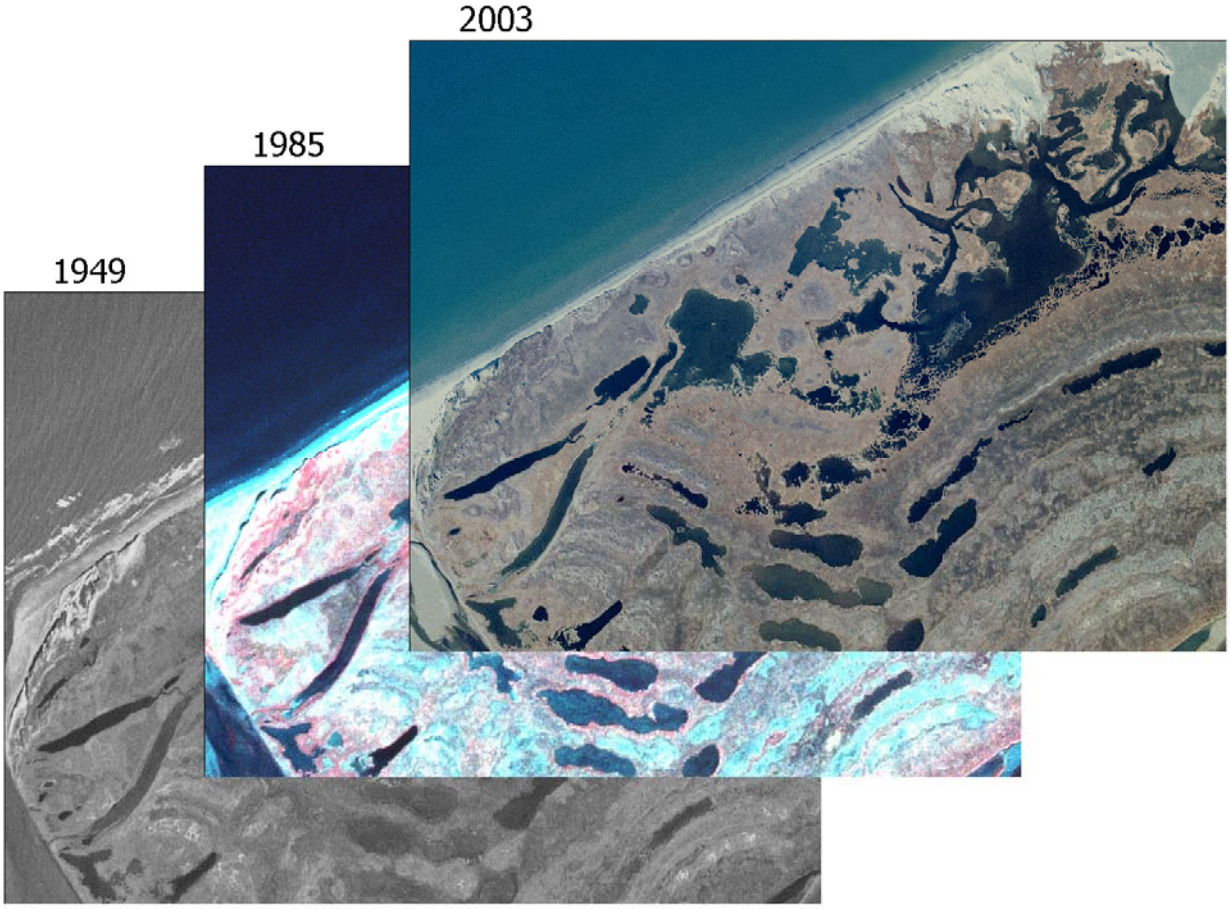
High-Resolution Imagery for Analysis of Environmental Change in Northern Alaska: Tutorial for Hands-On Activities



William F. Manley and Leanne R. Lestak
University of Colorado, INSTAAR

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INTRODUCTION

Ecoystems and habitats in northern Alaska are changing rapidly due to shifting climate and a variety of external "stressors". At the same time, technologies in Geographic Information Systems (GIS) and Remote Sensing are advancing. It is now possible to observe, detect, document, and analyze environmental change at high resolution. Aerial photography and satellite imagery – at a resolution of 1 meter or less – convey details of ecosystem components at the scale of narrow beaches, outcrops, small streams, tundra ponds, patterned ground, and vegetation communities. If processed correctly, the images can be manipulated as map layers with neglible errors. Multiple years of imagery – spanning the last several decades – can provide a time series for detailed investigation of environmental change.

This tutorial provides step-by-step guidance for hands-on, interactive activities conducted as part of an informal workshop entitled "High-Resolution Imagery for Analysis of Environmental Change in Northern Alaska". The workshop will take place in Fairbanks on Friday, October 17, 2008, following the "Park Science in the Arctic" conference. The activities using ArcGIS Desktop are outlined in the sections that follow, focus on recently released high-resolution orthoimagery for coastal ARCN, and will enable you to explore visualization, mapping, change detection, and analysis.

During the afternoon activities, each exercise will begin with a preview of the tasks to be followed, and will end with additional clarification and demos.

Some **tips and tricks** to keep in mind:

- For additional help with specific tools or functions in ArcGIS, look for links in the PDF document to online ArcGIS Help documents.
- Ask for help from your workshop partner, or one of the "floaters" moving around the room (Bill, Leanne, Scott, or Paul).

EXERCISE 1: GETTING STARTED – FILES, MAP LAYERS, ETC

Objective Open ArcMap and become familiar with the available map layers.

In this section you'll learn about some important details such as where the tutorial map document is located on your computer's hard drive, and which map layers are already loaded in the map document. You'll open the map document in ArcMap, become familiar with the available map layers, turn them on and off, and start visualizing coastal ARCN.

What Files are Where?

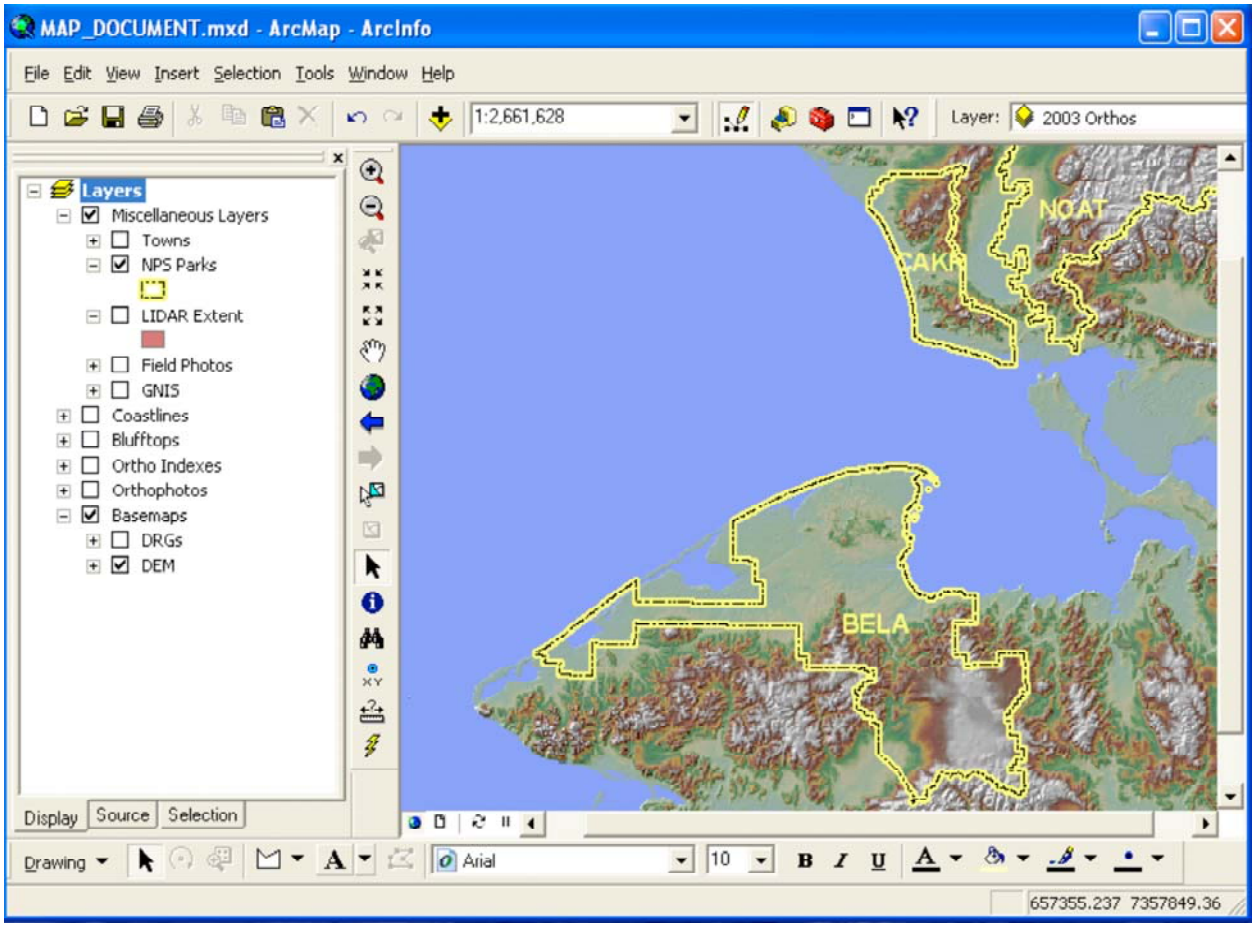
All the files you'll need are in a folder on your "C" hard drive. There's a desktop shortcut to this folder. It actually resides at: **`C:\High_Res_Workshop`**. The most important files to be aware of are:

- **`High_Res_TUTORIAL.pdf`** (this document)
- **`MAP_DOCUMENT.mxd`**

Other files are nested in the "data" subfolder.

Tasks

1) If it's not already, **open the `MAP_DOCUMENT.mxd`** by navigating to the **`C:\High_Res_Workshop`** directory and double-clicking on the file icon. It should look like this:



The **`MAP_DOCUMENT.mxd`** *window in ArcMap.*

2) Become familiar with the **"Table of Contents"** at the left side of the window. Map "layers" are arranged in "Groups" (such as "Miscellaneous Layers", "Coastlines", etc). You can close a group by clicking on the "–" symbol to the left of the checkbox, and open it by hitting it again.

3) **Turn the "Towns" layer "on"** (make it visible) by clicking the check box. Then turn the "Ortho Indexes" group on. You can also turn individual layers on and off inside this group. Turn off the "Orthos Indexes" group.

4) Become familiar with **all the available map layers and groups** by opening and closing groups, and turning groups or map layers on and off.

If a map layer isn't visible as expected: Make sure that both the map layer and its group are "checked" to be visible.

Are any of the towns located within the park boundaries?

What color are the 2003 coastlines? the 1980 and 1950 coastlines? (Hint: expand the "Coastlines" group and the map layers inside it.

Are the orthophotos limited to the coast? (Hint: turn on the Ortho Indexes group, expand it, and turn individual layers on and off)

Are all of the orthophoto images made available to you? (Hint: turn on the Orthophotos group)

For Help ...

Some "help pointers" are provided below. Click on the hyperlink in the pdf document to open an ArcMap on-line help document.

Opening a Map
Using the ArcGIS Table of Contents
Managing Group Layers

If you have time ...

If time permits, you can explore the following tasks. Some of these will be demo'ed in front of the group at the end of this exercise.

- view layer properties (right click on a layer / select Properties ...)
- open the attribute table (right click on a layer / select open attribute table)

- use the identify tool
- use arc catalog

For Help ...

Setting Layer Properties
An overview of tables and attribute information
Identifying features
An overview of ArcCatalog
An overview of ArcMap
Tutorials

EXERCISE 2: NAVIGATION

Objective Learn some ArcMap navigation tools: zoom in, zoom out, go back to previous extent, pan, and use bookmarks.

ArcMap navigation tools are contained on the “Tools” toolbar and are one of the primary ways to interact with map layers in ArcMap. The last task below explores the use of "bookmarks", which allow you to zoom into a predefined area.

Tasks

1) **Turn on the “Towns” layer** (inside the “Miscellaneous Layers” group), and the **“Basemaps” group**. Turn off all other groups.

2) Select the **Zoom In tool** (by clicking on it once), and **zoom in to Kotzebue**: click repeatedly, or drag a box.

3) Select the **Zoom Out tool**, and **zoom out** by clicking or dragging a box.

4) Click the **back tool** to go back to the previous map extent.

5) Select the **pan tool**, which allows you to move the data frame in any direction. **Pan north to the southeastern edge of CAKR**. (Hint: North is up.)

The next part of this exercise uses "bookmarks", located in the "View" menu.

6) First, zoom back out to the entire area: Click the "View" menu, select "Bookmarks", and then select "**Overview**".

7) Experiment with other bookmarks: "**BELA**", "**CAKR**", etc.

For Help ...

ArcMap Tools Toolbar
Bookmark tutorial
Working with spatial bookmarks

If you have time ...

If time permits, you can explore the following tasks. Some of these will be demo'ed in front of the group at the end of this exercise.

- Zoom to layer extent - Right-click a layer, and select "Zoom To Layer".
- Zoom to a selected feature
- Zoom to raster resolution - Right-click a raster layer, and select "Zoom to Raster Resolution".
- Look at the DRG basemaps (Digital Raster Graphics – scanned topos); how do they compare in resolution to other layers?

For Help ...

Zooming to a layer's extent
Zooming to the selected features
Displaying the raster's spatial resolution

EXERCISE 3: DETECTING CHANGE – ON/OFF

Objective Zoom in and visualize environmental change by turning the imagery "timeslices" on and off.

For the next two exercises, you'll zoom in using bookmarks and then work with the high-resolution coastal orthoimagery to detect and evaluate environmental change.

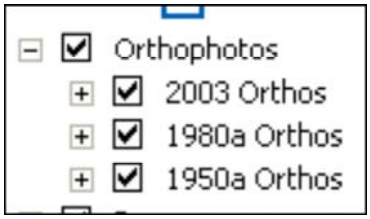
Tasks

1) **Turn off all groups except for “Orthophotos” and "Basemaps"**.

Explore environmental change at the **Red Dog Port** site:

2) Select the **"Red Dog Port" bookmark** to zoom into that area.

3) Open the **"Orthophotos" group**:



4) **Turn off** and **on** the 2003, 1980a and 1950a groups to view change at the Red Dog port site over time.

5) **Zoom way in** to see the change in more detail. Zoom out and pan to explore nearby areas.

Dramatic change?

When was the port site constructed?

Was there any change between 1950 and 1980?

Are the orthophotos properly co-registered? Ie., are relatively stable features in the same place on each "timeslice"?

EXERCISE 4: DETECTING CHANGE – SWIPE, FLICKER

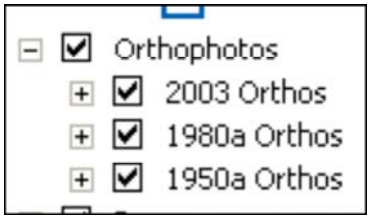
Objective Detect environmental change and fine-tune the appearance of the imagery by using the "Effects" toolbar.

You'll use two tools to interactively view change. The "Swipe" tool allows you to quickly and easily hide a map layer to see the one below it, using up/down or left/right motions. The "Flicker" tool rapidly turns the selected layer on and off. Other tools allow you to adjust brightness, contrast or transparency.

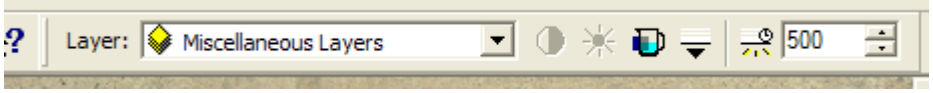
Tasks

1) Select the **"Kiligmak Inlet" bookmark** to zoom into that area.

2) Make sure all the groups within the **"Orthophotos" group** are turned on:

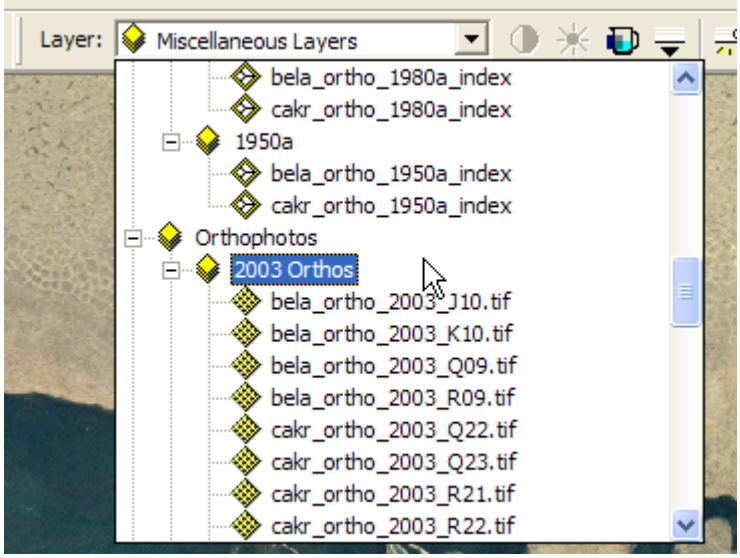


3) **Select the "2003 Orthos" group in the Effects toolbar**: First, find the Effects toolbar at upper right:



If the effects toolbar is not visible, then click the view menu, point to Toolbars, then click Effects.

To the right of the Layer selection box, click on the drop-down arrow , scroll down, and select the **"2003 Orthos"** group:



This is the raster group you'll manipulate. The effects toolbar should now look like:

4) Click once to **select the Swipe Layer tool** . Using the mouse, click and hold from the top, bottom, left, or right side of the map window, pause for a moment or two, and move the tool toward the opposite edge. View the change between 2003 and 1980.

This is an area of dramatic change, with closure of an inlet causing flooding of a large area of tundra. Zoom in and out to get a sense of scale.

5) Now view the change between 1980 and 1950 (hint: you will have to change the drop-down layer to 1980a and turn off 2003 in the table of contents).

Less dramatic, but there has been some change to the shoreline and the outlet of the Kiligmak River.

Next we'll use the Flicker tool.

6) Make sure all groups in the Orthophotos group are turned on, and that the "2003 Orthos" group is selected in the Effects toolbar.

7) Click once on the **Flicker Layer** tool . View the change that has taken place between 2003 and 1980. Click again to turn it off. Similarly, view the change between 1980 and 1950 (hint: turn off 2003, select 1980, hit the flicker tool).

Now we'll use the transparency tool.

8) Make sure all groups in the Orthophotos group are turned on, and that the "2003 Orthos" group is selected in the Effects toolbar.

9) Now use the **transparency tool** . Drag the slider bar to adjust the transparency until you can partly see the 1980 layer underneath. Experiment with different transparency values. Finally, drag the slider bar back down to 0%.

OK, we've seen some environmental change. Before we go further, let's adjust the imagery.

10) Use the **brightness tool** or **contrast tool** to change the 2003 layer. Make sure the "2003 Orthos" group is selected. Drag the brightness slider bar to increase or decrease the brightness. Do the same with the contrast tool. Experiment for the different "timeslices". Finally, return both brightness and contrast sliders to 0%.

11) Choose some of the other bookmarks to view change in other areas.

Has the environment changed? How so?

How far can you zoom in?

What's the best way to observe this change within ArcMap?

For Help ...

Effects toolbar
Interactively reveal rasters using the Swipe Layer or flicker tools
Improving the display of raster data

If you have time ...

- Use the Overview window to keep track of where you are (pull down Window / Overview)
- Use the Magnifier window to really zoom in (pull down Window / Magnifier)
- If you are interested in a particular area that isn't covered by the imagery already loaded in this ArcMap document, ask one of the "floaters" if they could bring over and set up an external hard drive. (The coastal orthoimagery is too large to load onto each workstation ...).

DISCUSSION: HAS THE ENVIRONMENT CHANGED?

Time now for some discussion. Some things to consider:

- Which components of the earth's surface have changed the most? Ie., coastline, inlets and lagoons, streams, lakes, permafrost and patterned ground, etc?
- Have there been significant changes to habitats?
- Does this imagery have the required spatial resolution? Does it have the required spatial accuracy? Temporal resolution?
- How could the imagery be useful for study of environmental change? For vital signs and the Inventory and Monitoring Program? In particular, for your area or topic of interest?

EXERCISE 5: ALASKAMAPPED.ORG & WMS IN ARCMAP

Objective Use an excellent online resource to view the best available imagery across Alaska.

Pete Hickman and Tom Heinrichs, from the Geographic Information Network of Alaska (GINA) will lead a demo showcasing AlaskaMapped.org – a web mapping application and service. In particular, they will show how to use high-resolution imagery in ArcMap using a network connection.

EXERCISE 6: MEASURE DISTANCE AND AREA

Objective Use the measure tool to get length and area measurements.

In this exercise, you'll measure the length and area of natural features, to gain a sense of scale and as a means of quantifying environmental change.

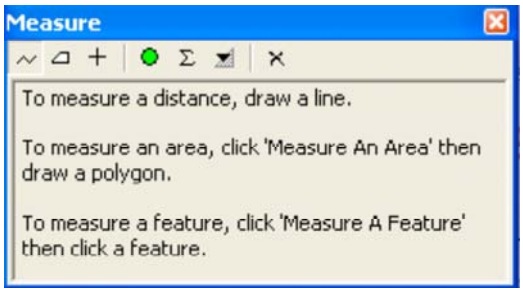
Tasks

1) Choose the **"Changing thaw lakes" bookmark** from the view pull-down menu. **Turn on the "Orthophotos" group and turn on all years of photography.** Turn off all other groups. **Turn photo years off and on to view lake change over time.** Turn on "2003 Orthos" group.

Which thaw lakes drained completely between 1980 and 2003? Which ones drained only partly?

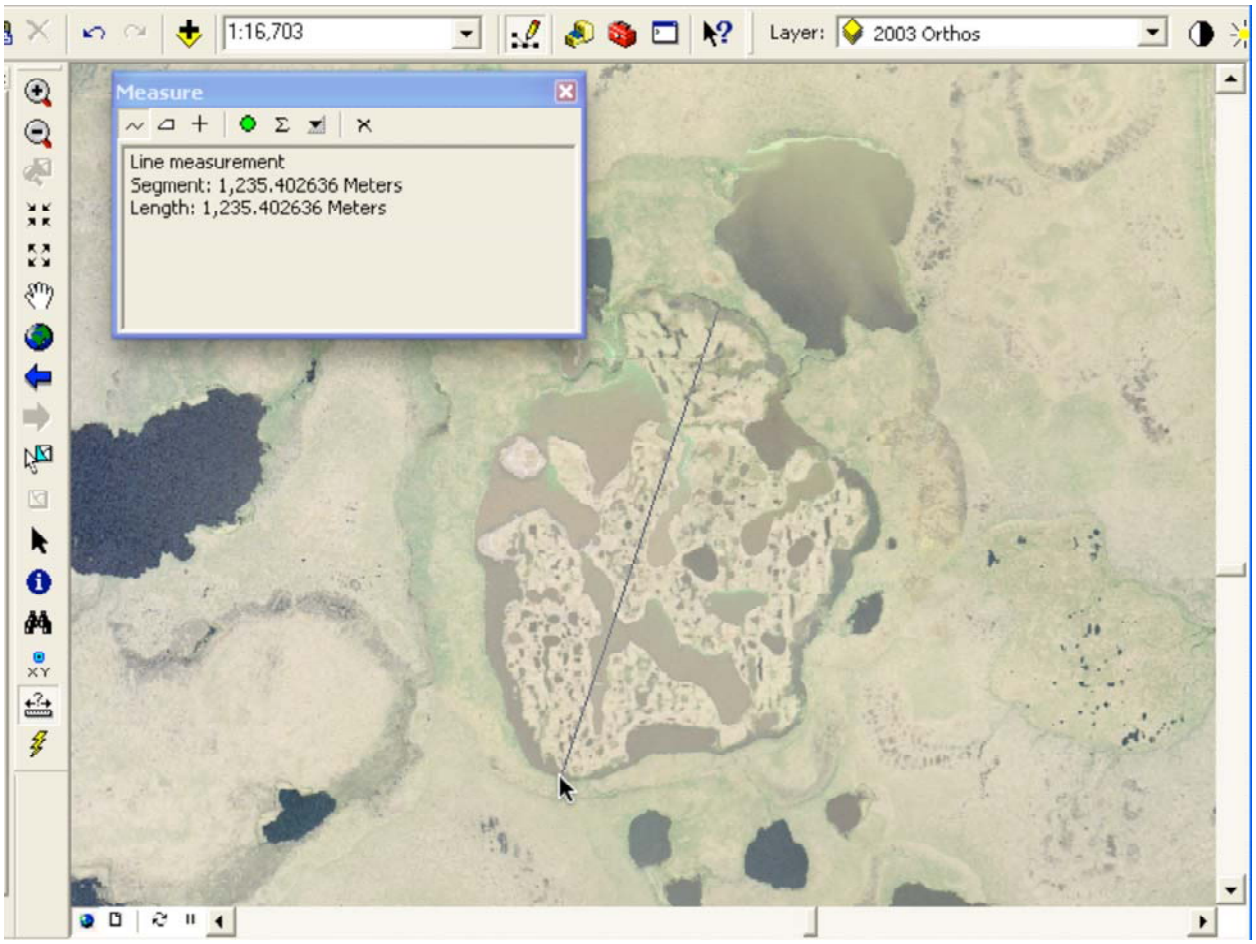
Was there any change between 1950 and 1980?

2) Click the **Measure tool** (near the bottom of the vertical Tools toolbar). The measure tool information box will appear:



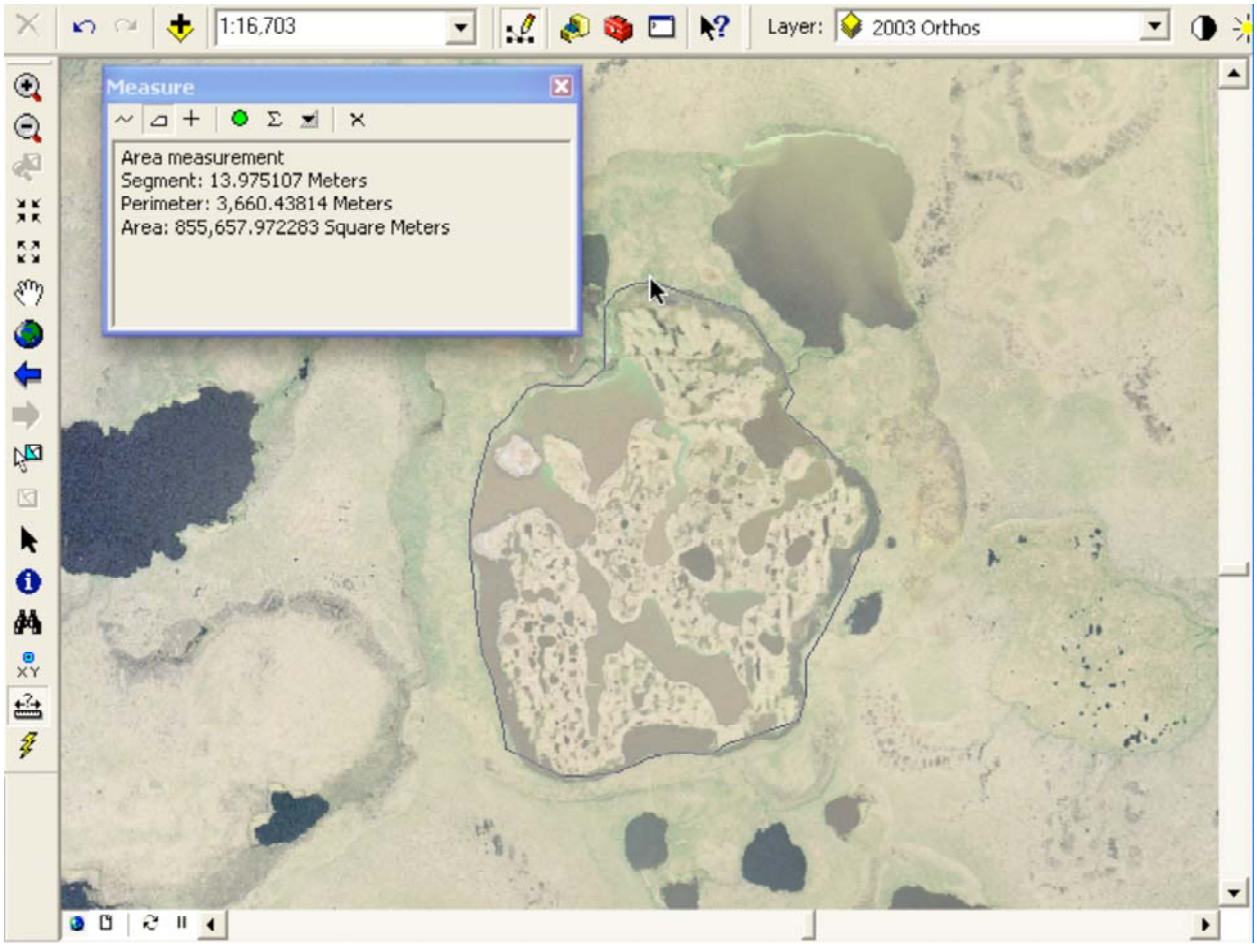
3) Hover over each tool to see map-tips on tool usage.

4) Choose the “measure line” tool and **measure the length of one of the changed lakes** as shown below:



Click the map at the top of the lake (north) and then move the pointer to the southern point and click. Double-click when you want to end the line. Get a sense of the scale of the landscape.

5) Choose the “measure an area” tool and **measure the total area of the lake**. Digitize around the lake as shown below:



The Measure tool is a quick and dirty way of quantifying change. A better way would be to digitize point, line, or polygon map layers over the imagery, and then analyze them using more sophisticated tools.

Which units are you measuring in?

In terms of distance or area, are these environmental changes significant?

For Help ...

About measuring distances and areas

If you have time ...

- Measure the lake that has totally disappeared.
- Use the Drawing toolbar tools to roughly digitize or highlight features.

For Help ...

Working with graphic elements, pictures and neatlines

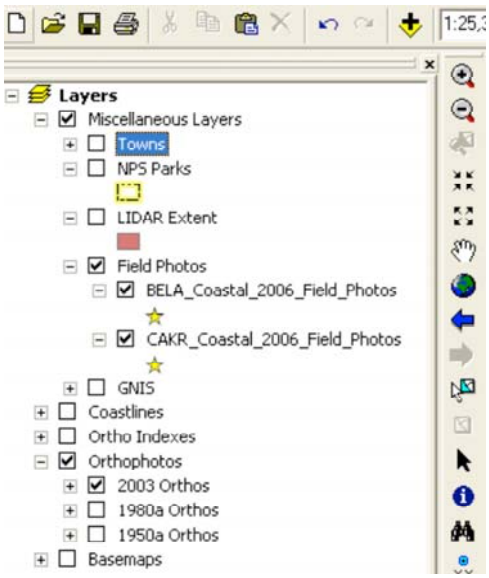
EXERCISE 7: PHOTO HYPERLINKS

Objective Use hyperlinks to view field photographs of selected areas.

You can use ArcMap to navigate to an area and view photographs of that area taken from the field. We'll use the Hyperlink tool to open photos taken in 2006 for the coastal change project.

Tasks

1) Turn on the **"Orthophotos"** group, the **"2003 Orthos"** group, the **"Miscellaneous Layers"** group, and the **"Field Photos"** group. Turn off all other groups. Open the Field Photos group and make sure the layers for BELA and CAKR are on. Your Table of Contents should now look like this:



2) Select the **"Kotzebue" bookmark** from the view pull-down menu.

3) Click the **Hyperlink tool** (at the bottom of the vertical Tools toolbar). All active hyperlinks show up as a blue dot inside a yellow star:

4) Find the point feature just south of the runway (circled above). **Click on the blue dot**. You might have to be careful to position the tip of the "lightning" cursor directly on the point (until it turns black). A photo of the lagoon taken from the airport runway should appear:

It's possible to make any field photos available in ArcMap in this way. Essentially, it involves "geotagging" or georeferencing the photos, if they haven't been already. Then making a point shapefile and setting up a hyperlink attribute.

If the hyperlinks aren't working, let one of the "floaters" know.

5) **Click on the other 5 hyperlinks** around Kotzebue to view additional field photographs.

6) Once a field photo is visible, you might be able to simply hit the **left or right arrow keys** (on the keyboard) to see other photos from nearby.

7) There are hundreds of field photos in this data set. Explore some of the other **"bookmark" areas**. Some of the points are associated with more than one photo.

How helpful are the field photos?

For Help ...

Adding hyperlinks to features

EXERCISE 8: VIEW METADATA

Objective Open, view and explore a layer's metadata file to learn more about data source, resolution, accuracy, etc.

The ARCN datasets released by the QGIS laboratory come with attached FGDC (Federal Geographic Data Committee) metadata. FGDC metadata describes geospatial data. Before using geospatial data, a GIS user should become familiar with the many attributes described in the metadata. This exercise will cover some of the metadata features available in ArcMap.

Tasks

1) Turn off all groups, except for the "**Orthophotos**" group and the "**2003 Orthos**" layer.

2) Open the **"2003 Orthos"** group. You'll see a list of 15 .tif files (out of a total of 103 tiles for the 2003 orthophoto mosaic).

3) Right-click on one of the .tif layers, choose "**Data**", then choose "**View Metadata**".

4) **Become familiar** with the information contained under various headings and subheadings. If you have a choice, select a different "stylesheet" to view the same information in different ways.

Metadata can be time-consuming to produce. But it provides information that guides the end user about the appropriateness of a data set for any given study. FGDC metadata can also be widely distributed through clearinghouses to promote data sharing. (For example, this metadata is available through the NPS Data Store).

What was the scale of the photos used for this data set? When were they taken? What is the resolution and accuracy?

How important is metadata?

For Help ...

About metadata
Exploring an item's metadata
Changing the default stylesheet

EXERCISE 9: DETECTING COASTAL EROSION

Objective View and discuss digitized coastlines and measure erosion.

Finally, if there's time, we'll explore coastal erosion in more detail, viewing and discussing 480 km of coastline recently digitized for each of the "timeslices".

Tasks

1) Turn on **"Coastlines"** and **"Orthophotos"** groups. Choose the **"Coastal erosion"** bookmark. Make sure all years of photography are turned on and all coastline years are turned on.

Coastlines are colored by year: blue for approx. 1950, green for approx. 1980, and red for 2003. Zoom in and out, turn photography years off and on, or use effects tools to view the coastlines and orthoimagery. Become familiar with coastal change in this area.

2) Click on the **measure tool** **.** Measure the **distance between the 2003 coastline and the 1950a coastline**. Measure the distance in a few areas along the coast. Zoom in to get more accurate measurements. Measure the **distance between the 1980a/2003 and 1950a/1980a coastline**.

These coastlines were recently digitized for all of BELA, CAKR, and surrounding areas. In detail, this hinges on a chosen definition of a "shoreline reference feature" – in this case the waterline. The digital coastlines will be further analyzed using an extension to ArcGIS called the Digital Shoreline Analysis System (DSAS).

Is the coastline eroding in some or most areas?

Where is it accreting?

What are the rates of change?

Is there much spatial variability? And has the rate of erosion increased or decreased through time?

What other types of coastal change are detectable? Changes to inlets or lagoons? Changes to dune systems? Overwash deposits and sand flats? Nearshore lakes and ponds?

If you have time ...

- View hyperlinked field photos for this area
- Zoom way in to evaluate the position of the shorelines in detail.
- View blufftop map layers for some areas
- Discussion of the shoreline reference feature (SRF)
- Discussion of digitizing and orthorectification errors

DISCUSSION: BRAINSTORMING THE OBSTACLES AND POTENTIAL

Both the morning talks and afternoon activities were intended for "scientists interested in applying the potential of high-resolution imagery to environmental research in northern Alaska".

What is the potential?

What are the obstacles?

Next steps?