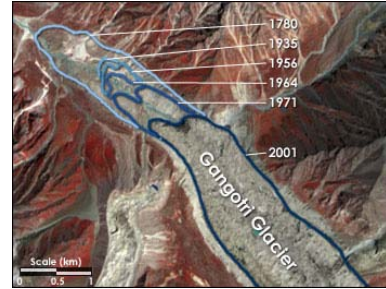


# ICE-DRAINAGE BASIN DELINEATION AND GLACIER CLASSIFICATION FOR THE ARCTIC ICE CAPS USING GIS AND GLIMSVIEW SOFTWARE

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*A Step-by-Step Process Description  
for the Novice to Intermediate  
GIS Technician*

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February, 2006

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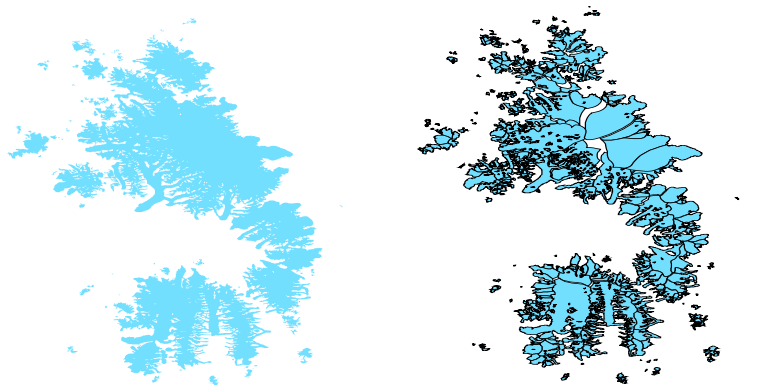
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## 1.0 Introduction

The GLIMS project aims to collect geospatial information about the glacier ice-cover of the entire world. The University of Alberta, under the direction of Dr. Martin Sharp is participating in the GLIMS project by contributing geospatial information about glaciers in the Canadian high arctic islands.

The GLIMS project was originally designed with mid-latitude alpine glaciers in mind. Consequently, GLIMSView software works well for isolated alpine glaciers, but is awkward for the large ice-caps and ice-sheets that are found in the Canadian high arctic islands. Ice-cap/sheets in the arctic are much larger than alpine glaciers, and may extend for hundreds of kilometres. They tend to be composed of many ice-drainage basins and have many outlet glaciers and termini. If an arctic ice-cap/sheet was included in the GLIMS database as a single glacier the simple attributes that are available for glacier description in GLIMSView would not be adequate for the many margins, termini, sources, etc. of an arctic ice-cap/sheet.

For this reason the GLIMS community has decided to break arctic ice-caps/sheets up into ice-drainage basins. The GLIMS glacier classification and quantification will then be carried out on an individual glacier-basin that represents all the confluent ice flow from an ice-cap/sheet to a single terminus. If need be, an ice-caps/sheet can easily be studied by merging all its component ice-drainage basins (Figure 1).



**Figure 1 - Ice-cap divided into ice-drainage basins in which all ice is flowing toward one particular glacier terminus.**

The following procedure has been developed as a step-by-step guide for delineating arctic ice-drainage basins, classifying their respective attributes in GLIMSView, and uploading them to the GLIMS database. The procedure outlined here differs markedly from the procedure that would typically be used for an isolated alpine glacier because of the complexity and scale of arctic glaciers.

## **2.0 Basic Setup**

### **2.1 Step 1 - Organize**

Create a folder under your own name on the GLIMS2 server (map network drive to GLIMS2 server along the following path: entire network > eos\_labs > eoslweb1 > GLIMS2). You will keep current copies of all your files here. Create folders and organize the data in a hierarchy that makes sense so that someone else may access your work. A hierarchy may be organized as follows: island/ice sheet name > data types (shapefile, raster), data progress (GLIMS prep, GLIMS ready, GLIMS output), etc.

*Example:*

*In the GLIMS2/Greg/Axel/Raster folder there are Landsat images of Axel Heiberg Island (onsaxel\_ls99\_z17\_b1-5\_subset which contains the 30m Landsat visible/NIR data, onsaxel\_ls99\_b8 which contains the 15m Landsat panchromatic data and onsaxel\_ls99\_b542 which contains bands 5, 4 and 2). There is also a folder containing a DEM.*

*In the GLIMS2/Greg/Axel/Shapefiles folder there are shapefiles of the ice extents in 1960 (from aerial photographs) and 1999 (from Landsat imagery). There are also many shapefiles (basin1 to basin629) that delineate ice-drainage basins of the main ice sheet (based on the 1999 ice outline).*

*In the GLIMS2/Greg/Axel/GLIMS\_ready\_basins folder are the same basin shapefiles as above except that they have been formatted to be compatible with GLIMSView, i.e. they have been projected in the WGS1984 geographic projection.*

*In the GLIMS2/Greg/Axel/GLIMSoutput folder are the final GLIMSView output files that are ready to be merged together and uploaded to the GLIMS database.*

### **2.2 Step 2 - Download**

Visit the GLIMS website (<http://www.glims.org/>) and download the most recent version of GLIMSView software, and the GLIMS glacier classification manuals. Print the manuals because you will need to reference them frequently. Install the GLIMSView software.

### **2.3 Step 3 - Install**

If it is not already loaded onto your machine, install ArcView 9.x. You may need to speak with the EOSL lab manager (Mei Mei Chong) or, the department's technical assistant for help installing this program. ArcView 9.x is superior to 8.x for GLIMS work because it is more stable, and introduces fewer inconsistencies when drawing shapefiles. Operation of version 9 is similar to 8 except that many tools have been placed in the ArcToolbox.

Notes:

1. *If you are familiar with ArcView 3.x, please refer to Appendix One of this manual. Advanced users of version 3 will not have difficulty delineating ice-drainage basins, but, for the intermediate user version 9 will be faster and easier.*

## **2.4 Step 4 - Find the data**

Map network drive to the old GLIMS server (entire network > eos\_labs > Eoslserv1 > GLIMS) and locate the files you will need for the particular ice-sheet you are working on. These files will likely include: 1) the satellite imagery for the area (usually several files or a mosaic), 2) the 1960, and 1999 ice-outlines of the ice-sheet, 3) a DEM of the island you are working on, and 4) any ice-drainage basins that have already been created for the ice sheet (several ice sheets have only been partially completed). Copy the files you need from the old GLIMS server to your space on the GLIMS2 server.

You are ready to begin ice-drainage basin delineation in GIS!

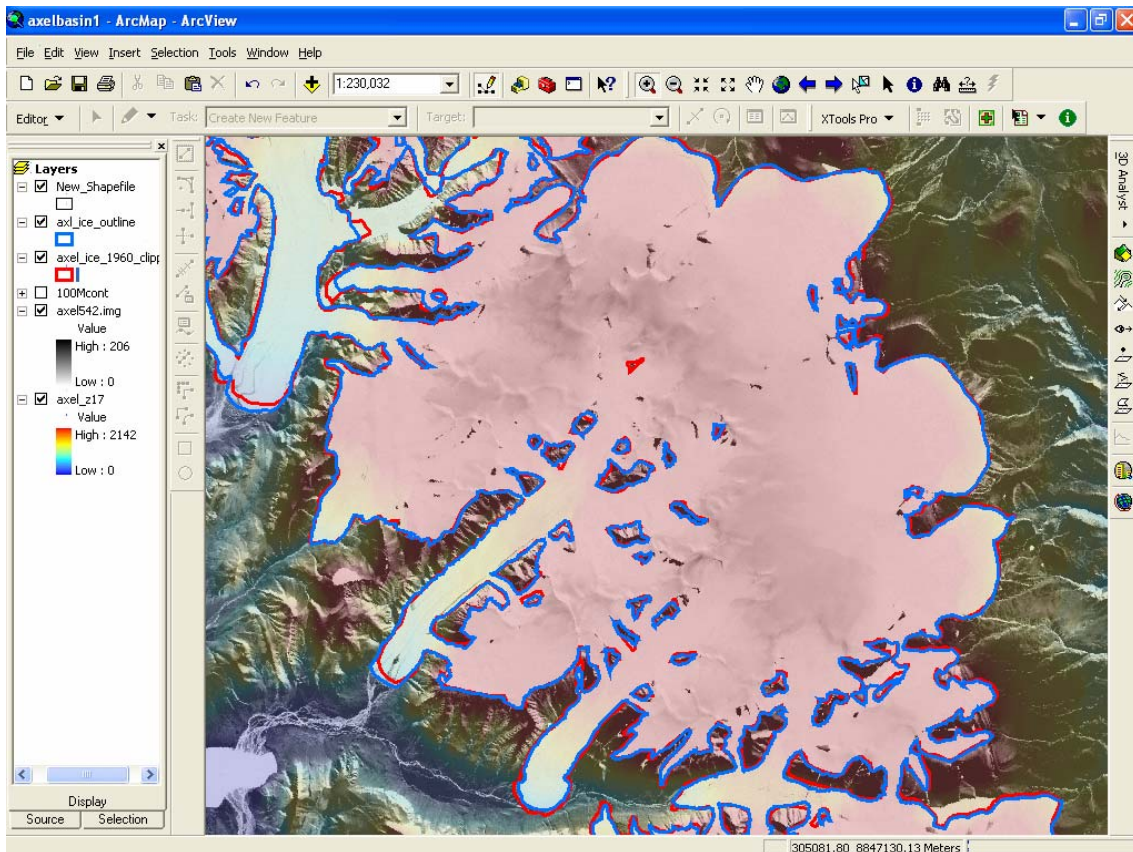
Notes:

1. *You may have to dig around a bit to find all the files that exist for a particular ice-sheet. Please remember that many different people have been working on the GLIMS project part-time, and everyone has a different filing system. If you are not sure what has been done, ask others in the research group and check the GLIMS glacier viewer (on the GLIMS website) to see if the ice-sheet you are about to do has not already been uploaded.*
2. *Most GLIMS-related files are located in the “GLIMS\_databasing” folder on the GLIMS 1 server. However, useful files and images may be located in other folders on this server. The “Ice\_outlines” folder contains ice outline shapefiles that have been produced from the 1960 and 1999 images. The “Fiona” folder contains another folder called GLIMS where many GLIMS-related files may be found.*

## **3.0 Ice-Drainage Basin Delineation in GIS**

### **3.1 Step 5 - Make the map**

Start up ArcView 9.x and select a *new empty map*. Add the 1960 and 1999 ice outlines for the ice-sheet you are working on. Also add the satellite image or images, if more than one is required. If ice-drainage basin delineation work has been partially completed for this ice-sheet, add the completed basins. Find the DEM for this area and add it too. Organize the layers by dragging them so that the ice-outlines are on top of the basins, which are on top of the images which are, in turn, are on top of the DEM (Figure 2).



**Figure 2 - Basic map set-up.**

Open ArcCatalogue and insert a new, empty polygon file in the directory in which you will be creating your ice-drainage basin polygons. Add the empty shapefile to the map and leave the filename as “newshapefile”.

Right-click the *layers* text at the top of the layer menu and select *map properties*. Find the coordinate system and change it to UTM, North American Datum 1983 and select the UTM zone that you are working in. GLIMSVIEW only accepts shapefiles that are WGS 1984 geographic, but it is much easier to work in UTM when using ArcView. You will change the projections of all the shapefiles that are destined for input into GLIMSVIEW later.

### **3.2 Step 6 - Adjust the map for drainage basin delineation**

The 1999 ice-outline has been created by remote sensing and edge detection and completely surrounds the ice-sheet that you are working on. Your job is to break this ice-sheet up into ice-drainage basins. An ice-drainage basin is a portion of the main ice-cap/sheet in which all the ice is flowing toward one particular glacier terminus.

To break the ice-cap/sheet into ice-drainage basins, you will need to know the direction in which ice at any one point on the ice-cap/sheet surface is flowing. Information that will guide you as you determine the direction of ice-flow may include: flow banding and debris trains on the ice surface that are visible in the

satellite image, the slope of the ice surface as defined by the DEM, and the general shape of the portion of the glacier that you are analyzing.

For the purpose of delineating ice-drainage basins, the most important elements are the ice-outlines, the satellite image, and the DEM. These elements must be adjusted so that the information they portray can be viewed simultaneously. They must also be adjusted so that the information in one layer compliments that in the others. ArcView is a powerful program for visualizing and organizing geospatial data. There are many adjustments that may be made to the layers in a map. The adjustments one makes will depend on personal preference, or on the data that is being viewed.

The layers can be adjusted by right-clicking on the layer name in the layer list and selecting *properties*. Most of the display choices can be found under the *symbology* and *display* tabs. The display options for a raster image or DEM, for example, are almost limitless. The data may be classified or stretched. Histograms for stretched display can be infinitely adjusted (although several pre-defined choices are available). Almost any colour combination can be used to display every map element. The transparency can be adjusted so that one layer is visible through another. Shapefile polygons can be displayed as filled or hollow, and the outlines can be thick or thin, and coloured infinitely.

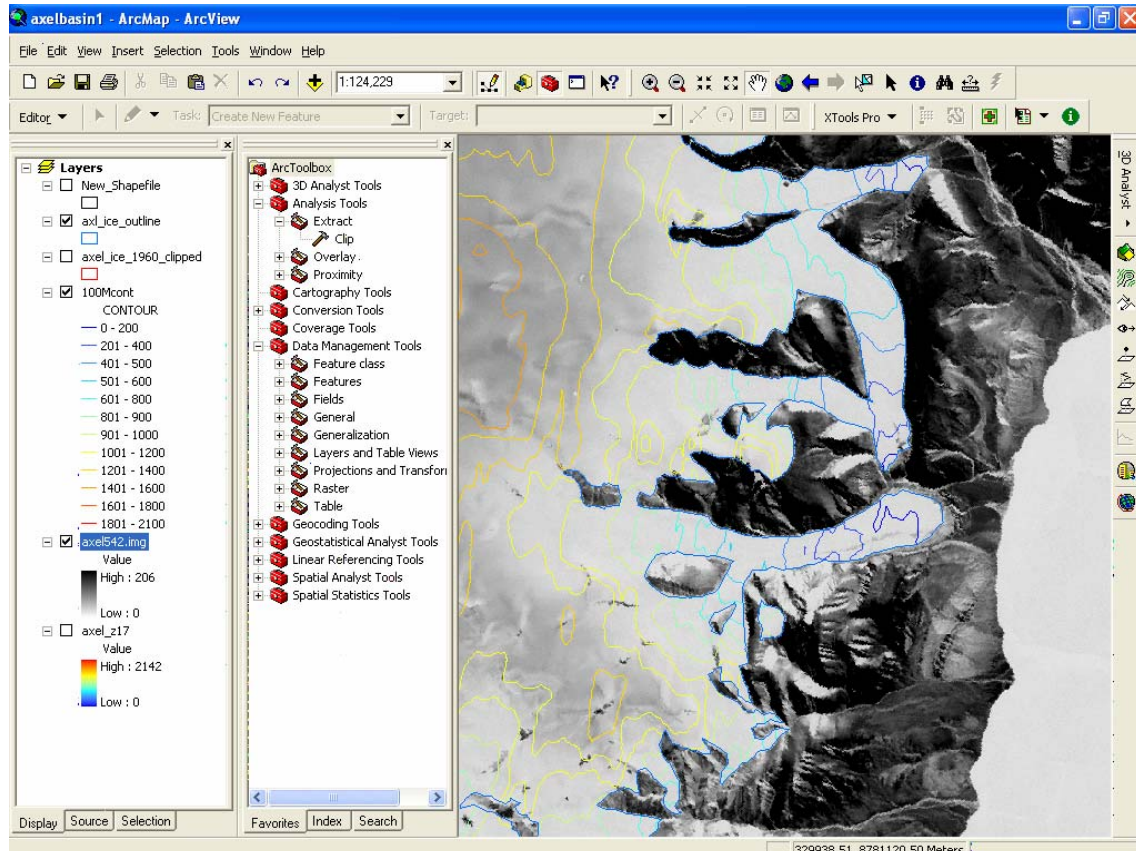
In Figure 2 for example, the 1999 ice outline polygon is displayed with a blue line. The polygon is not filled in, because we need to see the satellite image and DEM below this layer. The ice outline provides the raw shape of the ice-cap/sheet which must be broken into ice-drainage basins. The satellite image is displayed as a grey-scale with high contrast which allows easy visual separation of light and dark, or glacier ice and bedrock/debris. Flow lines and ice limits stand out under this arrangement. The image has also been made 30% transparent so that we can see the DEM below it. The DEM is displayed as a colour-gradient of highly contrasting colours (warm colours for high elevation, cold colours for low elevation). This gives us an easy visual indication of altitude, and can not be confused with the image which is composed of contrasting grays. The DEM has been made 50% transparent so that it does not over-power the image.

Creating contour lines to display elevation data is a useful alternative to displaying the data as a classified or stretched colour gradient. This may be especially useful if the satellite image is coloured (red-green-blue). You may construct contour lines with the *3D analyst*. Open *view > tools* and check the *3D analyst*. Click the *3D analyst* button on the toolbar and select *surface analysis*, and then select *create contours*. Store the file in a sensible location.

Add the file to the map and open the ArcToolbox. You will now clip the contours to the ice-extent so that the contours look clean and less of your computer's processing power is used to render (display) the shapefile. Select *analysis tools*, then *extract* and then *clip* from the ArcToolbox menu. Use the contour file as the layer that is to be clipped, use the 1999 ice outline as the layer that the clip is to be based on. Store the output file somewhere that makes sense. Right-click on

the original contour layer in your map and remove the layer. Add the new clipped layer (if it is not already added). The contour line shapefile has been cut to the dimension of the ice outline.

In Figure 3, the DEM has been turned off (unchecked), and the elevation data is displayed solely by the contour lines. The same warm to cool colouring system is used to differentiate the contour lines. The satellite image is 0% transparent, providing better resolution than the map in Figure 2. ArcToolbox is open showing the path to the *clip* function.



**Figure 3 - Elevation displayed as contour lines. Full resolution of satellite image.**

Spend some time adjusting your map with the *layer properties* dialogue boxes until you have the data arranged in such a way that you can determine ice-flow direction with confidence.

*Notes;*

1. *Please be mindful that DEM's in arctic regions have large cell sizes, and often contain errors. The DEM should only be considered as a rough approximation of relief. If the DEM relates information that seems to contradict what you see on the image, default to the image for ice-flow direction.*



### 3.3 Step 7 - Delineate the first ice-drainage basin

Familiarize yourself with the ice-cap/sheet that you are working on by navigating around the map and try to conceptualize the general ice-flow patterns. Begin by selecting an area where you are confident that you know exactly how the ice is flowing. Open the *view*, select *toolbars* and check the *editor*. Open the *editor* and select *start editing*. A dialogue will appear where you will select your empty polygon “newshapefile” as the edit target. Check the “newshapefile” box so that the polygon will be visible and adjust the layer (right-click, *properties*) so that it is hollow, and its border is easily identified. Set the *editor* toolbar task menu to *create new feature* and click the pencil. Draw the polygon around the ice-drainage basin you wish to delineate. Double-click to finish drawing.

Figure 4 shows a rough outline drawn around an ice-drainage basin. Contour lines and flow lines on the ice-cap’s surface have been used to separate this basin from its neighbors.

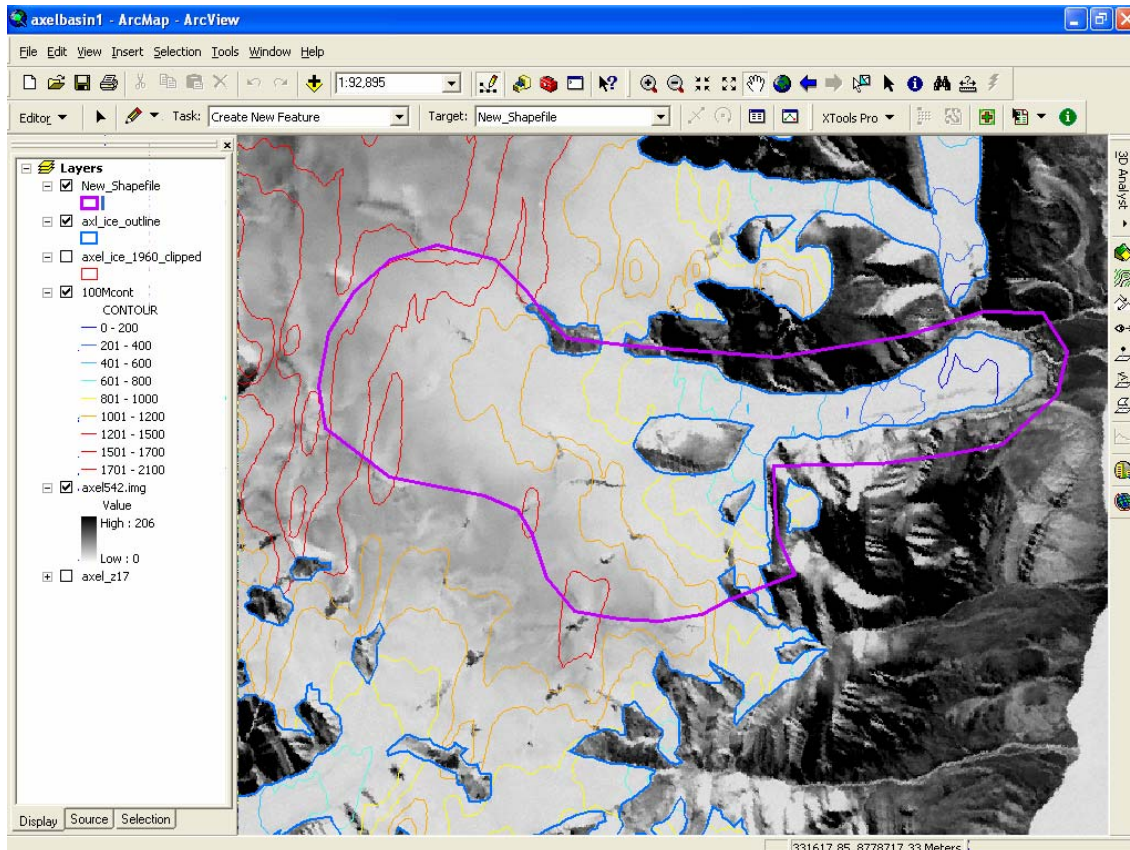


Figure 4 - Rough basin outline drawn.

Adjust the rough outline by selecting the pointer from the *editor* toolbar. Double-click the polygon border to show the nodes that may be moved or deleted. If need be, more can be added by right-clicking the line. As per Figure 4, try and get the line positioned accurately where it crosses glacier ice on an ice-divide. Simply place the line outside of the 1999 ice outline where it falls adjacent to the margins or terminus of the ice-drainage basin. When you are satisfied with your

polygon, select the *editor* drop down menu from the *editor* toolbar and select *save edits*, then select *stop editing*.

Now you must clip the “newshapefile” to the extent of the 1999 ice outline. You will follow the same procedure that you used to clip the contour lines in section 3.2. Open the ArcToolbox and select *analysis tools*, then *extract* and then *clip*. Use “newshapefile” as the layer that is to be clipped, use the 1999 ice outline as the layer that the clip is to be based on. Name the output file something like “basin1” and store it somewhere that makes sense. The cut-out is automatically loaded into your map, and as shown in Figure 5, the “newshapefile” has been cut to the dimension of the ice outline. Start the *editor* again specifying the “newshapefile” as the editing target. Select the outline of “newshapefile” with the pointer and delete it. You are going to re-use this shapefile to create the next ice-drainage basin, and you don’t want any part of it left-over from “basin1”.

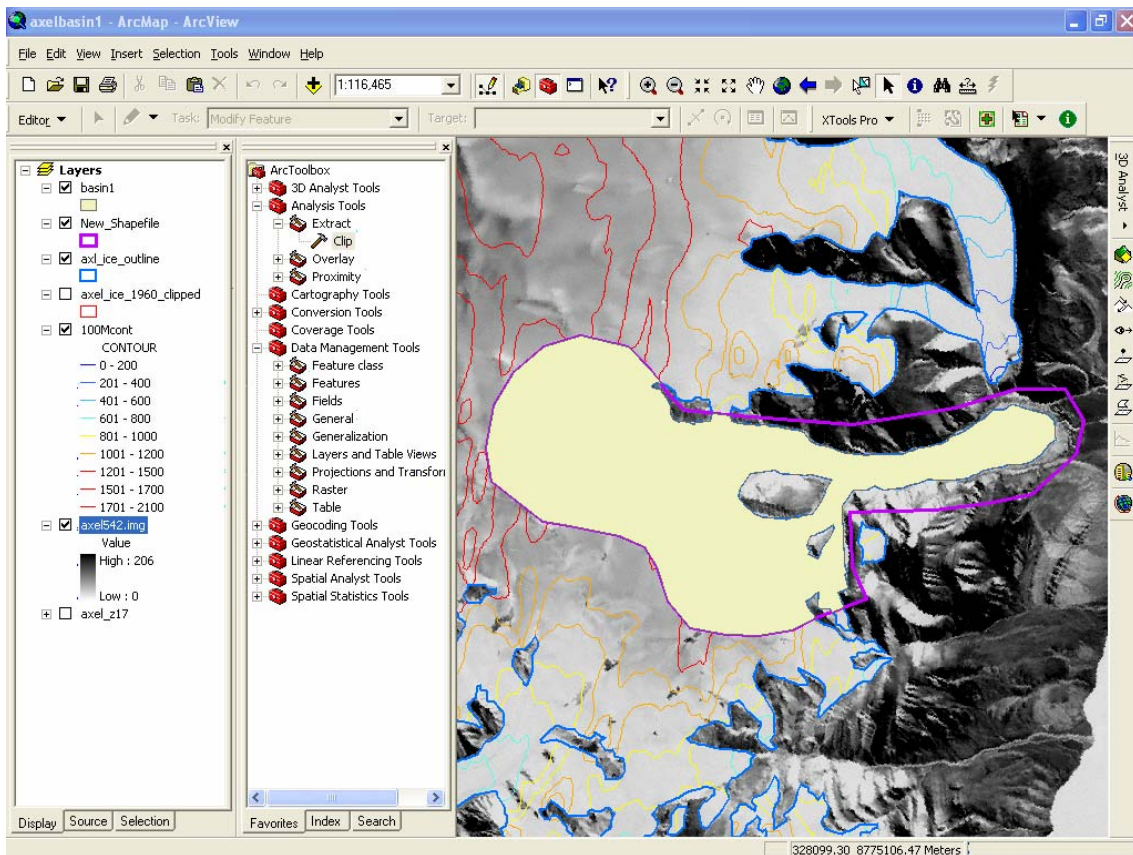


Figure 5 - “basin1” is clipped from the “newshapefile”.

Notes:

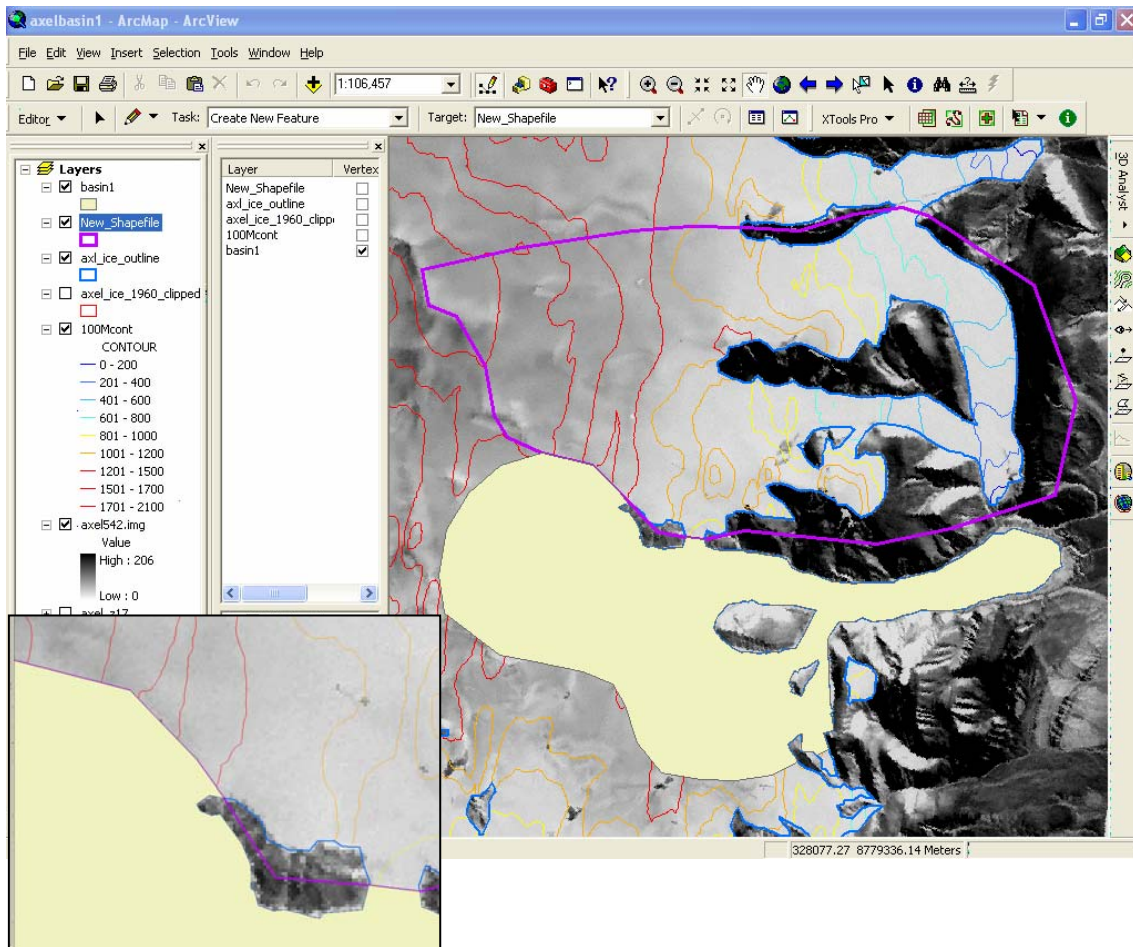
1. If you find that the 1999 ice-outline is not accurate, you may edit the outline the same way that you would edit any other shapefile. This is true for ice-margins/termini, and especially nunataks within the ice-cap/sheet. To exclude a nunatak area from the ice-outline you must arrange the ice-outline shapefile such that the nunatak appears through a hole in the ice-outline. Do this by grabbing two nodes of the ice outline and overlapping them so a loop is formed. Select cut

- polygon features *from the editor menu to cut the loop free. Edit the loop so that it defines the nunatak area and re-shape the edge from which you cut the loop.*
2. *Make any modifications to the ice-outline in an area where you are about to define an ice-drainage basin BEFORE you define the basin. This will save you extra work.*
  3. *If the basin you are delineating has nunataks isolated within it you must push the explode multi-part feature button on the advanced editor toolbar. Do this while you are in an edit session, but after you have clipped the basin from the 1999 ice-outline. This will ensure that the nunatak outlines are not attached to the basin outline surrounding them.*
  4. *If point 3 above doesn't work, you can isolate nunatak outlines from the main polygon by using AcrCatalog to create an empty polyline shapefile. Open ArcView with a new empty map and add the empty polyline and the polygon shapefiles to the map. Turn on the editor and copy & paste the polygon into the polyline. Hit explode multi-part feature when the polyline is highlighted. Convert the polyline projection to WGS 1984 and move the file to the GLIMSReadyBasins folder. Name the file accordingly.*
  5. *Remember that you are delineating ice-drainage basins, not water-drainage basins. Ice flows plastically whereas water flows fluidly. Several programs, including ArcView 9.x will model fluvial drainage basins, but these models are based on flow following the steepest path. Ice does not always follow the steepest path. Furthermore, arctic ice often terminates in a piedmont or lobe while a fluvial drainage basin will terminate at a point. Lastly, the DEM is often wrong causing any model based on it to also be wrong.*

### **3.4 Step 8 - Delineate the rest of the ice-drainage basins**

With a few extra steps, you may follow the procedure outlined in section 3.3 to delineate the rest of the ice-drainage basins. The extra steps will ensure that any new ice-drainage basin that you delineate will adjoin the existing ice-drainage basins exactly in places where they share a common boundary.

To do this you begin creating the ice-drainage basin by editing the “newshapefile”. Click the *editor* menu and select *snapping*. Select the *vertex* of the neighbor ice-drainage basins as the snap-to targets. In Figure 6, the vertex of “basin1” has been selected. Start creating the basin by editing the “newshapefile”. You will notice that when your cursor approaches a node of “basin1” it will go to it automatically like a magnet. You can adjust the degree of “magnetism” in the *editor options* dialogue. You can zoom in and out while editing and you may need to zoom in to ensure that common boundaries between “newshapefile” and existing basins match exactly. When you have finished creating your basin, adjust the “newshapefile” layer so that it is hollow, and the border is thin. Then you can zoom into areas of common boundaries to ensure that there are no slivers, overlaps or gaps. Problems are common in areas where 1) the shape is complex, 2) where two basins adjoin and abut against an area of rock, 3) in areas where ice-drainage divides are separated by a nunatak, and 4) where nodes are placed very close together.



**Figure 6 - The second basin borders the first. The common boundary is *snapped* together so no gaps, slivers or overlaps exist (inset).**

Now you must clip the second basin following the procedure you used for the first as outlined in section 3.3. Call the basin “basin2” and store it in the same folder where you stored “basin1”. Continue delineating ice-drainage basins until the entire ice-cap/sheet is completely covered. If you find that too much processing power is being used to render all the basin shapefiles, you can remove shapefile layers from your map that are not adjacent to the area in which you are currently working.

*Notes:*

1. Notice that the second basin in Figure 6 is formed from two confluent glaciers. In this case we define the basin as one, because a basin represents all the ice that is flowing toward a single glacier terminus.

### **3.5 Step 9 - Merge the basins together into one shapefile**

At this point you have probably created several hundred drainage basins. To check the integrity of your data you could add all the drainage basins to your map and look for any parts of the 1999 ice-outline that are not covered by an ice-drainage basin. This is effective but rendering so many shapefiles at once

demands a lot of computing power and is very slow. Since you will probably want to view your entire dataset many times, it makes sense to merge all the ice-drainage basins into one large shapefile that can be rendered quickly, and turned on and off easily.

Merge the basins by opening ArcToolbox. Select *data management tools*, then select *general* and then select *append*. Add all the basins you have created as *input features*. Select your “newshapefile” as the *output feature*, or the feature to which all the basins will be appended (make sure you have edited the “newshapefile” such that it is empty or clean). You can then re-name the “newshapefile” as something like “icecapmerge”. Figure 7 shows the merged basins for Axel Heiburg Island.

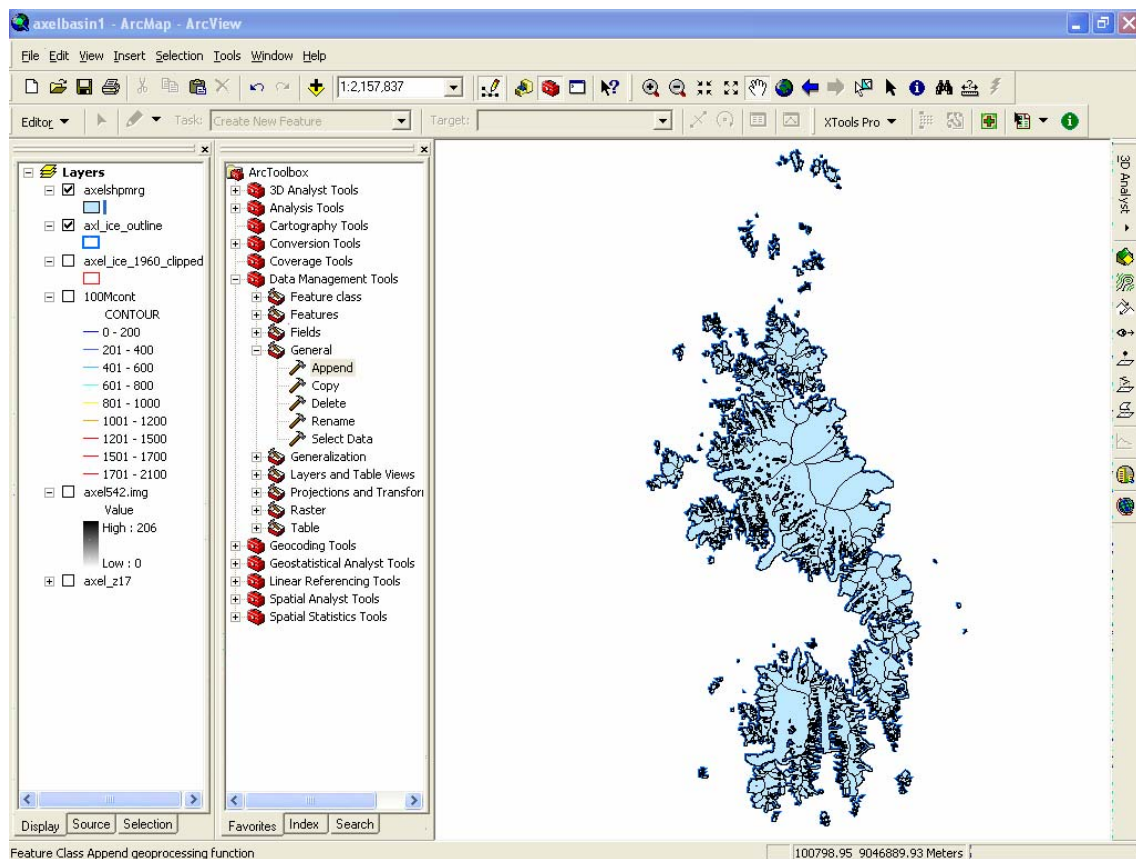


Figure 7 - Merged basins for Axel Heiburg Island.

### 3.6 Step 10 - Change the projection of the basins

All the ice-drainage basin polygons you have created thus far have a projection that is either UTM, or undefined. This must be changed because the GLIMSVIEW software that you will use to assign attributes to your ice-drainage basins will only accept shapefiles that are in the WGS 1984 geographic projection.

To change the projection of a shapefile you must open the ArcToolbox and select *data management tools*, then select *projections and transformations*, then select *feature*, then select *batch project*. Add all your drainage basins as *input features*,

and select an *output workspace* for the newly projected shapefiles to go. Click the button next to the *output coordinate system* and choose *select*, then choose *geographic coordinate systems*, then choose *world*, and select *WGS1984.prj*.

*Notes:*

- 1. The output workspace for the newly projected shapefiles should be a separate folder from the one in which the basin shapefiles currently reside. You will want to separate the WGS 1984 geographic projected shapefiles from the undefined or UTM projected shapefiles. Creating a folder entitled "GLIMSReady" is appropriate because these shapefiles are ready to be imported into GLIMSView. This folder should be created at the same level in the folder hierarchy as the original basin shapefiles folder so that the data progress can be assessed in one view of your file navigator.*
- 2. Some shapefiles will require that their projection be defined before they can be re-projected. If this is necessary, select define projection from the ArcToolbox menu and assign the projection as whatever it currently is. You can find out what a shapefile's current projection is by right-clicking on it in the layer menu and opening properties, then selecting source. Alternatively, you can find out the current projection by viewing the metadata of a shapefile in ArcCatalogue.*
- 3. Sometimes the batch process doesn't work. It may be necessary to project each shapefile individually, or in small batches.*

### **3.7 Step 11 - Save and back up everything you have done so far**

Congratulations! You have finished delineating drainage basins for an ice-cap/sheet and you are ready to begin assigning attributes to the basins using GLIMSView. Do not forget to back up your data in a separate location from the one in which you have created it. If you have been working on the GLIMS2 server, copy everything you have done to your folder on the D:\ drive of the machine you are working on.

## **4.0 Assigning Glacier Attributes in GLIMSView**

The free-ware program GLIMSView will be used to assign attributes to the glacier drainage basins you have created. GLIMSView is not as sophisticated as ArcView, and in many ways the current version is insufficient for assigning attributes to arctic ice-drainage basins. For example, if you were to import all the ice-drainage basins for a particular ice-sheet at once, you would have trouble assigning attributes to any one basin because you can not specify the edit target. In areas of common boundaries, you would not be able to identify or control which boundary you are editing. For this reason, among others, you will import and export one basin at a time from the GLIMSView edit session.

GLIMSView always exports files with the same file names. To prevent GLIMSView from overwriting your last basin with the current one, you need to create separate output folders for each of your basins. Create one folder for every basin that you have delineated and give the folder the basin name. Place all of these folders in a higher-level folder that is entitled something like "GLIMSOutput".

#### **4.1 Step 13 - Configure the glacier basin in GLIMSVIEW**

Open GLIMSVIEW. Select *project* and then select *create new project*. When the dialogue box appears, browse for the satellite image you used in ArcView. Load the various bands with a red-green-blue combination that highlights the glacier ice. Alternatively, and if it provides a better visualization, load a grayscale of the image. Close the *band chooser*. Push the gear button to open the *configuration* window. Select *window* and choose *tile* to arrange the windows in a tile pattern.

Practice navigating in GLIMSVIEW by zooming in and out of the various windows and dragging the zoom box around in one window as it controls the view in the other. The “whole view” window stays “as is”, and provides an overview of your current location.

Select *project*, then select *import/export*, then select *import generic shapefile*. In the dialogue box that appears, browse for the WGS 1984 geographic projected “basin1” file that you have recently created and import it. Navigate the map so that the “basin 1” is completely contained within the *fixed* window, and the *zoom* window shows a zoomed view of the glacier source area.

Select *glacier config* from the *configuration* window and press the green “ID” button on the toolbar. You are now going to put a point feature within the source area of your glacier-basin by clicking within the basin outline. Try and put the point over thick, source-area ice. The database is being created for posterity, and if you put the glacier ID in a position from which the glacier will retreat in 20 years, the ID is useless. Notice that a glacier ID (GID) appears in the *configuration* window when you put the point on the map. This is the GLIMS ID for “basin1”. All information about this glacier basin will be identified with this ID from this point forward. Figure 8 shows a properly adjusted GLIMSVIEW screen, with a glacier ID set in an appropriate position.

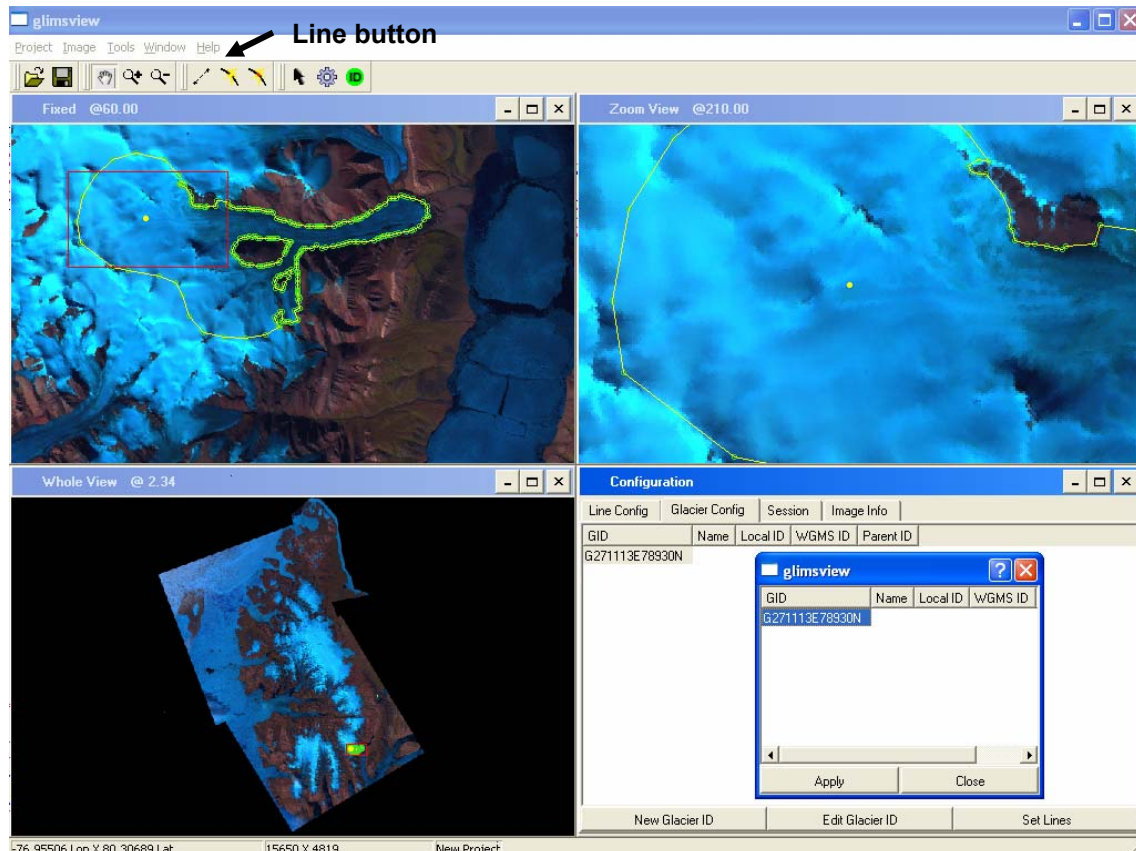
Press the line button followed by the pointer button. Select the outline of “basin1” by dragging the pointer across it, and press the *set lines* button in the configuration window. Highlight the GID of “basin1” (only one GID should be available) and press *apply*. What you have just done is assign the same GID to every segment of your basin. Now the basin segments and all associated attributes can be identified by the GID.

Highlight the glacier ID in the *configuration* window. Press the *edit glacier ID* button to open the glacier ID dialogue box. The options available in this dialogue box will be used to describe your glacier basin. Most descriptors are available through drop-down menus, but others you must enter manually. At this point, you should consult the glacier classification documentation that you have downloaded from the GLIMS website. Familiarize yourself with the choices that are available and classify the glacier as accurately as you can. It is understood that not every glacier basin can be pigeon-holed into the short list of categories that are available, but please try and be consistent with your choices.

Width, length and area of a glacier basin can be calculated in ArcView. Also, the *tongue activity* must also be assessed in ArcView by comparing the 1999 ice-outline with the 1960 ice-outline.

Notes:

1. It is helpful to keep ArcView running at the same time that you are doing the GLIMSVIEW work so that you can assess these attributes easily. It is best to work on a computer with two monitors so that you can run GLIMSVIEW on one and ArcView on the other.



**Figure 8 - GLIMSVIEW screenshot showing proper arrangement of the windows and proper placement of the GID. The configuration window is open and the GID is about to be applied to the selected lines.**

#### **4.2 Step 14 - Configure the glacier basin outline in GLIMSVIEW**

Select the *line config* tab in the *configuration* window. A list will appear containing a line segment descriptor matrix. You are going to break your ice-drainage basin outline up into segments that are assigned different combinations of descriptors according to the options available in the *line config* descriptor matrix. Since many segments will have the same descriptors, you can adjust the choices in this list so that a row in the matrix will have attributes (column choices) that are shared by many common lines. It is safe to assume that the choices in the default arrangement are wrong, so highlight each row and select *edit* to adjust the choices in a way that makes sense to you.



At this point you should refer to the GLIMS documentation to understand the meaning of the choices that are. However, Figure 9 shows a particular *line config* matrix that was used on several arctic ice-caps with success. You may wish to copy this arrangement.

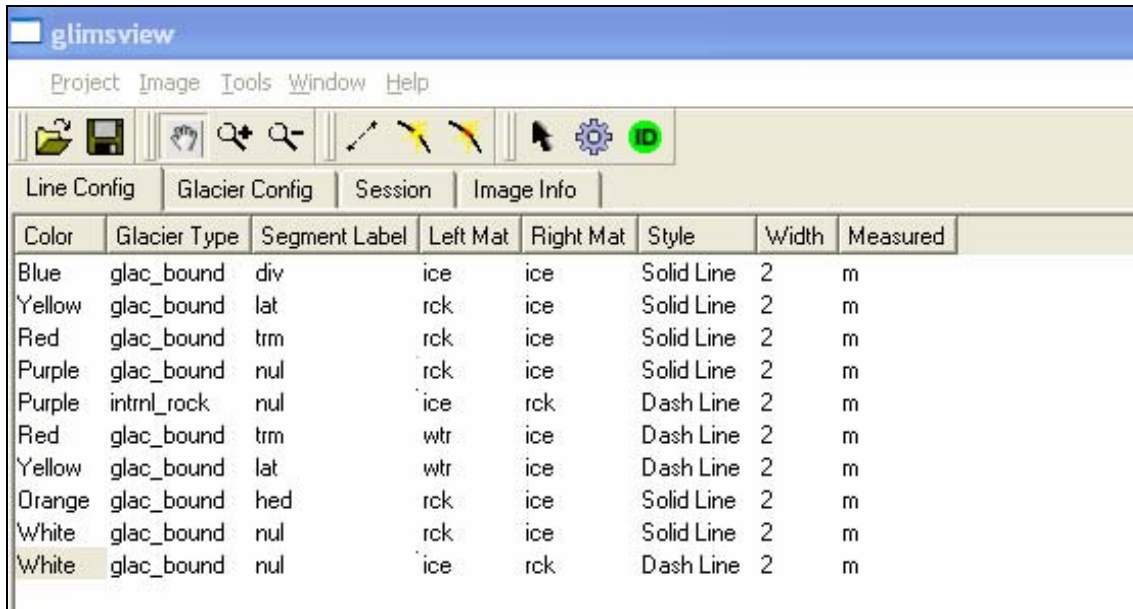


Figure 9 - A useful line config matrix.

The first row is used to describe a glacier ice-drainage divide that is internal to the ice-cap. The second row describes the lateral margin of a glacier basin. The third row describes a glacier basin terminus. Row four describes an area where a glacier ice-drainage divide abuts against a nunatak. The nunatak separates two glacier ice-drainage basins, thus the text “glac\_bound” is found under the *glacier type* column and not “intrnl\_rock”. If you use “intrnl\_rock” to describe a nunatak that separates two ice-drainage basins, the program will not be able to recognize the perimeter of the basins. All basins must be defined on their outside perimeter by segments that are all categorized as “glac\_bound”. Row five is used to describe nunataks that are enclosed completely in a glacier basin. Note that row five has the text “intrnl\_rock” in column two. The program will not try and associate the internal rocks with a glacier boundary perimeter, but instead, will keep these rock outlines with the glacier basin in which they lay. Row six describes a glacier that terminates in water. Row seven describes a glacier margin that is flanked by water (such as an ice-marginal lake). Row eight describes a glacier head (such as a cirque headwall). Row nine is used for any segment that does not fit into any available category. Row ten has not been set up, and contains only the default attributes that it was originally assigned. Row ten is not used at all in this example.

The screen-shot in Figure 10 provides a closer look at the *line config* edit dialogue box.

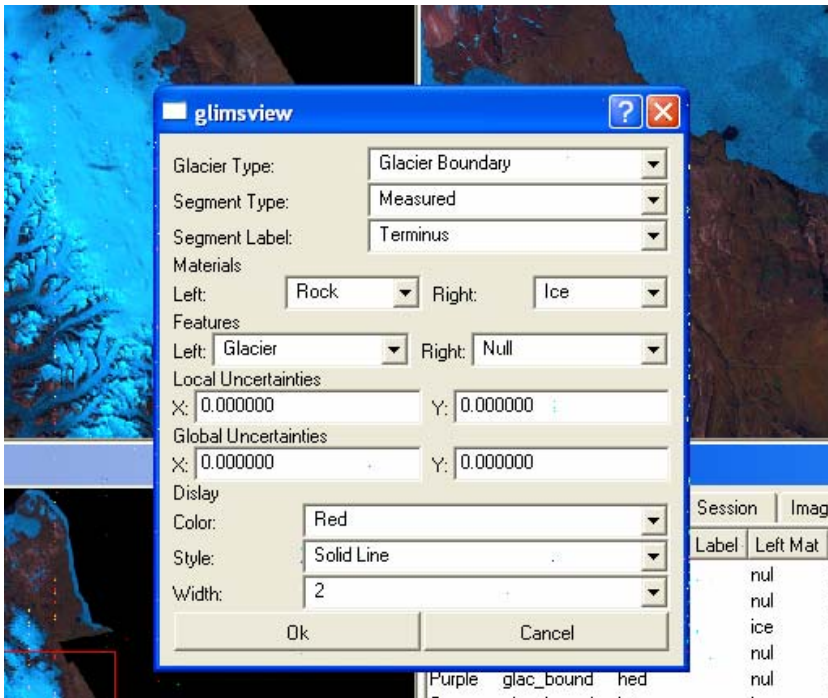


Figure 10 - Line config edit dialogue box.

The first option *glacier type* is where you will define the type of boundary you are drawing. The choices that you make here will depend on the level of detail that you wish to include, but please remember that every ice-drainage basin must be enclosed by “Glacier Boundary” lines. All internal rocks that do not separate ice-drainage basins must be enclosed by “Internal Rock” lines. The “Basin Boundary” definition is for bedrock basins - something that is generally not defined for the massive arctic ice-sheets.

The *segment type* option can generally be assigned as “Measured”. This is because the ice outlines have been created by remote-sensing and computer processing and thus, are very accurate.

The *materials left* and *materials right* options refer to what is on the left and right of the line you are drawing. ArcView 9.x draws polygon lines in a clockwise direction. Thus you must assign the materials to the right and left accordingly. If you have created the basin polygons in ArcView 3.x, refer to Appendix One for information about determining the direction of a line.

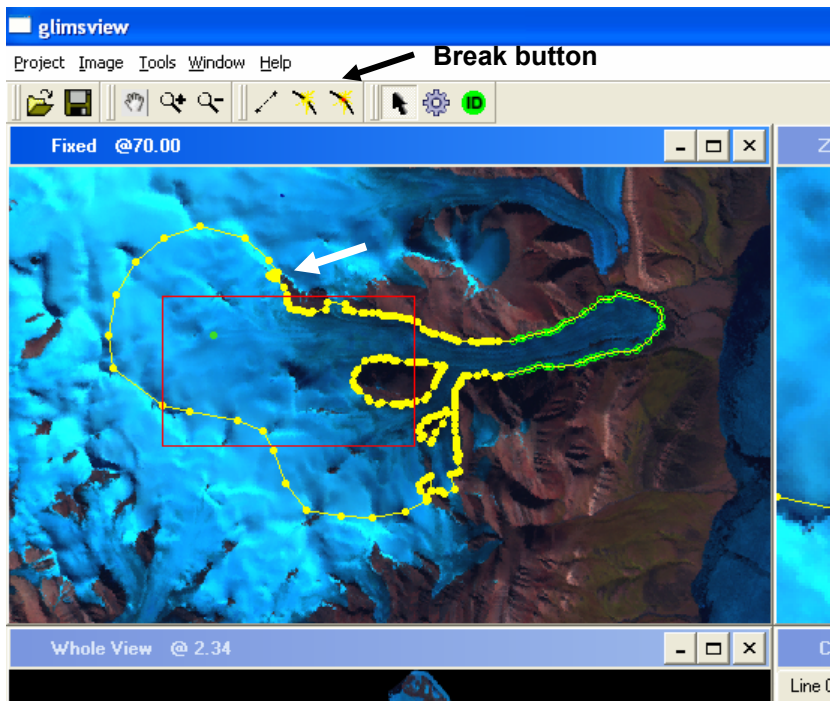
The *features left* and *features right* options are selected in a similar fashion to the *materials left* and *materials right* options.

The *local uncertainties* options may all be set to zero. This is because we have not assessed what our uncertainties are. A value of zero is the same as a null value in the GLIMSVIEW database.

The *display* options may be set according to personal preference.

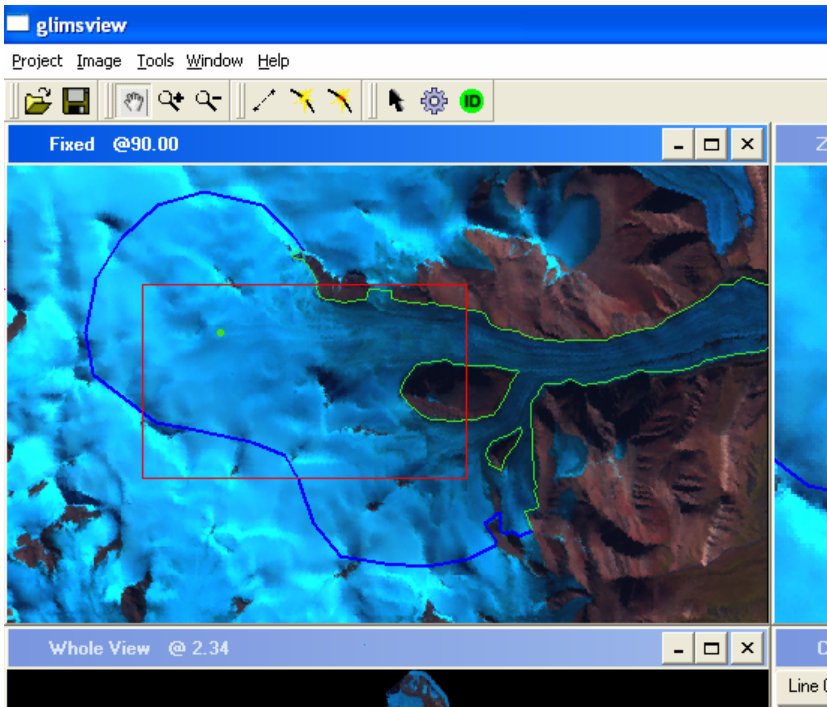
You may wish to set up all the *line config* options before you begin assigning attributes to various lines, or you can set up the *line config* options while you are assigning the attributes. The latter option is recommended because it will allow you to make choices based on what you actually have in the data, rather than making the choices based on what you think you may have. The *line config* options can develop organically under this circumstance. Expect the first few basins to go rather slowly while you fine-tune the *line config* options, but once adjusted, this process will be very quick as you assign pre-defined lines to your glacier basin outline segments.

To assign attributes to a line segment you will begin by pressing the *line* button, followed by the *pointer* button on the GLIMSVIEW toolbar. Then click and drag the pointer across the glacier basin outline to highlight the outline and its nodes as shown in Figure 11.



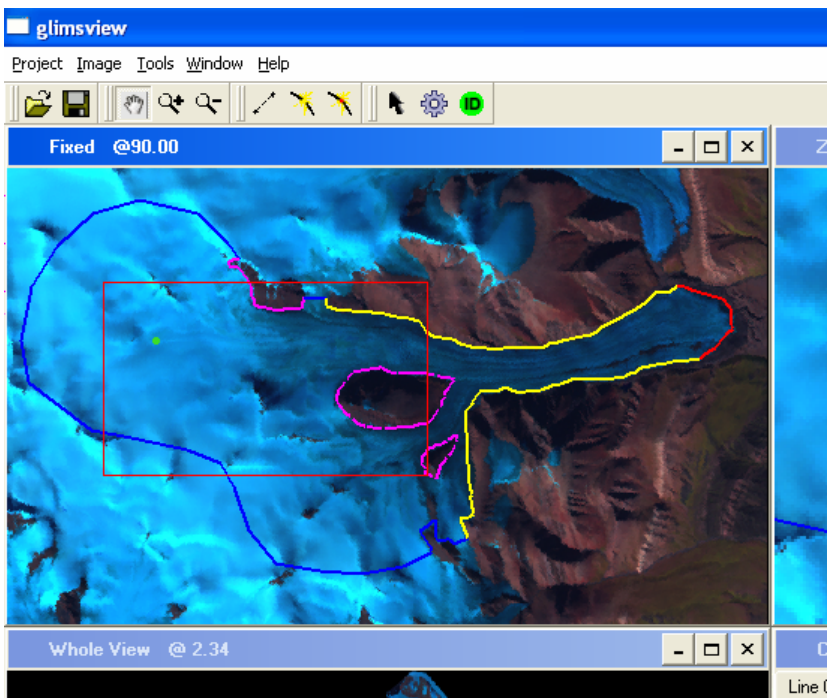
**Figure 11 - Glacier outline is ready for editing.**

Identify a node that represents a transition between line types. In Figure 11, the white arrow points toward a node that represents a transition between an internal ice-divide and an outlet glacier's lateral margin. Select the node by holding the pointer over the node and clicking. You will notice that you can only select a node when the pointer turns into a target shape. Break the line at this selected node by pressing the break button on the GLIMSVIEW toolbar. Break the other end of the ice-divide segment as well. In Figure 12 the ice divide has been broken out of the original basin outline and has been classified as an internal ice-divide within the main ice-cap.



**Figure 12 - Blue segment has been given ice-divide attributes.**

Continue breaking out and classifying segments until every segment has been assigned attributes. Figure 13 shows how the example ice-drainage basin should be classified.



**Figure 13 - A properly classified ice-drainage basin.**

In Figure 13 the lines represent segment attributes as follows: the blue line represents an internal ice divide; the yellow line represents a lateral margin; the red line represents a glacier terminus; the solid purple lines represent nunataks that separate ice-drainage basins; and the dashed purple lines represent nunataks that are completely enclosed within an ice-drainage basin.

*Notes:*

1. *GLIMSVIEW is very touchy. If you try and select a node and the pointer is not directly above the node, it will suck the node towards the pointer, thereby changing the shape of your basin.*
2. *You can undo a mistake in GLIMSVIEW by pressing CTRL-Z.*
3. *If you need to join two line segments, you can do so by highlighting the two loose ends and pressing the weld button (next to the break button).*
4. *You can draw segments in GLIMSVIEW by pressing the line button.*

### **4.3 Step 15 - Export the completed basin from GLIMSVIEW**

Now that the ice-drainage basin's glacier attributes and line attributes have been defined, export the data by selecting *project*, then *import/export* and finally *export GLIMS shapefile* from the GLIMSVIEW toolbar. Choose the "basin1" folder that you have already created for the GLIMSVIEW output.

If you navigate to this folder with your file navigator program, you will see that it contains many files that are generally organized under the headings "glaciers", "segments", "image", and "session". There is a .dbf (database) file under each of these headings that contains most of the information for the basin that you have assigned to it in GLIMSVIEW. If you open the "glaciers" .dbf, you will see a database that contains the glacier classification information that you have entered, although here, it is in numerical format. If you open the "segments" .dbf, you will see a database that contains the segment classification information that you have entered, also in numerical format. You can change values here, but you must refer to the GLIMS manuals for an explanation of the numerical format.

Notice that every line segment has the same GID as the glacier with which it is associated. The GLIMSVIEW database will use the GID to keep line segments, segment attributes, and glacier attributes together.

Eventually you will merge all the "glacier" files and "segment" files for every basin into one large file. After the merger, the "glacier" and "segment" .dbf files will contain a number of rows corresponding to, respectively, the number of glacier basins and segments that you have created. Ignore the "image" and "session" files for now. These files need only be updated once for the entire ice-cap. The "image" files describe your satellite image. The "session" files refer to the person who did the glacier classification (that's you) and the process by which they did the work.

When you have finished exporting the data, select every line on the GLIMSVIEW display and delete them. Then press the green *GID* button, followed by the pointer button and select the green GID dot. Delete this feature as well. You are

going to import, process, and export the next basin. Because GLIMSVIEW exports everything on its screen at once, you must not have any GID dots or segments left over from an older glacier classification session.

Continue *ad nauseam* until every ice-drainage basin is done.

## **5.0 Validate the Data in GIS and Prepare it for Upload into the GLIMS Database**

Now that attributes have been assigned to the ice-drainage basins, they must be merged, corrected, and transformed into a format that can be ingested by the GLIMS database.

### **5.1 Step 16 - Merge the data using GIS**

Open ArcCatalogue and create two new empty shapefiles; one in point data format and the other in polyline data format. Place these new files at the same level in the hierarchy as the folders which contain the GLIMS output data. Name the point shapefile “glac\_mrg”; name the polyline shapefile “seg\_mrg”.

Open ArcMap and set up a *new empty map*. Choose the WGS 1984 geographic projection and call the map something that makes sense like “GLIMSOutput”. Open the ArcToolbox and select *data management tools* followed by *general* followed by *append*. In the dialogue box that appears add, as input features, each of the “glacier” shapefiles from the GLIMS output folders. Select the “glac\_mrg” shapefile as the output feature or, the feature to which the input features will be appended. Execute the merge.

Follow the steps outlined above to merge the “segments” shapefiles for every basin. Choose the new “seg\_mrg” file as the file to which the input features will be appended.

Add the “seg\_mrg” file and the “glac\_mrg” file to your map and remove all other segment and glacier files. Save the map.

### **5.2 Step 17 - Validate the data (basic)**

Now the data must be validated. GLIMSVIEW is a poor tool for manipulating shapefiles. The program, most likely, will have generated errors in both the shapefiles and the .dbf files. The data can be validated using ArcMap. Open the map that you have just created in section 5.1 to begin validating the data.

There are many aspects of the data that are worth checking, but most importantly, you want to ensure that the polyline shapefiles outlining the glacier-basins were not altered from the original polygon shapefiles during the GLIMSVIEW editing session. You also want to ensure that the attributes you assigned to each line segment and glacier have been exported correctly from GLIMSVIEW.

Begin validating your data by giving it a general “once-over” check. Add the “icecapmerge” polygon shapefile that you created in step 9 (section 3.5) to your map. Adjust the map such that the “icecapmerge” layer is under both the “seg\_mrg” and “glac\_mrg” GLIMS output shapefiles. Navigate around the map to see if there are any areas where the “seg\_mrg” polylines are not directly over the “icecapmerge” polygon boundaries. If you happen to find errors in the polyline shapefile, you can correct them by editing as you would edit any shapefile. Specify the “seg\_mrg” polyline as the edit target and specify the “icecapmerge” polygon’s vertices as the snap-to target. Now you may snap the misaligned polylines back to their original positions as per the polygon boundaries. While giving the data a “once-over” check, you may also wish to look for missing glacier ID points, extra unidentified polylines, or anything else unusual.

If everything looks good during the “once-over” check, and there are no glaring problems, it is time to begin checking the data more thoroughly. Right-click the “glac\_mrg” layer and open its *attribute table*. The attribute table of any shapefile is the .dbf file that you will find associated with the shapefile if you navigate to its location in the file hierarchy. You may scroll through the attribute table and search for errors. You may also edit the attribute table directly if the *editor* is turned on, and the file you are trying to edit is specified as the edit target.

Errors you may find in the “glac\_mrg” attribute table may include 1) missing data (identified as a zero value where a zero value is inappropriate) and 2) corrupted data (generally hard to identify). Replace and repair missing and corrupted values.

*Notes:*

1. *GLIMSView may corrupt the data that you have entered for length, width and area by shifting the decimal point such that there is one digit to the left of the decimal and all the rest are on the right regardless of what the original number was. This is extremely frustrating, and there is no easy fix. You will have to go back to ArcMap to re-measure/calculate these values.*
2. *Zero is the default for a null-value in GLIMSView. Therefore zero may be an appropriate value for many fields. However, GLIMSView tends to “loose data”. The program then replaces the lost data with a zero value - BEWARE!*

When the “glac\_mrg” file has been repaired begin checking and repairing the “seg\_mrg” file. Open its attribute table and check for missing and/or corrupted data as you did for the “glac\_mrg” file.

Errors you may find in the “seg\_mrg” attribute table may include 1) missing data (identified as a zero value where a zero value is inappropriate) and 2) corrupted data (generally hard to identify). Replace and repair missing and corrupted data as you did with the “glac\_mrg” file.

*Notes:*

1. *GLIMSView may randomly drop the GID from individual segments. Scroll through the attribute table to identify segments with a missing GID. If you should*

*find any, you can highlight them individually in the attribute table, then right-click on the “seg\_mrg” layer name and click selection, then click zoom to selected feature. Now you can identify the proper GID by finding the GID dot that corresponds with the polyline that is missing its GID. Click the identify button on the ArcMap toolbar and click the GID dot. The GID will be available in the box that appears.*

2. *Again, beware of zero values.*

At this point, the values for both the “glac\_mrg” file and the “seg\_mrg” file have been corrected. However, the “seg\_mrg” polylines likely have geometry errors that you did not identify during the “once-over” check; because they were not visible at a small scale (i.e. the displacements are only visible when you are zoomed way in). Open the attribute table of the “seg\_mrg” file and highlight all the segments that correspond to a particular GID at once, starting with the first group of segments. Right click on the layer name of “seg\_mrg” and click *selection*, followed by *zoom to selected feature*. Now you can check to see if the polylines form a closed polygon (this is essential). You can also check to see if the polylines match the polygon outlines more thoroughly than you did during the “once-over” check. Edit as required. Do this for every group of segment polylines.

*Notes:*

1. *The snap function that you use to ensure polylines join other polylines or polygons at their vertices works best when the snapped line and the snap target are in the same projection. Re-project shapefiles with different projections. Change the map projection as necessary to ensure that the snapping is accurate.*

Now that the missing/corrupted data has been replaced/repared and the geometry has been, for the most part, corrected, you can perform a few basic visual checks on your data using the display features in ArcMap. Open the *properties* dialogue of the “seg\_mrg” shapefile. Under the *symbolology* tab select *categories* and choose *unique values*. In the *value field* choose “label”. Note that the choices in the *value field* are the same as the headers in the attribute table. Click *add all values* to add the segment labels to the list. You can adjust the colours of the segment to correspond with the colours that you used in the GLIMSVIEW glacier classification sessions. Click *OK*.

Your map will now display the “seg\_mrg” polylines with colours corresponding to the segment label. Navigate around the map to ensure the integrity of your data. If anything is labeled incorrectly, you can edit it in the attribute table.

Following the procedure outlined above, display the polylines according to their “category” values. The category should be one of two choices, “glac\_bound” and “intrnl\_rock”. Remember that “glac\_bound” polylines should completely surround every ice-drainage basin, and “intrnl\_rock” polylines should define nunataks that are contained entirely within an ice-drainage basin. Navigate around the map to ensure the integrity of your data and edit as necessary.



### **5.3 Step 18 - Validate the data (advanced)**

The data is nearly ready for submission. However, there are almost certainly, geometry problems still associated with the polylines. You can perform more thorough geometry checks using visual basic scripts (small programs) that people have written to solve just the type of problems that you are encountering.

Open your web-browser and go to the ESRI support centre homepage (<http://support.esri.com/>). Note that you can search both the “knowledge base” and the “downloads” pages for scripts and instructions that will help you deal with many problems that the default ArcMap tools aren’t capable of dealing with.

Some common geometry problems that are probably present in your data are dangles and slivers. Dangles are simply polylines whose ends are not snapped to other polyline ends. Slivers are small gaps between polylines where the polylines should abut exactly. Search these terms in the “knowledge base” and “downloads” pages to see how others have dealt with these problems.

Since the “knowledge base” and the “downloads” pages are constantly being improved and updated, it would be pointless to provide a list of useful scripts here. However, one useful download is called “X-Tools”. This is a suite of helpful tools that you may download for a free 30-day trial after which you must buy the program. The tools are useful enough that the purchase is worthwhile (talk to your supervisor). For instance, “X-Tools” will find dangles quickly if you use the *convert polylines to polygons* function. Because “X-Tools” can’t make a polygon out of polylines with dangles, it will identify the dangles with a graphic. Then you can easily find and repair the dangle. “X-Tools” will also calculate the area of a polygon or many polygons at once. Thus you could use the tool to calculate all the areas of your “icecapmerge” file at once. Then you could simply *join* the “area” column from the “X-Tools” output with your “glac\_mrg” file and you would not have to individually enter the area values during the GLIMSVIEW glacier classification session.

Benefit from the knowledge and experience of others by utilizing the information that is available on the ESRI support centre homepage.

You have now done as much with the data as you can possibly do. If errors remain in the data, there is very little chance that you can find them without help. Luckily, the people at the National Snow and Ice Data Centre in Boulder Colorado (The GLIMS people) have developed software that will identify errors in GLIMS data.

#### *Notes:*

- 1. Running some of the visual basic scripts requires that you know how to use the visual basic editor that is commonly available with Microsoft programs and ArcMap. Spending some time to learn how to run this feature is worthwhile.*

## **5.4 Step 19 - Upload the data to the GLIMS database**

Locate the “glac\_mrg” file and the “seg\_mrg” file using ArcCatalogue. Change their names to “glaciers” and “segments” respectively. In the same folder, add copies of any “image” and “session” files from one of the GLIMSOutput folders. Open the .dbf files for the “image” and “session” files and add/correct as much information in the various fields as you possibly can.

Navigate to the location of these files with your file navigator. Select all files that are associated with the “glaciers”, “segments”, “image” and “session” files and zip them together. Call the .zip file something that is related to the ice-cap/sheet you have been working on.

Make e-mail contact with Bruce Raup ([braup@nsidc.org](mailto:braup@nsidc.org)) at the National Snow and Ice Data Centre and introduce yourself as the new GLIMS technician at the U of A. Inform Bruce that you would like to upload completed GLIMS data. Bruce will likely provide you with a GLIMS ID and password that will give you access to the GLIMS ftp site.

Open your web browser and go to the GLIMS ftp site (<http://glims.colorado.edu/submissions/>). Note that the University of Alberta is GLIMS Regional Centre 3. Follow the steps on this webpage to upload your zipped data. You will come to a page that asks for specific information about the image processing method. Enter the following information...

### General Image Data

- Make data available immediately
- Geocoding - YES (i.e. the image has lat/lon detail attached)
- Georegistration - NO (i.e. no ground points used to register the image - not enough in the way of suitable locations on an ice cap!)
- Orthorectification - NO (i.e. elevation data not accurate enough and topography not severe enough to merit this)
- DN to radiance - YES (i.e. radiometric conversion carried out prior to us getting the imagery)
- Sun elevation - NO (i.e. no attempts made to correct for solar angle - most of our images are summer, early afternoon when the sun was relatively high in the sky)
- Relative radiometric - NO (i.e. we did no additional radiometric correction)
- Atmospheric - NO (i.e. Arctic air is clean enough and the atmosphere thin enough not to require this for our purposes)
- Anisotropic - NO (i.e. no efforts made to accommodate different reflectance characteristics for different surfaces as most of our interest is snow/ice)
- Slope-aspect - NO (i.e. consideration made of shadowing on slopes)
- Band ratio - YES (i.e. Normalized Difference Snow Index applied in order to discriminate ice boundaries)
- Spatial filtering - YES (i.e. small ice masses below a threshold size identified by classification removed)
- Texture analysis - NO (i.e. no discrimination of ice based on textural differences to non-ice)
- Manual - YES (i.e. cleaning up of lines)
- % lines - you know how much you did, but I would say 10-15%

- Supervised classification - NO (i.e. no classification of regions based on training samples of specific known pixel types)
- Unsupervised classification - YES (i.e. classes determined on the basis of their similarity statistically using ISOADATA algorithm)

#### Process Description

- Landsat ETM+ images of the area were mosaiced using definable ground control points. A Normalized Difference Snow Index image was created ( $\text{band2} - \text{band5} / \text{band2} + \text{band5}$ ). A ratio image of  $\text{band2} / \text{band5}$  was created and added to the NDSI image. An unsupervised classification (ISODATA) with two classes was run on the combined image to discriminate snow/ice from non-snow/ice. Small areas of less than 0.1ha were removed from the classified image and a minimum filter run on the resulting image. The raster product was vectorised and cleaned up manually - the majority of this cleaning being to remove the outlines of small snow patches, amend the outlines of some internal rocks and clarify ice/water boundaries.

#### Analysis Tools

- GLIMSView
- ERDAS-Imagine
- ESRI-ArcGIS
- ENVI

Bruce will perform several checks on the data that you cannot perform. Quite likely, he will find errors that he will identify for you. You will then correct these problems and re-submit the data.

**Congratulations! You have completed your task. You have also provided the climatology/glaciology world with important data now, and into the future.**

# Appendix One

## ***Notes for drainage basin delineation for the Arctic ice caps using ArcView GIS 3.3***

**By Fiona Cawkwell**

Create a folder in GLIMS2 under your name where, for now, you can keep all your work. In this folder there are Landsat image files of Axel Heiberg

onsaxel\_ls99\_z17\_b1-5\_subset which contains the 30m Landsat visible/NIR data

onsaxel\_ls99\_b8 which contains the 15m Landsat panchromatic data

onsaxel\_ls99\_b542 which contains bands 5, 4 and 2 which are optimum for this

A folder containing the DEM data in the UTM zone17 format

Shapefiles of the ice extents in 1960 (from aerial photographs) and 1999 (from Landsat imagery)

There are also two Arc extension files (SnapThemes and snap\_adv) which need to be copied into the C drive of the computer you are using C:/ESRI/ARCVIEW/EXT32

### **Preparation**

Open ArcView GIS - for the first time – with a new view – subsequently with an existing project

Change the working directory to be the one where your data are stored

**File – Set Working Directory – x:\greg**

Add some extensions

**File – Extensions – check : Geoprocessing, IMAGINE support, Snap Theme v1.0, Advanced Snapping Tool**

For the first time add data to the view

**View – Add Theme – Feature Data Source – Axel\_ice\_1960 and 1999**

**View – Add Theme – Image Data Source – Axel542**

**View – Add Theme – Grid Data Source – Axel\_z17**

Change both the shapefiles to show just outlines

**Double click on filename - double click on coloured box – on fill palette select unfilled box and from colours, outline, e.g. green/blue – apply**

Make both shapefiles active by checking box beside name

Make image file active by checking box beside name

Increase number of classes in DEM

**Double click on filename – click on Classify – change number of classes to 30 – ok – apply**

Change order of layers so DEM is at the bottom, image above that, shapefiles on top

Set the View units

**View – Properties – Map Units = km, Distance Units = m**

**Work – focus on the main ice cap to start off with and use the DEM and image texture to delineate drainage basins**

Create a polygon roughly approximating to drainage basin area

**View – New Theme – Polygon – z.shp**

**Click on the draw polygon icon**  
**Draw rough outline of basin on the display**  
 Make the Axel\_1999 layer selected  
**Click on the Axel\_1999 filename**  
**Theme – Start Editing – Save Edits to z.shp**  
**Click within the Axel\_1999 ice outline on the display**  
 Clip the boundaries of the basin polygon to the 1999 ice outline  
**View – Geoprocessing Wizard – Clip one theme – next – Input theme = z1.shp, Overlay theme = Axel\_1999.shp, Output file = basin1.shp – finish**  
 Refine the basin boundaries  
**Turn off (uncheck) z1.shp**  
**Turn on (check) basin1.shp and change to just an outline**  
**Theme – Start Editing – Save Edits to Axel\_1999.shp**  
**Zoom to active theme**  
**Select the vertex edit tool**  
**Click within the basin1 outline on the display**  
**Move mouse cursor over vertex box and click and drag or delete to create basin of the desired shape**  
**If you make a mistake press Ctrl-Z to delete last change**  
**Theme – Stop Editing – Save Edits**  
 Click on z1.shp  
**Edit – Delete Theme**  
 Double click on basin1.shp and select the filled box option  
 Repeat ad nauseum until the ice cap is complete!

### **Other useful things to know**

Make sure there are no gaps between adjacent drainage basins, or between basins and the margin, by snapping the vertices together with the basin theme active

**Click on Snapping icon – Enable Snapping – Theme to snap to is either another basin or Axel\_1999.shp – Snap to vertex – Set snapping tolerance to 100 –set**

**Right click on image – select TTools Set Snap Theme – choose theme to snap to (as above) – ok – Snap to Vertex – ok**

**When you drag a vertex a circle will appear marking the 100m buffer so make sure that the vertex to which you are snapping is within the circle**

To clear selected features (when the basins are yellow the image) click on the clear features icon

Save the work you do as a project

**File – Save Project – x:\greg\axel.apr**

### **To edit GV files in Arc**

open segments.shp

run xyz2xy .ave script to convert to 2d file

open Convert Polyline to Polygon extension

run check dangle nodes to identify points of non-joined ends

snap dangles back together working through dangles in attribute table selecting one at a time to ensure all are done.

## Appendix Two

### ***GLIMSView Procedures (Older Version)***

**By R. Wessels**

Glimsview is a multi-platform application designed for manual digitization of glacier features into an ingest ready format for the GLIMS-NSIDC glacier database. This document briefly outlines a typical work flow, then demonstrates the specific steps used to digitize glaciers.

Glimsview was designed to be the base application that will later incorporate automated digitizing algorithms developed by the GLIMS Algorithms working group.

### **Work flow outline for creating ingest ready shapefiles**

1. Project -> New to open a new georeferenced image to start a new session
2. Tools -> Open config to setup line types
3. Digitize whole glacier polygon using line tool
4. Insert glacier IDs
4. Assign a glacier ID to the polygon
5. (Optional) Break polygon into specific types of segments related to segment label types, etc.
6. Enter ancillary data in appropriate database fields
7. Save project to a unique directory (**Please save often as the current version has no autosave feature!**)
8. Check the shapefiles using any shapefile viewer/editor
9. Compress the project folder and send to NSIDC for ingest

#### **Step by step recipe for creating an ingest:**

GLIMS view supports ASTER HDF-EOS and all formats supported by the GDAL library. It has been successfully tested using ASTER L1B, Landsat 7 (NLAPS, FastL7A and Geotiff).

On Windows: run gv.exe in the gvbin folder

On unix: run glimsviewer in the gvbin folder

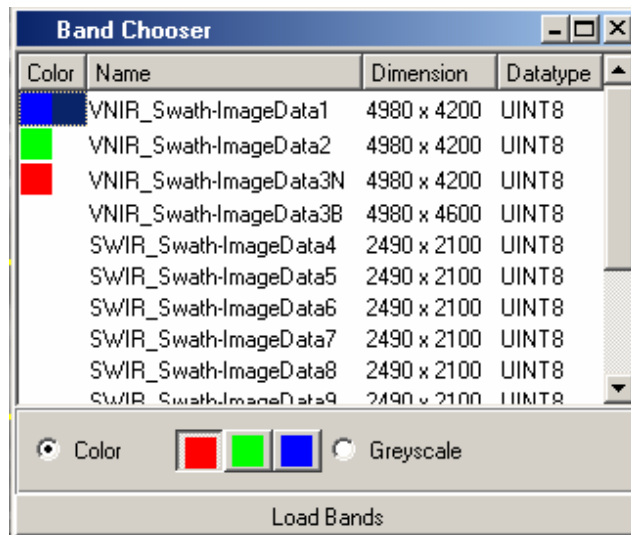
### **1. Open a georeferenced image**

To start a new session, open a new georeferenced image to be digitized:

Project -> New choose an image to display

Choose file for ASTER, \*\*\* for NLAPS, any\*.tif for L7 geotiff,  
and \*\*\* for FastL7A

Band Chooser window opens and displays all available bands



-Chose one band for grayscale;  
 -For Color, check COLOR box, then select the Red band, select the Green band, and select the Blue band (of the same dimensions), click “Load Bands”

-Whole View, Fixed, Zoom View windows may be moved and resized as desired. Select Window > Tile to make the image windows completely fill with glimsvew window space.

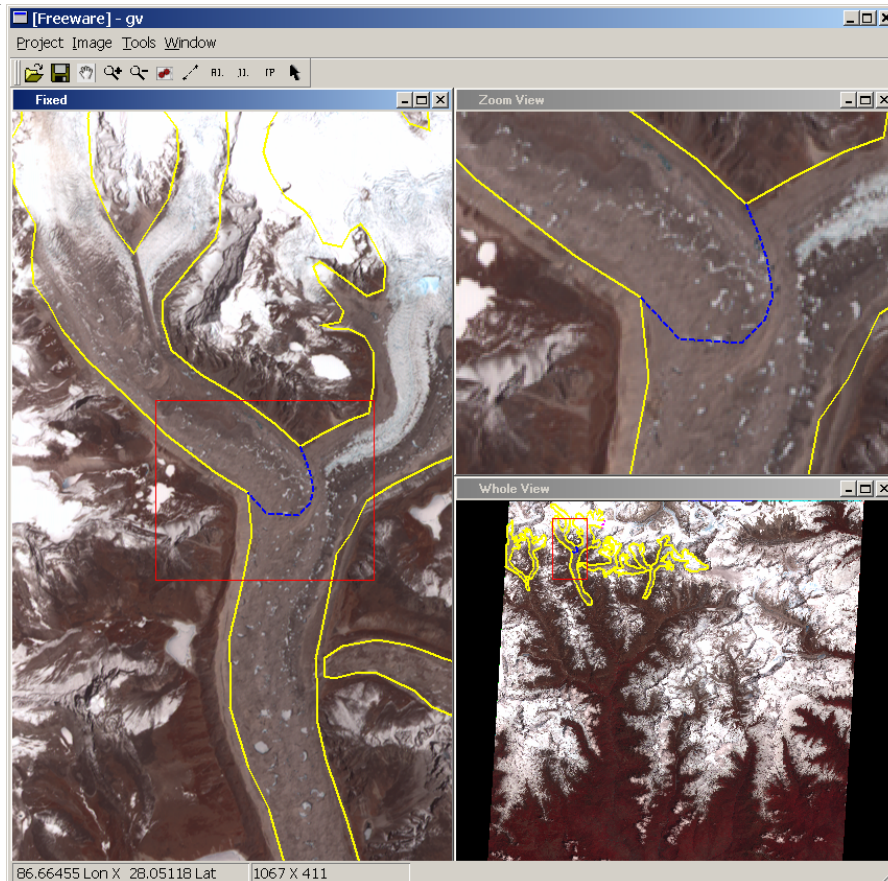
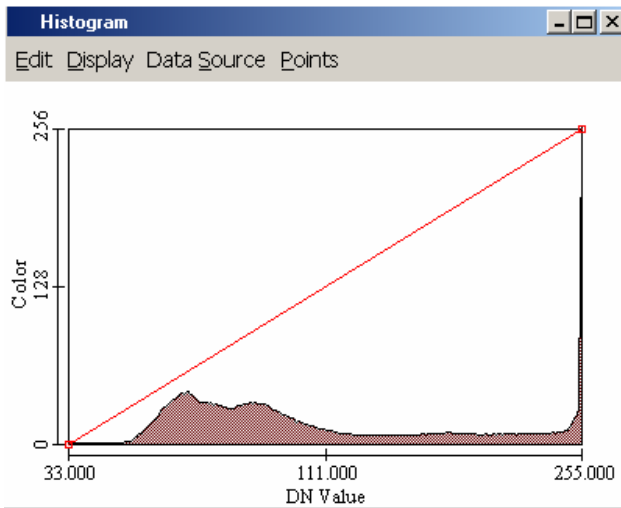




Image > histogram opens the histogram to adjust contrast stretch each displayed band.  
 To change the default stretch, double-click the diagonal line to make a new node.  
 The node(s) can be moved to create a custom piecewise stretch.



## **2. Configure line types in GLIMSLineTool (or import predefined attributes)**

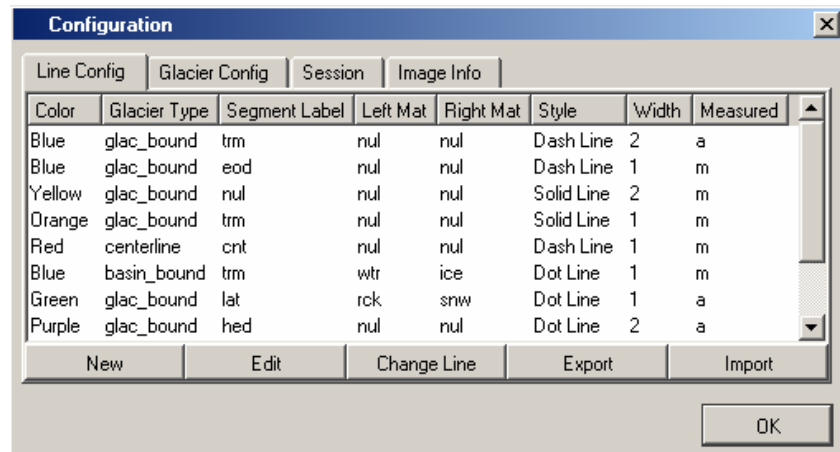
Before one can begin to digitize, various line types and attributes need to be defined to represent the types of glacier features and boundaries seen in the image. The *global.ldf* file in the *gvbin* folder is used to provide basic boundary types. Each Regional Center or User may modify and add to these types and export the new user defaults to a new *global.ldf* file (remember to make backup of the original).

To begin setting up the session, select from the main menu:

Tools> OpenConfig:

The Configuration window appears:

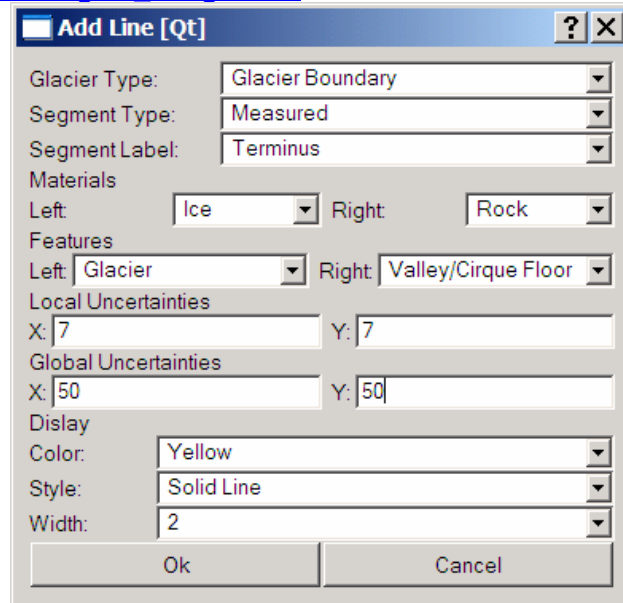
The user may edit default line types, create new line types, or import a previously exported line file.



Select an existing line to “Edit” or click “New” to create a new line type entry. Line types may be created or changed at any time during a digitizing session.

<!--[if !supportEmptyParas]--> <!--[endif]-->

See the GLIMS data dictionary for notes regarding database field requirements at: [http://www.glims.org/db\\_design.html](http://www.glims.org/db_design.html)



### **3. Digitize whole glacier polygon using GLIMSLineTool**

For each glacier, the user must first digitize the whole glacier as a closed polygon. The polygon may be divided into several specific segment types after the glacier ID has been assigned.



To begin digitization, choose the “Activate line layer” icon

Choose a line type in the line configuration window.

Select the left mouse button for each point to digitize in the polygon

To close the polygon Select Control-Right Mouse button

Each node on the polygon line may be moved using the “Selection Tool” arrow. First drag a box over the line to be selected. All of the nodes on that line will be highlighted as open circles. Individual nodes may be selected by a left click.

Nodes may also be inserted by first selecting the node where insertion is to begin, then click the “Activate Line Layer” icon, the left click the mouse where new nodes are to be inserted.

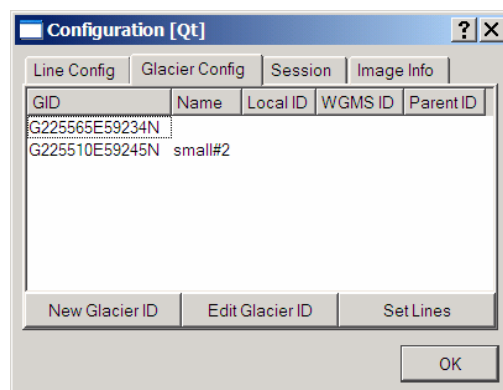
Selected nodes may be deleted by first selecting the node, then press the delete key on the keyboard.

**\*\*User Tip: Use "Control-Z" to undo your last edit if you make any mistakes.**

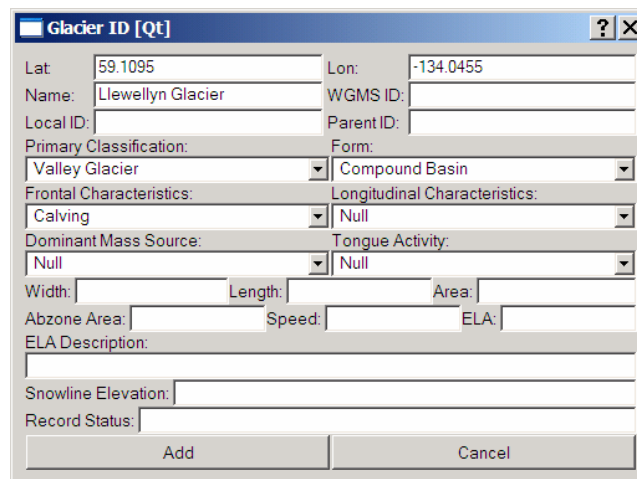
#### **4. Create and Assign a glacier ID to the polygon**

The minimum requirement for the glacier info is a Glacier ID based on the Latitude/Longitude position of a user selected center point on the glacier. This point may be selected from the image, or manually entered by the user based on another source.

A glacier ID is created using the “Activate GID Layer” icon in main toolbar. After the icon is selected, each left mouse click in any of the image viewers will add a new point to the view. Each point represents a new glacier ID (GID) that is automatically created and displayed in the “Glacier config” tab of the configuration window.



To relocate a glacier id,  
drag a selection box over the point to select it,  
left click the selected point when the cursor changes to a cross-hair,  
drag the point to a new location (the GID changes to reflect the new lat/lon).



Fill in the remainder of the Glacier ID form now, or add the information later using “Edit Glacier ID.”

Select “Add” to add the ID and close the window.

To assign a Glacier ID to a digitized feature or features, use the selection arrow to drag a selection box to select glacier polygons and other features associated with one GID. All node points in a feature will be visible when selected.

When all features related to one glacier are chosen,

Select the appropriate Glacier ID from the Glacier Config list

Press the “Set Lines” to associate the Glacier ID to those features

NOTE: Previously defined Glacier IDs with centers located off the current image may be manually entered using the “New Glacier ID” button. Simply enter the coordinates in the Lat and Lon fields and other associated data, then click “Add”. The new GID will appear in the GID list, **but** no point will appear in the viewers. Currently, manual edits of lat/lon values of GIDs that were selected using the viewer IP tool will not move the visible point in the viewer. This deficiency is related to an ASTER legacy issue. We will be addressing this in a future release of glimsview.

## **5. Break polygon into specific segment types related to segment label types, etc.**

Again, we strongly recommend that each glacier outline be **first digitized as one continuous polygon**. After the polygon is created and a Glacier ID is assigned, more detail about each glacier boundary may be specified by breaking the polygon into separate segments, each with its own attributes.

For example, if the interpreter wanted to add more attributes to only the terminus of a glacier:

Select the polygon to reveal the line nodes

Select a node for the start of the terminus

Break (Ctrl-B or the “BL” icon) the polygon at this node

Repeat for the other end of the terminus segment

Select the new terminus segment

Create or edit a terminus line type that describes the pertinent attributes

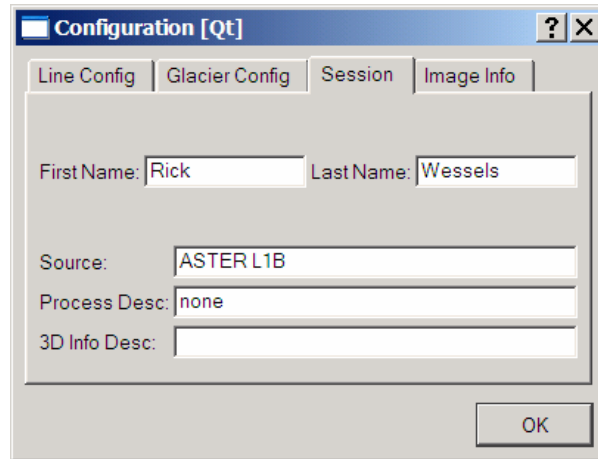
Select that line type in the line configuration list

Press “Change Line” to apply the new attributes to the selected segment.

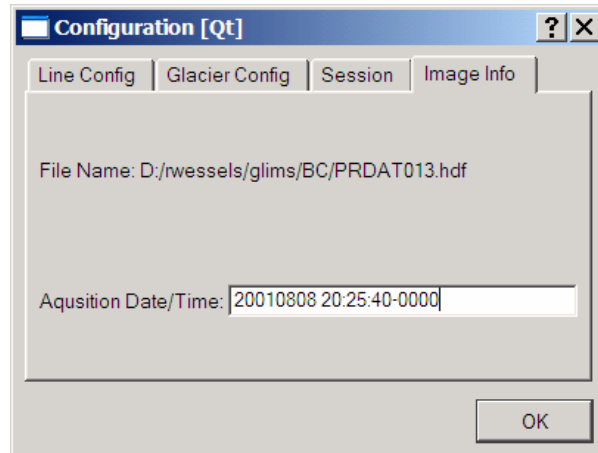
## **6. Enter ancillary data in appropriate database fields**

The Session and Image Info tabs contain several more fields that require input for a complete GLIMS Database ready file set.

The Session tab contains **several REQUIRED** fields about the interpreter name, data source, and processing description. The "3D info Desc:" field is used to describe where height (Z) information was obtained for each point. This field is not required if only 2D data were used.



The “Image Info” tab allows the input of the Acquisition Date/Time. This is done automatically for ASTER L1B data in the BETA version.



## **7. Save project to a unique directory**

Each project from a GLIMSVIEW session is stored in a unique directory. The directory contains GLIMS database transfer shapefiles and a “gvdataset.xml.” DO NOT CHANGE THE FILENAMES of files within this directory. Only the directory name should be changed.

The newly digitized data must be saved using “Project->Save As” from the main toolbar. When the “Find Directory” window appears, “Create New Folder” and click the “New Folder 1” to rename it for the new dataset. Hit “Enter” on the keyboard to change the dir name. Click “OK”

## **8. Check the shapefiles using any shapefile viewer/editor**

The newly created .shp files may be viewed using any application that allows the viewing of shapefiles ( Arcview, ArcGIS, ERDAS, ENVI, ArcExplorer [Free], etc ). Check the attribute tables for completeness and fill in missing items as needed. Check that each line

segment listed in the table has an associated GlacierID. Save these changes to the same shapefile.

### **9. Compress the folder and send to NSIDC for ingest**

After the files have been checked, they are ready to send to NSIDC for ingest into the GLIMS database. We suggest that the folder be first compressed into one archive. For example, in Windows, one may simply drag and drop the folder onto the Winzip (or similar app) icon and give a filename for the new archive. In unix, enter “tar cfz *newarchivefile.tgz projectfoldername*”. There are several other ways to accomplish this. Please see your local computer support for further help. After the archive(s) is created, notify Bruce Raup ([braup@nsidc.org](mailto:braup@nsidc.org)) to arrange for the transfer.

Please send questions or bug reports to [rwessels@usgs.gov](mailto:rwessels@usgs.gov) or [braup@nsidc.org](mailto:braup@nsidc.org)

\*\*\*Last changed on 6/6/03 by RLW\*\*\*