Exercise 2 (January 20, 2015)
Glacier volume assessment methods

Goals

1. Modell the ice thickness distribution and ice volume for the mapped glacier using GlabTop.
2. Calculate the volume of your mapped glaciers and those from different inventories according to the scalar methods presented.
3. Derive the ice volume of an inventory data set according to the volume-area scaling and the slope dependent thickness approach.

1. Modelling of ice thickness distribution with GlabTop

GlabTop (Glacier bed Topography) is a model for assessing the spatial distribution of ice thickness by estimating the glacier depths at several points along so-called glacier branch lines. This model is implemented in ArcGIS Model-Builder and requires only three datasets: a DEM, glacier outlines and branch lines. DEM and glacier outlines you have already from exercise A. You only have to digitize the branch lines for the respective glaciers to run the model. You find the GlabTop model here: http://www.geo.uzh.ch/~alinsbau/ihcap/level2/ex2_glacier_volumes/data/model_GlabTop.zip together with a documentation and a test dataset from the Swiss Alps.

1. Read the GlabTop documentation and explore the test data from the Swiss Alps
2. Create the required directories and add the input data (from exercise 1: your mapped glacier outlines and a DEM from the baseline data folder)
3. Create the branch lines for the four mapped glaciers

   Hint: Create a new shapefile and start an editing session. Follow the rules for the branch line digitizing from Paul and Linsbauer, 2012:

   - *The lines should be digitized from bottom to top (easier than vice versa) and perpendicular to the elevation contour lines.*
   - *They should end about 20-100 m before the glacier outline (at the bottom and top).*
   - *All important branches of a glacier should be covered. At confluence points, they should merge but without snapping.*
   - *Local surface structures, which are related to erosion or accumulation processes (e.g., moraines, lakes, water channels, moulins), should not be crossed.*
   - *For the tongues of larger valley glaciers, the branch lines should be digitized in parallel (one line for every 200–400 m of glacier width).*

4. Try to run the GlabTop model according to the documentation.
5. Examine the generated output files and the values about ice thickness and volume in the attribute table.

2. Estimating glacier volume with scalar approaches

From the shapefile with your mapped outlines for the four glaciers, export the attribute table with the inventory-data to excel and derive there the volume for the four glaciers according to the volume-area scaling approach and the slope-dependent thickness estimation from Haeberli and Hoelzle 1995 (use the lecture slides and the document Frey_etal_2014_extract_methods.pdf).

Hint. Open shapefile Attribute Table → Table Options → Export

2a) Volume-area scaling

$V = c\, A^{\gamma}$

with V representing the glacier volume, A the glacier area and c and γ the two scaling parameters. Look up values for the scaling parameters in the extract from Frey et al. (2014), implement the equation in excel and derive the glacier volumes accordingly.

2b) Slope-dependent thickness estimation

Haeberli and Hoelzle (1995) presented an approach for estimating glacier volume based on the average surface slope. In the extract of Fey et al. (2014) this parameterization scheme is also described in a short summary with all the required equations. Follow the explanation of Frey et al. (2014) and derive the parameters and volumes of your glaciers.

3. Comparisons and questions to answer

From http://www.geo.uzh.ch/~alinsbau/ihcap/level2/ex2_glacier_volumes/data/inventories.zip access the ICIMOD, GlobGlacier and RGI outlines for the mapping scene.

Derive area (using GIS and zonal statistics) and volume (as done before) and compare the outlines, the area and the volume with your own results and comment the differences with a few short sentences.

Hint: Create a table for your report (containing different area and volume values) where you compare the data (for the four mapped glaciers). It will not be possible to show all your data → display a reasonable selection.

Answer the following questions with a few short sentences.

1. Is it useful to derive the ice volume by volume-area scaling only for your mapped four glaciers? Explain your reasons.
2. What are the main problems of the volume-area scaling approach?
3. What are the problems and challenges of the slope-dependent thickness estimation approach?
4. What are the main advantages and shortcomings of distributed ice thickness models like GlabTop?

4. Volume calculation for an inventory data set

If both approaches, the volume-area- scaling and the slope-dependent thickness estimation, are implemented in excel and give reasonable results for your four glaciers, expand it to the inventory-data of the Himalaya-Karakorum. Derive the total volume of all glaciers stored in the inventory data set and compare the obtained values (three from volume-area scaling, one from the slope dependent approach) in a bar chart.

http://www.geo.uzh.ch/~alinsbau/ihcap/level2/ex2_glacier_volumes/data/hk_inventory.xls

5. Deliverables

A maximum two page report containing:

1. One figure with caption displaying the modelled ice thickness and the digitized branch lines.
2. A table comparing values (area, inventory parameter, volume) of the four glaciers, based on the different glacier outlines and the three applied methods (GlabTop, slope dependent thickness estimation, three volume area scaling laws) to derive the volume. The table has to be accompanied with a short discussion about differences.
3. The answers to the questions from 3
4. A bar plot with the results from 4 (total volume of HK)
5. A short paragraph discussing the values of the total volumes and on own opinion (and the reasons why), which method/value you trust most.