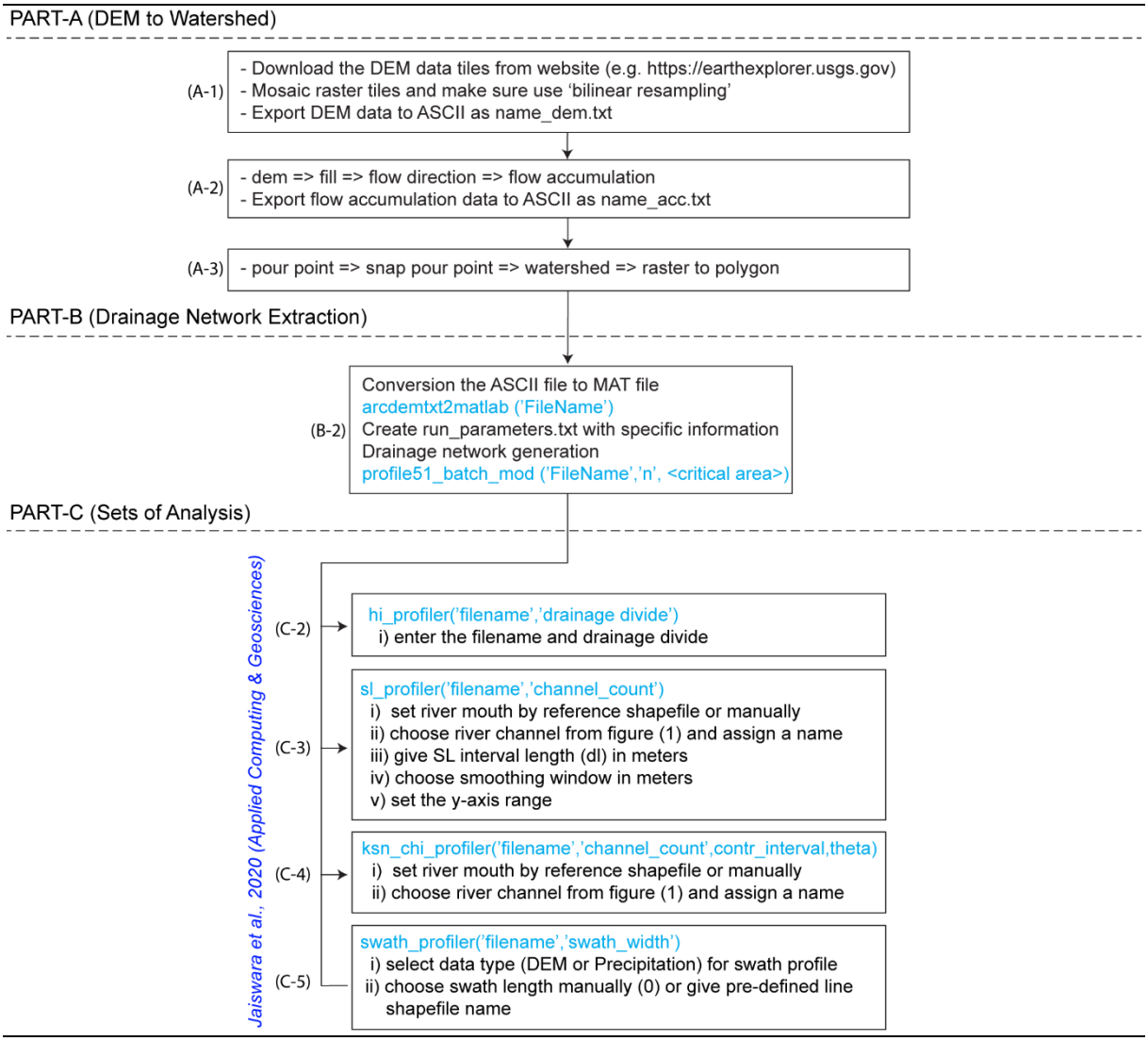
Geomorphic indices

Workflow chart



PART-A (DEM to Watershed)

A-1. Data preparation

a) Download the required DEM data from the data distributor (we have used SRTM and ASTER data from https://earthexplorer.usgs.gov/)

b) If DEM data has multiple files, mosaic the file at GIS platform

c) The DEM should be projected into UTM projection system. (we have used UTM_Zone_46N). [note: often the projection of data involves resampling, make sure to select **'bilinear'** resampling technique and mentioning the cell size is optional]

d) For later use raw DEM grid need to be exported as ASCII files and named as <filename> followed by suffix 'dem'.

Note: A1, A2, A3 and B1 section can be perform using any GIS software (e.g. ArcGIS, QGIS). Here, we have used ArcGIS and the steps are explained in the following text.

A-2. Flow accumulation generation

Generate Flow accumulation file in any GIS platform (e.g. ArcGIS). Save DEM and Flow accumulation as ASCII files in the working directory by naming <filename> followed by suffix 'dem', 'acc' and/or '.prcpt' respectively.

(dem => fil => fdr => fac)

a) Filling Sinks (fil) - This process will fill the sinks in a grid data and keep "Z limit (optional)" **unchecked**.
b) Flow Direction (fdr) - This process will compute flow direction using the eight direction pour point (D8) method. Keep the "force all edge cells to flow outward (optional)" **unchecked**.
c) Flow Accumulation (fac) - This process uses flow direction grid and generates a grid having cells that assigned by a number of connecting draining cells. Make sure that the output data type should be in **integer**.
d) For later use Flow accumulation grid need to be exported as ASCII files and named as <filename> followed by suffix 'acc'.

   Note: Make sure that the flow accumulation grid is generated from the same DEM which will be used to generate ASCII file for further processing.

A-3. Drainage divide extraction

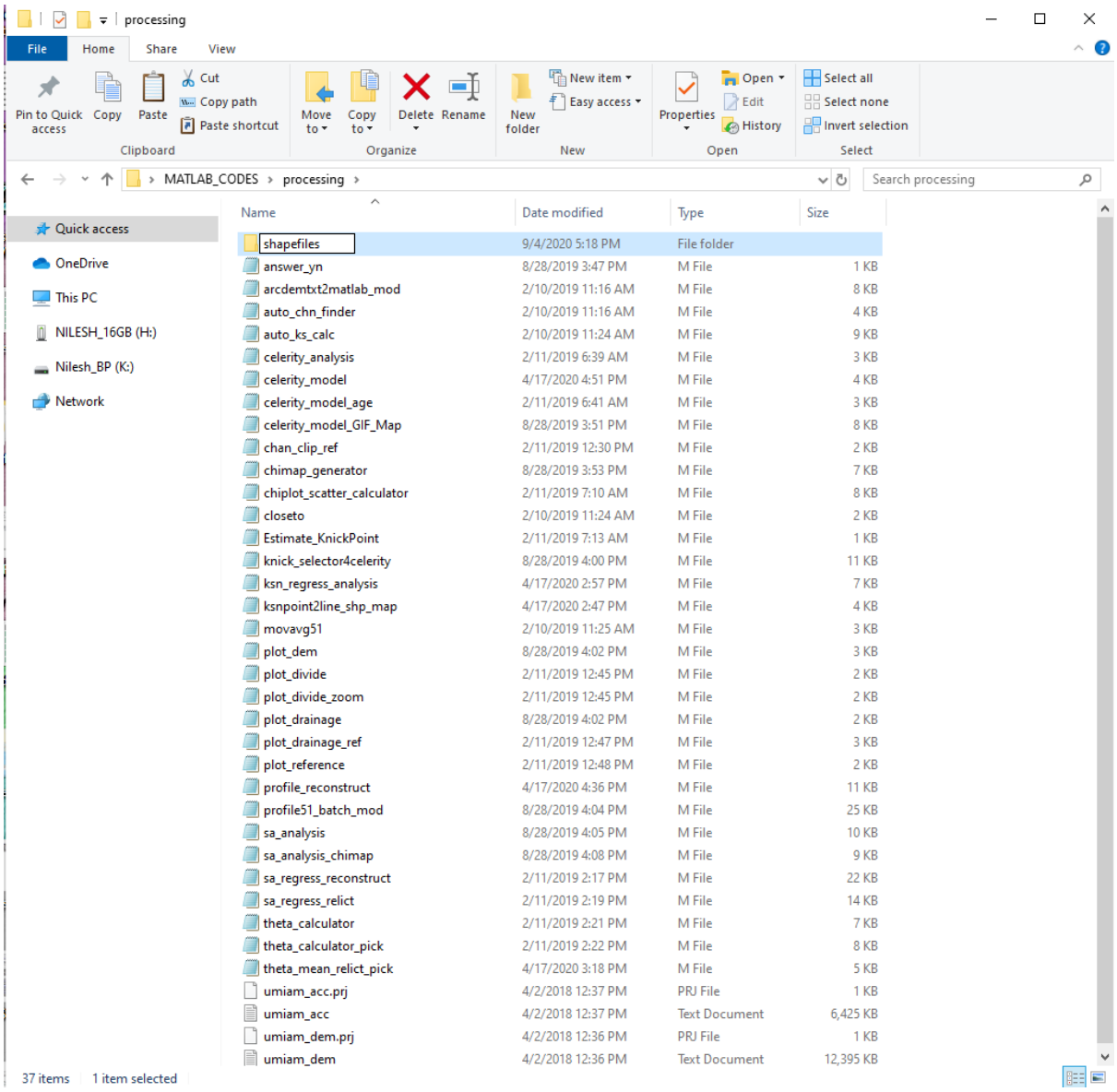
a) Create a pour point shapefile to determining the drainage basin outlet
b) Snap pour point to rasterize the pour point.
c) Generate watershed raster for drainage divide boundary
d) Convert the extracted watershed raster to polygon shapefile and keep inside the shapefile folder.

Part-B (Drainage Network Extraction)

B-2. Drainage Network extraction (MATLAB)

Keep the ASCII files of DEM and Flow accumulation along with the extracted MATLAB scripts in a working directory/folder (make sure that the directory name and path should not contain any ‘space’, instead of ‘space’ use ‘_’ while naming the directories). Make a new directory with the name of ‘shapefiles’ within the working directory, and keep shapefiles of drainage divide and other GIS files. The ‘shapefiles’ folder would contain all the input and output GIS files. Make sure the prefix of ‘dem’ and ‘acc’ ASCII files (.txt) is same (In present example ‘umiam_’ before ‘dem’ and ‘acc’).

The working directory would look something like this,



The drainage network extraction is being performed using the modified code adapted from (http://geomorphtools.geology.isu.edu/index.htm).

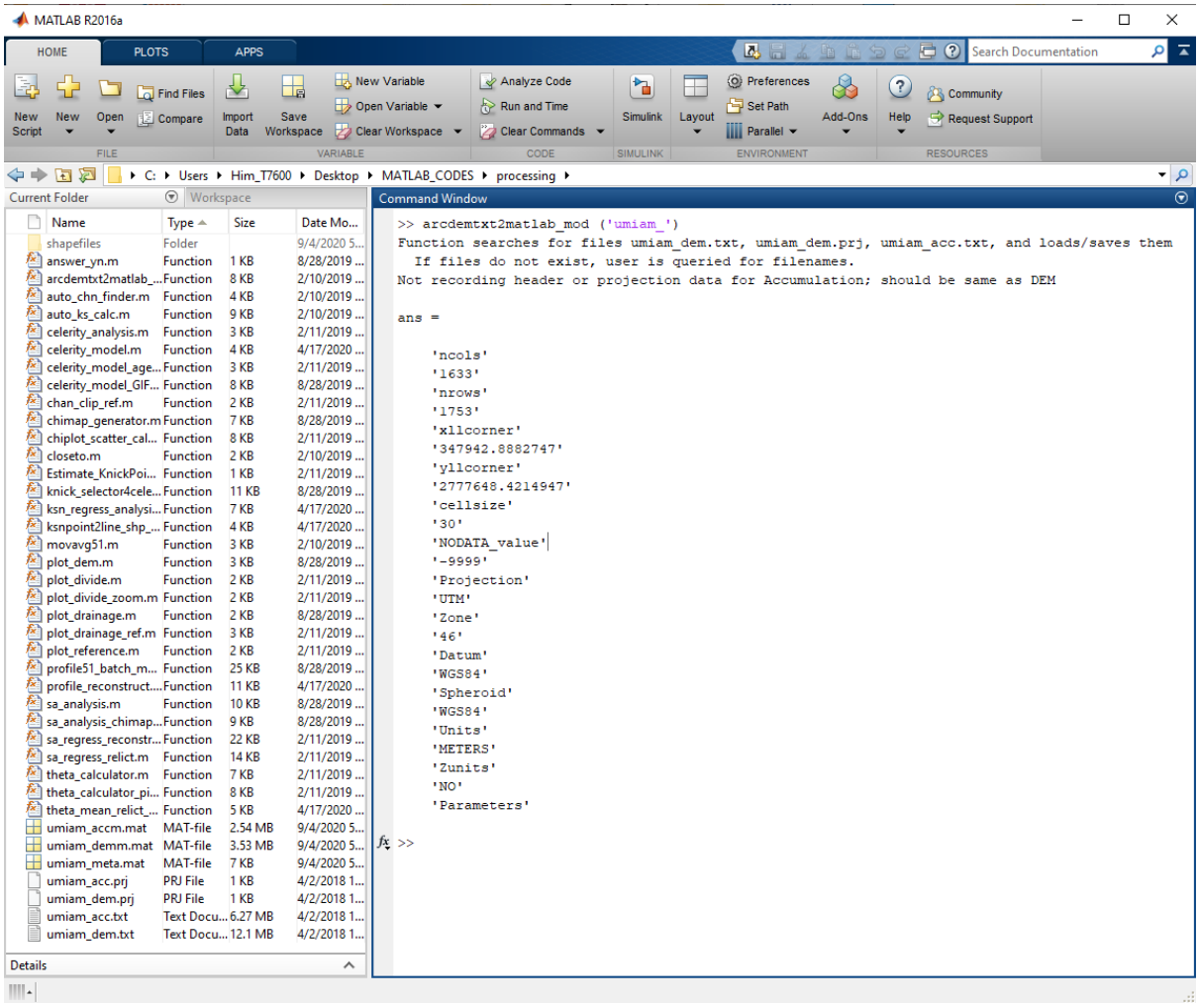
a) Conversion of ASCII file to MAT file

arcdemtxt2matlab_mod ('filename')

>> e.g. arcdemtxt2matlab_mod ('umiam_')

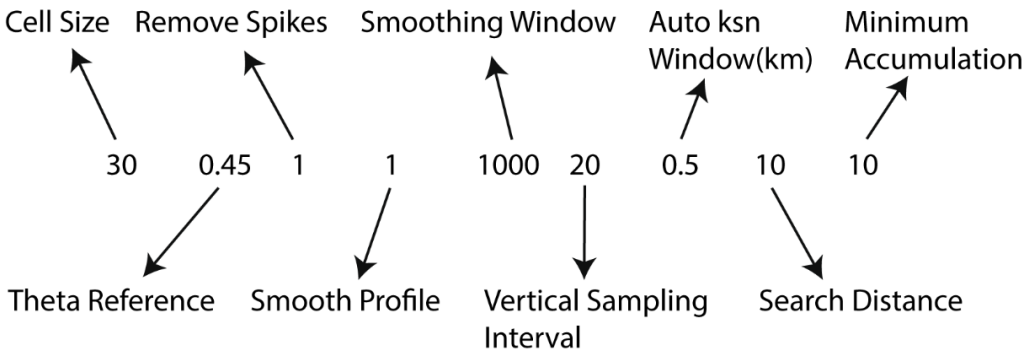
[Note; write the initials without suffix (e.g. for file named as umiam_dem.txt and umiam_acc.txt, write as 'umiam_')]

Output: MAT files of DEM, flow accumulation and metadata.



b) Create a text file with few predefined parameters

Create a text file named as "**run_parameters.txt**" file mentioning the input variables with space separated in following order;



(i) Cell Size: Pixel size of the raster grid

(ii) Theta Reference: generally, for bedrock river, default reference concavity is considered as 0.45. theta for more accuracy compute the theta reference for particular basin by using theta_calculator.m function (see section 4)

(iii) Remove Spikes (0/1): data spikes due to DEM artefact could be removed.

(iv) Smooth Profile (0/1): Whether to smooth elevation data or not

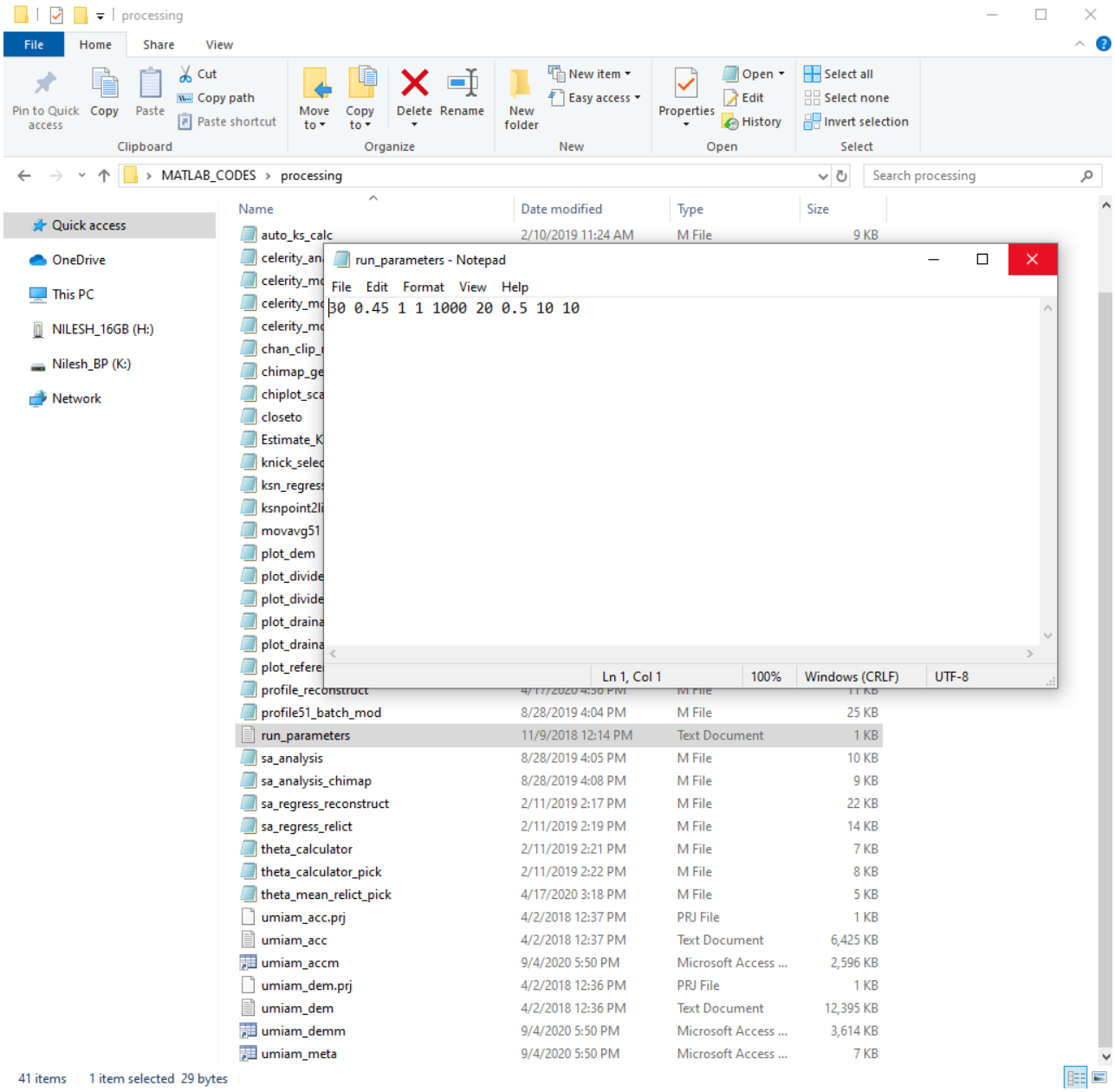
(v) Smoothing Window: Smoothing window in meter

(vi) Vertical Sampling Interval: Contour sampling interval (in meter) used for calculating the local slope.

(vii) Auto k_{sn} Window (km): Width of window (in meter) used in estimation of normalized steepness index

(viii) Search Distance: It is a distance for selecting the actual downstream river path from channel head.

(ix) Minimum Accumulation: Minimum area for determining the channel head.



c) Delineation of drainage network with channel steepness (k_{sn})

- The drainage network extraction has been performed using the modified code taken from (http://geomorphtools.geology.isu.edu/index.htm).

  Run the following script,

  profile51_batch_mod ('filename','n',<critical_area>)

  e.g. >> profile51_batch_mod('umiam_','n',1e7) [1e7=10000000]

  [Note; <critical_area> is a value in m^2 which is considered as the lowest accumulation area for automatically selecting the channels. Smaller the critical area, larger the number of identified channels.]

  Output: creates chandata.mat files containing various estimated variables.

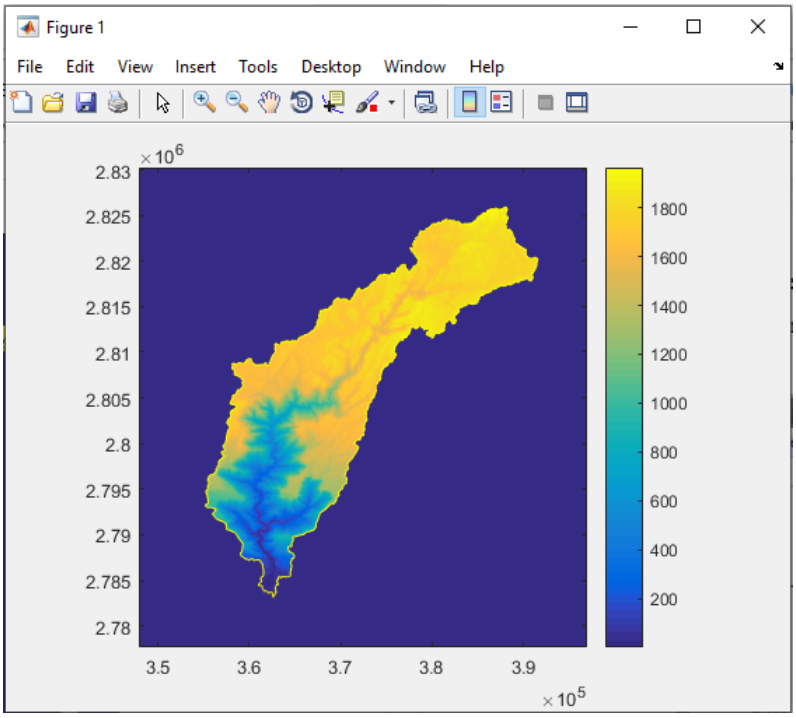
PART-C (Sets of analysis)

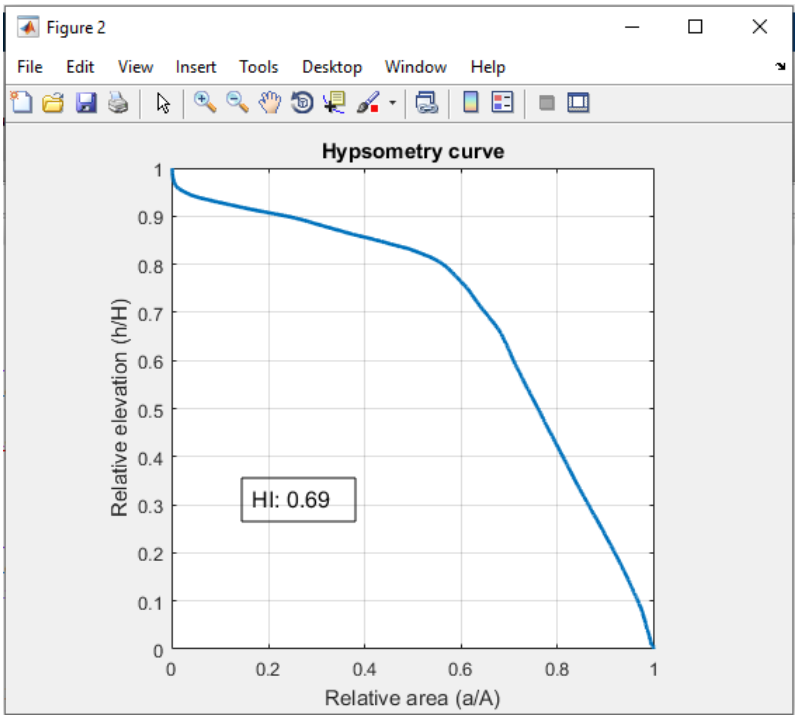
(C-2) Hypsometric Integral

hi_profiler('filename', 'drainage divide')

e.g. >> hi_profiler ('umiam_', umiam_divide')

- Input: ‘filename’ and ‘drainage divide’ [Note; drainage divide file keeps as a .shp file in a folder]
- Output figures (1) shows the drainage basin and figure (2) shows Hypsometry integral





(C-3) SL- Index

sl_profiler('filename',channel_count)

e.g. >> sl_profiler('umiam_', 79)

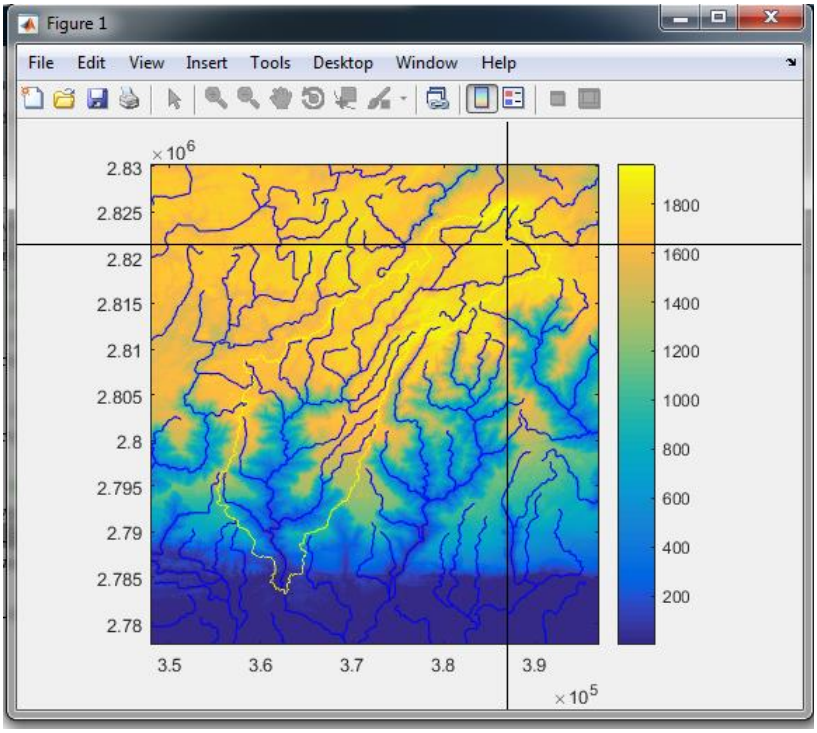
- Input: ‘filename’ and ‘channel_count’

[Note: channel_count can be seen in the command window after run the program]

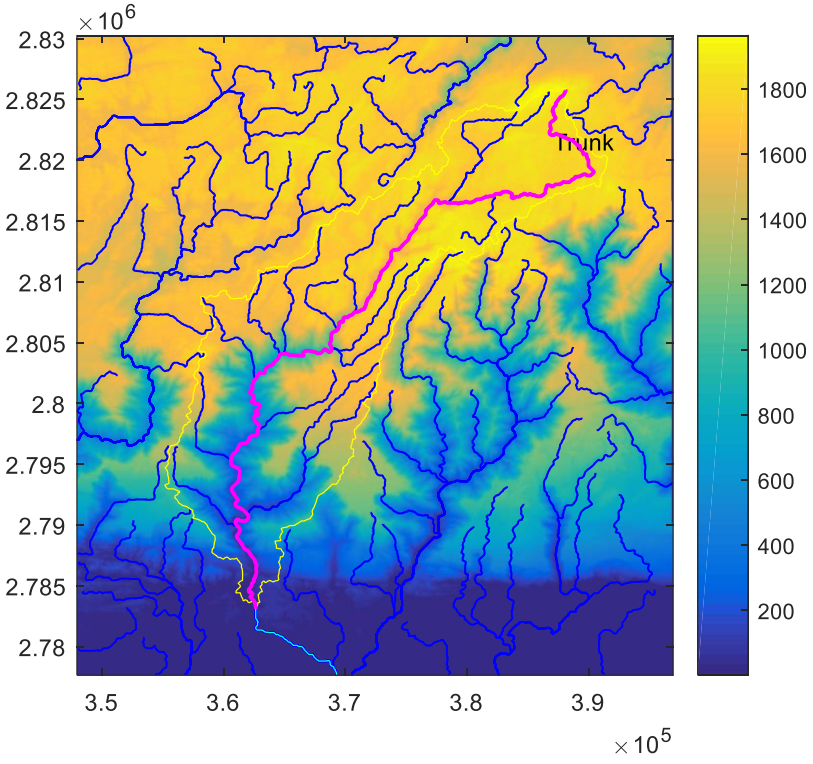
i) enter the mouth reference shapefile name or for choosing reference manually, enter <0>:

ii) select the reference point near the mouth of the drainage by clicking on figure (1)..

iii) select channel from the figure (1) by clicking near the river head and assign a name...



iv) enter the channel name :



v) Enter SL interval in meter else go for the default(5000m) interval by giving " 0 ":

vi) Enter smoothing interval OR to choose default interval(1000m) enter < 0 > :

vii) Do you want to change y-axis limits (1/0) :

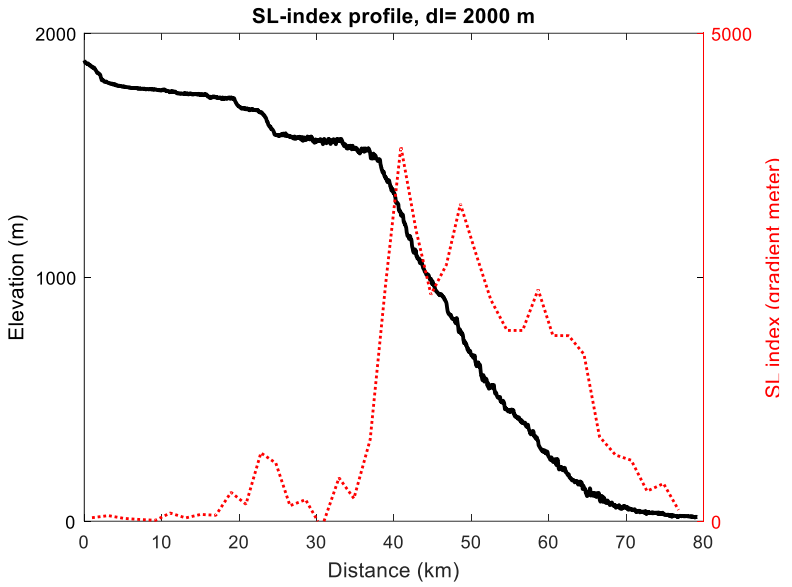
(1) Enter the Elevation y-axis minimum limit :

(2) Enter the Elevation y-axis maximum limit :

(3) Enter the SL y-axis minimum limit :

(4) Enter the SL y-axis maximum limit :

viii) Do you want select another channel (1/0) :



(C-4) Normalized steepness index (k_{sn})

The steepness indices are being automatically calculated for each channel while running the '**profile51_batch_mod**' code at the reference theta mentioned in the 'run_paraeters.txt' file. For visualization and plotting purposes, run the following code with the given soothing window.

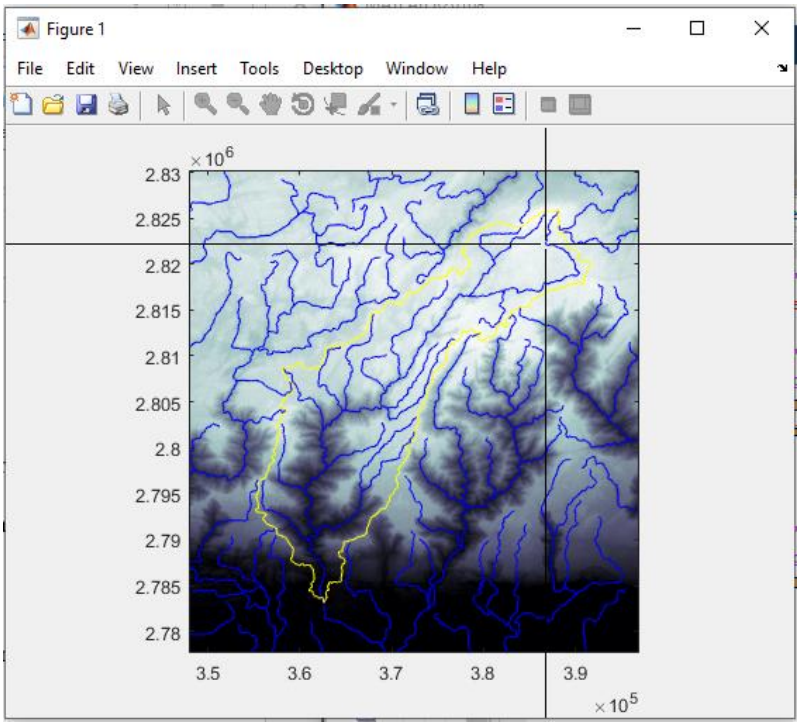
ksn_chi_profiler(file_name, ChanNum, Cont_Intv, theta)

e.g. >> ksn_chi_profiler('umiam_', 79,20,0.45)

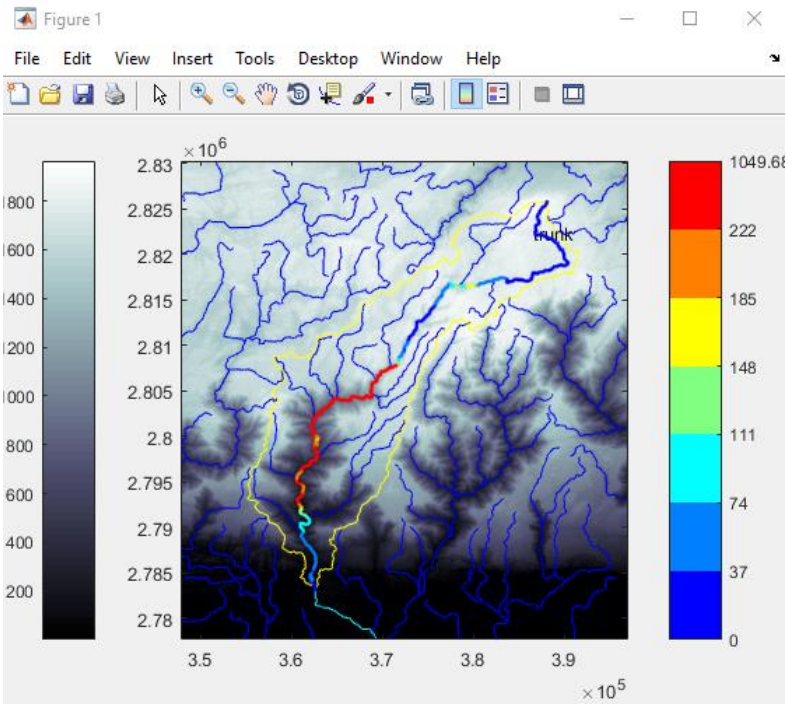
Input: drainage divide filename and

i) enter the reference shapefile name in single inverted comma Or choose manually by entering <0>:

ii) select the channel by clicking near the river head and assign a name...



iii) enter the channel name in single inverted comma :



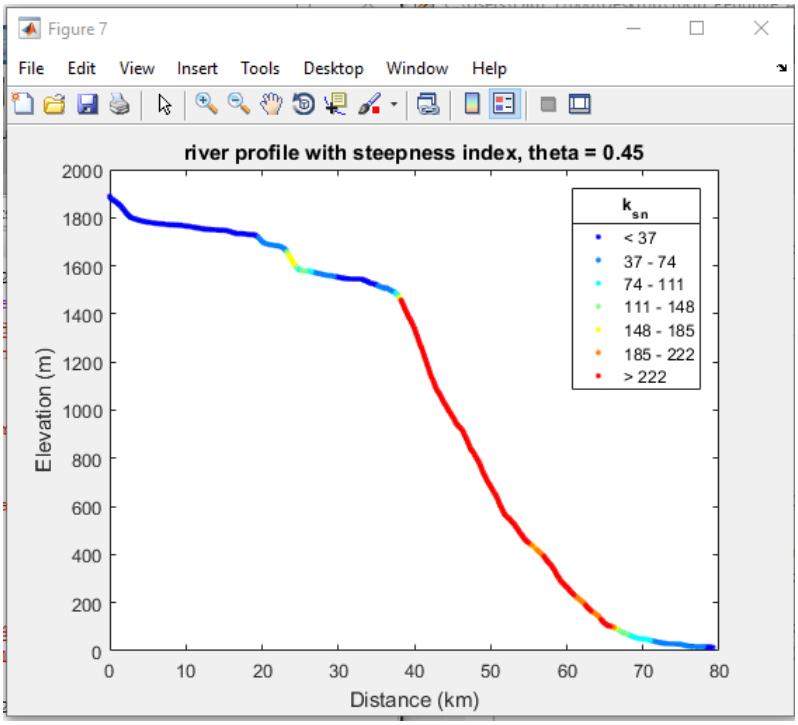


Figure 7
File Edit View Insert Tools Desktop Window Help
river profile with steepness index, theta = 0.45
Elevation (m)
Distance (km)
k sn
< 37
37 - 74
74 - 111
111 - 148
148 - 185
185 - 222
> 222

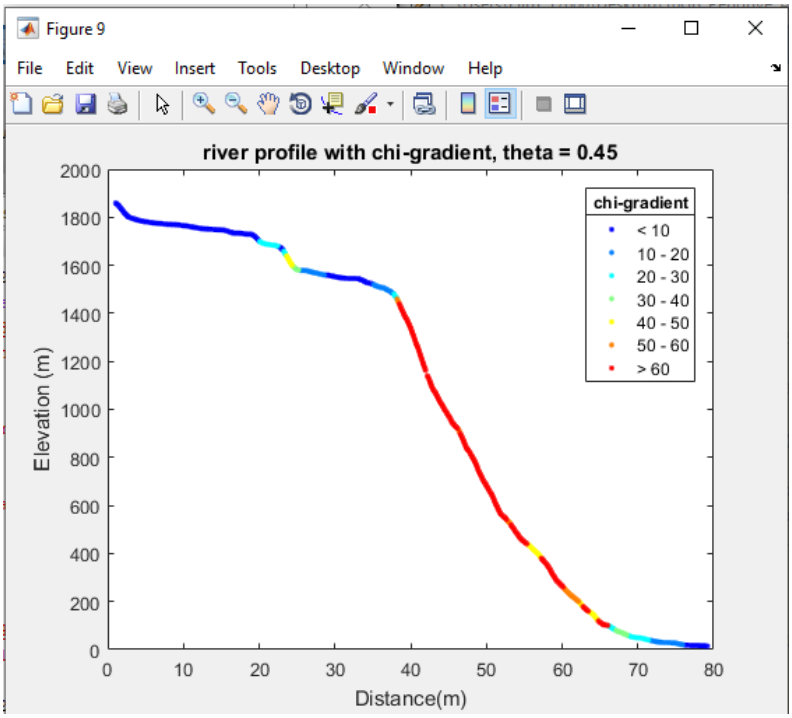
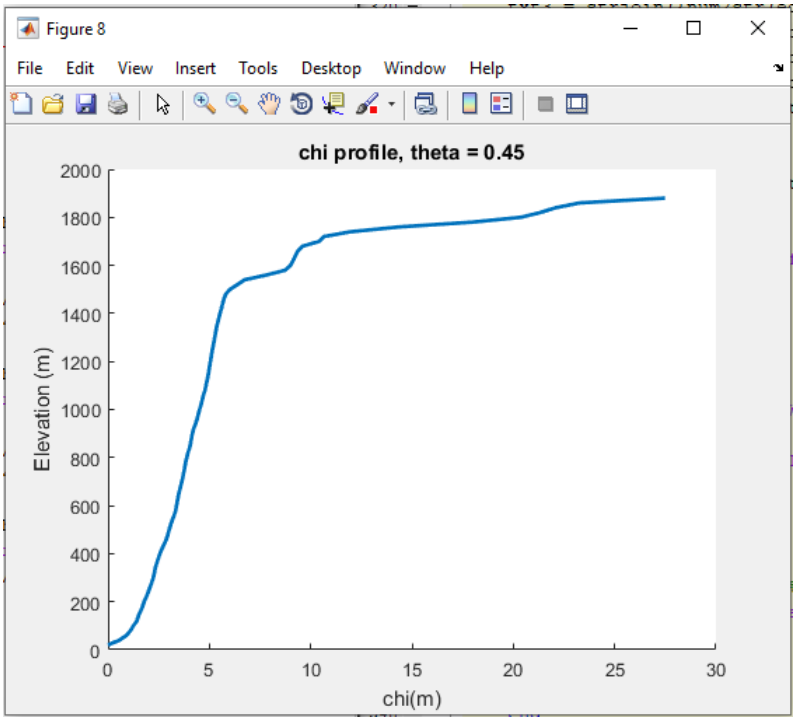


Figure 9
File Edit View Insert Tools Desktop Window Help
river profile with chi-gradient, theta = 0.45
Elevation (m)
Distance(m)
chi-gradient
< 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
> 60



iv) do you want select another channel (1/0) :

Note: The k_{sn} values which falls within the desired basin boundaries are only reliable because they are being estimated for the respective accumulation area (which covers the entire basin area).

(C-5) Swath Profile

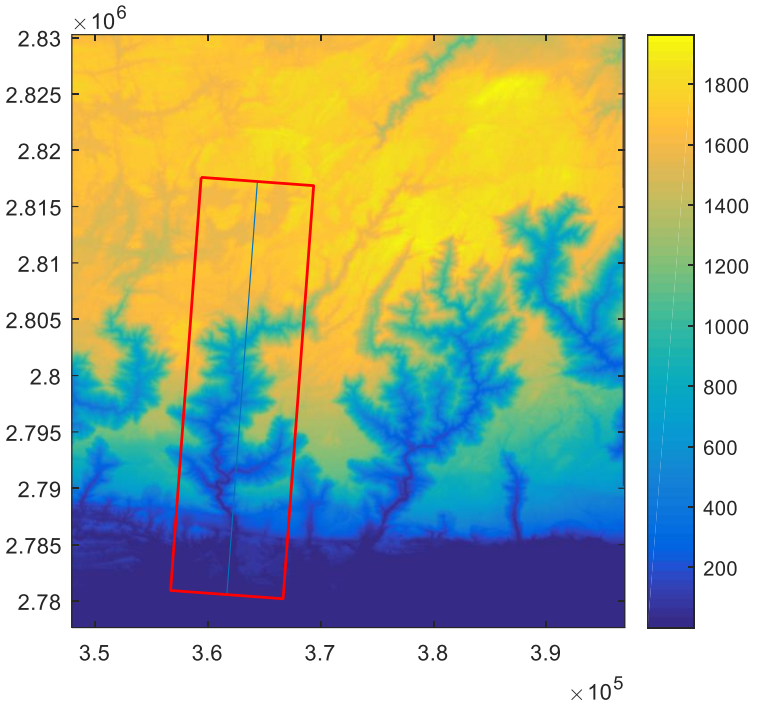
swath_profiler('filename', 10)

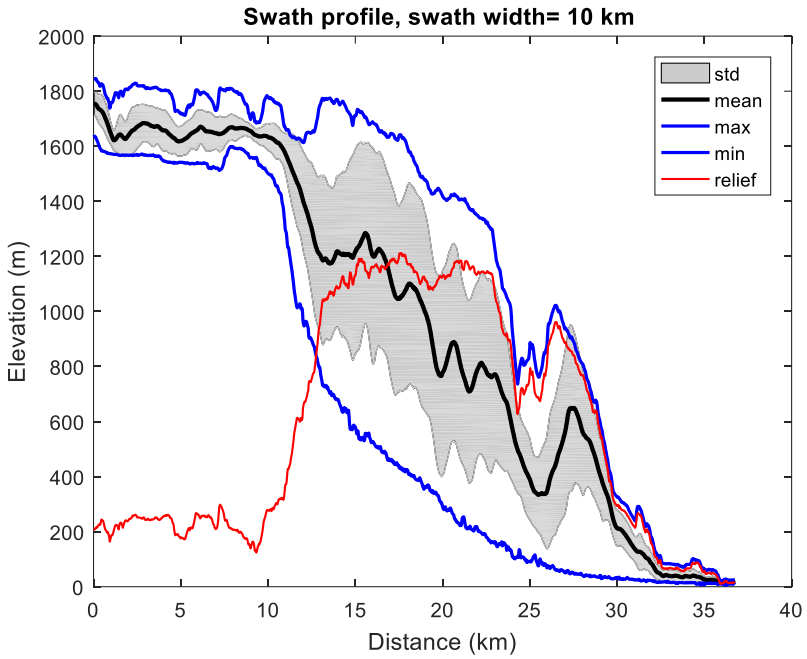
e.g. >> swath_profiler('umiam_', 10)

Input: ‘filename’ and ‘swath width’ in km

i) for swath profile from DEM, enter "1" OR for precipitation data enter "0" : **1**

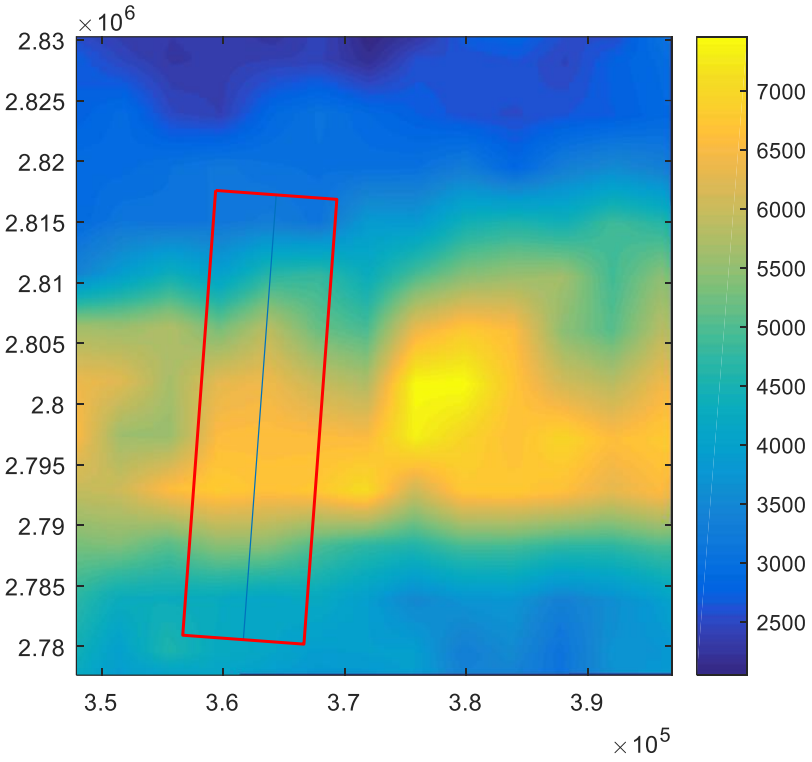
ii) for pre-defined swath line, enter "1" OR for manual input in figure(1), enter "0" : **'swath_umiam'**

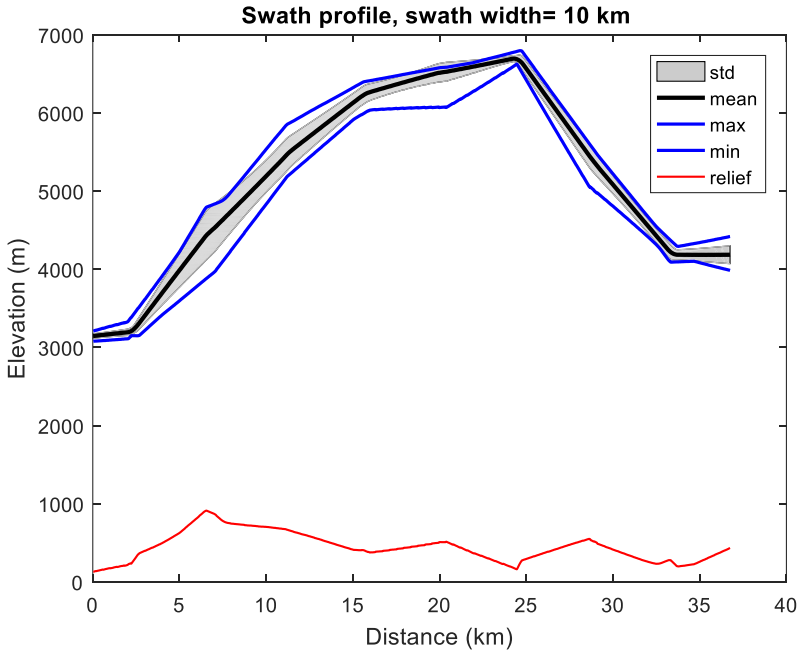




i. for swath profile from DEM, enter "1" OR for precipitation data enter "0" : **0**

ii. for pre-defined swath line, enter "1" OR for manual input in figure(1), enter "0" : '**swath_umiam**'


×10^6
2.83
2.825
2.82
2.815
2.81
2.805
2.8
2.795
2.79
2.785
2.78
3.5
3.6
3.7
3.8
3.9
×10^5
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500


Swath profile, swath width= 10 km
std
mean
max
min
relief
Elevation (m)
Distance (km)
0
1000
2000
3000
4000
5000
6000
7000
0
5
10
15
20
25
30
35
40