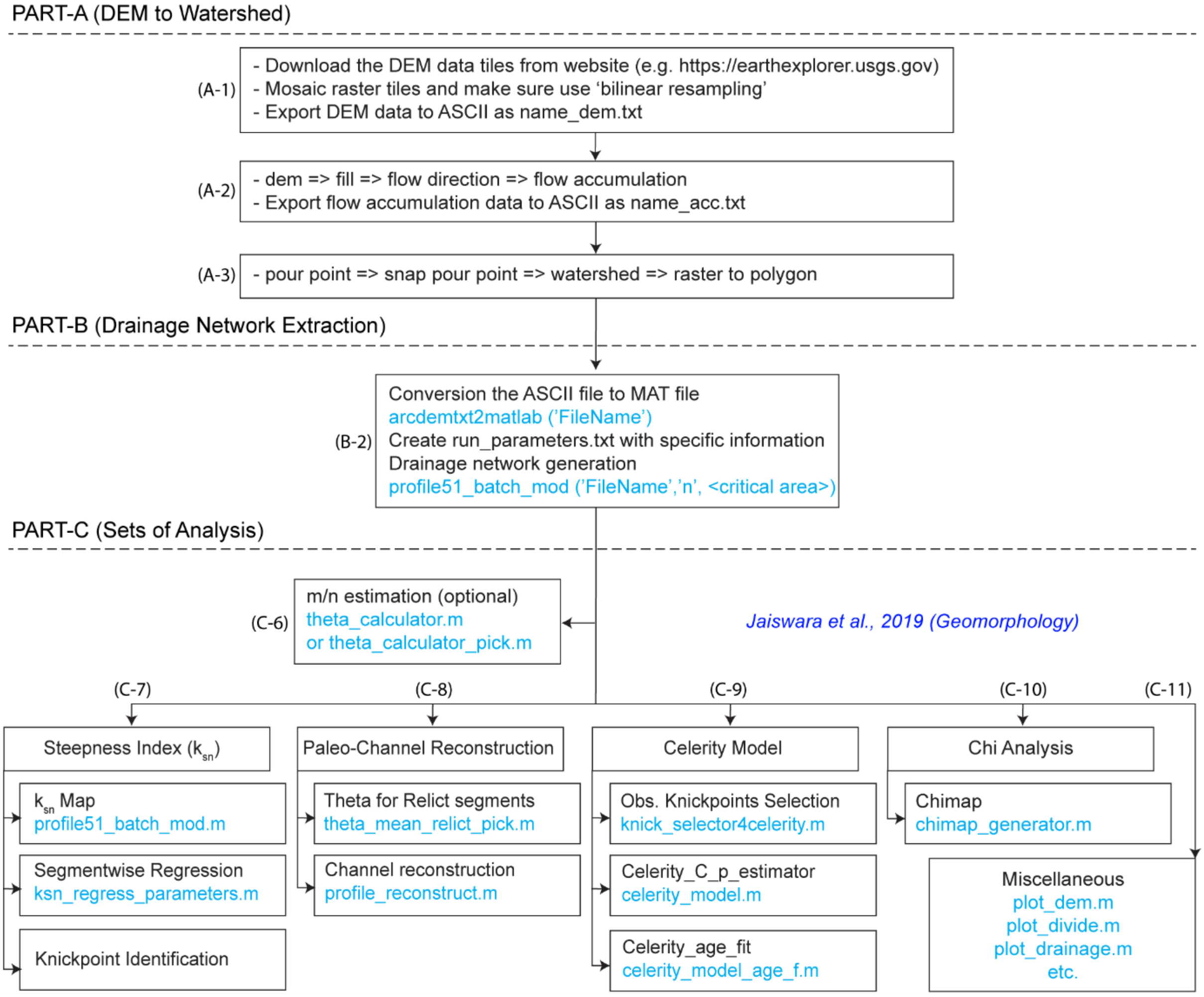
Transient Profiler

Please cite this work as: N.K. Jaiswara, S. Kr Kotluri, A.K. Pandey, P., Pandey, (2019). Transient basin as indicator of tectonic expressions in bedrock landscape: Approach based on MATLAB geomorphic tool (Transient-profiler), *Geomorphology*, https://doi.org/10.1016/j.geomorph.2019.106853 (Article copy: https://authors.elsevier.com/c/1Zg06,3sl3j7wm)

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

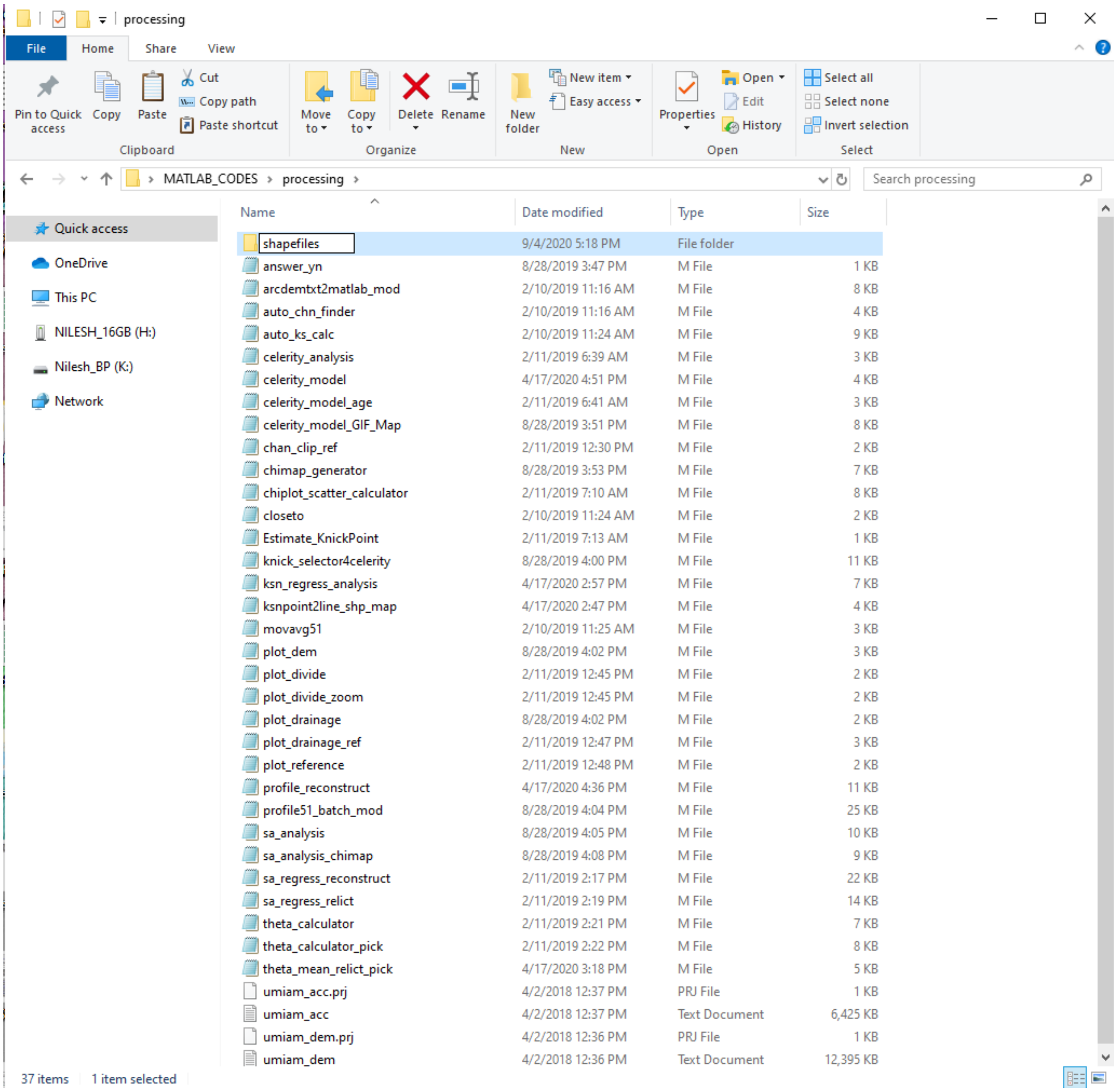
d) Convert the extracted watershed raster to polygon shapefile and keep inside the shapefile folder.

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).

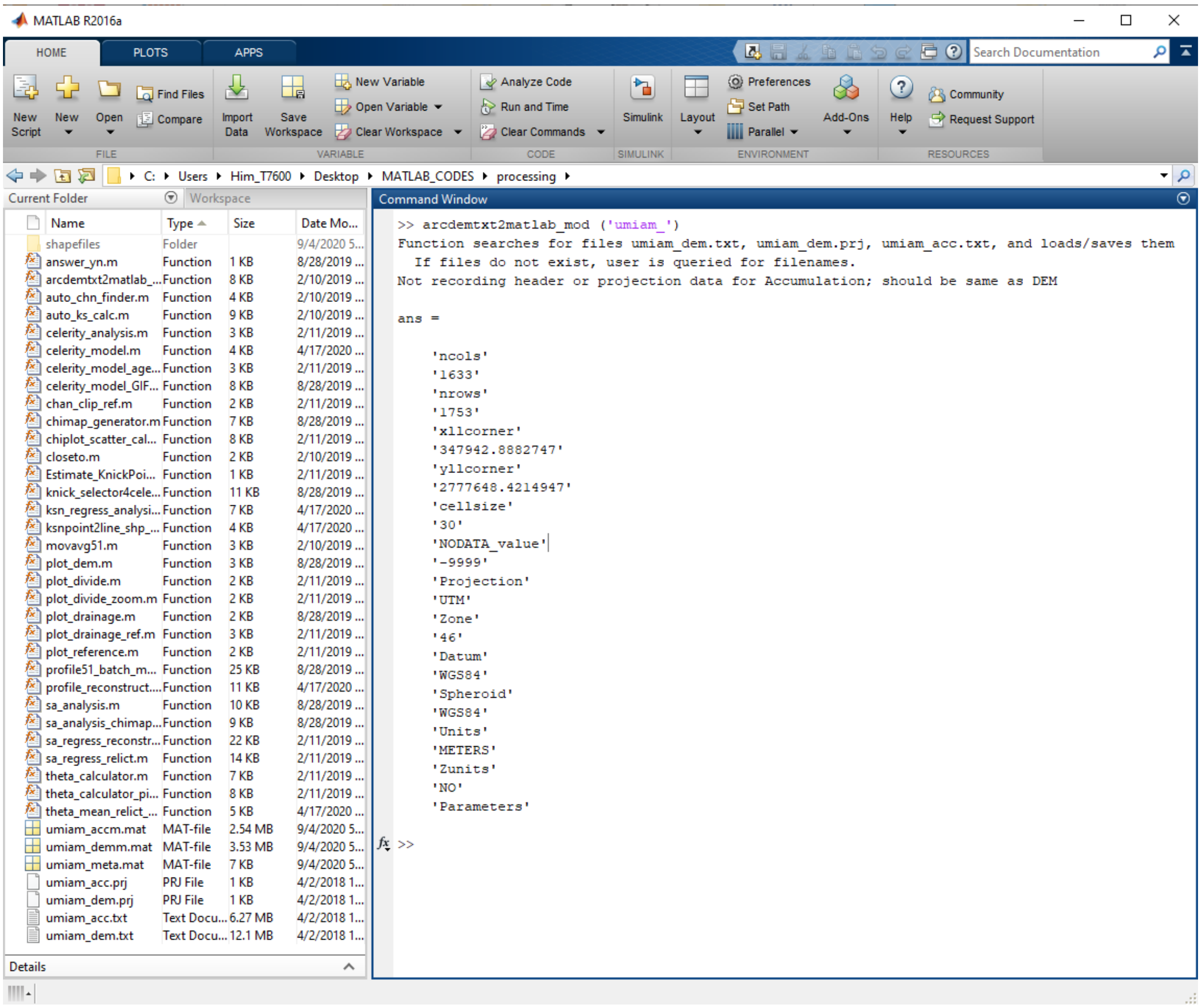
a) Conversion of ASCII file to MAT file

arcdemtxt2matlab_mod ('filename')

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

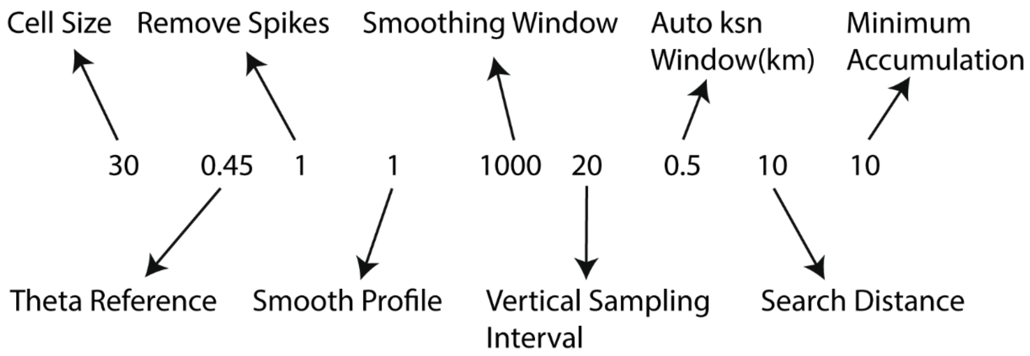
[Note; write the initials without suffix (e.g. for file named as umiam_dem.txt and umiam_acc.txt, write as 'umiam_')]

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

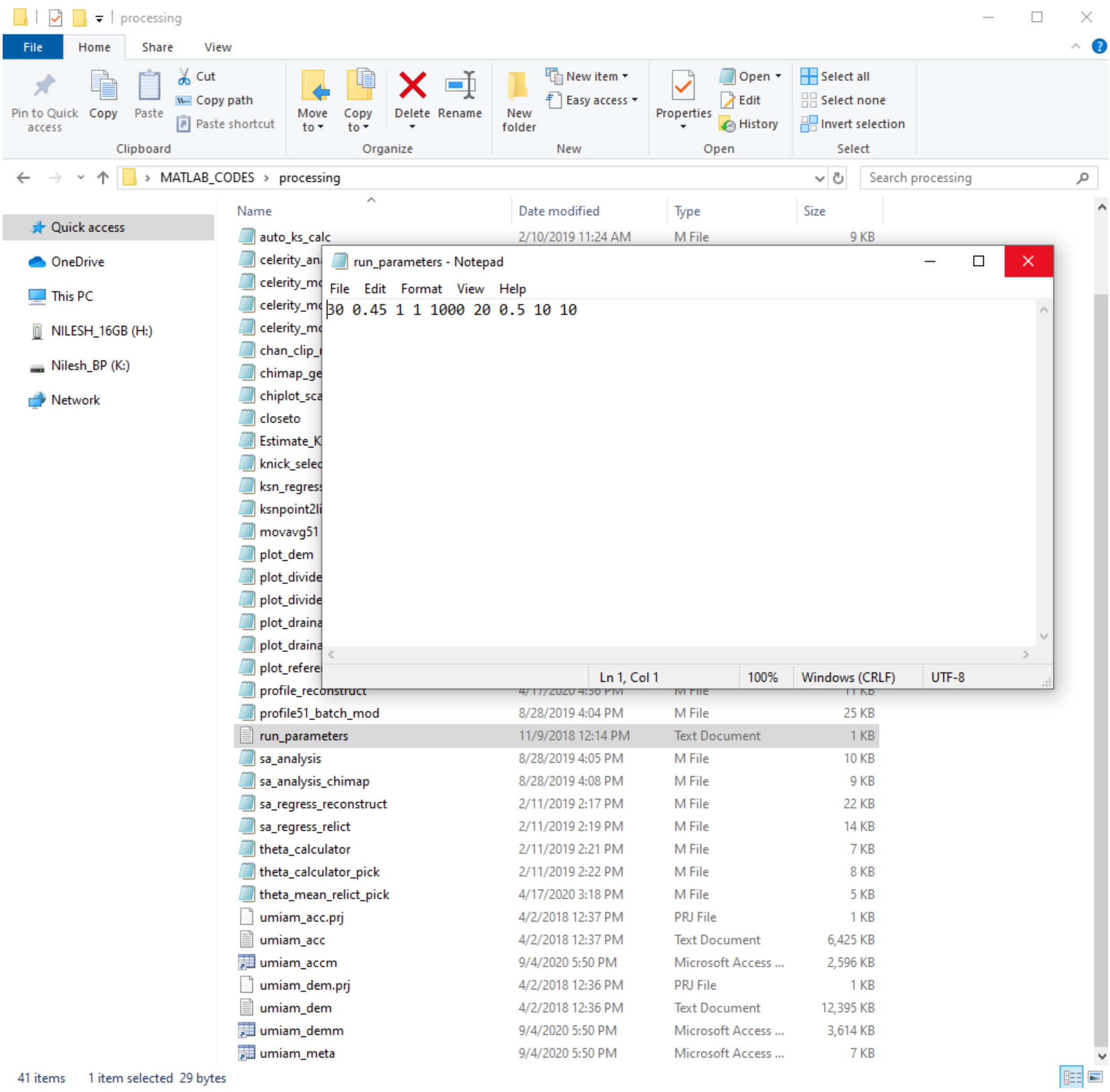
(v) Smoothing Window: Smoothing window in meter

(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.

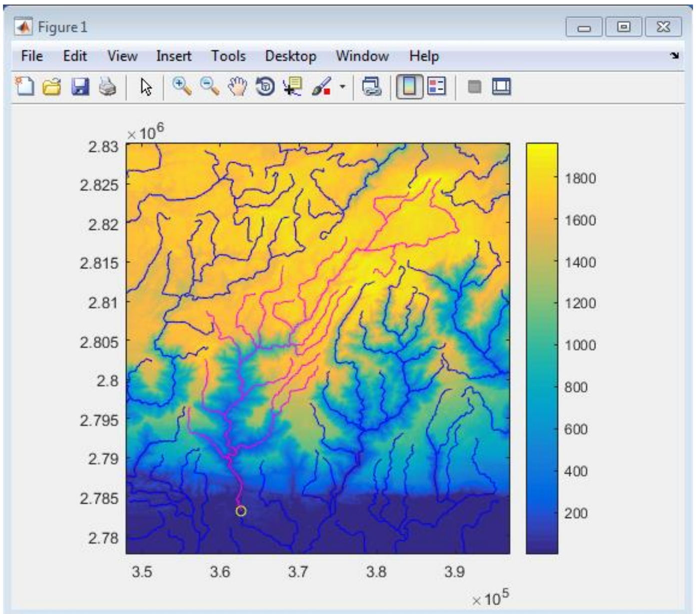
PART-C (Sets of analysis)

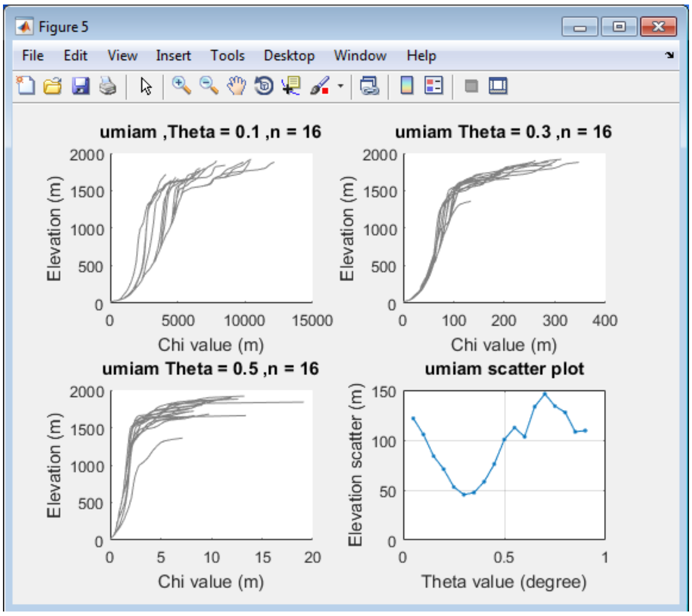
(C-6) Theta reference estimator (Optional)

Keep the reference .shp file in the shapefiles folder. You can give drainage divide (boundary) as reference file.

theta_calculator('filename', 'ref_filename',chanNum)

e.g. >> theta_calculator('umiam_','umiam_pour_pt',79)



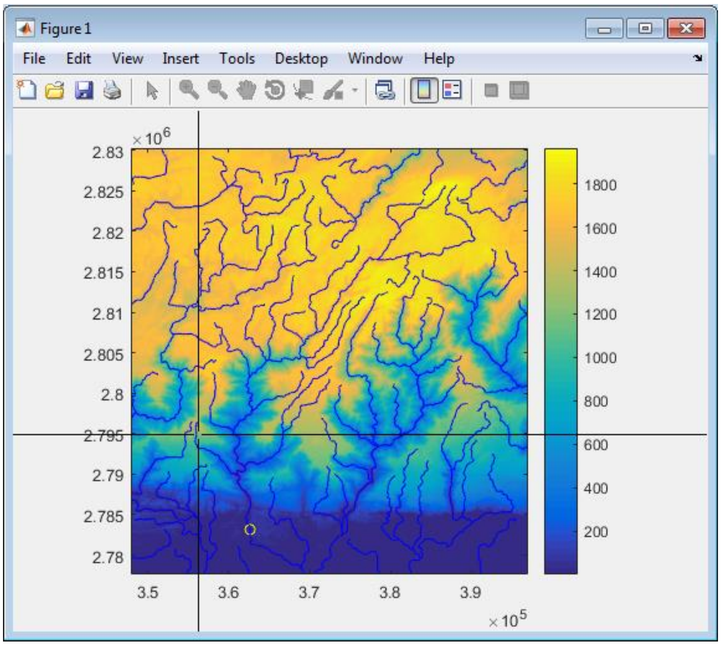


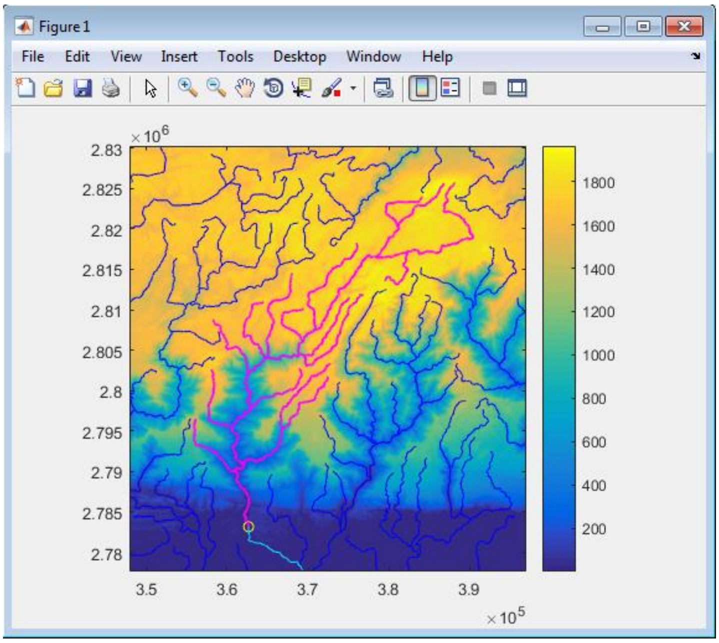
theta_calculator_pick('dem_filename','ref_filename',chanNum)

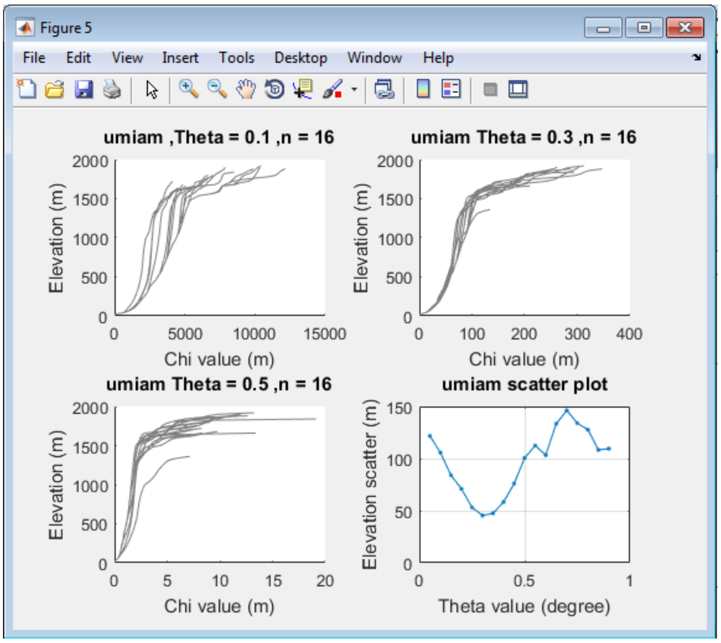
e.g. >>theta_calculator_pick('umiam_','umiam_pour_pt',79)

i) enter the number of channel that are being considered : **16**

ii) select channel from the figure (1) by clicking near the river head...







(C-7) Steepness index (ksn) analysis

(C-7.1) ksn map generation (regional map)

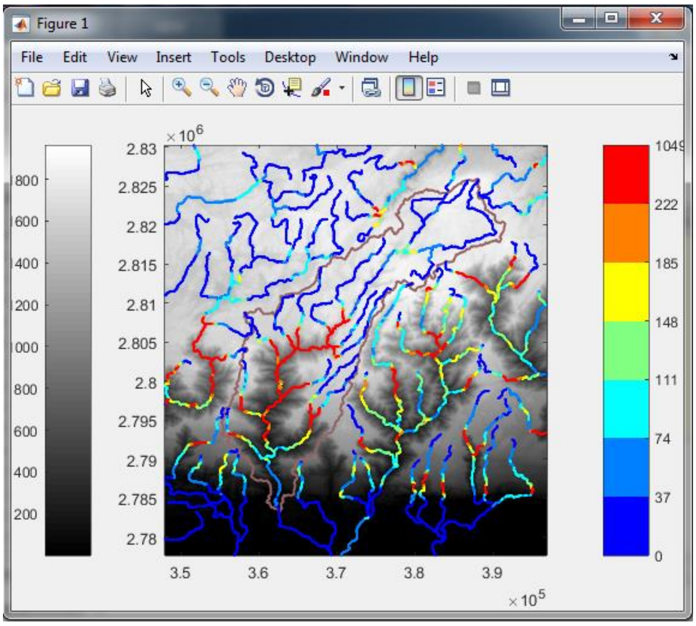
The steepness indices are being automatically calculated for each channel while running the '**profile51_batch_mod**' code at the reference theta mentioned in the 'run_paraeters.txt' file. For visualization and plotting purposes, run the following code with the given soothing window;

ksnpoint2line_shp_map('dem_name', 'ref_name', smooth_wind, chanNum)

e.g. >> ksnpoint2line_shp_map('umiam_','umiam_divide',10,79)

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

For recalculating the theta k_{sn} at different reference theta, first modify the '**run_parameters.txt**' and run the '**profile51_batch_mod**' code again.



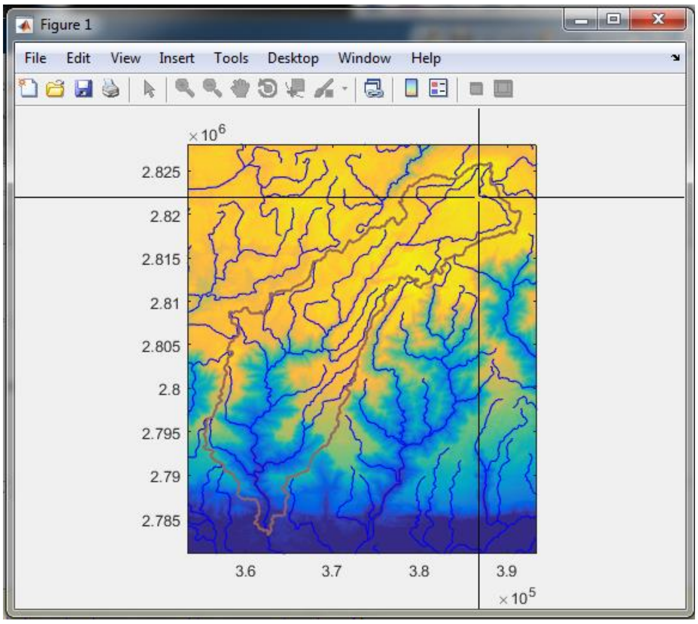
Output files: ‘ksn_shapefile’ would be created inside the ‘shapefile’ directory which can be used in a GIS platform.

(C-7.2) ksn regression parameters

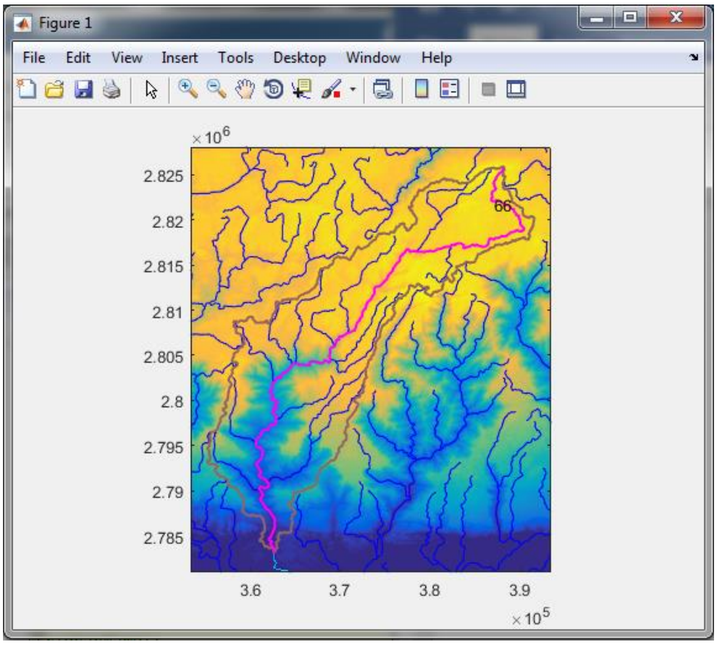
Steepness index for the segment of channel via regression

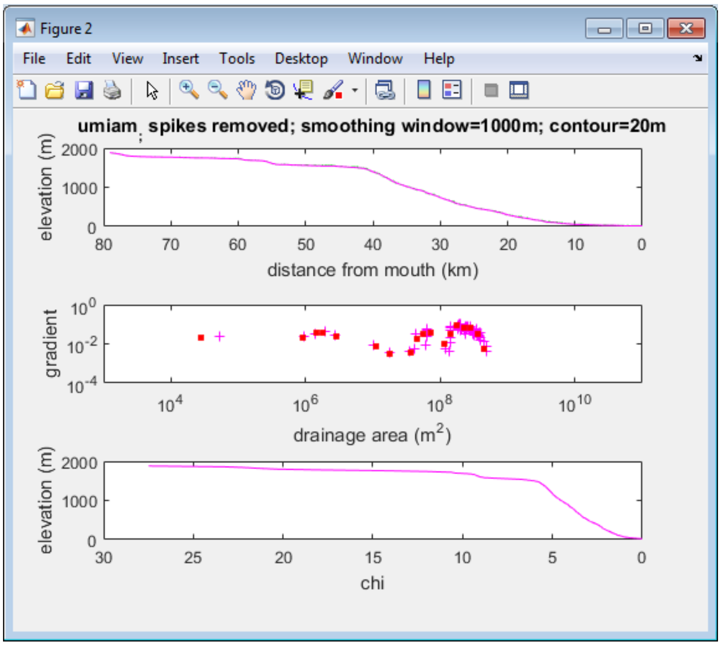
ksn_regress_analysis('dem_name','divide_name','ref_name',ChanNum,Theta_ref)

e.g. >>ksn_regress_analysis('umiam_','umiam_divide','dauki_fault',79,0.45)



iii) select channel from the figure (1) by clicking near the river head…



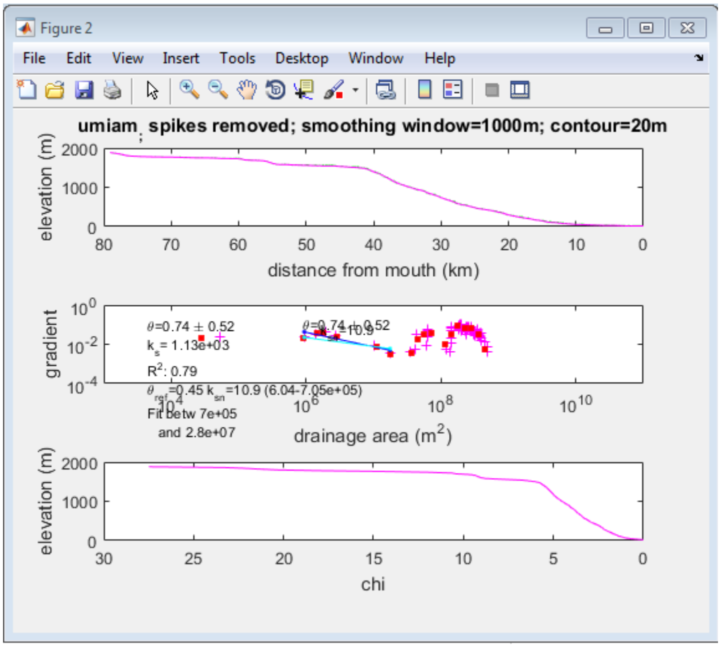


iv) From which plot would you like to pick regression limits? (or enter "d" for manual input)

a) logS-logA (fig2 plot3); b) long profile (fig2 plot1); c) Chi(distance) : **b**

v) Include Click on LEFT (max dfm) then RIGHT (min dfm) bounds for regression from STREAM PROFILE (fig2, plot 1)

Regress bounds must include at least 3 data points -- crosses on LOG(S)-LOG(A) PLOT…



vi) do you want to keep the regress value (y) or reselect regression range (n) : (y/n).... y

If ‘**n**’, it will go to step (iii) and start freshly.

vii) do you want another S-A regression : (y/n).... **n**

If ‘**y**’, it will go to step (iii) and ask the for another regression range

viii) Click the upper left corner to locate temporary parameter text.

ix) do you want to go for another channel : (y/n).... **n**

If ‘**y**’, return to figure (1) and repeat the steps from (i) to (vii) for another channel selection.

Output files: S-A regression plots, S-A regress mat files and figure with selected channel

(C-8) Paleo-channel reconstruction

The paleo-base level of any transient state river can be reconstructed based on the scaling parameters (steepness and concavity index) of relict reach which assumed as representative of previous uplift-erosion setting. The geomorphic and hydrological variation at a smaller drainage area can lead to the great variation in steepness index (k_{sn}) (Clark et al., 2005; Wobus et al., 2006; Gallen et. al., 2013). To avoid such complication, channel steepness indices (k_{sn}) were normalized using the mean concavity (θ_{ref}) of all the identified relict reaches. The function mention below can be used to analyse the channels having relict reaches and estimate the θ_{ref}.

The selected regression segment should be within the relict reach and contain significant number of data points.

(C-8.1) Mean theta estimation

theta_mean_relict_pick('dem_name', 'divide_name','ref_nae',ChanNum,Theta_ref)

e.g. >>theta_mean_relict_pick('umiam_','umiam_divide', 'umiam_divide',79,0.45)

(The steps are similar with the steps involve in '5.1. ksn regression parameters')

i) select channel from the figure (1) by clicking near the river head

ii) From which plot would you like to pick regression limits? (or enter "d" for manual input)

a) logS-logA (fig2 plot3); b) long profile (fig2 plot1); c) Chi(distance) : **a**

Click on minimum THEN maximum bounds for drainage area from LOG(S)-LOG(A) PLOT (fig2, plot 3)

Include at least 3 data points -- crosses on LOG(S)-LOG(A) PLOT

iii) do you want to keep the regress value (y) or reselect regression range (n) : (y/n)....

iv) do you want to go for another channel : **(y/n)....**

[Repeat step (i) to (v) until all the relict reaches are covered]

Output file: mat files containing SA regress parameters of relict reaches will be produced and the estimated mean theta will be shown in the command window. The mean theta will be latter used as theta_ref for the reconstruction of paleo-base level.

(C-8.2) Paleo-base level reconstruction

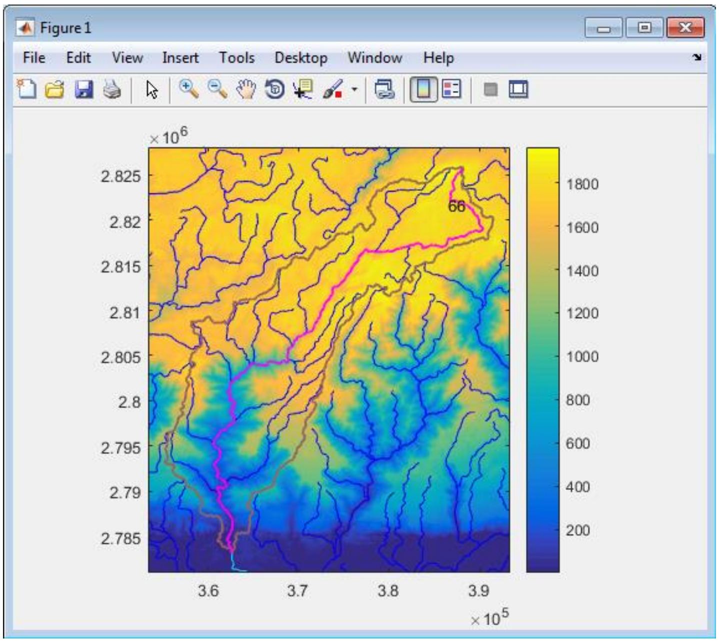
Once the mean theta has calculated, the paleo-base level can be reconstructed using the following matlab function,

profile_reconstruct('dem_name','divide_name','ref_name',ChanNum,Theta_ref)

e.g. >> profile_reconstruct('umiam_','umiam_divide', 'umiam_divide',79,0.3)

(The steps are similar with the steps involve in '5.1. ksn regression parameters')

i) select channel from the figure (1) by clicking near the river head



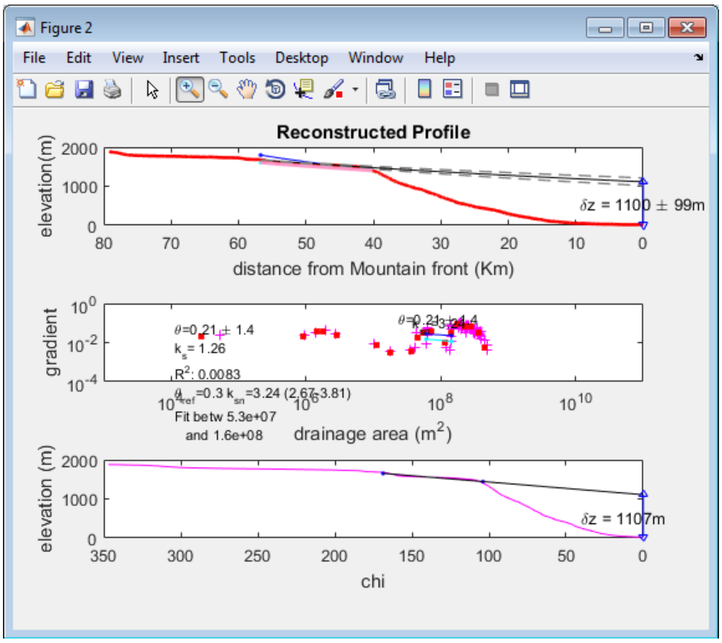
i) a) logS-logA (fig2 plot3); b) long profile (fig2 plot1); c) Chi(distance); (fig3 plot2): **a**

ii) Click on minimum THEN maximum bounds for drainage area from LOG(S)-LOG(A) PLOT (fig2, plot 3)

Include at least 3 data points -- crosses on LOG(S)-LOG(A) PLOT

Click the upper left corner to locate temporary parameter text.

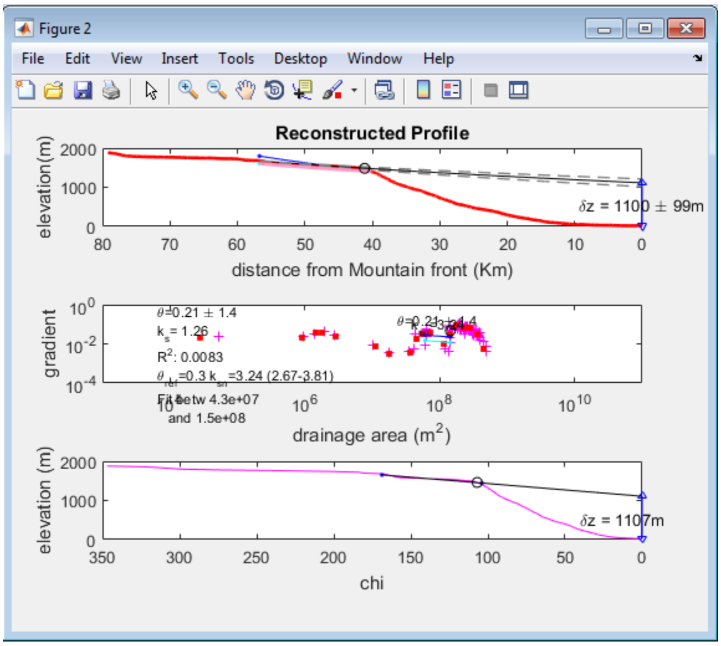
iii) do you want to perform the reconstruction (y) or go for reselect the relict segment (n) : (y/n).... **y**



iv) do you want another S-A regression : (y/n).... **n**

v) Mark points on long profile? (y/n)....

vi) a) logS-logA (fig2 plot 3); b) long profile (fig2 plot1); c) logS-dfm (fig3 plot 2): **b**



vii) Classify this point? (y/n) ....

viii) Major Knick; 2) Minor Knick; 3) Start of Steep Sect.; 4) End of Steep Sect.; 5) Other? **1**

ix) Mark another point? (y/n).... **n**

x) select another channel selection : (y/n).... **n**

(C-9) Knickpoint retreat model (Celerity model)

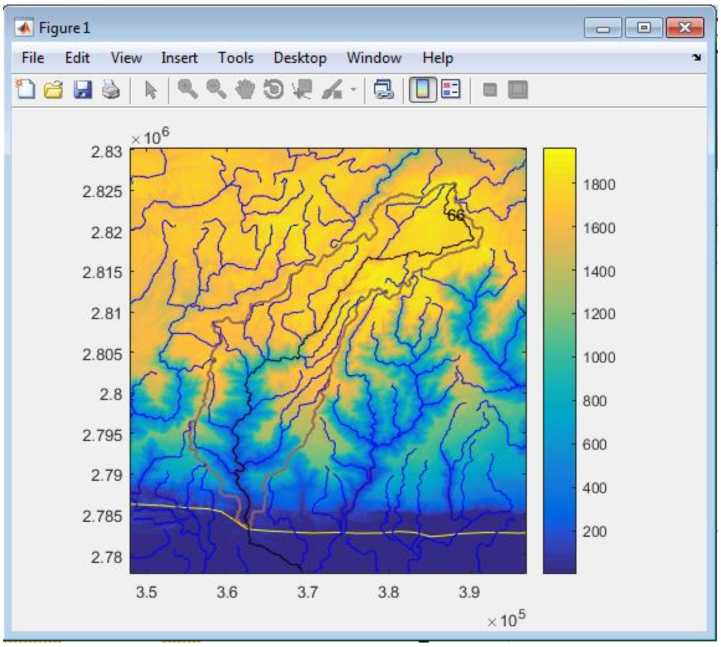
(C-9.1) Knickpoint identification

% listing the observed knickpoints

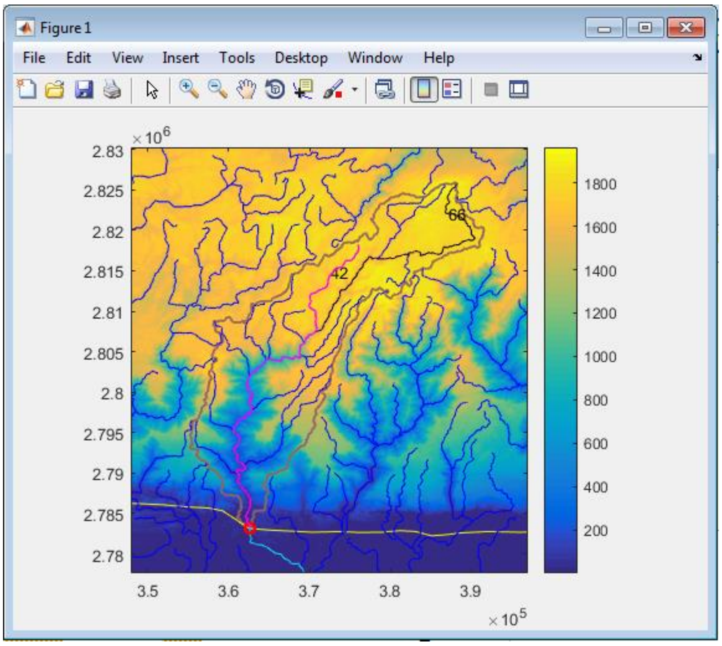
knick_selector4celerity ('dem_filename','divide_filename', 'ref_filename',chanNum)

>> knick_selector4celerity ('umiam_','umiam_divide', 'dauki_fault',79)

ii) select Trunk channel for reference from the figure (1) by clicking near to the channel head...



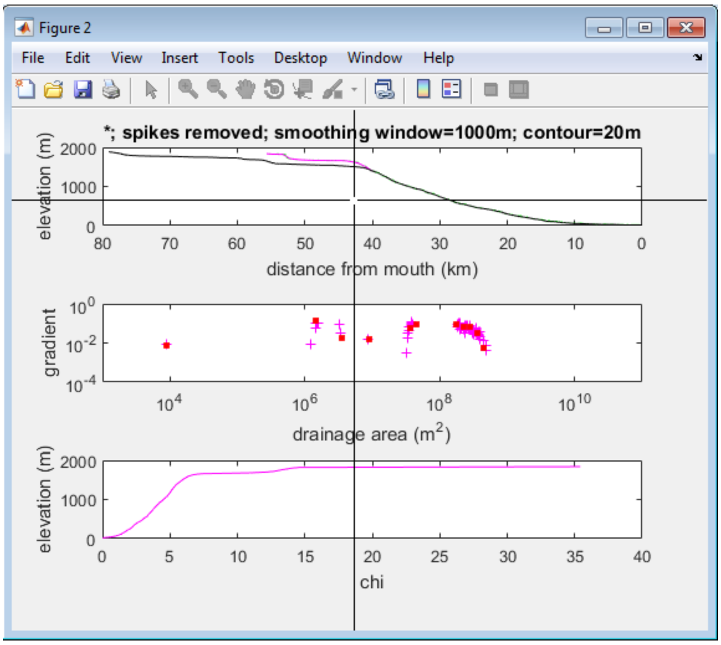
iii) select channel from the figure (1) by clicking near the river head…



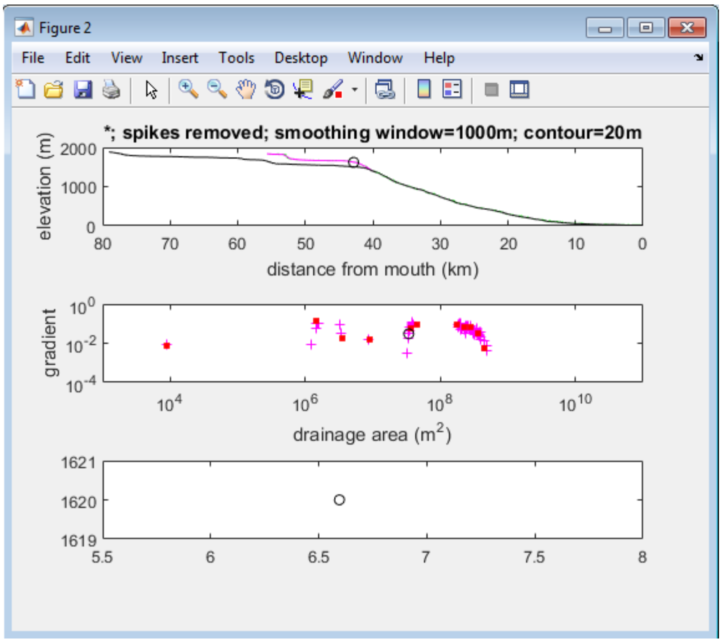
iv) Mark points on long profile? (y/n)....

v) From which plot would you like to mark points?

a) logS-logA (fig2 plot 3); b) long profile (fig2 plot1); c) logS-dfm (fig3 plot 2): **b**



vi) Classify this point? (y/n)....



vii) How do you want to classify it?

1) Major Knick; 2) Minor Knick; 3) Start of Steep Sect.; 4) End of Steep Sect.; 5) Other? **1**

viii) Mark another point? (y/n).... **n**

ix) select another channel selection : (y/n).... **n**

select another channel : (y/n).... n

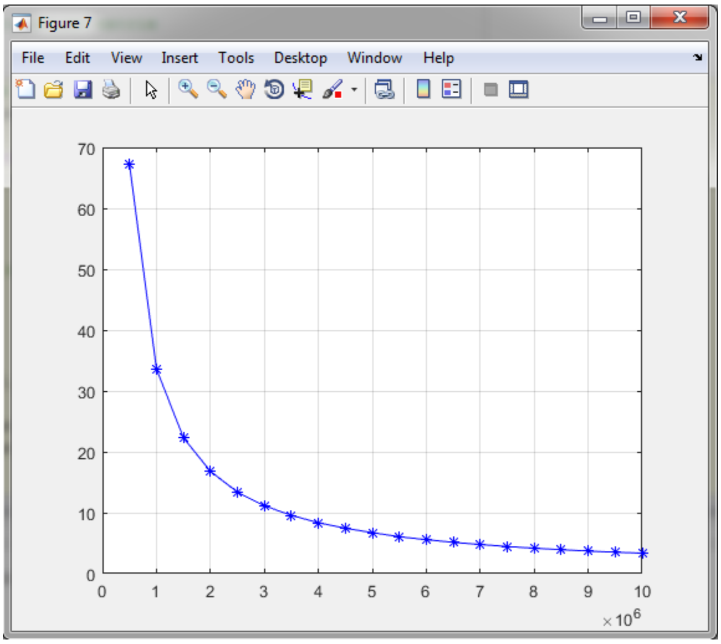
(C-9.2) Celerity parameters estimator (Celerity Model)

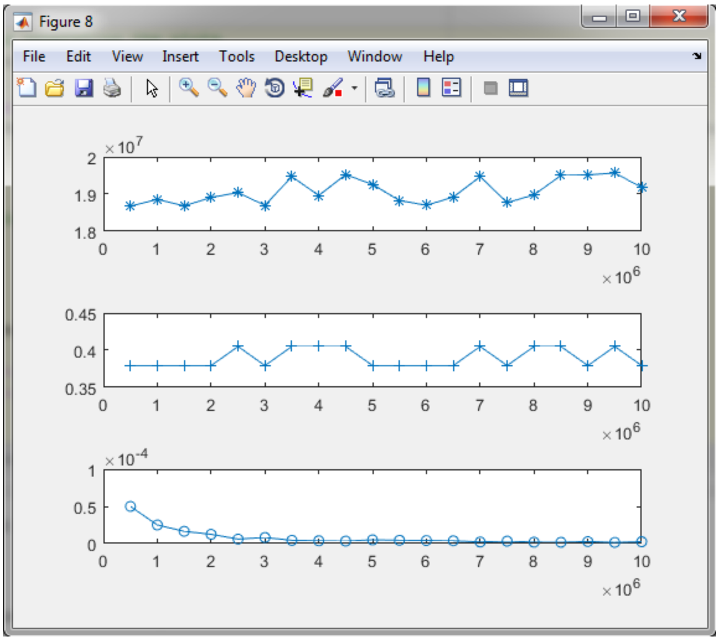
% modify the input parameters and run directly

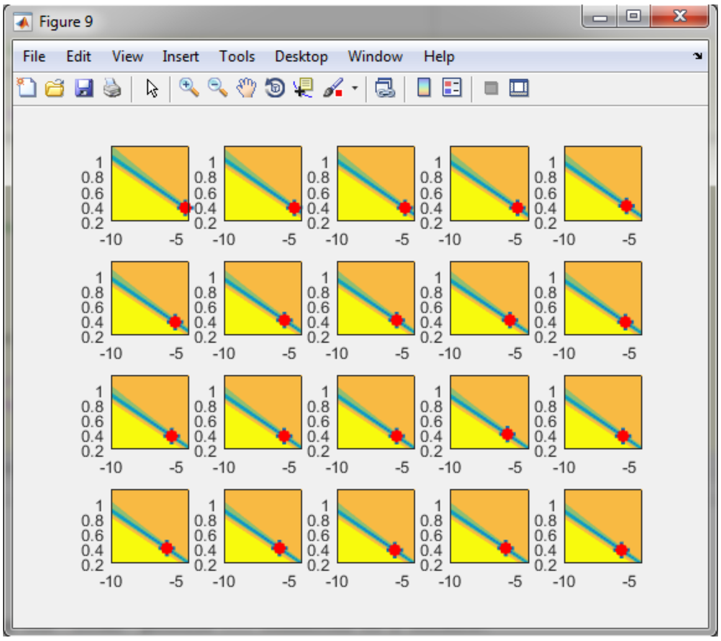
celerity_model('dem_name_',ref_name',ChanNum)

e.g. >>celerity_model('umiam_','dauki_fault',79)

i) enter the age range for celerity run = **(0.5:0.5:10)*10^6**







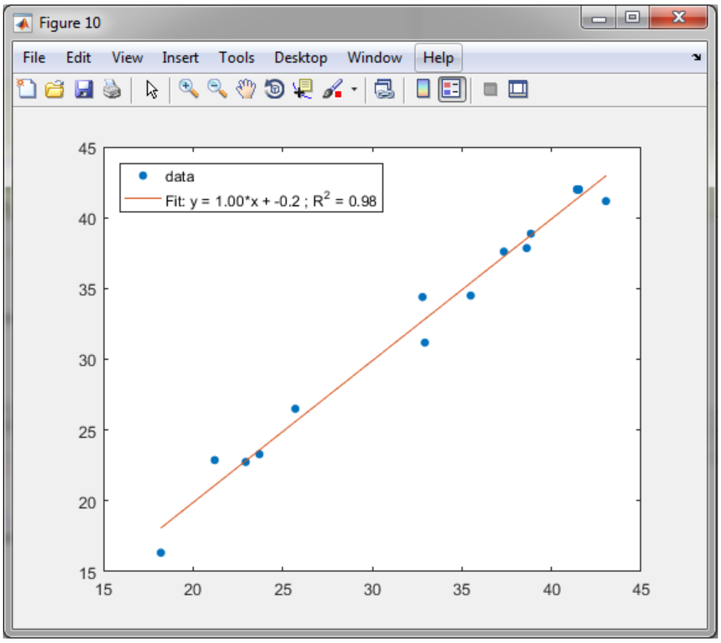
Output files: knickpoint retreat rate plot, misfit plot and m vs K parameters plot

(C-9.3) Celerity model for an age fit

celerity_model_age('umiam_','dauki_fault',79)

e.g. >>celerity_model_age('umiam_','dauki_fault',79)

i) enter the age to the examine the observed vs modeled knickpoits = **4*10^6**\

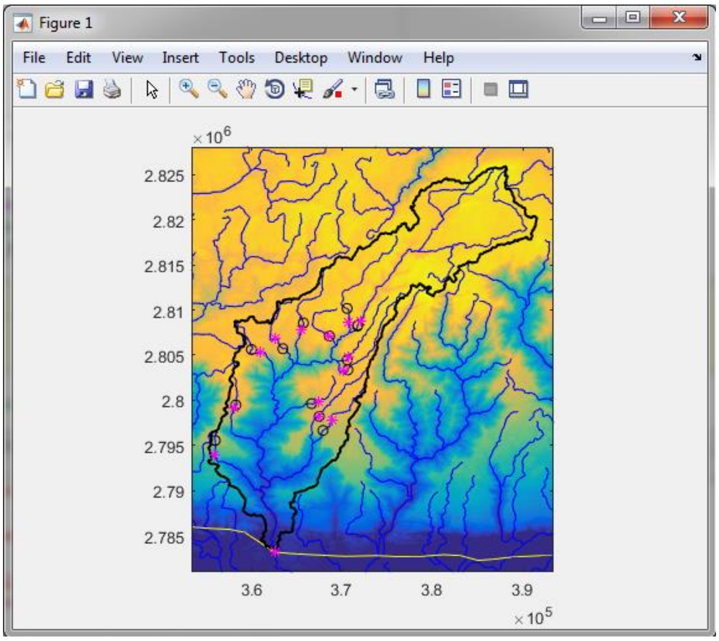


(C-9.4) GIF animation for Celerity Model for given age

celerity_model_GIF_Map('dem_name',’divide_name', 'ref_name',Chan_name)

e.g. >>celerity_model_GIF_Map('umiam_','umiam_divide', 'dauki_fault',79)

i) enter the age to the examine the observed vs modeled knickpoits = **1.5*10^6**

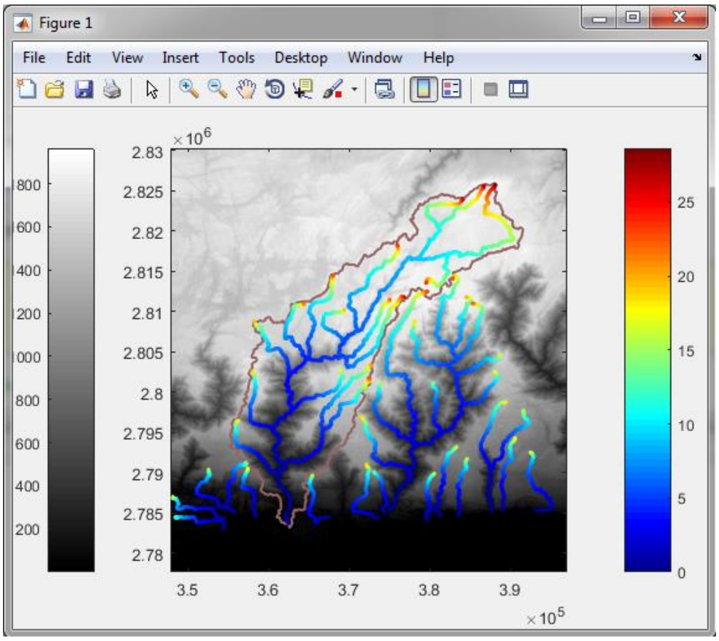


(C-10) Spatial chimap generation

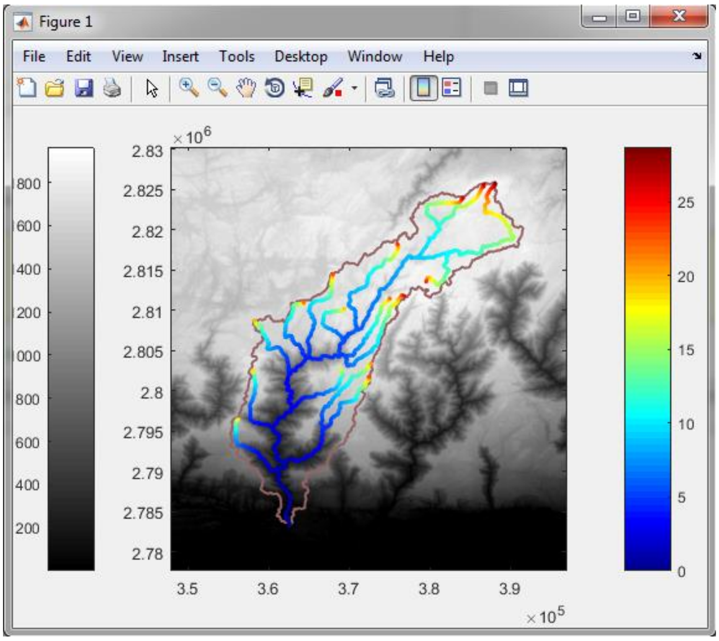
chimap_generator('dem_name', 'divide_name', 'ref_name',ChanNum)

e.g. >>chimap_generator('umiam_', 'umiam_divide', 'contour_20', 79)

x) Enter contour value OR enter "0" for confluence reference : **20**



e.g. >>chimap_generator('umiam_', 'umiam_divide', 'umiam_pour_pt', 79)

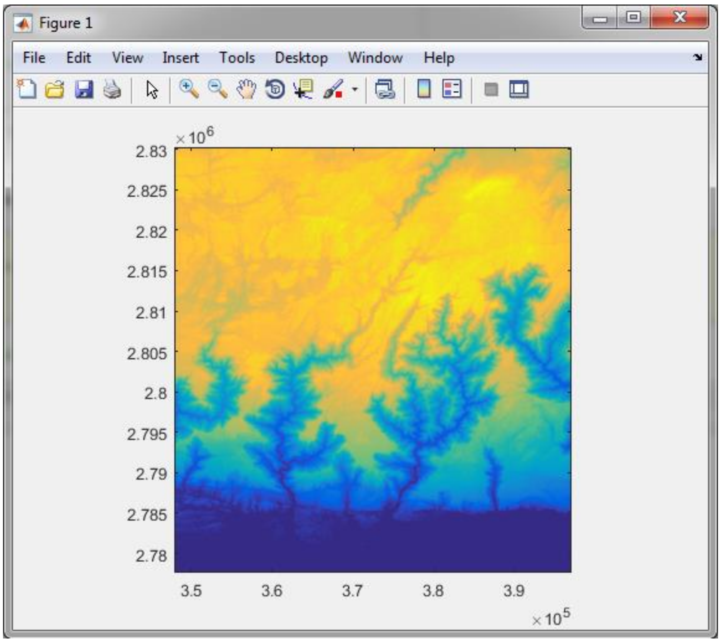


(C-11) Miscellaneous functions

% data visualization

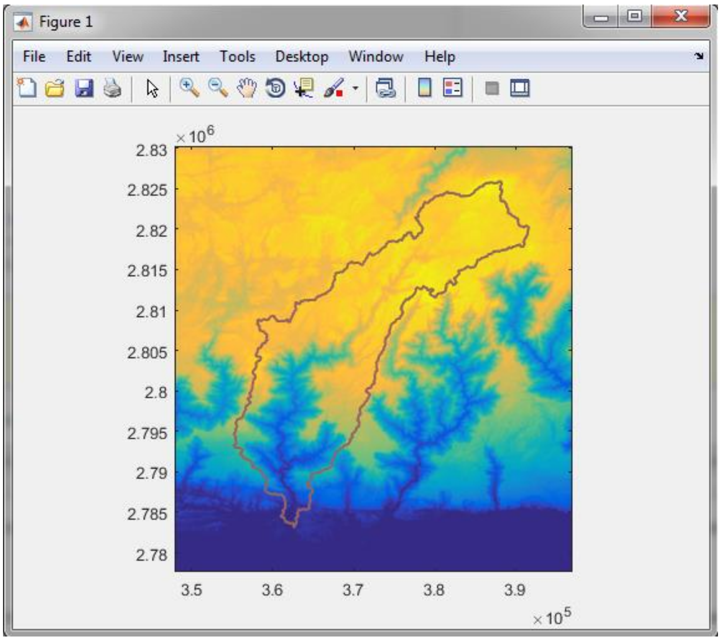
plot_dem('dem_name')

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



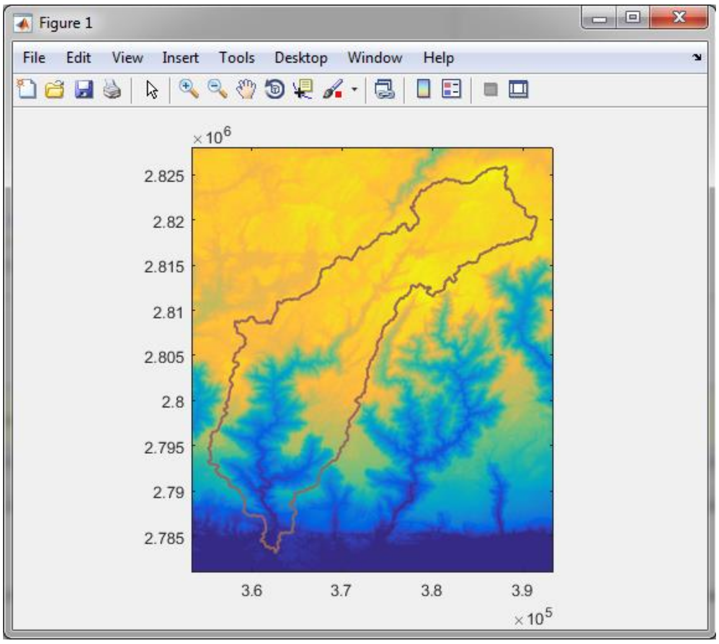
plot_divide('divide_name')

e.g. >>plot_divide('umiam_divide')



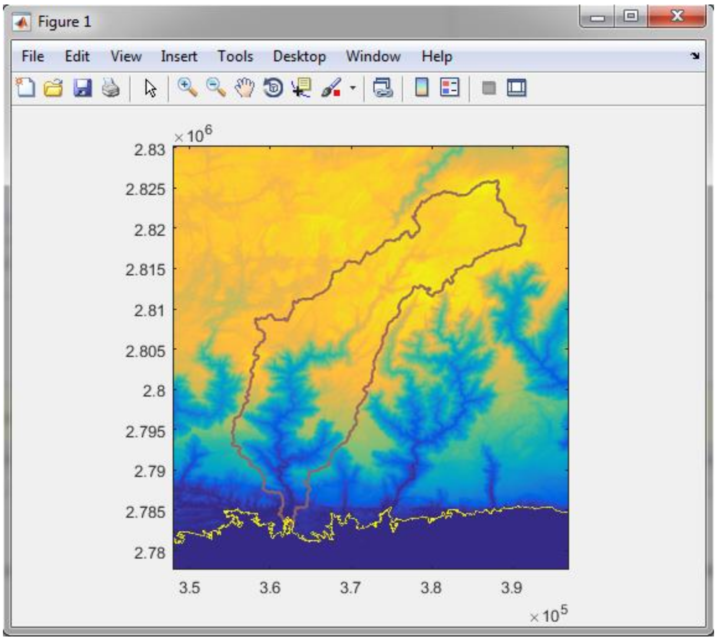
plot_divide_zoom('divide_name')

e.g. >>plot_divide_zoom('umiam_divide')



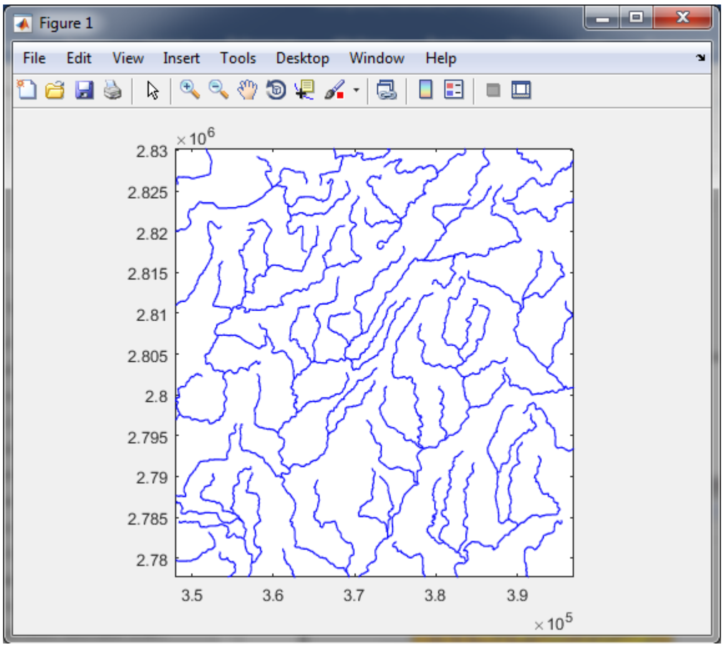
plot_reference('ref_name')

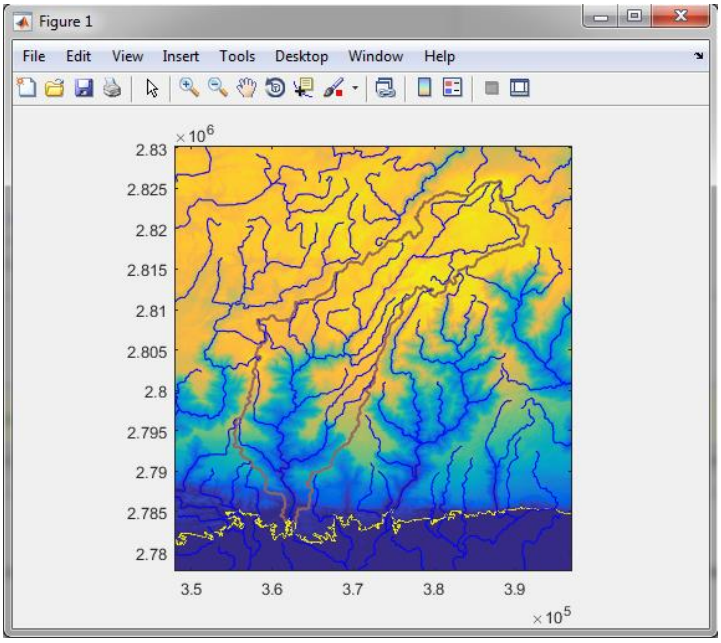
e.g. >>plot_reference('contour_20')



plot_drainage(ChanNum)

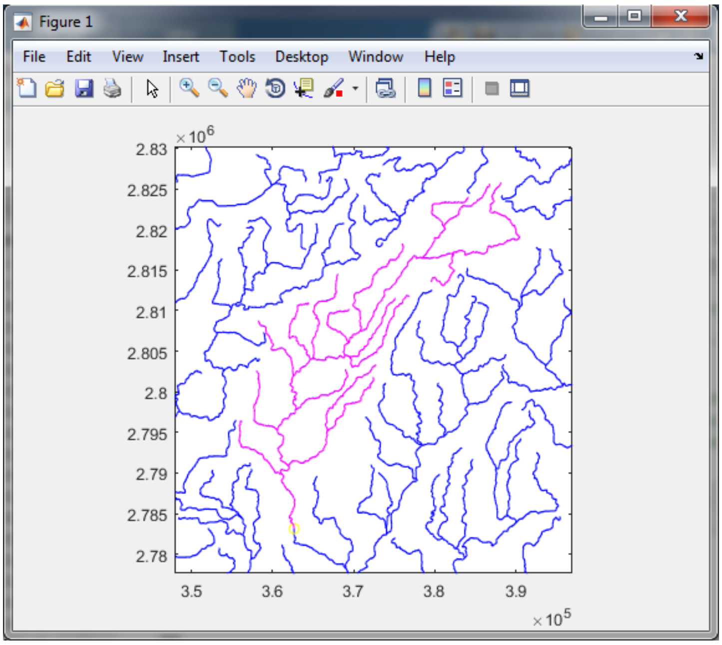
e.g. >>plot_drainage(79)





plot_drainage_ref('ref_name',ChanNum)

e.g. >>plot_drainage_ref('umiam_pour_pt',79)



Point data to shapefile converter

For chimap:

chipoint2line_shp('chimap_pointdata.txt',smooth_wind)

e.g. >>chipoint2line_shp('chimap_pointdata.txt',10)

For steepness map:

ksnpoint2line_shp('ks_pointdata.txt',smooth_wind)

e.g. >>ksnpoint2line_shp('umiam_ks_data.txt',10)
