KZ_picker Users Guide

Al Neely: abn5031@psu.edu

Bodo Bookhagen: bodo.bookhagen@uni-potsdam.de

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I) Common Practical Uses for this Software

General Application and DEM scale

This software package quickly locates knickzones on a regional DEM and measures height, length, and slope of each knickzone. The algorithm has been tested on DEM resolutions ranging from 1 – 30 m. An option to calibrate parameters and calculate uncertainty in selections is included.

Importance/Applications

Outputs record knickzone position and geometry throughout a landscape. The presence and distribution of knickzones may indicate whether a landscape is in steady state; and moreover, can help pinpoint spatial contrasts in rock uplift, rock strength, and/or catchment hydrology (any deviation from flints law/expectations from a simple stream-power incision model).

Runtime:

- On a fast computer in the year 2016, with a DEM size < 0.5 GB, code runtime is typically less than 15 minutes. Memory capacity in matlab limits size of input DEM, namely while performing *topotoolbox* functions to generate flow direction and accumulation arrays.
- Code is designed to run effectively while requiring minimal installation of other software
- **NOTE:** you are prompted to select drainage basins for analysis after starting the code. Usually occurs within 5 mins after starting code (depends on input DEM size)
    - **Code is fully automated except for the above step ^^**

II) Installation

1. '*TopoToolbox*' (https://topotoolbox.wordpress.com/download/). We suggest using the github repository (https://github.com/wschwanghart/topotoolbox).

- Unzip TopoToolbox files and place these in a convenient directory.

- *TopoToolbox* requires the Image Processing Toolbox and the Statistics Toolbox (which are mostly installed in academic environment). The Mapping Toolbox will come in handy, but is not required. The Curve Fitting Toolbox will be used if available.

2. *KZ-Picker* (https://github.com/UP-RS-ESP/DEM-KZP).

- Download .zip file from github repository.
- Extract .zip file in a convenient directory.

- Within extracted folders, enter folder -> KZ-picker -> Matlab
    - Move scripts PARAMETERS_INPUTS_KZ_picker.m and MASTER_RUN_KZ.m to the folder containing the DEM you wish to analyze.

- Open PARAMETERS_INPUTS_KZ_picker.m
    - Adjust run parameters using this file.
        - Make sure to specify the DEM name and tune any smoothing/filtering parameters to match the DEM resolution. Each parameters should have a commented description included in the file to help you choose values.
        - NOTE: if you are calibrating parameter values, make sure line 89 = 1 (if you are not calibrating parameter values, line 89 = 0)

- Open MASTER_RUN_KZ.m
    - Add path to directory storing topotoolbox scripts (Line 152)

Ex: `'C:\Users\Documents\KZ_picker_CSDMS\topotoolbox-master'`

    - Add path to directory storing KZ-picker scripts (Line 157)

Ex: `'C:\Users\Documents\KZ_picker_CSDMS\DEM-KZP-master\KZ-Picker\Matlab'`

III) DEM Preparation

1. DEM Projection: Your DEM MUST have square grid-cells. If you are using a lat-long projection, we suggest using ArcMap to reproject your DEM into UTM coordinates.

2. Clipping DEM: Use *extract by mask* or the *watersheds* tool with a buffer in ArcGIS.

- KZ-picker can analyze any watershed that lies fully within the bounds of DEM coverage:
    - Make sure drainage basins of interests are fully covered by your DEM. If not, you may need to mosaic multiple DEM rasters in ArcGIS to include all basins.
- KZ_picker uses a drainage-area dependent model to extract knickzones. This model is designed for erosional landscapes, so contribution from areas of deposition or non-erosion should be removed from the analysis.
    - **Recommended**: Clip large, alluvial or flat features out of your DEM, such as: lakes, bajadas, or other broad stretches of open-flat land at baselevel.
    - Regions that are not eroding over long-timescales impact your calculation of '*chi*' which is a measure of relative upstream drainage area as a function of upstream distance. Including these regions in analysis of erosional landscapes alters your chi-elevation regression and measured K_{sn} (normalized stream steepness)!
- Larger DEM size increases computational expense and runtime.
    - Quickly clip out any other portions of your DEM that you are certain you will not analyze in your study.

IV) Choosing Parameters for DEM Preprocessing and Knickzone Selection

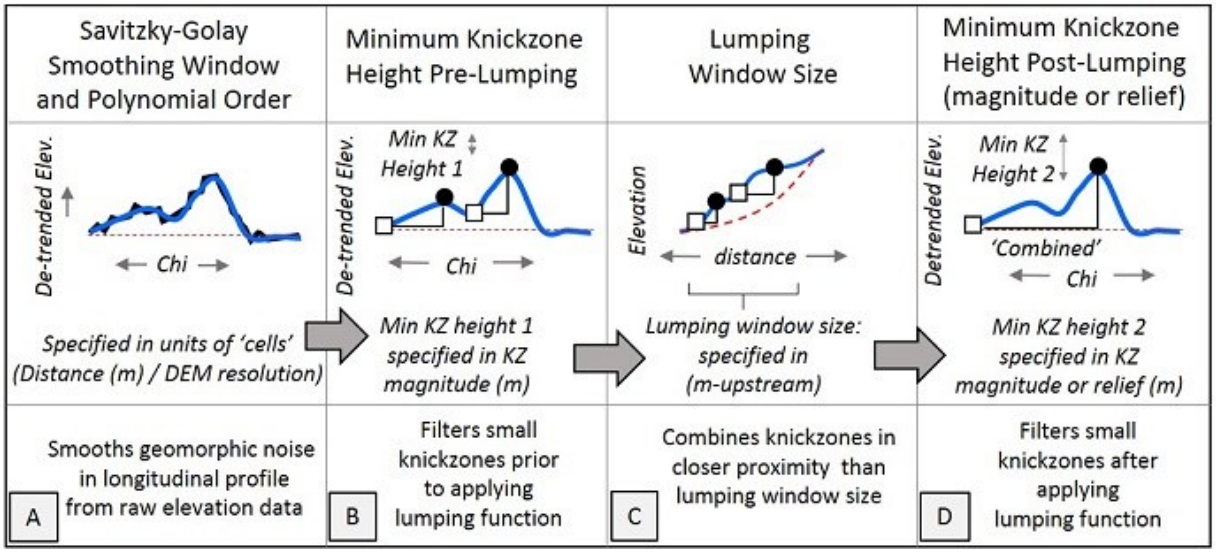
- If necessary: refer to Neely et al., 2017 for a detailed discussion of parameter calibration and code construction: http://onlinelibrary.wiley.com/doi/10.1002/2017JF004250/full

4a. Suggested Parameter Values for Different DEM resolutions from (Neely et al., 2017):

- See figure below table for visualization (panels are labeled A-D)

Parameter Name	1-m DEM	10-m DEM	30-m DEM
`Min_trib_size (cells)`	Larger than Smoothing Window size		
`(A) smoothing_window (cells)`	25 - 125	No smoothing - 15	
`(B) min_kp_size1 (m)`	0.5 - 1.5	0.5 - 2	0.5-5
`(C) lumping_dist_upstream (m)`	25 – 150 * relatively insensitive to DEM resolution		
`(D) min_kp_size2_magnitude (m)`	Final height of smallest knickzone considered		
`(D) min_kp_size2_relief (m)`	Final height of smallest knickzone considered		

4b. Demonstration of Parameter Functions:



4c. Running Parameter Calibration to Help Choose Parameter Values/Estimate Uncertainty

- Algorithm provides option for you to calibrate 4 parameters listed above (section 4b)

- If you are calibrating parameters, line 89 in PARAMETERS_INPUTS_KZ_picker.m = 1

- Calibration knickzones are located manually. Make sure to select ALL knickzones within the calibration catchment and be as consistent as possible with your selection criteria.

    - The profiler toolbar (Whipple et al, 2007) works well:
      Whipple, K.X., Wobus, C., Crosby, B., Kirby, E. and Sheehan, D., 2007. New tools for quantitative geomorphology: extraction and interpretation of stream profiles from digital topographic data. *GSA Short Course*, *506*.

- You must provide at least one .csv file of all knickzone lip positions (we suggest UTM easting and northing) within a calibration catchment.

- If you also have a .csv file with knickzone base positions and knickzone relief measured, you may calibrate knickzone bases and measure geometric accuracy of algorithm selections.

    - Each row in the .csv file should be location of a different knickzone. Rows in .csv file for knickzone bases must correspond to the same knickzone in the .csv file for knickzone lips
        - (i.e. row 1 in *lips.csv* -> knickzone 1 lip postion: row 1 in *bases.csv* -> knickzone 1 base position)

- Move .csv files of your calibration knickzones to the directory storing your DEM.

- If you only have knickzone lip positions, line 92 PARAMETERS_INPUTS_KZ_picker.m = 0

    - Specify the name of the calibration .csv files in parameters script

    - Specify the column numbers in the .csv files containing northing, easting, and knickzone relief information (if only calibrating lips, no relief column read)

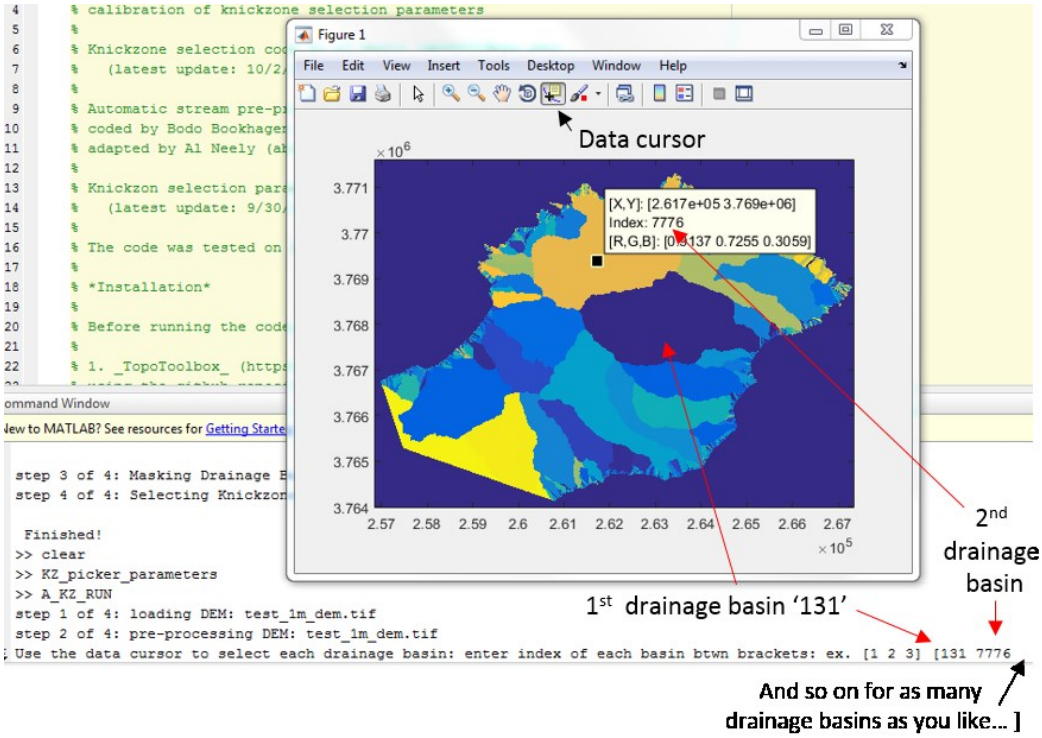
    - Specify error tolerance (varies with size of basin)

    - Specify the range of parameter values you wish to cycle through (lines 140-158)

- After completing parameter calibration, change PARAMETERS_INPUTS_KZ_picker.m line 89 = 0 and run script to locate knickzones over full region using best fit parameters

V) Running Script

- After completing inputs in PARAMETERS_INPUTS_KZ_picker.m script and setting path directories in MASTER_RUN_KZ.m script, run MASTER_RUN_KZ.m script.
- **After a few seconds to a few minutes** (depends on DEM size), the script will display a map of the drainage basins in your DEM.
- Use the data cursor tool to select each drainage basin you want to analyze.
- Record the index number of each drainage basin you'd like to analyze between brackets in the matlab command window. E.g. ['basin index #1' '#2' '#3'… 'final basin index #']



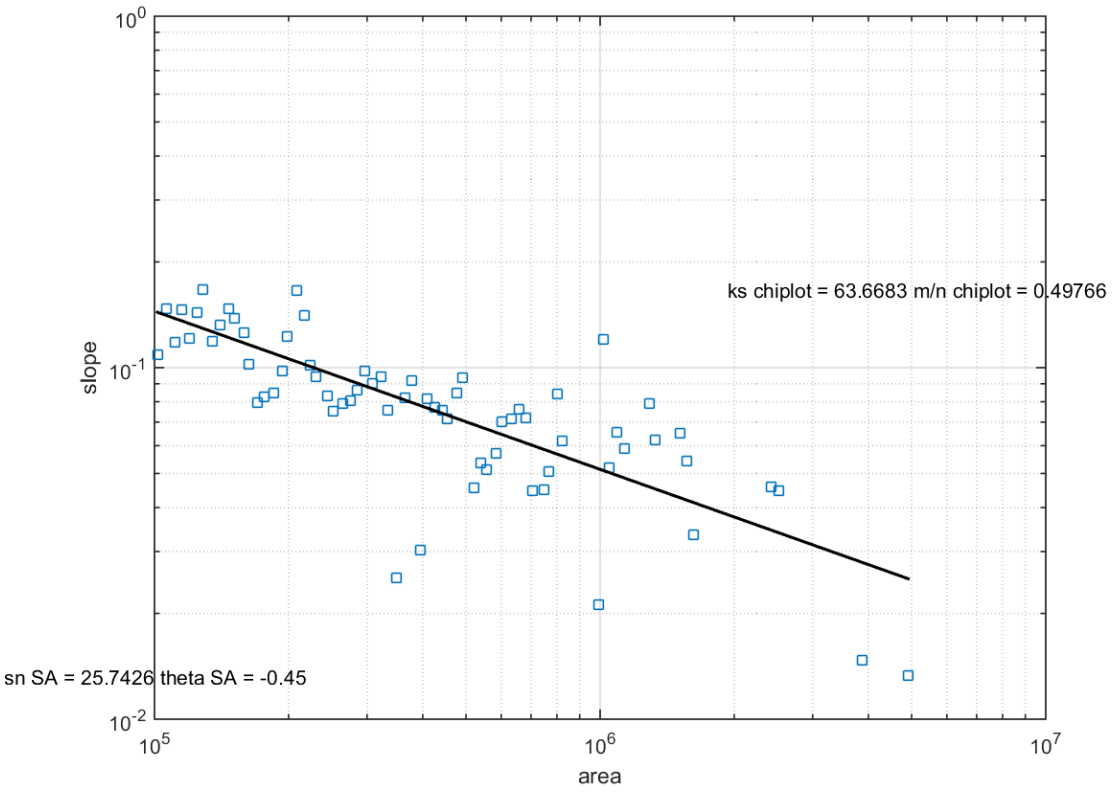
Unfortunately, this function is not fully automated, but allows you to control which basins are analyzed. Each basin will produce its own set of output figures and results! This is useful!

- NOTE: If the basin 'index' exceeds 9999, the code will crash.
    - Solution: clip the edge of the DEM to contain fewer small drainage basins
- Once you enter your basin index vector in the command window, the code will run to completion and produce outputs for each drainage basin you selected.
- It is a good idea to copy and write down these basin ID numbers with the real basin names so you can identify these later.

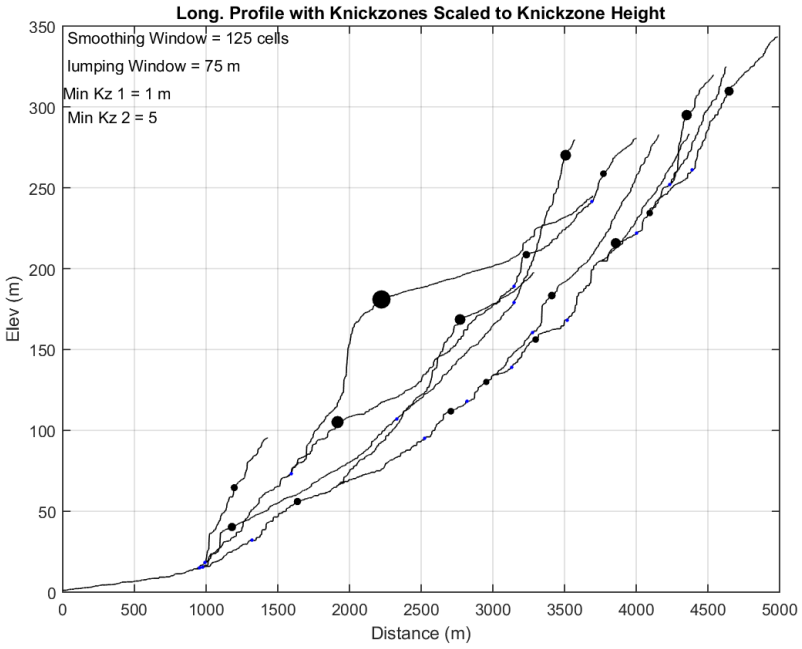
VI) Output Figures and Importing outputs to Arcmap

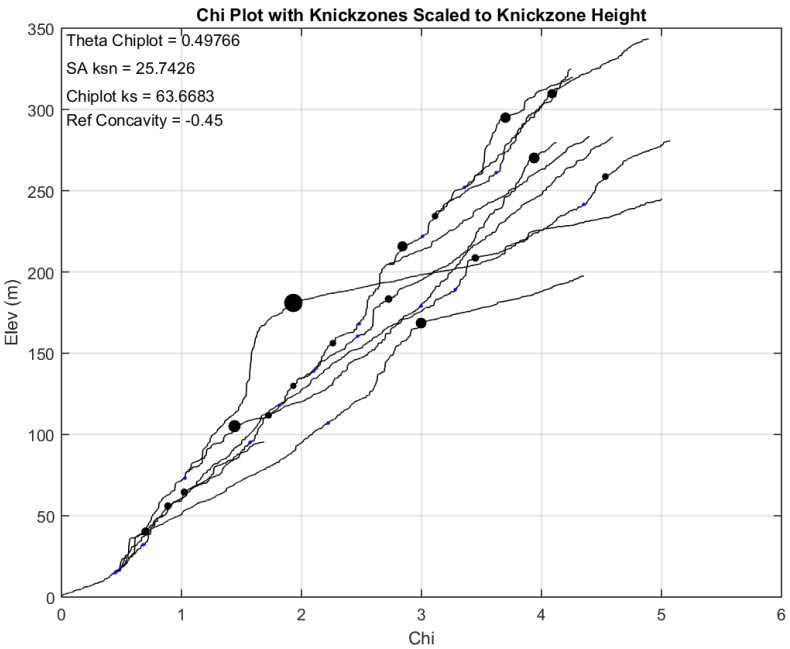
- **Output Directory: \SA_plots**
  - Contains slope-area plots for each drainage basin analyzed
  - Use this to verify your estimate of Min_DA_threshold (line 10 parameters script) or compare k_{sn} (normalized channel steepness) between streams
    - Note: ksn is calculated based off of the slope/area regression and reference concavity and if selected, the best-fit m/n ratio and a regression through χ/elevation data
    - For specifics on slope area regression technique, see script: *D_KZ_masking_DBs.m* which is contained in the KZ-picker script folder (line 90)

Example Slope Area Plot (crude but contains important information):



- **Output Directory: \maps_and_chi_plots**
    - Contains chi plot and longitudinal profile for each basin with knickzones plotted.
        - Knickzone lips are scaled according to knickzone size (height)
        - If knickzones are too big, adjust parameters script line 84 (scale: 0-1)
    - Longitudinal profile displays selection parameters used
    - Chi plot displays a summary of best-fit m/n (from chiplot), and ksn derived from chiplot and S-A regression.





< -- Example Output Figures

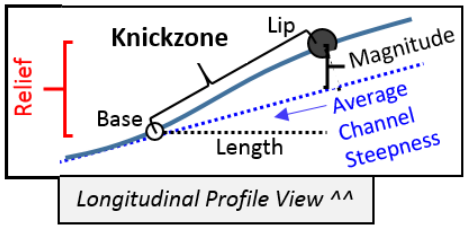
(Basic but useful to identify whether selected results are reasonable)

- **Output Directory: \csv_KZ_databases**
  - **<u>Contains .csv files of knickzone position and geometry information that can be loaded into ArcMap or further analyzed</u>**
  - *kz_lips_all.csv* and *kz_bases_all.csv* store information for all knickzone bases and lips selected across the entire DEM.
  - Each basin analyzed has a separate .csv database for KZ lips and bases found within the basin. These are named using the basin ID from the data cursor.
    - Each row contains attributes and measurements for a different knickzone lip or base

<u>Databases contain the following information:</u>

<u>Column/Field</u>	**<u>Description</u>**
1	Id # for each knickzone lip or base
2	Basin index # for basin containing knickzone lip or base
3	Ksn from slope area plot for the basin
4	Ks calculated using the m/n used in the chiplot regression for the basin
5	m/n used in the chiplot regression for the basin
6	Tributary Id# with the basin
7	Ks calculated from chiplot regression for current tributary within the basin
8	**Chi coordinate of knickzone lip or base**
9	**Elevation of knickzone lip or base (m)**
10	**Knickzone Magnitude: De-trended elevation drop across knickzone (m)**
11	**Knickzone Relief: Elevation drop across knickzone (m)**

Illustration of knickzone magnitude & relief:



12	**UTM easting position of knickzone lip or base (m)**
13	**UTM northing position of knickzone lip or base (m)**
14	**Contributing drainage area upstream from knick zone lip or base (m^2)**
15	**Stream-wise distance of knickzone lip or base from stream outlet (m)**
16	**Channel Slope of knickzone reach (degrees)**
17	**Streamwise length of knickzone (m)**
18	Parameter: (A) Savizky-Golay smoothing window size (cells)
19	Parameter: (A) Savizky-Golay polynomial order
20	Parameter: (C) Knickzone lumping window size (distance)

21	Parameter: (B) Minimum knickzone height pre-lumping (m)
22	Parameter: (D) Minimum knickzone height post-lumping (m)
23	Parameter: Minimum knickzone slope (degrees)
24	Parameter: Minimum stream reach size considered for analysis (cells)
25	Parameter: minimum drainage area of stream network (m^2)

^^ Bolded attributes refer to measurements of knickzone position or geometry

(Other attributes are attributes of basins or tributaries analyzed, or parameters values used)

6a. *Loading Knickzone Databases in ArcMap:* *(Output Directory: \csv_KZ_databases)*

- You can load knickzone databases into ArcMap to visualize results and combine with other geospatial data/analysis! *(helpful output metrics to plot are bolded above)*
    - To load into Arcmap: *file -> add data -> add XY data ->* select "*filename".csv*
        - For 'X field' use column 12 (UTM easting position)
        - For 'Y field' use column 13 (UTM northing position)
        - Scale another knickzone attribute such as magnitude, relief, slope, chi coordinate, or upstream drainage area, by color or markersize

Example: