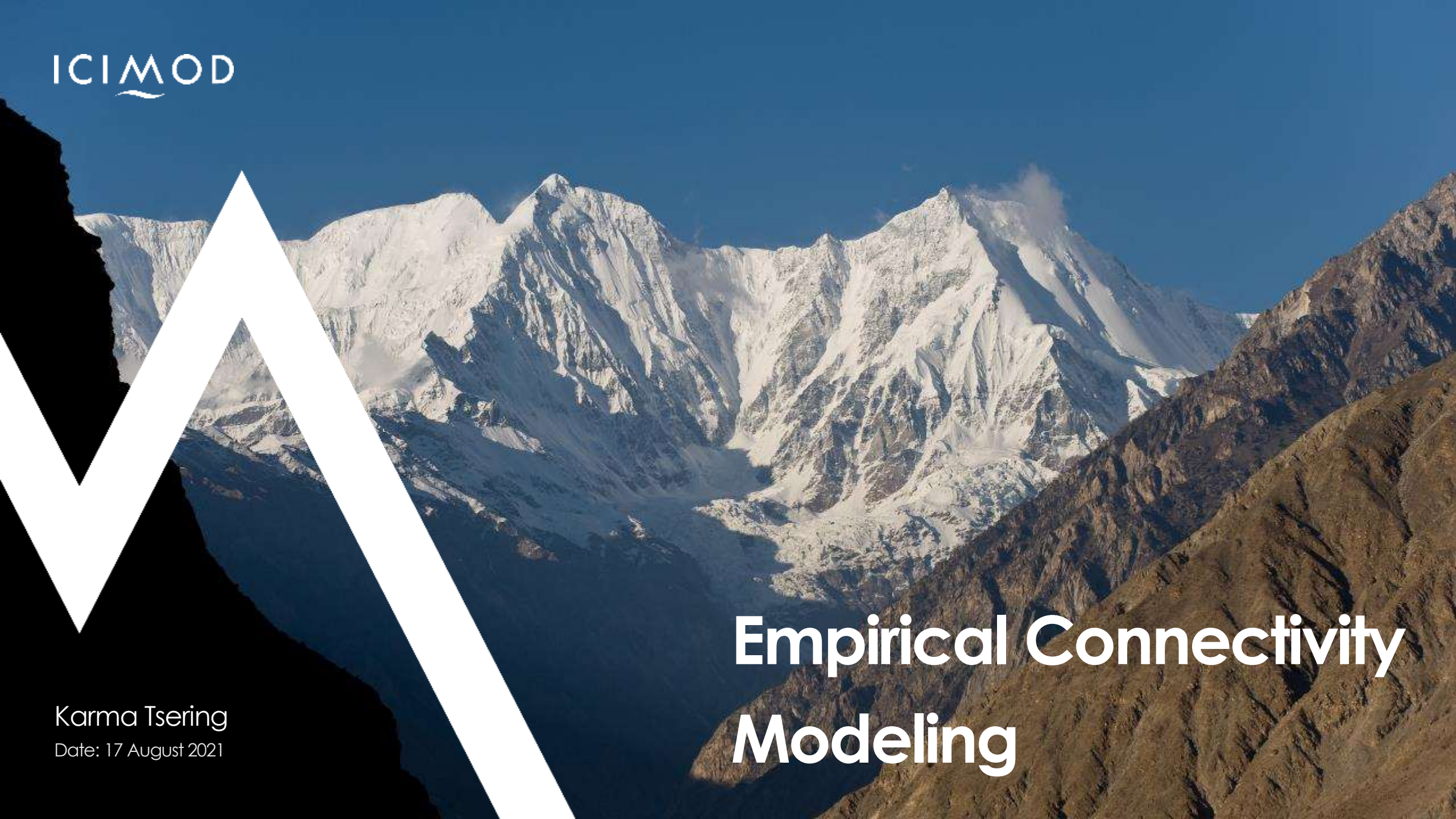


Empirical Connectivity Modeling

Karma Tsering

Date: 17 August 2021

Connectivity Modeling – Least Cost Pathway

Inverse of habitat suitability map as resistance map or travel cost map assuming suitability means permeability

Resistance (travel cost) = max suitability – pixel suitability

Identify edge/points of habitat blocks as start- and end-points for modeling corridors

Calculate cost-distance (pixel to terminus) of each pixel and select appropriate slice/swath as modeled corridor wide enough for movement and narrow enough to minimize cost of conservation

Width x2 wider than home range width for corridor dwellers, and ad-hoc for passage species

choosing the right corridor slice is an iterative process

Do not recommend corridor of single pixel least cost path

Cost distance

Calculate each pixel's accumulative cost-distance

lowest possible cumulative resistance from each pixel to terminuses in each habitat block marks corridor plane profile

Transform to meaningful categories using appropriate cost-distance thresholds

Evaluate linkages for utility using frequency distribution of habitat suitability within corridor, bottleneck and width, inter-patch distance, etc.

Cricuitscape

Circuitscape is currently one of the most widely-used connectivity modeling tools

Known for its robustness, ease of use, lack of reliance on commercial software

supportive and accessible community of users.

Two versions of Circuitscape are available

- A stand-alone version;
- a version that runs within ESRI ArcGIS software (ESRI, 1999-2015).

toolbox and can be added to any ArcGIS application e.g. ArcCatalog or ArcMap

"Circuitscape for ArcGIS" tool for exporting ESRI-format data into formats readable by Circuitscape

Tests showed negligible difference in processing time between the stand-alone and ArcGIS versions

stand-alone version is more visually intuitive

the same functionality is available from either version.

Step 3: Button-Pushing – Running the Model

Download and install Circuitscape

Prepare data for use in the model

- Advanced Mode Run: needs additional input rasters

Convert data to raster ASCII format preferably .asc extension

Each core area raster must have a unique identifier (core_ID), and NODATA for the rest

Raster resolution, coordinate system and extent of core raster must be identical to that of resistance surface

- Resolution determined by the modeling scale and processing power

Resistance surface must not contain isolated "islands", surrounded on all sides by NODATA pixels

Core areas cannot overlap with any NODATA pixels

How Circuitscape Works

Network (nodes and links) and raster data types

Links and raster cells attributed with resistance values (or conductance)

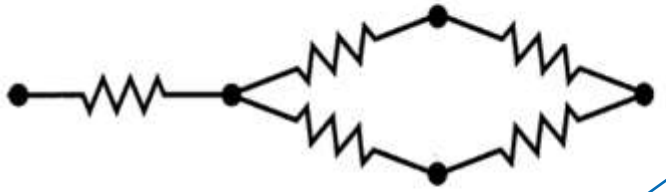
4 modes: pairwise and advanced (raster and network), one-to-all and all-to-one (raster only).

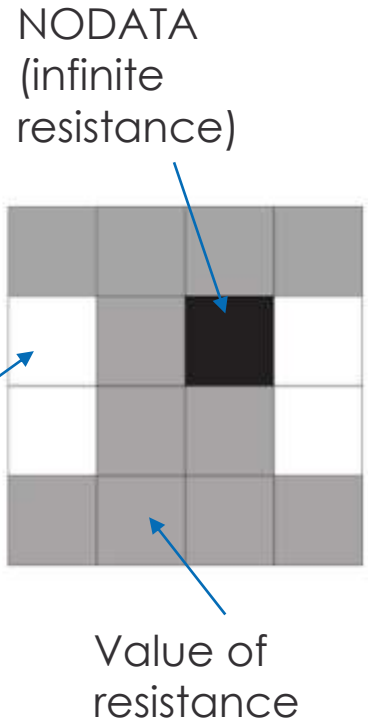
For each pair of focal nodes (core areas) one is current source and other grounded.

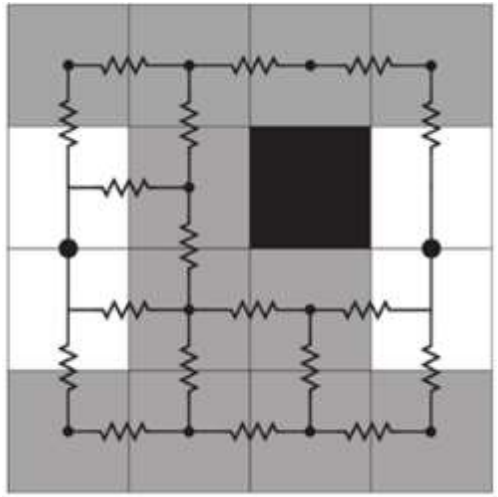
Effective resistance calculated between all pairs.

n focal nodes require n(n-1)/2 calculations; n focal points = n calcs

Sources and grounds can be provided in separate input files



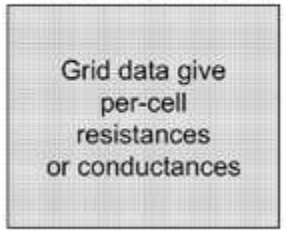




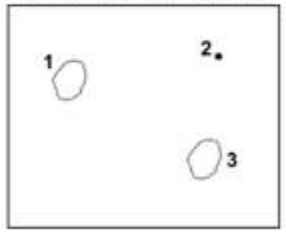
Every grid cell with finite resistance is represented as a node connected to neighboring cells. Cells with infinite resistance are dropped. Cells with 0 resistance are short-circuited.

Analyses with raster data

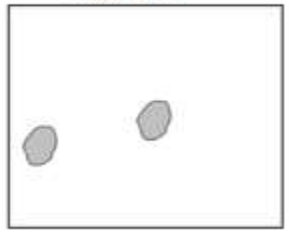
Resistance or conductance grid



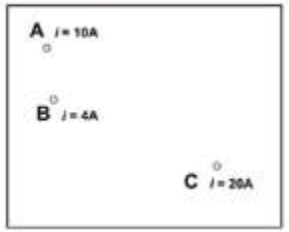
Focal points and/or regions (grid or list)



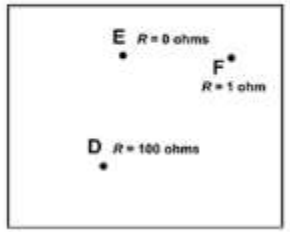
Grid of short-circuit regions



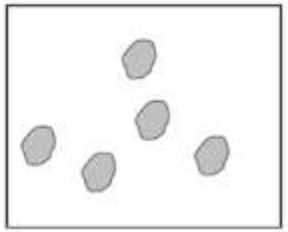
Current source file (grid or list)



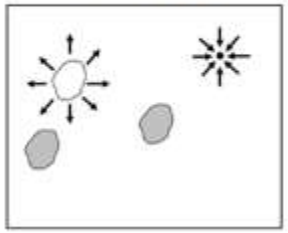
Ground file (grid or list)



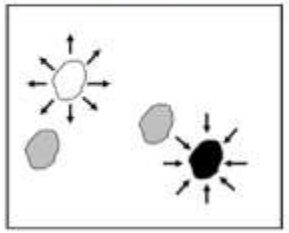
Grid of short-circuit regions



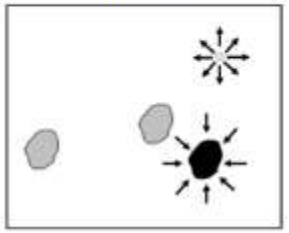
Nodes 1 and 2 activated



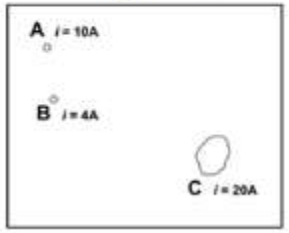
Nodes 1 and 3 activated



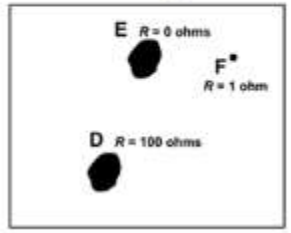
Nodes 2 and 3 activated



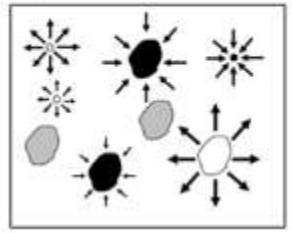
Effective current source configuration



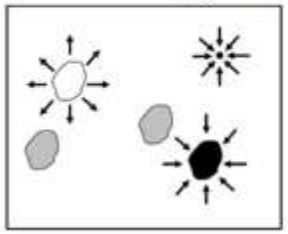
Effective ground node configuration



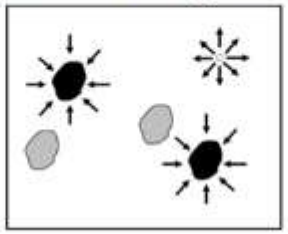
Result: all sources and grounds activated



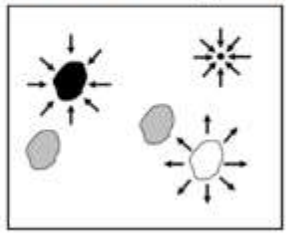
Node 1 = source
Nodes 2 & 3 = ground



Node 2 = source
Nodes 1 & 3 = ground



Node 3 = source
Nodes 1 & 2 = ground



Step 3: Button-Pushing – Running the Model

Set input data type to Raster

Set mode to Pairwise

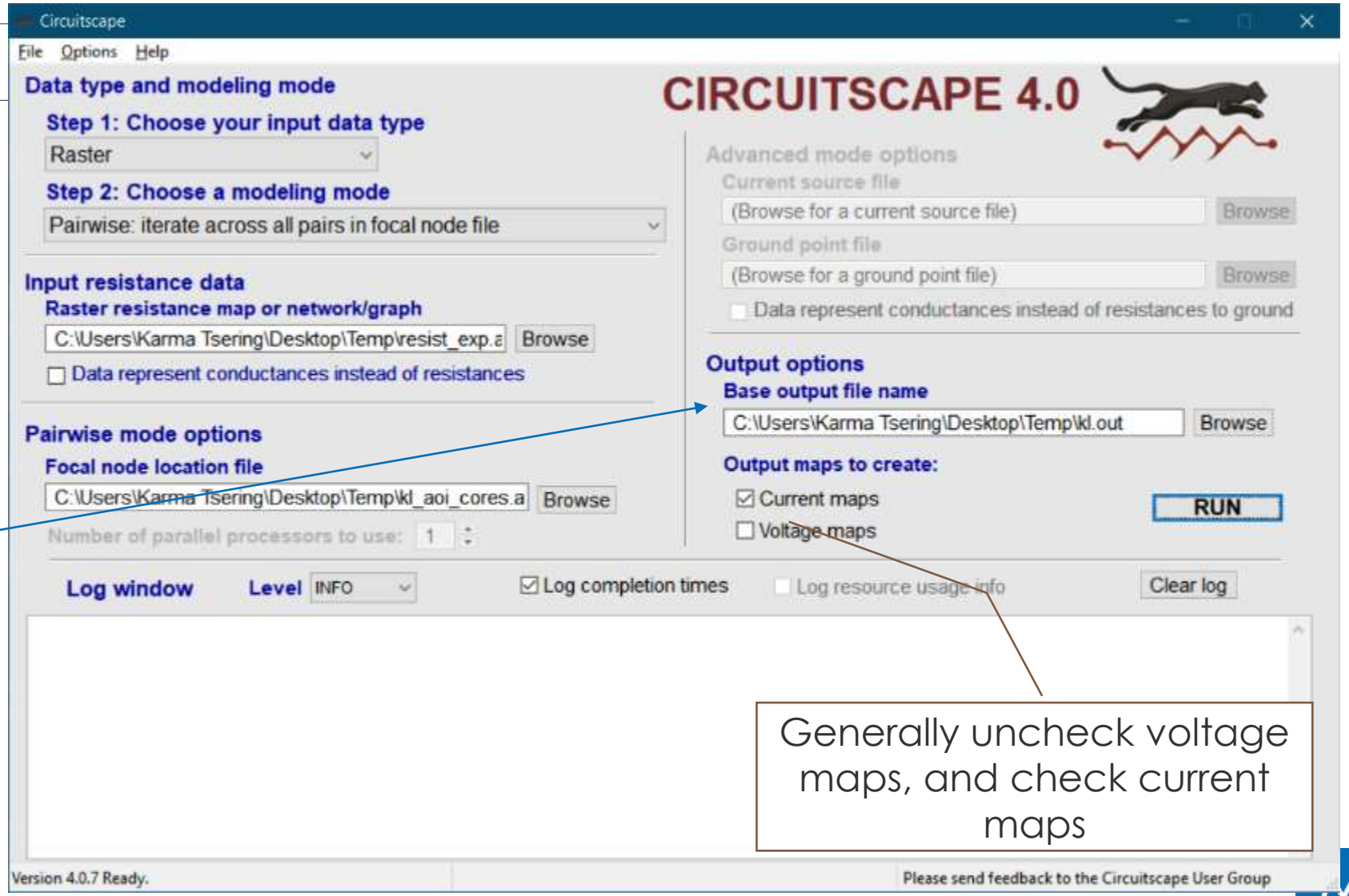
Browse to your ASCII resistance map; uncheck box below

Browse to your ASCII Focal node location file

Browse to choose location for your output files;

Create a new folder for each run

Give them a base name to identify the different runs



Generally uncheck voltage maps, and check current maps

Step 3: Button-Pushing – Running the Model

Only options available for the active mode will be accessible

The "Connect raster cells to FOUR neighbors instead of EIGHT" box should be UNCHECKED.

CHECK the "Write cumulative & max current maps only" box

CHECK the "Set focal node currents to zero" box

In most cases, it's best to leave the "Log-transform current maps" box UNCHECKED.

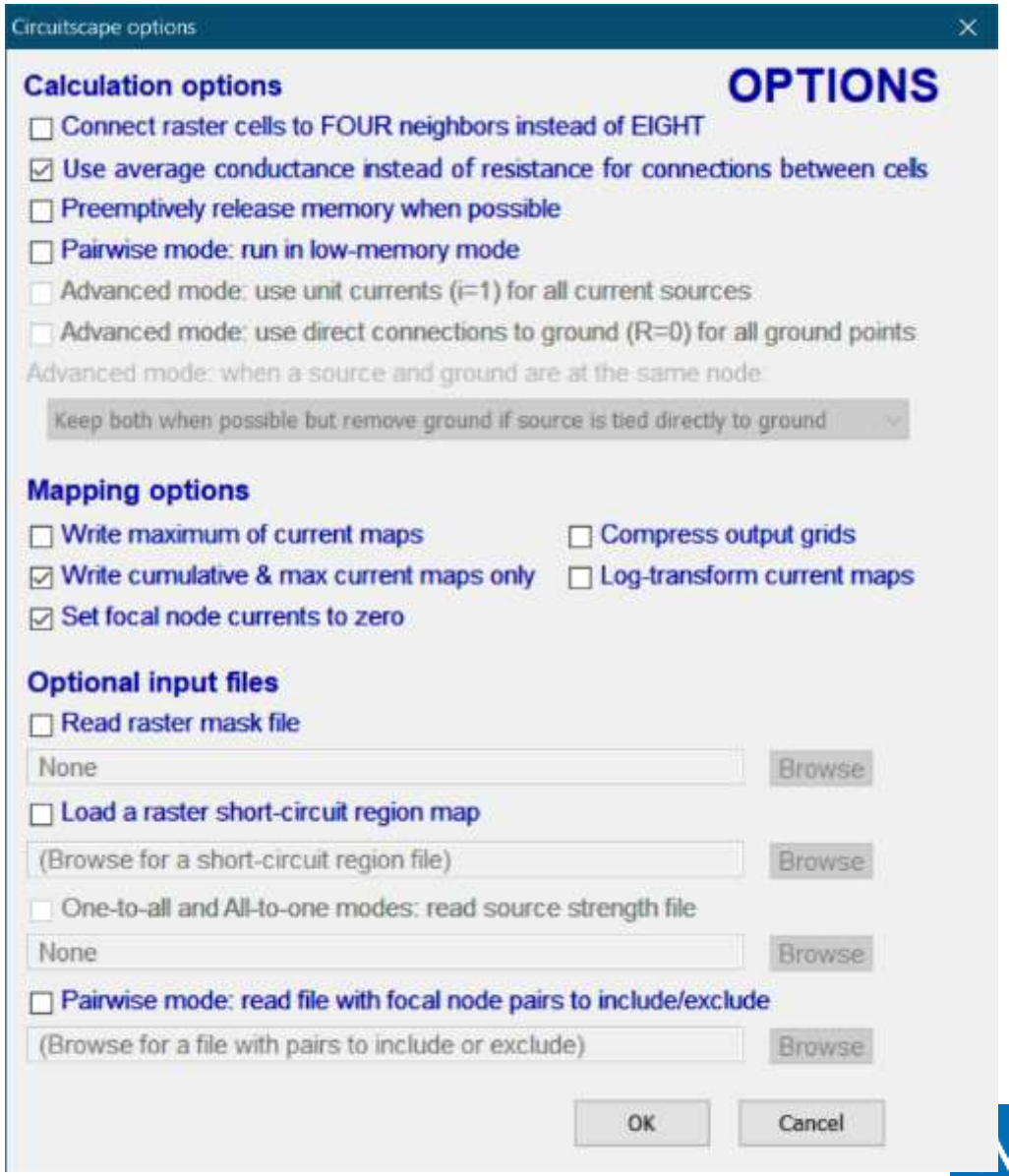
Review the options you've selected and deselected, and click "OK" to return to the main interface

Save your model settings - go to "File > Save Settings" - before running the model.

Close all other programs to dedicate processor and memory resources to the model; ensure power till run completion; disable scheduled, automatic system updates;

Review your model settings (and options) one last time

Hit RUN button



Post-Processing, refining model outputs

Locate output files in specified run folder. Two important ones:

The file ending in "_cum_curmap.asc" is the cumulative current map, which is the map of connectivity across your study area, and the base input from which you will build all spatial data layers described below.

The log file ending in "_rusages.log", which tells you about the results of your modeling and confirms that everything worked. If there is a second .log file - this shows computer processing times, if you have chosen to log them) and can be viewed in any text editor.

Step 5: Model Results and How to Use Them

Map continuous connectivity surface showing areas of high current and low current or permeability across the landscape

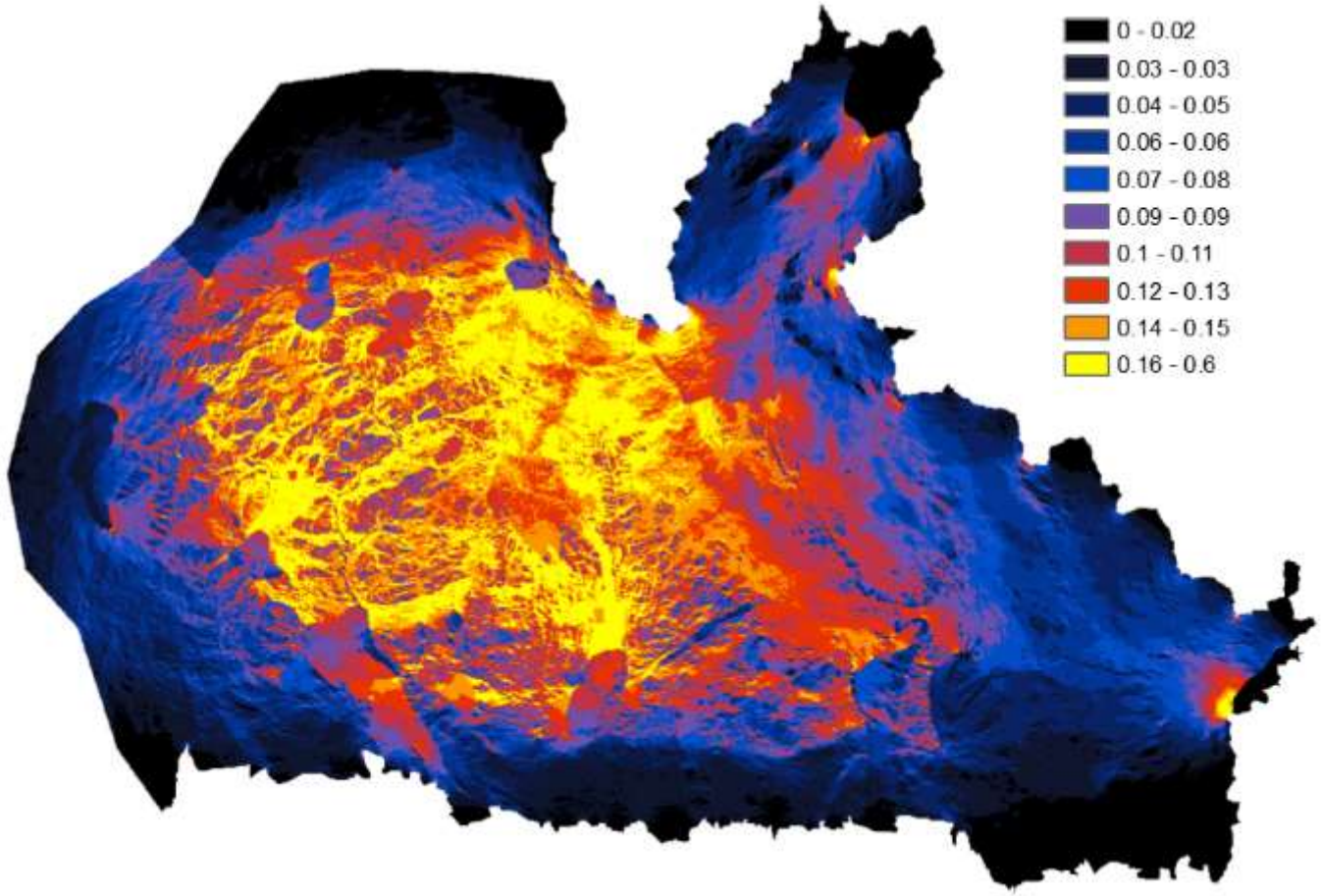
- Show narrow, focused regions of connectivity to broader, more diffuse regions, and everything in between

Map discrete zones of connectivity- extract and delineate highest connectivity regions within the study area

Analyze histogram of cumulative current raster values, setting appropriate threshold, and reclassifying data, setting meaningful class boundaries

Change detection and overlays between scenarios of spatial or temporal changes.

- normalize outputs before comparison



Linkage Mapper

hybridizes least-cost corridor modeling with Circuitscape

Connectivity conservation priority –weighted overlay of Linkage Pathways, Pinchpoint Mapper, Linkage Priority tools

Connectivity restoration priority (all above overlaid with the highest priority sites identified by Barrier Mapper

Trouble-shooting

If you run into any errors, problems, unexpected results, or other issues, a valuable resource for discussing them is the Circuitscape Forum Google Group. Here you can post questions and get answers from experienced Circuitscape users; you can also search the forum to see if someone else has already encountered a similar problem and found resolution through the group.

I will be around, reach me through the WhatsApp group

Thank you

Protect the pulse.

Convert landcover to some biologically relevant resistance values

Adapted from Theobald (2012) ranging from null (0) to highest (100) resistance

code	Land_cover_class	resistance
0	No Data	0
11	Open Water	0
21	Developed, Open Space	52
22	Developed, Low Intensity	64
23	Developed, Medium Intensity	76
24	Developed, High Intensity	85
31	Barren Land (Rock/Sand/Clay)	24
41	Deciduous Forest	7
42	Evergreen Forest	7
43	Mixed Forest	7
52	Shrub/Scrub	5
71	Grassland/Herbaceous	17
81	Pasture/Hay	56
82	Cultivated Crops	68
90	Woody Wetlands	11
95	Emergent Herbaceous Wetlands	11