

R: A New Topography-based Subgrid Architecture for Land Surface Modeling

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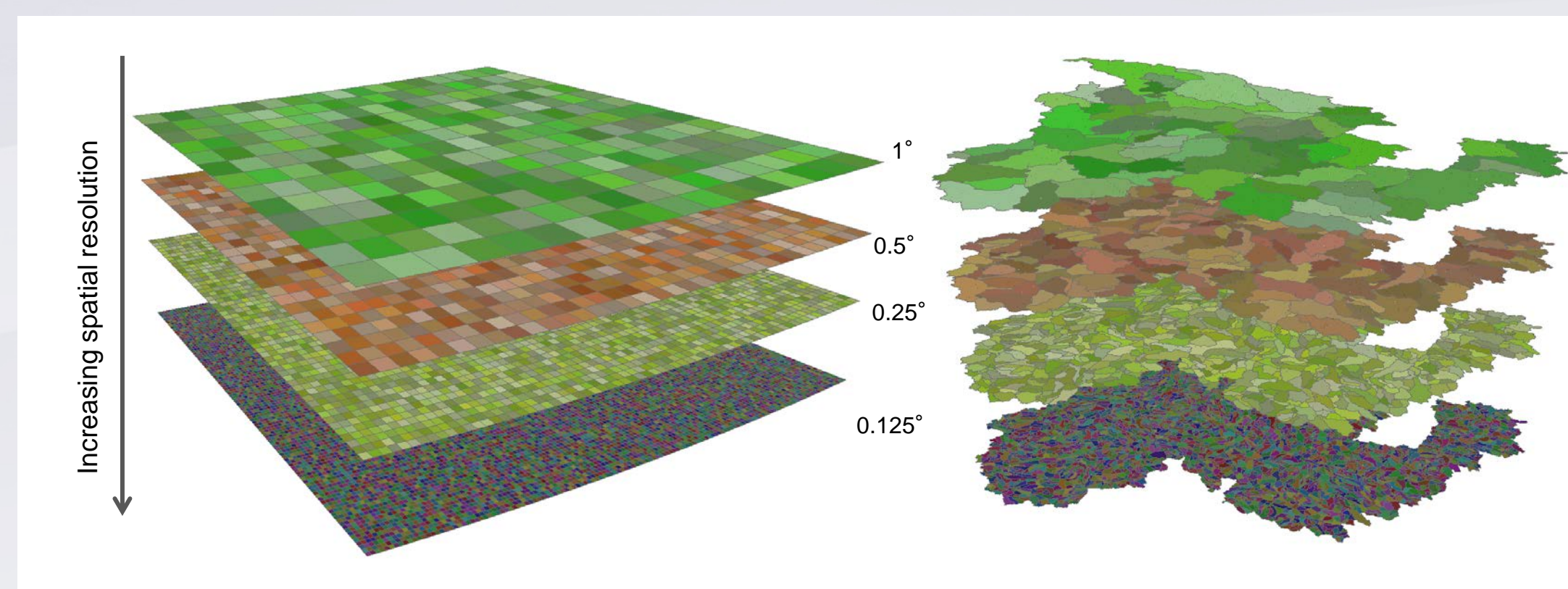


Introduction

Topography exerts a major control on land surface processes through its influence on atmospheric forcing, soil and vegetation properties, network topology and drainage area. Spatial structure of land surface models that captures spatial heterogeneity influenced by topography may improve representation of land surface processes. For example, land surface modeling using subbasins instead of regular grids as computational units has demonstrated improved scalability of simulated runoff and streamflow processes (Tesfa et al. 2014a&b).

A new land surface spatial structure is being developed by further dividing subbasins into subgrid units based on elevation, topographic slope and aspect to take advantage of the emergent patterns and scaling properties of atmospheric, hydrologic, and vegetation processes in land surface models. In this study, two methods (local and global) to derive topography-based subgrid land units are explored.

Applying the two methods to two topographically contrasting regions in the Northwestern United States shows that the local method reflects the topographic patterns better than the global method (i.e., more subgrid units are used in complex terrain to capture the subgrid topographic variations). The local method is being applied to develop a global dataset of subgrid land units for the Community Land Model (CLM4.5).



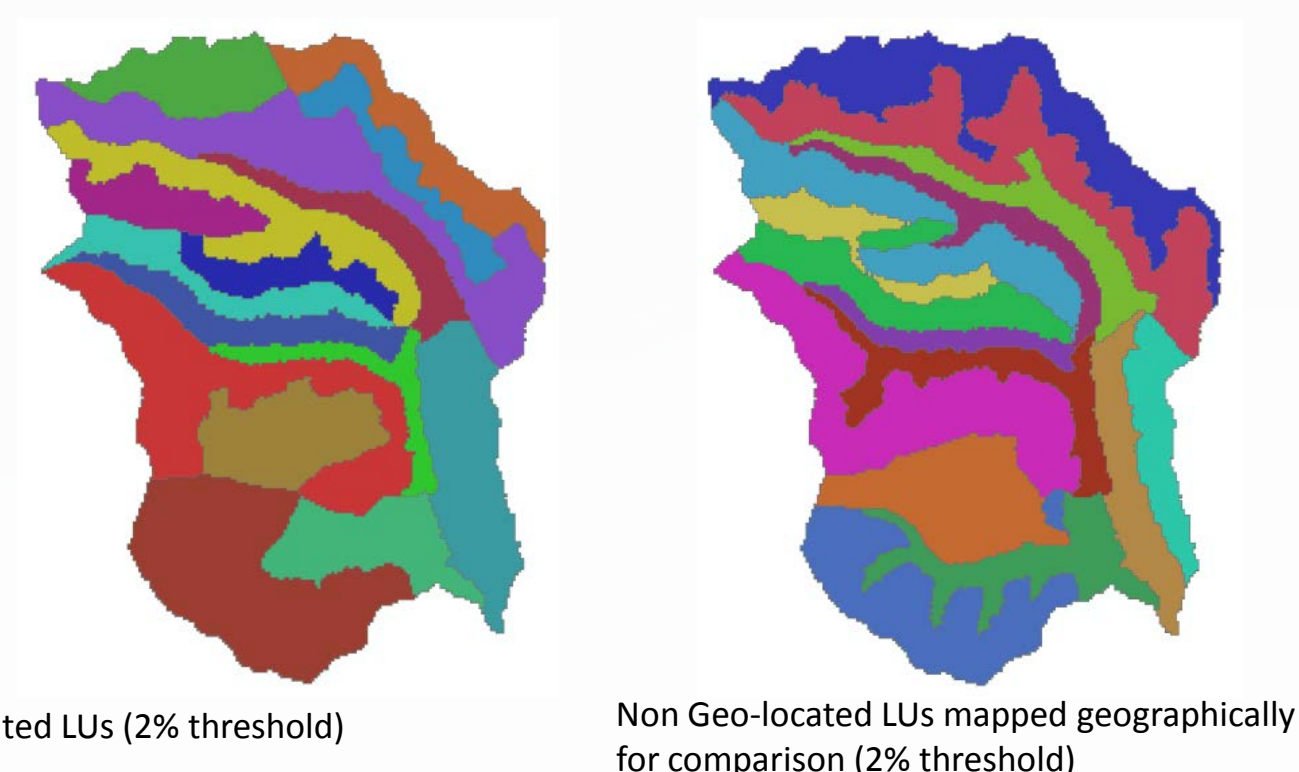
Approach

Watershed delineation and deriving topographic variables from DEM:

- Watersheds (Subbasins) are delineated from a high resolution Digital Elevation Model developed by merging the HydroSHEDS (Hydrological Data and maps based on Shuttle Elevation Derivatives at multiple Scale) with other elevation datasets to generate globally more consistent DEM. The non HydroSHEDS elevation data were downloaded from <http://www.viewfinderpanoramas.org/dem3.html>.
- Topographic variables such as slope and aspect are derived from the DEM using TauDEM (Terrain Analysis Using Digital Elevation Models), a set of DEM tools developed for the extraction and analysis of hydrologic information from DEM topographic data.

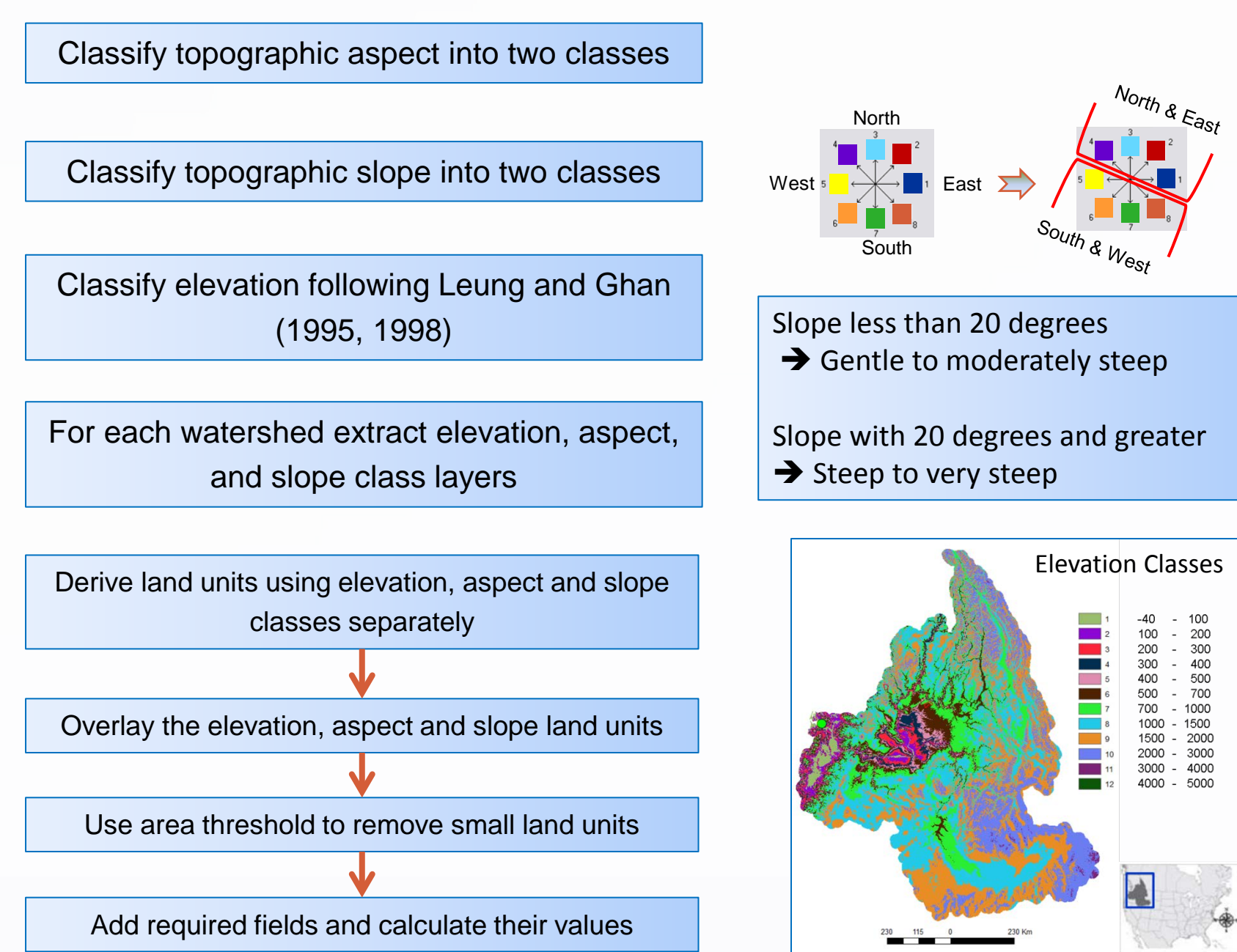
Develop Subgrid Land Unit Delineation Methods:

- Two Land Unit delineation methods are developed and explored for their ability to capture topographic heterogeneity and pattern using the Columbia River Basin as test bed.
- The two methods are employed to delineate two types of subgrid land units (geo-located and non geo-located) over the test bed. Geo-located land units represent contiguous area with explicit geographic location, while non geo-located land units are spatially non-contiguous areas of the subbasin described by fractional areas. Both methods utilize ArcGIS and Python tools.



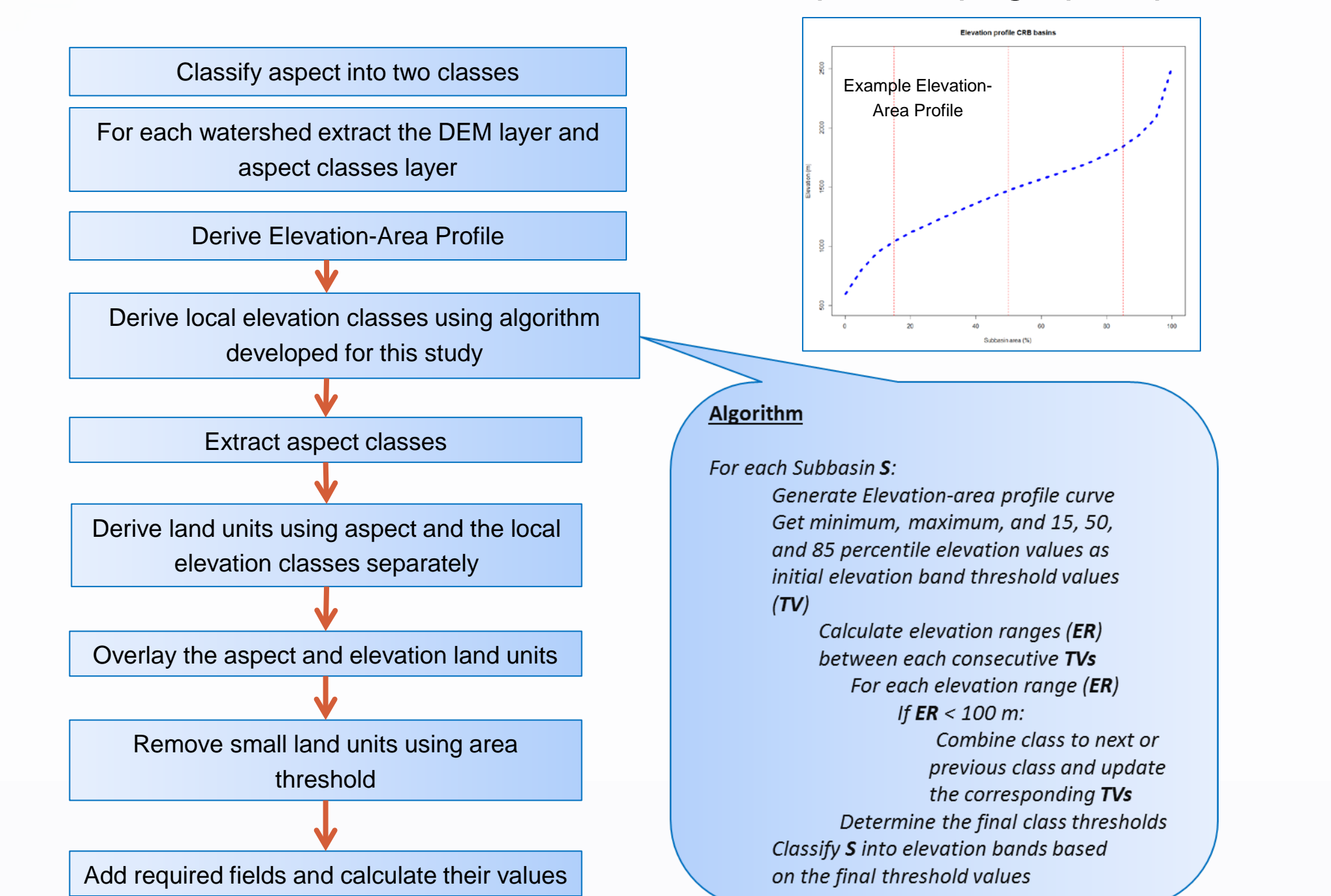
Global Land Unit Delineation Method:

- Elevation classes for each subbasin are extracted from a global elevation classification of the whole study domain based on Leung and Ghan (1995, 1998).

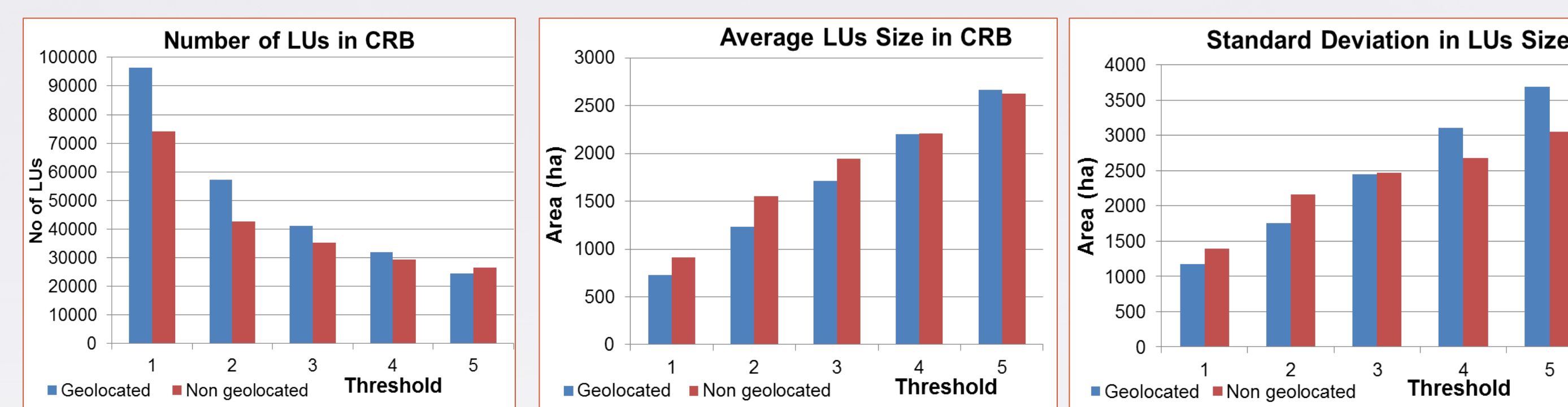


Local Land Unit Delineation Method:

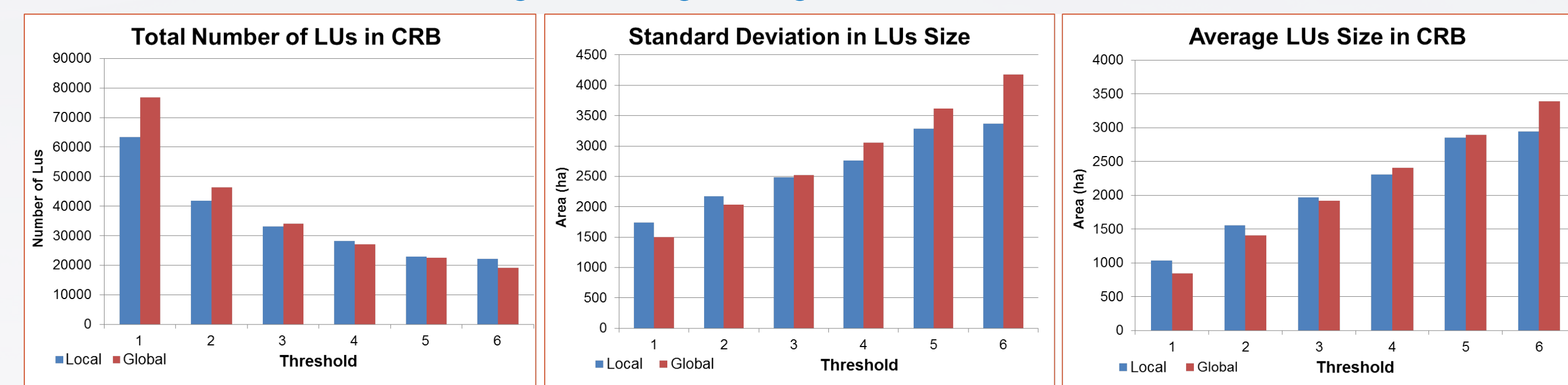
- Elevation classes for each subbasin are derived based on its elevation-area profile to determine the elevation class breaks and threshold value derive land units that capture topographic pattern.



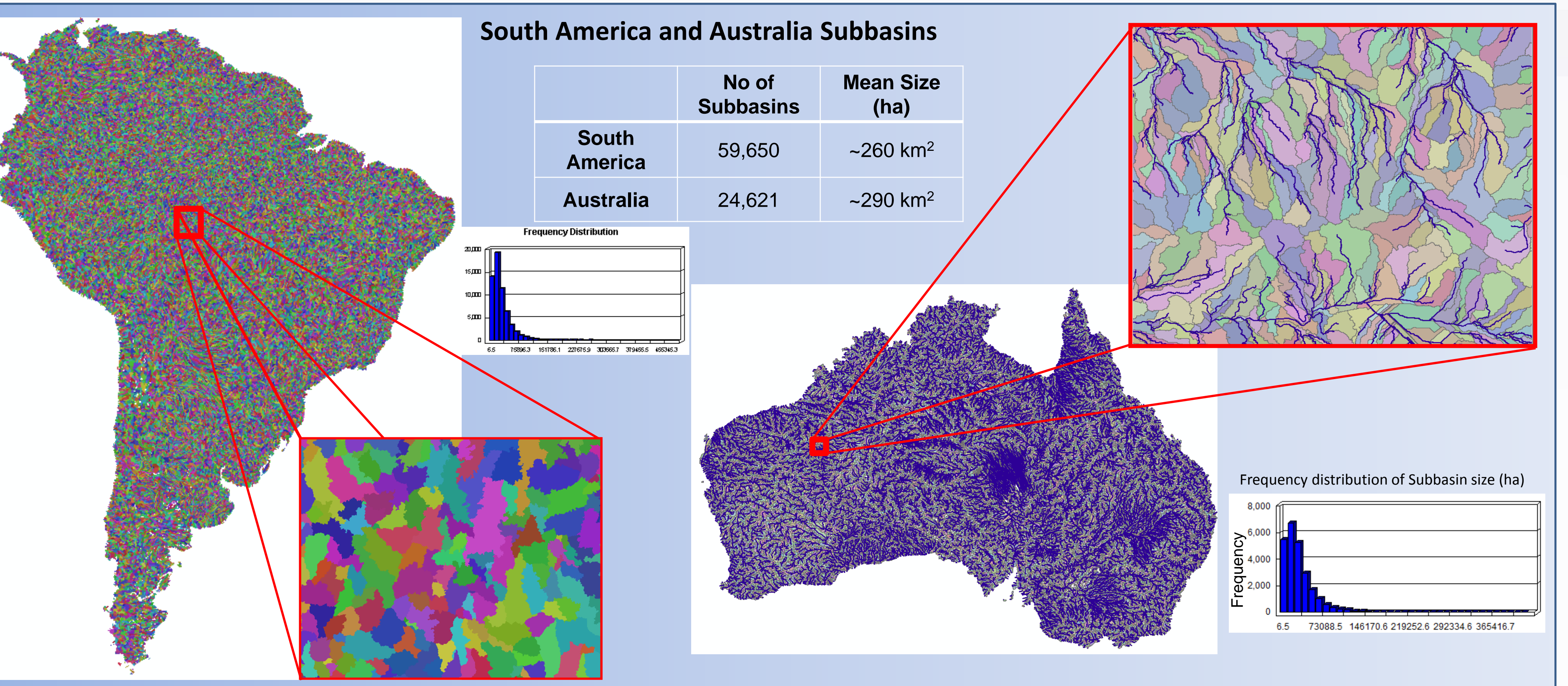
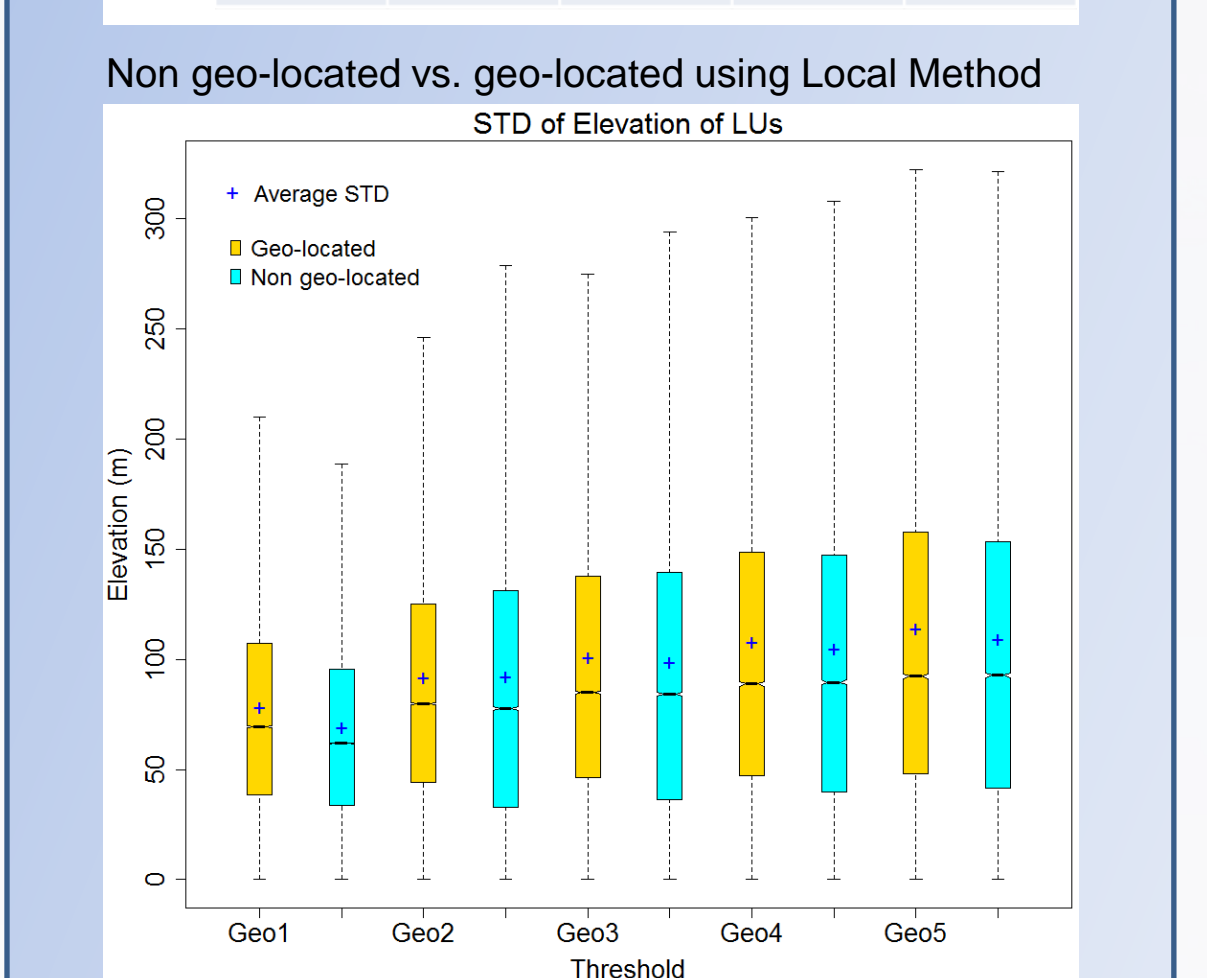
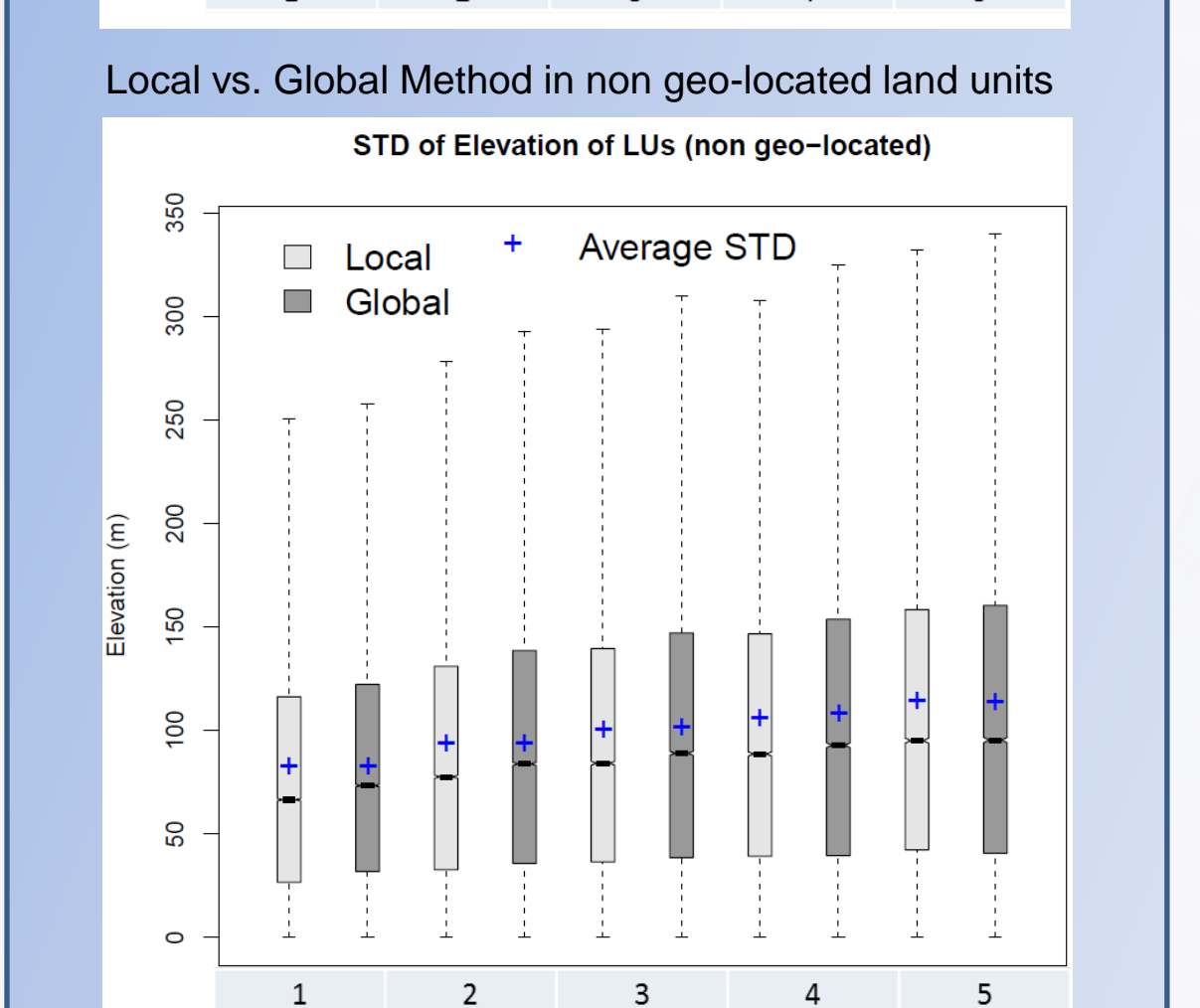
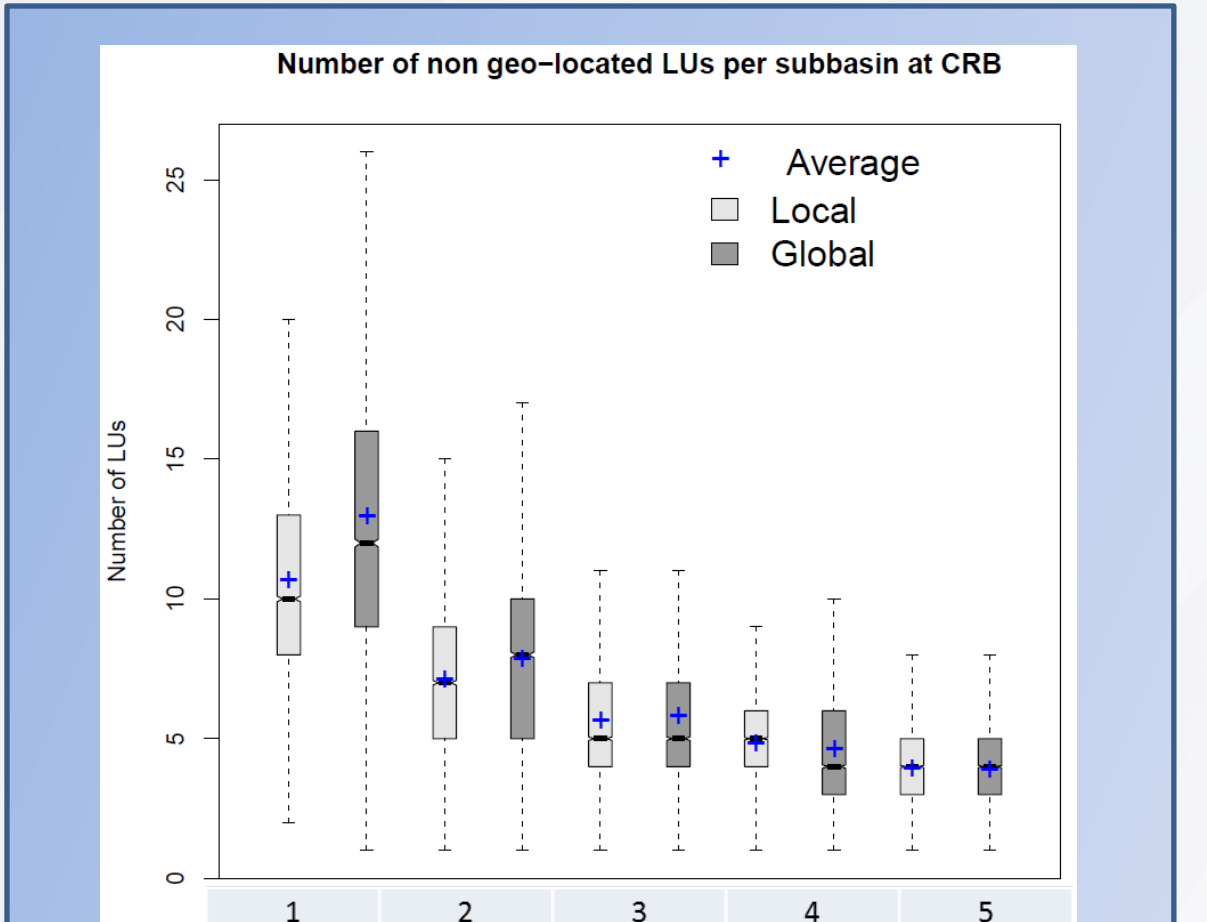
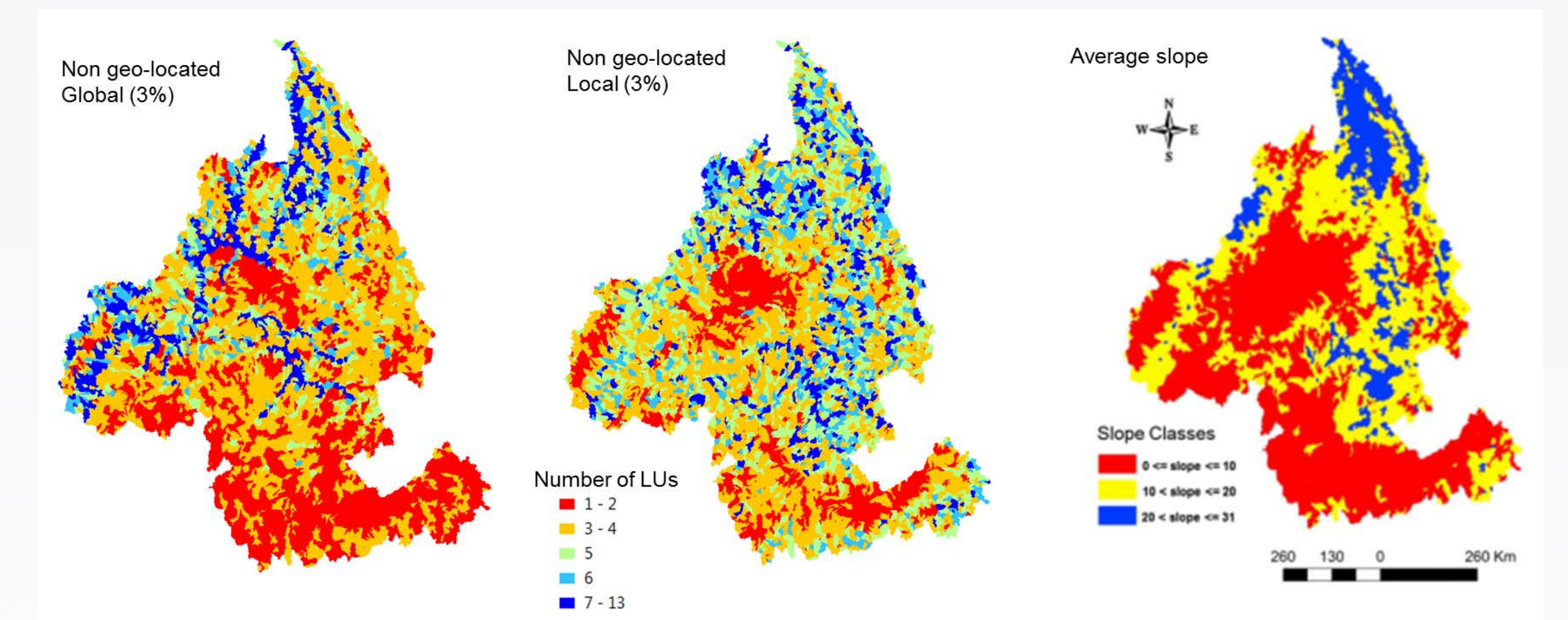
Non geo-located vs. geo-located LUs using Local Method



Local vs. Global Method in generating Non geo-located land units



Local vs. Global Method in capturing topographic patterns



Impact

- Global and Local Methods have been developed to derive a new topography-based land surface spatial structure (subgrid land units) for CLM.
- Both methods have been tested over the Columbia River Basin in deriving both geo-located and non geo-located LUs.
- On average, there are fewer Non geo-located LUs that are larger in size compared to Geo-located LUs.
- The Local Method captures the topographic pattern better than the Global Method and is more consistent across thresholds in the number of LUs per subbasin.
- A new subbasin dataset for Australia and South America has been developed from the globally consistent high resolution DEM developed in this effort. The Local Method for Non geo-located LUs is being applied globally to generate a global topography-based land surface structure for CLM.