Developing Topography-based Global Subgrid Datasets for the ACME Land Model

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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. Land surface spatial structure that captures spatial heterogeneity influenced by topography is expected to improve representation of land surface processes in land surface models. 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. 2014 a&b).

In this study, a global subbasin dataset has been developed. A local classification method is applied to derive a new land surface spatial structure defined 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. For this purpose, a more consistent 90 meter resolution global surface elevation data has been developed by blending elevation data obtained from various sources. Taking the advantage of the global surface elevation data, various land surface datasets are being developed for the ACME Land Model (ALM). This poster reports recent results.
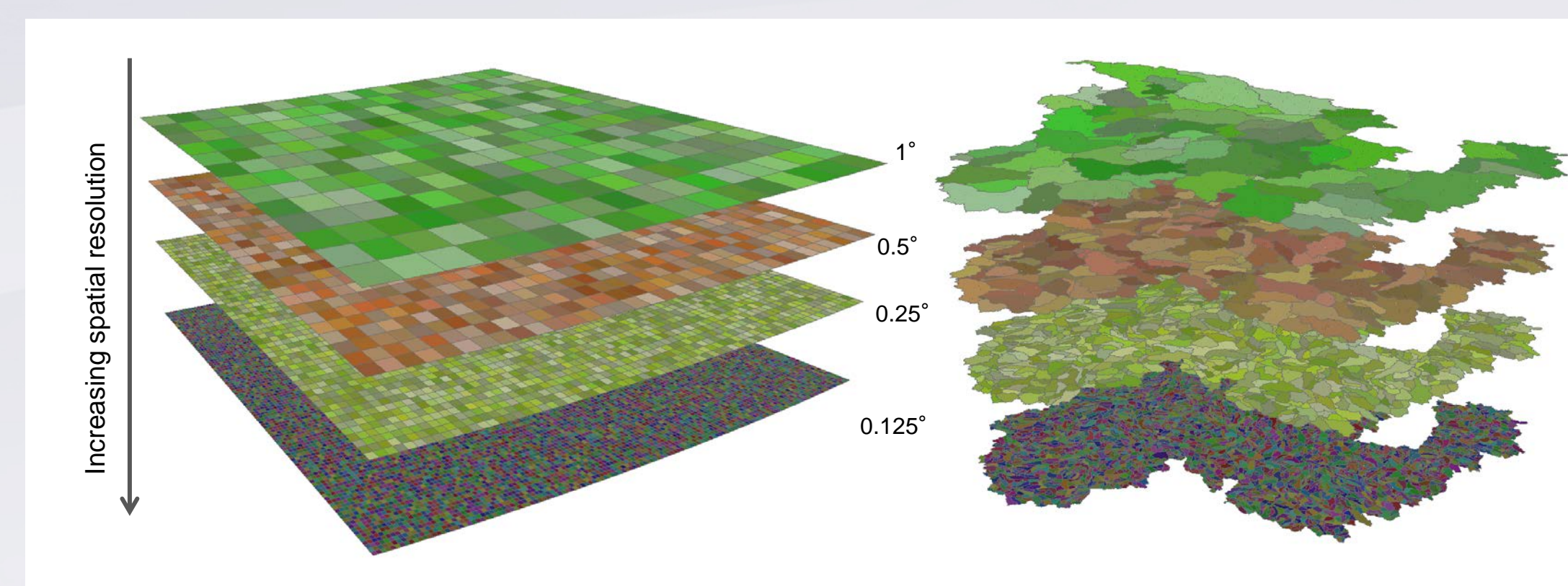
Approach

Developing a consistent high resolution global Digital Elevation Model (DEM):

The HydroSHEDS DEM does not cover areas north of 60 degree latitude. A more consistent 90 meter resolution global elevation dataset has been developed by blending the HydroSHEDS DEM with other elevation datasets covering areas that are missing in the HydroSHEDS DEM dataset. The non HydroSHEDS elevation data were downloaded from http://www.viewfinderpanoramas.org/dem3.html.
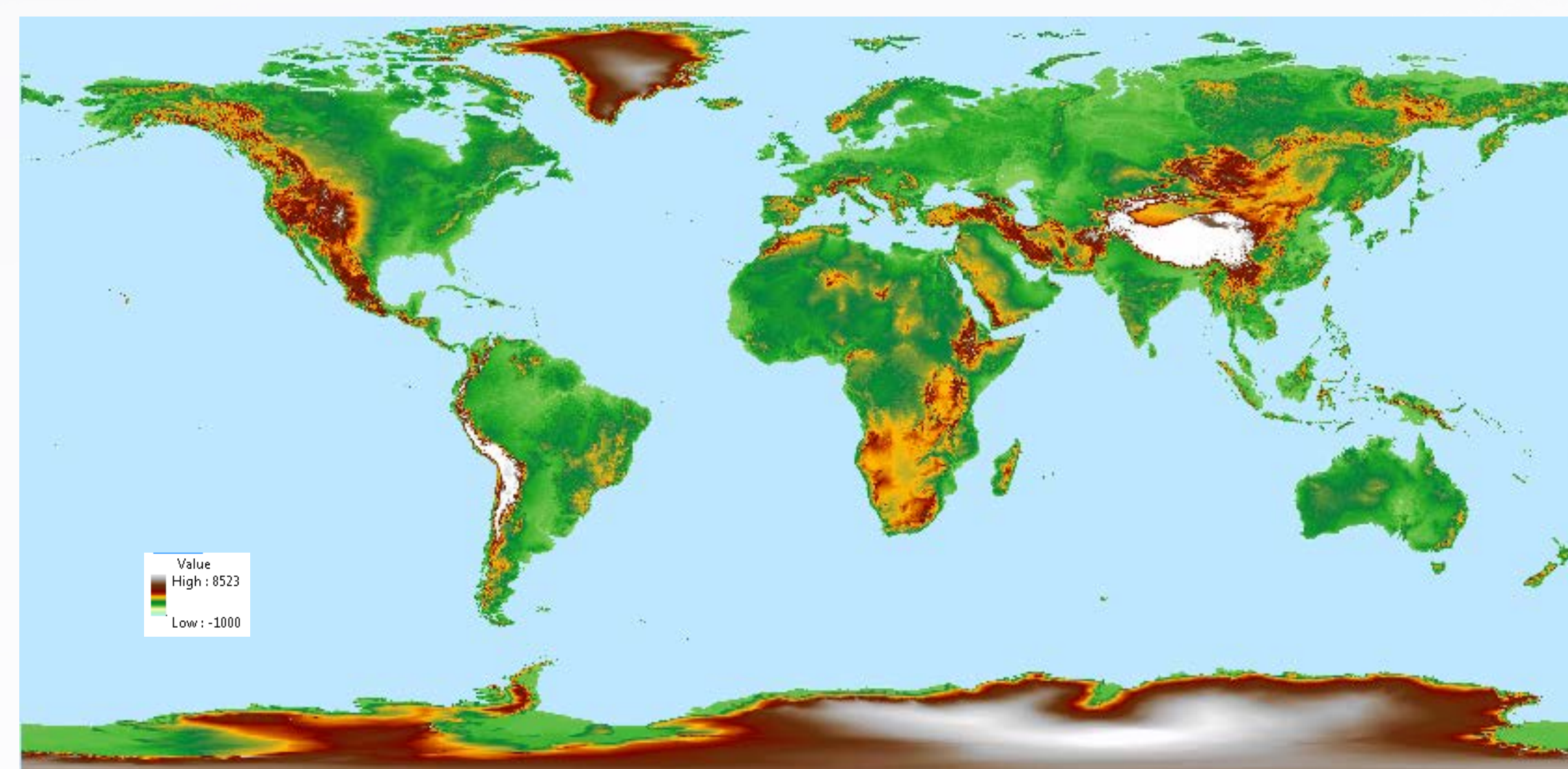
Developing a grid-based subgrid structure for the ACME Land and Atmospheric models:

➢ A global topography–based subgrid structure has been developed for both the ACME Land and Atmospheric Models using a local elevation classification scheme developed in this effort.
➢ In the local classification scheme, a polygon shape dataset is first developed from the latitude-longitude information at the vertices of the atmospheric grids.
➢ Elevation data are extracted for each pentagon shape from the 90 meter resolution DEM, and an elevation-area relationship is derived.
➢ The elevation-area profile is discretized into 12 elevation classes using the 10th, 20th, 30th, 40th, 50th, 60th, 70th, 80th, 85th, 90th, and 95th percentiles. .
➢ Subgrid with elevation range less than 100m is merged to its neighbor.
➢ Finally, each grid is discretized into multiple non geo-located subgrid units represented as fractional areas.
➢ The elevation classification scheme has been automated using ArcGIS, GDAL and Python utilities.
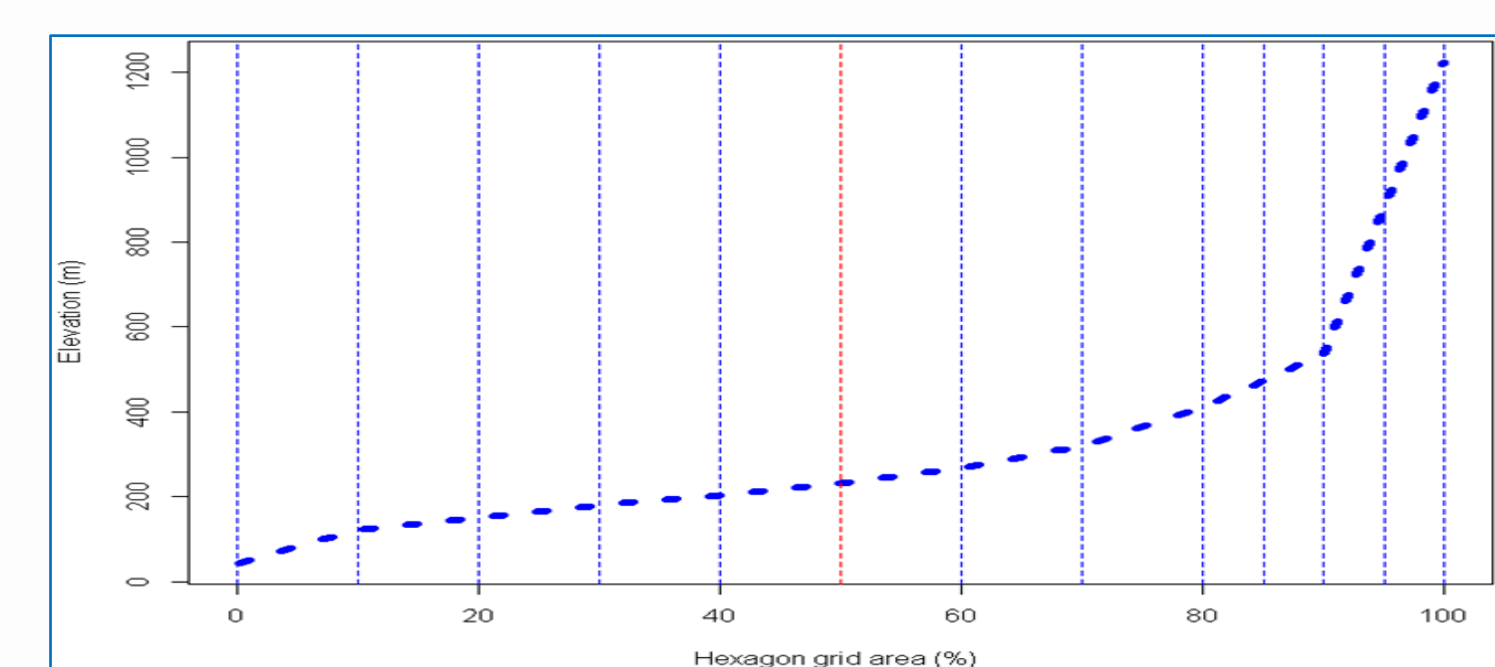
Algorithm

For each grid **G**:
Generate Elevation-area profile curve
Get minimum, maximum, and 10, 20, 30, 40, 50, 60, 70, 80, 85, 90 and 95 percentile elevation values as initial elevation   class break values (**CB**)
    Calculate elevation ranges (**ER**) between each   consecutive **CBs**
    For each elevation range (**ER**):
        If **ER** < 100 meter: Combine the class to the neighboring class with smaller **ER** and update the corresponding **CBs**
    Determine final **CBs**
    Classify **G** into elevation subgrid units based on the final **CBs** values
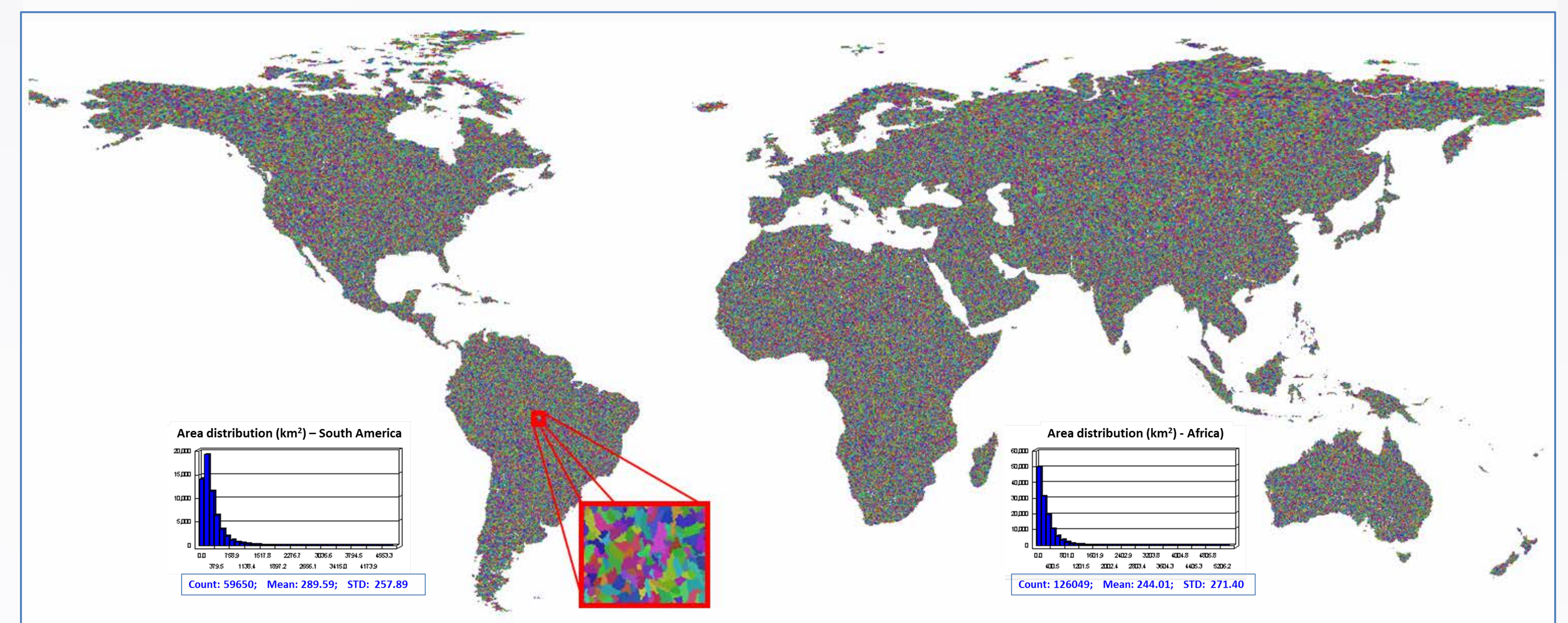
Developing surface datasets for the ACME Land Model:

➢ Surface datasets of PFTs, soils, and land cover type have been developed for the ACME Land Model using the subgrid structures derived based on the atmospheric pentagon grids.
➢ Variables are first converted from netCDF into one of GIS grids. Then, values for each subgrid unit are calculated by averaging the grids falling within its boundary.

Average = 4.4

Number of Subgrid Units
- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 9
- 10 - 13
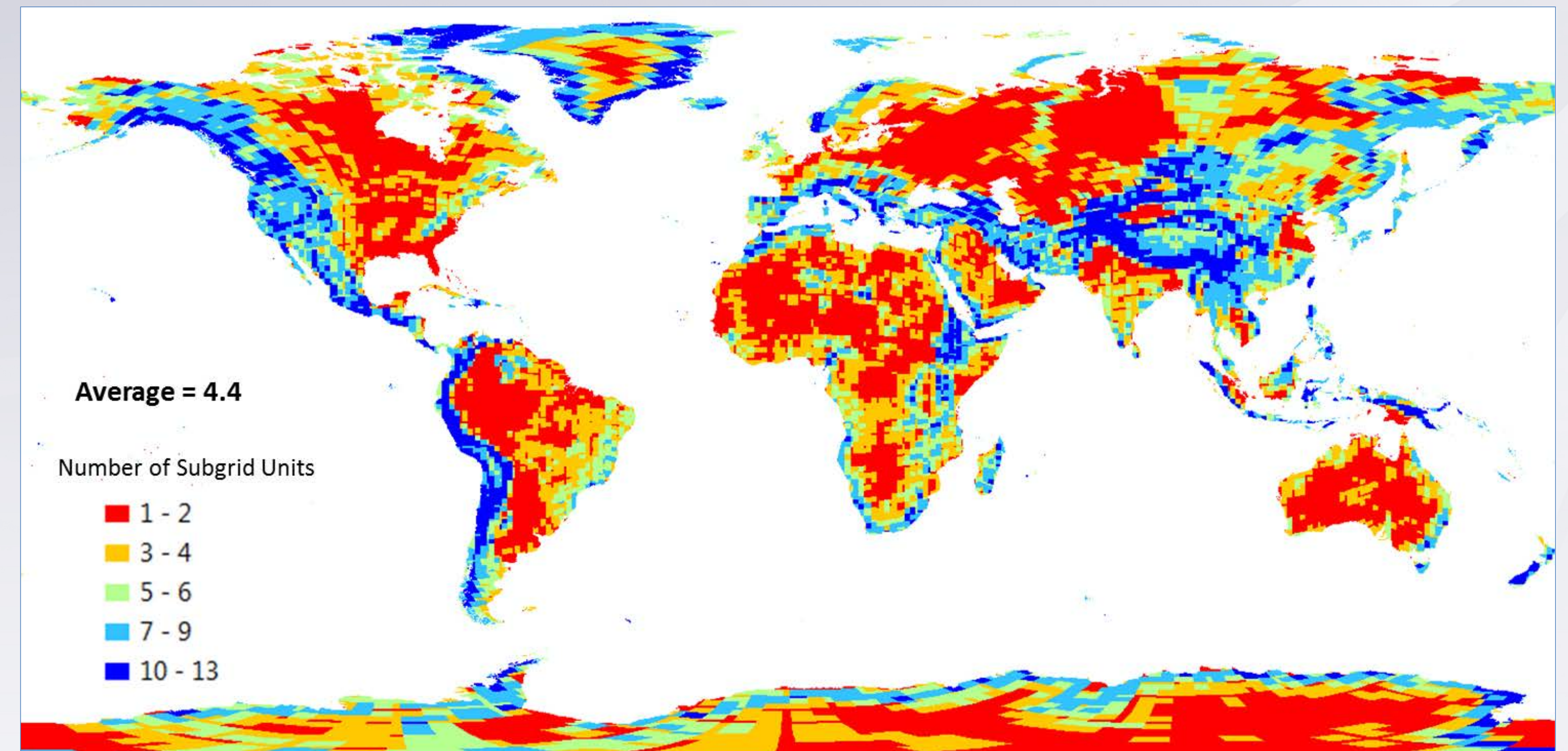
Developing a new global subbasin dataset:

➢ New global subbasin (watershed) and stream network datasets are derived from the high resolution globally consistent DEM developed in this effort. The Terrain Analysis Using Digital Elevation Models (TauDEM), a set of DEM analysis tools developed for the extraction and analysis of hydrologic information from DEM topographic data, was used to delineate the watersheds for each continent and islands represented in the DEM.
➢ Topographic attributes such as slope and aspect are derived from the DEM using TauDEM to be used for deriving the subbasin-based subgrid land unit dataset globally.

Area distribution (km²) – South America
Count: 59650;   Mean: 289.59; STD: 257.89

Area distribution (km²) - Africa
Count: 126049;   Mean: 244.01; STD: 271.40

Impact

➢ A new topography-based subgrid structure has been developed based on the atmospheric grids (ne30np4 - pentagon) using the 90 meter resolution global DEM developed in this effort. The subgrid structure is applicable for both ACME Land and Atmospheric Models.

➢ A local elevation classification scheme was used to discretize each grid into multiple subgrid units. The number of subgrid units per grid varies with topographic complexity of the grid.

➢ Surface datasets including PFTs, soil and land cover type have been developed for the ACME Land Model based on the grid-based subgrid structures.

➢ A new global dataset of subbasins, stream network and other topographic attributes have been developed from the globally consistent high resolution DEM. A local subbasin discretization method for Non geo-located LUs is being applied globally to generate a global topography-based land surface structure for the ACME Land Model.

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