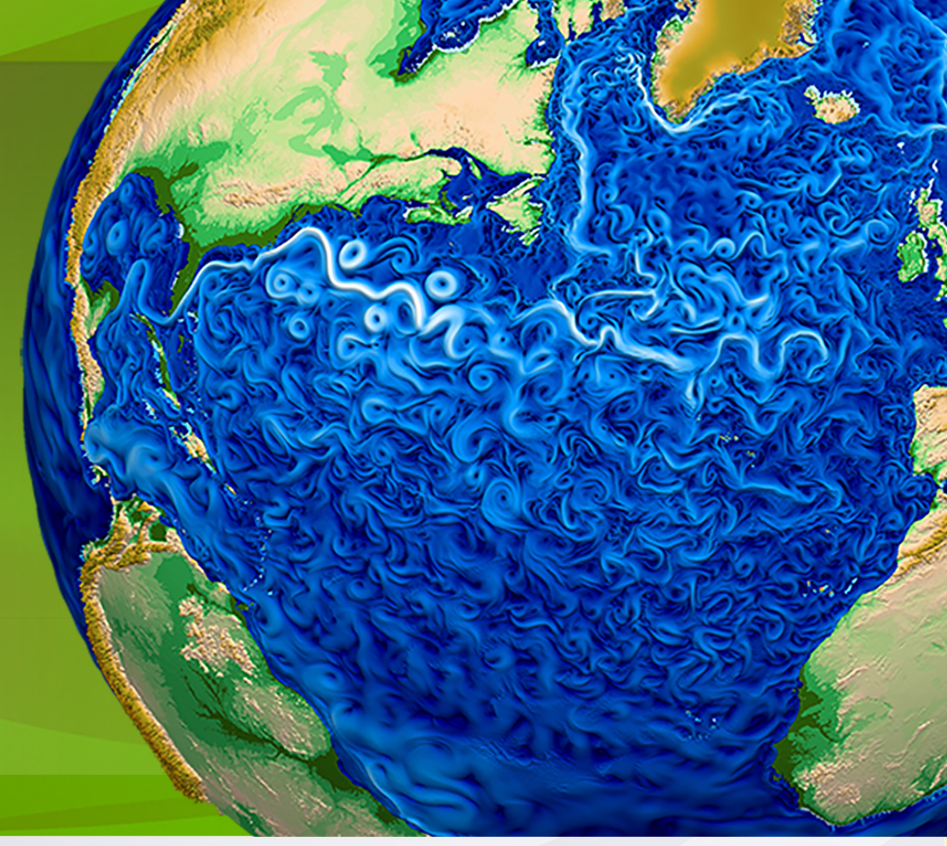
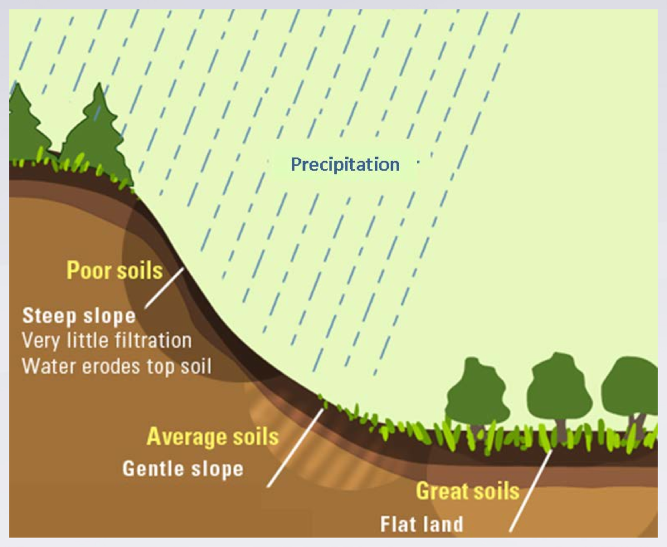
R: Exploring the Capability of Topography-based Subgrid Structures to Capture Variability of Soil Properties in Global Datasets

Teklu K. Tesfa and L. Ruby Leung



Introduction

- Topography is an important factor in soil formation, thus exerting dominant control on the spatial patterns of soil properties such as soil depth over watersheds.
- Soil formation is a function of topography, parent material, organisms, climate and time.
- For example, soils are deeper and finer in texture over valleys or flat land compared to the shallower and coarser texture over ridges or steep slopes of watersheds.
- To improve representation of the effect of topographic heterogeneity in land surface processes, recently, a new topography-based subgrid structure has been developed for the ACME land model.



Impact of topography on soil variability (Source: www.eschooltoday.com)

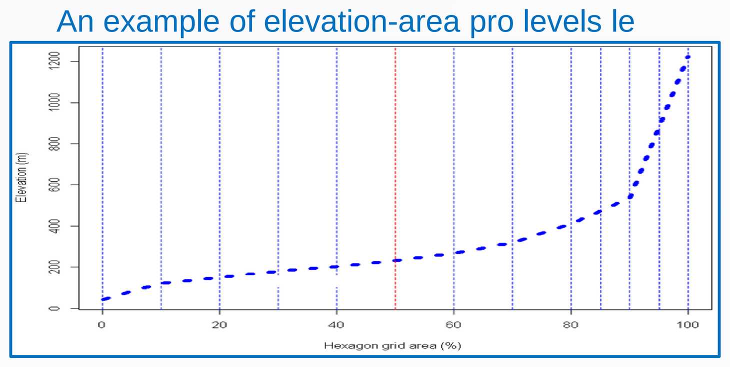
- Recent study, evaluating the new subgrid structure over topographically heterogeneous regions showed improved capability to capture spatial variability of climate and land cover (Tesfa and Leung, 2017).
- In this study, the new subgrid structure is evaluated for its capability to capture spatial pattern of various soil properties using globally available datasets such as depth to bedrock and soil texture.

Methods and Data

Deriving the topography-based subgrid units and evaluating their capability to capture soil properties:

- For each quadrilateral polygon (NE30 grids) elevation data are extracted from the 90 meter DEM. An elevation-area profile relationship is derived using the elevation data from the 90 meter DEM
- The elevation-area profile is discretized into a fixed number of distinct subgrid elevation classes based on values corresponding to the 10th, 20th, 30th, 40th, 50th, 60th, 70th, 80th, 85th, 90th, and 95th percentiles of elevation.
- A local elevation classification method using the elevation-area profile is applied to each atmospheric cell to derive the subgrid units. Subgrid with elevation range less than 100 m is merged to its neighbor. The method utilizes ArcGIS and Python tools.
- Soil properties are mapped to the NE30 grids and subgrid units. Standard deviation values of the soil properties at grid and subgrid unit levels are compared.

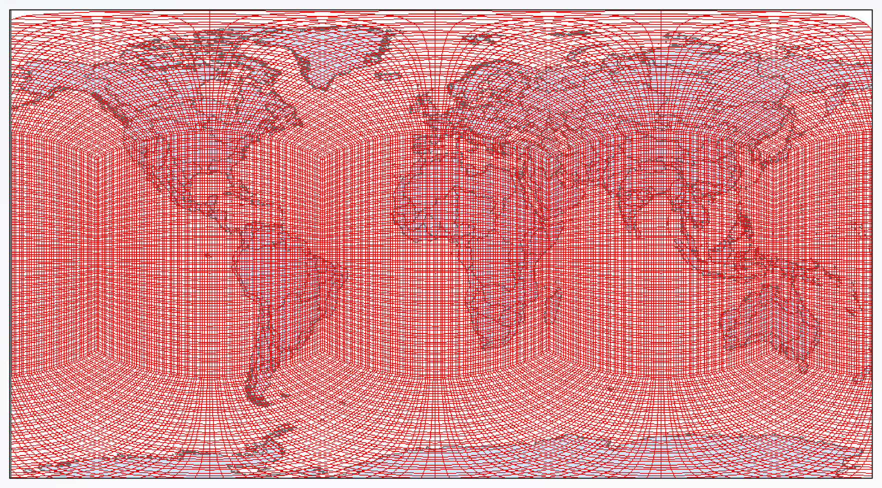
An example of elevation-area pro levels le



Algorithm

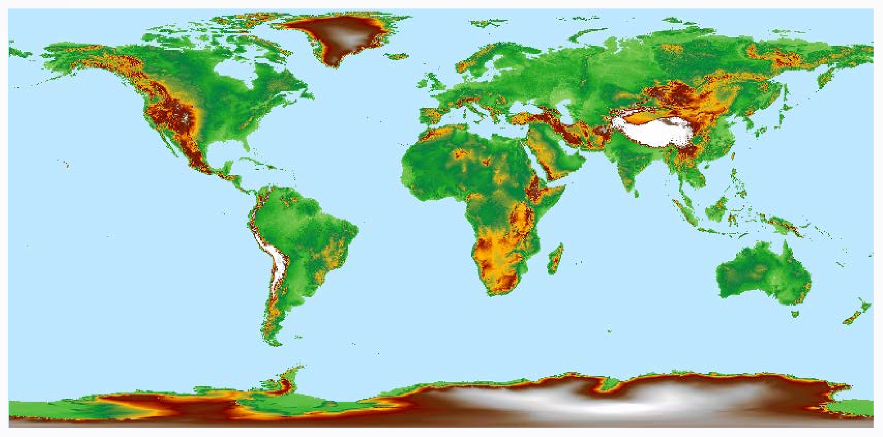
*For each grid **G**:*
Generate Elevation-area profile curve
*Get minimum, maximum, and 10, 20, 30, 40, 50, 60, 70, 80, 85, 90 and 95 percentile elevation values as initial elevation class break values (**CB**)*
*Calculate elevation ranges (**ER**) between each consecutive **CBs***
*For each elevation 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*

NE30 global grids

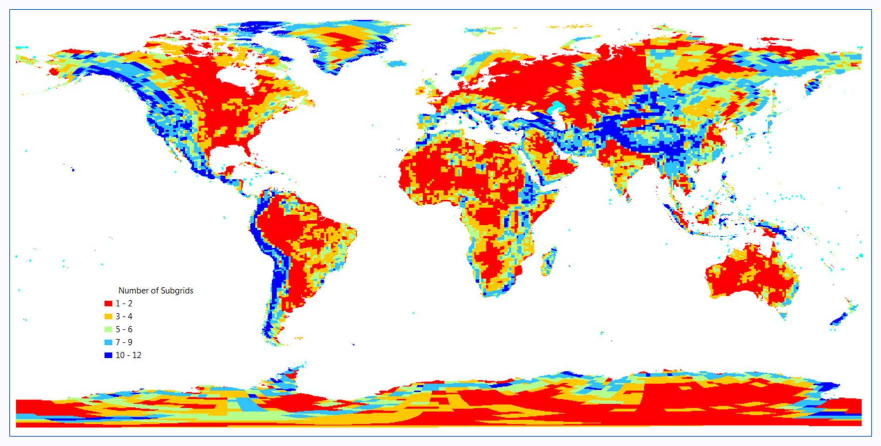


+

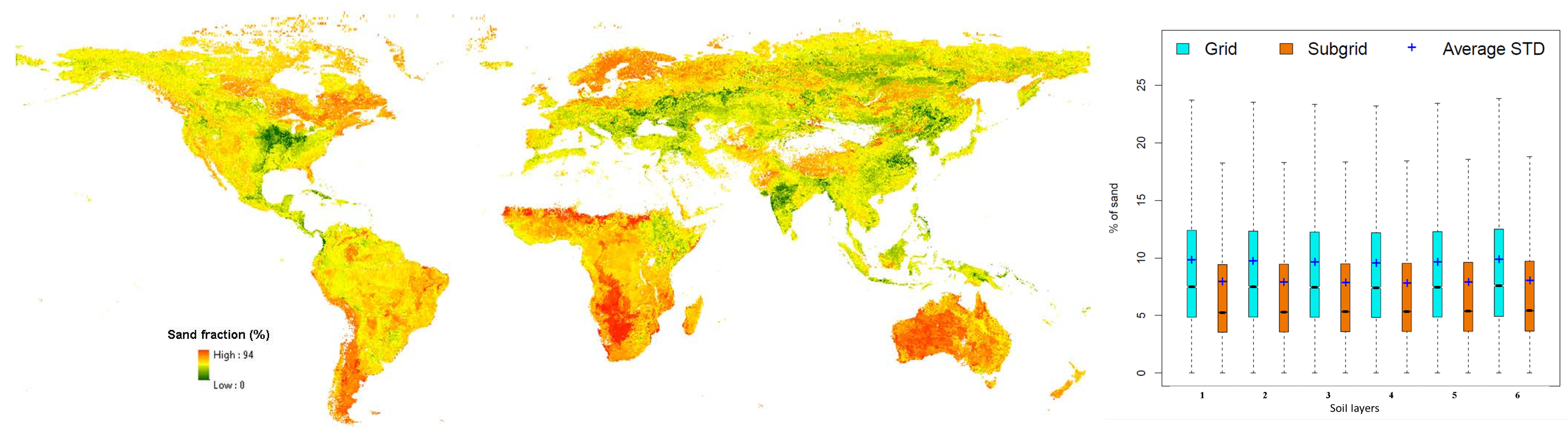
90 meter resolution digital elevation data



Number of subgrid units per NE30 grid

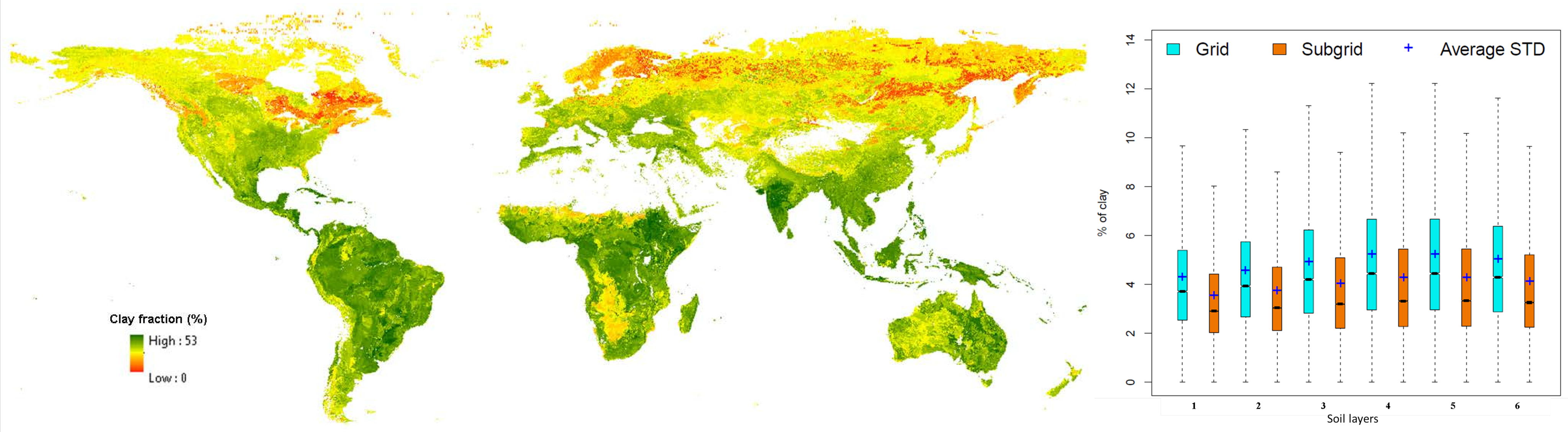


Results



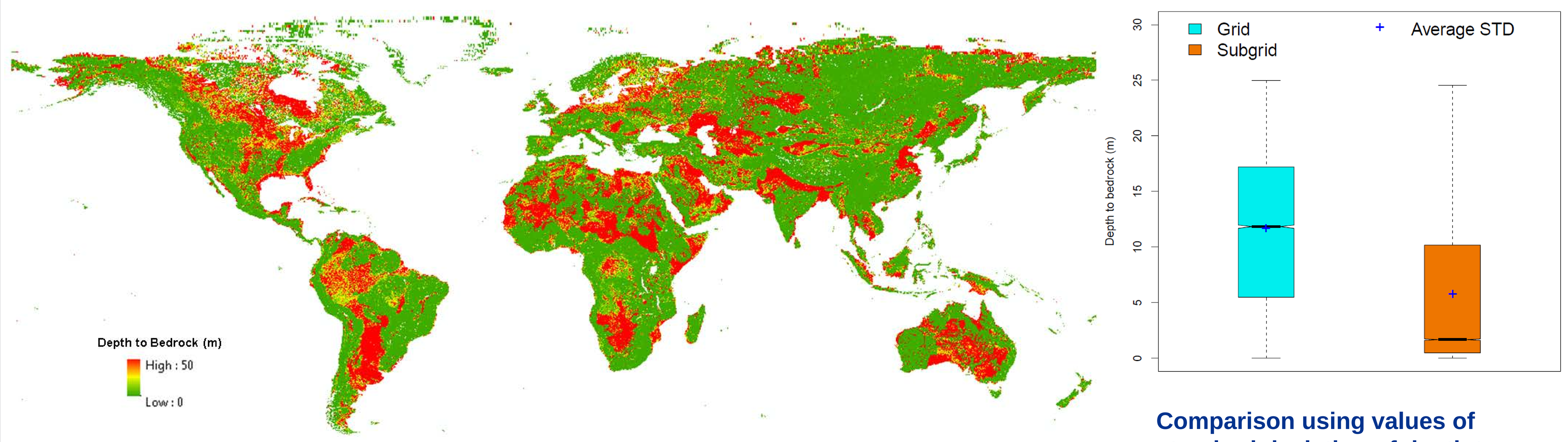
Spatial pattern of sand fraction (%) based on a 1 km resolution global dataset obtained from the global soil data product generated at the ISRIC – World Soil Information

Comparison using values of standard deviation of sand fraction (%) for grid vs. subgrid representations.



Spatial pattern of clay fraction (%) based on a 1 km resolution global dataset obtained from the global soil data product generated at the ISRIC – World Soil Information

Comparison using values of standard deviation of clay fraction (%) for grid vs. subgrid representations.



Spatial pattern of depth to bedrock (m) based on a 1 km resolution global dataset developed by Pelletier et al., 2016.

Comparison using values of standard deviation of depth to bedrock (m) for grid vs. subgrid representations.

Summary and Conclusions

- Generally, results demonstrated the subgrid representation yields much lower values of standard deviation values of clay, sand and depth to bedrock compared to those of the grid representation.
- The results suggest that the subgrid representation improved the capability to capture subgrid variability of fractions of clay and sand and depth to bedrock.

ACME Accelerated Climate Modeling for Energy

For additional information, contact:

Teklu K Tesfa
Engineer
(509) 372-4479
Teklu.Tesfa@pnnl.gov

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle *Since 1965*

climatemodeling.science.energy.gov/acme

U.S. DEPARTMENT OF ENERGY