R: Deriving Subgrid Units for the ACME Atmospheric Model from High Resolution Surface Elevation Data

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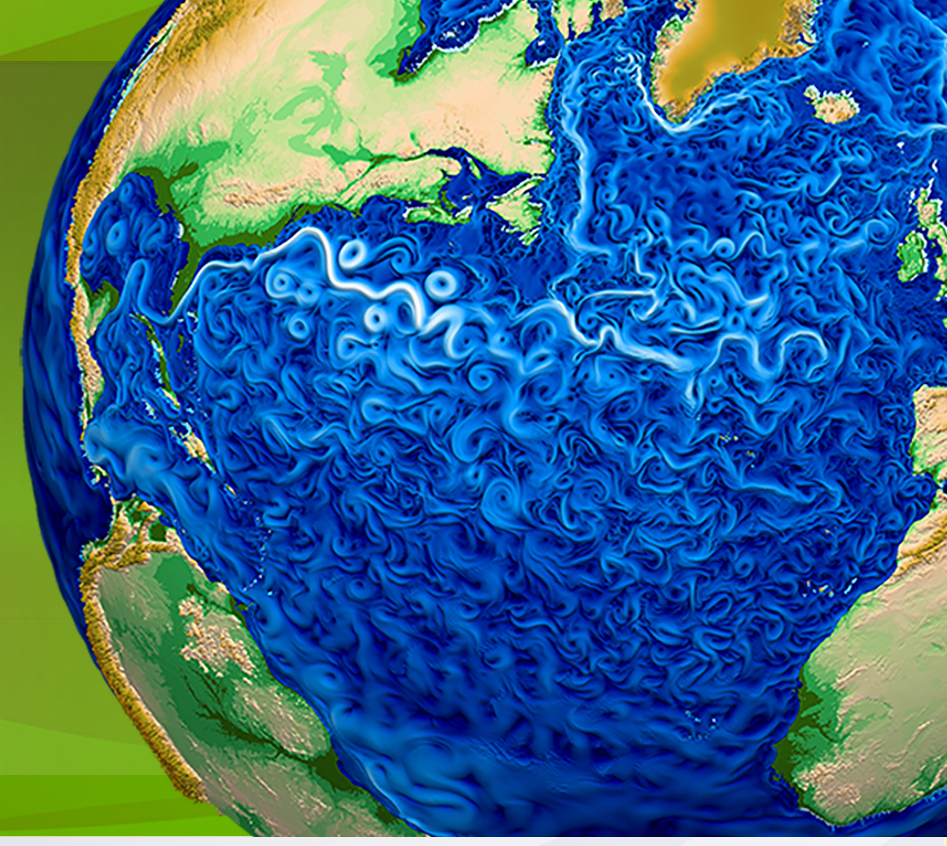


Introduction

Assessment of climate change impacts on water resources in regions with complex terrain requires precipitation simulations at sufficiently fine resolutions to capture orographic effects, which is not practical for a global model. To address this challenge, a topography-based subgrid dataset is being developed, where each grid cell is discretized into up to 12 subgrid units based on surface elevation classes derived from high resolution global elevation data.

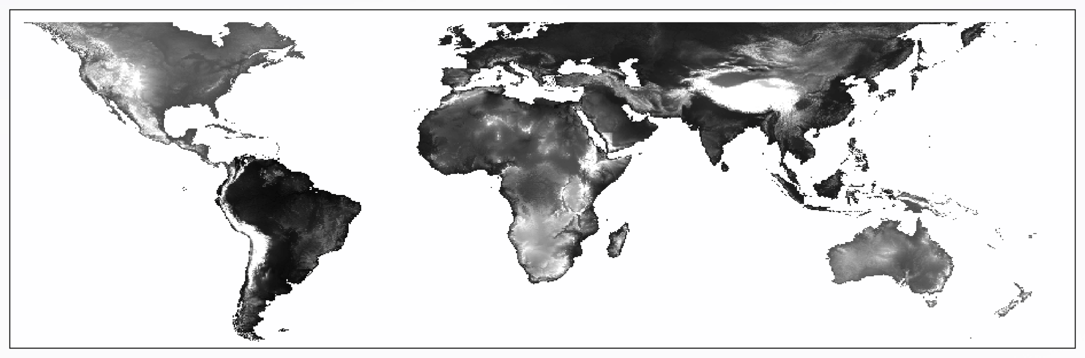
Each subgrid unit represents the area within a range of surface elevation. To determine the intervals of the surface elevation, a local elevation classification method, which uses an elevation-area profile relationship to capture topographic patterns, is employed in each atmospheric grid cell to derive the subgrid units. The local elevation classification method results in more subgrid units over mountainous regions than flat regions. For consistency, the same surface elevation data and classification method are used to define subgrid topographic landunits for the land model. Here we describe the methods employed and show results for some continents.

Approach

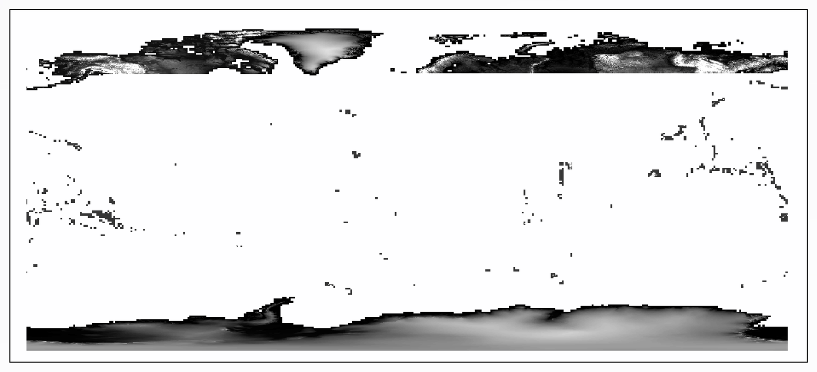
Development of high resolution elevation dataset:

The HydroSHEDS Digital Elevation Model (DEM) does not cover areas north of 60 degree latitude. A more consistent 90 meter resolution global elevation dataset is developed by merging the HydroSHEDS DEM with other elevation datasets covering areas that are missing in the HydroSHEDS DEM. The non HydroSHEDS elevation data were downloaded from http://www.viewfinderpanoramas.org/dem3.html.

HydroSHEDS DEM



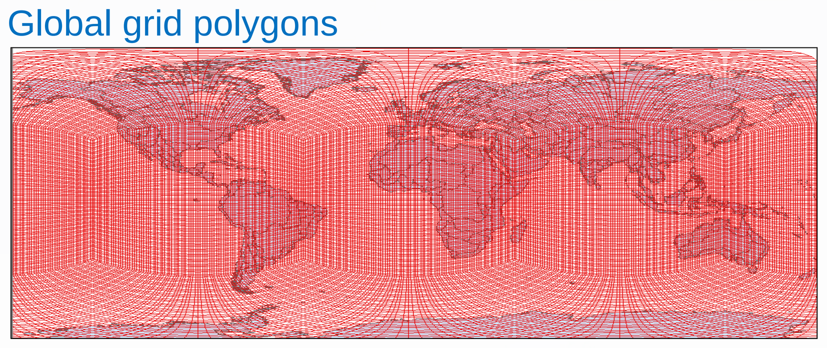
Other non HydroSHEDS DEM



Generating quadrilateral polygons (Shapes):

Polygons representing the boundaries of the grids of the Atmospheric Model are generated based on the latitude and longitude coordinates of the corners.

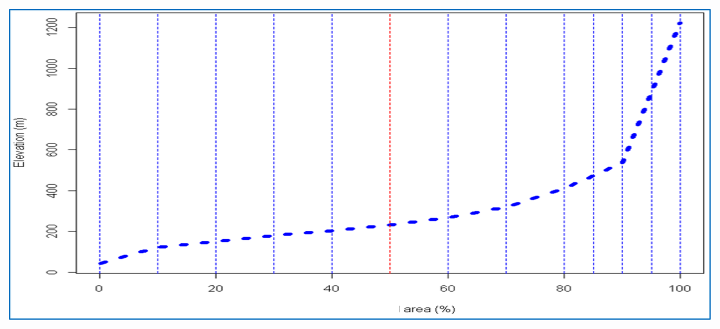
Global grid polygons



Deriving the Subgrid Units:

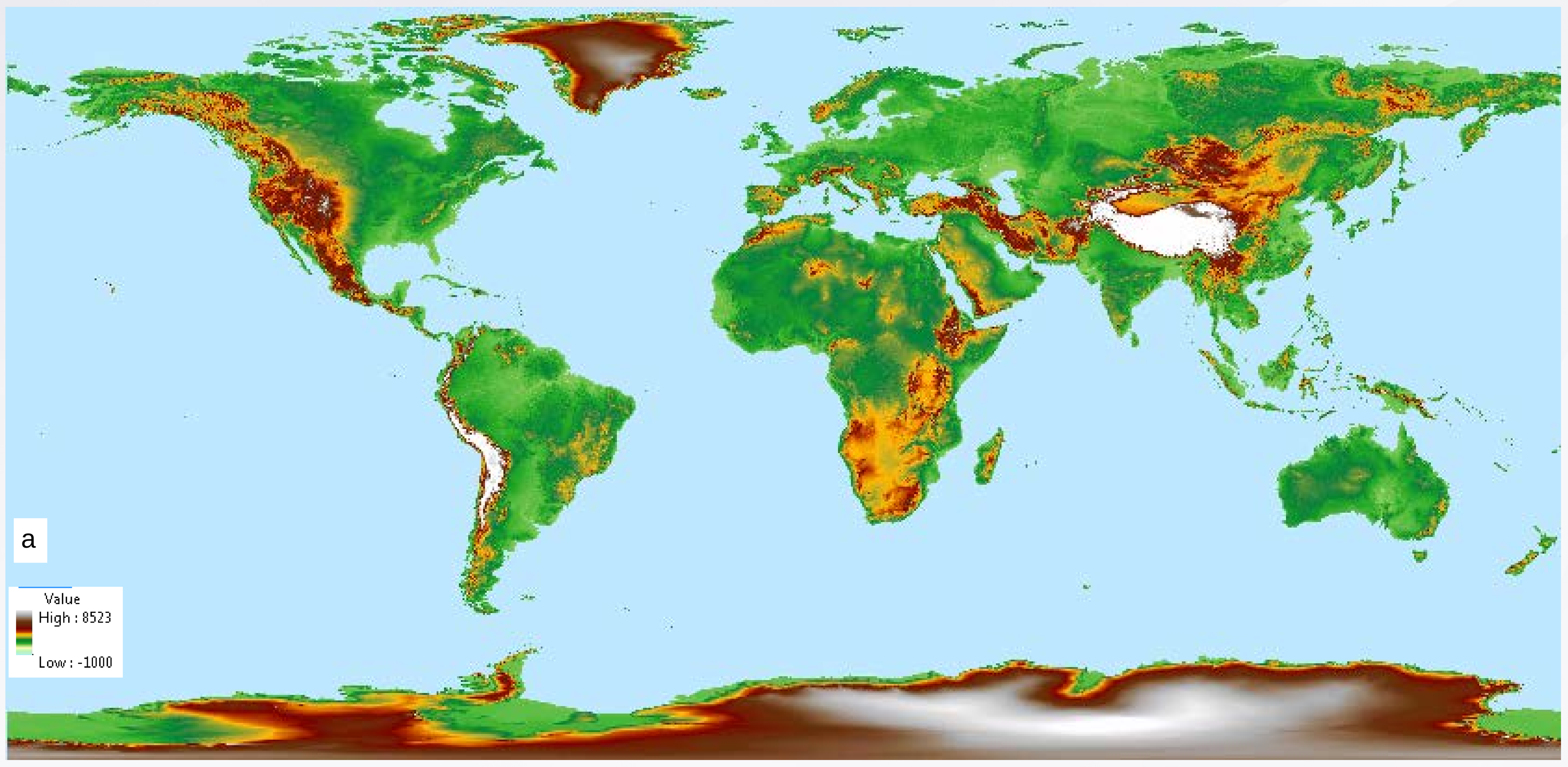
- For each quadrilateral polygon elevation data are extracted from the 90 meter DEM
- An elevation-area profile relationship is derived using the elevation data from the 90 meter DEM
- The elevation-area profile is discretized into a fixed number of distinct subgrid elevation classes based on values 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 (see algorithm).

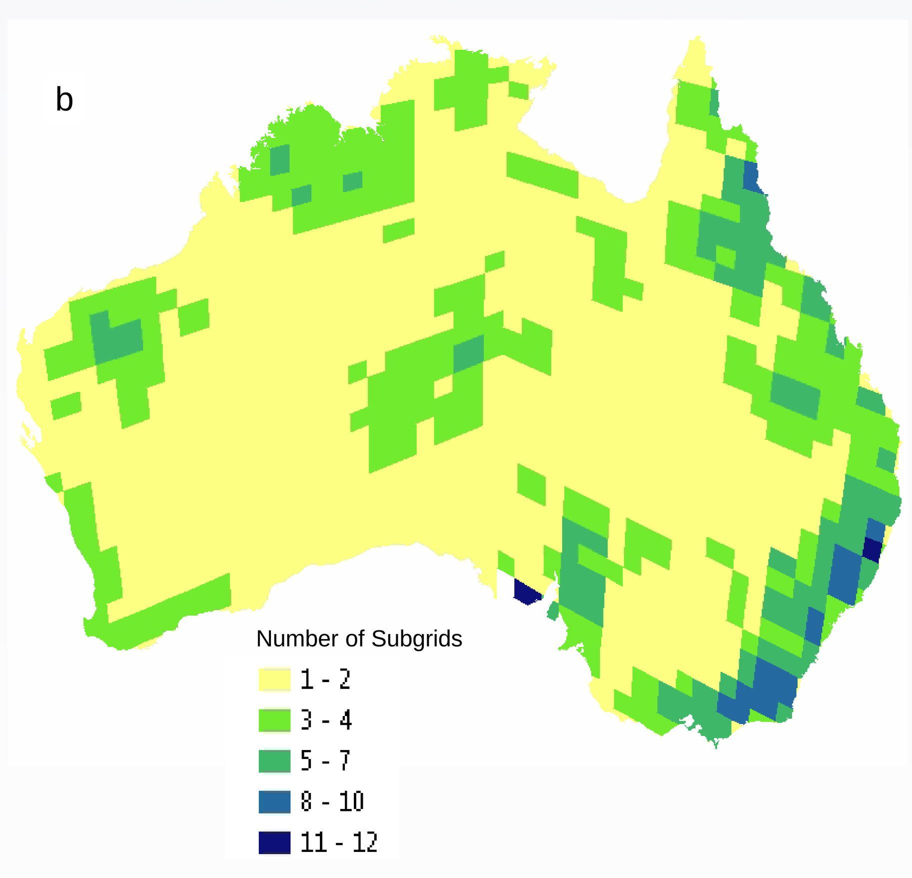
An example of elevation-area profile



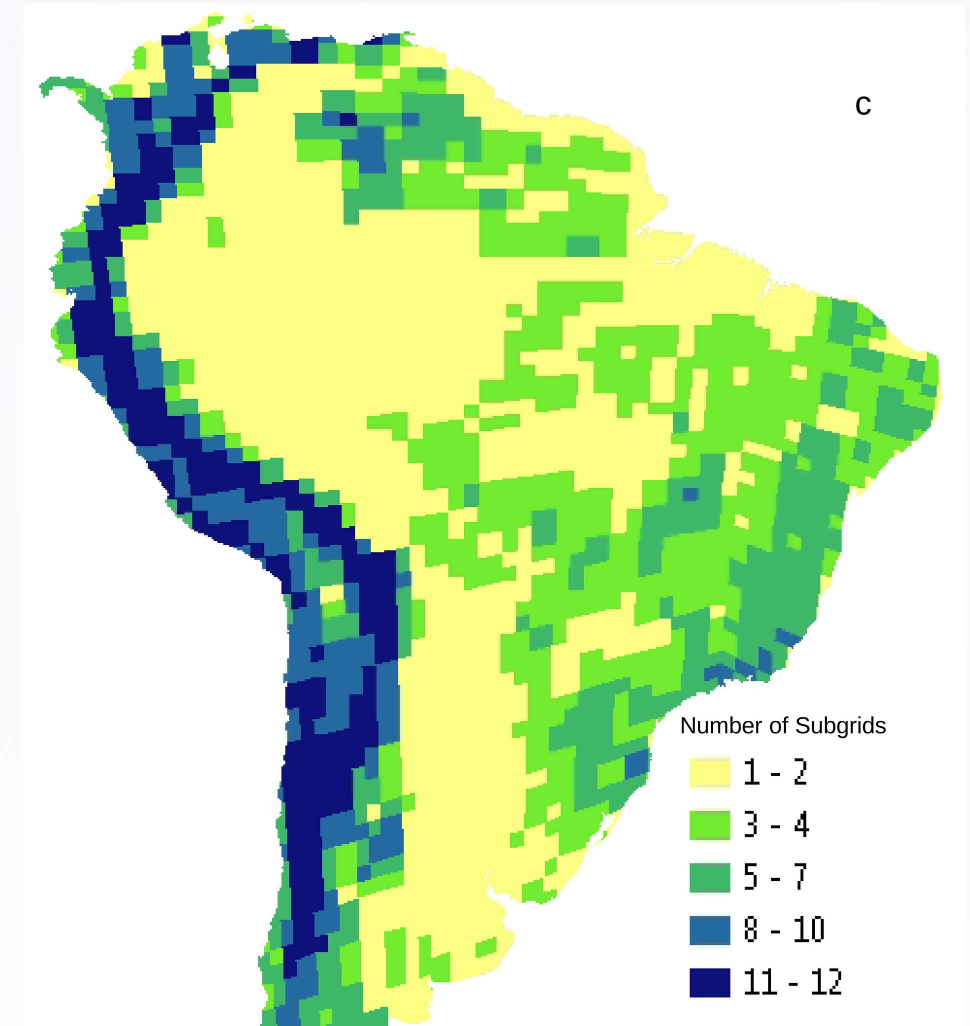
Algorithm

*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*





Statistics:
Number of grids: 882
Number of subgrids: 2207
Minimum: 1
Maximum: 12



Statistics:
Number of grids: 1872
Number of Subgrids: 7424
Minimum: 1
Maximum: 12

Figures show the newly developed high resolution global DEM (a), the number of subgrid units per grid for Australia (b) and South America main lands (c).

Impact

- A globally consistent high resolution Digital Elevation Model has been developed to enable derivation of topography-based subgrid structures for the ACME Atmospheric Model. For consistency, the same elevation dataset are used to derive the subgrid land units for the ACME Land Model.
- The local elevation classification method is able to capture topographic patterns resulting in more subgrid unis per grid over mountainous areas compared to flat areas. This better captures orographic effects over mountainous regions while reducing the number of subgrid units over flat regions to optimize the number of subgrid units for computational efficiency.
- The method have been applied over Australia and South America. Results show more subgrid units over mountainous regions as compared to flat regions.
- Subgrid unit dataset generation for other continents is in progress.

ACME Accelerated Climate Modeling for Energy

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