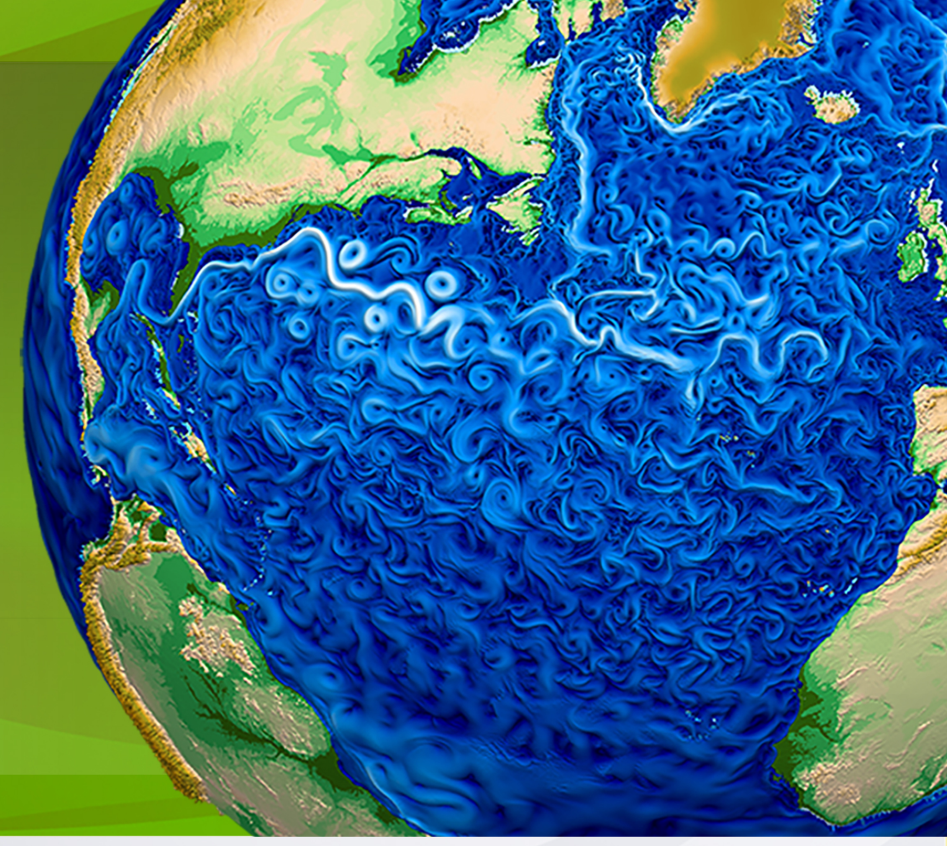


R: Landscape Orientation Improves Topography-based Subgrid Structures for the ACME Land Model

Teklu K. Tesfa and L. Ruby Leung

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 models with spatial structure that captures spatial heterogeneity influenced by topography may improve representation of land surface processes. Previous studies found that land surface modeling using subbasins instead of regular grids as computational units improves scalability of simulated runoff and streamflow processes (Tesfa et al. 2014a&b).

Recent study, exploring new land surface spatial structures to improve representation of land surface processes in Earth System Models, evaluated two methods (Global and Local) and two types of land surface spatial structures (geo-located and non-geo-located). The methods discretize each subbasin into subgrid units based on its topographic properties including surface elevation, slope and aspect. Results showed that the Local method and non-geo-located subgrid units effectively and robustly capture topographic, climatic, and vegetation variability important for land surface modeling (Tesfa and Leung, under review).

The Local method combines concepts of hypsometric analysis with landscape orientation to discretize each subbasin into subgrid structures. To evaluate the role of landscape orientation in the Local method, in this study, non-geo-located subgrid structures are derived with and without landscape orientation over the Columbia River basin. Remote sensing data are then utilized to evaluate how landscape orientation improves capability of the Local method to capture vegetation and snow variability.

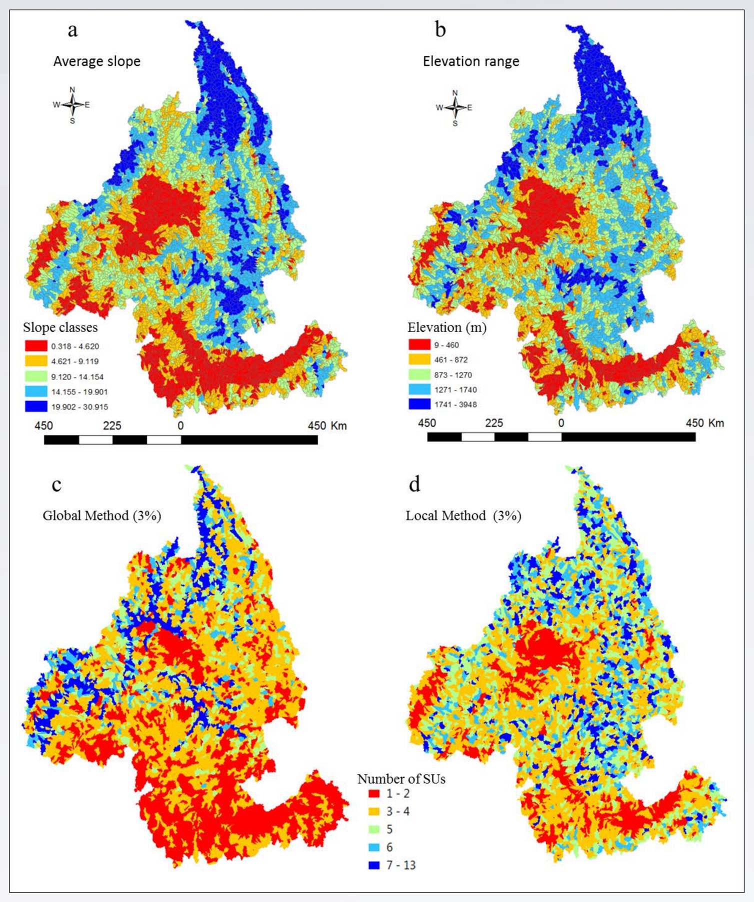


Fig. 1: The Local method captures the topographic pattern across the study domain by discretizing steep subbasins into more subgrid units and flat subbains into fewer subgrid units.

Methods and Input and Output Data

The Local Method of Subbasin Discretization:

- Elevation classification based on hypsometric analysis following Willgoose and Hancock [1998] and Sinha Roy [2002] combined with aspect classification and area threshold values to derive subgrid structures.

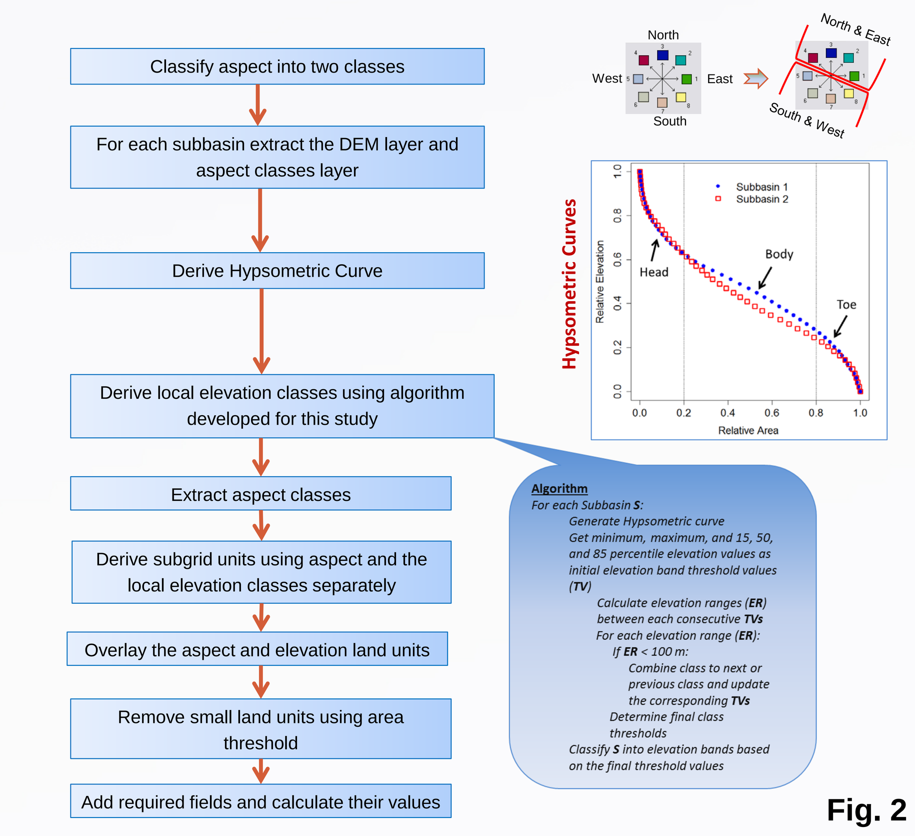


Fig. 2

Input and Output Data:

- The Local subbasin (SBN) discretization method uses surface elevation, landscape orientation (Aspect) and Subbasin boundaries as inputs and derives non-geo-located subgrid units (SUs) as output.

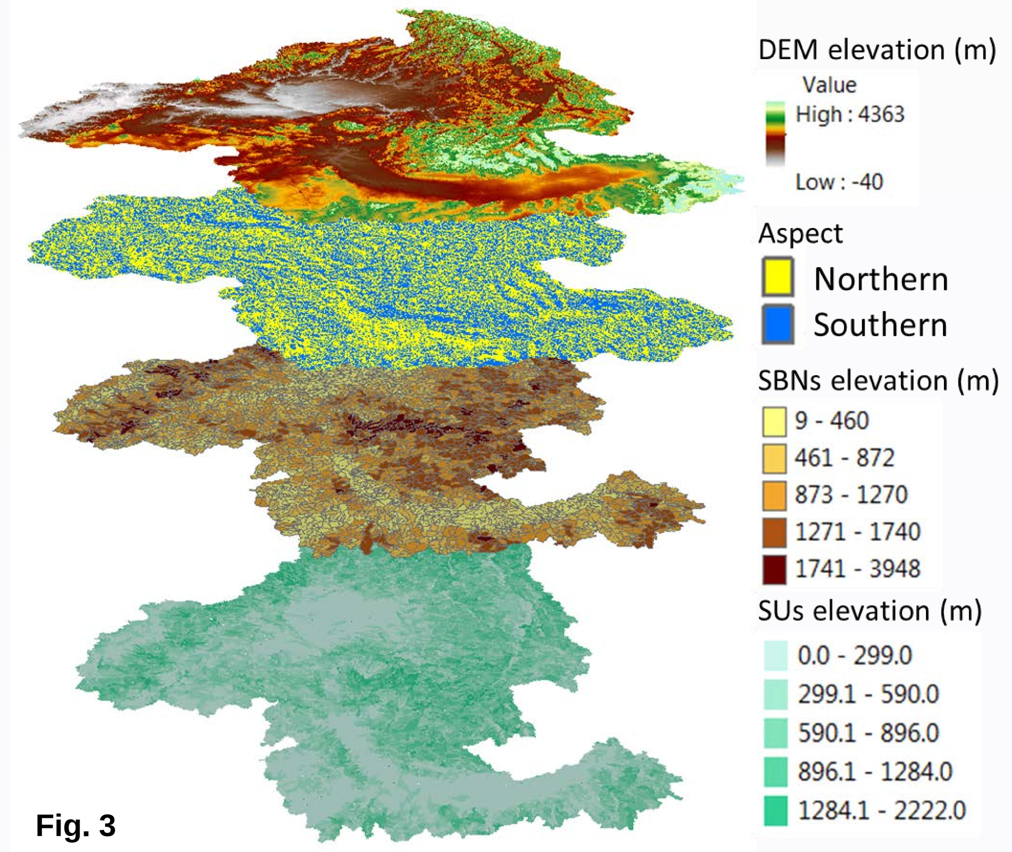
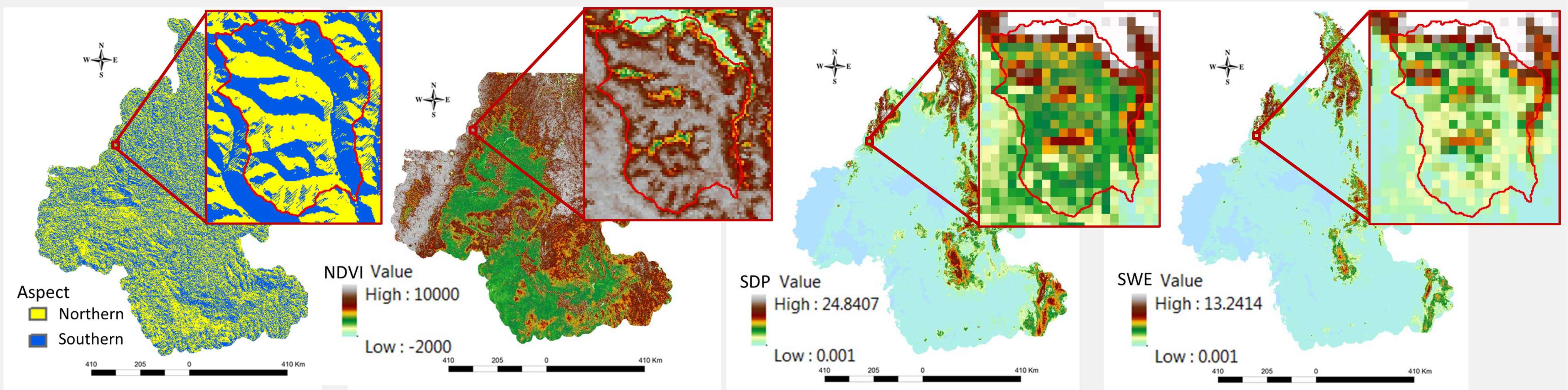


Fig. 3

- The Local method is applied to derive non geo-located subgrid units over the Columbia River basin (CRB) with and without aspect to evaluate the role of landscape orientation in capturing variability of vegetation, snow depth (SDP) and snow water equivalent (SWE).
- Non-geo-located subgrid units are spatially non-contiguous areas of the subbasin described by fractional areas.
- Normalized area threshold values are used to merge small units with the neighboring larger units and the capability to capture variability of vegetation and snow are evaluated across different values of area threshold over the CRB.

Results

Fig. 4: Maps of landscape orientation, NDVI, Snow Depth (SDP) and Snow Water Equivalent (SWE) over CRB:



NDVI is obtained from eMODIS datasets at http://earthexplorer.usgs.gov/. SDP and SWE are obtained from SNODAS at nsidc.org.

Fig. 5: Comparison using NDVI:

- Subgrid units including aspect better capture NDVI variability over CRB.

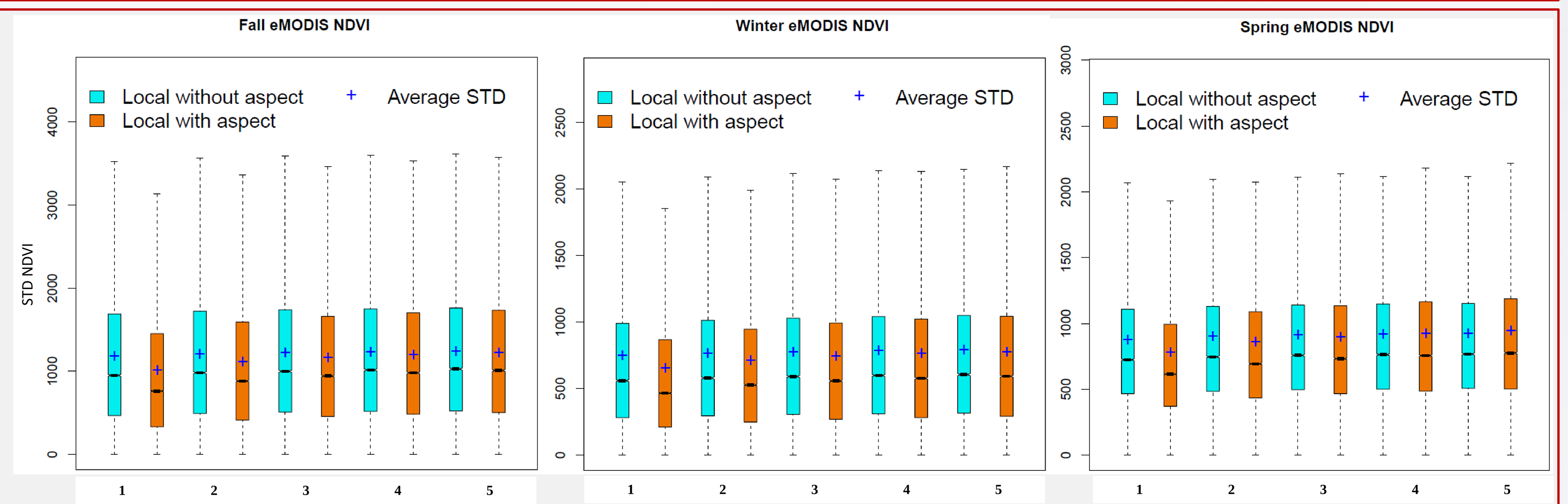


Fig.6: Comparison using Snow Depth:

- Subgrid units including topographic aspect better capture snow depth variability over CRB.

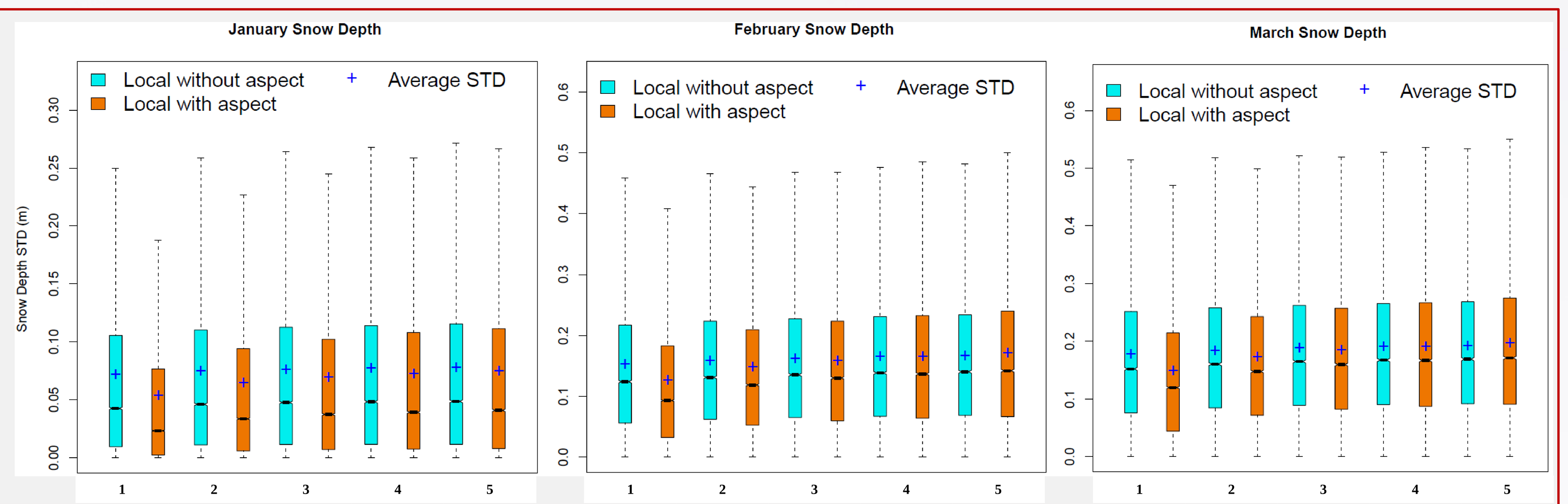
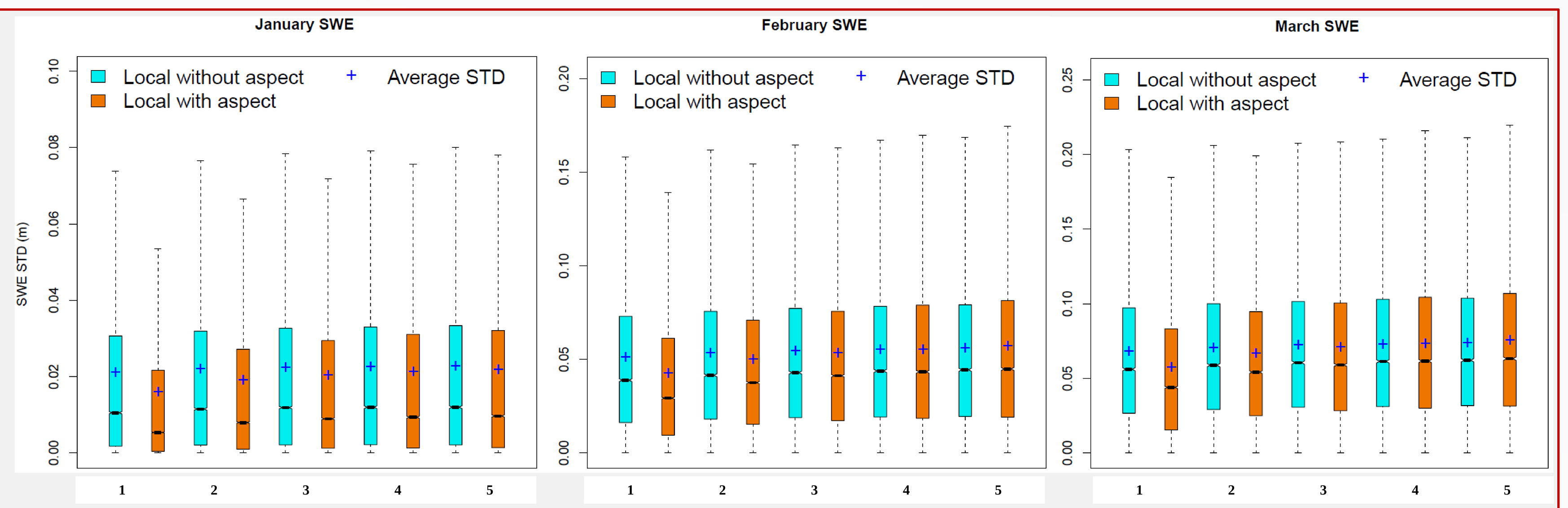


Fig. 7: Comparison using Snow Water Equivalent:

- Subgrid units including aspect better capture snow water equivalent variability over CRB.



Summary and Conclusions

- Generally, results demonstrated that the non-geo-located subgrid structures derived using the Local method with both hypsometric analysis and landscape orientation are capable to capture variability of NDVI, snow depth and snow water equivalent better than those using the Local method without landscape orientation.
- The results also suggest that the improvement in capturing variability of NDVI, snow depth and snow water equivalent are sensitive to the values of area threshold applied to merge smaller subgrid units with the neighboring larger units.

ACME Accelerated Climate Modeling for Energy

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