Landscape Characterization and Representativeness Analysis for Understanding Sampling Network Coverage

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Introduction

- Tropical vegetation is poorly represented in current Earth system models (ESMs).
- Spatial heterogeneity of highly diverse tropical forests is absent from ESMs.
- Understanding potentially vulnerable tropical systems is important under a changing climate (DOE, 2012).
- Logistics and resource constraints limit where and when measurements can be made.
- Tropical forest research will require upscaling methods and qualitative quality assessment of currently available data.

Methods

1. Classify ecoregions using Multivariate Spatiotemporal Clustering (MSTC).
2. Label unsupervised classification with ecoregion type names using Mapcurves.
3. Quantify representativeness of single and combined network coverage using distance in a hyper-volume data space.

(See Hoffman et al. (2013).)

Ecoregion Delineation

Figure 1: Multivariate Spatiotemporal Clustering (MSTC)

Mapcurves

Figure 2: Mapcurves compares the agreement and disagreement of categorical maps in a way that is independent of differences in resolution, the number of categories, or the direction of comparison (Hargrove et al., 2006).

Representativeness Analysis of Points and Networks

1. Representativeness analysis compares a single point to all other points in data space.
2. Euclidean distance in data space is mapped as a dissimilarity score in geographic space, where darker colors indicate high degrees of dissimilarity.
3. A single map is created from all maps (sites) in a set by selecting the minimum values for each grid cell from the collection of maps (network of sites).

Table 1: Variables used in MSTC for ecoregion delineation and representativeness analysis. These data are order with a fifth resolution.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar interception</td>
<td>kW/m^2</td>
</tr>
<tr>
<td>Nitrogen content of soil</td>
<td>g/cm^3</td>
</tr>
<tr>
<td>Carbon content of soil</td>
<td>g/cm^3</td>
</tr>
<tr>
<td>Bulk density of soil</td>
<td>g/cm^3</td>
</tr>
<tr>
<td>Available water holding capacity</td>
<td>g/cm^3</td>
</tr>
<tr>
<td>Day/night diurnal temperature</td>
<td>°C</td>
</tr>
<tr>
<td>Ratio of precipitation to potential evapotranspiration</td>
<td></td>
</tr>
</tbody>
</table>

Ecoregion Classification

Figure 3: The MSTC algorithm was used to group the 17 observation vectors (Table 1) into regions with equal variance across all clusters. Clustering was repeated until 0.06% of all observations changed cluster membership between iterations (Kumar et al., 2011). The results are categorical maps of regions. The derived ecoregions were then identified for type using the mapcurves algorithm developed by Hofmann et al. (2006) with a suite of expert ecoregion maps (Table 2). The k=50 map was manually reclassified to group similarly labeled regions (d).

Figure 4: Single Point Representativeness: CTFS-ForestGEO, Mpala, Kenya. Representativeness of the entire globe with respect to an individual sampling point quantified in data space. Euclidean distance in data space is mapped as a dissimilarity score in geographic space, where darker colors indicate high degrees of dissimilarity.

Table 2: Total number of sites for each network used in the representativeness analysis.

<table>
<thead>
<tr>
<th>Network</th>
<th>Number of Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAINFOR</td>
<td>368</td>
</tr>
<tr>
<td>CTFS-ForestGEO</td>
<td>59</td>
</tr>
<tr>
<td>Fluxnet</td>
<td>240</td>
</tr>
</tbody>
</table>

Figure 5: Network representativeness map was created from all single point maps (sites) in a set by selecting the minimum values for each grid cell from the collection of maps (network of sites). Table 3 lists the number of points in each sampling network. Darker colors indicate high degrees of dissimilarity.

Figure 6: Combined Representativeness of Fluxnet (a), CTFS-ForestGEO (b), and RAINFOR (c) for tropical forested regions globally. Forested regions were defined using MSTC (Figure 3(d)). Color combinations of RGB represent the combined coverage of the three networks where white areas are combinations of all three and dark areas lack coverage of any network.

Conclusions

(1) Landscape classification with MSTC, (2) Mapcurves, and (3) representativeness analysis are a suite of tools suitable for the quantitative assessment of data from monitoring networks in space and time.

References


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