Regionalization of Annual Precipitation in Ghana

Holli Capps, MS student[1]; Peter Waylen, PhD[1]; Kwadwo Owusu, PhD[2]
[1]Geography Department, University of Florida; [2]Department of Geography and Resource Development, University of Ghana

Introduction

- Have there been any changes in the magnitude, frequency and timing of extremely large daily rainfall totals across Ghana?
- The first step → identify regions of reasonably homogeneous precipitation
- Preferably this regionalization would be based on extremes, however
  - Extremes, by definition, are "noisy"
  - Only 23 meteorological stations
- Therefore, focus on more stable properties
  - Mean and standard deviation of annual precipitation

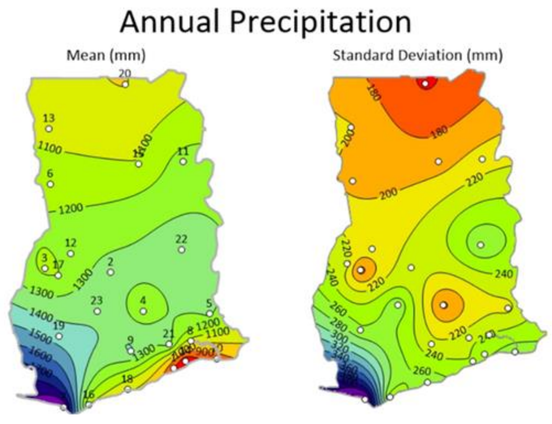

Figure 1. Maps of annual precipitation (mm) indicating mean (left) and standard deviation (right) based on 23 stations

Methods

- Data from the Ghana Meteorological Agency (GMet) 23 stations with long run (1960-2016), near-complete records. (**Figure 1**).
- Can then run grouping algorithms to help define regions of reasonably homogeneous mean and standard deviation.
- Grouping proceeds in a stepwise fashion one station, or group of stations at a time, starting from 23 individual stations and end with one group for the entire country.
- Each station's mean is converted to a standardized measure by differencing from the national mean (1197mm) and dividing by the standard deviation of that estimate (265mm).
  - A similar process standardizes each station's standard deviation (interannual variation) (mean 237mm, standard deviation 60 mm) as means of displaying groupings.

Results

- Ward, Complete linkage, Single linkage, Median Centroid linkage and Average method grouping algorithms yield consistent results from which five regions emerge **(Figure 2)**
- Five distinct groups emerge rapidly without greatly increasing in-group variability (vertical axis)
  - Navrongo and Axim most dissimilar stations, and are not grouped until the very last steps.
- Stations and the standardized properties are plotted an identified by group in figure **(Figure 3)** and the spatial distribution of above/below national values mapped in **Figure 4**

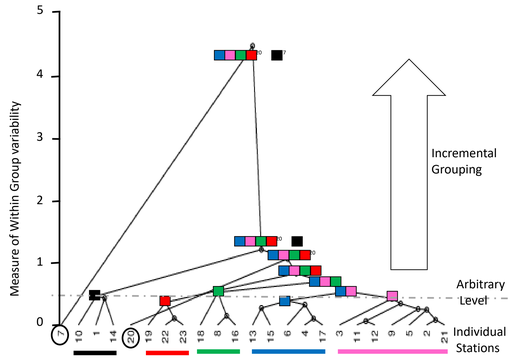

Figure 2. Summary of grouping algorithms, based on mean and standard deviation of annual precipitation of 23 stations, to create 5 groups

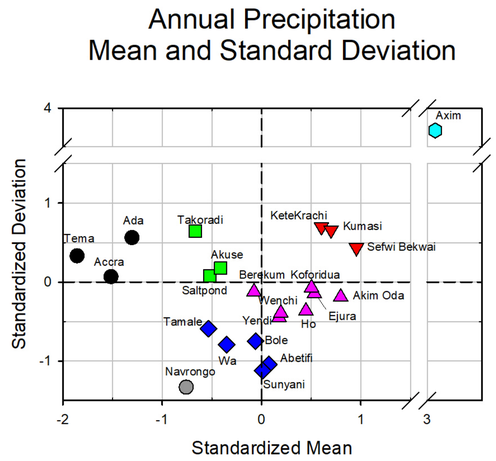

Figure 3 Plot of standardized station properties, with group membership identified by color

Discussion and Conclusions

- Validation of regionalization:
  - Consistency of the results from the grouping algorithms
    - Highest mean and lowest variance → runs from southwest coast to the middle of the eastern boundary
    - Below mean and variance levels → north
    - Below mean and above variance → along the eastern coast
- Regions are similar to the agro-ecological classification of Gmet **(Figure 5),**
  - Some notable exceptions, possibly explained by the fact that regions in this study only consider only annual precipitation, while agro-ecological zones consider other variables like soils and temperatures

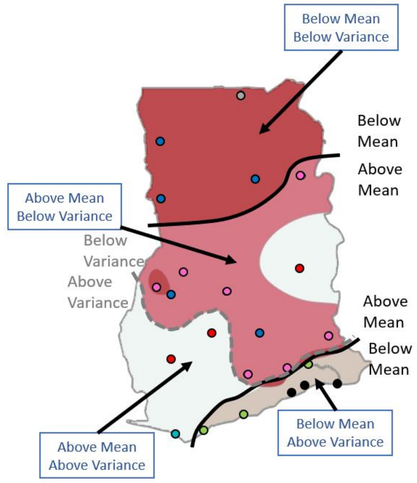

Figure 4. Locations of Above mean and variance, Above mean and below variance, Below mean and above variance, and Below mean and below variance

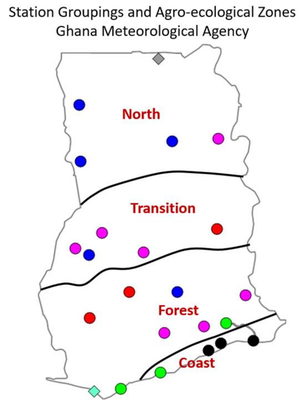

Figure 5. Regions defined in this study, compared to the GMet Agro-ecological Zones

Future Work

- Next stage in exploring and defining the representativeness of these regions, of each historic record:
  - Compare the annual characteristics of each station within a region, to the surrounding data, from a gridded data set Ghana
- Once completed, analyses of the daily records at that set of representative stations will proceed.

References

1. Amekudzi, L., Yamba, E., Preko, K., Asare, E., Aryee, J., Baidu, M., & Codjoe, S. (2015). Variabilities in Rainfall Onset, Cessation and Length of Rainy Season for the Various Agro-Ecological Zones of Ghana. Climate, 3(2), 416–434. doi: 10.3390/cli3020416
2. Becker, R. A., Chambers, J. M. and Wilks, A. R. (1988). The New S Language, Wadsworth & Brooks/Cole. (S version.)
3. GMet - GHANA METEOROLOGICAL AGENCY. (2019). Retrieved from https://www.meteo.gov.gh/gmet/
4. Gordon, A. D. (1999). Classification, Second Edition. London: Chapman and Hall / CRC
5. Murtagh, F. (1985). Multidimensional Clustering Algorithms, in COMPSTAT Lectures 4, Wuerzburg: Physica-Verlag
6. McQuitty, L.L. (1966). Similarity Analysis by Reciprocal Pairs for Discrete and Continuous Data, Educational and Psychological Measurement, nr. 26, 825-831
7. Wessa, P. (2017). Hierarchical Clustering (v1.0.5) in Free Statistics Software (v1.2.1). Office for Research Development and Education, URL https://www.wessa.net/rwasp_hierarchicalclustering.wasp/

Acknowledgements and Thanks

- Dr. Timothy Fik