

Max Warnock

GEOG 4103

Essay 2

12/9/24

Scale in GIScience

The challenge of measuring, representing, modeling, and analyzing phenomena on the Earth's surface has been a long standing problem dating back centuries. Humans have often struggled to find the best methods for accurately representing Earth's intricacies across a vast range of differently sized features and quantities (Lukinbeal, p. 20). In today's world, it's possible to study everything from incomprehensibly small subatomic particles to the vast distances of space. Even comparing lesser differences in size, such as features in our everyday environment pose challenges. The concept of scale is important for understanding how to make comparisons between different sizes and this can be applied to many fields of study. Within the study of geography, scale is most often concerned with spatial relationships (Montello, 2001). Additionally, comparing phenomena at different scales has implications for making accurate representations, calculating statistics, and drawing conclusions (Marceau, p. 8). Therefore the concept of scale is a particularly important part of any research or analysis that deals with phenomena, representations, models, or data across different scales, and equally important is understanding the implications of these comparisons on results and conclusions.

Scale is important in GIScience because data is often collected at different resolutions depending on the data type, measurement equipment, methodology, and purpose. If datasets have different resolutions, they don't share the same cardinality and can't easily be compared. However, comparison is often necessary to fulfill research and analytical goals (Marceau, p. 3-4)

Within GIS software, raster data is a common way of representing spatial features, and this data type can be manipulated to fit different scales for comparison. For example, a fine resolution raster dataset can be manipulated using a resampling tool that uses defined mathematical methods (e.g majority rule) to create a new raster matching the coarser resolution of a target raster. This process is called “upsampling” and allows for comparison of the two datasets. However, resampling introduces the mixed pixel problem where larger more homogenous features are preserved or even overrepresented, and smaller features may be completely removed from the resampled data (Johnson p. 1-2). The resampling methodology (e.g. bilinear interpolation) may also contribute to problematic resampling results by increasing autocorrelation in the data (Marceau, p. 9).

To reduce these problems, a study by Johnson et al. (2021) proposes a new resampling method for upsampling which utilizes both a global and zonal approach to preserve area and demonstrates this through resampling landcover classification data. The study’s resampling algorithm first identifies the “global percentage of each class” which determines how many cells of each class can be included in the target raster, thereby preserving area. Then, a majority function determines the majority class of each target cell, while also calculating the percentages of any other classes within the cell. From this, a zonal grid is created for each class which is divided into zones representing the percentage of the majority class in each target cell. Next, the algorithm starts with the class of the smallest area, and assigns that class to the proportionate number of target cells to maintain area. This process repeats for all classes in order of ascending class area. This iterative process prioritizes the preservation of area of each class and it forces the preservation of smaller classes by assigning them first. The study argues that this area

preservation method produces more accurate resampling results and helps to maintain the structure of the data by preserving minority classes (Johnson, 2021).

Another approach to resampling land classification data involves converting from vector to raster data. A study by Pacheco, et al (2018) provides evidence that resampling from vector polygon data to a coarser raster resolution provides a more accurate landcover classification when compared to the same method, except beginning with a fine resolution raster dataset. The study also emphasized the importance of finding a resolution that most optimally represents the objects or features being studied. A resolution that is too fine may have too much noise and would need a moving window smoothing technique applied to it. A resolution that is too coarse may not have enough detail to accurately identify objects of interest (Pacheco, p. 184).

Examining scale through the lens of raster datasets of different resolutions helps to show just one aspect of this complex topic. Encountering different scales is very common when doing research or analysis with spatial data, and therefore it's very important to be versed in the methods for how to make comparisons between different resolutions, and implications of data manipulation through resampling and focal techniques.

Works Cited

- Díaz-Pacheco, J., van Delden, H., Hewitt, R. (2018). The Importance of Scale in Land Use Models: Experiments in Data Conversion, Data Resampling, Resolution and Neighborhood Extent. In: Camacho Olmedo, M., Paegelow, M., Mas, JF., Escobar, F. (eds) *Geomatic Approaches for Modeling Land Change Scenarios. Lecture Notes in Geoinformation and Cartography*. Springer, Cham.
https://doi.org/10.1007/978-3-319-60801-3_9
- Johnson, J. Michael, and Keith C. Clarke. 2021. "An Area Preserving Method for Improved Categorical Raster Resampling." *Cartography and Geographic Information Science* 48 (4): 292–304. doi:10.1080/15230406.2021.1892531.
- Lukinbeal C., 2016. Scale and Its Histories. *Yearbook of the Association of Pacific Coast Geographers*. 78(1):15-27.
- Marceau D. J. 1999. The scale issue in social and natural sciences. *Canadian Journal of Remote Sensing* 25(4):347-356.
- Montello D. R. 2001. Scale in geography. In: Smelser, N. J., & Baltes, P. B. (Eds.) *International Encyclopedia of the Social & Behavioral Sciences*. Pergamon, Oxford, pp. 13501-13504.