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Position Paper by Robert Gilmore Pontius Jr (rpontius@clarku.edu) 29-30 June 2011

I assume my contribution to this workshop is to offer my experience in designing mathematical measurements to quantify changes across space and time. I have been developing a philosophy to design spatial metrics in a manner that captures rigorously the patterns that the human eye can see, and avoids conceptual pitfalls of methods that are frequently taught in statistics courses. Pontius, Thontteh and Chen (2008) present the foundation of the approach in the context of comparing two maps of the same real continuous variable, i.e. a predicted NDVI comparison map versus an observed NDVI reference map in Southeastern Africa. The approach focuses on the differences between the maps rather than the similarities, because it is usually more important to characterize the differences for practical interpretation. The approach separates the total difference into two types: quantity difference and allocation difference. Quantity difference is the amount of absolute difference between the comparison map and the reference map that is due to the less than perfect match in the overall quantity of the mapped variable, e.g. vegetation. Allocation difference is the amount of difference between the comparison map and the reference map that is due to the less than optimal match in the spatial allocation of the variable, given the quantity of the variable in the comparison and reference maps.

Pontius and Millones (in press) present the latest developments concerning how this philosophy applies to the categorical variable case. The paper presents an approach to compare two maps of the same place for the same set of categories for two different time points. We show how the measurement of overall all difference and its separation into quantity difference and allocation difference is more useful for practical purposes than the conventionally used kappa indices of agreement, especially because randomness is usually not a relevant baseline.

Pontius and Connors (2010) is the latest in a sequence of papers that show how to compare two maps of a categorical variable when the pixels in the maps consist of soft-classified fuzzy categories, where each pixel can contain partial membership to several categories. Mixed pixels are more common than pure pixels in land cover mapping, because pixels do not correspond perfectly to units of pure categories on the ground. Scientists frequently re-classify a mixed pixel into the most prominent single category because methods to analyze mixed pixels are not widely known, but the conversion from mixed pixels to pure pixels corrupts the information in the maps.

Elements in the map, e.g. pixels, do not necessarily represent meaningful elements on a landscape, so it is important to be able to analyze maps at multiple scales, so we can see how the selection of the units influences the comparison measurements. Pontius, Peethambaram and Castella (2011) give my latest thoughts on how to compare three maps that share the same categorical variable, in a manner that considers multiple spatial resolutions. It is important to compare three maps in the context of predictive change modeling, where the three maps are: reference of time 1, reference of time 2, and prediction of time 2. The paper shows also the importance of comparing a predictive model to a null model of pure persistence between time 1 and time 2, because it is common that most of the landscape does not change between time 1 and time 2, while investigators are usually interested in change, not persistence (Pontius et al. 2008). Pontius et al. (2007) establish the importance of considering a naïve model, which is a prediction that the investigator would make after thinking about the problem for approximately one minute. For example, a naïve model that predicts deforestation along the Trans Amazonian Highway is more accurate at the pixel resolution than a more complicated model that considers the behavior of agents of deforestation.

The latest version of the GIS software *Idrisi* has the ability to characterize changes at multiple temporal resolutions for a set of raster map at several time points. *Idrisi*'s Earth Trends Modeler (ETM) can measure the association between trends in time series data and other explanatory variables.

I am now applying my philosophy to the comparison of a Boolean map to a Rank map, such as a map of species presence versus a map of relative desirability of species habitat. This research seeks to improve upon the work of Pontius and Batchu (2003) concerning the Relative Operating Characteristic (ROC). I have another research agenda to consider whether the noise in data is larger than signal in data (Pontius and Petrova 2010).

Volunteered data is a hot new research topic that is relevant to our group's work. Volunteered data is extremely important to citizens who do not trust their own government's official data. I have seen Russians who are using Google Earth to map incidences of illness in proximity to polluting energy plants, because the citizens do not trust their government's data. As another example, volunteered data via the internet is perhaps the only way that concerned citizens can report safely on the drug wars in Mexico. This technology has tremendous potential, especially to report information that is more reliable than official information. However I am concerned that it would be extremely easy for any special interest group, such as the political organizations, to write computer code to generate apparently volunteered data in order to intentionally spread misinformation. I have no expertise on this topic.

Our group plans to explore flows of phenomena across the globe. Therefore, cartographic projection is important. Methods that I mention above assume that the spatial extent is so small that Euclidean distances are acceptable. We will need to consider cartographic projection for global phenomenon.

LITERATURE available at www.clarku.edu/~rpontius

1. Pontius Jr, RG and K Batchu. 2003. Using the relative operating characteristic to quantify certainty in prediction of location of land cover change in India. Transactions in GIS 7(4): 467-484.
2. Pontius Jr, RG, W Boersma, J-C Castella, K Clarke, T de Nijs, C Dietzel, Z Duan, E Fotsing, N Goldstein, K Kok, E Koomen, CD Lippitt, W McConnell, A Mohd Sood, B Pijanowski, S Pithadia, S Sweeney, TN Trung, AT Veldkamp, and PH Verburg. 2008. Comparing the input, output, and validation maps for several models of land change. The Annals of Regional Science 42(1): 11-47.
3. Pontius Jr, RG and J Connors. 2009. Range of categorical associations for comparison of maps with mixed pixels. Photogrammetric Engineering & Remote Sensing 75(8): 963-969.
4. Pontius Jr, RG and M Millones. 2011. Death to Kappa: birth of quantity disagreement and allocation disagreement for accuracy assessment. International Journal of Remote Sensing.
5. Pontius Jr, RG, S Peethambaram, and J-C Castella. 2011. Comparison of three maps at multiple resolutions: a case study of land change simulation in Cho Don District, Vietnam. Annals of the Association of American Geographers 101(1): 45-62.
6. Pontius Jr, RG and S Petrova. 2010. Assessing a predictive model of land change using uncertain data. Environmental Modeling & Software 25(3): 299-309.
7. Pontius Jr, RG, O Thontteh and H Chen. 2008. Components of information for multiple resolution comparison between maps that share a real variable. Environmental and Ecological Statistics 15(2): 111-142.