Three-Dimensional Spatial Association Measures

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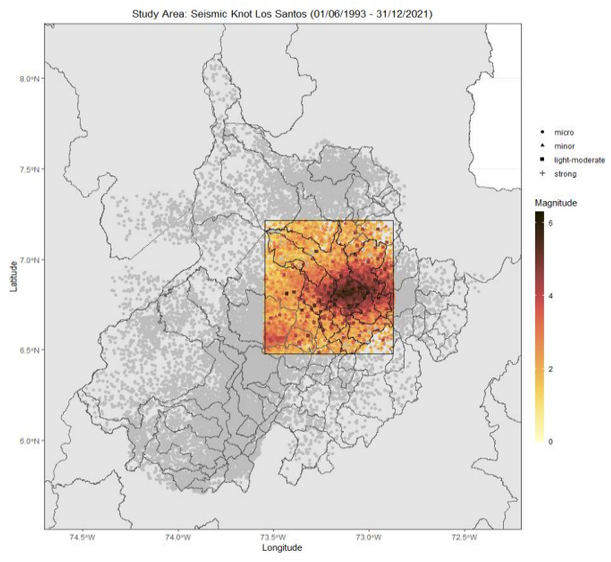
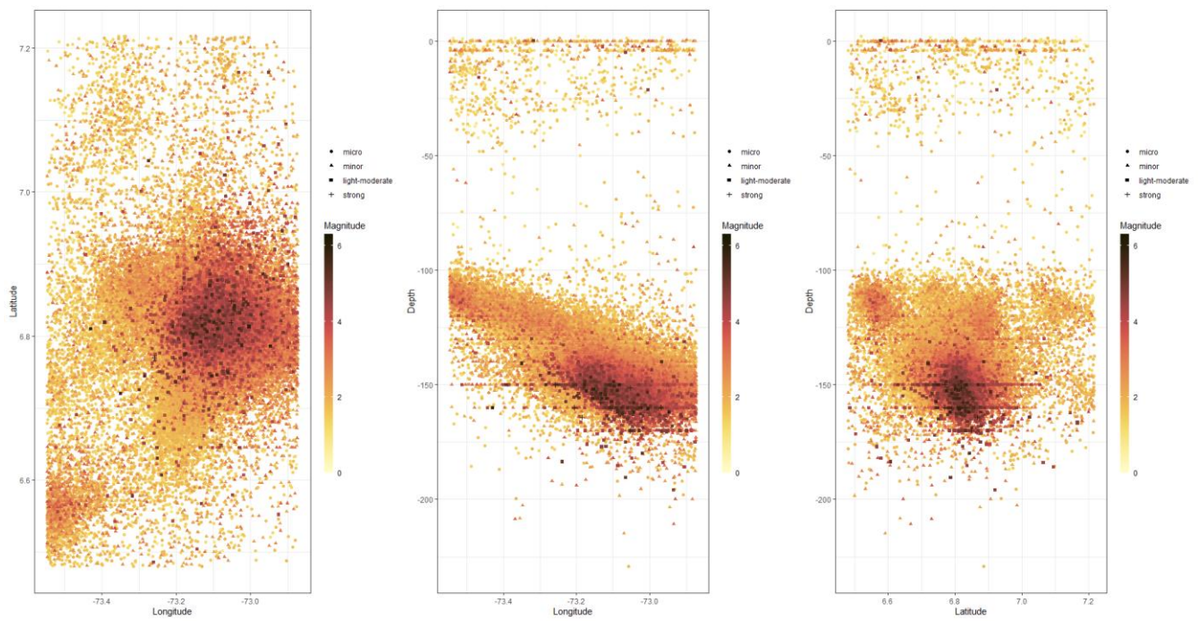
Introduction

The use of two dimensions is common when calculating measures of spatial association, however, the inclusion of a third dimension (altitude or depth) can provide more complete information when evaluating spatial relationships. This work exposes the possible effects on the measures of spatial association with the inclusion of a third dimension in the calculation of Euclidean distances.

Methods

Data Origin





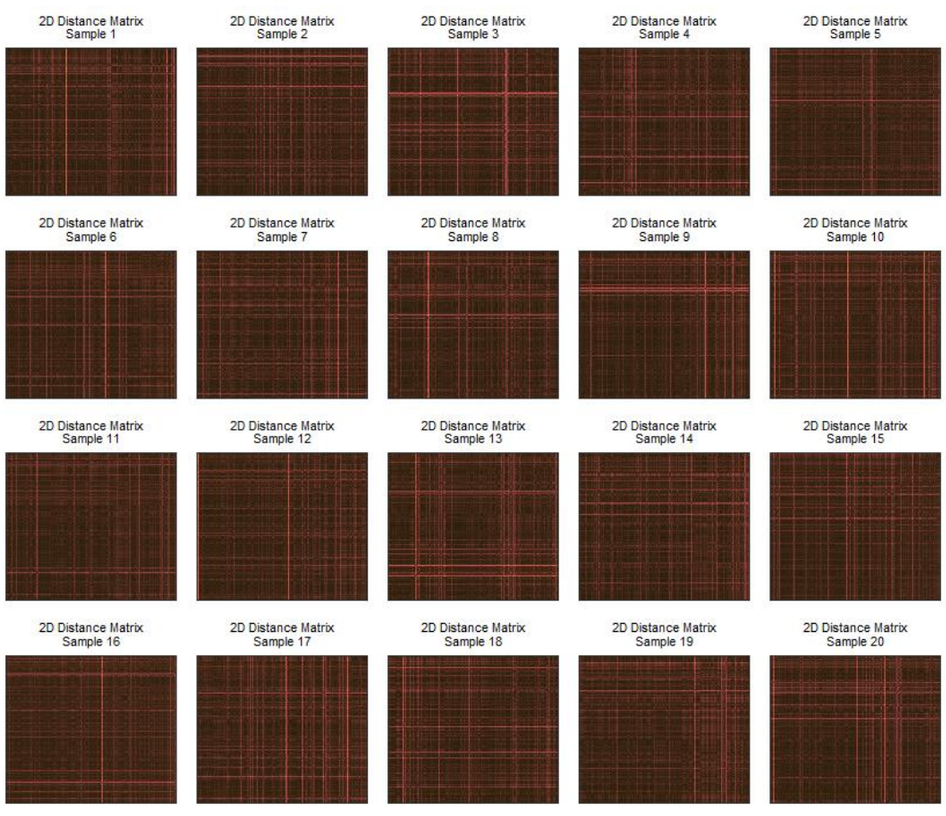
$$d_{2d}^2 = x^2 + y^2$$

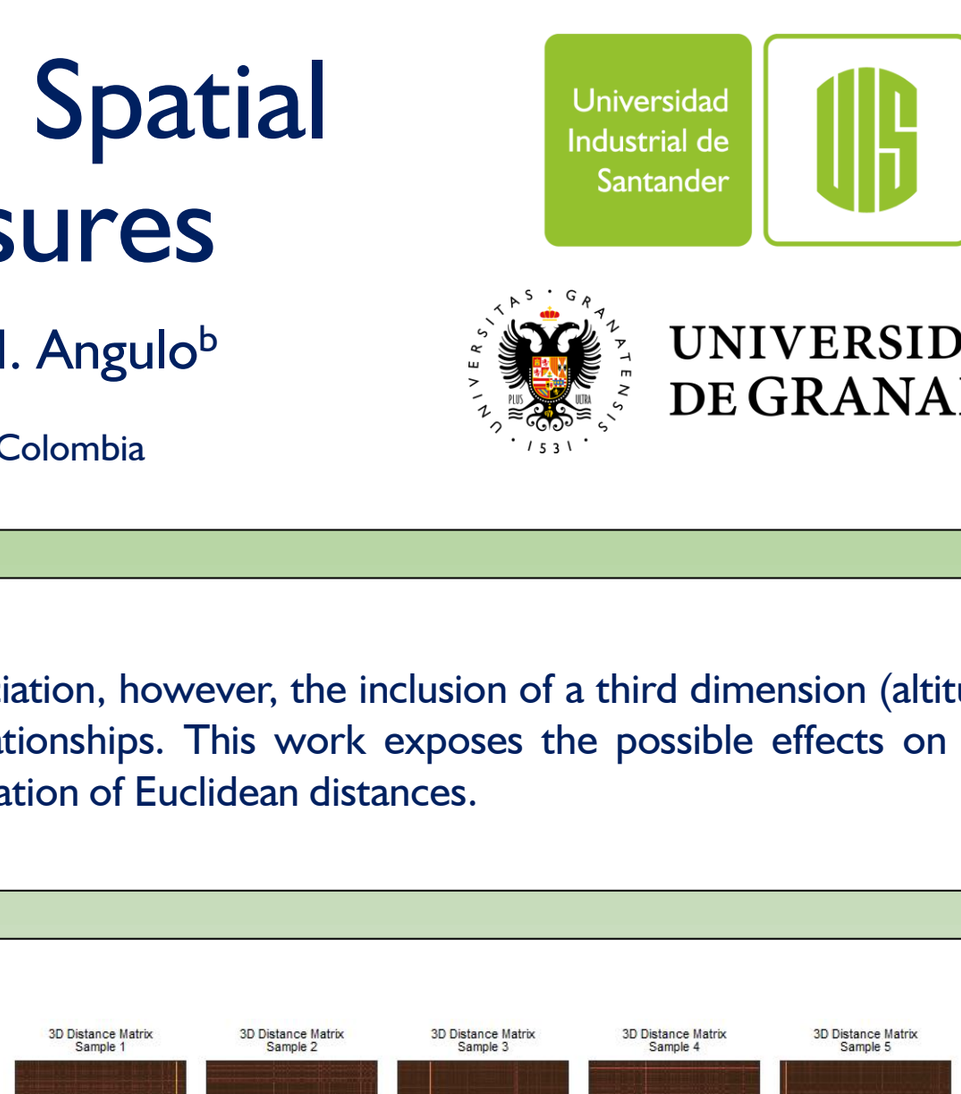
$$d_{3d}^2 = x^2 + y^2 + z^2$$

$$I = \frac{n}{\sum\sum w_{ij}} \frac{\sum\sum w_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\sum(y_i - \bar{y})^2}$$

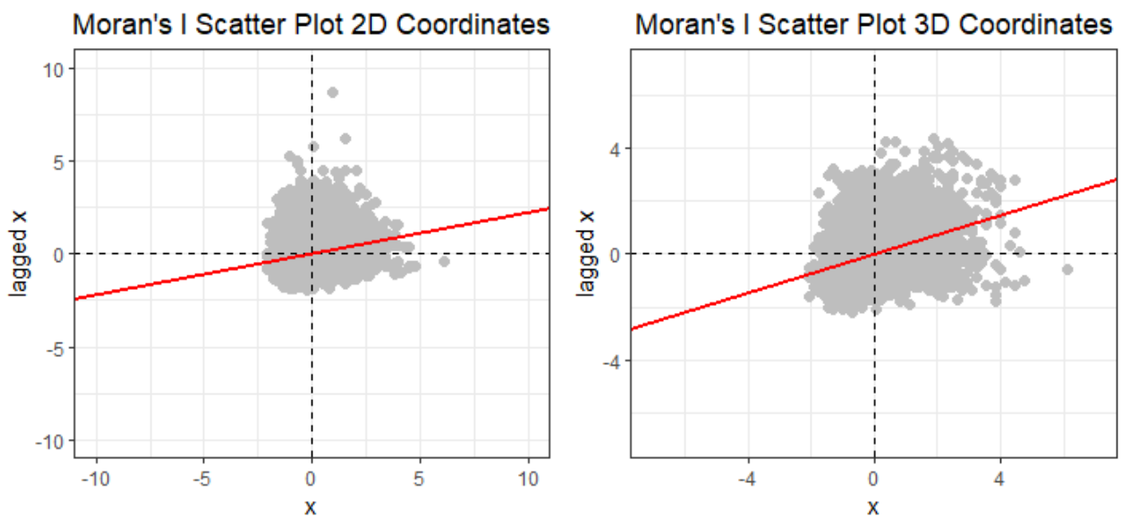
$$I_i = \frac{(y_i - \bar{y})\sum w_{ij}(y_j - \bar{y})}{\frac{\sum(y_i - \bar{y})^2}{n}}$$

Results





Discussion and Conclusions



Moran's I Local (2D)

ID	Ii	Ei	Vi	Zi	p.value	Xi	wXj
1	1,402350	-0,000400	1,998148	0,992354	0,321025	0,958886	0,571326
2	-1,656243	-0,000400	1,998148	-1,171400	0,241438	0,958886	-1,074154
3	1,087060	-0,000600	2,997221	0,628252	0,529839	-0,711594	0,649682
4	5,820550	-0,000400	1,998148	4,117941	0,000038	2,173781	1,198176
5	0,164069	-0,000400	1,998148	0,116351	0,907374	-0,104147	-0,995797
6	2,030702	-0,000600	2,997221	1,173316	0,240669	0,958886	2,530231

Moran's I Local (3D)

ID	Ii	Ei	Vi	Zi	p.value	Xi	wXj
1	1,111056	-0,000400	1,998148	0,786282	0,431702	0,958886	0,708225
2	-1,073654	-0,000400	1,998148	-0,759256	0,447699	0,958886	-0,692610
3	-0,716435	-0,000400	1,998148	-0,506547	0,612472	-0,711594	0,614836
4	2,518747	-0,000400	1,998148	1,782132	0,074728	2,173781	0,708225
5	-0,073217	-0,000400	1,998148	-0,051513	0,958917	-0,104147	0,428058
6	1,547998	-0,000400	1,998148	1,095390	0,273346	0,958886	0,988392

Conclusions

- Introducing the third dimension in the distance measures has effects on the spatial weight matrix in the calculation of spatial association measures such as Morán's Local I.
- In some specific cases of variables, a third dimension plays the role of a covariate and should not be considered as an element for calculating distances.

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References

- Baronio, A., Vianco, A. \& Rabanal C. (2012). Una Introducción a la Econometría Espacial. Dependencia y Heterogeneidad. Recovered from: http://http://www.econometricos.com.ar/.
- Bongiovanni, R. (2008). Econometría Espacial Aplicada a la Agricultura de Precisión. Actualidad Económica - Año XIX - Nº 67.
- Fajardo, C., Reyes, O. M., & Ramirez, A. (2015). Seismic Data Compression Using 2D Lifting-Wavelet Algorithms. Ingeniería y Ciencia, 11(21), 221–238. doi: 10.17230/ingciencia.11.21.11
- Lovelace, R. and others (2015). Introduction to Visualising Spatial Data in R. Recovered from: https://cran.r-project.org.
- Pebesma, E. (2012). Spacetime: Spatio-Temporal Data in R. Recovered from: https://www.jstatsoft.org.
- R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.
- Zhukov, Y. (2010). Applied Spatial Statistics in R. Recovered from: http://scholar.harvard.edu/zhukov/classes/applied-spatial-statistics-r.