Discussion of "Visualizing spatiotemporal models with virtual reality: from fully immersive environments to applications in stereoscopic view" by Stefano Castruccio, Marc G. Genton and Ying Sun

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We congratulate the authors on this timely paper, which explores modern visualization tools for communicating statistical results and uncertainty more efficiently for spatiotemporal models defined on complex domains.

Although the authors chose to focus on classical space-time applications, the benefits of advanced visualization tools reach far beyond the standard Gaussian geostatistical setting. We highlight two different examples below of risk assessment applications.

Statistics of extremes (Davison *et al.*, 2012; Davison and Huser, 2015; Davison *et al.*, 2018) focuses on estimating low-probability tail events, and has obvious applications in Earth science and finance, where the notion of risk is often related to individual or simultaneous extreme events. Genton *et al.* (2015) used "visuanimations" to dynamically explore the dependence characteristics of a (highly non-Gaussian) spatiotemporal model for precipitation extremes proposed by Huser and Davison (2014). In this context, interactive visualization tools could be very useful, especially when adding an extra "tail" dimension, allowing one to dynamically explore the estimated joint tail behavior and efficiently visualize extreme spatiotemporal return levels for increasing return periods.

The most important object to estimate and visualize from point pattern data (Cressie, 1993), such as wild fire or landslide data, is their *intensity function*. Lombardo *et al.* (2018)

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used a log-Gaussian Cox process to model landslides and create spatial predictive maps to identify regions at risk in Italy. The data and the fitted intensity function were visualized using `Google Earth`™; see Figure 1 and https://vimeo.com/266344095. The visualization of risk maps and how they evolve in time would highly benefit from immersive virtual reality (VR) tools, which more realistically render three-dimensional (3D) perspective.

Figure 1: Visualization of landslide data and fitted log-Gaussian Cox process intensity function using `Google Earth`™; see also https://vimeo.com/266344095.

As explained by the authors and further motivated above, advanced 3D, immersive, or portable VR visualization techniques may be used to dynamically and interactively "*explore and assess the structure of the data and to improve resulting statistical models*". We fully concur, although we want to point out that using such modern facilities as the KAUST 3D visualization cave, and creating smartphone or VR headset applications for scientific visualization often require a significant investment of time and the support from a specialized staff. Although this is undoubtedly worthwhile for the *communication of results* from statistical analyses, we think that for *data exploration*, simpler approaches such as `R Shiny` applications, or popular Geographic Information System (GIS) environments including `Google Earth`™, which are visually efficient, cheaper, accessible, and significantly less time-demanding to set up, are still useful.

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