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Does spatial averaging of thermochronometric data contain a bias towards acceleration?

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Low-temperature thermochronometry has proven to be a useful tool in establishing cooling and thus exhumation histories for rocks exhumed by surface erosion. The combination of multiple chronometric systems or different path lengths provided by age-elevation relationships provides resolving capability even for changes in exhumation rate. The challenge with such methods is to find a sufficient number of data to resolve exhumation histories over space and time. Towards this goal, we (Fox et al., 2014) presented a Bayesian spatial analysis method designed to integrate disparate data distributed across space and time in order to resolve exhumation histories. Herman et al. (2013) applied this method to argue that mountainous regions worldwide have dominantly accelerated in erosion over the last ca. 5 Ma, which is further highlighted in the Alps (Fox et al., 2015). It has recently been argued (Schildgen et al., 2018) that this method is biased towards acceleration, calling into question these results. To address this, we conducted a comprehensive resolution and bias analysis of our method. We found that results depend strongly on the resolving capability of the age data; if resolution capability is good our method has no issues recovering complex histories and sharp boundaries in uplift rate with no bias towards acceleration. If data resolution is poor or spatial averaging is excessive, solution error increases, but the error remains largely unbiased. Very poor data resolution does show bias towards the prior model, but is easily identifiable by posterior resolution analysis. Excessive spatial averaging leads to an overly smooth solution, but again does not lead to systematic false accelerations and is easily identifiable by examination of data residuals. We critique the Schildgen et al. (2018) analysis and find that they have misidentified the Bayesian bias to the prior as a type of spatial correlation bias which, in fact, does not exist. They present models that are all examples of false acceleration that arises from low resolution data distributions combined with a low value prior, but are examples of Bayesian bias to the prior and are not the result of spatial averaging as claimed. Furthermore, most of their interpretation of our results is based on a post-processing of our results using a normalization method. We show that this normalization method introduces artifacts, and we demonstrate that these artifacts degenerate our results to the point that they have no statistical significance.

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