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Accounting for multiple testing in the analysis of spatio-temporal environmental data

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The statistical analysis of environmental data from satellite products and Earth system simulations entails the analysis of gridded spatio-temporal data, where a test statistic is obtained for each pixel. When the whole image or set of pixels is analysed, the problem of multiple testing arises. For example, in a 100 by 100 grid and a significance level of $\alpha = 0.05$, we perform 10,000 simultaneous tests and expect to detect, on average, 500 false positives under the null hypothesis. When the data is correlated in space it can give rise to clustered spurious rejections which can mislead the researcher when analyzing spatial patterns. In this work, solutions for the multiple testing problem are analyzed. These solutions are independent of the test statistic - any test statistic can be used, e.g. tests for trends or change points in time series. Special attention is given to permutation methods, which require less assumptions than their parametric counterparts and are shown to have more power; these methods also allow us to test for spatial patterns in a statistically rigorous way. The methodology is introduced and results are compared. In conclusion, several statistically rigorous methods are presented to analyze spatio-temporal environmental data and control the false positives. These methods allow us to use any test statistic in a wide range of applications in environmental sciences and remote sensing.