

remotePARTS: Spatiotemporal autoregression analyses for large data sets

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Summary

Remote sensing produces enormous quantities of detailed data owing to the high spatial and temporal resolution provided by modern technologies. Data generated by these means can provide unparalleled insight into trends across the landscapes and time periods they represent. Data collected across space and through time, however, exhibit autocorrelation (the tendency of nearby observations in space and time to be more similar than distant ones) that needs to be accounted for during analyses. The size of remote-sensing data sets poses a substantive computational challenge as regression-type analyses that are designed to test hypotheses and account for autocorrelation struggle to fit large data sets (e.g., millions of pixels).

Statement of need

remotePARTS ([Ives & Morrow, 2023](#)) is an R package for statistical estimation and hypothesis testing of large spatial and spatiotemporal data sets. The package implements the PARTS (partitioned autoregressive time series analysis) methods outlined by Ives et al. ([2021](#)) and Ives et al. ([2022](#)), wherein a spatiotemporal problem is broken down into a series of smaller problems by “partitioning” the data into random sub-samples, analyzing the individual partitions, and then combining the results together for a synoptic result that accounts for correlations among partitions. The package also provides tools for running full spatial and spatiotemporal regressions without partitioning the data, for data sets that are small enough to allow this.

The primary feature that differentiates remotePARTS from other statistical packages that can perform spatiotemporal analyses (e.g., sdmTMB, spaMM, R-INLA, the Python PySAL/spreg library) is its ability to handle very large maps. The PARTS method can handle millions and potentially billions of pixels whereas other statistical methods typically cannot, due to memory and computational constraints (i.e., from inverting an $N \times N$ distance matrix), which are relaxed with the partitioning approach.

remotePARTS was designed to be used in ecological and remote sensing research, and has already been used in published science (e.g., Lewińska et al. ([2023](#))). Nonetheless, it is flexible enough to be used to answer a variety of spatial and spatiotemporal questions. The package contains a vignette ([Morrow, 2023](#)) that demonstrates the core functionality of the package and its most commonly used functions.

Author Contributions

Clay J. Morrow: Methodology, Data Curation, Software, Validation, Visualization, Writing – Original Draft, Project Administration.

Anthony R. Ives: Conceptualization, Methodology, Data Curation, Funding Acquisition, Writing – Review & Editing.

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References

- Ives, A. R., & Morrow, C. J. (2023). remotePARTS: Spatiotemporal autoregression analyses for large data sets. In *CRAN repository*. cran. <https://doi.org/10.32614/CRAN.package.remotePARTS>
- Ives, A. R., Zhu, L., F., W., Morrow, C. J., & Radeloff, V. C. (2021). Statistical inference for trends in spatiotemporal data. *Remote Sensing of Environment*, 266. <https://doi.org/10.1016/j.rse.2021.112678>
- Ives, A. R., Zhu, L., F., W., Morrow, C. J., & Radeloff, V. C. (2022). Statistical tests for non-independent partitions of large autocorrelated datasets. *MethodsX*, 9. <https://doi.org/10.1016/j.mex.2022.101660>
- Lewińska, K. E., Ives, A. R., Morrow, C. J., Rogova, N., H., Y. N., Elsen, P. R., de Beurs, K., Hostert, P., & Radeloff, V. C. (2023). Beyond “greening” and “browning”: Trends in grassland ground cover fractions across eurasia that account for spatial and temporal autocorrelation. *Global Change Biology*, 29. <https://doi.org/doi/10.1111/gcb.16800>
- Morrow, C. J. (2023). Alaska: NDVI analysis with remotePARTS. In *GitHub repository*. github. <https://morrowcj.github.io/remotePARTS/Alaska.html>