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More accurate, calibrated bootstrap confidence intervals for correlating two autocorrelated climate time series

Kristin B. Olafsdottir (1,2,3) and Manfred Mudelsee (1)

(1) Climate Risk Analysis, Schneiderberg 26, 30167 Hannover, Germany, (2) Department of Geosciences, University of Bremen, 28334 Bremen, Germany, (3) MARUM, Center for Marine Environmental Sciences, University of Bremen, 28334 Bremen, Germany

Estimation of the Pearson's correlation coefficient between two time series to evaluate the influences of one time depended variable on another is one of the most often used statistical method in climate sciences. Various methods are used to estimate confidence interval to support the correlation point estimate. Many of them make strong mathematical assumptions regarding distributional shape and serial correlation, which are rarely met. More robust statistical methods are needed to increase the accuracy of the confidence intervals.
Bootstrap confidence intervals are estimated in the Fortran 90 program PearsonT (Mudelsee, 2003), where the main intention was to get an accurate confidence interval for correlation coefficient between two time series by taking the serial dependence of the process that generated the data into account. However, Monte Carlo experiments show that the coverage accuracy for smaller data sizes can be improved. Here we adapt the PearsonT program into a new version called PearsonT3, by calibrating the confidence interval to increase the coverage accuracy. Calibration is a bootstrap resampling technique, which basically performs a second bootstrap loop or resamples from the bootstrap resamples. It offers, like the non-calibrated bootstrap confidence intervals, robustness against the data distribution. Pairwise moving block bootstrap is used to preserve the serial correlation of both time series. The calibration is applied to standard error based bootstrap Student's t confidence intervals.
The performances of the calibrated confidence intervals are examined with Monte Carlo simulations, and compared with the performances of confidence intervals without calibration, that is, PearsonT. The coverage accuracy is evidently better for the calibrated confidence intervals where the coverage error is acceptably small (i.e. within a few percentage points) already for data sizes as small as 20.
One form of climate time series is output from numerical models which simulate the climate system. The method is applied to model data from the high resolution ocean model, INALT01 where the relationship between the Agulhas Leakage and the North Brazil Current is evaluated. Preliminary results show significant correlation between the two variables when there is 10 year lag between them, which is more or less the time that takes the Agulhas Leakage water to reach the North Brazil Current.

Mudelsee, M., 2003. Estimating Pearson's correlation coefficient with bootstrap confidence interval from serially dependent time series. Mathematical Geology 35, 651-665.