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The joint influence of break and noise variance on the break detection capability in time series homogenization

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Relocations of climate stations and changes in observation techniques cause artificial breaks in climate records that hamper the study of true climatic changes. Homogenization algorithms are searching for abrupt changes in the difference time series between two neighboring stations to detect such breaks. In multiple breakpoint methods, the optimal segmentation is searched using the maximum explained variance as criterion.

We test this commonly applied detection method by artificial data that contain inhomogeneities with normally distributed amplitudes at random positions and that is additionally superimposed by random scatter. In case of artificial data the true signal is known and the skill of any segmentation can be easily assessed by the mean square difference. In real cases, multiple breakpoint methods rely on the maximum explained variance as criterion. We show that these two metrics, true skill and maximum explained variance are only weakly correlated for signal-to-noise ratios (SNRs) of $\frac{1}{2}$. That can be understood by considering the growth of the explained variance with growing break number separately for the break and noise part. Both obey similar mathematical formulae, but on different scales.

We find that random segmentations explain already about half of the break variance; for the noise fraction, optimum segmentations are superior by to random segmentations by a factor of five. Therefore, maximum variance is often attained where break positions are optimized according to the noise, especially when the SNR is smaller than 1. As consequence, break detection based on maximum explained variance becomes inaccurate and alternative formulations need to be investigated. For higher SNRs, such as assumed in the HOME benchmark, this problem is less severe.