



## Piecewise continuous trends of time series

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Piecewise continuous trends of time series is a simple non-linear approach that mimics the subjective analysis of a time series as that one may perform with a pen on a piece of paper, yet using an objective numerical method that minimizes the mean square error of the fitting. The method consists in fitting the data with a set of continuous line segments, where the number of segments, the location of the breakpoints, and the slopes of the different segments are simultaneously optimized (Tomé and Miranda, 2004, 2005).

This method offers clear advantages over simple linear trend analysis. The method is also much simpler and easier to interpret than most non-linear function fitting. In many cases it leads to results that are similar to subjective curve analysis. Because the method gives a continuous fit of the data it always provides a global analysis. However, if the conditions are carefully chosen, it adjusts itself to sharp changes in the series, highlighting important episodes in the series history, which may be more important than its overall trend.

The proposed methodology is clearly an univariate time series analysis technique. However, it defines, for a given time series, a new set of parameters, the breakpoints, that can be used to perform spatial aggregation of a time varying spatial field. Thus, when applied to spatially distributed data that share some spatial dependence, as is the case of surface temperature, the method is able to identify well defined spatial boundaries where the temperature slow evolution behavior strongly differs, as in the breakpoints years and also in the trend signals before and after breakpoints. We applied this methodology to the GISS surface temperature data for the last 100 years and looked into the evolution of the Earth surface temperature, by separately averaging the surface temperature of regions that are experiencing similar warming/cooling behavior. We were also able to classify the world's globe surface, by their surface trend temperature behavior in the last 100 years, into 5 main classes: 1) warming+cooling+warming (59% of the Earth surface), 2) later cooling after an initial warming (10% of the Earth surface), 3) continuous warming (6% of the Earth surface), 4) cooling+warming+cooling (5.9% of the Earth surface); 5) later warming after an initial cooling (1.2% of the Earth surface).