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Detecting and adjusting the inhomogeneity in daily temperature series using wavelet analysis

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Daily meteorological observations have increasingly been used in the field of climate change related to climate extremes or unusually anomalous weather fluctuations. However, the long-term homogeneity of daily observations remains questionable, not only due to potentially untraceable changes in observing locations and protocols, but also sometimes due to subjective data processing. The inhomogeneities or discontinuities in a climate series caused by non-climatic changes affect not only estimates of the trend in mean climate but also those of climate extremes in different ways. Numerous methods were developed in recent years for detecting and adjusting inhomogeneities in climate series (e.g., MASH, HOM, RHtest). However, there is still potential of improvement in methodology especially dealing with climate extremes such as heat waves and cold surges. In particular, as climate extremes are in general caused by unusual weather fluctuations, they depend to a large extent on weather timescale variability. Most of previous methods somehow overlooked this point, thus the resulted adjustments distort the spectrum of variability and exert an effect on a variety of climate extreme indices derived from the daily series. Wavelet analysis reveals changing climate variability at different timescales and hence helps to recognize incoherent signals that are hardly recognizable via conventional statistics.
Yan and Jones (2008) proposed a novel method using wavelet analysis to detect inhomogeneities in conventionally adjusted daily climate series. Here we further the study by adjusting inhomogeneities in daily climate series based on wavelet analysis. Highlighting examples include the well-established Central England daily mean temperature series 1772-2003 (CET) and a MASH-based homogenized daily mean temperature series 1960-2009 at Henan station in China. The inhomogeneity in CET was mainly due to the change of the calculation of daily mean temperature (from a one-station to a three-station average on 1 January 1878); that in the Henan series was due to a relocation (with a change in elevation from 1974.4m to 3500m on 1 January 1981). The Morlet wavelet analysis clearly detects the inhomogeneities in the daily temperature series, which have been 'homogenized' with conventional approaches. For CET, the multi-site average mainly diminished local daily variability (DV) rather than large-scale variability such as weather variability (WV); while for HN, the relocation to a higher mountainous site enhanced WV. The wavelet-based adjustments have no effect on trends of mean temperature, but improve the estimation of trends in climate extremes indices such as the frequencies of hot days, cold days, heat waves and cold surges.

Keywords: inhomogeneity, daily mean temperature, daily variability, weather variability, wavelet analysis, climate extremes