



Statistics of regional surface temperatures post year 1900. Long-range versus short-range dependence, and significance of warming trends.

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We explore the statistics of instrumental surface temperature records on $5^\circ \times 5^\circ$, $2^\circ \times 2^\circ$, and equal-area grids. In particular, we compute the significance of deterministic trends against two parsimonious null models; autoregressive processes of order 1, AR(1), and fractional Gaussian noises (fGn's). Both of these two null models contain a memory parameter which quantifies the temporal climate variability, with white noise nested in both classes of models. Estimates of the persistence parameters show significant positive serial correlation for most grid cells, with higher persistence over oceans compared to land areas. This shows that, in a trend detection framework, we need to take into account larger spurious trends than what follows from the frequently used white noise assumption. Tested against the fGn null hypothesis, we find that $\sim 68\%$ ($\sim 47\%$) of the time series have significant trends at the 5% (1%) significance level. If we assume an AR(1) null hypothesis instead, then the result is that $\sim 94\%$ ($\sim 88\%$) of the time series have significant trends at the 5% (1%) significance level. For both null models, the locations where we do not find significant trends are mostly the ENSO regions and the North-Atlantic. We try to discriminate between the two null models by means of likelihood-ratios. If we at each grid point choose the null model preferred by the model selection test, we find that $\sim 82\%$ ($\sim 73\%$) of the time series have significant trends at the 5% (1%). We conclude that there is emerging evidence of significant warming trends also at regional scales, although with a much lower signal-to-noise ratio compared to global mean temperatures. Another finding is that many temperature records are consistent with error models for internal variability that exhibit long-range dependence, whereas the temperature fluctuations of the tropical oceans are strongly influenced by the ENSO, and therefore seemingly more consistent with random processes with short-range dependence. Four different data products, HADCRUT4, NOAA mlost, GISS and Berkely Earth, are analyzed in this project, with similar results in all cases.