Climatological temperature records: persistence at asymptotic time-scales (EMS2008-A-00149)

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Climate Model Simulations

We consider the global coupled general circulation model ECHAM4, which consists of the atmosphere model ECHAM4 (approx. 3.75° × 3.75°, 19 vertical levels) and the ocean model ROMS (21 layers, 20 vertical levels). Coral reef average surface fluctuations of heat and freshwater is applied in order to avoid climate drift in such a long simulations.

Analysis of temperature records

We first subtract the annual cycle of each daily temperature record

\[ \Delta T = \text{temp} - \text{temp}_{\text{annual}} \]

and then applied DFA/DFA3 [1–2]. To obtain the fluctuation exponent α, we fit a power law to the fluctuation function between 2 and 200 years, as is related to the correlation exponent y = 2 − 2α (Fig. 1).

In some areas, especially in the Equatorial Pacific, almost regular biannual cycles occur, which cannot be subtracted completely. Therefore we also consider times series of biannual temperature (i.e., averaged over two years of daily data). With this normalization (aggregation) we also verify that scaling in the daily data is not due to a correlation length below two years. Figure 2 shows the results for the fluctuation exponents obtained by DFA2.

- Values of α below 0.475 (red) and above 0.425 (black) are not determined, since we are only interested in stationary long-term correlated data (0 < α < 0.5).
- Values of α between 0.475 and 0.525 indicate white noise behavior in appear in violin, while values in α between 0.975 and 0.925 indicate 1/f noise in red.

In Fig. 2, we find large violet and white areas where α ≤ 0.5 close to the Equator, and red and black areas where α ≥ 1.0 close to the Antarctica or Greenland. These findings will be discussed separately below.

Reconstructed NH temperatures

Figure 5 presents results of six reconstructions of Northern Hemisphere (NH) temperature [10].

Discussion

We would not verify the claim that the long-term correlations vanish in the middle of the continental US that the strength of these correlations increase from the Polar to the Equator (our outcome indicate the opposite). The exponents obtained for continental sites from the historical data are rather in agreement with the values found by [9], who report α = 0.6 ... 0.7 with a maximum at 0.65, and 0.7, which was 0.61 ± 0.06, which is consistent approximately 0.69.

We have found, however, that these long-term correlations hold at least up to 200 years in the historical run, considerably extending the largest scales for instrumental records of typically 50 years. The comparison between control run and historical run shows that the exponents are essential for the long-term correlations in the temperature records. The findings are supported by the analysis of NH temperature reconstructions exhibiting long-term correlations on continental scales, such as the Moberg et al. 2005 record with α ≈ 0.86.

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References: