Fluctuations and Long-Term Memory in Climate

Research Objectives
The main objective of the proposed Mini-Project is to understand the mathematical derivation and all assumptions of the Detrended Fluctuation Analysis (DFA) method and to apply this method to data produced by global climate models and observed data (e.g. surface temperature time series from around the world).

Why is it interesting?
The DFA method is a way to investigate fluctuations in observed data and determining their statistical self-affinity. It is useful for analysing time series that appear to be long-memory processes. It is a widely used method to analyse data in such diverse areas as DNA sequences, medicine, stock markets and climate amongst others.

In climate sciences it is usually used to either present evidence for long-range dependency of observed temperature data or to compare the observed variability with the variability of coupled global climate models. The issue of long-range dependency is an important issue for the current climate change debate since it raises the interesting question if and to what amount the global climate system is itself able to produce local trends and what is due to external forcing like greenhouse gases. Furthermore, the DFA method can also be used to examine if current climate models reproduce the observed climate variability.

In this mini-project we would like to investigate how well the assumptions for deriving the DFA method are valid for the climate system. This mini-project would involve both theoretical work and data analysis.

Background to be assimilated
Literature on DFA and basic Climate Theory.

Suggested Literature:
- Peng, C.-K., S. V. Buldyrev, S. Havlin, M. Simons, H. E. Stanley and A. L. Goldberger, 1994: Mosaic organization of DNA nucleotides. Phys. Rev. E. 49, 1685-1689.
- Rybski, D., A. Bunde and H. von Storch, 2008: Long-term memory in 1000-year simulated temperature records. J. Geophys. Res., 113, D02106, doi:10.1029/2007JD008568

Techniques Required
Basic knowledge of Applied Mathematical methods, Brownian Motion Theory, Random Walk Theory, Time Series Analysis from your Msc courses.

Prospective Deliverables
- Careful derivation of the DFA with special emphasis on all assumption made in the derivation in order to check their suitability for climate data sets. Comparison of DFA method with wavelet based method.
- Investigation of the impact of periodic signals in time series on DFA. A major periodic signal is the annual cycle.
- Analysis of various data sets already available at British Antarctic Survey with DFA.

Relation to end/downstream users
The Natural Complexity Group at the British Antarctic Survey is working on related issues for various observed data sets.

Prospects for this mini-project leading into a PhD project
This area is one of the areas who the BAS co-supervisor Dr. Nick Watkins is considering for a possible PhD topic.