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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Long-memory processes in global ozone and temperature variations" *by* C. Varotsos and D. Kirk-Davidoff

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1. Introduction

The authors describe the Detrended Fluctuation Analysis (DFA), introduced by Peng et al. (1994), and apply it to data sets of global column ozone (TOZ) and tropospheric brightness temperature (TBT).

2. Choice of the data sets

It is unfortunate that, for the comparison of results, the authors chose two data sets that differ in the quantity measured (ozone <-> temperature) and the location (mainly stratosphere <-> troposphere).

Half of the results have already been published elsewhere (Fig. 2 is identical to Figs. 2 and 3 of Varotsos, 2005).

3. Choice of the method

3.1. Does DFA work properly?

Strictly speaking, the application of DFA is only justified for self-similar processes, which do not have a preferred time scale. The latter assumption is very likely violated for the data analysed, because a significant fraction of the TOZ variability originates from processes with a clearly defined time scale like the Quasi-Biennial Oscillation (QBO), El Niño / Southern Oscillattion (ENSO), and the 11-year solar cycle (e.g., Steinbrecht at al., 2003). As an oscillation, superimposed on the data, distorts the linear relation in the log-log plot of the DFA (Hu et al., 2001), it is very probable that the occurrence of several oscillations in the atmosphere causes problems for DFA. It should be discussed whether one of the following effects prevails in the analyses presented: a) Is DFA so insensitive that it is not influenced by oscillations that contribute a significant fraction to the TOZ variability? b) Can the combined effect of several oscillations produce an effect that is (falsely) interpreted as long-range memory by DFA?

The argumentation of the authors with respect to oscillations is not clear: "Column ozone fluctuations in tropics are more closely tied to the QBO and ENSO (Camp et al., 2003), and so would be expected to exhibit some persistence at time scales of more than two years." (p. 4334, l.20) <=> "... tropics... The long-range correlations obtained do not signify the presence of cycles with definite periodicities (i.e. as described in Camp et al., 2003)." (p. 4330, l. 27)

3.2. Why have more direct methods been discarded as supporting tools?

DFA is related to the power spectrum and to the auto-covariance function of the process under investigation. The authors reject the more straight-forward calculation of the auto-correlation function or the power spectrum "due to noise superimposed on the data" (p. 4326, l. 21; p. 4330, l. 16). On the other hand, they calculated the correlation function of TOZ (at least over the tropics) and concluded that it decays more slowly than any exponential function (p. 4330, l.13). Unfortunately, the corresponding results

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are neither shown, nor discussed in more detail.

4. Reliability of the results

4.1. Really long-range memory?

As indicated by H. Rust in his comment (12.06.2006), some of the results of the manuscript do not prove the existence of long-range memory for the analysed data, because a seemingly identical plot (to Figs. 2a, 2c) may be obtained from an AR(1) process, i.e. from a short-memory process. This illustrates that a visual inspection of a log-log plot of the highly derived quantity F(n) is not sufficient for distinguishing between long- and short-memory processes for data sets of the length investigated here. For a more detailed treatment of the difficulties associated with DFA see Maraun et al. (2004).

The value alpha $>$ 1 in Fig. 2b deserves a more detailed investigation. Beran (1994, p. 53) concluded that the self-similarity parameter H of a self-similar process with finite second moments satisfies 0 $<$ H $<$ 1. Which of the assumptions (self-similarity, finite second moments) might be violated for the data in Fig. 2b?

The slope of approximately 0.5 in the upper part of Fig. 3b strongly suggests the absence of long-range memory in the underlying data.

4.2. Treatment of short time scales

The authors try to analyse the alleged power-law decay of the auto-correlation function also for time lags shorter than 2 years (p. 4331, l. 7, l. 12). For comparable time scales, the detailed analysis of the auto-correlation function of TOZ by Fioletov and Shepherd (2003), Fig. 2, reveals a rather complicated structure. The authors should clarify why they assume that the assumption of a power-law decay is nevertheless meaningful.

The relation between the alpha from DFA and the exponent gamma of a power-law decay of the correlation function is only true asymptotically. It is not possible to convert a value of alpha calculated for a certain (finite) time interval [t_1, t_2] into an expo-

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nent gamma on the same time interval (Maraun et al., 2004, Section 7.3). This is also reflected by the fact that DFA systematically overestimates crossover points (e.g., approximately by a factor of 2 for the artificially generated examples of Kantelhardt et al., 2001, Fig. 5).

4.3 Error estimation

The authors do not state how they calculated the error bars of their results. As the values F(n) are statistically dependent by construction, it is not appropriate to use the error bars that a standard linear regression code (assuming independent errors) would calculate for alpha. More sophisticated methods are needed (cf. Weron, 2002).

How representative are the data analysed? For instance, Blender and Fraedrich (2003) tackled a similar question by segmentation of the time series (a spatial segmentation might also be considered here).

5. Interpretation of the results

The speculation on possible mechanisms behind the observed features is very vague. It is not clear why the authors assume that there is relatively low persistence in temperature gradients (associated with the position of the jet stream) compared to the persistence of temperature itself. Earlier findings of other authors concerning the ocean as the origin of memory (e.g., Fraedrich and Blender, 2003) are ignored.

6. Relevance of the results

It should be substantiated in more detail why the results of the manuscript "could improve predictions of global warming and future column ozone depletion (or recovery)" (p. 4334, l.29). It should be kept in mind that the investigation of long-range memory corresponds to the determination of the rate of convergence (towards zero) of the autocorrelation function. It does not specify the correlations for any fixed time lag; in fact, each individual correlation can be arbitrarily small (Beran, 1994, p. 43).

Furthermore, it seems unlikely that the comparison of just one number (the scaling ex-

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ponent alpha) between observations and models is helpful in pointing the way towards an improvement of the models. More detailed comparisons between the variability of TOZ in measurements and models are already available (e.g., Steinbrecht et al., 2006).

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