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Interactive Comment

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

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Reply to Reviewer 2

Regarding paragraph 2 (Choice of the data sets) of the reviewer's comments

We chose these two data sets in order to explore the memory effects in two crucial environmental problems, notably the ozone depletion and the global warming.

In the text of the online version of our paper we cited our announcement to the ICCS 2005 (Symposium held in Atlanta, 2005) regarding the memory effects in total ozone (Varotsos, 2005). In the Fig.2 of the revised version we will also add this citation.

Regarding paragraph 3 of the reviewer's comments

3.1 DFA is a method that not only applies to processes that have no preferred time scale, but as discussed in our reply to H. Rust, it can also identify the presence of short range time correlations which are viewed as transition time scales (see Hu et al. 2001, Varotsos 2002, 2003a, 2003b). We note that the data treated here are deseasonalized data and much of the influence of QBO and ENSO is removed. We agree that "an oscillation superimposed on the data, distorts the linear relation in the log-log plot of the DFA (Hu et al.2001)", but the resulting behavior is opposite to that observed in our data. If there were an influence from periodic oscillations, the slope of the DFA fluctuation measure should increase with increasing time scale rather than decreasing (see Fig.6 of Hu et al., 2001) below the period of the trend; for time scales just larger than this period, the slope should abruptly become zero. Thus, when comparing Fig.6 of Hu et al. 2001 with our Fig.2(a), for example, we see that the presence of the influence from periodic oscillations should be excluded.

3.2 The power spectrum and the auto-covariance are useful quantities when examining stationary time series. However, DFA was built to treat nonstationary signals also (e.g., Peng et al., 1994). For the reader's convenience we provide here http://www.uoa.gr/~nsarlis/Reply_to_Reviewer(2)Autocorrelation.htm the autocorrelation function

Regarding paragraph 4 of the reviewer's comments

4.1 In our reply to the comment by H. Rust we have shown that any AR1 processes violates the statistics of our data. On the use of DFA for the small data lengths investigated here, we refer to the study of Audit et al. (2002), which showed that DFA is the best estimator for the scaling properties. As concerns the question on why α can exceed unity, we refer to the well known example[e.g. see Varotsos et al. PRE 73 031114 (2006) and references therein] of fractional Gaussian noise (fGn) and fractional Brownian motion (fBm) . An fBm of a given $H(0 < H < 1)$ is non-stationary and exhibits a DFA slope (see 3.2 above) $\alpha = 1 + H$, while an fGn (i.e., the time-series of the increments of an fBm) is stationary and exhibits a DFA slope $\alpha = H$. Concerning the last point in 4.1 related to the upper part of our Figure 3(d), we agree that our analysis shows no long term memory in this time range. As we wrote on page 4333: "whilst for time scales from about 2 to 7 years (e.g. El Nino-Southern Oscillation) [the temperature fluctuations] obey a random walk ($\alpha_2 = 0.50 \pm 0.04$)"

4.2 The relation between the autocorrelation function, the power spectrum and DFA has been the subject of the detailed study of Talkner and Weber (2000). The change of the slope of the DFA in the small scales can be a result of a change of the power law exponent of the power spectrum as in the models presented by Talkner and Weber (2000)). There one can see that the relation between 945; and the power law exponent of the power spectrum is not only asymptotically (see Fig.3 and Eq.(3.15) of Talkner and Weber (2000)). Indeed, for a piecewise power law behavior of the power spectrum, the slope of the DFA conforms with the corresponding power-law in each region. The autocorrelation function on the other hand suffers from oscillations which mask the presence of the intermediate scaling region (see Fig.3 of Talkner and Weber (2000)). This is the reason why we preferred DFA to other conventional methods (see also 3.2 above). The asymptotic behavior results only in the case where distinct time scales are present, as in the case of Markovian RTS (Varotsos et al. 2002, 2003a, 2003b) or in the case of AR(1) (see our reply to H. Rust). Even in such a case, however, the DFA slope changes continuously (see our reply to H. Rust).

Regarding paragraphs 5 and 6 of the reviewer's comments

We have removed in the revised version speculative elements of our discussion, and inserted a more specific, limit argument that DFA analysis of model and observed time series provides a help tool for visualizing errors in the treatment of long-range correlations, whose correct modeling would greatly enhance confidence in long-term climate and atmospheric chemistry modeling.

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