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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Past and future simulations of NO_2 from a coupled chemistry-climate model in comparison with observations" *by* H. Struthers et al.

H. Struthers et al.

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We thank the reviewer for their effort in reviewing this manuscript and appreciate the insights they provide.

In regards to the three major points stated:

1) It is difficult to determine exactly the difference between the NO2 fields generated self consistently in the UMETRAC model and the column model. Extracting NO2 amounts directly from the UMETRAC model at a given location is possible but it is not possible to remove transport effects when tracking the diurnal changes. Thus it is somewhat problematic comparing directly the UMETRAC NO2 and the column model NO2.

At 30km the net radiative heating rate varies from approximately +2K per day to -2K per day (eg see Brasseur and Solomon "Aeronomy of the Middle Atmosphere"). We tested the sensitivity of NO2 vertical columns calculated in the column model (Lauder) to uniform temperature changes of +/-2K. The NO2 column changes by up to 1.9% (over the 4K temperature range) with the sensitivity varying during the day (greatest just prior to sunrise and during the local afternoon). This is an indicative number and will vary with latitude and season but suggests that the fact that the column model does not use self consistent temperatures will not have a great effect on the resulting NO2 columns.

The affects of a diurnal temperature cycle on the model NO2 results used in this study are expected to be small and systematic and are not expected to vary significantly over the 40 year period of the model simulation (because the diurnal temperature cycle is not expected to systematically change over this time period). Thus the derived trends will not be significantly affected by the use of a daily mean temperature in the column model. It is more likely that the absolute values of the slant columns will be more strongly influenced by this effect.

2) You are correct in saying that the trend model used to analyse the observations included a basis function for the observed QBO whereas the analysis of the model results did not include a basis for the model generated QBO. This could have been made more clear in the original text. At the time of writing we only had the UMETRAC family concentrations and temperatures available and thus could not generate a model QBO basis function for the regression analysis.

We do not expect the QBO to strongly affect the results from the trend analysis. There will be approximately 10 QBO cycles in the 20 year data records we analyse and there is no indication of a change in the strength of the QBO over this time period (1980-2020), thus the largest effect of including the QBO basis is expected to be on the uncertainty estimate of the trends rather than the trend values themselves.

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Interactive Comment

We test this by removing the QBO basis from the analysis of the NO2 observations at Lauder.

am 6.5 +/- 2.3 % per decade (including QBO basis function) 6.4 +/- 2.7 % per decade (no QBO basis)

pm 6.0 +/- 1.8 % per decade (including QBO basis) 6.0 +/- 2.0 % per decade (no QBO basis)

The full UMETRAC data set has recently been made available to us so we can now generate a model QBO proxy which we are in the process of doing. When the model QBO basis is available, we intend to reanalyse the model data including the QBO term which will be more consistent with the analysis of the observations.

3) Although the underlying model used for the trend analysis of the Lauder and Arrival Heights time-series is same, it is applied in quite different ways for the two sites. Our original intention was to use the same approach for Lauder and Arrival Heights but it quickly became evident that, because of the nature of the Arrival Heights measurements (discontinuities over the winter and summer and the distinct meteorological regimes present during spring and autumn), applying the Lauder trend model to the Arrival Heights data would not produce satisfactory results.

The temperature basis was introduced because stratospheric temperatures have been identified as being correlated with NO2 columns over Arrival Heights, particularly in springtime. The problem in determining the NO2 trends at Arrival Heights, both observations and model, is the time-series contain significant noise that could not be correlated with the standard basis terms from the Lauder trend model. This leads to large uncertainties in the derived trends. Modest improvements in the uncertainties was found when the temperature basis was introduced.

Interactive comment on Atmos. Chem. Phys. Discuss., 4, 4545, 2004.