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Interactive Comment

Interactive comment on "Attribution of observed changes in stratospheric ozone and temperature" *by* N. P. Gillett et al.

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Response to Referee 1

Thanks to the referee for the positive and helpful comments. We respond to all the points raised below.

Since we wrote the ACPD manuscript, a new SCN-B2b simulation of UMUKCA-UCAM has become available. We therefore now include the REF-B1, REF-B2 and SCN-B2b simulations from UMUKCA-UCAM in our analysis. An SCN-B2c simulation of LMDZrepro has also now become available, so we also include this simulation in our analysis. Inclusion of the additional simulations from UMUKCA-UCAM has had only small effects on most of our results, with the exception of the detection analysis applied to total ozone trends, for which we now find no inconsistency between the simulated and observed response to greenhouse gas changes. We have revised the text accordingly.

1) While the authors have extensive experience in the statistical methodology of detection and attribution, this may be less well-known to the stratospheric focus group of this paper. I recommend that the authors include a brief but explicit explanation of the details for less experienced readers (for example, state that regression coefficients from Eq. 1 equal to 1.0 provide the relevant attribution tests). Can you briefly explain the 40 EOF truncation?

We have now added some text on the interpretation of the regression coefficients, including a reference to the chapter of the 2001 IPCC Third Assessment Report:

A regression coefficient which is significantly greater than zero indicates a detectable response to the forcing concerned: The projection of the observations onto the simulated response to this forcing is inconsistent with simulated internal variability. A regression coefficient consistent with one indicates simulated and observed responses to the forcing concerned of a consistent magnitude. The attribution of an observed change to a given combination of forcings requires a demonstration both that the observed change is inconsistent with internal variability, and that it is consistent with the simulated response to the given set of forcings, where all plausible alternative explanations for the change have been ruled out (Mitchell et al., 2001).

We have also added some text on the 40 EOF truncation:

The choice of EOF truncation is somewhat arbitrary: The number of EOFs needs to be high enough to represent the main features of the simulated response patterns, but not too high since simulated variability in the highest order EOFs is often underestimated (Allen and Tett, 1999). The results presented here were not sensitive to moderate variations in the EOF truncation, except where noted in the text.

We already include an explicit description of the regression method underlying the

ACPD
10, C9019–C9022, 2010

detection and attribution methodology.

2) I have other questions on data analysis details. Why are 3-year mean anomalies used in the statistical analysis? What is the sensitivity to other averages (2-year, 4-year, etc.). What are the details of the trend calculations? Are simple linear fits used, or is some sort of multivariate regression? What are the units of the trends in the various figures (stated as DU or K, but trends should include a unit of inverse time). How do you interpret the small natural cooling trends in Fig. 3b (perhaps linked to the El Chichon volcanic eruption in the early part of the record, and hence somewhat of an artificial trend?)

Temporal filtering was applied because filtering reduces the number of elements of the observation vector **y** and makes it easier to estimate EOFs from a limited number of realizations of internal variability. Assuming that the forced response does not strongly project on the high frequencies which are filtered, this makes it easier to detect the response to external forcings. 3 years was chosen because 3 is factor of 27 (the number of years used), yet it is short enough to still allow the response to volcanoes to be represented. In response to this comment, we repeated the attribution analysis of total ozone and MSU temperatures using 2-yr and 4-yr anomalies. As with the 3-yr anomalies, in both variables and for both 2-yr and 4-yr anomalies, the ODS and NAT responses were detectable, with the exception of the ODS response in stratospheric temperature using 4-yr means. The regression coefficients using 2-yr anomalies were similar to those derived using 3-yr anomalies, while the regression coefficients derived using 4-yr anomalies differed somewhat. This may because the volcanic component of the natural response is harder to constrain using 4-yr means. In the caption to Figure 3, we now state that similar results were obtained using 2-yr means.

We display linear least-squares trends throughout. We already stated that the trends were least squares in the caption to figure 1, but we have now inserted 'linear' before this, and we now state that trends are 'linear least-squares trends' in the captions to figures 4 and 7 as well.

ACPD

10, C9019–C9022, 2010

The units of all the trends we show in Figure 1 are DU/27 yr and K/27 yr for total ozone and temperature respectively. We think that the units of the ozone trends are already clear from our description 'DU over the 27-period 1979-2005'. We have now changed the text to clarify that the temperature units are similarly 'K over the 27-yr period 1979-2005'. We have added the units dDu/27 yr and K/27 yr to the caption to Figure 3b. The units of the trends shown in figures 4 and 7 are already described in the captions.

We agree that the cooling trend due to natural forcings is very likely due to the stratospheric warming caused by El Chichón in the first half of the record, while there were no eruptions in the latter half of the record. Figure 1c, showing the temperature timeseries, illustrates that this is likely the case. This mechanism is physically plausible, and the simulated and observed responses are consistent in magnitude, so we don't consider that this trend is artificial. Solar forcing is unlikely to have been a large contributor because the period considered began just before a solar maximum and ended shortly after one, so the trend in solar forcing over the period considered is small. In the text we now state:

The small NAT cooling is likely due to the fact that El Chichón warmed the stratosphere in the first half of the record, while there were no volcanic eruptions in the second half of the record, resulting in a cooling trend due to natural forcing (Fig. 1c). The warming due to Pinatubo occurred close to the centre of the record, therefore it had little effect on the 1979-2005 trend (Fig. 1c).

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 17341, 2010.