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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Nitrous oxide emissions 1999–2009 from a global atmospheric inversion" *by* R. L. Thompson et al.

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We thank Dr. M. Krol for his thoughtful and constructive review.

Comment concerning Section 3.1:

Our test of adjusting the fluxes in tropical South America was simply to see whether or not such a change would be detectable by the current observation network, which is quite sparse in the tropics. As Fig. 3 shows, such a change would be detected at the key tropical sites of Samoa and Ascension. On the other hand, while we agree with the statement: "0.3 ppb perturbations in the concentration do not necessarily drive tropical flux adjustments" this was not what we were testing for. Furthermore, while the error reduction (Fig. 4 and Table 5) gives an indication of the observational constraint, it is

also sensitive to the assigned prior flux uncertainties and the correlation between these as well as to the observation uncertainty. Therefore, the error reduction is not as clear an indication for the sensitivity of the observation network to changes in the tropical fluxes. For these reasons, we prefer to leave in this sensitivity test and Fig. 3.

Comment concerning stratosphere-troposphere exchange:

It is correct that the error due to the inaccurate modelling of stratosphere-troposphere transport is not a random error. We have found that there is a considerable phase-shift between the LMDZ4 modelled and observed seasonal cycle of N2O in the SH mid and high latitudes (namely at CGO and SPO), which leads to a maximum difference between the model and observations of about 1 ppb in the months of April – May and October – November (opposite directions). This result will be submitted very soon in a paper on the TransCom inter-comparison for N2O. The comparisons of the seasonal cycle in N2O (and CFC-12) at other sites do not show any significant phase shifts or amplitude differences, therefore, we are confident that the modelled stratosphere-troposphere transport is reasonable in the tropics and northern mid to high latitudes. Also, stratosphere-troposphere exchange is not symmetric between the hemispheres. In the NH, it has been shown to be very seasonally dependent (e.g. Schoeberl et al. 2004) while it is less so in the SH. There is also a strong influence of polar vortex in the SH on the seasonal cycle of N2O in the SH, which also leads to the model-observation mismatch in the SH. For these reasons, we decided to increase the error in the observational error for the SH mid to high latitudes. The impact of the transport errors in LMDZ4, would be significant in monthly fluxes, however, since we only present the annual mean fluxes, this is less important.

Comment concerning the posterior error estimate:

It is correct that the posterior error is estimated only for 1 year and it is assumed that this error is representative for all years. The posterior error is mostly dependent on the observational constraint. For the inversion, IAVR, the observational constraint is

very similar in all years (i.e. same number of sites and approximately same frequency of measurements), therefore, we expect that this error estimate is fairly representative for all years in this inversion. There may be small differences from year-to-year owing to inter-annual variations in the atmospheric circulation, e.g. related to ENSO. However we expect that the influence of this on the posterior error to be small compared to the overall error. For the inversion IAVA, there are larger differences in the number of observations for each year compared to IAVR, however, we chose to calculate the posterior error for 2003, which we consider to be a fairly representative year in terms of the observations available. Owing to the large computational requirements for performing variational inversions, it is not yet possible to perform a Monte Carlo analysis for every year within reasonable wall clock time, but we expect interannual variations in the posterior errors to be well within the uncertainty of the posterior errors themselves.

P15710: To account for the modelled transport errors in the SH mid to high latitudes we made two adjustments: 1) we increased the observation error by 1 ppb for SH mid to high latitudes sites where the 1 ppb was determined based on the comparisons of the modelled and observed seasonal cycles for these latitudes, and 2) we reduced the prior flux uncertainty for the SH land regions by 1/3rd in order reduce the degrees of freedom for these regions. The factor of 1/3rd was chosen after running a number of test inversions. We found with larger prior uncertainty estimates that the monthly fluxes for southern South America varied strongly in order to compensate for the model-observation mismatch in the seasonal cycle and a reduction of the prior uncertainty by about 1/3rd meant that these spurious monthly fluxes no longer occurred.

Figure 5. We have added a figure (Fig. 5b) as suggested showing the standard deviation of the annual mean fluxes, thereby indicating which regions have the strongest inter-annual variations.

The minor corrections have also been made.

References:

Schoeberl, M. R.: Extratropical stratosphere-troposphere mass exchange. J. Geophys. Res. -Atmos., 109, (D13), 10.1029/2004jd004525, 2004.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 15697, 2013.