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Interactive Comment

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. C. Nevison for her thoughtful and constructive review.

Comment concerning role of transport for inter-annual variability in N2O mole fractions:

It is certainly true that inter-annual variability in transport influences the inter-annual variability in the growth rate of a number of atmospheric tracers (this has been shown previously for Samoa as the C. Nevions states). Our atmospheric transport model, LMDZ4, is nudged to ECMWF (ERA40) wind fields and thus reproduces inter-annual variations in transport. Although all atmospheric transport models have errors, they are able to represent large-scale circulations to a reasonable degree of accuracy. The influence of ENSO on transport is taken into account in our inversion and, therefore, the optimized fluxes are those that best match the observations having accounted for the influence of transport. Furthermore, the magnitude of the inter-annual variability in the global N2O flux from our inversion is of the same order as that in the prior.

Concerning ORCHIDEE estimates of soil emissions:

In ORCHIDEE O-CN the contributions (given for the year 2000) are 3.8 TgN/y for agriculture and 6.8 TgN/y for natural soils. This is close to the AR4 estimates for agriculture of 2.8 TgN/y and for natural soils of 6.6 TgN/y, which are the means for 1990s. O-CN also calculates the indirect emissions, including those from N-deposition. Further details about O-CN can be found in the online supplementary material in Zaehle et al. 2011. We have now included the separation into agricultural and natural emissions in Table 3.

Concerning Section 2.4:

The data were adjusted to the NOAA2006A scale by applying a scalar and an offset. Table 2 shows the mean offset as well as the regression coefficient calculated from a linear regression of the given network/station against NOAA where the parallel measurements were available.

Concerning Section 2.6 & 3.1:

The motivation for this sensitivity test was to see if a hypothetical change in the fluxes in the tropics, specifically in tropical South America as this tropical region has an important contribution to the global N2O emission, would be detectable by the current observation network. It was thus only a test for capability of the network to detect such a change if it were to exist. In these tests (as in the inversions), LMDZ4 was nudged to ECMWF ERA40 meteorological analysis data and, therefore, LMDZ4 reproduces inter-annual variability in transport. The years that we looked in the sensitivity tests, i.e. 1998 and 1999 were El Nino and La Nina years, respectively. Fig. 3 shows the difference between the run in which the flux over South America was perturbed and the run with-

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out flux perturbation (using the same meteorology for both runs and only changing the fluxes). This shows that even with the transport effect of ENSO, the observation network still was sensitive to this hypothetical change in flux. Concerning the Multivariate ENSO Index (MEI), this is based on 6 variables: sea-level pressure, zonal and meridional components of the surface wind, sea surface temperature, surface air temperature, and total cloudiness fraction of the sky (http://www.esrl.noaa.gov/psd/enso/mei/). Regarding the correlation of growth rate variability and tradewinds (Fig. R2), while indeed changes in the tradewinds likely influence the observed mixing ratios at sites in the tropics (here Samoa), it must be remembered that a correlation does not necessarily indicate a direct cause and effect. Rather this correlation could also be because of the correlation of the tradewinds with ENSO, which has well known and strong effects on precipitation in the subtropics, especially in South America, which is upwind of Samoa.

Concerning Figure 1:

There was an error in the plot, which put a “dot” at 0°E, 0°N and we apologize for this mistake. This has now been corrected.

Concerning distinguishing the tropical land/ocean sources:

The best measure of well the inversion can distinguish the ocean versus land as well as different continents in the tropics, is the error reduction. The error reduction is sensitive to the observational constraint (i.e. the number and uncertainty of the observations) and strongly reflects the observation network “footprint” (see Fig. 4). The error reductions for each region is given in Table 5, for the ocean region 20S – 20N and South America there is a modest error reduction of 21% and 17%, respectively. For Africa, the error reduction is quite considerable, 43%. Therefore, the distribution of the fluxes between the ocean and land and between South America and Africa is more certain a posteriori than it was a priori.

Concerning Figure 10 and the flux anomalies in South America and Africa:

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Fig. 10 shows the anomaly in the N_2O flux integrated over the region (it is not per unit area), therefore, the size of the anomalies also reflect the extent of the region. There are also other factors that determine the N_2O flux response to climate variability (i.e. precipitation, soil moisture and temperature) such as the soil type and ecosystem productivity.

Concerning p. 15719, lines 10-14:

The value of 0.21 TgN/y is from Werner et al. (2007) and is the estimated change in N_2O emissions from African rainforests between 1993 and 1994. The standard deviation of emissions from our inversion over all years for Africa (i.e. all ecosystem types) is 0.30 TgN/y, which is comparable. For South and Tropical America the maximum year-to-year difference is 0.6 TgN (i.e. 20% of the total regional emission) and the standard deviation is 0.26 TgN. The standard deviation is close for both regions.

Concerning p. 15714:

From the inversion, we cannot discriminate between natural and agricultural sources of N_2O, therefore, any discussion of which of these two sources is underestimated is only based on auxiliary information. We know that N-fertilizer input in O-CN (used to calculate the soil emissions in the prior) is underestimated for years 2006-2009 and that the manure input is unconstrained by data and may be also underestimated. Therefore, it is probable that the agricultural N_2O source for tropical Africa is underestimated in the prior. However, it is also possible that the natural source is underestimated. Natural input of N via NO_y deposition is an important source of reactive for tropical regions, in particular for tropical Africa, and may also contribute to an underestimate of the natural N_2O source. However, there are also other reasons why O-CN underestimates the source of N_2O (natural or agricultural) e.g. due to errors in soil moisture. We have expanded this paragraph to include these other potential sources of error in the prior estimate.

References:

Zaehle et al.: Carbon benefits of anthropogenic reactive nitrogen offset by nitrous oxide emissions, Nature Geosci, 4 (9), 601-605, 2011.

Werner et al.: A global inventory of N2O emissions from tropical rainforest soils using a detailed biogeochemical model. Global Biogeochem. Cycles, 21, (3), doi: 10.1029/2006gb002909, 2007

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