Reply to Anonymous Referee #1 (Received and published: 16 April 2012)

The paper describes comparisons between TCCON measurements and corresponding tracer transport simulations for CO2, CH4 and N2O using the ACTM model. The combination of multiple species is suitable for attribution of model-data mismatches to uncertainty in transport vs. surface-atmosphere fluxes. I regard this manuscript as a useful contribution, and recommend publication after a few minor revisions.
Thank you very much for providing critical and useful comments and suggestions.

*********General comments:**********

The basic question when assessing a models performance is "how good is good enough?", so I think a more quantitative assessment needs to be based on what inverse models are required to provide based on the atmospheric observations. So one should start with the requirements for inverse modelling of CO2 and CH4 (may be also N2O) to provide surface-atmosphere fluxes at a specific spatiotemporal resolution with a targeted uncertainty, and relate these to the required model-data mismatch.
The goodness of model-observation agreement is generally measured using data variability at a particular site. Say, if the synoptic scale variability is 2 ppm for CO_2, then model-data differences less than 2 ppm is considered good or in other words the model and observed concentrations are less distinct. This has been the traditional approach for the inverse modeling community while assigning covariance to the observed concentrations.

In the revised version we will include 1σ standard deviations (RSD) for the measured variability at each sites (residuals shown in black in Fig. S8-S10) in Table 1. If the b or d are greater than the RSDs, the model simulations can be considered poor and vice versa.

Regarding the N2O results: The fact that N2O column variability is dominated by the variability in the stratosphere should have stimulated the authors to take a closer look not only at effects from tropopause height variations, but also to effects from photochemistry and stratospheric circulation. As shown in Figure 6, partial columns of N2O in the stratosphere indeed show a large spatial variability. Thus errors in stratospheric circulations or in photochemistry will result in significant model-data mismatches. To differentiate these from tropopause height effects, the authors should have a look at comparisons between simulated tropopause heights in ACTM with those derived from radiosondes.
The N_2O simulations by ACTM have been compared with Microwave Limb Sounder measurement in the stratosphere (Ishijima et al., 2010), and CONTRAIL (Ishijima et al., 2010) or CARIBIC (Patra et al., ACP, 2011) measurements in the upper troposphere and lower stratosphere. These provided check on reasons for realistic N_2O simulations by ACTM. Since we nudge the AGCM simulated winds and temperature with reanalysis products, the location of tropopause in ACTM is as good as those produced in the reanalysis. Additional the Brewer-Dobson circulation and N_2O (or CH_4) loss rates calculation in the stratosphere involves approximations on photolysis rate, O^1D (or other radicals). However, all these model properties in ACM have been checked to consistent with our common understanding of the dynamics and chemistry in the altitude range of the earth's surface to stratosphere (Patra et al., 2009,

www.atmos-chem-phys.net/9/1209/2009/; Ishijima et al., JGR, 2010; Patra et al., 2011, www.atmos-chem-phys.net/11/12813/2011/).

**********Specific comments:**********

1. P 5683 L19: What was the spin-up period for the simulated tracer fields? This should be specified.
The simulations were started in 01 January 1980. This sentence has been added.

2. P 5683 L25: Using a single year for fluxes at monthly resolution for a four-year transport simulation is likely to introduce errors (diurnal cycle, interannual variations), those should be discussed.
We have added this text here:
Exclusion of diurnal, synoptic and interannual flux variations in these simulations are likely to introduce some errors in simulations species concentrations. However, as seen from this study, these errors do not affect our analysis of latitudinal and temporal variations significantly..

3. P5685 L2: It should be mentioned whether the dry air column abundance is taken from the model or from the observations.
We have used model dry air column abundance. The sentence is modified as "The tracer total column abundance is then divided by the corresponding ACTM dry air column abundance"

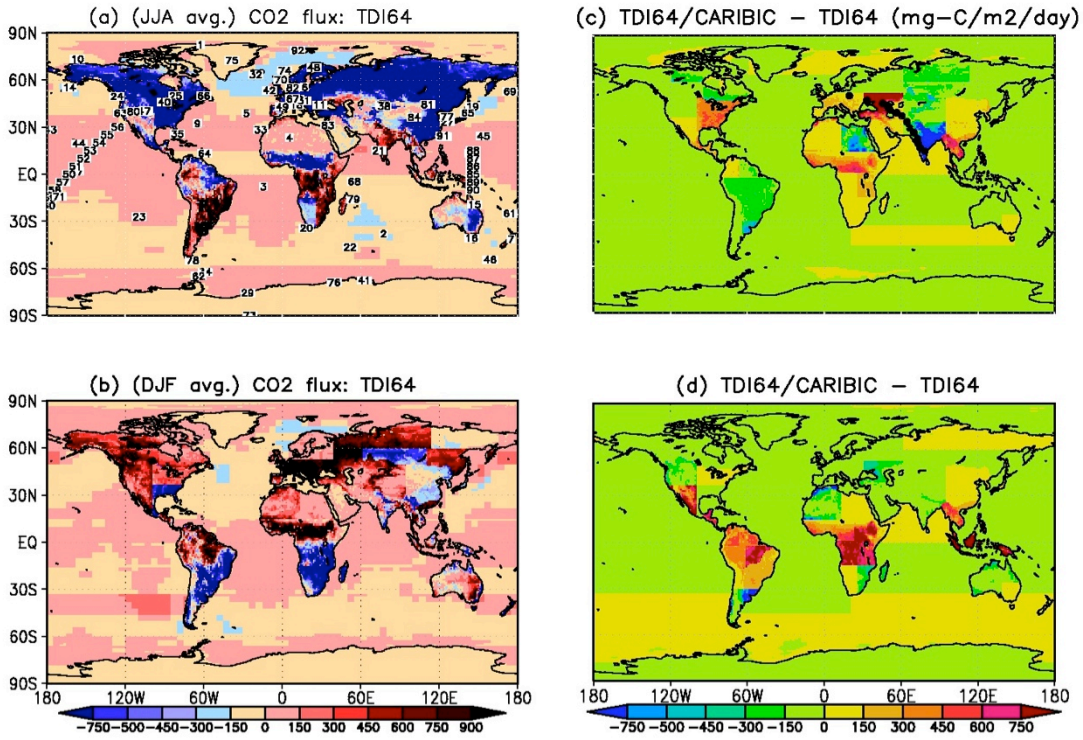
4. P5685 L5: some explanation on the potential origin of the offsets for N2O and CH4 would be appropriate
Since we used bottom-up fluxes, which fail to simulate the recent increase in CH_4 concentrations in 2007, and similarly for N_2O slight imbalance in emission and loss rates give such an offsets.
Added this sentence "Imbalance in surface emissions and loss rates over the time of simulations lead to these offsets in CH_4 and N_2O values."

5. P5685 L15: Why does the integral over dp not include the water vapour pressure? It is unclear to me how this can result in dry air partial columns.
Calculations for both the total and partial columns include a component of the water vapor pressure profile, following Eq. (6) in Wunch et al., 2010. The integral over dp is just simplified by a general definition for a total column.

6. P5685 L17-L19, table 1: According to the definition of the bias b and the RMS difference d, d should always be larger than the absolute value of b. However, table 1 shows several sites where this is not the case. Is it possible that the authors used the standard deviation of the difference rather than the RMS difference?
Thank you very much. As you say, the values in the table 1 and Fig. 5 were not RMS but standard deviation of the difference. We replace the text "RMS" with standard deviation.

7. P5690 L13: As the CASA model is used for a priori fluxes of the inversions, it is not sufficient to say that the coarseness of the flux regions is to blame. In addition the CASA model does not seem to capture those variations at the regional scale. The same also applies to the discussion of the seasonal cycle phase at BIK and ORL. This

should be discussed a bit more in detail.
We agree that CASA fluxes have sufficient spatial resolution for the ACTM runs at horizontal resolution of T42 spectral truncations. However, our inverse model has only 64 regions (section 2, para 2). As you can see from the plot below, the locations of Lamont and Park Falls are poorly separated by the inverse model resolution (seen as sharp changes in fluxes at the region boundaries).



Modified from Patra et al. (2011; www.atmos-chem-phys.net/11/13359/2011/)
Figure (2) Three-monthly mean flux distribution maps for June-July-August (JJA; top row) and December-January-February (DJF; bottom row) 2008, prepared by distributing 64 region fluxes on to 1×1 latitude-longitude grids for TDI64 inversion using GLOBALVIEW-CO2 and ACTM forward transport (left column; (a) and (b), respectively). The right column panels (c and d) show differences in estimated fluxes by including CARIBIC data additionally in inversion (TDI64/CARIBIC).

Technical comments:
P5684 L24: replace "Rogers" by "Rodgers"
P5684 L28: ad subscript j to x_a
These corrections are made.

P5685 L13: the "x" in the integral should be capitalized
We intended for x to be lowercase, presenting the concentration at a particular model level

Figure 3, caption: symbol colours in figure do not agree with those in the caption
Supplement, Figure S4: The caption reads "Figure 4" instead of "Figure S4"
These corrections are made.