**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "Carbon monoxide (CO) and ethane (C$_2$H$_6$) trends from ground-based solar FTIR measurements at six European stations, comparison and sensitivity analysis with the EMEP model" *by* J. Angelbratt et al.

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Reply to referee #2 This paper investigates trends in the tropospheric partial columns of CO and C2H6 as measured from four ground based stations in Europe. The data were recorded at all stations with high resolution Fourier Transform Spectrometers, using the sun as a light source over the period of time from 1996 to 2006. From these data trends were computed. In order to explain the observed trends, the EMP model (with both regional and global scale capabilities) was run in a series of sensitivity tests with a range of different scenarios. The regional model was shown to have reasonable skill

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in capturing some of the seasonal effects. The global scale model was employed to investigate trends, but was run only for the 2006 year, with the sensitivity scenarios increasing/deceasing source emissions from Europe, North America and Asian sectors. In doing so the authors conclude that the trend observed in CO could be explained by changes in the anthropogenic emissions. The model chemistry for C2H6 was not adequately described by the model, so no conclusions were given for this component.

The paper is an interesting and useful contribution to the literature on source attribution for CO and demonstrates that nicely the currently skill of regional models.

From this point of view the paper is suitable for publication in ACP. The grammatical errors and suggestions are detailed below under technical comments. The pages and line numbers refer to the original manuscript acp-2011-240-manuscript-version1.pdf.

Comments:

1. The authors describe the use of previous work by Angelbratt et al. to compute trends using HF as a tracer to reduce dynamical variability. Why could this method not be used to produce tropospheric partial columns by subtracting off an HF corrected stratospheric column?

Reply: HF in the trend method is ONLY used to reduce the time series variability (on short time scales i.e. day to day variability) and thereby the uncertainty of the estimated trend. In this method, HF is not related to the absolute amount of CO in the stratosphere. This is clearly stated in the trend paper by Angelbratt et al, 2011.

2. It is the assumption of the reviewer that the authors did not take into account the averaging kernel functions inherent in the FTIR measurements. By default, the model weighting functions, even with missing physics and chemistry will have "perfect" kernels. Therefore the model profiles must be smoothed by the FTIR averaging kernels, and subsequent model partial columns computed. The averaging kernel for the CO FTIR measurements is close to unity in the troposphere for the total column, but is this

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also the case for the partial column? For C2H6, a relatively weak absorber, the averaging kernel is not, but peaks around 4 to 5 km. The model should therefore be smoothed by the FTIR averaging kernels and then the comparison made. The underestimation of the C2H6 columns by the models could be due to this problem of the different ways the FTIR and models are sampling the atmosphere. It is strongly encouraged that this process be done before any effort is put into adjusting the global boundary conditions for the European EMEP model.

Reply: We believe that smoothing with model data will introduce more errors than it will improve the results. For this reason we have chosen not to carry out this procedure. The reason for this is a) The model only calculates CO up to about 15 km. If the FTIR averaging kernels are used to smooth the data than the lower stratospheric CO model data will be underestimated. The reason for this- is that the averaging kernels are 5-10 km broad and for instance the data at 13 km will hence correspond to information from 18 km down to 8 km and since the model data is zero above 15 this will result in a lowering of the data. b) Smoothing by averaging kernels decreases the precision of the measurements (even though the accuracy may be improved).

3. The partial columns errors are reported on page 5, based on the work of Zhao et al. Of these numbers, state components for the random and systematic parts.

Reply: The authors agree and column errors (systematic and random) based on Zhao et al. are added to the article.

4. The EMEP model does well for O3 in the free troposphere compared to other models; what about CO, how does it fair?

Reply: We have added text on the performance of the EMEP model for tropospheric CO, within the paragraph dealing with the HTAP comparisons. Model calculations from the global model used here have not yet been compared to other models for CO in the free troposphere. Results from an earlier Hemispheric version have been compared to an ensemble of global models within the framework of TF HTAP (http://www.htap.org/).

The EMEP results in that comparison were at the high end of the ensemble of the hemispheric CO calculations. The current model (as used in this study) has substantially lower CO in the free troposphere, and should be close to the TF HTAP ensemble. Within TF HTAP a new set of model calculations are planed for 2012. The EMEP model will take part in this model intercomparison.

5. Why were global model trends for C2H6 only shown for Harestua?

Reply: The authors do not understand the comment. Both FTIR and global model trends from the sensitivity scenarios are presented in Table 6 and 8 for Jungfraujoch, Zugspitze, Harestua and Kiruna. Model trends for Bremen and Ny-Ålesund is also presented in Table 8.

Technical Comments: Page 1 line 22, define FTIR Page 1 line 26 model acronym EMEP MSC-W not expanded until later in the manuscript. Maybe its next apparition, page 3 line 9 might be a good place. Page 2 line 12, theses -> these Page 3, line 30, "where also the contribution from biomass burning is included", -> "where the contribution from biomass burning is also included" Page 3, line 31, "line major source for CO is the natural one and that the" -> "major source for CO is natural and that the . . ." Page 4 line 10 ". . .CO accounts for significant fractions of OH loss. . ." -> ". . .CO accounts for a significant fraction of the OH loss . . ." Page 5 line 9 reference for line parameters? (hitran2004, hitran2008?) Page 5, line 11; line broadening in the spectra is caused by other processes as well as the instrument (Lorentzian, Doppler) Page 5 line 14 ". . .that is solved with the . . ." -> ". . .that is solved in this paper with the . . ." Page 5 line 17 ". . .is a weight of an a priori profile of the target gas and the measurement.." -> ". . .is a statistical weight between an a priori profile of the target gas and the measurement. . . Page 5 line 21 ". . .which use PROFFIT." -> ". . .which uses PROFFIT ." Also reference for PROFFIT. Page 5 line 24 "For, CO the species O3, H2O, CO2, N2O and OCS act as interfering species while CH4, O3 and H2O 24 interact with C2H6" -> "For CO, the interfering species O3, H2O, CO2, N2O and OCS are fitted simultaneously, while CH4, O3 and H2O are co-fitted in the C2H6 window" Page 5 line 31 ". . .adjust for the line

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broadening ..." -> "adjust for any non-ideal instrumental line shapes ..." Page 9 line 12 "...this corresponds to ..." -> "...corresponding to..." Page 9 line 29 "...resulting e.g. from ..." -> " .. resulting, for example, from ..." Page 10 line 19 "...global-scale model, the scenarios..." -> "...global-scale model. The scenarios..." Page 11, line 6 "...in Europe have shown to decrease..." -> "...in Europe are shown to decrease..." Page 11, line 7 "...emissions have show to decrease..." -> "...emissions are shown to decrease..." Page 11 line 11 "....of the scenarios not to overestimate the change in the modeled CO partial columns." -> "...of the scenarios so the change in the modelled CO partial columns is not overestimated." Page 11 line 23 "...reduced with 20% for..." -> "...reduced by 20% for ..." Page 11 line 25 "...species have decreased these scenarios..." -> "...species have decreased, these scenarios..." Page 11 line 31 "...increased with 0.2°Cyr-1 the last decades..." -> "...increased by 0.2°Cyr-1 over the last decades, .." Page 12 line 3 " .. of CH4 have shown..." -> "...of CH4 are shown..." Page 12 line 4: both references should be inside one set of brackets. Page 12 line 23 "..or lower than, than this default." -> "...or lower than, this default." Page 12 line 29 "...contribute to up to..." -> "...contribute up to..." Page 13, line 8 "To further quantify the differences; average values, standard deviations and seasonal amplitudes are calculated for the two species, these are presented in Table 4." -> To further quantify the differences, average values, standard deviations and seasonal amplitudes are calculated for the two species, and are presented in Table 4." Page 13, line 12 " ...high altitude and thereby the fact that a large part of the partial column..." -> "...high altitude since a large part of the partial column..." Page 14, line 7 "...sometimes with as much as a factor of two." -> "...sometimes by as much as a factor of two." Page 14 line 14 "...level, this is presented..." -> "...level, as presented..." Page 14 line 19 "...reasons to the strong negative..." -> "...reasons for the strong negative..." Page 15 line 13 "...for detection trends... " -> "...for detecting trends..." Page 15 line 14 "... CO trends the..." -> "...CO trends, the ..." Page 15 line 23 "...tends to overestimates..." -> "...tends to overestimate .." Page 15 line 28 "...and for some with as much as..." -> "...and for some sites by as much as ..." Page 16 line 3 "...Table 8 as relative

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change. . ." -> ". . .Table 8 as a relative change . . ." Page 16 line 5 ". . .influence of the model. . ." -> ". . .influence on the model. . ." Page 16 line 7 ". . .reduction with 20% . . ." -> ". . .reduction of 20% . . ." Page 16 line 11 ". . .reduction with 20% . . ." -> ". . .reduction of 20% . . ." Page 16 line 12 ". . .0.15-0.18%yr-1, this region . . ." -> ". . .0.15-0.18%yr-1; this region. . ." Page 16 line 14 ". . .column by 0.4%yr-1 (GcCH41.2) and an increase in the 14 global temperature by 0.2°C during. . ." -> ". . .column of 0.4%yr-1 (GcCH41.2) and an increase in the global temperature of 0.2°C during . . ." Page 16 line 17 ". . .estimations this highlights. . ." -> ". . .estimations, this highlights. . ." Page 16 line 20 ". . .Jungfraujoch, Harestua and Kiruna will have modeled trends that are close to the measured ones while the modeled trend at Zugspitze deviate with a factor of two from. . ." -> ". . .Jungfraujoch, Harestua and Kiruna, will have modeled trends that are close to the measured ones, while the modeled trend at Zugspitze deviate by a factor of two from . . ." Page 16 line 25 ". . .modeled, this. . ." -> ". . .modeled; this. . ." Page 16 line 30 ". . .explanation to the. . ." -> ". . .explanation for the. . ." Page 17 line 9 "Since OH affect.." -> "Since OH affects .." Page 17 line 30 ". . .illustrate that.." -> ". . .illustrates that. . ." Page 18 line 2 ". . .level, this. . ." -> ". . .level. This. . ."

Reply: All above technical corrections are adjusted in the paper.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 13723, 2011.