

Editor Comments and Request for Minor Revisions:

1) As referee #1 points out, there might be a potential issue with inter-hemispheric transport in TM5. Even though you are probably not able to resolve this issue within the scope of your study, it must be mentioned/discussed (with references) in the manuscript (the latter must stand on its own, without readers being forced to read the previous discussion). Thus, please add a short paragraph on this where appropriate.

2) Both referees raised their concern about using meteo-data (ECMWF operational analyses) which are not consistent over the studied period. As you mentioned the vertical resolution changed, but also the assimilated data. In addition you also modified the vertical resolution of TM5 in the studied period.

Again, even though you might not be able to reveal the impact of those inconsistencies within the present study, these important issues need to be discussed in the manuscript, not only in the on-line discussion.

Thus, please add a short paragraph where appropriate, to make the reader aware of the issues and briefly discuss it as in your replies.

Response:

We revised the section on the transport model to cover in more detail the issues of using the forecast EC fields rather than the reanalysis, and the possible biases in the model's representation of the N-S gradient. We had several references to support our claims. For convenience, we have included the entire section below with the additional text highlighted in yellow.

2.3 TM5 Atmospheric Transport Model

Transport Model 5 (TM5, Krol et al, 2005) is a community supported global model with two-way nested grids. For CarbonTracker-CH₄, we ran the simulation at 4° latitude x 6° longitude resolution without zoom regions. TM5 is developed and maintained jointly by the Institute for Marine and Atmospheric Research

Utrecht (IMAU, The Netherlands), the Joint Research Centre (JRC, Italy), the Royal Netherlands Meteorological Institute (KNMI, The Netherlands), and NOAA ESRL (USA). TM5 has detailed treatments of advection, convection (deep and shallow), and vertical diffusion in the planetary boundary layer and free troposphere. The winds used for transport in TM5 come from the European Center for Medium range Weather Forecast (ECMWF) operational forecast model. This "parent" model currently runs with ~25 km horizontal resolution and 60 layers in the vertical prior to 2006 and 91 layers in the vertical from 2006 onwards.

The ECMWF meteorological data are preprocessed into coarser grids and are converted from wind fields to mass conserving horizontal and vertical mass fluxes. TM5 runs at an external time step of three hours, but due to the symmetrical operator splitting between advection, diffusion, emissions and loss the effective time step over which each process is applied is shorter. The vertical resolution of TM5 used with CarbonTracker-CH₄ is 34 hybrid sigma-pressure levels (from 2006 onwards; 25 levels for 2000-2005), unevenly spaced with more levels near the surface. At the time the calculations discussed in this study were done, we did not have the ERA-Interim reanalysis driving meteorology and older reanalyses did not cover the time span we were interested in. Comparisons of forward simulations suggest that differences between ERA-I and OD for CH₄ at surface sites is very small, both before and after the change in the vertical levels. Assimilations run with both data products for CarbonTracker (CO₂) produce virtually indistinguishable results in estimated fluxes (see <http://www.esrl.noaa.gov/gmd/ccgg/carbontracker/>).

As noted by Peters et al. (2004), TM5 overestimates the meridional gradient of SF₆ by about 20%. A systematic comparison of a suite of transport models described by Denning et al. (1999) found that some transport models appear to underestimate mixing processes, especially near the surface, while others mix emissions more rapidly throughout the lower atmosphere. They also found that models that underestimate mixing produce relatively good simulations

of marine boundary layer sites while overestimating concentrations at continental sites. More diffusive models produced worse marine boundary layer simulations, but did better for continental sites. TM5 falls into less-diffusive category, but current ongoing development is aimed at improving the situation. It must be acknowledged that the emissions estimates in our study may be biased due to inadequate vertical mixing. For example, more vertical mixing will diffuse emissions throughout a deeper atmospheric column, and this may result in higher emissions in order to match observations.