We would like to thank reviewer for contributing to improvement of the manuscript. We made several changes on the manuscript, which we list up further along our replies to reviewer's comments.

Problem 1

1) In the introduction, page 2051, the statement "in the case of Eulerian model the evolution is described by PDE" is somewhat misleading. In that context, after the explanation of LPDM, it seems that the authors claim that LPDM are not based on PDE, which would be a wrong statement. LPDM are based on probability density function (pdf) transport equations (i.e. PDE, Fokker-Planck equation) both forward and backward in time (see e.g. Thomson 1987, 1990). The Lagrangian particle representation, through stochastic differential equations (SDE) used in LPDM is perfectly equivalent to the PDE for the transport of the pdf. Indeed it can be easily proved (see e.g. Monin and Yaglom 1971) that the PDE for concentration with a K closure often used in Eulerian models is equivalent to an SDE on the particle position (i.e. the particle position is assumed as a Markov process). Also in the same paragraph the authors write that Eulerian PDE model equations are solved numerically using finite differences. This is also somewhat misleading. It would be better to write a more general statement since finite differences methods is only one possibility (for example, grid based discretization methods).

Answer 1

We will replace "in the case of Eulerian model the evolution is described by PDE" with:

"In the case of Eulerian models, the evolution of the concentration field is described by partial differential equations and is solved numerically using finite difference approximations to the partial differential equation of a tracer transport on the fixed grid rather than along trajectory path."

Problem 2

2) *Page 2054, the conditional probability P(xr,tr| x,t)with tr>t should be rewritten as P(x,t|xr,tr) with tr>t. the conditioning event is that the particles pass through the receptor point (xr,tr) and it is customary in probability to write it after the random variable.*

Answer 2

We follow notation introduced by Holzer et al., (2000) and Lin et al. (2003) who put receptor on the left side as established in Green's function notation which can be opposite to probability notation. Also, T. K. Flesch et al. (1994) showed the equivalence of forward and backward conditionals probabilities ($P^b(x_r,t_r| x,t)= P^f(x,t |x_r,t_r)$). So we would like to save consistency in terms used by other authors.

Problem 3

3) *I would prefer to not use the wording "imaginary particle" but "notional particle".*

Answer 3

We changed "imaginary particle" to "notional particle" in text.

Problem 4

4) *In section 2.2 more details must be given about the adaptation needed to use the JCDAS data in FLEXPART (e.g. transformation of coordinate, vertical and horizontal interpolation). This will improve the reproducibility of the proposed work.*

Answer 4

Actually we use only horizontal bilinear interpolation and original vertical levels. The text is changed to:

"We used FLEXPART version 8.0 adapted to using JCDAS data (Onogi et al., 2007), which are provided on hybrid sigma-pressure levels and a Gaussian grid (40 model levels, T106 grid). Original model was designed for use ECMWF data on a regular latitude-longitude horizontal grid and on hybrid sigma-pressure vertical levels. Therefore to adapt JCDAS data for FLEXPART model the required parameter values were obtained via bilinear horizontal interpolation from Gaussian grid to regular 1.25x1.25 grid. Vertical structure of JCDAS data was used without any modifications, thus FLEXPART source code was adjusted for new parameters describing JCDAS vertical levels".

Problem 5

5) *Again in section 2.2, was any interpolation used from the Eulerian grid to the particle position (space and time) ?*

Answer 5

We don't use any interpolation in time, because temporal interval of output corresponds to the time of coupling. For spatial pattern we regard the following situation: if the particle is inside the grid cell then we take concentration value from this cell without any interpolation.

The following text was added to the end of section 2.2:

"; the corresponding temporal resolution was 1 hour (the same as time of coupling). Background values were used in the model without interpolation to particle position within Eulerian grid box during coupling."

Problem 6

6) *In section 3.1 page 2058 first line. The authors write that it is possible to use the same approach used for anthropogenic fluxes also for "land fluxes". Do the authors mean terrestrial biogenic fluxes?*

Answer 6

Yes, we mean biospheric fluxes. We changed "land fluxes" to "biospheric fluxes".

Problem 7

7) *In section 3.3 the authors explain how the model VISIT has been used to define the terrestrial biosphere fluxes. However, I'm not sure from the text if the MODIS land cover was used inside the VISIT model (albeit with a redefinition of the biomes and spatial aggregation) or if it was only used afterwards for the interpolation to obtain a 1kmx1km flux map. Could the authors clarify this point?*

Answer 7

MODIS map was used only afterwards for the interpolation to obtain a 1kmx1km flux map.

Problem 8

8) *In section 4.1, figure 1, the simulations showing the results obtained by using only the Eulerian model NIES-TM should be added for all the measurement stations.*

Answer 8

We replaced figure 1 and added NIES-TM values. We corrected text section 4.1 after including NIES TM values:

"To demonstrate the differences between the usage of low- and high-resolution CO_2 fluxes and between Eulerian and coupled model, we performed a "synthetic" test that examined the transport of CO_2 around the city of Moscow, where several large power plants are located, emitting strong plumes of CO_2 that are transported to the east of the city by winds. We selected three prospective observation sites (separated from each other by ~50 km) located east of Moscow and performed the calculations. The model results for the three sites are shown in Fig. 1. It is difficult to distinguish concentrations simulated by Eulerian model (Fig. 1a). For coupled model and fluxes at a resolution of $1° \times 1°$ (Fig. 1b), the results are similar for all three sites, but sharper structure is resolved. For a resolution of 1×1 km (Fig. 1c), however, the results differ among the sites, clearly showing the impact of the plumes. We note that this case study serves to demonstrate the effect of flux resolution on the model results; observation data are not available from these sites for verification of the results."

Problem 9

9) *CASA should be explicitly defined.*

Answer 9

We changed "CASA model" to "Carnegie-Ames-Stanford Approach (CASA) terrestrial ecosystem model (Werf et al., 2003)" and provided reference.

Problem 10

10) *Why a different emission was used for the (terrestrial) biosphere fluxes in the Eulerian simulations? This seems to introduce an un-necessary inconsistency between the Eulerian and Lagrangian models.*

Answer 10

The reason of usage different biospheric emissions for Eulerian and Lagrangian models is the following: We use Eulerian model to describe seasonal variation of CO2. And Lagrangian part reconstructs short-term variations. But at that moment VISIT fluxes couldn't provide seasonal variation in Eulerian model. So we had to use optimized CASA emissions to describe seasonal variations of concentration by biosphere in Eulerian part of the model. VISIT reconstructs synoptic variations well and we can use this model with high spatial resolution. So each model used the appropriate fluxes.

Problem 11

11) *In the conclusion the authors state that the use of a 1kmx1km resolution has a clear advantage in reproducing high concentration spikes over the 1degreex1degree simulations. This is conceptually true but for these simulations (as the author states*i *n the previous section 4.3) in some cases there is no clear*

advantage. Indeed, in the case of Egham (for 2006) there is a slight worsening of the performances and there is no change for Fyodorovskoye. This should be discussed in the conclusions

Answer 11

We added the following text that explains possible disagreement in results to the conclusion:

“The simulated concentration variation is higher at high resolution, which results in larger misfit in cases where the timing and amplitude of the high concentration events simulated with a model do not match observations, main reasons supposedly being the misrepresentation of the wind fields and fluxes at high resolution.”

References:

Flesch, T.K., Wilson, J. D. and Yee, E.: Backward-Time Lagrangian Stochastic Dispersion Models and Their Application to Estimate Gaseous Emissions, Journal of Applied Meteorology, 34,1320-1332,1994

Holzer, M. and Hall, T. M.: Transit-time and tracer-age distributions in geophysical flows, J. Atmos. Sci., 57, 3539–3558, 2000.

Lin, J. C., Gerbig, C., Wofsy, S. C., Andrews, A. E., Daube, B. C., Davis, K. J., and Grainger, C. A.: A near-field tool for simulating the upstream influence of atmospheric observations: The Stochastic Time-Inverted Lagrangian Transport (STILT) model, J. Geophys. Res., 108(D16), 4493, doi:10.1029/2002JD003161, 2003.

van der Werf, G. R., Randerson, J. T., Collatz, G. J., and Giglio, L.: Carbon emissions from fires in tropical and subtropical ecosystems, Global Change Biol., 9, 547–562, 2003.