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Interactive Comment

Interactive comment on "Characterization of the ^{222}Rn family turbulent transport in the convective atmospheric boundary layer" *by* J.-F. Vinuesa and S. Galmarini

J.-F. Vinuesa and S. Galmarini

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We thank the reviewer for the positive comments. We think that we have addressed all the points raised by him and modified the manuscript accordingly.

Point 1: "Firstly, it would be very useful to see profiles of exchange coefficients for the various decaying species as compared to an inert scalar."

In convective boundary layers driven by large-eddy motions as in our simulations, transport can appears to flow up the gradient e.g. the counter-gradient transport for potential temperature. Thus applying K-theory that is relating the fluxes to the gradients by using eddy diffusivities or exchange coefficients may result in finding negative values of exchange coefficients. With that respect, this approach can not be used in convective

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boundary layers.

In addition, we found that positive concentration gradients can be associated with positive (upward) fluxes. Figure 4 show positive gradients for S2 and S3 up to the mid-CBL whereas their fluxes are upwards (Figure 5). This reveals that for radionuclide with a decay of the same order of the turnover time of the convective boundary layer, “counter-gradient transport” can be expected.

Point 2: “Secondly, the authors need to present results from simulations with a range of entrainment (ventilation) conditions at the boundary layer top in the quasi-steady state, and discuss how variations in entrainment effects the profiles of concentrations, fluxes and exchange coefficients. This would be extremely interesting for researchers considering the use of radon as a proxy tracer for ventilation in box models, for example. It would also be a good way to touch on the important role of boundary layer cumulus in ventilating the mixed layer, without the need for introducing the complication of humidity and clouds into the simulation. “

As suggested by the reviewer, we performed extra simulations of the steady-state case based on weaker inversion strengths. We used potential temperature jumps at the top of the CBL of 1, 2 and 3 K (named as W1, W2 and W3, respectively). We found very similar (almost identical) results as in the present manuscript. The independence of our findings to the inversion strength will be mentioned in the revised version of the manuscript. As far as we know, it is not possible to include figures to the on-line discussions. However, the figures will be included to the final response to the editor. These figures give the Vertical profiles of the dimensionless fluxes for Radon and its daughters and of the contributions to the flux budget equations of S1 for the simulations W1, W2 and W3.

Not only the presence of boundary layer cumulus will affect the ventilation of the mixed layer but also will enhance the vertical mixing in the boundary layer and then reduce the turnover time of the convective boundary layer. Basically, the whole turbulent structure

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will be affected. With that respect, the present study can only give some hints of what could be the effect of the presence of clouds but this topic should be tackle by simulating cloudy boundary layer even with a simple cloud representation.

Point 3: “Thirdly, the authors need to re-consider their set-up for the unsteady case, to make it more physically reasonable. In particular, they should consider using a surface heat flux that exhibits a diurnal (sinusoidal?) variation, and perhaps relax the strong potential temperature gradient in the residual ("reservoir") layer to a more realistic value (zero, or at least much weaker).”

As suggested by the reviewer, we performed an unsteady simulation where the surface heat flux follows a diurnal variation (from 0.05 to 2 Km.s-1) and the potential temperature jump of 2.5 K (the simulation is named V4). For this simulation, we increased the number of vertical levels from 60 to 80. The main difference with the present simulation is that the boundary layer is growing faster. As a result, it grows under the free troposphere after around 250 minutes entraining even lower concentrated air masses than during the growth within the reservoir layer. However, the same overall results are found: decrease of the concentrations due to the ventilation, enhancement of the fluxes at the top of the boundary layer, correlation between mixed-layer radon concentration and entrainment to surface fluxes ratio, vertical discrepancy of the radioactive contribution to the concentrations.

The set-up presented in the manuscript allowed us to show the adequacy between (1) entrainment to surface radon fluxes ratio with absolute values higher than 1 and decrease of the radon mixed-layer concentrations and (2) absolute values of this ratio lower than I and increase of the mixed-layer concentration. For weaker inversions/stronger surface heat fluxes and diurnal-like variation of the heat flux, there is no coexistence of periods during which this value is higher and lower than 1 (and therefore period where the radon concentration increases and decreases). Therefore the set-up contained in the manuscript is more suitable to give an overall picture of the turbulent dispersion of radon and its progeny in a growing convective boundary layer.

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As for the results of the steady-state extra simulations, the figures will be included to the response to the editor. These figures represent the time evolution of the radon concentration and flux and time evolution of the radon mixed layer concentration and entrainment to surface flux ratio.

Point 4: All specific comments have been considered and the text and figures have been changed accordingly. Thank you.

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 8917, 2006.

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