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Interactive Comment

# *Interactive comment on* "The diurnal evolution of $^{222}$Rn and its progeny in the atmospheric boundary layer during the Wangara experiment" *by* J.-F. Vinuesa et al.

**J.-F. Vinuesa et al.**

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We thank the reviewer for the positive, detailed comments and valuable suggestions. We think that we have addressed all the points raised by his review and modified the manuscript accordingly.

**Specific comments**

**Point 1:**

*"1. One thing that immediately strikes the reader, especially if they have an experimental background, is that the authors have simulated an environmental case study for which there are no existing radon measurements for comparison! This seems very*

*strange, especially when the authors assert in the Introduction that "Ground-based measurements and vertical distributions have been extensively studied to characterize the turbulent properties of the ABL" (p8898, lines 6-7). In fact, the reader could be perfectly forgiven for wondering: "Why on Earth did the authors not choose one of the many radon studies for their simulation?". The answer of course is that, contrary to the authors' assertion, there are in fact very few studies that have concentrated on obtaining quality radon measurements throughout the whole depth of the boundary layer, especially over the course of a diurnal cycle. The authors need to discuss this more carefully in their Introduction, as it is crucial to understanding their choice of simulation. One possibility is that the paragraph is split on p8898 line 16 just before "In a recent study, ...", and the following inserted: "Despite many experimental studies in the literature, there have been very few studies that have reported measurements of the vertical variation of radon and its daughters through the whole ABL under a variety of conditions. This has been mainly attributable to the slow development of detection technology of suitable accuracy that can practically be mounted on an aircraft. In the absence of such datasets, LES is an option and [in a recent study...]".*

We have added the paragraph suggested by the reviewer in the introduction of the revised manuscript and modified the assertion mentioned by the reviewer. Thank you.

**Point 2:**

*"2. It appears that the initial condition used for the whole simulation (i.e. 9:00 LST on Day 33) was a constant distribution of about 20 Bq m-3 of radon throughout the full depth of the model domain. Is this correct? (please define the initial profile more clearly in the text). Whereas this may be a reasonable guess up to the top of the previous day's residual layer (actually, it's a bit too big: see below), above this altitude it is unrealistic and should be much smaller. Zero would have been a better approximation, or perhaps a "background" value from the literature (e.g. 0.5 Bq m-3 from Zaucker et al. 1996, JGR 101 D22, p29,149-29,164). Having such large values for radon above the ABL top in the simulation means that the beta_0 values you obtain in Figure 12 may be*



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*too modest, and should actually be bigger in magnitude! In other words, the effects of entrainment on ABL radon concentrations in your simulation are actually likely to be underestimated! I suggest that you should run the model with an initial profile of 10 Bq m-3 within the ABL, stepping down to a small "background" radon concentration (0 or 0.5 Bq m-3, as discussed above) above the top of the residual layer from the previous day. The 10 Bq m-3 concentration within the ABL is the value generally assumed to be a global average measured close to land surface (UNSCEAR 2000 Report Vol. I, Sources and effects of Ionizing Radiation, Annex B, page 103). "*

As suggested by the reviewer, we performed a new simulation using initial radon profile of 10 Bq m-3 within the ABL and zero radon concentration above it. The figures and text have been changed accordingly in the revised manuscript. By using these new initial conditions, we found the same trends as before and therefore we reach the same conclusion. Even so, we found enhanced radon and its short lived daughters activity ratios that make our results of broader interest. Thank you for your suggestion.

**Point 3:**

*"3- In connection with (2) above, your discussion of Figure 12 at the end of Section 7 would be a lot different if the radon values in the free troposphere were more realistic (i.e. very low). When the CBL top reaches the free troposphere, large beta_0 values may actually persist despite the decline in w_e, due to the large gradient encountered. When beta_0 values are large, we might expect to see appreciable S0 gradients within the mixed layer itself, due to the "top-down bottom-up" mixing process. This is evident in Figure 10a at 12:30 (corresponding to the maximum in beta_0), and I expect would be a feature of the S0 profiles whenever beta_0 is large in magnitude. These features of radon behaviour in the CBL indicate a strong potential for the use of radon measurements as a delineator of CBL entrainment, and I think they should be emphasized more in your text."*

The change in initial concentration in the ABL and in the free troposphere does not



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induce drastic changes of $\beta_0$ even if higher values are found after the decline of the entrainment velocity. However this behavior is evident in the new figure 4 (suggested by the reviewer in point 4). We have added the following paragraph following the referee's suggestion in the discussion of Figure 12 (i.e. figure 14 in the revised manuscript):

**When the CBL top reaches the free troposphere, large $\beta_0$ values persist despite the decline in the entrainment velocity. These large values are due to the large gradient encountered in that region. When $\beta_0$ values are large, we found appreciable $S_0$ gradients within the mixed layer itself, due to the CBL turnover mixing process. This is clearly shown by the 12 LST's the profile of radon in Fig. 5. The same feature is also shown in Fig. 4 whenever $\beta_0$ is large in magnitude. These features of radon behavior in the CBL indicate a strong potential for the use of radon measurements as a delineator of CBL entrainment.**

**Point 4:**

*"4. The colour contour plots are generally very effective in presenting a large amount of information concisely to the reader in a quickly and easily interpretable form. However, it is sometimes hard to extract by eye certain subtleties (e.g. gradients) and to make comparisons between different plots. I think it would help the clarity of the discussion if the authors were to strategically include some additional graphs of the more conventional altitude-versus-value type, when certain details of the results need to be emphasised. In particular, it would be nice to see the following four graphs, that could perhaps be placed into one additional Figure: a. Individual profiles of radon at significant times during the 24-hr period (say, 20:00, 03:00, 09:00, 12:30 and 16:00); b. As (a), but for fluxes; c. Si profiles for all radionuclides at 08:00; and d. As (c), but for fluxes.."*

We added all the figures suggested by the reviewer.

**Point 5:**

*"5. In Figure 4, it would be helpful to show a longer period (maybe the whole period, with the night-time shaded in grey?), and also to present the time-series of friction velocity (u*) and Obukhov length (L), for completeness of the presentation and for reference when studying Figures 14 and 15.*

The time evolution of the sensible surface heat flux, the friction velocity and the obukhov length for the whole period of simulation has been added. In addition, we also plot the results from the analyses of the Wangara observations by Hicks (1981).

**Technical corrections**

We made all the editorial corrections as suggested by the reviewer.

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Interactive comment on Atmos. Chem. Phys. Discuss., 7, 8895, 2007.