Atmospheric Chemistry and Physics Discussions

Interactive comment on "Evaluation of the vertical diffusion coefficients from ERA-40 with ^{222}Rn simulations" *by* D. J. L. Olivié et al.

Anonymous Referee #2

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This paper describes a comparison between vertical diffusion coefficients archived during the recently completed ECWMF 40-year reanalyis, and those calculated by an offline method using ECMWF prognostic variables. The offline calculated values are obtained with two different boundary layer parameterizations, for time steps of 3 and 6 hours. The calculated diffusion values are used in the TM3 model and compared to measurements of BL heights, as well as 222Rn.

Overall, this paper addresses important work for the modeling community and has the potential to give interesting results. The description of the diffusion schemes is good and reasonably extensive measurements are used to evaluate the model. This paper could become an interesting contribution to the field, if (1) the presentation and organization is *significantly* improved, and (2) the comparison was extended so that more substantial conclusions were drawn. This can only be done with substantial additional

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analysis and quite rigorous adjustments to the text in its current form.

As an example of better organization, the text is still saturated with remarks about the characteristics of each scheme, whereas Table 1 summarizes this information already. All references to differences in 3-hourly, non-local, averaged, instantaneous, and ABL heights can thus be removed from the text. Also, results and methods are not well separated and often discussed too briefly. The paper is furthermore filled with superfluous remarks on possible shortcomings and errors in the method which distracts the reader from the results being presented. Mostly though, the authors need to determine what their scientific questions and message will be and organize the paper around it.

For more in depth analysis, I would like to see:

1) diffusion coefficients in time for all schemes from selected regions of the world representing different situations (tropical/continental/coastal/oceanic/mountain). 2) An analysis of ABL heights separated by time of day and local condition, with more discussion of the physics underlying differences from one day to the next, and differences between the schemes at particular days. 3) A comparison to 222Rn at shorter temporal scales. The extensive averaging and aggregation done now likely obscures the differences we need to see and analyze.

An extensive list of suggested changes and points to address is included. I have taken the time to compile this list since I hope the authors will try to revise/resubmit this manuscript accordingly so it can contribute interesting results to the scientific discussion.

Abstract:

- "instead of..." use versus
- "by investigation of the effect on..." awkward language
- "we conclude that..." based on what? what tracers are done well? What time scales? This conclusion is not really substantiated and too general.

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Introduction:

This part needs better organization. Following the first section on the importance of turbulence, a separate section should be added on the ERA-40 project including some discussion on archiving of the output. This part should contain the reference to Allen et al, as well the few notes on the ERA-15 project. Next, you can introduce the TM3 model, and explain that it can use the output from ERA40/15 to run tracer experiments using different BL schemes.

Then, you introduce the BL schemes and explain that local or non-local formulations can make a difference. This difference can be evaluated using TM3 and 222Rn (next paragraph). Finally, clearly describe how this paper is organized, and what your research questions will be (!).

- "appeared to be..." was this result unclear in the Holtslag paper?? I want to know if the moisture transport was much more pronounced or not...
- If Wang et al used 222Rn and CH4 to study the BL schemes, then why did they draw conclusions on O3 and CO?
- It is not the fact that O3 comes down and CO goes up that's relevant, you want to make a statement here about vertical exchange, please change.
- "Chemistry transport models..." this paragraph can be deleted since it is really not relevant. The remark about offline models using archived data can be put somewhere else.
- "frequently (6-hours)" that is not frequent, it is regular
- "made small" = minimized
- "sampling interval" what are you sampling here?

- "The 3-hourly offline scheme..." delete sentence, irrelevant
- "The 3-hourly... differences in the schemes" just state that it is interesting to study the different results from the four schemes without enumerating what you will compare with what and when they've been used previously etc.

Section 2:

Rename this section to "Methods" or so, since it also includes information on 222Rn sources, BL schemes, ERA40, etc. Start with a general description of TM3, and then focus in on diffusion in the model. This will naturally lead to a description of the BL schemes offline and online. After that, you can introduce the emission scenario. Then describe the measurement campaigns and instrumentation, and finally summarize the experiments.

- "where Kh is.." please give units on all variables.
- 2.1.1 Make a story out of this: explain that different formulations are used bases on the stability regime, which is determined by the virtual potential temperature flux at the surface (I don't think virtual heat flux is the correct term). Then introduce the three regimes and discuss them
- There should not be three paragraphs in the first 4 sentences of section 2.1.1
- "The coefficients...values" this information keeps coming back, please mention it once and no more.
- do you know why the excess coefficient was reduced to 2?
- is "capping inversion" a special term, or just an inversion at the top of the BL? That is where they usually are found, right?
"This ABL height is available every 3 and 6 hours" on page 9 you say that "no 3 hourly values were archived" which is correct?
- Figure 1 is worthless without some explanation. What do these parameters represent, how should the reader interpret the differences? Moreover, you should not introduce results in this section, and certainly not before discussing the other schemes.
- (ii) There is no entrainment formulation... Do you suggest there is no entrainment, or is it not accounted for through a separate parameterization? I assume its this second, and Kz values or some fluxes in your convective paramaterization take over this role. A model without entrainment can never do very well.

- "222Rn is..." we have read this in the intro already, including all the references. please delete and start with next sentence

- "generally accepted" strange remark. Is it scientifically proven? Did measurements show this? Change please.

- "natural and anthropogenic changes..." specify what you mean by changes. I assume you mean the atmospheric composition can be modeled with different surface fluxes?

- Limit the TM3 references to one comprehensive paper, or include all references to the model, this is a very arbitrary subset of TM3 related work and does not do justice to the wide use of TM3 in the community.

- section 2.4: This is part of your results, not of "The TM3 model"

- "summer winter variations" I just see slight differences, what variations are you refering to? This word suggests a change in time which I can not see from two figures only.

-" almost identical" I would not say that, since they differ sometimes by a factor of 2. Everything looks identical on a log-scale.

- "One should note that..." you have already said this earlier in this paragraph, please delete.

- I would like to see the difference in diffusion coefficients specifically for different cases: one over a continental coastal region, one in the middle of the continent, one in the tropics, one at mid-latitudes, one over the ocean (not at all included now), one near orography. You could then make contour plots in time for E6/E3/H3/L6 (up to 3 km is enough, nothing much happens above that) on the same scale and compare them. This should tell you much more on what the expected differences are under different conditions and in different seasons. By aggregating over all land regions and only showing two snap-shots, the real differences are likely masked and your conclusion that they are similar could be false.

Section 3

- "some days" were these selected convective days? Random days? Just the days when data was available? Be more specific.

- The description of your measurements and how they were obtained is part of your methods, not the results. You should add a paragraph to section 2 to describe them properly (time/location/measurement method/frequency/data selection).
- "The profiles have a resolution of..." below what? above what?
"continuous modelled" interpolating does not mean you modeled it continuously. - " a flat correlation curve " What do you mean by this, where is this curve and what does its flatness indicate?
"Due too a strong..." too=to, why do you say 'maybe'? Have you checked the model's heat flux vs that of Cabauw?
- Next two paragraphs: you repeat yourself here in saying that clouds complicate ABL height measurements. This is really the whole point of these two paragraphs, please summarize this more efficiently.
- GMT vs LT. Unless you can give a specific example, this is kind of a theoretical argument. Please show me this effect.
- Generally, you cast a lot of doubt on your intercomparison by first describing the agreement, and then making an elaborate description of everything that might be wrong. You could just summarize the possible causes for differences in one sentence: "The comparison between model and observations is hampered by representation error in modeled fluxes, the presence of clouds during daytime, and limited space and time resolution of the model." This would save 5 paragraphs of obvious arguments and allow you to focus more on the comparison.
- The nocturnal BL height at Cabauw is overestimated strongly in July 1996, but is much better (and lower) in August of that year. What process controls this in the model, and what is wrong in July?
- On 8/15/1996 the measurements indicate a convective BL at Cabauw until noon, but the model produces quite a different structure. Is this related to the stability regime in the model? Is it due to clouds? The diurnal cycles on 7/8 and 7/9 1987 look similar in the model, what is the difference in terms of physics with the deeper BL's on the previous days?

- Why is the difference between E6 and H3 so large during the first five days in Figure 4?

- Instead of showing all diurnal cycles and concluding that they agree 'reasonably well', you could select different types of situations (clouds/no clouds, day/night, large difference H3/E6 or not). This might lead to more insight and deeper conclusions.

- The BL heights you show were all measured in summer, convective conditions. You should state this explicitly and make sure your conclusions on BL representation reflect this limitation.

- Table 2 does not serve any purpose and has almost no information. These correlations are quite meaningless also, since the model values were interpolated and not every measurement could be compared objectively to a model value. Correlations should always include the sample size (N=???).

- Include a simple sine wave as an artificial estimate of the diurnal ABL height, does your model give better correlations than that?

-section 3.2 can go to the method section, together with the description of the sources

-" We compared ...diffusion" ABL diffusion is a strange concept, use ABL mixing, or diffusion coefficients.

-What does the correlation of the daily mean values represent? Synoptic variability? Is this a correlation in time between obs and model? What is the correlation of the deviation from the mean value? What is correlated with what? I have learned nothing from this section, and quite frankly do not know what you're trying to state here.

- Why did you average the daily cycle over multiple days? This would dampen variability and can only be done if you consider these days highly similar in terms of BL growth, height, and diffusion.

- If you identify "some deviation" then what does that mean for ERA40 diffusion (the topic of this work)?

- Were model and measurements sampled on the same time and day?

- I cannot clearly see the times when the model fields were updated in figure 8.

- What is 'high frequency variability of the daily cycle'? I do not see any high-frequency variability in Figure 8?
- Why would you expect the influence of ABL turbulence on the tracer concentration to be strong particularly in JJA, and not in other seasons?
- Correlation: are you now looking at the synoptic variability in the amplitude?
- 3.2.3 How do you explain the differences that you have written down? Why are maxima underestimated and minima underestimated? Is there a physical process missing?
- correlations: are these r-values? What is the sample size? 8 timesteps?
- Timeshifts: are you suggesting now that the ERA40 diffusion coefficients should be shifted in time to work well? What do you conclude/recommend based on these figures and results?

- What does this ratio mean? Explain why you use this ratio?
- "We would certainly advise" delete sentence, everybody knows its better to do that and it is not something based on your work.
- "a large drop" you mean the ratio would go to 1.0.
- course=coarse
- The last paragraph of 3.2.5 only enumerates differences I can see by myself in figure 11, but it does not give any analysis on why these differences exist. Again, the many comments on model shortcomings, local influences, and large scatter cloud any message that might be in this paragraph. If these shortcomings prohibit you from making sound conclusions, you should try another approach to learn from these data.

- "climatological sense" what do you mean?
- "seems to be " is it much smaller, or not. Be clear.
- what is an "observed morning peak concentration"?
- "seem to fail" do they fail or not. Why??

- Why did you average all measurements to a mean daily cycle? What is the standard deviation on the mean you show? How variable is the 222Rn daily cycle during the month?
- What happens in the morning that causes a steep drop in observed 222Rn, and is not captured by the model?
- " The effect of diffusion is such that" Diffusion leads to...
- "effect or influence" choose one word
- " If the diffusive transport changes" How is there compensation? This model is just a linear model and does not calculate its own physics, correct? Thus, advection can not increase, and convective fluxes are also fixed. There is no process in the model that depends on the concentration so I do not see how compensation can occur.

Conclusions:

- "Using the E3 scheme..." quantify the difference in the free troposphere.
- you enumerate all the differences between the E3 and H3 scheme as possible causes: Isn't the point of this paper to study these differences? I want to know what specifically makes such a difference. To do that, you need to identify a regime in which E3 and H3 differ strongly (that is not the global, latitudinal, or monthly mean, but shorter time and spatial scales).
- Why did you not include a counter gradient term if you say that would be interesting to study?

References:

- subhemipsheric=subhemispheric
- arhived=archived
- review your accents on your letter e's

Tables:

2: not needed
3: a mean should always be accompanied by a standard deviation
5: What is N for each of these correlations?
6: where is E3, what is the sample size N?
7: what is the sd?

Figures:

all: use colors

1: needs discussion and explanation
4 and 5: eliminate white space between the figures and make larger
6: squares and crosses indistinguishable, include 1-on-1 line
8: contract y-axis
9: left,right,lower wrong
10: 407 or 409 meter layer?
12: include 1-on-1 line

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