Reply to Referee 1

The study by Brinkop and Jöckel describes an extension of the Lagrangian transport module ATTILA, which is online coupled to the ECHAM5/Messy model through the Messy coupling framework. The extension includes several new modules for diabatic vertical velocities, convective transport, and inter-parcel mixing, as well as new tools for diagnosis and emission treatment. Furthermore, MPI parallelization (decomposing by parcels rather than by sub domains) and a careful treatment of the random number generator (essential for this type of modeling) have been implemented. This reviewer considers these extensions as relevant and significant. The manuscript is very well written and easy to follow. A model evaluation against Radon (troposphere) and Age-of-Air observations is presented, which highlights the benefits of diabatic vertical velocities to better represent the stratospheric age-of-air distribution. Although this is not a new finding, the model evaluation suggests that the implementation of diabatic velocities within ATTILA has been done properly.

Reply: We thank the referee for these positive comments.

The only weak point of the manuscript is the fact that the evaluation of the convective transport does not receive similar attention as the evaluation of the diabatic velocities. It would have been nice to see the effect of the convective transport on the vertical profiles of Radon in the troposphere. Why has this not been done? I clearly recommend publication of this manuscript with only minor corrections (and after addressing the weak point mentioned above).

Reply:
Indeed, it seems like we did not pay too much attention to the effect of convection on the distribution of trace species. But this was not the case!
We performed different test simulations, though at a lower resolution (T21L19), but decided not to show them as part of the manuscript, because the findings do not help to evaluate the model. It is well known that convective tracer transport in the troposphere is essential to reproduce the vertical gradients. Thus, without the LG convection scheme we can hardly expect any meaningful results, which further cannot be evaluated (since there are no observations without convection).
Nevertheless, the results for Radon with and without LG convection are presented in Figure 1 below. The underlying simulation was a perpetual January simulation in T21L19 vertical resolution of EMAC (24 months).
Displayed are zonally averaged tropical vertical profiles of Radon simulated with ATTILA with and without LG convection in comparison to the grid-point calculation (which has been evaluated already earlier, see Jöckel et al., 2010).
For the reasons given above, we are hesitating to include such an analysis into the manuscript, because we think it is not of value.

Small points:
Introduction section: It would be useful to mention some typical (planned or past) applications of ATTILA. End of page 4, beginning of page 5: In the list of new modules, it is not necessary to state "have been added" , "has been implemented" after each point. This could be stated once at the beginning, e.g. "the following new modules have been implemented:"

Reply:
We introduced a small paragraph in the introduction, in which we describe, how ATTILA was used in the past, and describe future applications in the summary (now Summary and Outlook) section.

Further, we removed the “has been implemented” etc. as suggested.

Page 5, Line 10: What do you mean by "transformations"?

Reply:
Here, transformations describe, for instance, the conversion of variables between grid-point representation and Lagrangian representation, and vice versa.

We clarify this in the revised manuscript.

Page 6, line 5: "depending whether" -> "depending on whether"

Reply: Corrected.

Page 8, line 21: I didn't really understand, how the "kinematic velocity" mixes with the "diabatic velocity" in equation 7. Rather it seems that vertical transport in these coordinates can occur by pressure changes (since f depends on pressure).

Reply:
Equation (7) is simply the time derivative of equation (3). We add some text to clarify this.

Page 10, Line 17: Isn't the convection scheme only mass conserving in the limit of a large number of air parcels? What happens if there is no air parcel available in the column that could be used to compensate the up- and downward motions?

Reply:
This case cannot happen by design. If there would be indeed the case of only one parcel in a column, this single parcel would compensate itself and would therefore result in a vanishing net transport. Therefore, the LG convection scheme is even strictly conserving the local mass. To clarify this, we modified the text slightly.

Page 11, Line 14: Doesn't the mixing parameter d depend on the time step?

Reply:
In our specific setup the mixing parameter was set constant, i.e. independent of the time step, but differently for troposphere and stratosphere (as mentioned on page 11, lines 22-25). However, as outlined in line 20 of the same page, it can also be recalculated in every time step, depending on a time-dependent variable (channel object). We clarify this in the revised text.

Page 13, Line 22: What do you mean by "working space"? Memory?

Reply:
Indeed, we meant neither nor but more general computational resources. And since it is not really an argument (because simulations including chemistry would be possible, though computationally expensive) we removed the statement in the revision.

Page 15, Line 1: How can the overall burdens be different between the simulations, if the emissions of Radon are identical and Radon decays with a constant e-folding time?

Reply:
The differences occur, because the horizontal distribution of parcels in the boundary layer (where the source is picked up) differs slightly, depending on the chosen vertical velocity. And since Radon emissions occur only over land, differences in the burden cannot be excluded.
We clarify this in the revision and remove the sentence about the burden, because it is not discussed any further.

Page 16 Line 3: You may also refer to Karstens et al. (2015): https://www.atmos-chem- phys.net/15/12845/2015/

Reply: Thank you for the hint. We added the reference in the text.

Caption of Figure 12: "difference between and" -> "difference between"

Reply: Corrected.

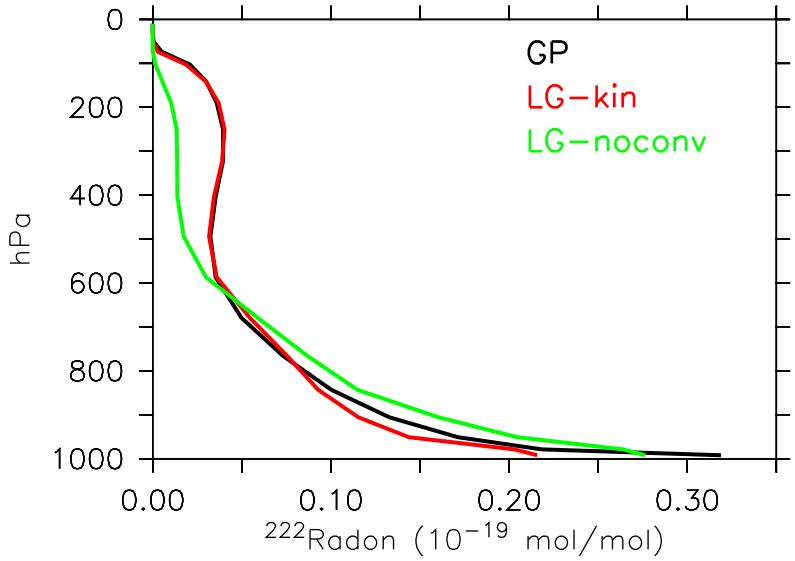

Figure 1. Zonally averaged tropical Radon mixing ratio (10^{19}mol/mol) versus pressure altitude from a perpetual January simulation with EMAC-ATTILA in T21L19 resolution. Black line: GP simulation, red line: Lagrangian simulation WITH LG convection, green line: LG simulation WITHOUT LG convection.