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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Evaluation of observed and modelled aerosol lifetimes using radioactive tracers of opportunity and an ensemble of 19 global models" *by* N. I. Kristiansen et al.

Anonymous Referee #2

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In this study, the authors apply the radioactive tracer-based constraint obtained by Kristiansen et al. (2012) to assess the aerosol lifetimes simulated by 19 global models. They find that modelled lifetimes vary over a wide range but are generally too short. To interpret their constraint, the authors propose to represent aerosol lifetime as a succession of increasingly long timescales related to the strengths of aerosol sinks, themselves a function of altitude.

The paper is interesting and well-written. It falls short of pinpointing the exact causes of model diversity in aerosol lifetimes, but demonstrates the usefulness of their constraint, which should help modellers improve their aerosol schemes in the future. Figures and

Tables are informative and well-chosen.

In my comments below, I recommend clarifying the discussion in places to avoid seemingly contradicting aspects of the analysis and to support the reader in understanding the implications of the results. Addressing those comments should not amount to more than minor revisions.

1 Main comments

- The study is not interested in emission injection heights. In section 3, this is justified by citing Croft et al. (2014), but that study in fact finds otherwise: to quote their abstract, "Global mean lifetimes are shown to strongly depend on the altitude of injection." So the statement on line 26 page 24521 is incorrect and the lack of interest in injection height (and the lack of a corresponding discussion in section 6.2) is unjustified. This silence is difficult to reconcile with the analysis in sections 6.1 and 6.3: if removal timescales, and specifically the first, τ_1, are so crucially dependent on the vertical location of the aerosols (page 24536, lines 17–20) then surely the injection height must matter?
- Figure 7 is also interesting to look at within the multiple timescale framework of section 6.1. However, there seems to be a mismatch between the timescales one could derive from Figure 7 and those quantified in Table 4. In Figure 7, it is remarkable that the models all show a large variability in lifetime before day 40, followed suddenly by a well-behaved increase in lifetime with time. That sudden change cannot be a signature of different horizontal patterns, so it must be due to the vertical distribution, but why such a good agreement on a 40-day timescale? And why doesn't that timescale appear more clearly in Table 4?
- The author reserve a special treatment to high-latitude stations, perhaps because of the importance of transport to the Arctic. They imply several times, most clearly

on Page 24529 lines 14–16, that transport to those high-latitude stations somehow tell us more about wet deposition. But is that really the case? One reason could be that those stations are reached after a long transport, but arguably Ulan Bator is the most remote station when accounting for transport pathways (Figure 2). Another reason is that extra-tropical precipitation frequency and intensity are more difficult to model accurately. Perhaps, but 75% of total precipitation is in the Tropics. So do high-latitude stations really tell us something that other stations cannot?

2 Other comments

- Page 24517, lines 16–17: It would be the right place to remind modellers of the difference between lifetime and residence time, the latter being the ratio of burden to deposition/emission/production. It is unfortunate that modellers never use the proper terminology.
- Page 24517, line 27: the "while" is not strong enough to convey the contradiction between the results of Samset et al. (2014), which hint at the need for shorter lifetimes in models, and comparisons against observations in the Arctic, which suggest the need for longer lifetimes. As stated later in the introduction and in section 6.6, the regional dependence of lifetime likely explains the contradiction, but it means that comparisons are to be used cautiously when making statements about the quality of simulated lifetimes in models.
- Page 24518, line 26: Is there a reference for the fact that Cesium uptake by aerosol is proportional to surface area? Aren't soluble particles preferred in any way?
- Page 24521, line 20: The description of model experiments is not sufficiently

detailed. What did you ask modellers to do exactly? What was the emission rate? For how long are the emissions imposed? Where are the emissions injected? How long are the simulations?

- Page 24523, lines 14–26: This paragraph also looks like a good opportunity to formalise the difference between lifetime and residence time.
- Page 24526, lines 24–26: I do not follow the reasoning here: since the radioactive tracers must end up deposited at the surface, using ground- based measurements should not be a problem when assessing lifetimes, irrespective of how high the tracer goes during its time in the atmosphere.
- Page 24528, line 7: At least as long as models are driven by or nudged to analyses... Free-running models are not assessed in this study.
- Page 24529, line 4: How to interpret that temporal trend? Is it due to an accumulation of the underestimation, i.e. if an aerosol had to be deposited before time T, then obviously it should also have been deposited before time T+1?
- Page 24529, line 13: It is worth mentioning here that both horizontal and vertical spatial dimensions matter.
- Page 24537, section 6.4: This section is speculative because the authors lack coordinated sensitivity experiments by all models, e.g. doubled or halved wet deposition rates, emitting in September instead of March, etc. This is unfortunate, but probably too late to fix. It is now up to individual modellers to run those sensitivity experiments in their model development cycle.

3 Technical comments

- Page 24522, line 14: Missing hyphen "decay-corrected"

- Page 24525, line 24: Replace “of” with “is”
- Page 24526, line 1: “a too quick removal”: too quick a removal

Figures 4 and 5: Rigorously speaking, those are Tables, not Figures.

Figures 4 and 5: The choice of colour is not great: green/red are widely used to denote "ok/not ok", whereas here they both denote "not ok". Blue/red would be a more usual choice to indicate an under/over-estimate.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 24513, 2015.