Geoscientific Model Development Discussions

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Comment on gmd-2021-56

Anonymous Referee #2

Referee comment on "Application of CCM SOCOL-AERv2-BE to cosmogenic beryllium isotopes: description and validation for polar regions" by Kseniia Golubenko et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-56-RC2, 2021

This paper aims to develop the capability of modeling cosmogenic Beryllium-7 (Be-7) in the chemistry-climate model (CCM) SOCOL-AERv2-Bev1. The production rates of beryllium isotopes (Be-7 and Be-10) are calculated using the CRAC:Be (Cosmic-Ray Atmospheric Cascade: application to Beryllium) model, which allows spatiotemporally varying beryllium sources being incorporated in the CCM. Wet/dry deposition as well as Be-7 radioactive decay are considered. Model simulated surface Be-7 concentrations are evaluated with observations from four high-latitude locations. The model reproduces reasonably well the observed seasonality and interannual variability in Finland and Canada in most years of 2002-2008, with larger discrepancy between the model and (~2-yr) observations at two locations in the Southern Hemisphere. While there are some interesting aspects (e.g., production and transport of Be-7 from a major solar energetic-particle event) in the presented material, this work (including presentation, model development, and model evaluation) is not ready to be published.

Major comments:

1) It appears that the authors are not fully aware of other existing global models that have been used to simulate atmospheric Be-7. For example, at the beginning of the abstract (or similarly on P2, L50-51), it is stated that ""Previously, modelling of the beryllium atmospheric transport was performed using simplified box-models or air back-tracing codes. While the ability of full atmospheric dynamics models to model beryllium transport was demonstrated earlier, no such ready-to-use model is currently available." There has been a long history of simulating Be-7 using global models, e.g., Brost, R.A., J. Feichter, and M. Helmann, Three-dimensional simulation of 7Be in a global climate model, JGR, 96, 22,423-22,445, 1991 (https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/91JD02283). The authors mentioned a few modeling papers (sometimes not accurately; see below for example) but there are many more.

2) P2, L47-48: "A full 3D modelling of the production and transport of beryllium isotopes in the Earth's atmosphere was performed earlier using the ECHAM5-HAM atmospheric model (Heikkilä et al., 2008a,b)." -- Heikkila et al. (2008a) used a two-box model and did not use a 3-D model. Heikkila et al. (2008b) used the production rates from Masarik and Beer (1999) and did not do a full 3-D modeling of the production of beryllium isotopes. P14, L273: Brattich et al. (2020) is not relevant to sudden stratospheric warming (SSW) events at all.

3) P3, L53-55: "while several models of different complexity and accuracy have been developed in the recent past to model transport and deposition of beryllium isotopes, most of them have been abandoned and not supported further and cannot be directly applied in new analysis works." – Which "several models"? Which ones were abandoned and not supported further? There are other existing global models (see point 1 above). Are you saying that a global model of transport and deposition coupled with a Be-7 production model is needed? Was the CRAC:Be model coupled with SOCOL previously? More generally, it would help to list (in a table or schematic with references) the model components that already existed and those that this paper would like to develop or improve. The evaluation or performance of the original SOCOL model in simulating Be-10 also needs a bit of elaboration. While this paper focuses on Be-7, the same processes (except decay) control Be-7 and Be-10 in the troposphere.

4) Section 2.3: "beryllium is considered as a gas tracer" – This is confusing. As authors also stated, after production, Be-7 attaches to ambient aerosols. That's why Be-7 has long been used as an aerosol tracer. Therefore it should be treated as an aerosol in the model. It should not be treated as "gas form" as also stated in the last sentence of this paragraph.

5) Section 2.3: How is convective transport represented in the model? How about turbulent mixing in the boundary layer? How realistic is the stratosphere-to-troposphere transport of Be-7 (or other tracers)?

6) Section 2.4: "tropospheric washout of gases is calculated by…" - Be-7 is an aerosol tracer.

7) section 2.4: "Deposition of beryllium isotopes is parameterized as a function of surface properties, solubility and reactivity of the considered species (Kerkweg et al., 2006). This scheme considers actual meteorological conditions, different surface types, and trace gas properties like solubility and reactivity. Since beryllium is transported like a gas in the CCM SOCOL, the dry deposition scheme is similar to other gases in the model (e.g., Revell et al., 2018). Moist convection contributes significantly to transport of energy, momentum, water, and trace gases in global modelling." - Again, Be-7 should be treated as aerosol (not gas) in both dry deposition and wet deposition parameterizations.

8) P8, L159-160: "Scavenging coefficients for gas-phase species are calculated based on

Henry's law equilibrium constants." - If Be-7 is treated like a gas, it means Henry's law has been applied to Be-7 (actually an aerosol tracer) in the model, which does not make sense. Since scavenging is the largest Be-7 sink in the troposphere, more detailed description of the scavenging scheme is required here beyond simply citing the reference of Tost et al. (2010), for example, how large-scale (stratiform) vs. convective scavenging and in-cloud vs below-cloud scavenging are separately treated.

9) P12, L218: a) if SPE-produced Be-7 is hardly detectable in the background, please explain why it is still necessary or interesting to study the transport of SPE-produced beryllium; b) The reason for differences in seasonal transport is not given. Is it because of the seasonal minimum of stratosphere-to-troposphere transport in fall? L221: what's the faster removal mechanism in winter?

10) What's Be-7 residence time against deposition in this model, as compared to those in other models (e.g., Brost et al. 1991; Koch et al., 1996, https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/96JD01176)? Simulated surface Be-7 concentrations are sensitive to wet/dry deposition.

More comments:

11) The text uses the word "beryllium isotopes" a lot but the paper mainly deals with Be-7 (and occasionally Be-10). Can you just say Be-7 (or Be-10)?

12) Abstract: "An interactive deposition scheme was applied including both wet and dry depositions" - I don't think you applied a single deposition scheme that include both wet and dry deposition. L10: you actually presented results for 2002 (Fig.8), so it's not a spinup year. By "lateral deposition", do you mean surface deposition? "including a perfect reproduction of the annual cycle" – I don't think it's perfect (see Fig.8). Please avoid using the word "perfect" in the text.

13) "Comparison with the real data of 7Be concentration in the near-ground air fully validates the model and its high accuracy." – Comparison with surface Be-7 observations from a limited number of locations does not fully validates the model. Again, I suggest the authors look up current literatures especially those on global modeling of Be-7, where information on global data sets of surface Be-7 concentrations, deposition fluxes, and/or high-altitude observations are available.

14) P2, L40-41 (also see P6, L126): "these models cannot be applied for the short-living 7Be isotope, whose half-life time is shorter than the typical atmospheric transport time" – Typical transport timescale in the troposphere is only ~hours to days.

15) P5, Figure 1: It is interesting to compare the production rates of Be-7 produced by GCR and SPE (even though they differ by magnitudes). However, these two panels use different units, making it hard to compare. Could you represent the production rates by SPE in “rates” instead of total production?

16) Figure 9: specify in caption which two stations and their locations (latitude/longitude). Y-Title should be "Deposition (Bq/m2/TIME)" since each quarter may contain different hours.

17) P14, L277-279: Why and how?

18) P15, L321-322: “The modelled beryllium distribution is also in general agreement with earlier computations based on a similar approach.” -- Which earlier work?