Atmos. Chem. Phys. Discuss.,
doi:10.5194/acp-2016-568-AC1, 2016

Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Processes controlling the seasonal variations of ^{210}Pb and ^{7}Be at the Mt. Cimone WMO-GAW global station, Italy: A model analysis" *by* Erika Brattich et al.

Erika Brattich et al.

hongyu.liu-1@nasa.gov

Received and published: 28 November 2016

We thank Reviewer # 1 for the detailed comments on our manuscript. Below please find our itemized replies.

1) page 10, line 9: What is the spatial resolution of the model simulations?

Reply – We have added this information in the text: "Meteorological data used to drive the CTM at 2° latitude by 2.5° longitude resolution, e.g., horizontal winds, convective mass fluxes and precipitation fields, are the Modern-Era Retrospective analysis for Research and Applications (MERRA) assimilated data set from the NASA Global Modeling and Assimilation Office (GMAO) (Rienecker et al., 2011)."

2) page 11, lines 3-6: The authors state " For the simulations of radionuclides, each simulation was run for six years, recycling the meteorological data for each year of the simulation, to equilibrate the lower stratosphere as well as the troposphere". Does this practically mean that it is simulated the same year for six times and that the first five years were used as a spin up time? Also please mention again here that the actual year of the simulation is 2005.

Reply – Yes. Thanks for pointing it out. Now the text reads "For the simulations of radionuclides, each simulation was run for six years, recycling the MERRA meteorological data for 2005, to equilibrate the lower stratosphere as well as the troposphere (Liu et al., 2001). The sixth-year output was used for analysis."

3) page 13, lines 20-21: The authors state that " In the model Mt. Cimone appears to be in a location where there is a large horizontal gradient of wind (transport)." Mind though that the model's winds in Figure 2 are from specific months in a single year (the year 2005) and hence do not actually represent a wind climatology of the respective months.

Reply – Indeed, the model's winds in Figure 2 are from specific months in a single year (2005) and do not represent a wind climatology of the respective months. However, we do not mean to represent a wind climatology here. We have revised the sentence to "In the model Mt. Cimone appears to be in a location where there is a large horizontal gradient of wind (transport) during 2005."

4) page 14, line 10-14: Note also that the etesian wind system at eastern Mediterranean in July is also well represented in Figure 2.

Reply – Indeed. We have added a sentence at the end of this paragraph: "However, MERRA is able to capture the summertime north-north easterly winds in the eastern Mediterranean (Aegean Sea), known as the Etesian winds, generated by thermal effects."

5) page 15, line 11-14: The authors state that "Large differences between the MERRA precipitation and that locally observed at the station are instead present (not shown): in particular, the MERRA precipitation is larger during winter-autumn, while it is much more similar to that observed during spring-summer." I would suggest to add information or a graph with the station-based observations of precipitation at Mt Cimone (even as supplementary material). Of course, MERRA data reflect large scale precipitation features while the station-based observations reflect local features. Nevertheless in your analysis you compare modelled Pb-210 and Be-7 radionuclide concentrations with the respective station based measurements at Mt Cimone, but these station based radionuclide measurements are presumably linked more with the local observation of precipitation than with large scale MERRA precipitation data.

Reply - We thank the reviewer for the suggestion. As reported later on in the manuscript (page 15, lines 16-22) the local precipitation pattern at Mt. Cimone is different from the regional pattern of the surrounding area, and this difference could partially explain the disagreement between the observed and simulated pattern of precipitation. As commented by the reviewer and discussed in the paper (page 14, lines 23-25; page 15, lines 1-2), local precipitation at the site is important to the scavenging of radionuclides and the difference between the observed and MERRA precipitation could contribute to the biases in our model simulations due to the errors in the precipitation scavenging of radionuclides. We have added information and revised the text to “Large differences between the MERRA precipitation and that locally observed at the station are instead present. While the daily mean observed 2005 precipitation is 0.81 mm, which is close to the corresponding precipitation (0.73 mm) in MERRA at the “ij” grid (i.e., a negative bias of -0.08 mm); the model bias is positive and much higher (0.31 – 1.28 mm) at adjacent grids. This bias may very well reflect again the fact that the observed surface precipitation is localized, whereas the satellite and MERRA precipitations correspond to a much larger scale (about 200 km).”

6) page 17, line 21-23: The authors state that "The correlation between observed and

simulated monthly 7Be activities also increases from R2 = 0.03 at “ij” to R2 = 0.11-0.60 at adjacent model gridboxes." Please specify at which grid-box you get 0.6 and discuss the reason for this considerable improvement.

Reply – The revised text reads “The largest value of R2 = 0.6 was obtained at the “ij-1” gridbox to the south of “ij” (Figure 6). This improvement is due to the large horizontal gradient in the simulated 7Be concentrations near the site (Figure 2).”

7) page 17, line 21-23: The authors state that " As for 7Be, the model well captures the March maximum (i.e., secondary maximum in the observations) and the general seasonal pattern during the cold and transition seasons." I think that this statement is not very consistent with Figure 5b. Actually, according to Figure 5b the model does not seem to capture the general seasonal pattern for Be-7.

Reply – To avoid confusion, we have revised the sentence to “As for 7Be, the model well captures the March maximum (i.e., secondary maximum in the observations) and the month-to-month variation during the cold and transition seasons (January-April, October-December).”

8) page 18, line 19-21: The authors state that " The simulated seasonal pattern of the 10Be/7Be ratio is very similar to the observations at Zugspitze (Germany, 2962 m asl) (Zanis et al., 2003), characterized by a not-pronounced seasonal cycle". In fact the simulated Be-10/Be-7 ratio in Figure 5d has a clear seasonal cycle and looking the respective graph Figure 3 from the cited paper of Zanis et al., 2003, I see a better agreement with Jungfraujoch than with Zugspitze.

Reply - Thanks the reviewer for pointing this out to us. Accordingly, we have revised the text to “The simulated seasonal pattern of the 10Be/7Be ratio is very similar to the observations at Jungfraujoch (Switzerland, 3580 m asl) (Zanis et al., 2003), characterized by a clear seasonal cycle with peak ratios in spring.”

9) page 19, line 9-11: The authors state that " However, the model tends to over-

estimate the observed 7Be concentrations and 7Be/210Pb ratios during December-February, suggesting that STE and/or subsidence in the model is likely too fast in this region." This is a rather speculative comment. It needs more justification. What do you mean with too fast? Maybe stronger STE fluxes? Are there any references showing how the STE fluxes of this model compares with other global CTMS or GCMs?

Reply – This statement is for the site of Mt. Cimone and year 2005, and is only suggestive. To address the reviewer's concern, we have added a new reference and revised the text to "However, the model tends to overestimate the observed 7Be concentrations and 7Be/210Pb ratios during December-February, suggesting that stratospheric influence and/or subsidence in the model is probably too strong in this region at this time of the year. It is noted that globally integrated STT mass fluxes in the MERRA reanalysis are actually smaller than in some other reanalyses, e.g., ERA-Interim, JRA-55, and MERRA-2 (Boothe and Homeyer, 2016)."

10) page 19, line 11-13: The authors state that "As reported by Huang et al. (2013), a stronger net subsidence of air masses to the surface could be due to unrealistic meteorological conditions (e.g., boundary layer structure, wind fields, vertical mixing)." This is a rather general comment. Is this true for the meteorological data used here in the CTM? Please clarify this issue.

Reply – To avoid confusion, we have removed this sentence.

11) page 20, line 19-20: The authors state that "The model annual average biases are about 8% for 210Pb and about 19% for 7Be, respectively. By contrast, the model average bias for 7Be/210Pb ratios is about -13% (Figure 7)." Please comment on the error propagation on the ratio.

Reply – We comment on the error propagation on the ratio after this statement: "The smaller model bias for 7Be/210Pb ratios than for 7Be concentrations reflects the fact that the ratio cancels out the errors in precipitation scavenging (Koch et al. 1996) that contribute to the underestimate of 210Pb and 7Be activities. On the other hand, the

negative model bias for the 7Be/210Pb ratio again points to weak downward mixing from the free troposphere."

12) page 22, line 8-9: The authors state that " ... suggesting that large-scale circulation in this region with complex topography may not be resolved by the coarse-resolution model." I guess you mean that regional and local circulations are not resolved by the global model.

Reply – Indeed. We have revised the sentence to "None of our simulations is able to describe the observed 7Be summertime peak, suggesting that local and regional circulations in this region with complex topography may not be resolved by the coarse-resolution model."

13) page 24, line 1-4: The authors state that "The model underestimate of 7Be levels in the warm months is partly due to the sensitivity to spatial sampling in the model, but also suggests that the mixing of air masses between the PBL and the lower free troposphere is likely too weak." If the model mixing between the PBL and the lower free troposphere becomes stronger then this will result in more mixing of PBL air poor in Be-7 with free tropospheric air, hence even smaller concentrations of Be-7 and larger model underestimate of Be-7 at Mt Cimone.

Reply - The vertical mixing between the PBL and the lower free troposphere includes both an upward motion from the PBL to the lower free troposphere (poor in 7Be), and a downward motion from the lower free troposphere to the PBL (richer in 7Be). We have changed the sentence to "The model underestimate of 7Be levels in the warm months is partly due to the sensitivity to spatial sampling in the model, but also suggests that the mixing of air masses between the PBL and the lower free troposphere (e.g., via convection and compensating subsidence) is likely too weak during summer when the Mt. Cimone station is located within the PBL."

14) To my understanding, the authors claim that the CTM cannot capture the observed seasonal cycle of Be-7 with a summer max at Mt Cimone because of local features

which are not resolved in the model. However mind that the summer maximum Be-7 at Mt Cimone is also apparent at Jungfraujoch, Sonnblick and Zugspitze (see e.g. Figure 7 in Gerasopoulos et al., 2001). So maybe this feature does not seem to be a very local phenomenon but is rather of larger horizontal scale.

Reply - The fact that the CTM cannot capture the observed seasonal cycle of 7Be is due to a combination of factors. Firstly, results show sensitivity to spatial sampling in the model, which can be clearly seen from a better simulated 7Be seasonal cycle at some adjacent gridboxes. Secondly, the summer 7Be maximum observed at mountain sites such as Mt. Cimone, Jungfraujoch, Sonnblick, and Zugspitze results from downward transport of 7Be due to compensating subsidence associated with summertime convective mixing (Gerasopoulos et al., 2001), which the coarse-resolution model may not be able to correctly represent.

Interactive comment on Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-568, 2016.