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Interactive comment on "Sensitivity of Global Modeling Initiative chemistry and transport model simulations of radon-222 and lead-210 to input meteorological data" *by* D. B. Considine et al.

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We thank the referees for their numerous useful comments and suggestions. Our revised manuscript will take these comments and suggestions into account. Below is a detailed response to the referee comments, including our planned manuscript revisions.

Reply to Referee 1:

1. The referee is correct that the convective parameterizations used by the MACCM3, GISS II', and GEOS- STRAT models are responsible for some of the differences in the GMI radionuclide simulations described in this paper. This is so because the

parameterizations generate the convective mass fluxes as well as the cloud entrainment and detrainment rates which are used in the GMI CTM. The convective data from GEOS-STRAT was generated by the Relaxed Arakawa-Schubert scheme of Moorthi and Suarez (1992). The convective data from the GISS II' GCM was generated by the parameterization of DelGenio and Yao (1992), and the data from MACCM3 was generated by the Zhang and McFarlane (1995) scheme. We will include this information in the revised manuscript.

2. The influence of vertical resolution on vertical tranport through the troposphere and into the stratosphere is an interesting question. However, we feel that it is not possible to make a general statement regarding the influence of vertical resolution in the meteorological data sets on convective transport in the GMI simulations presented in this paper. This is because we do not know how changes to vertical resolution in the parent models generating the meteorological data which was used to drive the GMI CTM would affect the convective parameterizations of those models. Also, vertical resolution changes in the parent models will affect large-scale horizontal and vertical wind fields, upon which the role played by convection will also depend.

3. A freely-running general circulation model which is not being disturbed by insertion of observational data will develop a climate solution that is unique to that GCM, but is hopefully a good approximation to the climate of the Earth. Because GCMs have internal variability, each year will be somewhat different from the previous year. None of these years can be said to correspond to a particular year on Earth, however. This is the case with MACCM3 and GISS. When a GCM is incorporated in a data assimilation system, the run is constrained by observations and becomes an approximation of the specific time period during which those observations were made. This is the case with the GEOS-STRAT meteorological data. Thus we can say that the GEOS-STRAT data set corresponds to a particular year, but the other two data sets do not.

4. We will make the suggested technical corrections in the revised manuscript.

Reply to Referee 2:

1. We will add the reference and correct the wording on pages 5328 and 5330, as suggested.

2. Although the simulation description (section 3) repeats some material already covered prior to the section, we feel that it is useful to include a section that describes reasonably completely the simulations we evaluate in this paper. Since the section is quite short we do not feel that its repetition of previously explained details compromises the paper unduly.

3. The referee is correct that transport could be playing a role in the overprediction at high latitudes in the Northern Hemisphere of Pb-210 deposition in all of the simulations. Since high latitude Rn-222 emission is small compared to emission at lower latitudes, transport between mid and high latitudes would need to be overly vigorous to be responsible for the overestimate of high latitude Pb-210 deposition. (Too weak transport would tend to isolate the high latitudes from midlatitude Pb-210 concentrations, thus lowering high latitude Pb-210 deposition rather than raising it.) Our omission of this possibility in the manuscript was an oversight which we will correct in the revised version.

Reply to Referee 3:

1. The simulations were conducted for six years in order to ensure convergence of the Pb-210 distribution to an approximate annually repeating steady- state condition in the upper troposphere/lower stratosphere. (The lifetime of Pb-210 can get long in the upper troposphere/lower stratosphere due to weak scavenging in this region.) The meteorological data was recycled for each year of the simulations. If we had only run for one or two years we would not know whether model/measurement differences were due to the characteristics of the meteorological data used to drive the simulations, or lack of convergence. After five or six years, year-to- year changes in modeled distributions are quite small, so there is no reason to continue a simulation beyond that point.

We will explain this more carefully in Section 3 of the revised version.

2. Our comment that Pb-210 deposition can be used as a check of Rn-222 emissions is based on the fact that in a steady-state situation, production and loss must be equivalent. The only source of Pb-210 is emission of Rn- 222 and subsequent radioactive decay of Rn-222 to Pb-210. Since the vast majority of Rn-222 which is emitted in our simulations decays to Pb-210 before it is deposited to the surface, it must be that Rn-222 emission and Pb-210 loss balance, at least in a globally-averaged sense. The processes of transport, mixing, and scavenging can affect the geographical distribution of Pb-210 deposition, and they can also determine atmospheric concentrations of Pb-210. (For instance, if the scavenging rate is too high, atmospheric concentrations will be low.) Regardless the deposition will still balance emissions.

Because the geographic distribution of deposition is influenced by the physical processes mentioned by the referee, the referee is correct that these factors can influence the meridional distribution of deposition shown in Figure 2 of the manuscript. The revised version will include a revised discussion of the figure in order to better explain its implications.

3. The referee is correct that there are substantial known variations in the emission rate of Rn-222. Our source specification is thus valid only in an average sense. This is mentioned briefly in Section 3. In the revised version we will discuss this more completely, and refer to the Lee et al. (2004) study mentioned by the referee as evidence of local fluctuations in Rn-222 emission.

4. The Lee et al. (2004) paper mentioned by the referee discusses Pb-210 measurements made at two sites in China. At one of these sites, measurements were made for over a year, at the other they were made for several months. The Pb-210 concentrations measured at these locations are quite a bit higher than measurements made at other locations in the same latitude bands. If these two measurements were included in the set of observations used to construct Figure 8, the discrepancy between the

simulations and the observations at the latitudes of the Chinese observations would certainly increase. Lee et al. (2004) compared a global model simulation similar to ours to the Chinese measurements and concluded on the basis of the model's under-prediction of the measurements that local Rn-222 emissions at these two sites could be up to a factor of three larger than their 1 atom/cm/s model assumption. Because the high Pb-210 measurements discussed in Lee et al. (2004) are likely to be due to local Rn-222 source variations, and those local variations are not included in our Rn-222 source function, we believe that it is inappropriate to include the observations from China in the set of observations used to construct Figure 8 and Table 2. It is beyond the scope of this paper and our relatively low-resolution model to examine specific locations in detail.

5. See answer 4, above.

6. As we discuss in our paper, the comparison of simulated and observed Pb-210 deposition shown in Figure 2 suggests that the Rn-222 emissions used in the simulations are adequate on the global scale and in the Northern Hemisphere midlatitudes. Thus on page 5340 we suggest that the lower-than-observed surface concentrations of Pb-210 in the Northern Hemisphere midlatitudes could be due to excessive scavenging. If Rn-222 emissions over Asia were increased sufficiently to produce good agreement of simulated and observed surface Pb-210 concentrations elsewhere, the simulated deposition shown in Figure 2 might then be too high. A comprehensive study would be necessary to quantitatively establish the global role of Asian Rn-222 emissions. While very interesting, such a study is beyond the scope of this paper.

7. Yes. We use the terms interchangeably.

8. In our simulations the effects of convective transport on Rn-222 and Pb-210 differ substantially because Pb-210 is scavenged in convective updrafts while Rn-222 is not. For Rn-222, convection is the dominant vertical transport process in all three cases, while large-scale (resolved scale) vertical transport plays an important but secondary

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role. The effect of convection on Pb-210 concentrations is different. Scavenging of Pb-210 in the convective updraft competes with the upper tropospheric Pb-210 source that results from convective transport of Rn-222. In the GMI/GMAO simulation, scavenging wins and Pb-210 concentrations are lower everywhere than they would be in the absence of convection. In the other two simulations, scavenging does not completely negate the upper tropospheric Pb-210 source, so there are increases at higher altitudes in these simulations. There is therefore no conflict in these results.

9. We will make the technical corrections suggested by the referee.

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Interactive comment on Atmos. Chem. Phys. Discuss., 5, 5325, 2005.