

Vertical transport of tropospheric aerosols as indicated by ^7Be and ^{210}Pb in a chemical tracer model

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Abstract

We use the natural radionuclides ^7Be and ^{210}Pb as aerosol tracers in a three-dimensional chemical tracer model (based on the Goddard Institute of Space Studies general circulation model (GCM) 2) in order to study aerosol transport and removal in the troposphere. Beryllium 7, produced in the upper troposphere and stratosphere by cosmic rays, and ^{210}Pb , a decay product of soil-derived ^{222}Rn , are tracers of upper and lower tropospheric aerosols, respectively. Their source regions make them particularly suitable for the study of vertical transport processes. Both tracers are removed from the troposphere primarily by precipitation and are useful for testing scavenging parameterizations. In particular, model convection must properly transport and scavenge both ascending ^{210}Pb and descending ^7Be . The ratio $^7\text{Be}/^{210}\text{Pb}$ cancels most model errors associated with precipitation and serves as an indicator of vertical transport. We show that over land the annual average $^7\text{Be}/^{210}\text{Pb}$ ratio for surface concentrations and deposition fluxes varies little globally. In contrast, the seasonal variability of the $^7\text{Be}/^{210}\text{Pb}$ concentration ratio over continents is quite large; the ratio peaks in summer when convective activity is maximum. The model overestimates ^7Be in the tropics, a problem which we relate to flaws in the GCM parameterization of wet convection (excessive convective mass fluxes and no allowance for entrainment). The residence time of tropospheric ^7Be calculated by the model is 23 days, in contrast with a value of about 9 days calculated for ^{210}Pb , reflecting the high-altitude versus low-altitude source regions of these two tracers.
