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Effect of Rain Scavenging on Altitudinal Distribution of Soluble Gaseous Pollutants in the Atmosphere

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Wet deposition, including precipitation scavenging by rains, is one of the most important removal mechanisms that control the distribution, concentration and life-time of many gaseous species in the atmosphere. We analyze precipitation scavenging of soluble hazardous gases from the atmosphere by rain droplets. The developed model is valid for low gradients of soluble gaseous pollutants in a gaseous phase and is suitable for predicting scavenging of moderately soluble gases, e.g., sulfur dioxide (SO2), ammonia (NH3) etc. from the atmosphere. Using the equation of mass balance for soluble gaseous species in gaseous and liquid phases we derived a nonstationary convective-diffusion equation for evaluating the amount of precipitation required for scavenging of various soluble gaseous pollutants from the atmosphere and determined transient altitude distribution of these gases in the atmosphere during rain fall. This equation was derived without assumption of "equilibrium scavenging" of soluble gases by rain droplets. Numerical solution of the derived equation with the appropriate initial and boundary conditions showed that soluble gas in the atmosphere is washed down by precipitation and is smeared by diffusion. Using the suggested model we analyzed the temporal evolution of the vertical profiles of ammonia and sulfur dioxide in the atmosphere caused by their washout. We calculated also scavenging coefficient. It was showed that the magnitude of scavenging coefficient varies with time and altitude and depends on the vertical distribution of soluble gaseous pollutants in the atmosphere, parameter of gas solubility and on the rain intensity.
In addition, we suggest simple analytical formulas for "equilibrium scavenging" of moderately soluble gases and for scavenging of highly soluble gases, such as HNO3 or H2O2 by rain. Model of equilibrium scavenging is developed under the assumption about the equality between the instantaneous concentration of the dissolved gas in a droplet and concentration of saturation in liquid corresponding to the concentration of a trace soluble gas in an atmosphere at a given height. Formulas for evolution of vertical profile and scavenging coefficient of highly soluble gases are independent of the solubility parameter.

Keywords: rain droplet, hazardous gases, gas absorption, scavenging, atmosphere

References

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