EMS Annual Meeting Abstracts
Vol. 8, EMS2011-558, 2011
11th EMS / 10th ECAM

Forecasting the weather
- ensemble techniques
in probabilistic weather prediction

Rain Scavenging of Moderately and Highly Soluble Gaseous Pollutants in the Atmosphere

B. Krasovitov (1), T. Elperin (2), and A. Fominykh (3)

(1) Department of Mechanical Engineering, The Pearlstone Center for Aeronautical Engineering Studies, Ben-Gurion University of the Negev, P.O.Box 653, 84105, Israel (borisk@bgu.ac.il / Fax: +972-8-6472813), (2) Department of Mechanical Engineering, The Pearlstone Center for Aeronautical Engineering Studies, Ben-Gurion University of the Negev, P.O.Box 653, 84105, Israel (elperin@bgu.ac.il / Fax: +972-8-6472813), (3) Department of Mechanical Engineering, The Pearlstone Center for Aeronautical Engineering Studies, Ben-Gurion University of the Negev, P.O.Box 653, 84105, Israel (fominykh@bgu.ac.il / Fax: +972-8-6472813)

We analyze precipitation scavenging of soluble trace gases from the atmosphere by rain. The developed model is valid for low gradients of soluble gaseous pollutants in a gaseous phase. Using mass balance equation for soluble gaseous species in gaseous and liquid phases we derived a transient convective-diffusion equation for evaluating the amount of precipitation required for scavenging of moderately soluble gaseous pollutants such as sulfur dioxide (SO_2) and ammonia (NH_3) from the atmosphere and determined transient altitudinal 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. In our calculations we assumed the log-normal size distribution of raindrops with Feingold and Levin parameterization based on the long-time measurements of rain drops size spectra in Israel. Droplet size distribution was taken into account using the Monte Carlo method whereby the trace gas concentration profile was calculated by solving the diffusion equation with effective Peclet number for a droplet diameter that was randomly sampled from the probability density function. We analyzed the temporal evolution of the vertical profiles of ammonia and sulfur dioxide in the atmosphere caused by their washout and determined 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.

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 a liquid corresponding to the concentration of a trace soluble gas in an atmosphere at a given height. The derived first order partial differential equation describing "equilibrium scavenging" of soluble gaseous pollutants with appropriate initial and boundary conditions was solved by the method of characteristics. It is shown that the process of "equilibrium scavenging" is independent on the coefficients of diffusion in gaseous and liquid phases.

We also suggest simple analytical formulas for temporal evolution of the vertical concentration profile of highly soluble gases, such as HNO_3 or H_2O_2 in the atmosphere caused by rain scavenging. Formulas for evolution of the vertical profile and scavenging coefficient of highly soluble gases are independent of the solubility parameter.

Keywords: droplet, gaseous pollutants, gas absorption, scavenging, atmosphere

References

Elperin T., A. Fominykh and B. Krasovitov, Scavenging of soluble trace gases by falling rain droplets in inhomogeneous atmosphere, *Atmospheric Environment*, **44**, 2133–2139, 2010.

T. Elperin, A. Fominykh, B. Krasovitov and A. Vikhansky, Effect of Rain Scavenging on Altitudinal Distribution of Soluble Gaseous Pollutants in the Atmosphere, *Atmospheric Environment*, **45**, 2427–2433, 2011.