ELSEVIER

Journal of Quantitative Spectroscopy & Radiative Transfer 102 (2006) 257–260

Journal of Quantitative Spectroscopy & Radiative Transfer

www.elsevier.com/locate/jqsrt

Cosmic ray–aerosol–cloud interactions in the atmospheric environment: Theoretical aspects

Z.N. Begum*

Department of Science and Technology (NCMRWF), New Delhi

Received 30 June 2005; accepted 7 February 2006

Abstract

The microphysical and radiative processes involved in the interaction of cosmic radiation with the aerosol particulates in the atmosphere aggravate the ion-induced formation of aerosol particles that can act as cloud condensation nuclei (CCN). This may in turn affect the cloud droplet distribution and optical properties of clouds and enhance the process of rising global temperature depending upon the microphysical mechanism. Major observational information about the abundance of aerosols in the tropical atmosphere are obtained from the Indian Ocean experiment (INDOEX) field experiments and about the solar activity and solar cycle from the satellite observations. It has been noticed that when solar activity is less, more cosmic rays pass through the atmosphere, which activate the aerosols already present in the tropical atmosphere. The fluctuations in the cosmic rays due to variations in the solar activity can produce significant changes in the atmospheric environment.

Keywords: Cosmic ray–aerosol–cloud interactions; Atmospheric environment

1. Introduction

Cosmic rays are mainly nucleons, protons and neutrons of an atom. It is estimated that only 1% of cosmic rays are electrons and positrons. Cosmic rays can have extremely high energies (up to 10^{20} eV or 10 J for a single particle). Cosmic rays lead to the formation of atmospheric ions. Cosmic rays vary in energy, but the lowest energy cosmic rays are affected by changes in the solar activity; when the sun is active, the cosmic ray flux is reduced. Atmospheric ions can influence the formation and growth of new atmospheric aerosols. The charged molecular clusters, condensing around natural air ions, are much more stable and can grow significantly faster than corresponding neutral clusters. Studies found correlations between variations in cosmic radiation and many aspects of the atmosphere which may be significant in climate change, including low cloud formation, which has significant influence on the atmospheric radiation budget. It has been demonstrated that air ions generated by galactic cosmic ray (GCR) ionization may play an important role in the production of new particles under typical tropospheric conditions [1,2]. The aerosols influence the

*Correspondence address. B4-421, Ekta Gardens, 9, I.P. Extension, Patpar Ganj, Delhi-110092, India Tel.: +91 11 22723245.
E-mail address: begumzn@hotmail.com.

0022-4073/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jqsrt.2006.02.016

formation and growth of clouds in two ways: aerosols scatter directly and absorb solar radiation both in cloud free and cloudy condition and indirectly via their role as cloud condensation nuclei (CCN). Aerosols modify the optical properties of clouds. Increase in aerosols and CCN concentrations affects the radiative properties of clouds by increasing the optical thickness of clouds. The chemical and physical properties of atmospheric aerosol particles strongly affect the development of clouds and precipitation. As aerosols pass through the cloud, some of them are activated to form CCN which grow to become cloud droplets. Indian Ocean experiment (INDOEX) observations reveal the presence of abundant aerosols and gases in the tropical atmosphere. Interaction of cosmic ray ions may enhance the process of new particle formation, and hence the aerosol cloud nucleation process.

2. Theoretical aspects

Cosmic ray activity influences the climate on Earth's atmosphere. Clouds play a major role in the energy budget of the troposphere. There is a correlation between the amount of cosmic rays and cloud cover. The anthropogenic particles such as aerosol black carbons emanating as smokes and soots are responsible for solar absorbtion and hence warming, though there are aerosol particles which are more reflective and cause cooling effect. Continental aerosols (INDOEX) mostly causing warming effects are released during the burning of fossil fuels, etc. As long as the nonabsorbing particles predominate the atmosphere, it loses energy, it gains energy only with absorbing supplementary materials such as soot, admixture of carbonaceous residues from combustion processes and dust particles that warm up the atmospheric environment. The air ions generated by

Fig. 1. Cosmic ray shower in the Earth's atmosphere.