Cloud cover anomalies at middle latitudes: links to troposphere dynamics and solar variability

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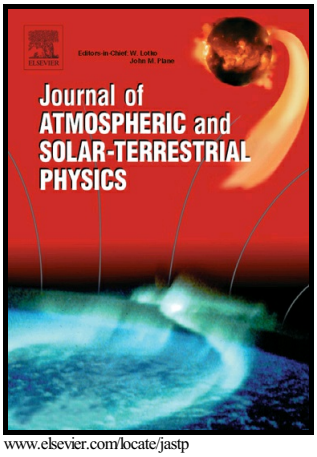

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Cloud cover anomalies at middle latitudes: links to troposphere dynamics and solar variability

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Abstract

In this work we study links between low cloud anomalies (LCA) at middle latitudes of the Northern and Southern hemispheres and galactic cosmic ray (GCR) variations used as a proxy of solar variability on the decadal time scale. It was shown that these links are not direct, but realized through GCR/solar activity phenomena influence on the development of extratropical baric systems (cyclones and troughs) which form cloud field. The violation of a positive correlation between LCA and GCR intensity which was observed in the 1980s-1990s occurred simultaneously in the Northern and Southern hemispheres in the early 2000s and coincided with the sign reversal of GCR effects on troposphere circulation. It was suggested that a possible reason for the correlation reversal between cyclonic activity at middle latitudes and GCR fluxes is the change of the stratospheric polar vortex intensity which influences significantly the troposphere-stratosphere coupling. The evidences for a noticeable weakening of the polar vortices in the Arctic and Antarctic stratosphere in the early 2000s are provided. The results obtained suggest an important role of the polar vortex evolution as a reason for a temporal variability of solar activity effects on the lower atmosphere.

Key words: solar-atmospheric links, galactic cosmic rays, clouds, atmosphere dynamics

1. Introduction

The hypothesis that cloud cover changes associated with variations of galactic cosmic rays (GCRs) is an important link in solar-climate connections has been widely discussed for the last two decades. This idea was first proposed by Dickinson (1975) who suggested that high-level clouds may be affected by GCRs which results in changes of the radiative-thermal budget of the atmosphere. Later possible mechanisms of GCR influence on cloud microphysics were developed in a number of works. One can stress electric mechanisms involving changes in atmospheric electric current density which influence electrofreezing and electroscavenging in clouds (Tinsley and Deen, 1991; Tinsley, 2008; Lam and Tinsley, 2015), as well as mechanisms involving ion-mediated nucleation of aerosol particles (Yu, 2002, 2004). Experimental data suggesting cloud-GCR links were obtained by Pudovkin and Veretenenko (1995), the data from ground-based actinometric stations being used. A noticeable reduction of cloud amount associated with short-term decreases of GCR fluxes (Forbush decreases) was detected at the stations at middle and high latitudes in Russia. On the decadal time scale a strong positive correlation between monthly values of global cloud amount and galactic cosmic rays was found by Svensmark and Friis-Christensen (1997), the data by satellite observations ISCCP (International Satellite Cloud Climatology Project) being used. These results gave rise to intensive discussion of GCR effects on clouds (Kernthaler et al., 1999; Gierens and Ponater, 1999; Jorgensen and Hansen, 2000; etc). According to the further research by March