Abstract

Amr A Thabet Abouzaid

An Influence of Solar Variation on Radiative Forcing of the Earth’s Climate

The study of solar variability and its influence on the Earth has always been a challenging problem for researchers, as it describes many different processes occurring mostly in the Sun’s convection zone, the photosphere and atmosphere. Three topics describe the influence of solar variability on the Earth's climate, which are: solar variability, solar-terrestrial interactions and the mechanisms of the Earth’s climate system. The solar outputs are responsible for the changes in the Earth’s environment which cause disturbances in the geomagnetic activities and produces geomagnetic storms with various magnitudes. Also, the solar magnetic field directly or/and indirectly disturbs the interplanetary space, ionosphere, magnetosphere and even atmosphere. Galactic cosmic ray rates (GCRs), cloud condensation nuclei (CCN), solar-cycle length, the aa geomagnetic activity index, CO2 concentration, global surface temperature (GST), the near-Earth temperatures and the atmospheric and ozone layers, have been examined. The present work confirmed the contribution of changing galactic cosmic ray flux to global warming. It implies that GCR provides a significant effect in helping condensation nuclei to form clouds. Well correlations between IR low cloud amounts and primary GCRs, which act as nuclei for cloud condensation, clearly displayed that the decrease in GCRs results in lesser low cloud cover. Thus then, the reduction of albedo radiation that reflected back into space increases the surface temperature of the Earth. We presented evidence showing that the radiative forcing component due to the decrease in GCRs during the recent years is 0.48 Wm–2, which is about 30 % of that due to CO2 increase. The variations of TSI can explain the increase in temperature, and it accounts 0.32 ºC of the 0.8 ºC warming experienced from 1950 to 2016. It signifies that other forcings (most probably anthropogenic emission of greenhouse gases) are responsible for the rapid increase in surface temperature observed during the 20th century. Therefore, we think that the future prediction of global warming should take into account the effect due to long-term changes in the galactic CRs, the low-level cloud condensations, and of course the geomagnetic indices. Extrapolation of the intensity of galactic cosmic radiation using 10Be measurements in deep polar ice as a proxy clearly showed that the GCR has decreased by 14 % during the recent 56 years and in turn, the TSI has increased by 0.48 W/m2, due to the continuing increase in solar activity (~ 26 %). In addition, the concentrations of CO2 increased in the upper atmosphere by 19 % during last 65 years. That rising of CO2 is largely responsible for climate change over the recent years. The ISCCP IR measures of global cloud condensation cover at low level showed a strong correlation with the observed variation of CR during the period from 1984 to 1998. In the next years from 1999 to 2009, the data do show nearly a steady decreasing low cloud cover which is matched by an increase in middle-level cloud cover. This could be caused by a small shift in cloud height. Strong correlation between LCC and GST has been obtained, which comes out to be -0.9 ± 0.03. Our results clearly showed that there is a linear relationship between LCA and GST at opposite/different time lags. The anti-correlation between LCA and GST displayed that even at late earlier months the correlation between them still exist which confirmed that any observed reduction in the LCA, as a result of a reduction in GCRs, will be reflected an increase in the observed global surface temperature. The variation of global temperature anomaly ?T with the CR rate showed a quasi-relationship every 18-21 year. Both measurements confirmed that there exists two opposite directions/correlations in a cyclic extends for 18-21 yrs. Every solar activity cycle has different behavior to the sensitivity of GST according to different modulations of CRs by solar wind/magnetic parameters. Higher solar irradiance, lower cosmic ray fluxes, and greater geomagnetic activity, all occur when solar activity is greater. Furthermore, the correlations between Rz and the northern hemisphere, southern hemisphere and global temperatures are 0.374, 0.514 and 0.4435, respectively. That is, the sunspot numbers can explain between 40 % and 50 % of temperature variance in the troposphere layer. In the case of TSI, the correlation values increase to 0.879,

0.900 and 0.903, respectively. That is, the TSI has a greater role, between 75% and 85%, for the temperature variance. Furthermore, analytical study of the links between solar-geomagnetic activities and global-regional surface temperatures by using the wavelet analysis technique has been examined. The monthly and yearly of geomagnetic aa, Ap, and Kp indices, total solar irradiance, sunspot number, coronal index, solar radio flux of 10.7 cm, galactic cosmic rays (GCRs) of Climax counting rates, and global surface temperature, have been used. Also, we used Egypt surface temperatures as a case study of regional climate change. The global wavelet spectra for monthly parameters showed that the dominant period of 10.7-yr is clearly reflected in spectra of aa, Ap, Kp, and Rz, while TSI and CI displayed a significant of 9.8-yr peak. The GST during 1850-1940, indicated significant periods of 5.8-yr, 9.8-yr, 19.6-yr, and 23.3-yr which may be related to the solar and geomagnetic activities. For the period the period 1971-2015, there are periodicities of wavelengths of 3.5-yr, 8.3-yr, and 19.7-yr. In case of regional climate, Egypt's surface temperatures displayed irregular and progress changes (or increases) during the second half of the 20th century to the beginning of the 21st century, especially for the last four decades (1970-2015). The WPS of EST reveals periods of 2.7, 5.3, 8.3, 23.4, 39.3, and 60.6 years, confirming a remarkable role of solar-geomagnetic indices and GCRs on Egypt's climate, whereas the peak ~ 5.3-yr appeared in all geomagnetic indices. The Hale cycle periodicity (~ 23.3-yr) that appeared in Egypt's GWS found in all solar parameters (TSI, Rz, CI, and F10.7cm) and geomagnetic aa-index. In addition, the peak around 39.3 years also found in aa, Ap, Kp, and Rz global wavelet spectrum. Moreover, the periodicity of 60.6-yr that appeared in EST spectra with maximum power in GWS did not appear in any solar-geomagnetic indices, except in GCRs spectrum.