Astrophys Space Sci (2012) 338:217–226
DOI 10.1007/s10509-011-0932-2

ORIGINAL ARTICLE

Solar cycle variations in the growth and decay of sunspot groups

J. Javaraiah

Received: 28 July 2011 / Accepted: 13 November 2011 / Published online: 30 November 2011

Abstract We analysed the combined Greenwich (1874–1976) and Solar Optical Observatories Network (1977–2011) data on sunspot groups. The daily rate of change of the area of a spot group is computed using the differences between the epochs of the spot group observation on any two consecutive days during its life-time and between the corrected whole spot areas of the spot group at these epochs. Positive/negative value of the daily rate of change of the area of a spot group represents the growth/decay rate of the spot group. We found that the total amounts of growth and decay of spot groups whose life times ≥ 2 days in a given time interval (say one-year) well correlate to the amount of activity in the same interval. We have also found that there exists a reasonably good correlation and an approximate linear relationship between the logarithmic values of the decay rate and area of the spot group at the first day of the corresponding consecutive days, largely suggesting that a large/small area (magnetic flux) decreases in a faster/slower rate. There exists a long-term variation (about 90-year) in the slope of the linear relationship. The solar cycle variation in the decay of spot groups may have a strong relationship with the corresponding variations in solar energetic phenomena such as solar flare activity. The decay of spot groups may also substantially contribute to the coherence relationship between the total solar irradiance and the solar activity variations.

Keywords Sun: dynamo · Sun: surface magnetism · Sun: activity · Sun: sunspots · (Sun:) solar-terrestrial relations

J. Javaraiah (✉)
Indian Institute of Astrophysics, Bangalore 560034, India
e-mail: jj@iiap.res.in

1 Introduction

Solar activity affects us in many ways. Flares and coronal mass ejections pose a serious hazard to astronauts, satellites, polar air-traffic, electric power grids and telecommunications facilities on short time-scales ranging from hours to days. The solar radiative output affects planetary and global climate on much longer time-scales (from decades to stellar evolutionary time-scales). The study of varitions in solar activity is important for understanding the underlying mechanism of solar activity and for predicting the level of activity in view of the activity impact on space weather and global climate (Hathaway 2009).

Recently (Javaraiah 2011a, hereafter Paper-1) using the combined Greenwich (May/1874 to 1976) and Solar Optical Observatories Network (1977–2009) data on sunspot groups, we studied the long-term variations in the daily mean percentage growth and decay rates of sunspot groups. Two of the main results found from this study are: (i) From the beginning of Cycle 23 the growth rate is substantially decreased and near the end (2007–2008) the growth rate is lowest in the past about 100 years. (ii) In the extended part (beyond the length of the declining part of a normal cycle) of the declining phase of this cycle, the decay rate steeply increased and it is largest in the beginning of the current Cycle 24. These unusual properties of the growth and the decay rates during Cycle 23 may be related to cause of the very long declining phase of this cycle with the unusually deep and prolonged current minimum. However, no significant correlation was found either between spot group growth rate and sunspot number or between the latter and spot group decay rate. The patterns of variations in the growth and decay rates are found to be considerably different in different cycles. In fact, the mean percentage growth rate of the spot groups in the declining phases of some cycles is found to be