Long-Term Datasets for the Understanding of Solar and Stellar Magnetic Cycles
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Variation of the meteor count rate and echo height during solar cycle 23 and 24

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Abstract. The meteoroid ablation is an important source of upper atmosphere metal atoms. Many meteoroids ablate between 70 - 110 km and form an ionized plasma trail which is detected by radar technique. It is also known that the ablation heights of the meteors depend on various factors such as velocity, mass, and its composition, etc. The meteor ablation height provides new opportunities to gather information on the neutral atmosphere in the Mesosphere and Lower Thermosphere (MLT) region. In this study, we analysed the 11 years of meteor radar data (2005 - 2015), i.e., descending phase of solar cycle 23, and ascending phase of solar cycle 24, detected by all sky meteor radar at Thumba. We found that the solar activity influences the meteor ablation height, here, during the solar maxima meteor peak detection height rise to few hundred meters higher altitudes. We also examined the long term pattern of the meteor count rate which shows a decreasing trend and has good agreement with the sunspot number (SSN).

Keywords. Meteor, Meteor radar, Solar cycle

1. Introduction

A radar meteor echo is the scattering signature of free electrons generated by the entry of extraterrestrial meteoroid particle that ablates in the Earth's atmosphere (McKinley, 1961). The meteor ablation is the only source of metallic ions in this region of the ionosphere. The atmosphere and the ionosphere varies with the change of solar activity. To know the properties of this region of the atmosphere, the radar echoes from underdense meteor trails have been using for decades. Modern meteor radars provide information of the height distribution of meteor echoes which vary between 70 and 110 km with a peak around 90 km (Stober *et al.*, 2008). The meteor ablation height depends on its size, entry velocity and density in the Earth's atmosphere. The meteor ablation also gives an opportunity to get the further information on the neutral atmosphere in the MLT-region. The purpose of present study is to understand the effect of seasonal and solar cycle variation on sporadic meteor count rate and its peak occurrence height during the solar cycle 23 and 24.

2. Observations

The present study is based on sporadic meteor observations at Thumba (8.5°N, 77°E), India. The radar system operates at 35.24 MHz frequency, transmitting 2144 pulses/sec with three-element Yagi transmitting antannae, and using five receiver antennas forming an interferometric array. Interferometric analysis of the received meteor signal provides the information to find out its position in the sky with an angular resolution of less than 2°. In order to measure the radial velocity along the line of sight of the trail, the radar uses the Doppler shift of the reflected radio wave from ionized meteor trails. Further technical details and system description of the sky meteor radar can be found in Hocking *et al.* 2001, including criteria for meteor trail detection.

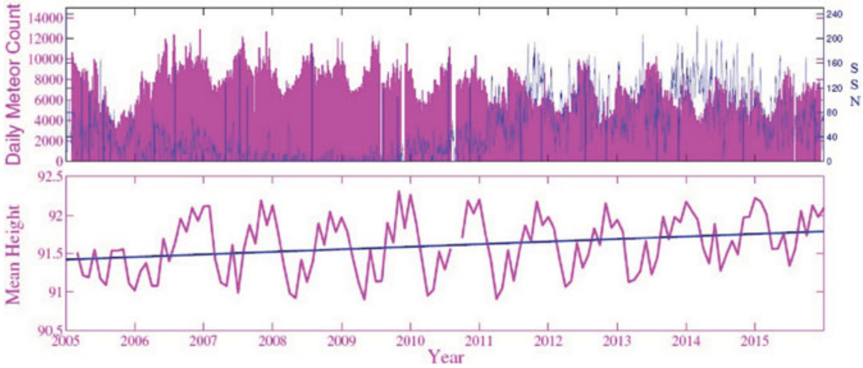

Figure 1. Variation of daily meteor count rate (upper) and monthly mean meteor height (lower) for the time interval 2005 - 2015

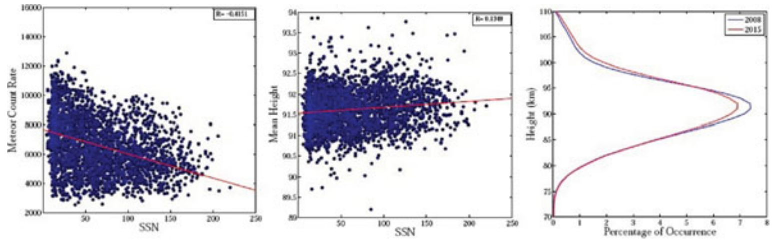

Figure 2. The correlation of meteor count rate (left) and its peak occurrence height (middle) with SSN where linear fit is shown with redline. Also shows the height distribution of meteors (right) during solar minimum (2008) and solar maximum (2015)

3. Results and Discussion

The dataset used for this study is from Jan, 2005 - Dec, 2015, which make up one full solar cycle. The radar detecting 6000 - 16000 meteors per day, where the number varies with the seasons. Only unambiguous echoes with zenith angle between 10° and 70° were selected to increase data reliability. The meteor activity shows a clear diurnal as well as seasonal variation (Refer figure 1(upper)). The daily count rate variation is as a result of the atmospheric scale height variations. The count rate shows a clear seasonal pattern with minimum (maximum) in winter (summer). The count rate also noticed the long term variation of meteor count rate has a minimum/maximum during the solar maximum (2012 - 2015)/minimum (2005 - 2011). This long term variation is resulted by changing atmospheric density gradient in the meteor region controlled by the solar activity, most likely caused by variation in the solar X-ray and Ultraviolet flux. The monthly mean occurrence height is also shown in figure 1(lower), where minimum heights were recorded in winter and maximum in summer with a $\sim$2 km difference identified throughout the solar cycle. From figure 2, we found a negative correlation for daily meteor count rate and a positive correlation for mean occurence height. Figure 2 also shows the height distribution of meteor count rate during solar minimum and maximum periods.

References

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