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Atmospheric parameter monitoring at Mt. Abu

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Abstract: Several atmospheric / meteorological parameters, including atmospheric dust load, sky condition and solar UV (λ = 270 – 310 nm) radiation flux have been monitored on a daily basis at the GRACE observatory site in Mt. Abu for the last several years. In the present communication we report the results of our preliminary analysis of these data, especially the diurnal and seasonal variations in various parameters and their effect on observations with the TACTIC imaging Cerenkov telescope array.

Key words : Cerenkov technique – TACTIC array – Atmospheric parameters

1. Introduction

The Bhabha Atomic Research Centre (BARC) , Mumbai, India, is setting up an international class astrophysical research facility called GRACE (for Gamma – Ray Astrophysics through Coordinated Experiments) at Mt. Abu, Rajasthan , for high sensitivity investigations of cosmic gamma-ray sources and phenomena over the energy range extending from 100's of GeV to 100's of TeV. The first experimental facility, called the TACTIC (for TeV Atmospheric Cerenkov Telescope with Imaging Camera), which is a 4 element array of imaging Cerenkov telescopes, is already operational at a provisional site near Oriya village in Mt.Abu. As the terrestrial atmosphere itself acts as the transducer in the Cerenkov technique, it is important to monitor the related atmospheric characteristics on a daily basis in order to correctly convert the recorded Cerenkov signals to the energy of the primary particles and to reliably infer the possible time variations of the recorded gamma-ray signals. Moreover, atmospheric monitoring also helps in identifying and excluding data sets of doubtful quality taken during periods of varying sky transparency conditions. In view of these important considerations, we have carried out a long – term monitoring of various atmospheric / meteorological parameters, atmospheric dust load and solar UV radiation flux on a daily basis to understand the diurnal and seasonal variations in these parameters and their likely effect on the quality of the recorded data. Here we present a brief report based on the preliminary analysis of these data.

2. Data analysis and results

2.1: Sky condition : Fig. 1 shows the mean monthly percentage of clear (cloudless) days for the two year period 1999 – 2000, derived on the basis of visual daytime monitoring of the cloud cover. Also shown for comparison is the mean monthly percentage of clear nights for the 4 – year period 1988 – 1991, derived from the analysis of INSAT – 1B cloud imagery data in the visible and infra – red bands (Kaul et al, 1994 and references therein). There is a reasonably good agreement between the two patterns, even on a month to month basis, indicating that the condition of the daytime sky is a fair representation of the sky conditions to be expected at night. The average mean percentage of clear days / nights during the year (excluding the 4 monsoon months of June to September) is ~ 60 % as compared to a value of ~28 % for the

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four monsoon months. The relatively high percentage of clear nights during most of the year qualifies the chosen site as an excellent location for Cerenkov experiments in India.

2.2: Atmospheric dust content : Dust samples have been collected at Oriya, Mt. Abu, with a dry rotary type suction pump with a free flow of 200 litres per minute. The pump is connected with the Perspex filter holder through a rubber tubing and the filter holder is placed ~ 5 meters above the ground. Samples have been collected on glass fibre filters of 2.5 cm diameter and 0.5 – 1 mm thickness. The filters are first dessicated, pre-weighed (~ 0.1 mg precision) and then placed in the filter holder. Fig. 2 shows the monthly average dust load (total suspended particulate matter) in units of $\mu g\ m^{-3}$ .It is found that the atmospheric dust load increases significantly to > 60 $\mu g\ m^{-3}$ immediately before and during the monsoon months (April – July), as compared to an annual average value of ~ 40 $\mu g\ m^{-3}$. As the average wind speed during the monsoon months is relatively low, it indicates that the increased dust load during this period is not of a local origin, i.e., dust raised in to the atmosphere by local winds, but may be carried to Mt. Abu from distant parts of the Rajasthan desert. Accumulation of the dust on the mirror facets of the TACTIC light collectors is thus a serious problem as it degrades the mirror reflectivity and causes scratches on the mirror surfaces. It has been found that the average useful life of a front – coated mirror is ~ 1 year and the mirror facets need to be re-aluminized to upgrade their reflectivity and to maintain a constant threshold detection energy.

2.3: Solar UV radiation flux : A home – built photometer is being used at the observatory to monitor the solar UV radiation flux in the 270 – 310 nm wavelength range, with the main aim of determining the extinction in this spectral band. Fig. 3 shows two representative examples of the hourly variation of this flux recorded during January and February, 2001.As expected, the UV flux is seen to increase with solar zenith angle but undergoes a deep and wide depression centered around the local noon. Preliminary data analysis shows that this diurnal pattern seems to be season dependent, with a single broad peak in the UV flux during summer months. It seems that the observed diurnal pattern is related to the build – up and depletion of atmospheric ozone, although the exact mechanism is not clear at present .Comparison of the derived diurnal variation patterns in the solar UV flux with the corresponding diurnal variation patterns of atmospheric ozone content, measured at Trombay (Daoo et al, 1991) , seems to indicate a strong anticorrelation between the two, especially when the atmospheric ozone content is above a threshold value. Attempts to quantify this correlation are on at present.

2.4: Meteorological parameters : Fig. 4 shows the month-to-month variation in the wind speed, temperature (maximum and minimum) and rainfall for the 2-year period 1999-2000. While the average wind speed is ~ 20 m s^{-1} , high wind speeds of ~ 70 m s^{-1} are generally encountered in the winter months (October – February). The maximum temperature varies within 10^0 C of the average value of ~ 25^0 C throughout the year, while the minimum temperature drops to 0^0 C in January – February. Temperatures below the freezing point of water are encountered very rarely. It is also observed that, except in the winter months (January – March), the wind speeds are generally low and the wind direction is generally from the northeast

3. Discussion and conclusions

Measurements of various atmospheric parameters at the GRACE observatory site, including the visual observations of the cloud cover, indicate that, except during the monsoon period , this site provides one of the best locations in the country for astronomical research .Our measurements of the solar UV flux, using a simple home-made photometer, have shown that the recorded flux values can be used as a precise indicator of the atmospheric ozone content, especially during the day time. More accurate observations of the atmospheric ozone content, preferably using photometers which directly give the ozone content, may be needed to evaluate the possibility of using the TACTIC and other GRACE experiments during twilight and partially moonlit conditions.

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2002BASI...30..441G

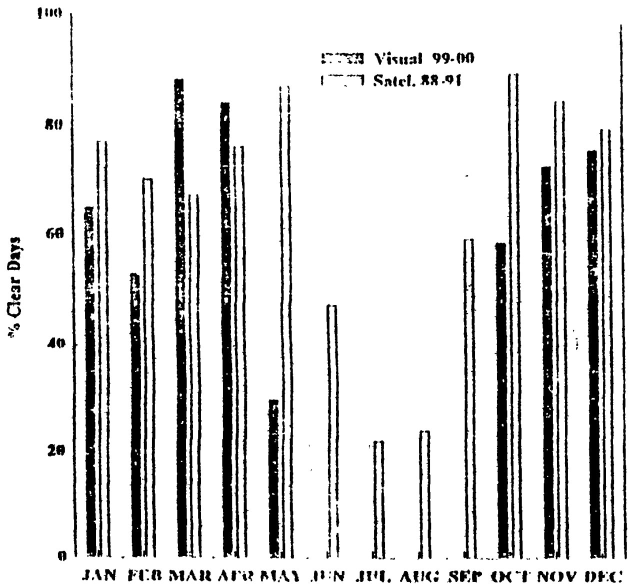

Fig 1. Mean monthly percentage of clear nights at Mt. Abu, obtained from visual observations ( ) and satellite imagery data ( ), for the period 1999-2000 (visual) and 1988-1991 (satellite)

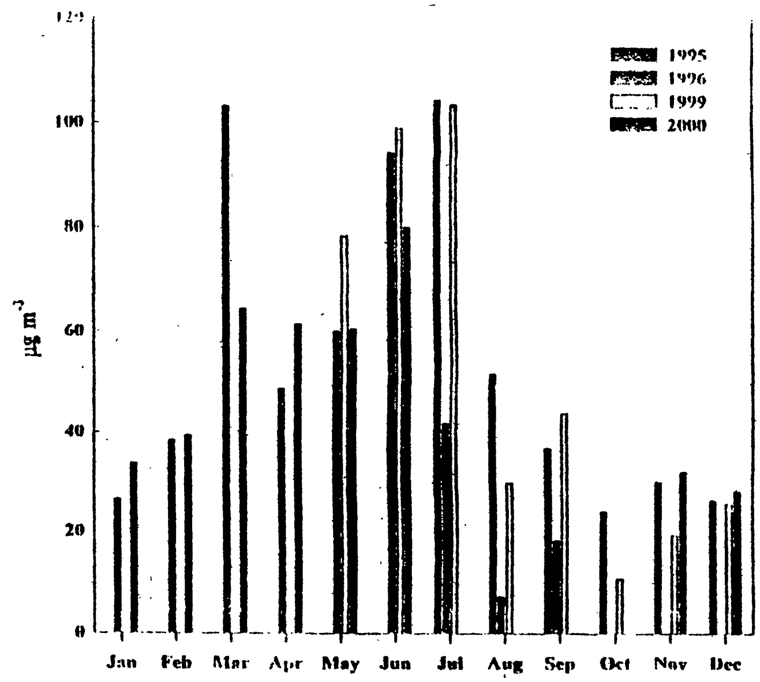

Fig 2: Monthly Variation in the average dust-load (Total suspended particulateMatter) at Mt. Abu, for 4 years

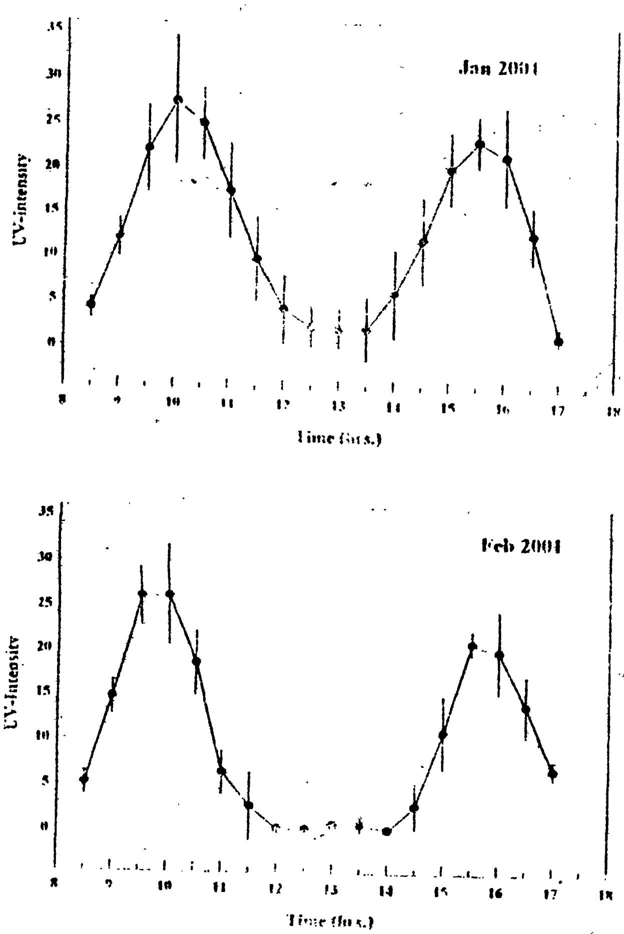

Fig 3 Two representative examples of half-hourly variation in solar UV (λ 240-300 nm) flux at Mt. Abu during Jan-Feb 2001

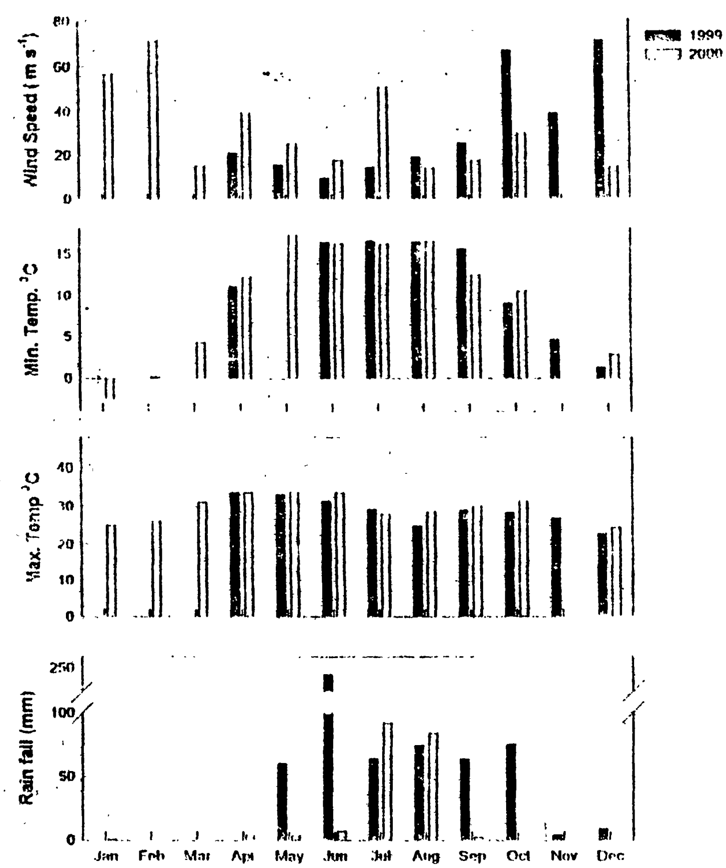

Fig 4 Monthly variation in the wind speed, maximum minimum temperature and Rain-fall at Mt. Abu for 1999 and 2000

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2002BASI...30..441G

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