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The measurements of atmospheric electric field at Gulmarg

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ABSTRACT. Atmospheric electric field was measured continuously in fair weather at Gulmarg by using passive antenna system with and without snow lying on the ground. The results in general appear to be consistent with the view that conduction current in the morning is increased as a result of change in the sign of convection current. It is shown that the morning rise in potential gradient at Gulmarg is a pronounced effect which gets considerably enhanced under the conditions of snow. The measurements during the period of snow can be explained if excess positive charge is assumed to be present at the station.

1. Introduction

Though quite a large number of measurements have been made on the atmospheric electric field, yet to our knowledge there are comparatively very few data on potential gradient measurements under the conditions when snow was both present and absent from the ground at a station. We therefore consider it worthwhile to report and discuss such measurements as made in Gulmarg.

2. Experimental arrangement and equipment

The work was carried out at the Gulmarg Research Observatory, Gulmarg, situated at 2700 m a.s.l. (34·1° N, 74·4° E). The observatory runs a meteorological station in collaboration with the India Meteorological Department. The observations on atmospheric electricity are carried out in the same lawns where the meteorological station is located. The data on temperature of the air (t) and the relative humidity (RH) were obtained from a thermograph and a hair hygrograph respectively placed inside a standard Stevenson screen.

The potential gradient was measured during fair weather only by using passive antenna system devised by Crozier (1963). The outstanding advantage of this method apart from its stability and reliability is that there is very little disturbance of natural conditions. 20-m aluminium wire with a diameter of 1 mm was used as an antenna and was stretched parallel to the level ground at the height of one metre. The details of field installation of the antenna and its associated circuitory were kept the same as those described by Crozier (1963). As an additional precaution some silica gel was placed in the electrometer head to reduce the effect of moisture. The continuous recording of the electric field was done by Esterline Angus Strip Chart Recorder. Care was taken to remove cob webs every morning. There was a considerable flat space on both sides of the antenna and the grass was cut occasionally to maintain the effective height of the antenna at one metre above the ground. Under the conditions of snow the height of antenna above the snow surface was measured twice a day at a number of places and the mean value was used to indicate the height above snow level.

Perhaps it would be of interest to make some comments on the overall performance of the passive antenna system in the light of remarks made by Dolezalek (1963) regarding the great susceptibility of the antenna to disturbances from convection current hitting it and its picking up stray charges from dust and precipitation etc. We did observe strong agitation in potential gradient record during wind disturbed days when dust blew all over the station. But this being low wind area the occurrence of such days is rare. The disturbance in the record in such cases is very easily seen. Further we did not observe any agitation or distortion in the normal fair weather electric field record with wind speeds ranging between 4 to 5 m per sec (though usual wind speeds are lower). This to a certain extent may be attributed to the topography of this location and that of the surrounding area. Preliminary experiments showed that the effect of convection current on the antenna was little. This was particularly true in the case of a single thin wire antenna when compared to other shapes of antenna used by us like wire mesh type or spiral type. No difficulty

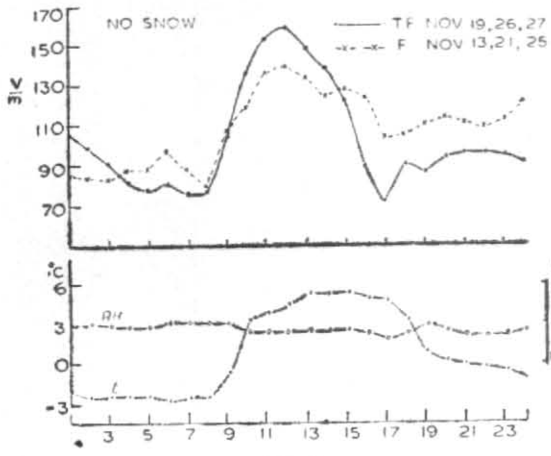

Fig. 1

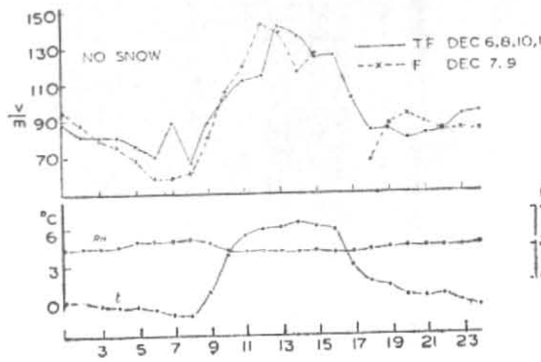

Fig. 2

Figs. 1 and 2. Potential gradient variations during truly fine and fine days in November and December (with no snow on the ground); temperature and relative humidity variations corresponding to truly-fine days only are also shown

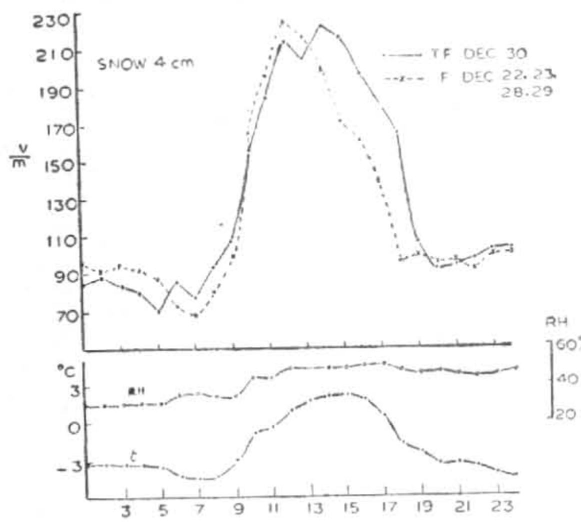

Fig. 3

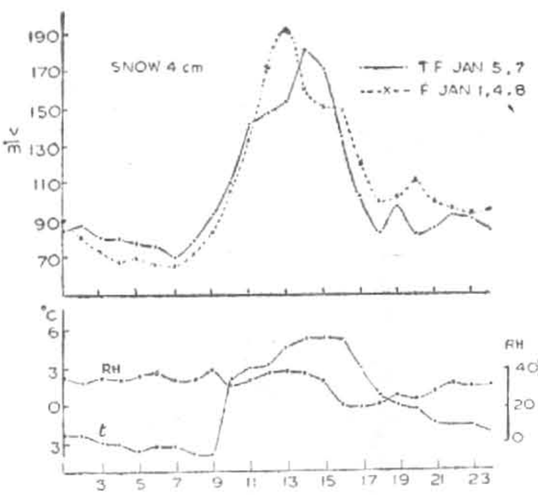

Fig. 4

Figs. 3 and 4. Potential gradient variations during truly fine and fine days in December and January (with 4 cm snow on ground); temperature and relative humidity variations corresponding to truly-fine days are also shown

was experienced in high humidity conditions. No charging of the antenna even by fairly large insects was observed. However, dust raised by vehicular traffic or exhaust fumes from the automobiles did charge the antenna on certain occasions. This could easily be seen on the record and the antenna had to be grounded for the charge to leak off quickly. Further the antenna was kept grounded whenever there was strong electrical activity in the nearby clouds. On the whole the general performance of the passive antenna system was remarkably good.

3. Results and observations

For analysing the data we attempted to divide days into the following categories:

(1) Truly-fine weather (no snow and with snow on the ground)

(a) RH $<$ 60 per cent

(b) RH $>$ 60 per cent

(2) Fine weather with above sub-classification

(3) Fair weather with above sub-classification.

No truly-fine or fine weather day with relative humidity exceeding 60 per cent was observed in the period for which data have been analysed. Truly-fine day has been taken as that day when no cloud, however, small was visible throughout the sky for the whole day. It was difficult to conform to this condition during nights, while selecting data, because of the difficulty of visual observations at that time. Fine weather consisted of only those days when small amount of cloud was present in the sky and this amount did not exceed one or two oktas. All other days were treated as fair weather days provided no precipitation occurred at the station.

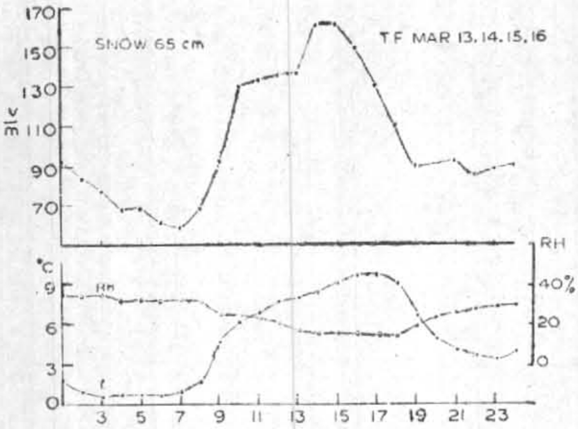

Fig. 5

Potential gradient, temperature and relative humidity variations during truly-fine days in March (with an average thickness of 65 cm of snow)

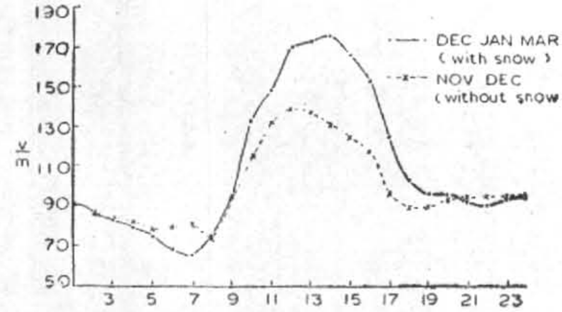

Fig. 6

Comparison of potential gradient variations for truly-fine and fine days with and without snow

In the present paper we propose to present data obtained during truly-fine and fine weather days. Further all the days for which the data have been presented had the same visibility conditions. Most of these days were either calm or had wind speeds less than 3 m per sec. A period between two consecutive hours was marked at three places each corresponding to 15 minutes interval and the mean of 5 values including those corresponding to two end ordinates was taken to represent the value for that hour which occurred at the end of each period.

Figs. 1-5 give variations in potential gradient for truly-fine and fine days occurring in each month (August 1970 to March 1971) without snow and with snow lying on the ground. Temperature and humidity variations corresponding to only truly-fine days are also shown in these figures. Fig. 6 gives variations of potential gradient with and without snow cover and was drawn by combining curves in Figs. 3-5 and Figs. 1-2 respectively. From the study of these curves and those corresponding to individual days (not presented here) the following observations could be made.

(1) In general the potential gradient rises in the morning first slowly and then comparatively fast. Furt er it seems to rise either at the same time or about an hour early than the rise of temperature of the air.

(2) The time to reach the morning maximum as measured from the instant of rise of potential gradient is around 5 hours when there was no snow on the ground and around 6-7 hours when snow was present on the ground. Further the rate of rise of potential gradient was higher under the conditions of snow cover.

(3) The morning rise which is also referred to as the 'sunrise effect' is found to be pronounced in all the months for which the data have been presented and with no snow on the ground the potential gradient rose by a factor of around 2 over the values of morning minima. However, in the presence of snow the effect became even stronger and the values of morning maxima were found to be greater by a factor of around 3 than the values of morning minima though in both the cases the total rise in temperature during the period corresponding to the morning minimum and maximum of potential gradient was practically the same.

(4) During the period of sunshine the values of the potential gradient under the conditions of snow cover were found to be much higher on the whole than the corresponding values when no snow was present on the ground. Further the values of the morning minima were generally lower with snow lying on the ground than those corresponding to the absence of snow.

4. Discussion of results

The morning rise of potential gradient has been discussed by Holzer (1955), Kasemir (1956), Isräel (1957), Muhleisen (1958), Law (1963), Chalmers (1967) and many others. We think that our observations are consistent with the view that the sunrise effect as observed by us is related to the increase of conduction current in the morning with little or no change in conductivity. Our results are better understood if the increase in conduction current is associated with the change in sign of convection current as discussed by Law (1963).

Further our measurements of electrical conductivity of air at Gulmarg in the period, June-October 1971 have shown that conductivity at or soon after sunrise remains practically constant for atleast about 3 hours. Another recent measurement now being carried out by us (to be reported elsewhere) with snow lying on the ground also indicate little change in conductivity during the morning hours. In view of these results we are inclined to think that conductivity may no be an important factor for the morning rise of potential gradient at Gulmarg.

The results under the conditions of snow cover appear to be interesting. It is expected that convection on the snow will be comparatively slow as is also evident from the slower rate of temperature rise. Therefore the potential gradient may take more time to reach the maximum value.

The higher values of potential gradient during the period of snow may be explained if the presence of excess positive charge can be assumed over the station. Such a charge may originate directly or indirectly by the presence of snow at and around the station. This charge would raise the potential gradient during the day. In the evenings when convection current starts subsiding it may enhance the night-time electrode effect as shown by Crozier (1963) particularly in calm or low wind conditions. This should also explain the higher rate of rise of potential gradient observed in the morning in the presence of snow. Bent and Hutchinson (1965) made a number of direct measurements of space charges with snow present on the ground and on one occasion (with wind speeds of 10 metres per sec) they observed negative space charge over the melting snow with maximum concentration near the ground which they attributed to the separation of charge at the surface. They also observed positive space charge higher up which they considered to have come from the blowing of snow. Our recent measurement (as referred to earlier) with snow lying on the ground and wind speeds 2-3 m per sec does indicate the presence of excess positive charge in the morning.

The higher values of potential gradient in the months of December and January with 4 cm thick snow cover on the ground compared with those in March with an average of 65 cm of snow can be understood if we consider the condition of ground frost. Regarding general lower morning minima during the period of snow cover it is not clear how far this can be attributed to stronger temperature inversions expected over snow because on the other hand one would expect a higher level of potential gradient due to reduced ionisation near the ground in the presence of snow. It is hoped that measurements of the radioactivity near the ground and detailed study of convection current will throw more light on this point. These studies are being planned and shall be carried out shortly.

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