Kodaikanal Obs. Bull. (1997) 13, 155-159

Results of the October 24, 1995 Solar Eclipse Balloon Experiments from Thumba

K.S. Appu, K.S. Santhikumar, R. Padmanabha Pillai and V. Narayanan
Meteorology Facility, TERLS
VSSC, ISRO P.O Trivandrum 695 022
and
C.K. Chandrasekharan
Meteorological Centre, Observatory Trivandrum 695 012

Abstract

Nine high-altitude meteorological radiosonde balloon ascents were conducted from Thumba and Trivandrum during 23rd - 25th October, 1995 to study the partial solar eclipse induced variations of the temperature and winds in the tropospheric and middle stratospheric regions. The study confirms the earlier results on the occurrence of a strong warming of the middle stratosphere during the end phase of the eclipse. The study also reveals a new feature - a delayed response of a very intense cooling of tropospheric layer with maximum 9°C at 14 km, after about 3 hours of the eclipse. Further experiments are needed to confirm this feature.

Key Words : Radiosonde balloon ascents, Tropospheric and stratospheric winds and temperatures

Introduction

At Thumba (8° 32'N. 76° 52'E) the solar eclipse was partial with maximum obscuration of 46% at 0841 hrs. The eclipse started at 0740 hrs and ended at 0951 hrs. Totally six 1680 Mhz. radiosonde (IMD,1972) ascents were conducted from Thumba, two each on 23rd, 24th and 25th October, 1995 at about 0800 and 1100 hrs. The experiment was supplemented by the daily morning (0500 hrs) 401 MHz radiosonde (IMD, 1972) data from the Meteorological Centre, Trivandrum, 15 Km away from Thumba. The data on 23rd and 25th are meant to construct the control data. Temperature measurements in the radiosonde system are done using a bead thermistor and winds by tracking the drift of the balloon by radar. The rms error in temperature and wind measurements are 1°C and 2 mps respectively. Details of the data collected are summarised in Table 1. These data are utilised to determine the changes in the atmospheric temperature and wind circulation due to the solar eclipse upto an altitude of about 35 Km. The main results are presented in this report.

Table 1 : Details of the radiosonde experiments conducted from Thumba and Meteorological Centre, Trivandrum (TRV)

Date	Time of the ascent (IST)	Location	Temp Data available altitude layer (km)	Winds
23.10.95	04 : 45	TRV	0-26	0-26
23.10.95	08 : 02	Thumba	0-38	0-38
23.10.95	11 : 03	Thumba	0-38	0-37
24.10.95	04 : 45	TRV	0-26	0-26
24.10.95	08 : 15	Thumba	0-34	0-34
24.10.95	11 : 06	Thumba	0-35	0-35
25.10.95	04 : 50	TRV	0-26	0-30
25.10.95	08 : 31	Thumba	0-39	0-39
25.10.95	11 : 00	Thumba	0-38	0-38

Results and Discussion

Fig.1 to 3 show the vertical temperature, zonal and meridional wind profiles of the 3 days grouping the 0500, 0800 and 1100 hrs. data. Following are the main observational results:

The thermal structure and wind circulation of troposphere and stratosphere during the pre-eclipse phase were normal (Fig.1a, 2a & 3a).

Stratospheric temperature in the 20-34 Km layer has undergone a sharp increase with maximum of 8°C around 33 Km during the end phase of the eclipse (Fig.1b). This warming seem to remain at least for 3 hrs (Fig.1c).

The occurrence of a slight warming of 2-3°C in the lower stratosphere was first noted at Wallops Island, (38N, 75W) during the total solar eclipse of March 7, 1970, and was explained due to subsidence as a result of the cooling of the upper layers (Quiroz and Henry, 1972). The rocket campaign conducted from Thumba during the Feb.16,1980 eclipse showed this warming as very intense with a magnitude of 10°C at 34 Km. Intense cooling above 38 Km altitude with maximum of 14°C at 58 km was also observed from this rocket experiment (Appu, *et al.* 1982; and Datta and Chakravarthy 1986). In both of the rocket and the present balloon experiments, temperatures around 30 Km altitude layer were monitored when the solar obscuration was about 10%.

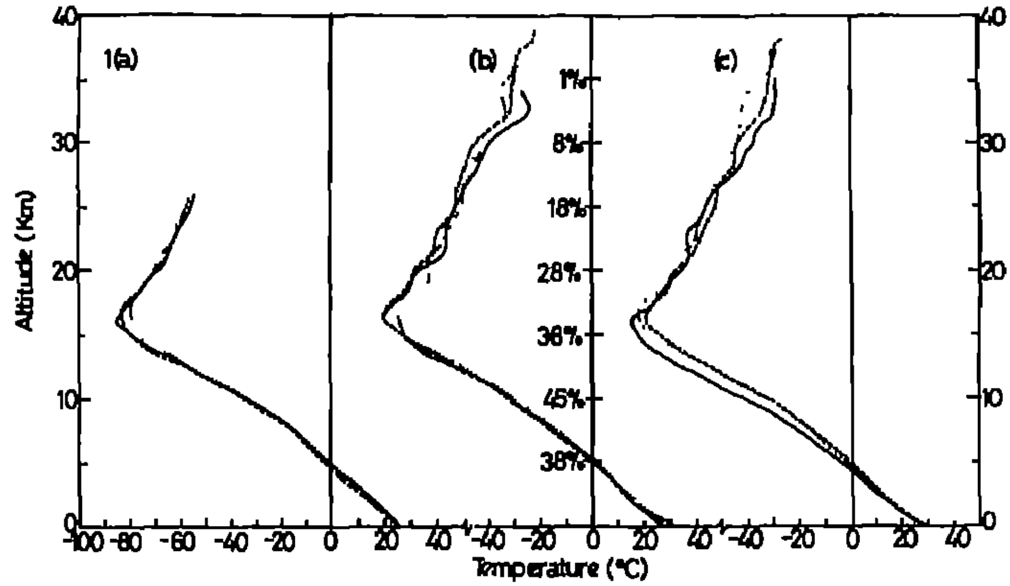

Figure 1 : Vertical temperature profiles of 23rd, 24th and 25th Oct.1995 corresponding to 0500 (a), 0800 (b) and 1100 hrs (c) data. Solar obscuration in percent with respect to the balloon ascent altitudes is given in Fig. 1b. Dotted, straight and broken curves represent for 23rd, 24th and 25th Oct, respectively.

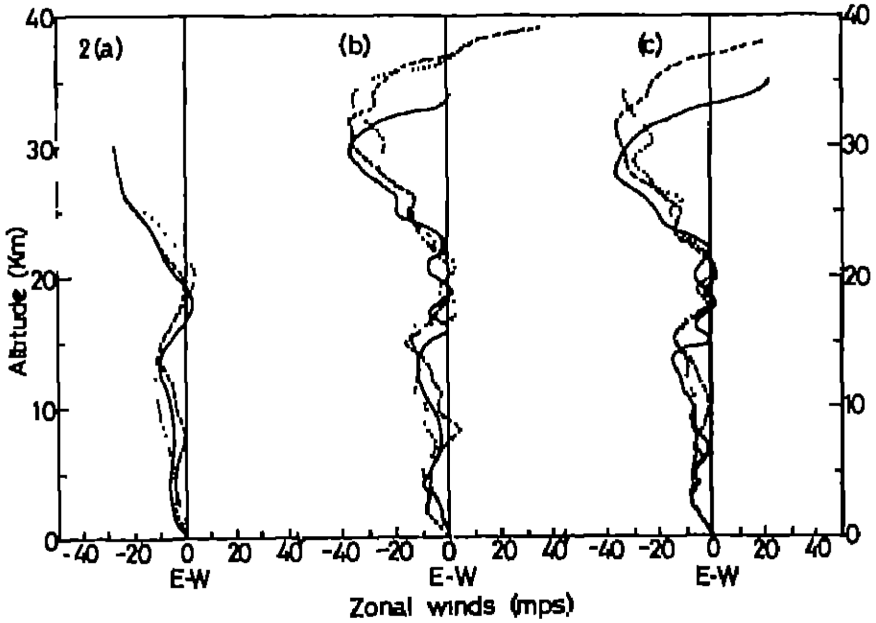

Figure 2 : Vertical profiles zonal wind of 23rd, 24th and 25th of Oct, 1995 corresponding to 0500 (a), 0800 (b) and 1100 hrs (c) data. Dotted, straight and broken curves represent for 23rd, 24th and 25th Oct. respectively.

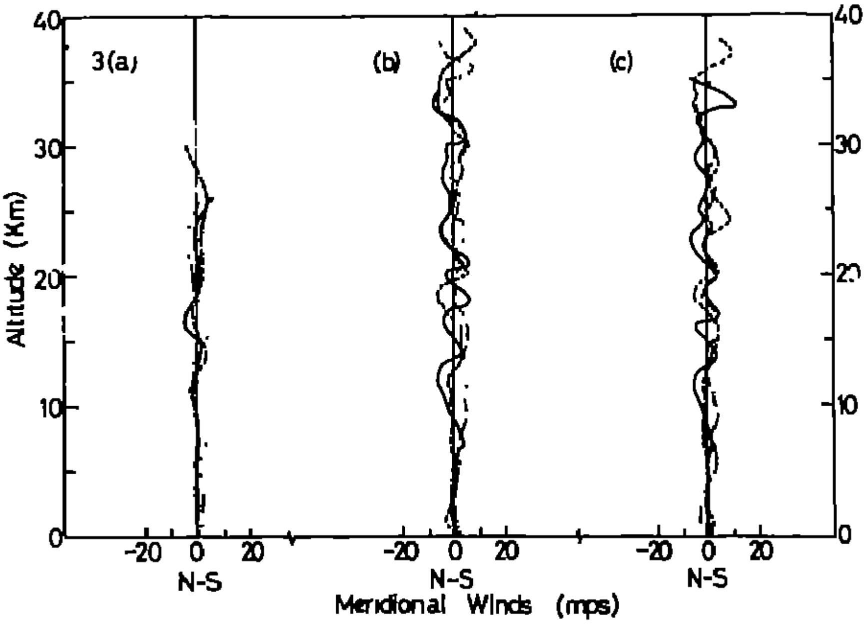

Figure 3 : Same as Fig 2 but for the meridional wind.

A new feature noted is the occurrence of a strong cooling of the tropospheric layers during the 1100 hrs observation. This delayed response of cooling is very strong reaching maximum of 9.5°C around 14 Km (Fig. 1c). Here it has to be noted that there are evidences for temperature dropping after 3-4 hours of the eclipse at boundary layers 1.3 m (Narasimha, *et al.* 1982).

Zonal and meridional winds above 10 Km show a trend of strengthening during eclipse phase (Fig. 2b & 3b). The level of the zonal wind reversal from easterly to westerly, direction in the middle stratosphere, lowered by 3 km during the eclipse phase (Fig. 2b & 2c). But this cannot be confidently attributed to the effect of the eclipse since data are not available above 30 km altitude in the 0500 hrs data (Fig. 2a).

Concluding Remarks

The present experiment confirms the strong warming of the lower stratosphere towards the end of the eclipse. The experiment also reveals a new feature - a delayed response of a strong cooling in the tropospheric levels after about 3 hours of the eclipse. Further detailed observations at some future eclipses are needed to draw any final conclusions on this aspect. The observed strong thermal perturbations of the atmosphere associated with the eclipse cannot be explained based on the existing radiative heating and cooling models of lower and middle atmosphere (Murgatroyd 1970 and Lindzen 1967). A new model incorporating the heating and cooling rates, photochemistry and dynamical processes is required to explain all the observed features of eclipse-related variations of the middle atmosphere. That may also put more light on the overall complex radiative and dynamic processes of the middle atmospheric region.

Acknowledgement

The authors are very grateful to Shri M.B.Oonnithan, Dy.General Manager, TERLS and the team of engineers especially from METF, GSF, RTCF and RSF for the encouragement and support in successfully conducting the balloon campaign as per the schedule.

References

Appu K.S., Krishnamoorthy B.V., Narayanan V., Reddy C.A and Sen Gupta K., 1982, Proc.Indian Natn., Sci, Acad, 48A, 506.

Datta J, and Chakravarthy S.C., 1986, ISRO-IMAP-SR-23-86, Indian Space Research Organisation, Bangalore.

Lindzen R.S., 1987, Quart J. Roy. Meteor. Soc., 93, 18.

Meteorological Instruction Manual, No.72, Indian Met.Department, New Delhi.

Murgatroyd R.J., 1970, The structure and dynamics of the stratosphere, The global circulation of the atmosphere, G.A. Corby, Ed, London, Royal Met, Soc, London.

Narasimha R., Prabhu A., Narahari Rao K. and Prasad C.R., 1982, Proc.Indian Natn., Sci., Acad., 48A, 175.

Quiroz R.S. and Henry R.M., 1973, J.Atmos, Sci, 30, 480.