Journal of Agrometeorology 3(1&2) : 67 -77 (June-December 2001)

Variation of surface energy budget at Anand during different seasons of LASPEX-97

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ABSTRACT

Energy balance components near the surface, measured directly at Anand, the central site of Land Surface Processes Experiment (LASPEX), are analyzed to study the partition of net radiation into soil, sensible and latent heat fluxes in the months of May, July, September and December, four representative months of pre-monsoon, monsoon, post-monsoon and winter. The analysis shows that soil heat flux is relatively high in July as compared to that in May because of increased thermal conductivity of wet soil. Latent heat flux increases by about 100 Wm^{-2} in July at the expense of sensible heat flux. Seasonal variation of meteorological parameters, radiation and albedo are discussed.

Key words: Sensible heat flux, Latent heat flux, Soil heat flux, Net radiation

One important component of present research effort is to improve numerical model performance by representing the effects of soil moisture and vegetation changes in the boundary layer. Consequently, various vegetation and soil moisture schemes are being used for soil-vegetation-atmosphere transfer (SVAT) studies. Earlier, some field experiments such as FIFE (Sellers *et. al.*, 1992) were conducted to understand the interaction between atmospheric turbulence, soil and vegetation. On similar lines but on a smaller scale, a Land Surface Processes Experiment (LASPEX) was conducted in the Sabarmati river basin of Gujarat. The net energy available at surface depends on net radiation and soil heat flux. Net radiation is a function of albedo, which in turn depends on soil type, vegetation and soil moisture content. Net energy at surface is partitioned into sensible and latent heat fluxes, which determine the temperature and humidity of atmospheric boundary layer. The complex land-surface-atmosphere interactions have to be understood from observations and require to be simulated as realistically as possible by simple and efficient parameterization schemes in various weather forecast models. In this paper diurnal variations in surface energy balance components in four representative months are discussed.

MATERIALS AND METHODS

The Sabarmati river basin was chosen because this area lies in the semi-arid part of western Indian region and provides quite contrasting meteorological situations from one season to another as well as variety of weather conditions in the individual weeks within a season. The soil type varies between alluvial to sandy and influences the runoff and ground water recharge and hence on the sub-basin to basin scale hydrological processes. Full site descriptions are given by

Pandey *et.al.* (2001) and the instrumentation are described by Shekh *et.al.* (2001). The intensive observation period of five days each in the months of May, July, September and December were chosen for analysis. In all the four months the instrumented tower at Anand was surrounded by vegetation or grass with various crops in different stages of growth. Energy balance components i.e., net radiation (Rn), soil heat flux (G) and sensible heat flux (HF) were measured with net radiometer, flux plate and sonic anemometer (Metek, Germany) respectively. Data was sampled at 1Hz and stored 1-minute mean values. Half-hourly mean values were computed and further averaged for 5 days (IOP) i.e., 13-17 of each month that was taken to represent mean-IOP of the month. Likewise, mean diurnal variation of energy balance and other parameters for the four selected months were computed.

RESULTS AND DISCUSSION

The IOP-mean energy balance components are plotted in Fig. 1 for May, July, September and December. Net radiation maximum is (about 600 Wm^{-2}) in May, July and September whereas it is reduced to 500 Wm^{-2} in December. Sensible heat flux at 1200 IST in the pre-monsoon (May) month was about 250 Wm^{-2} and it reduced to 100 Wm^{-2} during the monsoon (July). Soil heat flux had its peak value in July (125 Wm^{-2}) and remained at about 80 Wm^{-2} in other seasons amounting to a reduction by 45 Wm^{-2}. The increase in soil heat flux during the monsoon is attributed to increased thermal conductivity of wet soil. With the onset of the southwest monsoon in this region on 17 June, latent heat flux at noon (residual of energy budget) increased by about 100 Wm^{-2} from its pre-monsoon value at the expense of sensible heat flux. Correspondingly Bowen ratio decreased from 0.9 to 0.3.

Time series of half-hourly mean air/soil temperatures and wind speed at 1, 2, 4 and 8 m levels above surface are shown in Figs. 2, 3 and 4 respectively for the months of May,

Table 1 : Noon time values of air and soil temperature, rainfall, Bowen ratio and albedo at Anand during IOP (5-day average) in different months.

Parameter	May	July	September	December
Rainfall (mm)	0	0.8	0	0
Bowen ratio	0.9	0.3	0.2	0.3
Air temp. at 1 m (_°C)	41	34	32	26
Wind speed at 8 m (ms^{-1})	2.5	4.2	2.5	3.0
Albedo	0.20	0.20	0.15	0.15
G/Rn	0.17	0.22	0.10	0.15
Soil temp. at surface (_°C)	56	42	40	37

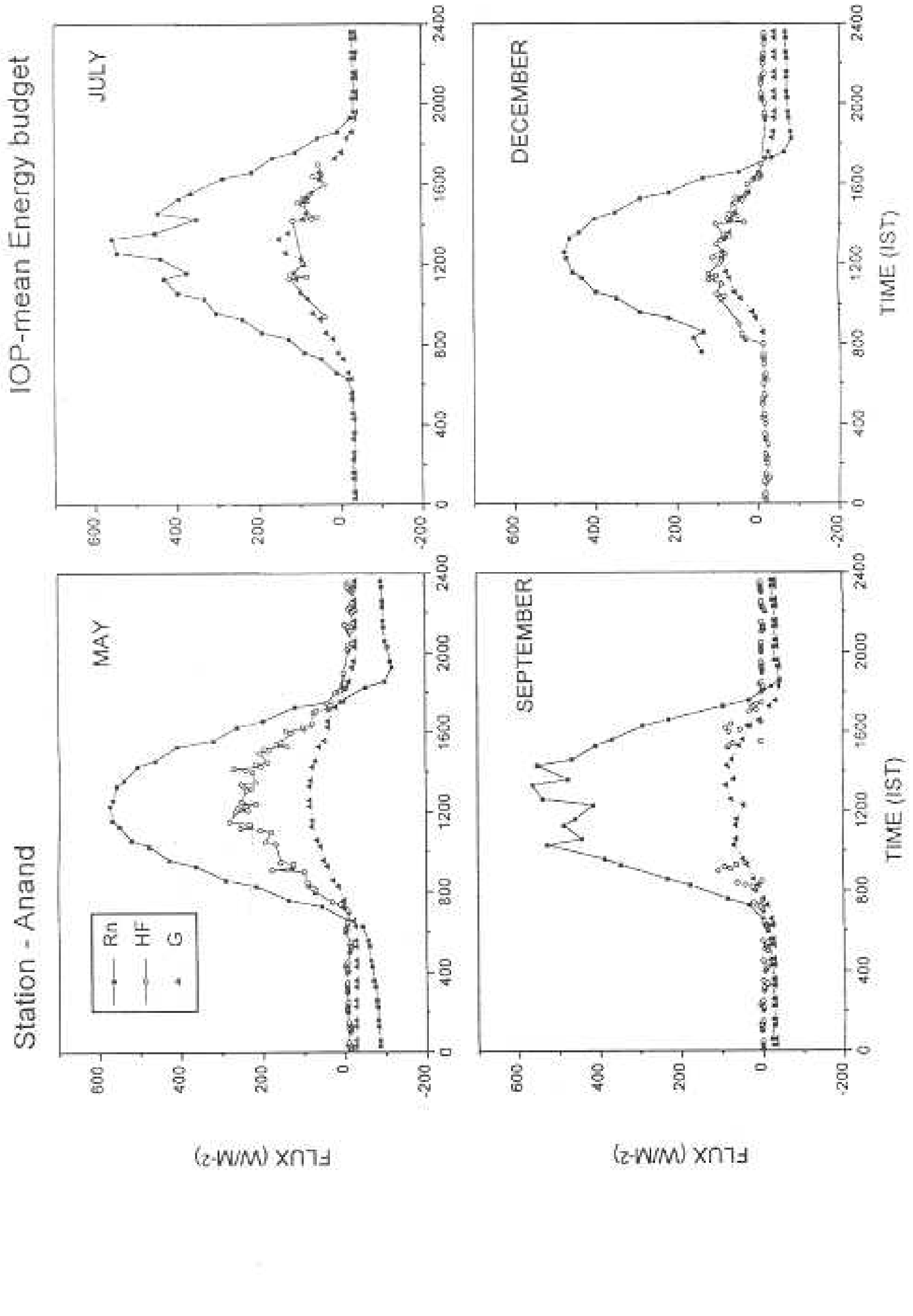

Fig. 1 : Diurnal variation of surface energy budget at Anand in different months during IOP (5-day mean)

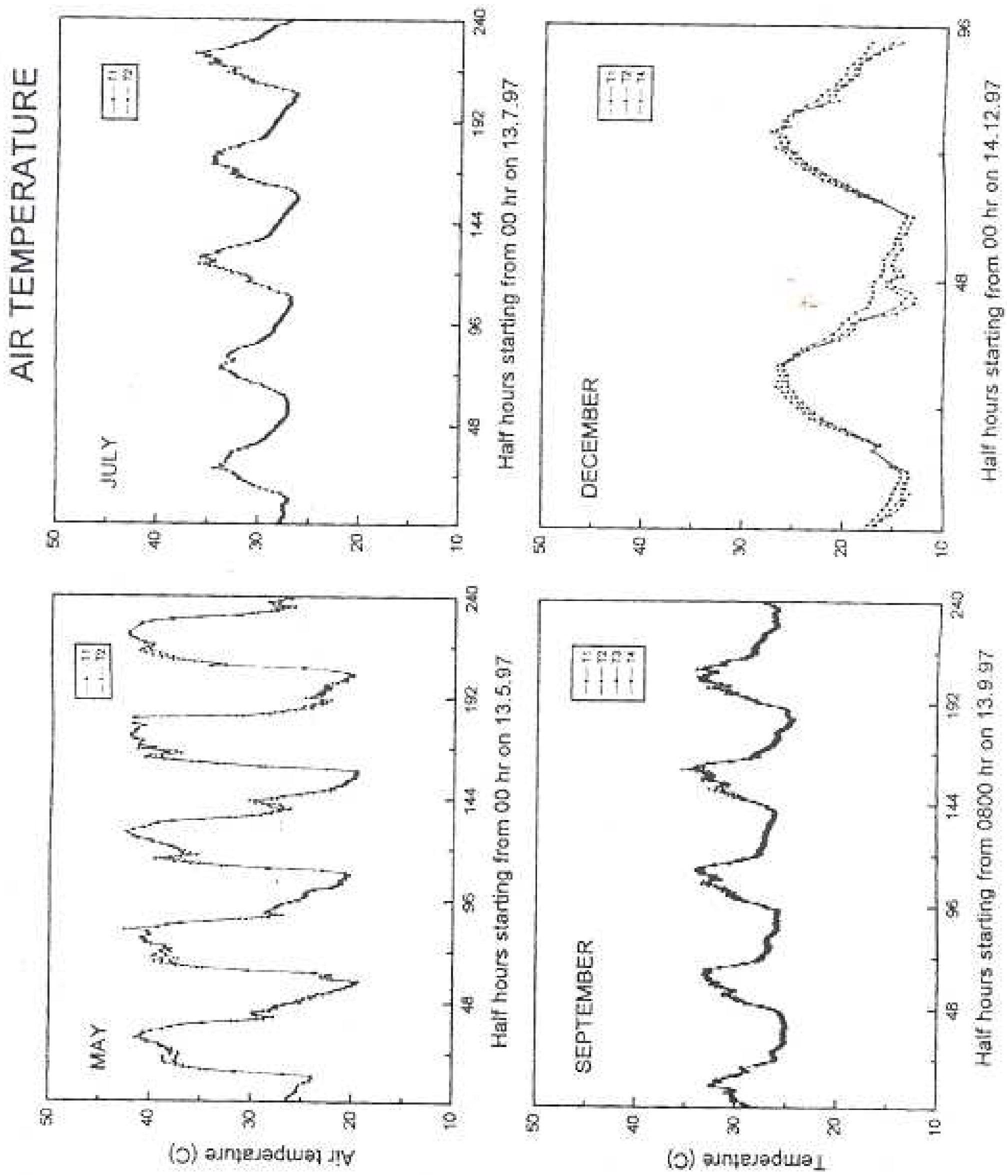

Fig. 2 : Variation of air temperature in different months at Anand during IOP

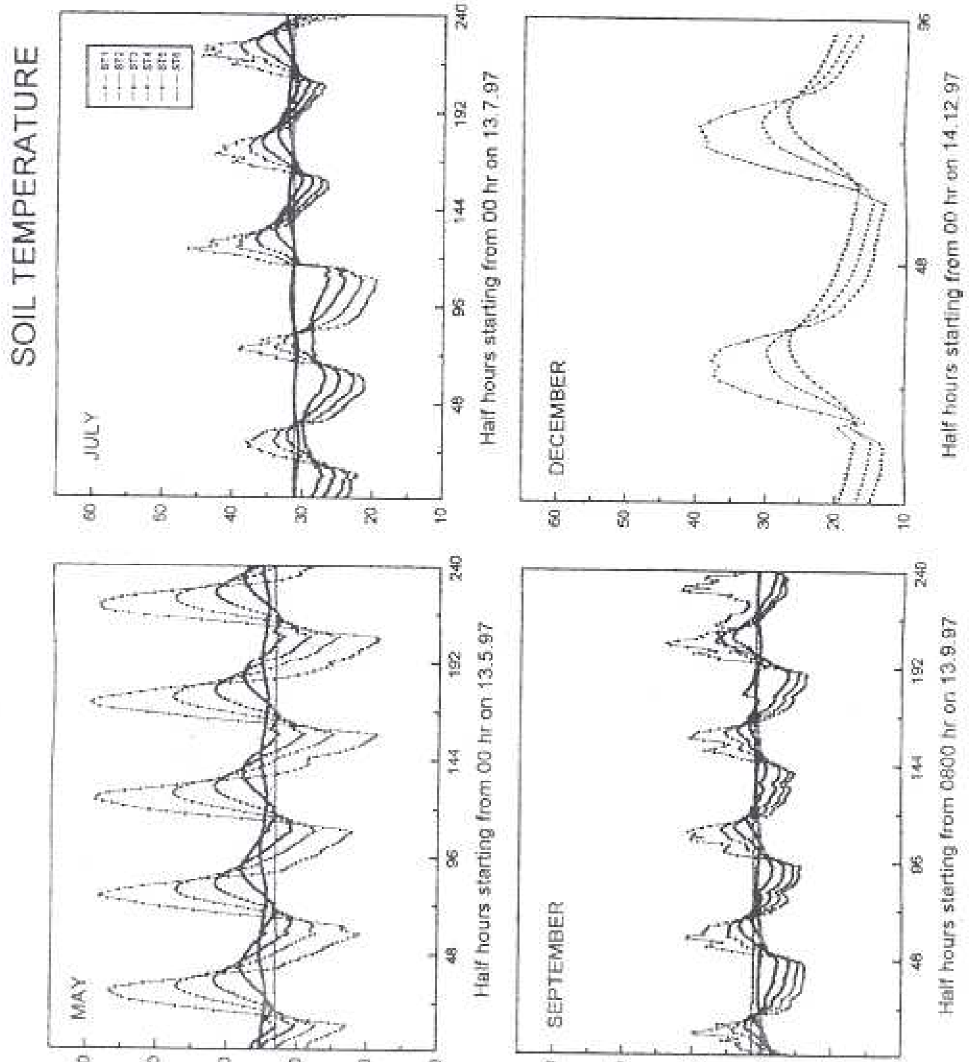

Fig. 3 : Variation of soil temperature in different months at Anand during IOP

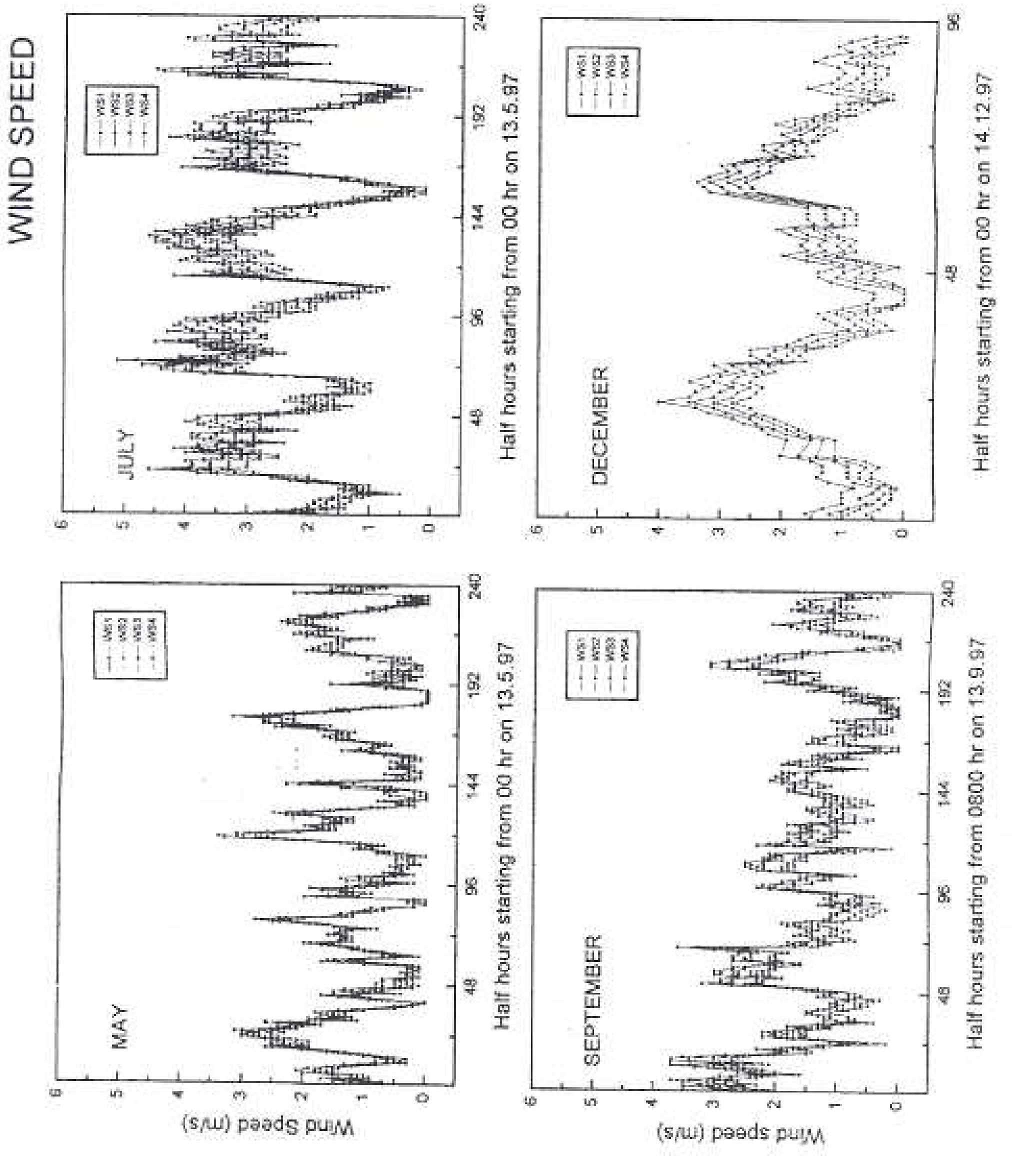

Fig. 4 : Variation of wind speed in different months at Anand during IOP

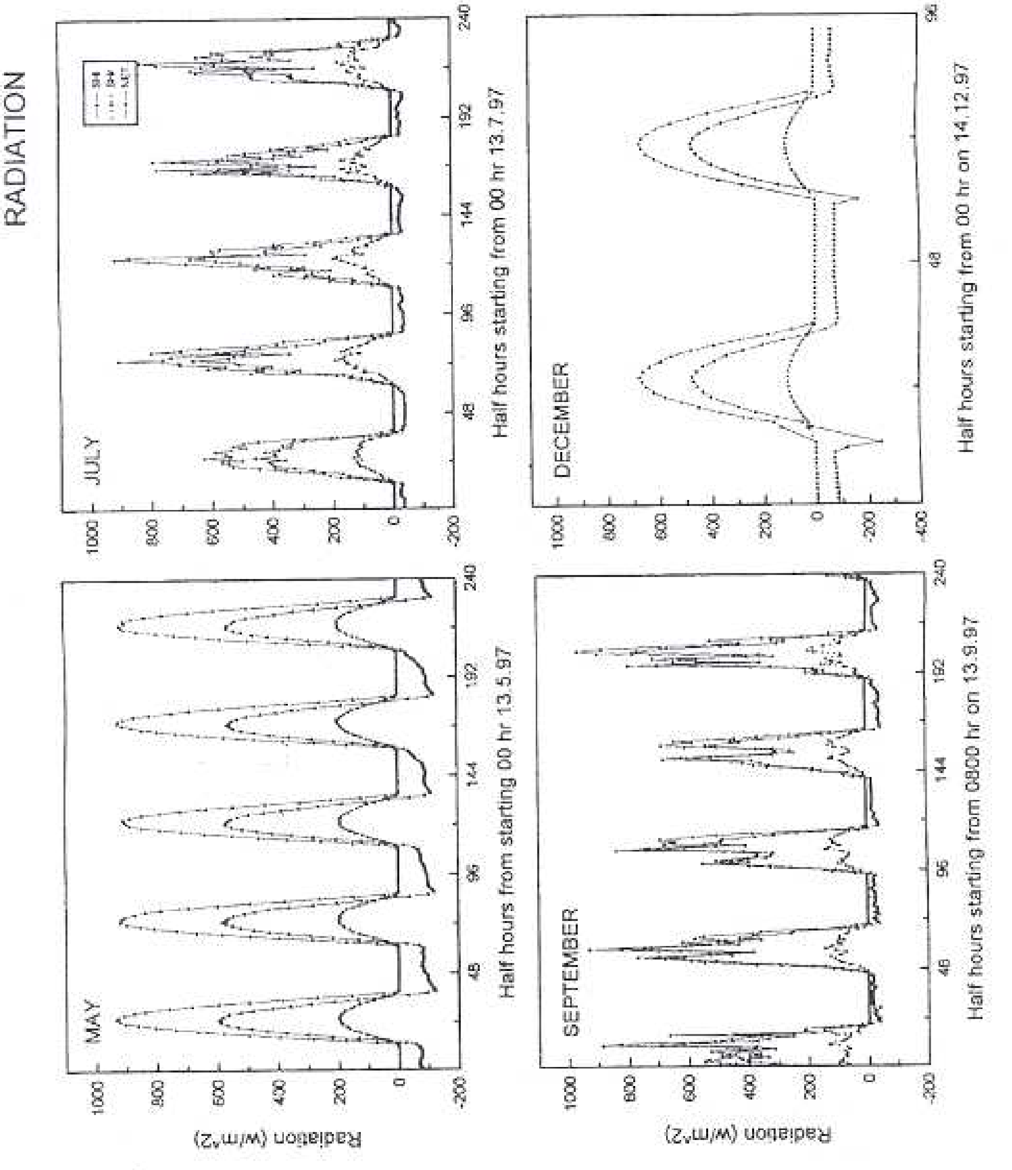

Fig. 5 : Variation of radiation components in different months at Anand during IOP

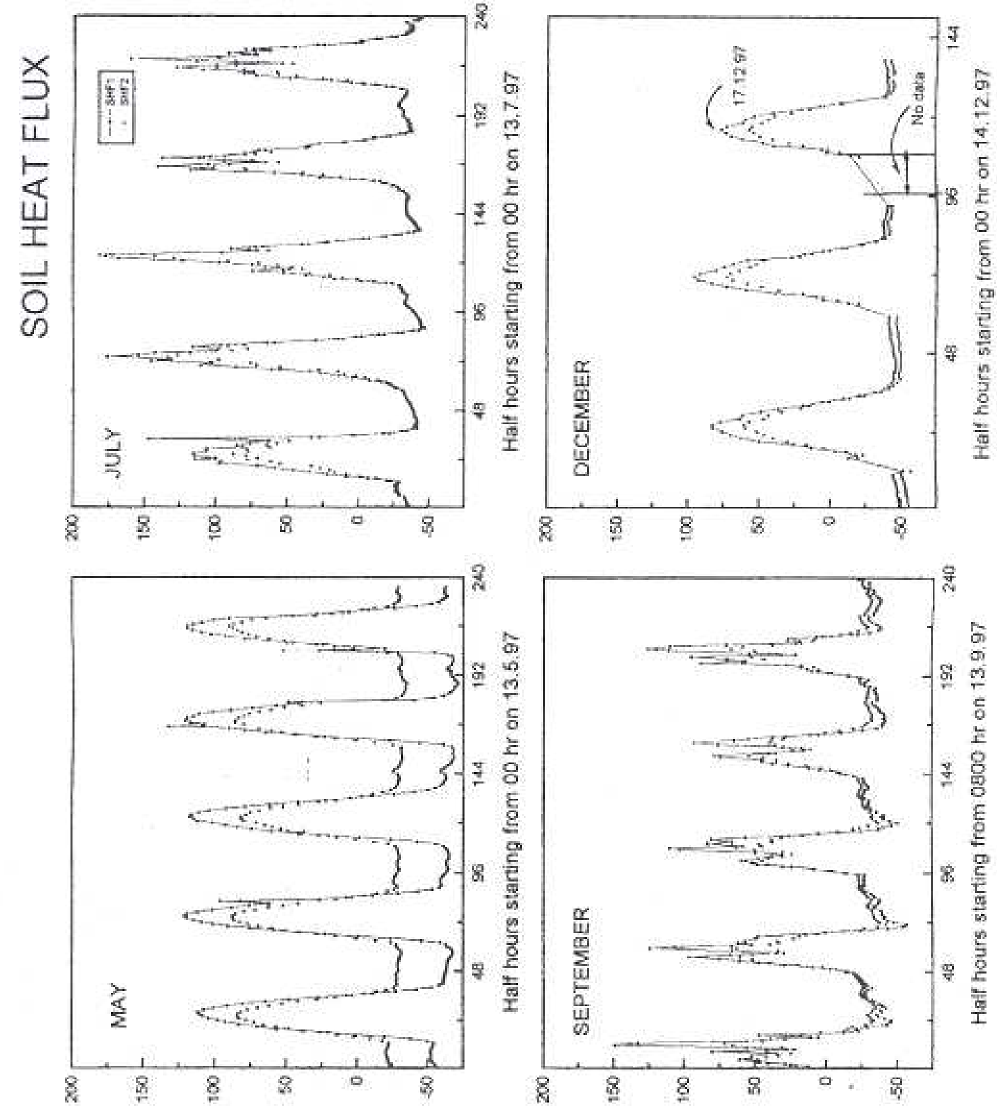

Fig. 6 : Variation of soil heat flux in different months at Anand during IOP.

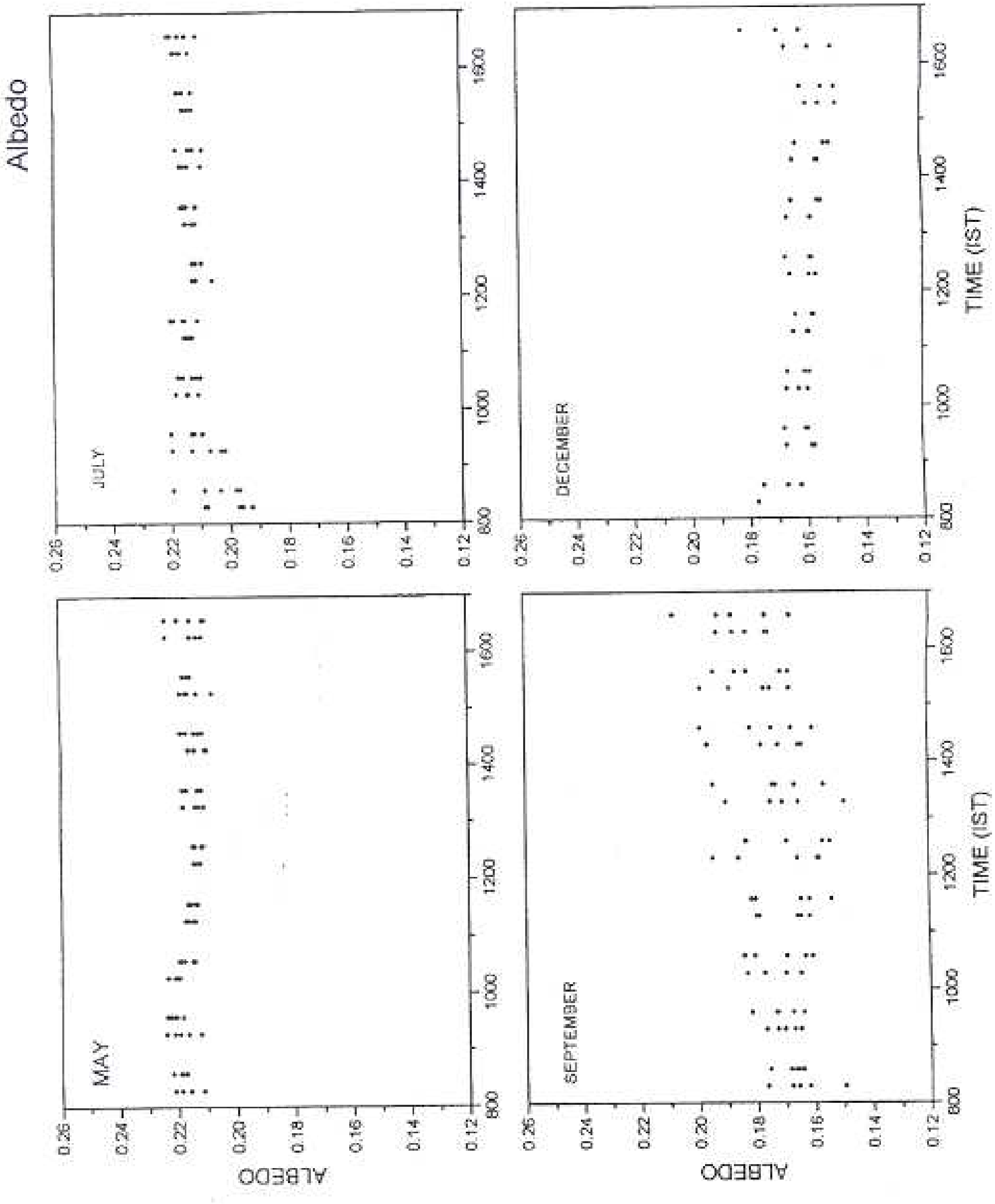

Fig. 7 : Variation of albedo in different months during IOP

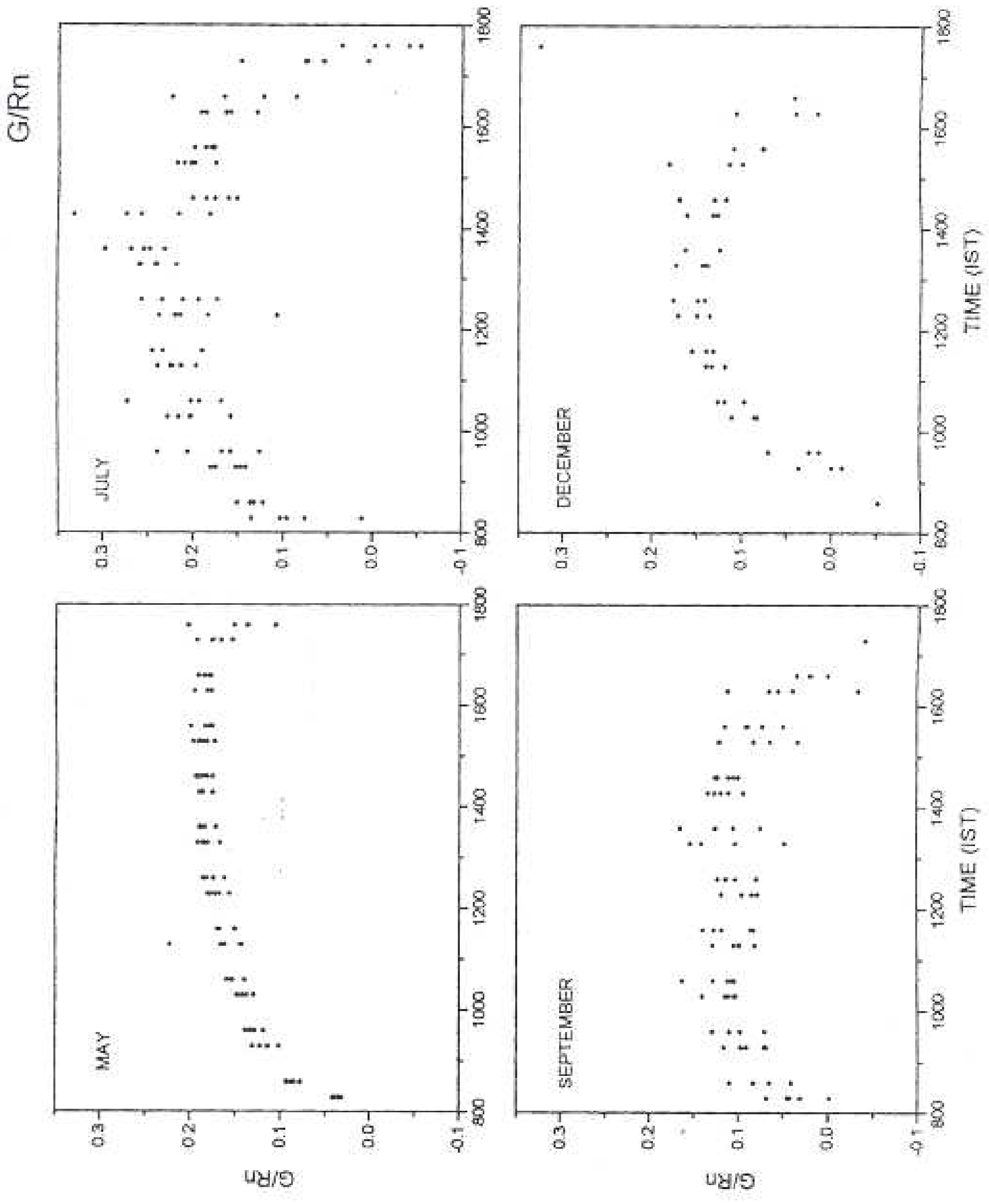

Fig. 8 : Variation of G/Rn in different months during IOP.

July, September and December. Half-hourly averaged radiation components i.e., net (NET), incoming short wave (SHi) and reflected short wave (SHr) radiation, soil heat flux (SHF), measured by flux plates placed a few millimeters just below the surface are plotted in Figs. 5 and 6 respectively. Figs. 7 and 8 show variation of albedo and G/Rn during daytime i.e., 0800 IST to 1800 IST. The peak value of air temperature at 1 m at 1200 IST was maximum (41 °C) in May and minimum (26 °C) in December (Table 1). Surface winds were high (4.2 ms^{-1} at noon) during the monsoon. The incoming solar radiation (SHi) is smooth and similar on all five days in May and December. In July and September there were fluctuations in the radiation values due to passing cloud patches. The magnitude of peak solar radiation ranged from about 900 Wm^{-2} in May to about 700 Wm^{-2} in December. The soil heat flux difference, measured by flux plates separated by a few millimeters, was high in May during night hours as compared to that in July and September. In July, both plates recorded almost same soil heat flux indicating that there was no net absorption of heat by the soil layer between the plates. This may be due to high thermal conductivity of wet soil that allows transportation of heat to deep soil layer with little loss in the layers just below the surface. Albedo, one of the important land-surface parameters, is dependent on soil type, vegetation and soil moisture content. Figure 8 shows seasonal variation of albedo during day hours (0800-1800 IST). May and July showed almost same albedo (0.20) whereas it was 0.15 in September and December.

CONCLUSIONS

The analysis showed that soil heat flux increased significantly from pre-monsoon to monsoon season attributable to increased thermal conductivity of wet soil. Precipitation in July resulted in more partitioning of net radiation into soil and increase in latent heat flux at the expense of sensible heat flux.

ACKNOWLEDGEMENTS

The authors would like to thank the colleagues of IITM who have participated in LASPEX for their kind cooperation during the experiment. Thanks are also due to Dr G. B. Pant, Director, IITM and Shri S. Sinha, Head, BL&LSPS division, IITM for providing research facilities. LASPEX was sponsored by Department of Science & Technology, Government of India.

REFERENCES

Pandey, V., Kumar, M., and Shekh, A.M. 2001. Agroclimatic Teatures of LASPEX sites. *J. Agrometeorol.*, 3 : 39-55.

Sellers, P. J., Hall, F. G., Asrar, G., Strebel, D. E., and Murphy, R. E. 1992. An overview of the First International Satellite Land Climatology Project (ISLSCP) Field Experiment (FIFE). *J. Geophys. Res.*, 97 : 1 8345-18371.

Shekh, A.M., Vernekar, K.G., and Keshavamurthy, R.N. 2001. The beginnings of LASPEX-97. *J. Agrometeorol.*, 3: 31-37.