Institute of Hydrology

Overseas Development Report

[redacted]

Natural Environment Research Council

(First Draft - prior to revision by INPE)

ANGLO-BRAZILIAN AMAZONIAN CLIMATE PROJECT

(Proposed September 1990, as the
'Anglo-Brazilian Amazonian
Climate Observational Study' [ABRACOS])

INTERIM REPORT NO 3 (1 January 1991 - 30 June 1991)

Prepared by

Institute of Hydrology, UK (IH)

Instituto Nacional de Pesquisas Espaciais, Brazil (INPE)

Draft as at
27 June 1991

CONTENTS

1. ABRACOS: PROJECT OVERVIEW

1.1. **Progress** in the period 1 January 1991 to 30 June 1991.

(a) The analysis of the micrometeorological and climate data has proceeded on schedule with two papers in first draft stage;

(b) analysis of the forest biomass experiment data was delayed as a result of shipping delays and the time taken to dry the timber samples, but is well advanced;

(c) progress on the analysis of the soils data has been slower as a result of limited available staff time;

(d) a successful co-ordination meeting was held in São José dos Campos in March, at which progress on analysis and planning of the next field mission were discussed;

(e) a new lysimeter system has been designed and built, to give further information on how the evaporation is partitioned between soil and plants at the Fazenda Dimona site;

(f) collaborating scientists for the proposed studies in Parà and Rondonia have been identified, and the agreement of their institutions obtained to allow them to participate;

(g) the necessary administrative procedures for working on Indian Reservations (the preferred sites) in Parà and Rondonia have been initiated in Brazil;

(h) the towers and vehicles for the sites in Parà and Rondonia have been purchased and shipped;

(i) the first visit of a Brazilian collaborating scientist to IH under the training programme took place successfully.

1.2. **Problems**

(a) The radio transmitters for the transfer of weather station data via satellite have still not been delivered. Whilst this does not affect the data collection which continues to be stored on the loggers, it has resulted in some faults not being detected as rapidly as they would otherwise have been.

1.3. **Plans** for the next six months include:-

(a) the second field mission to the Fazenda Dimona site near Manaus;

(b) installation of the tower, weather station and soil moisture monitoring network in Parà (starting in July 1991), and

(c) in Rondonia (starting in September 1991);

(d) the initiation of plant physiological measurements from the Parà site tower;

(e) preparation of final drafts of the micrometeorological and climatological papers, and the first draft of that reporting the results of the forest biomass experiment.

2. REQUISITION AND SHIPMENT

2.1. Land Rovers

Two further Land Rovers have been purchased, shipped and sea-freighted. These have now arrived in Brazil. The vehicle destined for the ABRACOS studies in Parå has arrived at Belem and awaits clearance from customs. The vehicle allocated to Rondonia (Ji-Parana) is one of a batch sent to Manaus, the remainder being donated to INPA. This vehicle will clear customs at Manaus and be sent by barge to Ji-Parana.

The first two ABRACOS Land Rovers sent to Manaus in 1990 and based at INPA were inspected in March 1991. They were still in very good condition and the slight damage to a door of one had been very neatly repaired. There was a report that one of these vehicles later developed a starter motor problem immediately after the visit of Mrs Lynda Chalker. The local diesel agent, MOPEL, have been engaged to rectify this fault.

Two more shock absorbers are being air-freighted to Manaus for the ABRACOS Land Rovers there. It is clear from first experiences with the Land Rovers that burst shock absorbers are to be an on-going problem, and a good stock ready for immediate replacement should be maintained to avoid more serious problems developing from the severe jolting experienced by unclamped suspensions.

2.2. Equipment

2.2.1. Transmitters

There are continuing delays in the supply of the satellite transmitting systems for the automatic weather stations. Recent meetings with Didcot Instrument Company have revealed that the equipment has not yet been submitted to the European Space Agency for their approval and subsequent registration with Meteosat. It is therefore unlikely that the systems will be delivered to IH before the end of this calendar year. Close contact with Didcot Instrument Company is being maintained to improve communication and monitor progress in the production of this equipment. Late delivery continues to distort the spending profile of this Budget Line in the Rolling Project Budget (see Section 7.2).

2.2.2. Towers

The towers required for the two new paired sites in Parå and Rondonia were purchased in the 1990/91 financial year. These have been shipped by sea freight to their two destinations in Brazil in good time to allow tower construction to commence at the beginning of July.

2.2.3. Soil Phyics Equipment

During the visit to Manaus in March, soil physics equipment stored at the EMBRAPA field station was sorted and packed for dispatch to the new sites in Parå and Rondonia. Most of this equipment was sent to Ji-Parana.

In the UK, access tubing and a soil moisture probe were purchased for each of the two new sites. New installation equipment has been purchased for the Maraba site, since installation of access tubes during Mission M1 at Fazenda Dimona proved very arduous and slow. The new installation equipment consists of a hydraulic hammer and hydraulic drill powered from a small, portable hydraulic power pack. This should speed up the process of access tube and tensiometer installation considerably. It is hoped that once the work at Maraba has been completed, it will be possible to airfreight this equipment to Ji-Parana in the month (September) between soil moisture study missions.

2.2.4. Lysimeter Studies

In the coming Mission the soil monoliths with associated clearing vegetation will be extracted and weighed during several sample days. These determinations will provide estimates of evaporation loss from different soil cover types in the clearing, ranging from bare soil to fully developed pasture. The monoliths (25 cm diameter x 30 m depth, enclosed in steel cylinders) will be maintained in position in pits of slightly larger dimensions with a steel lining, and weighed at hourly and daily intervals with a portable, high-capacity, precision balance. The weight losses will provide a capability to partition latent heat fluxes (transpiration) determined from the micrometeorological measurement systems to components of the ground cover. This study has particular relevance in understanding and modelling the changes in surface energy balance - in particular the latent heat flux which declines sharply during dry periods - and in such periods, significant changes in the relative contribution from soil or vegetation may occur.

3. SCIENTIFIC RESULTS

3.1. Micrometeorology

During the first half of 1991, efforts were concentrated on the validation of the energy balance data by cross-checking between independent measurement systems. This work has confirmed the encouraging results reported last year, showing excellent agreement between systems.

3.1.1. Evaporation and heat flux measurements

As a consequence of the agreement between systems, it has been possible to calculate hourly energy fluxes for the entire period of micrometeorological measurements at Fazenda Dimona. Fig. 3.1.1. shows the daily totals of latent heat flux (evaporation) and sensible heat flux together with the rainfall. The raingauge was not installed until 1 October 1991. Also shown in the figure is the daily evaporation normalized, as a ratio, to the total available energy.

Compared to previously issued graphs (ODA Report No. 2) showing similar results, Fig. 3.1.1. shows more clearly the response of evaporation to rainfall and changes in available moisture. Particularly during the period 5/10/90 to 22/10/90 when evaporation (61mm) exceeded rainfall (5mm) by 56 millimetres of water. The absence of any trend in sensible heat flux over the whole data period suggests stable surface temperatures and good aerodynamic coupling between the vegetation and the atmosphere.

3.1.2. Surface roughness

Wind profiles (6 levels) have been analyzed to give the first estimates of zero plane displacement, d, and roughness length, z_0, for Amazonian ranchland. These parameters describe the bulk surface roughness characteristics of the surface and are of prime interest to climate modellers.

Using 10 minute average profiles of potential temperature, Richardson Number, Ri, was evaluated to select only the most neutral conditions for analysis. Values of d and z_0 logarithmically adjusted 10 minute wind profiles. Fig. 3.1.2. shows the histograms of d and z_0 estimates. These results show a clear peak for both parameters and give mean values of:

$$d = 0.169 \text{ m}$$

and

$$z_0 = 0.025 \text{ m.}$$

or 60% and 9% of the vegetation height respectively

3.2. Soil Physics

Data collected between the end of Mission M1 in early November, and mid-January have been brought to the UK and have undergone preliminary analysis. These data, from the wet season, provide a good indication of the maximum profile storage (how wet the soil can become), and in this way a "datum" against which changes in profile water storage in the clearing and forest can be compared more reliably. Data collection is continuing on a weekly basis.

Mission 1: 1990

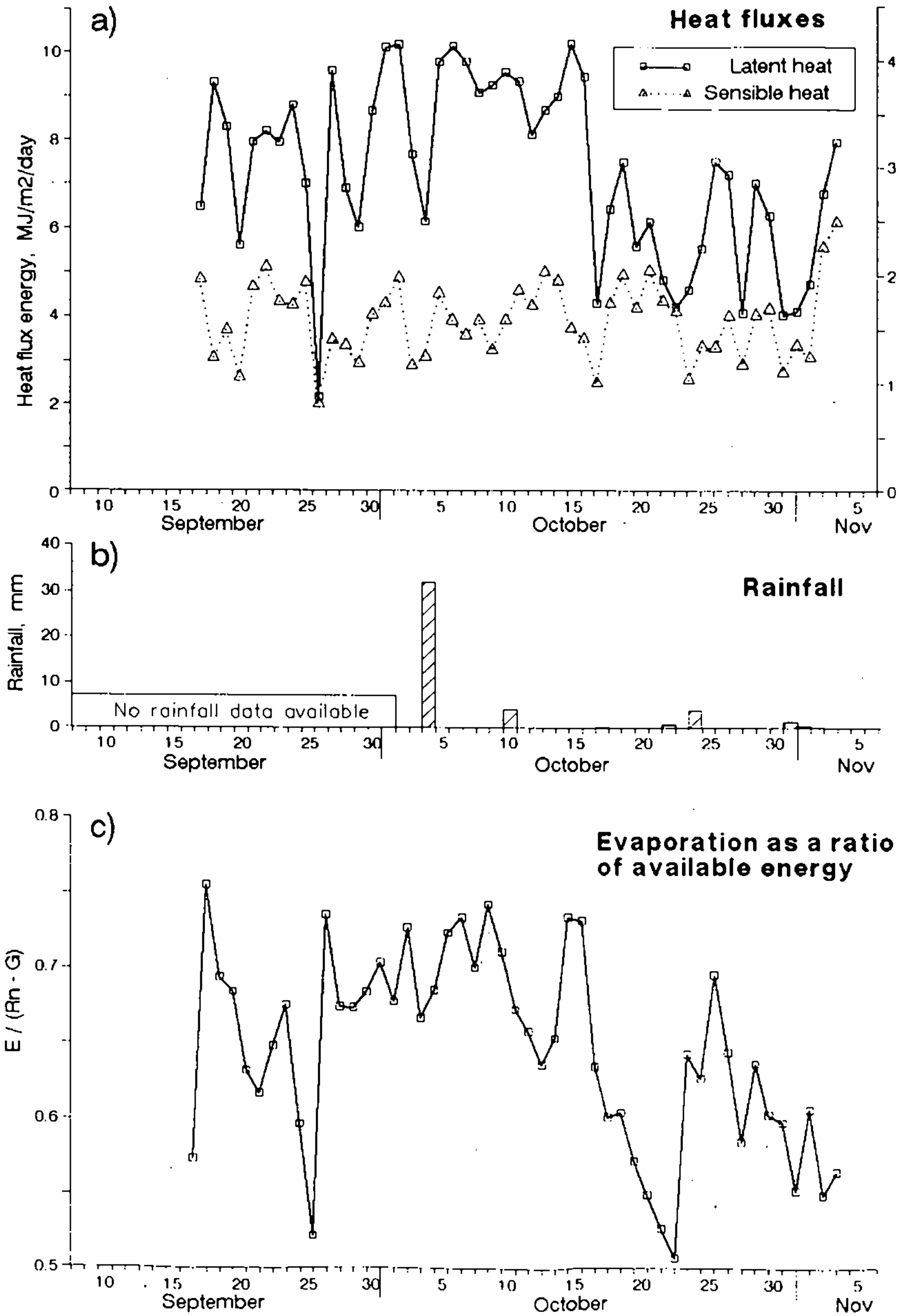


Figure 3.1.1

Mission 1: 1991

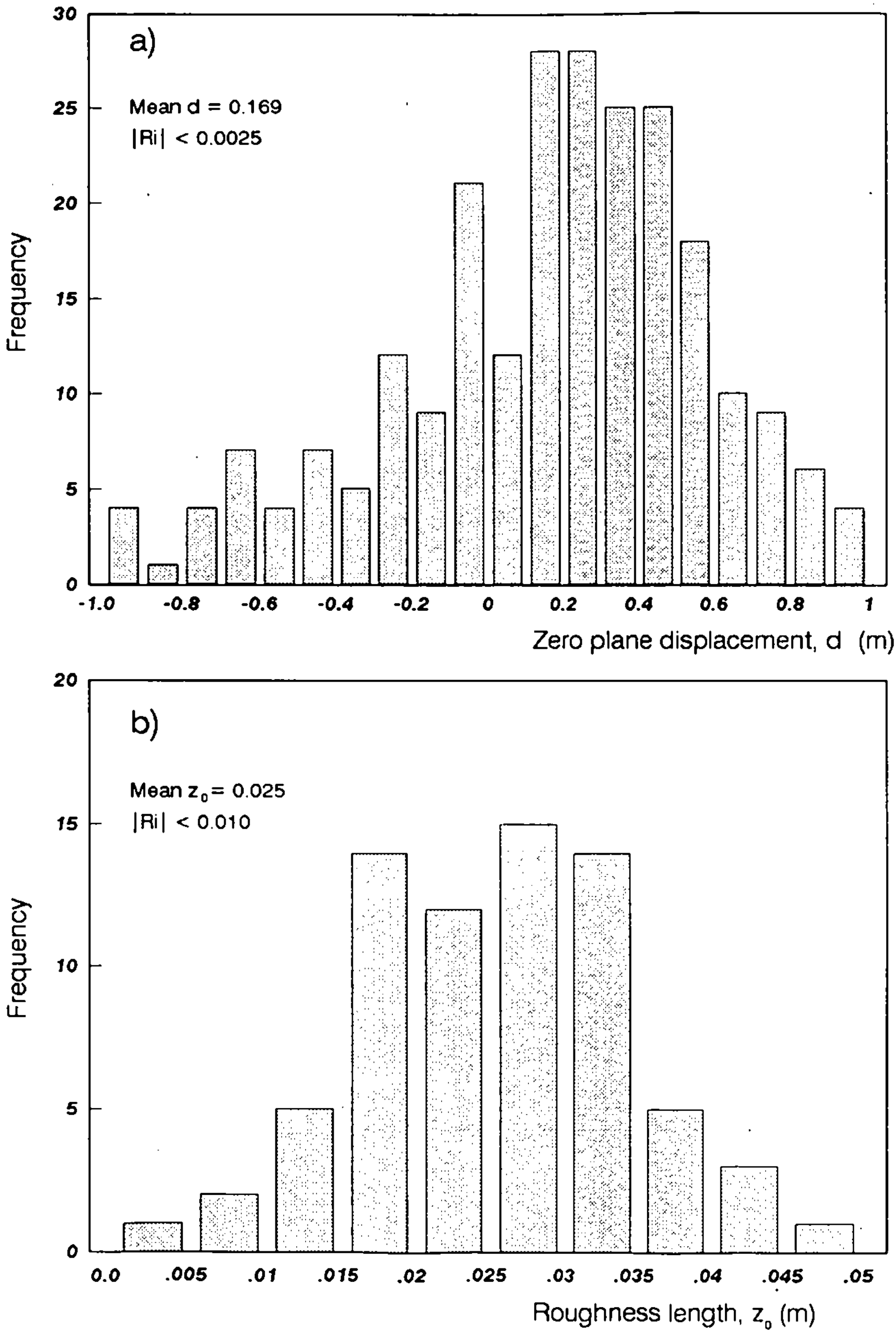


Figure 3.1.2

Further neutron probe calibration work was carried out at Fazenda Dimona after the meeting in São Josè dos Campos in March. The data obtained (during the wet season) have allowed better definition of the calibration relationship. The calibration gradient is approximately 10% greater than the estimated calibration used in preliminary data analysis. As a result, estimates of evapotranspiration based on measurements of soil water content are now closer to those produced by the micrometeorological techniques.

To further define the calibration, soil samples have been sent to the Service de Radio-Agronomie at Cadarache, France, who will determine the calibration relationship by an alternative and independent method.

3.3. **Climatology**

Analysis of the climatological data during the first half of 1991 has concentrated on a continuous 60-day data record from Reserva Ducke and Fazenda Dimona. This period (12 October - 10 December 1990) covers the end of the dry season and the beginning of the wet season in this part of Amazonas, as can be seen from the rainfall record shown in Figure 3.3.1. Noticeable differences have been observed between the forest and clearing comparisons for 10-day wet and dry season periods, but it is as yet not clear whether these have statistical significance.

3.3.1. Radiation Components

A regression was calculated between the solar and net radiation at both the forest and clearing sites using data values between sunrise and sunset. From these regression equations the net radiation was calculated as 12% greater at the forest site than at the clearing. During the wet season this difference is smaller, with 8.5% greater net radiation at the forest. At night the outgoing radiation can be up to 100% greater over the forest than at the clearing.

3.3.2. Albedo

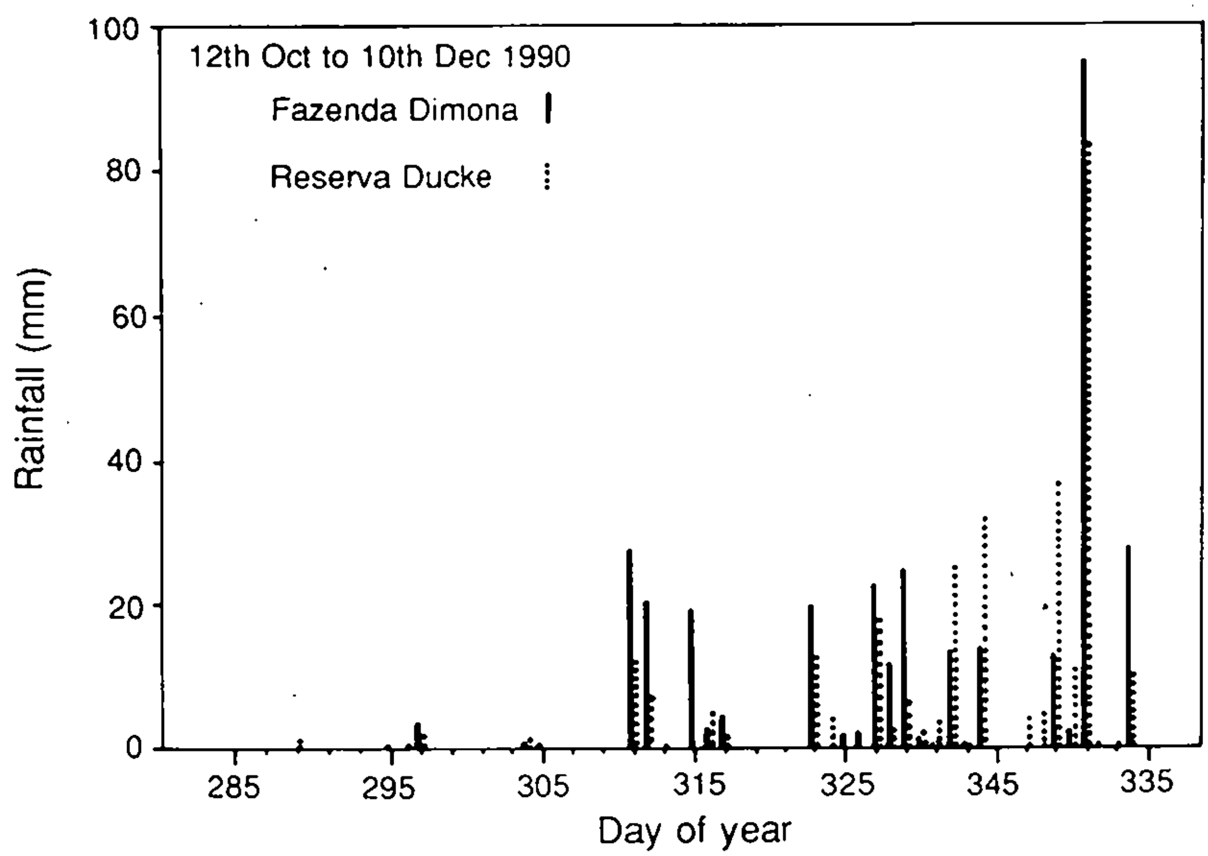
The mean daily total albedo (i.e. the ratio of the total reflected to the total incoming solar radiation for each day, averaged over the whole period) for the whole period is 15.9% at the clearing, and 12.9% at the forest. The effect of cloudiness on diurnal albedo variation is considerable, as shown in Figure 3.3.2. Mean values of albedo for three consecutive clear days (14-16 November) are shown in Figure 3.3.2a, and for three consecutive cloudy days (5-7 December) in Figure 3.3.2b.

3.3.3. Temperature

It is now clear that the diurnal variation in temperature between the two sites (reported in Interim Report 2) is much more pronounced during the dry season 10-day average (12-21 October), see Figure 3.3.3a, than during the wet season period (1-10 December), see Figure 3.3.3b.

3.3.4. Available Energy

The energy available at the ground for return to the atmosphere has been calculated using estimates of forest energy storage based on previous work at the Reserva Ducke site, and neglecting



12th Oct to 10th Dec 1990
Fazenda Dimona
Reserva Ducke
Rainfall (mm)
100
80
60
40
20
0
285
295
305
315
325
345
335
Day of year

Figure 3.3.1.

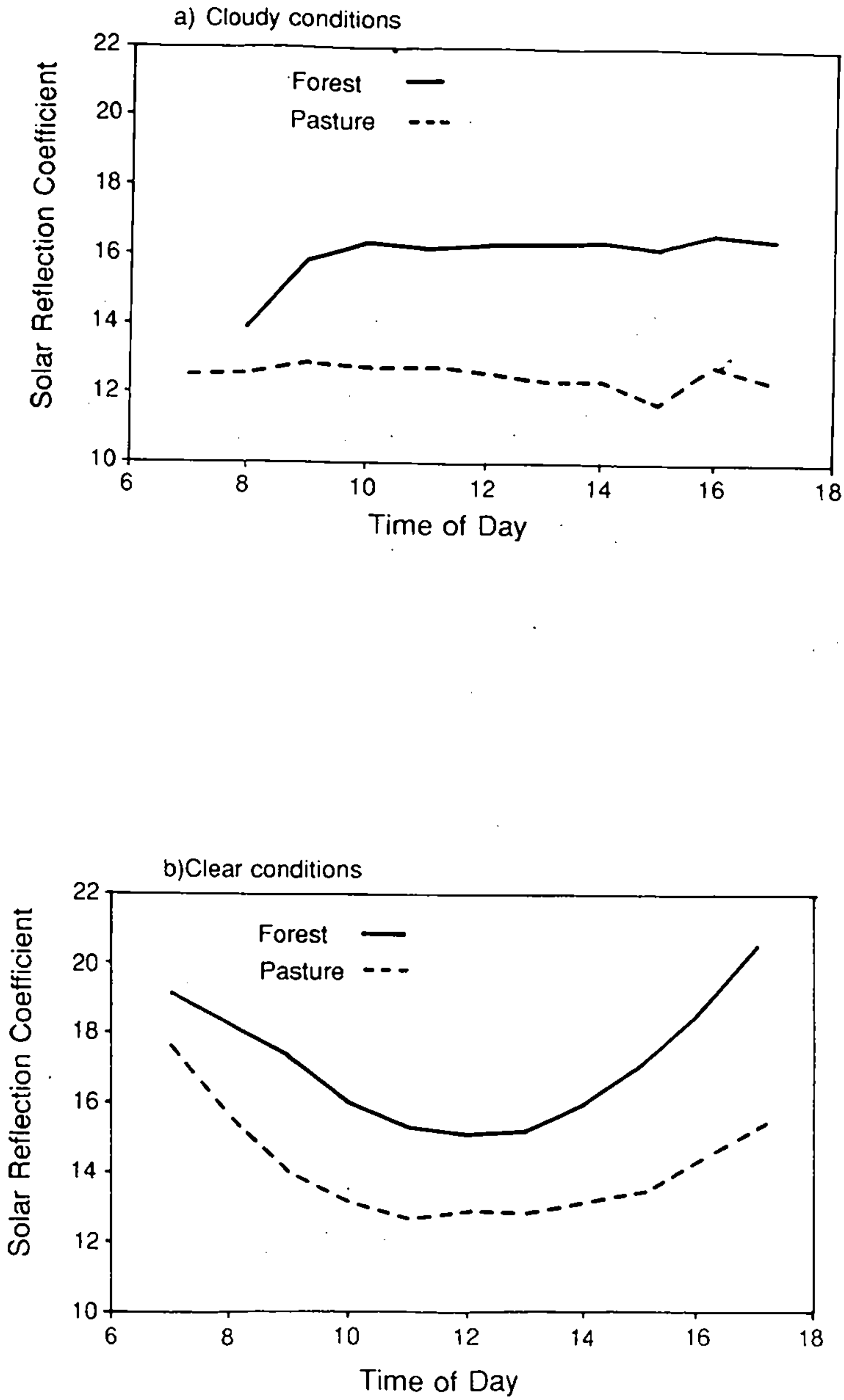
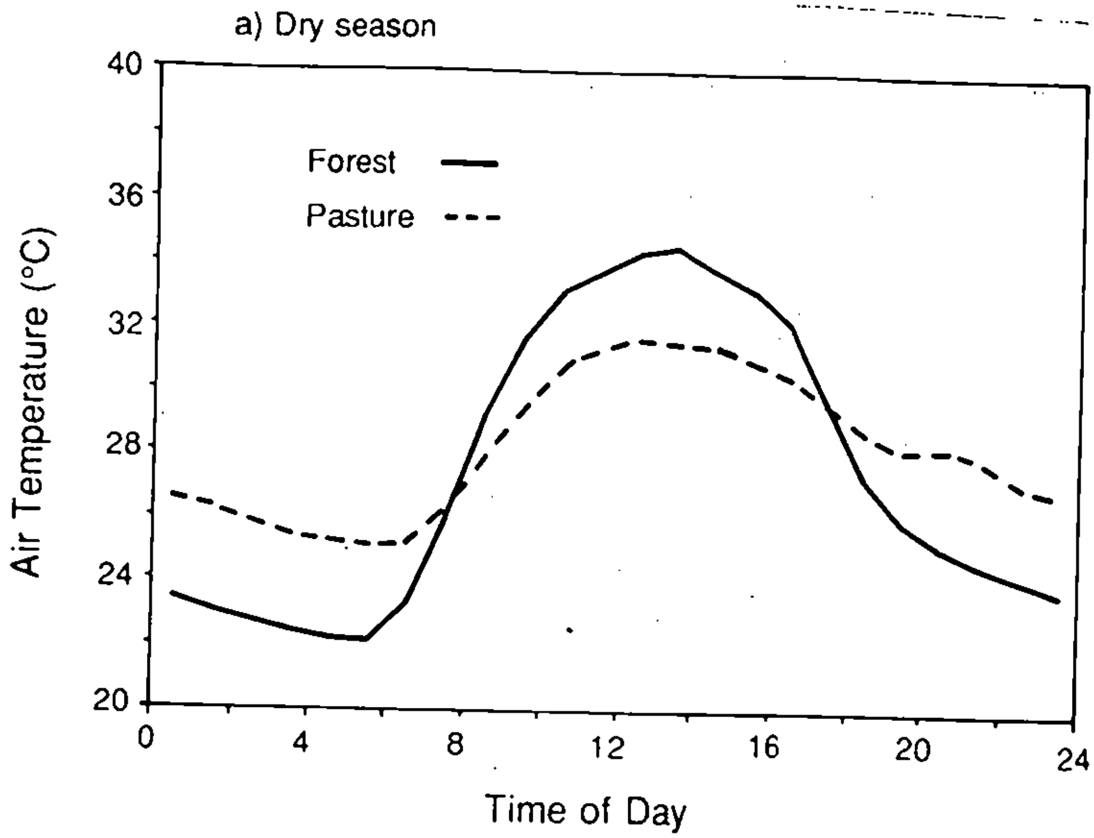


Figure 3.3.2. Average daily course of solar reflection coefficient for forest and pastureland in (a) cloudy (b) clear conditions



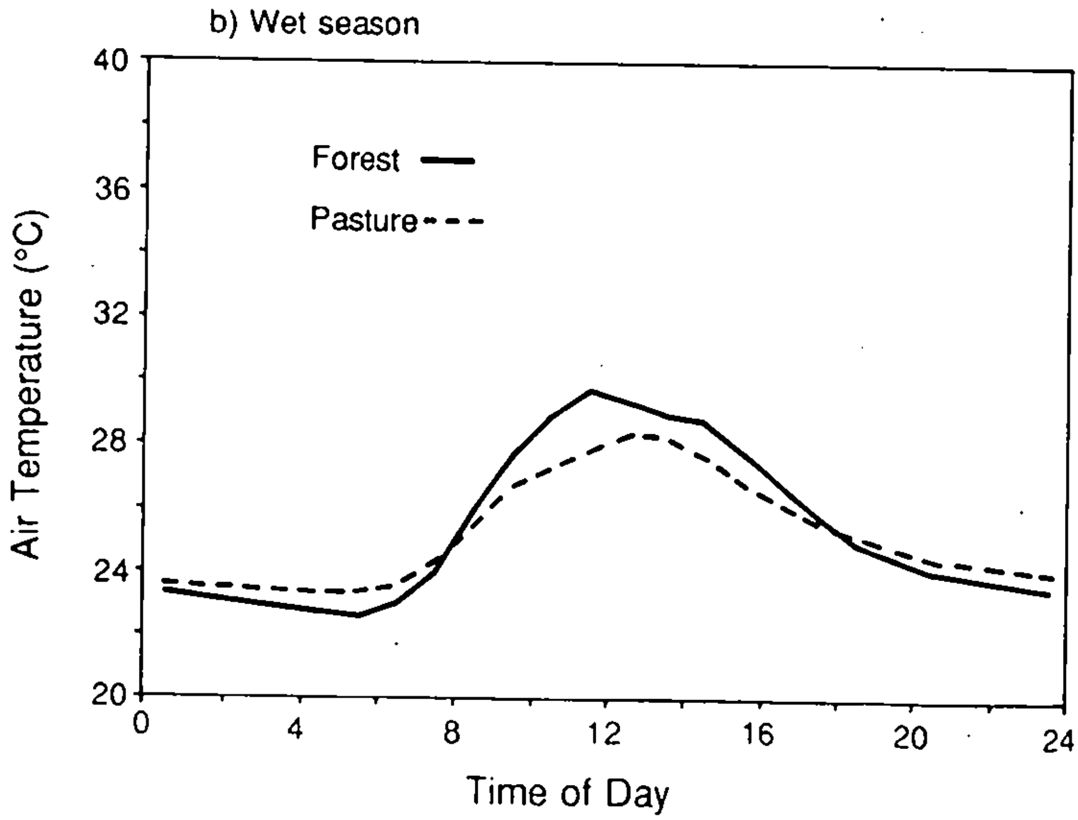


Figure 3.3.3. Ten day average daily course in air temperature above forest and pastureland (a) in the late dry season, and (b) in the early wet season.

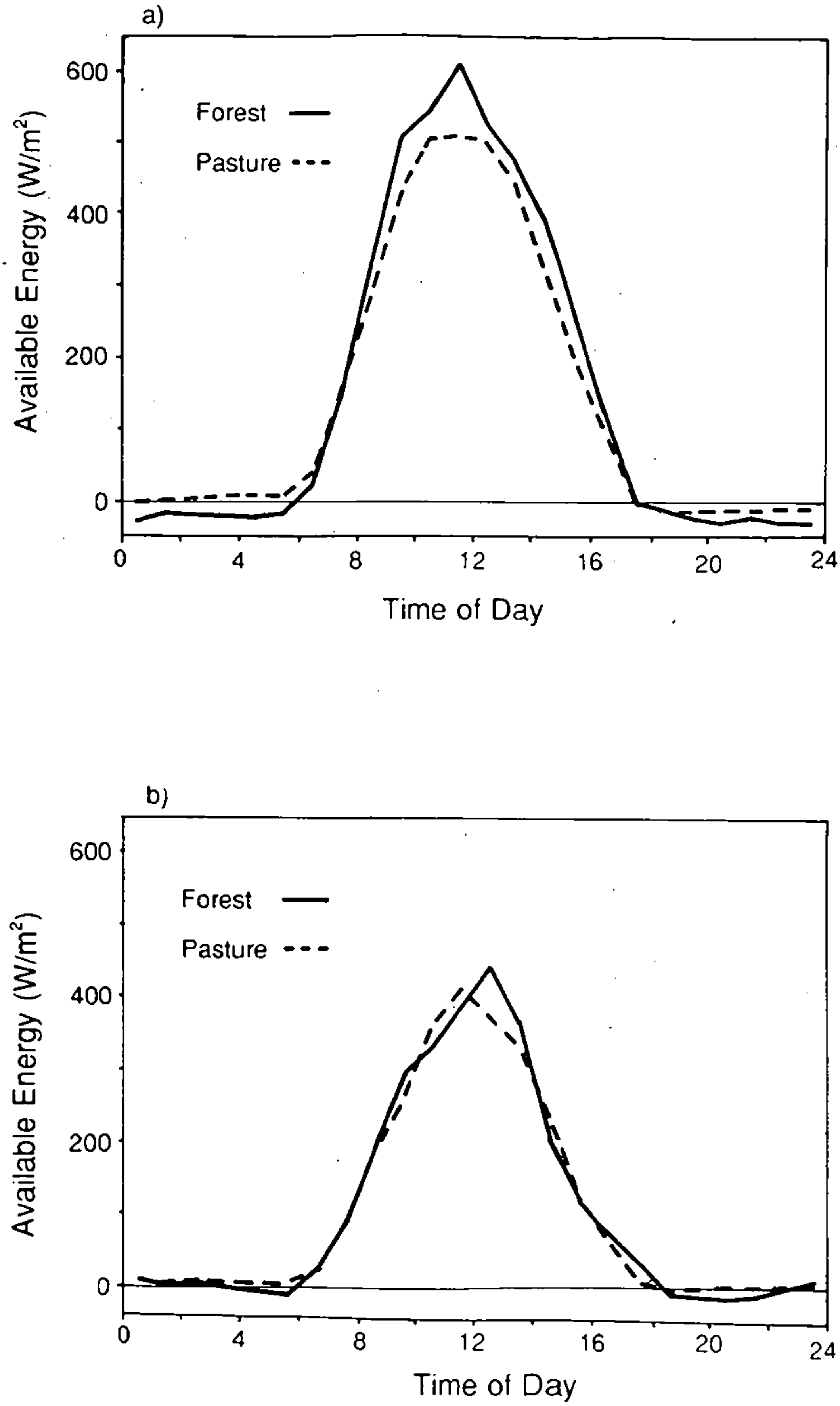


Figure 3.3.4. Ten day average daily course in estimated available energy for forest and pastureland (a) in the late dry season, and (b) in the early wet season.

the storage term at the clearing site. The difference in available energy between the forest and the clearing during the dry season is shown in Figure 3.3.4a, and during the wet season in Figure 3.3.4b.

3.4. **Plant Physiology**

As stated Interim Report No. 2, the overall objectives of the plant physiological studies in Mission M1 were:

- to estimate the vertical distribution of leaf area and biomass in rainforest and adjacent pasture;
- to measure leaf gas exchange (photosynthesis and transpiration) and water relations in forest and adjacent clearing;
- to measure within-canopy microclimatic factors contributing to transpiration.

Details of the experimental methods used and the data collected were given in Interim Report No. 2. However, the large woody material from the biomass sampling study which had to be sea freighted to the UK, has now arrived safely and is in the process of being dried at Wallingford. But this is proving to be a protracted process, and only when these values of dry weight are available can realistic estimations be made of the biomass and its vertical distribution in the rainforest.

3.4.1. Profile of forest micrometeorology at Reserva Ducke

A multi-layer form of the Penman-Monteith formulation has been developed using data from earlier experiments at the Reserva Florestal Ducke, but this formulation requires within-canopy micrometeorological variables. An important objective of ABRACOS studies at this reserve is to expand and enhance the use of this model by collecting the relevant micrometeorological profiles.

Some of the preliminary analyses of the micrometeorological data are illustrated in Fig. 3.4.1. Values were averaged hourly and represent the mean of 7 consecutive days. Results from the 45m height were obtained from the automatic weather station installed at the top of the tower. The temperature difference between the base and the top of the forest was below $2^{o}C$. Specific humidity differences (SHD) varied by a maximum of 5 g kg^{-1}. The wind profile varied most between 25m and 45m in the canopy (maximum difference between ground and top 2 m s^{-1}). From 5m to 25m the in wind speed did not exceed 0.5 m s^{-1}, and is arguably prone to anemometer stalling errors.

3.4.2. Plant Water Relations

The data presented represent stomatal conductances (Figs 3.4.2. and 3.4.3.) and water potentials (Figs 3.4.4. and 3.4.5.) on two separate days at the Fazenda Dimona clearing. During the course of the day, there was a steep decline in stomatal conductance, presumably in response to increased air temperatures and development of water deficits. Although both dominant grass species were measured for conductance, there was no overall

Figure 3.4.1. Profile of Micrometeorology
Reserva Florestal Ducke (average of 7 days)

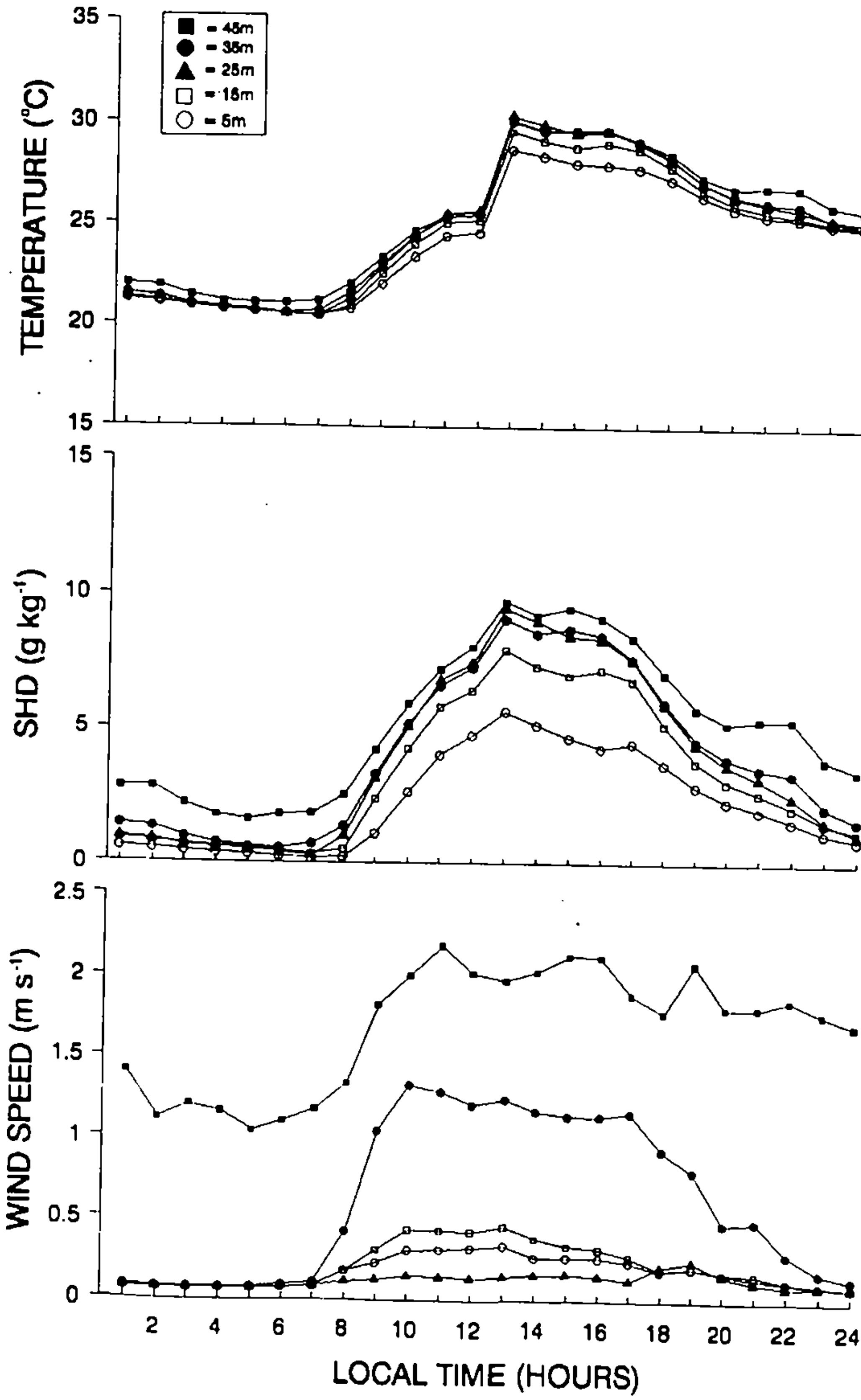


Figure 3.4.2. Stomatal conductances - 04/10/90
(both leaf types)

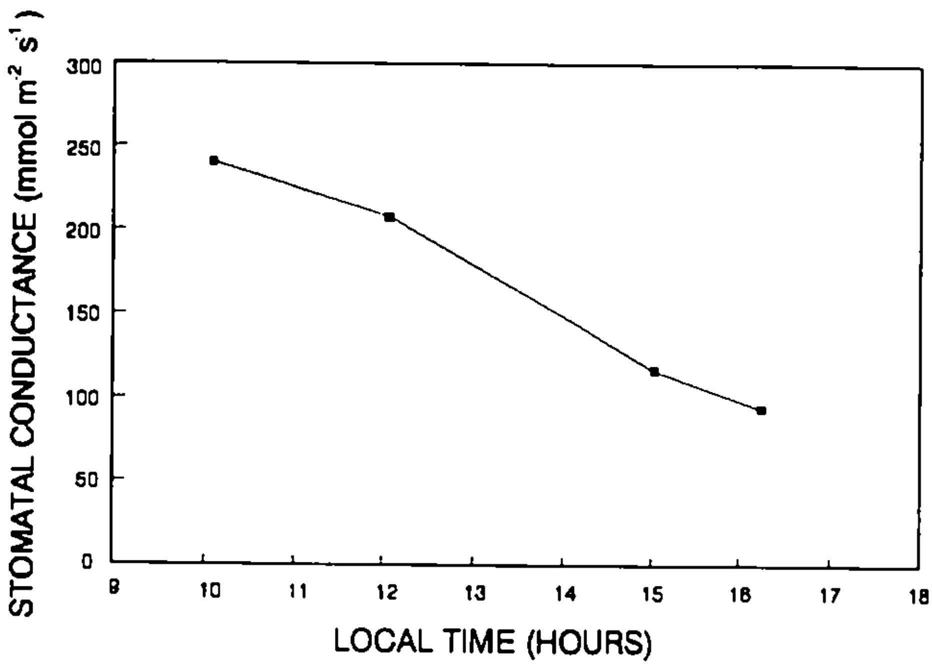


Figure 3.4.3. Stomatal conductances - 10/10/90
(both leaf types)

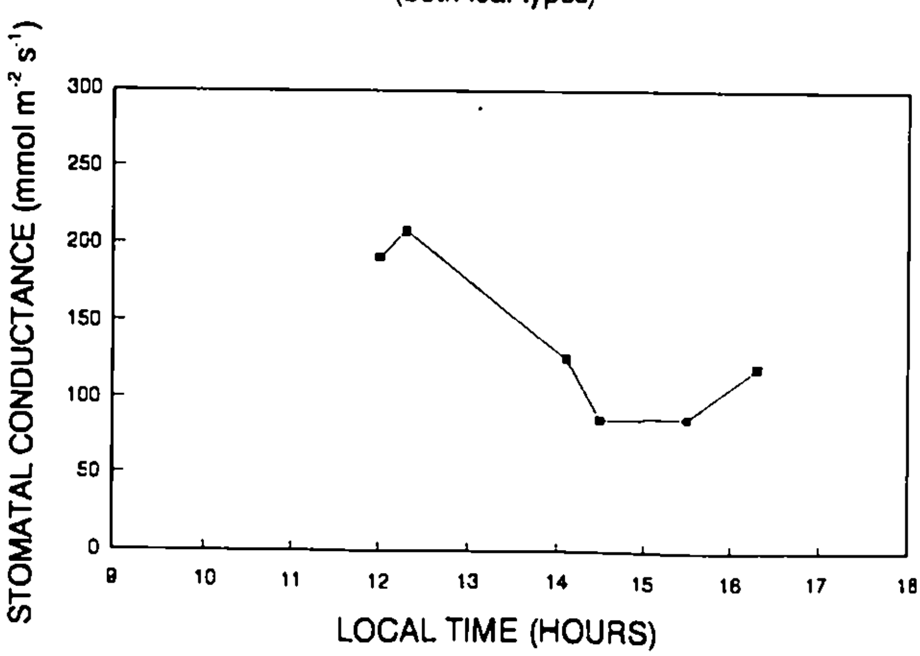


Figure 3.4.4. Leaf water potentials - 04/10/90

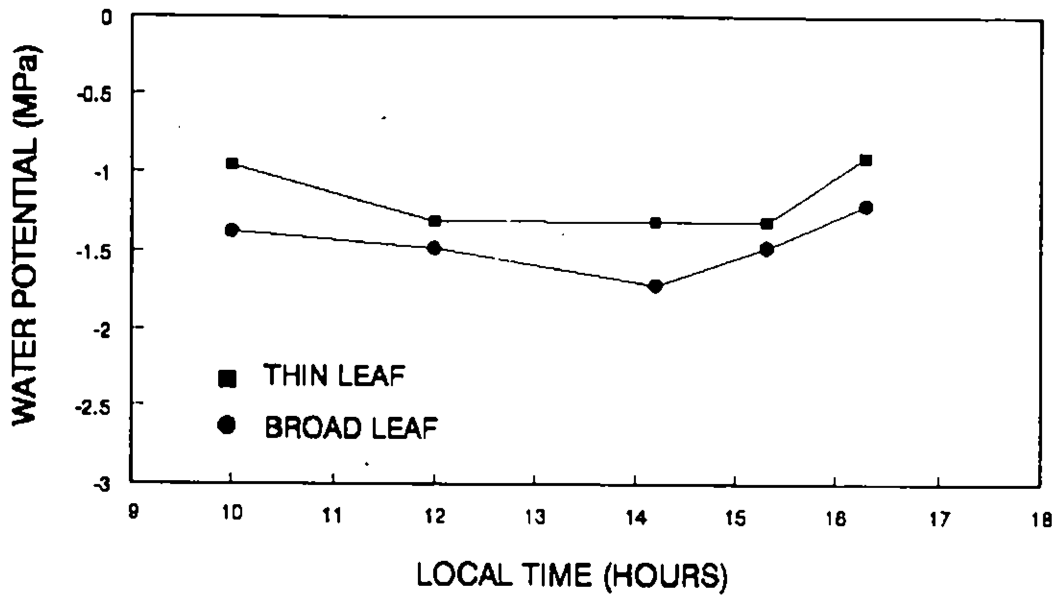
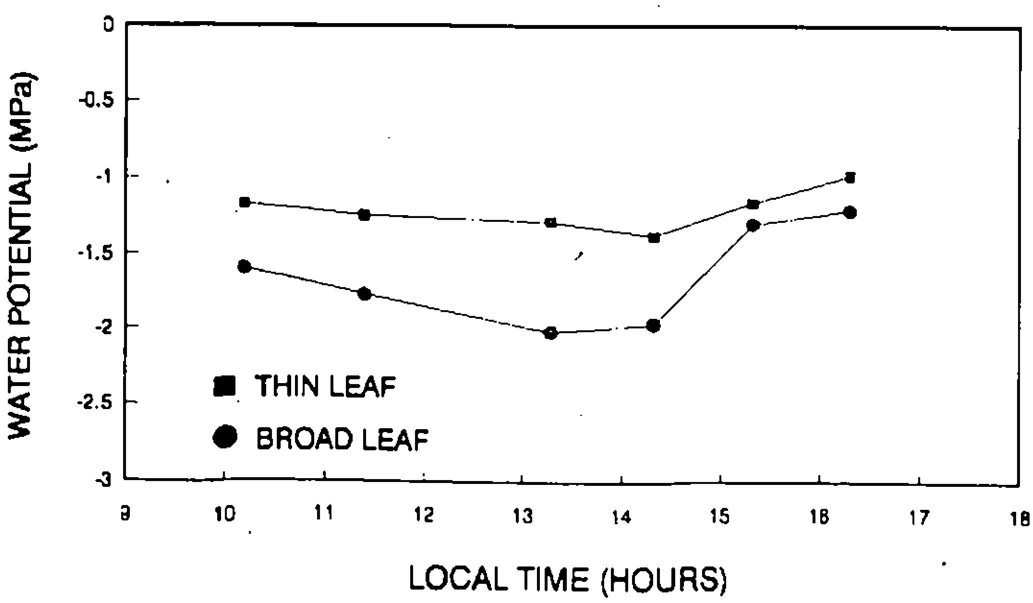


Figure 3.4.5. Leaf water potentials - 10/10/90



difference between the two: the values shown are the mean stomatal conductances. However, there were more systematic differences in the water potential of the two species, and values are therefore given separately. Water potentials showed a lag in response time, but the overall trend was the same as for the conductance.

Calculations of transpiration were made for these sample days using a simple form of the Penman-Monteith evaporation formulation. This used weather variables from the nearby automatic weather station and surface conductance derived from the hourly values of stomatal conductance (i.e. the data shown in Figs 3.4.2. and 3.4.3.) multiplied by the leaf area index for the Dimona clearing (0.83). The total transpiration rates for those days were calculated to be 1.83 and 1.59 mm d^{-1} for 04/10/90 and 10/10/90 respectively. This suggests that the plants were quite severely water stressed, the low transpiration rates resulting from a combination of reduced leaf area index and low stomatal conductances at the end of the dry season.

3.5. **Climate Modelling**

Plans for using the data to calibrate global circulation models are now being made. At least three models will be calibrated:

(i) the UK Hadley Centre (HC) model;
(ii) the Brazilian climate centre model; and at a slightly later time,
(iii) the French meteorological research institute (CNRM) model.

Current plans are that (i) will be carried out by H Bastable (IH) and C Nobre (INPE) at Bracknell, working in collaboration with P Rowntree (HC). (ii) will be carried out by H da Rocha (INPE) and I Wright (IH), at both Wallingford and the new climate centre in Brazil. If the computer for the new centre in Brazil is not commissioned before the work is ready to start, then this work may be carried out using computer time made available by the manufacturer, most probably in the USA. (iii) will be carried out by J Gash (IH) and A Manzi (INPE) in Toulouse in collaboration with J C André (CNRM). It is hoped that all of this work will start before the end of 1991, but early progress has been made in calibrating the Simple Biosphere Model (SiB) which is the land surface description to be used in (ii). This is described in detail in the next section.

3.5.1. First tests of the Simple Biosphere (SiB) Model

In the last five years there has been a great deal of work towards developing algorithms that describe the transfer of energy, mass and momentum between the atmosphere and the vegetated surface of the earth through parameterization of the physical, physiological and morphological elements of the surface layer.

These models have been coupled to a number of GCMs and one of the main goals of ABRACOS is to provide a range of data for typical Amazonian forest and post-deforestation pasture vegetation against which to calibrate, validate, and further improve these models. The SiB (Simple Biosphere) Model (Sellers et. al., 1986) is one of the most important of such novel models. SiB has been coupled to the Center for Ocean-Land-Atmosphere Interactions (COLA) GCM. A version of the COLA GCM will be implemented at the Brazilian Center for Weather Forecasting and Climate Studies (CPTEC) for climate modelling studies.

Calibration of SiB for forested areas in Amazonia has been done (Sellers et al., 1989) using data collected at Reserva Ducke in the early 1980s during the first Anglo-Brazilian Amazon Regional Micrometeorological Experiment (ARME) (Shuttleworth et al., 1984).

ABRACOS will provide the means for:

(i) calibration and validation of the SiB Model for natural vegetation and also for vegetation typical of cleared areas in Amazonia, and

(ii) further improvement of algorithms in sub-models within SiB.

Data

A sample of the data collected at the Fazenda Dimona site during the period 18-21 October 1990 was used first to initialize SiB, and then as the forcing variables. The forcing data set comprised: net radiation, downward shortwave radiation, horizontal wind, dry and wet bulb temperature, and precipitation, all of them recorded by the Automatic Weather Station. Data for comparison with the calculated energy fluxes and albedo were obtained from three independent measurements: the latent and sensible heat fluxes from the CSI Bowen Ratio, the reflected solar radiation from the AWS, and the soil heat fluxes taken at plates connected to the tower measurements.

SiB makes use of a number of parameters to describe the physical, physiological and morphological features for each of 12 biome types. In Nobre et al. (1991) a new set of parameters was created to represent typical Amazonia degraded pasture vegetation. Data taken during the First Intensive Campaign were used to modify a number of SiB parameters as shown in Table 3.5.1.1.

Preliminary Results

The fluxes related to the energy budget (sensible, latent and soil heat fluxes) and the total albedo are calculated by SiB given the input of the local atmospheric variables, and these values are compared to local independent measurements. Figs. 3.5.2.1. and 3.5.2.2. show the calculated and observed diurnal cycle of sensible and latent heat fluxes, respectively. SiB calculates values which are very close to the observed values. Calculated values during most of the daytime are slightly smaller than the observed values. However, it must be taken into consideration that CSI flux measurements values shown do not take into account the soil heat flux contribution on the flux's computation. If this flux is taken into account, smaller sensible and latent fluxes are to be expected, mostly during the hours around midday when downward soil heat flux is expected to be maximum. The total daily amount of evaporated water to the atmosphere was computed and compared to the observed values in Table 3.5.2. Differences are very small (in the order of 0.1 mm/day). Therefore, SiB gives a good estimate of the total daily water evaporated to the atmosphere.

Table 3.5.1.1. - Parameters used in SiB to describe the pasture vegetation at the Fazenda Dimona site and those used in Nobre et al. (1991) for degraded pasture (only the parameters which were changed are shown).

Parameter	Nobre et al (1991)	Fazenda Dimona (October 1990)
Height of the canopy top (m)	0.600	0.300
Height of the canopy bottom (m)	0.101	0.050
Roughness length (m)	0.07678	0.067
Zero plane displacement height (m)	0.25802	0.045
Green leaf fraction of total leaf and stem LAI of canopy top	0.74349	0.875
Soil reflectance for PAR	0.100	0.050
Soil reflectance for NIR	0.200	0.100
Canopy leaf and stem LAI	2.152	2.500
Ground cover leaf and stem LAI	2.400	0.100
Fractional area covered by canopy vegetation	0.800	0.850
Fractional area covered by ground cover vegetation	0.850	0.900

The initialization of deep soil temperature and soil moisture wetnesses in SiB for the computation of fluxes is important. The values used are shown in Table 3.5.1.2.

Table 3.5.1.2. - Initialization values in the SiB run for the period 18-21 October 1990.

Soil wetness fraction of surface layer	0.720
Soil wetness fraction of root layer	0.750
Soil wetness fraction of drainage layer	0.800
Deep soil temperature (K)	303.0

Table 3.5.2. - values of total daily pastureland evaporation (mm) as computed by SiB and observed by CSI Bowen Ratio system.

DAY	SiB	CIS
18 October	3.2	3.3
19 October	2.9	3.0
20 October	3.1	3.0
21 October	2.7	2.8

Figs. 3.5.2.3 and 3.5.2.4 show the calculated and observed diurnal cycle of soil heat flux and albedo respectively. SiB-calculated values seem to be in close agreement with the observed ones.

Plans

Future plans for SiB testing and modelling are as follows:

- to refine the parameterization of pasture vegetation type in SiB with data collected at Fazenda Dimona
- to use SiB as a tool to calculate heat fluxes for the forest and clearing sites in Rondonia and Parà
- to improve SiB hydrological sub-models to allow for water extraction by deep roots.

References used in Section 3.5.

Nobre, C. A., P. J. Sellers and J. Shukla, 1991: Amazonian deforestation and regional climate change (submitted to J. of Climate).

Sellers, P. J., Y. Mintz and A. Dalcher, 1986: A Simple Biosphere Model (SiB) for use within General Circulation Models. J. Atmos. Sci. 43(6), 505-531.

Sellers, P. J., W. J. Shuttleworth, J. L. Dorman, A. Dalcher and J. M. Roberts, 1989: Calibrating the Simple Biosphere Model for Amazonian tropical forest using field and remote sensing data. Part I: average calibration with field data. J. Appl. Meteor., 28(8), 727-759.

Shuttleworth, W. J., J. H. C. Gash, C. R. Lloyd, J. M. Roberts, A. D. O. Marques Filho, G. Fisch, V. de Paula Silva Filho, M. de Nazare Goes Ribeiro, L. C. B. Molion, L. D. de Abreu Sa, J. Carlos, C. A. Nobre, O. M. R. Cabral, S. R. Patel and J. C. de Moraes, 1984: Eddy correlation of energy partition for Amazonian forest. Quart. J. Roy. Meteor. Soc., 110, 1143-1162.

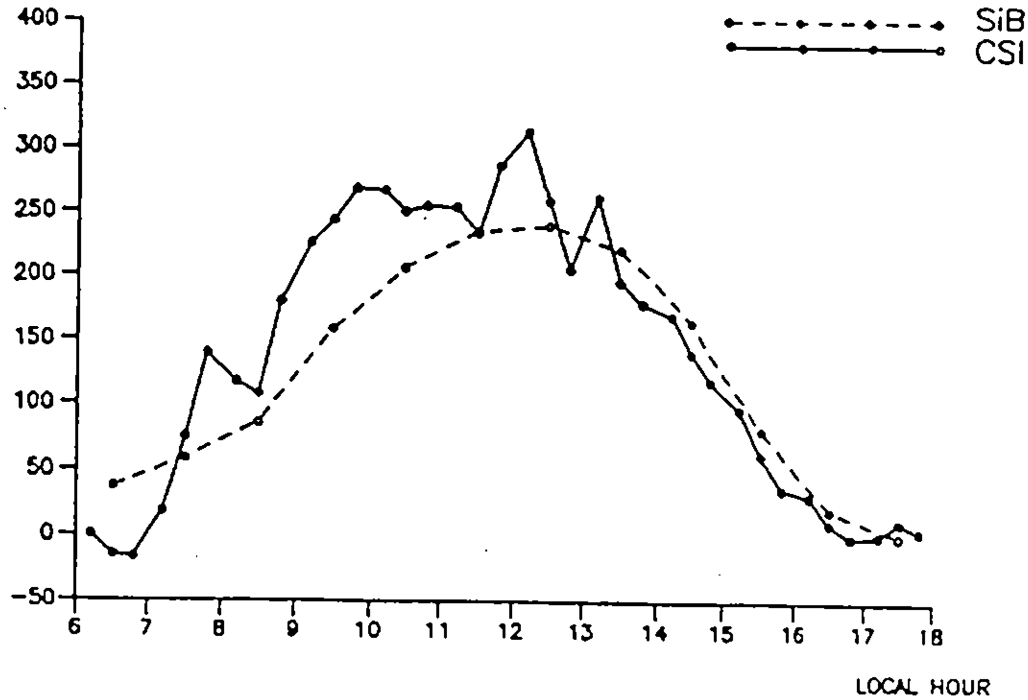


Fig. 3.5.2.1 - Sensible heat flux (W.m-2) as calculated by SiB (dashed line) and measurements by the CSI Bowen Ratio System (solid line). The values are averaged for the period 18-21 October.

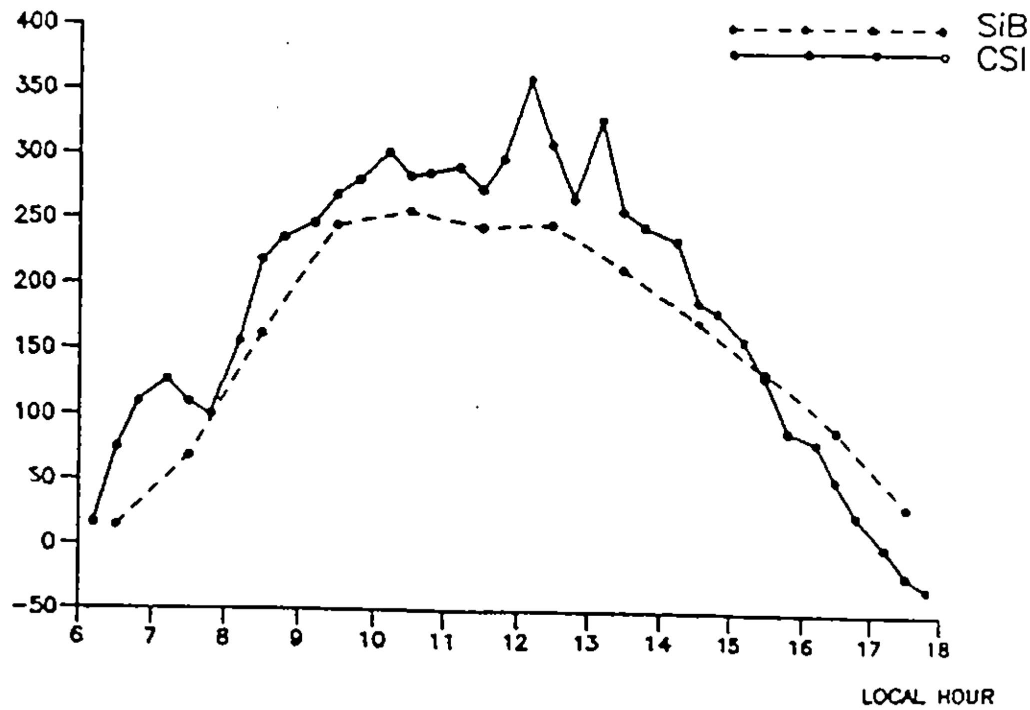


Fig. 3.5.2.2 - Latent heat flux (W.m-2) as calculated by SiB (dashed line) and measurements by the CSI Bowen Ratio System (solid line). The values are averaged for the period 18-21 October.

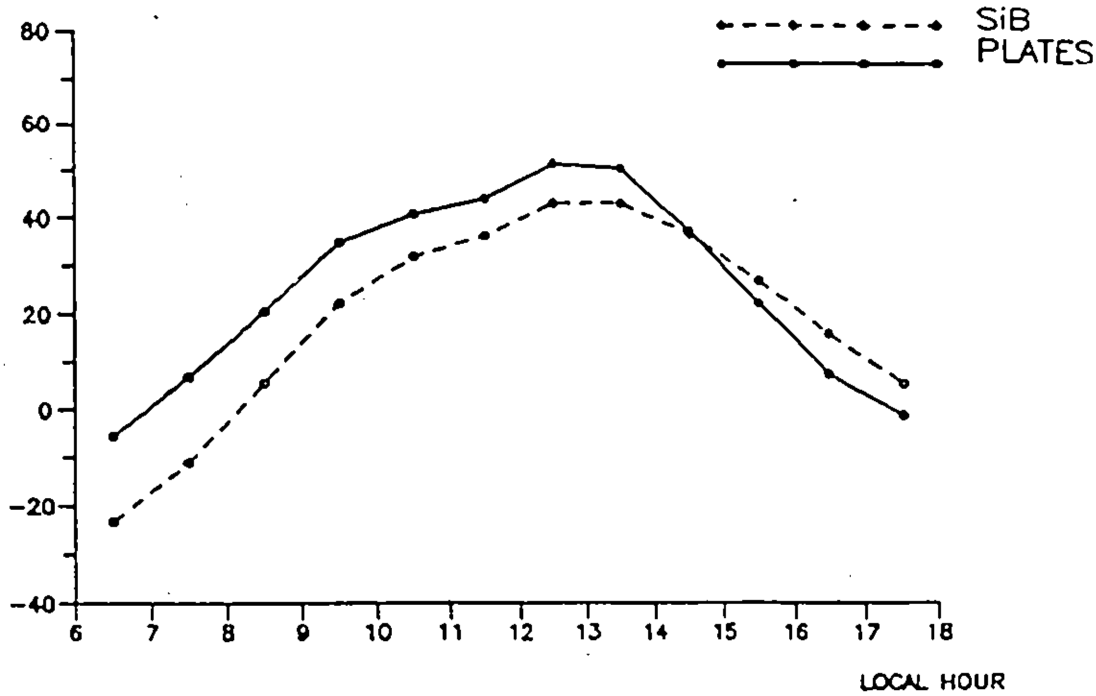


Fig. 3.5.2.3 - Soil heat flux (W.M-2) as calculated by SiB (dashed line) and measured by soil heat flux plates (solid line). The values are averaged for the period 18-21 October.

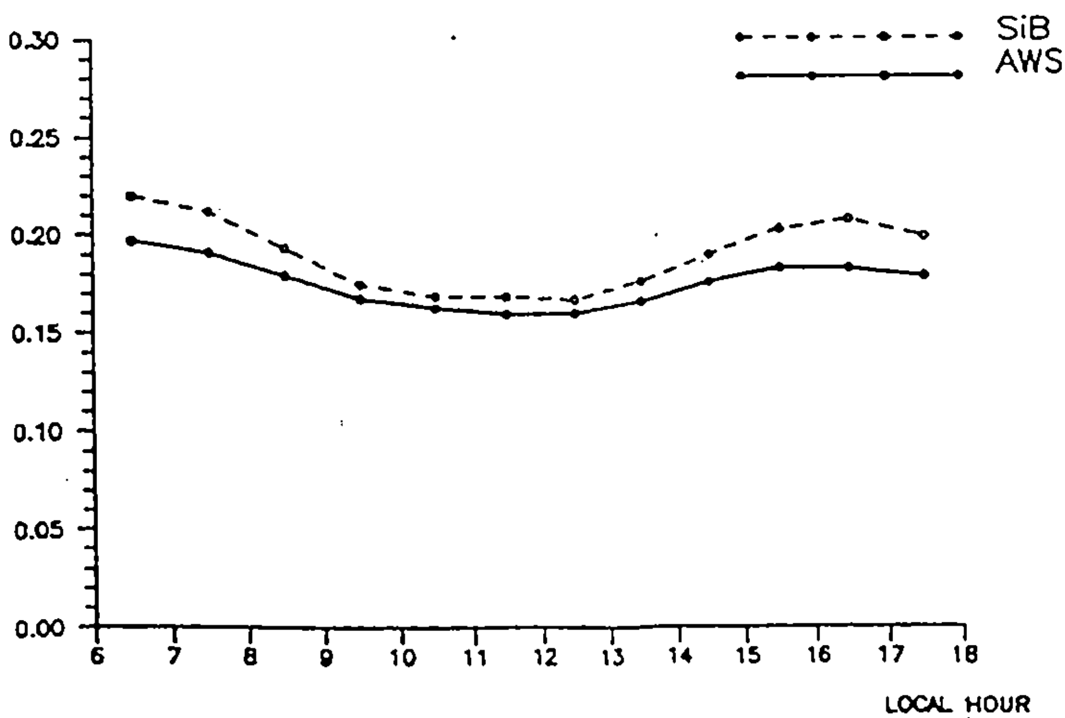


Fig. 3.5.2.4 - Albedo as calculated by SiB (dashed line) and computed by measurements of reflectometer and solarimeter at the AWS (solid line). The values are averaged for the period 18-21 October.

4. TRAINING

4.1. Visit of Dr P R A de Carvalho

The first short-term training visit to the UK by a Brazilian participant, Pedro Rubens Alvim de Carvalho, occurred in the period under review. There were some minor complications to do with per diem support (see 4.2.) but the visit was otherwise an unqualified success, both from the standpoint of individual on-the-job training and project development. The focus of activity was familiarization with existing instrumentation, and with the Hydra instruments and Campbell loggers in particular, but with a substantial element of instrumental development. A prototype system for indirectly measuring surface energy exchange was developed, and this will be tested during Mission M2.

4.2. Responsibility for training visits

At a meeting between IH and the British Council in Brasilia on 14 March 1991, it was suggested that it might be administratively simpler for IH to organise the arrangements for visiting scientists direct, rather than using the standard British Council procedures. At the same meeting, the British Council pointed out that they run English language courses in Brazil and that these might be an appropriate precursor for some visiting scientists. Permission was therefore requested to include these as part of the training programme.

Subsequently, at a meeting between IH and ODA LCAD on 10 June 1991, these issues were discussed. A decision was taken to assign IH responsibility for organizing the short training visits, and agreement given to include the option for British Council English language courses for up to 5 Brazilian ABRACOS participants per year.

Budget Line 2.4. in the Rolling Project Budget (see 7.2) has accordingly been modified to include three elements. The first, A, is the existing provision for counterpart travel to the UK for project development purposes; the second, B, estimated as £18K per annum, is for short training visits; and the third, C, is the training component which remains under British Council control. In the current budget this last element only includes provision for up to five English Courses, estimated as costing £1.7K each, with no provision for the possible long-term training elements which were envisaged in the original project proposal.

5. DISSEMINATION OF INFORMATION

5.1. In the previous Interim Report (No. 2, 30 December 1990), a request was made for additional budgetary provision to cover the financial demands on the project for this activity, since the high requirement for dissemination products was not foreseen at the time of project proposal. Approval for this has not been given at the time of writing, but pending a decision on this the recommended levels have been retained in the Rolling Project Budget (see 7.2).

5.2. In the period 1 January 1991 to 30 June 1991, the primary dissemination products have been an updated, four-page glossy overviewing the project, and an associated twelve-minute video. Both these include information on the first results obtained in Mission M1. These products have been widely distributed but, in particular, were provided as briefing material to the Prince of Wales and to the UK Minister for Overseas Development prior to the Royal Visit to Brazil in late March 1991, and the associated visit by the Minister to the ABRACOS site in Manaus. Display material was also provided for use in this last context.

5.3. Over the last six months, Dr Shuttleworth has made verbal or poster presentations on the project and its first results: in February, at Imperial College, London and Oxford University; in March, at the UK Meeting on Terrestrial Remote Sensing (TERRA-1) in Winchester, and University College, London; in April, to the UK Meteorological Research Committee at the Hadley Centre, and to the European Geophysical Society in Wiesbaden, Germany; in May, at the opening of the Edinburgh Centre for Tropical Forest; in June, as input to the second meeting of the Joint World Climate Research Programme (WCRP)/International Geosphere-Biosphere Programme (IGBP) Working Group on Land Surface Experiments in Baltimore, and to the IGBP Working Group on Global Data Systems in Toulouse.

5.4. The scientific paper reviewing post-Amazonian studies and previewing research under ABRACOS delivered verbally in August 1990 to the Symposium on Hydrology and Water Management of the Amazon Basin in August 1990, is now in the final stages of publication in the Journal of Hydrology. Two scientific papers on the first meteorological and climate data from ABRACOS have been prepared as advanced first drafts, and progress made towards a paper describing the biomass study carried out in Mission M1. These papers all have joint Anglo-Brazilian authorship. Plans for further papers were made at the ABRACOS workshop in INPE in March 1991, and their potential authorship defined.

6. PROGRESS IN THE NEW SITES

6.1. Parà

During March 1991, Dr John Roberts (IH) and Professor Josè Carvalho de Moraes, Department of Meteorology, Federal University of Parà jointly pursued aspects necessary for the establishment instrumentation of sites in Parà.

This involved visiting the Museum Goeldi, Belem to discuss with Dra Benedito (Administration Section) the means used by the Museum for importing equipment, and to determine the Despachante they use. Roberts and Carvalho then travelled to Maraba, and further investigated the location of a clearing area site. A suitable site was defined north of Maraba, and negotiations are now under way with the farmer to allow location of the clearing experiment on his property.

Discussions were held with Dr Lealia Brasil, the campus co-ordinator of the Federal University of Parà at Maraba, about the specific requirements for locating the base of the ABRACOS study at the campus. The main points covered were the room space requirements, and the possibility that one or two students become local participants in ABRACOS. In the event, and in response to an earlier visit to the campus in November 1990, two students had been identified and were introduced to Carvalho and Roberts.

Finally, enquiries were made at three local diesel vehicle agents or service centres about the feasibility of servicing the ABRACOS Land Rover to be based at Maraba. Only one of these garages seemed suitable or willing to undertake the work.

6.2. Rondonia

The principal collaborator at the proposed site in Rondonia is to be Eng. Nelson Escudeiro, Director of the Ji-Parana Campus of the Univerity of Rondonia. Further developments in definition of the Rondonia site will necessarily have to be rapid over the next three months.

6.3. General

The preferred sites in both Parà and Rondonia are Indian reservations, and permission to work there needs to be obtained from FUNAI, the organisation responsible for Indian Affairs. At the time of writing, such permission is being actively sought at the highest level, and in this context it has proved appropriate to offer to fund a visit by the President of FUNAI and his top aide to the ABRACOS sites in Manaus and Maraba. Should such a visit occur, it would send the actual spend on Budget Line 2.3. over budget by approximately £2K in the 1990/91 present financial year.

7. FINANCIAL OVERVIEW

7.1. Budget Line Revisions

7.1.1. The Rolling Project Budget given in 7.2. is based on that given in Interim Report No. 2 (December 1990). It therefore includes the recommended changes in the allocations for Freight Costs and for Staff Costs (in 1990/91 for dispatching equipment to Manaus, and in 1991/92 for tower construction) given in that report. Approval for these increases was given for planning purposes by ODA on 28 February 1991, but formal approval is awaited. Freight costs are continuing high and, at the time of writing, it seems likely that the figures estimated for 1991/92 are conservative.

7.1.2. This budget also includes the additional budgetary provision for Dissemination of Information as requested in Section 5 of Interim Report No. 2: however, the approved level of financial provision for this component has not been set by ODA at the time of writing.

7.1.3. The main changes in the current budget are due to the revised training arrangements described in detail in Section 4. In particular, the provision for short-term training visits has now become explicit within the IH controlled portion of the budget as Budget Line 2.4B; at ODA's request, other training elements are recognized under Budget Line 2.4C, though they are only approximately estimated in this report.

7.1.4. Apart from the changes highlighted in the last paragraph, the net project budget remains unchanged from December 1990. The main revisions in this Rolling Budget are otherwise enforced carry forward in the Capital Costs from 1990/91 to 1991/92, due to late delivery of equipment. These are in Budget Lines 1.1.1 (£4.4K); 1.2.1 (£57.9K); 1.3.1 (£7.3K); 1.3.2.A. (£2.6K); and 1.3.3 (£2.4K). In addition there is some small carry forward in Recurrent Costs (Budget Line 2.1) totalling £1.9K, but early spend in Budget Line 1.2.2 (£3.7).

7.1.5. An application was made to Mr G Duffy of ODA Natural Resource and Environment Department on 20 February 1990 in the form of a Concept Note describing proposed activity, complementary to ABRACOS, to investigate the Atmospheric Boundary Layer above cleared and uncleared Amazonian forest. This was originally submitted as a proposal to NRED's Environmental Research Programme, but has now been recommended for support under the Brazilian Environment Programme, as an additional activity under this project. Outline approval for this was given by ODA LCAD on 10 June and a more detailed proposal is in active preparation. It was agreed that for reasons of efficiency, the costings and monitoring provision would be prepared in a format identical to ABRACOS with a view to their future merger. This element is an extension to ABRACOS and will operate under the same ODA/ABC Subsidiary Agreement.

7.1.5. The present Rolling Project Budget contains no provision within the Counterpart Travel element (Budget Line 2.3) for the very heavy travel costs associated with senior Brazilian participants resolving administrative issues with the Brazilian authorities. In practice, this is proving to be a heavy demand and in IH's opinion there is a very real probability of significant overspend in this Budget Line, possibly as high as £10K in the current year, and £5K per year in future years.

7.2. **ROLLING PROJECT BUDGET** (in £K)

		Year 1 89/90	Year 2 90/91	Year 3 91/92	Year 4 92/93	Year 5 93/94	Year 6 94/95	Totals
1.	CAPITAL COSTS							
1.1.	Hardware associated with Phase 2							
1.1.1.	Micrometeorological Equipment	0.5	43.2	29.4	23.0	5.0	-	101.1
1.1.2.	Plant Physiological Equipment	-	71.8	7.0	-	-	-	78.8
1.1.3	Soil Moisture Equipment	1.3	13.4	-	-	-	-	14.7
1.2.	Hardware associated with Phase 3							
1.2.1.	Climatological Equipment and Receiving Stations	-	77.5	57.9	-	-	-	135.4
1.2.2.	Soil Moisture Equipment	-	38.7	6.3	-	-	-	45.0
1.3.	Transport and Site Facilities							
1.3.1.	Forest Towers	-	62.7	7.3	-	-	-	70.0
1.3.2.A.	Transport Facilities (Op. and Maint.)	-	6.4	11.6	9.0	9.0	-	36.0
B.	Transport Facilities (Purchase)		(88.0)					(88.0)
1.3.3	Site Facilities	-	4.1	27.4	-	-	-	31.5
1.4.	UK-based Hardware and Facilities							
1.4.1.	Computers	-	24.0	-	-	-	-	24.0
	TOTAL CAPITAL:	1.8	341.8	146.9	32.0	14.0	-	536.5
			(429.8)					(624.5)

		Year 1 89/90	Year 2 90/91	Year 3 91/92	Year 4 92/93	Year 5 93/94	Year 6 94/95	Totals
2.	RECURRENT COSTS (other than vehicle support)							
2.1.	Sundry Scientific Supplies	-	24.6	26.9	27.0	27.0	17.0	122.5
2.2.	Freight Charges	-	27.8	25.0	10.0	10.0	-	72.8
2.3	Contribution to Counterpart Travel Costs	-	21.1	20.2	38.8	18.4	-	98.5
2.4.A	Counterpart travel to UK	0.2	4.6	5.4	5.4	5.4	23.5	44.5
B	Short-term training in UK	-	-	18.0	18.0	18.0	18.0	72.0
C	Other training elements	-	-	(8.5)	(8.5)	(8.5)	(8.5)	(34.0)
2.5.	Institute of Hydrology Travel Costs	-	71.0	83.0	82.5	82.5	38.0	357.0
2.6.	Institute of Hydrology Consultant	0.5	9.3	6.2	8.5	8.4	8.0	40.9
2.7	Institute of Hydrology Staff Costs	34.4	234.4	252.4	252.6	265.5	207.0	1246.3
	TOTAL RECURRENT:	35.1	392.8	437.1	442.8	435.2	321.5	2054.5
TOTAL PER YEAR		36.9	734.6	584.0	474.8	449.2	321.5	2591.0
		(36.9)	(822.6)	(592.5)	(483.3)	(457.7)	(330.0)	(2713.0)
PROPOSAL ESTIMATE OF COSTS (including 10% contingency element)		(..........1348..........)			426.6	411.4	276.7	2462.0

PROJECTED TOTAL COST OF PROJECT (as at 30 December 1990): £2,591,000 or including 10% £2,850,100

(£2,713,000) contingency element (£2,984,300)

Natural
Environment
Research
Council