Institute of Hydrology

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ANGLO-BRAZILIAN AMAZONIAN CLIMATE PROJECT

(proposed September 1990, as "Anglo-Brazilian Amazonian Climate Observation Study" [ABRACOS])

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Contents

1 Summary

1.1 Work during the past 6 months has concentrated on analysis of the results and preparation of material and papers for the Symposium in September.

1.2 Comparison of observed climate with climate model predictions has revealed a systematic under-estimation of solar radiation by the Hadley Centre climate model.

1.3 Systematically less solar radiation has been observed in the Ji Paraná clearing site than at the forest, indicating a possible signal of changed climate resulting from deforestation.

1.4 The optimisation of the surface conductance model for Ji Paraná pasture and clearing has been completed. The applicability of the Manaus parameter set to estimating the Ji-Paraná evaporation has been tested.

1.5 Leaf gas exchange data of the Ji-Paraná forest and pasture have been fully analysed. Variation in stomatal conductance at particular levels in the forest canopy is most strongly associated with air specific humidity deficit. In the pasture, on the other hand, solar radiation and soil moisture deficit have the largest influences.

1.6 Analysis of three years of leaf litter data from the Reserva Vale Forest at Marabá has shown consistent annual falls of around 5.3. The specific leaf area data has been analysed and shows promise as a means of defining the vertical distribution of the forest canopy.

1.7 Comparison of soil water behaviour on the plateau, slope and valley floor showed that the influence of lateral subsurface movement of water within the groundwater body must be taken account of in GCM formulation.

1.8 The hydraulic and water retention properties of the Amazonian soils studied are very different for those of temperate soils. Relationships derived for temperate soils to predict soil hydraulic properties from more commonly measured soil parameters must be avoided.

1.9 The ABRACOS soil water record from Fazenda Dimona was compared with the record predicted from the 27 year rainfall record from Reserva Ducke. For the forest the deficit measured in December 1991 was the second most extreme after 1976. For the pasture, the measured deficit on 5 November 1990 was the fifth driest on record.

1.10 Both the Hadley Centre and COLA, in the USA, have performed GCM deforestation experiments using the Fazenda Dimona data to calibrate thir deforested/pasture model scenario, broadly similar results have been obtained, with decrease in rainfall over eastern Amazonia and increased rain over Colombia.

1.11 The training programme has continued with two more visits by Brazilian scientists to Wallingford.

2 Progress

2.1 INTRODUCTION

The six months of this reporting period have been largely devoted to analysis of the data and preparation of material and papers for the project Symposium in Brasilia in Spetember 1994. A booklet describing the results in non-scientific terms has been prepared and 16 posters have been prepared for the exhibition which will be held in parallel with the Symposium.

Progress in analysing the results has been good on all fronts, but with particularly rapid progress being made in the processing and analysis of the soil moisture data.

2.2 CLIMATOLOGY AND MICROMETEOROLOGY

2.2.1 Climatology

Automatic weather stations
In April and May Dr Culf from IH and Sr José Carlos dos Santos from INPE visited all the automatic weather stations to service the instruments and to check that they were operating correctly. The visit was also used to train Sr dos Santos in the operation, maintenance and programming of the weather stations. He will take over responsibility for maintaining the AWS network at the end of the project.

Satellite data transmission
The Institute of Hydrology satellite data receiver has been thoroughly tested by the manufacturers BURL and found to be operating correctly. The problems experienced with the system have been traced to the computer which was connected to the receiver. Three new computers recommended by BURL are now on order and will be fully tested in conjunction with the Institute's receiver by the manufacturers before installation. The re-establishment of this link both in the UK and in Brazil should greatly improve the speed with which instrument failures can be identified and acted upon.

Data Analysis
Analysis of the climatology data has been proceeding on two fronts. Firstly comparisons have been made with monthly averages of climatological variables and the outputs from two General Circulation Models; the Unified Model of the Hadley Centre and the forecasting model of the European Centre for Medium Range Weather Forecasting.

The long term data sets generated by the project are extremely useful for validating the output of GCMs and can help to point out problems with the representation of both the land surface and the atmosphere in such models. In Figure 2.2.1 the monthly average solar radiation from Reserva Ducke is compared with the solar radiation predicted by the Hadley Centre GCM in a ten year simulation of the Amazonian climate. The model predicts too much solar radiation during the wettest part of the year probably because cloud cover is under predicted. This error feeds through to an under prediction of rainfall.

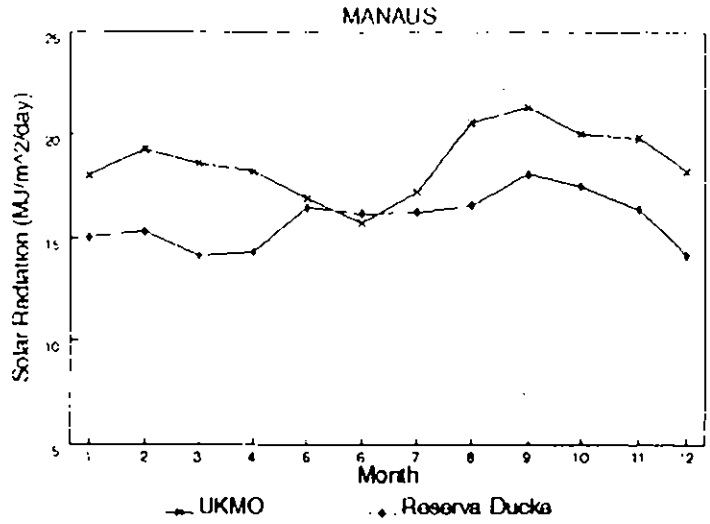

Figure 2.2.1 A comparison between the solar radiation observed at Reserva Ducke with that predicted by the Hadley Centre GCM. The model under-predicts solar radiation for most of the year.

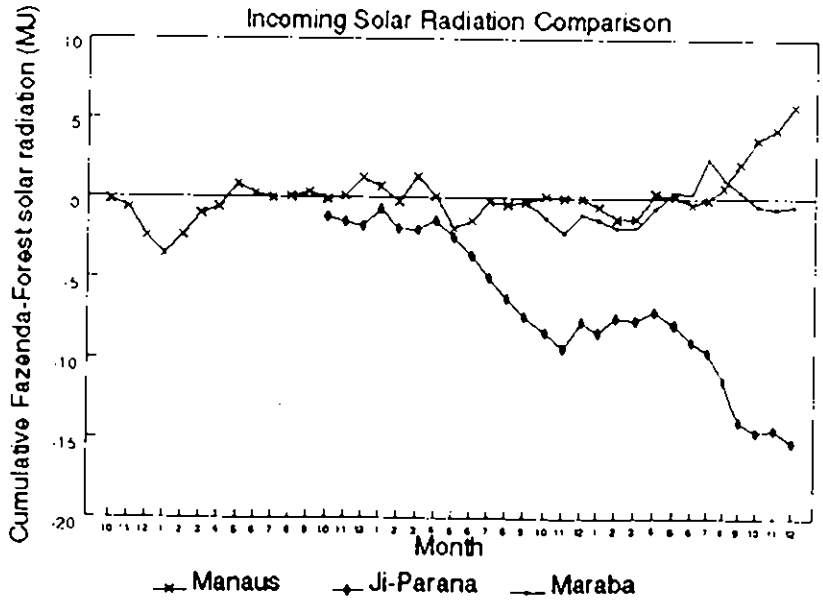

Figure 2.2.2 The difference between daily totals of solar radiation at the pasture and forest sites plotted cumulatively. Whilst there is little or no difference for the Marabá or Manaus sites, at Ji Paraná there is less solar radiation over the pasture during the dry part of the year.

The second area of analysis is the comparison of solar radiation between the forest and pasture sites. This work has revealed that, at the Ji-Paraná sites where the forest and pasture areas are both large, there is less incoming solar radiation over the pasture than over the forest during the dry season.

The work is in its early stages but it seems that this difference is related to cloud cover and may indicate that the boundary layer grows higher and faster over the pasture at his time of year. The result fits in with the observations made in RBLE in 1993. Although the differences in solar radiation are quite small the result is important since it illustrates that the atmosphere can respond to relatively small scale deforestation. The boundary layer measurements to be made in RBLE3 in August this year may further substantiate these results.

2.2.2 Micrometeorology

Calibration of stomatal conductance

To model the rate of transpiration from vegetation it is necessary to calibrate the response of the leaf stomatal opening to surface or near-surface climate. After calibration of the 'Jarvis' model of surface conductance for Manaus pasture (submitted for publication), this work has been extended to include the pasture and forest at Ji Paraná, RO.

Figure 2.2.3 and 2.2.4 show the optimised shape of the model functions relating to radiation, humidity deficit, temperature and (pasture only) soil moisture together with the data on which the optima were derived. The conductances shown have been normalised with respect to the optimised maximum conductance in all cases.

The various similarities and dissimilarities in these parameters gives an insight into the possibility of deriving a general parameterisation for Amazonia. For example, the similarity in the pasture parameters suggests that the two monocultures of similar grasses are reacting to climate in a very similar way. The difference in the maximum conductance parameter can be partially explained in terms of the different leaf area indices at the two sites (see below).

The differences in forest stomatal control parameters aremore complex and are currently under study. Smaller data ranges (see Fig. 2.2.4c) and the possibility of parameter interdependence produce less confident optima and require careful interpretation. The large species diversity in the forest and different forest structures would not necessarily be expected to yield directly comparable radiation and humidity parameters. However, as is shown in the next section, the different parameter sets produce similar predictions of transpiration.

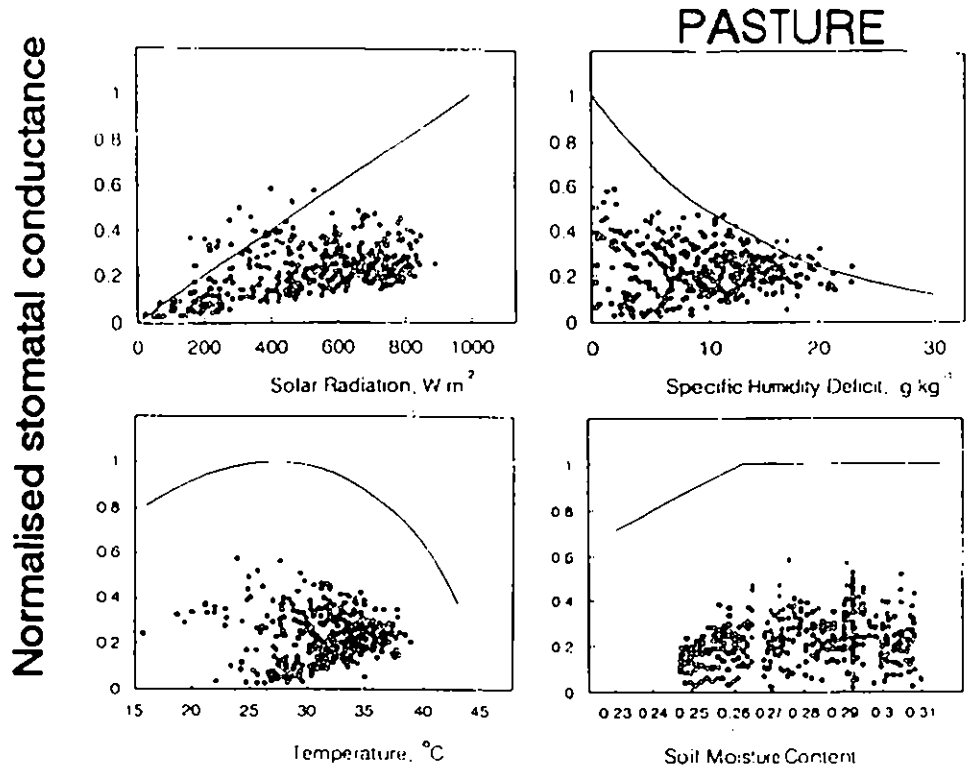

Figure 2.2.3 Environmental control functions for Ji Paraná pasture; for (a) solar radiation, (b) canopy-level specific humidity deficit, (c) canopy-level temperature, (d) soil moisture.

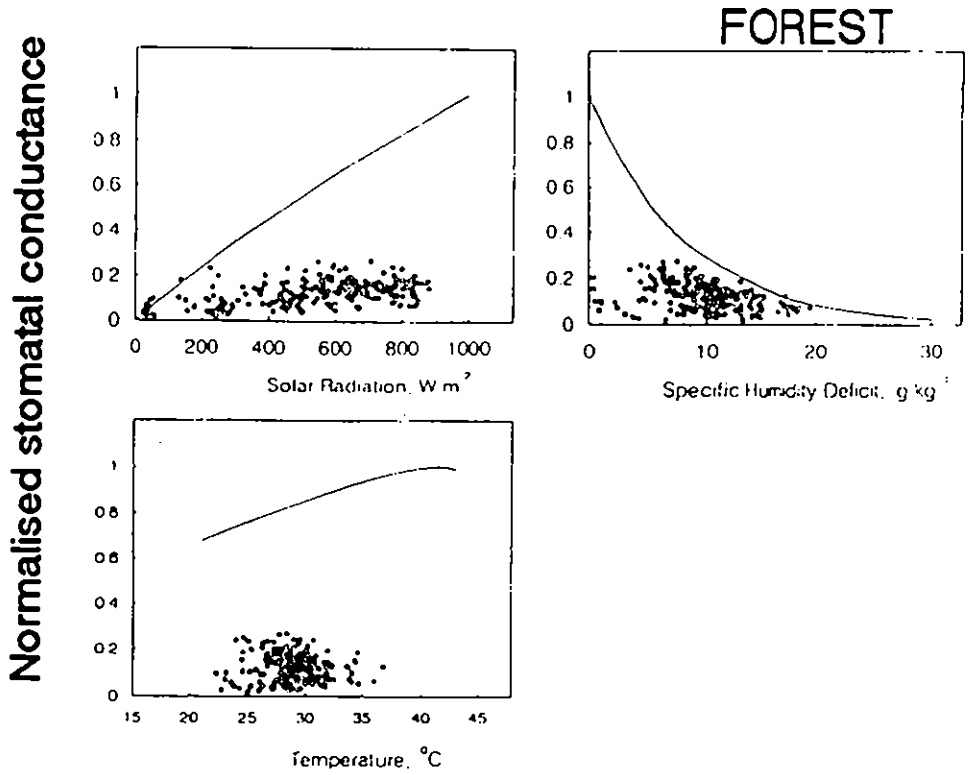

Figure 2.2.4 Environmental control functions for Ji Paraná forest; for (a) solar radiation, (b) canopy-level specific humidity deficit, (c) canopy-level temperature.

Towards a parameterisation for Amazonia

As an experiment to investigate the possible errors that might be incurred if parameters from one site were used to model the transpiration from another, the optimised parameters from Manaus pasture and forest were used to predict the transpiration from the two Ji Paraná sites. All parameters where left unmodified, except for the soil moisture parameter, which must be normalised to account for the very different soil types between sites. It was assumed that the only available information at the Ji Paraná sites was hourly weather station data, a simple (height related) estimate of the aerodynamic conductance and the limits to soil water storage.

Figure 2.2.5 and 2.2.6 show the predicted hourly evaporation rates compared to those measured during the 1993 intensive field campaign.

The pasture experiment produces an expected underestimate of transpiration due to the higher leaf area index at the Ji Paraná site. However, Fig. 2.2.5b indicates that it is only necessary to increase the leaf area to 1.8 to achieve the best estimate, rather than a higher value more in line with those measured in the field (2.5 - 3.9). This is clear indication of the effect of self shading by the denser grass canopy, yet the value of 1.8 suggests that the shading process may be invoked at a lower leaf area than has previously been suggested in published literature.

The forest estimate of transpiration is also underestimated at the Ji Paraná site when Manaus forest parameters are used. Of particular interest is that the estimate is not as bad as the dissimilarity in the parameters would suggest. In fact there is compensation between parameters emphasising the importance of maintaining the groups of parameters as complete sets, especially when derived by multivariate optimisation. The differences between parameters are not yet well enough understood to begin interchanging parameters from different sites on the basis of physical understanding.

2.3 PLANT PHYSIOLOGY

During the six months reporting period the predominant activity has been data analysis although leaf litter collections and determinations of specific leaf area from the Marabá forest site has been continuing.

2.3.1 Ji-Paraná Site

Detailed analysis of the Reserva Jaru (forest) and Fazenda Aparecida (pasture) sites at Ji-Paraná, Rondonia have been substantiated previous findings from the Reserva Ducke (Forest) and Fazenda Dimona (pasture) sites at Manaus. At Reserva Jaru a significant decline in g_l associated with increasing specific humidity deficit (D) is observed (Figure 2.3.1.). Data from Missions 3, 4 and 5 are compared in this figure and show that the differences due to soil moisture deficit are small. Figure 2.3.2. shows that in contrast to the behaviour observed in the forest the pasture at Ji-Paraná behaves quite differently. For the pasture the relationship with D is poorly defined but there are highly significant correlations with photosynthetically

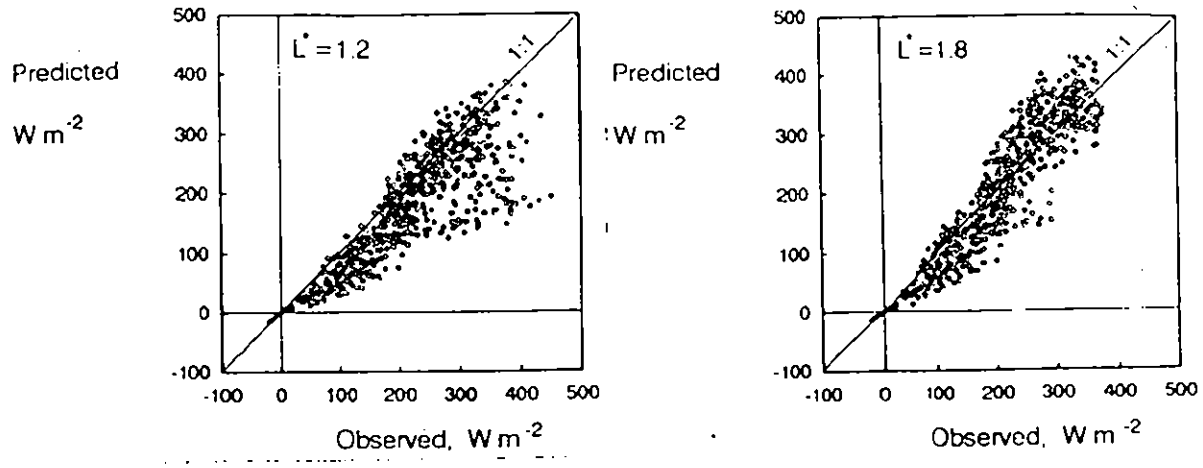

Figure 2.2.5 Predicted evaporation for Ji Paraná pasture using optimised parameters derived for Manaus plotted against observed evaporation: (a) with Leaf Area Index equal to 1.2 (Manaus value), (b) Leaf Area Index equal to 1.8 (optimum value).

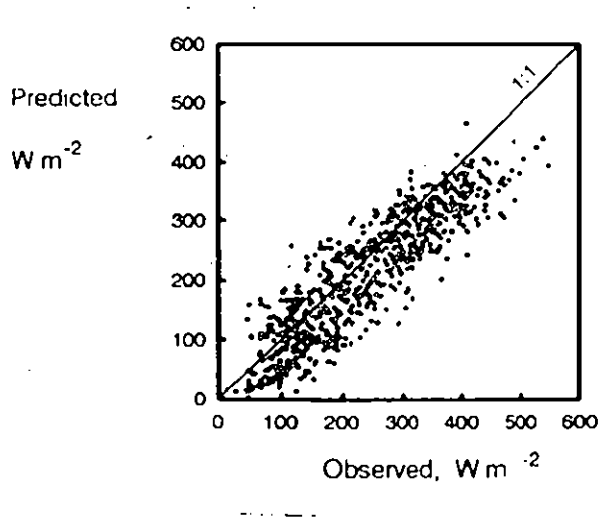

Figure 2.2.6 Predicted evaporation for Ji Paraná forest using optimised parameters derived for Manaus plotted against observed evaporation.

active radiation (Q_p) and leaf water potential (ψ). Leaf photosynthesis in the predominant pasture species (*Brachiaria brizantha*) is not so affected by lowered soil moisture levels as is g_l (compare M4 with M5 in Figure 2.3.3). A consequence of this interesting response is that water use efficiency increases in the C_4 pasture species as soil water deficit increases.

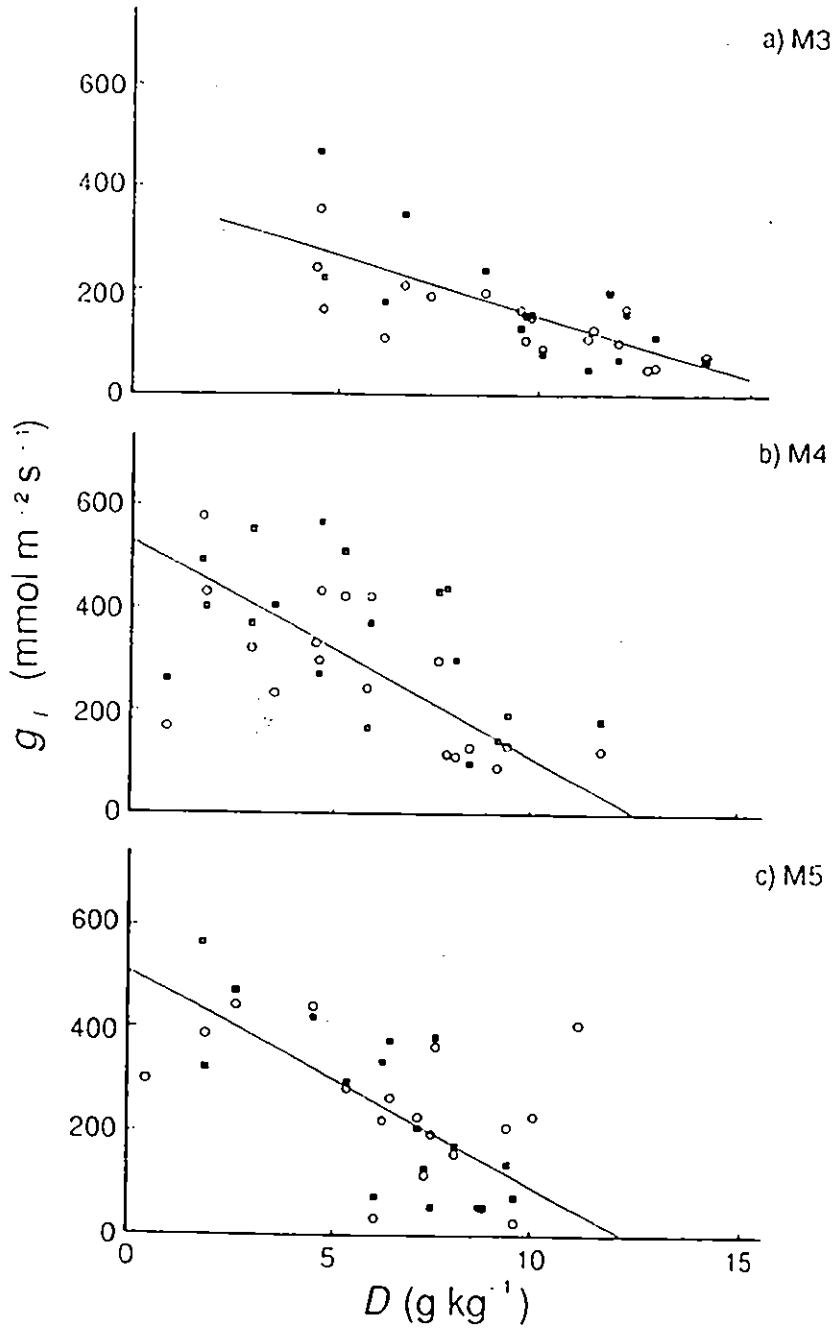

Figure 2.3.1 The relationship between g_l and D for canopy species Inga (■) and Cedrella odorata (•).

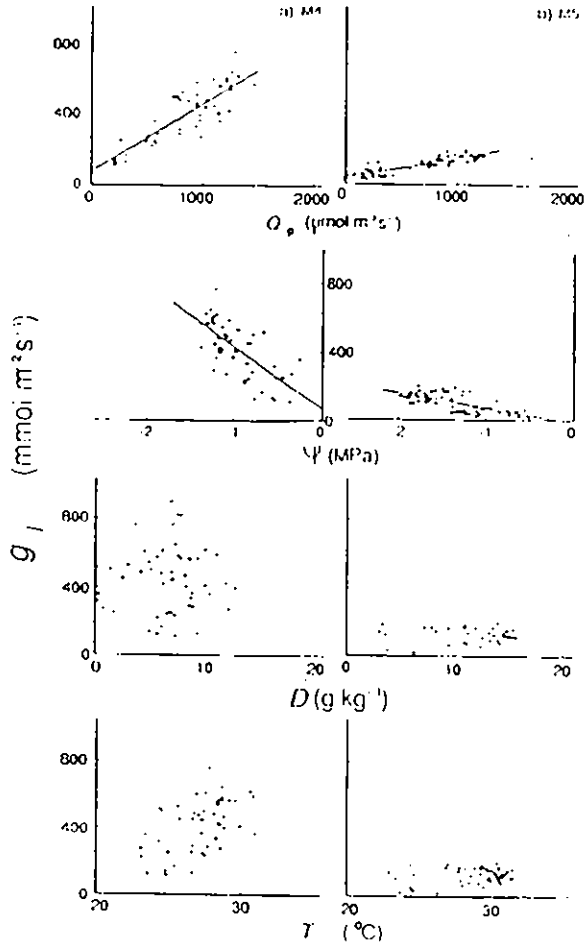

Figure 2.3.2 The relationship between g_l and Q_p, ψ, D and T in Brachiaria brizantha during (a) M4 and (b) M5.

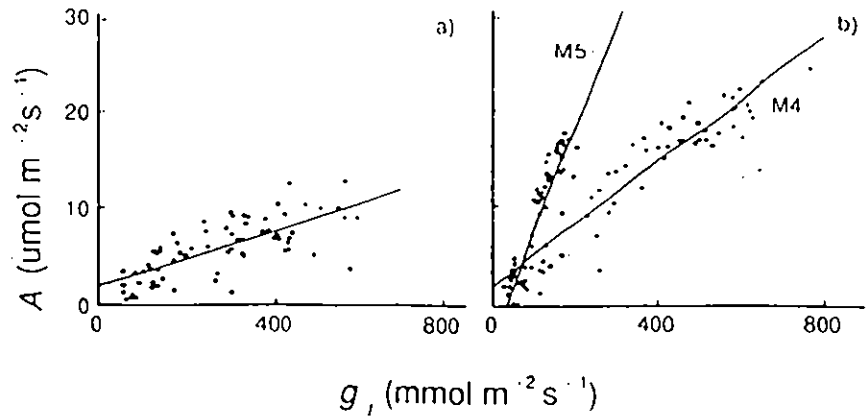

Figure 2.3.3 The relationship between A and g_l in (a) canopy species Cedrella odorata, M4 (■) and Inga, M5 (•) from Reserva Florestal Jaru and (b) pasture species Brachiaria brizantha, (■) M4 and (•) M5.

2.3.2 Marabá site

A major objective of the physiology programme is to obtain information on leaf gas exchange, canopy quantities and within canopy microclimate to be incorporated in the CLATTER model. Although direct measurements of total leaf area index and its vertical distribution has been obtained for the Reserva Ducke forest site at Manaus but the exercise required considerable time and labour. Within ABRACOS attention has been focused on deriving this type of detailed information by alternative, less time consuming means. At the Reserva Vale forest in Marabá detailed studies have been made of the leaf litter to evaluate if quantities and characteristics of the forest litter can be used to provide the information required on total leaf area index (L^*) and its vertical distribution. If the leaf life span is assumed to be 12 months the annual leaf litter collection will equal the total L^*. Figure 2.3.4 shows the trends in the cumulative litter leaf area index measured for nearly three years and consistent annual totals for L^* are observed (~ 5.3).

The area of individual leaves divided by their weight is the specific leaf area, σ_f, ($m^2\ kg^{-1}$) and has been shown in many cases to decline linearly downwards through forest canopies, being mainly a response to prevailing radiation conditions through the canopy. As an initial investigation of using σ_f to discriminate positions in canopies from which leaves have come from, a detailed study has been made of the frequency distribution of σ_f observed in the litter collections. Figure 2.3.5 shows a frequency distribution of σ_f derived from individual leaf areas and weights of over 5000 litter leaves collected over an 18 month period in the Reserva Vale forest at Marabá. Leaves with lowest σ_f values are from the top of the canopy and the large values of σ_f correspond to leaves from the lowest canopy levels. Further analysis will investigate if there are seasonal patterns in the distribution of σ_f in the litter fractions which might prove helpful in determining when foliage from different heights in the canopy is lost.

The CLATTER model reveals interesting and useful information about the relative roles of different canopy levels. Figure 2.3.6. shows that at the Reserva Ducke in Manaus although there is a substantial amount of foliage in the bottom layers of the forest these layers contribute relatively much less to the total forest transpiration compared to foliage in the upper part of the canopy. This analysis suggests that total L^* for the forest sites might be adjusted to an "effective" L^* based on the type of information in Figure 2.3.6.

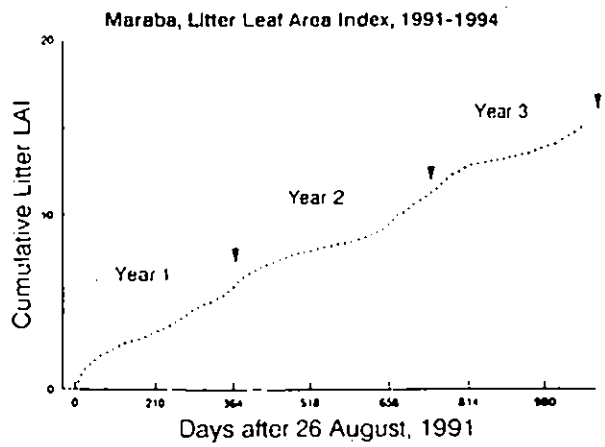

Figure 2.3.4 Cumulative litter leaf area index at the Reserva Vale do Rio Doce, Marabá.

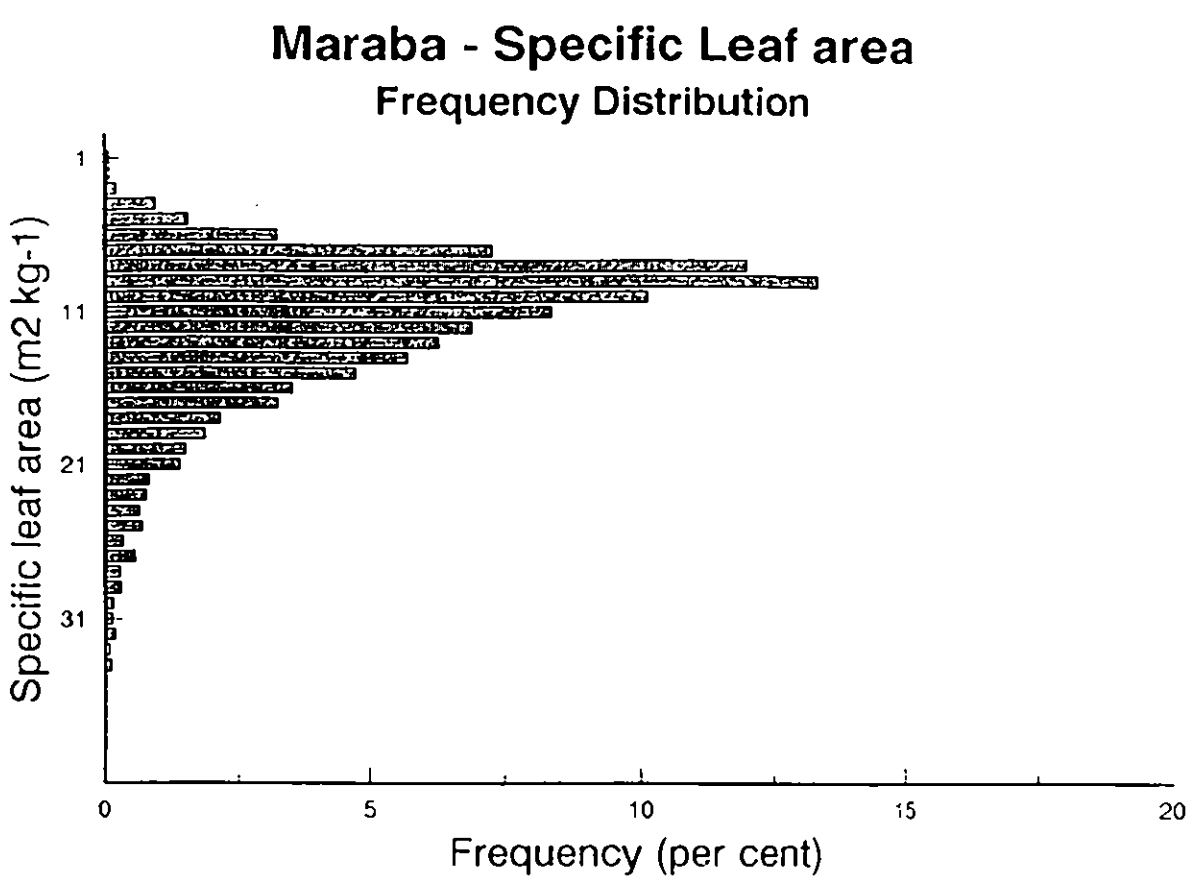

Figure 2.3.5 Frequency distribution of specific leaf area of litter samples from the Reserva Vale do Rio Doce, Marabá.

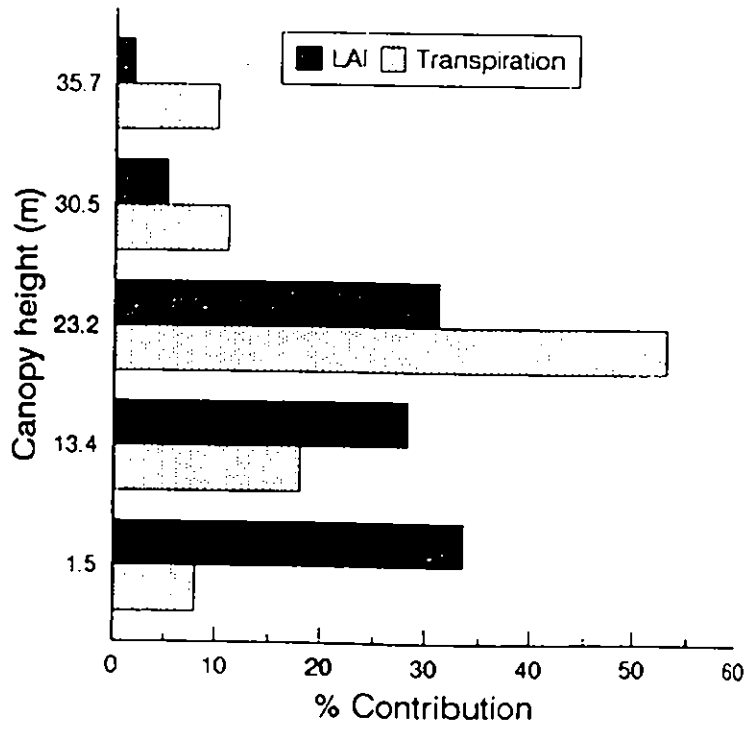

Figure 2.3.6 Percentage of total forest leaf area index in individual canopy layers and estimates from the CLATTER model of the contribution of individual canopy layers to total forest transpiration.

2.4 SOIL MOISTURE STUDIES

2.4.1 Database

The unique ABRACOS soil water data-set has now been transferred entirely into the new SWIPS soil water data processing system, recently developed at IH. The use of this package has greatly improved and speeded the data handling process. To allow time for data analysis, a cut-off was set for the processing and quality control of soil water data under ABRACOS. Data collected up to December 1993 was processed, and data collected thereafter will be the responsibility of the interim project which is ensuring the continuity of data collection in the interval between ABRACOS and LAMBADA-BATERISTA.

Quality control and presentation of the neutron probe and tensiometer data in a processed and readily accessible form has been completed. There are now 3 years of weekly data from the Manaus sites (October 1990 - December 1993), 2 years from the Marabá sites (August 1991 - October 1993) and 2 years fron the Ji-Paraná sites (November 1991 - December 1993). The latter part of this work was carried out very competently by Marcos Oyama, and allowed him to gain experience to be able to continue this work in Brazil.

2.4.2 Within site comparisons

Figure 2.4.1 shows the Fazenda Dimona forest soil water storage to a depth of 1 m (a) for the plateau, (b) for the slope and (c) for the valley floor over the period of study. There are various important points to note:

1. There was very little difference between the soil water response on the slope compared to the plateau. If surface runoff occurred frequently on the slope (it was never observed), differences in soil water storage might have been expected. The data imply that the processes of water input, redistribution and loss are almost identical on the slope and on the plateau.

2. The soil water storage behaviour in the valley was very different to that on the slope or plateau. The timing of many of the storage peaks are identical, as might be expected, but there are clearly some important differences in the processes occurring. For example, between 1990 and 1991, the maximum storage change in the valley was 30 mm, compared to 90 mm on the plateau. There was a rapid decrease in soil water in the valley after October 1991, but little change on the plateau. The driest conditions observed on the plateau/slope occurred in November 1990, December 1991 and February 1992. In contrast, the driest conditions in the valley were in November 1992.

   The main difference in response arises from the variations in the depth of the water table in the valley. In 1990 -91 the soil water storage was dominated by the presence of a shallow water table which fell below 1 m depth only in late 1991. The data for 1992 show, for the most part, the response of an unsaturated profile. The water table rose back into the measured profile in early 1993 and again dominated the storage response.

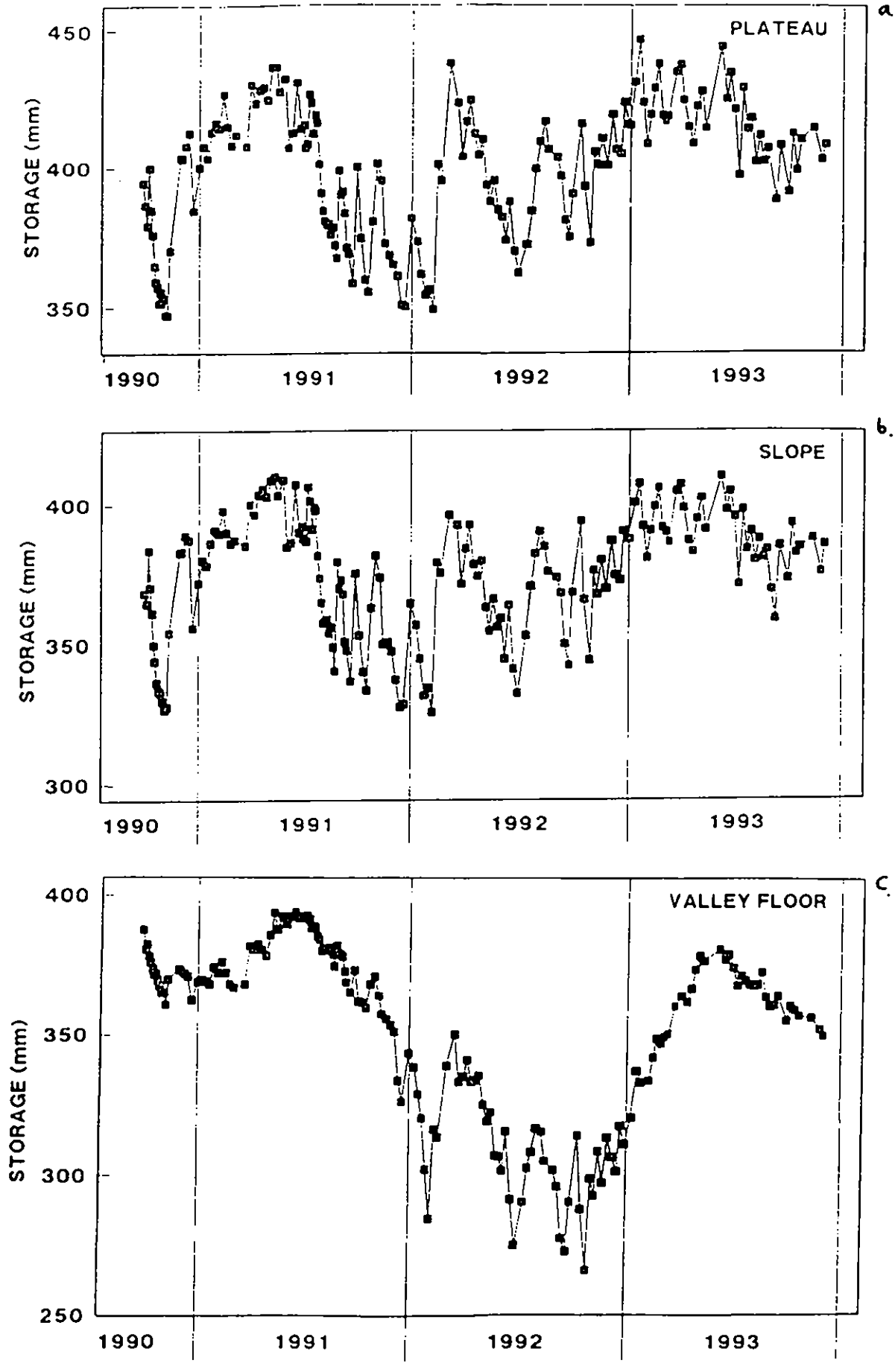

Figure 2.4.1 Fazenda Dimona forest, soil water storage to a depth of 1 m for (a), the plateau, (b), the slope and (c), the valley floor.

The water table depth in the valley is the result of the balance between outputs (local uptake by the trees, stream discharge, and down-valley groundwater movement) and inputs (local recharge and lateral movement of groundwater fed by deep recharge from beneath the plateau and slope areas). In the valley, soil water storage, and hence availability, is clearly influenced by lateral subsurface flow. The amount of water available for evaporation by the vegetation is normally controlled by the rainfall, the evaporation and the soil properties, but in the valley situation, there is the the additional influence of lateral subsurface movement of water within the groundwater body. These processes must be taken account of in GCM formulation. The depth of the water table is also very important hydrologically as it will have a significant influence on the generation of storm runoff.

3. There was a marked inter-annual variation in the pattern of soil water storage, reflecting the considerable differences in rainfall quantity and distribution within years. The latter part of the 1990 dry season was very dry. The 1990-91 wet season appears to have been particularly wet, but was followed by an extended dry season and a much delayed and weak 1991-92 wet season. The very low groundwater levels during 1992 resulted from this. The long term context of the 3 year run of data shown in Figure 2.2.1 has been investigated and is discussed in Section 2.4.3 below.

2.4.3 Long-term context of Fazenda Dimona dataset

The context of the ABRACOS soil water data-set from Fazenda Dimona was examined. Models were developed for forest and pasture to predict the soil water storage behaviour in the top 2 m of the soil profile using only daily rainfall as input data. The models were developed and calibrated using rainfall, soil water content and micro-meteorological data from the ABRACOS study period. Evaporation and deep drainage were related to the soil water storage through linear and exponential functions respectively, allowing the soil water storage to be determined from a simple water balance.

The incidence of periods with very low soil water storage (large deficit) is of particular interest because of the control it exerts (through soil water stress) on transpiration and hence on the energy balance and climate. Soil water storage was predicted from a 27 year rainfall record from the Reserva Ducke site and compared with the ABRACOS soil water data set. For the ABRACOS forest data, the most severe measured deficit occurred in December 1991 and was intermediate between the 2 most extreme years predicted from the R.Ducke data (1967 and 1976). It is notable that the deficits predicted from the Reserva Ducke rainfall data for 1991 were not extreme, showing that the spatial variability of the rainfall in Central Amazonia has a major impact on the incidence of severe deficits. For the pasture, the most severe observed deficit occurred in 1990, on 5 November. The pasture deficits predicted from the Reserva Ducke rainfall data showed that this observed deficit would have been surpassed in only 4 years of the 27 year record.

2.4.4 Soil hydraulic properties

Preliminary results from the conductivity studies at Fazenda Dimona were presented in the previous report. The data from both instantaneous profile method (IPM) experiments at this site have now been fully processed and analysed. Javier Tomasella was largely responsible for this work.

The two IPM experiments produced very similar results, both showing the same trend of conductivity change with depth. The highest saturated conductivities were at a depth of 0.75 m, but once the potential had fallen below -3 kPa, the pores responsible for this high conductivity emptied and the unsaturated conductivity of this layer became the lowest of the 5 depths measured. The unsaturated conductivity decreased rapidly at all depths as the soil drained. After 10 days the drainage rate had become extremely slow (<0.5 mm d^{-1}), limiting the range of conductivity which could be measured. This near cessation of drainage at a depth of 1.35 m effectively marks "field capacity".

The soil component of GCMs are moving towards the use of either the van Genuchten, or the Brooks-Corey models of soil hydraulic properties. The aim was therefore to fit these models to the water release and hydraulic conductivity data obtained from the IPM measurements. However, the data obtained were very limited in the range of matric potential (0 to -9 kPa), with the result that application of the fitted curves outside the range of the measurements could lead to considerable errors in the water release and conductivity curves. In order to improve the overall curves, data from two other sources were used within a complex optimisation procedure. Water release data derived from the ongoing monitoring of soil water content and potential were used to extend the potential range to -85 kPa. In addition, the residual water content (usually derived during optimisation) was directly estimated from field measurements of water content.

Table 2.4.3.1 shows the van Genuchten parameters derived for the pasture site.

Table 2.4.1 Van Genuchten parameters, n, α and l, for the Fazenda Dimona pasture soil. θ_{sat}, θ_r and K_s are the saturated and residual water contents and the saturated hydraulic conductivity, respectively.

Depth (m)	n	α (cm^{-1})	l	θ_{sat} ($m^3.m^{-3}$)	θ_r ($m^3.m^{-3}$)	K_s ($mm\ h^{-1}$)
0.3	1.4960	0.0745	5.3959	0.4479	0.3048	546
0.5	1.6184	0.0967	1.9829	0.4856	0.2989	676
0.75	1.3265	0.4622	-1.766	0.5725	0.3044	1096
1.05	1.2039	0.6640	-4.912	0.5646	0.3549	422
1.35	1.3679	0.0196	3.6470	0.5258	0.4200	18

The parameter set derived for the Fazenda Dimona soil is very different from those suggested for clay soils in the literature. These Amazonian soils present properties of both sandy and clayey soils. Although the value of θ_{sat} for the Fazenda Dimona soils is within the range for the North American clay soil data presented by Rawls and Brakensiek, the residual water content, θ_r is much higher, leading to a lower available water capacity. It is therefore necessary to stress that the use in GCM modelling of soil parameters deduced for temperate soils may lead to severe errors in the simulation of soil water processes.

2.5 CO-ORDINATION

A coordination meeting was held in January, when Dr Carlos Nobre visited IH in Wallingford, a further coordination meeting was held at INPE in May. Informal presentations of on-going analyses from a wide spectrum of disciplines within ABRACOS were presented by UK and Brazilian participants. Planning discussions for the forthcoming seminar in Brasilia in September were also held.

Dr Carlos Nobre (INPE) and John Gash, John Roberts, Alistair Culf and Martin Hodnett (IH) travelled to Brasilia after the meetings at INPE. At Brasilia, hotel options as the venue for the seminar in September were examined and further logistics examined. The IH group met Dr Phil Mitchell and Dr David Harrison of the British Council, Brasilia. Dr Mitchell was due to take up a council post in the UK and Dr Harrison will be Science Officer until later in the year. The overall progress of ABRACOS and the plans for the seminar in Brasilia were discussed. Dr Harrison requested to be kept informed of planning progress for the seminar. The ABRACOS participants wish to extend warm thanks to Dr Mitchell for all his support and interest in the project since its beginning in 1990 and to wish him well in his new posting.

Visits were made to two cerrado (savannah) sites with Dr Antonio Miranda, Departamento Ecologia Vegetal. Universidade Federal, Brasilia. One of these sites was selected as a location for the future installation of an automatic weather station which will combine with that of the ABRACOS network of stations. Dr John Gash, Dr John Roberts and Dr Carlos Nobre also visited the Delegation of the European Union in Brasilia and met Sra Maria Christina Araujo (Science Officer). The objectives and results from ABRACOS were discussed as well as future research initiatives and possible funding sources within the EU Directorates.

3 Publications

No papers were published during this reporting period but three papers have been submitted to International Journals. These are:-

1) "Surface conductance of Amazonian pasture: model application and calibration for canopy climate." by I.R. Wright, A.O. Manzi and H.R. da Rocha. Submitted to: Agricultural and Forest Meteorology.

2) "A vegetation-atmosphere interaction study for Amazonian deforestation using field data and single column model." by H.R. da Rocha, C.A. Nobre, J.P. Bonatti and I.R. Wright. Submitted to: Quarterly Journal of the Royal Meteorological Society.

3) "The albedo of Amazonian forest and ranchland." by A.D. Culf, G. Fisch and M.G. Hodnett. Submitted to: Journal of Climate.

4 Training

4.1 SR JAVIER TOMASELLA

Sr Javier Tomasella of the Instituto Pesquisas Hidraulicas, Porto Alegre began a six month visit to IH in January. He has been working with Martin Hodnett initially analysing soil hydraulic conductivity data obtained in intensive work at Fazenda Dimona, Manaus in July 1993. Following on from this analysis, modelling studies have been undertaken to provide mathematical fits to the field data. A simple model was developed to predict soil water storage/deficit from rainfall data alone. This was used to assess how extreme the conditions observed during ABRACOS field missions had been. Some novel approaches have emerged from Javier's visit and a number of Symposium and Journal papers will appear as a consequence.

4.2 SR MARCOS OYAMA

Sr Marcos Oyama came to IH in April to begin a three month visit. He has also been working with Martin Hodnett and has been familiarising himself with many aspects of 'state of the art' soil moisture processing software, SWIPS, other soil moisture software and analysis and interpretation of data. These skills are very important to the future success of research in Brazil initiated in the ABRACOS project and any future projects involving subtantial amounts of soil moisture data. Marcos also undertook an investigation of the possibility of predicting the water availability of Amazonian soils from particle size data.

4.3 FUTURE VISITS

It is planned that future visitors under the training programme will include Dra Tatiana Sá (EMBRAPA-CPATU, Belem). This will be Tatiana's second visit to IH and she will analyse physiology data from Marabá. However it must be recognised that it is likely that there will not be a sufficient number of visiting scientists during the final six months of this phase of the project to use all of the resources available.

5 Vehicles

Overall the Land Rovers at all sites continued to function effectively needing only routine servicing and a moderate amount of expenditure on non-service repairs. The Marabá vehicle was rolled on to its side in the forest in the wet season and sustained body damage which has been repaired. The vehicle also needed repairs to gearbox and steering but the problems have not seriously affected data collection. This Land Rover has accumulated nearly double the kilometrage of the the other ABRACOS vehicles.

6 Future plans

6.1 FIELD WORK

The network of climate and soil moisture stations will continue in operation. Responsibility for the maintenance of the network has now been passed to INPE.

There are no major ABRACOS field campaigns this year, but Dr Alistair Culf and Dr Christopher Huntingford will be participating in the final boundary layer campaign of RBLE, which has been run in parallel with the prevous ABRACOS campaigns. They will be providing the sensible heat flux measurements over the pasture and forest sites at Ji-Paraná.

6.2 SYMPOSIUM

The Symposium will be held in the Hotel Nacional in Brasilia. As planned in the response to the Mid-Term Review it will take the form of a three day scientific meeting (19 to 21 September) at which the results of the project will be presented and discussed. There will be an exhibition of posters and equipment which will be on display during an evening reception where politicians, diplomats, policy-makers, representatives of NGOs and the press will be able to see the results of the project and discuss them in an informal way with the project scientists. A second reception will be aimed at education with university professors, teachers and students.

Following the Symposium in Brasilia the exhibition of posters will move to Manaus and then to Belém where there will be similar receptions.

Subject to peer review, the scientific papers presented at the Symposium will be published as a book by John Wiley.

6.3 ANALYSIS

The final six months of the main phase of the project will be largely spent writing up results for inclusion in the Symposium volume and the open international literature.

7 Modelling studies

7.1 HADLEY CENTRE

The Hadley Centre have completed a GCM experiment using the Mission 1 and 2 data from Fazenda Dimona to calibrate the deforested/pasture scenario. Full results of this experiment will be presented at the Symposium but an initial analysis of the results predicts a decrease

in rainfall with a maximum effect over the mouth of the Amazon, but an increase in rainfall over Columbia.

7.2 COLA

The data have also been used to calibrate the COLA GCM in Maryland, USA, prior to that model being installed in the new Brazilian Weather and Climate Forecasting Centre (CPTEC). A GCM experiment has also now been run with this model and similar results were obtained to those found at the Hadley Centre. These results are currently being written up for publication.

8 Public dissemination of results

8.1 PROJECT LEAFLETS

A new project leaflet has been produced in this reporting period. In this instance the amount of material made it more suitable to have separate versions in English and Portuguese. Both versions have already been widely distributed in Brazil and the UK and sufficient copies have been produced to satisfy demands at the ABRACOS symposium in Brasilia also. Copies of the leaflet in both languages are bound in with this report as Annex 1.

8.2 LECTURE

In March, Martin Hodnett was invited to give a lecture to the graduate students in the Department of Soil Science at the University of Reading.
The talk covered the results of the long-term observations of soil water storage at Fazenda Dimona, and then moved to describing the findings of the July 1993 field mission to measure soil hydraulic properties. Particular mention was made of the unusual properties of the soil (very high clay content, low available water capacity and very high saturated conductivity). The methods used to obtain the soil physical parameters for GCM modelling from the field measurements wer also covered.

8.3 "FOLHA DA FLORESTA"

"Folha Da Floresta" is the ABRACOS project newsletter which aims to provide a forum for informal exchange of information and news for participants. It is currently edited by Alistair Culf (IH) and Gilberto Fisch (CTA) with help from Isobel Nogueira at INPE/CPTEC. The inaugural issue produced in January was very well received. Issue 2 has just appeared and a copy is bound into this report as Annex 2. Future editions will be edited and produced in Brazil.

8.4 PILPS

PILPS (Project for the Intercomparison of Land-surface Parameterization Schemes) is an international project under WRCP/GEWEX (World Climate Research Program/Global Energy and Water Balance Experiment) with the objective of comparing global circulation model land surface schemes. The data from missions 1 and 2 have been submitted to PILPS as a possible candidate dataset for use in that project.

8.5 DATABASE

The end date for the ABRACOS database has been set at 31 December 1993 and this data is being assembled for the project database. No CD ROM equipment has yet been purchased. When the database is complete a decision will be made as to whether the data should be disseminated on CD ROM or disk, or whether it can be distributed electronically over the computer network. Ideally the database will be sufficiently small to enable it to be distributed by disk, as this medium is most widely used and will ensure maximum access to the data.

9 Financial overview

9.1 SUMMARY

The Rolling Project Budget is given on the following pages. The actual spend for 1993/94 is incorporated. There was an underspend of £23k, which has been transferred to the same budget lines for 1994/95. The main cause of this underspend was Budget Line 2.7, IH staff time (£10k), and 2.4B, short term training (£7.2k). The underspend in IH staff time will be made up this current year but the underspend in short term training is unlikely to be. Efforts continue to find suitable candidates who are available for short term training in the final six months of this phase of the project (see also Section 4.3 of this report).

Rolling project budget (in £k)

Revised to incorporate continuation of network to end of calendar year 1995

		Year 1 89/90	Year 2 90/91	Year 3 91/92	Year 4 92/93	Year 5 93/94 revised	Year 6 94/95 revised	Year 7 95/96 revised	Total revised
1	CAPITAL COSTS								
1.1	Hardware associated with Phase 2								
1.1.1	Micrometeorological equipment	0.5	43.2	10.4	11.5	34.3	10.2		110.1
1.1.2	Plant physiological equipment		71.8	10.7					82.5
1.1.3	Soil moisture equipment	1.3	13.4						14.7
1.2	Hardware associated with Phase 3								
1.2.1	Climatological equipment		77.5	42.3	10.4	1.1	9.1		140.4
1.2.2	Soil moisture equipment		38.7	1.3	1.1	2.5	1.4		45.0
1.3	Transport and site facilities								
1.3.1	Forest towers		62.7	5.7		0.0			68.4
1.3.2A	Transport (Op. & Maint)		6.4	8.2	8.8	12.0	9.2	8.3	52.9
1.3.2B	Transport (Purchase)		88.0						88.0
1.3.3	Site facilities		4.1	21.3	4.8	1.2	0.1		31.5
1.3.4	Site computers						10.5		10.5
1.4	UK based hardware facilities								
1.4.1	Computers		24.0	0.3					24.3
	TOTAL CAPITAL	1.8	429.8	100.2	36.6	51.1	40.5	8.3	668.3

rollbudb.wk3

2. RECURRENT COSTS
(other than vehicle support)

		Year 1 89/90	Year 2 90/91	Year 3 91/92	Year 4 92/93	Year 5 93/94 revised	Year 6 94/95 revised	Year 7 95/96 revised	Total revised
2.1	Sundry scientific supplies		24.6	15.9	32.0	11.3	30.7	6.0	120.5
2.1A	Exhibition & publication						18.9		
2.2	Freight charges		27.8	25.1	9.6	3.3	5.2	2.0	73.0
2.3	Counterpart travel (scientific)		21.1	25.0	32.2	18.7	6.3	6.0	109.3
2.4A	Counterpart travel (project man)	0.2	4.6	5.4	3.9	2.1	5.9		22.1
2.4B	Short term training in UK			6.3	7.0	10.8	35.2		59.3
2.4C	English Language Training				13.0	0.0	2.0		15.0
2.4D	Dissemination of results						24.6		24.6
2.5	IH travel costs		71.0	80.2	89.6	62.5	55.7	4.5	363.5
2.6	IH consultant	0.5	9.3	8.7	6.1	9.2	7.1		40.9
2.7	IH staff costs	34.4	233.1	260.9	272.9	264.1	253.3	13.6	1332.3
2.8	Mid-term review					30.0			30.0
	TOTAL RECURRENT	35.1	391.5	427.5	466.3	412.0	444.9	32.1	2209.4
	TOTAL PER YEAR	36.9	821.3	527.7	502.9	463.1	485.4	40.4	2877.7
	New financial limit (including contingency)								3057.7

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Institute of Hydrology

PRESIDÊNCIA DA REPÚBLICA
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INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Amazonian deforestation and climate

Anglo-Brazilian Amazonian Climate Observation Study: ABRACOS

ABRACOS is an experiment designed to improve predictions of the climatic effects of Amazonian deforestation. British and Brazilian scientists are collaborating to measure how the the vegetation and soil interact with the atmosphere to control the climate of both tropical rain forest and cleared forest used for pasture.

52m high tower in Reserva Biológica do Jaru, Rondônia

Climate modelling

For more than fifteen years, evidence has been accumulating from climate model experiments that the climate is sensitive to variation in evaporation and energy balance at the land surface. A major contribution to this variation will be the type of vegetation cover of the land surface and the short and long-term changes in it. The largest change would be a permanent one from moist tropical rain forest to short vegetation such as pasture or crops.

Three characteristics of vegetation are important in determining their surface energy balance and heat flux exchange with the atmosphere. These are *albedo*, the reflectivity of the surface to solar radiation, the *aerodynamic roughness* of the vegetation which determines the facility of exchange of heat, gases and momentum between the vegetation and the atmosphere, and *surface conductance*, which quantifies the freedom of water vapour to move from inside the leaves into the free atmosphere.

Climate change predictions are made with Global Circulation Models (GCMs), essentially the same computer models as those used to forecast weather but which run for long periods, i.e. years rather than days. Land surface processes in GCMs are linked to the upper atmosphere through the atmospheric boundary layer. Changes in vegetation and the consequent surface behaviour will in turn influence the boundary layer. These surface and boundary layer properties for different vegetation types need to be represented in GCMs. Baseline climatic data associated with each vegetation type are also needed to calibrate and validate GCM simulations.

The distribution over the globe and the sizes of the sources and sinks of greenhouse gases (particularly carbon dioxide, CO_2) is still poorly understood. A fundamental requirement for modelling and prediction of the effects of increases in CO_2 is basic information about the flux of carbon and its controls in important biomes: rainforests and secondary vegetation created after forest clearance being especially important.

Both the Brazilian and British governments are anxious to improve the value of climate model predictions. One of the major projects which has resulted from their joint Memorandum of Understanding is the Anglo-Brazilian Amazonian Climate Observation Study (ABRACOS). This collaborative project is funded by the United Kingdom Overseas Development Administration and by the Brazilian Government.

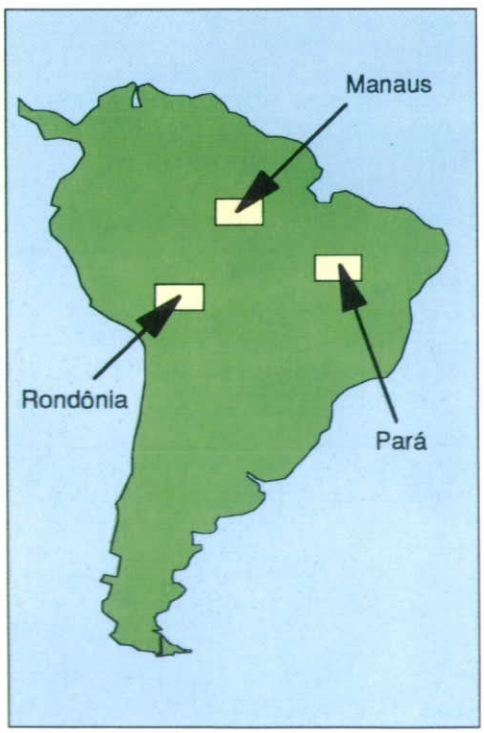
Measurements

Detailed studies of surface climatology, micrometeorology, plant physiology and soil hydrology are being made at pairs of forested and adjacent cleared sites at three localities across Amazônia in Brazil. The three locations differ particularly in length of dry season, the extent of the clearing site area and the distance of the site from the influence of the Atlantic Ocean. Climatology and soil hydrology measurements are being maintained throughout the study with micrometeorological and plant physiology studies concentrated into six intensive field "missions".

A Brazilian research initiative to study the development of the Amazonian boundary layer and its possible links with changes of surface vegetation is the Rondônia Boundary Layer Experiment (RBLE). RBLE has collected profiles of windspeed, air temperature and humidity up to 15 km using both radiosondes and tethered balloons.

CO_2 fluxes have been measured over forest and pasture in the western Amazonian ABRACOS site by a team from Edinburgh University, under the TIGER (Terrestrial Initiative in Global Environmental Research) banner, and by the University of Brasilia, whilst Swansea University, jointly with INPE and INPA are studying the use of remote sensing to quantify carbon uptake by forest regrowth.

Use of tethered balloon for measurement of temperature and humidity profiles in atmospheric boundary layer, Fazenda Aparecida (cleared area), Rondônia



Overview of Anglo-Brazilian Amazonian Climate Observation Study (ABRACOS).

The ABRACOS network will be maintained and extended in future years to be the framework of a multidisciplinary and multinational study of the meteorology, biogeochemistry, ecology and hydrology for biomes across Amazonia (LAMBADA/BATERISTA).

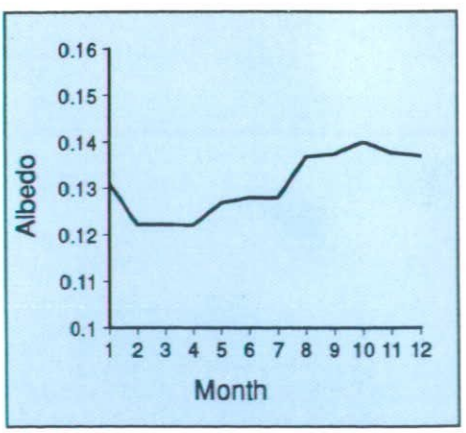
Results

Albedo of pasture is around 18.5 per cent, a few per cent lower than values previously used in GCMs. Forest has an even lower albedo, with an annual mean of 13 per cent, and shows a previously unobserved seasonal variation; the highest values coincide with periods of greatest soil water deficit.

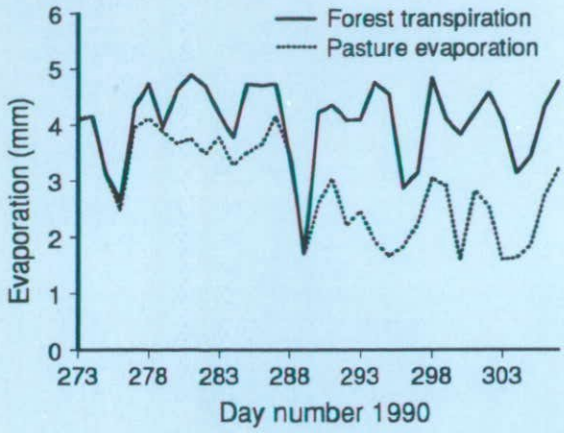
Micrometeorological and soil hydrology studies have both shown that when soil water availability is not a limiting factor, transpiration is equal for both forest and cleared areas. During dry periods extending beyond 10-14 days, however, pasture transpiration declines while that in the forest is sustained. Abstraction of soil water in forests is from a greater volume of soil because of substantially greater rooting depths. So far, soil water conditions at the end of the dry season have not been observed to limit forest transpiration, even at the driest site at Marabá in the eastern Amazon.

An important observation is the failure of the 1992 wet season rainfall to recharge the soil water store at the Marabá forest site. This will have the effect of reducing water available for transpiration in the following dry season. These results must be put in the context of high interannual variation in rainfall in Amazonia

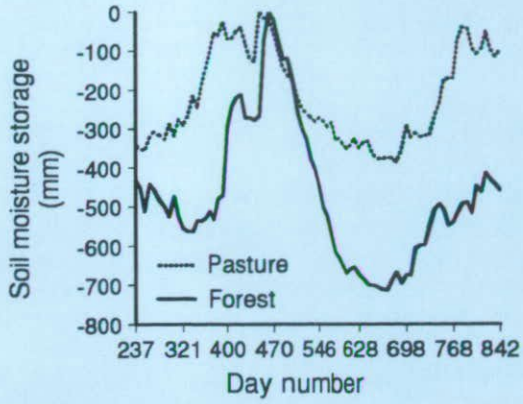
Detailed plant physiological studies have provided an insight of the differing responses of forest and pasture to increasing soil water deficit. During drought episodes surface conductance of pasture areas falls as a



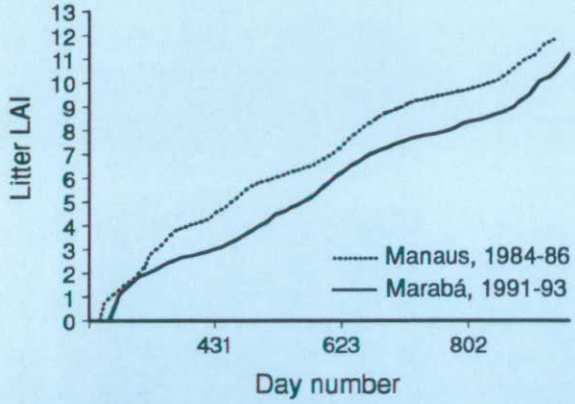
Seasonal variation in forest albedo, Reserva Biológica do Jaru, Rondônia



Changes in forest and pasture transpiration during a 30-day dry period following heavy rainfall.



Soil moisture storage changes beneath forest and adjacent pasture area, Marabá, Pará



Cumulative litter leaf area index over two years at Reserva Ducke, Manaus and Reserva Vale, Marabá.

Seasonal variation in leaf area index at clearing sites at Ji-Paraná, Rondônia and Marabá, Pará

Date		Ji-Paraná	Marabá
January	1992		1.42
June	1992		0.89
August	1992	1.55	
September	1992	1.66	0.49
December	1992		0.57
April	1993	3.90	1.64
June	1993	2.55	0.71

consequence both of stomatal closure and reduction in leaf area, both falling to around half the maximum value at the point when soil moisture deficits are greatest. Seasonal changes in leaf area are far less easy to quantify for the forest, but are regarded as being a substantially smaller change in total leaf area, which is at least double that of the pasture areas when soil water is not limiting — but much more in the dry season.

As well as large seasonal variation in leaf area of the pasture it appears that substantial differences exist between sites in any one season. This contrasts with the situation for forests at different localities where differences are thought to be rather small. The leaf area of two forest sites has been obtained by measuring forest litter over a two-year period. Assuming leaf life spans are 12 months suggests that leaf area index in both forests is just below six: this has been confirmed for one of the sites by destructive sampling.

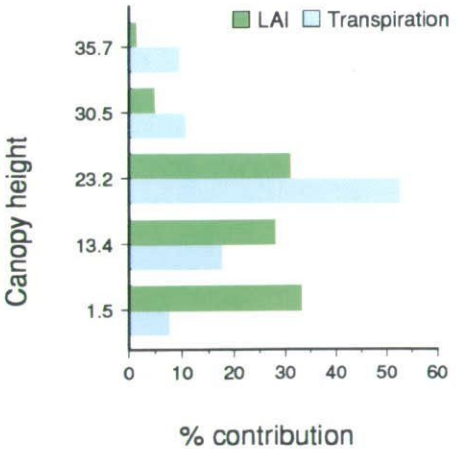
It is interesting to consider why with double the leaf area transpiration from forest does not exceed that from pasture when soil water is not limiting. A multi-layer transpiration model has revealed that there is a very limited contribution from the lower canopy to the total forest transpiration although it comprises a substantial proportion of the total foliage.

Preliminary results from the boundary-layer sounding experiments have indicated that boundary-layer growth over the pasture is likely to be much greater than over forest. This could have important implications for local and regional climate.

Fifty days of carbon dioxide flux data have been collected spanning periods of contrasting temperature, radiation, soil wetness and ambient CO_2 concentration. The measurements show the forest taking up carbon dioxide during the day and releasing it by night. Preliminary analysis shows the forest accumulating carbon, albeit slowly.

Areas of forest regrowth of differing ages were located around Manaus and

Three-dimensional sonic anemometer and air sampling tube for eddy covariance measurement of CO_2 and H_2O flux over tropical rain forest at Reserva Biológica do Jaru, Rondônia



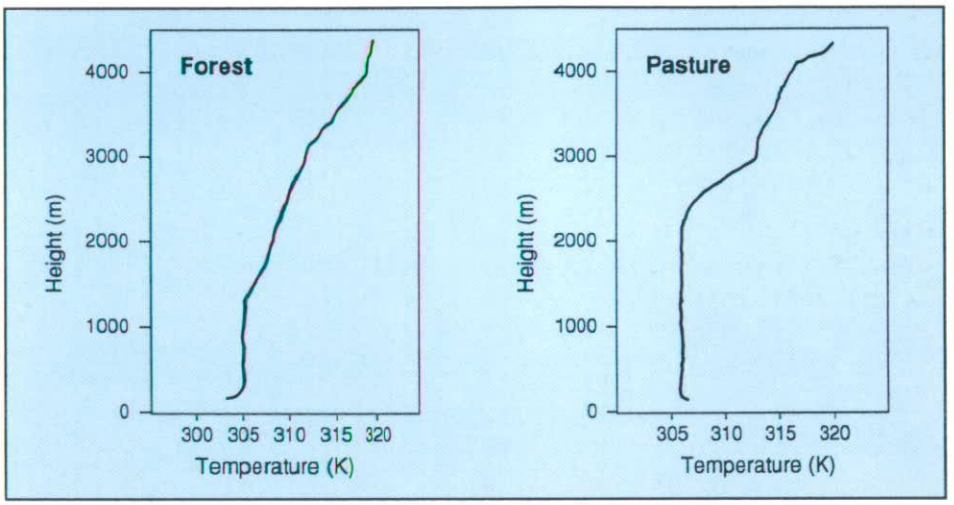
Vertical distribution of leaf area index in tropical rain forest, Manaus, Amazonas and contribution to forest transpiration.

Measurement of stomatal conductance in pasture area, Marabá, Pará

estimates of their biomass were made during a field survey. Remote sensing images will be used to extrapolate these results.

Database

The data have already been used to calibrate GCMs at the UK Meteorological Office and at the Brazilian Centre for Weather and Climate Prediction. In due course all the data will be assembled in a database and will be available to the worldwide scientific community.



Temperature profile through the boundary layer above tropical rain forest and nearby pasture, Ji-Paraná, Rondônia

Participating institutions

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Centro de Pesquisa Agroflorestal da Amazônia (CPAA / EMBRAPA)
Centro de Pesquisas Agropecuárias do Trópico Úmido (CPATU / EMBRAPA)
Companhia Vale do Rio Doce (CVRD)
Departamento de Ciências Atmosféricas, Universidade de São Paulo
Institute of Hydrology (IH)
Instituto de Aeronaútica e Espaço / Centro Técnico Aerospacial (IAE / CTA)
Instituto Brasileiro de Meio Ambiente e Recursos Renováveis (IBAMA)
Instituto Nacional de Colonização e Reforma Agrária (INCRA)
Instituto Nacional de Pesquisas da Amazônia (INPA)
Instituto Nacional de Pesquisas Espaciais (INPE)
Instituto Tecnológico de Aeronaútica (ITA)
Universidade Federal de Alagoas (UFAL)
Universidade Federal de Mato Grosso (UFMT)
Universidade Federal do Pará (UFPA)
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Impactos climáticos dos desmatamentos na Amazônia

Anglo-Brazilian Amazonian Climate Observation Study: ABRACOS

ABRACOS é um experimento que visa melhorar as previsões do efeito do desmatamento da Amazônia no clima. Cientistas britânicos e brasileiros estão colaborando na realização de medidas para aumentar a compreensão de como a vegetação e o solo interagem com a atmosfera no controle do clima de áreas de floresta e desmatadas (pastagem)

Torre micro-meteorológica de 52 m de altura na Reserva Biológica do Jaru, Rondônia

Modelagem Climática

Durante os últimos 15 anos, experimentos de modelagem climática têm evidenciado que o clima é sensível a variações da evapotranspiração e do balanço de energia à superfície. A maior contribuição para estas variações advem do tipo de cobertura vegetal e das modificações de curto e longo prazos da vegetação. A mais dramática mudança seria a troca permanente da cobertura vegetal de floresta tropical úmida por vegetação de baixo porte, tais como pastagens ou culturas agrícolas.

Três características da vegetação são importantes na determinação do balanço de energia à superfície e das trocas de calor com a atmosfera. Estas são: *albedo*, a refletividade da superfície à radiação solar; *rugosidade aerodinâmica* da vegetação, que determina a facilidade para troca de calor, gases e quantidade de movimento entre a vegetação e a atmosfera; e *condutância superficial*, que quantifica a facilidade do vapor d'água em se mover de dentro da folha para a atmosfera.

Previsões de mudanças climáticas são realizadas através de Modelos da Circulação Geral da Atmosfera (MCGAs), que essencialmente são do mesmo tipo dos modelos computacionais utilizados para previsão do tempo, mas com integração no tempo por um período maior, ou seja, anos ao invés de dias. Os processos físicos à superfície nos MCGAs acoplam-se às camadas mais altas da atmosfera através da camada limite atmosférica. Portanto, mudanças na vegetação e nas características da superfície influenciarão na camada limite atmosférica. Estas propriedades da superfície e da camada limite devem ser representadas nos MCGAs. Conjuntos de dados climáticos de referência associados com cada tipo de vegetação são necessários para calibração e validação de simulações dos MCGAs.

A distribuição global da intensidade das fontes e sorvedouros de gases do efeito estufa (particularmente do dióxido de carbono, CO_2) ainda é pouco conhecida. Uma necessidade fundamental para modelagem e previsões do efeito do aumento do CO_2 na atmosfera é a informação básica sobre o fluxo de carbono em diferentes biomas: floresta tropical e vegetação secundária.

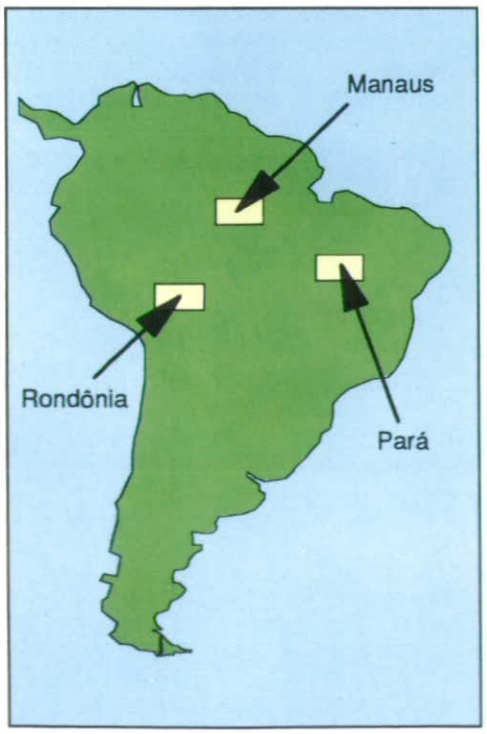
Os governos brasileiro e britânico estão preocupados em melhorar as previsões climáticas. Um dos maiores projetos resultante de Memorando de Entendimento entre o Brasil e o Reino Unido é o projeto "Estudo Anglo-Brasileiro de Observações Climáticas na Amazônia" (ABRACOS). Este projeto de colaboração é financiado pela Overseas Development Agency (ODA) do Reino Unido e pelo Governo Brasileiro.

Medidas

Estudos detalhados de climatologia da superfície, micrometeorologia, fisiologia vegetal e hidrologia da camada superior do solo estão sendo realizados em áreas adjacentes de floresta e pastagens em três localidades na Amazônia brasileira. Estas três localidades diferem particularmente com relação à duração da estação seca, à extensão espacial das áreas de pastagens e à proximidade ao Oceano Atlântico. Medidas de climatologia e de hidrologia do solo estão sendo realizadas continuamente durante o projeto, ao passo que dados de micrometeorologia e fisiologia vegetal são coletados em seis campanhas intensivas.

Uma iniciativa de pesquisa brasileira para o estudo do desenvolvimento da camada limite amazônica e suas possíveis ligações com o tipo de cobertura vegetal da superfície é o Experimento da Camada Limite de Rondônia (RBLE). Este experimento já coletou, em duas campanhas, perfis verticais de velocidade do vento, temperatura do ar e umidade até 15 km de altura, usando radiossondagens e balão cativo.

Medidas de fluxos de CO_2 foram efetuadas em áreas de floresta e pastagem no sítio experimental do ABRACOS em Rondônia pela Universidade de Edimburgo, financiadas pelo Projeto TIGER



Localização dos sítios experimentais do Projeto ABRACOS

Utilização do balão cativo para medidas de perfis de temperatura, vento e umidade da camada limite atmosférica. Fazenda Nossa Senhora Aparecida (pastagem), Rondônia

(Terrestrial Initiative in Global Environmental Research) e pela Universidade de Brasília, ao passo que a Universidade de Swansea em conjunto com o INPE e INPA estão estudando a técnica de sensoriamento remoto para quantificar o CO_2 absorvido pela regeneração da floresta.

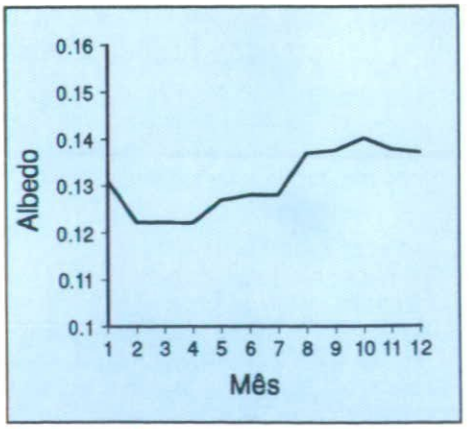
Os sítios experimentais do projeto ABRACOS deverão ser mantidos e estendidos nos próximos anos para servir como base a um grande projeto multidisciplinar e multinacional de meteorologia, biogeoquímica, ecologia e hidrologia na Amazônia (LAMBADA/BATERISTA).

Resultados

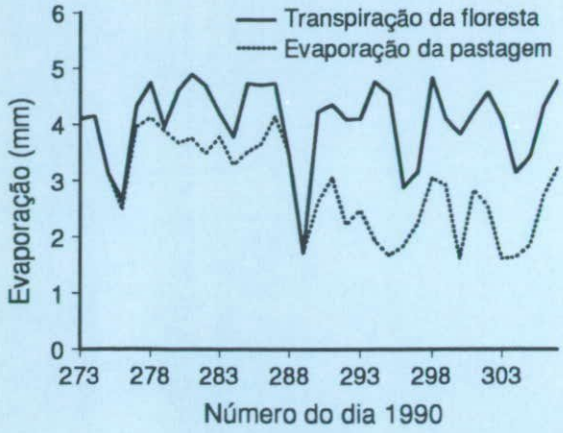
O albedo da pastagem é aproximadamente de 18.5 porcento, um pouco menor do que os valores usualmente utilizados nos MCGAs. O albedo da floresta é ainda menor, com uma média anual de 13 porcento, mostrando uma variação sazonal não antecipada: os maiores valores coincidem com os períodos de maior déficit de água no solo.

Estudos de micrometeorologia e de hidrologia do solo mostraram que, quando a disponibilidade de água no solo não é limitante, a transpiração é similar em áreas de floresta e de pastagem. Entretanto, para períodos de 10-14 dias sem chuvas, a transpiração na pastagem decresce enquanto que a da floresta se mantém. A absorção de água do solo em áreas de floresta é feita em um grande volume de solo, pois o sistema radicular é mais profundo. Com os dados obtidos até o momento, não foi observado que o armazenamento de água no solo limite a transpiração da floresta, mesmo considerando o final da época seca no sítio experimental que esta é mais pronunciada (Marabá, Pará).

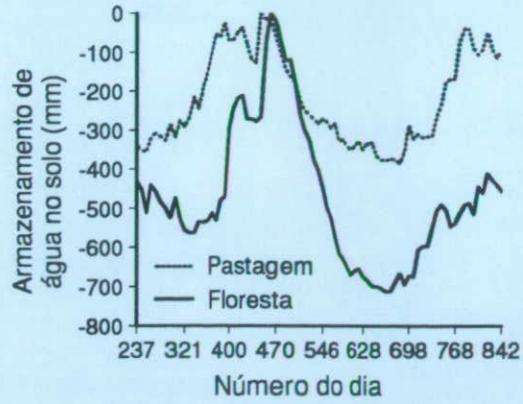
Uma importante observação foi a de que a estação chuvosa de 1992 em Marabá não foi suficiente para recarregar o armazenamento de água no solo da floresta. Isso pode causar o efeito de reduzir a água disponível para transpiração durante a subsequente estação seca. Estes resultados devem ser analisados no contexto da alta variabilidade interanual das chuvas na Amazônia.



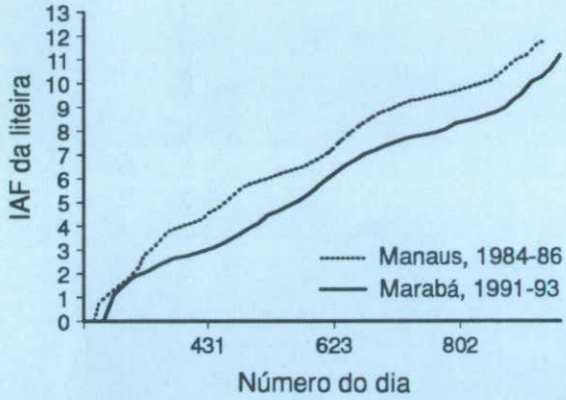
Variação sazonal do albedo da floresta, Reserva Biológica do Jaru, Rondônia



Variação da transpiração da floresta e pastagem durante um período de 30 dias sem chuva subsequentes a uma chuva intensa



Variação do armazenamento de água no solo da floresta e área de pastagem em Marabá, Pará



Índice de área foliar acumulado na liteira durante 2 anos na Reserva Ducke, Manaus e Reserva Vale, Marabá

Variação sazonal do índice de área foliar nos sítios experimentais de pastagem em Ji-Paraná, Rondônia e Marabá, Pará

Data		Ji-Paraná	Marabá
Janeiro	1992		1.42
Junho	1992		0.89
Agosto	1992	1.55	
Setembro	1992	1.66	0.49
Dezembro	1992		0.57
Abril	1993	3.90	1.64
Junho	1993	2.55	0.71

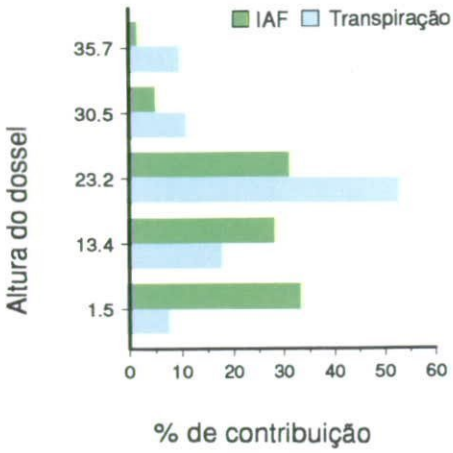
Estudos detalhados de fisiologia vegetal geraram novos conhecimentos das diferentes respostas das vegetações de floresta e pastagem ao aumento do déficit de água no solo. Durante episódios de seca, a condutância superficial da área de pastagem decai em decorrência do fechamento dos estômatos e da redução da área foliar, ambos decaindo para aproximadamente metade do valor máximo para os maiores valores do déficit de água no solo observados. Variações sazonais no índice de área foliar são mais difíceis de quantificar na floresta, mas podem ser interpretados como tendo uma variação substancialmente menor na área foliar total, o qual é, pelo menos, o dobro do caso de pastagem, quando a água no solo não é fator limitante, e muito maior durante a época seca.

Assim como existem grandes variações sazonais relacionadas com a área foliar de pastagem, também existem diferenças substanciais entre os sítios em um mesmo período. Isto contrasta com a situação para floresta onde as diferenças sazonais são pequenas. A área foliar em dois dos sítios de floresta foi obtida através da medida das folhas que caem (na liteira), durante um período de dois anos. Assumindo que o tempo de vida de uma folha seja de 12 meses, isto sugere que o índice de área foliar na floresta é um pouco inferior a seis. Este resultado foi confirmado através de medições destrutivas em um dos sítios experimentais.

É interessante considerar porque a transpiração da floresta não é maior do que no caso de pastagem, quando a água no solo não é limitante, uma vez que o índice de área foliar na floresta é o dobro daquele da pastagem. Um modelo de estimativa de transpiração com várias camadas revelou que a contribuição da porção inferior do dossel para a transpiração total é muito pequena, embora contribua substancialmente para a área foliar total.

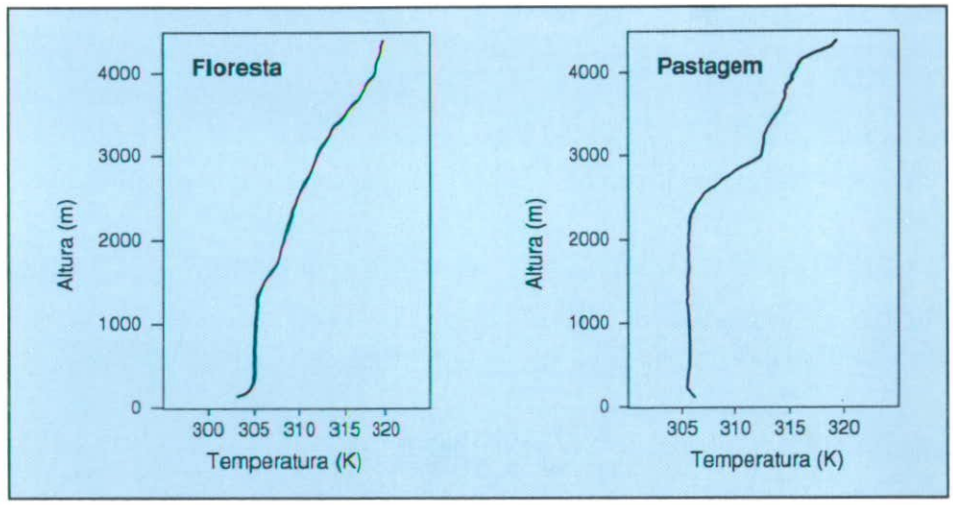
Resultados preliminares do experimento de sondagens da camada limite em Rondônia indicam que o crescimento (altura) da camada limite é maior, e a quantidade de vapor d'água na coluna atmosférica é menor, sobre a pastagem durante a estação seca do que sobre a floresta. Estes resultados podem ter implicações

Anemômetro sônico tri-dimensional e tubo de amostragem do ar para medidas de correlação turbulenta de fluxos de CO_2 e H_2O sobre floresta tropical na Reserva Biológica do Jaru, Rondônia



Distribuição vertical do índice de área foliar na floresta tropical, Manaus, Amazonas e sua contribuição para a transpiração

Medidas da condutância estomática para área de pastagem em Marabá, Pará



Perfis de temperatura na camada limite para áreas de floresta tropical e pastagem em Ji-Paraná, Rondônia

importantes para o clima local e regional.

Dados de fluxos de CO_2 foram coletados durante 50 dias sob várias condições de temperatura, radiação, umidade do solo e concentração de CO_2. As medidas efetuadas mostram que a floresta absorve CO_2 durante o dia e o libera durante a noite. Análises preliminares mostram a floresta acumulando carbono, embora lentamente.

Áreas de rebrota da floresta tropical de diferentes idades foram selecionadas ao redor de Manaus e estimativas de suas biomassas foram realizadas em missão de campo. Imagens de sensoriamento remoto serão usadas para extrapolar estes resultados.

Banco de Dados

Os dados obtidos já estão sendo utilizados para calibrar o MCGA do Serviço Britânico de Meteorologia e do Centro de Previsão de Tempo e Estudos Climáticos (CPTEC) do INPE. Em seu devido tempo, todos os dados coletados serão reunidos em um único conjunto de dados e colocado à disposição da comunidade científica nacional e internacional.

Instituições participantes

Centro de Energia Nuclear na Agricultura (CENA), Universidade de São Paulo
Centro de Pesquisa Agroflorestal da Amazônia (CPAA / EMBRAPA)
Centro de Pesquisas Agropecuárias do Trópico Úmido (CPATU / EMBRAPA)
Companhia Vale do Rio Doce (CVRD)
Departamento de Ciências Atmosféricas, Universidade de São Paulo
Institute of Hydrology (IH)
Instituto de Aeronaútica e Espaço / Centro Técnico Aerospacial (IAE / CTA)
Instituto Brasileiro de Meio Ambiente e Recursos Renováveis (IBAMA)
Instituto Nacional de Colonização e Reforma Agrária (INCRA)
Instituto Nacional de Pesquisas da Amazônia (INPA)
Instituto Nacional de Pesquisas Espaciais (INPE)
Instituto Tecnológico de Aeronaútica (ITA)
Universidade Federal de Alagoas (UFAL)
Universidade Federal de Mato Grosso (UFMT)
Universidade Federal do Pará (UFPA)
Universidade Federal do Rio de Janeiro (UFRJ)
Universidade Federal de Rondônia (UFRO)
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FOLHA da FLORESTA

Number 2 August 1994

Editorial

Este já o segundo número do nosso periódico Folha da Floresta de comunicação entre os participantes do Projeto ABRACOS, após seis meses do número inicial. Esperamos estar alcançando a todos e recebar contribuições. A partir deste número estamos também contando com o apoio da Bel Nogueira (INPE) na tradução e editoração da Folha da Floresta. Seja bemvinda, Bel!

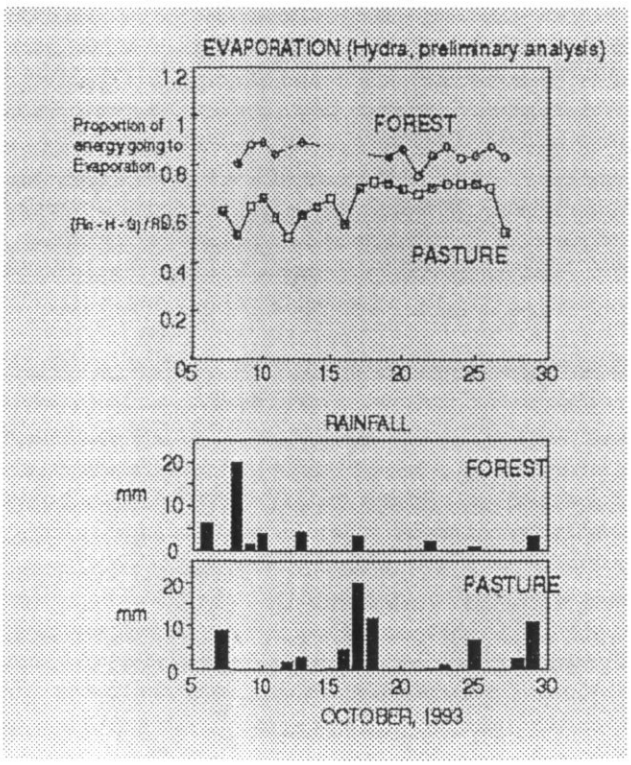
This is the second issue of the newsletter Folha da Floresta for ABRACOS participants appearing six months after the first edition. We hope to reach all members of the project and to receive your contributions for publication. As from this issue Bel Nogueira will be working with us on the translation and editorial work for Folha da Floresta. Welcome Bel !

A Secret Mission ?

In the first issue of Folha da Floresta an article appeared under the title Final field missions chronicling ABRACOS missions 4 and 5. These two missions, run together, will produce an extended four month database that would have been unimaginable at the start of the project. However, this was not, in fact, the final mission. As if M4 and M5 were not enough there was still one last piece of work to complete the full ABRACOS set - Marabá and the ultimate mission - M6. Mission 6 was designed to retrieve about 3 - 4 weeks of Hydra data from the forest and pasture sites at Marabá, and thereby achieve comparative flux measurements at all three of the paired sites. Also we hoped to achieve a sufficiently useful snapshot of the aerodynamic characteristics of the Marabá forest and pasture, both of which have a noticeably different structure to the Ji Paraná and Manaus sites. The timing of M6 was critical. To get the maximum benefit from a short mission it was necessary to try and span a period of rapidly changing soil moisture. October 1993 was the only realistic window of opportunity and fortunately this period gave us the required conditions.

The diagram shows the evaporation ratio and the rainfall at the Marabá sites for October 1993. The rainfall is quite different between the sites, but more or less shows the first storms of the developing wet season. Although the forest Hydra failed to run continuously, the evaporation measurements span 21 days, of which there are 14 days of comparative measurements. The Hydra in the forest was left running for some time after this period to gain more momentum flux information. As has been observed at the other forest sites the forest evaporation appears to be unaffected by seasonal factors and partitions a steady 80% of the available energy to evaporation. The pasture evaporation is clearly responding to the onset of the wet season. At the beginning of October the evaporation ratio was fairly low, about 60% while during the second half of the month this has risen to 70%. This latter rate is typical of the wet season evaporation rates from pasture at the other ABRACOS sites.

No primeiro número do Folha da Floresta, saiu um artigo sob o título de "Missões finais do ABRACOS". Essas duas missões, realizadas em conjunto, produzirão um extenso banco de dados que seria inimaginável no começo do Projeto. Entretanto, essa não foi, na verdade, a missão final. Como se não fossem suficientes a M4 e M5, ainda havia trabalho por fazer para completar o total do ABRACOS - Marabá e a última Missão - M6. Espera-se que a Missão 6 gere cerca de 3 a 4 semamas de dados de floresta e pastagem, coletados através do Hydra, nos sítios de Marabá, e assim produza medições de fluxo comparativo nos três sítios. Esperávammos também obter uma rápida imagem, suficientemente utilizável, das características aerodinâmicas da floresta e da pastagem de Marabá, ambas das quais têm uma estrutura notadamenta diferente dos sítios de Ji Paraná e Manaus. Administrar o tempo da Missão 6 foi uma tarefa crítica. Precisamos agir rápido e estender o periodo de trabalho. O diagrama mostra os índices de evaporação e de chuva nos sítios de Marabá para outubro de 1993. O índice de chuva é bastante diferente entre os sítios, mas mostra mais ou menos as primeiras tempestades da estação chuvosa em desenvolvimento. Embora o Hydra instalado na floresta não tenha funcionado continuamente, as medições de evaporação ocorreram por 21 dias, dos quais14 dias foram de medições comparativas. O Hydra da



Floresta continuou trabalhando por algum tempo depois desse período para obter mais informações de fluxo de momento. Como se tem observado nas florestas dos outros sítios, a evaporação na floresta parece não ser afetada por fatores sazonais e mostra um estável índice de 80% da energia disponível usada para evaporação. A evaporação na pasagem está respondendo claramente ao começo da estação chuvosa. No começo de outubro, o índice de evaporação foi bastante baixo, cerca de 60%, enquanto durante a segunda metade do mês, chegou a 70%. Esse último índice é típico das taxas de evaporação da estação chuvosa da pastagem nos outros sítios do ABRACOS.

Automatic weather stations

In April and May Alistair Culf (IH) and José Carlos dos Santos (INPE) made a tour of all the ABRACOS weather stations. The network is generally in good shape, but several of the stations had small problems, mostly due to the age of the batteries. These were changed where necessary and, hopefully the stations should now operate without further problems for several months. Over the next year INPE will take over the responsibility for running the ABRACOS weather station network and for processing and archiving the data and Zé Carlos will be in charge of maintaining the weather stations in good working order.

There are problems with the computers at all of the sites, but currently IH is in the process of buying new desktop computers which will replace the laptops currently in use. These new machines should be much more reliable than the laptops and make the data transfer and soil moisture data input an easier process.

Em abril e maio, Alistair Culf, do IH, e José Carlos dos Santos, do INPE, fizeram um tour pelas estações automáticas do ABRACOS. Em geral, os equipamentos estão em bom estado, mas várias estações tiveram pequenos problemas, na sua maioria devidos ao tempo de uso das baterias. Onde foi necessário, elas foram trocadas e, esperamos, devem voltar a operar sem problemas por vários meses. Para o próximo ano, o INPE assumirá a responsabilidade pelo funcionamento das estações climáticas do ABRACOS, pelo processamento e pelo arquivo dos dados, e José Carlos se encarregará de manter as estações em plena ordem para um bom funcionamento.

Há problemas com os computadores em todos os sítios, mas, no momento, o IH está em processo de compra de novos computadores de mesa que substituirão os atuais "laptops". Essas novas máquinas deverão ser muito mais confiáveis que os "laptops" e tornarão o processo de transferência de dados e de coleta de dados de água do solo muito mais fácil.

Amazonia Parameterisation

The objective of producing a paper which sets out all the parameters required for GCM modelling of Amazonia for both forest and pasture came a step closer last month when a meeting to discuss this important issue was held at INPE in São José dos Campos. The meeting took place over two days and was attended by Regina Alvala, Ralf Gielow, Gilberto Fisch, Vinicius Ubarana, Humberto Rocha, Martin Hodnett, Ivan Wright, Eugenio Vertamatti and Iria Vendrame. The main problem in providing a parameterisation for the whole of Amazonia is the variability of soils across the region and therefore identifying a simple scheme to present those parameters (about 70%) which are dependent upon soil type. Eugenio Vertamatti gave a very clear and informative presentation on the soils of Amazonia and it became increasingly apparent that the soil categories represented by the Manaus and Ji-Parana soils may only represent a minor proportion of the Amazon area. However it was decided not to impose a parameterisation entirely based on these well modelled soils, but to base the parameterisation partly on other sources, with the research from ABRACOS providing the overall model framework. It was proposed to create 1°by 1° digital maps for soil texture, pedology, colour and for water table depth. Investigations are to be made into whether any of this information currently exists in a digitised form. A further meeting and intensive workshop session will be held in the near future.

A tentativa de produzir um paper que estabeleça todos os parâmetros requeridos para modelagem de GCM da Amazônia em áreas de floresta e pastagem, avançou algums passos no último mês, quando foi realiza, no INPE, em São José dos Campos, uma reunião para discutir esse assunto. Foram dois dias de reunião contando com as presenças de Regina Alvalá, Ralf Gielow, Gilberto Fisch, Vinícius Ubarana, Humberto Rocha, Martin Hodnett, Ivan Wright, Eugênio Vertamatti e Iria Vendrame. O principal problema em conseguir essa parametrização para toda a Amazônia é identificar um esquema simples para a apresentação de parâmetros (cerca de 70%) que dependem do tipo de solo, numa região com grande variabilidade de solo. Eugênio Vertamatti apresentou informacações bastante claras sobre os solos da Amazônia e ficou bem aparente que as categorias de solo apresentadas em Manaus e Ji Paraná podem apresentar apenas uma proporção menor da Área Amazônica. Ficou decidido, no entanto, não impor uma parametrização inteiramente baseado em mapas de solos modelados, mas baseandoése esta parametrização em outras fontes,com a pesquisa do ABRACOS gerando uma estrutura básica. Foi proposto criar mapas digitais 1°x1° para textura do solo, pedologie, coloração e profundidade do lençol freático. Investigações devem ser realizadas para saber se estas informações já existem na forma digital. Em um futuro próximo, outro workshop deverá ser realizado sobre este assunto.

Anna McWilliam Leaves IH

Anna McWilliam left IH at the end of April to live in France with her new husband Jamie. They were married in Scotland in Edinburgh Cathedral on 30th April. The ceremony was followed by a lively reception at which the future happiness of the bride and groom was liberally toasted with champagne Anna still intends to come to the project symposium in Brasilia in September where she will present

a paper on leaf gas exchange in central and south west Amazonia.

Anna McWilliam deixou o IH no final de abril para morar na França com seu marido, Jamie. Eles se casaram na Catedral de Edinburgh, na Escócia, onde a felicidade dos noivos foi devidamente brindada com champagne. Anna ainda pretende participar do Simpósio do Projeto ABRACOS, em setembro, em Brasília, onde ela apresentará um paper sobre trocas gasosas das plantas na região central e sudeste da Amazônia.

ABRACOS Symposium

Preparations for the end of project symposium are now well underway and it looks set to be an extremely interesting, as well as enjoyable, scientific meeting. The symposium will take place from the 19th to the 21st of September at the Hotel Nacional in Brasilia. 34 papers covering all aspects of ABRACOS and the related projects will be presented during the meeting. In addition there will be 4 keynote presentations made by E.Salati (Land use changes in Amazonia), L. Bruijnzeel (Hydrological impacts of tropical deforestation), E. Medina (Ecophysical responses of tropical forests) and R. Dickinson (Advances in land surface parameterisations for GCMs). All the papers will be refereed and a selection will be published as a book which will form a major contribution to Amazonian climate research. During the evenings there will be receptions for politicians, civil servants, students and teachers, etc. at which there will be a display of posters describing the research, demonstrations of equipment used during the project.

Os preparativos para o simpósio de encerramento do Projeto estão a todo vapor e parece que será um encontro científico dos mais interessantes, além de muito agradável. O simpósio se realizará entre os dias 19 e 21 de setembro, no Hotel Nacional de Brasília. Serão apresentados 34 artigoés científicos cobrindo todos os aspectos do ABRACOS e dos projetos a ele ligados. Haverá ainda 4 apresentações especiais feitas por Eneas Salati (Uso da Terra e Mudanças na Amazônia), L. Bruijnzeel (Impactos hidrológicos do destamento tropical), E.Medina (Respostas Ecofísicas das Florestas Tropicais), e R. Dickinson (Avanços na parametrização da superfície da terra para GCM). Todos os trabalhos serão analisados por um corpo editorial e selecionados para a publicação de um livro que será uma imensa contribuição para a pesquisa climática da Amazônia. A noite haverá recepções a políticos, personalidades, estudantes e professores, além da comunidade civil, e haverá exposição de posters descrevendo a pesquisa realizada, com demonstrações dos equipamentos usados durente o trabalho.

O Experimento RBLE 3

Durante os dias 16 a 20/05/94, ocorreu uma reunião de planejamento das atividades do RBLE 3, na qual estiveram presentes os Profs. Roberto Lyra (UFAL), Edson P. da Rocha e Antonio Carlos Lola da Costa (UFPA), Gilberto Fisch e Evandro P. de Mello (CTA/IAE),, Neliton A.A. Pereira e Vinicius N. Ubarana (INPE). O experimento será conduzido nos sítios experimentais do Projeto ABRACOS de pastagem e floresta, simultâneamente, durante o período de 7 a 29 de agosto de 1994 (época seca). O objetivo do RBLE 3 é o de amostrar a estrutura da Camada Limite Atmosférica (CLA), nas áreas de floresta e pastagem, e de estudar a evolução diurna e noturna desta camada. Serão realizadas radiosondagens (8,11,14 e 17 HL) e perfilamentos com o balão cativo (05h30, 07h00, 08h30, 17h30, 19h00, 21h30 e 24h00 HL). O IH participará do experimento (através de Alistair Culf e Chris Huntingford), com medições dos fluxos turbulentos à superfície (HYDRA). Os recursos financeiros serão provenientes da FAPESP, INPE, CNPq e do Projeto ABRACOS. As entidades que estão participanto desta campanha de coleta de dados são o INPE, CTA/IaE, IH, UFAL, UFPA, USP, INCRA e UNIR.

A planning meeting for RBLE3 was held during May. The meeting was attended by Prof Roberto Lyra (UFAL), Edson Rocha and Antonio Carlos Lola da Costa (UFPA), Gilberto Fisch and Evandro P. de Mello (CTA/IAE), Neliton A.A. Pereira and Vinicius Ubarana (INPE). The experiment will run at both the forest and pasture sites simultaneously between the 7th and the 29th August 1994 (the dry season). The objective of this experiment is to sample the atmospheric boundary layer structure over the pasture and forest areas, and to study the evolution of the layer throughout the day and night. Radiosondes will be launched at 530, 700, 830, 1730, 1900, 2130 and 2400 local time. Drs Alistair Culf and Chris Huntingford will participate in the experiment measuring surface turbulent fluxes using the Hydra instrument. Financial support will be given by FAPESP, INPE, CNPq and ABRACOS. The institutions participating in this RBLE campaign are INPE, CTA/IAE, IH, UFAL, UFPA, US, INCRA and UNIR.

European Funds For Using ABRACOS Data In Planning BATERISTA

The European Union has approved a four nation - France - Germany - Netherlands - UK - project to start planning the BATERISTA component of LBA (the new acronym of LAMBADA -BATERISTA - AMBIACE). BATERISTA is the meso-scale component of the experiment, which is likely to be based on the existing ABRACOS sites in Rondonia. IH and INPE will use the ABRACOS data from Missions 3, 4 and 5 to calibrate the French and Dutch meso-scale models which will then be used to help design the experiment. The best way to deploy the expected soil moisture, surface flux, aircraft flux, balloon and aircraft remote sensing teams will be assessed on the basis of meso-scale modelling experiments initiated using data from RBLE 3. The work will be carried out over two years starting in July 1994. The project will cost about US$1000000, with approximately US$600000 being provided by the European Union.

A comunidade Européia aprovou um Projeto envolvendo 4

nações - França, Alemanha, Holanda e Itália para iniciar o planejamento do BATERISTA, componente do LBA (o novo acrônimo para Lambada-Baterista-Ambiace). Baterista é o componente do meso-escala do experimento, e deve ser baseado nos sítios do ABRACOS existentes em Rondônia. O IH e o INPE usarão os dados das Missoes 3, 4, e 5 do ABRACOS para calibrar os modelos franceses e holandeses do meso-escala que serão usados para ajudar a delinear o experimento. O sistema ideal de medição de umidade do solo, fluxo de superficie, fluxo em altitude, sensoreamento remoto por balão e avião, será estimado com base mos experimentos de modelagem de meso-escala iniciada usando dados do RBLE 3.

Congresso Brasileiro de Meteorologia (CBMet)

Durante o período de 18 a 25 de Outobro de 1994, será realizado o VIII CBMet, na cidade de Belo Horizonte (MG). Alguns resultados cientificos obtidos pelo projeto ABRACOS serão apresntados pelos participantes, dos quais podemos citar:

RBLE: Experimento da Camada Limite Atmosférica Amazônica. Carlos A. Nobre, Humberto R.Rocha, Gilberto Fisch, Edson P. da Rocha, Antonia Carlos Lola da Costa e Roberto Lyra;

Experimentos Observacionais e Modelagem de Perdas por Interceptação da Precpitação na Floresta Amazônica. Vinicius N. Uberana e Carlos A. Nobre;

Aspectos Observacionais e de Moelagem no Crescimento da Camada Limite Atmosferica Convectiva na Região Amazônica. Gilberto Fisch, Alistair D. Culf e Carlos A. Nobre.

Análise do Comportamento da Camada Limite Atmosférica durante um evento de friagem no sul de Rondônia. Gilberto Fisch, Roberto Lyra, Edson P.Rocha;

Comparações do Balanço de energia em Áreas de Floresta e Pastagem na Região Amazônica. Gilberto Fisch e Ivan R. Wright.

Perfis de Temperatura e de Difusividade térmica em Solos sob Pastagens na Amazônia. Ralf Gielow e Regina C. dos Santos Alvalá;

Modelo de Balanço de energia em Área de pastagem na Amazônica Central. Regina C. dos Santos Alvalá e Ralf Gielow;

Efeitos do Desmatamento sobre a Termodinâmica da Baixa Atmosfera. Roberto Lyra, Gilberto Fisch, Carlos A. Nobre, Edson P. da Rocha, Humberto R. Rocha e Solange Souza.

Estudo do Comportamento de Variáveis Meteorológicas em Áreas de Floresta e Pastagem Durante o RBLE2. Edson P. da Rocha, Antonio Carlos Lola da Costa e Joao Batista Ribeiro;

Clima Local em área de Várzea e Floresta e de Terra Firme Amazônia Central. Osvaldo Cabral, Alistair D. Culf e Uwe Thein.

During the period from 18th to 25th of October 1994 the VIII CBMet will be held in Belo Horizonte (MG). Some of the scientific results obtained by the ABRACOS project will be presented by the participants. Some of the papers to be presented are listed above.

Congratulations

Congratulations are due to Eduardo Conceição de Lacerda (INCRA, Ji-Paraná) and his wife Rose on the birth of their son, Edward, in Brasilia in May. Vinicius and Janete Ubarana (INPE) are expecting a baby in October, so the ABRACOS project continues to increase (and augment) the populations of Brazil and the UK. Currently the score is 4 (almost 5) to 1 !

Registramos nossas congratulações ao Eduardo Conceição de Lacerda (INCRA, Ji Paraná) e sua esposa Rose, pelo nascimento de seu filho Eduard, em maio último, em Brasilia. O próximo bebê é o de Vinícius e Janete Ubarana (INPE), que deve nascer em novembro próximo. O projecto ABRACOS continua a aumentar as populações do Brasil e do Reino Unido. O placar está 4 (quase 5) a 1!

Lola muda-se para UFSCAR

Antonio Carlos Lola da Costa mudou-se para a Universidade Federal de São Carlos (UFSCAR) para realizar o seu doutoramento. Mesmo assim, Lola continua envolvido com o projeto ABRACOS e participará da próxima campanha de coleta de dados do RBLE3.

Antonio Carlos Lola da Costa has moved to Universidade Federal de São Carlos (UFSCAR) to start his PhD programme. Nevertheless, he will still be involved in the project and will participate in the next field mission of RBLE 3.

Folha da Floresta

FOLHA DA FLORESTA is an occasional newsletter to the ABRACOS research community. It aims to keep participants informed of project activities and up to date with current results and data availability. Short articles on any aspect of ABRACOS or associated projects are welcomed from anyone involved. Articles, which can be in English or Portuguese should be send to Dr Alistair Culf, Institute of Hydrology, Wallingford, Oxon, UK or to Gilberto Fisch, CTA/IAE, Av Nelson D'Avila s/n, CP 6019, 12001 Sao José dos Campos, SP, Brazil.

FOLHA DA FLORESTA é um jornal informativo para a comunidade do Projeto ABRACOS. O objetivo deste é manter todos os participantes informados das atividades atuais, dos resultados alcançados e da disponibilidade dos dados coletados. Artigos sobre qualquer aspecto do ABRACOS e/ou dos projetos associados são bemvindos e podem ser escritos na língua portuguêsa ou inglêsa. Os referidos artigos devem ser enviados para Dr. Alistair Culf, Intitute of Hydrology, Wallingford, OX10 8BB, United Kingdom ou para Gilberto Fisch, CTA/IAE, Av. Nelson D'Avila, s/n, CxP 6019, CEP 12228-904, São José dos Campos-SP. Brasil.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