Institute of
Hydrology

Overseas Development Report

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 5 (1 Jan. 1992 - 30 June 1992)

Prepared by

Institute of Hydrology, UK (IH)

Instituto Nacional de Pesquisas Espaciais, Brazil (INPE)

30 June 1992

1. SUMMARY

1.1. Progress in the period 1 January 1992 to 30 June 1992

(a) The routine collection of climate and soil data has continued. This has been augmented by plant physiological measurements at the Maraba sites. The transmitting part of the satellite data transfer system is now operational.

(b) The analysis of the Mission 1 and 2 data has proceeded, with three papers being completed. Emphasis is increasingly being given to using these data for calibrating GCMs.

(c) The equipment required for Mission 3 has been moved from Manaus to Ji-Parana.

1.2. Problems

(a) Although the satellite data transmission system is now operational, there are persistent problems with the receiver computers which are now being upgraded.

(b) Plans for additional boundary-layer measurements have been abandoned as an application for funds for this addition to the project was rejected.

1.3. Plans for the next six months include:-

(a) Calibration of Hadley Centre, CPTEC/COLA (Brazilian/USA) and French GCMs using Mission 1 and 2 data.

(b) Mission 3: a period of intensive measurements based on Ji-Parana in Rondonia.

(c) Parallel intensive plant physiological measurements to be made in Maraba.

(d) Initiation of English Language Training courses for Brazilian participants at the British Council Training Centre in Recife.

2. EQUIPMENT

2.1. Land Rovers

One of the two project Land Rovers, which were up to now based at Manaus, has been transferred to Ji-Parana to support the activities of the intensive field campaign of Mission 3 in August and September 1992.

The Land Rover based at Maraba has developed a crack in the front axle casing identical to those which appeared earlier in the front axles of the Manaus Land Rovers. Land Rover UK have sent a new axle casing under warranty.

2.2 Satellite Transmission Systems

Provision of refurbished Oceanspace DCP satellite transmission systems was completed by the Instrument Section of the Institute of Hydrology in March. This equipment was then sent by air to the three ABRACOS study areas in Brazil. The seven systems were successfully installed in April, one at each of the Automatic Weather Station sites.

However, since coming into operation, recurrent problems have been experienced with the recommended computer hardware dedicated to the control of the DCP receiving stations. As yet the suppliers of these four computers have been unable to provide a satisfactory solution to the problem. Suitable replacement computer systems will be installed in the next few months to enable the satellite DCP systems to become fully operational.

3. SCIENTIFIC RESULTS

3.1. Publications

To ensure that the scientific results of the project are applied as widely as possible, the project has the policy of publishing in international scientific journals. The following publications have either been accepted for publication or are currently being reviewed by journals. In the interests of brevity only the abstracts are presented here.

Observations of Climate, Albedo and Surface Radiation over Cleared and Undisturbed Amazonian Forest

by H. G. Bastable, W. J. Shuttleworth, R. L. G. Dallarosa, G. Fisch and C. A. Nobre.

Submitted to the International Journal of Climatology

ABSTRACT

Measurements from the first comparative study of climate over Amazonian tropical forest and an embedded deforested clearing are presented. Observations comprise a continuous 60-day run of data from mid-October to mid-December 1990, covering the end of the dry season and the beginning of the wet season. Mean hourly observations are calculated for the whole period; and for two ten day periods, one in the dry season and one at the start of the wet season. Much greater variation in weather variables was observed at the clearing compared to over the forest. While the mean values of temperature and specific humidity deficit differed by less than 1°C and 1 g kg^{-1} respectively, their daily ranges at the clearing were twice that at the forest. Mean daily albedo of the forest was 13.1%, agreeing well with other tropical forest measurements, and of the clearing was 16.3%, somewhat lower than the values currently being used in GCMs. The surface energy balance was investigated and mean available energy calculated for each site. The significant difference in the daily pattern of net radiation between the sites was found to be at least as much due to differences in the longwave radiation balance as to differences in albedo. The diurnal pattern of net radiation therefore changed between dry and wet periods as the higher plant water stress experienced by clearing vegetation altered the daily temperature cycle.

Leaf Area Index and Above-ground Biomass of *Terra Firme* Rainforest and Adjacent Clearings in Amazonia

By A-L. C. McWilliam, J. M. Roberts, O. M. R. Cabral, M. V. B. R. Leitao, A. C. L. da Costa, G. T. Maitelli and C. A. G. P. Zamparoni.

Submitted to Functional Ecology

ABSTRACT

Leaf Area Index (L^*) and above-ground biomass were determined by destructive sampling for a 400 m^2 area of *terra firme* Amazonian rainforest and for an adjacent clearing. While L^* in the forest varied considerably with height through the canopy for four separately sampled 100 m^2 sub-plots, the cumulative L^* was similar with a mean value of 5.7 +/- 0.5. The total above-ground dry biomass of the forest was 265 +/- 95 t ha^{-1}, while the leaf dry biomass was 6.3 +/- 0.5 t ha^{-1}. The specific leaf area (SLA, cm^2 g^{-1}) was determined, and found to vary linearly with canopy depth rising from 65 cm^2 g^{-1} at the canopy top, to 114 cm^2 g^{-1} at 5 m above the forest floor. The average for the four sub-plots was 90 cm^2 g^{-1}. The leaf area index of grass in the clearing (blade only) averaged 0.8 +/- 0.4, and total green area index (blade and stem) was 2.3 +/- 0.6. Total above-ground dry biomass (blade, stem) was 2.3 +/- 0.6 t ha^{-1}, while including dead plant material gave a total dry biomass of 5.6 +/- 2.1 t ha^{-1}. Specific leaf area of the grass was 79 cm^2 g^{-1}. The results clearly demonstrate the profound change in leaf area and biomass which accompany Amazonian deforestation.

Dry Season Micrometeorology of Central Amazonian Ranchland

by I. R. Wright, J. H. C. Gash, H. R. da Rocha, W. J. Shuttleworth, C. A. Nobre, G. T. Maitelli, C. A. G. P. Zamparoni and P. R. A. Carvalho.

Accepted for publication in the Quarterly Journal of the Royal Meteorological Society

ABSTRACT

This paper presents the first comprehensive micrometeorological measurements to be recorded over post-deforestation Amazonian ranchland. The ranch was managed for the production of beef cattle and had been created by felling and burning the original rainforest 12 years previously. The measurements allow derivation of the aerodynamic roughness, and a description of the response of the energy balance and surface conductance to the progressing dry season. Zero plane displacement and roughness length were derived from windspeed profiles as 0.17 +/- 0.03 m and 0.026 +/- 0.03 m respectively, while measurement of energy

partition was achieved, with excellent agreement, between three independent measurement systems. During the 1990 dry season average evaporation diminished from 3.8 to 2.1 mm d^{-1} as the Bowen ratio increased from 0.43 to 0.67. Values of surface conductance were derived and these compare well with expected trends.

Albedo of Tropical Grass: a case study of pre- and post-burning

by G. Fisch, I. R. Wright and H. G. Bastable

Submitted to The International Journal of Climatology

ABSTRACT

Measurements of reflected shortwave radiation were made at an Amazonian ranchland site for a period in which the grass was completely burnt and then subsequently regrew. For the 35 days prior to the fire the mean albedo was 0.19. After the fire the albedo was reduced by a factor of two and thereafter took about 80 days to recover to its previous value. The influence on the energy balance is described and it is suggested that such seasonal albedo changes during the dry season may need to be described in climate models for the prediction of the seasonal impact of deforestation.

A comparison of dry season soil water depletion beneath Central Amazonian pasture and rainforest.

by L. Pimentel da Silva, M. G. Hodnett, R. Cruz Senna and H. Rocha

Prepared for Brazil Meteorological Congress in September 1992

ABSTRACT

Soil water content and potential, and soil-water storage were measured to a depth of 2.0 m at adjacent sites (1 km apart) beneath pasture and undisturbed rainforest for a period of 18 months. The soil type was the same at both sites.

The maximum water storage change recorded (from wettest to driest conditions) was 165 mm under the forest and 140 mm under the pasture. In the upper 1 metre of the soil profile the patterns of soil water storage changes were virtually identical at both sites. In the second metre of the profile clear differences were apparent. Storage changes were very similar in the wet season, but in the dry season the rate of depletion under the forest was significantly

greater than under the pasture, resulting in 25 mm more depletion. This is equivalent to a difference in evaporation rate of about 0.5 mm d^{-1}. The water content and potential data under the forest strongly indicated that there was significant abstraction from below 2 m depth. Deeper access tubes have been installed to monitor this.

The following papers have been accepted for presentation at the Brazilian Meteorological Congress during a special session on Amazonian Micrometeorology. The Congress is to be held in São Paulo during September 1992.

1. **Anglo-Brazilian Research to Improve the Prediction of Post-Deforestation Amazonian Climate.** C. A. Nobre and W. J. Shuttleworth

2. **Wise Forest Management and its Links to Climate Change**. W. J. Shuttleworth and C. A. Nobre

3. **Observa des Micrometeorologicas em Clareira e Floresta na Regiao Tropical Amazonica. Parte I: Elementos Climaticos.** G. Fisch, H. G. Bastable, W. J. Shuttleworth, R. L. G. Dallarosa and C. A. Nobre

4. **Leaf Area Index and Above-Ground Biomass of *Terra Firme*** Rainforest O. M. R. Cabral, A-L. C. McWilliam, J. M Roberts,M. V. B. R. Leitao, A. C. L. da Costa, G. T. Maitelli and C. A. G. P. Zamparoni

5. **Comparison of Dry Season Soil Water Depletion beneath Central Amazonian Pasture and Rainforest.** L. P. da Silva, M. G. Hodnett, R. C. Senna and H. R. Rocha

6. **Amazonian Ranchland in the 1990 Dry Season: the Micrometeorology of Central Rainforest and Adjacent Clearings in Amazonia.** H. R. Rocha, I. R. Wright, J. H. C. Gash, W. J. Shuttleworth, C. A. Nobre, G. T. Maitelli, C. A. G. P. Zamparoni and P. R. A. Carvalho

7. **Simulacoes do Contraste Floresta-Pastagem na Amazonia por um Modelo Unidimensional.** H. R. Rocha and C. A. Nobre

POSTER SECTION

8. **Calibracao do Modelo SiB Para Areas de Pastagem na Amazonia.** H. R. Rocha and C. A. Nobre

9. **Observacoes Micrometeorologicas em Clareira e Floresta na Regiao Tropical Amazonica. Parte II: Balanco de Radiacao.** G. Fisch, H. G. Bastable, W. J. Shuttleworth, R. L. G. Dallarosa and C. A. Nobre.

3.2. Maraba

Physiological studies of stomatal conductance and leaf water status have been made at two monthly intervals at the forest and clearing site at Maraba since the site was established in August 1991. This information will provide insight into seasonal changes in behaviour of the different vegetation types. Additionally collections of leaf litter are made monthly in the forest from which estimates of leaf area index will be made. Leaf area index of the pasture areas has been measured directly. The information on physiological behaviour and leaf area index quantities will be combined with microclimatic data to provide estimates of transpiration from forest and clearing.

4. TRAINING

4.1. Visit of Gilberto Fisch

Senõr Gilberto Fisch visited the Institute of Hydrology at Wallingford from 29 December 1991 to 26 March 1992, working with I. R. Wright and H. G. Bastable on aspects of climate and micrometeorology. The working objective was to help advance ABRACOS data analysis, both with respect to the immediate requirements of the project and at a more academic level in line with Snr Fisch's own particular interests in near-surface turbulence. These objectives were fully met in a particularly productive three months.

a. Using data from the six main weather stations, a large quantity of radiation measurements were analysed to observe any coincident differences in incoming solar energy caused by cloudiness, smoke or suspended particles. It was concluded that differences were evident but too small for a confident statement. As a result a program of additional measurements and intercalibrations has been implemented.

b. Snr Fisch extracted a unique sequence of data describing the changes in albedo resulting from pasture burning at Maraba. This interesting result was documented during the three month visit and has been submitted as a 'short communication' to The International Journal of Climatology (see Section 3).

c. Ten minute wind and temperature profiles from Missions 1 and 2 were studied in detail as part of Snr Fisch's own interest in near surface atmospheric stability.

4.2. Visit of Luciene Pimentel

Luciene Pimentel da Silva worked at IH for 3 months between 28 February and 27 May 1991. Snra Pimentel works in the Civil Engineering Department at the Federal University of Rio de Janiero and has joined the project for field missions in 1990 and 1991, working mainly on the soil water studies.

Snra Pimentel's studies at IH concentrated on the soil water data, mainly that from the Manaus site, which has the longest data record. The work was divided into 3 main areas:

a. Data collation, checking and quality control. The data from all 3 sites (Manaus, Maraba and Ji-Parana, - 56 access tubes) was checked up to January 1991. This initial phase of quality control included familiarisation with the techniques and the development of software to append data (sent from Brazil by mail) to master data files of quality controlled data.

b. The data from the Manaus site, which was established in September 1990, were then analysed in detail up to mid February 1992. Comparisons of the behaviour of the soil water reservoir under forest and pasture were made, concentrating mainly on the plateau areas. Comparisons of the behaviour on slopes and on the valley floor remain to be carried out. Areas of interest were profile storage changes, distribution of water content with depth, spatial variability, derivation of water release curves and water balance studies. Snra Pimentel made a particular study on the water balance and was, as a result, also able to work on evaporation and interception data.

c. Preparation of papers. A paper has been accepted for presentation at the Brazilian Meteorological Congress in September 1992. A further paper is under preparation for submission to a scientific journal, probably "Hydrological Processes".

During her visit, Ms Pimentel was able to visit three Universities with a view to studying for a PhD on physically based hydrological modelling. She has gained a place at the University of Newcastle upon Tyne and funding for her studies from CNPq in Brazil.

4.3. English Language Training

English language training (ELT) is provided to prepare Brazilian scientists coming to work in the UK under the ABRACOS training scheme, and also as an aid to better communication and efficient running of the project. To date no ELT courses have been undertaken, partly because both Sr. Fisch and Snra Pimentel have good English language skills, but also through lack of other volunteers. However several candidates have now come forward and this part of the training programme should soon be underway.

ODA have confirmed that IH will have responsibility for administering the arrangements and finances for these courses and will include these additional costs in their quarterly invoices.

5. PLANS FOR FUTURE FIELD WORK

5.1. Interception

A proportion of the rain falling on a plant canopy is intercepted and re-evaporated back into the atmosphere, never reaching the soil. This intercepted rainfall is a significant water loss for forests, where the rough surface results in high evaporation rates. To allow long-term (annual) estimates of the water use of both forest and ranchland, forest rainfall interception must be measured. The initial programme did not contain any plans to do this work, but an increased contribution by Brazilian scientists will now make this possible.

Previous measurements of interception loss from Reserva Ducke, Manaus, mean that further work is not required there. However, the two other forest sites will be instrumented with a network of simple bottle gauges which will be moved at regular intervals to new random positions on the forest floor: water flowing down the stems of the trees will also be monitored. Vinicius Nobrega Ubarana of INPE will be responsible for this initiative. He will be visiting the Institute of Hydrology during July to discuss the design of the experiment and construct the gauges. IH staff will play only an advisory rôle in this Brazilian initiative.

5.2. Climatology

At the time of the next intensive field mission it is planned to install additional rainguages at the forest and clearing Automatic Weather Station sites. These will be read on a weekly basis and used as verification and backup to the recording guages currently in operation.

Additional reflected radiation instruments have been installed at two of the forest sites to improve the spatial representation of the measurement of albedo; the diffuse radiation instruments have been converted to provide an additional measurement of incoming solar radiation at all sites. There are plans for intercalibration and verification between radiation instruments at adjacent sites, during the next field mission.

5.3. Soil water studies

Data collection is proceeding extremely well at all 3 sites, with a 21 month record of weekly/twice weekly data from Manaus and 10 month and 8 month records of weekly data from Maraba and Ji-Parana respectively.

The data from Manaus up to mid-February 1992 has been studied and analysed in some detail, but the data from the other sites has not yet been examined. Priority will be given to the checking and analysis of data from these sites.

Plans for the next 6 months are:

UK:	Complete papers on the Manaus data. Quality control incoming data. Begin analysis of Maraba and Ji-Parana data.
Manaus:	Continue regular monitoring. Collect calibration samples for depths >2 metres. Determine hydraulic conductivity of surface layers in forest and pasture. Install water level logging sensors in valley.
Maraba:	Continue regular monitoring.
Ji-Parana:	Continue regular monitoring. Determine soil bulk density profile at forest and pasture sites.

Equipment and data collection procedures will be checked at all sites in the course of Mission 3.

5.4. **Maraba**

In parallel with the main Mission 3 activities at Ji-Parana in August and September, studies will be made at Maraba in September of stomatal conductance and leaf water status in a profile through the forest and also in the cleared area. In addition it is planned to establish a profile of instrumentation on the forest tower at Maraba to provide detailed within-canopy information on temperature, humidity deficit, windspeed and net radiation. This information will be used for a calculation of forest transpiration.

5.5. **Ji-Parana**

The third mission of intensive micrometeorological and plant physiological measurements will be operated over the forest and pasture sites near Ji-Parana. All necessary equipment has been transported from Manaus to Ji-Parana ready for the start of the mission in early August 1992. The plant physiological work will again involve the measurement of plant transpiration, photosynthesis and leaf area index in the virgin rainforest and nearby cleared pastures. This time leaf area index in the pasture will be measured over the duration of the Mission to look at changes with time. This will be carried out destructively, while leaf area index in the forest will be measured by indirect optical methods. For the micrometeorology, the experimental design will be similar to the successful configuration used at Fazenda Dimona in M1 and M2, including the increased frequency of soil moisture and plant physiological measurements, but will be enhanced in the following ways:

a. Evaporation and heat flux measurements will be made at both the forest and pasture sites.

b. A new simple flux measurement logger will be calibrated at each site and, if successful, left running for continuous flux measurements after the mission has finished.

c. Soil surface moisture content will be measured using a new type of capacitance probe recently developed at the Institute of Hydrology.

During Mission 3 two other research organisations, one Brazilian and one British, will take advantage of the intensive period of detailed measurements.

a. Plans for additional boundary-layer measurements during Mission 3 have been abandoned because an application for funds for this work was rejected. However, Dr Carlos Nobre of INPE (São Jose dos Campos) will be operating a tethered balloon to measure profile characteristics at higher levels in the atmospheric boundary layer. The forest and pasture measurements will provide the surface flux information necessary for this work, which focuses on the blending of different surface fluxes at higher levels.

b. Dr John Grace of Edinburgh University will work at the forest and pasture sites to measure fluxes of carbon dioxide. The CO_2 measurement technique is similar to that of the 'Hydra' vapour flux instrument and it is expected that the co-location of these instruments will be of significant mutual benefit.

5.6 **Manaus**

The routine climatological and soil moisture measurements currently being made at Manaus will continue.

6. MODELLING STUDIES

6.1. UK

In the last six months climate modelling work has concentrated on preparing the biosphere sub-model for validation before full implementation in the UK Met. Office Unified Model of global circulation and climate. Initially it was necessary to agree on details of formulation and divide the relevant field measurements into either 'forcing' or diagnostic variables. It was then possible to make the necessary coding changes and prepare the measurement data base for compatibility with the UK Met. Office code. By supplying sample data to the Met. Office, this has now been achieved. Also a model has been calibrated, describing the response of plant transpiration to climatic variables.

High quality data periods from Mission 1 and 2 are currently being prepared for the first validation trials.

6.2. US-based studies on the Brazilian Model

There has been little progress in using the ABRACOS data in the Brazilian GCM which is currently under development at the Center for Ocean, Land and Atmospheres (COLA) in Greenbelt Maryland. Progress has been stalled until recently by the proposed relocation of the COLA modelling centre. It has now been decided that COLA will delay relocation until at least June 1993 and the original plans to calibrate the land surface scheme in the Brazilian model and then run a deforestation experiment can now proceed. Dr Bastable and Humberto Rocha will join the CPTEC team in the USA in the course of the next few months, and modelling work will then proceed co-ordinated by local COLA personnel supported by regular supervisor visits by Dr Shuttleworth.

Meanwhile plans remain to use the ABRACOS data in the National Center for Atmospheric Research's Community Climate Model, with a Brazilian student located at the University of Arizona. They will be developed further in the course of a visit to the University of Arizona by Dr Shuttleworth and Dr Nobre in early July 1992. This student will be jointly supervised by Dr Shuttleworth and Dr Nobre, and by Dr Robert Dickinson who is on the faculty of the University of Arizona.

6.3. France

Antonio Manzi of INPE, who participated in ABRACOS Mission 2, is currently using the French GCM to conduct preliminary deforestation studies. He is working with the Centre National de Recherche Meteorologique in Toulouse. Dr Manzi visited IH in February 1992 and carried out a preliminary calibration of the land surface scheme using Mission 1 data.

Following the completion of his current studies he will carry out a complete calibration using all the Mission 1 and 2 data. It is expected that a deforestation experiment will then be performed before the end of this year.

6.4. Model Intercomparison

To facilitate comparison of the results of these modelling experiments, all the GCMs' runs will be initialised with the same atmospheric and soil conditions.

7. DISSEMINATION OF INFORMATION

7.1. Primary activity in this area over the last six months has focused on providing information and support to displays and visits linked to UNCED.

7.2. The project provided a component of the display mounted by INPE at ECO-92. This comprised a series of digital images illustrating the project, which were sequentially displayed on a colour monitor linked to a work station (donated by Hewlett Packard); two illuminated backdrops, comprising collages describing the project, and a new colour brochure on the project with text in English and Portuguese, which were widely distributed throughout the conference. The new brochure is included as an annex to this report.

7.3. The Secretary of State for the Environment, the Right Hon. Michael Howard, MP, visited the project tower in Reserva Ducke. This visit resulted in considerable interest in the project in the British press and television.

8. FINANCIAL OVERVIEW

8.1. The overall projected budget (see 9.4) has been revised to incorporate the 1991/92 Full Economic Cost staff rates for IH specialists as agreed with ODA, and a projected 5% inflation on these new rates for future years. The projected budget remains well within the financial limit (of £2,905,760) approved by ODA on 3 April 1992.

8.2 The Rolling Project Budget given in 8.4 has several minor changes in the distribution of carry forward expenditure from that given in Interim Report 4 (January 1992). Specifically these occur in Budget Lines 1.1.1, 1.2.1, 1.2.2, 1.3.1, 1.3.2A, 1.3.3, 2.1, 2.2, 2.3, 2.4A, 2.4B, 2.4C, 2.5, 2.6. These small changes have no impact on the overall project budget, and represent fine tuning of the budget in response to perceived changes in scientific priorities.

8.3. In addition it is now recognised that there have also been small overspends of £3.7K and £0.3K on Budget Lines 1.1.2 and 1.4.1 respectively. The proposed total spend on Budget Line 1.2.1 has been reduced by £4K so that these have neutral impact on the overall capital budget.

8.4 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. <u>Hardware associated with Phase 2</u>							
1.1.1. Micrometeorological Equipment	0.5	43.2	10.4	26.0	21.0	-	101.1
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. <u>Hardware associated with Phase 3</u>							
1.2.1. Climatological Equipment and Receiving Stations	-	77.5	42.3	11.6	-	-	131.4
1.2.2. Soil Moisture Equipment	-	38.7	1.3	5.0	-	-	45.0
1.3. <u>Transport and Site Facilities</u>							
1.3.1. Forest Towers	-	62.7	5.7	1.6	-	-	70.0
1.3.2.A. Transport Facilities (Op. and Maint.)	-	6.4	8.2	11.0	10.4	-	36.0
1.3.2.B. Transport Facilities (Purchase)	-	88.0	-	-	-	-	88.0
1.3.3. Site Facilities	-	4.1	21.3	6.1	-	-	31.5
1.4. <u>UK-based Hardware and Facilities</u>							
1.4.1. Computers	-	24.0	0.3	-	-	-	24.3
TOTAL CAPITAL:	1.8	429.8	100.2	61.3	31.4	-	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	15.9	26.0	25.5	16.5	108.5
2.2. Freight Charges	-	27.8	25.1	10.0	9.9	-	72.8
2.3. Counterpart Travel Costs (Scientific)	-	21.1	25.0	34.0	18.4	-	98.5
2.4.A. Counterpart travel (Project Management)	0.2	4.6	5.4	5.4	5.4	23.5	44.5
B. Short-term training in UK	-	-	6.3	22.0	22.0	21.7	72.0
C. English Language Training	-	-	-	13.0	12.5	8.5	34.0
2.5. Institute of Hydrology Travel Costs	-	71.0	80.2	79.5	75.5	30.8	337.0
2.6. Institute of Hydrology Consultant	0.5	9.3	8.7	8.5	8.4	5.5	40.9
2.7. Institute of Hydrology Staff Costs	34.4	233.1	260.9	266.6	280.0	218.3	1293.3
TOTAL RECURRENT:	35.1	391.5	427.5	465.0	457.6	324.8	2101.5
TOTAL PER YEAR:	36.9	821.3	527.7	526.3	489.0	324.8	2726.0

Currently approved financial limit for project (including contingency) = 2906.0

Institute of Hydrology

PRESIDÊNCIA DA REPÚBLICA
SECRETARIA DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

The ABRACOS Project
(Anglo-Brazilian Amazonian Climate Observation Study)

Under a Memorandum of Understanding between the governments of Brazil and Britain, the UK's Overseas Development Administration is sponsoring the ABRACOS project - the Anglo-Brazilian Amazonian Climate Observation Study. Measurements are being made of the energy and water balance and near-surface climate for both tropical rainforest and cleared forest areas, data which will be fed into climate models to aid understanding on how Amazonian deforestation might change the climate.

A ODA (Overseas Development Administration), organização britânica, está patrocinando o projeto ABRACOS (Anglo-Brazilian Amazonian Climate Observation Study) com base num Memorando de Entendimento estabelecido pelos Governos do Brasil e do Reino Unido. Algumas medidas tem sido feitas no sendido de avaliar o equilíbrio de energia, balanço hídrico, bem como o clima próximo à superfície em áreas desmatadas e de floresta. Estes dados servirão para alimentar modelos de circulação global da atmosfera. A utilização destes modeles ajudará na compreensão de como os desmatamentos da Amazônia poderão causar mudanças no clima.

Tropical rainforest viewed from the ABRACOS tower near Maraba

Floresta tropical vista da torre do projeto ABRACOS próximo à Marabá

Climate modelling

Changes in vegetation alter the energy balance and there is no greater change than from lush rainforest to pasture. Because the sun's rays penetrate more deeply into tall forest less are reflected. Removing the forest can thus drastically change the reflectivity of the earth's surface.

Deforestation will also change how much of the sun's energy is used for evaporation. This will depend on the plants' response to the climate and the water available in the soil. For example, trees catch and then re-evaporate rain rapidly. Conversely, in dry periods they normally transpire less water from the soil through their leaves, so that in long dry spells they continue to evaporate water long after smaller plants have died.

Until recently, climate models paid little attention to this complex but important hydrological control exerted by vegetation, but now improved models, coupled with accurate field calibration data, allow the possibility of realistic prediction of climate change.

Modelagem do clima

Mudanças na vegetação alteram o equilíbrio de energia. A troca de uma floresta exuberante por uma pastagem representa uma mudança bastante drástica. Os raios solares penetram mais profundamente em florestas de grande altura, ou seja, um percentual menor desta energia é refletido. Desta forma a remoção da floresta pode alterar drasticamente a refletividade da superfície terrestre.

O desmatamento poderá também mudar a quantidade de energia solar usada para a evaporação. Isto dependerá da resposta das plantas ao clima e à água disponível no solo. Por exemplo, as árvores coletam e reevaporam a chuva rapidamente. Em períodos de seca as árvores transpiram menos água do solo através de suas folhas. Assim, em períodos de seca longos, por terem raízes mais profundas, elas poderão continuar evaporando enquanto plantas menores já teriam secado e morrido.

Até bem pouco tempo, os modelos climatológicos não prestavam a devida atenção a este complexo e importante controle hidrológico exercido pela vegetação. Atualmente, modelos aperfeiçoados acoplados a dados precisos coletados no campo para sua calibração permitem previsões mais realísticas e confiáveis sobre as mudanças no clima.

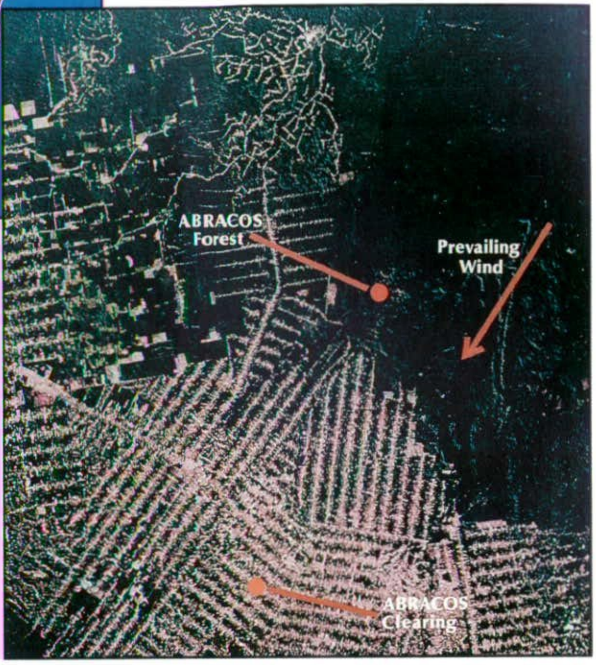
Experimental systems

The ABRACOS project has three study sites across the Amazon Basin. At each location long-term comparative measurements are being made of the near-surface climate above cleared areas and adjacent virgin forest, and of the water in the soil beneath. In Central Amazonia forest removal is still restricted to a few small clearings, so ABRACOS studies near Manaus look for differences associated with small-scale clearance. At the Maraba site in Para in eastern Amazonia, forest clearance is extensive and long established, while at the Ji-Parana site in Rondonia, clearance is more recent but more rapid. Measurements at these two sites are made to study the impact of large clearings in areas with seasonal rains of very different severity.

In addition to this long-term monitoring, detailed studies of the different energy, water and momentum exchanges for pastureland and forest are made during intensive study missions of 2-3 months at one of the three sites. Complex instruments are then used to measure the sun's energy reaching the ground and how much of this is used to evaporate water or alternatively warm the air, and to determine the efficiency of the aerodynamic exchanges for the different vegetations. During these periods the plant and soil processes which control these water and energy interactions are also investigated. Data from such missions are used to calibrate Global Climate Models (GCMs).

ABRACOS study areas sample the climate and clearance across Amazonia

Áreas de estudo do projeto ABRACOS amostram o clima e os padrões típicos de desmatamento na Amazônia



Satellite photograph showing ABRACOS sites in forested and cleared (pink) areas in Rondonia

Imagens de satélites mostram as áreas de estudo do projeto ABRACOS em floresta e pastagem (em rosa) em Rondônia

Micrometeorological instruments measure the energy exchanges of pastureland

Instrumentos de micrometeorologia monitoram as trocas de energia na pastagem

Experimentos

O projeto ABRACOS possui três áreas de estudo na Bacia Amazônica. Em cada área estão sendo feitas observações de longo prazo do clima próximo à superfície e da disponibilidade de água no solo, comparativamente, em regiões de clareira (pastagem) e floresta. Na Amazônia Central o desmatamento ainda é restrito à pequenas clareiras, portanto os estudos do projeto ABRACOS próximos à Manaus pesquisam diferenças associadas ao desmatamento em pequena escala. Em Marabá, no estado do Pará, região leste da Amazônia, as áreas desmatadas são maiores e foram estabelecidas há mais tempo. Já em Ji-Paraná, Rondônia, o desmatamento é mais recente e tem ocorrido de forma mais acelerada. Nestas duas áreas, as observações estão sendo feitas com o objetivo de estudar o impacto do desmatamento de maior escala em áreas sujeitas a chuvas sazonais de diferentes intensidades.

Além deste monitoramento, estão sendo feitos estudos detalhados das trocas de energia, quantidade de movimento e umidade em campanhas intensivas que duram 2-3 meses nas três diferentes localidades, nas áreas de pastagem e floresta. Nestas campanhas são usados instrumentos de alta complexidade para medir a energia solar incidente, os percentuais de energia que são usados para evaporação ou para aquecer o ar e para determinar a eficiência das trocas aerodinâmicas para as diferentes vegetações. Durante estes períodos são estudados os processos de fisiologia vegetal e física de solos que controlam estas interações de água e energia. Os dados coletados nessas campanhas são usados para calibrar os modelos climáticos globais (MCGs).

Surface energy differences

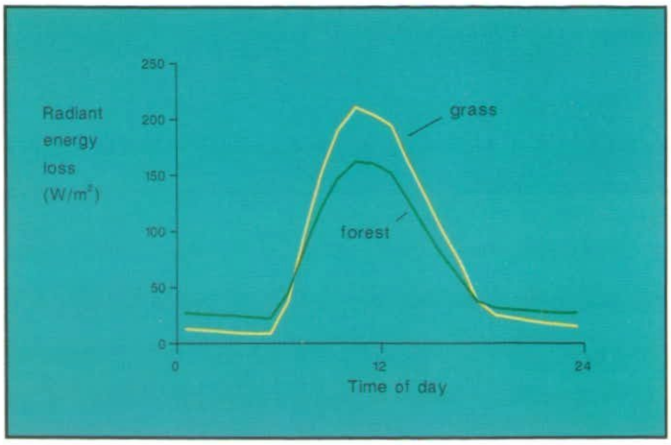
ABRACOS instruments show that less of the sun's energy is reflected by forest. The light rays are trapped by multiple reflections within the deep forest canopy. Grass is more reflective: about twice as much solar (or visible) radiation is reflected back into the atmosphere.

Forest also gives off less thermal (or infra-red) radiation. The rough forest surface creates a strongly turbulent airstream which mixes up the air close to the surface and thus keeps the canopy cool. The surface of grass, on the other hand, can become relatively hot: 10°C above air temperature is not uncommon. Hotter surfaces give off more infra-red radiation so the grass surface not only reflects more visible radiation, it also emits more infra-red radiation.

The grassland has less energy available to use either for evaporating water through plants, or for converting into convective heat. This reduction in energy at the surface means less energy to drive atmospheric weather systems and the possibility of permanent changes in weather patterns. Accurate measurements of this reduction in radiation over deforested land allow climate models to make predictions of just how this will affect climate.

Evaporation differences

Results of the measurements in central Amazonia show that when there is no shortage of moisture in the soil, evaporation from the grassland and forest is similar, but that in dry periods they behave very differently. After about 10 days without rain, evaporation from grass starts to fall as the small amount of water accessible to the shallow roots is quickly used up. In contrast, the deeper rooted forest continues to evaporate water at much the same rate as before. This different response is confirmed by the soil moisture measurements which show greater extraction by roots below one metre under the forest.



The net radiant energy lost from the ground is greater for pastureland than for forest

A radiação líquida refletida é maior para a pastagem do que para a floresta

Diferenças no equilibrio de energia

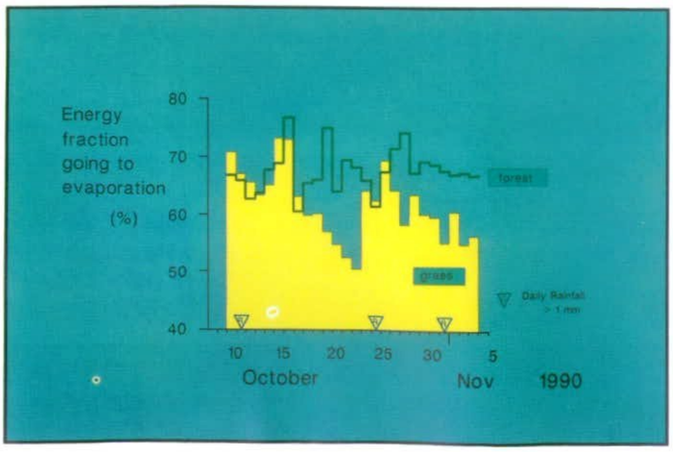
Os instrumentos instalados pelo projeto ABRACOS mostram que na floresta a energia solar refletida é menor. Os raios solares são absorvidos por múltiplas reflexões dentro do profundo dossel da floresta. A vegetação do pasto é mais reflectiva: aproximadamente o dobro de radiação solar (ou visível) é refletida e volta à atmosfera.

Na floresta, menos radiação térmica (ou infra-vermelho) deixa a superfície. A rugosidade da superfície da floresta cria um fluxo de ar turbulento, o qual misturando-se às camadas de ar próximas à superfície, promove um resfriamento do dossel. No pasto, por outro lado, a superfície se mantém relativamente aquecida, não sendo incomuns valores da ordem de 10°C acima da temperatura do ar. Assim, a superfície da pastagem não só reflete mais radiação na faixa visível como também emite mais radiação infra-vermelha.

Na pastagem a evaporação de água através das plantas e a conversão de energia em fluxo de calor convectivo (sensivel) é menor. Por sua vez, isto significa menos energia para movimentar os sistemas atmosféricos e a possibilidade de causar mudanças permanentes no padrão do tempo. Medidas precisas destas alterações de radiação na superfície desmatada torna possível que os modelos climáticos sejam utilizados para prever como o clima poderá ser afetado.

Diferenças na evaporação

Os resultados das medições efetuadas na Amazônia Central mostram que, nos períodos quando não há escassez de água no solo, a evaporação na pastagem e na floresta são similares, mas em períodos de seca o comportamento das duas áreas é bem distinto. Após um período de aproximadamente 10 dias sem chuva, a evaporação na pastagem começa a diminuir. A pequena quantidade de água disponível, acessível às plantas com raízes pouco profundas, é rapidamente consumida. Por outro lado, as raízes na floresta são mais profundas e continuam evaporando à mesma taxa que antes. Esta diferença de comportamento é comprovada pelas medidas de umidade do solo na floresta, que mostram maior extração de água pelas raízes nas profundidades abaixo de 1 metro.



In dry spells the fraction of energy used for evaporating water from pastureland falls much more quickly than for forests

Em períodos secos, a fração de energia utilizada para evaporar água na pastagem cai muito mais rapidamente do que para florestas

The Carbon Store

One of the indirect ways in which deforestation acts to change climate is by contributing to greenhouse warming. The carbon stored in the biomass of the forest is released as carbon dioxide during deforestation, either rapidly by burning or more slowly by the removal and subsequent decay of the timber.

There is great uncertainty about the amounts of carbon being released in this way, with little quantitative data from which to produce statistics. One ambitious task of the ABRACOS field campaigns has been to measure in detail the amount of wood and leaves in a representative 20m x 20m plot of forest.

Plant differences

The leaf area index and the total weight of the biomass have been measured by destructive sampling. These measurements will be invaluable both in modelling the ecological behaviour of the forest and in assessing the carbon released when it is felled.

Armazenamento de carbono

Uma das formas indiretas dos desmatamentos atuarem nas mudanças climáticas é através do aumento do efeito estufa. O carbono armazenado na biomassa da floresta é liberado na forma de dióxido de carbono durante o desmatamento, quer seja pelas queimadas ou, mais lentamente, pela remoção das árvores e posterior decomposição da madeira.

Ainda existem dúvidas sobre as quantidades de carbono que estão sendo liberadas desta forma, uma vez que os dados disponíveis são insuficientes para produzir estatísticas confiáveis. Um dos objetivos das campanhas de campo do projeto ABRACOS é medir detalhadamente a quantidade de madeira e folhas numa área representativa de floresta de 20m x 20m.

Diferenças da cobertura vegetal

O índice de área foliar e o peso total da biomassa têm sido quantificados por ensaios destrutivos. Estas medidas terão valor inestimável na modelagem do comportamento ecológico da floresta, bem como na avaliação da quantidade de carbono liberado após o desmatamento.

271 tonnes

6 tonnes

Deforestation reduces the amount of material stored in the biomass to about 2% of its forest value

O desmatamento reduz a quantidade de material armazenado na biomassa para aproximadamente 2% dos valores encontrados na floresta

Brazilian participating institutions – Instituições brasileiras participantes

Centro do Energia Nuclear na Agricultura, Universidadade de São Paulo
Centro de Pesquisas do Setor Elétrico/Eletrobrás
Centro de Pesquisa Agroflorestal da Amazônia, Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA)
Centro de Pesquisas Agropecuárias do Trópico Umido/EMBRAPA
Companhia Vale do Rio Doce
Instituto de Atividades Espaciais / Centro Técnico Aeroespacial
Instituto Brasileiro do Meio-Ambiente e Recursos Renováveis
Instituto Nacional de Colonização e Reforma Agrária
Instituto Nacional de Pesquisas da Amazônia
Instituto Nacional de Pesquisas Espaciais
Unidade de Extensão e Pesquisa Agropecuária de Porto Velho / EMBRAPA
Universidade Federal de Mato Grosso
Universidade Federal do Pará
Universidade Federal do Rio de Janeiro
Universidade Federal de Rondônia

Further information is obtainable from

Dr W James Shuttleworth
Institute of Hydrology
Crowmarsh Gifford
Wallingford
Oxfordshire OX10 8BB
United Kingdom

Telephone: (+44) 491 38800
Fax: (+44) 491 32256
Telex: 849365 HYDROL G

Contatos para informações adicionais

Dr Carlos A Nobre
Instituto Nacional de Pesquisas Espaciais
Avenida dos Astronautas, 1758
CP 515
12 201–970 São José dos Campos
SP, Brazil

Telephone: (+55) 123 41 8977
Fax: (+55) 123 21 8743 / 123 41 1876
Telex: 1233530 INPE BR
Internet: CPTEC@FPSP.FAPESP.ANSP.BR
Omnet: INPE.MET

ODA
XWAY sistemas
EDISA HEWLETT PACKARD

Natural
Environment
Research
Council