CALIBRATING THE SIMPLIFIED SIMPLE BIOSPHERE MODEL (SSiB) FOR AMAZONIAN PASTURE

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INTRODUCTION

The land-surface is an important source and sink of radiation, sensible heat, water, momentum, and trace gases to the atmosphere. A parameterized representation of these exchanges is an important component in all climate and weather models. Land-surface parameterizations have undergone a tremendous development in the past decade, and now include a much greater degree of biophysical realism and self-consistency than was being used just a few years ago (Sellers *et al.* (1986); Xue *et al.* (1991); Flerchinger *et al.* (1998); Delire and Foley (1999); Nagai (2002) and Nagai (2003). These soil-vegetation-atmosphere transfer schemes (SVATS) are physically and biologically more realistic than the preexisting land surface parametrizations used in the general circulation models (GCM). Using these models, some experiments have been carried out to investigate the Amazon deforestation (Nobre *et al.* (1991); Zhang *et al.* (1996); Costa e Foley (2000)), and African desertification (Xue *et al.* (1990)). One problem faced in these models is the high number of parameters that are required to simulate different sites or large areas. Therefore, efficient calibration procedures are needed. This study describes an attempt to calibrate the Simplified Simple Biosphere Model (SSiB) (Xue *et al.* (1991)) with micrometeorological and hidrological measurements taken in one tropical pasture site in the Amazon basin, during the Large Scale Biosphere-Atmosphere Experiment in Amazonia - LBA (http://lba.cptec.inpe.br/lba/). The SSiB was designed to simulate the interations between the Earth's land surface and the atmosphere by treating the vegetation explicity and realistically, thereby incorporating the biosphysical controls on the exchanges of radiation, momentum, and sensible and latent heats between the two systems.

SITE DESCRIPTION AND CALIBRATION PROCEDURE

The experimental site was a pasture located at the Fazenda Nossa Senhora (10°45'S, 62°22'W) about 50km east-northeast of Ji-Paraná, Rondonia (Brazil). The site is a cattle ranch created by clearing a primary "terra firme" forest about 23 years ago. The dominant grass species is *Brachiaria brizantha*, a perennial kind of grass. Routine meteorological measurements were made on an automatic weather station mounted at the height of 6m on an aluminium tower, and consisted of: incoming shortwave radiation, horizontal wind speed, air temperature and humidity, incoming longawave radiation, atmospheric pressure and precipitation. Soil moisture was measured at 0.2m depth intervals up to 2.60m using a neutron probe. The latent and sensible heat fluxes were measured on a nearby 6m mast, using the eddy correlation technique. The calibration of the SSiB model was effected using an off-line mode to obtain the best parameters representative of the experimental data collected at the above mentioned site pasture. In this mode, the SSiB model is decoupled from the atmospheric model and forced by the meteorological surface variables. The following days were chosen for calibration: 1, 4 ,6-11, 18, 20 and 31 August; and 6, 17-19 September 2001. The calibration procedure minimizes the diference between simulated surface fluxes and values measured by optimizing only those parameters which have the most uncertainty, or have no associated field measurements. For the optimization procedure, an initial set of parameters representing degraded pasture was taken from Rocha *et al.*, (1996). The iterative optimizatiom method is summarized in the following steps: (a) parameters measured *in situ* replaced the initial input data set, and the model is run using the near-surface meteorological data as forcing variables to calculate the surface fluxes with 30 minutes intervals; (b) an assessment of quality of the simulation is given by the difference between the calculated and the observed evaporative fraction, weighted by the absolute value of the observed latent-heat flux (Equation 1); (c) the deviations for each time step are used to calculate the mean deviation error (Equation 2) and input to a least-squares minimizating algorithm, ZXSSQ (IMLS 1984), to determine numerically the partial derivatives of each deviation with respect to the optimized parameters. The procedure is repeated until the best set of parameters is found, that is until each deviation cannot be reduced further. Sellers *et al.* (1989) have thoroughly described the iterative optimization method.

$$F_i = \left\{ \left(\frac{\lambda E_i}{\lambda E_i + H_i} \right)_C - \left(\frac{\lambda E_i}{\lambda E_i + H_i} \right)_O \right\} |\lambda E_i|_O \quad (1)$$

$$\bar{F} = \left(\frac{1}{N} \sum_{i=1}^{N} F_i^2 \right)^{1/2} \quad (2)$$

where F_i is the deviation computed for time step i, and λE_i e H_i are the latent and sensible heat fluxes for time step i (Wm^{-2}), respectively. The subscripts "C" and "O" refer to computed and observed values, respectively. $\bar{F}$ is the mean deviation error and N the number of computed and observed flux pairs.

CALIBRATION RESULTS

For the SSiB model, the surface resistance is a dominant factor to determine the energy partition over vegetation, and consequently, the surface latent and sensible fluxes. This resistance is related to morphological, physiological and physical parameters used to calculate the surface fluxes. The parameters used in this calibration procedure are the canopy leaf area index (L_t), the green leaf fraction (N_c), the fractional area covered by canopy (V_c), the light dependent stomatal response parameters (a, b, c), the roughness lenght (Z_0), the zero-plane displacement (D), the porosity (θ_s), the saturated hydraulic conductivity (K_s), the stomatal response factor to water vapour deficit (h_5) and the leaf-water-potential parameters (ψ_1, ψ_2). Table 1 summarizes the values of the initial and optimized parameters. The root-mean-square deviation (rms) between the observed and calculed turbulent fluxes is also shown to illustrate the quality of the simulation.

The root-mean-square (rms) fall about 65%, decreasing from 4245.1 to 1521.3. The great reduction of the rms deviation is due to the high non-linearity of the system, despite of the fact that, in general, the parameters showed few variations during the optimization, and some of them were not changed, as the roughness lenght and porosity. The light dependent stomatal response parameter (a) showed more variations than the others. The observed and calculated fluxes, using the initial and optimized set of parameters for Fazenda Nossa Senhora are shown in Figure 1. These results show that the initial set overestimated the latent-heat flux and underestimated the sensivel-heat flux, while the optimized set considerably improved the estimation and fitted the observed latent fluxes with satisfatory agreement. The few changes in the parameters during the calibration procedure can be related to two factors: first, the initial set was already adjusted to this site; second, the observed sensible and latent fluxes used here were measured using a sonic anemometer eddy-correlation device. Although this instrumentation has been used successfully in several experiments

Table 1: RESULTS OF SIMULATIONS USING INITIAL AND OPTIMIZED SETS OF PARAMETERS. COLUMN I REFERS TO THE INITIAL SET (ROCHA *et al.* 1996); COLUMNS II SHOW THE OPTIMIZED SET OF PARAMETER AT FAZENDA NOSSA SENHORA

Parameters	I	II
Canopy leaf area index (L_t) (m^2m^{-2})	1.610	1.530
Green leaf fraction (N_c)	0.930	0.901
Fractional area covered by canopy (V_c)	0.790	0.742
Light dependent stomatal response parameters		
(a) (Jm^{-3})	11554.00	11591.4
(b) (Wm^{-2})	2.100	2.899
(c) (sm^{-1})	110.00	107.90
Roughness lenght (Z_0) (m)	0.022	0.020
Zero-plane displacement (D) (m)	0.170	0.200
Porosity (θ_s) (m^3m^{-3})	0.460	0.490
Saturated hydraulic conductivity (K_s) (ms^{-1})	$1.0.10^{-5}$	$1.5.10^{-5}$
Stomatal response factor to water vapour deficit (h_5) (hPa^{-1})	0.0184	0.0165
Leaf-water-potential parameters		
(ψ_1) (m)	−26.000	−21.980
(ψ_2) (m)	−224.00	−219.900
root-mean-square deviation (F)	4245.1	1521.3

in Amazonian and provided experimental data for other calibrations Wright *et al.* (1995), the use of the sonic anemometer does not guarantee closure of the energy balance and may account for some of the discrepancy for the calibrated procedure, since that SSiB model flux calculations must close the energy balance.

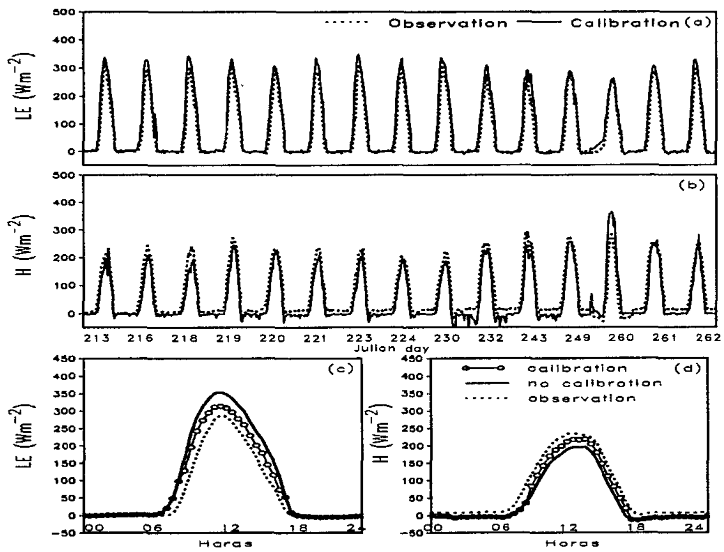

Figure 1: Surface turbulent energy fluxes over Fazenda Nossa Senhora site as measured by eddy correlation technique and calculated by SSiB model using the calibrated set of parameters: (a) latent-heat flux (LE), (b) sensible-heat flux (H) and (c) diurne cycle latente and sensible heat.

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