SMEX03 Soil Moisture, Meteorological, and Vegetation Data: Brazil

Field Campaign Report
Barreiras, Bahia
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"Some are weatherwise; some are otherwise"

Benjamin Franklin

SUMMARY

ABSTRACT

This document reports the most important methodological aspects and data gathering procedures related to the field campaign conducted in December, 2003 over the Barreiras region. This area is located in the western part of the Bahia State, Brazil, and presents a mixture of Cerrado and Caatinga vegetation covers and a dominant underneath sandy soils. Extensive annual crops (soybean, maize and cotton) and cultivated pastures are the major land use classes found in the study area. The goal of this research is to validate existing algorithms to retrieve soil moisture from Aqua/AMSR (Advanced Microwave Sensing Radiometer) data from tropical savanna. Twelve sampling sites were selected based on a Landsat TM scene and on two preliminary field surveys conducted in early 2003. Soil temperatures, soil samples for moisture content and leaf samples for plant water content were obtained during the time period of December 2-8. Meteorological stations were installed in three sampling sites during the entire campaign. FieldSpec radiometric data from some bare soil sites and mostly all day soil surface temperatures were also obtained in order to evaluate the visible & near infrared CBERS (China-Brazil Earth Resources Satellite) and thermal NOAA/AVHRR satellite data. Aqua/AMSR data acquisition and processing are now ongoing.

1. What´s SMEX03 Brazil?

The SMEX03 Brazil is a Brazil-U.S. joint research project titled "Soil Moisture Experiment of 2003 in Brazil". It has been developed under the technical cooperation between the Brazilian Space Agency (AEB – Agência Espacial Brasileira) and NASA, signed on August 5th, 2003. The overall objective of the project is to calibrate the passive radar system named AMSR (Advanced Microwave Sensing Radiometer), onboard the Aqua satellite, for estimating the surface soil moisture (0-5 cm soil depth) over the Brazilian Cerrado ecosystem. The Brazilian Cerrado covers more than 208 million hectares in central part of this country and corresponds to a mixture of grasslands, shrublands and woodlands. The proportion of each stratum defines the different Cerrado physiognomies: Cerrado grassland, shrub Cerrado, Cerrado *strictu sensu*, Dense Cerrado, etc.

Soil moisture, soil temperature and leaf water content data have been planned to be acquired in the field in Barreiras, Bahia State, in the time period of Nov. 30th and Dec. 9th, 2003. We selected Barreiras because of: low to intermediate vegetation cover (near border of semi-arid vegetation called Caatinga); gentle topography; presence of large fields of annual crops and cultivated pastures; proximity with Brasília (~ 600 km from Brasília); and availability of an airport.

The following institutions are involved in this project: Embrapa Cerrados, Embrapa Informática Agropecuária, Embrapa Instrumentação Agropecuária, University of Campinas (UNICAMP), National Space Research Institute (INPE), Federal University of Rio de Janeiro (UFRJ/COPPE), Brazilian Geological Survey (CPRM), NASA and USDA/ARS.

The SMEX03 Brazil is a follow-up of the american part of the project, where field works have already been conducted in Oklahoma, Georgia and Alabama in June and July, 2003. It is expected that the results of this research will contribute significantly for the:
a) Improvement of the robustness of the existing algorithms for retrieving soil moisture from AMSR by including new soil types and vegetation covers;
b) Increasing the understanding of the passive microwave response from tropical regions, more specifically, from low to moderate vegetation cover of the Brazilian Cerrado;
c) Improvement of the Brazilian crop yield forecast. This will be possible because the crop yield prediction depends strongly on the water balance models. One of the most important input parameters of such models is the spatially distributed soil moisture data;
d) Formation of a national team capable to process satellite passive radar data provided by the Aqua AMSR system;
e) Short and long-term training of Brazilian researchers and students in U.S. in the passive radar data processing.

More details about SMEX03 can be found in http://hydrolab.arsusda.gov. Our near future plan is to convert Barreiras region as the most important Cerrado´s field laboratory to calibrate different sensors. Within this goal, site characterization,

spectrorradiometric and surface temperature data were also collected in order to evaluate other sensors such as CBERS-2, MODIS and NOAA imageries.

2. Time period

This field campaign was developed from November 28, 2003 to December 09, 2003. Lúcio Feitoza, Balbino A. Evangelista, Flávio Magina and Antônio Carlos Barbosa from Embrapa Cerrados and Inpe CPTEC left Brasília on November 28 with three sets of automatic meteorological stations. The second group left Brasilia on November 30 (Embrapa & Unicamp, mostly). The last group left Brasilia on December 1st (U.S. team).

3. Sampling points

Figure 1 shows the 12 field sampling points selected for soil moisture, soil temperature, surface temperature and leaf water content data gathering. The image in this figure corresponds to the Landsat TM from December 12, 2001. The yellow dot lines correspond to the GPS track obtained from two preliminary field campaigns (March and June, 2003). The red line corresponds to the interstate highway BR-020. Because of the distance problem, the originally selected five sampling points near Luis Eduardo city, numbered from 1 to 5, were not considered after the field survey conducted on November 30th, 2003. Table 1 presents the coordinates of each site (datum = WGS84).
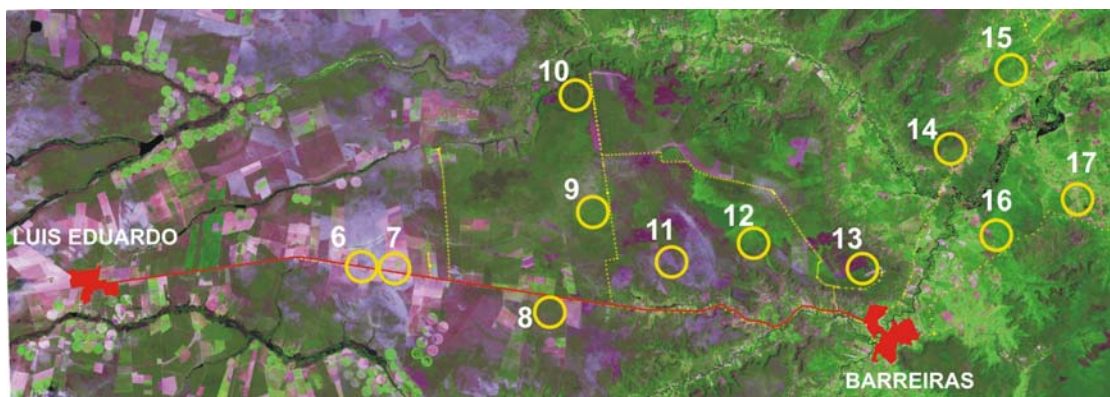

Figure 1. Field sampling points over the Barreiras region.

Table 1. Geographical coordinates of 12 sampling sites near Barreiras, BA.

Site	South Latitude	West Longitude
6	12 05 45.9	45 21 39.5
7	12 05 43.5	45 21 07.8
8	12 07 17.4	45 17 20.6
9	12 01 20.7	45 16 23.7
10	11 55 11.8	45 17 24.3
11	12 03 21.0	45 13 26.7
12	12 02 23.1	45 09 05.6
13	12 04 58.4	45 00 27.8
14	11 57 29.7	44 54 43.1
15	11 54 59.4	44 53 06.6
16	12 02 55.4	44 52 32.7
17	12 01 35.2	44 48 11.3

4. Biophysical parameters

We measured the following biophysical parameters in this field campaign:

a) Surface gravimetric soil moisture (0-5 cm depth);
b) Vitel hydro probe soil moisture (0-5 cm depth);
c) Bulk density;
d) Surface soil temperature (0-5 cm depth);
e) Air temperature;
f) Relative air humidity;
g) Plant water content;
h) Surface temperature
i) Spectrorradiometry; and
j) Automatic meteorological data.

Five daily-based, randomly distributed samples of soil moisture were collected per site (average distance between samples = 10 –20 meters). Flags were used in order to acquire samples in the same spots in following days. Soil samples were collected by using a ring (5 cm depth x 5 cm diameter) and stored in a ziploc plastic bags. The time period was from 1:00 – 2:00 PM. The wet weights were obtained in the same day with a 2-fold scale. The dry weights were obtained in Brasilia (Soil Physics Lab, Embrapa Cerrados), after oven-dried for 24 hours. In order to convert gravimmetric soil moisture to volumetric moisture, five undisturbed soil samples for bulk density per site were also gathered. Four theta-probe sensors from USDA/ARS also gathered moisture content data in the study area. Vitel hydra soil moisture probes were also used in this campaign.

Plant leaves for leaf water content estimation were also obtained for the following sites at the end of field campaign (Dec 6, 7 and 8th): BA-07, BA-08, BA-09, BA-10, BA-11 and BA-17. For each site, we selected three squares of 1 m x 1 m where all leaves inside these squares were collected manually and weighed before and after oven-dried at 60 ^{o}C for 24 hours. Only for BA-09, the field sampling area was increased for 2 m x 2 m because of its higher plant density. Because of time frame restriction, only two spots were sampled at this site.

For each site, soil temperatures were measured at 5-cm depth, every 15 minutes (from 9:00 AM to 2:00 PM). Thermohydrographers installed in each site also provided air temperature and relative air humidity every 15 minutes.

Vitel hydroprobes were installed in the following sites: BA-07, BA-09, BA-14 and BA-16. This probe provides four voltage measurements which is converted to soil moisture and soil temperature.

Three meteorological stations were installed in the study area. Field spectroradiometric data in bare soil sites were also obtained from FieldSpec radiometer from Inpe. Surface temperature in two sites were obtained from a infrared termometer.

5. Participants

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6. Future field tasks

- collect 2004 dry, wet and end of wet seasons field soil moisture and temperatures over the 12 sampling sites;
- install an automatic meteorological station in the BA-10 sampling site; and
- collect soil samples for determining water retention curves over each site.

7. Acknowledgments

8. Summary of some results

a) Rainfall data (automatic met stations):

Date	Sites		
	BA-06	**BA-13**	**BA-17**
Dec, 02	10	11,5	0
Dec, 03	4	2	0,75
Dec, 04	1,75	0	0
Dec, 05	11,5	9	0
Dec, 06	0	5,5	0
Dec, 07	0	0,25	0
Dec, 08	0	16,75	0

b) Leaf water content:

Sampling Sites	Leaf Water Content (g/m^2)
BA-07	186,02
BA-08	326,79
BA-09	705,65
BA-10	600,29
BA-11	438,59
BA-17	118,39

c) Bulk density:

Sampling Sites	Bulk Density (g/cm^3)
BA-06	1,51
BA-07	1,59
BA-08	1,47
BA-09	1,28
BA-10	1,46
BA-11	1,58
BA-12	1,45
BA-13	1,49
BA-14	1,17
BA-15	1,45
BA-16	1,42
BA-17	1,39

d) Gravimetric soil moisture:

(sites BA-06 and BA-07 are OK; the others have some restrictions due to possible lab processing errors).

Site	Day	Average Moisture (g/g)
BA-06	Dec, 02	9,29
	Dec, 03	7,46
	Dec, 04	6,81
	Dec, 05	12,05
	Dec, 06	9,06
	Dec, 07	8,17
	Dec, 08	5,18
BA-07	Dec, 02	10,31
	Dec, 03	9,41
	Dec, 04	7,66
	Dec, 05	14,02
	Dec, 06	9,71
	Dec, 07	9,40
	Dec, 08	7,30
BA-08	Dec, 02	8,78
	Dec, 03	10,21
	Dec, 04	7,54
	Dec, 05	12,36
	Dec, 06	7,65
	Dec, 07	7,14
	Dec, 08	7,55
BA-09	Dec, 02	17,34
	Dec, 03	14,47
	Dec, 04	14,79
	Dec, 05	14,98
	Dec, 06	11,28
	Dec, 07	9,53
	Dec, 08	9,48
BA-10	Dec, 02	12,65
	Dec, 03	14,24
	Dec, 04	10,46
	Dec, 05	12,00
	Dec, 06	9,28
	Dec, 07	6,47
	Dec, 08	3,53
BA-11	Dec, 02	11,38
	Dec, 03	7,84
	Dec, 04	10,52
	Dec, 05	13,18
	Dec, 06	10,08
	Dec, 07	7,66
	Dec, 08	4,59

BA-12	Dec, 02	10,58
	Dec, 03	8,29
	Dec, 04	7,51
	Dec, 05	8,79
	Dec, 06	6,23
	Dec, 07	5,32
	Dec, 08	4,53
BA-13	Dec, 02	10,92
	Dec, 03	11,60
	Dec, 04	8,85
	Dec, 05	13,60
	Dec, 06	8,33
	Dec, 07	6,88
	Dec, 08	5,33
BA-14	Dec, 02	1,90
	Dec, 03	2,17
	Dec, 04	2,12
	Dec, 05	1,34
	Dec, 06	-
	Dec, 07	-
	Dec, 08	-
BA-15	Dec, 02	2,92
	Dec, 03	9,08
	Dec, 04	5,20
	Dec, 05	3,47
	Dec, 06	-
	Dec, 07	-
	Dec, 08	-
BA-16	Dec, 02	1,41
	Dec, 03	14,74
	Dec, 04	11,61
	Dec, 05	7,81
	Dec, 06	5,62
	Dec, 07	3,18
	Dec, 08	2,42
BA-17	Dec, 02	3,29
	Dec, 03	3,92
	Dec, 04	3,55
	Dec, 05	2,00
	Dec, 06	1,01
	Dec, 07	0,91
	Dec, 08	0,75

e) Theta probe surface soil moisture

Site	Date	Time		Mean	Mean Soil
		Start	**End**	**VSM (%)**	**Temp (5 cm)**
BA-06	12/02/03	11:15	01:32	13,3	33,7
	12/03/03	10:05	01:45	10,4	30,2
	12/04/03	11:00	01:35	9,2	34,3
	12/05/03	12:00		18,7	28,1
	12/06/03	10:57	13:29	10,0	34,4
	12/07/03	10:54	13:28	10,8	31,0
	12/08/03	09:06	09:56	8,9	29,3
BA-10	12/02/03	10:08	01:53	15,9	32,9
	12/03/03	10:40	14:33	17,5	31,4
	12/04/03	10:34	13:11	14,1	33,6
	12/05/03	10:34	12:34	16,7	31,8
	12/06/03	10:34	12:31	11,2	34,3
	12/07/03	10:31	12:43	8,5	34,2
	12/08/03	9:10	10:55	6,5	36,0
BA-11	12/03/03	10:46	13:38	12,0	34,0
	12/04/03	11:17	13:36	15,7	34,4
	12/05/03	11:04	13:36	20,8	29,1
	12/06/03	10:58	13:38	15,5	32,5
	12/07/03	10:54	13:36	12,4	32,4
	12/08/03	09:01	10:05	9,9	28,8
BA-13	12/02/03	11:02	13:38	14,4	32,7
BA-17	12/02/03	12:35	13:57	5,4	42,6
	12/03/03	11:24	13:34	6,4	35,5
	12/04/03	11:24	13:35	4,7	37,1
	12/05/03	11:15	13:17	4,8	36,8

f) Surface soil temperature (5 cm depth):

Site	Time	Day of the Month (December, 2003)						
		Dec, 02	**Dec, 03**	**Dec, 04**	**Dec, 05**	**Dec, 06**	**Dec, 07**	**Dec, 08**
BA-06	13:15	34,3	37,1	44,1	29,1	36,1	36,6	41,6
	13:30	36,3	36,6	41,1	30,1	37,1	38,1	39,6
	13:45	37,3	39,6	42,1	30,1	34,1	38,6	38,6
BA-07	13:15	34,7	34,7	36,7	28,7	35,7	34,7	34,7
	13:30	33,7	34,7	35,7	28,7	35,7	34,7	34,7
	13:45	34,7	34,7	35,7	29,7	34,7	34,7	33,7
BA-08	13:15	39,9	37,9	39,9	26,9	39,7	36,9	37,7
	13:30	40,9	39,4	37,9	26,9	39,9	39,9	34,9
	13:45	41,4	39,9	37,9	27,4	37,9	38,4	33,7
BA-09	13:15	32,5	31,0	35,0	24,2	30,5	31,2	35,5
	13:30	33,2	34,5	33,8	24,2	30,5	31,0	34,0
	13:45	34,2	35,8	33,0	24,5	29,5	31,5	33,0

BA-10	13:15	34,5	32,0	33,5	30,5	32,5	33,5	38,5
	13:30	34,5	32,5	32,5	28,7	32,5	33,5	38,5
	13:45	35,0	31,5	33,0	29,5	32,4	34,5	37,5
BA-11	13:15	32,7	33,7	33,7	27,7	32,7	34,7	32,7
	13:30	31,7	34,7	32,7	27,7	32,2	34,7	31,7
	13:45	30,7	35,7	32,7	28,7	30,7	33,2	30,7
BA-12	13:15	32,0	33,8	31,2	28,0	34,8	35,0	31,0
	13:30	32,0	33,4	30,6	28,8	34,0	33,0	30,6
	13:45	30,8	32,6	30,0	28,8	32,8	33,0	30,0
BA-13	13:15	34,0	37,9	36,4	32,4	41,4		37,9
	13:30	34,4	38,9	35,4	32,4	41,4		38,9
	13:45		38,4	34,9	31,9	41,4		38,4
BA-14	13:15	43,7	43,2	42,7	42,7			
	13:30	45,2	43,7	42,7	42,7			
	13:45	45,7	43,2	43,2	43,2			
BA-15	13:15	47,6	37,6	34,1	37,1			
	13:30	45,6	38,1	34,1	37,6			
	13:45	45,6	37,6	34,1	37,6			
BA-16	13:15	33,8	30,8	29,8	30,3	30,8	32,3	32,8
	13:30	33,8	30,8	28,8	30,8	30,3	32,8	33,3
	13:45	32,8	30,8	28,8	29,8	30,3	33,3	32,8
BA-17	13:15	41,7	39,2	37,2	39,7	43,2	42,7	46,7
	13:30	42,7	39,7	36,7	39,2	43,2	43,2	47,2
	13:45	42,7	40,2	36,7	38,7	43,2	43,2	47,7

ANNEX 1 - PHOTOS OF FIELD SAMPLING SITES

BA-06 (Bare soil with *Brachiaria*)

BA-07 (Cultivated pasture)

BA-08 (Cerrado/caatinga natural vegetation)

BA-09 (Cerrado/caatinga natural vegetation)

BA-10 (Abandoned rice field)

BA-11 (Cerrado/caatinga natural vegetation)

BA-12 (Cerrado/caatinga natural vegetation)

BA-13 (Secondary vegetation near airport)

BA-14 (Disturbed vegetation near highway, under hilly topography and rocky soil)

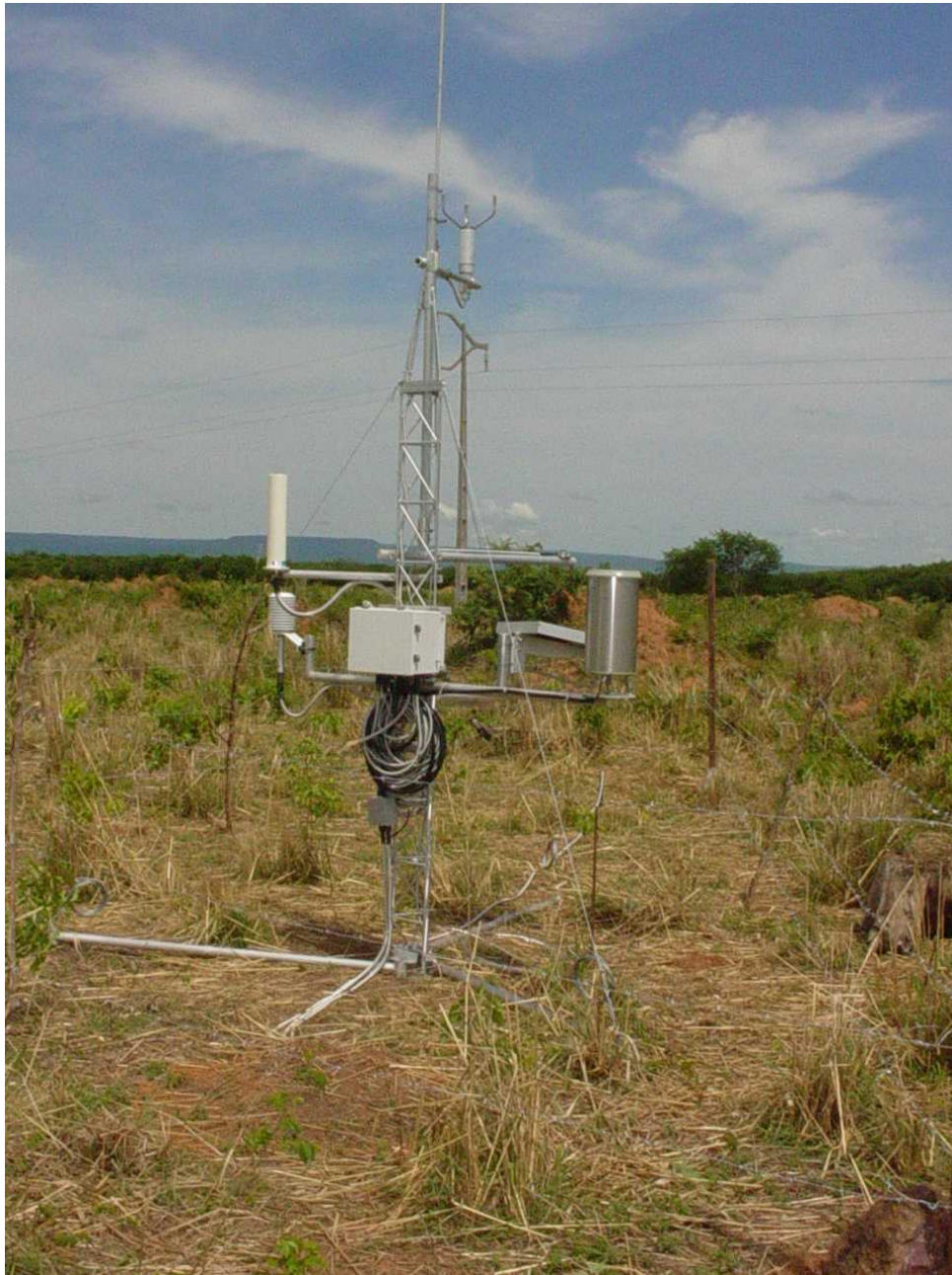BA-15 (Disturbed vegetation, near highway, recent fire)

BA-16 (Dense Cerrado)

BA-17 (Cultivated pasture with huge termiters)

ANNEX 2 – PHOTOS OF SOME EQUIPMENTS USED IN THE FIELD

Automatic Meteorological Station (BA-17 Sampling Site)

Soil moisture measurements by a theta probe (BA-17)

Leaf Water Content Sampling (BA-11)
Before

After

Soil Termometer and Vitel Hydro Probe (BA-16)

Thermohydrographer (BA-15)

Bulk Density (BA-14)