LBA-ECO ND-11 Soil Water Pressure and Flow Measurements under Tree Crops

Summary:

This data set contains information that can be used to examine water fluxes in soils beneath tree crops in an Amazonian agroforest. The data consists of repeated measurements of soil matrix pressure and soil moisture content at several depths. The study was carried out at the Empresa Brasileira de Pesquisa Agropecuaria (Embrapa)-Amazonia Ocidental, 29 km North of Manaus, Brazil (-3.13472 S, -59.88 W, 40–50 m above sea level), in 1998 and 1999.

Microaggregated tropical soils have shown high water conductivity even under unsaturated conditions in laboratory experiments. It is not clear, however, what depth the infiltrating soil water reaches during storm events under humid tropical conditions. Dynamics and fluxes of water were determined with high temporal resolution to a depth of 5 m in a Xanthic Hapludox of central Amazonia, Brazil. The soil water percolated to a depth of 0.9 m within 2 h of a rainfall event of 48 mm. Water fluxes were significantly slower below 0.9 m (17% of infiltration at 0 - 0.9 m) due to higher bulk densities. Percolation not only started rapidly after a rainfall event when soil water suction reached a certain threshold (ca. 20 - 30 hPa) but was also reduced to background levels less than 1 h after the rain had ended. The demonstrated extremely short-term dynamics of water fluxes have implications for measurement design of water availability and solute leaching in microaggregated tropical soil that require correct time integrals of solution concentrations and soil water dynamics. Measurement intervals of 30 min or less were necessary in our study. Rapid water flows may explain the observed high nutrient losses from the topsoil of microaggregated tropical soil and the large accumulation of nutrients in the deep soil (> 5 m).

Data Citation:

Cite this data set as follows:

Renck, A. and J. Lehmann. 2007. LBA-ECO ND-11 Soil Water Pressure and Flow Measurements under Tree Crops. Data set. Available on-line [http://www.daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

Implementation of the LBA Data and Publication Policy by Data Users:

The LBA Data and Publication Policy [http://daac.ornl.gov/LBA/lba_data_policy.html] is in effect for a period of five (5) years from the date of archiving and should be followed by data users who have obtained LBA data sets from the ORNL DAAC. Users who download LBA data in the five years after data have been archived must contact the investigators who collected the data, per provisions 6 and 7 in the Policy.

This data set was archived in August of 2007. Users who download the data between August 2007 and July 2012 must comply with the LBA Data and Publication Policy.

Data users should use the Investigator contact information in this document to communicate with the data provider. Alternatively, the LBA Web Site [http://lba.inpa.gov.br/lba/] in Brazil will have current contact information.

Data users should use the Data Set Citation and other applicable references provided in this document to acknowledge use of the data.

Table of Contents:

1. Data Set Overview:

Project: LBA (Large-Scale Biosphere-Atmosphere Experiment in the Amazon)

Activity: LBA-ECO

LBA Science Component: Nutrient Dynamics

Team ID: ND-11 (Lehmann / Passos / Couto)

The investigators were Renck, Andreas and Lehmann, Johannes . You may contact Lehmann, Johannes (cl273@cornell.edu)

LBA Data Set Inventory ID: ND11_Soil_Water_Pressure

This data set contains information that can be used to examine water fluxes in soils beneath tree crops in an Amazonian Agroforest. The data consists of repeated measurements of soil matrix pressure and soil moisture content at several depths.

During this study, soil matrix pressure ranges from 0 (saturation) to 866 cm suction (-866 cm). Soil moisture ranges from 19.2 percent (0.192 cm3 water per cm3 soil) to 78.5 percent. At the onset of the rainy season, soil water suction near the soil surface (0.1 m depth) under pueraria (Pueraria phaseoloides (Roxb.) Benth.) dropped from 100 to 300 hPa in January to about 50 hPa and remained at that level until the end of the rainy season in May. Although weekly averages were constant throughout the rainy season, the soil water suction was highly variable on short time scales of days and hours. During a single day, soil water suction could drop to 0 hPa (saturation) or increase to more than 100 hPa. Water fluxes calculated with soil water suction dynamics using a gradient approach ranged from < 1 to >10 mm day-1, if daily means were used. Using weekly averages, fluxes ranged only between 2 and 5 mm day-1. Longer measurement intervals decreased total fluxes calculated by up to 93%. Since fluctuations in water percolation were less pronounced at greater depths, the error associated with using larger measurement intervals decreased with depth.

2. Data Characteristics:

One comma-delimited ASCII file is provided. Values of -9999 in the ASCII file indicate missing values.

Soil_Water.csv

One Excel file is provided. Missing values are indicated by blank cells.

Soil_Water.xls

Both files have the same contents. The files provide soil matrix pressure (negative values denote tension) and soil moisture data at depth below tree species

Example Records from Soil_Water.csv:

```
"""File Name: Soil_Water.csv"""

"""File Contents: This file provides soil matrix
pressure (negative values denote tension) and soil
moisture data at depth below tree species."""

"""Values of -9999 in ascii file indicate missing
values."""

"""----Column 1: Tree species name: Values
include:"""
"""------------cup=cupuacu=Theobroma grandiflorum
(Willd. ex Spreng.) K. Schum"""
"""------------puer=Pueraria phaseoloides (Roxb.)
Benth. (Pueraria)"""
"""------------pup=pupunha=Bactris gasipaes Kunth."""
"""------------urucum=Bixa orellana L. (annatto)"""
"""----Column 2: Day (DD)"""
```

"""----Column 3: Month (MM)"""
"""----Column 4: Year (YY)"""
"""----Column 5: Soil matrix pressure at 10cm depth, (hPa)"""
"""----Column 6: Soil matrix pressure at 30cm, (hPa)"""
"""""---Column 7: Soil matrix pressure at 90cm, (hPa)"
"""----Column 8: Soil matrix pressure at 150cm, (hPa)"""
"""""---Column 9: Soil matrix pressure at 250cm, (hPa)"
"""----Column 10: Soil matrix pressure at deepest measurement point """,,,,,,,,,,,,,
"""---------- Deepest for pup = 500cm""",,,,,,,,,,,,,
"""---------- Deepest for cup = 400cm""",,,,,,,,,,,,,
"""---------- Deepest for puer = 400cm""",,,,,,,,,,,,,
"""----Column 11: Soil moisture at 10cm, volumetric water content (%)""",,,,,,,,,,,,,
"""----Column 12: Soil moisture at 30cm, volumetric water content (%)""",,,,,,,,,,,,,
"""----Column 13: Soil moisture at 90cm, volumetric water content (%)""",,,,,,,,,,,,,
"""----Column 14: Soil moisture at 150cm, volumetric water content (%)""",,,,,,,,,,,,,
"""----Column 15: Soil moisture at 250cm, volumetric water content (%)""",,,,,,,,,,,,,

Tree spp,Day,Month,Year,Matrix pressure at 10cm, Matrix pressure at 30cm,Matrix pressure at 90cm, Matrix pressure at 150cm,Matrix pressure at 250cm, Matrix pressure at deepest,Soil moisture at 10cm,Soil moisture at 30cm,Soil moisture at 90cm,Soil moisture at 150cm,Soil moisture at 250cm
pup,29,9,98,-159,-433,-174,0,-137,-9999,-9999,-9999,-9999,-9999,-9999
pup,1,10,98,-264,-740,-223,0,-133,-9999,-9999,-9999,-9999,-9999,-9999
pup,6,10,98,-250,-720,-200,0,-130,-9999,-9999,-9999,-9999,-9999,-9999
...

Site boundaries: (All latitude and longitude given in degrees and fractions)

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Geodetic Datum

Amazonas (Manaus) EMBRAPA DAS Experiment - km 29 (Amazonia Ocidental) (Amazonas (Manaus))	-59.88	-59.88	-3.13472	-3.13472	World Geodetic System, 1984 (WGS-84)

Time period:

- The data set covers the period **1998/09/29 to 1999/11/04.**
- Temporal Resolution: Continuous

Platform/Sensor/Parameters measured include:

- FIELD INVESTIGATION / TIME DOMAIN REFLECTOMETER / SOIL MOISTURE/WATER CONTENT
- FIELD INVESTIGATION / TENSIOMETER / SOIL WATER PRESSURE
- FIELD INVESTIGATION / TENSIOMETER / SOIL MATRIX PRESSURE

3. Data Application and Derivation:

Data set contains results from a field study of water fluxes within agroforest soils.

4. Quality Assessment:

No known problems with data.

5. Data Acquisition Materials and Methods:

The study was carried out at the Empresa Brasileira de Pesquisa Agropecuaria (Embrapa)-Amazônia Ocidental, 29 km North of Manaus, Brazil, in 1998 and 1999. The rainfall distribution is unimodal, with maximum rainfall between December and May (211–300 mm per month; 75% of annual rainfall) and mean annual precipitation of about 2500 mm, air temperature of 26 degree C, and atmospheric humidity about 84%. The vegetation is a tropical lowland rainforest. The soils are Xanthic Hapludox, which are derived from Tertiary sediments. They are very deep and clayey, with low pH and medium levels of organic C and N.

Water fluxes were investigated in a multi-strata agroforestry system with Theobroma grandiflorum (Willd. ex Spreng.) K. Schum. (cupuacu); Bactris gasipaes Kunth. (peach palm); Bertholletia excelsa Humb. & Bonpl. (Brazil nut); and Bixa orellana L. (annatto), and a legume cover of Pueraria phaseoloides (Roxb.) Benth. (pueraria).

Each replicate tree in the three plots was equipped with time domain reflectometry sensors (TDR, EASY TEST®, Lublin, Poland; mounted on shafts) at soil depths of 0.1, 0.3,0.9, and 1.5 m. Suction cups were installed in duplicate at 0.1-, 0.6-, and 2.0-m depths. In 1996, holes for all instruments were prepared using an auger of the same diameter as the shafts and filled with a slurry using the soil material to provide optimum contact. The instruments were inserted at an angle of 25 degrees in a radius of 1 m around the stems, and rubber discs were installed around the tubes on the soil surface to prevent preferential flow along the shafts. In addition, one soil pit was dug to a depth of 3 m in 1997 and equipped horizontally with TDR sensors at depths of 0.1, 0.3, 0.9, 1.5, and 2.5 m, with tensiometers at depths of 0.1,0.3,0.9, 1.5, 2.5, 4.0, and 5.0 m, and with suction cups at depths of 0.1, 0.6, 1.2, 2.0, 3.0, and 4.0 m for the pueraria, cupuacu, and peach palm, respectively (one sensor or sampler per depth and position). The cups were made of Al2O3 (70%) and SiO2 (29%), with an average pore size of 1 um (UMS, Munich, Germany). TDR sensors were read with a hand-held meter (EASY TEST®, Lublin, Poland), and vacuum in the headspace of the tensiometers was measured by inserting a needle through a rubber septum (UMS, Munich, Germany). TDR readings were transformed into volumetric water contents using field calibrations in the same soil (Teixeira, 2001).

The rate of water percolation in the soil profile was estimated by calculating the time that was required for the soil water suction to reach a local minimum at a given depth after a rainfall event. This time was called retardation time. The onset of soil water percolation at the upper boundary was set as the time when the soil water suction at a depth of 0.1 m decreased by 10% or more. Soil water and nutrient leaching was obtained by two different approaches: the gradient method using Darcy’s equation and water balance. For the gradient method, soil water suction was obtained from the installed tensiometers. The saturated hydraulic conductivity was obtained from disc infiltrometers and laboratory experiments (constant-head) in adjacent soils.

Sensors used include:

- TIME DOMAIN REFLECTOMETER
- TENSIOMETER

6. Data Access:

This data is available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) or the EOS Data Gateway.

Data Archive Center:

Contact for Data Center Access Information:

E-mail: uso@daac.ornl.gov
Telephone: +1 (865) 241-3952
FAX: +1 (865) 574-4665

7. References:

Renck A. and J. Lehmann. 2004. Rapid Water Flow and Transport of Inorganic and Organic Nitrogen in a Highly Aggregated Tropical Soil. Soil Science 169(5):330-341.