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Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and David E. Knapp, Editors

Volume 20

BOREAS HYD-1 Soil Hydraulic Properties

S.F. Kelly and R.H. Cuenca

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

July 2000

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BOREAS HYD-1 Soil Hydraulic Properties

Shaun F. Kelly, Richard H. Cuenca

Summary

The BOREAS HYD-1 team coordinated a program of data collection to measure and monitor soil properties in collaboration with other science team measurement needs. This data set contains soil hydraulic properties determined at the NSA and SSA flux tower sites based on analysis of in situ tension infiltrometer tests and laboratory-determined water retention from soil cores collected during the 1994-95 field campaigns. Results from this analysis are saturated hydraulic conductivity, and fitting parameters for the van Genuchten-Mualem soil hydraulic conductivity and water retention function at flux tower sites. The data are contained in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS HYD-01 Soil Hydraulic Properties

1.2 Data Set Introduction

Soil hydraulic properties were determined at the flux tower sites based on analysis of in situ tension infiltrometer tests and laboratory-determined water retention from soil cores collected during the 1994-95 field campaigns. Results from this analysis are saturated hydraulic conductivity, and fitting parameters for the van Genuchten-Mualem soil hydraulic conductivity and water retention function at flux tower sites.

1.3 Objective/Purpose

The objective of this study was to determine the soil hydraulic properties needed for physical simulation modeling of soil-vegetation-atmosphere-transfer processes.

1.4 Summary of Parameters

The properties determined for each site were saturated hydraulic conductivity, KSAT; soil water retention using the van Genuchten (1980) function, THETA (H, N, ALPHA, SAT, RESID, M) where M = 1-(1/N); and unsaturated hydraulic conductivity using the Mualem (1976)-van Genuchten (1980) function, K (H, N, ALPHA, KSAT, M) where M = 1-(1/N).

1.5 Discussion

In situ tension infiltrometer tests and laboratory soil core water retention data were combined to determine soil hydraulic properties at the sites of the flux towers operating during the 1994-95 BOReal Ecosystem-Atmosphere Study (BOREAS) field campaigns. At each flux tower site, between 6 and 20 tension disk infiltrometer tests were performed at the soil surface (A-horizon). Laboratory soil core water retention data from the soil surface (A-horizon) were obtained from soil surveys conducted during 1993-94 by Darwin Anderson (southern sites) and Hugo Veldhuis (northern sites).

Saturated hydraulic conductivity at each site was estimated by extrapolating the low tension conductivities of all tests to zero tension to obtain a site average saturated hydraulic conductivity. The unsaturated hydraulic conductivity function and soil water retention function were determined using the combined infiltrometer data of each site and the soil core water retention data. The tension infiltrometer data were determined at low tensions between 0 and 20 cm, and the soil core water retention data were determined at high tensions between 100 cm and 15,000 cm. Combining these two data sets using soil physics theory provides more information across the whole range of tensions from saturation at 0-cm tension to the permanent wilting point at 15,000-cm tension.

The soil hydraulic properties were measured on a scale ranging from 5 to 20 cm, but distributed simulation models more often require these properties on a scale ranging from tens of meters to kilometers. Spatial variations in soil hydraulic properties of this data set were minimized by performing multiple tests at each site. The quality of this data set will be checked by using these parameters in a physics-based model (SWMS-2D finite element model of soil water movement) and comparing with soil moisture profiles collected at the sites during the BOREAS experiment.

1.6 Related Data Sets

BOREAS TE-20 Soils Data over the NSA-MSA and Tower Sites in Raster Format
BOREAS TE-20 Soils Data over the NSA-MSA and Tower Sites in Vector Format
BOREAS TE-20 NSA Soil Lab Data
BOREAS TE-01 Soils Data over the SSA Tower Sites in Raster Format
BOREAS TE-01 SSA Soil Lab Data

2. Investigator(s)

2.1 Investigator(s) Name and Title

Richard H. Cuenca, Professor
Department of Bioresource Engineering
Oregon State University

2.2 Title of Investigation

Coupled Atmosphere-Forest Canopy-Soil Profile Monitoring and Simulation

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3. Theory of Measurements

Disk tension infiltrometers are designed to measure soil water infiltration rates at a controlled negative water pressure or tension within a circular interface at the soil surface. The analysis of data in this data set is based on the approximation of flow from a circular source based on Wooding, 1968. From each test the steady-state infiltration rate is used to calculate a conductivity, K, at the specified tension, H. The paired K, H data obtained from each test site run across tensions ranging from 3 cm to 20 cm using two different disk radii. Saturated hydraulic conductivity and the unsaturated hydraulic conductivity at each site were summarized using the Mualem-van Genuchten model (Mualem, 1976; van Genuchten, 1980). Water retention function was simultaneously fitted to the data from the laboratory soil cores.

4. Equipment

4.1 Sensor/Instrument Description

Disk tension infiltrometer:

The disk tension infiltrometer is designed to measure unsaturated flow of water into soil. It consists of: 1) a bubble tower that controls tension at the soil surface, 2) a water reservoir from which water flows into the soil, and 3) a baseplate with a membrane to establish hydraulic continuity with the soil. The water level in the reservoir is monitored using pressure transducers and a datalogger to record infiltration rates during the tests. Infiltrometers with baseplate disk diameters of 8 and 20 cm were used.

4.1.1 Collection Environment

The tension infiltrometer tests were performed throughout the 1994-95 BOREAS Intensive Field Campaigns (IFCs) in both the Northern Study Area (NSA) and the Southern Study Area (SSA) from May to September.

4.1.2 Source/Platform

The ground surface.

4.1.3 Source/Platform Mission Objectives

The objective was to measure hydraulic properties of the soil.

4.1.4 Key Variables

Saturated conductivity, hydraulic conductivity function, and water retention function.

4.1.5 Principles of Operation

The tension infiltrometer applies water to the soil surface at a constant tension and records the resulting infiltration rate in time. Hydraulic conductivities may be calculated using theoretical approximations of steady-state unconfined infiltration rates into the soil from circular sources. Hydraulic conductivities are determined at a number of tensions, and the hydraulic conductivity function is determined by fitting the appropriate function through the measured hydraulic conductivity versus tension data.

4.1.6 Sensor/Instrument Measurement Geometry

The tension infiltrometer is set on the soil surface; therefore, only the hydraulic properties of the soil surface (A-horizon) are determined.

4.1.7 Manufacturer of Sensor/Instrument

Tension infiltrometer
Soil Measurement Systems
7266 N. Oracle Road
Suite 170
Tucson, AZ 85704
(602) 742-4471
(602) 742-4379 or (602) 797-0356 (fax)

The tension infiltrometer was automated by Shaun Kelly using pressure transducers and a recording datalogger.

Pressure transducers
Honeywell 136PC05G2, 5 PSI transducers available from Soil Measurement Systems
Datalogger-Campbell Scientific CR10
Campbell Scientific, Inc.
815 W 1800 N
Logan, UT 84321-1784
(801) 753-2342
(801) 750-9540 (fax)

4.2 Calibration

Pressure transducers are calibrated in the lab using a standing water column. Transducer output in mV is linearly related to pressure. The infiltrometer is calibrated for the desired operating tensions before taking the unit to the field. Tension at the membrane on the baseplate in contact with the soil surface is controlled by the air entry ports in the bubble tower using one of three air entry tubes set at each desired tension. The air entry tubes are adjusted in the lab following the calibrating instructions in the manual.

4.2.1 Specifications

4.2.1.1 Tolerance

None given.

4.2.2 Frequency of Calibration

Pressure transducers have a tendency to drift and were calibrated before each IFC. Air entry tubes were calibrated once and required no further calibration unless it was desired to change the targeted tensions of 3, 5, and 15 cm tension.

4.2.3 Other Calibration Information

Actual tensions applied were determined using the bottom transducer or the transducer mounted closest to the baseplate. The actual tension applied varied depending on the vertical distance between the baseplate and the bubble tower.

5. Data Acquisition Methods

Operation of the tension infiltrometer is described in the user's manual supplied with each tension infiltrometer. The tension infiltrometer was modified to record the water level automatically with two pressure transducers and a datalogger. Each test was run at three target tensions: 3 cm, 6 cm, and 15 cm. Disk radii of 4 cm and 10 cm were used. Actual field operating tensions were calculated using the pressure recorded by the bottom transducer.

6. Observations

6.1 Data Notes

None given.

6.2 Field Notes

None given.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

The data represent determinations of the soil hydraulic properties based on multiple measurements made in the vicinity of the flux tower. The North American Datum of 1983 (NAD83) coordinates for the tower locations are:

SITE	LONGITUDE	LATITUDE	BOREAS_X	BOREAS_Y
SSA Young Aspen (YA)	105.32314°W	53.65601°N	374.607	310.761
SSA Old Black Spruce (OBS)	105.11779°W	53.98717°N	385.012	348.646
NSA OBS	98.48139°W	55.88007°N	778.216	613.516
NSA Old Jack Pine (OJP)	98.62396°W	55.92842°N	768.494	617.236
NSA Young Jack Pine (YJP)	98.28706°W	55.89575°N	789.845	617.424
SSA Old Aspen (OA)	106.19779°W	53.62889°N	317.198	303.403
SSA OJP	104.69203°W	53.91634°N	413.52	343.226
SSA YJP	104.64529°W	53.87581°N	416.988	339.008

7.1.2 Spatial Coverage Map

None.

7.1.3 Spatial Resolution

These data values were determined from a series of point measurements.

7.1.4 Projection

Not applicable for point data.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

In situ measurements were taken in conjunction with soil moisture monitoring during the growing seasons of 1994 and 1996.

7.2.2 Temporal Coverage Map

None.

7.2.3 Temporal Resolution

Although these soil properties were determined from data collected in 1994 and 1996, the values do not change significantly with time.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameters contained in the data files on the CD-ROM are:

Column Name
SITE_NAME
SUB_SITE
START_DATE
END_DATE
SAT_HYD_CONDUCTIVITY
N_FITTING_PARAM
ALPHA_FITTING_PARAM
SAT_VOL_WATER_CONTENT
RESID_VOL_WATER_CONTENT
BULK_DENSITY
SOIL_TEXTURE
CRTFCN_CODE
REVISION_DATE

7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
START_DATE	The date on which the collection of the reference data commenced.
END_DATE	The date on which the collection of the referenced data was terminated.
SAT_HYD_CONDUCTIVITY	Saturated hydraulic conductivity of the soil.
N_FITTING_PARAM	The N fitting parameter of the van Genuchten (1980) function.
ALPHA_FITTING_PARAM	The ALPHA fitting parameter of the van Genuchten (1980) function.
SAT_VOL_WATER_CONTENT	Saturated volumetric water content of the soil.
RESID_VOL_WATER_CONTENT	Residual volumetric water content of the soil.
BULK_DENSITY	Bulk density of the soil.
SOIL_TEXTURE	The soil texture (e.g. sand, clay).
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified

	by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
START_DATE	[DD-MON-YY]
END_DATE	[DD-MON-YY]
SAT_HYD_CONDUCTIVITY	[meters][day^-1]
N_FITTING_PARAM	[unitless]
ALPHA_FITTING_PARAM	[meter^-1]
SAT_VOL_WATER_CONTENT	[meters^3 H2O][meters^-3 soil]
RESID_VOL_WATER_CONTENT	[meters^3 H2O][meters^-3 soil]
BULK_DENSITY	[kilograms][meter^-3]
SOIL_TEXTURE	[none]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

The source of the parameter values contained in the data files on the CD-ROM are:

Column Name	Data Source
SITE_NAME	[Assigned by BORIS]
SUB_SITE	[Assigned by BORIS]
START_DATE	[Supplied by Investigator]
END_DATE	[Supplied by Investigator]
SAT_HYD_CONDUCTIVITY	[Supplied by Investigator]
N_FITTING_PARAM	[Supplied by Investigator]
ALPHA_FITTING_PARAM	[Supplied by Investigator]
SAT_VOL_WATER_CONTENT	[Supplied by Investigator]
RESID_VOL_WATER_CONTENT	[Supplied by Investigator]
BULK_DENSITY	[Supplied by Investigator]
SOIL_TEXTURE	[Supplied by Investigator]
CRTFCN_CODE	[Assigned by BORIS]
REVISION_DATE	[Assigned by BORIS]

7.3.5 Data Range

The following table gives information about the parameter values found in the data files on the CD-ROM:

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	NSA-OBS-FLXTR	SSA-YJP-FLXTR	None	None	None	None
SUB_SITE	HYD01-SHP01	HYD01-SHP01	None	None	None	None
START_DATE	01-JAN-94	01-JAN-94	None	None	None	None
END_DATE	31-DEC-94	31-DEC-94	None	None	None	None

```
SAT_HYD_CONDUCTIVITY .25            1.91           None    None   None    None
N_FITTING_PARAM      1.1            1.56           None    None   None    None
ALPHA_FITTING_PARAM  .9             9.5            None    None   None    None
SAT_VOL_WATER_       .21            .65            -999    None   None    None
CONTENT
RESID_VOL_WATER_     .01            .17            -999    None   None    None
CONTENT
BULK_DENSITY         1190           1450           -999    None   None    None
SOIL_TEXTURE         N/A            N/A            -999    None   None    None
CRTFCN_CODE          CPI            CPI            None    None   None    None
REVISION_DATE        04-JUN-98      04-JUN-98      None    None   None    None
-------------------------------------------------------------------------------
Minimum Data Value -- The minimum value found in the column.
Maximum Data Value -- The maximum value found in the column.
Missng Data Value  -- The value that indicates missing data. This is used to
                      indicate that an attempt was made to determine the
                      parameter value, but the attempt was unsuccessful.
Unrel Data Value   -- The value that indicates unreliable data.  This is used
                      to indicate an attempt was made to determine the
                      parameter value, but the value was deemed to be
                      unreliable by the analysis personnel.
Below Detect Limit -- The value that indicates parameter values below the
                      instruments detection limits.  This is used to
                      indicate that an attempt was made to determine the
                      parameter value, but the analysis personnel determined
                      that the parameter value was below the detection
                      limit of the instrumentation.
Data Not Cllctd    -- This value indicates that no attempt was made to
                      determine the parameter value.  This usually
                      indicates that BORIS combined several similar but
                      not identical data sets into the same data base table
                      but this particular science team did not
                      measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value.
N/A   -- Indicates that the value is not applicable to the respective column.
None  -- Indicates that no values of that sort were found in the column.
-------------------------------------------------------------------------------
```

7.4 Sample Data Record

The following are wrapped versions of data records from a sample data file on the CD-ROM.

```
SITE_NAME,SUB_SITE,START_DATE,END_DATE,SAT_HYD_CONDUCTIVITY,N_FITTING_PARAM,
ALPHA_FITTING_PARAM,SAT_VOL_WATER_CONTENT,RESID_VOL_WATER_CONTENT,BULK_DENSITY,
SOIL_TEXTURE,CRTFCN_CODE,REVISION_DATE
'NSA-OBS-FLXTR','HYD01-SHP01',01-JAN-94,31-DEC-94,.46,1.15,1.5,.65,.17,1300,
'Clay','CPI',04-JUN-98
'NSA-OJP-FLXTR','HYD01-SHP01',01-JAN-94,31-DEC-94,.77,1.35,8.7,.21,.01,1450,
'Sand','CPI',04-JUN-98
```

8. Data Organization

8.1 Data Granularity

The smallest unit of data tracked by the BOREAS Information System (BORIS) was the entire data set.

8.2 Data Format(s)

The Compact Disk-Read-Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

9. Data Manipulations

9.1 Formulae

Wooding's equation (1958):

$$Q=pi*r^2*K*(1+(4*lc)/(pi*r))$$

where Q is water infiltration [vol/time].
K is hydraulic conductivity [length/time].
r is disk radius [length].
lc is the macroscopic capillary length [length].

Gardner's hydraulic conductivity function (1958):

$$K(H)=KSAT*exp(ALPHAG*H)$$

where ALPHAG is a fitted parameter.
H is the soil water tension.
KSAT is the saturated conductivity.
K is the hydraulic conductivity.

van Genuchten soil water retention equation (1980):

$$THETA(H)=RESID+(SAT-RESID)/(1+(ALPHA*H)^{N})^{(1-(1/N))}$$

where THETA is the volumetric water content [vol/vol].
RESID is the residual water content at some large negative tension [vol/vol].
SAT is the saturated water content [vol/vol].
ALPHA is an empirical fitting parameter or (1/lc)[1/length].
N is a fitting parameter.
H is the soil water tension.

Mualem(1976)-van Genuchten (1980) unsaturated hydraulic conductivity function:

$$K(H) = \frac{KDAT*(1-(|ALPHA*H|^{(N-1)}) * (1+(|ALPHA*H|^{N}))^{((1/N)-1)})^{2}}{(1+|ALPHA*H|^{N})^{((N-1)/2*N)}}$$

where KSAT is the saturated hydraulic conductivity [length/time].
the vertical bars '|' represent "absolute value".

All other variables are the same as those in the water retention equation.

9.1.1 Derivation Techniques and Algorithms

An average value for KSAT was determined by extrapolating a fitted Gardener. (1958) exponential function to zero tension using the low tensions from each sequence of infiltration runs. The parameters for the water retention and hydraulic conductivity were then simultaneously fitted using a nonlinear fitting routine. The variables optimized were the sum of the squared difference between the natural log of the calculated and the measured steady state infiltration rates for the hydraulic conductivity and the weighted volumetric water contents for the water retention function. The fitting parameters N, ALPHA, SAT (saturated volumetric water content), and RESID (residual water content) are subject to the following constraints: $0 < N < 1$, $1 < ALPHA < 2$, SAT < observed maximum soil moisture, and $RESID > 0.01$.

9.2 Data Processing Sequence

9.2.1 Processing Steps

None given.

9.2.2 Processing Changes

None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

None given.

9.3.2 Calculated Variables

Saturated hydraulic conductivity, hydraulic conductivity, water infiltration, and volumetric water content.

9.4 Graphs and Plots

See Sections 10 and 11 for graphs and plots that are applicable to those sections.

10. Errors

10.1 Sources of Error

Possible sources of error are poor contact of the infiltrometer disk with the soil surface, which reduces the actual effective disk radius (up to 1 cm), and pressure transducer drift in the offset, which may affect the actual tension applied to the soil (+/-2 cm). There is no additional information available to provide a quantitative error analysis of this data.

10.2 Quality Assessment

Soil bulk density was not measured in the field and is an estimated value. It is not a parameter used in the retention or conductivity functions and is provided for reference only. It is the value given in the laboratory soil core data performed independently by other BOREAS researchers (see Section 1.6, Related Data Sets). Where bulk density was not provided in other data sets, a value was estimated from known values of soils with similar texture.

Saturated and residual volumetric water content, SAT and RESID, were not directly measured in the field. These values were treated as fitting parameters when calculating retention and conductivity functions. Appropriate limits were placed on these parameters based on observed minimum and maximum water contents observed in the field measured with a neutron probe and Time Domain Reflectometry (TDR). These values may not be the same as would be found during soil core analysis because of entrapped air, existence of macropores, etc. Nevertheless, these values gave the best fit to the limited set of retention data collected.

10.2.1 Data Validation by Source

Data were validated by comparing calculated parameters with soils of similar texture from the UNSODA data base (United States Department of Agriculture (USDA) Salinity Lab). Parameters are currently being used in physics-based soil water transport models (HYDRUS and WAVE) to simulate soil water movement and for comparing to site measurements of soil water content observed at the BOREAS sites from 1994-96.

10.2.2 Confidence Level/Accuracy Judgment

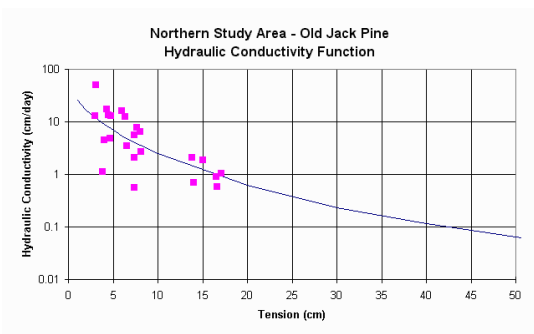
The authors feel that the quality of the data is very good for use at the tower flux sites because of the numerous measurements made at the sites.

10.2.3 Measurement Error for Parameters

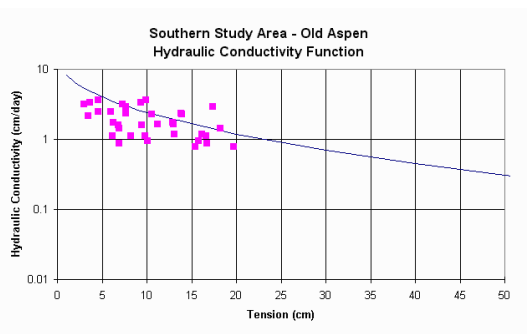
None given.

10.2.4 Additional Quality Assessments

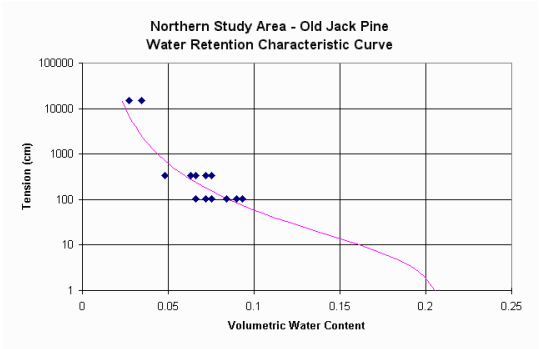
Quality assessments of the goodness of fit are shown in the following graphs of the hydraulic conductivity function and the soil water retention function for the north OJP site and the south OA site. Actual field data are plotted with the calculated values using the parameters determined.



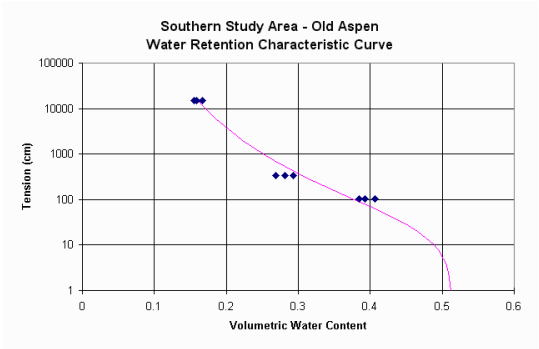
NSA-OJP Hydraulic Conductivity Function



SSA-OA Hydraulic Conductivity Function



NSA-OJP Water Retention Characteristic Curve



SSA-OA Water Retention Characteristic Curve

10.2.5 Data Verification by Data Center

The data were loaded into a data base table and reviewed to ensure that no errors occurred in loading the data.

11. Notes

11.1 Limitations of the Data

As one moves farther from the site, the variability of soils due to natural geologic soil genesis processes will limit the spatial extent of the data. Although these are point measurements, it is expected that these parameters will be used for modeling of soil water processes at sites with soils similar to those at the tower site.

The parameters were derived from tension infiltrometer data from the surface of the first mineral soil layer at each site (A-horizon). Therefore, these parameters would most accurately represent the soil water properties of the top 15 cm of soil. Although caution should be used when extrapolating the use of these parameters to greater soil depths, it is expected that these parameters will be used to model soil water properties at depths greater than 15 cm.

11.2 Known Problems with the Data

None given.

11.3 Usage Guidance

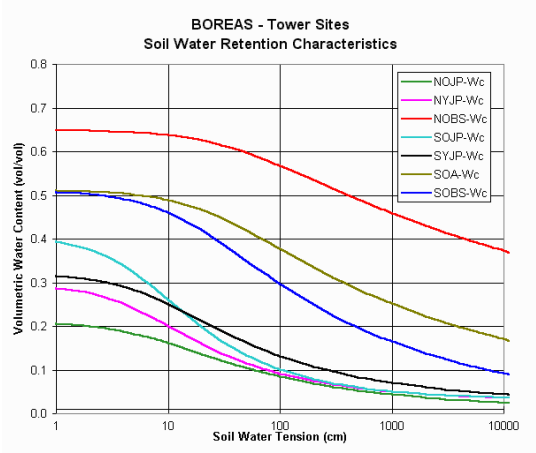
See Section 12.

11.4 Other Relevant Information

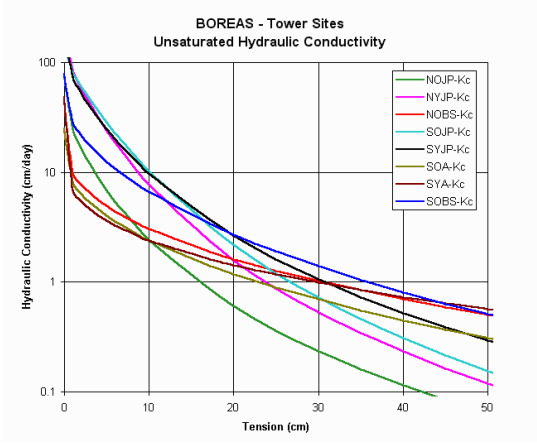
None given.

12. Application of the Data Set

This data set is particularly useful for use in models needing soil water hydraulic properties. The data are derived from in situ measurements and parameters developed from the theories of soil physics. This data set can be used to convert water contents to corresponding soil water tensions and vice versa. This data set can also be used to determine the hydraulic conductivity of the soil when soil water content or tension is known. The data set can be summarized in the following plots of the conductivity and retention functions at each site.



Volumetric water content vs. soil water retension curves for flux tower sites.



Hydraulic conductivity vs. tension curves for flux tower sites (unsaturated hydraulic conductivity)

13. Future Modifications and Plans

These data are currently being used for calibration of a finite element model of soil water movement for the BOREAS tower sites. These data are being used for initial calibration of the model. Model verification is being made using the soil water transect data collected during the 1994 IFCs and the data currently being collected at NSA-OBS, NSA-OJP, NSA-YJP, SSA-OBS, and SSA-OA. In the future, it is planned to calculate sorptivity parameters for soils at each site.

14. Software

14.1 Software Description

Microsoft Excel for Windows 95, Version 7.0
HYDRUS - finite element model of soil water movement
WAVE - finite difference model of soil water movement
Mathcad, Version 6.0

14.2 Software Access

Microsoft Excel and Mathcad are proprietary software packages. The availability of HYDRUS and WAVE software is not known.

15. Data Access

The HYD-01 soil hydraulic properties data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information

For BOREAS data and documentation please contact:

ORNL DAAC User Services
Oak Ridge National Laboratory
P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407
Phone: (423) 241-3952
Fax: (423) 574-4665
E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov/ [Internet Link].

15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products

None.

16.2 Film Products

None.

16.3 Other Products

These data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

Tension Infiltrometer User's Manual. Soil Measurement Systems, 7266 N. Oracle Road, Suite 170, Tucson AZ, 85704.

17.2 Journal Articles and Study Reports

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Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. Bulletin of the American Meteorological Society. 76(9):1549-1577.

Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. Journal of Geophysical Research 102(D24): 28,731-28,770.

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Wooding, R.A. 1968. Steady infiltration from a shallow circular pond. Water Resour. Res. 4:1259-1273.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

ALPHA is an empirical fitting parameter, or (1/lc)[1/length]. ALPHAG is a fitted parameter in the Gardner equation, or (1/lc)[1/length]. H is the soil water tension [length]. K is hydraulic conductivity [length/time]. KSAT is the saturated conductivity [length/time]. lc is the macroscopic capillary length [length]. N is a fitting parameter. Q is water infiltration [vol/time]. r is disk radius [length]. RESID is the residual water content at some large negative tension [vol/vol]. SAT is the saturated water content [vol/vol]. THETA is the volumetric water content [vol/vol].

19. List of Acronyms

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ASCII   - American Standard Code for Information Interchange
BOREAS  - BOReal Ecosystem-Atmosphere Study
BORIS   - BOREAS Information System
CD-ROM  - Compact Disk-Read-Only Memory
DAAC    - Distributed Active Archive Center
EOS     - Earth Observing System
EOSDIS  - EOS Data and Information System
GIS     - Geographic Information System
GSFC    - Goddard Space Flight Center
HTML    - HyperText Markup Language
HYD     - Hydrology
IFC     - Intensive Field Campaign
NAD83   - North American Datum of 1983
NASA    - National Aeronautics and Space Administration
NSA     - Northern Study Area
OA      - Old Aspen
OBS     - Old Black Spruce
OJP     - Old Jack Pine
ORNL    - Oak Ridge National Laboratory
PANP    - Prince Albert National Park
SSA     - Southern Study Area
TDR     - Time Domain Reflectometry
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TE      - Terrestrial Ecology
URL     - Uniform Resource Locator
USDA    - United States Department of Agriculture
YA      - Young Aspen
YJP     - Young Jack Pine
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Also, cite the BOREAS CD-ROM set as:

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13. ABSTRACT *(Maximum 200 words)*

The BOREAS HYD-1 team coordinated a program of data collection to measure and monitor soil properties in collaboration with other science team measurement needs. This data set contains soil hydraulic properties determined at the NSA and SSA flux tower sites based on analysis of in situ tension infiltrometer tests and laboratory-determined water retention from soil cores collected during the 1994-95 field campaigns. Results from this analysis are saturated hydraulic conductivity, and fitting parameters for the van Genuchten-Mualem soil hydraulic conductivity and water retention function at flux tower sites. The data are contained in tabular ASCII files.

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