BOREAS FOLLOW-ON HMET-03 HOURLY METEOROLOGICAL DATA AT FLUX TOWERS, 1994-1996

Get Data

Summary

Point data developed from in situ observations at four flux tower sites were combined to produce continuous, above the canopy, meteorological forcing data sets. Data from the OA and OBS sites in the SSA and the Fen and OBS sites in the NSA were used to create continuous time series with a time step of one hour, covering the period from 1-Jan-1994 through 1-Dec-1996.

Meteorological variables of interest are surface air pressure, air temperature, dew point temperature, wind speed, wind direction, precipitation, incoming solar (shortwave) radiation, and incoming infrared (longwave) radiation.

This data set was Phase I among three categories of meteorological forcing data sets that have been assembled for BOREAS Hydrometeorological and Carbon Assimilation Model Intercomparison Projects as part of the BOREAS Follow-on activities. Additional meteorological forcing data sets, Phase II and III data, at study area and regional grid scales, respectively, have also been produced.

Data Citation

Cite this data set as follows (citation revised on October 30, 2002):

Lettenmaier, D. P., and B. Nijssen. 2001. BOREAS Follow-On HMet-03 Hourly Meteorological Data at Flux Towers, 1994-1996. 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.

Table of Contents

1.0 Data set Overview

Meteorological variables of interest are surface air pressure, air temperature, dew point temperature, wind speed, wind direction, precipitation, incoming solar (shortwave) radiation, and incoming infrared (longwave) radiation.

The data set contains continuous three year, hourly, meteorological time series at selected BOReal Ecosystem Atmosphere Study (BOREAS) tower sites. The data are meant as drivers for model studies. The tower sites are:

Northern Study Area (NSA):
- Old Black Spruce (NSA-OBS)
- Fen (NSA-FEN)

Southern Study Area (SSA):
- Old Black Spruce (SSA-OBS)
- Old Aspen (SSA-OA)

1.1 Data set Identification

BOREAS Follow-On HMet-03 Hourly Meteorology Data at Flux Towers 1994-1996

1.2 Data Set Introduction

Surface station and remote sensing data sets over BOREAS region were acquired and quality controlled in order to provide investigators of Hydromet & Carbon Model Subgroups with standardized meteorological forcing data sets. Data are prepared for period January 1, 1994 through November 30, 1996.

1.3 Objective/Purpose

Although the BOREAS field period covered a period of about three years (1994-1996), few of the sites operated continuously during that period. However, most hydrological models require a continuous meteorological data set to operate. To construct a continuous, hourly time series of meteorological model forcings, data from a large number of sites had to be combined.

Data sets were assembled in order to provide investigators of Hydromet and Carbon Model Subgroups with standardized meteorological forcing data for model intercomparison studies. Six (6) different hydrometeorological models and nine (9) different carbon models were selected for intercomparison purposes.

1.4 Summary of Parameters

The variables included in the data set are for each tower site:

Variable	Units
Time	YYYY MM DD HH (UTC)
Air Temperature	degrees C
Vapor pressure deficit	Pa
Zonal Wind speed	m/s
Meridional Wind speed	m/s
Pressure	Pa
Incoming shortwave radiation	W/m^2
Incoming longwave radiation	W/m^2
Precipitation	mm/hr

1.5 Discussion

This data set is Phase 1 among 3 categories of meteorological forcing data sets that have been assembled for BOREAS Hydrometeorological and Carbon Assimilation Model Intercomparison Projects as part of the

BOREAS Follow-on activities. Additional meteorological forcing data sets, Phase II and III data, at study area and regional grid scales, respectively, have also been produced.

1.6 Related Data Sets

BOREAS Follow-on HMet-03 Hourly Meteorology Data at Flux Towers 1994-1996
BOREAS TF-1 SSA-OA Tower Flux, Meteorological, and Soil Temperature Data
BOREAS TF-2 SSA-OA Tower Flux, Meteorological, and Precipitation Data
BOREAS TF-3 NSA-OBS Tower Flux, Meteorological, and Soil Temperature Data
BOREAS TF-6 SSA-YA Surface Energy Flux and Meteorological Data
BOREAS TF-8 NSA-OJP Tower Flux, Meteorological, and Soil Temperature Data
BOREAS TF-9 SSA-OBS Tower Flux, Meteorological, and Soil Temperature Data
BOREAS TF-10 NSA-Fen Tower Flux and Meteorological Data
BOREAS TF-10 NSA-YJP Tower Flux, Meteorological, and Porometry Data
BOREAS TF-11 SSA-Fen Tower Flux and Meteorological Data
BOREAS AFM-07 SRC Surface Meteorological and Radiation Data
BOREAS HYD-09 Belfort Rain Gauge Data
BOREAS HYD-9 Tipping Bucket Rain Gauge Data
BOREAS Gridded Met Data Over the Hydro-Meteorological Study Area 1994-1996
BOREAS TF-09 SSA OBS Tower Flux, Meteorological, and Soil Temperature Data
BOREAS AES Campbell Scientific Surface Meteorological Data
BOREAS AES MARSII Surface Meteorological Data
BOREAS AES READAC Surface Meteorological Data
BOREAS TGB-4 NSA-BVP Tower Flux and Meteorological Data
BOREAS HYD-5 Winter Surface Flux Data
BOREAS TF-4 SSA-YJP Tower Flux, Meteorological, and Canopy Condition Data
BOREAS TE-6 1994 Soil and Air Temperatures in the NSA

Return to top of document.

2. Investigator(s)

2.1 Investigator(s) Name and Title

Dr. Dennis P. Lettenmaier, Professor of Civil Engineering

2.2 Title of Investigation

BOREAS surface radiation, energy, water, and carbon budget variability studies at three different spatial scales using field measurements, remote sensing, and combination of hydrometeorological and carbon assimilation models.

2.3 Contact Information

Contact 1:
Bart Nijssen, Research Assistant
University of Washington
Seattle, WA
Fax: (206) 685 3836
E-mail: nijssen@u.washington.edu

Contact 2:
Dr. Dennis P. Lettenmaier, Professor of Civil Engineering

University of Washington
Seattle, WA
Fax: (206) 685 3836
E-mail: dennisl@u.washington.edu

Return to top of document.

3. Theory of Measurements

See the following publications for the theory of measurements:

1. 1st BOREAS Special Issue in 1997 Journal of Geophysical Research (vol 102/issue D24).
2. Special Issue on Remote Sensing in BOREAS in 1997 Canadian Journal of Remote Sensing (vol 23/no 2).
3. 2nd BOREAS Special Issue in 1999 Journal of Geophysical Research (vol 104/issue D22).

Return to top of document.

4. Equipment

See relevant sections of the individual documents referenced in section 1.6

Return to top of document.

5. Data Acquisition Methods

Data from about 50 different sites have been used in constructing this continuous data set. See relevant sections of the individual documents referenced in section 1.6. The sites used are as follows:

BOREAS Site Id	Descriptive Location
Atmospheric Environment Service (AES) Canada 15 minute continuous stations	
REG-999-WFF01-STAFF-AES01	Melfort, SK
REG-999-WLJ01-STAFF-AES01	Meadow Lake, SK
REG-999-WSR01-STAFF-AES01	Spiritwood West, SK
SSA-999-WBU01-STAFF-AES01	Nipawin, SK
SSA-999-WLV01-STAFF-AES01	Waskesiu Lake, SK
Canadian historic stations: daily.	
NSA-999-THO01-STAFF-HISDY	5062922 - Thompson A, MB
REG-999-BRI01-STAFF-HISDY	4060620 - Big River, SK
REG-999-CAM01-STAFF-HISDY	4051080 - Cameo, SK
REG-999-CHO01-STAFF-HISDY	4071560 - Choiceland, SK
REG-999-ETH01-STAFF-HISDY	4052448 - Ethelton, SK
REG-999-LRI01-STAFF-HISDY	4074640 - Lost River, SK
REG-999-NIP01-STAFF-HISDY	4075518 - Nipawin, SK
REG-999-RON01-STAFF-HISDY	4064150 - La Ronge A, SK
REG-999-WAB01-STAFF-HISDY	5063041 - Wabowden, MB
SSA-999-WSK03-STAFF-HISDY	4068560 - Waskesiu Lake, SK
Canadian historic stations: hourly.	
REG-999-PRA01-STAFF-HISHY	4056240 - Prince Albert A, SK
REG-999-RON01-STAFF-HISHY	4064150 - La Ronge A, SK
NSA-999-THO01-STAFF-HISHY	5062922 - Thompson A, MB

```
Saskatchewan Research Council Meteorological Stations, suite A, 15 min., late 1993 - Nov 1996
 NSA-9BS-YTHSA-AFM07-SRCA1     Thompson Airport, MB (spruce stand)
 NSA-OJP-FLXTR-AFM07-SRCA1     NSA-OJP Flux Tower, MB
 REG-999-MDLSA-AFM07-SRCA1     Meadow Lake, SK
 REG-999-RONSA-AFM07-SRCA1     La Ronge, SK
 SSA-9OA-FLXTR-AFM07-SRCA1     SSA-OA Flux Tower, SK
 SSA-OJP-FLXTR-AFM07-SRCA1     SSA-OJP Flux Tower, SK

Saskatchewan Research Council Meteorological Stations, suite B, 15 min., early 1994 - Nov 1996
 NSA-FEN-FLXTR-AFM07-SRCB1     Nelson House, MB
 SSA-9OA-FLXTR-AFM07-SRCB1     SSA-OA Flux Tower, SK
 SSA-OJP-FLXTR-AFM07-SRCB1     SSA-OJP Flux Tower, SK

Flux tower sites, 15 min.
 NSA-BVP-FLXTR-TGB04-FLX01     NSA Beaver Pond Flux Tower
 NSA-FEN-FLXTR-9TF10-FLX01     NSA Fen Flux Tower
 NSA-OBS-FLXTR-9TF03-FLX01     NSA Old Black Spruce Flux Tower
 NSA-OJP-FLXTR-9TF08-FLX01     NSA Old Jack Pine Flux Tower
 NSA-YJP-FLXTR-9TF10-FLX01     NSA Young Jack Pine Flux Tower
 SSA-9OA-FLXTR-9TF01-FLX01     SSA Old Aspen Flux Tower
 SSA-9OA-FLXTR-9TF02-FLX01     SSA Old Aspen Flux Tower
 SSA-9YA-FLXTR-9TF06-FLX01     SSA Young Aspen Flux Tower
 SSA-CLR-FLXTR-HYD05-FLX01     HYD-5 Tower Bear Trap Forest
 SSA-FEN-FLXTR-9TF11-FLX01     SSA Fen Flux Tower
 SSA-OBS-FLXTR-9TF09-FLX01     SSA Old Black Spruce Flux Tower
 SSA-OJP-FLXTR-9TF05-FLX01     SSA Old Jack Pine Flux Tower
 SSA-WAT-FLXTR-HYD05-FLX01     HYD-5 Tower Namekus Lake
 SSA-YJP-FLXTR-9TF04-FLX01     SSA Young Jack Pine Flux Tower

Forestry meteorological stations operating in summer 1994
 SSA-999-CND01-STAFF-FRS01     CANDLE LAKE, SK
 REG-999-COO01-STAFF-FRS01     COOKSON, SK
 REG-999-EBC01-STAFF-FRS01     EBCAM, SK
 REG-999-LBE01-STAFF-FRS01     LITTLE BEAR, SK
 REG-999-WAB01-STAFF-FRS01     WABENO, SK
 SSA-999-WSK01-STAFF-FRS01     WASKESIU, SK
 REG-999-WYK01-STAFF-FRS01     WAYAKWIN, SK

Forestry meteorological stations operating in summer 1995
 SSA-999-CND01-STAFF-FRS01     CANDLE LAKE, SK
 REG-999-COO01-STAFF-FRS01     COOKSON, SK
 REG-999-EBC01-STAFF-FRS01     EBCAM, SK
 REG-999-FLC01-STAFF-FRS01     FORT A LA CORN, SK
 REG-999-LBE01-STAFF-FRS01     LITTLE BEAR, SK
 REG-999-WAB01-STAFF-FRS01     WABENO, SK
 SSA-999-WSK01-STAFF-FRS01     WASKESIU, SK
 REG-999-WYK01-STAFF-FRS01     WAYAKWIN, SK
```

Return to top of document.

---

6. Observations

6.1 Data Notes

The observations can be subdivided into a limited number of categories based on the data source. For more detailed information the reader is referred to the documentation for the original data sets (all of which are part of the BORIS data archive):

AES 15 minute continuous stations

These stations are long-term meteorological sites operated by Atmospheric Environment Canada, which record observations based on a 15 minute interval. A large suite is variables is measured including windspeed, wind direction, humidity, and pressure. No shortwave or longwave radiation is measured.

Canadian historic stations: daily

These stations are also operated by Atmospheric Environment Canada, and only record daily minimum, maximum, and mean temperature and precipitation.

Canadian historic stations: hourly

These stations are also operated by Atmospheric Environment Canada, and record observation on an hourly basis. A larger suite of variables is measured than in the daily stations, including windspeed, wind direction, humidity, pressure, and cloudiness. No shortwave or longwave radiation is measured.

Saskatchewan Research Council stations

These stations were installed and operated by the Saskatchewan Research Council for the BOREAS project. The stations recorded observations based on a 15 minute interval. This data set provides the most complete coverage (temporally and spatially) of meteorological conditions in the Southern and Northern Study Area during the period 1994-1996. Unlike most flux towers, these stations also operated during the winter months. The stations observed a full set of meteorological observations, although only a limited number measured longwave radiation.

Flux tower sites

The largest number of variables was measured at the BOREAS flux tower sites. Most towers measured all basic meteorological data at different levels. All levels have been retained in the quality-controlled data set. Few towers operated during the entire period from 1994-1996.

Canadian Forest Service stations

These stations recorded hourly observations in the summers of 1994 and 1995 of air temperature, humidity, wind speed, wind direction, and precipitation.

6.2 Field Notes

Not applicable.

Return to top of document.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

Site Id	Longitude	Latitude	UTM Easting	UTM Northing	UTM Zone

SSA-OBS-SE501	105.11779° W	53.98717° N	492276.5	5982100.5	13
SSA-9OA-SE501	106.19779° W	53.62889° N	420790.5	5942899.9	13
NSA-OBS-SE501	98.48139° W	55.88007° N	532444.5	6192853.4	14
NSA-FEN-SE501	98.42072° W	55.91481° N	536207.9	6196749.6	14

7.1.2 Spatial Coverage Map
Not applicable

7.1.3 Spatial Resolution
Not applicable

7.1.4 Projection
Not applicable.

7.1.5 Grid Description
Not applicable

7.2 Temporal Characteristics

7.2.1 Temporal Coverage
Data cover the period from Jan 1, 1994 through Dec 1, 1996.

7.2.2 Temporal Coverage Map
Not applicable

7.2.3 Temporal Resolution
The temporal resolution is hourly.

7.3 Data Characteristics

7.3.1 Parameter/Variable
The parameters contained in the data files are:

Column Name
SITE_NAME
DATE_OBS
TIME_OBS
AIR_TEMP
VAPOR_PRESS_DEF
U_WIND_SPEED
V_WIND_SPEED
PRESS
SHORT_RAD_IN
LONG_RAD_IN
PRECIP
CRTFCN_CODE
REVISION_DATE

7.3.2 Description/Definition
The descriptions of the parameters contained in the data files 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.
DATE_OBS	The date on which the data were collected.
TIME_OBS	The Greenwich Mean Time (GMT) at the beginning of the observation interval. In this data set a backward time tag convention is used (i.e., time tag n indicates data record applies to hourly period n to n+1).
AIR_TEMP	Air temperature above the canopy
VAPOR_PRESS_DEF	Vapor pressure deficit above the canopy
U_WIND_SPEED	Zonal wind speed above the canopy
V_WIND_SPEED	Meridional wind speed above the canopy
PRESS	Surface pressure
SHORT_RAD_IN	Incoming shortwave radiation above the canopy
LONG_RAD_IN	Incoming longwave radiation above the canopy
PRECIP	Precipitation
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 are:

Column Name	Units
SITE_NAME	[none]
DATE_OBS	[DD-MON-YY]
TIME_OBS	[HHMM GMT]
AIR_TEMP	[degrees C]
VAPOR_PRESS_DEF	[Pascals]
U_WIND_SPEED	[meters][second^-1]
V_WIND_SPEED	[meters][second^-1]
PRESS	[Pascals]
SHORT_RAD_IN	[Watts][meters^-2]
LONG_RAD_IN	[Watts][meters^-2]
PRECIP	[millimeters][hour^-1]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

The source of the parameter values contained in the data are (see Table 9.2 for detailed information):

Column Name	Data Source
SITE_NAME	[BORIS Designation]
DATE_OBS	[Human Observer]
TIME_OBS	[Various, see section 5]

```
AIR_TEMP                        [Various, see section 5]
VAPOR_PRESS_DEF                 [Various, see section 5]
U_WIND_SPEED                    [Various, see section 5]
V_WIND_SPEED                    [Various, see section 5]
PRESS                           [Various, see section 5]
SHORT_RAD_IN                    [Various, see section 5]
LONG_RAD_IN                     [Various, see section 5]
PRECIP                          [Hmet-01 Phase 3 data set]
CRTFCN_CODE                     [BORIS Designation]
REVISION_DATE                   [BORIS Designation]
```

7.3.5 Data Range

The data ranges for each variable were not computed for this data set.

7.4 Sample Data Record

The following are wrapped versions of data record from a sample data file:

```
SITE_NAME,DATE_OBS,TIME_OBS,AIR_TEMP,VAPOR_PRESS_DEF,U_WIND_SPEED,
V_WIND_SPEED,PRESS,SHORT_RAD_IN,LONG_RAD_IN,PRECIP,CRTFCN_CODE,
REVISION_DATE
NSA-FEN-FLXTR,1-Jan-94,0,-33.11,6.18,2.22,0.04,98837.48,0.03,161.26,0,
CPI,27-Dec-00
NSA-FEN-FLXTR,1-Jan-94,100,-34.19,5.48,2.19,-0.27,98837.48,0.02,159.28,0,
CPI,27-Dec-00
NSA-FEN-FLXTR,1-Jan-94,200,-33.89,5.52,1.9,0.04,98827.89,0.15,160.01,0,
CPI,27-Dec-00
```

Return to top of document.

8. Data Organization

8.1 Data Granularity

There is one file for each year at each site, from 1994 through 1996.

8.2 Data Format(s)

The files are ASCII, comma-delimited, one record of data per hour. There are no spaces between the fields.

Return to top of document.

9. Data Manipulations

See also section 6, which describes how the individual station data were "cleaned" before constructing continuous data sets.

9.1 Formulae

Not applicable

9.1.1 Derivation Techniques and Algorithms

Not applicable

9.2 Data Processing Sequence

9.2.1 Processing Steps

After cleaning and aggregating the individual data sites as described in section 6, these individual sites were combined to produce continuous, above canopy, data sets at the tower flux sites.

Data processing consisted of the following steps:

1. The general procedure for constructing a continuous data set started with the selection of a base data set for each of the variables at each of the flux towers (Table 9.1). This base data set covered as much of the period as possible, and was as complete as possible. In general, if available, SRC data sets were selected for this purpose, otherwise, tower observations were chosen.

   Next, correlation and regression equations were calculated between the base variables, and all similar variables at the same and other sites. For example, the above canopy air temperature measured at the SSA-OA SRC site was chosen as the base variable for the above canopy air temperature at the SSA-OA site. This temperature series was then correlated with all other air temperatures within a radius of 250 km, at all levels. That is, the above canopy temperature was correlated with temperatures measured at other levels at the same site, as well as with temperatures at all levels at other sites.
2. The other data series were then sorted according to decreasing correlation with the base data set, and were used in that order for filling in missing data. Only data series that had more than one hundred points in common with the base data set were used in the filling process (since otherwise the correlation could easily be erroneous). For this reason it is important that the base data set covers as long a period as possible.
3. Missing values of air temperature, zonal and meridional wind speeds, pressure and longwave radiation were filled based on the regression equation between the base data sets and the other data sets. Thus

   $$Xnew = a + b * X$$

   where:

Xnew	New data value (missing in the base data set)
a, b	regression coefficients
X	Value in data set that has the highest correlation with the base data set and that is not missing.

   Missing values of vapor pressure deficit and shortwave radiation were filled by scaling the value in the "other" data series by the ratio of the means. This was done to prevent the occurrence of negative values, thus

   $$Xnew = M\_base/M\_other * X$$

where:

Xnew	New data value (missing in the base data set)
M_base	Mean of the base data set based on those values coincident with the other data set
M_other	Mean of the other data set based on those values coincident with the base data set
X	Value in data set that has the highest correlation with the base data set and that is not missing.

4. The above procedure does not produce satisfactory results for precipitation, since precipitation is not highly correlated between various sites on such short time scales (1 hour). Thus, the precipitation has been taken from the regional data set produced by Valentijn Pauwels. This regional data set covers the entire BOREAS region, and has a spatial resolution of 5' longitude by 10' latitude.

Table 9.2 Base data set used for each variable for each site.

Tower Site	Variable	Base Site	Base Variable
NSA-FEN	AIR_TEMP	NSA-FEN-FLXTR-9TF10-FLX01	air temperature at 7.5 m
	VAPOR_PRESS_DEF	NSA-FEN-FLXTR-9TF10-FLX01	generated from temperature and relative humidity at 7.5 m
	U_WIND_SPEED	NSA-FEN-FLXTR-9TF10-FLX01	generated from wind speed and wind direction at 6 m
	V_WIND_SPEED	NSA-FEN-FLXTR-9TF10-FLX01	generated from wind speed and wind direction at 6 m
	PRESS	NSA-FEN-FLXTR-9TF10-FLX01	atmospheric station pressure
	SHORT_RAD_IN	NSA-FEN-FLXTR-9TF10-FLX01	downwelling solar radiation at 10.47 m
	LONG_RAD_IN	NSA-FEN-FLXTR-9TF10-FLX01	downwelling longwave radiation at 10.33 m
	PRECIP	Val Pauwels' data set	cell 014-052
NSA-OBS	AIR_TEMP	NSA-OBS-FLXTR-9TF03-FLX01	air temperature at 30 m
	VAPOR_PRESS_DEF	NSA-OBS-FLXTR-9TF03-FLX01	generated from air temperature and relative humidity at 30 m
	U_WIND_SPEED	NSA-OBS-FLXTR-9TF03-FLX01	generated from wind speed and wind direction (no height specified in NSA-OBS TF03 file)
	V_WIND_SPEED	NSA-OBS-FLXTR-9TF03-FLX01	generated from wind speed and wind direction (no height specified in NSA-OBS TF03 file)
	PRESS	NSA-FEN-FLXTR-9TF10-FLX01	atmospheric station pressure
	SHORT_RAD_IN	NSA-FEN-FLXTR-9TF10-FLX01	downwelling solar radiation at 10.47 m
	LONG_RAD_IN	NSA-FEN-FLXTR-9TF10-FLX01	downwelling longwave radiation at 10.33 m
	PRECIP	Val Pauwels' data set	cell 014-052
SSA-OBS	AIR_TEMP	SSA-OBS-FLXTR-9TF09-FLX01	air temperature at 26 m
	VAPOR_PRESS_DEF	SSA-OBS-FLXTR-9TF09-FLX01	generated from air temperature at 26 m and vapor pressure at 24 m
	U_WIND_SPEED	SSA-OBS-FLXTR-9TF09-FLX01	generated from wind speed

			and wind direction at 24 m
	V_WIND_SPEED	SSA-OBS-FLXTR-9TF09-FLX01	generated from wind speed and wind direction at 24 m
	PRESS	SSA-OJP-FLXTR-AFM07-SRCA1	atmospheric station pressure
	SHORT_RAD_IN	SSA-OBS-FLXTR-9TF09-FLX01	downwelling shortwave radiation at 16 m
	LONG_RAD_IN	SSA-OJP-FLXTR-AFM07-SRCB1	downwelling longwave radiation at 35.1 m
	PRECIP	Val Pauwels' data set	cell 037-012
SSA-OA	AIR_TEMP	SSA-9OA-FLXTR-AFM07-SRCA1	air temperature at 23.71 m
	VAPOR_PRESS_DEF	SSA-9OA-FLXTR-AFM07-SRCA1	generated from air temperature and relative humidity at 23.71 m
	U_WIND_SPEED	SSA-9OA-FLXTR-AFM07-SRCA1	westerly component of the wind speed at 23.71 m
	V_WIND_SPEED	SSA-9OA-FLXTR-AFM07-SRCA1	southerly component of the wind speed at 23.71 m
	PRESS	SSA-9OA-FLXTR-AFM07-SRCA1	atmospheric station pressure at 21.87 m
	SHORT_RAD_IN	SSA-9OA-FLXTR-AFM07-SRCA1	downwelling solar radiation at 23.71 m
	LONG_RAD_IN	SSA-9OA-FLXTR-AFM07-SRCB1	downwelling longwave radiation at 36.83 m
	PRECIP	Val Pauwels' data set	cell 041-005

9.2.2 Processing Changes

Not applicable

9.3 Calculations

9.3.1 Special Corrections/Adjustments

Since the purpose was to construct an hourly record for the tower flux sites, all data sets were aggregated to an hourly time step. This was done by averaging all observations during a one-hour interval (arithmetic mean). Missing data were not counted in the averaging process. Of course this has the consequence that not all intervals may have included the exact same number of observations (if certain values were missing).

Note: See also section 9, which describes how the continuous data sets were constructed after "cleaning" the individual station files. Some of the variables needed more processing than just quality checking. These additional procedures are discussed below.

9.3.2 Calculated Variables

Vapor Pressure Deficit

For sites that reported relative humidity instead of vapor pressure deficit, vapor pressure deficit was calculated based on the temperature and relative humidity at the same level (or as close as possible). If either the temperature or relative humidity were missing for a given time step, the vapor pressure deficit value was set to 'missing'.

Zonal and Meridional Wind Speeds

or sites that recorded wind speed and wind direction, wind speed was divided into zonal and meridional components. If no further information was given about the wind direction, the assumption was made that it was measured in degrees from true north. If it was indicated that direction was measured with regard to magnetic north, the appropriate correction was made.

Precipitation

All values that were outside reasonable limits were found to correspond to measurement errors. For precipitation, these limits were set to 0 as a minimum, and 200mm as a maximum. See Phase 3 Document (Phase II and III Gridded Meteorological Data set at BOREAS Flux Towers 1994-1996) for more information.

Shortwave Radiation

Additional shortwave time series were generated from the daily historic stations operated by the AES Canada. A daily average transmissivity of the atmosphere was calculated based on the difference between the maximum and minimum daily temperatures, and this correction was applied to the top of the atmosphere radiation generated using standard algorithms. Although this will most likely lead to a biased shortwave radiation amount, the methods used for filling in the missing data at the tower flux sites, as explained in section 9, should remove this bias to some extent. This was done only a last resort.

Longwave Radiatuon

Longwave radiation was only measured at a limited number of sites in the BOREAS area, and even using all available observations it was not possible to construct a continuous record from observations alone. To augment the record, longwave radiation was calculated from air temperature, humidity, and cloudiness reported by he hourly historic stations operated by AES Canada.

9.4 Graphs and Plots

Not applicable

Return to top of document.

10. Errors

10.1 Sources of Error

Errors for any given point or grid position can result from following:

1. Measurement errors (systematic and random sensor errors).
2. Diurnal cycle was imposed on temperature data by assuming that minimum temperature occurred in hour before sun rise and maximum temperature in afternoon when solar zenith angle increases most rapidly. Second order Hermite polynomials were then fit through these daily minimum and maximum temperatures. Resulting data series then resembles observed diurnal cycle and preserves observed minimum and maximum temperatures.
3. No LW observations were available for first 20 days of January-1994 (hour 0 on Jan 1 to hour 20 on Jan 20). These data are filled in from an approximation formula based on air temperature, humidity, and cloud cover at AES hourly sites and then interpolated.
4. For December, January and February of each year, on a few occasions, the diurnal cycle was imposed on daily measured precipitation to produce hourly precipitation. Therefore, attention should be given to daily totals rather than hourly totals. Since in winter, precipitation amount is more important than exact time precipitation falls, this source of error is assumed to be acceptable for modeling purposes.
5. Winter precipitation is probably on low side. Not only are measurements during this period limited, but measurement of snowfall is generally more problematic than measurement of rainfall.

10.2 Data Quality Assessment

10.2.1 Data Validation by Source

All the sites were quality checked by first removing obvious outliers, and then a visual check was performed on all the remaining data by plotting the variables. All data points that were obviously problematic were assigned missing values.

In addition the following changes were made:

1. all relative humidity values greater than 100% were set to 100%
2. all vapor pressure deficits smaller than 0 were set to 0
3. all incoming SW radiation fluxes smaller than 0 were set to 0

10.2.2 Confidence Level/Accuracy Judgment

None.

10.2.3 Measurement Error for Parameters

None given.

10.2.4 Additional Quality Assessments

None.

10.2.5 Data Verification by Data Center

None.

Return to top of document.

11. Notes

11.1 Limitations of the Data

See section 10.1 and 11.2.

11.2 Known Problems with the Data

The winter precipitation is probably on the low side. Not only are measurements during this period limited, but measurement of snowfall is generally even more problematic than measurement of rainfall.

Since the individual variables have been processed independent of each other, it is possible that at certain times "odd" combinations may occur. It might be worthwhile to attempt and calculate missing longwave data from the radiation balance when all other components are available (as has been done by Dr. Alan K. Betts for a site in the North).

No longwave data were available at the beginning of January 1994. This data is therefore calculated from cloud cover, temperature, and humidity at the AES hourly sites, then interpolated. Care should be taken in using this data.

11.3 Usage Guidance

Care has been taken in constructing the best data set possible. The data is not "error-free". The user should thus make sure that the data set is appropriate for his or her modeling purposes. Please contact "Contact 1" in section 2 if you discover any obvious problems with the data not mentioned here.

11.4 Other Relevant Information

None.

Return to top of document.

12. Application of the Data

Development of these data was motivated by the need to provide standardized meteorological forcing data for different hydrometeorological and carbon assimilation models used in two BOREAS model intercomparison projects. Other applications involving climatological analysis, diagnostic analysis, and modeling experiments are encouraged. Studies are encouraged both within the context of BOREAS scientific framework and within the context of independent investigator-driven projects.

Return to top of document.

13. Future Modifications and Plans

None.

Return to top of document.

14. Software

14.1 Software Description

Custom software was written to manipulate the data files.

14.2 Software Access

The processing software is available upon request, but may not be of much interest to outsiders. The software is closely tied to the data format used for the original files (NetCDF). The final data set is provided in ASCII format.

Return to top of document.

15. Data Access

15.1 Contact for Data Center/Data Access Information

These BOREAS data are available from the Earth Observing System Data and Information System (EOS-DIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC). The BOREAS contact at ORNL is:

ORNL DAAC User Services
Oak Ridge National Laboratory
(865) 241-3952
ornldaac@ornl.gov
ornl@eos.nasa.gov

15.2 Procedures for Obtaining Data

BOREAS data may be obtained through the ORNL DAAC World Wide Web site at http://www.daac.ornl.gov/ [Internet Link] or users may place requests for data by telephone or by electronic mail.

15.3 Output Products and Availability

Requested data can be provided electronically on the ORNL DAAC's anonymous FTP site or on various

media including, CD-ROMs, 8-MM tapes, or diskettes.

Return to top of document.

16. Output Products and Availability

16.1 Tape Products

None.

16.2 Film Products

None.

16.3 Other Products

The three phases of the BOREAS hydrometeorological model intercomparison forcing data are also available on CD-ROM. Contact Eric Smith to obtain this set.

Return to top of document.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

None.

17.2 Journal Articles and Study Reports

Sellers, P., F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

Sellers, P., F. Hall. 1996. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1996-2.0, NASA BOREAS Report (EXPLAN 96).

Sellers, P., F. Hall, K.F. Huemmrich. 1996. Boreal Ecosystem-Atmosphere Study: 1994 Operations. NASA BOREAS Report (OPS DOC 94).

Sellers, P., F. Hall, K.F. Huemmrich. 1997. Boreal Ecosystem-Atmosphere Study: 1996 Operations. NASA BOREAS Report (OPS DOC 96).

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.

17.3 Archive/DBMS Usage Documentation

None.

Return to top of document.

18. Glossary of Terms

None.

Return to top of document.

19. List of Acronyms

```
    AES     - Atmospheric Environment Service
    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
    FEN     - Fen
    IFC     - Intensive Field Campaign
    GMT     - Greenwich Mean Time
    GSFC    - Goddard Space Flight Center
    NASA    - National Aeronautics and Space Administration
    NSA     - Northern Study Area (BOREAS)
    OA      - Old Aspen
    OBS     - Old Black Spruce
    ORNL    - Oak Ridge National Laboratory
    PANP    - Prince Albert National Park
    SSA     - Southern Study Area (BOREAS)
nbsp;   URL     - Uniform Resource Locator (a World Wide Web address)
```

Return to top of document.

20. Document Information

20.1 Document Revision Date

Written: 02-Mar-1999
Last Updated: 23-Jan-2001 (citation revised on 30-Oct-2002)

20.2 Document Review Date(s)

BORIS Review: 31-Oct-2000
Science Review:

20.3 Document ID

hmet03_hourlymet

20.4 Citation

Cite this data set as follows (citation revised on October 30, 2002):

Lettenmaier, D. P., and B. Nijssen. 2001. BOREAS Follow-On HMet-03 Hourly Meteorological Data at Flux Towers, 1994-1996. 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.

20.5 Document Curator:

webmaster@daac.ornl.gov

20.6 Document URL:

http://daac.ornl.gov/BOREAS/FollowOn/guides/hmet03_hourly_met_p1_doc.html

---

Keywords
Meteorological forcing
Model forcing
Vapor Pressure Deficit
Zonal Wind Speed
Meridional Wind Speed
Longwave Radiation
