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

Forrest G. Hall and Jeffrey A. Newcomer, Editors

Volume 16
BOREAS AFM-08 ECMWF Hourly Surface and Upper Air Data for the SSA and NSA

P. Viterbo and A. Betts

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

June 2000
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Volume 16

BOREAS AFM-08 ECMWF Hourly Surface and Upper Air Data for the SSA and NSA

Pedro Viterbo, European Center for Medium-Range Weather Forecasts
Alan Betts, Atmospheric Research

National Aeronautics and Space Administration

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Greenbelt, Maryland 20771

June 2000
Summary

The BOREAS AFM-8 team focused on modeling efforts to improve the understanding of the diurnal evolution of the convective boundary layer over the boreal forest. This data set contains hourly data from the ECMWF operational model from below the surface to the top of the atmosphere, including the model fluxes at the surface. Spatially, the data cover a pair of the points that enclose the rawinsonde sites at Candle Lake, Saskatchewan, in the SSA and Thompson, Manitoba, in the NSA. Temporally, the data include the two time periods of 13-May-1994 to 30-Sept-1994 and 01-Mar-1996 to 31-Mar-1997. The data are stored in tabular ASCII files. The number of records in the upper air data files may exceed 20,000, causing a problem for some software packages.

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1. Data Set Overview

1.1 Data Set Identification
BOREAS AFM-08 ECMWF Hourly Surface and Upper Air Data for the SSA and NSA

1.2 Data Set Introduction
These data were produced by Pedro Viterbo at the European Center for Medium-Range Weather Forecasts (ECMWF) from the operational model at the time, by Pedro Viterbo (ECMWF). They were reviewed by Alan Betts.
1.3 Objective/Purpose
This is an hourly data set for a single column of air from the ECMWF operational model from below the surface to the top of the atmosphere, including the model fluxes at the surface. It is intended to be used primarily for the comparison of the model with surface observations.

1.4 Summary of Parameters
There are two components in this data set:
• A surface component with subsurface variables:
  • Temperature and soil moisture for the first model layer (0-7 cm); and an average for the next three soil layers, 7-289 cm.
  • Surface fluxes of energy, radiation, and water.
  • Atmospheric variables of wind, temperature, mixing ratio, and pressure at model 31, which is about 30 m above the surface.
• An atmospheric component with atmospheric meteorological variables of wind, temperature, mixing ratio, and pressure at 31 levels, starting at approximately 30 m above the surface. The first level is duplicated on the surface data set for convenience. In 1996-97, the atmospheric part contains an additional field for vertical p-velocity (of unknown quality).

These data are values from the ECMWF model and are subject to the errors of the ECMWF model at that time and to the operational model changes.

1.5 Discussion
These are ECMWF model data, which should be useful for comparison with surface flux measurements and as drivers for offline vegetation models, needing continuous atmospheric time-series.

1.6 Related Data Sets
BOREAS ECMWF 6-Hour Analysis and Forecast Data
BOREAS AFM-05 Level-1 Upper Air Network Data
BOREAS AFM-05 Level-2 Upper Air Network Standard Pressure Level Data
BOREAS AES Campbell Scientific Surface Meteorological Data
BOREAS AFM-07 SRC Surface Meteorological Data
BOREAS AES MARSII Surface Meteorological Data
BOREAS AES READAC Surface Meteorological Data

2. Investigator(s)

2.1 Investigator(s) Name and Title
Alan Betts
Atmospheric Research

Pedro Viterbo
ECMWF

2.2 Title of Investigation
Boundary Layer Research for BOREAS

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2.3 Contact Information

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011-44-1189-869450 (fax)

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Code 923
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Greenbelt, MD 20771
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(301) 286-0239 (fax)
Jeffrey.Newcomer@gsfc.nasa.gov

3. Theory of Measurements

These data are from the ECMWF operational model. The user is encouraged to see the ECMWF manuals for the model physics.

4. Equipment

4.1 Sensor/Instrument Description
The ECMWF uses surface and upper air data from numerous sources and locations around Earth to create its 6-hour forecast product. The output data are created using multivariate optimal interpolation analysis, followed by nonlinear normal model initialization, before 29-Jan-1996 and 3D-VAR from 30-Jan-1996, and a high-resolution spectral model that produces a first-guess forecast for the subsequent analysis. Data were assimilated every 6 hours.

4.1.1 Collection Environment
The input data used in the ECMWF models are collected from a wide range of global stations that are operated in ambient atmospheric conditions.

4.1.2 Source/Platform
The platforms from which the input data were collected include human observers, fixed towers of various sorts, and tethered and free-flying balloons.
4.1.3 Source/Platform Mission Objectives
Not applicable.

4.1.4 Key Variables
This data set contains meteorological parameters that were produced from an ECMWF model.

4.1.5 Principles of Operation
Not applicable.

4.1.6 Sensor/Instrument Measurement Geometry
Not applicable.

4.1.7 Manufacturer of Sensor/Instrument
The ECMWF in Reading, England.

4.2 Calibration

4.2.1 Specifications
Not applicable.

4.2.1.1 Tolerance
Not applicable.

4.2.2 Frequency of Calibration
Not applicable.

4.2.3 Other Calibration Information
The land-surface scheme is discussed in Viterbo and Beljaars (1995).

5. Data Acquisition Methods
The ECMWF uses surface and upper air data from numerous sources and locations around Earth to create its 6-hour forecast product. The 6-hour data are created using multivariate optimal interpolation analysis, followed by nonlinear normal model initialization, before 29-Jan-1996 and 3D-VAR from 30-Jan-1996, and a high-resolution spectral model that produces a first-guess forecast for the subsequent analysis. Data are assimilated every 6 hours.

6. Observations

6.1 Data Notes
None given.

6.2 Field Notes
Not applicable.
7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage
The Candle Lake data are a 2-grid point average of grid points between 53.4° N and 54.5° N latitude and 104.4° W and 105.4° W longitude. Each grid point is approximately 50 x 50 km. The Thompson data are a single grid point at 55.88° N latitude, 98° W longitude in 1994 and 55.88° N, 98.44° W in 1996. The difference in grid cell location over Thompson between the years is due to a change in the ECMWF grid. These points are marked on Figure 3.2.2 of the BOREal Ecosystem-Atmosphere Study (BOREAS) May 1994 Experiment Plan (Sellers and Hall, 1994). Although their location may shift a little during the experiment, they are to be considered as representative of the Southern Study Area (SSA) and Northern Study Area (NSA).

The approximate boundaries of the areas described above are listed below in BOREAS grid coordinates based on the North American Datum of 1983 (NAD83).

SSA

<table>
<thead>
<tr>
<th>Corner</th>
<th>BOREAS_X</th>
<th>BOREAS_Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northwest</td>
<td>361.990</td>
<td>404.083</td>
</tr>
<tr>
<td>Northeast</td>
<td>426.452</td>
<td>409.746</td>
</tr>
<tr>
<td>Southeast</td>
<td>438.053</td>
<td>287.745</td>
</tr>
<tr>
<td>Southwest</td>
<td>371.837</td>
<td>281.928</td>
</tr>
</tbody>
</table>

NSA 1994

<table>
<thead>
<tr>
<th>Corner</th>
<th>BOREAS_X</th>
<th>BOREAS_Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northwest</td>
<td>782.800</td>
<td>643.991</td>
</tr>
<tr>
<td>Northeast</td>
<td>832.800</td>
<td>643.991</td>
</tr>
<tr>
<td>Southeast</td>
<td>832.800</td>
<td>593.991</td>
</tr>
<tr>
<td>Southwest</td>
<td>782.800</td>
<td>593.991</td>
</tr>
</tbody>
</table>

NSA 1996

<table>
<thead>
<tr>
<th>Corner</th>
<th>BOREAS_X</th>
<th>BOREAS_Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northwest</td>
<td>755.762</td>
<td>638.971</td>
</tr>
<tr>
<td>Northeast</td>
<td>805.762</td>
<td>638.971</td>
</tr>
<tr>
<td>Southeast</td>
<td>805.762</td>
<td>588.971</td>
</tr>
<tr>
<td>Southwest</td>
<td>755.762</td>
<td>588.971</td>
</tr>
</tbody>
</table>

7.1.2 Spatial Coverage Map
Not available.

7.1.3 Spatial Resolution
Each original grid cell was approximately 50 x 50 km. Since the data for the SSA were derived from averaging two adjacent (east-west) grid cells together, the SSA data represent a 100 km (east-west) by 50 km (north-south) area.

7.1.4 Projection
Not applicable.
7.1.5 Grid Description
Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage
The data cover the periods of 13-May-1994 to 30-Sept-1994 and 01-Mar-1996 to 31-Mar-1997. We have included a full 13-month year for 1996-97 because there was a significant model change in August 1996, which corrected the subsurface temperatures and in December 1997, which corrected the snow albedo error. Comparing the 1996 and 1997 data will draw attention to this issue.

7.2.2 Temporal Coverage Map
Not available.

7.2.3 Temporal Resolution
Each 24-hr day of hourly model data is the 12- to 35-hr forecast (the 11-35 hr forecast for the fluxes) extracted from a daily 72-hr global forecast from the preceding 1200 Universal Time Code (UTC) analysis. Occasional forecasts are missing, and that day's data then come from the 36- to 59-hr forecast (36- to 59-hr for fluxes) from the preceding day's 1200 UTC analysis. The data are given in hourly time steps.

Note that all the flux values are averages for the preceding hour. All other variables are instantaneous values at that time. Consequently, flux data labeled for UTC = 00 are actually from the preceding day at 2300-2400.

7.3 Data Characteristics

7.3.1 Parameter/Variable
The parameters contained in the data files on the CD-ROM are:

**APM08_ECMWF_SURFACE**

<table>
<thead>
<tr>
<th>Column Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
</tr>
<tr>
<td>SUB_SITE</td>
</tr>
<tr>
<td>DATE_OBS</td>
</tr>
<tr>
<td>TIME_OBS</td>
</tr>
<tr>
<td>FORECAST_DATE</td>
</tr>
<tr>
<td>ATMOSPHERIC_PRESS_L31</td>
</tr>
<tr>
<td>U_COMPAT_WIND_VELOC_L31</td>
</tr>
<tr>
<td>V_COMPAT_WIND_VELOC_L31</td>
</tr>
<tr>
<td>AIR_TEMP_L31</td>
</tr>
<tr>
<td>MIX_RATIO_L31</td>
</tr>
<tr>
<td>SOIL_TEMP_0_7_CM</td>
</tr>
<tr>
<td>SOIL_WATER_0_7_CM</td>
</tr>
<tr>
<td>SOIL_TEMP_7_289_CM</td>
</tr>
<tr>
<td>SOIL_WATER_7_289_CM</td>
</tr>
<tr>
<td>SNOW_DEPTH</td>
</tr>
<tr>
<td>SURFACE_PRESS</td>
</tr>
<tr>
<td>NET_SHORTWAVE_RAD</td>
</tr>
<tr>
<td>NET_LONGWAVE_RAD</td>
</tr>
<tr>
<td>LATENT_HEAT_FLUX</td>
</tr>
<tr>
<td>LATENT_HEAT_FLUX_SNOW</td>
</tr>
<tr>
<td>SENSIBLE_HEAT_FLUX</td>
</tr>
<tr>
<td>HEAT_FLUX_SOIL_1_2</td>
</tr>
</tbody>
</table>

Page 6
HEAT_FLUX_SNOW_MELT
WATER_SNOW_MELT
LARGE_SCALE_RAIN
CONVEXTIVE_SCALE_RAIN
LARGE_SCALE_SNOW
CONVEXTIVE_SCALE_SNOW
SOIL_WATER_1_2
RUNOFF_1
DEEP_RUNOFF
CRTFCN_CODE
REVISION_DATE

**AFM08 ECMWF_UPPER_AIR**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
<td>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.</td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>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.</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>The date on which the data were collected.</td>
</tr>
<tr>
<td>TIME_OBS</td>
<td>The Greenwich Mean Time (GMT) when the data were collected.</td>
</tr>
<tr>
<td>FORECAST_DATE</td>
<td>Initial date of forecast analysis.</td>
</tr>
</tbody>
</table>

**7.3.2 Variable Description/Definition**

The descriptions of the parameters contained in the data files on the CD-ROM are:
The atmospheric pressure at Level 31, which is approximately 30 m above the surface.
The U component wind velocity at Level 31, which is approximately 30 m above the surface.
The V component wind velocity at Level 31, which is approximately 30 m above the surface.
The air temperature at Level 31, which is approximately 30 m above the surface.
The atmospheric mixing ratio at level 31, which is approximately 30 m above the surface.
The soil temperature at a depth of 0 to 7 cm.
The soil water content at a depth of 0 to 7 cm.
The soil temperature at a depth of 7 to 289 cm.
The soil water content at a depth of 7 to 289 cm.
The depth of snow on the ground.
The surface pressure.
The net shortwave radiation.
The net longwave radiation.
The latent heat flux.
The latent heat flux (evaporation above snow).
The sensible heat flux.
The heat flux from soil layer 1 (surface) to layer 2.
The heat flux from snow melt.
The water added to soil from snow melt.
The large-scale rain.
The convective scale rain.
Large scale snow.
Convective scale snow.
The flux of water from soil layer 1 to layer 2.
Runoff from layer 1.
The deep runoff.
The BOREAS certification level of the data.
Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-?? (CPI but questionable).
The most recent date when the information in the referenced data base table record was revised.

**AFM08_ECMWF_UPPER_AIR**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
<td>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.</td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>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</td>
</tr>
</tbody>
</table>
To represent the vertical variation of the dependent variables (wind components, temperature, specific humidity, cloud cover, cloud liquid water contents, and cloud ice water contents, the atmosphere is divided into NLEV layers. These layers are defined by the pressures at the interfaces between them (the 'half-levels'), and these pressures are given by

\[ p(k+1/2) = A(k+1/2) + B(k+1/2) \times ps \]

for 0 <= k <= NLEV, and where ps is surface pressure. The A(k+1/2) and B(k+1/2) are constants whose values effectively define the vertical coordinate (see table below). Notice that model levels are labeled top to bottom, i.e., the half-levels p(0+1/2) and p(NLEV+1/2) are, respectively, top of the atmosphere and surface.

The prognostic variables are represented by their values at 'full-level' pressures p(k), 1 <= k < NLEV. Values for p(k) are given by

\[ p(k) = 0.5 \times [p(k-1/2) + p(k+1/2)] \]

1 <= k <= NLEV

As can be seen in the table below, the model levels are pressure levels at the top (B=0) and sigma levels at the bottom (A=0). The name hybrid levels reflects that.

<table>
<thead>
<tr>
<th>k</th>
<th>A(k+1/2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0+1/2</td>
<td>0.0000000</td>
</tr>
<tr>
<td>1+1/2</td>
<td>2000.000000</td>
</tr>
<tr>
<td>2+1/2</td>
<td>4000.000000</td>
</tr>
<tr>
<td>3+1/2</td>
<td>6000.000000</td>
</tr>
<tr>
<td>4+1/2</td>
<td>8000.000000</td>
</tr>
<tr>
<td>5+1/2</td>
<td>9976.135361</td>
</tr>
<tr>
<td>6+1/2</td>
<td>11820.539617</td>
</tr>
<tr>
<td>7+1/2</td>
<td>13431.393926</td>
</tr>
<tr>
<td>8+1/2</td>
<td>14736.356909</td>
</tr>
<tr>
<td>9+1/2</td>
<td>15689.207458</td>
</tr>
<tr>
<td>10+1/2</td>
<td>16266.610500</td>
</tr>
<tr>
<td>11+1/2</td>
<td>16465.005734</td>
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<tr>
<td>12+1/2</td>
<td>16297.619332</td>
</tr>
<tr>
<td>13+1/2</td>
<td>15791.598604</td>
</tr>
<tr>
<td>14+1/2</td>
<td>14985.269630</td>
</tr>
<tr>
<td>15+1/2</td>
<td>13925.517858</td>
</tr>
<tr>
<td>16+1/2</td>
<td>12665.291662</td>
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<td>21+1/2</td>
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<td>23+1/2</td>
<td>2911.569385</td>
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<tr>
<td>24+1/2</td>
<td>1954.805296</td>
</tr>
<tr>
<td>25+1/2</td>
<td>1195.889791</td>
</tr>
</tbody>
</table>
\[
\begin{aligned}
A(26+1/2) &= 638.148911 \\
A(27+1/2) &= 271.626545 \\
A(28+1/2) &= 72.063577 \\
A(29+1/2) &= 0.000000 \\
A(30+1/2) &= 0.000000 \\
A(31+1/2) &= 0.000000 \\
\end{aligned}
\]

\[
\begin{aligned}
B(0+1/2) &= 0.0000000000 \\
B(1+1/2) &= 0.0000000000 \\
B(2+1/2) &= 0.0000000000 \\
B(3+1/2) &= 0.0000000000 \\
B(4+1/2) &= 0.0000000000 \\
B(5+1/2) &= 0.0003908582 \\
B(6+1/2) &= 0.0029197006 \\
B(7+1/2) &= 0.0091941320 \\
B(8+1/2) &= 0.0203191555 \\
B(9+1/2) &= 0.0369748598 \\
B(10+1/2) &= 0.0594876397 \\
B(11+1/2) &= 0.0878949492 \\
B(12+1/2) &= 0.1220035886 \\
B(13+1/2) &= 0.1614415235 \\
B(14+1/2) &= 0.2057032385 \\
B(15+1/2) &= 0.2541886223 \\
B(16+1/2) &= 0.3062353873 \\
B(17+1/2) &= 0.3611450218 \\
B(18+1/2) &= 0.4182022749 \\
B(19+1/2) &= 0.4766081754 \\
B(20+1/2) &= 0.5358865832 \\
B(21+1/2) &= 0.5950842740 \\
B(22+1/2) &= 0.6535645569 \\
B(23+1/2) &= 0.7105944258 \\
B(24+1/2) &= 0.7654052430 \\
B(25+1/2) &= 0.8171669567 \\
B(26+1/2) &= 0.8649558510 \\
B(27+1/2) &= 0.9077156297 \\
B(28+1/2) &= 0.9442132326 \\
B(29+1/2) &= 0.9729851852 \\
B(30+1/2) &= 0.9922814815 \\
B(31+1/2) &= 1.0000000000 \\
\end{aligned}
\]

ATMOSPHERIC_PRESS
U_COMPNT_WIND_VELOC
V_COMPNT_WIND_VELOC
AIR_TEMP
ECMWF_MIX_RATIO
ATMOS_OMEGA_VELOC

The atmospheric pressure.
The westerly (from the west) vector component of the wind speed and wind direction.
The southerly (from the south) vector component of the wind speed and wind direction.
The air temperature.
The atmospheric mixing ratio.
The atmospheric omega velocity.

Note: ATMOS_OMEGA_VELOC is also described as the rate of change of pressure in the model hybrid levels.
The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-?? (CPI but questionable).

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:

<table>
<thead>
<tr>
<th>AFM08_ECMWF_SURFACE</th>
<th>Column Name</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
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<td></td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>[none]</td>
<td></td>
</tr>
<tr>
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<td>[meters][second^-1]</td>
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</tr>
<tr>
<td>AIR_TEMP_L31</td>
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<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>SOIL_TEMP_0_7_CM</td>
<td>[degrees Celsius]</td>
<td></td>
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<tr>
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<td>[fraction by volume]</td>
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</tr>
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<td>[fraction by volume]</td>
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</tr>
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<td>SNOW_DEPTH</td>
<td>[millimeters]</td>
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</tr>
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<td>[Watts][meter^-2]</td>
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</tr>
<tr>
<td>NET_LONGWAVE_RAD</td>
<td>[Watts][meter^-2]</td>
<td></td>
</tr>
<tr>
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<td>[Watts][meter^-2]</td>
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<tr>
<td>LATENT_HEAT_FLUX_SNOW</td>
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<td>SENSIBLE_HEAT_FLUX</td>
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<tr>
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<tr>
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<td>WATER_SNOW_MELT</td>
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<tr>
<td>LARGE_SCALE_RAIN</td>
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<tr>
<td>CONVECTIVE_SCALE_RAIN</td>
<td>[kilograms][meter^-2][second^-1]</td>
<td></td>
</tr>
<tr>
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<td>CONVECTIVE_SCALE_SNOW</td>
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<td>[kilograms][meter^-2][second^-1]</td>
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<td>REVISION_DATE</td>
<td>[DD-MON-YY]</td>
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### AFM08_ECMWF_UPPER_AIR

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<td>DATE_OBS</td>
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<tr>
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<td>LEVEL_NUM</td>
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<td>ATMOSPHERIC_PRESS</td>
<td>[kiloPascals]</td>
</tr>
<tr>
<td>U_COMPNT_WIND_VELOC</td>
<td>[meters][second^-1]</td>
</tr>
<tr>
<td>V_COMPNT_WIND_VELOC</td>
<td>[meters][second^-1]</td>
</tr>
<tr>
<td>AIR TEMP</td>
<td>[degrees Celsius]</td>
</tr>
<tr>
<td>ECMWF_MIX_RATIO</td>
<td>[kilograms water vapor][kilogram dry air^-1]</td>
</tr>
<tr>
<td>ATMOS_OMEGA_VELOC</td>
<td>[Pascals][second^-1]</td>
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<td>CRTFCN_CODE</td>
<td>[none]</td>
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<tr>
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<td>[DD-MON-YY]</td>
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### 7.3.4 Data Source

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

### AFM08_ECMWF_SURFACE

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<th>Data Source</th>
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<td>[Assigned by BORIS]</td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>[Assigned by BORIS]</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>[Supplied by Investigator]</td>
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<tr>
<td>TIME_OBS</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>FORECAST_DATE</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>ATMOSPHERIC_PRESS_L31</td>
<td>[Supplied by Investigator]</td>
</tr>
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<td>U_COMPNT_WIND_VELOC_L31</td>
<td>[Supplied by Investigator]</td>
</tr>
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<td>V_COMPNT_WIND_VELOC_L31</td>
<td>[Supplied by Investigator]</td>
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<tr>
<td>AIR_TEMP_L31</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>MIX_RATIO_L31</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>SOIL_TEMP_0_7_CM</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>SOIL_WATER_0_7_CM</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>SOIL_TEMP_7_289_CM</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>SOIL_WATER_7_289_CM</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>SNOW_DEPTH</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>SURFACE_PRESS</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>NET_SHORTWAVE_RAD</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>NET_LONGWAVE_RAD</td>
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</tr>
<tr>
<td>LATENT_HEAT_FLUX</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>LATENT_HEAT_FLUX_SNOW</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>SENSIBLE_HEAT_FLUX</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>HEAT_FLUX_SOIL_1_2</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>HEAT_FLUX_SNOW_MELT</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>WATER_SNOW_MELT</td>
<td>[Supplied by Investigator]</td>
</tr>
<tr>
<td>LARGE_SCALE_RAIN</td>
<td>[Supplied by Investigator]</td>
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<tr>
<td>CONVECTIVE_SCALE_RAIN</td>
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<tr>
<td>LARGE_SCALE_SNOW</td>
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<tr>
<td>CONVECTIVE_SCALE_SNOW</td>
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</tr>
<tr>
<td>SOIL_WATER_1_2</td>
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The following table gives information about the parameter values found in the data files on the CD-ROM.

### AFM08 ECMWF_SURFACE

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<th>Missng</th>
<th>Unrel</th>
<th>Below</th>
<th>Data Limit</th>
<th>Clldct</th>
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<tbody>
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LATENT HEAT FLUX -535.01 33.834 None None None None
LATENT HEAT FLUX SNOW -260.01 41.209 None None None None
SENSIBLE HEAT FLUX -533.31 216.31 None None None None
HEAT_FLUX_SOIL_1_2 -107.74 104.86 None None None None
HEAT_FLUX_SNOW_MELT -116.18 6.576 None None None None
WATER_SNOW_MELT 0 .0003 None None None None
LARGE_SCALE_RAIN 0 .003 None None None None
CONVECTIVE_SCALE_RAIN 0 .001 None None None None
LARGE_SCALE_SNOW 0 .001 None None None None
CONVECTIVE_SCALE_SNOW 0 0 None None None None
SOIL_WATER_1_2 0 .002 None None None None
RUNOFF_1 0 0 None None None None
DEEP_RUNOFF 0 0 None None None None
CRTFCN_CODE CPI CPI None None None None
REVISION_DATE 14-JAN-99 15-JAN-99 None None None None

AFM08_ECMWF_UPPER_AIR

<table>
<thead>
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<th>Column Name</th>
<th>Minimum Data Value</th>
<th>Maximum Data Value</th>
<th>Missng Data Value</th>
<th>Unrel Data Value</th>
<th>Below Detect Limit</th>
<th>Data Limit Collectd</th>
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<td>19-JAN-99</td>
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</tbody>
</table>

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.
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 sample data files on the CD-ROM.

AFM08 ECMWF SURFACE
SITE_NAME, SUB_SITE, DATE_OBS, TIME_OBS, FORECAST_DATE, ATMOSPHERIC_PRESS_L31, U_COMPNT_WIND_VELOC_L31, V_COMPNT_WIND_VELOC_L31, AIR_TEMP_L31, MIX_RATIO_L31, SOIL_TEMP_0_7_CM, SOIL_WATER_0_7_CM, SOIL_TEMP_7_289_CM, SOIL_WATER_7_289_CM, SNOW_DEPTH, SURFACE_PRESS, NET_SHORTWAVE_RAD, NET_LONGWAVE_RAD, LATENT_HEAT_FLUX, LATENT_HEAT_FLUX_SNOW, SENSIBLE_HEAT_FLUX, HEAT_FLUX_SOIL_1_2, HEAT_FLUX_SNOW_MELT, WATER_SNOW_MELT, LARGE_SCALE_SNOW, CONVECTIVE_SCALE_SNOW, SOIL_WATER_1_2, RUNOFF_1, DEEP_RUNOFF, CRTFCN_CODE, REVISION_DATE

'NSA', '', 13-MAY-94, 0, 12-MAY-94, 97.422, -2.5635, 1.5938, 9.95, .0035819, 4.88, .23921, -12.71, .26537, 0.0, 97.8, 153.73, -39.502, -48.044, -21.509, 41.824, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 'CPI', 15-JAN-99

'NSA', '', 13-MAY-94, 100, 12-MAY-94, 97.383, -3.0332, 1.1714, 9.0, .0036931, 4.53, .23925, -12.69, .26536, 0.0, 97.761, 44.485, -31.159, -21.423, 0.0, 34.528, 40.097, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 'CPI', 15-JAN-99

AFM08 ECMWF UPPER AIR
SITE_NAME, SUB_SITE, DATE_OBS, TIME_OBS, FORECAST_DATE, LEVEL_NUM, ATMOSPHERIC_PRESS, U_COMPNT_WIND_VELOC, V_COMPNT_WIND_VELOC, AIR_TEMP, ECMWF_MIX_RATIO, ATMOS_OMEGA_VELOC, CRTFCN_CODE, REVISION_DATE

'NSA', '', 01-SEP-96, 0, 31-AUG-96, 1, 1.0, 6.6485, -2.3998, 41.39, .0000024097, .0011975, 'CPI', 19-JAN-99

'NSA', '', 01-SEP-96, 0, 31-AUG-96, 2, 3.0, 1.7841, -3.5077, -48.044, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 'CPI', 19-JAN-99
8. Data Organization

8.1 Data Granularity
The smallest unit of data tracked by the BOREAS Information System (BORIS) was the data collected at a given site on a given date.

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

9.1.1 Derivation Techniques and Algorithms
For a detailed description of the ECMWF/WCRP Level III-A Global Atmospheric Data Archive, see ECMWF ECMWF/WCRP Level III-A Global Atmospheric Data Archive Technical Attachment.

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
See Section 9.1.1.

9.3.2 Calculated Variables
See Section 9.1.1.

9.4 Graphs and Plots
None.
10. Errors

10.1 Sources of Error
These are ECMWF model data and are subject to the errors of the ECMWF model at that time. Note the following model changes:
- July 1 +/-, 1994: The root zone soil water reservoir was reflooded. There is a discontinuity on that date.
- November 1994: Soil water nudging was added.
- April 1995: Major model change; prognostic cloud scheme and new orographic drag scheme.
- September 1996: Changes to the stable BL scheme and the coupling to the ground; this affects ground temperatures.
- December 1996: Changes to the snow albedo scheme. Prior to this date there are large errors over the boreal forest in surface albedo, net radiation, and surface temperature, when there is snow on the ground in the model. The data in March and April 1996 have this error. Comparing March 1996 and 1997 will show differences.

10.2 Quality Assessment

10.2.1 Data Validation by Source
Refer to papers listed in Section 17.2 on validation and structure of ECMWF model surface physics by Viterbo and Beljars (1995), Beljars et al. (1996), and Betts et al. (1996, 1997a, 1997b).

10.2.2 Confidence Level/Accuracy/Judgment
None given.

10.2.3 Measurement Error for Parameters
None given.

10.2.4 Additional Quality Assessments
None given.

10.2.5 Data Verification by Data Center
The data were reviewed for general content and consistency with descriptions provided by the science team. BORIS staff loaded the data received from Airborne Fluxes and Meteorology (AFM)-08 and checked to make sure that no errors occurred during the loading process.

11. Notes

11.1 Limitations of the Data
These are ECMWF model data and are subject to the errors of the ECMWF model at that time. The reader is encouraged to review the provided references.

11.2 Known Problems with the Data
See Section 10.

11.3 Usage Guidance
These are ECMWF model data, subject to the errors of the ECMWF model at that time. Note that all the flux values are averages for the preceding hour. All other variables are instantaneous values at that time. Consequently, flux data labeled for UTC = 00 are actually from the preceding day at 2300-2400. The number of records in each of the upper air data files may exceed 20,000, causing a problem for some software packages.
11.4 Other Relevant Information

Other data points are available, but we believe that these two will be the most useful to BOREAS investigators, given the quality of the operational model at the time. We had hoped to get these data from the later ECMWF reanalysis, but at present this reanalysis stops at February 1994.

The upper air tendency and advection data are still questionable, so we have not included them. The upper air omega data may have some use, so we have included them in 1996, but they have not been validated in any way and could be in error.

12. Application of the Data Set

This is a single-column hourly data set from the ECMWF operational model from below the surface to the top of the atmosphere, including the model fluxes at the surface. It is intended to be used primarily for the comparison of model with surface observations.

13. Future Modifications and Plans

We recommend that users of these data contact the Principal Investigators (PIs) to be informed of any relevant results.

14. Software

14.1 Software Description

The software used were the ECMWF operational model and some postprocessing by the Research Department.

14.2 Software Access

Requests for ECMWF software should be sent directly to the Director, ECMWF. It is not generally available to nonmember countries, but specific physics subroutines might be released on request.

15. Data Access

The ECMWF hourly surface and upper air 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
15.3 Procedures for Obtaining Data
Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.orl.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
None.

17.2 Journal Articles and Study Reports


17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

AFM - Airborne Fluxes and Meteorology
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
ECMWF - European Centre for Medium-Range Weather Forecasts
EOS - Earth Observing System
EOSDIS - EOS Data and Information System
GIS - Geographic Information System
GMT - Greenwich Mean Time
GSFC - Goddard Space Flight Center
HTML - HyperText Markup Language
NASA - National Aeronautics and Space Administration
NSA - Northern Study Area
ORNL - Oak Ridge National Laboratory
PANP - Prince Albert National Park
PI - Principal Investigator
SSA - Southern Study Area
URL - Uniform Resource Locator
UTC - Universal Time Code
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Science Review:

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20.4 Citation
When using these data, please include the following acknowledgment as well as citations of relevant papers in Section 17.2:
This data set was produced by Pedro Viterbo at ECMWF, and Alan Betts of Atmospheric Research with support from NASA under Contract NAS5-32356.

If using data from the BOREAS CD-ROM series, also reference the data as:

Also, cite the BOREAS CD-ROM set as:

20.5 Document Curator

20.6 Document URL
The BOREAS AFM-8 team focused on modeling efforts to improve the understanding of the diurnal evolution of the convective boundary layer over the boreal forest. This data set contains hourly data from the ECMWF operational model from below the surface to the top of the atmosphere, including the model fluxes at the surface. Spatially, the data cover a pair of the points that enclose the rawinsonde sites at Candle Lake, Saskatchewan, in the SSA and Thompson, Manitoba, in the NSA. Temporally, the data include the two time periods of 13-May-1994 to 30-Sept-1994 and 01-Mar-1996 to 31-Mar-1997. The data are stored in tabular ASCII files. The number of records in the upper air data files may exceed 20,000, causing a problem for some software packages.