BOREAS FOLLOW-ON HMET-02 AREA AND REGIONAL HOURLY GRIDDED MET. DATA, 1994-1996

Get Data

Summary

Area (Phase 2) and regional (Phase 3) gridded data sets have been generated by an objective analysis scheme using all of the surface meteorological station data over BOREAS region for 1994-1996. Additionally, FSU GOES incoming solar radiation retrievals and BOREAS rain radar retrievals during portions of 1994 and 1996 were used when remote sensing products were available. Two Phase 2, Northern Study Area (NSA) and Southern Study Area (SSA) grids, and one Phase 3, Regional, gridded data sets have been assembled on a hourly time step.

The meteorological variables in this data set are surface air pressure, air temperature, dew point temperature, wind speed, wind direction, precipitation, incoming solar (shortwave) radiation, and incoming infrared (longwave) radiation.

Note that some of the data files have been compressed using Zip compression. See Section 8.2 for details.

Data Citation

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

Wood, E., and V. Pauwels. 2001. BOREAS Follow-On HMet-02 Area and Regional Hourly Gridded Met[eorological] Data, 1994-1996. 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. Data Set Overview

1.1 Data Set Identification

BOREAS Follow-On HMet-02 Area and Regional Hourly Gridded Met. Data, 1994-1996

1.2 Data Set Introduction

BOREAS Hydromet/Carbon Model Subgroups meteorological forcing data sets for Phases I, II, & III modeling intercomparisons.

1.3 Objective/Purpose

Surface station data and remote sensing data over the BOREAS region were gridded in order to provide the investigators of the BOREAS Follow-On Water/Energy modeling subgroup with a standard model forcing data set for intercomparison studies. Six (6) different hydrometeorological models & nine (9) different carbon models were selected for intercomparison purposes.

1.4 Summary of Parameters

Meteorological forcing data consist of following eight (8) parameters: 1) Air temperature 2) Dew point temperature 3) Wind speed 4) Wind direction 5) Air pressure 6) Incoming solar radiation 7) Incoming long wave radiation 8) Precipitation

1.5 Discussion

This data set includes Phases 2 and 3 of the three categories of meteorological forcing data sets that have been assembled for the BOREAS Hydrometeorological and Carbon Assimilation Model Intercomparison Projects as part of the BOREAS Follow-on activities. The first phase of the meteorological forcing data sets, Phase I data, at point/tower scale, has also been produced.

1.6 Related Data Sets

BOREAS AES MARSII Surface Meteorological Data
BOREAS AES READAC Surface Meteorological Data
BOREAS AFM-07 SRC Surface Meteorological and Radiation Data
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-4 SSA-YJP Tower Flux, Meteorological, and Canopy Condition 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 TGB-4 NSA-BVP Tower Flux and Meteorological Data
BOREAS RSS-14 Level-2 GOES-7 Shortwave and Longwave Radiation Images
BOREAS Follow-on HMet-02 Area and Regional Hourly Gridded Met. Data, 1994-1996

Return to top of document.

2. Investigator(s)

2.1 Investigator(s) Name and Title

Professor Eric Wood

2.2 Title of Investigation

A terrestrial water and energy budget for the BOREAS study region scale using field measurements, remote sensing, and modeling.

2.3 Contact Information

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Return to top of document.

3. 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

All variables were, when possible, taken from measurements above canopy.

AES Continuous Recording Stations: 15 min

These stations are long-term meteorological sites which record continuous observations at 15 minute interval. Standard suite of meteorological variables is measured including pressure, temperature, humidity, wind speed, and wind direction. SW and LW radiation fluxes are not measured. Fourteen (14) Automatic Meteorological Station (AMS)-type systems collected data from August '93 through December '96. Six (6) Meteorological Automatic Reporting System II (MARS-II) stations and one Remote Environmental Automatic Acquisition Concept (READAC) station collected data during 1994 IFCs only. All of these stations collected standard meteorological data and no radiation data.

SRC Meteorological Stations Suite A & B

These stations were installed and operated by SRC specially for BOREAS project and recorded observations at a 15 minute interval. This data set provides most complete coverage (temporally and spatially) of meteorological conditions in Southern and Northern Study Areas during period 1994-1996. Unlike most flux towers, these stations also operated during winter months. Stations recorded full suite of meteorological measurements, although only subset (Suite B) measured LW radiation fluxes.

Flux Tower Sites: 15 min

Largest suites of variables were measured at BOREAS flux tower sites. Most towers measured all standard meteorological variables at different levels. All levels are retained in quality controlled BORIS data sets. Few towers operated during entire period from 1994-1996.

HYD-09 Belfort and Tipping Bucket Rain Gauges

HYD-09 Science Team operated dense precipitation gauge network in Northern and Southern Study Areas during much of BOREAS field period, although most observations were obtained during summer months of 1994 and 1996.

Canadian Forest Service Meteorological Stations

These stations recorded hourly observations during summers of 1994 and 1995 obtaining temperature, humidity, wind speed, wind direction, and precipitation.

Canadian Historical Stations: Daily

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

Canadian Historical Stations: Hourly

These stations, also operated by AES Canada, record observations on an hourly basis, involving larger suite of variables than measured by daily stations, including pressure, temperature, humidity, wind speed, wind direction, and cloudiness. SW and LW radiation fluxes are not measured.

During winter months, when precipitation estimates by each of the previously listed stations were missing, daily precipitation data were resampled into hourly estimates using the average diurnal cycle of precipitation, and then during December, January, and February, these precipitation data were gridded.

Remote sensing data from following sources were also used in the gridding:

GOES satellite retrievals (Gu & Smith SRB algorithm):

Retrievals of incoming solar radiation over The BOREAS region, from days 36-263 (Feb 5-Sep 20)-1994 and days 43-296 (Feb 12-Oct 22)-1996, were blended into gridded data sets -- treating each GOES pixel as a separate station.

Enterprise WSR-100 radar:

Retrievals of precipitation over Southern Study Area, from days 132-266 (May 12-September 23)-1994, were blended into gridded data sets -- treating each radar pixel as a separate station.

In order to eliminate drizzle originating from the interpolation of rainfall over large distances, all precipitation values of intensity lower than 0.25 mm hr-1 have been set to zero.

Return to top of document.

6. Observations

Not applicable.

Return to top of document.

7. Data Description

7.1 Spatial Characteristics

The data sets were prepared at two different scales and projections. For the study areas, the phase II data, a 2 kilometer UTM grid was used. For the regional data set, the phase III data, a 5 minutes (vertical) by 10 minutes (horizontal) grid was used.

7.1.1 Spatial Coverage

The grid chosen by the Water/Energy modeling subgroup was used for this data set.

For Phase II NSA data set, grid corner locations are (UTM zone 14)

Corner	Northing (UTM)	Easting (UTM)
NW	6202000	514000
NE	6202000	548000
SW	6170000	514000
SE	6170000	548000

For Phase II SSA data set, grid corner locations are (UTM zone 13)

Corner	Northing (UTM)	Easting (UTM)
NW	6000000	488000
NE	6000000	528000
SW	5964000	488000
SE	5964000	528000

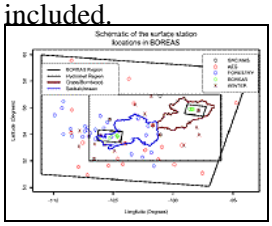
For Phase III regional data set, grid corner locations are:

Corner	Latitude (degrees)	Longitude (degrees)
NW	57°N	107°W

NE	57°N	96°W
SW	52°N	107°W
SE	52°N	96°W

7.1.2 Spatial Coverage Map

A map of the geographic locations of the surface station sites, together with boundaries of the BOREAS region, study areas, original modeling region, and the Saskatchewan and Grass-Burntwood watershed basins (used for routing model validation) can be found in the GIF file 'locate.gif' (see below). Boundaries of GOES and Rain Radar coverage maps are not included.



7.1.3 Spatial Resolution

The resolution is 2 x 2 km for Phase II study area data sets, and 10' horizontal (longitude) by 5' vertical (latitude) for Phase III regional data set.

7.1.4 Projection

Projection is UTM for the Phase II study area data sets, and Geographic (latitude-longitude) for the Phase III regional data set.

7.1.5 Grid Description

The NSA grid is 17 columns (longitude) by 16 rows (latitude). The SSA grid is 20 columns (longitude) by 18 rows (latitude). The regional grid is 66 columns (longitude) by 60 rows (latitude). The images are all binary with each pixel being stored as a four-byte binary float.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

Data gridded were from January 1, 1994 through December 31, 1996.

7.2.2 Temporal Coverage Map

Not applicable.

7.2.3 Temporal Resolution

Data were gridded at an hourly interval. Temporal units are in GMT.

7.3 Data Characteristics

7.3.1 Parameter/Variable

Variable	Image prefix
Air pressure	Pres
Air temperature	Ta
Dew point temperature	Td

Wind speed	U
Wind direction	Ud
Precipitation	Prec
Incoming SW radiation	Rsi
Incoming LW radiation	Lwi

7.3.2 Variable Description/Definition

See section 7.3.1. Times are in GMT using backward time tag convention (i.e., time tag n indicates data record applies to hourly period n to n+1).

7.3.3 Unit of Measurement

Variable	Measurement Units
Air temperature	C
Dew point temperature	C
Wind direction	Degrees
Wind speed	m/s
Air pressure	kPa
Incoming SW radiation	Rsi
Incoming LW radiation	Lwi
Precipitation	mm/h

7.3.4 Data Source

For data sources we refer to documentation files of individual input data sets.

7.3.5 Data Range

Variable	Minimum Value	Maximum value	Missing value indicator
Ta	-46.013359	37.548920	-9999
Td	-53.659573	47.275021	-9999
Ud	0.000008	360.000000	-9999
U	0.000019	42.264545	-9999
Pres	86.865944	101.601524	-9999
Rsi	-4.899975	1042.467407	-9999
Lwi	55.841991	447.747894	-9999
Prec	0.000000	176.934235	-9999

7.4 Sample Data Record

Not applicable.

Return to top of document.

8. Data Organization

8.1 Data Granularity

Data exist for every hour when available. The hour files have been organized into daily folders/directories. Each filename has the following structure:

yy-mm-dd_hh_sss_V2.bin

where yy is the two-digit year, mm is the 2-digit month, dd is the 2-digit day, hh is the hour of day (in GMT), sss is the site (nsa or ssa), and V2 is the variable (such as "pres", with a 2 or 3 following it for Phase 2 or Phase 3 data).

Each of the eight variables has the same directory structure. Each variable has three yearly subdirectories (94, 95, and 96). Each yearly subdirectory contains 12 monthly Zip archive files. Each of the Zip archive files contains daily subdirectories, which each contain the 24 hourly data files.

For example, Northern Study Area Pressure on 1 November 1995 at 14:00 UTC would be found in the following Zip file:

gridded_mesonet_p2/nsa/pres2_95_nsa/95-11-00_nsa_pres2.zip

Once decompressed, this Zip file would yield a directory for November 1995, and the specific file would be:

95-11-00_nsa_pres2/95-11-01_nsa_pres2/95-11-01_14_nsa_pres2.bin

8.2 Data Format(s)

The data are stored as 4-byte binary float images, one image per hour per variable (the data may need to be byte swapped to display properly). The regional grid is 66 columns by 60 rows. The NSA grid is 17 columns by 16 rows and the SSA grid is 20 columns by 18 rows.

For this archive, the image files have been compressed with the MS Windows-standard Zip compression scheme. These files were compressed using Aladdin's DropZip on a Macintosh. DropZip uses the Lempel-Ziv algorithm (Welch, 1994), also used in Zip and PKZIP programs. The compressed files may be uncompressed using PKZIP (with the -expand option) on MS Windows and UNIX, or with StuffIt Expander on the Mac OS. You can get newer versions from the PKZIP Web site at http://www.pkware.com/download-software/ [Internet Link].

Return to top of document.

9. Data Manipulations

9.1 Formulae

The data were interpolated using the weighted distance average of each pixel relative to each station. First, for each station the distance to the center of each pixel was determined, then the square of the inverse distances were summed. The ratio of the square of the inverse distance to a given pixel to this sum was used to weight each pixel.

This procedure did not produce satisfactory results for precipitation. In order to eliminate the large number of very low-intensity precipitation events caused by the interpolation of observed precipitation over large distances, a threshold method was applied for each grid. All time steps with a precipitation rate lower than the specified threshold were set to zero and their precipitation amounts were added to the nearest event with a precipitation rate larger than the threshold. This method was found to yield the best results using a threshold precipitation rate of 0.075 mm/h.

As a next step, the total number of rain-hours for each grid was calculated. For all grids there were approximately 5000 total rain-hours over the three years (as opposed to the approximately 1500 rain-hours observed by the gauges). To solve this discrepancy, the length of all individual storms was scaled by multiplying the length of the storm by the ratio of the number of observed to interpolated rain-hours. The new storm duration was centered around the mid-point of the original storm. For example, if an original storm lasted from 10 through 19 GMT (10 hours), and the length of the contracted storm was 5 hours, then the

contracted storm would occur from 12 through 17 GMT. The total storm volume was conserved by first calculating the total volume of precipitation for both the original and contracted storms, and then by multiplying the precipitation rate of each time step of the contracted storm by the ratio of the original and contracted storm volumes. Using this method, the diurnal cycle of precipitation and the total rainfall amounts, together with the storm duration and the distribution of rainfall rates (as observed by the various rain gauges) were conserved.

9.1.1 Derivation Techniques and Algorithms

Not applicable.

9.2 Data Processing Sequence

9.2.1 Processing Steps

First the station data were converted to a common format, temporal resolution, and into common units. Using this derived data set the interpolation was done.

9.2.2 Processing Changes

Not applicable.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

All station observed values that were outside reasonable limits were found to correspond to be measurement errors. For all variables these values are:

Variable	Minimum Allowed	Maximum Allowed
U	0	120
Ud	0	360
Ta	-60	60
Td	-60	60
Rsi	-5	1200
Lwi	50	600
Pres	85	110
Prec	0	200

Wind directions were afterward corrected in range 0-360 degrees.

9.3.2 Calculated Variables

Air temperature, dew point temperature, wind speed, wind direction, air pressure, incoming long wave radiation, incoming short wave radiation and precipitation.

9.4 Graphs and Plots

Not applicable.

Return to top of document.

10. Errors

10.1 Sources of Error

Errors in the data for each pixel can originate for the following reasons:

1. Measurement errors (systematic and random sensor errors).
2. For Phase I, II, and III data sets, for December, January and February of each year, on a few occasions, the diurnal cycle was imposed on daily measured 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.
3. 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.
4. No LW observations were available for first 20 days of January-1994 (hour 0 on Jan 1 to hour 20 on Jan 20). For Phase II & III data sets, missing LW values have been synthesized from surface Ta-Td dependent expression due to Idso (1981: WSR, 17, 295-304) which assumes clear sky conditions.

10.2 Data Quality Assessment

10.2.1 Data Validation by Source

For this purpose we refer to the documentation files of the individual data sources. See section 3.0.

10.2.2 Confidence Level/Accuracy Judgment

The level of accuracy of the interpolated data is essentially the same as the accuracy of the station data in the southern part of the region, in the north additional error can be expected due to the scarcity of surface stations.

10.2.3 Measurement Error for Parameters

For this purpose we refer to the documentation files of the individual data sources.

10.2.4 Additional Quality Assessments

Phase II & III gridded data sets were checked as follows, with few inconsistencies found using these procedures:

1. Extracted time series for various grids were compared with original station data for that grid -- this was done for each of BOREAS flux towers, for 2 AES stations, for 2 SRC/AMS stations, and for 2 Forestry Canada stations.
2. Regional averages were calculated & checked for inconsistencies.
3. Regional average monthly diurnal cycles of each individual variable were compared to ECMWF Numerical Weather Prediction (NWP) data.

10.2.5 Data Verification by Data Center

Random files were checked for format and size consistency.

Return to top of document.

11. Notes

11.1 Limitations of the Data

Due to the scarcity of stations in the northern portion of BOREAS region, variability of Phase II & III gridded forcing data (other than GOES Rsi estimates) is underestimated. However, average values of parameters are found to be consistent with ECMWF model results.

11.2 Known Problems with the Data

See section 10.1.

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.

11.4 Other Relevant Information

None.

Return to top of document.

12. Application of the Data Set

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

Zip uses the Lempel-Ziv algorithm (Welch, 1994) used in the zip and PKZIP commands.

14.2 Software Access

Zip is available from many Web sites across the Internet. You can get newer versions from the PKZIP Web site at http://www.pkware.com/download-software/ [Internet Link]. Versions of the decompression software for MS Windows, Mac OS, and several varieties of UNIX systems are included in this archive.

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 BOREAS hydromet model intercomparison forcing data are all obtainable through CD-ROM. Contact Eric Smith in order to obtain this CD-ROM.

Return to top of document.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

Not applicable.

17.2 Journal Articles and Study Reports

The data set processing, intercomparison with ECMWF data, and preliminary model results using the data set are described in:

Pauwels, V.R.N., Examination of the Sources of Uncertainty in Land-Atmosphere Model Results for Boreal Ecosystems, Ph.D. thesis, Department of Civil Engineering and Operations Research, Princeton University,

1999.

Pauwels, V.R.N., J. Gu, B. Nijssen, A.K. Betts, K.R. Snelgrove, E.A. Whidden, N. Kouwen, D.P. Lettenmaier, E.A. Smith, E.D. Soulis, and E.F. Wood, A multiscale surface meteorological data set for BOREAS, in preparation.

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

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AES     - Atmospheric Environment Service of Canada
ASCII   - American Standard Code for Information Interchange
BOREAS  - BOReal Ecosystem-Atmosphere Study
BORIS   - BOREAS Information System
DAAC    - Distributed Active Archive Center
ECMWF   - European Center for Medium-Range Weather Forcasting
EOS     - Earth Observing System
EOSDIS  - EOS Data and Information System
GMT     - Greenwich Mean Time
GSFC    - Goddard Space Flight Center
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HYD     - Hydrology
IFC     - Intensive Field Campaign
NASA    - National Aeronautics and Space Administration
NSA     - Northern Study Area
NWP     - Numerical Weather Prediction
ORNL    - Oak Ridge National Laboratory
PANP    - Prince Albert National Park
SSA     - Southern Study Area
URL     - Uniform Resource Locator (a World Wide Web address)
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Return to top of document.

20. Document Information

20.1 Document Revision Date

Written: 01-Apr-1999
Last Updated: 29-Jan-2001 (citation revised on 30-Oct-2002)

20.2 Document Review Date(s)

BORIS Review: 10-Apr-2000
Science Review:

20.3 Document ID

hmet02_gridded

20.4 Citation

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

Wood, E., and V. Pauwels. 2001. BOREAS Follow-On HMet-02 Area and Regional Hourly Gridded Met[eorological] Data, 1994-1996. 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/hmet02_met_phase2_3_doc.html

Keywords:
ECMWF
Surface Pressure
Surface Temperature
Surface Flux
Precipitation
Albedo
Wind direction

Wind speed
Radiation
GOES Images

Return to top of document.
