BOREAS FOLLOW-ON HMET-01 MERGED SSM/I AND RAIN GAUGE PRECIPITATION DATA
Get Data

Summary

A gridded data set has been assembled over the BOREAS hydro-meteorological study region that combines a precipitation data set based on a rain gauge network with precipitation estimates based on SSM/I satellite images. The result is an hourly precipitation data set covering 122 consecutive days beginning on June 1, 1996.

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):

Smith, E. A., J. Lamm, and J. Gu. 2001. BOREAS Follow-On HMet-01 Merged SSM/I and Rain Gauge Precipitation Data. 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.

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1. Data Set Overview

1.1 Data Set Identification

BOREAS Follow-On HMet-01 Merged SSM/I and Rain Gauge Precipitation Data

1.2 Data Set Introduction

None given.

1.3 Objective/Purpose

The BOREAS rain gauge data that contributed to the BOREAS Phase II Gridded Meteorological data is sparse, causing many rain rate values to be interpolated. The Special Sensor Microwave/Imager (SSM/I) data is also sparse. The data set provided here combines the BOREAS Phase II Gridded Meteorological data and the hourly microwave rain rate images from the SSM/I sensor into a gridded precipitation product with fewer interpolated values.

1.4 Summary of Parameters

Precipitation in mm/hr.

1.5 Discussion

This data set combines a rain rate data set based on 3 SSM/I satellites with a data set based on interpolated rain gauge data. This combined SSM/I and rain gauge data set corresponds to the 122 successive days starting on June 1, 1996 and ending on Sept. 30, 1996.

1.6 Related Data Sets

BOREAS Gridded Meteorological Data Over Hydromet Study Area 1994-1996
GPROF 4.0 6-Hourly Global Microwave Rain Rate Images

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2. Investigator(s)

2.1 Investigator(s) Name and Title

Dr. Eric A. Smith, Professor

2.2 Title of Investigation

Retrieval of Surface Radiation Fluxes Over BOREAS

2.3 Contact Information

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3. Theory of Measurements

The only difference between the combined data set and the BOREAS Phase II Gridded Meteorological Data is that many of the rain gauge values are replaced with rain rates based on SSM/I measurements.

For additional information on each input data set, see section 9.1.1 and appropriate references and documentation for those data.

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4. Equipment

For the equipment used in the collection of each of the data sources we refer to the documentation files of each data source individually.

4.1 Sensor/Instrument Description

None given.

4.1.1 Collection Environment

None given.

4.1.2 Source/Platform

None given.

4.1.3 Source/Platform Mission Objectives

None given.

4.1.4 Key Variables

Precipitation.

4.1.5 Principles of Operation

None given.

4.1.6 Sensor/Instrument Measurement Geometry

None given.

4.1.7 Manufacturer of Sensor/Instrument

None given.

4.2 Calibration

None given.

4.2.1 Specifications
None given.

4.2.1.1 Tolerance
None given.

4.2.2 Frequency of Calibration
None given.

4.2.3 Other Calibration Information
None given.

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5. Data Acquisition Methods

None given.

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6. Observations

6.1 Data Notes
None given.

6.2 Field Notes
Not applicable.

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7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

Corner	Latitude	Longitude
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
Not available.

7.1.3 Spatial Resolution
The resolution of the data set is 10 minutes horizontal by 5 minutes vertical.

7.1.4 Projection
The projection is latitude-longitude.

7.1.5 Grid Description
The grid size is 66 columns by 60 lines.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage
This combined SSM/I and rain gauge data set corresponds to the 122 successive days starting on June 1, 1996 and ending on Sept. 30, 1996.

7.2.2 Temporal Coverage Map
Not applicable.

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

7.3 Data Characteristics

7.3.1 Parameter/Variable
Precipitation.

7.3.2 Variable Description/Definition
Precipitation amount, also referred to as rain rate.

7.3.3 Unit of Measurement
mm/hour

7.3.4 Data Source
Data sources are the hourly BOREAS Phase II Gridded Meteorological data and the 6-hourly microwave rain rate images from the SSM/I sensor.

7.3.5 Data Range
None given.

7.4 Sample Data Record
Not applicable to binary gridded data.

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8. Data Organization

8.1 Data Granularity
File names for the combined set are of the form:

96-mm-dd_hh_ssmi.zip

where 'mm' is the month, 'dd' is the day, and 'hh' is hours GMT for the starting time of the corresponding one-hour interval.

Text file hmet01_ssmi_filecounts.dat provides the number of pixels in each image that were derived based on satellite versus rain gauge. See comments within that file for more info.

8.2 Data Format(s)

Files for the combined data set are written out as 4 byte real numbers representing rain rates in mm/hr (the data may need to be byte swapped to display correctly). The format for this combined data set is exactly the same as the BOREAS Phase II Gridded Meteorological data. For instance, they are both formatted as binary files (see included FORTRAN program in section 14 for reading files). The corresponding latitude and longitude for each pixel is the same as that for the BOREAS Phase II Gridded Meteorological data. The text file, hmet01_ssmi_lat_lon.dat has also been provided, it lists the lat/long corresponding to each 4 byte value as they appear consecutively in a file. Positive latitude values are North, negative longitude values are West.

Each SSM/I file corresponds to one of the following four six-hour time intervals:

1. 2100 GMT of the previous day to 0200 GMT of present day
2. 0300 GMT of the present day to 0800 GMT of present day
3. 0900 GMT of the present day to 1400 GMT of present day
4. 1500 GMT of the present day to 2000 GMT of present day

Thus, each SSM/I file corresponds to exactly six rain gauge based files that fall within its 6-hour time interval. An exception is the SSM/I file for time period 1 of day 1, since there is no rain gauge data for times 2100 GMT 2200 GMT and 2300 GMT of May 31. Also, rain gauge files for day 122 times 2100 GMT, 2200 GMT, and 2300 GMT have no corresponding SSM/I files and thus remain unchanged from BOREAS Phase II Gridded Meteorological data.

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].

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9. Data Manipulations

9.1 Formulae

9.1.1 Derivation Techniques and Algorithms

For the input data sets for this product:

Rain gauge network

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 the pixel was determined, then the square of the inverse distances were added. For each station the square of the inverse distance to the pixel divided by the sum was used as a weight to obtain the interpolated value for the 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 reset 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 a total of 5000 rain-hour over the three years total (as opposed to the approximately 1500 rain-hours observed by the gauges). To solve this discrepancy, the length of all individual storms was rescaled 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 midpoint of the original storm. For example, if an original storm lasted from 1000 through 1900 GMT (10 hours), and the length of the contracted storm was 5 hours, then the contracted storm would occur from 1200 through 1700 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, we were able to conserve 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).

SSM/I precipitation

The Goddard Profiling Algorithm, Version 4 (GPROF4.0), is used to generate global rain rate maps every six hours centered on 00, 06, 12, and 18Z (i.e. 06Z is from 03 to 09Z). The global grid is 0.5 degrees latitude by 0.5 degrees longitude and extends from 90N to 90S and 0 to 360, resulting in an array size of 360 rows by 720 columns. The center of the grid box at position (1,1) is thus 89.75 N, 0.25 E.

Each time period produces two files; rain rate and observation population. The rain rate file contains floating-point values (R*4) in mm/hr. The observation file contains short-integer values (I*2) of the total pixels per grid box. Values in the observation files are negative when the corresponding rain rate is considered questionable. "Questionable" is defined as grid boxes that contain 10 percent or more "ambiguous" and "cold surface" pixels (as determined by the GPROF4 algorithm).

9.2 Data Processing Sequence

The only difference between the combined data set presented here and the BOREAS Phase II Gridded Meteorological Data is that many of the rain gauge values are replaced with rain rates based on SSM/I measurements.

The method for making these replacements is as follows.

1. For every pixel in a given rain gauge file, acquire the SSM/I based rain rates for that pixel. Because there are three SSM/I satellites (F10, F11, F13) there can be as much as three of these SSM/I based rain rates. Also, because wide gaps exist between SSM/I swaths, there may be no SSM/I data for a given pixel.
2. If no SSM/I measurements exist, retain the rain gauge measurement. Otherwise, average the one or more SSM/I based measurements and use this as the new rain rate value for that pixel.

9.2.1 Processing Steps

None given.

9.2.2 Processing Changes

None given.

9.3 Calculations

None given.

9.3.1 Special Corrections/Adjustments

None given.

9.3.2 Calculated Variables

None given.

9.4 Graphs and Plots

None.

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10. Errors

10.1 Sources of Error

This data set was completed around May 13, 1999. Therefore, changes made to the BOREAS Phase II Gridded Meteorological data in August 1999 or any changes to the SSM/I data after this date have NOT been taken into account.

10.2 Quality Assessment

None given.

10.2.1 Data Validation by Source

None given.

10.2.2 Confidence Level/Accuracy Judgment

None given.

10.2.3 Measurement Error for Parameters

See Section 11.

10.2.4 Additional Quality Assessments

None given.

10.2.5 Data Verification by Data Center

None.

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11. Notes

11.1 Limitations of the Data

None given.

11.2 Known Problems with the Data

None given.

11.3 Usage Guidance

WARNING: This data set was completed around May 13, 1999. Therefore, any changes made to the BOREAS Phase II Gridded Meteorological data or the SSM/I data after this date have NOT been taken into account.

11.4 Other Relevant Information

None given.

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12. Application of the Data Set

These data were derived for temporal and spatial modeling at regional scales.

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13. Future Modifications and Plans

None.

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14. Software

14.1 Software Description

Software code that can be used to read the data is provided below.

14.2 Software Access

NOTE: The file names for this data set have been changed from "SSMIGauPrec_96_212_11.binC" to "96-07-30_11_ssmi_prec.bin" to conform with the standard file naming scheme used in BOREAS. The following program has *not* been rewritten to handle the new file names. You must do that yourself (sorry).

```
FORTRAN Program For Reading In Data

    program readrr

    parameter (nx=66,ny=60)
    real    rr(nx   ,ny   )

    character fname*80,julian*3,ihr*2

    call getarg(1,fname)
    open (1,file=fname,status='old',form='unformatted',
   &        access='direct',recl=15840)
    read (1,rec=1) rr

c12345678901234567890123456789O
cSSMIGauPrec_96_212_11.binC

    read (fname,'(15x,a3,1x,a2)') julian,ihr

    rrm=0
    do 20 j=1,ny
      do 10 i=1,nx
```

```
        rrm=rrm+rr(i,j)
10    continue
20  continue
    rrm=rrm/(nx*ny)

    write (*,'(a3,a2,f10.2)') julian,ihr,rrm
    stop

    end
```

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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.

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16. Output Products and Availability

16.1 Tape Products

None

16.2 Film Products

None.

16.3 Other Products

None.

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17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

None.

17.2 Journal Articles and Study Reports

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.

GPROF 4.0 6-Hourly Global Microwave Rain Rate Images for 122 days in 1996 See ftp site: camille.gsfc.nasa.gov, pub/ssmi/BOREAS Contact Eric Nelkin (nelkin@hilda.gsfc.nasa.gov) or George Huffman (huffman@agnes.gsfc.nasa.gov).

17.3 Archive/DBMS Usage Documentation

None.

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18. Glossary of Terms

None given.

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19. List of Acronyms

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ASCII  - American Standard Code for Information Interchange
BOREAS - BOReal Ecosystem-Atmosphere Study
BORIS  - BOREAS Information System
CD-ROM - Compact Disk-Read-Only Memory
DAAC   - Distributed Active Archive Center
DAT    - Digital Archive Tape
EOS    - Earth Observing System
EOSDIS - EOS Data and Information System
FSU    - Florida State University
GMT    - Greenwich Mean Time
GSFC   - Goddard Space Flight Center
ISCCP  - International Satellite Cloud Climatology Project
NAD83  - North American Datum of 1983
NASA   - National Aeronautics and Space Administration
NOAA   - National Oceanic and Atmospheric Administration
NSA    - Northern Study Area
ORNL   - Oak Ridge National Laboratory
SSM/I  - Special Sensor Microwave/Imager
URL    - Uniform Resource Locator
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20. Document Information

20.1 Document Revision Dates

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20.2 Document Review Dates

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Science Review:

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20.5 Document Curator:

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