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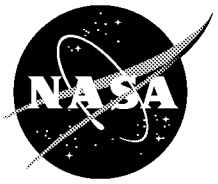

Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and Jeffrey A. Newcomer, Editors

Volume 120

BOREAS ECMWF 6-Hour Analysis and Forecast Data

Pedro Viterbo, ECMWF, Shinfield Park, Reading, United Kingdom
Alan Betts, Atmospheric Research, Pittsford, Vermont
Richard Strub, Raytheon ITSS, NASA Goddard Space Flight Center, Greenbelt, Maryland

National Aeronautics and
Space Administration

Goddard Space Flight Center
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September 2000

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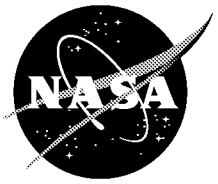

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BOREAS ECMWF 6-Hour Analysis and Forecast Data

Pedro Viterbo, Alan K. Betts, Richard Strub

Summary

In cooperation with BOREAS atmospheric research efforts, the ECMWF agreed to provide BOREAS with a customized subset of its 6-hourly forecast data. This data set contains parameters from three ECMWF data products in GRIB format: Surface and Diagnostic Fields, Supplemental Fields, and Extension Data. Sample software and information are provided to assist in reading the data files. Temporally, the atmospheric parameters are available for the four main synoptic hours of 00, 06, 12, and 18 UTC from 1994 to 1996. Spatially, the data are stored in a 0.5- by 0.5-degree latitude/longitude grid. To cover the entire BOREAS study area, the grid extends from 48 to 62 degrees latitude and -92 to -114 degrees longitude. The data are stored in binary data representation known as FM 92 GRIB. Due to the complexity of the content and format of this data set, users are advised to read Sections 6, 7, 8, and 14 before using data.

Based on agreements between BOREAS and ECMWF, users may legally obtain and use these data only by having a set of the BOREAS CD-ROMs that contain the data. Possession or use of these data under any other circumstance is prohibited. See Sections 11.3 and 20.4 for details.

Note that the data files on the BOREAS CD-ROMs have been compressed using the Gzip program. See Section 8.2 for details on the compression.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS ECMWF 6-Hour Analysis and Forecast Data

1.2 Data Set Introduction

In cooperation with BOReal Ecosystem-Atmosphere Study (BOREAS) atmospheric research efforts, the European Centre for Medium-Range Weather Forecasts (ECMWF) agreed to provide a customized subset of their 6-hourly forecast data. This data set contains parameters from three ECMWF data products: Surface and Diagnostic Fields, Supplemental Fields, and Extension Data. The data cover the four main synoptic hours of 00, 06, 12, and 18 Universal Time Code (UTC) from 1994 to 1996 and are stored in a 0.5- by 0.5-degree regular latitude/longitude grid. Before using these data, users are advised to carefully read Sections 6.1 and 11.3, which discuss model changes, known errors, and proper use and referencing of the data.

1.3 Objective/Purpose

The ECMWF data sets were obtained in order to compare these large-area modeled data with more localized data sets and to provide data for large-area models.

1.4 Summary of Parameters

This data set contains parameters from three ECMWF data products: Surface and Diagnostic Fields, Supplemental Fields, and Extension Data. The data are reported at time intervals ranging from 6 to 24 hours. See Sections 7.3.1 and 8 for details.

1.5 Discussion

These are the operational ECMWF analyses for the period 1994 to 1996, covering the entire large-scale BOREAS area at a 6-hour time resolution and a 0.5-degree lat/long resolution. Their advantage over point data is that they are gridded and continuous with no gaps for the whole domain for 3 years. However, they are subject to known and unknown model errors, and the ECMWF model had several significant changes made to the model physics during this time period.

Although the global analysis uses the upper air observations and some surface synoptic data, the diurnal cycle of temperature and humidity and the surface fluxes over land away from the analysis times are calculated from the model radiation, cloud, and land-surface parameterizations. Consequently, they are subject to any errors in the model parameterizations. In particular, the subsurface variables, for which there are no input data, can drift with time unless constrained.

Users are advised to carefully read Section 6.1, which discusses model changes and known errors, before using these data.

1.6 Related Data Sets

BOREAS AFM-05 Level-1 Upper Air Network Data
BOREAS AFM-05 Level-2 Upper Air Network Standard Pressure Level Data
BOREAS AFM-07 SRC Surface Meteorological Data
BOREAS AES Campbell Scientific 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

BOREAS Staff Science

2.2 Title of Investigation

BOREAS Staff Science Meteorological Data Acquisition Program

2.3 Contact Information

Contact 1:
Pedro Viterbo
ECMWF
Shinfield Park
Reading RG2 9AX
UK
011-44-1189-499734
011-44-1189-869450 (fax)
pedro.viterbo@ecmwf.int

Contact 2:
Keith Fielding
Data Services
ECMWF
Shinfield Park
Reading RG2 9AX
UK
(0118) 949-9453
(0118) 986-9450 (fax)
Data.Services@ecmwf.int

Contact 3:
Alan K. Betts
Atmospheric Research
58 Hendee Lane
Pittsford, VT 05763
(802) 483-2087
(802) 483-6167 (fax)
akbetts@aol.com

Contact 4:
Jeffrey A. Newcomer
Raytheon ITSS
NASA GSFC
Code 923
Greenbelt, MD 20771
(301) 286-7858
(301) 286-0239 (fax)
Jeffrey.Newcomer@gsfc.nasa.gov

3. Theory of Measurements

The theory behind the acquisition of a high-resolution gridded data set with several weather parameters is to provide data for large-area models after validation against localized data.

These model products are conveniently gridded, and extend for the 3 years of BOREAS. The land-surface scheme is discussed in Viterbo and Beljaars (1995). Some of the characteristics of the surface analyses and fluxes of the ECMWF model after April 1995 are discussed in Betts et al (1998a,b,c).

Users are advised to carefully read Section 6.1, which discusses model changes and known errors, before using these data.

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 960129 and 3D-VAR from 960130, 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 are collected include human observers, fixed towers of various sorts, and tethered and free-flying balloons.

4.1.3 Source/Platform Mission Objectives

The objective is for the platforms to support the instrumentation that is being used to make the various measurements.

4.1.4 Key Variables

This data set contains parameters from three ECMWF data products: Surface and Diagnostic Fields, Supplemental Fields, and Extension Data. The data are reported at time intervals ranging from 6 to 24 hours. See Sections 7.3.1 and 8 for details.

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). Some of the characteristics of the surface analysis of the ECMWF model after April 1995 are discussed in Betts et al. (1998a,b,c).

Users are advised to carefully read Section 6.1, which discusses model changes and known errors, before using these data.

5. Data Acquisition Methods

The current model resolution, introduced into operation on 17-September-1991, is T213 with 31 levels in the vertical.

ECMWF produces routine global analyses for the four main synoptic hours 00, 06, 12, and 18 UTC and global 10-day forecasts based on 12 UTC data. As a forecasting center with the emphasis on the medium range, ECMWF operates with long data collection times of between 18 hours for the 18 UTC analysis and 8 hours for the 12 UTC final analysis. This schedule ensures the most comprehensive global data coverage including the Southern Hemisphere surface data and global satellite sounding data.

6. Observations

6.1 Data Notes
Users are advised to carefully read this section, which discusses model changes and known errors, before using these data.

This is an operational analysis, so the user needs to be aware of heterogeneity's introduced when new model physics cycles were introduced to correct known model problems. (A reanalysis is planned for 1999 with a current model version.)

Key changes affecting the boreal forest land surface are:

- **04-Aug-1993:** 4-layer prognostic land surface scheme introduced (Viterbo and Beljaars, 1995).
- **04-Jul-1994:** Soil reservoirs refilled because they had partially dried out after model had run freely for one year. The impact of this is that the evaporation increases after 04-Jul-1994; probably too low before that date and too high after.
- **06-Dec-1994:** Nudging of soil water introduced to control long-term drifts of soil water (Viterbo and Courtier, 1995).
- **04-Apr-1995:** ERA-15 Reanalysis model introduced into operations. Including prognostic cloud scheme of Tiedtke (1993) and new subgrid orography scheme (Lott and Miller, 1997). The impact of this is that it improves radiative fluxes at surface, probably incoming solar is too high before this date. The summer surface evaporation in this model appears to be too high over the boreal forest (see Betts et al., 1998b), although in spring it is low because of an albedo error (see below).
- **30-Jan-1996:** The 3-dimensional variational data assimilation technique (3D-VAR) replaces the optimal interpolation (OI) method. For a description see Courtier et al. (1998) and Rabier et al. (1998); for a description of the impact on analysis and forecasts see Andersson et al. (1998).

- **19-Sep-1996:** Soil freezing plus new stable boundary layer parameterization and increased soil heat flux coupling introduced. The impact of this is that it reduces cold bias in winter caused by lack of latent heat of phase change and uncoupling of surface temperature from atmosphere under stable boundary layer (Viterbo et al., 1997). It also reduces cold temperature bias at night, caused by stable boundary layer uncoupling, and may affect daytime diurnal cycle of humidity (Betts et al, 1998a).
- **10-Dec-1996:** New boreal forest snow albedo introduced (Viterbo and Betts, 1997, 1998), which reduces maximum snow albedo of boreal forests from 0.8 to 0.2. The impact is that before this, the winter of 1996-97 net radiation is small until snow melts in spring and spring temperatures are too cold by 10 to 15 K. (Betts et al., 1998b).

Primary validation studies all deal with the model version after 04-Apr-1995 and are as follows

- Betts et al., 1998a, dealing with comparison with the First International Satellite Land Surface Climatology Project (ISLSCP) Field Experiment (FIFE) data.
- Betts et al., 1998b, dealing with both a comparison with the FIFE data and the BOREAS TF#3 black spruce site west of Thompson, Manitoba.
- Betts et al., 1998c, dealing with basin scale studies of the Arkansas-Red River basin with the ERA-15 reanalysis model. This addresses the impact of nudging on the soil hydrology and the errors in the diurnal cycle of precipitation, which appears to affect the BOREAS region also. In brief, the model has a 25-30% spin-up of precipitation in the analysis cycle and the 12-24 hour forecast, which brackets the observed gridded precipitation from Higgins et al. (1996) over the United States. The model has a near local noon precipitation maximum which may be related to a morning peak of mixing ratio.

In this data set the model spin-up can be assessed by comparing the three fields:

ECMWF Parameter Number	Description	Units
142	Large Scale Precipitation	(m)
143	Convective Precipitation	(m)
228	Total Precipitation	(m)

Fields 142 and 143 are from the analysis cycle, and field 228 is convective plus large-scale precipitation from a 12- to 36-hour forecast after the model has spun up. Field 228 is probably a better estimate of total precipitation, but 142+143 give a crude estimate of the diurnal cycle.

Evaporation (field 182) and latent heat flux (field 147) are inconsistent. There was a numeric problem in the computations related to the interception reservoir, which results in the surface latent heat flux being higher than the liquid evaporation in the subsurface hydrology, when converted to the same units. The ratio is variable, as it depends on the variable interception. For Mississippi basin averages it was on the order of 1.07 (see Betts et al., 1998c).

Beljaars et al., 1996, and Betts et al., 1996, deal with the improvements associated with the introduction of the 4-layer soil water model in 1993 (Viterbo and Beljaars, 1995)

6.2 Field Notes

Not applicable.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

The BOREAS ECMWF data cover the area of 48° N to 62° N latitude and 114° to 92° W longitude. The North American Datum of 1983 (NAD83) corner coordinates of the BOREAS region are:

	Longitude	Latitude
Northwest	111.000 W	59.979 N
Northeast	93.502 W	58.844 N
Southeast	96.970 W	50.089 N
Southwest	111.000 W	51.000 N

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

The BOREAS Information System (BORIS) ECMWF data were extracted in a 0.5-degree by 0.5-degree grid. The 0.5-degree grid was interpolated from the original model resolution of Gaussian N160 for the physics calculations. The points in the 0.5- x 0.5-degree grid are at whole degrees and half degrees in both latitude and longitude, and they represent the center of the 0.5 x 0.5 box surrounding them.

7.1.4 Projection

The coordinates for the BORIS ECMWF data are latitude and longitude.

7.1.5 Grid Description

The BORIS ECMWF data are stored in a systematic latitude/longitude grid.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

With the exception of parameters 236 and 237 (Soil Temperature and Soil Wetness level 4) for 1994, BORIS has all of the ECMWF parameters listed in Section 7.3.1 for every day of the years 1994 through 1996. Different parameters were modeled for different times (see Section 7.2.3).

7.2.2 Temporal Coverage Map

Not available.

7.2.3 Temporal Resolution

All the ECMWF parameters, except for Total Precipitation, are given once every 6 hours. All fluxes are accumulated for the forecast period. The Total Precipitation values are given once every 24-hour period, calculated from the 12-36 hour forecast from 1200 UTC the preceding day.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameters that are included in each of the three ECMWF data products and their associated descriptions and units are:

Surface and Diagnostic Fields

Note that in 1994, data set parameters 236 and 237 (Soil Temperature and Soil Wetness level 4) are

missing. All of the ECMWF parameters are available for every day during 1995 and 1996. Different parameters were modeled for different time intervals (see Section 7.2.3).

ECMWF Parameter Number	Description	Units
129	Geopotential	(as gz in m^2/s^2)
134	Surface Pressure	(Pa)
139	Soil Temperature level 1	(K)
140	Soil wetness level 1	(see * below)
141	Snow Depth	(m)
151	Mean Sea Level Pressure	(Pa)
165	U-Wind Component at 10m	(m/s)
166	V-Wind Component At 10 m	(m/s)
167	Temperature At 2m	(K)
168	Dewpoint At 2m	(K)
170	Soil Temperature level 2	(K)
171	Soil Wetness level 2	(see * below)
172	Land/Sea Mask	(see ** below)
173	Surface Roughness	(m)
174	Albedo	(see *** below)
183	Soil Temperature level 3	(K)
184	Soil Wetness level 3	(see * below)
236	Soil Temperature level 4	(K)
237	Soil Wetness level 4	(see * below)

These are values every 6 hours at 00, 06, 12, and 18 UTC.

* The units of soil water in this archive are unusual. They are (m^3 of water)/(0.07 m^3 of soil) for all levels 1-4. That is, if the value in the ECMWF file is X, the value W (m^3 of water)/(m^3 of soil) will be W = X/0.07. The 4 soil levels represent depths of 0 to 7 cm, 7 to 28 cm, 28 to 100 cm and 100 to 289 cm.

** The land/sea mask contains values of 0 to indicate sea (or water) and 1 to indicate land areas.

*** The albedo values range from 0 to 1 indicating from 0 to 100% reflectance of the incoming radiation by the surface.

Supplemental Fields

These are 0- to 6-hour accumulated fluxes from short-term forecasts starting at 00, 06, 12, and 18 UTC. The units are peculiar in that they are accumulated in seconds of forecast time (6 hours x 3600 secs/hour). Heat and radiation fluxes are therefore in W/m^2, stresses in N/m^2; while precipitation, snowfall and evaporation are in accumulated meters. Snowfall is the sum of convective and large-scale snowfall. Evaporation and latent heat flux are numerically inconsistent (see Section 6.1).

The 1994 supplemental field data were delivered to BOREAS in two pieces. As such, two files are required to make a complete set of supplemental variables for a given date. See Section 8 for more information.

ECMWF Parameter Number	Description	Units
142	Large Scale Precipitation	(m)
143	Convective Precipitation	(m)
144	Snow Fall	(m)
146	Surface Sensible Heat Flux	((W * seconds)/m^2)
147	Surface Latent Heat Flux	((W * seconds)/m^2)
164	Total Cloud Cover	(see **** below)
176	Surface Solar Radiation	((W * seconds)/m^2)
177	Surface Thermal Radiation	((W * seconds)/m^2)
178	Top Solar Radiation	((W * seconds)/m^2)
179	Top Thermal Radiation	((W * seconds)/m^2)
180	East/West Surface Stress	((N * seconds)/m^2)
181	North/South Surface Stress	((N * seconds)/m^2)
182	Evaporation	(m)

**** The Total Cloud Cover values range from 0 to 1 indicating from 0 to 100% cloud cover.

Extension Data

These are 24-hour accumulated precipitation from the 12- to 36-hour forecast starting from 12 UTC the previous day.

ECMWF Parameter Number	Description	Units
228	Total Precipitation	(m)

7.3.2 Variable Description/Definition

See Section 7.3.1.

7.3.3 Unit of Measurement

See Section 7.3.1.

7.3.4 Data Source

The data were provided to BOREAS by ECMWF personnel.

7.3.5 Data Range

None given.

7.4 Sample Data Record

Not applicable.

8. Data Organization

8.1 Data Granularity

The ECMWF data are stored in multi-date GRIB files. The smallest unit of data is a multi-date block containing several of the ECMWF parameters. Refer to section 7.3.1 for the organization of parameters.

8.2 Data Format(s)

8.2.1 Uncompressed Data Files

The BOREAS ECMWF data set consists of multi-date blocks of three ECMWF data products (Surface and Diagnostic Fields, Supplemental Fields, and Extension Data) and associated software files.

The data products contain data for multiple days, with the file names containing the start date of the multiple day period. The data in a file are stored in chronological order in a binary data representation known as FM 92 GRIB. GRIB is a common standard used by the operational meteorological centers for storage and exchange of gridded fields. The major advantages of the GRIB format are that files are typically 1/2 to 1/3 of the size of normal binary files, the fields are self-describing, and GRIB is an open, international standard.

```
On the BOREAS CD-ROM set, the format of the uncompressed file names is:
YY-MM-DD_REGION_FILETYPE

where YY_MM_DD is the starting date (YY - year, MM - month, DD - day of month)
              of the data contained in the file,
        REGION is a constant field indicating that the spatial coverage
              of the data is the entire BOREAS region, and
      FILETYPE is a three or four character string indicating the file type
              (EC1, EC2, EC2a, EC2b, or EC3), where:
              EC1  files contain the Surface and Diagnostic Field data,
              EC2* files contain the Supplemental Fields data.  In 1994 the
                   Supplemental Fields data were delivered in two components,
                   EC2a and EC2b files.  The EC2a files contain parameters
                   146, 147, 164, and 176 through 181 of the Supplemental
                   Fields data.  EC2b files contain parameter numbers 142, 143,
                   144, and 182 of the Supplemental Fields data.  In 1995 and
                   1996, all of the Supplemental Fields data are stored in a
                   single EC2 file.
              EC3  files contain the Extension data.
```

Two American Standard Code for Information Interchange (ASCII) software files are provided with the data. The first one (SOFTWARE1) contains source code that when built and run, uses the second file (SOFTWARE2) as input and divides the SOFTWARE2 file into various components. See the associated gribex_readme.txt file for more information about these files, and section 14.1. The specification of the GRIB code is given in the World Meteorological Organization (WMO) Publication 306, Manual on Codes.

8.2.2 Compressed CD-ROM Files

On the BOREAS CD-ROMs, the ECMWF data and software files have been compressed with the GNU zip (Gzip) compression program (file name *.gz). These data have been compressed using gzip version 1.2.4 and the high compression (-9) option (Copyright (C) 1992-1993 Jean-loup Gailly). Gzip uses the Lempel-Ziv algorithm (Welch, 1994) used in the zip and PKZIP programs. The compressed files may be uncompressed using gzip (-d option) or gunzip. Gzip is available from many Web sites (for example, ftp site prep.ai.mit.edu/pub/gnu/gzip-*.*) for a variety of operating systems in both

executable and source code form. Versions of the decompression software for various systems are included on the CD-ROMs.

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

BORIS staff adapted the ECMWF software to extract metadata, verify the data set content, and inventory the data in the BORIS Oracle data base. BORIS staff compressed the binary files for release on CD-ROM.

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

Users are advised to carefully read Section 6.1, which discusses model changes and known errors, before using these data. The land-surface scheme is discussed in Viterbo and Beljaars (1995). Some of the characteristics of the surface analysis of the ECMWF model after April 1995 and its errors are discussed in Betts et al. (1998a,b,c).

10.2 Quality Assessment

10.2.1 Data Validation by Source

Users are advised to carefully read Section 6.1, which discusses model changes and known errors, before using these data. The land-surface scheme is discussed in Viterbo and Beljaars (1995). Some of the characteristics of the surface analysis of the ECMWF model after April 1995 and its errors are discussed in Betts et al. (1998a,b,c).

10.2.2 Confidence Level/Accuracy Judgment

Users are advised to carefully read Section 6.1, which discusses model changes and known errors, before using these data. The precipitation data have a known spin-up of 25 to 30% from the 6-hour analysis cycle to the 12- to 36-hour forecast that is in the extension data set. Use the latter to assess this and read the discussion in Betts et al. (1998c) for the Arkansas-Red River basin.

In this data set, the model spin-up can be assessed by comparing three fields.

```
142  Large Scale Precipitation
143  Convective Precipitation
228  Total Precipitation
```

Fields 142 and 143 are from the analysis cycle and field 228 accounts for convective and large-scale precipitation from a 12- to 36-hour forecast after the model has spun up. Field 228 is probably a better estimate of total precipitation, but 142+143 give a crude estimate of the diurnal cycle.

Model data sets will reflect model parameterizations and model problems. For example, in the ECMWF model, the 2-m surface temperature is not itself a model variable - it is derived from the lowest model level at ~ 30 m elevation above the surface and the skin temperature, using similarity theory. The surface 'skin' temperature is sensitive to radiation errors (particularly at night), which are themselves sensitive to model cloud amount. Thus, a variable like Tmin in a model must be used with caution. Values may have absolute biases because of model cloud biases even if horizontal gradients across the BOREAS domain are of interest. Comparison with data time series at key locations should show these biases.

10.2.3 Measurement Error for Parameters

Users are advised to carefully read Section 6.1, which discusses model changes and known errors, before using these data. The land-surface scheme is discussed in Viterbo and Beljaars (1995). Some of the characteristics of the surface analysis of the ECMWF model after April 1995 and its errors are discussed in Betts et al. (1998a,b,c).

10.2.4 Additional Quality Assessments

None.

10.2.5 Data Verification by Data Center

BORIS adapted the sample software supplied by ECMWF to extract information about the parameters contained in each data file and the spatial and temporal extent of the data. This information was then used to inventory the data files in the BORIS data base. The actual parameter values were not verified or reviewed.

11. Notes

11.1 Limitations of the Data

Users are advised to carefully read Section 6.1, which discusses model changes and known errors, before using these data. The land-surface scheme is discussed in Viterbo and Beljaars (1995). Some of the characteristics of the surface analysis of the ECMWF model after April 1995 and its errors are discussed in Betts et al. (1998a,b,c).

11.2 Known Problems with the Data

Users are advised to carefully read Section 6.1, which discusses model changes and known errors, before using these data. The refilling of the soil water reservoirs on 04-Jul-1994 will increase evaporation after that date. The winter temperatures are biased cold (by as much as 10-15 K in spring before the winter of 1996-97, because of a stable boundary layer error (corrected on 19-Sep-1996) and a forest snow albedo error (corrected on 10-Dec-1996) (see Viterbo et al., 1997; Viterbo and Betts, 1997).

11.3 Usage Guidance

Before uncompressing the Gzip files on the CD-ROM, be sure that you have enough disk space to hold the uncompressed data files. Then use the appropriate decompression program provided on the CD-ROM for your specific system.

The ECMWF data may be used while noting the following:

- The 0.5-degree grid was interpolated from the original model resolution of Gaussian N160
- The data sets are adapted to a specific model orography; the data sets have biases that are only partially documented
- No surface observations of T, q, precipitation, or surface wind observations over land were used in the analysis
- Model spin-up can seriously affect the 6-hour forecast data supplied from the supplementary fields (precipitation, fluxes, radiation, surface stress, total cloud cover, and evaporation). A check on precipitation can be made using the data supplied from the Extension data set, which represents a day (0000 UTC to 2400 UTC) of total precipitation. This is derived from the 36-hour forecast time step minus the 12-hour time step to reduce the effect of spin-up
- Several fields such as soil moisture and temperature (4-levels) and snow depth, although included in the analysis data set, are not analyzed but evolve during the assimilation cycle.

The ECMWF provided data for the BOREAS CD-ROM set from the ECMWF/WCRP Level III-A Global Atmospheric Data Archive. ECMWF data on the CD-ROM set are provided under the following conditions:

- Based on agreements between BOREAS and ECMWF, users may legally obtain and use these data only by having a set of the BOREAS CD-ROMs that contain the data. Possession or use of these data under any other circumstance is prohibited.
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- Articles, papers, or written scientific works of any form, based in whole or in part on data supplied by ECMWF, will contain an acknowledgment concerning the supplied data. The data may be cited as follows: ECMWF 1994. The Description of the ECMWF/WRCP Level III-A Global Atmospheric Data Archive.

Although every care has been taken in preparing and testing the data and software, ECMWF cannot guarantee that the data are correct in all circumstances, or that the software will work correctly in all circumstances; neither does ECMWF accept any liability whatsoever for any error or omission in the data or software, or for any loss or damage arising from its use.

11.4 Other Relevant Information

None.

12. Application of the Data Set

These are the operational ECMWF analyses for the period 1994 to 1996, covering the entire large-scale BOREAS area at a 6-hour time resolution and a 0.5-degree latitude/longitude resolution. Their advantage over point data is that they are gridded and continuous with no gaps for the whole domain for 3 years. However, they are subject to known and unknown model errors, and the ECMWF model had several significant changes made to the model physics during this time period. The ECMWF data sets were obtained in order to compare these large-area modeled data with more localized data sets and to provide data for large-area models.

13. Future Modifications and Plans

A reanalysis is planned in 1999 for the period of 1979 to 1998 with a 1998/99 version of the ECMWF model. This model will have several improvements over the operational model. In particular, the winter surface temperatures will be improved, and the boreal forest may be better represented.

During the BOREAS follow-on research period (1998 to 1999), a gridded data set will be produced from the various surface meteorological data sets that should be helpful in further analyzing the ECMWF results.

14. Software

14.1 Software Description

Two ASCII software files are provided with the data. The first one (SOFTWARE1) contains Fortran source code (data_split) that when built and run, uses the second file (SOFTWARE2 - a file of routines) as input and divides the SOFTWARE2 file into its several subroutine components. The file ecmwf_grib.pdf is also provided as an information source. This is a paper describing the GRIBEX subroutine for encoding and deocoding GRIB data.

There are various sources of software on the WWW for reading GRIB format data. Two sites provided particularly useful utilities for reading and/or inventorying the GRIB files. These sites are mentioned below.

http://wesley.wwb.noaa.gov/reading_grib.html

This site is a great resource for users of data stored in GRIB, complete with syntax examples for different platforms. This site has a pointer to the c-program wgrib.c that is more user-friendly than that provided by ECMWF. The program wgrib.c processes one variable per time-step. Using the wgrib code one can extract desired variables and put them in one image per time-step per variable. A comment on this site states that "One's first impulse is to convert the GRIB file into some "understandable" format. It is better to extract the desired data and leave it in GRIB. This extraction can take as little as one command line using wgrib. Keep the data min GRIB until you need it immediately."

http://www.nerc-bas.ac.uk/public/icd/wmc/perl.html

There isn't much documentation and information here, but this site provides a handy perl script for decoding standard GRIB files.

14.2 Software Access

Gzip is available from many Web sites across the Internet (for example, FTP site prep.ai.mit.edu/pub/gnu/gzip-*.*) for a variety of operating systems in both executable and source code form. Versions of the decompression software for various systems are included on the CD-ROMs.

The GRIB software provided on the CDROM to convert the data from GRIB Binary Representation to ASCII is available from ECMWF. There are various additional sources on the World Wide Web (WWW), see section 14.1.

Please note the following regarding the ECMWF-provided software: The proprietary rights and copyright of the software remain with ECMWF. The software supplied is intended solely for use with ECMWF data and must not be used for any other purpose. The ECMWF data and software will not be supplied in whole or in part to any third party without the authorization of ECMWF. Data and software will not be used for commercial purposes. Although every care has been taken in preparing and testing the data and software, ECMWF cannot guarantee that the data are correct in all circumstances, or that

the software will work correctly in all circumstances; neither does ECMWF accept any liability whatsoever for any error or omission in the data or software, or for any loss or damage arising from its use.

15. Data Access

The ECMWF 6-hour analysis and forecast data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information

For BOREAS data and documentation please contact:

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

15.2 Data Center Identification

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

15.3 Procedures for Obtaining Data

Although the BOREAS ECMWF data are being held in a public archive, agreements between BOREAS and ECMWF limit the distribution and use of the data. The BOREAS CD-ROM series is publicly available, and the ECMWF data on the CD-ROMs are available for use by the owner of the CD-ROM set only. See Section 11.3 and please contact the ORNL DAAC User Services office to get the most recent information.

Users may obtain information on these data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] 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

Welch, T.A. 1984. A Technique for High Performance Data Compression. IEEE Computer, Vol. 17, No. 6, pp. 8-19.

17.2 Journal Articles and Study Reports

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

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

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

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

Sellers, P., F. Hall, and 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.

ECMWF Physics and Its Validation (Key References):

Andersson, E., J. Haseler, P. Unden, P. Courtier, G. Kelly, D. Vasilijevic, C. Brankovic, C. Cardinali, C. Gaffard, A. Hollingsworth, C. Jakob, P. Janssen, E. Klinker, A. Lanszinger, M. Miller, F. Rabier, A. Simmons, B. Strauss, J.-N. Thepaut, and P. Viterbo. 1998. The ECMWF implementation of three-dimensional variational assimilation (3D-VAR). III: Experimental results. Quart. J. Roy. Meteor. Soc., in press.

Beljaars, A.C.M., P. Viterbo, M.J. Miller, and A.K. Betts. 1996. The anomalous rainfall over the United States during July 1993: sensitivity to land surface parameterization and soil moisture anomalies. Mon. Wea. Rev., 124, 362-383.

Betts, A.K., J.H. Ball, and A.C.M. Beljaars. 1993. Comparison between the Land surface response of the ECMWF model and the FIFE-1987 data. Quart. J. Roy. Meteor. Soc., 119, 975-1001.

Betts, A.K., J.H. Ball, Beljaars, A.C.M., M.J. Miller, and P. Viterbo. 1996. The land-surface-atmosphere interaction: a review based on observational and global modelling perspectives. J. Geophys. Res. 101, 7209-7225.

Betts A.K., P. Viterbo, and A.C.M. Beljaars. 1998a. Comparison of the land-surface interaction in the ECMWF reanalysis model with the 1987 FIFE data. Mon. Wea. Rev., 126, 186-198.

Betts A.K., P. Viterbo, A.C.M. Beljaars, H-L. Pan, S-Y. Hong, M.L. Goulden, and S.C. Wofsy. 1998b. Evaluation of the land-surface interaction in the ECMWF and NCEP/NCAR reanalyses over grassland (FIFE) and boreal forest (BOREAS). J. Geophys. Res., in press.

Betts, A.K., P. Viterbo, and E. Wood. 1998c. Surface Energy and water balance for the Arkansas-Red River basin from the ECMWF reanalysis. J. Climate, in press.

Courtier, P., E. Andersson, W. Heckley, J. Pailleux, D. Vasilijevic, M. Hamrud, A. Hollingsworth, F. Rabier, and M. Fisher. 1998. The ECMWF implementation of three-dimensional variational assimilation (3D-VAR). I: Formulation. Quart. J. Roy. Meteor. Soc., in press.

Higgins RW, K.C. Mo, S.D. Schubert. 1996. The moisture budget of the central United States in spring as evaluated in the NCEP/NCAR and the NASA/DAO reanalyses. Monthly Weather Review 124: (5) 939-963. MAY 1996.

Lott, F. and M.J. Miller. 1997. A new sub-grid scale orographic drag parameterization: Its formulation and testing . Quart. J. Roy. Meteor. Soc.,123, 101-127.

Morcrette J.-J. 1990. Impact of changes to the radiative transfer parameterization plus cloud optical properties in the ECMWF model. Mon. Wea. Rev., 118, 847-873.

Morcrette J.-J. 1991. Radiation and cloud radiative properties in the European Centre for Medium-Range Weather Forecasts forecasting system. J. Geophys. Res., 96, 9121-9132.

Rabier, F., A. McNally, E. Andersson, P. Courtier, P. Unden, J. Eyre, A. Hollingsworth, and F. Bouttier. 1998. The ECMWF implementation of three-dimensional variational assimilation (3D-VAR). III: Structure functions. Quart. J. Roy. Meteor. Soc., in press.

Tiedtke M. 1984. The effect of penetrative cumulus convection on the large scale flow in the general circulation model. Beitr. Phys. Atmos. 57, 216-239.

Tiedtke M. 1989. A comprehensive mass flux scheme for cumulus parameterization in large-scale models. Mon. Wea. Rev., 117, 1779-1800.

Tiedtke, M. 1993. Representation of clouds in large-scale models, Mon. Wea. Rev., 121, 3040-3061.

Viterbo, P., A.C.M. Beljaars, J.-F. Mahfouf, and J. Teixeira. 1997. The role of soil water freezing in the interaction of the surface with the stable boundary layer. Internal ECMWF memo. Available from ECMWF, Shinfield Park, Reading RG2 9AX, UK.

Viterbo, P. and A.C.M. Beljaars. 1995. An improved land-surface parameterization in the ECMWF model and its validation. J. Clim., 8, 2716-2748.

Viterbo, P. and A.K. Betts. 1997. The forecast impact of changes to the snow albedo of the boreal forests. CAS/JSC Working Group on Numerical Experimentation. #25., Research Activities in Atmospheric and Oceanic Modelling.

Viterbo, P. and A.K. Betts. 1998. The forecast impact of changes to the albedo of the boreal forests in the presence of snow. J. Geophys. Res.(submitted).

Viterbo, P. and P. Courtier. 1995. The importance of soil water for medium-range weather forecasting. Implications for data assimilation, Workshop on Imbalance of Slowly Varying Components of Predictable Atmospheric Motions, World Meteorol. Org., Beijing, China. [Available from ECMWF, Shinfield Park, Reading RG2 9AX, England].

ECMWF Initialization and Analysis System:

Bengtsson, L., M. Kanamitsu, P. Kaliberg, and S. Uppala. 1982. FGGE 4-dimensional data assimilation at ECMWF. Bull. Amer. Meteor. Soc., 63, 29-43.

Hollingsworth, A. and P. Linnberg. 1986. The statistical structure of short-range forecast errors as determined from radiosonde data. Part I: The wind field.

Hollingsworth, A., D.B. Shaw, P. Linnberg, L. Illari, K. Arpe, and A.J. Simmons. 1986. Monitoring of observation and analysis quality by a data assimilation system. Mon. Wea. Rev., 114, 5, 861-879.

Linnberg, P. and A. Hollingsworth. 1986. The statistical structure of short-range forecast errors as determined from radiosonde data. Part II: The covariance of heights and wind errors, Tellus 38A, 137-161.

Lorence, A.C. 1981. A global three-dimensional multivariate statistical interpretation scheme. Mon. Wea. Rev., 109, 701-721.

Machenhauer, B. 1977. On the dynamics of gravity oscillations in a shallow water model, with application to normal mode initialization. Beitr. Phys. Atmos. 50, 259-271.

Shaw, D.B., P. Linnberg, A. Hollingsworth, and P. Undén. 1987. Data assimilation: The 1984/85 revision of the ECMWF mass and wind analysis. Quart. J. Roy. Meteor. Soc., 113, 533-566.

Undén, P. 1989. Tropical data assimilation and analysis of divergence. Mon. Wea. Rev., 117, 2495-2517.

Temperton, C. 1988. Implicit normal mode initialization. Mon. Wea. Rev., 116, 1013-1031.

Temperton, C. and D.L. Williamson. 1981. Normal mode initialization for a multivariate grid-point model: Part I linear aspects. Mon. Wea. Rev., 109, 720-743.

Wergen, W. 1988. The diabatic ECMWF normal mode initialization scheme. Beitr. Phys. Atmosph. 61, 274-304.

Williamson, D.L. and C. Temperton. 1981. Normal mode initialization for a multivariate grid-point model: Part II nonlinear aspects. Mon. Wea. Rev., 109, 744-757.

ECMWF Prediction Model:

ECMWF provides a comprehensive service from the Level II data archive, which is documented under ECMWF. 1996. The Description of the ECMWF/WRCP Level III-A Global Atmospheric Data Archive. ECMWF. Reading RG2 9AX, England. Interested users may write to The Director, ECMWF, Shinfield Park, Reading RG2 9AX, U.K., for further information.

Geleyn, J.F. 1988. Interpolation of wind temperature and humidity values from model levels to the height of measurements. Tellus, 40A, 347-351.

Geleyn, J.F. and A. Hollingsworth. 1979. An economical analytical method for the computation of the interaction between scattering and line absorption of radiation. Beitr. Phys. Atmos., 52, 1-16.

Geleyn, J.F. and H.J. Preuss. 1983. A new data set of satellite-derived surface albedo values for operational use at ECMWF. Arch. Meteor. Geophys. Bioclim., Ser. A, 32, 353-359.

Hortal, M., Simmons A., 1991. Use of reduced Gaussian grids in spectral models. Mon. Wea. Rev., 119, 1057-1074.

Janssen, P., A. Beljaars, A. Simmons, and P. Viterbo. 1992. On the determination of the surface stress in an atmospheric model. Mon. Wea. Rev.

Jarraud, M., A. Simmons, and M. Kanamitsu. 1988. Sensitivity of medium-range weather forecasts to the use of an envelope orography. Quart. J. Roy. Meteor. Soc., 114, 989-1025.

Miller, M., A. Beljaars, and T. Palmer. 1992. The sensitivity of the ECMWF model to the parameterization of evaporation from the tropical oceans. J. of Climate, 5, 418-434.

Miller, M., T. Palmer, and R. Swinbank. 1989. Orographic gravity - wave drag: its parameterization and influence in general circulation and numerical weather prediction model. Meteor. Atmos. Phys., 40, 84-109.

Simmons, A. and D. Dent. 1989. The ECMWF multi-tasking weather prediction model. computer Physics Reports, 11, 165-194.

Simmons, A.J., D.M. Burridge, M. Jarraud, C. Girard, and W. Wergen. 1989. The ECMWF medium-range prediction models. Development of the numerical formulations and the impact of increased resolution. Meteor. Atmos. Phys., 40, 28-60.

Slingo, J.J. 1987. The development and verification of a cloud prediction scheme for the ECMWF model. Quart. J. Roy. Meteor. Soc., 213, 899-927.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

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
ECMWF    - European Centre for Medium Range Weather Forecasts
EOS      - Earth Observing System
EOSDIS   - EOS Data and Information System
FIFE     - First ISLSCP Field Experiment
GIS      - Geographic Information System
GSFC     - Goddard Space Flight Center
HTML     - HyperText Markup Language
ISLSCP   - International Satellite Land Surface Climatology Project
MARS     - Meteorological Archive and Retrieval System
NAD83    - North American Datum 1983
NASA     - National Aeronautics and Space Administration
NSA      - Northern Study Area
OI       - Optimal Interpolation
ORNL     - Oak Ridge National Laboratory
PANP     - Prince Albert National Park
PDF      - Portable Document Format
SSA      - Southern Study Area
URL      - Uniform Resource Locator
UTC      - Universal Time Code
WMO      - World Meteorological Organization
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If using data from the BOREAS CD-ROM series, also reference the data as:

BOREAS Staff Science, "BOREAS Staff Science Meteorological Data Acquisition Program." In Collected Data of The Boreal Ecosystem-Atmosphere Study. Eds. J. Newcomer, D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers. CD-ROM. NASA, 2000.

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13. ABSTRACT *(Maximum 200 words)*

In cooperation with BOREAS atmospheric research efforts, the ECMWF agreed to provide BOREAS with a customized subset of its 6-hourly forecast data. This data set contains parameters from three ECMWF data products in GRIB format: Surface and Diagnostic Fields, Supplemental Fields, and Extension Data. Sample software and information are provided to assist in reading the data files. Temporally, the atmospheric parameters are available for the four main synoptic hours of 00, 06, 12, and 18 UTC from 1994 to 1996. Spatially, the data are stored in a 0.5- by 0.5-degree latitude/longitude grid. To cover the entire BOREAS study area, the grid extends from 48 to 62 degrees latitude and -92 to -114 degrees longitude. The data are stored in binary data representation known as FM 92 GRIB. Due to the complexity of the content and format of this data set, users are advised to read Sections 6, 7, 8, and 14 before using data. Based on agreements between BOREAS and ECMWF, users may legally obtain and use these data only by having a set of the BOREAS CD-ROMs that contain the data. Possession or use of these data under any other circumstance is prohibited. See Sections 11.3 and 20.4 for details.

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