1. TITLE

1.1 Data Set Title

ISLSCP II Reanalysis Near-Surface Meteorology Data

1.2 Database Table Name(s)

Not applicable to this data set.

1.3 File Name(s)

There are 136 compressed data files with this data set. The files include data with fixed, monthly, monthly-3-hourly (i.e. mean diurnal cycle), and 3-hourly temporal resolutions**.** A complete listing of all parameters included in this data set is given in Section 8.2. The individual files (provided in the compressed files) are in standard arc/info ASCII grid format (.asc) and are named using the following naming convention; however, the user should also refer to the naming conventions described in section **1.3.1 File Organization and Structure:**

N2_*variable*_1d_YYYYMMDD_hHH.asc

where

N2	Stands for NCEP II.
variable	This is the variable name (See Section 8.2 for listing). This can also include "_fixed" for time invariant fields, "_av" for average or mean, "_sd" for standard deviation, "_mn" for minimum, "_mx" for maximum, or "_in" for instantaneous data.
_1d_	This identifies the spatial resolution of the data: "1d" for 1-degree in both latitude and longitude.
YYYY	4-digit year from 1986 to 1995.
MM	2-digit month from 01 to 12.
DD	2-digit day. A value of 00 means that the file is a monthly average.
HH	2-digit hour (GMT) from 03 to 24. Depending on the parameter, this can be the end of the measurement period or the value at the HH time (e.g. 06 means this is either an average from 03 to 06, or an instantaneous value at 06, denoted by "_av" or "_in"

in the filename). **NOTE***:** A value of 24 is either an average from 21 to 24 or a value at 24 GMT, where 24 is the start of the next day, or hour 00. The hour 00 is not used here. Also note that the hourly time stamps are not provided for monthly data.

.asc This is the file extension, indicating that the file is in the ASCII, or text, format (See Section 8.4 for data format).

1.3.1 File Organization and Structure

All data files are named by variable first, then by temporal frequency (monthly, diurnal, 3-hourly), then by time stamp (e.g. year, month, day, and 3-hourly period).

Fixed Fields and Boundary Conditions

All of these files are within the compressed file N2_fixed_1d.tar.gz. The individual files are named **N2_*variable*_fixed_1d_mZZ.asc**, where ZZ is either 00 for time invariant fields or the month from 01 to 12 for the monthly varying fixed fields. Note that all fixed field data are year-independent.

Monthly Mean Fields

The compressed files for the monthly fields are of the form: N2_*variable*_1d_monthly.tar.gz. Within these compressed files, the individual files are named **N2_*variable*_av_1d_YYYYMMDD.asc**, where MM is the month from 01 to 12, and DD= 00. Note that "av" stands for mean (average), but that part of the file name can also contain "sd" for standard deviation, "mn" for minimum, or "mx" for maximum.

As an example, the file **N2_snd_1d_monthly.tar.gz**, when uncompressed, yields the following for the year 1986, which contains 12 monthly data files organized as follows:

N2_snd_av_1d_19860100.asc	file
N2_snd_av_1d_19860200.asc	file
…	
N2_snd_av_1d_19861200.asc	file

Monthly-3-Hourly (Mean Diurnal Cycle) Fields

The compressed files for the monthly 3-hourly fields are of the form
N2_*variable*_1d_diurnal.tar.gz.

Within these compressed files, the individual files are named **N2_*variable*_av_1d_YYYYMMDD_hHH.asc**, where DD denotes a monthly value and HH is the time stamp as described above. Note that two types of variables exist in the monthly-3-hourly data sets: "in" means instantaneous -- the data are valid exactly AT the given 3-hourly time stamp (i.e., 03, 06,...,24) and then averaged over an entire month; "av" means averaged -- the data were averaged from hourly periods to 3-hourly periods, and then over a month.

As examples, the file named **N2_dlw_av_1d_19920200_h12.asc** is the monthly average of the surface downward longwave flux from 09 to 12 GMT for February 1992. The file named **N2_pres_in_1d_19920200_h12.asc** is the monthly average of the surface pressure at 12 GMT for February 1992.

3-Hourly Fields

The compressed files for the 3-hourly fields are of the form:

N2_*variable*_1d_YYYY_3hourly.tar.gz,

where YYYY is the year from 1986 to 1995 (for each variable, there are 10 compressed files, one for each year, 1986-1995, with the exception of the variable *surface downward long wave radiation* (dlw) which has no data for 1986).

Within these compressed files, the individual 3-hourly files are named **N2_*variable*_av_1d_YYYYMMDD_hzz.asc**, where zz is the time stamp. Note that two types of variables exist in the 3-hourly data sets: "in" means instantaneous -- the data are valid exactly AT the given 3-hourly time stamp (i.e., 03, 06,...,24); "av" means averaged -- the data were averaged from hourly periods to 3-hourly periods.

As examples, the file named **N2_dlw_av_1d_19920210_h12.asc** is the average of the surface downward longwave flux from 09 to 12 GMT for February 10, 1992. The file named **N2_pres_in_1d_19920210_h12.asc** is the instantaneous surface pressure at 12 GMT on February 10, 1992 (See Section 8.2 for a listing of parameters).

1.4 Revision Date of this Document

June 9, 2014

2. INVESTIGATOR(S)

2.1 Investigator(s) Name and Title

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- Wesley Ebisuzaki, Climate Prediction Center, National Centers for Environmental Prediction, National Weather Service, National Oceanographic and Atmospheric Administration

2.2 Title of Investigation

The COLA ISLSCP II Version of the NCEP/DOE AMIP-II Reanalysis

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2.4 Data Set Citation

Dirmeyer, P., M. Zhao, G. White, and W. Ebisuzaki. 2014. ISLSCP II Reanalysis Near-Surface Meteorology Data. In Hall, Forrest G., G. Collatz, B. Meeson, S. Los, E. Brown de Colstoun, and D. Landis (eds.). ISLSCP Initiative II Collection. Data set. Available on-line [http://daac.ornl.gov/] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, USA.

2.5 ISLSCP Initiative II Collection References

Users of the International Satellite Land Surface Climatology (ISLSCP) Initiative II data collection are requested to reference the following publications when these data are used:

Hall, F.G., E. Brown de Colstoun, G. J. Collatz, D. Landis, P. Dirmeyer, A. Betts, G. Huffman, L. Bounoua, and B. Meeson, The ISLSCP Initiative II Global Datasets: Surface Boundary Conditions and Atmospheric Forcings for Land-Atmosphere Studies, *J. Geophys. Res.*, 111, doi:10.1029/2006JD007366, 2006.

Ebisuzaki, W., M. Kanamitsu, J. Potter, and M. Fiorino, 1999: An Overview of Reanalysis-2. *Proc. of 23rd Annual Climate Diagnostics and Prediction Workshop*, Miami, Florida (Oct 26-30, 1998). U.S. Dept. of Commerce, 119-122.

Kanamitsu, M., W. Ebisuzaki, J. Woollen, J. Potter and M. Fiorino, 2000: Overview of NCEP/DOE Reanalysis-2. *Proc. of the 2nd WCRP International Conf. on Reanalyses*, 23-27 Aug. 1999, Wokefield Park, UK. World Meteorological Organization, Geneva, Switzerland, WCRP-109, WMO/TD-No. 985, 1-4.

Kanamitsu, M., W. Ebisuzaki, J. Woollen and S.-K. Yang, 2002: NCEP/DOE AMIP-II Reanalysis (R-2). Submitted for publication in *Bulletin of the American Meteorological Society***.**

Kistler, R., E. Kalnay, W. Collins, S. Saha, G. White, J. Woollen, M. Chelliah, W. Ebisuzaki, M. Kanamitsu, V, Kousky, H. van den Dool, R. Jenne, and M. Fiorino, 2001: The NCEP-NCAR 50 year reanalysis monthly means CD-ROM and documentation. *Bull. Amer. Meteorol. Soc.*, *82*, 247-267.

3. INTRODUCTION

3.1 Objective/Purpose

The Center for Ocean-Land Atmosphere Studies (COLA) near-surface meteorology data set for ISLSCP II has been derived from the NCEP/DOE AMIP-II reanalysis (http://www.cpc.ncep.noaa.gov/products/wesley/reanalysis2/, Kanamitsu et al., 2000, 2002) that covers the years from 1979-2003. The data set for ISLSCP II covers the period from 1986 to 1995. The purpose of the NCEP/DOE Reanalysis is to provide an improved version of the original NCEP/National Center for Atmospheric Research (NCAR) reanalysis (Kalnay et al. 1996; Kistler et al. 2001) for use by the Atmospheric Model Inter-comparison Project (AMIP) II (Gleckler 1996; http://www-pcmdi.llnl.gov/projects/amip/index.php) for General Circulation Model (GCM) validation. The NCEP/DOE reanalysis uses a very similar analysis system to the NCEP/NCAR reanalysis and an upgraded version of the same general circulation model, with known errors fixed and assimilation of a more complete stream of observational data after 1993. Near-surface meteorological state variables and fluxes from the NCEP/DOE reanalysis are of potentially great value to the ISLSCP data user community. To co-register the NCEP/DOE reanalysis to the ISLSCP 1-degree Earth grid, the reanalysis data set was re-gridded from its native T62 Gaussian grid resolution (192 x 94 grid boxes globally) to the 1-degree spatial resolution required by ISLSCP II.

3.2 Summary of Parameters

The fields that are provided for ISLSCP II are near surface meteorological fields, fluxes of heat, moisture and momentum at the surface, and land surface state variables, all with a spatial resolution of 1 degree in both latitude and longitude. There are four temporal categories of data; time invariant and monthly mean annual cycle fields (together referred to as “fixed” fields); monthly mean fields; monthly-3-hourly (mean diurnal cycle) fields, and 3-hourly fields. Two types of variables exist in this data; instantaneous fields (primarily state variables), and average fields (primarily flux fields expressed as a rate). A detailed description and listing of all available parameters is given in Section 8.2.

3.3 Discussion

The analysis increment for the NCEP/DOE AMIP-II reanalysis is six hours, and output data are routinely reported every hour or six hours. In order to satisfy the ISLSCP II requirement for 3-hourly data, twice daily 36 hour forecasts were made and hourly output were obtained from the 24-36 hour forecasts. The 24-36 hour forecasts were chosen to minimize "spin-up/spin-down" problems. The one-hour data were later combined to produce 3-hourly data. Time averaging was performed on the native reanalysis grid. For the 3-hourly and the monthly-3- hourly data, the hour in the file name refers to the end of the 3-hour period. For example, 03Z refers to the value at 03Z (for instantaneous data) or the average over the preceding period 00Z-03Z (for the flux fields and snow cover fraction).

Regridding was performed using bi-linear interpolation from the original T62

Gaussian grid to the regular 1-degree grid. When possible, NCEP land grid points are mapped to ISLSCP land grid points, and NCEP water grid points are mapped to ISLSCP water grid points. See Section 9 for a complete description of the re-gridding procedures.

3.4 Differences Between NCEP and ECMWF Reanalyses

The ISLSCP II data collection contains complementary near-surface meteorology fields from both the COLA/NCEP data set discussed here and the European Centre for Medium-range Weather Forecasts (ECMWF) data set "ISLSCP II ECMWF Near-Surface Meteorology Parameters" (Beljars et al. 2014), archived and distributed through the Oak Ridge National Laboratory (ORNL) DAAC for Biogeochemical Dynamics at http://daac.ornl.gov. The following table lists some of the fundamental differences between the reanalysis products. Some differences, such as spatial resolution, are not evident to the user of the ISLSCP II versions of the products since they have been co-registered on the same 1-degree grid.

Property	NCEP/DOE AMIP-II	ERA-40
Original horizontal resolution	T63 (approx. 1.9 degrees on Gaussian grid)	T159 (approx. 125 km on a reduced Gaussian grid)
Full period of coverage	1979-2003	1957-2001

4. THEORY OF ALGORITHM/MEASUREMENTS

Routine analyses are produced by operational meteorological centers in real time several times each day using the current version of the centers' global forecast model. These models are constantly being updated and improved, so that over time fundamental climatological properties of the model are also updated and improved. This makes a long time series of *operational* analyses useless for examining long-term trends or variations in climate. A reanalysis is a way to produce a global analysis of the state of the atmosphere at regular intervals over an extended period of time (many years or decades) with no gaps in space or time. This is done by using a "frozen" version of the analysis model, and performing a retrospective analysis using archives of observations going back throughout the period of record. A reanalysis also allows for the use of more observational data, as many high-quality observations are not available to the operational centers in real-time.

Observational networks do not cover the entire globe uniformly, but have gaps in space and vary in their coverage over time. However, observational measurements provide the best estimate of the state of the atmosphere where they are taken. On the other hand, a geophysical fluid-dynamical model of the atmosphere containing parameterizations of important physical processes like radiative transfer, convection, turbulent transfer and diffusion of heat, moisture and momentum, can provide a complete global simulation of the atmosphere and is also sued for forecasting purposes as it can be integrated forward in time. However, the models are imperfect representations of the atmosphere, and are prone to systematic errors, drift, and limitations owing to their finite spatial and temporal resolutions. A reanalysis is a combination of model and measurement, using observations to constrain the dynamical model to optimize between the properties of complete coverage and accuracy. The insertion of observations into the model integration is called data assimilation.

The NCEP/DOE AMIP-II reanalysis (Kanamitsu *et al.*, 2000, 2002) is an updated and corrected version of the NCEP/NCAR reanalysis (Kalnay *et al.*, 1996; Kistler *et al.*, 2001). It was done with a global spectral model of resolution T62 (about 210 km) and 28 vertical layers. Physical parameterizations, including radiation, were calculated on a Gaussian grid of 192 x 94, roughly 2 degrees. A time step of 20 minutes was used for the dynamics and physics, except for the full atmospheric radiation, which was calculated every hour.

The NCEP-II reanalysis used the same analysis system as the NCEP/NCAR reanalysis, the Spectral Statistical Interpolation (SSI or 3D variational) analysis (Parrish and Derber, 1992; Derber *et al.*, 1991), and nearly the same raw observational data, with some additional data after 1993. It used temperature retrievals from the National Environmental Satellite, Data, and Information Service (NESDIS) and not raw satellite radiances. It used observations of surface pressure over land but not surface layer winds, temperatures and specific humidity over land. Orography was derived from a NAVY orography with 10 minute resolution and area-averaged to the Gaussian grid of the model. Roughness lengths over land were derived from the data of Dorman and Sellers (1989) that included 12 vegetation types but was not a function of orography. Plant resistance is constant in time but varies with location.

The atmospheric model used in the NCEP/NCAR reanalysis is essentially the NCEP operational medium-range forecast model of 1995. Details of the model dynamics and physics can be found in NOAA/NMC Development Division (1988), Kanamitsu (1988) and Kanamitsu *et al*. (1991), with some major changes, such as the use of a simplified Arakawa-Schubert convective parameterization developed by Pan and Wu (1994) based on Grell (1993), a better diagnostic cloud scheme (Campana *et al*., 1994), and a soil model based on Pan and Mahrt (1987) with a shallow and deep soil layer. The cloud scheme diagnoses stratiform clouds from an empirical humidity-cloud cover relationship based on U.S. Air Force "RTNEPH" (Real Time Nephanalysis) cloud analyses (Hamill *et al*., 1992). The model used in the NCEP-II reanalysis contains corrections and improvements to this model, including but not limited to improvements to the NCEP operational global model after 1995.

Two-meter variables are created during the model integration. The similarity profile function is evaluated at the first sigma level and at 2 meters. The ratio is then used to derive the 2-meter temperature. The derivation assumes that the heat flux is constant between the surface and the first sigma level. For moisture, the procedure is slightly different. When there is upward moisture flux, the surface humidity is computed inversely from the land surface model derived evaporation rate. When there is dew formation, the surface specific humidity is assumed to be the saturation value at the skin temperature and the constant flux assumption is used to derive the 2-meter q. Relative humidity is then computed in the post-processor. The formula for surface fluxes are used such that the same flux will be obtained whether the computation is with sigma level one fields or the 2-meter fields (Hua-lu Pan, personal communication).

The NCEP-II reanalysis corrected errors in the NCEP/NCAR reanalysis, including a mistake in the snow cover analysis for 1974-94, a mistake in horizontal diffusion that concentrated snow over orography, discontinuities in relative humidity-cloudiness relationship, and the snow melt term. Correcting the snow cover analysis tended to increase near-surface temperatures during Sept.-Nov. by 1.6 degrees K. Correcting the horizontal diffusion resulted in a much more realistic-looking and smoother precipitation distribution over the wintertime continents.

The NCEP-II reanalysis added the use of 5-day mean CPC Merged Analysis of Precipitation (CMAP) (Xie and Arkin, 1996, 1998) to update soil moisture (and removed a damping of the deep layer soil moisture to climatology), smoothed orography, and the use of model snow depth when it is consistent with the observed snow cover. Soil moisture and the land surface water balance were dramatically improved over the NCEP/NCAR reanalysis (Maurer *et al*., 2000). The smoother orography led to less evidence of unrealistic small-scale features in precipitation and surface fluxes. NCEP-II has deeper and more spatially variable snow depth than the NCEP/NCAR reanalysis.

The NCEP-II reanalysis improved the model physics, adding the Hong-Pan planetary boundary layer that utilizes non-local diffusion (Hong and Pan, 1996), a new short-wave radiation (Chou, 1992; Chou and Lee, 1996), a minor tuning of the convective parameterization, more realistic cloud-top cooling and recalibrated cloud tuning coefficients for stratiform clouds. Summertime precipitation over the southeast United States became more realistic and surface radiation fluxes were improved. Implementation of the improved boundary layer followed a study by Betts, Hong and Pan (1996) that compared the NCEP/NCAR reanalysis to 1987 First ISLSCP Field Experiment (FIFE) data.

The NCEP-II reanalysis also used different fixed fields than the NCEP/NCAR reanalysis, including a new albedo over land from Briegleb et al. (1996) and sea surface temperatures and sea-ice fields from AMIP-II. A Northern Hemisphere snow cover analysis produced by the joint National Snow and Ice Data Center on a weekly basis (until Sept. 1998) was interpolated differently than in NCEP/NCAR to daily values. The new albedo algorithm handled direct and diffuse components separately and divided the solar spectra into visible and near infrared bands, increasing the albedo over deserts. Surface and top of the atmosphere radiative fluxes appear to be more realistic in NCEP-II than the NCEP/NCAR reanalysis. The NCEP-II reanalysis also improved cloud diagnostics fields and included a more complete snow budget in the diagnostics.

5. EQUIPMENT

This data set is derived from models, using a wide variety of surface and/or near-surface observations. It is beyond the scope of this document to describe the various instruments and their calibration information. The user is referred to the references in this document for more information. The distribution of observations for each month of the NCEP/NCAR reanalysis is available on the monthly mean CD-ROM published in Kistler *et al.* (2001). The NCEP-II reanalysis used nearly the same set of observations, with some additional observations after 1993.

5.1 Instrument Description

5.1.1 Platform (Satellite, Aircraft, Ground, Person)

Observations used by the NCEP reanalyses include:

- Radiosondes, dropsondes, pibals
- Conventional aircraft winds
- Aircraft Communications Addressing and Reporting System (ACARS) aircraft
    - winds and temperatures
- Marine winds, temperature and specific humidity in the surface layer
- Land surface pressure
- Satellite cloud-track winds
- NESDIS temperature retrievals
- PAOBS (Australian Pressure Observations)
- Sea Surface Temperature (SST) and snow-cover analyses

The NCEP reanalyses did not include the following observations:

- Precipitation (except to correct soil moisture in the NCEP-II reanalysis)
- Radar, profilers
- Special Sensor Microwave Imager (SSM/I) winds and precipitable water
- Surface stations' observations of land winds, temperature, specific humidity
- Most cloud information
- Radiances from satellite
- Satellite humidity estimates
- Soil/albedo/snow depth

5.1.2 Mission Objectives

Various.

5.1.3 Key Variables

Various.

5.1.4 Principles of Operation

See Kistler *et al.* (2001) and other references for more information.

5.1.5 Instrument Measurement Geometry

See Kistler *et al.* (2001) and other references for more information.

5.1.6 Manufacturer of Instrument

Various.

5.2 Calibration

5.2.1 Specifications

5.2.1.1 Tolerance

See Kistler *et al.* (2001).

5.2.2 Frequency of Calibration

See Kistler *et al.* (2001).

5.2.3 Other Calibration Information

See Kistler *et al.* (2001).

6. PROCEDURE

6.1 Data Acquisition Methods

The original NCEP/DOE data were provided to COLA by Drs. Glenn White and Wesley Ebisusaki from NOAA/NCEP. See Kistler *et al.* (2001) for more information on acquisition of near-surface observations for the NCEP/DOE reanalysis.

6.2 Spatial Characteristics

6.2.1 Spatial Coverage

The NCEP/DOE reanalysis has global coverage.

6.2.2 Spatial Resolution

The NCEP/DOE reanalysis has a spatial resolution identical to the general circulation model used to perform the analysis – a version of the operational Medium-Range Forecast (MRF) model. The resolution is T62 on the Gaussian grid (192 x 94) or exactly 1.875 degrees longitude by approximately 1.915 degrees latitude. For ISLSCP II, the data have been regridded onto a uniform, equal-angle, global Earth grid with a spatial resolution of 1 degree in both latitude and longitude.

6.3 Temporal Characteristics

6.3.1 Temporal Coverage

The NCEP/DOE reanalysis begins from 1 January 1979, and will be extended as a climate data assimilation system until a new global reanalysis replaces it. The data prepared for ISLSCP II span the period 1 January 1986 – 31 December 1995.

6.3.2 Temporal Resolutions

- Time invariant
- Climatological monthly mean annual cycle
- Monthly mean
- Monthy-3-hourly mean diurnal cycle
- 3-hourly

7. OBSERVATIONS

7.1 Field Notes

Not applicable to this data set.

8. DATA DESCRIPTION

8.1 Table Definition with Comments

Not applicable to this data set.

8.2 Type of Data

8.2.1 Para	8.2.2 Parameter/ Variable Description	8.2.3 Data Range	8.2.4 Units	8.2.5 Data Source
Fixed Fields				
falbedo	Snow-free surface albedo (climatological monthly mean annual cycle)	Min = 11.00 Max = 75.00	percent	NCEP
forogrd	Orographic height above MSL	Min = -523.15 Max = 5618.81	m	NCEP
fresis	Plant resistance function	Min = 34.80 Max = 182.70	s/m	NCEP
frough	Surface roughness length for momentum and heat (climatological monthly mean annual cycle)	Min = 0.00 Max = 2.70	m	NCEP
imask	Data mapping mask (see section 9.1.1)	Min = -1 Max = 1	See Section 9.1.1	COLA
Monthly Mean Fields				
snc_av	Fraction of snow cover (see section 9.1.1)	Min = 0.00 Max = 1.00	fraction	COLA
snd_av	Snow cover in terms of water equivalent depth (mass per unit	Min = 0.00 Max = 55005.54	kg/m2	NCEP
10_av	Surface layer (0-10 cm) volumetric soil moisture	Min = 1.38e-4 Max = 0.42	fraction	NCEP
sw10_mn	Minimum value of sw10_av	Min = 0.00 Max = 0.38	fraction	COLA
sw10_mx	Maximum value of sw10_av	Min = 2.03e-4 Max = 0.43	fraction	COLA
sw10_sd	Standard deviation of sw10_av	Min = 4.93e-8 Max = 0.14	fraction	COLA
sw200_av	Subsurface layer (10-200 cm) volumetric soil moisture	Min = 1.19e-3 Max = 0.42	fraction	NCEP
sw200_mn	Minimum value of sw200_av	Min = 1.19e-3 Max = 0.42	fraction	COLA
sw200_mx	Maximum value of sw200_av	Min = 1.19e-3 Max = 0.43	fraction	COLA
sw200_sd	Standard deviation of sw200_av	Min = 6.53e-9 Max = 9.48e-2	fraction	COLA
t10_av	Surface layer (0-10 cm) soil temperature	Min = 199.97 Max = 312.88	degrees k	NCEP
t10_mn	Minimum value of t10_av	Min = 199.96 Max = 305.75	degrees k	COLA
t10_mx	Maximum value of t10_av	Min = 199.98 Max = 321.76	degrees k	COLA
t10_sd	Standard deviation of t10_av	Min = 9.50e-6 Max = 16.88	degrees k	COLA
t200_av	Subsurface layer (10-200 cm) soil temperature	Min = 199.89 Max = 306.95	degrees k	NCEP

t200_mn	Minimum value of t200_av	Min = 199.87 Max = 306.68	degrees k	COLA
t200_mx	Maximum value of t200_av	Min = 199.91 Max = 307.17	degrees k	COLA
t200_sd	Standard deviation of t200_av	Min = 0.00 Max = 4.99	degrees k	COLA
Monthly-3-hourly (Mean Diurnal Cycle) Fields				
dlw_av	Surface downward long wave radiation	Min = 37.85 Max = 466.41	W/m2	NCEP
dsw_av	Surface downward short wave radiation	Min = 0.00 Max = 1138.11	W/m2	NCEP
lh_av	Surface latent heat flux	Min = -260.92 Max = 592.52	W/m2	NCEP
prec_av	Total precipitation rate	Min = 0.00 Max = 1.10e-3	kg/m2/s	NCEP
pres_in	Surface pressure	Min = 48246.85 Max = 104949.20	Pa	NCEP
roff_av	Surface runoff	Min = 0.00 Max = 8.28e-4	kg/m2/s	COLA
sh_av	Surface sensible heat flux	Min = -775.35 Max = 792.26	W/m2	NCEP
snlw_av	Surface net long wave radiation	Min = -508.19 Max = 10.85	W/m2	COLA
snr_av	Snowfall rate	Min = 0.00 Max = 1.67e-4	kg/m2/s	NCEP
snsw_av	Surface net short wave radiation	Min = 0.00 Max = 1078.60	W/m2	COLA
spfh_in	Specific humidity at 2 m AGL (see section	Min = 2.00e-6 Max = 2.32e-2	kg/kg	NCEP
tmax_in	Maximum of temperature at 2 m	Min = 192.43 Max = 314.95	degrees k	NCEP
tmin_in	Minimum of temperature at 2 m AGL	Min = 192.00 Max = 314.73	degrees k	NCEP
tmp_in	Temperature at 2 m AGL	Min = 192.29 Max = 314.74	degrees k	NCEP
tnlw_av	TOA (Top of Atmosphere) outgoing long wave radiation	Min = 85.75 Max = 371.07	W/m2	NCEP
tnsw_av	TOA (Top of Atmosphere) net shortwave radiation	Min = 0.00 Max = 1233.13	W/m2	COLA
u10_in	Zonal component of wind at 10 m AGL	Min = -32.97 Max = 18.84	m/s	NCEP
ustr_in	Zonal wind stress	Min = -3.42 Max = 0.94	N/m2	NCEP
v10_in	Meridional component of wind at 10 m AGL	Min = -40.47 Max = 17.97	[m/s]	NCEP
vstr_in	Meridional wind stress	Min = -1.95 Max = 0.91	N/m2	NCEP
3-hourly Fields				
cpr_av	Convective precipitation rate	Min = 0.00 Max = 4.05e-3	kg/m2/s	NCEP
dlw_av	Surface downward long wave radiation	Min = 27.36 Max = 523.89	W/m2	NCEP
dsw_av	Surface downward short wave radiation	Min = 0.00 Max = 1248.81	W/m2	NCEP
prec_av	Total precipitation rate	Min = 0.00	kg/m2/	NCEP

		Max = 7.95e-3		
snd_in	Snow cover in terms of water equivalent depth (mass per unit area)	Min = 0.00 Max = 55033.55	kg/m2	NCEP
snlw_av	Surface net long wave radiation	Min = -799.01 Max = 81.12	W/m2	COLA
snr_av	Snowfall rate	Min = 0.00 Max = 1.90e-3	kg/m2/s	NCEP
snsw_av	Surface net short wave radiation	Min = 0.00 Max = 1155.28	W/m2	COLA
spfh_in	Specific humidity at 2 m AGL (see section	Min = 0.00 Max = 4.28e-2	kg/kg	NCEP
tmp_in	Temperature at 2 m AGL	Min = 176.36 Max = 326.71	degrees k	NCEP
w10_in	Wind speed at 10 m AGL	Min = 7.23e-3 Max = 48.03	m/s	COLA

*A data source of COLA means that the field is not a direct product of the NCEP/DOE reanalysis, but has been derived or calculated from fields of the NCEP/DOE reanalysis. Descriptions of the derivation procedures are given in section 9.1.1.

8.3 Sample Data Record

Not applicable to this data set.

8.4 Data Format

All of the files in the ISLSCP Initiative II data collection are in text format. The file format for the NCEP data files consists of numerical fields in scientific, or E-notation (e.g. "1.6300E+01") with a fixed 11-character length, which are delimited by one or two spaces and arranged in columns and rows. The files contain 360 columns by 180 rows. Missing data are encoded as "-9.9900E+02".

These files are gridded to a common 1 degree equal-angle lat/long grid, where the coordinates of the upper left corner of the files are located at 180 degrees W, 90 degrees N and the lower right corner coordinates are located at 180 degrees E, 90 degrees S. Data in the files are ordered from North to South and from West to East beginning at 180 degrees West and 90 degrees North.

8.5 Related Data Sets

Beljaars, A.C.M, A.K. Betts, and E. Brown de Colstoun. 2014. ISLSCP II ECMWF Near-Surface Meteorology Parameters. In Hall, Forrest G., G. Collatz, B. Meeson, S. Los, E. Brown de Colstoun, and D. Landis (eds.). ISLSCP Initiative II Collection. Data set. Available on-line [http://daac.ornl.gov/] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, USA. http://dx.doi.org/10.3334/ORNLDAAC/1222

Additional ISLSCP II data sets can be obtained at http://daac.ornl.gov/ISLSCP_II/islscpii.shtml.

9. DATA MANIPULATIONS

9.1 Formulas

9.1.1 Derivation Techniques/Algorithms

The NCEP analysis cycle used in generating the NCEP/DOE reanalysis operates on a 6-hour cycle four times a day. For ISLSCPII, at 0000UTC and 1200UTC, a global integration is initialized from observations assimilated into a “first guess” field taken from the 6-hour forecast of the previous analysis cycle, and then integrated forward for 36 hours. This large infusion of observational data introduces a shock into the dynamical fields. In addition, the diabatic physical processes in the atmospheric model (e.g., condensation of water vapor into cloud and precipitation) begin from a so-called “cold start” at the beginning of each analysis increment. Thus, there is an initial spin-up of these processes, such that quantities such as precipitation and downward shortwave radiation have large biases during the first few hours of the analysis cycle. Global cloud cover appeared to take 24 hours to "spin up". Ironically, this is the time period when the atmospheric state variables (e.g., winds, pressure, and temperature) are most accurate. The errors in these fields gradually increase during the first 36 hours, as the flux fields actually improve. Because of the importance of surface radiative and water fluxes for land surface processes, and for consistency among all reanalysis fields, it was decided to use the 24-35 hour forecast data from each analysis cycle for ISLSCP Initiative II. Fields labeled with the source as “NCEP” in Section 8.2 are standard NCEP model output fields that have been directly time-averaged and interpolated as below. Fields labeled with the source as “COLA” are not standard NCEP model output fields, but have been calculated or derived from them prior to time averaging and interpolation. No information other than that contained in the original NCEP/DOE reanalysis data set are used to calculate the fields in this data, with the exception of the ISLSCP land-sea mask, as described in section 9.3.1. No attempt has been made to correct systematic errors, or otherwise produce a “hybrid” data set, as was done for the near-surface meteorology fields in ISLSCP Initiative I.

Monthly fractional snow cover *snc_av* is calculated by the following procedure. At each hourly time step at each NCEP land grid box, a fractional cover is calculated based on the snow water equivalent. If the snow water equivalent is greater than or equal to 10 kg/m^2, fractional coverage is 1. If snow water equivalent is less than 10 kg/m^2, the fractional coverage = snow water equivalent / 10 (C. A. Schlosser, personal communication). Then the fractional coverage for each hour of the month is averaged to obtain a value for the month. Thus, *snc_av* is a spatio-temporal fractional coverage for the month.

The monthly standard deviations of soil moisture and temperature are based on daily mean data for those fields. However, the minimum and maximum values are calculated from hourly data.

Three-hourly wind speed *w10_in* is calculated as the magnitude of the wind vector represented by the zonal and meridional components of the wind.

Energy fluxes (sign convention):

Positive upward:

tnlw_av, sh_av, lh_av,

Positive downward:

snsw_av, snlw_av, dsw_av, dlw_av, tnsw_av,

There are three precipitation fields in the 3-hourly data. Total precipitation *prec_av* includes all forms of precipitation; rain and snow, convective and large-scale. Also provided are the convective precipitation rate *cpr_av* and the snowfall rate *snr_av*. The large-scale precipitation rate can be derived as (*prec_av* – *cpr_av*). The rainfall rate can be derived as (*prec_av* – *snr_av*).

9.2 Data Processing Sequence

9.2.1 Processing Steps and Data Sets

Time averaging is conducted on the native NCEP model grid. The time-averaged data are then interpolated to the 1-degree ISLSCP II grid. During interpolation, special consideration is paid to whether the data are over land or water — section 9.3.1 describes this procedure in detail.

9.2.2 Processing Changes

None given.

9.2.3 Additional Processing by the ISLSCP Staff

The ISLSCP Staff did not make any changes to the data.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

Data on the T62 NCEP model grid have been interpolated to the ISLSCP 1-degree x 1-degree grid, as much as possible consistent with the land/water mask definitions of each grid. The NCEP land sea mask and the ISLSCP land/water masks are used to ensure that land points are transformed into land points and water points are used for water points. For every grid box on the target ISLSCP grid, there are from 1 to 4 overlapping grid boxes of the input NCEP grid; only those points are selected that are of the same type as the target grid point (water for water and land for land). No distinction is made over land between permanent ice and ice-free grid points. All intersecting grid boxes of same type are used to perform a bi-linear interpolation of the data. If none of the intersecting grid boxes have the same type, they are all used for bi-linear interpolation, and the box is flagged in the file imask.asc. This may occur at locations where, for instance, the ISLSCP mask has a lake, whereas the NCEP mask has only land points in the surroundings. In this case, the consistency between land sea masks is lost. Figure 1 shows the values of imask; values of –1 are blue (ISLSCP has land, but NCEP has water), +1 are red (ISLSCP has water, but NCEP has land), 0 are white (consistent data were interpolated). The meanings of the values of *imask* are consistent with the ECMWF mask.

Specific humidity at 2 m AGL has been checked after interpolation to ensure that it does not exceed the saturated value for the interpolated value of surface temperature at 2 m AGL. Because of the nonlinear nature of the Clausius-Clapeyron equation, the arithmetic mean of specific humidity for two or more grid boxes, when near saturation (100% relative humidity), may result in a value greater than the saturated specific humidity for the corresponding arithmetic mean of temperature over the same grid boxes. If the interpolated specific humidity exceeds the saturated value for the temperature at the corresponding ISLSCP grid box, it is adjusted down to the saturation value. All positive definite quantities have been checked to ensure they are not less than zero as a result of round-off error during the interpolation calculations.

9.4 Graphs and Plots

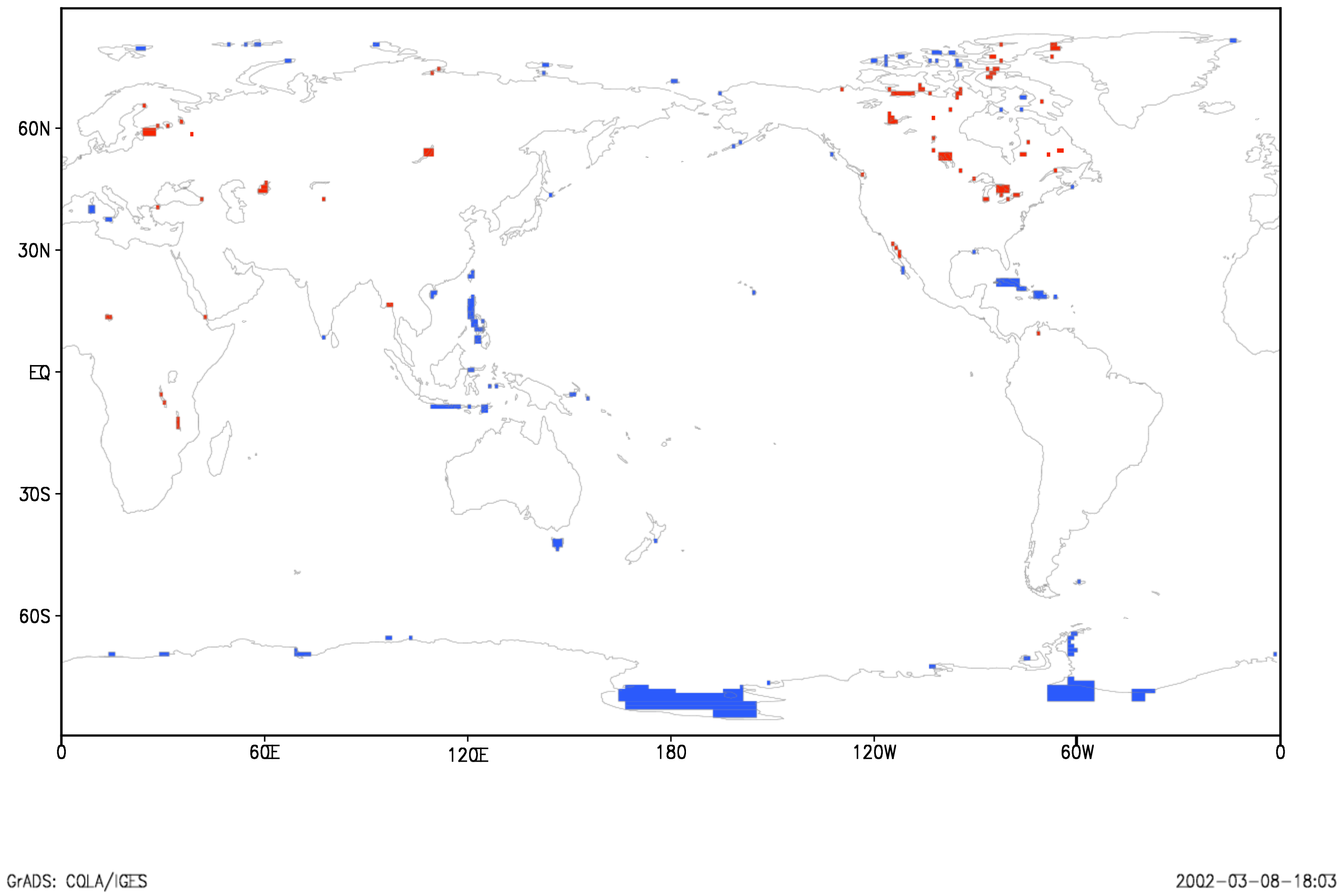

Figure 1 ISLSCP grid boxes where; ISLSCP is water, but NCEP is land (red); ISLSCP is land but NCEP is water (blue).

10. ERRORS

10.1 Sources of Error

Measurement and sampling errors exist in assimilated *in situ* observations (surface station measurements, radiosondes, dropsondes, aircraft measurements, pilot balloons and marine buoys) while errors or assumptions in retrieval algorithms may contribute additional errors to remotely sensed quantities (satellite soundings, cloud track winds).

The analysis model itself is also a source of error. Many physical processes are approximated by empirical parameterizations that contain assumptions and simplifications that compromise accuracy. The model has a finite spatial resolution and time stepping interval which can contribute to numerical errors (aliasing, smoothing, numerical instability) and the spectral nature of the numerical representation of state variables in the model means that sharp gradients in state variables are not well represented. Finite resolution also means that features of the topography and vegetation cover smaller than several hundred kilometers cannot be properly represented. Also, the nonlinear chaotic nature of atmospheric fluid dynamics means that any error, no matter how small, will grow over time and eventually saturate if not constrained by the constant assimilation of observational data. Thus, in areas with few observations, the errors in the reanalysis are likely to be larger.

10.2 Quality Assessment

10.2.1 Data Validation by Source

Observations of state variables only are assimilated into the reanalysis. Because of the interpolative nature of the analysis model and the necessity for physical consistency across space, the reanalysis is not necessarily identical to the observed value at the point and time where the observations is assimilated.

Flux fields (e.g., precipitation) are not assimilated in this reanalysis, so these fields will be heavily influenced by the character of the model itself. These variables can be independently evaluated where measurements exist (see Section 10.2.4)

10.2.2 Confidence Level/Accuracy Judgment

Kalnay et al. (1996) provide an appendix which rates the confidence level of each variable in the reanalysis. Four categories are used. Type **A** indicates analysis variables that are strongly influenced by observed data. The highest rating of any of the surface variables in this data set are considered to be type **B**, where although there are observational data that directly affect the value of the variable, the model also has a strong influence on the analysis value. Most variables are of type **C**, indicating that there are no observations directly affecting the variable, so that it is derived solely from the model fields forced by the data assimilation to remain close to the atmosphere. Fixed fields that are specified as boundary conditions of parameter fields for physical sub-models are listed as type **D**. The table below provides the confidence categories for each variable. There are no parameters in this data set with a confidence category of **A**.

Temporal Resolution	Category **B**	Category **C**	Category **D**
Fixed Fields			All
Monthly Fields		All	
Monthly 3-Hourly Fields	*tmp_in, tmin_in, tmax_in, spfh_in, pres_in, u10_in, v10_in, ustr_in, vstr_in*	*snsw_av, snlw_av, dsw_av, dlw_av, tnsw_av, tnlw_av, sh_av, lh_av, prec_av, snr_av, roff_av*	
3-Hourly Fields	*tmp_in, spfh_in, w10_in*	*snsw_av, snlw_av, dsw_av, dlw_av, snr_av, cpr_av, prec_av, snd_in*	

10.2.3 Measurement Error for Parameters and Variables

See Section 10.1.

10.2.4 Additional Quality Assessment Applied

Evaluations of the reanalyses over the ocean surface can be found in Taylor (ed., 2000, Sect. 11.4) and White (ed., 2001). Taylor (ed., 2000, Sect. 4.4) contains a description of the NCEP-II and other reanalyses.

White conducted an intercomparison of monthly mean precipitation and surface fluxes from the NCEP/NCAR, NCEP-II and ERA-15 (the predecessor to the ERA-40 reanalysis included in ISLSCP-II) reanalyses with CMAP precipitation for 1981-92 and Surface Radiation Budget-1 (SRB) (the predecessor to SRB-2 included in ISLSCPII) surface shortwave radiation for July 1983-June 1991.

Monthly mean precipitation estimates from the reanalyses show many similar differences from CMAP estimates and display stronger maxima over the tropical continents and more precipitation over land than CMAP. NCEP-II and NCEP/NCAR have too much rainfall over Canada, Eurasia and the southeast U.S. during the northern summer; NCEP-II is more realistic over the southeast U.S. than NCEP/NCAR. NCEP-II also has much improved patterns of snowfall reflecting a correction to horizontal diffusion of moisture. NCEP-II and ERA overestimate month-to-month variability in precipitation in the tropics; all the reanalyses overestimate it in the northern mid-latitudes. NCEP-II appears to have a more realistic climatological annual cycle in precipitation over land than the NCEP/NCAR reanalysis; however, it displays a larger RMS difference from CMAP in monthly mean precipitation anomalies from climatology than does NCEP/NCAR, especially in the tropics.

The NCEP/NCAR reanalysis had too much downward solar radiation at the surface (which was compensated by too high a surface albedo, especially over the ocean); the NCEP-II reanalysis and ERA-15 agree much better with SRB estimates. Over land NCEP-II agrees much better with ERA-15 than with NCEP/NCAR. The NCEP-II reanalysis had more cloudiness than the NCEP/NCAR reanalysis, an improved shortwave radiation parameterization and a lower albedo over land, except over the Sahara. The NCEP-II albedo was lower than ERA-15's as well, except over deserts and polar latitudes. Over land NCEP-II surface net shortwave exceeds SRB outside the tropics and is less than the SRB shortwave in the tropics. While NCEP-II shows better agreement than NCEP/NCAR with SRB in the long-term zonally averaged mean over land, NCEP-II monthly anomalies in net shortwave do not show better agreement than NCEP/NCAR with SRB net shortwave anomalies, especially in the northern mid-latitudes.

NCEP-II has the least upward sensible heat flux over land of the three reanalyses and more evaporation over land than ERA-15. In the annual mean over higher latitudes NCEP-II tends to have a large downward sensible heat flux.

Arpe, Klepp and Rhodin (2000) compared precipitation from the NCEP-II, NCEP/NCAR and ERA-15 reanalyses with other estimates including CMAP and the Global Precipitation Climatology Project (GPCP). They found generally very good similarity in long-term means, but found that the diurnal cycle was deficient in the reanalyses and that no one reanalysis was superior in all respects.

11. NOTES

11.1 Known Problems with the Data

No attempt has been made to match NCEP and ISLSCP masks for permanent ice in the interpolation process. As a result, inconsistencies may exist with parameters such as surface albedo between the ISLSCP land cover data set, and the NCEP fixed field *falbedo.*

As described in section 9.1.1, spin-up of the model makes data from the first hours of each analysis cycle undesirable for this application; therefore 24-35 hour forecasts from the 0000 and 1200 GMT analysis cycles, launched at 12-hour increments, are used.

For some of the analysis cycles there are errors internal to the original GRIB files. In these cases, data from the 12-23 hour forecasts of the subsequent analysis cycle are substituted. The following 12-hour intervals had to be substituted in this fashion:

Valid Time	Original Forecast Start Time	Substituted Forecast Start Time
1200-2300 UTC on April 21, 1987	1200UTC 20 April 1987	0000UTC 21 April 1987
1200-2300 UTC on February 13, 1990	1200UTC 12 February 1990	0000UTC 13 February 1990

There are scattered grid points, especially near coastlines, where there are inconsistencies in the precipitation fields. Specifically, there may be points where the convective precipitation rate is slightly greater than the total precipitation rate. Likewise, there may be locations where the snowfall rate exceeds the total precipitation rate. These inconsistencies are a result of the land-sea differentiated interpolation procedure. If this would pose a problem for your application of this data set, please adjust the snowfall or convective precipitation rate downward at those points, so that it equals the total precipitation rate.

11.2 Usage Guidance

It should be noted that the quantity and quality of assimilated observations vary greatly in space, and somewhat in time, in the reanalysis product. Where dense operational observational networks are in place (e.g., Europe, N. America, East Asia, Australia), reanalysis fields are likely to be more accurate than over data sparse regions where the reanalysis fields are almost entirely a product of the NCEP general circulation model.

In addition, certain fields are more constrained by observational data than others, and thus potentially more accurate. Appendix A of Kalnay *et al.* (1996) provides a ranking of all reanalysis variables by "class" as an estimation of trustworthiness (see section 9 of that paper for details and Section 10.2.2 of this document). Users are strongly urged to heed these class designations before making any decisions or conclusions based on these data.

NCEP-II uses 5-day mean CMAP precipitation to update the soil moisture; otherwise, precipitation data is not assimilated. Precipitation reflects the model physics to a large extent; it is derived from parameterizations of large-scale and convective precipitation. The distinction between large-scale and convective precipitation is model-dependent. The reanalysis systems at ECMWF and NCEP are very similar to the systems used for operational numerical weather prediction. These systems are designed to analyze and forecast mid-latitude weather; fields and features more directly related to mid-latitude synoptic weather should be better handled than other features, such as the details of the diurnal cycle and the tropics. Moisture fields are not as well-defined as mass, wind or temperature fields; NWP systems are improving their parameterization of cloudiness, but still have major problems with cloudiness. Some fields from reanalysis exhibit substantial time-mean differences from independent estimates; however, anomalies of these fields from a long-term mean can still display considerable agreement with anomalies in the independent estimates.

Users should be aware that, while the NCEP-II data prepared for ISLSCP II is on a 1-degree grid, the reanalysis was done on an approximately 2-degree grid. ERA-40 (Simmons *et* *al.*, 2000) is being done at higher resolution with a more recent analysis/forecast system that reflects considerable efforts to correct problems found in ERA-15.

11.3 Other Relevant Information

A good deal of information can be found in the proceedings of two reanalysis conferences, WCRP 1998 and 2000); however, because of the timing the NCEP/NCAR and ERA-15 (Gibson *et al.*, 1997) reanalyses are emphasized. The NCEP-II reanalysis is discussed at the second conference.

Kanamitsu *et al.* (2000, 2002) found that the NCEP-II reanalysis improved over the NCEP/NCAR reanalysis in:

- soil moisture, especially interannual variations
- winter-time precipitation, surface temperatures and fluxes in high latitudes
- tropical and southeast U.S. precipitation
- short wave radiation flux
- transient disturbances in the Southern Hemisphere
- snow cover and land surface temperature
- larger precipitable water in tropics, in better agreement with SSM/I observations
- smaller budget residuals.

The NCEP-II reanalysis differed from NCEP/NCAR in warmer soil and 2-meter temperatures, and larger cloud amount (56% global mean total cloud cover vs. 44%). NCEP-II also has a long-term spin-down of soil moisture in polar latitudes.

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Note: Information on the NCEP operational global analysis/forecast system and recent changes to it can be found at:

http://www.emc.ncep.noaa.gov/gmb/

The NCEP/NCAR reanalysis is described at:

http://www.cpc.ncep.noaa.gov/products/wesley/

The NCEP-II reanalysis is described at:

http://www.cpc.ncep.noaa.gov/products/wesley/reanalysis2/

13. DATA ACCESS

13.1 Data Access Information

The ISLSCP Initiative II data are archived and distributed through the Oak Ridge National

Laboratory (ORNL) DAAC for Biogeochemical Dynamics at http://daac.ornl.gov.

13.2 Contacts for Archive

E-mail: uso@daac.ornl.gov
Telephone: +1 (865) 241-3952

13.3 Archive/Status/Plans

The ISLSCP Initiative II data are archived at the ORNL DAAC. There are no plans to update these data.

14. GLOSSARY OF ACRONYMS

ACARS	Aircraft Communications Addressing and Reporting System
AGL	Above Ground Level
AMIP	Atmospheric Model Inter-comparison Project
ASCII	American Standard Code for Information Interchange
CMAP	CPC Merged Analysis of Precipitation
COLA	Center for Ocean-Land-Atmosphere Studies
CPC	Climate Prediction Center
DAAC	Distributed Active Archive Center
DODS	Distributed Oceanographic Data System
DOE	Department of Energy
DVD	Digital Video Disc
ECMWF	European Centre for Medium-range Weather Forecasts
ERA	ECMWF Re-Analysis
FIFE	First ISLSCP Field Experiment
GCM	General Circulation Model
GRIB	Gridded Binary
GSFC	Goddard Space Flight Center
ISLSCP	International Satellite Land-Surface Climatology Project
MRF	Medium-Range Forecast
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction

NESDIS	National Environmental Satellite, Data, and Information Service
NMC	National Meteorological Center
NOAA	National Oceanic and Atmospheric Administration
ORNL	Oak Ridge National Laboratory
PAOBS	Australian Pressure Observations
ROM	Read-Only Memory
RTNEPH	Real Time Nephanalysis
SSI	Spectral Statistical Interpolation
SSM/I	Special Sensor Microwave Imager
SST	Sea Surface Temperature
UTC	Coordinated Universal Time