1. TITLE

1.1 Data Set Identification

ISLSCP II Global Precipitation Climatology Centre (GPCC) Monthly Precipitation

1.2 Database Table Name(s)

Not applicable to this data set.

1.3 File Name(s)

The GPCC rain gauge-only precipitation data set (Version 2) provided here is made up of five types of files on two common Earth grids with spatial resolutions of 0.5 and 1.0 degree in both latitude and longitude. Difference files are included (with an extension of ".dif") that hold all the points from each precipitation map that did not match the ISLSCP II land/water mask, and were either removed or added through interpolation. Monthly correction factors for systematic guage-measuring errors (unitless) are based on Legates (1987). Change maps show which points were removed or added (ASCII map file). The 10 files are named as follows:

1) **gpcc_precip_1d.zip**: Gridded monthly precipitation rates, in mm/month, provided at 1.0 degree spatial resolution. When expanded, provides 120 .asc files, 1 file for each month for 1986-1995. The "00" means it is a monthly average.
2) **gpcc_precip_hd.zip**: Gridded monthly precipitation rates, in mm/month, provided at 0.5 degree spatial resolution. When expanded, provides 120 .asc files, 1 file for each month for 1986-1995. The "00" means it is a monthly average.
3) **gpcc_numgauges_1deg.zip**: Gridded number of rain gauges used in the production of the gridded monthly precipitation rate provided as 1.0 degree spatial resolution.
4) **gpcc_numgauges_hdeg.zip**: Gridded number of rain gauges used in the production of the gridded monthly precipitation rate provided as 0.5 degree spatial resolution.
5) **gpcc_correction_factor_1deg.zip**: Gridded monthly gauge correction factors (unitless), after Legates (1987), provided as 1.0 degree spatial resolution. When expanded, this contains 12 .asc files. Note that these factors do not vary on a yearly basis.

6) **gpcc_correction_factor_hdeg.zip**: Gridded monthly gauge correction factors (unitless), after Legates (1987), provided at 0.5 degree spatial resolution. When expanded, this contains 12 .asc files. Note that these factors do not vary on a yearly basis.
7) **gpcc_precip_1d_changemap.asc**: Gridded ASCII map showing the results of applying the land/sea mask: all points added (positive number), all points unchanged ("0"), and all points removed ("-1"). This file is at 1.0 degree spatial resolution.
8) **gpcc_precip_hd_changemap.asc**: Gridded ASCII map showing the results of applying the land/sea mask: all points added (positive number), all points unchanged ("0"), and all points removed ("-1"). This file is at 0.5 degree spatial resolution.
9) **gpcc_dif-files_1deg.zip**: 120 "difference" files (.dif files), 1 file for each month for 1986-1995, that hold all the points from each precipitation that don't match the ISLSCP II land/sea mask, and were removed or added. This file is at 1.0 degree spatial resolution.
10) **gpcc_dif-files_hdeg.zip**: 120 "difference" files (.dif files), 1 file for each month for 1986-1995, that hold all the points from each precipitation that don't match the ISLSCP II land/sea mask, and were removed or added. This file is at 0.5 degree spatial resolution.

1.4 Revision Date of this Document

February 15, 2011

2. INVESTIGATOR(S)

2.1 Investigator(s) Name and Title

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2.2 Title of Investigation

Global Precipitation Climatology Project (GPCP).

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2.4 Data Set Citation

GPCC. 2011. ISLSCP II Global Precipitation Climatology Centre (GPCC) Monthly Precipitation. 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, U.S.A. doi:10.3334/ORNLDAAC/995

2.5 Requested Form of Acknowledgment

Users of the International Satellite Land Surface Climatology (ISLSCP) Initiative II data collection are requested to cite the collection as a whole (Hall et al. 2006) as well as the individual data sets. Please cite 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 Data sets: Surface Boundary Conditions and Atmospheric Forcings for Land-Atmosphere Studies, *J. Geophys. Res.*, 111, doi:10.1029/2006JD007366, 2006.

Please acknowledge Dr. Bruno Rudolf and the team of the Global Precipitation Climatology Centre (GPCC) at Deutscher Wetterdienst, Germany for permission to use these data. A quotation of the following GPCC papers is requested under references of papers:

Rudolf, B., H. Hauschild, W. Rueth, and U. Schneider. 1994. *Terrestrial Precipitation Analysis: Operational Method and Required Density of Point Measurements. In Global Precipitation and Climate Change,* M. Desbois and F. Desalmand, Eds., NATO ASI Series, Vol. 1, No. 26, Springer-Verlag, 173-186.

Rudolf, B., T. Fuchs, W. Rueth and U. Schneider. 1997. Precipitation Data for Verification of NWP Model Re-Analyses: The Accuracy of Observational Results. *In Proceedings WCRP International Conference on Reanalyses*, Washington, DC, 27-31 Oct 1997, WMO/TD-No. 876, WCRP-104, 215-218.

3. INTRODUCTION

3.1 Objective/Purpose

The Global Precipitation Climatology Project (GPCP) was initiated by the World Climate Research Programme (WCRP). The main purpose of the GPCP (for details see WCRP, 1990) is to evaluate and provide global gridded data sets of monthly precipitation based on all suitable observation techniques as a basis for:

- verification of climate model simulations,

- investigations of the global hydrological cycle, and
- climate change detection studies.

The Global Precipitation Climatology Centre (GPCC), which is operated by the Deutscher Wetterdienst (National Meteorological Service of Germany), is a component of the GPCP with the main emphasis on the treatment of the global *in-situ* observations. The GPCC simultaneously contributes to the Global Climate Observing System (GCOS) and other international research and climate monitoring projects. This rain gauge data set was acquired from GPCC and resampled to 0.5 and 1 degree gridboxes for use in the International Satellite Land Surface Climatology Project (ISLSCP) Initiative II data collection. This is the GPCC full data product, Version 2 for the period 1986-1995.

3.2 Summary of Parameters

Gridded area-mean monthly precipitation amounts (mm/month), based on rain gauge observations, along with the following complementary information: (a) number of rain gauges per gridbox and (b) monthly mean correction factors (Legates 1987) for compensation of the systematic gauge-measuring error.

3.3 Discussion

The GPCC collects precipitation data which are locally observed at rain gauge stations and distributed as CLIMAT and SYNOP reports via the Global Telecommunication System of the World Weather Watch (GTS) of the World Meteorological Organization (WMO). The Centre acquires additional monthly precipitation data from meteorological and hydrological networks which are operated by national services. Area-mean precipitation on the grid is derived by the GPCC as described in Sections 4 and 9.

The data sets have been produced by the GPCC and modified by the staff of the ISLSCP II data collection to match the land/water boundaries of the ISLSCP II land/water mask. Files are provided that show the differences between the original GPCC data and the ISLSCP II land/water mask. “Differences” files are also provided containing any data point in the original data that has been changed (see Section 9.2.3). This was done to ensure land/water consistency between the many different data sets in this collection.

4. THEORY OF ALGORITHM/MEASUREMENTS

Rain gauges or precipitation gauges provide a direct measurement of precipitation fallen during a given observation period (e.g. 1 hour, 6 hours or 1 day). However, this measurement is subject to systematic errors due to evaporation losses and wind drift of droplets – see Sections 9.3.1 and 10.1 – and it represents local features at the observing station.

Area-mean precipitation on the grid is calculated from the precipitation-gauge point measurements using a spatial interpolation scheme (see Section 9.1). All rain gauge data used are individually quality-controlled (see Section 9.2), but not corrected for the systematic gauge-measuring error. Correction factors to compensate for the systematic gauge-measuring error are given as separate data layers (see Section 9.3).

5. EQUIPMENT

5.1 Instrument Description

5.1.1 Platform (Satellite, Aircraft, Ground, Person)

The height of the rain gauge orifice varies between zero and more than 1 m above the ground. This is defined by country's national standards (see Section 5.1.4 for more detail).

5.1.2 Mission Objectives

To measure precipitation.

5.1.3 Key Variables

Precipitation.

5.1.4 Principles of Operation

The operation and type of precipitation-gauges vary depending on the country (See Section 5.1.5 for details). Generally, national daily standard rain gauges measure precipitation at or near the ground, and are observed at least once a day.

5.1.5 Instrument Measurement Geometry

A large variety of instrument types for precipitation-gauge measurements are in use worldwide (ca. 100). The geometry and size of the different instrument types can vary considerably (see Sevruk, 1982).

National daily standard precipitation-gauges are observed at least once a day and thus must be big enough to collect more than the average one-day or maximum 1-2 hour precipitation which differs according to various climatic conditions. The standard rain gauges are also commonly used to measure both rain and snow, and the latter affects fundamentally the form and dimensions of a particular national gauge (i.e. snow gauges are bigger).

Thus, in countries with negligible snowfall but much rain, or where different gauges are used for rain and snow (e.g. Canada), it is advantageous if the gauge orifice is small (Canada, 47 cm^2; Belgium, 100 cm^2, UK 125 cm^2, but Australia 324 cm^2) or the collector is shallow with a steep funnel (Australia, Belgium), to keep the wetting losses relatively small. In areas with little snowfall, gauges can be installed so that the rim is near to the ground (0.3 m in Australia, Belgium, Canada (in summer) and UK, 0.4 m in Holland). This reduces losses from wind and consequently the systematic error. In contrast, in countries with heavy snowfall the gauges are, in general, large (500 cm^2 in the former Czechoslovakia and Finland; 325 cm^2 in USA, but 200 cm^2 in most European countries) and the collectors are deep. Thus the wetting losses for rain tend to be relatively large. In addition, the precipitation-gauges in these countries are set high above ground-level (1 m in the former Czechoslovakia, Federal Republic of Germany and the USA; 1.5 m in Denmark, Finland and Switzerland; and 2 m in the former USSR) and the systematic error for measurement of rain is relatively greater. In some countries or regions which experience heavy snowfall, the daily standard precipitation-gauges are even equipped with windshields (Finland, Norway, and former USSR) or special snowgauges may be used (Canada).

5.1.6 Manufacturer of Instrument

Varies by country - documented in country's national metadata archive.

5.2 Calibration

5.2.1 Specifications

5.2.1.1 Tolerance

Not available at this revision.

5.2.2 Frequency of Calibration

Not available at this revision.

5.2.3 Other Calibration Information

None.

6. PROCEDURE

6.1 Data Acquisition Methods

The GPCC collects monthly precipitation totals received in climate reports via the World Weather Watch Global Telecommunication System (GTS) and calculates monthly totals from synoptic reports. The GPCC also acquires monthly precipitation data from international, regional and national meteorological and hydrological services/institutions. These additional monthly precipitation data are acquired in the framework of the WCRP Global Precipitation Climatology Project with support of the World Meteorological Organization (WMO) and on the basis of bilateral contacts (see Rudolf et al., 1992; 1994).

6.2 Spatial Characteristics

6.2.1 Spatial Coverage

The coverage of the gridded surface observation precipitation data is global, but for land areas only. The correction factor files are global, including water bodies and oceans. Data in each file are ordered from North to South and from West to East beginning at 180 degrees W, 90 degrees N. Point (1,1) represents the grid cell centered at 89.75 degrees N and 179.75 degrees W for the 0.5 degree data, and 89.75 degrees N and 179.75 degrees W for the 1 degree data.

6.2.2 Spatial Resolution

The data are given in two regular equal-angle lat/long Earth grids that have spatial resolutions of 0.5 degree by 0.5 degree and 1.0 degree by 1.0 degree in both latitude and longitude.

6.3 Temporal Characteristics

6.3.1 Temporal Coverage

January 1986 through December 1995.

6.3.2 Temporal Resolution

Monthly totals. The corrections factors vary by month but not by year.

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 Parameter/ Variable Name	8.2.2 Parameter/ Variable Description	8.2.3 Data Range*	8.2.4 Units of Measurement	8.2.5 Data Source
Monthly Precipitation Maps (*.asc)				
Monthly Precipitation Rates	Monthly precipitation rates as analyzed from rain gauge measurements.	Min=0 Max=1800 Water=-99 No Data= -88	[mm/month]	Rain-gauge measurement s
Number of Gauges Maps (*.asc)				
Number of Gauges	Number of rain gauges per gridbox.	Min=0 Max=141	[Unitless]	
Monthly Correction Factor Maps (*.asc)				
Monthly Correction Factors	Monthly correction factors for systematic gauge-measuring errors.	Min=1 Max=3	[Unitless]	Legates (1987)
Differences Tables (*.dif)				
Lat	Latitude for the center of a cell. South latitudes are negative.	Min=-90 Max=90	Decimal Degrees	Earth Grid
Lon	Longitude for the center of a cell. West longitudes are negative.	Min=-180 Max=180	Decimal Degrees	Earth Grid
Precip_Removed	Precipitation value in each cell of the original file that	Min=0 Max=141	[mm/month]	Original Data

	did not match the ISLSCP II land/water mask, and was removed.			
Precip_Added	Precipitation value for each cell added to the original file because the ISLSCP II land/water mask indicated land, so an interpolated point was added.	Min=0 Max=141	[mm/month]	Computed
Interpolation_ Level	The number of times the interpolation routine was run to get a precipitation value for this point. The higher the number, the less reliable the value is.	Min=1 Max=10	Unitless	Computed
Change Map (*_changemap.asc)				
Point Changed	Differences between the ISLSCP II land/water mask and the original data: -1 = ISLSCP II mask is water and original data is land (data removed) 0 = Data sets agree over land or water (data unchanged) ≥1 = ISLSCP II mask is land and original data is water or missing (data interpolated)	Min=-1 Max=10	See 8.2.2	Computed

***Note: The data ranges can vary depending on resolution. Estimates are given here.**

8.3 Sample Data Record

The "differences" file is an ASCII table with some header lines, then the Lat and Lon coordinates of each point removed, then the value of precipitation point at that point. At the bottom of the file are the coordinates and data for all points added. See the sample below.

```
ISLSCP II Differences for the files 'gpcc_precip_1d_19860100.asc'. This file
contains the Lat-Lon coordinates and precipitation for each point in the two
original files that differed from the ISLSCP II Land/Water mask, and thus was
removed. Points added using interpolation are listed at the bottom of this
file.

Lat,Lon,Precip_Removed
83.5,-78.5,2.01
83.5,-77.5,2.01
83.5,-76.5,2.01
83.5,-75.5,2.00
83.5,-74.5,2.00
83.5,-73.5,2.00
```

```
83.5,-72.5,2.00
83.5,-71.5,2.00
83.5,-70.5,2.00
83.5,-69.5,2.00
83.5,-68.5,2.00
83.5,-47.5,3.22
83.5,-46.5,3.33
83.5,-45.5,3.52
   "      "
   "      "
   "      "
Lat,Lon,Precip_Added,Interpolation_Level
46.5,47.5,14.74,1
46.5,48.5,11.42,1
46.5,49.5,10.17,1
45.5,47.5,11.65,1
-7.5,138.5,301.84,1
-7.5,139.5,284.86,1
```

8.4 Data Format

All of the files in the ISLSCP Initiative II data collection are in the Arc GIS ASCII Grid format. The file format consists of numerical fields of varying length, which are delimited by a single space and arranged in columns and rows. The 0.5 degree files in this data set all contain 720 columns by 360 rows. The 1 degree files all contain 360 columns by 180 rows. The precipitation rates and correction factor file are written as real numbers. The files with the number of gauges are written as integer values. Missing values over water are assigned the value of -99. Missing values over land are assigned the value of -88.

The ASCII map files (with the extension of ".asc") have all had the ISLSCP II land/water mask applied to them. All points removed from the original files are stored in "differences" files (with the extension ".dif"). These ASCII table files contain the Latitude and Longitude location of the cell-center of each point from the precipitation that don't match the ISLSCP II land/water mask, and were removed. At the bottom of each file is also a list of all points added to the file through "nearest neighbor averaging" interpolation (see Section 9.2.3), where the land/water mask indicated land but there was no data in the original file (if there were no "neighbor" pixels with data, the missing data was assigned a value of -88). There is also a column called "Interpolation_Level" that contains the number of times the interpolation routine was run to get a value for that point. The higher the number, the less reliable the value is. There is one ".dif" file for each ASCII map file.

The "change map" files show the results of applying the land/water mask, as a viewable ASCII map: all points added (positive number, containing the "Interpolation_Level", see above), all points unchanged ("0"), and all points removed ("-1"). There is one file per spatial resolution.

All files are gridded to a common equal-angle lat/long grid with spatial resolutions of 0.5 and 1.0 degree lat/long, where the coordinates of the upper left corner of the files are located at 180 degrees West and 90 degrees North and the lower right corner coordinates are located at 180 degrees East and 90 degrees South.

8.5 Related Data Sets

There are several other precipitation data sets within the ISLSCP II data collection. Users may wish to examine the following web sites for additional data sets: The Global Runoff Data Centre (http://www.bafg.de/GRDC/EN/Home/homepage__node.html) , the Water System

Analysis Group (http://www.wsag.unh.edu/), and the Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC) http://daac.ornl.gov/ISLSCP.islscpii.html.

9. DATA MANIPULATIONS

9.1 Formulas

9.1.1 Derivation Techniques/Algorithms

The algorithm used for estimating the area-average precipitation is based on spatial interpolation of the precipitation-gauge point measurements to a coarser spatial resolution. Legates (1987) evaluated several interpolation algorithms and Shepard's (1968) empirical weighting scheme was found to be reliable. Since the region of consideration is the entire globe, a spherical adaptation of the code (following Willmott et al., 1985) was used. This method overcomes some deficiencies typical of a pure distance weighting, first by using only the four to 10 nearest stations, second by clustering near-neighbour measurements (directional weighting), and third by the extrapolation of estimated gradients of the precipitation field to yield extremes not covered by measurements.

Shepard`s (1968) weighting scheme is given by:

$$W_i = S_i^k(1 + D_i), \quad (1)$$

where S_i is the distance component for station *i* and D_i is the directional component. Following Shepard (1968) a value of 2.0 is used for the exponent *k*. In the analysis, the gauge-measured precipitation is weighted by $1/W_i$. The weighting scheme is described by Willmott et al. (1985).

Using this code known as SPHEREMAP, the conventionally measured monthly precipitation depths from about 6700 stations are interpolated on gridpoints with distances of 0.5 degree, and the areal means on a 0.5 x 0.5 degree grid are calculated by averaging the interpolated values from the gridpoints located at the gridbox corners (Rudolf et. al. 1992, 1994).

9.2 Data Processing Sequence

9.2.1 Processing Steps and Data Sets

Since large observation or recording errors may exist in station meta information, as well as in the monthly precipitation totals, the rain gauge precipitation data are carefully quality-controlled. In this process, every effort is made to retain as much data as possible, in part by correcting many obvious errors as described in Schneider (1993). This procedure avoids inadvertently eliminating useful information in data sparse areas of the globe. First, the monthly precipitation amounts are checked for extreme values using a statistical check based on frequency distributions of precipitation and also compared with climatology. Next, the point-measured precipitation data from different sources are intercompared to check for discrepancies. As a last step in the automatic quality-control procedure, the spatial homogeneity of the point-measured monthly precipitation data is checked. Subsequent to these automatic quality-control checks, data flagged as incorrect or questionable during this process are checked manually at a graphics workstation which can display all station-related information (e.g. geographical coordinates, elevation) and overlay topographic fields (such as orography) as background information. The processing steps for the data set are:

- reformatting of the acquired station-related data,
- quality-control of the meta-data (station coordinates)
- loading into the precipitation point data bank (PDB), i.e. merging the station-related data from different sources (GTS, national data sets, other collections) to one worldwide data set of surface-observed precipitation,
- first objective analysis using the original precipitation records,
- automatic quality-control of the precipitation record (comparison with area means from step 4 and the local frequency distribution of precipitation),
- visual expert quality-control and interactive correction with workstation assistance (comparison with climate maps, orographical data, extreme-event-catalogs, etc.),
- second objective analysis using the quality-controlled precipitation data,
- storage of the gridded data from the second analysis run (step 7) as the final results.

9.2.2 Processing Changes

None.

9.2.3 Additional Processing by the ISLSCP Staff

The ISLSCP II staff took the original data files, which were stored in monthly-column format by year, and separated them out into individual monthly ASCII maps (precipitation and number-of-gauges maps for each month). During this processing, the original ‘no data’ flag in the precipitation files (-99999.99) was reset to -99, and the newly created map files were named in accordance with the naming convention given in Section 1.3.

The ISLSCP II staff then processed the ASCII map files by comparing them against the ISLSCP II land/water mask. Missing land data in these files were added in the form of -88 values. All added values then had these -88 missing values replaced with "nearest neighbor averaging" interpolation. New ASCII table files containing the removed and added points (points that didn't match the land/water mask), also called "differences" files with the extension ".dif", were also created. These files contain the Latitude and Longitude of the cell-center of each point removed from the precipitation maps, and the value removed from each map. At the bottom of the file are the added precipitation points, and a column called "Interpolation_Level" that contains the number of times the interpolation routine was run to get a value for that precipitation point. The higher the number, the less reliable the value is. Note: the number-of-gauges maps were not masked using the ISLSCP II land/water mask.

Finally, a "change map" was created for each spatial resolution, showing the results of applying the land/water mask, as a viewable ASCII map: all points added (positive number, containing the "Interpolation_Level", see above), all points unchanged ("0"), and all points removed ("-1"). Users can use the data, the “.dif” files and the change map to re-create the original data set as it was submitted by the Principal Investigator.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

Since the correction of precipitation data with regard to systematic measuring errors (see Section 10.1) is empirical and the required metadata is mostly not available, the data that are presented here as part of the ISLSCP Initiative-II data collection were reformatted from the original data provided by GPCC. Correction of the gridded data is recommended, but left to the users. A complementary file providing monthly climatological gridded correction factors (based on Legates' climatology 1987) is available with this revision.

9.4 Graphs and Plots

GPCC uses 'GRADS' to visualize the gridded products in form of maps, time-series of regional mean precipitation, scatter plots for data set comparison. The GPCC Web site (http://gpcc.dwd.de) provides the operational 'GPCC Monitoring Product' (monthly precipitation on 1 x 1 and 2.5 x 2.5 degree grids) near real-time for download as well as a 'Visualizer' which enables to the user to create maps of monthly, seasonal or annual precipitation totals or anomalies on own demand.

10. ERRORS

10.1 Sources of Error

Although analyses of conventional rain gauge measurements are considered to provide the most reliable precipitation information over land areas, they can be affected by different sources of uncertainty, which can be classified into two major error types: (1) a methodological component in obtaining area-average precipitation from point measurements depending on the analysis method used (Bussieres and Hogg, 1989), on the spatial density and on the distribution of the point measurements (WMO, 1985; Schneider et al., 1993), and (2) inaccuracies of the point precipitation measurements themselves.

The second error type consists of two parts, the systematic gauge-measuring error and a random error component. The systematic error generally results in an undercatch of the true precipitation, mainly due to wind effects, especially on snowfall, as well as wetting and evaporative losses (Sevruk, 1982; Legates and Willmott, 1990). For rainfall the systematic error is about 5%, whereas for snowfall it can reach 50% or even more. Random errors can be caused by the gauge (e.g., leakage from or damage to the gauge), by the observer (e.g., inaccuracies in reading the instrument) or by errors in the course of data processing and transmission (see Groisman and Legates, 1994; Schneider et al., 1993). The systematic error in the measurement of precipitation is affected by gauge characteristics, such as dimensions, form and material. Differences in the characteristics of various types of gauges complicate the comparison of both precipitation measurements and correction formulae. There is, as yet, no generally accepted theory for the physical nature of the problems associated with precipitation-gauges. Consequently, if a correction formula developed for one type of gauge is to be used for another, special field and/or laboratory investigations are required. In each case, a review is made of the results of comparisons made elsewhere together with an examination of the gauges involved.

10.2 Quality Assessment

10.2.1 Data Validation by Source

The rain gauge data used were visually and expertly quality-controlled using interactive correction with graphical workstation assistance, as described in Section 9.2.1.

10.2.2 Confidence Level/Accuracy Judgement

Not available at this revision for 0.5 degree or 1.0 degree data sets. For rain gauge analyses on the 2.5 degree grid, the spatial sampling error has been estimated for the dense rain gauge networks of Australia, Germany and the USA (Rudolf et al. 1994). The spatial sampling error decreases with increasing station density (number of stations per grid). An assessment of the other error components is in preparation.

10.2.3 Measurement Error for Parameters and Variables

These case studies indicated that at least 2 to 8 stations per 2.5 degree grid (depending on orographic and climatological conditions in the grid) are required to estimate area-average precipitation with a relative error of less than 10% (Schneider et al., 1993).

10.2.4 Additional Quality Assessment Applied

None.

11. NOTES

11.1 Known Problems with the Data

The rain gauge measurements used for this gridded data set have not been corrected for the systematic gauge-measuring error (in general an underestimation of the true precipitation which varies between 5% and more than 100% of the measured data for monthly accumulations depending on the weather conditions during the month). Correction of the gridded data is recommended, but left to the users. A complementary file including gridded correction factors (based on Legates' climatology 1987) is available with this revision. In complex terrain additional uncertainties may be introduced because most stations are located in valleys (slopes and mountain sites are generally underrepresented).

Users may encounter some water points (value=-99) where the number of gauges is greater than zero. This is a combination of the application of the ISLSCP II land/water mask but also is present in the original data submitted by GPCC. GPCC calculates gridded analysis results for land cells with a land portion of at least 25%. So some small islands where there is a station contain no calculated value because the land portion may be less than 25%. This can occur in coastal areas with a small land portion.

11.2 Usage Guidance

In data void/sparse continental areas, the quality of the analysis results will be poor. Users are urged to consult the ISLSCP II Precipitation Overview Document to better understand the strengths and weaknesses of all the various precipitation data sets that are included in the data collection.

Users who may wish to re-create the original data set should combine the data provided here with the data provided in the "differences" files or use the "change maps" to visualize the spatial distribution of points that have been changed from their original value. The latest GPCC data sets are also available at http://gpcc.dwd.de.

11.3 Other Relevant Information

None.

12. REFERENCES

12.1 Satellite/Instrument/Data Processing Documentation

WCRP. 1990. The Global Precipitation Climatology Project - Implementation and Data Management Plan. WMO/TD-No. 367, Geneva, June 1990, 47 pp. and appendices.

12.2 Journal Articles and Study Reports

Barrett, E.C., J. Dodge, M. Goodman, J. Janowiak, E. Smith, and C. Kidd. 1994. The First WetNet Precipitation Intercomparison Project (PIP-1). Remote Sensing Review, Vol. 11 (1-4), pp. 5-21 and 49-60.

Bussieres, N., and W.D. Hogg. 1989. The objective analysis of daily rainfall by distance weighting schemes on a meso-scale grid. Canadian Meteorol. and Oceanographic Society, Atmosphere-Ocean, 27(3):521-541.

Groisman, P.Y., and D.R. Legates. 1994. The accuracy of United States precipitation data. Bull. Amer. Met. Soc., 75(2):215-227.

Hauschild, H., M. Reis, and B. Rudolf. 1994. Global and terrestrial precipitation climatologies: An overview and some intercomparisons. Global Precipitation and Climate Change, M. Desbois and F. Desalmand, Eds., NATO ASI Series, Vol. 1, No. 26, Springer-Verlag, 419-434.

Huffman, G.J., R.F. Adler, B. Rudolf, U. Schneider, and P.R. Keehn. 1995. Global Precipitation Estimates Based on a Technique for Combining Satellite-Based Estimates, Rain gauge Analyses and NWP Model Information. Journal of Climate 8(5), p. 1284 - 1295.

Huffman, G.J., R.F. Adler, P.A. Arkin, A. Chang, R. Ferraro, A. Gruber, J. Janowiak, A. McNab, B. Rudolf, and U. Schneider. 1997. The Global Precipitation Climatology Project (GPCP) Combined Precipitation Data set. Bull. Americ. Meteor. Soc. 78(1), 5-20.

Janowiak, J. E. 1992. Tropical rainfall: A comparison of satellite-derived rainfall estimates with model precipitation forecasts, climatologies and observations. Mon. wea. Rev., 120, 448-462.

Janowiak, J.E., A. Gruber, C.R. Kondragunta, R.E. Livezey, and G.J. Huffman. 1998. A Comparison of the NCEP-NCAR Reanalysis Precipitation and the GPCP Rain Gauge-Satellite Combined Data set with Observational Error Considerations. Journal of Climate 11, p. 2960-2979.

Krishnamurti, T.N., G.D. Rohaly, and H. S. Bedi. 1994. Improved precipitation forecast skill from the use of physical initialization. Global Precipitation and Climate Change, M. Desbois and F. Desalmand, Eds., NATO ASI Series, Vol. 1, No. 26, Springer-Verlag, 309-324.

Lapin, M. 1994. Possible impacts of climate change upon the water balance in central Europe Global Precipitations and Climate Change, M. Desbois and F. Desalmand, Eds., NATO ASI Series, Vol. 1, No. 26, Springer-Verlag, 161-170.

Legates, D.R., and C.J. Willmott. 1990. Mean seasonal and spatial variability in gauge-corrected global precipitation. Internat. J. Climatol., 9:111-127.

Legates, D.R. 1987. A climatology of global precipitation. Publ. in Climatology, 40 (1), Newark, Delaware, 85 pp.

Nicholls, N. 1988. El Nino-Southern Oscillation and rainfall variability. J. Climate, 1:418-421.

Rosenzweig, C., and M.L. Parry. 1994. Potential impact of climate change on world food supply, Nature, 367: 133-138.

Rudolf, B. 1993. Management and analysis of precipitation data on a routine basis. Proc. Internat. WMO/IAHS/ETH Symp. on Precipitation and Evaporation. Slovak Hydrometeorol. Inst., Bratislava, Sept. 1993, (Eds. M. Lapin, B. Sevruk), 1:69-76.

Rudolf, B. 1996. Global Precipitation Climatology Center activities. GEWEX News, vol. 6, No. 1.

Rudolf, B., T. Fuchs, W. Rueth and U. Schneider. 1997. Precipitation Data for Verification of NWP Model Re-Analyses: The Accuracy of Observational Results. Proceedings WCRP International Conference on Reanalyses, Washington, DC, 27-31 Oct 1997, WMO/TD-No. 876, WCRP-104, 215-218.

Rudolf, B., A. Gruber, R. Adler, G. Huffman, J. Janowiak and P. Xie. 1999. GPCP Precipitation Analyses Based on Observations as a Basis of NWP and Climate Model Verification. Contribution to the 2nd International Reanalysis Conference, Reading UK, 23-27.08.1999

Rudolf, B., H. Hauschild, M. Reiss, and U. Schneider. 1992. Beitraege zum Weltzentrum fuer Niederschlagsklimatologie - Contributions to the Global Precipitation Climatology Centre. Meteorol. Zeitschrift N.F., 1(1):7-84 (In German, with Abstracts and Summary in English).

Rudolf, B., H. Hauschild, W. Rueth, and U. Schneider. 1994. Terrestrial Precipitation Analysis: Operational Method and Required Density of Point Measurements. Global Precipitations and Climate Change, M. Desbois and F. Desalmand, Eds., NATO ASI Series, Vol. 1, No. 26, Springer-Verlag, 173-186.

Schneider, U. 1993. The GPCC quality-control system for gauge-measured precipitation data. In: Report of a GEWEX workshop "Analysis methods of precipitation on a global scale", Koblenz, Germany, September 1992, WCRP-81, WMO/TD-No. 558, June 1993, A5-A7.

Schneider, U., B. Rudolf, W. Rueth. 1993. The spatial sampling error of areal mean monthly precipitation totals analyzed from gauge-measurements. Proc. 4th Internat. Conf. on Precipitation "Hydrological and meteorological aspects of rainfall measurement and predictability", Iowa City, Iowa, April 1993, pg. 80-82.

Sevruk, B. 1982. Methods of correction for systematic error in point precipitation measurement for operational use. Operational Hydrology, Rep.-No. 21, World Meteorological Organization, Geneva, WMO Rep.-No.589, 91 pp.

Shepard, D. 1968. A two-dimensional interpolation function for irregularly spaced data. Proc. 23rd ACM Nat. Conf., Brandon/Systems Press, Princeton, NJ, 517-524.

Willmott, C.J., Rowe, C.M., Philpot, W.D. 1985. Small-Scale Climate Maps: A Sensitivity Analysis of Some Common Assumptions Associated with Grid-Point Interpolation and Contouring. The American Cartographer, 12(1): 5-16.

WMO. 1985. Review of requirements for area-averaged precipitation data, surface-based and space-based estimation techniques, space and time sampling, accuracy and error; data exchange. WCP-100, WMO/TD-No. 115, 57 pp. and appendices.

WCRP. 1990. The Global Precipitation Climatology Project - Implementation and Data Management Plan. WMO/TD-No. 367, Geneva, June 1990, 47 pp. and appendices.

Xie, P. and P.A. Arkin. 1997. Global precipitation: A 17-year monthly analysis based on gauge observations, satellite estimates and numerical model outputs. Bull. Americ. Meteor. Soc. 78(11): 1539-2558.

13. DATA ACCESS

13.1 Contacts for Archive/Data Access Information

The ISLSCP Initiative II data are available 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

DAAC	Distributed Active Archive Center
ISLSCP	International Satellite Land Surface Climatology Project
GCOS	Global Climate Observing System
GPCC	Global Precipitation Climatology Centre
GPCP	Global Precipitation Climatology Project
GSFC	Goddard Space Flight Center (NASA)
GTS	WWW Global Telecommunication System
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
ORNL	Oak Ridge National Laboratory
PDB	Point Data Bank
WCRP	World Climate Research Programme
WMO	World Meteorological Organization
WWW	World Weather Watch of WMO World Climate Data and Monitoring Program