1. TITLE

1.1 Data Set Identification

ISLSCP II Gauge-Based Analyses of Daily Precipitation over Global Land Areas

1.2 Database Table Name(s)

Not applicable to this data set.

1.3 File Name(s)

The gridded daily precipitation data set provided here is based on rain gauge measurements obtained through the Global Telecommunication System (GTS). It is made up of files on two common Earth grids with spatial resolutions of 0.5 and 1.0 degree in both latitude and longitude:

1) daily precipitation rates (mm/day) based on GTS rain gauge measurements (ASCII map file).

2) the number of rain gauges per cell used to produce the values in #1 (ASCII map file).

3) "difference" files (with an extension of ".dif") that hold all the points from each precipitation map that do not match the land/water mask used in this International Satellite Land Surface Climatology (ISLSCP) Initiative II data collection, and were either removed or added through interpolation (ASCII table).

4) 2 "change maps" showing the spatial distribution of those points that were removed or added (ASCII map file).

The data files are named using the following naming convention:

gts_precip_daily_1deg.zip: Gridded daily precipitation rates, at one degree spatial resolution. Expands to gts_precip_1d_YYYYMMDD.asc where **YYYY** is the year from 1986 to 1995, **MM** is the month from 01 to 12, and **DD** is the day of the month from 01 to 31. This file also includes a changemap file **gts_precip_1d_changemap.asc** which provides a gridded ASCII map showing the results of applying the land/water mask: all points added ("≥1"), all points unchanged ("0"), and all points removed ("-1").

gts_precip_daily_hdeg.zip: Gridded daily precipitation rates, at half degree spatial resolution. Expands to gts_precip_hd_YYYYMMDD.asc where **YYYY** is the year from 1986 to 1995, **MM** is the month from 01 to 12, and **DD** is the day of the month from 01 to 31. This file also includes a changemap file **gts_precip_hd_changemap.asc** which provides a gridded ASCII map showing the results of applying the land/water mask: all points added ("≥1"), all points unchanged ("0"), and all points removed ("-1").

gts_numguages_daily_1deg.zip: Gridded number of rain gauges used in the production of the gridded daily precipitation rate data set above at one degree spatial resolution. Expands to gts_numguages_1d_YYYYMMDD.asc where **YYYY** is the year from 1986 to 1995, **MM** is the month from 01 to 12, and **DD** is the day of the month from 01 to 31.

gts_numguages_daily_hdeg.zip: Gridded number of rain gauges used in the production of the gridded daily precipitation rate data set above at half degree spatial resolution. Expands to gts_numguages_hd_YYYYMMDD.asc where **YYYY** is the year from 1986 to 1995, **MM** is the month from 01 to 12, and **DD** is the day of the month from 01 to 31.

gts_dif-files_1deg.zip: Expands to "difference" files at one degree spatial resolution gts_precip_1d_YYYYMMDD.dif, that hold all the points from each precipitation map that do not match the ISLSCP II land/water mask, and were removed or added (see Sections 8.4 and 9.2.3 for more details). **YYYY** is the year from 1986 to 1995, **MM** is the month from 01 to 12, and **DD** is the day of the month from 01 to 31.

gts_dif-files_hdeg.zip: Expands to "difference" files at half degree spatial resolution gts_precip_hd_YYYYMMDD.dif, that hold all the points from each precipitation map that do not match the ISLSCP II land/water mask, and were removed or added (see Sections 8.4 and 9.2.3 for more details). **YYYY** is the year from 1986 to 1995, **MM** is the month from 01 to 12, and **DD** is the day of the month from 01 to 31.

1.4 Revision Date of this Document

February 25, 2011

2. INVESTIGATOR(S)

2.1 Investigator(s) Name and Title

Dr. Pingping Xie and Mr. John E. Janowiak, Climate Prediction Center (CPC), National Oceanic and Atmospheric Administration (NOAA)/National Weather Service (NWS)

2.2 Title of Investigation

Gauge-Based Analyses of Daily Precipitation over Global Land.

2.3 Contacts (For Data Production Information)

	Contact 1	Contact 2
2.3.1 Name	Dr. Pingping Xie	Mr. John E. Janowiak
2.3.2 Address	Climate Prediction Center	Climate Prediction Center

City/St. **Zip Code** **Country**	NOAA/NWS 5200 Auth Road, #605 Camp Springs, MD 20746 U.S.A.	NOAA/NWS 5200 Auth Road, #605 Camp Springs, MD 20746 U.S.A.
2.3.3 Tel. No. **Fax No.**	(301)763-8000, ext. 7572 (301)763-8125	(301)763-8000, ext. 7537 (301)763-8125
2.3.4 E-mail	pingping.xie@noaa.gov	john.janowiak@noaa.gov

	Contact 3 (ISLSCP2)
2.3.1 Name	Mr. David Landis
2.3.2 Address **City/St.** **Zip Code** **Country**	Code 614.4 NASA/GSFC Greenbelt, MD 20771 USA
2.3.3 Tel. No. **Fax No.**	(301) 614-6605 (301) 286-0239
2.3.4 E-mail	david.r.landis@gsfc.nasa.gov

2.4 Data Set Citation

Xie, P. and J. E. Janowiak. 2011. ISLSCP II Gauge-Based Analyses of Daily Precipitation over Global Land Areas. 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/1001

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 Datasets: Surface Boundary Conditions and Atmospheric Forcings for Land-Atmosphere Studies, J. Geophys. Res., 111, doi:10.1029/2006JD007366, 2006.

The suggested wording of acknowledgement is “The GTS gauge-based analyses of daily precipitation are created at the Climate Prediction Center (CPC) of NOAA”.

3. INTRODUCTION

3.1 Objective/Purpose

The objective of this work was to construct a long-term data set of daily precipitation on 0.5 degree and 1.0 degree latitude/longitude grids over the global land areas. The analyses are defined by interpolating station observations from GTS (Global Telecommunications System) gauges using the algorithm of Shepard (1968).

3.2 Summary of Parameters

This GTS gauge-based data set for ISLSCP II contains: 1) area mean daily precipitation rates (mm/day) and 2) number of reporting gauges over each 0.5 degree or 1.0 degree lat/lon grid cell. Files are also provided that show the differences between the original land/water mask used and the ISLSCP II land/water mask.

3.3 Discussion

The GTS gauge-based analyses of daily precipitation are defined by interpolating gauge observations using the algorithm of Shepard (1968). The gauge observations used here are those available through the Global Telecommunications System (GTS). The algorithm of Shepard (1968) has been widely used to interpolate gauge observations of monthly, pentad, and daily precipitation (Rudolf 1993, Xie et al. 1996, other precipitation data sets are also in this collection).

4. THEORY OF ALGORITHM/MEASUREMENTS

The algorithm of Shepard (1968) is used to interpolate the irregularly distributed station observations onto grid points. The weighting coefficients are inversely proportional to the gauge-grid point distance and are adjusted by a cosine function taking into account the directional isolation of each gauge relative to all other nearby gauges. Based on an intercomparison of 4 interpolation algorithms, Bussieres and Hogg (1989) found that the Shepard (1968) is the second best in defining daily precipitation analysis, only next to the Optimal Interpolation (OI) method.

5. EQUIPMENT

5.1 Instrument Description

5.1.1 Platform (Satellite, Aircraft, Ground, Person)

The daily precipitation analyses presented here are derived from rain gauge observations from 6000-7000 stations throughout the globe. More details on the gauge observations of precipitation may be found in Sevruk (1982) and Rudolf (1993).

5.1.2 Mission Objectives

Reports of gauge-observed daily precipitation are available through the Global Telecommunications System (GTS) on a real-time basis. On average, reports from about 6000-7000 stations are received everyday.

5.1.3 Key Variables

The primary variable used as inputs to produce daily precipitation analyses are the gauge observations of 24-hour precipitation accumulation from over 6000 GTS stations distributed over the global land areas.

5.1.4 Principles of Operation

The operation and type of precipitation-gauges vary depending on the country. Generally, national daily standard raingauges 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).

5.1.6 Manufacturer of Instrument

Varies by country.

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

GTS gauge observations of daily precipitation are available from Dr. Pingping Xie of NOAA/Climate Prediction Center.

6.2 Spatial Characteristics

6.2.1 Spatial Coverage

Global land areas.

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 and 0.5 degree by 1.0 degree and 1.0 degree in both latitude and longitude.

6.3 Temporal Characteristics

6.3.1 Temporal Coverage

January 1, 1986 – December 31, 1995

6.3.2 Temporal Resolution

Daily (24 hours). The user should note that the starting/ending time (Prime Time) for the 24-hour accumulation is different from country to country. A list of the prime time for all GTS gauge stations is available from Dr.Pingping Xie of NOAA/CPC (See Contact 1 in Section 2.3).

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
Daily Precipitation Maps (*.asc)				
Daily Precipitation Rates	Daily precipitation rates as analysed from rain gauge measurements.	Min=0 Max=500 Water=-99 No data over land=-88	[mm/day]	Rain-gauge meas. from GTS Network
Number of Gauges Maps (*.asc)				
Number of Gauges	Number of rain gauges per gridbox.	Min=0 Max=50	[Unitless]	GTS network
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	Data value in each cell of the original file that did not match the ISLSCP II land/water mask,	N/A	[mm/day]	Original data

	and was removed.			
Precip_Added	Data value for each cell added to the original file because the ISLSCP II land/water mask indicated land, so an interpolated point was added.	N/A	[mm/day]	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=11	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=11	See 8.2.2	Computed

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, and the number-of-gauges at that point. At the bottom of the file are the coordinates and data for all points added. See the sample below.

```
ISLSCP-2 Differences for file 'gts_precip_1d_19860101.asc'.
Contains Lat-Lon coordinates and data for each point in the original file
that differed from the ISLSCP-2 Land/Sea mask, and thus was removed.
Points added using interpolation are listed at the bottom of this file.



Lat,Lon,Precip_Removed
84.5,-41.5,0.00
84.5,-40.5,0.00
84.5,-39.5,0.00
84.5,-38.5,0.00
84.5,-37.5,0.00
"   "
Lat,Lon,Precip_Added,Interpolation_Level
-67.5,-61.5,0,1
-67.5,-60.5,0.01,1
-68.5,-60.5,0,1
-68.5,-59.5,0,1
-69.5,-.5,0,1
```

8.4 Data Format

All of the files in the ISLSCP Initiative II data collection are in the 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 1.0 degree files all contain 360 columns by 180 rows. The precipitation rates are written as real numbers and the number of gauge files as integers. Cells over water are assigned the value of –99 and cells with no data over land are assigned the value of -88 on all data layers.

All files are gridded to a common 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 W, 90 degrees N.

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 map 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, 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 were kept at -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.

8.5 Related Data Sets

There are several other precipitation data sets within the ISLSCP II data collection. Users should consult the ISLSCP II Precipitation Overview Document for a description of these products. These data sets along with a project description can be obtained from the Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC) http://daac.ornl.gov/ISLSCP_II/islscpii.shtml

9. DATA MANIPULATIONS

9.1 Formulas

9.1.1 Derivation Techniques/Algorithms

The analyzed value of daily precipitation is defined by interpolating station observations using the spherical implementation of Shepard (1968). Developed by Legates (1987), this implementation takes into account of the spherical effect of the earth surface and has been applied successfully by Legates and Willmott (1990), Rudolf (1993) and Xie et al. (1996) in constructing monthly climatology and analyses of gauge-observed precipitation over global land.

9.2 Data Processing Sequence

9.2.1 Processing Steps and Data Sets

The GTS gauge-based analyses of daily precipitation are constructed in two steps. First, daily precipitation values at 0.5 degree lat/lon grid points are calculated by interpolating 4-10 nearby gauge observations. The weighting coefficients are inversely proportional to the gauge-grid point distance and are adjusted by a cosine function taking into account the directional isolation of each gauge relative to all other nearby gauges. The area-mean value for each 0.5 degree lat/lon grid box is then defined as the arithmetic mean of the point values at its 4 corners.

9.2.2 Processing Changes

None.

9.2.3 Additional Processing by the ISLSCP II Staff

The ISLSCP II staff has processed the original files by comparing the original data set for consistency against the ISLSCP II land/water mask. Water cells in the ISLSCP II land/water mask were assigned the value of –99. Any points with missing data over land were replaced with "nearest neighbor averaging" interpolation. If no "neighbor" pixels with actual data were present, the cell was assigned a value of –88 (i.e. No data over land). New ASCII table files containing the removed and added points (points that did not 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 and maps, and the value removed from each of those maps. At the bottom of each file is also a list of all points added to the file through "nearest neighbor averaging" interpolation, where the land/water mask indicated land but there was no data in the original file (mostly over ice sheets in Antarctica). Then there is a column for number of gauges added (always set to zero), 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.

Finally, a "change map" was created for each spatial resolution, showing the spatial distribution of differences between the ISLSCP II land/water mask and the land/water mask used in the original data. In these change maps all points added are assigned a positive number, containing the "Interpolation_Level" (see above), all points unchanged ("0"), and all points removed ("-1").

9.3 Calculations

9.3.1 Special Corrections/Adjustments

None.

9.4 Graphs and Plots

None.

10. ERRORS

10.1 Sources of Error

- error in the input station observations of daily precipitation;

- error caused by the interpolation procedures.

10.2 Quality Assessment

10.2.1 Data Validation by Source

No systematic validation is conducted for the gauge-based analyses of daily precipitation. A brief examination showed that the analyses are more reliable over regions with dense gauge networks (e.g. U.S., Europe and China) while they may present unrealistic distribution over regions with poor gauge coverage. The user should use the number of gauges available in each grid box as an index of the analysis quality.

10.2.2 Confidence Level/Accuracy Judgment

Not available at this version.

10.2.3 Measurement Error for Parameters and Variables

Not available at this version.

10.2.4 Additional Quality Assessment Applied

Not applicable to this data set.

11. NOTES

11.1 Known Problems with the Data

a) The quality of the gridded fields is relatively good over grid boxes with gauges but is unreliable over regions with poor gauge coverage (e.g. central Africa);
b) No thorough quality control is applied to the input station observations and the final analyses;
c) No adjustment is applied to the gauge observations for wind effects. Bias (under-estimation) may exist in the input gauge observations and the analysis values, especially for snowfall;
d) The starting/ending time for the daily accumulation differs from country to country. Inconsistency therefore exists among the gauge data for different countries.
e) No topographic effects are taken into account in the interpolation algorithm used here;
f) The raining area is wider than the real situation because of the interpolation.

11.2 Usage Guidance

The quality of the gauge-based analyses of daily precipitation is less desirable than that for the merged gauge/satellite analyses, which take advantage of satellite observations. The Global Precipitation Climatology Project (GPCP) 1.0 degree gauge/satellite data set for the later period from 1997 to the present.

We recommend that the user should use the number of gauges in each grid box as an index of the analysis quality. In general, analysis values over a grid box where no gauge reports are available within 200-300 km are not very reliable and should be used with caution.

The ISLSCP II staff has modified the original data sets in order to provide consistency with land/water boundaries throughout the entire collection. However, users can reconstruct the original files using the differences files, the change maps and the data provided.

11.3 Other Relevant Information

None.

12. REFERENCES

12.1 Satellite/Instrument/Data Processing Documentation

Not applicable to this data set.

12.2 Journal Articles and Study Reports

Bussieres, N. and W. Hogg, 1989: The objective analysis of daily rainfall by distance weighting schemes on a meso-scale grid. Atmos. Ocean, **27**, 521 – 541.

Legates, D.R, 1987: A climatology of global precipitation. Publ. Climatol., **40**, 85pp.

Legates, D.R., and C.J. Willmott, 1990: Mean seasonal and spatial variability in gauge corrected, global precipitation. Int. Climatol., **10**, 111-127.

Rudolf, B., 1993: Management and analysis of precipitation on a routine basis. Proc. Internat. WMO/IAHS/THE SYMP. On Precip. And Evap., Slovak Hydromet. Inst., Bratislava, Sep. 1993, **1**,69-76.

Sevruk, B., 1982: Methods of correction for systematic error in point precipitation measurement for operational use. WMO Oper. Hydro. Rep., **21**, 88pp.

Shepard, D., 1968: A two dimensional interpolation function for regularly spaced data. 23rd National Conference of American Computing Machinery, Princeton, N.J.

Xie, P., and co-authors, 1996: Gauge-based monthly analysis of global land precipitation from 1971 to 1994. J. Geophy. Res., **101D14**, 19023 – 19034.

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

CPC	Climate Prediction Center
DAAC	Distributed Active Archive Center
GPCP	Global Precipitation Climatology Project
GSFC	Goddard Space Flight Center
GTS	Global Telecommunication System
ISLSCP	International Satellite Land Surface Climatology Project
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
ORNL	Oak Ridge National Laboratory
NWS	National Weather Service