1. TITLE

1.1 Data Set Identification

ISLSCP II Global Sea Ice Concentration

1.2 Database Table Name(s)

Not applicable to this data set.

1.3 File Name(s)

The following files are included in this data set:

sea_ice_data_XX_YYYY.csv: Original files submitted by the Principal Investigator in tabular format. These original data contain gridded monthly sea ice concentrations, in percent of area, arranged within 10 yearly files. XX is qd, hd, or 1d indicating a spatial resolution of one quarter, one half, or 1 degree, respectively, in both latitude and longitude. YYYY is the year from 1986 to 1995. These files are in the "sea_ice_data" directory. See Section 8.2 for complete file description.

sea_ice_map_1d_YYYYMM00.asc: 120 files with the 1 degree gridded sea ice concentrations arranged on a global grid. YYYY is the year from 1986 to 1995 and MM is the month from 01 to 12. The 00 means this is a monthly average. These files are in the "sea_ice_map" directory. **NOTE***:** At this revision, these files are only available at a 1 degree spatial resolution.

sea_ice_changemap_1d.asc: gridded ASCII map showing the differences between the ISLSCP II land/water mask and the original data set: All points with negative values ("-1") are those where the ISLSCP II mask showed water but where the original data set showed land and this point was removed. All points with a value of zero are those points where the two land/water masks agreed.

1.4 Revision Date of this Document:

April 15, 2010

2. INVESTIGATOR(S)

2.1 Investigator(s) Name and Title

Richard L. Armstrong, Senior Research Scientist, Cooperative Institute for Research in Environmental Sciences (CIRES) and National Snow and Ice Data Center (NSIDC), University of Colorado, Boulder.

2.2 Title of Investigation

Global Sea Ice Concentrations.

2.3 Contacts (For Data Production Information)

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2.4 Data Set Citation

Armstrong, R.L. and K. Knowles. 2010. ISLSCP II Global Sea Ice Concentration. 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/981

2.5Requested 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 the National Snow and Ice Data Center (NSIDC), University of Colorado, Boulder, when these data are used.

3. INTRODUCTION

3.1 Objective/Purpose

Because snow and ice surfaces represent exceptionally high albedo, with associated effects on surface energy exchange, it was considered important to create a data set which provided the longest possible time series of combined snow cover and sea ice extent. Sea ice in particular is important because it regulates the exchange of heat, moisture and salinity in the polar oceans. It insulates the relatively warm ocean water from the cold polar atmosphere except where cracks, or leads, in the ice allow exchange of heat and water vapor from ocean to atmosphere. This complete time series is also important because fluctuations in snow and ice extent are considered important indicators of climate change.

3.2 Summary of Parameters

Global monthly sea ice concentrations from 1986 to 1995, are provided in their original tabular format by year (three spatial resolutions), and as individual monthly files on a global 1 degree Earth grid. The individual monthly files have been made consistent with the 1 degree land/water mask used in this collection. An ancillary file that shows the differences between this mask and the land/water boundaries in the original 1 degree data sets is also provided.

3.3 Discussion

This International Satellite Land Surface Climatology Project (ISLSCP) Initiative 2 data set is based on the Goddard Space Flight Center (GSFC) Sea Ice Concentrations from Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR) and the Defense Meteorological Satellites Program (DMSP) Special Sensor Microwave/Imager (SSM/I) Passive Microwave Data. These original data were re-gridded by NSIDC from their original 25km spatial resolution and EASE-Grid into equal angle Earth grids with spatial resolutions of 1.0 degree, 0.5 degree, and 0.25 degree in both latitude and longitude. The ISLSCP II staff have also adjusted the re-gridded 1 degree original data to match the ISLSCP II land/water mask.

4. THEORY OF ALGORITHM/MEASUREMENTS

The NASA GSFC sea ice concentration data set, from which this ISLSCP II data subset is derived, is in the polar stereographic projection and is produced using brightness temperature data

from the Scanning Multichannel Microwave Radiometer (SMMR) and Special Sensor Microwave/Imager (SSM/I) instruments. It is designed to provide a consistent time series of sea ice concentrations (the percentage of ocean area covered by sea ice) spanning the coverage of several passive microwave instruments. To achieve this goal, sea ice algorithm coefficients are changed to reduce differences in sea ice extent and area as estimated using the SMMR and SSM/I sensors. The original NSIDC data set includes daily and monthly averaged sea ice concentrations derived from Nimbus-7 SMMR and Defense Meteorological Satellites Program DMSP-F8, -F11 and -F13 SSM/I daily brightness temperatures at a grid cell size of 25 x 25 km. The original GSFC data set begins October 1978 and continues through December 2000. These sea ice concentrations are generated by the Oceans and Ice Branch, Laboratory for Hydrospheric Processes at NASA GSFC, using SMMR brightness temperatures that were processed at NASA GSFC and SSM/I brightness temperatures that were processed at the National Snow and Ice Data Center (NSIDC). Both of these data sets are archived at NSIDC.

For more details see http://www.nsidc.org/data/docs/daac/nsidc0051_gsfc_seaice.gd.html. For further details also see Cavalieri et al. (1997).

5. EQUIPMENT

The ISLSCP II monthly sea ice concentrations are derived from Nimbus-7 SMMR and DMSP-F8, -F11 and -F13 SSM/I daily brightness temperatures at an original grid cell size of 25 x 25 km as described in Section 4.

5.1 Instrument Description

5.1.1 Platform (Satellite, Aircraft, Ground, Person)

The SMMR is a ten-channel instrument delivering orthogonally polarized antenna temperature data at five dual-polarized (horizontal, vertical) frequencies: 6.6, 10.7, 18.0, 21.0 and 37.0 GHz. The SSM/I is a seven channel, four frequency, orthogonally polarized, passive microwave radiometric system. The instrument measures radiances at 19.3, 22.2, 37.0 and 85.5 GHz. For more details see Cavalieri et al. (1997) or http://www.nsidc.org/data/docs/daac/nsidc0051_gsfc_seaice.gd.html

5.1.2 Mission Objectives

The Nimbus-7 SMMR was an experimental Earth-imaging passive microwave sensor launched as a follow-on to earlier experimental NASA radiometers (ESMR, NEMS, and SCAMS) launched by NASA on previous satellites in the Nimbus series (Nimbus-5 and -6). The SMMR was designed primarily for remote observations of oceanic, cryospheric, and tropospheric moisture-related phenomena. Key geophysical variables observable by the SMMR included sea surface temperature, sea surface wind speed, columnar water vapor over the ocean, cloud liquid water over the ocean, rain rate, sea ice concentration and type, snow extent and depth, and potentially other land parameters such as soil moisture, surface temperature, and vegetation extent.

The mission of the Defense Meteorological Satellite Program (SSM/I) is to provide global coverage of visual and infrared cloud data and other specialized near real-time meteorological, oceanographic and solar-geophysical data required to support worldwide Department of Defense operations and high-priority programs. Timely data are supplied to Air Force Global Weather Central, the Navy Fleet Numerical Meteorology and Oceanography Center (FNMOC) and to deployed tactical receiving terminals worldwide.

The DMSP SSM/I advanced the SMMR instrumentation by improving resolution with the addition of an orthogonally polarized 85.5 GHz channel.

5.1.3 Key Variables

Global sea ice concentrations.

5.1.4 Principles of Operation

See Cavalieri et al. (1997).

5.1.5 Instrument Measurement Geometry

See http://www.nsidc.org/data/docs/daac/nsidc0051_gsfc_seaice.gd.html

5.1.6 Manufacturer of Instrument

The SMMR sensor was manufactured by NASA. SSM/I sensors are manufactured by the Hughes Aircraft Company.

5.2 Calibration

See http://www.nsidc.org/data/docs/daac/nsidc0051_gsfc_seaice.gd.html for specific calibration information.

5.2.1 Specifications

5.2.1.1 Tolerance

See above.

5.2.2 Frequency of Calibration

See above.

5.2.3 Other Calibration Information

See above.

6. PROCEDURE

6.1 Data Acquisition Methods

The combined SMMR and SSM/I sea ice concentration time series is produced from brightness temperatures (TBs) obtained from GSFC and NSIDC. The four sets of satellite data currently used to create this data stream and the periods for which the data are usable are: the Nimbus-7 SMMR from October 26, 1978 through August 20, 1987, the DMSP-F8 from July 9, 1987 through December 18, 1991, the DMSP-F11 from December 3, 1991 through December 31, 1996, and the DMSP-F13 from 5 May 1995 to present.

SMMR: Sea ice concentrations were processed by GSFC using SMMR TBs (see http://www.nsidc.org/data/docs/daac/nsidc0051_gsfc_seaice.gd.html Data Manipulations section). The SMMR TBs were processed and quality checked at GSFC (Gloersen et al. 1992).

SSM/I: SSM/I F8, F11, and F13 data used to create the sea ice concentration time series are distributed by NSIDC. Processing of SSM/I F13 TBs is ongoing. Data acquisition, filtering bad

data, handling geolocation errors, implementation of an antenna pattern correction, and finally the swath-to-grid conversion are all described in the documentation for DMSP SSM/I Daily and Monthly Polar Gridded Sea Ice Concentrations (http://nsidc.org/data/nsidc-0002.html).

6.2 Spatial Characteristics

6.2.1 Spatial Coverage

The spatial coverage of this data set is global, except for continental land masses. Small inland water bodies are not resolved in the original data set.

6.2.2 Spatial Resolution

Original sea ice concentration data are processed at a spatial resolution of 25 by 25 km. This ISLSCP II data set is provided on an equal-angle Earth grid with spatial resolutions of 1/4, 1/2 and 1 degree in both latitude and longitude.

6.3 Temporal Characteristics

6.3.1 Temporal Coverage

1986 through 1995.

6.3.2 Temporal Resolution

All data layers are provided as monthly averages of sea ice concentrations.

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
1) Original Files (sea_ice_data_XX_YYYY.csv)				
LONG	Longitude for the center of a cell. West longitudes are negative.	-179.50 degrees to 179.50 degrees	Decimal Degrees	NSIDC
LAT	Latitude for the center of a cell. South latitudes are negative.	87.50 degrees to –78.50 degrees	Decimal Degrees	NSIDC
JAN	Average sea ice concentration for the month of January of the	0-100	Percent	Multiple satellites

	year YYYY.			
FEB	Average sea ice concentration for the month of February of the year YYYY.	0-100	Percent	Multiple satellites
...	...	...	...	...
DEC	Average sea ice concentration for the month of December of the year YYYY.	0-100	Percent	Multiple satellites
LAND_MASK	Value of the ISLSCP II land/water mask: 0= Water 1= Land	0-1	See 8.2.2	ISLSCP II land/water mask
2) "Mapped" Files (sea_ice_map_1d_YYYYMM00.asc)				
Sea Ice Concentration	Average monthly sea ice concentrations.	0-100 Land=-88	Percent	Multiple satellites
3) File sea_ice_changemap_1d.asc				
Points 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 or water and original data is missing (fill value used).	-1 to 1	See 8.2.2	Original data and ISLSCP II land/water mask

8.3 Sample Data Record

Sample data records for the original file **sea_ice_data_1d_1986.csv** are given below:

```
LONG,LAT,JAN,FEB,MAR,APR,MAY,JUN,JUL,AUG,SEP,OCT,NOV,DEC,LAND_MASK
-179.50,84.50,99,99,97,98,100,98,93,88,92,97,96,96,0
-178.50,84.50,99,99,96,98,100,97,93,88,92,96,96,96,0
-177.50,84.50,99,99,96,98,100,97,93,87,92,96,96,96,0
-176.50,84.50,99,98,96,97,100,96,92,87,91,96,97,96,0
```

8.4 Data Format

All of the files in the ISLSCP Initiative II data collection are in the Arc GIS ASCII Grid format. The original data files **sea_ice_data_XX_YYYY.csv** all have a total of 15 columns separated by a single comma and a number of rows that ranges from 10511 (File **sea_ice_data_1d_1986.csv**) to 182399 (File **sea_ice_data_qd_1995.csv**). No data are written to the tables for cells which had 0% sea ice for the entire year. Only numerical fields are included as described in Section 8.2.

The file format for the "mapped" monthly sea ice concentration files **sea_ice_map_1d_YYYYMM00.asc** and the **sea_ice_changemap_1d.asc** files consists of numerical fields of varying length, which are delimited by a single space and arranged in columns

and rows. The files each contain 360 columns by 180 rows. All values in these files are written as real numbers. Land cells in the **sea_ice_map_1d_YYYYMM00.asc** files are given the value –88.

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 map 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

See References and http://www.nsidc.org/. ISLSCP II project information and data sets can also be obtained from the Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC) http://daac.ornl.gov/ISLSCP_II/islscpii.html .

9. DATA MANIPULATIONS

9.1 Formulas

9.1.1 Derivation Techniques/Algorithms

See Section 4.0 and the following web site for more information:
http://www.nsidc.org/data/docs/daac/nsidc0051_gsfc_seaice.gd.html

9.2 Data Processing Sequence

9.2.1 Processing Steps and Data Sets

The global sea ice concentration files represent the monthly averages of the daily sea ice concentration derived from passive microwave satellite data using algorithms described in Cavalieri et al. (1997). The original monthly average sea ice concentrations from SSM/I and SSMR were regridded at NSIDC to 1/4, 1/2 and 1 degree, lat/lon grids using bilinear interpolation. No data were written in the **sea_ice_data_XX_YYYY.csv** files for cells which had 0% sea ice for the entire year. There is also a hole at the North Pole north of about 85^{o}N latitude where there are no satellite measurements. While it is reasonable to assume that the average concentration of this 'pole hole' is 100%, no data have been provided for this region in the original files.

9.2.2 Processing Changes

None.

9.2.3 Additional Processing by the ISLSCP II Staff

The ISLSCP II staff have taken the 1 degree resolution original data provided by the Principal Investigators and created global maps of monthly sea ice concentration. Every cell in the **sea_ice_data_1d_YYYY.csv** files was assigned to its corresponding location on a global 1^{o} grid using the latitude and longitude coordinates that were provided. Individual monthly files were created and written to the ASCII format. These files are named **sea_ice_map_1d_YYYYMM00.asc**. The 'pole hole' has been filled as 100% sea ice concentration on all of these monthly files.

The **sea_ice_map_1d_YYYYMM00.asc** files have all been made consistent with the ISLSCP II 1 degree land/water mask. Because no land/water mask was provided with the original data, mismatches between these data and the ISLSCP II mask were identified by overlaying the ISLSCP II 1 degree mask onto an average of all the 1 degree , monthly sea ice concentrations from 1986 to 1995. The 1986-1995 average was used because cells with zero sea ice concentration near coastlines were not easily identifiable as either open leads in the ice pack or an actual mismatch between the land/water mask used in the original processing of the data and the ISLSCP II mask. Cases where the ISLSCP II mask showed land and the original data had any sea ice concentration retrieval from 1986 to 1995 (n=532) were assigned the value of –88, along with all other land cells in the ISLSCP II mask. Cases where the ISLSCP II mask showed water yet had no sea ice concentrations from 1986 to 1995 had to be separated into actual open ocean cells and water cells with no data near coastlines. The latter (n=92) were identified by searching for any such cell that also had a land cell within a 3 by 3 window of surrounding cells. All of these 92 cells, except one, were filled from an average of the sea ice concentration of any non-land cell(s) in the 3 by 3 window surrounding the cell. One cell located in Northern Greenland at 81 degrees 30'N and 25 degrees 30'W could not be filled using the above methods and was left with zero values. A file that shows all of the cells which were changed was produced (file **sea_ice_changemap_1d.asc**), showing the results of applying the land/water mask, as a viewable ASCII map: all points added ("1"), all points unchanged ("0"), and all points removed ("-1").

Some inland water bodies such as the Great Lakes have ice concentration values over the 1986-1995 period. Other smaller inland water bodies do not. While the filling procedure described above did create ice concentrations over some of these water bodies, in many cases no valid ice concentration data could be found within the 3 by 3 window so that the cell was left with a zero value. It was not possible at this time to distinguish between inland water bodies with no ice concentrations from those resulting in a mismatch between the two 1 degree land/water masks.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

None.

9.4 Graphs and Plots

Not available at this revision.

10. ERRORS

10.1 Sources of Error

There is a hole at the North Pole, north of approximately 85 degrees N latitude, where there is no satellite coverage. It is reasonable to assume that the sea ice concentration within this region is 100%. The ISLSCP II staff have filled this hole with 100% sea ice concentration. The user should clearly understand that there are no satellite data in this region of the Earth.

The data filling procedure described in Section 9.2.3 introduces some 'synthetic' data into the data layers, albeit from actual sea ice concentrations surrounding the cells. This procedure

introduces some errors. Also, some of the 92 cells that were filled may be located near the ice edge and near coastlines, and may increase the extent of the ice in small areas.

10.2 Quality Assessment

10.2.1 Data Validation by Source

Not available at this revision.

10.2.2 Confidence Level/Accuracy Judgment

Sea ice concentration errors are generally less than 5% but may be as large as 10% in some locations and under certain conditions, see Cavalieri et al. 1997, 1995, 1992, 1991.

10.2.3 Measurement Error for Parameters and Variables

See Cavalieri et al, 1997; 1995; 1992, 1991

10.2.4 Additional Quality Assessment Applied

None.

11. NOTES

11.1 Known Problems with the Data

There are no reported problems with the original **sea_ice_data_XX_YYYY.csv** files. Some of the issues related to the **sea_ice_map_1d_YYYYMM00.asc** files have been listed in Section 10.1.

11.2 Usage Guidance

Users should clearly understand the relationship between the original data (**sea_ice_data_XX_YYYY.csv**) and the data that have been re-processed by the ISLSCP II staff (**sea_ice_map_1d_YYYYMM00.asc**). Should any questions arise, the user can always refer to the original files because these are unchanged from what was submitted by the Principal Investigators. Users should exercise caution when using the sea ice data over inland water bodies except over large areas such as the Great Lakes. Users should also consult the **sea_ice_changemap_1d.asc** file to better understand those 1 degree points that were filled and/or masked with the ISLSCP II land/water mask.

11.3 Other Relevant Information

None.

12. REFERENCES

12.1 Satellite/Instrument/Data Processing Documentation

Fu, C.C., D. Han, S.T. Kim, and P. Gloersen, 1988. *User's guide for the Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR) CELL-ALL tape*, NASA Reference Publication No. 1210, National Aeronautics and Space Administration, Washington, D.C.

Gloersen P., W.J. Campbell, D.J. Cavalieri, J.C. Comiso, C. L. Parkinson, H.J. Zwally. 1992. *Arctic and Antarctic Sea ice, 1978-1987: Satellite Passive Microwave Observations and Analysis*. NASA Special Publication 511.

Gloersen, P. and others, 1984, A summary of results from the first Nimbus-7SMMR observations, *J. Geophysical Res*., 89, 5335-5344.

Hollinger, J.P., J.L. Pierce, and G.A. Poe. 1990. SSM/I instrument evaluation. *IEEE Transactions on Geoscience and Remote Sensing*, 28(5):781-790.

12.2 Journal Articles and Study Reports

Cavalieri, D.J., C.L. Parkinson, P. Gloersen, and H.J. Zwally. 1997. *Arctic and Antarctic sea ice concentrations from multichannel passive-microwave satellite data sets: October 1978 to December 1996, User's Guide.* NASA Technical Memorandum 104647. 17 pages.

Cavalieri, D.J., K.M. St. Germain, and C.T. Swift. 1995. Reduction of weather effects in the calculation of sea ice concentration with the DMSP SSM/I. *Journal of Glaciology*. 41(139):455-464.

Cavalieri, D.J., J. Crawford, M. Drinkwater, W.J. Emery, D.T. Eppler, L.D. Farmer, M. Goodberlet, R. Jentz, A. Milman, C. Morris, R. Onstott, A. Schweiger, R. Shuchman, K. Steffen, C.T. Swift, C. Wackerman, and R.L. Weaver. 1992. *NASA sea ice validation program for the DMSP SSM/I: final report.* NASA Technical Memorandum 104559. National Aeronautics and Space Administration, Washington, D.C. 126 pages.

Cavalieri, D.J., J. Crawford, M.R. Drinkwater, D. Eppler, L.D. Farmer, R.R. Jentz and C.C. Wackerman. 1991. Aircraft active and passive microwave validation of sea ice concentration from the DMSP SSM/I. *Journal of Geophysical Research* 96(C12):21,989-22,009.

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

CIRES	Cooperative Institute for Research in Environmental Sciences
DAAC	Distributed Active Archive Center
DMSP	Defense Meteorological Satellite Program
EASE	Equal Area Scalable Earth (Grid)
FNMOC	Fleet Numerical Meteorology and Oceanography Center
GSFC	Goddard Space Flight Center (NASA)
ISLSCP	International Satellite Land Surface Climatology Project
NSIDC	National Snow and Ice Data Center
ORNL	Oak Ridge National Laboratory
SMMR	Scanning Multichannel Microwave Radiometer
SSM/I	Special Sensor Microwave/Imager
TB	Brightness Temperature