

6.2. ICE/SNOW DATA PRODUCT (IS)

6.2.1. OVERVIEW

As part of the ISCCP cloud analysis, information concerning the presence of sea ice and snow aids in separating clear and cloudy scenes (Rossow and Garder 1993a). Although these data are also available from the original sources, the version used in the ISCCP processing (called IS data) is archived with the cloud climatology to document the complete ISCCP data analysis procedure and to provide these data in a more convenient format especially suited to satellite data processing. IS data are also included in the Stage D1 cloud product and summarized in the Stage D2 cloud product.

The **original sea ice dataset** used by ISCCP through 1991 is a digital version of the weekly analyses prepared by the U.S. Navy as paper maps since 1972 and is obtained from the Navy/National Oceanic and Atmospheric Administration Joint Ice Center:

NAVY/NOAA Joint Ice Center
4301 Suitland Road
Washington, DC 20390
USA

The weekly sea ice analyses combine data from shore station reports, ship reports, aerial reconnaissance and satellite image analysis. The satellite-based information constitutes 90-98% of the total and comes from visible/infrared imagery from the operational weather satellites and microwave imagery from experimental and operational satellites (when available). If new data do not arrive during the analysis cycle, older values are retained.

In 1993, NOAA ceased preparation of the digital sea ice cover dataset for an indefinite period; the last year of data available is 1991. The **new sea ice dataset** is based solely on a daily analysis of microwave measurements from the SSM/I on U.S. Air Force DMSP weather satellites using the "NASA Team" algorithm (Cavalieri et al. 1984). These data are prepared by and available from

National Snow and Ice Data Center
Cooperative Institute for Research in Environmental Sciences
Campus Box 449
University of Colorado
Boulder, CO 80309-0449

The **original snow dataset** is the digital version of the Northern Hemisphere Weekly Snow and Ice Cover Charts prepared by the Synoptic Analysis Branch at National Oceanic and Atmospheric Administration since 1966 (Dewey 1987). These data may be obtained from

NOAA/NESDIS
Washington, DC 20233
USA

Snow cover is estimated by daily visual inspection of all available visible band satellite imagery; the presence of snow at a particular location represents the latest cloud-free observation of that site available within the week. Unilluminated portions of the polar regions are assumed to be completely snow-covered; Greenland is always reported as snow-covered. In the ISCCP version, Antarctica is also assumed to be permanently snow-covered; all other Southern Hemisphere land is assumed to be snow-free since there is no information available.

The ISCCP version of the snow/ice data is a merger of the separate snow and sea ice datasets and reports only fractional coverage.

6.2.2. ARCHIVE TAPE LAYOUT

Each IS data archive tape has four header files, followed by 73 data files for each year arranged chronologically. The total number of data files depends on the number of years reported. Each data file represents a 5-day period.

Table 6.2.1. IS Archive Tape Layout.

| FILE | CONTENTS | FORMAT | RECORD LENGTH (BYTES) |
|------|----------------------|--------|-----------------------|
| 1 | README file | ASCII | 80 |
| 2 | Table of Contents | ASCII | 80 |
| 3 | Read Software | ASCII | 80 |
| 4 | Ancillary Data Table | ASCII | 80 |
| 5-77 | IS Data | Binary | 10400 |

***Note:** The GPC produces archive tapes using IBM standard label format which means that there are label records written before and after each file on the tape. On IBM systems, these labels provide information to the operating system about the name and format of the file and will appear transparent to the user. On non-IBM systems these label records will appear as extra short files surrounding each file listed above and should be skipped by the user. The presence or absence of these files depends on which archive supplies tape copies to the user, as they may either provide an exact copy (labels present) or a modified copy (labels absent).*

6.2.3. HEADER FILE CONTENTS

File 1 is the **README** file that contains ASCII text providing descriptive information about the tape format and contents, similar to what is in this section. The first line of text (80 bytes) gives the ISCCP tape designator code that identifies the contents (Table 2.5.12).

File 2 is the **Table of Contents** file that lists the center dates of the 5-day intervals for the ISCCP data, the sources of the data and the center dates of the time intervals for the original datasets in ASCII columns defined in Table 6.2.2.

Table 6.2.2. Table of Contents Layout.

| COLUMN | DESCRIPTION |
|--------|---|
| 1 | File number on archive tape |
| 2 | Data set name |
| 3 | Center date of file (YYMMDD) |
| 4 | Source of sea ice data |
| 5 | Original date of East Sector - Navy Northern Sea Ice data or Start date of NSIDC Northern Sea Ice data (YYMMDD) |
| 6 | Original date of West Sector - Navy Northern Sea Ice data or End date of NSIDC Northern Sea Ice data (YYMMDD) |
| 7 | Original date of Navy Southern Sea Ice data or Start date of NSIDC Southern Sea Ice data (YYMMDD) |
| 8 | 000000 or End date of NSIDC Southern Sea Ice data (YYMMDD) |
| 9 | Source of Snow data |
| 10 | Original date of Snow data (YYMMDD) |

File 3 contains **FORTTRAN programs** and subroutines for reading, decoding (see Section 2.1.4), and using the snow/ice data as follows:

| | |
|-------------------|---|
| Program SAMPLE | Example of how to use the subroutines |
| Subroutine ISOPEN | Open an IS file and initialize |
| Subroutine ISREAD | Unpack IS data for one latitude band |
| Subroutine RDANC | Read ancillary data file |
| Subroutine EQ2SQ | Convert equal-area map to equal-angle map |

File 4 contains the **Ancillary Data Table** that lists characteristics of each map grid cell in ASCII columns defined in Table 6.2.3.

Table 6.2.3. Ancillary Data Table Layout.

| COLUMN | DESCRIPTION |
|--------|--|
| 1 | ISCCP map grid cell number (1 - 41252) |
| 2 | Equal-area latitude index (south-to-north = 1 - 180) |
| 3 | Equal-area longitude index |
| 4 | Western-most equal-angle longitude index |
| 5 | Eastern-most equal-angle longitude index |
| 6 | Map grid cell center latitude in degrees |
| 7 | Map grid cell center longitude in degrees |
| 8 | Map grid cell area (km ²) |
| 9 | Land cover fraction (%) |

6.2.4. DATA FILE CONTENTS

Each IS data file contains 4 records of 10400 bytes each, presenting one global map of ice and snow cover. Each data record has an 87 byte prefix (Table 6.2.4) followed by data for 10313 map grid cells (Figure 6.2). See Section 6.2.5 for definitions of map grids used. Each map grid cell has one variable represented by a single byte code value (Table 6.2.5).

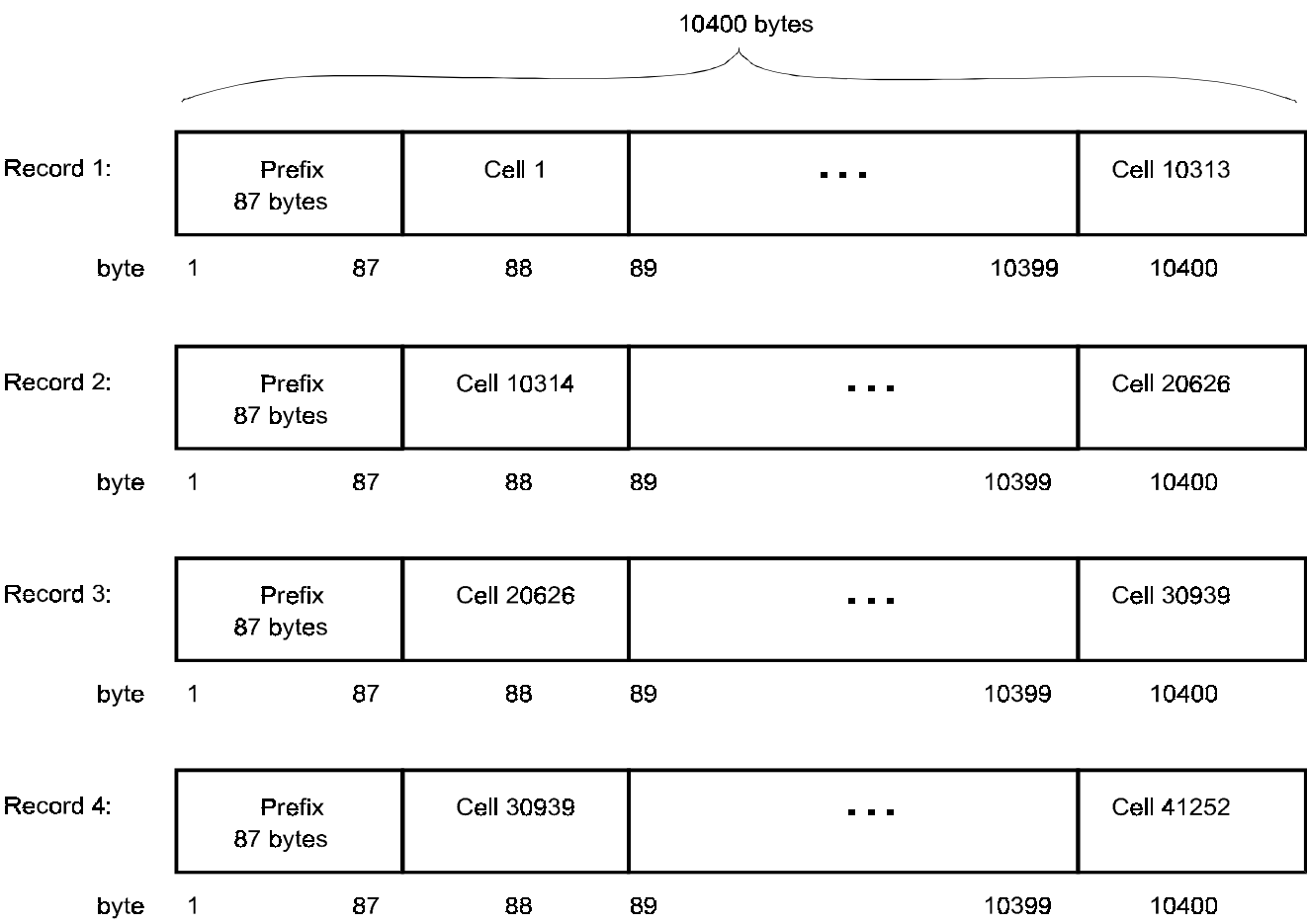


Figure 6.2. IS Data File Layout.

Table 6.2.4. IS Data Record Prefix Layout.

| BYTE # | DESCRIPTION |
|---------|--|
| 1 | File number on archive tape (5-77) |
| 2 | Record number in file (1-5) |
| 3 | Data type (ice/snow = 0) |
| 4 | First latitude index in record |
| 5 | Last latitude index in record |
| 6 | Year of dataset (YY) |
| 7 | Month of dataset (MM = 1 - 12) |
| 8 | Day of dataset (DD = 01 - 31) |
| 9 | Sea ice data source code (see Table 2.5.10) |
| 10 - 12 | Year, Month, Day of Navy Northern Hemisphere (East) sea ice data or Start Date of NSIDC Northern sea ice data |
| 13 - 15 | Year, Month, Day of Northern Hemisphere (West) sea ice data or End Date of NSIDC Southern sea ice data |
| 16 - 18 | Year, Month, Day of Southern Hemisphere sea ice data or Start Date of NSIDC Southern sea ice data |
| 19 - 21 | All zeros or End Date of NSIDC Southern sea ice data |
| 22 | Snow data source code (see Table 2.5.10) |
| 23 - 25 | Year, Month, Day of Northern Hemisphere snow data |
| 26 - 87 | 255 (not used) |

Note: A value of zero for the three bytes representing the date indicates that no data are available; to date there have been no Southern Hemisphere snow data.

6.2.5. MAP GRID DEFINITIONS

The ISCCP ice/snow data are collected into a global EQUAL-AREA map grid with a cell area equal to a 1° latitude/longitude cell at the equator. The cells are formed by equal increments in latitude and variable longitude increments selected to preserve, approximately, the area of the cell and to provide an integer number of cells in a latitude zone. There are 41252 cells in this grid. The position (Greenwich, equator) is a cell corner.

The ISCCP ice/snow data can be converted to a global EQUAL-ANGLE map with 1° increments in latitude and longitude by the Subroutine EQ2SQ contained in ISREAD. There are 64800 map cells in this grid. The position (Greenwich, equator) is a cell corner. The EQUAL-ANGLE version of the data is created by replicating the EQUAL-AREA values within a latitude zone.

6.2.6. VARIABLE DEFINITIONS

The ice/snow cover for each map grid cell is given by a one byte classification code (Table 6.2.5):

Table 6.2.5. Ice/Snow Cover Classification Codes. All fractions are given in 10% increments.

| INTEGER VALUE | DEFINITION |
|---------------|---|
| 0 - 10 | Sea ice fraction for all water cells |
| 20 - 30 | Sea ice fraction for water mixed with snow-free land |
| 40 - 50 | Sea ice fraction for water mixed with snow-covered land |
| 60 | No snow (either snow-free land or water with no sea ice data) |
| 70 | Snow-covered land cell (no water) |
| 255 | No data |

For example, codes 3, 23, and 43 represent 30% sea ice coverage for an all water cell, 30% for a mixed land/water cell with snow-free land, and 30% for a mixed land/water cell with snow-covered land. All land cells over Antarctica are set to code 70.

6.2.7. TIME RESOLUTION AND COVERAGE

The ISCCP snow/ice data are presented as a series of datasets representing 5-day intervals and labeled by the center date. Thus, the first dataset, covering the period from 1 - 5 July 1983, is labelled by the date 3 July 1983. The data reported come from the original NOAA snow and Navy/NOAA sea ice datasets, representing 7-day time intervals, with center dates closest to the center of the 5-day interval. The original NSIDC sea ice dataset has daily resolution, so 5-day composites are formed for each 5-day time interval (see Section 6.2.8). The sea ice datasets cover both hemispheres, but the snow data are only for the Northern Hemisphere. In the ISCCP dataset, Antarctica is labelled as permanently snow covered; however, occasional snow cover over the Andes and in southern-most Chile/Argentina are not reported.

6.2.8. MERGING ICE AND SNOW DATASETS

The ISCCP version of these two datasets is produced by re-gridding them to a common grid compatible with the ISCCP analysis grids and merging the sea ice and snow information. In addition all land south of 60°S (Antarctica) is labelled as permanently snow covered. The sea ice and snow datasets are mapped to an equal-area grid, equal to 1° latitude/longitude at the equator. The ISCCP grid is lower resolution than the original sea ice grid, so an average fractional cover is calculated from all original sea ice grid cells included within each ISCCP grid cell. The ISCCP grid is approximately the same resolution as the original snow grid, so reported values are either 0 (no snow) or 1 (snow) according to the nearest value in the original grid.

The NSIDC sea ice dataset differs from the Navy analysis (four overlapping years of data, 1988 - 1991, have been examined) in three notable ways: generally lower ice fractions, particularly over the summer Arctic, much more ice along all coastlines, even in summer and at low latitudes, scattered areas of low ice concentration in open ocean even at low latitudes. The first difference is presumably associated with the assumed relation of ice concentration with microwave brightness temperature in the analysis algorithm. The second difference is associated with "side lobe" contamination in coastal scenes where the much higher emissions from land may produce spurious ice signals. The third difference is the result

of surface wind, cloud and precipitation effects on the microwave radiances that have not been completely removed by the "weather" filter. To adjust the NSIDC characteristics to resemble the Navy analysis (we do not know which is more accurate), five tests are applied to produce 5-day composites.

1. To raise the overall concentrations, the maximum value for 5 days is used. In addition, if the maximum concentration is $< 75\%$, it is re-set to 50% and if the maximum is $> 75\%$, it is re-set to 100%.
2. To eliminate spurious low ice concentrations, the maximum value is set to 0 if the **average** value is $< 20\%$.
3. If the number of water grid points is $< 65\%$ of the total, the grid cell is changed to "all land" (i.e., sea ice cover is zero).
4. If an ice concentration value is isolated (ie, no nearest neighbors with non-zero concentration), then it is set to 0.
5. If no observations are available in a 5-day period, the average of any available observations in the nearest map grid cells is substituted. If more than 30 map grid cells still lack observations, then the compositing period is extended until all grid cells are filled (the longest extension to date has been to 9 days).

Figures 6.3 and 6.4 illustrate two comparisons of the sea ice cover from the adjusted NSIDC dataset and the Navy analyses. Almost all of the difference between the two datasets in Figure 6.3 occurs in coastal regions, which were not used in the cloud analysis anyway. This is shown by the agreement of the number of map grid cells **totally** covered by sea ice from the two datasets (Figure 6.4).

Finally, the snow and sea ice information are merged. Most locations are either completely land-covered or ocean-covered, so that a single snow or sea ice value can be reported in the merged dataset. To report both snow and sea ice with a single code value in map grid cells with a mixture of land and water, special code values were devised to indicate all combinations of snow/land and ice/ocean cover (Table 6.2.5).

The ISCCP version of these data is arranged in uniform time intervals of 5 days. The original datasets represent different weekly time intervals, each identified by its center date. The merged data are created by reporting the values from the dataset with the center date closest to the center of each 5-day interval. The original time intervals of each data set merged into the ISCCP version are indicated in the prefix of each data record.

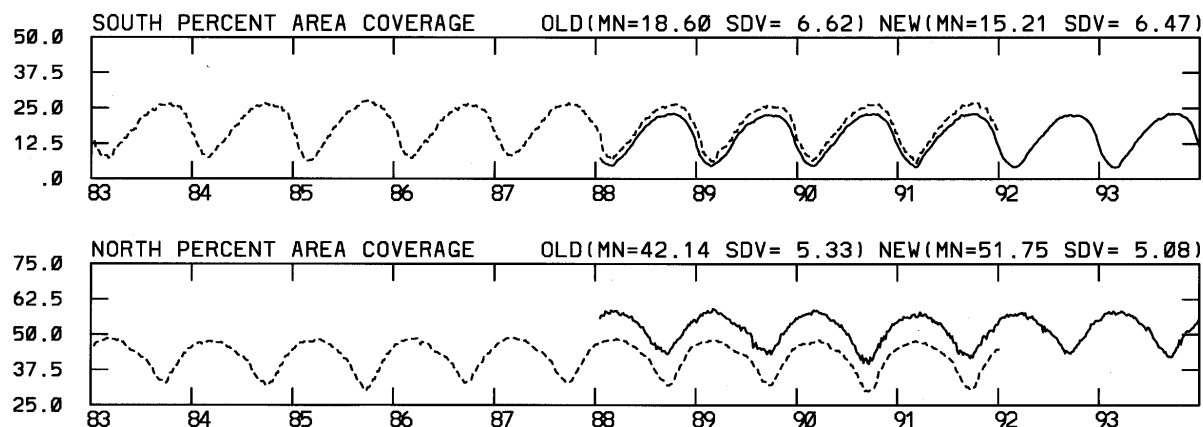


Figure 6.3. Monthly mean sea ice cover in the Southern and Northern hemispheres (as fraction of hemispheric area) from the Navy analysis (old, dashed) and the adjusted NSIDC (new, solid) datasets used in the ISCCP cloud analysis.

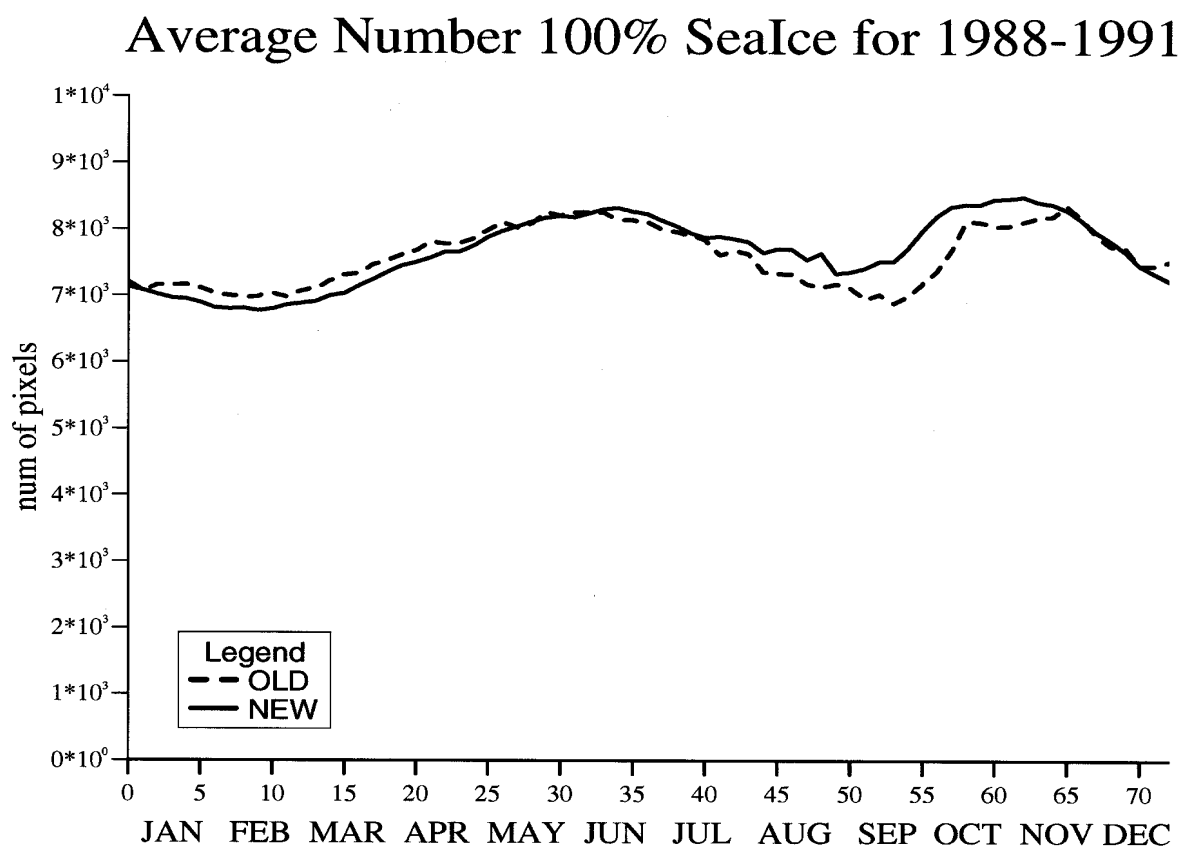


Figure 6.4. Average annual cycle of the number of 1° map grid cells totally covered by sea ice in 5-day intervals from the Navy analysis (old, dashed) and adjusted NSIDC (new, solid) datasets used in the ISCCP cloud analysis.