Selected Buoy and Sea Ice Information

- Coverage of world drifting buoys
  - Much data for 1979 – on

- Includes Arctic buoys

- History of moored buoys in tropics

- Some information about sea ice, and Great Lakes ice
  - And water level for Great Lakes, 1900 – on

- Monthly ice motion and atmospheric pressure,
  Arctic, 1979 – on

- 75% done by Mar 2001

- This has 14 items and 91 pages

Roy Jenne
Jan 25, 2002
Selected Buoy and Sea Ice Information
Roy Jenne
27 Feb 2001
Rev 24 Jan 2002

This has information about drifting buoys, Arctic buoys on drifting ice, fixed buoys, sea ice, Great Lakes ice, etc.

There are 14 reports here with 85 pages plus 6 pages in front.

1. The location and coverage of world drifting buoys (1979 – 98).
   - 10 pages are given here.

2. Some Arctic ice buoy locations (7 p here)


   - This shows maps of the locations of US fixed buoys. The period of record for each buoy is given.
   - There are about 8 buoys in the Great Lakes, 7 in the Gulf of Mexico, 18 along the East Coast, 16 along the West Coast, 3 in the Gulf of Alaska, and 4 near Hawaii, etc.

5. Arctic Ice Buoy and Ice Island Data Meeting, 9 p
   - Minutes, by R. Jenne and others, 9 p here. It was a very useful meeting. This document should help. The University of Washington (Ignatius Rigor) Polar Science Center has had a program for many years to place reporting buoys on the Arctic drifting ice (341 buoys placed during 1979 – 90).
   - The data gets into the COADS dataset.

------- 1 PAGE TO INTRODUCE THE NEXT 14 PAGES -------

   - And 3 more pages about NASA sea ice for 1973 – 76.


   - User’s Guide for sea ice and radiances on CD-ROM.


12. Sea Ice Information and Great Lakes, 3 p and cover (items 12 & 13 have a total of 8 p)

13. Other sheets about Great Lakes ice cover and water levels (4 p here).
   - There is an annual report that gives monthly water levels for 1900 – on.
   - There is a report (once every 5 years) “Great Lakes Water Levels, 1860 – 1990” that gives monthly and annual data.

   - Several sheets from AIDJEX Bulletins (7 p)
   - A sheet with some DARMS buoy locations (1958 – 72) (2 p)
   - Summary about DARMS data (9 p)
     - Information from a CD-ROM
NOAA Data Buoy Office Programs

Abstract
The NOAA Data Buoy Office (NDBO) buoys provide vital meteorological and oceanographic reports from data-sparse marine areas. To provide a better understanding of the scope and potential of the buoy system, the buoy network, monitoring capabilities, real-time processing and dissemination, archival data quality and availability, and future programs are described.

1. Introduction
The NOAA Data Buoy Office (NDBO) develops and operates moored buoys in coastal and offshore U.S. waters to provide real-time environmental observations. The principal users of the reports are the National Weather Service (NWS), military weather services, and private forecast organizations, all of which use the data for marine weather and oceanographic analysis and prediction. Coastal communities, marine transportation interests, fisheries, recreational boating, and offshore construction enterprises benefit most directly from the data, although large-scale hemispheric and global numerical models use the data for initial analyses. Some scientific investigators employ the buoy data for ground truth, validation of theoretical models, and climate monitoring studies. NDBO also has a significant program for development and deployment of drifting buoys, which provides valuable environmental observations for many purposes.

NDBO buoy reports represent a unique set of environmental data. Thus, in order for the operational and research communities to become more aware of the capabilities of the system, the acquisition, transmission, processing, and dissemination of the data are discussed.

2. Background
Recognizing the need for a comprehensive data buoy development program, the Ocean Engineering Panel of the Interagency Committee on Oceanography, in 1966, suggested the creation of a national data buoy system.

![NDBO Buoy Locations](image)

**Fig. 1.** NDBO buoy locations.
Buoy oh buoy: Comprehensive El Niño data

The El Niño Pacific warming of 1997 and 1998 shut down the nutritional conveyor belt to a vast swath of ocean surface, newly released data show. The 1998 La Niña cooling, in turn, switched this belt to fast forward, fertilizing the biggest bloom of microscopic plants yet measured in the equatorial Pacific.

"This is the largest El Niño-La Niña event ever observed, and it was observed in great detail," comments biological oceanographer Michael R. Landry of the University of Hawaii at Manoa in Honolulu. Landry says the new measurements provide a first overview of how ocean ecosystems, global carbon dioxide concentrations, and the physical forces behind El Niño interrelate. "This is a tremendous technical and conceptual achievement," says Landry.

The data come from two sources: buoy-mounted sensors, which transmit readings from 72 equatorial sites, and an optical satellite sensor. The combined systems report wind speed and direction, temperature, and marine concentrations of carbon dioxide, nutrients, and chlorophyll—the green, light-harvesting molecule that plants produce.

The measurements show that during the 1997–1998 El Niño, the equatorial Pacific ceased producing carbon dioxide and became a net absorber of that greenhouse gas.

While scientists had already surmised from scattered shipboard readings that such a transition had occurred, marine geochemist Taro Takahashi of Columbia University comments that the new data detail the phenomenon for the first time. He says these numbers will figure critically in global-warming predictions.

Other measurements confirm that across most of the equatorial Pacific, El Niño deepens the warm-water layer inhabited by the primary producers in the ocean food web—the photosynthetic plankton.

Earlier evidence suggested that this deepening would diminish the nutrient supply to these microbes by pushing the cold equatorial undercurrent downward and farther from the plankton. The cold water originates near South America and carries nutrients to the relatively infertile midocean region along the equator. Scientists have proposed that trade winds draw this cold water upward.

Multiple measurements confirm the basic elements of this system. During the last El Niño, nutrient upwelling halted as winds flagged, the undercurrent lost strength, and chlorophyll concentrations across the equatorial Pacific plummeted to their lowest recorded levels.

* During the subsequent La Niña, these trends reversed, with a vengeance.

"The dramatic bloom that occurred after El Niño was completely unexpected," says Francisco P. Chavez, a biological oceanographer at the Monterey Bay Aquarium Research Institute in Moss Landing, Calif. He and his colleagues describe the recent findings in the Dec. 10

SCIENCE NEWS, VOL. 156

DECEMBER 11, 1999
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RNO DC
for Drifting Buoys
pour les bouées dérivantes

1989

Annual Report
Rapport annuel
CNRDO

Fisheries and Oceans
Pêches et Océans
intention to continue to write the NODCs every six months requesting copies of any new data submitted. Principal investigators are invited to submit historical data to the NODC in their country or directly to MEDS. All NODCs may request copies of drifting buoy data from MEDS at any time for users in their country.

![Graph](image)

**Figure 2** NUMBER OF DRIFTING BUOY MESSAGES ARCHIVED IN MEDS

It is known that the data archived represents only a fraction of the data that has been and is now being collected. During December, 1989, of the 537 buoys that were deployed and working, only 255 transmitted their data over the GTS. MEDS estimate that it received data from only 40% of the total number of operational buoys floating on the oceans. In a literature review done by the U.S. NODC, a total of 1400 buoys were identified and it is felt that the list was incomplete. From these figures, it is felt that less than half of the drifting buoy data that is collected is making its way to the archive centres. It is therefore important that the acquisition of the historical data be pursued.

7. Quality Assurance Policy

Data centres have the fundamental responsibility to preserve the integrity of the original data while at the same time striving to improve the quality of data in the archive. To ensure high quality of data in the archive, it has been argued that only data of known and acceptable accuracies be admitted. By implementing this policy, an archive would exclude data that others consider of value even with acknowledged deficiencies. An archive must attempt to satisfy both interests. To this end, data centres do two things. Firstly the source of the data and the status of its processing are identified in the archive. For example, information on whether the data from a particular drifting buoy came from the GTS or from the principal investigator after he had done the analysis and quality control is kept with the data.
but there was a drop of 2% in the number of messages received in MEDS. The prospect for 1989 is approximately the same as for 1988. Figure 1 also illustrates the number of operating buoys for the year. The darker portion of the histogram shows the number of buoys for which MEDS received data from while the lighter portion shows the total number of operating buoys within that particular month.

Figure 1. DRIFTING BUOY STATISTICS BY MONTH for 1988

4. Strategy for Acquisition of Present and Future Drifting Buoy Data

In order to provide services to users at all time scales and have available at each time scale the best data available, MEDS has decided to request and accept all data by all three paths as follows.
Global Drifting Buoy Track Charts for Month, Year

In June, 1986, MEDS was accredited by the Intergovernmental Oceanographic Commission (IOC) as the global Responsible National Oceanographic Data Centre for oceanographic data from Drifting Buoy (RNODC/DB). The RNODC/DB seeks out and archives the oceanographic data derived from all drifting buoys worldwide and makes them available globally, on request, within the framework of the World Data Centers (Oceanography).

The RNODC/DB now receives the data only from drifting buoys which transmit in the DRIBU format on the WMO/IOC Global Telecommunications System and for which it has the permission of the principal investigators. This accounts for less than half of the data now being collected at sea. Consequently, the RNODC/DB is seeking wider permission for the remaining data, and investigating additional mechanisms of acquisition. Principal investigators are invited to contact the RNODC/DB through MEDS at the address given or to communicate with MEDS via telephone or SCIENCENET.

The attached track chart displays the month's movement of the reported operational drifting buoys which passed the buoy position and data quality checks. Each track is one buoy: the large dot is the buoy's last-reported position in the month.

Requests for information about the RNODC/DB, or comments on the services provided, can be addressed to MEDS:

- Postal address: 1202-200 Kent Street
  Ottawa, Ontario
  K1A OE6
- Phone number: (613) 990-0231
- FAX: (613) 993-4658
- INTERNET: bolduc@ottmed.meds.dfo.ca

Roy Jones
Some Arctic Ice Buoy Locations

- Data coverage charts
- By Polar Science Center (University of Washington)
- 7 pages, including this one

Roy Jenne
Jan 2002
Arctic buoys on ice (by Univ. of Washington)
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</table>

* Recently deployed buoys are listed in bold.

**Buoys that have seized operating during the past month.**

<table>
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<th>ARGOS ID</th>
<th>WMO ID</th>
<th>EXPR #</th>
<th>GTS HEADER</th>
<th>LATITUDE</th>
<th>LONGITUDE</th>
<th>DATA BYTES</th>
<th>P</th>
<th>T</th>
<th>BUOY DESCRIPTION</th>
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<td>X</td>
<td>X</td>
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</tr>
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</table>
International Arctic Buoy Program
4 Nov 1996
Argos Buoys
Land Stations
Brief history of moored buoys in the Pacific and Atlantic – non-NDBC
Steve Worley, February 23, 2001

First Pacific phase: 1979-1991, EPOCS program, four low-lying islands, eight buoys
  • 1983 – four buoys
  • 1988 – eight buoys

EPOCS: mostly Eastern Tropical Pacific

• 6 pages including this page
* Full deployment to buoys.
TAO Array Implementation

Moored buoys in Tropical Pacific
To select mooring sites, you may click individual sites on the map above, draw a rectangle around a group of sites, or use the buttons below. Solid squares show where there are data.

Array: PIRATA (Atlantic)
Data: Sea Surface Temp
Averaging: Daily

Start date: 1997 SEP 11
End date: 2001 FEB 23

Structure: files by site
Format: ASCII
Compression: Z

Availability, Clear, Deliver

Non-JAVA Data Delivery

Full array shown above:

1998 - 5 buoys
1999 - 6 buoys
2000 - 9 buoys
2001 - 7 buoys
Development of the Tropical Atmosphere Ocean (TAO) array was motivated by the 1982-1983 El Nino event, the strongest of the century up to that time, which was neither predicted nor detected until nearly at its peak. The event highlighted the need for real-time data from the tropical Pacific for both monitoring, prediction, and improved understanding of El Nino. As a result, with support from NOAA's Equatorial Pacific Ocean Climate Studies (EPOCS) program, PMEL began development of the ATLAS (Autonomous Temperature Line Acquisition System) mooring. This low-cost deep ocean mooring was designed to measure surface meteorological and subsurface oceanic parameters, and to transmit all data to shore in real-time via satellite relay. The mooring was also designed to last one year in the water before needing to be recovered for maintenance.

Under the direction of PMEL scientist Stan Hayes, prototype ATLAS were field tested in early 1984, and a modest scale array was deployed along 110W in late 1984. Additional ATLAS deployments were made beginning in 1985 at the start of the 10-year (1985-94) International Tropical Ocean Global Atmosphere (TOGA) program. The array, named the Tropical Atmosphere Ocean (TAO) array, grew slowly during the first half of TOGA as the proof of concept for a sustained buoy observing system was evaluated. Initial successes led to a rapid expansion of the array during the second half of TOGA with the widespread support of the climate community.

The full array of nearly 70 moorings was not completed until the final month of TOGA (Dec 1994). During the 10 years in which the array was under development, over 400 buoys were deployed on 83 cruises, using 17 different ships from 6 different countries. Accomplishing this feat required a multi-national partnership of institutions in the US, Japan, France, Taiwan, and Korea.

After TOGA ended in 1994, the TAO array continued under sponsorship of the international Climate Variability and Predictability (CLIVAR) program, the Global Ocean Observing System (GOOS), and the Global Climate Observing System (GCOS). In 1996, the NOAA Ship KA'IMINOA was commissioned to service the TAO array east of 165E. In 1997, the US Congress authorized long term sustained support of the TAO array as part of an operational El Nino/Southern Oscillation (ENSO) observing system. On 1 January 2000, the TAO array officially became the TAO/TRITON array, with sites west of 165E occupied by TRITON (Triangle Trans Ocean Buoy Network) buoys maintained by the Japan Science and Technology Center (JAMSTEC).

The operationally supported measurements of the TAO/TRITON array consist of winds, sea surface temperature, relative humidity, air temperature, and subsurface temperature at 10 depths in the upper 500 m. Five moorings along the equator also measure ocean velocity. Additional moorings and/or enhancements to the basic measurement suite are often incorporated to the operational array in support of research studies to understand specific physical processes not well measured by the existing network. Other measurements may be made for satellite or numerical model validation purposes. These research efforts are usually of limited duration and/or geographical scope, and done in collaboration with other institutions in the US and abroad.
To meet the demands of both operational and research measurements in the TAO array, an engineering redesign of the ATLAS was initiated in 1994 to update it with greater measurement capabilities, improved ocean temperature sensor accuracies, and more modular construction. The Next Generation ATLAS now has the capability to measure and transmit in real-time salinity, rainrate, long and shortwave radiation, barometric pressure, and ocean velocity. These measurements are made at selected sites to meet the needs of specialized research experiments. A robust high-latitude version of the ATLAS mooring has also been designed, capable of deployments for up to one year in the more energetic oceanic regimes of the extratropics.

The TAO/TRITON array is currently supported by the US (NOAA), Japan (JAMSTEC), and France (IRD).
CLIMATIC SUMMARIES FOR NDBC BUOYS AND STATIONS UPDATE 1

Prepared for the National Data Buoy Center by the National Climatic Data Center

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National Weather Service
National Data Buoy Center
NSTL, MS 39529

February 1990
I. INTRODUCTION

NOAA produced a publication (NOAA Data Buoy Center, 1983) summarizing environmental information collected at 18 buoy stations in the North Atlantic, North Pacific, and Gulf of Mexico. A second publication (NOAA Data Buoy Center, 1986) updated the original publication with data through 1984 for 46 buoy stations. Elements summarized in the second publication included wind direction and speed, sea level pressure, air temperature, sea surface temperature, significant wave height, dominant wave period, and peak gust for buoys with at least three years of data. These publications provided comprehensive summarization of data collected for a long period of record from moored buoys and platforms in the near coastal areas adjacent to the U.S. mainland and the deep ocean. They have proved to be of great utility to many segments of the marine community including ship designers, fishing and energy interests, and the U.S. Coast Guard (Buckley, 1983, 1987, 1988; Changery, 1987). This publication is an update of the 1986 publication. Additional locations are summarized for the buoy period of record through 1988. The only significant changes are the inclusion of 1 C-MAN (coastal) station and a minor modification of the wave period categories.

II. DATA QUALITY

The quality of the data is considered to be better than ship data for a number of reasons. First, the location and shielding of each sensor was carefully considered to avoid exposure problems (Holmes, 1975). For example, the thermistor on buoys was located at the 5 or 10m level to avoid unrepresentative heating near the deck. This can be a significant problem with ship observations. Second, measurement sampling frequencies and averaging periods were determined by computer simulation based on buoy motion, environmental variability, and each sensor's time constraint (Withee and Bird, 1974). Third, each sensor is calibrated before deployment and coefficients unique to each sensor are used to obtain the operational data. Finally, all data are monitored in near real-time to detect sensor abnormalities (Gilhousen, 1988). Failures of each sensor or electronic unit are logged and chronic problems identified for resolution. Because duplicate sensors measure air temperature, sea level pressure, and wind, the analyst can choose between the sensors for archival.

Table 1 lists the estimated total system accuracy for each buoy measurement and typical reporting ranges, sampling intervals, and averaging periods (there are minor variations between payload classes). Field intercomparisons of buoy and platform data support these accuracies (Gilhousen, 1987).

III. DEFINITION OF WAVE ANALYSIS PARAMETERS

In this publication, significant wave height and dominant wave period are used. Dominant wave period (period of maximum wave energy) rather than average wave period is used due to its greater utility for most interests. Dominant wave period data were not available prior to 1979 and therefore all data in the wave related tables were obtained from the period beginning in 1979.
Table 1. The estimated total system accuracy for each buoy measurement and typical reporting ranges, sampling intervals and averaging periods.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Reporting Range</th>
<th>Sampling Interval</th>
<th>Averaging Period</th>
<th>Total System Accuracy (10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Speed</td>
<td>0 to 120 knots</td>
<td>1 sec</td>
<td>8.5 min</td>
<td>± 1.9 knots or 10%</td>
</tr>
<tr>
<td>Wind Direction</td>
<td>0 to 360°</td>
<td>1 sec</td>
<td>8.5 min</td>
<td>± 10°</td>
</tr>
<tr>
<td>Wind Gust</td>
<td>0 to 160 knots</td>
<td>1 sec</td>
<td>5 sec</td>
<td>± 1.9 knots or 10%</td>
</tr>
<tr>
<td>Air Temperature</td>
<td>-40° to 50°C</td>
<td>90 sec</td>
<td>90 sec</td>
<td>± 1°C</td>
</tr>
<tr>
<td>Sea Level Pressure</td>
<td>900-1100hPa</td>
<td>4 sec</td>
<td>8.5 min</td>
<td>± 1hPa</td>
</tr>
<tr>
<td>Significant Wave Height</td>
<td>0 to 35m</td>
<td>0.39 sec</td>
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<td>± 0.2m or 5%</td>
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<tr>
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<td>3 to 30 sec</td>
<td>0.39 sec</td>
<td>20 min</td>
<td>± 1 sec</td>
</tr>
<tr>
<td>Surface Water Temp</td>
<td>-7° to 41°C</td>
<td>1 sec</td>
<td>8.5 min</td>
<td>± 1°C</td>
</tr>
</tbody>
</table>

1Peak wind gust is the highest 5 second window average obtained during the 8.5 minute period.
Significant wave height ($H_{1/3}$) is the average height of the highest one-third of waves present during the sampling interval. $H_{1/3}$ is proportional to the square root of the area under the spectral wave curve. NDBC calculates the height by expressing the wave spectrum form in terms of moments of the distribution where the $n^{th}$ moment is given by:

$$M_n = \int_0^\infty f^n S(f) \, df$$

In this formula $S(f)$ represents the energy, at the frequency $f$, per unit of interval of $f$, so that $S(f) \, df$ denotes the energy contained in the interval $f$ and $f+df$. The zeroth moment equals the area under the spectral curve so the significant wave height is

$$\bar{H}_{1/3} = 4\sqrt{M_0}$$

The dominant wave period is the period which contains the highest spectral energy.

IV. DATA PROCESSING AND TABULATION

In the 1986 publication and this update, data were obtained from NCDC’s Tape Data Family 1138. All buoy reported elements are archived in this format.

All observations (generally hourly since 1979) were used in all tables except the persistence of wind speed/wave height tables for which only 3-hourlies were used. Although most buoys reported only every third hour prior to 1979, all data were combined. As a test, several tables were produced using only 3-hourly data. Comparison of these with tables which included all data show insignificant variations. Therefore the change in reporting interval did not introduce any biases to this summary.

In order for a station to be included in this publication, approximately three years of data were needed. Fifty-eight stations met this requirement and are shown in figures 1 and 2. When compared with the 1986 publication, a nearly equal number of additional buoys are summarized in this publication for both the Atlantic and Pacific basins. In addition, a C-MAN (Coastal-Marine Automated Network) station near Chesapeake Bay is included because it measured wave data. Period of record, latitude/longitude, and approximate number of observations are also shown.

Buoys deployed in the Great Lakes are removed from the Lakes during the heavy icing season November/December to March/April. Therefore, the data tables for these locations generally show no summaries for the winter season and the annual period of record.

During the period of this study (1972-1988), seven different buoy hulls were used. Table 2 describes these hulls, shows the time periods they
Figure 1. North Atlantic, Gulf Coast and Great Lakes Buoys
Figure 2. North Pacific Buoy List

<table>
<thead>
<tr>
<th>Locator Number</th>
<th>Station Number</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Period of Record</th>
<th>Number of Obs.</th>
<th>Number of Obs.</th>
<th>Period of Record</th>
<th>Number of Obs.</th>
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<td>63.3N</td>
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<td>1981-1984</td>
<td>06.9K</td>
<td>123.3W</td>
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<td>2</td>
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<td>60.3N</td>
<td>172.3W</td>
<td>1981-1984</td>
<td>08.0K</td>
<td>122.7W</td>
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<td>55.9K</td>
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<td>137.7W</td>
<td>1977-1988</td>
<td>71.1K</td>
<td>162.3W</td>
<td>1981-1988</td>
<td>51.9K</td>
</tr>
<tr>
<td>10</td>
<td>46002</td>
<td>42.5N</td>
<td>130.3W</td>
<td>1975-1988</td>
<td>89.5K</td>
<td>160.8W</td>
<td>1984-1988</td>
<td>31.7K</td>
</tr>
<tr>
<td>11</td>
<td>46027</td>
<td>41.8N</td>
<td>124.4W</td>
<td>1983-1988</td>
<td>35.5K</td>
<td>157.6W</td>
<td>1984-1988</td>
<td>29.4K</td>
</tr>
<tr>
<td>12</td>
<td>46022</td>
<td>40.8N</td>
<td>124.5W</td>
<td>1982-1988</td>
<td>55.7K</td>
<td>152.6W</td>
<td>1984-1988</td>
<td>25.4K</td>
</tr>
<tr>
<td>13</td>
<td>46014</td>
<td>39.2N</td>
<td>124.0W</td>
<td>1981-1988</td>
<td>64.1K</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Approximate number of observations (10.1K = 10,100)
were deployed at each station, and gives the height of the anemometers and air temperature sensors. Sea level pressure is measured inside the hull at the water line. Sea surface temperature is measured at a one-meter depth except one-half meter on 3-meter discus buoy hulls. Following are a few exceptions to the instrument heights given in Table 2.

The anemometer height on platform 42008 was 14.9M. The air temperature sensor height was 14.1M. On platform 42011 the anemometer height was 11.3M and air temperature sensor height was 12.5M. Platforms 46016 and 46017 were on St. Lawrence and St. Matthew Islands in the Bering Sea. The anemometer and air temperature sensors' height was 3M AGL. Atmospheric pressure was reduced to sea level pressure before archival.

Table 2. The hull types used at each buoy station during the period of record.

<table>
<thead>
<tr>
<th>Buoy Platform</th>
<th>Hull Type(s) and Deployment Periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>41001</td>
<td>6/75-2/85 12D, 3/85-12/88 6N</td>
</tr>
<tr>
<td>41002</td>
<td>12/73-7/78 12D, 1/79-8/82 10D, 8/82-12/88 6N</td>
</tr>
<tr>
<td>41003</td>
<td>5/77-10/77 12D, 10/79-1/82 6N</td>
</tr>
<tr>
<td>41004</td>
<td>6/78-7/82 5D, 2/86-3/86 3D</td>
</tr>
<tr>
<td>41005</td>
<td>3/79-1/82 6N</td>
</tr>
<tr>
<td>41006</td>
<td>5/82-12/88 6N</td>
</tr>
<tr>
<td>42001</td>
<td>8/75-3/77 12D, 5/77-8/79 6N, 8/79-12/88 10D</td>
</tr>
<tr>
<td>42002</td>
<td>9/76-7/78 12D, 8/78-12/88 10D</td>
</tr>
<tr>
<td>42003</td>
<td>11/76-7/80 6N, 9/80-12/88 10D</td>
</tr>
<tr>
<td>42007</td>
<td>1/81-12/88 12D</td>
</tr>
<tr>
<td>42008</td>
<td>8/80-7/84 Platform</td>
</tr>
<tr>
<td>42009</td>
<td>9/80-10/84 5D, 4/86-1/87 10D</td>
</tr>
<tr>
<td>42011</td>
<td>1/82-9/84 Platform</td>
</tr>
<tr>
<td>44001</td>
<td>10/75-12/77 5D, 7/78-10/79 6N</td>
</tr>
<tr>
<td>44002</td>
<td>10/75-9/80 6N</td>
</tr>
<tr>
<td>44003</td>
<td>3/77-4/84 6N</td>
</tr>
<tr>
<td>44004</td>
<td>9/77-9/85 12D, 12/85-12/88 6N</td>
</tr>
<tr>
<td>44005</td>
<td>12/78-3/83 12D, 4/83-12/88 6N</td>
</tr>
<tr>
<td>44007</td>
<td>2/82-12/88 LNB</td>
</tr>
<tr>
<td>44008</td>
<td>8/82-12/88 LNB</td>
</tr>
<tr>
<td>44009</td>
<td>1/84-12/88 LNB</td>
</tr>
<tr>
<td>44011</td>
<td>5/84-2/85 10D, 3/85-12/88 6N</td>
</tr>
<tr>
<td>44012</td>
<td>6/84-12/88 LNB</td>
</tr>
<tr>
<td>44013</td>
<td>8/84-12/88 LNB</td>
</tr>
<tr>
<td>45001</td>
<td>5/79-11/84 6N, 8/85-12/88 12D</td>
</tr>
<tr>
<td>45003</td>
<td>5/80-12/86 6N, 3/87-11/88 3D</td>
</tr>
<tr>
<td>45005</td>
<td>6/80-9/85 6N, 6/86-11/88 3D</td>
</tr>
</tbody>
</table>
1 Hull Types (continued):

6N - A boat shaped hull, 6 meters long and 3 meters wide. Anemometers and air temperature sensors are located at 5 meters above the water.

LNB - A discus hull, 12 meters in diameter. Anemometers are located 13.8M above the water. Air temperature sensors are located 11.4M above the water.

ENB - A discus hull, 2.7 meters in diameter. Anemometers are located 6.6M above the water. Air temperature sensor is 5.8M above the water.

During a portion of the period of this update, selected buoys were equipped with a package utilizing a scalar method of averaging for the hourly wind speed, as opposed to the vector average method used prior to 1985. Investigations (Gilhousen, 1987) determined a maximum difference of 7% under worst case conditions in comparing speeds measured by both methods. All wind speeds, therefore, were combined in a single table. A more serious consequence of the scalar averaging package was a temporary 1 meter/second resolution for the wind speed instead of the earlier .1 meter/second resolution. Upon conversion of the 1 meter/second data to knots for the frequency distribution tables, only alternate knot categories (even knots to 16 knots, odd knots from 17 knots) will contain converted data. Thus for certain buoys, the frequency and cumulative frequency data are not smoothly spaced over all available wind speed categories. Table 3 documents the type of averaging method for all buoys.

Table 3. Wind Averaging Methods used at each buoy station during the period of record.

<table>
<thead>
<tr>
<th>Stations</th>
<th>Wind Averaging Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>41001</td>
<td>V</td>
</tr>
<tr>
<td>41002</td>
<td>V</td>
</tr>
<tr>
<td>41003</td>
<td>V</td>
</tr>
<tr>
<td>41004</td>
<td>6/78-7/82 V, 2/86-3/86 S</td>
</tr>
<tr>
<td>41005</td>
<td>V</td>
</tr>
<tr>
<td>41006</td>
<td>V</td>
</tr>
<tr>
<td>42001</td>
<td>V</td>
</tr>
<tr>
<td>42002</td>
<td>9/76-5/88 V, 6/88-12/88 S</td>
</tr>
<tr>
<td>42003</td>
<td>11/76-12/87 V, 5/88-12/88 S</td>
</tr>
</tbody>
</table>

viii
1994 NDBC Station Performance Summary

NDBC's network of automated weather stations continues to provide an increasing number of data messages in support of the NWS's critical forecasting and warning mission. Together, NDBC's fleet of 71 moored buoys and 58 Coastal-Marine Automated Network (C-MAN) stations delivered 1,386,148 hourly messages in 1994 (Figure 3), while maintaining a combined station performance record of 88 percent for meteorological observations and 84 percent for wave observations (Figure 4). In addition, 39 drifting buoys delivered 79,283 synoptic messages, and Profiler Surface Observing Stations (PSOS) delivered 987,690 6-minute messages. These figures combined account for a total of 2,453,121 data messages delivered by NDBC's 182 operational stations in 1994.

NDBC's success rate is measured annually to provide a performance record for all operational stations reporting synoptically. The system performance percentage represents the usable number of synoptic observations reported, compared to the number of observations expected while the station was properly configured. The 88- and 84-percent figures noted above represent a successful blend of engineering and operations strategies considering the remote locations, the resources available to address outages, and the often difficult conditions under which servicing takes place.

During 1994, NDBC stations along and offshore the eastern seaboard reported the development of a low pressure system (The September Storm of 1994) off northeastern Florida. This storm moved nearly parallel to the coast until reaching the Gulf of Maine. Stations 41004, 41009, DSLN7, 44008, and 44005 reported data during the development of this storm; and over the 36-hour period it impacted the nearshore waters of the east coast. Winds were reported up to 25.7 m/s (50 kn), and significant wave heights up to 4.6 to 6.1 m (15 to 20 ft) were measured.

Another event in 1994 was Tropical Storm Alberto. After forming near the Yucatan Straits in the Gulf of Mexico, it moved northward affecting northwestern Florida during the peak of the summer tourist season. Winds were reported up to 28.3 m/s (55 kn). NDBC stations 42001, 42003, 42036, and CSBF1 were all important contributors to forecasting and warning for this storm. Throughout NDBC's history, it has increasingly supported NWS's operational data requirements at the shoreline, in the coastal zone, and in the deep ocean.

Michael K. Burdette,
NDBC Data Systems

Figure 3. Total Number of Messages Per Year Delivered by NDBC Moored Buoys and C-MAN Stations

Figure 4. Station Performance for Moored Buoy and C-MAN Meteorological and Wave Data
A meeting was held in Boulder, CO on 2 February 1992 to discuss the status of Arctic ice buoy and ice island data. Attendees: Ignatius Rigor of the U. Washington Polar Science Center (PSC), Roger Barry, Sue Hafezadeh, Claire Hanson, Mark Serreze, Vince Troisi, and Ron Weaver of WDC/NSIDC, Roy Jenne (NCAR), and Scott Woodruff (NOAA/ERL). Participating via teleconference were: Roger Colony (PSC), and Dave Benner and Frank Kniskern of the Navy/NOAA Joint Ice Center (JIC). See Appendix 1 for contact points.

A. Datasets of ice buoy data (starting in 1979)

Number of ice buoys: Over the period 1979-90 there have been 341 buoys, including 29 PMEL buoys.

The group defined the different levels of ice buoy data as follows:

Level 0. Basic ice buoy data from Argos. Rules are needed to decode the basic data, and the decoding program is about 30 pages long. Argos hasn’t changed the rules, but the data format can change depending on whether the data are put onto GTS by Argos. For example, if the data from a buoy are not on GTS, the Argos temperature will be basic engineering bits; otherwise it will be a real temperature. (In recent years the pressure is nearly always decoded into actual pressure by Argos; temperature is decoded by Argos about half of the time.) For one satellite overpass (about 10 minutes long), the satellite gives the latest location for a given buoy, and typically 2 to 5 readouts of the instrument data spanning several hours (see Appendix 2 for satellite information).

Level 1a. Decoded Argos ice buoy data (in geophysical units). This includes location, pressure, temperature, time of location, and time of instrument data. Only one “best” set of instrument data is kept for this archive.1 A few buoys have winds, often of poor quality. The wind data have not been carried to this archive but are available in the Level 0 data.

Level 1b. Refined calibrated version of Level 1a. Each report still includes data for location, pressure, temperature, and the two times. In the event of pressure drift, or if the pressure trace looks suspicious, the pressure is set to missing (information is not readily available about how many buoys have been affected or what amount of data from each buoy has been set to missing).

Level 2a. Data interpolated for each 3-hour period. The location, pressure, and temperature are in separate files. The input data is Level 1b.

Level 2b. Data interpolated for each 3-hour period. The files from Level 2a have been merged so that each report now has location pressure, and temperature at the given time.

Level 3a. 12-hourly pressure, temperature, buoy positions, and interpolated ice velocity, 1979-90 (continues pending funding). For 1979-85 only, ice velocity data are once daily (at 1200 UTC), not 12-hourly.

1 The quality code (reported by Argos) is the number of duplicate readings per pass. For example, if a pressure of 1002 and a temperature of -40 were received 8 times during a pass, and readings of 1002 and -39.8 were received 6 times, the quality codes and data would be reported as follows:

\[
\begin{align*}
\text{...8...1002-40.0} \\
\text{...6...1002-39.8}
\end{align*}
\]
B. Buoy construction and data reliability

About half of the Arctic buoys are deployed by air drop. Most current buoys are 62 cm in diameter and come down by parachute. There is a crash pad to cushion the fall. Other buoys look more like a cylinder, perhaps 20 cm in diameter with the temperature sensor about 130 cm above the surface of the ice. Documentation of buoy types (physical configurations) over the life of the program will be prepared when Roger Colony is funded to continue the program.

Pressure measurement/analysis documentation is presented in the following PSC data reports (publication dates are one year later than data dates in each case): Thorndike and Colony (1980) p. 3-8, Thorndike and Colony (1981) p. 1-3, Thorndike et al. (1982) p. 2-3, Thorndike et al. (1983) p. 123-132. For early buoys, typical pressure drift was roughly 1 mb over the ~400-day life of a buoy. Buoys deployed after 1983 are believed not to have an appreciable pressure drift. PSC now considers the complete time series of pressure data generally accurate to within 1 mb; accuracy of the instrument is ±0.15 mb.

PSC is starting to check the temperatures. Note that the 62-cm air drop buoys are small enough to be buried in the snow. Also, the temperature sensor is within the hull of that buoy type; if sun shines on the hull, the recorded temperature will not be typical of the air temperature.

C. Missing data

1. Missing basic Argos data. All of the basic Argos (level 0) tapes are available from 1986 on; data for 1986-September 1990 have been provided to Boulder and thence to MEDS, Canada. Data from 1979-1985 were provided to NSIDC by Ignatius Rigor at the meeting. In the 1979-85 period, the tapes are missing for six scattered months. However, the 3-hourly data are probably available for these months. NSIDC can check this when the 3-hourly data are added to the NSIDC’s Earth Observing System (EOSDIS) Distributed Active Archive Center (DAAC) inventory.

2. Some ice buoys are not available on PSC’s Argos tapes. PMEL receives buoy data back from Argos, but then provides processed data to PSC in a different format. Over the period of record, about 15% of the total buoys have been PMEL buoys, not on PSC Argos tapes (29 total PMEL buoys).

D. Recommended long-term archives

Level 0. The basic data should be archived at NSIDC and at MEDS if they agree, but will probably not have to be used. However, this is now the only source for the wind data on some of the buoys.

Level 1a. Decoded Argos. This will be archived so that sensor drifts, etc. can be restudied as necessary.

Level 1b. Decoded Argos, corrections applied. This is the primary archive of the basic data. The data from PMEL needs to be added to the data available from Level 1a. Much of this has been done but it will be repeated to ensure that all data are in.

Level 2b. Data for each 3-hour period. This will be the basic dataset that will be most used for many purposes.
E. New ice buoy project

We understand that the PMEL data will be merged in with the original Level 1b data and that new data for Level 2b will be generated during 1992. The resulting merge at the 1b Level may still have gaps because of the six months of missing Argos data. Since the present 3-hourly data probably has data for the missing months, these data will be used to ensure that the new Level 2b tape is as complete as possible.

F. Volume of ice buoy data

Level 0. 1979-85: About 90 MB compressed (by Unix); 180 MB uncompressed. 1986-90: About 180 MB uncompressed.

Level 1a. 1979-90: Guess about 80 MB (uncompressed).

Level 1b. 1979-90: Guess about 80 MB (uncompressed).


Status of data for 1991: This will be worked on, pending funding.

G. Processing documentation (metadata)

It would be valuable to have documentation available describing the processing of the ice buoy data through the various levels. Computer software might constitute the algorithmic descriptions, supplemented by a few general textual comments. Consideration should be given to making software and possibly other comments available in digital form (see sec. I).

H. Information about ice buoys and ice islands (metadata)

1. For each of the ice buoys it would be desirable to have the following digital information:
   - Argos number and WMO number\(^2\) if applicable; otherwise a missing value. Some of the lists have WMO number present but Argos number missing because WMO numbers are allocated in batches and not yet assigned to a specific buoy.
   - What instruments were on buoy (e.g., pressure, air temp., wind, height of sensors, internal temp., water temp., temp. and salinity with depth, current).\(^*\)
   - Deployment start and end dates (year-month) for buoy. Include separate records for multiple deployments with the same buoy number, if available.\(^*\)
   - Flag indicating whether data were supplied to GTS, if known.
   - Buoy construction (photographs or figures for metadata files, see sec. I).\(^*\)
   - PI information.\(^*\)

Roger Colony said that information is easy to provide for recent buoys and for 70% of the older buoys (\(^*\) above indicates information that Roger said he would put together when he is funded). The most important information needed is the correspondence between Argos and WMO numbers; next in importance are dates of operation. We recommend that WMO or Argos numbers not be reused without a one calendar year time gap.

\(^2\) The first two digits of the 5-digit WMO buoy number indicate the WMO region and subarea in which the buoy was deployed; for drifting buoys the last three digits should fall within 501-999.
2. For each of the ice islands it would be desirable to have instrumental and platform information, similar to that for the ice buoys, available in digital form. In designing this database it may be helpful to consult the annual WMO (1955-) Publication 47 of ship information, due to the possible similarity of observing practices aboard ships to those on manned ice islands. For modern ice island data obtained so far only via GTS, dates of operation and “ship” call signs are most important. Similar to the ice buoys, we note that call signs for the ice islands may have been reused.

I. Metadata: coordination with other projects

For COADS updates as well as for global reanalysis projects (see Appendix 2) it is highly desirable to be able to recognize the platform type. Without time-keyed lists of the ID numbers or call signs of ice buoys or ice islands, such as described above, we are unable to flag platform type in COADS. Type of ID also may be of importance for future track checking, etc. (see Appendix 4).

Other groups are assembling or making available some buoy platform metadata (not just for Arctic buoys): MEDS (Bob Keeley) is initiating efforts to retain metadata as submitted by PI’s. The Drifting Buoy Cooperation Panel (Etienne Charpentier) has some Omnet information. In addition, WMO has a monthly letter on the World Weather Watch/Marine Meteorological Services, and NDBC has a weekly platform status report.

WDC/NSIDC will explore the possibility of publishing metadata and other documentation as part of its Special Publications. In addition to published documents, metadata should be made available in digital form if feasible. For example, lists of ice buoy and ice island ID’s should be available in digital form to be of maximum utility. Various computer systems then may be used to access the metadata.

For example, NOAA has a “Metadata project” for development of a Macintosh- and PC-based “Hypertext” metadata storage and retrieval system (Metalog), with COADS as the prototype dataset. Although the system is currently geared toward comments or “grey” literature, the system also includes some example entries from WMO Pub. 47 (1955-) as a first step toward implementation of structured metadata. Since it is based on Hypertext technology, the system could eventually accommodate, e.g., digitized photographs of buoys.

J. Overview of available Arctic buoy and automated ice island data

1. Drifting Automatic Radio Meteorological Station (DARMS) Program, 1953-72. Data from a number of Russian ice islands. The PSC has all of the location data, but only for 10-day positions. The surface weather data are not available yet. There is a feeling that Russia may not have been able to locate the weather data as yet.

2. AIDJEX, 1972-78. There were about 40 or 50 buoys North of Barrow. There is a tape with the buoy locations. Were there any pressure data? Official surface meteorological reports are not available at PSC, but NSIDC is on the track of some of these data (NSIDC now has surface and geostrophic winds (2- and 9-meter temperature data not yet located), and 2- and 30-meter ocean current velocities at the four manned camps).

3. US oil companies (Arctic Oil and Gas Association). Exxon probably has the best set of buoy data, also based on Argos. This may have been combined with data from other companies. Roger Colony thinks the rules are that none of the data can be released unless all participating AOGA companies agree.
K. Overview of available Arctic manned ice island and expedition data

1. Fram, 1893-96. Six volumes about the expedition from the Norwegian Research Center are in the PSC library (Nansen, [date?]).

2. Maud, 1922-24 (2 years). Sverdrup (1933); the Ocean Library at U. Washington has this publication.

3. Russian North Pole (NP) ice islands. Except for NP-1 (1937-38), these started about 1950 and data from two islands at a time have usually been available. The data include rawinsonde data as well as surface data. Some of the data have been on GTS. Jon Kahl has obtained some. Roger Colony has a very complete set of 6-hourly NP station data (pressure, temperature, and surface winds) for 1950-90. Roger will soon provide this pressure and temperature data to NSIDC and thence to NCAR for NMC/NCAR work on the global reanalysis project; wind data will be held until Roger's work with Dr. Appel of Geography Institute, Moscow, is completed.

4. Fletcher's T3. Some boxes of original T3 data from Bill Dehn have been sent from PSC to NSIDC, thence to NCDC. Also, NCDC may have undigitized T3 data (form type 1130) for parts of the period 1949-71. T3 was not manned after September 1974.

L. Digitization of Arctic ice island and expedition data

There are many unanswered questions as to what extent complete surface weather records from all the various historical ice islands or expedition ships are available in digital form.

PSC has a dataset with selected weather elements (time, location, pressure, and temperature) for various ice islands (Figure 1), in which the data are usually available every 6 hours (the original data were 3-hourly, but not all data were digitized). COADS contains a deck (186) of Russian ice islands, which according to the original card deck reference manual covers 1937-60 (NP 1, 2, 4, 6, 7, 8, 9). Some recent Russian ice island data are available in COADS from GTS sources; the reports seem indistinguishable from ship data except by knowledge of specific call signs.

To assist in answering these questions, NCDC is providing Roger Colony with COADS Release 1 individual observations (TD-1129 format) North of 70°N for 1854-1979, and provisional data for the same region from the "Period of Record" file for 1980-84. Data used in Hastings (1971) are not available in digital form from the Army Corps of Engineers.

In preparation for COADS Release 2 (planned for the mid 1990s), NCDC has funding to key undigitized ship records from a variety of US and international sources. NOAA/NESDIS has provided funding through the ESDIM data rescue program to key enter eight historical data sets at NCDC (see attached "Scope estimate"). The data should be made available to NSIDC and to COADS by June 1993. We understand that NCDC would be happy to consider expanding this effort to include the digitization of other missing historical ice island or expedition data.

3 Colony et al. (1990) show NP-1 data only within 1937, whereas Hastings (1971) shows NP-1 data for 1937-38.
References


Appendix 1. Contact points

These minutes were written primarily by Roy Jenne; Roger Barry, Dave Benner, Roger Colony, Claire Hanson, Ignatius Rigor, and Scott Woodruff were involved in preparation or review of the minutes. Following are contact points at the participating organizations (contact Claire Hanson or Scott Woodruff with comments on the minutes):

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Omnet: D.BENNER
Appendix 2. Polar orbiting satellites and Argos

A series of polar orbiting NOAA satellites started with the launch of TIROS-N in late October 1978. These satellites have the ability to read data transmitted from surface sensors. They determine the location of the transmitted data and record the location, time, and data received. Argos, a joint program of the French Space Agency (CNES), NASA, and NOAA, processes and disseminates environmental data from the satellites. The Argos package is flown on NOAA spacecraft, and service has been continuous since 1979.

Appendix 3. Data for global reanalysis projects

Data are being organized so that projects to prepare new 6-hourly analyses of the global atmosphere can begin (Kalnay and Jenne, 1991). Plans now call for using data for 1958-92. Later, we hope that we can start at an earlier time, perhaps 1946-50. Some of the component data sets are:

- World rawinsonde and pibal data
- World ocean surface data (use COADS)
- Global land synoptic observations (each 3 or 6 hours)
- Cloud drift winds from satellites
- Aircraft reports
- Polar region surface data (from sea-ice buoys and ice-cap buoys)
- Satellite sounder data

The output from the atmospheric analyses will include not only the usual temperature, height, winds, and moisture, but also many model diagnostic terms. These will include precipitation, radiation components, clouds, 2-m temperature, 10-m winds, etc.

The low-level analyses from the atmosphere will be used to drive ocean analyses that also use ocean data. These analyses make use of surface ocean data (such as SST), ocean observations, atmospheric forcing, and the constraints of consistency obtained from an ocean model. Jenne has other texts about various data sets for reanalysis. One text discusses reanalysis and COADS (Jenne, 1992).

Appendix 4. Platform types and ID types for COADS

The following platform types and ID types are defined in the current COADS binary format:

<table>
<thead>
<tr>
<th>Platform Type</th>
<th>ID Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = US Navy or &quot;deck&quot; log/unknown</td>
<td>0 = ID present, but unknown type</td>
</tr>
<tr>
<td>1 = merchant ship or foreign military</td>
<td>1 = ship, OSV, or ice station call sign</td>
</tr>
<tr>
<td>2 = ocean station vessel—off station</td>
<td>2 = generic ID (e.g., SHIP, BUOY, etc.)</td>
</tr>
<tr>
<td>3 = ocean station vessel—on station</td>
<td>3 = WMO 5-digit buoy number</td>
</tr>
<tr>
<td>4 = lightsip</td>
<td>4 = other buoy number (e.g., Argos/national)</td>
</tr>
<tr>
<td>5 = ship</td>
<td>5 = C-MAN ID</td>
</tr>
<tr>
<td>6 = moored buoy</td>
<td>6 = station name</td>
</tr>
<tr>
<td>7 = drifting buoy</td>
<td>7 = NODC platform/cruise</td>
</tr>
<tr>
<td>8 = ice buoy</td>
<td>8 = IATTC pseudo ID</td>
</tr>
<tr>
<td>9 = ice station (manned)</td>
<td>9 = national ship number</td>
</tr>
<tr>
<td>10 = oceanographic station data (SD/Co22)</td>
<td>10 = composite information fr early ship data</td>
</tr>
<tr>
<td>11 = mechanical bathythermograph (MBT)</td>
<td></td>
</tr>
<tr>
<td>12 = expendable bathythermograph (XBT)</td>
<td></td>
</tr>
<tr>
<td>13 = Coastal-Marine Automated Network (C-MAN)</td>
<td></td>
</tr>
<tr>
<td>14 = other coastal/island station</td>
<td></td>
</tr>
<tr>
<td>15 = fixed ocean platform (plat, rig)</td>
<td></td>
</tr>
</tbody>
</table>
Figure 1. Timelines for stations manned since 1950.

The North Pole (NP) stations were operated by Russia.
Arctic drifting station key-entry project: Scope estimate

C. Hanson and R. Colony
92/08/04 [updated on 93/01/12]

Data Set 1:

Norwegian North Polar Expedition with the "Maud", 1918 - 1925. Volume III: Meteorology, Part II, Table XVII, basic met. data: 180 pages x 60 lines per page = 10800 lines

Data Set 2:

Norwegian North Polar Expedition with the "Maud", 1918 - 1925. Volume III: Meteorology, Part II, Table XXVII, Temperature differences: 11 pages x 31 lines per page = 341 lines

Data Set 3:

Norwegian Polar Expedition 1893 - 1896 (the "Fram"). Volume VI. Basic observations; sledge expedition: 257 pages x 60 lines per page = 15420 lines

Data Set 4:

AIDJEX, 1970 - 1979. Handwritten observation logs from four ice camps. About 12000 lines of data. Copies of the logs were just completed in Boulder, and are ready to ship to NCDC. An old tape of AIDJEX met data, translated from CDC internal format by NOAA/CMDL, may contain some of these data, but appears to contain only 2- and 9-meter air temperature, wind vectors u and v, and time averaged wind speed.

Data Set 5:

North Pole Station 6 and North Pole Station 7 radiation data, 1957 - 1958: 150 pages x 32 lines per page = 4800 lines [table text is being translated from Russian at NSIDC]

[other tables are: air temperature, snow surface temperature, humidity, atmospheric pressure, wind speed and direction, cloudiness, "collection of precipitation", snow cover, visibility, "atmospheric phenomena"; need to determine which are of interest to key-enter]

Data Set 6:

A. T-3 data: whatever is in Asheville that needs to be keyed (microfilm, original sheets, etc.); may be called "Ice Skate B", or "Fletcher's Ice Island" [J. Elms will provide line count estimate]
B. T-3 data: 2/62 - 12/68 coding sheets received from R. Colony/Polar Science Center, shipped to J. Elms/NCDC on 8/21/92; [last box of miscellaneous records shipped to NCDC on 9/17/92. As of December 1992, NCDC had nearly completed keying the T-3 data in their possession. A status report was promised shortly.

Data Set 7:

ARLIS I, ARLIS II (in Asheville): [J. Elms/NCDC will provide line count estimate]

Data Set 8:

Ice Skate A (in Asheville): [J. Elms/NCDC will provide line count estimate]
Pages Mostly About Polar Sea Ice Follow:

- Antarctic sea ice, 1973 – 1976
- Arctic sea ice, 1973 – 1976
- Arctic and Antarctic sea ice, 1978 – 1987, NASA information
- Nimbus-7 SMMR on CD-ROM (NSIDC)
- Monthly ice motion and atmospheric pressure in Arctic Basin, 1979 – 1993 (3 p here)
- 14 pages follow with these topics

Roy Jenne
Jan 2002
ANTARCTIC SEA ICE, 1973-1976:
SATELLITE PASSIVE-MICROWAVE OBSERVATIONS

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ARCTIC SEA ICE, 1973-1976: SATELLITE PASSIVE-MICROWAVE OBSERVATIONS

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Monthly color plots of ice concentration.
Satellite-Derived Ice Data Sets No. 2: Arctic Monthly Average Microwave Brightness Temperatures and Sea Ice Concentrations, 1973-1976

39 pages

C. L. Parkinson, J. C. Comiso and H. J. Zwally
Goddard Space Flight Center
Greenbelt, Maryland

Roy - Here are the Tech Memos for the 2 ESMR atlas & tape data sets. Lists & dates are flagged. You're welcome to keep these copies.

- Claire Parkinson
94/04/28
April 1994
SATELLITE-DERIVED ICE DATA SETS NO. 2:
ARCTIC MONTHLY AVERAGE MICROWAVE BRIGHTNESS TEMPERATURES
AND SEA ICE CONCENTRATIONS, 1973-1976

C. L. Parkinson, J. C. Comiso, and H. J. Zwally
Goddard Laboratory for Oceans

ABSTRACT

This report describes the availability on magnetic tape of a summary data set for four years of Arctic sea ice conditions in the mid 1970s. This data set was derived from brightness temperature data collected by the Electrically Scanning Microwave Radiometer (ESMR) on board the Nimbus 5 satellite over the period 1973 through 1976. The data included on the tape are gridded into 293 by 293 grids that cover a polar stereographic map enclosing the 50°N latitude circle. The grid size varies from about 32 kilometers by 32 kilometers at the poles to about 28 kilometers by 28 kilometers at 50°N. The variables included are the following: (a) monthly averaged microwave brightness temperatures for January, February, June, and July of 1973, September 1973 through May 1975, and September 1975 through October 1976; (b) monthly averages of an ice concentration parameter calculated from the brightness temperatures together with mean climatological atmospheric temperatures; (c) multiyear monthly averages of the brightness temperatures and the ice concentration parameter; (d) yearly and four-yearly averages of the brightness temperatures and the ice concentration parameter; (e) monthly climatological surface air temperatures; and (f) monthly climatological sea level pressures. The ice concentration parameter is calculated assuming the field of view contains only open water and sea ice, with all ice having an emissivity of 0.92. Because first-year sea ice does have an emissivity of approximately 0.92 at the 19-GHz frequency of the ESMR data, the ice concentration parameter represents sea ice concentrations for
regions with exclusively first-year ice and open water. In regions which are complicated by the existence of multiyear ice, which has an emissivity of approximately 0.84, the multiyear ice fractions as well as the ice concentration parameter are needed for the determination of actual ice concentrations. As a result, the values of the ice concentration parameter are termed "pseudo" ice concentrations. A nomogram is presented relating the pseudo ice concentrations to the total ice concentrations and the multiyear ice fractions. Considerations of multiyear ice fraction are not necessary for the determination of ice extents, and consequently maps of monthly and multiyear monthly ice extents from the ESMR data are included at the end of this report.

ARCTIC AND ANTARCTIC SEA ICE, 1978-1987:
SATELLITE PASSIVE-MICROWAVE OBSERVATIONS AND ANALYSIS

Pat Gloersen
William Campbell

290 pages

GB 2595
A72
1992
months, the ESMR data were used to obtain a measure of the distribution of multiyear ice across the Arctic basin (Gloersen et al., 1973; Campbell et al., 1978; Parkinson et al., 1987). The ambiguity between the first-year and the multiyear ice concentrations limits the accuracy of the derived total ice concentrations.

Even though the compiled ESMR ice concentrations covered only a 4-year period and were less accurate than those derived from the SMMR data, the ESMR data revealed previously unrecognized features that reflected unusual large-scale oceanic events as well as significant regional and interannual variations. An unexpected discovery was a major opening in the Weddell ice pack (the Weddell Polynya), which was found to have occurred in 3 of the 4 ESMR years. Its extent and duration were recorded and examined in conjunction with atmospheric and oceanic data (Zwally et al., 1976, 1983a; Zwally and Gloersen, 1977; Gordon, 1978; Carsey, 1980; Parkinson, 1983). Further analysis showed significant decreases in ice extent in the Weddell and Ross Seas during the 1970s. The maximum extent of sea ice in the southern ocean as a whole was found to have decreased by 6% over the 4 ESMR years (Zwally et al., 1983b). Large areas of reduced ice concentration were found in the Arctic Ocean (Gloersen et al., 1978; Campbell et al., 1984; Parkinson et al., 1987). Out-of-phase fluctuations between the adjacent Bering and Okhotsk Seas were determined and analyzed (Campbell et al., 1981; Cavalieri and Parkinson, 1987). Many other studies of ice-atmosphere and ice-ocean interactions were also undertaken with the ESMR data set (e.g., Cavalieri and Parkinson, 1981; Crane et al., 1982; Parkinson and Cavalieri, 1982; Crane, 1983; Parkinson, 1983; Parkinson and Gratz, 1983; Zwally et al., 1985; Parkinson, 1990; Comiso and Zwally, 1984; Cahalan and Chiu, 1986).

With the launch of the Nimbus 7 SMMR on October 24, 1978, the requisite multichannel passive-microwave data set for obtaining more accurate sea ice concentrations, multiyear ice concentrations, and sea ice temperatures began to be collected. This book provides a systematic analysis of the spatial and temporal variations in the global sea ice cover from October 26, 1978 through August 20, 1987, using sea ice concentrations and extents derived from the SMMR data. A summary of the initial results obtained by the SMMR Team of the Nimbus Project is provided by Gloersen et al. (1984). Previous analyses of the SMMR data examined

- The variability of sea ice and multiyear ice (e.g., Cavalieri and Zwally, 1985; Comiso, 1986; Zwally and Walsh, 1987; Parkinson, 1991, 1992).
- Time series of sea ice extents (e.g., Gloersen and Campbell, 1988a; Parkinson and Cavalieri, 1989; Gloersen and Campbell, 1991a,b).
- Ice-ocean and ice-atmosphere and Martin, 1985; Zwally et al., 1987; Comiso and Gordon, 1989; Jacobs and Parkinson, 1990). Correlation of melt water production from SMMR data) with phytoplankton color satellite data (Su et al., 1990; Mitchell et al., 1992).

1.4 Synopsis

This volume extends by nearly 5 years the SMMR data in the north and south polar regions through stereographic projections with an appropriate variety of time series plots and data sets and for nine subregions within the Arctic. These maps and analyses form the core of this volume. The microwave properties of sea ice concentrations, sea ice temperatures.

The ability to distinguish unambiguously between ice types is not possible before SMMR, and indeed of long-term studies of ice production, from the inherent increase in the accuracies resulting from this information, comparisons between field data, air measurements, and satellite observations to provide estimates of the accuracy of the results.

Chapter 3 contains monthly maps of multiyear ice concentrations, additional data, and an analysis of the 9 years of Arc and as a whole). Chapter 4 contains time analyses for the Antarctic, but without reasons given in Chapter 2). Chapter 5 contains global variations of sea ice. A pressure, temperature, and buoy-drift program (courtesy of R. Colony) and the Arctic and Antarctic polar ster
obtain a measure of the distribution of ice concentrations covered only a 4-those derived from the SMMR data, unrecognized features that reflected as well as significant regional and discovery was a major opening in the a), which was found to have occurred duration were recorded and examined oceanic data (Zwally et al., 1976,ordon, 1978; Carney, 1980; Parkinson, significant decreases in ice extent in the 70s. The maximum extent of sea ice had to have decreased by 6% over the Large areas of reduced ice concentrations. 3Loersen et al., 1978; Campbell et al., t-of-phase fluctuations between the e determined and analyzed (Campbell 1, 1987). Many other studies of ice were also undertaken with the ESMR 1, 1981; Crane et al., 1982; Parkinson erson, 1983; Parkinson and Gratz, 1990; Comiso and Zwally, 1984; 7 SMMR on October 24, 1978, the owave data set for obtaining more tyear ice concentrations, and sea ice This book provides a systematic analysis on the global sea ice cover from October sign sea ice concentrations and extents amary of the initial results obtained by ct is provided by Gloersen et al. (1984). nd multiyear ice (e.g., Cavalieri ), 1986; Zwally and Walsh, 1987; nts (e.g., Gloersen and Campbell, alieri, 1989; Gloersen and snow (Anderson et al., 1985;

- Ice-ocean and ice-atmosphere interactions (e.g., Cavalieri and Martin, 1985; Zwally et al., 1985; Alftuls and Martin, 1987; Comiso and Gordon, 1987; Gordon and Comiso, 1988; Gloersen et al., 1989; Jacobs and Comiso, 1989; Martin and Cavalieri, 1989; Parkinson, 1990).
- Correlation of melt water production from sea ice (inferred from SMMR data) with phytoplankton blooms (derived from ocean color satellite data) (Sullivan et al., 1988; Comiso et al., 1990; Mitchell et al., 1992).

1.4 Synopsis

This volume extends by nearly 9 years the data record provided by the two ESMR Atlases. Monthly average maps of sea ice concentrations from the SMMR data in the north and south polar regions are presented for each month from November 1978 through August 1987, mapped onto polar stereographic projections with an approximately 25-km grid spacing. A variety of time series plots has been generated for both polar regions, for the global total, and for nine subregions within the Arctic and five subregions within the Antarctic. These maps and plots, along with the associated analyses, form the core of this volume. Chapter 2 describes the SMMR instrument, the microwave properties of sea ice, and the algorithm used for determination of sea ice concentrations, multiyear ice concentrations, and ice temperatures.

The ability to distinguish unambiguously between first-year and multiyear ice was not possible before SMMR, and is important both from the standpoint of long-term studies of ice production, destruction, and distribution, and from the inherent increase in the accuracy of total ice-concentration calculations resulting from this information. Also in Chapter 2 are the results of comparisons between field data, airborne observations, and satellite observations to provide estimates of the accuracy of the sea ice algorithm.

Chapter 3 contains monthly maps of Arctic sea ice concentrations and multiyear ice concentrations, additional maps and time series of the Arctic data, and an analysis of the 9 years of Arctic sea ice coverage (both regionally and as a whole). Chapter 4 contains the corresponding maps, plots, and analyses for the Antarctic, but without the multiyear concentrations (for reasons given in Chapter 2). Chapter 5 examines the regional, interannual, and global variations of sea ice. Appendix A contains monthly mean pressure, temperature, and buoy-drift data from the Arctic Ocean Buoy Program (courtesy of R. Colony) and the SMMR ice temperatures mapped onto the Arctic-and Antarctic polar stereographic grids.
National Snow and Ice Data Center

CD-ROMs

Nimbus-7 SMMR Polar Radiances and Arctic and Antarctic Sea Ice Concentrations on CD-ROM

User's Guide

Version 3

Num 1994

23 pages (3 p. here)

National Snow and Ice Data Center
Cooperative Institute for Research in Environmental Sciences
University of Colorado, Boulder, Colorado, USA
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Nimbus-7 SMMR Polar Radiances and Ice Concentration Grids for the Polar Regions on CD-ROM

In this shipment:

1. SMMR Polar Radiances Volume 9, Revision 1. This volume contains grids for the period October 6 through December 25, 1981 which were previously missing on the original CD-ROM. 

   PLEASE NOTE: This is new CD-ROM. Please throw away the old volume 9 and replace it with the new volume enclosed.


   PLEASE NOTE: NSIDC anticipates that this will be the last update to this dataset. All of our SMMR users should be on our NSIDC Notes mailing list a quarterly publication intended to keep our users informed of availability of datasets, errors and other topics of interest.

NSIDC requests that all of our users send us two copies of any publication which cite the use of data we have distributed. These publications will help us determine the level of use of data products we distribute, which helps to justify continued funding for distribution of data products, and also keeps our information center current.

Please address all correspondence to:

World Data Center A for Glaciology
National Snow and Ice Data Center
CIRES, Campus Box 449
University of Colorado
Boulder, Colorado 80309 USA
Telephone (303) 492-1390 [Data Request Services]
Telex 7401426 WDCA UC
Fax (303) 492-2468
Internet nsidc@sitka.colorado.edu
Monthly Ice Motion and Atmospheric Pressure in the Arctic Basin, 1979 - 1993

by Ignatius G. Rigor and Roger L. Colony

at Univ of Washington
Polar Science Center

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Technical Memorandum
APL-UW TM??-94

Applied Physics Laboratory, University of Washington
1013 NE 40th Street, Seattle, Washington 98105-6698
Sea level fluctuations have many causes (3). Daily tides are associated with a divergence in horizontal volume flux with no attendant significant change in density. Direct atmospheric heating and cooling of the water column and exchanges of fresh water are associated with expansion and contraction on time scales from days to millennia. Local changes in temperature and salinity, and hence of density, are also associated with lateral shifts due to ocean currents. Changes with no immediate density signature, as with the tides, are "barotropic" and are not directly relevant to inferences about stored heat; otherwise, changes are "baroclinic." For example, the observed secular rise in sea level (4) is a combination of the melting of glaciers (barotropic) and thermal expansion. Determining the relative contributions of barotropic and baroclinic processes on the myriad time scales of climate change is complex.

Theoretical studies provide some clues as to the relative importance of barotropic and baroclinic fluctuations. A recent model study (5) suggested that wind-driven changes in ocean circulation are largely baroclinic in the tropics, but barotropic at higher latitudes. Observations with sparse current meter moorings in the North Pacific (6) show that on a time scale of 100 days the relative contribution of barotropic processes varied between 10 and 70%, depending on the location. Here we examine the evidence on time scales from months to years.

Observations and Model

Acoustic component. Ocean acoustic tomography (7) has the ability to sample and average the large-scale oceanic thermal structure, synoptically, along several sections and at regular intervals. In late October 1995, the ATOC program deployed an acoustic source at a depth of 939 m on Pioneer Seamount, 100 km west of San Francisco, California (8). Transmissions began in December 1995, and the transmitted signals have been received on U.S. Navy Sound Surveillance System (SOSUS) and other arrays. The arrays consisted of those mounted on the sea floor (for example, k, l, n, and o in Fig. 1) and two 40-hydrophone vertical line arrays (v1 and

### Table 1. Annual harmonic amplitude (in centimeters) and, in parentheses, phase (in days) of range-averaged sea level anomaly (n) along the acoustic sections.

<table>
<thead>
<tr>
<th>Component</th>
<th>Acoustic section</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>l</td>
</tr>
<tr>
<td>T1</td>
<td>2.5 (273)</td>
</tr>
<tr>
<td>T2</td>
<td>2.9 (255)</td>
</tr>
<tr>
<td>T3</td>
<td>2.7 (304)</td>
</tr>
<tr>
<td>T4</td>
<td>2.5 (262)</td>
</tr>
<tr>
<td>T5</td>
<td>4.0 (271)</td>
</tr>
</tbody>
</table>

*To whom correspondence should be addressed.*

The ATOC Consortium: A. B. Baggieroer, T. G. Birdsal, C. Clark, J. A. Colosi, B. D. Cornuelle, D. Costa, B. D. Dushaw, M. Dzieciz, A. M. G. Forbes, C. Hill, B. M. Howe, J. Marshall, D. Menemenlis, J. A. Mercer, K. Metzger, W. Munk, R. C. Spindel, D. Stammer, P. F. Worcester, and C. Wunsch.* A. B. Baggieroer is in the Department of Ocean Engineering, Massachusetts Institute of Technology (MIT), Cambridge, MA 02139, USA. T. G. Birdsal and K. Metzger are in the Department of Electrical Engineering and Computer Sciences, University of Michigan, Ann Arbor, MI 48109, USA. C. Clark is in the Laboratory of Ornithology, Cornell University, Ithaca, NY 14853, USA. J. A. Colosi is in the Department of Applied Ocean Physics and Engineering, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA. B. D. Cornwall, M. Dzieciz, W. Munk, and P. F. Worcester are at Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA 92039, USA. D. Costa is in the Biology Department, University of California, Santa Cruz, CA 95064, USA. B. D. Dushaw, B. M. Howe, J. A. Mercer, and R. C. Spindel are at the Applied Physics Laboratory, University of Washington, Seattle, WA 98105, USA. A. M. G. Forbes is at the Division of Oceanography, CSIRO, Hobart, Tasmania 7001, Australia. C. Hill, J. Marshall, D. Menemenlis, D. Stammer, and C. Wunsch are in the Department of Earth, Atmospheric, and Planetary Sciences, MIT, Cambridge, MA 02139, USA.
a representation of Newton’s laws of motion and thermodynamics for the fluid ocean driven at the sea surface through exchanges with the atmosphere of stress (winds) and buoyancy fluxes (heat and fresh water). We used a GCM constructed for ATOC (16) that “predicts” the fields observed by acoustic tomography and altimetry.

Comparison of the Data
Each of the measurement types—acoustic, altimetric, and XBT—can be used to produce an estimate of components of the sea level anomaly, \( \eta_{acoustic} \), \( \eta_{altim} \), and \( \eta_{XBT} \), respectively, over all or part of the domain. The available climate estimates, \( \eta_{altim} \), is restricted to the mean seasonal cycle (15). Another estimate, \( \eta_{GCM} \), comes from the GCM.

The altimetric and GCM records roughly track the climatological annual cycle, albeit with different amplitudes (Table 1) and with obvious evidence of both higher frequency and interannual variability. Acoustic results also track \( \eta_{altim} \) for all sections except v1, but they do not exhibit the short period fluctuations of \( \eta_{altim} \) and \( \eta_{GCM} \). Differences between \( \eta_{altim} \) and \( \eta_{acoustic} \) (2.4 cm rms) result from salt and barotropic contributions to \( \eta \) present in \( \eta_{altim} \) as well as from uncertainties in the altimetric and acoustic estimates.

The amplitude of \( \eta_{acoustic} \) at the annual period is, on average, half that of \( \eta_{altim} \). Similarly, \( \eta_{XBT} \), which is consistent with the acoustic data during the overlapping period, has an rms difference from \( \eta_{altim} \) of 2.9 cm, larger than the likely errors in the altimetric (\( \sim 1 \) cm rms) and XBT (\( \sim 0.2 \) cm rms for the 800-m thermal contribution) measurements (17). A small number of salinity measurements along section v1 suggest a considerably (\( \sim 2 \) cm rms) salt contribution to \( \eta \) on seasonal to interannual time scales, especially in the transition zone between the low-salinity waters of the California Current and saltier subtropical waters offshore.

Short-period fluctuations in \( \eta_{altim} \) and \( \eta_{GCM} \) are primarily caused by wind-forced barotropic Rossby waves. These waves are not sensed either by the acoustic (18) or temperature measurements. A study (19) comparing XBT and altimetric data over a period of 4 years along a trans-Pacific section concluded that about 80% of the variance of \( \eta_{altim} \) and \( \eta_{XBT} \) was coherent at wavelengths of 500 to 3000 km, which could be interpreted as implying a barotropic variance contribution of about 20%.

Insufficient information exists to separate fully the salt, thermal, and mass contributions to the low-frequency sea level anomaly from data alone (6), but a partial estimate can be obtained from the GCM prediction. Of the total GCM sea level variability in the ATOC region, 28% lies in the barotropic mode at periods exceeding a few months, and this serves as our a priori estimate of low-frequency mass contributions to \( \eta_{altim} \). All estimates of sea level variability are consistent if in this area 1/3 to 1/2 of the low-frequency variance is contributed by processes not reflecting heat content changes.

Model-Data Combinations
Because the observations and the model produce independent estimates of the oceanic fluctuations with distinctly different expected errors, we can attempt a statistical best estimate of the oceanic state through their formal combination (20). Let \( x_{ocean}(t) \) represent the true oceanic state vector defined as a set of physical quantities (typically velocity, temperature, salinity, and surface pressure) on a three-dimensional grid that, along with initial and boundary conditions, provides sufficient information to calculate the oceanic state one time step, \( \Delta t \), in the future:

\[
x_{ocean}(t + \Delta t) = L[x_{ocean}(t), u(t), q(t)]
\]

(1)

Operator \( L \) represents the GCM (a lengthy computer code), vector \( u(t) \) comprises known elements of initial and boundary conditions, and vector \( q(t) \) comprises unknown elements of initial and boundary conditions, indeterminate model parameters (for example, mixing coefficients), and other errors in the physics of the model. We assumed that the second moment matrix, \( Q(t) = \text{cov}(q(t)) \), is at least

---

**Fig. 3.** The range-averaged sea level anomaly along the acoustic sections inferred by several independent methods: (i) thick black lines indicate the ATOC acoustic measurements converted to equivalent sea surface height for comparison with the altimeter data, (ii) thin black lines are from the TOPEX/POSEIDON altimeter data, (iii) dashed lines represent the climatological thermal anomaly converted to sea surface height, (iv) blue lines are the GCM estimates, and (v) the asterisks along section v1 are the XBT data. Uncertainties are indicated for the acoustic estimates: the possible errors are largest along section v1 because the upper ocean variability is unresolved due to a lack of surface-reflecting rays near the receiver.
Sea Ice Information

& Great Lakes

• Got at NCDC library, Asheville, Nov 15, 2000

• 7 pages follow

Roy Jenne
Contact: William J. Brennan  
(303) 497-6286

RELEASE: Tuesday,  
May 29, 1984

A comprehensive atlas of Great Lakes ice cover spanning the  
20 winters from 1960 through 1979 has been produced for public  
use by the National Oceanic and Atmospheric Administration.

Developed at NOAA's Great Lakes Environmental Research  
Laboratory in Ann Arbor, Mich., the atlas is intended for use by  
federal and state agencies, the shipping industry, power  
companies, marine engineering firms, municipal and county  
planners, and others in the fields of operations and research  
requiring information about ice on the Lakes.

The atlas, according to Dr. Frank Quinn of the Ann Arbor  
laboratory, is unique in that it is generated from a computerized  
data base. Its three major sections focus on ice-cover  
concentration, ice thickness at nearshore locations, and winter  
temperature severity. Charts show maximum, minimum, and normal  
ice concentrations on each of the five Lakes in half-month  
intervals; the range of ice thickness to be expected around the  
shorelines; and, 80-year mean freezing degree-day values for 25  
locations around the Lakes.

The "NOAA Great Lakes Ice Atlas" may be ordered from the  
National Technical Information Service, Department of Commerce,  
5285 Port Royal Rd., Springfield, VA 21151, Order Number PB  
84160811, price $13.00.

The ice concentration statistics and data base used in the  
atlas are available on nine-track, computer-compatible magnetic  
tape from the National Snow and Ice Data Center, CIRES, Campus  
Box 449, University of Colorado, Boulder, CO 80309. The Center  
is operated by CIRES on contract to NOAA's National Geophysical  
Data Center.
GREAT LAKES ICE ATLAS

DONALD R. RONDY

SEP 28 1978

~ 49 pages
Great Lakes Water Levels

1994

Daily and Monthly Average Water Surface Elevations

August 1995

I found this in the NCDC Asheville library.

- Roy Jones
INTRODUCTION

The Office of Ocean and Earth Sciences (OES), within the National Oceanic and Atmospheric Administration (NOAA), is responsible for collecting water level data for the entire Great Lakes Basin watershed (295,000 square miles), and for maintaining the International Great Lakes Datum (IGLD). In meeting these responsibilities, close coordination is maintained with other Federal agencies and Canadian counterparts. Exchanges of water level data with Canada are made under treaties that require regulation of operations and support of cooperative power generation. These exchanges are coordinated under the International Joint Commission (IJC), a group of six commissioners appointed by the President of the United States and the Prime Minister of Canada. Parties involved in meeting the international agreements include: several boards of control, IJC committees of two Federal agencies, eight states and two Canadian Provinces.

Beginning in 1970 (under authority of Presidential Reorganization Plan No. 4 (now part of U.S. Code 33 Title 83)), OES's predecessor organization began a program of monitoring and collecting water levels, and maintaining a vertical control reference system for the Great Lakes and their connecting channels. The program, required by Congress and by international treaties, has a mission of providing a hydraulic vertical reference datum by which the governments of Canada and the United States manage water resources in the Great Lakes Basin. International management of water resources in the Great Lakes Basin is vital to ensuring the safety of the lakes many users. The Great Lakes Program takes into account fluctuations of the lakes water levels and the outflows of rivers relative to: regulation, lake level forecasting, shipping, international cooperative treaties and agreements, riparian interests, hydroelectric power generation, construction, dredging, litigation, and other water resources management and development activities.

Presently, the Great Lakes Program is divided into office and field functions to address: basic water level measurements, vertical datums, earth movement (for the International Great Lakes Datum), basin precipitation, abstracts of diversions, vertical control support for hydrographic surveys, construction and maintenance activities, and needs of user communities. Since 1973, real-time data has been provided for emergency water planning situations by using water-level gauges with electronic telemetry units. Presently, 29 of these water level measurement units are operating in the field; OES plans to, and is presently installing new state-of-the-art electronic telemetry systems.
This report, published annually, contains water level gauge records for the Great Lakes in units of both meters and feet. The following information is presented in tabular form for the calendar year:

1. Daily and monthly average water levels for each gauge in the network;

2. The highest and lowest daily average water level for each month;

3. A frequency distribution of daily average water levels that shows the number of times each month recorded levels were at or above specific elevations; and

4. Monthly average water level stages for each lake, from 1900 to the present.

OES gauges record water levels, in either analog or digital form, on strip charts retained by OES. Recorded hourly values are used to compute daily averages; monthly values are derived from daily averages.

Locations of gauges for recording water levels are shown on the inside cover page. An index on subsequent pages lists gauge identification numbers, their locations, and their geographic coordinates.

A separate publication, printed every five years, shows only monthly and annual averages, and highest and lowest monthly averages for the period of record (latest issue: Great Lakes Water Levels, 1860-1990). A hydrograph, that depicts data for master control gauges for each lake, is available for a nominal fee by writing: National Ocean Service, Office of Ocean and Earth Sciences, N/OES21, Silver Spring, Maryland, 20910-3281.

DATUM OF REFERENCE: All tabulated elevations are referred to the International Great Lakes Datum 1985. A complete explanation of the datum can be obtained at no charge by writing the address above.
Russian DARMS Arctic Ice Stations

- For 1958 – 1975
- 18 pages follow

Roy Jenne
Jan 2002
AIDJEX BULLETIN

ARCTIC ICE DYNAMICS JOINT EXPERIMENT

ABOUT DARMS DATA

RAY FOMME
AIDJEX BULLETIN No. 22
August 1973
Arctic Data Buoys

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Front cover: Installation of an IRLS buoy during the 1972 AIDJEX pilot study.

Back cover: A Soviet DARMS being installed in the Arctic ice.
AIDJEX BULLETIN No. 22
August 1973

ARCTIC DATA BUOYS

* * * * *

Financial support for AIDJEX is provided by the National Science Foundation, the Office of Naval Research, and other U.S. and Canadian agencies.

* * * * *

Arctic Ice Dynamics Joint Experiment
Division of Marine Resources
University of Washington
Seattle, Washington 98105
From: sdw@cdc.noaa.gov (Scott Woodruff)  
Date: Mon, 24 Feb 1997 16:45:24 -0700  
To: jenne@ncar.ucar.edu  
Subject: DARMS information

Roy, Here is what little information I was able to locate on the DARMS data 
(attached e-mail messages from Claire Hanson and Ignatius Rigor). I believe 
that the files indicated by Ignatius were limited to daily data, and as far 
as I know the status and availability of the individual observations was never 
further clarified.

I talked to Claire today, and perhaps the DARMS data will be discussed during 
or conjunction with the EWG meeting this week, because the DARMS data are 
listed as one of the "Data Sources" to be used for the planned CD-ROM. That 
EWG text states:
"E. Drifting Automatic Radio-Meteorological Stations (DARMS). Automatic 
weather stations were deployed on Arctic ice floes from 1958 to about 
1972. They reported temperature, pressure, and wind speed and direction 
(see Appendix C)."

(Appendix C was not part of the draft material I received from Roger Barry.)  
-Scott

==From hanson@kryos.Colorado.EDU Mon Apr 8 15:51 MDT 1996 
==From: hanson@kryos.Colorado.EDU 
==Date: Mon, 8 Apr 1996 15:51:46 -0600 (MDT) 
==To: sdw@cdc.noaa.gov 
==Subject: Re: DARMS data?, etc. (fwd) 
==Mime-Version: 1.0 
==
==Scott - The DARMS data is available from the ftp site at Polar 
in the directory /ICEATLAS/DARMS. -Claire
==
==-------- Forwarded message --------
==Date: Mon, 8 Apr 1996 13:16:59 -0700 
==>From: Ignatius <igr@apl.washington.edu> 
==>To: hanson@kryos.Colorado.EDU 
==>Cc: Ignatius <igr@apl.washington.edu> 
==>Subject: Re: DARMS data?, etc. 
==
==Hi Claire, 
==
==Yes, the DARMS data is from some type of buoy. We got a portion of the DARMS 
data here. What we got was obs every 10 days or so. We interpolated this to 
1-day, but honestly, I only use the data when I am really desperate. Its time 
spacing is really dismal from a sampling point of view. This stuff is available 
from my web pages as part of this Ice Atlas database that we distributed a few 
years ago. 
==
==Ignatius 
==
==
AIDJEX BULLETIN No. 7
April 1971
Arctic Data Buoy and Positioning Systems

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AIDJEX BULLETIN No. 7

April 1971

ARCTIC DATA BUOY AND POSITIONING SYSTEMS

Arctic Ice Dynamics Joint Experiment
Joseph O. Fletcher, Program Coordinator
Division of Marine Resources
University of Washington
Seattle, Washington 98105
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Summary of Drifting Automatic Radiometerological Stations (DARMS) information for
Roy Jenne
Steve Worley, 6 March 2001

Information taken from a CD-ROM produced by NSIDC.

Title: The Arctic Climatology Project Arctic Meteorology and Climate Atlas
Version 1.0, 1 April 2000
Part of the Environmental Working Group (EWG) Joint U.S.-Russian Arctic Atlas

Parameters: wind speed and direction, air pressure, and temperature
Daily values of parameters were prepared for the EWG project, and all data files are
available on the CD-ROM.

Attachments:

1. Overview documentation from the CD-ROM
2. Data Sampling Inventory histograms
Drifting Automatic Radiometeorological Stations

Documentation provided by V. Radionov; edited by F. Fetterer

Overview, observations of ice drift and meteorological parameters from DARMS

The Drifting Automatic Radiometeorological Station (DARMS) for weather and sea ice drift data recording was developed at the Arctic and Antarctic Research Institute (AARI) by Yu. K. Alexeyev for operation in remote and otherwise inaccessible sites in the Arctic Ocean. Placed on the pack ice of the Arctic Ocean by aircraft or icebreaker, DARMS automatically transmitted information on wind speed and direction, air pressure and temperature. From 1957 through 1976, AARI continuously had DARMS units in operation.

Figure 9 shows the structure of a DARMS unit. A hollow steel bar that passed through ice was the principal feature of the station design. A hermetically closed container housed batteries and a clock mechanism, and was fixed to the lower end of the bar under ice. The station antenna, a 12 m duraluminum mast, was supported by three stays. These were fixed by anchors frozen into ice. The anchors were fitted with guide runners, in which the supporting tripod could move freely. This design decreased the possibility of station damage due to ice cracking. DARMS units were equipped with a special tent, stretched above the ice surface, to prevent anchors from melting out of ice due to solar heating. The duration of autonomous DARMS operation on ice with daily data transmission was about 1 year.

A radio transmitter and receiver, as well as meteorological unit, were mounted at a height of two meters over ice surface. The DARMS meteorological unit (Figure 9, right) measured air temperature, air pressure, and wind direction and speed.

A bimetallic thermometer measured air temperature. An aneroid barometer with temperature compensation by the bimetallic strip was used as pressure sensor. A large weather vane turned the meteorological unit around the vertical axis into the wind direction. Wind direction was determined by magnetic compass reading. Two smaller weather vanes measured wind speed. For that purpose the dynamic anemometer principle was used.

The mechanical systems of the sensors were damped. This excluded the influence of vibrations that came with high wind speeds on the temperature and pressure sensor readings. Wind speed and direction were averaged automatically over an eight or 10 minute period.

The DARMS units measured meteorological data within the following ranges:

- Air pressure from 960 mbar up to 1050 mbar, with a precision of 1 mbar.
- Air temperature from -55 °C up to +30 °C with a precision of 1 degree.
- Wind speed from 1 m/s up to 25 m/s with a precision of 1 m/s.
- Wind direction through 16 points (360 degrees) with a precision of 22.5 degrees (1 point).

The data were transformed into radio signals by means of a code block and transmitted by Morse code on fixed frequency in the 551-584 kHz range. The signals were received by American radio transmitting and bearing stations DAN-2. Nine stations were mounted in the Arctic during the Second World War to guide the transit flights of airplanes from the USA (Alaska) through the Arctic and Siberia.
to the Soviet-German front. High-frequency radio waves were used to fix position of the DARMS unit by triangulation. The sensitivity of the antenna was 1 mV, and bearing accuracy was ±1 degree. Signals were received from distances up to 1500 kilometers.

The long term (1957 through 1976) of the observation program for ice drift and meteorological parameters was due to the very dependable DARMS equipment and excellent radio bearing capabilities.

At the time of their acquisition, DARMS data were used in weather forecasting. Now the weather observations obtained by these stations supplement the information collected by the Russian North Pole drifting stations.

**Preparation of DARMS data for the Atlas**

Daily values of surface air pressure, two-meter air temperature, wind speed, wind direction, and DARMS positions were prepared for this Atlas. The time of daily values is given as 0000 GMT. Values from the archive at AARI for position and the meteorological observations were quality controlled by checking them against the original daily synoptic chart.

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Figure 9. (Left) A DARMS station. 1. Container for batteries and a clock mechanism. 2. Hollow steel...
Russian Drifting Automatic Radiometeorological Stations (DARMS)

data directory: DATA/FLOATING_PLATFORMS/RUSSIAN_DARMS

1958-1959

![Graph showing data for 1958-1959]

1960-1961

![Graph showing data for 1960-1961]
1970-1971

1972-1973