GeoResJ 14 (2017) 92–97

Contents lists available at ScienceDirect

GeoResJ

journal homepage: www.elsevier.com/locate/georesj

# Revealing our melting past: Rescuing historical snow and ice data

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ARTICLE INFO

*Article history:*
Received 14 May 2017
Revised 16 October 2017
Accepted 27 October 2017
Available online 28 October 2017

ABSTRACT

Analog archival data can supplement modern digital research, but only if those data are preserved, described, and migrated to appropriate formats. The National Snow and Ice Data Center (NSIDC) at the University of Colorado Boulder (CU) is responsible for managing, archiving, and disseminating cryospheric and polar data. The clear majority of these data are digital, but the NSIDC also houses a collection of historical archival materials that include measurements related to the earth's glaciated regions prior to the development of modern instrumentation. Their formats, however, are not conducive to contemporary analysis, rendering them ostensibly "lost" to research. This paper describes a series of efforts to provide access to these collections that date back to their original acquisition, as long ago as the mid-nineteenth century, with focus primarily on activities over the last 15 years. The most recent effort was funded by the Council on Library & Information Resources and won the 2016 International Data Rescue Award. The intent is to highlight key challenges, and our proposed own solutions to those challenges, in designing a digitization project centered on providing online access to analog data in glaciological, geomorphological, and related research.



## 1. Introduction

The International Coalition of Scientific Union's Committee on Data (CODATA) long included a Data at Risk Task Group, which was "concerned with the plight of many sets of scientific data which are not in modern electronic formats and whose information is therefore not accessible to the research that needs it" [1]. Somewhat synonymously referred to as 'legacy' or 'heritage' data (or with respect to format, as "analog" data), they are usually available from one generation to the next not due to foresight or active planning or preservation efforts, but "more by circumstance than by design, and reflect a woeful lack of any planning for use by future generations for whatever purpose(s) they might eventually serve" [2]. Preserving these data, whether for intentional or potential analysis, can be a costly process, requiring labor-intensive physical processing, arranging, curating, description, and digitization. The effort and expense, however, has contributed greatly to research in biodiversity, oceanography, climatology, and other disciplines [2].

Such is the case with NSIDC's Analog Archives Collection, which houses legacy sea ice charts, maps, explorer diaries, more than 20,000 glacier photograph prints dating back to the 1850s, and other imagery of ice covered regions. The collection began when William O. Field started collecting historical materials, including many taken by Harry F. Reid, recognized as one of the early pioneers in geophysics and glaciology [3]. Collected by Field after Reid's death in 1945, the materials include approximately 5000 prints, 600 glass plate negatives and prints, 22 expedition notebooks, and about 1 cubic foot of manuscript materials (including drafts of Reid's map of Glacier Bay). Other subsets include:

- 13 Rocky Mountain National Park Glacier Survey Reports and the accompanying 264 glacier photographs;
- 79 terrestrial photographs taken by chemist and mountaineer Fred D. Ayres in Peru during the 1950s;
- 360 images of Colorado's Arapaho Glacier taken in the early 1900s by Junius Henderson (first curator of the University of Colorado Museum of Natural History), and;

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https://doi.org/10.1016/j.grj.2017.10.002

- Over 1200 photographs of Greenland glaciers, donated by the U.S. Coast Guard.

Additional materials, such as images from southern Colorado, Glacier National Park, the Cascades, and much of Alaska across several decades, have been added to the collection, which continues to grow even today.

These analog, heritage data have been carefully preserved for over forty years by volunteers, scientists, librarians, and archivists, and are a part of the history and current activities of NSIDC.

### 1.1. Scientists looking to the future: a data center's history

Photographing discoveries of glaciological expeditions began with the invention of the camera. The first International Polar Year (IPY) of 1881–1884 created a wealth of data [4]. One expedition, led by Lieutenant Adolphus Greely, to Lady Franklin Bay off the northeastern shore of Ellesmere Island, endured immense hardship, sacrifice, and even death, all to preserve data they had so laboriously obtained:

*"Greely was aware that if a relief steamer did not arrive after their second winter they would be forced to retreat to safety on their own. He made condensed copies of their scientific records (amounting to some 500 observations per day for two years), and when they abandoned Fort Conger in August 1883 they took with them—in lieu of extra rations—these copies sealed in three tin boxes weighing 50 pounds each…The scientific records were the only meaningful legacy of their effort. If they were lost, all of their hardships would have been for nothing"* [5].

Of the 24 men that started the expedition, only six, including Greely, survived. They realized the paramount need to preserve their work for use by other scientists in the future, and other scientists have also had this same realization, including William O. Field.

As a young glaciologist, Field realized the need for a place to house historical photographs and notebooks like those from the Greely expedition. In 1932, Field started a collection with $100 USD remaining from one of his earlier expeditions [6]. Initially, the collection was housed in the office of another glaciologist at the Library of Congress. Field found various funding sources through the years for the collection, finally bringing it under ownership of the American Geophysical Society (AGS) in 1945 where he worked at the time.

In 1957, during the first International Geophysical Year (IGY), the U.S. National Committee for the IGY awarded the operation of World Data Center A for Glaciology (WDC-A) to the AGS under the direction of Field. World Data Centers were formed to handle the unprecedented data of IGY. The WDC-A for Glaciology was particularly responsible for archiving all available glaciological information at the time. In 1970, the WDC-A was moved to Tacoma, Washington, where it was operated by the U.S. Geological Survey, Glaciology Project Office, under the direction of Dr. Mark F. Meier until 1976.

In 1976, responsibility for the WDC for Glaciology was transferred to the National Oceanic and Atmospheric Administration (NOAA) Environmental Data and Information Service (EDIS); and the center moved to the University of Colorado in Boulder, Colorado, under the direction of Professor Roger G. Barry. As Director of the WDC for Glaciology, Barry saw the need for a data center dedicated to the archiving of snow and ice data and suggested that such a data center be created [7]. In 1982, NOAA officially established NSIDC.

During the next two decades, NSIDC expanded with NASA funding for the Snow and Ice Distributed Active Archive Center (DAAC) and National Science Foundation (NSF) funding to manage selected Arctic and Antarctic data and metadata.

To help capture the history of the center, NSIDC digitized 1694 files documenting the history of the WDC for Glaciology in Boulder and NSIDC. This was accomplished through support from a NOAA Preserve America Initiative Grant (PAIG), an effort by NOAA to preserve the nation's heritage by promoting preservation and developing conservation plans for historically significant resources [8].

## 2. Modernizing NSIDC's archives

As NSIDC's efforts expanded and included massive amounts of digital data collected through modern instrumentation, including satellites, projects began to further organize and migrate analog datasets into modern formats. As resources permitted, records of arctic ice dynamics, cold land field experiments, drifting stations, sea ice charts and historical glacier photographs were digitized and described in order to integrate these paper records and prints into NSIDC's data discovery tools. Most efforts have focused on sea ice charts and glacier photographs, and they have added value to research in several projects.

### 2.1. Sea ice charts

Funding from NOAA's Climate Database Modernization Project (CDMP) and the National Geophysical Data Center (NGDC) allowed NSIDC to digitize approximately 6800 sea ice charts donated by the estate of William H. Dehn. These hand drawn maps can be viewed as image files that record ice edge position and some ice concentration information for waters around Alaska. The charts were made between 1953 and 1986, primarily using visual observations gathered during aerial ice reconnaissance missions. Relatively costly and extensive scanning of these charts has contributed to a variety of analyses. One project used them to compare with and validate recovered satellite data in order to more accurately measure arctic ice cover at the dawn of the satellite era. Part of a larger analysis, the recovered and validated satellite record "will yield a climate record of sea ice approaching 50 years in length that will put the recent changes, especially the dramatic decline of Arctic summer sea ice extent, into a longer-term context" [9].

The digitized chart series predates the satellite record, thereby pushing the start of the record even further back in time. Another project used them and other analog data, including records of nineteenth century whaling ships, to create a database of sea ice fluctuations dating to 1850. This study demonstrated "there is no precedent as far back as 1850 for the recent minimum extent of sea ice on the pan-Arctic scale," and that "the rate of retreat since the 1990 s is also unprecedented in the historical record for the pan-Arctic total ice cover" [10].

Findings such as these, of great importance not only to climatology, but also to public policy, relied in part on the work of efforts to rescue analog data at NSIDC.

### 2.2. Historical glacier photographs

Another example of efforts to modernize the data in these archives is the digitization of glacier photographs. Glacier photographs have helped demonstrate regional climate change in Alaska [11], lateral moraine retreat of specific glaciers (through lichenometrical dating) since the sixteenth century [12], and even contributed to studies of human history and living conditions in Alaska dating to the fourth millennia B.C.E. [13].

They also provide striking testament to the rapid glacial retreat typifying the last century, rendering them useful in a variety of contexts. Repeat photography projects (see Fig. 1) enable analysis and interpretation that yield information related to geomorphology and glacier dynamics [14]. In addition to journal articles, dissertations, and exhibits in closely related disciplines, these images have