A gridded database of Arctic sea ice extending back to the 1800s

John Walsh[1], Florence Fetterer[2], William Chapman[3]

[1]*University of Alaska, Fairbanks*
[2]*National Snow and Ice Data Center, University of Colorado*

[3]*University of Illinois, Urbana*

(Photo courtesy K. Wood)

The challenge

- **A perspective on recent sea ice trends requires information pre-dating the satellite era**

- **Pre-satellite sources of sea ice data exist, but they are diverse and often ungridded – hence not consolidated with more recent data**

HadISST Northern Hemisphere Sea Ice Extent : January and July
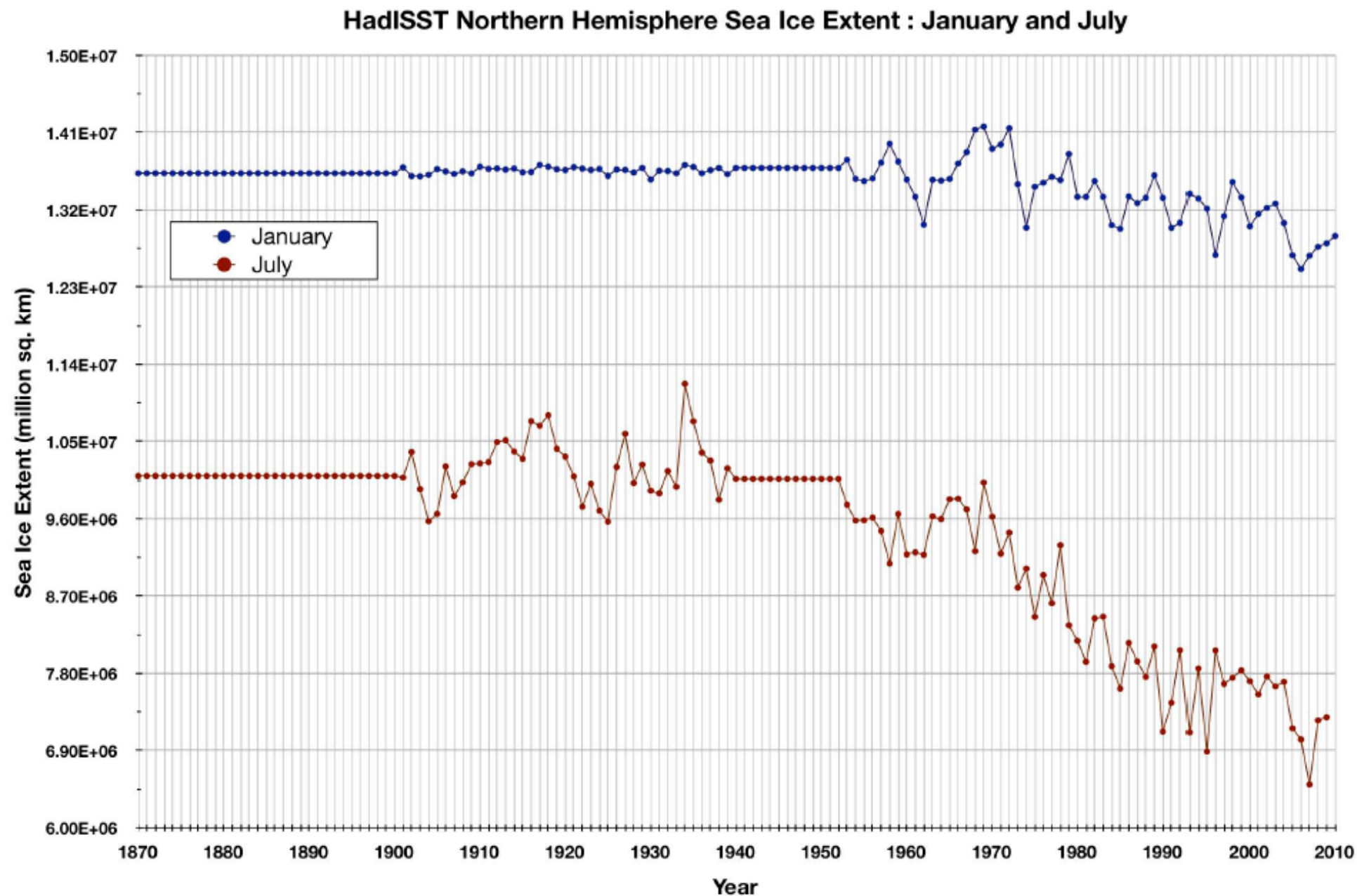
The objective

- **A digital sea ice atlas that maximizes the useful information on historical sea ice conditions**

  -- consistently formatted through time
  -- monthly, back to the mid-1800s
  -- documentation of sources and uncertainties
  -- provide users an optional space-time reconstruction over areas without observations

- **Online access with supporting software**

  -- ice extent and concentrations
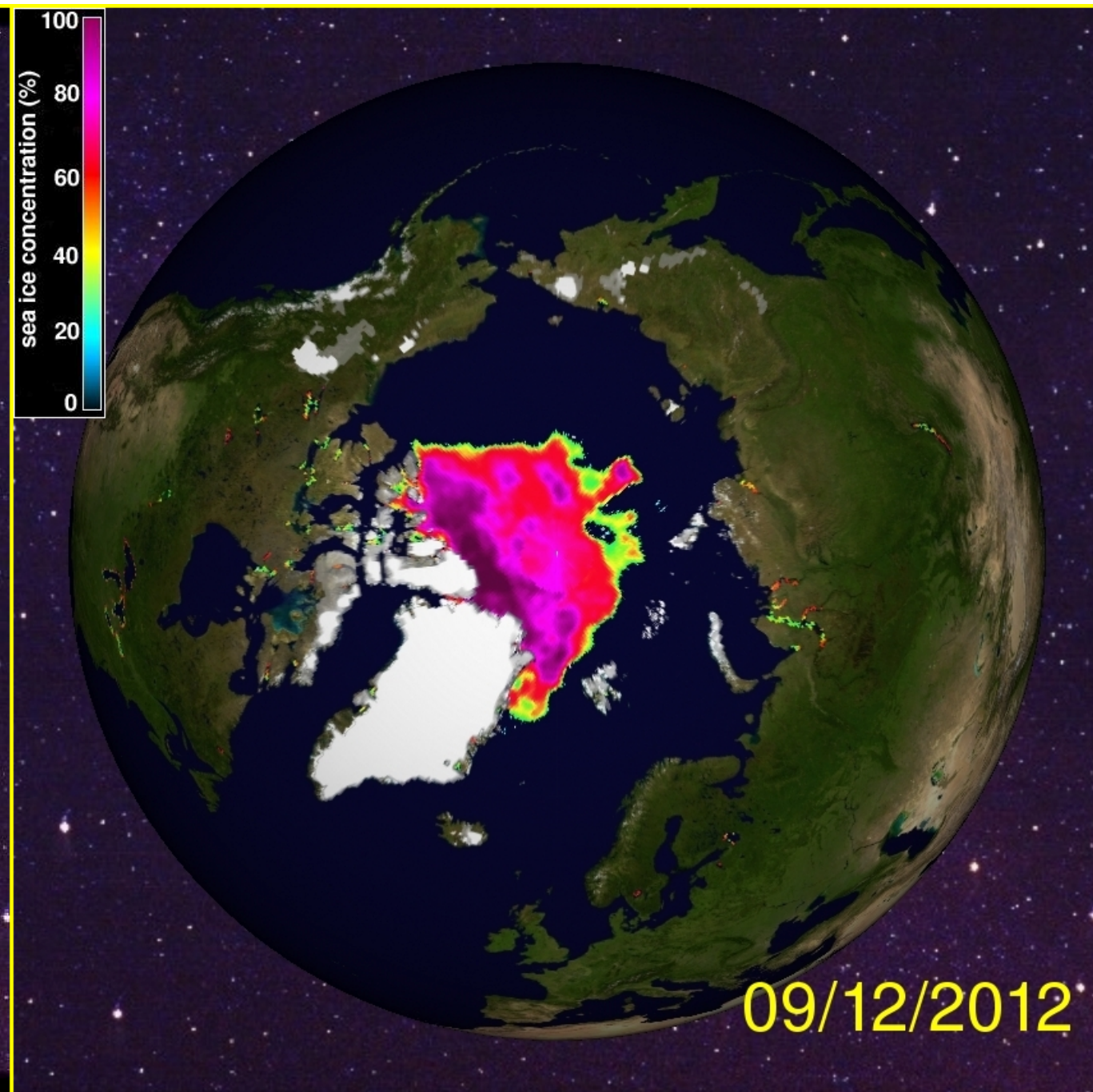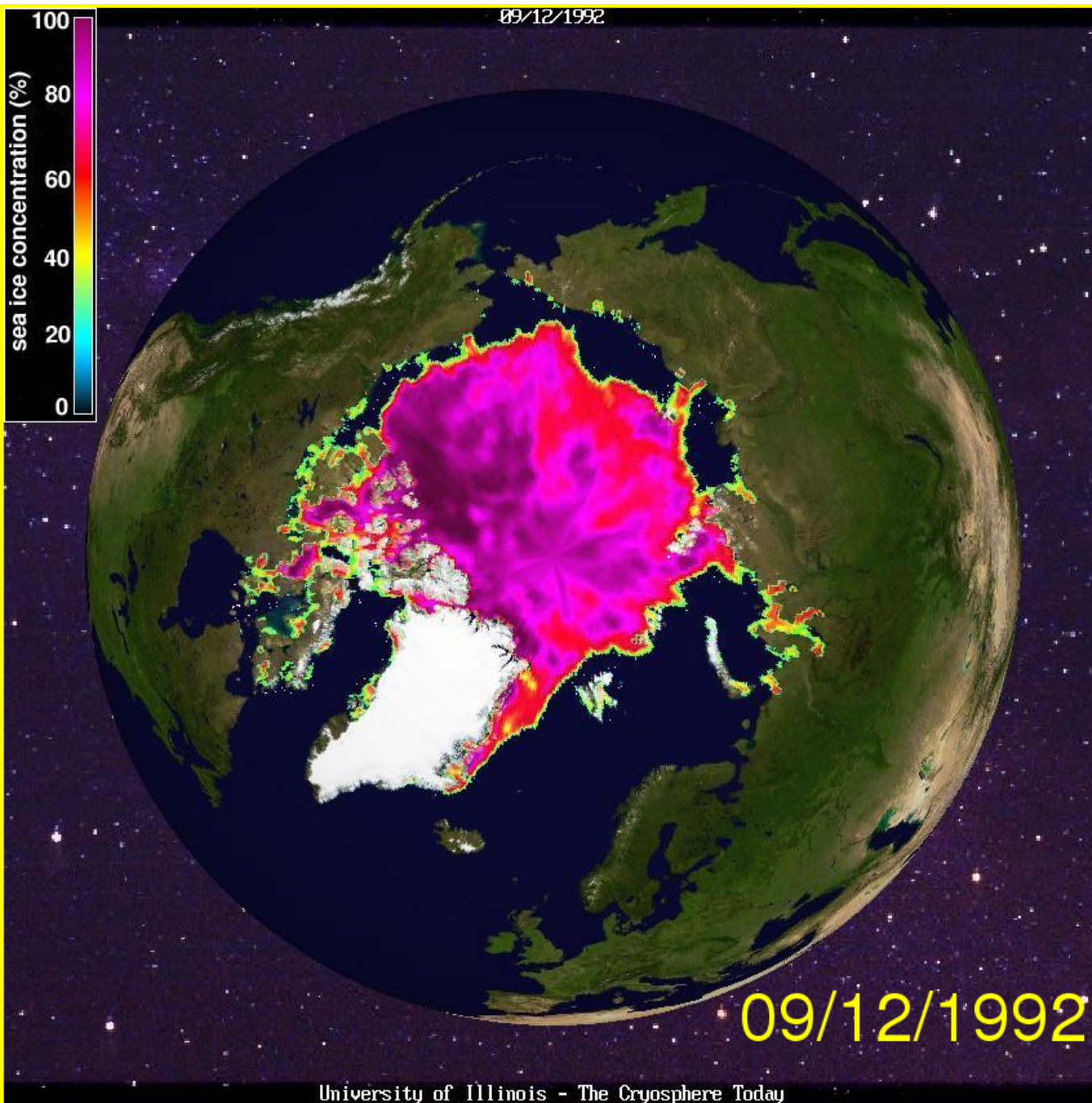 **-- other tools in response to user needs**

Primary sources

- Satellite passive microwave fields, 1979-present

- North American Ice Center digital data (grids from U.S. National Ice Center, 1972-1978; Canadian Ice Service, 1958-1979)

- U.S. Naval Oceanographic Office (1953-1971)

- Dehn charts (from NSIDC), NOAA Alaska Ice Desk charts for Alaska, 1953-1979

- Arctic and Antarctic Research Institute (AARI) ice charts, 1933-1979

- Danish Meteorological Institute monthly ice charts (Apr-Sep) and ship reports, 1870s-1950s

- Arctic Climate System Study (ACSYS) database, 1850-1970s

- National Research Council of Canada (Brian Hill): Baffin Bay/Labrador Sea, 1850s-1960s

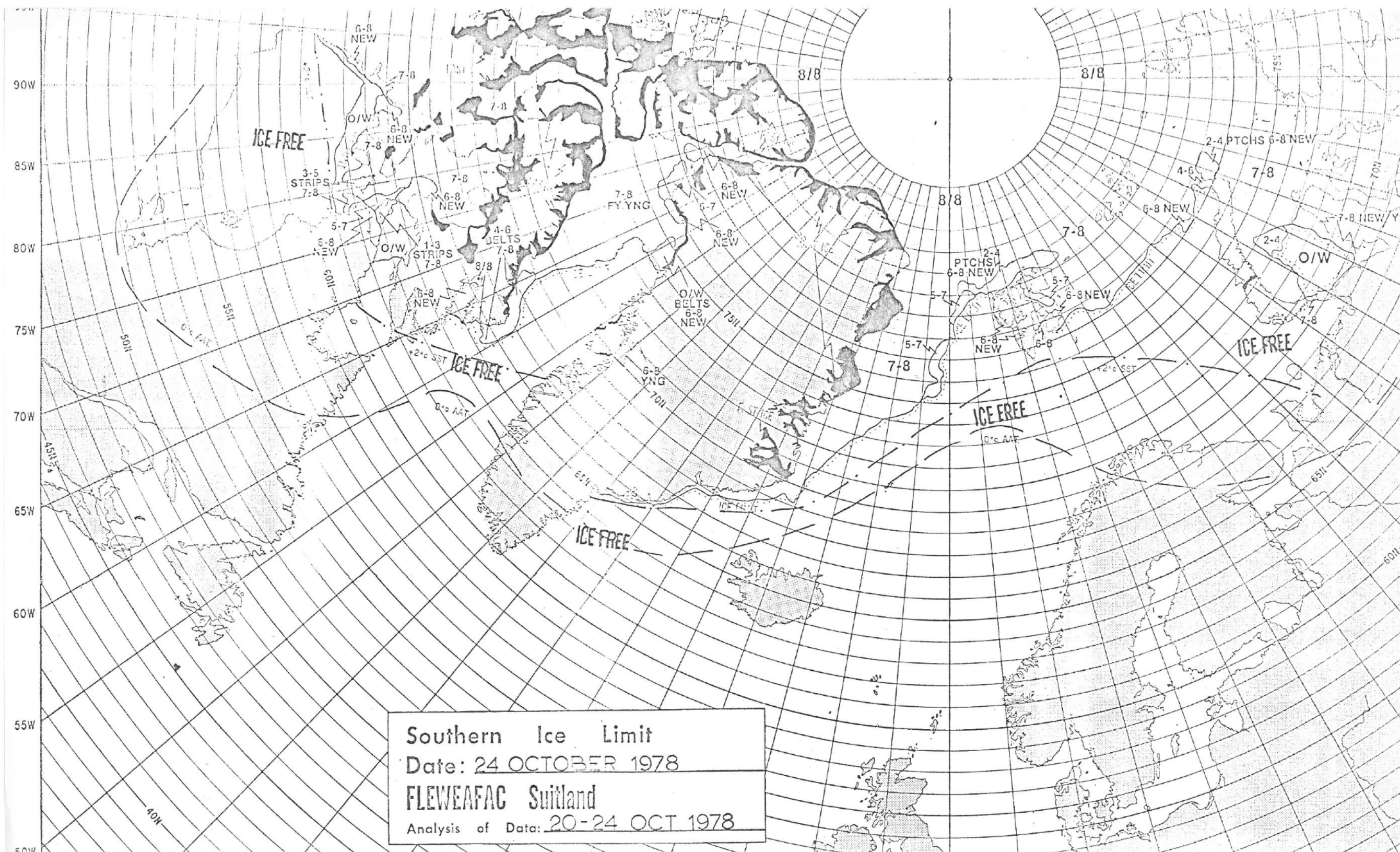- Alaskan ship reports (whaling and others) -- K. Wood and Bockstoce/Mahoney/Eicken, 1850-early 1900s

Satellite passive-microwave-derived sea ice concentrations
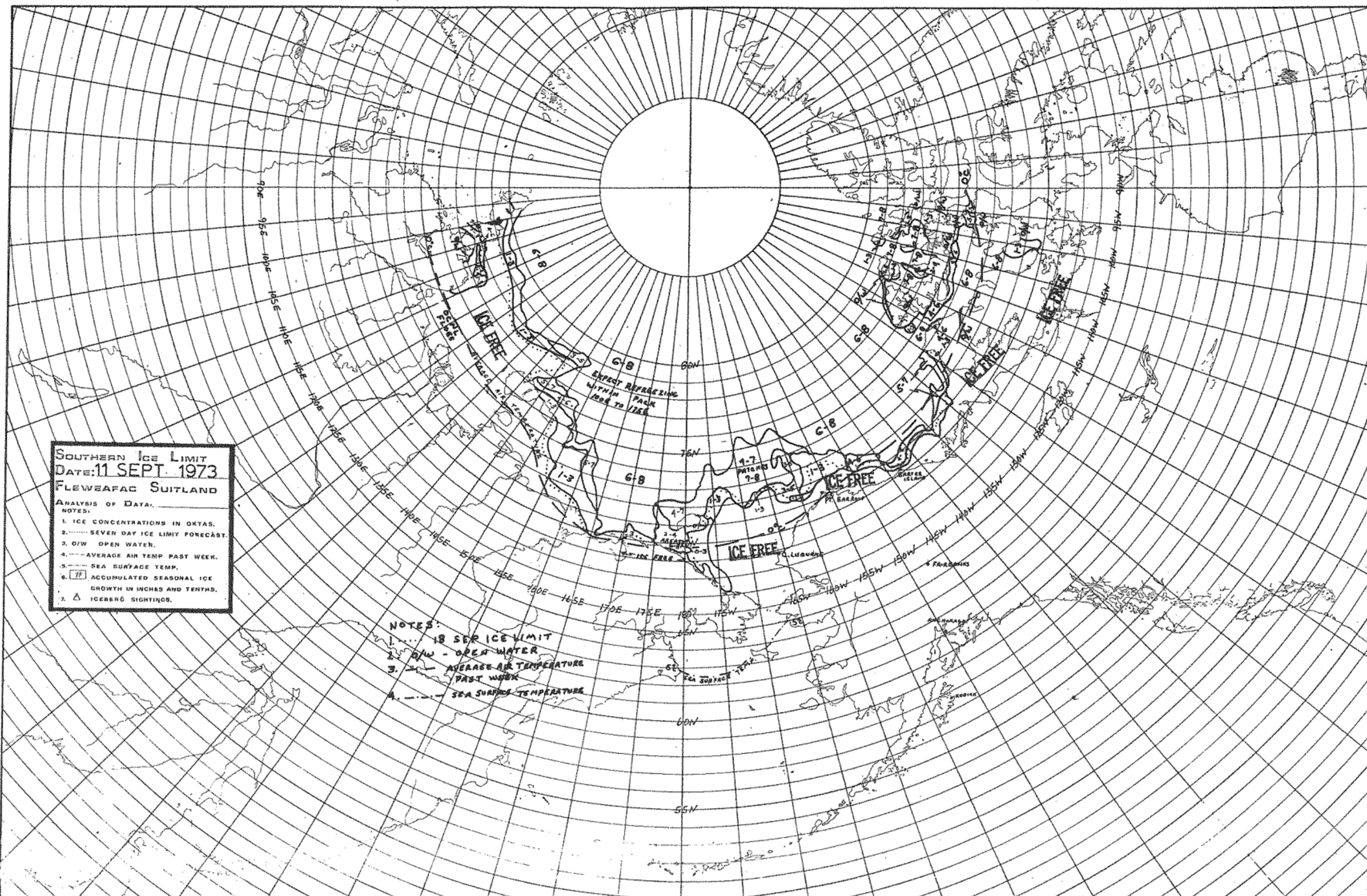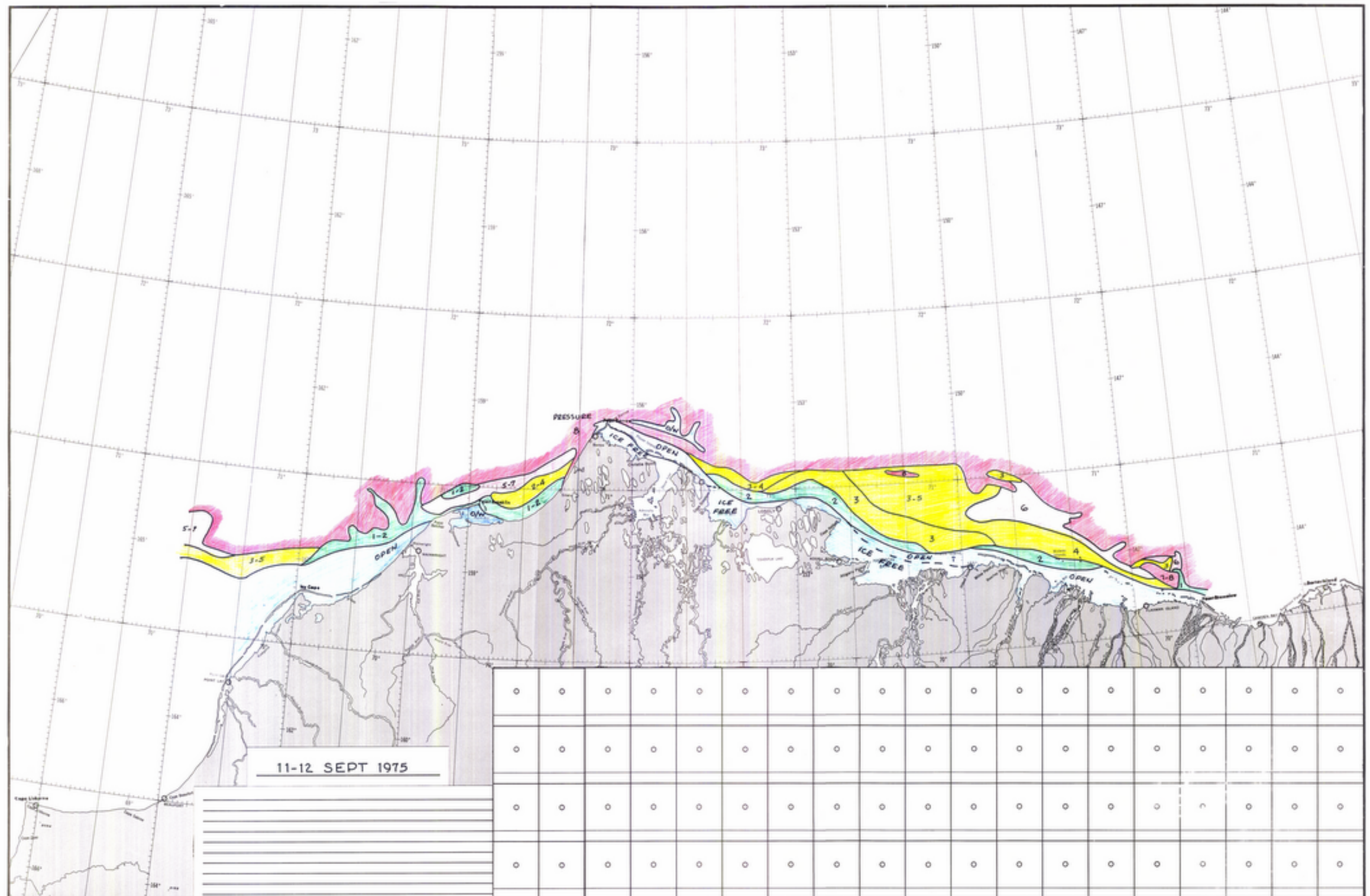
Sep. 12, 1992

Sep. 12, 2012

National Ice Center chart from the 1970s

Southern Ice Limit

Date: 24 OCTOBER 1978

FLEWEAFAC Suitland

Analysis of Data: 20-24 OCT 1978

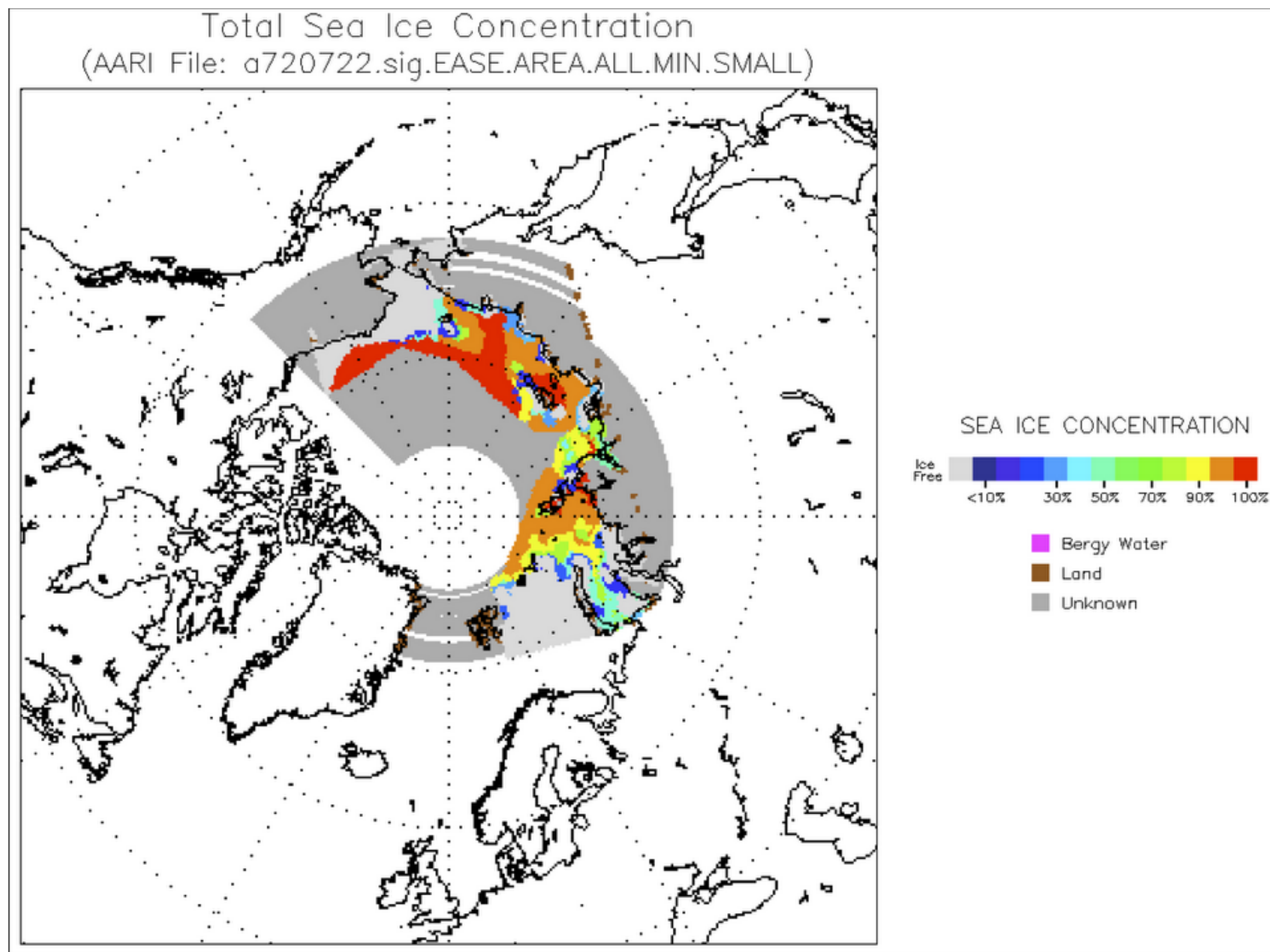# National Ice Center chart from the 1970s

Dehn chart (concentration categories), 11-12 Sep. 1975

11-12 SEPT 1975

Portion of sample chart from Dehn collection   (8 Sept. 1953)

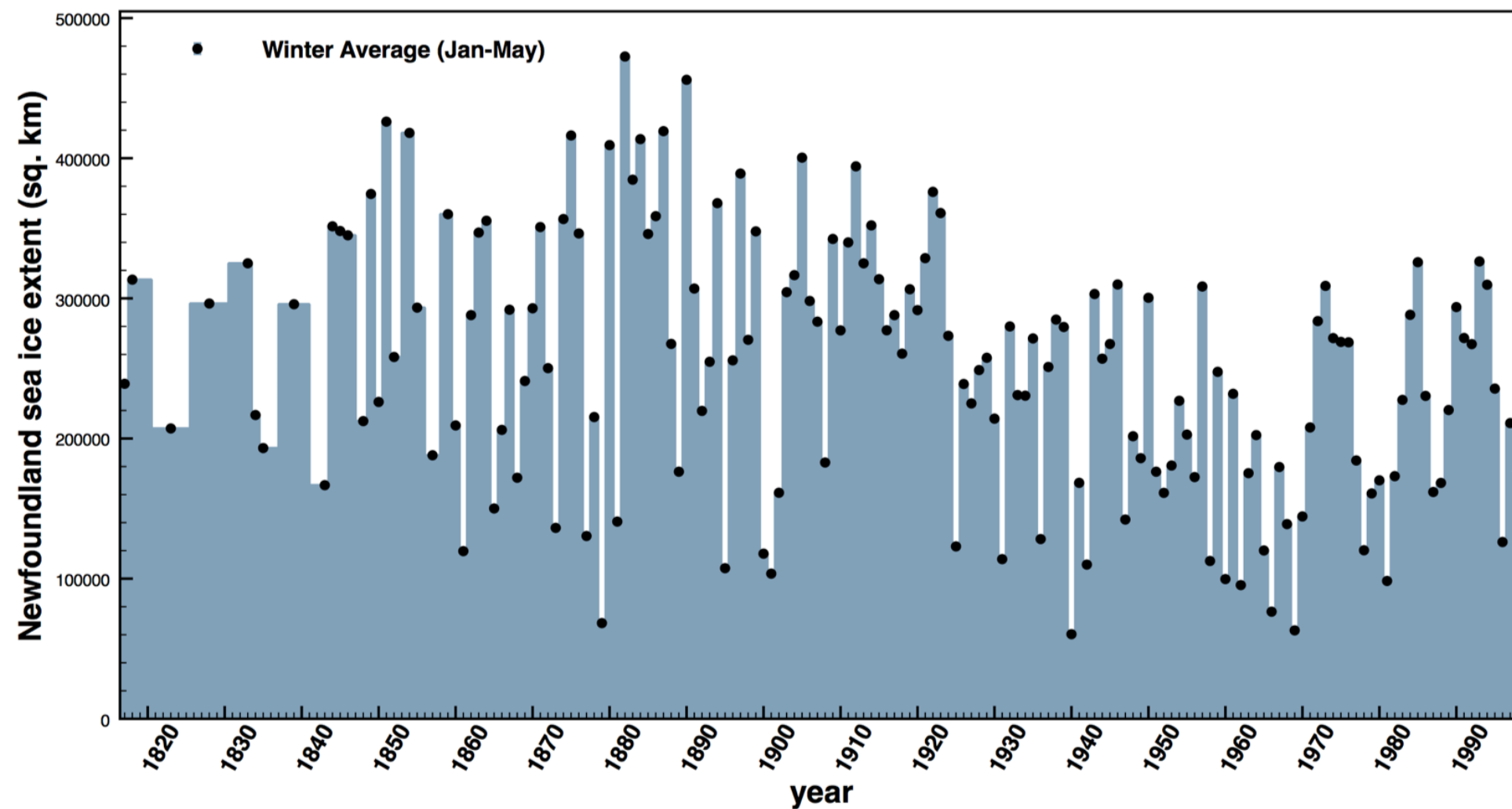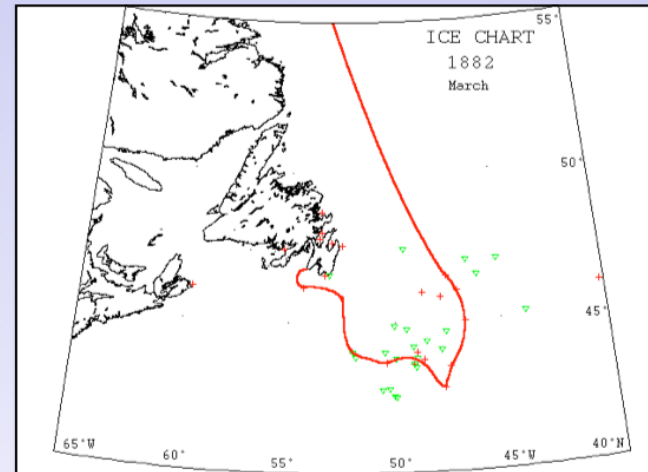**Sample ice concentration chart from AARI (Russia), 1930s-1970s**

Danish Meteorological Institute (DMI): charts, narratives back to 1870s
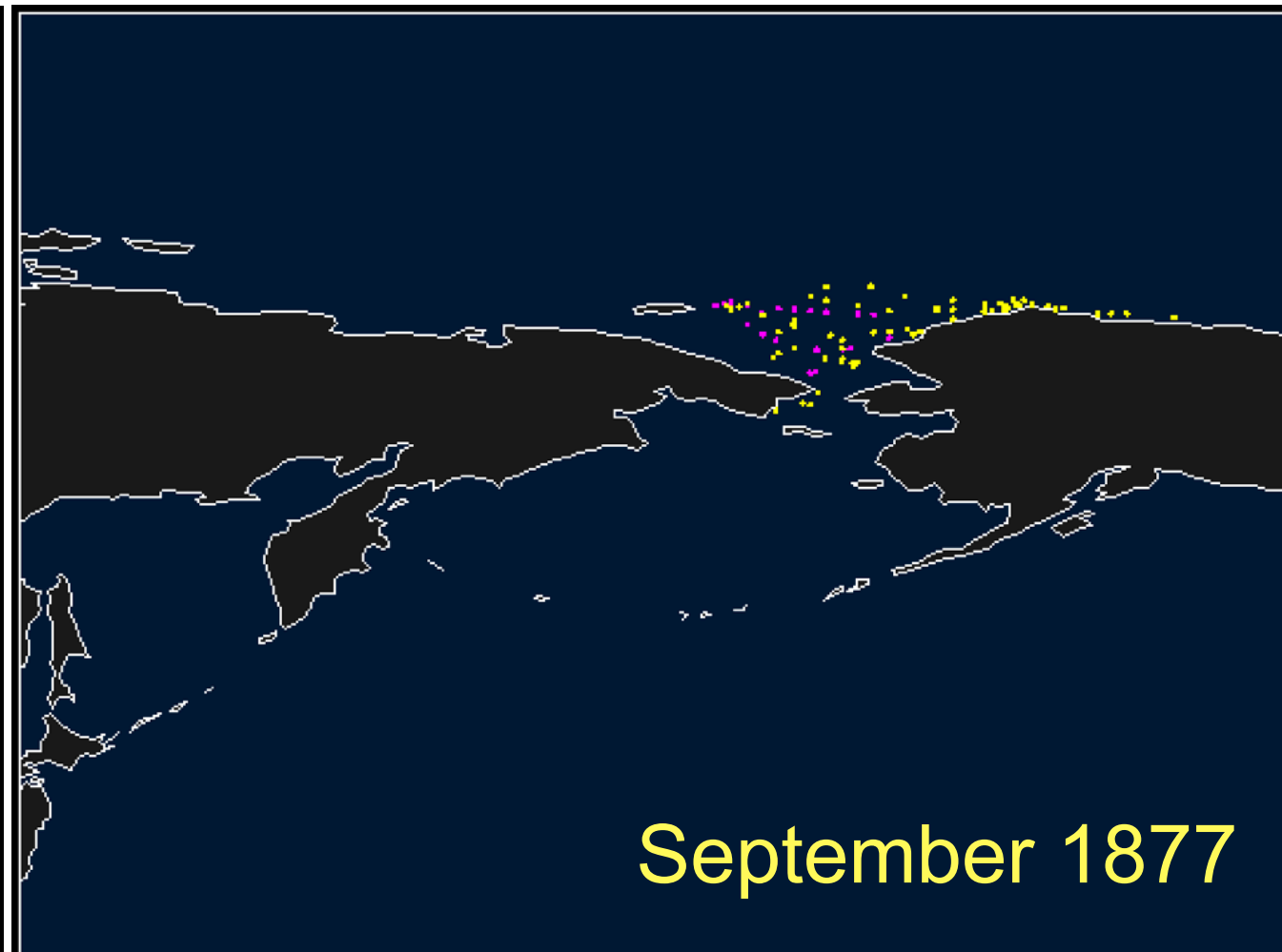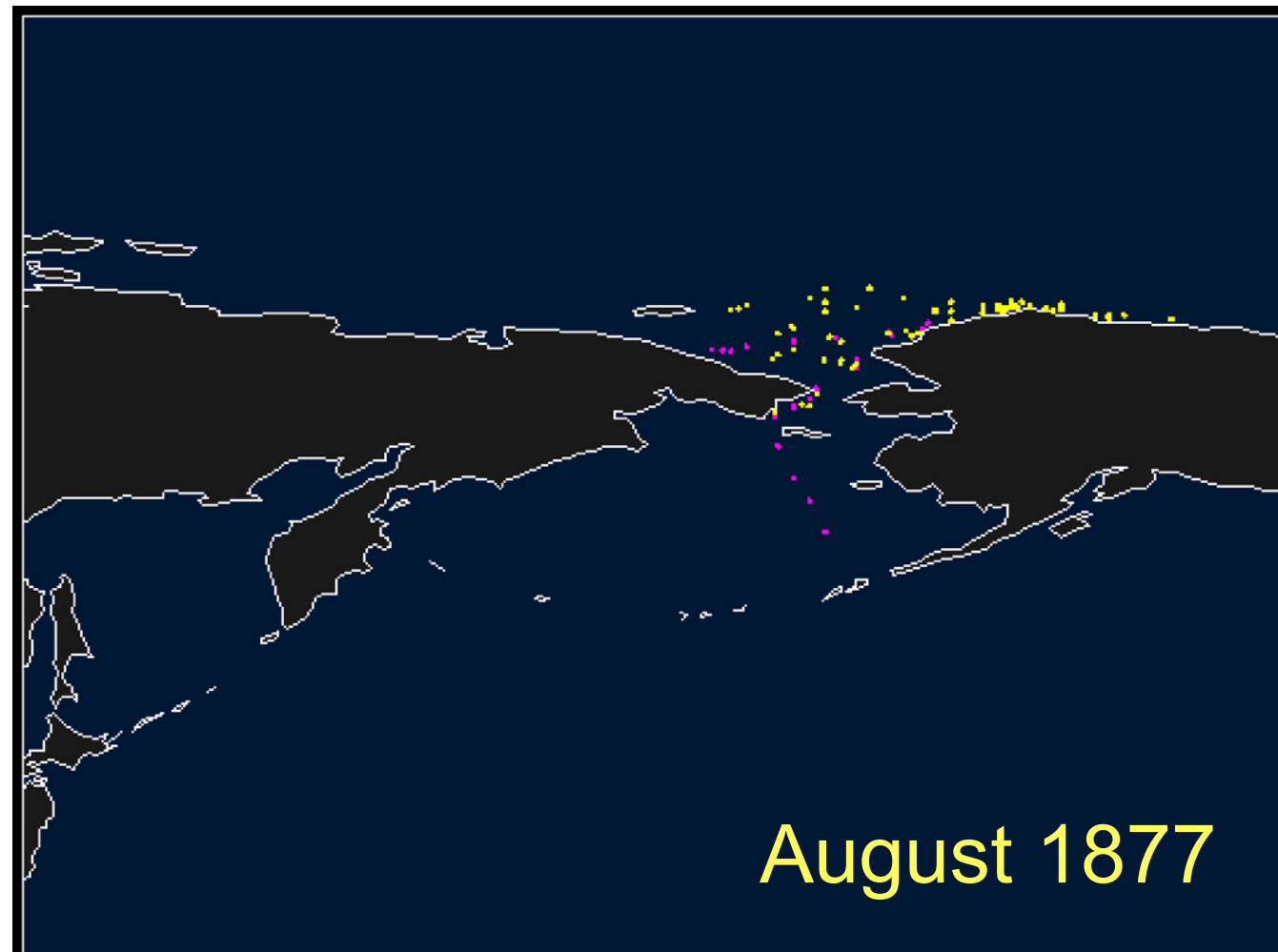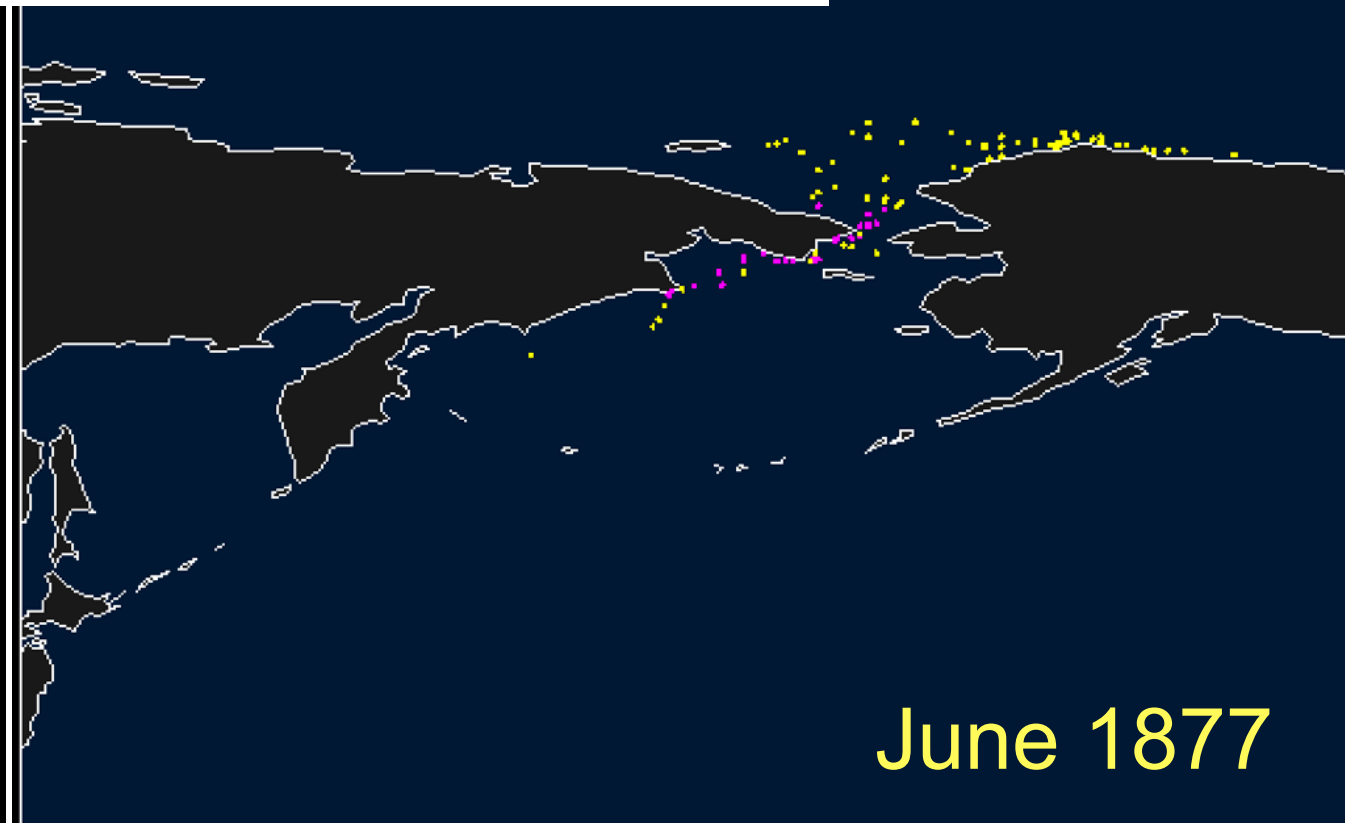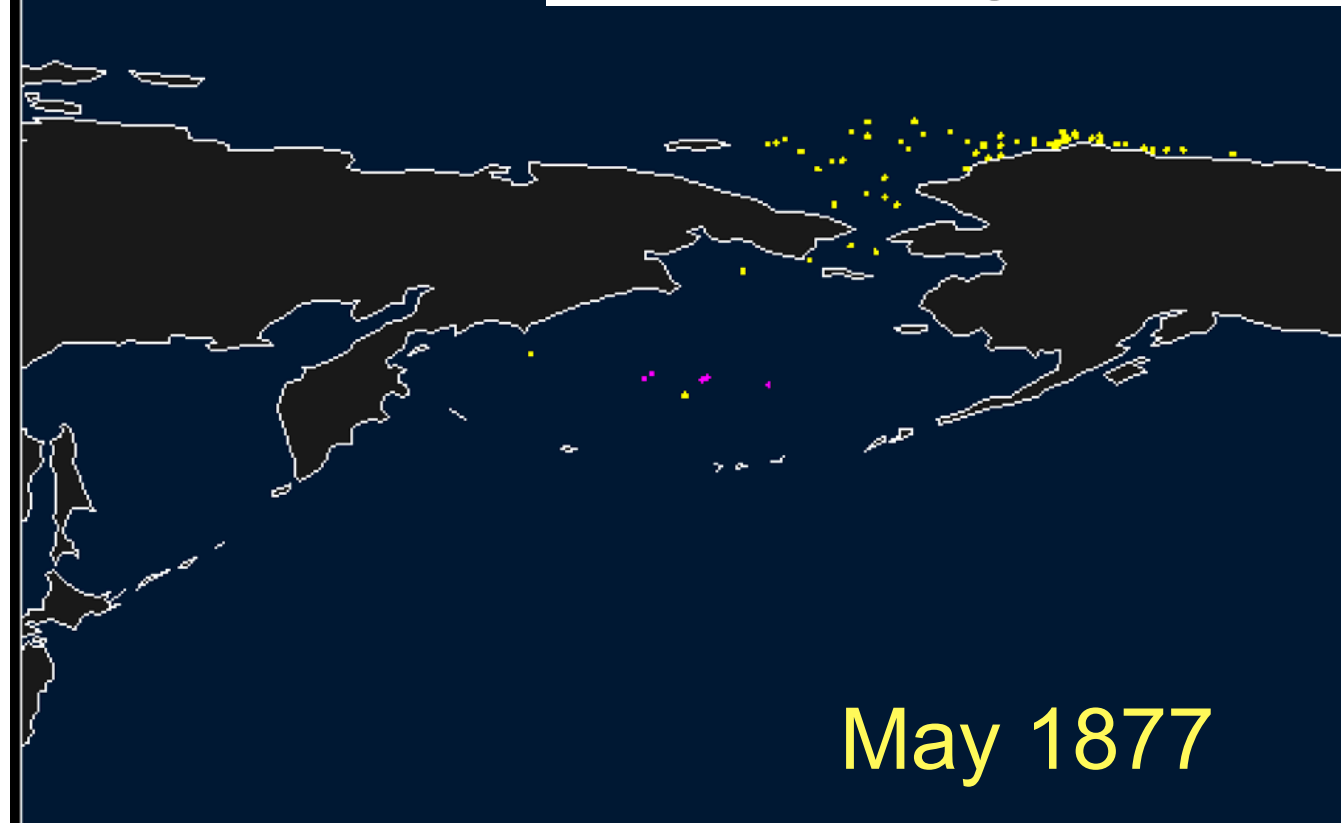
National Research Council of Canada (Brian Hill)

Whaling ship ice observations

May 1877

June 1877

August 1877

September 1877
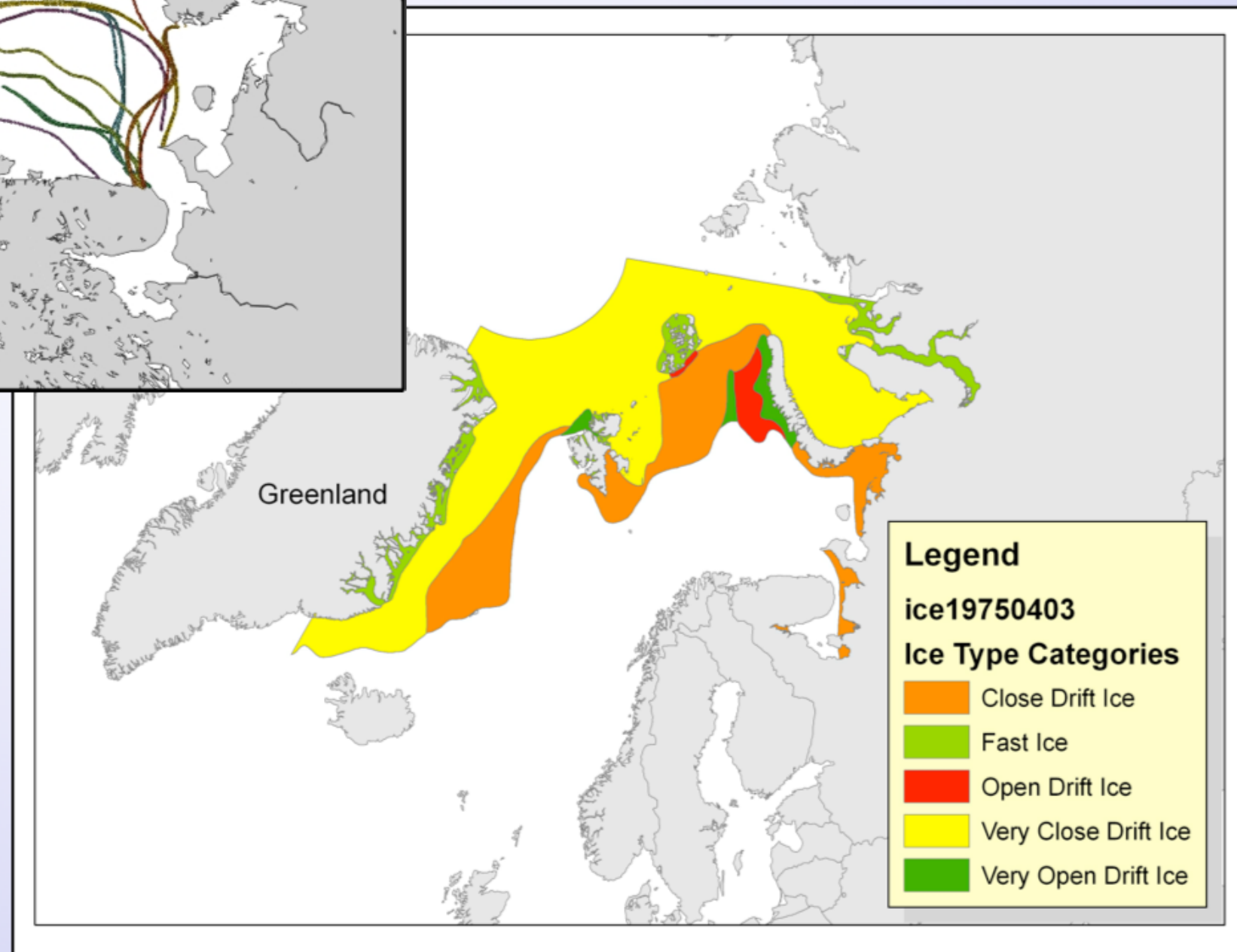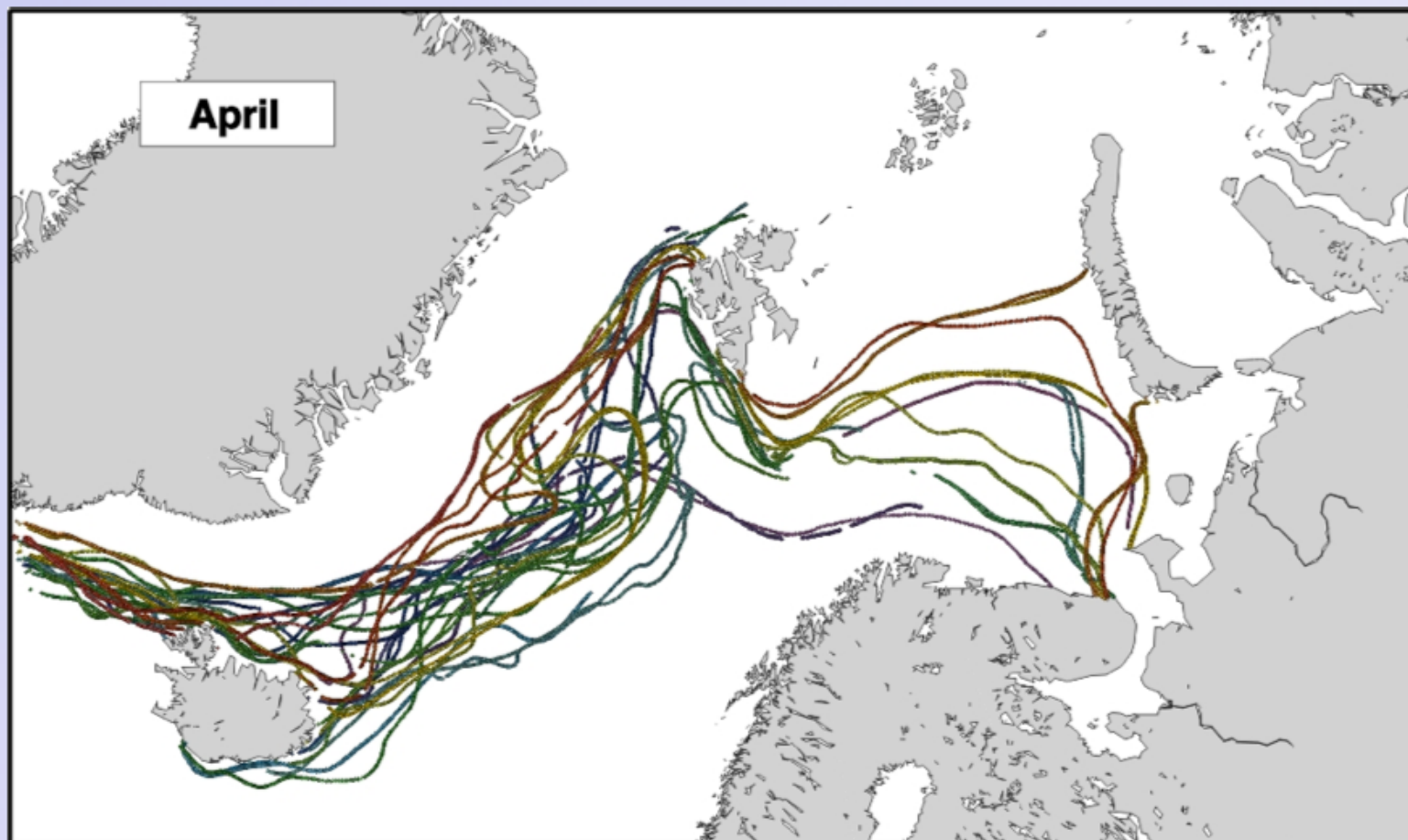
Arctic Climate System Study (ACSYS): 1800s-1970s

Approach

Data sets vary greatly in coverage, format, resolution, information content, etc. -- from whaling records ("ice" or "no ice" at scattered points) to detailed visual observations drawn on a paper charts

How to synthesize?

- **Create monthly data set "master" files in same format**

- **Fill grid cell layers with ice dataset concentration, or ice presence/absence flag**

- **When multiple sources of data are available for same region/time, assign weights (can be 1/0)**

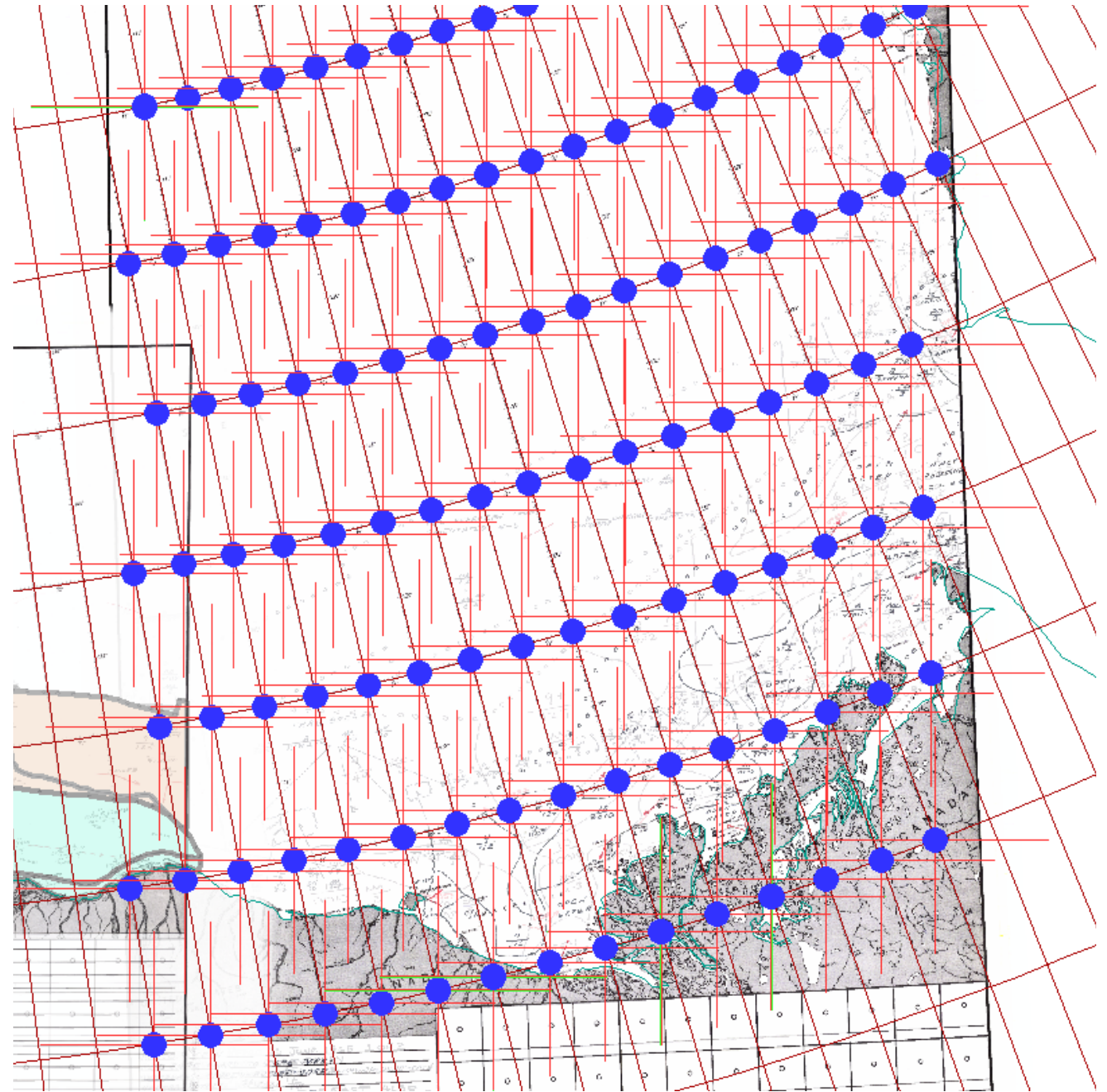**Spatial resolution of dataset: 1/2º longitude x 1/4º latitude**

Digitizing
(e.g., Dehn charts):

Geo-Referencing

3-4 Maps per hr.
RMS error <= 100m

Approach (cont.)

- Data sets vary greatly in coverage, format, resolution, information content, etc. -- from whaling records ("ice" or "no ice" at scattered points) to detailed visual observations drawn on a paper charts

How to synthesize?

- Create monthly data set "master" files in same format

- Fill grid cell layers with ice dataset concentration, or ice presence/absence flag

- When multiple sources of data are available for same region/time, assign weights (can be 1/0)

Enhancements for alternative versions of datasets

- In areas where only ice edge information is available, impose proxy concentrations based on data from satellite era

- Fill data voids using time-space interpolation with seasonally varying basis functions
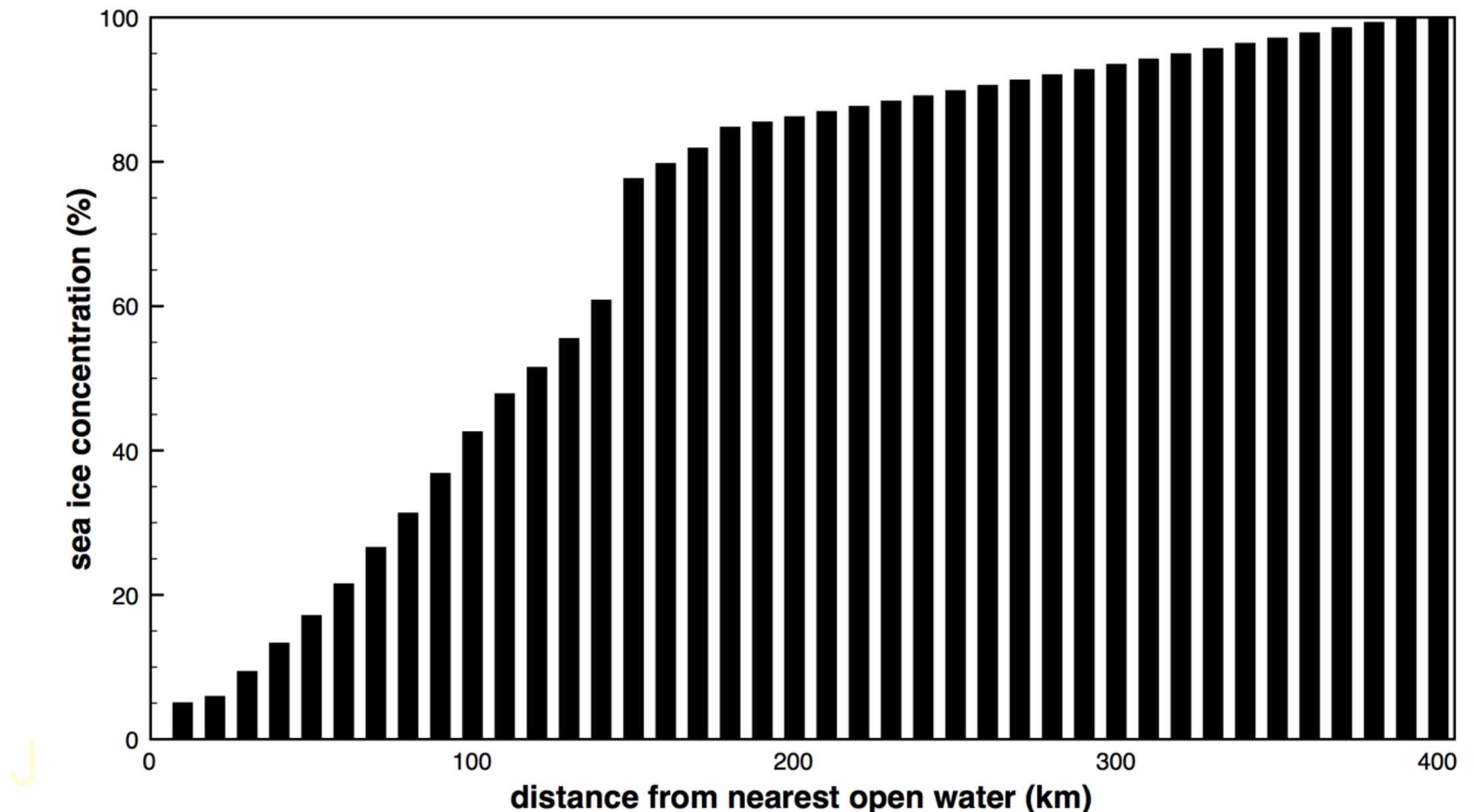
How do we get from this...

ACSYS:June 1882

to this?

June 1882
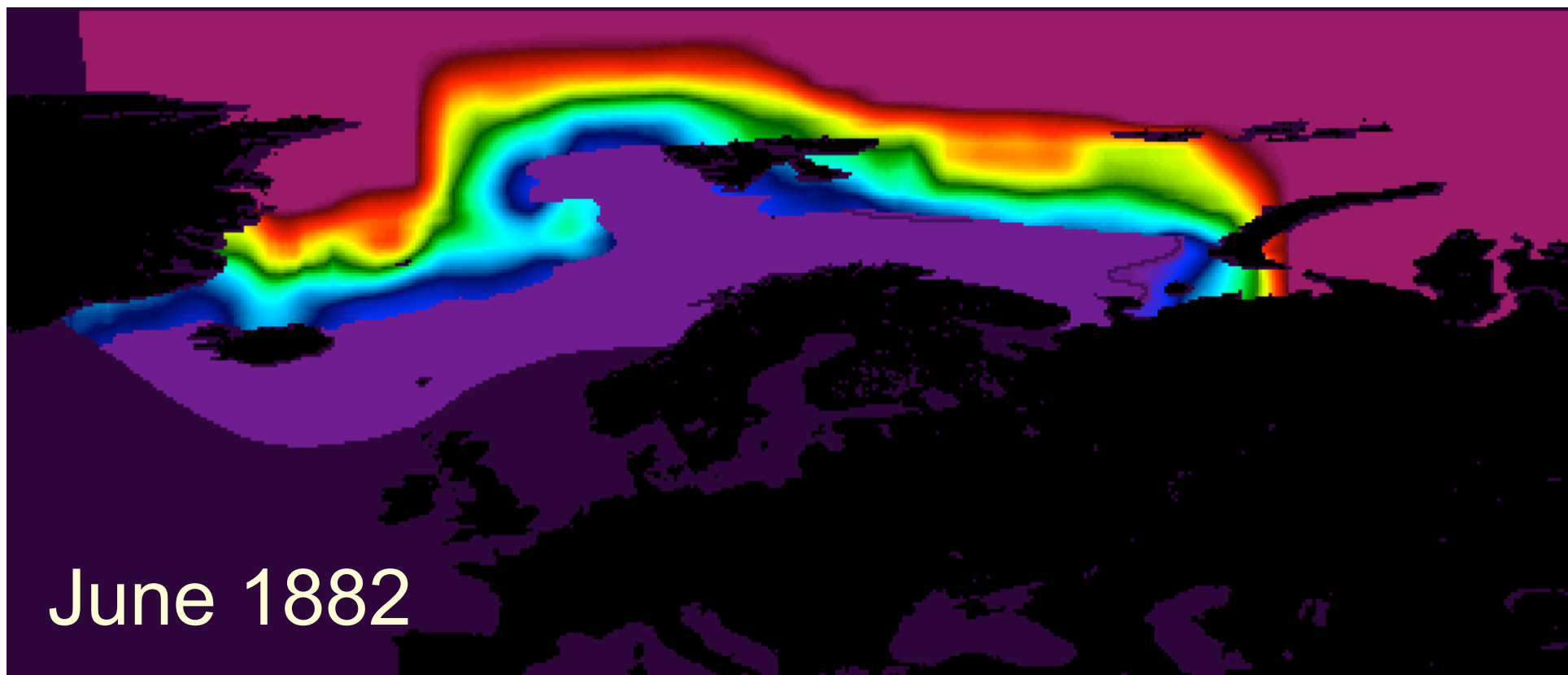
Develop sea ice concentration gradient profiles as a function of distance from nearest open water

One gradient profile per grid point per month;
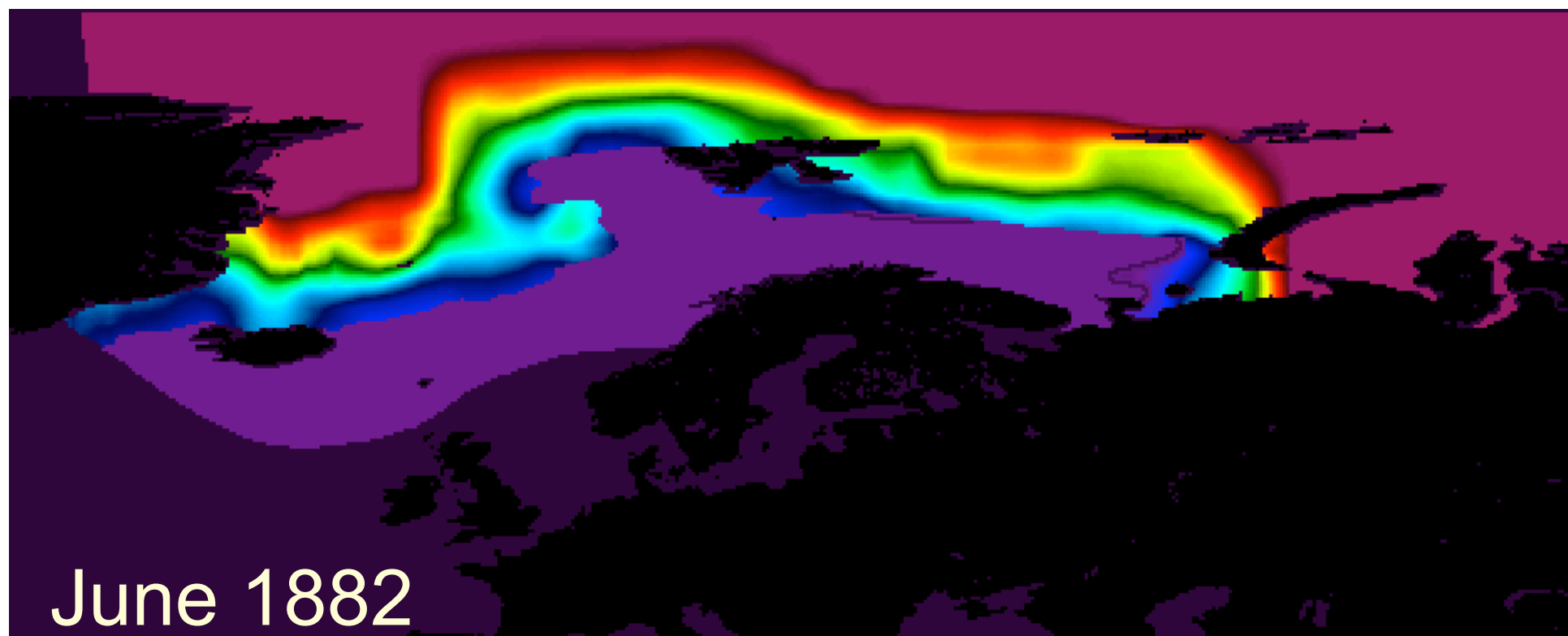Profile based on concentration observations from NIC grids, 1972-2006
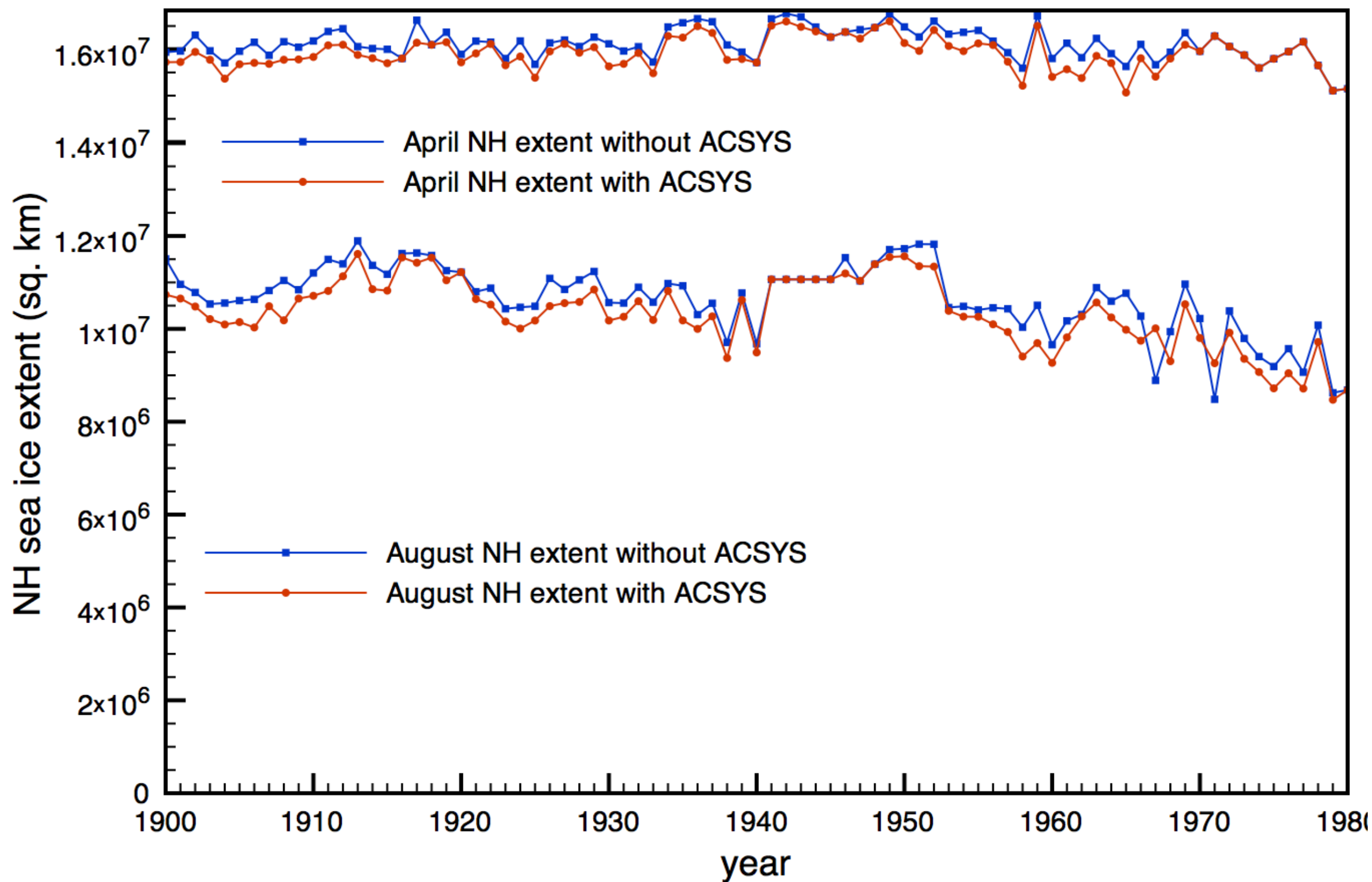
Example:

starting with extent regions

June 1882

apply gradient profiles to extent data using proximity to open water
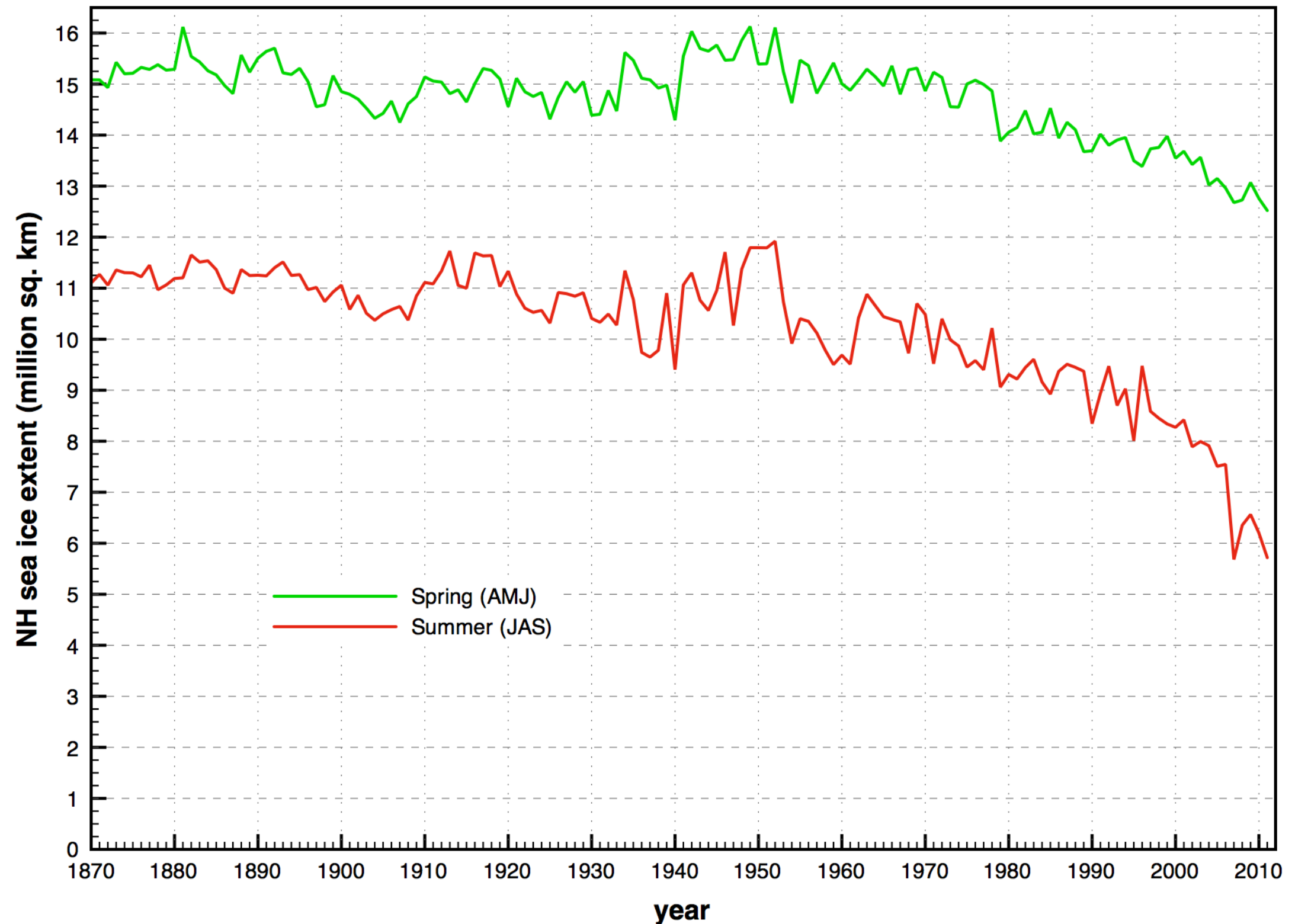

June 1882

Time series of pan-Arctic ice extent, April and August
[illustrating information added by ACSYS historical data]

Extended time series of Arctic ice extent, 1870-2011
[incorporating ACSYS, AARI sea ice data]

Prototype available at NCAR: https://climatedataguide.ucar.edu

Participants:

- **University of Alaska Fairbanks**

  John Walsh
  Lena Krutikov
  Corey Peterson

- **University of Colorado/NSIDC**

  Florence Fetterer

- **University of Illinois**

  Bill Chapman

Also linked to this work indirectly are Kevin Wood, Univ. of Washington; Hajo Eiken and Andy Mahoney, UAF