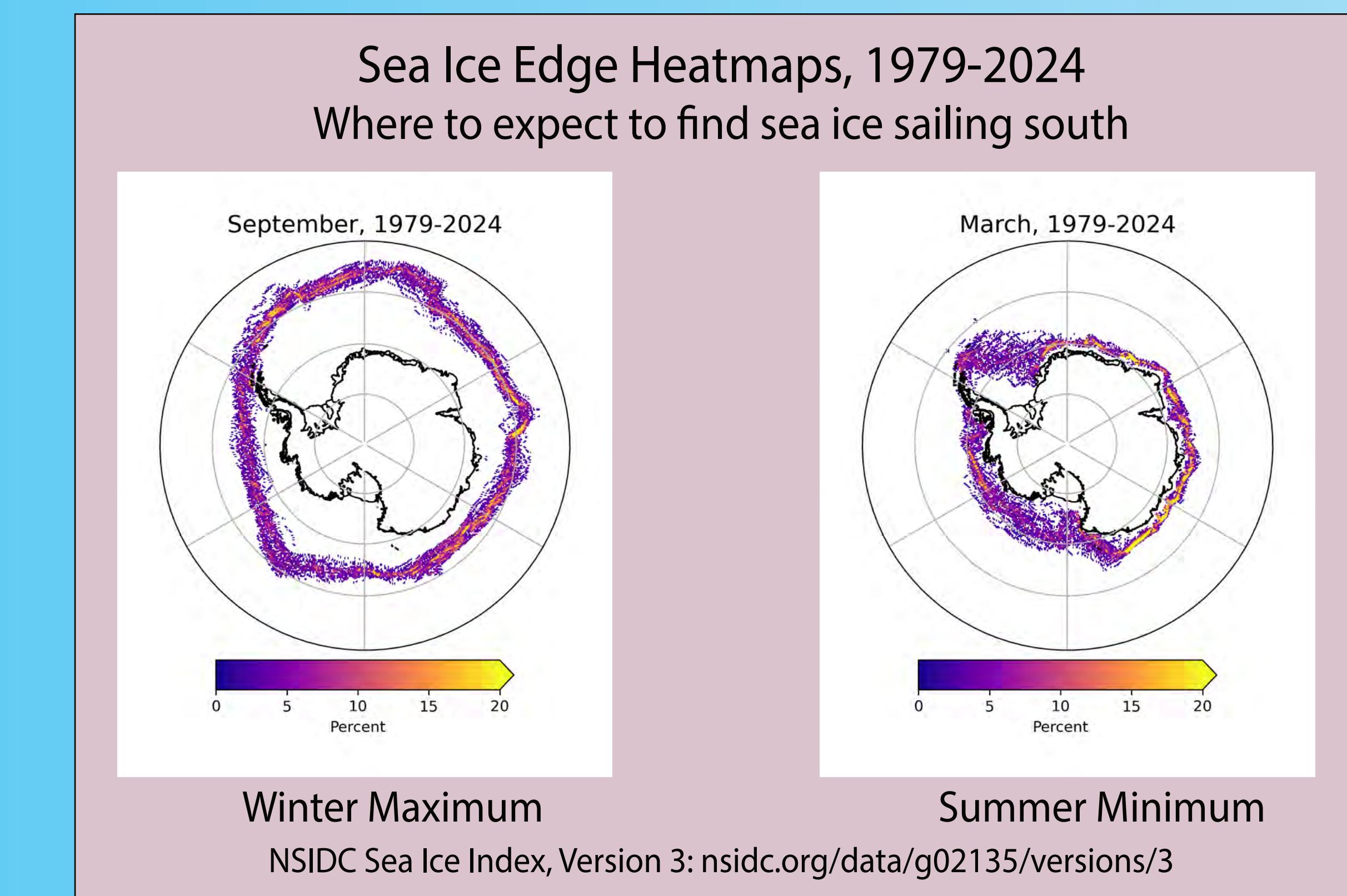
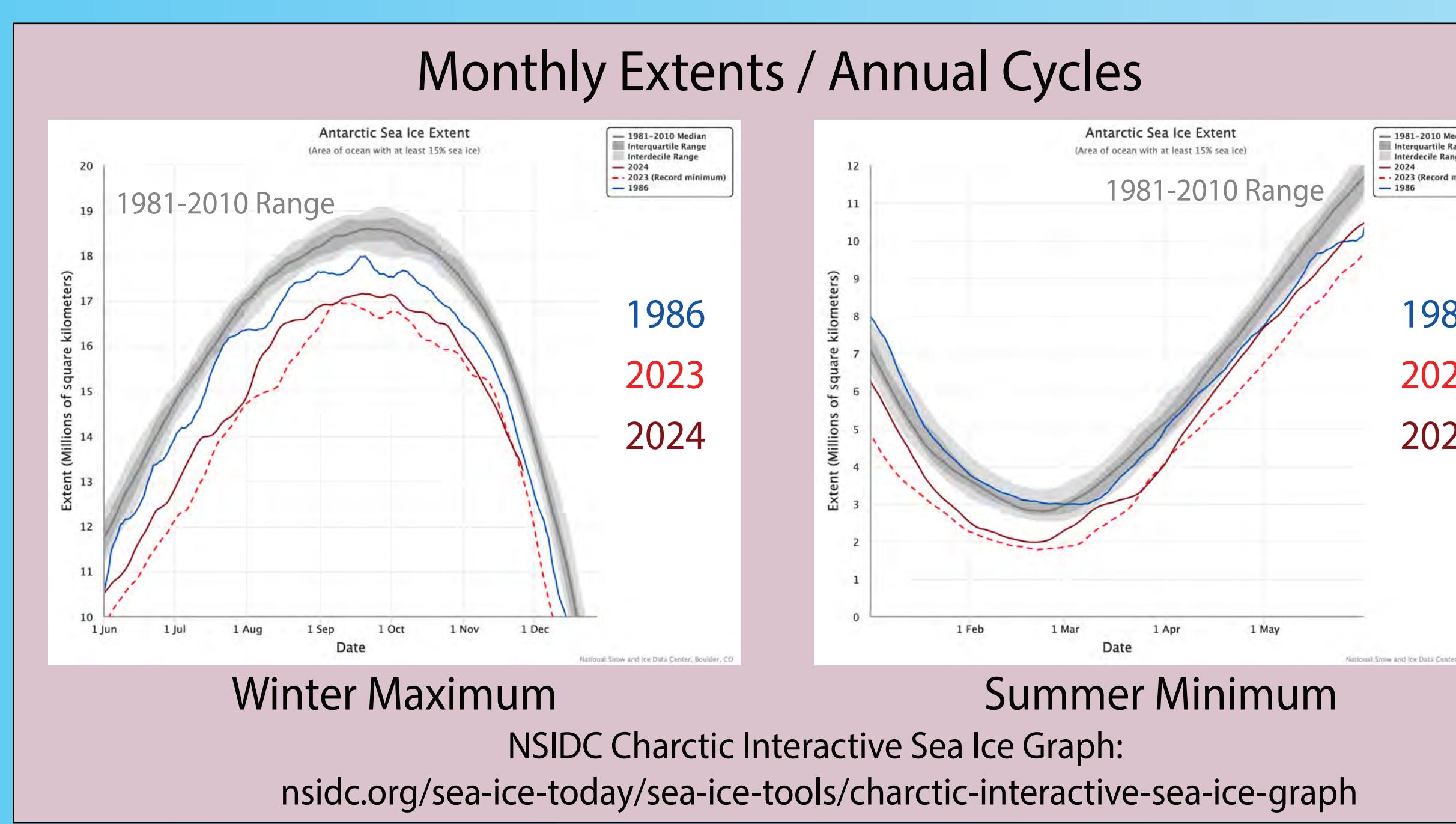
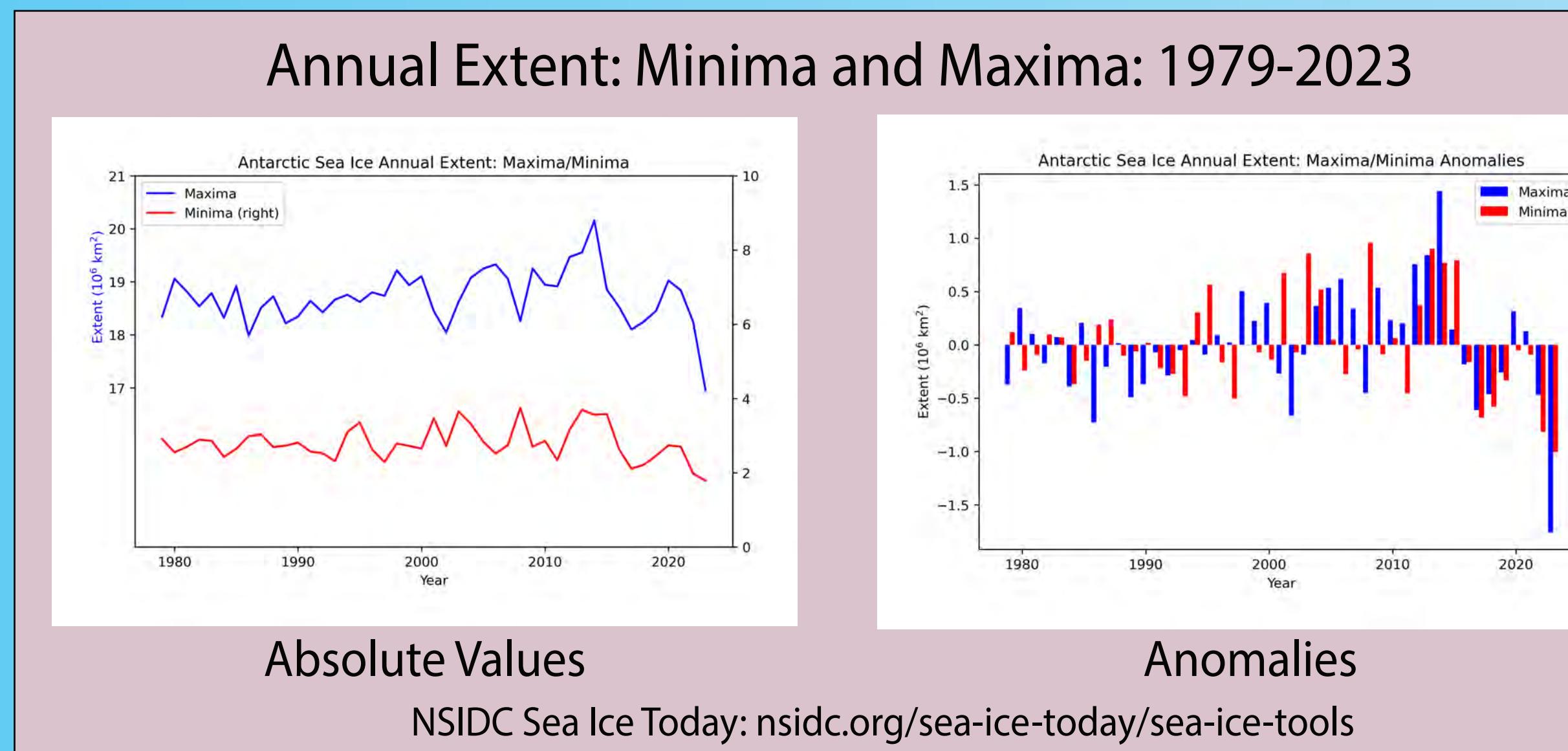
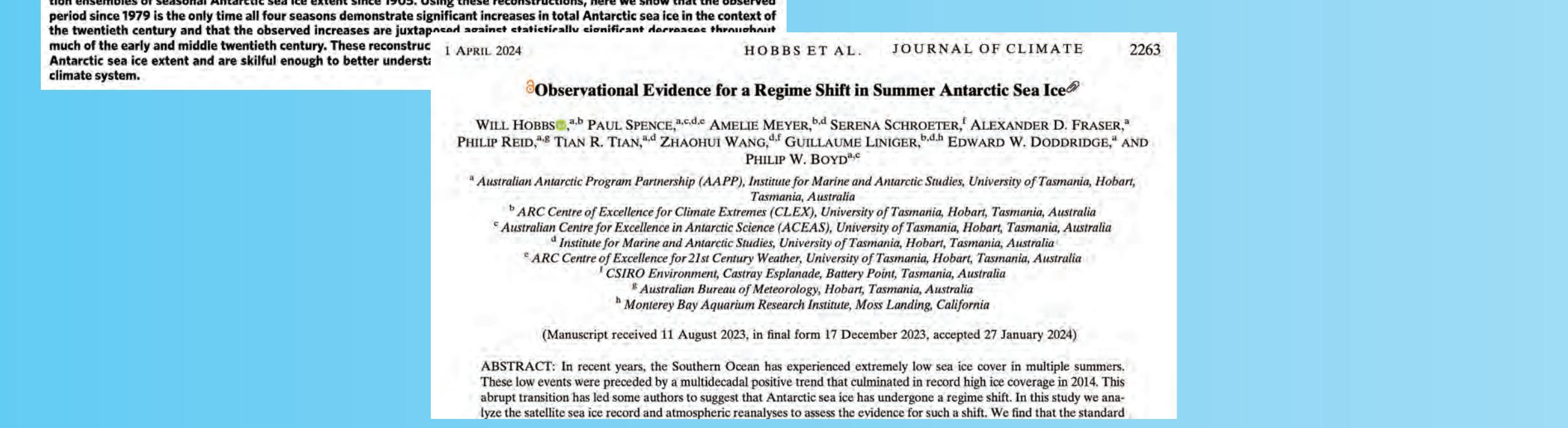


A. Introduction & Motivation

Antarctic sea ice has been getting increasing attention from the press as new record lows in winter maximum have been set in recent years. Numerous research studies have extended and improved our long-term historical records. One outcome has been growing evidence for a "regime shift" in seasonal behavior.

The experience of the *Belgica* expedition in 1898-1899 provides a rare window on sea ice conditions well before regular observations were common. By looking at modern sea ice observations, we aim to create a larger context for *Belgica*, i.e., was it just bad luck? (Spoiler: quite possibly...)



Sailing the *Belgica* Through Modern Seas: Recent and Historical Change in Antarctic Sea Ice

David B. Reusch

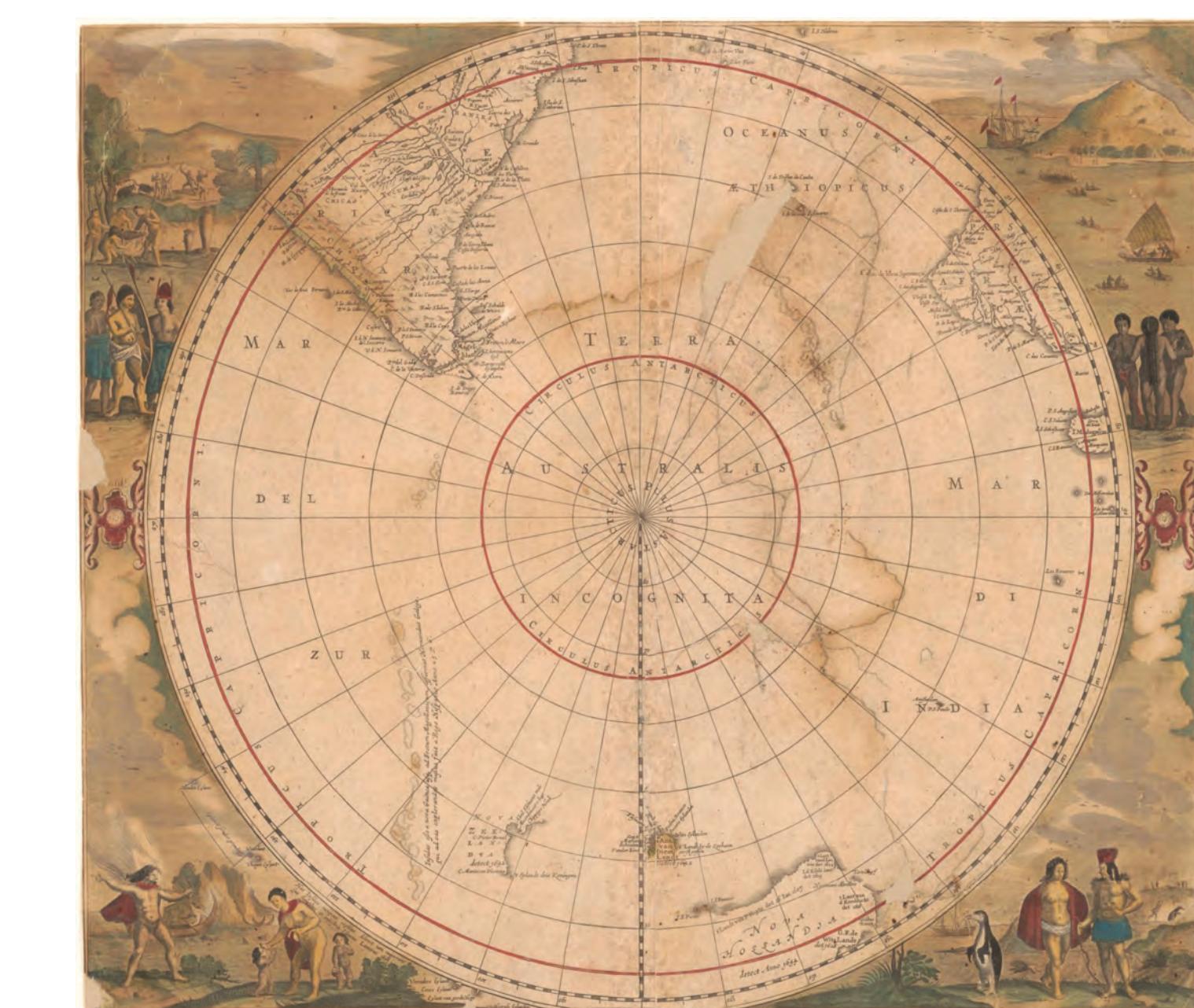
Dept of Earth and
Space Sciences
University of Washington
Seattle, WA 98195
dreusch@uw.edu

OS21C-0620

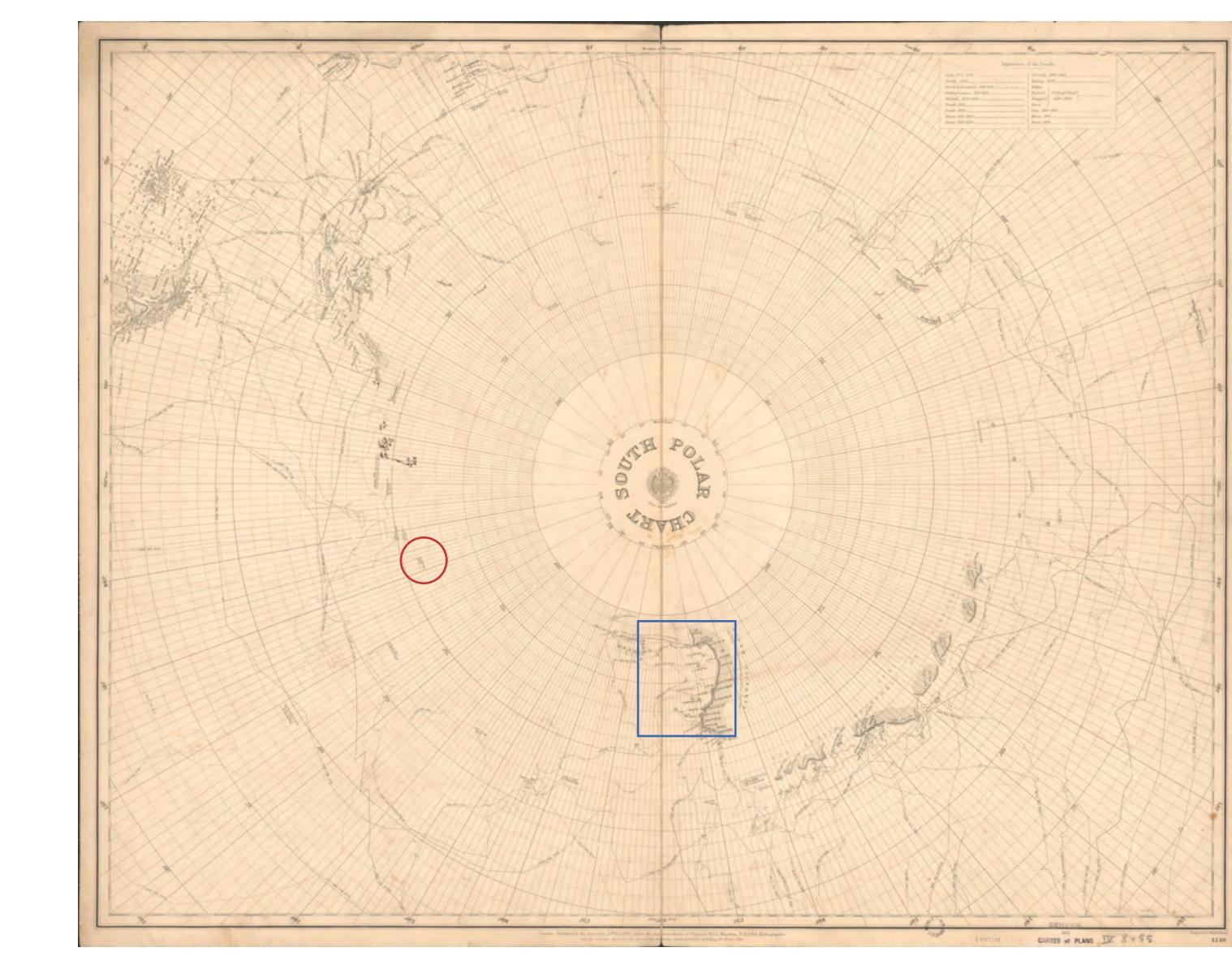
UNIVERSITY of
WASHINGTON

Sidebar: Early Antarctic Exploration

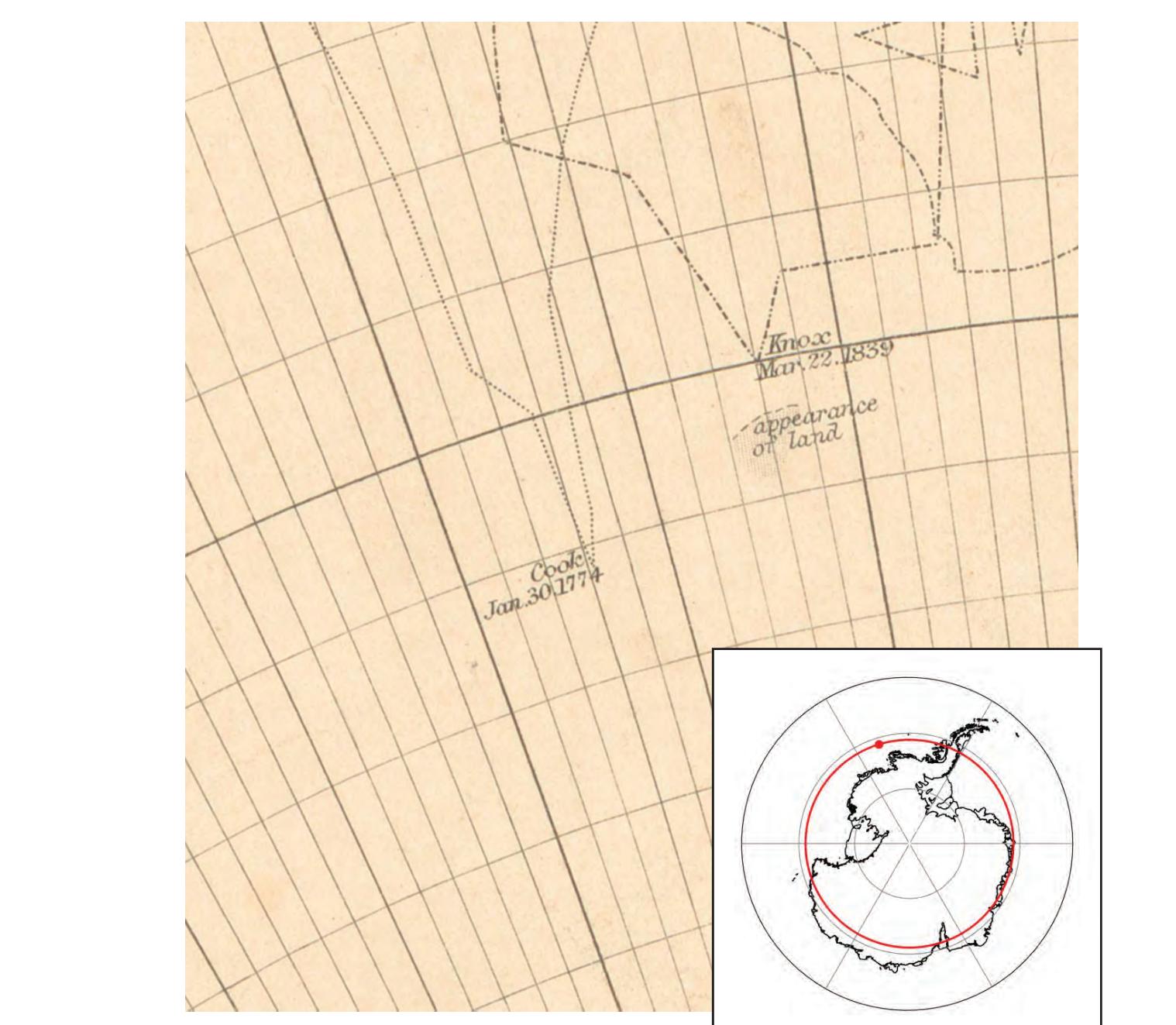
All maps from the Royal Belgian Library
opac.kbr.be/LIBRARY/doc/SYRACUSE/<number>



Map of the Antarctic regions, 1656 <21353137>
A European view of the south polar regions in the early/mid 17th century: Terra Incognita!



South Polar Chart, 1887 <21183978>
The coastline is partially discovered and the overall outline is starting to appear.
Red circle (Cook) and blue box (Ross) enlarged below.



Captain Cook's farthest south ($71^{\circ} 10'$)
Jan 30, 1774: Cook misses discovering Antarctica by being in the wrong hemisphere.



James Clark Ross expedition, Western Ross Sea segment, Jan 1841 & Feb 1842
Detail of South Polar Chart, 1887

B. *Belgica* trapped by the ice pack

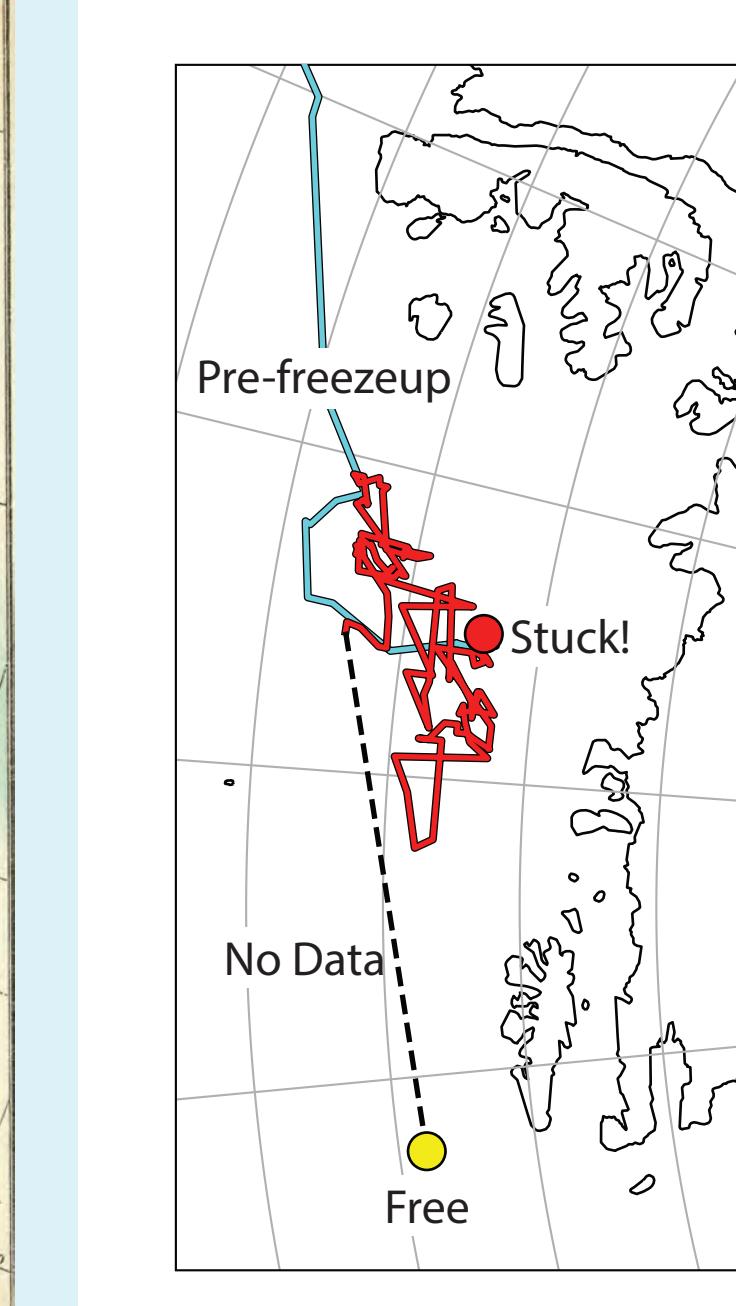
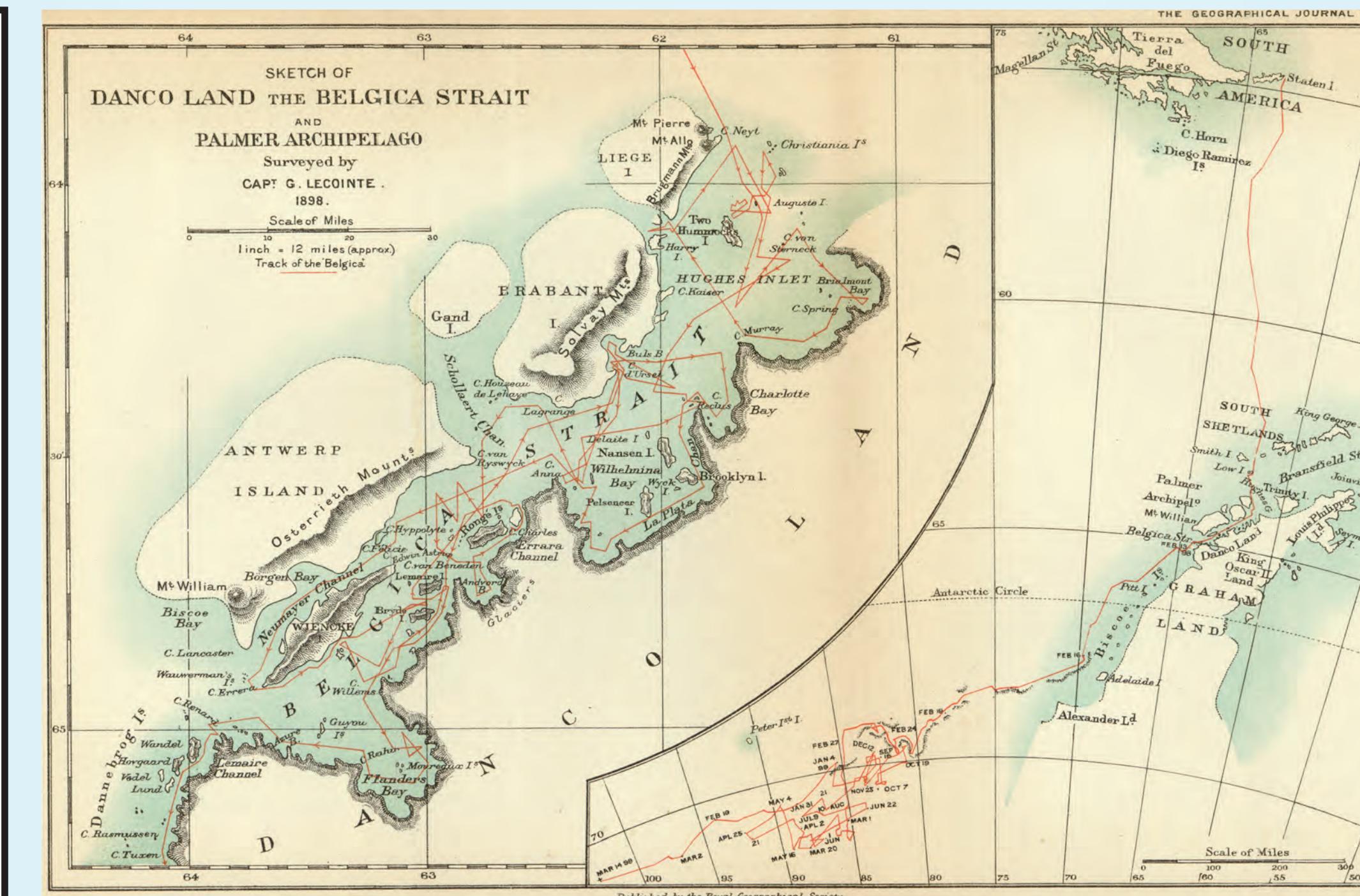
The maps at right (left: Arctowski 1901; right: data from Cook 1900) show the path of the *Belgica* during its Antarctic explorations, Jan 1898 - Mar 1899.

Mid-February 1898: After discovering and mapping the Belgica Strait, winter is coming on and *Belgica*'s progress southward is hindered daily by sea ice.

Feb 28, 1898: a storm opens an unexpected path southward after breaking up the ice pack.

Mar 4, 1898: After gaining another 167 km, the pack closes in to trap the *Belgica* for the next 53 weeks and the crew becomes the first to overwinter south of the Antarctic Circle (see center lower part of large map).

Mar 14, 1899: After extensive efforts to open a channel through the pack ice, *Belgica* regains open water.

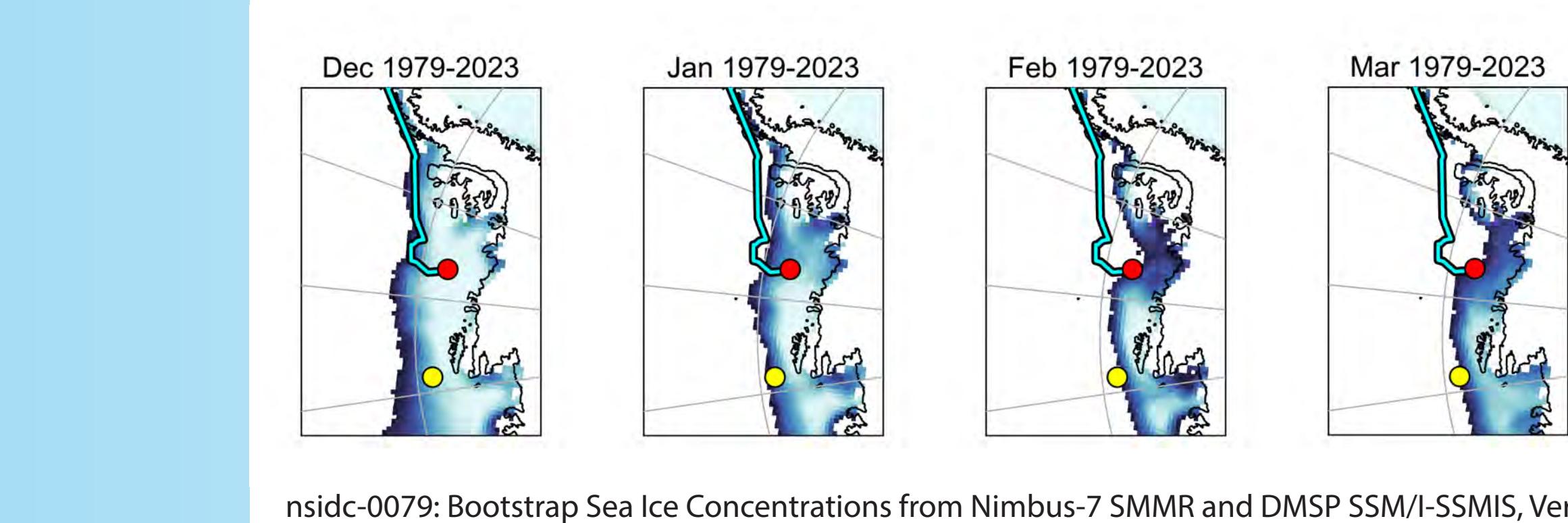


C. Modern sea ice concentrations

The plots below show (1) median sea ice concentration (1973-2023) by month and (2) a "random" subset of monthly February and March concentrations, both in the region of the *Belgica*'s 1898-99 voyage.

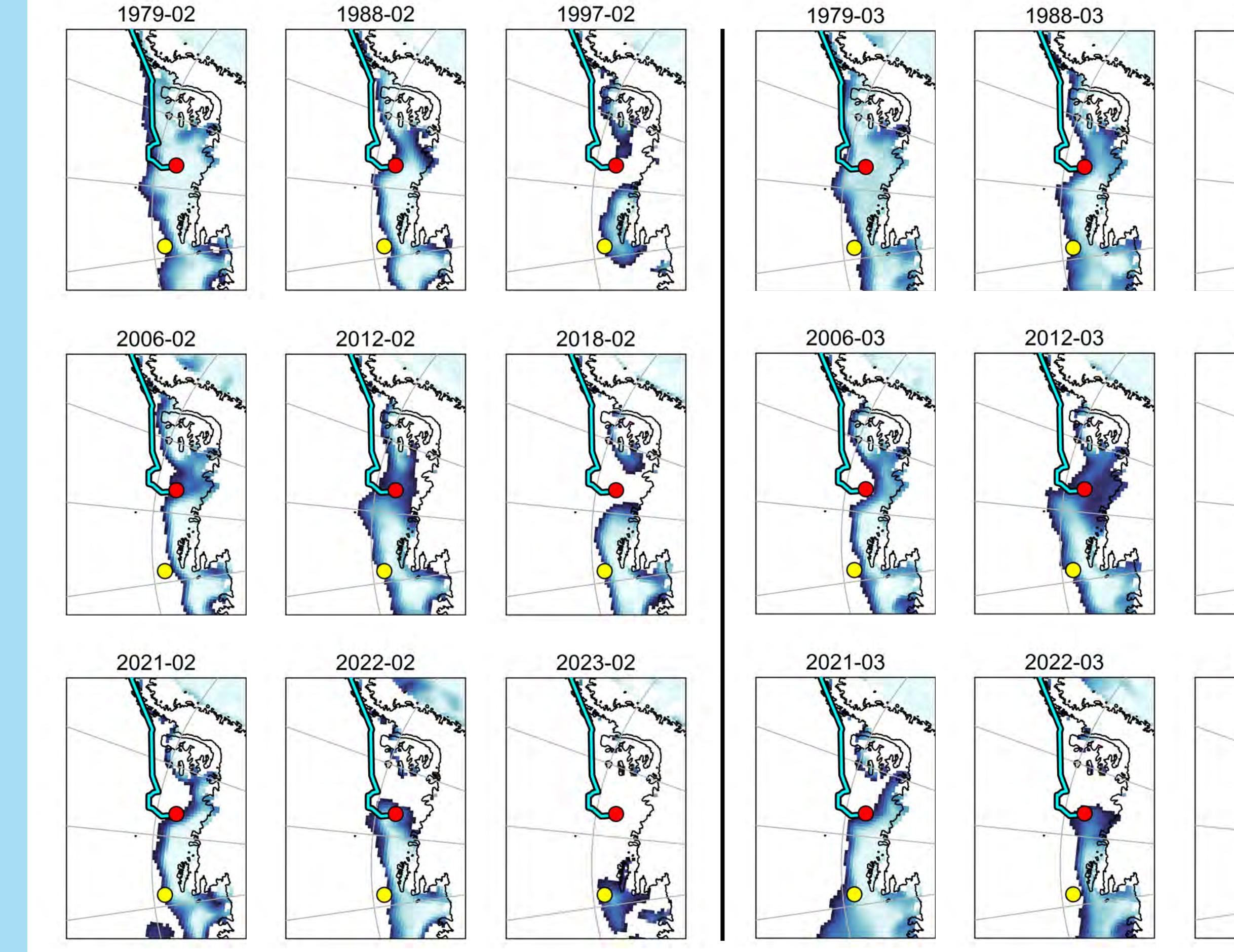
The median values strongly support February and March as the best months to be exploring this area in recent decades. The monthly observations also indicate that *Belgica* would have had few to no problems navigating this region in recent years.

1. Median Sea Ice Concentration



nsidc-0079: Bootstrap Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM/I-SSMIS, Version 4

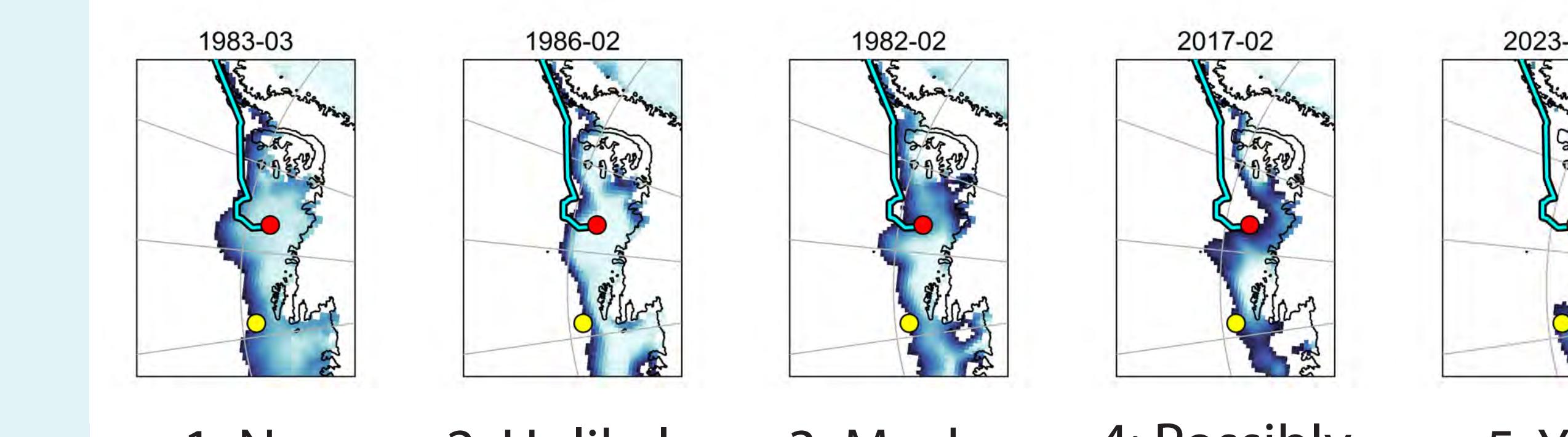
2. February



nsidc-0079: Bootstrap Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM/I-SSMIS, Version 4

D. Quantifying *Belgica*'s chances

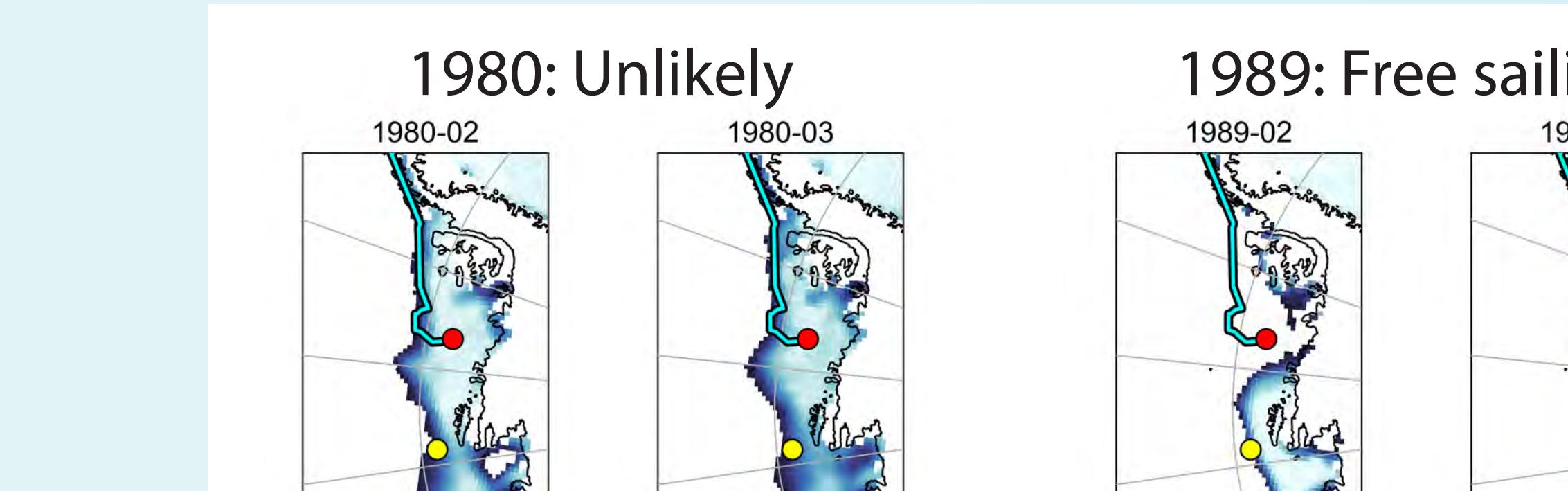
The five point scale below, drawn from the 45-year satellite record, attempts to subjectively quantify whether *Belgica*'s voyage track would be feasible or not in recent decades. Note that this assessment depends much more on the late stages of the track as much of the early/middle track remains in open water or lower concentrations even in the "No" and "Unlikely" examples.



A qualitative scale to judge feasibility of the *Belgica* track in modern times

E. *Belgica* versus the modern record

After a subjective evaluation of all February/March conditions on the scale above, only six years fell into the "no/unlikely" bins (e.g., 1980, below left) while 27 years landed in the "possibly/yes" bins (e.g., 1989 below right), i.e., 27/45 years had favorable sailing conditions. This supports the earlier analyses of median and "random" years.



F. Take home message

Four decades of modern observations show a >50% chance of favorable sea ice conditions in this region during February and March.

We can't say what the 1890s-1900s were like (not enough data) but *Belgica* would likely have a much less eventful trip sailing this region in modern times!

Acknowledgements and Appreciation:

All historical maps are from the Royal Library of Belgium (www.kbr.be/en).
The National Snow and Ice Data Center web site and data archive was invaluable (nsidc.org).
Colormap for sea ice concentration is from the cmcean module (matplotlib.org/cmcean)

Search keywords for online articles:

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"Antarctica, Earth's largest refrigerator, is defrosting": economist antarctica refrigerator
"The first Antarctic expedition: tracing the voyage of the Belgica": first antarctic expedition tracing voyage belgica