Coastal sea ice: a case study in observing system analysis

Alice Bradley, Rachel Obbard (Dartmouth College, USA)
abradley@dartmouth.edu

A study of coastal sea ice conditions highlighted both certain gaps in the Arctic Observing system and the potential for different types of observational techniques to fill in those needs.

Motivating problem:

In preparation for a Fall 2017 field campaign based around freeze-up near Utqiagvik (formerly Barrow), Alaska, our research group was having a hard time finding information on the timing of sea ice formation in the region. Questions regarding freeze-up dates, the stability of the initial ice cover, and the frequency of open water events were critical to our planning purposes, and the lack of available observations to address these questions highlighted specific gaps in the observational system.

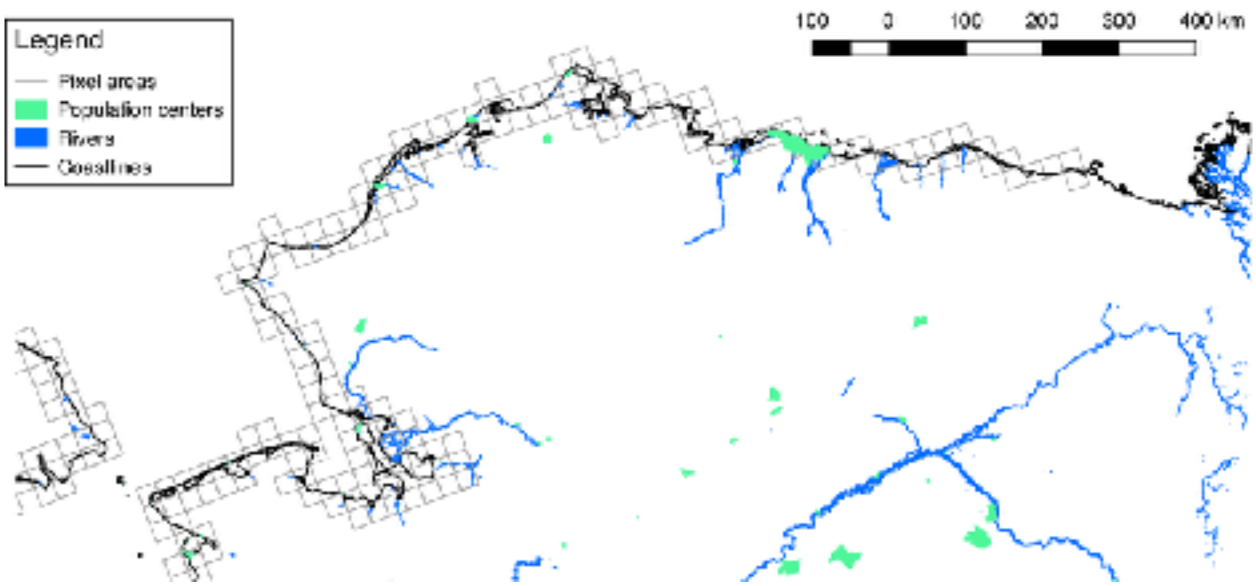
General concept:

While little of the Arctic can be said to be throughly monitored, some locations, seasons, and conditions are better monitored than others. Investing in platforms to fill in existing gaps in the observation network is necessary to improving the overall observational system. Remote sensing resources offer remarkable geographic coverage and often frequent temporal repeat, but have physical limitations that mean that certain locations and certain times of year are not well studied. Just as the IceBridge campaigns provide some continuity between satellite operations, well-placed observational systems can bridge gaps between remote sensing approaches across geography and season. The approach used in this case study illustrates how complimentary observational techniques can fill gaps in the observing system, leveraging available resources and opportunities to better understand the changing Arctic environment. An optimized Arctic Observing System will place special care to identify observing needs around the edges of the scope of remote sensing and in situ observational platforms and strategically fill those gaps wherever possible.

Observing system analysis:

To address the question regarding historical timing of freeze-up in the area surrounding the field sites, we first accessed remote sensing data. Passive microwave sea ice extent datasets, which provide daily repeat frequency in the Arctic, have been used to study freeze-up timing in the central Arctic [Stroeve 2014]. Unfortunately, these retrievals are undefined near shorelines [Cavalieri 1996], leaving a line of missing pixels surrounding the areas of interest. Visible imagery is particularly limited during the freeze-up season, when lack of sunlight and frequent cloud cover make for few images between October and February [e.g., Hall 2015]. SAR satellite coverage is extremely limited, though the extant data is of high spatial resolution and extends right up to shore.

Figure 1 shows a map of the northern Alaska coastline, with major rivers and population centers noted in blue and green respectively. Coastal pixel areas are shown in gray boxes, dividing space between the pixel centers evenly to define the grid [Maslanik 2004]. These pixels contain both a non-zero area of land and a non-zero area of ocean, and are therefore undefined in the passive-microwave sea ice extent records. These areas are a particular challenge to observe, especially in the winter season when visible imagery is unavailable to supplement the lower-resolution passive microwave retrievals. These areas include a number of shoreline types, including river outlets, permafrost bluffs, and rocky cliffs. Sea ice is an integral part of the ecosystem, but without better data regarding the presence of ice in these areas, the research on coastal ice interactions is limited. Population centers are marked in green, which are both locations where reliable sea ice extent information would be most



valuable for human activity and locations that would be easiest to gather additional information.

Because the area of interest for our study was near Utqiagvik (formerly Barrow), Alaska, the research questions could be addressed using a combination of archived webcam images (http://seaice.alaska.edu/gi/observatories/barrow_webcam) shore-based sea ice radar (http://seaice.alaska.edu/gi/observatories/barrow_radar), and local records of ice conditions archived through the ELOKA (eloka-arctic.org). These resources proved invaluable to working around an observation bias towards clear days that resulted in working from the limited visible imagery.

Known observing system needs and opportunities:

Coastal sea ice remains under-observed, especially in the freeze-up season where darkness and persistent cloud cover obscures satellite-based visible imagery. While in-situ assets are difficult to maintain in remote locations, strategic placement of several sea ice observing stations would extend the sea ice extent record to the shoreline. Communities along the Arctic coastline reduce the logistical cost of these investments, as even simple notes of sea ice conditions near shore dramatically improve the available information on the subject. Investing in training and compensating local reporters, and supplementing their notes with a few webcams and/or sea ice radars at locations with regionally representative sea ice conditions, would go a long ways towards improving the observing system's coverage of a scientifically, economically, and ecologically dynamic environment.

References:

Cavalieri, D. J., C. L. Parkinson, P. Gloersen, and H. J. Zwally. 1996, updated yearly. *Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM/I-SSMIS Passive Microwave Data, Version 1*. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: https://doi.org/10.5067/8GQ8LZQVL0VL

Hall, D. K. and G. A. Riggs. 2015. *MODIS/Aqua Sea Ice Extent 5-Min L2 Swath 1km, Version 6*. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: https://doi.org/10.5067/MODIS/MYD29.006.

Stroeve, J. C., Markus, T., Boisvert, L., Miller, J., & Barrett, A. 2014. Changes in Arctic melt season and implications for sea ice loss. *Geophysical Research Letters*, *41*(4), 1216-1225.

Maslanik, J. and J. Stroeve. 2004, updated 2017. *DMSP SSM/I-SSMIS Daily Polar Gridded Brightness Temperatures, User guide*. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: https://doi.org/10.5067/AN9AI8EO7PX0.