

Sea Ice Trafficability Support Using Unmanned Aircraft Near Barrow, Alaska

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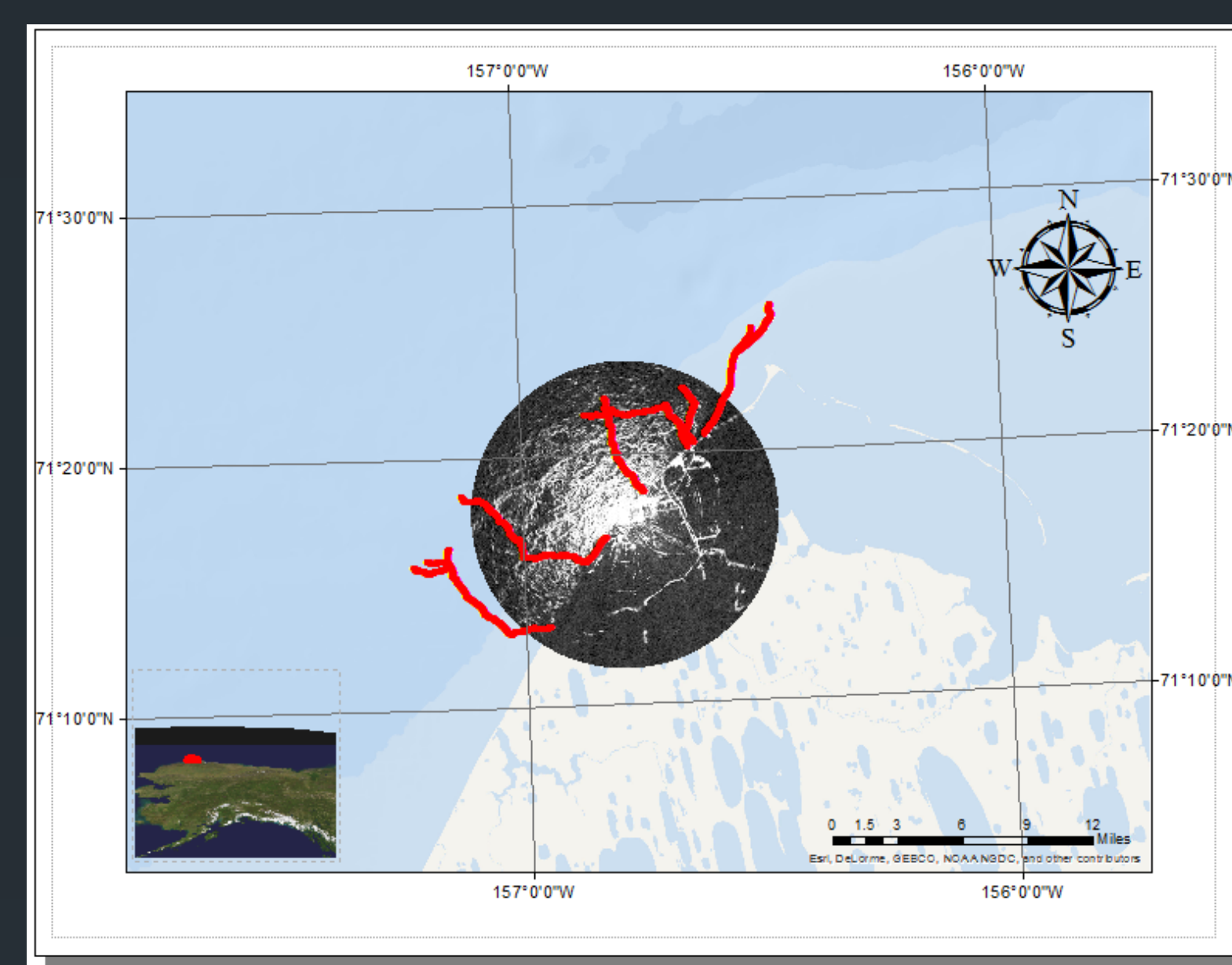
Abstract

Arctic sea ice undergoing rapid changes is currently a major concern in the context of climate change, indigenous ice uses and resource development in the North. Considering the need for Arctic residents to adapt to such change, evaluating what technological advances can provide critical information about the ice trafficability to coastal residents is particularly important.

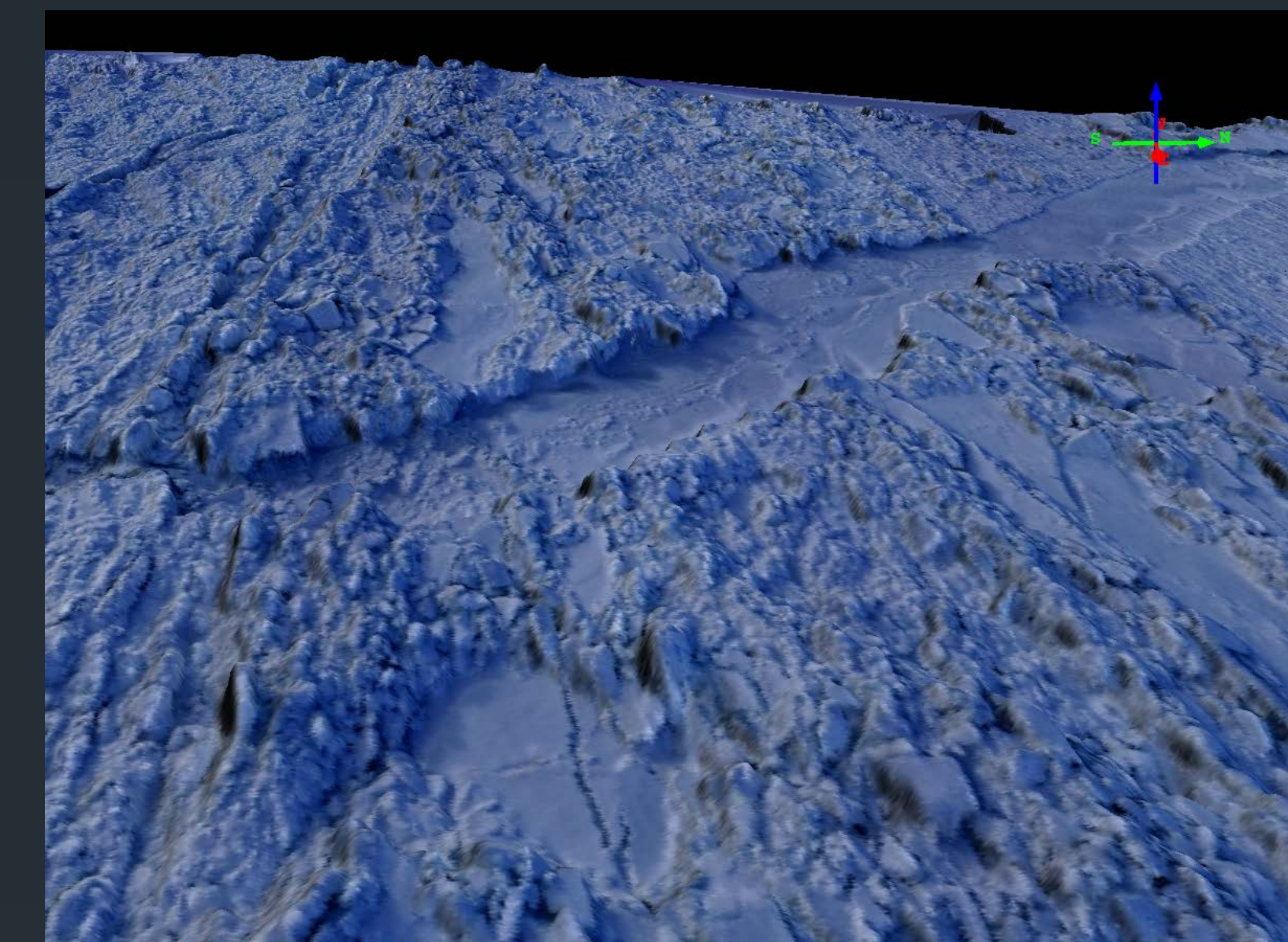
The community of Barrow is dependent on sea ice for the annual subsistence spring whaling. New trails in the ice are created each year and the locations depend on ice conditions and in large part the roughness of the ice. The topography of the ice dictates the amount of resources needed to build trails as well as provide important information about the ability of the ice to withstand wind and ocean forcing by added stability from grounded ridges. Roughness of sea ice is difficult to assess from shore for ice users as well as using existing remote sensing tools such as the coastal marine radar that is stationed in Barrow as part of the Barrow Sea Ice Observatory.

In a joint effort between the sea ice group and the Alaska Center for Unmanned Aerial System Integration (ACUASI) at the University of Alaska Fairbanks, ice topography was mapped in conjunction with the annual ice trail mapping effort as part of the Seasonal Ice zone Observing Network (SIZONet). The goal of this pilot study is (1) to investigate UAV capabilities to map roughness of the landfast ice (e.g. pressure ridges, rubble fields, refrozen leads) using structure-from-motion and (2) explore the potential benefits of ice roughness information for local whalers prior to trail building. A small hexacopter was equipped with a high-precision GPS and a camera setup designed by ACUASI to perform under high-latitude conditions. The survey strategy was developed in collaboration with local whalers to maximize the benefit of the final product.

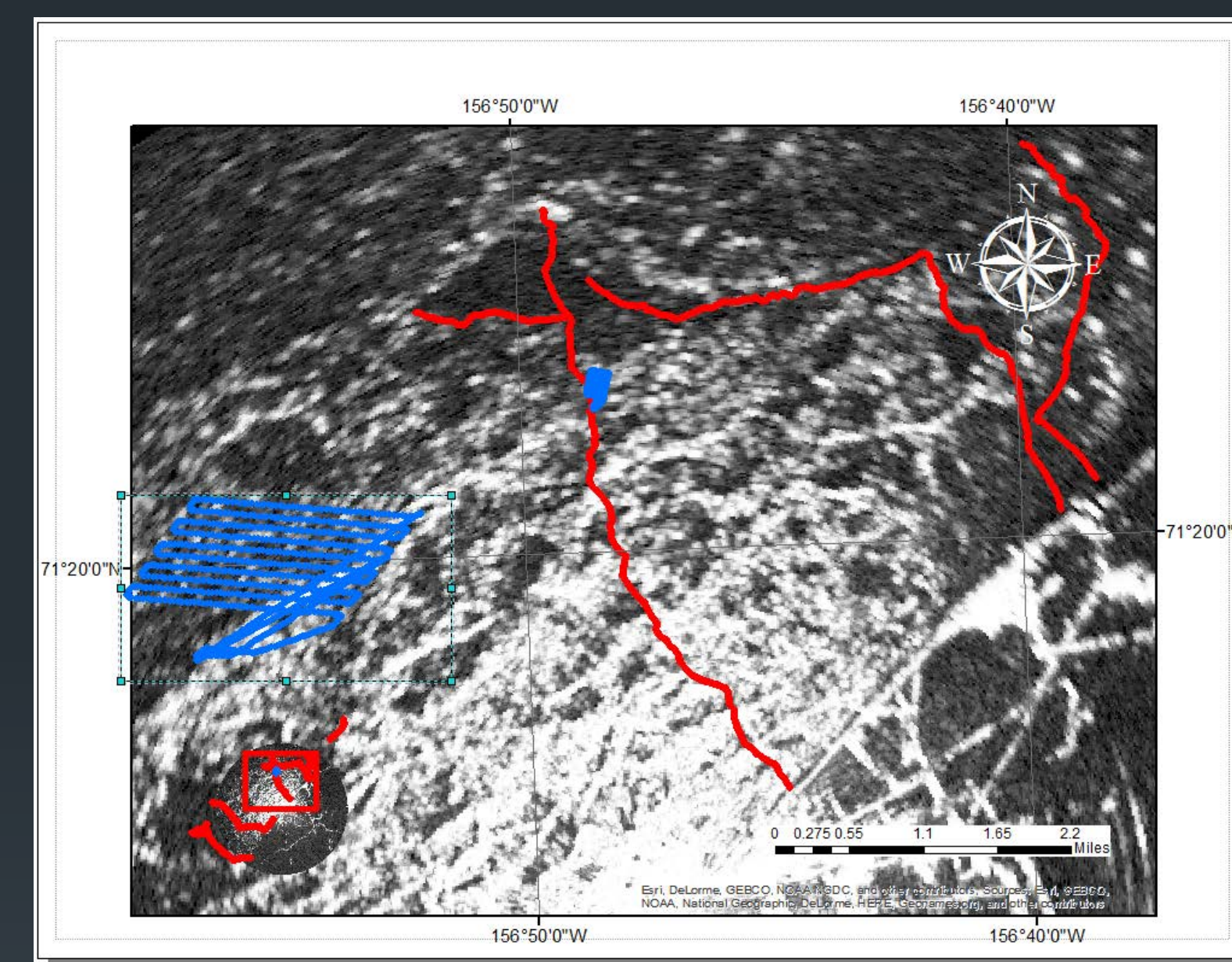
Data collection sequence



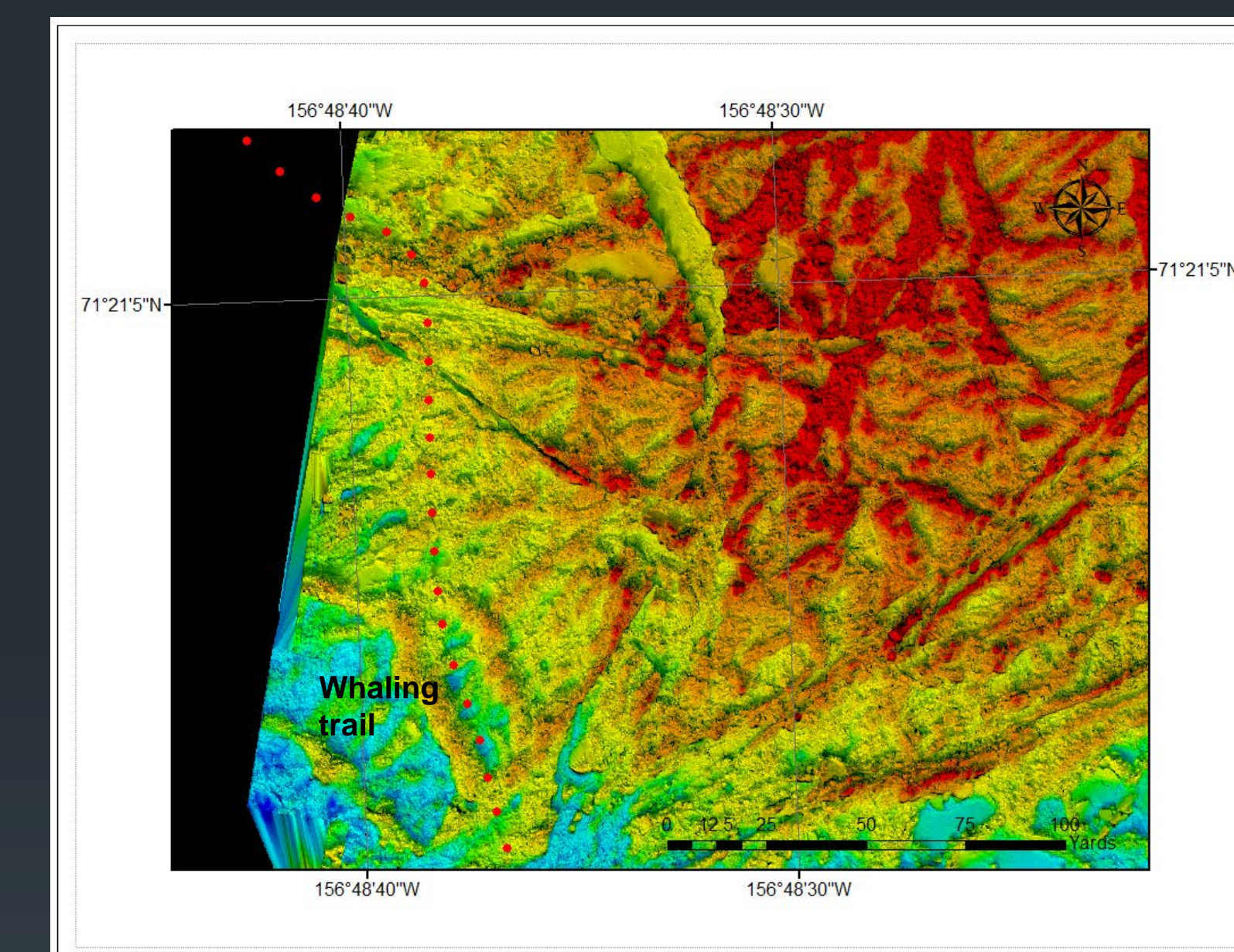
Local ice trails (red) superimposed on marine radar image (part of sea ice observing network in Barrow). The radar detects ice up to about 7 miles off shore and is continuously operating



A UAS-generated 3D image shows a refrozen lead as well as a crack (extending from the bottom of the image towards the center). Each pixel shows the color captured by the Sony 24.3 MP camera giving the appearance of a 3D image.



Enhanced image above showing the trail where survey was conducted. Bright (dark) areas indicate rough (smooth) surface. While the radar provides important information about extent of rough areas, it does not provide the height of the ridges (critical for trail building). Other limitations are spatial coverage, resolution, and radar shadows. Survey flight path is shown in blue (over the trail) and is enhanced on the left side of the figure.



A subset of the Digital Elevation Model (DEM) constructed from the survey. The map is generated using a technique called "Structure from Motion" using optical georeferenced images captured by the UAV. The height difference between ridges (red) and lower areas (blue) is roughly 5m. The red dots mark the ice trail avoiding the roughest part (red).

Challenges operating in the Arctic and potentially extreme weather

- ❖ Survey was conducted at ~5 F and at times during wind gusts and blowing snow
 - Weather is hard on equipment and makes it difficult to keep batteries warm to sustain long flights
 - Keeping people warm for long periods of time handling fragile equipment and remote control
 - Sudden weather changes makes planning difficult
- ❖ Global Navigation Satellite System (GNSS) and Internal Motion Unit (IMU) are less reliable in Alaska and specifically in the Arctic
 - Major concerns regarding aircraft compass and the impact on the UAS autopilot
 - Periods that GPS quality was too poor to fly
- ❖ Large data files (~5 GB for a 400m x 400m) that needs to be downloaded in the field
- ❖ Air space
 - Operations near airport require constant coordination with air traffic regulators to share airspace with airplanes in the area

Conclusions

- ❖ Hunters found the maps helpful and expressed an interest in a continuation of this project mapping larger areas aiding in decision-making of future trail building
- ❖ For extensive flights below the temperatures experienced on this trip (~5F), pilot and equipment will need to be sheltered from the elements with use of tents etc.
- ❖ To map larger areas, UAS need to operate at comparable altitude as manned aircraft.
- ❖ Nearby airfields and associated regulations can be a challenge for optimal survey strategy (additional complications when the UAS needs to be operating at altitudes exceeding 1000ft near airports)

Potential future work

- ❖ Expand survey area by using a fixed-wing UAV
- ❖ Start surveying earlier in the season to allow for timely distribution of maps to community to aid decision making of trail building
- ❖ Work with hunters to explore optimal data products for hazard mitigation and safety during trail building (e.g. map of grounded ridges, map of trafficable ice etc.)
- ❖ Improve data accessibility by making products available on smartphones that can be used by the hunters on the trails
- ❖ Extend approach to evaluate ice safety and escape, evacuation and rescue (EER) approaches in coastal shorefast ice for industry operations and Search and Rescue

Acknowledgements

We thank the Barrow Whaling Captains Association and the community of Barrow providing guidance for this work both prior and during the mission. We particularly acknowledge the contribution by whaling captain Eugene Brower and Harry Brower Jr. We thank Craig George and the rest of the Department of Wildlife Management for guidance and logistic support in the field. We acknowledge UIC Science for their logistic support making this mission possible. We thank the pilot John Roberts for his efforts including coordinating the airspace.

Steps carried out critical for a successful UAV mission in support of local indigenous people

- ❖ Prior visit to Barrow and meeting with representatives of the Barrow Whaling Captains Association to discuss benefits and potential concerns with respect to the mission. The meetings allowed for development of a mission tailored to the hunters' interest from the perspective of health and safety as well as securing the necessary approvals
- ❖ Selection of aircraft and payload that can perform under local conditions and provide data addressing key questions and information needs
- ❖ Conduct noise tests and make sure levels are below acceptable range for the hunters
- ❖ First test flight in Barrow to establish UAV capabilities at high latitudes and safe operating conditions
- ❖ Second test flight to determine necessary logistic operations, range of the UAV, battery capacity and data collection
- ❖ Communication with local hunters in the field to make last-minute changes in flight plan in accordance with their trail breaking route plan
- ❖ Distributing data in town and on the trail and receive feedback on product, its use, and future improvements to ensure safety and hazard mitigation during trail building

Illustrated mission sequence



Breaking trails to the water is a community effort that can take up to several weeks



Testing and calibrating aircraft compass. Up to the test flight, there were concerns among engineers how well the aircraft compass would operate at high latitudes



Checking aircraft and payload before takeoff to make sure everything is working properly



Programming and testing payload before survey



Aircraft is taking off to survey the ice ridges ahead of the crews breaking trail



Maps constructed from survey were made accessible and shared with hunters out on the trail