

DMS
Digital Mapping System

IceBridge Applications of DMS Imagery

John Arvesen - Cirrus Digital Systems

Ryan Dotson - Fireball Information Technologies

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Seattle IceBridge Science Meeting June 29, 2010

DMS – Digital Mapping System

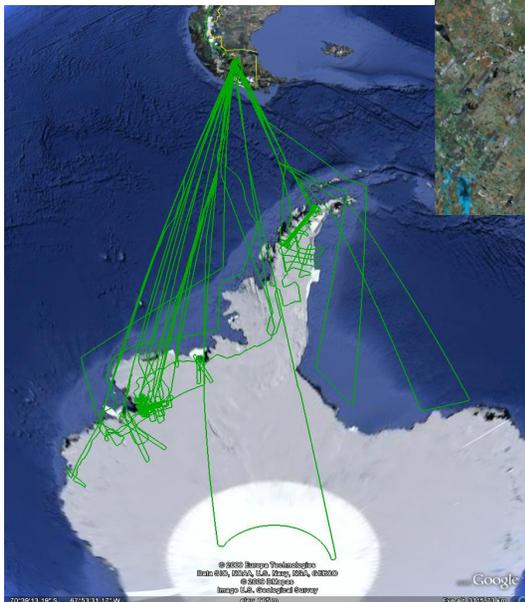


- Modern digital camera to capture multi-view imagery at the low altitudes and high speeds of the DC-8 and P-3 aircraft
- Approximately the same total field-of-view as ATM (25 degrees)
- High-resolution: 10cm over ~400 meter swath (4000 pixels)
- Image “events” marked on high-accuracy Applanix GPS/INU system
- DMS is Airborne Science Program facility Instrument (*as of 2010*)

IceBridge DMS Data Collection and Processing

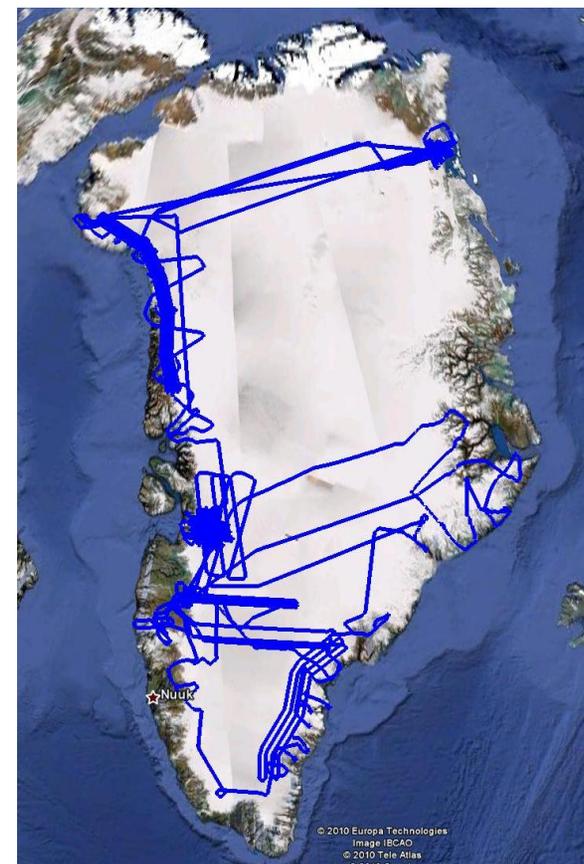


DC-8 October-November 2009



DC-8 March-April 2010

P3 May 2010



DMS Data Processing Status



Antarctic DC8 Deployment (Oct/Nov 2010)

- 1.966 TB data collected
- 2m resolution @ 34,000' (5.0 sec frame interval)
- 10cm resolution @ 1600' (1.3 sec frame interval)
- All Antarctic Data (237,536 frames) have been processed and shipped to NSIDC, total processed data volume 5.1TB
- Processing is geo-rectification only and not elevation

Greenland DC8 Deployment (Mar/Apr 2010)

- 1.365 TB data collected (179,000 frames)
- Processing underway

Greenland P3 Deployment (May 2010)

- 1.187 TB data collected (166,000 frames)
- Processing underway





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Digital Mapping System

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Sample DMS Imagery



These images are from Operation ICE Bridge, collected in the Fall of 2009.

+ More NASA Multimedia

OVERVIEW

The Digital Mapping System (DMS) is an airborne digital camera that acquires high resolution natural color and panchromatic imagery from low and medium altitude research aircraft. Data acquired by DMS are used by a variety of scientific programs to monitor variation in environmental conditions, assess global change, and respond to natural disasters.

Missions are collected, processed, and maintained by the Airborne Sensor Facility (ASF) located at the NASA Ames Research Center in Mountain View, California. The ASF is operated under contract by the University of California at Santa Cruz.

CAMPAIGNS



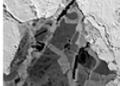
Operation ICE Bridge 2010
Dates: 22 March - 27 May, 2010
Location: Greenland
Status: In Progress
[+ View this campaign](#)

RELATED WEB SITES

NSIDC Home Page
The National Snow and Ice Data Center supports research into our world's frozen Cryosphere.
[+ Visit the website](#)

ICE Bridge Information
Operation Ice Bridge, a six-year NASA field campaign, is the largest airborne survey of Earth's polar ice ever flown.
[+ Visit the website](#)

IMAGE GALLERY



Operation ICE Bridge
Images acquired by DMS during the Operation ICE Bridge Campaigns.
[+ Click to view images](#)

MOVIE GALLERY



Operation ICE Bridge 2009
Movies about and shot during the Operation ICE Bridge 2009 Antarctica Campaign.
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+ E.E.O. Data Posted Pursuant to the No Fear Act
+ USA.gov
+ ExpectMore.gov



NASA Official: Matt Fladeland
Project Manager: Jeff Myers
Website Editor: Eric Frain
Last Updated: April 10, 2010

DMS Web Site

<http://asapdata.arc.nasa.gov/DMS/>

What else can DMS do for IceBridge?

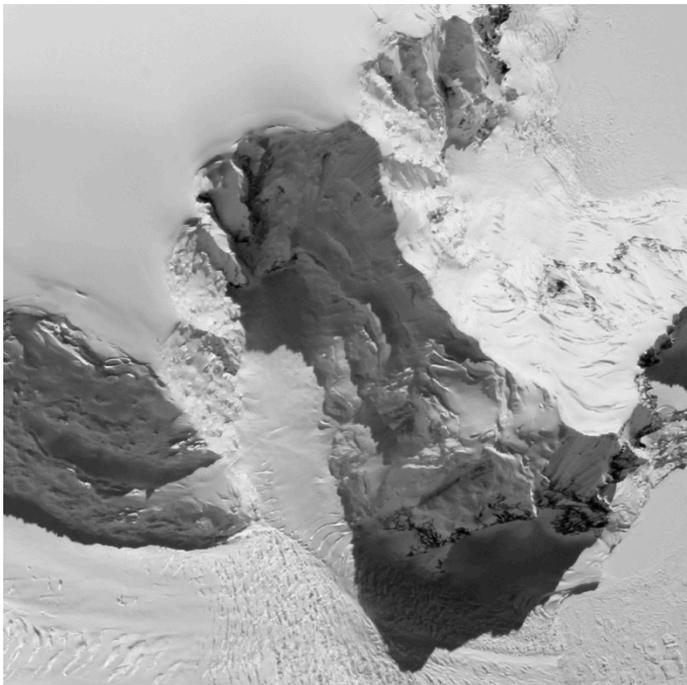


- Answer: **Potentially, a lot more!**
 - Generate an independent high-resolution, high-accuracy elevation model
 - Potential: better than 20cm horizontal x 20cm vertical
 - Sea ice elevation based on *true* local sea level, not orthometric sea level
 - Generate high-res “Digital Reality” ice surface over IceBridge study areas
 - Provide high-impact visual products that will grab public and student interest
 - Show the science community what the surface is “really like”
 - Improve the horizontal resolution of ATM and LVIS products
- Some background:
 - **John Arvesen**: background in airborne remote sensing and building specialized camera systems for NASA manned and unmanned aircraft
 - DC-8, P-3, ER-2, WB-57, Altair, Pathfinder
 - **Ryan Dotson**: developer of parallel DEM extraction software for precision geo-referencing and creation of 3-D imagery models
 - The film and video media world is undergoing a revolution that has resulted in a quantum leap in 3-D image processing capability

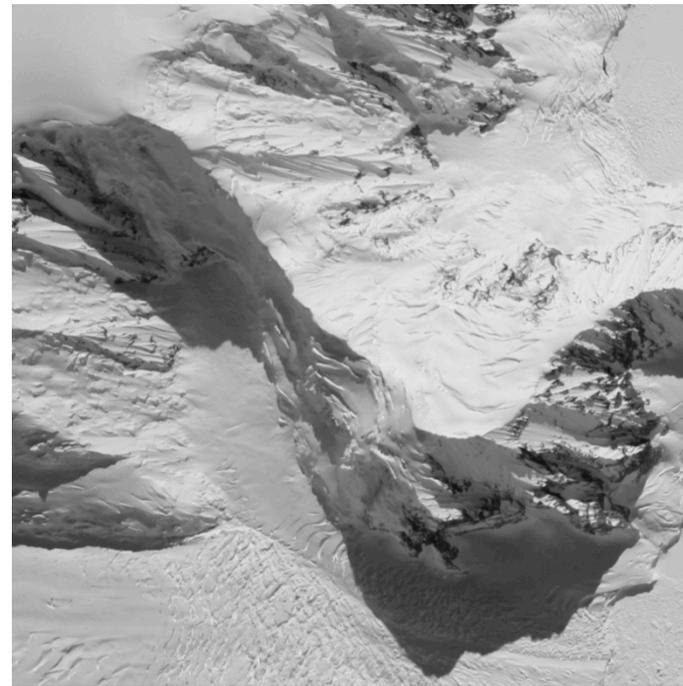
DMS-derived Elevation Model



- Independent high-resolution elevation model using DMS multi-view imagery and sub-pixel processing



30° view angle from left



30° view angle from right

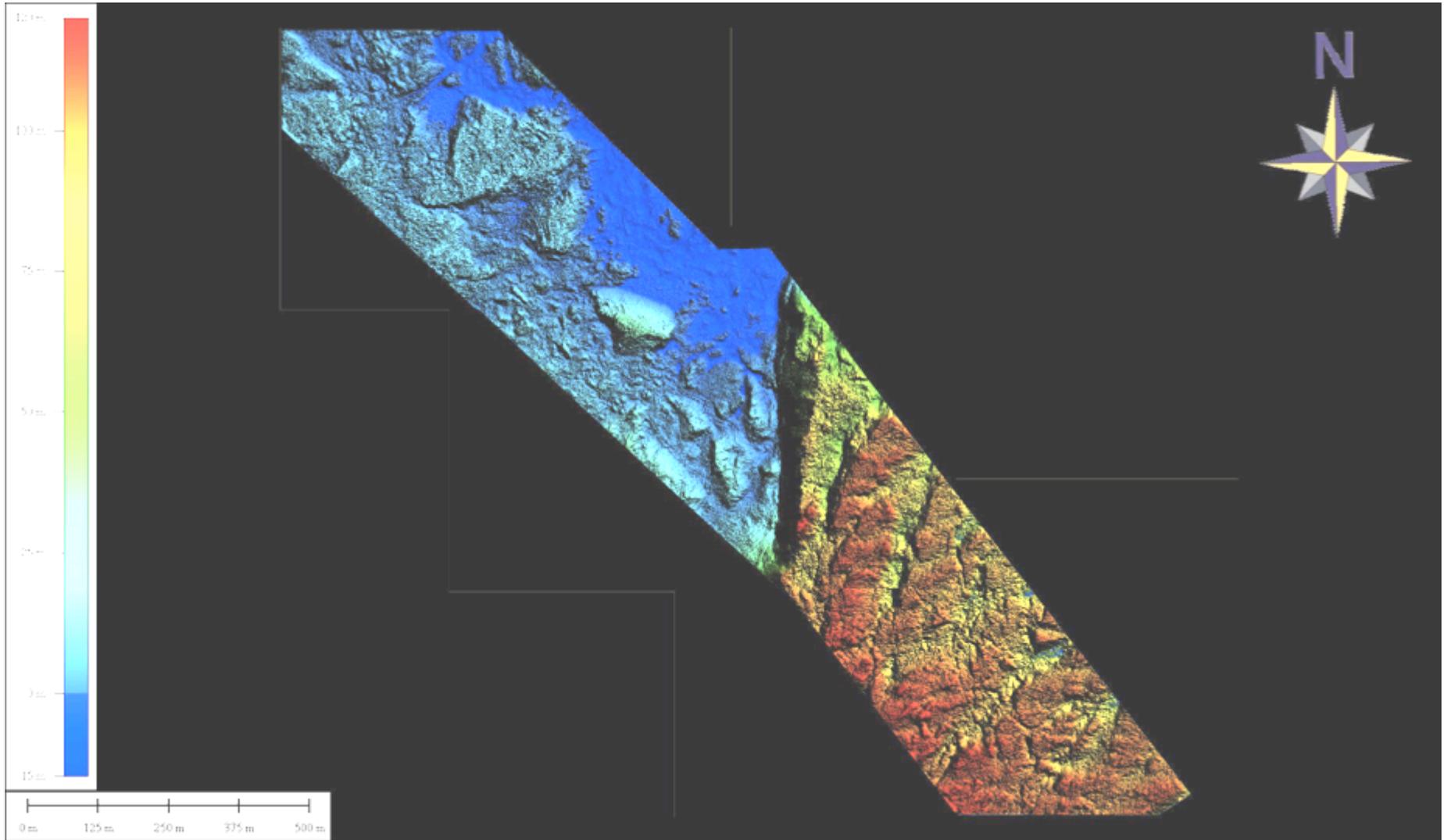
DMS DEM Extraction



- Generation of high-resolution elevation model
 - **COMPUTER RECOGNITION OF COMMON IMAGE POINTS**
 - Estimate surface elevation at regularly-spaced grid points
 - Points are estimated based on a global cost function minimization
 - Simple Form: $F(x, y, z) = P(x, y, z) + k \cdot S(x, y, z)$
 - $P(x, y, z)$ represents the photogrammetric “cost” of an unknown elevation at grid point (x, y) .
 - $S(x, y, z)$ represents a smoothness constraint, based on neighboring grid points
 - k is smoothness weighting coefficient
 - Solved iteratively using a Belief Propagation method
 - **Image-based elevation extraction method is computationally intensive, but powerful**

DMS-derived elevation Jakobshavn Glacier

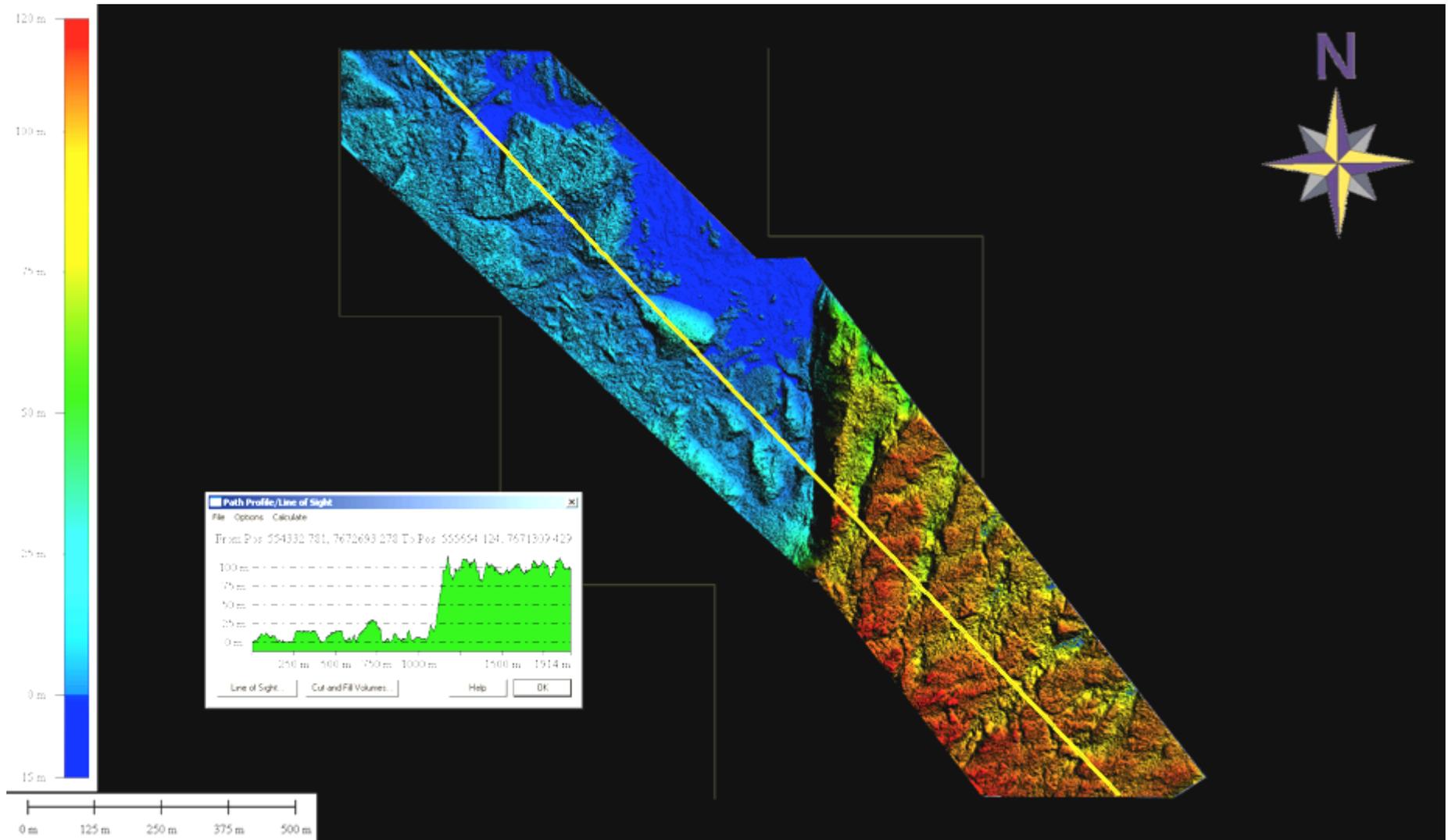
1900 x 350 meters



DMS Path Profile

Jakobshavn Glacier

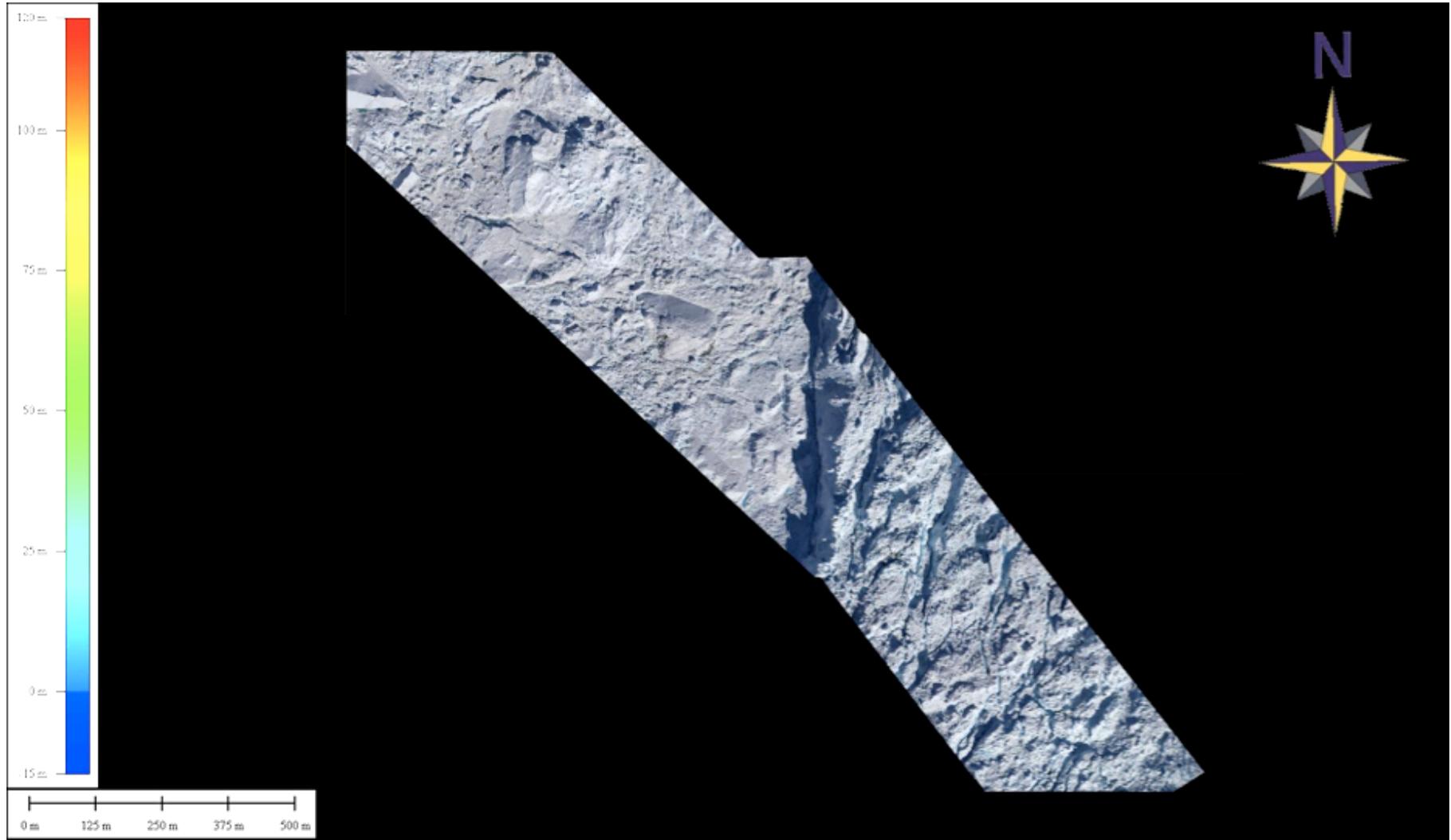
1900 x 350 meters



DMS image overlay on DEM

Jakobshavn Glacier

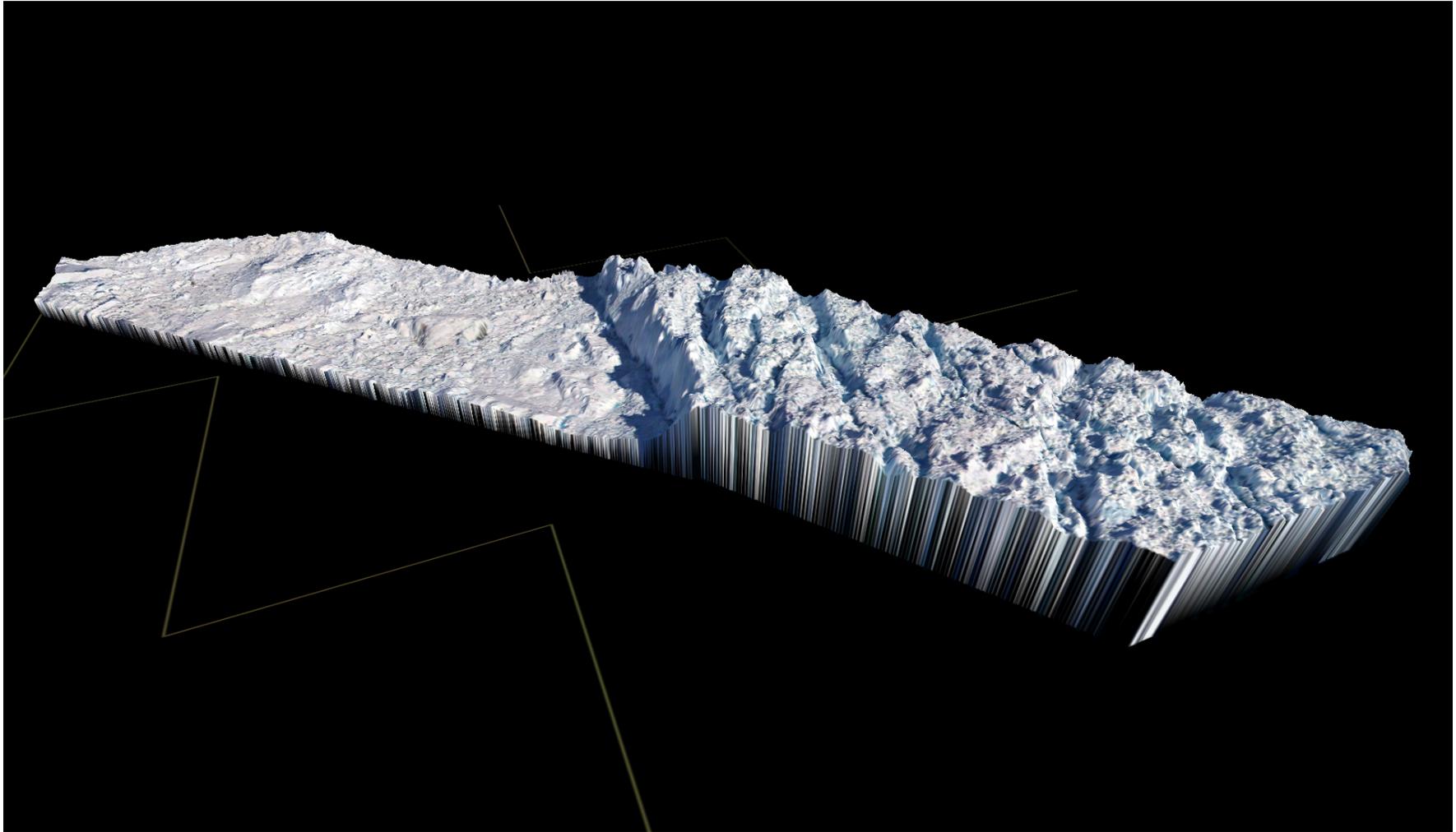
Image registration: perfect



DMS image overlay

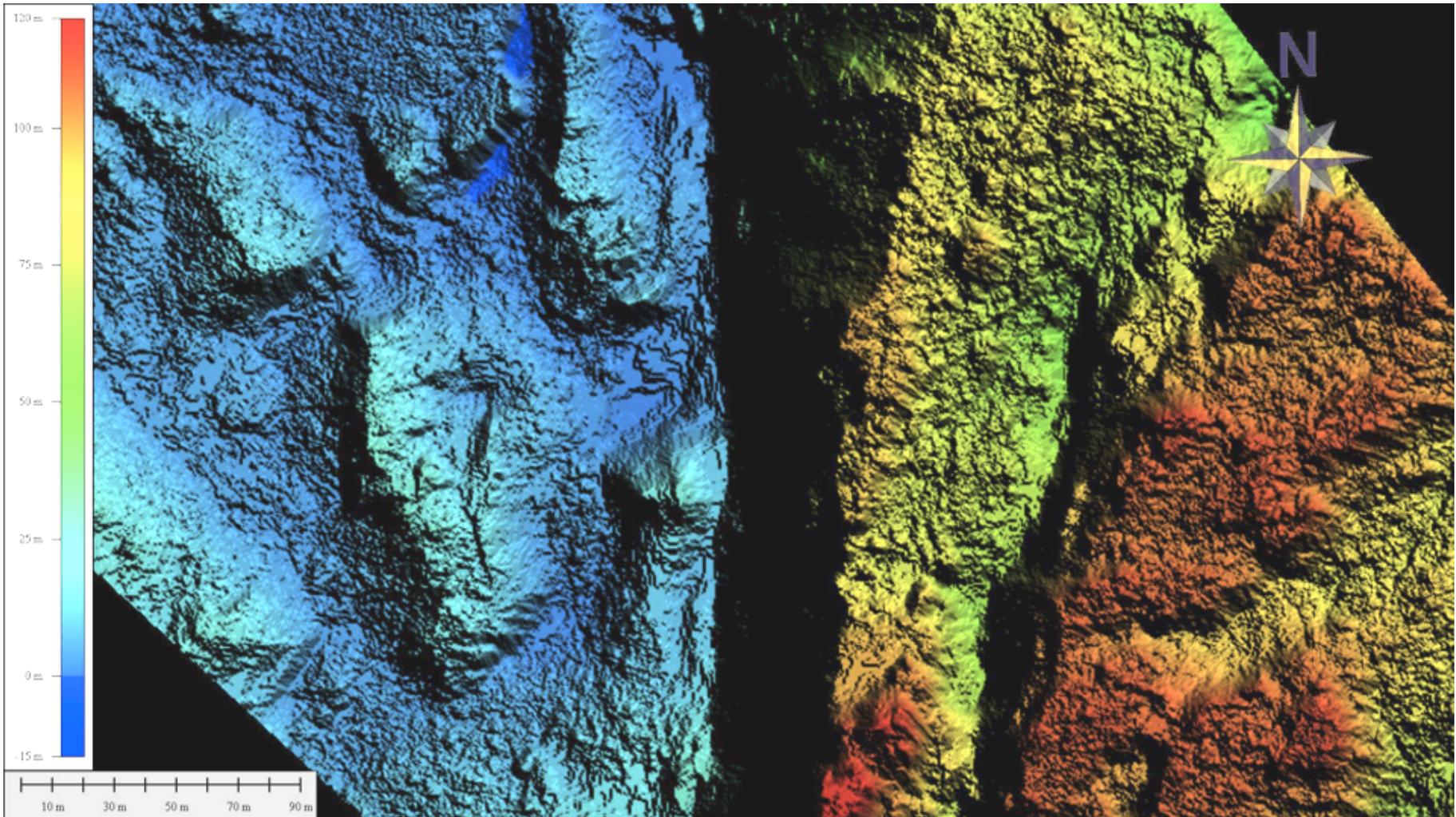
Jakobshavn Glacier from SW

oblique view



Elevation model Jakobshavn Glacier Face

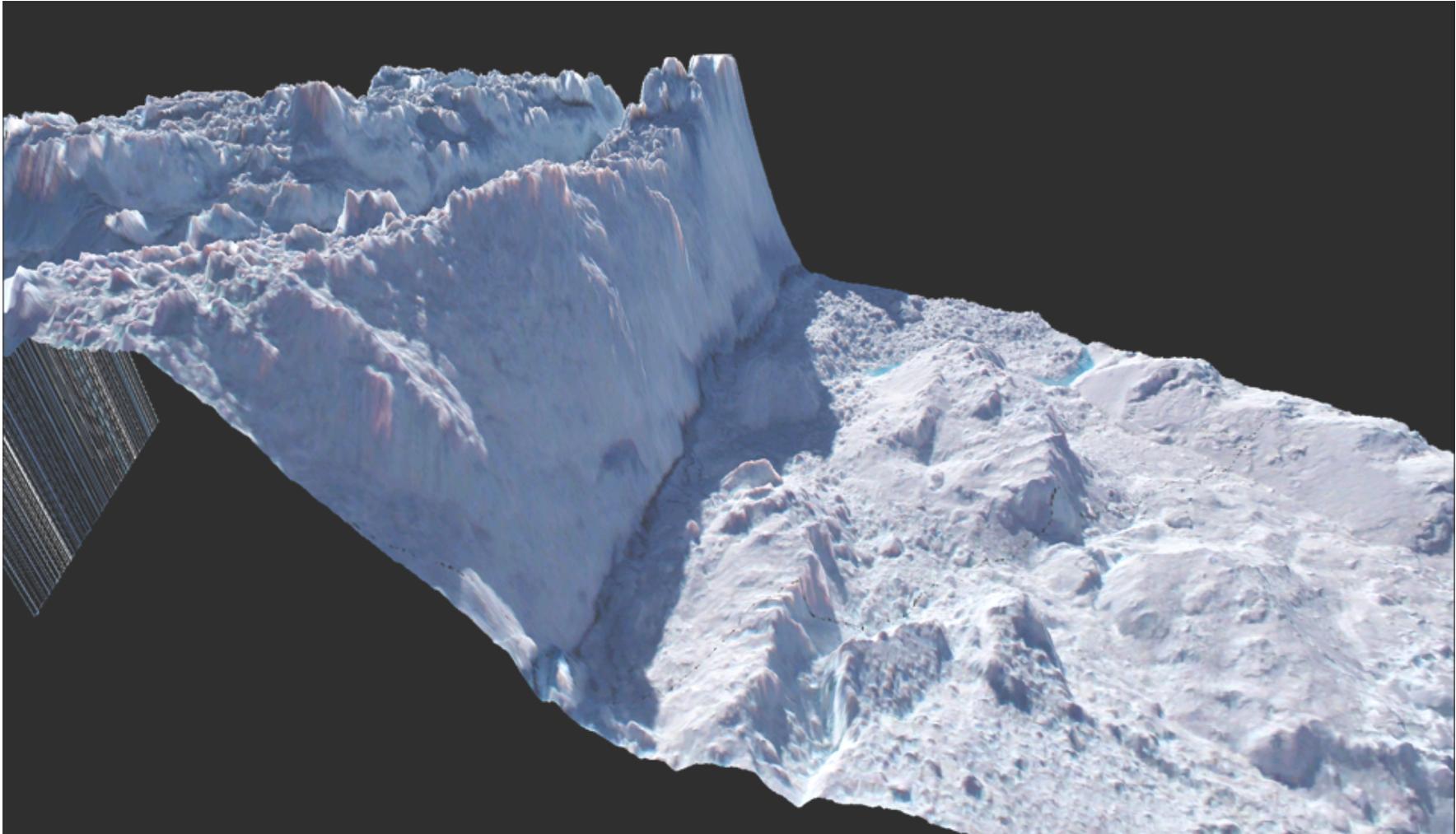
6x higher resolution



DMS image overlay

Jakobshavn Glacier face from NW

6x



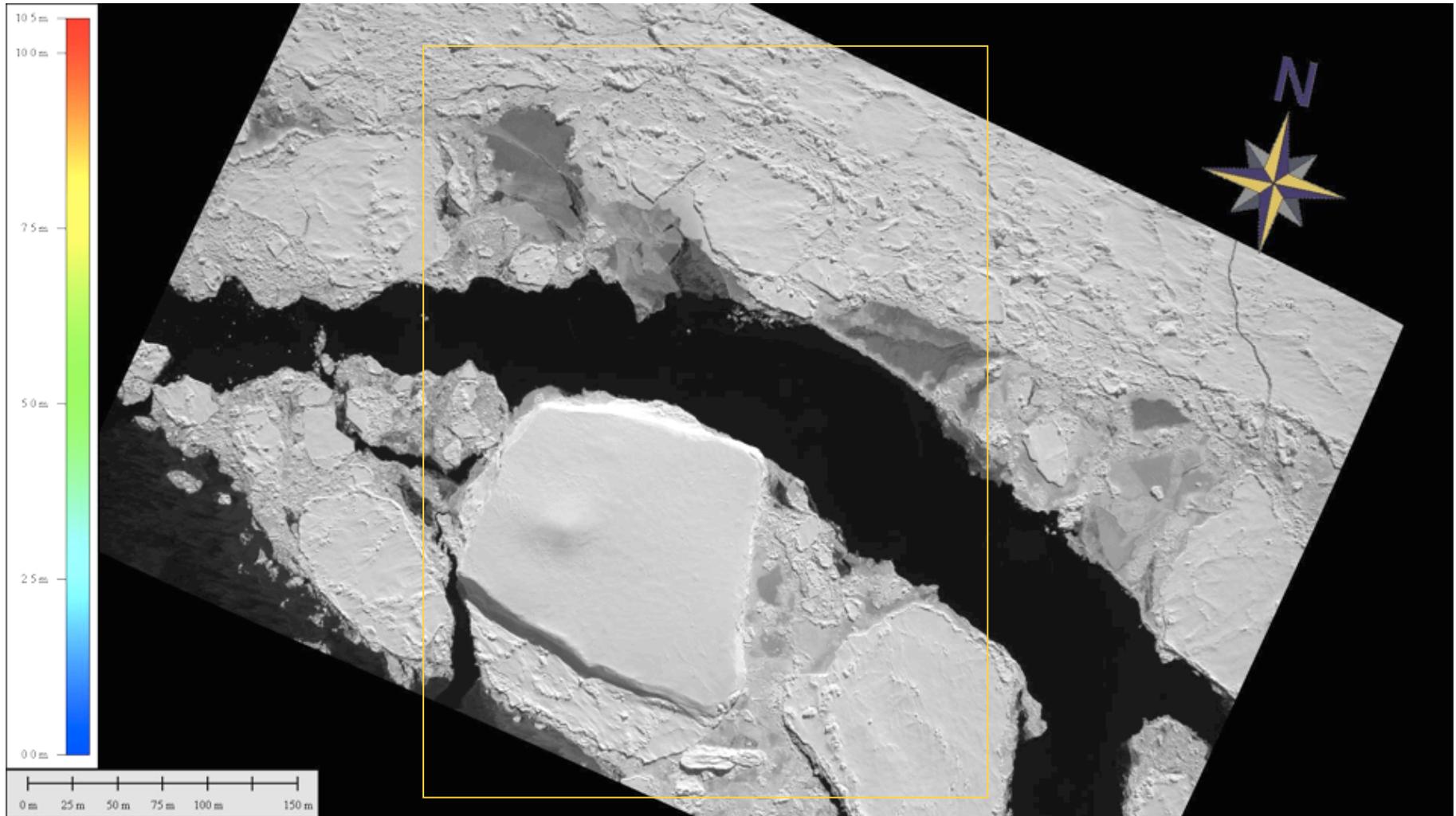
Sea Ice Applications



- Open leads in the ice can be easily discriminated by DMS
 - Water is easily detected against ice background
- Possible that *zero-level* ice freeboard can be accurately determined wherever open-water leads are detected
 - Eliminate errors in orthographic model due to tides, swells, gravity anomalies, etc.
 - Use ice-water interface as base for differential elevation calculations
- 3-D visualization provides increased understanding of the study area

Sea Ice Applications

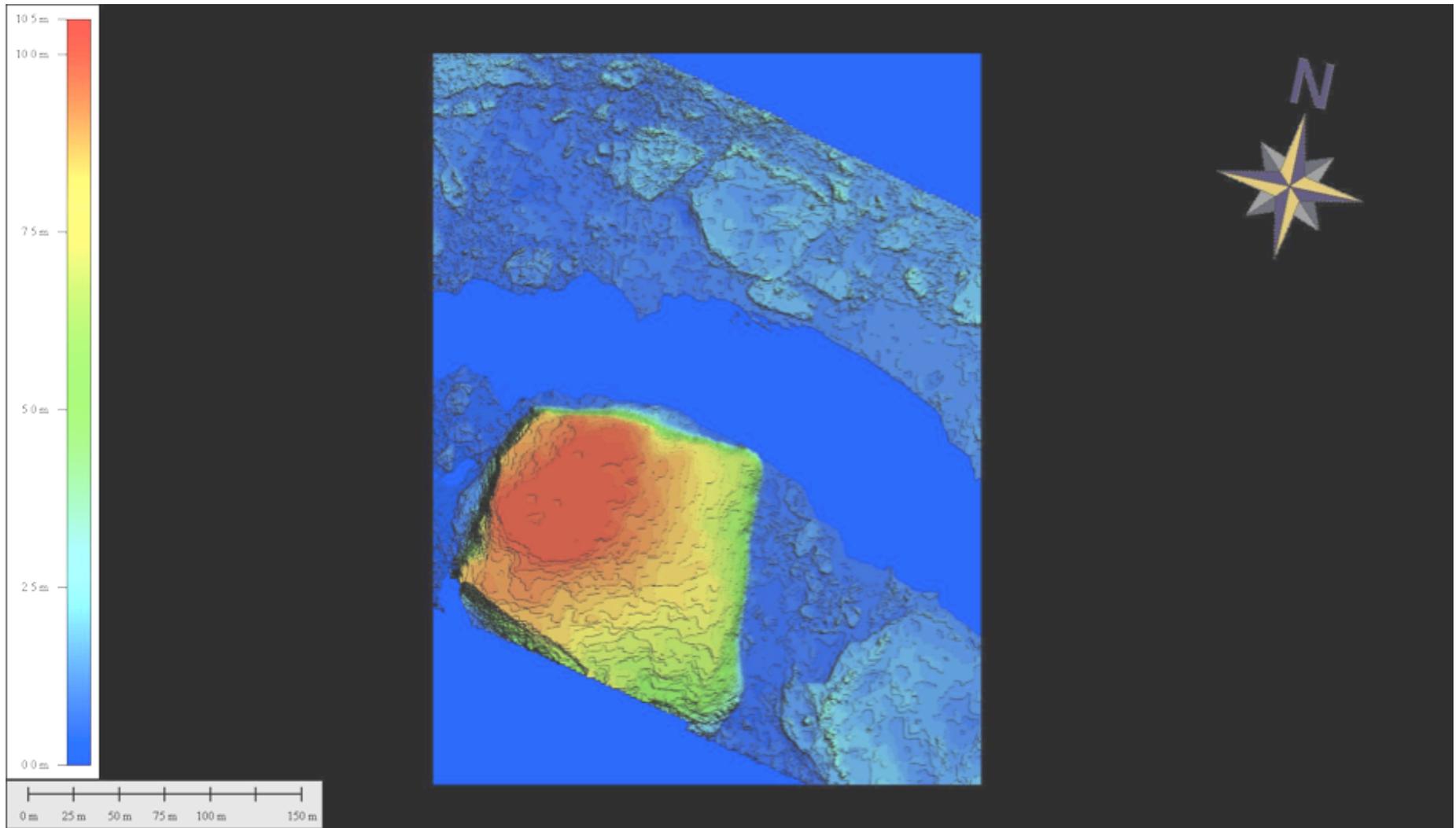
Bellingshausen Sea



Sea Ice Applications

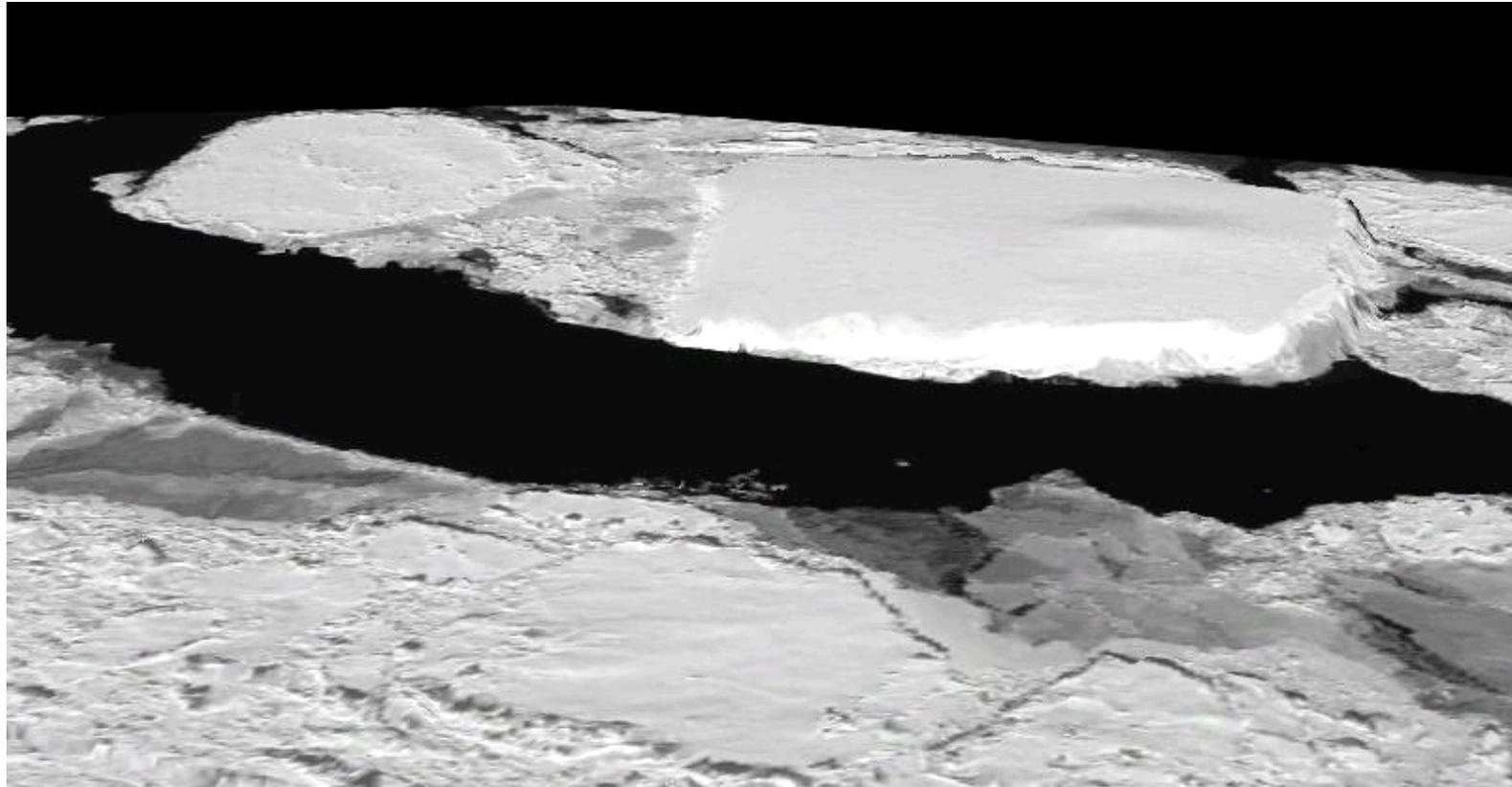
Bellingshausen Sea

Elevation model



Sea Ice Applications

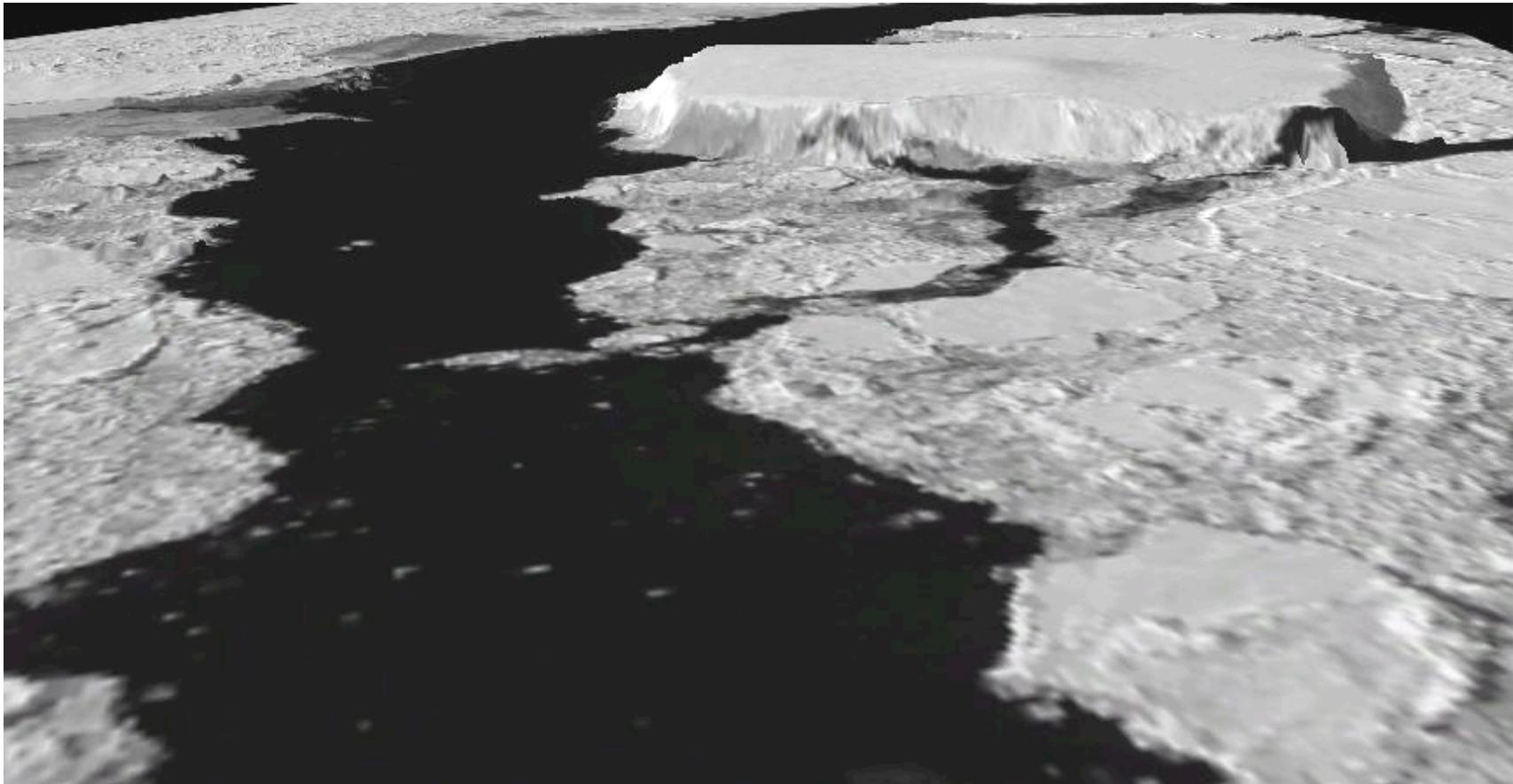
Bellingshausen Sea



View from North

Sea Ice Applications

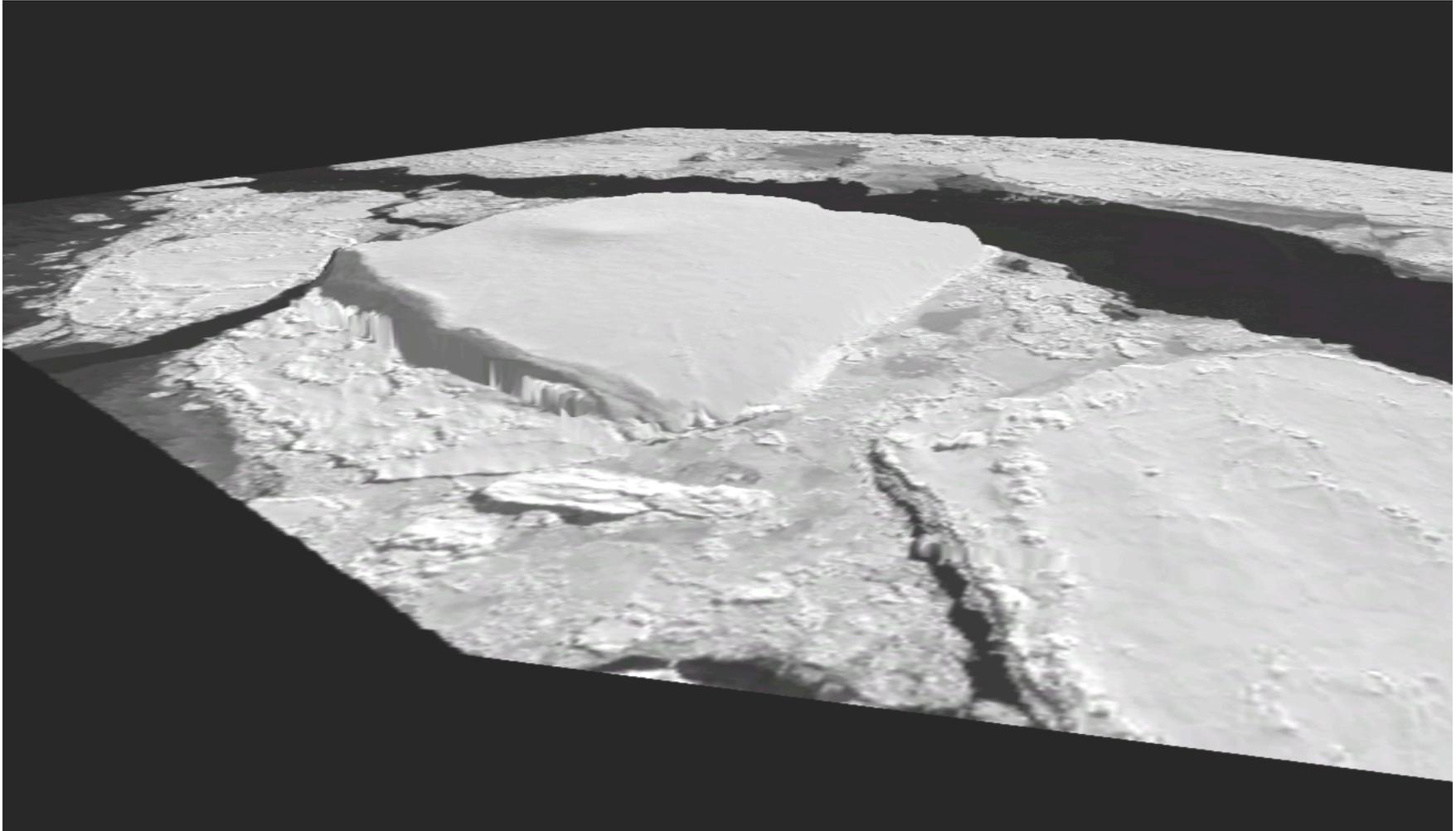
Bellingshausen Sea



View from East

Sea Ice Applications

Bellingshausen Sea



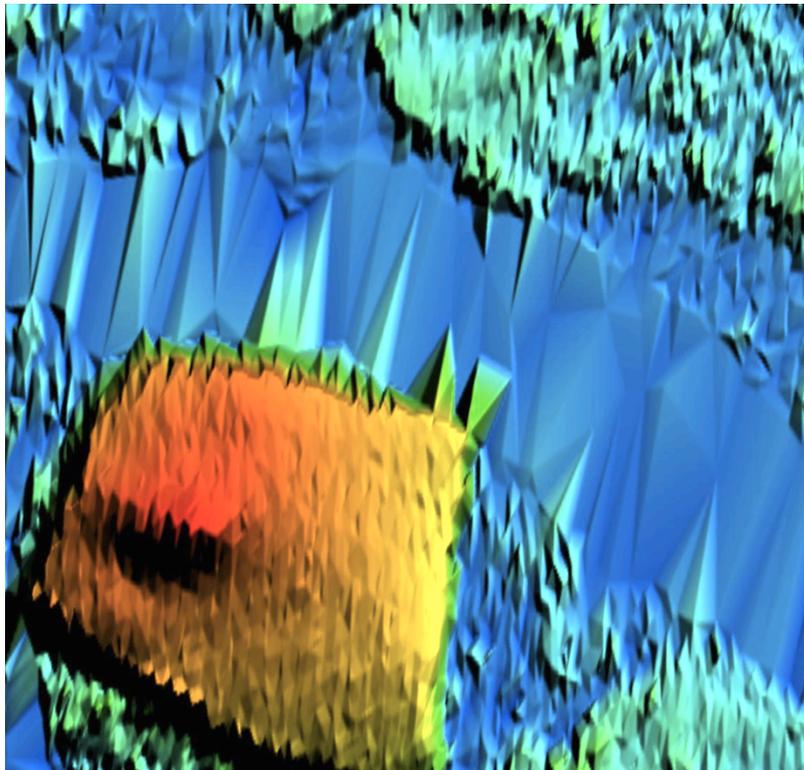
View from Southeast

Can DMS improve ATM and LVIS products?

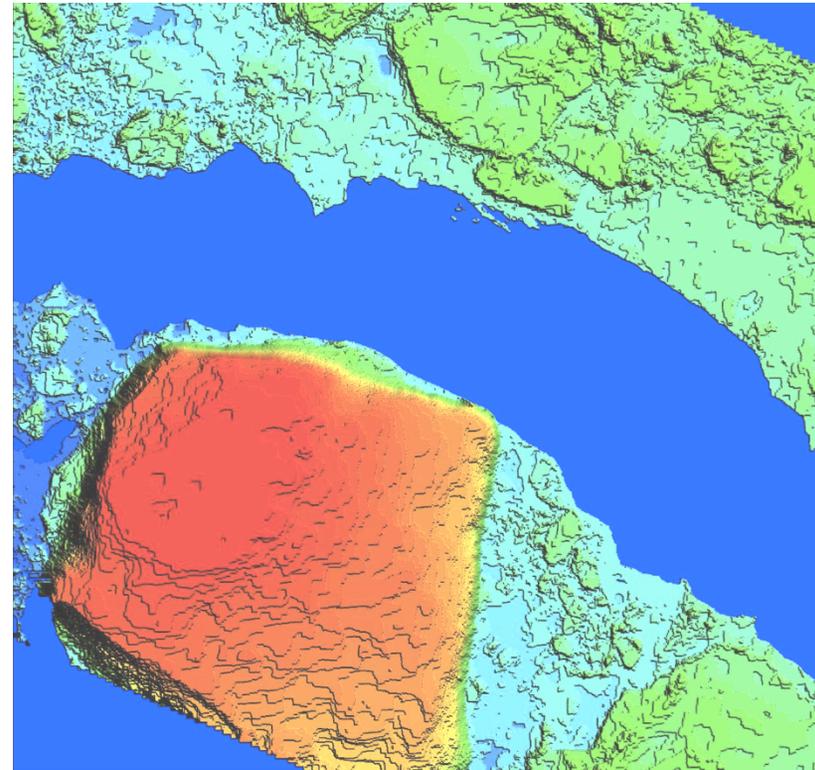


- Our processing of DMS data can produce a stand-alone elevation model with high horizontal resolution and accuracy
 - Approximately 5x the horizontal resolution of ATM and LVIS
 - Excellent discrimination between ice and water
- However,
 - Approximately 5x less vertical resolution and accuracy of ATM
 - Approximately 20x less vertical resolution and accuracy of LVIS
- Can we synergistically merge with ATM and LVIS vertical data to create improved IceBridge elevation model??

Horizontal resolution comparison



ATM-derived DEM

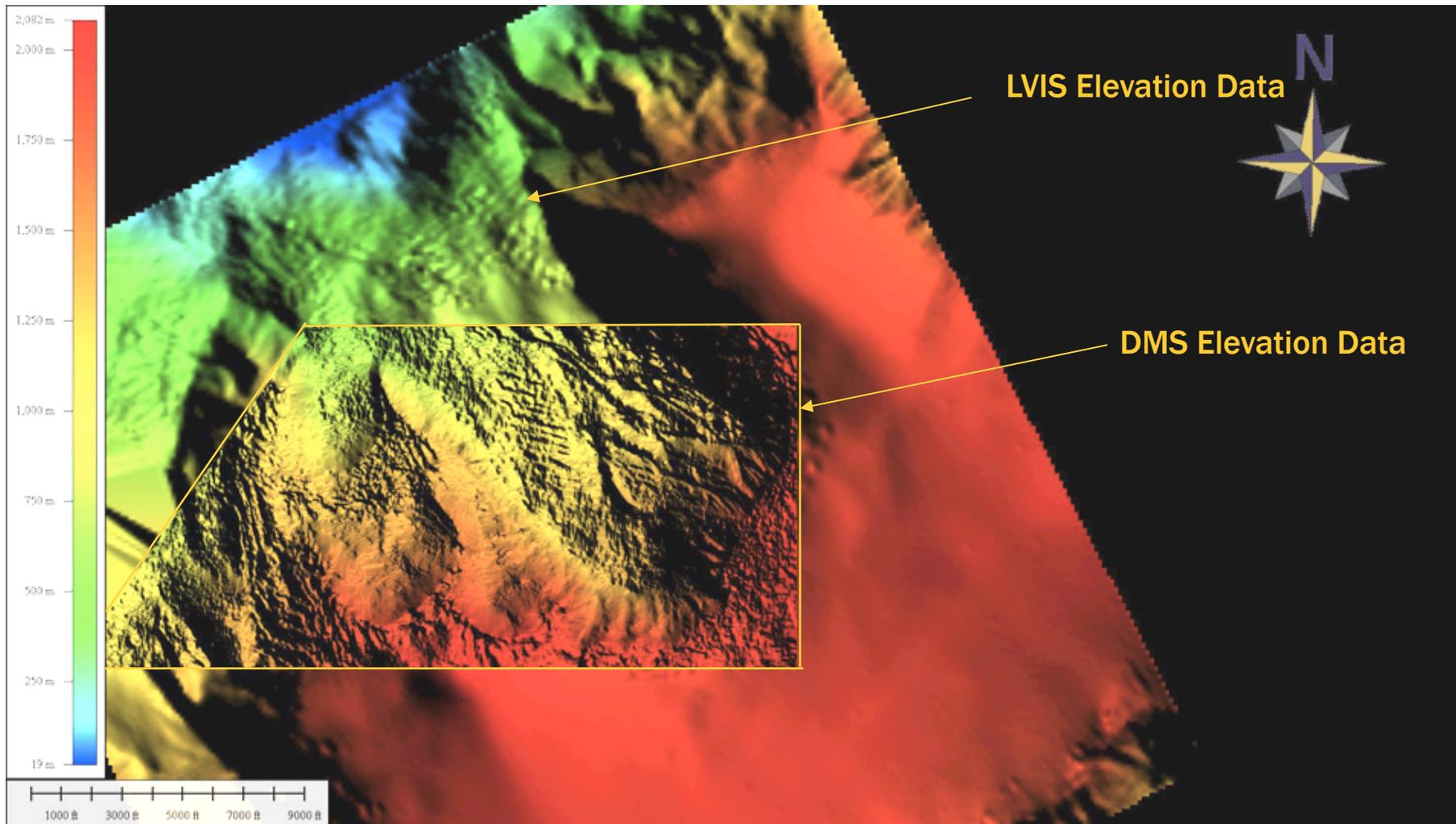


DMS-derived DEM

Horizontal resolution comparison

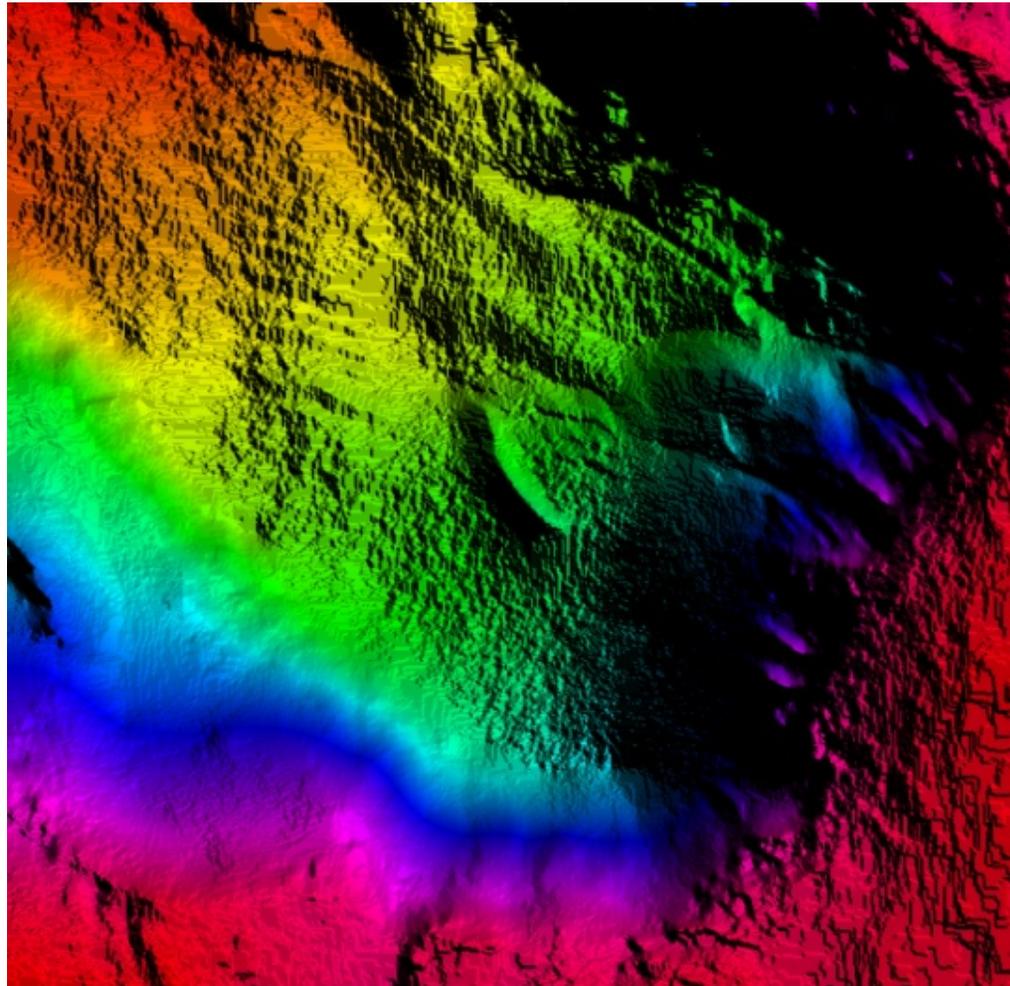
Crane Glacier

35,000 ft flight altitude



DMS elevation extraction

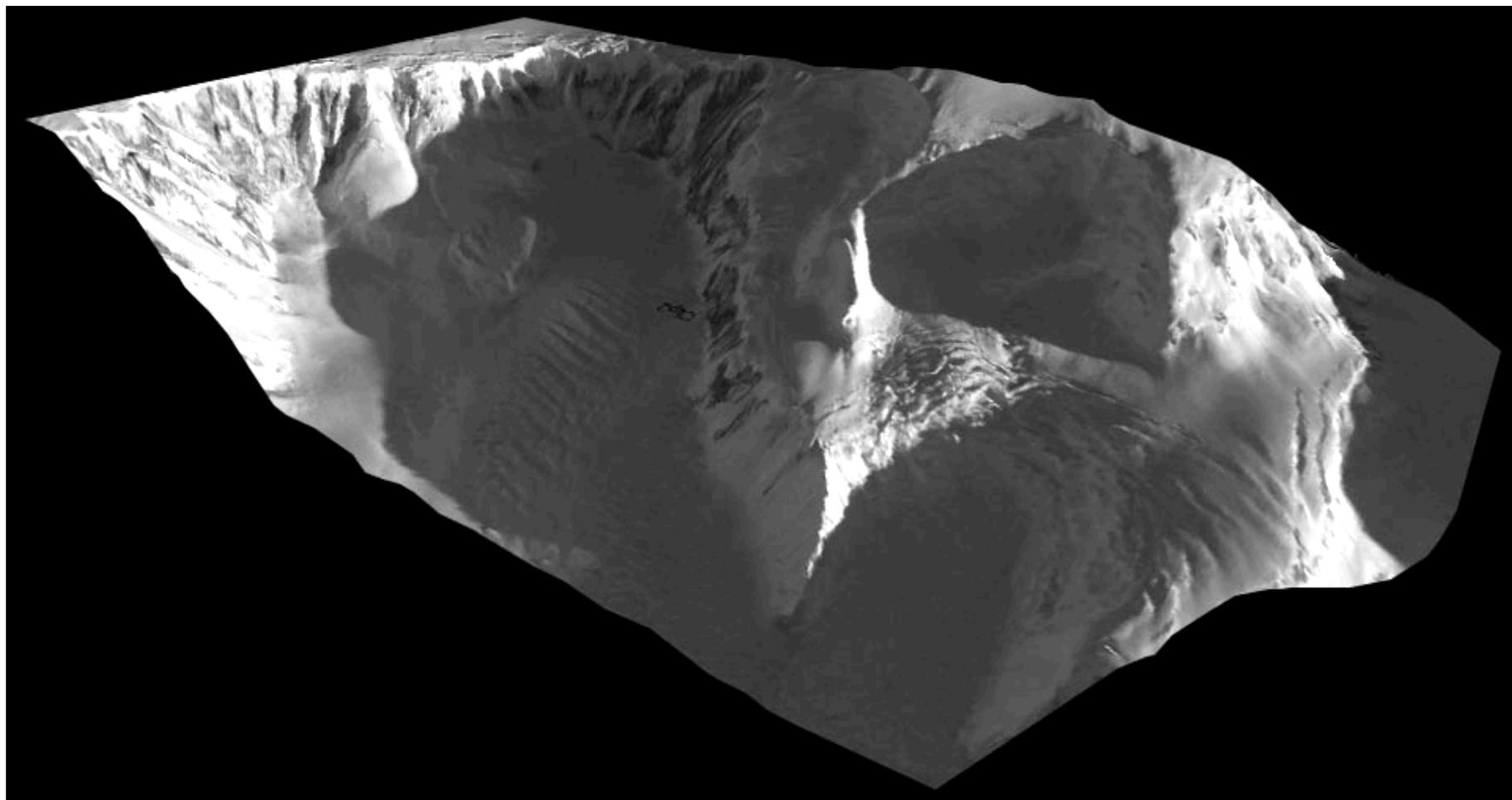
35,000 feet



3km x 3km area from Crane Glacier @ 5m horizontal resolution

DMS Image Overlay

Crane Glacier



Concluding Remarks



- Processing the DMS data with presently-available tools can produce an independent, high-resolution, high-accuracy elevation model
 - Potential: better than 20cm horizontal x 20cm vertical
 - Sea ice elevation based on local sea level, not orthometric sea level
- A high-resolution “Digital Reality” can be achieved over IceBridge study areas
 - Provide high-impact visual products that will grab public and student interest
 - Science community can better visualize what the surface is “really like”
- Potentially increase the horizontal resolution of ATM and LVIS products