Frequently asked Questions about OIB Airborne Gravity

Opportunities and Challenges

Photo:
Seelye Martin

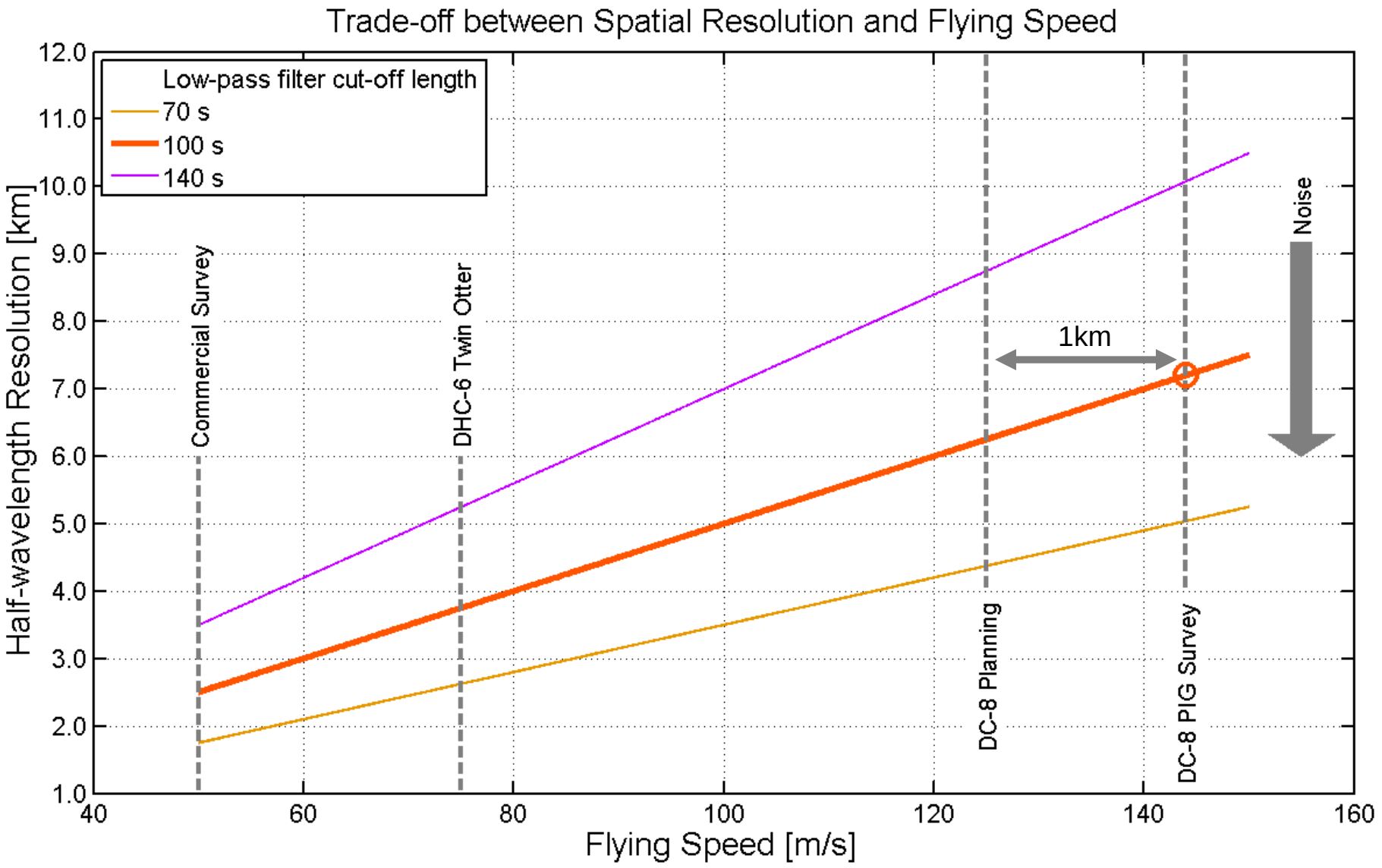
RESOLUTION AND ACCURACY OF OIB AIRBORNE GRAVITY

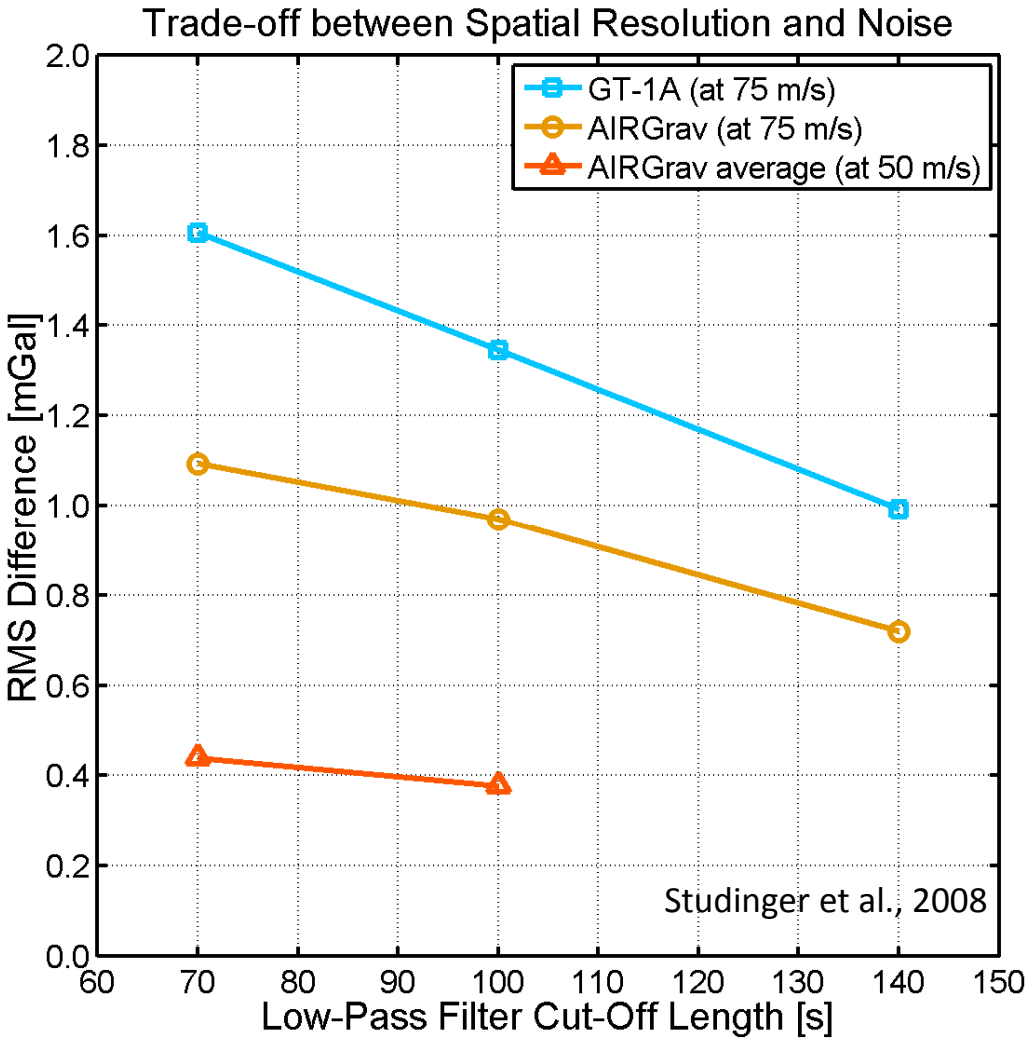
General Principle of Airborne Gravity

Separate aircraft accelerations from gravitational accelerations caused by changes in subsurface density structure:

- Estimate aircraft accelerations from DGPS positioning
- Low-pass filtering of raw gravity data (this talk)

Low-pass filtering of data implies that faster flying speeds will have lower spatial resolution in the gravity data


Trade-off between Spatial Resolution and Flying Speed
Low-pass filter cut-off length
70 s
100 s
140 s
Commercial Survey
DHC-6 Twin Otter
DC-8 Planning
DC-8 PIG Survey
1km
Noise
Half-wavelength Resolution [km]
Flying Speed [m/s]
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
40
60
80
100
120
140
160

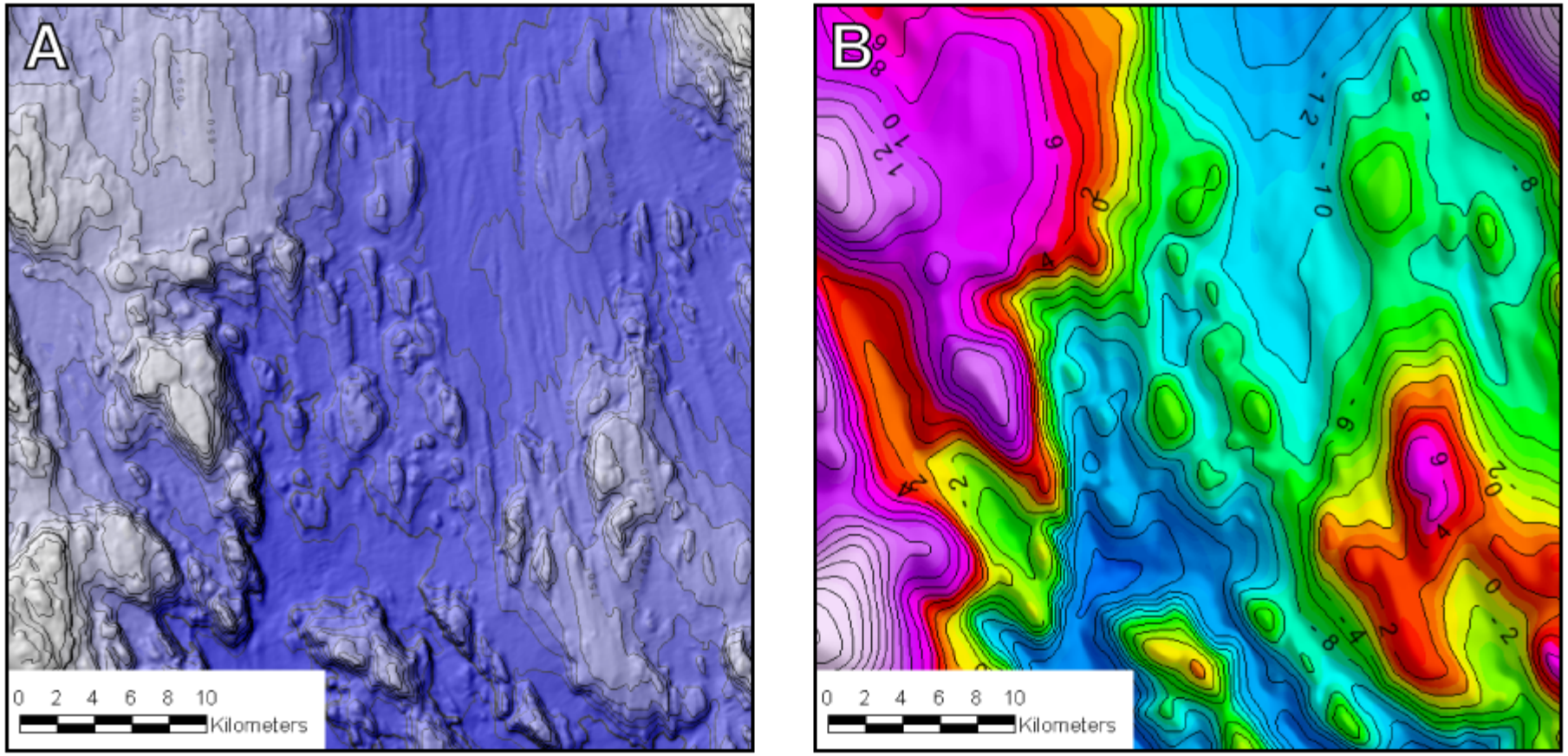


Noise in airborne gravity data decreases generally with longer low-pass filters and thus decreasing spatial resolution of the gravity measurements.

ESTIMATING BATHYMETRY FROM AIRBORNE GRAVITY

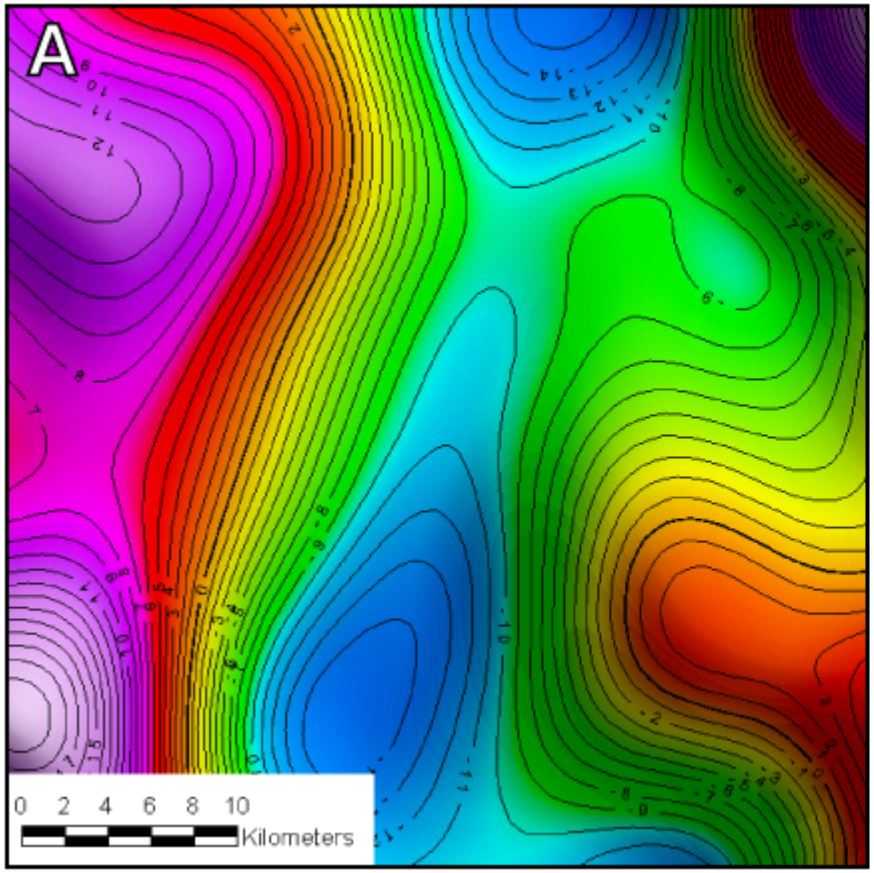
Seeing bathymetry through a gravity lens

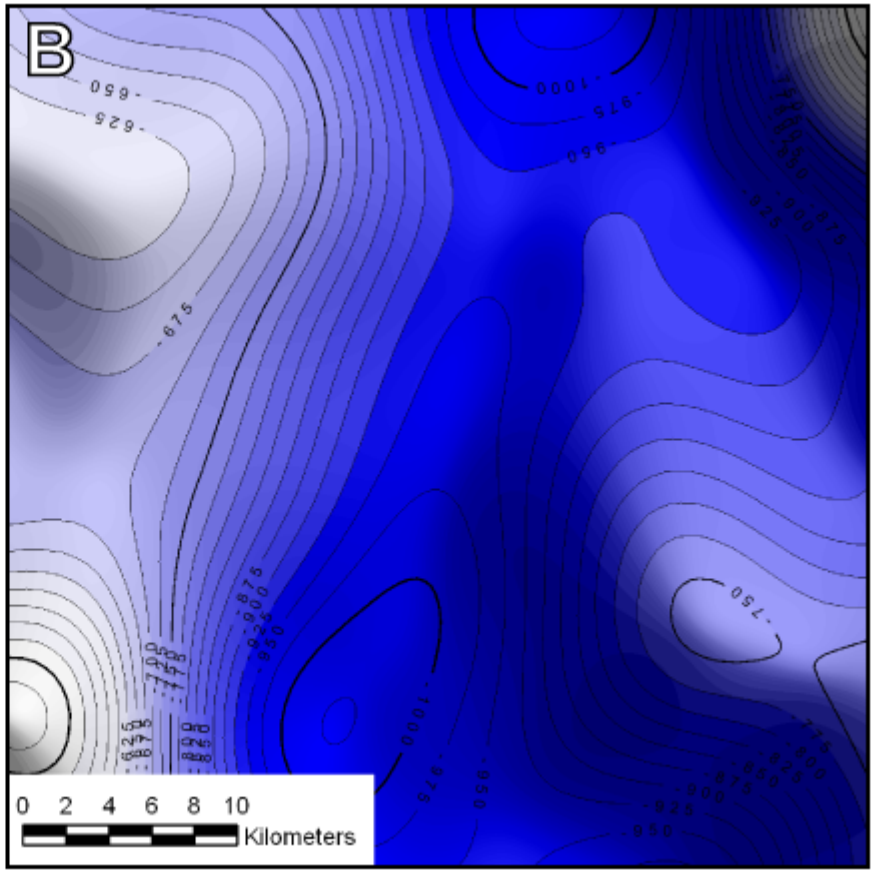
- The perfect world: capabilities and limitations of the inversion method
- Reality check: dealing with unknowns
- Greenland 2010 – what can be done



A) Multi-beam bathymetry in Pine Island Bay (F. Nitsche, unpublished data). The image is 40×40 km wide with 50 m contours ranging from 1100 m to 250 m water depth. Darker colors indicate deeper bathymetry.

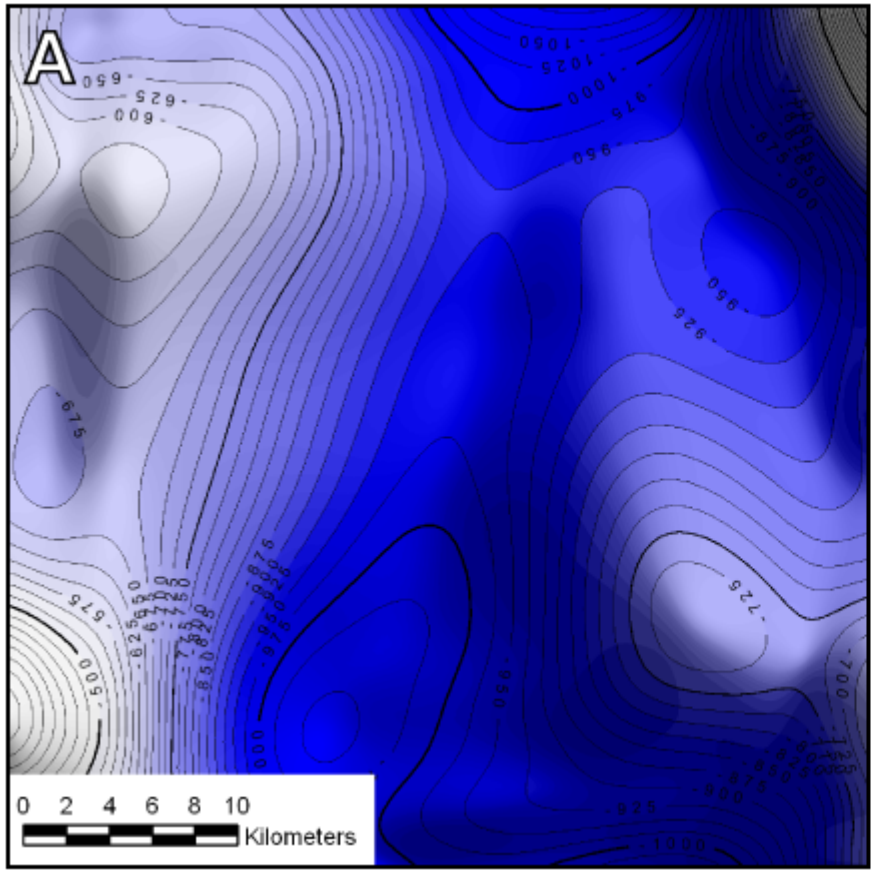
B) Forward model of the free-air gravity anomaly (in mGal) at flight elevation (1500 ft ASL) using bathymetry in A).

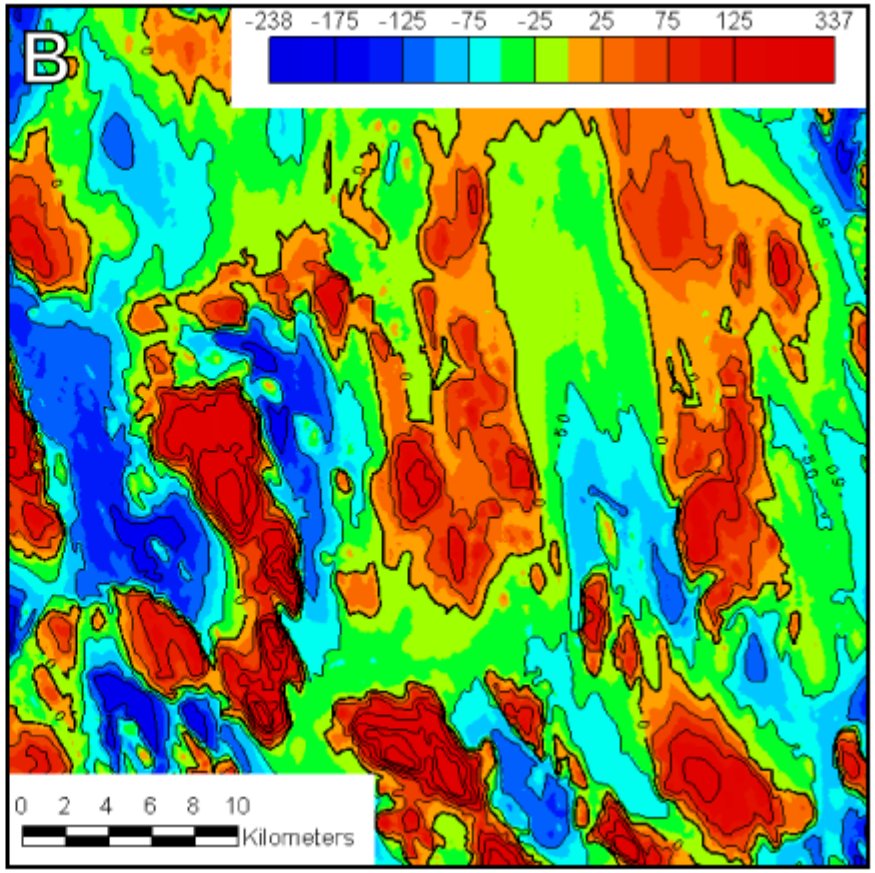




A) Simulated gravity effect of the bedrock/water interface at flight elevation that an AIRGrav system flown at 150 m/s can detect.

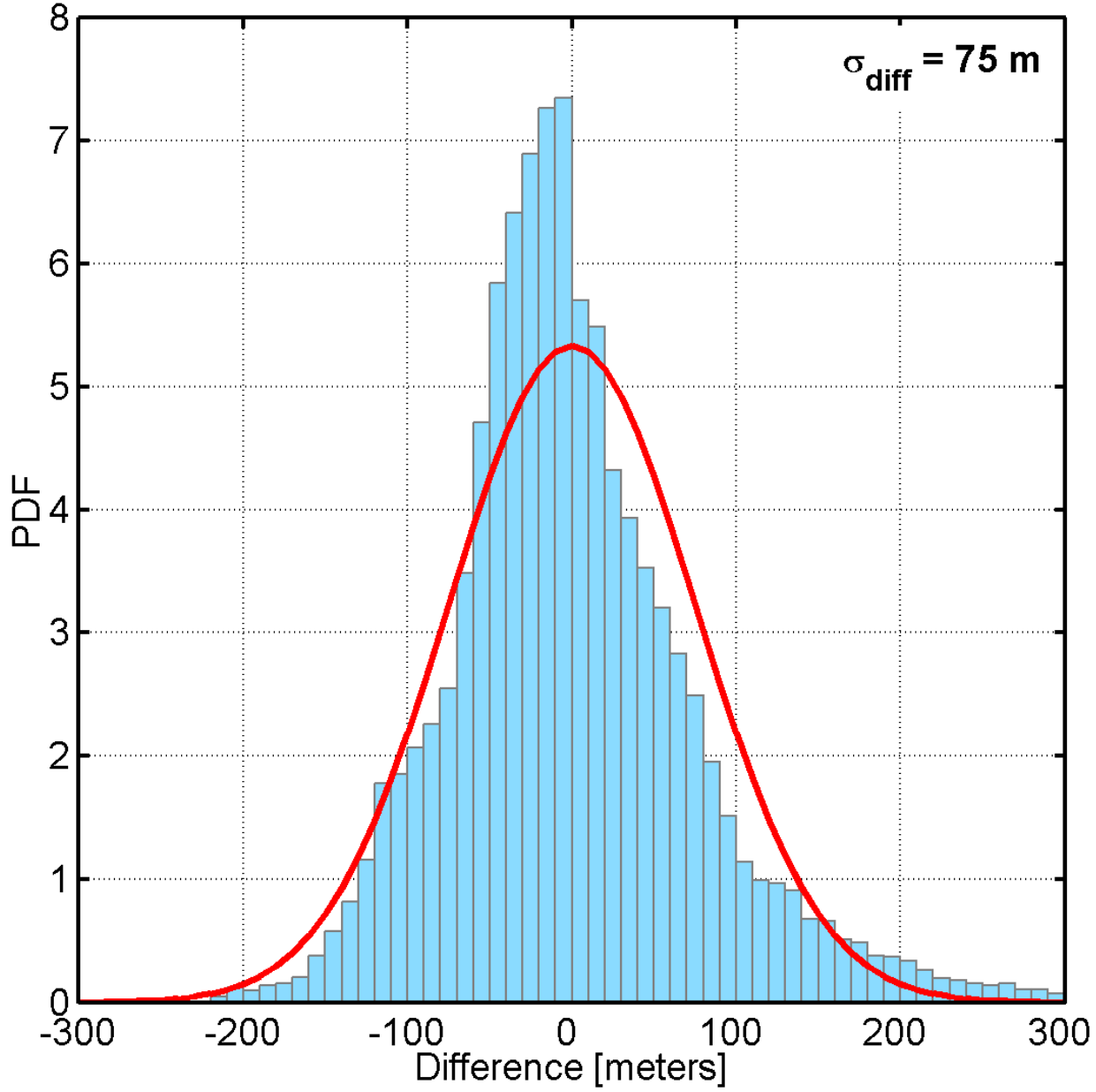
B) A similar low-pass filter has been used to remove short wave-length components from the multi-beam bathymetry in Fig. 3A. The structure of the low-pass filtered bathymetry resembles closely the gravity field that an airborne gravimeter would measure.

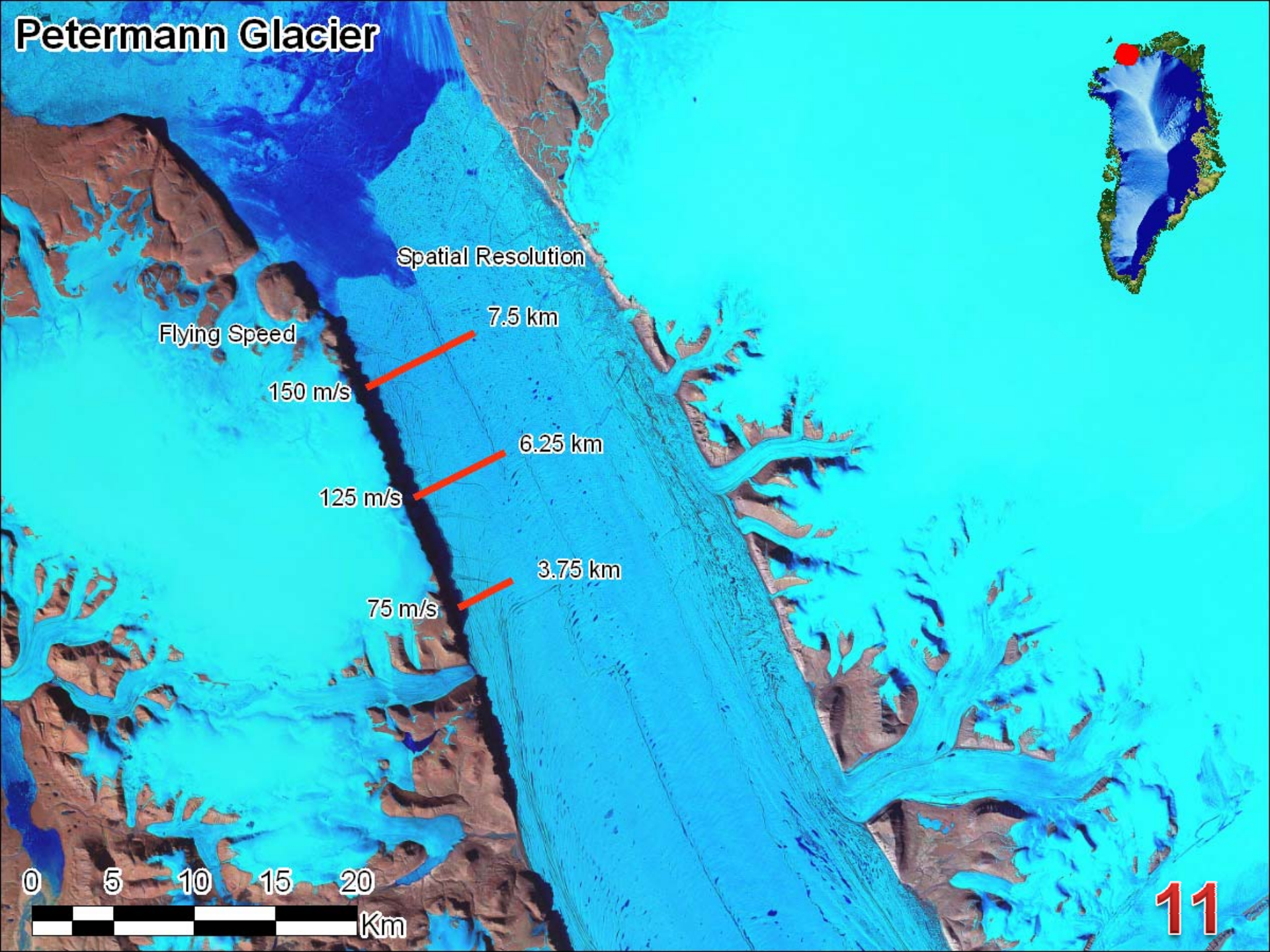


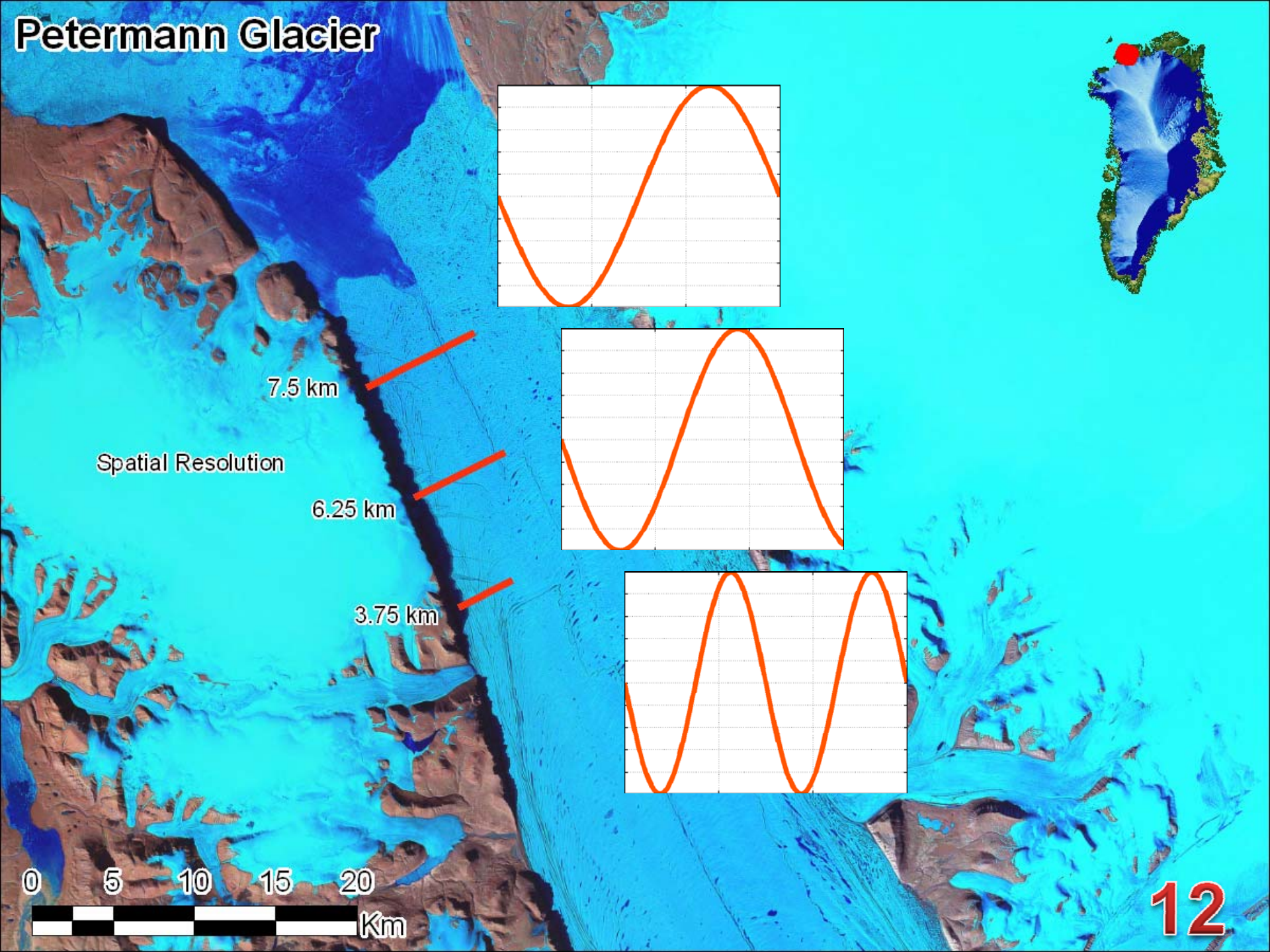


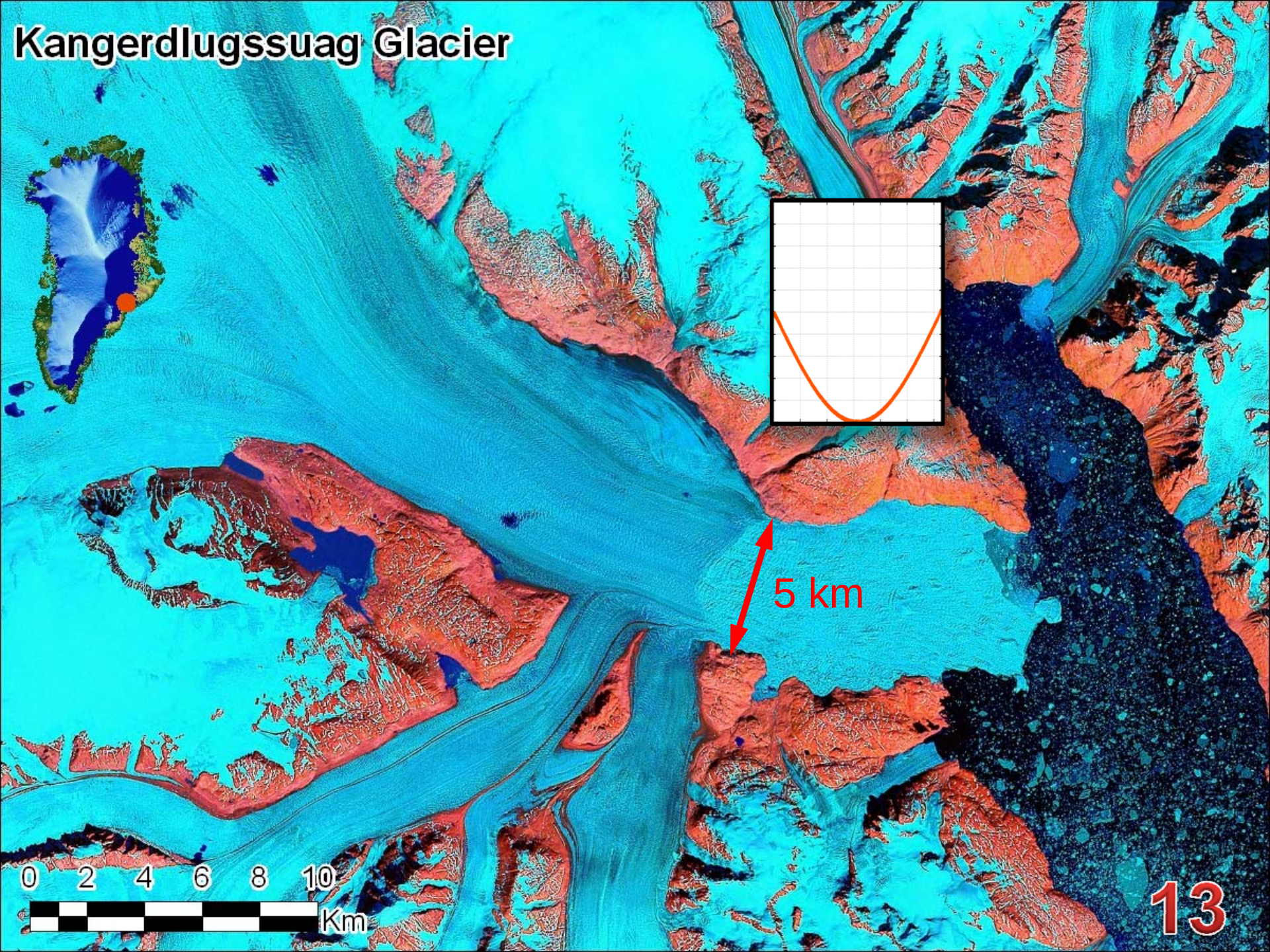
A) Bathymetry estimated from simulated airborne gravity data at 1500 ft AGL and 150 m/s speed of the survey aircraft.

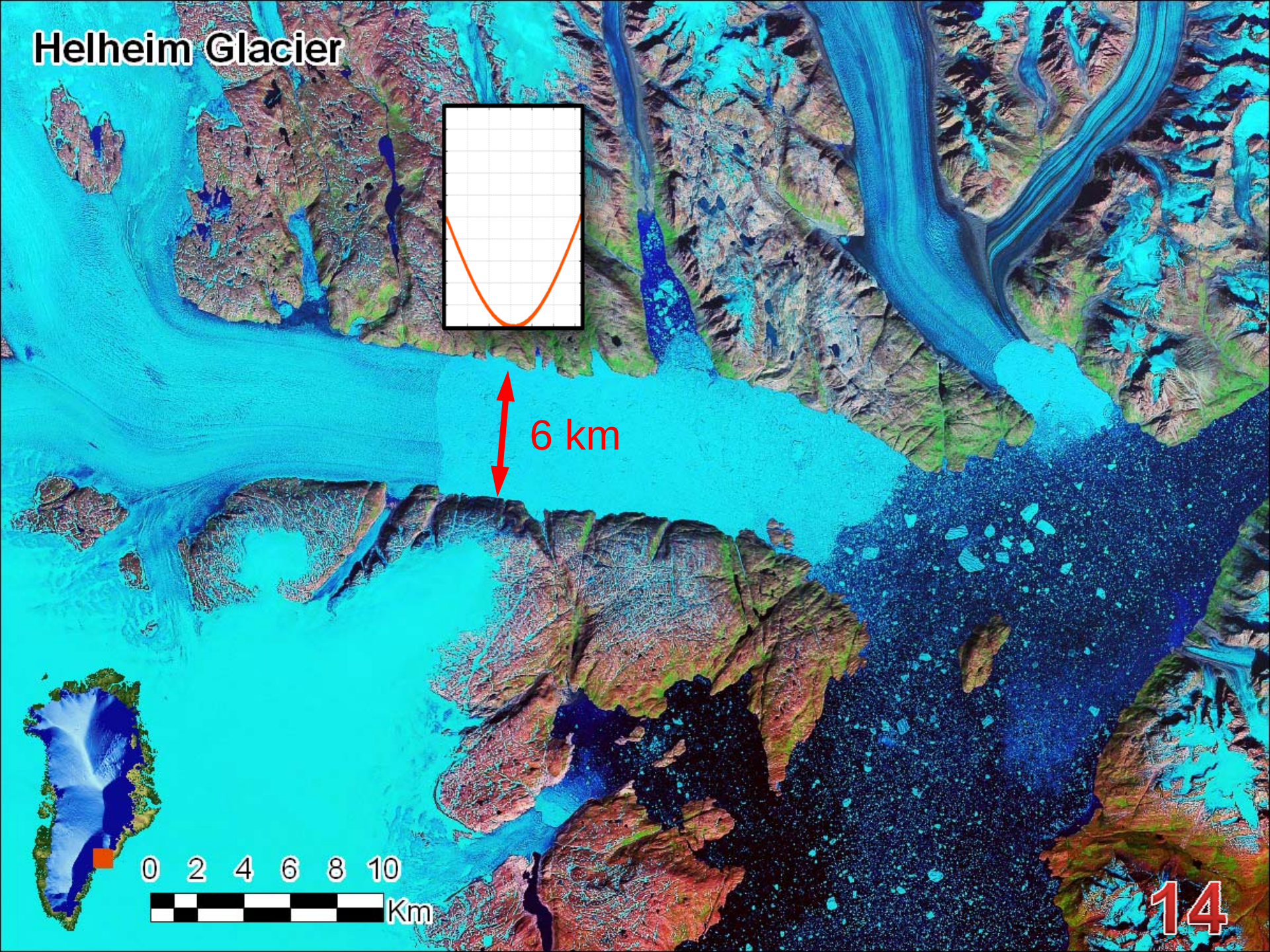
B) Difference between bathymetry estimated from simulated airborne gravity and observed multi-beam bathymetry (Fig. 3A). The minimum difference is -238 m and the maximum is 337 m.


σ_{diff} = 75 m
PDF
Difference [meters]
0
1
2
3
4
5
6
7
8
-300
-200
-100
0
100
200
300


Petermann Glacier
Spatial Resolution
7.5 km
Flying Speed
150 m/s
6.25 km
125 m/s
3.75 km
75 m/s
0
5
10
15
20
Km
11


Petermann Glacier
7.5 km
Spatial Resolution
6.25 km
3.75 km
0
5
10
15
20
Km
12

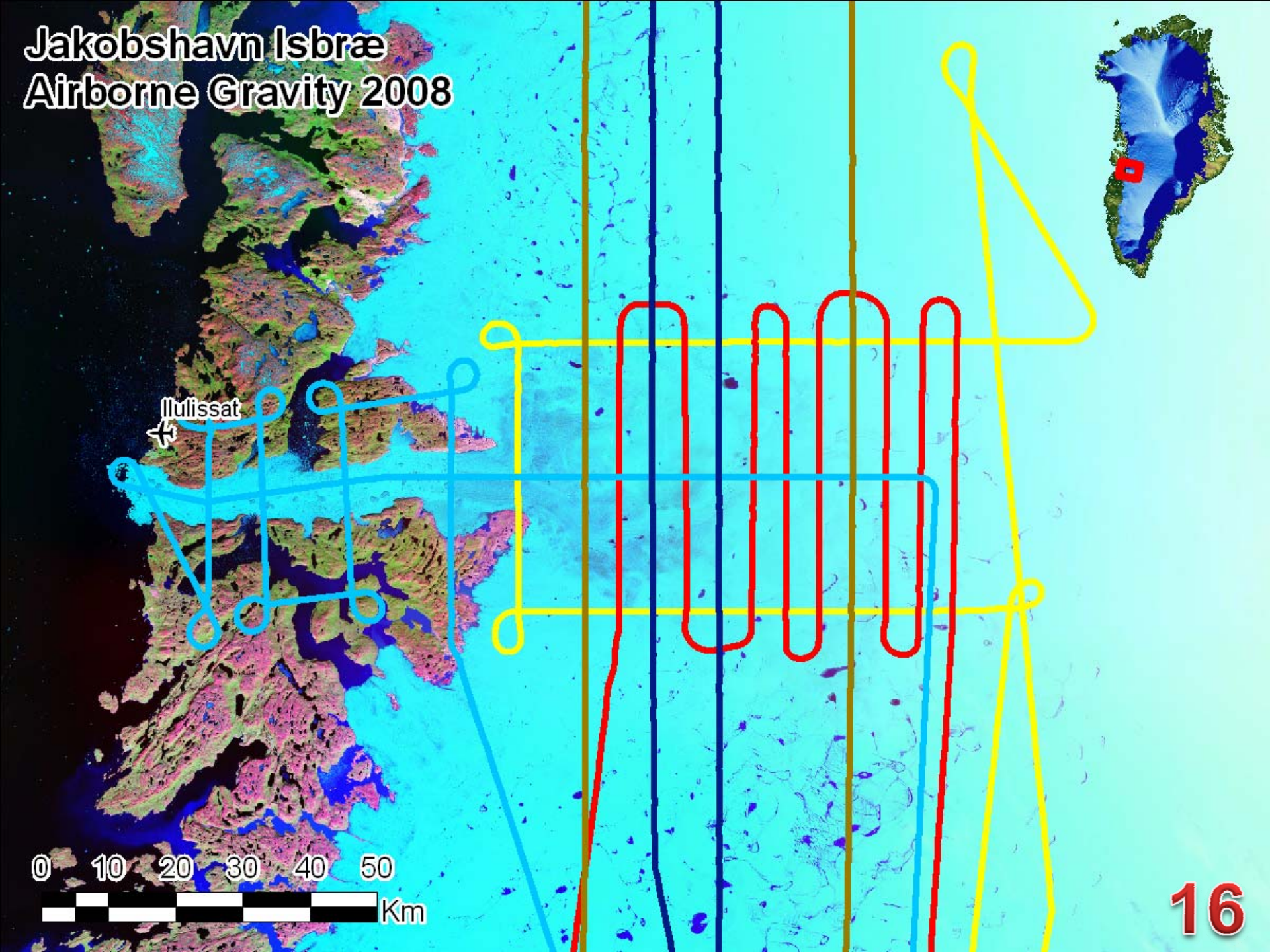

Kangerdlugssuag Glacier
5 km
0 2 4 6 8 10
Km
13

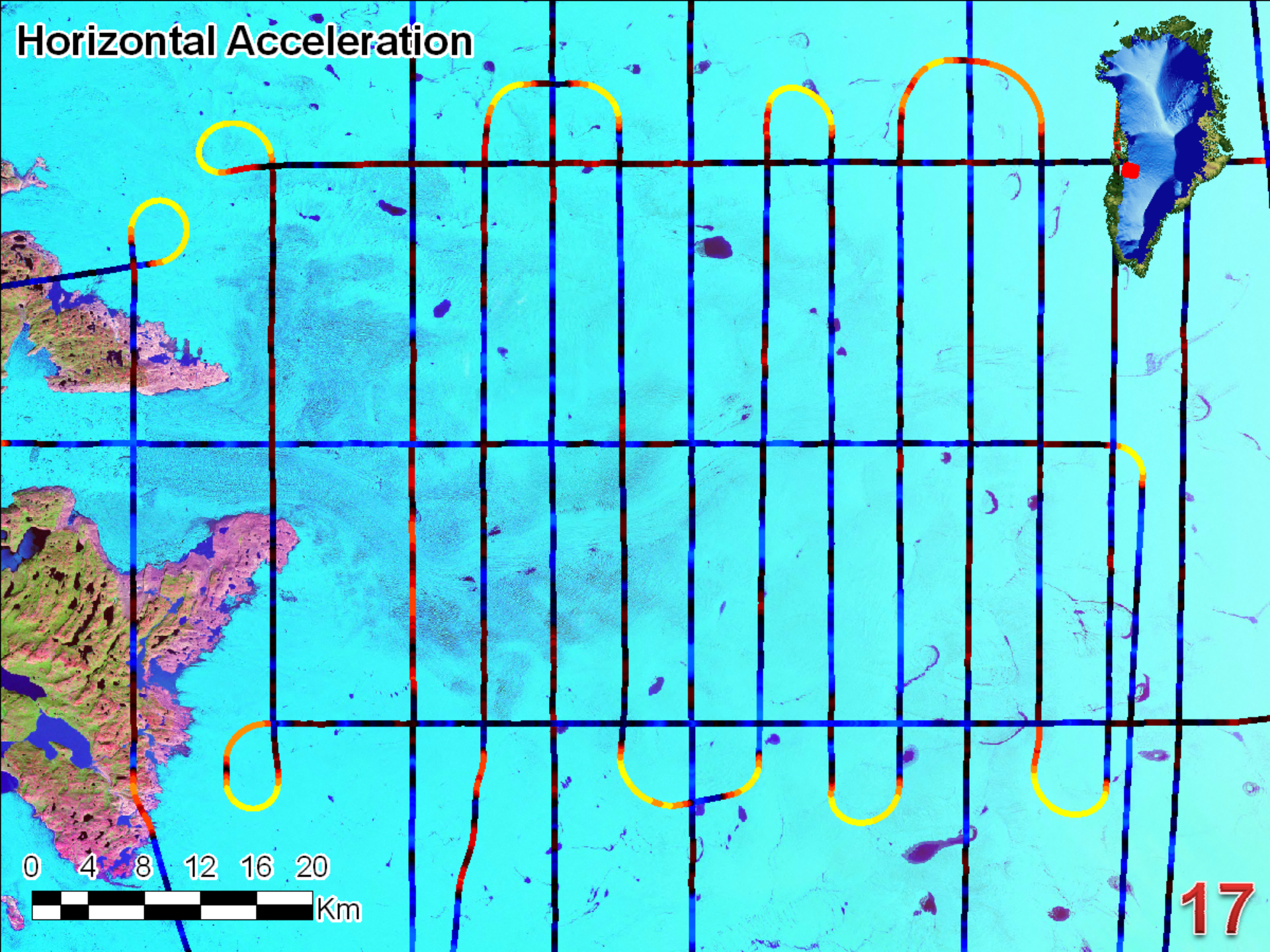

Helheim Glacier
6 km
0 2 4 6 8 10
Km
14

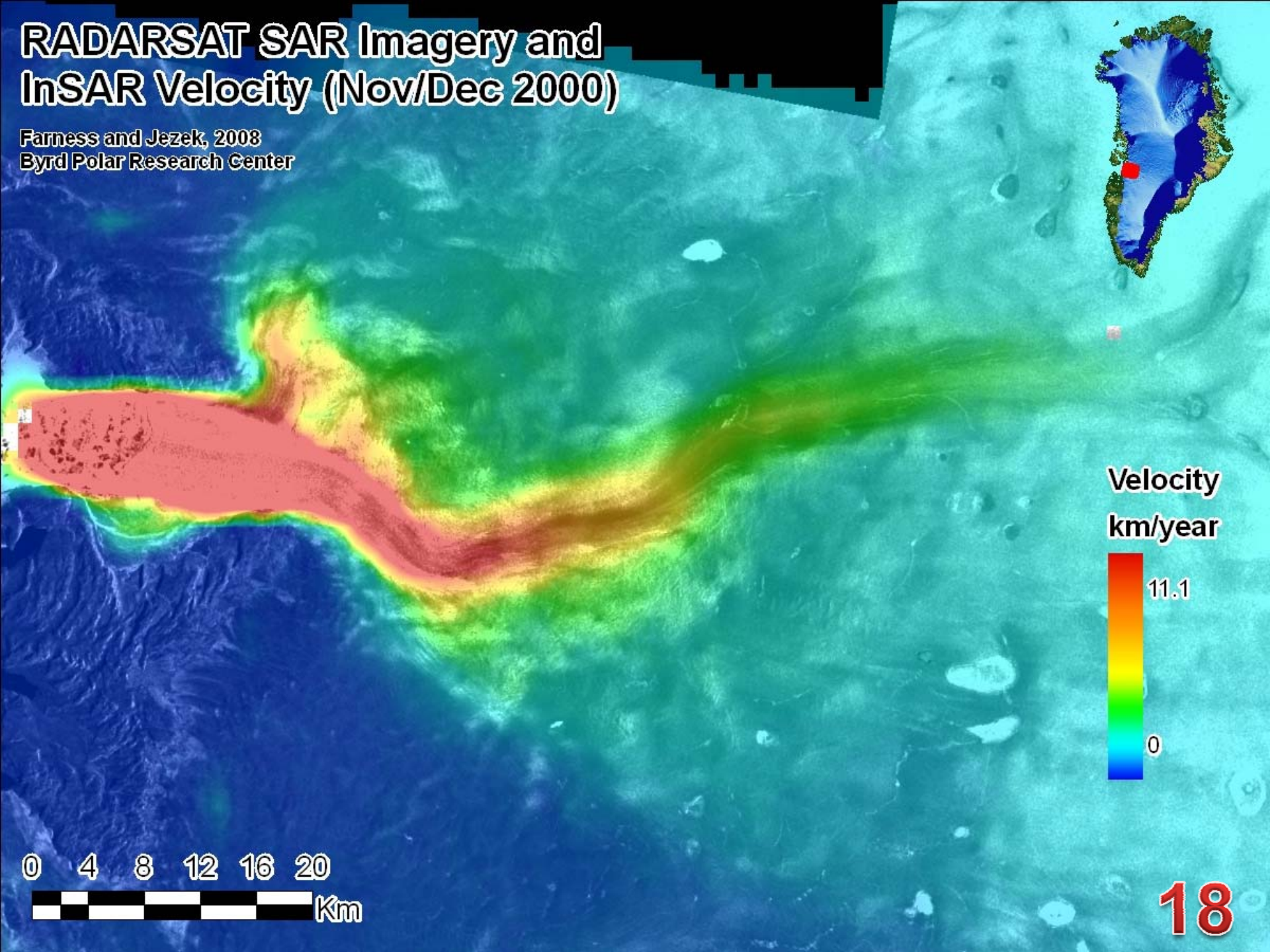
JAKOBSHAVN ISBRÆ

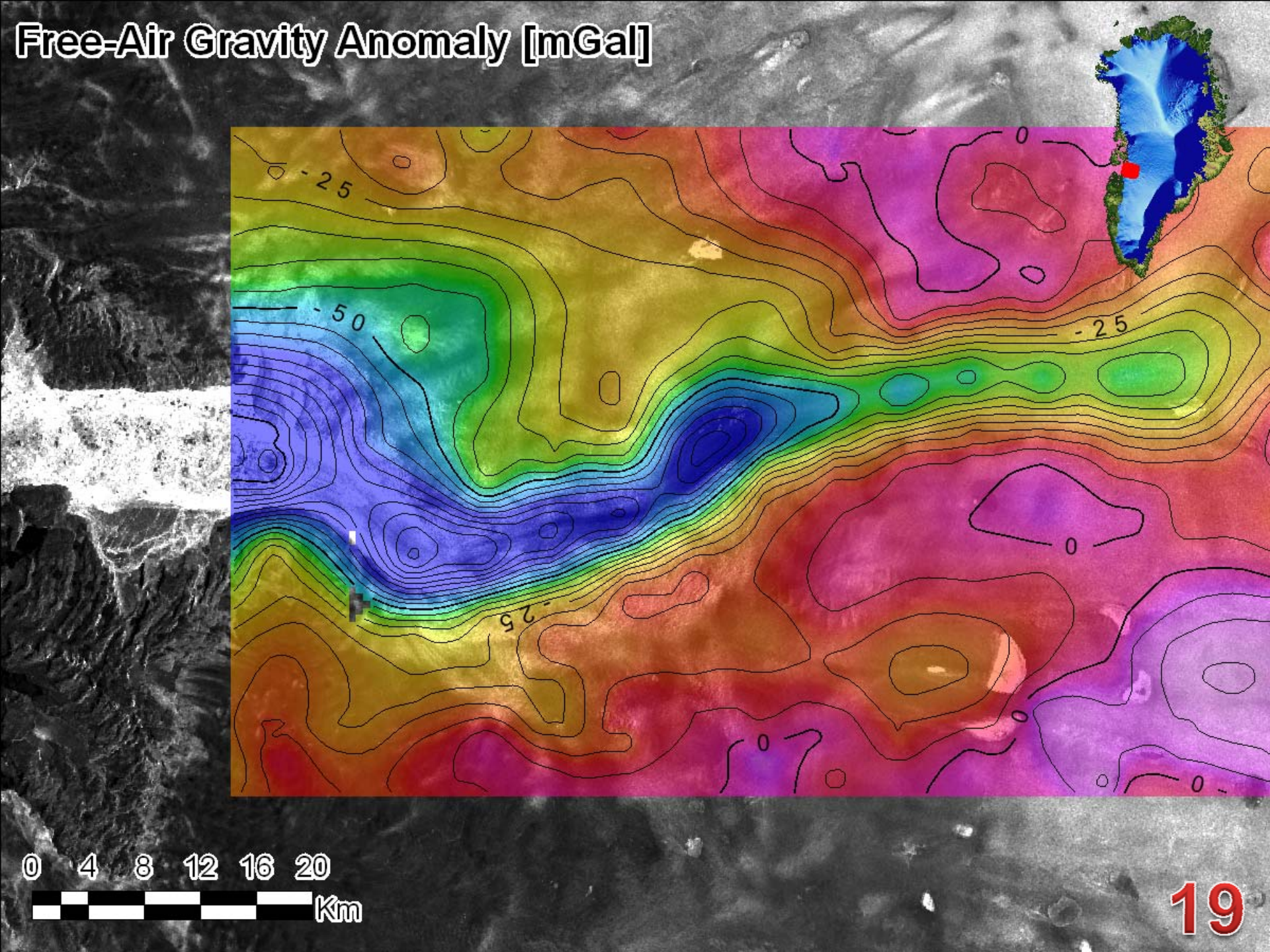
or

Dealing with Reality


Jakobshavn Isbræ
Airborne Gravity 2008
Ilulissat
0 10 20 30 40 50
Km
16

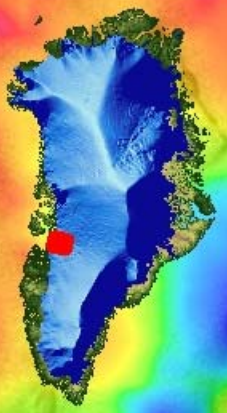

Horizontal Acceleration
0 4 8 12 16 20
Km
17


RADARSAT SAR Imagery and
InSAR Velocity (Nov/Dec 2000)
Farness and Jezek, 2008
Byrd Polar Research Center
Velocity
km/year
11.1
0
0 4 8 12 16 20
Km
18


Free-Air Gravity Anomaly [mGal]
-25
-50
0
-25
0
-25
0
0
0 4 8 12 16 20
Km

Jakobshavn Isbræ Bedrock Elevation

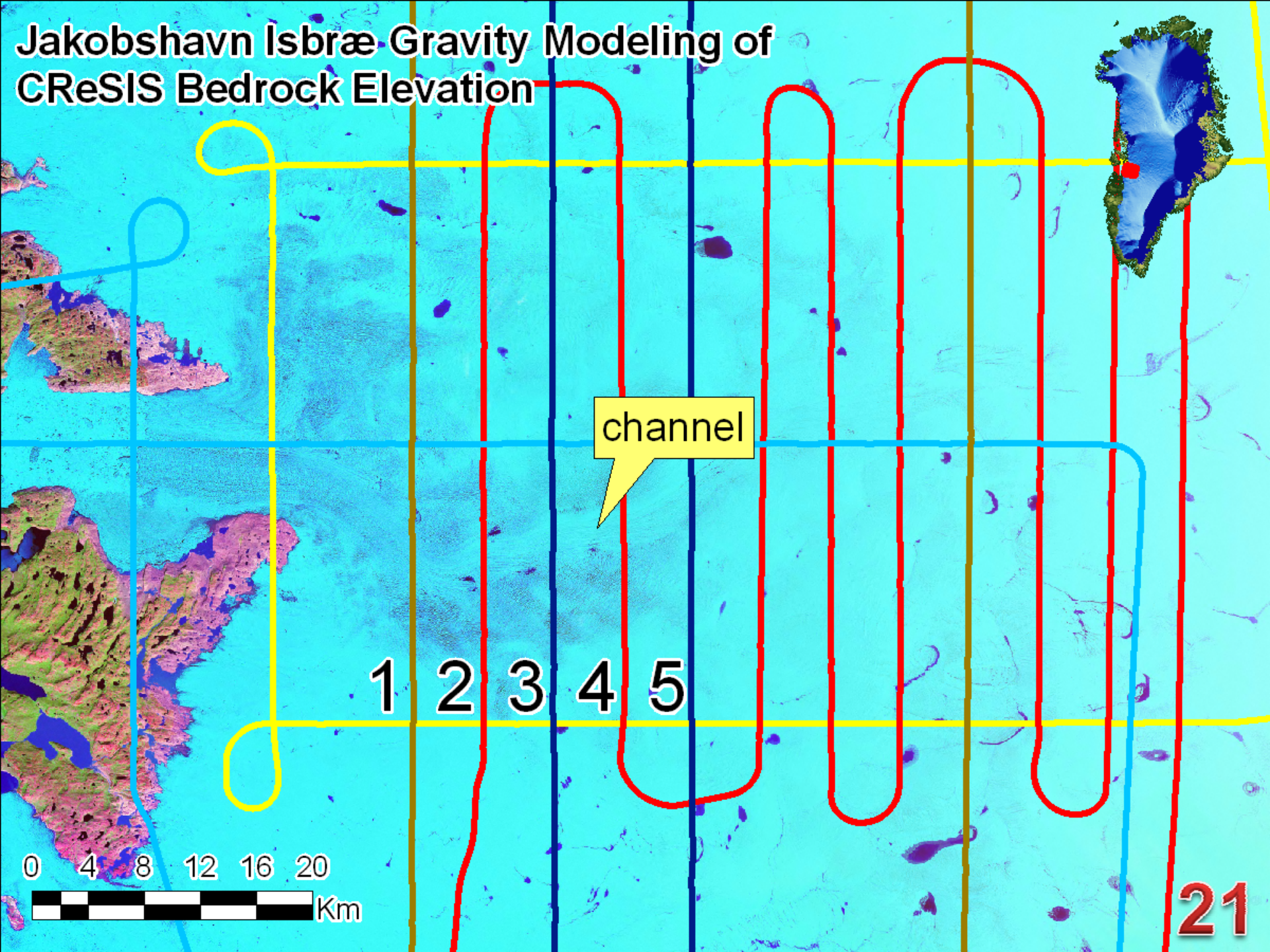
Center for Remote Sensing of Ice Sheets (CReSIS)
at the University of Kansas



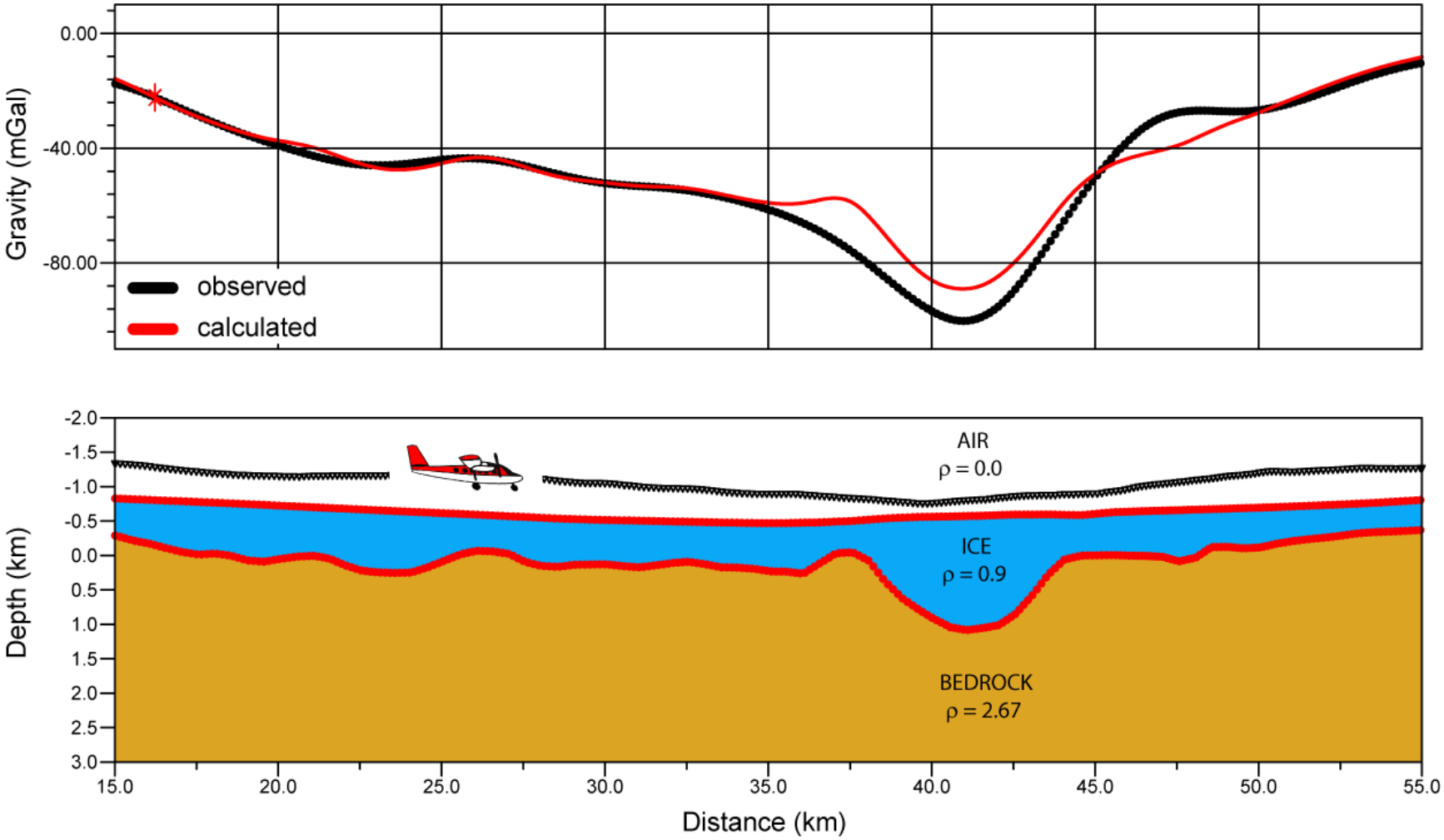
Bed Elevation
m
740
-1450

0 4 8 12 16 20
Km

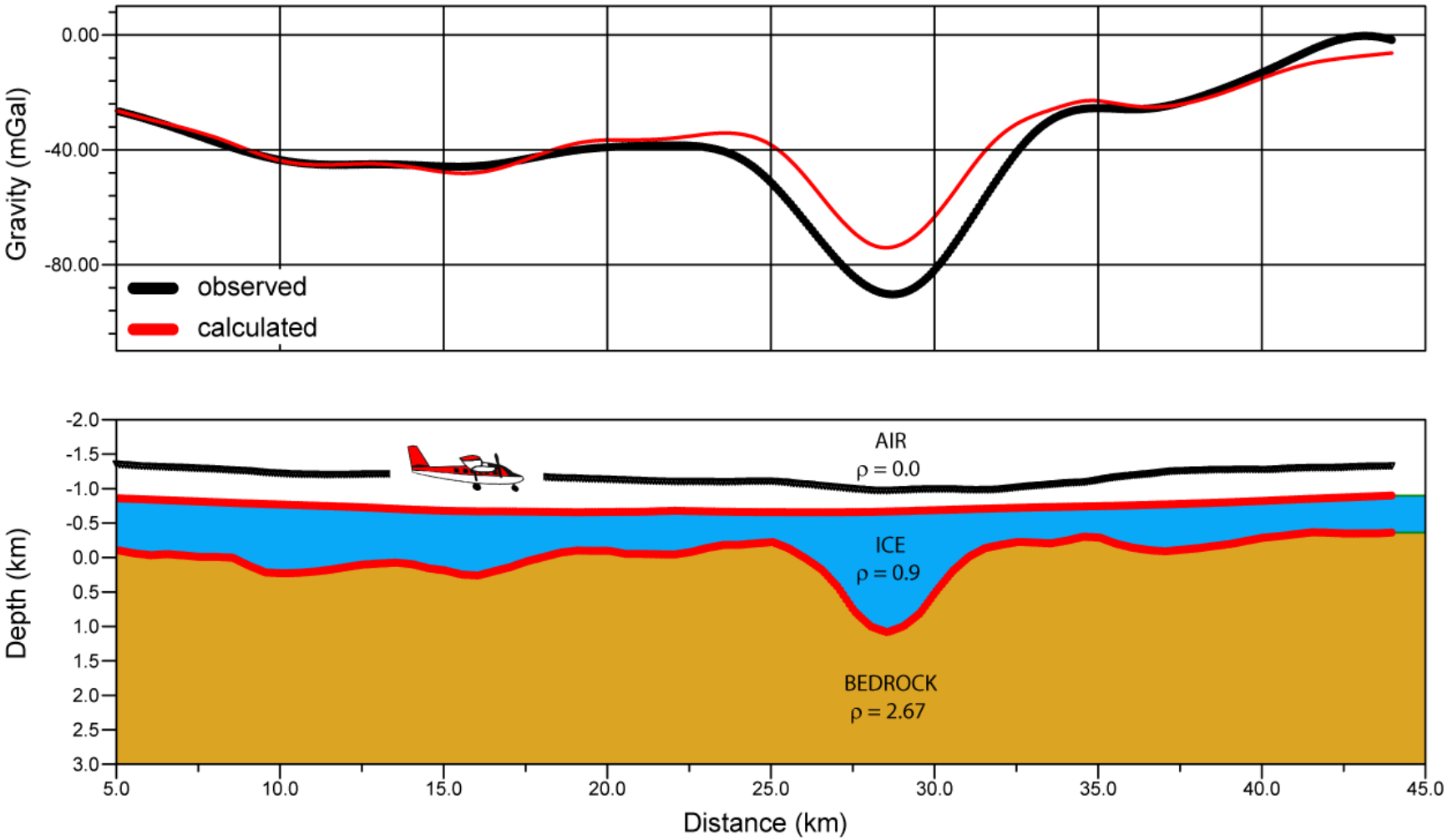
20


Jakobshavn Isbræ Gravity Modeling of
CReSIS Bedrock Elevation
channel
1 2 3 4 5
0 4 8 12 16 20
Km
21

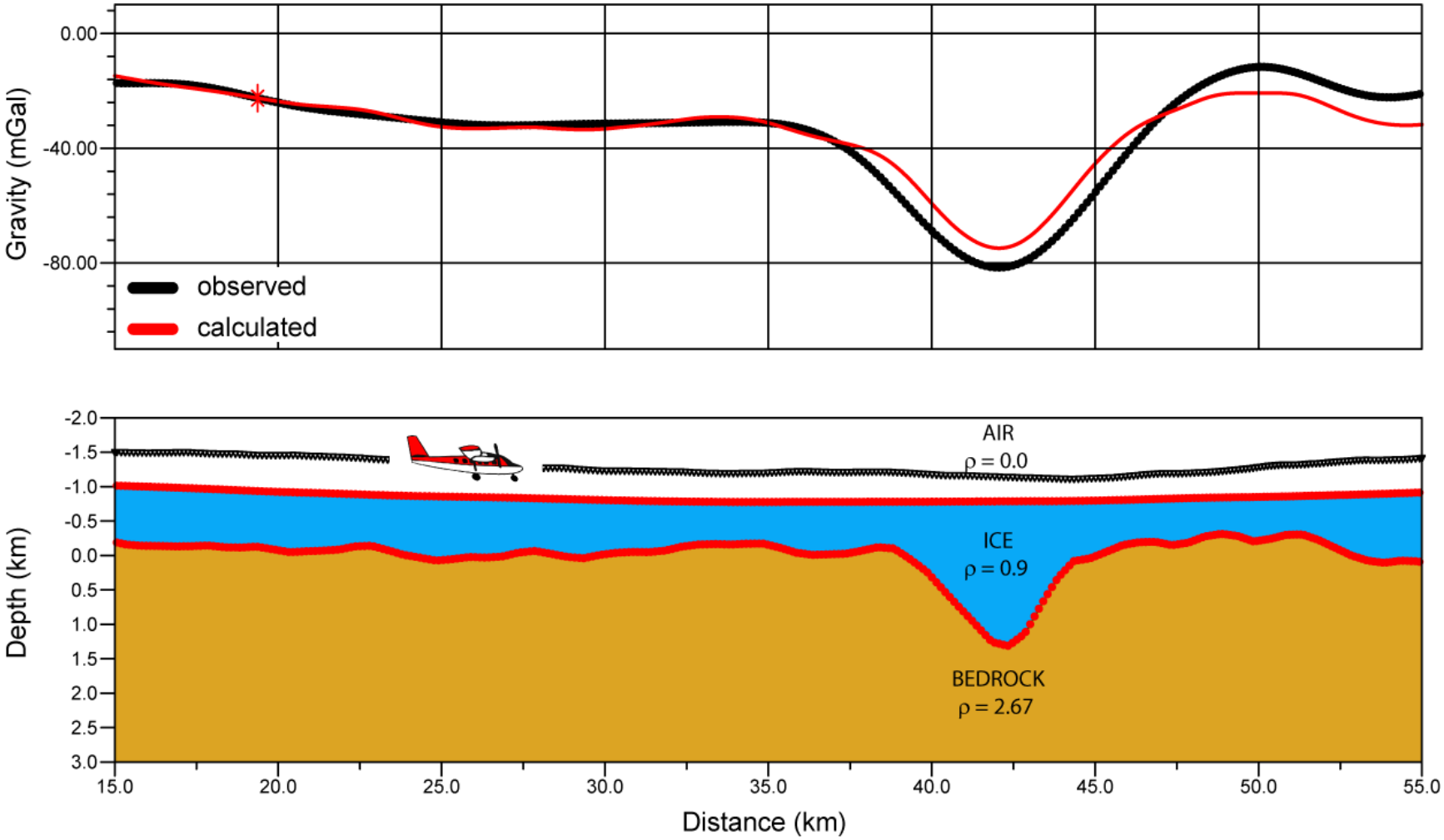
Profile 1: gravity calculated from bedrock elevation from CReSIS grid



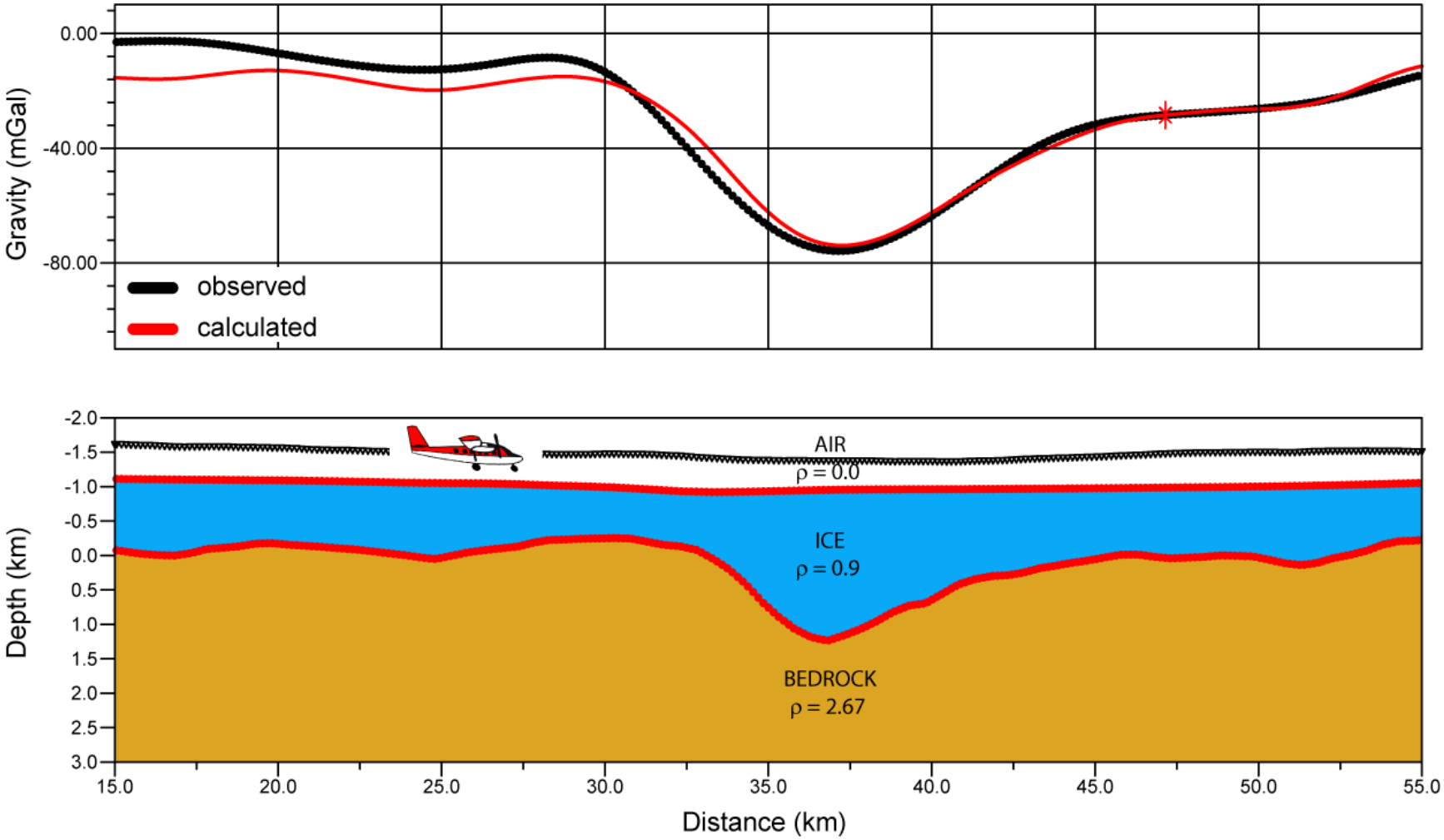
Profile 2: gravity calculated from bedrock elevation from CReSIS grid



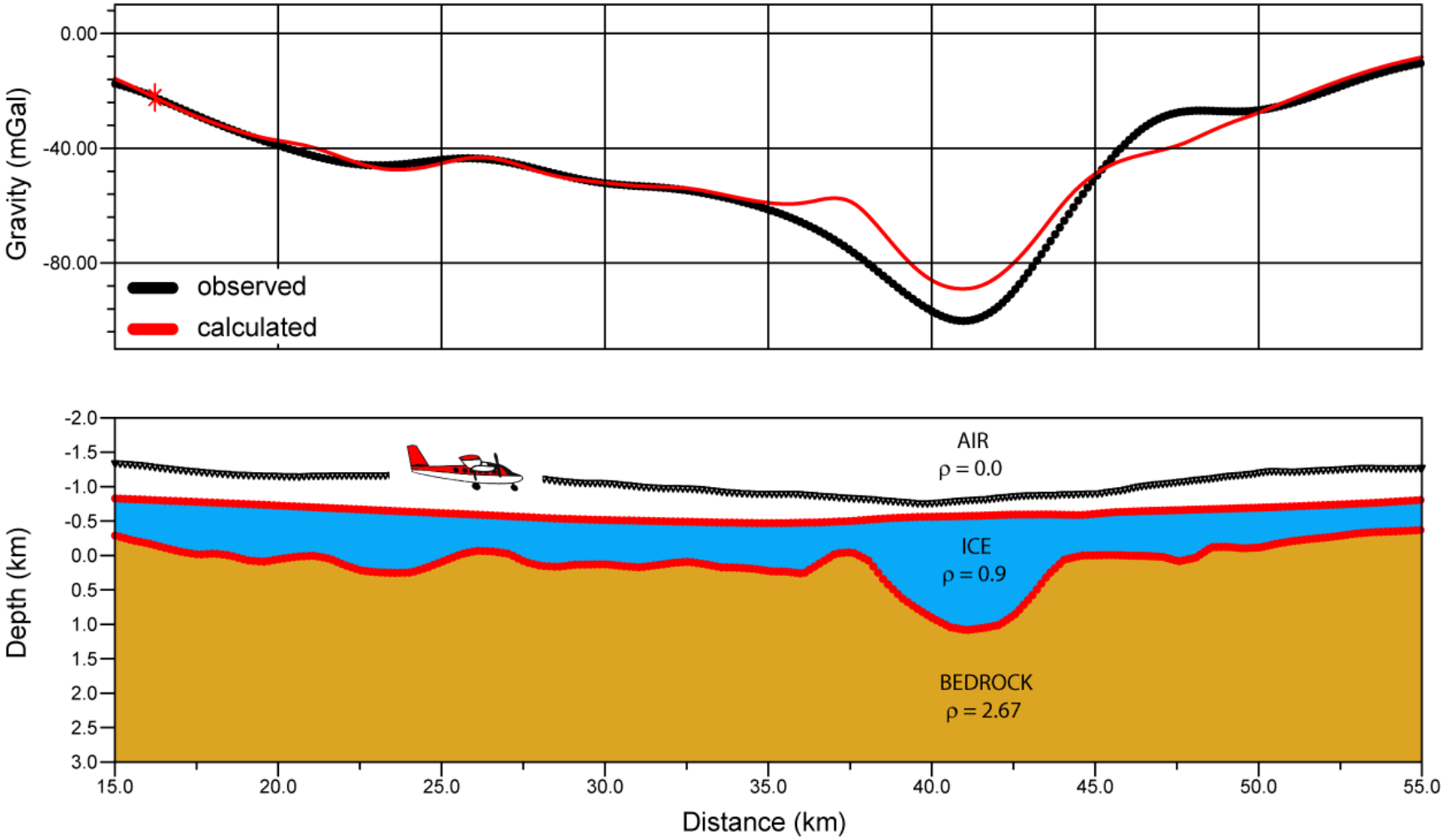
Profile 3: gravity calculated from bedrock elevation from CReSIS grid



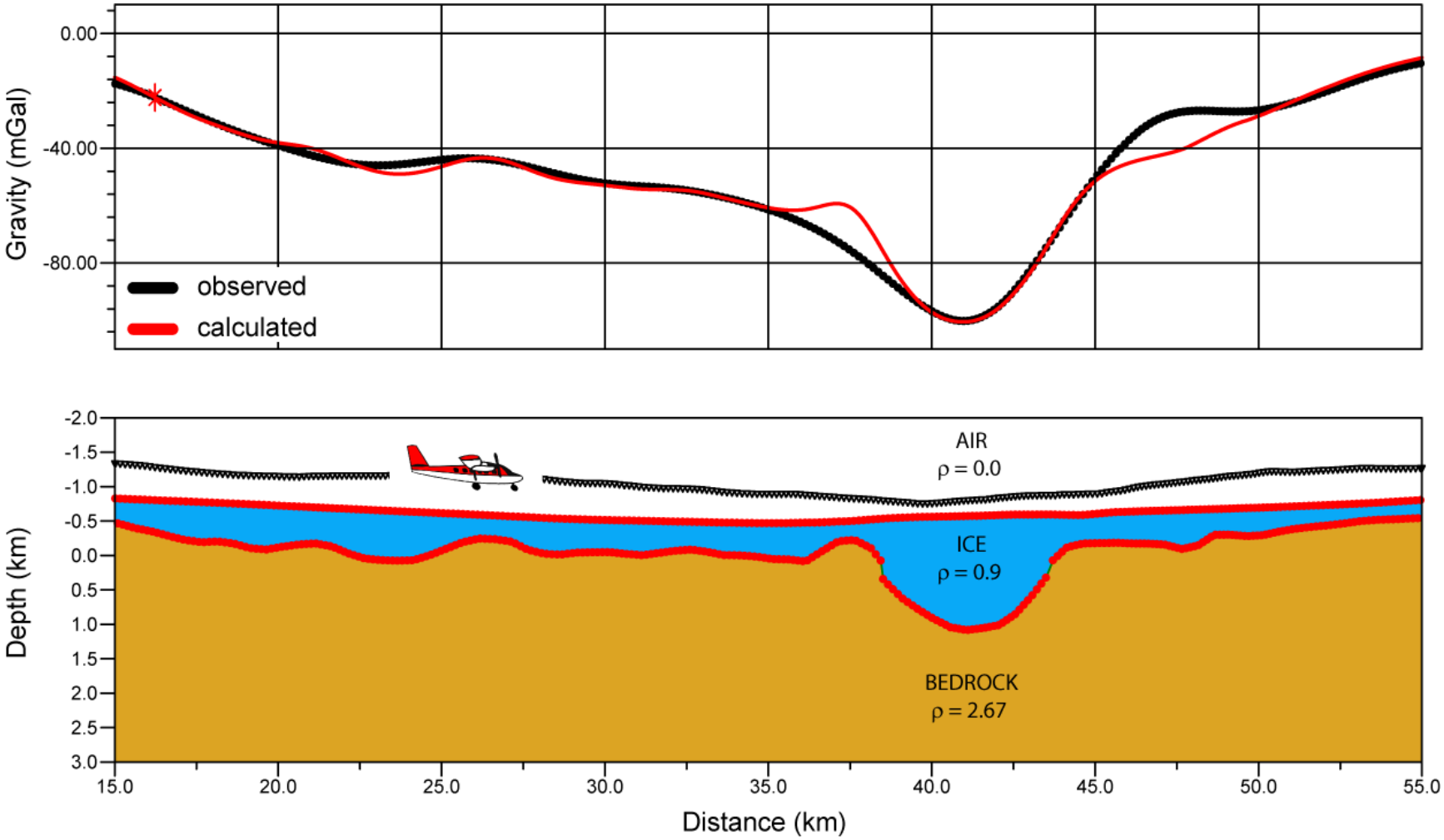
Profile 5: gravity calculated from bedrock elevation from CReSIS grid



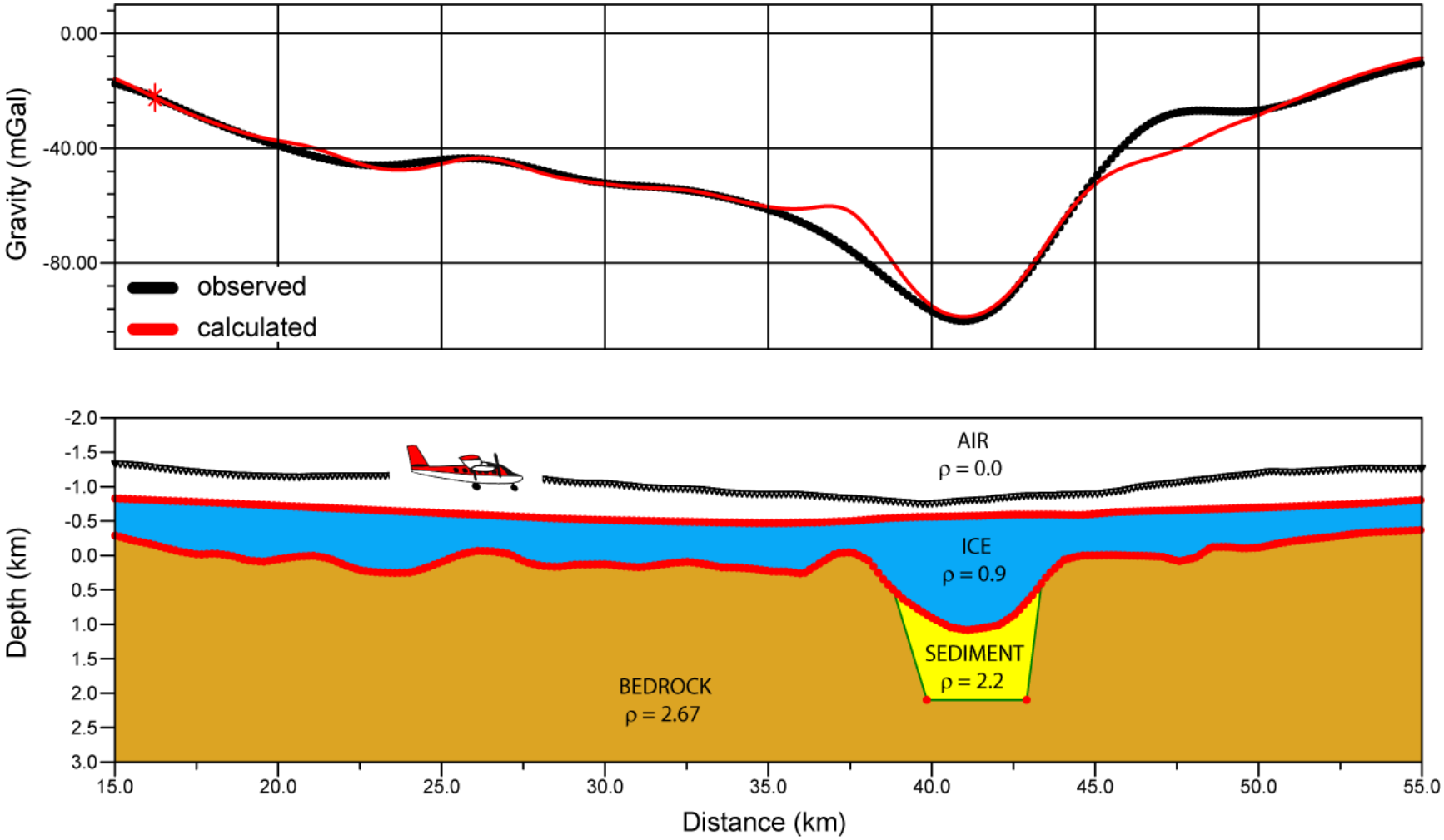
Profile 1 again: gravity calculated from bedrock elevation from CReSIS grid



Profile 1: increase ice thickness by > 200 m to match modeled and observed gravity an unlikely scenario



Profile 1: include a low density sediment body of 1 km thickness to match modeled and observed gravity: more likely scenario



The width of the channel is only slightly larger than the spatial resolution of the gravity data, which means the gravity field may have been undersampled.

Jacobshavn Isbræ Gravity Models

- CReSIS ice thickness grid and airborne gravity can be used as test case for model validation
- Predicted gravity is too high
  possible reasons:
  underestimated ice thickness (unlikely)
- More likely: a 1-km thick sediment wedge that is thinning towards inland and fading out can explain the differences
- **Example illustrates challenges for gravity estimates of ice thickness and bathymetry**