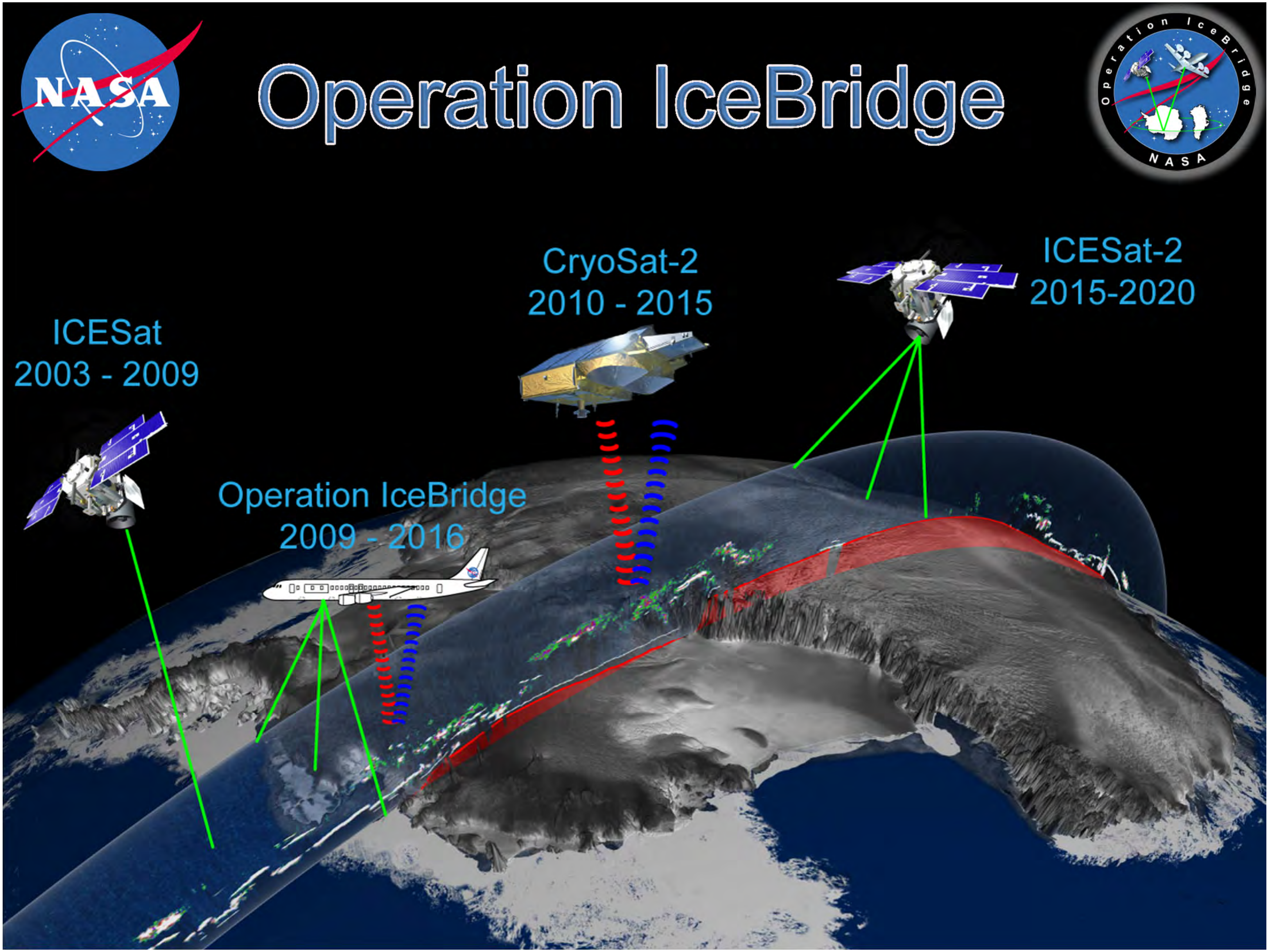
Operation IceBridge

Michael Studinger &
IceBridge Science Team &
Instrument Teams

Image: M. Studinger


NASA
Operation IceBridge
Operation IceBridge
NASA
CryoSat-2
2010 - 2015
ICESat-2
2015-2020
ICESat
2003 - 2009
Operation IceBridge
2009 - 2016

Operation IceBridge

- IceBridge will produce a robust, cross-calibrated 17-year time series of ice sheet and sea ice elevation data together with ICESat, CryoSat-2, and ICESat-2

- The 17-year time series will be the definitive resource for predictive models of sea ice and ice sheet behavior

- In addition to laser altimetry, IceBridge is using the most comprehensive and sophisticated suite of instruments ever flown in polar research to yield an unprecedented three-dimensional view of the Arctic and Antarctic ice sheets, ice shelves, and the sea ice

IceBridge Background

2008: feasibility and cost analysis: "An analysis and summary of options for collecting ICESat-like data from aircraft"

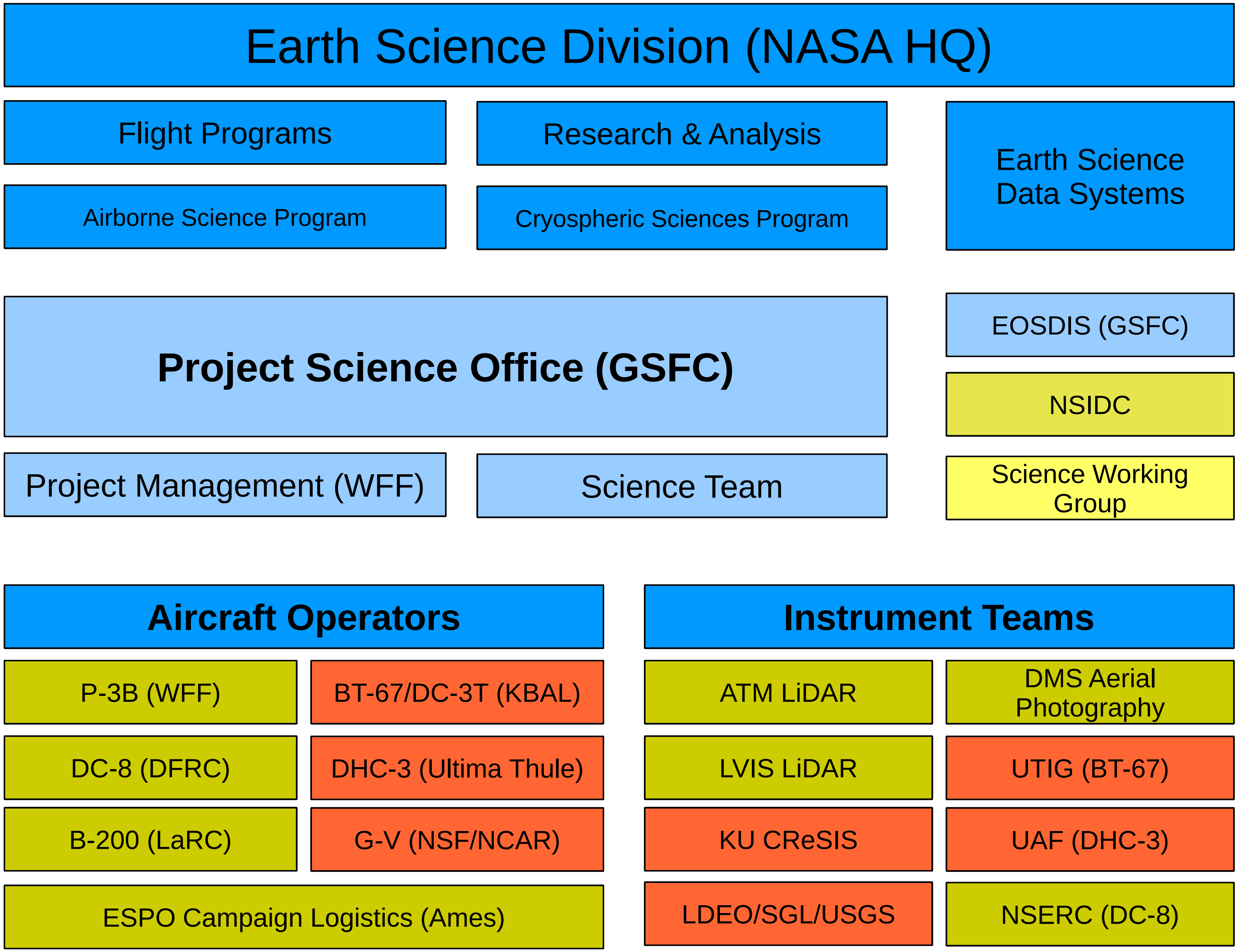
2009: solicited proposals for instruments for DC-8 campaign Punta Arenas and Greenland 2010

ad hoc community-based steering committee responsible for flight planning

2010: ROSES call for instrument teams and IceBridge Science Team members

IceBridge Science Team and instrument teams selected based on competitive proposals
shift from ad hoc steering committee to directed mission: level 1 science requirements and science justification

2011: ROSES call for IceBridge science



Earth Science Division (NASA HQ)
Flight Programs
Research & Analysis
Earth Science Data Systems
Airborne Science Program
Cryospheric Sciences Program
Project Science Office (GSFC)
EOSDIS (GSFC)
NSIDC
Project Management (WFF)
Science Team
Science Working Group
Aircraft Operators
Instrument Teams
P-3B (WFF)
BT-67/DC-3T (KBAL)
ATM LiDAR
DMS Aerial Photography
DC-8 (DFRC)
DHC-3 (Ultima Thule)
LVIS LiDAR
UTIG (BT-67)
B-200 (LaRC)
G-V (NSF/NCAR)
KU CReSIS
UAF (DHC-3)
ESPO Campaign Logistics (Ames)
LDEO/SGL/USGS
NSERC (DC-8)

Platform and Instrument Suite

Northern Hemisphere

Wallops P-3B (Arctic Ocean & Greenland)

- 2 ATM laser altimeters (NASA/GSFC/WFF)
- MCoRDS radar sounder (CReSIS/KU)
- Accumulation radar (CReSIS/KU)
- Snow radar (CReSIS/KU)
- Ku-band radar altimeter (CReSIS/KU)
- Digital Mapping System (NASA/Ames)
- Gravimeter (Sander Geophysics/CU)
- Magnetometer (Sander Geophysics/CU)

Langley B-200 (southern Greenland)

- LVIS laser altimeter (NASA/GSFC)

UAF DHC-3 (Southeast Alaska)

- Riegl laser altimeter (UAF)
- WISE radar sounders (NASA/JPL)

Southern Hemisphere

Dryden DC-8 (S Ocean & Antarctica)

- 2 ATM laser altimeters (NASA/GSFC/WFF)
- MCoRDS radar sounder (CReSIS/KU)
- Snow radar (CReSIS/KU)
- Ku-band radar altimeter (CReSIS/KU)
- Digital Mapping System (NASA/Ames)
- Gravimeter (Sander Geophysics/CU)
- Onboard data system (NSERC/UND)

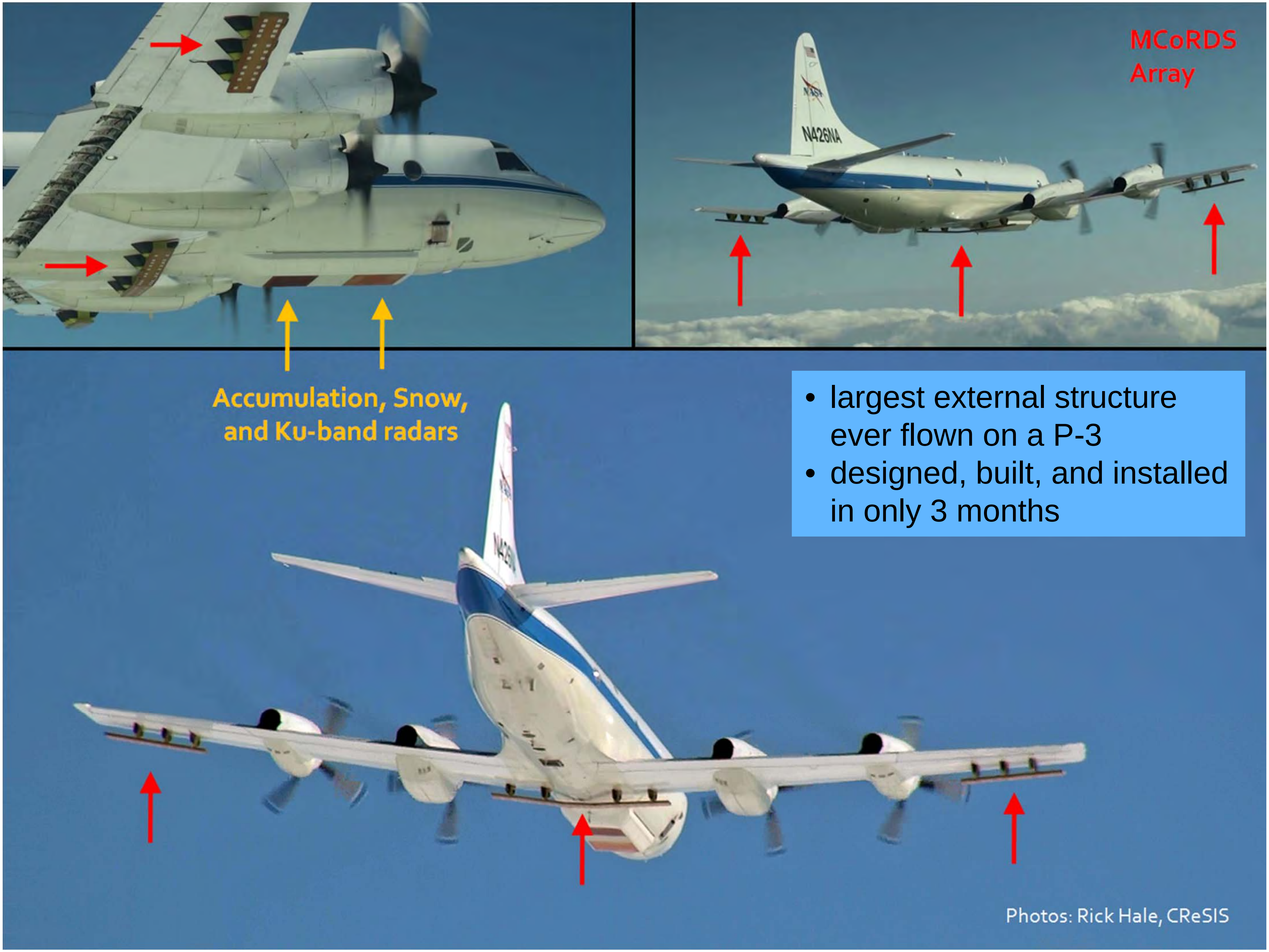
NSF/NCAR G-V (Antarctica)

- LVIS laser altimeter (NASA/GSFC)

ICECAP/UTIG DC-3/BT-67 (Antarctica)

- Riegl laser profiler (UTIG)
- Photon counting laser scanner (Sigma Space)
- HiCARS radar depth sounder (UTIG)
- BGM-3 gravimeter (UTIG)
- Magnetometer (UTIG)

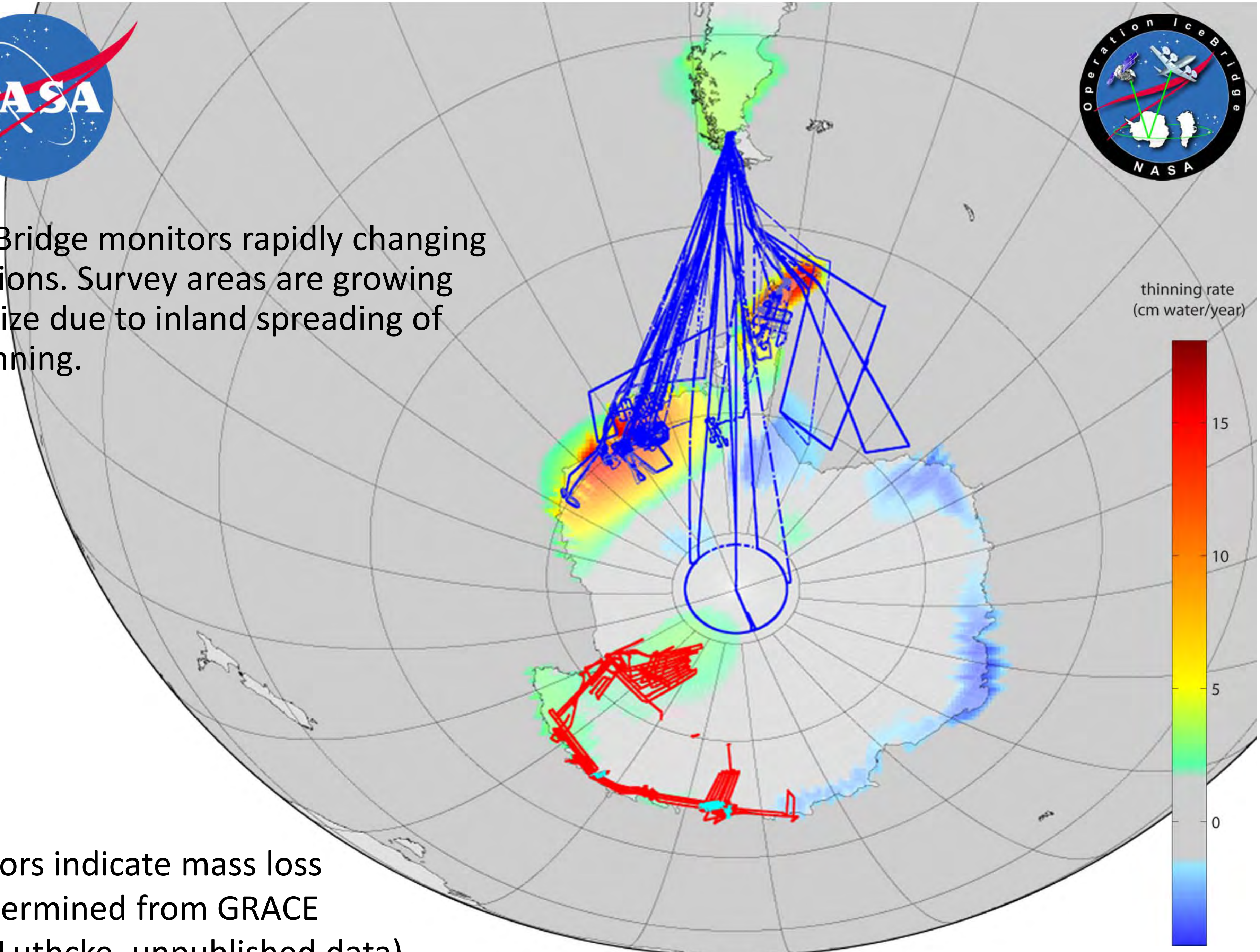
Total of 6 aircraft and 16 science instruments


MCoRDS
Array
N426NA
NASA
Accumulation, Snow,
and Ku-band radars
• largest external structure ever flown on a P-3
• designed, built, and installed in only 3 months
Photos: Rick Hale, CReSIS

Next Phase of IceBridge

Ikhana and Global Hawk

IceBridge monitors rapidly changing regions. Survey areas are growing in size due to inland spreading of thinning.



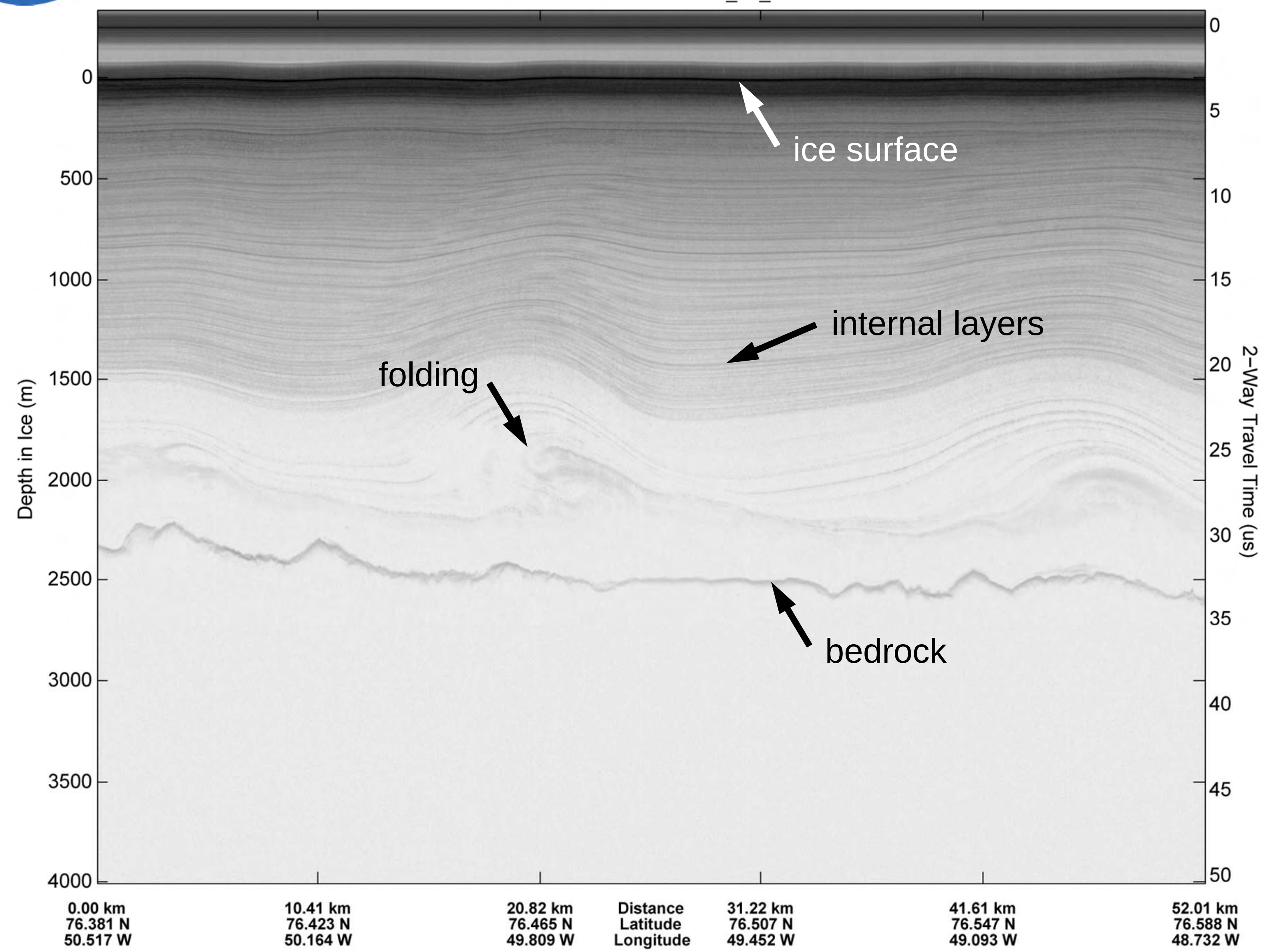
Colors indicate mass loss determined from GRACE (S. Luthcke, unpublished data).

IceBridge is imaging Ice Sheets in unprecedented detail

Greenland 2011: CryoSat-2 underflight, March 29

MCoRDS Radar Quick Look Image

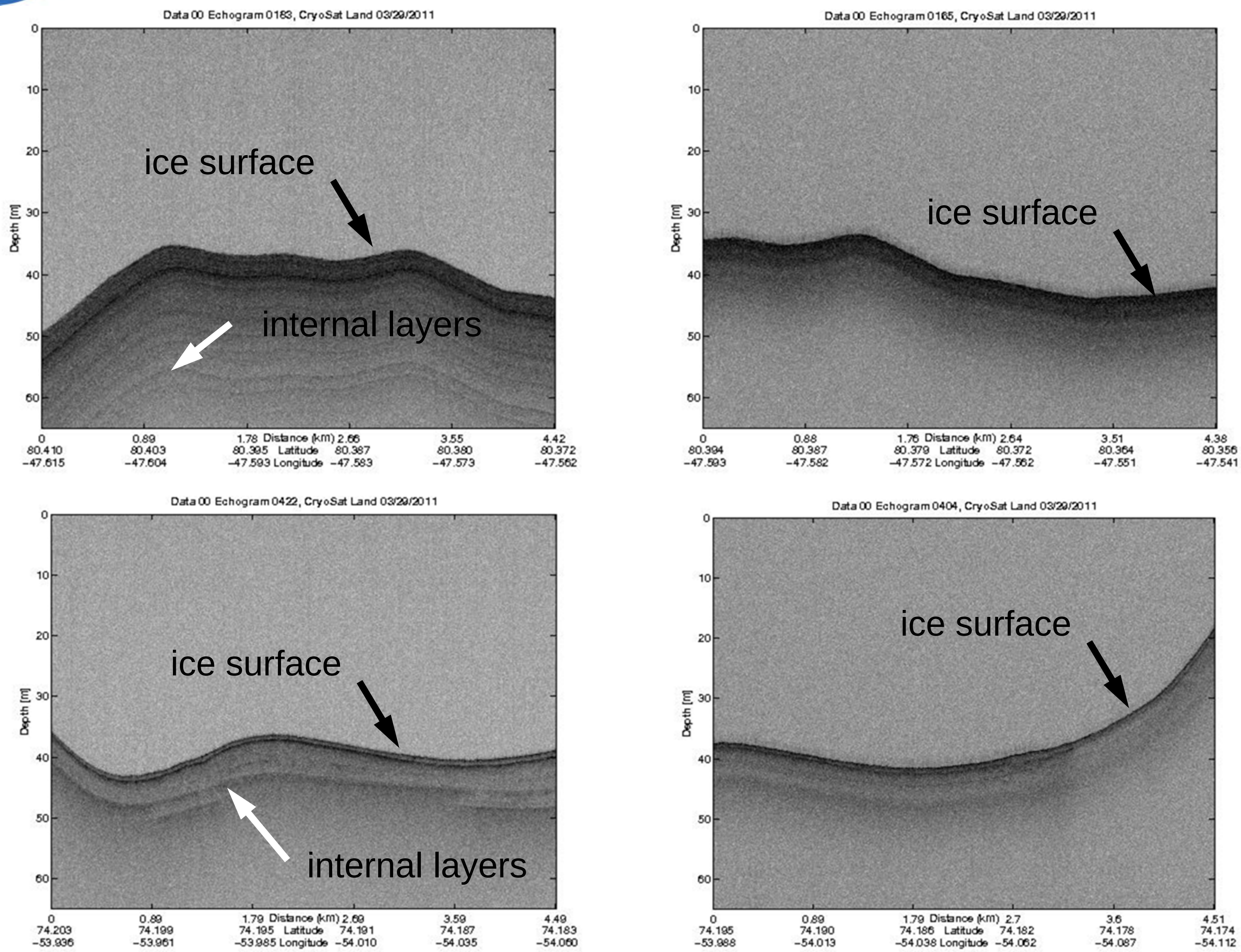
Data Frame ID: 20110329_02_020



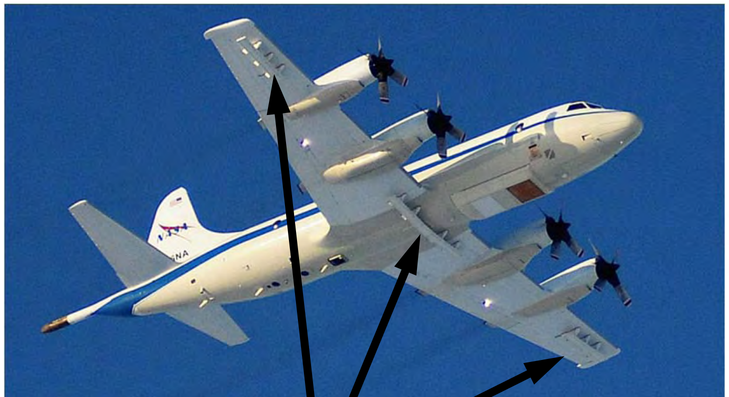
IceBridge is imaging Ice Sheets in unprecedented detail

Greenland 2011: CryoSat-2 underflight, March 29

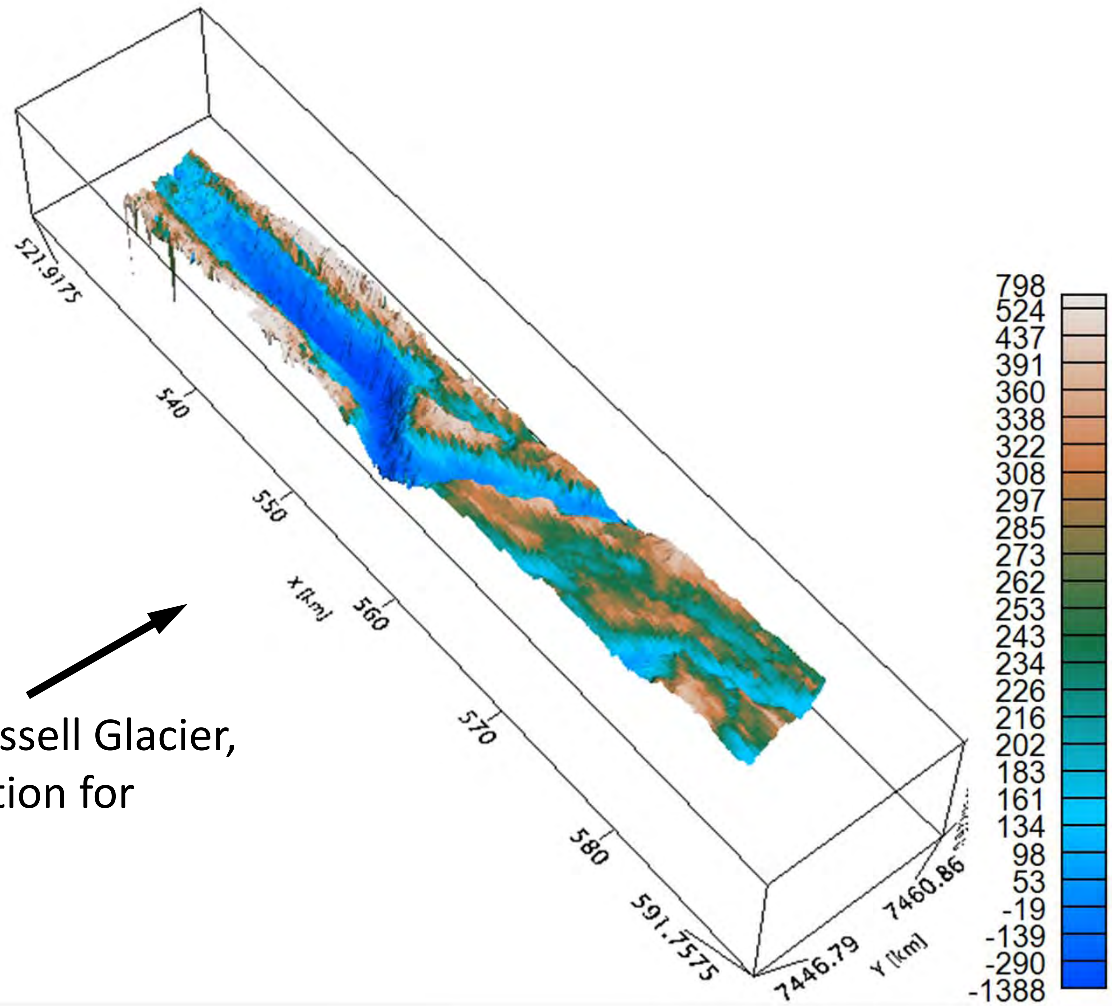
Snow radar (left) and Ku-band radar (right) Quick Look Images



IceBridge is imaging ice sheets in unprecedented detail



unique 15 element antenna array
for radar imaging on P-3
allows for SAR mapping of
bedrock below the glacier



High-resolution (500 m) Survey of Russell Glacier, Greenland to produce bedrock elevation for improved ice sheet models

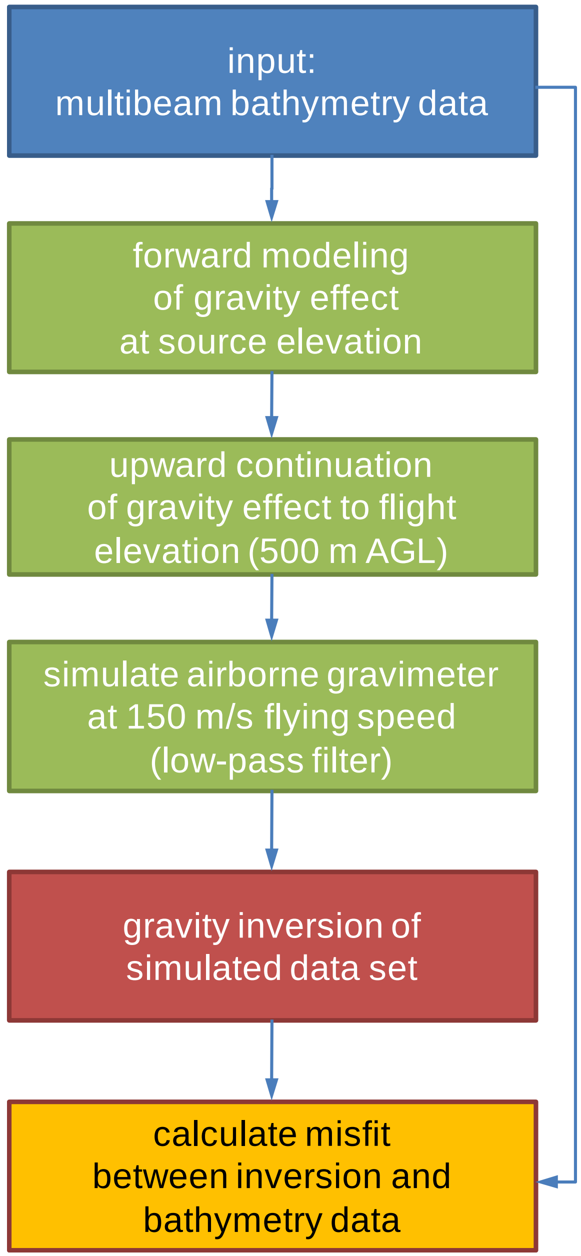
Data: John Paden, CReSIS

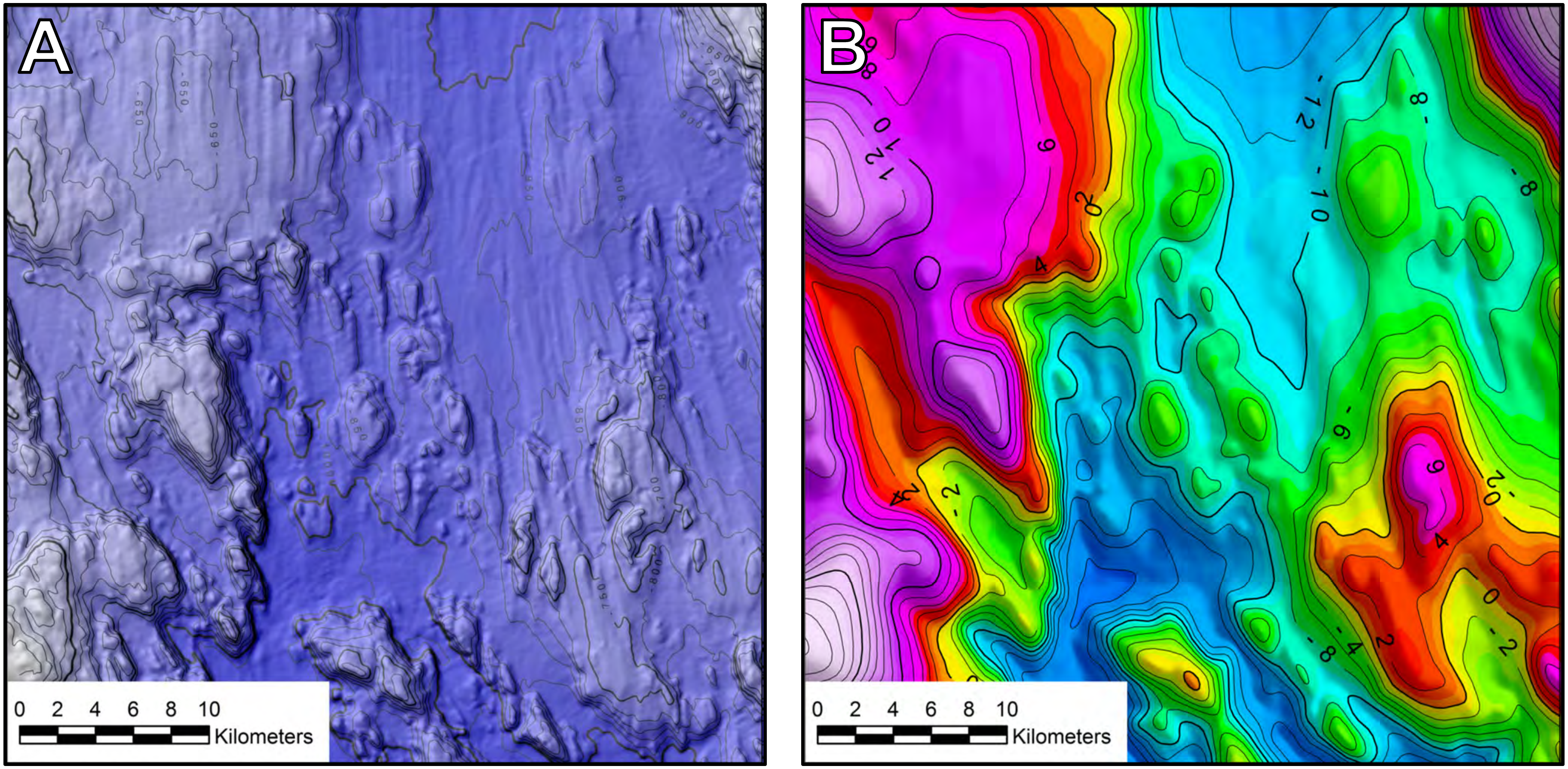
Accuracy and Resolution

The accuracy and spatial resolution of bathymetry inverted from airborne gravity depends on many factors:

- resolution of airborne gravimeter system
- flying speed
- distance between gravity sensor and the sub-surface density contrast
- flight line spacing
- ruggedness of the bathymetry
- knowledge of bedrock densities
- knowledge of lateral density variations from geologic sources
- availability of independent data such as: multibeam bathymetry, ice-penetrating radar and seismic data

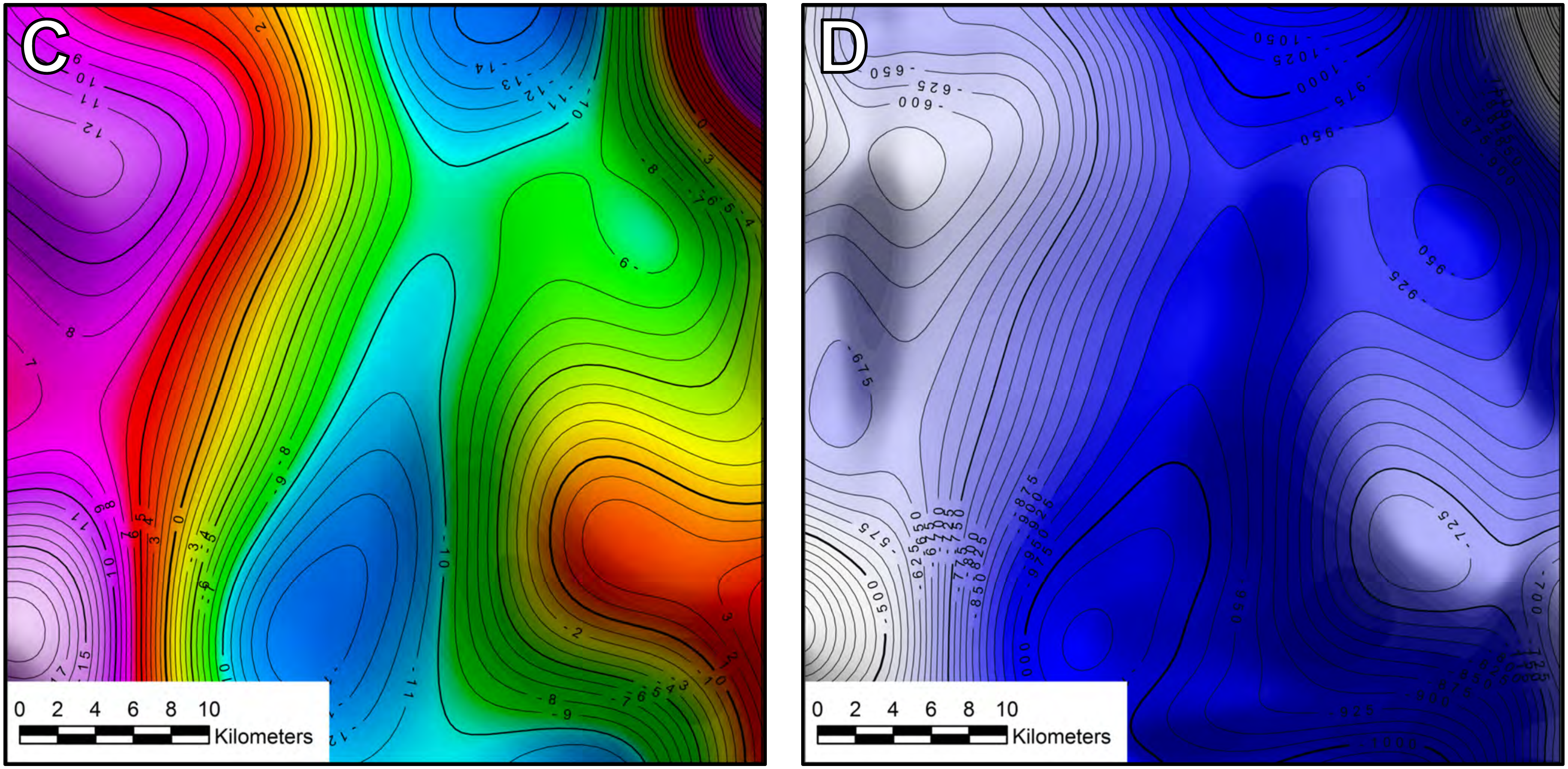
Useful to know: a 25 meter undulation in water depth at 1000 m depth causes a change in the gravity field at the surface of about 1 mGal (roughly the uncertainty in the data).





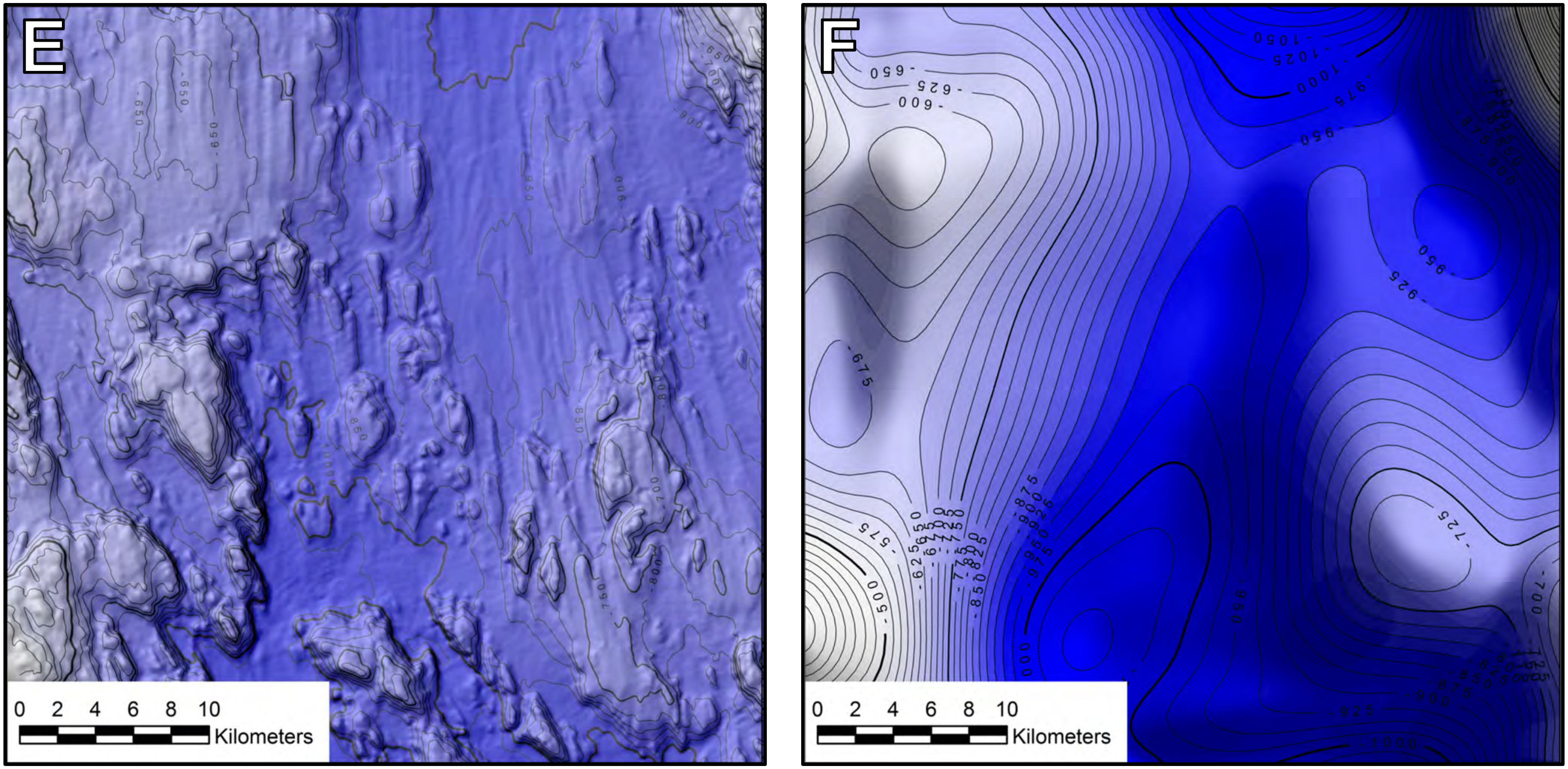
A. Multi-beam bathymetry in Pine Island Bay (F. Nitsche *et al*., unpublished data). The image is 40 40 km wide with 50 m contours ranging from 1100 m to 250 m water depth. Darker colors indicate deeper bathymetry.

B. Forward model of the free-air gravity anomaly (in mGal) at flight elevation (500 m ASL) using bathymetry from A). This is the gravity field an ideal gravimeter could measure.



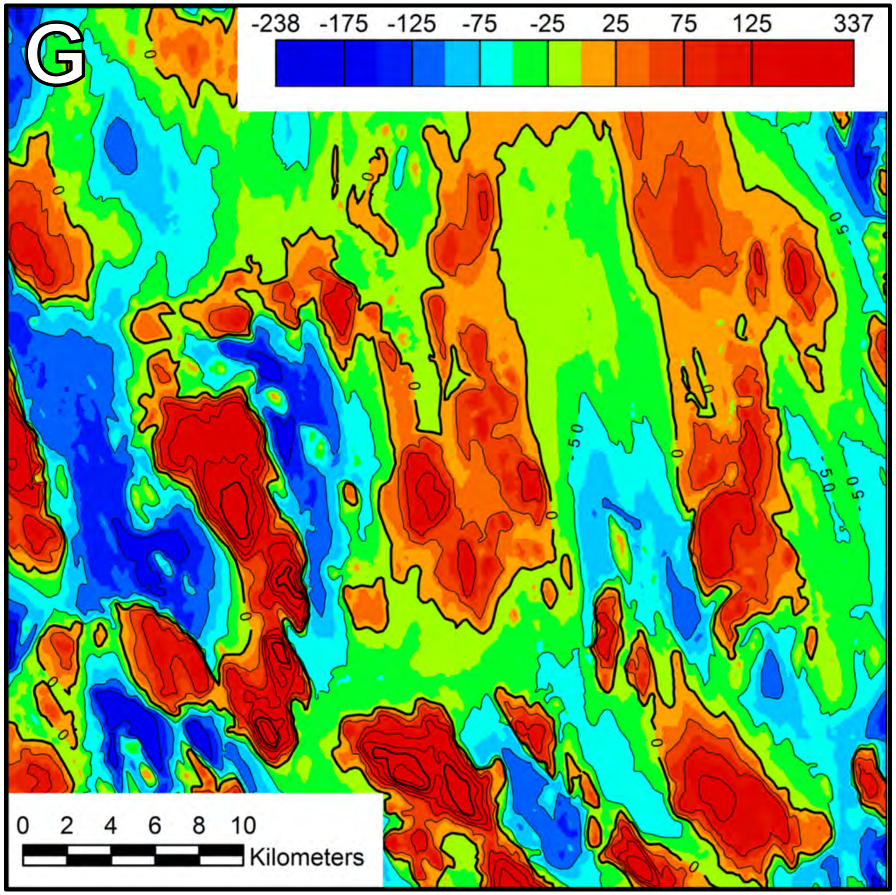
C. Simulated gravity effect of the bedrock/water interface at flight elevation that an AIRGrav system flown at 150 m/s can detect.

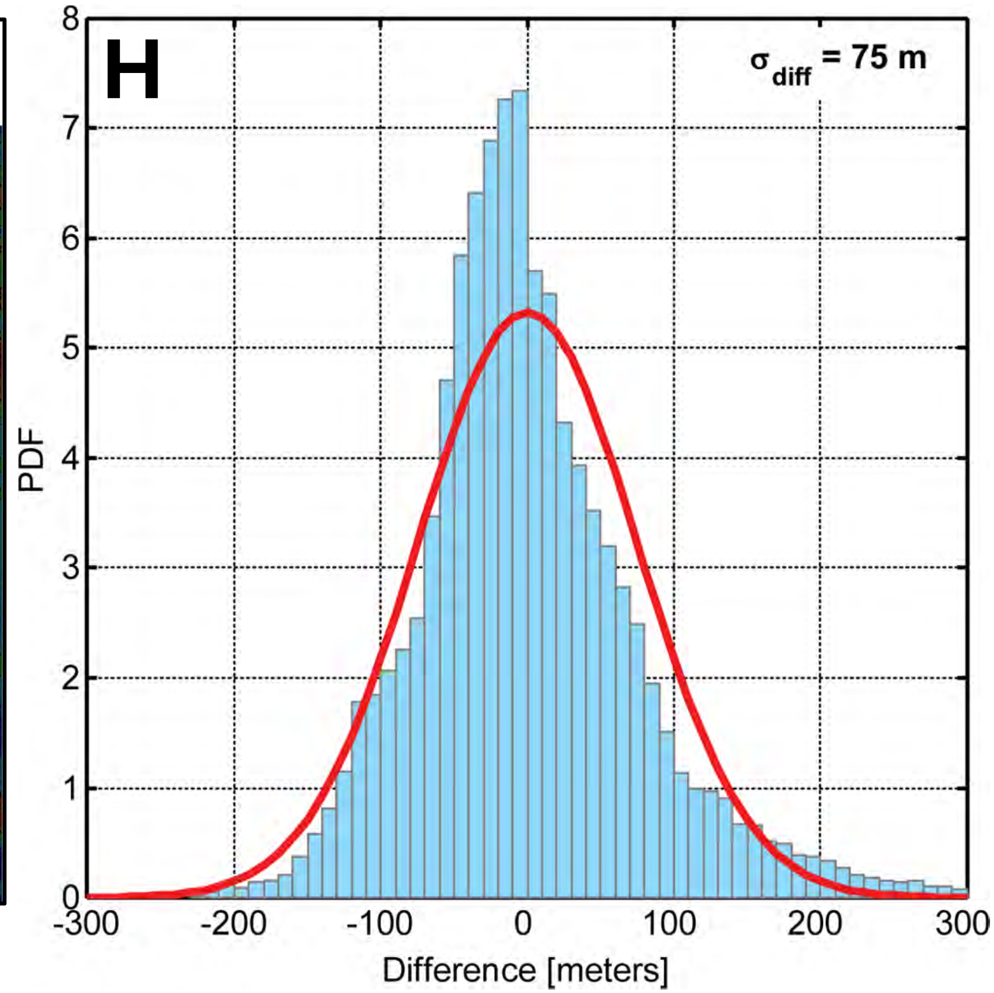
D. Bathymetry estimated from simulated airborne gravity data (left) at 500 m above ground level and 150 m/s speed of the survey aircraft.



E. Multi-beam bathymetry in Pine Island Bay (F. Nitsche *et al*., 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.

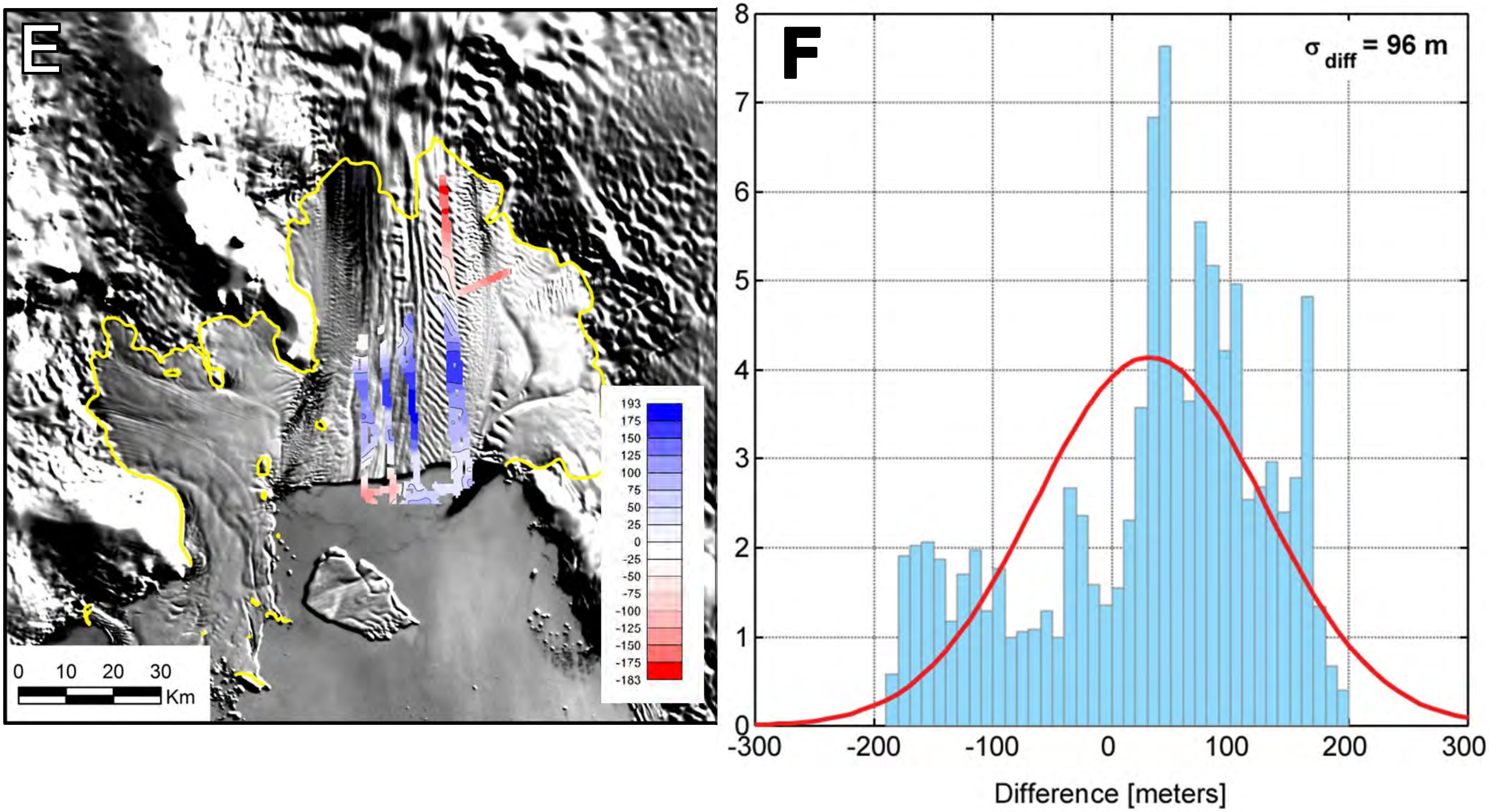
F. Bathymetry estimated from simulated airborne gravity data (left) at 500 m above ground level and 150 m/s speed of the survey aircraft.





G. Difference between bathymetry estimated from simulated airborne gravity and observed multi-beam bathymetry. The minimum difference is -238 m and the maximum is 337 m.

H. Histogram distribution of the difference between bathymetry estimated from simulated airborne gravity and observed multi-beam bathymetry. The standard deviation is 75 m.



E. Difference between gravity inversion minus autosub (meters). Negative numbers indicate gravity inversion is below autosub bathymetry and positive numbers mean gravity inversion is above autosub bathymetry.

F. Histogram distribution of the difference between bathymetry estimated from inverted airborne gravity and autosub (meters). The standard deviation is 96 m.

IceBridge and the Research Community

IceBridge seeks the involvement of the broad research community to:

- *Use IceBridge data to measure and understand current changes in ice thickness*
- *Incorporate IceBridge data into predictive models of changing ice cover*
- *Use IceBridge data to improve and enhance the ICESat data set, the developing CryoSat-2 data set and the planned ICESat-2 data set*

In addition, we seek community contributions that:

- *Vet the scientific accuracy and usability of IceBridge data and data products*
- *Develop new techniques and algorithms necessary to address IceBridge Projected Science Requirements: http://bprc.osu.edu/rsl/IST/*

Operation IceBridge

Operation IceBridge:

http://www.nasa.gov/icebridge

Science Team:

http://bprc.osu.edu/rsl/IST/

Data is available at
National Snow and Ice Data Center (NSIDC)

http://nsidc.org/data/icebridge/

No period of exclusivity!

Flight planning tool:

http://icebridge.sr.unh.edu/icebridge/ant/