Operation IceBridge

An Airborne Science Mission for Earth's Polar Ice

Michael Studinger
NASA/Goddard

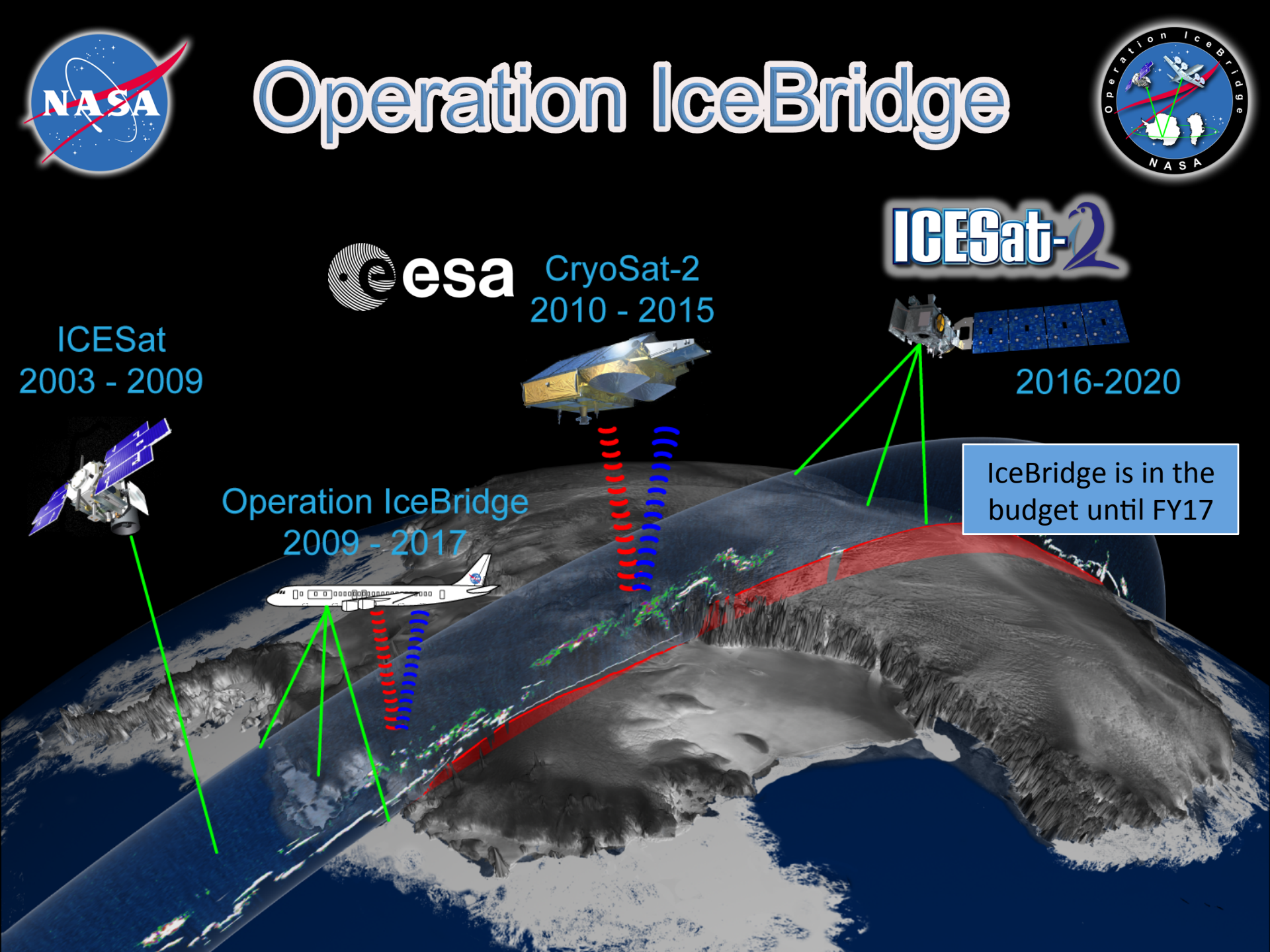
Image: M. Studinger

Presentation Outline

Part I: Mission overview

Part II: IceBridge activities and data products over the Arctic Ocean

Operation IceBridge



Operation IceBridge

- IceBridge utilizes a highly specialized fleet of research aircraft and the most sophisticated suite of innovative science instruments ever assembled to characterize annual changes in thickness of sea ice, glaciers, and ice sheets.
- In addition, IceBridge collects critical data used to predict the response of Earth's polar ice to climate change and resulting sea-level rise.
- IceBridge also helps bridge the gap in polar observations between NASA's ICESat satellite missions.

Photo: Michael Studinger

Sea Ice Science Goals

- Document the spatial and inter-annual changes in the mean sea-ice thickness and the thickness distribution in the Arctic and Southern Oceans between ICESat and ICESat-2, in support of climatological analyses and assessments.
- Improve sea ice thickness retrieval algorithms by advancing technologies for measuring sea ice surface elevation, freeboard, and snow depth distributions on sea ice.

Photo: Michael Studinger

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 (LDEO/Sander Geophysics)
- Magnetometer (USGS/LDEO)
- KT-19 skin temperature (NASA/WFF/ATM)

Langley B-200 or HU-25 C Falcon (southern Greenland)

- LVIS laser altimeter (NASA/GSFC)
- Digital aerial photography

UAF DHC-3 (Southeast Alaska)

- Riegl laser altimeter (UAF)
- Digital aerial photography (UAF)
- WISE radar sounder (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 (LDEO/Sander Geophysics)
- Onboard data system (NSERC/UND)
- KT-19 skin temperature (NASA/WFF/ATM)

NSF/NCAR G-V (Antarctica)

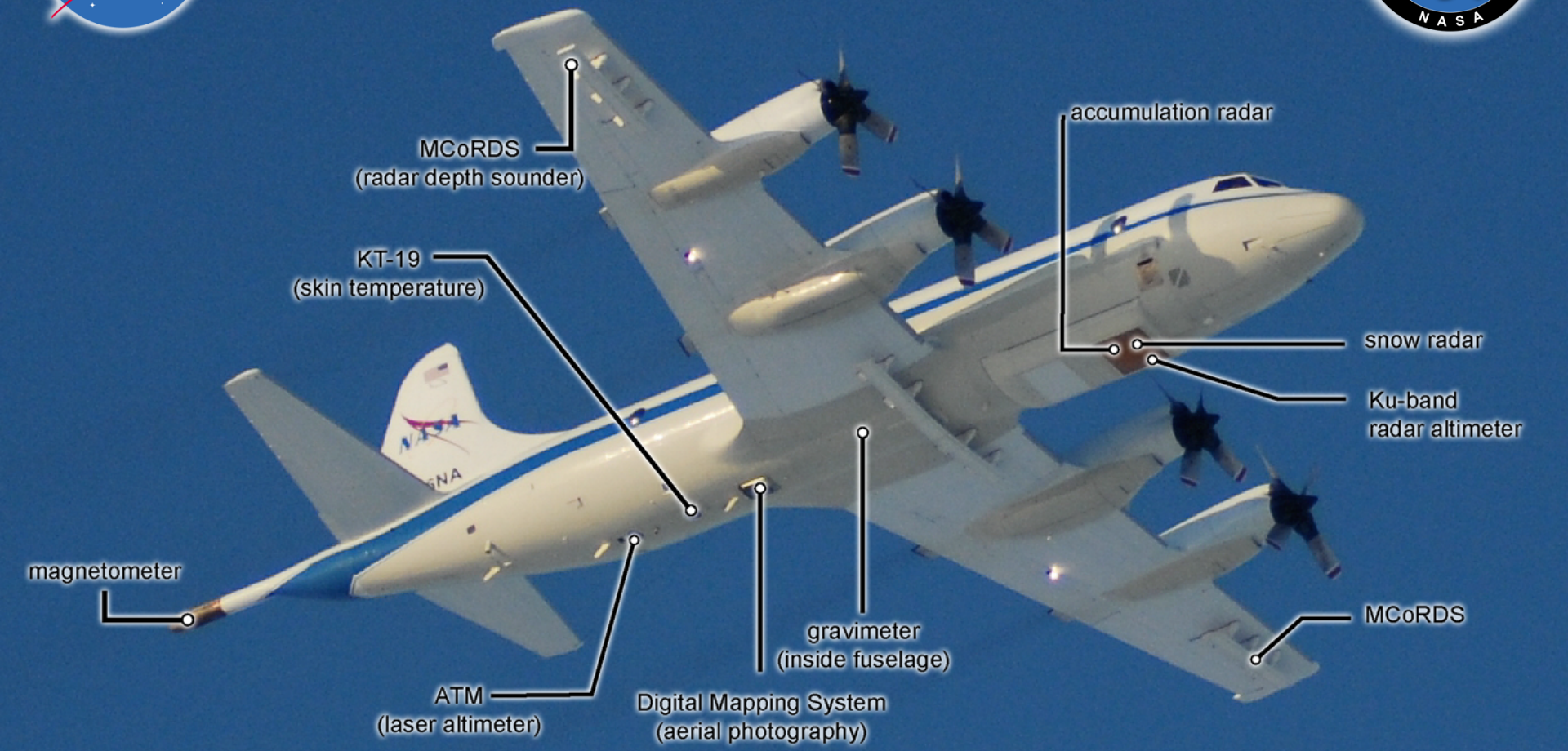
- LVIS laser altimeter (NASA/GSFC)
- Digital aerial photography

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 7 aircraft and 19 science instruments

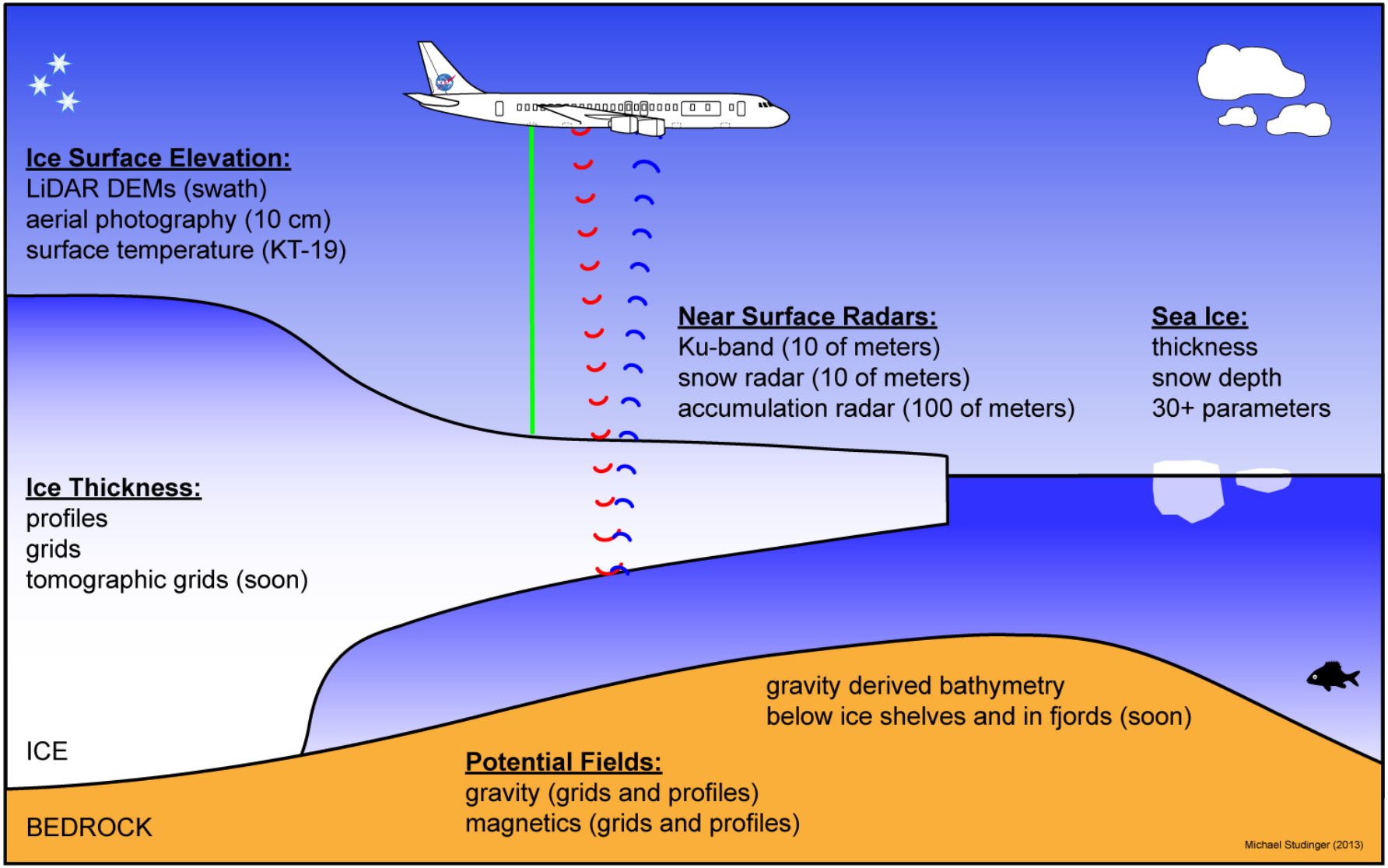
P-3 Aircraft and Instrument Suite



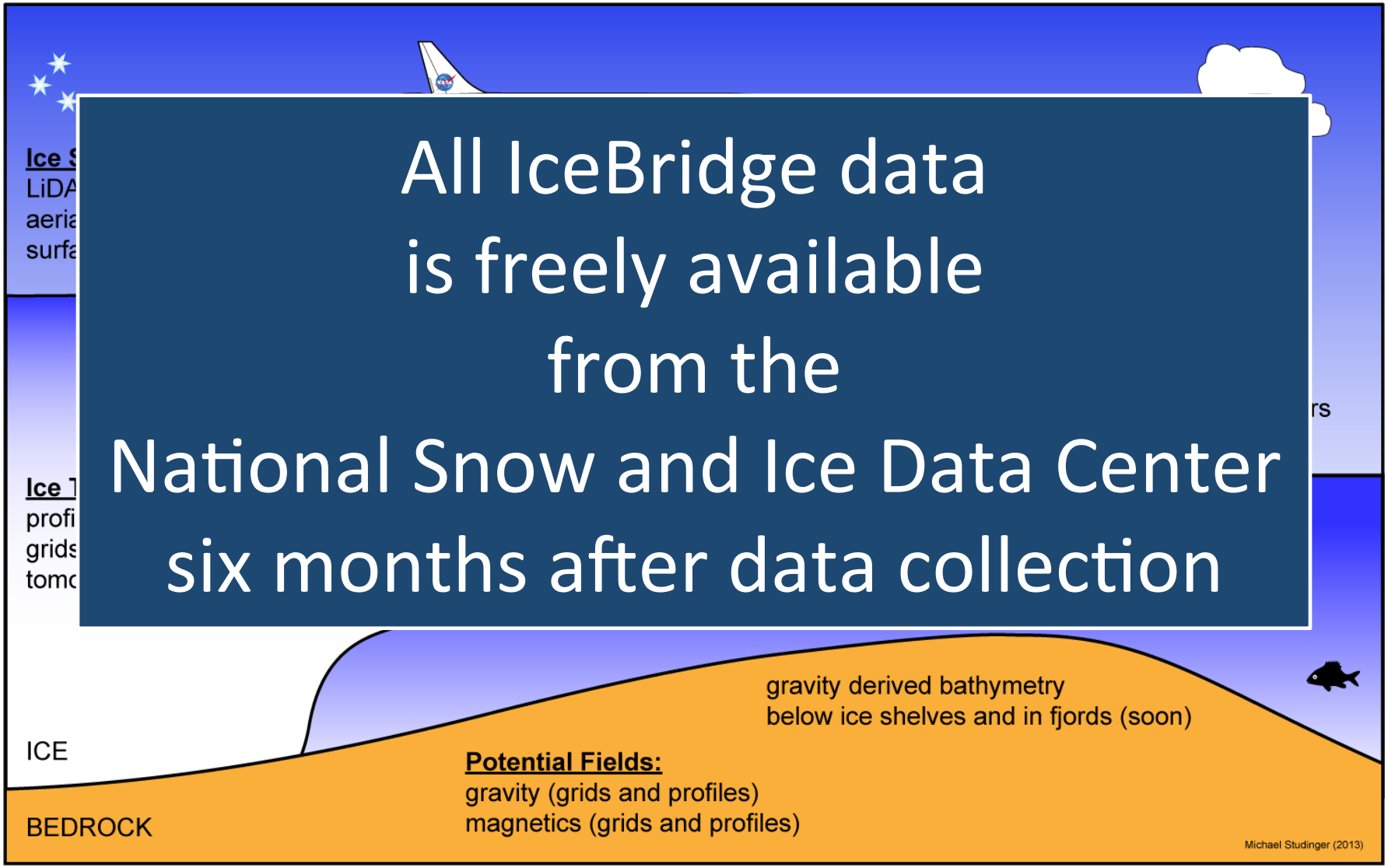
9 science instruments

P-3B photo courtesy of US Navy

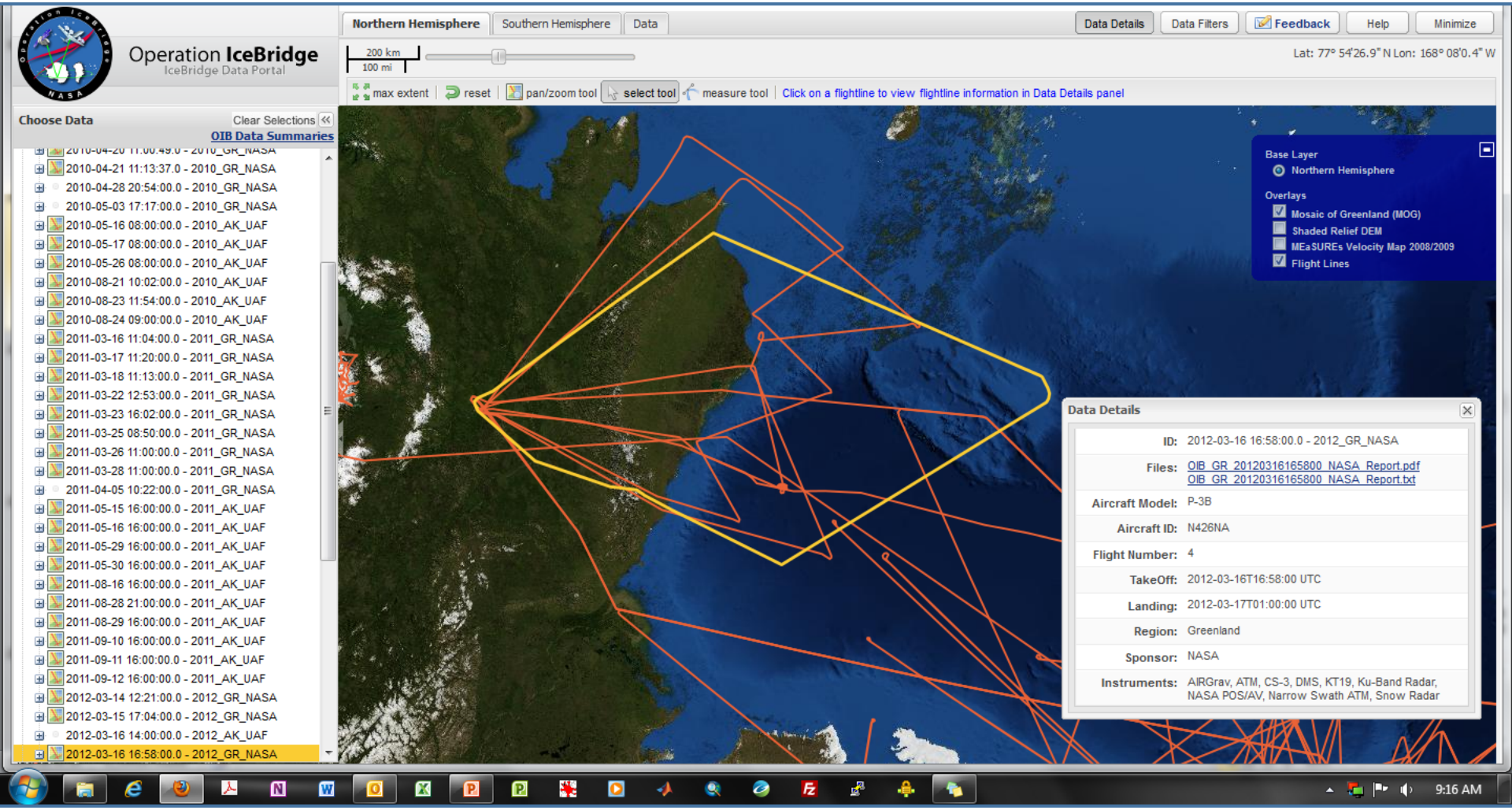
IceBridge Data Products

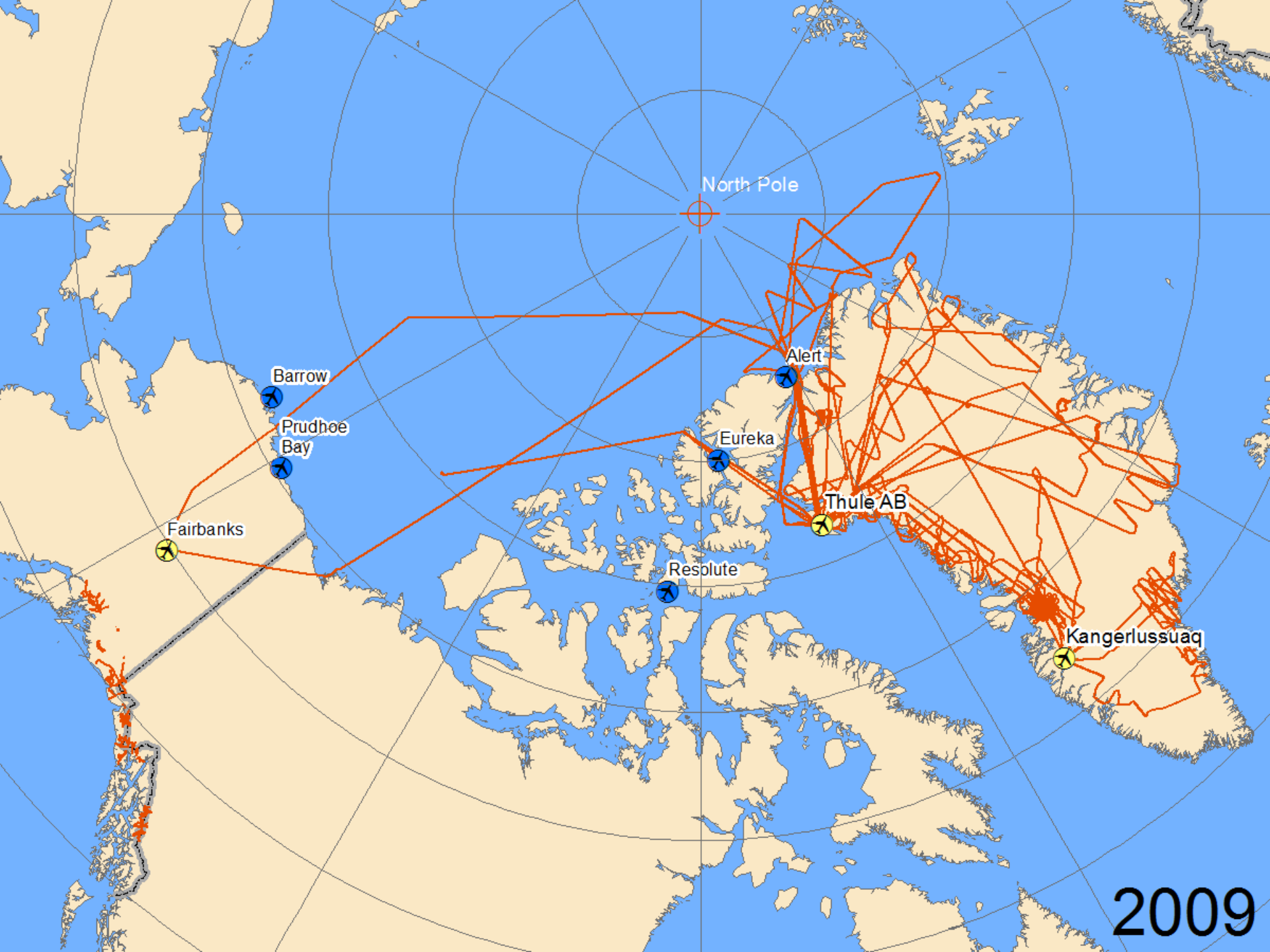


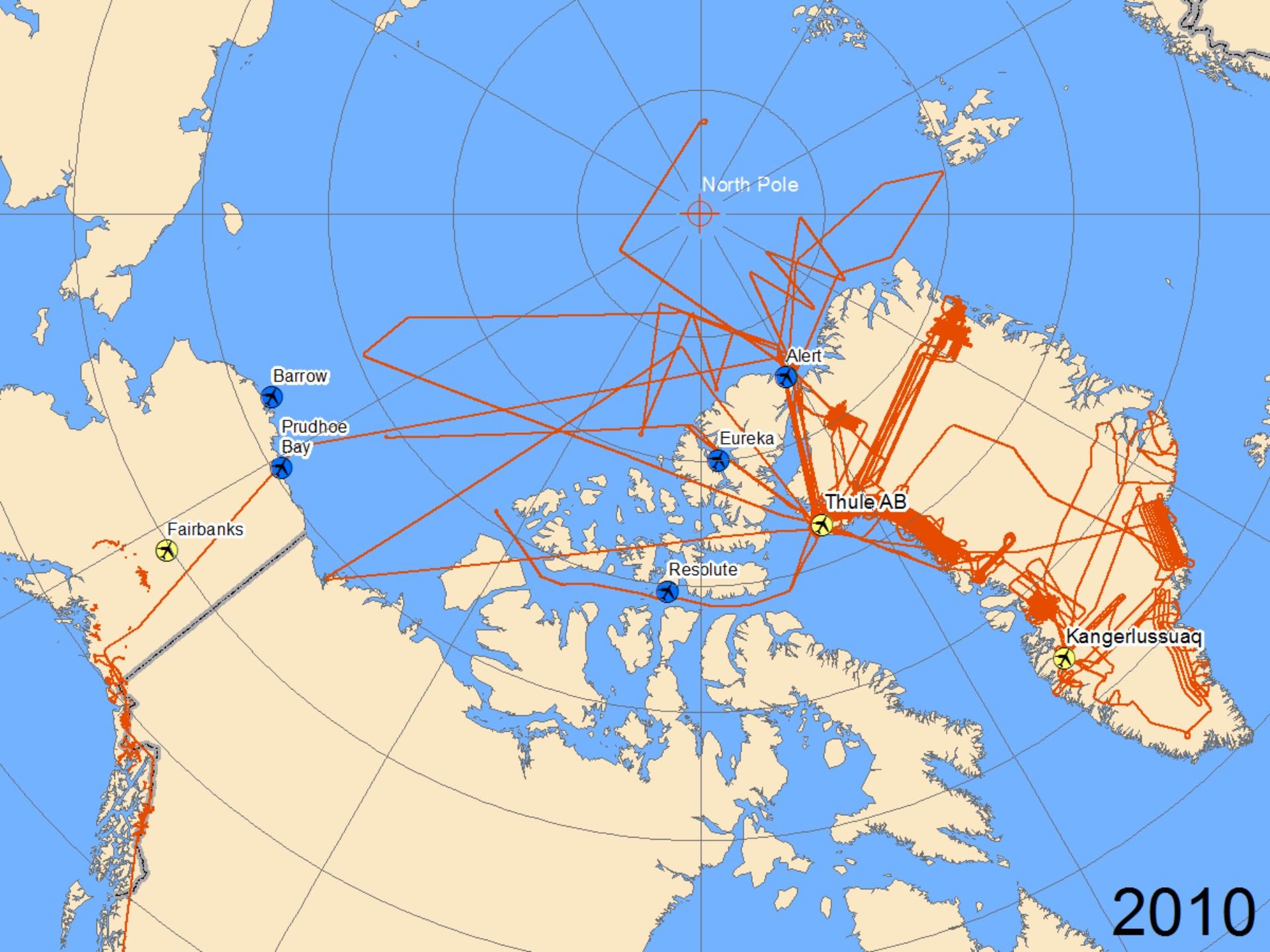
IceBridge Data Products

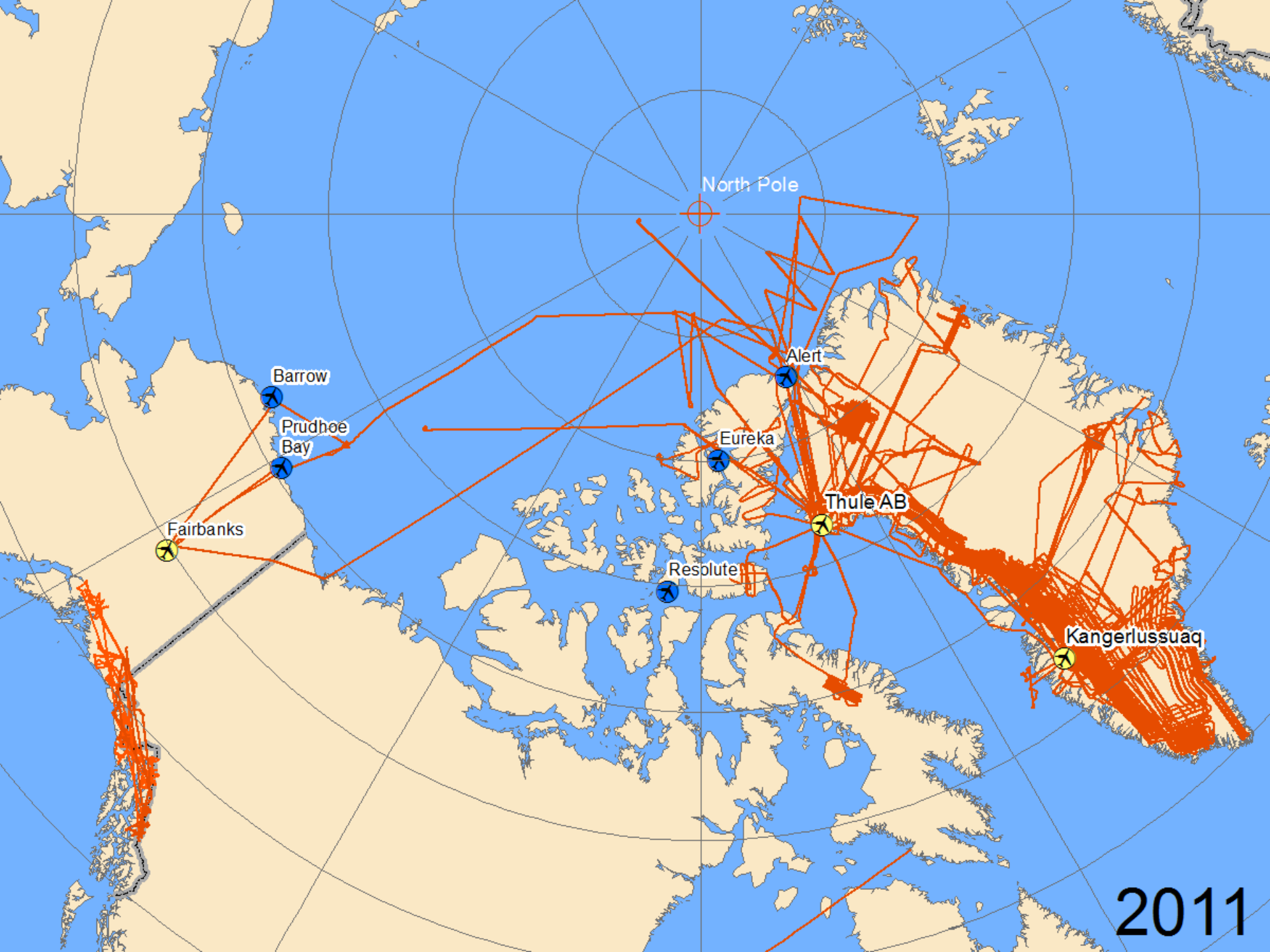


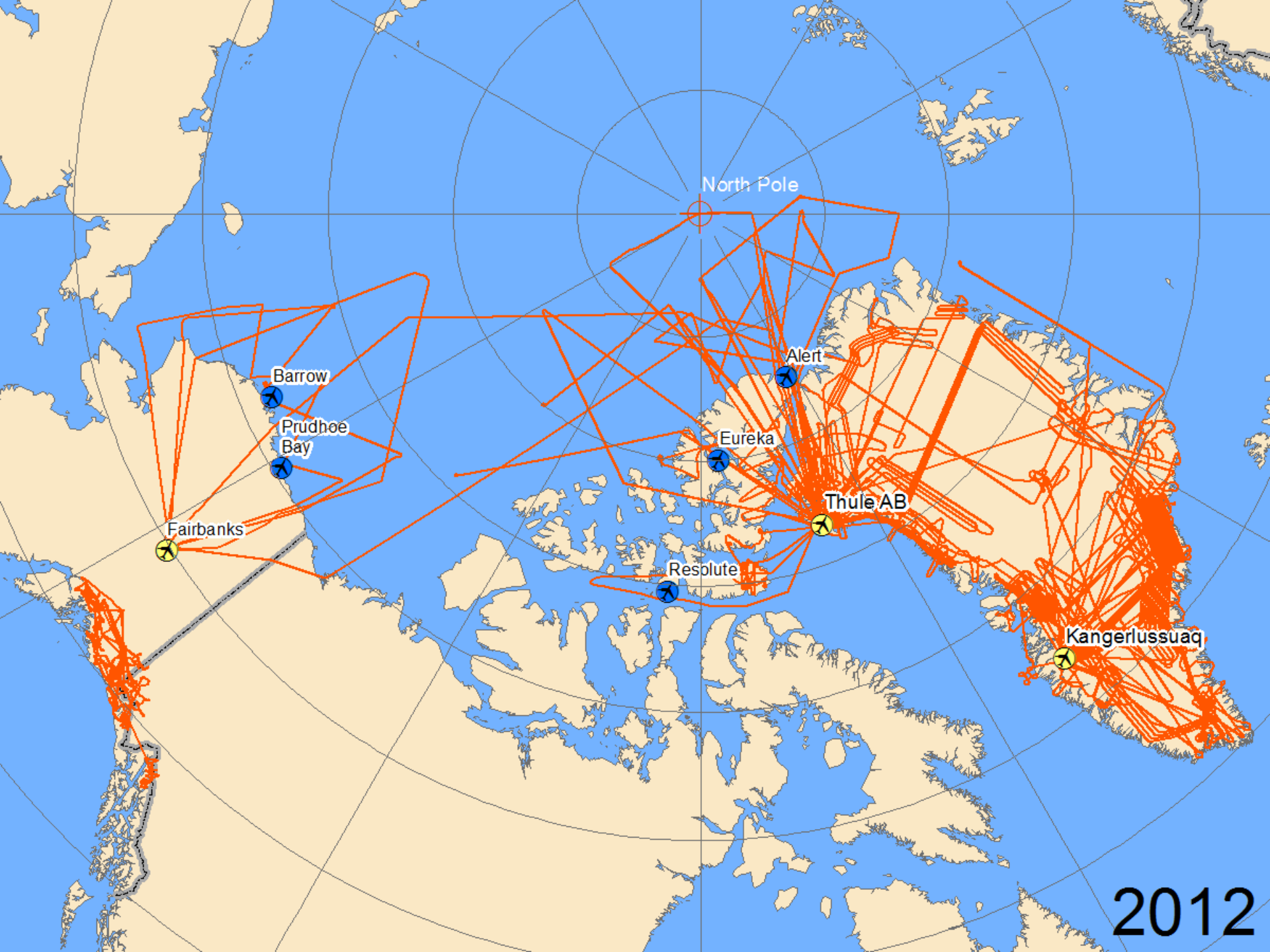
NSIDC IceBridge Data Portal

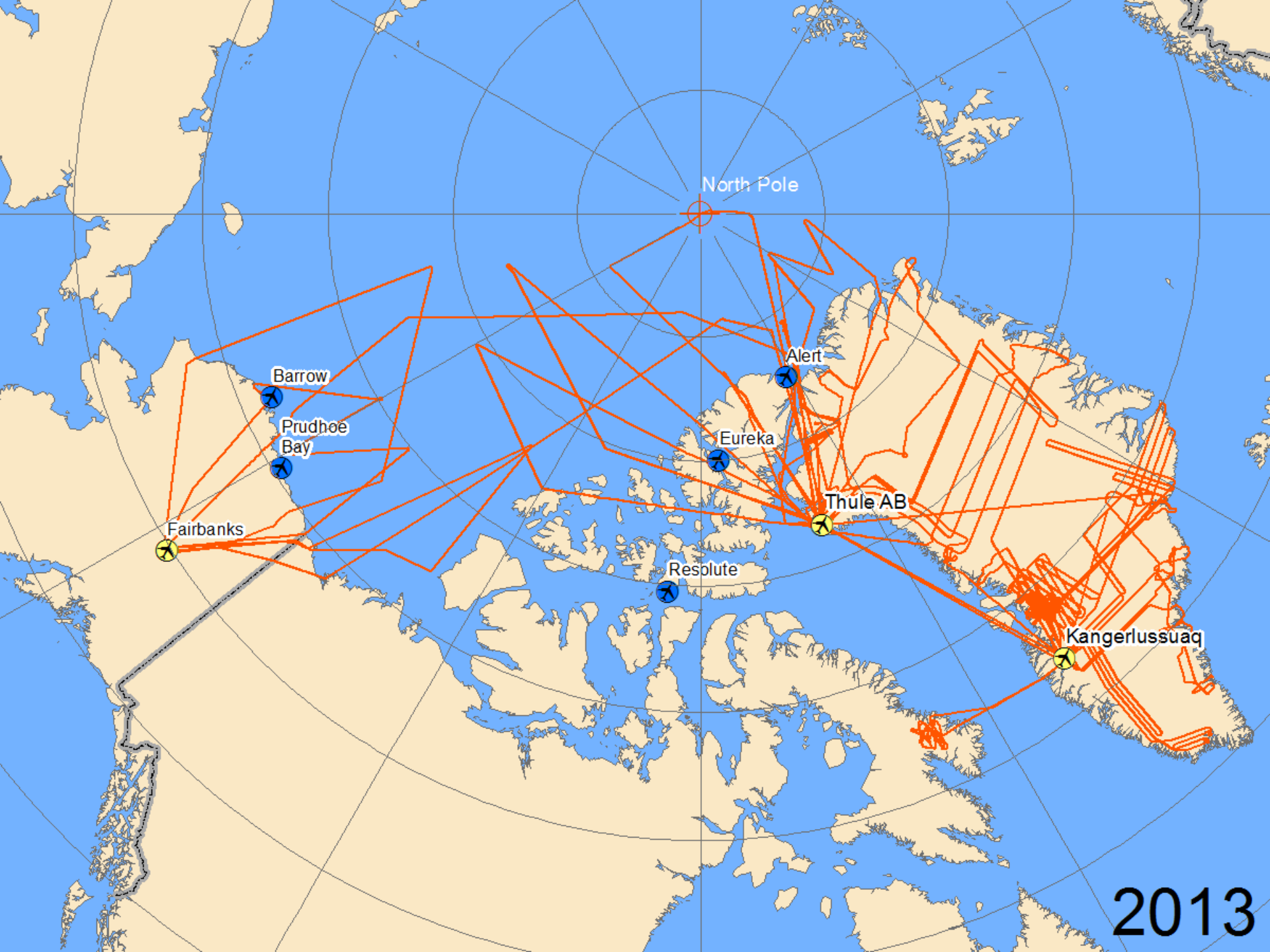


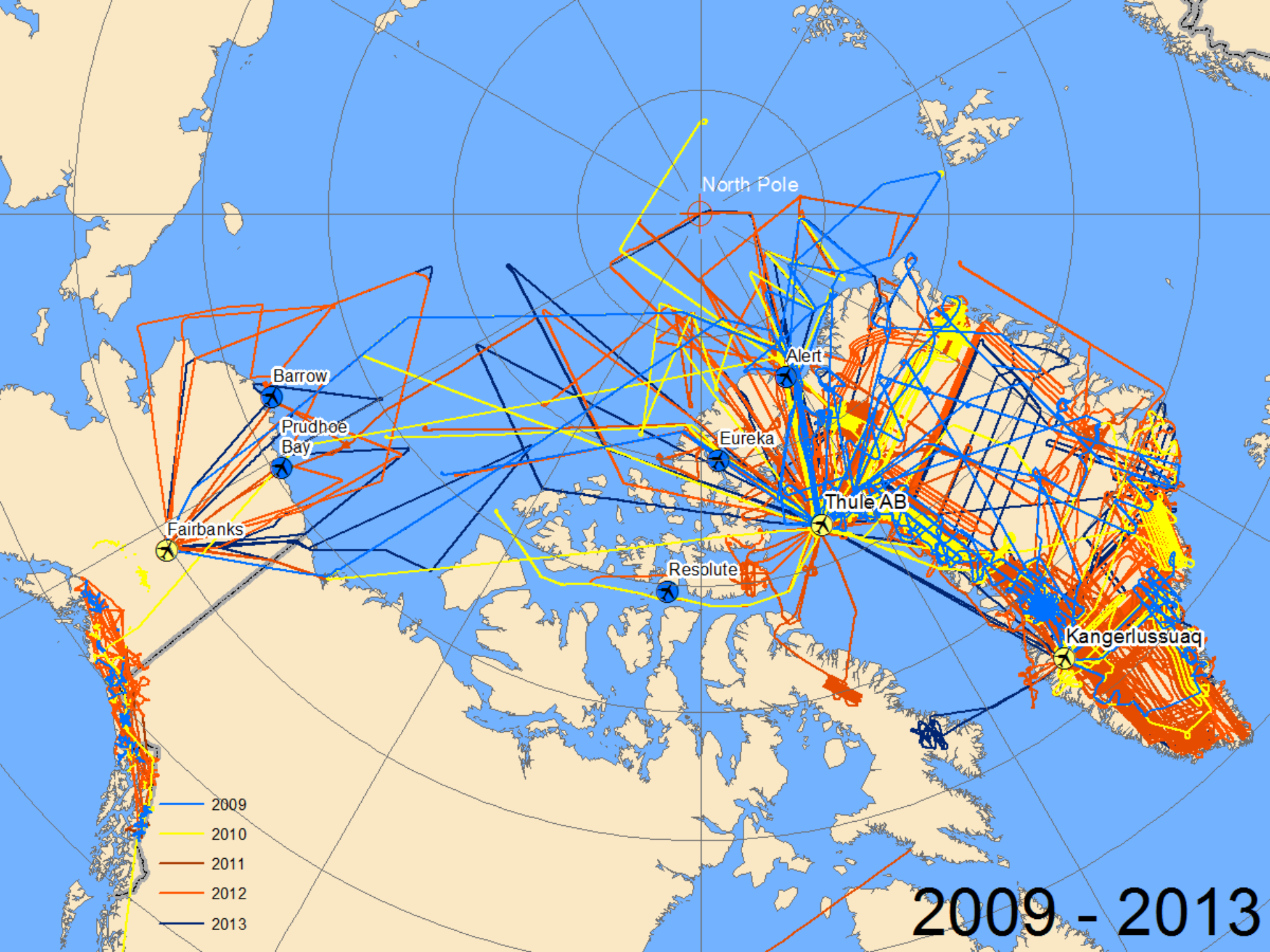

North Pole
Barrow
Prudhoe Bay
Fairbanks
Alert
Eureka
Thule AB
Resolute
Kangerlussuaq
2009

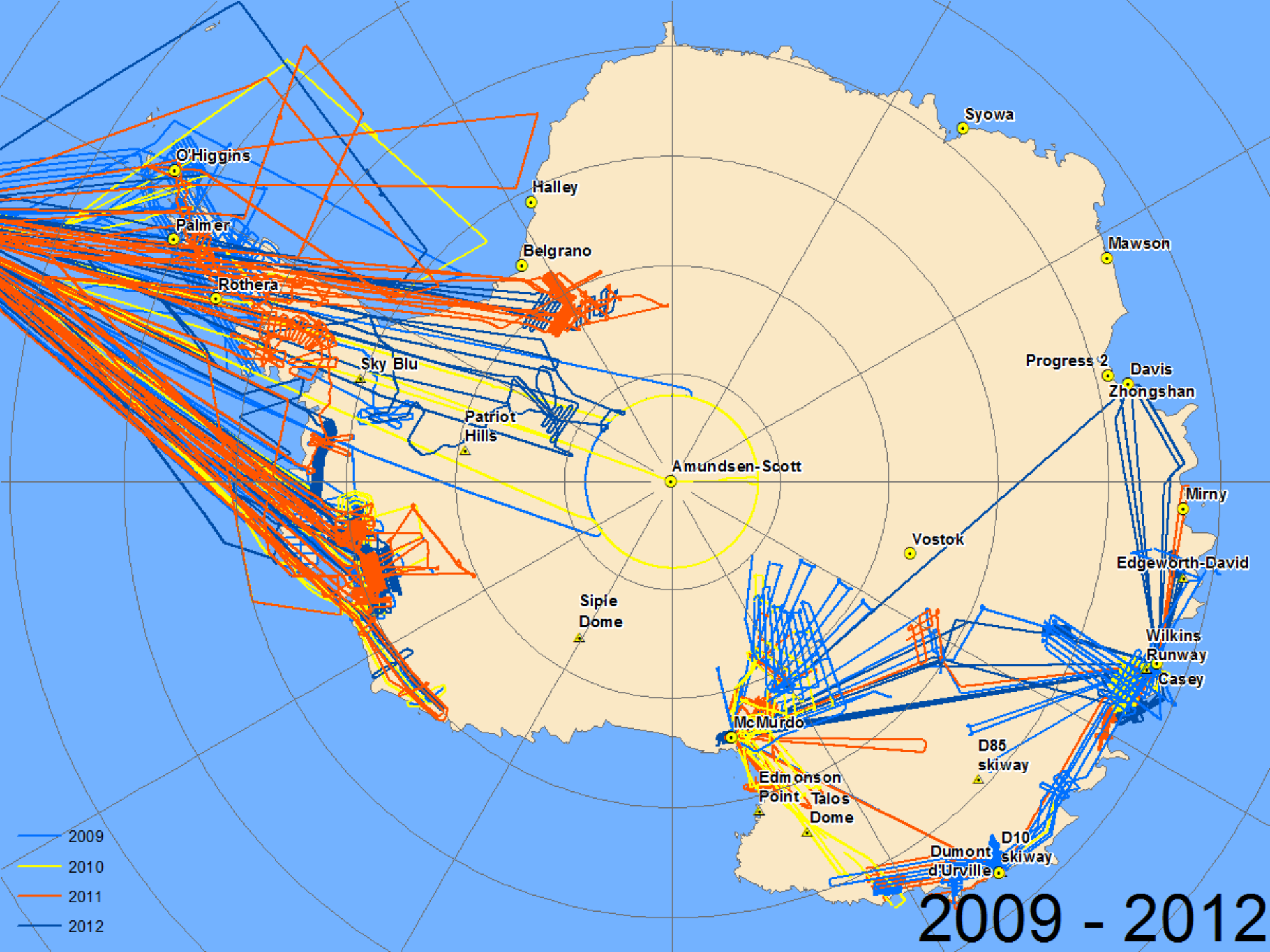

North Pole
Alert
Barrow
Prudhoe Bay
Eureka
Thule AB
Fairbanks
Resolute
Kangerlussuaq
2010


North Pole
Barrow
Prudhoe Bay
Fairbanks
Alert
Eureka
Thule AB
Resolute
Kangerlussuaq
2011


North Pole
Barrow
Prudhoe Bay
Fairbanks
Alert
Eureka
Thule AB
Resolute
Kangerlussuaq
2012


North Pole
Barrow
Prudhoe Bay
Fairbanks
Alert
Eureka
Thule AB
Resolute
Kangerlussuaq
2013


North Pole
Alert
Barrow
Prudhoe Bay
Eureka
Thule AB
Fairbanks
Resolute
Kangerlussuaq
2009
2010
2011
2012
2013
2009 - 2013


Syowa
O'Higgins
Halley
Palmer
Belgrano
Mawson
Rothera
Progress 2
Davis
Zhongshan
Sky Blu
Patriot
Hills
Amundsen-Scott
Mirny
Vostok
Edgeworth-David
Sipie
Dome
Wilkins
Runway
Casey
McMurdo
D85
skiway
Edmonson
Point
Talos
Dome
D10
skiway
Dumont
d'Urville
2009
2010
2011
2012
2009 - 2012

PART II

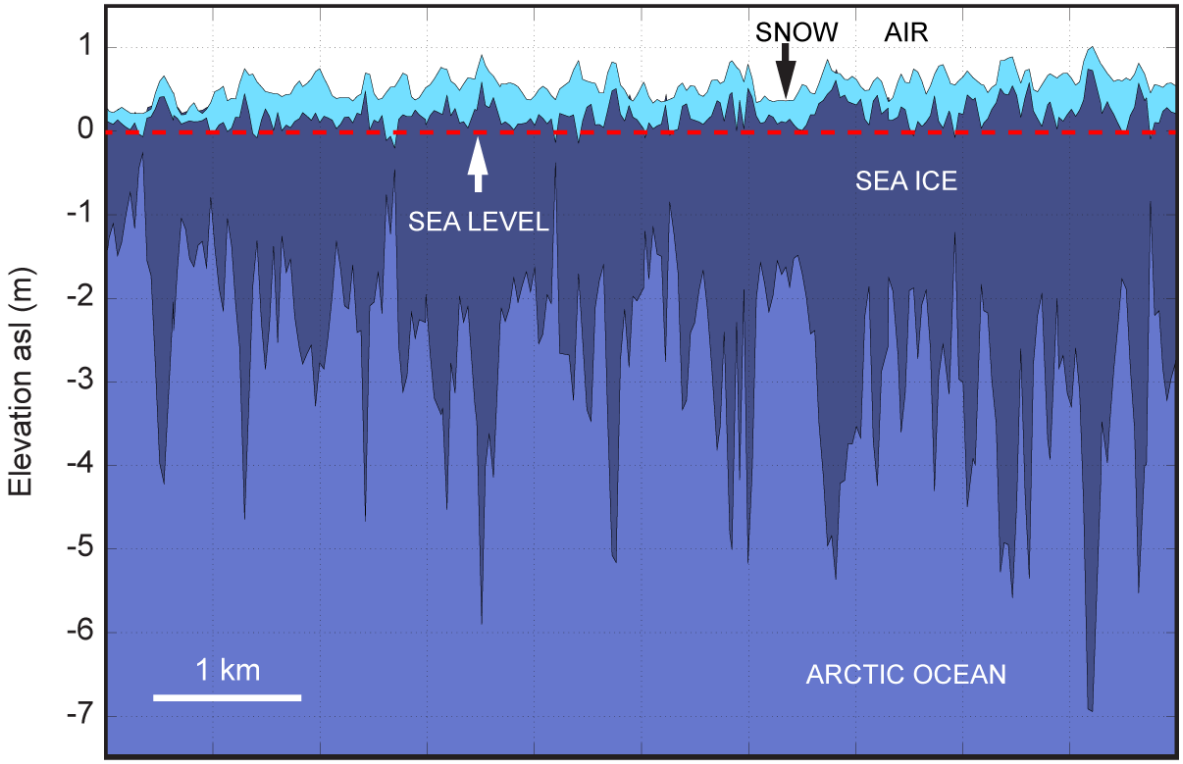
IceBridge over the Arctic Ocean

- Annual sea ice flights in March/April over Arctic Ocean
- Quicklook sea ice thickness and snow depth product available in May/June
- Extensive coordination and collaboration with other ongoing campaigns and field activities such as ice camps, airborne campaigns and satellite underflights (CryoSat-2)

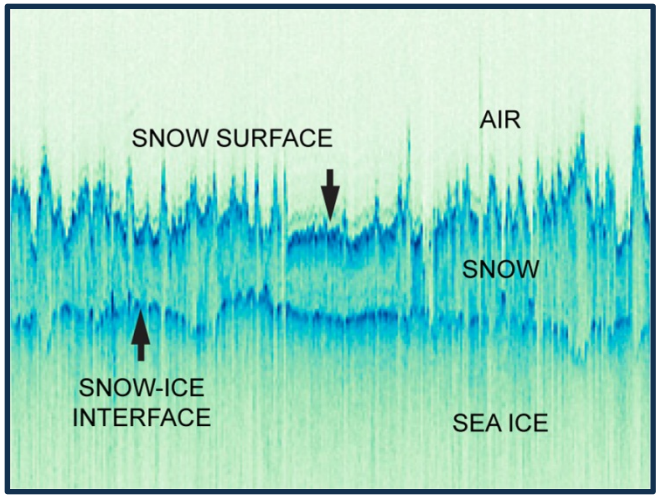
New estimation of snow depth and sea-ice thickness over the Arctic Ocean

- Knowledge of snow depth over sea ice is critically important, because of the **tenfold multiplication of freeboard uncertainties in the estimation of sea-ice thickness**.
- IceBridge is the only project that estimates both, snow depth and sea-ice thickness, over large areas.
- IceBridge has developed a **new sea-ice thickness and snow depth product** with over 40 parameters that will be published by the National Snow and Ice Data Center within the next two weeks.

Upcoming Arctic campaign: try to develop a quick turnaround sea-ice thickness product for seasonal forecasts that will be available to the modeling community in early May. We will be evaluating the impact the product will have on improving predictions for the sea ice minimum and for operational purposes.



Left: New IceBridge snow depth and sea-ice thickness product.
Bottom: Snow radar data over sea ice showing the air/snow and snow/ice interfaces.



SEARCH September Sea Ice Outlook uses new IceBridge Sea Ice Thickness Product from March/April 2012/13

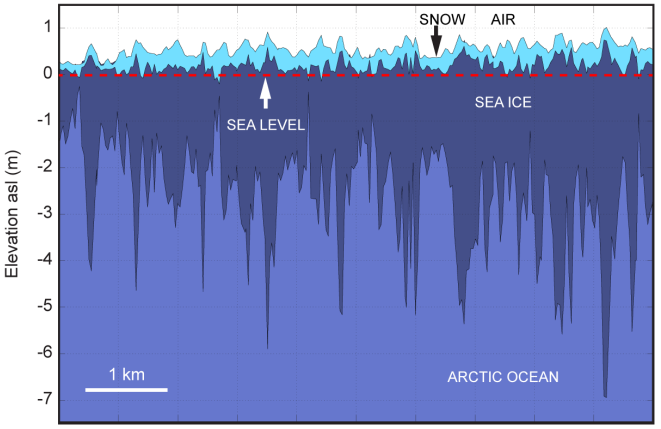
http://www.arcus.org/search/seaiceoutlook/2012/june

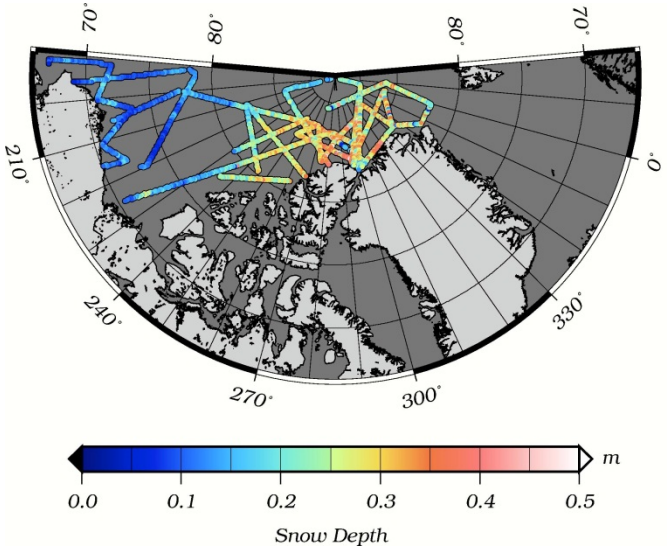
http://www.arcus.org/search/seaiceoutlook/ice-thickness-data

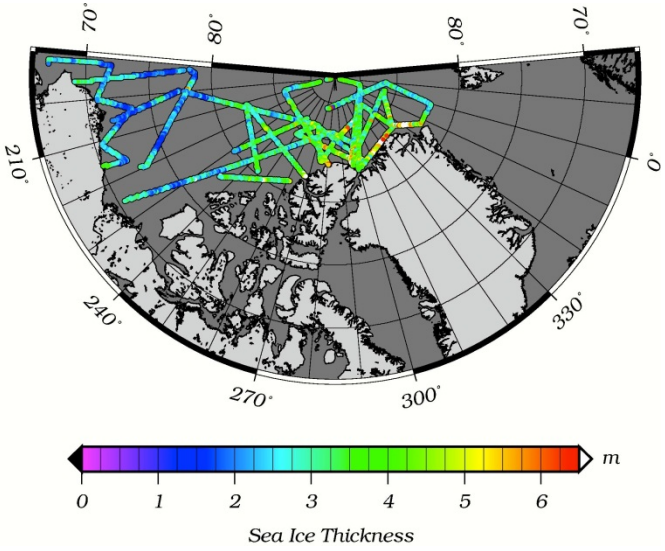
New estimate of snow depth and sea-ice thickness over the Arctic Ocean

In Spring 2012 and 2013 NASA's Operation IceBridge undertook a coordinated effort to provide large-scale airborne survey data that supported the development of seasonal summer sea ice prediction capabilities. A major challenge in providing support for predictions of the summer sea ice conditions was the need to dramatically increase the rate of delivery of these data, with the aim of making available by mid-May just 1 month after its collection.

The new quicklook product is designed to be applicable for time-sensitive projects such as seasonal sea ice forecasting. There are high thickness values near the Greenland coast, offshore the values are variable along the aircraft flight tracts. Sea ice was generally thin (<3 m) in the Beaufort Sea. Thicker ice tends to have a deeper overlying snow cover.

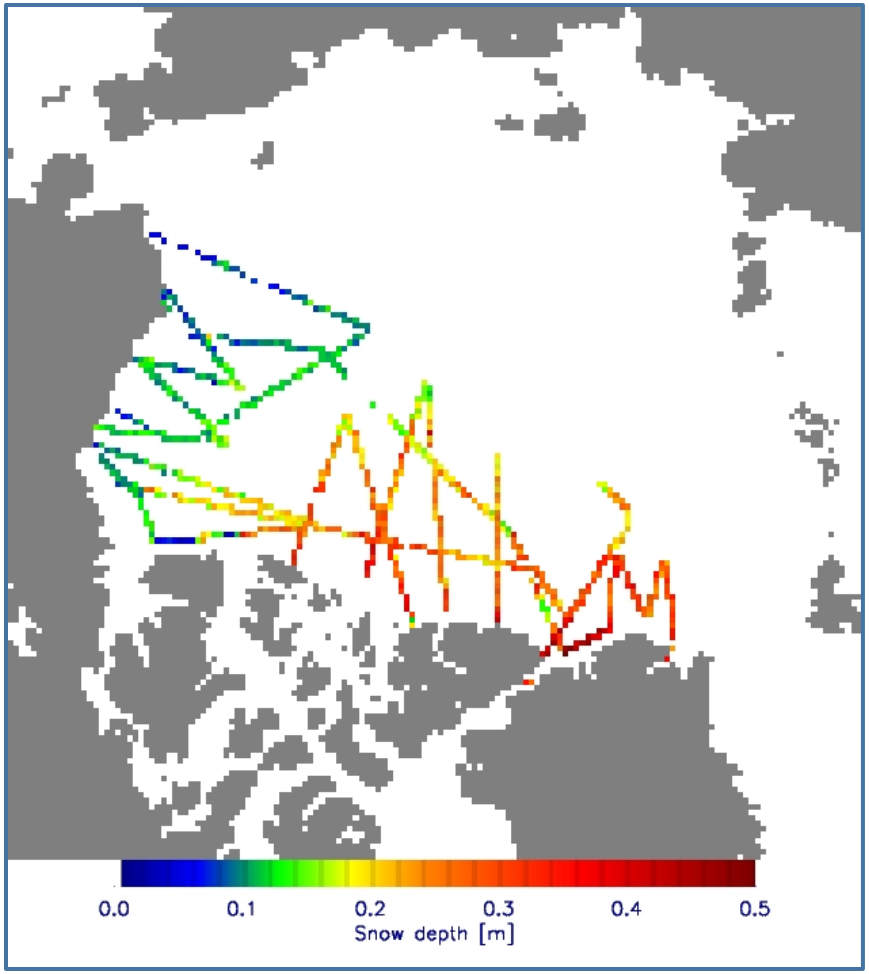


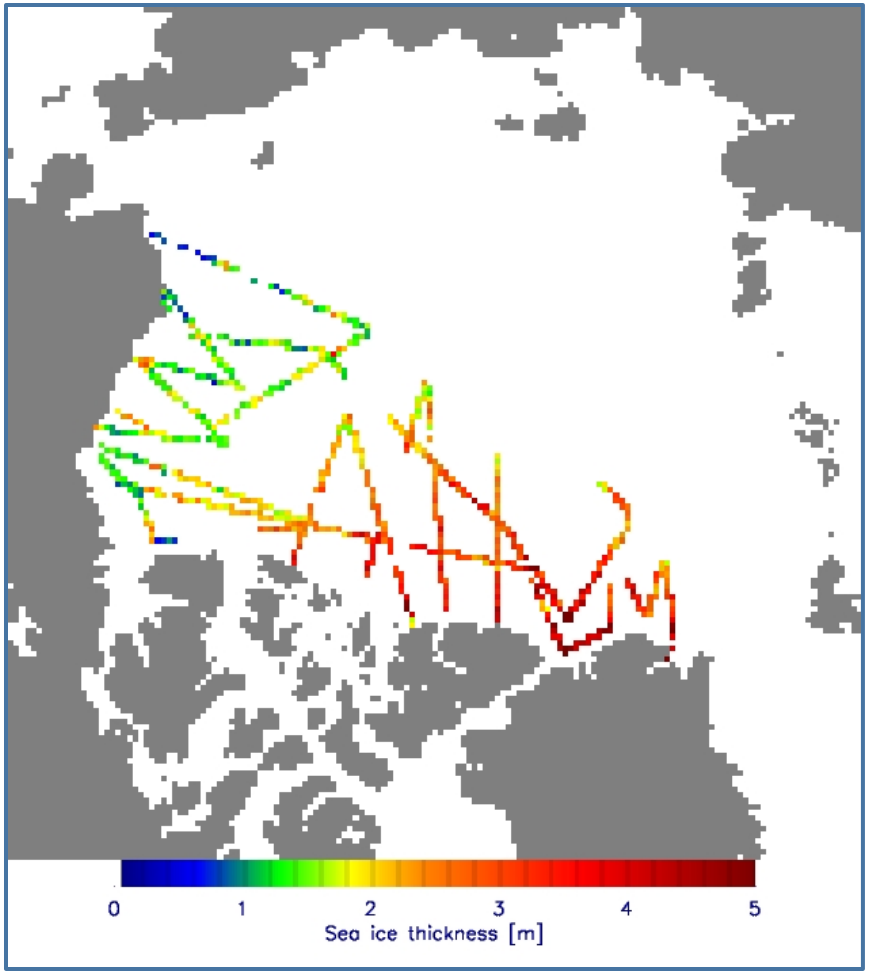




Left: New IceBridge snow depth and sea-ice thickness product. The data has been collected during flights over the Arctic Ocean in March and April 2012. The new data set contains derived geophysical data products from several IceBridge instruments.

March/April 2013





Operation IceBridge

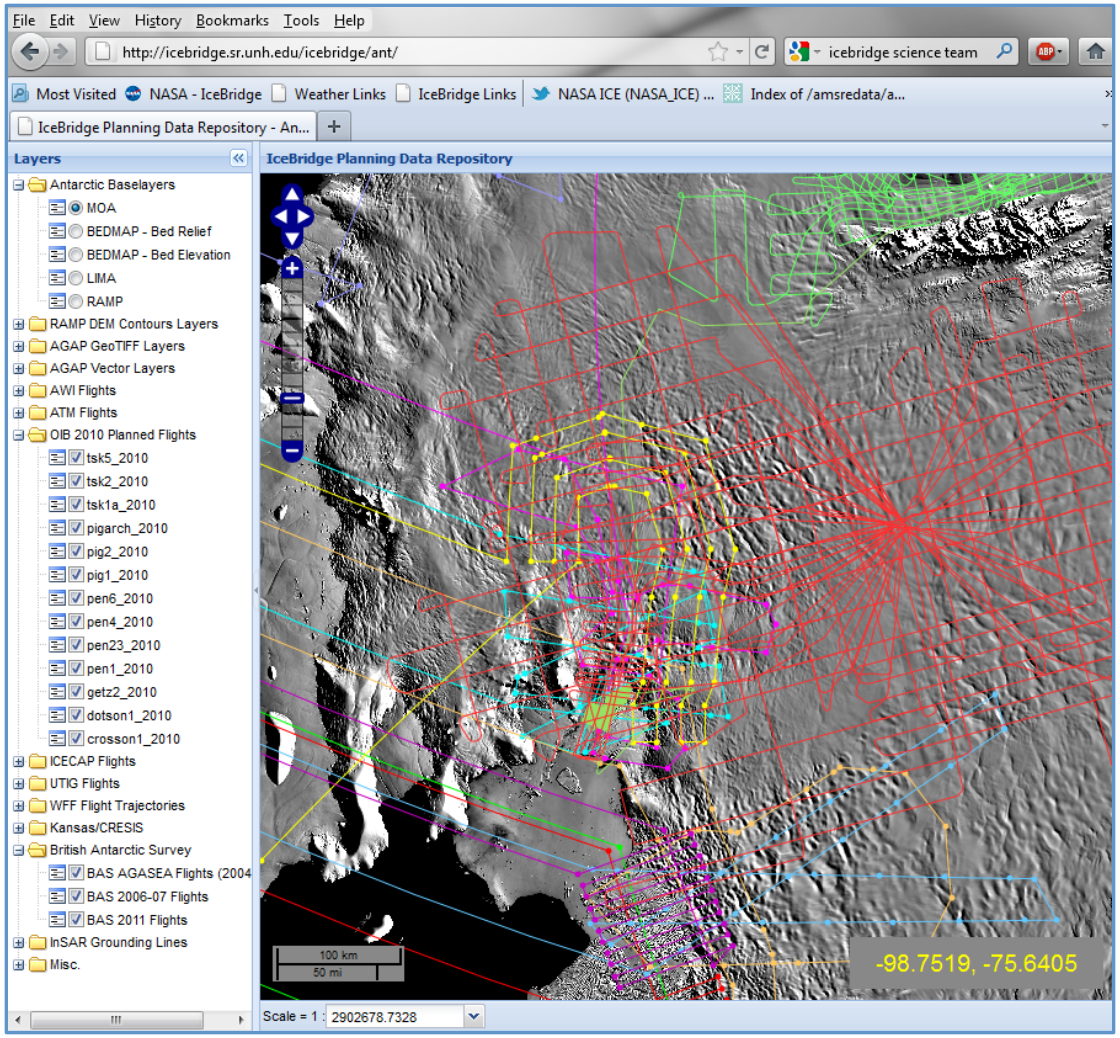
Operation IceBridge:
http://www.nasa.gov/icebridge

New Science Website:
http://icebridge.gsfc.nasa.gov/

Flight planning tool:
http://icebridge.sr.unh.edu/

Social Media:
Facebook and Twitter, Flickr, etc.

All IceBridge data is freely available from NSIDC 6 months after data collection.
No period of exclusivity.



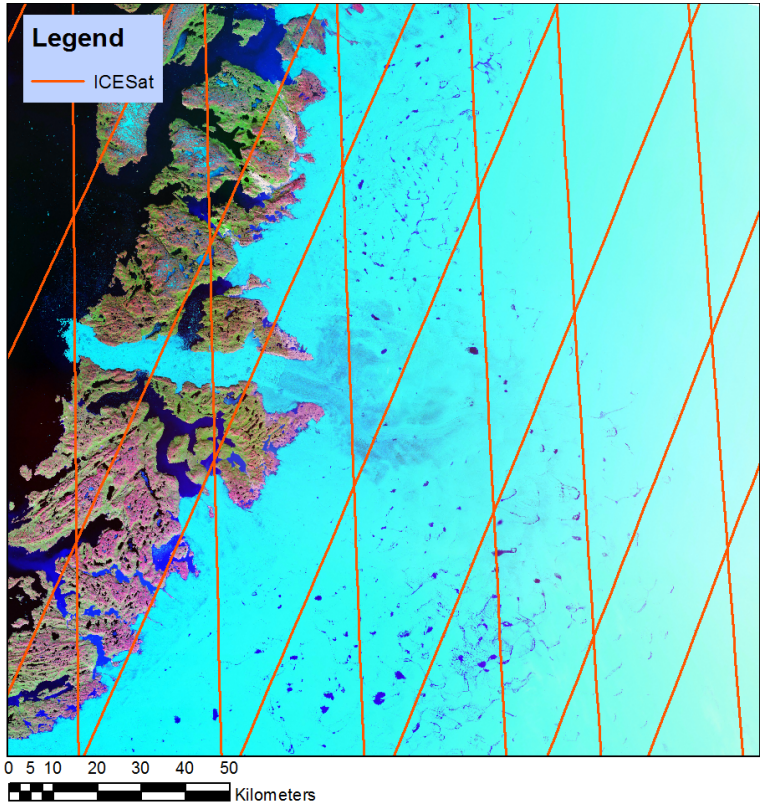
Take Home Messages

- IceBridge is currently in the budget until FY17
- All IceBridge data is freely available from NSIDC 6 months after data collection
- Quick look sea ice thickness and snow depth product is widely used (available in May/June for March data)
- Sea ice thickness is emerging as a critical data set in addition to spatial extend
- Snow depth is becoming a critical data set for other missions

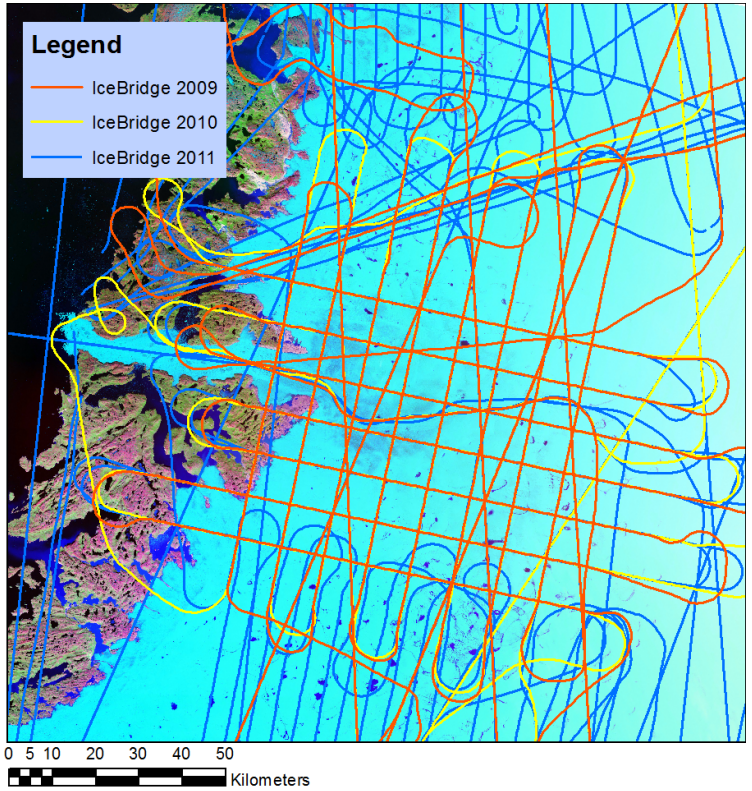
BACKUP SLIDES

IceBridge Multi-Sensor Coverage

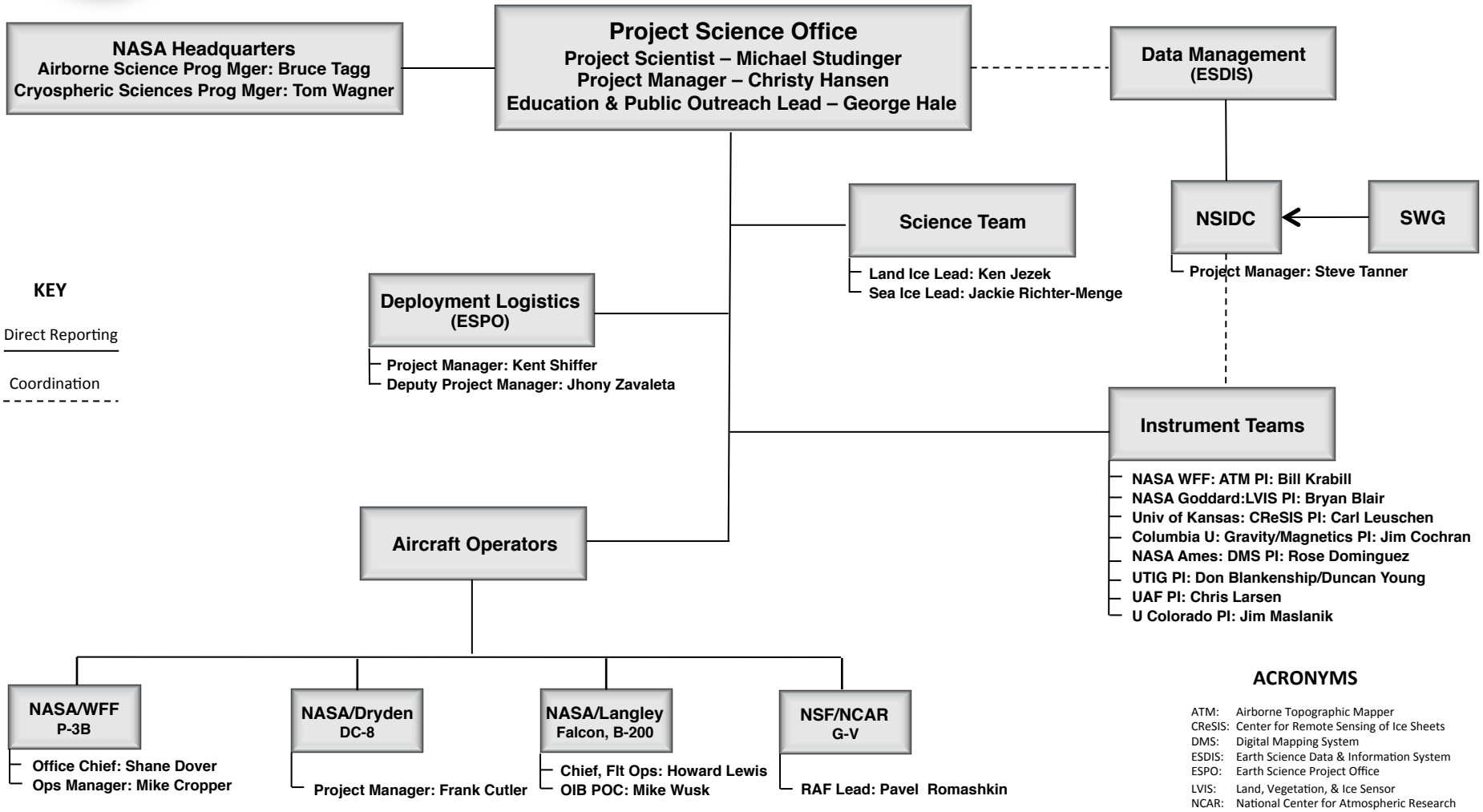
Jakobshavn Isbræ is the largest and fastest glacier draining the Greenland Ice Sheet and is discharging about 30 km^3 ice per year. The image below shows the large spacing between ICESat tracks with laser altimeter data. The data set is not suitable for monitoring critical processes and be able to turn the knowledge into predictive models of sea level rise.



IceBridge adds detailed coverage that will transform our conceptual understanding of physical processes into quantitative knowledge for input into predictive models. **The image below shows a dense grid of IceBridge flight lines that includes 8 different instruments to image the glacier from the surface to the bed.**



Operation IceBridge Project Organization



ACRONYMS

ATM:	Airborne Topographic Mapper
CReSIS:	Center for Remote Sensing of Ice Sheets
DMS:	Digital Mapping System
ESDIS:	Earth Science Data & Information System
ESPO:	Earth Science Project Office
LVIS:	Land, Vegetation, & Ice Sensor
NCAR:	National Center for Atmospheric Research
NSF:	National Science Foundation
NSIDC:	National Snow & Ice Data Center
PI:	Principal Investigator
RAF:	Research Aviation Facility
SWG:	Science Working Group
UAF:	University of Alaska - Fairbanks
UTIG:	University of Texas Institute for Geophysics

IceBridge Deployment Statistics

Number & Type of Days

Total	Flight	Wx	Unplan'd Maint	Plan'd Maint	Crew	(Un)pack	External
732	451	82	40	11	42	26	52

Number & Type of Flights

Total	Science	Transit	Check	Non-OIB
501	404	69	41	11

Aircraft Hours

Flight	Science
3252	1806

Notes:

1. Metrics are counted from Arctic 2009 to Arctic 2013 campaigns
2. Prelim science and distance #s are used for recent campaigns until calculations are complete
3. Science collection times are defined by laser altimeter on/off times
4. Wx. days reflect canceled flights due to bad weather
5. Metrics include the following OIB Aircraft:
   a) Wallop's P-3B
   b) Dryden DC-8
   c) UAF DHC-3
   d) UTIG/GROGG BT-67
   e) B-200
   f) Langley HU-25 Falcon
   g) NCAR G-V

Distances

Total Flight	Science	ICESat	CryoSat-2
1,365,307 km	752,322 km	127,699 km	21,307 km

Operation IceBridge

- IceBridge images Earth's polar ice in unprecedented detail to better understand processes that connect the polar regions with the global climate system.
- IceBridge utilizes a highly specialized fleet of research aircraft and the most sophisticated suite of innovative science instruments ever assembled to characterize annual changes in thickness of sea ice, glaciers, and ice sheets.
- In addition, IceBridge collects critical data used to predict the response of Earth's polar ice to climate change and resulting sea-level rise.
- IceBridge also helps bridge the gap in polar observations between NASA's ICESat satellite missions.

Photo: Michael Studinger

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 Antarctic campaigns 2009 and Arctic campaign 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 proposals

2012: ROSES call for next phase of IceBridge (instrument teams)

2013: ROSES call for IceBridge Science Team

IceBridge is a directed mission.
Project resources are available to meet level 1 science requirements and mission goals, rather than support for individual PI-led projects.