

Operation IceBridge Annual Report 2013



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1.0 Introduction

NASA's Operation IceBridge welcomed exciting change and improvements in the 2013 calendar year. This new annual report will serve to inform the community of these developments, capturing updates and summaries ranging from scientific and publications highlights, to deployment and metrics summaries. Additional key areas discussed include an introduction to new teams and team members, data product standards, aircraft, and education and outreach. For further information or details on any of these topics, contact the IceBridge Project Manager, Christy Hansen, or the IceBridge Project Scientist, Michael Studinger.

Operation IceBridge Mission Statement



NASA's Operation 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.



2.0 Project Updates & Highlights

2013 brought with it a season of positive growth for Operation IceBridge. The Project Science Office welcomed several new team members' onboard, new standards to its data products, and new deployments. New publications and scientific discoveries have also continued to grow, and the education and outreach office has continued to improve upon IceBridge's website usability and accessibility. The sections below address a few significant highlights.

2.1 IceBridge Science Team (IST) Awards

A new IceBridge Science Team (IST) was announced in 2013, starting another three year cycle supporting the IceBridge Project. Eric Rignot (NASA, JPL) has replaced Ken Jezek (Ohio State University) as the Land Ice team lead, and Jackie Richter-Mengie (CRREL) remains the Sea Ice team lead. The IST Leads conducted their first OIB science team meetings at Goddard Space Flight Center (GSFC) this January (2014). For more information on the IST, go to Icebridge's **new science website**, located at: http://icebridge.gsfc.nasa.gov/?page_id=1070, and select the "IceBridge Science Team" tab.

2.2 IceBridge Independent Review Team (IRT) Introduction and Status

Per direction and guidance by the NASA Program Manager for Cryospheric Sciences, Tom Wagner, an Independent Review Team (IRT) was assembled to evaluate and provide constructive feedback to the IceBridge Project and IceBridge Science Team (IST). Throughout 2013, the IRT, led by Bea Csatho (University at Buffalo), has evaluated OIB's scientific planning goals, flight planning targets, data products availability and usability, and ability to meet the Project's Level 1 Science Requirements. A final report, including recommendations for constructive change and/or any improvements will be published in March, 2014.

2.3 New Deployments in 2013

P-3 in McMurdo

From early November to early December, the NASA P-3B aircraft deployed to McMurdo Station, Ross Island, for the very first time. The NASA P-3 is the *first* large, wheeled, scientific aircraft to be *based* in McMurdo, supporting a science mission. This was a significant accomplishment for NASA and IceBridge, breaking new ground and becoming a game changer for data collection in the Antarctic.

C-130 Seasonal Deployment to Greenland

The 2013 season supported a new deployment, allowing the IceBridge Project to collect summer melt season data in Greenland for the very first time. In late October to mid-November of 2013, IceBridge employed the use of Wallop's new C-130, and paired it with our high altitude laser altimeter, the Land, Vegetation, and Ice Sensor (LVIS).

2.4 New NSIDC Project Manager Assigned

In 2013, NSIDC introduced a new Project Manager to the team, Steve Tanner. Steve and his team have been integral to several recent improvements, including effective communication, data access and usability, portal capabilities, and IceBridge data metrics.



2.5 New Data Format Standards and Ingest Process to NSIDC Portal

The *Earth Science Data and Information System (ESDIS)* office, the National Snow and Ice Data Center (NSIDC) and the Operation IceBridge (OIB) management team identified and developed formal documentation to capture data format and delivery requirements that reflect current NASA data standards. Developed and released in 2013, the **Data Management Plan (DMP)** documents the new required formats and deadlines for each OIB data product, as well as discusses the new data ingest tool (MetGen) required by NSIDC. The formats were selected based upon existing NASA standards, usability, and compatibility with current usage. The MetGen tool automates the generation of metadata, the intent being to provide improved search and access to OIB's data products. The DMP is located at the following website: http://icebridge.gsfc.nasa.gov/?page_id=980.



3.0 IceBridge Publications and Science Highlights

3.1 Engaging the Wider Science Community

During 2013, the Project Science Office, together with the IceBridge science team leads and colleagues from the European Space agency, proposed and organized an IceBridge session at the fall meeting of the American Geophysical Union (AGU) in San Francisco. The two oral and one poster session on “Monitoring Changes in Polar Ice Sheets and Sea Ice Using Airborne and Satellite Remote Sensing” combined 48 presentations. In addition to this, many IceBridge presentations were given in other sessions.

The Project Science Office also organized and hosted an open town hall meeting to continue the line of annual town hall meetings that has begun in 2009. The meeting was announced in the AGU program and advertised on Cryolist.

From January 29-31 2013, IceBridge co-hosted the Program for Arctic Regional Climate Assessment (PARCA) meeting at Goddard. Since 2009, annual PARCA meetings have been held in conjunction with IceBridge Science Team meetings. The PARCA meeting was held over the first 1.5 days, with more than 110 people attending and many staying for the IceBridge Science Team meeting. IceBridge data and science were prominently featured at the PARCA meeting. Parallel to the PARCA meeting, Jackie Richter-Menge hosted a community sea ice workshop with more than 30 participants to engage the wider community in IceBridge and coordinate field work with international partners and other government agencies. A second IceBridge Science Team meeting was hosted in June 2013 by Eric Rignot from the University of California/Irvine, and focused on flight planning for the Arctic campaign.

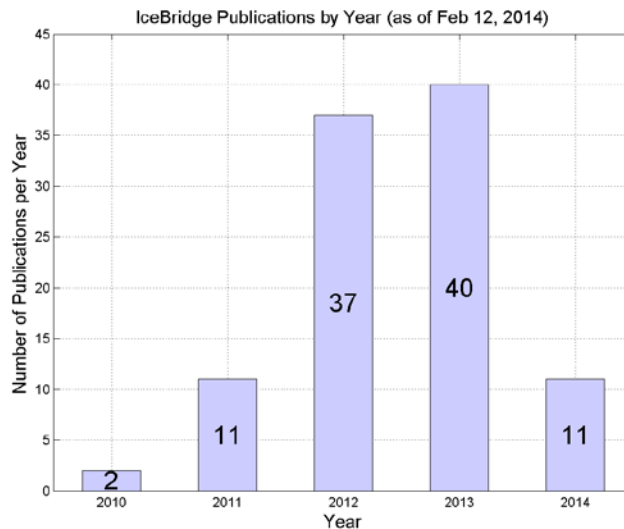
Nathan Kurtz from the Project Science Office wrote an EOS article that introduced the community to the new quick look sea ice thickness product. The availability of the quick look sea ice thickness product is also announced on Cryolist and on the SEARCH website.



3.2 IceBridge Publications and Science Highlights

Summary of Publications

During the calendar year 2013, **40 peer-reviewed articles were published** that acknowledged either IceBridge data or IceBridge funding (see **Appendix A**). The number of publications per year is growing rapidly. In 2013, 42% of all IceBridge publications to date (a total of 92 peer reviewed papers) were published. Two publications appeared in the journal *Science* and 4 publications appeared in *Nature/Nature Geoscience*. The current list of all IceBridge publications can be found at: http://icebridge.gsfc.nasa.gov/?page_id=596.



The amount of data that IceBridge collects allows scientists to look at processes over the entire Greenland Ice Sheet, work that is typically beyond the scope of individual projects. Two examples of large-scale uses of IceBridge data are given below.

Discovery of a Mega-Canyon beneath the Greenland Ice Sheet

In 2013, data collected by CReSIS radars during IceBridge science missions revealed evidence of a large and previously unknown canyon hidden under a mile of Greenland ice. The canyon has the characteristics of a winding river channel and is at least 460 miles (750 kilometers) long, making it longer than the Grand Canyon. In some places, it is as deep as 2,600 feet (800 meters), on scale with segments of the Grand Canyon. This immense feature is thought to predate the ice sheet that has covered Greenland for the last few million years. Jonathan Bamber and colleagues published their findings in the journal *Science* (Bamber, J. L., Siegert, M. J., Griggs, J. A., Marshall, S. J., and Spada, G. (2013), Paleofluvial Mega-Canyon Beneath the Central Greenland Ice Sheet, *Science*, 341(6149), 997-999.).

A large portion of this data was collected from 2009 through 2012 by NASA's Operation IceBridge, an airborne science campaign that studies polar ice. One of IceBridge's scientific instruments, the Multichannel Coherent Radar Depth Sounder, operated by the Center for the Remote Sensing of Ice Sheets at the University of Kansas, can see through vast layers of ice to measure its thickness and the shape of bedrock below.

In their analysis of the radar data, the team discovered a continuous bedrock canyon that extends from almost the center of the island and ends beneath the Petermann Glacier fjord in northern Greenland. At certain frequencies, radio waves can travel through the ice and bounce off the bedrock underneath. The



amount of times the radio waves took to bounce back helped researchers determine the depth of the canyon. The longer it took, the deeper the bedrock feature. The enormous amount of data collected by IceBridge, and the work of combining it with other datasets into a Greenland-wide compilation of all existing data, were two key accomplishments that lead to the discovery of the mega-canyon.

Enormous Aquifer Discovered Under Greenland Ice Sheet

Buried underneath compacted snow and ice in Greenland, lies a large liquid water reservoir that has now been mapped by researchers using data from NASA's Operation IceBridge airborne campaigns. The research is being presented in two papers: one led by University of Utah's Rick Forster in the journal *Nature Geoscience*, and a second one led by NASA's Lora Koenig in the journal *Geophysical Research Letters*. The findings will significantly advance the understanding of how melt water flows through the ice sheet and contributes to sea level rise.

The team of glaciologists serendipitously found the aquifer while drilling in southeast Greenland in 2011 to study snow accumulation. Two of their ice cores were dripping with water when the scientists lifted them to the surface, despite air temperatures of minus 4 F (minus 20 C). The researchers later used NASA's Operation IceBridge radar data to confine the limits of the water reservoir, which spreads over 27,000 square miles (69,930 square km) – an area larger than the state of West Virginia. The water in the aquifer has the potential to raise global sea level by 0.016 inches (0.4 mm).

Researchers think that the perennial aquifer is a heat reservoir for the ice sheet in two ways: melt water carries heat when it percolates from the surface down the ice to reach the aquifer. And if the trapped water were to refreeze, it would release latent heat. Altogether, this makes the ice in the vicinity of the aquifer warmer, and warmer ice flows faster toward the sea.



4.0 NSIDC and Data Product Updates

4.1 Updates to Data Formats, Delivery Process, and NSIDC Portal

The Earth Science Data and Information System (ESDIS) office, the National Snow and Ice Data Center (NSIDC), and the Operation IceBridge (OIB) management team worked together on efforts to improve data discovery, access, and usability of IceBridge data products.

The group developed and put into place a **Data Management Plan**, which formalized the expected formats and deadlines for each OIB data product. The formats were selected based upon existing NASA standards, usability, and compatibility with current usage. Data providers have either already complied with the new DMP standards and formats, or are in the process of doing so. The DMP link is: http://icebridge.gsfc.nasa.gov/?page_id=980.

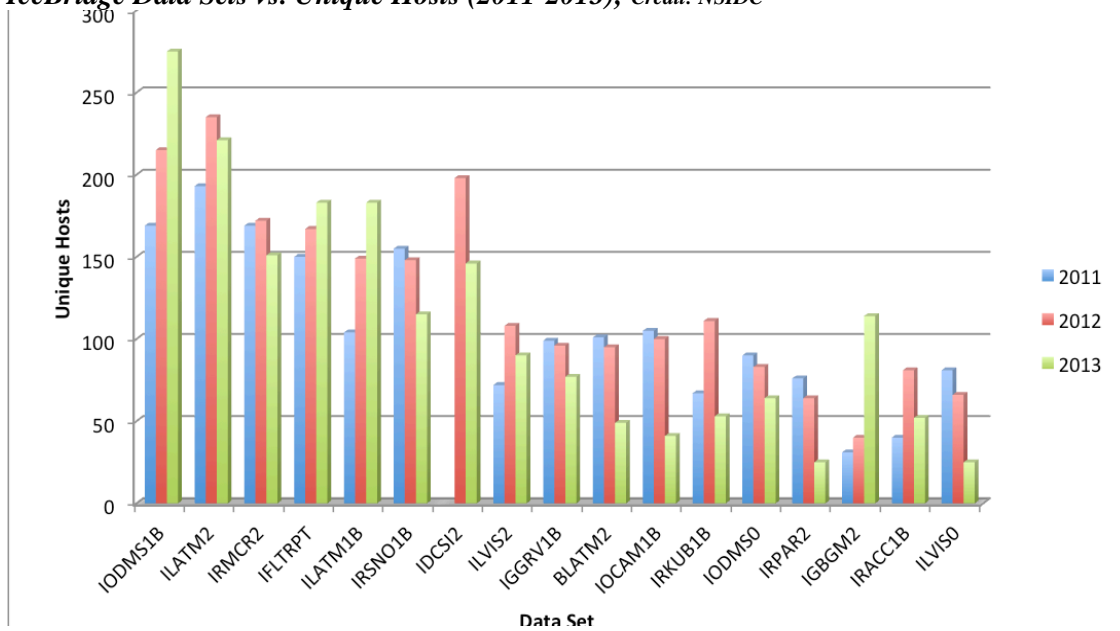
In addition, there has been a focus on using search and discovery tools provided by ESDIS that have more capabilities than the FastTrack process initially used by OIB. To that end, NSIDC has been working with OIB data providers to make their data available through the *EOSDIS Core System* (ECS). This includes providing a capability called **MetGen** that automates the generation of metadata that is required by ECS - metadata that will be used to provide improved search and access. A number of data providers have used the process and data products are being migrated from the old FastTrack system to ECS.

NSIDC also provided new improvements to the data portal user interface. These improvements are meant to make finding and downloading data faster and easier. The team developed new filter capabilities so that users could focus their searches only on flights containing specific instruments. The ability to add new base-layers to the display now provides users visual access to select data products so they may find flight lines that cover areas of specific interest. Base-layers currently include: The Mosaic of Greenland (MOG), Digital Elevations Models (DEM), and a MEaSURES Velocity Maps. Users can now also use a Tar-on-the-fly capability when downloading data products, making the need to download each individual data file separately a thing of the past.

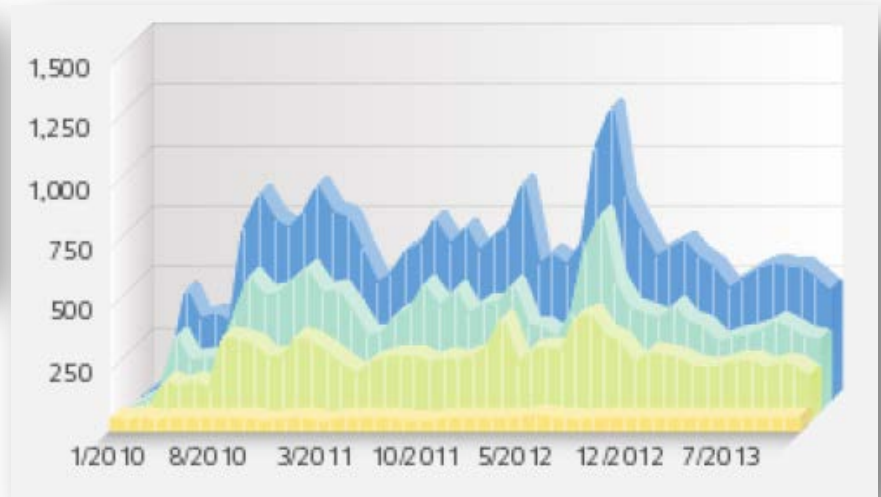


4.2 IceBridge Data Metrics

IceBridge Data Sets vs. Unique Hosts (2011-2013); Credit: NSIDC



Visitors to the IceBridge Portal (2011-2013); Credit: NSIDC





5.0 Campaign Summary and Metrics

5.1 2013 Deployment Summary

Operation IceBridge successfully conducted a total of **four airborne deployments** in 2013; two of which were first-ever, ground-breaking missions. The Spring of 2013 began with two Arctic deployments; one utilizing the P-3B aircraft that supported airborne surveys over land ice and sea ice in Greenland and the Arctic Ocean, and the second utilizing the University of Alaska’s (UAF) DHC-3 Twin Otter to conduct polar surveys over Alaskan glaciers. In addition, IceBridge planned and led its first seasonal late summer/early Fall Greenland deployment, employing the use of Wallop’s new C-130 aircraft, in conjunction with its high-altitude laser altimeter, LVIS. 2013 concluded with a historic, first-ever, Fall (austral Spring) deployment to McMurdo, Antarctica, utilizing NASA’s P-3B aircraft.

5.2 2013 Campaign Metrics Summary

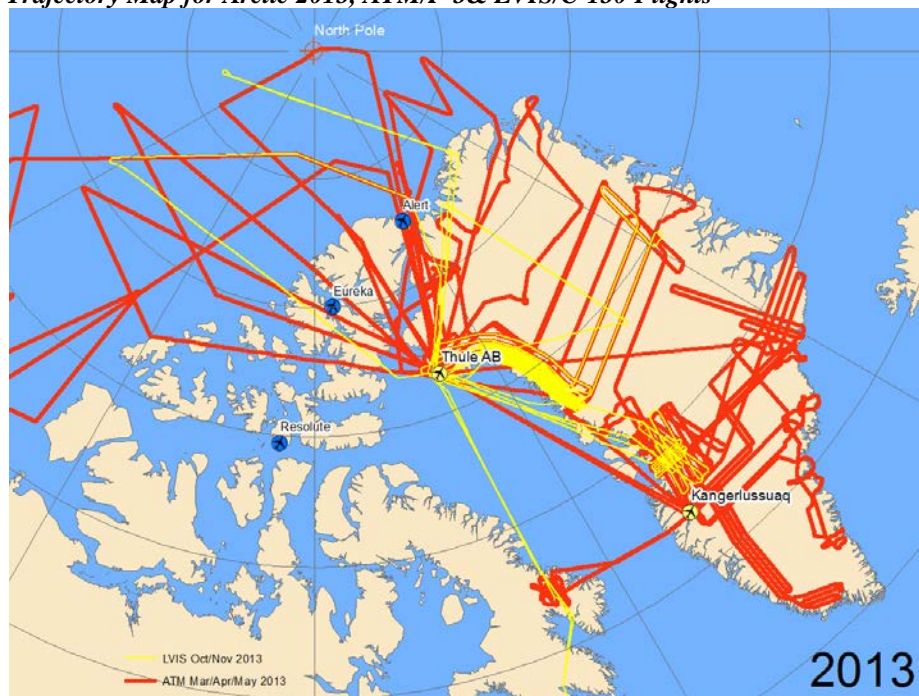
Arctic 2013 Metrics & Trajectory Maps

In early March to late May of 2013, the P-3B deployed to Greenland, collecting polar geophysical data utilizing the following instrumentation: the Airborne Topographic Mapper (ATM), the KT-19 skin temperature sensor, the Digital Mapping System (DMS), and the University of Kansas’ Radar Suite. A summary of deployment metrics is below:

P-3 Deployment Metrics

<i>Days in Field</i>	<i>Total # of Flights</i>	<i># of Science Flights</i>	<i>Science Hours Flown</i>	<i>Science Distance Flown (km)</i>
46	30	26	146.4	63972.5

Trajectory Map for Arctic 2013, ATM/P-3& LVIS/C-130 Flights





In May of 2013, UAF's DHC-3 collected data over various Alaskan glaciers, using its laser scanner, the Riegl LMS-Q240i, as the primary instrumentation. A summary of deployment metrics is below:

UAF DHC-3 Deployment Metrics

<i>Days in Field</i>	<i>Total # of Flights</i>	<i># of Science Flights</i>	<i>Science Hours Flown</i>	<i>Science Distance Flown (km)</i>
11	11	11	50.8	7247

Trajectory Map for Arctic 2013, including Alaska Flights



Seasonal 2013 Metrics

The 2013 season supported a new deployment, allowing the IceBridge Project to collect summer melt season data in Greenland for the very first time. In late October to mid-November of 2013, we employed the use of Wallop's new C-130, and paired it with our high altitude laser altimeter, the Land, Vegetation, and Ice Sensor (LVIS). The LVIS deployment faced the challenges of deploying with a new aircraft as well as a government shutdown, and nevertheless met with great success. A summary of deployment metrics is below:

C-130 Deployment Metrics

<i>Days in Field</i>	<i>Total # of Flights</i>	<i># of Science Flights</i>	<i>Science Hours Flown</i>	<i>Science Distance Flown (km)</i>
17	14	9	52.09	27769



Antarctic 2013 Metrics & Trajectory Map

From early November to early December, the NASA P-3B aircraft deployed to McMurdo Station, Ross Island, for the very first time. The NASA P-3 is the *first* large, wheeled, scientific aircraft to be *based* in McMurdo, supporting a science mission. This means that the aircraft office at Wallop’s, and the IceBridge Project Science Office, were granted specific permission by the National Science Foundation (NSF) to conduct science using the P-3 directly based from the sea ice runway (NZIR) in Antarctica. The proximity of the airfield to our science targets allowed for a more direct and efficient approach to collecting useable scientific data much sooner in our flight profiles than on previous deployments. This season’s deployment was cut short due to the Government Shutdown (by approximately 75%), but we were able to conduct 6 science missions in the very short window of time that we were there. The shutdown introduced a series of new threats that could have prevented IceBridge from deploying this season in its entirety. Resources in McMurdo were significantly reduced, creating a challenge for NSF to best determine which science teams could be supported within these limitations. The IceBridge Project was determined to be supportable, and we were granted final permission to deploy.

The mission utilized the following instrumentation: the Airborne Topographic Mapper (ATM), the KT-19 skin temperature sensor, the Digital Mapping System (DMS), the Gravimeter, the Magnetometer, and the University of Kansas’ Radar Suite. A summary of deployment metrics is below:

P-3 Deployment Metrics

<i>Days in Field</i>	<i>Total # of Flights</i>	<i># of Science Flights</i>	<i>Science Hours Flown</i>	<i>Science Distance Flown (km)</i>
21	20	6	43.1	20600.8

Trajectory Map for Antarctic 2013





6.0 Education and Outreach Summary

6.1 E/PO Highlights

IceBridge's communications and public outreach activities for 2013 included written products like feature articles and blog posts, videos and visualizations, and social media engagement and educational outreach.

In addition to its standard nasa.gov website, Operation IceBridge also maintains a new **Science web page** aimed at researchers and members of the public interested in more about the mission's science. On this site are links to IceBridge data hosted by the National Snow and Ice Data Center, instrument descriptions, photos from previous campaigns, and a list of published scientific papers that used IceBridge data. The website also features a section for the IceBridge Science Team that has campaign documents, scientific presentations, and a link to an online flight planning tool. Go to: http://icebridge.gsfc.nasa.gov/?page_id=1070.

News releases and feature articles focused on major campaign milestones and science papers using IceBridge data. Some of these scientific findings include improvements to sea ice forecasts and the discovery of a canyon in the rock beneath Greenland's ice. In addition, news updates and blog entries described campaign activities and gave a more behind-the-scenes view of IceBridge field work.

Three IceBridge visuals were popular with viewers on YouTube and media outlets like NPR, CNN and National Geographic. **Visualizations** of the new **Antarctic bedrock map** and **Greenland canyon** each generated more than one million views on YouTube and a video showing highlights of the Arctic campaign picked up more than 200,000. In addition, IceBridge was visited by a production crew that recorded footage for an upcoming Showtime television series.

IceBridge also engaged with teachers, students and the public through **Google+ Hangouts**, including one held live from McMurdo Station, and a series of **educational text chats** via the P-3's satellite communication system. Through these activities, IceBridge answered the questions of students, journalists and members of the public around the country. In addition, IceBridge worked with the NSF-funded PolarTREC program to provide a **field research experience** for a high school science teacher from Illinois.

This past Arctic deployment to Greenland included **teachers** from the United States, Denmark, and Greenland. These teachers worked together to collaborate new ideas that could be brought into the classroom; they interviewed our field teams and built real-time lesson plan material that they subsequently shared with their classrooms while still in the field this included blogs and Skype sessions.

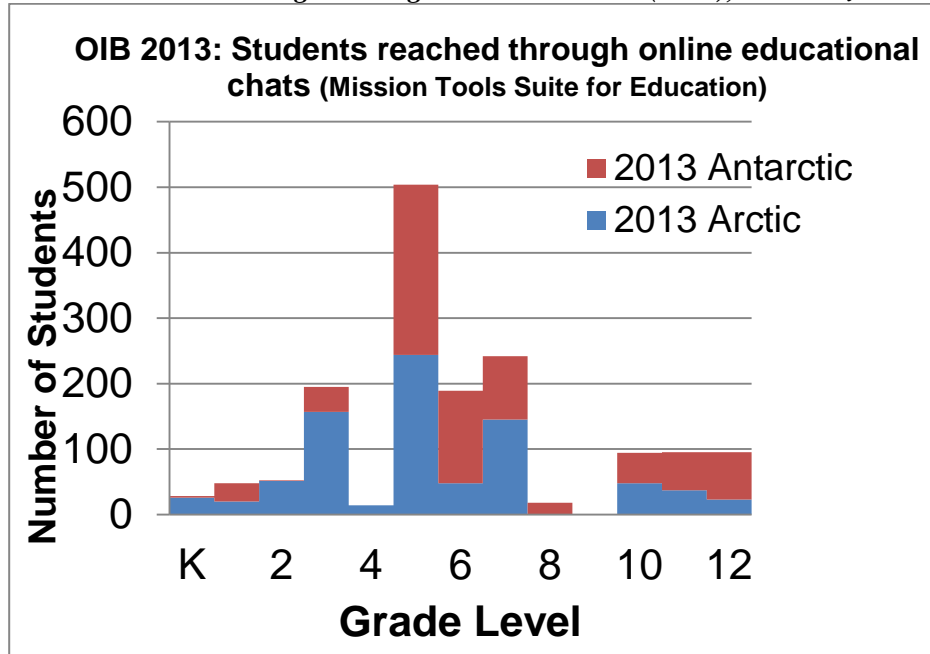
Refer to **Appendix B** for a detailed list of news releases, features, and blogs; including their respective links.



6.2 X-Chat Summary

Several hundred K-12 students from across the United States participated in real-time text chatting (referred to as X-chat) during IceBridge’s P-3 science flights over Greenland this year. Students and teachers interacted with our instrument teams, flight crew, scientists, and management team as we collected data on Greenland’s fast-moving glaciers, its ice sheet, and surrounding sea ice. Students were interested in a wide-range of topics, including the science behind polar ice, the weather, our views from the aircraft, as well as the entire range of human factors and comfort while flying in the Arctic. **We reached 1574 K-12 students this year** during our x-chat sessions conducted during the Arctic and Antarctic deployments.

Students Reached during IceBridge X-Chat Sessions (2013); credit: Emily Schaller





Appendix A: IceBridge Publications

- 1) Bamber, J. L., Siegert, M. J., Griggs, J. A., Marshall, S. J., and Spada, G., Paleofluvial Mega-Canyon Beneath the Central Greenland Ice Sheet, *Science*, Vol. 341(6149), 997-999, <http://dx.doi.org/10.1126/science.1239794>, 2013.
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- 4) Brucker, L., and Markus, T., Arctic-scale assessment of satellite passive microwave-derived snow depth on sea ice using Operation IceBridge airborne data, *Journal of Geophysical Research: Oceans*, Vol. 118(6), 2892-2905, <http://dx.doi.org/10.1002/jgrc.20228>, 2013.
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- 6) Chandler, D. M., Wadham, J. L., Lis, G. P., Cowton, T., Sole, A., Bartholomew, I., Telling, J., Nienow, P., Bagshaw, E. B., Mair, D., Vinen, S., and Hubbard, A., Evolution of the subglacial drainage system beneath the Greenland Ice Sheet revealed by tracers, *Nature Geosci*, Vol. 6(3), 195-198, <http://dx.doi.org/http://www.nature.com/ngeo/journal/v6/n3/abs/ngeo1737.html#supplementary-information>, 2013.
- 7) Cochran, J. R., Jacobs, S. S., Tinto, K. J., and Bell, R. E., Tectonic and oceanographic controls on Abbot Ice Shelf thickness and stability, *The Cryosphere Discuss.*, Vol. 7(6), 5509-5540, <http://dx.doi.org/10.5194/tcd-7-5509-2013>, 2013.
- 8) Cowton, T., Nienow, P., Sole, A., Wadham, J., Lis, G., Bartholomew, I., Mair, D., and Chandler, D., Evolution of drainage system morphology at a land-terminating Greenlandic outlet glacier, *Journal of Geophysical Research: Earth Surface*, Vol. 118(1), 29-41, <http://dx.doi.org/10.1029/2012jf002540>, 2013.
- 9) Darnell, K. N., Amundson, J. M., Cathles, L. M., and MacAyeal, D. R., The morphology of supraglacial lake ogives, *Journal of Glaciology*, Vol. 59(215), 533-544, <http://dx.doi.org/10.3189/2013JoG12J098>, 2013.
- 10) Enderlin, E. M., and Howat, I., Submarine melt rate estimates for floating termini of Greenland outlet glaciers (2000–2010), *Journal of Glaciology*, Vol. 59(213), 67-75, <http://dx.doi.org/10.3189/2013JoG12J049>, 2013.
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Appendix B: IceBridge E/PO Highlights & Videos

News Releases and Features

1. *NASA Begins New Season of Arctic Ice Science Flights*
http://www.nasa.gov/mission_pages/icebridge/news/spr13/arctic-begins.html
2. *NASA Scientists Part of Arctic Sea Ice Study*
<http://www.nasa.gov/topics/earth/features/arctic-seaice-study.html>
3. *NASA's IceBridge Finishing Up Successful Arctic Campaign*
http://www.nasa.gov/mission_pages/icebridge/news/spr13/campaign-ends.html
4. *Science Teachers See NASA IceBridge Research*
http://www.nasa.gov/mission_pages/icebridge/news/spr13/embedded-teachers.html
5. *NASA Begins Airborne Campaign to Map Greenland Ice Sheet Summer Melt*
<http://www.nasa.gov/content/nasa-begins-airborne-campaign-to-map-greenland-ice-sheet-summer-melt/>
6. *Change of Venue for NASA's IceBridge Antarctic Operations*
<http://www.nasa.gov/content/icebridge/news/fall13/change-venue-nasa-icebridge-antarctic-operations/>
7. *NASA Begins First Antarctic Campaign from McMurdo Station*
<http://www.nasa.gov/content/goddard/nasa-begins-first-antarctic-airborne-campaign-from-mcmurdo-station/>
8. *NASA Pilots Train for Antarctic Flying*
<http://www.nasa.gov/content/goddard/nasa-pilots-train-for-antarctic-flying>
9. *Airborne Radar Looking Through Thick Ice During NASA Polar Campaigns*
<http://www.nasa.gov/content/goddard/airborne-radar-looking-through-thick-ice-during-nasa-polar-campaigns>

Campaign News Updates - Arctic

http://www.nasa.gov/mission_pages/icebridge/news/spr13/index.html#.Uuf_mhAo5aQ

1. *Off to a Productive Start*
2. *New Collaborations and a Return to Thule*
3. *Sampling the Strait*
4. *Filling a Gap and Repeating Measurements*
5. *East and West Coast Glaciers*
6. *Best Conditions in the Area*
7. *Surveying the Geikie Peninsula and a Canadian Ice Cap*
8. *Back to Thule*
9. *Filling in Gaps*
10. *Expanding IceBridge's Reach*
11. *A Stormy Finish*



Campaign News Updates - Seasonal

http://www.nasa.gov/mission_pages/icebridge/news/sum13/index.html#.Uv0BqPldWoM

1. *NASA Team Finishes Greenland Campaign*
2. *A Second Round from Thule*
3. *Productive Flights for NASA Greenland Campaign*

Campaign News Updates - Antarctic

http://www.nasa.gov/mission_pages/icebridge/news/fall13/index.html#.UugADRAo5aQ

1. *IceBridge Prepares for Mission of "Firsts" in Antarctica*
2. *Three in a Row for NASA's IceBridge*
3. *IceBridge Surveys Siple Coast*
4. *One More Mission and Off the Ice*
5. *IceBridge Wraps Up Successful Antarctic Campaign*

Blog Posts

1. *Operation IceBridge Featured in EOS*
http://blogs.nasa.gov/icebridge/2013/01/22/post_1358192762223/
2. *NASA Goddard Hosts IceBridge Science Team Meeting*
http://blogs.nasa.gov/icebridge/2013/02/04/post_1360000024226/
3. *Preparations for Arctic Campaign Under Way*
http://blogs.nasa.gov/icebridge/2013/03/05/post_1362502606956/
4. *IceBridge Arctic 2013 Check Flights Complete*
http://blogs.nasa.gov/icebridge/2013/03/15/post_1363371223155/
5. *NASA Operation IceBridge: Notes from the Field (Arctic 2013)*
http://blogs.nasa.gov/icebridge/2013/03/22/post_1363965063558/
6. *Crossing the Basin: IceBridge in Alaska*
http://blogs.nasa.gov/icebridge/2013/03/29/post_1364503092537/
7. *PolarTREC Teacher's Path to IceBridge*
http://blogs.nasa.gov/icebridge/2013/04/01/post_1364826187669/
8. *Greenland Teacher to Gain Insight on Arctic Ice*
http://blogs.nasa.gov/icebridge/2013/04/02/post_1364921834107/
9. *Teacher and Science Adviser to Experience IceBridge*
http://blogs.nasa.gov/icebridge/2013/04/03/post_1364926465941/
10. *IceBridge Field Work – A Project Manager's Perspective*
http://blogs.nasa.gov/icebridge/2013/04/04/post_1364929923987/



11. *Live Twitter Chat with Operation IceBridge*
http://blogs.nasa.gov/icebridge/2013/04/05/post_1365178028069/
12. *Rock, Ice and Fire: Volcanoes of Greenland's Past*
http://blogs.nasa.gov/icebridge/2013/04/16/post_1366140794166/
13. *Grounded in Truth*
http://blogs.nasa.gov/icebridge/2013/05/30/post_1369405133813/
14. *IceBridge Science Team Meets at UC Irvine*
<http://blogs.nasa.gov/icebridge/2013/06/21/icebridgeteammeetsatucirvine/>
15. *Cryo Lab at Goddard's Science Jamboree*
<http://blogs.nasa.gov/icebridge/2013/07/19/cryo-lab-at-goddards-science-jamboree/>
16. *PolarTREC Teacher to Share IceBridge Experience*
<http://blogs.nasa.gov/icebridge/2013/08/02/polartrec-teacher-to-share-icebridge-experience/>
17. *Last Steps Before the Ice*
<http://blogs.nasa.gov/icebridge/2013/11/21/last-steps-before-the-ice/>
18. *Keeping in Touch: Communication in the Field*
<http://blogs.nasa.gov/icebridge/2013/11/25/keeping-in-touch-communication-in-the-field/>
19. *IceBridge Antarctic 2013: A Year and a Half in the Making*
<http://blogs.nasa.gov/icebridge/2013/11/28/icebridge-antarctic-2013-a-year-and-a-half-in-the-making/>
20. *A Clear View: Operating the Digital Mapping System* <http://blogs.nasa.gov/icebridge/2013/12/01/a-clear-view-operating-the-digital-mapping-system/>
21. *Gearing Up for Greenland: Part 1*
<http://earthobservatory.nasa.gov/blogs/fromthefield/2013/10/31/gearing-up-for-greenland-part-1/>
22. *Gearing Up for Greenland: Part 2*
<http://earthobservatory.nasa.gov/blogs/fromthefield/2013/11/01/gearing-up-for-greenland-part-2/>



Social Media

1. *Live Twitter Chat on Apr. 9, 2013*
2. *Google+ Hangout Media Event on Oct. 29, 2013*
<https://www.youtube.com/watch?v=yLZ7eRq95yk&list=PLiuUQ9asub3RlwXFxtBa09VCyAdsvzJDB&index=2>
3. *Google+ Educational Hangout Live from McMurdo Station on Nov. 27, 2013*
<https://www.youtube.com/watch?v=65bQfm-78f4>

IceBridge Videos

Fully Produced Videos and Animations

1. *Getz Mission in Three Minutes*
 - http://www.youtube.com/watch?v=E9ht_Y7qzdU
2. *Wheels Down in Thule*
 - http://www.youtube.com/watch?v=oru_uz_fk2Y
3. *Keeping a Close Eye on Jakobshavn*
 - <http://www.youtube.com/watch?v=yzMybcwHnBE>
4. *Flying Low Over Southeast Greenland*
 - <http://www.youtube.com/watch?v=XjFi9KDM0AA>
5. *The Bedrock Beneath*
 - <http://www.youtube.com/watch?v=usDzh7l5HZw>
 - 1 million+ views on YouTube
 - Picked up by Wired, Gizmodo, National Geographic, and *Mother Jones*.
6. *From the Cockpit: Best of IceBridge Arctic '13*
 - <http://www.youtube.com/watch?v=fPkLrSMbJoU>
 - 200,000+ views on YouTube
 - Picked up by *Der Spiegel*, *The Telegraph*, and *Seattle Post-Intelligencer*
7. *From the Cockpit: Arctic Sea Ice with Commentary*
 - <http://www.youtube.com/watch?v=cX8arylKebU>
8. *Greenland's Mega Canyon*
 - <http://www.youtube.com/watch?v=ENg9Hci9y3M>
 - 1 million+ views on YouTube
 - Generated major news coverage including NPR, BBC, CNN, and National Geographic
9. *A Laser Scientist Answers 5 Questions About LVIS*
 - <http://www.youtube.com/watch?v=cIMBvzFeNQA>
10. *First Landing: IceBridge on the Sea Ice Runway*
 - <http://www.youtube.com/watch?v=oeHz4KXdYBU>
11. *Ross Sea Highlights*
 - <http://svs.gsfc.nasa.gov/goto?11438>
 - featured on Slate.com in a piece written by an Antarctic Artist in Residence



- http://www.slate.com/articles/health_and_science/science/2013/12/ice_formation_in_antarctica_photos_and_video_of_crevasses_pressure_ridges.html

IceBridge Footage used in Other Products

1. Other NASA videos
 - *Warm Ocean Melting Pine Island Glacier*
 - <http://www.youtube.com/watch?v=qzVM-aR-e60>
 - *GROVER Heads to Greenland*
 - <http://www.youtube.com/watch?v=1QlpTNTufv4>
 - *Sea Ice Max 2013: An Interesting Year for Sea Ice*
2. Satellite media tour
 - Arctic Sea Ice Update, Aug. 2013 featuring Tom Wagner
 - <http://www.youtube.com/watch?v=04bmGa9dRMc>
3. External videos
 - White House video on the polar vortex
 - <http://www.youtube.com/watch?v=5eDTzV6a9F4>

