

INTRODUCTION TO POLAR GEOSPATIAL CENTER

Webinar



Products, Services & Support

OUTLINE:

Basic introduction for newly funded polar researchers and logistics personnel, recent partners and the general public to learn about the Polar Geospatial Center, the nature of our work and who we support.

Background Information


- Mission
- Timeline
- Funding & Users
- Support Roles
- User Services

Products & Services

- Public vs Restricted Data
- Products & Services
- Support Examples
- Requesting Support

Q&A w/ PGC Staff

Guides

 Search Articles...


User Services

6 Articles

-  Introduction to User Services
-  Information for Proposers
-  Working with PGC


Commercial Imagery

10 Articles

-  Introduction to Satellite Imagery
-  DigitalGlobe Satellite Constellation
-  Imagery Eligibility

Stereo Elevation Models

5 Articles

-  Introduction to Stereoscopic Imagery
-  Processing Algorithms
-  Usage Guidelines

ArcticDEM

4 Articles

-  Introduction to ArcticDEM
-  Data Description
-  Distribution

Web Mapping Applications

4 Articles

-  Using PGC Web Mapping Services in ArcGIS Desktop, Pro, and QGIS
-  PGC Imagery Viewers
-  PGC Coordinate Converter

Miscellaneous

3 Articles

-  Polar Satellite Imagery Resources
-  Polar GIS Data Resources
-  Polar Elevation Resources

**PGC website
provides exhaustive
information about
PGC: background,
data, services, news,
and tutorials.**

Check out our growing
online Guides section
pgc.umn.edu/guides

PGC Introduction

The Polar Geospatial Center is a polar science and logistics support organization at the University of Minnesota with core funding provided by the National Science Foundation's (NSF) Office of Polar Programs (OPP).



MISSION

- Domain and institutional knowledge to solve a broad range of polar geospatial problems
- Access to sub-meter commercial satellite imagery for the Antarctic and Arctic and the expertise to task, manage, process, and deliver high-level, value-added products
- Educational courses and online material to transfer PGC's knowledge and experience to the community

Timeline

Quick Look

- 2007 Founded as the Antarctic Geospatial Information Center (AGIC) for support to the U.S. Antarctic Program (USAP)
- 2010 Transitioned to the Polar Geospatial Center (PGC) to support research and logistics for Antarctic and Arctic
- 2015 PGC receives supplemental \$ to launch ArcticDEM
- 2020 Approximately 15 employees, EarthDEM project



PGC Funding & Users



General
Public



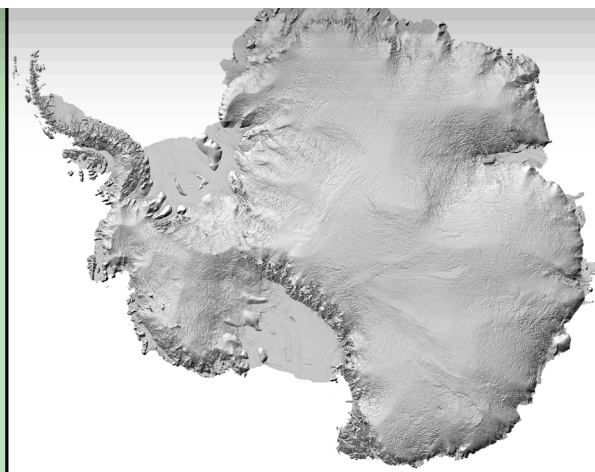
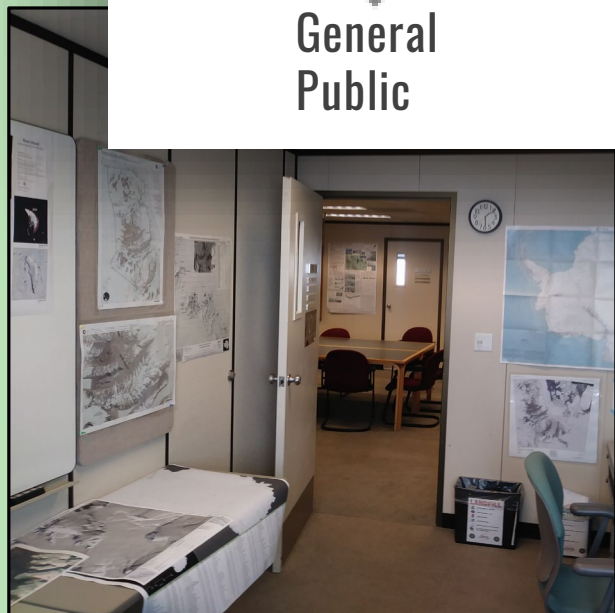
Polar Logistics
& Operations



Polar Grantees
& Researchers



Other Agency
Agreements



Funding

- National Science Foundation

Primarily through Office of
Polar Programs (OPP)

2016-2021 NSF Cooperative
Agreement #1559591

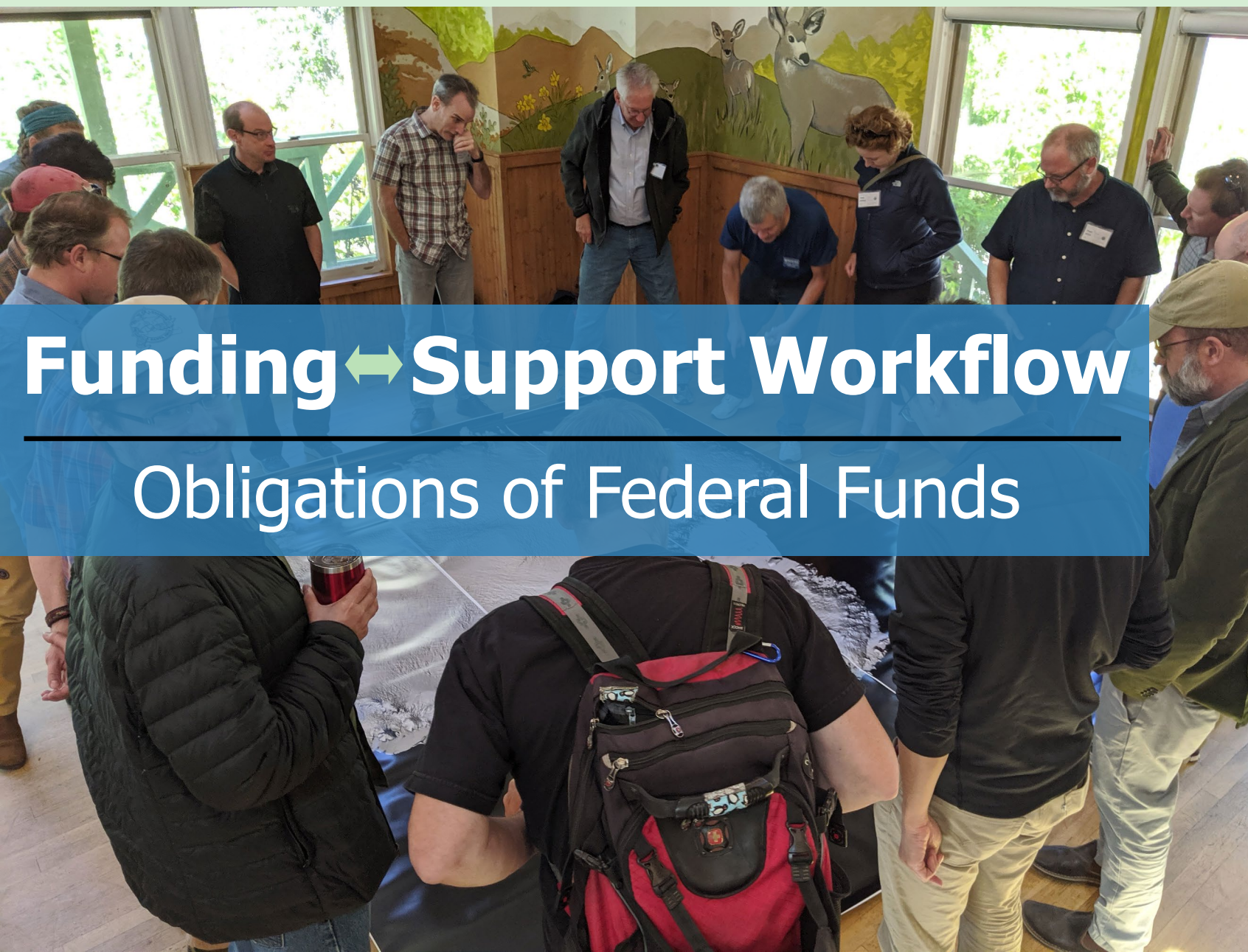
Other Awards (Past & Present)

- ArcticDEM from NSF
- NASA Cryosphere, ABoVE,
and High-Mountain Asia
Programs
- U.S. Fish & Wildlife Service
- University of Minnesota



Funding ↔ Support Workflow

Obligations of Federal Funds



Funding ↔ Support Workflow

Obligations of Federal Funds

Direct Users – Core

- NSF OPP and NASA Cryo funding provides specialized support for NSF OPP / NASA Cryo grantees as well as Arctic/Antarctic logistics & operations contractors

Indirect Users – Public

- Publicly available datasets:
 - ❖ High-resolution digital elevation models (DEM)
ArcticDEM / REMA / EarthDEM
 - ❖ Aerial photography
 - ❖ Historical & contemporary polar maps



PGC's role to **SCIENTISTS**

- Provide geographic **data**
 - Serve as a **conduit** to an archive of high-resolution commercial satellite imagery licensed for US. Federally-funded users
 - Provide **expertise** relating to GIS, Mapping, Remote Sensing, Photogrammetry
 - Process and manipulate data to **enable** scientific objectives
-

PGC's role to **LOGISTICS**

- Facilitate **safe** navigation and travel
- Provide satellite **imagery** and derivative cartographic materials to increase situational awareness
- Create **reference** materials for planning and movement objectives
- Reduce programmatic costs through remote site **monitoring** and reconnaissance
- **Assist** with emergency response and SAR scenarios



PGC's role to **COMMUNITY**

- **Transfer** PGC's knowledge and expertise
- Provide comprehensive materials to teach and **enable** use of PGC products
- Reach broad audience to facilitate **self-service**
- Reduce duplicated efforts w/ solutions **beyond** direct support

The screenshot shows the PGC Map Catalog website. At the top, there are three main navigation buttons: "Antarctic Viewer", "Arctic Viewer", and "World Viewer". Each button has a corresponding icon and a brief description of the viewer's function. Below these, there is a section for "Decimal Degrees (DD)" and "Degrees Decimal Minutes (DDM)" coordinates. The "Decimal Degrees (DD)" section shows Latitude: -77.508333 and Longitude: 164.754167. The "Degrees Decimal Minutes (DDM)" section shows Latitude: 77° 30.5' S and Longitude: 164° 45.25' E. At the bottom, there are two large buttons: "VIEW ANTARCTICA MAPS »" and "VIEW ARCTIC MAPS »".

Antarctic Viewer
View the land of snow & ice of the southernmost continent.
WGS84 Antarctic Polar Stereographic Projection
[Launch Antarctica »](#)

Arctic Viewer
View the dynamic landscape of glaciers & permafrost for Greenland & Alaska.
NSIDC Sea Ice Polar Stereographic Projection North
[Launch Arctic »](#)

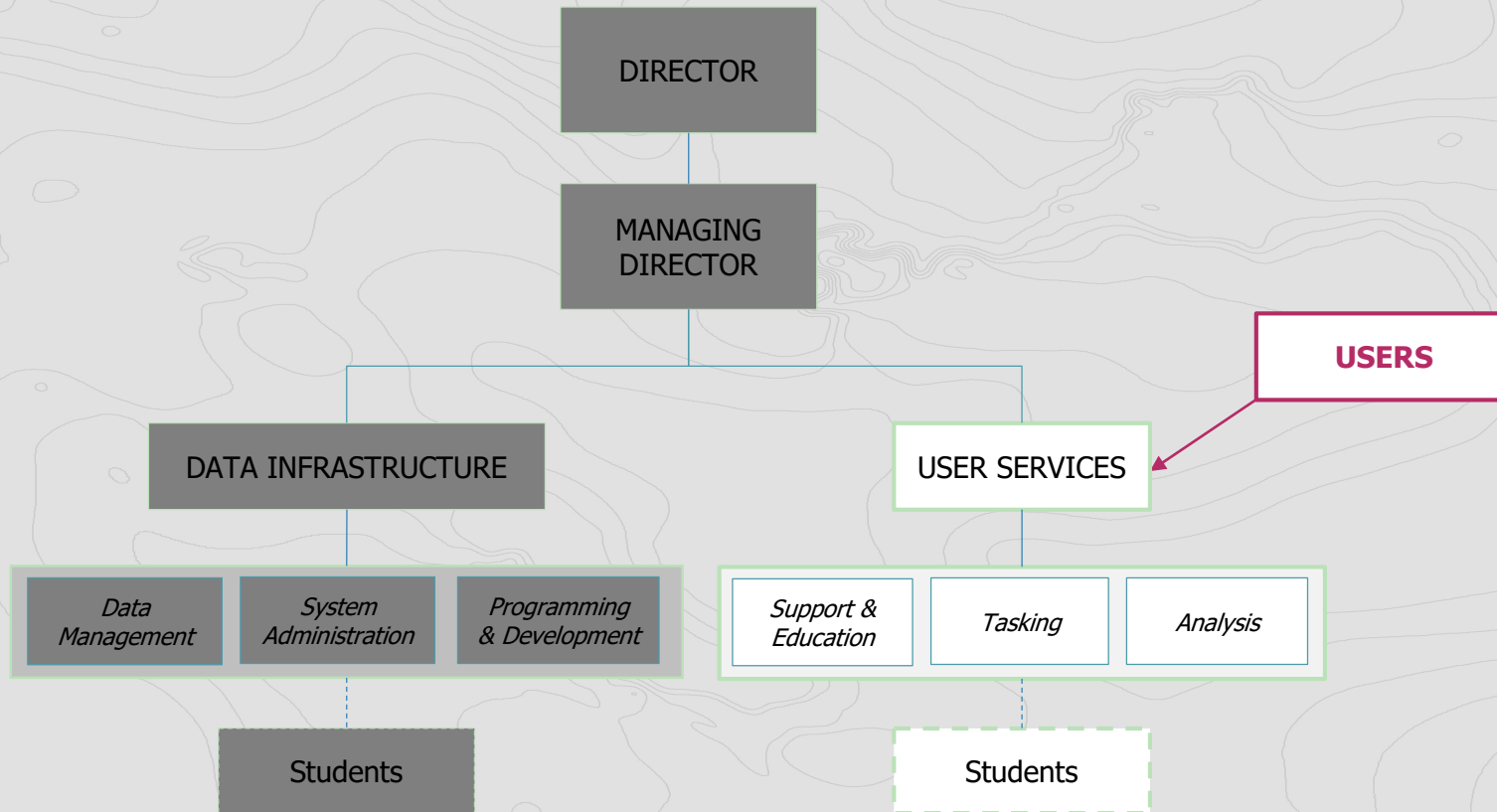
World Viewer
View the snowcaps, ice fields, & glaciers throughout the world.
WGS84 Web Mercator Projection
[Launch World »](#)

Decimal Degrees (DD)
Latitude: -77.508333
Longitude: 164.754167

Degrees Decimal Minutes (DDM)
Latitude: 77° 30.5' S
Longitude: 164° 45.25' E

PGC Map Catalog
[VIEW ANTARCTICA MAPS »](#) [VIEW ARCTIC MAPS »](#)

USER Services



ABOUT

- Connection to the polar community
- PGC Team that provides dedicated support to our core users
- Responds to data & support requests
- Coordinates project responsibilities

USER SERVICES Staff

7 full-time staff members

3 graduate research assistants

Domain Expertise

GIS, geography, remote sensing,
computer science, earth &
atmospheric sciences, web
development

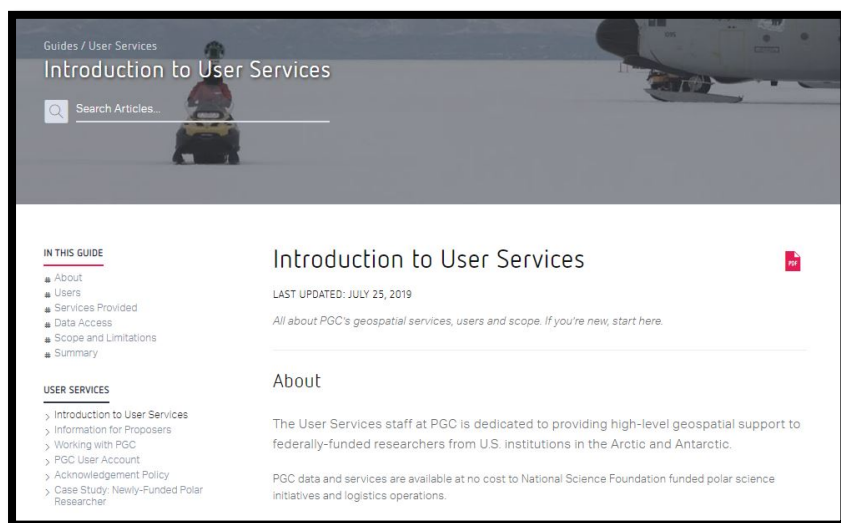
Point-of-Contact System





Core Activities & Primary Services

User Services creates, locates, maintains, and aggregates information about requesting parties to provide the most efficient and effective support



- Geospatial expertise & guidance
- Satellite imagery processing & analysis
- Custom mapping
- Digital elevation model (DEM) creation
- Seasonal on-site support at

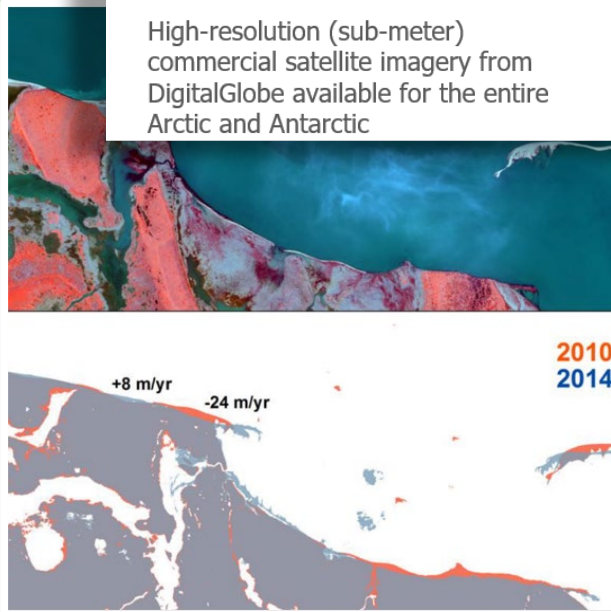
📍 McMurdo Station, Antarctica 

PGC Products & Services



Satellite Imagery

High-resolution (sub-meter) commercial satellite imagery from DigitalGlobe available for the entire Arctic and Antarctic



Terrain Models

High-resolution Digital Elevation Models (DEM) derived from Stereoscopic DigitalGlobe imagery



Digital Maps

Historical and custom map products for logistics planning, field site selection, publications, reference, etc.



Geospatial Support

Advanced solutions and expertise for novel or challenging remote sensing and geospatial problems



PUBLIC Data



Maps

Historical and contemporary polar maps from many organizations available in digital formats.

Includes

Antarctic maps
Arctic maps
Custom maps



Aerial Photography

Historic and contemporary aerial photography of the polar regions.

Includes

Antarctic TMA Project
Alaska AHAP Project



ArcticDEM

High-resolution, high-quality digital surface model (DSM) of the Arctic built with optical stereoscopic imagery, high-performance computing, and open source photogrammetry software.

Includes

2m posting scenes
2m posting mosaic



Reference Elevation Model of Antarctica (REMA)

High-resolution, high-quality digital surface model (DSM) of the Antarctic built with optical stereoscopic imagery, high-performance computing, and open source photogrammetry software.

Includes

2m & 8m posting scenes
8m posting mosaic



More Elevation Data

Spaceborne and airborne elevation datasets for the polar regions.

Includes

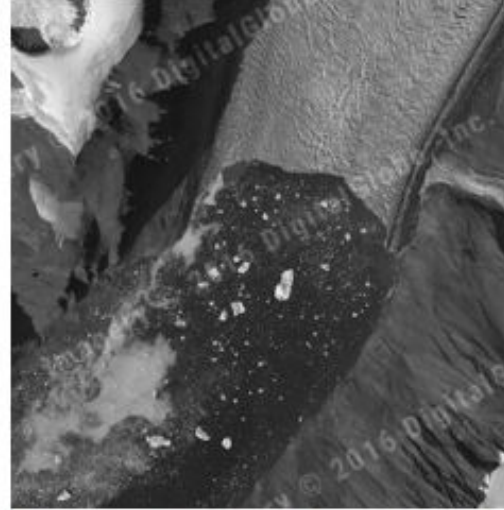
Antarctic LiDAR Campaigns
Stereo DEMs

RESTRICTED Data



- **Commercial satellite imagery** from Maxar's DigitalGlobe, Inc.
- Browser-based mapping application including **50 cm imagery mosaics** from PGC
- Restricted **maps** due to:
 - > formal copyright
 - > licensed imagery
 - > sensitive information
 - > authoring organization's request

WORLDVIEW-1 (PANCHROMATIC)



Íngia Isbræ, Greenland. Imagery © 2016 DigitalGlobe, Inc.

WORLDVIEW-2 (MULTISPECTRAL)



Herbert Volcano, Aleutian Islands, Alaska. Imagery © 2012 DigitalGlobe, Inc.

WORLDVIEW-3 (MULTISPECTRAL)



North Slope, Alaska. Imagery © 2016 DigitalGlobe, Inc.

WORLDVIEW-2 (MULTISPECTRAL)

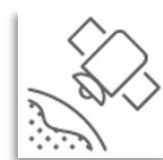


McMurdo Station, Antarctica. Imagery © 2015 DigitalGlobe, Inc.



Source: Aerial photo of Taylor Valley by PGC

Commercial Satellite Imagery



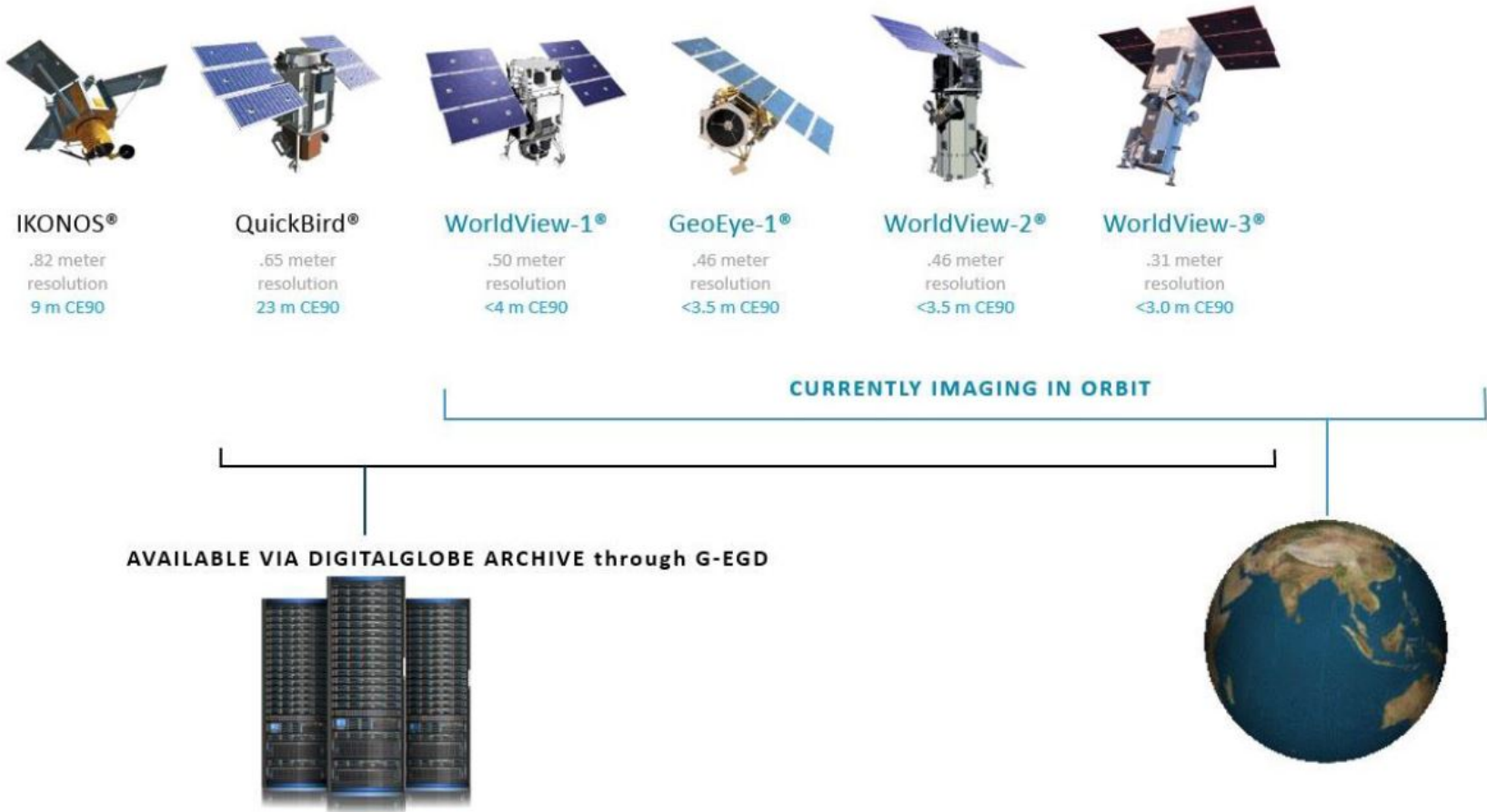
SPECS

ACCESS

VALUE – ADDED PROCESSING

APPLICATIONS

DigitalGlobe Overview



About:

DigitalGlobe, Inc., is a commercial satellite imagery company founded in 2001 and merged into the Maxar Technologies family in 2017. They are currently headquartered in Westminster, CO

Imagery Specifications:

- Resolution of 32-50 cm panchromatic and 1.2-2 m multispectral
- 4 and 8 multispectral bands in visible and near-infrared
- 17 km wide images up to 100 km long (postage stamps vs strips)
- Polar orbiting satellites with ~100 min orbits

NextView License

LICENSE TERMS

- Imagery available for a U.S. Government purpose only (civilian researchers, contractors included)
- Derived Products (e.g. DEMs, NDVI, feature extraction) are not subject to the license, but must include acknowledgement
- Must not compete with the “commercial interest” or shared publicly

USER REQUIREMENTS

- Supply proper copyright and acknowledgement
- Use for the intended purpose (project) only while actively funded

PGC’S ROLE

- Provide the imagery to NSF-OPP actively-funded researchers & contractors
- Provide approachable reference documentation (e.g. PGC Acknowledgement Policy, Imagery Eligibility, Usage Guidelines guides online)
- Coordinate “Public Release” approval with NGA (required)



NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY

Know the Earth... Show the Way... Understand the World

UNCLASSIFIED

NextView License and You

You must:

- Properly attribute (mark) all NV imagery and imagery derived products (IDP) with its Copyright information and educate anyone shared with on the license terms. Example of proper attribution:

Copyright 2011, DigitalGlobe, Inc.

You may:

- Share imagery or any IDPs with anyone directly working with/for the USG, including:
 - U.S. Government Employees/Contractors*
 - Universities supporting USG via contract(s)
- Share imagery or IDPs with those supporting USG interests
 - State/Local Governments
 - Foreign Governments
 - Intergovernmental Agencies
 - NGO's & Non-profit Organizations
- Post properly attributed reduced-resolution **non-manipulatable** imagery on public web sites
- Post/disseminate imagery using access-controlled web/FTE sites
- *Contractors' Government sponsor must provide oversight and approval for this sharing arrangement.

You must not:

- Provide/share imagery or IDPs made from NV licensed imagery with anyone planning to sell it or **use** it for commercial gain
- Post-full resolution imagery on a web site

You should seek clarification (see POC list) before:

- Publicly releasing or openly disseminating imagery or IDPs with image metadata
- Sharing with Educational Institutions for strictly educational/research purposes (**not connected with the Government**)
- Sharing with a company or other entity that might profit from the imagery shared
- Posting imagery to a web site without access controls
- Allowing Imagery or IDPs to be shared with a third party
- Sharing Imagery or IDPs with Universities with USG grant(s)
- Contacting the Vendors directly

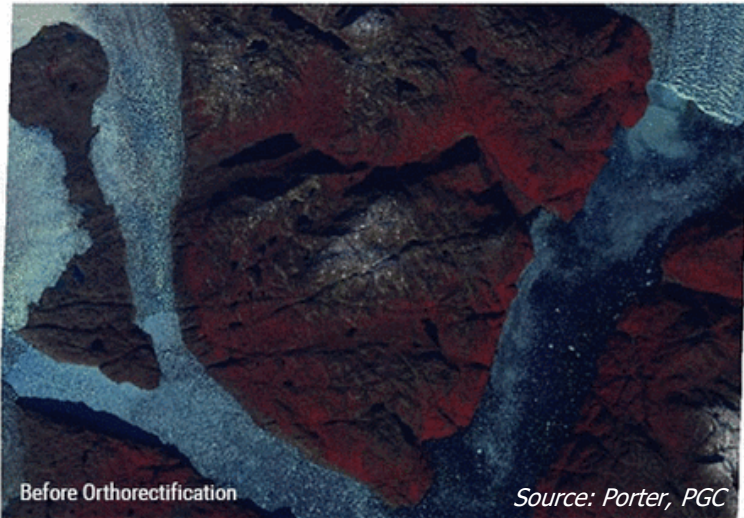
Definitions

- Imagery is the image and associated metadata. Imagery can be further manipulated, enhanced, & processed. Example: GeoPDF, GeoTiff, NITF.
- Image Derived Product (IDP) – any product created from raw imagery – could include metadata, but generally does not and often referred to as “dumb-image”
- Third Party Partner – Party otherwise affiliated with the original USG sharing partner, but not the USG directly.

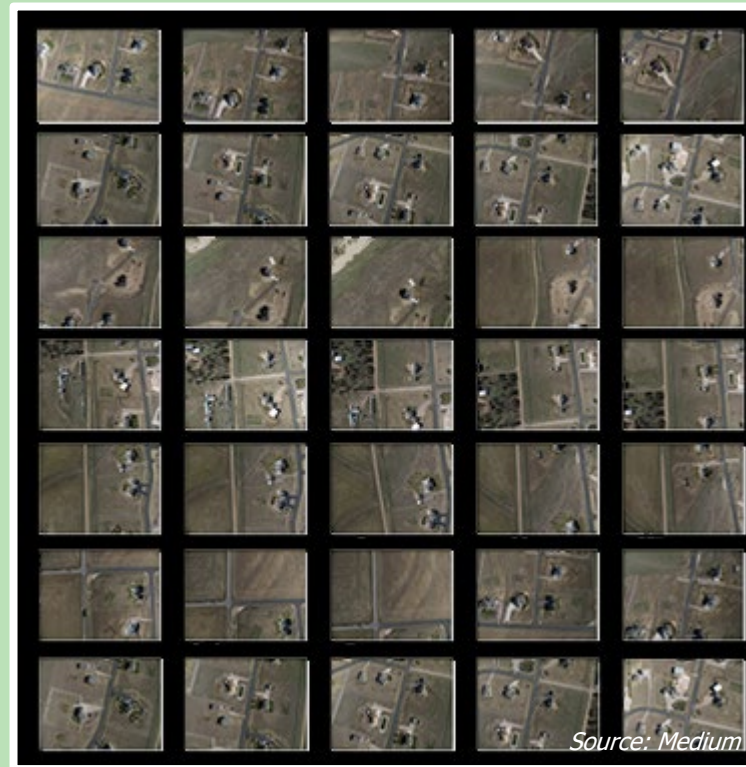
UNCLASSIFIED

Commercial Imagery | Value Added Processing

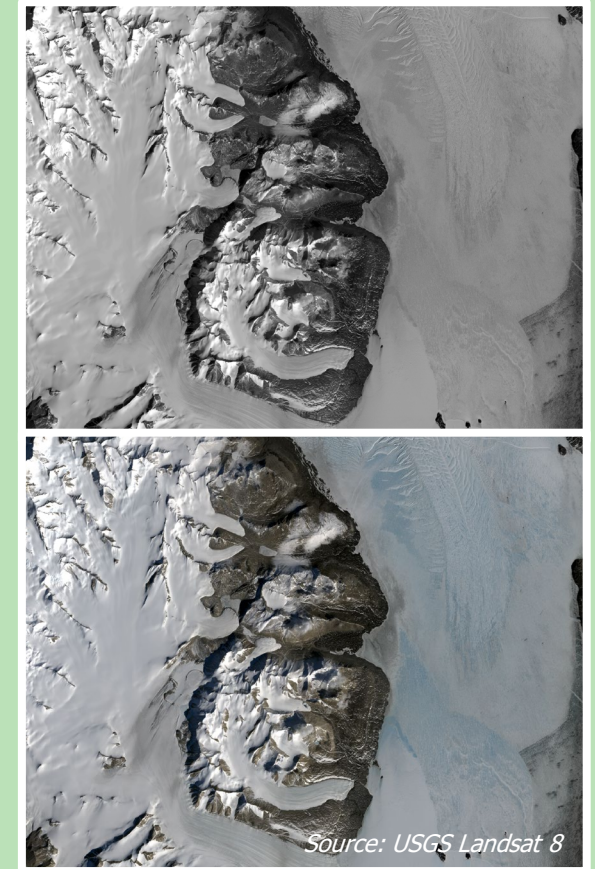
- Terrain & radiometric correction
*most commonly:
orthorectification, TOA*
- Terrain extraction from stereo imagery
- Web-applications for non-GIS users: viewers.apps.pgc.umn.edu




- Automated custom orthomosaics



- Pansharpening



PGC Imagery Mosaic Viewers




Antarctic Viewer

View the land of snow & ice of the southernmost continent.

WGS84 Antarctic Polar Stereographic Projection

[Launch Antarctica »](#)




Arctic Viewer

View the dynamic landscape of glaciers & permafrost for Greenland & Alaska.

NSIDC Sea Ice Polar Stereographic Projection North

[Launch Arctic »](#)




World Viewer

View the snowcaps, ice fields, & glaciers throughout the world.

WGS84 Web Mercator Projection

[Launch World »](#)

- High-resolution **0.5-meter** panchromatic Arctic, Antarctic & High-Mountain Asia orthomosaic
- PGC User Account **credentials required**
 - (actively NSF-OPP & NASA-Cryo funded)
- Available online as a **web-map** application at <https://viewers.apps.pgc.umn.edu/>
- Available in **image service** on ArcGIS online and ArcGIS server
- **Multispectral** version in select Antarctic areas
- **Updated** imagery approximately once a year



Tasking Capabilities

EXPECTATIONS

- Under DigitalGlobe & NGA control
- PGC does not guarantee collection
- Nearly impossible to task collection on specified day (*even +/- 3 days*)
- Limited on-demand tasking & imagery for SAR

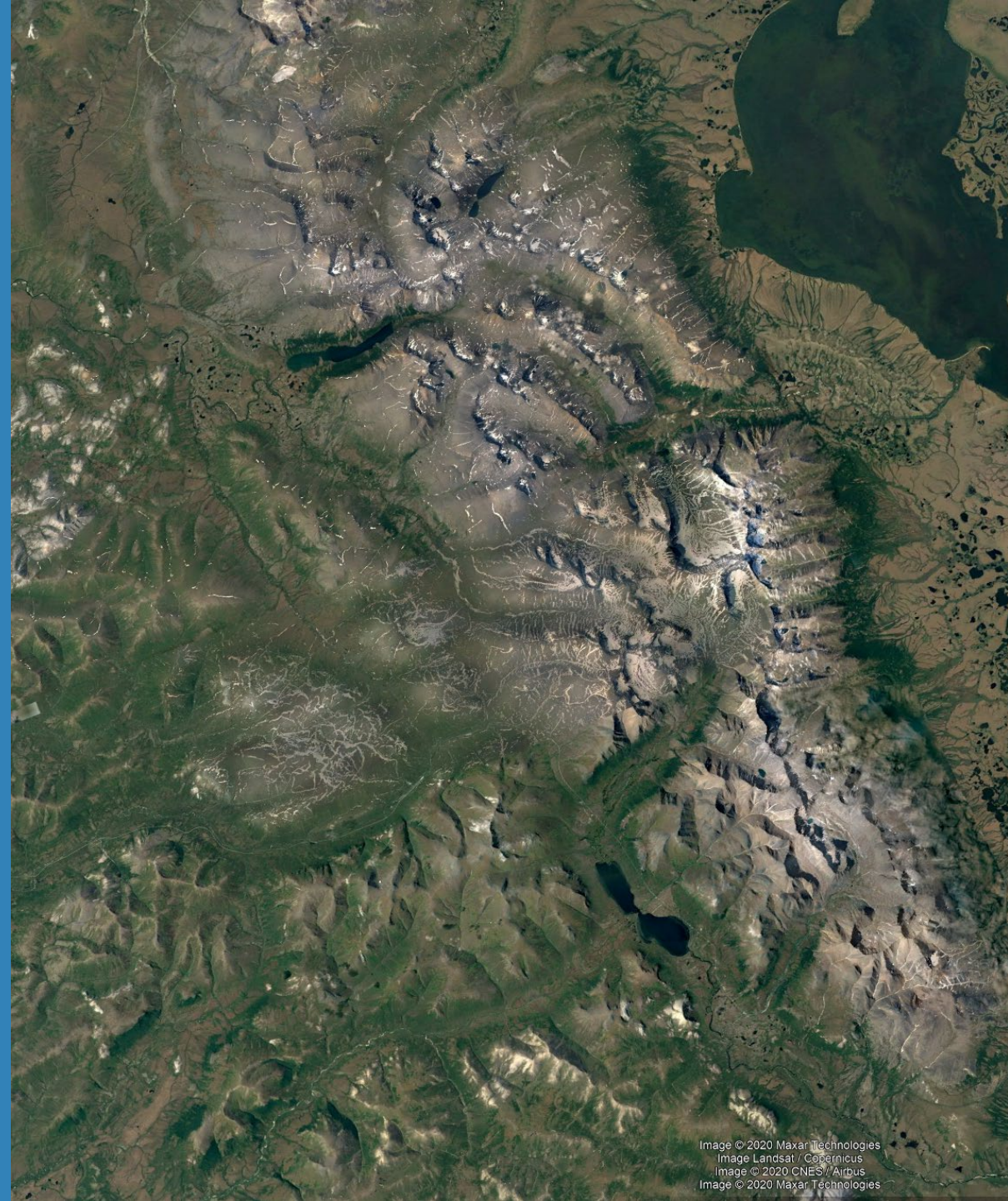
PGC assembles a tasking plan, submitted to NGA, for new imagery acquisition from the DigitalGlobe sensors.

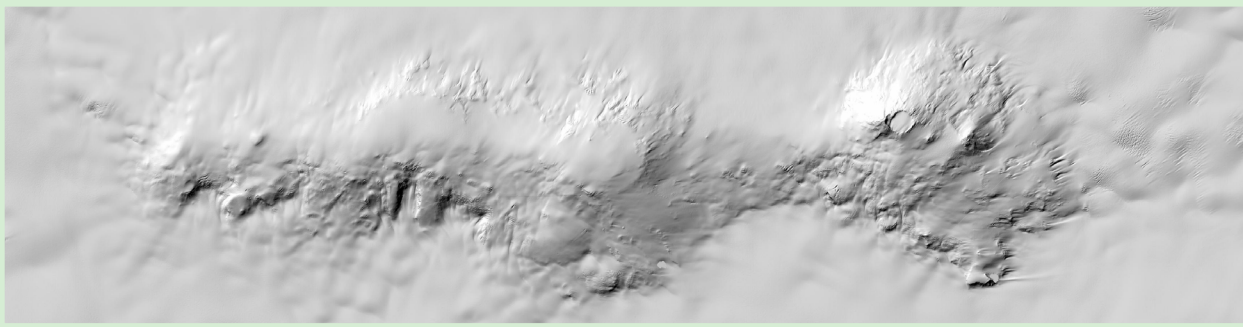
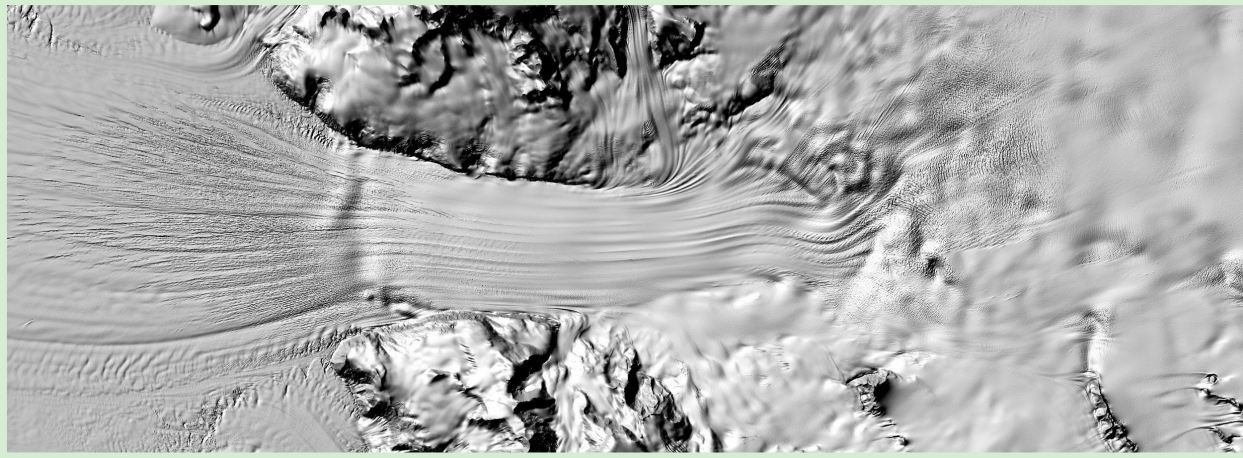
Each year, PGC solicits locations and AOIs from the science and logistics community
(Arctic in January & Antarctic in July).

PGC User Services coordinates requests in a standard template and our Satellite Tasking Coordinator aggregates into a cohesive plan in accordance with NGA requirements.

Commercial Imagery Applications

- Imagery as a **basemap**
- **Classification** – vegetation, ice, water, etc.
- **Change detection** – here today, gone tomorrow
- Observation and **measurement**
- **Visual** interpretation of the Earth's surface
- Locating and **identifying** spatial distribution of features





Terrain Models



PGC-CREATED DEMs

LiDAR

AIRBORNE THEMATIC MAPPER

ACCESS & APPS

DEM Strips

- Overlapping area of input stereoscopic images
- Provided at 2m & 8m 32-bit GeoTIFFs
- Elevation units are meters and referenced to WGS84 ellipsoid
- Time stamps preserved

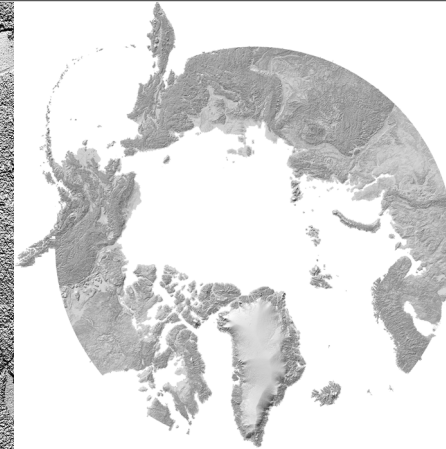
DEM Mosaic Tiles

- 100x100 km tiles at 2m, 8m
- Resampled versions available at 100m, 200m, 1km resolutions
- Best quality strips mosaicked with coregistration and feathering between tiles

- > Derived from DigitalGlobe, Inc. stereoscopic imagery
- > Photogrammetric extraction algorithm – SETSM
- > Free from license restrictions
- > Typical elevation errors <1 m

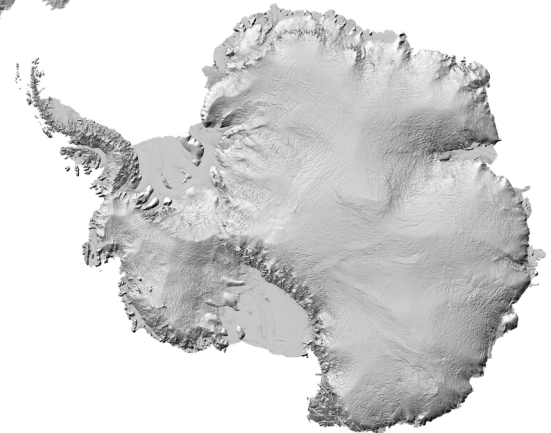
PGC Elevation Products

Specs & Regions



ArcticDEM

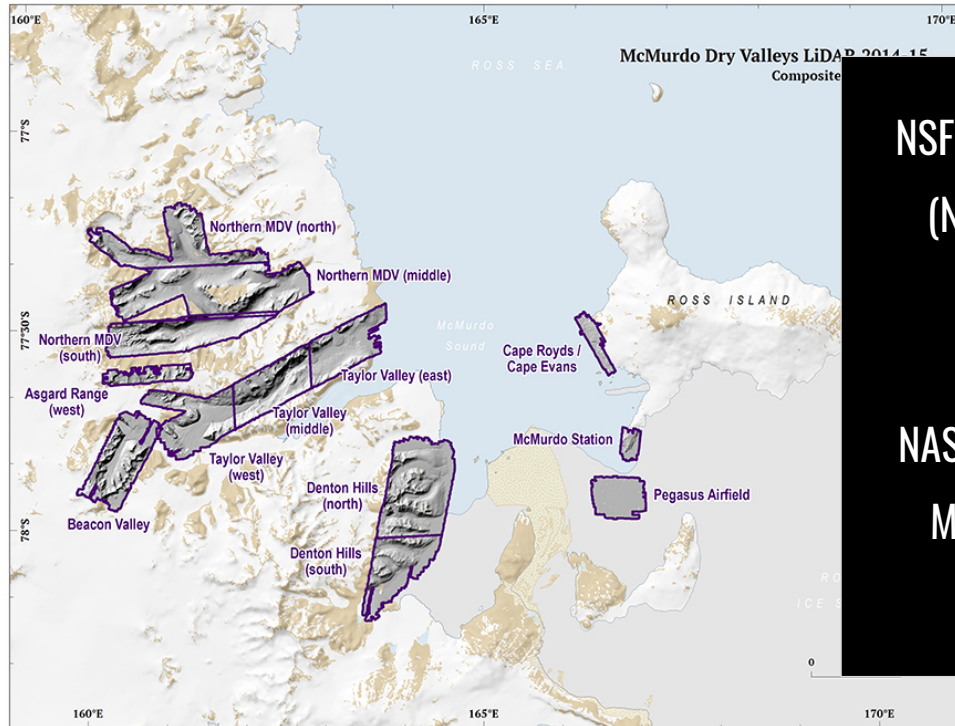
REMA
*Reference
Elevation
Model of
Antarctica*



EarthDEM *coming soon*

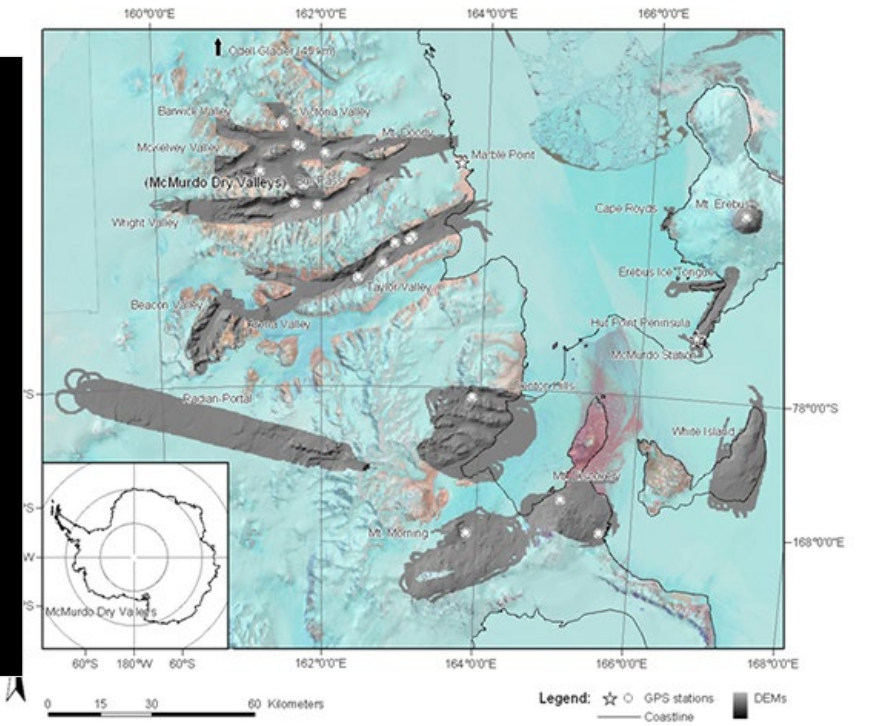
Airborne Products | LiDAR & ATM

*External acquisition campaigns over polar regions
available on PGC server*

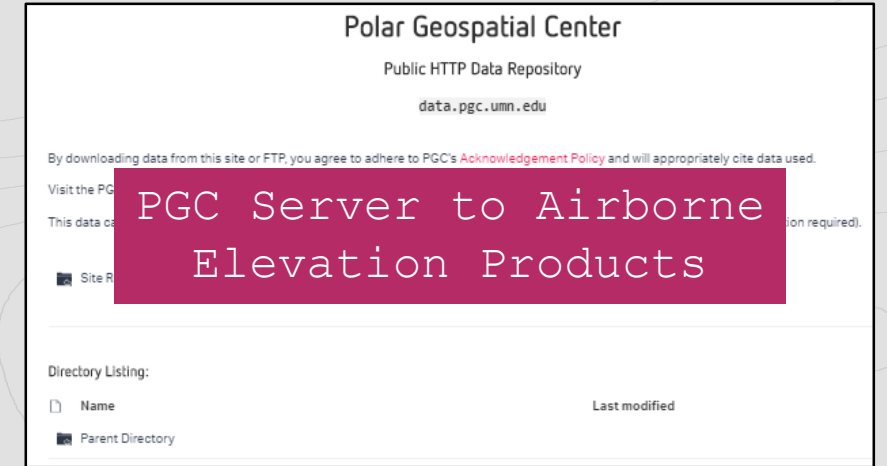
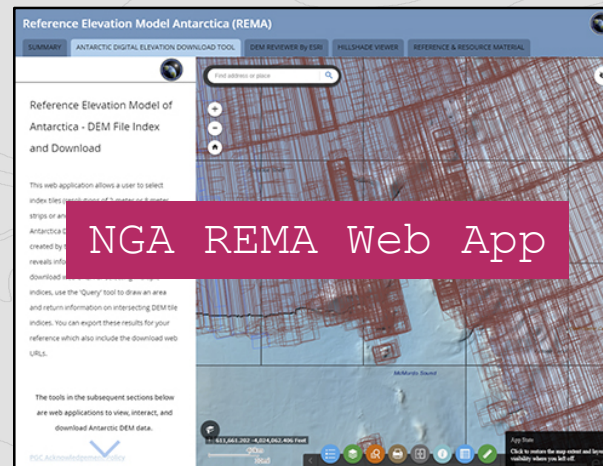
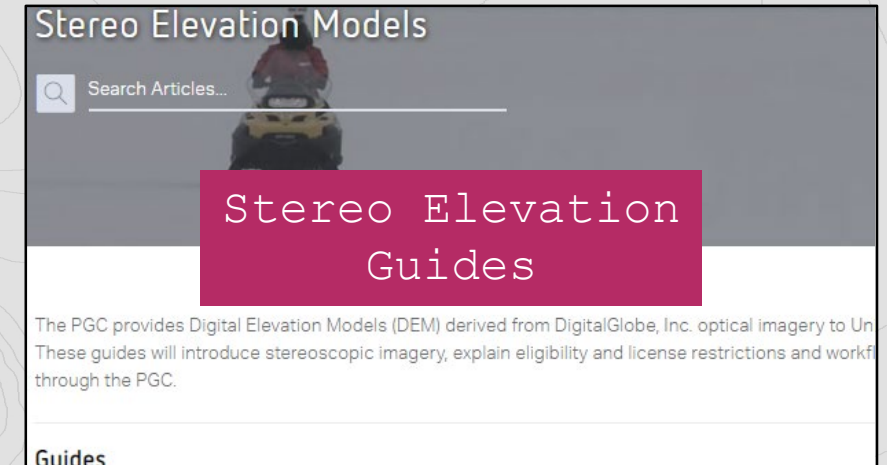
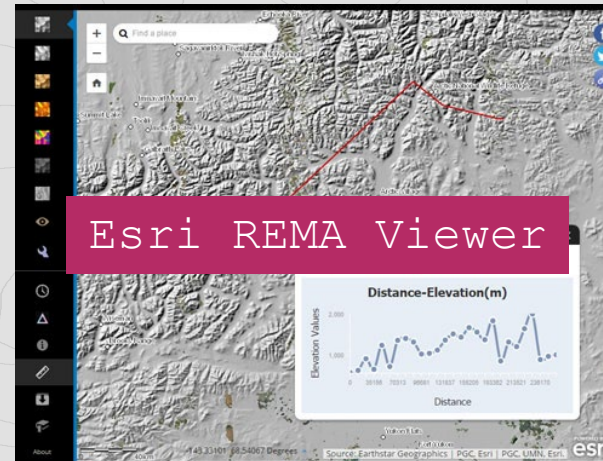
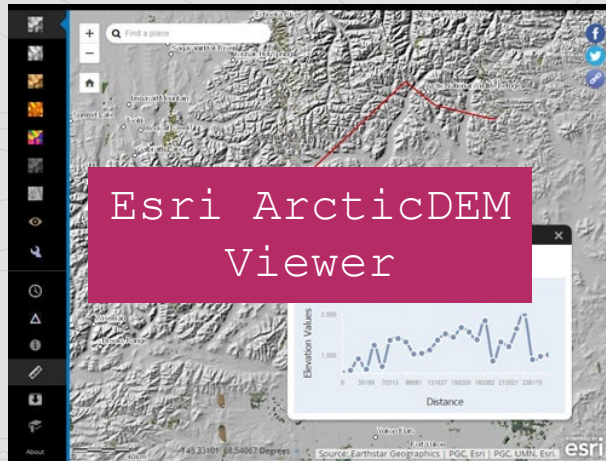


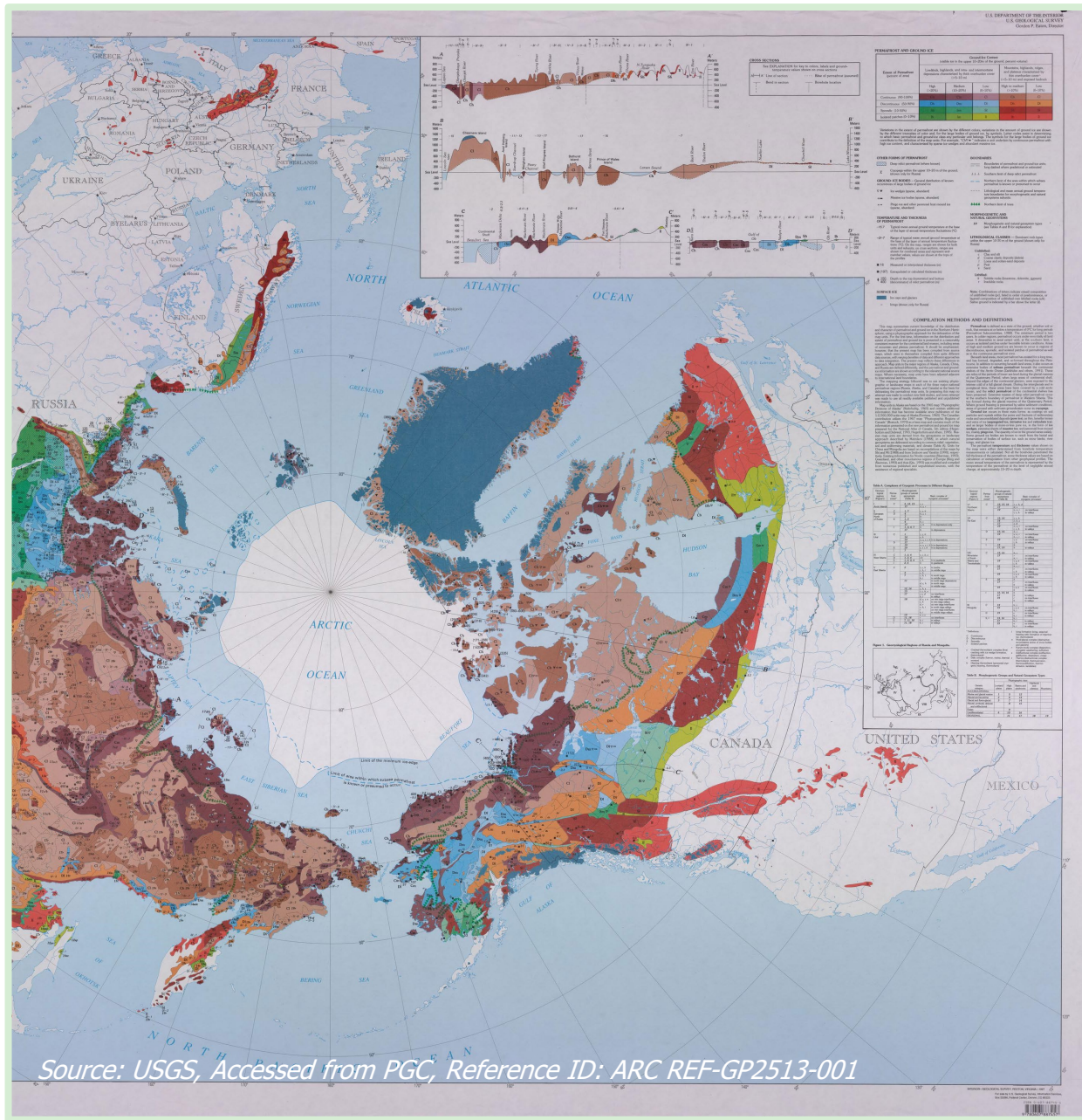
NSF Center for Airborne Laser Mapping
(NCALM) 2014-15 Composite Grids
(left)

NASA – NSF – USGS Airborne Thematic
Mapper (ATM) 2001 Gridded DEMs
(right)



ELEVATION Access & Apps





Digital Maps



SPECS

ACCESS

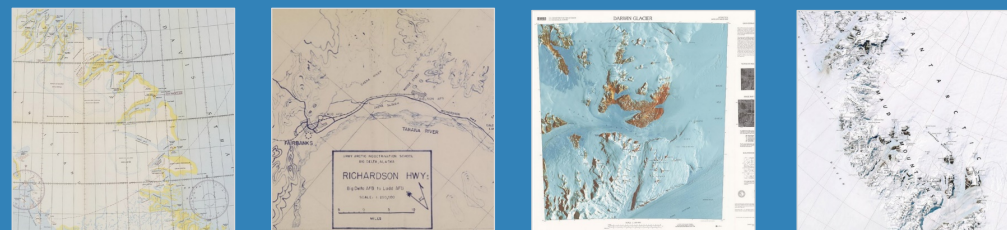
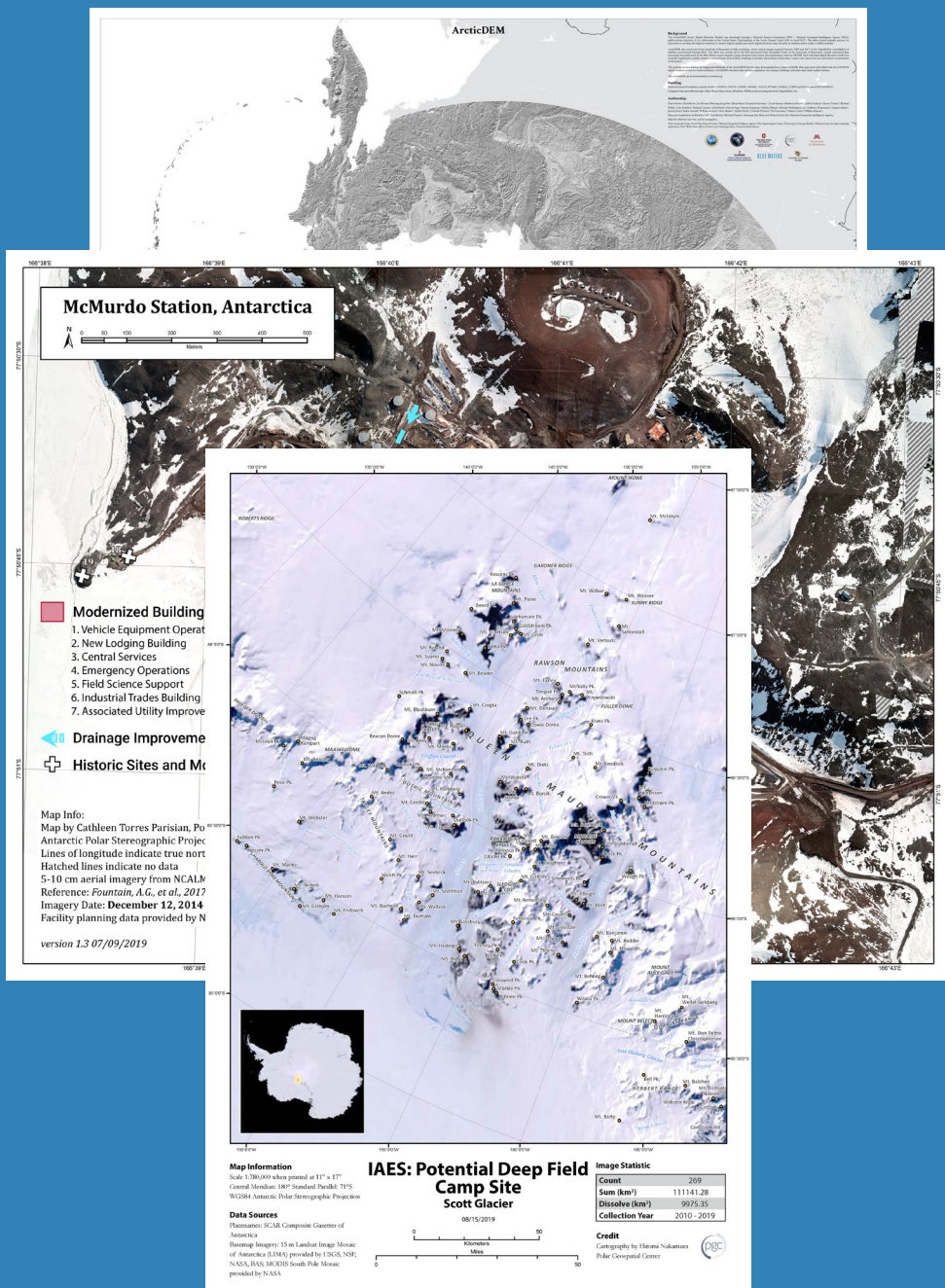
VALUE – ADDED FORMATTING

APPLICATIONS

PGC MAPS

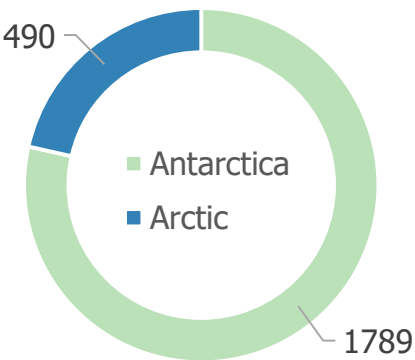
Historical | Contemporary | Custom

- PGC Map Catalog is **searchable** online
- Libraries of **paper** maps, scanned at high-resolution and provide digital copies in many file formats
- **Restricted & custom** maps can be requested by *Core Users* via [Data + Services](#) page or from your **PGC POC**



PGC MAP CATALOG

- Archive of historical and contemporary polar maps



File Formats
 PDF
 Preview JPG
 TIF
 GeoTIFF
 Cropped GeoTIFF

Map Purpose	# Maps
Reference	1427
Navigation	347
Summary	346
Planning	128
Index	31

DATA EXPLANATION

The satellite images were recorded by the Landsat thematic mapper in the multispectral mode and are composed of spectral bands 2 (0.63-0.68 micrometers, greenish-blue), 4 (0.76-0.86 micrometers, near-infrared) and 7 (2.08-2.35 micrometers, middle-infrared) and by the SPOT high-resolution visible recorded in the panchromatic mode.

The imagery was controlled using geodetic control points identified on aerial photographs held in the U.S. Antarctic Research Center and registered by the field collection of coordinates. To directly correlate topographic or geologic features, digital elevation modeling was used during the processing of the satellite data to correct surface view distortion through the sensor. The Landsat thematic mapper imagery was resampled in 15-meter cells, and the scene was mosaicked, true colored, and filtered using a 25x25 pixel adaptive filter to which 10 percent of the unfiltered data were added back. The SPOT panchromatic imagery was resampled in 15-meter cells, the georeferenced SPOT scenes were true balanced, mosaicked, and filtered using a 5x5 pixel adaptive filter to which 50 percent of the unfiltered data were added back. The georeferenced Landsat thematic mapper data were then registered to the georeferenced SPOT panchromatic data for each map quadrangle separately, both data sets were merged using the Channel Blue method, and the resulting image was tone enhanced.

Mosaic bands 7, 4, and 2 are shown in red, green, and blue on the map. The two original satellite data sets were acquired at two different times and dates, and the sun had different azimuths and (or) elevations, creating other two different shadows for the same area.

SATELLITE IMAGE INDEX

OBLIQUE PHOTOGRAPH

PGC MAPS

Catalog & Custom

Produced by the U.S. Geological Survey with support from the National Science Foundation, Interagency Agreement OPP 9118747

U.S. Geological Survey

U.S. Antarctic Research Center

U.S. Antarctic Program

PGC CUSTOM MAP REQUESTS

- Only NSF-OPP & NASA-Cryo
- Example of uses:
 - > Non-GIS users: scientist's field-site selection or surface characteristics for traverse planning and logistics
 - > Change detection
 - > Publications and presentations

**** NGA Approval ****

<https://www.pgc.umn.edu/guides/commercial-imagery/citation-and-publication-approval/>

- Data dependent on audience – *it's a legal matter!*
- Request to POC or <https://www.pgc.umn.edu/data/request/>

Geospatial Support



OTHER SERVICES

GUIDES

ANTARCTIC OFFICE

SUPPORT INFORMATION PACKAGES



Source: Photo by Suzan, ASC



Other Services & Guides

DATA CONVERSION

Manipulation of geospatial data file formats, projections, datums to suit the user and purpose

TERRAIN ANALYSIS

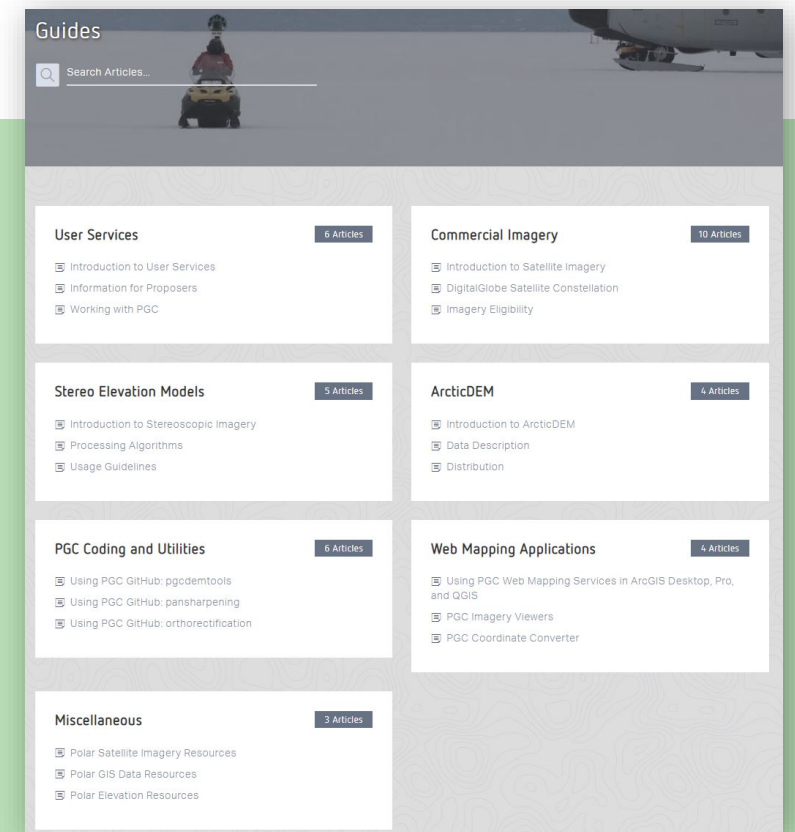
Slope / aspect geoprocessing

ADVICE

Where can I find this data?
How do I use this tool?
What are the capabilities of...?
Why are there large offsets, holes, etc. in the data?

GUIDES

Over 30+ guides & growing!
Topics ranging from DEMs, GitHub and satellite imagery

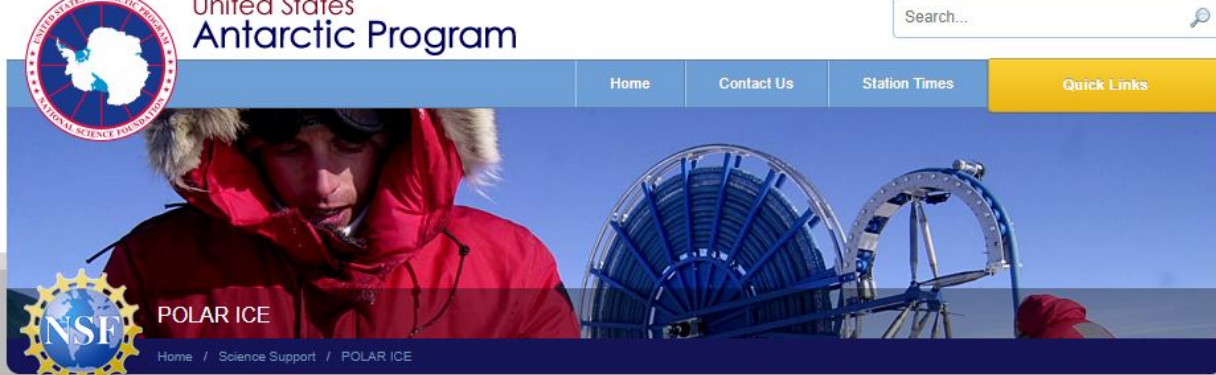


On-Ice Support

- Since '08 User Services staff deploy to McMurdo Station, **Antarctica**
- Typically 1-2 person presence in **Crary Laboratory** from mid-October to late-January
- Provide **on-site** geospatial support to science and logistics groups
 - ❖ Custom, on-demand mapping
 - ❖ Hazard and risk management
 - ❖ Site selection and movement planning
 - ❖ Distribution of annual map products
 - ❖ Provide archive of recent satellite imagery



Source: Photo by Suzan, ASC



FUTURE USAP

The latest information on USAP station modernization

[About the USAP](#)

[About Antarctica](#)

[Grantee Support](#)

[Research Opportunities](#)

[Information for Proposers](#)

[Calendars and Schedules](#)

[Conferences, Committees, and Workshops](#)

[Science Support](#)

[Vessel Science and Operations](#)

[Travel and Deployment](#)

[POLAR ICE](#)

[Online Learning Center](#)

[Surveys](#)

[Program Operations](#)

[USAP Science](#)

RECENT TWEETS

NSF Polar Prog
@NSF_OPP

A Herculean 60th anniversary: on Jan. 23, 1960, seven C-130 Hercules cargo #aircraft arrived at NSF's McMurdo Station, #Antarctica. Today, the LC-130, flown uniquely

POLAR ICE

To perform research in Antarctica is to truly push the bounds of science. Participants in the United States Antarctic Program (USAP) must pass stringent physical qualifications and extensive safety training in preparation for deployment to the "Ice."

The Participant On-Line Antarctic Resource Information Coordination Environment (POLAR ICE) is the web-based software application used to assist in deployment preparation, and coordinate and facilitate support for Antarctic research missions.

Researchers who have been awarded NSF funding for work in Antarctica use POLAR ICE in the following ways:

- Complete a Support Information Package (SIP) each deployment year to detail all logistical and support needs, and to better plan appropriate mission resources.
- Coordinate and manage overall support and resources.

Security Considerations

Users are reminded to consider privacy issues and avoid entering sensitive information that is not required by the application. Such sensitive information may include personal phone numbers and/or addresses as well as any unique identifiers utilized by your project team or institution. Social security numbers are neither required nor should they be entered at any time.

System Requirements

POLAR ICE is designed to work cross-platform, including PC, Apple®, and UNIX machines. Due to the vast array of browser types, capabilities, and compatibility levels, it works optimally in the latest available versions of Internet Explorer, Google Chrome™, and Mozilla Firefox™. Additionally, users should ensure they have Adobe Reader™ installed for PDF viewing and printing.

POLAR ICE Tutorial

The POLAR ICE tutorial contains important information about navigating the site, how to create a new document, and how to create comprehensive content. First-time users are strongly encouraged to complete the tutorial prior to using POLAR ICE.

[Launch Tutorial](#)

Feedback

There are two mechanisms by which you can supply feedback on your experience using POLAR ICE, and both are submitted to the design and development team. Please feel free to submit as many comments as you like; your input continues to improve the POLAR ICE product.

First Time Users

Information about POLAR ICE can be found on this page using the links below.

- [Security Considerations](#)
- [System Requirements](#)
- [Tutorial](#)
- [Feedback](#)
- [Technical Support](#)

Launch

[LAUNCH POLAR ICE](#)

INPUT
SIP Input
ASC and NGP Comments
Grantee Changes

OUTPUT
NSF Deliverables, ASC
Data Streams to Support
Scheduling Phase

SCHEDULING
Personnel, Resource, and
Equipment Allocation for
On-Ice Support

ON-ICE SUPPORT
Resource and Equipment
Tracking, Inventory Updates

RESEARCH ARTIFACTS
Outbrief Data, Master Permit,
GPRA, Antarctic Treaty

Support Information Packages (SIPs)

Strictly for researchers deploying to Antarctica:

Please include PGC in your SIPs if you know or even suspect you may need support for the upcoming field season whether prior to deployment or on the ice.

PGC prepares for each field season according to SIP requests to prepare the proper data. We reach out to SIP participants prior to each field season to ensure the most effective and efficient support.

Support Examples

Arctic Logistics: *Image processing & machine learning*

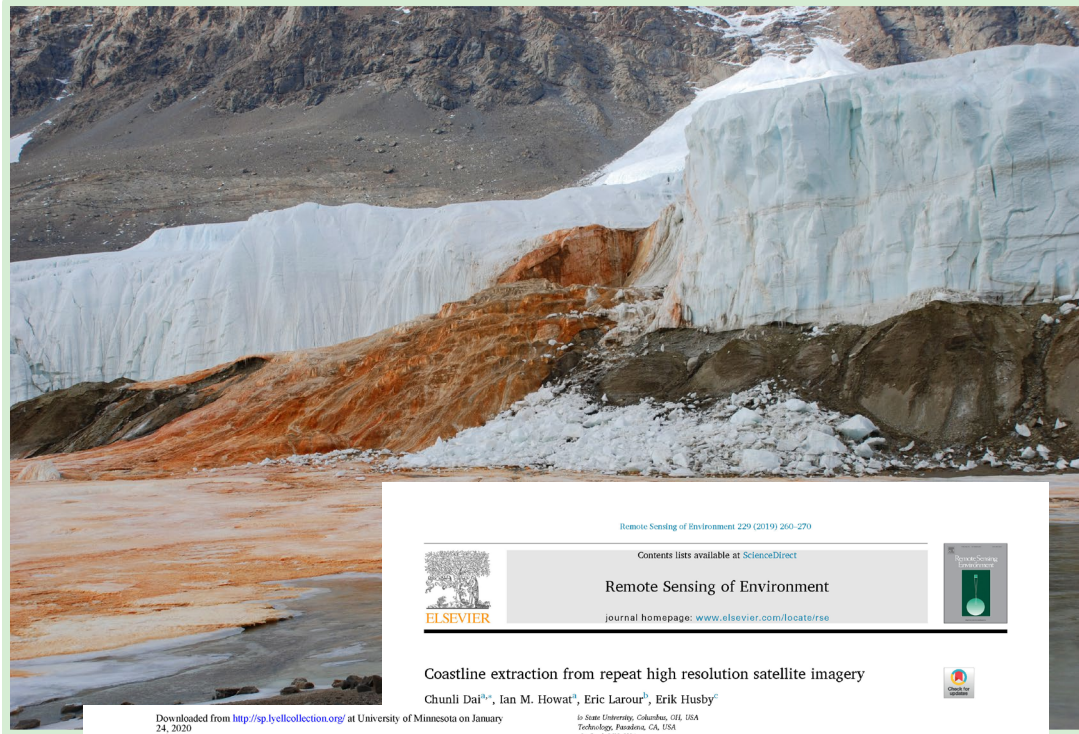
Arctic Science: *Custom DEM example*

Pan-Arctic Science: *Large scale support*

Antarctic Logistics: *Custom map*

Antarctic Science: *Web-application*

Pan-Antarctic Science: *Large scale support*



Morphological characterization of landforms produced by springtime seasonal activity on Russell Crater megadune, Mars

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Abstract. We describe in detail an annual seasonal process that occurs on the surface of the Russell Crater megatube on Mars. We give these features the name 'perennial rills', because their surface topographical expression persists from year-to-year and they form a distinctive, downwesterward-trending, linear, branching, and/or meandering pattern. We use a combination of high-resolution stereophotogrammetry and spectral data to characterize the evolution of these features over 6 Mars years. Growth and modification of these networks occurs abruptly in spring (at a solar longitude of approximately 100°), and they are most prominent in the summer (at approximately 180°). The morphology of perennial rills seems to be the only aspect that sets them apart from active linear dune gullies. By comparison to terrestrial analogues, we identified two conditions favoring the production of such a network: (a) the presence of an impermeable layer; and (b) the repeated formation of a surface seal. The formation of perennial rills is not dependent on the presence of a water table that can explain the formation of both the perennial rills and the active linear dune gullies are levitating CO₂ blocks or liquid debris flows of water/brine, but neither can completely satisfy all the

ABSTRACT

This paper presents a new coastline extraction method that improves water classification accuracy by benefiting from an ever-increasing volume of repeated measurements from commercial satellite missions. The widely-used Normalized Difference Water Index (NDWI) method is tested on a sample of around 12,000 satellite images for statistical analysis. The results of the new water classification method is then compared with the NDWI method based on the stacking of repeat measurements, which can mitigate the effects of translational effects of images and the classification errors caused by clouds and cloud shadows. By integrating QuickBird, WorldView-2 and WorldView-3 multiresolution images, the final data product provides a 2 m resolution coastline, as well as a 2 m water probability map and a repeat-count measurement map. Improvements on the existing coastline (GSHHS: the Global Self-consistent, Hierarchical, High-resolution Shoreline Database, 50 m/5000 m) in terms of resolution (2 m) is substantial, thanks to the combination of multiple data sources.

economically important ecosystems mapping is essential for navigating, as well as coastal resource management (Hansen et al., 2006). The variations in tides and weather, hydrological processes, and geological processes, as well as sea level rise (Scheffé et al., 2008), have increased the need for coastal monitoring (Hansen et al., 2008). Given sea-level rise is expected, accurate detection and assessment to provide needed information is required.

In datasets are the Global Soil on Shoreline Database (GSHHS) and the Global Wetland Inventory (GWI) from the National Aeronautics and Space Administration (NASA), the World Bank's Global Water Survey (GWS) (NASA, 2007), ranging from 56° south to 90° north, covering approximately 99% of the Central Intelligence Agency's (CIA) National Geospatial Intelligence Agency (NGA) (United States Department of Defense, 2009).

Historically, coastlines were manually identified and traced from high-resolution aerial images by experts in cartographic applications (Liu et al., 2007; Liu et al., 2008). However, manual extraction is labor intensive and often subjective, several automatic coastline extraction methods have been proposed, including the edge tracing algorithm for Synthetic Aperture Radar (SAR) imagery (Lee and Chen, 2004), the fuzzy logic approach for Landsat TM satellite imagery (Jia and Jozak, 2004), a coherence thresholding method for interferometric SAR (InSAR) (Delpeigne et al., 2004), an active contour model for SAR images (Zhang et al., 2005), and an active contour method for multiresolution imagery (Zhang et al., 2013), an active contour method for Polarimetric SAR images (Liu et al., 2017), the normalized difference vegetation index (NDVI) method (Huang et al., 2016), and the fuzzy membership function method (Mansour et al., 2016). For multispectral satellite images (McFeeters, 1995; Magliolo et al., 2014), in addition to above shoreline detection from images, some studies have used digital elevation models have also been explored (e.g., Liu et al., 2007).

The ever-increasing volume of remote sensing data has a significant impact on studies of Earth surface processes and surface water changes. High resolution satellite remote sensing provides more detailed information

resolution (50–500 m) between 1985 and 1989 by the Defense Mapping Agency, now the National Geospatial-Intelligence Agency (NGA) (Soluri and Woodson, 1990; Wessel and Smith, 1996).

Historically, coastlines were manually identified and traced from high-resolution aerial images by experts in cartographic applications (e.g., [Liu et al., 2002](#); [Delgado et al., 2003](#)). Since the advent of remote sensing, the use of satellite data for coastline extraction and coastline labor-intensive methods have been replaced by automatic coastline extraction methods have been proposed, including the edge tracing algorithm for Synthetic Aperture Radar (SAR) images ([Lee and Juchiewicz, 1990](#)), an image segmentation method for radar and optical images ([Liu et al., 2001](#)), a region-based coastline extraction method for interferometric SAR (InSAR) ([Liu et al., 2004](#)), a combined method integrating image segmentation, region growing, and edge detection for multispectral imagery ([Zhang et al., 2013](#)), an active contour method for Polarimetric SAR images ([Liu et al., 2017](#)), the watershed segmentation method for multispectral images ([Liu et al., 2016](#)) and the Normalized Difference Water Index (NDWI) index method for multispectral satellite images ([McFeeters, 1996](#); [Magliorini et al., 2014](#)). In addition to the above shoreline detection from images processing, methods based on digital elevation models have also been

The ever-increasing volume of remote sensing data has a significant impact on studies of Earth surface processes and surface water changes. High resolution optical (visible to near infrared band) satellite images

Active Martian surface processes that are linked to the seasonal cycle are responsible for the most prevalent surface changes observed over recent decades and their origin is heavily debated. Repeat imaging by high-resolution (better than 10 m/pixel) sensors has enabled us to investigate how Martian surface

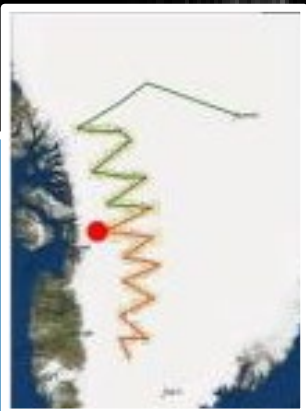
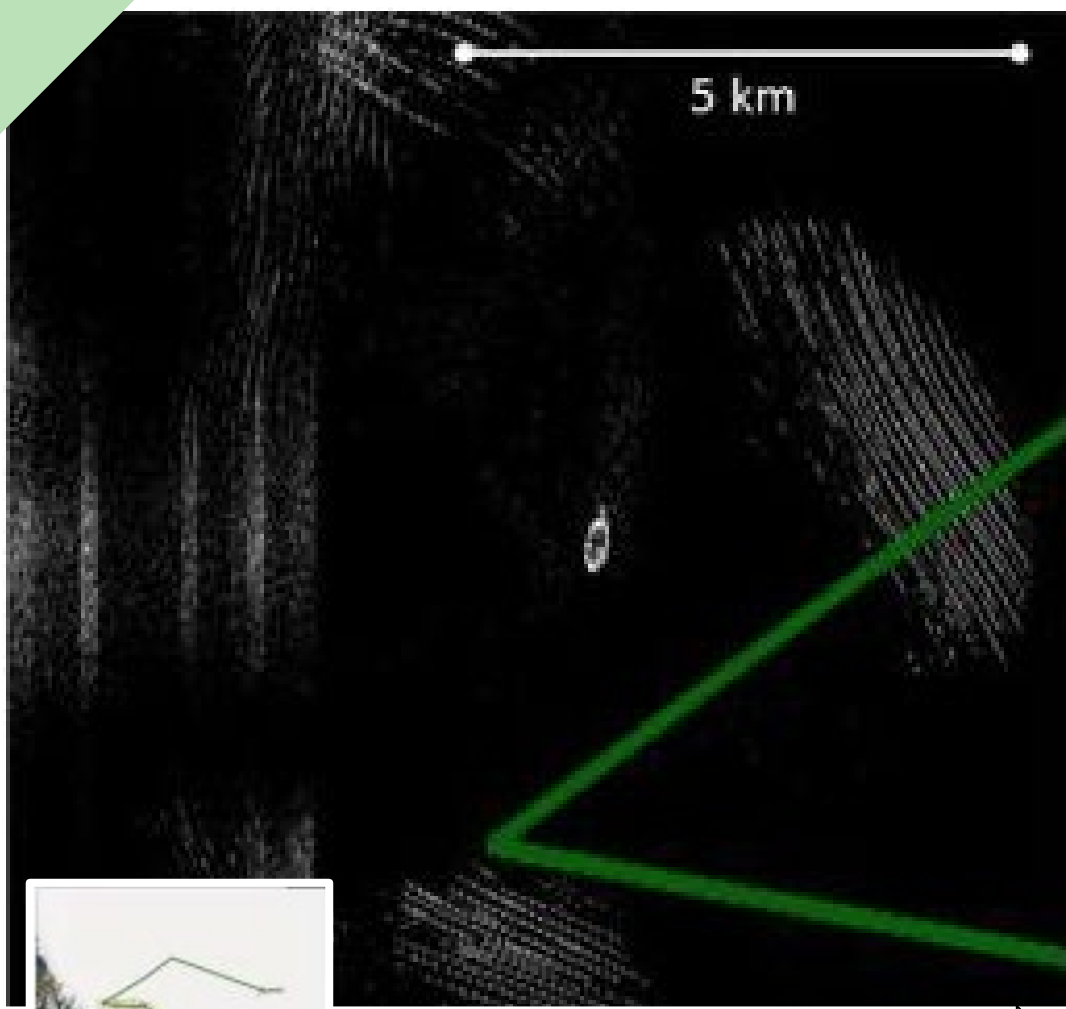
ephemeral visual traces, some cause measurable topographical change (e.g. spider-like forms: Piqueux *et al.* 2003). Seasonal processes acting on dark Martian sand dunes are particularly active, and they have a wide range of timings and morphologies. These include: the formation and extension/

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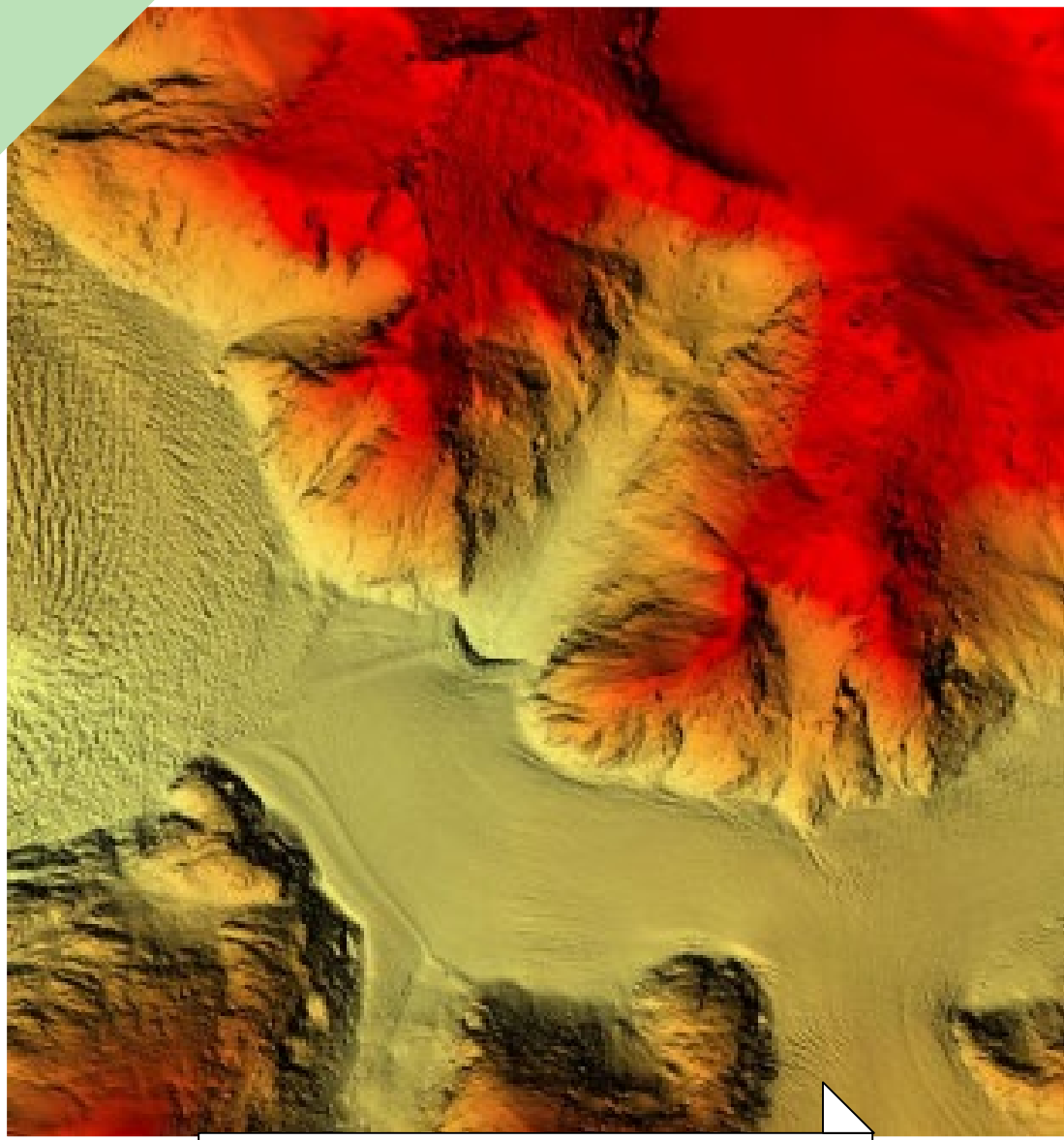
revised form 5 April 2019; Accepted 9 April 2019

Green TrACS Traverse Route Planning Support

- Planned for 2nd field season (April – June **2017**) to develop snow accumulation and firn density records
- PGC processed **839** satellite images dated from 2009 – 2016 (**~800 GB**) covering **70,000 km²**
- Used high-resolution satellite imagery and custom crevasse detection algorithm to **safely map** a route across Western Greenland



Potential crevassed areas show up more clearly in the crevasse detection algorithm results (above) than in the source imagery

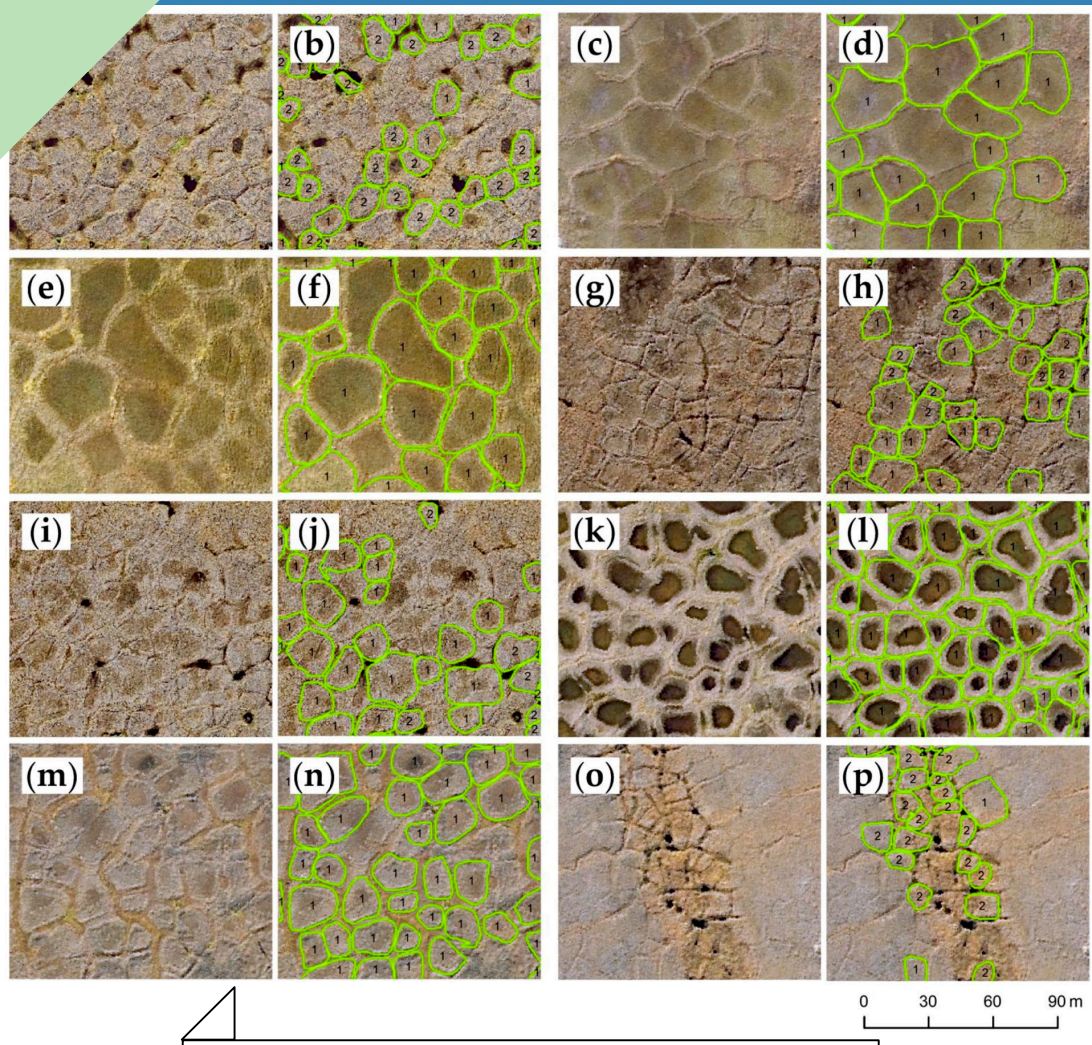


*2m resolution stereo-derived
elevation model of LeConte Glacier*

LeConte Glacier, Alaska

Seasonal DEMs

- **Tracked** movement and retreat of LeConte Glacier, Alaska
- Each year since 2015, PGC generated **DEMs** from stereo WorldView satellite imagery over spring, summer and fall months
- Imagery collection was requested during each annual PGC Arctic Imagery **Tasking Solicitations**



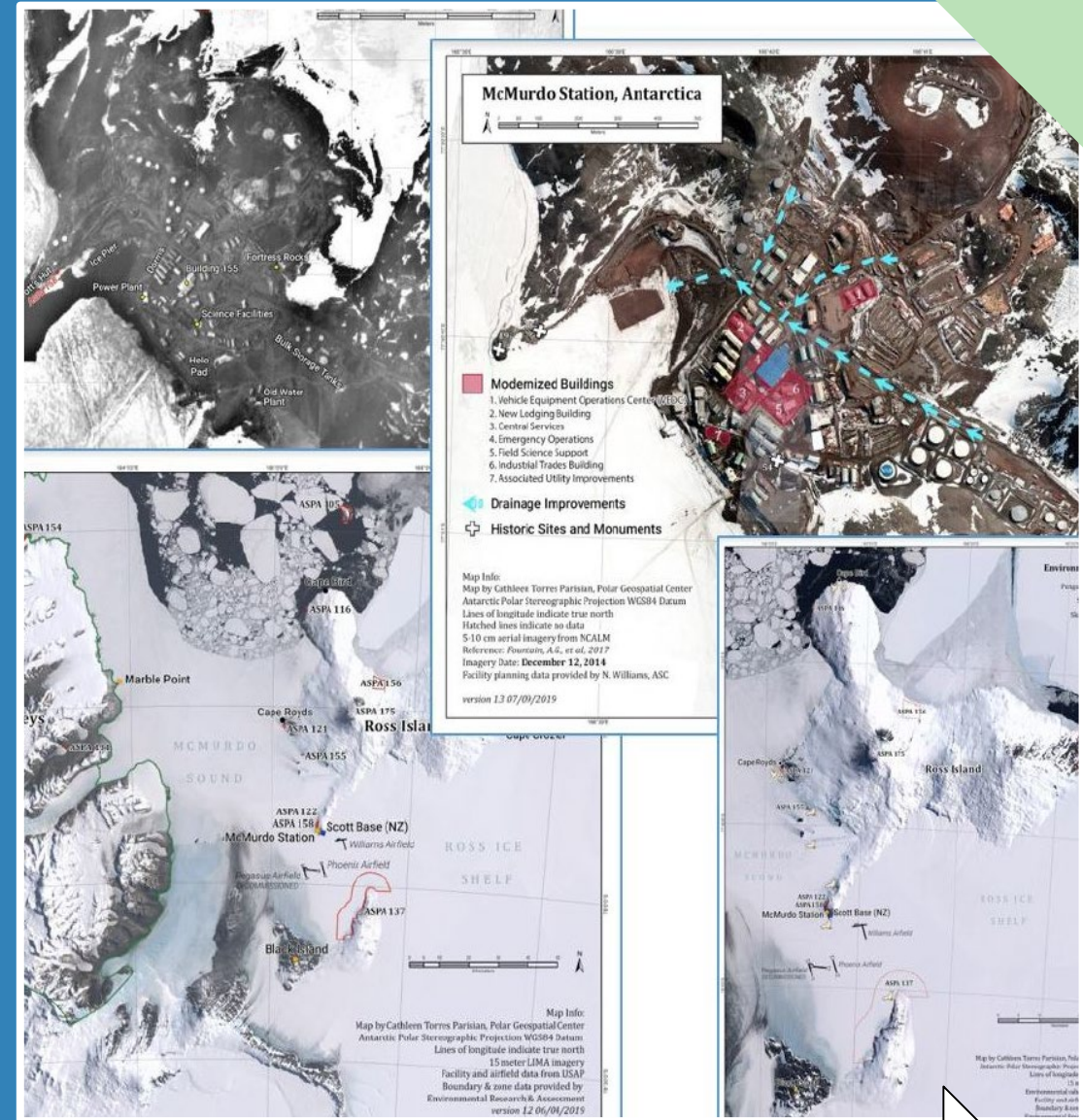
Example of ice wedge polygon delineation on very high-resolution aerial imagery, Nuiqsut, Alaska

Arctic Ice Wedge Polygon Detection from Remote Sensing Data

- Conducting **Arctic-wide survey** of ice wedges to help researchers understand the spatial and temporal dynamics
- PGC supports this project with image selection, processing (**pan-sharpening**) and delivery
- Using convolutional neural network to **automatically** delineate in imagery

NSF McMurdo Report Custom Map Figures

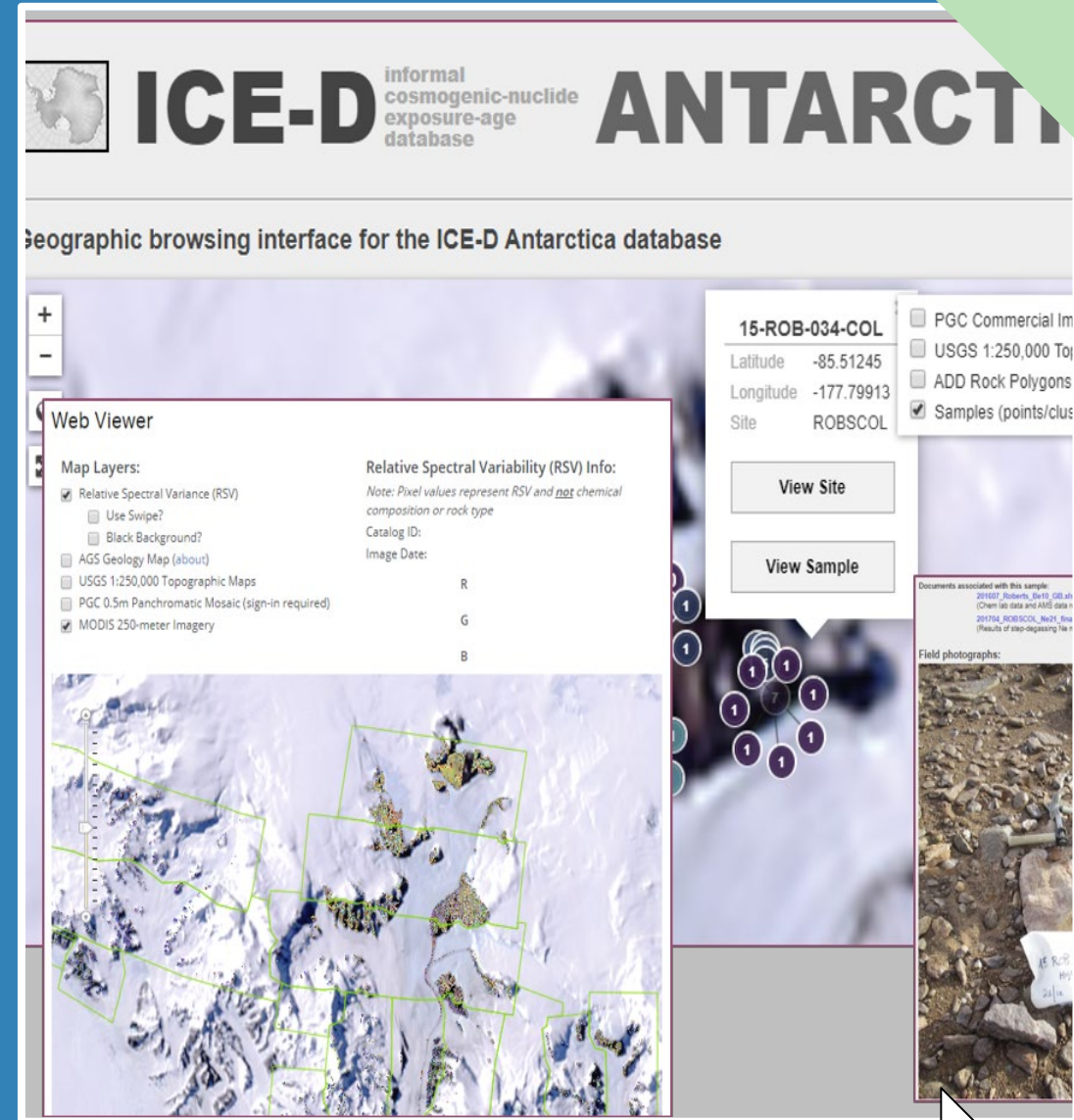
- NSF Comprehensive Environmental Evaluations **public report** for McMurdo modernization activities
- Assorted **purposes** for 8 maps:
 - ❖ Reference
 - ❖ Compare change from historical imagery
 - ❖ Illustrate planned demolition
 - ❖ Record present-day
 - ❖ Bring awareness to regions w/ environmental value



*Custom maps using open sourced data
for easy publication and dissemination*

User-derived GIS Web-App Development

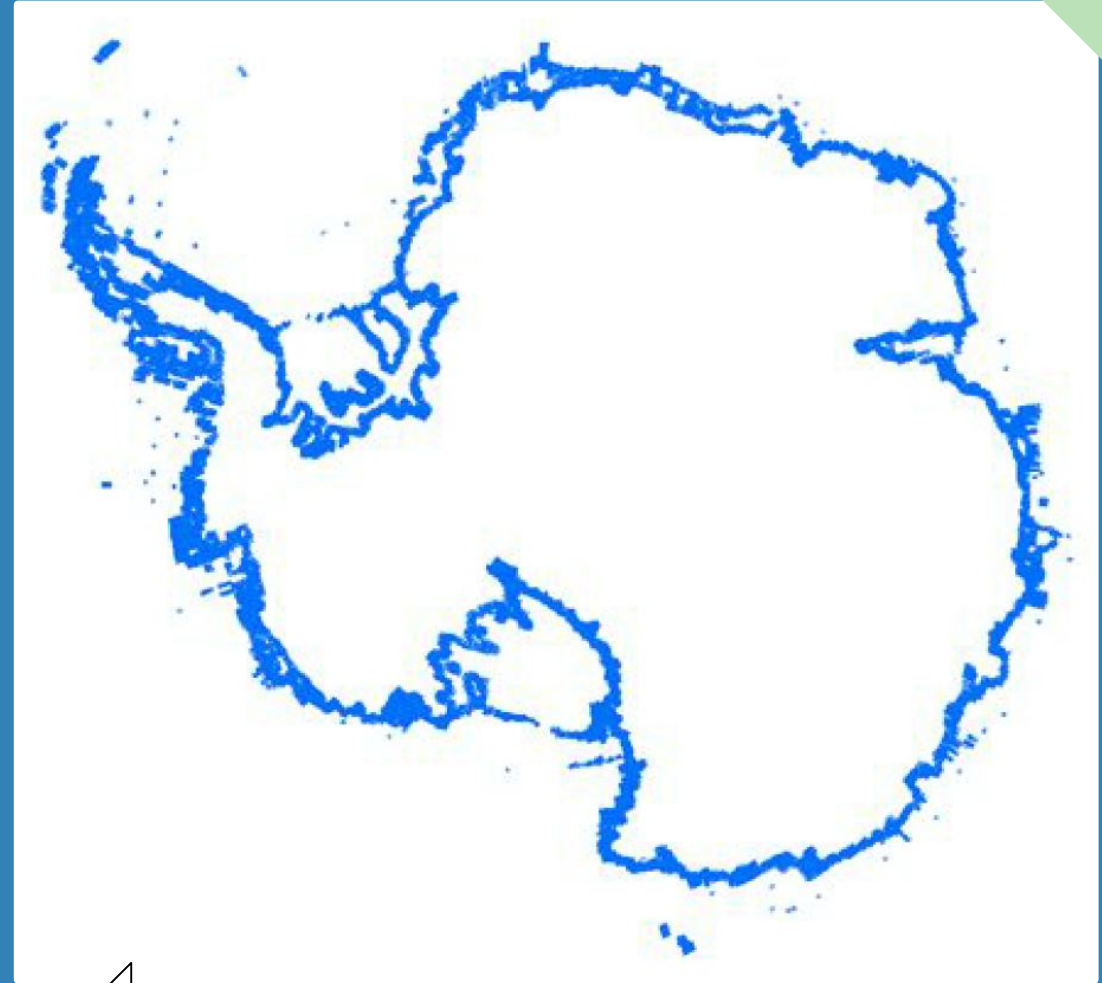
- PGC develops online **web mapping** interfaces and applications for interactive user-derived GIS
- **Combination** of PGC source datasets (imagery/elevation layers) and User's spatial data
- **ICE-D** is a browsing interface for the Berkley Geochronology Center's cosmogenic nuclide Antarctic database




Check out the web map at:
<http://hess.ess.washington.edu/iced/map/>

Quantifying Seabirds Parameterized by Sub-meter Imagery

- Quantified coastal Antarctic seabird populations of previously uncounted colonies with **automated** algorithms
- PGC provided **cluster compute** resources to process and orthorectify over **10,000** discrete scenes of sub-meter satellite imagery



Polygonal footprint of all 2017-2018 WorldView-3 imagery near and over coastal waters

ABOUT **DATA + SERVICES** 

Create your PGC account


An account with the PGC allows you immediate access to public content, comments and feedback. Restricted access to the secured layers in the high-resolution satellite imagery, FTP deliveries, and PGC services is limited to researchers with current awards, federal employees, or subcontractors limited to, the National Science Foundation (NSF) and National Aeronautics and Space Administration (NASA) Members of the DoD/IC and Antarctic/Arctic support personnel may also be eligible.

After verification of funding source, you will receive email notification from the PGC Point of Contact with whom you can work directly to request our imagery tasking, and imagery delivery.

Personal information collected from the registration form will not be shared with third parties.

If you have any questions about licensed imagery usage restrictions, please contact the PGC Point of Contact.

[REQUEST AN ACCOUNT](#)

 **USER ACCOUNT**

Polar Geospatial Center

[Log In](#) [Sign Up](#)

☐ I agree to PGC's Acknowledgement Policy

[SIGN UP >](#)

PGC Account Registration

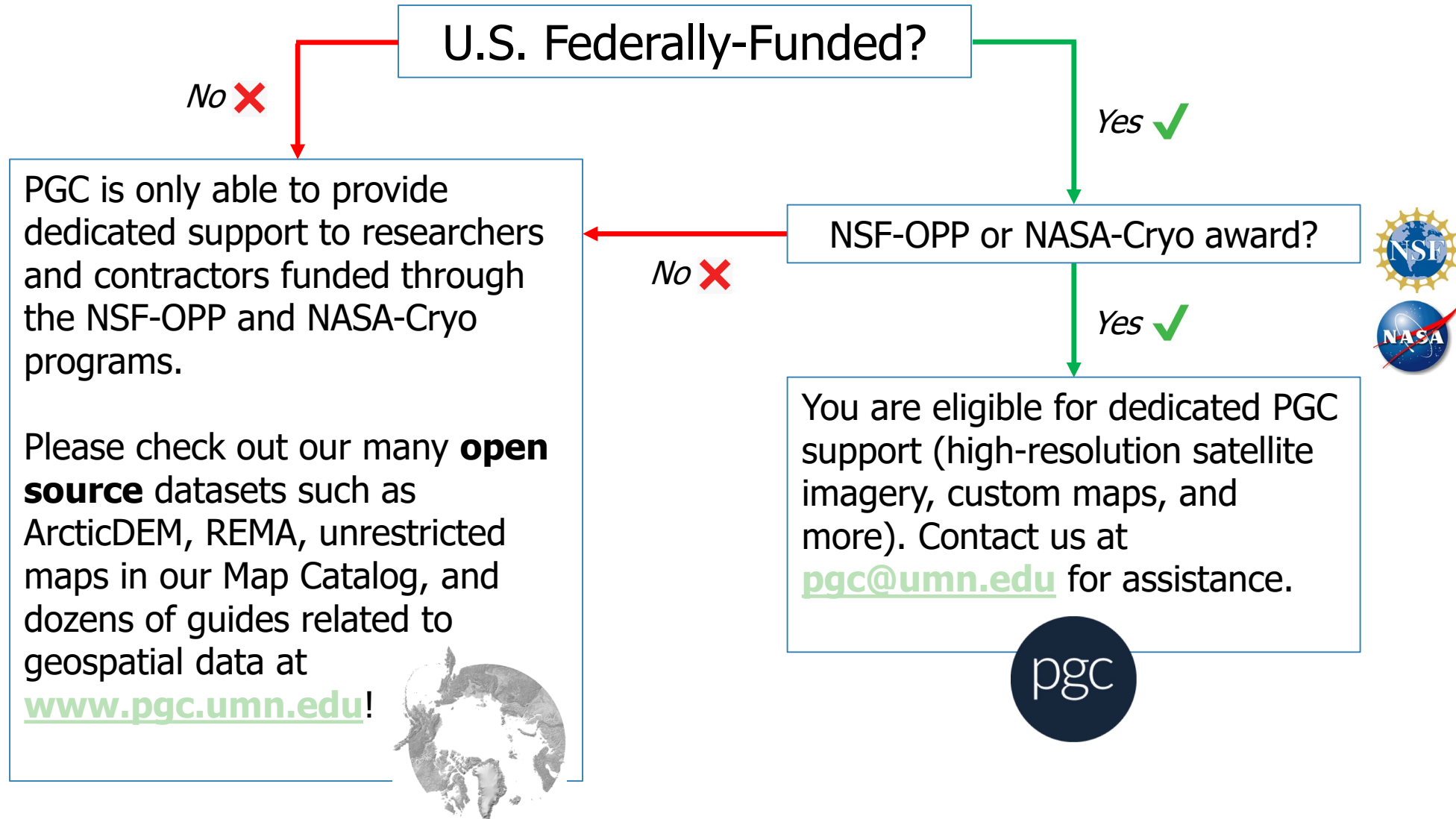
Eligible users (actively NSF OPP & NASA Cryo funded) gain access to:

- PGC services (imagery, DEM, map requests)
- Restricted imagery layers in PGC Viewers
- FTP data deliveries
- and future FRIDGE

(Federal Researcher Imagery Download & Geodata Exploration system)

<https://users.pgc.umn.edu/request>

Are you eligible for PGC support?





Q&A



ctorresp@umn.edu

PGC Point-of-Contact

pgc@umn.edu



<https://www.pgc.umn.edu/data/request/>



THANK YOU

Useful Links

PGC <https://www.pgc.umn.edu/>

PGC Guides <https://www.pgc.umn.edu/guides/>

Intro to User Services Guide <https://www.pgc.umn.edu/guides/user-services/introduction/>

PGC Commercial Imagery
Usage Guidelines <https://www.pgc.umn.edu/guides/commercial-imagery/usage-guidelines/>

PGC Acknowledgement Policy <https://www.pgc.umn.edu/guides/user-services/acknowledgement-policy/>

PGC User Account Sign-Up <https://users.pgc.umn.edu/request>