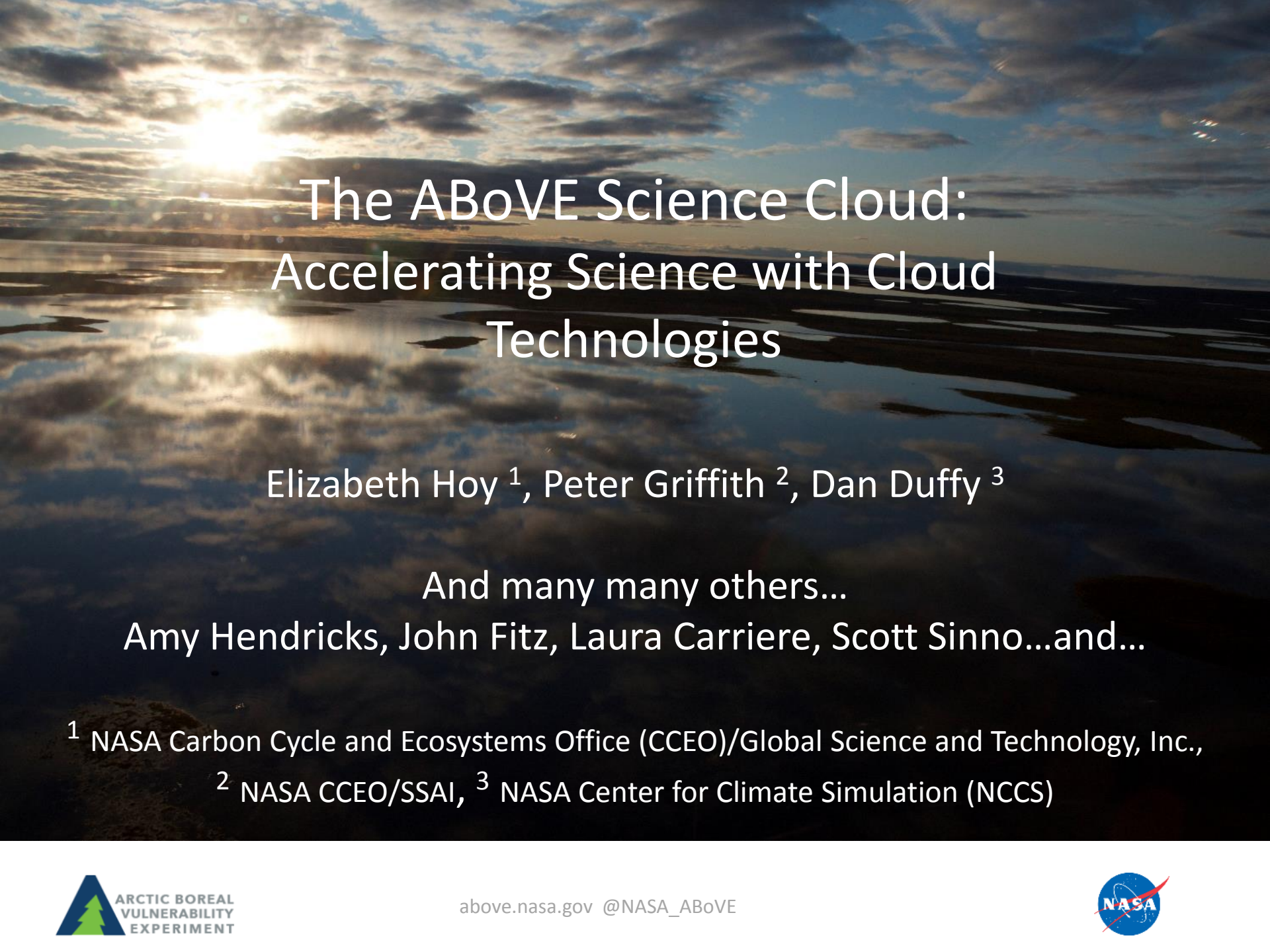


The ABoVE Science Cloud: Accelerating Science with Cloud Technologies

Elizabeth Hoy [1], Peter Griffith [2], Dan Duffy [3]

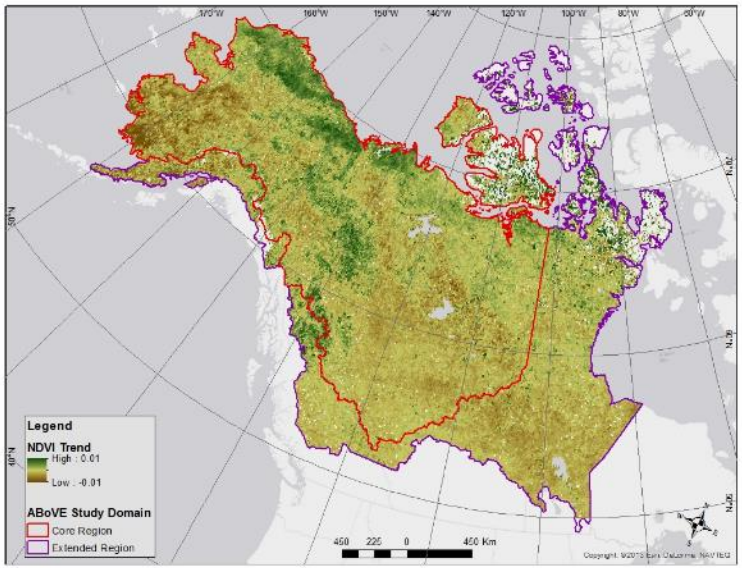
And many many others…
Amy Hendricks, John Fitz, Laura Carriere, Scott Sinno…and…

[1] NASA Carbon Cycle and Ecosystems Office (CCEO)/Global Science and Technology, Inc.,
[2] NASA CCEO/SSAI, [3] NASA Center for Climate Simulation (NCCS)

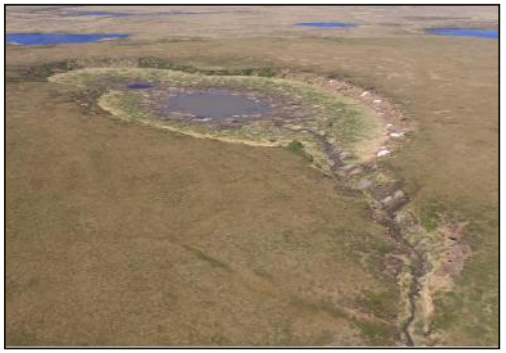
ABoVE is a 10-year field campaign to improve understanding of significant and novel changes to Arctic and boreal ecosystems

Low-severity fire

High-severity fire



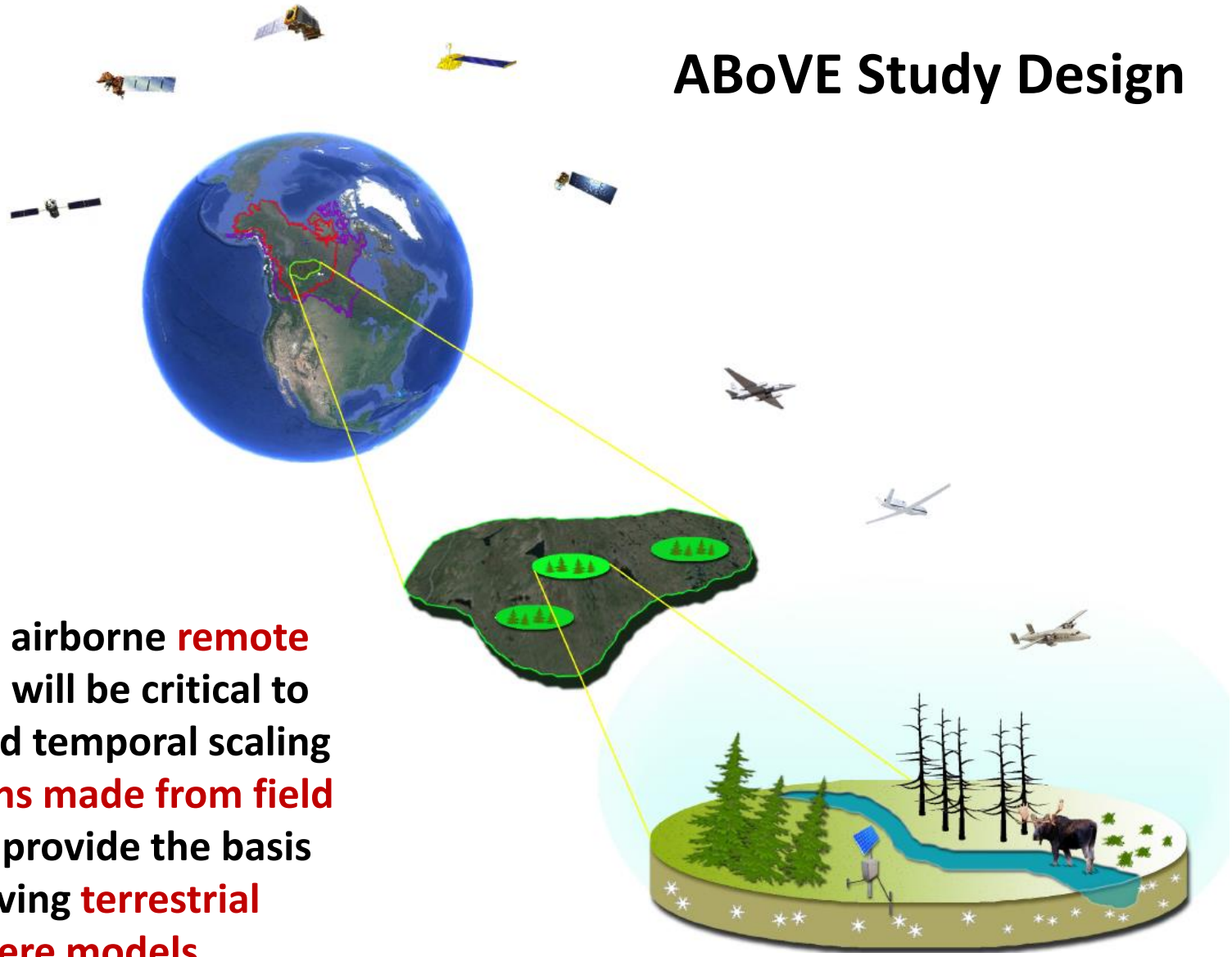
Satellite-observed patterns of greening and browning



Variations in post-fire succession

Lake drainage and thermokarst from thawing of permafrost

ABoVE Study Design



Satellite and airborne **remote sensing data** will be critical to the spatial and temporal scaling of **observations made from field studies**, and provide the basis for improving **terrestrial biosphere models**.

Science Team Membership

- 49 total projects (including NASA funded, Partner, & Affiliated)

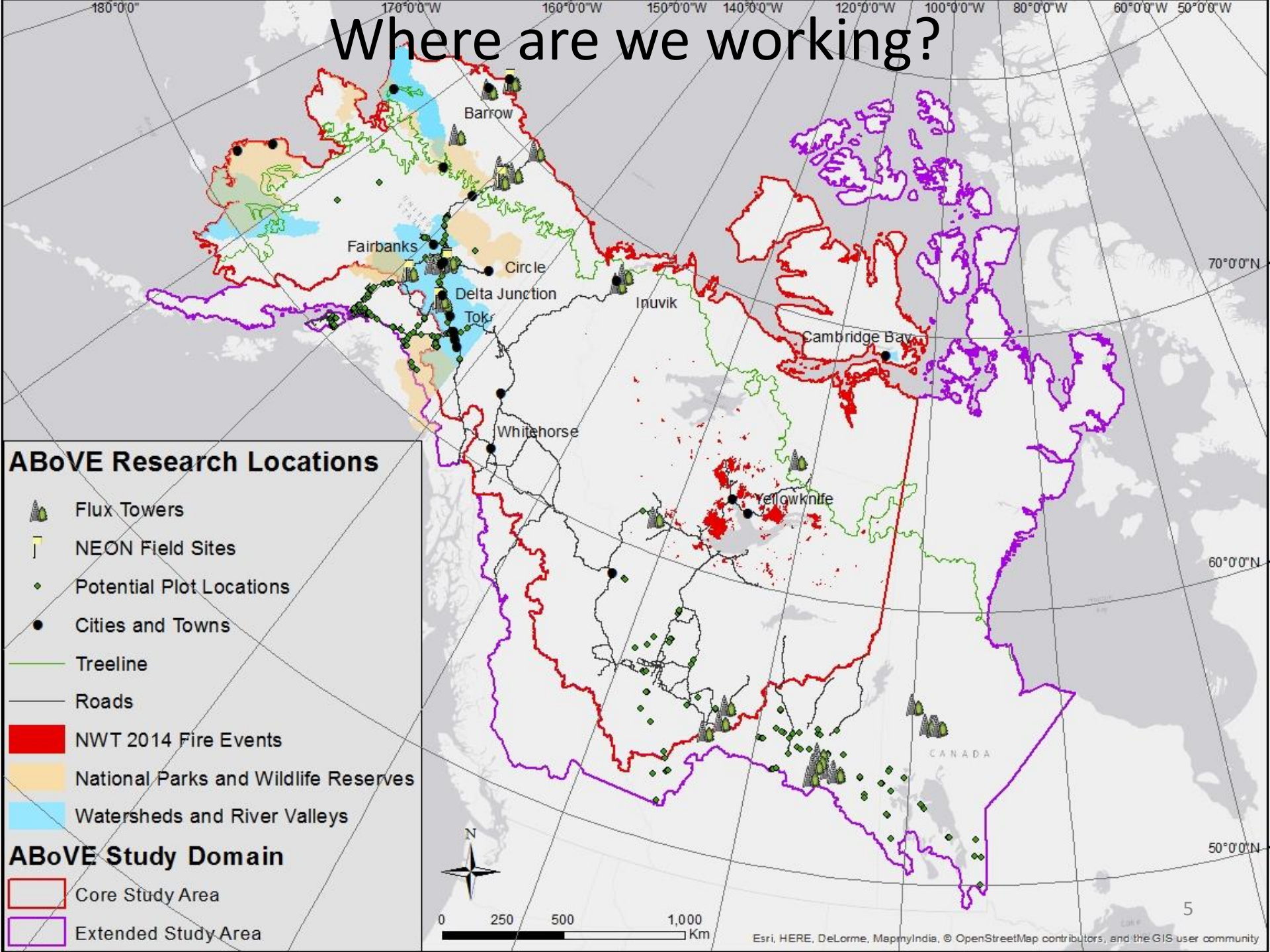
Role	No. People
Project Leads	44
Co-Investigator	86
Collaborator	137
Participant	79
Post-Doc	16
Grad and Undergrad Students	26
Total ST Members	341*

Organizations Represented

	U.S.	Canada	Europe	Japan	Total
University	44	14	3		61
National Agencies/Labs	9	7	4	1	21
State/Provincial/Territorial	2	6			8
Private	8	2	1		11
Native/Aboriginal Organization	1	1			2
Total	***64***	***30***	***8***	***1***	**103**

* These roles do not add up – one person can have multiple roles via different projects.

Where are we working?



Why do we need a new approach?

- Science datasets are becoming larger, with intensive computation needed for data processing
- And collaboration across diverse research groups is essential,
- But it is often time consuming and expensive to transfer, download, process and share data with others
- Therefore the ABoVE Science Cloud (ASC) was created to meet the needs of ABoVE investigators and encourage collaboration within the field campaign.

Advanced Data Analytics Platform (ADAPT)
"High Performance Science Cloud"

High Performance Science Cloud is uniquely positioned to provide data processing and analytic services for NASA Science projects. A portion of ADAPT is dedicated to ABoVE (the ABoVE Science Cloud).

Adjunct to the NCCS HPC environment

- Lower barrier to entry for scientists
- Customized run-time environments
- Reusable HPC/Discover hardware

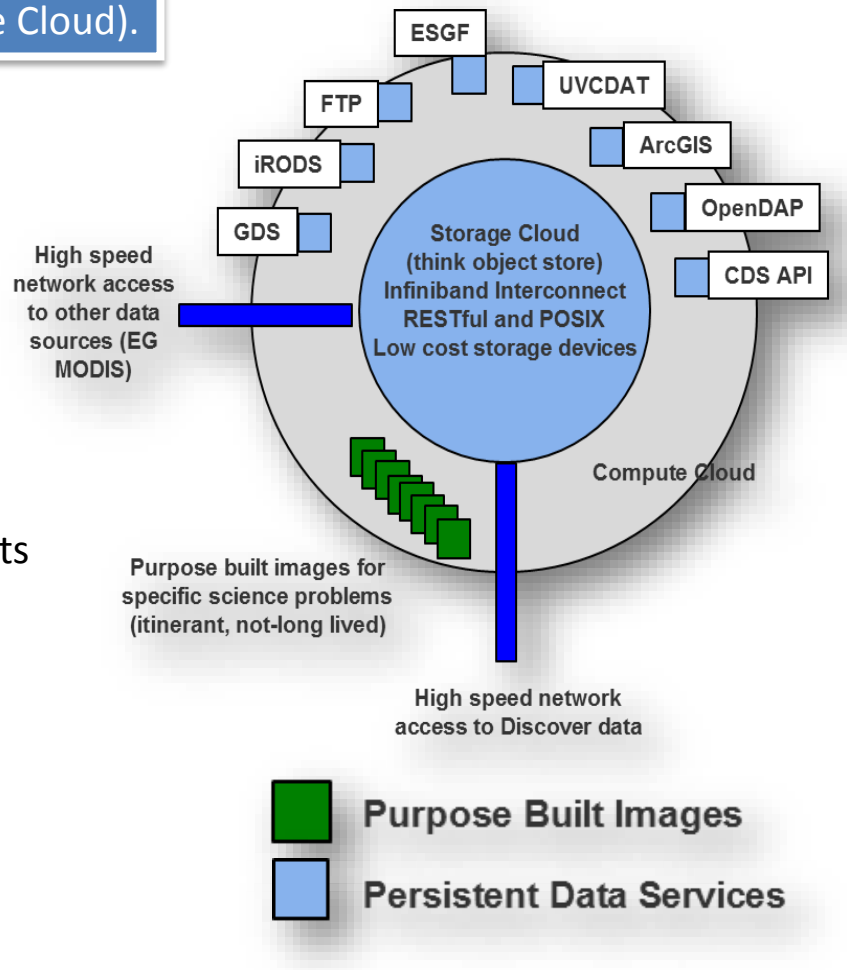
Expanded customer base

- Scientist brings their analysis to the data
- Extensible storage; build and expand as needed
- Persistent data services build in virtual machines
- Create purpose built VMs for specific science projects

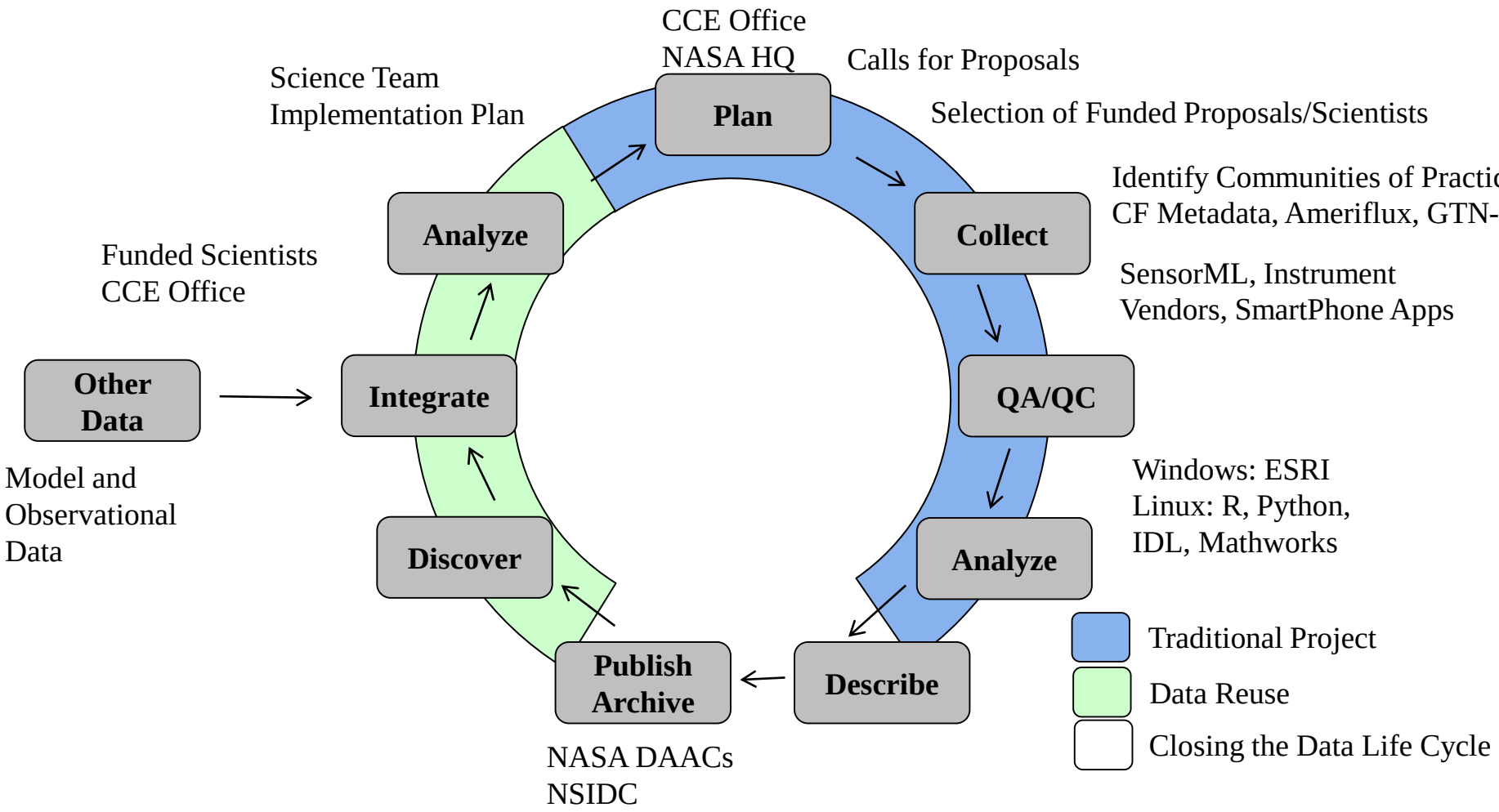
Difference between a commodity cloud

- Platform-as-a-Service that comes close to matching HPC levels of performance
- Critical Node-to-node communication – high speed, low latency
- Shared, high performance file system
- Management and rapid provisioning of resources

High Performance Science Cloud Conceptual Architecture

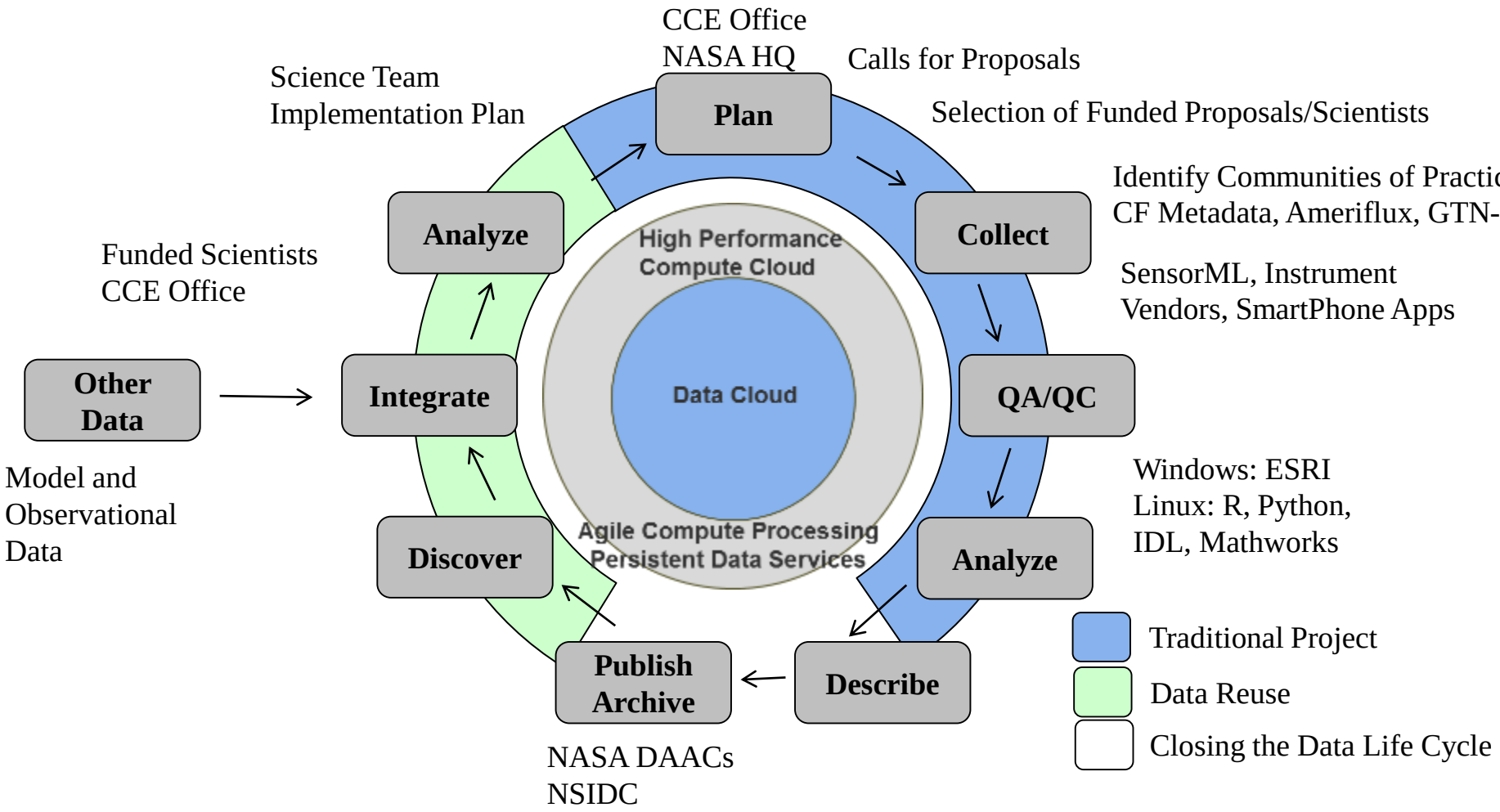


The ABoVE Science Cloud is the center of the data lifecycle.



Augmented from Rüegg et al 2014 in *Front Ecol Environ*

The ABoVE Science Cloud is the center of the data lifecycle.



Augmented from Rüegg et al 2014 in *Front Ecol Environ*

ASC System Components/Configuration

Capability and Description	Configuration
 **Persistent Data Services** Virtual machines or containers deployed for web services, examples include ESGF, GDS, THREDDS, FTP, etc.	8 nodes with 128 GB of RAM, 10 GbE, and FDR IB
 **DataBase** High available database nodes with solid state disk.	2 nodes with 128 GB of RAM, 3.2 TB of SSD, 10 GbE, and FDR IB
 **Remote Visualization** Enable server side graphical processing and rendering of data.	4 nodes with 128 GB of RAM, 10 GbE, FDR IB, and GPUs
 **High Performance Compute** More than 1,000 cores coupled via high speed Infiniband networks for elastic or itinerant computing requirements.	~100 nodes each with 32 to 64 GB of RAM
 **High-Speed/High-Capacity Storage** Petabytes of storage accessible to all the above capabilities over the high speed Infiniband network.	10 storage nodes with about 3 PB of raw storage capacity

Science Team Planned Geospatial Data Use

Common Satellite Datasets	No. of Projects
Landsat (surface reflectance, others?)	18
MODIS (multiple products)	15
DigitalGlobe Imagery	11
Radar: AMSR-E, SMMR, SSM/I, SSMIS, SAR, SAR/PALSAR/ERS, Radarsat-2, ERS, Sentinel, SMOS, SMAP, ALOS(2), GPR, InSAR, IfSAR	16

Variations in spatial and temporal scales across ABoVE projects.

Other satellite data mentioned: AVHRR, GPM, Hyperion, VIIRS, MISR, IceSat/IceSat-2/GLAS, GPM, Sentinel-2, GOSAT, OCO-2/3, GEDI, GRACE, Soumi NPP

Science Team Planned Geospatial Data Use

Aerial*
AHAP – 4 groups
LiDAR
CARVE
AirMoss

*Mentioned more than once

Other datasets/products mentioned: GIMMS3g, MEASURES, NASA/GEWEX Surface Radiation Budget, Reanalysis products (NARR, MERRA), WRF, HIPPO, AIRMETH, NAIP, AEM, PFA, ACG, ABLE3A, ARCTS-airborned, GMD

Ancillary Datasets
ASTER GDEM (or best available DEM) – 4 groups
Fire perimeters
Soils database
Climate variables
Lightning strikes
Lake location
Core variables (SNOTEL, CALM, AmeriFlux, BNZ LTER, GTN-P)
Vegetation/fuels maps
Pre-ABoVE datasets

Long-tail data during ABoVE

- Engage existing communities of practice whenever possible
- Use ORNL DAAC best practices

ABoVE shares data with others

NSF Arctic Data Center

Geographic Information Network of Alaska

ARCTIC OBSERVING VIEWER
collaborative mapping of data collection sites

armap
Arctic Research Mappi

IARPC COLLABORATIONS

ARCTIC BOREAL VULNERABILITY EXPERIMENT

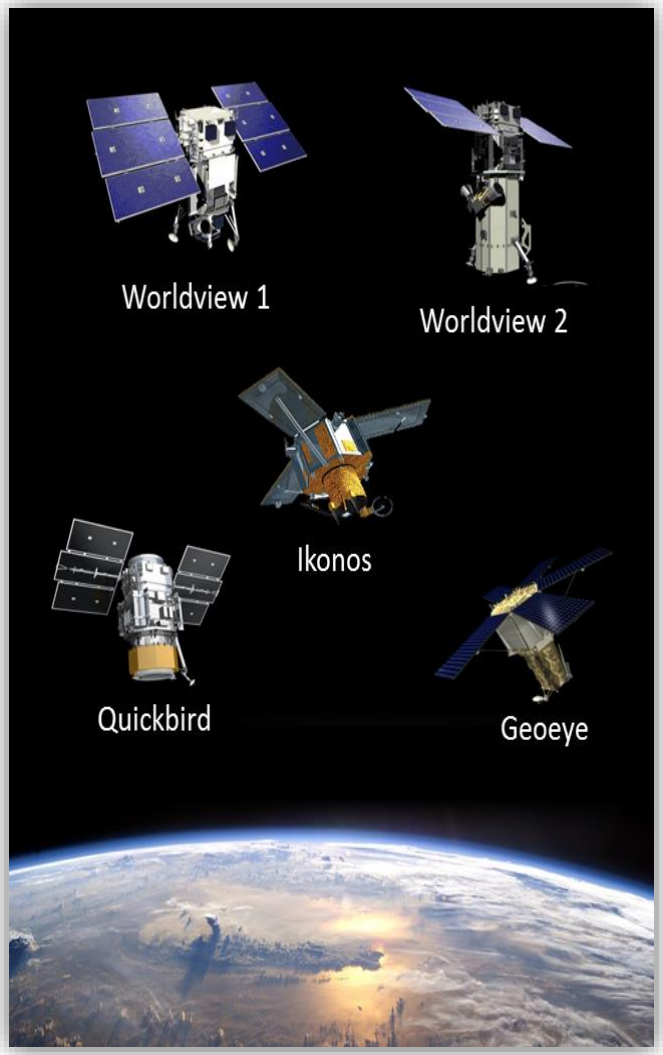
DigitalGlobe High Resolution Commercial Satellite Imagery Support for ABoVE

National Geospatial Agency (NGA) has licensed all DigitialGlobe > 0.5 m satellite imagery for US Federal use, i.e., NSF, NASA and NASA funded projects

- Archive of 4.2 billion km^2 of data from 2000 to present; plus future
- Six satellites: Worldview-1, Worldview-2, Worldview-3, Ikonos, Quickbird, and Geoeye-1
- At no cost to NASA

Satellite	Bands	Nadir Panchromatic Resolution (m)	Nadir Multispectral Resolution (m)
Ikonos	***Pan, R, G, B, Near IR***	***1.0***	***4***
GeoEye	Pan, R, G, B, Near IR	0.5	2.0
Quickbird	***Pan, R, G, B, Near IR***	***0.6***	***2.4***
WorldView-1	Panchromatic only	0.5	N/A
WorldView-2	***Pan, R, G, B, Near IR 1 Near IR 2,Coastal, Red Edge, Yellow***	***0.5***	***2.0***

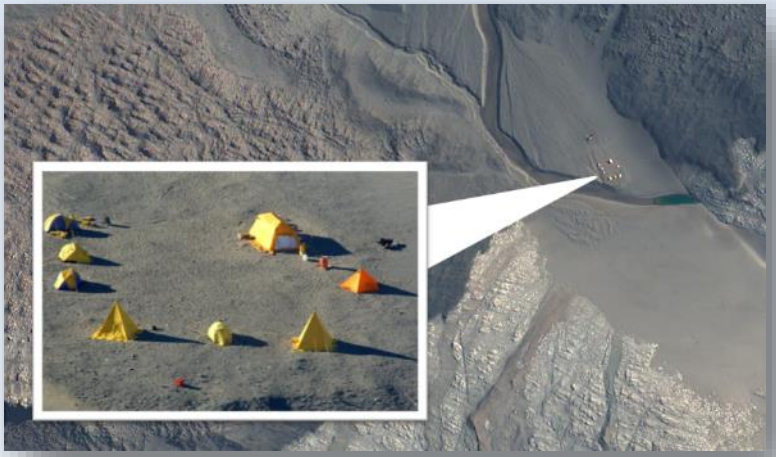
** Worldview 3 images will be offered once available*



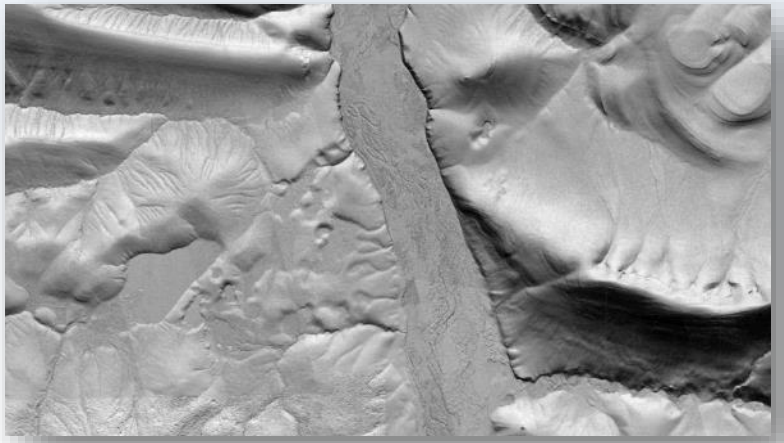
High Resolution Commercial Satellite Imagery Use by ABoVE

- **GOAL 1: (OBTAIN)** Establish access to NGA data through strong partnerships with NGA, Digital Globe, PGC, and NSF
- **GOAL 2: (STAGE)** Collect and store ABoVE domain specific NGA data into the ABoVE Science Cloud
- **GOAL 3: (TASK)** Provide short-term data access, system compute, processing and analytics services for ABoVE science team & collaborators

GOAL 4: (ANALYZE) Produce panchromatic orthomosaics and first-order elevation model

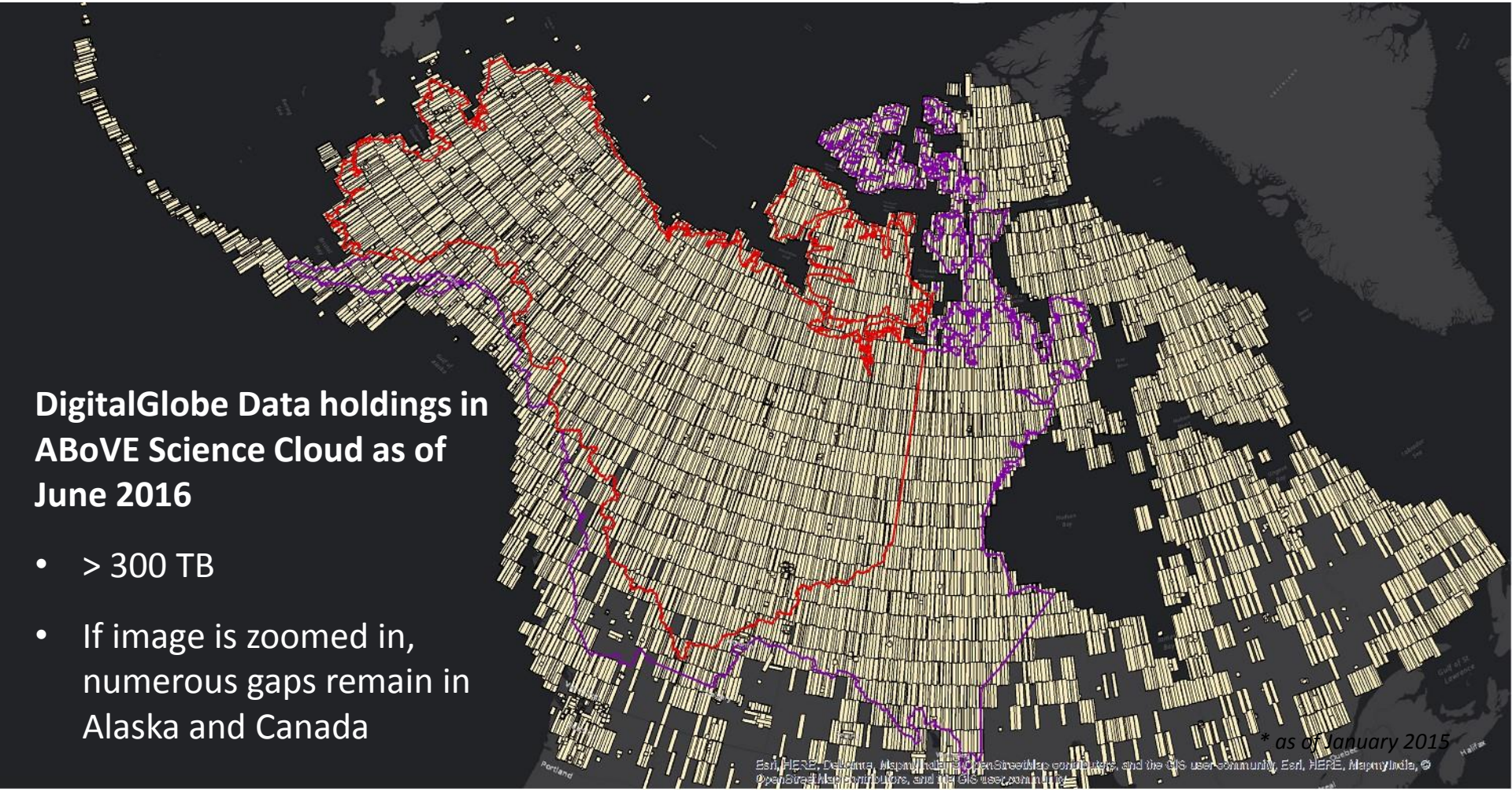


PGC camp in Bull Pass QuickBird-2 (January 2009)



Shaded relief image of a 4m posting elevation model near the Toolik LTER on the north slope of Alaska; Polar Geospatial Center (PGC)

Digital Globe Data Holdings in ABoVE Science Cloud

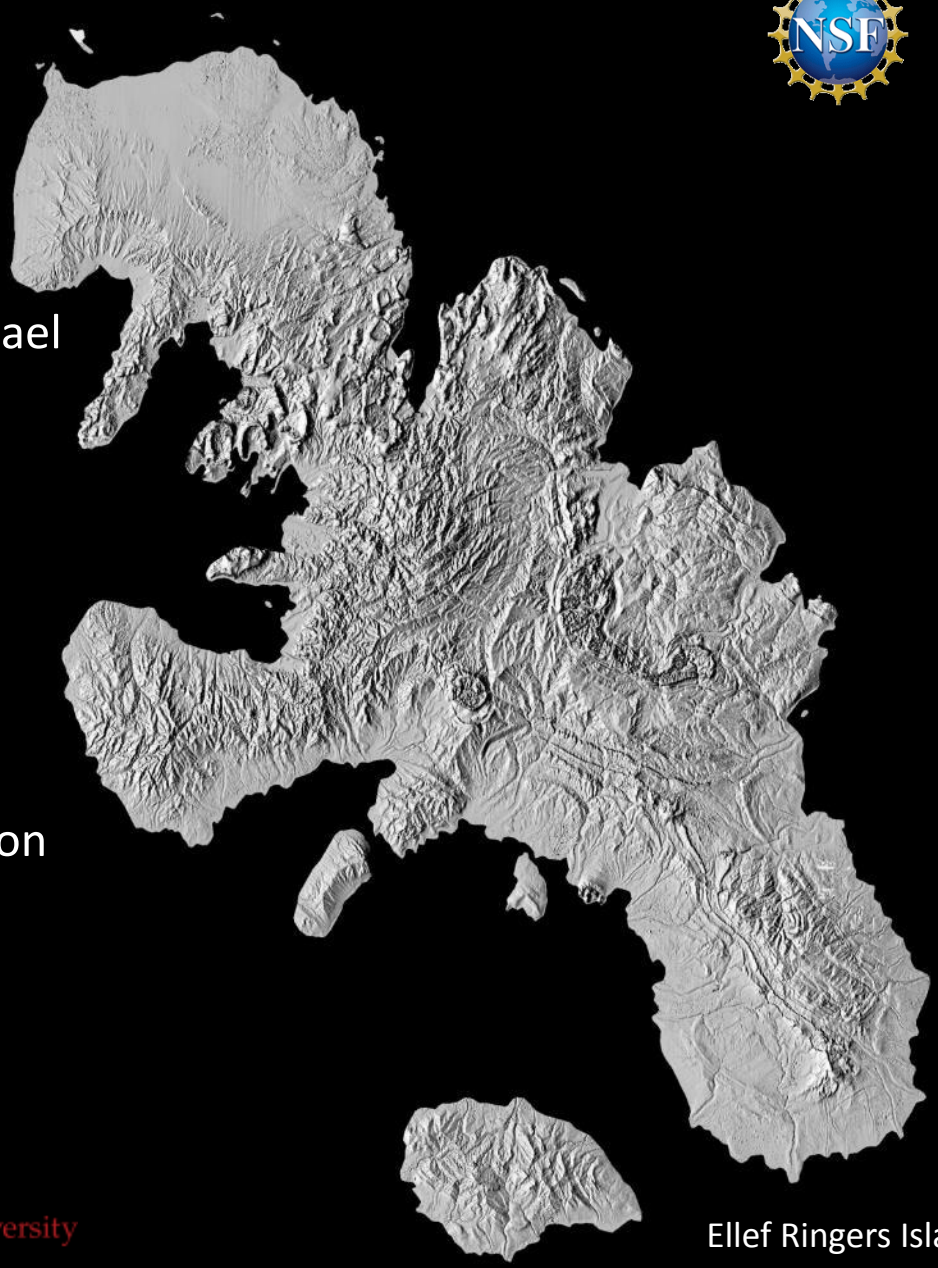


DigitalGlobe Data holdings in ABoVE Science Cloud as of June 2016

- > 300 TB
- If image is zoomed in, numerous gaps remain in Alaska and Canada

** as of January 2015*

The ArcticDEM



Paul Morin, Claire Porter & Michael Cloutier

Polar Geospatial Center, University of Minnesota

Ian Howat & MJ Noh

Byrd Polar, the Ohio State University

Michael Willis

Earth and Atmospheric Sciences, Cornell University,

Brian Bates & Cathleen Williamson

National Geospatial-Intelligence Agency

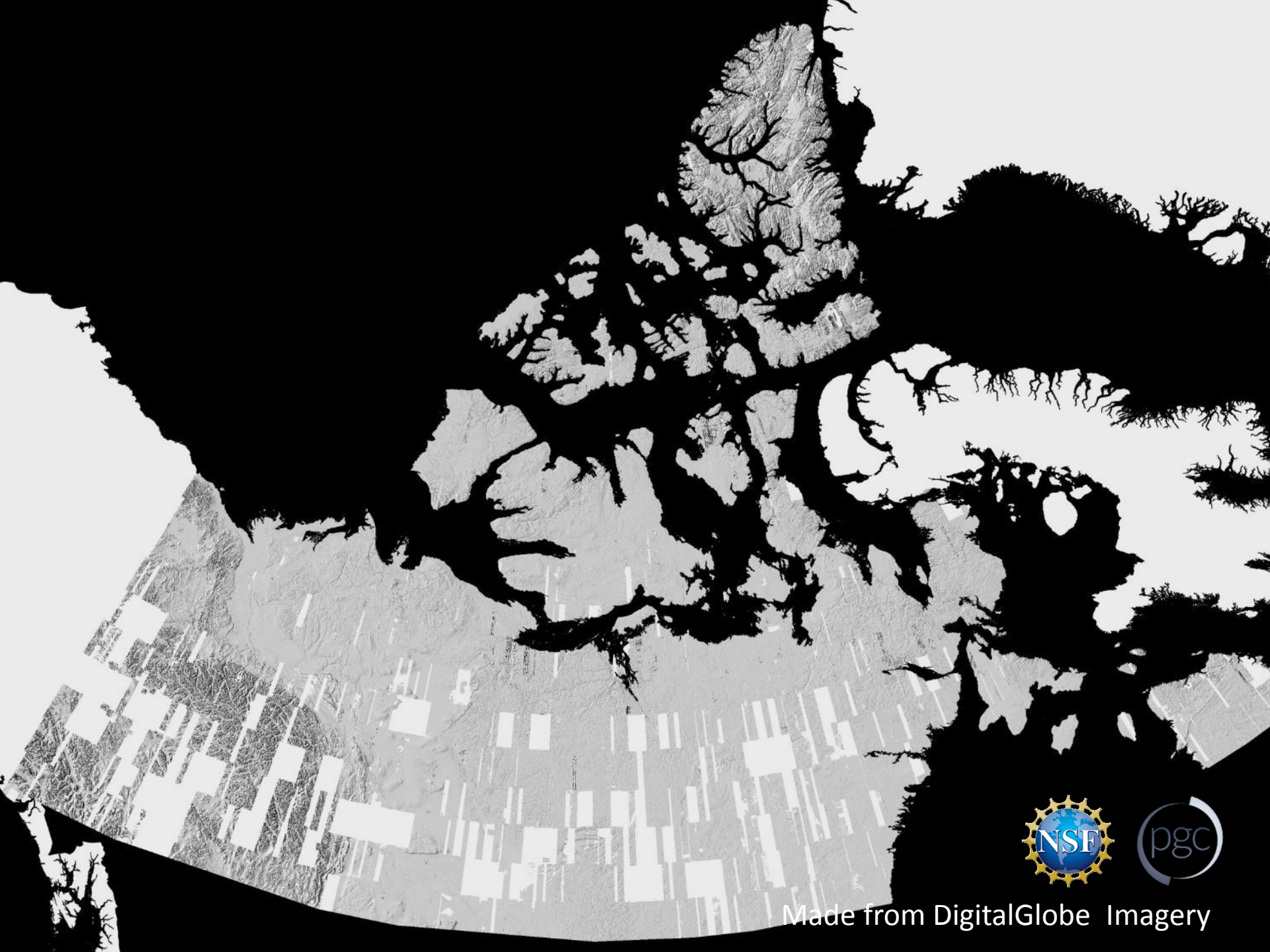
Ellef Ringers Island, Nunavut

ArcticDEM Goal

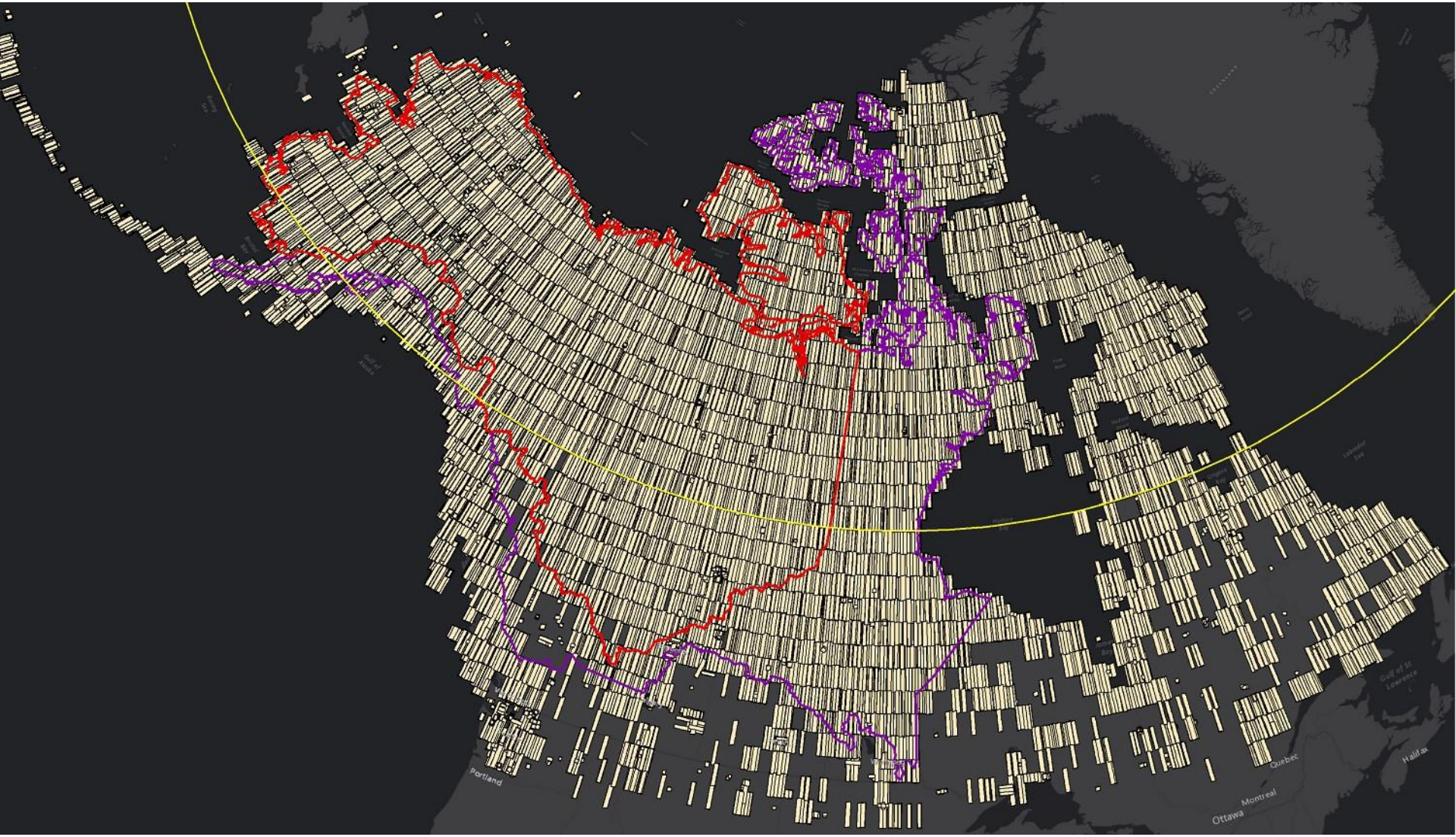
Produce a 2-8m posting digital surface model of the Arctic during the US Chairmanship of the Arctic Council using DigitalGlobe stereo imagery.

http://pgc.umn.edu/arcticdem

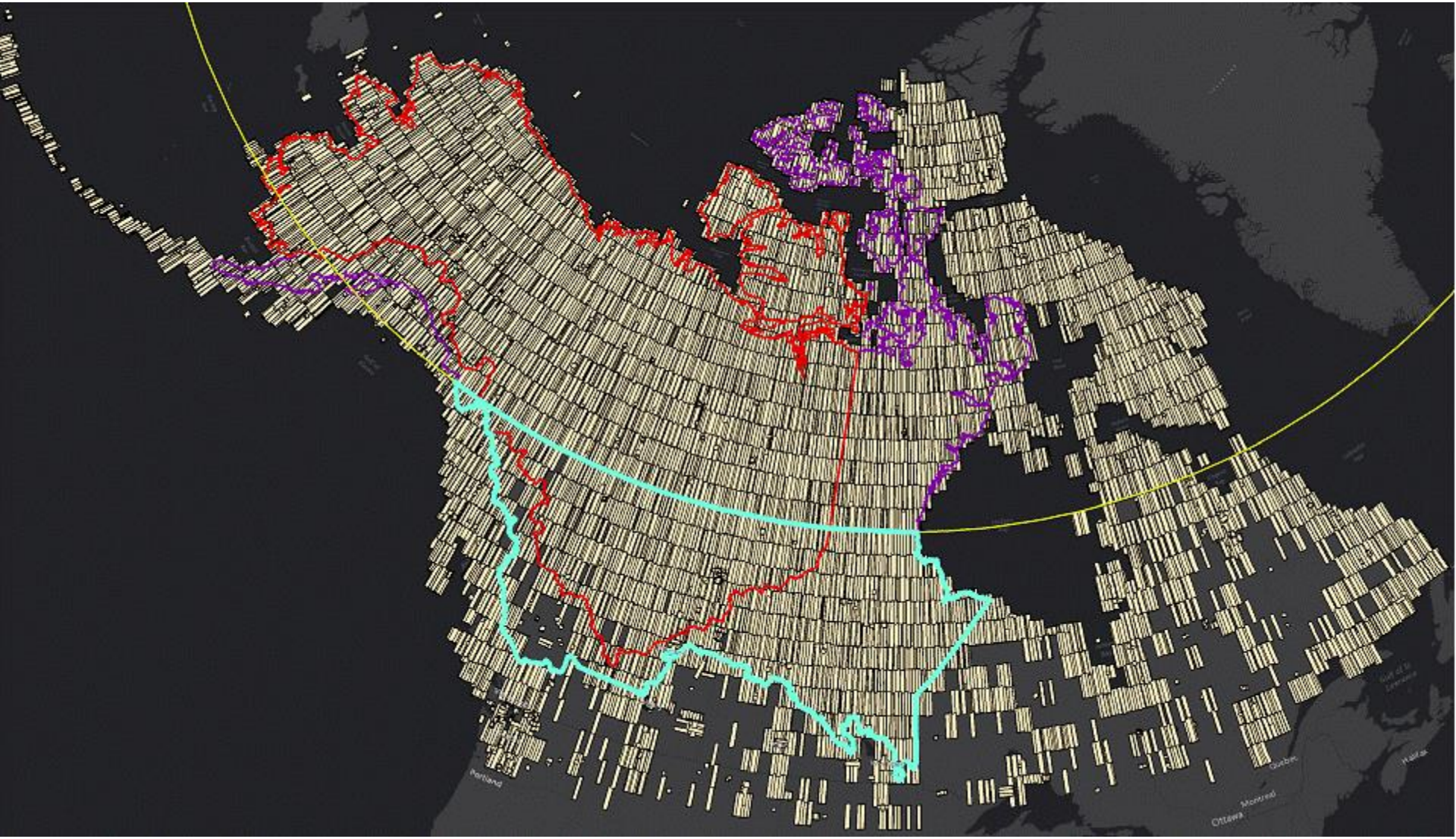

Made from DigitalGlobe Imagery


NSF
pgc
Made from DigitalGlobe Imagery

ABoVE will add to the ArcticDEM using PGC's code.



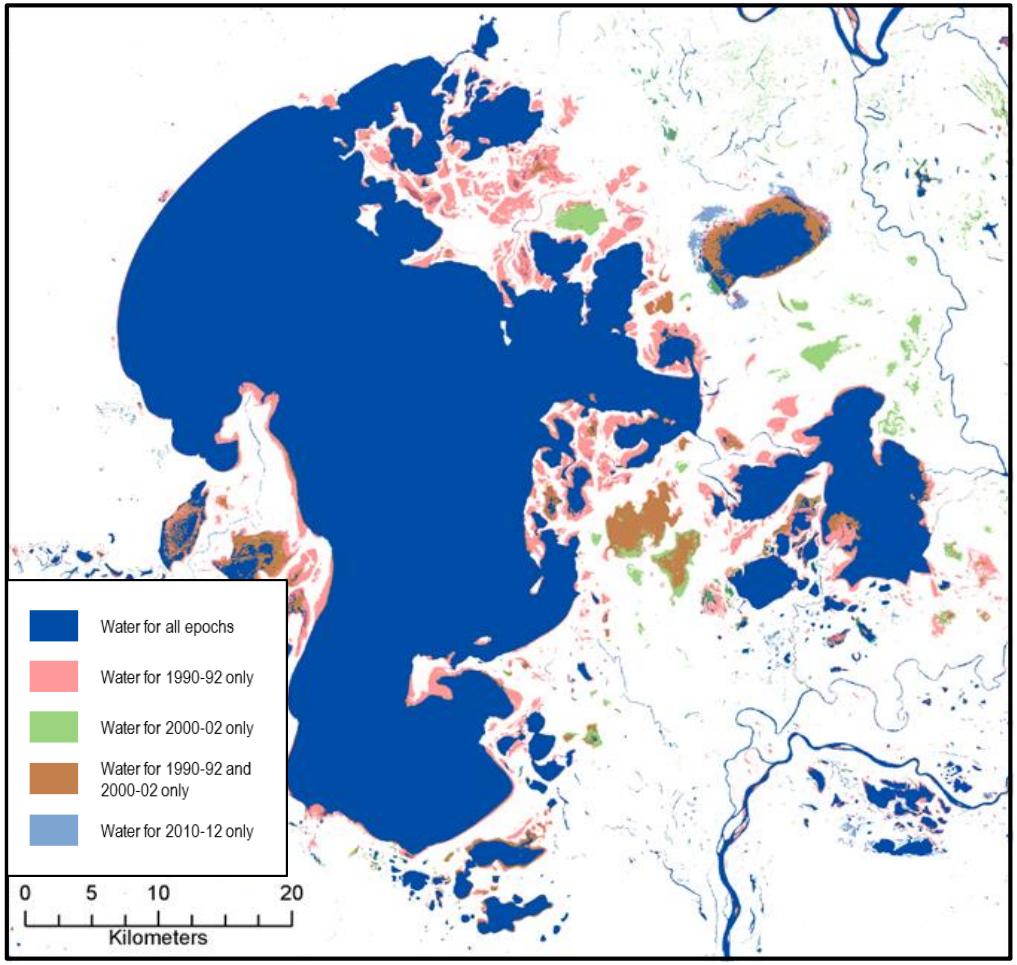
ABoVE will add to the ArcticDEM using PGC's code.



Examples of the ASC In Action

ABoVE Decadal Water Maps – M. Carroll

- Series of maps at 30m spatial resolution depicting nominal water extent for a given epoch (1990–1992, 2000-2002, 2010-2012) produced from Landsat data
- Data produced operationally in the ABoVE Science Cloud (ASC) speeding processing from a projected 9 months on 2 workstations down to 6 weeks in the ASC

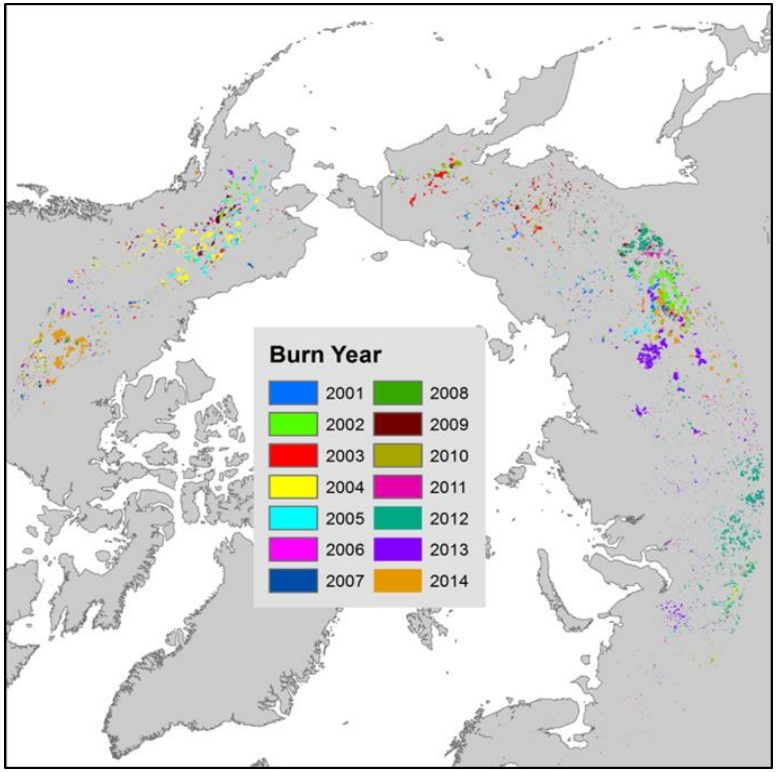


Change in Surface water in Lake Claire, Canada 1990 – 2012 using ABoVE Decadal Water Maps

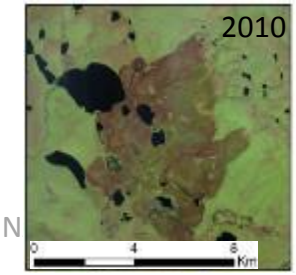
Carroll et al. 2016, Remote Sens

Fire History for ABoVE – T. Loboda & M. Miller

- Fire history across the ABoVE study region is compiled from available and new data products and enhanced
- Multiple VMs on the ASC are used to process Landsat and MODIS data to develop the burn severity characterization



Landsat data record



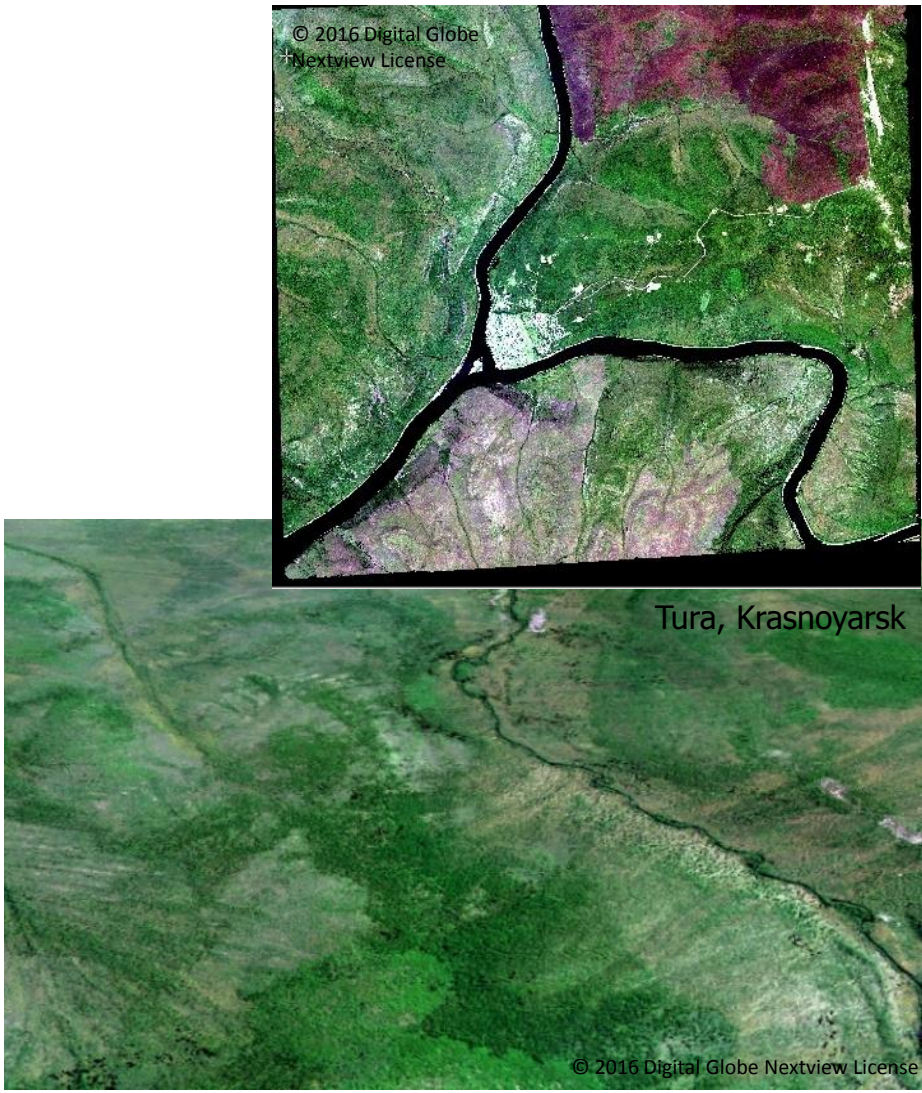
Burned area

Burn severity

Forest Canopy Surface Elevations – C. Neigh

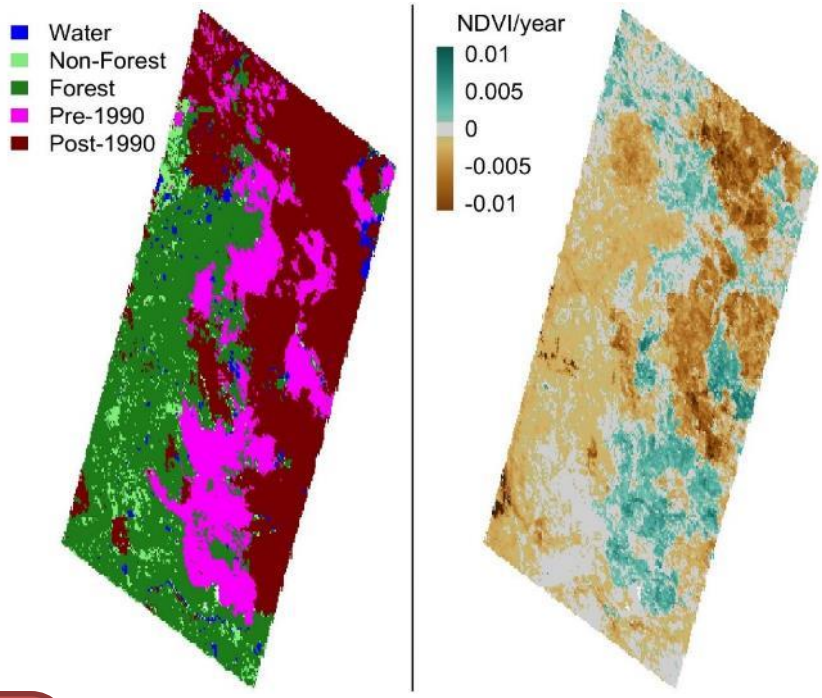
- Understanding forest patterns using DigitalGlobe high-resolution satellite imagery
- Using multiple VMs and Ames Stereo Pipeline (ASP) on the ASC to process Digital Elevation Models

See his talk at ICRSS: 9/15 @ 1:40pm



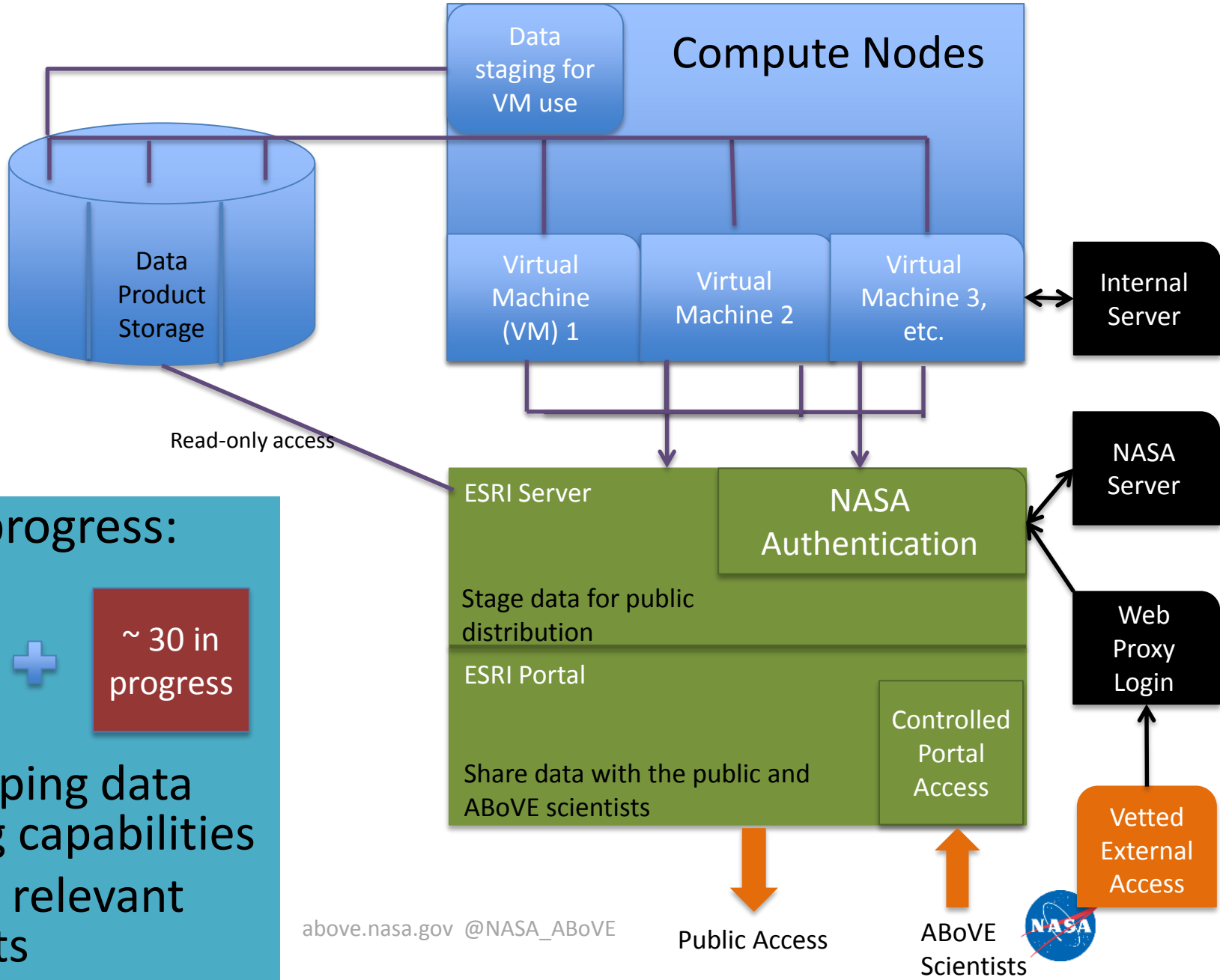
Landscape-Scale Histories of Disturbance, Seasonality and Greenness Trends - D. Sulla-Menashe

- 30+ year historical record and ongoing characterization of disturbance events and phenology across the ABoVE study domain
- Using multiple VMs to move Landsat data into the ABoVE grid and then develop the landscape histories



See his talk at ICRSS: 9/13 @ 2:30pm

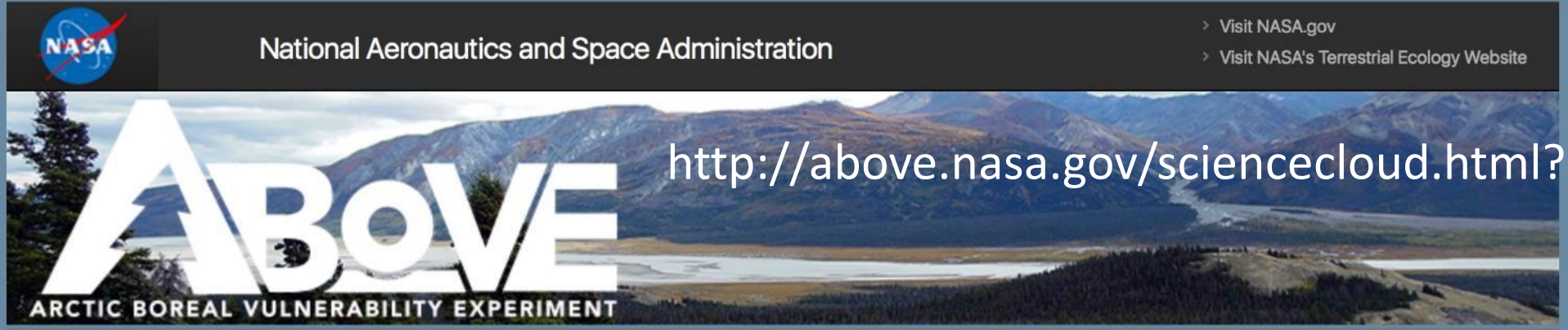
What's next for ABoVE Science Cloud Configuration?



Current progress:

62 Current Users + ~ 30 in progress

- Developing data sharing capabilities
- Adding relevant datasets



Sign In | My Account | Sign Out

- Home
- About
- Science Team
- Meetings & Events
- Publications
- Data
- Safety & Logistics
- Funding
- Jobs

The ABoVE Science Cloud (ASC)

Referenced on page A.4-8 in NASA Research Announcement for Terrestrial Ecology: Airborne Campaign For ABoVE NNH16ZDA001N-TE

Science Cloud Setup Instructions
About the Science Cloud
Webinar

The NASA Center for Climate Simulation (NCCS) has partnered with the NASA Carbon Cycle and Ecosystems Office (CCE Office) to create a high performance science cloud for this field campaign. The ABoVE Science Cloud combines high performance computing with emerging technologies and data management with tools for analyzing and processing geographic information to create an environment specifically designed for large-scale modeling, analysis of remote sensing data, copious disk storage for "big data" with integrated data management, and integration of core variables from in-situ networks. The ABoVE Science Cloud is a collaboration that promises to accelerate the pace of new Arctic science for researchers participating in the field campaign. Furthermore, by