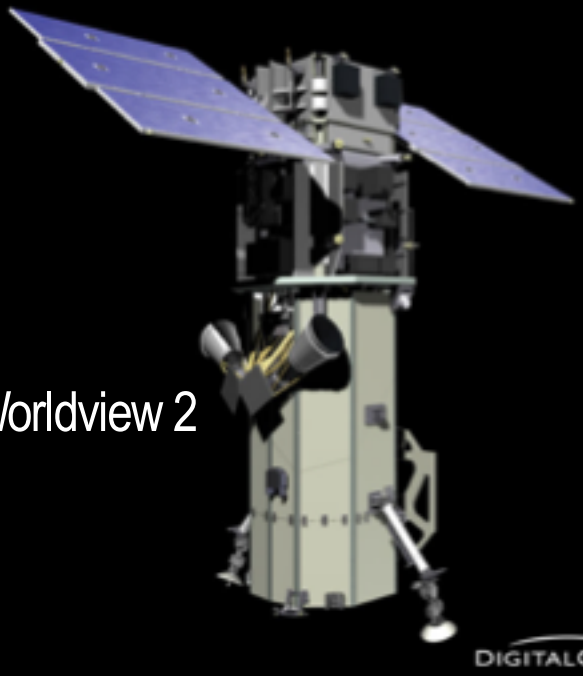
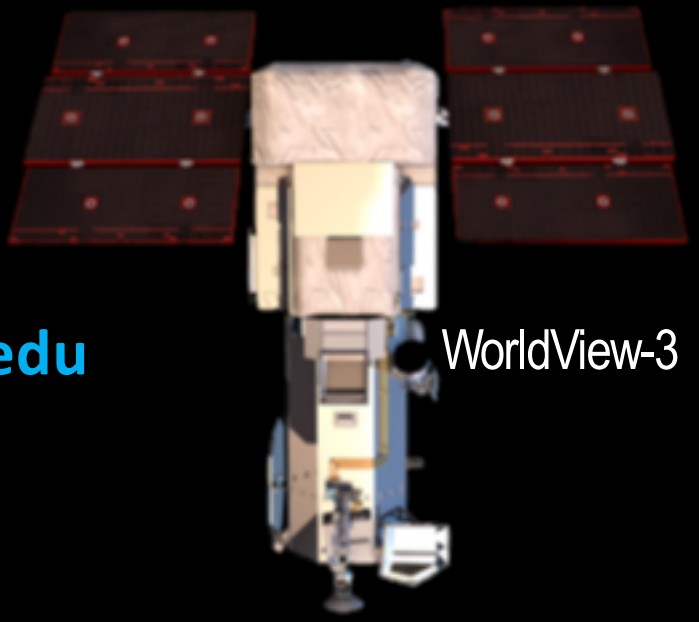
Private Eyes Are Watching You

Michael J. Willis

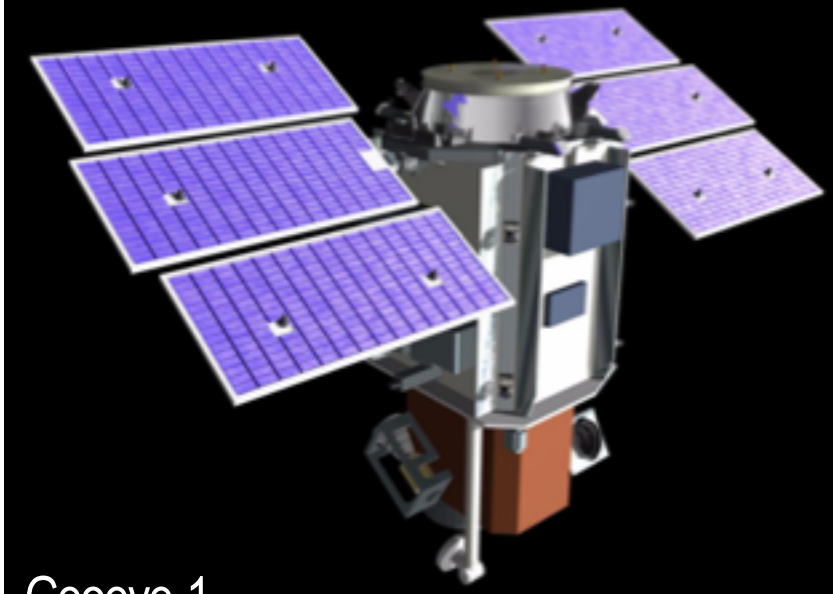
Mike.Willis@Colorado.edu



Worldview 2



WorldView-3

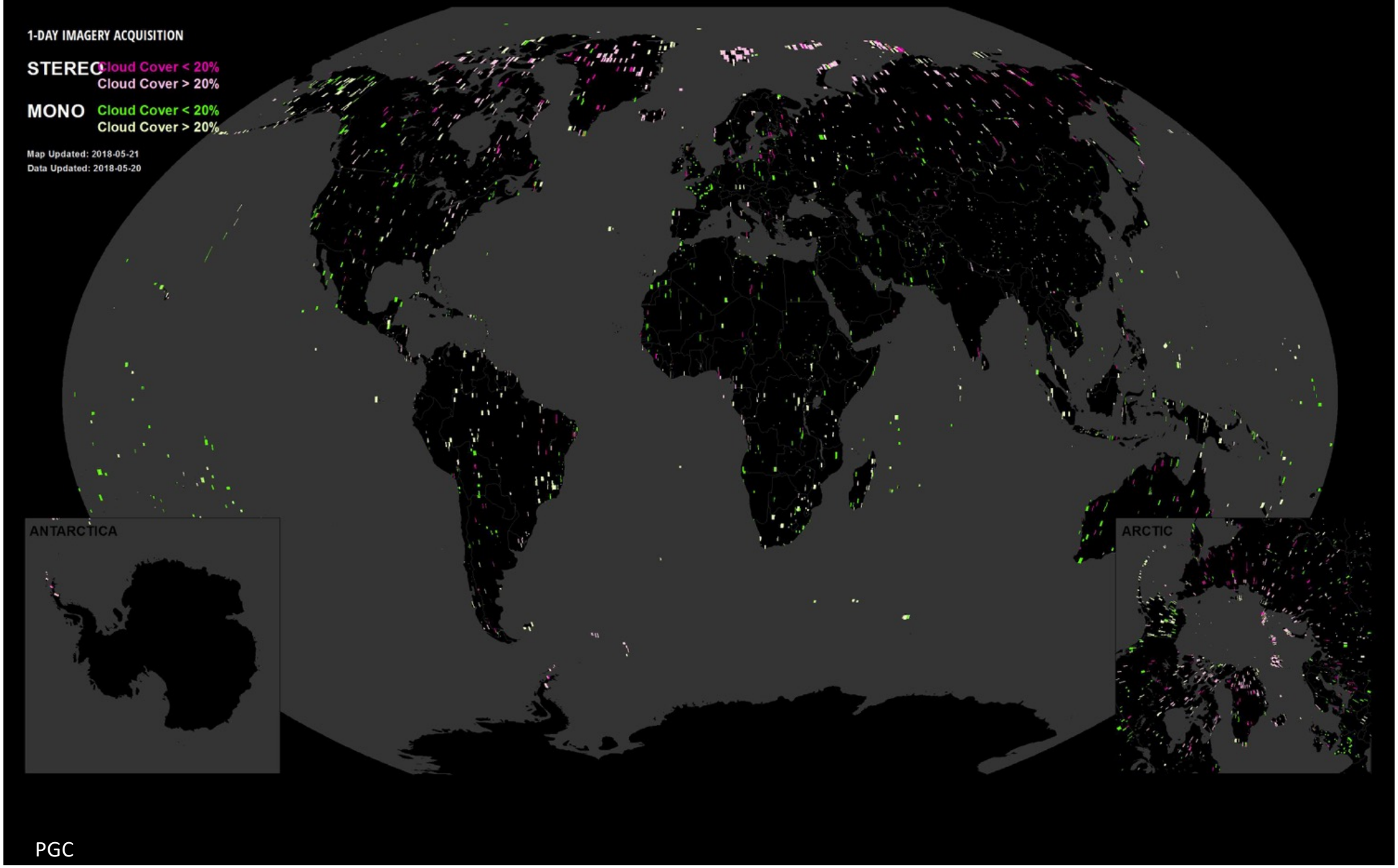


Geoeye-1

Worldview 1

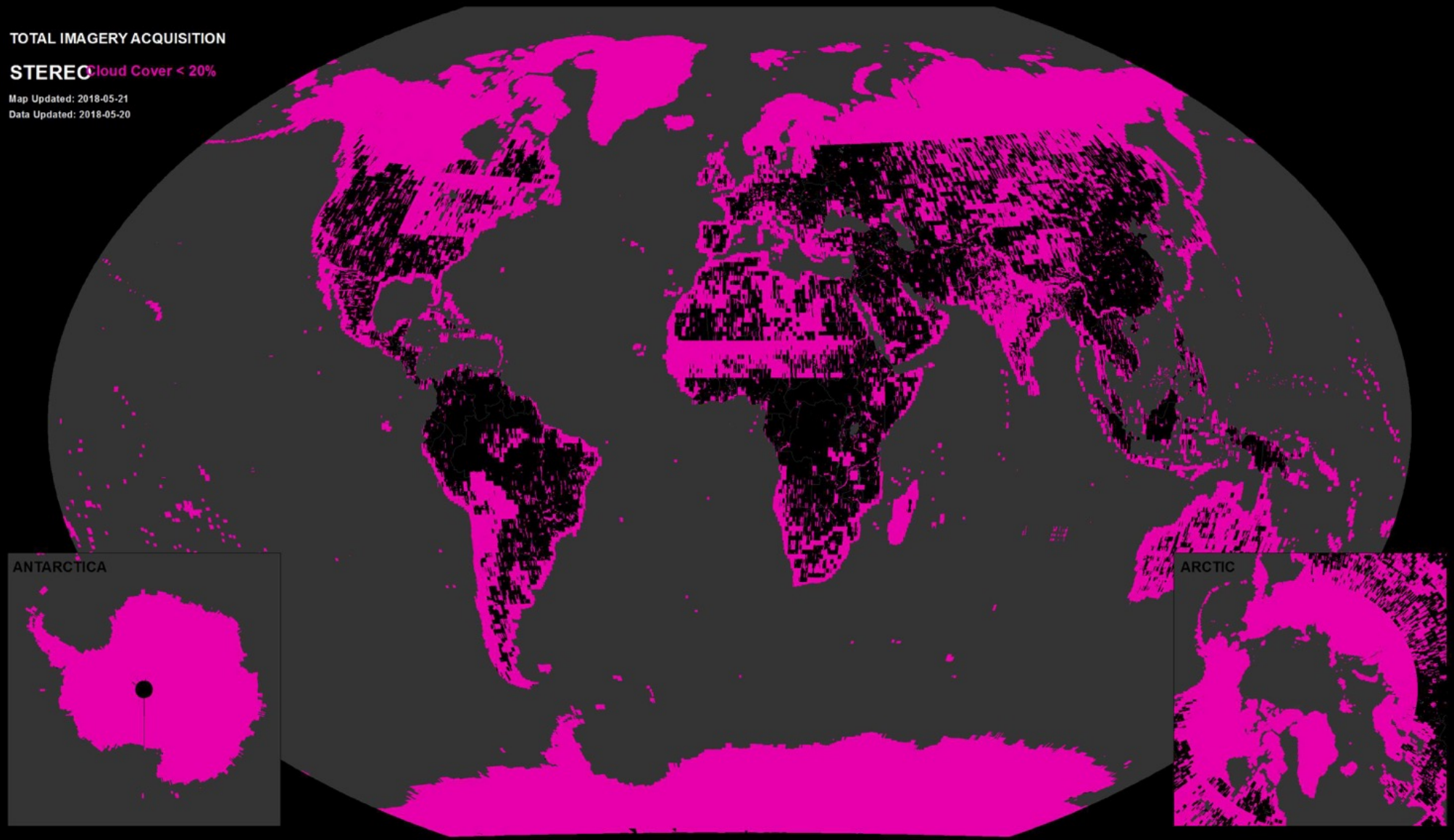
DIGITALGLOBE

DigitalGlobe Acquisitions - Yesterday



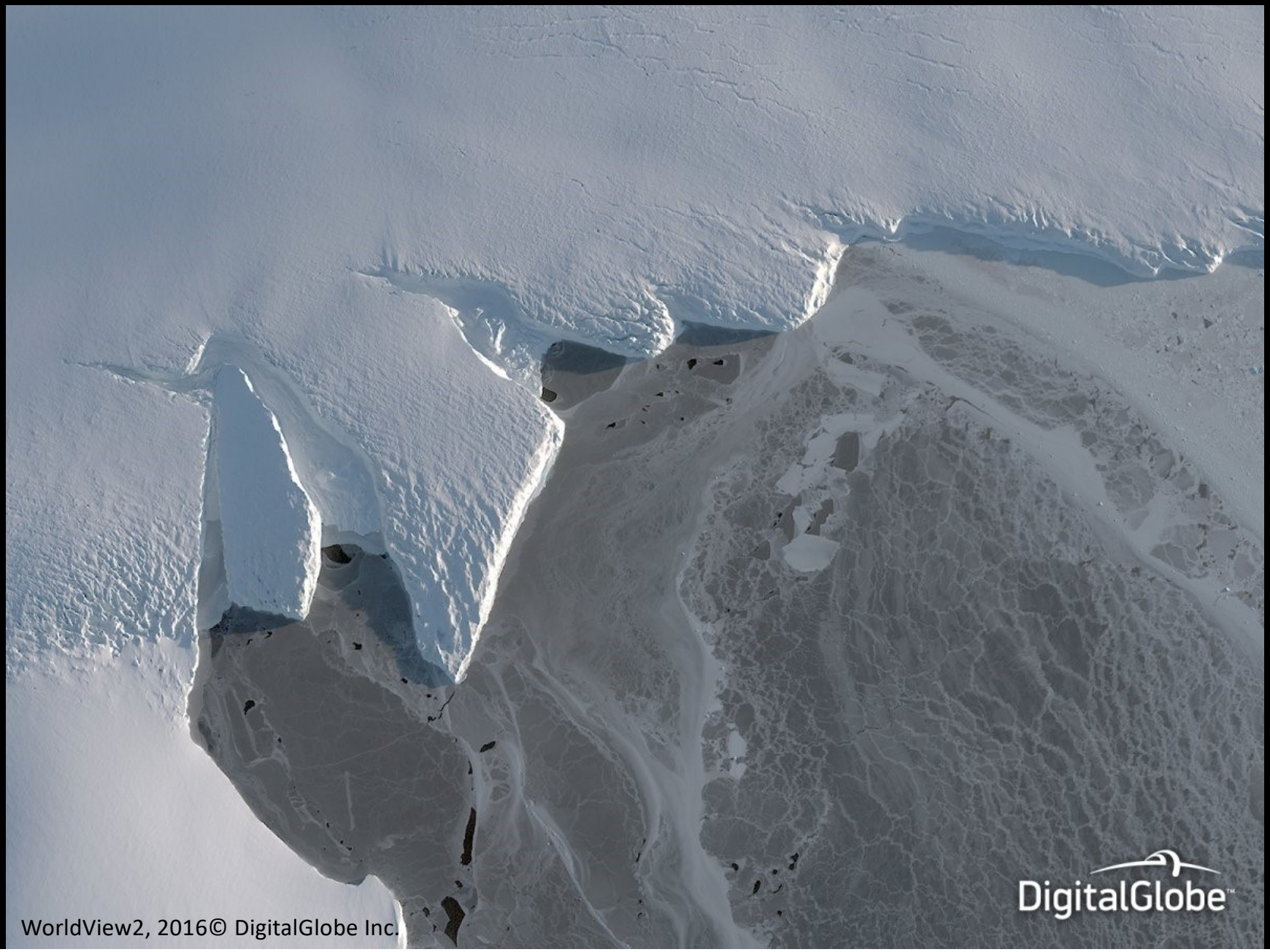
PGC

Stereo DigitalGlobe Acquisitions All Time



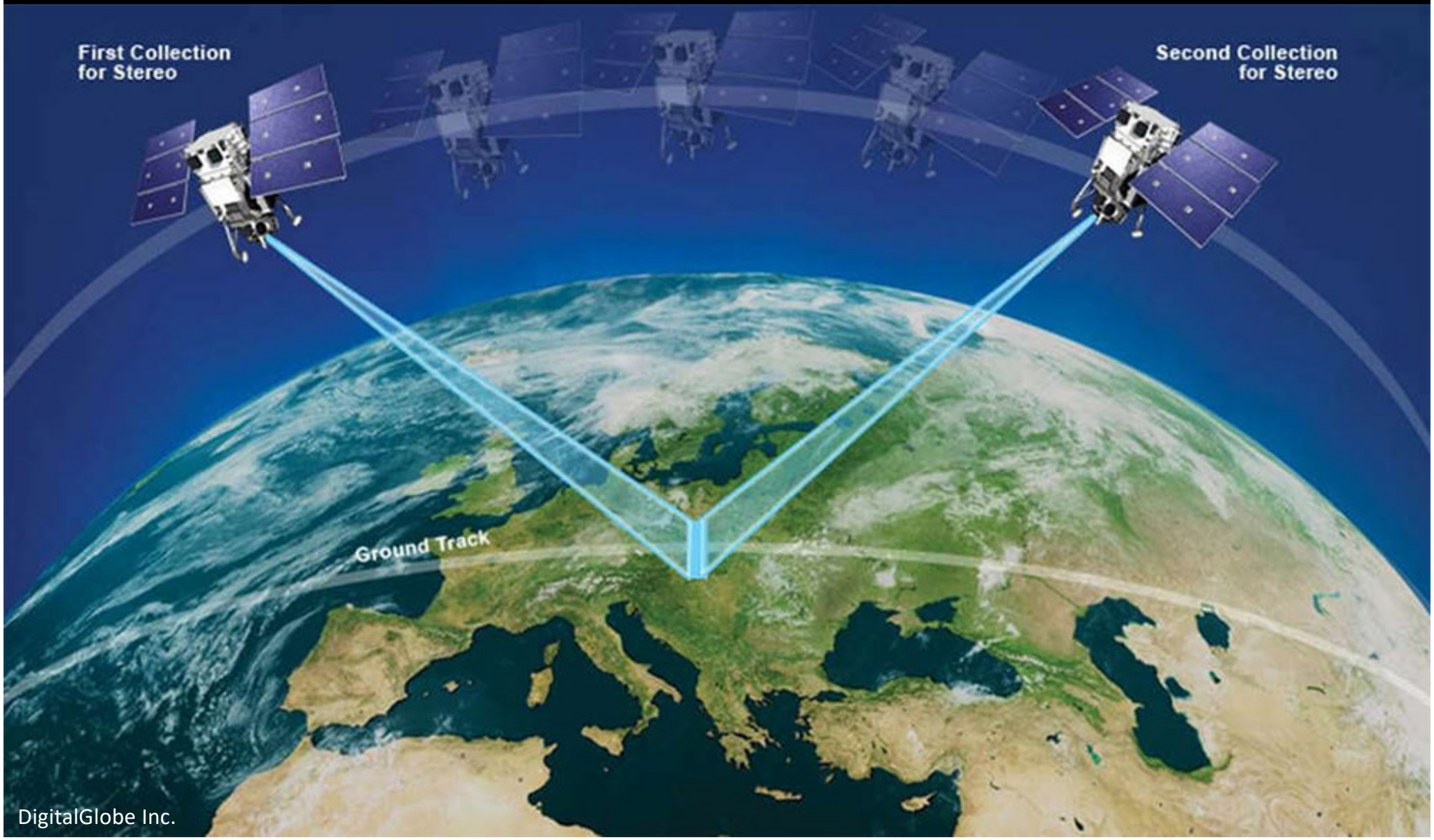
PGC

Radiometric and Geometric Resolution
Idea of the capability of this satellite series



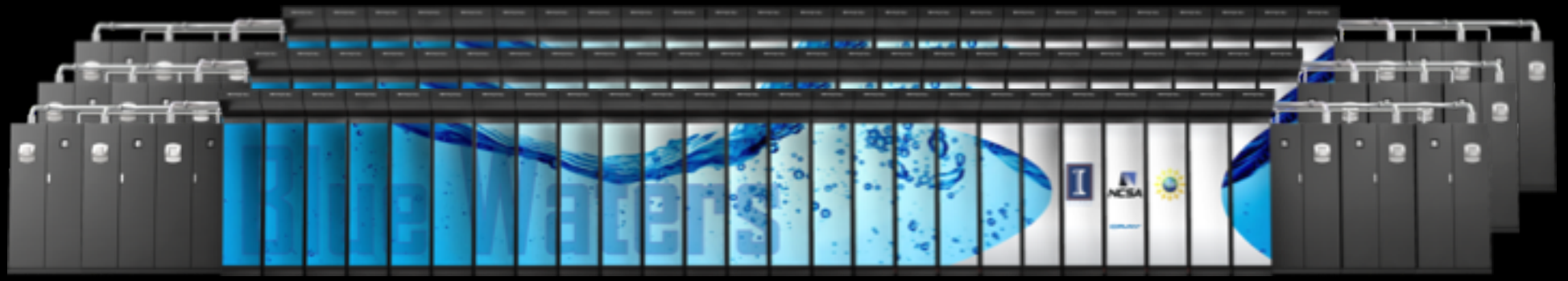
WorldView2, 2016© DigitalGlobe Inc.

Along-track stereo imaging



Convergence of HPC, Imagery and Software

Blue Waters Computing System



Aggregate Memory – 1.5 PB

Scuba Subsystem -
Storage Configuration for User Best Access

10/40/100 Gb Ethernet Switch

External Servers

IB Switch

>1 TB/sec

120+ Gb/sec

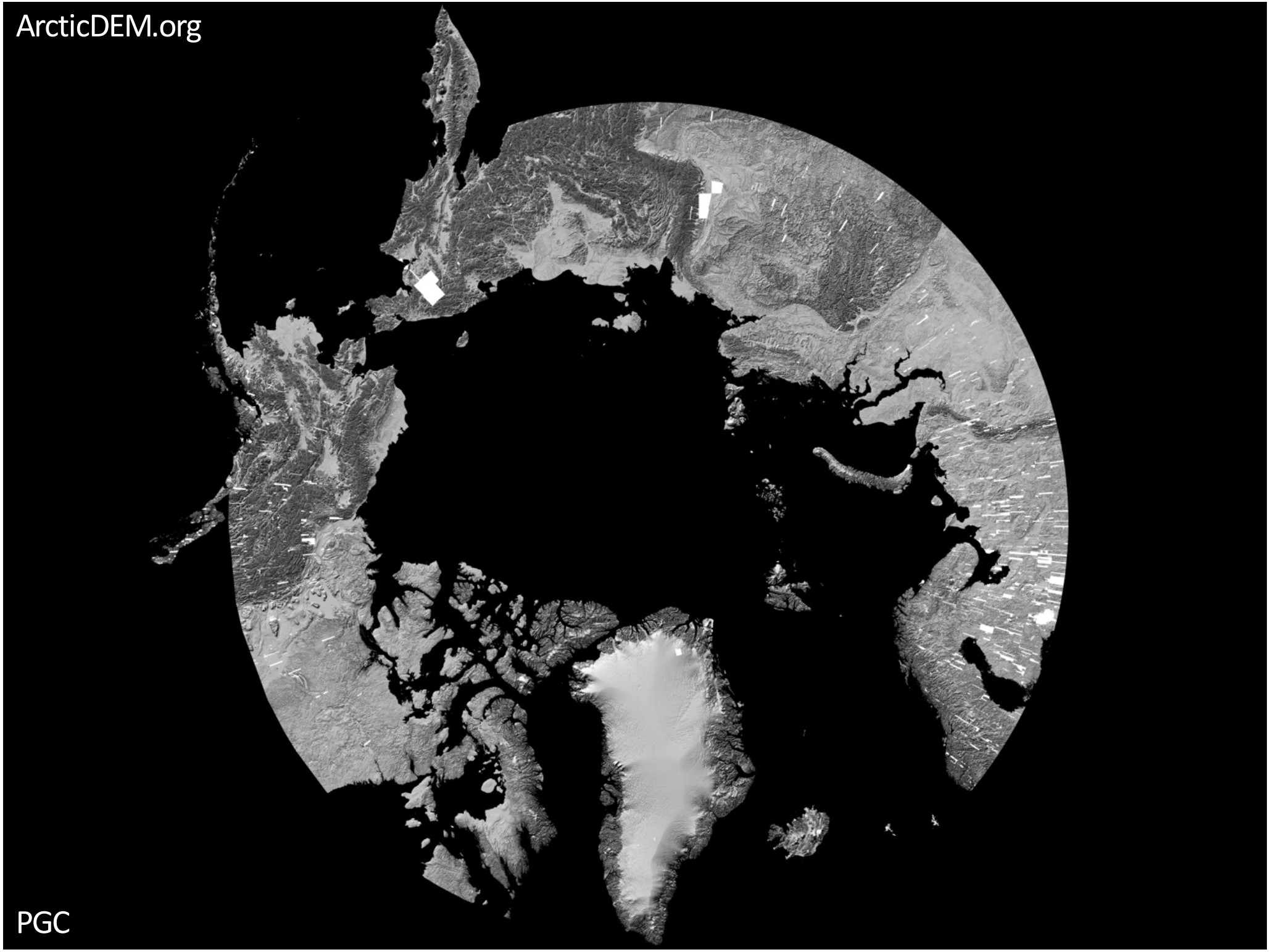
100 GB/sec

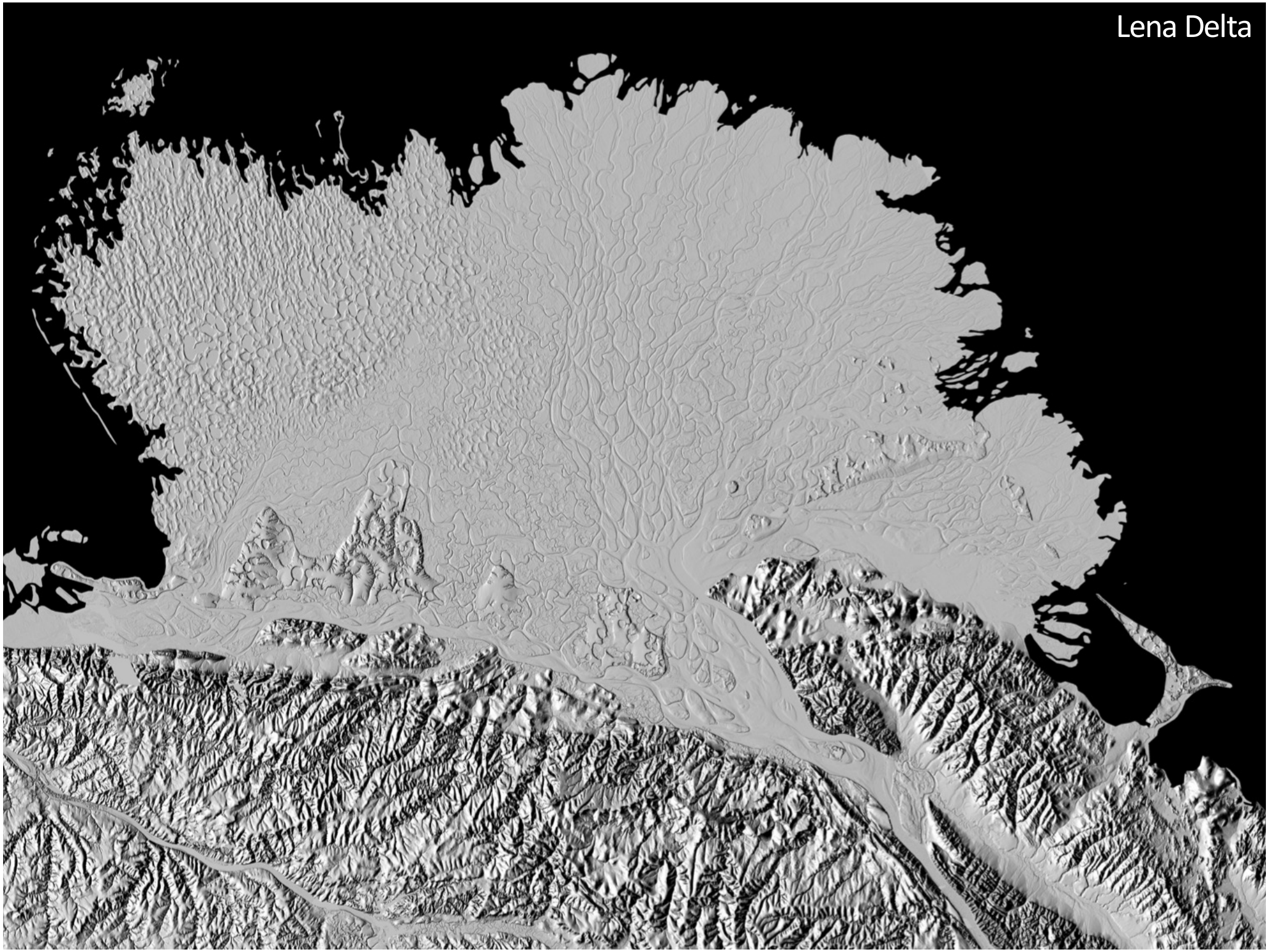
100-300 Gbps WAN

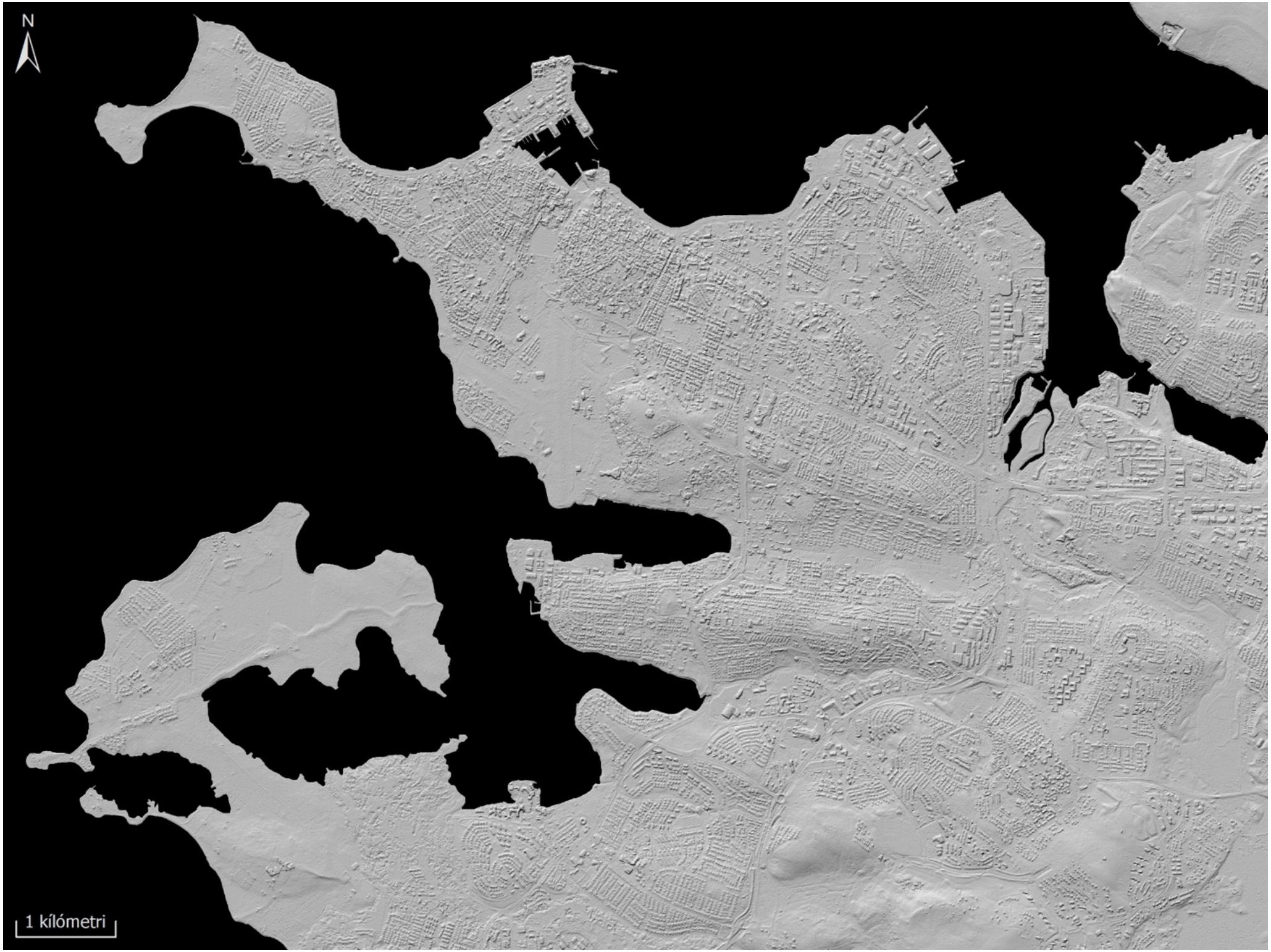
Spectra Logic: 300 usable PB

Sonexion: 26 usable PB

NSF


ArcticDEM.org
PGC


Lena Delta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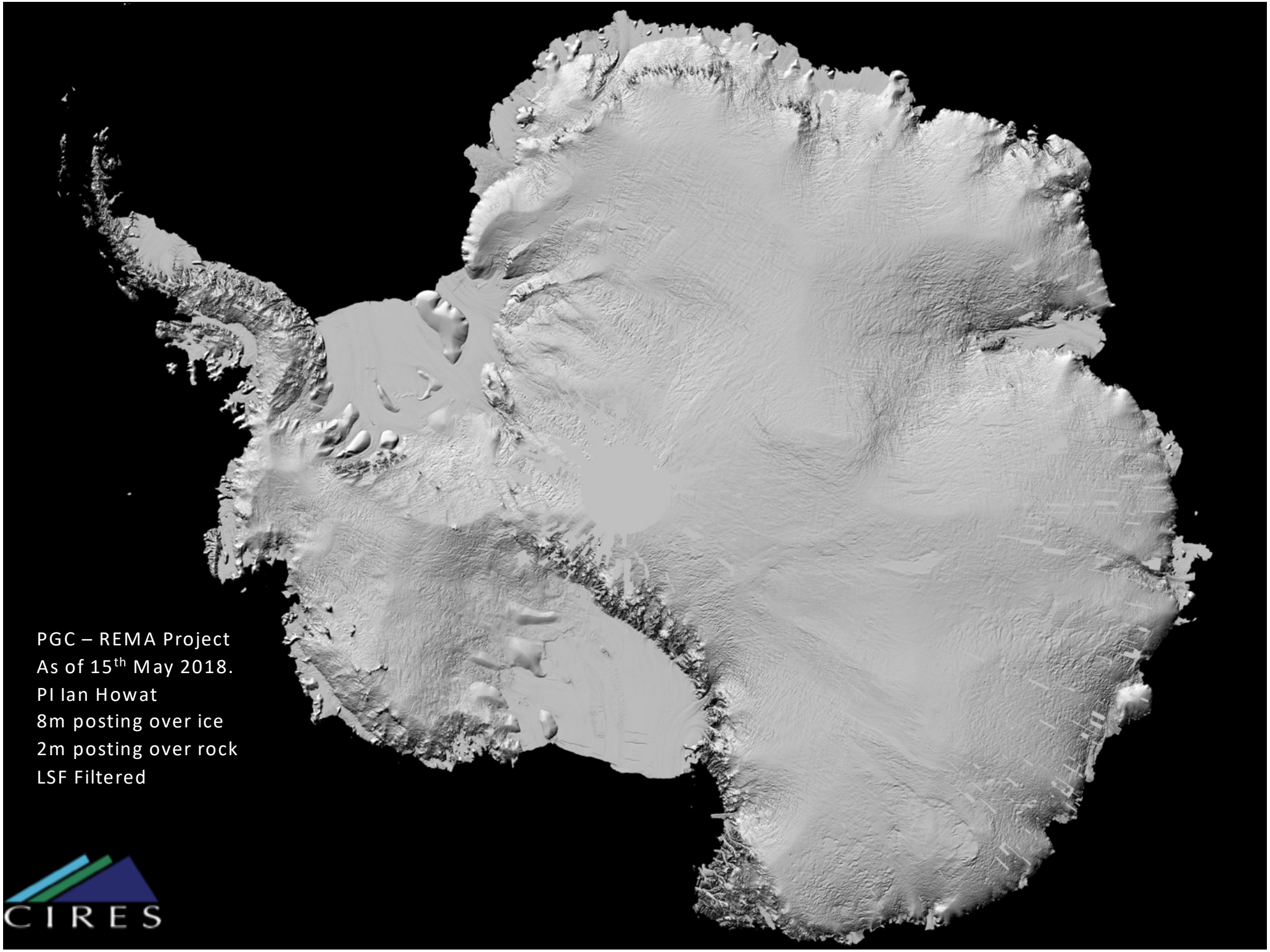
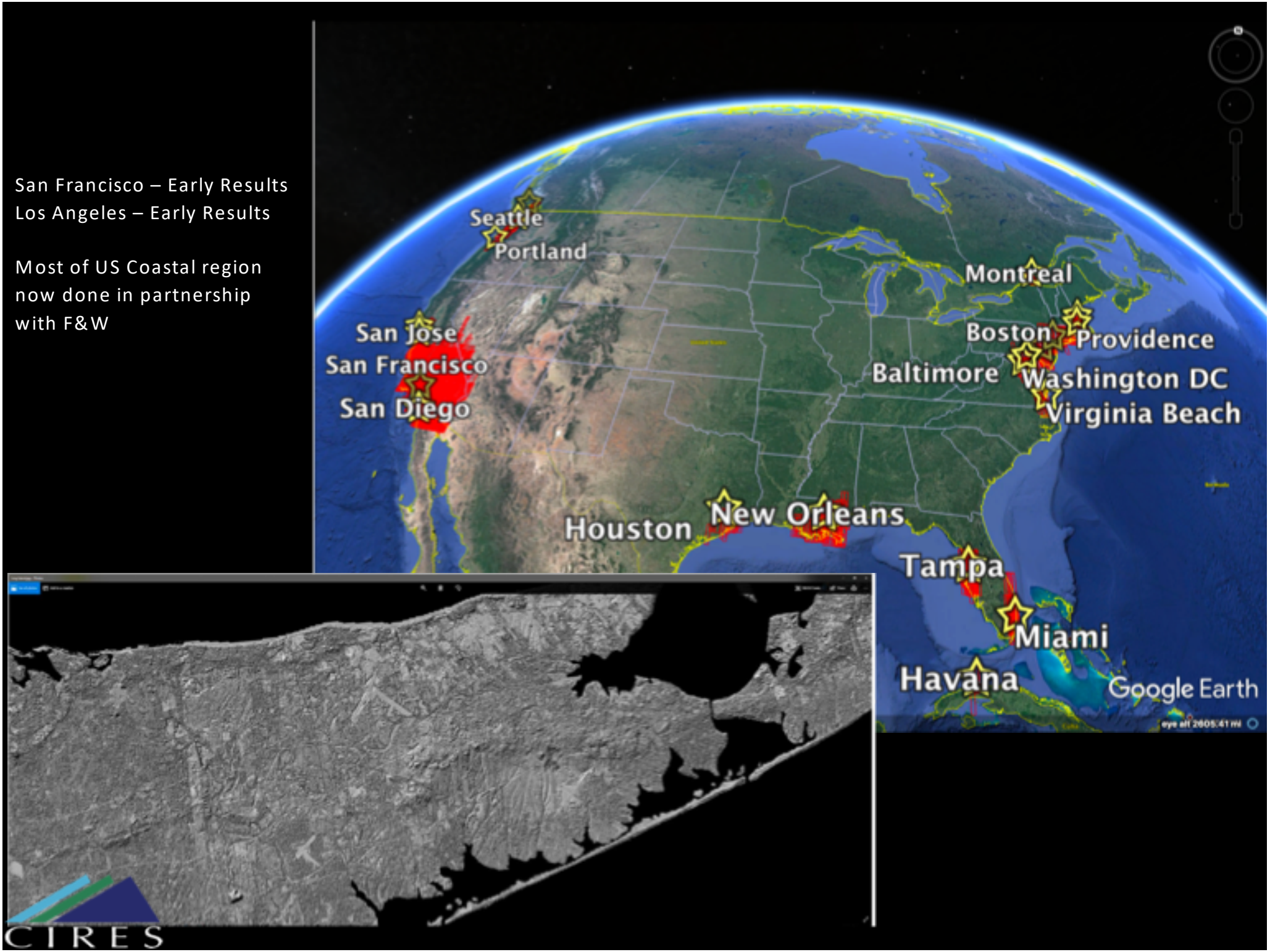
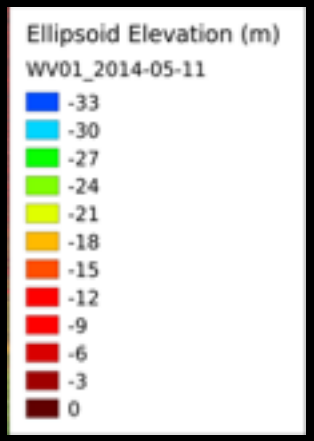

PGC – REMA Project
As of 15th May 2018.
PI Ian Howat
8m posting over ice
2m posting over rock
LSF Filtered
CIRES

San Francisco – Early Results
Los Angeles – Early Results

Most of US Coastal region now done in partnership with F&W

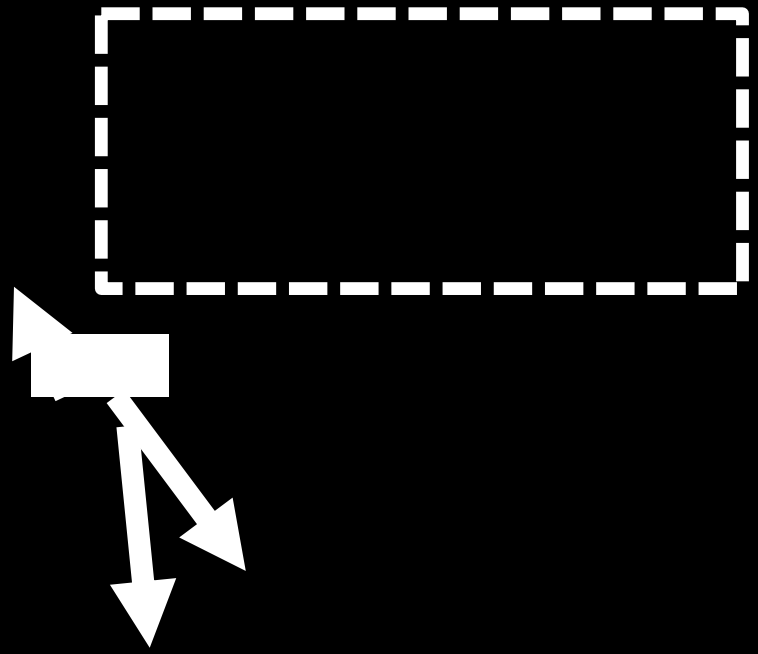


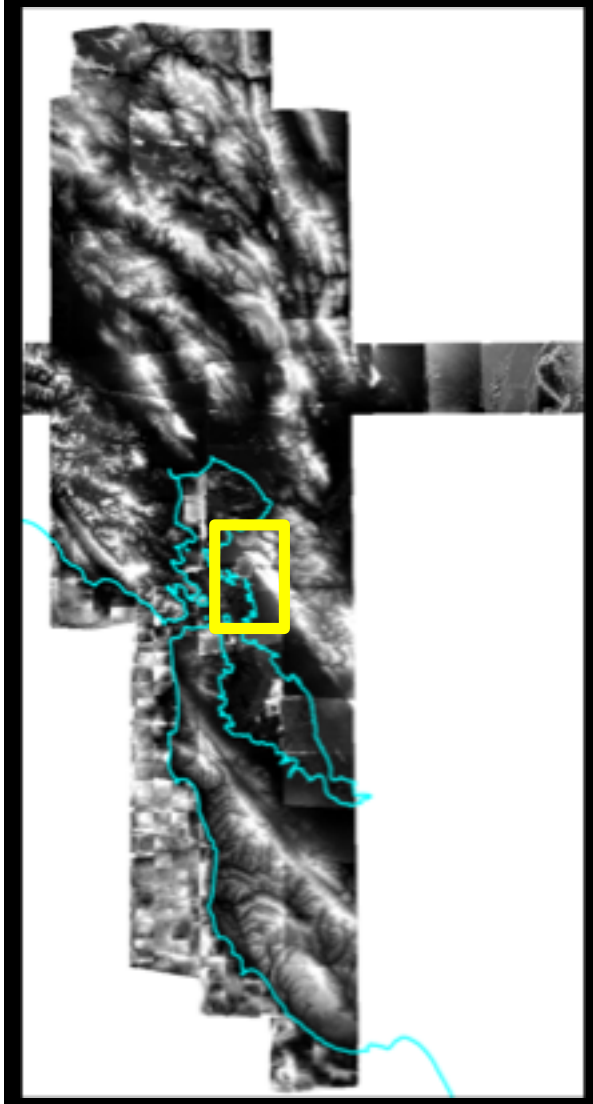
Inundation studies of urban centers and vulnerable coasts – With Steve Nerem & Southern-California with Bill Barnhart

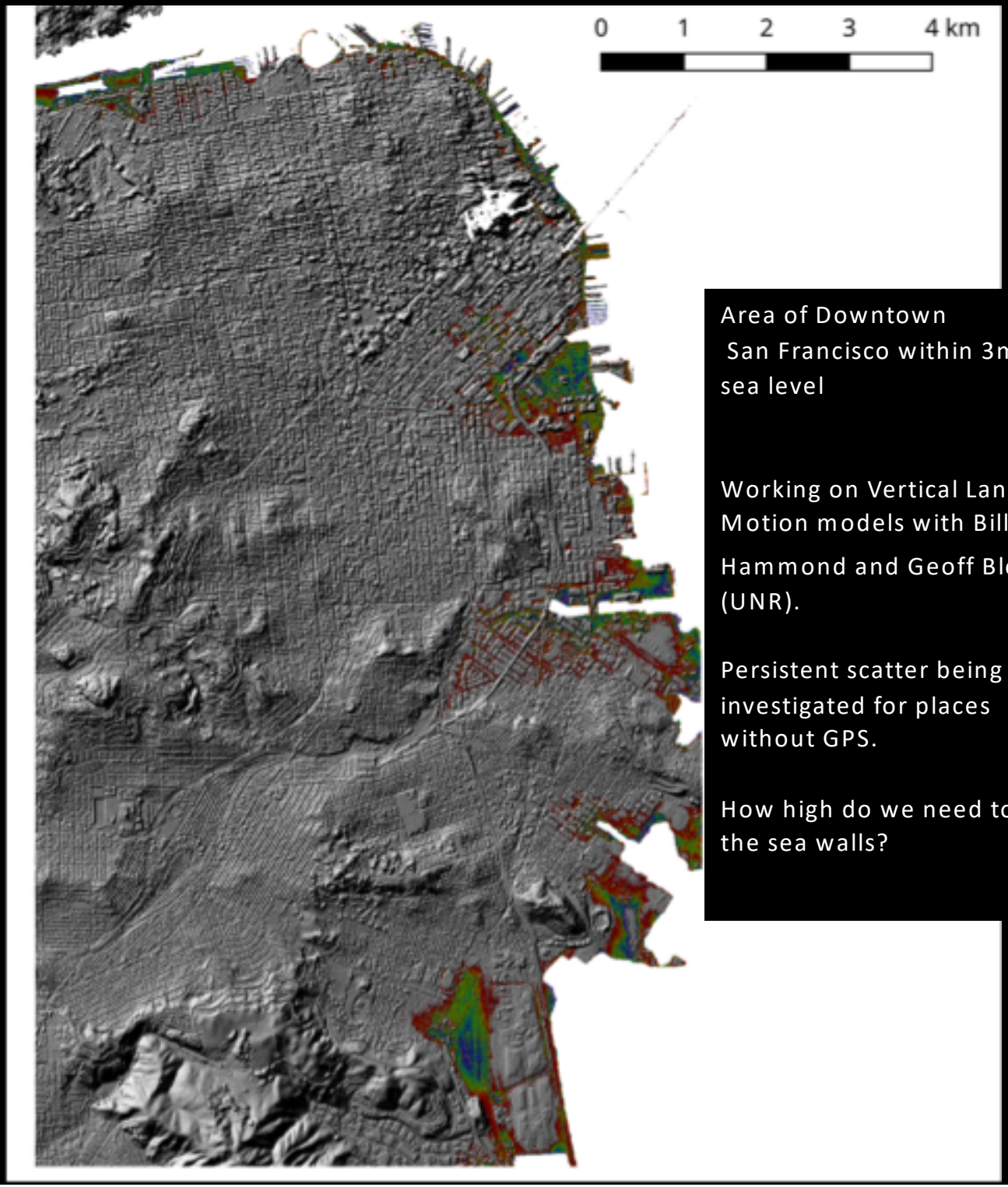


Seal Beach, Los Angeles

Dark Blue: within 3 m of sea level







Area of Downtown San Francisco within 3m of sea level

Working on Vertical Land Motion models with Bill Hammond and Geoff Blewitt (UNR).

Persistent scatter being investigated for places without GPS.

How high do we need to build the sea walls?

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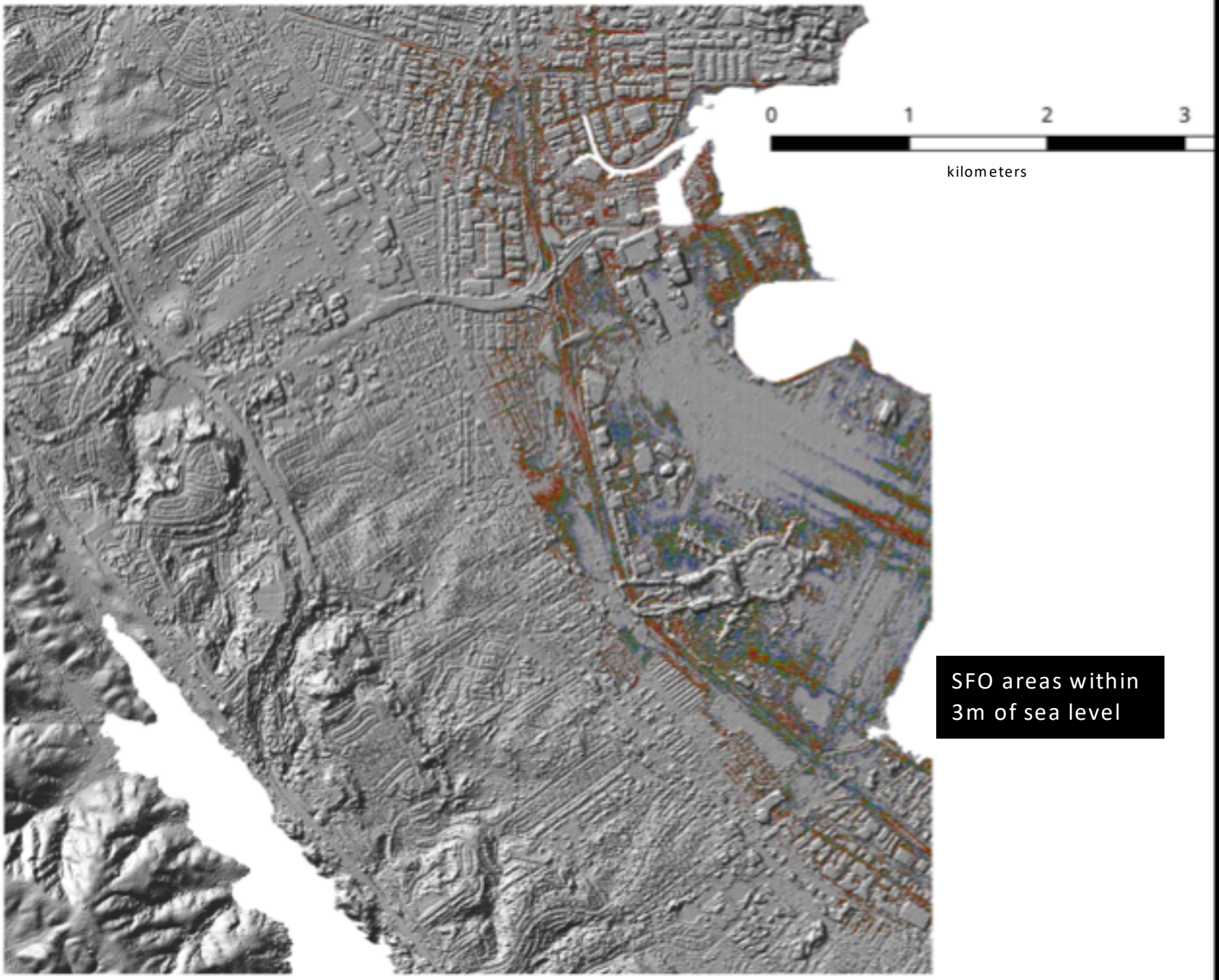

SFO areas within 3m of sea level

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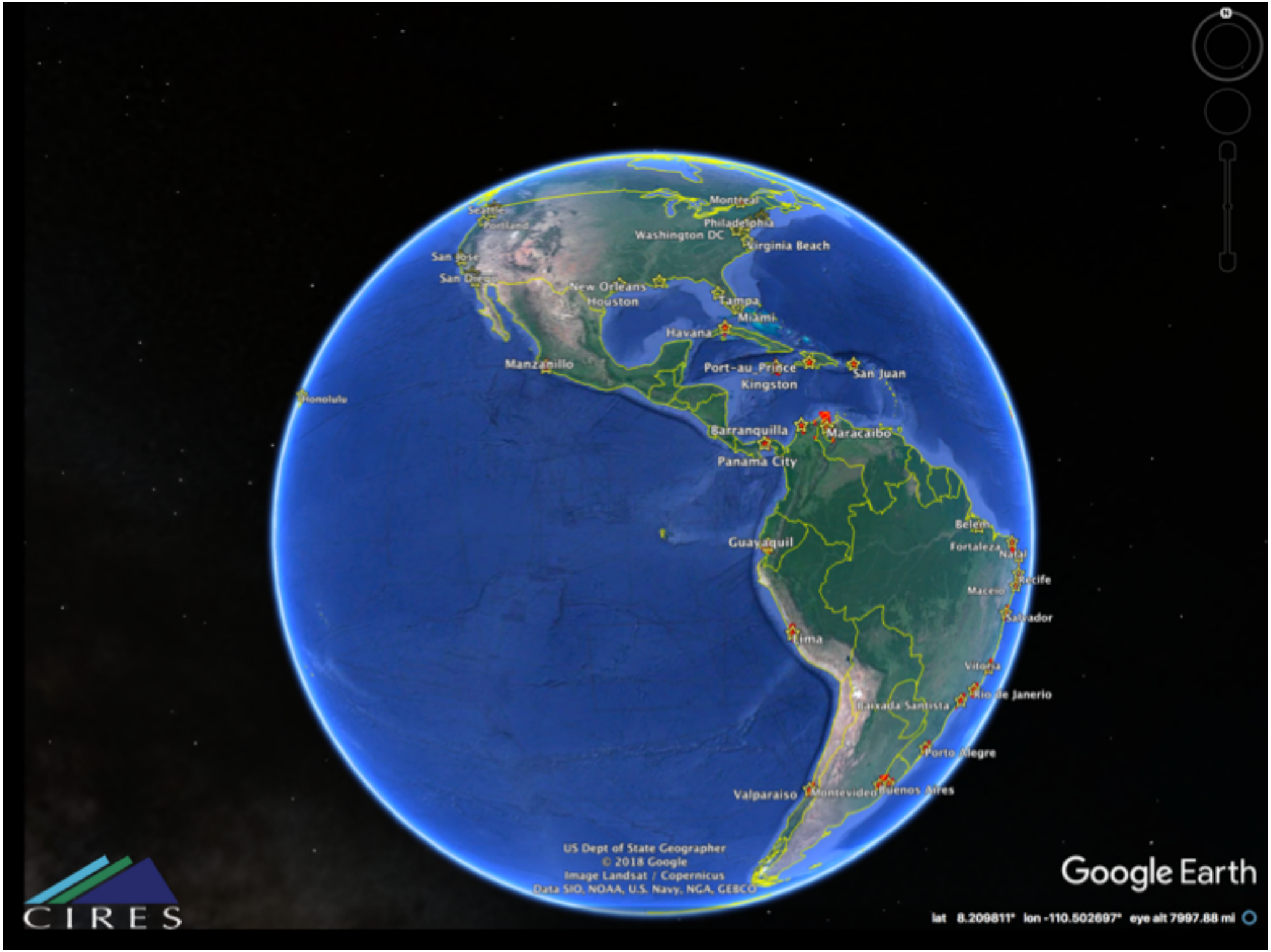
Montreal
Seattle
Portland
Philadelphia
Washington DC
Virginia Beach
San Jose
San Diego
New Orleans
Houston
Tampa
Miami
Havana
Manzanillo
Port-au-Prince
Kingston
San Juan
Honolulu
Barranquilla
Maracaibo
Panama City
Belem
Guayaquil
Fortaleza
Natal
Recife
Maceio
Salvador
Lima
Vitoria
Rio de Janerio
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Porto Alegre
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US Dept of State Geographer
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google Earth
lat 8.209811° lon -110.502697° eye alt 7997.88 mi
CIRES


Glasgow
Dublin
London
Hamburg
Stockholm
Helsinki
St Petersburg
Le Havre
Venice
Odessa
Porto
Barcelona
Marseille
Valencia
Lisbon
Naples
Istanbul
Algiers
Athens
Rabat
Casablanca
Tripoli
Benghazi
Beirut
Port Said
Alexandria
Kuwait City
Dubai
Karachi
Jeddah
Surat
Mumbai
Dakar
Conakry
Cochin
Abidjan
Lome
Douala
Maldives
Muqdisho
Belem
Fortaleza
Natal
Recife
Maceio
Salvador
Luanda
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Durban
Cape Town
US Dept of State Geographer
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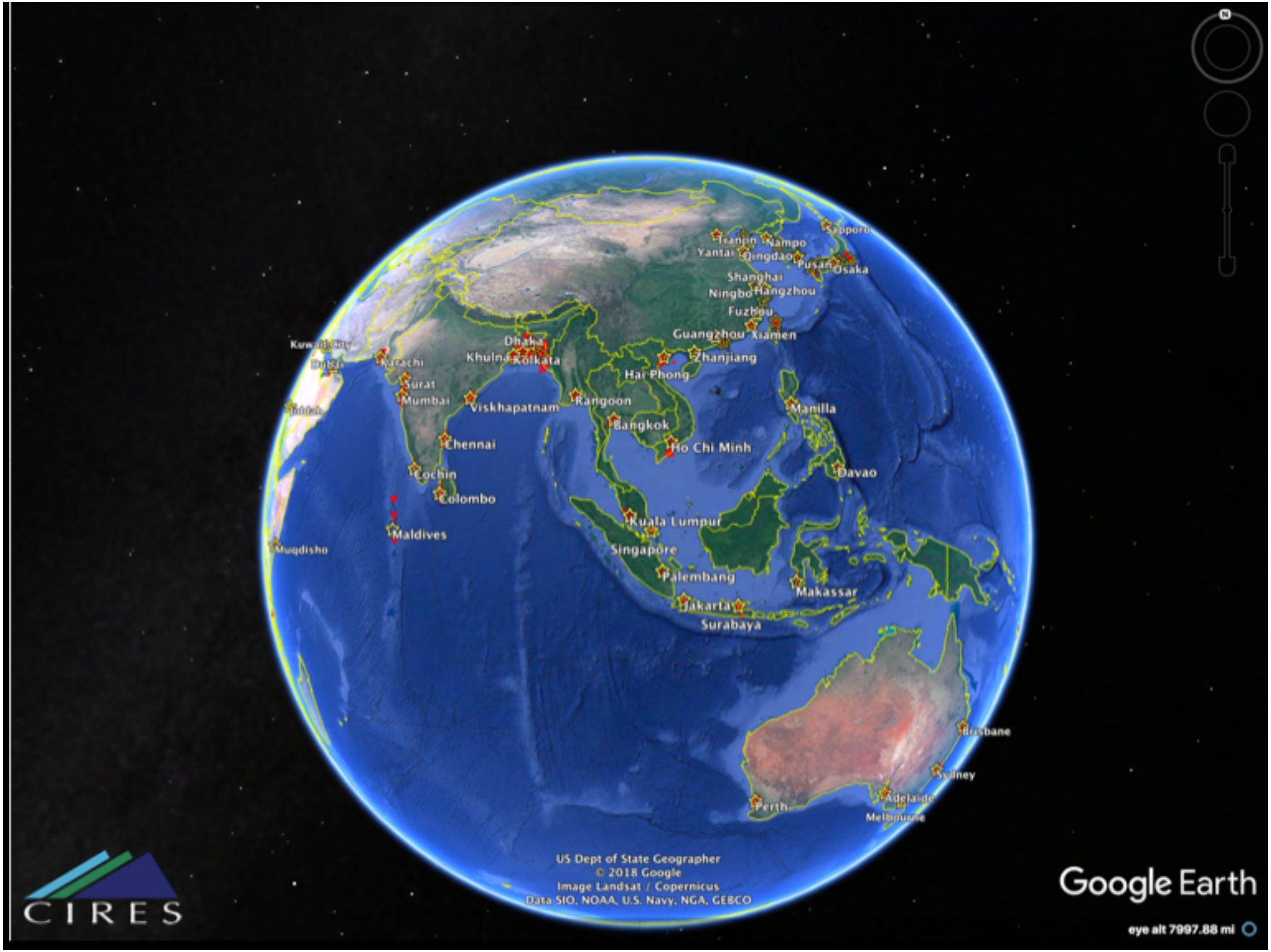
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google Earth
eye alt 7997.88 mi
CIRES


Sapporo
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Pusan
Osaka
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Hangzhou
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Zhanjiang
Dhaka
Khulna
Kolkata
Karachi
Surat
Mumbai
Viskhapatnam
Rangoon
Hai Phong
Manilla
Bangkok
Ho Chi Minh
Chennai
Cochin
Colombo
Davao
Maldives
Kuala Lumpur
Singapore
Palembang
Makassar
Jakarta
Surabaya
Brisbane
Sydney
Perth
Adelaide
Melbourne
US Dept of State Geographer
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CIRES
Google Earth
eye alt 7997.88 mi

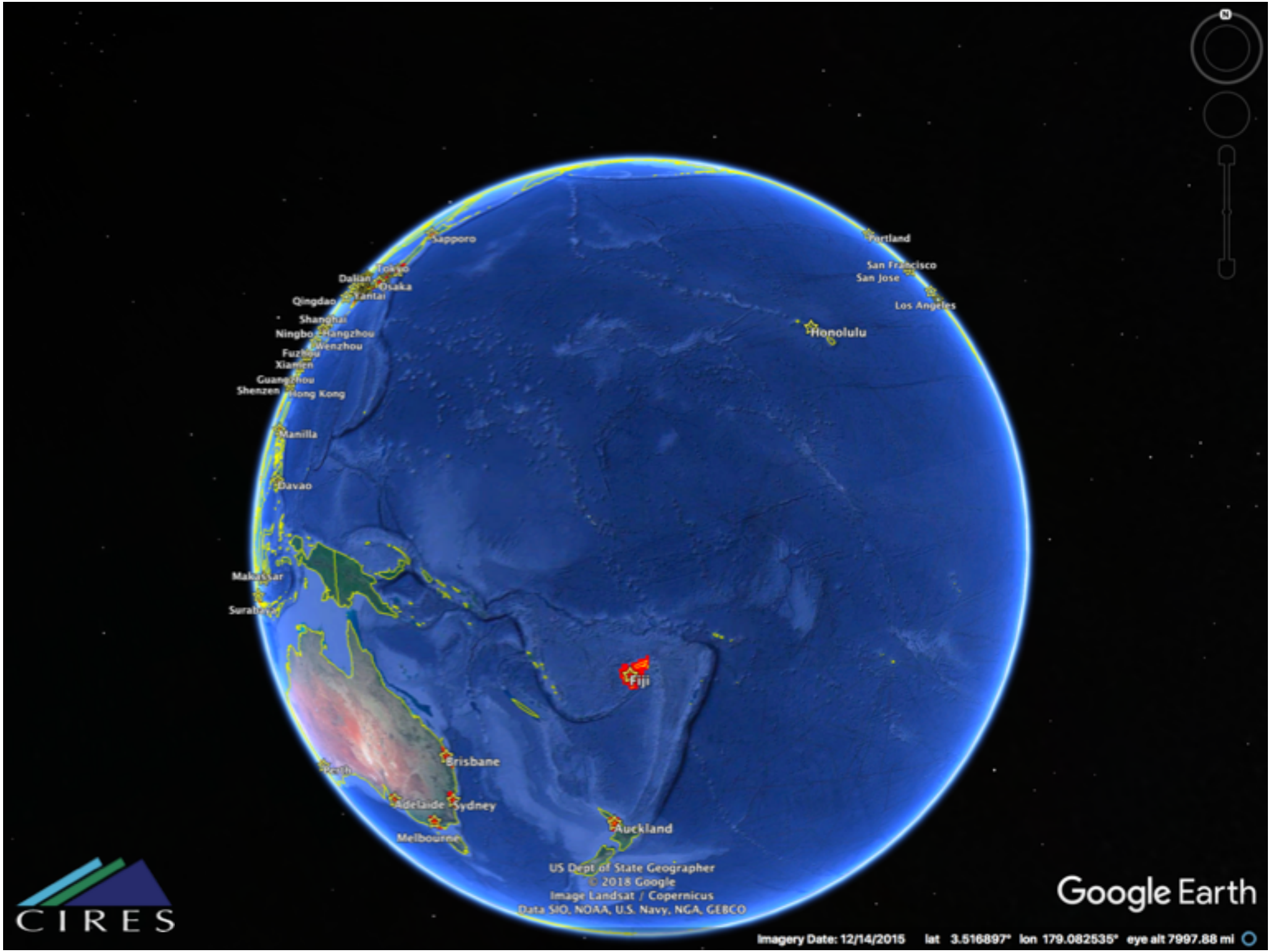
Sapporo
Portland
San Francisco
San Jose
Los Angeles
Honolulu
Tokyo
Dalian
Osaka
Tantai
Qingdao
Shanghai
Ningbo
Hangzhou
Wenzhou
Fuzhou
Xiamen
Guangzhou
Shenzen
Hong Kong
Manilla
Davao
Makassar
Surabaya
Fiji
Brisbane
Perth
Adelaide
Sydney
Melbourne
Auckland
US Dept of State Geographer
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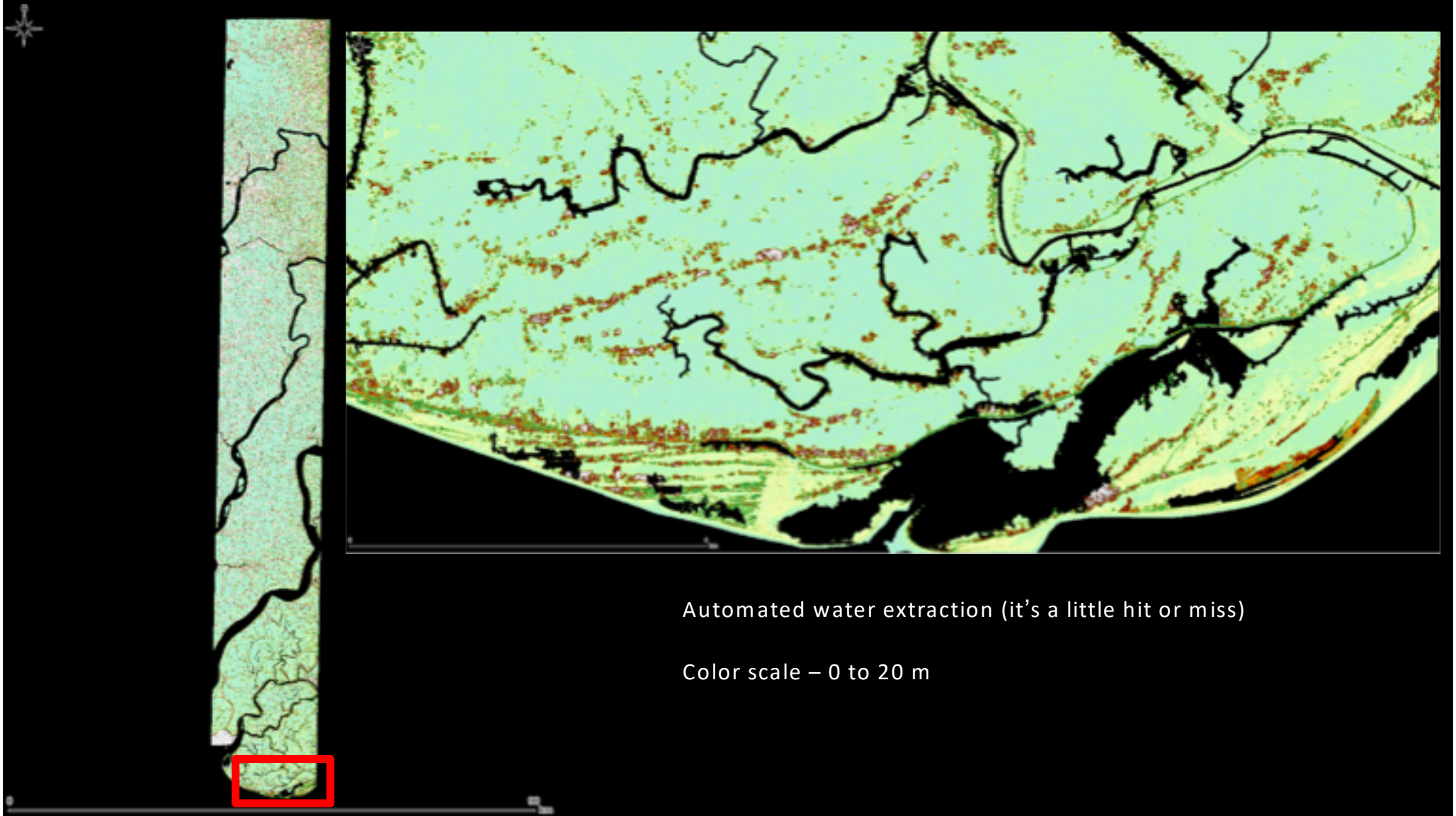
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google Earth
Imagery Date: 12/14/2015 lat 3.516897° lon 179.082535° eye alt 7997.88 mi
CIRES

Bangladesh



Automated water extraction (it's a little hit or miss)

Color scale – 0 to 20 m

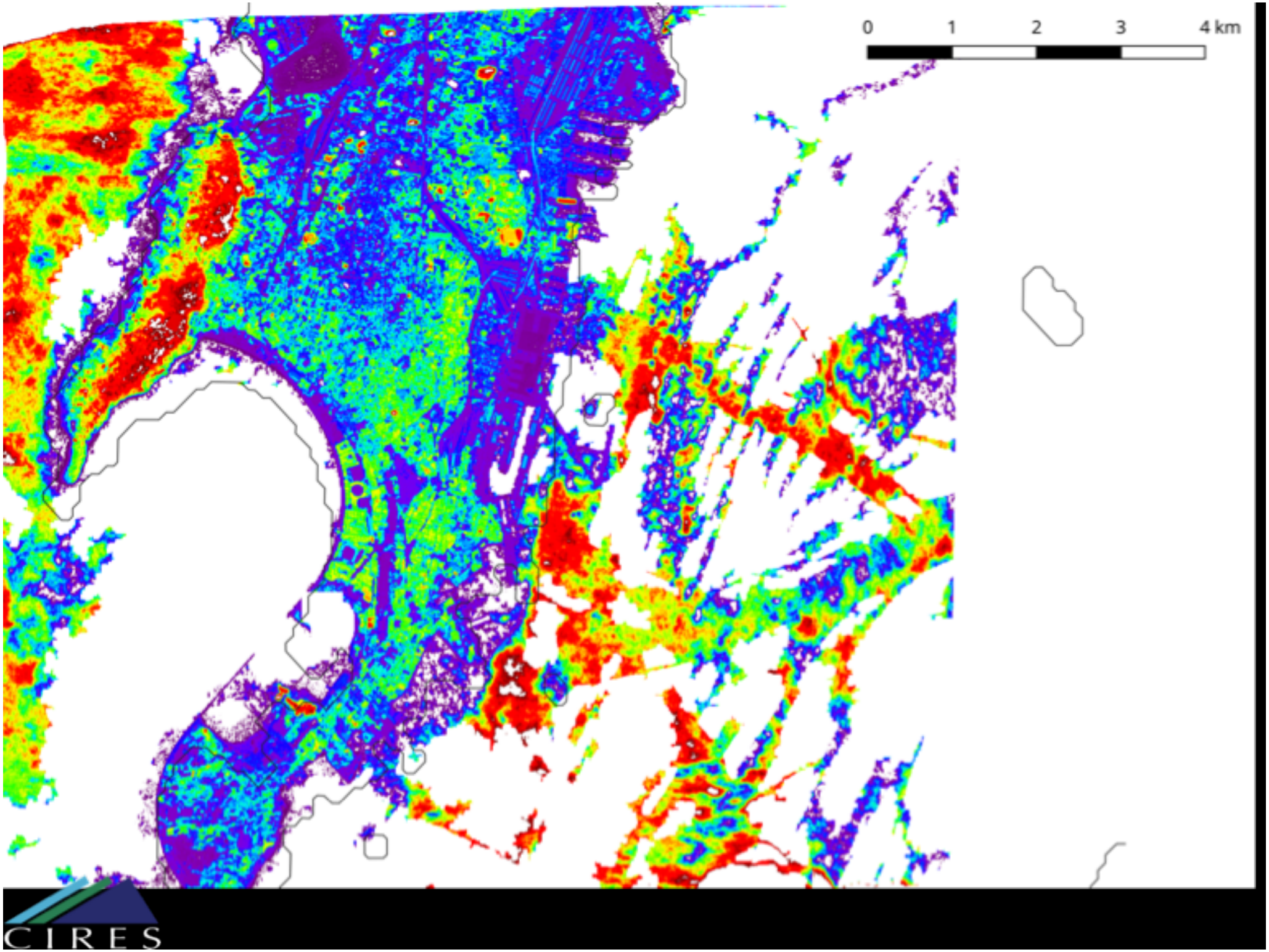
CIRES

Inundation studies of urban centers and vulnerable coasts – With Steve Nerem

ORTHO PHOTOS OF SUNDABUNS

Sundabun Mangroves, southern Bangladesh 2m posting – color scale 20m

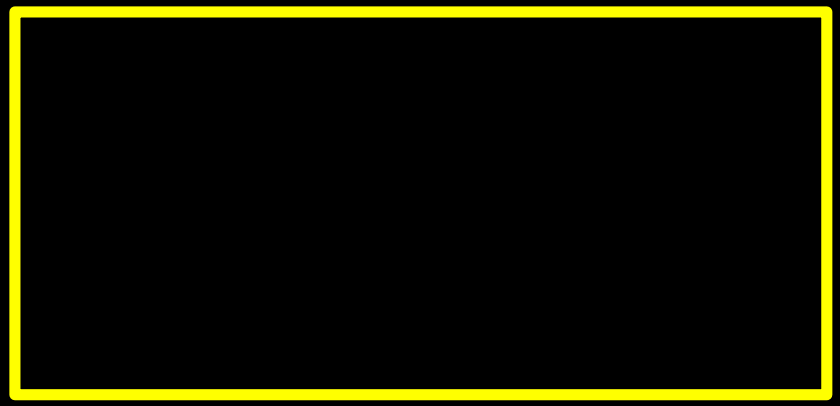
CIRES


0
1
2
3
4 km
CIRES

ORTHO IMAGE OF MUMBAI

CIRES

ORTHO IMAGE OF MUMBAI



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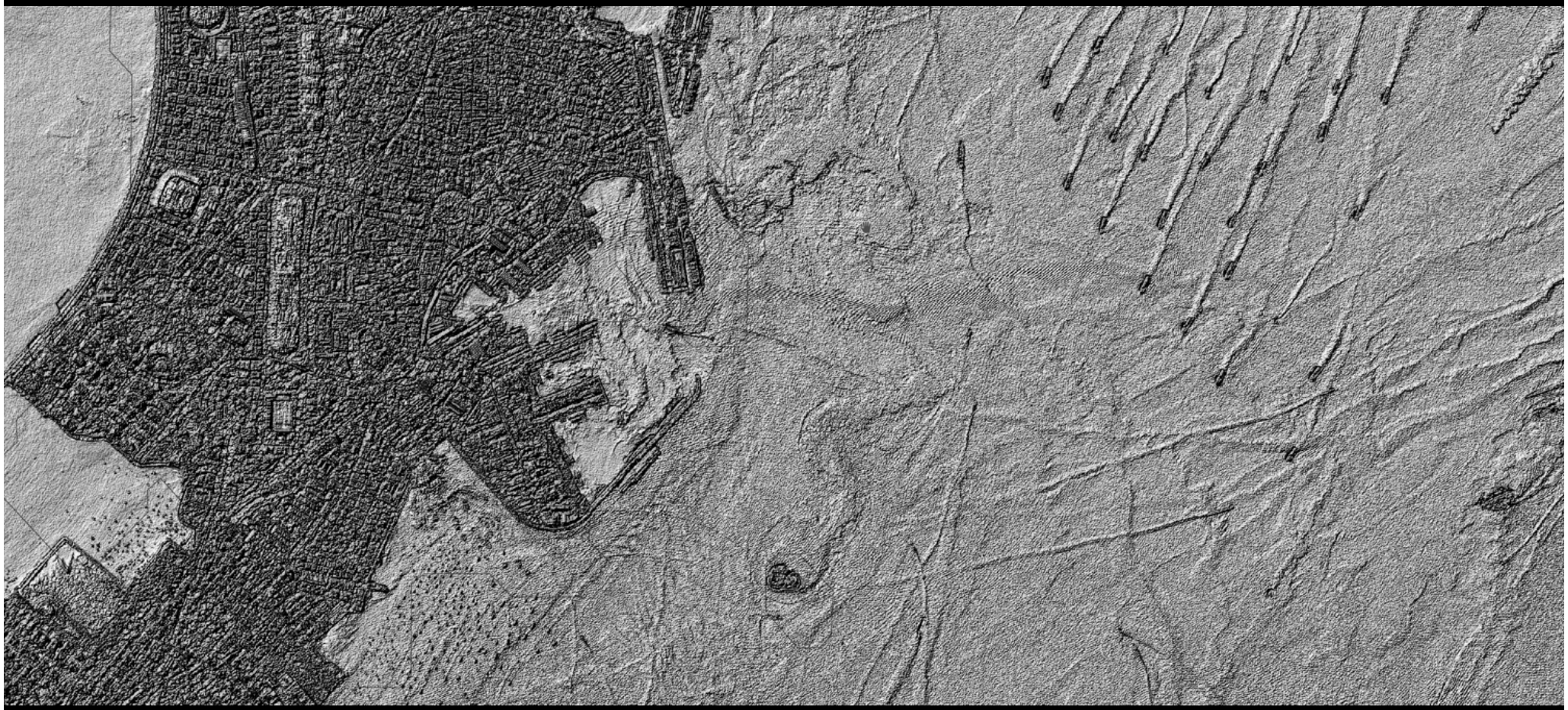
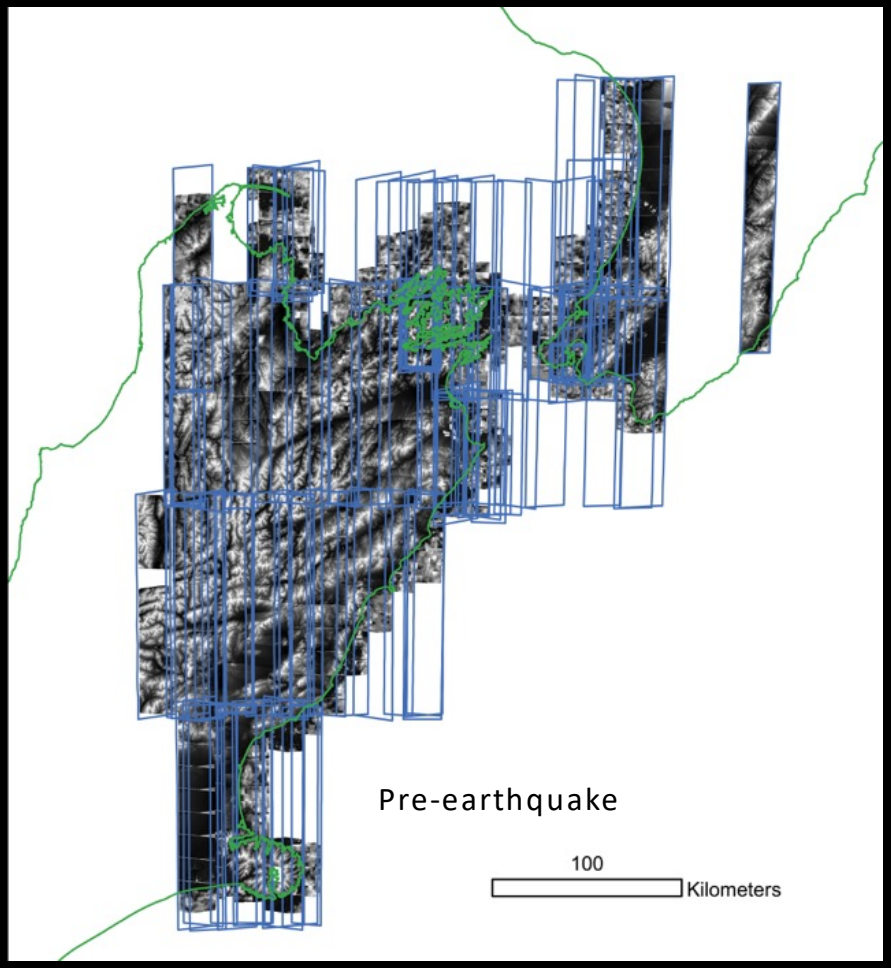
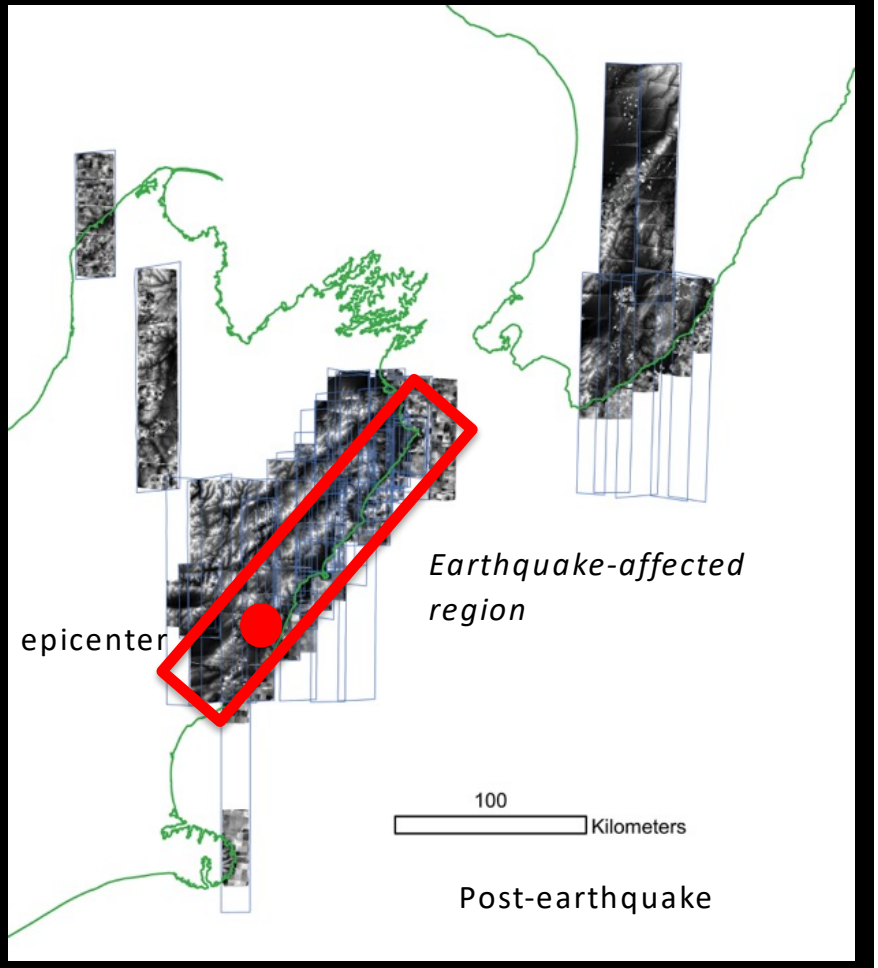


CIRES

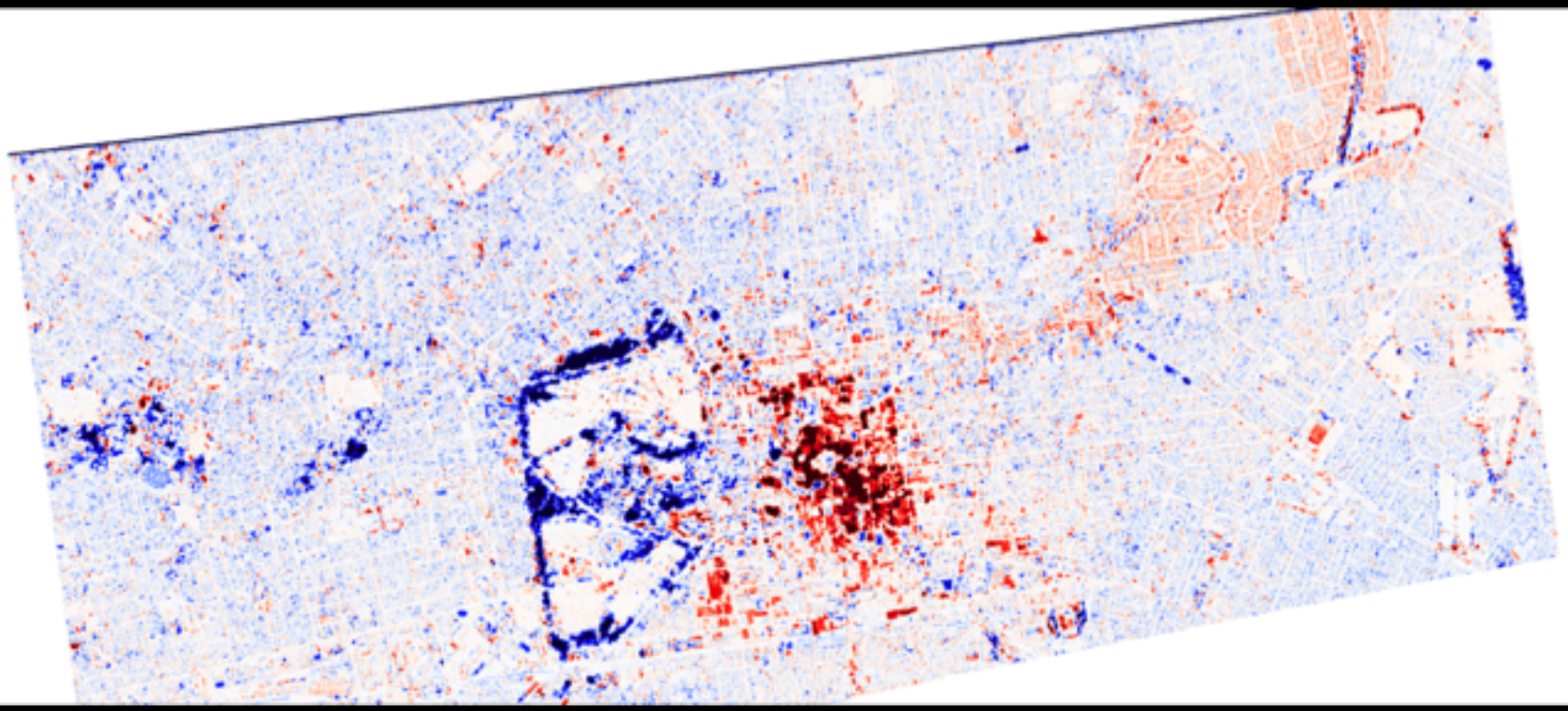
2m Satellite DSM coverage of the New Zealand 2015 Kaikoura M7.8 earthquake affected region





CIRES

Subsidence and building destruction after earlier Christchurch NZ



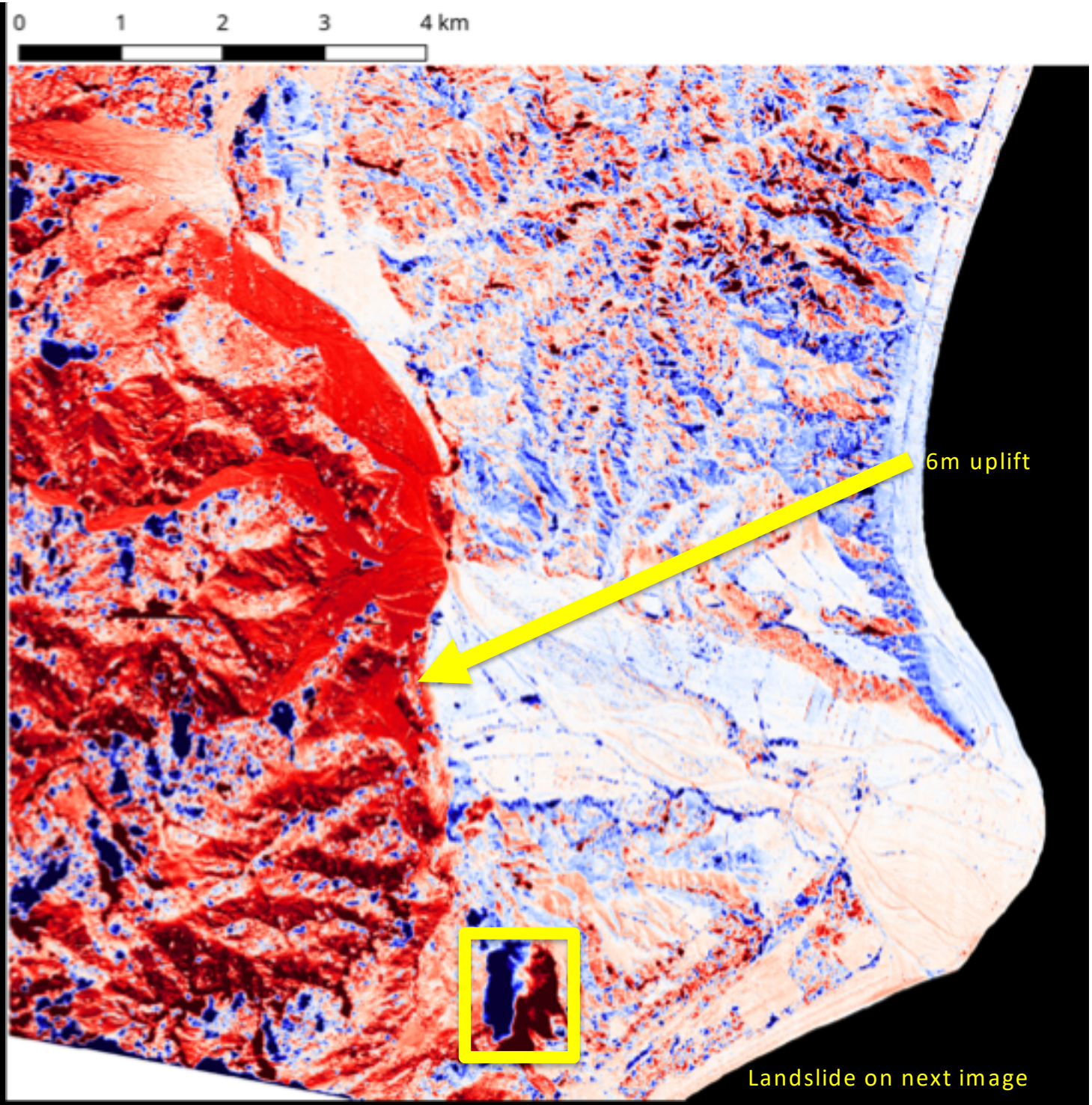
Supported by NSF RAPID Geomorphology and Land Use Dynamics, Tectonics and Engineering for Natural Hazards

CIRES

Papatea Fault Rupture,
Waipapa Bay,
Kaikoura Earthquake, NZ

Allows strain and rupture close to faults to be examined. InSAR usually decorrelates close to a fault.

High-res provides more information on shallow depth strain to fault modelers. Improves models and understanding of seismic risk.



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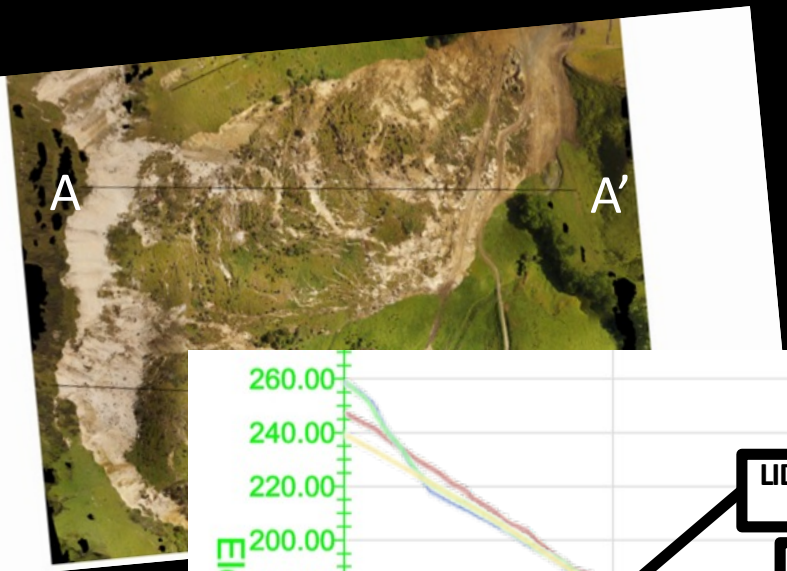
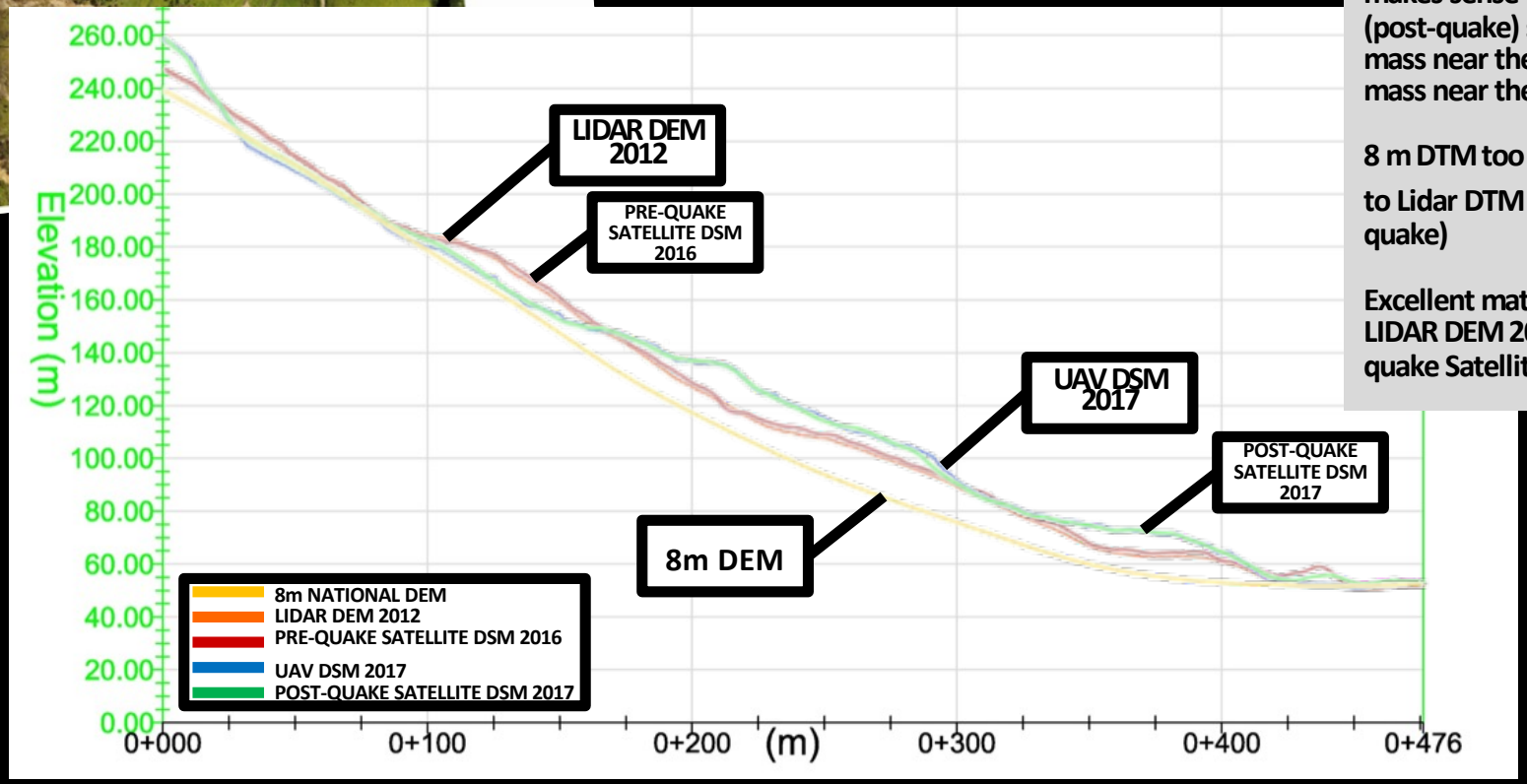




LIDAR DEM (pre-quake)

makes sense with UAV DSM (post-quake) showing more mass near the crest and less mass near the toe

8 m DTM too rough compared to Lidar DTM (both pre-quake)

Excellent match between LIDAR DEM 2012 and pre-quake Satellite DSM

Comparison of Worldview DSM and Drone DSM.
Mean difference of -0.01 m and standard deviation of ~2m

Marin Clark

Taan Fjord Landslide and Tsunami

Collaborators:
Bretwood Higman, Ground Truth Trekking
Dan Shugar, University of Washington – Tacoma
+ Many, many, many others

Funded by NSF EAR Geophysics.

Collaboration between various Universities in US and Canada, US Geological Survey, the National Park Service and local Alaskan 501c3 organizations.

Processed on local HPC resources.

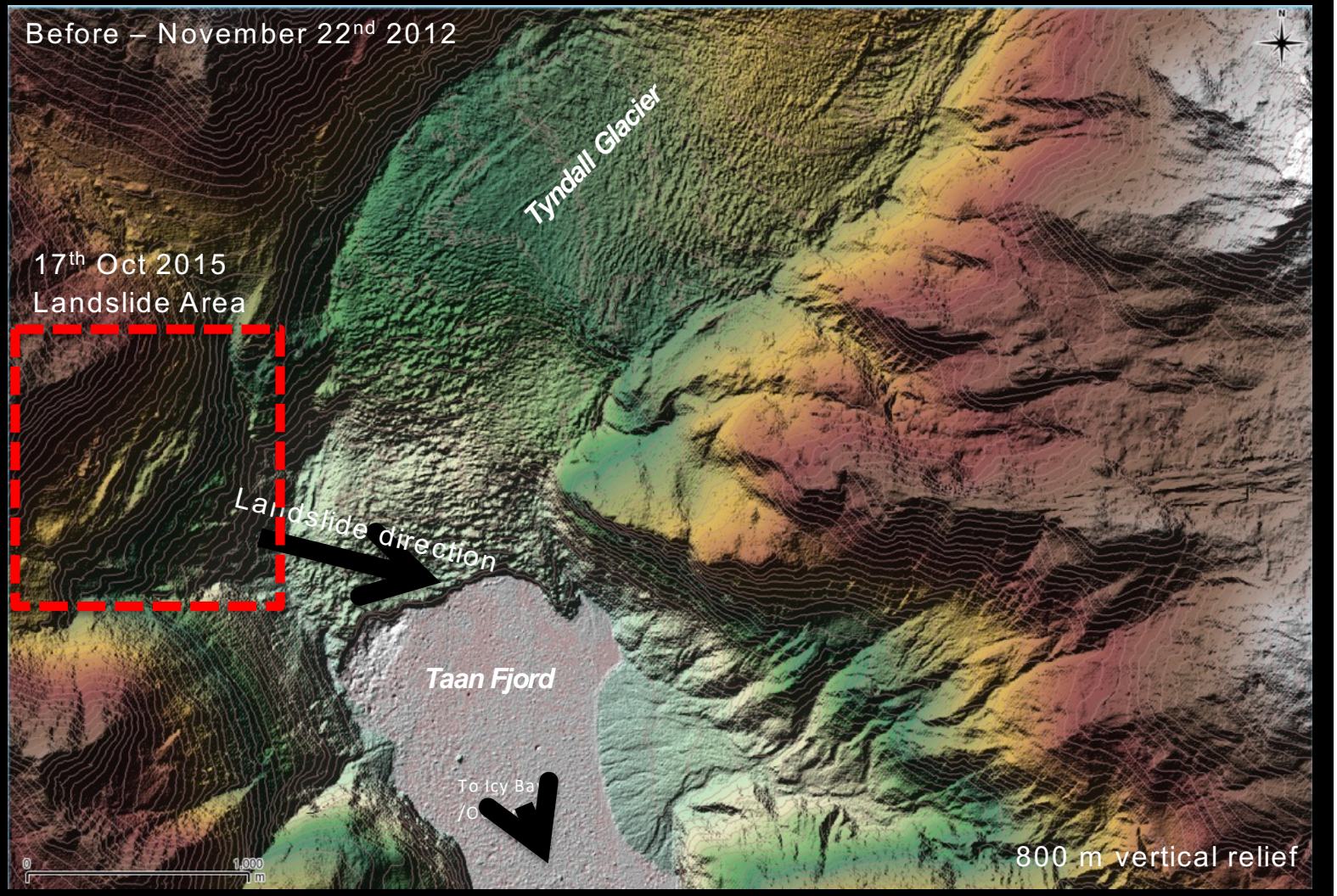
Premise: Glacier retreat leaves behind fjord walls and mountain slopes that are “over steepened.”

Over-steepened slopes are prone to failure, especially in regions where earthquakes occur.

The resulting landslides, if they hit a fjord, produce the largest tsunami waves ever measured.

The implications for the cruise ship industry are clear, but the risks are extremely hard to quantify.

Tyndall Glacier has thinned rapidly in the last few decades.
Landslide occurred in an area that had slumped before, in 1995.

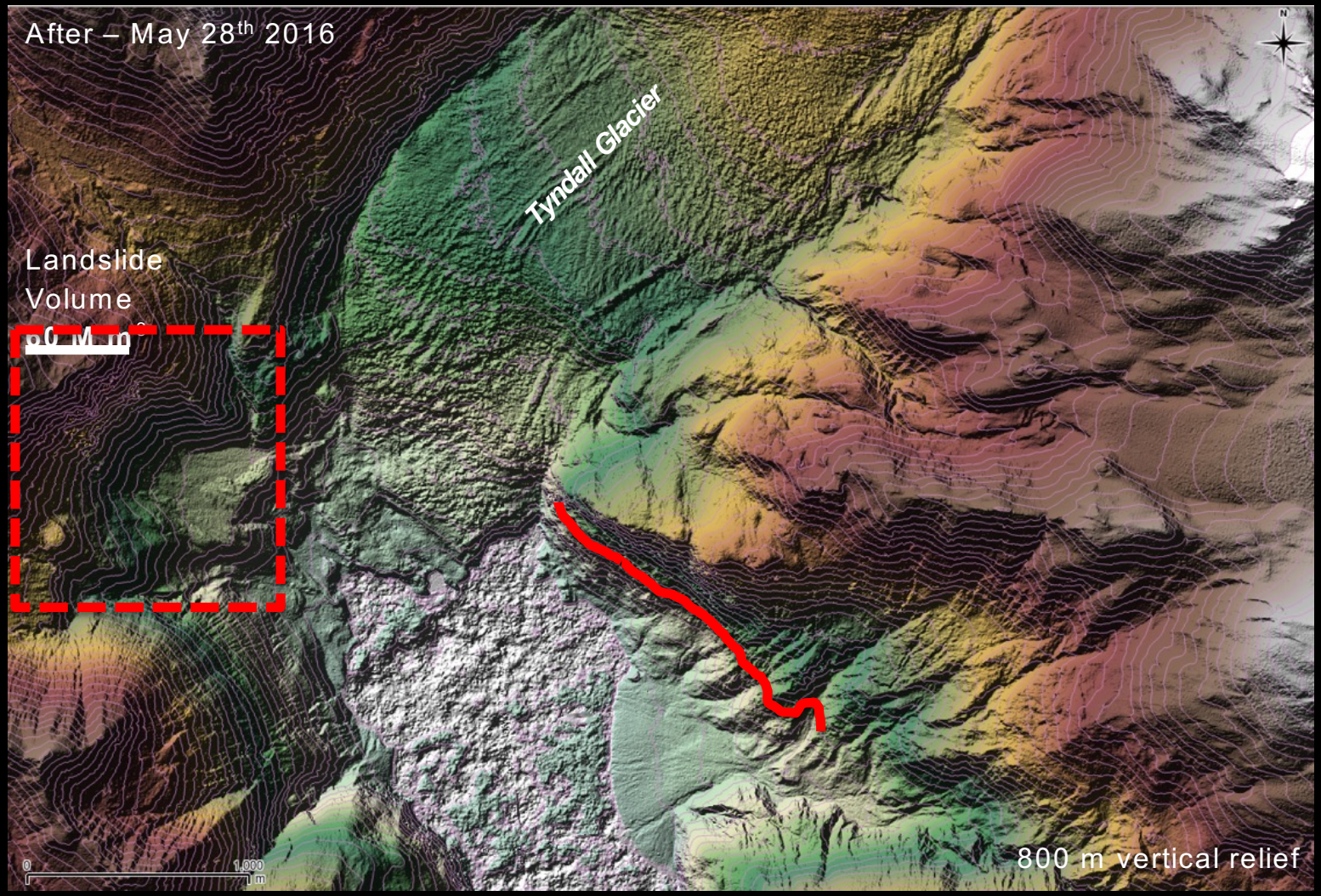


CIRES

Taan Tyndall Landslide, Alaska

NSF Award 1639010 The 2015 Taan Fiord landslide tsunami: An interdisciplinary study of cause & effect

Volume of slide, derived from difference of DSMs and converted to mass by assuming rock density is in near perfect agreement with estimates derived from seismic observations by Stark and Ekstrom at LDEO.

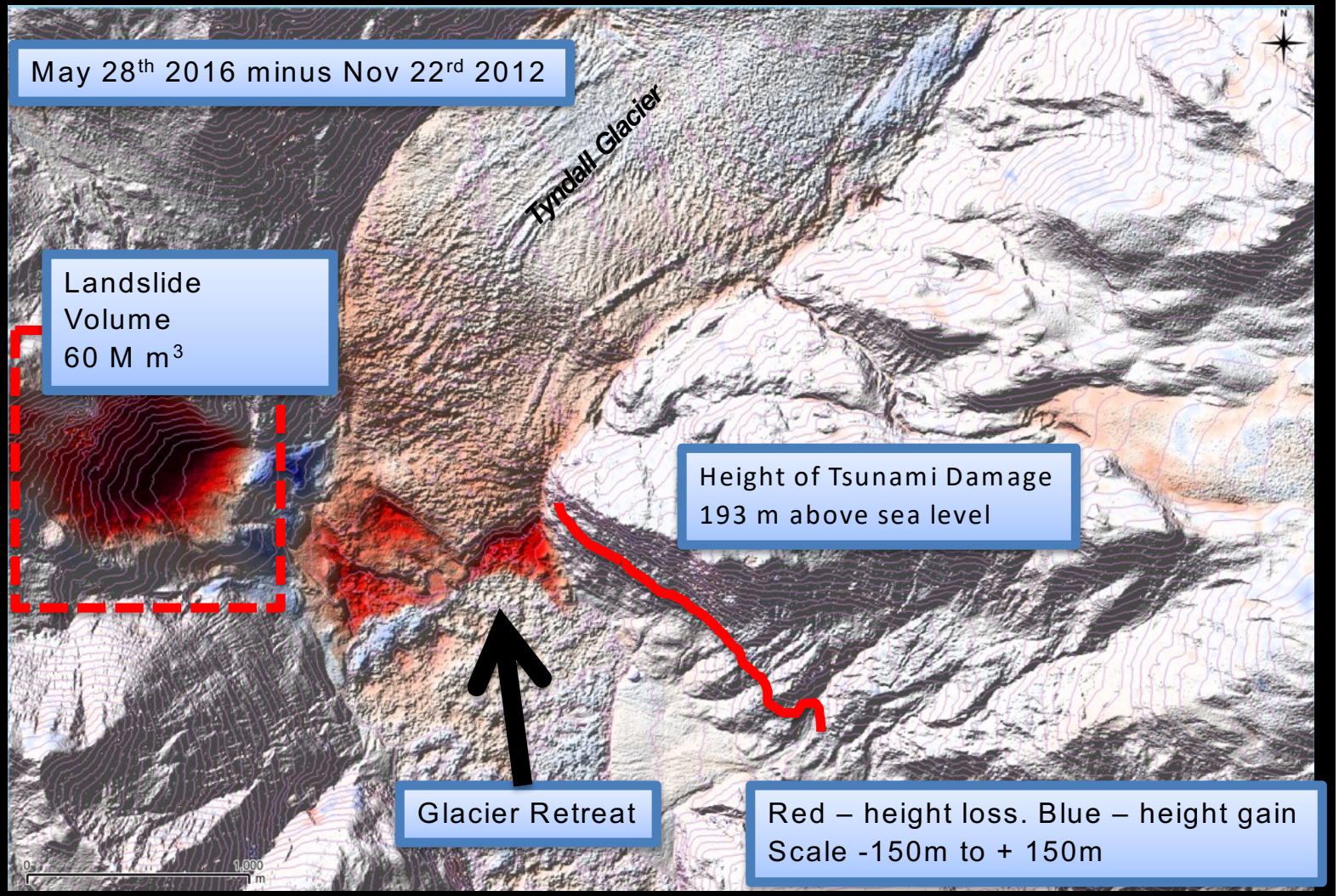


CIRES

Taan Tyndall Landslide, Alaska.

NSF Award 1639010 The 2015 Taan Fiord landslide tsunami: An interdisciplinary study of cause & effect

Combined field and remote sensing project is ongoing, examining morphology and sedimentology of tsunamigenic deposits on far side of fjord.



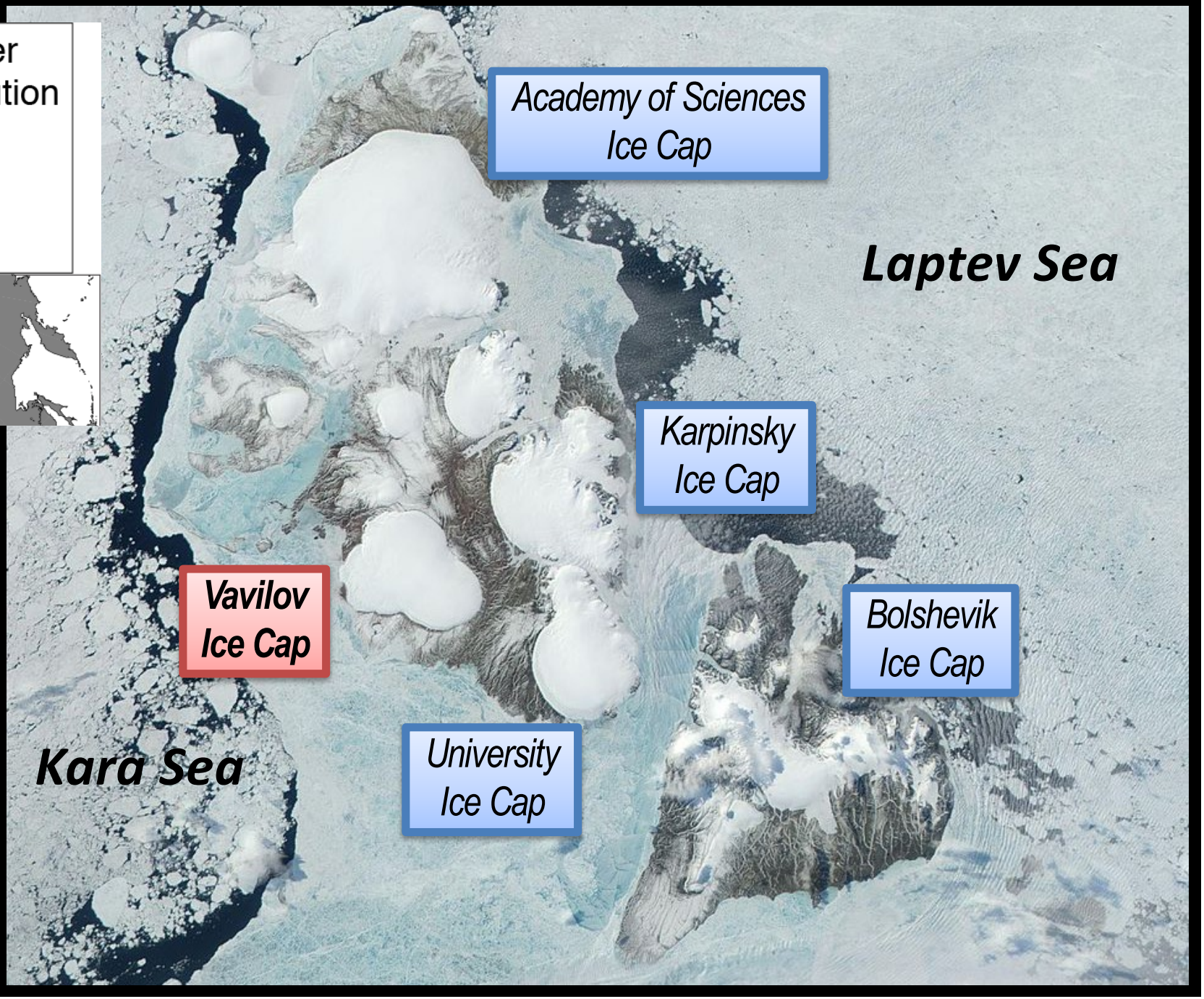
CIRES

Catastrophic Collapse of an Arctic Ice Cap

Rational

- Arctic sea ice extent, volume and persistence is decreasing.
- More moisture is available to the atmosphere, radiation balances are changing
- Precipitation patterns and intensity are changing (Increasing number of Arctic storms)
- How do these changes affect cold-based ice caps of the Russian Arctic?

Location: Severnaya Zemlya



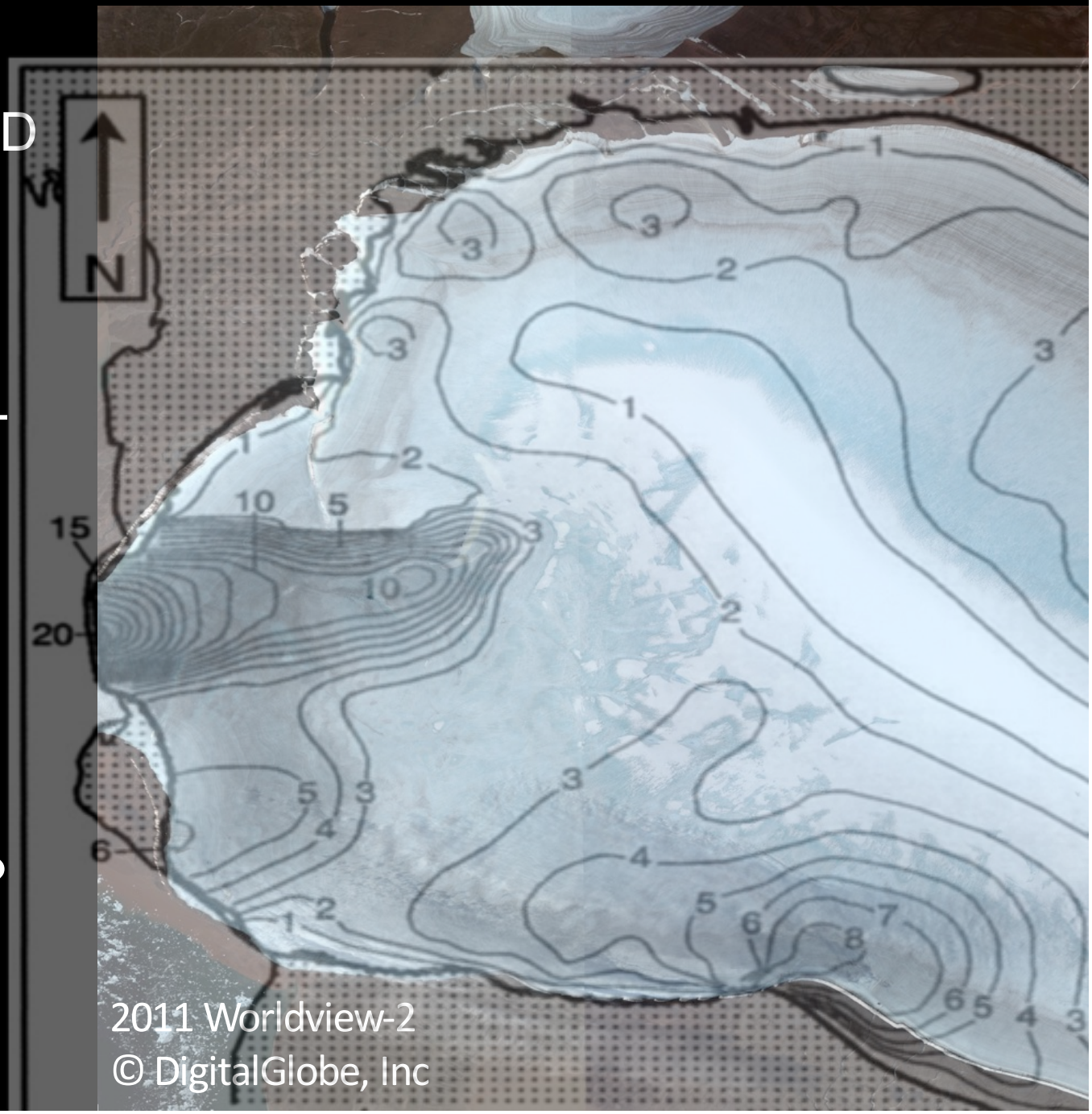
NASA, 2001

Vavilov Ice Cap

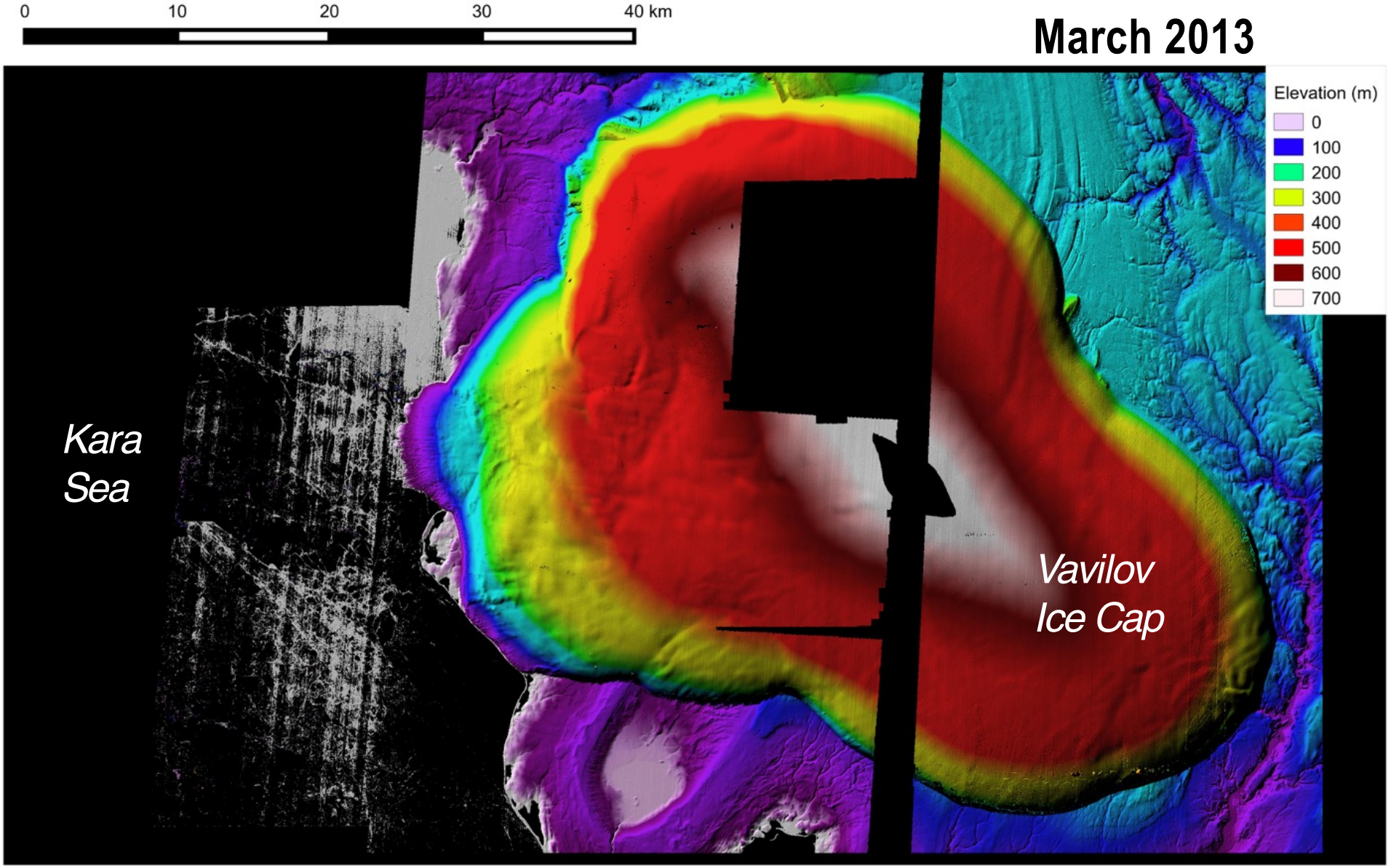
SEDIMENT BANDS CONTINUOUS AROUND CIRCUMFERENCE OF ICE CAP.

DISTORTED IN WEST WHERE ICE FLOW IS 20M/YR IN 1996.

LIKELY SOME SLOW BASAL SLIDING – MARINE SEDIMENTS?



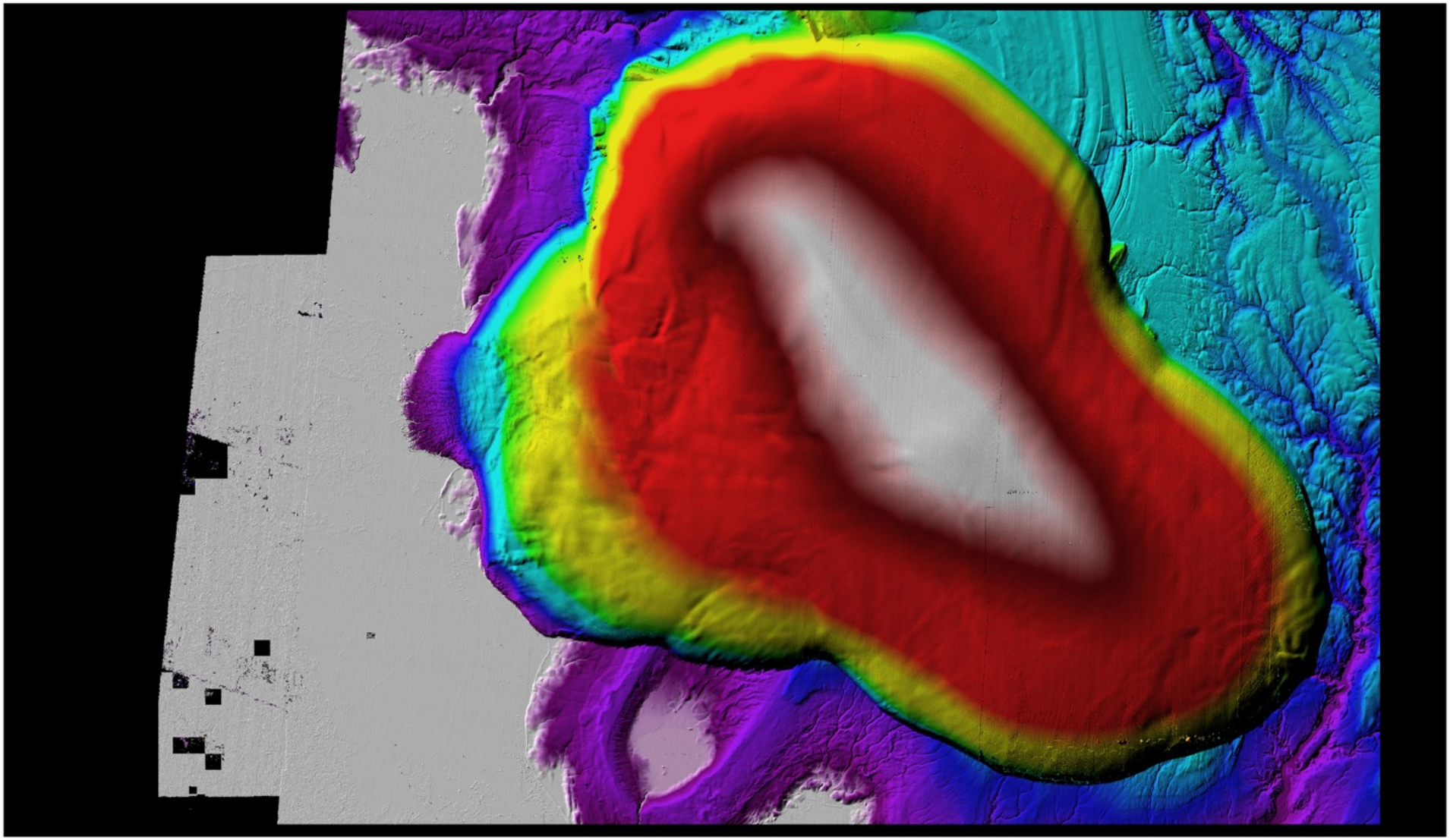
Vavilov Ice Cap



Worldview DEMs from DigitalGlobe Imagery

Vavilov Ice Cap

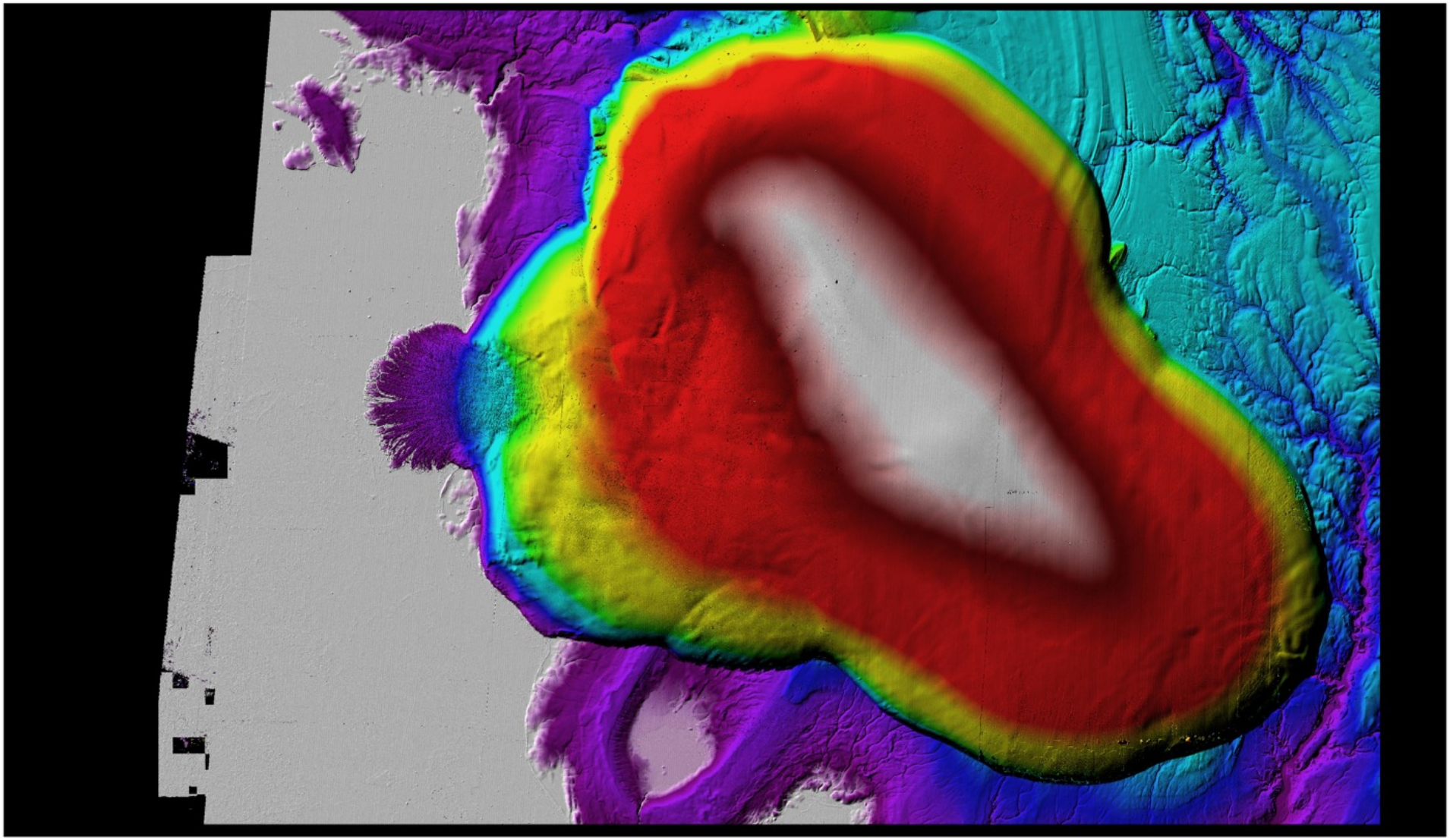
March 2014



Worldview DEMs from DigitalGlobe Imagery

Vavilov Ice Cap

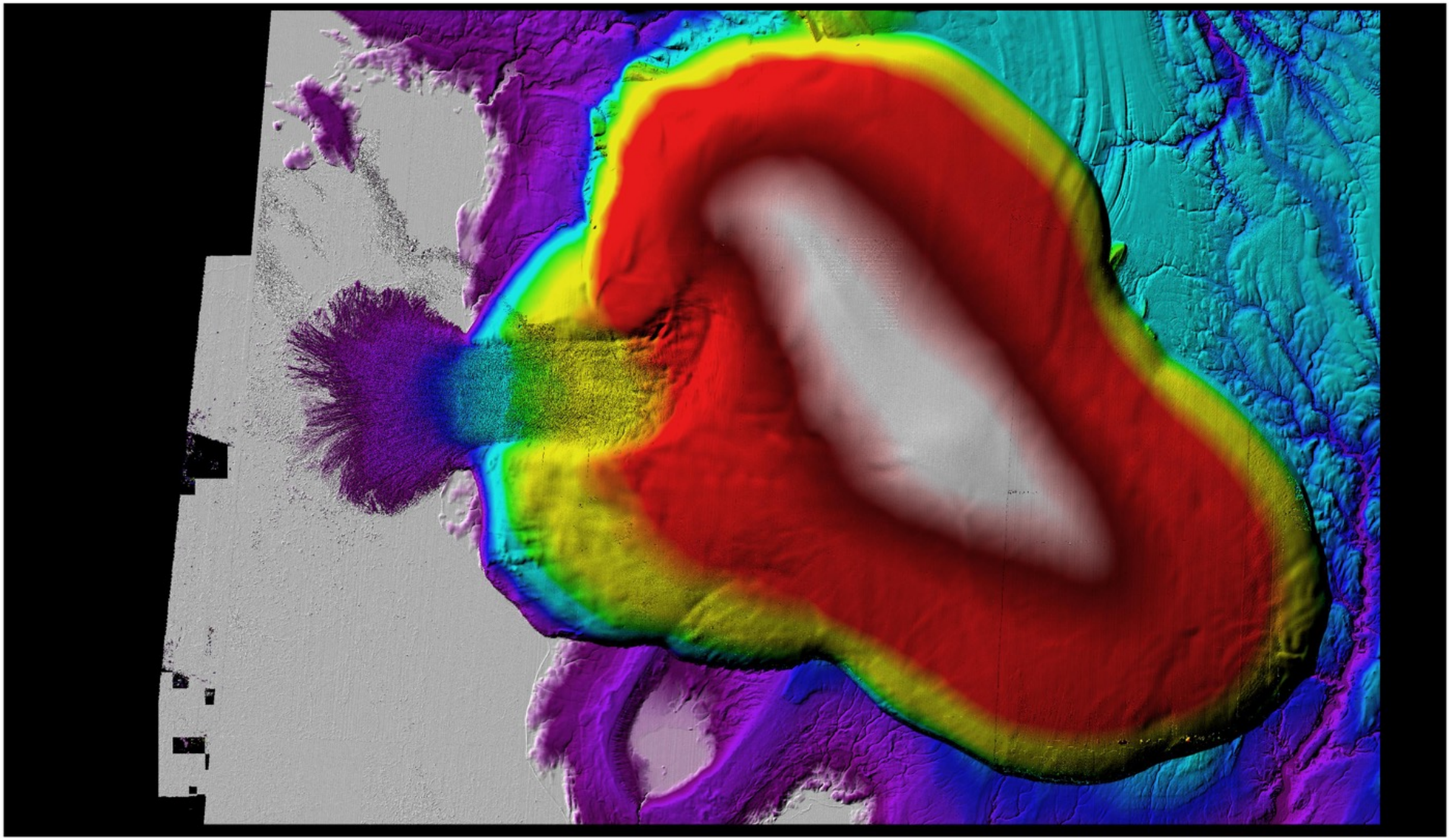
March 2015



Worldview DEMs from DigitalGlobe Imagery

Severnaya Zemlya

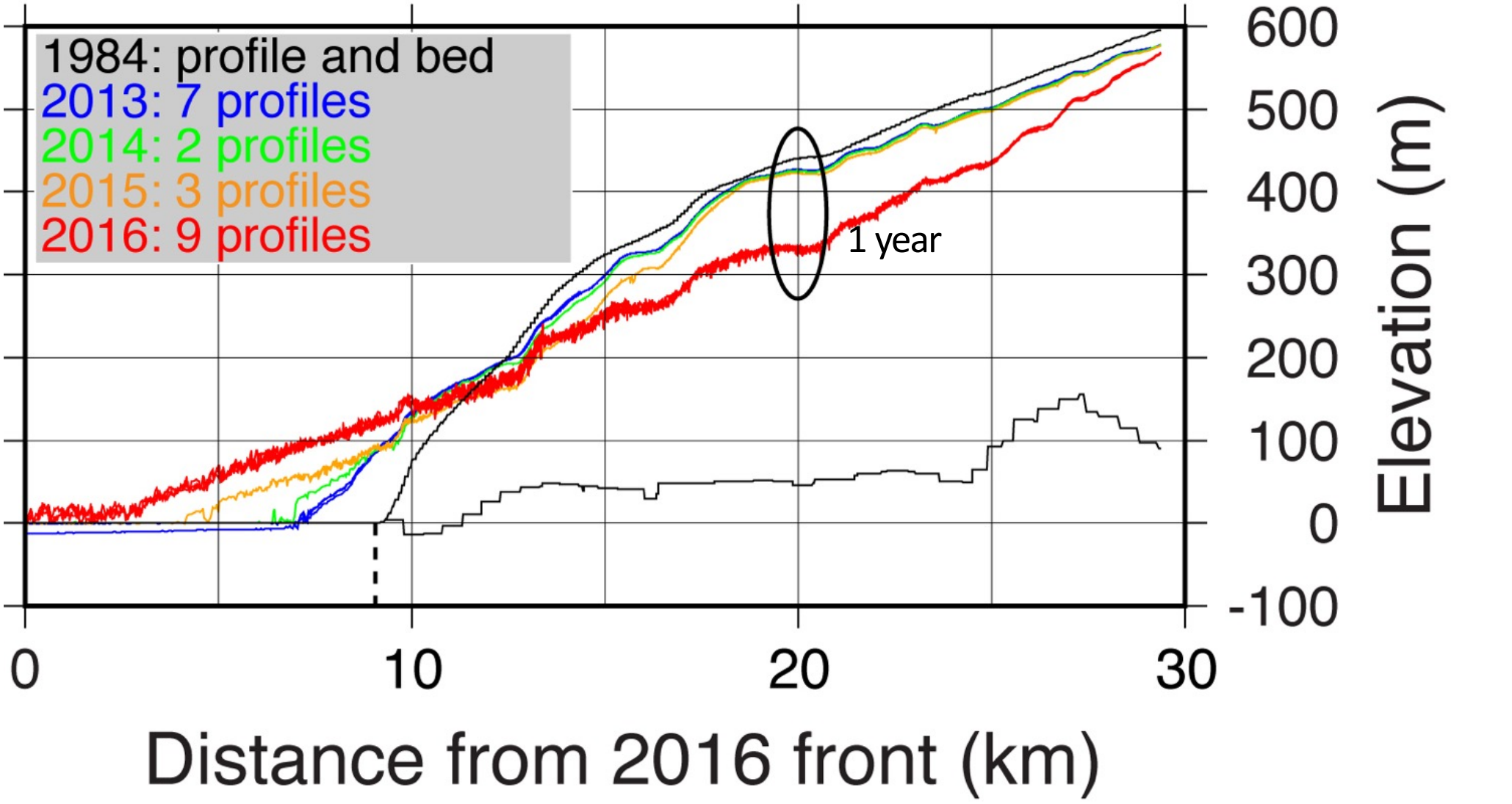
March 2016



Worldview DEMs from DigitalGlobe Imagery

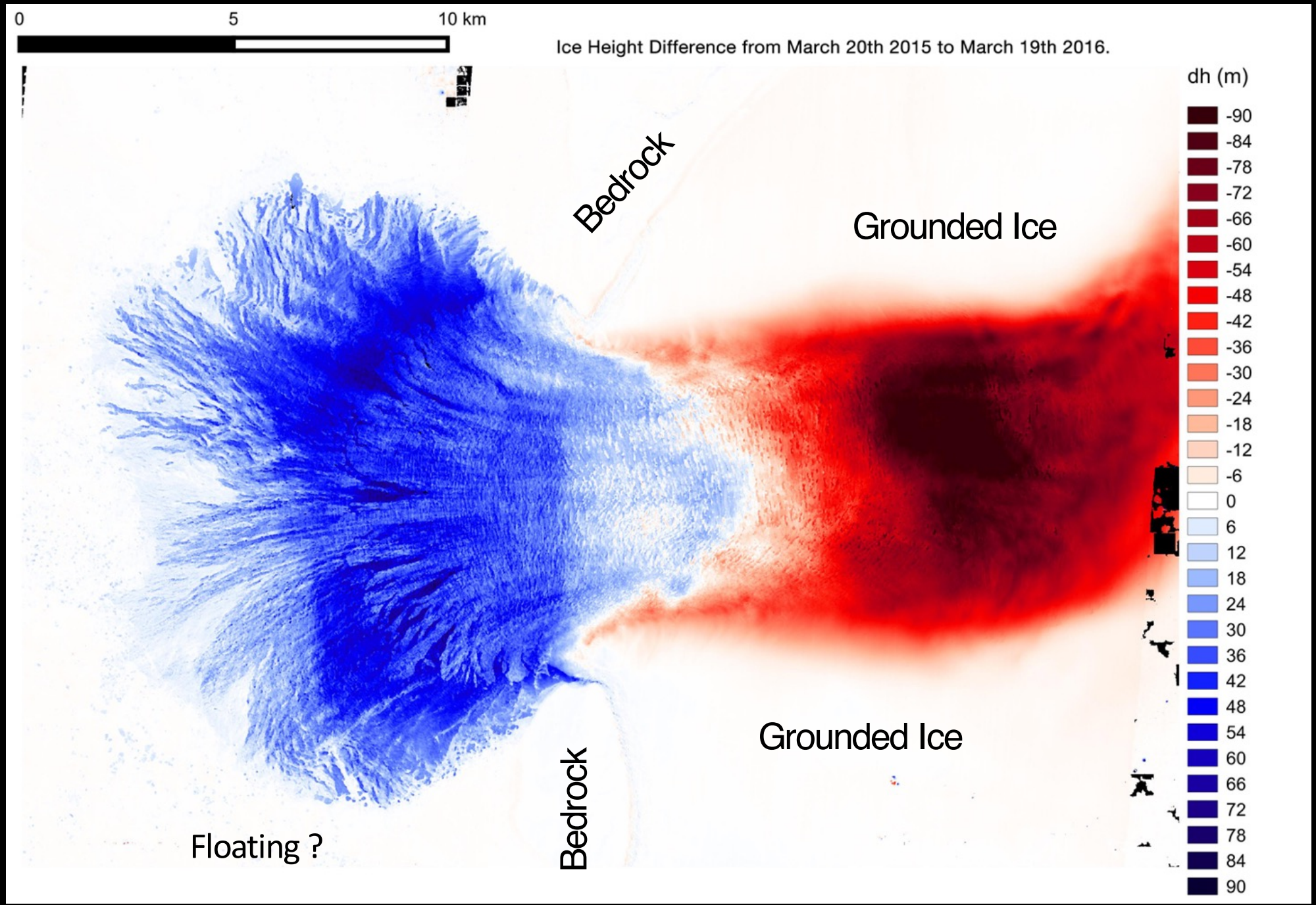
Vavilov Ice Cap

Centerline Elevation Profiles

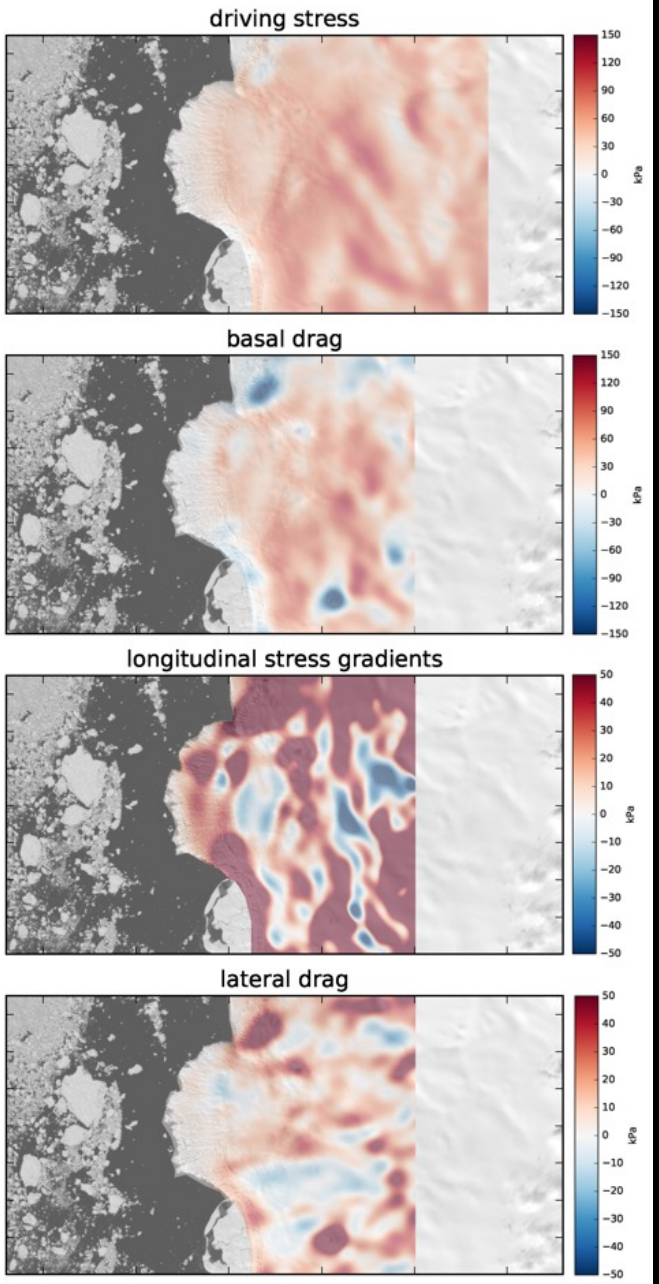


Bed from J. Dowdeswell

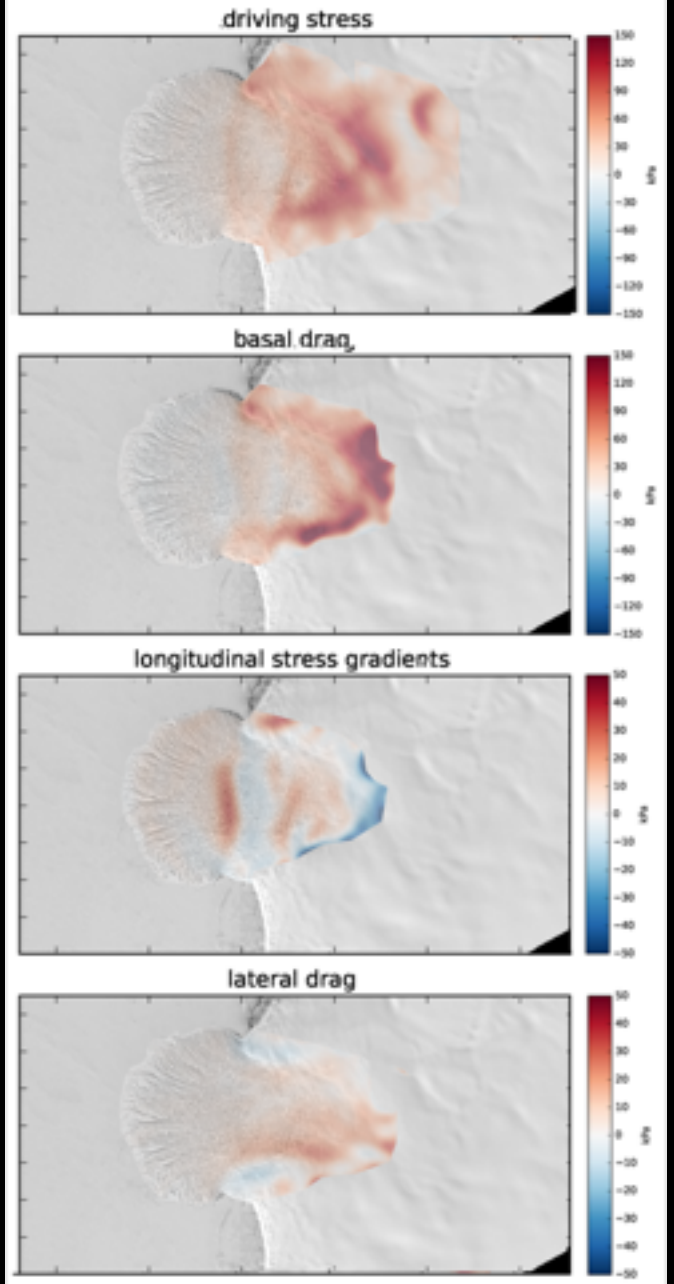
Vavilov Ice Cap



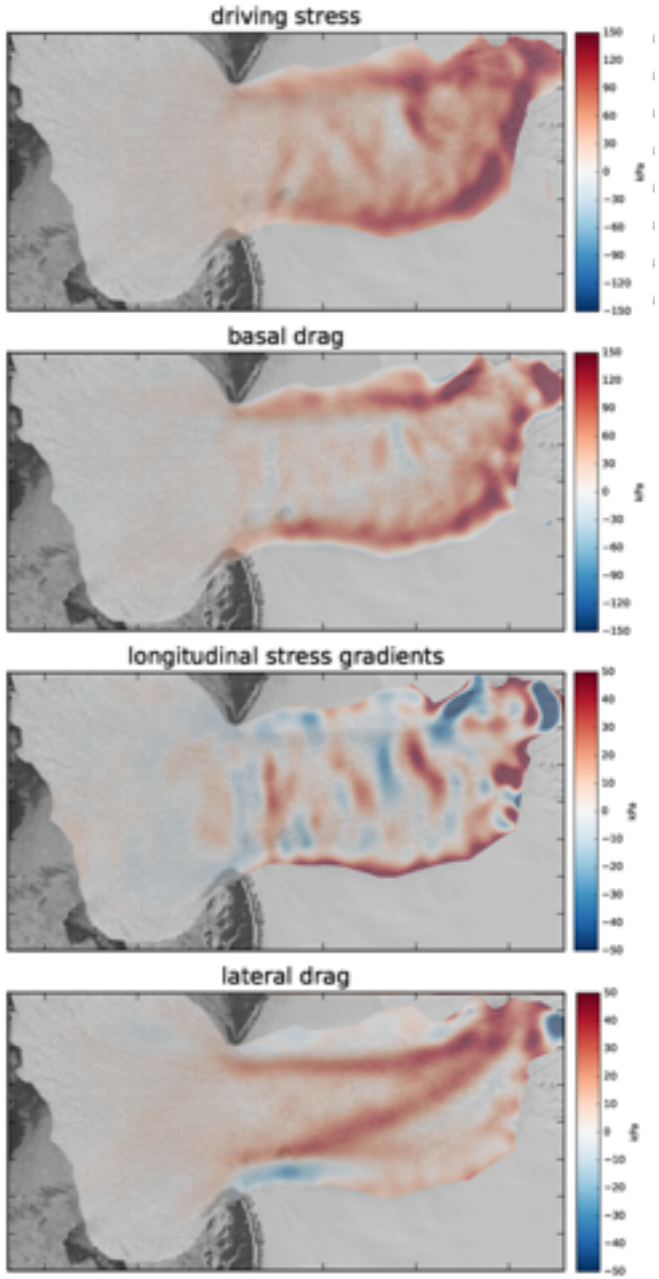
2013



2015



2016



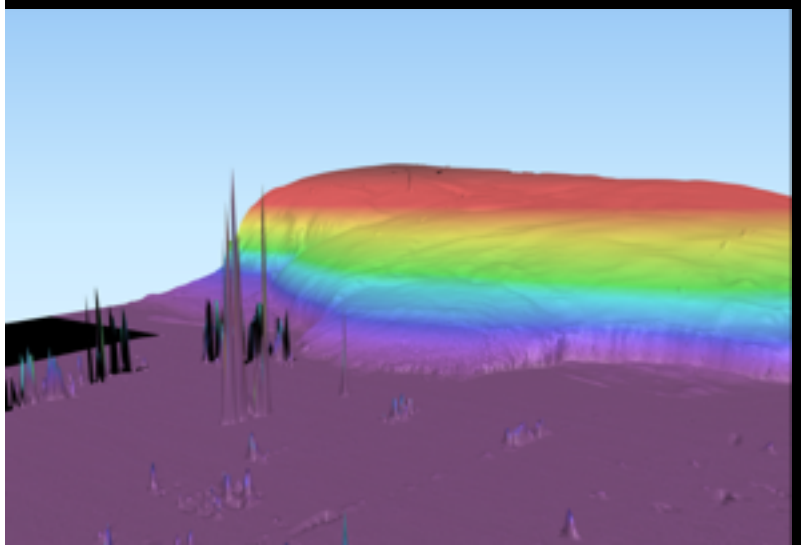
Vavilov Ice Cap

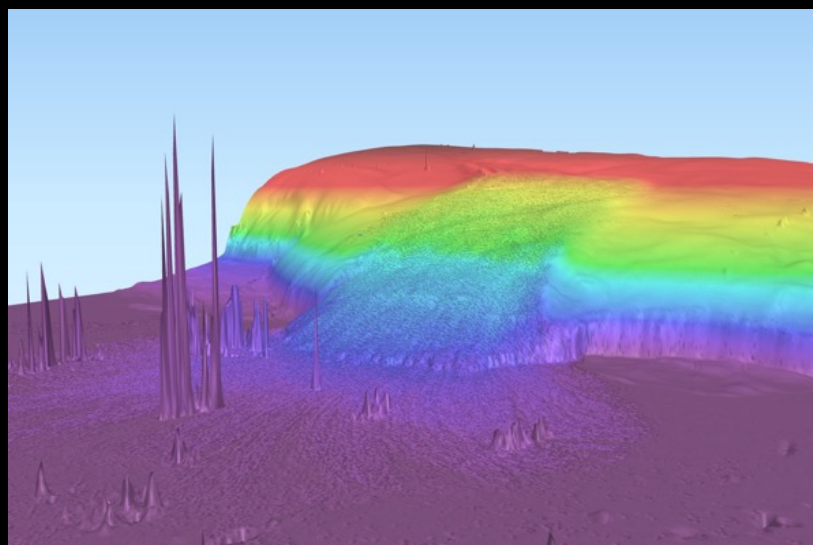
Average mass change for Vavilov Ice Cap

1984 to April 2013: -0.04 ±0.02 $km^3\ yr^{-1}$ w.e.

April 2014 to April 2015: -0.84 ±0.004 $km^3\ yr^{-1}$ w.e.

April 2015 to April 2016: -4.48 ±0.004 $km^3\ yr^{-1}$ w.e.
(~0.9 % of the ice cap)





Vavilov Ice Cap

Questions remain:

- Why and how did the ice speeds and elevation changes occur so rapildy at an, until now, mostly cold based ice cap?

Influence of unconfined front?

How is ice entrained into the floating piedmont?

Influence of marine sediments?

Cryohydrological warming?

Happening elsewhere?

Conclusions

New capabilities allow detailed investigation of the Arctic.

Vavilov Ice Cap, really started surging in late 2015.

Surge initiated as the ice front advanced onto low friction sediments. Inland speed increase likely generating water – has transitioned from cold based bed to temperate environment.

Largest single source of mass loss in the Russian Arctic.

Summary and Future

About 1/5TH of the planet now covered with 2m posting DEMs.

Accuracy close to airborne LIDAR

ArcticDEM Open to public, interface in active development, New tiles will be 2m instead of 5m

Future SETSM

Planet Labs, Worldview Scout and Legion Sats?

Doing Urban Centers around the planet + the entire country of Bolivia.

New Filters

Acknowledgments

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All elevation models were produced using data from DigitalGlobe, Inc

Using Bluewaters Petascale Compute Facility at University of Illinois
University of North Carolina, Chapel Hill High Performance Computing resources
University of Colorado, Boulder HPC resources
Beginning to use NCCS @ GSFC.