Enhanced Very-High Resolution (EVHR) Products for NASA's Earth Science Investigators

Short project title: EVHR Products

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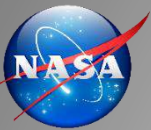
Matthew Macander (Co-I, ABR)

Dr. Scott Geotz (Collaborator, NAU)

Dr. Gerald Frost (Collaborator, ABR)

Dr. Jorge Pinzon (Collaborator, SSAI NASA-GSFC)

Dr. Daniel Duffy (Collaborator, NASA-GSFC)

* Margaret Wooten (SSAI, NASA-GSFC)

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Roger Gill (Inovim, NASA-GSFC)
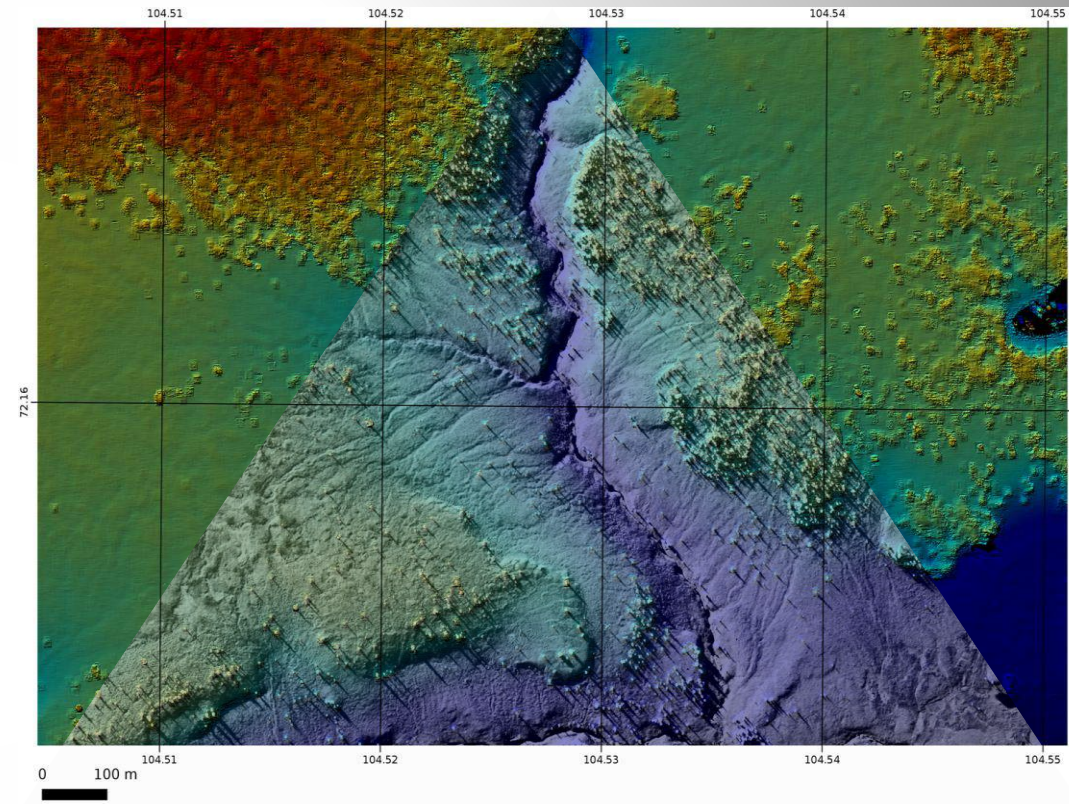
Example of a color-shaded relief version of a WorldView DSM overlayed with panchromatic pseudo color orthoimage in northern Siberia. ©DigitalGlobe NextView 2014

Outline

1) **Overview of the Enhanced Very-High Resolution (EVHR) products project**
   – Current status of "no-direct cost access" to DigitalGlobe data
   – Scientist needs for commercial sub-meter data products
   – Science products derived from the API
   – Project timeline and status

2) **Examples of how derived products are used in Earth Science (brief literature review)**
   – Terrestrial ecology
   – Cryospheric sciences
   – Hydrology
   – Training data for thematic mapping classification algorithms
   – Validation/site characterization

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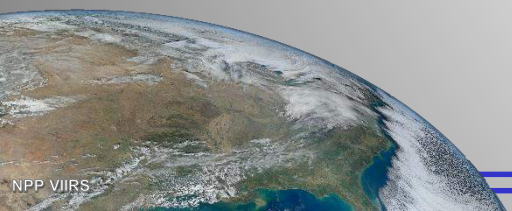
Commercial Data Status

1. The volume of commercial sub-meter remotely sensed data is growing at rates exceeding petabytes per year and the costs for data storage systems and computing have both dropped exponentially.

2. US federal contracts and licensing agreements with DigitalGlobe has opened the door for "Big Data" processing to characterize land surface phenomena in HEC environments yet integration into NASA Earth Science has been slow (Neigh *et al.* 2013).
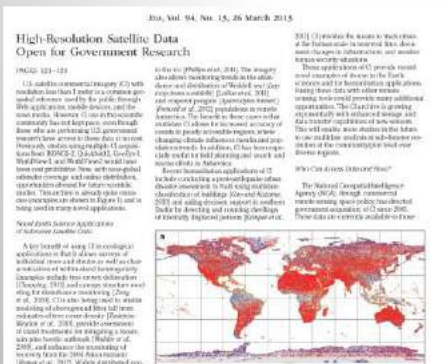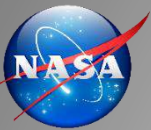
Neigh et al. 2013 EOS

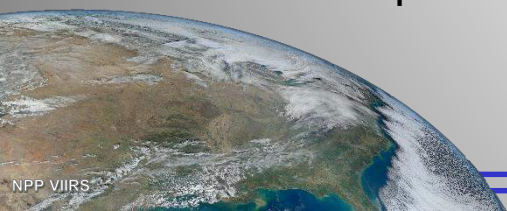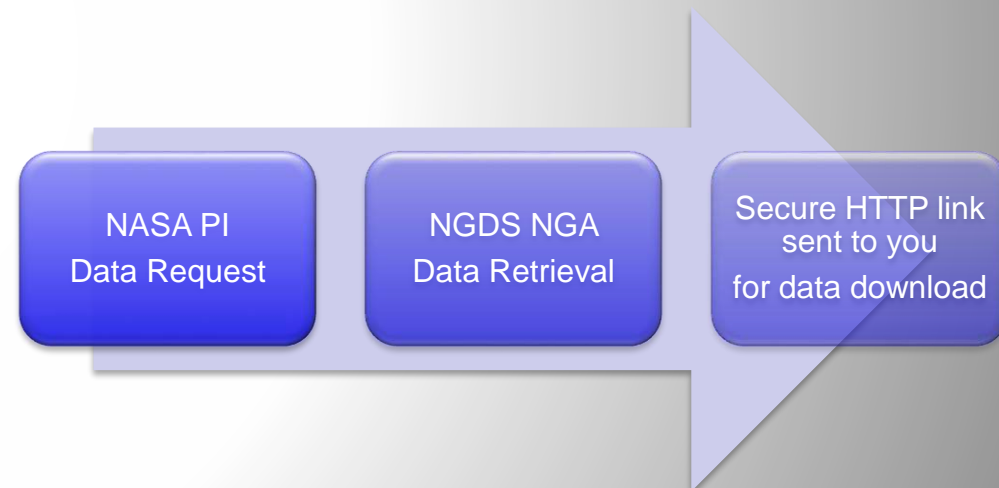**Data are difficult to use by Earth scientists for 3 main reasons:**

1. most of the very high-resolution (VHR) data received at NASA-GSFC are not in a standard, GIS-ready format, they come in Department of Defense (DOD) National Imagery Transit Format (NITF);

2. the data have poor horizontal and vertical co-registration; and

3. once ortho GeoTiffs are produced the data can have large file sizes (~5 Gigabytes for an individual image at 0.3 m to 30+ Gigabytes for a strip of those images) and require HEC environments to process and analyze many images in an efficient manner.
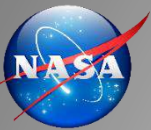
Access has been provided via NGA to archived DigitalGlobe imagery for use in NASA-funded research

- The National Geospatial-Intelligence Agency's (NGA's) extensive archive of commercial satellite data are available federally-funded users free of direct cost.

- We manage data acquisition for these users, many of whom are university affiliates without access to interfaces such as NGDS.

- Users register on our site, we verify NASA grant information for non-NASA users, provide license information and a data use agreement. Users are provided passwords that allow for data request submission, which we fill once signed DUAs are provided.

- Currently: 300+ registered users, over 8 years we have fielded > 400 user requests that have resulted in > 40 publications.

NGA Commercial Archive Data
Access to High-Resolution Data for NASA Earth Science Investigators

https://cad4nasa.gsfc.nasa.gov

| NASA PI Data Request | NGDS NGA Data Retrieval | Secure HTTP link sent to you for data download |

From our 8 years of experience delivering these data to NASA funded PI's, a bottleneck exists that impedes two common uses of these data:

1) Individual scenes for evaluation and validation of coarser resolution NASA EO products; and

2) Analyses of VHR scenes to quantify environmental phenomena with object-based classification or 3D-reconstruction from one of many individual VHR scenes.

The target audience is broadly the community of NASA-funded Earth scientists, specifically scientists funded through ABoVE, HiMAT, and registered users of cad4nasa.gsfc.nasa.gov. Access to the VHR data is limited to NASA-funded researchers so we are targeting the ABoVE and HiMAT communities that are already users of the ADAPT system.
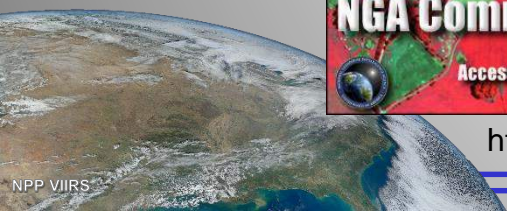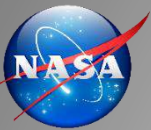

https://above.nasa.gov/

http://cad4nasa.gsfc.nasa.gov
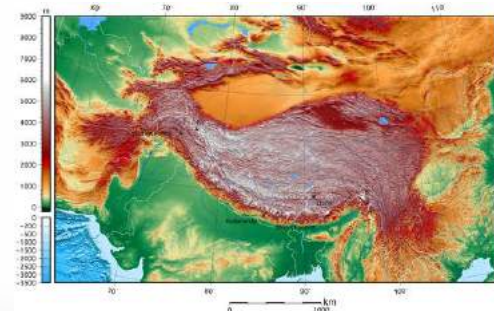
himat.org

Advanced Data Analytics Platform (ADAPT)

https://www.nccs.nasa.gov/services/adapt

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DigitalGlobe Data Licensing and Copyrights

NextView License

- U.S. Government including, all branches, departments, agencies, and offices

- Temporary Licensed Users :

    - State Governments

    - Local Governments

    - Foreign Governments and inter-governmental organizations

    - NGO's and other non-profit organizations

All high-resolution commercial satellite imagery purchased by NGA is NextView licensed.

USG may provide the imagery to the above organizations when collaborating on an official purpose.

More information available here: https://cad4nasa.gsfc.nasa.gov/images/NGA-NextView-License.png
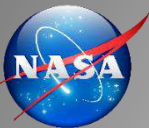
Objectives
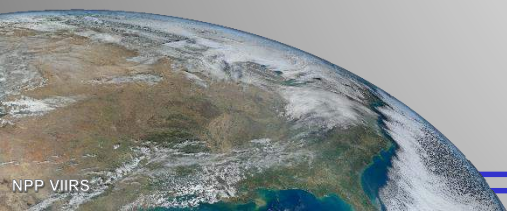
Our work seeks to provide tools as an Application Program Interface (API) for mass processing spatially contiguous and temporally consistent archived NASA-GSFC DG VHR data that can only efficiently be performed on NASA HEC resources due to DG-NGA licensing limitations and computational requirements.

Our objectives are to:

1. **Improve VHR data querying:** using databases and ArcGIS mosaic datasets within NASA-GSFC's ADAPT global archive of DG VHR imagery;

2. **Produce on demand VHR regional mosaics:** automating estimates of surface reflectance, ortho-rectifiying and normalizing 1 m mosaics for pan and 2 m for multi-spectral; and

3. **Produce on demand 2 m posting DEMs:** leveraging HEC processing and open source NASA-Ames software.
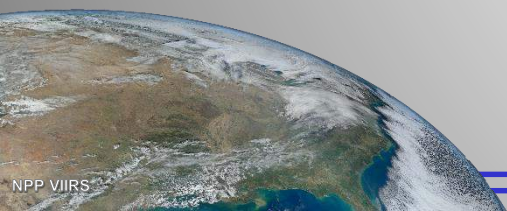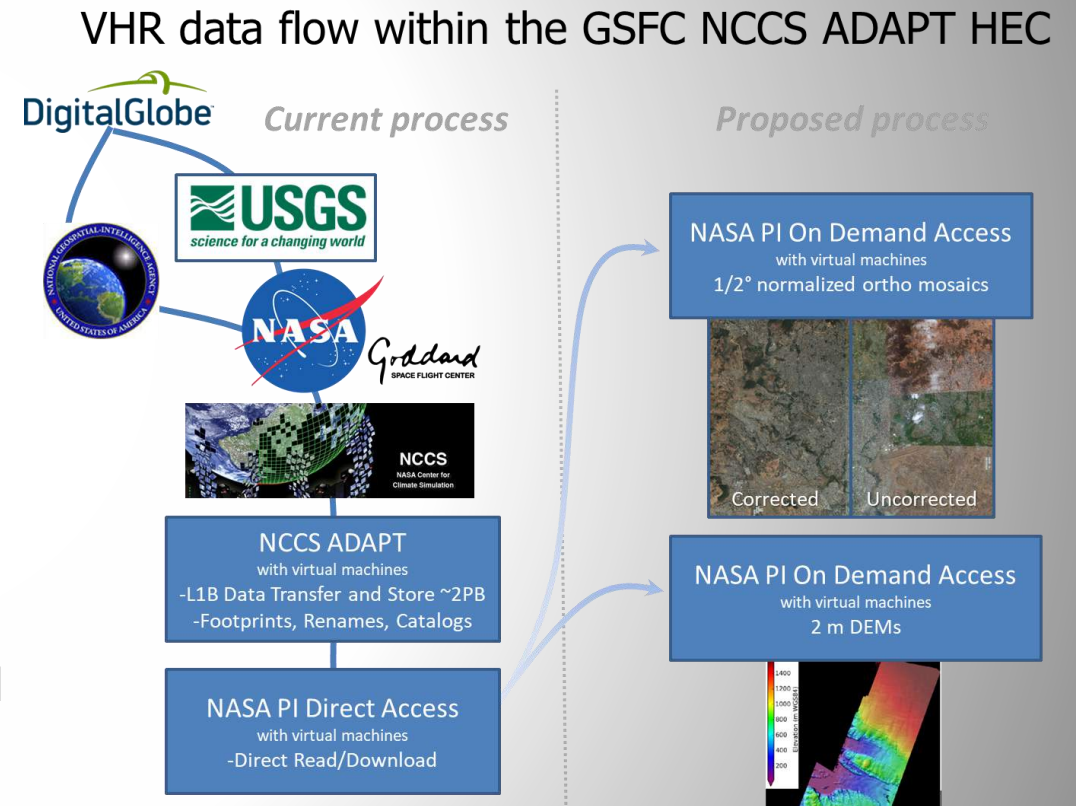
VHR data flow within the GSFC NCCS ADAPT HEC
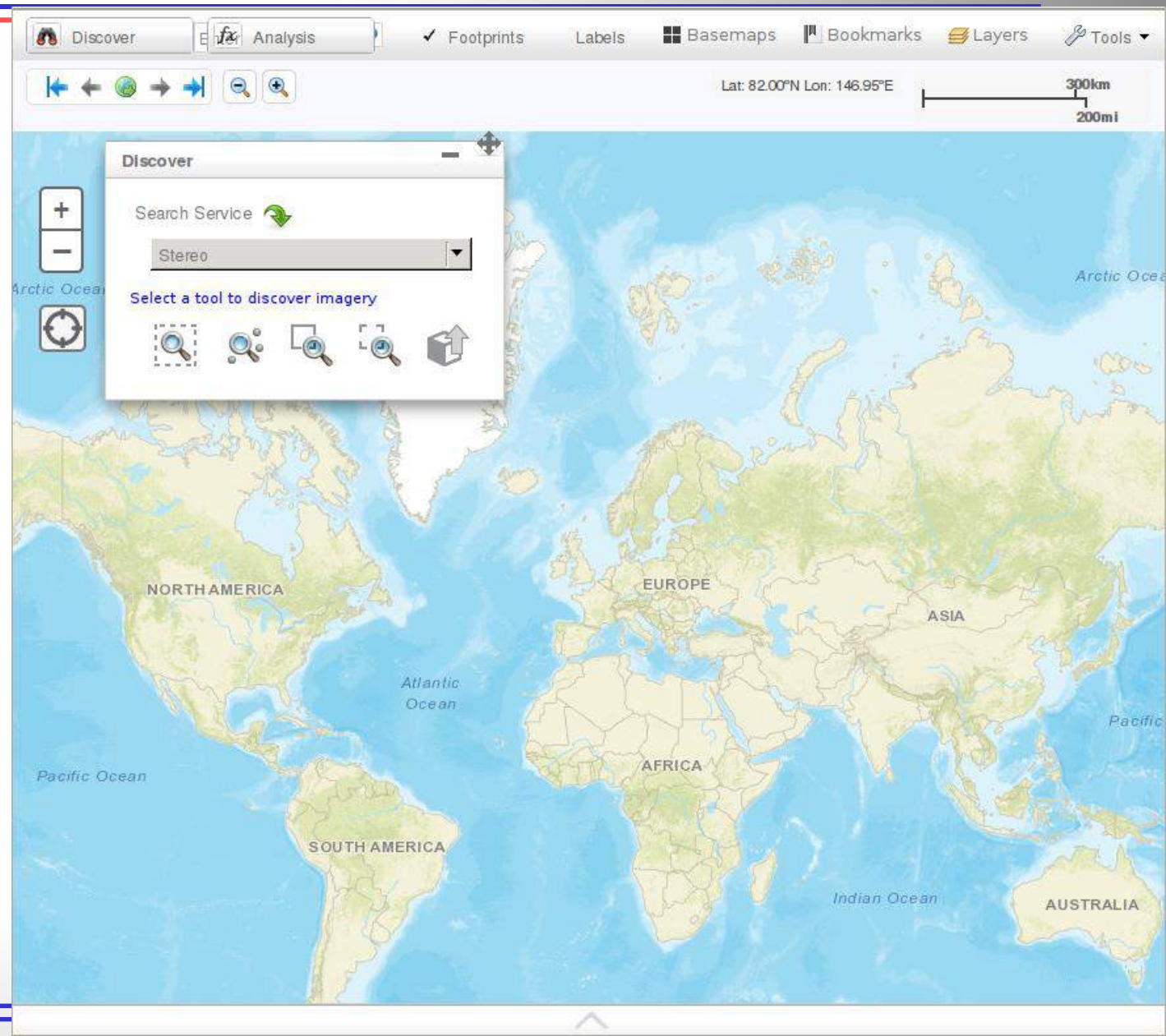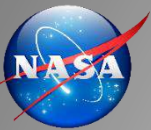
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Automated Database

- Querying from a firefox browser on ADAPT:

  – Spatial search on individual image services

  – Preview returned images; filter on attributes.

  – Create selection, and export to CSV or shapefile

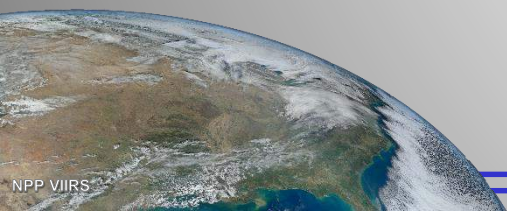 – Query results can be sent to the API

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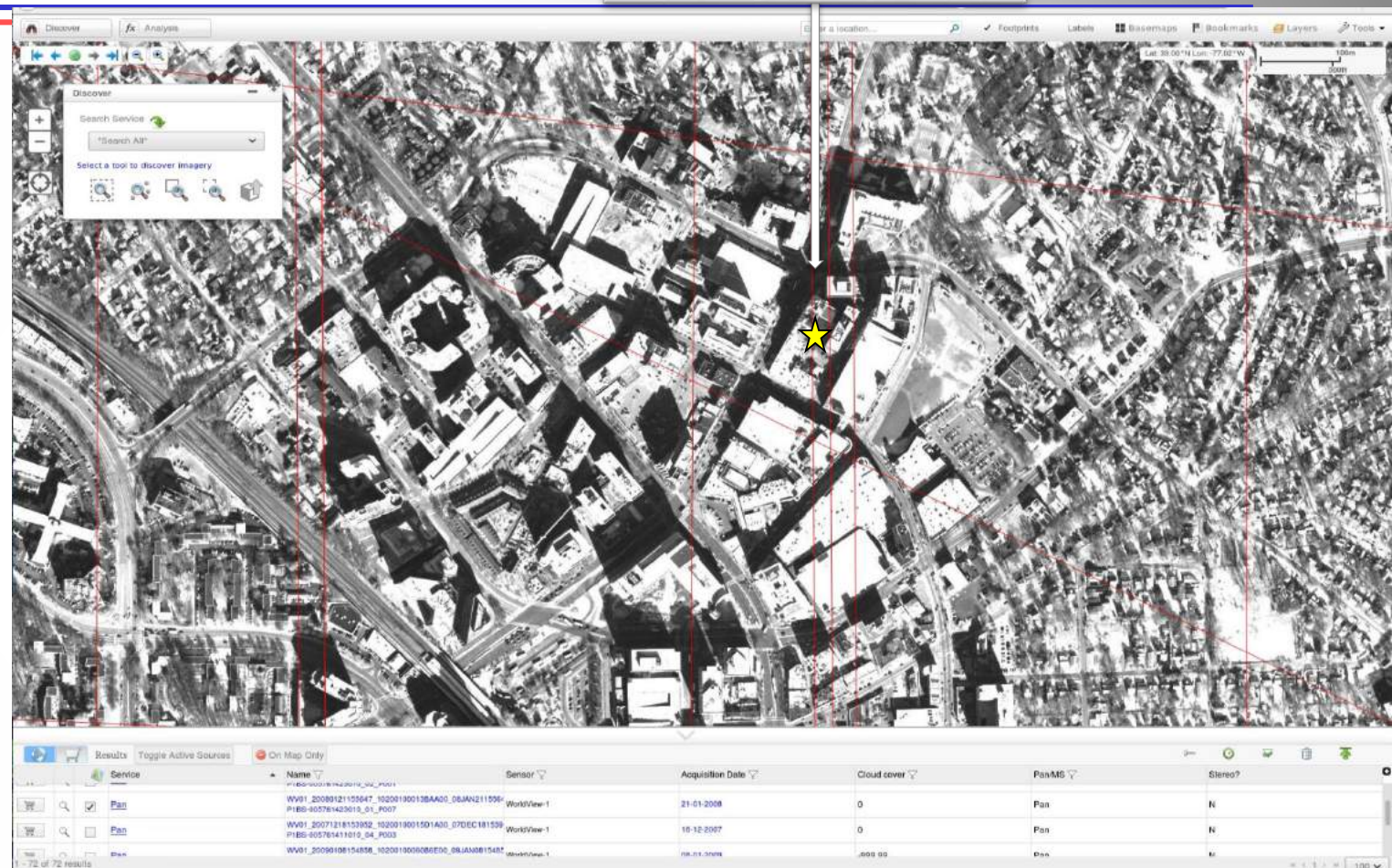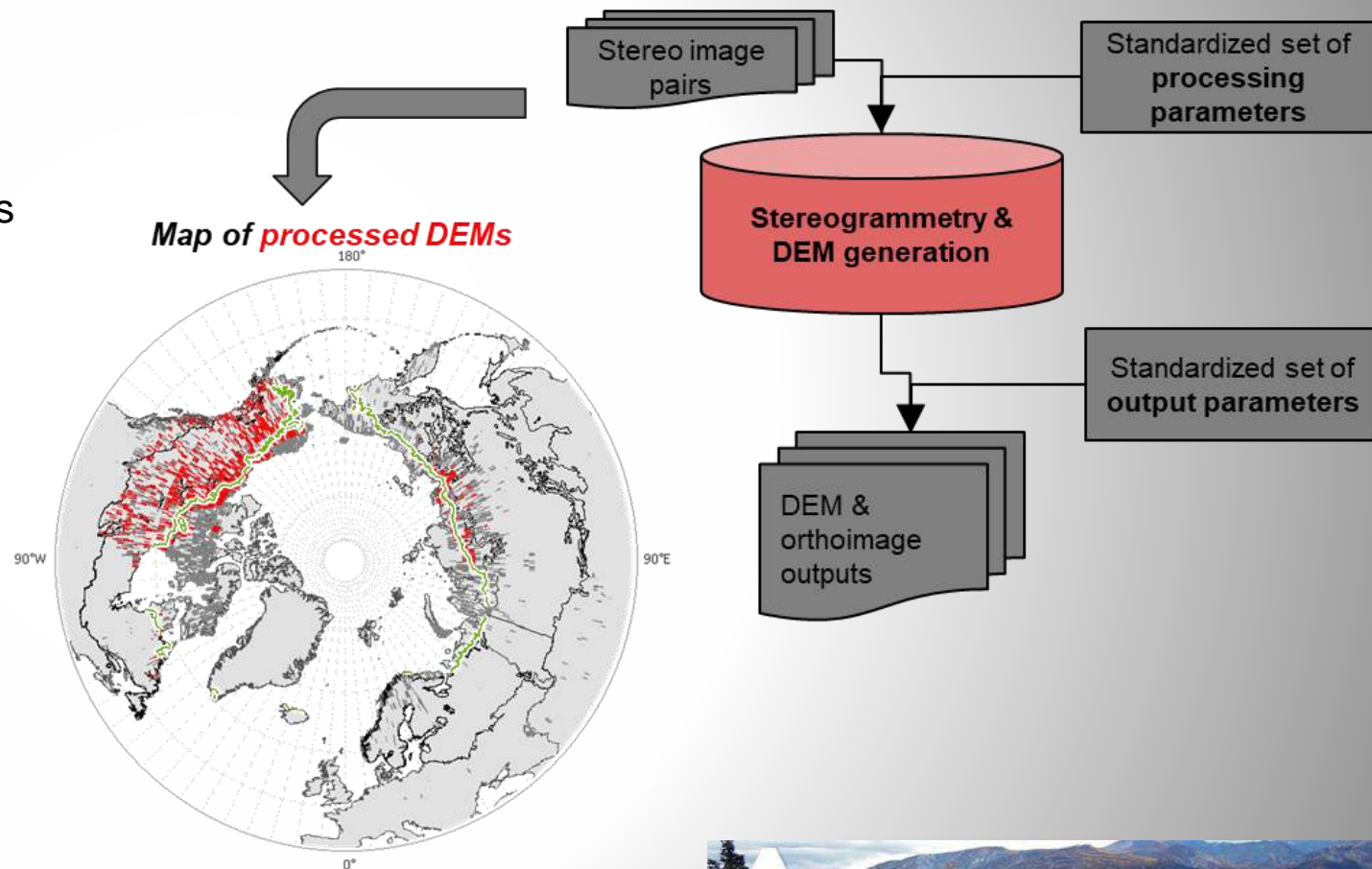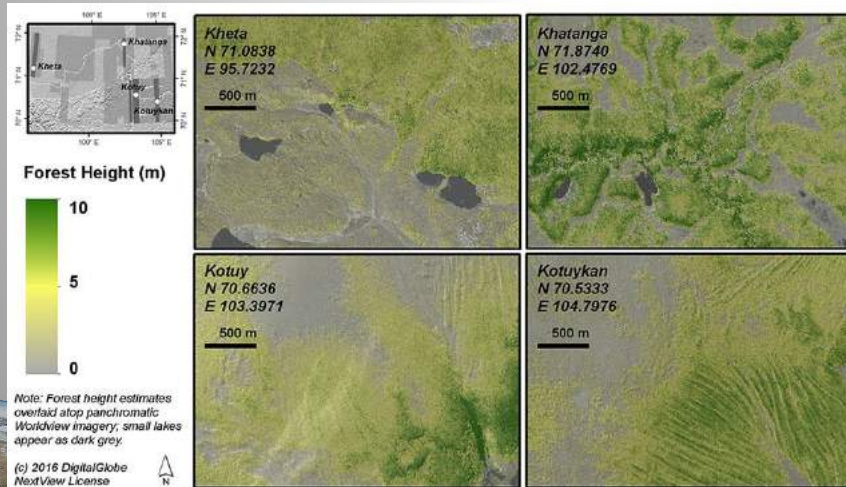
©DigitalGlobe NextView 2008

DEM workflow

Standardize the processing of the image pairs returned from data queries:

- Incorporate lessons learned from **7,000+** DEMs processed using **14,000+** image strip pairs.

- Use tested parameters to maximize efficiency.

Co-I Montesano Hi-Res DEM processing for TE NASA CCS

Map of *processed DEMs*

Stereo image pairs → Standardized set of **processing parameters**

Stereogrammetry & DEM generation

Standardized set of **output parameters**

DEM & orthoimage outputs

https://above.nasa.gov/

Montesano, Neigh et al. RSE 2017

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DEM Workflow: cont.
linking scientists with developers

Optimize the workflow on the NCCS **ADAPT** linux cluster **(Co-I Dan Duffy)**

- facilitate on-demand processing of imagery for study sites

- increase processing speed & efficiency, maximizing the use of HEC

The workflow will benefit from interaction between scientists & developers

- To guide on-going software updates

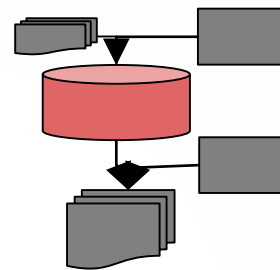- To inform software functionality based on science objectives.

<u>The NASA Ames Stereo Pipeline</u> (**Co-I Oleg Alexandrov**)

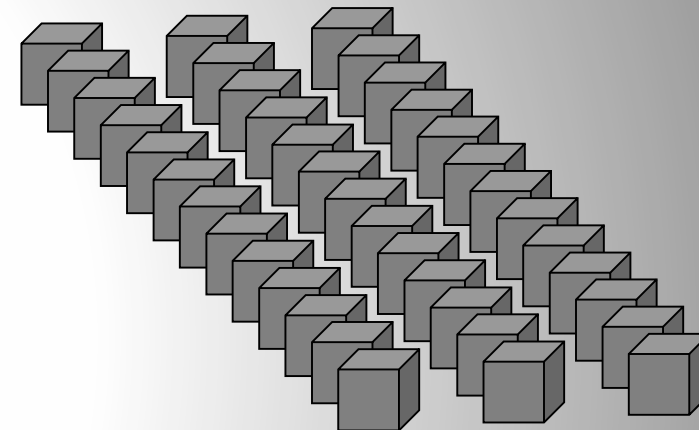- stereogrammetry routines for processing DigitalGlobe image pairs

<u>Python & bash scripts</u> (**Co-I David Shean**)

- wrapper scripts to optimize the stereogrammetry workflow
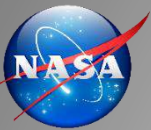
DEM workflow   ***ADAPT** linux cluster*


Shean, Alexandrov et al. P&RS 2016

We have found through our own research that VHR data provide a wealth of site level information that enhances NASA Earth observation products and scientific results.
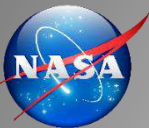
Our work builds on the significant progress from previous work supported by NASA's Programs:
- Terrestrial Ecology (TE)
- Carbon Cycle Science (CCS)
- Interdisciplinary Science (IDS)
- Cryospheric Sciences (CS)
- Advancing Collaborative Connections for Earth System Science (ACCESS)
- Land-Cover Land-Use (LCLUC)

Numerous science applications can be performed with science ready VHR products!
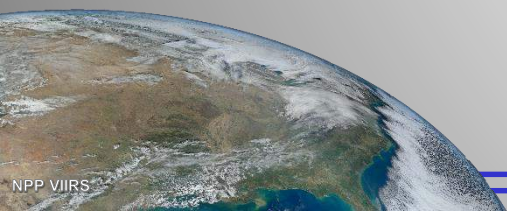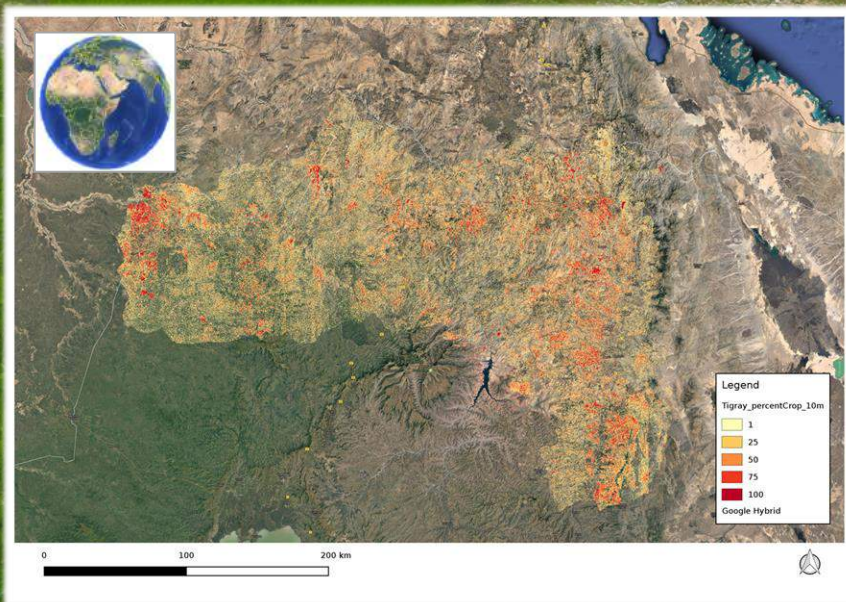
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August 2016
Near Ruba Felege Tigray, Ethiopia 13.96N 39.73E
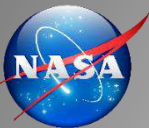*Photo by B. Powell*

©DigitalGlobe NextView 2014

0   300 m

Global food production in the developing world occurs within sub-hectare fields that are difficult to identify with moderate resolution satellite imagery. Knowledge about the distribution of these fields is critical to food security programs. We developed a semi-automated high-performance computational methodology to rapidly extract cropped area from thousands of WorldView-1, and 2 images for Tigray, Ethiopia using NASA HEC resources.
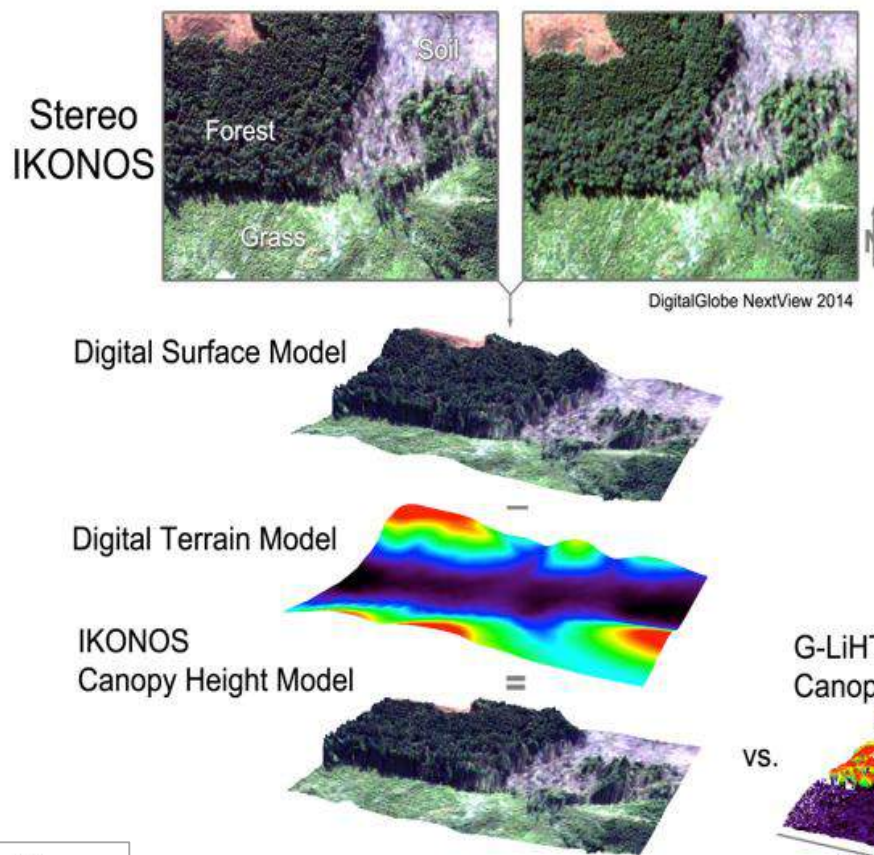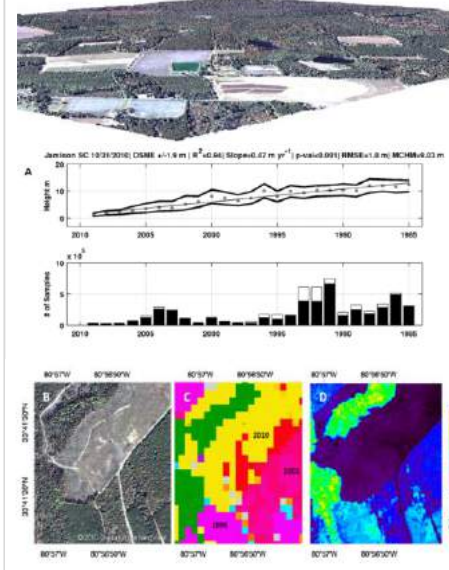
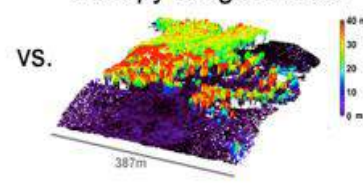*Neigh, Carroll, Wooten et al. 2018 RSE*

Forest carbon (C) stock is a poorly understood component of the C-cycle. Growth estimates from IKONOS and Landsat are analogous to height and carbon sequestration estimates from field data. IKONOS DEMs were found to be a reasonable alternative to airborne LiDAR. Landsat disturbance history was then used in a space-for-time swap to estimate rates of young forest growth with IKONOS in 20 locations throughout the CONUS.
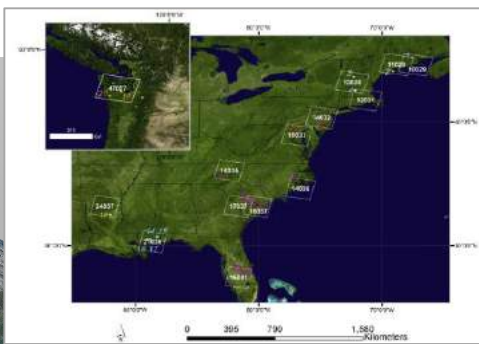

Stereo IKONOS

Forest

Soil

Grass

DigitalGlobe NextView 2014

Digital Surface Model

Digital Terrain Model

IKONOS Canopy Height Model

G-LiHT Canopy Height Model

vs.

387m

©DigitalGlobe NextView 2010

Very Hi-Res DEM processing

Neigh et al. 2016 RSE
Neigh et al. 2014 RS
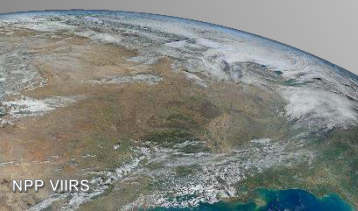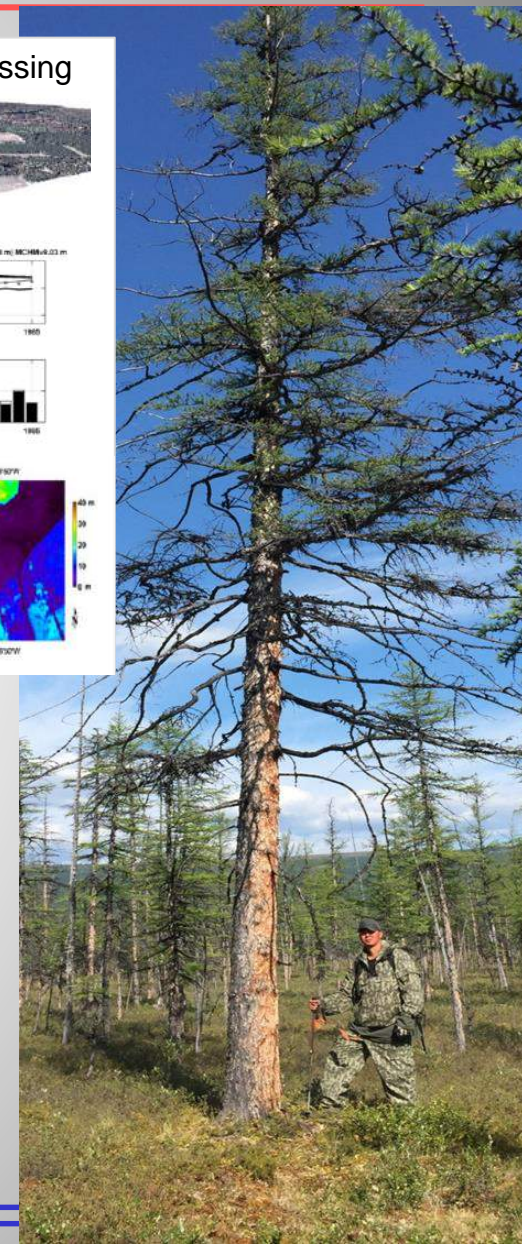
NORTH AMERICAN CARBON PROGRAM
CONTINENTAL CARBON BUDGETS • PROCESSES • MANAGEMENT

https://www.nacarbon.org/

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Can high-resolution commercial data be used to understand sub 30 m pixel variability in Hyperion data in the Libya-4 Pseudo Invariant Calibration Site (PICS)?

3D Surface View of Subset Area

Hyperion True Color Convolved 8/09/12
Red   630-690 nm
Green   510-580 nm
Blue   450-510 nm
Cubic Convolution 2m

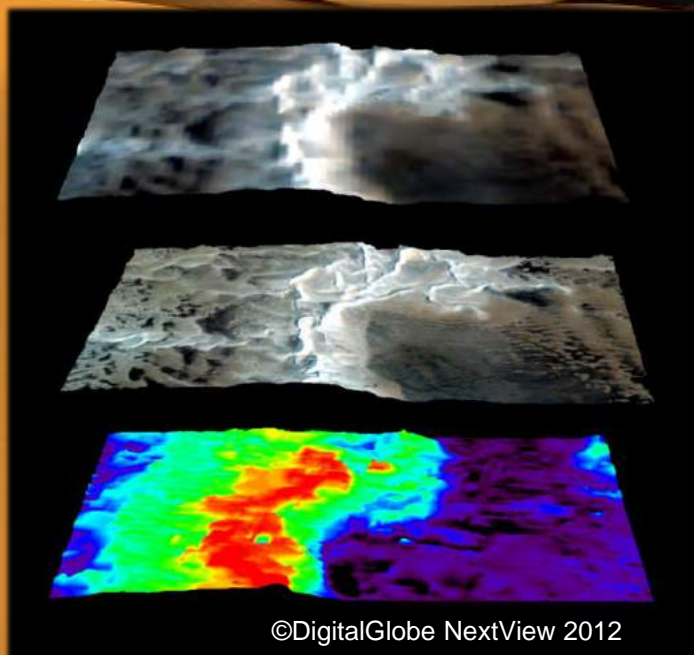WorldView-2 True Color 8/12/12
Red   Band 5 630-690nm
Green   Band 3 510-580nm
Blue   Band 2 450-510 nm
2m

WorldView-2 – WorldView-1
2m Digital Terrain Model

©DigitalGlobe NextView 2012

Elevation and slope have a strong influence on WV-2 band agreement with Hyperion data, ranging from low agreement at dune tops ($R2 < 0.05$) to higher agreement in sand flats ($R2 > 0.6, P < 0.001$). RMSEs increase with height as well.
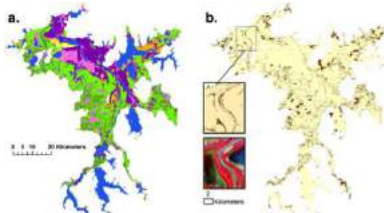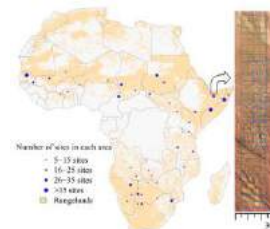
Neigh et al. 2015, IEEE GSRL
Neigh et al, 2016, IEEE GSRL
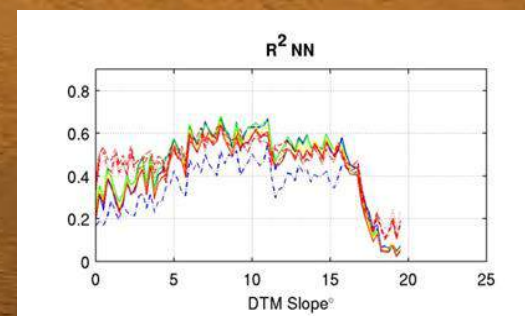
Small scale changes in Hydrology – PI Gong (NESSF)
Dronova et al. 2015 RSE
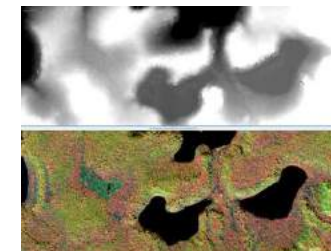
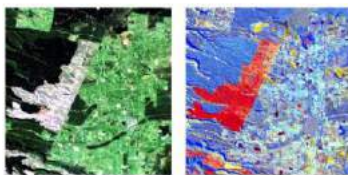Analysis of woody vegetation properties and change across African savannas – PI Hanan (TE) *Axelsson et al. 2018 JB*

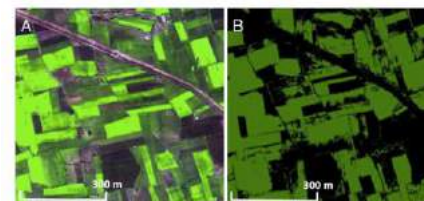Validation of Landsat Tree Canopy Cover – PI Ranson (CCS)
Montesano et al. 2016 RS

Disturbance analysis in New Zealand, mapping validation – PI (LCLUC)
de Beurs et al. 2016 IJAEOG

Mapping Cropping Intensity in Gujarat, India – PI DeFries (LCLUC)
Jain et al. 2013 RSE

Validation of paddy rice planting expansion in NE China– PI Dong (LCLUC)
Dong et al. 2015 RSE

Mangrove canopy height estimation for blue carbon – PI Fatoyinbo (TE – CMS)
Lagomasino et al. 2016 RS
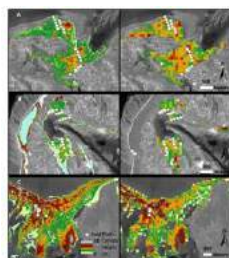
Tall shrub and tree expansion in NW Siberian Tundra – PI Walker (LCLUC)
Frost et al. 2014 ERL
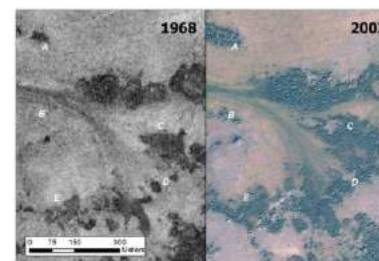
Training data for habitat mapping for shorebirds in California– PI Swenson (NESSF)
Schaffer-Smith et al. 2017 RSE
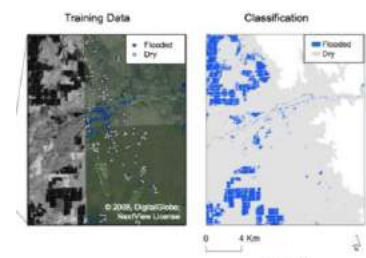
Landsat 8 Ground Control Point (GCP) improvements with WorldView – PI Storey (Landsat Science Team)
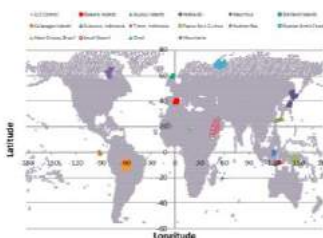
LCLUC in southern Ghana, validation – PI Stow (LCLUC)
Coulter et al. 2016 RSE

Characterizing a Cal/Val site in Bolivia – PI McCorkel (Landsat Science Team)
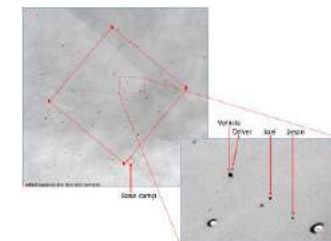
Science / ESD Value

There is a pool of scientists that could potentially benefit from the 3+ Petabytes of VHR data stored on ADAPT who are currently not using it.

- ABoVE has > 71 funded/affiliated projects with > 430 participants, of which 38 projects and 82 individuals have requested access to VHR data. Improvements in the ease of use of the VHR data would increase the usage among this group of potential users (personal communication Dr. Elizabeth Hoy NASA ABoVE management team).

- HiMAT has > 80 scientists and has recently been funded to develop VHR DEMs for central Asia (Co-I Shean). This group is also beginning to use ADAPT for systematic analysis of data. The API would be of direct benefit to these two groups of ADAPT users.

- Pending success with these existing users there could be future expansion to users that are not currently in ADAPT such as those who are registered (300+ users from multiple NASA programs) through https://cad4nasa.gsfc.nasa.gov.
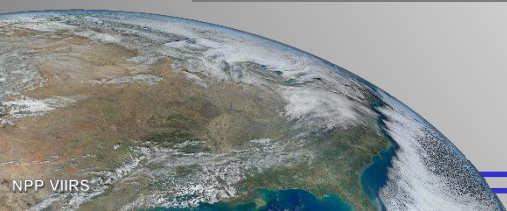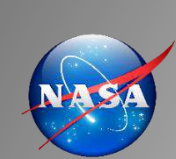
Thank You

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McCarty, J.L., Neigh, C.S.R., Carroll, M.L., & Wooten, M.R. (2017). Extracting smallholder cropped area in Tigray, Ethiopia with wall-to-wall sub-meter WorldView and moderate resolution Landsat 8 imagery. Remote Sensing of Environment, 202, 142-15. 10.1016/j.rse.2017.06.040

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