EarthCube Research Coordination Network Workshop - Advancing the Analysis of High Resolution Topography (A^2 HRT)

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Workshop Details:
August 21-24, 2018
Omni Interlocken Hotel, Broomfield, CO

Workshop Webpage:
https://opentopography.org/workshops/18EC_A2HRT

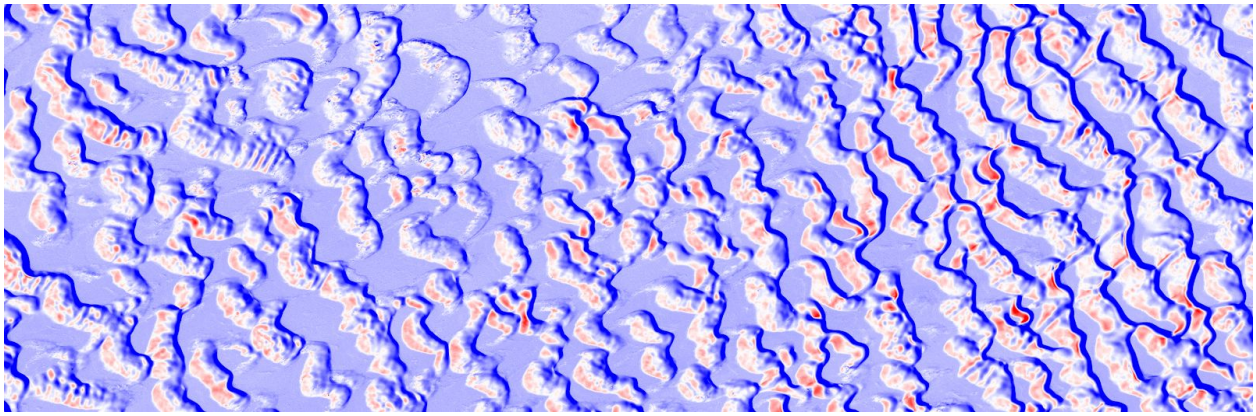

Image: *Vertical topographic difference between September 2009 (https://doi.org/10.5069/G9ZK5DMD) and June 2010 (https://doi.org/10.5069/G97D2S2D) airborne lidar datasets collected at White Sands, NM. Blue is accumulation of sediment, red is erosion of sediment. Dominant wind direction from the SW.*

Executive Summary

The workshop “Advancing the Analysis of High Resolution Topography (A^2 HRT)” was held in Broomfield, CO, August 21-24, 2018. This workshop was organized under an EarthCube Research Coordination Network (RCN) project by the same name. The workshop had 55 participants representing a range of disciplines in the Earth sciences and institutions across the U.S. The workshop included 12 talks, 2 poster sessions with 35 poster participants, and 3 brainstorming sessions. The workshop also included two hands-on training sessions focused on emerging techniques for topographic differencing. The brainstorming sessions were focused on the themes of our EarthCube RCN: (1) New emerging technology and needs for tools, (2) Integration across disciplines, and (3) Integration of high resolution terrain, bathymetry, and vegetation structure (HRT) data and numerical modeling. The main points that emerged from the brainstorming sessions as community needs were: (i) Standardization of workflows for operations on HRT, (ii) Identification of standard data sets for workflow and numerical modeling testing, (iii) continuous opportunities for training on HRT data across disciplines. The discussion has motivated the creation of focus groups within this RCN community to focus on workflows and HRT-model integration.

Introduction and motivation

Technologies such as lidar, multibeam sonar, structure from motion photogrammetry, and synthetic aperture radar have transformed the acquisition of high resolution terrain, bathymetry, and vegetation structure (HRT) data. Petabytes of data have been collected, but their full scientific utilization is still limited. This NSF-funded EarthCube Research Coordination Network (RCN) brings together the Earth science community to discuss technical challenges and cyberinfrastructure requirements to answer scientific questions, coordinate research activities, and share best practices and resources. This workshop (August 2018) was the first workshop planned as part of the RCN to exchange ideas on three themes in HRT, facilitate collaboration among scientists, and offer training on site on advanced HRT data analysis techniques. The three themes of the RCN are: (1) New emerging technology and needs for new tools, (2) Integration across disciplines, and (3) Integration of HRT data in models. The activities in this first workshop were centered around discussion and outcomes within these themes. Activities included talks by leaders in the field, brainstorming sessions, and poster sessions over two days. In addition, we dedicated one day of the workshop to user training in change detection.

The targeted outcomes of the themed brainstorming activities were to develop whitepapers to identify future needs for software, cyberinfrastructure, and other resources to support the HRT community, workflows, and best practices. Additional outcomes of the workshop included networking to enhance community development of HRT and user training to increase competency in advanced HRT analyses. The main findings of the brainstorming sessions are summarized in this report.

Summary of Brainstorming Sessions

Three brainstorming sessions, on the themes of (1) New emerging technology and needs for new tools, (2) Integration across disciplines, and (3) Integration of HRT data in models, were

organized. Each of the themed brainstorming sessions were motivated by 2-3 invited introductory talks, and followed by breakout sessions where participants were asked to specifically address (i) Workflows, (ii) Best practices, and (iii) Cyberinfrastructure needs. The main findings of each of the three brainstorming sessions are summarized below. Common themes that emerged in all sessions were: (i) The need for repositories of data and tools; (ii) Identify best practices for HRT data analysis; (iii) Identify standard data sets for model and tool testing and comparison; (iv) Offer opportunities for training and discussion via workshops across disciplines.

Here is link to brainstorming docs

Theme 1: New technologies for data acquisition and need for tools

The main points that emerged from this session were: the need for standardization of workflows (including for the quantification of uncertainty), identification of sample data sets to be used for tool testing, and the need for 'community building' also translated in a centralized repository for tools and best practices and access to a 'universal' online Q/A forum for Earth Science and HRT, as in "Stack Overflow".

Specific points that emerged during the discussion and divided by category:

Workflows:

- Develop procedures for quantifying uncertainties from different sources of data (e.g., lidar vs photogrammetry). In particular, for SfM methods need to be developed as there are currently no approaches developed for uncertainty quantification;
- Need for development and maintenance of a centralized repository of workflows and best practices users can refer and contribute to;
- Identify standardized sample datasets to allow testing of new tools on the same landscapes and data type and thus facilitate a robust comparison of available and new tools and allow for interdisciplinary analysis.

Best Practices:

- Encourage cloud based analysis and use the opportunity to link studies to data sets and results to promote repeatable science;
- Create and maintain an active knowledge base for support, specific to Earth science applications but accessible to the community at large;
- Encourage publication of both raw and refined datasets;
- Support and contribute to crowd-sourcing data validation and analysis.

Cyberinfrastructure:

- Identify common standards for data release, error reporting, and tool development and release;
- Identify metadata requirements in common across HRT applications;

- Work with publishers to encourage authors to publish data to appropriate repositories in agreement with the FAIR data initiative;
- Identify standardized sample datasets for testing cyberinfrastructure.

The discussion on workflows stimulated the need to query our community first to identify common operations and series of operations performed by HRT data. A possible way of collecting and summarizing this information is shown in Figure 1.

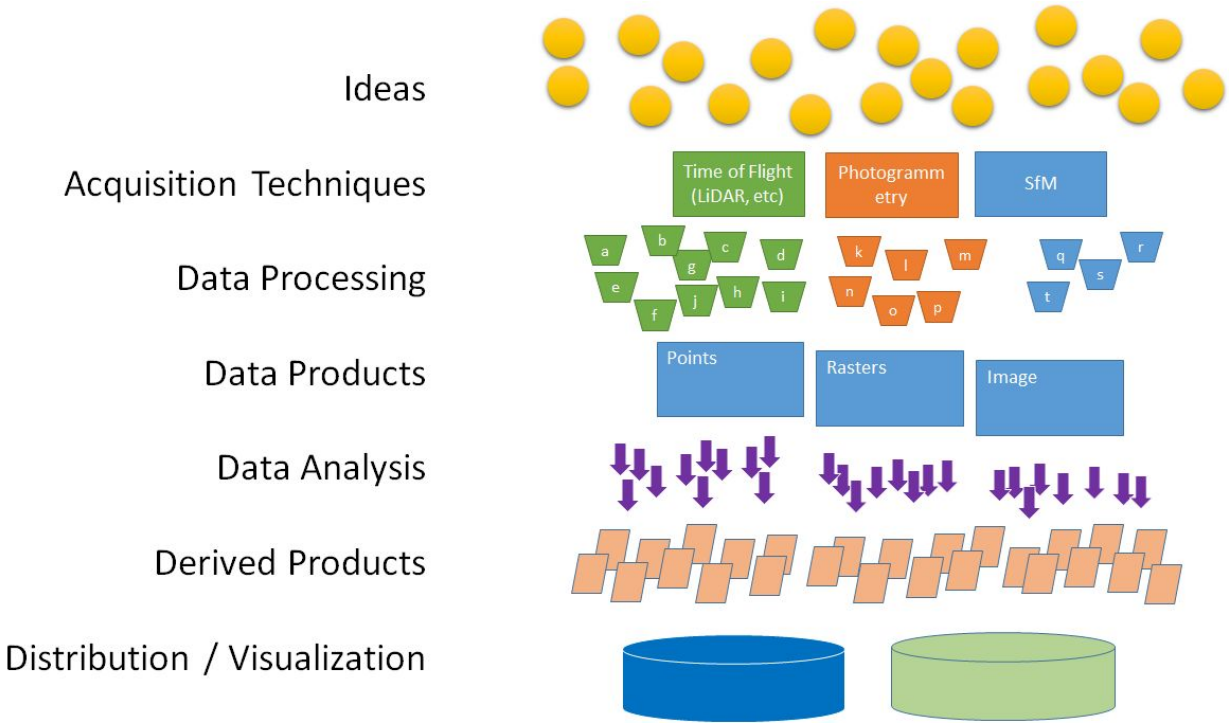

Figure 1*: Diagram developed by workshop participant Dr. Ben Crosby (Idaho State University) to illustrate an HRT workflow. The flow chart exemplifies points of divergence (processing, analysis techniques) and convergence (acquisition, products, distribution) along the workflow. Some pathways through the workflow are more popular or well established than others and worth creating streamlined, accessible, and standardized tools for. Metadata files need to reflect these paths as well as uncertainty quantification.*

Theme 2: Integration across disciplines

Throughout the discussion, the participants voiced the need to facilitate the integration of research and tools across disciplines on targeted goals and identify data sources and tools from other disciplines that would benefit the Earth science community. Error and uncertainty analysis in workflows and best practices were also discussed at length.

Specific points that emerged during the discussion and divided by category:

Workflows:

- Need to report workflows when publishing to allow the identification of tools and practices used in the analysis of HRT data by various communities;
- Review the existing workflows that have worked well across disciplines;
- Create focus groups within this RCN community to develop user manuals to be released to the community. (A survey circulated after the workshop and the results are summarized at the end of this report. Through this survey we have identified community members interested in leading these focus groups).

Best Practices:

- Need to identify and promote the use of standards for naming and schemas to facilitate discussion and collaboration across disciplines;
- Learn from the computer science and modeling community by establishing a stronger connection with CSDMS and other relevant groups;
- Integrate interdisciplinary approaches in the undergraduate and graduate curriculum, challenging traditional discipline boundaries to train the next generation of Earth scientists;
- Develop strategies for marketing HRT data; offer motivation to use them and outreach to other disciplines.

Cyberinfrastructure:

- Connect to other disciplines that work on similar problems via workshops such as this one;
- Organize short courses and workshops across disciplines and joint workshops, webinars, and sessions at AGU and other relevant meetings;
- Identify tools and workflows that work across disciplines (see also Figure 1).

Theme 3: Using high resolution data in numerical models

The main point that emerged during this discussion is that the HRT user community has been in a phase of discovery ("mapping") when the data were first released. While we are still learning and experimenting with possible mechanisms, we agree that the availability of HRT data has opened up many initial modeling explorations that were not possible previously (e.g., longitudinal profiles, non-linear hillslope sediment production, etc).

Specific points that emerged during the discussion and divided by category:

Workflows:

- Determine 'slope breaks' from HRT data. These boundaries are very useful for modelers, particularly for separating fine-grid and coarse-grid areas for variable resolution mesh models. Robust automated techniques using HRT would be useful;

- Tailor HRT techniques to modeling inputs or parameterization of variables, for example roughness, which is still a big unknown in the modeling community and requires high resolution surface information;
- Develop tools to identify the relevant scales for simulation and fieldwork.

Best Practices:

- Identify standard data sets to be used for model validation so that existing and new models and geomorphic transport laws are tested on the same set of landscapes;
- Enhance the use of adaptive meshing approaches. A strong collaboration between CSDMS and the HRT community would advance this point;
- Engage the modeling community to identify knowledge gaps and needs;
- Use multi-scale or multi-resolution modeling approaches that are common in other disciplines, for example in climate modeling;
- Achieve modeling at high spatial resolution and high temporal resolution to explore non-steady phenomena;
- Identify the appropriate resolution/scale and accuracy of the model to answer the question of interest.

Cyberinfrastructure:

- Organize short courses and workshops across disciplines, including hackathons;
- Focus on training for cloud-computing;
- Provide means to download different resolution datasets in data repository for modeling.
- Develop additional tools to understand uncertainty and perform interactive post-processing.

Workshop Agenda

The overall structure of the workshop included introductory talks for each of our 3 themes, which were followed by brainstorming sessions to develop community needs around these themes. We also had two evening poster sessions to exchange scientific ideas and results, and to promote networking. Lastly, we had two hands-on training sessions on change detection. These sessions were organized such that participants could attend both trainings.

Tuesday August 21

3:30 PM – Workshop starts – Intro to the EarthCube RCN goals

4:00 – Ice-breaker/participant introductions

4:30 - Introductory talks:

(I) New technologies for data acquisition and need for tools – Craig Glennie
(II) Integration across disciplines- Joe Wheaton
(III) Using high resolution data in numerical models – Irina Overeem

5:30 – Lightning poster introductions from first 1/2 of participants
6:30 - Poster viewing and evening reception

Wednesday August 22
7:30 AM – breakfast

8:30 – Intro talks on theme New Technologies for Data Acquisition and Tools

Jason Stoker: "Evaluating Single Photon and Geiger-Model Lidar"
Mike Olsen: "Resources available for Researchers through the NSF Natural Hazards Research Infrastructure (NHERI) Rapid Facility"

9:15 – brainstorming on topic in small groups (participants will be divided into 3 groups of ~15-20 each)

10:00 – coffee break

10:15 - Groups select one idea to report out
10:30 - Reporting from each group
11:00 - Writing session

12:00 – Lunch (Introduction to NEON AOP - Tristan Goulden)

1:30 - Intro talks on theme Integration across Disciplines
Josh Roering: "Point Clouds, Critical Zones, and Conflagrations in the Cascadia Canopy"
Vicki Ferrini: "Making elevation data accessible to non-specialist users"
2:15 - brainstorming on topic in small groups

3:00 - coffee break

3:15 - Groups select one idea to report out
3:45 - Reporting from each group
4:15 - Writing session
5:00 - Lightning poster introductions from second 1/2 of participants
6:00 - Poster viewing and evening reception

Thursday August 23
7:30 AM – breakfast

8:30 – Intro talks on theme Using high resolution data in numerical models

Fiona Clubb: "New techniques for clustering of river profiles: examples from both real and synthetic landscapes"

Ramon Arrowsmith: "2.5D to 4D initial and boundary conditions and testing numerical models with high resolution topography"
9:30 – Brainstorming on topic and writing
10:45 - Reporting from each group
11:15 - Workshop outcomes and group discussion
11:45 - Group photo

12:00 – lunch (group photo)

1:00-2:00 – Joe Wheaton: "Principles of topographic change detection"

2:00-2:10 - break

2:10-3:00 - Craig Glennie: "Challenges with change detection" & introduction to PIV change detection
Chelsea Scott: "3D Topographic Differencing of Meter-Scale Topography"
3:00 – 6:00 Parallel sessions:
1) Cloud-to-cloud change detection (Scott)
2) PIV change detection (Glennie)

Friday August 24
7:30 AM – breakfast

8:30-11:30 – Parallel sessions (groups switch):

1) Cloud-to-cloud change detection (Scott)
2) PIV change detection (Glennie)

11:30-12:30 - Lunch and departure

Funding
The workshop was funded by the NSF EarthCube RCN: Connecting the Earth Science and Cyberinfrastructure communities to advance the analysis of high resolution topography data (NSF-EAR #1642611). Additional support and funding was provided by NSF NEON (NSF-EF #1550916), UNAVCO GAGE Facility (NSF EAR #1261833), OpenTopography (NSF-EAR #1557484).

Workshop Participants

The A2HRT workshop was attended by 55 participants. Demographics of participants are summarized below.

Participant Type	#
Faculty	19
Post-doc	10
Other professionals	12
Graduate students	14
TOTAL	**55**

First Name	Last Name	Current Affiliation
Jordan	Adams	INSTAAR, University of Colorado Boulder
Ramon	Arrowsmith	ASU/OpenTopography
Abra	Atwood	University of Southern California
Scott	Baker	UNAVCO
Matthew	Beckley	UNAVCO
Tadesse	Berhanu	Oklahoma State University
Hayley	Brown	University of Northern Colorado
Dana	Carstens	Tulane University
Fiona	Clubb	University of Potsdam
Christopher	Crosby	UNAVCO
Benjamin	Crosby	Idaho State University
Bill	Dietrich	UC Berkeley
Nicholas	Ellett	Boise State University
Vicki	Ferrini	LDEO
John	Gartner	University of Massachusetts Amherst
Rachel	Glade	University of Colorado Boulder
Nancy	Glenn	Boise State University
Craig	Glennie	NCALM
Tristan	Goulden	Battelle Ecology
Hima	Hassenruck-Gudipati	UT Austin
Seyed Mohammad Hossein	Hosseiny	Civil and Environmental Engineering Department, Villanova University

Trevor	Host	University of Minnesota
Shantenu	Jha	Rutgers University
Kerri	Johnson	University of Nevada, Reno
Sam	Johnstone	USGS
Ranbir	Kang	Western Illinois University
Emily	Kleber	Utah Geological Survey
Matt	Lancaster	UNAVCO
Quinn	Lewis	Indiana University
Katherine	Lininger	University of Colorado Boulder
Manel	Llena Hernando	University of Lleida
Emmons	McKinney	California Polytechnic University Pomona
J. Toby	Minear	University of Colorado, Boulder
Viswanath	Nandigam	San Diego Supercomputer Center, UC San Diego
Michael	Olsen	Oregon State University
William	Ouimet	University of Connecticut
Irina	Overeem	Community Surface Dynamics Modeling System, University of Colorado
Ioannis	Paraskevakos	Rutgers, The State University of New Jersey
Paola	Passalaqua	UT Austin
Keith	Pelletier	University of Minnesota - Remote Sensing and Geospatial Analysis Laboratory
Beth	Pratt-Sitaula	UNAVCO
Josh	Roering	University of Oregon
Danica	Roth	University of Oregon
Ken	Rubin	University of Hawaii
Robert	Sare	Stanford University
Chelsea	Scott	Arizona State University
Tony	Song	JPL
Jason	Stoker	USGS
Panshi	Wang	University of Maryland
Thad	Wasklewicz	East Carolina University
Joseph	Wheaton	Utah State University
Scott	White	University of South Carolina
Tarka	Wilcox	Pacific Lutheran University
Bo	Zhang	UC Davis
Feng	Zhao	NOAA

Post-workshop Survey

We developed a post-workshop survey in which we had 23 respondents (see results below). The survey was designed to receive feedback on the most valuable aspects of the workshops and identify next steps for community needs and activities to advance HRT. Most of the respondents either strongly agreed or agreed that the workshop activities were effective and a good use of their time. Importantly, the respondents identified presentations, hands-on training, and networking opportunities as the top three workshop activities which helped to advance their HRT work. Respondents also provided ideas for hands-on training, presentations, and discussion topics for the next workshop(s). Example hands-on topics included advanced change detection (e.g., with point clouds, algorithm development, and machine learning) and drone photogrammetry. Presentation and discussion topics that were identified included fusing multi-resolution data, new developments in mobile mapping, and big data analysis. Several discipline-specific focus for HRT in hazards, geomorphology, and ecology were identified.

An outcome of the brainstorming sessions during the workshop was to convene working groups that will develop products for the HRT community. A number of survey respondents indicated that they would be interested in leading or participating in a working group that will develop workflows. Second most popular was a working group to develop test datasets. We also had a number of respondents interested in community outreach / training. One respondent indicated that they would be willing to lead a modeling working group. In addition, we polled respondents on topical ideas for hackathons and suggestions included: drone photogrammetry, image processing (e.g., segmentation), test datasets and workflows, change detection, ground filtering, surface modeling, open source data processing, real time lidar streaming.

Survey Responses available here:
https://drive.google.com/file/d/1VtpZb0IytMW_QhOshj-7C1T_MvVpo691/view?usp=sharing