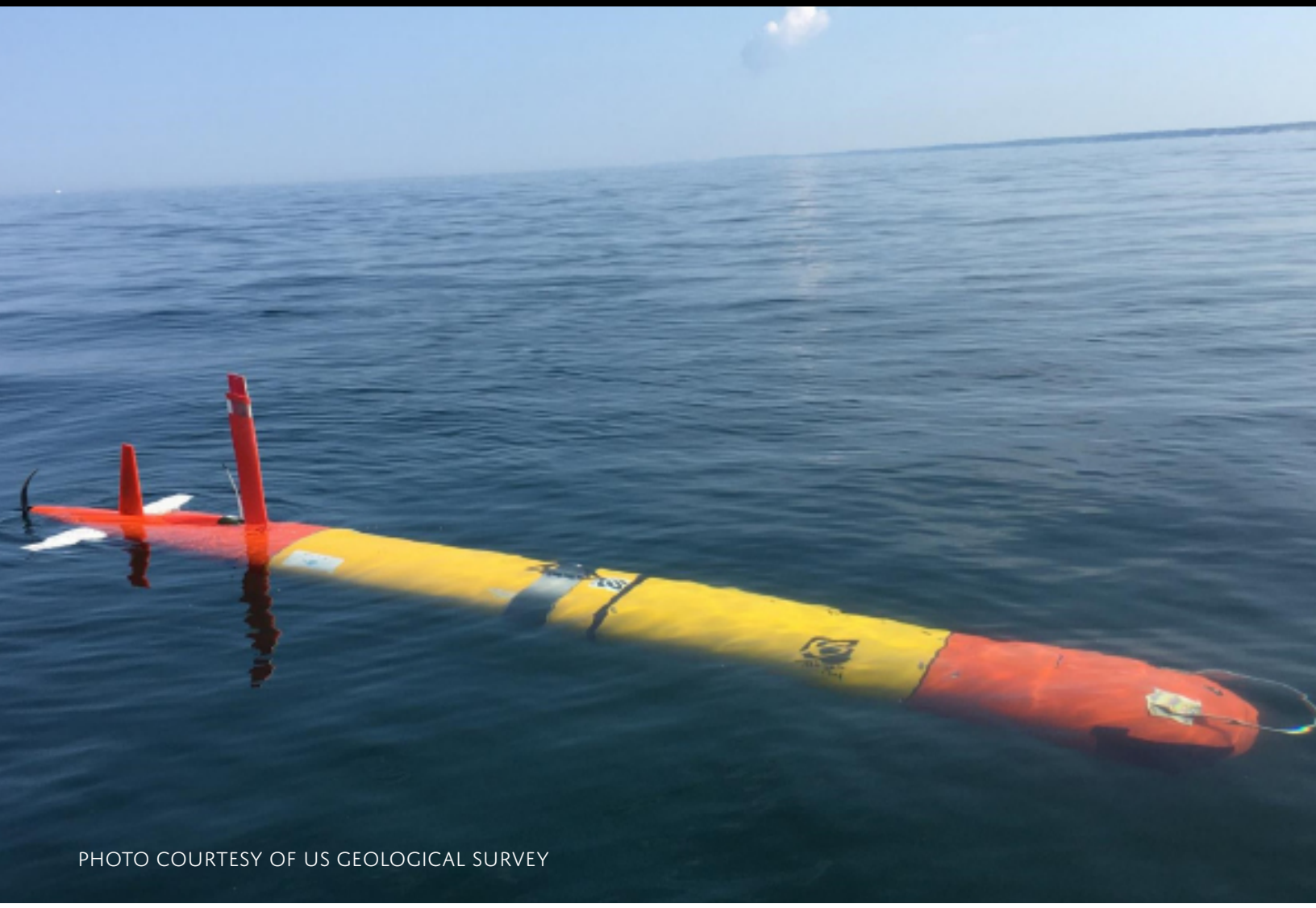
CIROH TECHNICAL REPORT #1



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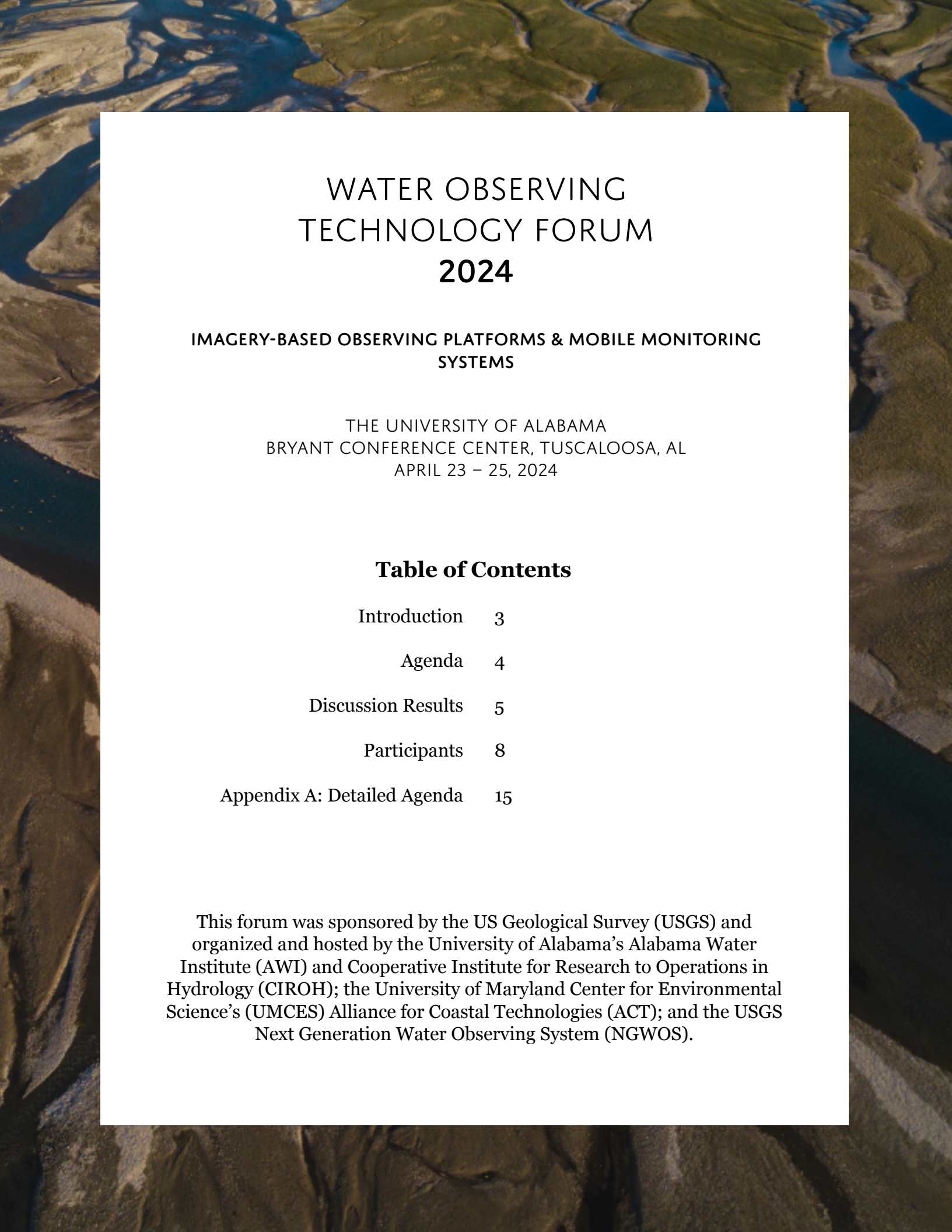
WATER OBSERVING TECHNOLOGY FORUM

THE UNIVERSITY OF ALABAMA® | Alabama Water Institute

USGS science for a changing world

CIROH Cooperative Institute for Research to Operations in Hydrology

ALLIANCE FOR COASTAL TECHNOLOGIES



WATER OBSERVING TECHNOLOGY FORUM **2024**

IMAGERY-BASED OBSERVING PLATFORMS & MOBILE MONITORING SYSTEMS

THE UNIVERSITY OF ALABAMA
BRYANT CONFERENCE CENTER, TUSCALOOSA, AL
APRIL 23 – 25, 2024

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This forum was sponsored by the US Geological Survey (USGS) and organized and hosted by the University of Alabama's Alabama Water Institute (AWI) and Cooperative Institute for Research to Operations in Hydrology (CIROH); the University of Maryland Center for Environmental Science's (UMCES) Alliance for Coastal Technologies (ACT); and the USGS Next Generation Water Observing System (NGWOS).

INTRODUCTION

Overview
The Water Observation Technology Forum (WOTF) was designed to showcase the latest research into innovative technologies and methods for measuring water quantity, quality, and availability. The aim of the WOTF is on identifying gaps in our traditional monitoring technologies and where science, innovation, and partnerships can help fill those gaps. The WOTF brings together federal agency representatives, academic researchers, and industry leaders with expertise in water observations and broad environmental innovations.

Inaugural Event
The first WOTF took place on April 23-25, 2024, at The University of Alabama. It focused on two technology themes: imagery as data and mobile monitoring systems. The forum included keynote and plenary presentations, open discussions, an industry showcase, facility tours, and partnership meetings.

Imagery-Based Observing Platforms
Research into the utility of imagery-based observing platforms in regional and national surface and ground water monitoring networks has expanded greatly in the last five years. This research has included the evaluation of methods that incorporate satellite, airborne, proximal, and mobile in-situ remote sensing platforms and has yielded useful and exciting results. Establishing data requirements and standards as well as data transfer and delivery tools for imagery data are critical gaps that have been addressed through several coordinated efforts that were discussed at the forum.

Mobile Monitoring Systems
The water monitoring community is also exploring the use of mobile monitoring systems to measure water parameters. These systems include small uncrewed aerial and underwater vehicles as well as surface vessels. Having the ability to locate sensors in locations that are otherwise expensive or unsafe to send field staff and collect data over a large area in a short amount of time makes these platforms attractive. As advancements in artificial intelligence and machine learning continue to expand this field, the application of these types of models into the operational algorithms of uncrewed automated observing platforms could lead to the capability for “smart swarming” algorithms. The WOTF provided the opportunity to discuss and strategize ways to coordinate these advances.

Participation
Nearly 150 participants from agencies, industry, academia (faculty and students), resource management agencies, and NGOs took part in this three-day event (Appendix A). Attendees were challenged with identifying critical observation gaps and emerging water monitoring and sensing technologies for future investment. For a list of speaker abstracts, presentations and biographies, please visit: https://ciroh.ua.edu/water-observing-technology-forum/water-observing-technology-forum-speakers/

AGENDA

Participants in the first WOTF were provided with (a) a series of topic-specific presentations and discussions, (b) access and exposure to relevant technologies and technology innovators and providers, (c) opportunities for networking and capacity building, and (d) a tour of new state-of-the-art the new USGS Hydrologic Instrumentation Facility. Speakers and poster presenters provided updates on their water monitoring research and technologies or available processes/opportunities that facilitate environmental innovation. All participants were engaged in discussions of the specific forum themes and provided insight and recommendations forward.

Day 1: Imagery as Data

Presentations, with questions and answers, were provided on active research and development of imagery-based scientific applications, including fixed and mobile camera systems, such as infrared, hyper- and multi-spectral imaging.

Open Discussion Topics

- Hardware and software options for environmental monitoring,
- Quality assurance procedures and privacy concerns,
- Fusing open-source software development with commercial products, and
- Hurdles for operational implementation of imagery in regional and national monitoring networks.

Day 2: Mobile Monitoring Systems

Presentations, with questions and answers, were provided on active research and development of mobile monitoring systems, including uncrewed/autonomous surface and submerged vehicles, remotely operated vehicles, drifting platforms, vertical profiling platforms, and low-altitude drones.

Open Discussion Topics

- Barriers to implementation,
- Re-engineering technology from oceans to rivers, and
- Fusing open-source software development with commercial products.

AGENDA (CONT.)

Day 3: Industry Showcase

Presentations, with questions and answers, were provided on industry-academia-government partnerships with a focus on developing water monitoring technologies for “Imagery as Data” and “Mobile Monitoring Systems”. The third day included interactions with on-site vendors, presentations on facilitating partnerships, tours of the new USGS HIF, and networking opportunities.

DISCUSSION RESULTS

On both Day 1 and Day 2, attendees were provided a series of survey questions using the Mentimeter application. These questions were specific to the technology themes for the WOTF. Attendees were given about 10 minutes to discuss each question with the others at their table before submitting their results, and each table was then given the opportunity to discuss their responses in more detail.

Day 1: Imagery as Data

Q1: Prioritize ways to improve camera imagery monitoring in rivers and near-shore waters:

1) Establish data standards,
2) Develop machine learning algorithms,
3) Create deployment methods for remote sites,
4) Research into processes captured by imagery, and
5) Enhance image resolution and clarity.

Although combined responses were ranked in this order, all five had very similar levels of interest and were seen as high priorities.

Q2: Prioritize the actions for overcoming barriers to the use of camera imagery for monitoring of rivers and near-shore waters:

1) Conduct pilot studies and field trials,
2) Establish collaborative partnerships,
3) Offer no risks testing in a range of environments,
4) Provide training, and
5) Advocate for policy changes.

There was clear agreement on this rank order, with the first two options being of the highest priorities.

Q3: Rank the following technology-related opportunities for advancing the use of camera imagery in monitoring of rivers and near-shore waters:

1) Deploy networked camera arrays,
2) Adopt open-source and community-driven platforms for data analysis,
3) Incorporate multispectral and hyperspectral imaging,
4) Develop underwater drone platforms, and
5) Explore VR/AR and other technology for interpretation.

The first three responses were agreed upon as top priorities.

DISCUSSION RESULTS (CONT.)

Day 2: Mobile Monitoring Systems

Q1: Prioritize the ways to overcome barriers to autonomous underwater vehicles (AUVs) for monitoring of rivers and near-shore waters:

1) Integrate sensors (e.g., multi-spectral, chemical) into AUVs,
2) Advance common protocols and acoustic modems,
3) Increase ruggedness and durability of AUV design,
4) Research and development to improve maneuverability, and
5) Standardize deployment and operations protocols.

There was strong agreement on this rank order, with the first two options as clear highest priorities.

Q2: Prioritize the outreach efforts for promoting AUVs for monitoring rivers and near-shore waters:

1) Providing training to stakeholders and users,
2) Offer no-risk opportunities for testing in a range of environments,
3) Advocate with policy makers for increased funding and support,
4) Host public forums and workshops, and
5) Establish community science and volunteer programs.

There was obvious agreement on this rank order, with the first two responses being the top priorities.

Q3: Rank the AUV technology innovations by impact:

1) Develop modular AUV platforms / customizable for different missions.
2) Adopt open-source platforms to engage the research community,
3) Innovate power sources (e.g., solar, fuel cells),
4) Integrate AIML for data analysis and decisions, and
5) Deploy swarms/fleets of AUVs.

There was agreement on this rank order, with the first response by far the highest priority.

Day 3: Industry Showcase

On Day 3 participants were asked to suggest future water technology topics that could be addressed by the WOTF, and this question was also asked as part of the post-forum survey (see below). In-person responses, in the order they were received, included:

- Remote sensing, drones, and satellites;
- Biosensors;
- Water quality technologies (including groundwater) - specifically nutrients, chlorophyll, optical/spectral;
- Cameras of opportunity (e.g., traffic cameras);
- Data telemetry, management, integration, processing, and presentation;
- Rapid response coordination;
- Technology transfer;
- Acoustic water monitoring;
- Continuous monitoring of solute fluxes;
- Water monitoring networks;
- Urban flood warning technologies;
- Mapping technologies;
- Under ice water monitoring technologies;
- Navigation technologies for autonomous platforms;
- Remote sensing of water level and bathymetry; and
- Modular open source sensing systems and standards.

PARTICIPANT POST-WOTF SURVEY RESULTS

Responses from participants indicated that the first WOTF was a success and valuable, which was the consensus of the planning/organizing committee. WOTF provided an opportunity for people from across academics and industry to interact, discuss new technologies, and increase awareness of the growing water research hub in Tuscaloosa, Ala. This event successfully united the water-observing community, fostering new opportunities and collaborations within the field and all of the survey respondents stated that they would recommend the conference to peers.

Survey results suggest that participants were very happy with the WOTF. Nearly all those who responded selected "excellent" (81% to 48%) or "good" (33% to 15%) when asked about the following:

- overall satisfaction
- pre-forum communication
- forum venue
- virtual participation (when applicable)
- presentations
- networking opportunities
- relevance and usefulness

When participants were asked "Why did the forum meet your expectations?", two main responses were (a) networking opportunities with fellow researchers and (b) direct applicability of the technology-related sessions.

When participants were asked "Why did the forum not meet your expectations?", suggested areas for improvement included (a) more time for presentation (some seemed rushed), (b) more time spent on defining the problem before discussing technical solutions, and (c) the separation of, or distinct room for, presentations and technology developers/provider exhibits.

Ten of the exhibitors provided additional feedback and were generally very positive. A few stated that it would have been better if there were more time designated for the exhibits (so participants could spend more time interacting with technology developers/providers) and they expressed a desire for additional networking events.

All participants showed interest in additional WOTF and suggested the following themes for consideration (similar to some of the recommendations received at the event itself):

a) Water technology infrastructure for research and education,

b) Hardware interoperability and modularity,

c) Microfluids, fluid monitoring technology as applied in non-hydrologic settings,

d) Data assimilation technology,

e) Soil moisture measurement,

f) Aerial vehicles for images and sampling,

g) Water filtration and capture, and

h) Acoustic monitor of currents, seafloor, and water column

CONCLUSIONS AND RECOMMENDATIONS

The 1st WOTF was successful in bringing a diverse set of innovators in the water monitoring arena to Tuscaloosa, Ala., to network, share updates on research, and look for ways they can collaborate with other partners across the country and abroad. After discussing the event among the planning committee and considering the feedback received from the participants, the following conclusions and recommendations will be considered for the FY25 WOTF.

- Maintain three-day agenda at same time of year
- Provide vendors with a separate room away from the speakers
- Allow vendors more time to visit the HIF
- Increase student involvement
- Include hands-on technology interactions and demonstrations

PARTICIPANTS

Participants represented diverse federal agencies, industry, academia, resource management agencies, and NGOs. Attendees were challenged with identifying critical observation gaps and emerging water monitoring and sensing technologies for future investment.

Attendees:

First Name	Last Name	Affiliation
Graeme	Aggett	Lynker
Brodie	Alexander	University of Alabama
Richard	Allen	US Army Corps of Engineers
Amobichukwu	Amanambu	University of Alabama
Stephen	Anderson	University of Alabama
Dan	Angelescu	Fluidion US Inc.
Cory	Angeroth	US Geological Survey
Ann	Arnold	Geological Survey of Alabama
Mahmoud	Ayyad	Stevens Institute of Technology
Rebecca	Bearden	Geological Survey of Alabama

PARTICIPANTS (CONT.)

First Name	Last Name	Affiliation
Curtis	Bertrand	Environment and Climate Change Canada
Dan	Blakley	University of Alabama
Boyce	Blanks	US Geological Survey
James	Bomhof	Environment and Climate Change Canada
Nate	Booth	US Geological Survey
Martin	Briggs	US Geological Survey
Jerry	Brotzge	Western Kentucky University
Jenna	Brown	US Geological Survey
Chris	Buchner	OTT HydroMet
Justin	Burrus	Department of Natural Resources
William	Butler	US Army Corps of Engineers
Jeffrey	CAPILI	University of Alabama
Luca	Centurioni	Scripps Institution of Oceanography
Mark	Cheng	University of Alabama
Anika	Cho	University of Alabama
Ed	Clark	National Oceanic and Atmospheric Administration
Prabhakar	Clement	University of Alabama
Ian	Conery	US Army Corps of Engineers
Brett	Connell	Trutta Environmental Solutions
Ken	Conner	Campbell Scientific Inc
Todd	Crowl	Florida International University
David	Dalkin	KISTERS North America

PARTICIPANTS (CONT.)

First Name	Last Name	Affiliation
Lisa	Davis	University of Alabama
Kyle	Donohoo	Dell Technologies
Rob	Douglas	Cradlepoint
Jennifer	Duan	University of Arizona
Jack	Eggleston	US Geological Survey
Frank	Engel	US Geological Survey
Peter	Esselman	US Geological Survey
Paul	Fanelli	National Oceanic and Atmospheric Administration
Nathan	Farrar	OTT HydroMet
Cole	Feely	Dell Technologies
Chase	Ferrell	US Army Corps of Engineers
Laura	Fiorentino	National Oceanic and Atmospheric Administration
Brandon	Forbes	US Geological Survey
Chris	Gazoorian	US Geological Survey
Troy	Gilmore	University of Nebraska - Lincoln
Erfan	Goharian	University of South Carolina
Tomislav	Grubesa	Geolux d.o.o.
Matt	Gyves	US Geological Survey
Insley	Haciski	Xylem
Makayla	Hayes	Deep Analytics LLC
Hongsheng	He	University of Alabama
Keith	Helms	Dell Federal

PARTICIPANTS (CONT.)

First Name	Last Name	Affiliation
Gregory	Hewitt	Deep Analytics LLC
Shannon	Hicks	Stroud Water Research Center
Nathan	Holcomb	National Oceanic and Atmospheric Administration
Stephan	Howden	University of Southern Mississippi
Theo	Jass	Southeast Coastal Ocean Observing Regional Association
Bishal	Karmakar	University of Alabama
Tyler	King	US Geological Survey
Zach	Krauss	Alabama Water Institute
Kevin	Labbe	Xylem
Darrell	Lambeth	US Geological Society
Lisa	Landry	Xylem
Tim	Lane	UNICOM Engineering
Kristen	Leonard	Dell Technologies
Tosca	Lichtenheld	Sofar Ocean
Kai	Liu	University of Alabama
Hongxing	Liu	University of Alabama
Michael	Lohmiller	Cradlepoint
Wade	Loseman	Ott HydroMet
Yuehan	Lu	University of Alabama
Meredith	Martin	US Geological Survey
Julia	Masterman	CUAHSI
Ekaterina	Miliutina	University of Alabama

PARTICIPANTS (CONT.)

First Name	Last Name	Affiliation
James	Mitchell	US Geological Survey
Bryan	Moore	US Geological Survey
Teresa	Murphy	National Weather Service
Rob	Myers	US Geological Survey
Ronan	O'Maitiu	Aquatic Informatics
Thomas	Ott	H2O.ai
Brandon	Overstreet	US Geological Survey
Anindya	Palaparthi	University of Alabama
John	Parks	US Geological Survey
Matt	Parse	Dell Technologies
Arpita	Patel	CIROH
Arpita	Patel	Alabama Water Institute
Stephanie	Paul	University of Alabama
Colin	Peake	US Geological Survey
Gheorghe	Ponta	Geological Survey of Alabama
Ge (Jeff)	Pu	Cleveland Water Alliance
Heidi	Purcell	University of Michigan
Andres	Ramirez Molina	University of Alabama
Jordan	Read	CUAHSI
Bryce	Redinger	US Geological Survey
James	Rigby	US Geological Survey
Aswanth	Sampathkumar	University of Alabama

PARTICIPANTS (CONT.)

First Name	Last Name	Affiliation
Patrick	Sanders	Aquatic Sensors
Daniel	Schar	Univ of Hawai'i Mānoa
Andrew	Schiller	DNR/MGS/WRC
Jihee	Seo	University of Alabama
Brad	Simmons	US Army Corps of Engineers
Kevin	Simpson	Xylem
Laura	St Pierre	Xylem
Bert	Tanner	University of Delaware
Marouane	Temimi	Stevens Institute of Technology
Pawan	Thapa	University of Alabama
Dan	Tian	University of Alabama
Josh	Turner	Department of Natural Resources
Andrea	Vander Woude	National Oceanic and Atmospheric Administration
Christine	VanZomeren	Bureau of Reclamation
David	Velasco	Nortek
Eddie	Verhamme	LimnoTech
Chad	Wagner	US Geological Survey
Kyle	Waits	Xylem
Peter	Ward	KISTERS
Nimisha	Wasankar	University of Alabama
Jason	Webster	Jaia Robotics
Daniel	West	Geological Survey of Alabama

PARTICIPANTS (CONT.)

First Name	Last Name	Affiliation
Marian	Westley	National Oceanic and Atmospheric Administration
Matt	Womble	Alabama Water Institute
Molly	Wood	US Geological Survey
Xue	Wu	University of Alabama
Maggie	Yancey	National Aeronautics and Space Administration
Navid	Yazdi	Evigia Systems
Sierra	Young	Utah State University
David	Young	RoboNation, Inc.
Lynn	Zanow	US Army Corps of Engineers

PLANNING AND ORGANIZING COMMITTEE

Steve Burian – University of Alabama, Cooperative Institute for Research to Operations in Hydrology (CIROH)

Russ Lotspeich – USGS, Next Generation Water Observing System (NGWOS)

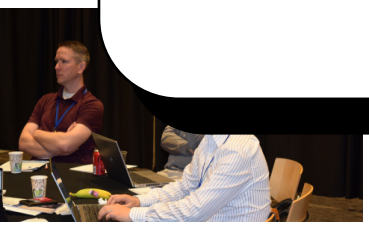
Meredith Marsh – University of Alabama, Alabama Water Institute (AWI)

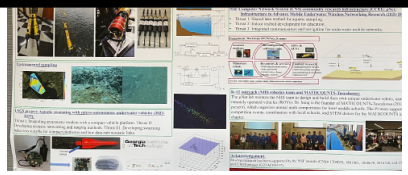
Lanna Nations – University of Alabama, Alabama Water Institute (AWI)

Brian Pellerin – USGS, Next Generation Water Observing System (NGWOS)

Mario Tamburri – University of Maryland Center for Environmental Science, Alliance for Coastal Technologies (ACT)

APPENDIX A: DETAILED AGENDA





WATER OBSERVING TECHNOLOGY FORUM

THE UNIVERSITY OF ALABAMA® | Alabama Water Institute

April 23-25, 2024

Sellers Auditorium
Tuscaloosa, AL

DAY 1

Tuesday,
April 23, 2024
Central Time (CT)

Imagery as Data

Sellers Auditorium

Time	Topic
8:30-8:45	**Welcome, Logistics and Introductions** Steve Burian, Alabama Water Institute Matt Womble, Alabama Water Institute
	Keynote Presentations
8:45-9:00	**The University of Alabama College of Engineering's Water Observing Technology Research and Education** Cliff Henderson, University of Alabama College of Engineering
9:00-9:15	**The University of Alabama Strategy to Support the Advancement of Water Observing Technology** Bryan W. Boudouris, University of Alabama VP for Research and Economic Development
9:15-9:45	**Next Generation Water Observing for the Nation** Chad Wagner, USGS
9:45-10:00	Coffee/Soda Break
	Plenary Presentations
10:00-10:30	**Camera Networks for Weather Monitoring** Jerry Brotzge, Western Kentucky University
10:30-11:00	**Operational Implementation of Imagery in USGS Water Science** Jack Eggleston, USGS
11:00-11:30	**Crewed to Uncrewed Systems: Transitioning Hyperspectral Imaging across Platforms to Monitor Harmful Algal Blooms and Water Quality Parameters Across the Great Lakes** Andrea Vander Woude, NOAA Great Lakes Environmental Research Laboratory
11:30-13:30	Buffet Lunch/Poster Sessions
	Technology Application Presentations
13:30-13:50	**WebCOOS: Delivering Data for Decisions** Theo Jass, SECOORA
13:50-14:10	**Leveraging USGS HIVIS to Remotely Monitor Streamflow Conditions in the US** Marouane Temimi, Stevens Institute of Technology
14:10-14:30	**GRIME-AI: Open-source Software for Ecohydrological Science and Education using Ground-based Time-lapse Imagery** Troy Gilmore, University of Nebraska
14:30-15:00	Coffee/Soda/Snacks Break
15:00-15:20	**Operationalizing Remote Measurements of Streamflow with Fixed and Mobile Camera Platforms** Frank Engel, USGS
15:20-15:50	**Hydrologic Monitoring using Cameras: Key Takeaways from Initial Deployments** Sierra Young, Utah State University Erfan Goharian, University of South Carolina
15:50-16:50	**Open Discussion:** Imagery as Data for Inland and Near-Shore Waters
16:50-17:00	**Day 1 Closing Remarks** Steve Burian, Alabama Water Institute

DAY 2

Wednesday, April 24, 2024
Central Time (CT)

Mobile Monitoring Systems

Sellers Auditorium

Time	Topic
8:30-8:45	**Welcome and Logistics** Russ Lotspeich, USGS
	Keynote Presentations
8:45-9:15	**Creating an Educational Pathway for Autonomous Technology Innovators** David Young, RoboNation
9:15-9:45	**The Global Drifter Program: Real-Time In-Situ Observation with Autonomous Drifters** Luca Centurioni, Scripps Institute of Oceanography
9:45-10:00	Coffee/Soda Break
	Plenary Presentations
10:00-10:30	**Autonomous Monitoring for Hypoxia in the Gulf of Mexico** Stephan Howden, University of Southern Mississippi
10:30-11:00	**Autonomous Distributed Measurement for Water Quality Estimation using Mobile Sensor Networks** Bert Tanner, University of Delaware
11:00-11:30	**Monitoring South Florida's Coastal Ecosystems: Protecting our Health, Wealth and Happiness** Todd Crowl, Florida International University
11:30-13:30	Buffet Lunch/Poster Sessions
	Technology Application Presentations
13:30-13:50	**Integrated Acoustic Communications with Underwater Autonomy** Aijun Song, University of Alabama
13:50-14:10	**USACE ERDC Uncrewed Survey System Development** Ian Conery, USACE ERDC
14:10-14:30	**Monitoring Great Lakes Fisheries 'at scale' with autonomous vehicles** Peter Esselman, USGS
14:30-15:10	Coffee/Soda/Snacks Break
15:10-15:30	**Autonomous Power Distribution System for Underwater Vehicles** Nina Mahmoudian, Perdue University
15:30-15:50	**Recent Development and Operation of CO-OPS' Real-Time, Shallow Water CURrents BuoY (CURBY)** Laura Fiorentino - NOAA Center for Operational Products and Services (CO-OPS)
15:50-16:50	**Open Discussion:** Mobile Observing Platforms for Inland and Near-Shore Waters
16:50-17:00	**Day 2 Closing Remarks** Russ Lotspeich, USGS

DAY 3

Thursday,
April 25, 2024
Central Time (CT)

Innovation Partnerships and Technology Showcase

Sellers Auditorium

Time	Topic
8:30-8:45	**Welcome, Logistics and Introductions** Brian Pellerin - USGS
	Plenary Presentations
8:45-9:15	**Impact of UA Research and Economic Development Enterprise / Techstars Water Tech and Sustainability Accelerator** Dan Blakley, University of Alabama Justice Smyth, Tuscaloosa County Economic Development Authority
9:15-9:45	**The Alliance for Coastal Technologies: Enabling Environmental Innovations and Observations** Mario Tamburri, University of Maryland Center for Environmental Sciences
9:45-10:15	**Government - Industry Innovation Partnerships: How to Make Them Work** Maggie Yancey, NASA
10:15-10:45	**Smart Lake Erie and CWA Accelerator for a Freshwater Economy** Jeff Pu, Cleveland Water Alliance
10:45-11:00	**Closing Remarks** Brian Pellerin - USGS Tim Haskew, University of Alabama
11:30-13:00	Boxed Lunch Pickup Window Generously Sponsored by Dell
11:00-17:00	**Vendor Exhibits / HIF Tours / Government Tech Transfer and Partnership Talks**
	Government Tech Transfer and Partnership Talks
13:00-13:30	**NSF Convergence Accelerator** Catherine O'Reilly, Program Director (virtual)
13:30-14:00	**USGS Technology Transfer Office** James Mitchell, Technology Enterprise Specialist
14:00-14:30	**USBR Prize Competitions** Christine VanZomeren, Program Administrator
14:30-15:00	**USACE ERDC and ERDCwerx** Lynn Zanow and William Klauser (virtual)
16:00	Adjourn (vendors have until 17:00 to exit Sellers)

DAY 3

Exhibitors

Ott HydroMet
Fluidion
Pacific Gyre
University of Alabama
Cradlepoint
Dell
Xylem Analytics – SonTek
Kisters North America
Evigia Systems
Stroud Water Research Center
Campbell Scientific
Trutta Environmental Solutions
Fondriest Environmental
RoboNation
Sofar Ocean
USGS
Jaia Robotics
iSENSYS, LLC
Aquatic Sensors
In-Situ Inc
Geolux d.o.o.