

# 2023 ASPRS International Technical Symposium

ASPRS is happy to announce the dates of its virtual conference. The 2023 ASPRS International Technical Symposium will take place.

#### The symposium will consist of:

- 15-minute oral presentations
- 5-minute Ignite-style presentations
- Poster Gallery
- Sustaining Member Vendor Spotlights
- ASPRS Society Highlights

Sessions will run each day from 10:00 AM to 6:00 PM Eastern Daylight Time (UTC - 4). All sessions will be recorded and made available on-demand to conference registrants. Presenters are eligible to submit full manuscripts for publication in the ISPRS Archives.

#### **Registration Fees**

<ul> <li>ASP</li> </ul>	RS Member	\$150 USD
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- ASPRS Student Member \$ 50 USD
- ASPRS Emeritus Member \$25 USD
- Non Member \$250 USD

#### Sponsorship Opportunities

- Vendor Spotlight/Product Demo
- Day Sponsor
- Session Sponsor
- Workshop Sponsor

"We are happy to offer this educational opportunity to the geospatial community. Virtual events are an excellent way to exchanammunity without the cost and time constraints of travel," said Karen Schuckman, ASPRS Executive Director

VIRTUAL

## HTTPS://MY.ASPRS.ORG/2023SYMPOSIUM/

## **INDUSTRY**NEWS

#### **ANNOUNCEMENTS**

NV5 Global, Inc., a provider of technology, conformity assessment, and consulting solutions, announced today the closing of its acquisition of L3Harris Technologies, Inc.'s Visual Information Solutions commercial geospatial technology and software business ("VIS"). First announced in December, the acquisition has received regulatory approvals and enhances NV5's position as North America's premiere provider of geospatial data solutions, accompanying the acquisition of Axim Geospatial completed earlier this year.

"This acquisition supports NV5's expansion in a subscription-based geospatial product and service model and strengthens our role in supporting the nation's defense and intelligence communities through geospatial information management and analytics," said Dickerson Wright, PE, Chairman and CEO of NV5. "As the only provider of software solutions to analyze over 200 geospatial data types and comprehensive inhouse lidar, topobathymetric lidar, and full ocean depth sonar capabilities, NV5 has built a distinct competitive advantage and robust platform to support accelerated organic growth."

The VIS acquisition includes 16 U.S. Patents for geospatial data analytics. NV5 will also receive ownership of an additional 13 U.S. and non-U.S. Trademark Registrations for leading geospatial software applications with approximately 500,000 global users. These software products include prominent applications such as ENVI, IDL, Jagwire, Amplify, and Helios, which are relied upon by the United States Department of Defense and federal civilian agencies for the analysis and management of geospatial data.

For more information on NV5, visit www.nv5.com.

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UP42, the geospatial developer platform and marketplace, has significantly expanded its aerial imagery and elevation data portfolio through a partnership with **Vexcel**-a 30-year industry leader in the photogrammetric and remote sensing space. The Vexcel Data Program delivers geospatial data products with high accuracy, spatial resolution, and consistency.

Vexcel's aerial data collection initiative is the largest in the world capturing ultra-high-resolution imagery (at 7.5 to 15cm resolution) and related geospatial data in more than 30 countries, including the U.S., Canada, U.K., Western and Eastern Europe, Australia, New Zealand, and Japan. Known for their remarkable image quality, Vexcel products are used extensively by local governments, utilities, telecoms, and AEC (architecture, engineering, construction) companies.

"With a rich heritage in the geospatial industry, the Vexcel name is synonymous with reliability and quality," said Sean Wiid, CEO of UP42. "Our partnership with Vexcel highlights UP42's commitment to offer our customers a portfolio of products that continues to grow in diversity and geographic coverage."

Vexcel has built its excellent reputation over decades in the geospatial sector, first as developer of the marketleading UltraCam airborne sensor line deployed globally by aerial mappers. Leveraging the UltraCam's ultrahigh resolution and accuracy combined with world-class processing software, Vexcel launched its data collection program and amassed a comprehensive library of cloudbased aerial imagery and elevation data.

"Our aerial data helps end users solve some of the toughest geospatial challenges, especially when it comes to infrastructure and asset management," shared Jason Jones, Director of Channels and Alliances for Vexcel. "End users are able to support better decision-making, enhance workflows, and generate more accurate automated insights using our premium imagery. We're thrilled our partnership with UP42 provides this opportunity to their customers."

The clear and accurate Vexcel aerial imagery now available on the UP42 marketplace enables users to gain greater context and insights from the world around them. These products include: oblique and true ortho urban images at 7.5 cm resolution, or better; orthos at 15-20 cm; and Digital Surface Models (DSM) at 7.5cm resolution and Digital Terrain Models (DTM) at 15-20 cm resolution

The consistent quality of Vexcel image products across all geographic locations delivers insights and analysis in a variety of applications, including: vegetation management and infrastructure monitoring by energy utilities and telecommunication companies; vite inspection and property assessment by AEC firms; and urban planning and environmental protection by local governments.

"We launched UP42 with the objective of becoming the one-stop-shop that changes the way geospatial data is accessed and analyzed — and our partnership with Vexcel further assists us in achieving that goal," said UP42's Wiid.

For more information visit https://vexceldata.com/au or https://up42.com.

### **INDUSTRY**NEWS

#### ACCOMPLISHMENTS

**Dewberry**, a privately held professional services firm, has announced that Executive Vice President and Federal Market Leader Phil Thiel has been named to the National Geospatial Advisory Committee (NGAC) by the U.S. Department of the Interior.

The NGAC provides advice and recommendations on national geospatial policy and management issues, the development of the National Spatial Data Infrastructure (NSDI), and the implementation of the Geospatial Data Act of 2018.

Thiel serves as principal-in-charge for Dewberry's major geospatial contracts with the Federal Emergency Management Agency, National Oceanic and Atmospheric Administration, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, U.S. Geological Survey, and numerous other federal agencies and clients, providing surveying, remote sensing, geographic information systems, information technology, and other professional services.

"The National Geospatial Advisory Committee plays a vital role in advancing the nation's adoption and implementation of geospatial technologies, and I'm truly honored and humbled to join the committee," Thiel says.

For more information on Dewberry, visit www.dewberry.com.

In December 2022, the US joined an international coalition committed to preserving 30 percent of the planet's lands and oceans by 2030, an initiative known as 30 by 30. An inherently geographic issue, one major tool already in use to achieve this goal is mapping technology. **Esri**, the global leader in location intelligence, has been at the forefront of applying maps and analytics to conservation since its inception. One key mission for founders Jack and Laura Dangermond has been understanding the connection between humans and the planet to help build a more sustainable world. In recognition of their work, the International Land Conservation Network (ILCN) has awarded Jack and Laura Dangermond the Conservation Visionary Award.

"We have always been passionate about protecting the natural world, and this award is an incredible honor for us," said Jack Dangermond, Esri founder and president. "We hope our work inspires and motivates individuals and other organizations to pursue similar opportunities to conserve remaining natural areas important to the health of our planet, especially as we embark on the ambitious goal of protecting a third of the planet's lands and oceans."

Jack and Laura Dangermond founded Esri in Redlands, California in 1969, and it is now the leading geographic information system (GIS) software company in the world. Esri has supported environmental efforts by offering lowcost access to software, content, and resources through its Nonprofit Organization Program. The company has also donated or pledged more than \$1 billion worth of free Esri software to schools and environmental organizations.

In addition to company support, the Dangermonds personally established the Jack and Laura Dangermond Preserve at Point Conception, California, in 2017. Their \$165 million donation to The Nature Conservancy helped protect 24,000 acres of California's central coastal land. Currently, the organization is building a digital twin of the preserve available online, and empowering researchers to study the preserve from anywhere in the world.

The ILCN connects civic and private organizations around the world to accelerate the protection and strengthen land and natural resource management. The organization's Conservation Visionary Award honors individuals who have made outstanding contributions to the field of conservation. Recent awardees have included Minister of the Environment of Chile, Marcelo Mena; Director for Biodiversity in the European Commission's Directorate General for the Environment, Humberto Delgado Rosa; and Conservation Director at the Fundacion Catalunya al Pedrera, Miquel Rafa Fornieles.

The Dangermonds' award was presented to Jack and Laura at the 2023 Esri Geodesign Summit.

For more information on Esri, visit www.esri.com.

#### **CALENDAR**

- 12-16 June, ASPRS 2023 International Technical Symposium. For more information, visit https://my.asprs. org/2023Symposium/.
- · 16-19 October, GIS-Pro 2023, Columbus, Ohio. For more information, visit www.urisa.org/gis-pro.

#### PHOTOGRAMMETRIC ENGINEERING & REMOTE SENSING

PE&RS

The official journal for imaging and geospatial information science and technology

June 2023 Volume 89 Number 6



### Top Geospatial Trends to Watch in 2023

By Qassim Abdullah, Ph.D., PLS, CP, Woolpert Vice President and Chief Scientist



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Yunping Chen, Yue Yang, Lei Hou, Kangzhuo Yang, Jiaxiang Yu, and Yuan Sun

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Zhikang Lin, Wei Liu, Yulong Wang, Yan Xu, and Chaoyang Niu

The detection of changes in synthetic aperture radar (SAR) images based on deep learning has been widely used in landslides detection, flood disaster monitoring, and other fields of change detection due to its high classification accuracy. However, the inherent speckle noise in SAR images restricts the performance of existing SAR image change detection algorithms by clustering analysis. Therefore, this article proposes a novel method for SAR image change detection based on clustering fusion and deep neural networks.

### 385 Strategies for Forest Height Estimation by High-Precision DEM Combined with Short-Wavelength PolInSAR TanDEM-X

Hongbin Luo, Wanqiu Zhang, Cairong Yue, and Si Chen

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#### See the Cover Description on Page 336

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linkedin.com/groups/2745128





# **COVER DESCRIPTION**



A bright spot has emerged after California's particularly wet and dreary winter: a sea of wildflowers in Southern California. In the western tip of the Mojave Desert, orange, gold, and yellow flowers have flooded the valleys and hills of Antelope Valley California Poppy Reserve.

On April 7, 2023, the Operational Land Imager (OLI) on Landsat 8 acquired the image (cover) of the valley. Bright golden-orange California poppies (Eschscholzia californica) are on full display with yellow California goldfields (Lasthenia californica), among other species of flowers.

On April 15, 2023, the Operational Land Imager-2 (OLI) on Landsat 9 captured another vibrant view of the bloom (above). By this time, the golden-orange poppies had faded in places, while canary yellow flowers in the upper left of the image pop out. The yellow flowers are surrounded by panels from a solar farm.

During the same week in April 2020, orange hues of the California poppy dominated images of the reserve. But in these views in 2023, a mosaic of orange and yellow is on display.

Although wildflowers make their appearance on these hills almost every spring, this year California is experiencing a larger "super bloom." Much of California had a wetter-than-average winter, and this abundant precipitation fuels the large wildflower blooms.

For more information, visit https://landsat.visibleearth.nasa.gov/view. php?id=151227.

NASA Earth Observatory images by Lauren Dauphin, using Landsat data from the U.S. Geological Survey. Story by Emily Cassidy.



### PHOTOGRAMMETRIC ENGINEERING & REMOTE SENSING

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All written correspondence should be directed to the American Society for Photogrammetry and Remote Sensing, PO Box 14713, Baton Rouge, LA 70898, including general inquiries, memberships, subscriptions, business and editorial matters, changes in address, manuscripts for publication, advertising, back issues, and publications. The telephone number of the Society Headquarters is 301-493-0290; the fax number is 225-408-4422; web address is www.asprs.org.

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\*Note: Subscription prices for Canada includes 5% of the total amount for Canada's Goods and Services Tax (GST #135123065). **PLEASE NOTE: All Subscription Agencies receive a 20.00 USD discount**.

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## Top Geospatial Trends to Watch in 2023 by Qas

### by Qassim Abdullah, Ph.D., PLS, CP

Woolpert Vice President and Chief Scientist For the last six years, I have been writing this "Top Geospatial Trends" column, which is usually published in January or February. Some years, the columns write themselves, as advancements in the industry emerge or innovative perspectives demand input and conversation. This year, because the industry is still working to shake off the dust from the pandemic, this column is being published in June.

For this year's edition, I'll revisit how the trends highlighted last year fared and if they will continue to shape our year ahead, spotlight some things to watch in the last half of 2023, and provide my perspective about the future of geospatial through the lens of our revised American Society for Photogrammetry and Remote Sensing (ASPRS) Accuracy Standards for Digital Geospatial Data, which are due to be published later this year.

### >Navigating Recovery, Gaining Strength

Four months into 2023, the pandemic continues to impact the geospatial industry. In 2021 and 2022, supply chains and productivity were disrupted, leading to shortages of critical materials, parts, and products, some of which compromised vital survey hardware. However, our industry has shown resilience as many companies and manufacturers have implemented new workplace safety protocols, increased automation, and diversified supply chains to mitigate the impact of future disruptions. In addition, geospatial hardware manufacturers have continued to advance new and unique capabilities for data acquisition.

**Digital Twin:** Last year, I shared how BIM and GIS provide the foundation for digital twin, and how the nearly synonymous term of "metaverse" was gaining traction. Over the last year, the collective benefits and returns on investment for the digital twin have continued to expand. As the value of the digital twin is increasingly realized, demand for this technology will skyrocket. A digital twin is a digital replica of a physical environment, whether it is an asset, process, highway corridor, river, ocean, or even the Earth. This digital representation comprises the entire life cycle of the asset or the project, from the planning stage to design and construction, and continuing through operating the asset—all in one place.

Since the digital twin mimics the real-world characteristics of the physical environment in real time, with the help of Internet of Things (IoT) sensors, a facility engineer can remotely observe the operational environment of a building to manage environmental controls, power consumption, air quality, fire alarm systems, etc. A city emergency response team can simulate disaster scenarios to identify evacuation routes and aid access through a digital twin, or a port authority can manage its assets and port operations, guiding incoming and outgoing ships through its navigation channel by way of precision navigation. This capability can save billions of dollars at commercial ports that have restricted visibility due to fog or other environmental conditions that can impede navigation.

Additionally, the smart city concept coupled with the IoT will continue to expand, generating a wealth of data and information that can be used for geospatial analysis through artificial intelligence. The digital twin concept is fertile ground for using AI tools to extract useful information and

Photogrammetric Engineering & Remote Sensing Vol. 89, No. 6, June 2023, pp. 337-341. 0099-1112/22/337-341 © 2023 American Society for Photogrammetry and Remote Sensing doi: 10.14358/PERS.89.6.337 predict future trends and phenomena. Increasingly, software companies are providing platforms for building and hosting digital twins. Companies like Microsoft, through its Azure digital twin platform, and Bentley, Autodesk, and Esri have developed capabilities to support digital twin development.

**Virtual Collaboration Rooms and Mixed Reality:** Several technologies that support virtual collaboration and data visualization were spotlighted in 2022. Those platforms generate the need for 3D data while providing a new means of data modeling and interpretation. These include Microsoft Mesh and HoloLens 2; Bentley's mixed reality platform, SYNCHRO XR; and the NVIDIA Omniverse platform. Demand for higher-resolution 3D geospatial data has grown rapidly in the past year. This will continue to fuel multiverses that interface to human factors through augmented and virtual reality, offering new possibilities for visualization, design, and analysis. This mixed reality tech trend will trend upward as more applications of AR and VR are discovered and applied to support multiple industries.

**Deep into Miniaturized Sensors:** Smartphones continue to branch out geospatially, putting lidar capabilities in the hands of the masses while expanding opportunities for professional surveyors and mappers to conduct geospatial survey on small projects. A sneak preview of smartphones coming out this year indicates that they will include even more advanced lidar systems. This underscores how sensor systems will continue to get smaller, more efficient, and more technologically advanced.

**High-Definition Maps for Autonomous Driving:** I made a plea last year for the geospatial industry to take the lead on creating and standardizing high-definition maps for a global road network in support of autonomous vehicles. Sadly, a year has passed, and the situation remains unaltered. This precision location data should include lane numbers, freeway exit lanes, pedestrian crosswalks, bridges, overpasses, tunnels, locations of traffic control devices, 3D trajectories for road edges and boundaries, etc., with accuracy to the centimeter level, meter-by-meter road grade, and road superelevation. Addressing this situation continues to be an immense opportunity for our industry and the future of safe autonomous transportation.

**Rising Drone Demand:** As predicted, uncrewed aircraft system-based lidar took off in 2022 and will continue to rise, providing a healthy offering of new and affordable lidar. In 2021, growth was spurred by the DJI lidar system, Zenmuse L1, which provided high accuracy at a comparably lower cost. Today, while most affordable UAS-based lidar systems are based on Livox laser technology, UAS-based lidar systems based on Hesai technology (or Hesai scanners) are gaining growing interest, having proved to be more robust and better suited for general survey, mapping, and inspection applications. An example of this is the RESEPI XT32 by Inertial Labs, which features a 360-degree field of view and 32 lasers.



Woolpert collected lidar data of this Wyoming canyon in Yellowstone National Park to create a digital elevation model for the U.S. Geological Survey. \*Image courtesy of the United States Geological Survey.



The geospatial industry can advance the future of safe, autonomous transportation by standardizing high-definition maps for a global road network. Photo courtesy of Getty Images.



Lidar continues to be a mover and a shaker for the geospatial industry and will remain so for the foreseeable future. Graphic courtesy of Woolpert The manufacturer claims the RESEPI XT32 provides 1-centimeter accuracy.

For drones overall, the industry demand is strong, especially for mapping and inspection applications.

Whirl Around the Coastal Regions: Coastal wind energy contracts were highlighted in my article last year as part of a larger effort by the U.S. to transition to cleaner, renewable sources of energy and to reduce reliance on fossil fuels. In 2022 and into 2023, this effort continues to grow, with coastal wind farms approved and constructed along the nation's coastlines.

On a larger scale, the demand for airborne lidar bathymetric data is on the rise and best demonstrated by the Florida Seafloor Mapping Initiative (FSMI), which is being managed by Florida Department of Environmental Protection, as well as a multitude of projects in the Pacific. These projects are aimed at collecting critical foundation data needed for coastal inundation modeling, resilience planning, and engineering projects.

**Data Democratization:** In the past year we witnessed an explosion in the demand for high-resolution, high-frequency geospatial information from denser point clouds to more crowd-sourced location data. New market entrants are using AI to extract infrastructure features in exquisite detail. The market is hungry for good, raw 3D data to feed these algorithms. With the higher demand for geospatial data, we should see prices fall and higher shelf-life decrease. The quality and availability of publicly available data will also increase.

AI and the Cloud: AI and machine learning both play a significant role in geospatial analysis and mapping. Thanks to private sector investments, cloud data hosting and processing, serverless cloud computing, off-the-shelf and open-source technologies, and streamlined workflows with AI tools all continue to trend upward. I am still hoping that federal and public funding can be used to entice further creativity in this field. Without these investments outside the private sector, the most cutting edge geoanalytics will not be available to the broader market.

**Lidar Growth:** As you likely have seen from its mention in multiple topics above, lidar continues to be a mover and a shaker for the geospatial industry and will remain so for the foreseeable future. Lidar efficiencies continue to expand across other industries to support robotic applications such as autonomous driving and machine learning.

Bathymetric lidar also has been getting more attention. Leica recently announced the release of its newest deep bathymetric lidar sensor, the Leica HawkEye-5, which reportedly has a 25% increase in performance. Woolpert and the Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) announced Bathymetric Unmanned Littoral LiDar for Operational GEOINT (BULLDOG) technologies and sensor. These technologies enable the collection of high-resolution topo-bathy data at a higher altitude, resulting in a broader swath than previously developed lidar systems.

The introduction of these new bathymetric lidar capabilities is timely, as they are being employed to serve the many vital statewide and national coastal mapping initiatives, as noted above with initiatives like FSMI. States are using this federal funding window to collect data essential to everything from asset management to infrastructure planning to disaster response. What is key to these opportunities is that contracting agencies make sure they collect consistent, high-quality data so they can reap the rewards of this funding for years to come. Miniature lidar manufacturing, especially for sensors mounted on drones, is getting a healthy share of the lidar market as more surveying and mapping businesses embrace the technology.

#### Other noteworthy trends

Here are a few other quick-hitting geospatial trends in technologies and methodologies to watch in 2023:

- Indoor mapping will continue to become more sophisticated, opening the door for improved indoor wayfinding and asset management.
- Location data will be subjected to increasing privacy and security regulations and standards. For the extra layer of security it provides, we may witness increased use of blockchain technology in geospatial data management and sharing.
- With more user-friendly data visualization tools available to all industries, 3D geospatial data will be increasingly used in training, gaming, planning, design, asset management, navigation, and other applications.

### >ASPRS Accuracy Standards Update

When we published the ASPRS Positional Accuracy Standards for Digital Geospatial Data Standards in 2014, we knew we would have to modify it based on user experience and feedback. And sure enough, after eight years of fast-changing sensor technologies and evolving applications, it became clear that significant changes needed to be made to the standards to make them more adaptable to today's mapping practices.

One of the most important changes that our revision working group has endorsed is easing the accuracy of field surveying requirements for ground control and checkpoints. As we are producing more accurate products, we have realized that the current accuracy requirement for checkpoints of three times better than the accuracy of the tested product have rendered nearly useless our affordable RTK-GPS



techniques, which are predominately used for surveying. This requirement has forced contracting agencies to specify more expensive surveying techniques, which has proved to be a cost prohibitive for completing these contracts.

Another important change is the addition of five addendums on best practices and guidelines in project notes and data reporting, photogrammetry, lidar, UAS, and field surveying. When we published the first edition in 2014, we designed it to be a modular standard to accommodate additional materials as the industry evolved. Since then, we have witnessed an unprecedented acceleration in geospatial technologies and practices. This growth necessitated guidelines and best practices in multiple aspects of geospatial mapping to help users of the standards navigate these rapidly changing advancements. These addendums were crafted by industry leaders who specialize in these fields.

In addition, an important change is coming regarding the way we evaluate product accuracy. Currently, we ignore the

error in survey checkpoints. That practice was acceptable when geospatial mapping product accuracy was low, and the surveying techniques applied did not represent a substantial enough source of error to be considered in computing product accuracy. As we are moving into more accurate products, i.e., in the range of a few centimeters, it has become apparent that the 2cm error embedded in the RTK-GPS survey technique can no longer be ignored. The new method will consider the fit of the product to the checkpoints plus the error of the survey.

The second edition of these standards will be published in the next few months. Keep an eye out for a forthcoming article that highlights the changes and their ramifications which are designed to advance the geospatial industry. Above all else, this will have a long-lasting impact on the geospatial industry.

Woolpert Vice President and Chief Scientist Qassim Abdullah, Ph.D., PLS, CP, has more than 40 years of combined industrial, R&D, and academic experience in analytical photogrammetry, digital remote sensing, and civil and surveying engineering. When he's not presenting at geospatial conferences around the world, Abdullah teaches photogrammetry and remote sensing courses at the University of Maryland and Penn State, authors a monthly column for the ASPRS journal PE&RS, and mentors R&D activities within Woolpert.

This article is running in running in *PE&RS* Journal and *Lidar Magazine*.

The layman's perspective on technical theory and practical applications of mapping and GIS

**MAPPING MATTERS** 

## YOUR QUESTIONS ANSWERED

by Qassim Abdullah, Ph.D., PLS, CP Woolpert Vice President and Chief Scientist

Have you ever wondered about what can and can't be achieved with geospatial technologies and processes?

Would you like to understand the geospatial industry in layman's terms? Have you been intimidated by formulas or equations in scientific journal articles and published reports?

Do you have a challenging technical question that no one you know can answer?



If you answered "YES" to any of these questions, then you need to read Dr. Qassim Abdullah's column, Mapping Matters.

In it, he answers all geospatial questions—no matter how challenging—and offers accessible solutions. Send your questions to Mapping\_Matters@asprs.org To browse previous articles of Mapping Matters, visit http://www.asprs.org/Mapping-Matters.html

"Your mapping matters publications have helped us a lot in refining our knowledge on the world of Photogrammetry. I always admire what you are doing to the science of Photogrammetry. Thank You Very much! the world wants more of enthusiast scientists like you."

"I read through your comments and calculations twice. It is very clear understandable. I am Honored there are experienced professionals like you, willing to help fellow members and promote knowledge in the Geo-Spatial Sciences."

## **YOUR COMPANION TO SUCCESS**

## GIS Tips Tricks

## Srinu Ratnala, Andrew Peters, GISP, and Al Karlin, Ph.D. CMS-L, GISP

#### **Easy Contours in Global Mapper**

While many GIS Tips & Tricks columns focus on the Esri-based ArcGIS and ArcGIS Pro software packages, there are many other software packages that offer similar GIS-based analytical tools. In this column we will explore using Global Mapper<sup>™</sup> to quickly produce contour lines from a Digital Elevation Model. This workflow is relatively straightforward; it uses a basic Global Mapper license, no extensions required, and only requires a bare earth Digital Elevation Model (DEM) which can easily be downloaded from the USGS



Figure 1. Starting the Generate Contours Dialog Box from the Analysis Tab in Global Mapper™.

National Map (https://apps.nationalmap.gov/downloader/) or the NOAA Digital Coast (https://coast.noaa.gov/dataviewer/#/), both of which have been discussed in other GIS Tips & Tricks columns. Global Mapper<sup>™</sup> provides the end-user with multiple options for constructing contours, including custom intervals, major and minor contours, and smoothing algorithms accessed directly from a simple dialog box system.

#### **THE BASIC WORKFLOW**

- Step 1 Load a bare earth DEM into Global Mapper,
- Step 2 Select the "Analysis" Tab on the Ribbon,
- Step 3 Select the "Generate Contours (from Terrain Grid) tool on the dropdown,
- Step 4 Update/Fill-in a few parameters on a dialog box,
- **Step 5** [optional] Export the generated contours to a permanent file of your choice.

#### **EXAMPLE WORKFLOW**

Note: For this example, we downloaded a 1-meter DEM for the Pisgah National Forest area in North Carolina from the U.S. National Map. The DEM was referenced to UTM Zone 17N/NAD83 in meters (EPSG:26917). The file format is a 32bit Floating Point GeoTIFF.

- Step 1 Load the bare earth DEM.
- Step 2 From the menu bar, click the Analysis Tab and select the "Generate Contours (from Terrain Grid) tool as in Figure 1).

Step 3 — Fill in the Contour Generation Options Dialog. Notice that there are four Tabs across the top of this Dialog.

The Contour Generation Options Tab (Figure 2) is used to specify the contour interval and other optional characteristics of the lines. In this case, we will generate 10-meter contours with Minor Contours every 10-meters and Major Contours every 100 meters in this very rugged terrain. Notice that Global Mapper<sup>™</sup> reports the elevation ranges in the DEM (345.9 to 861 meters in this example) and there are options for resampling the DEM, smoothing the contour lines, and removing closed (small circular looping) contour lines on this Tab.

#### **TIP #1**

The "Discard Closed Contour Lines Shorter than" will omit closed (looping) contour lines of a length less than the specified measure. This is important if you want to remove small circular contours that can be prevalent in lidar-derived DEMs. Depending on your use-case, this value can range to hundreds of meters and may require empirical testing.

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#### **Contour Generation Options**

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contour lines that take up less space. Typically you'll just want to accept the defaults.
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Denoting Ne Descent Neither)
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Interpolate to Fill Small Gaps in Data
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Smooth Contour Lines/Areas to Improve Appearance
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meters meters
Create Spot Elevation Points at Min/Max Elevation Locations
Export Contours Directly to Package Files Rather Than Displaying in the Main Map View. Use with Tiling Option to Allow Contouring of Very Large Areas
Advanced Options
Create Contours Where Elevations Pass Down to Contour Value Rather Than as They Go Down From One (Good for Shoreline Generation)
Discard Closed Contour Lines Shorter than 100 meters
Copy Script OK Cancel Help

Figure 2. The Global Mapper Contour Options Tab used when generating contours.

#### **TIP #2**

The Simplification Tab (Figure 3) provides a slider to adjust the number of non-essential points along a contour line. The more points maintained to define the contour's shape, the larger the size of the resulting file, but the better the shape of the lines. The default value is 0.10, and of course, "never accept the defaults", we recommend a 0.20 as a starting setting and increasing the value if the file size is too large or decreasing this value if the contour lines are too jagged for your use-case.

Zooming in to a smaller area in this DEM shows the 100-meter Major and 10-meter Minor contours symbolized in different line weights (Figure 4.)

#### **TIP #3**

The Pisgah National Forest DEM used in this example was 356 MB in size (10,000 x 10,000 cells) and processed the 10-meter contours in a little over one minute and four seconds. When processing very large DEM mosaics, try resampling the DEM with one of the optional methods (See Figure 2) to decrease processing time.



×

Simplification is the process by which points that do not significantly contribute to the shape of a feature are removed.

Using a larger simplification threshold (right side of slider) will result in a smaller data file, however the curves in the resulting features will be less smooth.

Using a smaller simplification threshold (left side of slider) will result in larger data files that better maintain the integrity of the feature shapes.

Figure 3. The Simplification Tab slider is used to control the number of nodes per contour line; this also influences the file.

Step 4A — Save your Global Mapper<sup>™</sup> Workspace to make the GENERAGED CON-TOURS permanent for Global Mapper<sup>™</sup>, and/or

Step 4B — Export the contours to another GIS Format for use in ArcGIS, GRASS, and/ or other mapping packages.

Here are the steps to Export the GENERATED CONTOURS to an Esri shapefile.

- Step 5 Right-click on the GENERATED CONTOUR layer in the Control Center, scroll to the Layer bar and slide to the right to open the options, and select EXPORT – Export Layer(s) to New File (Figure 5)
- **Step 6** Select the Layers to Export from the Dialog Box (Figure 6)
- Step 7 Use the Dropdown selections (Figure 7) and scroll down the list to find the file format to export. In this case "Shapefile" is far down the alphabetical listing.



Figure 4. 10-meter Minor and 100-meter Major contours Global Mapper™ generated from the DEM.



Figure 5. Starting the Global Mapper™ EXPORT dialog to export the GENERATED CONTOURS line file



Figure 6. The Global Mapper™ "Select Layers" dialog box used to select the layer to export.

	Select Export Format	×	1 H
	Select the format to export your loaded data to. See https://www.bluemarblegeo.com/products/global-mapper-formats.php for information on the available formats.		
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#### **TIP #4**

Key-in the letter "S" on the keyboard by selecting the Dropdown list for quick navigation.

Step 8 — On the Shapefile Export Options dialog box (Figure 8), when you check the "Export Lines" box, a Windows file browser will appear; navigate to a writable directory and specify a file name (Global Mapper<sup>™</sup> will append .shp to your filename. Be careful to check the "Generate Projection (PRJ) for each Exported SHP File". There are several more options and additional Tabs with other parameters and press "OK" to export/write the file.

Global Mapper<sup>TM</sup> provides an efficient, extremely flexible option for constructing contours from a DEM. It really is that easy.

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Figure 8. The Global Mapper™ Export Shapefile Options dialog box showing four tabs (across the top) and multiple options screens.

Send your questions, comments, and tips to GISTT@ASPRS.org.

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### GEORGE E. BROWN, JR. CONGRESSIONAL HONOR AWARD

The 2021 award was presented to Congresswoman Betty McCollum on March 16th, 2023 during the "State of Our River - Mississippi River Dialogue" Meeting.

This award was established in honor of Congressman George E. Brown, Jr. and the contributions he made to advance the benefits of remote sensing imagery and geospatial information to the profession and society. The award is given periodically to recognize members of the U.S. Congress whose leadership and personal efforts have advanced the science, engineering, application, education, and commerce of remote sensing imaging and geospatial information systems.



On the left, Congresswoman Betty McCollum listens to Brian Huberty, ASPRS Western Great Lakes Region give a short history about the ASPRS Brown Award. (Photo Credit: Emmet Rice)

Thanks to COVID, it took additional time for ASPRS to award, in person, the 2021 George E. Brown, Jr. Congressional Honor Award to Congresswoman Betty McCollum (MN 4th District) for her support as a member of the House Appropriations Committee. She currently serves as the Chair of the Defense Subcommittee, the Vice Chair of the Interior-Environment Subcommittee, and as a member of the Agriculture and Rural Development Subcommittee. As one can imagine, she is quite busy with her roles in Congress. In these roles, she has continued to ensure funding for civil and defense remote sensing and geospatial information systems and programs.

Her 'behind the scenes' work includes multiple civil, defense and international collaborations to push global and regional remote sensing science mapping applications. The largest global example is an on-going collaboration between the National Science Foundation (NSF), National Geospatial-Intelligence Agency (NGA), NASA, and the Universities of Minnesota, Illinois, Texas,

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### **ASPRS**NEWS



(L\_R) Congresswoman Betty McCollum and Brian Huberty, ASPRS Western Great Lakes Region. (Photo Credit: Emmet Rice)

Washington, and the Ohio State University. This group, led by the University of Minnesota, Polar Geospatial Center (PGC), has developed techniques for producing EarthDEM<sup>1</sup> - a global scale, two-meter, surface topographic dataset using high resolution, time-dependent, MAXAR satellite optical imagery with open-source software and U.S. Government-funded, high-performance computing (Blue Waters) to produce a large volume of high-quality, publicly distributed, geospatial data.

Another regional example spun out of a U.S. Fish & Wildlife Service-Great Lake Restoration Initiative project mapping the Great Lakes Basin surface vegetation canopies. This project produced wetland maps with Canada by dovetailing the EarthDEM work by PGC. Again, thanks to NGA, and monthly Radarsat 2 images, over a dozen sites across the Great Lakes were able to produce wetland inundation maps for a five-year period. This work was done by the University of Minnesota, PGC and the Remote Sensing and Geospatial Analysis Laboratory; Michigan Tech University, Michigan Tech Research Institute; SharedGeo, the Minnesota Department of Natural Resources, Resource Assessment; Natural Resources Canada, Canada Centre for Remote Sensing; Environment & Climate Change Canada, Geomatics Research. This project led to the creation of the binational Great Lakes Alliance for Remote Sensing.<sup>2</sup>

The award was presented on March 16th, 2023 during the "State of Our River - Mississippi River Dialogue" meeting Congresswoman McCollum led at the Science Museum of Minnesota in St. Paul, Minnesota. On the award, a digital surface model of her district was created from a 2011 Fugro-Horizons lidar project under contract by the Minnesota Department of Natural Resources. The map was created by Jim Klassen, Sharedgeo who happens to be one of her constituents.

#### Author

Brian Huberty, Remote Sensing Advisor, Sharedgeo.org.

<sup>&</sup>lt;sup>1</sup> https://www.pgc.umn.edu/data/earthdem/

<sup>&</sup>lt;sup>2</sup> https://glars.org

## LANDSAT'S ENDURING LEGACY PIONEERING GLOBAL LAND OBSERVATIONS FROM SPACE



#### Landsat Legacy Project Team

Samuel N. Goward Darrel L. Williams Terry Arvidson Laura E. P. Rocchio James R. Irons Carol A. Russell Shaida S. Johnston After more than 15 years of research and writing, the Landsat Legacy Project Team published, in collaboration with the American Society for Photogrammetry and Remote Sensing (ASPRS), a seminal work on the nearly half-century of monitoring the Earth's lands with Landsat. Born of technologies that evolved from the Second World War, Landsat not only pioneered global land monitoring but in the process drove innovation in digital imaging technologies and encouraged development of global imagery archives. Access to this imagery led to early breakthroughs in natural resources assessments, particularly for agriculture, forestry, and geology. The technical Landsat remote sensing revolution was not simple or straightforward. Early conflicts between civilian and defense satellite remote sensing users gave way to disagreements over whether the Landsat system should be a public service or a private enterprise. The failed attempts to privatize Landsat nearly led to its demise. Only the combined engagement of civilian and defense organizations ultimately saved this pioneer satellite land monitoring program. With the emergence of 21st century Earth system science research, the full value of the Landsat concept and its continuous 45-year global archive has been recognized and embraced. Discussion of Landsat's future continues but its heritage will not be forgotten.

The pioneering satellite system's vital history is captured in this notable volume on Landsat's Enduring Legacy.

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## Call for PE&RS Special Issue Submissions

### Ushering a New Era of Hyperspectral Remote Sensing to Advance Remote Sensing Science in the Twenty-first Century

Great advances are taking place in remote sensing with the advent of new generation of hyperspectral sensors. These include data from, already in orbit sensors such as: 1. Germany's Deutsches Zentrum fur Luftund Raumfahrt (DLR's) Earth Sensing Imaging Spectrometer (DESIS) sensor onboard the International Space Station (ISS), 2. Italian Space Agency's (ASI's) PRISMA (Hyperspectral Precursor of the Application Mission), and 3. Germany's DLR's Environmental Mapping and Analysis Program (EnMAP). Further, Planet Labs PBC recently announced the launch of two hyperspectral sensors called Tanager in 2023. NASA is planning for the hyperspectral sensor Surface Biology and Geology (SBG) to be launched in the coming years. Further, we already have over 70,000 hyperspectral images of the world acquired from NASA's Earth Observing-1 (EO-1) Hyperion that are freely available to anyone from the U.S. Geological Survey's data archives.

These suites of sensors acquire data in 200 plus hyperspectral narrowbands (HNBs) in 2.55 to 12 nm bandwidth, either in 400-1000 or 400-2500 nm spectral range with SBG also acquiring data in the thermal range. In addition, Landsat-NEXT is planning a constellation of 3 satellites each carrying 26 bands in the 400-12,000 nm wavelength range. HNBs provide data as "spectral signatures" in stark contrast to "a few data points along the spectrum" provided by multispectral broadbands (MBBs) such as the Landsat satellite series.

The goal of this special issue is to seek scientific papers that perform research utilizing data from these new generation hyperspectral narrowband (HNB) sensors for a wide array of science applications and compare them with the performance of the multispectral broadband (MBB) sensors such as Landsat, Sentinels, MODIS, IRS, SPOT, and a host of others.

#### Papers on the following topics are of particular interest:

- 1. Methods and techniques of understanding, processing, and computing hyperspectral data with specific emphasis on machine learning, deep learning, artificial intelligence (ML/DL/AI), and cloud computing.
- 2. Issues of hyperspectral data volumes, data redundancy, and overcoming Hughes' phenomenon.
- 3. Building hyperspectral libraries for purposes of creating reference training, testing, and validation data.
- 4. Utilizing time-series multispectral data and hyperspectral data over many years to build data cubes and apply advanced computational methods of ML/DL/AI methods and approaches on the cloud.

- 5. Discussions of hyperspectral data analysis techniques like full spectral analysis versus optimal band analysis.
- 6. Developing hyperspectral vegetation indices (HVIs) for targeted applications to model and map plant biophysical (e.g., Yield, biomass, leaf area index), biochemical (e.g., Nitrogen, anthocyanins, carotenoids), plant health/stress, and plant structural quantities.
- 7. Classification of complex vegetation and crop types/species using HNBs and HVIs and comparing them with the performance of multispectral broadband data.

All submissions will be peer-reviewed in line with PE&RS policy. Because of page limits, not all submissions recommended for acceptance by the review panel may be included in the special issue. Under this circumstance, the guest editors will select the most relevant papers for inclusion in the special issue. Authors must prepare manuscripts according to the PE&RSInstructions to Authors, published in each issue of PE&RS and also available on the ASPRS website, https://www.asprs.org/ asprs-publications/pers/manuscript-submission.

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#### **Important Dates**

Manuscripts Due — December 15, 2023 Final Papers Due — May 1, 2024 Tentative Publication Date — 2024 Please submit your manuscript www.editorialmanager.com/asprs-pers/ select "Hyperspectral Remote Sensing"

## Call for PE&RS Special Issue Submissions

### Special Issue on the Scholarship and Impacts of Professor Nina S. N. Lam

**Expected Date for Publication: 2024** 

Special Issue Editors Michael Leitner (mleitne@lsu.edu) Jane Read (jaread@syr.edu)

This special issue recognizes Professor Nina S. N. Lam's ~45 years of contribution to Geographic Information and Environmental Sciences. From her first publications on spatial/ areal interpolation methods in the early 1980s, she evolved into an internationally recognized scholar known for her leadership in diverse research areas, from scale, resolution, and fractals to environmental health, disaster resilience, and sustainability. Professor Lam, who currently holds the E. L. Abraham Distinguished Professor of Louisiana Environmental Studies title, has been the recipient of many honors and awards, including the inaugural Carolyn Merry Mentoring Award from the UCGIS (2016), being named a Fellow of both the AAG (2020) and the UCGIS (2016), as well as being named a LSU Rainmaker, recognizing one of the top 100 research and creative faculty (2008), and the LSU Distinguished Faculty Award (2006). Her legacy in research, teaching, and service continues through her many students, who are actively contributing to Geographic Information Science (GISc) in academia, government, and the private sector, including the second co-guest editor of this special issue.

This special issue celebrates the outstanding scholarly work of Professor Lam. We invite original contributions from her students, collaborators, and anyone impacted and influenced by her work. Topics covered should be broadly situated within remote sensing, disaster/environmental sciences, sustainability, environmental health, and GISc, including but not limited to subjects related to her research and impact. Please contact special issue editors for questions and suggestions.

Interested authors should send a manuscript title and short abstract (about 250 words, including the authors' names and affiliations) to the special issue editors (mleitne@lsu.edu; jaread@syr.edu) by July 15, 2023 (see complete publication timeline below).

Manuscript length should be around 5,000-6,000 words. All submissions will be subject to standard *PE&RS* peer review processes. See Instructions for authors (https://www.asprs. org/asprs-publications/pers/pers-instructions-for-authorssubmitting-a-manuscript-for-peer-review). All submissions should be made online at the Photogrammetric Engineering and Remote Sensing Manuscript Central site (https://www. editorialmanager.com/asprs-pers/). Authors must select "Special Issue" when they reach the "Article Type" step in the submission process and identify the "Scholarship and Impacts of Professor Nina S. N. Lam Special Issue" in their cover letter. New users should first create an account. Once logged on to the site, submissions should be made via the Author Dashboard. Online user guides and access to a help desk are available on this website.

Timenne for publication	of FEans Special
Manuscript Proposal Deadline (Title and Abstract)	July 15, 2023
Submission Deadline	January 31, 2024
Information about Acceptance	On a rolling basis
Submission of Revised Manuscript Deadline	June 30, 2024
Publication in <i>PE&amp;RS</i>	2024

Timeline for publication of *PE&RS* Special Issue

## **3D Scene Modeling Method and Feasibility Analysis of River Water-Land Integration**

Xiaoguang Ruan, Fanghao Yang, Meijing Guo, and Chao Zou

#### Abstract

Aiming at the problem of rapid construction of a river three-dimensional 3D scene, this article integrates remote sensing, 3D modeling, and CityEngine technology to construct a 3D scene model reconstruction method of river water-land integration. The method includes intelligent extraction of underwater topography, refined modeling of hydraulic structures, and construction of a water-land integrated real scene model. Based on this method, the high-fidelity land-underwater seamless digital terrain and the water-land 3D real scene models can be formed. Through experiments, the feasibility and limitations of this method are verified. It can effectively extract the shallow underwater terrain of inland rivers, and the overall accuracy of the study area is less than 2 m. The performance of the seamless fusion 3D terrain is better than the public digital elevation model data set. In the inland basin of Class I to II water quality, it can meet the needs of intelligent perception of a river- and lake-integrated 3D scene model.

#### Introduction

The progress of surveying and mapping, remote sensing, and GIS technology makes the digital twin of water conservancy possible. On the whole, the lack of intelligent perception ability of river, lake, and reservoir management is still a problem. There are insufficient emergency and normalized monitoring methods for the whole life cycle of water conservancy project planning and construction and operation and a lack of point, line, and surface collaborative perception ability. It cannot effectively support the modernization and development needs of water governance. The integrated production method of high-fidelity land-underwater seamless digital terrain and the water-land 3D real scene models is one of the most critical technical bottlenecks.

#### **Underwater Terrain Extraction Method**

Shipborne sounder and Global Navigation Satellite System (GNSS) RTK are widely used to obtain underwater depth and position information. A single measurement has more or fewer limitations, such as limited measurement area and low efficiency (Collin *et al.* 2018a). Fortunately, medium- and high-resolution multispectral satellite images are increasingly used to to observe underwater topography, geomorphology, and sediment types (Tang *et al.* 2003; Duan *et al.* 2016). Theoretical, semi-empirical, and empirical models are often used in satellite-derived bathymetry (SDB) (Duan *et al.* 2016; Collin *et al.* 2018b, 2018b; Ma *et al.* 2020). The theoretical model is based on many radiative transfer parameters, which is difficult to obtain in the field and is susceptible to environmental conditions, resulting in low terrain accuracy (Collin *et al.* 2018a; Ma *et al.* 2020). Semi-empirical models use single or multiple bands to fit water depth by combining radiation attenuation and analytical regression (Gholamalifard *et al.* 2013). Among them, the

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accuracy of Lyzenga polynomial model is obviously better than that other models (Lyzenga 1981). The empirical model uses prior knowledge to fit the statistical relationship between water depth and radiation intensity (Collin et al. 2017). Sentinel-2 has the advantages of both spatial resolution and revisit period, which is suitable as a data source for SDB (Hedley et al. 2018; Taganos et al. 2018). However, the lack of measured data in river basins is still a problem. NASA launched ICESat-2 single-photon lidar satellites in 2018. After data processing, the ICESat-2 Advanced Topographic Laser Altimeter System (ATLAS) can be used as reference data for shallow underwater water depth extraction based on active and passive remote sensing fusion (Parrish et al. 2019). Thanks to a more sensitive photon counting detector and green light beams capable of penetrating water columns, ICESat-2 ATLAS is capable of detecting the seabed up to 40 m deep in areas with excellent water quality (Parrish et al. 2019; Albright and Glennie 2020). The single-photon lidar satellite signal is seriously attenuated after being affected by sunlight, clouds, and water bodies (Leigh et al. 2014). Therefore, ICESat-2 spaceborne photon point cloud denoising and extraction are necessary.

#### **3D Terrain Fusion Method of Land-Water Integration**

The problem of data void filling in the land-water transition zone is the key to digital terrain model fusion. In addition to commonly used spatial interpolation methods such as kriging, spline, and inverse distance weighting, which can be used for void filling, the delta surface fill method can obtain better results (Grohman et al. 2006; Robinson et al. 2014). Before void filling, the difference between digital elevation models (DEM) and auxiliary data needs to be solved. These differences can occur in horizontal and vertical data, spatial resolution, production errors, first-order or second-order trends, and spatial distribution of errors (Okolie and Smit 2022). After data fusion, terrain smoothing is also performed, such as adaptive smoothing (Yue et al. 2017; Ruan et al. 2020), low-pass filtering, or high-pass filtering, to remove terrain artifacts (Robinson et al. 2014; Pham et al. 2018). The global open DEM data sets (such as SRTM, ASTER, and AW3D) have been growing steadily, with a resolution better than 30 m, which can be used as supplementary data for terrain data fusion (Okolie and Smit 2022).

In the aspect of 3D scene modeling, using remote sensing images, CAD drawings, field photos, and other data, based on 3D Max, Revit, Blender, and other technologies for manual modeling, is a structured modeling method. Its disadvantage is low efficiency; the advantage is the detailed expression of complex models, and the model and its accessories are independent of each other (Du *et al.* 2019). The 3D scene modeling method based on lidar and oblique photogrammetry can collect multi-view image data at a low cost, which is highly automated and realistic, but the model is not fine enough (Zhou *et al.* 2016; Zhang *et al.* 2018). Therefore, it is necessary to integrate a variety of 3D modeling methods and integrate multi-source heterogeneous 3D models to realize the complementary advantages of 3D real terrain and individual models (Badwi *et al.* 2022), which is a technical problem faced by the construction of land and water 3D real scene (Ruan *et* 

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#### **In-Press Articles**

Multi-level Perceptual Network for Urban Building Extraction from High-Resolution Remote Sensing Images. Jinlong Chen, Yueming Sun, Xiao Huang, Hongsheng Zhang.

*Classifying Building Roof Damage Using High Resolution Imagery for Disaster Recovery.* Elaina Gonsoroski, Yoonjung Ahn, Emily W. Harville, Nathaniel Countess, Maureen Y. Lichtveld, Ke Pan, Leslie Beitsch, Samendra P. Sherchan, and Christopher K. Uejio

A Lightweight Conditional Convolutional Neural Network for Hyperspectral Image Classification. Linfeng Wu, Huajun Wang, and Huiqing Wang.

*Estimation of the Forest Stand Biomass and Greenhouse Gas Emissions Using Lidar Surveys.* Rida Sultanova and Radik Mustafin. Edge Detection Method for High-Resolution Remote Sensing Imagery by Combining Superpixels with Dual-Threshold Edge Tracking. Yanxiong Liu, Zhipeng Dong, Yikai Feng, Yilan Chen, and Long Yang

Expansion of Urban Impervious Surfaces in Lahore (1993–2022) Based on GEE and Remote Sensing Data. Muhammad Nasar Ahmad, Zhenfeng Shao, Akib Javed, and Fakhrul Islam.

Small Object Detection in Remote Sensing Images Based on Window Self-Attention Mechanism. Jiaxin Xu, Qiao Zhang, Yu Liu, and Mengting Zheng.

### Innovative Methods for Geospatial Data using Remote Sensing and GIS

Internationally comparable data is a global need for managing resources, monitoring current trends and taking actions for sustainable living. Even though there has been a significant progress on geospatial data availability, extensive data gaps are still a major problem for general assessment and supervise the progress through the years. According to United Nations 2022 The Sustainable Development Goals Report, while health and energy sectors have the highest data available, limited data available for climate action.

The COVID-19 crisis has also shown that there are innovative data collection methods utilizing information and computer technologies. However, only 5% of the countries have benefit from remote sensing technologies to measure the impact of COVID-19. Additionally, novel approaches such as artificial intelligence should be used in conjunction with assessments to make sure they are put to use for critical situations. The recent developments in remote sensing, geographic information systems and ICT have provided a wide accessibility to create geospatial data for various purposes. The proposed special issue focuses on "Innovative Methods for Geospatial Data using Remote Sensing and GIS" for wide range of applications. This special issue aims to bring researchers to share knowledge and their expertise about innovative methods to contribute to fill data gaps around the world for a better future.

The proposed special issue aims to contributes ASPRS's key mission on 'Simplify and promote the use of image-based geospatial technologies for the enduser', 'Promote collaboration between end users and geospatial experts to match data and technology to applications and solutions' and 'promote the transfer of geospatial data and information technology to developing nations' by providing innovative methods to create geospatial data using remote sensing and geographic information systems utilizing state-of-theart developments and solutions.

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#### **Guest Editors**

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## High-Resolution Aerosol Optical Depth Retrieval in Urban Areas Based on Sentinel-2

Yunping Chen, Yue Yang, Lei Hou, Kangzhuo Yang, Jiaxiang Yu, and Yuan Sun

#### Abstract

In this paper, an improved aerosol optical depth (AOD) retrieval algorithm is proposed based on Sentinel-2 and AErosol RObotic NETwork (AERONET) data. The surface reflectance for AOD retrieval was estimated from the image that had minimal aerosol contamination in a temporal window determined by AERONET data. Validation of the Sentinel-2 AOD retrievals was conducted against four Aerosol Robotic Network (AERONET) sites located in Beijing. The results show that the Sentinel-2 AOD retrievals are highly consistent with the AERONET AOD measurements (R = 0.942), with 85.56% falling within the expected error. The mean absolute error and the root-mean-square error are 0.0688 and 0.0882, respectively. In addition, the AOD distribution map obtained by this algorithm well reflects the fine-spatial-resolution changes in AOD distribution. These results suggest that the improved high-resolution AOD retrieval algorithm is robust and has the potential advantage of retrieving high-resolution AOD over urban areas.

#### Introduction

Air pollution is a byproduct of urban and industrial development, and it not only pollutes the environment and reduces visibility but also causes respiratory and cardiovascular diseases (Shirangi *et al.* 2022). Because of its spatial and temporal variability, monitoring air quality and understanding its distribution in a timely and accurate manner can effectively improve pollution control (Islam *et al.* 2022; Zheng *et al.* 2019; Mazlan *et al.* 2023). Due to its large-scale, continuous timeliness and low-cost observations, satellite remote sensing technology has become a powerful means of regional and global air quality monitoring (Singh *et al.* 2021).

In recent decades, some aerosol optical depth (AOD) retrieval algorithms and satellite aerosol products have been developed (Hou *et al.* 2020; Kaufman *et al.* 1997; Hsu *et al.* 2004). However, most of these satellite aerosol products have coarse resolutions and cannot reflect the fine-spatial-resolution changes in aerosol distributions caused by changes in construction, traffic distribution, and population density in urban areas. Thus, it is difficult to meet the demand for fine-scale air quality monitoring in urban areas (Zhang and Cao 2015; Li *et al.* 2019). Therefore, aerosol retrieval based on high spatial-resolution remote sensing images has important research value and broad application prospects.

The most crucial challenge for high spatial resolution aerosol retrieval is estimating surface reflectance. The methods used to estimate surface reflectance in aerosol retrieval algorithms can be broadly classified into two types, namely, methods based on empirical relationships of specific bands and methods based on surface reflectance databases, represented by the dark dense vegetation (DDV) algorithm and deep blue (DB) algorithm, respectively. The widely used DDV algorithm, which is based on the reflectance relationship between the Short-Wave InfraRed (SWIR) band and red/blue band, was proposed for moderate resolution imaging spectroradiometer (MODIS) (Xiong *et al.* 2016;

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Chen et al. 2014). However, due to the difference in the spectral response of different sensors in the same band, the empirical relationship for MODIS may cause errors when applied to high-spatial-resolution sensors. Some improvements have been made in recent years. Wei et al. used a large number of Landsat series high-spatial-resolution images to refit the empirical relationship between the SWIR band and red/ blue over dense vegetation pixels, i.e., normalized difference vegetation index (NDVI) greater than 0.55. This improved DDV algorithm was applied to Landsat series images to retrieve AOD products with a 30 m resolution (Wei et al. 2013). Olivier et al. used Landsat 5 and Landsat 7 data to fit the empirical relationship between the reflectance of the SWIR band and red/blue band, where NDVI was greater than 0.2 (Olivier et al. 2015). However, the empirical relationships between the reflectances of specific bands in the above studies still had time and space limitations, making it difficult to apply them to different locations and different times.

Inspired by the DB algorithm (Hsu *et al.* 2004), some AOD retrieval algorithms based on the surface reflectance database have also been applied to the AOD retrieval of high-spatial-resolution images. Wei *et al.* used Landsat 4-7 surface reflectance products and constructed a 30 m resolution surface reflectance database divided by month for AOD retrieval (Wei *et al.* 2013). Bilal and Qiu used Landsat 8 images to construct a surface reflectance database combined with the Simplified Aerosol Retrieval Algorithm (SARA) algorithm for AOD retrieval (Bilal and Qiu 2018). Omari *et al.* used Landsat 8 images to construct a surface cataloged by year to retrieve AOD in the United Arab Emirates (Omari *et al.* 2019). However, due to the low temporal resolution, cloud contamination and other weather factors, Landsat 8 images are usually inadequate for establishing a surface database.

In this study, an improved method for high-spatial-resolution AOD retrieval is proposed by conducting high-spatial-resolution AOD research using *Sentinel-2* remote sensing images. *Sentinel-2*'s high spatial resolution and relatively high revisit time are taken advantage of in this algorithm, and the ground AERONET monitoring data are used to determine the "cleanest" image in a temporal window. The surface reflectance of *Sentinel-2* corresponding to the "cleanest image" then constitutes the surface reflectance database. Based on this database, the AOD of the *Sentinel-2* images, which share the same time window as the images in the database, can be retrieved. In this study, *Sentinel-2* images from 2017 to 2019 in the Beijing area are obtained from AOD retrieval experiments, and the retrieval results are validated by AERONET AOD data.

#### **Study Area and Data**

#### Study Area

Beijing is located in the northwestern part of the North China Plain, 39.4°–41.6° N, 115.7°–117.4° E, and has a total area of 16 410.54 square km. Beijing has a complex surface and a variety of land use types. As shown in Figure 1, to the west, north, and northeast of

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## Change Detection in SAR Images through Clustering Fusion Algorithm and Deep Neural Networks

Zhikang Lin, Wei Liu, Yulong Wang, Yan Xu, and Chaoyang Niu

#### Abstract

The detection of changes in synthetic aperture radar (SAR) images based on deep learning has been widely used in landslides detection, flood disaster monitoring, and other fields of change detection due to its high classification accuracy. However, the inherent speckle noise in SAR images restricts the performance of existing SAR image change detection algorithms by clustering analysis. Therefore, this paper proposes a novel method for SAR image change detection based on clustering fusion and deep neural networks. We first used hierarchical fuzzy c-means clustering (HFCM) to process two different images to obtain HFCM classification results. Then a fusion strategy is designed to obtain the fused image from the two HFCM classified images as the pre-classification result. Furthermore, a lightweight deep neural network composed of a decomposition convolution module and an auxiliary classification module was proposed; the former module could reduce network parameters by 28%, and the latter could reduce network parameters by 33.3%. To improve the recognition performance of the network, the classification layer was replaced by the regression layer at the outcome of the network. By comparing the experiments of different methods on five data sets, the performance of our proposed method is superior.

#### Introduction

Synthetic aperture radar (SAR) can penetrate clouds, in contrast to optical radar, is unaffected by the weather and can obtain detailed geographic information, which is crucial in certain circumstances (Zhang et al. 2016). For example, emergency events such as landslides, floods, and earthquakes occur with rain and dark clouds. In these cases, realtime optical images will not be available, but change detection based on SAR images will be a feasible method. Therefore, SAR images are widely used in change detection and have been applied in flood detection (Lu et al. 2014; Schlaffer et al. 2015), urban analysis (Yousif and Ban 2013; Hu and Ban 2014), forest monitoring (Pantze et al. 2014), and other fields, and in-depth research has been carried out in the past few years. The purpose of change detection is to analyze two remote sensing images taken at different times in the same geographical region (Bazi et al. 2005; Bazi et al. 2010; Blaschke 2010). There are many multi-temporal SAR data available for monitoring and application with the progress of SAR imaging technology. However, the inherent speckle noise in SAR images makes relevant studies difficult (Hussain et al. 2013; Oliver and Quegan 2004).

Traditional research on SAR image change detection generally involves two fundamental processes (Schubert et al. 2013): difference image (DI) generation and DI analysis. One approach to generating DI is through the application of a single operator operation (Villasensor et al. 1993; Longbotham et al. 2012). For example, the subtraction operator or ratio operator can be applied pixel by pixel to the intensity of two multi-temporal images to produce a DI (Celik 2010). Ratio operators are widely used because they are more suitable for SAR image statistics

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and are robust to radiation errors (Rignot and Van Zyl 1993). Log-ratio (LR) (Hou et al. 2014; Gao et al. 2014; Dekker 1998) is the most widely used technique to obtain DI, and log-ratio operators are considered robust to calibration and radiation errors. Therefore, the effect of speckle noise can be reduced. However, the noisy region remains in the DI generated by the log-ratio operator. Improved LR can effectively suppress unwanted speckle noise (Gao et al. 2014). The other is the combined operation of several DIs (Zheng et al. 2013), such as joint difference image and neighborhood-based ratio (NR) (Gong et al. 2011). However, the degree of difference between pixel classes cannot be improved entirely by a single operator. Joint operators can enhance the difference between two types of pixels. Using artificial methods to design the fusion mode of each operator, such as the weighted sum of two detectors, work well for parts but not for the whole image (Li et al. 2016).

For DI analysis methods, collaborative representation technology (Zhang et al. 2011) has attracted extensive attention from researchers in remote sensing applications. Li and Du (2014) developed a collaborative representation method based on the spatial and spectral features for hyperspectral image classification. Jiang et al. (2017) proposed a hyperspectral image classification method to integrate spatial information, adding spatial regularization terms into the representation objective function of collaborative representation. Inspired by these works, Gao et al. (2018) uses the neighborhood ratio cooperative representation change detection method (NR CR), which can classify by using the spatial information of neighborhood pixels, suppressing multiplicative speckle noise and improving the performance of change detection. Additionally, neighborhood ratio and extreme learning machine (NR-ELM) (Gao et al. 2016) were used to find the changed areas in the image, which is a traditional method of rapid change detection. Su et al. (2017) used a binary mathematical morphological filtering algorithm for change detection maps, Wuhan University (2006) applied a Markov random field (MRF) model to describe environment-related information, and Chen et al. (2014) developed a variational model for change detection in multi-temporal SAR images. All these traditional change detection methods can improve the accuracy and reliability of change detection.

In recent years, due to the powerful capability of deep learning in high-dimensional feature extraction and autonomous learning, some breakthrough SAR image change detection methods have been proposed one after another. Deep neural networks have good detection ability due to their excellent ability to extract deep features, and the accuracy of deep learning change detection methods is widely better than traditional change detection methods. In 2017, Liu et al. (2017) recommended a two-channel convolutional neural network (CNN) change detection method. In this method, two original images were processed by CNN and the obtained results were wholly connected to generate segmentation results. Simultaneously, a monitoring frame for polarimetric SAR change detection through deep learning was proposed to detect urban change (De et al. 2017). In 2018, Liu et al. (2018) suggested a SAR

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## Strategies for Forest Height Estimation by High-Precision DEM Combined with Short-Wavelength PolInSAR TanDEM-X

Hongbin Luo, Wanqiu Zhang, Cairong Yue, and Si Chen

#### Abstract

The purpose of this article is to explore forest height estimation strategies using topographic data (DEM) combined with TanDEM-X while comparing the effect of volume scattering complex coherence selection on forest height estimation in the traditional random volume over ground (RVoG) three-stage algorithm. In this study, four experimental strategies were designed for comparison based on TanDEM-X polarized interferometric synthetic aperture radar (PolInSAR) data, TanDEM-DEM, and 42 field-measured data. Our results show that in the RVoG model, (1) a reference ground phase to select the volume scattering complex coherence provides greater accuracy in determining forest height, (2) forest height estimation can be achieved by directly using DEM as ground phase information without relying on model solving and obtaining a more accurate forest height than TanDEM-X alone, and (3) the highest estimation accuracy is obtained by using DEM as coherence information among all schemes. Although the difference in forest height estimation results is not significant in this study, it still proves that the forest height estimation strategy of high-precision DEM combined with short-wavelength PolInSAR can not only improve the forest height estimation accuracy but also simplify the solving process of the RVoG model, which is an important reference for global forest parameter estimation and ecosystem detection based on spaceborne PolInSAR.

#### Introduction

Forests are an important component of terrestrial ecosystems, and monitoring forests is particularly crucial in the context of global climate change (Gholz 1982; Houghton 2005; Hall *et al.* 2011). As a key parameter of forest vertical structure, height is an effective indicator of forest biomass, carbon stock, and forest health, and it also can be used to describe forest succession and change (Goetz and Dubayah 2011; Huang *et al.* 2012; Bispo *et al.* 2019) Therefore, for dynamic forest resource monitoring, it is important to acquire forest height information accurately and efficiently. However, traditional forest height measurement relies mainly on manual field surveys, which are accurate but inefficient and expensive in terms of manpower and money, so the traditional method is not suitable for large-area surveys. On the other hand, remote sensing technology can considerably improve the efficiency of forest resource surveys, and it has been widely used in this context (Chirici *et al.* 2016).

At present, remote sensing techniques applied in forest surveys include mainly optical remote sensing, lidar, remote sensing, microwave remote sensing, and so on (Xu *et al.* 2019). Optical remote sensing has

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the advantages of a short revisit period, wide coverage, and many data sources, and it has been widely used to estimate forest stock volume or biomass, classify forest types, and monitor forest change; however, it is vulnerable to bad weather and can acquire only optical reflectance information, which is not sensitive to the forest vertical structure (Cao et al. 2012). Lidar can obtain information about the forest canopy and the 3D structure inside a forest (Maltamo et al. 2020) and is not limited by weather conditions, but the observation coverage of lidar is often limited by the use of an airborne platform, and its data acquisition cost is high (Gang and Hay 2011; Wang et al. 2020). As for spaceborne lidar platforms, such as ICEsat1, ICEsat2, and GEDI, although they can cover large-scale areas, they can acquire only strip-scale data and cannot obtain continuous surface data (Silva et al. 2021). Different from optical remote sensing and lidar, microwave remote sensing not only is active and independent of weather but also can collect data over large areas, so it has significant advantages in monitoring forests (Zhang et al. 2017).

As a part of microwave remote sensing, polarized interferometric synthetic aperture radar (PolInSAR) is a combination of polarimetric SAR (PolSAR) and interferometric SAR (InSAR), so it has the characteristics of both PolSAR and InSAR and is sensitive to the shape, backscatter orientation, space distribution, and vertical structure of vegetation over the ground (Graham 1974; Garestier and Le Toan 2010). Therefore, PolInSAR has become one of the main techniques used to estimate forest height. The random volume over ground (RVoG) coherence scattering model is the most widely used model in PolInSAR forest height estimation (Treuhaft et al. 1996; Liao et al. 2018), and the three-stage forest height inversion method was developed on the basis of the RVoG model (Cloude and Papathanassiou 2003). The three-stage method can use quad-polarized SAR data to first estimate the ground phase through the distribution of multiple interferometric complex coherence, and it then uses a lookup table to invert forest height; it has been successfully applied to different frequencies, including C-, L-, P-, and X-bands (Wang et al. 2016; Schlund et al. 2019; Kumar et al. 2020).

In 2010, the German Aerospace Center (DLR) launched the first dual-satellite simultaneous observation mission—TanDEM-X—which eliminates the temporal decorrelation problem and increases the possibility of accurately estimating forest height and other forest parameters (Kumar *et al.* 2017; Persson *et al.* 2017; Chen *et al.* 2019). However, in forest areas, TanDEM-X could present a problem in obtaining the ground scattering information due to its short-wavelength X-band, the penetration of which into the forest is weak, so the coherence phase centers of various polarized scattering calculated from TanDEM-X data are usually close to the top of the forest canopy. As a result, it is hard for the coherence optimization algorithms to extract phase centers relevant to the surface scattering of the ground. In addition, the observed polarimetric interference complex coherence values of the forest area can deviate from their ideal values for system errors, signal noise, and terrain, and this could cause errors in the ground phase

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