Pacific Northwest NATIONAL LABORATORY

Organized in cooperation with

IAEA International Atomic Energy Agency
Atoms for Peace and Development

Autonomous Measurements and Processing with an end-to-end Cloud-Based Framework

October 24, 2023

Patrick Royer
Data Scientist

2023 Global Summit
on Environmental Remediation
@REMPLEX

U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

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AETHER – Backbone of the Framework
In Development Since 2017 – Race to the Cloud!

- Complete framework with access control, file management, and abstracted for custom modules
- 100% Cloud-based, emphasis on serverless architecture
- End-to-end automation of complex, computationally rich algorithms
- Emphasis on business-2-business API, integrated commercial API's and other national labs
- Real-time/near real-time connectivity with streaming data sources
- Enterprise-scale "Production Ready" application suite, extensively tested
- Developed in close collaboration with PNNL Risk and Governance for robust security profile
- Rich distributed compute model with extensive data architecture/modeling for petabyte scale data

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AETHER Implementations

PROJECT	
Electrical Grid Resilience and Assessment System (EGRASS)	DOE/FEMA – Office of Recovery
Rapid Analytics for Disaster Response (RADR)	DOE – Cybersecurity, Energy Security and Emergency Response
EV-Charging	Joint Department of Energy and Department of Transportation
Chemical Security Mapping Tool (CSMT)	DHS – Defense Threat Reduction Agency
Enhanced Plume Modeling for Rapid Response to Explosives (EPMRE)	DHS – Office of State
Suite Of Comprehensive Rapid Analysis Tools for Environmental Sites (SOCRATES)	DOE – Environmental Management
National Transmission Expansion (NTP)	DOE – Office of Electricity
OPEN WELL	DOE – Environmental Management
Western Offshore Wind – Resilience Planning (WOW-RP	DOE - Office of Electricity
Stakeholder Tool for Assessing Radioactive Transport (START)	DOE – Office of Nuclear Energy

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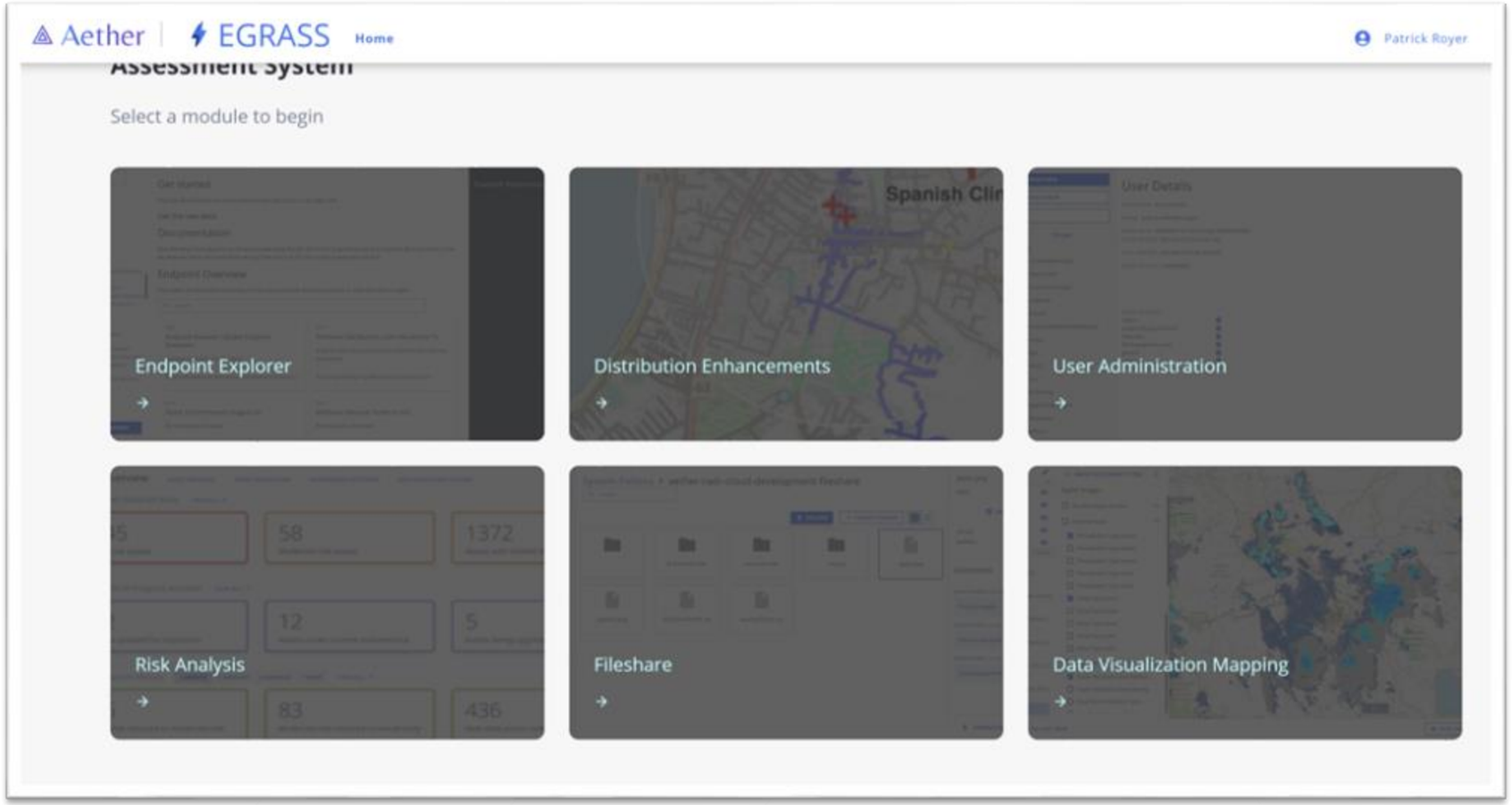
AETHER Landing page



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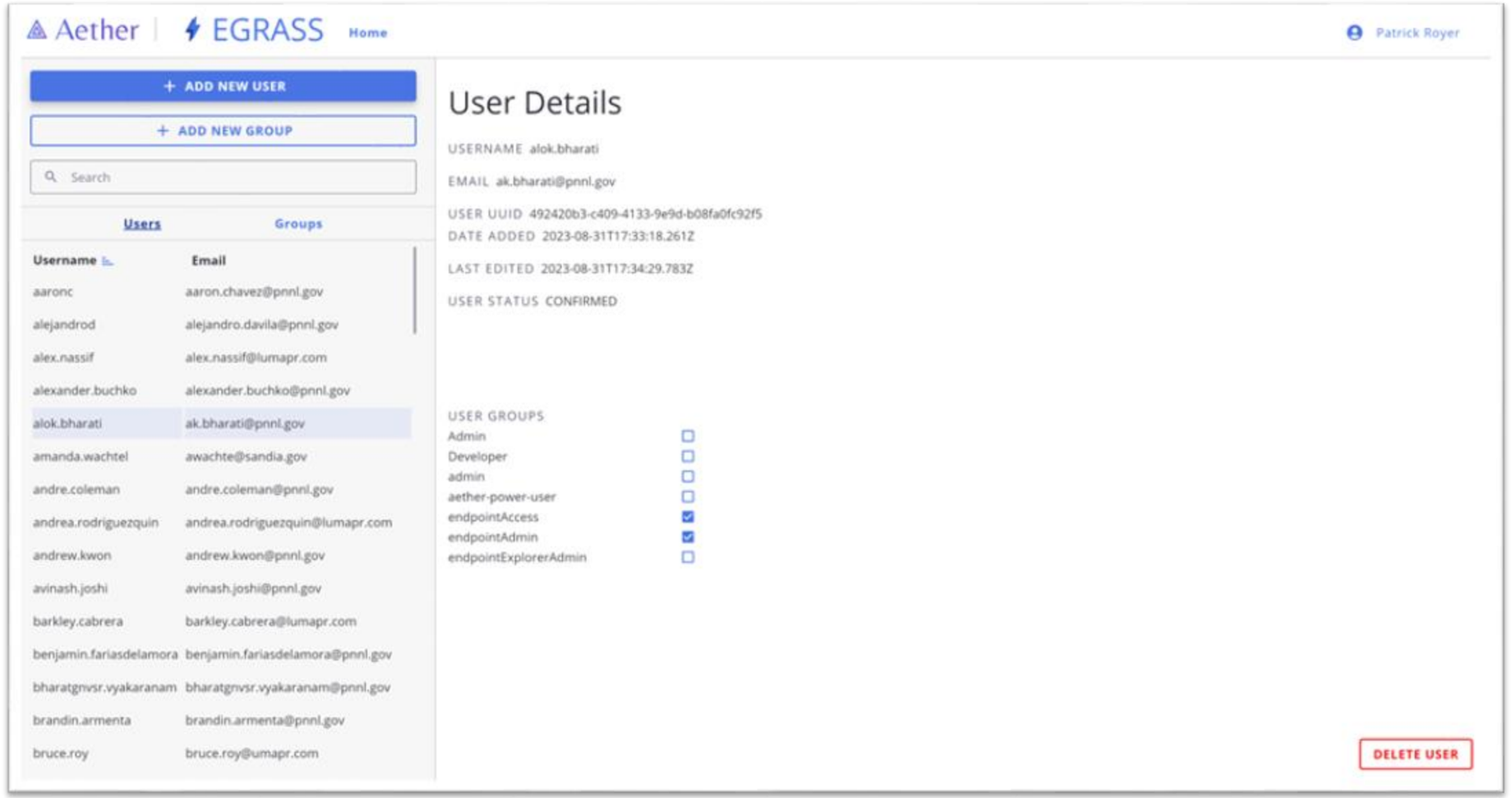
AETHER Universal Modules

User Admin and access control

AWS Service Highlights;

- Cognito
- IAM



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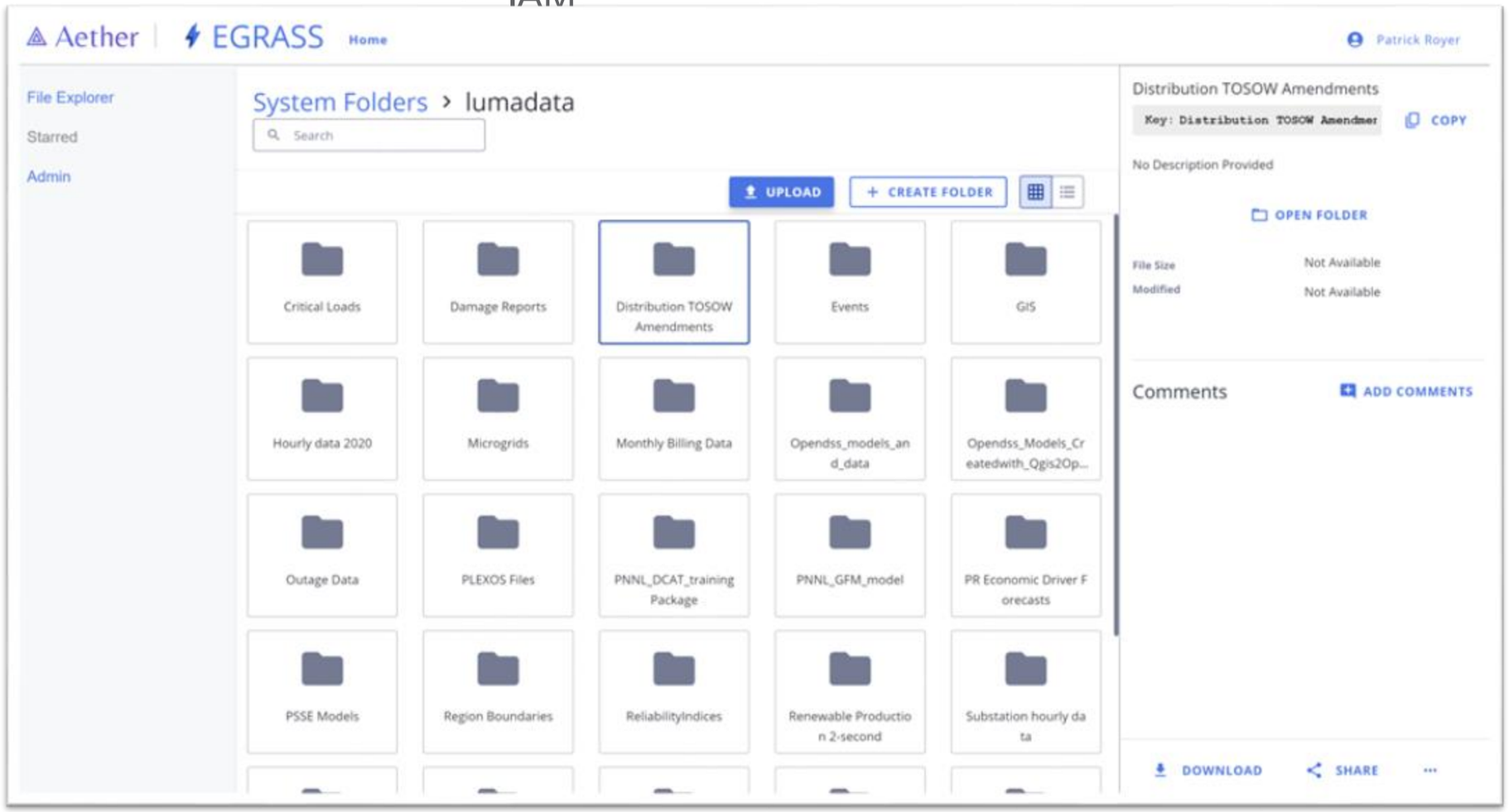
AETHER Universal Modules

File Share

AWS Service Highlights;

- S3
- S3 lifecycle management
- IAM



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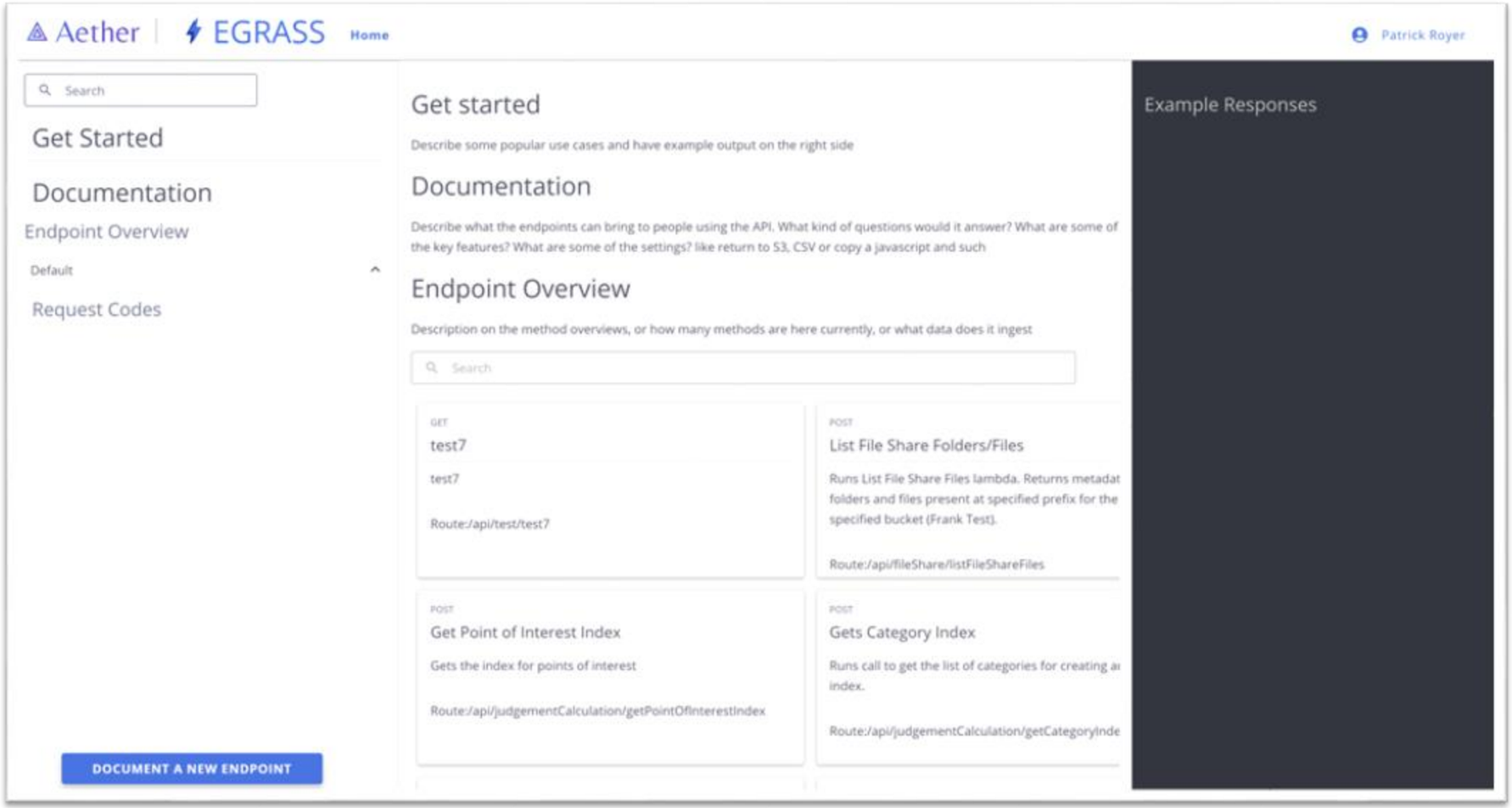
AETHER Universal Modules

API Explorer

AWS Service Highlights;

- Lambda
- Aurora



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Internet of Things (IoT)

Devices with sensors, processing ability, software and other technologies that connect and exchange data with other devices and systems over the Internet or other communications network

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Remote Sensing offers Invaluable Alternative to Field-Based Monitoring

- Synoptic perspective for detecting changes and variation at different scales
- Return periods ranging from 2 weeks to 1 day depending on location for characterizing temporal trends
- Many data offerings are available at no charge

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Projects at PNNL

- Electrical resistivity tomography (ERT) for monitoring groundwater treatment, visualize l near-time results
- Advanced Remote-sensing Image USer Interface (ARIUS). Thermal monitoring for characterizing ground water flux & radar-based analysis for detecting geologic subsidence.
- Rapid Analytics for Disaster Response (RADR) Early alert for flood detection and disaster preparedness;

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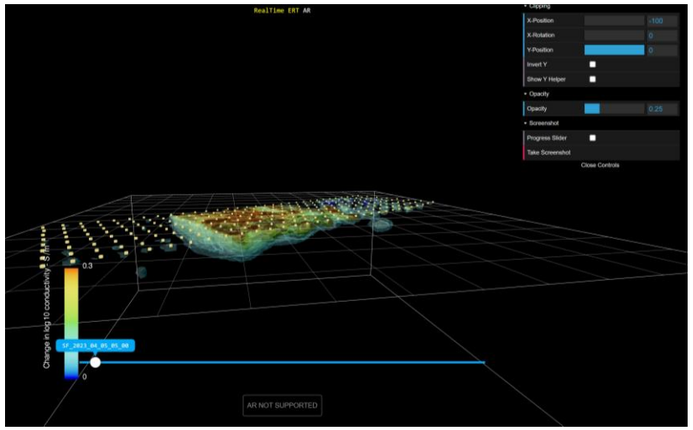
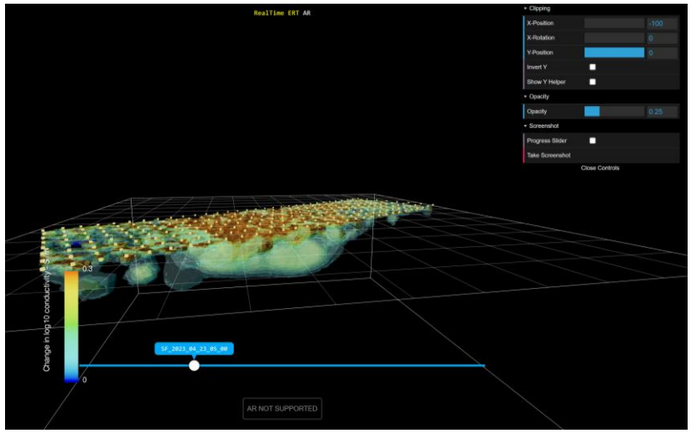
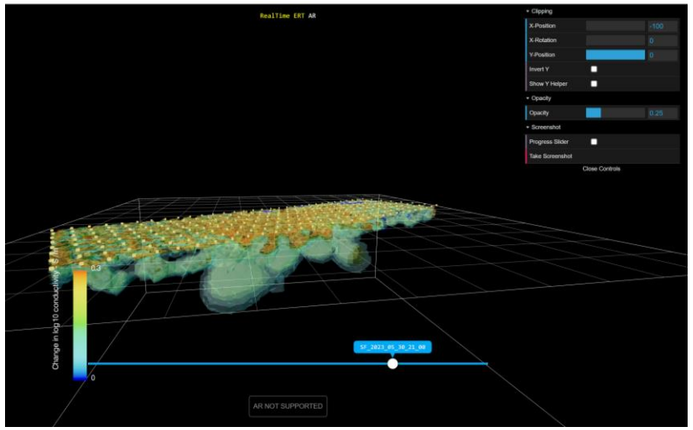
Real-Time Visualization of ERT During Treatment

- Electrical resistivity tomography (ERT) for monitoring delivery of groundwater treatment for uranium, visualize near-time results







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Real-time feeds: Electrical Resistivity Tomography (ERT) Monitoring of Soil Flushing of Chromium

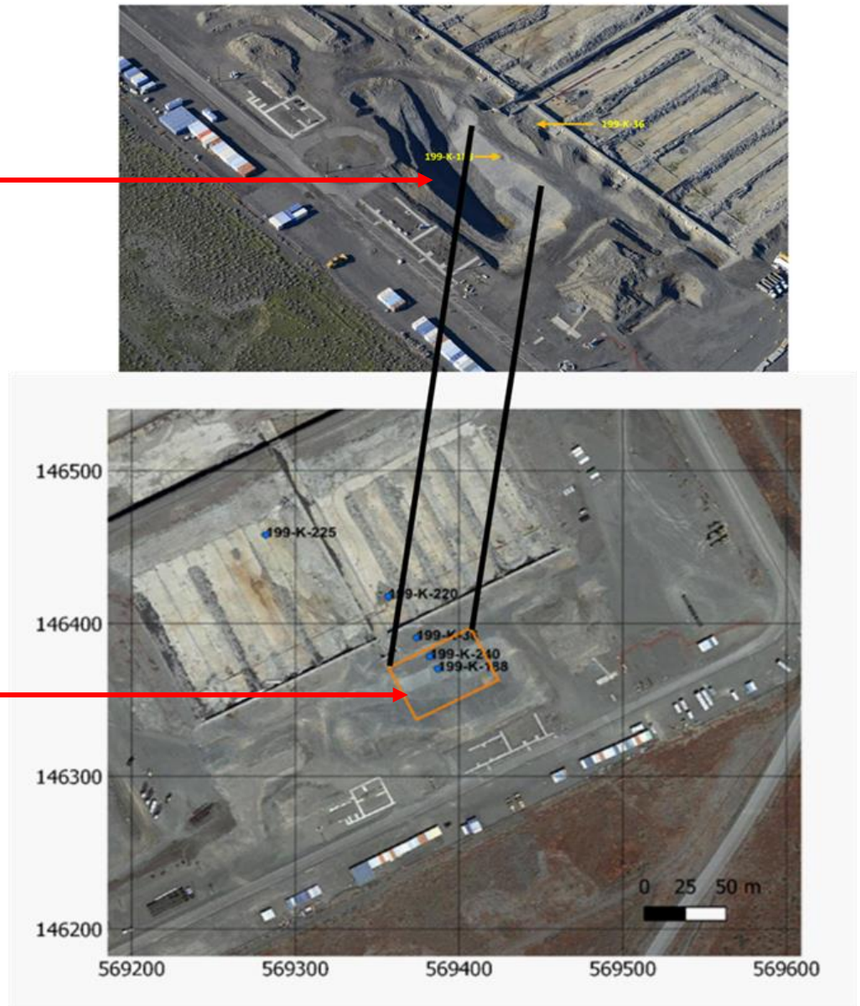
- Soil Flushing
  - Surface infiltration to mobilize residual chromium in soils above the water table
  - Hydraulic capture and treatment of mobilized chromium with groundwater pump-and-treat
- ERT Monitoring Technology
  - Sensitive to changes in porosity, saturation, chemistry and mineralogy
  - Time-lapse 3D imaging using E4D software
- Real-time and Web-based Monitoring Advantages
  - Improved remediation performance evaluations
  - Time-lapse 3D ERT imaging shows spatial and temporal distribution of soil flushing fluids within the targeted treatment zone
  - Guides operational decisions such as surface application rate and duration of flushing
  - Conventional analysis and visualization software (licenses) can be expensive

3D Soil Flushing Monitoring (CPCCo)

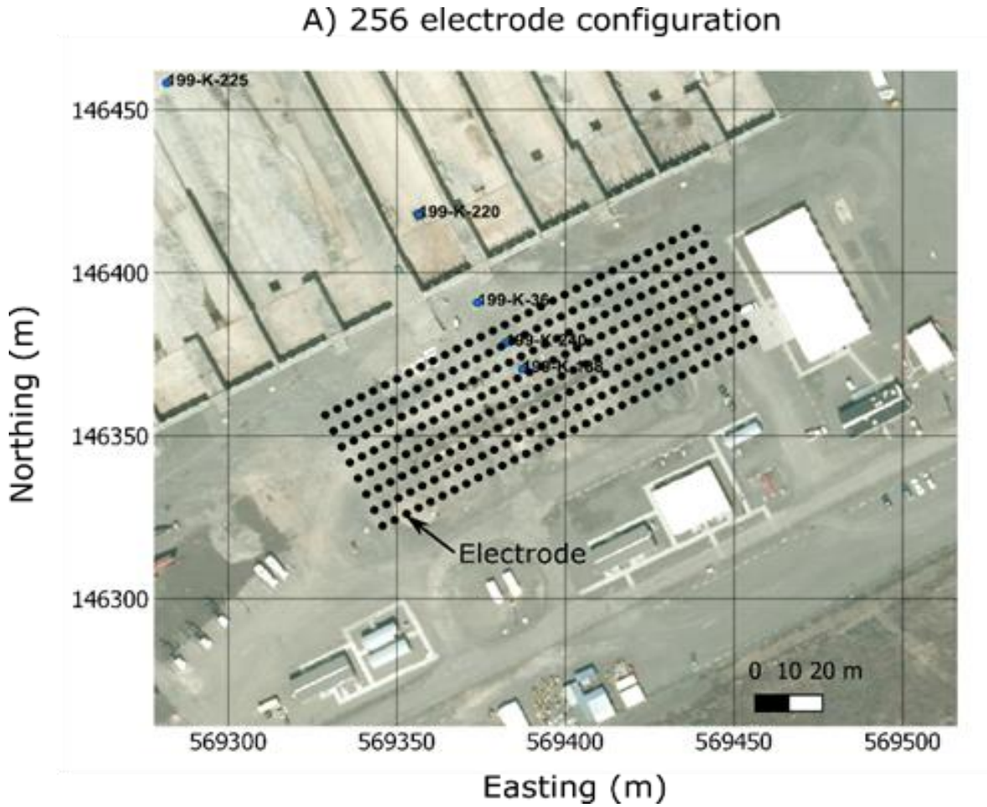
Hanford Site 100-K East Area

chromium contamination excavation

soil flush water infiltration footprint



Surface ERT Array



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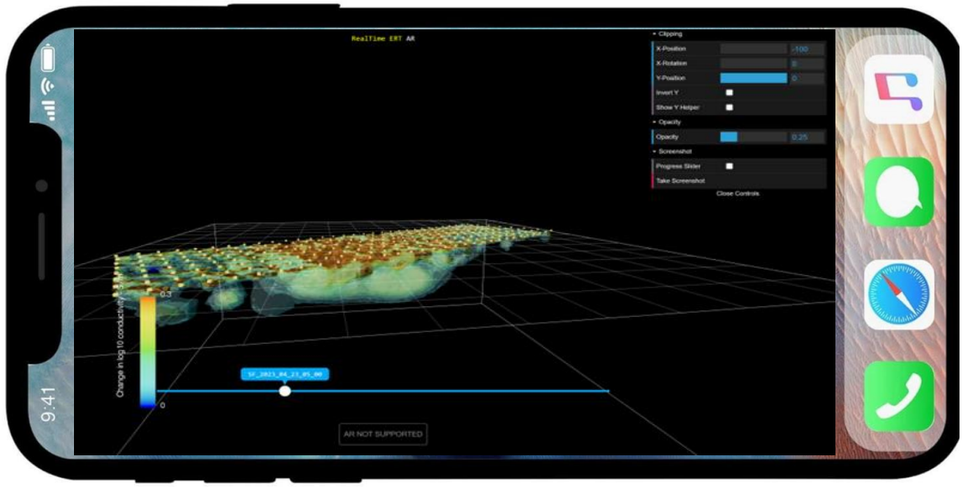
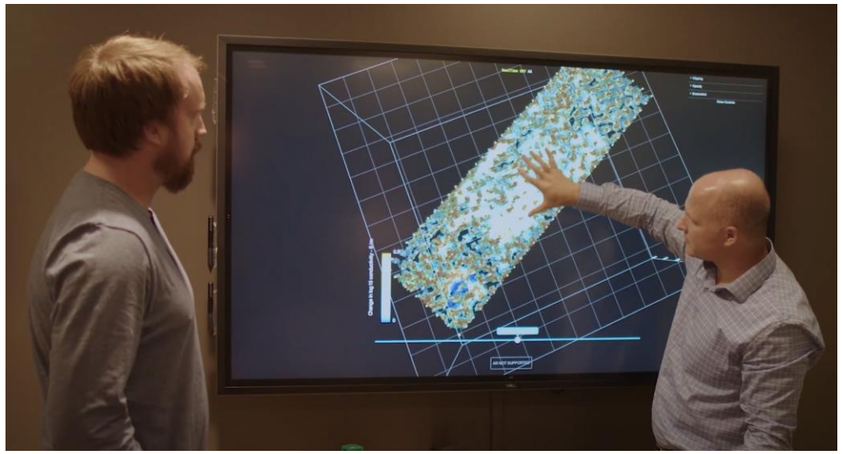
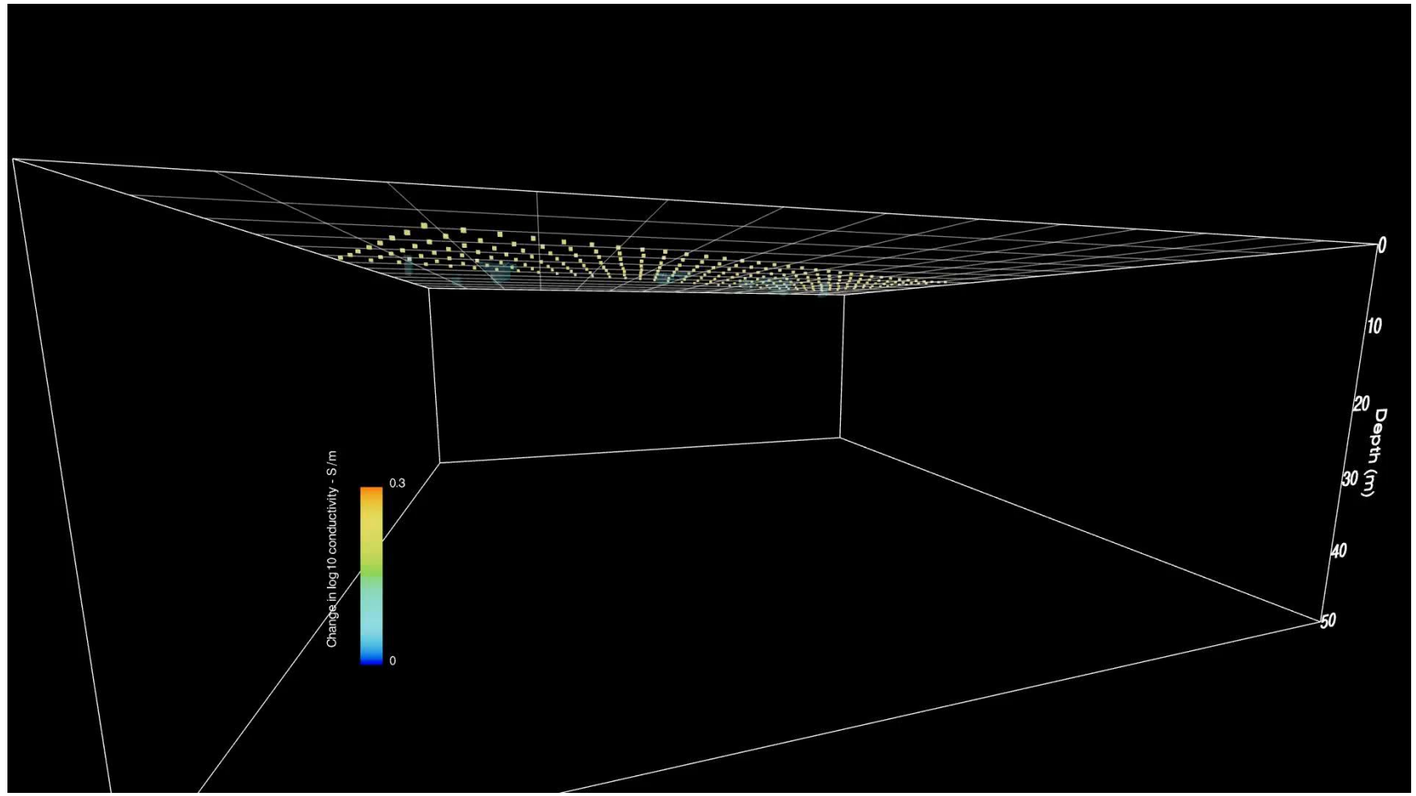
Real-time feeds: ERT Soil Flushing



- Web-based
  - Built on previous work
  - Fast spin-up
  - Accessible and interactive
  - Real-time data feeds
- Remote user access
  - Increased stake-holder engagement





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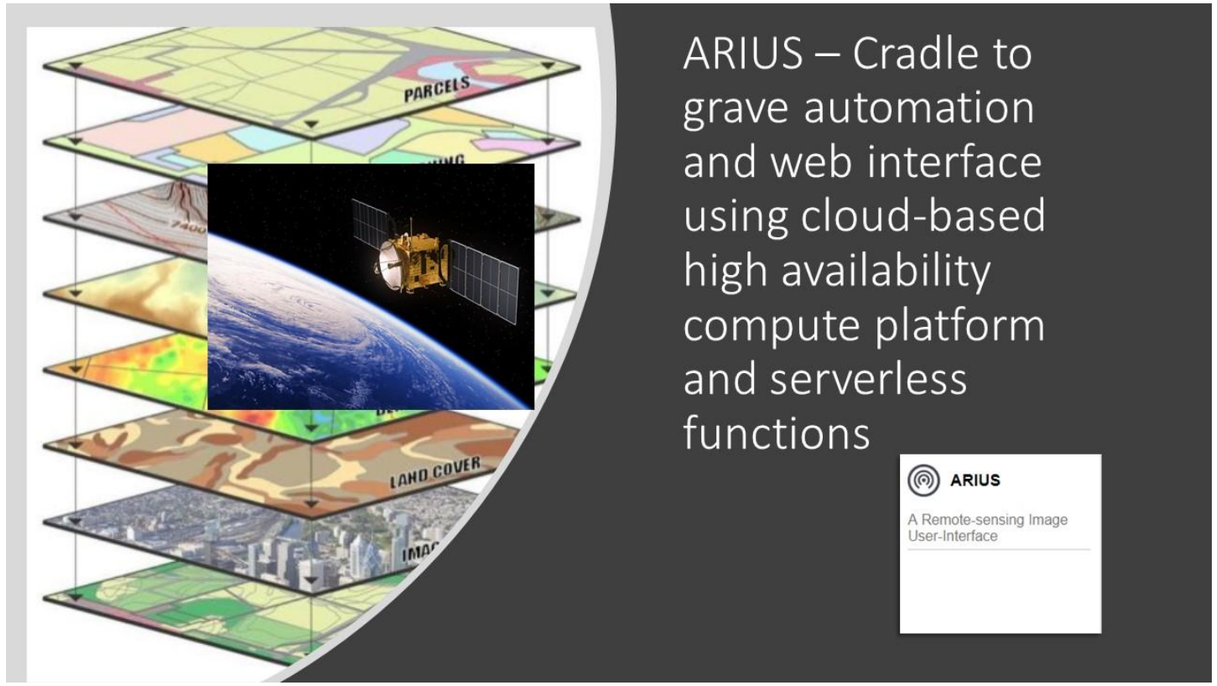
Satellite Data for Characterizing Variation in Columbia River Extent and Ground Water Flux

- Thermal monitoring for characterizing ground water flux & radar-based analysis for detecting geologic subsidence.
- Auto detect new thermal imagery available from Landsat with queue in AWS cloud storage
- Auto start satellite data processing and analysis
- Correlation analysis with field-based monitoring
- Alert users that new data is available



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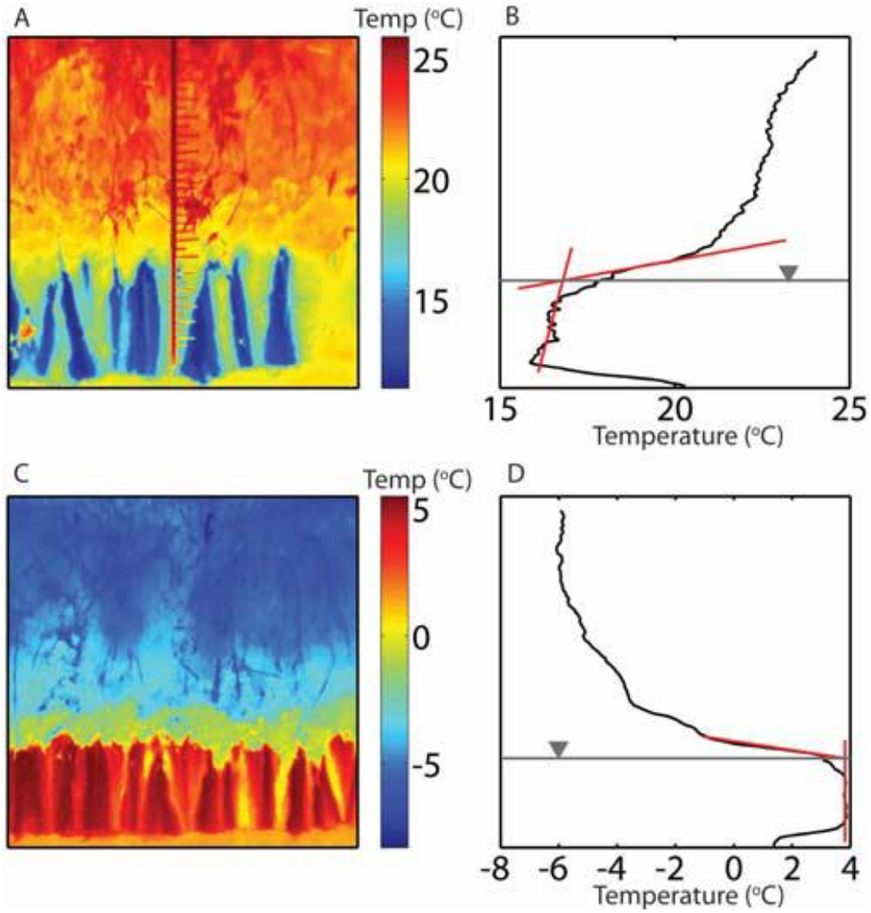
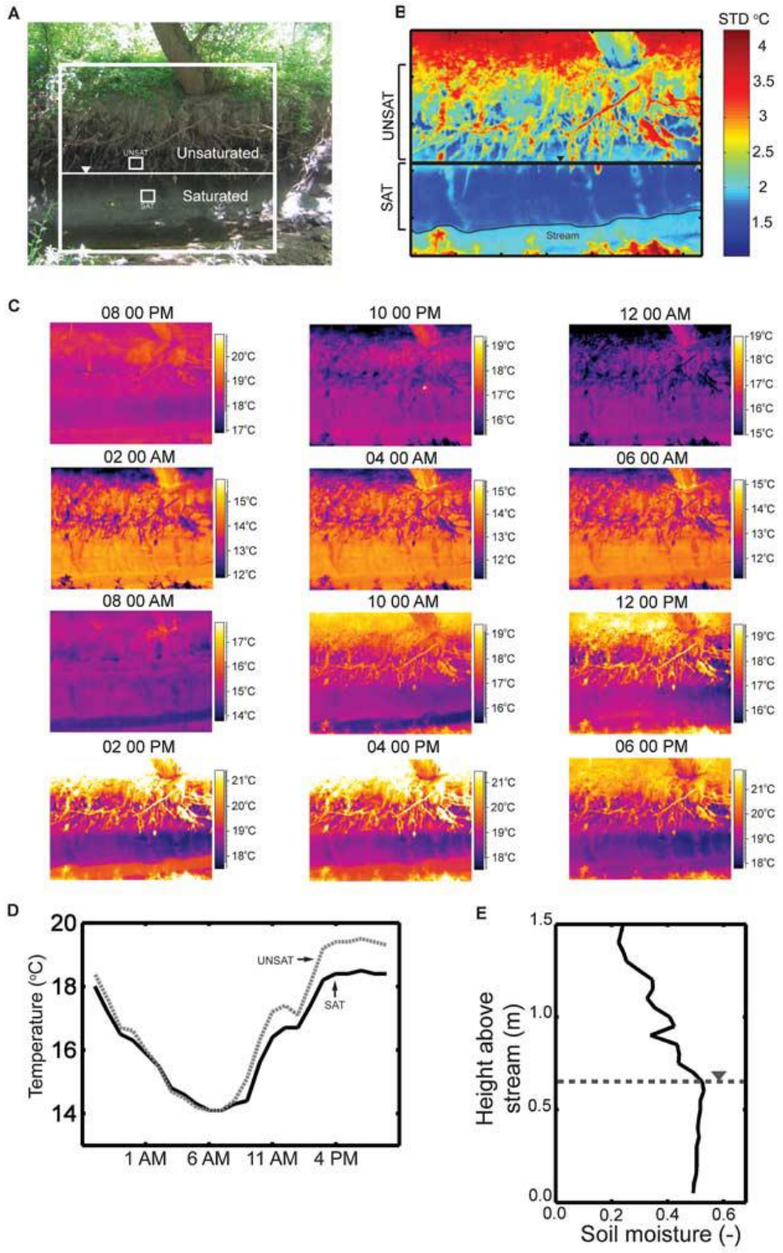
Characterizing Flux with Thermal Data





GEOPHYSICAL RESEARCH LETTERS, VOL. 36, L14401, doi:10.1029/2009GL038103, 2009

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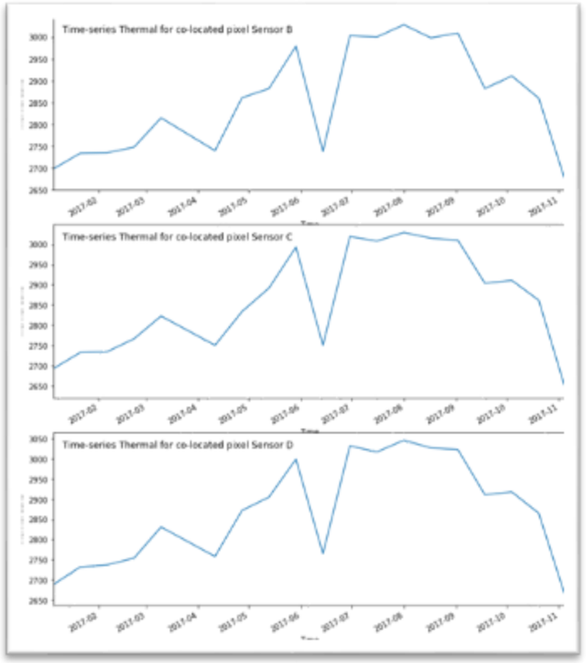
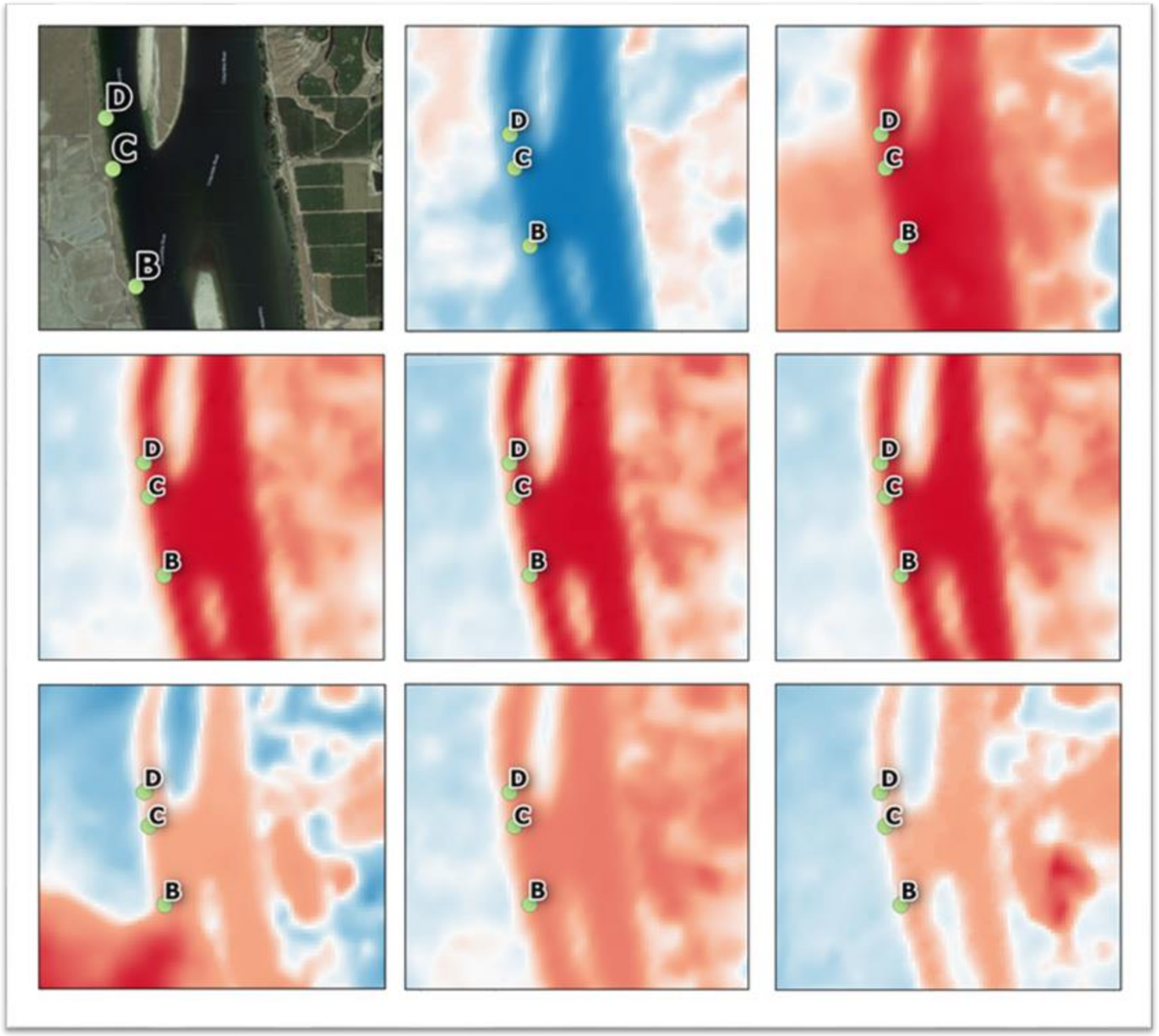
Using Thermal Imagery to Characterize Extent and Ground Water Flux





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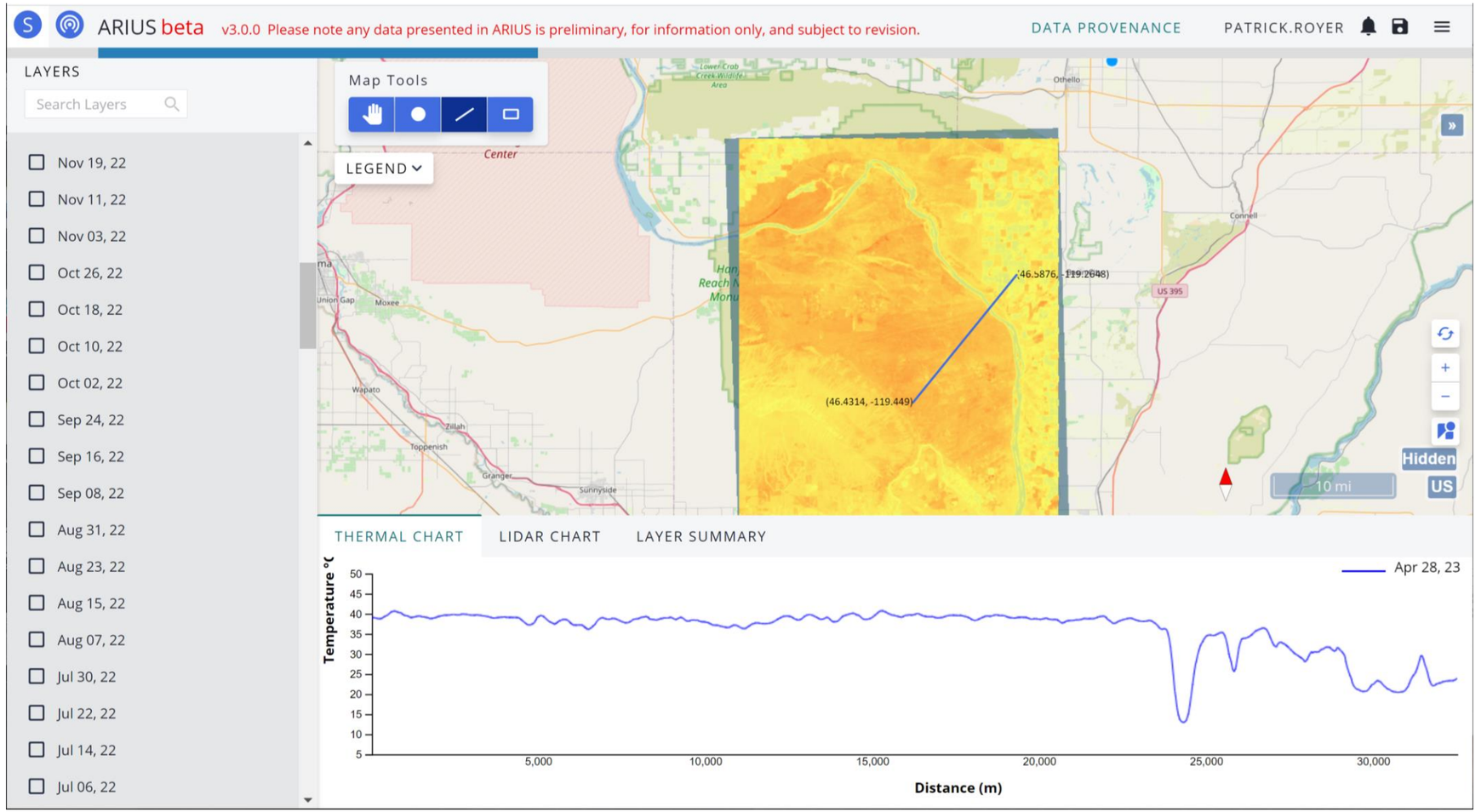
ARIUS User Interface and Demonstration



https://socrates.pnnl.gov/arius/

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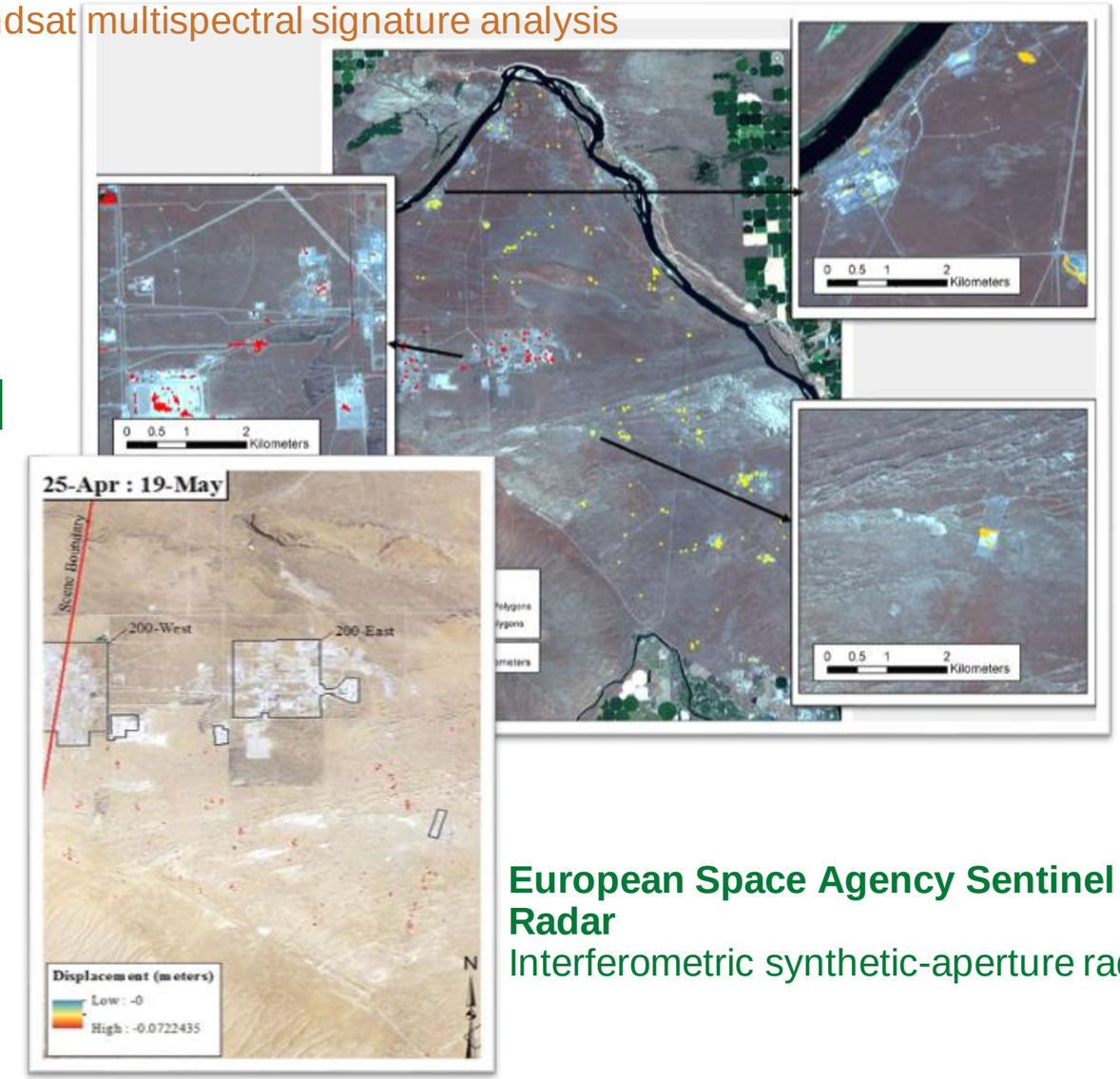
Using Interferometric synthetic-aperture Radar and Multispectral Imagery to Detect Geologic Subsidence

Landsat multispectral signature analysis



European Space Agency Sentinel 1 Radar
Interferometric synthetic-aperture radar

Tagestad, J., Royer, P., and K. Larson. 2017. *Analysis of Remotely Sensed Datasets to Detect Changes in Waste Sites*. PNNL-27157, Pacific Northwest National Laboratory, Richland, Washington.

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Motivation:
Hanford
200 Area Tunnel
Collapse in May 2017

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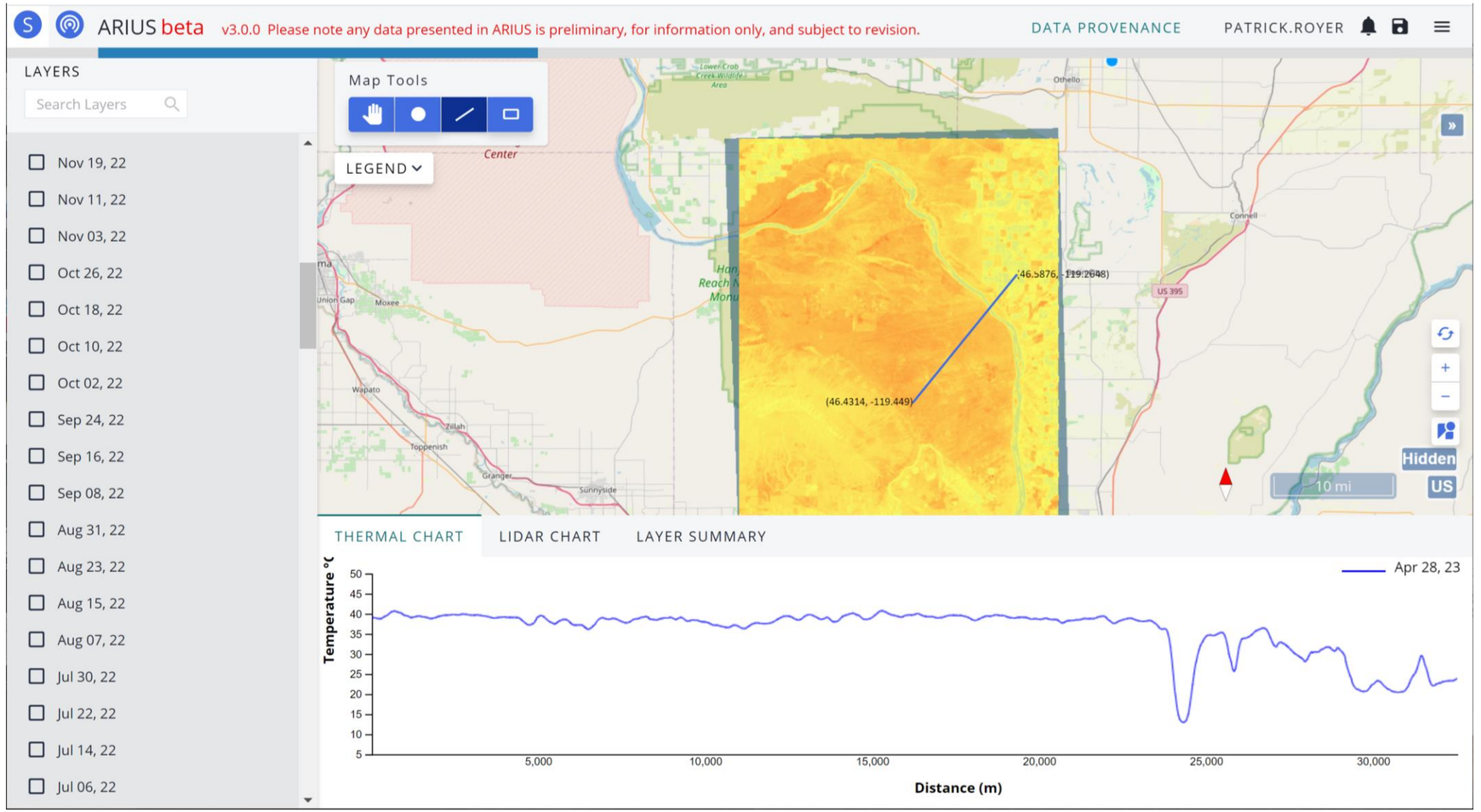

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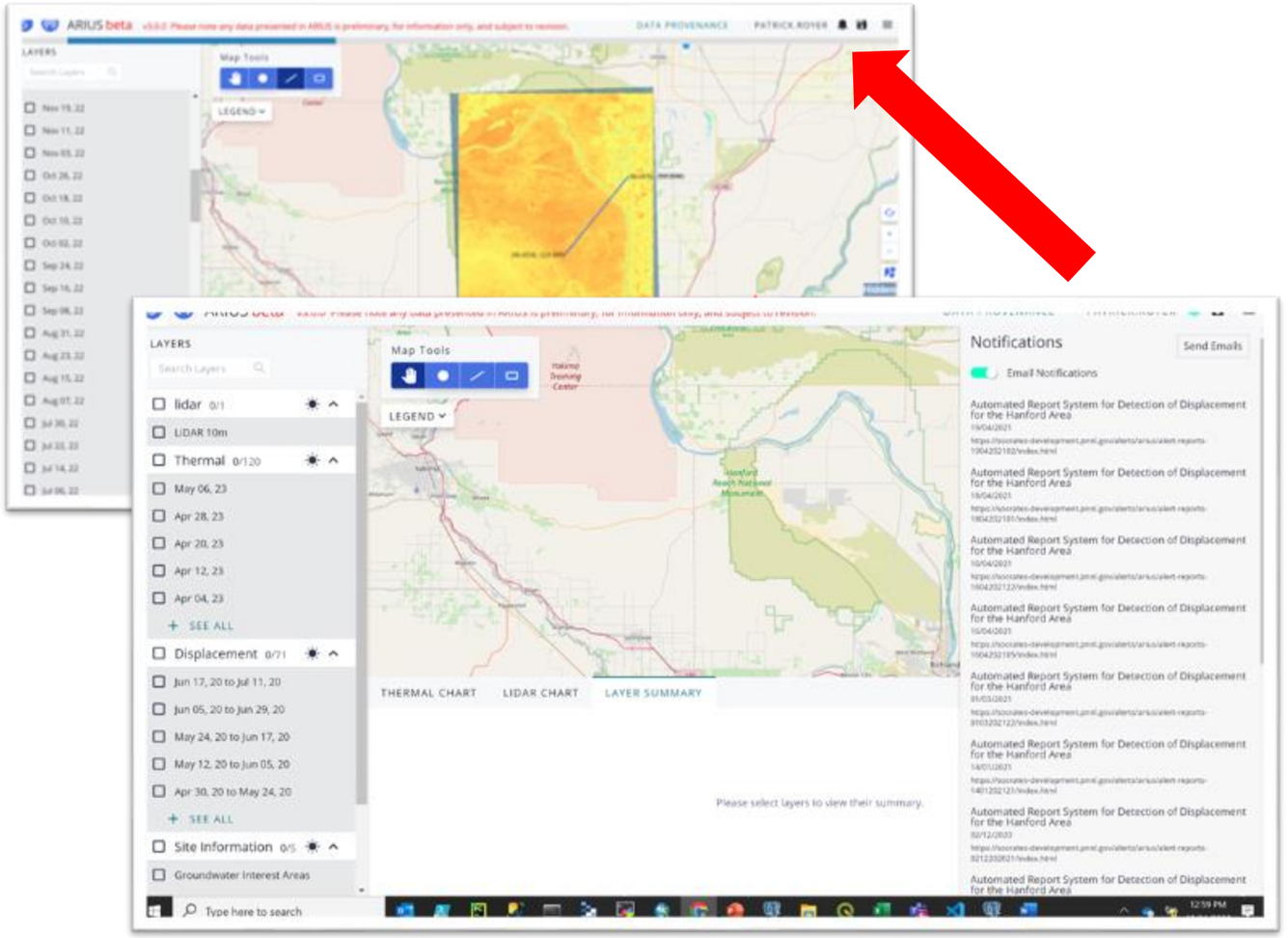
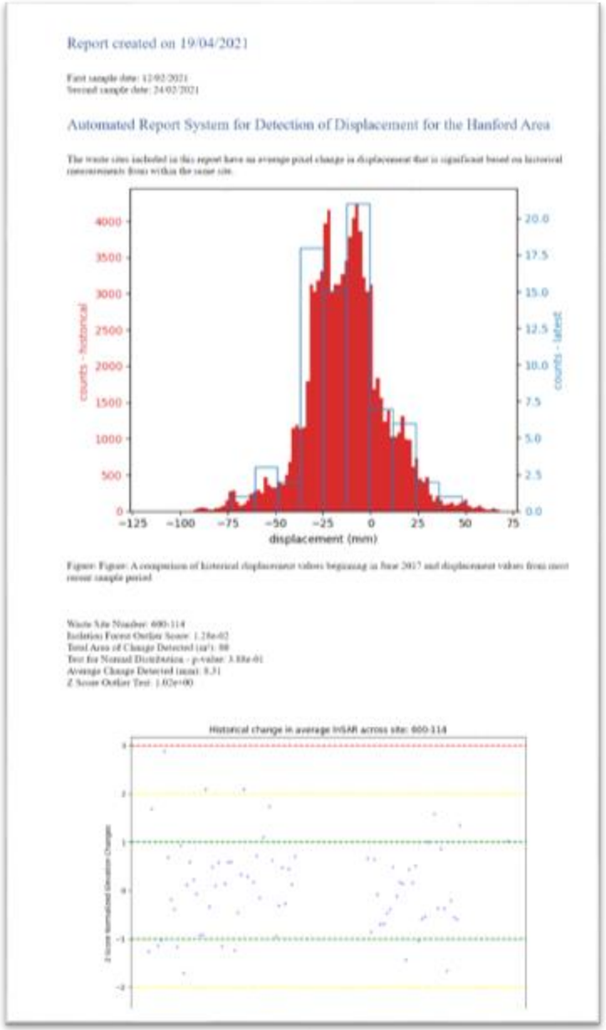
ARIUS User Interface and Demonstration

Event Management and Alerts





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Thank You

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