NWRRI - Desert Research Institute

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Newsletter written and compiled by Nicole Damon

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RFPs

If you have questions about submitting a NWRRI proposal, email Amy Russell (Amy.Russell@dri.edu).

For current RFP information, visit the NWRRI website (www.dri.edu/nwrri).

The Pahrump Valley Land Subsidence Problem: Using Machine Learning to Identify Predominant Causes and Make Predictions

As populations in the southwestern United States continue to grow, the demand on water resources also increases. One region experiencing this stress on its groundwater resources is Pahrump Valley in southern Nye County, Nevada. Pahrump Valley is one of the fastest growing counties in Nevada, which has led to groundwater-related issues such as land subsidence. "Land subsidence has been reported in Pahrump Valley since the 1960s," says Dr. Hai Pham the principal investigator (PI) of this project, which also includes co-PIs Karl Pohlmann, Susan Rybarski, and Kevin Heintz and research assistant Larry Piatt. "It has caused damage to building foundations and slabs, fissuring, shearing of well casings, and extensive damage to roadbeds."

A concrete well pad exposed by land subsidence around the well casing (right) observed during a field survey in May 2019 (photo by Karl Pohlmann).

In their 2017 Water Resources Plan Update, the Nye County Water District determined that land subsidence is one of the key issues related to population growth in Nye County (Giampaoli, 2017). However, the causes of land subsidence still haven't been clearly identified. "Previous studies failed to precisely map spatiotemporal evolutions of subsidence, or adequately clarify the

(Project Spotlight continued)

causes of subsidence," Pham says. "These studies were limited by data quantity and quality. The goal of this project is to identify and prioritize predominant factors that cause subsidence and make predictions using machine learning algorithms and big data."

Land subsidence is a complicated process that is driven by multivariate intercorrelated factors, such as groundwater decline, soil and sediment types, and tectonic and geologic settings. For example, excessive groundwater pumping results in soil compaction, which has been identified as a primary cause of land subsidence in Pahrump Valley. However, the magnitude of soil compaction depends on aquifer materials, and therefore understanding the geologic structure of Pahrump Valley is vital to evaluating future subsidence. The advantage of using machine learning to assess potential areas of land subsidence is that it can help illuminate complicated data relationships that may not be as obvious using traditional data analysis techniques.

A fissure at land surface in Pahrump Valley observed during a field survey in May 2019 (photo by Karl Pohlmann).

"Incorporating these high-resolution datasets will help us identify and prioritize the causes of subsidence and make better predictions."
– Hai Pham

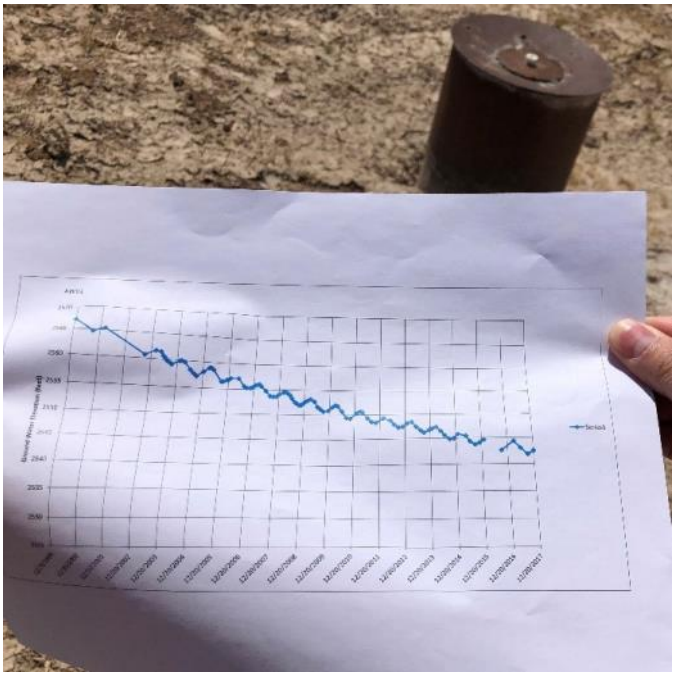
In this project, the researchers will use machine learning algorithms and high-resolution data sets to identify the predominant factors causing land subsidence in Pahrump Valley. "In this study, we will derive spatiotemporal subsidence maps using recent high-quality satellite images and the Interferometric Synthetic Aperture Radar [InSAR] technique," Pham says. "InSAR is a powerful technique that allows us to measure and map vertical changes on the earth's surface as small as a few millimeters."

The researchers will then build three-dimensional (3-D) computer models of the subsurface geological structures in Pahrump Valley at a very fine (one-foot) vertical resolution using data from 13,000 boreholes. "Compaction of aquifer materials can accompany excessive groundwater pumping and it is by far the single largest cause of subsidence, but the magnitude of soil compaction differs by soil type,"

(Project Spotlight continued)

Pham explains. "Therefore, it is important that we account for these well log data to construct high resolution 3-D models of geologic structures." The researchers will also develop groundwater drawdown maps by processing data from records of 130 groundwater observation wells that range from the 1940s to the present. "Incorporating these high-resolution datasets will help us identify and prioritize the causes of subsidence and make better predictions," Pham adds.

Because of the limitations of existing field data, the researchers will generate high-resolution datasets to train and validate the machine learning algorithms. Advanced machine learning algorithms will then be run on supercomputers to analyze the data. By analyzing this data, the researchers hope to identify the factors that cause subsidence and ultimately predict possible subsidence in the future. "Once we have identified these factors, we can roughly predict areas that are prone to subsidence," Pham explains. "This information can also be used to predict subsidence in other arid and semiarid regions." ■



The groundwater level has declined approximately 25 feet from December 1999 to December 2017 (photo taken in May 2019 by Karl Pohlmann).

References

Giampaoli, M., 2017. Nye County Water District Water Resources Plan Update.

Upcoming Events

AWRA Annual Water Resources Conference
November 3-7, 2019
Salt Lake City, UT
www.awra.org/Members/Events_and_Networking/Events/2019_Annual_Water_Resources_Conference.aspx

2019 ASA-CSSA-SSSA International Annual Meeting: Embracing the Digital Environment
November 10-13, 2019
San Antonio, TX
www.acsmeetings.org/

Groundwater Week
December 3-5, 2019
Las Vegas, NV
groundwaterweek.com

AGU Fall Meeting 2019
December 9-13, 2019
San Francisco, CA
www.agu.org/Fall-Meeting

NWRA 2020 Annual Conference Week Activities
February 10-13, 2020
Las Vegas, NV
www.nvwra.org/2020-annual-conference-week

Ocean Sciences Meeting 2020
February 16-21, 2020
San Diego, CA
www.agu.org/Ocean-Sciences-Meeting

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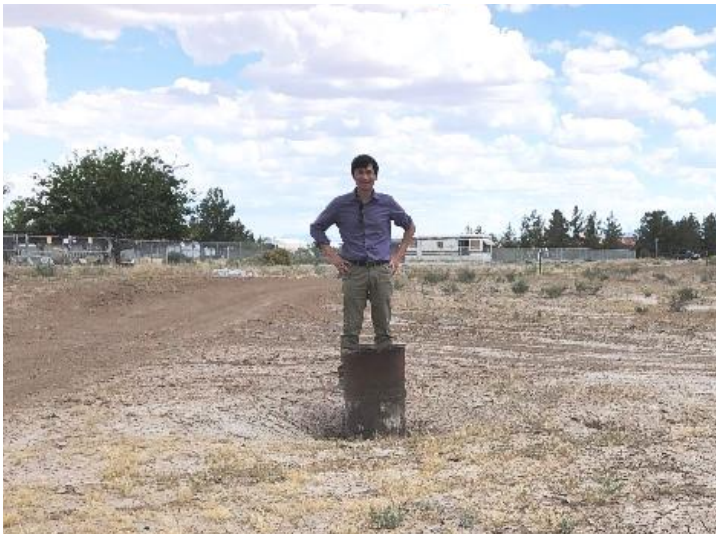
PI Spotlight: Dr. Hai Pham

Groundwater systems in arid and semiarid regions, such as Nevada, face a variety of stressors, including drought and overpumping. Therefore, protecting groundwater systems is vital for ensuring their sustainable use. "Groundwater plays an important role in the socioeconomic development of arid and semiarid regions, but in these regions, rainfall is scarce and surface water is often not available or can be of poor quality," explains Dr. Hai Pham. "Nevada is facing major groundwater issues, such as groundwater availability and natural and artificial groundwater recharge. My research goal is to find new ways to model the Nevada groundwater systems to protect, restore, and promote sustainable groundwater use."

What Pham finds most interesting about his current project, "The Pahrump Valley Land Subsidence Problem: Using Machine Learning to Identify Predominant Causes and Make Predictions," is the increase in possible applications for machine learning, particularly in solid earth geosciences. "The success of this Maki pilot project will help pave the way for a new research area for me, in which cutting-edge machine learning algorithms, big data, and supercomputers will be used for data-driven discoveries in geoscience research," he says.

This research project is highly significant because, based on Pham's previous research, it will be the first to overcome the common data limitations of previous studies by using high-resolution datasets. Through this project, the researchers hope to demonstrate that high-resolution datasets will outperform traditional approaches in identifying the predominant factors of land subsidence. "Our goals for this project are to show that big data can help us have a better understanding of the predominant factors that cause land subsidence and improve our understanding of the subsidence phenomena in the Pahrump Valley," Pham says. "This will allow us to provide recommendations to stakeholders that will prevent further subsidence and support the sustainable growth of the valley."



Hai Pham visiting a groundwater observation site in Pahrump Valley (photo taken in May 2019 by Karl Pohlmann).

In addition to his interest in new developments in machine learning. Pham is also interested in new ways to model groundwater flow, as well as contaminant fate and transport in porous and fractured media. "Advanced data analytics, high-performance computing, and using 3-D printing technology for scientific research are some of the areas that I'd like to incorporate into my future research projects," he says. When he has a chance, Pham enjoys spending time outside, whether it's camping, sightseeing, playing soccer, or getting a chance to visit beautiful geologic structures such as the Grand Canyon and Zion National Park. ■

"The success of this Maki pilot project will help pave the way for a new research area for me, in which cutting-edge machine learning algorithms, big data, and supercomputers will be used for data-driven discoveries in geoscience research."
– Hai Pham

Student Interview: Larry Piatt

We asked undergraduate research assistant Larry Piatt about his current studies and plans for the future. Here's what he had to say:

1) What field are you currently studying and what sparked your interest in that field?

I am currently studying environmental resource science. I have worked most of my adult life in either heavy industry or mining. During that time, I have seen the best of what companies can do to preserve the environment and the worst. These experiences led me to the realization that I wanted to learn and do more to make an impact on environmental preservation.

2) What research project are you currently working on and what research are you doing?

I am currently working with Dr. Hai Pham on subsidence issues in specific regions of southern Nevada. I have also been working on collating data that relates to the effects of climate change on seasonal trends in rainfall in the Northeast and how that might affect the feeding and mating habits of regional wildlife.

Photo by Nicole Damon

3) What do you hope to learn more about from this project?

I am hoping to learn more about Python programming and using Python to create GIS maps for data analysis and information presentation.

4) What are you looking forward to most about working on this project?

I'm looking forward to the opportunity to work on a project that will have a direct impact on a community and how it manages its water resources.

5) What are your goals for the next steps in your studies/career?

I am planning to work for a few years in either city planning or field work in southern Nevada before going to graduate school for a master's in sustainable urban planning and design.

6) Do you have a favorite dish that you like to make and why is it your favorite?

My favorite dish to prepare is spaghetti. Growing up, we had a family friend who would host a large Sunday dinner for family and friends every month or two. They always served homemade spaghetti at these dinners. Trying to recreate the spaghetti that I remember from my childhood has kept me passionate about cooking.

7) What is something that we might not know about you (hobbies, interests, etc.)?

I'm a voracious reader and I read approximately one book a day. ■

"I'm looking forward to the opportunity to work on a project that will have a direct impact on a community and how it manages its water resources."
– Larry Piatt

Events Continued

2020 Spring Conference: Geospatial Water Technology Conference: Complex Systems Tribute to David Maidment
March 23-26, 2020
Austin, TX
www.awra.org/Members/Events_and_Networking/Events/2020_Spring_Conference.aspx

116th Annual Meeting of the Cordilleran Section
May 12-14, 2020
Pasadena, CA
www.geosociety.org/GSA/Events/Section_Meetings/GSA/Sections/cd/2020mtg/home.aspx

EWRI World Environmental & Water Resources Congress
May 17-21, 2020
Henderson, NV
www.ewricongress.org/

Photo by Rick Cooper

EWRI Watershed Management Conference
May 20-21, 2020
Henderson, NV
www.watershedmanagementconference.org/

UCOWR 2020 Annual Conference
June 9-11, 2020
Minneapolis, MN
ucowr.org/2020-conference/

GSA 2020
October 25-28
Montreal, Quebec, Canada
www.geosociety.org/GSA/Events/Future_Annual_Meetings/GSA/Events/Annual_Meeting.aspx?hkey=b840a83c-3698-41d1-95e0-c0a792db3f38

2020 Annual Water Resources Conference
November 9-12, 2020
Kissimmee, FL
www.awra.org/Members/Events_and_Networking/Events/2020_Annual_Water_Resources_Conference.aspx

Success and the dedication to quality research have established the Division of Hydrologic Sciences (DHS) as the Nevada Water Resources Research Institute (NWRRI) under the Water Resources Research Act of 1984 (as amended). As the NWRRI, the continuing goals of DHS are to develop the water sciences knowledge and expertise that support Nevada's water needs, encourage our nation to manage water more responsibly, and train students to become productive professionals.

Desert Research Institute, the nonprofit research campus of the Nevada System of Higher Education, strives to be the world leader in environmental sciences through the application of knowledge and technologies to improve people's lives throughout Nevada and the world.

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Desert Research Institute | Nevada Water Resources Research Institute

www.dri.edu/nwrri

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Page 5: Larry Piatt by Nicole Damon

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