W4188 Annual Meeting 2024 Agenda

Dates: Jan 2-3, 2025, 8 am to 5 pm, Pacific Time

Location: Rogers Auditorium, Desert Research Institute, 755 E Flamingo Rd, Las Vegas, NV 89119

Chair: Jingyi Huang Secretary: Ray Anderson Treasurer: Thomas Harter Suggestions to speakers:

Based on the suggestions from the last meeting, we plan to schedule the presentations in a new way. Each speaker will have 20 min to present their research updates and 10 min for interactive discussions. During the 10-min discussion, the speaker can choose to 1) summarize the emerging challenges from their research and ask the group for potential solutions, 2) discuss some long-standing problems in Soil Physics and Hydrology, and 3) let the group ask questions based on the research updates from the speaker.

Virtual meeting link Via MS Teams:

https://teams.microsoft.com/l/meetup-join/19%3ameeting_YTk4ZmQ5NDItZDZlZi00MzU4LTg4MmQtNWU2NGZjOTQyMGIx%40thread.v 2/0?context=%7b%22Tid%22%3a%2233c1e122-3fec-49d1-aff8-2affbef66f4e%22%2c%22Oid%22%3a%224e111e69-b84a-4b6b-8740-9bf3263fa01c%22%7d

Student travel award presenters:

Wenyi Cui (wencui@ucdavis.edu); Ali Karbalaye Ghorbanpour (akghorbanpour@ucdavis.edu); Floyid Nicolas (fnicolas@ucdavis.edu); Mingxiu Wang (mingxiuw@tamu.edu); Dallas Williams (dmwilliams22@tamu.edu); Chihiro Dixon (chihiro.dixon@usu.edu);

Posters: Ray Anderson, Wei Dai (Louisiana State University)

Day 1, Thursday, Jan 2, 2025

8:00-8:40: Continental breakfast

Morning sessions:

8:40-8:45: Welcome: Markus Berli, Desert Research Institute

8:45-9:35: Business meeting: Jingyi Huang, Ray Anderson, Markus Berli, and Thomas Harter (a brief

update on the financial status of the meeting and discussing the 2026 meeting schedule)

9:35-10:45: Presentations from travel award recipients (7 min talk + 3 min Q&A per speaker):

10:45-11:15: Coffee break

11:15-11:45: Todd Skaggs and Elia Scudiero, United States Salinity Laboratory

11:45-12:15: Helen Dahlke, University of California, Davis

12:15-13:15: Lunch break

Afternoon sessions:

13:15-13:45: Isaya Kisekka, University of California, Davis

13:45-14:15: Thomas Harter, UC-Davis

14:15-14:45: Coffee break

14:45-15:15: Jiri Simunek, University of California, Riverside

15:15-15:45: Morteza Sadeghi, California Department of Water Resources and Ebrahim Babaeian, University of Florida

15:45-16:15: Yingxue Yu, Connecticut Agricultural Experiment Station

16:15-16:45: Yan Jin, University of Delaware

16:45-17:15: Elnaz Ebrahimi, Iowa State University

17:15-17:45: Ole Wendroth, University of Kentucky

17:45-19:00: Catered dinner, poster presentation, and discussions at the DRI

Day 2, Friday, Jan 3, 2025

8-8:30: Continental breakfast

Morning sessions:

8:30-9:00: Ji-Jhong "JJ" Chen, University of Wyoming

9:00-9:30: Qinyuan Cao and Rui Li, Michigan State University

9:30-10:00: John Nieber, University of Minnesota

10:00-10:30: Coffee break

10:30-11:00: Rose Marie Shillito, ERDC, U.S. Army Corps of Engineers

11:00-11:30: Hannes Bauser, University of Nevada, Las Vegas and Laura Rosales, Nevada State University

11:30-12:00: Salini Sasidharan, Oregon State University

12:00-12:45: Lunch break

Afternoon sessions:

12:45-13:15: Hassan Dashtian, University of Texas at Austin

13:15-13:45: Scott Jones and Asghar Ghorbani, Utah State University

13:45-14:15: Joan Wu, Washington State University

14:15-14:45: Markus Flury, Washington State University

14:45-15:15: Robert Ewing

15:15-15:45: Tyson, Ochsner, Oklahoma State University

15:45-16:00: Meeting Adjoin

Minutes of W5188 Annual Meeting 2024

Location: Rogers Auditorium, Desert Research Institute, 755 E Flamingo Rd, Las Vegas, NV 89119

Virtual meeting link:

https://teams.microsoft.com/l/meetup-join/19%3ameeting_YTk4ZmQ5NDItZDZlZi00MzU4LTg4MmQtNWU2NGZjOTQyMGIx%40thread.v2/0?context=%7b%22Tid%22%3a%2233c1e122-3fec-49d1-aff8-2affbef66f4e%22%2c%22Oid%22%3a%224e111e69-b84a-4b6b-8740-9bf3263fa01c%22%7d

Dates: Jan 2-3, 2025

Chair: Jingyi Huang

Secretary: Ray Anderson

Treasurer: Thomas Harter

Participants:

In-person: Jingyi Huang, Markus Berli, Tyson Ochsner, Jameson Ochsner, Hassan Dashtian, Sahar Bakhshian, Scott Jones, Asghar Ghorbani, Ole Wendroth, Thomas Harter, Rose Shillito, John Nieber, Salini Sasidharan, Morteza Sadeghi, Helen Dahlke, Yingxue (Charlie) Yu, Behzad Ghanbarian, Jirka Simunek, Ray Anderson, Elia Scudiero, Todd Skaggs, Nan Li, Teamrat Ghezzehei, Isaya Kisekka, Ebrahim Babaeian, Yan Jin, Elnaz Ebrahimi, Ji-Jhong Chen, Qinyuan Cao, Rui Li, Hannes Bauser, Laura Rosales, Zach Perzan, Joan Wu, Markus Flury, Robert Ewing, Jing Yan

Online: Tim Green, Briana Wyatt, Laura Rosales Lagarde, Manoj Shukla, Thijs Kelleners, Wenyi Cui, Karletta Chief, Chihiro, Dixon, Michael Young, Mingxiu Wang, Dallas Williams, Felix Ogunmokum, Jan Hopmans, Jennifer Edmonds, Georgios Kourakos, Srinivasa Rao Peddinti, Cassie Bonfil, T. Burke Parham, AJ Wolff

Day 1, Jan 2, 2025, 8:40 AM-9:35 AM

1. Introductions of new/incoming members

2. Annual Reports submission to Jingyi:
   Send to Ray Anderson, by Friday, February 7, 2025.
   Ray will send a follow-up email with the template and deadline.

3. Finances Update (Thomas Harter):

New UC-Davis system is a challenge but should be resolved soon. Money will not be transferred from U. of Idaho to UC-Davis. Plan is to spend down remaining balance at Idaho and close account there.

4. 2025 Annual Meeting Planning
   CES is week of January 5th, 2026. Proposed alternate meeting location in Riverside, CA (UC-Riverside and USDA-ARS George E. Brown Jr. Salinity Laboratory) for the week of January 5, 2026

5. 2026 Incoming chair/Secretary
   Helen Dahlke and Ebrahim Babaeian nominated for 2026 secretary. Helen was selected by in-person and online vote.

6. Other business:
   Ole Wendroth: need to work with experiment station directors to get new project participants formally approved and added in NIMSS. For next year's meeting, we can reach out to the USDA program representatives and invite them to join our meeting and give a talk.

Day 1, 9:35-10:45 AM

Student presentations (travel award recipients)

a) Wenyi Cui (UC-Davis) – Agricultural Managed Aquifer Recharge (Ag-MAR). Ag-MAR has concerns of leaching contaminants (especially nitrate) to groundwater as well as managing growing season N and soil moisture. Wenyi's research found increased nitrate concentrations from soil N mineralization following Ag-MAR. Modeling study was conducted with DSSAT at Terranova Ranch (San Joaquin Valley, CA).

b) Ali Ghorbanpour (UC-Davis) – Assessing evapotranspiration accuracy with satellite imagery and eddy covariance observations is crucial due to the uncertainty with satellite-based ET products. This research focused on applying an optimization algorithm to SEBAL. Approach was tested at four eddy covariance sites in California.

c) Mingxiu Wang (Texas A&M) - Land conversions in Texas affect deep drainage. Restored savannah has higher drainage than woody encroached land.

d) Floyid Nicolas (Oregon State) – Reducing nitrate leaching is an important conservation goal in California. This study evaluated practices to reduce nitrate leaching using multiple models (APEX, MODFLOW, RT3-D) and evaluating the results against observations in a field near Davis, CA. Five conservation practices were simulated for a 30-year period.

e) Dallas Williams (Texas A&M) – Rain gardens are an important tool for urban water management. Original clayey soils are often removed and replaced with sandy soils to increase infiltration rates. However, this creates additional challenges and expenses with removing clay soil and replacing with sand imported from elsewhere. In this project, other waste materials (e.g. shale, shell, and glass) were mixed with clay soil in a column study to assess infiltration rates. The shell treatment had the highest drainage rates, while the shale had the best amelioration of pollutant concentrations.

f) Chihiro Dixon (Utah State) – Plant growth systems for the International Space Station are needed to provide fresh food for astronauts. However, soil water retention under microgravity conditions is unknown. HYPROP evaporation experiments were applied to peat moss to determine the soil water retention curve.

Day 1, 11:15-12:15

a) Todd Skaggs (USDA-ARS, George E. Brown Jr. Salinity Lab) – The Salinity Lab has developed a number of tools and publications over the years. Todd's talk focused on synthesizing some of this work and discussed his efforts to develop a web-based tool. Todd also reviewed the existing W5188 website on NIMSS and asked the group if he should follow up on his earlier offer to create a separate project website. After discussion, it was decided that the existing NIMSS website is sufficient

b) Helen Dahlke (UC-Davis) - Managed aquifer recharge (MAR) in agricultural landscapes is an increasing approach for reducing groundwater depletion and to effectively manage floodwaters. However, there is a concern that MAR would increase nitrate pollution unacceptably. Helen's talk focused on recent developments with MAR implementation in the San Joaquin Valley. Helen reviewed recent experiments in the Western San Joaquin Valley on MAR.

Day 1, 13:15-14:45

a) Isaya Kisekka (UC – Davis) – NRCS Conservation Effects Assessment Project (CEAP) in California is concerned with reducing nitrogen loading to groundwater. Isaya's talk focused on observations of effectiveness of conservation practices on reducing nitrate leaching. Observational approaches include field scale mass balance, vadose zone monitoring, and groundwater monitoring. Observations show rapid mobilization and leaching of nitrate following atmospheric rivers.

b) Thomas Harter (UC-Davis) – Thomas presented an overview of his group's work at the groundwater-food nexus. Specific examples include (1) a flow framework model for Northern California (with Claire Kouba), (2) Nonpoint Source Assessment Tool.

Day 1, 14:45-17:45

a) Jirka Simunek (UC – Riverside) – Jirka presented numerous case studies with HYDRUS modeling across a wide range of applications. These included (but were not limited to) (1) a new root water uptake formulation (Thomas et al. 2024), (2) effect of different irrigation water sources on soil temperature, (3) effect of leaching strategies on salt dynamics (Guo et al. 2024), (4) impact of solar farms on recharge (Mulla et al. 2024), (5) using Google Earth Engine for mapping regional root water uptake, and (6) modeling PFAS transport with HYDRUS.

b) Morteza Sadeghi (CA Department of Water Resources) – Large scale ground water monitoring in California will be needed to implement the Sustainable Groundwater Management Act (SGMA). Morteza presented a case study using satellite gravimetry (GRACE satellite) to monitor changes in groundwater storage. GRACE can monitor changes in terrestrial water storage, but it has a coarse spatial resolution compared to the size of the SGMA management units (Groundwater Sustainability Agencies). Downscaling approaches including water balance and machine learning downscaling were explored.

c) Ebrahim Babaeian (Univ. of Florida) – Floridian agriculture features sandy soils which require frequent irrigation and can have higher nutrient leaching. Ebrahim presented on new radiometric approaches to monitor soil moisture in these soils. The lowest error in brightness temperature occurred at a view angle of 40 degrees. Overall, the model had best accuracy at 30 cm depth.

d) Yingxue (Charlie) Yu (Connecticut Agricultural Experiment Station) – Plastic mulch has numerous applications in agriculture, but most mulch is non-biodegradable and contributes to plastic waste. Charlie's presentation focused on different types of biodegradable polymers that could replace current plastics for agricultural applications. Different types of biodegradable mulch were surveyed along with their performance and potential for easy breakdown after use.

e) Yan Jin (Univ. of Delaware) – Yan presented updates with her group, including from the ACTIONS monitoring project looking at impacts of sea level rise on ecosystem physics and biogeochemistry. Group is starting to use isotopes to see if they can serve as potential tidal tracers. Jing Yan presented his work with evapotranspiration and bacteria in these ecosystems.

f) Elnaz Ebrahimi (Iowa State University) – Elnaz presented two case studies. One was how installation of a natural gas pipeline (Dakota Access) affected crop productivity in the

disturbed right of way path for the pipeline. The APSIM model was used for this work. Disturbance significantly reduced plant height, soil water holding capacity, and yield. The second case study was a "smart" rhizobox for rooting studies.

g) Ole Wendroth (Univ. of Kentucky) – Ole presented three case studies. One was the effect of cover crops on soil physical properties and organic carbon. No significant differences in soil organic were observed, but the hydraulic conductivity was lowest under winter fallow. The second case study was an ongoing farm study for model decision support in a karst region in Kentucky.

Day 2, Jan 3, 2025, 8:30-10:00

a) JJ Chen (Univ. of Wyoming) – JJ presented case studies on harvesting strategies for space-based agricultural systems, with a contrast between single harvest cycle and continuous harvesting. Continuous harvesting had lower salinity and more efficient nitrate uptake. Sub-surface irrigation also had lower salinity than overhead irrigation. Impacts of other substrates (e.g. lunar regolith) and sensor-based irrigation management were also explored.

b) Qinyuan Cao (Michigan State University) – Qinyuan presented a study on heavy metal uptake by carrots. She examined the impact of uptake under five growth stages with different irrigation regimes. Wetter irrigation regimes had greater translocation of Lead, Arsenic, and Cadmium, especially in later growth stages.

c) Rui Li (Michigan State University) – Rui presented a study on the potential for using machine learning to predict contaminant transport with an emphasis on PFAS. Random Forest and Extreme Gradient Boosting approaches were used in this study. Rui is examining developing a more comprehensive model for species-specific plant uptake of PFAS. General challenges with machine learning approaches (e.g. black box) were also discussed.

d) John Nieber (Univ. of Minnesota) – John presented an overview of a number of different projects from Minnesota. These included (a) assessment of groundwater pollution from road salt, (b) quantifying benefits from peatland restoration, (c) improved infiltration model for watershed applications using the Layered Green and Ampt/Talbot-Ogden (LGARTO) approach, (d) estimating sustainability of hydrologic flows for the Upper Mississippi River Basin with a focus on shipping impacts (low flows inhibiting barge traffic), and (e) prediction of nutrients and streamflow with guided machine learning.

Day 2, 10:30-12:00

a) Rose Shilito (ERDC, US Army Corps of Engineers) – Rose presented a study on understanding the post-fire impacts on hydrology. Her case study focused on higher elevation fires and hydrophobic soils in the Rocky Mountains. Parameterizations for burn severity and hydrophobicity were discussed. Advancements in fire and smoke modeling and near real-time modeling and responses were examined.

b) Hannes Bauser (Univ. of Nevada – Las Vegas) – Hannes presented his work on hydrologic impacts of biological soil crusts. Discussed elements include growing artificial biocrusts in the laboratory, processed-based modeling of crusts, monitoring of crusts on the SEPHAS lysimeter (DRI), monitoring of the U of Arizona Landscape Evolution Observatory (Biosphere 2).

c) Zach Perzan (Univ. of Nevada – Las Vegas) – Zach presented some of his work on vadose zone heterogeneity impacts on managed aquifer recharge. Field scale observations of electrical resistivity and cone penetration tests were presented.

d) Laura Rosales (Nevada State Univ.) – Laura presented resources to teach soils and water. Resources included (a) HYDROLEARN model (community developed modules). Learning taxonomies (e.g. Bloom's taxonomy) were presented.

e) Salini Sasidharan (Oregon State Univ.) – Salini presented work on managed aquifer recharge in Oregon. Work on multiple benefits that can engage multiple stakeholders was emphasized. Previous work with drywells in California was discussed. Current drywell research at Corvallis (demonstration) and Lower Umatilla Basin was presented, including ancillary geophysical surveys (tTEM). Regulatory differences between Oregon and California with drywells and managed aquifer recharge were discussed.

Day 2, 12:45-16:00

a) Hassan Dashtian (Univ. of Texas – Austin) – Hassan presented his work on forecasting soil moisture. He primarily focused on using SMAP and developing predictors for simulating observations in a case study in the Houston, Texas, area. Future work will seek to improve forecasts up to 11 days in advance. Other analysis of social media mentions of flood and drought was also presented.

b) Scott Jones (Utah State University) – Scott reported on a number of research projects including a root module for space agriculture (NASA-funded). Some of the challenges include appropriate sensor selection, containment of the substrate (surface cover), and management of peat substrate (including water retention curve and bubbling pressure for irrigation tube).

c) Asghar Ghorbani (Utah State University) – Asghar reported on an improved version of the van Genuchten soil water retention model. Asghar's model showed improvement vs. the original model at the dry end of the retention curve. Asghar presented other elements incorporating vapor and evaluating hydraulic conductivity.

d) Joan Wu (Washington State University) – Joan reported on projects from Washington State, including (a) urban stormwater management (green stormwater infrastructure – GSI). This work combines soil and geographic parameters to determine suitable areas for bioretention systems. GIS was used to map suitable GSI areas for the study region. Joan also reported on water erosion in the Inland Pacific Northwest. This work focused on dryland cropping systems and sought to understand long-term erosion trends and potential changes under future climate.

e) Markus Flury (Washington State University) – Markus presented research on the fate and transport of plastics. There is international political pressure to reduce plastic pollution, but no agreement so far. Research on transfer of microplastics through biosolids application to land in Central Washington and atmospheric deposition was presented. Root uptake of microplastics was explored through electron microscopy. Markus concluded by discussing his incoming role as editor-in-chief for SSSA and discussed reasons for publishing in society journals.

f) Robert (Toby) Ewing (Climate Corporation) – Toby presented on soil carbon work. He contrasted soil carbon modeling to soil hydrology (what if we didn't have matric potential concept). Toby proposed a C model parameterization with a decomposability component in the ProCarbon-Soil (PROCS) model. Example simulations from Brazil and synthetic data (perturbations of Century model outputs) were presented.

g) Tyson Ochsner (Oklahoma State University) – Tyson emphasized the need for hydrologic monitoring in Oklahoma due to hydrologic extremes and their impacts on the state. The Oklahoma Hydronet seeks to monitor soil water, groundwater, and surface water reservoirs as a complement to Oklahoma's Mesonet. Soil moisture sensor evaluation and deeper sensor installation were explored. Questions about sensor depths were explored. Tim Green suggested a paper from ARS-Ft. Collins (https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/141255) on optimal sensor depth.

Accomplishments

Short-term outcomes

University of California, Riverside (Hoori Ajami)

- Performed global sensitivity analysis of semi-distributed ecohydrologic models to improve parameter identification and reduce predictive uncertainty
- Contributed to development of an approach for reducing uncertainty in evapotranspiration partitioning using stable water isotopes data
- Contributed to developing a topographic correction approach for hyperspectral imaging of intact soil samples for soil carbon estimation
- Contributed to developing a computationally efficient hydrologic model at a watershed scale
- Characterized mountain system recharge processes to valley aquifers in southern Sierra Nevada
- Contributed to understanding of managed aquifer recharge processes

University of California, Riverside (Jirka Šimůnek)

In 2024, we organized four short courses on using HYDRUS models. The first three courses were on-site (in Prague, mainly for participants from Europe, in Cameroon, Africa, and in Santiago in Chile), while the fourth one was online and mainly for participants from Northern America (US and Canada). Over 100 students participated in these short courses.

University of California, Davis (Thomas Harter)

- Maintained highly efficient water and nutrient management practices in almond orchard of a 140- acre commercial operation, with nutrient use efficiency above 90%.
- In about 100 events, reached out to over 4,000 local, state, national, and international policy- and decision-makers, researchers, and grower-representatives about nonpoint source pollution of groundwater and its sources, and about sustainable groundwater management.
- Provided local and state decision-makers and NGOs a comprehensive manual to the Scott Valley Integrated Hydrologic Model
- Validated and improved watershed model for the upper Scott Valley watershed
- Developed a methodology for interpreting geophysical data for development of aquifer textural classification
- Supported the impact assessment of the 2024 Scott-Shasta Valley Drought Emergency Order, which was approved by the State of California in 12/2023.
- Provided training on groundwater hydrology to over 30 Western U.S. judges and justices

- In close coordination with local officials and state regulators, revised the Butte Valley groundwater sustainability plan and developed unique new approach to water budget accounting; engaged water users in decision-making process on reducing groundwater use.
- Educated water managers, agency personnel, growers, agricultural representatives, leaders in the agricultural banking sector, and attorneys on California groundwater issues during two Water Education Foundation tours: 1-Day Groundwater Tour and 3-Day Central Valley tour.
- Organized and hosted unique international conference on "Toward Sustainable Groundwater in Agriculture" in San Francisco, June 17-20, 2024, with global leaders on issues related to the groundwater-food nexus (over 250 attendees).
- Educated nationally selected group of NSF-funded graduate students a summer field camp to study and compare groundwater and drought management in California, Spain, and The Netherlands.
- Workshops to educate water managers, growers, grower organizations, NGOS, local/regional/state representatives and decision/policy makers on the relationship between crop management practices and groundwater pollution based on nitrogen budgets, current and historic groundwater pollution, groundwater forensics to identify sources of nitrate (by specific crops), application of machine-learning algorithms to identify agriculture's role in groundwater nitrate pollution, and on N balance; understanding the dynamics of future groundwater pollution improvements from current changes in management practices.
- Over a dozen consultation meetings with regulatory agencies, agricultural coalition representatives, and environmental NGOs on the technical merits of proposed policy solutions to regulating agricultural nitrate discharges to groundwater.
- Monthly consultations with state regulatory water rights division on developing drought enforcement assessment tools

University of California, Davis (Majdi Abou Najm)

A lot of focus was given to outreach and building pilot experiments in agrivoltaics which made large impact in terms of bringing attention and interest in this new and promising technology. This year, I also participated in numerous talks, presentations, and outreach meetings with different stakeholders. Furthermore, and in collaboration with the German-American Chamber of Commerce, we built on last year's success and launched California's second conference on Agrivoltaics, which was very well received and attended (attendance around 175) with representations from growers, to policy, energy and industry groups. The conference worked as a catalyst bringing all those groups together and help each group connect with other groups. Also, I have worked with policy groups including California Climate and Agriculture Network (CalCAN) and American Farmland Trust (AFT) among other agencies.

In the summer, we had a one-acre experiment in the Campbell Tract at UCD where we tested how crops react to a wide range of light treatments, simulating different Agrivoltaics technologies. We experimented with tomatoes and peppers and the field was visited by a large number of stakeholders, so it served as a demonstration site for introducing the prospects of the

technology. Our preliminary results demonstrated that the shade positively helped the peppers and didn't impact the yields, and increased the water use efficiency of both peppers and tomatoes while reducing the yield (per acre not per water volume) of tomatoes. Furthermore, we have secured funding and completed the design of a 200KWp agrivoltaics facility that will serve as California's first agrivoltaics demonstration site and I hope that its construction will commence in 2025 and will be ready for experimentation and demonstrations in 2025-2026.

In addition, my work on a significant review of soil infiltration came to fruition with having this review accepted for publication. The review will appear in Vadose Zone Journal in early 2025 and will be the most comprehensive document on the theory and application of soil-water infiltration. We have identified and documented 138 unique infiltration models and traced their theoretical and applied backgrounds to aid researchers and practitioners in understanding this complicated process.

University of California, Davis (Helen E. Dahlke)

- Developed 1D models to simulate mobile-immobile vadose zone transport of pesticide residues across multiple soil textures in response to intentional flooding for groundwater recharge.
- Pesticide residue transport data and modeling shows that subsurface heterogeneity and specifically the fraction of sand present in the subsurface control the degree of preferential flow present in the vadose zone and can vary travel times by up to 38 %.
- Analysis of the transport of pesticide residues under AgMAR showed that profiles with a higher sand content demonstrated more pronounced preferential flow, faster water flow, higher groundwater recharge efficiency, but also more soil pesticide and salt leaching correlating with increased risks of groundwater contamination. Choosing fewer mobile pesticides (e.g., *chlorantraniliprole* and *methoxyfenozide*) and extending the time interval between the last pesticide application and the Ag-MAR event are important for reducing groundwater pollution risks. In contrast, profiles with finer textures showed less preferential flow, slower water flow, lower groundwater recharge efficiency, but raised concerns about the accumulation of pesticides or salts and elongated anaerobic conditions in upper soil layers due to capillary barriers, which could severely impact soil structure, biochemical reactions and crop growth.

Desert Research Institute (Markus Berli)

- A model to describe the relationship between sorptivity, effective contact angle and initial water content.
- A method to adjust soil sorptivity for different levels of soil burn severity.
- Prototype of a UAS-based robot that can carry out water drop penetration time (WDPT) tests semi-autonomously.

Washington State University (Markus Fleury and Joan Wu)

- Better understanding how much plastics is on biosolids
- Discovery that atmospheric plastic deposition to soils is substantial compared to input by biosolids
- Micro- and nanoplastics are mobile in soils and sediments
- Biodegradable plastics are a viable alternative to conventional plastics

University of Wyoming (Thijs Kelleners)

- Improved a coupled hydro-geophysics inversion code that uses surface-based electrical resistivity and/or seismic refraction data to estimate subsurface porosity distribution along a transect.
- Demonstrated how airborne and surface-based electromagnetic induction data can be used as calibration targets for integrated watershed models to predict soil moisture, groundwater, and streamflow dynamics.

University of Arizona (Marcel Schaap, Craig Rasmussen, and Karletta Chief)

- Published manuscript in VZJ regarding high resolution mapping of soil hydraulic properties in contiguous USA (based on SoilGrids+)
- Published open-source code in GitHub to support mapping high resolution mapping of soil hydraulic properties in contiguous USA
- Published GEOTIFF files (350 GB) of output of previous two points.
- Downloaded and performed initial verification of the NRCS SOLUS100 data which will become the next iteration of the soil hydraulic maps.
- Hired one MS student to work on soil hydraulic property mapping (two more will become active soon).
- Extended existing Rosetta 3 code with unsaturated hydraulic properties.
- Presented at one on-campus poster regarding hydraulic mapping of soil hydraulic properties.
- Presented at one international conference regarding hydraulic mapping of soil hydraulic properties.
- Integrated recent research findings in ENVS 470/570 “Soil Physics”

Utah State University (Scott B. Jones, Asghar Ghorbani, David A. Robinson (adjunct), and Morteza Sadeghi (adjunct)

- A novel shorting standard was demonstrated using a conductive silver fabric for calibration of open-ended dielectric probes and other devices where a short is required.
- The measurement error associated with solution electrical conductivity on the output (e.g., voltage, permittivity, period) of electromagnetic-based water content sensors was demonstrated in a peer-reviewed publication for eight commercially available devices.
- The sampling volume of seven commercially available electromagnetic sensors was evaluated and reported in a peer-reviewed manuscript.
- A generalized - van Genuchten (1980) model was developed and presented with improved soil water retention data fitting capabilities.
- A US perspective on collaboration between soil science societies in the USA and China was developed and reported.

University of Nebraska (Aaron Daigh)

1. Artificial Intelligence in Agricultural Research. The adoption of artificial intelligence (AI) in agricultural and environmental research has increased exponentially, with AI-enhanced models improving data analysis and decision-making efficiency. This has led to faster identification of soil and crop management strategies, optimizing productivity while reducing resource inputs. Clearer communication of AI applications in research were identified and disseminated in peer-review commentaries, which is expected to enhance its adoption and effectiveness in agriculture and environmental research.

2. Salinity Management with Subsurface Drainage. The implementation of subsurface drainage over nine years in a soybean–wheat–corn rotation in North Dakota led to a measurable reduction in soil salinity, with a decrease of 0.15 dS m^{-1} per year in drained fields, compared to an increase of 0.03 dS m^{-1} per year in undrained fields. Additionally, soybean yields increased by 0.18 Mg ha^{-1} per year in drained areas, significantly outpacing the 0.06 Mg ha^{-1} per year increase in undrained areas, demonstrating the adoption of subsurface drainage as an effective strategy for improving crop productivity and soil quality.

3. Calcium Amendments for Brine-Impacted Soils. Laboratory investigations showed that calcium acetate (Ca-Ac) is many times more soluble than gypsum and more effectively improves hydraulic conductivity and sodium reduction in brine-impacted soils. This research suggests that Ca-Ac can be a superior alternative to gypsum in remediating sodium-affected soils, potentially accelerating soil recovery and reducing the environmental impact of oilfield brine spills.

4. Landslide Risk Assessment in North Dakota. Analysis of 66,894 landslides in North Dakota identified key geological and hydrological factors contributing to slope instability. The investigation highlighted the role of sodium adsorption and total dissolved solids in reducing soil shear strength, emphasizing the need for improved land management strategies to mitigate infrastructure damage and economic losses from landslides.

5. Phosphorus Saturation in Reservoir Sediments. Sediment in the Des Lacs Reservoir System in North Dakota was found to be over 95% saturated with phosphorus, limiting its ability to sequester additional nutrients and contributing to persistent cyanobacteria blooms. This high saturation level indicates that reducing external phosphorus inputs alone will not mitigate eutrophication, necessitating alternative interventions such as sediment dredging or in-lake phosphorus binding treatments to improve water quality.

6. Ornamental Grasses for Stormwater Management. Several ornamental grass species demonstrated strong tolerance to cyclical flooding, drought, and submergence, with switchgrass and Chinese silvergrass maintaining acceptable foliar conditions under extreme conditions. These findings provide practical guidance for urban planners and landscape designers in selecting resilient plant species for stormwater management systems such as rain gardens, improving urban flood resilience.

7. Machine Learning for Greenhouse Gas Emissions Prediction. A rye cover crop significantly reduced early-season N_2O emissions by 34% and resulted in a net reduction of 1,061 kg CO_2e ha^{-1} compared to conventional practices. The study also demonstrated that machine learning, particularly the random forest model, accurately predicted daily N_2O–N (73% accuracy) and CO_2–C (85% accuracy) emissions, providing a robust tool for optimizing carbon sequestration strategies in agriculture.

Oklahoma State University (Tyson Ochnser)

- We evaluated the correlations between soil moisture predictions from the TOPOFIRE model and the measurements from >1,000 in situ monitoring stations across the US. The correlations coefficients were typically between 0.5 and 1.
- Cosmic-ray neutron rover surveys were conducted in four watersheds within Oklahoma: the Little Washita River Watershed, the Fort Cobb Watershed, the Wild Horse Creek Watershed, and the Deep Red Creek Watershed. Cosmic-ray neutron rover surveys were completed on two dates in each watershed to capture soil moisture patterns in relatively wet and dry conditions.
- We worked on estimating the soil hydraulic properties that are needed to estimate drainage rates using in situ soil moisture observations. We documented that Rosetta3 produces soil hydraulic property estimates that result in unrealistically high drainage estimates.
- We collaborated with colleagues in other states to maintain coordinated in situ soil moisture sensor testbeds. Soil moisture sensor testbeds in Kansas, Oklahoma, Texas, and Maryland are being used to test soil moisture sensing technologies in different soils and climates.
- We continued released an improved version (v. 9) of the open-access soil physics textbook "Rain or Shine: An Introduction to Soil Physical Properties and Processes". The most significant improvement in version 9 is the addition of podcast-style audio summaries of each chapter that were generated by a collaborator using the AI tools in Google NotebookLM.

Texas A&M University (Binayak P. Mohanty)

- Using satellite remote sensing of precipitation, soil moisture, in-situ soil texture, and monitored ground water table data, a physics-augmented machine learning (ML) tool was developed for estimating regional "preferential flow" to shallow groundwater systems across the continental USA. This is first-of-its-kind effort for preferential flow estimation at regional scale and found to be transferrable to other regions.
- Using global surface soil moisture (SM) from NASA's Soil Moisture Active Passive (SMAP) satellite, we characterized seasonal preferential hydrologic states of SM and derive three tipping characteristics to estimate the intensity (Mean Tipping Depth, $\bar{\varepsilon}$), frequency (Tipping Count, η), and duration (Mean Tipped Time, $\bar{(\tau)}$) of the excursion of SM from wet- to dry-average conditions.
- Developed relationship between surface soil moisture (SM) and evaporative fraction (EF) derived using spaceborne observations from the Soil Moisture Active Passive (SMAP) mission and the Moderate Resolution Imaging Spectroradiometer (MODIS) to estimate rootzone soil moisture dynamics for the Contiguous U.S. at 9-km grid resolution. We further demonstrated that this approach can be extended into a near-real-time agricultural drought monitor to assess drought impacts on vegetation using surface soil moisture observations.
- Established the Texas Water Observatory to study coupled water-energy-carbon cycle under multiple land use and land covers in Gulf coast region of Texas. This facility supports the study of various soil, water, carbon processes, properties, and management practices under changing climate.
- Studied the up/downscaling aspect of soil moisture (SM) and evapotranspiration (ET) coupling from local to remote sensing footprint scales. Characteristics features across various hydroclimates were discovered that may be used to reflect the sub grid heterogeneity and resiliency of various ecosystems globally.

Texas A&M University (Briana Wyatt)

- Developed precision turfgrass management strategies to inform water and nutrient applications on golf courses

Louisiana State University – Agriculture Center (Xi Zhang)

- Develop an interpretative framework linking cover cropping effects on soil structure to mass and energy fluxes for understanding biogeochemical processes, promoting the adoption of cover cropping in the mid-south, and developing management practices to improve agroecosystem services.
- Improve field water and nutrients management practices by delineating management zones based on the spatial variability of soil properties.

University of Kentucky (Ole Wendroth)

Agricultural land in one of the main production areas in West Kentucky is located on Karst topography with heterogeneous terrain attributes, pronounced spatial variability in soil type and related hydrologic attributes and crop growth. The resulting challenges are management of water, nutrients, their adequate simulation in agro-ecosystem models, and avoiding soil degradation as a consequence of soil compaction. One of our main outcomes is the parameterization for one- and three-dimensional agro-ecosystem models to optimize water and nutrient management and tillage systems.

North Carolina State University (Josh Heitman)

- We (in collaboration with Robert Horton at ISU) developed methods to estimate soil hydraulic properties from thermal and electrical conductivities.
- We (in collaboration with Robert Horton at ISU) described the use of thermo-TDR sensors to measure dynamic soil temperature, water content, bulk density, water flow rates, and soil water evaporation rates.
- We determined water and energy requirements for bioenergy cropping systems.
- We developed management strategies to improve erosion control in disturbed, post-construction soils.

Iowa State University (Robert Horton, Elnaz Ebrahimi, Richard Cruse)

- We (in collaboration with Josh Heitman at NCSU) developed methods to estimate soil hydraulic properties from thermal and electrical conductivities.
- We developed a model to describe heat and water movement in deformable soil.
- We developed a model to describe winter rye cover crop growth.
- We (in collaboration with Josh Heitman at NCSU) described the use of thermo-TDR sensors to measure dynamic soil temperature, water content, bulk density, water flow rates, and soil water evaporation rates.
- We developed a new model to estimate maize evapotranspiration.
- We developed a new model to identify hotspots for soil erosion in farm fields
- We illustrated the importance of optimum spatial resolution variability between different watersheds with different topographic and soil properties
- We developed and implemented AI-based Smart Rhizoboxes to enable real-time tracking of root growth in response to soil compaction and water films
- We demonstrated the impact of compaction on soil water distribution and seedling growth.

Virginia Tech (Ryan Stewart)

- Developed methods to identify and remediate water-repellent soils, which can help to safeguard water quality and quantity for the public.
- Developed methodology for nursery producers and practitioners to assess hydraulic properties of soilless growing media.
- Increased awareness of best-management practices for utility-scale solar developers.

- Identified strategies to reduce tree mortality in urban tree planters, which will help to improve stormwater quality.

University of Delaware (Yan Jin)

- Developed experimental setups and methods to investigate how a Plant Growth-Promoting Rhizobacteria (PGPR) can affect saltwater evaporation at interface-, pore-, and column scales.
- Maintained a field site for long-term monitoring of chemical/physical properties and related biogeochemical processes to assess how saltwater intrusion may affect coastal soil functions
- Developed procedures for sampling and analysis of stable isotope of water

University of Wisconsin-Madison (Jingyi Huang)

- Published machine learning-based high-resolution soil moisture model (ML-HRSM 1.0) for the continental US
- Developed printed soil moisture and nitrate sensors for nutrient transport modeling

Kansas State University (Andres Patrignani)

- Cosmic-ray neutron Python Library: Developed CRNPy, which is an open-source Python library for processing and analyzing data collected with stationary and rover cosmic-ray neutron probes. The library is available in GitHub for collaborative maintenance and growth and has examples for common devices used in scientific research.
- Calibration and validation of Teros sensor series: We collected a wide range of soils to calibrate and validate a new series of sensors commonly used in agriculture and hydrology applications to monitor soil moisture. This study resulted in the validation of current calibration equations and the determination of the error across multiple soils.
- Soil respiration response soil moisture: We collected analyzed undisturbed soil cores in 3 different land covers to study the response of soil respiration to soil moisture. We found that regardless of the land cover and soil type, soil respiration responses to soil moisture are best described by water-filled porosity rather than matric potential.
- Grain sorghum yield gap: We collected data from the USDA National Statistics Service and yield contest data to quantify potential yield, attainable yield, and current yield for grain sorghum in Kansas, which is the lead sorghum producer in the country. We found that state-level current yield represents 77% of attainable yield and 49% of water-limited potential yield.
- Mesoscale maps of soil water storage: We combined gridded outputs from a simple dry down model with observations from the Kansas Mesonet to create a blended soil moisture product at 250-m spatial resolution that is more accurate than using the model alone or the interpolated observations from the stations alone.

Montana State University (Jack Brookshire)

- We published and communicated findings on soil biogeochemical response of conifer encroachment to prescribed fire in the Northern Great Plains.
- We completed and submitted for publication a process-based and observation-constrained analysis of carbon cycling in U.S. rangelands.
- We completed and published a natural abundance isotope model of plant N use across global climate gradients.

Oregon State University (Carlos Ochoa)

- Installed instrumentation to monitor weather parameters and soil moisture and soil temperature in eight different rangeland sites in eastern Oregon.
- Field data collection and analyses of soil physical properties and C, N, and OM from 16 different fields distributed among 8 counties in Oregon.

University of Florida (Ebrahim Babaeian)

- Developed a new remote sensing framework for estimating root zone soil moisture in sandy soils at the field scale by integrating L-band passive microwave observations with a physically based radiative transfer model and machine learning algorithms.
- Continued in situ measurements of surface to root zone soil moisture and hydraulic soil properties to improve irrigation management in Florida's sandy agricultural fields.
- Supervising 10 graduate (MS/PhD) students, serving as a major advisor for four students and as an advisory committee member for six.
- Contributed to the University-wide Faculty AI Working Group.

Connecticut Agricultural Experiment Station (Yingxue Yu)

- Biodegradable nanoplastics are mobile in soils
- Biodegradable plastic mulch will not accumulate substantially in agricultural soils if in-field degradation is satisfying
- Biodegradable plastics are a viable alternative to conventional plastics

Outputs

University of California, Riverside (Hoori Ajami)

Research findings were disseminated via:

- 8 publications in peer-reviewed journals
- 14 conference abstracts and presentations
- Taught 1 upper division undergraduate course in Groundwater Hydrology (4 units) and taught an Introductory course in Environmental Sciences (4 units).
- Served on 3 PhD dissertation committees
- Served as an Associate Editor of California Agriculture and Journal of Hydrology
- Served as the Editor of Journal of Hydrology-X

University of California, Riverside (Jirka Šimůnek)

Research findings were disseminated via refereed journal publications, conference proceedings, and presentations at national and international meetings (see the publication section with **23 peer-reviewed journal articles and 14 conference abstracts** below). HYDRUS models have been updated with several new capabilities and options that have been developed for various research projects, which in turn have been published in peer-reviewed journals.

University of California, Davis (Thomas Harter)

Research findings were disseminated via:

- 7 peer-reviewed publications
- 20 conference abstracts and presentations
- 23 invited presentations
- 1 conference special session organized
- 4-day international conference organized and hosted
- Audience reached in online or in-person presentations: 4,200

University of California, Davis (Majdi Abou Najm)

Research findings were disseminated via:

- 7 publications in peer-reviewed journals
- 3 abstracts and conference proceedings and several invited talks.
- Organized California's Second Agrivoltaics Conference attended by 175 participants
- 7 invited talks

University of California, Davis (Helen E. Dahlke)

Research findings were disseminated via:

- 2 publications in peer-reviewed journals and two manuscripts currently in review
- 3 research reports

- 5 conference abstracts and presentations including my presentation at the 2024 W5188 meeting
- Several media interviews to the public by NPR, AgAlert, CapRadio, NorthCal Media and others
- Technical testimony to the Natural Resources subcommittee on Water, Wildlife and Fisheries of the US House of Representatives led by congressman Cliff Bentz (Oregon 2nd district) on water storage solutions.

Desert Research Institute (Markus Berli)

Our work focused on experimental and numerical models to describe the water dynamics of semi-arid and arid soils and their impact on desert hydrology with special focus on post-fire conditions.

Research findings were disseminated via:

- 1 publication in a peer-reviewed journal
- 1 research report
- 16 conference abstracts and presentations

Washington State University (Markus Fleury and Joan Wu)

Research findings were disseminated via:

- 8 publications in peer-reviewed journals
- 4 research reports
- 10 conference abstracts and presentations

University of Wyoming (Thijs Kelleners)

Research findings were disseminated via:

- 1 publication in a peer-reviewed journal

University of Arizona (Marcel Schaap, Craig Rasmussen, and Karletta Chief)

Research findings were disseminated via:

- 5 publications in peer-reviewed journals
- 1 book chapter
- 3 research reports (MS reports)
- 1 MS thesis
- 17 conference abstracts and presentations
- 1 source code repository

- 1 open data set
- 10 extension workshops
- 3 K-12 STEM students and teachers' workshops on food, energy and water systems
- 5 tribal IRB presentations

Utah State University (Scott B. Jones, Asghar Ghorbani, David A. Robinson (adjunct), and Morteza Sadeghi (adjunct)

Research findings were disseminated via:

- 10 peer-reviewed publications
- 10 conference abstracts and presentations
- Hosted the National Soil Moisture Workshop at Utah State University
- 3 invited presentations

University of Nebraska (Aaron Daigh)

Research findings were disseminated via:

- 7 publications in peer-reviewed journals
- 8 conference abstracts
- 1 book chapter

Oklahoma State University (Tyson Ochnser)

- Version 9 of the "Rain or Shine" textbook
- Azizi, S., Wyatt, B. M., Patrignani, A., Cosh, M. H., & Ochsner, T. E. (2024, November). Mapping Soil Moisture at Point and Field Scales. In ASA, CSSA, SSSA International Annual Meeting. ASA-CSSA-SSSA.

Texas A&M University (Binayak P. Mohanty)

Research findings were disseminated via refereed journal publications, conference proceedings, project reports, and a number of presentations at national and international meetings (see the publication section below).

- 7 journal publications
- 14 technical abstracts
- 1 Book chapter
- 3 project reports
- 27 presentations in national and international meetings and other institutions

Texas A&M University (Briana Wyatt)

Research findings were disseminated via:

- 2 publications in peer-reviewed journals
- 2 research reports
- 23 conference abstracts and presentations

Louisiana State University – Agriculture Center (Xi Zhang)

Research findings were disseminated via:

- 8 publications in peer-reviewed journals
- 12 conference abstracts and presentations
- 2 articles in newsletter

University of Kentucky (Ole Wendroth)

Research findings were disseminated via:

- 6 publications in peer-reviewed journals
- 0 research reports
- 3 conference abstracts and presentations

North Carolina State University (Josh Heitman)

Research findings were disseminated via:

- 14 publications in peer-reviewed journals
- 7 research reports
- 23 conference abstracts and presentations

Iowa State University (Robert Horton, Elnaz Ebrahimi, Richard Cruse)

Research findings were disseminated via:

- 15 publications in peer-reviewed journals
- 2 research reports
- 17 conference abstracts and presentations

Virginia Tech (Ryan Stewart)

Research findings were disseminated via:

- 3 publications in peer-reviewed journals
- 4 research reports
- 8 conference abstracts and presentations

University of Delaware (Yan Jin)

Research findings were disseminated via:

- 5 publications in peer-reviewed journals
- 2 research reports
- 8 conference abstracts and presentations

University of Wisconsin-Madison (Jingyi Huang)

Research findings were disseminated via:

- 11 publications in peer-reviewed journals
- 7 conference abstracts and presentations

Kansas State University (Andres Patrignani)

Research findings were disseminated via:

- 6 publications in peer-reviewed journals
- 6 conference abstracts
- 3 invited presentations

Montana State University (Jack Brookshire)

Research findings were disseminated via:

- 3 publications in peer-reviewed journals
- 2 publications submitted, one in revision, one pending acceptance
- 1 research report
- 2 conference abstracts and presentations
- 2 invited presentations

Oregon State University (Carlos Ochoa)

- Conference contribution presenting findings related to soil moisture, soil C and N, and soil physical properties such as bulk density and clay content differences at different depths in multiple managed ecosystems, including irrigated and non-irrigated pastures, riparian areas, and grazed rangeland areas.
- Conference contributions presenting soil-water-vegetation monitoring and assessment in one long-term and two new projects to evaluate juniper control effects on the ecohydrology function at the watershed-scale (1000 to 5000 acres).

University of Florida (Ebrahim Babaeian)

Research findings were disseminated via:

- 2 publications in peer-reviewed journals

- 4 national and international conference abstracts and presentations

Connecticut Agricultural Experiment Station (Yingxue Yu)

Research findings were disseminated via:

- 4 publications in peer-reviewed journals
- 1 research report
- 2 conference abstracts and presentations

USDA-ARS, George E. Brown Jr. Salinity Laboratory/UC-Riverside (Todd Skaggs, Ray Anderson, and Elia Scudiero)

Research findings were disseminated via:

- Research findings were disseminated via 4 refereed journal publications, one trade journal publication, a web-based database (https://www.handbook60.org/home/), and several in-person presentations at national and international meetings.
- Extension and educational activities, especially as part of a NIFA-SAS funded project.

Activities

University of California, Riverside (Hoori Ajami)

- Characterizing mountain flow paths using geochemical data and mixing models to determine the degree of connectivity between the mountain and valley aquifers
- Comparing performance of micrometeorologic and isotopic methods for evapotranspiration partitioning
- Improving streamflow bias correction approaches for climate change impact assessment
- Improving soil hydraulic properties parameterization for hydrologic and Earth System Models

University of California, Riverside (Jirka Šimůnek)

Meetings attended:

1. W4188 Western Regional Soil Physics Group Meeting, Las Vegas, Nevada, January 3-5, 2024.
2. CMWR 2024: Computational Methods in Water Resources, Tucson, Arizona, October 1-3, 2024.
3. Annual Meeting of Soil Science Society of America, San Antonio, Texas, November 10-13, 2024.

HYDRUS Teaching:

1. Teaching a short course "Advanced modeling of water flow and contaminant transport in porous media using the HYDRUS software packages" organized by Czech University of Life Sciences, Prague, Faculty of Agrobiology, Food and Natural Resource, Prague, Czech Republic, June 24-26, 2024. Other instructors: M. Th. van Genuchten and R. Kodešová (25 participants, mostly from Europe).
2. Teaching a short course "Modeling of water flow and contaminant transport in porous media using the HYDRUS-1D software package" organized by Bundesanstalt für Geowissenschaften und Rohstoffe in Hannover, Germany, in Yaoundee, Cameroon, June 18-20, 2024. Sole instructor, 10 participants from Cameroon.
3. Teaching a short course[121] "Advanced modeling of water flow and contaminant transport in porous media using the HYDRUS software packages" organized by Pontificia Universidad Católica de Chile. Santiago, Chile, August 20-22, 2024. Sole instructor, 24 participants.
4. Teaching an online short course "Modeling of water flow and contaminant transport in porous media using the HYDRUS software packages" organized by PC Progress, Prague, Czech Republic, September 9-10, 2024. Sole instructor (48 participants, mostly from the US and Canada).

Public service:

Guest Editor of the Vadose Zone Journal special issue in tribute to Dr. van Genuchten's Wolf Prize (2023-2024).

Invited Presentations:

1. Invited presentation "*Numerical Modeling of Vadose Zone Processes using HYDRUS and its Specialized Modules*," Escuela de Química, Facultad de Química y de Farmacia Pontificia Universidad Católica de Chile, Santiago, Chile, August 21, 2024.
2. Invited presentation: *"The use of HYDRUS and its add-on modules for simulating flow and transport of various contaminants within the context of the SOILPROM project.*" SOILPROM, Wageningen University, The Netherlands, online, December 17, 2024.

Abstracts:

1. Vahedian, F., J. A. K. Silva, J. Šimůnek, and J. E. McCray, The influence of tension-driven flow on the transport of AFFF in vadose zone, Thirteenth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Abstract 433, Denver, Colorado, June 2-6, 2024.
2. Silva, J. A.K., M. Olson, F. Krembs, J. Šimůnek, and J. E. McCray, Field validation of a modified HYDRUS model for simulating PFAS leaching in the vadose zone, Thirteenth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Abstract 817, Denver, Colorado, June 2-6, 2024.
3. Lazarovitch, N., and J. Šimůnek, Improving fertigation scheduling by combining continuous monitoring and numerical modeling of the root zone, EGU24-158, Section SSS9.17: The irrigation challenges to tackle uncertainty in water resources, *EGU General Assembly 2024*, Vienna, Austria, April 14-19, 2024.

4. Pawlowicz, M., B. Balis, A. Szymkiewicz, J. Šimůnek, A. Gumuła-Kawęcka, and B. Jaworska-Szulc, Development of a new computer tool for coupling HYDRUS-1D and MODFLOW, EGU24-18902, HS8.1.1 – Hydrobiogeochemical processes in heterogeneous multiphase systems across scales, *EGU General Assembly 2024*, Vienna, Austria, April 14-19, 2024.
5. Šimůnek, J., E. Diamantopoulos, T. K. D. Weber, Implementation of the Brunswick model system into the Hydrus software suite, EGU24-21133, HS8.1.1 – Hydrobiogeochemical processes in heterogeneous multiphase systems across scales, *EGU General Assembly 2024*, Vienna, Austria, April 14-19, 2024.
6. Brunetti, G., R. Kodešová, M. Fér, A. Nikodem, A. Klement, and J. Šimůnek, Dissecting the spatio-temporal variability of soil hydraulic properties in an agricultural eroded area, EGU24-21207, HS8.1.1 – Hydrobiogeochemical processes in heterogeneous multiphase systems across scales, *EGU General Assembly 2024*, Vienna, Austria, April 14-19, 2024.
7. Rahman, A. T. M. S., J. Šimůnek, S. A. Bradford, H. Ajami, M. B. Meles, L. Chen, A. Szymkiewicz, M. Pawlowicz, J. A. C. Trasvina, and S. Beegum, A new externally coupled physically-based multi-model framework for simulating subsurface and overland flow hydrological processes, CMWR 2024 (Computational Methods in Water Resources), Tucson, Arizona, September 30-October 4, 2024.
8. Biesek, B. J., A. Szymkiewicz, J. Šimůnek, A. Gumuła-Kawęcka, and B. Jaworska-Szulc, Effects of plant water uptake and soil organic carbon distribution on PFAS migration in the vadose zone, CMWR 2024 (Computational Methods in Water Resources), Tucson, Arizona, September 30-October 4, 2024.
9. Brunetti, G., and J. Šimůnek, On the information content of cosmic ray neutron data in vadose zone modeling, Coordinated Cosmic-Ray Observation System (CCROS) conference, University of Nebraska–Lincoln, City Campus, Nebraska, October 14-16, 2024.
10. Šimůnek, J., The Legacy of Rien Van Genuchten, a Recipient of the 2023 Wolf Prize for Agriculture, *SSSA Annual Meeting 2024*, San Antonio, Texas, November 10-13, 2024.
11. Lazarovitch, N., I. Kisekka, T. Ebong Oker, G. Brunetti, T. Wöhling, L. Yong, T. H. Skaggs, A. Furman, S. Sasidharan, I. R. Hoffman, and J. Šimůnek, Modeling of Irrigation and Related Processes with Hydrus, *SSSA Annual Meeting 2024*, San Antonio, Texas, November 10-13, 2024.
12. Tigabu, T. B., A. Casillas-Trasvina, M. Meles, S. Bradford, and J. Simunek, Multi-model approach for analysis of sustainable groundwater management strategies in California's Central Valley, Abstract ID#: 1662075, H33Q-05, *AGU Annual Meeting*, Washington, D.C., December 9-13, 2024.
13. Rahman, A. T. M. S., J. Šimůnek, S. A. Bradford, H. Ajami, M. B. Meles, L. Chen, A. Szymkiewicz, S. Beegum, and M. Pawlowicz, An innovative multi-model coupling strategy for simulating watershed-scale surface and subsurface flow interactions, Abstract ID#: 1747948, H11S-0942, *AGU Annual Meeting*, Washington, D.C., December 9-13, 2024.
14. Zhou, T., G. Brunetti, N. Ruud, J. Šimůnek, W. Cui, A. Liao, P. Nasta, J. Gao, E. Levintal, C. P. Garcia, and H. E Dahlke, The impact of agricultural managed aquifer recharge on the fate and transport of pesticides in the unsaturated zone, Abstract ID#: 1551442, H52C-04, *AGU Annual Meeting*, Washington, D.C., December 9-13, 2024.

University of California, Davis (Thomas Harter)

- Measured water and nitrogen fluxes in our instrumented 140 acre field-site with three monitoring networks for water and nitrogen: landscape (irrigation and fertilizer application monitoring, ET, harvest monitoring); vadose zone monitoring (soil water tension, soil water content, soil water solution.
- Calibrated HYDRUS-based approaches to modeling the vadose zone.0
- Demonstrated the variability in deep vadose zone properties and resulting variability in recharge front behavior under AgMAR.
- Analyzed shortcomings of incomplete Butte Valley Groundwater Sustainability Plan and developed alternative approaches to completing the plan
- Analyzed indicators within the functional flow framework to predict environmental instream flows and developed a functional flow forecasting tool for an intermontane, irrigated agricultural basin (Scott Valley, California) as a decision-making tool for surface water and groundwater management
- Developed a novel imputation method to simulate actual well screen locations in an aquifer for which only limited data on well construction is available
- Developed AI-technology to assess drought awareness among the public
- Installed, monitored, and evaluated deep vadose zone monitoring system in an irrigated tomato-field crop rotation for improved understanding of water and nitrogen fluxes across the deep vadose zone
- Developed a universal particle tracking algorithm for highly efficient transport simulations in numerical groundwater models
- Provided a review of federal groundwater policy options
- Engaged with social scientists to improve understanding of stakeholder perceptions with respect to use of models as decision-support tools in groundwater management
- Conducted numerous outreach and extension meetings to educate a wide range of audience members on groundwater issues.

University of California, Davis (Majdi Abou Najm)

Activity 1: California's second Agrivoltaics conference: around 175 attendees from policy, agriculture, energy, academia and industry attended this conference which worked as a catalyst to connect all those groups together and push this new technology forward.

Activity 2: Conduct a critical review on soil infiltration: a full review is accepted to Vadose Zone Journal, tracing the evolution of infiltration theory that led to the development of 138 unique infiltration models over the past 2 centuries. This critical review is one of the most comprehensive documents on infiltration theory and will help identifying barriers and challenges, as well as recommending a roadmap for future directions.

Activity 3: Agrivoltaics field experiment: we experimented two crops (tomatoes and peppers) with 5 different shade/lighting treatments over a one-acre plot in the Campbell Tract at UCD. We

tested how crops react to a wide range of light treatments, simulating different Agrivoltaics technologies.

Conferences:

1) Heroux KM, Agarwal S, Chaboya G, Gervin C, Labban R, Morgan A, Tabassum M, Tokushige B, Xi Y, Daccache A, **Abou Najm M.** Plant, Soil, and Microclimate Responses to Agrivoltaic Systems in a Semi-Arid Climate. AGU24. 2024 Dec 9.
2) Camporese M, la Cecilia D, Tang F, Pauwels VR, Campana PE, Lu SM, **Abou Najm M**, Daccache A, Vico G. Ecohydrological Modeling of Agrivoltaic Systems to Evaluate Trade-offs within the Energy-Food-Water nexus. AGU24. 2024 Dec 9.
3) Fernandes, G., Burguet Marimon, M., Paz Salazar, M., Marras, E., Murgia, I., Kaffas, K., Giadrossich, F., D. Stewart, R., R. **Abou Najm, M**., Comegna, A., Lassabatère, L., Penna, D., Massari, C., and Di Prima, S.: Tree influence on water dynamics in sloped forest soils: insights from stemflow and throughflow experiments and time-lapse ground-penetrating radar monitoring, EGU General Assembly 2024, Vienna, Austria, 14–19 Apr 2024, EGU24-12832, https://doi.org/10.5194/egusphere-egu24-12832, 2024

University of California, Davis (Helen E. Dahlke)

We analyzed the impact of large, continuous water applications (e.g. intentional flooding of agricultural soils for groundwater recharge) on pesticide leaching and mobilization. The intentional flooding (1.2 m^3/m^2 of applied water) of an agricultural field for groundwater recharge caused the clear mobilization of four common pesticides (imidacloprid, chlorantraniliprole, methoxyfenozide, thiamethoxam) in the unsaturated zone. To study the fate of pesticide residue under AgMAR, an experiment was conducted at the Terranova Ranch, located southwest of Fresno, CA, USA, within the Kings River basin. A 32,376 m^2 (8 acres) recharge plot was flooded in February 16–24, 2021, using pumped groundwater. A total of 38,774.74 m^3 of water (1.2 m in depth) was applied at a flow rate of ~3.35 m^3/min. The start times of flooding at each soil profile location were deduced from the time of water content increase. At each profile, 541 g of Br^- (806 g of KBr) dissolved in 100 L of water were applied to introduce a conservative tracer for model calibration. Sensors were installed at depths of 0.2, 0.6, 1.0, and 2.5 m at each soil profile. Sensors measuring ponding depth (CS-451, Campbell Scientific, Logan, UT, USA), soil water content, electrical conductivity (EC), and soil temperature (TEROS-12, METER Inc., San Francisco, CA, USA), soil O2 (Figaro KE-25, Figaro Sensors, Rolling Meadows, IL, USA), and oxidation–reduction potential (ORP; built in house) were logged at a 10- minute time interval. Breakthrough curve data for the KBr tracer and pesticides were collected using high-volume dual-chamber suction cups (Model 1920 F1L24-B02M2, SoilMoisture Inc., Goleta, CA, USA), which were installed at depths of 20, 60, 100, 175, and 250 cm. Water flow and the transport of potassium bromide (KBr) and pesticides in the unsaturated zone were simulated using the single and dual-porosity models (SPM and DPM) of the HYDRUS-1D software (˘Simůnek et al., 2016). SPM assumes that flow and transport processes in soil are uniform and can be described using the Richards and advection-dispersion

equations, respectively. DPM divides the soil pore space into mobile and immobile regions (i.e., considering preferential flow/transport). Water flow or solute transport occurs only in the mobile region, as described by the Richards and advection-dispersion equations, respectively. At the same time, there can be water/solute transfer between these two regions (Zhou et al. 2024). Using these models, we quantify the impact of unsaturated zone heterogeneity on water and pesticide mass balances and water travel times and associated uncertainties. We also estimate the maximum transport depths (MTDs) of the four pesticides and the potential groundwater contamination risks in response to Ag-MAR by testing all possible permutations of towed transient electromagnetic (tTEM) soil texture data derived from geophysical surveys.

Peaks in pore water pesticide concentrations occurred within hours of applying floodwater in the near-surface soil layers and as delayed as 4-8 days in the deeper soil profile (1.2- 2.5 m). Concentrations of chlorantraniliprole were one order of magnitude greater in porewater than observed for the other three pesticides, likely due to its most recent (7 months prior) application time.

Flow velocities and transit times of the infiltrating floodwater and the mobilized pesticides varied between 32.69 and 40.65 cm/days, clearly reflecting the differences in soil texture and particularly the sand content between the three profiles. Leaching efficiency of pesticides was greatest in the sandiest profile (84% sand) with 59-75% for imidacloprid, but less pronounced at the medium sand (61% sand) and less sandy (41%) profiles, with leaching efficiencies of 29-47% and 3.0-3.4%, respectively. Texture had little effect on water balance (6%) but determined whether preferential flow features and capillary barriers accelerated or attenuated pesticide transport into the deeper unsaturated zone.

The fate and transport of pesticides within deep unsaturated zones (70 m) is most sensitive to their adsorption within the top soil layer, particularly in sandy profiles where adsorption is facilitation by soil carbon, and their degradation in complex profiles where restrictive layers slow transport. The higher the sand content of the unsaturated zone, the deeper pesticides will be transported depending on pesticide type (40 m for thiamethoxam, methoxyfenozide, 70 m for chlorantraniliprole, imidacloprid). Presence of intermittent layers of clay, sandy loam, loam, or sandy clay loam are crucial in controlling the pesticides transport to groundwater.

Field data and modeling results show that unsaturated zones that contain a higher fraction of sand and therefore present ideal sites for Ag-MAR supports slightly higher recharge rates (+7%) but also much faster (+80.6%) pesticide transport. Less sandy unsaturated zones can still achieve similar recharge efficiencies, but water flow and solute transit times may be longer but still can have distinct impacts on the groundwater contamination risk.

Intentionally flooding farm fields in the winter for groundwater recharge did increase the maximum transport depths (MTDs; depth when the pesticide residue concentration reached zero) for all pesticides across all profiles compared to a Rainfall-only scenario. While relative differences in maximum transport depths (RMTDs) between Ag-MAR and Rainfall scenarios were largest at the sandy profile (59.7–71.0%), the absolute maximum transport depths (MTDs) were actually lower (10.5–12.0 m) than in the less sandy profiles in both the Rainfall and Ag-

MAR scenarios. Therefore, balancing the magnitude of both effects is crucial in real-world applications when selecting Ag-MAR sites. In addition, the MTDs of pesticides during Ag-MAR can be decreased by 77%-80% if a capillary barrier is present at specific depths of less sandy profiles. This underlines the effectiveness of subsurface heterogeneity in general and occurrence of a capillary barrier system in a deep unsaturated zone more specifically for controlling pesticide pollution of groundwater during Ag-MAR.

Using the field-collected pesticide and bromide tracer data and HYDRUS 1D models allowed comparison of different tracer methods for their use to estimate transit times of water or contaminants in the unsaturated zone. To assess the vulnerability of groundwater to contamination, travel time approaches are commonly used, but assessing travel time in multilayered soil profiles influenced by preferential flow remains a major challenge. Using the collected data, we compared results from a wavelet coherence analysis (WCA) of field-measured soil temperature data using heat as a tracer to travel times estimated with well-established synthetic tracer methods in HYDRUS-1D including i) particle tracking, ii) the peak displacement method, and iii) transit time distribution estimation. Our results reveal that WCA gave the shortest recharge travel time compared to tracer or synthetic methods due to the sole consideration of heat convection and more preferential flow than the HYDRUS-1D model captured. Regarding synthetic methods, particle tracking tended to show faster water movement due to its sole reliance on water flow (convection). On the other hand, recharge travel times obtained by transit time distribution estimation using pesticide data were generally longer than for the peak displacement method because of adsorption. The differences between experimental and synthetic methods provided a quantitative approach to discern the magnitude of lateral (LF) and preferential (PF) flows. Together these results underscore the necessity of multidimensional modeling, careful data collection in the field, and appropriate estimation methods to accurately evaluate the flow and transport of water and contaminants in the environment.

Abstracts

- Waldman, K., Dahlke, H.E., Prieto Garcia, C., Fakhreddine, S., Levintal, E.. 2024. Geogenic Contaminant Risks in Flood-MAR: Balancing Groundwater Quality and Regional Water Security in California. Fall Meeting of the American Geophysical Union, Washington D.C., USA 9-13 December, 2024.

- Dahlke, H.E., Zhou, T., Levintal, E., Garcia, C., Kisekka, I. 2024. Impact of Ag-MAR and vadose zone heterogeneity on the fate and transport of pesticides. Biennial Symposium on Managed Aquifer Recharge, April 3–6, 2024, Tucson, AZ.

- Dahlke, H.E., Levintal, E., Murphy, N., Ganot, Y., Garcia, C. 2024. Agricultural Managed Aquifer Recharge (Ag-MAR) – A Method for Sustainable Groundwater Management. 2024 Joint 60th Conference of UCOWR/AWRA/NIWR, September 30-October 2, 2024, St. Louis, MO.

Desert Research Institute (Markus Berli)

1) Developed a model to describe the relationship between sorptivity, effective contact angle and initial water content.
2) Developed a method to calculate soil sorptivity for different levels of soil burn severity.
3) Helped developing a UAS-based robot that can carry out water drop penetration time (WDPT) tests semi-autonomously
4) Evaluated methods to measure sorptivity of sub-critically water-repellent soil in the field
5) Worked on an improved understanding of water infiltration, redistribution and evaporation for arid soils
6) Modeling soil heat transport under wildfires and changes in soil constituents
7) Shed light on the chemical nature of fire-induced soil water repellency.

Washington State University (Markus Fleury and Joan Wu)

See milestones from WSU.

University of Wyoming (Thijs Kelleners)

1) Maintained a soil moisture and rainfall monitoring network consisting of 17 sites in Wyoming rangelands
2) Maintained a snow, soil and groundwater monitoring network in the No Name headwater, Libby Creek watershed, Snowy Range Mountains, WY

University of Arizona (Marcel Schaap, Craig Rasmussen, and Karletta Chief)

1) We collaborated with Travis Nauman and Suzann Kienast (NRCS) regarding mapping soil hydraulic properties.
2) We collaborated with Trevor McKellar and Mike Crimmins (both at University of Arizona) on the topic of high-irresolution grid-based simulation of soil water dynamics and drought.
3) Hired one MS student who was immediately brought up to speed on high-performance computed as needed for research.
4) Purchased a 50 Terabyte data server for managing and preserving project data.
5) On request from W-5188 started including unsaturated hydraulic conductivity in the Rosetta 3 PTF (ongoing research)
6) Disseminated soil hydraulic data to UC-Riverside

Utah State University (Scott B. Jones, Asghar Ghorbani, David A. Robinson (adjunct), and Morteza Sadeghi (adjunct)

- Designed, fabricated and tested a NASA-funded Engineering Development Unit to serve as an automated plant growth root module for the Ohalo plant growth chamber to support the health of future travelers to Mars.
- Engaged companies (Campbell Scientific Inc., Meter Group Inc., Apogee Instruments Inc., Juniper Systems Inc.) to support and provide tours and training for over 60 participants at the 2024 National Soil Moisture Workshop.
- Monitored dryland agricultural production sites under winter wheat and rangeland to gather data for understanding indicators of yield, especially soil moisture.
- David is working on bulk density and porosity modeling, seeking to better understand the grain-scale behavior and how this contributes to the emergent response.
- Mentored Chihiro Dixon (Ph.D.) and Chieh-Yun Chang (M.S.), both of whom graduated in 2024.
- Continuing to mentor Juando Gonzalez-Teruel, a postdoc with electrical engineering background and Claudia Garrido Ruiz, a postdoc with agronomy background.

University of Nebraska (Aaron Daigh)

1) Initiated site selections for subsurface electromagnetic imaging with tTEM on crop producers lands in Nebraska followed by scheduling of vadose zone and aquifer core sampling to the depth of refusal. Research is aimed at creating 3D geologic models and 3D vadose zone transport models of deep reduction zones that impact aquifer water quality.
2) Initiated field investigations of soil water and nitrogen spatial variability within map units and long-term soil management practices in Nebraska.
3) Initiated experimental designs for evaluating new in-situ remediation enhancement technologies to reduce remediation timelines of zones contaminated with munitions.
4) Produced vadose zone models from core samples underlying long-term crop production in Nebraska and performed virtual experiments to evaluate the long-term effects of N fertilizer application rates, crop rotations, and weather.

Oklahoma State University (Tyson Ochnser)

- Recruited a new PhD student to work on the soil moisture modeling project.
- Held bi-monthly project meetings between our team, our research collaborators, and stakeholders within NRCS.

Texas A&M University (Binayak P. Mohanty)

- In 2024, field monitoring and laboratory experiments were conducted at Texas Water Observatory sites under different land use land covers for improved understanding of soil moisture, temperature, aggregate stability, and carbon dynamics.

- Using thermodynamics principles and various satellite observations for evapotranspiration and surface soil moisture at the footprint scale, we developed a unified framework of soil hydrology and energy balance coupling across multiple space-time scales.
- We provided a novel coherent theory on the dissipative energy barriers which decides the resilience potential of an ecosystem. These barriers are manifestation of lower bounds of entropy produced for unit anomaly transference from soil moisture to evapotranspiration.
- Using designed field and lab experiments, we studied organic and inorganic contaminants in various urban gardens of Texas. Data were analyzed using Graph Network. The findings led to better understanding of environmental and human health risks.

Special Issues Edited

- Tribute to Rien van Genuchten, Recipient of the 2023 Wolf Prize for Agriculture, Vadose Zone Journal (2023-2024)
- Ecohydrology of Inland and Coastal Waters in honor of Ignacio Rodriguez-Iturbe, Ecohydrology (2023-2024)

Meeting organized

Member, Organizing Committee, Third Annual Artificial Intelligence in Agriculture Conference, Texas A&M University (2024)

Meetings attended

American Geophysical Union Chapman Conference on Remote Sensing of the Water Cycle: Sensors to Science to Society, Honolulu, February 13-16, 2024.
Soil Science Society of America Annual Meeting, November 10-13, 2024.
American Geophysical Union Fall Meeting, December 10-15, 2023.

Book Chapters:

1. **Mohanty, B.P.** and B. Chun. Soil Carbon in Grassland *in Remote Sensing of Rangelands - Monitoring the Anthropocene*, *Editors*: Opha Pauline Dube and John Isaac Molefe, (**Invited**), CSIRO Pub, in Press.

Abstracts:

1. Mishra, D. and B.P. Mohanty, Can Remote Sensing Provide Evidence for Scaling Laws in Hydrology? AGU Chapman Conference Abstract, 2024.
2. Neelam, M., and B.P. Mohanty, Land-Atmosphere Interactions: Insights from Radiative Transfer Models Across Spatial and Temporal Scales, and Hydroclimates, AGU Chapman Conference Abstract, 2024.
3. Mohanty, B.P., V. Sehgal, and M. Mbabazi, Global Terrestrial Water-Energy Coupling Across Scales, Soil Science Society of America Annual Meeting Abstract, 2024.
4. Kocian, L. and Mohanty, B.P., Modeling the Drivers of Urban Garden Contaminant Transport Using Graph Theory, Soil Science Society of America Annual Meeting Abstract, 2024.
5. Chun, B., B.P. Mohanty, A.V.M. Ines, and S. Slack, Ecosystem Respiration Under Different

Temperature, Moisture, and Vegetation, Soil Science Society of America Annual Meeting Abstract, 2024.
6. Mishra, D., and B.P. Mohanty, Timescale Representations of Land-Atmospheric Coupling, Soil Science Society of America Annual Meeting Abstract, 2024.
7. Sehgal, V., and B.P. Mohanty, Rootzone Hydrologic and Hydraulic Processes Inferred Using Terrestrial Water-Energy Coupling, Soil Science Society of America Annual Meeting Abstract, 2024.
8. Mishra, D., V. Sehgal, and B.P. Mohanty, Emergent Signatures of SM-ET Coupling in Global Hydroclimates, American Geophysical Union Fall Meeting Abstract, 2024.
9. Kocian, L., B.P. Mohanty, and A. Sharif, Modeling the Drivers of Urban Garden Contaminant Transport Using Graph Theory, American Geophysical Union Fall Meeting Abstract, 2024.
10. Chun, B., B.P. Mohanty, A.V.M. Ines, and S. Slack, Ecosystem Respiration under Different Temperature, Moisture, and Vegetation, American Geophysical Union Fall Meeting Abstract, 2024.
11. Mohanty, B.P., and V. Sehgal, Ecosystem Linkages of The Preferential Soil Hydrologic States at Remote Sensing Scales, American Geophysical Union Fall Meeting Abstract, 2024.
12. Sedaghatdoost, A., B.P. Mohanty, and D. Dwivedi, Effect of Hydrological Dynamics on Deep Vadose Zone Biogeochemistry in Gulf Coastal Plains, American Geophysical Union Fall Meeting Abstract, 2024.
13. Bhalla, K., D. Mishra, B.P. Mohanty, FieldPost: Convergent Infrastructure for Eddy Covariance Data Post Processing, American Geophysical Union Fall Meeting Abstract, 2024.
14. Prasad, R., D. Mishra, and B.P. Mohanty, Pre-processing Automation Pipeline for Texas Water Observatory, American Geophysical Union Fall Meeting Abstract, 2024.

Invited Presentations:
1. Keynote Speaker, On Multiscale Soil Moisture-Evapotranspiration Coupling, *International Conference on Future of Water Resources*, IIT Roorkee, India, January 18-20, 2024.
2. Invited Speaker, On Multiscale Soil Moisture-Evapotranspiration Coupling, *University of California, Riverside*, May 1, 2024.
3. Invited Participant, AI for Agriculture Summit, *USDA-NIFA AI Institutes, National Academy of Sciences*, Washington DC, July 29-30, 2024.
4. Invited Participant, USDA Forum on AI Applications to USDA Science, *USDA and Texas A&M University*, College Station, Nov 19-21, 2024.

Texas A&M University (Briana Wyatt)

1) Conducted electromagnetic induction (EMI) surveys of golf course fairways
2) Applied EMI data to delineate management zones for irrigation and fertilizer

Louisiana State University – Agriculture Center (Xi Zhang)

1) Established fields with cover cropping management to explore soil water flux as influenced by changes in soil structure under cover crops.
2) Investigated the influences of cover crops on soil water storage, availability, and recharge for the following cash crop.
3) Served on SSSA 2024 Summer Conference Program Planning Committee.
4) Served as associate editor for *Soil Science Society of America Journal* and *Agrosystems, Geosciences and Environment*
5) Served on Editorial Board for *Soil and Tillage Research*
6) Attended ASA-CSSA-SSSA International Annual Meeting (San Antonio, TX. Nov. 10-13, 2024).

University of Kentucky (Ole Wendroth)

1) One of the main activities over the past year was the continuation of monitoring crop growth status and soil water dynamics at 24 profile locations in a farmer's field in West Kentucky. Soil water content was monitored with Drill&Drop Sentek Capacitance sensors in different topographic positions in the field grown with corn. The sensor results should guide the management of irrigation in this field. Over the growing season, the field was irrigated according to the farmer's schedule with a center pivot, 1100 feet diameter, 76 nozzles including overhang plus endgun. These nozzles are set-up for being controllable as a variable-rate system, i.e., individual nozzles can be shut-off at predetermined locations in the field. The PI had created irrigation-Apps according to the manufacturer's manual to apply water at different rates in different zones of the field. Early in the growing season, we found that shutting off many nozzles along the pivot did not work according to our prescription. It was a challenge to diagnose the functionality of the VRI system in the 10+feet tall corn. The manufacturer believed that the Apps were not properly set up but was willing to give guidance how to create functional apps. This happened when the corn was harvested. A test with engineers from the manufacturer resulted in the fact that indeed the apps created by the PI were correct, but 56 of the 76 solenoids turned out to technically defect. This dysfunctionality resulted in prohibiting the completion of the experiment that we had planned. Nevertheless, crop growth and soil water dynamics were observed throughout the growing season. The crop could be irrigated at the full rate, however, not site -specifically at variable rates which had been the plan for our experiment. We consider the observations taken over the season being valuable information that will help us to parameterize the crop growth and soil water process models. We continue and follow up to get the solenoids repaired and to continue our on-farm experiment.
2) In a project of one of my colleagues and their MS student, the effect of different cover crop management methods on soil hydraulic properties in the near-saturated range was investigated where I led the soil physical measurement efforts. These properties in the wet range are strongly affected by soil structure. Different cover crop management systems were investigated, i.e., spring-kill cover crops, winter-kill cover crops, weedy

fallow, and soybean cash crop rotation. It was hypothesized that cover crops would decrease bulk density, increase hydraulic conductivity, increase porosity, and increase the size and C content of water stable aggregates, and that the magnitude of these benefits would be proportionate to the amount of aboveground and belowground biomass produced by the winter covers. By relating these measurements to above- and belowground plant inputs, we aimed to better understand how winter cover management affects soil structure-related physical properties during the cash crop growing season. Interestingly, the winter-kill treatment revealed the highest hydraulic conductivity across tensions of 1, 5, and 10 cm as well as at extrapolated saturated hydraulic conductivity, followed by the weedy fallow. The winterkill also showed the largest volume of pores larger than 1,000 μm at soil depths from 2-8 cm and 17-23 cm. Good soil structural conditions were visible across all treatments. We interpret this behavior to be caused by the fact that the soil at the study site (Maury silt loam) falls under the class of well-drained soils, and that the site prior to the establishment of the experiment (2016) was under long-term grass land. No signs of compaction are visible in this soil. The winter fallow treatment showed the lowest hydraulic conductivity at saturation and 1 cm tension as a consequence of no plants were grown during this season and no roots were there that would keep the soil macropore system functional.

3) I was invited to give the opening keynote lecture at the 2024 Meeting of the International Soil & Tillage Research Organization (ISTRO) held at Virginia Tech University with participants from 42 countries. For this purpose, I reviewed the progress in soil tillage- and structure-related research over the past 51 years, i.e., since the foundation of ISTRO. An enormous amount of knowledge has been derived on the topics of soil structure and its relationship to water, gas, and solute transport, including the existence, phenomena, and mathematical description of preferential water flow and solute transport in soils. An extremely relevant ambiguity on the topic of soil compaction could be clarified: While the engineering industry produces heavier and bigger farm machinery for “better farming efficiency”, they try to neglect concerns from the science community on the hazardous impact of heavier machinery on soil compaction by suggesting larger tires with lower air pressure. Science has now shown that despite the pressure decrease from heavier machinery through larger tire size, the pressure unmistakably reaches deeper soil depths the larger the tire size is. This causes severe soil degradation in deep soil layers that can hardly or not at all be restored. The last section of my review targeted at a critical view on no-till and the need to de-mystify it and seek for optimum tillage systems for different soil types and optimum soil management strategies for specific landscape positions.

North Carolina State University (Josh Heitman)

1) We (in collaboration with Robert Horton at ISU) investigated correlations between thermal conductivity and water retention in unsaturated soils.
2) We (in collaboration with Robert Horton at ISU) calculated heat and water transfer in deformable soils.
3) We investigated water use and energy balance of cropping systems.

4) We tested soil physical properties and vegetation growth after disturbance and amendment with compost.

Iowa State University (Robert Horton, Elnaz Ebrahimi, Richard Cruse)

1) We (in collaboration with Josh Heitman at NCSU) investigated correlations between thermal conductivity and water retention in unsaturated soils.
2) We determined thermal diffusivity (α) variations within three central Iowa fields to estimate the required number of measurement sites within each field to determine α at a specified precision.
3) We (in collaboration with Josh Heitman at NCSU) calculated heat and water transfer in deformable soils.
4) We calculated winter rye cover crop growth.
5) We used a heat pulse sensor to determine frozen soil thermal properties.
6) We downscaled the Daily Erosion Project to identify erosion hotspots on the landscape.
7) We tested for the optimum spatial resolution required to give the best gully erosion susceptibility in topographically different watersheds.
8) We established a continuous visual monitoring system to capture root development throughout the growing period, integrating soil water distribution measurements at multiple depths.

Virginia Tech (Ryan Stewart)

1) We performed field measurements to better understand runoff generation processes in disturbed landscapes.
2) We developed theoretical models to describe infiltration in various soils, including heterogeneous and water-repellent conditions.
3) Developed a new method to quantify hydraulic and physical properties of soils and soilless substrates using tension infiltrometer measurements.
4) We installed instruments to analyze stormwater quantity and quality from utility-scale solar installations.
5) We performed field and laboratory experiments to understand and quantify how tree planter media and design characteristics affect stormwater management and urban tree health.

Reports

1) Klopf, S., Angel, H., Orndorff, Z., Daniels, W. L., Stewart, R., Donovan, P., & Reiter, M. (2024). Reclamation of Mineral Sands Mining.
2) Stewart, R. (2024). Improving Water Management in Pine Bark Substrates via Pore Size Characterization and Infiltration Testing - Final Report to the Horticultural Research Institute.

3) Daniels, W. L., R. D. Stewart, A. R. Possinger, S. Klopf, G. Evanylo, S. Nagle, A. Tilley, C. Herron, P. Donovan, R. Campos, and R. Reed. (2024). Final Research Report for Soil Media and Tree Planter Studies. Prepared for Fairfax County, Virginia, and published on the Fairfax County webpage and the Virginia Department of Environmental Quality webpage.
4) Stewart, R. D., A. R. Possinger, S. Klopf, W. L. Daniels, and H. Angel. (2024). Powell River Project 2022-2023 Annual Research Report: Long-Term Effects of Weathering on Mine Soil Properties and Biogeochemical Processes. Submitted to the Powell River Project.

University of Delaware (Yan Jin)

1) Collected monthly porewater samples from a coastal wetland, St. Jones Reserve, from piezometers installed at 30-cm and 120-cm depths at 4 locations in the field along a salinity gradient. The samplings were size fractionated into <1000 nm, <450 nm, <100 nm, and <2.3 nm to measure colloid and phosphorus concentrations.
2) Collected monthly porewater samples from the same piezometers for analyses of pH, EC, Eh, and water table level as well as chemical properties (e.g., various elements and TOC).
3) Ongoing continuous monitoring of soil redox potential (at 10, 50, 100, 150 and 200-cm depths), and others (at 60-cm depth) (pH, salinity, water level, and temperature) at St. Jones Reserve, using in situ Pt-redox probes, HOBO pH, and LTC sensors in 15-min time intervals.
4) Processed and synchronized time series data from field monitoring stations to facilitate machine learning (ML) model training to simulate and predict changes in salinity at St. Jones Reserve.
5) Organized multiple sampling companions at St. Jones Reserve to collect samples of porewater, creek water, rainwater over several 12-hour tidal period. These sample were analyzed for stable H and O isotope signatures, which are being used to evaluate feasibility of using isotopes for better characterization of subsurface hydrology at the field site and to help explain changes in measured chemical properties as well as biogeochemical processes.

Conference Abstracts

1. **Jin, Y**. **Keynote**. Hydrologic connectivity of soil pore network controls soil ecosystem functions across scales. International Workshop on Soil biophysical Processes and Mechanical Compaction. Nanjing Agricultural University, China, October 25-27, 2024.
2. **Jin, Y**. Colloids and their role in organic carbon cycling and retention in soil. State Key Laboratory of Soil and Sustainable Agriculture, Chinese Academy of Sciences, May 9, 2024, Nanjing, China
3. **Jin, Y**. Colloids and their role in organic carbon cycling and retention in soil. Xi'an University of Science and Technology, April 30, 2024, Xi'an, China
4. **Jin, Y**. Colloids and their role in organic carbon cycling and retention in soil. China Agricultural University, April 24, 2024, Beijing, China

5. Yan, J. *Bacillus Subtilis* affects the onset and morphology of salt precipitation during saltwater evaporation. AGU. Washington, D.C. December 9-13, 2024.
6. Sena, M., S. P. Inamdar, B. Joshi, M.M. Rahman, M. Peipoch, E. Moore, M. Afsar, Y. Jin. Controls of topography, hydrology, and soil characteristics on temporal redox variations in Riparian soils. AGU. Washington, D.C. December 9-13, 2024.
7. Yan, J., Zheng W., Knight B., Bais H., Jin Y., Effects of plant growth-promoting rhizobacteria (PGPR) on saltwater evaporation: a case study using *Bacillus Subtilis*, European Geosciences Union General Assembly, April 14-19, 2024, Vienna, Austria.
8. Bradach S., Yan J., Joshi S., Afsar M., Jin Y., Using stable water isotopes to estimate source water contribution in a tidal marshland, European Geosciences Union General Assembly, April 14-19, 2024, Vienna, Austria.

University of Wisconsin – Madison (Jingyi Huang)

- Worked on research projects funded by USDA Hatch - Multistate W4188, NSF, and USDA NIFA programs
- Advising two Ph.D. students, two M.S. students, and two undergraduate students and serving on the committee members of three Ph.D. and two M.S. students
- Teaching Soil Physics (Soil Science 622), Environmental Monitoring and Soil Characterization for Earth's Critical Zone (Soil Science 327), and Using R for Soil and Environmental Sciences (Soil Science 585)
- Reviewed 42 manuscripts for various journals

Kansas State University (Andres Patrignani)

Research findings were disseminated via:

- 6 publications in peer-reviewed journals
- 6 conference abstracts
- 3 invited presentations

Montana State University (Jack Brookshire)

1) We determined grassland annual aboveground net primary production across a fire chronosequence in grasslands of the Northern Great Plains
2) We developed a plant-soil iso-scape model across fire gradients to examine the distribution and dynamics of C3 and C4 grass-soil feedbacks
3) We collected novel measures of soil and stream chemistry in lowland and montane tropical forest of Ecuador.

Oregon State University (Carlos Ochoa)

1.1 Investigate soil water relations in irrigated and non-irrigated grass seed fields and hazelnut orchard to assess water and nutrient transport through the vadose zone and into the shallow aquifer [Collaboration with D. Godwin (OSU)].
   - Field and laboratory work related with soil physical properties and water transport through the unsaturated zone.

1.2 Investigate soil water relations in rangelands of Oregon and northern Mexico to assess soil-plant-water relations in arid and semiarid landscapes [Collaboration with H. R. Garduno (INIFAP-Mex) and Federico Villarreal (UACH-Mex)].

1.3 Investigate watershed hydrology and soil water relations in flood-irrigated pasture fields in northern New Mexico to determine multiple water budget components [Collaboration with A. Fernald (NMSU)].

1.4 Established two new watershed scale projects to evaluate juniper removal effects on soil-water-vegetation dynamics.

1.5 Investigate soil C content for the top 0.5 m and GHG fluxes with open and closed chamber systems in an irrigated pasture system in a semiarid location in eastern OR.

Conference Proceedings and Technical Report

Garduno, H. R., Ochoa, C. G., Villarreal, F., Sosa-Perez, G., Jurado-Guerra, P. (2024). Humedad superficial del suelo en condiciones de sequía extrema en dos ecosistemas semiáridos del norte de Mexico. (Topsoil moisture under extreme drought in two semiarid ecosystems of northern Mexico). (pp. 247-252). Sociedad de Manejo de Pastizales A.C and Universidad Autónoma Chapingo.

Garduno, H. R., Ochoa, C. G., Sosa-Perez, G., Jurado-Guerra, P. (2024). Soil moisture in rangelands (La humead del suelo en los pastizales) (pp. 20–23). Chihuahua, Chihuahua: Sociedad Mexicana de Manejo de Pastizales.

Conference Abstracts

Farha, S., Ochoa, C. G., Sabie, R., Fernald, A. (2024). Role of acequias in surface water and groundwater interactions in northern New Mexico. Las Cruces, NM: 69th New Mexico Annual Water Conference.

Ortega-Gonzalez, A., Ochoa, C. G., Iglesias, M., Gomez, D. G., Godwin, D. A comparison of post fire aerial seeding and natural regeneration on Great Basin rangelands. Society for Range Management.

Ochoa, C. G., Shipley, R., Iglesias, M., Gomez, D. G., Abdallah, M. A. B., Hickey, S., Kesling, J., Gallagher, A., Deboodt, T. Assessing Ecohydrology Response to Juniper Removal at the Watershed Scale. Society for Range Management.

Gomez, D. G., Iglesias, M., Ochoa, C. G., Godwin, D., Abdallah, M. A. B. Evaluating carbon, nitrogen, and organic matter content in irrigated and non-irrigated pasturelands in Oregon, USA. Society for Range Management.

Ochoa, C. G., Iglesias, M., Gomez, D. G., Godwin, D., Abdallah, M. A. B. Linking Atmospheric Carbon Fluxes, and Belowground and Aboveground Carbon Stocks in Rangeland and

Pasture Ecosystems. Society for Range Management.

Iglesias, M., Ochoa, C. G., Gomez, D. G., Godwin, D., Abdallah, M. A. B. Measuring atmospheric carbon fluxes in dryland pastures in Oregon, USA. Society for Range Management.

Garduno, H. R., Ochoa, C. G., Villarreal, F. Soil Moisture Response to Extreme Drought in Oak Woodland and Open Grassland Ecosystems. Society for Range Management.

Farha, S., Sabie, R., Ochoa, C. G., Fernald, A. (2024). Surface water and groundwater interactions in acequia-based irrigation systems of northern New Mexico. Washington, D.C. American Geophysical Union.

University of Florida (Ebrahim Babaeian)

- Maintained field experiments by installing multiple sensors including soil moisture, matric potential, proximal and remote sensing (microwave) instruments to measure soil water characteristics in Florida' sandy soils.
- Developed a deep learning model (ConvLSTM) for estimating subsurface soil moisture using multi-source multi-scale ground and remote sensing observations across the contiguous U.S.
- Designed a deep learning model to provide short-, mid-, and long-term nowcasts and forecasts of soil moisture based on long-term ground and satellite remote sensing observations (e.g., SMAP).
- Developed and tested a hybrid model that combines the tau-omega radiative transfer model with machine learning to estimate surface, near-surface, and root zone soil moisture at the field scale in sandy soils.
- Taught Environmental Soil Physics to undergraduate and graduate students from various disciplines.

Milestones

Objective 1: Connect New Understandings of Storage and Transport of Mass and Energy to Assess Environmental Change

University of California, Riverside (Hoori Ajami)

1) Improve understanding of groundwater recharge processes in mountain catchments using isogeochemical data
2) Improve parameterization of storage-discharge functions for estimating recharge in mountain watersheds across the western US

University of California, Riverside (Jirka Šimůnek)

We continue to expand the capabilities of the HYDRUS modeling environment by developing specialized modules for more complex applications that cannot be solved using its standard versions. The standard versions of HYDRUS, as well as its specialized modules, have been used by myself, my students, and my collaborators in multiple applications described below.

Hydrological Applications:

1. **Mulla et al. (2024)** measured and modeled (using the overland flow module of HYDRUS-2D) the impacts of soil, vegetation, and impervious arrays on soil moisture and runoff from solar farms at four locations (in Colorado, Georgia, Minnesota, New York, and Oregon). The also evaluated the overall system for 2-, 10-, and 100-year design storm depths.
2. **Liu et al. (2024a)** proposed an integrated approach to generate high-precision regional root water uptake maps. The approach involved the Google Earth Engine (GEE) platform, mathematical models (HYDRUS-1D), and machine learning algorithms. They extracted 31 covariates from the GEE platform, and used them, together with the HYDRUS-1D results, and the CatBoost algorithm to develop a machine-learning model for estimating regional-scale transpiration maps
3. **Liu et al. (2024b)** expanded the approach developed in Liu et al. (2024a), i.e., combining mathematical models and machine learning algorithms, to predict the future regional-scale actual transpiration by maize.
4. **Zhou et al. (2024)** evaluated the impact of managed aquifer recharge on the fate and transport of pesticides in deep agricultural soil profile by analyzing experimental data and using HYDRUS-1D.
5. **Faal et al. (2024)** assess aquifer vulnerability based on aquifer type, hydraulic conductivity, depth to groundwater level, distance from the coastline, current seawater intrusion, and thickness of the saturated zone using a numerical tool called GALDIT. They then used deep learning and machine learning approaches to capture complex relationships between inputs (GALDIT parameters) and aquifer vulnerability (TDS).

***Particle Transport*:**

6. **Behnam et al. (2024)** studied Pb^{2+} adsorption on functionalized biochar nanoparticles to provide insights from nanoparticle characterization and kinetic-isotherm analysis.
7. **Wang et al. (2024a)** studied how humic acid enhances the co-transport of colloids and phosphorus in quartz sand porous media using the HYDRUS-1D model.
8. **Wang et al. (2024b)** quantified the effects of size exclusion on colloidal particle transport in porous media at a pore- and column-scale using the HYDRUS-1D model.

PFAS:

9. **Vahedian et al. (2024a)** evaluated the influence of tension-driven flow on the transport of AFFF in unsaturated media using experimental column studies and the newly developed PFAS module of the HYDRUS software.
10. **Biesek et al. (2024)** carried out numerical modeling of PFAS movement through the vadose zone using the newly developed PFAS module of the HYDRUS software. They evaluated the influence of plant water uptake and soil organic carbon distribution on PFAS fate and transport.

11. **Vahedian et al. (2024b)** studied the influence of kinetic air-water interfacial partitioning on unsaturated transport of PFAS in sandy soils using column experiments and their analysis using the newly developed PFAS module of the HYDRUS software.

***HYDRUS Papers*:**

12. **Šimůnek et al. (2024)** provided a review of recent developments and applications of the HYDRUS computer software packages since 2016.
13. **Pawlowicz et al. (2024)** developed and documented a new web-based tool for coupling MODFLOW and HYDRUS-1D computer programs. They provided a detailed example of this coupled model for an aquifer in Poland.
14. **Diamantopoulos et al. (2024)** reported the implementation of the Brunswick model system into Hydrus software suite and its multiple applications. The Brunswick model system provides a more flexible description of soil hydraulic properties that can account for both capillary and non-capillary processes.
15. **Meles et al. (2024)** developed a computationally efficient hydrologic modeling framework to simulate surface-subsurface hydrological, solute transport, and erosion processes at the catchment scale by coupling the Kineros and HYDRUS-1D models. They validated the coupled model using simple slope-scale applications, as well as complex catchment applications.

***Other Papers*:**

16. **Hopmans et al. (2024)** written an introduction for the Special Issue of the Vadose Zone Journal tributing Rien van Genuchten and his Wolf Prize in 2023.
17. **Urdiales et al. (2024)** studied transport mechanisms of the anthropogenic contaminant sulfamethoxazole in volcanic ash soils at equilibrium pH using experimental column studies and their analysis using the HYDRUS-1D model.

University of California, Davis (Thomas Harter)

- Completed seventh year of long-term water and nitrogen flux monitoring in a 140-acre almond orchard, at the land surface, in the vadose zone, and in groundwater
- Completed first intensive analysis of deep vadose zone monitoring system in irrigated tomato-field crop rotation.

University of California, Davis (Majdi Abou Najm)

Outreach for Agrivoltaics technologies in California and beyond

1) California's second Agrivoltaics conference
2) Outreach via different webinars, venues and lectures

University of California, Davis (Helen E. Dahlke)

- Fate and transport of pesticides is mostly controlled by adsorption within the topsoil layer and largely facilitated by soil carbon content
- Sandier soils, such as at P2 (84% sand), exhibited a higher saturated hydraulic conductivity (Ks), which facilitated faster water flow and shorter pesticide travel times.

Desert Research Institute (Markus Berli)

- Model evaluation for water infiltration into hydrophobic soil using laboratory-scale measurements.
- Improved model to simulate water infiltration, redistribution and evaporation for arid soils.

Washington State University (Markus Fleury and Joan Wu)

We studied how biochar impacts carbon sequestration and carbon emission in farmland soils. We found that the application of biochar significantly increases the contents of soil organic carbon, dissolved organic carbon, and microbial biomass carbon in the topsoil, as well as soil organic carbon and dissolved organic carbon contents in the subsoil. These observed changes lead to stabilizing soil organic carbon, emphasizing mineral-associated organic carbon formation as a primary mechanism for carbon sequestration in both topsoil and subsoils. Mechanisms on how biochar impacts both top- and subsoil organic carbon were elucidated. Our results provide evidence that biochar contributes to the long-term organic carbon sequestration in calcareous farmland not only in the topsoil, but also in the subsoil.
We also studied the fate and transport of soil-biodegradable micro- and nanoplastics in soils. The mobility of pristine and weathered polybutylene adipate co-terephthalate (PBAT) nanoplastics in the absence and presence of proteins was investigated with column transport experiments. We found that (1) both pristine and the weathered PBAT nanoplastics were mobile; (2) positively charged lysozyme formed protein-coronas around PBAT nanoplastics and inhibited the transport; and (3) decreased water saturation promoted the retention of PBAT nanoplastics via physical straining. These results suggest that soil-biodegradable nanoplastics fragmented from soil-biodegradable plastic mulches are mobile and may readily migrate into deep soil layers but positively charged proteins and unsaturated flow would prevent such transport via formation of protein-corona and physical straining.

University of Wyoming (Thijs Kelleners)

1) Improve a 1-D numerical coupled soil water flow, heat transport, and solute transport model to better predict soil-plant-atmosphere water, heat, and carbon exchange in cold regions

University of Arizona (Marcel Schaap, Craig Rasmussen, and Karletta Chief)

1) We developed maps of soil hydraulic properties (mentioned several times already) for the contiguous United States. The resulting products also include complete (5-parameter) covariance matrices that would allow uncertainty assessments of hydraulic properties as well as derived products such as uncertainty in water dynamic simulations with Hydrus-1D for the purposes of mapping water resources and drought mitigation.

2) We synthesized data across critical zone observatories to understand energy and mass flows and transformations through soil-vegetation-landscape systems. The products include 1 peer reviewed book chapter presenting this data synthesis.

Utah State University (Scott B. Jones, Asghar Ghorbani, David A. Robinson (adjunct), and Morteza Sadeghi (adjunct)

1) USU published four-years of evapotranspiration data from 36 plots in four common vegetation types (Aspen, Conifer, Sage and Grass) of a mixed forest in the Intermountain Western US.

2) USU continued to develop new and improved soil water characteristic and flow equations for the Richardson-Richards Equation in support of modeling retention and transport processes across the entire water content range.

University of Nebraska (Aaron Daigh)

1) Identify prospective reduction zones in deep vadose zone and shallow aquifer formations.
2) Obtained soil samples and completed 50% of soil characterizations for research on soil and nitrogen spatial variability.

Oklahoma State University (Tyson Ochnser)

No milestones for this objective.

Texas A&M University (Binayak P. Mohanty)

1. We discovered that ecosystem tipping characteristics are defined by intensity, frequency, and duration of surface soil moisture excursions from wet- to dry-average state.
2. A key finding shows that soil moisture tipping characteristics capture soil-vegetation-climate coexistence patterns within global biomes.
3. Root zone soil moisture dynamics could be inferred at remote sensing footprint scale from surface soil moisture and exploiting water-energy coupling behavior.
4. Effective preferential flow to shallow ground water was estimated at regional scale and found to be more prominent during spring than other seasons.

Texas A&M University (Briana Wyatt)

No milestones for this objective.

Louisiana State University – Agriculture Center (Xi Zhang)

1) Improve mechanistic understanding of how cover crops influence soil structure development and thus water flux in agroecosystem.
2) Quantify the responses of soil organic matter and soil physical health to cover cropping under diverse management practices.

University of Kentucky (Ole Wendroth)

1) To optimize irrigation timing and amount in a farmer's field on Karst topography.

North Carolina State University (Josh Heitman)

1) We developed new insights on correlations between soil thermal conductivity and water retention. The critical water content (θ_c) of a thermal conductivity curve was strongly correlated to selected soil hydraulic and physical properties, such as water contents at wilting point (θ_{pwp}), inflection point (θ_i), and hydraulic continuity (θ_{hc}) determined from measured soil water retention curves, SWRCs, for a 23-soil calibration dataset. We investigated the underlying mechanisms for correlations between θ_c with θ_{hc} which dominated both heat transfer and water flow. This study provides the foundation for future studies to further investigate the general relationship between thermal conductivity versus water content curves and water retention curves.

2) The bulk electrical conductivity (σ) of porous media, as a function of pore fluid conductivity (σ_w), exhibits non-linear behavior (convex upwards) at low salinity and transitions to linearity behavior at high salinity. Classical models have difficulty in matching both low and high salinity conditions. We established asymptotic limits at zero and infinite salinity and then bridged the gap between two extremes by employing a Padé approximant. We evaluated the performance of the new approach by comparing it to five existing models using datasets obtained from literature. The new model was superior to the existing models. The new model is particularly advantageous in scenarios involving the interpretation of electrical data in low salinity environments.

Iowa State University (Robert Horton, Elnaz Ebrahimi, Richard Cruse)

1) We developed new insights on correlations between soil thermal conductivity and water retention. The critical water content (θ_c) of a thermal conductivity curve was strongly correlated to selected soil hydraulic and physical properties, such as water contents at wilting point (θ_{pwp}), inflection point (θ_i), and hydraulic continuity (θ_{hc}) determined from measured soil water retention curves, SWRCs, for a 23-soil calibration dataset. We investigated the underlying mechanisms for correlations between θ_c with θ_{hc} which dominated both heat transfer and water flow. This study provides the foundation for

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Virginia Tech (Ryan Stewart)

1) To publish the results of laboratory experiments aimed at quantifying gas diffusion rates and pore size distributions of nursery substrates, by June 2025.
2) To publish the results of laboratory experiments aimed at quantifying the effects of modifying pine bark particle size distributions on growing media hydraulic properties, by March 2025.
3) To publish the results of a field study on infiltration and ponding in various landscapes of Virginia, including areas developed with utility-scale solar, by August 2025.

University of Delaware (Yan Jin)

- Our findings from the field study at St. Jones Reserve improve understanding of biogeochemical cycling of OC and P in redox-driven environments
- Additionally, it provides a solid background for future research on the depth-distribution of colloidal OC in a marsh wetland.
- Development of advanced ML and DL-based models can contribute to the resilience planning in the face of climate-related challenges in the wetland.
- Predictive and forecasting models can provide valuable information for policymakers and funding agency (e.g., Department of Defense) to make evidence-based decisions related to marshland conservation and management

University of Wisconsin-Madison (Jingyi Huang)

No milestones for this objective.

Kansas State University (Andres Patrignani)

1) Investigate responses in heterotrophic soil respiration to changes in soil moisture conditions quantified by mass/volume-basis indicators and energy-state indicators.

Montana State University (Jack Brookshire)

1) Fire exclusion is a key factor driving conifer expansion into temperate semi-arid grasslands. However, it remains unclear how reintroducing fire affects the aboveground storage of carbon (C) and nitrogen (N) in the encroaching tree species and belowground in soils. To assess the impacts of fire reintroduction C and N pools and fluxes in areas of conifer expansion we targeted a region of the Northern Great Plains that has experienced extensive conifer expansion of two species: ponderosa pine (*Pinus ponderosa)* and juniper (*Juniperus spp)*. We quantified tree mortality of both species to estimate the amount of dead biomass C and N produced by a recent prescribed fire, in addition to changes in soil C, pyrogenic C (PyC), and N concentrations across a woody-cover gradient using a before/after/control experimental design. Post-fire soil chemical analysis revealed a 2-year increase in mineral soil C, PyC and N, suggesting the return of fire led to the transfer of partially combusted plant organic matter back to the soil. Further, we found that functional trait differences between the two species influenced the distribution of living conifer biomass-N prior to fire. Despite junipers having 41% less total aboveground biomass than ponderosa, they contained two times more aboveground N. Prescribed fire resulted in 88% mortality of all mature juniper stems and increased fire severity correlated with greater pre-fire juniper cover. Ponderosa mortality varied by size class, with >40 cm stem diameter class having only 28% mortality. High mortality and greater aboveground N storage in juniper biomass, compared to ponderosa, led to 77% of the total conifer biomass N lost. Consequently, the functional attributes of expanding trees differentially contribute to fluxes of C and N after the return of fire, with junipers acting as conduits for N movement due to their relatively higher N content in less fire-resistant tissues and ponderosa serving as important and more stable storage pools for C. Together, these findings highlight the importance of considering species-specific traits when planning WPE management strategies at landscape-scales, particularly when goals include C storage or soil nutrient status.

Oregon State University (Carlos Ochoa)

- Expanded soil moisture, surface, and groundwater monitoring network in rangelands and cropland systems encompassing 20 different fields or basins distributed across 8 counties in eastern and western OR.
- Expanded soil moisture and weather monitoring networks in rangelands in central Oregon and northern Mexico (Chihuahua).
- Established soil moisture and weather-telemetry network in four study sites in eastern Oregon.
- Conducted intensive field data collection and analysis of soil physical properties and C, N, and OM for multiple rangeland and cropland locations.

University of Florida (Ebrahim Babaeian)

No milestones for this objective.

Connecticut Agricultural Experiment Station (Yingxue Yu)

We investigated the fate and transport of soil-biodegradable nanoplastics in soils by studying the mobility of pristine and weathered polybutylene adipate co-terephthalate (PBAT) nanoplastics under various conditions using column transport experiments. Both pristine and weathered PBAT nanoplastics exhibited high mobility, indicating their potential to migrate into deeper soil layers. However, the presence of positively charged lysozyme formed protein coronas around the nanoplastics, significantly inhibiting their transport. Additionally, reduced water saturation promoted the retention of nanoplastics through physical straining. These findings suggest that while soil-biodegradable nanoplastics fragmented from plastic mulches are inherently mobile, their transport can be mitigated by protein interactions and unsaturated flow conditions, which enhance retention in soils.

USDA-ARS, George E. Brown Jr. Salinity Laboratory/UC-Riverside (Todd Skaggs, Ray Anderson, and Elia Scudiero)

No milestones for this objective.

Objective 2: Develop and Test New Methods and Models to Improve the Quality of Soil Information and Knowledge

University of California, Riverside (Hoori Ajami)

1) Develop a new pedo-transfer function for hydrologic and Earth System Models
2) Improve parameterization of dual porosity pedo-transfer functions using soil imaging techniques

University of California, Davis (Thomas Harter)

- Initiated phase 2 vadose zone modeling of pre- and post-implementation nitrate leaching, over an 80-year period at a California nut crop site
- Initiated phase 2 groundwater modeling of the heterogeneous aquifer conditions under a well-instrumented field site to assess monitoring well network source areas and long-term dynamics of nitrate pollution under changing fertilization practices

University of California, Davis (Majdi Abou Najm)

Conduct critical review on infiltration:

1) Completed analysis on 1D and 3D problems, paper under review
2) Completed review on infiltration models: paper accepted (VZJ)
3) Summarized the modeling frameworks of 138 models

University of California, Davis (Helen E. Dahlke)

- Despite higher groundwater recharge efficiency achieved by sandier profiles (up to 93.6%), the increased water flux facilitated by the coarser texture led to greater dilution of residual

pesticide concentrations, resulting in smaller maximum transport depths (MTDs of 10.5 to 12.0 m) during Ag-MAR.
- Finer-textured soils at P1 (41% sand) and P3 (61% sand) allowed deeper pesticide transport, with MTDs of 11.5 to 54.0 m at P1 and 10.5 to 64.5 m at P3.

Desert Research Institute (Markus Berli)

No milestones for this objective.

Washington State University (Markus Fleury and Joan Wu)

We investigated how land-applied biosolids impact the transfer of microplastics from wastewater treatment plants to soils. We quantified and characterized microplastics in soils that have been amended with biosolids over the past 23 years. We also collected atmospheric deposition samples to determine the amount and type of plastics added to soils through atmospheric deposition. Biosolids applications led to plastics concentrations of 361 to 500 particles/kg dry soil in the 0–10 cm depth. The dominant plastic types by number found in biosolids were polyurethane, followed by polyethylene, and polyamide. The most abundant plastics in soil samples were polyurethane, polyethylene terephthalate, polyamide, and polyethylene.

We wrote a comprehensive review article published in Advances in Agronomy, where we summarize and synthesize current knowledge about biodegradable plastic mulch films, including the history, definition and use, in-field degradation, agronomic performance, environmental impacts, and economic feasibility. Overall, current data indicate that biodegradable plastic mulches are a promising alternative of conventional polyethylene mulch films. Questions remain about in-field biodegradation, potential accumulation of BDM residues in soils, release of non-biodegradable additives, and off-site transport of biodegradable plastic residues (including micro- and nanoplastics) to air and water. We provide recommendations to address these questions and challenges to ensure safe and sustainable use of BDM films in agriculture. Increasing urbanization and development in the US Puget Sound region has adversely impacted local ecosystems, especially the spawning and rearing habitat for several salmonid species. Sustainable urban design strategies such as green stormwater infrastructure (GSI) are required in the region to manage stormwater onsite when new development occurs. However, the effectiveness of any GSI depends on its location relative to where stormwater is produced. We developed a Geographic Information System (GIS)-based framework for the optimal placement of GSI, specifically bioretention systems. We computed the Hydrologic Sensitivity Index for the lower Puyallup River Watershed study area and used it in combination with federal and state feasibility criteria to identify suitable sites for bioretention systems. The suitability of identified sites was verified through ground-truthing, including soil sampling and infiltration testing. Our framework can be readily applied to watersheds for which spatial data (topography, soil, and land use) are available.

University of Wyoming (Thijs Kelleners)

1) Apply a coupled hydro-geophysical inversion code to a snow-dominated mountain hillslope using synthetic and field-measured electrical resistivity and seismic reflection data to determine subsurface structure, hydraulic properties, water storage, and flow regime

University of Arizona (Marcel Schaap, Craig Rasmussen, and Karletta Chief)

1) We developed parallelized python code that can generate hydraulic estimates with PTFs on massive data sets. In the present project we are doing this for the contiguous USA (760 million points), but international colleagues are applying this code to worldwide soils data (10-20 billion points). In 2025 we will update this code to work efficiently with SOLUS100 data.

Utah State University (Scott B. Jones, Asghar Ghorbani, David A. Robinson (adjunct), and Morteza Sadeghi (adjunct)

1) USU demonstrated dryland crop yield estimation capabilities using machine learning and other AI tools to support farmer/rancher decision support efforts.

University of Nebraska (Aaron Daigh)

Calibrated and validated a vadose zone model and accomplished 50% completion of virtual experiments to understand the effects of long-term fertilizer application rates, crop rotations, and weather impacts on aquifer nitrate contamination.

Oklahoma State University (Tyson Ochnser)

- Complete simulations of soil moisture dynamics at in situ monitoring stations nationwide using SOILWAT2 and TOPOFIRE.
    - The TOPOFIRE simulations were completed. The SOILWAT2 simulations are ongoing.

Texas A&M University (Binayak P. Mohanty)

1. Coupled soil moisture and ET regime characteristics were discovered across various land use land covers and hydroclimates across the globe.
2. Ecosystem respiration, soil health, and GHG emission estimations were improved by accounting soil moisture, temperature, and land surface radiation dynamics.
3. Using satellite remote sensing, critical evaporative fraction and soil moisture thresholds were established for water- and energy-limited systems.

Texas A&M University (Briana Wyatt)

No milestones for this objective.

Louisiana State University – Agriculture Center (Xi Zhang)

No milestones for this objective.

University of Kentucky (Ole Wendroth)

1) To compare a 3D-Agricultural Ecosystem Model (SWAT+) with a 1-D model (RZWQM2) with regard to model output sensitivity to soil and soil hydraulic property input parameters.

North Carolina State University (Josh Heitman)

1) Our research recognized underlying correlations between soil water retention curves and soil thermal conductivity (λ) versus θ curves and developed methodologies to ascertain the parameters of the van Genuchten (vG) equation using $\lambda(\theta)$ measurements, described by the Ghanbarian & Daigle (GD) equation, and basic soil characteristics. Limitations intrinsic to the van Genuchten equation restrict the GD-vG approach to generate precise estimates only in the wet and medium suction range. We associated the Peters-Durner-Iden (PDI) model parameters to those of the GD model. An initial examination was performed on the linearization processes needed to derive the hydraulic continuity water content from the capillary water component as characterized by the PDI model and to choose the suction at oven dryness based on PDI model performance. Subsequently, two piecewise functions and two pedo-transfer functions were formulated to compute the PDI model parameters utilizing soil porosity, particle size distribution, and GD parameters, based on a calibration dataset comprising 25 different soils. The new GD-PDI approach was subsequently assessed with six independent soils and juxtaposed with the previous GD-vG approach.

2) Soil dry surface layer (DSL) thickness is often considered a key parameter for land surface resistance to gas exchange. Commonly used, simple models for DSL thickness are typically empirical in nature and based on limited observational evidence. Laboratory experiments were performed to test soil condition and boundary effects on DSL formation. DSL thickness was analyzed in soil columns with varying texture, initial water content, and potential evaporation rate. DSLs formed to greater depth in fine-textured compared to coarse-textured soils, when beginning from similar initial water content. Based on experiments, we compared a simple but physically based mass balance DSL model to an empirical DSL model from the literature. The mass balance model performed

better than the empirical relative-wetness-based model and is similar in structure to the current DSL parameterization in the Community Land Model. Results suggest soil resistance parameterizations can be improved by employing simple, but texture-dependent, physically based DSL formulations.

Iowa State University (Robert Horton, Elnaz Ebrahimi, Richard Cruse)

1) A thermo-time domain reflectometry (thermo-TDR) sensor combines a heat pulse sensor with a TDR waveguide to simultaneously measure coupled processes of water, heat, and solute transfer. The sensor can provide repeated in-situ measurements of several soil state properties (temperature, soil water content, and ice content), thermal properties (thermal diffusivity, thermal conductivity, heat capacity), and electromagnetic properties (dielectric constant and bulk electrical conductivity) with minimal soil disturbance. Combined with physical or empirical models, structural indicators, such as bulk density and air-filled porosity, can be derived from measured soil thermal and electrical properties. Successful applications are available to determine fine-scale heat, water, and vapor fluxes with thermo-TDR sensors. Applications of thermo-TDR sensors in complicated scenarios, such as heterogeneous root zones and saline environments, are also possible. Therefore, the multi-functional uses of thermo-TDR sensors are invaluable for in-situ observations of several soil physical properties and processes in critical zone soils.

2) We developed a generic model framework to perform coupled heat and water transfer (CHWT) simulations in heterogeneous and non-rigid soils. The model is established based on a newly developed mixed finite element method (FEM), which can solve the Philip and de Vries (1957) CHWT model and achieve conservation of mass and energy in both local and global scales. Heterogeneities include instantaneous variations in soil hydraulic and thermal properties due to transient water content and temperature distributions. Based on the mixed FEM scheme, a gradient measure and a clustering model ("k-means") are used to trace the regions with large instantaneous heterogeneities, and an adaptive mesh refinement technique is proposed to improve the spatial resolution and simulation accuracy in the heterogeneous regions. Deformation perturbates the local soil topography and affects the transient soil water and temperature regimes in the deformed regions. A quasi-static deformation model is developed as a separate module and prefixed to the mixed FEM scheme. When external load is applied, soil deformation is simulated with an updated Lagrange formulation, and the local water content and temperature changes variations due to soil volume changes are updated in the CHWT model. Numerical examples, including thermally induced soil water transfer and water infiltration, illustrate the ability of the model framework to provide plausible CHWT results, especially the refined solutions near the wetting fronts and the water content and temperature distributions when the soil is non-rigid. The method for incorporating soil spatial heterogeneity and non-rigidity in CHWT simulations can be applied to existing soil simulators, such as HYDRUS.

3) Cereal rye (*Secale cereale* L.) has been extensively studied as a winter cover crop in conservation agriculture using experimental and modeling approaches. Previous studies generally modeled cereal rye by modifying existing cash crop models. We develop and evaluate a new cereal rye vegetative growth model. The new model, namely RYESIM, employs object-oriented programming techniques and a linked-list data structure to present the emergence order of cereal rye organs, such as leaves, internodes, and tillers. Individual organs are abstracted as "classes," which encapsulate organs' morphological features and emergence-growth-senescence processes as member variables and functions. Multiple organs are assembled based on the tiller hierarchy to formulate the cereal rye plant architecture. RYESIM also contains "representative plant" as an average process among multiple individual plants, which bridges individual organs' growth and field-scale averaged plant morphology, as well as ensuring plant-level biomass and nitrogen (N) mass balance. Existing soil (2DSOIL) and biochemical photosynthesis models are incorporated to estimate soil water-nutrient supply, carbon assimilation and transpiration. RYESIM was evaluated using published field data measured in the Mid-Atlantic region of the USA. Compared to observed values, the relative mean absolute errors of RYESIM for tiller number, aboveground biomass and N mass were within 0.3, 0.4 and 0.5 (with exceptions), and the RYESIM simulated values fell within the value ranges from literature results. Therefore, RYESIM provides effective simulations on cereal rye vegetative growth, and the RYESIM model structure also provides a paradigm for future "multi-tiller" cash crop model development.

4) The Dual-Probe Heat-Pulse (DPHP) sensor experiences significant errors when used in partially frozen soils. The application of heat pulses leads to ice melting, and the existing DPHP theory, which does not consider phase changes, fails to accurately determine thermal conductivity (k) and heat capacity (C) in the temperature range of −5℃ to 0℃. There is a lack of DPHP theory specifically designed for use in partially frozen soils. The existing DPHP theory employs the Infinite Linear Source (ILS) approximation, which does not account for the melting process and the moving ice-liquid interface in transient heat conduction theory. Currently, there is no effective and reliable method to assess DPHP errors associated with measuring the thermal properties of partially frozen soil. To accurately determine k and C in frozen soil, it is essential to perform an error analysis regarding ice melting caused by a DPHP heat pulse input. In this study, (1) we considered the latent heat of ice melting and a moving ice-liquid interface in finite element simulations and compared the results with an analytical solution; (2) we performed simulations of DPHP measurements based on the temperature-dependent ice content, liquid water content, and melting latent heat of three frozen soils; (3) based on COMSOL simulation results for the three frozen soils, we determined the optimal heating parameter combinations (heating duration, t_0, and accumulated heating energy, ΔQ) to minimize DPHP measurement errors in frozen soil. The results showed that (1) Simulations that included the melting phase changes were in agreement with the analytical solution. (2) Including the ice-liquid moving interface significantly altered the spatial distribution characteristics of temperature, which were not captured by the ILS model in terms of the temperature distribution near the interface. (3) Below a temperature of −5.5℃, the simulations that included phase changes were consistent with measured results; (4) For

partially frozen soils with initial temperatures ranging from −0.5°C to 0°C, the relative errors in thermal conductivity fitted by the ILS model exceeded 100%. To mitigate the influence of ice melting, we recommend using $200 < \Delta Q < 400$ J m^{-1} for sand, loam, and silt loam soils with 8 s < t_0 < 60 s. For a loam soil with t_0 = 60 s, ΔQ = 800 J m^{-1} should be used. For a silt loam soil with t_0 = 60 s, we recommend using ΔQ = 600 J m^{-1}. If the ILS model is chosen to calculate soil thermal properties, we recommend using $200 < \Delta Q < 600$ J m^{-1} and 30 s < t_0 < 60 s for sandy and silt loam soils. For a loam soil, we recommend using $400 < \Delta Q < 800$ J m^{-1} and 30 s < t_0 < 60 s.

5) Traditional rhizoboxes have long been utilized in plant and soil science research to study root development and soil interactions. Building upon this foundational tool, we have developed the Smart Rhizobox System, an innovative advancement that integrates modern technology to enable real-time monitoring of root growth and soil water movement, particularly under varying soil compaction conditions. This system combines a development board with custom embedded software to manage data acquisition from multiple sensors, including eight soil moisture sensors, a temperature sensor, and a pH sensor, allowing continuous tracking of soil conditions. A GoPro camera-based imaging system captures high-resolution images of soil and plant roots throughout the growing period, which are then processed using a PC application equipped with AI-driven computer vision algorithms. Unlike hyperspectral imaging systems, which capture data across multiple narrow spectral bands to analyze plant stress, water content, and nutrient levels, GoPro cameras operate in the visible light spectrum using standard RGB imaging. While GoPro does not provide hyperspectral data, it offers a cost-effective and high-resolution solution for tracking root morphology, depth, and growth dynamics in real-time. The Smart Rhizobox PC application enhances analysis by automatically identifying and tracking root structures, distinguishing roots from soil using calibrated algorithms. The system allows for simultaneous monitoring of multiple rhizoboxes or multiple plants within a single rhizobox, generating quantitative data on root depth, total root area, and root diameter. Additionally, the system maintains a comprehensive database, offering interactive graphs and search functions for easy data access. By integrating real-time imaging with automated analysis, the Smart Rhizobox System provides an advanced platform to study root-soil interactions, water infiltration, and plant adaptation mechanisms under different soil types, and compaction scenarios. As a first-of-its-kind development, this system represents a significant advancement in soil physics research, delivering high-resolution spatial and temporal data that contribute to improved soil management strategies and precision agriculture practices. Furthermore, we have developed a user manual to support both research and education, ensuring that researchers, educators, and students can effectively utilize this system for studying soil-root interactions, environmental conditions, and plant responses in controlled experiments.

<u>Virginia Tech (Ryan Stewart)</u>

1) To improve the hydraulic characterization of soilless substrate growing media and translate that information to nursery growers by December 2025.

2) To build and test a new system for monitoring soil particle movement during erosion, by November 2025.
3) To test our new system for distributed measurements of CO_2 fluxes using low-cost sensors, by October 2025.
4) To develop a new approach for measuring evapotranspiration, by December 2025.
5) To publish a study comparing methods for rapidly assessing soil ped volumes, by July 2025.
6) To publish a study proposing a new model for rapid soil carbon assessment, by November 2025.

University of Delaware (Yan Jin)

- Developing and testing ML-based models to predict changes in salinity and redox potential based on multivariate input variables
- Implemented DL-based models to forecast changes in salinity and redox potential for marshland
- Conducted experiments to examine effects of a rhizobacteria, UD1022 on water retention and evaporation under different salinity
- Monitored soil water and salinity changes, and collected pore water samples in saltwater marshland to identify impacts of saltwater intrusion on soil salinization in coastal regions
- Investigated how saltwater intrusion affects coastal soil in changing ionic strength, sulfidation, alkalization, and phosphorus (P) dynamics

University of Wisconsin-Madison (Jingyi Huang)

- Models and an R package were developed for predicting surface and rootzone soil moisture dynamics across the continental USA
- Sensors developed for monitoring soil water and nitrate contents and gas emissions from soils

Kansas State University (Andres Patrignani)

1) Develop installation methods to quantify soil water retention curves in field conditions
2) Examine co-located soil moisture sensors to assess quality and accuracy of soil moisture information from a wide range of sensors.

Montana State University (Jack Brookshire)

1) Soil extractable nitrate, ammonium, and organic nitrogen (N) are essential N sources supporting primary productivity and regulating species composition of terrestrial plants. However, it remains unclear how plants utilize these N sources and how surface-earth environments regulate plant N utilization. We established a framework to analyze observational data of natural N isotopes in plants and soils globally, we quantify fractional contributions of soil nitrate (f_{NO3-}), ammonium (f_{NH4+}), and organic N (f_{EON}) to plant-used N in soils. We find that mean annual temperature (MAT), not mean annual precipitation or atmospheric N deposition, regulates global variations of f_{NO3-}, f_{NH4+}, and f_{EON}. The f_{NO3-} increases with MAT and reaches a

peak of 46% at 28.5°C. The f_{NH4+} also increases with MAT, achieving a maximum of 46% at 14.4°C, showing a decline as temperatures further increase. Meanwhile, the f_{EON} gradually decreases with MAT, stabilizing at about 20% when the MAT exceeds 15°C. These results clarify global plant N-use patterns and reveal temperature rather than human N loading as a key regulator, which should be considered in evaluating influences of global changes on terrestrial ecosystems.

Oregon State University (Carlos Ochoa)

No milestones for this objective.

University of Florida (Ebrahim Babaeian)

1) Characterized physical and hydraulic properties of twenty domestic soilless substrates for use as agricultural growth media.
2) Developed a deep learning framework for estimating daily subsurface soil moisture at large scale by integrating SMAP satellite ancillary data with NRCS SOLUS100 physical properties maps.

Connecticut Agricultural Experiment Station (Yingxue Yu)

We authored a comprehensive review article published in Advances in Agronomy, summarizing and synthesizing the current knowledge on biodegradable plastic mulch (BDM) films. The review covers their history, definition, usage, in-field degradation, agronomic performance, environmental impacts, and economic feasibility. Current data suggest that BDMs are a promising alternative to conventional polyethylene mulch films. However, questions remain regarding in-field biodegradation, the potential accumulation of BDM residues in soils, the release of non-biodegradable additives, and the off-site transport of biodegradable plastic residues, including micro- and nanoplastics, to air and water. To address these challenges, we provide recommendations to ensure the safe and sustainable use of BDM films in agriculture.

USDA-ARS, George E. Brown Jr. Salinity Laboratory/UC-Riverside (Todd Skaggs, Ray Anderson, and Elia Scudiero)

No milestones for this objective.

Objective 3: Integrate scale-appropriate methods to improve decisions of soil and water resources

University of California, Riverside (Hoori Ajami)

1) Develop computationally efficient modeling frameworks for fluid flow and transport at watershed scale
2) Improve parameterization of crops in numerical models
3) Integrating isogeochemical data with numerical models to improve recharge estimation

University of California, Riverside (Jirka Šimůnek)

***Agricultural Applications*:**

1. **Thomas et al. (2024)** implemented three processed-based root water uptake models (in addition to the existing two empirical root water uptake models) into HYDRUS-1D and evaluated them using experimental data involving root water uptake compensation and hydraulic lift.
2. **Kanzari et al. (2024)** carried out pot a field experiments with tomatoes irrigated with waters of different qualities (salinities). They analyzed the data using HYDRUS-1D and concluded that the multiplicative stress response model best described the collected data.
3. **Zhang et al. (2024)** evaluated the effects of different irrigation water sources (surface water and groundwater with different temperatures) on soil temperature using field experimental data and HYDRUS-2D. The considered the coupled movement of water, vapor, and heat when analyzing the experimental data.
4. **Guo et al. (2024)** collected experimental data on soil water and salt dynamics in a corn field with shallow saline groundwater, crop-season drip irrigation, and autumn post-harvest irrigations. They analyzed the experimental data using HYDRUS-1D (during the winter period involving the effects of freezing and thawing) and HYDRUS-2D (during the irrigation season). They optimized the irrigation management plan.
5. **Chen et al. (2024)** evaluated soil salt dynamics in a tomato-corn intercropping system with different spatial arrangements using field experiments and numerical modeling using HYDRUS-2D.
6. **Naderi et al**. **(2024)** carried out a comparative assessment of different methods for estimating gray water footprint estimation methods in paddy fields and concluded that the modeling approach with HYDRUS-2D is superior to other methods (i.e., tier-1 approach and field-based estimation).

University of California, Davis (Thomas Harter)

- Developed initial version of a salt feedback loop in our nonpoint-source assessment tool to simulate groundwater salinization in the Central Valley
- Continued collaboration with CV-SALTS to develop groundwater salinity transport model for the irrigated agricultural landscape of the Central Valley.

University of California, Davis (Majdi Abou Najm)

Agrivoltaics experiment:

1) Experimenting with different crops (tomatoes and peppers).

2) Experimenting with different light/shade treatments (red, blue, red-yellow-orange, full sun, full shade)

University of California, Davis (Helen E. Dahlke)

- Capillary barriers at 5-20 m of profiles P1 and P3 further reduced pesticide transport by up to 80%, highlighting their importance in mitigating groundwater contamination.
- Comparing recharge travel times in multilayered, structured soil profiles influenced by preferential flow under flooded conditions, using both experimental and synthetic methods revealed that Wavelet coherence analysis (WCA) of soil temperature data provided the shortest recharge travel time. Among the synthetic methods, particle tracking indicated faster water movement due to its focus on convective transport, while transit time distribution estimation with pesticide data resulted in longer travel times due to adsorption processes. The discrepancies between experimental and synthetic approaches highlighted the significant roles of lateral and preferential flows in influencing recharge dynamics.

Desert Research Institute (Markus Berli)

No milestones for this objective.

Washington State University (Markus Fleury and Joan Wu)

No activities

University of Wyoming (Thijs Kelleners)

Investigate the use of (airborne) electromagnetic induction data for watershed model calibration to improve soil water, groundwater, and streamflow predictions

University of Arizona (Marcel Schaap, Craig Rasmussen, and Karletta Chief)

1) We generated soil hydraulic property maps of five van-Genuchten parameters (theta_r, theta_s, alpha, n, and Ks) for the contiguous USA at 100-meter resolution and seven depths (surface to 2.5 meters). Data and code are available in open formats and results have been validated for accuracy with NCSS Soil Pedon data. The maps are 99% complete and allow anybody to retrieve VG data in grid points of 100 meters. This map will be updated with the most recent SOLUS100 data in 2025.
2) We quantified soil biogeochemical and hydraulic property change over time following wildfire across a range of ecosystems in Arizona and New Mexico. We found significant increases in nutrient concentrations across all ecosystems immediately after fire that decreased rapidly over the first 3 years of post-fire recovery. The response of soil

hydraulic properties varied significantly among ecosystems and appears to largely be depending on the quality of the surface organic matter before fire and the soil burn severity.

Utah State University (Scott B. Jones, Asghar Ghorbani, David A. Robinson (adjunct), and Morteza Sadeghi (adjunct)

1) USU and collaborators reported on commonly used soil water content sensor measurement performance and sampling size characteristics.

2) USU resolved uncertainty in water volume delivery in an automated irrigation system using a syringe pump through addition of a linear translation sensor incorporated into the pump.

University of Nebraska (Aaron Daigh)

No activities reported

Oklahoma State University (Tyson Ochnser)

No objectives for this milestone.

Texas A&M University (Binayak P. Mohanty)

1. Texas Water Observatory has been established in the Gulf coast region which facilitates various soil hydrologic, ecosystems, and land-atmosphere coupling studies.
2. Several new process-cum-data-driven models were developed including model for root zone soil moisture estimation, preferential flow to shallow ground water, scaled hydraulic properties, and characteristics soil health parameters.

Texas A&M University (Briana Wyatt)

Applied EMI data to delineate management zones for irrigation and fertilizer

Louisiana State University – Agriculture Center (Xi Zhang)

1) Analyze the spatial variability of soil properties and its influences on soil water dynamics and solute transport at the field scale.
2) Evaluate the water use by cover crops to quantify the impact of cover cropping on soil water storage, availability, and recharge in the fields.

University of Kentucky (Ole Wendroth)

1) To quantify the impact of spatial resolution and data aggregation from UAV- and Satellite-based remote sensing with regard to digital elevation, NDVI, LAI, and topographic indices for the accuracy of predicting crop yield variability.

North Carolina State University (Josh Heitman)

1) Urban and suburban development frequently disturbs and compacts soils, reducing infiltration rates and fertility, posing challenges for post-development vegetation establishment, and contributing to soil erosion. We investigated the effectiveness of compost incorporation in enhancing stormwater infiltration and vegetation establishment in urban landscapes. Experiments tested vegetation mix (grass, wildflowers, and grass-wildflowers), ground cover (hydro-mulch and excelsior), and compost (30% compost and no-compost) as factors. Over a 24-month period, bulk density, infiltration rate, soil penetration resistance, vegetation cover, and root mass density were assessed. Results highlighted that compost consistently reduced bulk density by 19–24%, lowered soil penetration resistance to under 2 MPa at both field-capacity and water-stressed conditions, and increased infiltration rate by 2–3 times compared to no-compost treatments. Vegetation cover assessment revealed rapid establishment with 30% compost and 60:40 grass-wildflower mix, persisting for an initial 12 months. Subsequently, all treatments exhibited similar vegetation coverage from 13 to 24 months, reaching 95–100% cover. Compost treatments had significantly higher root mass density within the top 15 cm than no-compost, but compost addition did not alter the root profile beyond the 15 cm depth incorporation depth. The findings suggest that incorporating 30% compost and including a wildflower or grass-wildflower mix appears to be effective in enhancing stormwater infiltration and provides rapid erosion control vegetation cover establishment in post-construction landscapes.
2) Environmental awareness about soil and water conservation in agroecosystems has shifted behaviors toward favoring conservation practices in agricultural management. Interest in conservation tillage and cover cropping has increased, but some regions encounter major challenges with adjusting management to accommodate these practices while optimizing crop production. In an Ultisol in the North Carolina Piedmont, a long-term corn (*Zea mays*) and soybean (*Glycine max*) rotation with tillage intensities ranging from no-till to moldboard plowing in a randomized complete block design was used to assess changes in physical soil properties after introducing wheat (*Triticum aestivum*) as a winter cover crop. Cover crop biomass was measured along with volumetric water content (VWC) and bulk density (BD) at 0–15 cm, water retention (WR), water-stable aggregation (WSA), and soil organic carbon (SOC) at 0–7.5 cm, and penetration resistance (PR) at 0–45 cm. No differences in VWC or WR could be solely attributed to cover cropping, but no-till with cover cropping had the highest macroporosity where there was no vehicle traffic. Vehicle traffic had a stronger effect on soil compaction (BD

and PR) than cover cropping regardless of tillage. Conservation tillage increased WSA and SOC when compared to plow tillage, but three seasons of a wheat cover crop did not significantly change these properties, possibly because wheat produced low biomass each year (750–1900 kg ha^{-1}). Wheat had minimal effect on physical soil properties in the short term, and potential for improvement with long-term optimal cover crop management in this region requires further assessment.

3) Miscanthus is a perennial grass that can yield substantial amounts of biomass in land areas considered marginal. In the Coastal Plain region of North Carolina, marginal lands are typically located in coarse-textured soils with low nutrient retention and water-holding capacity, and high erosivity potential. Little is known about miscanthus water use under these conditions. We conducted a study to better understand the efficiency with which miscanthus uses natural resources such as water and radiant energy to produce harvestable dry biomass in comparison to corn, a typical commodity crop grown in the region. Our measurements showed that miscanthus intercepted more radiant energy than corn, which led to greater albedo, lower net radiation, and lower soil heat flux than corn on average. Consequently, miscanthus had greater available energy and water use rates (by 14% or 0.5 mm day^{-1}) than corn throughout the growing season on average. Greater water use rates and radiation interception by miscanthus did not translate to greater water-use and radiation-use efficiencies than corn. Compared to literature values, our data indicated that water and radiation availability were not limiting at our study site. Thus, it is likely that marginal land features present at the Coastal Plain region such as low soil fertility and high air temperatures throughout the growing season may constrain agronomic yields even if soil water and radiant energy are non-limiting.

4) Miscanthus is a productive perennial grass that is suitable as a bioenergy crop in soils with low water holding capacity. However, little is known about the impact of miscanthus residues on vapor transport and soil water budgets. Laboratory experiments were conducted to measure the vapor conductance through miscanthus residues and its effect on soil water evaporation. During the first days of a 60-day drying experiment, cumulative evaporation showed logarithmic decay with increasing residue load. Conversely, cumulative evaporation during the last days of the study showed little difference between treatments. Measurements indicated that there is a "critical" residue load ($\sim$1.0 kg m^{-2}) beyond which evaporation no longer decreases appreciably when the soil is under the stage 1 evaporation regime. Results suggest that soil water conservation in marginal lands may be accomplished by maintaining moderate amounts of bioenergy grass residue covering the soil. Determining "critical" loads for different residue types is a knowledge gap that merits further research.

Iowa State University (Robert Horton, Elnaz Ebrahimi, Richard Cruse)

1) We determined thermal diffusivity (α) variations within three central Iowa fields under long-term tillage practices and to estimate the required number of measurement sites within each field to determine α at a specified precision. Three fields received different tillage

operations: one was moldboard plowed followed by spring disking (MP), another was chisel plowed followed by spring disking (CP), and the third was ridge no-tilled (RN) slot planted. The minimum number of samples needed to obtain a confidence interval of 7 cm^2 h^{-1} for α was two, five, and seven, respectively, for the CP, RN, and MP fields. The MP field had the largest mean α value and required the largest number of samples to determine α at a specified precision.

2) Quantifying evapotranspiration (*ET*) in rainfed cropping systems can be challenging due to site-specific soil, plant, and management factors. Tillage practices and planting patterns can lead to large variations in soil water status and maize plant density, which impact *ET*. Previous studies showed that near-surface soil water content (□) observations at multiple scales provided a potential way to estimate surface soil water fluxes. In this study, we introduced a new method to estimate daily field *ET* by using a soil water flux model mainly based on the time-series of □ at a depth of 2.5 cm. The new method required a calibration of soil water diffusivity using maximum net water flux in the near-surface soil layer, which was related to the redistribution of precipitation below the canopy. Finally, the new method was evaluated using observed *ET* values over a 2-year period in a maize field with a double-row planting pattern, where independent measurements of soil water evaporation (*E*) and transpiration (*T*) were made with heat-pulse sensors and sap-flow gauges, respectively. Local field observations showed that *E* dominated water loss (16% of total *ET*) in the maize field during the seedling stage. As the canopy fully developed, *E* sharply decreased to a value of 0.4 mm d^{-1}, and *T* dominated the water loss since the silking stage. The new method to estimate *ET* performed well during drying periods, while it tended to underestimate *ET* during wet periods with substantial infiltration into the surface layer. On rain-free days, the *ET* values estimated with the new method matched well with the measured *E*+*T* values, with R^2 and RMSE values of 0.85 and 1.93 mm d^{-1}. Therefore, the new approach provided an effective way to quantify maize *ET*.

3) Agriculture is one of the biggest sources of nonpoint source pollution to surface water bodies. It is high priority to identify and target high-contributing agricultural fields and sub-field areas for reducing soil erosion and sediment delivery. The Daily Erosion Project (DEP) is a daily estimator of precipitation, hillslope water runoff, soil detachment and soil loss covering 630 000 km^2 across the Midwest US. These estimates are reported daily and publicly at the hydrologic unit code 12 watershed resolution (approximately 100 km^2). We (Eduardo Luquin, Chelsea Ferrie, Brian Gelder, Daryl Herzmann, Emily Zimmerman, David James, Richard Cruse and Thomas Isenhart) developed the Overland Flow Element tool [OFEtool]) that downscales the watershed scale of DEP to estimate average runoff and soil displacement within a field, helping to locate erosive hotspots at multiple scales. The advantages of the OFEtool compared to other models are related to the use of an event-based modelling approach, such as DEP, with updated soil loss estimates based on temporal changes in climate inputs and land use and management. Results indicated that the spatial distribution of vulnerable fields (and parts of the fields) followed a similar trend as other tested indices. However, the risk level associated with each tool differed.

4) Gully erosion degrades our critical soil resource. Machine learning models have proven effective in mapping soil erosion susceptibility, at least for selected terrains. However, in areas with different terrain complexity, these models show significant differences in identifying in optimal spatial resolution and algorithms. Gully erosion susceptibility mapping in two small watersheds: one located in the complex terrain of the Loess Plateau and the other in the relatively flat terrain of the Northeast China Mollisol region, was used to test for differences in optimum resolution for model inputs. This study, conducted by Annan Yang, Chunmei Wang, Qinke Yang, Guowei Pang, Yongqing Long, Lei Wang, and Richard M. Cruse, indicates: 1) significant differences in optimal resolution of gully erosion susceptibility mapping exists in the two regions, 1–2.5 m for the Mollisol region, and 2.5–5 m for the Loess Plateau. The extreme boosting tree (XGBoost) algorithm delivered the best simulation results vs. the random forest (RF) and gradient boosting decision tree (GBDT) in both regions. 2) Slope gradient and contributing area impacted gully distribution in both watersheds, while land use in the Loess Plateau and distance from streams in the Mollisol region were most important. 3) Twenty five percent of the Loess Plateau area was highly susceptible to gully erosion, while only 1% of the Mollisol watershed was highly susceptible.

Virginia Tech (Ryan Stewart)

1) To provide recommendations for vineyard soil management that enhances wine-grape quality and soil health, by December 2025.

University of Delaware (Yan Jin)

- Conducted evaporation experiments at the interface, pore and column-scales to examine the influence of a PGPR on saltwater evaporation.

University of Wisconsin – Madison (Jingyi Huang)

- We organized a series of outreach events on 2024 Ag Discovery Day at Wisconsin State Fair Park and Wisconsin Science Festival (Science on the Square) to improve the diversity, equity, and inclusion of underrepresented groups particularly K-12 students in STEM disciplines

Kansas State University (Andres Patrignani)

1) Integrate multiple sources of soil moisture information to reduce uncertainty and create large-scale blended products.
2) Use digital images to quantify the amount of surface residue cover to assess erosion risk and the conservation tillage practices.

Montana State University (Jack Brookshire)

No activities for this milestone.

Oregon State University (Carlos Ochoa)

No activities for this milestone.

University of Florida (Ebrahim Babaeian)

1) Developed an initial version of pedo-transfer functions using convolutional neural networks that leverage multi-depth SOLUS100 maps to characterize soil hydraulic properties to improve agricultural water management and flood prediction in Florida.
2) Developed an initial version of a hybrid model that integrates field-scale passive microwave observations with physically based radiative transfer and machine learning models to provide root zone soil moisture estimates.

Connecticut Agricultural Experiment Station (Yingxue Yu)

We wrote a review paper in which we explored the challenges and opportunities of using treated wastewater (TWW) for irrigation, focusing on its variability, management strategies, and associated risks and benefits. We investigated factors influencing TWW quality, such as weather, household and industrial practices, and wastewater treatment infrastructure, and analyzed how these factors affected contaminant profiles and nutrient content. We examined current management strategies and proposed improvements or integrated frameworks for safe and sustainable irrigation. By reviewing case studies, we evaluated the impacts of TWW irrigation on crops and soil, identifying both successes and challenges. The paper highlighted the potential of optimized TWW practices to support sustainable water resource management in agriculture.

We evaluated the use of organic amendments to enhance soil water storage, increase soil carbon stocks, and reduce plant stress during drought conditions. Our focus was on kale, a high-value crop often grown in urban and small-scale agriculture where space is limited, and food security is important. Since irrigation on these farms is typically not synchronized with plant demands, we aimed to improve soil water retention, especially during high evapotranspiration. We tested organic amendments such as compost, leaf mulch, and manure to determine their impact on plant available water and soil carbon stocks. Our goals were to quantify the benefits of these amendments for water retention and evaluate their effects on crop yield and quality using plant drought stress indicators. The findings aimed to optimize amendment application for both plant water availability and soil carbon sequestration. We also carried out outreach to local farmers to promote sustainable and resilient agriculture practices.

USDA-ARS, George E. Brown Jr. Salinity Laboratory/UC-Riverside (Todd Skaggs, Ray Anderson, and Elia Scudiero)

Dhungel et al (2024) evaluated the use of OpenET in California citrus. The study showed that evapotranspiration assessment and modeling can be improved by integrating in situ eddy covariance and the Water and Energy Balance Model (BAITSSS) model. French et al. (2024) used in situ eddy covariance and remote sensing observations to estimate up to date crop coefficients for lettuce. Kandhway et al (2024) discussed increases in seasonal water uses in almond and pistachio crops due to climate change. They provided new information regarding crop growth, chill requirements and vulnerability to climate change. Climate change driven increase in seasonal water use in almond and pistachio crops. Li et al. (2024) analyzed relationship of soil moisture over time at hundreds of agricultural fields across the US. They showed that surface soil moisture is correlated with deeper soil layers and how these relationships are influenced at shorter scales by precipitation, evapotranspiration, climate, vegetation, and soil texture

Objective 4: Translate new concepts and methods to students, stakeholders, and the public
Utah State University (Scott B. Jones, Asghar Ghorbani, David A. Robinson (adjunct), and Morteza Sadeghi (adjunct)

1) USU taught environmental soil physics to a new group of undergraduate and graduate students and recruited a promising undergraduate student to work on our NASA-funded project as an M.S. level graduate student.

USDA-ARS, George E. Brown Jr. Salinity Laboratory/UC-Riverside (Todd Skaggs, Ray Anderson, and Elia Scudiero)

Scudiero et al. (2024) discussed novel means of integrating gamma ray spectrometry and apparent electrical conductivity sensing for particle soil fraction mapping in micro irrigated orchards to crop consultants via a trade journal publication.

Impact Statement

University of California, Riverside (Hoori Ajami)

This research has been focused on understanding of subsurface flow processes with a particular focus on groundwater recharge processes in mountain-valley aquifer systems, parameterizing subsurface hydraulic properties and croplands in numerical models. We shared our research results with various stakeholders at national and international conferences and local meetings. Our

research provides valuable information for sustainable water resource management in California and elsewhere.

University of California, Riverside (Jirka Šimůnek)

The HYDRUS models are continuously being updated based on the basic research carried out by the W5188 group. The HYDRUS-1D model was downloaded more than ten thousand times in 2024, and over sixty thousand HYDRUS users from all over the world registered at the HYDRUS website. We continue supporting all these HYDRUS users from the USA and around the world at the HYDRUS website using various tools, such as Discussion forums, FAQ sections, and by continuously updating and expanding a library of HYDRUS projects.

Additionally, we have added new capabilities to rigorously consider multiple new processes in the soil profiles, such as, for example, three processed-based root water uptake models, a new soil hydraulic property (Brunswick) model, etc.

Finally, in 2024 we have offered four short courses on using HYDRUS models in Europe, North America, South America, and Africa. Over 100 students participated in these short courses.

University of California, Davis (Thomas Harter)

- Our work has major impacts on nutrient management practices in irrigated agriculture.
- We have provided efficient and affordable new tools for assessing irrigation and nutrient management practices for their future impacts to groundwater, which is now being used by California to guide grower practices that better protect groundwater quality.
- Our exemplary and pioneering work in developing groundwater sustainability plans is shaping the future management of groundwater resources in basins with significant groundwater-surface water interactions.
- We are expanding our work with USDA NIFA funding into other western states.
- We are the technical service provider for the California water rights division in the State Water Board to provide guidance on drought emergency curtailment orders.

University of California, Davis (Majdi Abou Najm)

Agrivoltaics touches on a wide range of broad public interest topics, from saving water to improving soil health, to generating green energy while producing food, to agricultural resilience, to food and energy safeties. Our work is demystifying Agrivoltaics to farmers and proving more details and information on this dual-use technology. Many of the attendees of the agrivoltaics conference expressed how appreciative they were for learning about agrivoltaics and identifying resources and contacts in this area.

Agrivoltaics is a new technology that is quickly gaining the interest of our growers, but we don’t have much information about it in California. So far, there is no single Agrivoltaics farm in the

entire state, and this is the gap my group is trying to fill. Many growers have expressed interest in testing agrivoltaics in their land, and many found this work inspiring and helpful in different aspects of the way they handle their farms. We are currently securing some funding to help some pioneering growers to build some of those modules in their lands with the hope that this can bring visibility to agrivoltaics and expedite its scaling. We are also working on understanding the legislative, financial and socioeconomic aspects of agrivoltaics with hope that this will aid growers understand what options they have and how agrivoltaics can be a potential solution that they can explore.

University of California, Davis (Helen E. Dahlke)

The conducted research created improved understanding of water flow and solute transport processes in the unsaturated zone. Specifically, we learned that:

- Development of 1D models to simulate mobile-immobile vadose zone flow and transport are useful to estimate contaminant transport across multiple soil textures in response to intentional flooding for groundwater recharge.
- Subsurface heterogeneity and specifically the fraction of sand present in the subsurface control the degree of preferential flow present in the vadose zone and can vary travel times by up to 38 %.
- Analysis of the transport of pesticide residues under AgMAR showed that profiles with a higher sand content demonstrated more pronounced preferential flow, faster water flow, higher groundwater recharge efficiency, but also more soil pesticide and salt leaching correlating with increased risks of groundwater contamination. Choosing fewer mobile pesticides (e.g., *chlorantraniliprole* and *methoxyfenozide*) and extending the time interval between the last pesticide application and the Ag-MAR event are important for reducing groundwater pollution risks. In contrast, profiles with finer textures showed less preferential flow, slower water flow, lower groundwater recharge efficiency, but raised concerns about the accumulation of pesticides or salts and elongated anaerobic conditions in upper soil layers due to capillary barriers, which could severely impact soil structure, biochemical reactions, and crop growth.

Desert Research Institute (Markus Berli)

Improved our understanding of the water dynamics of desert soils and their impact on desert hydrology with respect to soils of reduced wettability and structural stability.

Washington State University (Markus Fleury and Joan Wu)

Our research has shown that micro- and nanoplastics are mobile in soils, and that these plastics can move from the source of deposition to ground- and surface waters, ultimately being transported to the ocean. Our research has informed federal legislation to amend the 2024 Farm Bill with the "Research for Healthy Soils Act: Microplastics in Land-Applied Biosolids and Farmland" which outlines research priorities to quantify the amounts and impacts of micro- and

nanoplastics in biosolids and farmland. For this act, we have formulated the following research priorities:

(A) conducting surveys and collecting data on microplastic concentration, particle size and chemical composition in land-applied biosolids on farmland.

(B) the development or analysis of waste-water treatment techniques to filter out or biodegrade microplastics from biosolids intended to be used for agricultural purposes.

(C) conducting an analysis of the impact on agricultural crops and soil health of microplastics in land-applied biosolids on farmland.

(D) conducting research to better understand how wastewater processing impacts microplastics; and

(E) conducting research to better understand the fate, residence time, and transport of microplastics on farmland

University of Wyoming (Thijs Kelleners)

- Hydrological monitoring data and geophysical measurements are used in combination with numerical models for (sub-)surface water flow to determine subsurface structure, hydraulic properties, water storage, and flow regime for forest and rangeland hillslopes and watersheds
- A 1-D soil water, heat transport, and solute transport model is improved to better predict soil-plant-atmosphere water, heat, and carbon exchange in cold regions where snow cover and soil freeze-thaw are significant

University of Arizona (Marcel Schaap, Craig Rasmussen, and Karletta Chief)

- A challenge facing the practitioners in the fields of crop production, environmental engineering, as well as climate, drought, and ecosystem service assessments is the availability of soil hydraulic properties (in the form of soil water retention and hydraulic conductivity) at high-resolution with respect to position and depth. Unfortunately, it is usually cost-prohibitive to use laboratory or field methods to measure such data for more than a few locations, let alone for a country as large as the USA. Soil experts from the University of Arizona, in Tucson Arizona, and Tianjin University in China combined high-performance computing and artificial intelligence to estimate soil hydraulic properties from existing gridded soils data sets available through the USDA-NRCS and other sources. The validated data sets describe nearly all locations (over 760 million points) within the contiguous USA at a resolution of 100 meters and seven layers up to 2.5 meters deep.
  The gridded “open” GIS-ready data sets contain standard hydraulic parameters as well as their covariance that are immediately useful in common soil water and solute transport

models. The maps should also be useful for improving drought and flood assessments. The work is presently being extended for global applications.

- Through the Indigenous Climate Hub funded by the Waverley Street Foundation, we have awarded $500,000 to 10 tribal community partners of $50K each to do environmental projects on climate adaptation, soil health, environmental conservation, food-energy-water security just transition and more. With many conversations with tribal leaders, tribes asked us to deepen partnership locally and are engaging with the Hopi Tribe, Tohono O'odham Nation, Pascua Yaqui Tribe, and San Carlos Apache Tribe. Central to this tribal partnership building is connecting tribes with faculty at the University of Arizona to conduct research with the tribes.
- A key accomplishment was the piloting of off-grid water systems on the Navajo Nation who are impacted by mining and where tribal citizens are drinking non-potable water. These systems were co-designed by Navajo NGOs, Navajo residents in partnership with University of Arizona and co-led by V. Karanikola (UA CHEE). Water quality was characterized, and a decision portal was created and led by Joe Hoover.

Utah State University (Scott B. Jones, Asghar Ghorbani, David A. Robinson (adjunct), and Morteza Sadeghi (adjunct)

- Fabrication and testing of our NASA-funded automated root modules have been successful and we are poised for additional funding for the next phase to support flight hardware fabrication with plans to launch our root modules to the ISS for incorporation within the Ohalo plant growth chamber being developed at Kennedy Space Center.

Grants:

- NASA - Wyoming EPSCoR - $100,000. (Sci-PI: J. Chen, Co-I: S.B. Jones) Sep2024-Aug 2025
  Biophysics-based rhizosphere-water and -carbon management for inhospitable soils using engineered lunar or Martian regolith simulant
- USGS - A104G, $499,681 (PI: W. Zhang, Co-I: N. Barth, S.B. Jones) Jan 2024-Dec 2025
  Quantification and projection of the conus water budget using a hierarchical modeling system

University of Nebraska (Aaron Daigh)

1. Artificial Intelligence in Agricultural Research. Artificial intelligence (AI) is transforming agricultural and environmental research by enabling unprecedented insights and efficiencies. Our work underscores the importance of clear communication about AI's potential and limitations, fostering trust and collaboration among researchers and the public. By providing guidelines for transparent reporting, we aim to accelerate ethical AI adoption across disciplines, driving innovations in sustainable farming and climate resilience. Continued emphasis on integrating AI will ensure its responsible use in addressing global challenges.

2. Managing Salinity with Subsurface Drainage. The Northern Great Plains faces significant agricultural challenges due to saline soils, which threaten crop productivity. Over nine years, our study demonstrated that subsurface drainage significantly reduces soil salinity, improving groundwater quality and increasing crop yields in soybean, wheat, and corn systems. These findings validate subsurface drainage as a long-term strategy for sustainable agriculture in saline-prone regions, offering farmers a practical tool to combat climate-induced soil degradation. Moving forward, this research sets the stage for broader implementation and refinement of salinity management practices, safeguarding food security while enhancing environmental sustainability.

3. Calcium Amendments for Remediating Brine-Impacted Soils. Oilfield brine spills jeopardize soil health and water quality, posing critical challenges for environmental restoration. Our research pioneers the use of calcium acetate, a highly soluble amendment, to enhance water flow and reduce sodium content in brine-impacted soils. Compared to gypsum, calcium acetate offers superior performance, facilitating faster remediation and restoring soil function. This innovation holds promise for accelerating land recovery in oil-producing regions, reducing ecological damage, and protecting water resources. Future efforts will focus on scaling this solution to meet the demands of remediating widespread brine contamination.

4. Understanding landslides in North Dakota. Landslides in North Dakota, though often understated, cause extensive economic and environmental damage. Our study analyzed over 66,000 landslide events, identifying key geological and climatic factors that contribute to slope instability. This knowledge enables more accurate risk assessments and proactive mitigation strategies, protecting communities and infrastructure. By advancing our understanding of landslide dynamics, we are equipping stakeholders with the tools to reduce future risks and foster resilience in vulnerable landscapes

5. Phosphorus Saturation in Reservoir Sediments. The Des Lacs Reservoir System faces persistent hypereutrophic conditions driven by phosphorus-saturated sediments. Our research highlights the critical need for innovative phosphorus management strategies, as sediment-bound phosphorus continues to fuel harmful algal blooms. Addressing this challenge is essential to restoring aquatic ecosystems, protecting biodiversity, and ensuring safe water supplies. Future efforts will focus on developing integrated solutions to manage phosphorus at both sediment and watershed levels, offering a path toward healthier water systems.

6. Resilient Ornamental Grasses for Stormwater Management. Urbanization intensifies stormwater challenges, but strategic planting can mitigate these impacts. Our study identified ornamental grasses that thrive under the cyclical flooding, drought, and submergence typical of rain gardens and bioretention systems. These grasses not only enhance aesthetic value but also improve stormwater management by stabilizing soils and filtering pollutants. By informing species selection for urban green infrastructure, our work empowers communities to build more resilient cities, addressing flooding risks while promoting ecological sustainability.

7. Quantifying Greenhouse Gas Impacts of Cover Crops. Cover crops are vital for sustainable farming, yet their greenhouse gas emissions remain underexplored. Our research quantified the carbon footprint of rye cover crops and developed machine learning models to predict emissions with remarkable accuracy. These insights reveal that cover crops can significantly reduce carbon dioxide equivalence under certain conditions, positioning them as a critical tool for mitigating climate change. Future work will refine predictive models and optimize cover crop management to enhance their environmental benefits.

Oklahoma State University (Tyson Ochnser)

- This research includes ongoing scientific and career mentoring for three PhD students.
- This research engages soil scientists within NRCS to help adjust research outputs to stakeholder needs and interests.

Texas A&M University (Binayak P. Mohanty)

Our multi-scale process studies linked numerical models, and innovative data analyses have provided efficient tools and techniques to address wide spectrum of challenges related to soil and environmental sciences, including water management, crop production, ecosystem resilience, climate forecasts, flood and drought prediction, groundwater recharge estimation, GHG emission, and soil pollution characterization. Specifically:

- Developed high resolution data for soil water management for precision agriculture.
- Provided better skills for hydrologic and climate models.
- Enhanced estimates for soil health and groundwater pollution.

Texas A&M University (Briana Wyatt)

- Future applications of EMI data have potential to reduce overuse of fertilizers and irrigation water, reducing environmental impacts of nutrient runoff and leaching and conserving water resources.

Louisiana State University – Agriculture Center (Xi Zhang)

- Provide local producers in Louisiana with baseline information on regionally appropriate management practices that improve soil functioning and promote the adoption of cover cropping practices to enhance productivity, profitability, and sustainability in the agroecosystem.
- Deliver lectures and outreach articles to growers and agricultural research stations in Louisiana on using conservation agriculture practices to improve agricultural system productivity.

- Receive support from federal funding agency and state and regional commodity boards.
  - Dodla, S., J. Wang, B. Tubana, M. Kongchum, C. Jeong, **X. Zhang**, N. Adusumilli and D. Morgan. Demonstration of climate-smart agricultural solutions for sugarcane and rice production in Southern U.S.A. *U. S. Department of Agriculture-Natural Resources Conservation Service, Conservation Innovation Grants*. Jul. 2023-Jun. 2026.
  - Jeong, C., J. Wang, M. Kongchum and **X. Zhang**. Climate-smart strategies of water management-cover crop system to enhance productivity, greenhouse gas mitigation, and soil health in rice production. *U. S. Department of Agriculture-Agriculture and Food Research Initiative*. Oct. 2023-Sep. 2026.
  - **Zhang, X.**, Y. Fan and C. Jeong. Exploring the potential of using cover cropping for making soil resilient to extreme weather and promoting weather-proofing agriculture. *U. S. Geological Survey through Louisiana Water Resources Research Institute*. Sep. 2023-Aug. 2024.
  - **Zhang, X.**, and C. Jeong. Untangling the soil-roots interactions in agroecosystem under cover cropping management. *LSU-AgCenter Center of Research Excellence in Plant Biotechnology and Crop Development*. Sep. 2023-Aug. 2024.
  - **Zhang, X.**, and C. Jeong. How does cover crops impact soil water dynamics and soybean production in Louisiana. *Mid-South Soybean Board*. Apr. 2023-Mar. 2026.

University of Kentucky (Ole Wendroth)

- Even though the solenoids of the VR center pivot system were dysfunctional for the season, one result was that yield depressions occurred in the clayey zones of the field that are found in backslope areas where the silt-loam former A-horizon was eroded long time ago and sedimented in foot-slope areas within this field. Soil water content observations show that the profile water storage in these clayey zones fell below the 60 % plant-available water limit which is considered the trigger point for initiating irrigation. We will work with the farmer this coming growing season (winter wheat followed by double-crop soybeans) to monitor water availability in clayey areas in the field and indicate the necessity of irrigation. Farmers usually do not irrigate winter wheat in Kentucky. It will be of interest to study whether or not irrigating at least clayey areas during the wheat growing season will help avoid plant water stress and yield depressions.
- For growers, we conclude from the results of this study growing any type of cover crops or having a weedy surface cover keeps the soil structure intact and the macropore system open for high water infiltration rates. Given the fact that increased rainfall intensity is observed as a consequence of climate change, growing cover crops in combination with no-till are an important strategy under on-farm conditions to maintain a pore system whose vertically continuous macropores allow the intake of heavy and high-intensity rainfall. The soil physical techniques and methods used in this experiment are efficient and useful for quantifying soil structural quality and effectiveness of macropore systems to contribute to rapid water infiltration. Farmers would probably not use tension infiltrometers to quantify soil structure in their fields. Nevertheless, farmers can easily examine soil structural quality in their fields by observing the land surface during and after high-intensity rainfall events, and whether or not puddles develop at the surface, and

crop residues at the land surface are floated by ponding water and surface runoff and are transported to low elevation positions downslope. We also conclude that the effect of cover crops on soil structure and important soil physical state variables and processes needs to be investigated on-farm for the reason that farmers' fields experience much more traffic during the operations, especially during harvest than university experimental research farms. Heavy machinery is running over the field causing soil compaction and possibly soil degradation under on-farm conditions. Besides doing research on university experimental farms, we need to monitor soil structure in real-world farms!

- The review pointed out that non-disturbing, non-disruptive tillage systems are important management methods for meeting one of the biggest challenges associated with climate change, i.e., high rainfall intensity. On-farm research in no-till systems and their modified versions are an urgent necessity for improving tillage systems and avoiding soil degradation that is currently taking place.

For the broader public:

a) Variable rate irrigation allows the farmer to apply water across their field based on site-specific needs by avoiding water stress in zones that are problematic due to their high soil clay content causing lower plant available water than in other areas. The consequence of optimizing water application rate and time is maximizing the water use efficiency and the use of other inputs such as fertilizer nutrients. This leads to three benefits for the public: i) higher quality of the harvested produce, ii) minimizing environmental hazard caused otherwise by nutrient leaching or trace gas emissions, iii) improving the farm economy by maximizing the resource use efficiency. The broader public is served through a cleaner environment, higher quality food, and strengthening of local farms.

b) Our results on the effect of growing cover crops within cash-crop rotations have shown that any biomass that is produced in agricultural fields during the time period between two cash crops improves soil structure and helps avoiding environmental damage that would otherwise be caused through soil erosion. Cover crop root systems keep the soil pore space open to store water for the following crop. This increases production in and productivity of farmers' fields and environmental quality. The results also demonstrate that growing biomass or its residuals left at the land surface helps minimizing erosion and nitrous gas emissions. This should be considered for construction work, especially soil areas alongside streets / highways that are under construction.

c) The science community of those engaged in soils and their tillage, i.e., ISTRO, has made substantial progress over the last 50+ years. Despite the fact that no soil scientist was included in the definition of the UN Sustainability Development Goals, soil scientists' input is necessary to help "end hunger" (goal 2), "take action to combat climate change" (goal 13), and "protect terrestrial ecosystems" (goal 15), as the recent report of Secretary General António Guterres reveals: "…Only 17 % of the SDG targets are on track, nearly

half are showing minimal or moderate progress, and progress over one third has stalled or even regressed."

North Carolina State University (Josh Heitman)

Our work examines soil structure at a variety of spatial and temporal scales in order to better understand and manage important soil processes. These processes include water retention and infiltration, the exchange of gases, dynamics of soil organic matter and nutrients, root penetration, and the soil's vulnerability to erosion.

Iowa State University (Robert Horton, Elnaz Ebrahimi, Richard Cruse)

1) We determined thermal diffusivity (α) variations within three central Iowa fields under long-term tillage practices and to estimate the required number of measurement sites within each field to determine α at a specified precision. Three fields received different tillage operations: one was moldboard plowed followed by spring disking (MP), another was chisel plowed followed by spring disking (CP), and the third was ridge no-tilled (RN) slot planted. The minimum number of samples needed to obtain a confidence interval of 7 cm^2 h^{-1} for α was two, five, and seven, respectively, for the CP, RN, and MP fields. The MP field had the largest mean α value and required the largest number of samples to determine α at a specified precision.

2) Quantifying evapotranspiration (*ET*) in rainfed cropping systems can be challenging due to site-specific soil, plant, and management factors. Tillage practices and planting patterns can lead to large variations in soil water status and maize plant density, which impact *ET*. Previous studies showed that near-surface soil water content (□) observations at multiple scales provided a potential way to estimate surface soil water fluxes. In this study, we introduced a new method to estimate daily field *ET* by using a soil water flux model mainly based on the time-series of □ at a depth of 2.5 cm. The new method required a calibration of soil water diffusivity using maximum net water flux in the near-surface soil layer, which was related to the redistribution of precipitation below the canopy. Finally, the new method was evaluated using observed *ET* values over a 2-year period in a maize field with a double-row planting pattern, where independent measurements of soil water evaporation (*E*) and transpiration (*T*) were made with heat-pulse sensors and sap-flow gauges, respectively. Local field observations showed that *E* dominated water loss (16% of total *ET*) in the maize field during the seedling stage. As the canopy fully developed, *E* sharply decreased to a value of 0.4 mm d^{-1}, and *T* dominated the water loss since the silking stage. The new method to estimate *ET* performed well during drying periods, while it tended to underestimate *ET* during wet periods with substantial infiltration into the surface layer. On rain-free days, the *ET* values estimated with the new method matched well with the measured *E*+*T* values, with

R^2 and RMSE values of 0.85 and 1.93 mm d^{-1}. Therefore, the new approach provided an effective way to quantify maize *ET*.

3) Agriculture is one of the biggest sources of nonpoint source pollution to surface water bodies. It is high priority to identify and target high-contributing agricultural fields and sub-field areas for reducing soil erosion and sediment delivery. The Daily Erosion Project (DEP) is a daily estimator of precipitation, hillslope water runoff, soil detachment and soil loss covering 630 000 km^2 across the Midwest US. These estimates are reported daily and publicly at the hydrologic unit code 12 watershed resolution (approximately 100 km^2). We (Eduardo Luquin, Chelsea Ferrie, Brian Gelder, Daryl Herzmann, Emily Zimmerman, David James, Richard Cruse and Thomas Isenhart) developed the Overland Flow Element tool [OFEtool]) that downscales the watershed scale of DEP to estimate average runoff and soil displacement within a field, helping to locate erosive hotspots at multiple scales. The advantages of the OFEtool compared to other models are related to the use of an event-based modelling approach, such as DEP, with updated soil loss estimates based on temporal changes in climate inputs and land use and management. Results indicated that the spatial distribution of vulnerable fields (and parts of the fields) followed a similar trend as other tested indices. However, the risk level associated with each tool differed.

4) Gully erosion degrades our critical soil resource. Machine learning models have proven effective in mapping soil erosion susceptibility, at least for selected terrains. However, in areas with different terrain complexity, these models show significant differences in identifying in optimal spatial resolution and algorithms. Gully erosion susceptibility mapping in two small watersheds: one located in the complex terrain of the Loess Plateau and the other in the relatively flat terrain of the Northeast China Mollisol region, was used to test for differences in optimum resolution for model inputs. This study, conducted by Annan Yang, Chunmei Wang, Qinke Yang, Guowei Pang, Yongqing Long, Lei Wang, and Richard M. Cruse, indicates: 1) significant differences in optimal resolution of gully erosion susceptibility mapping exists in the two regions, 1–2.5 m for the Mollisol region, and 2.5–5 m for the Loess Plateau. The extreme boosting tree (XGBoost) algorithm delivered the best simulation results vs. the random forest (RF) and gradient boosting decision tree (GBDT) in both regions. 2) Slope gradient and contributing area impacted gully distribution in both watersheds, while land use in the Loess Plateau and distance from streams in the Mollisol region were most important. 3) Twenty five percent of the Loess Plateau area was highly susceptible to gully erosion, while only 1% of the Mollisol watershed was highly susceptible.

<u>Virginia Tech (Ryan Stewart)</u>

- Many localities implement tree pit structures within built urban hardscapes, for example in sidewalks or adjacent to other paved areas. However, concerns have been raised about the relative effectiveness of common tree pit designs, including the ability of the soil media utilized to support medium- and long-term tree growth along with their relative

effectiveness at retaining nitrogen and phosphorus against leaching or drainage losses. There is also uncertainty related to the effectiveness of under-drainage systems that are often used with tree pit designs. We partnered with an urban municipality (Fairfax County, Virginia) on a 3-year study to characterize and improve tree pit performance. We characterized typical growing media samples from several local vendors and analyzed those products for their chemical and physical properties. Then we performed simulated leaching experiments using laboratory columns and larger-scale outdoor mesocosms to quantify nitrogen and phosphorus leaching dynamics through time. Our detailed analysis of 22 pairs of adjacent tree planters where relative tree growth (good/bad) differed strongly revealed a surprisingly high degree of variability in rooting zone conditions between and across sites. There were no overall consistent explanatory differences in soil properties between good/bad tree pairs; however, high soluble salts, lower extractable phosphorus, lack of suitable soil media, compaction, strong vertical variability, inclusions of non-soil materials and poor planting practices appeared to influence tree health between many of the studied pairs. Our efforts to evaluate bioretention soil media revealed that dissolved organic carbon, nitrogen and phosphorus release occurs for some period of time following bioretention system installation, and these releases may initially exceed local ground- and surface water criteria. This release drops quickly for organic carbon and phosphorus, but extended nitrogen release can occur unless countered by vigorous plant uptake and net removal of biomass from the system. Current well- to excessively drained designs do not allow sufficient duration of saturation for denitrification reactions to occur, and modifications should be considered by regulatory agencies and localities.

University of Delaware (Yan Jin)

- Improved the understanding how bacteria may affect evaporation and soil water retention under saline conditions by affecting the timing and location of salt precipitation
- Improved understanding of how saltwater intrusion may impact nutrient release in coastal regions endangered by sea level rise
- Demonstrated the usefulness of stable water isotopes in interpretation small-scale biogeochemical reactions that has large scale implications of nutrient transport and greenhouse gas emission.

University of Wisconsin-Madison (Jingyi Huang)

- We have been awarded one USDA NIFA award to work on the spatial modeling of soil health properties using remote sensing and ground-based observations
- We have published 11 peer-reviewed papers and presented at various conferences and stakeholder meetings

Kansas State University (Andres Patrignani)

- **Deep Learning for Soil and Water Conservation:**
  Deep learning and image segmentation techniques enable accurate classification of field

images, which can enable researchers and field practitioners distinguishing soil, crop residue, and vegetation using mobile devices or inexpensive point-and-shoot cameras. Our research aims at developing decision-support tools that enhance soil and water conservation efforts by improving erosion risk assessment, residue cover estimation, and land management decisions.

- **Multiscale Blended Soil Moisture Products:**
  Integrating point-level and gridded datasets through model-data fusion can improve soil moisture estimation by leveraging sparse, but accurate, observations from weather networks with gridded products obtained from remote sensing or model outputs. This approach enhances spatial coverage and corrects soil moisture dynamics using in situ sensors. Proximal sensing from cosmic-ray neutron detectors can be used for collecting independent validation datasets at intermediate spatial scales (e.g., watershed). The overall goal is to leverage the strengths of each dataset: accuracy in the case of point-level observations and spatial coverage in the case of gridded products.

Montana State University (Jack Brookshire)

Our findings from our work in the Northern Great Plains of Montana emphasize the strong influence of plant community composition on C and N fluxes following fire. The combustion of juniper significantly affects N fluxes, driven by its high relative contribution to aboveground N storage, elevated foliar to total biomass N ratio, high wood N content, and heightened susceptibility to combustion. Thus, one consideration for the reintroduction of fire into semi-arid temperate grasslands experiencing WPE is the possibility of juniper driven fire N-losses redirecting the ecosystem towards an alternative ecosystem state. However, despite this long-term theoretical possibility, we observed that the increase in surface soil N stocks after fire nearly offsets estimated N losses from total tree mortality. This suggests the possibility of using prescribed fire to reintroduce biomass-immobilized N back to the soil, after long periods of fire absence.

Additionally, our results have implications for ecosystem C balance. Lower severity fires in WPE prone areas promotes greater survival of larger ponderosa trees, thereby shifting ecosystem structure and C storage towards larger and older trees. Furthermore, we observe increases in soil PyC indicating that a significant fraction of aboveground biomass consumed in the fire was thermally transformed and redistributed back to soils. While the exact functional properties and long-term fate of PyC are still poorly understood, PyC generally enhances ecosystem soil C persistence and can improve nutrient retention. Consequently, increased frequency of prescribed fires to manage WPE may promote ecosystem C sequestration over time in these cold semi-arid environments, facilitated by slow overall decomposition and the gradual accumulation and burial of PyC. Together, these findings underscore the importance of considering species-specific traits when planning fire management strategies at ecosystem-scales, particularly when goals include C storage or soil nutrient status.

Oregon State University (Carlos Ochoa)

- Understanding the dynamics of soil water transport through the vadose zone and into the shallow aquifer in rangeland ecosystems provides critical information regarding the potential for shallow groundwater recharge in arid and semiarid landscapes of the Pacific Northwest.
- Understanding the dynamics of soil water transport through the vadose zone and into the shallow aquifer in agroecosystems connected to riparian areas helps understanding potential hydrologic flow paths that may affect water quality in the stream.
- Understanding the relationship among carbon and water cycle components under different management practices (e.g., irrigation, brush control, re-seeding, weed control) is critical to better inform management and policy issues related to C sequestration potential and GHG mitigation from agricultural and rangeland ecosystems.

University of Florida (Ebrahim Babaeian)

1) The acquired knowledge enhances our understanding of water dynamics and hydraulic properties and their influence on agricultural water and nutrient management in sandy soils, contributing to the sustainability of surface and groundwater resources.
2) The developed data-driven modeling tools, in combination with ground and satellite observations, will play a crucial role in advancing hydrologic modeling, improving soil health in agriculture, mitigating climate change impacts, and ensuring the security and sustainability of soil and water resources.
3) The hybrid modeling framework that integrates the tau-omega radiative transfer model with machine learning algorithms provides field-scale root zone soil moisture estimates for agricultural water management, a capability currently unavailable from microwave remote sensing observations.

Connecticut Agricultural Experiment Station (Yingxue Yu)

Our research has demonstrated that micro- and nanoplastics are mobile in soils, capable of migrating from their deposition sources to groundwater and surface waters and eventually reaching the ocean. This work has contributed to federal legislative efforts, influencing the amendment of the 2024 Farm Bill with the "Research for Healthy Soils Act: Microplastics in Land-Applied Biosolids and Farmland." This act establishes research priorities to quantify and address the presence and impacts of micro- and nanoplastics in biosolids and farmland. The identified priorities include:

(A) surveying and collecting data on microplastic concentrations, particle size distributions, and chemical compositions in land-applied biosolids.

(B) developing or evaluating wastewater treatment techniques to remove or biodegrade microplastics from biosolids designated for agricultural use.

(C) analyzing the impacts of microplastics in land-applied biosolids on crop productivity and soil health.

(D) investigating how wastewater treatment processes influence microplastic characteristics and behavior; and

(E) studying the fate, residence time, and transport mechanisms of microplastics in farmland environments.

These research initiatives aim to inform sustainable agricultural practices and mitigate the environmental risks associated with micro- and nanoplastics in agricultural systems.

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