W4188 2022 Annual Report

Project Information
Project Number: W4188
Title: Soil, Water, and Environmental Physics to Sustain Agriculture and Natural Resources
Period Covered: 10/01/2021 to 09/30/2022
Date of Report: 03/01/2023

W4188 2023 Meeting Minutes
Format: Hybrid in-person (Desert Research Institute, Las Vegas, NV) and virtual via MS Teams
Dates: January 3-4, 2023 from 8 AM to 5:00 PM PT
Group annual reports are due on Monday, February 17, 2023
Minutes taken by Briana Wyatt, Texas A&M University

Former Chair: Fred Zhang
Current Chair: Andres Patrignani
Secretary: Briana Wyatt
Treasurer: Robert Heinse

Participants (39 in-person and 20 remote)
In-person attendance: Andres Patrignani, Scott Jones, Jingyi Huang, Jirka Simunek, Karletta Chief, Lin Chen, Markus Flury, Majdi Abou Najm, Chieh Yun Chang, Hoori Ajami, Manoj Shukla, Wei Zhang, Morteza Sadeghi, Asghar Ghorbani, Chihiro Dixon, Thomas Harter, Tim Green, Salini Sasidharan, Spencer Jordan, Teena Armstrong, Chenxi Li, Ole Wendroth, Yingxue Yu, Sean Collins, Michael Young, Ray Anderson, Jack Brookshire, Dedrick Davis, Todd Skaggs, Markus Berli, Hui Yang, Yan Jin, Robert Heinse, Karletta Chief, Sean Schaeffer, Yongwei Fu, Rose Shillito. Bin Chang, Victor Teng, Yusen Yuan, Jerry Brown.

Remote attendance: Briana Wyatt, Markus Tuller, Tamir Kamai, Isaya Kisekka, Felix Ogunmokun, Iael Raij Hoffman, Elia Scudiero, Scott Alan Bradford, Joan Wu, Thijs Kelleners, Cassandra Bonfil, Isaya Kisekka, Hassan Dashtian, Aaron Daigh, Ryan Stewart, Robert Horton, Tyson Ochsner, Kosuke Noborio, Robert Ewing, Menberu Meles, Helen Dahlke

W4188 2022 Annual Report

Day 1- January 3, 2023

1. **Business Meeting Minutes**
   a. Introduction of new members, 12 new members in person, 5 new online
   b. 23 states represented, 65 members in Appendix E, 107 individuals on listserv
   c. Annual reports due late March/early April
      i. Individual reports due to Briana by Feb 17
   d. Finances update
      i. Currently ~$6000 available, including registration fees from annual meeting
      ii. $15,000 awarded to group, needs to be spent
      iii. Discussion on how to spend funds- student travel awards, etc.
   e. Selection of new secretary
      i. Jingyi Huang nominated, approved as incoming secretary
   f. Selection of new Treasurer?
      i. Discussion on how finances are handled
         1. How do other multi-state projects deal with finances?
         2. Where is the best place to keep money?
      ii. Many members seem to favor the idea of having a long-term treasurer over a rotating treasurer.
   g. Annual meeting 2024
      i. CES is Jan 9-12
      ii. Tentative meeting dates: Jan 3-5, 2024
   h. Next 5-year proposal due early 2024
      i. Writing group met at Tri-Societies meeting in Baltimore, will continue to meet to discuss and write up proposal
      ii. Potential to use third day of 2024 meeting to work on proposal

2. **Session I Minutes:**
   a. Michael Young, UT-Austin
      i. TxSON network updates, Internet of Water, flood forecasting
      ii. We need to do a better job of making sure decision makers understand the importance of soil.
   b. Manoj Shukla, New Mexico State
      iii. Improving water use efficiency, irrigation with produced/brackish water
      iv. Impacts of using brackish water will vary depending on crop, irrigation system type.
      v. Farmers are not necessarily interested in using produced water because of the perception that it is dangerous.
      vi. Regarding land management practices, it is necessary to work at the farmer's field scale.
   c. Jingyi Huang, Univ. Wisconsin- Madison
      vii. Soil moisture mapping, spectroscopy, nitrate sensing
      viii. Threshold of 0.25 m3/m3 for soil moisture sensors is due to sandy soil used for testing.
      ix. CO_2 chambers are specially designed to be opened and closed each hour.
      x. Nitrate sensor- working to account for temperature dependance.
   d. Ole Wendroth, Univ. Kentucky

   xi. Variable-rate irrigation applications and scheduling
   xii. Field- or landscape-scale studies needed to determine what level of error is acceptable for soil moisture sensors. Is it necessary to optimize absolute measurements, or is it more useful to focus on relative measurements (anomalies, etc.)?
   xiii. Water savings and yield data are not yet available.

e. Scott Jones, Utah State and Morteza Sadeghi, California Department of Water Resources
   xiv. Calibration and sensor standards, estimating flux from single sensor
   xv. RE: Scott- When calibrating heat pulse probe in ice at -20 *C, ice melting did not apparently affect the measurements.
   xvi. RE: Morteza- Flux estimates have not been compared to lysimeter measurements- potential area for future studies.

f. Update on W4188 Vadose Zone article
   xvii. Sections have been compiled, some additional editing is needed
   xviii. Target submission- early 2023
   xix. Manuscript will serve as a guide for the 2024 W-4188 proposal

3. Session II Minutes

a. Isaya Kisekka, UC Davis
   i. Agricultural nitrate contamination of groundwater
   ii. Crops have varying potential for nitrate leaching. Rainfall variations also impact leaching.

b. Hoori Ajami, UC-Riverside
   i. Groundwater dynamics in mountainous regions
   ii. Currently, isotope partitioning studies are used primarily in surface water studies, but there is potential for using these methods at depth and/or at multiple depths to gain a better understanding of entire systems.

c. Thomas Harter, UC-Davis and Spencer Jordan
   i. Groundwater-food nexus
   ii. High VWC values are likely a result of preferential flow at some depths.
   iii. High measured concentrations of nitrate are due to reduced irrigation applications; model results agree well with measurements.

d. Salini Sasidharan, Oregon State
   i. Managed aquifer recharge in Oregon
   ii. There is interest from producers in installing drywells, but it is unclear how those wells and their impact on groundwater quality would be monitored moving forward.
   iii. There is little regulation currently with regard to injection water quality unless there is a nearby drinking water well.

e. Ray Anderson, USDA-ARS
   i. Simulating ET and irrigation water salinity impacts
   ii. Discrepancies between energy balance model and CS-655 sensors is due to differences in modeled root zone and sensor installation depth.
   iii. Only surface or groundwater data were simulated as irrigation source for each year, never both in the same year.

4. Session III Minutes

a. Yan Jin, Univ. Delaware
    i. Investigate the role of preferential flow on biogeochemical processes such as carbon dynamics;
    ii. Measure effects of bacteria on soil water retention, evaporation and infiltration;
    iii. Examine the role of soil colloids on soil organic carbon retention and transport;
    iv. Measure saltwater evaporation from heterogeneous soil.
b. Sean Shaeffer, Univ Tenn.
    i. Impacts of soil physical characteristics on soil microorganisms, carbon cycling
    ii. No microbes were added to soil; study only measured those existing in the soil.
    iii. Results would likely be different if experiment was carried out using variable temperatures as in nature.
c. Yongwei Fu, NC State
    i. Soil structural determination from thermo-TDR
    ii. Future work may extend to larger scales than thermo-TDR sensing volume; multiple sensors may be able to provide information at a larger spatial scale.

Day 2- January 4, 2023

5. **Session IV Minutes**
    a. Jirka Simunek, UC-Riverside
        i. Update on new Hydrus model and modules
        ii. Gravity term can be changed within Hydrus; will allow for simulation of conditions outside Earth.
        iii. Uptake of chemicals in plants- active or passive? Both are possible, you can select which one you want to use or partition portions of uptake to each method.
    b. Wei Zhang, Michigan State
        i. Environmental pollutants, plant uptake
    c. Yingxue Yu
        i. Weathering of biodegradable plastics
        ii. Impacts of biodegradable plastics on air quality? Not clear, but an area for future studies.
        iii. Plastics persist in environment for long periods- how do we quantify plastic fluxes in the environment? We do not have a good understanding of transport of these particles at large scales.
    d. Majdi Najm
        i. Agrivoltaics, impact of agricultural practices on soil structure
        ii. Are certain wavelengths more efficient in generating solar electricity? Yes., though more research is needed.
        iii. Agrovoltaics systems are designed to be installed above the height of the farmer's equipment.
        iv. Similar concept in rangelands- range voltaics.
    e. Dedrick Davis, Alabama A&M
        i. Soil hydrology, amendments, and health
        ii. Soil samples have been collected from places where infiltration was measured, samples are in processing now.
        iii. Community garden provides unique opportunity for urban soils research and public education efforts.

f. Robert Heinse, Univ. Idaho
    i. Soil water stress in microgravity, optimizing water use in Palouse, Western Water Network
    ii. Automated water systems in space often over-water because systems are designed under different conditions.
g. Tim Green, USDA-ARS
    i. COSMIC soil moisture measurements
    ii. Lattice water content data from the literature were used in calibration.
    iii. Measured data were weighted equally because measurements were more dense near sensor.
h. Jerry Brown, Oklahoma State
    i. Upscaling in-situ sensors
    ii. Rover speed affect relationship?
i. Rose Shillito, USACE
    i. Wildfire impacts on water infiltration
    ii. Tension infiltrometers and ring infiltrometers were both used to measure sorptivity; tension infiltrometers are likely more accurate but are harder to use.
j. Andres Patrignani, Kansas State
    i. Update on Kanza Pulse network
    ii. SMAP error relative to measured in-situ values may be because of terrain, which has many slopes. SMAP may not account for surface roughness. Also, a portion of SMAP pixel falls outside watershed.

6. Discussion of Renewal Proposal

The plan is to have a tentative draft so that the group can work during the 2024 annual meeting. Below are the salient topics and notes from the group discussion centered on the three key objectives of W4188: Fundamental processes, methodologies and instrumentation, and applications.

Jamboard URL link: https://jamboard.google.com/d/1jP7bu1M1m2whO29Y7oPf70lF5BafC30-sp-9MOrculE/viewer?f=0

What is the next big thing that soil physics and vadose zone research needs to focus on? Consider topics like climate change, food security, and renewable energies

- Climate change: Study the role of soil physical properties on greenhouse gas emissions of nitrous oxide and methane.
- Soil function and soil resiliency
- Sensors and decision-support systems
- Deep vadose zone processes
- Define state-specific challenges within the water-food-energy-climate nexus
- Physics of porous media for food production in extraterrestrial soils
- Improve the definition of soil health from the perspective of soil physics

What soil physical and vadose zone processes need substantial understanding? Focus on the process and be specific (e.g., infiltration under post-fire conditions)

- Improve understanding of preferential flow and its role in biogeochemistry

- We need models that simulate soil water flow that operate at the pore level and include pore geometry
- Coupled heat and mass transfer processes in non-rigid soils
- Measurement and modelling of water flow in stony/rocky systems
- Process level understanding of aggregation
- Parameterization of models in the absence of soil data. Case for locations outside of the United States with limited soil information and soil geodatabases

What are soil physical and vadose zone processes that we still struggle to measure and for which we need innovative instrumentation and methodologies?

- Groundwater and vadose zone interactions. There is need for geophysical tools to better quantify subsurface heterogeneity. There is also need for improved translation of geophysical images into hydrologically relevant properties.
- We need to consider artificial intelligence and robotics
- Upscaling and downscaling. Use of satellite based technology, proximal sensing, and in situ non-invasive instrumentation.
- Measure dynamic changes in soil water retention properties
- Study nanoplastics quantification, characterization, and transport in soils.

What are the needs in terms of applying new concepts and methods to improve soil and water management?

- Making our science more actionable; working with stakeholders and decision makers. Improved pedagogy (teaching) methods. Incorporate more hands-on experiences (lab and field sessions). Address declining knowledge levels in incoming students. Improve outreach to get more students interested in soil physics
- Develop open data APIs, standardize data formats and protocols to integrate outputs across networks. and test new datasets like Open ET
- Use of remote sensing combined with models to derive soil data for applications in data-scarce regions.

Accomplishments

Short-term outcomes

Oregon State University (Salini Sasidharan)

- Proposed new design for small diameter drywells for enhanced groundwater recharge.
- Explored physical drivers of isotopic separations using 650 different model configurations of soil, climate, and mobile/immobile soil-water domain characteristics, without confounding fractionation or plant uptake effects
- Examined the complex vadose zone hydrology of fine-textured (gley) agricultural soils influenced by a shallow and dynamic groundwater levels.

University of California-Riverside (Hoori Ajami)

- Developed a method to assess the impacts of uncertainty in precipitation and temperature datasets on the water budget of a mountain catchment in the Sierra Nevada
- Developed a detection and attribution method based on the hydrologic modeling and time series data mining methods to understand causes of the Salton Sea decline in California
- Improved vegetation parameterization in integrated land surface –groundwater models using evapotranspiration partitioning data
- Contributed to developing a computationally efficient hydrologic model at hillslope scale

Alabama A&M University (Dedrick Davis)

- Soil hydraulic properties measured in-situ differ spatially and temporally under different land uses.
- Water retention and hysteresis for poultry litter and two highly weathered soils differed significantly for relatively dry conditions.
- Biopolymers used for soil stabilization alter soil hydraulic properties.
- Biochar affected soil thermal properties at water contents below field capacity

Kansas State University (Andres Patrignani)

- Developed a database of soil physical properties for the Kansas Mesonet. The database contains soil hydraulic and thermal properties for more than 300 soil samples.
- Tested soil water retention curves conducted using traditional and modern instrumentation.

Texas Tech University (Sanjit Deb)

- Developed and evaluated the potential use of generalized regression neural network (GRNN) to identify the optimal set of soil features to predict Ksat under arid and semi-arid environments.
- Demonstrated the production and beneficial impact of biochar amendments for vegetable crops under soil- and plant-based deficit irrigation strategies.
- Demonstrated the integration of biochar and deficit irrigation as a water-saving strategy to enhance root zone soil water and minimize crop yield losses to develop effective cropping systems

- Evaluated the spatial patterns of soil microbial communities and influencing factors for soil health assessment and site-specific management to improve crop production.
- Developed and evaluated soil-optimized early-season planting options under field conditions for cotton germplasms that have been identified to exhibit ≥80% germination ability and seedling vigor in response to low temperature stress under controlled conditions.
- Demonstrated and modeled soil water dynamics in the semiarid soil-cotton-atmosphere systems under various agronomic conditions, including deficit irrigation strategies, adverse effects of cotton-weed interactions, early season planting options, and various biochar amendments application.

<u>Oklahoma State University (Tyson Ochsner)</u>

- Seasonal streamflow forecasting methods were developed building on existing, proven streamflow modeling approaches used by the Natural Resources Conservation Service (NRCS). These existing methods were enhanced through the incorporation of remotely sensed soil moisture and terrestrial water storage data, which are increasingly available but thus far not widely utilized in operational streamflow forecasting. The resulting forecasts explained >70% of the variance in streamflow totals for the upcoming season in five watersheds across the US Great Plains.

<u>Iowa State University (Bob Horton) and North Carolina State University (Josh Heitman)</u>

- We developed methods to estimate soil hydraulic properties from thermal and electrical conductivities.
- We showed that applying of compost to soils reduced runoff volumes, improved runoff water quality, increased vegetation establishment, and influenced heavy metal mobility.
- We investigated the performance of TDR and heat pulse sensors in high salinity soils and in heterogeneous soils.

<u>Texas A&M University (Binayak Mohanty)</u>

- Developed new functional characterization/understanding of microorganisms growth/decay in vadose zone and the associated controlling factors. These findings provide new predictive modeling tools for microbially-driven carbon cycle in soil systems leading to GHG emission.
- Developed a new method for effective hydraulic parameterization of catchment-scale aquifer. Using the Dupuit-Boussinesq aquifer in the National Water Model (NWM) showcased the dynamic coupling between vadose zone, ground water aquifer, and surface stream. This algorithm is being implemented in NOAA-Geo Fluid Dynamics Lab (GFDL) Earth Systems Model Land Model (LM) component now.
- Formulated a new advanced data fusion algorithm for generating high spatio-temporal resolution (daily 30 m) evapotranspiration (ET) estimates within large agricultural fields using eddy covariance and Landsat satellite based data. This provides potential for ET-based tools for precision water management in large agricultural fields.
- Using satellite remote sensing of soil moisture and vegetation greenness, insitu 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.

<u>University of California- Davis (Majdi Abou Najm)</u>

- 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. From invited talks to outreach with growers, my agrivoltaics work is finally receiving a wide public attention. Furthermore, I published a new model that solves for the main interactions at a plant leaf scale and allows for the separation of light spectra, in an effort to start to understand and model the effect of shading that agrivoltaics result in and how optimizing the light spectra of soils can be effective for maximizing the benefits and returns from our working lands. The paper concluded that if we create panels that can harvest specific light spectra, then in a sun non-limited area (Ex.: California's central valley and for a wide range of crops) we can get great efficiencies by providing the plants mostly with the red light spectra (less energy per photon, thus assimilating carbon and building biomass with less energy leading to less transpiration, thus better water use efficiency), while harvesting a big part of the blue spectrum for energy since it has more energy per photon.
- In addition, my work on two significant reviews came to fruition with having those reviews compiled, written and accepted in two very well respected and high impact journals (papers will appear as 2023 publications). Those targeted (1) the effect of soil structure on soil infiltration and its hydrological properties; and (2) the effect of cover crops on the soil physical, chemical and biological properties. Each of those two reviews is a full summary of peer reviewed published literature and were summarized in a way that allows for technical and non-technical audience to understand and appreciate. Last but not least, I completed an optimization model that adds nitrogen to the water-energy-food nexus. This is not a trivial effort as the bulk of water-energy-food nexus research focuses on the downstream part of the problem, which is the allocation of those resources as a balance between supply and demand. They often ignore the upstream and more technical part of it, which focuses on the physical and biogeochemical interactions at the soil-water-plant-atmosphere system. To that effect, we added the nitrogen cycle to those biophysical interactions and updated the optimization problem to incorporate nitrogen.

<u>University of California- Davis (Thomas Harter)</u>

- Maintained highly efficient water and nutrient management practices in almond orchard of a 140-acre commercial operation, with nutrient use efficiency above 90%.
- Implemented first-ever California AgMAR experiment that included not only soil sampling but also groundwater monitoring at three replicated monitoring sites.
- Reached out to well over 1,000 local, state, and federal policy- and decision-makers, researchers, and grower-representatives about nonpoint source pollution of groundwater and its sources, and about sustainable groundwater management.
- Provided grower representatives and regulators with efficient tools for assessing nitrate pollution from agricultural activities and to develop groundwater protection targets for 379 townships in the Central Valley.
- Submitted groundwater sustainability (management) plans for three California groundwater basins.
- Provided three groundwater basin stakeholder groups with scientific information on potential future groundwater management scenario outcomes, which allowed the groups to better quantify groundwater management targets.
- Began development of a watershed model for the Scott Valley watershed
- Began development of a water rights database for the Scott Valley watershed
- Began updating the Scott Valley Integrated Hydrologic Model

- For the third time, taught COVID-19 appropriate, 5-week online short course (5 hours/week) to introduce groundwater hydrology, to water law, California's Sustainable Groundwater Management Act, and review of several case studies on a range of aspects in developing groundwater sustainability plans. 85 attendees: water managers, attorneys, teachers, growers, staff from local and state agricultural organizations, NGO staff, regulatory agency personnel
- 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

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

- The low-cost water sampler that we developed benefits the public by providing a new tool that researchers and regulators can use to prevent surface water contamination and impairment. This work was recently featured in CSA News magazine (doi: 10.1002/csan.20915).
- Our efforts to improve characterization of physical and hydraulic properties of soilless substrates allows producers to select growing media that has better water and nutrient-holding capacities, which helps to safeguard water quality and quantity for the public.
- One undergraduate student and two graduate students received training in data collection and curation, the scientific method and hypothesis testing, and scientific writing.

<u>New Mexico State University (Manoj Shukla)</u>

- Irrigation with brackish, RO and produced waters changes soil physical properties and germination, growth. and actual evapotranspiration rates of cool season grasses as well as chile.
- Demonstrated higher water use efficiency for chile using micro-gravity drip irrigation system.
- Optimizing planting density and irrigation depth of hydrid maize seed production under limited water availability. Research was done with China Agriculture University.

<u>University of Wisconsin-Madison (Jingyi Huang)</u>

- Developed machine learning based high-resolution soil moisture model for the continental USA
- Developed soil spectroscopy libraries for estimating soil properties and functions
- Developed printed soil moisture and nitrate sensors for nutrient transport modeling
- Developed soil gas emission monitoring sensor networks

New Mexico State University (Kenneth Carroll)

- Developed and compared electrical geophysical methods (resistivity and spontaneous potential) for soil and streambed sediment spatial characterization.
- Global distributions of per- and polyfluoroalkyl substances in the environment (literature review and meta-analysis of per and polyfluoroalkyl substances (PFAS) around the world).
- Developed a transient storage model parameter optimization using the simulated annealing method.
- Applied multiple chemical analysis methods to characterize produced water and surrounding surface water in the Permian Basin.
- Advised 7 graduate students as Chair, advised 2 postdoctoral researchers, and 3 undergraduate researchers.
- Developed international collaborators at China Agricultural University, China University of Geosciences, Univ. of Bern Switzerland, and Turkish Kocaeli University.
- External grants: $500K

Washington State University (Markus Flury)

- Developed an experimental technique to determine dynamic changes in contact angles at NAPL-water interfaces
- Demonstrated that biodegradable plastic mulches compare favorably compared to polyethylene mulches in terms of gas-exchange under field conditions
- Developed a spatially-distributed model to predict soil erosion based on landscape and soil characteristics

University of Kentucky (Ole Wendroth)

- We evaluated the identification of soil hydraulic property parameters in different zones of the field, and detected similarity between parameters in similar soil types and differences in parameters when different soil types were compared over a large scale. Hydraulic property parameters were inversely estimated within the Root Zone Water Quality Model (RZWQM2) which is a development of USDA-ARS scientists.
- Besides this on-farm irrigation and fertilization project, long-term cooperations on the following topics were continued during 2022. (In parentheses, the publication number is provided that is related to the specific field.):
    - Spatial variability of soil physical properties and modeling of spatial soil hydrologic processes at different scales (A146, A148)
    - Soil structure and its functions (A147, A152, A153)
    - Soil physical amendment using biochars (A149, A150, A154)
    - Agro-Ecosystem Models for simulating crop growth under different soil and crop management (151)

Montana State University (Jack Brookshire)

- We completed analysis of woody plant expansion (WPE) in the Northern Great Plains. Using remote sensing imagery and machine learning models, we determined the degree to which woody

plant expansion is contributing to vegetative greening and examined their respective environmental drivers.
- We completed a four-year experiment evaluating the carbon sequestration potential and greenhouse gas implications of bioenergy grass production using alternative cyano-fertilizers.
- We completed eddy covariance examination of gross primary productivity at our long-term subalpine grassland site.
- We completed work synthesizing the nitrogen isotope distributions across global montane tropical forest soils.
- We continued experimental work on the long-term effects of WPE and effects of prescribed fire in central Montana. We established a network of permanent vegetation and soil sampling plots and monitored ecosystem process before and after a large prescribed fire. We combine dendrochronology and biogeochemical measures to model the historical (1770- present) consequences of WPE and changes in fire regimes for progressive nutrient limitation of the vegetation carbon sink.

Desert Research Institute (Markus Berli and Dani Or)

- A model to describe the relationship between soil hydrophobicity and infiltration
- Methods to determine sorptivity of sub-critically water-repellent soil
- A method to assess the impact of fire on soil structure
- A model to simulate post-fire stream and debris flow

University of Florida (Ebrahim Babaeian)

- Developed a new data driven method for forecasting short- and long-term actual evapotranspiration based on ground and satellite remote sensing observations.
- Applying and testing a new radiometer sensor for high-resolution mapping of rootzone soil moisture in sandy soils in Florida.
- Conducting in-situ measurements of soil hydraulic properties using sensor pairing to improve irrigation efficiency in sandy agricultural soils in north central Florida.
- Supervising four graduate students (2 as a major advisor and 2 as advisory committee member).
- A national collaborative project focusing on developing new models for real-time soil water dynamics mapping from national soil survey data and remote sensing observations based on physics-informed data driven techniques was started.

Utah State University (Scott Jones)

- USU evaluated more than eight types of plant growth media for microgravity applications and peat-based growth media resulted in higher hydraulic conductivity and thus faster, more consistent growth rates than several synthetic media or calcined clay aggregates.

University of Wyoming (Thijs Kelleners)

- Incorporated the Fast Marching Method into a coupled hydro-geophysical model to calculate seismic travel times in the subsurface
- Incorporated the L-Curve Method into a coupled hydro-geophysical model to weigh the contributions of data misfit and model complexity to the model objective function

North Dakota State University (Aaron Daigh)

- Established water quality monitoring network in central North Dakota to evaluate linkages between soil microbial community structures and root zone losses of nitrates and phosphate in the vadose zone.
- Evaluated grass species tolerance to cyclical flood-drought, salinization, and submergence to simulate storm water retention zones.
- Evaluated algorithms for mapping high-resolution soil moisture across agricultural landscapes in the Red River Valley of the Upper Great Plains region by using machine learning with Landsat 8 imagery, soil characteristic maps, and regional weather mesonets.
- Evaluated a GIS database of landslide conditioning factors in North Dakota, including geologic formations, pore water salinity, inclination, etc.
- Evaluated tillage and cropping systems influence on soil water balances and salinization.
- Evaluated subsurface drainage effects on soil salinity on a no-till field with diversified cropping systems.

Louisiana State University (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 Arizona (Markus Tuller)

- Tested new sensors for measurement of stem water potential in cotton in course of a water stress experiment aimed at conserving irrigation water. This new technology is poised to significantly decrease water use of cotton, while sustaining yield and cotton quality.
- Developed new method to estimate cation exchange capacity (CEC) from water vapor sorption isotherms. This method may be applied by researchers to efficiently determine CEC from easy-to-measure soil properties.

Texas A&M University (Briana Wyatt)

- Developed seasonal streamflow forecasts for five watersheds in the US Great Plains using remote sensing-based soil moisture and terrestrial water storage anomaly data.

University of Delaware (Yan Jin)

- Established and instrumented a long-term monitoring at the St. Jones Reserve to observe the changes in soil biogeochemical and hydrological processes with seawater intrusion.
- Improved understanding of how seawater intrusion affects the evaporation of soil porous media, especially those with soil texture heterogeneity.
- Demonstrated the potential of using VIS-NIR soil spectral measurement to develop a rapid tool for determining soil salinization for both saltine and non-saline soil.
- Completed laboratory soil column experiments to investigate the effects of flooding and salinity on soil physical and hydraulic properties

Outputs

Oregon State University (Salini Sasidharan)

Research findings were disseminated via:

- Published 2 co-authored articles. The extent to which soil hydraulics can explain ecohydrological separation was published in the prestigious Nature Communication (Impact Factor:17.69), a collaboration with faculties at BEE and other universities. Modeling seasonal soil moisture dynamics in gley soils in relation to groundwater table oscillations in eastern Croatia was published on Catena, an international collaboration.
- Presently have 1 first author manuscript under revision at Vadose Zone Journal, 1 co-author manuscript under Review at Advances of Agronomy, and 7 in preparation (3 first authors, 3 with my postdocs, and 1 as a co-author with a large pool of researchers from W-4188 Soil, Water, and Environmental Physics to Sustain Agriculture and Natural Resources).
- Published a peer-reviewed report, Research Support For Watershed And Basin Hydrology And Water Quality In The Arid and Semi-Arid Southwest, USA Evaluation of Drywell Performance at Fort Irwin: Vadose Zone Study Final Report, that was commissioned and published by US EPA and USDA-ARS for EPA Interagency Agreement No. DW-012-92465401-5.
- Published an editor-reviewed, Managed Aquifer Recharge: Making the Invisible Visible and Beyond, under the theme ‘Hot Topic in Hydrology’ (invited due to my expertise in managed aquifer recharge) in Water Resources Impact Magazine by American Water Resources Association.
- Coordinated more than 20 researchers and partners from multiple institutions(universities, agencies, and industry) to participate in Building Climate Resilience and Competitiveness Through-System Level Water Management across
- Oregon for the 2022 Strategic Advantage Bold New Idea Ignite Sessions hosted by the College of Agricultural Sciences.
- Organized and convened (early career) the Advances in Managed Aquifer Recharge for Groundwater Sustainability Session (3 Oral, 1 Virtual, and 1 Poster session) at the AGU 2022.
- Presented my research at three prestigious international conferences ISMAR11 2022, 2022 ASA/CSSA/SSSA International Annual Meeting, and AGU 2022.
- Invited lecture on HYDRUS 2D/3D at the Advanced tools and techniques for Managed Aquifer Recharge (ATT-MAR) program sponsored by Asia Pacific Network for Global Change Research (APN)
- Invited lecture at the HYDRUS Course, The Jacob Blaustein Institutes for Desert Research, Israel
- In addition, I have also presented at CBEE seminar series, and co-authored presentations of my collaborators at several conferences AGU 2022, Western Groundwater Congress 2022, UC Merced, Groundwater Protection Council, and many other talks.
- Established connections with multiple institutions in Oregon and Washington.
- I have received Early Career Award 2022, Soil Science Society of America, Soil Physics and Hydrology, 2022 Link
- I have received Soil Physics and Hydrology Division Chair Award 2022, Distinguished services to the Soil Physics and Hydrology Division, SSSA, USA
- I was appointed as the elected Chair for the Lower Umatilla Basin Groundwater Management Area (LUBGWMA) Committee by the Oregon Department of Environmental Quality. Since then, I have conducted four public meetings at Hermiston. Since 25 years of the formation of this committee, I made this committee a public body by forming a 11 member Executive Board Committee representing the 10 categories Morrow County, Umatilla County, Science and Research, Industry and Business, Irrigated Agriculture, Livestock/Dairy/CAFO, Environmental,

City Government, Tribal Government, and General Public (2 positions), prepared the Bylaw for the first time, established and updated webpage, and represented in the legislative meeting.

University of California-Riverside (Hoori Ajami)

Research findings were disseminated via:

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

- Taught 1 upper division undergraduate course on Spatial analysis and remote sensing for environmental sciences (4 units), and co-taught a graduate level course in Integrated Hydrologic Modeling (4 units).
- Served on 1 PhD dissertation committee, 1 MS thesis committee and participated in 2 PhD qualifying exams
- Served as an Associate Editor of California Agriculture, Hydrological Sciences Journals, and Journal of Hydrology

Alabama A&M University (Dedrick Davis)

Research findings were disseminated via:

- 11 conference abstracts and presentations.

Kansas State University (Andres Patrignani)

Research findings were disseminated via:

- 7 peer-reviewed publications
- 5 presentations

Texas Tech University (Sanjit Deb)

Research findings were disseminated via:

- 5 publications in peer-reviewed journals
- 14 conference abstracts and presentations
- Research reports
- One Ph.D. dissertation

Michigan State University (Wei Zhang)

- We published 8 journal articles and gave 6 conference presentations.

Oklahoma State University (Tyson Ochsner)

Research findings were disseminated via:

- 2 conference abstracts and presentations
    - Wyatt, B., T.E. Ochsner, and M. Wang. 2022. Improving Seasonal Streamflow Forecasts by Incorporating Soil Moisture and Groundwater-Level Information Derived from Remote Sensing. In 102nd American Meteorological Society Annual Meeting. AMS, 2022.
    - Wang, M., B.M. Wyatt, and T.E. Ochsner. 2022. Remote Sensing Soil Moisture Data Improve Seasonal Streamflow Forecast Accuracy in Rainfall-Dominated Watersheds. ASA, CSSA, SSSA International Annual Meeting, Baltimore, MD.

University of Idaho (Robert Heinse)

Research findings were disseminated via:
- 2 publications in peer-reviewed journals
- 1 research reports
- 3 conference abstracts and presentations

Iowa State University (Bob Horton) and North Carolina State University (Josh Heitman)

Research findings were disseminated via:
- 28 publications in peer-reviewed journals
- 2 reports
- 30 conference abstracts and presentations

Texas A&M University (Binayak Mohanty)

Research findings were disseminated via refereed journal publications, conference proceedings, project reports, and a number of presentations at national and international meetings.
- 4 journal publications
- 16 technical abstracts
- 3 project reports
- 20 presentations in national and international meetings

University of California- Davis (Majdi Abou Najm)

Research findings were disseminated via:
- 6 publications in peer-reviewed journals
- 5 abstracts and conference proceedings and several invited talks.

University of California- Davis (Thomas Harter)

Research findings were disseminated via:
- 5 publications in peer-reviewed journals
- 3 peer-reviewed State of California groundwater sustainability plans
- 3 research reports
- Over 70 presentations, invited lectures, workshop presentation, public outreach event presentations and discussions, shortcourse lectures, stakeholder meetings, grower meetings.

Virginia Tech (Ryan Stewart)
Research findings were disseminated via:

- 5 publications in peer-reviewed journals
- 4 conference abstracts and presentations
- 1 peer-reviewed Extension article

New Mexico State University (Manoj Shukla)

- Research results were disseminated in collaboration with various involved groups through 7 peer-reviewed journal articles, 6 conference contributions, and interactions with stakeholders and growers.
- A new IOT system installed in Leyendecker Plant Science Digital Agriculture hub was expanded.
- Gave lectures on soil health and carbon sequestration at Mendel University in Brno, Czech Republic.

University of Wisconsin-Madison (Jingyi Huang)
Research findings were disseminated via:

- 9 publications in peer-reviewed journals
- 13 conference abstracts and presentations
- 1 US patent

New Mexico State University (Kenneth Carroll)
Research findings were disseminated via:

- 12 publications in peer-reviewed journals
- 1 conference proceedings paper
- 1 technical report
- 16 conference abstracts and presentations (including 3 invited talks)
- Web postings (ResearchGate, Twitter, LinkedIN, scienceofagriculture.com)
- Monthly Science Café webinar presentation series for Sigma Xi chapter

University of California- Riverside (Jirka Simunek)

- Research findings were disseminated via refereed journal publications, conference proceedings, and presentations at national and international meetings (see the publication section with 17 peer-reviewed journal articles 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. Additionally, we have added new capabilities to HYDRUS to rigorously consider the transport of PFAS in the vadose zone, to simulate fate and transport of ionizable compounds in the soil-plant continuum, to simulate the 1D colloid facilitated transport and the transport of fumigants, and the particle tracking algorithm to assess water travel times, etc.

Washington State University (Markus Flury)
Research findings were disseminated via:

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

University of Kentucky (Ole Wendroth)

- Two graduate students are involved in this research project. The MS student is expected to graduate in May 2023, and the PhD student to graduate in May 2024.
- Nine papers were published over the past year in peer-reviewed journals.

Montana State University (Jack Brookshire)

- We published six papers and submitted three others to peer-reviewed journals.

Desert Research Institute (Markus Berli and Dani Or)

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

University of Florida (Ebrahim Babaeian)
Research findings were disseminated via:

- 1 publication in peer-reviewed journals
- 1 book chapter published in Encyclopedia of Soils
- 2 book chapter under review in Encyclopedia of Soils

Utah State University (Scott Jones)
Research findings were disseminated via:

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

University of Wyoming (Thijs Kelleners)

Research findings were disseminated via:
- 1 paper published in the journal Water Resources Research
- 2 papers in review with the journal Water Resources Research
- 1 chapter in review for a book on soil salinity and sodicity

North Dakota State University (Aaron Daigh)

Research findings were disseminated via:
- 7 publications in peer-reviewed journals
- 2 research reports
- 18 conference abstracts and presentations
- 2 book chapters

Louisiana State University (Xi Zhang)

Research findings were disseminated via:

- 2 publications in peer-reviewed journals

- 2 conference abstracts and presentations
- 1 article in newsletter
- 1 lecture on LSU-AgCenter Water Quality and Irrigation Workshop

University of Arizona (Markus Tuller)
Research findings were disseminated via 4 publications in peer-reviewed journals

USDA-ARS, Bushland, Texas (Robert Schwartz and Steve Evett)

- Published video of soil water sensor installation methods (Caldwell et al., 2022)
- Published 9 peer reviewed journal articles and 6 datasets.
- Our team made 5 invited and 2 volunteered presentations in 2022.

USDA-ARS, US Salinity Laboratory, Riverside, California (Ray Anderson, Todd Skaggs, and Elia Scudiero)

- Research findings were disseminated via 9 refereed journal publications, a book chapter, database, and several virtual presentations at national and international meetings.
- Updated software for partitioning water and carbon fluxes measured with eddy covariance systems (https://github.com/usda-ars-ussl/fluxpart).
- Extension and educational activities, especially as part of a NIFA-SAS funded project.

Texas A&M University (Briana Wyatt)

Research findings were disseminated via:

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

University of Delaware (Yan Jin)

- 5 publications in peer-reviewed journals
- 4 invited talks and 9 conference abstracts and presentations
- 2 congressional visits

Activities

Oregon State University (Salini Sasidharan)

- Field measurements of hydrologic tracers indicate varying magnitudes of geochemical separation between subsurface pore waters. The potential for conventional soil physics alone to explain isotopic differences between preferential flow and tightly-bound water remains unclear. Here, we explore physical drivers of isotopic separations using 650 different model configurations of soil, climate, and mobile/immobile soil-water domain characteristics, without confounding fractionation or plant uptake effects. We find simulations with coarser soils and less precipitation led to reduced separation between pore spaces and drainage. Amplified separations are found with larger immobile domains and, to a lesser extent, higher mobile-immobile transfer rates. Nonetheless, isotopic separations remained small (<4‰ for δ2H) across simulations, indicating that contrasting transport dynamics generate limited geochemical differences. Therefore, conventional soil physics alone are unlikely to explain large ecohydrological separations observed elsewhere, and further efforts aimed at reducing methodological artifacts, refining understanding of fractionation processes, and investigating new physiochemical mechanisms are needed.
- This study aims to explain complex vadose zone hydrology of fine-textured (gley) agricultural soils influenced by a shallow and dynamic groundwater (GW) levels. The field site was located in the Biđ field (Eastern Croatia), where a detailed soil survey was performed. The simulations included a three-year period (2016–2018) at four locations. Soil hydraulic parameters (SHP) were estimated based on variables determined in the laboratory, while soil water flow was monitored using in-field zero-tension lysimeters. Piezometers were installed and used to monitor daily oscillations of groundwater levels (average depth to GW 2.2 m), while data from nearby Sava River was monitored. Unsaturated flow and water regime assessment was performed using HYDRUS-1D numerical modeling. Additional SHP optimization of van Genuchten-Mualem parameters (α and n) was performed using Shuffled Complex Evolution algorithm (SCE). The autocorrelation analysis was used to detect patterns in the precipitation, GW, and river level time series, while the Mutual Information (MI) was used to estimate the codependence of the processes in unsaturated zone and the main hydrological events. The model successfully (R2 0.72 – 0.94) reproduced measured lysimeters outflows. The outflows from lysimeters were connected to precipitation patterns, transpiration intensity, and soil moisture content influenced by the shallow water table. Comparable MI values obtained for precipitation, GW, and river level suggest a concurrent role of these parameters in the unsaturated flow dynamics. The relationship between upward flux/water storage change into the domain, and transpiration/growth stages, suggests a strong connection between the water fluxes and the root water uptake. Results confirm the importance of GW for the agricultural production due to the major influence on upper soil layer moisture.
- Groundwater used to be one of the most reliable sources of fresh water, and its over-exploitation compromised groundwater quantity and quality, with consequences for human health, agriculture, and the economy. Optimizing managed aquifer recharge (MAR) techniques is critical to address groundwater depletion worldwide in many arid and semi-arid regions. Numerical experiments were conducted to assess various drywell designs (e.g., drywell diameters, depths, and screening intervals) to enhance MAR. The cumulative infiltration (I) and recharge (R) decreased with the drywell diameter. However, only a 48% and 52% decrease in I and R were observed, respectively, after 1 year for a 5 cm in comparison to a 120 cm diameter drywell. Values of I and R also increased with the drywell depth and screening interval, especially when a heterogeneous soil profile allowed the drywell to bypass fine-textured layers and/or lenses. The lowest levelized costs associated with recharging a given water volume occurred for smaller and deeper drywells that recharged water over a shorter timeframe. Potential novel MAR applications of small

diameter and deep drywells were discussed, including (i) repurposing of existing dried irrigation supply and domestic wells; and (ii) inclusion of drywells into existing irrigation canal systems. Widespread application of these MAR approaches is predicted to rapidly recharge tremendous volumes of floodwater based on the available canal network (e.g., 8.30 × 108 to 1.66×109 m3 per year). However, technical challenges to implementing the proposed methods, such as clogging and potential impacts on groundwater quality, would need to be overcome by using low-cost pretreatments and/or optimizing the frequency of operation. Site-specific regulatory hurdles regarding water surface availability, land use, and groundwater quality would also need to be addressed. Pilot-scale studies are warranted to address these issues before large-scale implementation.

University of California-Riverside (Hoori Ajami)

- Improving vegetation parameterization in integrated groundwater-land surface models
- Comparing performance of micrometeorologic and isotopic methods for evapotranspiration partitioning
- Improving mountain system recharge prediction in the Sierra Nevada California
- Characterizing mountain flow path using geochemical data and mixing models
- Identifying major drivers of hydrologic change in the Salton Sea basin
- Assessing drought impacts on streamflow across the US

Alabama A&M University (Dedrick Davis)

- A field study was performed to investigate how in-situ soil hydraulic properties varied spatially and temporally under different land uses (pasture, corn, and soybeans).
- We investigated microclimate conditions inside and outside an agroforestry system and tree effects on near surface soil temperature, water content matric potential in the agroforestry system.
- Laboratory experiments were performed to evaluate the effects of biopolymers on soil hydraulic properties.

Kansas State University (Andres Patrignani)

- Maintained hydrological monitoring network at the Konza Prairie to study the connection between rootzone soil moisture and streamflow in tallgrass prairies.
- Deployed new soil moisture testbed at the Konza Prairie Biological Station. Similar testbeds have been deployed in Oklahoma, Texas, and Maryland.
- Continue work on prototyping a deep neural network to quantify bare soil, green canopy cover, and crop residue using digital images.

Texas Tech University (Sanjit Deb)

- Completed the 2022 growing season field experiments and modeling tasks on evaluating rootzone soil water dynamic under various agronomic practices/conditions in semiarid environments (TSSC-Cotton Incorporated funded project, PI), including (i) evaluating root water uptake of cotton under deficit subsurface drip irrigation, (ii) evaluating soil water dynamics in cotton production systems using numerical model HYDRUS (2D/3D) and agricultural system model RZWQM2, (iii) evaluating rootzone soil water dynamics under cotton-weed interactions, and (iv) evaluating effects of early season planting and soil physical environments on physiological responses and quality of cotton germplasms with cold germination ability.

- Continued modeling tasks on evaluating GHG emissions under different pasture management practices and evaluated mitigation scenarios that optimize resource use and productivity (USDA-NIFA-AFRI funded project, Co-PI).
- Completed the 2022 season field experiments on evaluating production and beneficial impact of biochar amendments for cotton germplasms with cold germination ability and vegetable crops under soil- and plant-based deficit irrigation strategies (TSSC-Cotton Incorporated funded, PI; and SCBGP, USDA, Co-PI).
- Continued field and lab experiments and numerical modeling tasks on the coupled energy-water-isotope transport in vadose zone of natural rangeland in semiarid environment.
- Completed undergraduate research project on the effects of long-term perennial and annual pasture systems on soil physical quality indicators in the semiarid Texas Southern High Plains.
- Advised one Ph.D. student (completed in fall 2022), three M.S. students, and one undergraduate researcher as Chair; advised one Ph.D. student and one M.S. student as Co-Chair; and served on six Ph.D. (three completed in 2022) and four M.S. (two completed in 2022) students' committees.
- Taught the following courses in two modalities (face-to-face and distance): (1) [Spring 2022] Graduate course PSS 5335 Soil Physics (cross-listed undergraduate course PSS 4336 Soil Physical Properties); and (2) [Fall 2022] Graduate course PSS 6331 Adv Environmental Soil Science (cross-listed undergraduate course PSS 4337 Environmental Soil Science)
- Served as an Associate Editor (two journals), a Guest Editor (one), and a Reviewer for peer-reviewed international journals.

<u>Michigan State University (Wei Zhang)</u>

- Our research focused on the fate and transport of environmental contaminants in soil, water, and plant systems. Specifically, we studied the interactions of infectious proteinaceous particles (prions, new group of emerging contaminants) with soil geosorbents. This study aims to understand environmental behaviors of chronic wasting disease prions and to develop novel cost-effective mitigation strategies, in collaboration with scientists from Creighton University. Our group used molecular dynamics simulation to explore the interactions of amino acids and eventually peptides, poly peptides, and prions with aromatic carbon surfaces, as well as metal cation bindings with prions. We also completed the study on the foliar uptake of silver nanoparticles (Ag NPs), the behaviors of Ag NPs in fresh produce washing water, and the effectiveness of washing practices in removing Ag NPs sorbed on lettuce leaves. We found that stomata are important entry points to Ag NPs. In chlorinated washing water, Ag NPs dissolve and form AgCl crystals or AgCl-Ag NP composite particles, which are embedded with organic matter in the presence of dissolved lettuce extract. Using batch systems and pilot-scale processing line, we found that washing with water or chlorine solution is generally not effective to remove the sorbed silver nanoparticles, probably due to strong binding of silver with plant organic materials. We studied the presence of per-and polyfluoroalkyl substances (PFAS) in biosolids from wastewater treatment facilities, interactions of PFAS with soils, and plant uptake of PFAS. In collaboration with engineers, soil chemists, agronomists, and food scientists, we also investigated electrochemical sensors for metal analysis, crop uptake of heavy metals, and strategies that could be used to minimize crop contamination of heavy metals, which could help reduce human exposure to heavy metals via dietary consumption. Finally we collaborated with Columbia University to develop the machine learning models to predict the plant uptake of organic contaminants, the chemical ecotoxcity, and the pesticide dissipation in plants.

Oklahoma State University (Tyson Ochsner)

- Continued research to determine the potential for applying soil moisture-informed streamflow forecasting methods using soil moisture and terrestrial water storage estimates from satellite remote sensing.
- Developed forecasts for cooperating surface water irrigation districts in three states who could use the forecasts for planning water allocations.

University of Idaho (Robert Heinse)

- Continued progress on characterizing soil heterogeneity at the Soil Stewards farm. We collected hydraulic and electric conductivities at fine resolution. The data will inform design and operation of small-scale precision irrigation and contribute to outreach and extension activities.
- Continued data analysis for the Advanced Plant Habitat.
- Workshopped the Western Water Network including co-organizing an assembly of stakeholders.

Iowa State University (Bob Horton) and North Carolina State University (Josh Heitman)

- We identified several thermal conductivity versus water content and soil water retention curve water content values that correlated well.
- We developed a method to estimate a complete soil water retention curve from soil thermal property measurements.
- We investigated salinity effects on the performance of TDR and heat pulse sensors.
- We evaluated the heat transfer patterns of a double-layered soil with different upper- and lower-layer properties.
- We performed a field experiment to measure soil thermal property values and variations in soil water content.
- We determined the efficacy of compost as a soil amendment to reduce runoff volume, improve runoff quality, and increase vegetation establishment.
- We examined the influence of compost application rates on nutrient and heavy metal mobility.

Texas A&M University (Binayak Mohanty)

- In 2022, 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, and carbon dynamics.
- Using various satellite observations, and soil dry-down process concepts at the footprint scale, we developed new soil hydraulic response units. This provides the foundation for a unified theory of soil hydrology across multiple space-time scales.
- Developed national inter-disciplinary team for developing Artificial Intelligence Institute related to agriculture and natural resources.
- Meetings organized
    - Chairman, Organizing Committee, Ignacio Rodriguez-Iturbe Memorial Symposium, Texas A&M University (2022)
    - Session Chair, Remote Sensing of Soil Processes, American Geophysical Union (AGU) Technical Session, AGU Fall Meeting, Chicago, IL (2022)
- Meetings attended
    - Frontier in Hydrology Meeting, American Geophysical Union, June 24-28, 2021.
    - Kirkham Conference, Soil Science Society of America, Aug 28 - Sept 2, 2021
    - American Geophysical Union Fall Meeting, December 13-17, 2021.

University of California- Davis (Majdi Abou Najm)

- Modeling framework for plant response to different light spectra: This is a new model that predicts transpiration, water use efficiency, stomatal opening and carbon assimilation under different light treatments. This is needed to establish a modeling framework under agrivoltaics systems. The model was published in Earth's Future Journal, and received wide media attention and coverage.
- Conduct a critical review on soil infiltration: we are tracing the evolution of infiltration theory that led to the development of more than 130 unique infiltration models over the past 2 centuries with the objective of identifying barriers and challenges, as well as recommending a roadmap for future directions.
- Two Systematic reviews on (1) how does soil structure affect infiltration and (2) how cover crops impact soil's properties: we collected data from hundreds of research papers and developed two databases with detailed information from unique plots with different treatments and are conducting a systematic review on the impact of those treatments on soil structure and infiltration capacity. Both reviews were accepted and will appear as journal articles in the Journal of Soil & Tillage Research and Science of the Total Environment in 2023.
- Incorporating Nitrogen in the Water-Energy-Food Nexus: nitrogen is key for the productivity of plants but is often ignored when optimizing for policy at the water-energy-food nexus scale. We proposed an optimization framework to incorporate nitrogen in the optimization problem.

University of California- Davis (Thomas Harter)

- Established a novel framework for the role of scientist communication in policy making.
- 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.
- Compared SWAT and HYDRUS modeling approaches to estimate nitrogen leaching from crop rotations with tomatoes under California conditions
- Assessed the role of spatial variability in aquifer geochemical heterogeneity on groundwater denitrification processes through stochastic analysis of a three-dimensional, highly heterogeneous alluvial aquifer system
- Developed water quality guidance for managers of agricultural or other managed aquifer recharge operations.
- Completed water quality threats assessment of dry wells as stormwater drainage and aquifer recharge tools, which included three years of field work, vadose zone modeling, and groundwater modeling.
- Performed economic analysis of grower behavior under various groundwater salinization scenarios that are likely to develop in many groundwater basins around the world to show, for the first time, farmer behavior under salinizing groundwater resource constraints.
- Developed three groundwater sustainability plans for three California groundwater basins, where each represents one of the three archetypes of California groundwater basins (alluvial basin with a low permeable bedrock upland system; volcanic aquifer system with basin – upland hydrogeologic continuity; alluvial basin with permeable bedrock upland system).
- Developed comprehensive methodology for measuring safe yield of groundwater basins
- Developed comprehensive framework and implemented case study for measuring stream depletion of surface water due to groundwater pumping.

Virginia Tech (Ryan Stewart)

- We performed a field test of the ability of different compounds to reduce soil water content and infiltration in vineyard soils as a way to better manage fruit quality.
- We continued our theoretical development of a new model to describe infiltration in water-repellent soils.
- We performed field measurements using geophysics (e.g., electrical resistivity tomography) to better understand preferential flow processes.
- We have published our design for a new device to passively collect flow-weighted water samples from surface runoff plots.
- We have completed a new theoretical and experimental framework to analyze gas diffusivity in soils and soilless substrates with non-uniform water contents.
- We have developed a new method to quantify hydraulic and physical properties of soils and soilless substrates using tension infiltrometer measurements.
- We performed a field test of a new low-cost system for measuring near-surface CO2 concentrations at the field-scale.

New Mexico State University (Manoj Shukla)

- Water scarcity is a major problem for crop production around the world including Southwestern United States and growers are increasingly using groundwater for agriculture in Southern New Mexico. This greenhouse study evaluated the effects of BGW and RO concentrate at various growth stages of two chile pepper cultivars, NuMex Joe E. Parker and NuMex Sandia Select. Five salinity treatments were applied to plants, three of them used saline waters of 0.6 (control), 4.0 (BGW), and 8.0 dS/m (RO) throughout the growing season, whereas the other two changed waters of 4.0 and 8.0 dS/m to waters of 2.0 and 6.0 dS/m from the beginning of the flowering stage. Changing to irrigation with reduced salinity at the flowering stage initiated reproductive development more rapidly and alleviated the adverse influence of salinity on plant than that with continuous irrigation with electrical conductivity (EC) of 4.0 dS/m and 8.0 dS/m beyond the flowering stage. Irrigation that practices a change from high salinity to lower salinity at the flowering stage can optimize the use of saline irrigation water for growing chile peppers.
- Optimizing planting density and irrigation depth of hybrid maize seed production is important for ensuring food and water security. The aim of this study was to establish an integrated model that optimized planting density and sufficient border irrigation depth to increase yield, ensure the vigor, and save water for hybrid maize seed production in an arid region. The integrated model was based on the modified AquaCrop and single crop coefficient models to predict grain yield and evapotranspiration, respectively. Kernel weight was estimated by grain yield and kernel number, and a monomolecular model was used to fit kernel number per plant and plant growth rate during the flowering stage. The integrated model is a useful tool to decrease irrigation amounts and increase yield of hybrid maize seeds in the arid areas of Northwest China.
- Cover crops are promoted to improve soil health and soil carbon (C) sequestration in agroecosystems, yet responses of various soil organic carbon (SOC) and nitrogen (N) components to cover cropping have not been quantified for water-limited environments. This study evaluated the response of SOC and N components to different cover crops and mixtures in limited irrigation winter wheat (Triticum aestivum L.)-sorghum (Sorghum bicolor L. Moench)-fallow rotation. This study showed a diverse response of SOC and N components to various cover crop treatments,

oats and their mixture as cover crops had greater SOC and total N than other cover crops. Cover cropping could improve soil health in crop-fallow rotations in water-limited environments.

University of Wisconsin-Madison (Jingyi Huang)

- Worked on research projects funded by USDA Hatch - Multistate W4188, NSF, and USDA NIFA programs
- Advising three Ph.D. students, two M.S. student, and three undergraduate students and serving on the committee members of three Ph.D. and one 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 80 manuscripts for various journals

New Mexico State University (Kenneth Carroll)

- Completed solute transport lab experiments and modeling
- Completed noninvasive geophysical and sensor methods for hyporheic zone characterization
- Applied multiple chemical analysis methods to characterize oil & gas produced water
- Developed/applied simulated annealing for solute transport parameter estimation
- Organized monthly Science Café webinar presentation series for Sigma Xi chapter
- Acted as Associate Editor for 4 peer-review international journals and completed additional manuscript reviews

University of California- Riverside (Jirka Simunek)

- In 2022, we organized two short courses on using HYDRUS models. The first one was mainly for participants from the US and Canada and the second one mainly for attendees from Israel. About 100 students participated in these short courses.

Desert Research Institute (Markus Berli and Dani Or)

- Review on fire-impacts on soil structure
- Evaluated methods to measure sorptivity of sub-critically water-repellent soil in the field
- Worked on an improved understanding of water infiltration, redistribution and evaporation from arid soils
- Modeling wildfire dynamics using WRF-fire for links with soil thermal alterations
- Modeling soil heat transport under wildfires and changes in soil constituents

University of Florida (Ebrahim Babaeian)

- Continued to develop a new method for short-, medium-, and long-term actual evapotranspiration forecasting based on ground and satellite remote sensing observations (Collaborators: The University of Arizona, Purdue University Northwest, Michigan Technological University).
- Purchased and installed various laboratory and field instruments to measure physical and hydraulic soil properties and processes in sandy soils.
- Designed and conducted a field experiment to measure in-situ soil water characteristic in sandy soils using sensor pairing methods.

- Installed various soil moisture sensors to measure soil water content distribution in sandy soils
- Developing radiative transfer models for passive radiometer sensor-based measurement of root zone soil moisture in sandy soils.
- Instructing Environmental Soil Physics to undergraduate and graduate students from various disciplines.

Utah State University (Scott Jones)

- Visiting Assistant Professor of Applied Mathematics, Asghar Ghorbani, from Ferdowsi University of Mashhad, Iran, arrived at USU in August to begin a yearlong sabbatical. Dr. Ghorbani along with Morteza Sadeghi (adjunct @ USU) and Scott Jones continued collaboration on a Physics-Constrained Machine Learning approach to develop new soil water flow equations.
- A Ph.D. student scholar from Spain, Juando González-Teruel, visited my lab for 3 months in early 2022 and continued collaboration with David Robinson (adjunct @ USU) and I on development of electromagnetic sensing and measurement methods in soil.
- I collaborated with a group from the Institute of Agrophysics (Lublin, Poland) and spent several weeks in their lab in May. Three of them in turn visited my lab in June for one month working on dielectric measurement techniques for field applications.
- Chieh-Yun Chang (M.S.) and Adam Blakeslee (B.S. Electrical Eng.) were mentored on two separate projects.
- I continued weekly meetings to support discussions with six graduate students at China Agricultural University (Wenyi Sheng, Major Professor and adjunct faculty at USU) aimed at advancing thermal and dielectric sensing capabilities.
- Scott Jones and Bruce Bugbee continued collaboration on a NASA-funded research grant to improve plant growth media for pick and eat production in reduced gravity conditions.
- Collaboration with the University of Arizona (M. Tuller) and the University of Florida (E. Babaeian) continued with development of a book chapter titled, "Proximal Sensing of Soil Moisture" in the Encyclopedia of Soils in the Environment, scheduled for release in August 2023.

University of Wyoming (Thijs Kelleners)

- Maintained a soil moisture and rainfall measurement network consisting of 17 sites in rangelands across Wyoming
- Disassembled Electrical Resistivity Tomography (ERT) sites in Reynolds Creek, Idaho and Dry Creek, Idaho after several years of continuous monitoring
- Maintained a snow and soil monitoring network consisting of 9 sites in the NoName watershed, Snowy Range Mountains, Wyoming

North Dakota State University (Aaron Daigh)

- Long-term research plots (established in the 1980s) and nine farmer fields were instrumented with lysimeters to monitor solution nitrate and phosphate below the root zones. Soil samples were also obtained to characterize the soil microbial community structures.
- Data from seven ornamental grass species were analyzed to evaluate species tolerances and ability to remediate petroleum contamination under various water and saline conditions.
- Six machine learning models were further compared for integrating satellite imagery, soil characteristics, and weather station data to predict high-resolution mapping of soil moisture

across the Red River Valley. An algorithm and workflow was finalized. The algorithm was validated and tested against measured data.
- A GIS database was further refined and analyzed for >24,000 landslides in North Dakota, soil salinity, geology, topography, etc. maps. Data analysis was performed to characterize landscape conditioning factors that are associated with landslides in this region.
- Soil water contents, water tables, crop development, and meteorological data were analyzed at an on-farm research site. This experiment is designed to improve our understanding of cover crop and tillage effects on the soil water balance in agricultural fields with seasonally frozen soils.
- Water table depths and major salt ion concentrations, soil salinity, and crop yields were analyzed on a long-term research site that is being used to evaluate subsurface drainage.

Louisiana State University (Xi Zhang)

- Established fields with cover cropping management to explore soil water and gas fluxed as influenced by changes in soil structure under cover crops with different root traits.
- Quantified the spatial variability of soil properties and their influences on field-scale soil water dynamics and crop growth.
- Served as a guest editor of Frontiers in Earth Science.
- Attended ASA Southern Branch Meeting (New Orleans, LA, Feb. 12-14) and ASA-CSSA-SSSA International Annual Meeting (Baltimore, MD, Nov. 6-9).

University of Arizona (Markus Tuller)

- Short- and mid-term forecasts of actual evapotranspiration with deep learning: Evapotranspiration is a key component of the hydrologic cycle. Accurate short-, medium-, and long-term forecasts of actual evapotranspiration (ETa) are crucial not only for quantifying the impacts of climate change on the water and energy balance, but also for real-time estimation of crop water demand and irrigation water allocation in agriculture. Applying a state-of-the- art deep learning (DL) approach, Long Short-Term Memory (LSTM) models were employed to nowcast (real-time) and forecast (ahead of time) ETa based on major meteorological and ground-measured (i.e., soil moisture) input variables and long ETa timeseries from the Moderate Resolution Imaging Spectroradiometer (MODIS) onboard of the NASA Aqua satellite.
- Genome Wide Association Study Uncovers the QTLome for Osmotic Adjustment (OA) and Related Drought Adaptive Traits in Durum Wheat: Drought is one of the most devastating abiotic stressors limiting crop yield, adaptability, and quality. Recent global climate models predict a consistent rainfall reduction in temperate drylands, hence destabilizing food systems and global food security. The plant reaction to drought is mediated by complex molecular systems linked to the transcriptome, as well as hormone signaling and metabolism. In particular, drought is the major abiotic stress curtailing yield and lowering quality durum wheat, the most cultivated wheat in the Mediterranean regions. This study is the first to report QTLs for OA in wheat.
- A novel physical-empirical model linking shortwave infrared reflectance and soil water retention: Soil hydraulic properties, including soil water retention, control various terrestrial hydrological processes such as infiltration, runoff, and evapotranspiration. Measuring and monitoring these properties at large scales is challenging. Therefore, over the past decade, remote sensing has been investigated as a promising tool for large-scale mapping of soil hydraulic properties. Nonetheless, a solid physical relationship between soil hydraulic and spectral properties is still lacking. To close this knowledge gap, this study introduces a novel physical-empirical model that to our best

knowledge for the first time connects the soil water retention curve (SWRC) to soil spectral reflectance. The new model has been developed based on the hypothesis that the capillary and adsorbed water components of the SWRC exhibit vastly different optical properties due to their distinct distribution within the soil porous system. The model was validated using soil water retention and reflectance measurements of 21 soils, vastly differing in physical and hydraulic properties. The model provides not only a new and accurate soil moisture-reflectance functional relationship, but also a potential means for retrieval of the soil water retention curve from spectral reflectance in the shortwave infrared domain.

USDA-ARS, Bushland, Texas (Robert Schwartz and Steve Evett)

- Work continued on a Cooperative Research and Development Agreement with Acclima, Inc. initiated in 2019 to utilize acquired waveforms from the new TDR-315N sensor for the characterization of soil properties and to improve water content calibrations specific to a given soil. Post-doctoral funding was awarded, and a post-doc was hired during this period to complete this work.
- Collaboration with the Centro Regional de Estudios de Agua (CREA) University of Castilla-La Mancha, Albacete, Spain was continued to adapt and improve irrigation scheduling strategies that involve some degree of planned or unplanned water stress. A joint study is being carried out in Ecuador to evaluate irrigation strategies for maize in the equatorial, dry winter zone in the province of Manabí.
- Collaboration was initiated with West Texas A&M University (lead) and Texas A&M Agrilife to develop a decision tool targeted to producers for optimizing acreage of irrigated corn and dryland cotton under conditions of limited irrigation capacities.
- We continued work with university partners (TTU, TAMU) to evaluate seasonal and depth dependent soil water use patterns, canopy temperatures, fiber yield and quality, and water productivity in response to water stress levels in cotton hybrids with diverse morphological expressions under SDI.
- We continued work with Texas A&M AgriLife Research on field testing of the Campbell Scientific SoilVue soil water sensing system with six installations, two each, respectively, in corn fields irrigated at 50%, 75% and 100% of full irrigation to meet crop ET requirements. SoilVue sensors were installed 30 cm from neutron probe access tubes, and TDR-315L and TDR-315H sensors were installed between the access tube and SoilVue sensors at the center depths of SoilVue sensors.
- We continued publishing quality controlled, peer reviewed weighing lysimeter dataset collections on the USDA ARS NAL Ag Data Commons for public access. Collections for multiple years of alfalfa, maize (grain), sunflower, and winter wheat are available now. Collections include evapotranspiration, irrigation, precipitation, dew and frost accumulation, solar irradiance, wind speed, air temperature, relative humidity, and air pressure on a 15-minute basis for all days of the year. Collections also include crop growth and yield data.

Texas A&M University (Briana Wyatt)

- Continued streamflow forecasting work, prepared manuscript for submission (currently under review)
- Prepare to share resulting forecasts with irrigation district partners in Oklahoma, Kansas, and Nebraska

University of Delaware (Yan Jin)

- Field monitoring: Major activities of as a team member include: (1) installing Pt-redox probes, reference probes, pH, and LTC sensors to gather in-situ real-time data; (2) collecting intact soil cores along the soil profiles from transects along salinity gradients; (3) for soil physical and chemical characterization, preparing soil samples from intact soil cores (grinding and sieving); (4) collection of pore water samples monthly (starting from April 2022) from piezometers that were set up at 30-cm and 120-cm depths to investigate the soil carbon and nutrient loss upon seawater intrusion; (5) gathering, processing, and storage of field sensor data.
- Saline water evaporation from heterogeneous soil: designed and conducted laboratory experiments with 2-D soil chambers packed with either fine or coarse sand or a combination of the two. The rate of water loss from evaporation was monitored over time via changes in weight and light transmittance.
- VIS-NIR aided soil salinity characteristics: Collected VIS-NIR spectra of topsoil samples from 13 different sites in Delaware and determined how salinity levels affected the spectral characteristics of the soil. Selected soils (non-saline and saline soils) were incubated with artificial seawater at various salinity levels to further quantatively assess the impacts of salinization from seawater. The data analysis and paper preparation are now underway.
- Collecting pore-water samples along the salinity grading at St. Jones Reserve; measuring pore-water pH, Eh, EC in the field, and fractioning them into <1000 nm, <100 nm, and <2.3 nm fractions
- Collecting different soil and pore-water chemical parameters using Pt-redox probes, HOBO pH, and LTC sensors for in-situ monitoring of the soil redox potential, pH, salinity, water level, and temperature in the field
- Measured the effects of salinity and flooding events on soil hydraulic properties, e.g., water retention capacity, evaporation rate, and saturated and unsaturated hydraulic conductivity
- Prepared two manuscripts on how the redox oscillation processes can influence the mobility of colloids and associated organic carbon in wetland
- Travel to MSU to learn how perform time-lapse zymography

University of Kentucky (Ole Wendroth)

- Established experiment in a farmer's field in a 600-m-long and 48-m-wide area consisting of four strips. In each strip 16 plots were established, each being 12 m wide and approximately 37 m long. Across the four strips uniform and variable rate applications of irrigation water and nitrogen fertilizer were established.
- During the growing season of corn, soil water content was monitored in 21 plots with a profile sensor, measuring soil water content at 10-cm-depth intervals down to 90 cm depth every 30 minutes. Data were downloaded every two weeks with a smart phone and blue-tooth connection.
- At five times, mineral soil nitrogen content was sampled in 53 plots at four depth increments (0-15, 15-30, 30-60, 60-90 cm; campaigns 3 and 4 only 0-15 and 15-30 cm depth). Each soil sample was composed from 3-4 augers.
- In 58 plots, we sampled at four times over the growing season plant height, above-ground biomass and at one time leaf area index. At the last two biomass samplings, samples were divided into ears and shoots, and ears were manually threshed. A yield map was obtained by the farmer for the four strips individually. We are waiting for access to these data.
- Five drone overflight campaigns were made over the growing season. We are currently processing the data and figure out software and analytical pathways to obtain information on crop biomass from these images. The data files are huge.

Milestones

***Objective 1:* To improve our fundamental understanding of vadose zone physical properties and processes, and how they interact with other environmental and biogeochemical processes across various spatial and temporal scales.**

University of California-Riverside (Hoori Ajami)

- Improve groundwater recharge estimation from mountain catchments by integrating hydrological and hydrochemical models
- Develop a data-driven method for estimating dynamic storage in mountain watersheds

Alabama A&M University (Dedrick Davis)

- Completed a laboratory study to determine the effect of biochar on soil thermal properties at water contents below field capacity microclimate and near surface soil temperature, water content, and matric potential.
- Completed a study to evaluate water retention and hysteresis for two highly weathered soils and poultry litter.
- Completed a laboratory study to determine the effects of a biopolymer on soil water retention and saturated hydraulic conductivity.
- Completed a laboratory study to determine the effects of a biopolymer on near saturated infiltration and hydraulic conductivity.
- Completed year one of a field study to measure in-situ soil water retention curves at different depths in the near surface soil environment.

Kansas State University (Andres Patrignani)

- Studied the transpiration responses of Palmer amaranth to soil drying. The goal was to quantify the soil matric potential at which the transpiration rate of Palmer amaranth starts to decline during soil drying conditions to determine the level of competition with summer crops.
- Advanced fundamental understanding between soil water potential and soil respiration in soils of different land covers to better simulate soil CO2 efflux under transient soil moisture conditions.

Texas Tech University (Sanjit Deb)

- Saturated hydraulic conductivity (Ksat), one of the critical soil hydraulic properties, is used to model many soil hydrological processes. However, measuring Ksat on a routine basis is a labor-intensive, time-consuming, and expensive process. Albalasmeh et al. (2022) used artificial neural networks (ANNs) to model and describe the most influential features affecting Ksat. Albalasmeh et al. (2022) developed and evaluated the potential use of generalized regression neural network (GRNN) to identify the optimal set of soil features to predict Ksat under arid and semi-arid environments.

University of Idaho (Robert Heinse)

- Completed first phase of APH irrigation analysis and recommendations.

Iowa State University (Bob Horton) and North Carolina State University (Josh Heitman)

- We developed an unsaturated hydraulic conductivity model based on the capillary bundle model, the Brooks-Corey model and the Waxman-Smits model. The model included two physically meaningful parameters. Based on a calibration dataset of 150 soils selected from the UNSODA database, parameter values were determined as -2.53 and 1.92, -4.39 and -0.14, -5.01 and -1.34, and -5.79 and -2.27 for four textural groups. The new model outperformed the Mualem-van Genuchten model and two commonly used pedotransfer functions. The new model can be used to estimate K under field conditions and for hydrologic modeling.
- We investigated correlations between the critical water content of the $\lambda(\theta)$ curve and some soil hydraulic and physical properties, such as water contents at wilting point, inflection point, and field capacity determined from measured soil water retention curves using 23 soil samples. The established relationships were then validated on seven soils and used to estimate $\lambda(\theta)$ curves from hydraulic property values. More importantly, our analysis revealed the general correlation between water flow and heat transfer processes.
- We further developed an approach to estimate a soil water retention curve, SWRC, from $\lambda(\theta)$ measurements. The capillary and adsorption regions of the SWRC were estimated based on the similarity between SWRC and $\lambda(\theta)$ curves and the correlation between the slope of the SWRC and the critical water content of the $\lambda(\theta)$ curve. The newly developed approach showed robustness on six independent soils.
- Soil thermal conductivity is an important input to heat transfer models. We developed a new model to estimate the thermal conductivity of soil solids from soil porosity using a combination of differential effective medium (DEM) theory and the geometric mean method. Results showed that our approach provided reliable estimates for both coarse- and fine- textured soils.
- We applied effective medium theory to develop a new electrical conductivity model. For specific conditions, the new model reduced to commonly available models. Although the new model only has three physical parameters, it accurately captures the dynamics of electrical conductivity at different salinity levels. The model has potential to determine soil salinity in unsaturated field conditions.

Texas A&M University (Binayak Mohanty)

- Coupled soil moisture and ET dynamic characteristics were discovered across various landuse land covers and hydroclimates across the globe.
- Enzymatic control of soil microorganisms were investigated for improving soil health and GHG emission processes.
- Using satellite remote sensing, critical evaporative fraction and soil moisture thresholds were established for water- and energy-limited systems.

University of California- Davis (Majdi Abou Najm)

- Published the plant response to light treatments model in Earth's Future Journal
    - Conducted a limited experiment with red and blue light filters to test the impact of different light spectra on tomatoes
    - Worked on the data analysis of the field experiment
- Conduct critical review on infiltration:
    - Completed review on 1D and 3D problems
    - Completed review on empirical models
    - Summarized the modeling frameworks of those 70 models

  - Generated near-ready to submit draft of manuscript with plan to complete additional components (including adding shrink-swell soils and other special cases) and submit in early 2023.
- Conduct systematic review on soil structure and its impact on infiltration
- Incorporating nitrogen in the water-energy-food nexus

<u>University of California- Davis (Thomas Harter)</u>

- Completed fifth 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 historic nitrogen and water mass balance of the above orchard.
- Completed first-ever California AgMAR experiment with three replicate sites that include comprehensive soil-, deep vadose zone-, and groundwater-monitoring.
- Completed phase 1 vadose zone modeling of pre- and post-implementation nitrate leaching, over an 80 year period at a California nut crop site
- Completed phase 1 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
- Successfully grew large crops of almonds with high-frequency low concentration fertigation technology.
- Completed three groundwater sustainability plans for three archetypical groundwater basins with overlying irrigated agriculture – an alluvial groundwater basin with a focus on managing the groundwater-surface water interface and protecting salmon habitat from the effects of groundwater over-pumping; a volcanic groundwater basin, also with a focus on managing the groundwater-surface water interface; and a volcanic groundwater basin with an overlying alluvial aquifer that has experience chronic water level decline.
- Completed collaboration with agricultural coalitions and stakeholders to develop groundwater protection targets in the irrigated agricultural landscape of the Central Valley.

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

- To publish the results of our greenhouse studies on neonicotinoid pesticide uptake by plants, by July 2023.
- To publish the results of laboratory experiments aimed at quantifying gas diffusion rates and pore size distributions of nursery substrates, by August 2023.

<u>New Mexico State University (Kenneth Carroll)</u>

- Tsai et al. (2022) Transient Storage Model Parameter Optimization Using the Simulated Annealing Method.
- Hitzelberger et al. (2022) PFOS Mass Flux Reduction / Mass Removal: Impacts of Lower Permeability Sand Lens Within Otherwise Homogeneous Systems.
- Johnson et al. (2022) Global distributions of per- and polyfluoroalkyl substances in the environment.
- Huang et al. (2022) The Co-Transport of PFAS and Cr(VI) in Porous Media.
- Farooq et al. (2022) Study the activation mechanism of peroxymonosulfate in iron copper systems for trichloroethane degradation.
- Huang et al. (2022) Cadmium removal mechanistic comparison of three Fe-based nanomaterials: Water-chemistry and roles of Fe dissolution.

- Tang et al. (2022) A mechanistic study of ciprofloxacin adsorption by goethite in the presence of silver and titanium dioxide nanoparticles.

University of California- Riverside (Jirka Simunek)

- Brunetti et al. (2022a) developed a novel multiscale biophysical model to predict the fate of ionisable compounds in the soil-plant continuum, validated it against experimental data, and implemented it into HYDRUS.
- Kacimov et al. (2022a) derived new analytical solutions for seepage from various topographic depressions (such as conical, spherical, and paraboloids), which can be applied in different environments, such as on Earth or Mars. The newly derived analytical solutions were verified against the results of the HYDRUS model.
- Gumuła-Kawęcka et al. (2022) estimated groundwater recharge on the Brda outwash plain in northern Poland using unsaturated zone modeling (using the HYDRUS-1D model), a water table fluctuation method, and tracer experiments, and compared results obtained by the three methods.
- Vanda et al. (2022) used a graph-based conflict resolution framework that considered spatial-temporal-quantitative uncertainties to evaluate reservoir operations under accidental MTBE pollution.
- Jaiswal et al. (2022) used parasite inversion of Parlange's three-parameter infiltration equation to determine the hydraulic properties and time-validity of Philip's two-term infiltration equation for 12 different textural classes.
- Brunetti et al. (2022b) developed a novel hybrid global-local optimization strategy for hydrological model calibration that balanced exploitation and exploration. We intend to implement this new strategy to the HYDRUS software.
- Silva et al. (2022a) compared various methods to estimate air-water interfacial areas for evaluating PFAS transport in the vadose zone. It is important to estimate the air-water interfacial area since it directly governs the degree of air-water interfacial adsorption of PFAS, which contributes to the transport retardation of these solutes within unsaturated porous media.
- Post et al. (2022) used the new Isotope module developed for HYDRUS-1D to estimate groundwater recharge rates using soil water isotope profiles for two contrasting dune types on Langeoog Island, Germany.
- Kacimov et al. (2022b) derived new analytical solutions for seepage to staggered tunnels and subterranean cavities. The newly derived analytical solutions were verified against the results of the HYDRUS model.
- Zhou et al. (2022) used the newly developed HYDRUS-1D Isotope module to evaluate the impact of evaporation fractionation on the inverse estimation of soil hydraulic and isotope transport parameters.
- Silva et al. (2022b) used the new PFAS module developed for HYDRUS-1D to simulate leaching of PFAS from land-applied municipal biosolids at agricultural sites.
- Chen et al. (2022) developed a computationally efficient hydrologic modeling framework to simulate surface-subsurface hydrological processes at the hillslope scale by coupling the Kineros and HYDRUS-1D models. This is the first step in the development of the catchment scale model, which will additionally also include MODFLOW.
- Gubiani et al. (2022) estimated using the inverse optimization algorithm in HYDRUS1D the soil hydraulic parameters of soils with rock fragments using both laboratory and

field infiltration data. Only the dual-porosity model of Durner (1994) could simultaneously describe both datasets.

Washington State University (Markus Flury)

- Mass transfer rates at liquid–liquid interfaces are relevant for a broad range of processes in natural and technical systems. We characterized and quantified convective flow along the interface between water and nonaqueous-phase liquids (NAPLs). Three NAPLs with different water solubility were used: 1-heptanol, 1-octanol, and 1-nonanol. The convective flow was visualized and recorded in a micromodel setup with fluorescent particles and an epifluorescence microscope. The fluid motion showed a persistent movement in the form of a rolling cell for at least 99 h, but a decreasing rotation speed over time. We attributed the convective flow dynamics to three mechanisms following different kinetic rates: (a) a short-lived Marangoni flow, (b) a medium-lived dissolution-driven flow, and (c) a long-lived evaporation-driven flow. Upon initial contact between water and NAPLs, the differences in surface tension caused a rapid Marangoni flow along the interface, which died out quickly as the surface tensions were equilibrated. The interaction of these three mechanisms caused enhanced mixing during multiphase transport. These result show that interfacial convections at contaminated sites can be an important mixing process that needs to be considered during remediation actions.

University of Florida (Ebrahim Babaeian)

- Characterizing and describing the variability of soil physical and hydraulic properties
- Enhancing understanding of soil water content dynamics at the farm scale through high spatial resolution remote sensing observations

Utah State University (Scott Jones)

- USU evaluated the idea of launching pre-wetted peat-based plant growth media at -10 kPa (-1 m) matric potential, which ensures the otherwise hydrophobic-when-dry media, remains wettable in reduced gravity, and at this potential, no free water should be released from media at the 6g launch force, i.e., based on centrifuge testing.

University of Wyoming (Thijs Kelleners)

- Used a coupled hydro-geophysical model informed by Electrical Resistivity Tomography (ERT) and Seismic Refraction (SR) data to quantify surface and subsurface water flow for a mountain hillslope in the NoName watershed, Snowy Range Mountains, Wyoming.

North Dakota State University (Aaron Daigh)

- We were able to identify that seven ornamental grasses are well adapted to survive and tolerate cycle drought, flooding, and submergence conditions for urban bioretention systems such as raingardens. However, soil contamination of deicing agents (i.e., NaCl) at rates similar to those used in the north central Plains region and motor oil contamination rates up to 5% by volume can cause substantial rates of plant depth and decline in tissue growth, which here highly dependent on grass species. Moreover, the combined stress of deicing agents and motor oil contamination severely affected some grass species.

Louisiana State University (Xi Zhang)

- Improve mechanistic understanding of how cover crops root activities influence soil structure development and thus water and gas fluxes in agroecosystem.

University of Arizona (Markus Tuller)

- Developed a new physical-empirical model that links shortwave infrared reflectance and soil water retention

University of Delaware (Yan Jin)

- Collected experimental data for study examining structure, flow, and enzyme activity near complete
- Gained improved understanding of the effects of salinity and flooding events on soil hydraulic properties
- Improved our knowledge of the effects of redox oscillation processes on the mobility of colloidal organic carbon in a soil column
- Demonstrated VIS-NIR potential to measure soil salinity level

University of Kentucky (Ole Wendroth)

- Soil mineral nitrogen dynamics and plant nitrogen uptake, and spatial biomass variability did interestingly not follow the spatial pattern of fertilizer application treatments but rather the spatial soil variability.
- Spatial variability of soil physical properties and modeling of spatial soil hydrologic processes at different scales.
- Soil structure and its functions.
- Soil physical amendment using biochars.
- Agro-Ecosystem Models for simulating crop growth under different soil and crop management.

Objective 2: **Develop and test new instrumentation, methods and models to improve the mechanistic understanding of soil processes and the quality of soil information and knowledge.**

University of California-Riverside (Hoori Ajami)

- Improve vegetation parameterization in land surface models
- Improve methodologies for sensitivity analysis and quantifying uncertainty in hydrologic models
- Develop pedo-transfer functions for dual-permeability models

Alabama A&M University (Dedrick Davis)

- Completed the first year of a field study to determine how soil matric potential, soil water content, and soil temperature vary spatially and temporally during the growing for different land uses (soybeans, corn, and pasture)

- Completed year 3 of a field study to determine the effects of an agroforestry system on microclimate and soil temperature, water content, and matric potential.

Kansas State University (Andres Patrignani)

- Tested modern and traditional methods for measuring soil water retention curves. The largest discrepancy between methods was consistently observed at moderate tensions of −33 and −70 kPa for the three soils, with an average MAD of 0.059 cm3 cm−3 for −33 kPa and a MAD of 0.083 cm3 cm−3 for −70 kPa. Plant available water capacity differed by up to 20% between the traditional and modern methods in a clay loam soil. While previous studies have mostly focused on the dry end of the SWRC, our study suggests that additional research comparing traditional and modern methods is required at moderate (−70 and −500 kPa) tension levels.
- Deployed soil moisture testbeds across multiple states to evaluate, calibrate, and disseminate existing and emerging research-grade and consumer-grade in-situ sensing technologies.
- Developing a method for automating soil evaporation measurements by instrumenting a microlysimeter.

Iowa State University (Bob Horton) and North Carolina State University (Josh Heitman)

- We investigated the effect of salinity on heat pulse signals and thermo-TDR measured electromagnetic waveforms, and the derived θ and thermal property values of packed soil columns with various textures, saturations and bulk electrical conductivity (σa) values. The results showed that: (1) at low salinity, the TDR method provided reliable θ, but it failed to estimate θ well at high salinity; (2) salinity had negligible effects on soil thermal property values, so the HP-based approach was able to derive θ and ρb values from thermal property measurements, with root mean square errors within 0.02 m3 m-3 for θ and within 0.12 Mg m-3 for ρb. Thus, the HP-based approach outperformed the thermo-TDR approach for determining θ and ρb values in soils with σa > 1.0 dS m-1.
- We evaluated the heat transfer patterns and models to analyze HP measurement data when a heating probe was positioned at the interface of a double-layered soil with different upper- and lower- layer properties. A parameterized hetero-cylindrical perfect conductors (CPC) model was proposed to describe temperature-by-time curves at the sensing probes in the upper and lower soil layers. The hetero-CPC estimates matched well with the simulated values, and its accuracy relied on the thermal property differences between the soil layers. The heat distributions caused by heat pulse inputs in the layered soils showed semi-circular isotherms with different radii centered on the heating source, therefore showing discrepancies in heat fluxes for the upper and lower soil layers. The proposed hetero-CPC model was able to accurately describe the combined effects of finite probe properties and heterogeneous soil thermal property values on the HP data in a double-layered soil system with the heating probe positioned at the layer interface.
- We combined the dual-probe heat-pulse (DPHP) technique with distributed temperature sensing (DTS) technology to measure soil thermal property values and variations in soil water content. A field experiment was performed over a 30 m transect in the Lake Wheeler Field laboratory in Raleigh, NC. Three different DPHP sensors were constructed from combinations of different fiber optic cables and heating elements and were tested to assess their performance and the effect of their construction characteristics on their accuracy. Measurements were taken over different soil moisture conditions, and the system performance was compared against independent soil water
- content sensors. The system was able to track changes in soil water content with a mean RMSE of 0.02 m3 m−3 using the optimal DPHP sensor. The key advantage of the tested system is that it does not require the site-specific calibration typically required for other DTS-based systems. The

findings of this study provide some practical information for successful DTS-DPHP construction and application under field conditions.

Texas A&M University (Binayak Mohanty)

- Developed model for dynamic coupling of vadose zone, ground water, and stream flow. This algorithm is now being implemented in National Water Model (NWM) and GFDL Earth Systems Land Model (LM). This enhances the overall skill of hydrologic and global circulation models.
- Developed model for soil microorganisms to regulate extracellular enzyme production to maximize their growth rate. This is a significant breakthrough for soil health prediction.
- Developed model for estimating regional scale effective preferential water flow to shallow ground water table using remote sensing data, soil physics concepts, and machine learning tools.

Virginia Tech (Ryan Stewart)

- To present measurements and model results from a field study examining neonicotinoid pesticide transport in row-cropping systems, by December 2023.
- To publish new methods and models for characterizing hydraulic properties of porous media, by July 2023.

New Mexico State University (Manoj Shukla)

- Proposed a new integrated model to optimize irrigation amounts and yield of hybrid maize seeds.
- Cover crops improve soil health in a limited-water environment.

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
- New vis-NIR spectral models developed for assessing soil microbial properties

New Mexico State University (Kenneth Carroll)

- Quantifying near-surface processes with instruments and analyses
- Pearson et al. (2022) Electrical resistivity monitoring of lower Rio Grande River-Groundwater intermittency.
- Jiang et al. (2022) Characterization of produced water and surrounding surface water in the Permian Basin, the United States.
- Jiang et al. (2022) Datasets associated with the characterization of produced water and Pecos River water in the Permian Basin, the United States.
- Hu et al. (2022) Toxicological characterization of produced water from the Permian Basin.

Washington State University (Markus Flury)

- Biodegradable plastic mulch is a suitable alternative to conventional polyethylene mulch. However, biodegradable plastic mulch must perform better or comparably to polyethylene mulch to be widely adopted. Gas exchange and soil microclimate are important factors impacted by the use of plastic mulch. A controlled-environment study was established in a greenhouse to assess gas exchange and soil microclimate dynamics under biodegradable plastic, polyethylene, and paper mulches with and without planting holes, as well as the impact of the mulches on the growth of sweet corn (Zea mays). We monitored CO2 concentrations in the vicinity of planting holes (chimney effect) in a greenhouse and agricultural field conditions under sweet corn production. The plastic mulches (both biodegradable plastic and polyethylene mulches) decreased the soil O2 concentration when compared to the no-mulch, and the plastic mulches reduced water loss within 50 days by 35-68 mm. There was an increase in the CO2 concentration at 2.5 cm above the planting holes in the plastic mulches compared to that under the no-mulch. The plastic mulches (both biodegradable plastic and polyethylene mulches) decreased the soil growth of sweet corn, possibly, because the canopy height of sweet corn was more than 15 cm within a few days after planting. The often reported improved growth of sweet corn from plastic mulching was attributable to other factors, such as weed control, reduced water loss, and early season soil warming, rather than elevated CO2 concentrations and fluxes in the vicinity of planting holes.

- Achieving sustainable agricultural productivity and global food security are two of the biggest challenges of the new millennium. Nanomaterials with the ability to encapsulate and deliver pesticidal active ingredients (AIs) in a responsive (for example, controlled, targeted and synchronized) manner offer new opportunities to increase pesticidal efficacy and efficiency when compared with conventional pesticides. We provided a comprehensive analysis of the key properties of nanopesticides in controlling agricultural pests for crop enhancement compared with their non-nanoscale analogues. Our analysis shows that when compared with non-nanoscale pesticides, the overall efficacy of nanopesticides against target organisms is 31.5% higher, including an 18.9% increased efficacy in field trials. Notably, the toxicity of nanopesticides toward non-target organisms is 43.1% lower, highlighting a decrease in collateral damage to the environment. The premature loss of AIs prior to reaching target organisms is reduced by 41.4%, paired with a 22.1% lower leaching potential of AIs in soils. Nanopesticides also render other benefits, including enhanced foliar adhesion, improved crop yield and quality, and a responsive nanoscale delivery platform of AIs to mitigate various pressing biotic and abiotic stresses (for example, heat, drought and salinity). Nonetheless, the uncertainties associated with the adverse effects of some nanopesticides are not well-understood, requiring further investigations. Overall, our findings show that nanopesticides are potentially more efficient, sustainable and resilient with lower adverse environmental impacts than their conventional analogues. These benefits, if harnessed appropriately, can promote higher crop yields and thus contribute towards sustainable agriculture and global food security.
- We evaluated a large combinations of soil, climate, topography, tillage, and crop rotation, and simulated these scenarios for twelve counties in eastern Washington, major areas for rainfed cereal-grain crops, with the Water Erosion Prediction Project (WEPP) model. Average annual erosion rates were lowest in the low-precipitation zone and highest in the intermediate-precipitation zone, exceeding the NRCS soil loss tolerable limit in many cases. Soil erosion maps based on the WEPP simulation results reveal critical-source areas (“hotspots”) where estimated erosion rates are more than five times the average rates. Temporally, high precipitation events and fallow periods in the rotation greatly increase erosion. This study provides crucial information for targeting management and increasing efficiency of conservation practices.

Desert Research Institute (Markus Berli and Dani Or)

- Model evaluation for water infiltration into hydrophobic soil
- Improved model to simulate water infiltration, redistribution and evaporation for arid soils

University of Florida (Ebrahim Babaeian)

- Developed and improved forecasting of the water cycle components (i.e., evapotranspiration) by fusing ground, climate, and remote sensing observations with AI techniques to enhance hydrologic modeling and water resources management.

Utah State University (Scott Jones)

- Asghar Ghorbani, Morteza Sadeghi, Markus Tuller and Scott Jones have derived novel hydraulic functions of water retention that yield improved K(h) function fitting to a variety of published data.

University of Wyoming (Thijs Kelleners)

- Demonstrated how coupled and uncoupled hydro-geophysical inversion of Electrical Resistivity Tomography (ERT) data can be used to determine layer-wise subsurface hydraulic parameters for a mountain hillslope

North Dakota State University (Aaron Daigh)

- Using our integrated remote sensing and machine learning algorithm, we were able to map high-resolution soil moisture in the Red River Valley (RRV) with RMSE within the range of common in-situ soil moisture sensors ($<0.05\ m^3\ m^{-3}$). The RRV land use is a mosaic of agricultural crops with seasonally frozen, smectitic soils. Validation of the algorithm was able to predict soil moisture across the growing season of 11 crops with an RMSE of $0.05\ m^3\ m^{-3}$ and r^2 of 0.70.

University of Arizona (Markus Tuller)

- Developed a new deep learning approach to forecast evapotranspiration from ground and remote sensing observations to aid with real-time estimation of crop water demand and irrigation water allocation in agriculture

USDA-ARS, US Salinity Laboratory (Ray Anderson, Todd Skaggs, and Elia Scudiero)

- New approaches to measuring soil salinity in drip-irrigated systems. Geophysical approaches such as EM measurements have long been used to map soil salinity. However, drip irrigation creates complex, bulb-like, patterns of moisture and salinity accumulation that confound EM measurements. Using a combination of field experiments and modeling, ARS and UCR researchers have developed new approaches and guidelines for making EM observations in drip and micro-irrigated systems. The results can enable more accurate use of EM in drip and micro-irrigated systems, which is critical for continued relevance of the EM approach due to the expansion of these irrigation systems.
- New open-source platforms and models provide improved evapotranspiration for crop water use and irrigation management. Recent droughts in the western United States have put tremendous strain on water resources, and there is increased pressure on the agricultural community to improve irrigation efficiency. However, established satellite evapotranspiration (ET) algorithms (and particularly thermal algorithms that work well in the western United States) are challenging for non-specialists to operate. ARS researchers at Riverside, California, and Maricopa, Arizona,

have evaluated a new open-source ET platform (Open ET) that relies on a suite of models for an ensemble observation of ET. They found that Open ET works well in perennial nut crops such as almonds, thus providing another tool for irrigators to assess crop water needs. This group also tested a novel ET model (BAITSSS) for assessing crop water requirements in lettuce.

University of Kentucky (Ole Wendroth)

- Variable-rate pivot irrigation technology is new in Kentucky. We are working with one of the first if not the first systems of this kind in Kentucky. During the growing season, we trouble-shot problems in the pivot system. We have records from each irrigation event, and how much water each of the 78 nozzles applied at what time and where in the field. Currently, we investigate the local water mass balance and investigate how to encounter lateral surface and subsurface water flow to be included in modeling water balance and crop water uptake for spatially specified irrigation decisions.

Objective 3: **Integrate scale-appropriate methods to improve decisions related to the management of soil and water resources.**

Oregon State University (Salini Sasidharan)

- Implementation of five drywell and one monitoring well in Fresno California to compare the performance of drywell vs Ag-MAR
- Developing a sustainable groundwater quantity and quality innovation pilot scale site to test various Managed Aquifer Recharge techniques.
- Developing a pretreatment system to remove sediment load from source water to mitigate clogging from drywell.

University of California-Riverside (Hoori Ajami)

- Develop watershed scale models to assess the impacts of climate variability and agricultural management practices on streamflow and lake-groundwater interaction
- Develop computationally efficient modeling frameworks for watershed scale simulations

Kansas State University (Andres Patrignani)

- Validating a data-assimilation framework to estimate soil moisture at the mesoscale level. The model integrates readily available point-level soil moisture information from the Kansas Mesonet. Validation is being conducted using stationary and roving cosmic-ray neutron detectors.

Texas Tech University (Sanjit Deb)

- Understanding the spatial patterns of soil microbial communities and influencing factors is a prerequisite for soil health assessments and site-specific management to improve crop production. However, soil microbial community structure at the field scale is complicated by the interactions between topography and soil properties. Neupane et al. (2022) characterized the spatial variability patterns of soil microbial communities at the field scale and assessed the influence of soil physicochemical properties, topography, and management on soil microbial biomass spatial variability.
- Integrating biochar and deficit irrigation is increasingly being evaluated as a water-saving strategy to minimize crop yield losses under reduced irrigation in arid and semi-arid regions.

Singh et al. (2022) demonstrated and assessed the effects of two types of biochar amendments (hardwood and softwood) and various deficit irrigation rates [100, 70, and 40% crop evapotranspiration (ETc) replacement] on the physiology, plant growth, and yield of sweet corn in semi-arid West Texas.

- Root modifications can be vital in crop adjustments to soil water deficit and are essential to understand root growth and soil water depletion patterns to develop effective cropping systems, especially in semi-arid regions like Texas High Plains. Singh et al. (2022) evaluated root growth, soil water depletion, and water productivity of sweet corn under deficit irrigation strategies [100 %, 70 %, and 40 % crop evapotranspiration (ETc)] and biochar amendments (hardwood and softwood biochar).
- Colored shading nets have been increasingly studied in semi-arid crop production systems, primarily because of their ability to reduce solar radiation with the attendant reductions in air, plant, and soil temperatures. Mohawesh et al. (2022) demonstrated and evaluated the effects of colored shading net treatments on the growth and instantaneous water use efficiency of vegetable crops such as sweet pepper.
- Understanding spatial and temporal patterns of rootzone soil water dynamics in semiarid cotton under subsurface drip irrigation is critically challenging due to the complexity of interactive water flow, heat transport, root growth, root water uptake processes, and the difficulties associated with the field measurements of these multidimensional processes. Singh (2022) evaluated and modeled (using both the agricultural systems model and multidimensional numerical simulation model) soil water dynamics in the semiarid soil-cotton-atmosphere systems under various agronomic conditions and options, including deficit irrigation strategies, adverse effects of cotton-weed interactions, early-season planting options, and a variety of biochar amendments application.

<u>Oklahoma State University (Tyson Ochsner)</u>

- Completed evaluations of seasonal streamflow forecasts utilizing both remotely sensed soil moisture and remotely sensed terrestrial water storage data.
- Drafted manuscript for submission to peer reviewed journal in 2023.

<u>University of Idaho (Robert Heinse)</u>

- Completed establishment of a demonstration site for small-scale vegetable production and soil management.
- Completed assessment for water-resource impacts for a conversion from dryland production to irrigation in the Palouse region.

<u>Iowa State University (Bob Horton) and North Carolina State University (Josh Heitman)</u>

- We determined the efficacy of compost as a soil amendment to reduce runoff volume, improve runoff quality, and increase vegetation establishment on a disturbed sandy clay subsoil representing post development conditions. Two sources of compost were tested. Runoff water quality did not differ among the compost additions. However, the certified compost increased biomass production proportionally to the amount added and compared to the uncertified compost at the same rate. The improved vegetation establishment with compost is important for long-term erosion control and ecosystem services. The results of this study suggest (1) tilling is a viable option to achieve high infiltration rates and reduce runoff volumes, (2) compost incorporation does not reduce nor improve water quality, and (3) compost may yield more robust vegetation establishment.

- We examined the influence of compost application rate on nutrient and heavy metal mobility. As compost rate increased, the Kd decreased for PO4 –P and Cr but increased for Cd, Cu, Ni, and Zn. The addition of compost reduced the sorption of PO4 –P and Cr, potentially making it a source of these pollutants. Simulated stormwater did not increase the amount of pollutants retained compared with DI water for compost blends, except for 100% compost columns. Nitrate was the only constituent that had a negative removal efficiency, suggesting that the compost was a source of NO3 –N. Column media retained >70% of the metals from the added stormwater solution. These results suggest that yard-waste compost blends at ≤50% have the potential to retain certain pollutants from infiltrating stormwater, but this effect may decline after several storm events.

Texas A&M University (Binayak Mohanty)

- Our high space-time resolution ET and soil moisture products provide the basis for water management in precision agriculture in large agricultural fields.
- Our new soil hydrologic response units provide the effective platform for futuristic resource management of soil, water, and ecosystem services at multiple scales.
- We developed a global flash drought monitoring tool using surface soil moisture from SMAP satellite. This tool is now being used by many across the globe for operational drought monitoring and management.

Virginia Tech (Ryan Stewart)

- To provide recommendations based on the results of our study on gaseous and leaching losses of nitrogen from common fertilizers in cotton production, by December 2023.
- To provide recommendations for vineyard soil management that enhances wine-grape quality, by May 2024.

University of California- Riverside (Jirka Simunek)

- Zhang et al. (2022) used experimental data and numerical simulations (with HYDRUS2D) to optimize drip irrigation with alternate use of fresh and brackish waters by analyzing salt stress in a corn field. They recommended the optimal strategy for the studied region, using most brackish water with only a minor decrease in the corn yield.
- Chen et al. (2022a) used experimental data and numerical simulations (with HYDRUS2D) to evaluate soil salts dynamics under biodegradable film mulching with different disintegration rates in an arid region with shallow and saline groundwater. He compared these data with conditions under a plastic film mulching and no mulching.
- Chen et al. (2022b) used experimental data and numerical simulations (with HYDRUS2D) to quantify the inter-species nitrogen competition in the tomato-corn intercropping system with different spatial arrangements.
- Zhang et al. (2022) evaluated using experimental data and HYDRUS-1D modeling the significance of non-DLVO interactions on the co-transport of functionalized multi-walled carbon nanotubes and soil nanoparticles in porous media (in laboratory column studies).

Washington State University (Markus Flury)

- Agricultural soils are important sources of two potent greenhouse gases, nitrous oxide (N2O) and methane (CH4), the atmospheric levels of which are steadily increasing. Increases in N2O also threaten the earth’s protective ozone layer. Only two reactions are known to degrade N2O and

CH_4 without requiring high temperatures and high energy inputs: those catalyzed by bacterial N_2O reductase (N2OR) and methane monooxygenase (MMO). Plants genetically engineered to constitutively express N2OR and MMO could potentially remove both gases from soil and atmosphere. Based on theoretical considerations, we set out to model the potential impact of N2OR- and MMO- transformed plants on emissions and uptake of N_2O and CH_4. Our calculations suggest that such plants could prevent 50% of soil emissions of N_2O and CH_4 and take up substantial N_2O from the atmosphere. If planted globally, N2OR- and MMO-engineered crop plants could potentially stop increases in N_2O and CH_4 in the atmosphere and slow increases in global warming, providing a strong incentive for research into this biotechnology.

North Dakota State University (Aaron Daigh)

- We were able to quantify a range of landslide conditioning factors across North Dakota. Of the 24,123 identified landslides, nearly 97% of those occurs in vadose zones with generally low pore water salinity and sodium adsorption ratios (SAR; i.e., <5.0 dS/m and <7.0 SAR, with maximum frequency occurring at 1.5 dS/m and 0.5 SAR) even though high pore water salinity and SAR is characteristic of many soils across the state.

Louisiana State University (Xi Zhang)

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

USDA-ARS, Bushland, Texas (Robert Schwartz and Steve Evett)

- Submitted soybean weighing lysimeter dataset collection to the USDA ARS NAL Ag Data Commons.

Texas A&M University (Briana Wyatt)

- Integrated multiple remote sensing-based datasets to develop streamflow forecasts for three surface water irrigation districts in the US Great Plains.

University of Kentucky (Ole Wendroth)

- In a first spatial analysis, we evaluated the identification of soil hydraulic property parameters in different zones of the field, and detected similarity between parameters in similar soil types and differences in parameters when different soil types were compared over a large scale.
- Hydraulic property parameters were inversely estimated within the Root Zone Water Quality Model (RZWQM2) which is a development of USDA-ARS scientists.

Impacts

Oregon State University (Salini Sasidharan)

- Our work will help to develop a climate resilient managed aquifer recharge and unmanaged aquifer recharge strategies for improving groundwater quantity and quality to enhance agriculture and industrial competitiveness in Pacific Northwest and California.

University of California-Riverside (Hoori Ajami)

- This research has focused on understanding of groundwater recharge processes in mountain catchments and quantifying streamflow response to meteorological droughts. As part of these efforts, we shared our research results with stakeholders such as NGOs and Groundwater Sustainability agencies in the Kaweah River watershed in Southern Sierra Nevada. This information will be valuable for sustainable water resource management in California and elsewhere. We also developed educational materials related to Hydrology and GIS for high school teachers. These materials are valuable to train the next generation of hydrologic scientists.

Alabama A&M University (Dedrick Davis)

- Our work to evaluate the effects of biochar on soil thermal properties provides much needed information as interest in the use of biochar as a climate smart agriculture practice increases.
- The work on evaluating water retention and hysteresis in two highly weathered soils and poultry litter provides an understanding of wetting and drying processes for poultry and can be used to mitigate odor and ammonia emissions from poultry litter and poultry houses.
- Our work to evaluate the impact of biopolymers on soil physical properties and processes will provide fundamental information for the US-DoD and USACE regarding their potential for soil stabilization and remediation.
- The work to examine soil water content, matric potential, and soil temperature will provide a basis for understanding soil water retention processes in-situ and their importance to field chemical and biological processes.

Kansas State University (Andres Patrignani)

- Konza Pulse: A Hydrological Network in the Konza Prairie with Emphasis on Rootzone Soil Moisture. K-State College of Agriculture $48,850
- In-situ Testbeds for Soil Moisture Sensing and Technology Transfer. USDA-NRCS. $693,334

Texas Tech University (Sanjit Deb)

- In groundwater-dependent agricultural production of the southern Ogallala Aquifer Region, developing and evaluating soil and water management strategies and technologies are major concerns for the economic viability of individual producers and the region. Different soil and water conservation and management practices addressed in our research (field, laboratory, and greenhouse experiments, including modeling approaches) during 2022 will extend our understanding of soil- and crop-based properties and processes that can substantially contribute to soil-crop-water-atmosphere relationships, soil water dynamics under crop-weed interactions, soil water balance, crop abiotic stresses and phenological responses, soil-optimized early season planting windows for crop genotypes exhibiting tolerance to the cold, beneficial use of organic amendments under the soil- and plant-based limited irrigation strategies, and water use efficiency in semiarid agricultural and horticultural crop production and pasture systems.

Michigan State University (Wei Zhang)

- Our research identified stomatal internalization as an important pathway for foliar uptake of silver nanoparticles. We found that typical washing practices are not effective in removing sorbed silver nanoparticles from lettuce, which points to the importance of pre-harvest intervention and developing new washing strategies to minimize food contamination by heavy metals. Collaboration between Michigan State University and Creighton University advanced the understanding on prion interactions with soil matrices and the persistence, bioavailability, and infectivity of prions in the environment, which could help understand prion disease ecology in wildlife populations and develop scientifically-sound mitigation strategy.

Oklahoma State University (Tyson Ochsner)

- This research includes scientific and career mentoring for one PhD student. This line of work has been leveraged in a subsequent USDA NRCS research grant focused on soil climate dynamics.

University of Idaho (Robert Heinse)

- Understanding the mechanisms governing the dynamics of capillary driven water distributions are critical to predicting root-zone performance for plant-based bioregenerative life support during space travel and on planetary habitats.
- Our work on the demonstration site is helping preserve groundwater resources for a stressed aquifer.

Iowa State University (Bob Horton) and North Carolina State University (Josh Heitman)

- Our results that characterize soil structure information from transport properties has a transformative potential to more deeply understand several fundamental processes in soils including water retention and infiltration, gaseous exchanges, soil organic matter and nutrient dynamics, root penetration, and susceptibility to erosion.

Texas A&M University (Binayak Mohanty)

- Our implementation and fusion of data from satellite and insitu platforms for Earth surface's soil moisture spatio-temporal distributions, dry down patterns, and associated hydrologic fluxes (ET and baseflow) estimation, and linked numerical models have provided unprecedented efficient tools and techniques to address wide spectrum of challenges related to soil and environmental sciences, including water management, crop production, climate forecasts, flood and drought prediction, groundwater recharge estimation, GHG emission, and pollution control. 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.

University of California- Davis (Majdi Abou Najm)

- We developed, validated and published a model to estimate plant response to different light treatments including changes to transpiration and water use efficiency. This has major impact on the developments in agrivoltaics and other leading food and energy co-generation solutions. Agrivoltaics hits a wide range of publicly very important aspects, from drought to soil health, to agricultural resilience, to food and energy safeties. The paper we published on modeling agrivoltaic systems received an extraordinary news and media coverage which led to great public outreach. The paper was covered by more than 20 news and media stories and scores on the top 1% of all published work according to Altmetric (which is an attention score metric).
- We published two reviews related to soil structure and health, incorporating the screening of thousands of journal articles and the development of two large global datasets that will be made available. We published a generic regional model for nitrogen as part of resource optimization and management at the scale of water-energy-food nexus.

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 new USDA NIFA funding into other western states.
- We are the technical service provide for the California water rights division in the State Water Board to provide guidance on drought emergency curtailment orders.

Virginia Tech (Ryan Stewart)

- We partnered with Fairfax County, Virginia, on a 3-year study to characterize and improve tree pit performance. In the first project year (2021-2022), we collected and analyzed media samples from tree pits that represented unhealthy or dead versus healthy trees. 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 N and P leaching dynamics through time.
- Our preliminary results indicated that some tree pit growing media has a higher-than-ideal amount of rock fragments from the topsoil component. This information has been relayed to partner entities and the Virginia Department of Environmental Quality. Our initial leaching tests indicated that fresh media can have an initial flush of carbon and P. Further work will be conducted to determine if this behavior is common and if it warrants greater concern.

New Mexico State University (Manoj Shukla)

- The project on “water use efficiency improvement using micro-gravity drip irrigation system. A research and demonstration experiment in Leyedecker Plant Science Center of NMSU demonstrated the potential to shift irrigation from flood to a more efficient micro-gravity drip irrigation system.

- The project on "brackish groundwater and produced water reuse for grasses" showed that use of saline water will augment irrigation water portfolio, increase carbon sequestration, and could help achieve the USDA's mission of food security.

New Mexico State University (Kenneth Carroll)

- "Transient Storage Model Parameter Optimization Using the Simulated Annealing Method"
- Nonunique parameter estimation has plagued the models use to simulate exchange between groundwater and rivers. We evaluated "simulated annealing" to optimize parameter estimation. Dr. Carroll's group demonstrated the robustness and capability of the simulated annealing method using a synthetic, hypothetical, case with known parameters, and applied simulated annealing for in-stream salt-tracer tests conducted at East Fork Poplar Creek, Tennessee. The simulated annealing method identified the correct parameters for different initial parameter guesses. Hydrologists can now estimate the optimal hyporheic model parameters, and this will allow us to better manage water resources, water quality, and ecosystems.

University of California- Riverside (Jirka Simunek)

- The HYDRUS models are continuously being updated based on the basic research carried out by the W4188 group. The HYDRUS-1D model was downloaded more than ten thousand times in 2022, 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 processes in the soil profiles with furrows (the Furrow module), to calculate cosmic-ray neutron fluxes (the Cosmic module), to simulate the translocation and transformation of chemicals in the soil-plant continuum (A Dynamic Plant Uptake module), and to consider the transport of PFAS in the vadose zone (the PFAS module).
- Finally, in 2022 we have offered two short courses on using HYDRUS models in America and Israel. About 100 students participated in these short courses.

Washington State University (Markus Flury)

- A hypothesis was developed to use genetic modifications of mitochondria in plants to transform N2O to N2. Numerical simulations indicate that this could effectively reduce N2O emissions from soil. If the experimental implementation is successful, this technology would have tremendous implications for climate change.
- We demonstrated that that nanopesticides can improve pesticide efficiency and reduce environmental pollution with non-used pesticides. This shows that nanopesticides can have an important impact on global food security.

Desert Research Institute (Markus Berli and Dani Or)

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

University of Florida (Ebrahim Babaeian)

- The acquired knowledge will enhance our understanding of the water dynamics and hydraulic properties of sandy soils as well as their influence on agricultural water and nutrient management and sustainability of surface and groundwater resources.
- Our new data-driven modeling tools, in conjunction with ground and satellite observations, will play a crucial role in advancing hydrologic modeling, soil health in agriculture, mitigation of climate change impacts, and the security and sustainability of soil and water resources.
- Our research resulted in a collaborative research grant from the USDA-NRCS to support two graduate students to conduct research on soil hydrology and dynamic soil survey.

Utah State University (Scott Jones)

- A Utah State University (Scott Jones, Bruce Bugbee) and Space Dynamics Laboratory (Curtis Bingham) proposal titled, “Design, Monitoring and Management Approaches for the Root-Zone in Microgravity: Phase B” was awarded a 2-year, $2M NASA Grant under their program - Development of Microgravity Food Production: Plant Watering, Volume Management, and Novel Plant Research on the International Space Station (NNH22ZDA002N)

University of Wyoming (Thijs Kelleners)

- Show how surface-based geophysical measurements can be used to determine (spatially variable) subsurface hydraulic parameters
- Use spatially variable hydraulic parameters to calculate surface and subsurface water storage and flow in snow-dominated mountain hillslopes

North Dakota State University (Aaron Daigh)

- The development of an integrated remote sensing and machine learning algorithm for accurate predictions of near-surface soil moisture results in a new tool to readily map water across the Red River Valley of the North where the agricultural landscape produces a mosaic of crop species. This work and the transfer of knowledge to producers and other stakeholders will result in improved ability for precision agricultural, including precision harvesting to avoid deep wheel-traffic compaction.
- A challenge to urban storm water bioretention systems in frigid regions is the combined influences of salt (i.e., natural and de-icing agents) and petroleum product contamination. The research on sedge and ornamental grass species will inform urban planners and homeowners of science-based options for simultaneously obtaining aesthetic green spaces, plant survival, flood control, and sediment and contaminate removal from stormwaters
- The quantification of landslide conditioning factors for North Dakota’s 24,000+ identified slope failures provides the foundation for future landslide risk mapping that is calibrated to its geographical regions and landscape conditions (semi-arid, continental climate, frigid and saline soils). The research will inform a broad range of stakeholders in the state for future planning of operations and land use to ensure human safety and minimize infrastructure damages.
- The activities and results of the project were disseminated in forms that are available to audiences well beyond the target audiences. This means that other stakeholders have access to the information and can use the findings to inform them on related and connected issues around soil

salinity and remediation, landslide conditioning, remote sensing tools for mapping water on the landscape, and petroleum and deicing contamination in urban settings.

Louisiana State University (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 to growers and agricultural research stations in Louisiana on using conservation agriculture practices to improve agricultural system productivity.
- Receive support from state and regional commodity boards.
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    - Jeong, C., and X. Zhang. Fertility loss via soil erosion and runoff water quality from rainfed and irrigated croplands. Louisiana Soybean and Grain Research and Promotion Board. Apr. 2021-Mar. 2024 ($97,125).

University of Arizona (Markus Tuller)

- The OPtical TRApezoid Model (OPTRAM) for estimation of soil moisture based on remotely sensed transformed SWIR surface reflectance that we developed in 2017 in collaboration with Utah State University (Morteza Sadeghi and Scott Jones) has been applied globally in numerous research projects in 2022.

USDA-ARS, Bushland, Texas (Robert Schwartz and Steve Evett)

- Use of drought-tolerant maize hybrids did not confer any advantages over a conventional hybrid with respect to root water extraction, biomass, and grain yield under moderate to severe water stress levels in the Texas High Plains. It is likely that drought-tolerant traits, such as a greater root exploration or early stomatal closure in response to vapor pressure deficit, have diminished effects on transpiration under the high atmospheric demand and dense soil profiles characteristic of this region.
- Standard methods for calibration of downhole soil water sensors, specifically the neutron probe, were published along with analysis of spatial variation in soil bulk density and water content from centimeter to multiple meter scales. Spatial variation in soil bulk density and water content was large enough to cause large errors in calibration if soil volumetric samples were not taken from the same soil volume that was explored by the sensor. Large errors are also possible if soil bulk density determined at another place and time is used to calculate volumetric water content from gram per gram water content values determined from soil samples of unknown volume.

Texas A&M University (Briana Wyatt)

- Produced first seasonal-scale streamflow forecasts for five watersheds in the Great Plains
- Potential to improve water management decision making for our irrigation district partners

University of Delaware (Yan Jin)

- Ecological models aiming to represent soil carbon dynamics are often driven by overly simplistic moisture functions such as volumetric water content. By doing our experimental work on soil structure and its relationship with hydrology and biology mechanistic information is being generated that may one day help in the development of new model parameters to represent C processes in soil.
- Understanding the contribution of Fe-speciation and crystallinity on the dynamics of size-fractionated colloids and colloidal organic carbon is critical for better predicting the cycling, transport, and stability of SOC in a redox fluctuating wetland
- By examining the effect of salinity, due to flooding and sea level rise (SLR), on the physical, hydrological, and chemical properties of soils we will be able to further estimate how this impacts soil's utility and suitability for military operations and mobility.

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Book Chapters

1. Daigh, A.L.M. 2022. Crop diversification and soil water. Chapter 5, pg. 85 - 108, In Blanco, H., Kumar, S., Anderson, S. (Eds.) Soil Hydrology in a Changing Climate. Australian CSIRO.
2. Oster, J.D., N.W.T. Quinn, A.L.M. Daigh, and E. Scudiero. 2022. Agricultural subsurface drainage water. Chapter 8, pg. 157-195, In Qadir, M., Smakhin, V., Koo-Oshima, S., Edeltruaud, E. (Eds.) Unconventional Water Resources. Springer Nature Switzerland AG.

Reports and Popular Press Articles

1. S, Sasidharan, Bradford, S. A., J. Šimůnek, 2022, Research Support For Watershed And Basin Hydrology And Water Quality In The Arid and Semi-Arid Southwest, USA Evaluation of Drywell Performance at Fort Irwin: Vadose Zone Study Final Report, USDA-ARS and USEPA

Interagency Agreement. (Peer Reviewed) Prepared for: Environmental Protection Agency Office of Research and Development. EPA Interagency Agreement No. DW-012-92465401-5
2. Poukrel, S. R. O. Maguire, W. E. Thomason, and R. D. Stewart. 2022. Building Healthy Soil with Best Management Practices. Virginia Cooperative Extension Publication SPES-408P.
3. Daigh, A., D. Clay, C. Gasch, D. Ripplinger, A. Wick, T. DeSutter, F. Casey, S. Clay, C. Reese, N. Derby, D. Gatchell, J. DeJong-Hughes, U. Acharya, R. Alghandi, Z. Leitner, U. Ghosh, D. Joshi, J. Moriles-Miller, G. Reicks, S. Westhoff, P. Oduor, D. Burkland, K. Johnson, M. Langseth, C. Langseth, S. Carlson, J. Schebeck, D. Renaas, and G. Anderson. 2022. Cover crops and no-tillage enhance soil water management in frigid northern Great Plains soils. Final report for CIG Project 69-3A75-17-282.
4. Meehan, M.A., C. Augustine, T. DeSutter, and A.L. Daigh. 2022. Amending soils for successful remediation of brine spills on range and crop lands. Technical report for USDA – CARE award.
5. Jones, S. B., Bugbee, B. G., & Bingham, G. NASA Final Report: Design, Monitoring and Management Approaches for the Root zone in Microgravity.
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Proceedings Papers and Conference Abstracts

1. Sasidharan, S., S. A. Bradford, Innovative Drywell Designs And Applications For Enhanced Managed Aquifer Recharge, AGU December 12-16, 2022, Chicago, USA, Link
2. Bradford, S.A., Sasidharan, S., Dhalke, H., Fogg, GE., Simunek, J, 2022, Simulated Assessment of Preferential Flow during Agricultural Managed Aquifer Recharge, AGU December 2022, Chicago, USA Link
3. Sasidharan, S., S. A. Bradford, Innovative Drywell Designs And Applications For Enhanced Managed Aquifer Recharge, ASA-ASSA-SSSA Annual Meeting November 6-9 2022, Baltimore, USA
4. Bradford, S.A., Sasidharan, S., Osterman, G, Optimizing the Benefits and Minimizing the Risks of MAR in the Central Valley, CA, Western Groundwater Congress 2022, September 19-21, 2022, Sacramento, USA
5. Bradford, S.A., Sasidharan, S., Osterman, G, Optimizing the Benefits and Minimizing the Risks of MAR in the Central Valley, CA Groundwater Protection Council on October 3, 2022
6. Sasidharan, S., S. A. Bradford, J. Šimůnek, 2022, Sustainable Groundwater Management using Managed Aquifer Recharge (Dry wells), International Symposium Managed Aquifer Recharge 11, April 11 - 15, 2022, Long Beach, Link
7. Singh, A., Deb, S. K., Singh, S., Slaughter, L. C., & Ritchie, G. (2022) A Multi-Model Approach to Simulate the Soil Water Dynamics in Cotton Production Systems [Abstract]. ASA, CSSA, SSSA International Annual Meeting, Nov 6-9, Baltimore, MD. https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/143583
8. Singh, A., Deb, S. K., Singh, S., Slaughter, L. C., & Ritchie, G. (2022) Role of Biochar to Improve Soil Physical and Hydraulic Properties in Early-Planted Cotton [Abstract]. ASA, CSSA, SSSA International Annual Meeting, Nov 6-9, Baltimore, MD. https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/143654
9. Deb, S. K., & Singh, A. (2022) Root Zone Water Dynamics and Cotton Production Under Various Agronomic Practices in West Texas [Abstract]. ASA, CSSA, SSSA International Annual Meeting, Nov 6-9, 2022, Baltimore, MD. https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/143619
10. Karn, R., Guo, W., Lewis, K. L., Ritchie, G., Deb, S. K., & Wang, C. (2022) Response of Cotton Fiber-Quality to Nitrogen Rates, Soil, and Topographic Properties [Abstract]. ASA, CSSA, SSSA

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11. Singh, A., & Deb, S. K. (2022) Understanding of Root Zone Soil Water Dynamics Under Cotton-Silverleaf Nightshade Interactions [Abstract]. ASA, CSSA, SSSA International Annual Meeting, Nov 6-9, 2022, Baltimore, MD. https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/143552
12. Slaughter, L. C., Arora, R., West, C. P., Deb, S. K., & Acosta-Martinez, V. (2022) Impacts of legume inclusion on soil greenhouse gas emissions in semi-arid pasture ecosystems [Abstract/Poster]. The 22nd World Congress of Soil Science, July 31-August 5, 2022, Glasgow, Scotland, UK.
13. Arora, R., Slaughter, L. C., West, C. P., Deb, S. K., & Acosta-Martinez, V. (2022) Influence of Legume Inclusion on Greenhouse Gas Emissions from Pasture Systems in the Southern High Plains of Texas [Abstract]. USDA-ARS & TTU Research Spotlight, Oct 18, 2022, USDA-ARS, TTU Office of Research and Innovation Lubbock, TX.
14. Arora, R., Slaughter, L. C., West, C. P., Deb, S. K., & Acosta-Martinez, V. (2022) Influence of Legume Inclusion on Greenhouse Gas Emissions from Pasture Systems in the Southern High Plains of Texas [Abstract]. ASA, CSSA, SSSA International Annual Meeting, Nov 6-9, 2022, Baltimore, MD. https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/143642
15. Karn, R., Guo, W., Lewis, K. L., Deb, S. K., Ritchie, G., and Wang, C. (2022). Optimizing Nitrogen Management in Dryland Cotton using Precision Agriculture Technologies in the Southern High Plains. Beltwide Cotton Conferences, January 4-6, 2022, San Antonio, TX.
16. Arora, R., L. Slaughter, C. P. West, S. K. Deb, and V. Acosta-Martinez. (2022) Singh, M., Singh, S., Deb, S. K., Petermann, B., and Siebecker, M.G. (2022). Does biochar application affect soil properties and sweet corn production under deficit irrigation? PSS Student Research Symposium, April 18, 2022, Texas Tech University, Lubbock, TX.
17. Singh, M., Singh, S., Deb, S.K., Ritchie, G. and Wallace, R.W. (2022). Can biochar improve root growth and water use efficiency of cucumber under deficit irrigation? The ASHS Annual Conference, July 30-August 3, 2022, Chicago, IL.
18. Arora, R., L. Slaughter, C. P. West, S. K. Deb, and V. Acosta-Martinez. (2022). Influence of legume inclusion on greenhouse gas emissions from pasture systems in southern high plains of Texas. Oral presentation at PSS Student Research Symposium, April 18, 2022, Department of Plant & Soil Sciences, Texas Tech University, Lubbock, TX.
19. Arora, R., L. Slaughter, C. P. West, S. K. Deb, and V. Acosta-Martinez. (2022). Influence of legume inclusion on greenhouse gas emissions from pasture systems in southern high plains of Texas. Poster presentation at 21st Annual Graduate Student Research Poster Competition, March 3, 2022, Texas Tech University, Lubbock, TX.
20. Arora, R., L. Slaughter, C. P. West, S. K. Deb, and V. Acosta-Martinez. (2022) Harnessing soil health to mitigate greenhouse gas emissions in semi-arid pasture ecosystems. Virtual oral presentation at Soil Survey and Land Resource Workshop, February 9-10, 2022, Texas A&M University, College Station, TX.
21. Zhang, W. 2022. Mechanistic and machine learning of emerging contaminants in soil-water-plant systems. The 23rd Meeting of Soil Environment Committee of Soil Science Society of China and Symposium on Ecosystem Protection and High-Quality Development of Agricultural Land in the Yellow River Basin, Zhengzhou, China, August 12-14 (oral presentation).
22. Zhang, W., H. Li, Y. Shen, F. Gao, and R.M. Benedict. 2022. Mechanistic and machine learning studies of emerging contaminants in the environment. AGU Fall Meeting, Chicago, IL, December 12-16 (oral presentation).
23. Li, C., Y. Shen, T. Sotthiyapai, Y. Liu, L.K. Tiemann, S.I. Safferman, and W. Zhang. 2022. Effect of biosolids application on soil enzymatic activities, microbial biomass, and soil carbon mineralization. ASA, CSSA, SSSA International Annual Meeting, Baltimore, MD, November 6-9 (oral presentation).

24. Zhang, W., Y. Shen, and H. Li. 2022. Rhizosphere as a hotspot for contaminant interactions with plants and microorganisms. ASA, CSSA, SSSA International Annual Meeting, Baltimore, MD, November 6-9 (oral presentation).
25. Benedict, R.M., H. Li, J. Bartz, and W. Zhang. 2022. Exploring the effects of electrolytes on adsorption of amino acids to aromatic carbon materials. ACS National Meeting & Exposition, Chicago, IL, August 21-25 (poster presentation).
26. Banna, H., J. Siegenthaler, R. Benedict, W. Zhang, and W. Li. 2022. Heavy metal sensing in vegetable and soil solutions using carbon fiber electrode. Hilton Head Workshop 2022: A Solid-State Sensors,
27. Actuators and Microsystems Workshop, Hilton Head Island, SC, June 5-9, 2022 (poster presentation).
28. Mohanty, B.P., and M. Hong, Representing the Stream-Hillslope Bidirectional Continuum in the National Water Model for Improved Predictability of Terrestrial Water and Energy Cycles, Frontier in Hydrology Meeting Abstract, 2022.
29. Hong, M., and B.P. Mohanty. Catchment-Scale Understanding of The Role of Bidirectional Stream-Hillslope Continuum in the Development of Land Surface Boundary Conditions, Frontier in Hydrology Meeting Abstract, 2022.
30. Mohanty, B.P. and V. Sehgal, Soil Response Units: Discretizing Watersheds Using Observed Soil Hydrological Behavior at Remote Sensing Scale, Frontier in Hydrology Meeting Abstract, 2022.
31. Mbabazi, V. Sehgal, and Mohanty, B.P., Coupling of Surface Soil moisture and Evapotranspiration from Field to Remote Sensing Footprint Scale, Kirkham Conference Abstract, 2022.
32. Kathuria, D. and B.P. Mohanty, Soil Moisture Data fusion Framework for Massive Datasets, Kirkham Conference Abstract, 2022.
33. Sehgal, V., and B.P. Mohanty, Emergent Properties of Soil Moisture Dynamics Beyond Darcy Scale and Their Applications in Hydrology, Kirkham Conference Abstract, 2022.
34. Mohanty, B.P., V. Sehgal, and D. Mbabazi, Global Carbon, Water, and Energy Coupling Relationships from the Field to Satellite Scale, Kirkham Conference Abstract, 2022.
35. Mohanty, B.P., N. Gaur, V. Sehgal, D. Mbabazi, and S. Rana, Revisiting Soil Hydrology Across Scales - From Point to Remote Sensing Footprint Scale, AGU Fall Meeting Abstract, 2022.
36. Kathuria, D., and B.P. Mohanty, Enhancing Soil Moisture Predictions Across CONUS Using Big Data Fusion, AGU Fall Meeting Abstract, 2022.
37. Sehgal, V. and B.P. Mohanty, What are the Preferential Hydrologic States of Global Surface Soil Moisture? AGU Fall Meeting Abstract, 2022.
38. Mbabazi, D., V. Sehgal, and B.P. Mohanty, Global Coupling of the Terrestrial Water and Carbon Cycles, AGU Fall Meeting Abstract, 2022.
39. Mishra, D. and B.P. Mohanty, Temporal Evolution of Global Terrestrial Water-Energy Coupling Dynamics, AGU Fall Meeting Abstract, 2022.
40. Sedaghatdoost, A., B.P. Mohanty. And Y. Huang, Subsurface Variation of Soil Physicochemical Properties and Redox-Sensitive Elements under Different Land Covers in Gulf Coastal Plains, AGU Fall Meeting Abstract, 2022.
41. Kocian, L., and B.P. Mohanty, Evaluating the Presence of Preferential Flow Using Remote Sensing, Inverse Modeling, and Machine Learning Algorithms, AGU Fall Meeting Abstract, 2022.
42. Jena, S., B.P. Mohanty, R.K. Panda, and M. Ramadas, Transfer Learning and Predictor Selector Algorithm for Developing a Generalizable Pedo-Transfer Function for Saturated Hydraulic Conductivity, AGU Fall Meeting Abstract, 2022.

43. Shukla, M. K., IICA-NMSU Joint Workshop on Digital Agriculture, IICA, San Jose, Costa Rica, "IoT Monitoring System for Digital Agriculture at NMSU Leyendecker Science Center", Scope: International, Invited or Accepted? Invited. (2022).
44. Shukla, M. K., International Conference, University of Durango, Durango, Mexico, "ACES Global Program and Aggies Go Global". (2022).
45. Shukla, M. K., International Week in Agriculture, University of Juarez Durango, Venicia, Mexico, "Use of marginal brackish and produced waters in agriculture: impact on soil and plant environment", Scope: International. (2022).
46. Shukla, M. K., Invited talk Mobility Program, Mendel University, Brno, Czech Republic, "Carbon sequestration under different land use and management systems". (2022).
47. Shukla, M. K., Mobility Grant EU, Mendel University, Brno, Czech Republic, "Soil Health". (2022).
48. Shukla, M. K., Water Resources Management and Sustainability: Solutions for arid regions, UAE University, Dubai, "Irrigation with brackish and produced waters: benefits and risks for agricultural sustainability of arid areas", Scope: International, published in proceedings. (2022).
49. Shukla, M. K., World Congress of Soil Science, International Association of Soil Science, Glasgow, UK, "Irrigation with brackish water: impact on the distribution of plant mineral nutrition". (2022).
50. Yang, H., Shukla, M. K., Tri Society Annual Meeting, ASA-CSSA-SSSA, Baltimore, MD, "Spatio-temporal changes in soil properties for uncultivated agricultural fields in the Lower Rio Grande Valley", Scope: International. (November 2022).
51. Yang, H., Shukla, M. K., Tri-Society Annual Meeting, ASA-CSSA-SSSA, Baltimore, MA, "Irrigation with brackish water: impact on the distribution of plant mineral nutrition and yield", Scope: International. (November 2022).
52. Ben Ali, A., Shukla, M. K., ASABE Annual Meeting, ASABE, Las Cruces, "Irrigation with desalinated and raw produced waters: effects on soil properties, and germination and growth of five forages". (October 21, 2022).
53. Yang, H., Shukla, M. K., ASABE Annual Meeting, ASABE, Las Cruces, "Irrigation with brackish and RO waters: impact on the distribution of plant mineral nutrition". (October 11, 2022).
54. Shukla, M. K., Kirkham Conference, Soil Science Society of America, Kruger, South Africa, "Irrigation with reverse osmosis concentrate and brackish groundwater effects soil microbial composition and soil health", Scope: International. (August 2022).
55. Shukla, M. K., Chile Growers Conference, NM Chile Pepper Institute, Las Cruces, "Growing Chile Peppers Using Micro-Gravity Drip Irrigation", Scope: Regional. (February 2022).
56. Shukla, M. K., Yang, H., W4188 Multi state Project, NIFA, Online, "Use of brackish groundwater and produced waters in Agriculture", Scope: International. (January 2022).
57. Shukla, M. K., Carbon Sequestration, NGL Water Solutions, "Can we increase soil organic C sequestration by efficient rangeland management?", Scope: State. (January 13, 2022).
58. Brungard, C. W., K.C. Carroll, D.F. Rucker, J. Triantafilis (2022), Geophysical Investigation of a Microplaya Landscape of the Desert Southwest, USA. SQU-NMSU virtual workshop, Virtual.
59. Noyes, C., A. Seltzer, J. Ng, R. Tyne, G. Ferguson, K.C. Carroll, K. Markovich, R. Purtschert, M. Stute, J. Severinghaus, and J.C. McIntosh (2022) Variations in Groundwater Recharge during the mid-Holocene Revealed in the Tucson Basin (Arizona, USA) using Radioisotopes and Noble Gases. American Geophysical Union Fall Meeting, Fall Meeting Abstract.
60. Aghababaei, M., T. Ginn, J. McCallum, R. González-Pinzón, K.C. Carroll, and A. Tartakovsky (2022) Hyporheic zone exchange and solute transport including memory functions for the river,

hyporheic zone, and a boundary layer. American Geophysical Union Fall Meeting, Fall Meeting Abstract.
61. Tunby, P., R. González-Pinzón, T.R. Ginn, M. Aghababaei, K.C. Carroll, and A. Tartakovsky (2022) Informing River Corridor Transport Modeling by Harnessing Community Data and Physics-Aware Machine Learning. American Geophysical Union Fall Meeting, Fall Meeting Abstract.
62. Carroll, K.C., C.-H. Tsai, D.F. Rucker, S.C. Brooks, and T. Ginn (2022) Transient Storage Model Parameter Optimization Using the Simulated Annealing Method. American Geophysical Union Fall Meeting, Fall Meeting Abstract.
63. Mohamed, R.A.M., M. Hitzelburger, N.A. Khan, M.L. Brusseau, and K.C. Carroll (2022) Modeling of Perfluorooctanesulfonic Acid Contaminant Transport in Saturated Heterogeneous Media and Evaluation of Back-Diffusion Retention and Removal Effects. 67th Annual New Mexico Water Conference, Our Interconnected Communities—and Interconnected Waters, October 26-27, Las Cruces.
64. Carroll, K.C., C.-H. Tsai, D.F. Rucker, S.C. Brooks, and T. Ginn (2022) Simulated Annealing Global-Optimal Parameter Estimation for Transient Storage Modeling of Stream-Groundwater Exchange. 67th Annual New Mexico Water Conference, Our Interconnected Communities—and Interconnected Waters, October 26-27, Las Cruces.
65. Jamil, A., D.F. Rucker, and K.C. Carroll (2022) Evaluation and Comparison of Machine Learning Algorithms for 2D Electrical Resistivity Inversion and Heterogeneous Subsurface Characterization. 67th Annual New Mexico Water Conference, Our Interconnected Communities—and Interconnected Waters, October 26-27, Las Cruces.
66. Carroll, K.C., M. Hitzelburger, N.A. Khan, R.A.M. Mohamed , and M.L. Brusseau (2022) Perfluorooctane Sulfonic Acid (PFOS) Transport and Mass Flux Reduction / Mass Removal in Homogeneous versus Heterogeneous Systems. ASA, CSSA, and SSSA International Annual Meeting, Nov. 6-9, Baltimore, MD.
67. Ulery, A.L., R. Gioannini, F.O. Holguin, K.C. Carroll, N. Hanan, C. Steele, B. Stringam, S. Whitley (2022) Soil, Plant & Environmental Science Careers. ACES 4H Camp, NMSU 4H Extension, Las Cruces, NM, August 22, 2022.
68. Gonzalez-Pinzon, R., P. Tunby, T.R. Ginn, M. Aghababaei, K.C. Carroll, and A.M. Tartakovsky (2022) Informing River Corridor Transport Modeling by Harnessing Community Data and Physics-Aware Machine Learning. AGU The Frontiers In Hydrology Meeting 2022, 19-24 June 2022, San Juan, Puerto Rico.
69. Carroll, K.C., R.A.M. Mohamed, Chia-Hsing Tsai, S.C. Brooks, D. Rucker, and A. Ulery (2022) Comparison of Multiple Direct and Indirect Characterization Methods for Hyporheic Zone Exchange. Waste Management Symposium (WM2022), March 6-10, Phoenix, AZ.
70. Jamil, A., D.F. Rucker, S.R. Dipon, C.-H. Tsai, H. Cao, S. Brooks, and K.C. Carroll (2022) Evaluation of Machine Learning Algorithms for Subsurface Resistivity Predictions Based on Geophysical Electrical Resistivity Data and Characterization of Hydrogeological Conditions. Waste Management Symposium (WM2022), March 6-10, Phoenix, AZ.
71. Johnson, C., C. Stice, K.C. Carroll, J. Szecsody, and C.-H. Tsai (2022) Organic Gas Injection Delivery Behavior for Vadose Zone Remediation. Waste Management Symposium (WM2022), March 6-10, Phoenix, AZ. [Peer-Reviewed Conference Proceedings Paper]
72. Xu, P., Y. Zhang, W. Jiang, L. Hu, X. Xu, K.C. Carroll, and N. Khan (2022) Characterization of Produced Water in the Permian Basin for Potential Beneficial Use. WRRI Technical Completion Report T-398. [Peer-Reviewed Technical Report]

73. Kacimov, A., Y. Obnosov, and J. Šimůnek, Subterranean holes in the arid vadose zone as perturbations of descending pore water fluxes: J. R. Philip's legacy revisited, Abstracts of the International Conference “Water Resources Management and Sustainability: Solutions for Arid Regions”, Edited by M. Sherif, M. A. Faiz and A. Sefelnasr, p. 46-49, Dubai, March, 22-24, 2022.
74. Brunetti, G., J. Šimůnek, and R. Kodešová, Modeling the translocation and transformation of chemicals in the soil-plant continuum: a dynamic plant uptake module for the HYDRUS, EGU22-1962, Section HS8.3.5 – Soil-Plant Interaction, EGU General Assembly 2022, Vienna, Austria, Online, April 3-8, 2022.
75. Šimůnek, J., M. Šejna, G. Brunetti, D. Jacques, and M. Th. van Genuchten, Recent Developments and Applications of the HYDRUS Software Packages and its Specialized Modules”, Proceedings of the conference “Computational Methods in Water Resources, CMWR 2022”, Gdańsk, Poland, June 19-23, 2022.
76. Brunetti, G., and J. Šimůnek, Towards a comprehensive calibration suite for the HYDRUS model, Proceedings of the conference “Computational Methods in Water Resources, CMWR 2022”, Gdańsk, Poland, June 19-23, 2022.
77. Gumuła-Kawęcka, A., V. K. Oad, A. Szymkiewicz, J. Šimůnek, and B. Jaworska-Szulc, Simulation of water table fluctuations and lateral outflow from a soil profile using a 1D vadose zone model, Proceedings of the conference “Computational Methods in Water Resources, CMWR 2022”, Gdańsk, Poland, June 19-23, 2022.
78. Kacimov, A., Yu. V. Obnosov, and J. Šimůnek, Commingling of Darcian seepage to two empty or partially-filled tunnels under a ponded or infiltrated soil surface, The 10th International Conference on the Analytic Element Method (AEM 2022), Princeton University, USA, June 2-3, 2022.
79. Zhou, T., J. Šimůnek, I. Braud, P. Nasta, G. Brunetti, and Y. Liu, The impact of evaporation fractionation on the inverse estimation of soil hydraulic and isotope transport parameters, abstract 141356, SSSA International Annual Meeting, Baltimore, Maryland, November 6-9, 2022.
80. Mulla, D. J., J. Galzki, J., and J. Simůnek, Hydrus-3D estimates of runoff from pollinator habitat at ground-mounted solar photovoltaic sites, abstract 145065, SSSA International Annual Meeting, Baltimore, Maryland, November 6-9, 2022.
81. Anderson, R. G., S. A. Helalia, T. H. Skaggs, and J. Šimůnek, Simulations of future seasonal salinity in almond trees' rootzone layers in eastern and western SJV, CA, ID# 1060520, AGU Annual Meeting, Chicago, Illinois, December 12-16, 2022.
82. Chen, L., J. Šimůnek, S. A. Bradford, H. Ajami, and M. B. Meles, A computationally efficient hydrologic modeling framework to simulate surface runoff and vertical infiltration at the hillslope scale, H53A session: Advances in Managed Aquifer Recharge for Groundwater Sustainability, ID#1074295, AGU Annual Meeting, Chicago, Illinois, December 12-16, 2022.
83. Visser, A., T. Zhou, J. Šimůnek, E. Oerter, E. Slessarev, K. Min, M. Kan, K. J. McFarlane, M. C. Saha, A. A. Berhe, J. Pett-Ridge, and E. Nuccio, Soil water isotope measurements (tritium, deuterium, oxygen-18) and Hydrus-1D simulations with evaporative fractionation to examine the impacts of deeply rooted switchgrass on soil hydrology, H016 Session: Advances in Tracer Methods and Modeling of Hydrochronology, Hydrologic Processes and Residence Times, ID# 1135373, AGU Annual Meeting, Chicago, Illinois, December 12-16, 2022.
84. Bradford, S. A., S. Sasidharan, H. E. Dahlke, G. E. Fogg, and J. Šimůnek, Simulated assessment of preferential flow during agricultural managed aquifer recharge, H010 session Advances in Managed Aquifer Recharge for Groundwater Sustainability, ID# 1162055, AGU Annual Meeting, Chicago, Illinois, December 12-16, 2022.

85. Berli, M., Shillito, R.M., Inouye, S., Nikolich, G. & Etyemezian, V. 2022a. Water drop penetriaton time revisited. In: EGU General Assembly 2022, pp. EGU22-10743. European Geosciences Union (EGU), Vienna, Austria.
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103. Carver, K., T. Young, C. Hargiss, J. Norland, and A. Daigh. 2022. Understanding sediment as a phosphorus reservoir and the role of eutrophication in predicting harmful cyanobacteria blooms. Joint Aquatic Sciences Meeting. Grand Rapids, MI. May 14-20, 2022.
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116. Schwartz, R.C. "Adaptation of MOPECO for Water Management Decisions in the Texas High Plains", International Conference for dissemination of PRIMA project results and interregional Conference of CIGR Section I. Albacete, Spain. 5-7 September 2022
117. Evett, S.R. "The Role of Irrigation Technology in Climate Change Adaptation" as an NRES Distinguished Lecture at the 2022 ASABE Annual International Meeting in Houston, Texas
118. Evett, S.R. "Biophysical Science and Engineering Drive Increased Crop Water Productivity in Diverse Climates with Dwindling Resources" at the USDA ARS and Texas Tech University Office of Research & Innovation Collaborative Research Spotlight in Lubbock, Texas, October 2022
119. Evett, S.R. "Biophysical Science and Engineering Drive Increased Crop Water Productivity in Diverse Climates with Dwindling Resources" to graduate and undergraduate classes (PSS-6323 Plant Water Relations; PSS-4325 Crop Water Management), October 2022
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121. Evett et al. (2022). Are crop coefficients for SDI different from those for sprinkler irrigation application? Presented to the 6th Decennial National Irrigation Symposium, December 2021, San Diego, CA
122. Evett, S.R., G. Marek, K. Copeland, B. Ruthartdt, P. Colaizzi, D. Brauer, and T. Howell, Sr. (2022). The Bushland Maize for Grain Datasets - A Machine Readable Resource. Presented at the 2022 ASABE Annual International Meeting in Houston, Texas
123. Jones, S. B., Naruke, C., Blakeslee, A., Fatzinger, B., Bugbee, B. G., ASA, CSSA, and SSSA International Annual Meetings, "Plant Growth Porous Medium Design and Management Considerations for Reduced Gravity." (November 8, 2022)
124. Naruke, C., Fatzinger, B., Bugbee, B. G., Blakeslee, A., Jones, S. B., ASA, CSSA, and SSSA International Annual Meetings, "Numerical Simulation for Water and Plant Root Uptake Under Various Gravity Conditions in Containerized Soilless Media." (November 7, 2022)
125. Jones, S. B., Sadeghi, M., Robinson, D. A., W4188 Soil Physics Working Group Virtual Meeting, "Utah State University Report," USDA. (January 3, 2022 - January 4, 2022)
126. Jones, S. B., Convergence of Nano-Engineered Devices for Environmental and Sustainable Applications (CONDESA) Seminar, "Soil Property Sensing: Measurement Principles, State of the Art and Future Opportunities," University of California - Merced, Merced, CA. (June 13, 2022 - Present)
127. Jones, S. B., Chang, C.-Y., González-Teruel, J. D., Robinson, D. A., Friedman, S. P., Skierucha, W., EGU General Assembly 2022, "A Framework for Standardizing Electromagnetic Water Content Sensor Assessment using Granular Porous Media." (2022)
128. González-Teruel, J. D., Jones, S. B., Robinson, D. A., Giménez-Gallego, J., Zornoza, R., Torres-Sánchez, R., EGU General Assembly 2022, "Assessment of a low-cost Handheld Vector Network Analyzer to Measure the Broadband Complex Permittivity of Soils." (2022)
129. Jones, S. B., Institute of Agrophysics Seminar, "Soil Water (Moisture) Content: Measurement Principles, State of the Art and Future Opportunities." (2022)

130. Jones, S. B., Sheng, W., National Soil Moisture Workshop, "Function, Circuitry and Measurement Quality of Today's Electromagnetic Water Content Sensors." (2022)
131. Jones, S. B., Silk Road International Symposium on Plateau Ecological Environment Protection and High-quality Development of the Yellow River Basin., "Quality Assessment Needs for Soil Water Content Sensors. Virtual Presentation at the Silk Road International Symposium on Plateau Ecological Environment Protection and High-quality Development of the Yellow River Basi." (2022)
132. Jones, S. B., Virtual Earth-Surface Ecosystems Sciences Lecture at China Agricultural University, "Soil Water (Moisture) Content: Measurement Principles, State of the Art and Future Opportunities." (2022)
133. Chang, C.-Y., Wu, Y., Sheng, W., Jones, S. B., ASA, CSSA, and SSSA International Annual Meetings, "Determining the Sampling Volume of Different Electromagnetic-Based Soil Moisture Sensors." (November 7, 2022).
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SOIL WATER RETENTION FROM NEAR SATURATION TO DRYNESS. Journal of the ASABE (accepted).

145. Peraza, J. and Patrignani, A. 2022. Mapping Mesoscale Rootzone Soil Moisture Using a Model-Data Fusion Approach. 2022 ASA-CSSA-SSSA International Annual Meeting Baltimore, MD.
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148. Patrignani, A. 2022. Quantifying Soil, Plant, and Residue Cover from Images of Agricultural Fields Using a Convolutional Neural Network. 2022 ASA-CSSA-SSSA International Annual Meeting Baltimore, MD.
149. Widanagamage, N. and Patrignani, A. 2022. Signatures of Soil Respiration and Soil Water Potential under Different Management Practices. 2022 ASA-CSSA-SSSA International Annual Meeting Baltimore, MD
150. Wyatt, B.M. 2022. Streamflow forecasting using remote sensing soil moisture and groundwater data. Kirkham Conference. South Africa.
151. Wang, M., B.M. Wyatt, and T.E. Ochsner. 2022. Remote Sensing Improves Seasonal Streamflow Forecast Accuracy in Rainfall-Dominated Watersheds. Soil Science Society of America Annual International Meeting. Baltimore, MD.
152. Wang, M., B.M. Wyatt, and T.E. Ochsner. 2022. Remote sensing soil moisture data improve seasonal streamflow forecast accuracy. National Soil Moisture Workshop. Columbus, OH.
153. Wang, M., and B.M. Wyatt. 2022. Improving seasonal streamflow forecasts for irrigation districts using remote sensing. Texas Water Observatory (TWO) Meeting. College Station, TX.
154. Wang, M. and B.M. Wyatt. 2022. Improving seasonal streamflow forecasts for irrigation districts using remote sensing. Texas Soil Survey and Land Resource Workshop. College Station, TX.
155. Jin Y. The (almost) unexplored role of preferential flow in soil carbon dynamics. Earth-Surface Ecosystems Sciences Lecture, International Webinar sponsored by China Agricultural University and Zhejiang University, November 15, 2022.
156. Jin Y. and S. Franklin. The role of preferential flow in biogeochemical processes. SSSA's Kirkham Conference, August 28 - September 2, 2022, South Africa.
157. Franklin, S., Guber, A., Kravchenko, A., Vasilas, B., Jin, Y. Impacts of non-equilibrium flow on microbial activity and carbon turnover (Oral). Soil Science Society of America International Meeting, Baltimore, MD, Nov. 6-9, 2022.
158. Yan, J., Zheng, W., Jin Y, The effects of sea water intrusion on evaporation in porous media with vertical texture contrast (Oral), Soil Science Society of America annual meeting, Baltimore, Maryland, November 6-9, 2022.
159. Afsar, M.Z., Mary Burrichter, and Y. Jin. Effect of Flooding and sea-level Rise on Soil Hydraulic Properties in Coastal Wetlands (Oral). Soil Science Society of America meeting, Baltimore, November 6-9, 2022.
160. Kaniz, F., W. Zheng, H. Bais, and Y. Jin. Plant growth-promoting rhizobacteria mediate soil hydro-physical properties: An investigation with Bacillus subtilis and its mutants (poster). Soil Science Society of America meeting, Baltimore, November 6-9, 2022.
161. Burrichter, M., B. Knight, K. Ludwig, C. Scott, H. Cao, K. Cobb, and Y. Jin. Evaluation of agrotexitiles from end-of-use cotton waste. Soil Science Society of America meeting, Baltimore, November 6-9, 2022.
162. Franklin, S., A. Guber, A., A. Kravchenko, B. Vasilas, and Y. Jin. Impacts of non-equilibrium flow on microbial activity and carbon turnover. SSSA's Kirkham Conference, August 28 - September 2, 2022, South Africa.

163. Jin, Y., S. Franklin, A. Guber, A., A. Kravchenko, B. Vasilas. The role of preferential flow in soil carbon dynamics. GRC – Flow and Transport in Permeable Media, Les Diablerets, VD, Switzerland, July 17-22, 2022.
164. Franklin, S., Guber, A., Kravchenko, A., Vasilas, B., Jin, Y. Impacts of non-equilibrium flow on microbial activity and carbon turnover. MicroSoil Workshop, St. Loup, France, July 2022.