Climate, Land Use, Agriculture and Natural Resources:

Activities in Interdisciplinary Research, Education and Outreach

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Pullman Campus, Washington State University, Pullman, WA

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Adam JC, Hull RE, Tague CL, Reyes J, Liu ML	jcadam@wsu.edu	Where should fine-resolution spatial heterogeneity be captured within Earth System Models?	Land-atmosphere interactions impact the environment in myriad of ways, such as through partially driving our climate system, and in changing the availability and usability of our natural resources. Earth System Models (EaSMs) are increasingly being used to explore these coupled dynamics from watershed to global scales. However, many EaSMs do not adequately represent landscape-scale spatial heterogeneity that influences land surface response, as relatively coarse resolution simulations are necessitated by computational limitations. Research is needed to understand which types of spatial heterogeneity, over which biomes and climate types, should be represented such that an EaSM accurately captures the aggregate land surface response to a changing climate. Spatial heterogeneity in a landscape arises due to differences in model forcings; in underlying soil, vegetation, and topographic properties that control moisture, energy and nutrient fluxes; and in land surface responses that arise due to spatially-organized connections. While our long-term goal is to understand how each of these sources should be represented in an EaSM, in this study we focus first on parameter heterogeneity. We apply the Regional Hydro-Ecological Simulation System (RHESSys), a distributed process-based model that was originally developed for catchment-scale applications. We explore the functional form of the hydrologic response of a RHESSys "patch" (a 200-400 m element with homogenous landscape parameters) to an invoked change. According to scale transition theory, a linear response makes it is possible to upscale (or aggregate) the model resolution without biasing the model response. We perform RHESSys simulations for more than 500 individual catchments within the Willamette and Yakima River basins in the Pacific Northwest region of the U.S. Each catchment was imposed with incremental perturbations of temperature and precipitation. The response curves for hydrologic variables such as evapotranspiration, soil moisture, and runoff are tested for linearity using the Pearson correlation coefficient. A cluster analysis is conducted then compared to biome and climate classifications to identify landscapes where upscaling is possible without biasing the aggregate hydrologic response.
Adam et al.	jcadam@wsu.edu	BioEarth: A Regional Biosphere-Relevant Earth System Model to Inform Agricultural and Natural Resource Management Decisions	As managers of agricultural and natural resources are confronted with uncertainties in global change impacts, the complexities associated with the interconnected cycling of nitrogen, carbon, and water present daunting management challenges. Existing models provide detailed information on specific sub-systems (land, air, water, economics, etc). An increasing awareness of the unintended consequences of management decisions resulting from interconnectedness of these sub-systems, however, necessitates coupled regional earth system models (EaSMs). Decision makers' needs and priorities can be integrated into the model design and development processes to enhance decision-making relevance and "usability" of EaSMs. BioEarth is a current research initiative with a focus on the U.S. Pacific Northwest region that explores the coupling of multiple stand-alone EaSMs to generate usable information for resource decision-making. Direct engagement between model developers and non-academic stakeholders involved in resource and environmental management decisions throughout the model development process is a critical component of this effort. BioEarth utilizes a "bottom-up" approach, upscaling a catchment-scale model to basin and regional scales, as opposed to the "top-down" approach of downscaling global models utilized by most other EaSM efforts. This paper describes the BioEarth initiative and highlights opportunities and challenges associated with coupling multiple stand-alone models to generate usable information for agricultural and natural resource decision-making.
Adams D, Boll J, Brooks E, Rivera L	druffdj@wsu.edu	Analysis of a complementary evaporative flux principle for field measurements	Brutsaert (2015) proposed a reformulation of the relationship between complementary evaporative fluxes based on inclusion of considerations relative to physical land-surface conditions. This newly refined principle has been primarily applied to field measurements using pan evaporation and energy fluxes. Further analysis should be performed to understand its application using other evaporation field measurement tools such as lysimeters. Three lysimeters are being used concurrently with pan evaporation to measure evaporative fluxes in the field. We hypothesize that analysis of lysimeter evaporative fluxes comparatively to pan evaporation measurements of actual evaporation will aid in further understanding of the relationship to apparent and potential evaporation yielding similar boundary conditions based on physical consideration as posed by Brutseart (2015). Such developments aid in the understanding of the complementary principle using a variety of environmental measurement tools under a wider array of field settings. The poster will outline the theory and field measurements that will contribute to validate our hypothesis.
Adewale C, Carpenter-Boggs L, Higgins S, Zaher U	adecorne.adewale@wsu.edu	Identifying Hotspots in the Carbon Footprint of a Small Scale Organic Vegetable Farm.	Despite its potential to mitigate greenhouse gas (GHG) emissions, organic farming is not immune to contributions to GHG emissions. A full accounting and understanding of the GHG emissions associated with specific activities, materials, and energy used in organic operations is needed in order to empower farmers to minimize their farm carbon footprint (CF). A small-scale organic vegetable farm in Washington State, USA, was used as a case study to determine the CF and GHG hotspots to support decision-making for GHG mitigation. A partial life cycle assessment was conducted to identify primary and secondary GHG fluxes associated with activities and materials used in production of potatoes, cauliflower, dry bush beans, winter squash, summer squash, chard, peppers, and onions. Across the farm as a whole, fuel use for both on-farm and upstream off-farm operations, energy use for irrigation, fertilization, and plastic based material use for pest management were identified as the major CF hotspots. Simulation of a switch to the use of biodiesel instead of gasoline and diesel, and the use of solar powered irrigation in place of the current hydroelectric powered irrigation, resulted in a 34% reduction in the total farm CF. The CF associated with each crop ranged from a low of 1.86 t CO2-eq ha-1 yr-1 for dry bush beans to a high of 3.00 t CO2-eq ha-1 yr-1 for peppers. Peppers had the highest CF followed by cauliflower and potatoes. By identifying the CF hotspots of a whole farm and individual crops, particular inputs and activities can be targeted for modification in order to effectively reduce farm's CF.
Allen E, Stephens J, Yorgey G, Kruger C, Ahamed S, Adam J	lizb.allen@wsu.edu	What do Agricultural Decision-makers in the Northwest Need to Know about Climate Change?	Based on a series of workshops conducted with professionals who specialize in water, atmospheric, forest, rangeland and agricultural management issues in the Northwest US, we describe the range of perspectives about regional climate science information. Our goal is to support academic researchers in producing and communicating actionable climate science information for decision-makers. The workshops analyzed for this study were held between 2013-2015 as part of the BioEarth research project, an interdisciplinary regional climate impacts modeling effort funded by USDA-NIFA. Workshop participants' information needs and reflections on communication and engagement processes are analyzed using transcripts of workshop discussions, pre- and post-workshop surveys, and responses to multiple-choice questions posed during workshops. Central recommendations from stakeholders to climate impacts modelers include: 1) explore policy changes expected on the horizon; 2) incorporate changing technologies and management practices; 3) investigate impacts of land use change; 4) test the impacts of applying current best management practices vs. what are understood to be "worst practices"; and 5) explore possible unintended consequences of management decisions. Considerable variation in types of climate science information deemed useful by agricultural decision makers was found. This analysis suggests opportunities for climate science researchers to collaborate with specific agricultural management audiences and address critical information needs.

Anderson SM, Albeke SE, Williams DG, Evans RD	sarah.anderson2@wsu.edu	Insights into Atmospheric Nitrogen Deposition from Herbaria Lichen Specimens	Atmospheric nitrogen (N) deposition has increased significantly throughout the 20th century with consequences for ecosystems. Negative environmental impacts make it imperative to understand how N deposition has changed over time. Lichens have been used as indicators of air pollution for over 150 years, and strong relationships are often observed between amounts of N deposition and lichen N content. We use this knowledge of lichens as air pollution indicators to study how N deposition has changed over the last century. Four species of herbaria lichen specimens were sub-sampled and analyzed for their elemental N content and stable isotope composition (δ15N) in order to provide insight into changes in the amount of deposition through the N content and into the sources of deposition through the δ15N. Lichens were originally collected throughout the western United States over the last 125 years. We see unique patterns among the different species and across the different regions. Two of the four species observed consistent increases in N content across most regions from the early 20th century until roughly 1990 which is when the Clean Air Act Amendments (CAAA) required reductions in N emissions from major emission sources. Two common patterns occur in lichen δ15N across species and regions: 1) a consistent depletion in δ15N throughout the 20th century and 2) a depletion in δ15N until the 1980s when lichen δ15N becomes enriched. The enrichment of δ15N may relate to major regulatory control measures enacted after the CAAA of 1970 and 1977.
Baret Q, Chung S, Adam J, Walden V, Carlson B, Stöckle C	quentin.baret@wsu.edu	The effect of wildfire aerosols on crop growth in the Pacific Northwest	In the western United States, forest fires occur each year in the summer. Climate change predictions suggest that temperatures will increase in summer and precipitation will decrease. In one projected scenario (A1B greenhouse gas scenario simulated from 20 different global climate models), the area burned by regional fires is expected to double by the 2040s and triple by the 2080s compared to the 1916-2006 period. Forest fires release a significant amount of smoke (aerosols) into the atmosphere. These aerosols alter the amount of solar radiation and proportion of diffused radiation received at the surface and, therefore, by crops. To investigate the impact of aerosols from wildfires on crops over the Columbia Plateau region in the Pacific Northwest, atmospheric and meteorological data from the 2015 summer fire season are used. Meteorological profiles are obtained from the Weather Research and Forecasting (WRF) model. These are used as input into the Rapid Radiative Transfer Model (RRTM). RRTM calculates the direct and diffuse solar radiation in both the upward and downward directions at the surface. The solar radiation calculations across the study area are then input into a crop system model for assessing the impacts of aerosols on wheat growth and yield near Pullman, WA. The crop model is a two-leaf hourly time step transpiration and photosynthesis model. The two-leaf model partitions the canopy into sunlit and shaded fractions using hourly solar zenith angle and allocates diffuse and direct radiation appropriately. A sensitivity study is conducted with simulations of clear-sky conditions without aerosols over June, July and August and with low, medium and high constant aerosol amount over the same three months. The next step will be to use aerosol optical depths (AOD) simulated from the Community Multiscale Air Quality (CMAQ) chemical transport model for the 2015 summer fire season.
Barik M, Liu M, Rushi B, Stöckle CO, Abatzoglou J, Adam JC	mbarik@wsu.edu	Is snowpack drought an increasing threat in the Pacific Northwest?	In spite of near normal precipitation during the winter of water year 2015, the Pacific Northwest (PNW) has experienced drought because of insufficient snow accumulation in the mountains, which was exacerbated by an unusually warm and dry summer. Low mountain snowpack resulted from an anomalously warm winter and subsequently affected water supply for irrigation, fish habitat, ecosystem, and recreation, necessitating a statewide drought emergency declaration in the Washington State. While the 2015 drought is likely a result of natural variability superposed with climate warming, we ask how the frequency of droughts of this character are likely to change as a result of anthropogenic climate change. Downscaled climate data from multiple Global Climate Models from the Fifth Climate Model Intercomparison Project were used with the Variable Infiltration Capacity (VIC) model to calculate both the Standardized Precipitation Index (SPI) and Snow Melt and Rain Index (SMRI) indices for quantifying meteorological and snowpack droughts, respectively, in the Columbia River Basin (CRB) under historic and future climate change scenarios. Our results show that snowpack droughts increase in severity and frequency in the future in response to the sensitivity of the snowpack to warming, whereas there is a less systematic trend in meteorological drought. Water resources in the CRB largely depend on the mountain snowpack and spring snowmelt. More frequent occurrence of snowpack drought will have serious implications in this system, which need to be addressed in future studies.
Baxter H, Nguyen T, Adam J, Barik M, Barber M, Hossain A	heather.baxter@email.wsu.edu	Impacts Of Future Changes On Low Flow In A Highly Connected River-Aquifer System: A Case Study Of The Spokane River And The Spokane Valley-Rathdrum Prairie Aquifer	The Spokane, Washington-Coeur d'Alene, Idaho Corridor contains the Spokane Valley-Rathdrum Prairie (SVRP) Aquifer, which is a sole source of drinking water for more than 500,000 people. This aquifer is highly connected to the Spokane River, making the river relatively vulnerable to climate and anthropogenic changes such as pumping. Recent studies have found a decline in minimum daily flow in the Spokane River in the last 100 years, raising concern for the sustainability of human and ecosystem water usages in the next decades. In this research, we investigated the potential impacts of future changes in both climate and human activities on low flows in the Spokane River – SVRP system. A distributed, physically-based hydrological model, the Precipitation Runoff Modeling System (PRMS), and a Modular three-dimensional finite-difference ground-water model (MODFLOW) were used to estimate recharge into the SVRP and the interaction of surface water and groundwater. The model was calibrated and validated at a daily time-step using 16 years of both observed streamflow and observed well data from 1990 to 2005. To assess future climate change impacts, statistically downscaled climate projections of temperature and precipitation between 2010 and 2050 from four general circulation models were used. The results from the coupled model provide insight on the interplay between climate and human activities on groundwater recharge and low flow discharge in the highly connected Spokane River – SVRP Aquifer system. Results can be used to help direct long term water resources management and planning in the region.
Carlson B, Khalil T, Uslar N, Frear C, Nelson R, Ma J, Stöckle C	bryan.carlson@email.wsu.edu	Dairy-CropSyst: a gaseous emission and nutrient fate modeling tool	Dairy confined animal feeding operations (CAFOs) may have deleterious effects on the environment by concentrating nutrients and emitting high amounts of greenhouse gasses. To reduce these effects in the United States, strict regulations are enforced on manure management. CAFOs are required to implement plans to minimize the natural resource contamination and to report greenhouse gas (GHG) and ammonia emissions that exceed certain values. Numerous modeling tools exist to aid CAFOs operators in completing such tasks. However, few, if any, of these tools integrate the impact of traditional and emerging manure management tools including anaerobic digestion, solids separation, and nutrients recovery. Furthermore, current models do not estimate the nutrient value of recovered products and effluent leaving the dairy system – an important consideration for the incorporation of crop simulations. The main objective of this study was to develop Dairy-CropSyt, a decision support tool for CAFOs managers and researchers to evaluate the effects of different manure treatment options on net GHG emission and manure nutrients fate applied to crop land. The tool tracks the fate of nutrients through the dairy system, including inorganic and organic forms of carbon, nitrogen, phosphorus, and potassium. This is accomplished by integrating established models, performance parameters from industrial data, and using a cropping model called CropSyst. Dairy-CropSyst may assist the dairy industry by aiding in decision making and as a tool for reporting GHG and ammonia emissions.

Du A, Zhu C, Lin Y	annie.du@wsu.edu	Nanotechnology for Clean Water	We have been working on development of nanomaterials and devices for water treatment and water monitoring in past 10 years. For water treatment, we have developed a class of new functionalized mesoporous silica (FMS) for removal of toxic metal ions (Hg, Cd, Pb, As, Cr) and radionuclides (U, Pu, Cs) from contaminated water and for enhanced sensitivity and selectivity in metal ion sensing. FMS has an immense surface area (~ 1000 m2/g) that may be loaded with reactive sites where molecules can bind. The technology has been commercialized by Steward Environmental Solutions. We also developed a nanomaterials-based electrically switched ion exchange (ESIX) technology for water treatments. It is a novel technology that combines both the principle of electrochemistry and ion exchange for removal of toxic ions (perchlorate, Cr6+) and radionuclides (TcO4-, Cs-137). For water monitoring, nanomaterials based sensors has been developed for detection of water pollutants such as toxic metals, pesticides, PCB, PAH, radionuclides. Carbon nanotubes, graphenes, quantum dots and other nanomaterials have been functionalized for sensor design and fabrications.
Forney WM, Harrison JA	william.forney@wsu.edu	Improvements to the Nutrient Export in WaterSheds model in the Columbia River Basin	Clean water is necessary for people and ecosystems. However, water quality in some Columbia River Basin (CRB) rivers is considered impaired due to excessive nutrient loading, with impairment of additional systems possible due to likely changes in land use and climate. As a result of its human health and ecosystem effects such as access to safe drinking water and recreation, eutrophication and decreased dissolved oxygen, and harmful algal blooms; dissolved inorganic nitrogen (DIN) is of particular concern. To better understand regional DIN dynamics, researchers applied the global Nutrient Export in WaterSheds model (NEWS2-DIN) in northern California watersheds, the Mississippi River Basin, and the CRB. Successes, challenges and model testing results associated with those efforts will be summarized briefly. Model efficiency and sensitivity tests of regional NEWS applications suggest that the CRB model application might be improved by refining the following model input variables: runoff, fraction of DIN lost due to removal of water, fraction of DIN lost in the river network, fraction of DIN retained in reservoirs, runoff modulation constant, watershed export coefficient of diffuse N input entering surface waters, total N applied as manure, total N applied as fertilizer, total N removed from crop harvest and export, total N input from natural fixation, and total N input from agricultural fixation. Furthermore, prior research in the CRB demonstrated that NEWS2-DIN performs well for basins larger than 10,000 km2, however, for basins smaller than 10,000 km2 it has no predictive power (Nash-Sutcliffe efficiency equals or less than zero). We propose a suite of refinements to NEWS2-DIN that we believe will improve the model's ability to capture nutrient export and system dynamics in smaller basins. These refinements include both 1) changes to the representation of nutrient processing, and 2) acquisition of new data. For the first set of refinements, equations in NEWS2-DIN of nutrient processes and drivers identified as candidates for improvement include: hydrology and water balance dynamics, watershed and river processing, reservoir retention, topographic complexity, and representation of seasonal dynamics. For the second set of refinements, potential improvements to input data include: differentiated fertilizer and manure application by crop type, improved representation of N fixation on agricultural and natural lands, improved representation of wetlands, records of water diversions, better stream representation and attribution, and improved basin delineation.
Fu XW, Wang Y, Murshed SMY, Liu J, Scudiero L, Zhong WH	xuewei.fu@wsu.edu	A Natural Pathway to Advanced Solid Polymer Electrolytes: Adjustable Ion Transportation in Denatured Soy Protein	Solid polymer electrolytes are of great interest for several decades due to the superiorities in mechanical properties, safety and electrochemical stability as compared with organic liquid electrolytes. However, the Li+-transportation is highly coupled with the mobility of polymer chain segments, which leads to a trade-off between ionic conductivity and mechanical properties and limits them from practical applications. Moreover, due to the increasing concerns on the environmental impacts from lithium ion batteries, developing "green" and sustainable high-performance solid polymer electrolytes is particularly significant. In this study, we surprisingly found that denatured soy protein can be a promising polymer host for lithium ions. The critical factors affecting the ion transportation including the denaturation of soy protein, the loading of lithium salt and the temperature for the evaporation process were investigated for the resultant soy-protein-Li+ system. For an optimized system, a high ionic conductivity around 10-5 S/cm and a modulus around 1 GPa were achieved at room temperature, which have never been realized in conventional solid polymer electrolytes. Via molecular modeling, three possible mechanisms for the ion-transportation inside the soy-protein matrix are proposed to understand the unique conduction of Li+ in the denatured soy protein. This study may open a new avenue for developing high-performance bio-solid polymer electrolytes with new Li+-transportation mechanisms, which can lead to significant advantages in not only functionalities (high ionic conductivity and high modulus), but also sustainability and environmental friendliness.
Hanan E, Abatzoglou J, Adam J, Alessa L, Anderson J, Brooks E, Hicke J, Kliskey A, Kruger C, Liu M, Paveglio T, Smith A, Yoder J, Kolden C	erin.hanan@wsu.edu	A modeling framework to reduce the risk of fire becoming a disaster in the Pacific Northwest	Fire management in the Western U.S. is facing unprecedented challenges in response to climate change, growing populations, and the expanding wildland-urban interface. Although fires are an intrinsic component of many ecosystems, a combination of biophysical and socioeconomic factors can turn them into social or natural disasters, with compounding negative impacts on both ecosystems and human communities. To address these new challenges, we must account for ecological, social, economic, and political dynamics over multiple spatial and temporal scales. Simulation modeling is a critical tool for exploring these complex feedbacks given the uncertainties associated with changing climate and growing populations. We are developing a modeling framework, FireEarth, which expands the Biosphere-relevant Earth system model (BioEarth) to incorporate fire, insect outbreaks, drought, and erosion. This framework will be used to simulate episodic disturbance events and their impacts on hydrologic and biogeochemical cycles. BioEarth incorporates the ecohydrologic model RHESSys to simulate biophysical processes in watersheds. FireEarth will link the existing fire spread model (WMFire) that is embedded in RHESSys with models for fire severity and the effects of fire on ecohydrologic processes. We are setting up a pilot study in the Johnson Creek watershed near Yellow Pine, ID for initial model development. We will then use a novel scaling approach to evaluate policy and other decision-making processes at scales ranging from the wildland-urban interface to geographic regions in the Western U.S. and elsewhere. Through this approach, we aim to reduce the risk of wildfire becoming a disaster and increase community and ecological adaptive capacities.

Haque Z	zannatul.haque@wsu.edu	Numerical simulation of a submerged circular turbulent impinging jet	Soil erosion may degrade water quality, cause riverbank instability, and damage infrastructure. Knowledge of soil resistance to erosion is required to study embankment breaching, riverbank and shoreline erosion, scour around hydraulic structures, and canal stability. Cohesive soil erosion is a complex process that depends on the physical, chemical and biological properties of soil as well as the interactions among properties. The jet erosion test is a cost-effective tool to measure erodibility of cohesive soils. In this test, erosion is generated by a submerged turbulent jet impinging on the soil surface. Erosion is assumed to be generated by the maximum shear stress due to the jet. A number of empirical models have been proposed to calculate this shear stress but little agreement has been achieved. Moreover, in the analysis procedure the eroded surface is considered to be flat throughout the erosion process. It is not yet known how this change in geometry impacts the shear stress distribution and progression of erosion. This study presents the results of the application of computational fluid dynamics (CFD) to study the shear stress distribution of a circular turbulent jet impinging on both non-eroded (flat) and eroded boundaries. The dimensions of the modeled flow domain are equivalent to the test apparatus with static geometry of the scoured surface. For eroded boundaries the scour holes are idealized to be rectangular in shape rather than having natural curved shape. Despite this simplification, the results demonstrate the influence of the scour region on the near wall hydrodynamics and distribution of shear stress applied by the jet. By incorporating the change in shear stress distribution with an evolving soil boundary, improved predictions of erosion parameters and cohesive soil behavior can be achieved.
Hegewisch K, VanSant D, Abatzoglou JT	khegewisch@uidaho.edu	Integrated Scenarios of Future Northwest Environment Project	The Integrated Scenarios (IS) of the Future Northwest Environment project resulted in several datasets describing projected changes in climate, hydrology and vegetation for the 21st century over the Northwestern US. However, these datasets pose several challenges to their use including 1) the sheer size of these datasets (~20 TB), 2) the specific file format (netCDF) for data access and, 3) the data being derived from global climate model experiments and necessitating appropriate statistical analysis. In an attempt to improve this situation and increase the accessibility of the Integrated Scenarios datasets to a broader range of stakeholders, the Integrated Scenarios Tools project was born. This poster shows off the features/tools resulting from this project and featured on a new webpage (http://climate.nkn.uidaho.edu/IntScenNew). This webpage aims to address 1) information on the climate, hydrology and vegetation models and the resulting data of the IS project, 2) tools to improve IS data access and 3) tools to appropriately visualize the IS data. The poster will be accompanied by a laptop demonstration of the functionality of the web tools in order to obtain feedback for further tuning of the webpage and tools.
Huang M	Maoyi.Huang@pnnl.gov	Quantifying Impacts of Land-use and Land Cover Change in a Changing Climate at the Regional Scale using an Integrated Earth System Modeling Approach	In this presentation, I will introduce research efforts at the Pacific Northwest National Laboratory towards quantifying impacts of LULCC on the water-energy nexus in a changing climate using an integrated regional Earth system modeling framework: the Platform for Regional Integrated Modeling and Analysis (PRIMA). Two studies will be discussed to showcase the capability of PRIMA: (1) quantifying changes in terrestrial hydrology over the Conterminous US (CONUS) from 2005 to 2095 using the Community Land Model (CLM) driven by high-resolution downscaled climate and land cover products from PRIMA, which was designed for assessing the impacts of and potential responses to climate and anthropogenic changes at regional scales; (2) applying CLM over the CONUS to provide the first county-scale model validation in simulating bioenergy crop yields and assessing associated impacts on the water and energy budgets . The studies demonstrate the benefits of incorporating and coupling human activities into complex ESMs, and critical needs to account for the biogeophysical and biogeochemical effects of LULCC in climate impacts studies, and in designing mitigation and adaptation strategies at a scale meaningful for decision-making. Future directions in quantifying LULCC impacts on the water-energy nexus under a changing climate using an Integrated Multi-scale, Multi-sector Modeling framework will also be discussed.
Khan MA, Stockle CO, Allen RG, Trezza R	muhammadazeem.khan@wsu.edu	Satellite imagery for actual ET estimation using surface energy balance algorithm	The conventional methods for evapotranspiration (ET) estimation including micrometeorological, water balance and plant physiology methods are mainly limited to field scale measurements. In addition to this, these methods produce good ET estimates for homogenous and uniformly irrigated fields. But for drylands the water stress and mixed field conditions make it difficult to assess ET accurately using conventional methods. The detailed energy balance studies with remote sensing (RS) for estimating ET in mixed filed conditions are becoming popular and easier, because of the modifications in the empirical equations from past studies and development of new methods of actual ET measurement like METRIC and SEBAL. In addition to, energy balance can detect reduced ET caused by water shortage it also can spot spatio-temporal variation in ET over the large scale.
Madsen K, Wickham R, Petrie J	kaleb.madsen@wsu.edu	Flow and Sediment Transport in Small Streams in Forested Watersheds	Recently, much interest has focused on converting biomass to generate biojet fuel. This study supports an investigation of the social, economic, and environmental feasibility of collecting residual woody biomass remaining after tree harvesting and converting the biomass to jet fuel. A key component of the project is environmental impacts, which are expected to affect physical and biological processes of both the hillslope and stream channel. This poster presents field work investigating the physical environmental impacts of biomass removal on stream channels. The study site, Cat Spur Creek, is a stream draining a forested watershed located two miles south of Clarkia, ID on land administered by the Idaho Panhandle National Forest. Timber harvesting activities have occurred in the watershed from 1964 to present. Field work was conducted in July 2014 and includes a stream channel elevation survey and bed particle grain size measurements. Preliminary analysis is shown for the field data and a two dimensional, depth-averaged hydraulic model capable of simulating flow, sediment transport (bedload and suspended load), and morphological changes of the bed and banks of rivers.
Nassiri S	snassiri@wsu.edu	Predicting thermal behavior of pervious concrete with different porosities	Pervious concrete pavements' benefits in stormwater management and pavement runoff control has made this relatively new technology a desirable pavement option for many municipalities, departments of transportation and other project owners. PCP mixture is designed to contain 15-25% voids in a unit volume, achieved by omitting or minimizing the fine aggregate content in the mixture. The voided structure inevitably affects the thermal properties and therefore temperature changes in pervious concrete compared to conventional concrete. It is particularly critical to understand the thermal behavior of previous concrete pavements for winter maintenance operations. The focus of our ongoing study is to establish the thermal properties of pervious concrete as a function of porosity in the laboratory and develop a model to predict thermal conductivity of pervious concrete as a function of mixture constituents. The figure below shows the results of our ongoing tests to establish the thermal conductivity of one pervious concrete mixture in dry (orange) and saturated conditions (blue) for various porosities. Our next step in the research is to use these properties in a heat transfer model to predict a pervious concrete sidewalk on WSU campus, instrumented with thermistors at various depths.

Nassiri S	snassiri@wsu.edu	Testing improvements to strength and durability of Pervious concrete	The implementation of pervious concrete (PC) pavements is becoming more popular due to its environmental benefits. However, relatively low mechanical properties and durability of PC limit its use for heavier traffic load. Number of studies proposed different mixture design improvements to enhance strength and durability of PC. In this study different sizes and dosages of recycled carbon fiber composite (rCFC) particles were incorporated into a PC mixture (rPC). The goal was to determine what kind of improvements in physical and mechanical properties of PC can be attained by the addition of rCFC. Seven mixture designs were prepared in order to investigate effects of rCFC dosage as well as rCFC particle sizes. The results indicated that rCFC enhanced the workability of the PC mixtures. rPC mixtures presented higher average infiltration rates when compared to a control mixture. Improvements in mechanical properties can be seen on 28-day compressive strength (4~11%), 7- and 28-day tensile strength (~26%) and in modulus of elasticity (6~45%). In terms of the abrasion resistance, rPC mixtures presented various behaviors. However, on both abrasion tests (Cantabro and surface abrasion) it was possible to identify the mixture that outperforms the control (plain PC).
Nergui T, Evans RD, Adam JC, Chung SH	tsengel.nergui@wsu.edu	The El Niño Southern Oscillation (ENSO)-induced Modulations in Precipitation and Nitrogen Wet Deposition Rates in the Continental United States	The ENSO affects atmospheric nitrogen (N) deposition rates through its modulation on N wet deposition. Precipitation and wet deposition measurements at 151 sites of the National Atmospheric Deposition Program/National Trends Network and the NINO3.4 SST climate index from the NOAA's Climate Prediction Center are analyzed to determine the impacts of the ENSO on N wet deposition and precipitation rates in the continental U.S. Precipitation and N wet deposition time series are dominated by high frequency components; however, they contain a wide range of inter-annual frequency components depending on the location. At the 2-to 6-year timescale, variability of precipitation and N wet deposition rates in the Pacific Northwest, the Rocky Mountains, the Gulf States, the Northeast, and the Great Lakes regions are correlated with that of the NINO3.4 index (r2= 0.09-0.59 for precipitation and r2= 0.09-0.52 for N wet deposition, p<0.05). The spatial patterns and strength of the correlations vary by region and season. The correlations are the strongest and most spatially extensive during winter; 46-62% and 46-53% of the 2- to 6-year variability of precipitation and N wet deposition rates in the Rocky Mountains, the Gulf of Mexico, and near the Great Lakes can be explained by ENSO activity. The wintertime relationships tend to hold through springtime in the Great Lakes, the Ohio River Valley, and the Northeast. During the El Niño winters and springs, N wet deposition rates are higher than normal (greater than the 70th percentile) in the southern Great Plains and the Gulf Coast. Winter and spring La Niña episodes bring precipitation and N wet deposition rates above normal over the Cascades, the Ohio River Valley, the Northeast and the Great Lakes regions. The ensemble mean of eleven coupled General Circulation Models (Yeh et al., 2009) shows that the weak ENSO cycles, having small to moderate amplitudes and reoccurring in shorter time intervals, are projected to dominate in the 21th century, implying that total N (dry and wet) deposition rates in some regions of the U.S. may increase due to increased N wet deposition from more frequent ENSO events. Continuing work includes analysis of total N deposition with climate variability at the intra-annual time scale to help explain total N deposition variability.
Nergui T, Lamb BK, Chung SH	tsengel.nergui@wsu.edu	An Atmospheric Nitrogen Budget in the Pacific Northwest during the 1997-98 El Niño Southern Oscillation	Excess reactive nitrogen (N) from anthropogenic activities is known to cause detrimental effects on the environment. Natural climate variability such as the El Niño Southern Oscillation (ENSO) can affect regional N budgets due to spatial patterns of atmospheric transport and other meteorological conditions associated with ENSO forcing. This study aims to quantify atmospheric N fluxes over the Pacific Northwest to improve our understanding of the regional N budget during a strong ENSO event. The WRF-MEGAN-SMOKE-CMAQ modeling framework is used to simulate atmospheric physical and chemical processes from summer of 1997 to spring of 1999 which includes one of the strongest ENSO events on record. Based on anthropogenic emissions from the 2002 National Emission Inventory, the MEGAN biogenic emission model, and the BlueSky modeling framework in combination with historical fire records, total N emissions were about 108 Gg N in summer (Jun-Aug) and 63 Gg N in winter (Dec-Feb). Total N emissions aggregated from transportation, electric generation, and industry sectors were relatively constant throughout the year, with seasonal average of 56±2 Gg N. On the other hand, total N emissions from agriculture, wildfire, and biogenic sources had a strong seasonality (32±16 Gg N), with a maximum in summer (49 Gg N) and a minimum in winter (9 Gg N). Total N deposition rates were lower (36 Gg N) in winter of 1997/1998 and higher in following spring (82 Gg N) and summer (81 Gg N). Dry deposition is dominant over wet deposition in the region. Depending on the season, dry and wet deposition accounted for 52-70% and 30-48% of the total monthly deposition rates, respectively. However, during the 1997-98 El Niño winter, wet and dry deposition contributed almost equally to the total deposition. A mass balance calculation with an assumption of no N accumulation in the troposphere indicates that about 26±9 Gg N was transported out of the region on a seasonal basis. Net N transport was higher in the summer and lower in the spring of 1998. The simulation for 1998-1999 is in progress. N advected in and out the domain boundaries still need to be quantified. The study results will provide a sense of upper and lower range of contributions of regional and imported N sources over the Pacific Northwest during a strong ENSO event.
Nguyen T, Adam J	tung.nguyen@wsu.edu	The role of watershed properties in governing headwater catchment recharge and streamflow response to climate change	Headwater catchments are important sources of surface water supply, groundwater recharge and, thus, groundwater supply for agricultural activities in the Yakima River Basin (YRB, one of the most important agricultural basins in the western U.S). These catchments are, however, vulnerable to projected climate change in future decades, particularly if their runoff is dominated by snowmelt. The goal of this study is to assess the potential impacts of climate change on the temporal and spatial distributions of groundwater recharge and streamflow in three headwater catchments in the YRB. A Regional Hydro-Ecologic Simulation System (RHESSys) is calibrated and evaluated with a global optimization tool (Covariance Matrix Adaptation Evolution Strategy - CMA-ES) using 27 years of observation data from 1979 to 2005. Statistically downscaled climate projections for the 2050s from eight global climate models driven by two different representative concentration pathways, RCP4.5 and RCP8.5 are used to predict future hydrologic changes. Our preliminary results show an increase in annual recharge between 2% and 13%, as well as in streamflow between 1% and 17%. Seasonal changes of recharge and streamflow are more pronounced with an increase up to 210% in winters and a decrease as high as 60% in summers in the 2050s. Both recharge and streamflow projections indicate timing shifts in all three catchments. The outcome from this study will be an integral part of a future study which investigates the impacts of climate change on surface water vulnerability due to supplemental pumping, potential recharge changes and related surface-groundwater interactions in the YRB using an integrated modeling approach that consists of three models: RHESSys, a groundwater model (MODFLOW) and a river and reservoir management model (RiverWare).

Ortega A, Fremier A	alineorteg@gmail.com	Monitoring carbon processing in streams to quantify and map ecosystem services	Recent research shows that inland waters play an active part in the global C cycle and that carbon efflux to the atmosphere from these systems is higher than previously thought. Although streams represent a small fraction of the area occupied by land, in-stream carbon processing (aka. stream metabolism), influences atmospheric carbon and is essential for sustaining ecosystem health. Yet, for the most part, stream metabolism has yet to be fully considered an ecosystem service. Carbon processing rates in streams are influenced by a variety of factors but riparian forest condition exerts an overriding control. By linking carbon processing with riparian cover, we link the ecosystem process to a mappable unit. We use data from a small tropical watershed in central Costa Rica to illustrate how riparian cover in agricultural lands significantly influence stream metabolism. Specifically, we (1) consider carbon processing in streams as an ecosystem service, (2) introduce stream metabolism as a quantitative measure of the supply of the service, and (3) argue that riparian forest cover should be used in payment of ecosystem service schemes to incorporate instream carbon processing for both diversity conservation and climate mitigation goals.
Parker L, Abatzoglou J	lparker@uidaho.edu	Using the MaxEnt in estimating the climatological niche for perennial agriculture	Although widely used in the ecological community, species distribution models (SDMs) are less common in agricultural research. Recent research suggests that empirical models can provide accurate crop distribution and yield results, however existing research has only addressed annual crops. Using cultivar locations from the 2014 USDA Cropland Data Layer, and climatological predictors derived from 20 CMIP5 global climate models over the period 1971 – 2000, we develop a niche model for the perennial crop Prunus dulcis (almond) using maximum entropy modeling. We utilize Princeton University's maximum entropy modeling software, MaxEnt, we highlight those variables with high relative contribution to modeling species presence, and we map the probability of almond presence across the western United States. Our results suggest that while almonds may be commercially cultivated almost exclusively in California, other locations in the western United States are thermally suitable for their survival and under climate change the species niche may grow.
Rabbani G	golam.rabbani@wsu.edu	Estimate Crop Coefficient for a Deciduous Tree using WEPP and Observe the Impact of Forest Cutting on Different Types of Forest	Evapotranspiration (ET) and crop coefficient are considered as one of the most dynamic issues of complex forest hydrology. In order to gather clear idea regarding water yield of a forest system, having clear concept of ET and crop coefficient for different forest species of variable ages has no alternative. One of the primary objective of this study is to find out probable crop coefficient for a deciduous tree with a known ET by using WEPP (Water Erosion Prediction Project) model and also observe the impact of forest cutting on different types of forest. Firstly, a forest environment was created in WEPP following a literature in order to simulate probable crop coefficient for intermediate hardwood (IHW) tree of 17 years old which is a deciduous tree. It has been found that the simulated crop coefficient for IHW is around 0.70. In order to observe impact of cutting on different types of forest, a database of forest cutting consisting of 114 catchments have been documented which are exposed to logging. This database is then categorized depending on the forest types. For coniferous forest extent of forest cutting and mean precipitation have shown significant trend with increased average water yield (R2 value 0.42 and 0.36 respectively). Whereas for deciduous and mixed forest no significant trend have been observed.
Rajagopalan K, Chinnayakanahalli K, Nelson R, Yorgey G, Malek K,Stockle C, Brady M, Kruger C, Adam J	kirti.rajagopalan@gmail.com	Impacts of climate change on irrigated agriculture in the Columbia River basin.	Irrigated agriculture is impacted by climate change both directly and indirectly. Warmer temperatures and elevated CO2 levels directly impact the plant growth cycle and potential crop yields. In addition to this, indirect effects include factors such as changes in water availability for irrigation, particularly in snowmelt dominated regions. This is especially relevant in regions that exercise irrigation water rights curtailment in times of shortages, e.g., to maintain environmental flows. The relative magnitudes and directions of both the direct and indirect effects will determine the net impact climate change on agricultural production in such regions. We examine the indirect impacts of climate change in the 2030s on irrigated agricultural production in the Washington state part of the Columbia River basin, using a coupled crop-hydrology model in conjunction with a water management model that includes an approximation of water rights curtailment in the region. The indirect effects are also considered relative to the direct impacts of climate change on agricultural production. Results indicate that although future curtailment rates are expected to be higher than historical conditions, the effects of curtailment on crop yields are not correspondingly larger in the future. Impacts are crop dependent and depend on the timing of curtailment in relation to crop growth stage. Earlier onset of crops and accelerated growing degree day accumulation under warmer future climate alter the crop growth cycle leading to interesting impacts of curtailment on agricultural production.
Reyes JJ, Adam JC, Tague CL	julianjonreyes@gmail.com	Assessing environmental controls on biomass in grasslands using an eco-hydrologic model	Grasses in rangeland ecosystems support livestock for agricultural production and provide a variety of ecosystem services. The allocation of carbon (C) between aboveground and belowground plant compartments is influenced by vegetation characteristics and environmental conditions. For grasses, accurate representation of C allocation can inform potential C storage and/or forage production under changing climate and management conditions. The objectives of this study are to (1) examine the sensitivity of biomass to uncertainty across soil drainage, ecophysiological, and allocation parameters, and (2) assess the sensitivity of biomass under different climatic conditions given parameter uncertainty. For this, we use the Regional Hydro-ecologic Simulation System (RHESSys), a physically-based model that simulates coupled water and biogeochemical processes. A Latin Hypercube Sampling approach is used to determine potential parameter sets across the aforementioned variables. Then, ranked partial correlation coefficients (RPCCs) are calculated for our grassland sites representing different climate regimes. RPCCs are used to examine biomass sensitivity to vegetation characteristics, soil drainage, and allocation parameters. Historical precipitation and temperature data are incrementally changed to simulate climatic change (i.e. warmer and/or wetter conditions). The assessment of parameter sensitivity using RPCCs is repeated under these perturbed conditions, along with biomass sensitivity to these climatic changes. Using RHESSys, we found distinct relationships among simulated biomass (both above and belowground) and different parameters representing eco-hydrologic processes. Parameters controlling C allocation were ranked in the upper quartile of RPCCs for both aboveground and belowground biomass across all grassland sites. This suggests that variation in allocation strategies can have substantial impacts on grassland biomass at our study sites. While simulating potential climatic changes, we found differential responses across sites. Biomass was more sensitive to changes in precipitation than temperature at arid sites. Large changes in minimum temperatures increased biomass sensitivity at the cooler grassland sites, while warmer sites responded with slightly smaller increases. Given the uncertainty in parameters that are used to develop our models, this work increases scientific knowledge on how biomass sensitivity may change under future environmental conditions. Improving our understanding of allocation in grasses can better inform sustainable management of our rangelands.

Reyes JJ, Tague CL, Kruger C, Johnson KA, Adam JC	julianjonreyes@gmail.com	Integrated Response of Grassland Biomass Along Co-varying Gradients of Climate and Grazing Management Using an Eco-hydrologic Model	Grasses in rangeland ecosystems cover a large portion of the contiguous United States and are used to support the production of livestock. These grasslands experience a wide range of precipitation and temperature regimes, as well as management activities like grazing. Assessing the coupled sensitivity of biomass to both climatic change and human activities is important to decision makers to ensure the sustainable management of their lands. The objective of this study is to examine the sensitivity of biomass under co-varying conditions of climate and grazing management. For this, we used the Regional Hydro-ecologic Simulation System (RHESSys), a physically-based model that simulates coupled water and biogeochemical processes. We simulated dominant grass species located in major climate zones. Historical precipitation and temperature data were incrementally perturbed to simulate climatic change (i.e. warmer and/or wetter conditions). Similarly, we perturbed historical grazing patterns to mimic possible changes in management. Changes in climate or grazing management alone produced shifts in the sensitivity of grassland biomass. However, co-varying climate conditions (temperature and precipitation) with either grazing intensity, frequency, or duration revealed different biomass responses. For example, some changes in grazing duration could be mediated by changes in climate. Effects of high intensity grazing could be buffered depending on the duration or timing of grazing (i.e. start and end date). This research employs process-based modeling with simple, incremental changes in both climate and grazing management. By doing so, we can provide information that is useful for land managers and ranchers for future planning.
Richey S	sasha.richey@wsu.edu	A Remote Sensing Analysis of Global Groundwater Stress	Groundwater is the largest stock of accessible freshwater on Earth, providing a dominant water supply source for over 2 billion people, but it is a finite resource if mismanaged. In order to manage a natural resource system, specifically a common pool resource like groundwater, basic information about the system's properties must be defined [Schlager et al., 1994]. This information can include estimates of natural fluxes in and out, total stocks, and dominant demands on the system. Methods to measure these factors for groundwater can be time intensive, costly, and challenging [McGuire et al, 2003; Konikow & Kendy, 2005; Shiklomanov, 2003], especially across the scale of a whole aquifer, which has resulted in minimal management of groundwater to date and a tragedy-of-the-commons threat. This study quantifies the balance between groundwater use and groundwater availability, termed "stress," in the world's 37 largest aquifers. In doing so, previous methods to estimate groundwater use and availability are revisited and ultimately, redefined. Groundwater use is defined as depletion to encompass both the rate of use and the response of the aquifer to human impacts (i.e. pumping) and natural variability (i.e. drought), both of which influence aquifer stress. Depletion is estimated with remote sensing observations from the Gravity Recovery and Climate Experiment (GRACE) satellite mission [Tapley et al., 2004].Groundwater availability is first defined as the renewable flux of recharge. Availability is then redefined as the total volume of groundwater in storage to understand the timescales of aquifer depletion and the ability of storage to act as a buffer against negative groundwater perturbations. Characteristic stress regimes are created to group aquifers based on the sign of use (depleting or gaining) and the sign of renewable availability (recharging or losing). Anthropogenic biomes [Ellis & Ramankutty, 2008] are used to better understand the driving factors behind different levels of stress in the aquifers. We find that current estimates of total aquifer storage are inadequate to assess depletion timescales and the characterization of "stressed" aquifers is highly dependent on how use and availability are defined. Overall, one third of the world's largest aquifers are found to be highly stressed and may or may not have available storage to buffer against continued use, most of which are in semi-arid/arid regions with large cropland areas.
Shehata M, Petrie J	m.ebrahimmosashehata@wsu.edu	Mixing zone hydrodynamics in a large confluence: a case study of the Snake and Clearwater Rivers confluence	Confluences are a basic component in all fluvial systems, which are often characterized by complex flow and sediment transport patterns. Addressing confluences, however, started only recently in parallel with new advances of flow measurement tools and computational techniques. A limited number of field studies exist investigating flow hydrodynamics through confluences, particularly for large confluences with central zone widths of 100 m or greater. Previous studies have indicated that the size of the confluent rivers and the post-confluence zone may impact flow and sediment transport processes in the confluence zone, which consequently could impact the biodiversity within the river network. This study presents the results of a field study conducted at the confluence of the Snake and the Clearwater rivers near the towns of Clarkston, WA and Lewiston, ID (average width of 700 m at the confluence center). This confluence supports many different and, sometimes, conflicting purposes including commercial navigation, recreation, and fish and wildlife conservation. The confluence properties are affected by dredging operations carried out periodically to maintain the minimum water depth required for safe flow conveyance and navigation purposes. Also, a levee system was constructed on the confluence banks as an extra flood control measure. In the recent field work, an Acoustic Doppler Current Profiler was used to measure water velocity profiles at cross sections in the confluence region. Fixed and moving vessel measurements were taken at selected locations to evaluate both the spatial and temporal variation in velocity throughout the confluence. The confluence bathymetry was surveyed with a multi-beam sonar to investigate existent bed morphological elements. The results identify the velocity pattern in the mixing zone between the two rivers.
Souzandeh H	hamid.souzandeh@email.wsu.edu	Biomaterials for air filtration	Biomaterial structures, such as various natural proteins, involve numerous active functional groups that can interact with multiple types of toxic molecules existing in air. However, rare studies have been conducted using biomaterials for air filtration applications. Proteins, an important class of natural polymeric biomaterials, possess numerous different active functional sites, which enable them to be able to interact with different types of pollutants including toxic gaseous molecules in the air. Commercial air filter cannot effectively purify the air from particles and chemicals simultaneously and disposing of used air filters causes further environmental issues due to their synthetic nature. To help mitigate environmental problems, protein-based nanofabrics could play an important role, which is successfully demonstrated in this study via fabricating nanofabrics from natural proteins using electrospinning technique. By controlling the morphology and surface composition of ultrafine protein-based nanofibrics, through employing a "green' solvent, high efficiency multi-functional air filtering materials were achieved. The protein-based nanofabrics have been demonstrated to efficiently purify the air from variety of particle matter (PM) with wide size ranges and toxic gas chemicals simultaneously with possessing only ca. 1/50 the areal density of a commercial High Efficiency Air filter, HEPA. More significantly, these multifunctional filtration capabilities are realized only by deploying the functional groups naturally existing inside the protein molecules, instead of via adding any active carbon or nanoparticles. Besides the super high filtration efficiency of PM with sizes from 0.3 to 10μm, the protein-based air filtering materials show very high removal efficiencies for toxic gases, such as formaldehyde (HCHO) and carbon monoxide (CO). These protein-based air filtering materials proved that effectively combining nanotechnology and biomaterials can provide a promising break-through for next-generation air filtering systems.

Sparks AM, Kolden CA, Smith AMS	spar5010@vandals.uidaho.edu	Fire Activity and Climate Change	Fire activity, in terms of intensity, frequency, and total area burned, is expected to increase with changing climate. A challenge for landscape level assessment of fire effects, termed burn severity, is that current assessments provide very little information regarding vegetation physiological performance and recovery, limiting our understanding of fire effects on ecosystem services such as carbon storage/cycling. An alternative pathway to evaluate fire severity that bridges fire combustion dynamics and ecophysiology via dose-response experiments is presented. We provide an illustrative example from a controlled nursery-combustion laboratory experiment. In this example, severity is defined through changes in physiological processes, including the ability of the plant to assimilate carbon at the leaf level. We also explore changes in the several spectral indices common to vegetation stress and burn severity research. These data will serve as the groundwork for the development of a spatial severity model that can either predict fire effects using observed or modeled energy release from field or remotely sensed data (e.g. MODIS Active Fire Product), or characterize fire effects using post-fire remotely sensed data (e.g. Landsat 8 Operational Land Imager).
Thornton M, Beall-King A	melanie.thornton@wsu.edu	Collaborative Modeling in the Spokane River Basin: Engaging Stakeholders to Explore Basin-wide Water Management Strategies	Complex issues related to climate change cannot be understood from a single disciplinary perspective, thus collaboration among diverse perspectives is essential for addressing regional water resource management strategies. The Spokane River Basin is a sub-basin of the Columbia River that spans the state line between northwestern Idaho and northeastern Washington. Management of this basin is complex because of interstate, multi-jurisdictional responsibilities and the dynamic interaction between groundwater and surface water. This research focuses on a collaborative modeling project in the Spokane River Basin that will allow stakeholders and scientists to jointly address key issues related to regional water resource decisions and climate change. This ongoing collaborative modeling process works iteratively with stakeholders in the region to create a user-friendly model of issues relevant to their water management systems. We developed a collaborative hydrologic model, based in OASIS software that integrates technical scientific information and historical data with local knowledge and interests to explore basin-wide management strategies. OASIS uses a fully configurable linear programming solver to simulate water routing and is designed to optimize system performance based on user-defined goals and constraints. Policy-relevant scenarios, which include different integrated water resource management alternatives, were developed with stakeholders to address issues related to low streamflow, and future water supply and demand. Collaborative modeling provides an integrated process for making water allocation and water use decisions in the basin, which allows for a more holistic and integrated water resources management strategy. Collaborative modeling sessions enabled stakeholders to explore different water management alternatives and evaluate management strategies that best suit the needs and interests of the entire basin. Model results and scenario evaluations will be presented. This participatory process aims to better understand how water resource decisions may change in the context of climate change.
Ward NK, Maureira F, Brooks E, Yourek M, Stockle C	nicole.ward@wsu.edu	CropSyst-Microbasin model as a tool to inform variable-rate nitrogen management and dryland farm profitability	Precision fertilizer management is a promising method to maintain high agricultural yields while using less fertilizer inputs in the highly heterogeneous Palouse region. This study assessed the use of CropSyst-Microbasin at a tool to inform fertilizer management practices. A highly-instrumented field site was used to parameterize CropSyst-Microbasin; the model accurately simulated spatial and temporal changes in soil water content, total surface runoff, and average crop yield. Fertilizer management scenarios were conducted with an analysis of total nitrogen loss, crop yield, and farm profitability. Simulated yields were analyzed with local costs of production and varying crop, fertilizer, and fuel costs to examine the sensitivity of profitable fertilizer management to varying market conditions. Hillslope scenarios demonstrate the capacity of CropSyst-Microbasin to simulate the contribution of lateral redistribution of nitrogen to down-slope yields. Field catchment (roughly 10 hectare) simulations demonstrate the unique capacity of CropSyst-Microbasin to simulate agricultural production on highly heterogeneous landscapes, capturing spatial and temporal variability. Simulations and field sites were examined in conjunction with other types of production measurements, such as NDRE-based N uptake predictions, to explore field-scale spatial and temporal drivers of production and risk to inform precision fertilizer management on the Palouse.
Williams J, Beutel M, Nurse A, Moore B, Hampton S, Saros J	jason.williams2@wsu.edu	Phytoplankton Responses to Nitrogen Enrichment in High Elevation Lakes at Mount Rainier, North Cascades, and Olympic National Parks	Limited information is available about threshold lake nitrogen concentrations necessary to stimulate phytoplankton species and biomass responses in remote nitrogen-limited mountain lakes. We conducted in situ enrichment bioassays in mountain lakes within Mount Rainier, North Cascades, and Olympic National Parks in Washington State, USA to characterize phytoplankton species and biomass responses to nitrogen enrichment, and associated nitrogen concentration thresholds. Based on biomass and growth measurements, phytoplankton were nitrogen-limited or co-limited by nitrogen and phosphorus in the nine bioassay lakes. We identified 20 taxa that responded to nitrogen enrichment, and estimated response thresholds using nitrogen Monod growth parameters for 18 of these taxa. We estimated dissolved inorganic nitrogen concentration thresholds for any increase in chlorophyll a (13 µg N L-1) and for an increase beyond typical inter-annual chlorophyll a variation (25 µg N L-1) in nitrogen-limited lakes. We then compared experimentally-defined nitrogen concentration thresholds for species and biomass changes to nitrogen concentrations observed in park mountain lakes to infer lake sensitivity to atmospheric nitrogen deposition. Approximately 75% of sampled mountain lakes in the parks have summer dissolved inorganic nitrogen concentrations below biomass response thresholds. This finding suggests phytoplankton in park mountain lakes are likely sensitive to future deposition-induced lake nitrogen enrichment.
Xin J, Guo X, Qin J, Zhang P, Wolcott MP, Zhang J	junna.xin@wsu.edu	Application development of lignin in valuable engineering polymers via mild thermochemical and mechanochemical process	Lignin was fully studied to be used in thermosetting polymers and PLA blends because of its characteristic aromatic structure and all kinds of hydroxyl groups. In order to improve the compatibility of lignin in polymer application, the lignin was firstly partially depolymerized via hydrogenolysis and base-catalyzed approaches under mild conditions. The effects of various reaction parameters on yield of depolymerization were investigated. The partial depolymerized lignins (PDL) were low molecular weight oligomers with increased hydroxyl value. PDL displayed greatly enhanced solubility in organic solvents and was further used to synthesize lignin based epoxy monomers and polycarboxylic acid curing agents. Results showed that the epoxy resin derived from PDL based epoxy monomers or curing agent cured with appropriate partners exhibited good mechanical and thermal properties. Lignin based epoxy resin was also utilized to modify asphalt to prepare epoxy asphalt with high performance. On the other hand, a solvent free method: mechanochemical approach was involved to degrade lignin and depolymerized lignin was simutaneously reacted with methyl oleate via transesterification reaction in one ball milling process. The oleated lignins blended with PLA and the properties of the blends could be greatly regulated by adjusting the content of oleated lignins. A novel hydrogel material based on the crosslinked copolymer of lignosulfonate and PEGDGE was investigated. It was noted when amino groups were introduced into lignosulfonate structure, the resulting hydrogels exhibited greatly improved swelling capacity.

Zhao M, Boll J, Brooks ES	mengqi.zhao@wsu.edu	Modeling of Forest Land Use Changes with Soil Moisture Routing Model in Mica Creek Watershed in North Idaho	Quantifying the hydrological impacts of land use and land cover change on hydrologic dynamics is still challenging for hydrologists. Various disturbances in forested watersheds change the pattern of runoff generation, snow accumulation and melt, evapotranspiration, soil moisture, water movement and other hydrologic processes which increase the difficulties and uncertainties in forest management. Under these circumstances, a hydrologic model based on physical reality is an effective way to detect the potential changes aroused by land use and land cover change. In this study, we use the Soil Moisture Routing (SMR) model, a geographic information system (GIS) based distributed model, in the Mica Creek Experimental Watershed (MCEW) to understand and quantify long-term land use and land cover changes on hydrologic dynamics and microenvironment. The SMR model represents landscape characteristics using physically-based parameters. The 28 km2 MCEW has a nested study design and allows for the analysis of cumulative effects of road building, tree harvesting as well as the traditional comparison of treatment versus control. We are using an abundant data set for seven watershed locations in the MCEW under different treatments since 1991. The poster will describe the data set, the treatments employed and will show preliminary modeling results. By simulating the hydrologic processes and analyzing the differences of model parameters under various treatments, our findings show impacts of forest management on surface and groundwater hydrology at the watershed scale.
Dobre M, Brooks ES, Elliot WJ, Frankenberger JR	mdobre@uidaho.edu	Development of a WEPP online watershed interface to predict effects of watershed management on runoff, and sediment and phosphorus delivery in the Lake Tahoe Basin	Forest and land managers need hydrologic models to evaluate the effects of different management practices on both water quantity and quality. Such tools exist, however, their applicability is limited by the user's proficiency in using the models, availability of data for the interest region, and the time required to download the data and set up the necessary input files. We enhanced an online GIS interface to the process-based Water Erosion Prediction Project (WEPP) model with input files developed specifically for the Lake Tahoe Basin. To run simulations of surface runoff and erosion, users only need an internet connection and minimum information about the location of interest. The interface remotely accesses national databases to download USGS 30-m National Elevation Data, USGS topographical maps, USGS land cover and NRCS soil data specific for the study area, and uses additional data and algorithms stored on a server to automatically create all the model input files. Users can choose between hourly and daily historical and future climate files developed for eight major SNOTEL stations within the Basin. The model allows users to assess the long-term effects of forest management practices on runoff and erosion from specific hillslopes and at the watershed outlet. Consistent with the current efforts in the Basin to reduce phosphorus transport to the Lake, our recent improvements to the model have focused on enhancing the interface with a phosphorus component that allows users to evaluate the effect of forest managements on phosphorus delivery to the lake.
K. Malek, J. Adam, C. Stockle, M. Brady	keyvanmalek@gmail.com	When should irrigators invest in more water-efficient technologies as an adaptation to climate change?	The western US is expected to experience more frequent droughts with higher magnitudes and persistence due to the climate change, with potentially large impacts on agricultural productivity and the economy. Irrigated farmers have many options for minimizing drought impacts including changing crops, engaging in water markets, and switching irrigation technologies. Switching to more efficient irrigation technologies, which increase water availability in the crop root zone, receives significant attention because of the promise of maintaining current production with less water. However, more efficient irrigation systems are almost always more capital-intensive adaptation strategy particularly compared to changing crops or trading water. A farmer's decision to switch will depend on how much money they project to save from reducing drought damages. The objective of this study is to explore when (and under what climate change scenarios) it makes sense economically for farmers to invest in a new irrigation system. This study was performed over the Yakima River Basin (YRB) in Washington State, although the tools and information gained from this study are transferable to other watersheds in the western US. We used VIC-CropSyst, a large-scale grid-based modeling framework that simulates hydrological processes while mechanistically capturing crop water use, growth and development. The water flows simulated by VIC-CropSyst were used to run the RiverWare river system and water management model (YAK-RW), which simulates river processes and calculates regional water availability for agricultural use each day. An automated computational platform has been developed and programed to perform the economic analysis for each grid cell, crop types and future climate projections separately, which allows us to explore whether or not implementing a new irrigation system is economically viable. Results of this study indicate that climate change could justify the investment in new irrigation systems during this century, but the timing of a farmer's response is likely to depend on a variety of factors, including changes in the frequency and magnitude of drought events. Other important factors affecting costs and benefits of implementing new irrigation systems are current irrigation systems, climatological characteristics within the basin, and crop type.