Research Summary—Sept 2023

My research is in the realm of "actionable science" i.e., I work with stakeholders in providing data, analyses, projections, and tools that can support decisions regarding the management of water resources threatened by climate change. Global climate models (GCMs) project a 4-11^{o}F increase in the annual air temperature in the Puget Sound region near the end of the century, which is driving climate resilience planning strategies by regional municipalities, industry, agriculture, and Indian tribes that are concerned about winter flooding and summer water availability and salmon recovery. I have received multiple external grants primarily from the Nooksack Indian Tribe and Stillaguamish Tribe of Indians indirectly through Federal grants from the Bureau of Indian Affairs, to model the impacts of climate change on hydrology in the Nooksack and Stillaguamish River basins, including changes in snowpack, streamflow, glacial recession, stream temperatures, and mass wasting.

Numerical modeling is the only tool by which to examine how a watershed will respond to projected warming climates. My research group uses the Distributed Hydrology Soils Vegetation Model (DHSVM) developed for mountainous regions at the University of Washington and Pacific Northwest National Lab. The DHSVM is a physically based, spatially distributed hydrology model that requires explicit physical characteristics of a watershed, including topography, land cover, soil type, soil thickness, and a streamflow network. The model simulates a water and energy balance at the pixel scale, including evapotranspiration, snow accumulation/melt, glacier dynamics, and streamflow, when "forced" with a time series of meteorological inputs: temperature, relative humidity, precipitation, wind speed, and incoming shortwave and longwave radiation. We are also using the River Basin Model (RBM) to simulate stream temperatures. Outputs of the DHSVM are used to drive the RBM. Our use of the RBM has led to a collaboration with Dr. John Yearsley, an affiliate at University of Washington (UW) Environmental & Engineering and research associate in the Geology Department at WWU.

We are forcing the DHSVM with gridded meteorological data—a new standard practice when modeling hydrology in large-scale watersheds, and the most rapidly changing aspect of our modeling efforts. Our use of these gridded data sets has led to a collaboration with Dr. Guillaume Mauger, a climate scientist with the Climate Impacts Group (CIG) at the UW. Gridded meteorological data are weather variables that are statistically or dynamically interpolated over a grid on the Earth's surface at a specific resolution, e.g., 1/16-degree latitude longitude (grid cells of about a 6 km side). The grid nodes can contain both a time series of historical data and projected climates produced by GCMs. We use both statistically derived and dynamically derived gridded data.

Our initial modeling works in the western Cascades assessed the impact of projected climate change on snowpack and glacier recession, and their effect on streamflow. Generally, we project that a warming climate will push snowlines to higher elevations causing a reduction in overall winter snowpack and lower snowmelt runoff in the spring and summer, hence lower streamflows. The results of these works led to questions and subsequent modeling projects to address how the projected reduction of snowpack and summer streamflows influence stream temperatures and salmon habitat. And, given that more high elevation landscape will receive more rainfall in the winter months than snow, questions about how increased winter runoff fostered projects to examine how warmer winters will impact peak flows and flooding risk, and mass wasting susceptibly.

Our emerging goals are to use the DHSVM, which requires forest landcover grids, to examine how select forest harvesting may increase snow retention and soil water in higher elevations, and hence increase summer streamflows—these studies are in collaboration with Dr. Susan-Dickerson-Lange of Natural Systems Design. We also plan to examine how forest harvesting may potentially intensify peak flows and flood risks. I spent my sabbatical this year working with Dr. Mark Wigmosta's research group at the Pacific Northwest National Lab in Richland in advancing these modeling efforts that will require DHSVM modifications. See my graduate student Kristen Carlson's thesis proposal (download pdf) for more detail.

Products

Mauger, G.S., J. Robinson, R.J. Mitchell, J. Won, and N. Cristea (2021). New Flood Projections for Snohomish County: Fine-scale Modeling and Dynamically-Downscaling. Report prepared for Snohomish County. Climate Impacts Group, University of Washington

Emily Smoot (2023) Modeling the effects of projected climate warming on stream temperatures in the Stillaguamish River basin (download pdf)

Evan Paul (2023) Modeling 21st Century Peak Flows in the Nooksack River Basin in Northwestern Washington State Using Dynamically Downscaled Global Climate Model Projections. WWU Graduate School Collection. 1161. https://cedar.wwu.edu/wwuet/1161

James Robinson (2022) Modeling 21st century peak streamflows in the Stillaguamish Watershed using dynamically downscaled general circulation model projections. WWU Graduate School Collection. 1150. https://cedar.wwu.edu/wwuet/1150

Clarke, Katherine (2020) Modeling the effects of climate change on streamflow and stream temperature in the South Fork of the Stillaguamish River. WU Graduate School Collection. 983. https://cedar.wwu.edu/wwuet/983

Freeman, Kyra (2019) Modeling the Effects of Climate Variability on Hydrology and Stream Temperatures in the North Fork of the Stillaguamish River. WWU Graduate School Collection. 855. https://cedar.wwu.edu/wwuet/855

Knapp, Kevin (2018) The Effects of Forecasted Climate Change on Mass Wasting Susceptibility in the Nooksack River Basin. WWU Graduate School Collection. 807. https://cedar.wwu.edu/wwuet/807

Truitt, Stephanie (2018) Modeling the Effects of Climate Change on Stream Temperature in the Nooksack River Basin. WWU Graduate School Collection. 642. https://cedar.wwu.edu/wwuet/642

Murphy, Ryan (2016) Modeling the Effects of Forecasted Climate Change and Glacier Recession on Late Summer Streamflow in the Upper Nooksack River Basin. WWU Graduate School Collection. 461. http://cedar.wwu.edu/wwuet/461

Dickerson-Lange, S. E., & Mitchell, R. (2013). Modeling the effects of climate change projections on streamflow in the Nooksack River Basin, Northwest Washington. Hydrological Processes, 28(20), 5236–5250. https://doi.org/10.1002/hyp.10012

Abstracts and Presentations (* graduate student)

Mitchell, R.J. and Paul, E.*, 2023. Modeling 21st century peak flows in the Nooksack river using dynamically downscaled climate projections. 93rd /101st Annual Meeting (NWSA/AAAS-PD), March 21-24, 2023. Western Washington University, Bellingham, WA.

Smoot*, E. and R. J. Mitchell, 2023. Investigating the impact of climate variability on summer stream temperatures in the Stillaguamish basin. 93rd /101st Annual Meeting (NWSA/AAAS-PD), March 21-24, 2023. Western Washington University, Bellingham, WA.

Paul*, E. and Mitchell, R., 2022, Modeling future peak flows in the Nooksack River using dynamically downscaled climate projections. 13th Washington Hydrogeology Symposium, May 10-12, Tacoma, WA.

Smoot*, E., Mitchell, R. and Robinson, J., 2022. Assessing the impacts of projected climate warming on stream temperatures in the Stillaguamish River 13th Washington Hydrogeology Symposium, May 10-12, Tacoma, WA. Accepted.

Paul*, E. and Mitchell, R., 2022, Modeling the effects of climate change on peak flows in the Nooksack River, North Cascades. Virtual Salish Sea Ecosystem Conference, April 26-28, 2022.

Smoot*, E., Mitchell, R. and Robinson, J., 2022. Modeling the effects of projected climate warming on stream temperatures in the Stillaguamish River basin. Virtual Salish Sea Ecosystem Conference, April 26-28, 2022.

Robinson*, J., and Mitchell, R. J., 2021, Applying dynamically downscaled climate projections to a mountainous watershed in Western Washington to estimate future peak flows, Geological Society of America Abstracts with Programs. Vol. 53. GSA Annual Meeting, Portland, OR, Oct 10-13, 2021.

Robinson*, J., Mitchell, R. J., and Mauger, G. 2021, Modeling the effects of climate change on peak flows in the Stillaguamish Watershed, Northwest Climate Conference, April 6-8, 2021, University of Washington (virtual).

Mitchell, R. J., Robinson*, J. and Mauger, G. 2020, Modeling the effects of projected peak flows in the Stillaguamish River, Geological Society of America Abstracts with Programs. Vol. 52. GSA Annual Meeting, Montreal, CA.

Mitchell, R. J., K.M. Clarke*, K. M. and J.R. Yearsley, 2019. Modeling the effects of climate change on streamflow and stream temperature in the South Fork of the Stillaguamish River. Geological Society of America Abstracts with Programs. Vol. 51. GSA Annual Meeting, Phoenix, AZ.

Clarke*, K. M., R. J. Mitchell, and J.R. Yearsley, 2019. Modeling the effects of climate change on streamflow and stream temperature in the South Fork of the Stillaguamish River. 10th Annual Northwest Climate Conference, Portland, OR.

Clarke*, K. M., R. J. Mitchell, and J.R. Yearsley, 2019. Modeling the effects of climate change on streamflow and stream temperature in the South Fork of the Stillaguamish River. 12th Washington Hydrogeology Symposium. April 9-11, 2019, Tacoma, WA.

Mitchell, R. J., K. M. Freeman*, and J.R. Yearsley, 2019. The Effects of Forecasted Climate Change on Hydrology and Stream Temperature in the North Fork of the Stillaguamish River Basin. 12th Washington Hydrogeology Symposium. April 9-11, 2019, Tacoma, WA. Invited along with participation on a climate change panel.

Mitchell, R. J., K. M. Freeman*, and J.R. Yearsley, 2018. Modeling the effects of climate change on hydrology and stream temperature in the North Fork of the Stillaguamish River Basin. Geological Society of America Abstracts with Programs. Vol. 50. GSA Annual Meeting, Indianapolis, IN.

Freeman*, K., R. Mitchell, R., J. Yearsley, Effects of Forecasted Climate Change on Hydrology and Stream Temperature in the North Fork of the Stillaguamish River Basin. October 10, 2018, Northwest Climate Conference, Boise ID.

Freeman*, K., R. Mitchell, R., J. Yearsley. Effects of Forecasted Climate Change on Hydrology and Stream Temperature in the North Fork of the Stillaguamish River Basin. November 3, 2018, Graduate Climate Conference, Pack Forest WA.

Truitt*, S., R. Mitchell, J. Yearsley, and O. Grah, 2018. The effects of climate on Stream Temperature in the Nooksack River Basin. 30th Anniversary Salish Sea Ecosystem Conferences, April 4-6, Seattle, WA.

Freeman*, K. M., R. J. Mitchell, and J.R. Yeasley, 2017. Calibration of a Hydrologic and stream temperature model to the North Fork of the Stillaguamish River for Climate Change Modeling. Geological Society of America Abstracts with Programs. Vol. 49, No. 6 doi: 10.1130/abs/2017AM-306102

Knapp*, K., R. J. Mitchell, and O. Grah, 2017. The potential effects of forecasted climate change on mass wasting susceptibility in the Nooksack River Basin. Geological Society of America Abstracts with Programs. Vol. 49, No. 6 doi: 10.1130/abs/2017AM-307248

Mitchell, R., 2017, Modeling the Effects of Forecasted Climate Change on Hydrology in the Nooksack River Basin, Baker-to-Bay Symposium (invited), September 20-21, Ferndale Events Center, Ferndale, WA.

Truitt*, S., R. Mitchell, J. Yearsley, and O. Grah, 2017. Calibration of a Hydrologic and Stream Temperature Model to the Nooksack River Basin for Climate Change Modeling. 11th Washington Hydrogeology Symposium. May 14-16, 2017 Tacoma, WA.

Knapp*, K., R. Mitchell, and O. Grah, 2017. Examining the Potential Effects of Forecasted Climate Change on Sedimentation in the Nooksack River Basin. 11th Washington Hydrogeology Symposium. May 14-16, 2017 Tacoma, WA.

Mitchell, R., R. Murphy*, C. Bandaragoda, and O. Grah, 2016. Impacts of Forecasted Climate Change on Snowpack in the Nooksack River Basin, presented at the 2016 Mountain Climate (MtnClim) Conference, Leavenworth, WA, October 17-21, 2016.

Grah, O., R. Mitchell, C. Bandaragoda, R. Murphy*, G. Beaulieu, M. Pelto, C. Frans, 2016. Impacts of Climate Change on Water Supply as a Result of Glacier Ablation and Altered Hydrologic Regime of the Nooksack River, presented at the Water Law in Washington Conference- Law Seminars International, Seattle, WA, July 19, 2016.

Mitchell, R., R. Murphy* C. Bandaragoda, C., and O. Grah, 2016. Modeling the effects of Forecasted Climate Change on Streamflow in the Nooksack River Basin, presented at the 2016 Salish Sea Ecosystem Conference, Vancouver, British Columbia, April 13-15, 2016.

Murphy*, R., R. Mitchell, C. Bandaragoda, C., and O. Grah, 2015. Impacts of Forecasted Climate Change on Snowpack, Glacier Recession, and Streamflow in the Nooksack River Basin, presented at the 2015 Fall Meeting, AGU, San Francisco, CA, Dec, 14-18, 2015.

Grah, O., G. Beaulieu, R. Mitchell, C. Bandgaragoda, and R. Murphy*, 2015. Instrumenting a Glacier Served Watershed in the Nooksack River, 6th Annual Northwest Climate Change Conference, Codeur D'Alene, ID, November 3-5, 2015.