

Curriculum Vitae

Xuehang Song

October 28, 2021

General Information

Address: Environmental Subsurface Science Group
Energy and Environment Directorate
Pacific Northwest National Laboratory
Battelle Memorial Institute
Richland, Washington 99352
Phone: 509-372-4214

E-mail address: Xuehang.Song@pnnl.gov

Website: <https://www.xuehangsong.com/>

Professional Preparation

2014 Ph.D. in Hydrology & Water Resources Engineering, Wuhan University.
Supervisor: Jinzhong Yang, Liangsheng Shi.

Song, Xuehang. (2014). *Data Assimilation Application to the Saturated-unsaturated Flow*. Doctoral dissertation, Wuhan University.

2009 B.E. in Hydrology & Water Resources Engineering, Wuhan University.

Nondegree Education and Training

2015–2018 Post-doc, Atmospheric Sciences & Global Change, Earth and Biological Sciences Directorate, Pacific Northwest National Laboratory.

2014–2015 Post-doc, Department of Scientific Computing, Florida State University.

Professional Experience

2021–present Senior Earth Scientist, Environmental Subsurface Science Group, Energy and Environment Directorate, Pacific Northwest National Laboratory. Responsible

2018–2020 research in the field of computational subsurface hydrology, reactive transport modeling, Bayesian data assimilation and geostatistics
Earth Scientist, Hydrology Technical Group, Energy and Environment Directorate, Pacific Northwest National Laboratory. Responsible research in the field of computational subsurface hydrology, reactive transport modeling, Bayesian data assimilation and geostatistics.

Current Membership in Professional Organizations

American Geophysical Union
Geochemical Society

Publications

Refereed Journal Articles

2021~present

Moghaddam M., Ferre T.P., Chen X., Chen K., **Song X.**, and Hammond G.. " Can Simple Machine Learning Tools Extend and Improve Temperature-Based Methods to Infer Streambed Flux." *Water*, 2021, 13(20), 283. <https://doi.org/10.3390/w13202837>

Hou Z., H. Ren, C.J. Murray, **X. Song**, Y. Fang, E.V. Arntzen, and X. Chen, et al. 2021. "A Novel Construct for Scaling Groundwater-River Interactions Based on Machine-Guided Hydromorphic Classification." *Environmental Research Letters*. In Press.
<https://doi.org/10.1088/1748-9326/ac24ce>

Song X., Y. Fang, J. Bao, W.A. Perkins, H. Ren, H. Zhou, and Z. Hou, et al. 2021. "Spatial variability of hydrological exchange flows and residence time in a large regulated river." *Journal of Hydrology* 598. <https://doi.org/10.1016/j.jhydrol.2021.126283>

Wu R., X. Chen, G.E. Hammond, G. Bisht, **X. Song**, M. Huang, and G. Niu, et al. 2021. "Coupling Surface Flow with High-performance Subsurface Reactive Flow and Transport Code PFLOTRAN." *Environmental Modelling & Software* 137.
<https://doi.org/10.1016/j.envsoft.2021.104959>

Ren H., **X. Song**, Y. Fang, Z. Hou, and T.D. Scheibe. 2021. "Machine Learning Analysis of Hydrologic Exchange Flows and Transit Time Distributions in a Large Regulated River." *Frontiers in Artificial Intelligence*. <https://doi.org/10.3389/frai.2021.648071>

2020

Fang Y., **X. Song**, H. Ren, W.A. Perkins, P. Shuai, M.C. Richmond, and Z. Hou, et al. 2020. "High-performance simulation of dynamic hydrologic exchange and implications for

surrogate flow and reactive transport modeling in a large river corridor." *Frontiers in Water* 2. <https://doi.org/10.3389/frwa.2020.564211>

Ren H., Z. Hou, Z. Duan, **X. Song**, W.A. Perkins, M.C. Richmond, and E.V. Arntzen, et al. 2020. "Spatial Mapping of Riverbed Grain-size Distribution Using Machine Learning." *Frontiers in Water* 2. <https://doi.org/10.3389/frwa.2020.551627>

Rizzoa, C. B., **Song, X.**, de Barrosa, F. P., and Chen, X.. (2020). Temporal Flow Variations Interact With Spatial Physical Heterogeneity to Impact Solute Transport in Managed River Corridors. *Journal of Contaminant Hydrology*. <https://doi.org/10.1016/j.jconhyd.2020.103713>

Song X., Chen, X., Zachara, J.M., Gomez-Velez, J., Shuai, P., Ren, H., and Hammond, G.. (2020). "River Dynamics Control Transit Time Distributions and Biogeochemical Reactions in a Dam-Regulated River Corridor." *Water Resources Research*, e2019WR026470. <https://doi.org/10.1029/2019WR026470>.

Tso C., Johnson, T.C., **Song, X.**, Chen, X., Kuras, O., Wilkinson, P., Uhlemann, S., et al. (2020). "Integrated hydrogeophysical modelling and data assimilation for geoelectrical leak detection." *Journal of Contaminant Hydrology*. <https://doi.org/10.1016/j.jconhyd.2020.103679>.

Zachara, J., Chen, X., **Song, X.**, Shuai, P., Murray, C., and Resch, C., (2020). Kilometer-Scale Hydrologic Exchange Flows in a Gravel Bed River Corridor and Their Implications to Solute Migration. *Water Resources Research*, e2019WR025258. <https://doi.org/10.1029/2019WR025258>

Rockhold, M., Robinson, J., Parajuli, K., **Song, X.**, Zhang, F., and Johnson, T. (2020). Characterization and Monitoring of a Complex Industrial Waste Site Using Electrical Resistivity Imaging. *Hydrogeology Journal*. <https://doi.org/10.1007/s10040-020-02167-1>

Before 2020

Song, X., Chen, X., Ye, M., Dai, Z., Hammond, G., and Zachara, J. M. (2019). Delineating Facies Spatial Distribution by Integrating Ensemble Data Assimilation and Indicator Geostatistics With Level-Set Transformation. *Water Resources Research*, (509), 2018WR023262. <https://doi.org/10.1029/2018WR023262>

Shuai, P., Chen, X., **Song, X.**, Hammond, G. E., Zachara, J., Royer, P., et al. (2019). Dam Operations and Subsurface Hydrogeology Control Dynamics of Hydrologic Exchange Flows in a Regulated River Reach. *Water Resources Research*, 2018WR024193. <https://doi.org/10.1029/2018WR024193>

Dai, H., Chen, X., Ye, M., **Song, X.**, Hammond, G., Hu, B., and Zachara, J. M. (2019). Using Bayesian Networks for Sensitivity Analysis of Complex Biogeochemical Models. *Water Resources Research*, 2018WR023589. <https://doi.org/10.1029/2018WR023589>

- Dai, H., Ye, M., Hu, B. X., Niedoroda, A. W., Zhang, X., Chen, X., et al. (2019). Hierarchical sensitivity analysis for simulating barrier island geomorphologic responses to future storms and sea-level rise. *Theoretical and Applied Climatology*, 136(3–4), 1495–1511. <https://doi.org/10.1007/s00704-018-2700-5>
- Song, X.**, Chen, X., Stegen, J., Hammond, G., Song, H., Dai, H., et al. (2018). Drought Conditions Maximize the Impact of High-Frequency Flow Variations on Thermal Regimes and Biogeochemical Function in the Hyporheic Zone. *Water Resources Research*, 54(10), 7361–7382. <https://doi.org/10.1029/2018WR022586>
- Zhou, T., Bao, J., Huang, M., Hou, Z., Arntzen, E., **Song, X.**, et al. (2018). Riverbed Hydrologic Exchange Dynamics in a Large Regulated River Reach. *Water Resources Research*, 54(4), 2715–2730. <https://doi.org/10.1002/2017WR020508>
- Dai, H., Chen, X., Ye, M., **Song, X.**, and Zachara, J. M. (2017). A geostatistics-informed hierarchical sensitivity analysis method for complex groundwater flow and transport modeling. *Water Resources Research*, 53(5), 4327–4343. <https://doi.org/10.1002/2016WR019756>
- Song, H.-S., Thomas, D. G., Stegen, J. C., Li, M., Liu, C., **Song, X.**, et al. (2017). Regulation-Structured Dynamic Metabolic Model Provides a Potential Mechanism for Delayed Enzyme Response in Denitrification Process. *Frontiers in Microbiology*, 8, 1866. <https://doi.org/10.3389/fmicb.2017.01866>
- Zhou, T., Huang, M., Bao, J., Hou, Z., Arntzen, E., Mackley, R., et al. (2017). A New Approach to Quantify Shallow Water Hydrologic Exchanges in a Large Regulated River Reach. *Water*, 9(9), 703. <https://doi.org/10.3390/w9090703>
- Shi, L., **Song, X.**, Tong, J., Zhu, Y., and Zhang, Q. (2015). Impacts of different types of measurements on estimating unsaturated flow parameters. *Journal of Hydrology*, 524, 549–561. <https://doi.org/10.1016/j.jhydrol.2015.01.078>
- Shi, L., Zhang, Q., **Song, X.**, and Fang, X. (2015). Application of groundwater level data to data assimilation for unsaturated flow. *Advances in Water Science*, 26(3):404-412. <https://10.14042/j.cnki.32.1309.2015.03.011>
- Song, X.**, Shi, L., Ye, M., Yang, J., and Navon, I. M. (2014). Numerical Comparison of Iterative Ensemble Kalman Filters for Unsaturated Flow Inverse Modeling. *Vadose Zone Journal*, 13(2). <https://doi.org/10.2136/vzj2013.05.0083>

Tan, X. C., Yang, J. Z., **Song, X.**, and Zha, Y. (2013). Estimation of groundwater recharge in North China Plain. *Advances in Water Science*, 24(1), 73–81.
<https://doi.org/10.14042/j.cnki.32.1309.2013.01.015>

Zha, Y., Yang, J., Shi, L., and **Song, X.** (2013). Simulating One-Dimensional Unsaturated Flow in Heterogeneous Soils with Water Content-Based Richards Equation. *Vadose Zone Journal*, 12(2), 0. <https://doi.org/10.2136/vzj2012.0109>

Submitted Journal Articles in revision

Chen, K., Chen, X., **Song, X.**, Briggs, M., Jiang, P., Shuai, P., Hammond, G., Zhan H., and Zachara, J.. Using Ensemble Data Assimilation to Estimate Transient Hydrologic Exchange Flow under Highly Dynamic Flow Conditions. *minor revision* Submitted to *Water Resources Research*.

Submitted Journal Articles under review

Shuai, P., Chen, X., Hammond G., **Song, X.**, Chen, K., Zachara, J., Perkins, W., Richmond, M., and Nugent, J. The Interplay between Subsurface Hydrogeology, River Geomorphology and Flow Dynamics Controls River Corridor Thermal Regimes. Submitted to *Journal of Hydrology*

Chen Y., Bao, J., Richmond, M.C., Perkins, W.A., Ren, H., Fang, Y., **Song, X.** et al. " Modeling of streamflow in a 30-kilometer-long reach spanning 5 years using OpenFOAM 5.x." Submitted to *Geoscientific Model Development*.

Bao J., Chen, Y., Fang, Y., **Song, X.**, Perkins, W.A., Duan, Z., Ren, H. et al. " Modeling framework for evaluating the impacts of hydrodynamic pressure on hydrologic exchange fluxes and residence time for a large-scale river section over a long-term period." Submitted to *Environmental Modelling and Software*, *minor revision*

Nonrefereed Reports

Rockhold M.L., X. Song, Z. Zhang, N. Qafoku, M.A. Jensen, J.L. Downs, and J.D. Tagestad, et al. 2020. Spatiotemporal Analyses of Groundwater and Shoreline Cr(VI) Concentrations in the 100 Areas at Hanford. PNNL-30483. Richland, WA: Pacific Northwest National Laboratory.

Asmussen R.M., Fang, Y., Tartakovsky, G.D., Song, X., Westsik, J.H., and Smith., G.L. 2019. Performance Metric for Cementitious Waste Form Inventory Release in the Integrated Disposal Facility. PNNL-28992. Richland, WA: Pacific Northwest National Laboratory.

Scheibe T.D., N.J. Hess, C. Henry, R. Chakraborty, R. Chakraborty, H. Song, and P. Weisenhorn, et al. 2019. Modeling Microbial Dynamics and Processes from Cells to Ecosystems. PNNL-28458

Rockhold M.L., Song, X., Tagestad, J.D., Thorne, P.D., Tartakovsky, G.D., and Chen., X. 2018. Sensitivity Analysis of Contaminant Transport from Vadose Zone Sources to Groundwater. PNNL-28065. Richland, WA: Pacific Northwest National Laboratory.

Yonkofski C., Appriou, D., Song, X., Downs, J.L., Johnson, C.D., and Milbrath, V.C. 2018. Water Application for Dust Control in the Central Plateau: Impacts, Alternatives, and Work Strategies. PNNL-28061. Richland, WA: Pacific Northwest National Laboratory.

Selected Presentations

Nonrefereed Presentations at Conferences

Hou Z., H. Ren, X. Song, Y. Fang, E.V. Arntzen, W.A. Perkins, and T.D. Scheibe. 12/08/2020. "Machine Learning of Hydrobiogeochemical Processes along the Columbia River Corridor." *AGU Online Conference*, United States.

Song X., H. Ren, K. Chen, T.C. Johnson, X. Chen, and T.D. Scheibe. 12/11/2020. "Spatiotemporal variations of hyporheic temperature and its biogeochemical implications in a dam regulated river." *AGU Online Conference*, California.

Ren H., X. Song, Z. Hou, E.V. Arntzen, and T.D. Scheibe. 12/09/2020. "Evaluate Salmon Redd Site Selection Using a Physical Informed Hierarchical Machine Learning Framework." *AGU Online Conference*, United States.

Shuai P., X. Chen, G.E. Hammond, and X. Song. 12/16/2020. "Influence of Hydrologic Exchange Flows on Biogeochemical Dynamics in A Regulated River Reach: 3-D Reactive Transport Modeling in PFLOTRAN." *AGU Online Conference*, California.

Brouns T.M., V.L. Freedman, and X. Song. 03/11/2020. "Analysis of Supplemental Treatment Approaches for Low-Activity Waste at the Hanford Nuclear Reservation." Presented by T.M. Brouns at *WM Symposia 2020*, Phoenix, Arizona.

Asmussen R.M., Fang, Y., Song, X., Tartakovsky, G.D., Westsik, J.H., Smith, G.L., Brown E.E., et al.. Defining a Metric to Assess Leachability of Contaminants from Cementitious Waste Forms in Lab. Conference Proceedings of *WM Symposium 2020*

Chen X., E. Cromwell, T.J. Johnson, H. Wang, G.E. Hammond, and X. Song. 02/13/2020. "Use of Deep Neural Networks for Estimating Subsurface Property Field from Time-Lapse Geophysical Imaging." Presented by X. Chen at *SIAM Parallel Processing for Scientific Computing*, Seattle, Washington.

Rockhold M.L., X. **Song**, X. Chen, and V.L. Freedman. 2019. "Complex Sources and Impacts on Remediation and Monitoring Approaches." In *WM SYMPOSIA 2019*.

- Shuai P., Chen, X., Song, X., Chen, K., and Hammond, G. (2019). Dam Induced Hydrologic Exchange Flows Alter River Corridor Thermal Regime. In *AGU San Francisco, California, United States*.
- Chen Y., Bao, J., Richmond, M.C., Perkins, W.A., Duan, Z., Ren, H., and Fang, Y. et al (2019). Modeling the effects of discharge nonstationarity and bathymetric heterogeneity on streambed resistance and dynamic pressure distribution in streams using OpenFOAM. In *AGU San Francisco, California, United States*.
- Bao J., Chen, Y., Fang, Y., Song, X., Perkins, W.A., Duan, Z., and Ren, H. et al. (2019). Three-dimensional OpenFOAM-PFLOTRAN coupled model for large-scale river hydrologic exchange flows over long-term period. In *AGU San Francisco, California, United States*.
- Song X., Fang, Y., Bao, J., Perkins, W.A., Ren, H., Zhou, H., and Hou, Z. et al. (2019). Spatial variability of hydrological exchange flows and resident time distributions in a large regulated river. In *AGU San Francisco, California, United States*.
- Shuai P., Chen, X., Song, X., and Chen, K., (2019). Boosting Research Reproducibility: Managing High Performance Model Simulation Workflow Using Jupyter Notebook. In *AGU San Francisco, California, United States*
- Ren H., Hou, Z., Song, X., Fang, Y., Perkins, W.A., Duan, Z., and Chen, Y. et al. (2019). Machine Learning Applied to Flux/Residence Times of Hydrological Exchange Flows in the Columbia River. In *AGU San Francisco, California, United States*.
- Chen K., Chen, X., Song, X., Briggs, M., Jiang, P., Shuai, P., and Hammond, G.E. (2019). Using Ensemble Data Assimilation to Estimate Transient Hydrologic Exchange Fluxes under Highly Dynamic Flow Conditions. In *AGU San Francisco, California, United States*.
- Song, X, Chen, X., Zachara, J. M., Gomez-Velez, J. D., Shuai, P., Ren, H., & Hammond, G. E. (2019). Dynamic River Stage Variations Lead to Multimodal Residence Time Distributions of Hydrological Exchange Flow. In *12th Washington Hydrogeology Symposium*,. Tacoma, WA, United States.
- Song, X, Chen, X., Zachara, J. M., Gomez-Velez, J. D., Shuai, P., Ren, H., & Hammond, G. E. (2018). Dynamic River Stage Variations Lead to Multimodal Residence Time Distributions of Hydrologic Exchange Flows. In *AGU Annual Meeting*. Washington DC, United States.
- Chen, X., Shuai, P., Song, X., Dai, H., Hammond, G. E., Johnson, T. C., & Zachara, J. M. (2018). Using Sensitivity Analysis and Data Assimilation to Improve Process Understanding of Hydrologic Exchange Flows in Dynamic River Corridors from km-to Reach Scales. In *AGU Annual Meeting*. Washington DC, United States.
- Johnson, T. C., Zhu, Y., Strickland, C. E., Thomle, J. N., Stegen, J., Song, X., & Chen, X. (2018). Joint hydrogeophysical inversion: application to dynamic mass flux monitoring at

- the groundwater/surface water interface. In *AGU Annual Meeting*. Washington DC, United States.
- Scheibe, T. D., Stegen, J., Chen, X., Huang, M., Bao, J., Fang, Y., et al. (2018). Merging Process Understanding with Numerical Models across Scales to Predict River Corridor and Watershed Function. In *AGU Annual Meeting*. Washington DC, United States.
- Shuai, P., Chen, X., Song, X., Hammond, G. E., Zachara, J. M., Royer, P., & Ren, H. (2018). Hydrogeomorphic Controls on Hydrologic Exchange Flows Dynamics within a Large Regulated River Corridor. In *AGU Annual Meeting*. Washington DC, United States.
- Chen, X., Song, X., Shuai, P., Hammond, G. E., Ren, H., & Zachara, J. M. (2017). Quantifying Km-scale Hydrological Exchange Flows under Dynamic Flows and Their Influences on River Corridor Biogeochemistry. In *AGU Annual Meeting*. New Orleans, LA, United States.
- Song, Xuehang, Chen, X., Shuai, P., Gomez-Velez, J. D., Ren, H., & Hammond, G. E. (2017). Hyporheic Zone Residence Time Distributions in Regulated River Corridors. In *AGU Annual Meeting*. New Orleans, LA, United States.
- Tso, C. H. M., Johnson, T. C., Song, X., Chen, X., & Binley, A. M. (2017). Using coupled hydrogeophysical models and data assimilation to enhance the information content in geoelectrical leak detection. In *AGU Annual Meeting*. New Orleans, LA, United States.
- Chen, X., Ren, H., Dai, H., Song, X., Goldman, A. E., Mackley, R., & Zachara, J. M. (2016). Understanding the Spatial and Temporal Variability of Groundwater and Surface Water Interaction Using a Multi-year Multi-sensor Dataset. In *AGU Annual Meeting*. San Francisco, CA, United States.
- Song X., Chen, X., Stegen, J., Hammond, G., and Song, H. (2017). Long-term Impact of Dam Operation On Thermal and Biogeochemical Dynamics in the Hyporheic Zone. In *11th Washington Hydrogeology Symposium*, Tacoma, WA, United States.
- Dai, H., Chen, X., Ye, M., Song, X., & Zachara, J. M. (2016). A Bayesian Network Based Global Sensitivity Analysis Method for Identifying Dominant Processes in a Multi-physics Model. In *AGU Annual Meeting*. San Francisco, CA, United States.
- Scheibe, T. D., Yang, X., Song, X., Chen, X., Hammond, G. E., Song, H. S., et al. (2016). A Multiscale Simulation Framework to Investigate Hydrobiogeochemical Processes in the Groundwater-Surface Water Interaction Zone. In *AGU Annual Meeting*. San Francisco, CA, United States.
- Song, H. S., Li, M., Qian, W., Song, X., Chen, X., Scheibe, T. D., et al. (2016). Functional enzyme-based modeling approach for dynamic simulation of denitrification process in hyporheic zone sediments: Genetically structured microbial community model. In *AGU Annual Meeting*. San Francisco, CA, United States.

Song, X., Chen, X., Dai, H., Hammond, G. E., Song, H. S., & Stegen, J. (2016). Quantifying Hydro-biogeochemical Model Sensitivity in Assessment of Climate Change Effect on Hyporheic Zone Processes. In *AGU Annual Meeting*. San Francisco, CA, United States.

Zachara, J. M., Chen, X., Murray, C. J., Shuai, P., Rizzo, C., Song, X., & Dai, H. (2016). Solute Transport Dynamics in a Large Hyporheic Corridor System. In *AGU Annual Meeting*. San Francisco, CA, United States.

Zhou, T., Bao, J., Huang, M., Hou, Z., Arntzen, E., Mackley, R., et al. (2016). Quantifying hyporheic exchange dynamics in a highly regulated large river reach. In *AGU Annual Meeting*. San Francisco, CA, United States.

Song X., X. Chen, M. Ye, Z. Dai, and G. H. (2015). Delineating Facies Spatial Distribution by Integrating Ensemble Data Assimilation and Indicator Geostatistics. In *AGU Annual Meeting*. San Francisco, CA, United States.

Invited Workshops

Song X., and Hammond, G.. (2018, December). PFLOTRAN Reaction Sandbox. Workshop delivered at AGU Fall Meeting 2018, Washington D.C.

The Profession

Editor Board

Editorial Board Member as Topic Editor for the Journal Water, Multidisciplinary Digital Publishing Institute, MDPI Open Access Journals, Subject of groundwater and reactive transport modeling

Guest Reviewer for Refereed Journals

Inverse Problems in Science & Engineering (2016-present).

Soil Science Society of America Journal (2016–present).

Advances in Water Resources (2017–present).

Water Resources Research (2017–present).

Journal of Hydrology (2018–present).

Journal of Hydrologic Engineering (2019–present)

Resources (2019–present)

Water (2019–present)