Paul Muñoz

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EDUCATION

December 2019 – June 2023

Ph.D. in Water Resources.
University of Cuenca, Cuenca, Ecuador.
Thesis: Towards the improvement of machine learning peak runoff forecasting by exploiting ground- and satellite-based precipitation data: A feature engineering approach.

September 2016 – September 2018

MSc. in Water Resources Engineering.
KU Leuven, Leuven, Belgium.
Thesis: Flash-flood forecasting in an Andean mountain catchment—development of a step-wise methodology based on the random forest algorithm.

September 2009 – November 2015

Bachelor's in civil engineering.
University of Cuenca. Cuenca, Ecuador.
Thesis: Effect of the resolution of tipping-bucket rain gauge and calculation method on rainfall intensities in an Andean mountain gradient.

HONORS, GRANTS, AND AWARDS

- Award for outstanding researchers at the Universidad de Cuenca, 2021. Vicerectorate of Research, Universidad de Cuenca. 2022.
- Travel grant to attend the HydroML Symposium on big data machine learning in hydrology and water resources. The Pennsylvania State University. May 2022.
- DAAD scholarship to complement doctoral studies at the Philipps-University at Marburg, Germany. Research Grants-Binationally Supervised Doctoral Degrees/Cotutelle, 2020/21, www.daad.de. 2020.
- Selected member of the young scientist program. International Research on Disaster Risk (IRDR), China, 2018. www.irdrinternational.org.
- VLIR-OUS scholarship to study in Belgium. Interuniversity Programme in Water Resources Engineering. 2016.
- Selected participant on the third award contest of undergraduate researchers of Ecuador, 2015. Secretaria de Educación Superior, Ciencia, Tecnología e Innovación (SENESCYT), Ecuador.

TEACHING EXPERIENCE

April 2022 – present

Master program in Hydrology mention Ecohydrology, Universidad de Cuenca, Ecuador.

Graduate courses: Advanced Hydrometry; Statistical methods; Data-driven environmental modelling; Hydrology; Hydrological modeling.

March 2023 - present

Master in Highway and transportation engineering, Universidad de Cuenca, Ecuador.
Graduate course: Fundamentals of Research Methodology.

October 2022 - present

Universidad de Cuenca, Ecuador. Undergraduate course: Introduction to Data Analytics.

October 2023

Hydrological Forecasting Techniques focused on ENSO events. Institute of Meteorology and Hydrology of Ecuador. 30 hours.

July 2019 – August 2019

International course on "Hydrology of Andean ecosystems: Introduction to ecohydrology and environmental tracers". https://www.ucuenca.edu.ec/idrhica/index.php/es/educacion/formacion-continua/.

RESEARCH AND CONSULTANCY EXPERIENCE

May 2024 – present

Postdoctoral researcher at the Department of Water and Climate. Vrije Universiteit Brussel, Belgium. Artificial Intelligence applications in Water and Climate.

July 2023 – present

Postdoctoral researcher at the Department of Water Resources and Environmental Sciences at Universidad de Cuenca, Ecuador. Project: Data fusion of near-real-time satellite products for improving runoff forecasting.

August 2023 - present

Specialist in impact assessments on water scarcity and agricultural droughts. Food and Agriculture Organization of the United Nations (FAO). External consultant. Project: FAO TCP RLA 3909 "Reducing the impact of droughts and water scarcity on livelihoods and food security without leaving anyone behind". https://www.fao.org/

January 2020 - January 2022

Consultancy for the Minas-San Francisco hydropower plant operated by the Corporación Eléctrica del Ecuador CELEC-EP. Project: Development of a real-time runoff forecasting system for the Minas-San Francisco hydropower dam.

October 2018 – July 2023

- Development of runoff and flash flood forecasting models for Andean basins
- Development of hydrological forecasting models using weather radar data in Andean basins.
- Comparison of methods for actual evapotranspiration estimation in a paramo ecosystem microcatchment.
- High-resolution radar analysis of precipitation extremes in Ecuador and north Peru and implications of the ENSO-dynamics.
- A research network for the resilience of headwater systems and water availability for downstream communities across the Americas.

July 2013 - August 2016

Junior Researcher at the Department of Water Resources and Environmental Sciences at Universidad de Cuenca, Ecuador. Duties included the installation, operation and maintenance of hydrometeorological stations. Analysis of hydrometeorological databases.

SKILLS

Programming languages: Python, R, MATLAB.

SUPPORTING STUDENTS AND MENTORING

November 2019

Mentor obtaining funding from the German Academic Exchange Service. Trip to Germany (15 days) to seek for doctoral opportunities for an entire master class (15 people).

November 2023 – present

Co-supervision PhD. Doctoral program in Natural Resources. An interpretable data-driven approach for unraveling hydrological forecasting drivers to aid reservoir management, Universidad de Cuenca, Ecuador.

October 2018 – present

Supervision of master thesis. Master program in Hydrology, mention ecohydrology, Universidad de Cuenca, Ecuador.

- Integrating geographic data and the SCS-CN method with LSTM networks for enhanced runoff forecasting in a complex mountain basin. *Published* (Scopus).
- Towards specialized forecasting of flood events. Application of a feature engineering approach using X-Band radar data. Submitted. *Published* (Scopus).
- Improving short-term runoff forecasting in a complex basin with satellite precipitation forecasting. *In review* (Scopus).
- Assessing the effectiveness of a Satellite Precipitation Data Fusion technique for improving short-term runoff forecasting. *In review* (Scopus).

September 2022 – March 2023

Mentoring in the Club of Statistical methods for Hydrometeorology. Universidad Agraria La Molina, Perú.

RESEARCH PROPOSAL EXPERIENCE

October 2020

1. Agency: Universidad de Cuenca and external funding from a public hydropower plant.
   Title: Data Fusion of Remote Sensing products and Machine Learning Feature Engineering Strategies for Near-Real-Time Runoff Forecasting.
   Amount: $427,000
   Status: Approved.
   Role: Leading PI.

April 2020

1. *Agency:* German Academic Exchange Service (Deutscher Akademischer Austauschdienst, DAAD).
   Title: Research Grants - Bi-nationally Supervised Doctoral Degrees/Cotutelle, 2020/21.
   Amount: $10,000
   Status: Approved.

August 2019

2. Agency: German Academic Exchange Service (Deutscher Akademischer Austauschdienst, DAAD).
   Title: Study trips for groups of foreign students in Germany, from 2019.
   Amount: $19,000
   Status: Approved.
   Role: Leading PI.

PEER-REVIEWED PUBLICATIONS

13. **Muñoz, P.**, Muñoz, D. F., Orellana-Alvear, J., & Célleri, R. (2024). Enhancing runoff forecasting through the integration of satellite precipitation data and hydrological knowledge into machine learning models. *Natural Hazards*, 1-23.

12. Álvarez-Estrella, J., **Muñoz, P.**, Bendix, J., Contreras, P., & Célleri, R. (2024). Enhancing Peak Runoff Forecasting through Feature Engineering Applied to X-Band Radar Data. *Water*, *16*(7), 968.

11. **Muñoz, P.**, Corzo, G., Solomatine, D., Feyen, J., Celleri, R. (2023). Near-real-time satellite precipitation data ingestion into peak runoff forecasting models. Environmental Modelling & Software, 160, 105582.

10. **Muñoz, P.**, Corzo, G., Solomatine, D., Feyen, J., Celleri, R. (2023). Use of Near-Real-Time Satellite Precipitation Data and Machine Learning to Improve Extreme Runoff Modeling. AGU books: Hydroinformatics. Accepted.

9. Merizalde M.J., P., **Muñoz P.**, Muñoz D.F., Corzo, G., Samaniego, E., Célleri, R. (2023). Integrating geographic data and the SCS-CN method with LSTM networks for enhanced runoff forecasting in a complex mountain basin. Frontiers in Water.

8. **Muñoz, P**., Orellana-Alvear, J., Bendix, J., Feyen, J., Celleri, R. (2021). Flood Early Warning Systems Using Machine Learning Techniques: The Case of the Tomebamba Catchment in the Southern Andes of Ecuador. Hydrology, 8(4), 183.

7. **Muñoz, P.**, Orellana-Alvear, J., Celleri, R. (2021). Application of a Machine Learning Technique for Developing Short-Term Flood and Drought Forecasting Models in Tropical Mountainous Catchments. In Integrated Research on Disaster Risks (pp. 11-35). Springer, Cham.

6. Muñoz, D. F., **Muñoz, P**., Alipour, A., Moftakhari, H., Moradkhani, H., Mortazavi, B. (2021). Fusing multi-source data to estimate the effects of urbanization, sea level rise, and hurricane impacts on long-term wetland change dynamics. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing.

5. Contreras P, Orellana-Alvear J, **Muñoz P.**, Bendix J, Celleri R. Influence of Random Forest Hyperparameterization on Short-Term Runoff Forecasting in an Andean Mountain Catchment. Atmosphere. 2021; 12(2):238.

4. Muñoz, D. F., **Muñoz, P.**, Moftakhari, H., Moradkhani, H. (2021). From local to regional compound flood mapping with deep learning and data fusion techniques. Science of the Total Environment, 782, 146927.

3. Orellana-Alvear, J., Celleri, R., Rollenbeck, R., **Muñoz, P.**, Contreras, P., Bendix, J. (2020). Assessment of Native Radar Reflectivity and Radar Rainfall Estimates for Discharge Forecasting in Mountain Catchments with a Random Forest Model. Remote Sensing, 12(12), 1986.

2. **Muñoz, P.**; Orellana-Alvear, J.; Willems, P.; Celleri, R. Flash-Flood Forecasting in an Andean Mountain Catchment—Development of a Step-Wise Methodology Based on the Random Forest Algorithm. Water 2018, 10, 1519.

1. **Muñoz, P.**; Celleri, R.; Feyen, J. Effect of the Resolution of Tipping-Bucket Rain Gauge and Calculation Method on Rainfall Intensities in an Andean Mountain Gradient. Water 2016, 8, 534.

CONFERENCES

- Oral presentation: **Water Security and Climate Change conference**. Germany, October 2024. Leveraging data-driven techniques for hydrological understanding and water management.
- Oral presentation: **Communications and dissemination of climate impacts**. PROCLIAS. Austria, September 2024. Facing hydrological extremes in South America: The energy crisis.
- Oral presentation: **HydroML Symposium on big data machine learning in hydrology and water resources**. The Pennsylvania State University. May 2022. Use of near-real-time satellite precipitation data and machine learning to improve extreme runoff modeling.
- Oral presentation: **EGU general assembly**, Austria. 2021. Long short-term memory networks for real-time runoff forecasting using remotely sensed data.
- Oral presentation: **Water Security and Climate Change conference**, Vietnam. 2021. Remote Sensing and Machine Learning for Real-Time Runoff Forecasting in Large Complex Mountainous Basins – Application to Hydropower Optimization.
- Oral presentation: **EGU general assembly**, Austria. 2020. Comparison of Machine Learning Techniques Powering Flood Early Warning Systems. Application to a catchment located in the Tropical Andes of Ecuador.
- Poster presentation: **EGU general assembly**, Austria. 2019. Short-term extreme flow forecasting in a tropical Andean mountain catchment.

LANGUAGES

- English, advanced. TOEFL test score: 112, date: August 2019.
- Spanish, native.

TRAINING

- Deep Learning Explained, On-line Microsoft course. 2020.
- Seasonal Water Resources Management, Regionalized Global Data and Transfer to Practice, Universidad Técnica Particular de Loja, Ecuador. 2019.
- Scientific writing (120 hours). Research direction, Universidad de Cuenca, Ecuador. 2018
- Forecasting of hydrometeorological variables: Use of decision tree-based models with R, November 2018, Universidad de Cuenca, Ecuador.
- International meeting on Environmental Law, March 2015, Spanish cooperation in Ecuador, Cuenca, Ecuador.
- International Workshop "Data quality control and preprocessing of precipitation and runoff data", March 2014, Universidad de Cuenca, Ecuador.