Kumar Puran Tripathy, Ph.D.

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Texas, USA (Willing to relocate)
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Summary

Hydrologist and computational scientist with 5+ years of experience in distributed hydrological modeling, land-atmosphere coupling analysis, and physics-guided machine learning for hydroclimatic extremes. Expert in soil moisture dynamics, water balance modeling, and integrating physical process understanding with advanced computational methods. Strong mathematical foundation and numerical modeling expertise across diverse hydrological systems—from land surface models (Noah LSM, VIC, CLM) to earth system models (CESM2, CMIP6) to custom physics-guided deep learning frameworks. Proven ability to implement, calibrate, and validate complex models while processing large-scale datasets on HPC systems.

Education

- **Doctor of Philosophy, Civil Engineering** Dec 2025
  Texas A&M University *College Station, TX*
  Thesis: *Quantifying Droughts & Heatwaves using Statistics and Deep Learning.*

- **Master of Technology, Civil Engineering** Jul 2020
  Indian Institute of Science (IISc) *Bangalore, India*
  Thesis: *Quantifying model and parameter uncertainties in IDF relationships for urban flooding under climate change*

- **Bachelor of Technology, Civil Engineering** Jun 2017
  Indira Gandhi Institute of Technology (IGIT), Sarang *Odisha, India*
  Project: *1D HEC-RAS Flood Mapping on the Brahmani River*

Skills Summary

- **Programming Languages:** Python (primary), R, MATLAB, Fortran, C++, Bash/Shell scripting; SQL (PostgreSQL/PostGIS)
- **Hydrological & Land Surface Models:** Noah LSM, Noah-MP, VIC, SWAT, CLM (Community Land Model), expertise in distributed hydrologic modeling, soil moisture dynamics, and evapotranspiration processes
- **Numerical Weather & Climate Models:** WRF, GFS, CESM2, CMIP6 GCMs; experience with model input preparation, calibration, validation, and ensemble analysis
- **Reanalysis & Climate Data:** ERA5, MERRA-2, ERA-Interim, NLDAS-2, GLEAM, NCA-LDAS; multi-decadal data processing and bias correction
- **Scientific Computing & Data Processing:** NumPy, Pandas, SciPy, Dask, xarray, netCDF4, h5py, Climate Data Operators (CDO), NCO; parallel processing and large-scale data pipelines
- **Machine Learning & Physics-Guided AI:** TensorFlow, PyTorch, Keras, JAX, scikit-learn; physics-informed neural networks, explainable AI (SHAP, LIME); hyperparameter optimization (Optuna, Keras-Tuner)
- **Remote Sensing & Geospatial Analysis:** Google Earth Engine (GEE), GDAL, rasterio, GeoPandas, Arcpy; QGIS, ArcGIS Pro; satellite products (MODIS, Landsat, Sentinel-2, SMAP)
- **Data Visualization & Communication:** Matplotlib, Seaborn, Plotly, Cartopy, GMT, ggplot2 (R); technical documentation and stakeholder presentations
- **High-Performance Computing & Infrastructure:** SLURM, MPI, Docker, Linux/Unix systems, AWS (EC2/S3), Git/GitHub; distributed computing and job scheduling

Publications

- **Tripathy, K. P.**, Mukherjee, S., Mishra, A. K., Mann, M. E., & Williams, A. P. (2023). Climate change will accelerate the high-end risk of compound drought and heatwave events. *Proceedings of the National Academy of Sciences*, 120(28), e2219825120.
- **Tripathy, K. P.** & Mishra, A. K. (2023). How unusual is the 2022 European compound drought and heatwave event? *Geophysical Research Letters*, 50(15), e2023GL105453.
- **Tripathy, K. P.** and Mishra, A. K., (2025). Spatiotemporal dynamics of surface and rootzone soil moisture droughts. *Journal of Hydrology*, p. 134455.
- **Tripathy, K. P.**, Mishra, A. K., Kumar, S. V., & Miralles, D. G. (2025). Lagged soil moisture controls on the persistence of drought and heatwaves in the United States. *Geophysical Research Letters*, 52, e2025GL115811.
- Sabut, A., **Tripathy, K. P.**, Mishra, A., Anderson, M., Cosh, M., Gao, F., & Cirone, R. (2025). Assessing the impact of climate indices on corn yield in the continental USA using a machine-learning approach. *Agricultural and Forest Meteorology*, 371, 110632.
- **Tripathy, K. P.** & Mishra, A. K. (2024). Deep learning in hydrology and water resources disciplines: Concepts, methods, applications, and research directions. *Journal of Hydrology*, 628, 130458.
- ***Ongoing (under review / preparation)***
  - **Tripathy, K.** & Mishra, A. K. Physics-guided Transformer for drought prediction integrating land–atmosphere feedbacks. *Revision: Journal of Hydrology.*
  - **Tripathy, K.** & Mishra, A. K. Attributing hydrological drought mechanisms across CONUS using explainable AI. *Under review: Water Resources Research.*
  - **Tripathy, K.** & Mishra, A. K. Global Flash Drought Diagnostics and Intercomparison of Eight Indices. *Under review: Earth's Future.*
  - **Tripathy, K.** & Mishra, A. K. Constraining Deep Learning Flash Drought Forecasts with Solar-Induced Chlorophyll Fluorescence: A Physically Consistent Multi-Index Framework. *currently working.*
  - **Tripathy, K.** & Mishra, A. K. FlashCAT: A Python toolkit for flash-drought computation and analysis (indices, detection, and attribution). *Under prep.*
  - Tung, Y., **Tripathy, K.**, Mishra, A. K. Assessing the Climatic Drivers of Wildfire Risk in the Southern United States Through Random-Forest-Based Attribution Analysis. *Under Prep.*

Professional Experience

- **Postdoctoral Researcher** Sep 2025 - Present
  Texas A&M University *College Station, Texas, USA*
  - Lead NSF-funded flash drought research project by coordinating weekly progress meetings with PI and Co-PIs across multiple institutions, ensuring project deliverables align with funding milestones and stakeholder expectations.
  - Develop FlashCAT, an open-source Python toolkit for flash drought identification, indices calculation, and characterization—designed to serve as a community standard for operational drought monitoring and research applications.
  - Spearhead flash drought prediction and attribution studies over croplands in eastern USA using explainable AI (SHAP, Integrated Gradients), collaborating with USDA and agricultural scientists to enhance early warning systems and inform proactive agricultural management decisions.
  - Establish partnerships with Texas farming communities to conduct field assessments of flash drought impacts, translating academic findings into actionable recommendations for agricultural stakeholders and emergency management agencies.
  - Contributed to development of NSF proposal on flash drought predictability and early warning systems, providing technical expertise in physics-guided machine learning approaches and experimental design frameworks.
  - **Techniques and Data used:** Python, XAI, PyTorch, TensorFlow, xarray, NetCDF, ERA5, NLDAS, GLEAM, MODIS, Sentinel-2

- **Graduate Teaching Fellow** Jan 2025 - May 2025
  Texas A&M University *College Station, Texas, USA*
  - Served as primary instructor for CVEN 311: Fluid Dynamics, independently designing curriculum, delivering lectures, conducting exams and quizzes, and evaluating performance for a class of 70+ undergraduate students.
  - Developed comprehensive teaching materials including lecture notes, problem sets, and computational examples to enhance student understanding of complex fluid mechanics principles.

- **Graduate Research Assistant** Jan 2021 - Dec 2024
  Texas A&M University *College Station, Texas, USA*
  - Conducted climate change detection and attribution analysis for compound drought-heatwave events across CONUS, employing statistical methods and causal inference frameworks to quantify anthropogenic climate signals in extreme event occurrence and intensity.
  - Investigated land-atmosphere feedback mechanisms and their role in triggering and amplifying droughts and heatwaves, analyzing surface and root-zone soil moisture dynamics using reanalysis datasets (ERA5, MERRA2, GLEAM, NCA-LDAS) and satellite observations (SMAP, SMOS).
  - Collaborated with NASA Goddard Space Flight Center scientists to quantify soil moisture memory effects and land-atmosphere coupling strength, revealing critical thresholds for drought onset and persistence across diverse climatic regions.
  - Published 4 peer-reviewed journal articles (with additional manuscripts under review) on drought mechanisms, background aridity controls, and large-scale teleconnection influences on compound extreme events—consistently delivering project milestones ahead of deadlines.
  - Developed physics-guided deep learning models (Physics-Informed Neural Networks, hybrid LSTM-CNNs) integrated with explainable AI techniques (Expected Gradients, SHAP) to improve drought prediction accuracy and interpretability for operational forecasting applications.
  - Assisted in preparation of competitive NSF proposals focused on flash drought early warning systems and physics-guided machine learning frameworks for hydroclimatic extremes prediction.
  - **Techniques and Data used:** Python, TensorFlow, PyTorch, XAI, physics-guided deep learning, causal inference, climate model analysis (CMIP6), ERA5, GLEAM, VIC, Noah-MP, MODIS, SMAP, SMOS, Landsat

- **Junior Research Fellow** Aug 2020 - Dec 2020
  Indian Institute of Science (IISc) *Bangalore, India*
  - Quantified parametric and climate model uncertainties in Intensity-Duration-Frequency (IDF) curves under climate change scenarios (CMIP5), providing critical uncertainty bounds for urban infrastructure design and flood risk assessment in Bangalore metropolitan region.
  - Delivered actionable recommendations for urban flood management through ensemble climate projections and Bayesian uncertainty quantification, directly informing city planning and stormwater infrastructure resilience strategies.
  - **Techniques used:** MATLAB, Python, CMIP5 climate models, statistical downscaling, Bayesian uncertainty quantification

Projects & Python Development

- **FlashCAT (Flash-drought Computation & Analytics Toolkit):** Research-grade Python package for flash-drought detection and characterization. Implements 8+ indicators (e.g., EDDI, ESI, SMVI, SESR), temporal scaling (daily/weekly/pentad/monthly), and event metrics (onset, termination, severity, intensification rate). Emphasizes reproducibility (tests, docs, examples) and modular design for community extension. GitHub.

- **Physics-Guided Transformer Model (PGTM):** Deep learning framework that embeds physical constraints within a Transformer to forecast meteorological drought (target: scPDSI). Regularization enforces piecewise-linear soil-moisture–energy flux relationships (LHF/SHF), with regime-aware training and explainability (e.g., Expected/Integrated Gradients). GitHub.

- **drought-indices-python (PyPI package):** Open-source library for computing drought and heatwave indices. Supports multiple statistical transformations (parametric and nonparametric), standardized anomaly computation, and extraction of event characteristics (frequency, duration, severity).Available on PyPI; next release in active development.

- **Compound Rain–Wind Risk via Bivariate Copulas (design RP analysis):** Built a Python pipeline to model joint extremes of precipitation and 10-m wind using copulas (Gaussian, t, Clayton, Gumbel, Frank), with best-fit selection by AIC/BIC and goodness-of-fit tests. Estimated *joint* and *conditional* return periods (AND/OR formulations), produced risk-consistent design curves, and quantified uncertainty via parametric bootstrap. Included nonstationary extensions with time covariates for both margins and dependence parameters. Stack: NumPy/SciPy, statsmodels, `copulas`/OpenTURNS, Matplotlib.

Conference & Symposium Presentations

- **Tripathy, K.** & Mishra, A. K. (2024, December). Explaining the influence of climate drivers on hydrological drought dynamics using an interpretive deep-learning framework in CONUS. *AGU Fall Meeting*, Washington DC, Session H41G-05.
- **Tripathy, K.** (2024). Explaining the causal influence of snow on hydrological droughts using an interpretive deep-learning framework. *Texas A&M University PhD Student Symposium*, Texas A&M Transportation Institute (TTI), College Station, TX.
- **Tripathy, K. P.**, Mukherjee, S., & Mishra, A. K. (2022). Spatiotemporal analysis of compound drought and heatwave events at a global scale. *ASCE–EWRI World Environmental & Water Resources Congress*, Atlanta, GA.
- **Tripathy, K.**, Mukherjee, S., & Mishra, A. K. (2021, December). A global analysis of compound drought and heatwaves. *AGU Fall Meeting*, New Orleans, LA (GC23D-04).

Relevant Courseworks

- **Data Science & Machine Learning (AI/ML):** Machine Learning, Deep Learning for Computer Vision, Deep Learning with TensorFlow, Data Structures and Algorithms, Applied Probability and Statistics, Multivariate Analysis, Amazon Web Services by Udemy.
- **Hydroclimate & Earth System Dynamics:** Climate System Dynamics and Modeling (ESMs), Ground Water Modeling, Surface Water Hydrology, Hydroclimatic Extremes, Stochastic Hydrology, Water Quality Modeling, Remote Sensing applications for Hydrology and Water Resources Engineering.
- **Computational Modeling & Numerical Methods:** Computational Fluid Dynamics (CFD), Finite Element Method, Finite Volume Method, Optimization Methods, Advanced Mathematics for Engineers.

Awards and Achievements

- **Glenn Graduate Fellowship (2021-2023)**
  Selected for a prestigious three-year fellowship ($15,000 total) recognizing sustained academic excellence and high-potential research in the Ph.D. program.
- **Graduate WAC/WID Fellowship (2022)**
  Awarded a $1,500 research grant for demonstrated contributions and innovative pedagogical approaches in integrating research-driven writing into university curriculum.
- **Ministry of Human Resource Development (MHRD) Scholarship (2018-2020)**
  Secured full financial scholarship from the Government of India for M.Tech. studies at the Indian Institute of Science (IISc), Bangalore, based on an All India Rank of **81** (99.61 percentile) in the GATE 2018 examination.

Professional Service

- **Journal Peer Review:** *JoH*; *GRL*; *WRR*; *Earth's Future*; *SERRA*; *Scientific Data*; *Journal of Hydrologic Engineering (ASCE).*
- **Lab Service:** Guest lectures / research seminars; graduate student mentor / code review for graduate students; data-management guidelines.
- **Open-Source & Community:** Maintainer/contributor: FlashCAT (flash drought analytics); reproducible notebooks & climate data utilities (Python/MATLAB). Contributor and maintainer of drought_indices_python repository.
- **Professional Memberships:** American Geophysical Union (AGU); ASCE–EWRI

References

1. **Ashok Kumar Mishra**
   Professor, Civil & Environmental Engineering (Hydrology & Water Resources)
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