

RESEARCH BRIEF

Seasonal River Forecasting for Shipping and Insurance Planning

This research demonstrates a proof of concept for an AI-driven hydrological forecasting and parametric risk-pricing approach that estimates the likelihood of low or high river flow that could disrupt shipping on the Mississippi River. Forecast improvements over historical climatology were concentrated at one- to four-month leads, with smaller average gains through month 11. The resulting risk estimates could support shipment planning and parametric insurance analysis.

Unmet Need: Reliable advance assessment of river navigation disruption risk

Low and high river levels can restrict cargo loads, delay shipments, or halt navigation, increasing transportation costs and disrupting supply chains. Existing systems provide river forecasts and seasonal outlooks, while parametric river-level insurance offers payouts tied to predefined water-level thresholds. However, translating advance forecasts into reliable estimates of navigation disruption and financial exposure remains a challenge. Better links between seasonal forecasts, navigation thresholds, and financial risk are therefore needed to support shipment planning and parametric insurance design and pricing.

The Research and Proposed Development

The research team has already combined historical river flow records with environmental information, including rainfall, soil moisture, snow, and temperature. The completed Phase 1 of this study used these inputs to forecast monthly river flow and estimate the uncertainty around those forecasts. Amazon's pretrained Chronos-2 model produced forecast percentiles for each month, which were used to estimate low- and high-water probabilities and calculate illustrative parametric insurance premiums and basis-risk measures. Retrospective tests at three Mississippi River basin outlets showed improvements over climatology, the historical distribution of flow for each calendar month. Gains were concentrated at one- to four-month leads, with smaller average improvements through month 11. A diagnostic experiment using observed future land conditions retained substantially greater skill, suggesting an opportunity to improve forecasts by predicting those conditions.

The faculty propose a 12-18-month Phase 2 project to develop and evaluate a prototype for potential operational use in collaboration with a commercial partner. River-stage observations and validated stage-discharge rating curves would connect forecasts more directly to Waterways Action Plan thresholds tied to operating restrictions. USACE stage records could also extend coverage to additional subbasins. The project would test seasonal forecasts of future land conditions to assess gains at longer leads, calibrate forecast uncertainty, and evaluate risk estimates against observed navigation restrictions where records are available. Industry partners would help assess the value of these estimates for shipment planning and parametric insurance design.

The completed Phase 1 serves as proof of concept:

- Demonstrated forecast improvements over a historical seasonal baseline
- Estimated probabilities of both low- and high-water conditions
- Connected river forecasts to illustrative insurance pricing and basis-risk analysis
- Applied a pretrained model without task-specific retraining
- Identified potential for greater skill through improved forecasts of future land conditions

Potential applications of Phase 2:

- Insurance analytics platforms
- Parametric insurance design and pricing
- Assessment of water-related supply chain risk
- Seasonal shipping and logistics planning
- Port and terminal disruption preparedness
- Supply chain resilience planning

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Related publications:

[Nakamura J, Nakamura X, Lall U. "Probabilistic streamflow forecasts for Mississippi River navigation risk and parametric insurance." Preprint in EarthArXiv](#)

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