Title: Improving Data-Driven Flow Forecasting in Large Basins using Machine Learning to Route Flows

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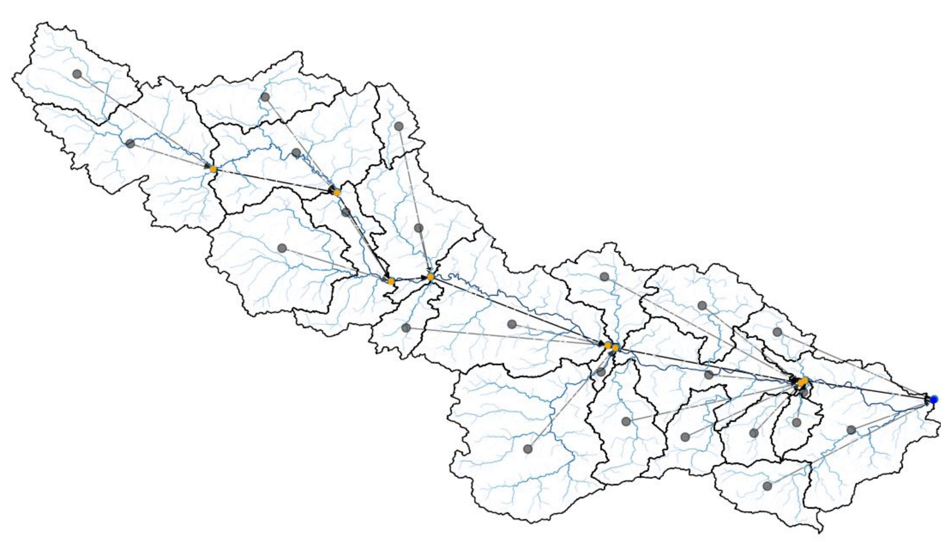
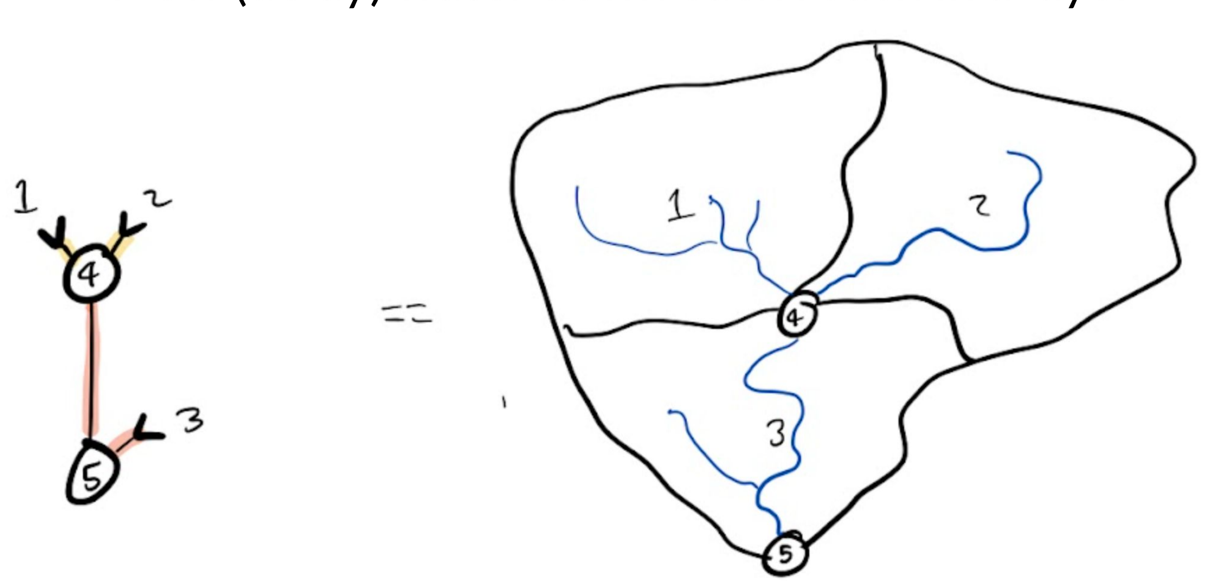
BACKGROUND: Making **accurate hourly** streamflow **forecasts** in **large and regulated** basins is difficult without a distributed model to divide the input data and routing so that peak magnitudes and timing are well captured.
Learn how we have incorporated a distributed model into HydroForecast's short-term model.

METHODS

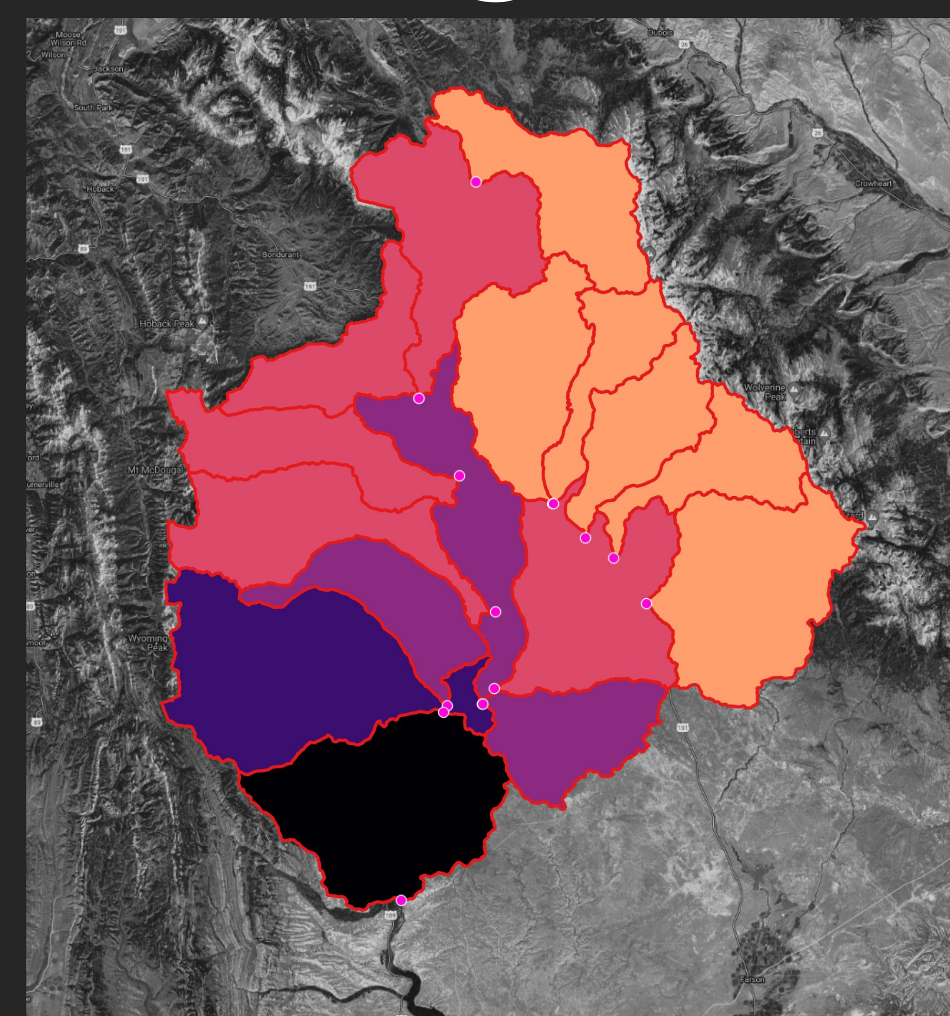
1. Start with HydroForecast core [*a theory-guided machine learning model*]
2. Delineate subbasins, split at upstream gauges



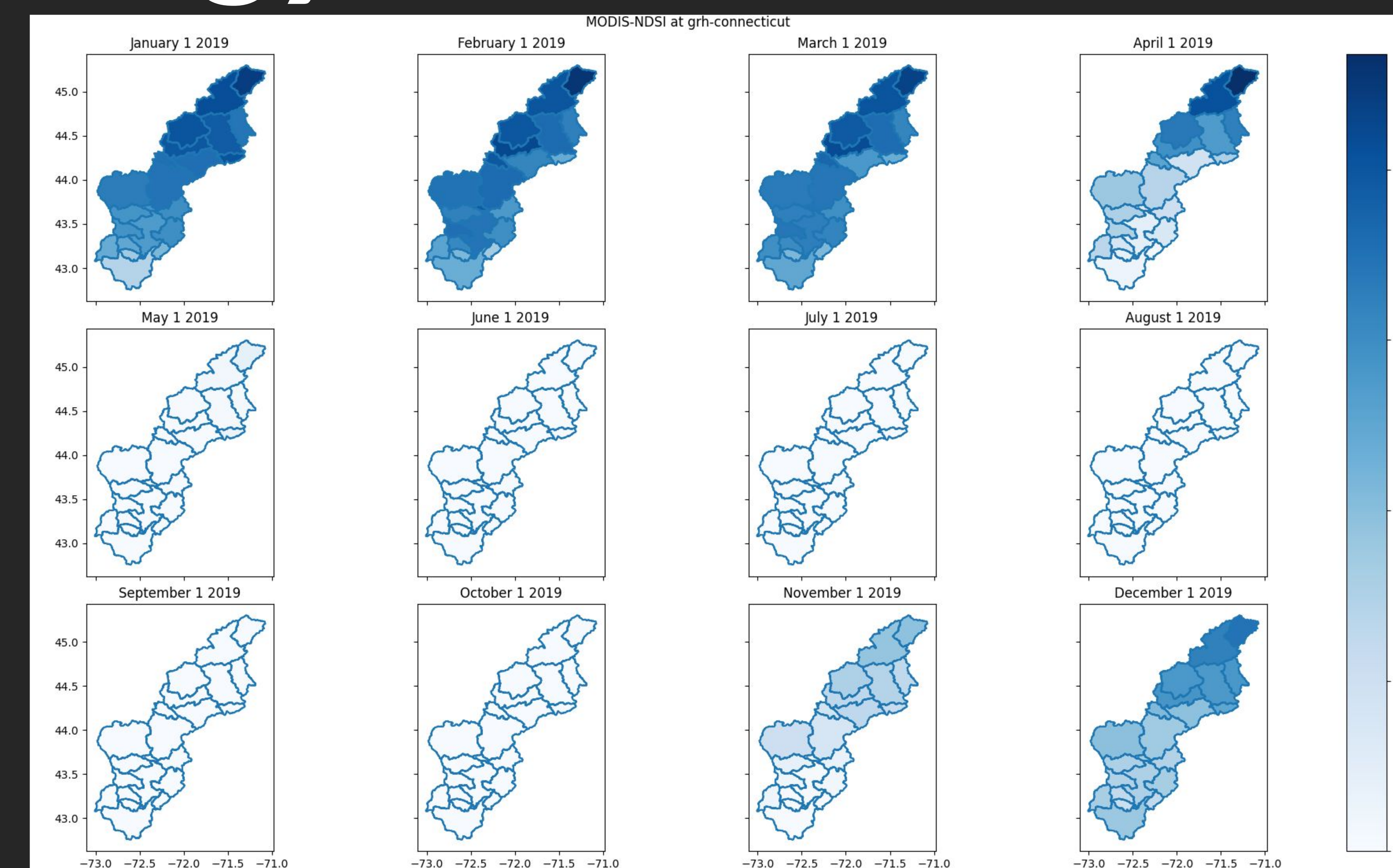
3. Predict runoff at each HRU
4. Route runoff through the river network. For each layer:
   - Add up inflows to each confluence in layer
   - Flow (delay) water down each reach in a layer



First operational, deep learning, hydrologic forecasting model that learns **routing** and **hydrology at once**

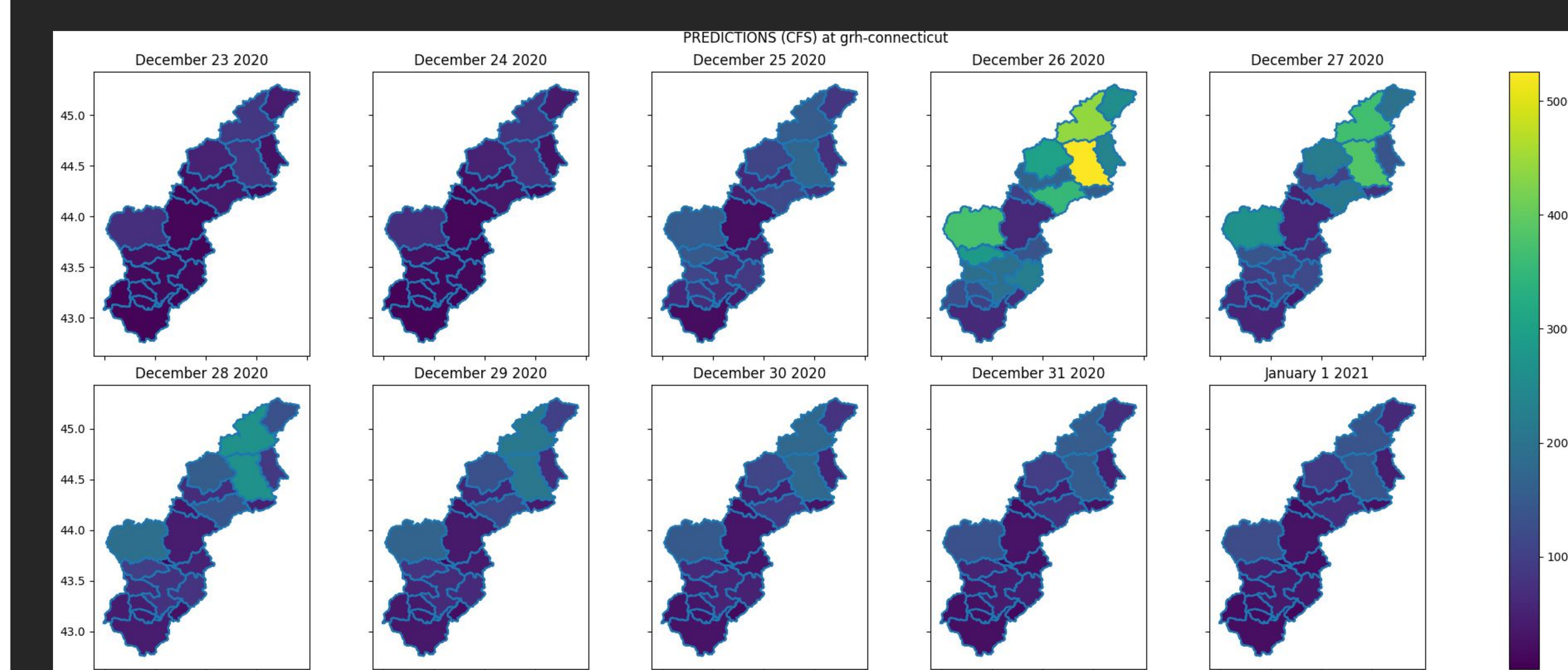


The distributed model efficiently routes flows by first determining upstream dependencies. Forecasts are produced for the upstream most subbasins (represented by the *lightest* colors) in parallel and added to the next layer of directly downstream subbasins. This allows the model to compute total flows at every point in the least amount of time while minimizing computational demand.



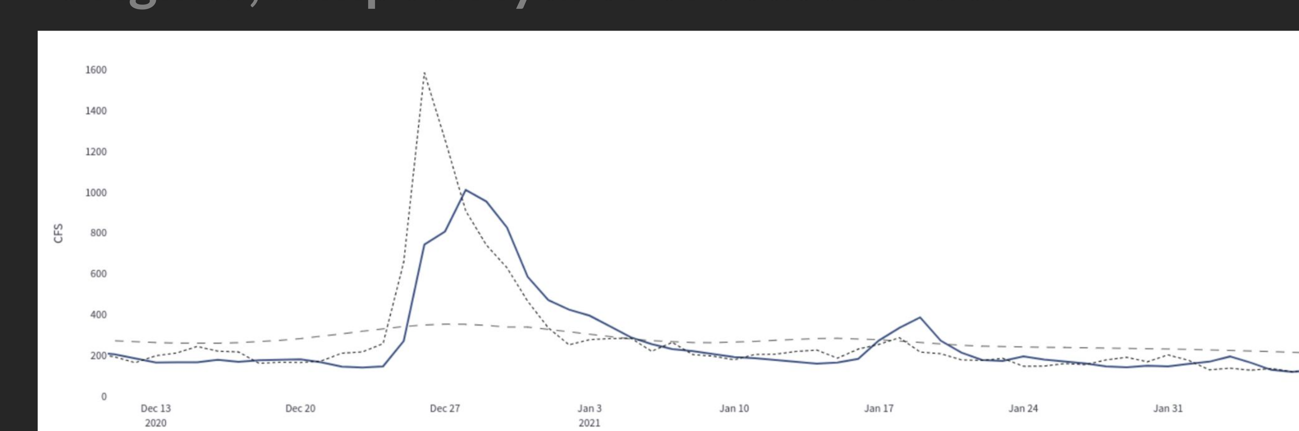
Monthly average snow cover, 2019.

Example, Christmas 2020 *rain on snow* event in White River, CT

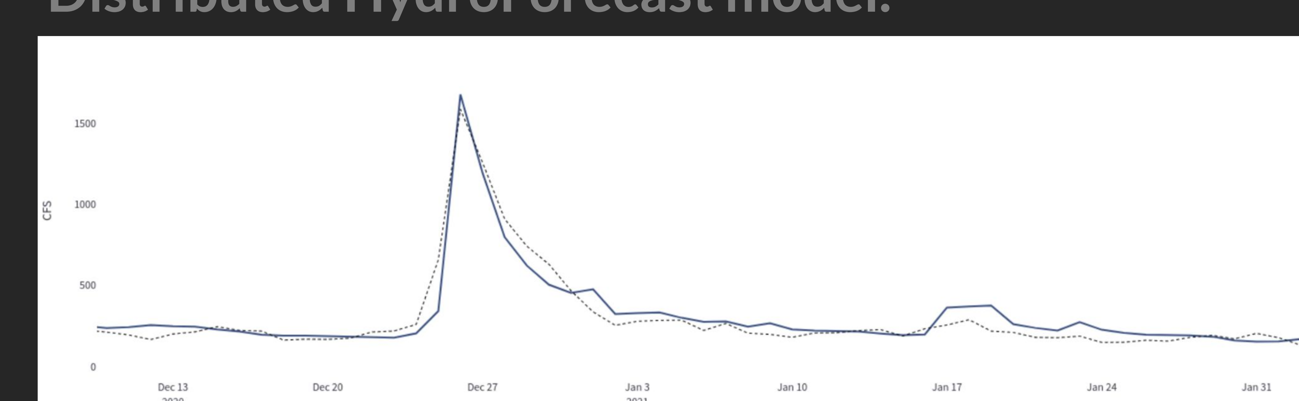


Streamflow (CFS) at the subbasin scale for the Christmas rain on snow event.

Original, lumped HydroForecast model.

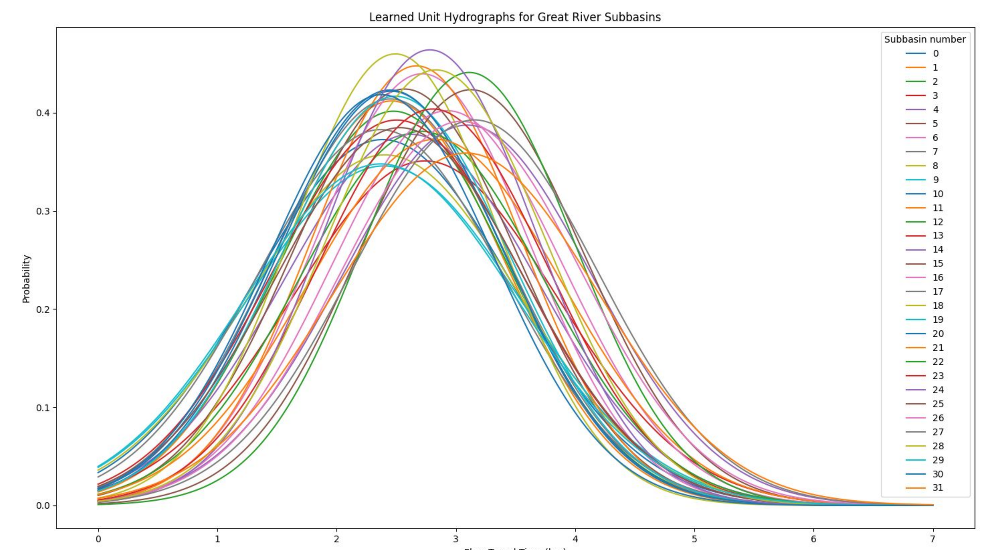


Distributed HydroForecast model.



What's especially unique and new

The model predicts **three components dynamically** at every time step for every reach: **the delay time, spread and volume gain/loss.**

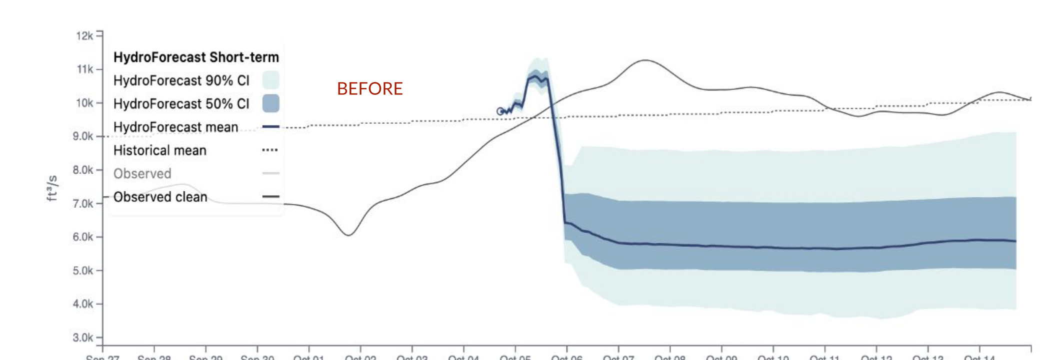


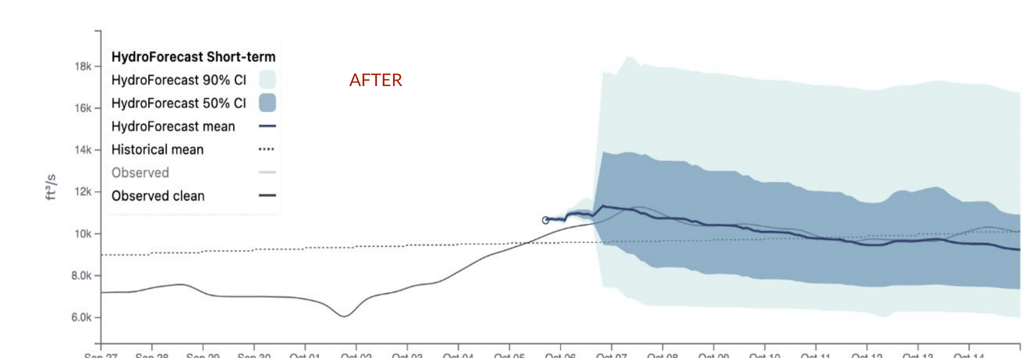
The model **learns** the dynamic routing properties

We use **matrix multiplication** to make this speedy fast. **Run time** for total **flow predictions** on a GPU:

- ~50,000 km^2 in ~**2 seconds**
- ~5,000 km^2 in ~ **< 1 second**

Assimilation: Impact of incorporating *upstream forecasts*





Special thanks to Great River Hydro for providing permission to show data.

UPSTREAM TECH