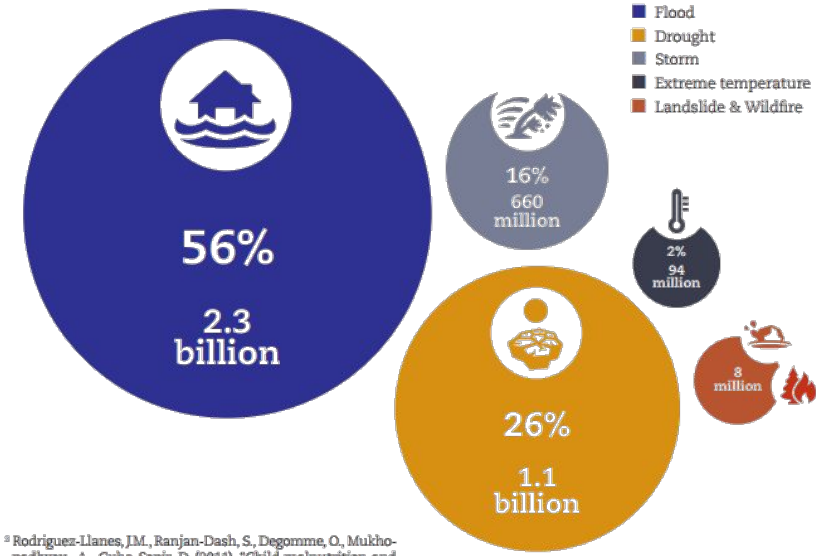
Flood Forecasting Everywhere

Guy Shalev, Google

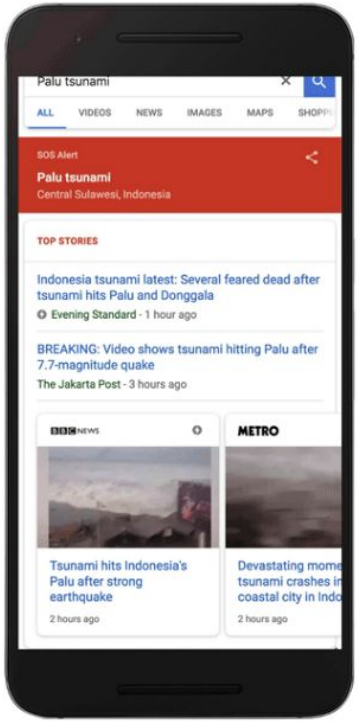
Flooding impact



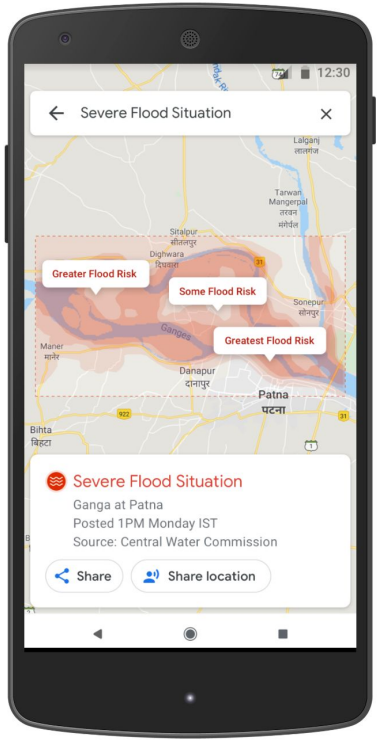
[8] Rodriguez-Llanes, J.M., Ranjan-Dash, S., Degomme, O., Mukhopadhyay, A., Guha-Sapir, D. (2011). "Child malnutrition and recurrent flooding in rural eastern India: a community-based survey". BMJ Open 2001;1: e000109.

Google Public Alerts

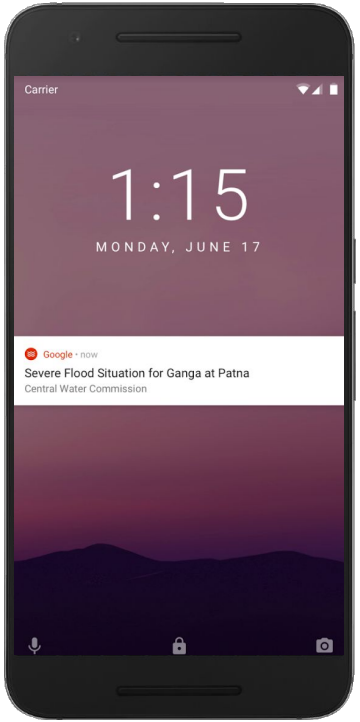
Search



Maps



Android



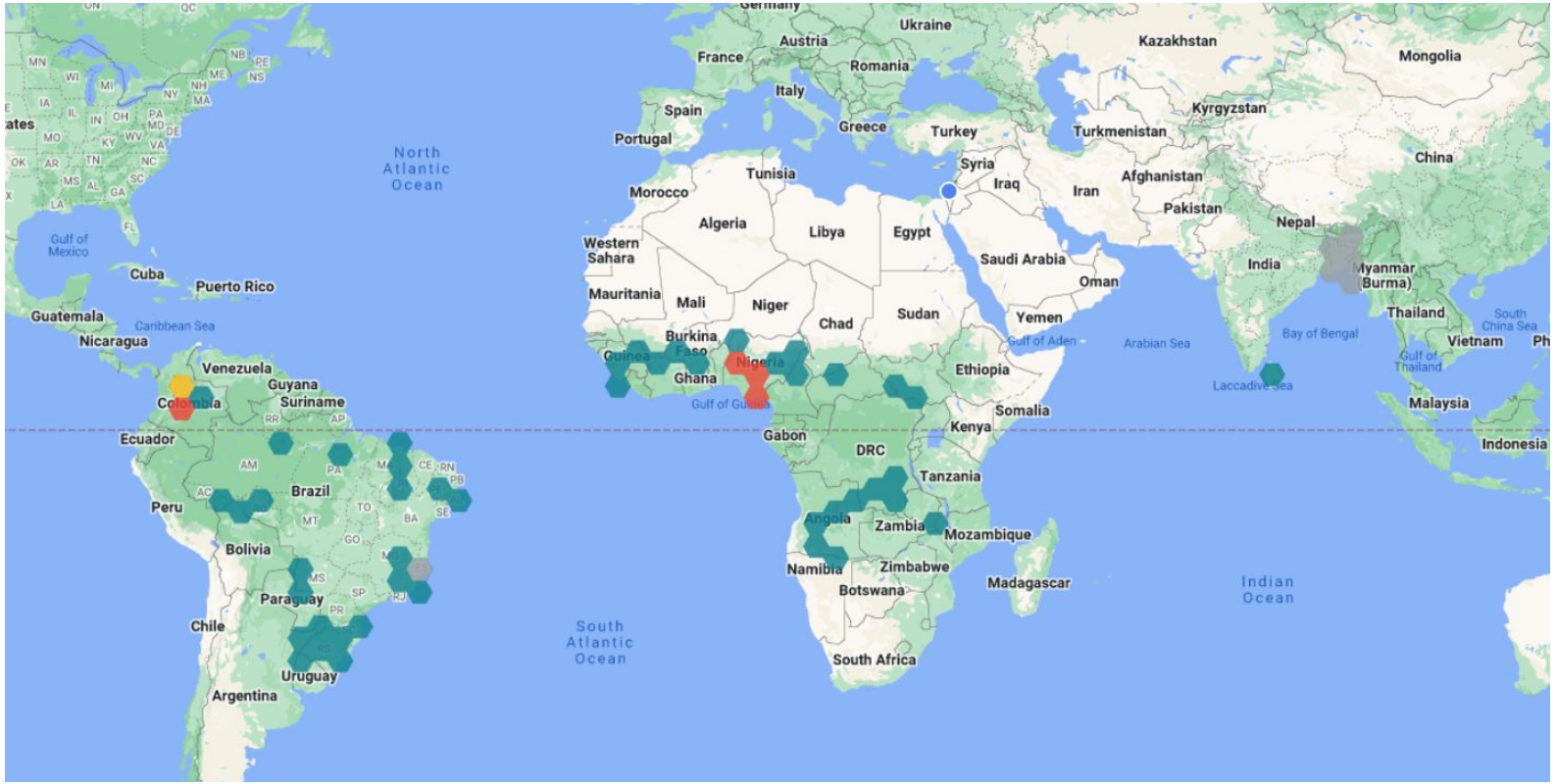
→ Help local and public authorities communicate emergency messages

→ Provide useful context like emergency numbers, how to protect yourself, and maps of the situation

Flood Forecasting Initiative

Google's Flood Hub

g.co/floodhub



Flood Forecasting Initiative

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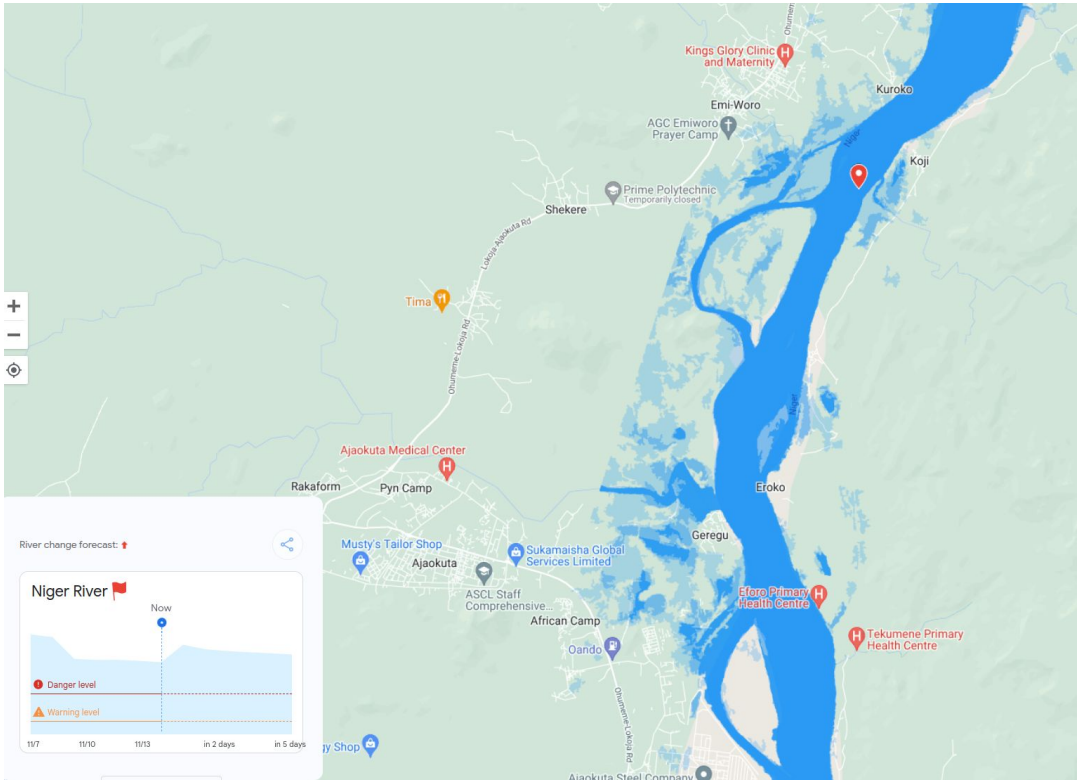
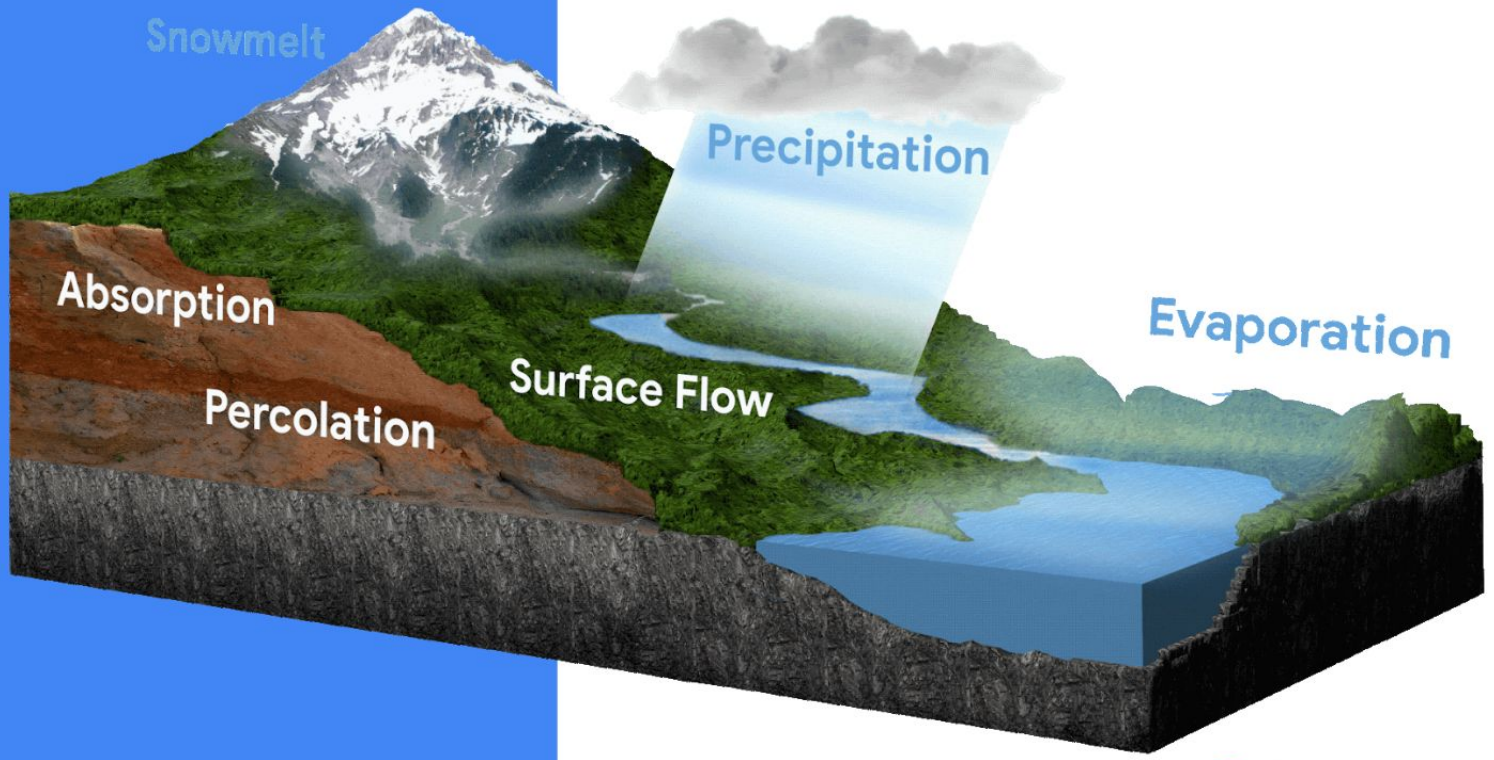


Flood Forecasting Initiative

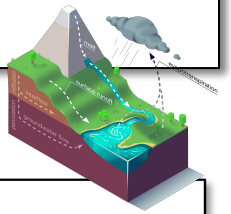
Hydrologic Model

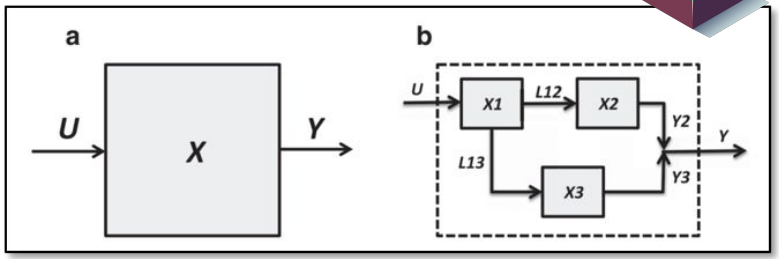


LSTMs & Conceptual Hydrologic Models

State space model:

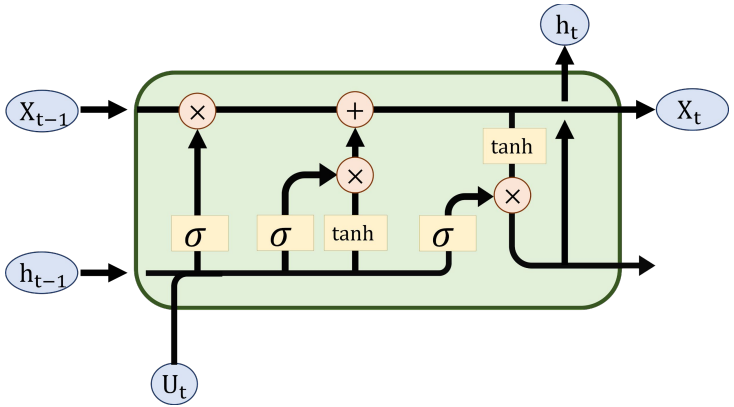
State[t] = F(State[t-1], Input[t], params)





LSTM model:

State[t] = F(State[t-1], Input[t], params)



Calibration / Training

Learning parameters from observed data

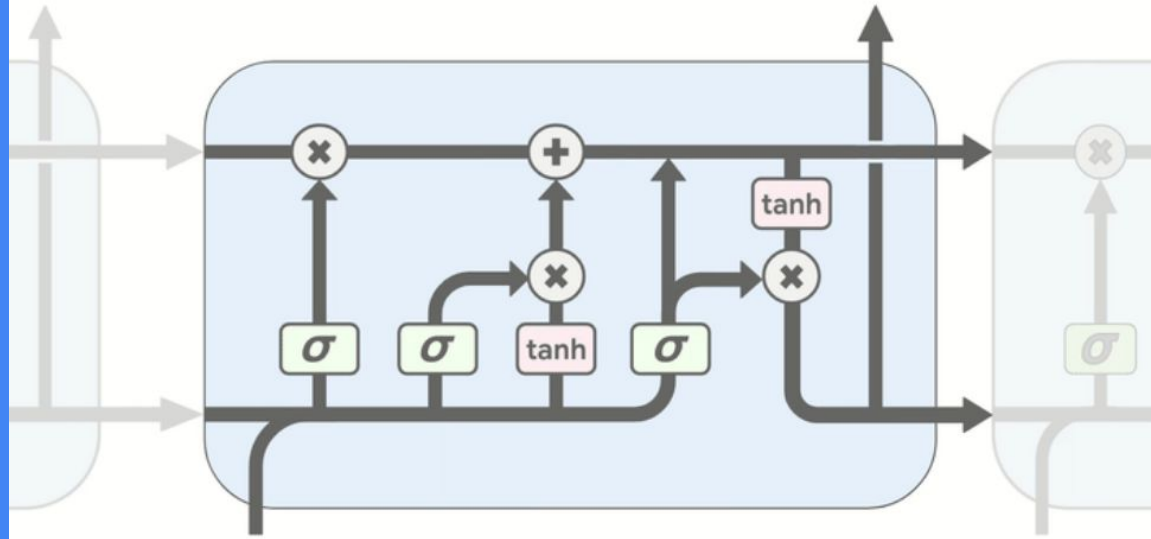
Hydrologic Model

→ Almost no explicit modeling

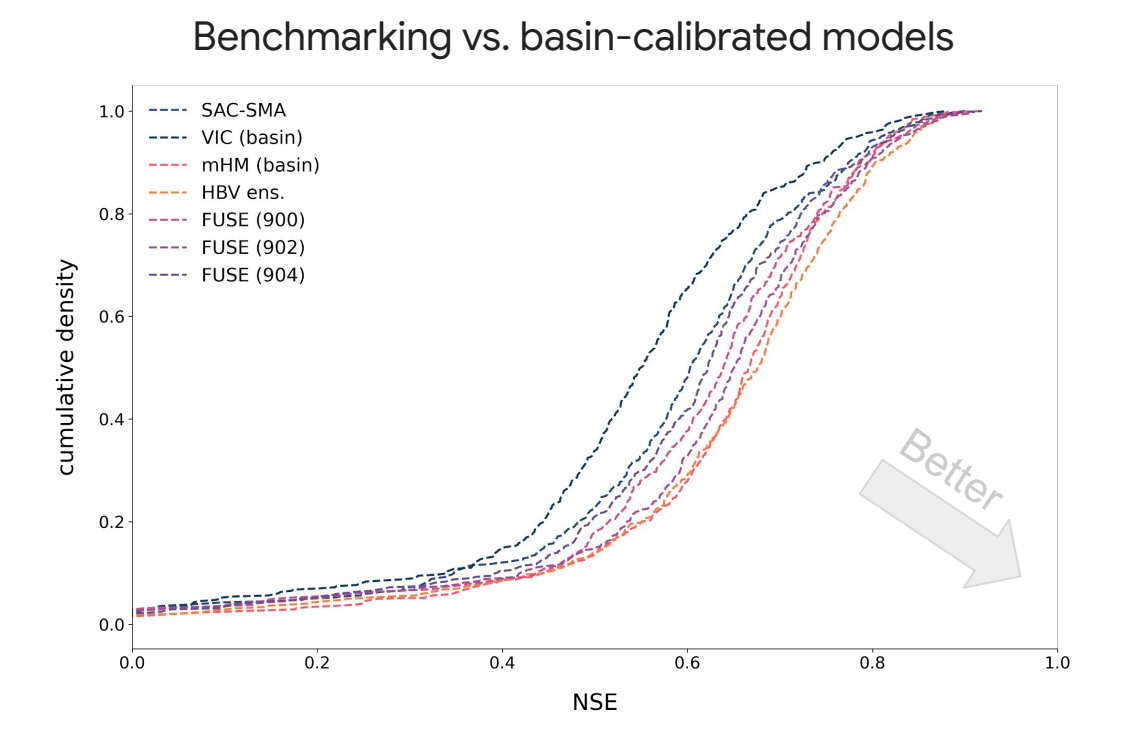
→ LSTM architecture for time series prediction

→ A single, shared LSTM to infer in all locations

ML-based Approach

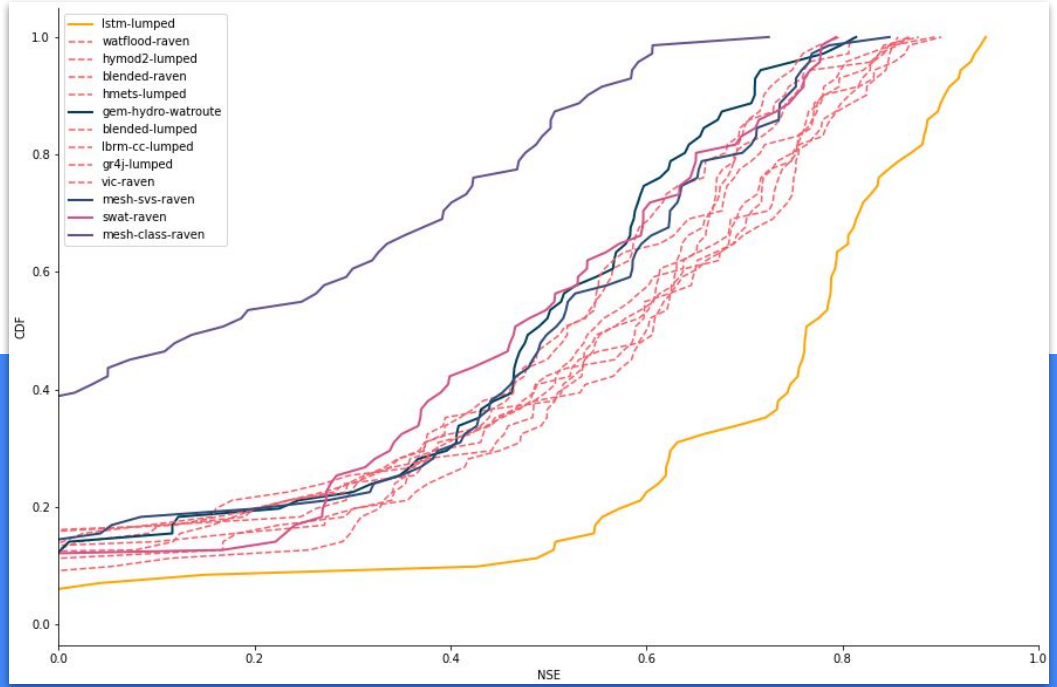


Hydrologic Model - ML-based



arxiv.org/abs/1907.08456 - Towards Learning Universal, Regional, and Local Hydrological Behaviors via Machine-Learning Applied to Large-Sample Datasets, Kratzert et al.

Prediction in Ungauged Basins

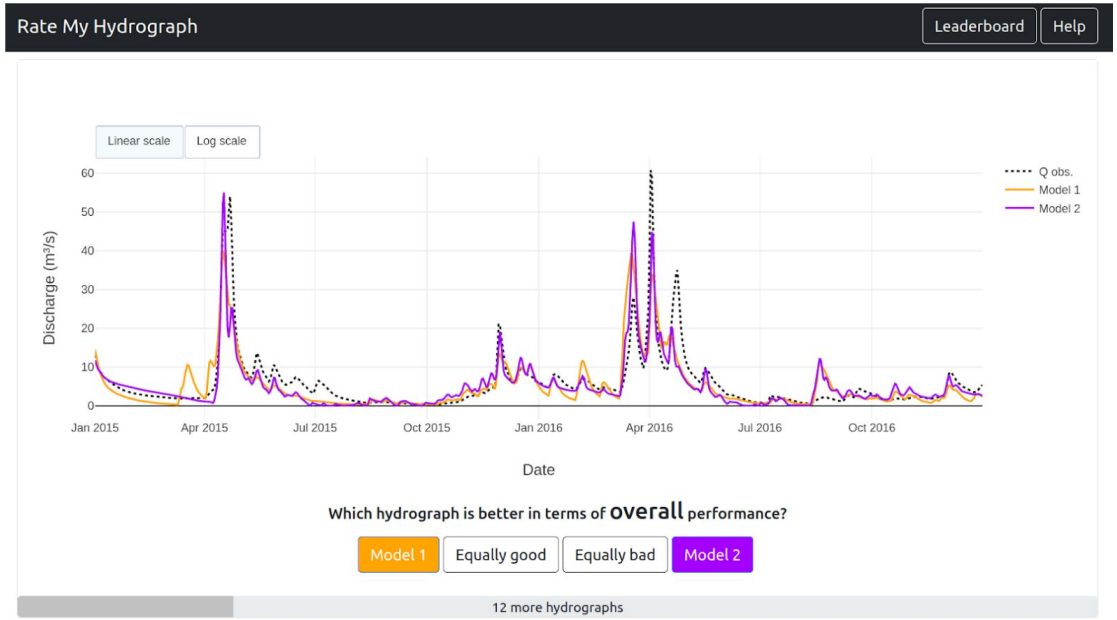


Intuition: if we train one model on 4000 or 4001 gauges, it doesn't really change the model - specifically for that one ungauged basin

The main problem: gauges that are completely unrepresented in the dataset.

https://doi.org/10.5194/hess-2022-113 - Mai, J., et al. : The Great Lakes Runoff Intercomparison Project Phase 4: The Great Lakes (GRIP-GL) [in review, 2022]

Visual Comparison



https://eartharxiv.org/repository/view/4586/ - In Defense of Metrics:Metrics Sufficiently Encode Typical Human Preferences Regarding Hydrological Model Performance

Visual Comparison - Results

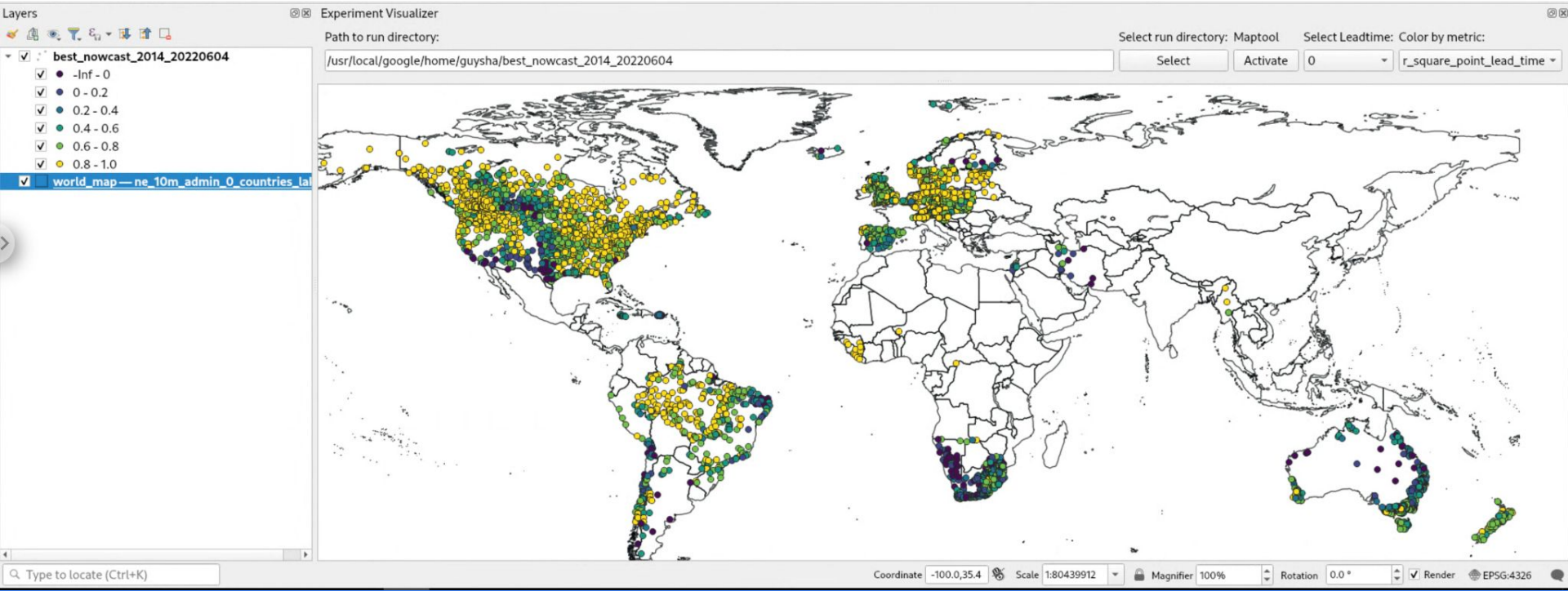
Table 4. Win percentage and median validation period KGE from the GRIP-GL study by model for the different rating tasks.

	Rating task	Win percentage			Median KGE from GRIP-GL
		Overall	High flow	Low flow	
Regionally calibrated	mesh-class-raven	22	33	18	0.45
	gem-hydro-watroute	23	22	35	0.46
	mesh-svs-raven	32	32	50	0.57
	swat-raven	33	32	35	0.56
	watflood-raven	36	37	33	0.62
Locally calibrated	lbrm-cc-lumped	49	53	42	0.75
	hymod2-lumped	53	54	43	0.76
	vic-raven	56	60	50	0.75
	hmets-lumped	58	58	57	0.75
	blended-raven	64	62	59	0.76
	gr4j-lumped	67	64	69	0.74
	blended-lumped	68	64	59	0.79
ML	lstm-lumped	87	81	90	0.82

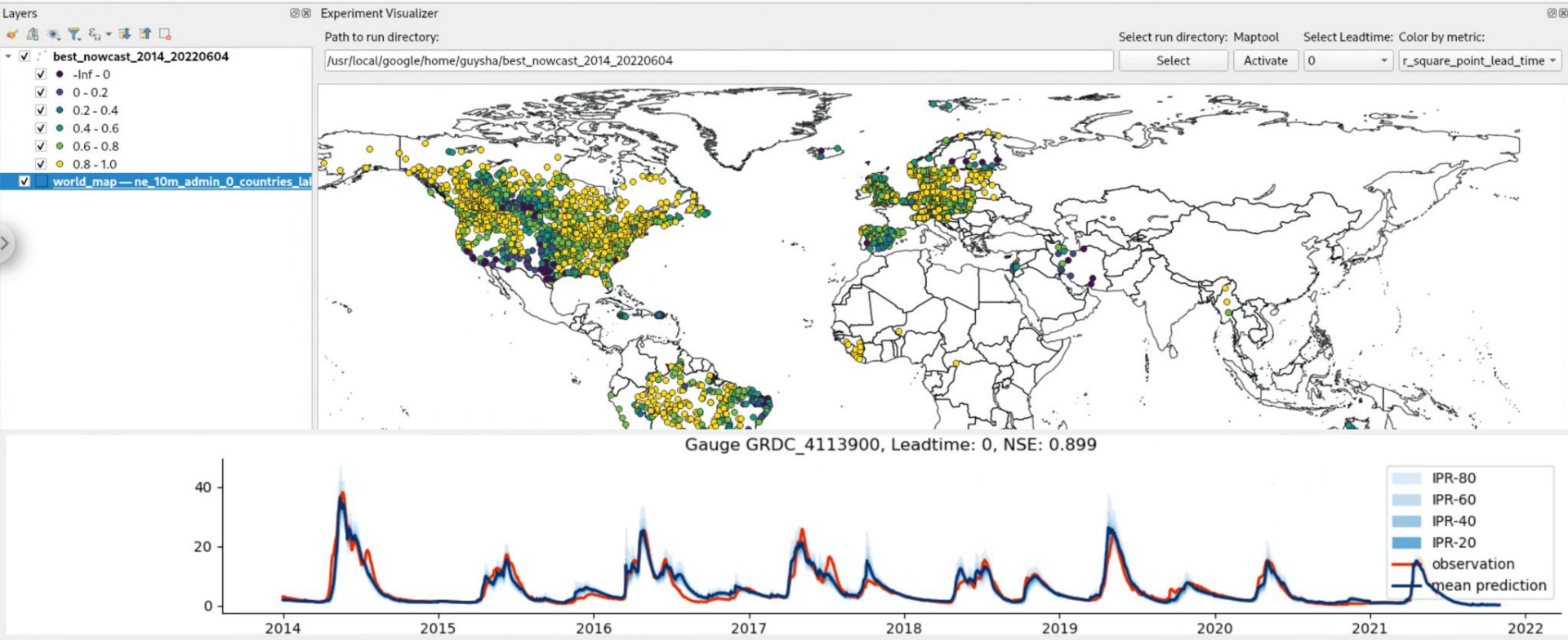
Bonus:
Metrics Are Sufficient

https://eartharxiv.org/repository/view/4586/ - In Defense of Metrics: Metrics Sufficiently Encode Typical Human Preferences Regarding Hydrological Model Performance

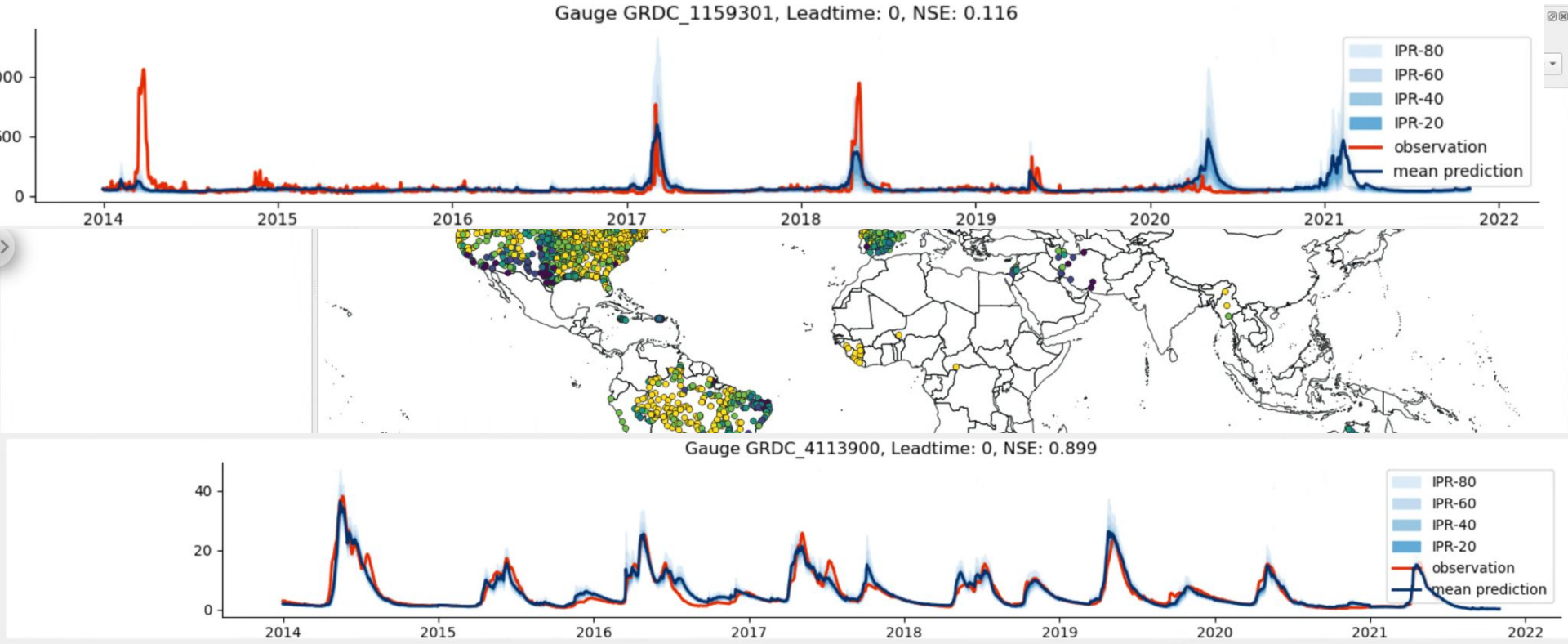
Global Model - Recent Results



Global Model - Recent Results



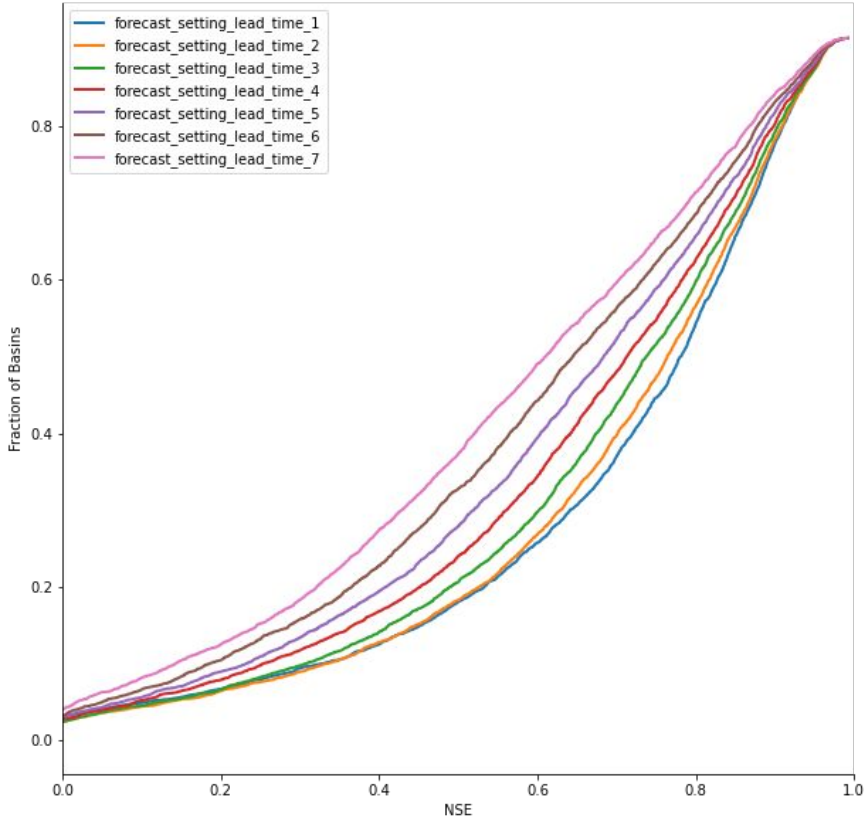
Global Model - Recent Results



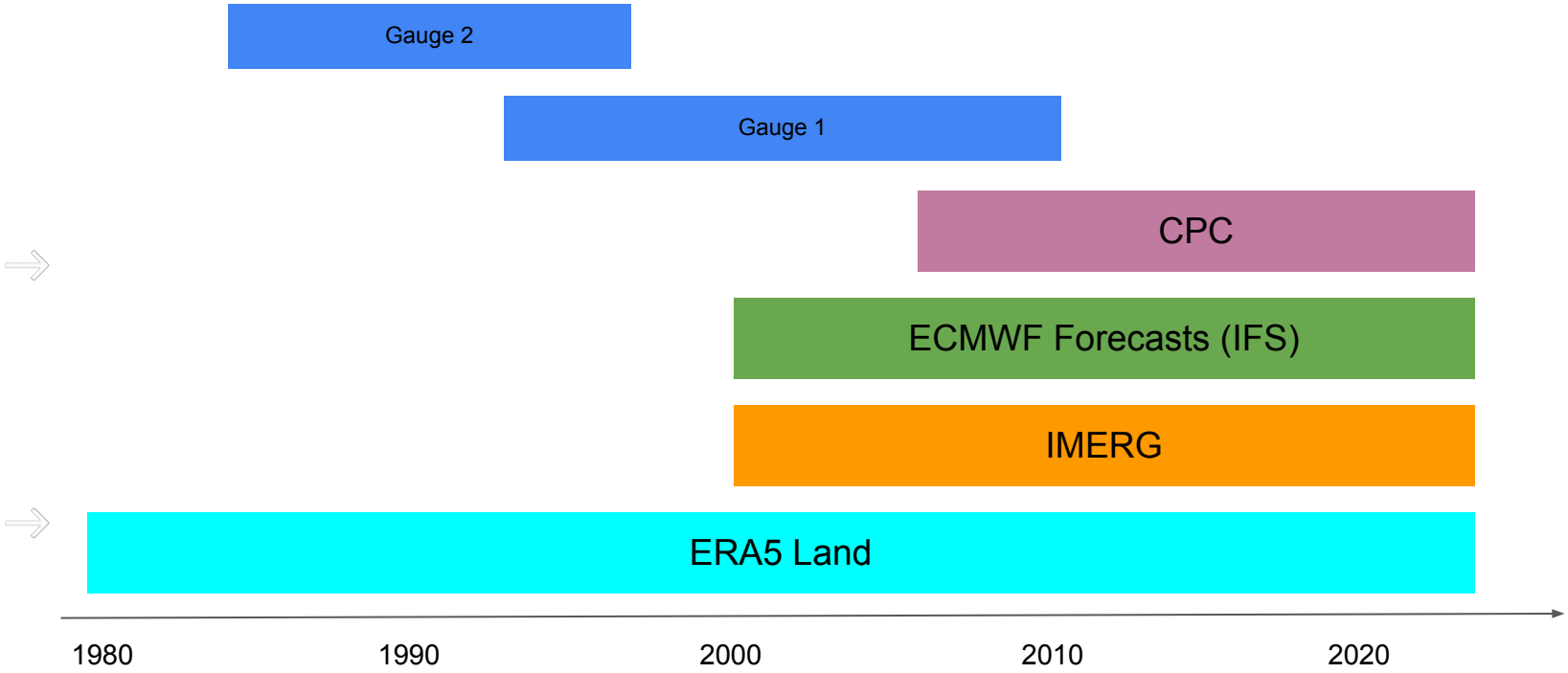
Recent Results: Forecasting

→ Slow degradation of performance with longer lead-time

→ More NWP products to be added



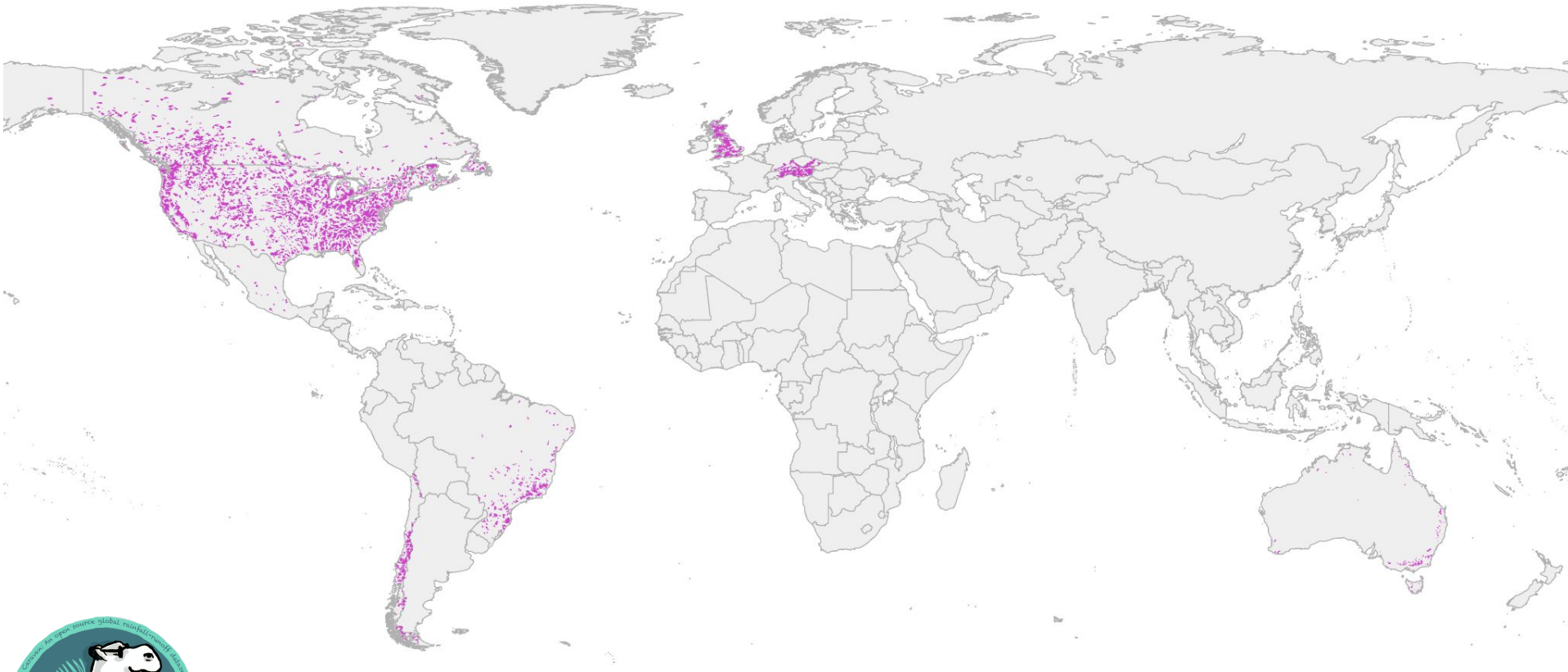
Missing Inputs - Masking & Union



A Global Community Dataset For Hydrology

- Global open rainfall-runoff dataset with more than 7000 basins
    - Median streamflow record length: 34 years
- Forcings (ERA5-Land) and attributes (HydroATLAS) derived on Earth Engine
- **The Vision: The community works to extend it together**

*Dataset of preprint contains ~2500 basins but we already processed 6600 additional basins.
Planned dataset extensions: CAMELS-FR, CAMELS-CH, CAMELS-DE and 300 basins from Denmark



Link to code/paper/dataset: github.com/kratzert/caravan
Detailed guide for contributors: github.com/kratzert/Caravan/wiki

Flood Forecasting Initiative

Advantages of ML for Global Hydrologic Modeling

- ✅ Quality of predictions
- ✅ Fast and cheap training - **less than a day** on a single GPU
  - Better science, fast research cycles
  - Easy to incorporate new data
- ✅ A single model, applicable anywhere - no need for retraining
- ✅ Spatial precision of gauge location (compared to 10km pixel)
- ✅ Multiple input sources for better accuracy and uncertainty estimation

Talk plan

*Floods intro, public alerts and new flood hub - **2 minutes***

*LSTMs vs. conceptual, better in gauged, ungauged and visual - **4 minute**.*

*Global hydrologic model described + results **2 minutes***

*Missing data - Union (ERA5/ECMWF) and input masking **2 minutes***

*Caravan, a way to improve gauged locations and do better science **2 minutes***

*All the extra ways ML model is better. **2 minutes***