Not All Water Consumption Is Equal:

An AI, Datacenter, and Semiconductor Perspective

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Computing is thirsty

- The rise of AI and computing comes with a hidden cost: **water consumption.**

10~50 GPT-3 queries
500 mL water

A Google's datacenter
3.7 million m^3 water

1,500

Intel
9.6 million m^3 water

23,000

Water consumption is high across the entire computing stack.

How much do we understand water consumption?

What is water consumption?

- **Water Withdrawal ≠ Water Consumption**
  Water Withdrawal: Total water taken from the environment
  Water Consumption: Water removed from the environment

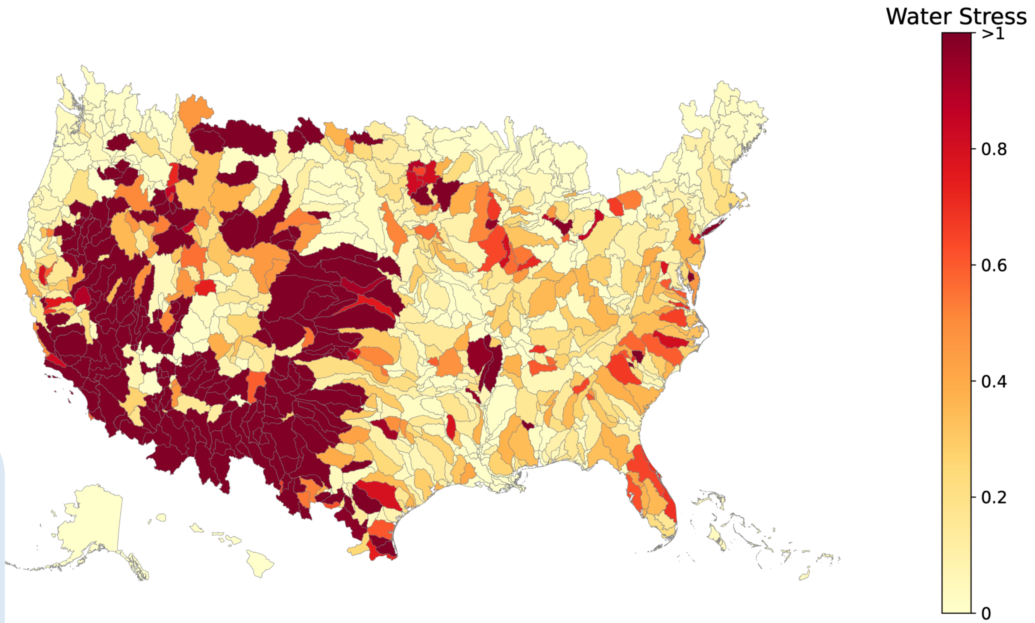
WATER CONSUMPTION = WATER WITHDRAWAL − WATER DISCHARGE

- **Water Consumption = On-site + Off-site**
  On-site consumption: Loss at facility (e.g., evaporation for colling in datacenters)
  Off-site consumption: Indirect consumption (e.g., power generation)

Water consumption is location-sensitive

$$\textit{Water stress} = \frac{\textit{Water Demand}}{\textit{Water Availability}} \quad [1]$$

Spatially, same amount of water consumption can lead to greater environment burden in arid regions than in water-abundant regions.



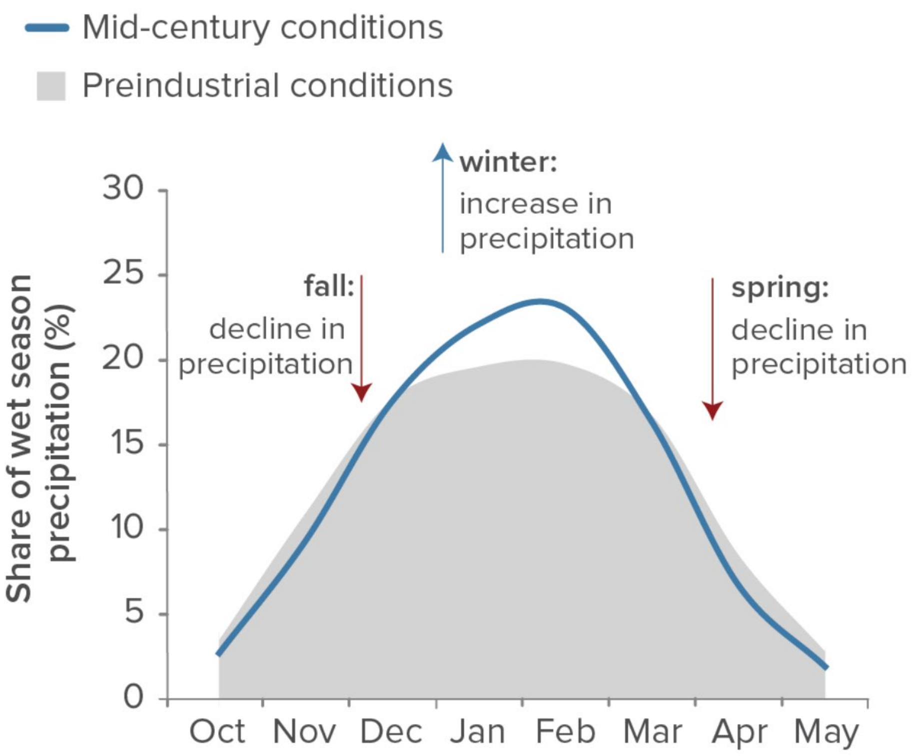
Water stress map of U.S.

[1] Kuzma et al. Aqueduct 4.0: Updated decision-relevant global water risk indicators. WRI 2023.

Water consumption is time-sensitive

- Water availability fluctuates over seasons
- Climate change influences water in long-term

Temporally, water supply fluctuates over time. We must account for both the **location** and **time** when analyzing water impact.



Seasonal Precipitation in California [2]

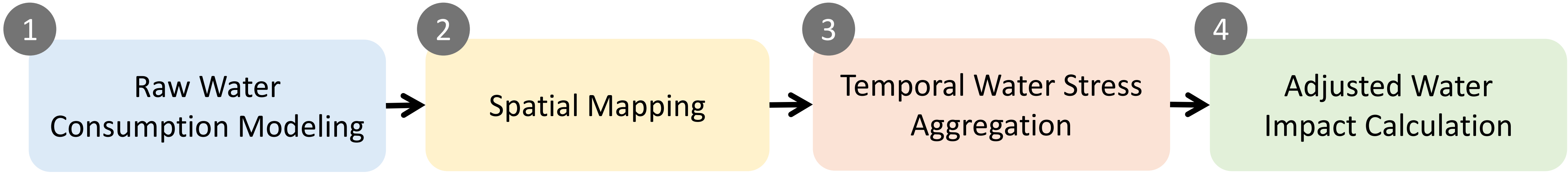
[2] Swain et al. Increasing precipitation volatility in twenty-first-century California. Nat Clim Change 2018.

Our Contributions

- **SCARF**: **S**tress-**C**orrected **A**ssessment of Water **R**esource **F**ootprint, a general framework for water impact evaluation in computing.
  - **Incorporate spatial and temporal variations of water stress** to better evaluate water consumption impact.
  - **Introduce Adjusted Water Impact (AWI)** a unified metric combining water consumption with local water stress.
  - **Conduct three case studies** across AI, datacenters, and semiconductor fabs

SCARF

- **SCARF**: Stress-Corrected Assessment of Water Resource Footprint
- **Insight:** Incorporate spatial and temporal variations



Case Study I: AI – Large Language Models (LLMs)

ChatGPT

Qwen

Gemini

LLaMA by Meta

Case Study I: LLM Serving

- Evaluate *per-request* Adjusted Water Impact (AWI) of 7B, 14B and 32B Qwen 2.5 model **in different regions.**

The adjusted water impact of deploying LLMs is highly **location-sensitive**. Same workloads can have 1000× differences depending on where they are served.

* *More results can be found in paper.*

Case Study I: LLM Serving

- Evaluate *per-request* Adjusted Water Impact (AWI) of 32B Qwen2.5 in **different months** but same regions (AZ vs WY).

Even in the same location, seasonal changes can significantly affect adjusted water impact. **When we deploy matters**—not just where.

** More results can be found in paper.*

Case Study II: Google Datacenters

Case Study II: Google Datacenters

- Evaluate *annual* Adjusted Water Impact (AWI) of datacenters in **different regions**.

Medium Stress

Low Stress

High Stress

Water stress alone is not sufficient to capture true water impact. High water consumption in medium-stress regions can cause greater impact than expected.

** More results can be found in paper.*

Case Study II: Google Datacenters

- Evaluate *annual* Adjusted Water Impact (AWI) of Google's datacenters with **different discount rates**.

Different planning perspectives lead to different sustainable decisions.

Case Study III: Intel Semiconductor Fabs

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- Evaluate *annual* Adjusted Water Impact (AWI) of Intel’s fabs in **different regions**.

Semiconductor fabs consume a large amount of water. Building fabs in water-scarce regions like Arizona causes higher environmental burdens.

Take Home Messages

SCARF quantifies water impact based on spatial and temporal variations in water stress.

- **Region matters.**
  Water stress level varies dramatically across regions.
- **Time matters.**
  Water stress shifts with seasons and long-term climate change.
- **Amount matters.**
  Large water consumption amplifies water impact even in low-stress area.
- **How we value the future matters.**
  Different priorities for future can reshape sustainability decisions.