WebGPU for Scalable Client-Side Aggregate Visualization

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MOTIVATION

Modern web technologies enable the creation of visualizations that are accessible **without any additional software.**

Existing web frameworks scale poorly for huge datasets, especially for aggregate visualizations.

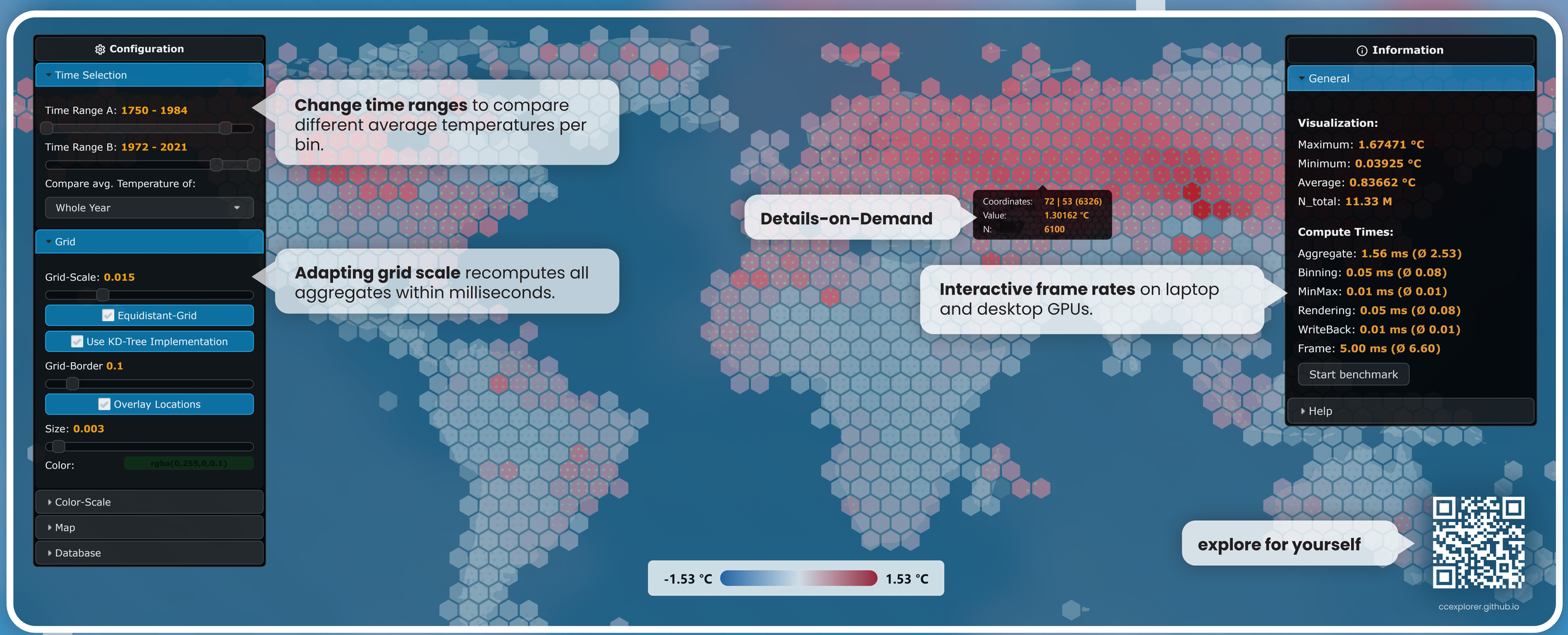
Client side compute shaders are now available with WebGPU. They allow **significant optimization** based on parallelization.

OUR GOAL

Showcase the potential of WebGPU for aggregate visualization. Enable users to **filter and aggregate millions of data points in realtime** to explore temperature changes around the world.

The Visualization
Render data as hexagonal bins over a world map. Aggregate visualizations limit the number of data points. Bin recomputation becomes the bottleneck.

CLIMATE CHANGE EXPLORER



BEHIND THE SCENES

Pre-Processing - *Offline Step*
Compression of ~10M temperature entries at 5,165 different locations (Berkeley Earth Local Temperature Dataset).

<< Recompute if time range or grid scale changes **<<**

Aggregation - *WebGPU Compute Pipeline*
Average temperatures per location depending on specified time range.

Binning - *WebGPU Compute Pipeline*
Calculate average temperature per bin. Neighborhood search utilizing a *k*-d tree.

RESULTS

We can maintain **interactive frame rates** with millions of data points. WebGPU's compute and render pipelines can **significantly accelerate the performance of client-side aggregate visualization** compared to state-of-the-art solutions.

Rendering - *WebGPU Rendering Pipelines*
Classical rendering pipelines for the world map and the hexagon overlay.

Min-Max - *WebGPU Compute Pipeline*
Evaluate the minimum and maximum grid values for the color scale. Parallel reduction leads to GPU peak performance.

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