Parallel Algorithms to Recognize Spatial Patterns in Climate Analysis

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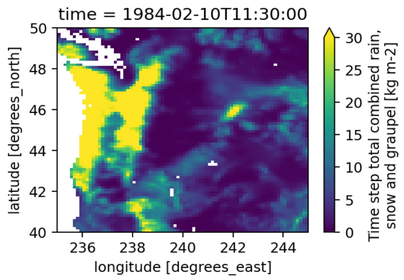
1. PROBLEM

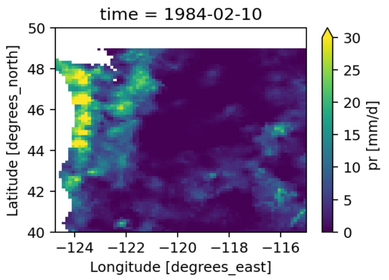
- We use global models to make future climate projections.
- But these models are run on very large scales making them less useful for local scale changes.
- ICAR is developed to downscale these global models so that we can better understand climate change on local scales.

2. SYSTEMATIC ERRORS AND BIAS CORRECTION

- However, there are systematic biases in models like ICAR.
- To correct these biases, there are various computationally expensive statistical methods and algorithms.



ICAR Output (overestimates the precipitation)



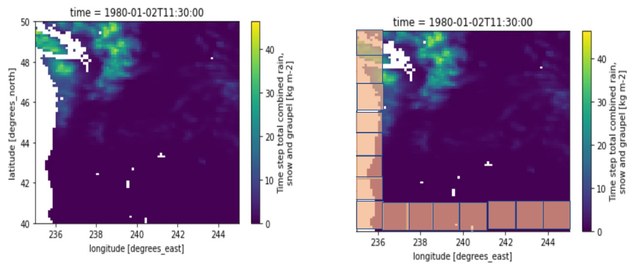
Observations

3. OUR GOAL

- To bias correct spatial patterns in ICAR more efficiently.
- We developed a spatial analog with multiple levels of complexity.
- Since this method is computationally expensive, we accelerated it using high performance computing.

4. EXPERIMENTAL SETUP

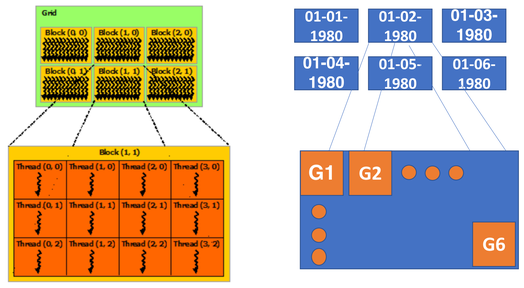
- We corrected the ICAR data for northwest United States from 1980 to 2010.
- **Task:** For every 10 by 10 grid and day, find the day with closest precipitation pattern and insert the corresponding observation to this grid
- **Inputs**: ICAR dataset (dimensions: time, latitude, longitude) and Observation dataset (dimensions: time, latitude, longitude)
- **Output:** Bias corrected ICAR dataset (dimensions: time, latitude, longitude)



Orange boxes represent 10 by 10 grids

5. ALGORITHMS

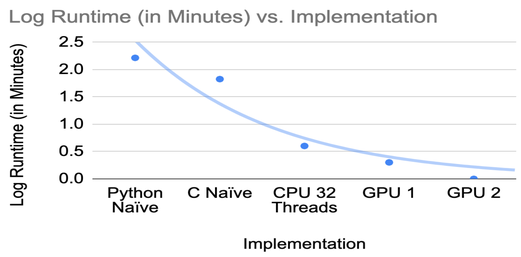
- **Naïve Algorithm:** process each data point sequentially
- **CPU parallelization**: split up the grid work among threads
- **GPU parallelization:** split up both the time steps and grid work among blocks and threads respectively



The figure shows how the work is split up on GPU

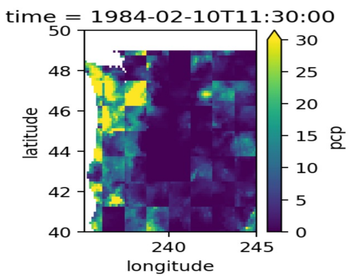
6. PERFORMANCE IMPROVEMENT

- With parallelization the runtime is reduced from 164 minutes to 1 minute

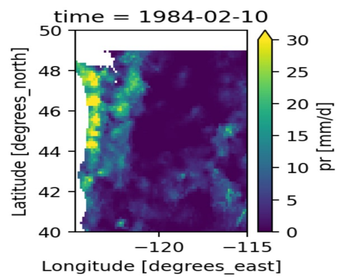


7. CONCLUSION

- The bias corrected output more closely marches the observations and only takes a minute to be generated.



Bias corrected ICAR output



Observations

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