Assignment 3 Question 1

Thinking back to the assumptions for the weather simulation for Assignment 2. What are some of the biggest factors that made the assumptions somewhat unrealistic for current weather simulations?

a) (4 marks) Describe four assumptions and discuss their impact. (roughly 100 to 150 words for each of the assumptions. Estimate the error for each of the assumptions)

Sometimes assumptions are made to slightly make our calculations easier. However, if there are too many assumptions or a big assumption, we can get an error in our final value.

Assumption 1: Each cell has same value calculation

For the two scenarios, we divided the entire area into small cells of equal size. Ontario was divided into $1km^2$ squares and Canada was divided into $10km^2$ squares. While calculating, we just calculated the memory required in one cell, and then multiply it by the total number of cells. What we are assuming here is that each cell probably has the same terrain and exactly same weather. When predicting weather, the supercomputer being used might have more calculations (consider a greater number of data) to do for regions with unstable terrain/higher altitudes.

Estimating the error -

Even though all the factors are floating point and take 8 bits, we can consider that the number of computations happening are +-2% for different cells. So in total it can be assumed, that the average error would be of +-2%.

Assumption 2: Not all factors were considered

We considered only 6 factors that are affecting the weather – wind speed in 3 directions, temperature, pressure, & humidity. However, there are many other factors that affect the weather. For example, amount and kind of cloud cover; amount and kind of precipitation, due point. This means that the amount of data being considered is more, so more calculations. This increases the amount of memory being used. Assuming these new values also as floating-point values – they will all take 8 bits more EACH. Which will create a big difference in the memory used.

Estimating the error -

Let's consider 3 more factors – 8 bits each = 24 bits more. But that is for one cell – so per cell there is 24 more bits. Previously we considered 6*8 = 48 bits. Taking percentage, 50% more bits are being used. Therefore, the value would be 50% more than what we got.

Assumption 3: One model required for prediction

Doing some research on how the weather is exactly predicted, I came across various models that are used for this prediction. These models vary and differ depending on the region & area. Which means, suppose cell 1 uses predictive model type 1, then cell 30 might be using predictive model type 2. However, we did not consider that and assumed the same predictive model is being used for all. These models focus on data analysis and thus predicting the weather with higher accuracy. There are models like statistical models, Atmosphere simulation, climate models & mesoscale models. (Anina OT. (2021, August 21). *How do computers simulate and predict weather.* MakeUseOf. https://www.makeuseof.com/how-do-computers-simulate-and-predict-the-weather/#:~:text=Current%20weather%20forecasting%20models%20can,anything%20further%20in%20the%20future.)

Estimating the error –

The error for this question should more or less be similar to the error we got from the first assumption, because again the models consider the data they get from different areas and regions. So that means, different regions and areas in the various cells is what will give us the error. We can assume that the average error would +-2% for the entire scenario.

Assumption 4: Every Minute/ Per Hour calculation

We assumed that the weather is calculated per minute or hour for both the scenarios. I searched for some information if weather really needs to be calculated that frequently, but no where did it say per minute calculations. Supercomputers used to predict weather can do around 14000 trillion calculations, and mostly internationally accepted time for weather observation are usually midnight & at 6 hourly intervals thereafter. But many stations also take data at hourly intervals. Therefore, we are using unnecessary memory using the memory every minute.

Estimating the error-

Assuming that few stations do hourly intervals – there should be only 24 times the usage of memory. But we made our supercomputer run 1440 times! This means, that only 1.6% of the memory calculated should actually be used per day.

b) (1 mark) Research and find a supercomputer architecture that has been used in the past or is currently used for weather or climate (longer timeframes) prediction. Summarize the characteristics of this supercomputer in your own words (roughly 150 words)

Weather and climate predictions and simulations have been in great demand over the years. The process requires a lot of analyzing of data, integrations of a wide range of interdependent variables and all done over a large geographical area. Such calculations require a lot of memory and processor. This is where supercomputers come in. There are a few supercomputers that have been designed until today. Currently, one of the most powerful supercomputers in the United States is being used for weather prediction. This supercomputer is called 'Summit' and it allows us to perform unprecedented weather simulation over the entire atmosphere of the Earth at a one-kilometer resolution for a four-month season.

Summit has a hybrid architecture, and each node contains multiple IBM POWER9 CPUs and NVIDIA Volta GPUs. In addition it has 4608 nodes and each of them hold over half a terabyte of coherent memory. Summit or OLCF-4 is the second fastest supercomputer after Japan's Fugaku. Some characteristics of Summit includes achieving a peak speed of 200 petaFLOPS, Peak power Consumption of 13 MW and power efficiency of 14,668 gigaFLOPS/watt. This power efficiency makes it the fifth most energy efficient computer in the world.