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Activity #1: Earth's Energy Balance & Climate Sensitivity

2) **Albedo (10 pts)**

Ranges:

Notes/References
0% reflectance; No reflective surfaces on Earth
covered in lava (https://en.wikipedia.org/wiki/Albedo)
Covered in forest canopy (https://earthobservatory.nasa.gov/images/84499/measuring-earths-albedo)
if earth were the moon (https://en.wikipedia.org/wiki/Albedo)
Current reflectivity
Before satilittes to collect data, predicted albedo (https://earthobservatory.nasa.gov/images/5484/earths -albedo-in-decline)
Covered in concrete (https://en.wikipedia.org/wiki/Albedo)
stratocumulis (https://earthobservatory.nasa.gov/images/5484/earths-albedo-in-decline)
covered in ice (https://earthobservatory.nasa.gov/images/84499/measuring-earths-albedo)
cloud coverage (https://earthobservatory.nasa.gov/images/5484/earths-albedo-in-decline)
100% reflectance; Snowball Earth

Indicate current Earth values on your graph> Indicated by red circle

Figure 1. Albedo and Surface Temperature

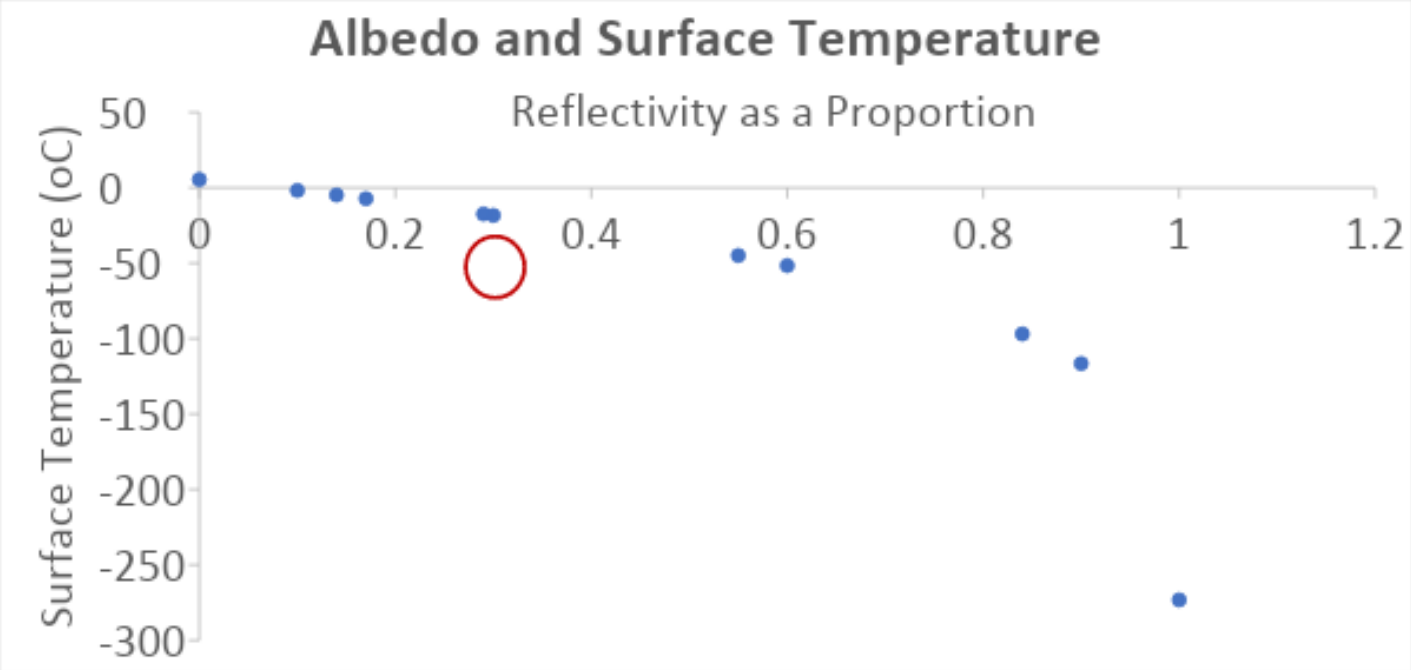
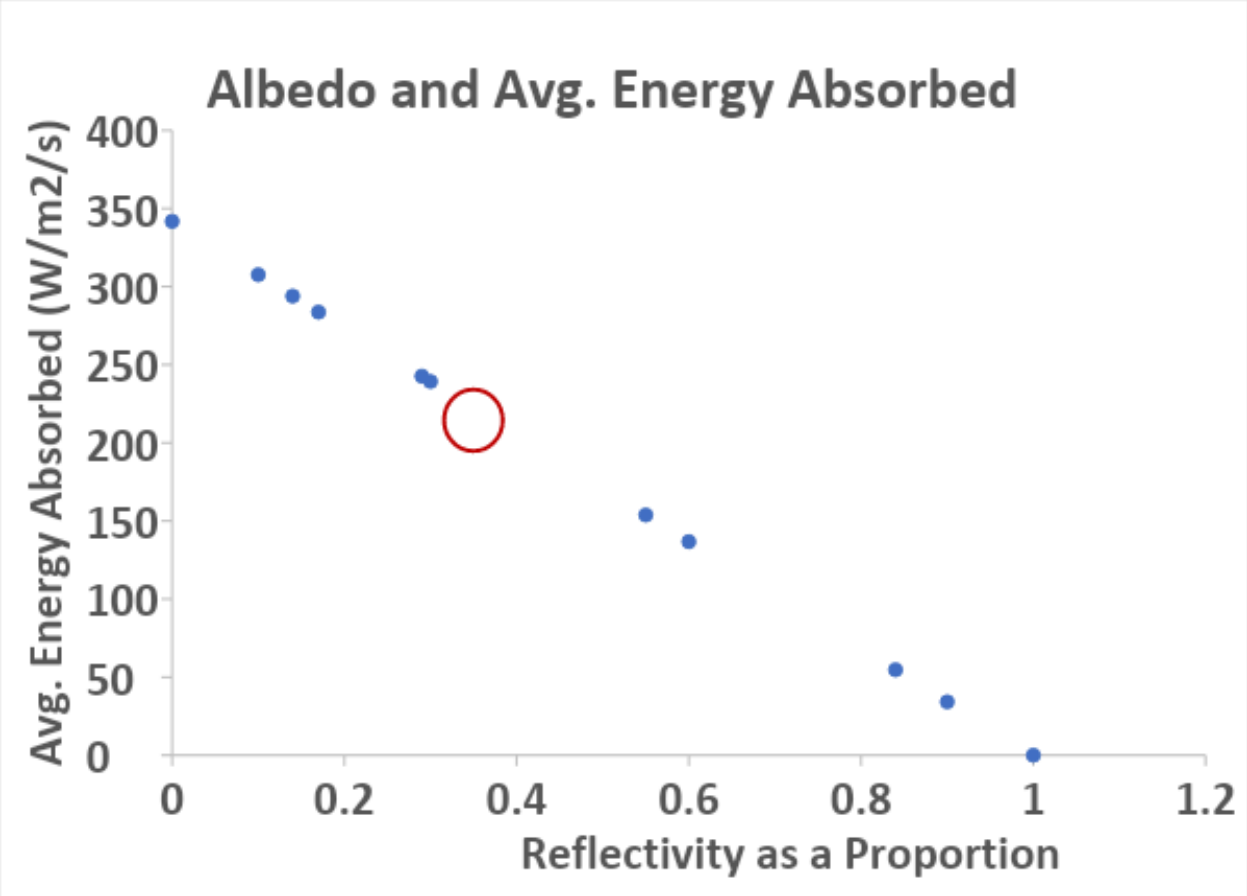


Figure 2. Albedo and Average Energy Absorbed



3) Greenhouse Effect (10 pts)

Ranges:

Notes
No GHGs in atmosphere
1900 conditions (https://www.epa.gov/climate-indicators/climate-change-indicators-us-greenhouse-gas-emissions)
1950 conditions (https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions)
1/27/2021 (https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions)
1979 conditions (https://www.epa.gov/climate-indicators/climate-change-indicators-us-greenhouse-gas-emissions)
Current conditions
2018 conditions (https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions)
2019 conditions (https://www.epa.gov/climate-indicators/climate-change-indicators-us-greenhouse-gas-emissions)
1750 conditions (https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions)
200 million years ago

Indicate current Earth values on your graph> indicated by red circle

Figure 3. Greenhouse Gases and Surface Temperature

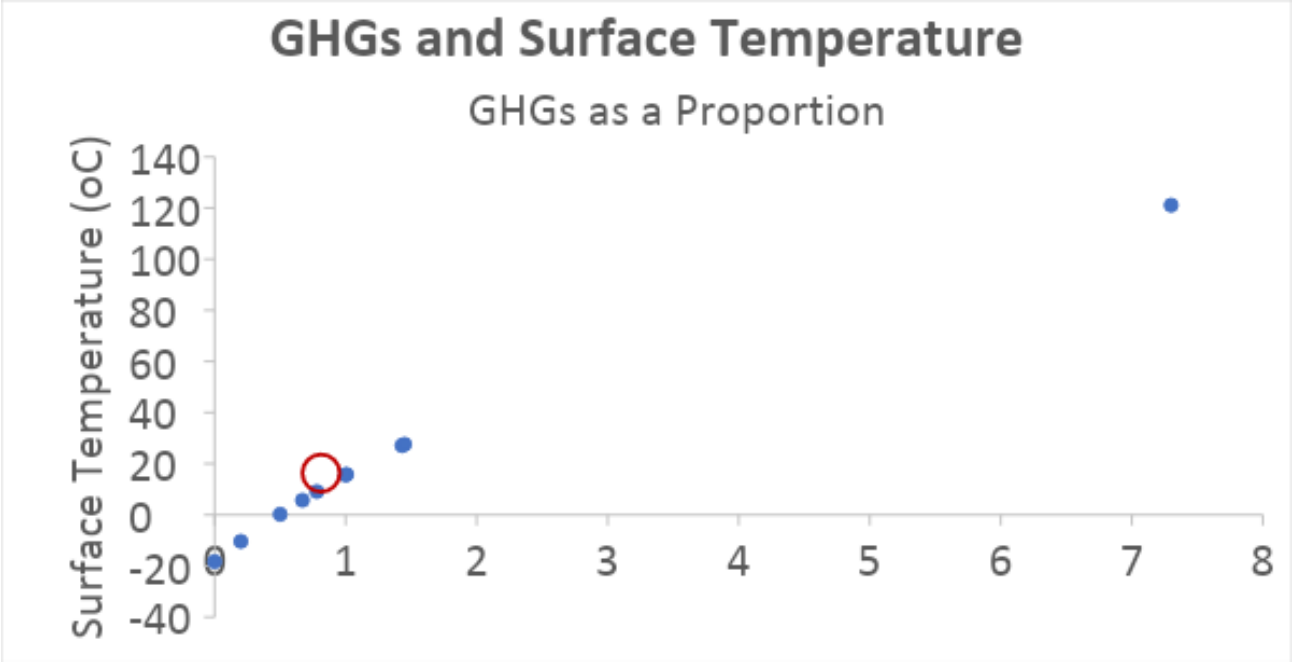
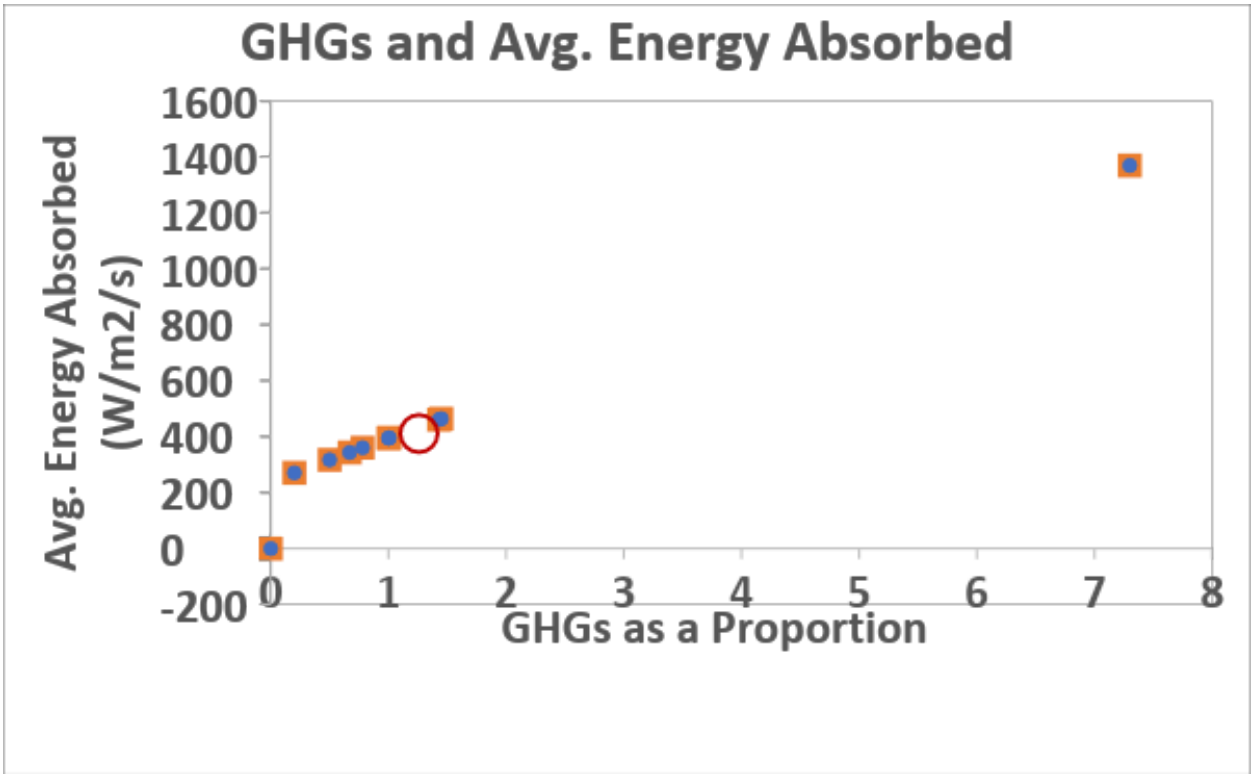


Figure 4. Greenhouse Gases and Average Energy Absorbed



4) **Answer These Questions (10 pts):** [Can discuss/do now or later, together or individually]

a) What do these graphs indicate about current and past climate? Discuss specific trends in the data and reference the figures in your answer.

Albedo and surface temperature show a decreasing proportion as the albedo reaches 1. In past climates, when the albedo was closer to 0, the proportion to surface temperature was lower (Figure 1). As albedo (surface reflectance) is low, it means that more energy can be absorbed. We see this in Figure 2, where albedo and average energy absorption show a very linear decreasing trend as albedo reaches 1, and energy approaches 0. This indicates that past climates with high albedos, like being covered in ice, had low temperatures because the energy was reflected instead of being absorbed. Our current albedo is 0.3, it allows us to absorb energy and warm the planet to a habitable temperature in most areas.

GHGs and surface temperature shows and increase in temperature as the proportion of GHGs increases (Figure 3). This means that as the proportion of greenhouse gases increases in the atmosphere, the temperature increases and effects the climate. Greenhouse gases trap heat and create less opportunities for reflectance; thus, we see an increase in surface temperature. In figure 4, this is also shown through average energy absorption. GHGs and average energy absorption shows an increase in average energy absorbed as the GHGs increase. The greenhouse gases make it so that the energy is not reflected and continues to be absorbed.

b) Given a reasonable range of values for each, which of the two factors you examined (albedo or GHGs) influences climate most directly or rapidly? Explain your reasoning.
The greenhouse gases seem to have a larger effect on average energy absorbed and surface temperature. The smallest increase in GHGs have a significant change in the energy and temperature and this is shown in the models. The data shows a significant trend that is more drastic than that of the albedo, so I think that the GHGs are more rapidly effecting climate.

c) It is likely that your calculated value for the average temperature of the Earth is significantly higher than current conditions (and predicted warming of ~1.6-7°C in the coming century). Why might this be? (watch this video clip from the National Academies to spark some thoughts: https://www.youtube.com/watch?v=hVvzVs1AKGY&list=UUliT4Dc2JUMM6QVhMo0ENrQ&index=2&feature=plcp)

According to the video, many factors are able to influence climate and the current conditions of the Earth. Greenhouse gases and water vapor for example are large factors that are not necessarily accounted for in the equation used to determine the average temperature of Earth. Additionally, this equation used could just be inaccurate because factors like this are constantly changing. It would be very hard to quantify the exact

percentage of greenhouse gases that are present. Also, the video mentions that the lifespan of the greenhouse gases differs so if the data being collected is older it may be an inaccurate depiction of our climate now. It is good to use this as a model as long as we acknowledge the gaps in its calculation. Also, we talked in class about how many devices used to catalog temperature are often not very accurate, so it becomes even more difficult.

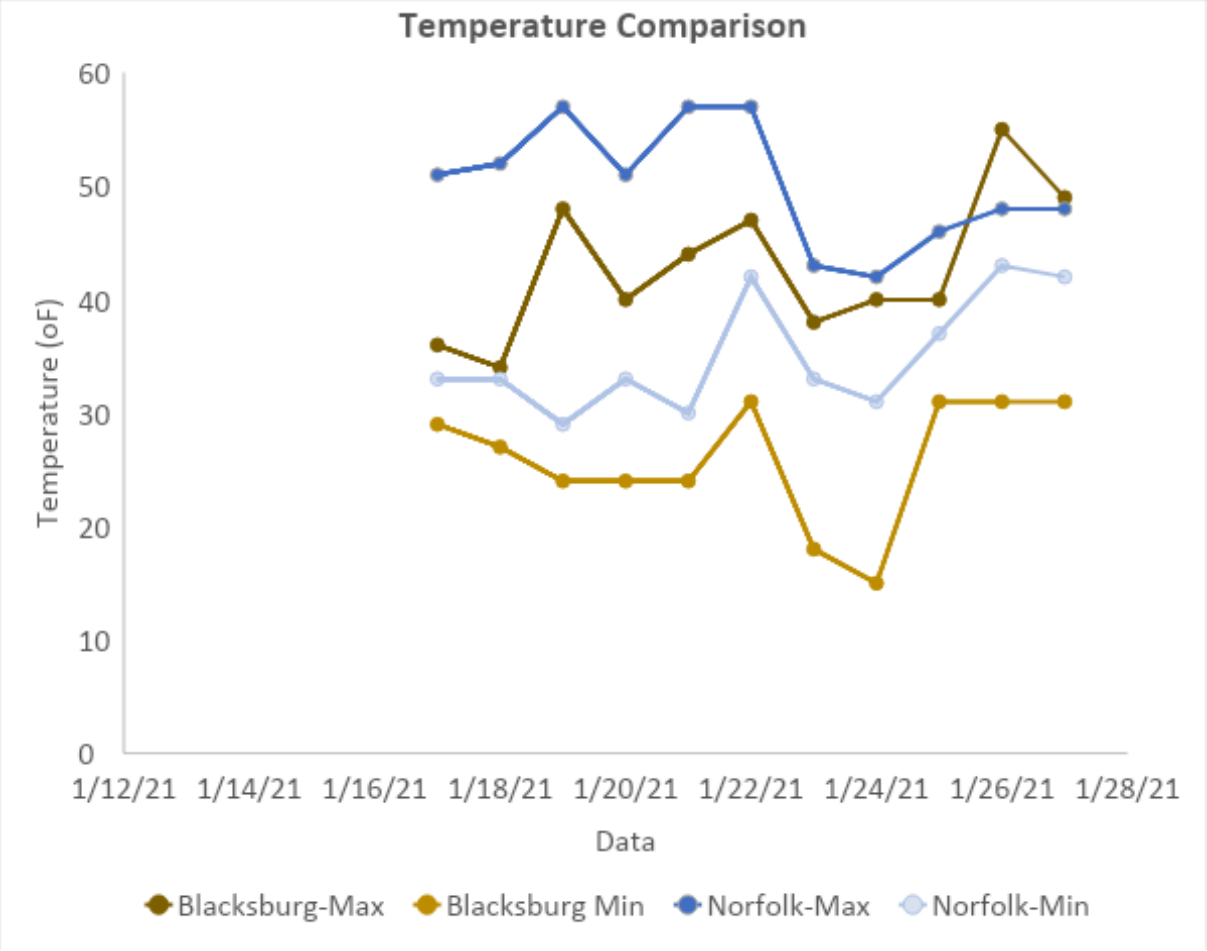
d) Think for a minute about the role of clouds. Why are clouds one of the most unpredictable pieces of the climate prediction puzzle?

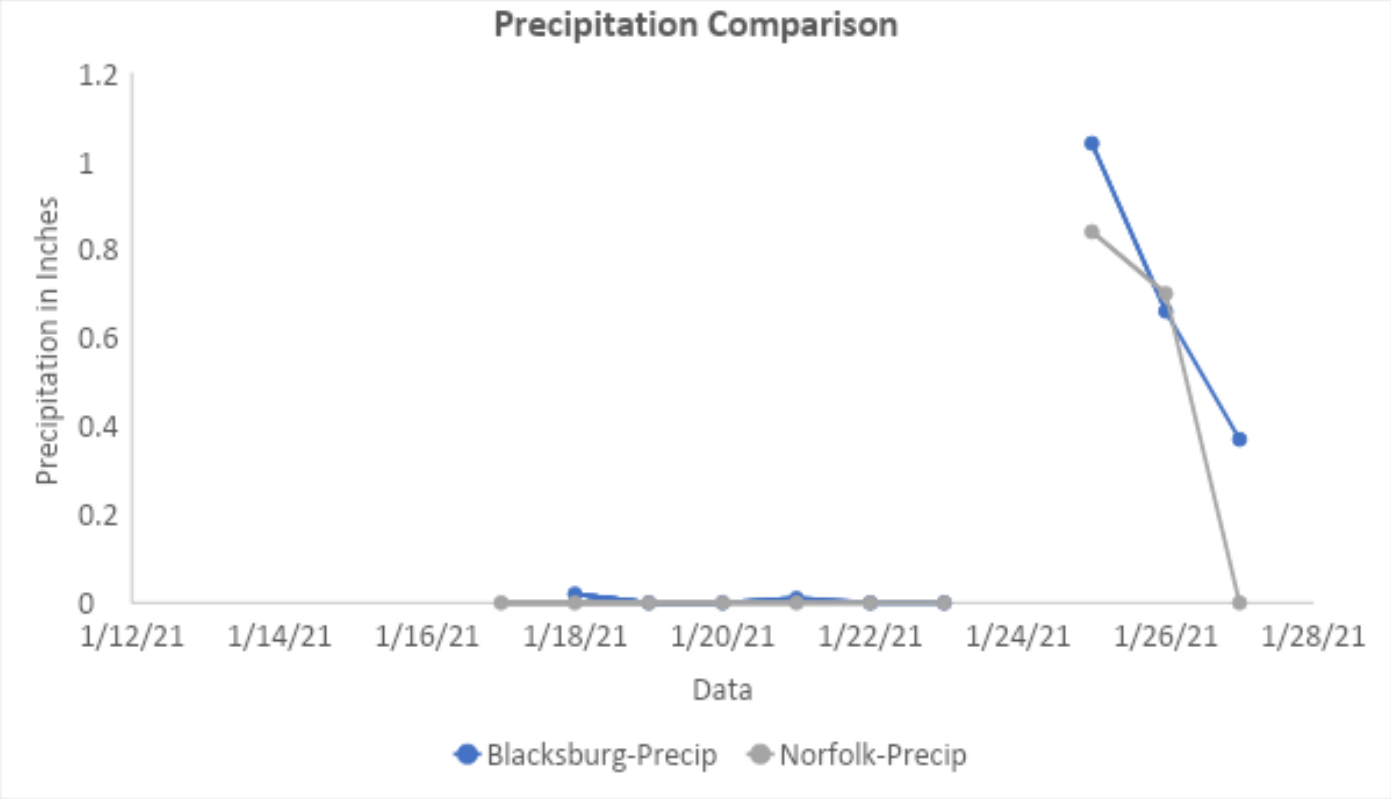
Clouds prevent energy from reaching the surface of the earth and since they occur in random patterns it is difficult to know how little or how much they will affect temperature. They move constantly as well meaning that the time the energy has to reach the surface is also unpredictable. They do however block a lot of energy, so it is important to try to estimate the amount of energy lost because of clouds. Even if energy can make it through, it will not be as much as if the cloud was not there. Very tricky!

PART II: MESO-SCALE CLIMATE DRIVERS [Can do now or later, together or individually]
In this part, you will compare weather reports for the past 10 days for Norfolk, VA and Blacksburg, VA, and think through what meso-scale climate drivers might explain the differences.

1) Instructions (10 pts):

- Navigate to www.weather.gov, click on "Past Weather", click on eastern Virginia
- Select "Preliminary Monthly Climate Data", and set the Location
  (use 'Climate Locations' tab to navigate to other locations)
- Select "Archived Data" and the appropriate month, then select "Go"
- Copy out Max and Min temperature data, and precipitation data (WTR) into Excel
  (May be easier to cut and paste as a table from a pdf)
- Plot temperature data and precipitation data by day (make two graphs)
- Repeat the process for location two. Add location two's data to your graphs.


Temperature Comparison
60
50
40
30
20
10
0
Temperature (oF)
1/12/21
1/14/21
1/16/21
1/18/21
1/20/21
1/22/21
1/24/21
1/26/21
1/28/21
Data
Blacksburg-Max
Blacksburg Min
Norfolk-Max
Norfolk-Min



2) Answer These Questions (10 pts):

a) How different were the average maximum and minimum daily temperatures over the last 10 days? What about average daily precipitation?
The average maximum temperature for Blacksburg was 48 and the maximum temperature for Norfolk was 57. This numbers are very different. The minimum for Blacksburg was 34 and the minimum for Norfolk was 42. These are also very different. The precipitation was higher for Blacksburg with 1.04 inches in one day, where Norfolk was 0.84 inches in one day. In the same state there are significant differences in average temperature and precipitation.

b) How might meso-scale climate drivers explain these differences?
Norfolk is located closer to the water and it is Winter which means the water should have a warming effect on the land. Blacksburg is landlocked so we would not expect the water to have any effect on the land there. Blacksburg is located on the leeward side of a mountain range so we would expect a cooler temperature and an increase in precipitation because of adiabatic cooling.

c) Were the pattern(s) what you anticipated? If not, why might that be the case?
These patterns were followed because comparatively, Blacksburg had lower temperatures than Norfolk did. Blacksburg also had more precipitation then Norfolk did as well. This can be explained because of the location of Blacksburg near the mountain range and Norfolk near the ocean. This might not be entirely accurate however because there were several days for Norfolk when the precipitation was not observed so there are some data missing. Still, from what we have it shows a consistent trend with the meso-climate drivers.

WHAT TO TURN IN: [turn in work individually even if you worked with a partner]

Part I: Albedo and greenhouse effect graphs
A note on the sources for the ranges used
Answers to the 4 questions [a few sentences each is sufficient]

Part II: Temperature and precipitation graphs
Answers to the 3 questions [again, a few sentences each is sufficient]

All answers should be typed, with graphs pasted into the word processing text. Write in complete sentences and proofread to make sure your work is complete and coherent. Upload document to Canvas.