SIO 15 (FQ 2024) – Homework #8 Due November 26, 2024 5 pm
Maximum score: 20 points + 0.5 bonus
NO LATE SUBMISSION BEYOND TUESDAY MIDNIGHT POSSIBLE
-2 point penalty for late submission (more than 30 min past due date), regardless of the reason.
Divide by 4 for contribution to total cumulative

ANSWERSHEET

Topics 20 - 22

1) Arctic Sea Ice decline. Click on the image in the lecture notes and follow the link to Wikipedia. Scroll down To the graph in question.
   a) What was the sea ice volume in April and September in 1980? (include units!) (0.5 pt)
   b) What was the volume for the two months in 2000 (include units!) (0.5 pt)
   c) Taking the 1980 values as baseline, by how much, in percent, did sea ice decline for the 2 months between 1980 and 2000? (0.5 pt)
   d) Now do the same as in b) and c) but for the year 2017 instead of 2000. (0.5 pt)
   (2 points total)

   a) about 33,000 km^3 (April) and 17,000 km^3 (September);
   also accepted: 32,000 km^3 for April; 16,000 km^3 for September
   -0.25 pt if the unit or the *1000 is missing (e.g. 34 km^3 receives only half credit)

   b) about 27,000 km^3 (April) and 12,000 km^3 (September);
   also accepted: 27,400 km^3 for April; 11,000 km^3 for September
   -0.25 pt if the unit or the *1000 is missing (e.g. 27km^3 receives only half credit)

   c) April: 14.4% decline or -14.4% (accepted range: 13 – 16%)
   September: 31.2% decline or -31.2% (accepted range: 30 – 33%)

   d) April 2017: 21,500 km^3. (21,000 also accepted) September 2017: 4,500 km^3 (4,000 also accepted)
   decline: April 34.8% decline or -34.8% (accepted range: 32 – 36%)
   September 73.5% decline or -73.5% (accepted range: 72 – 77%)

2) Work with the same chart as discussed in #1
   a) Make a table with three columns. Place the name of the categories in the top row: year, volume April in 1000 km^3, volume September in 1000 km^3 (0.25 pt)
   b) Tabulate the data for the following years: 1980, 1990, 2000, 2010, 2017, 2020 (0.75 pt)
   c) Access the PIOMAS website of University of Washington at
   https://psc.apl.uw.edu/research/projects/arctic-sea-ice-volume-anomaly/
   Work with Figure 2. The graphed values are supposed to be from an updated study. Add a line in your table and log the values for 2017 for April and September. (0.5 pt)

d) Discuss the difference in the values for both months in 2017 between what you get here and what you have in problem #1. (0.5 pt)
e) Using both Figure 2 and Figure 4, compare the April and September values for 2017 with those of 2024. It is recommended that you add a line in your table and log the 2024 as you have done for previous years. For which month has sea ice recovered, for which did it diminish going from 2017 to 2024? (0.5 pt)
(2.5 points total)

a)-b)
Table

year	volume April 1000 km^3	volume September 1000 mk^3
1980	33	17
1990	30	14
2000	27	12
2010	24	5
2017	21.5	4.5
2020	22.5	4
2017*	20.8	4

***c) added line from Figure 2**

a)/b) -0.75 pt if any other years are included

c) accepted range for April (20-21)
d) there is not much difference but the new value for April seems to be lower
e) April: 2024 is significantly higher (suggesting that winter ice has recovered)
September: 2024 is lower so extent of summer ice has declined

3) Work with Google Earth hw8-arctic-ice.kmz file. This kmz file comes from the U.S. National Ice Center. You will have to turn on and off some of the entries on in the 'Places' tab when comparing ice cover on September 16 for the years 2017 and 2024. The kmz file shows the sea ice extent with various stages, where red colors indicate the thickest, most stable pack ice (over 80% ice) and blue colors mean no ice (< 10% ice).
a) Find Prudhoe Bay, Alaska. With having the 2024 cover checked under 'Places', how far from there was the nearest marginal ice? How far was the nearest full-cover/thickest pack ice? (error margin: 70km) 0.5 pt
b) What are the values for 2017 (uncheck the year 2014 under the 'Places' tab. (error margin: 70 km) 0.5 pt
c) Find Svalbard and use the bottom of that placemark. How far from there was the nearest marginal ice (green) in 2017? How far was it in 2024? (error margin: 20 km) 0.5 pt
d) Now find Prince of Wales Island, Nunavut, Canada. Zoom out, if necessary, until you see Steffanson Island to the northwest. In 2024, what was the color/fraction of ice cover in the bay between the two islands? What was it in 2017? 0.5 pt
(2 points total)

a) marginal ice: 650 km accepted range: 580 – 720 km
full-cover ice: 854 km accepted range: 784 – 924 km
-0.25 pt for missing units
b) marginal ice: 355 km accepted range: 285 – 425 km
full-cover ice: 680 km accepted range: 610 – 750 km
-0.25 pt for missing unites
c) 2017: 430 km accepted range: 410 – 450 km
2024: 430 km accepted range: 410 – 450 km
d) 2024: barely bright green/marginal ice
2017: up to red; full ice cover

4) a) Apart from water vapor, which two gases contribute most to Earth's greenhouse? What is their relative contribution? (0.5 pt)
b) Which gas is third? Where does it come from? (0.5 pt)
c) In one sentence, explain what radiative forcing is? (0.5 pt)
d) Explain the radiative forcing of ozone in the troposphere and stratosphere. (0.5 pt)
(2 points)

a) CO2 60%; CH4 16%
b) CFCs; exclusively anthropogenic
c) relative contribution of a substance to global warming (cited from lecture slides)
also accepted: ratio of radiant energy received from the Sun and reflected back out;
difference of radiant energy received by Earth and energy reflected back to space
(cited from class notes)
d) radiative forcing is positive in both cases

5) a) During the last ice age, how was sea level different from today? Also add a number with unit. (0.5 pt)
b) How do scientists infer past climates from ice cores in Greenland and Antarctica, i.e. which part of the ice core is analyzed for which chemical compound? (0.5 pt)
c) Compare the duration of cooling going into an ice age vs warming at the end of an ice age. (0.5 pt)
d) Explain the cause for this difference. (0.5 pt)
(2 points total)

a) sea level was 130 m lower; also accepted: sea level was about 100 m lower
-0.25 pt if unit is missing
b) they analyze air bubbles trapped in the ice; they analyze the concentration of CO_2 and infer the climate when the ice was formed
c) cooling occurs slowly, warming is rapid
d) warming feedback mechanisms are stronger than cooling feedback mechanisms
NB: the mentioning of positive and negative feedback is wrong here

6) a) What are the main three NATURAL causes for a temperature increase in the last 150 years? Provide the causes and the possible temperature increase. Do not list anthropogenic contributions, including it will result in a reduction in points! (0.5 pt)

b) What is a possible natural cause for a drop between 1940 and 1970? (0.5 pt)
c) What is a possible cause for a drop in the early 1970s? (0.5 pt)
d) What is a possible natural cause for an increase since 1976? (0.5 pt)
(2 points total)

a) millennial warming (< 0.02°C); solar warming (0.2°C); lack of volcanism (exact number unknown)
-0.25 pt for missing numbers;
-0.25 pt if industrial revolution is listed as 4th cause
b) drop in solar activity
c) energy crisis
-0.25 pt for change in sunspot cycle
NB: a possible contribution from changes in solar output is possible but nearly insignificant
d) no natural cause

7) a) By how much has global sea level risen in the last 100 years? (0.5 pt)
b) What are the four main contributions to global sea level rise? Also provide the amount of contribution for each. (0.5 pt)
c) How does the melting of sea ice contribute to global sea level rise? (0.5 pt)
d) What is the realistic range of predicted sea level rise for the next 100 years? (0.5 pt)
(2 points total)

a) 15 cm (also accepted: about 1 ft)
-0.25 pt if unit is missing
b) thermal expansion (30%); melting of glaciers (20%); melting of Greenland ice sheet (20%); melting of Antarctic ice sheet (exact number unknown)
-0.25 pt if only three answers given
-0.5 pt if only two answers given
c) has no effect
NB: floating sea ice already displaces the sea water corresponding to the weight of the sea ice; so the Melting of the sea ice does not add weight, so does not raise sea level.
However, the melted water will undergo thermal expansion as it warms, and so will lead to a rise in sea level.
+.25pt for recognizing and mentioning this effect
d) between 40 and 100 cm
-0.25 pt if unit is missing

8) the Keeling Curve:
go to https://www.esrl.noaa.gov/gmd/ccgg/trends/

choose "trends in CO2", then Mauna Loa, then go to the interactive plots tab

a) Make sure to distinguish between the actual CO2 value (red) and the trend (blue) value.
Working first with the trend values, log the measurement for March 1958 and October 2024? (include units) (0.5 pt)
b) Compute the difference. Include units (0.25 pt)

c) Using the value for 1958 as the base, by how much is percent has the CO2 level increased? (0.5 pt)
d) Zoom in so that you see seasonal variations better. Log the values for October 2011 and May 2012 and determine the difference. Include units. (0.5 pt)
e) How does the difference under c) (seasonal variations) compare with the difference under b) (overall increase in the last 66 year)? (0.25 pt)
(2 points total)

a) March 1958: 314.44 ppm; October 2024: 425.65 ppm
-0.25 pt for missing units or one wrong number
b) 111.21 ppm
-0.25 pt for missing units (i.e. no credit for a correct number without unit)
c) 35.4 % also accepted: 35%
d) Oct 2011: 389.19 ppm; May 2012: 396.93 ppm; difference: 7.74 ppm (also accepted: 8 ppm)
-0.25 pt for missing units or the wrong difference
e) this difference is much smaller than the difference in the trend under b)

9) Use the same webpage as in 8). Choose trends in CH4
a) What was the value in July 2024? include units (0.25 pt)
b) Estimate the value for 1984. include units. (0.25 pt)
c) Using the 1984 value as baseline, determine the percentage increase for the 2024 value under a). (0.25 pt)
d) From the panel on the left, estimate the range of seasonal variations. For most consistency, use summer 2022 and the following winter in 2023. Include units. Careful here! To make an accurate estimate, you have to take into account the strong overall increase! (0.5 pt)
e) CH4 did not increase steadily. Which year between 1984 and 2024 has seen the biggest year-to-year drop in CH4? (0.25 pt)
f) Go to Wikipedia and search for atmospheric methane. Find that cause for the drop in methane under d). (0.5 pt)
(2 points total)

a) 1921.33 ppb
-0.25 pt if unit is missing (i.e. no credit for correct number without unit)
b) 1635 ppb accepted range: 1630 – 1640 ppb
-0.25 pt if unit is missing (i.e. no credit for correct number without unit)
c) 17.5% accepted range: 17.2 - 17.8 %
d) about 15 ppb accepted range: 13 – 17 ppb
-0.25 pt if unit is missing (i.e. no credit for correct number without unit)
NB: the actual difference is about 20 ppm; but the difference in the overall trend (5 ppm) needs to be subtracted
e) 2004
f) scientists have been unable to explain the decrease

10) Go to https://earth.nullschool.net. Upon first opening, you will see the current global winds. Choose the date 11/19/24 14:00 PST/22:00 UTC

a) There is a large/strong storm approaching the Pacific Northwest. Log the coordinates of the center of the storm. (0.5 pt)

b) Where relative to the center do we find the strongest winds? Log the highest wind speed? include units (0.5 pt)
c) Choosing the ocean mode and wave height (HTSGW) as overlay, what is the wave height in that area? include units (0.5 pt)
d) The storm has a strong advancing front. Given temperatures at an altitude corresponding to 850 hPa, what kind of front is this? (0.5 pt)
(2 points total)

a) 46.2 deg N; 131.9 deg W
b) to the south (also accepted: to the east); 116 km/h accepted range: 114 – 116 km/h (71 – 72 mph)
c) 8.4 m; accepted range: 8.00 -8.46 m
-0.25 pt if unit is missing (i.e. no credit for correct number without unit)
d) cold front

NB: the storm that you tracked here later turned out to be a monster of a storm. Weather experts at the NWS as well as news media talked about a bomb cyclone, as storm that intensified explosively in a span of only 24h. In fact, some experts even downplayed that this would be a once-a-decade storm. At some point, the surface air pressure was low, that the storm would have been a category 3 or 4 if it had been a hurricane. The center of the storm made landfall in the Pacific Northwest and caused significant wind damage in Washington state. The storm had a very long cold front where the jet stream blew along that front. In the process, it brought vast amounts of subtropical marine moisture, which caused an atmospheric river event that drenched northern California and caused wide-spread flooding. The storm claimed 2 lives. Watch an early report of the storm on CNN at https://www.cnn.com/2024/11/20/weather/bomb-cylone-west-coast-washington-climate/index.html

…. and yes, there is a typo in the name of that link, but it works!