

Climate Connections – Background information

Atmospheric CO₂ Levels – What is normal about change? What is not normal?

Before you begin:

1. Think about these questions and record your answers on your own paper or on the back of this page.
 - a. What is climate and what is weather?
 - b. How would you describe the climate in your own town?
 - c. Does climate have any direct effects on your life? Does the climate change? (Ask your parents or grandparents about climate changes they can recall?)
2. Brainstorm and record some ideas for this essential question:
 - a. How can we study climate changes?
 - b. What pieces of evidence can we look for to see how the Earth's climate has changed over decades, centuries, and millennia?

Background:

Scientists travel the world to collect long, continuous ice cores from ice caps, ice sheets, and glaciers, wherever they exist on our planet. They do this as part of a “rescue operation”, to collect the thick sequences of ice that contain-- layer after layer -- information about the climate of the past. The cores are collected using special drilling equipment that doesn't melt the ice. The core cores have to be stored and transported so they don't melt in transit to a core repository for study. One of the largest ice core storage facilities in our country is located in Denver at the US Geological Survey (<http://niel.usgs.gov/index.html>).

Objectives:

During this activity, you are asked to graph and analyze CO₂ data from Dome C of the EPICA Ice core project in Antarctica to determine how we can use these data to determine the human impact on green house gas emissions and resulting global warming.

Vocabulary:

Stable isotope
Firn
Snow metamorphism
Amplitude
Frequency

Materials:

- Rulers
- Graph paper
- Pencils

Procedure:

1. Among the other common indices of atmospheric change we can measure from ice cores are changes in green house gases (carbon dioxide, methane and water vapor, etc). Well-mixed atmosphere routinely becomes trapped in snow and firn (i.e., ice with a density less than 0.4 gram/cm³ or between 0.4 and 0.83 grams/cubic cm) and this continues until the firn becomes ice (density . 0.83 gms up to 0.91 gms/ cm³) and all of the air passages in the firn pack are closed off. Continuing compression of this glacial ice does not displace this trapped gas (fossil air), rather the gas is increasingly compressed into tight miniature ice bubbles. Hence, if we were to measure the gaseous contents of these bubbles trapped as “fossil air” in ancient layers of ice, we could use these data to determine past changes in CO₂ —esp. during times prior to the influence of humans and during natural shifts in Earth’s climate, so that we can be in an informed position to determine the real impact of humans on the Greenhouse gas content of our modern atmosphere.
2. If we measured the CO₂ trapped as fossil air in ice cores from Greenland and Antarctica would the gas content be the same or different? Why?
3. Scientists routinely compare the CO₂ content in ice cores with the isotopic composition of the enclosing ice to determine from the isotopes of oxygen a measure of past temperatures. This way they can evaluate the relationship between CO₂ and both regional and global temperatures. Table 1 shows the CO₂ concentration of ice and the ages of the ice sampled from Vostok Station in East Antarctica (The coldest recorded temperature on Earth, -128.6°F (-89.2°C) was measured here on July 21, 1983). Plot the CO₂ column versus ice “age” and connect the points on a sheet of graph paper from Table 1

Analysis:

- a. Look at the graph and describe what you see.
- b. What are the average highest and lowest values for CO₂? When did they occur in time?
- c. Is there a cycle to the highs and lows? Roughly how far apart are the highest highs?
- d. Now plot on the same scale the temperature versus ice “age” and connect the points on a sheet of graph paper.
 - What is the relationship between CO₂ and global temperatures?
 - What is the normal range of seasonal variability? (over the past 1ka, 100ka, 600ka)
- e. Now look at the atmospheric CO₂ measured in the atmosphere by Ralph Keeling on Mauna Loa since 1955 (chart below).
 - What causes seasonal changes in GHGs? Why is there a pattern?
 - What is the current level of CO₂ in the atmosphere today?
 - Is this value in the normal range of your data from Vostok?

- How much of the modern greenhouse gas change is natural and how much of it is clearly “us”?
- What can we do about CO₂? List some ideas you have or what you have heard discussed in the media or in the news.

Extensions:

1. Read and discuss “Global temperature change” by Hansen et al, 2006 from Proceedings of the National Academy, Sept. 25, v. 103
2. Research and examine how temperature and CO₂ relate to one another in Greenland Ice sheet and compare this record to Antarctica.

References:

Hansen, J., Mki. Sato, R. Ruedy, K. Lo, D.W. Lea, and M. Medina-Elizade 2006. Global temperature change. Proc. Natl. Acad. Sci. 103, 14288-14293, doi:10.1073/pnas.0606291103.

Keeling, Charles D. (1998). "Rewards and Penalties of Monitoring the Earth." Annual Review of Energy and the Environment 23: 25-82.

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Tabelle 1: CO₂ level and age of Vostok ice core. (plot every 4th pair for about 35 points)

<u>Gas age</u>	<u>CO₂ (in ppmv)</u>		
2342	284.7	105213	236.9
3634	272.8	106203	230.7
3833	268.1	108308	238.2
6220	262.2	108994	245.7
7327	254.6	110253	251.3
8113	259.6	111456	256.8
10123	261.6	112577	266.3
11013	263.7	113472	261.4
11326	244.8	114082	274.6
11719	238.3	114738	273.3
13405	236.2	116175	262.5
13989	225.3	117519	267.6
17695	182.2	118396	273.8
19988	189.2	119273	272
22977	191.6	120002	265.2
26303	188.5	120652	277.7
27062	191.7	121961	272.2
31447	205.4	122606	276.5
33884	209.1	123815	268.7
39880	209.1	123858	266.6
44766	189.3	124306	266.3
47024	188.4	124571	279.8
48229	210.1	124876	277.2
49414	215.7	125746	273.8
51174	190.4	126023	267.1
57068	221.8	126475	262.5
57799	210.4	126809	262.6
63687	195.4	127445	275.4
65701	191.4	128300	274.1
66883	195	128399	287.1
72849	227.4	128652	286.8
75360	229.2	129007	282.7
78995	217.1	129411	264.1
80059	221.8	129755	263.4
82858	231	130167	259
84929	241.1	131789	240.4
85727	236.4	133334	224
86323	228.1	134205	208.9
87180	214.2	135003	204.6
88051	217	135683	198.1
89363	208	135976	201.8
91691	224.3	136359	202.5
92460	228.4	136659	195.9
95349	232.1	137383	194.4
99842	225.9	137694	193.4
100833	230.9	138226	190.2
101829	236.9	139445	192.3
103372	228.2	141312	196.5



142357	190.4	224630	236.9
145435	197	225299	234.5
150303	191.9	225509	233.1
154471	189	225888	224.5
155299	185.5	226710	232.4
160494	204.4	227384	233.9
162996	191.6	227840	241.7
165278	183.8	230703	245.2
169870	197.9	231382	252.2
172596	197.8	231990	241.4
175440	190.3	232570	247.4
176271	190.1	233102	243.1
178550	207.7	233646	239.2
180779	213.2	234126	245.7
181617	217.7	234470	245.9
183355	199.8	234781	247.4
185063	203.5	235213	252.9
187199	210.7	236236	259.8
189335	231.4	237831	279
191057	231.5	238935	263.8
192632	218	239250	252.4
195625	220.1	239545	249.9
199025	242.6	240201	230.4
202212	251	240577	219.4
203191	239.1	242068	214.7
204283	247.7	243653	200.2
205148	244.4	244215	213.9
205715	232.2	244863	195.4
206119	228.7	245483	196.7
207991	238.2	247447	199
209414	242.2	248087	201.9
210022	244.6	248980	204
210830	247.3	250461	203.9
211005	252	251521	209.7
212281	257.4	252959	208.9
214153	251.2	253880	214.7
215041	241.4	255233	228.2
215593	240.3	256053	199.9
215879	242.7	256501	211.7
216459	247.5	257247	188.7
217009	251.7	258477	194.2
217271	251.2	259228	198.9
217676	245.4	259958	184.7
218342	240.5	260754	190.4
219680	212.2	261595	193.9
220182	216.2	262411	194.2
220760	207.2	263207	198.4
221054	208.9	264046	193.2
221612	205.7	264834	202.2
222958	203.4	266492	211
223446	215.7	267434	215.4



268679	223.7	322111	282.4
270680	231.4	322582	289.2
273012	226.4	322827	288.4
274445	230.4	323485	298.7
275218	231	324189	278.2
277925	220.4	324991	285.8
278602	217.2	325527	278.7
279543	207.7	326239	270.5
282301	212.7	327114	255.7
283492	213.2	328097	241.9
286217	224.4	329267	239.7
287846	236.2	330208	234.2
290571	240.2	332293	250.2
291769	240.7	333627	200.7
292474	250.2	335290	205.2
293676	244.9	336972	204.9
294615	225.9	340165	220.4
295849	227.9	342998	221.2
297131	233.2	344735	216.2
298051	237.9	347610	209.2
299020	239	350765	193
299877	241.9	352412	186.2
300646	251.7	356838	201.2
301496	256.8	359688	206.4
302456	257.2	362766	201.9
303334	246.9	366221	214.7
303953	272.7	369563	229.7
304590	251.7	373014	227
305306	244.7	374561	240
307131	255.9	378194	246.9
308101	249.2	379633	245.9
310039	256.3	384909	264.7
310930	260.4	386579	259.3
311774	260.3	390589	255.2
313493	266.3	392451	250.2
315143	266.2	394628	266.3
315940	270.2	396713	274.7
316681	271.9	400390	278
317445	275.2	405844	279.7
318980	265	409022	283.7
319754	271.8	410831	276.3
320378	272.7	414085	285.5
321386	273.2		