

CO₂ Monitoring Report FY22
By Colin Strickland



Lighter “ghosting” in high CO₂ in Ireland's Cave

City of Austin Balcones Canyonlands Preserve – Austin Water (AW)



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Introduction

Some Central Texas caves are known to have high levels of CO₂ during certain times of the year, with generally higher levels in the hotter months and lower levels in the cooler months. Some of these caves are utilized for public tours, and some are inhabited by rare karst invertebrates and require faunal surveys, so knowing when CO₂ levels are lower is important. To better understand how CO₂ levels vary and how the caves ventilate, CO₂ meters, temperature/barometric pressure data loggers and anemometers were set up in Grassy Cove Cave, Ireland's Cave and Whirlpool Cave by ZARA Environmental LLC (Figures 1-3). The pulling of data and maintenance of this equipment was transferred to The City of Austin Balcones Canyonlands Preserve (COA BCP) in late 2021. This report only covers new data that was pulled since the transfer, but some extends farther back into early 2021 since the devices held old data and everything was pulled when we took over monitoring.

Methods

CO₂ levels were measured in Ireland's and Whirlpool using Vaisala GM70 hand-held CO₂ meters logging at 3-hour intervals. This allows the data to be pulled every 35 days or so with some battery life remaining. Previously ZARA had three GM70s and would switch the Ireland's meter with a fresh meter, go to the office and charge that it, then later that day take it to Whirlpool and swap it out with the one in there. One of the GM70s succumbed to the humid cave environment and is no longer functional. Failure of one of the GM70s and accidentally deploying not fully charged units caused gaps in data seen in the graphs below. A new method was developed that involves pulling the remaining two GM70s from the caves, charging them at home overnight, and redeploying the next morning. It takes twice the trips, and you lose a day of data, but the results show there were no data gaps after the new method was adopted. Grassy Cove CO₂ levels are collected using a Vaisala GMP252 CO₂ meter connected to a Vaisala Indigo 201 Analog Output Transmitter and DL4000 Universal Data Logger by a communication cable going up through a borehole. CO₂ levels are recorded at 5-minute intervals since a solar panel provides power to the station. This data only goes through November which was the last time data was pulled. Temperature and barometric pressure were recorded in all three caves with Onset Hobo Barometric loggers. Cave airflow speed and direction were meant to be measured by ATMOS-22 Sonic Anemometers, but unfortunately it was discovered that the devices in both Ireland's and Whirlpool had been recording nothing but null values since before ZARA transferred them to COA BCP. The meter in Grassy Cove that was still working had been sabotaged by a mouse or rat that had chewed through the foam that held it vertical and oriented north. It was repositioned vertical, but a compass was needed to orient it correctly. On a return trip it was then oriented North, but when the data was later pulled near the end of 2022 it was found that it had only recorded for a couple weeks before it too started recording null values. The anemometers from Grassy Cove and Whirlpool have

been removed and will be redeployed with new CR300 data loggers and improved dry boxes to hopefully stop these errors. None of the airflow data was used in this analysis. A future analysis will utilize all the data collected by ZARA, but time limitations led to only analyzing the new data. The regressions of CO₂ level and barometric pressure for Ireland's and Whirlpool below were done by using an excel formula to convert the 30-minute barometric pressure intervals to the 3-hour intervals that the CO₂ meter was recording. Many of them lined up perfectly since the CO₂ meters were recording on the hour every three hours, but sometimes the recording interval was not on the hour such as this: 1:36, 4:36, 7:36, 10:36, etc. In these cases, the closest barometric reading before or after the CO₂ reading was used. So, there was no more than a 15-minute discrepancy between any readings. In the future delayed recording on the hour should always be used so the data can be lined up later. A regression was not able to be done on the Grassy Cove data for this analysis. When trying to use a formula to reduce the 5-minute interval CO₂ level data to the 30-minute interval barometric pressure data it was found that every few weeks the CO₂ data would skip a reading, such as this: 5:36, 5:41, 5:46, 6:06, 6:11, 6:16, 6:21. In the future a regression could be done, but it would take a lot of time to work through these skips in data for this very large dataset of 5-minute intervals covering multiple years.

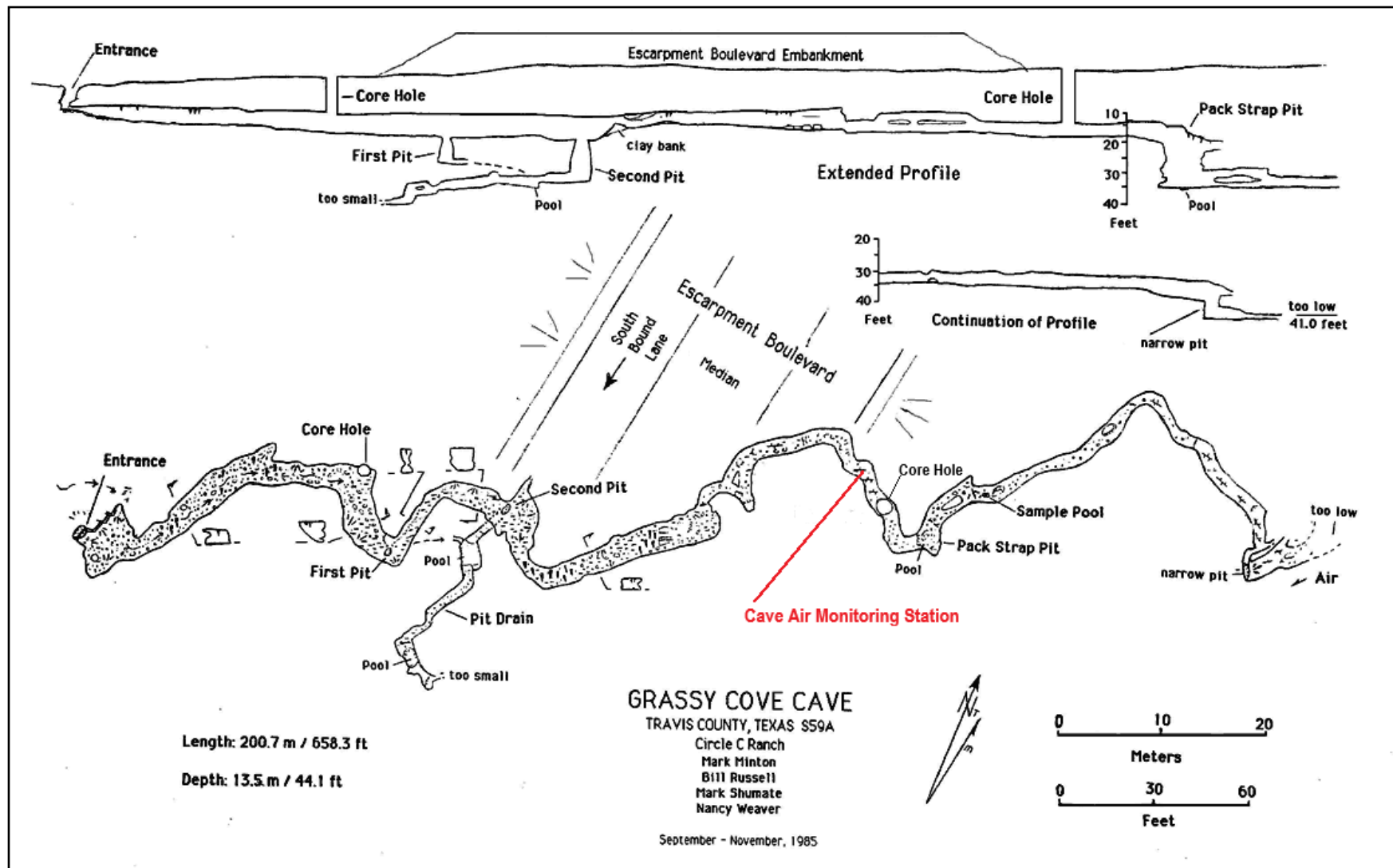


Figure 1. Grassy Cove Cave Air Monitoring Station Location

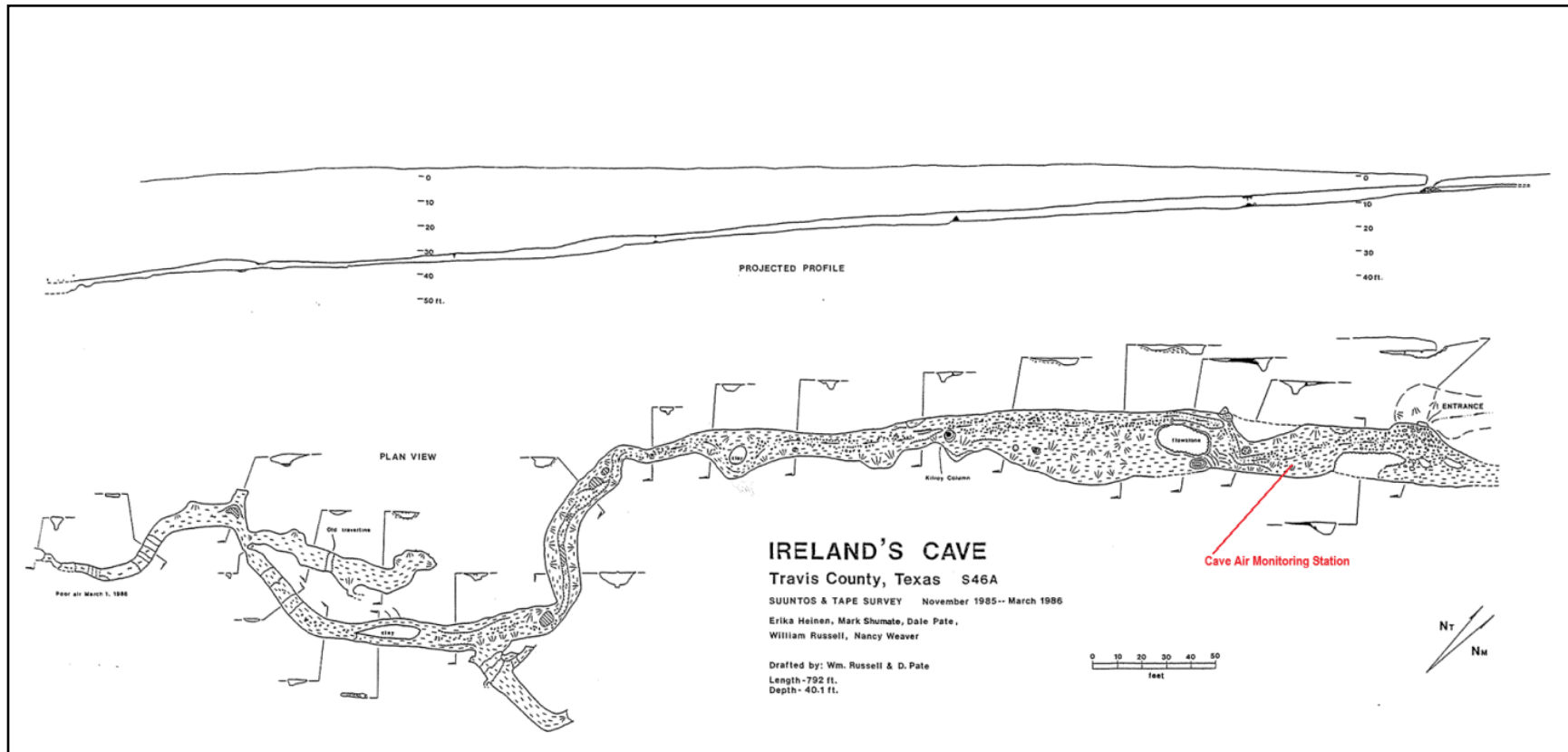


Figure 2. Ireland's Cave Air Monitoring Station Location

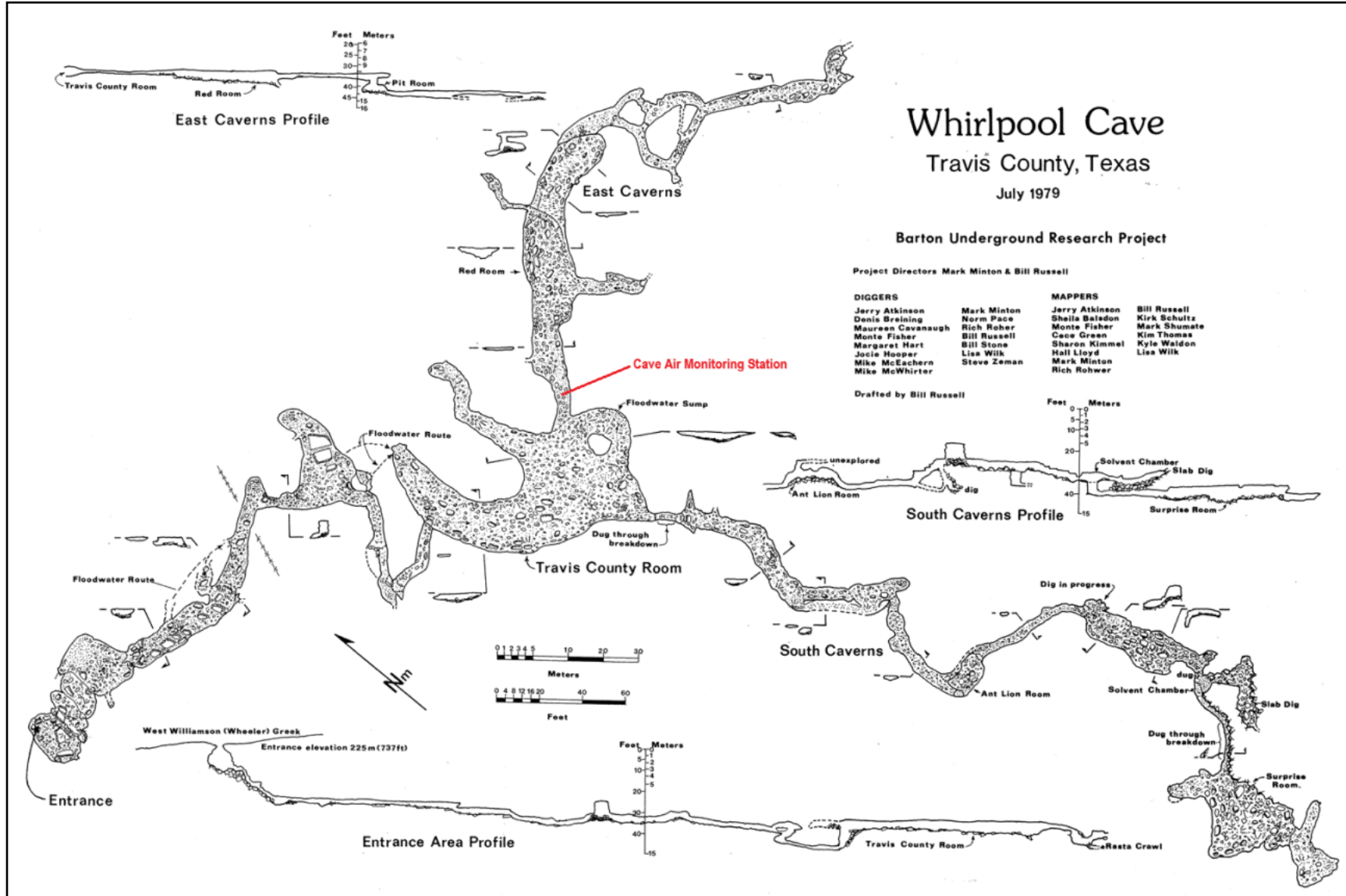


Figure 3. Whirlpool Cave Air Monitoring Station Location

Results

Figures 4, 5 and 6 show the average, median and max CO₂ levels in the three caves from April 2021 to November 2022. Due to equipment failures months with more than 10% of the days missing were excluded.

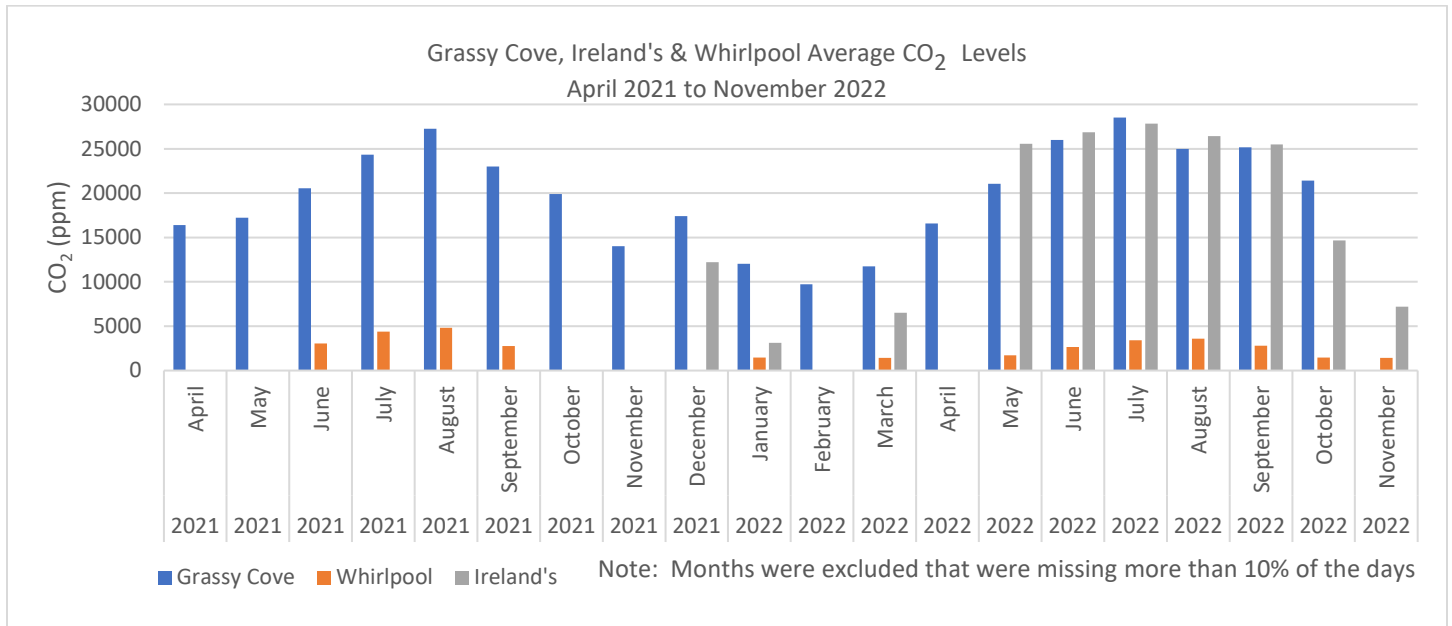


Figure 4. Grassy Cove, Ireland's & Whirlpool Average CO₂ Levels, April 2021 to November 2022

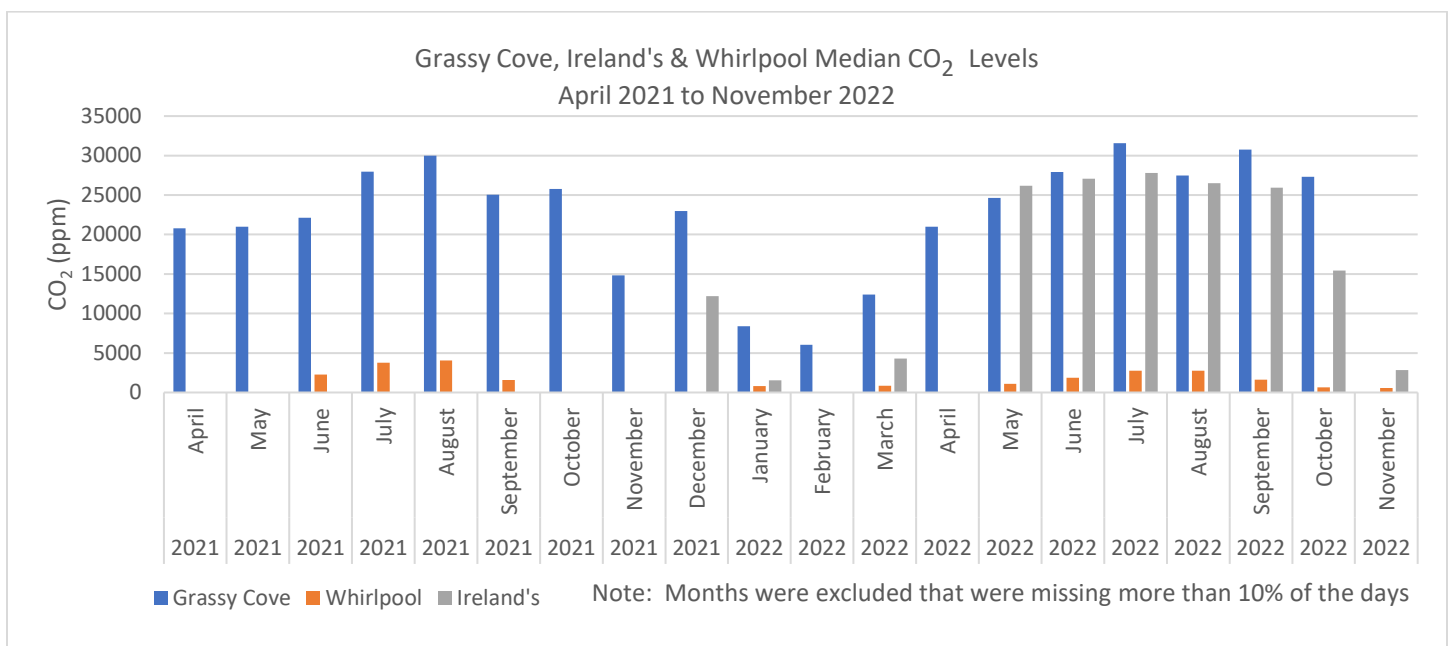


Figure 5. Grassy Cove, Ireland's & Whirlpool Median CO₂ Levels, April 2021 to November 2022

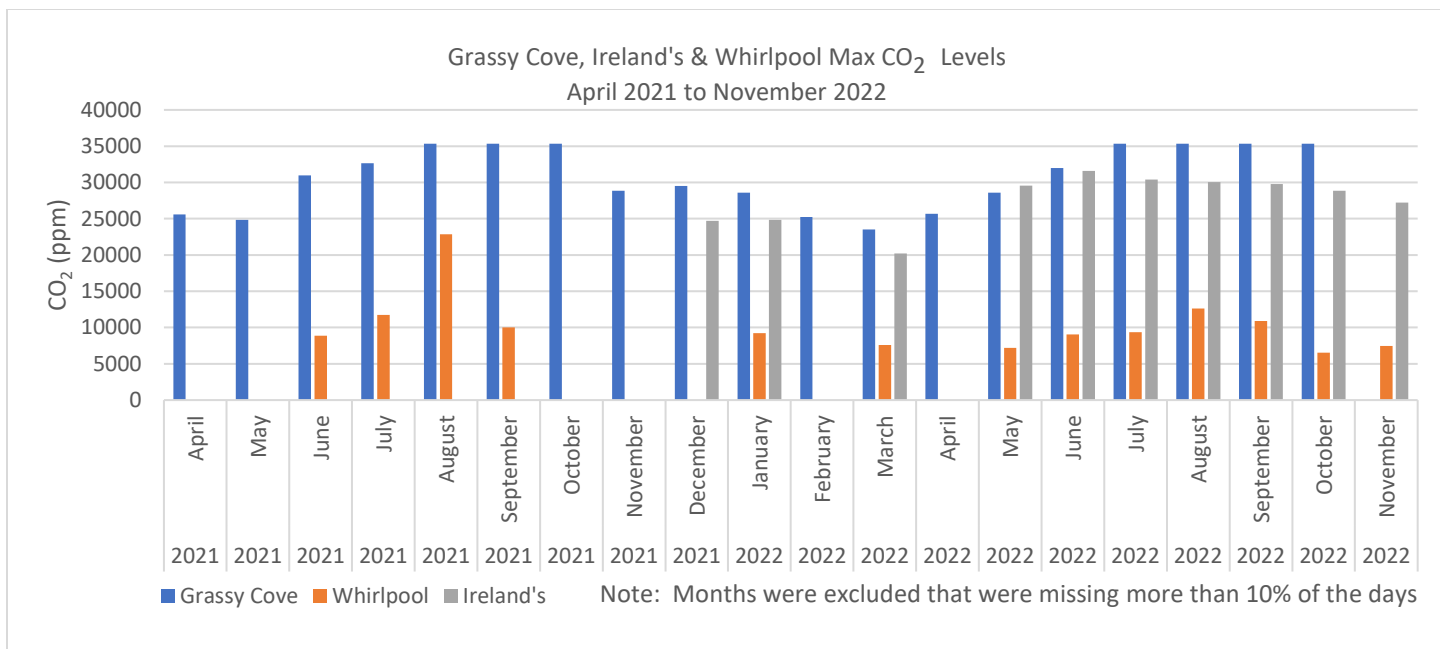


Figure 6. Grassy Cove, Ireland's & Whirlpool Max CO₂ Levels, April 2021 to November 2022

Figures 7, 8 and 9 show the average, median and max CO₂ values for each cave individually. Summary tables 1-3 with the values are in the appendix.

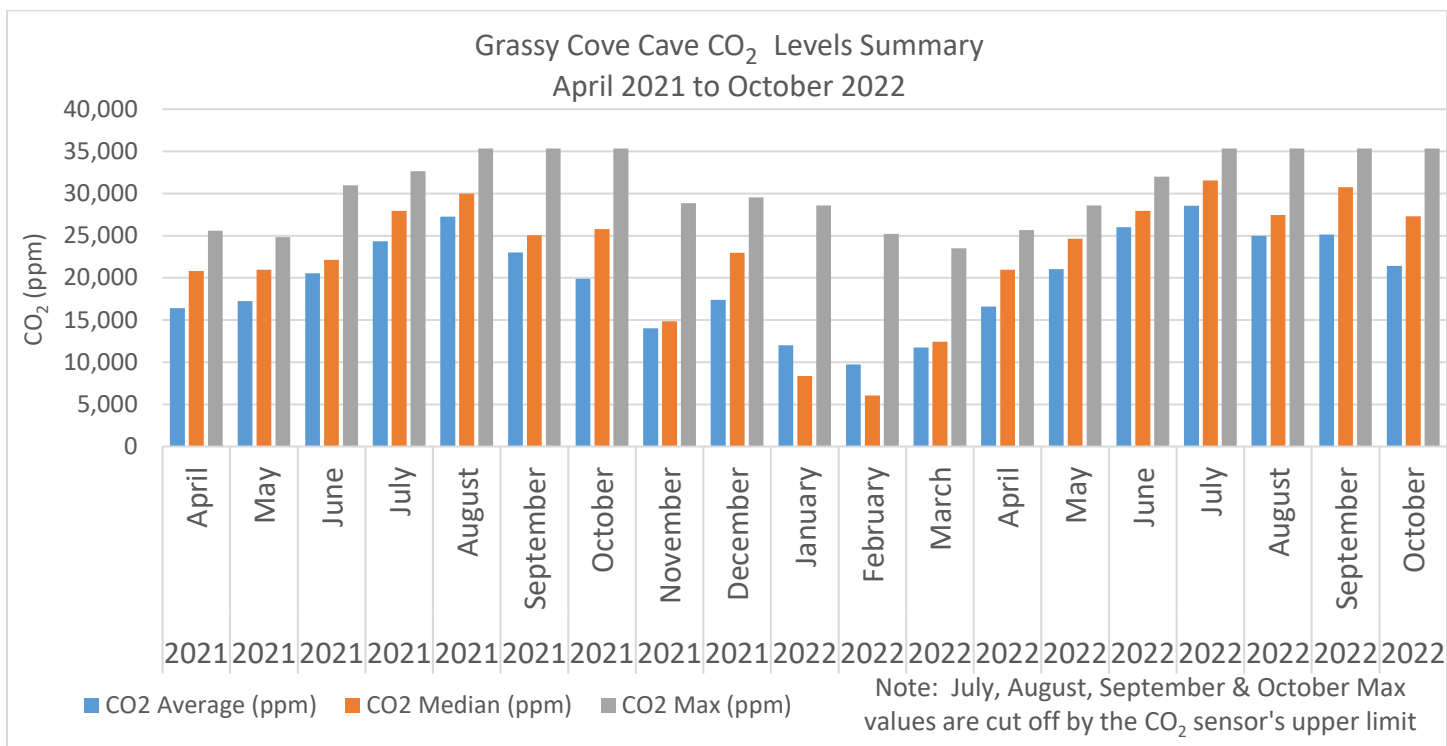


Figure 7. Grassy Cove Cave CO₂ Levels Summary, April 2021 to October 2022

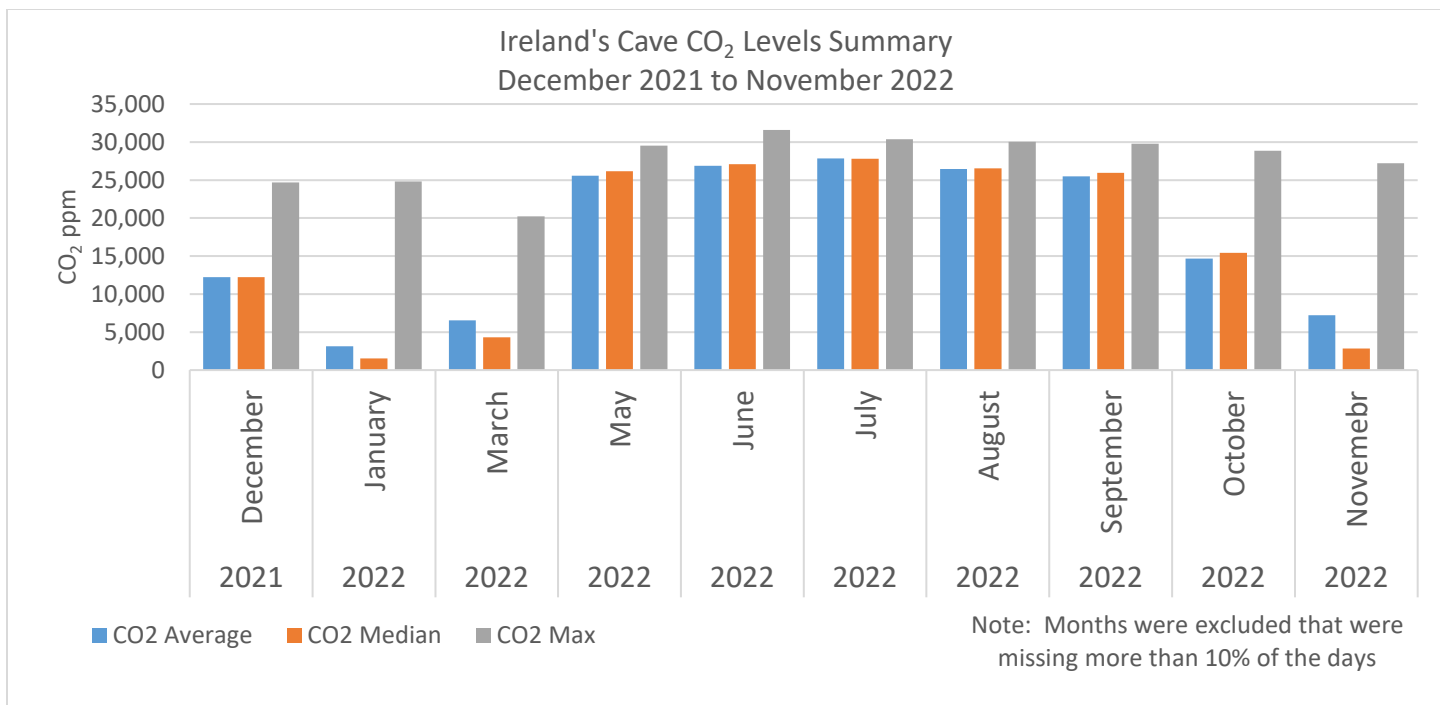


Figure 8. Ireland's Cave CO₂ Levels Summary, December 2021 to November 2022

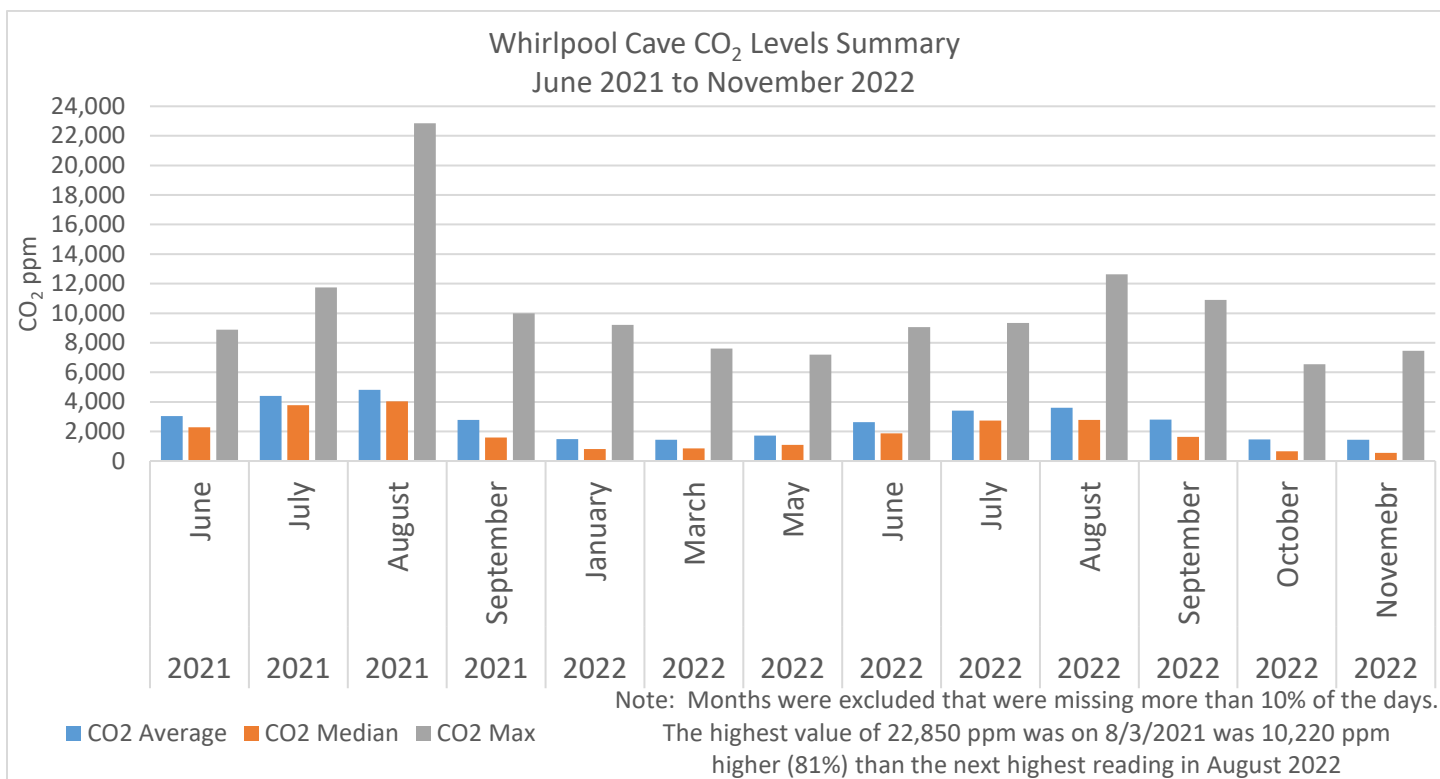


Figure 9. Whirlpool Cave CO₂ Levels Summary, June 2021 to November 2022

Figure 10 shows the temperatures in the three caves over a just under two-year period. Figure 11 shows one year of temperature from 6-1-2021 to 5-31-2022. When pulling data from the logger the sensor heats up giving higher readings for a while. The erroneous readings were replaced with an average from the reading just before and after the data was pulled.

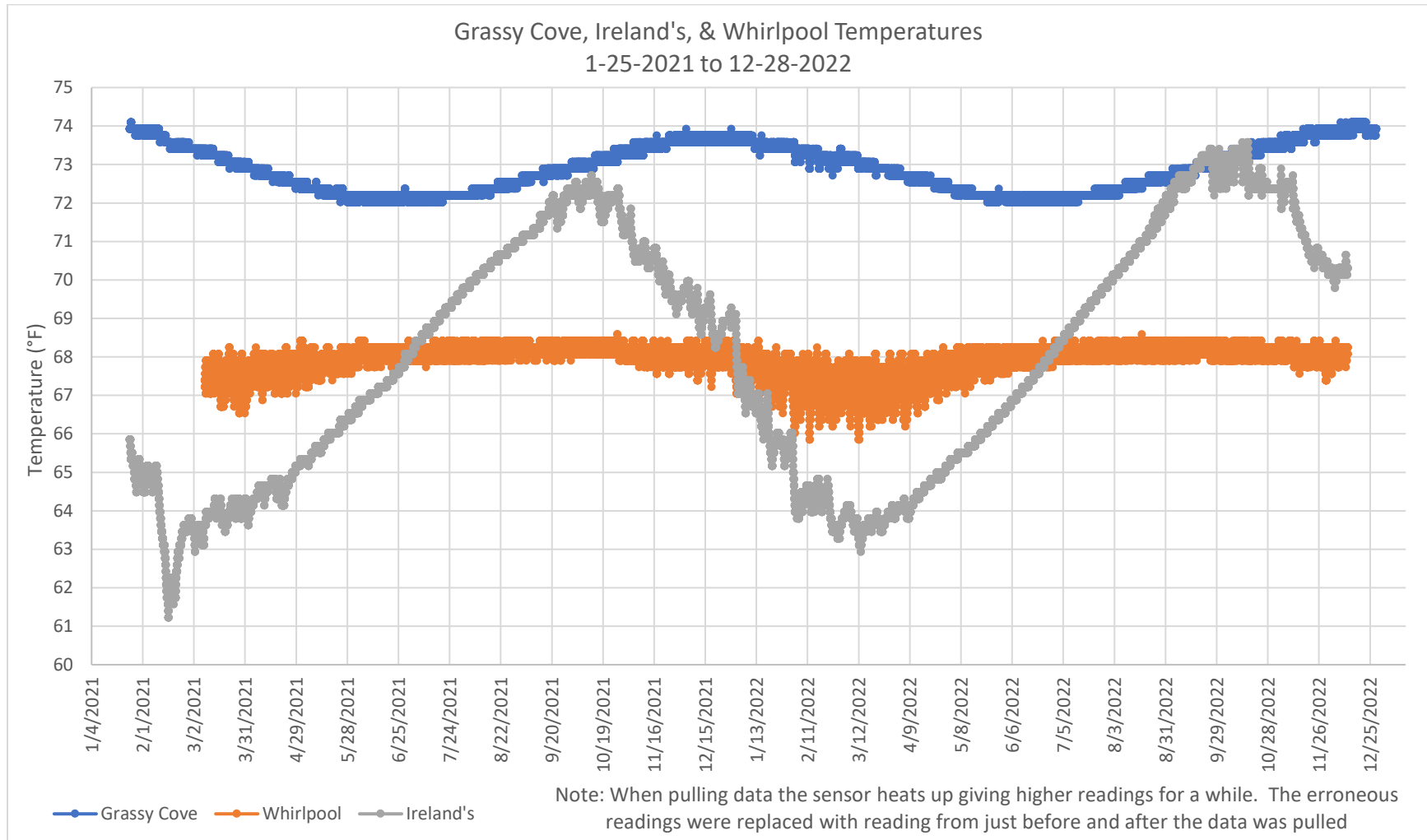


Figure 10. Grassy Cove, Ireland's, & Whirlpool Temperatures, 1-25-2021 to 12-28-2022

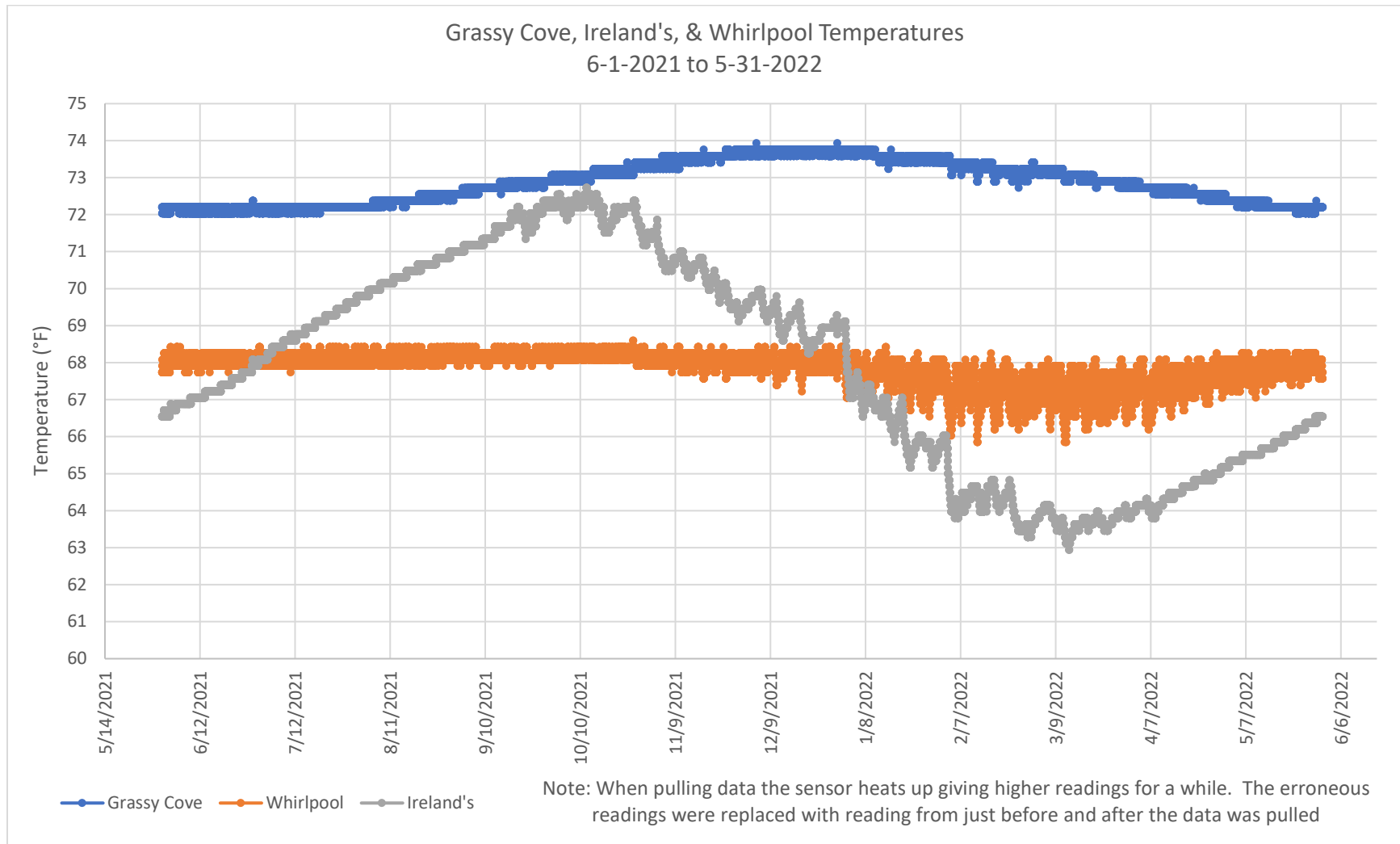


Figure 11. Grassy Cove, Ireland's, & Whirlpool Temperatures, 6-1-2021 to 5-31-2022

Figure 12 shows the relationship between CO₂ and barometric pressure in Whirlpool Cave. There is a significant negative relationship with higher CO₂ levels at lower pressures and lower CO₂ levels at higher pressures. Regression summary shown in Table 4 in the appendix.

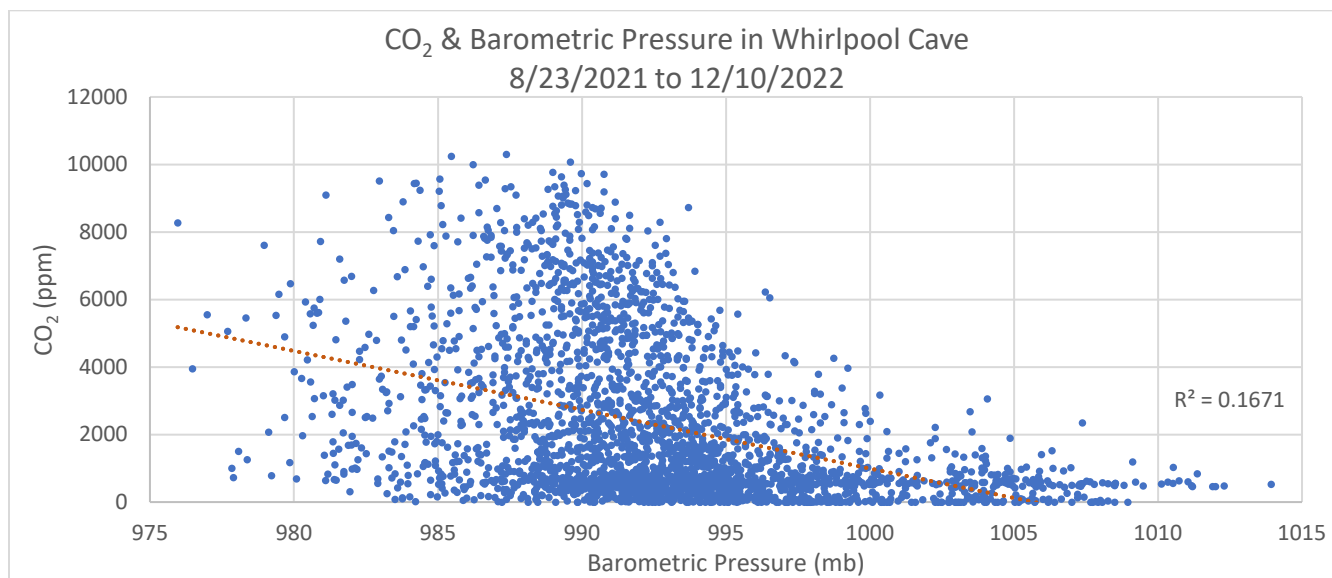


Figure 12. CO₂ & Barometric Pressure in Whirlpool Cave, 8/23/2021 to 12/10/2022, ($R^2 = 0.1671$, $F(1,2706) = 542.85$, $p < .0001$)

Figure 13 shows the relationship between CO₂ and temperature in Whirlpool Cave. There is a significant positive relationship with lower CO₂ levels at lower temperatures and higher CO₂ levels at higher temperatures. Regression summary shown in Table 5 in the appendix.

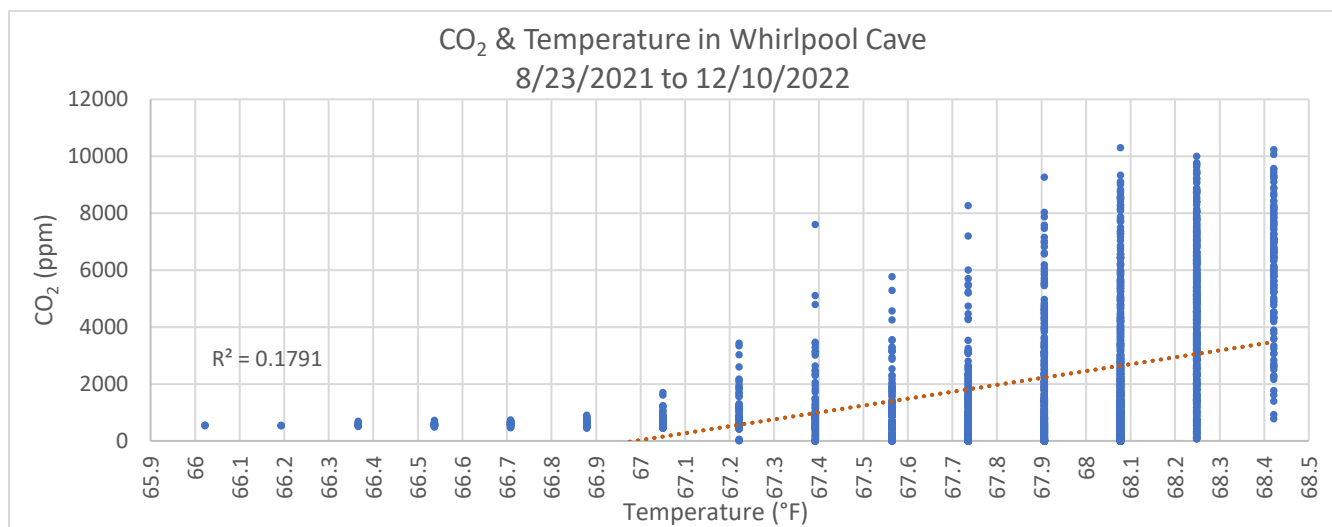


Figure 13. CO₂ & Temperature in Whirlpool Cave, 8/23/2021 to 12/10/2022, ($R^2 = 0.1791$, $F(1,2706) = 590.23$, $p < .0001$)

Figure 14 shows the relationship between CO₂ and barometric pressure in Ireland's Cave. There is a significant negative relationship with higher CO₂ levels at lower pressures and lower CO₂ levels at higher pressures. Regression summary shown in Table 6 in the appendix.

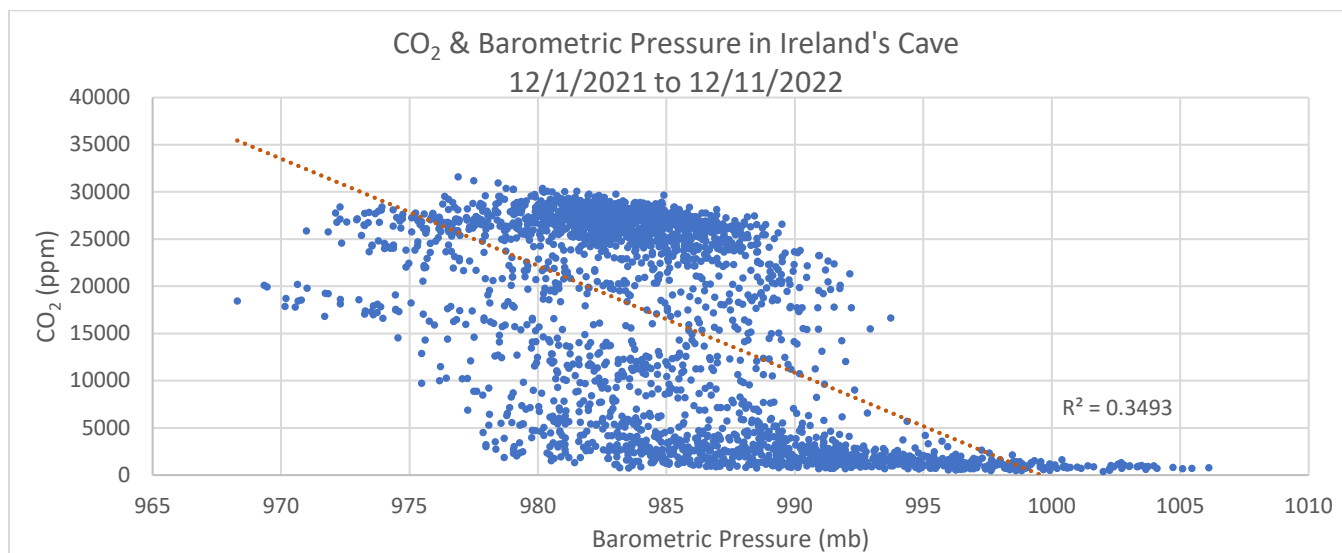


Figure 14. CO₂ & Barometric Pressure in Ireland's Cave, 8/23/2021 to 12/10/2022, ($R^2 = 0.3493$, $F(1,2649) = 1421.70$, $p < .0001$)

Figure 15 shows the relationship between CO₂ and temperature in Ireland's Cave. There is a significant positive relationship with lower CO₂ levels at lower temperatures and higher CO₂ levels at higher temperatures. Regression summary shown in Table 7 in the appendix.

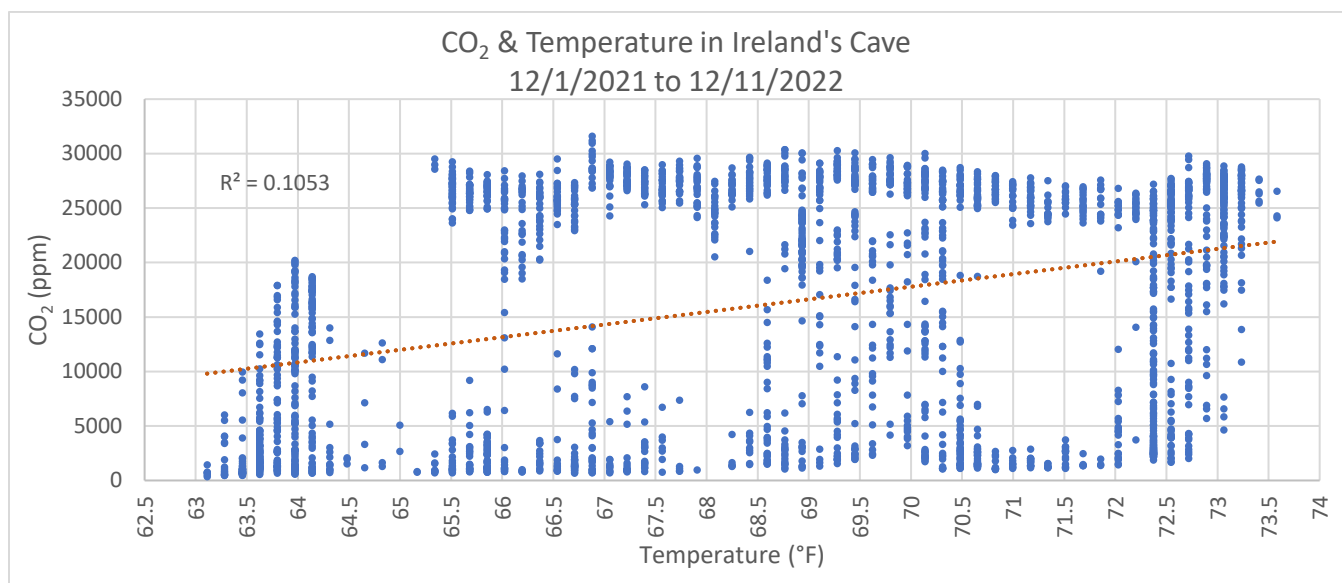


Figure 15. CO₂ & Temperature in Ireland's Cave, 8/23/2021 to 12/10/2022, ($R^2 = 0.1053$, $F(1,2649) = 311.65$, $p < .0001$)

Figure 16 show the CO₂ shows Grassy Cove CO₂ levels over a 20 month period. The sensor on the GMP252 seems to max out around 35335, with a few values of 35348. There were some negative values during periods of very high CO₂ levels that must have been caused by sensor malfunctions, these values were removed.

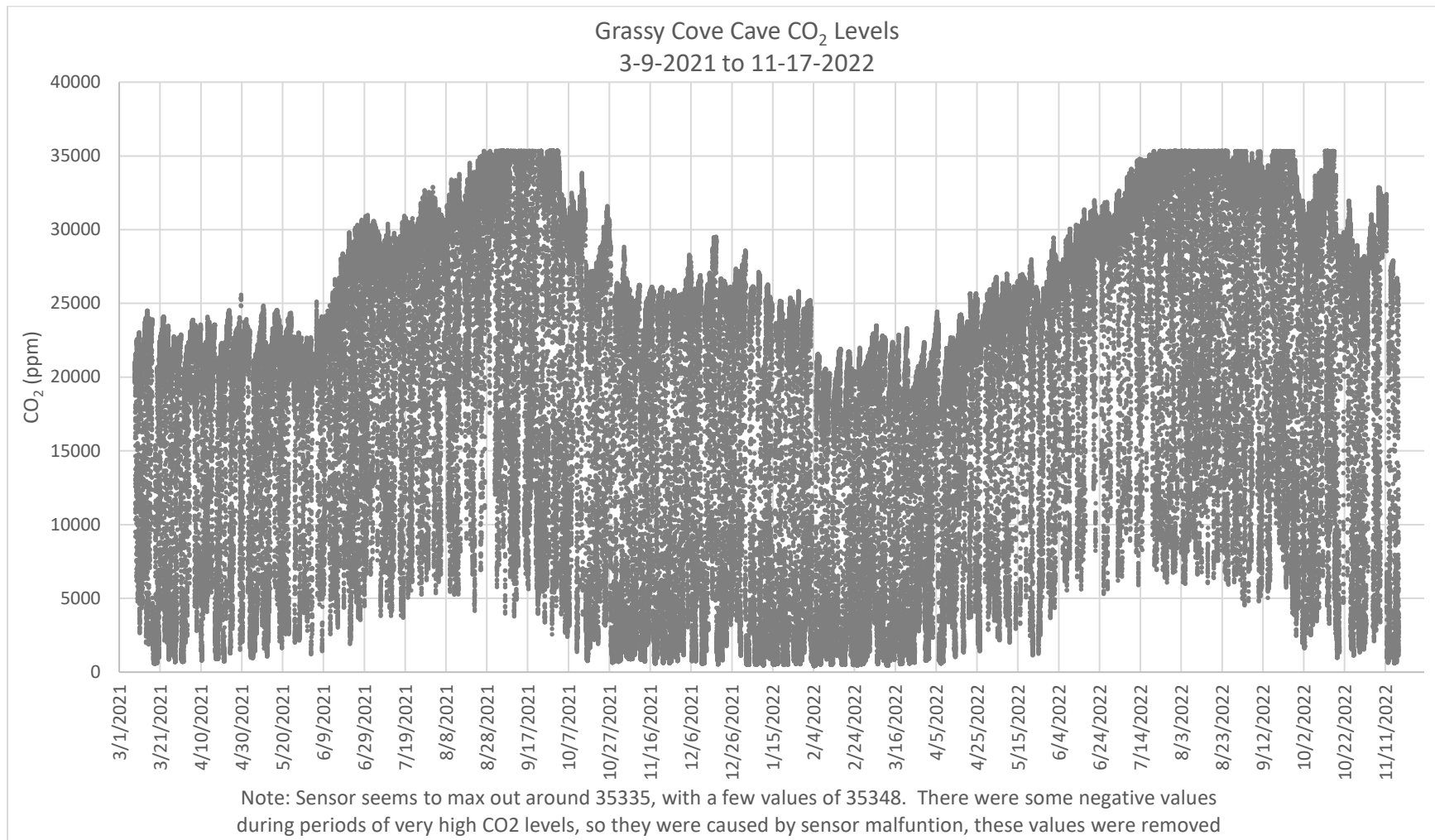


Figure 16. Grassy Cove Cave CO₂ Levels, 3-9-2021 to 11-17-2022

Figures 17 through 36 show CO₂ levels and barometric pressure in Grassy Cove over one-month periods. All graphs were adjusted so the CO₂ level and barometric pressure scales are the same on all the graphs for easier comparison.

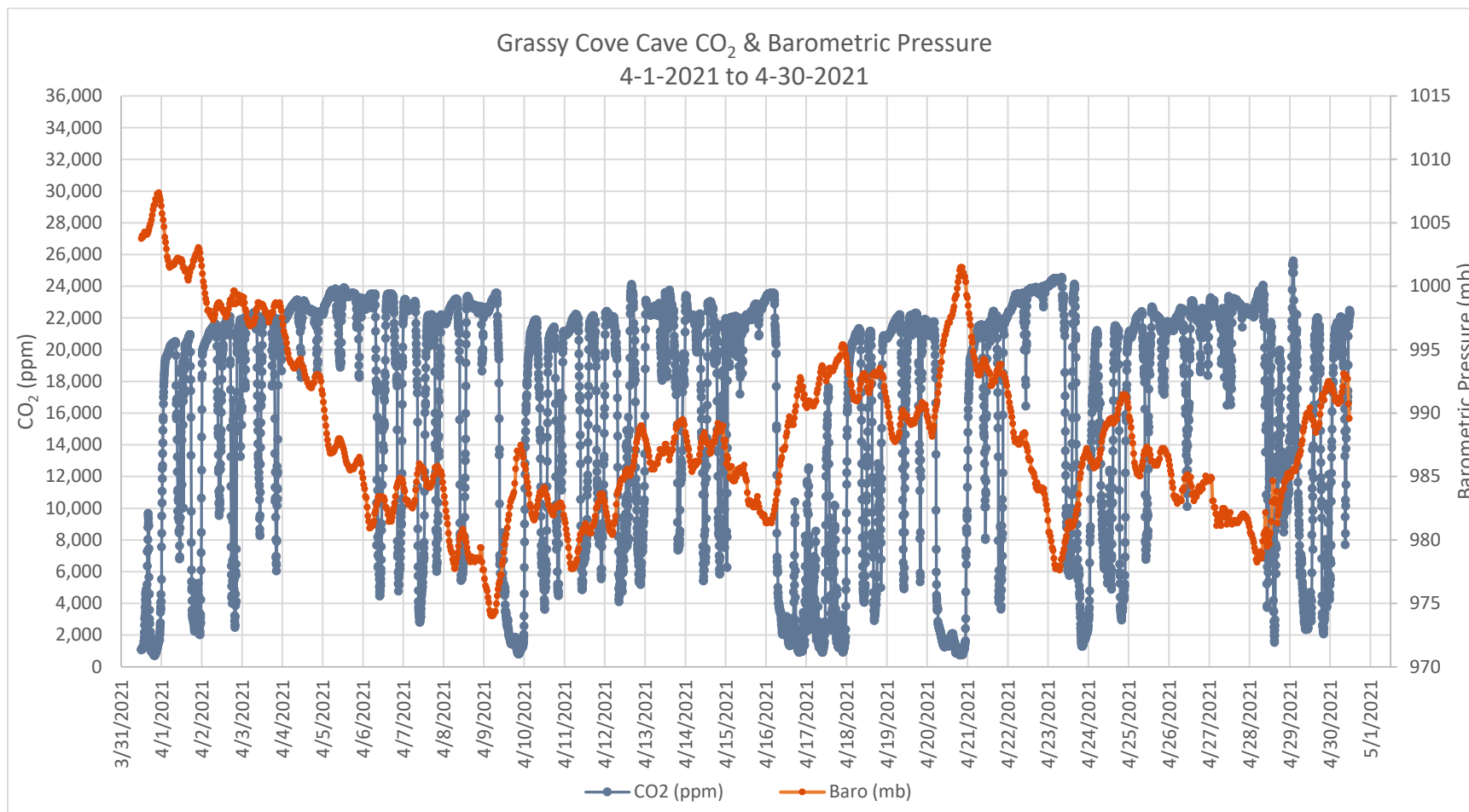


Figure 17. Grassy Cove Cave CO₂ & Barometric Pressure, 4-1-2021 to 4-30-2021

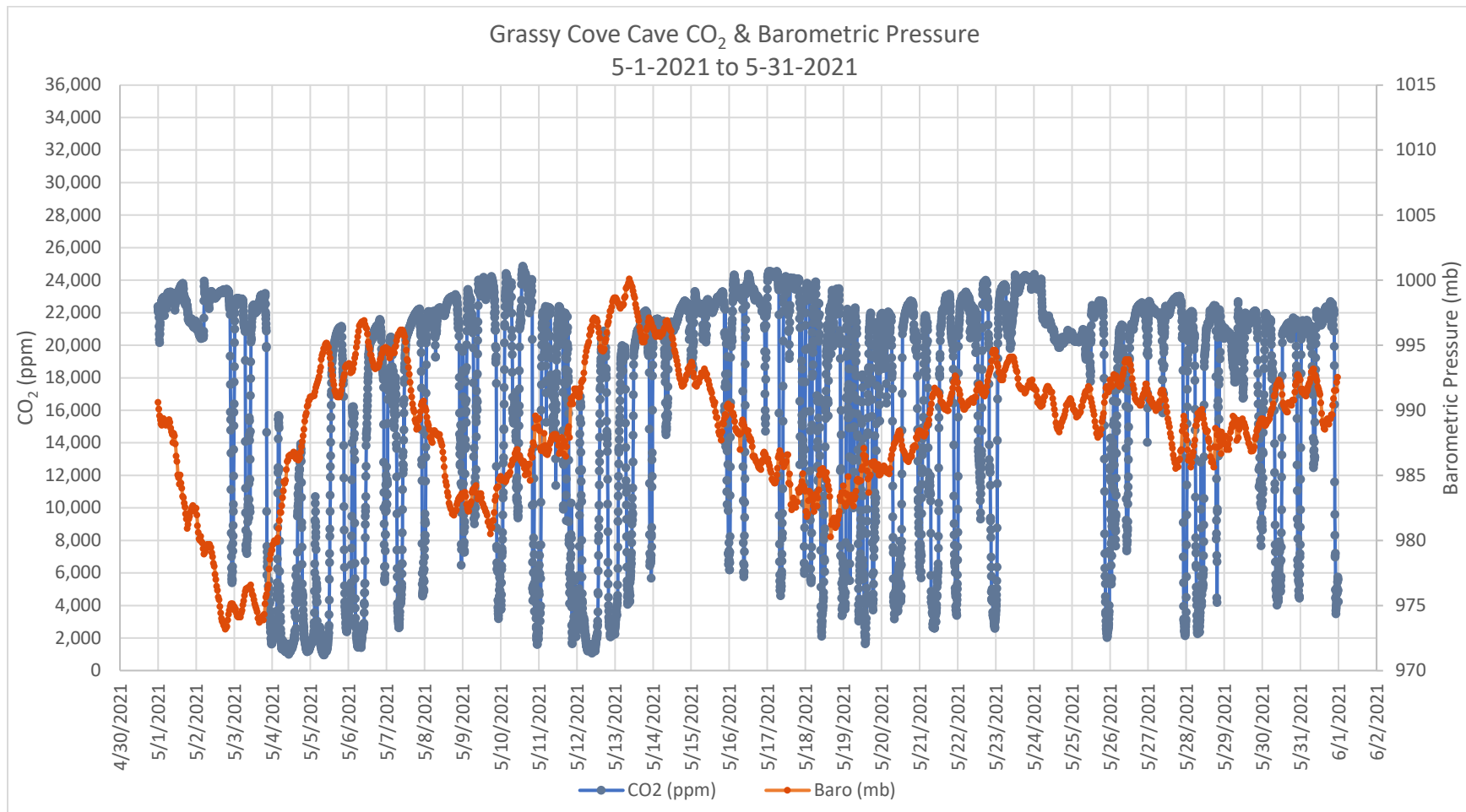


Figure 18. Grassy Cove Cave CO₂ & Barometric Pressure, 5-1-2021 to 5-31-2021

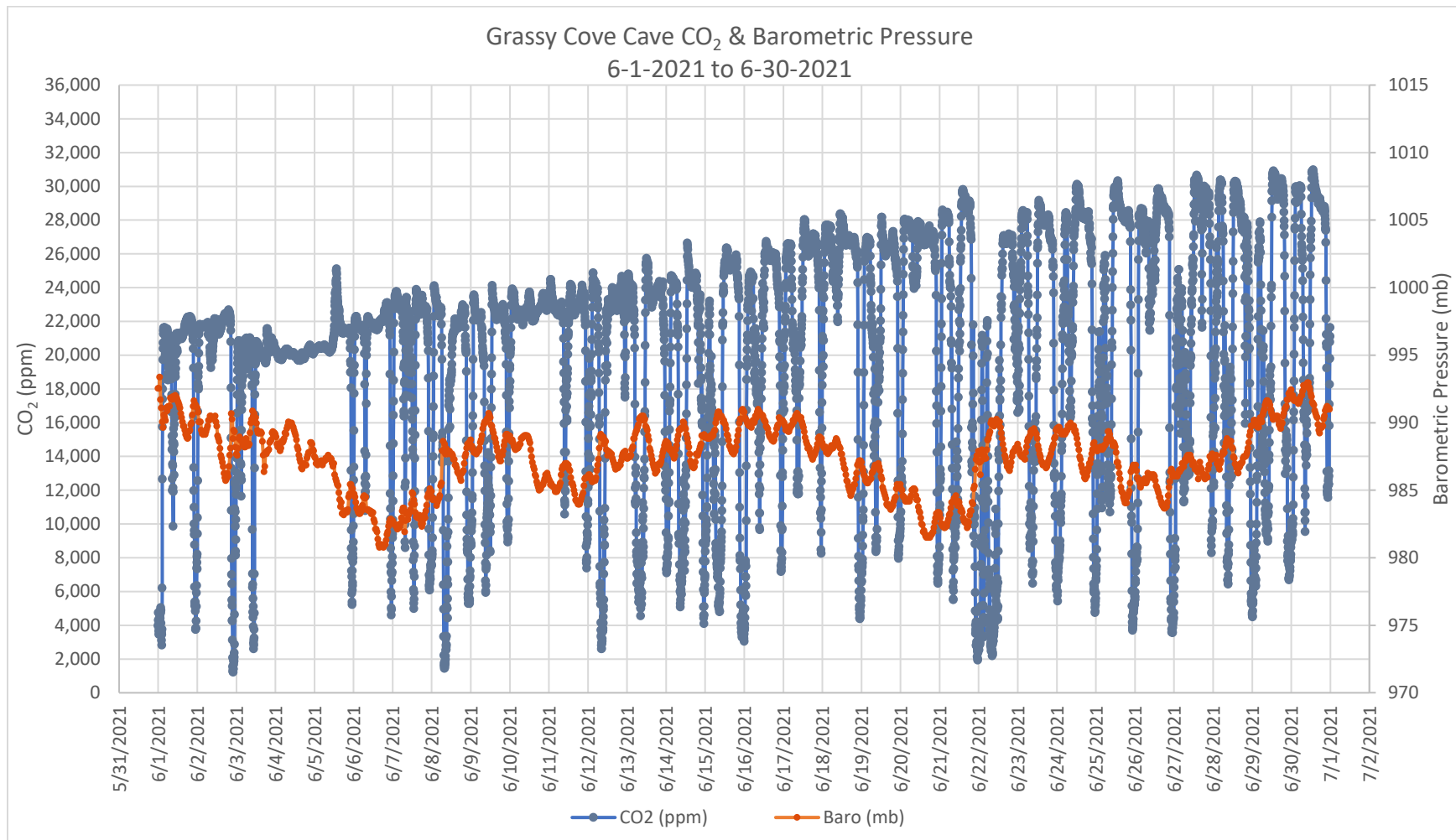


Figure 19. Grassy Cove Cave CO₂ & Barometric Pressure, 6-1-2021 to 6-30-2021

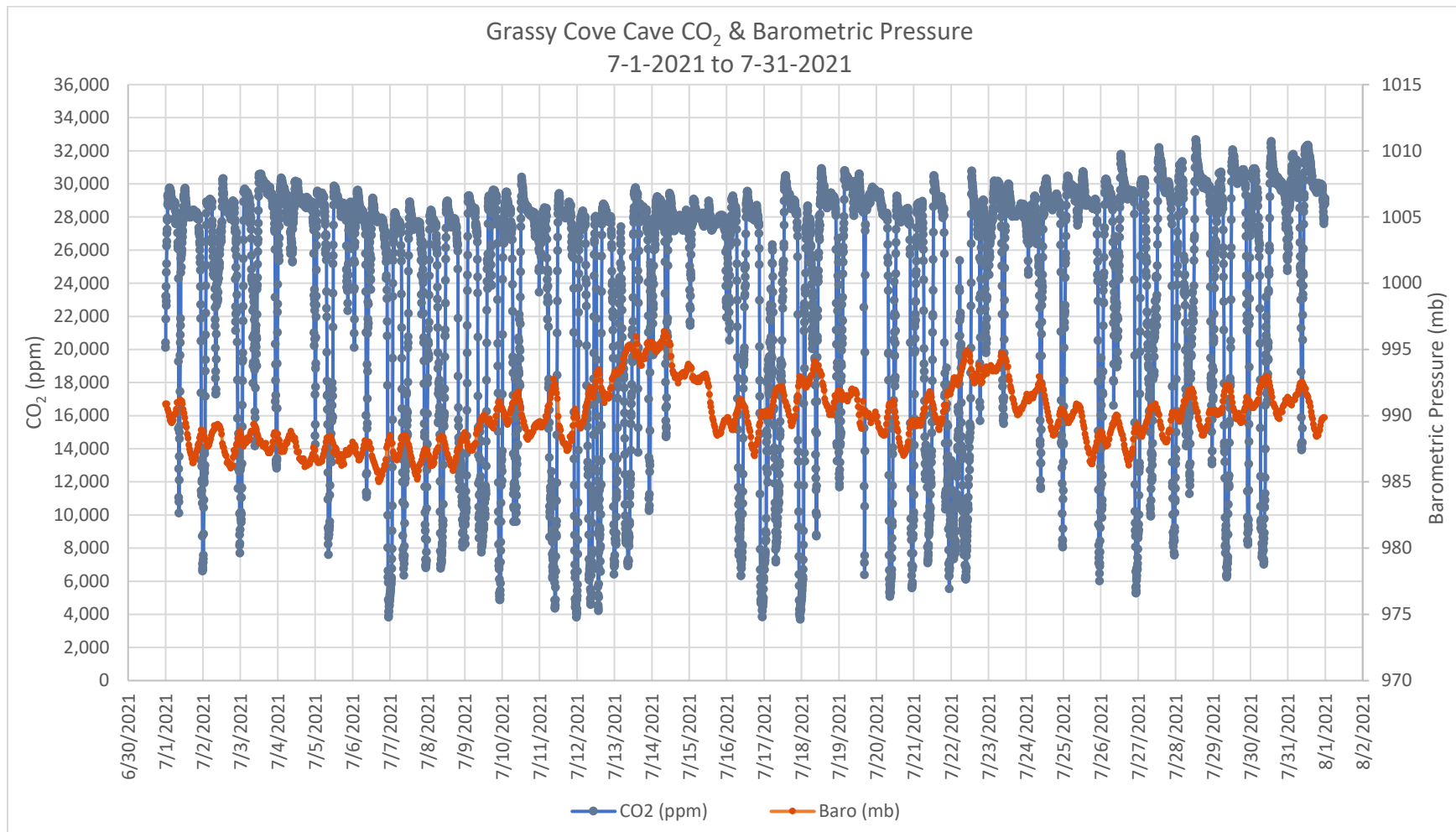


Figure 20. Grassy Cove Cave CO₂ & Barometric Pressure, 7-1-2021 to 7-31-2021

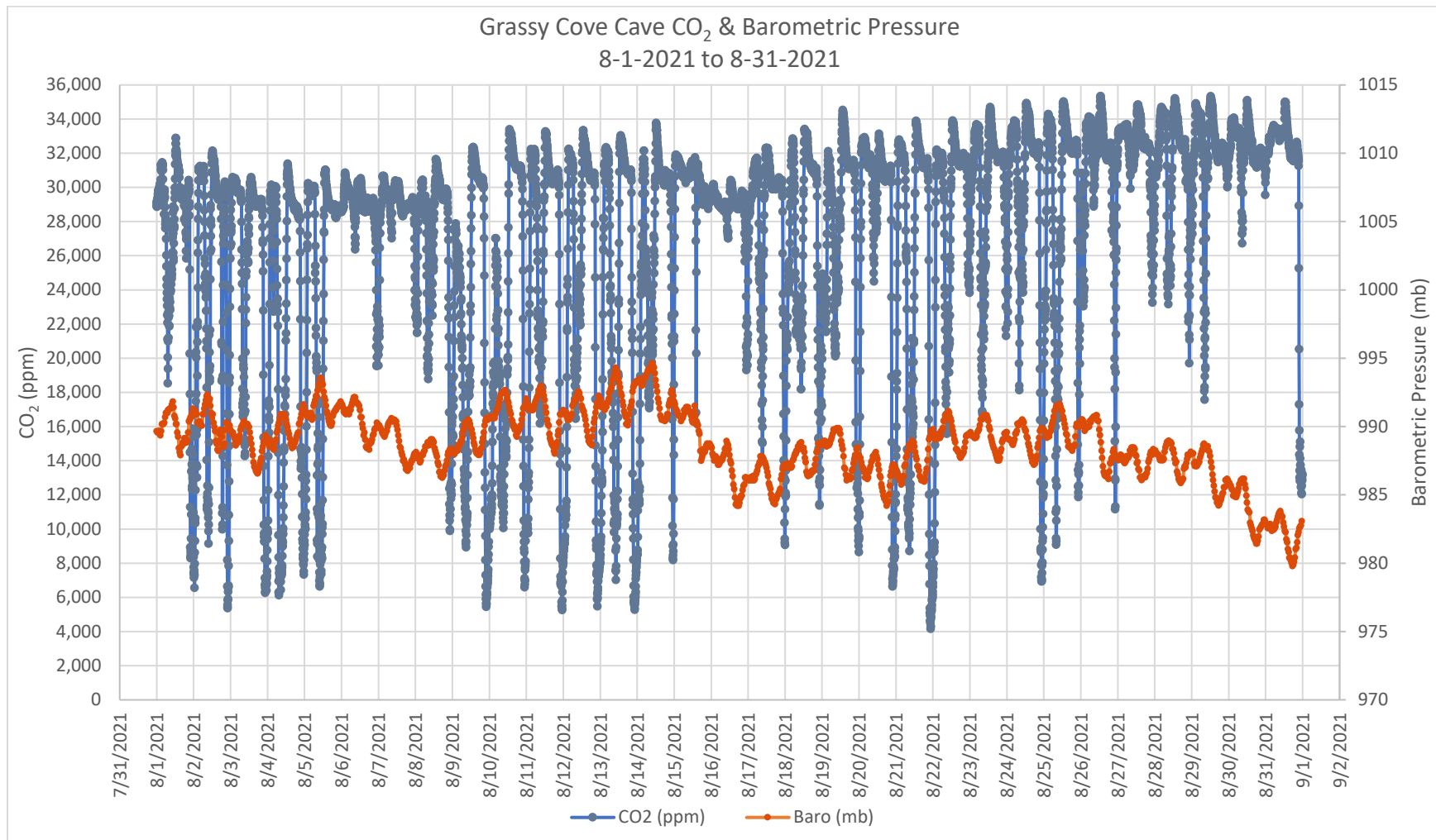


Figure 21. Grassy Cove Cave CO₂ & Barometric Pressure, 8-1-2021 to 8-31-2021

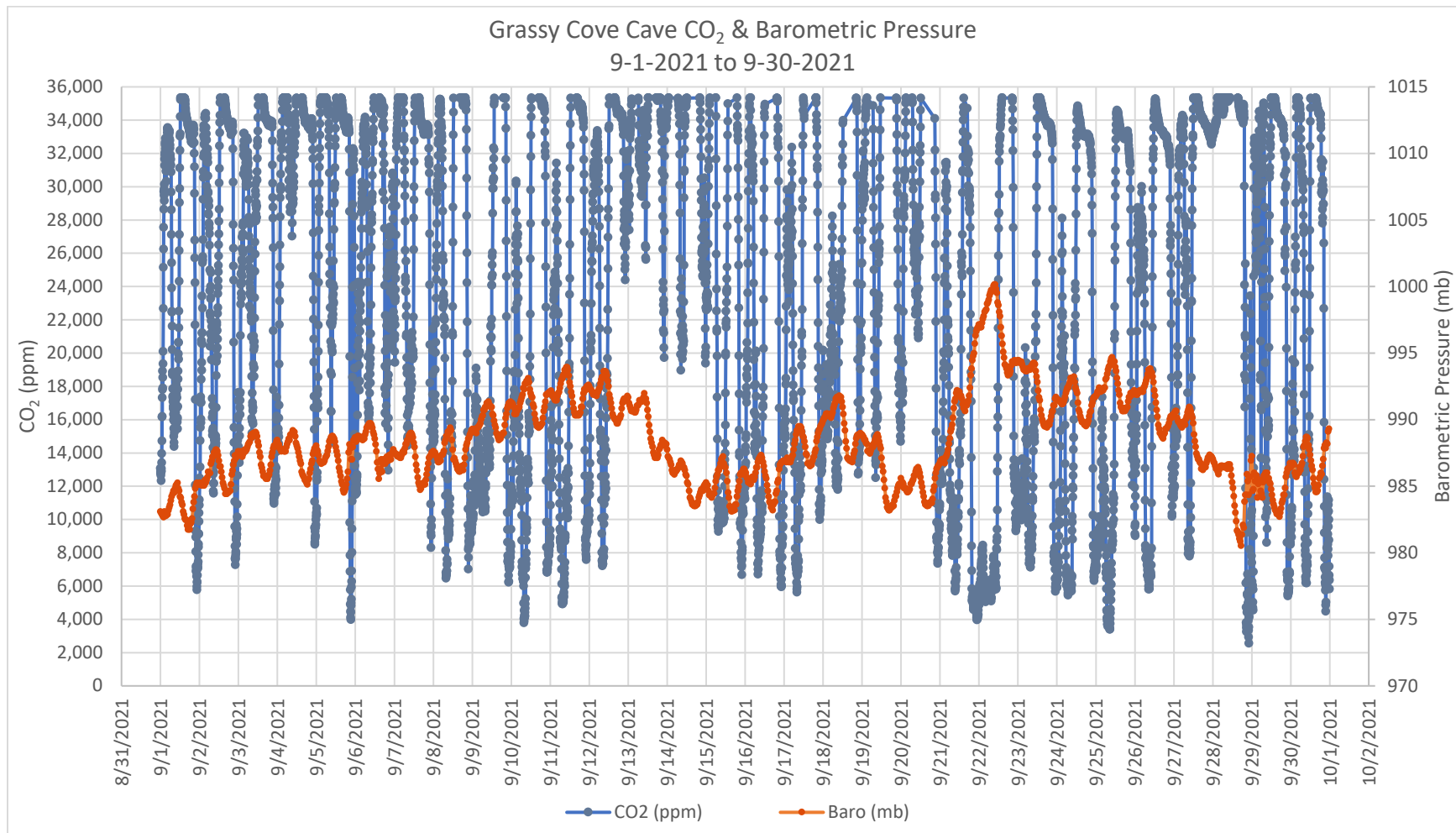


Figure 22. Grassy Cove Cave CO₂ & Barometric Pressure, 9-1-2021 to 9-30-2021

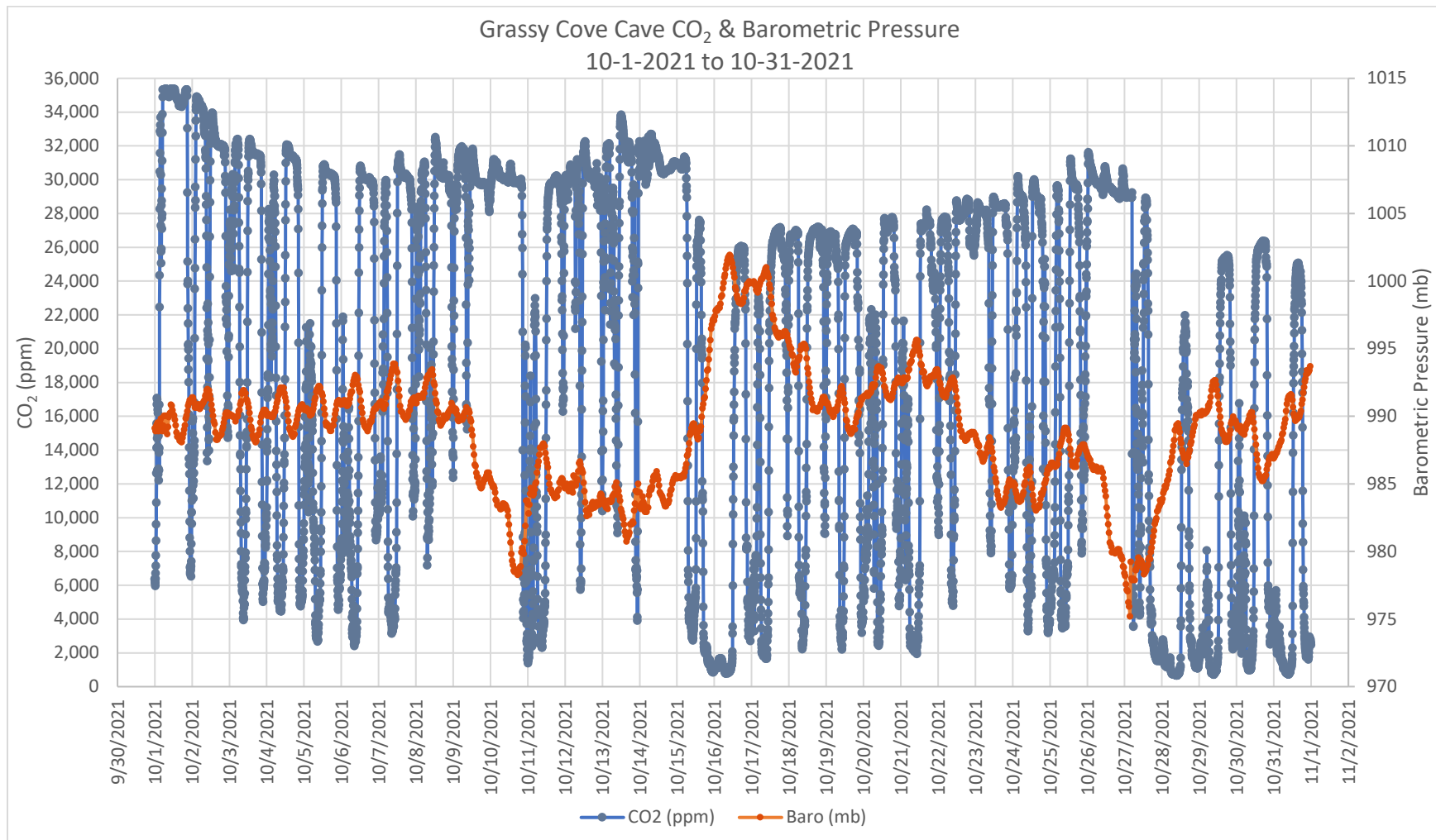


Figure 23. Grassy Cove Cave CO₂ & Barometric Pressure, 10-1-2021 to 10-31-2021

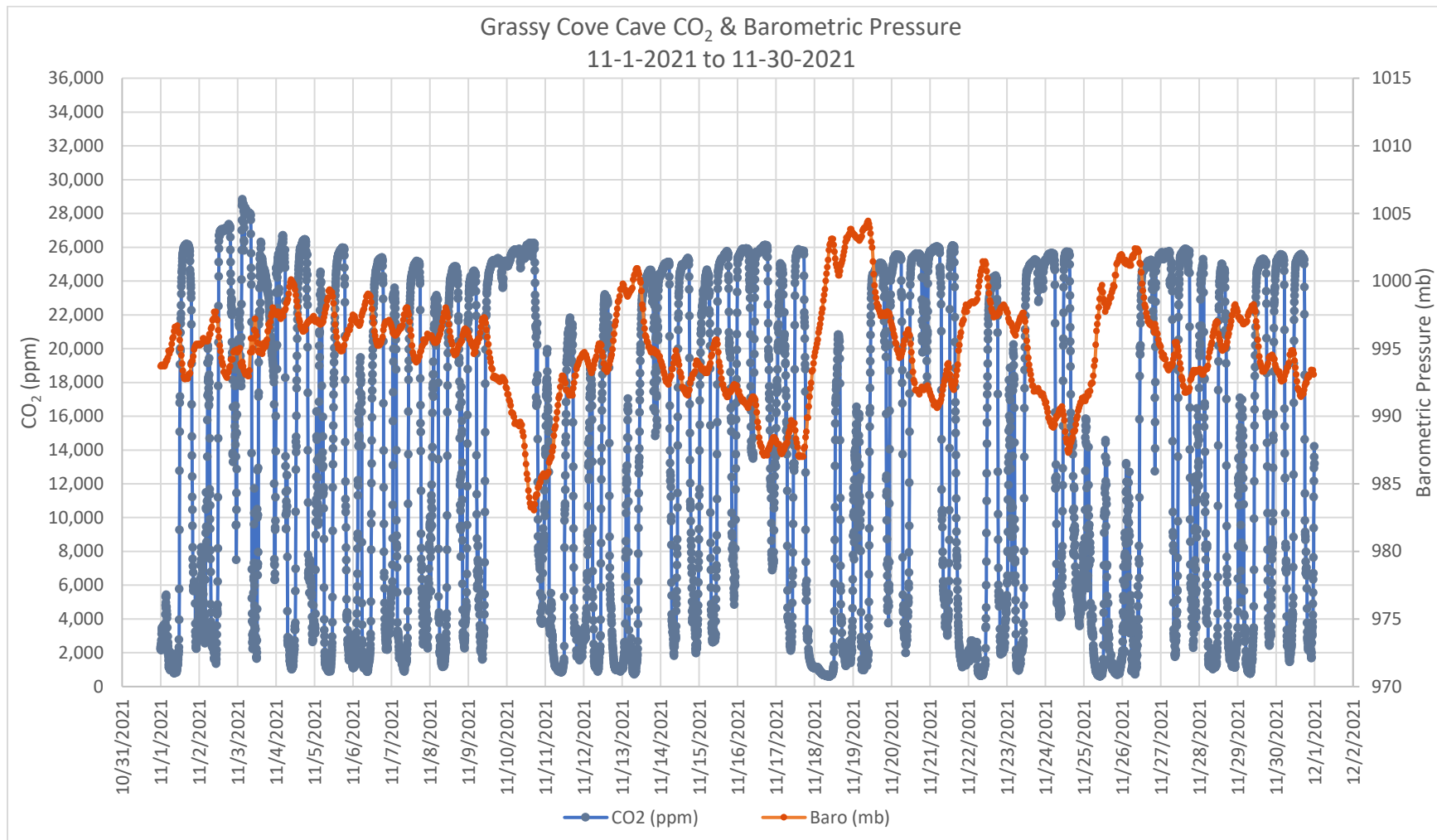


Figure 24. Grassy Cove Cave CO₂ & Barometric Pressure, 11-1-2021 to 11-30-2021

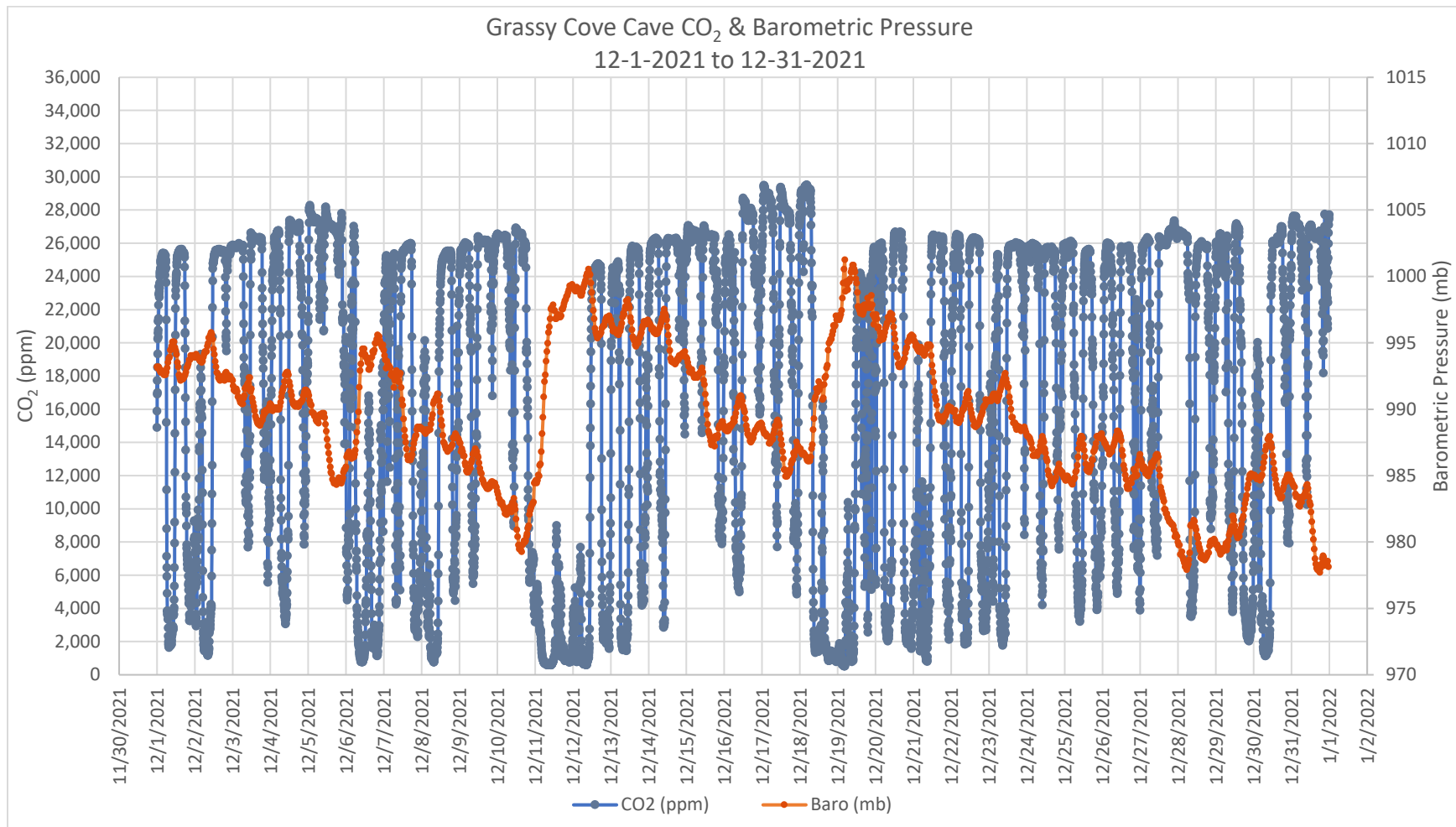


Figure 25. Grassy Cove Cave CO₂ & Barometric Pressure, 12-1-2021 to 12-31-2021

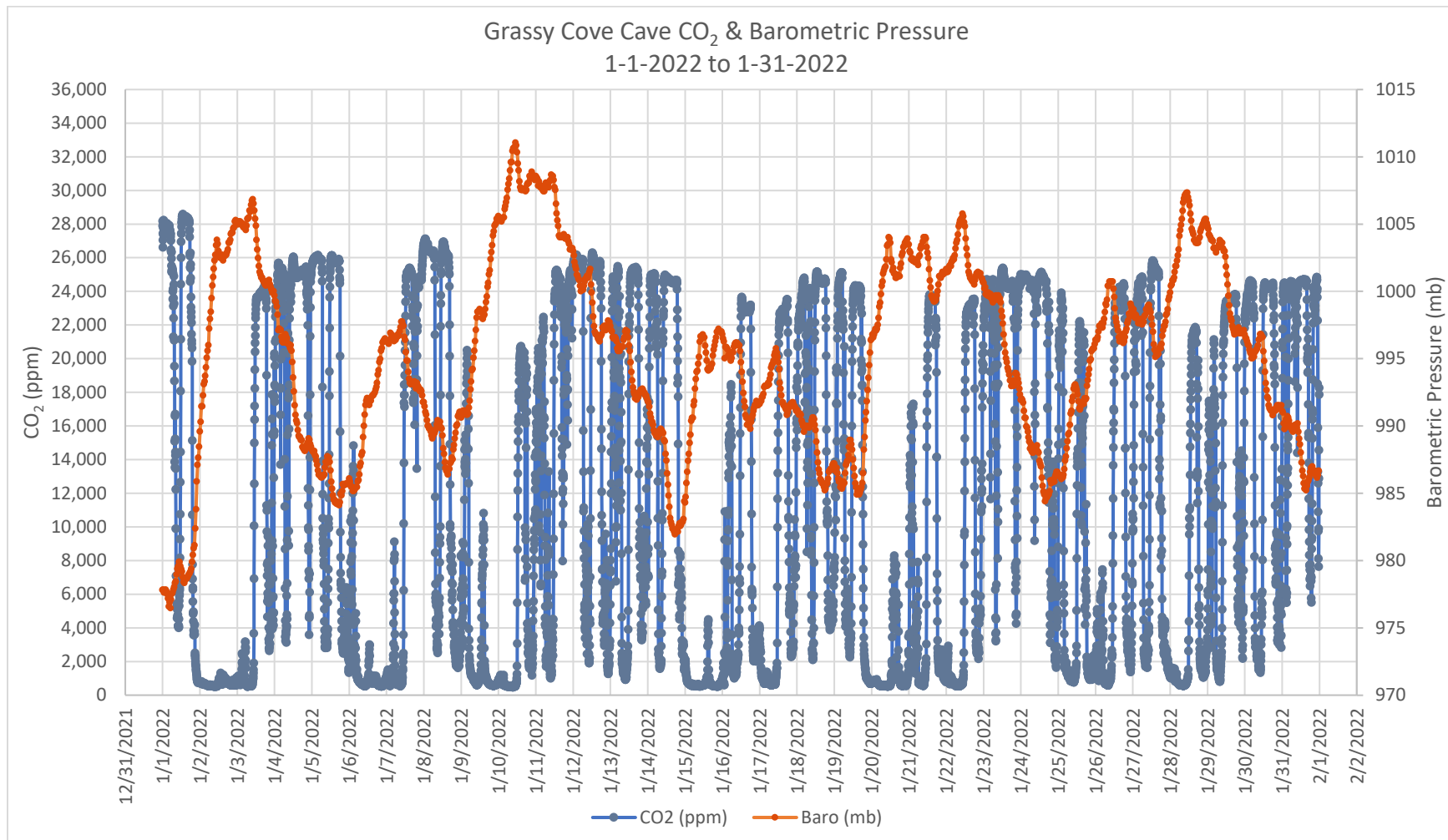


Figure 26. Grassy Cove Cave CO₂ & Barometric Pressure, 1-1-2022 to 1-31-2022

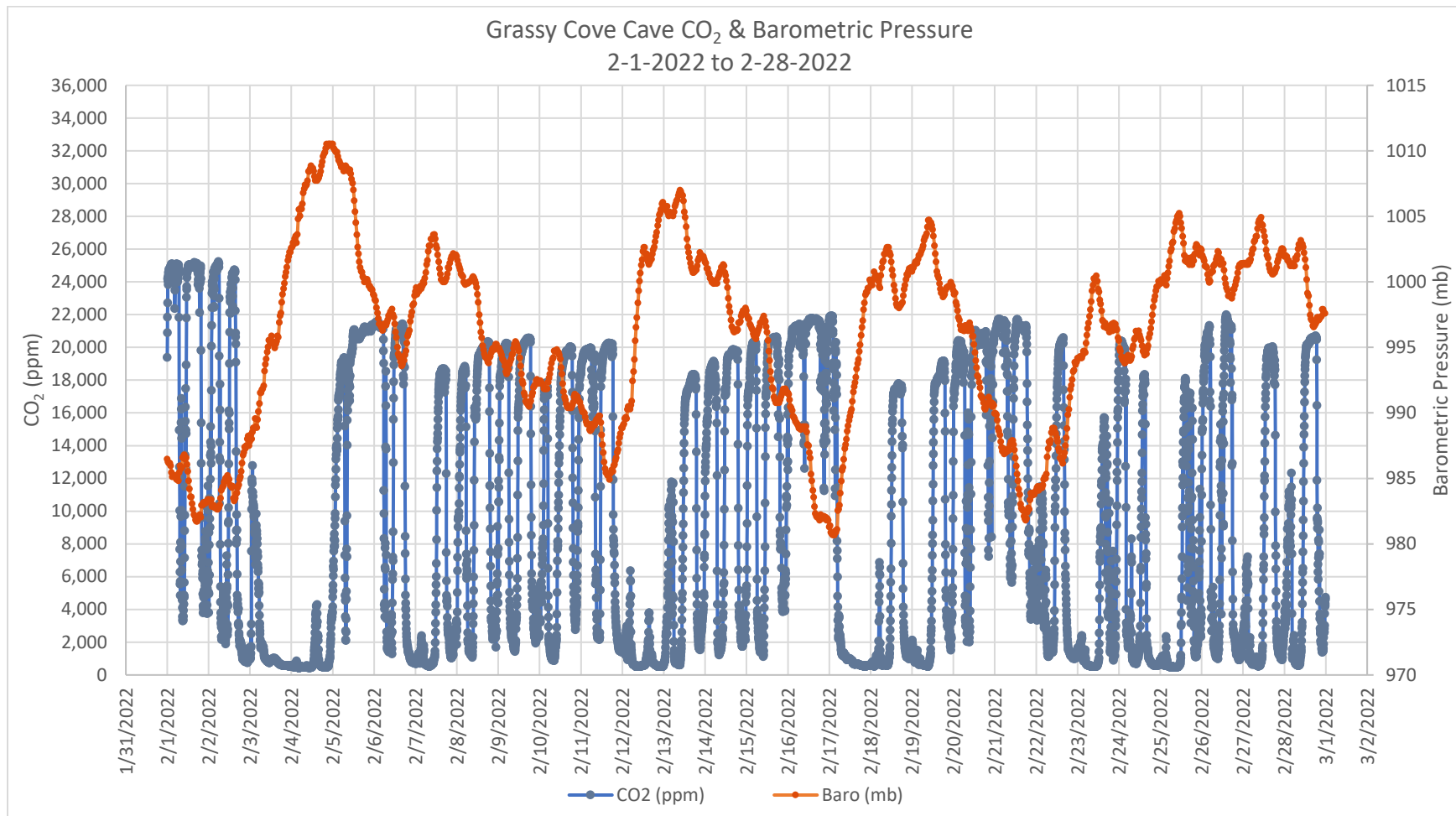


Figure 27. Grassy Cove Cave CO₂ & Barometric Pressure, 2-1-2022 to 2-28-2022

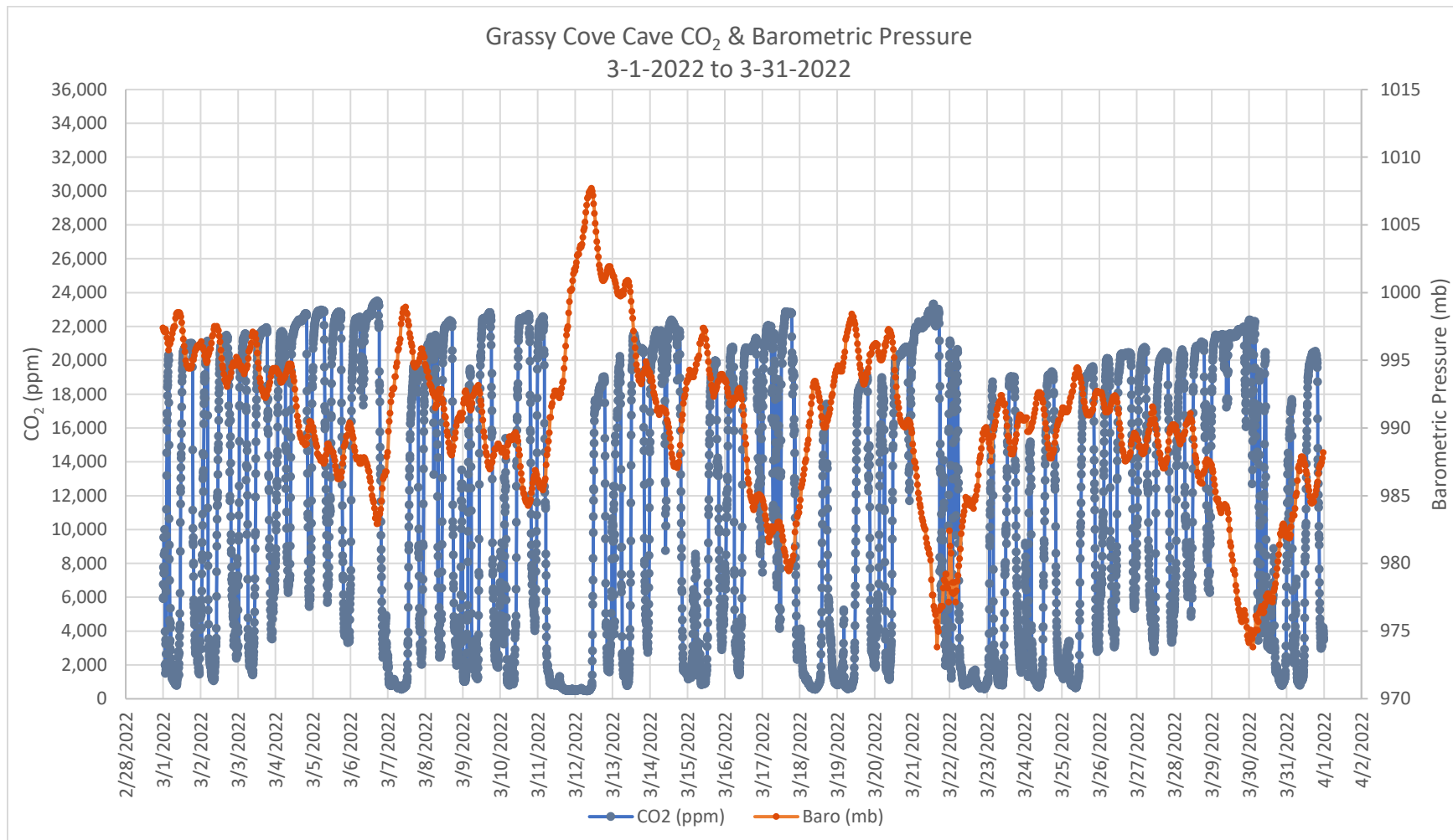


Figure 28. Grassy Cove Cave CO₂ & Barometric Pressure, 3-1-2022 to 3-31-2022

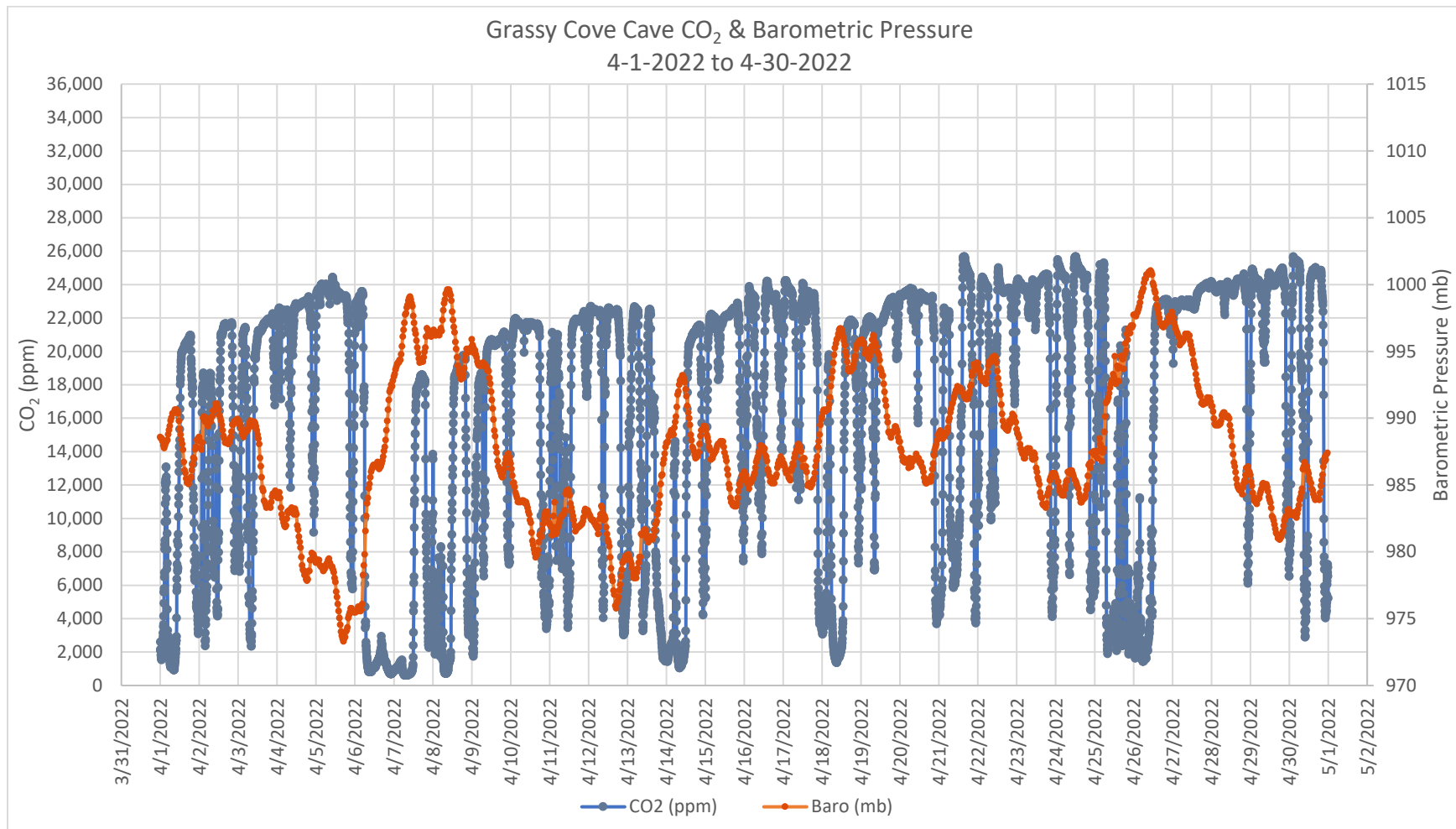


Figure 29. Grassy Cove Cave CO₂ & Barometric Pressure, 4-1-2022 to 4-30-2022

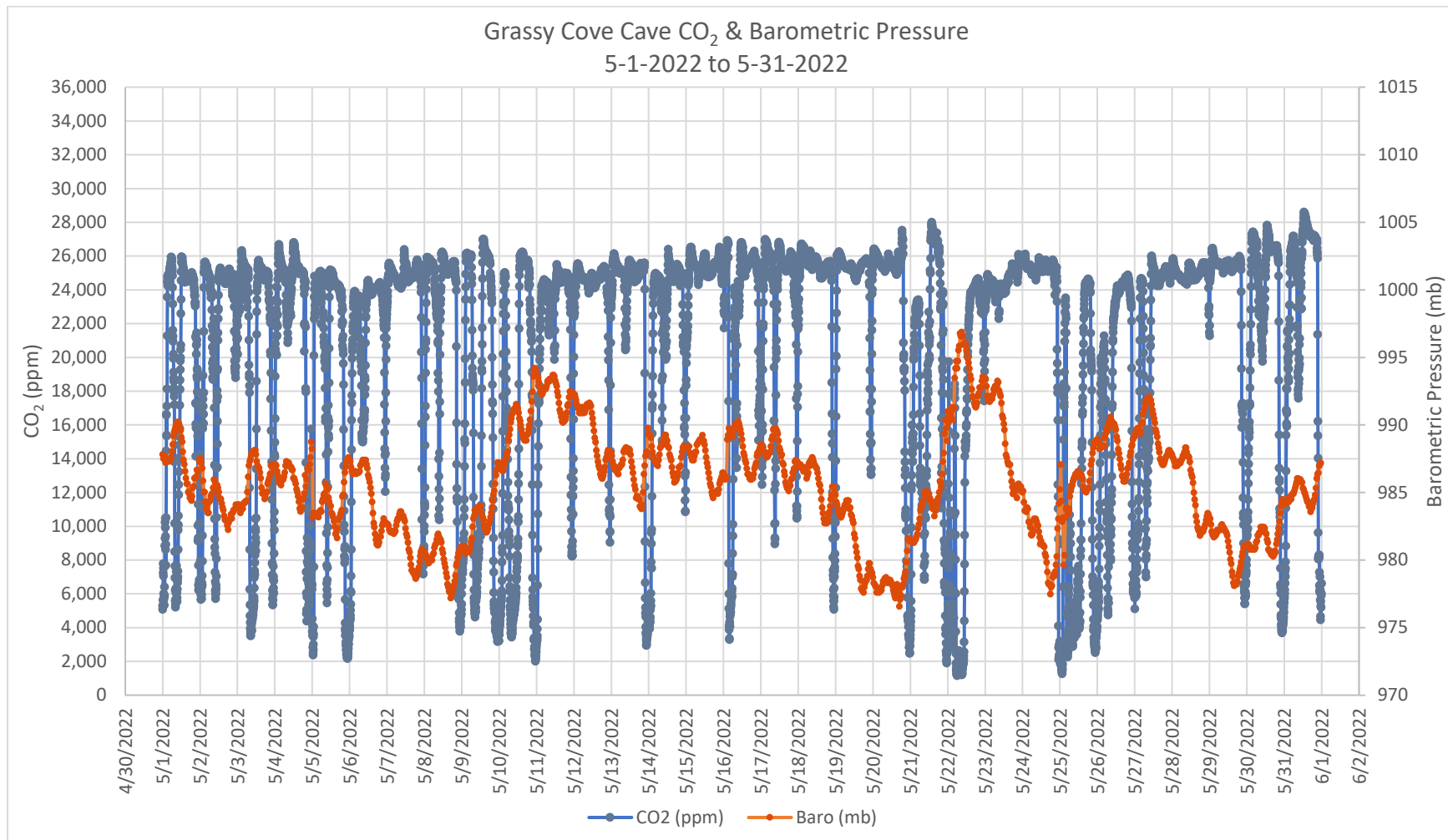


Figure 30. Grassy Cove Cave CO₂ & Barometric Pressure, 5-1-2022 to 5-31-2022

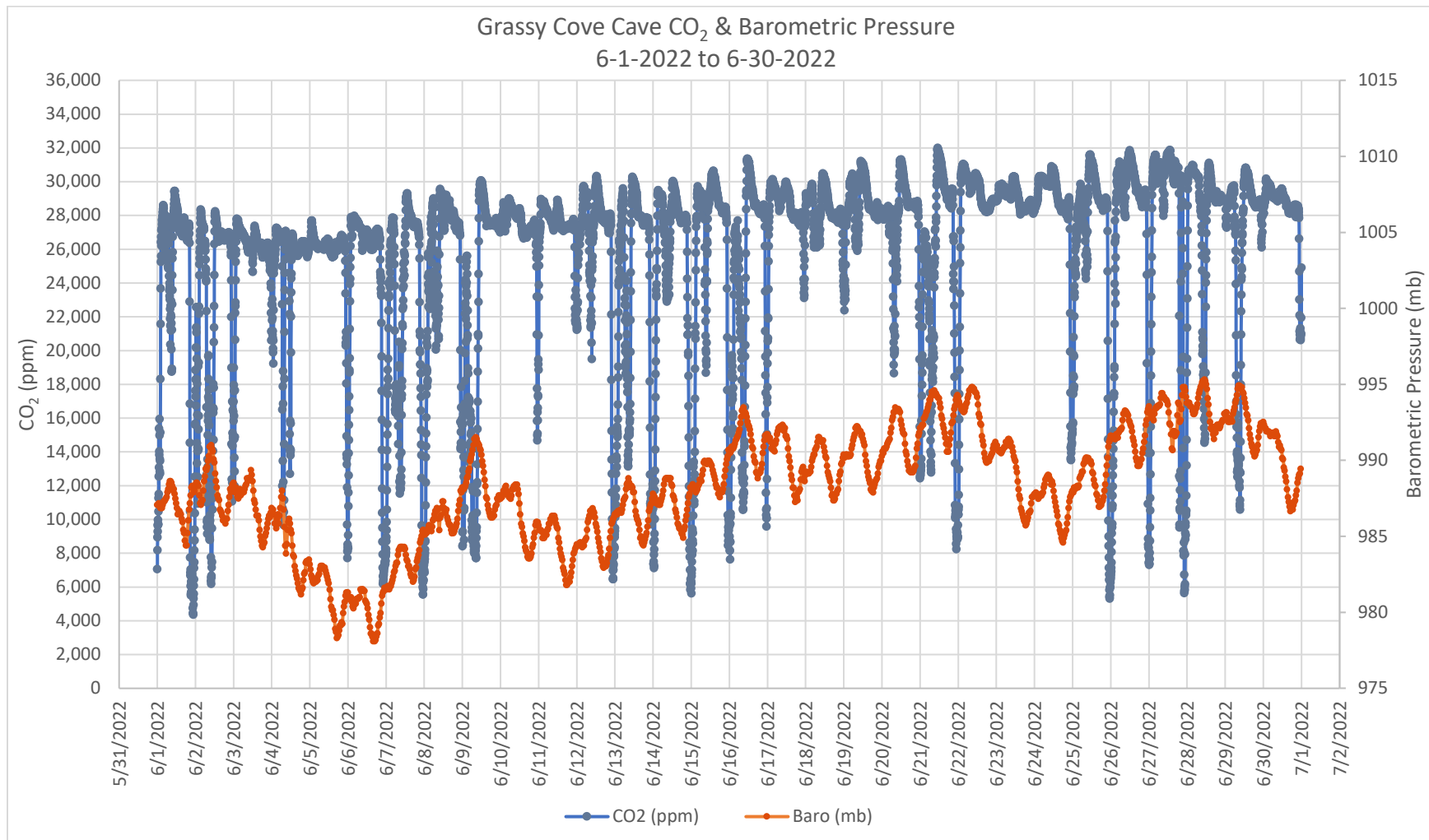


Figure 31. Grassy Cove Cave CO₂ & Barometric Pressure, 6-1-2022 to 6-30-2022

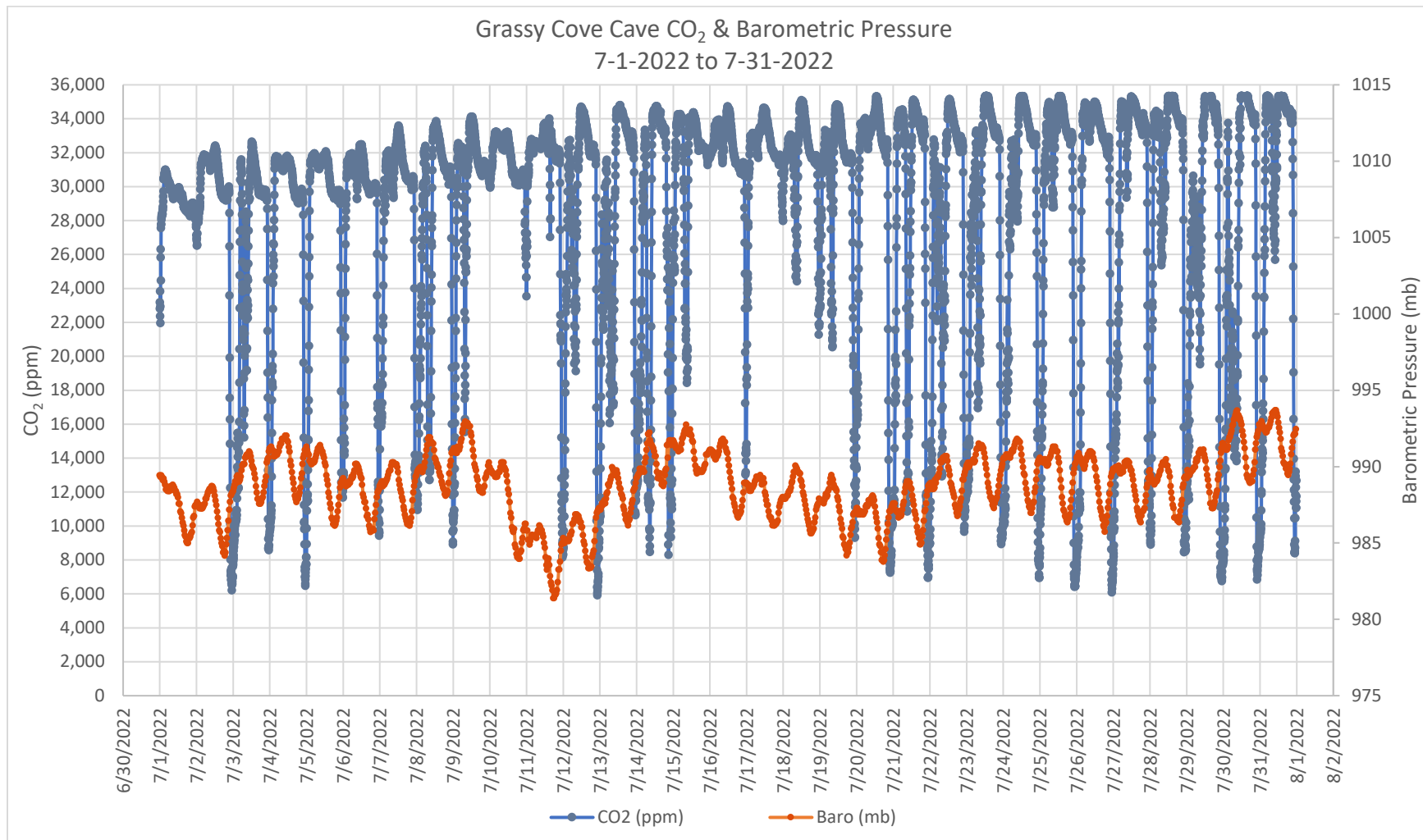


Figure 32. Grassy Cove Cave CO₂ & Barometric Pressure, 7-1-2022 to 7-31-2022

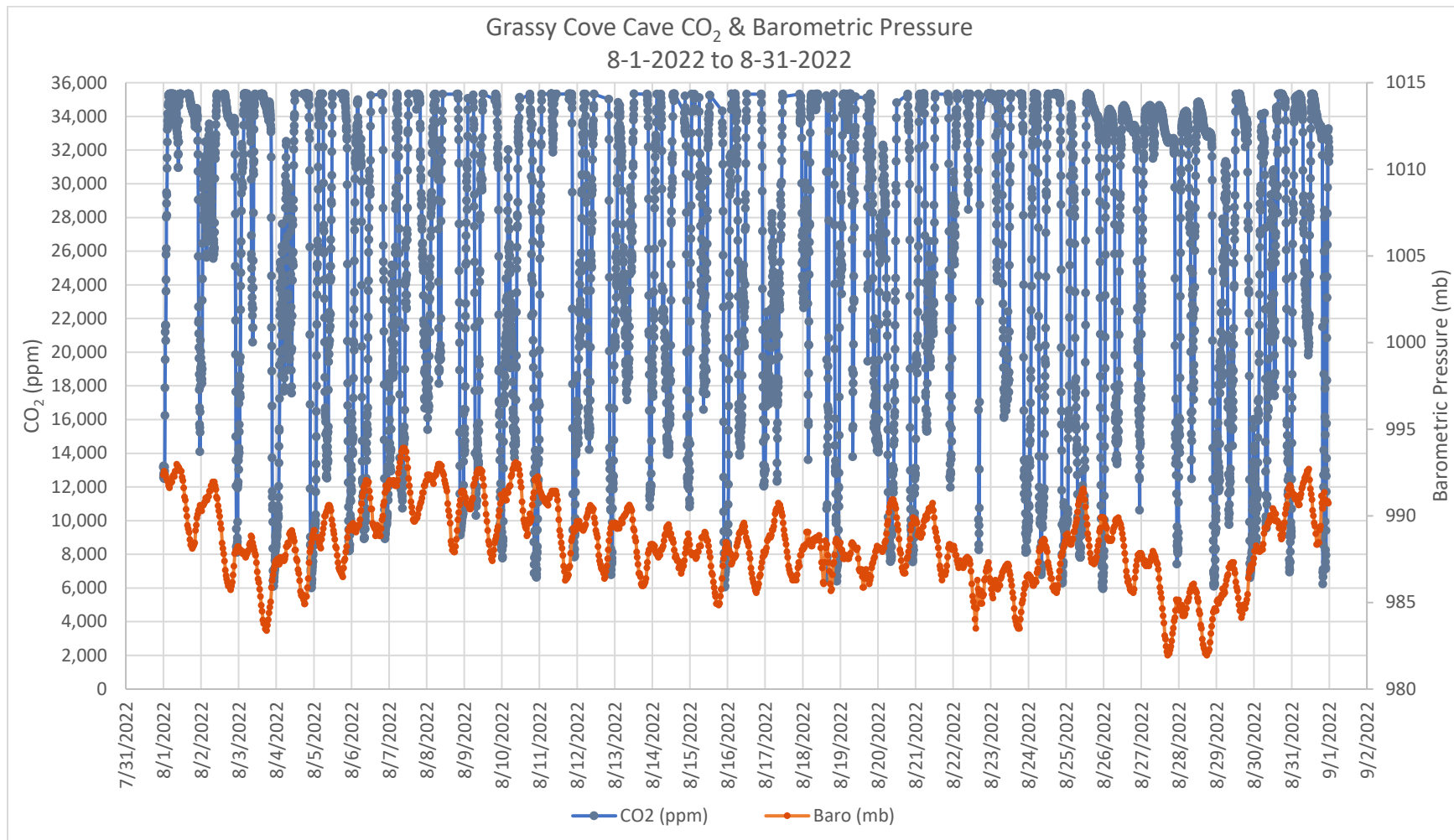


Figure 33. Grassy Cove Cave CO₂ & Barometric Pressure, 8-1-2022 to 8-31-2022

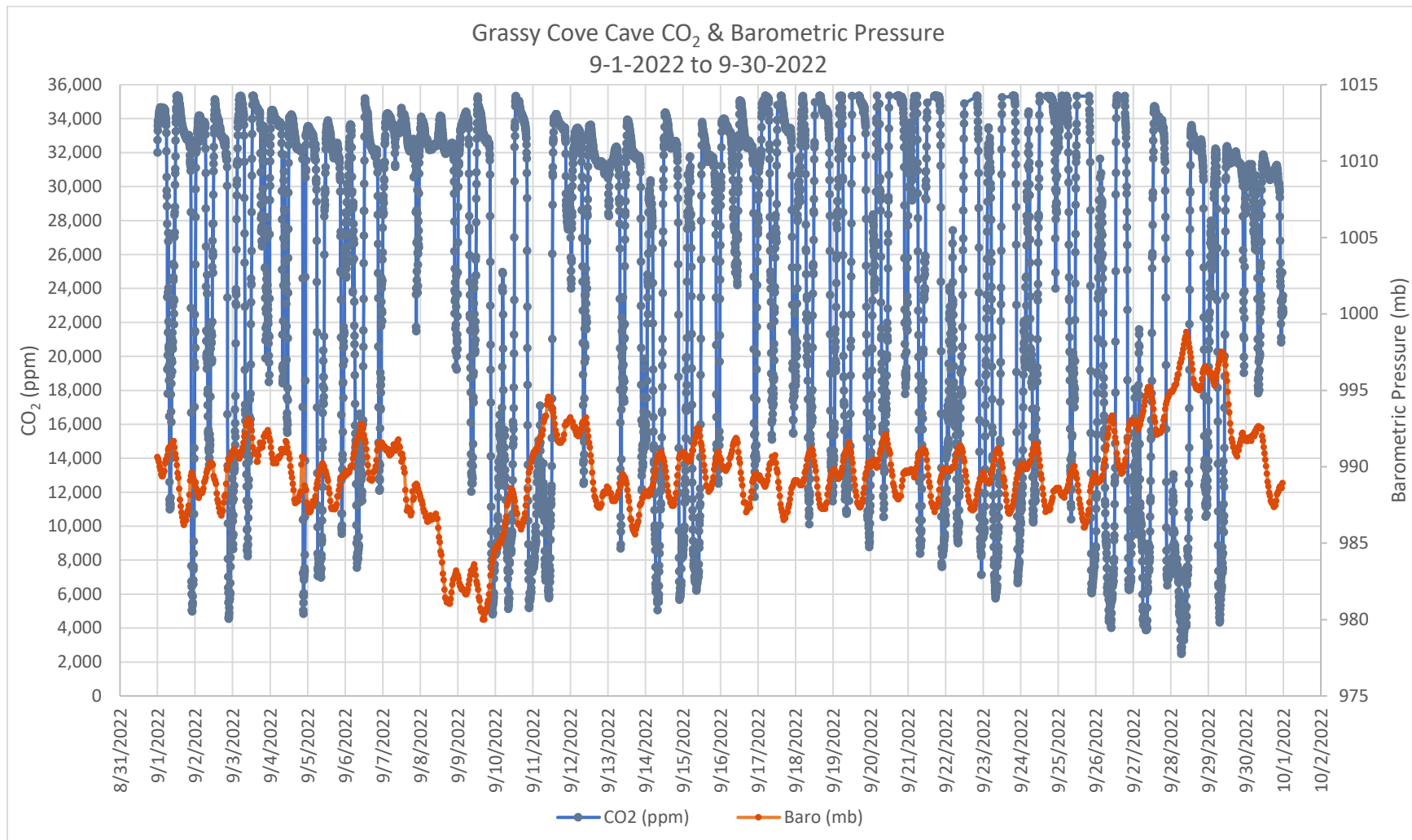


Figure 34. Grassy Cove Cave CO₂ & Barometric Pressure, 9-1-2022 to 9-30-2022

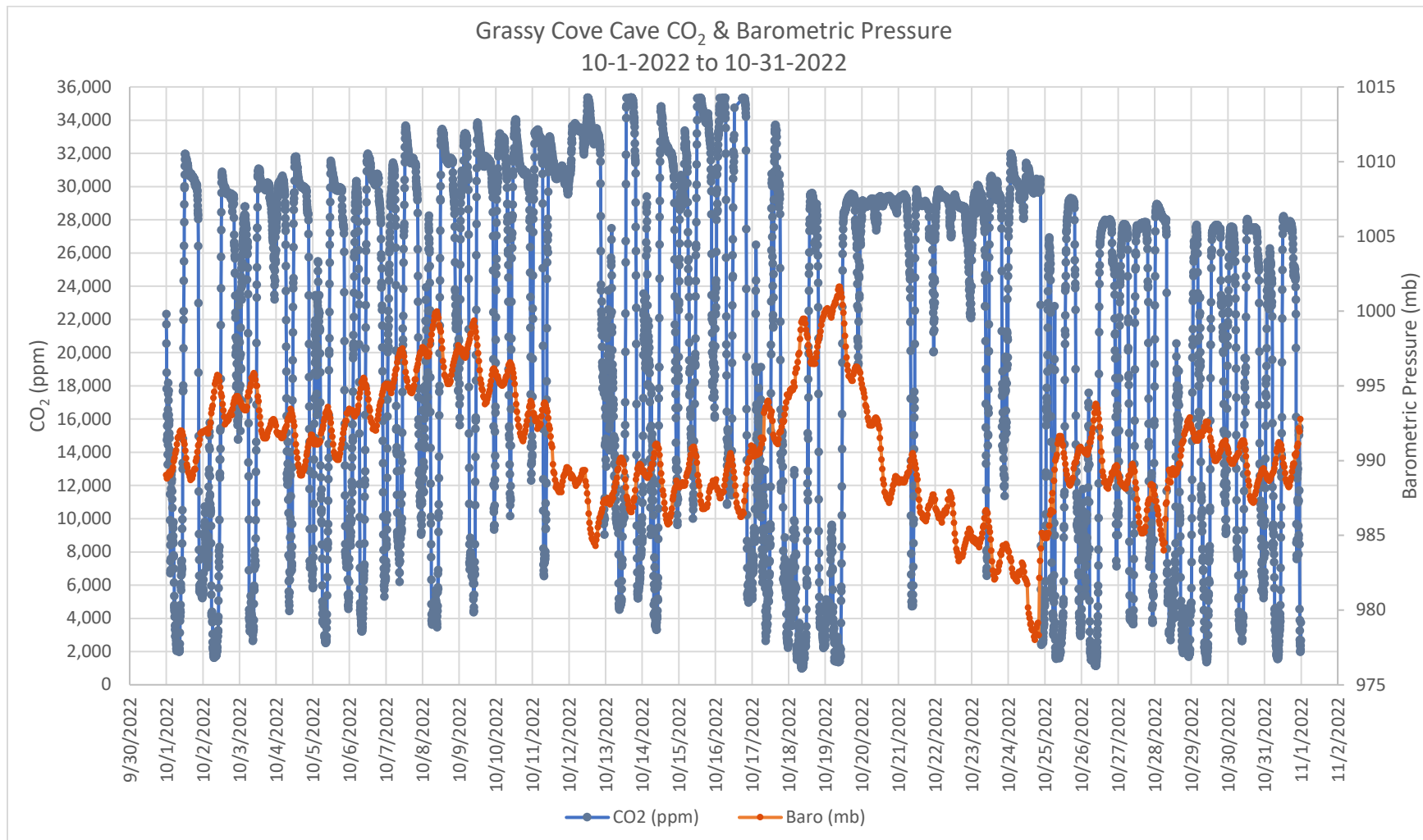


Figure 35. Grassy Cove Cave CO₂ & Barometric Pressure, 10-1-2022 to 10-31-2022

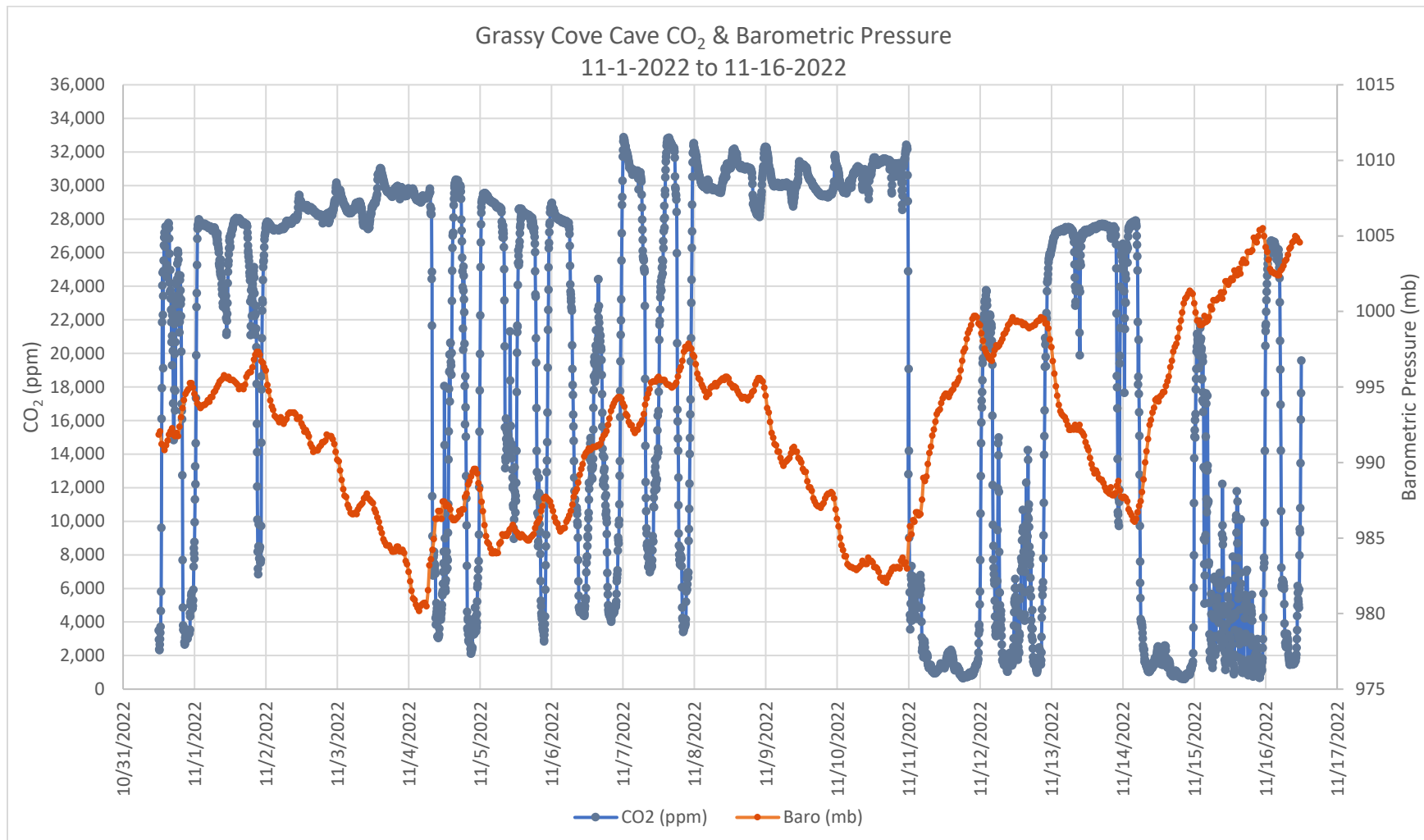


Figure 36. Grassy Cove Cave CO₂ & Barometric Pressure, 11-1-2022 to 11-16-2022

Figures 37 through 49 show CO₂ levels and barometric pressure in Ireland's Cave over one-month periods. All graphs were adjusted so the CO₂ level and barometric pressure scales are the same on all the graphs for easier comparison. Some graphs only show partial months or have gaps in CO₂ data due to equipment failures. Starting in June there are one day gaps in the CO₂ data from when the meters were pulled to be charged.

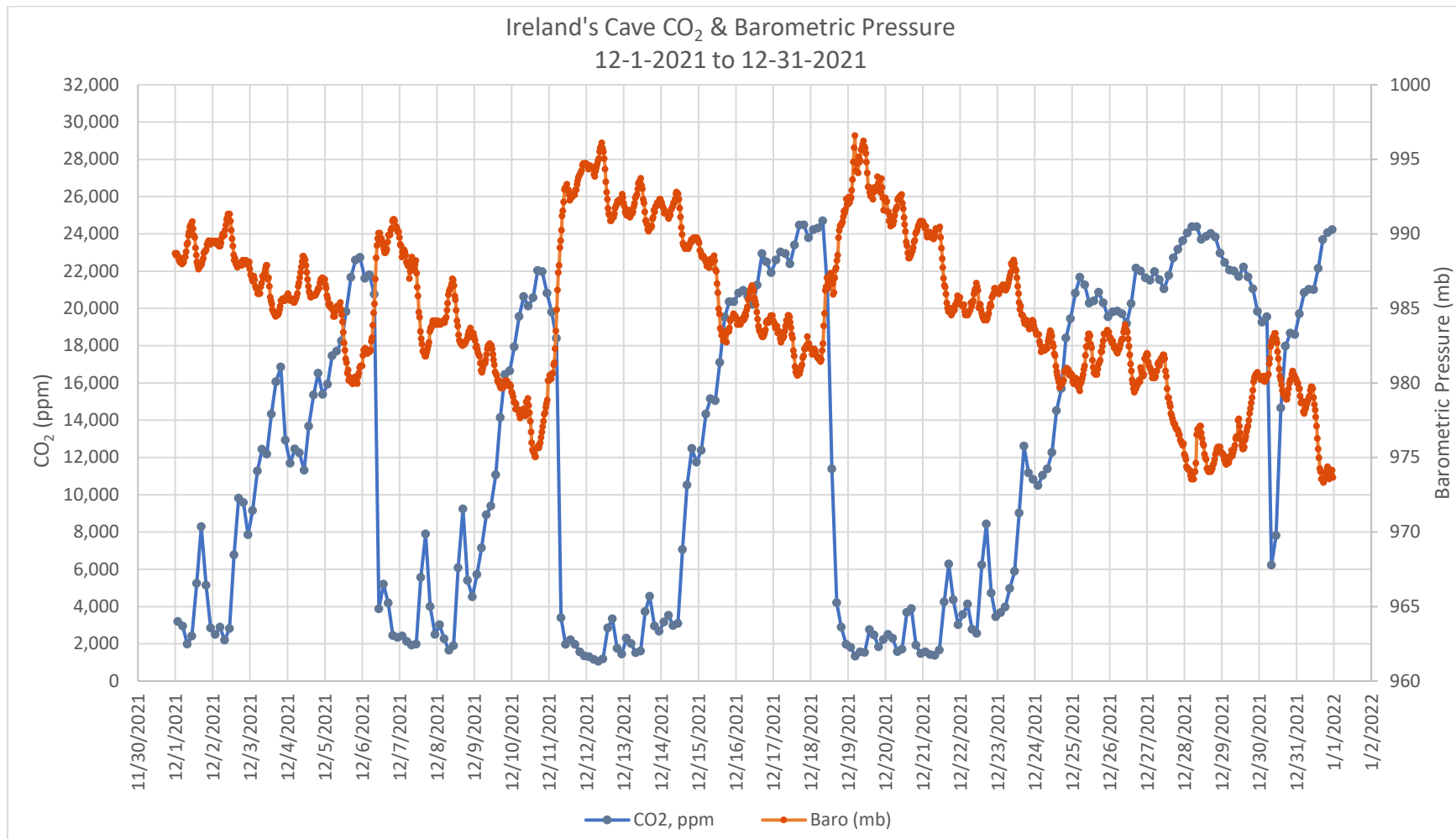


Figure 37. Ireland's Cave CO₂ & Barometric Pressure, 12-1-2021 to 12-31-2021

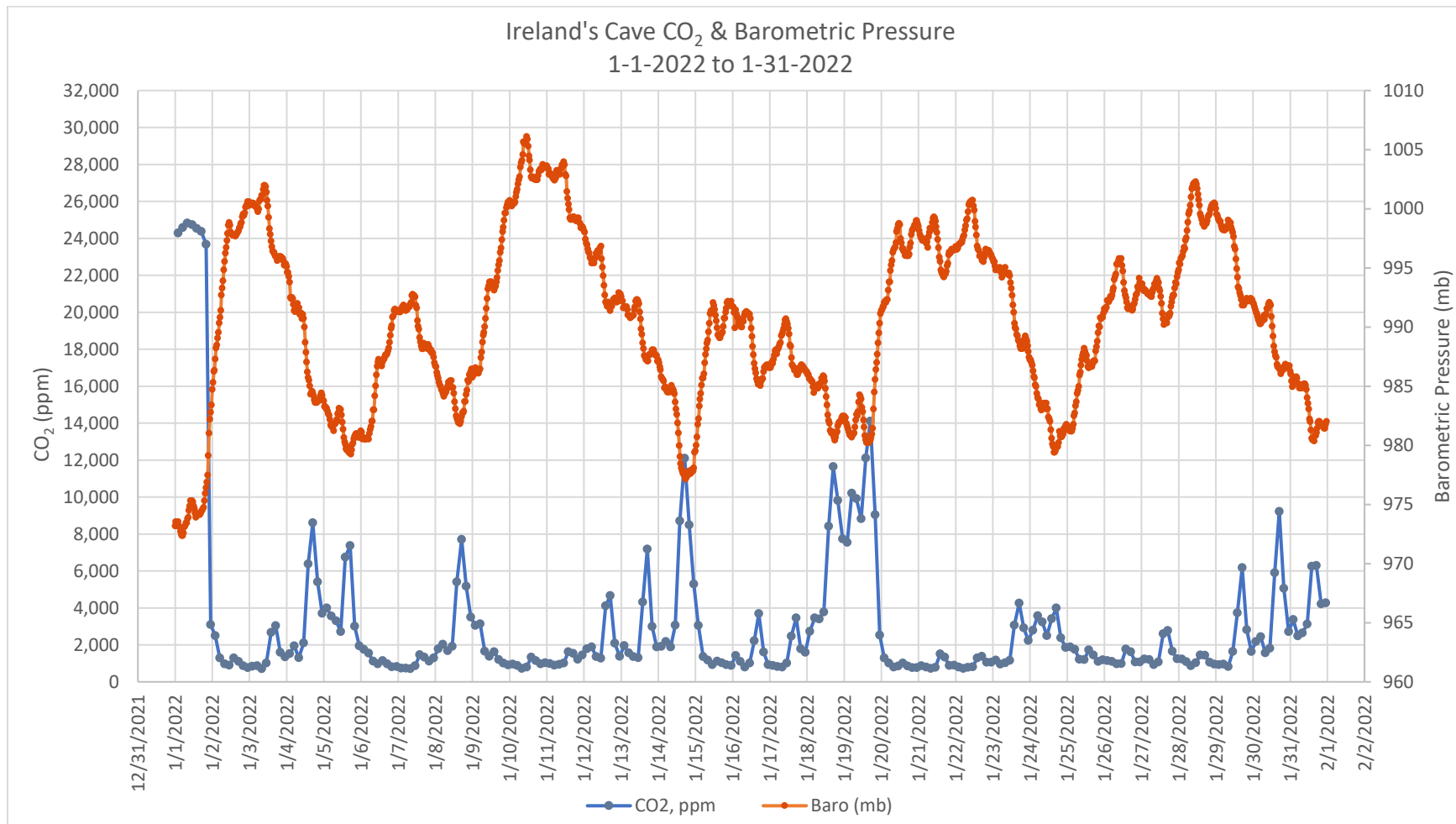


Figure 38. Ireland's Cave CO₂ & Barometric Pressure, 1-1-2022 to 1-31-2022

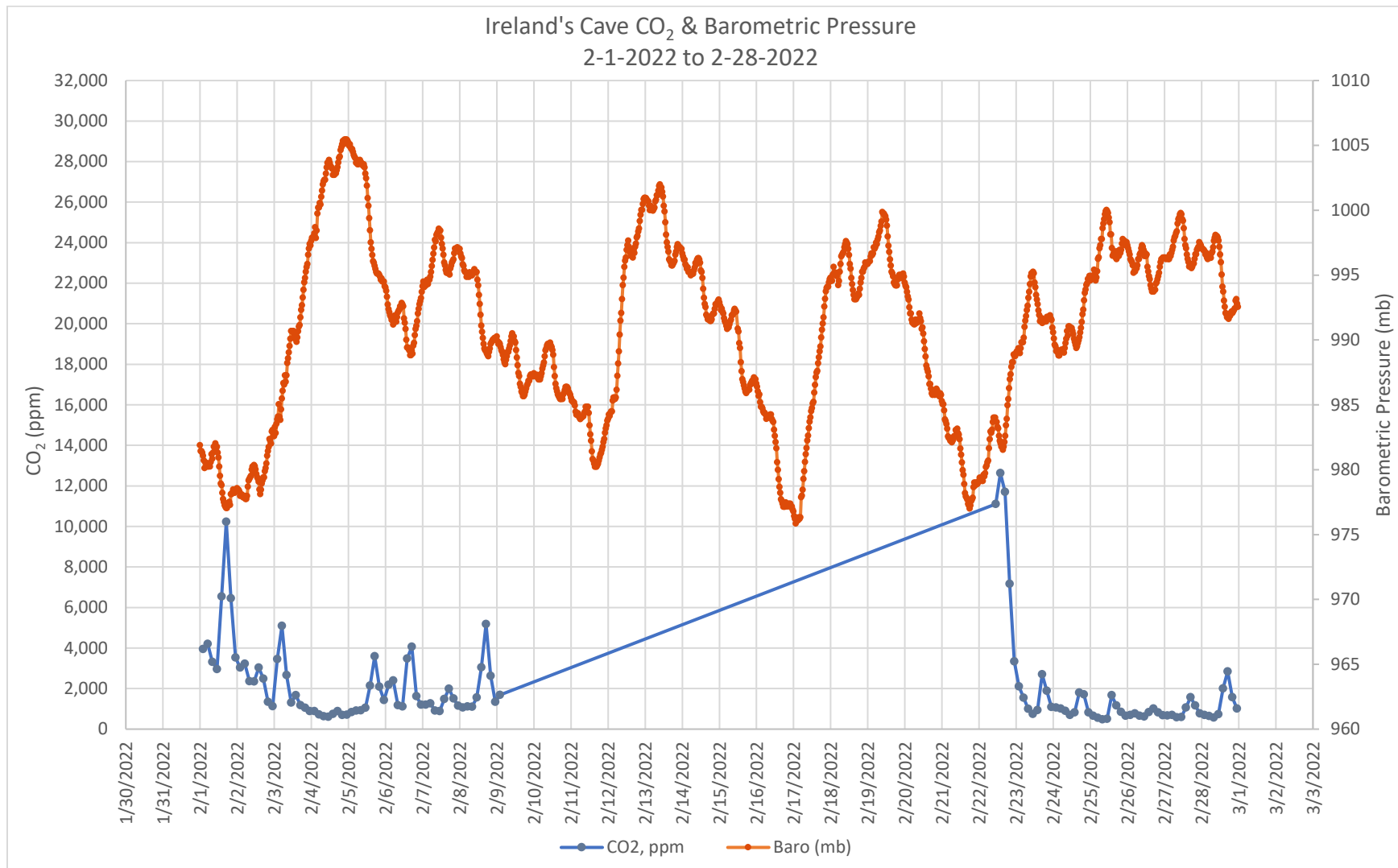


Figure 39. Ireland's Cave CO₂ & Barometric Pressure, 2-1-2022 to 2-28-2022

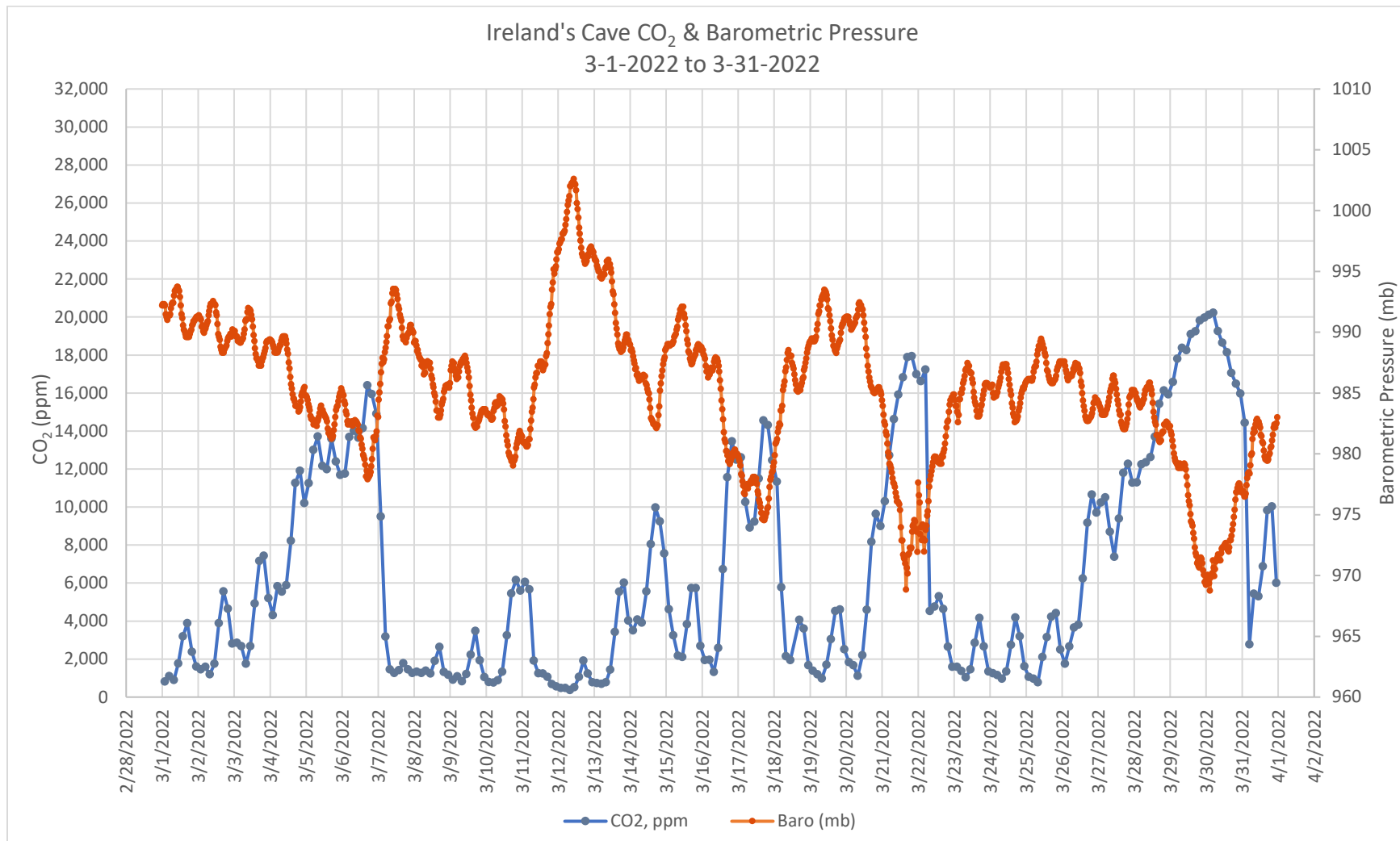


Figure 40. Ireland's Cave CO₂ & Barometric Pressure, 3-1-2022 to 3-31-2022

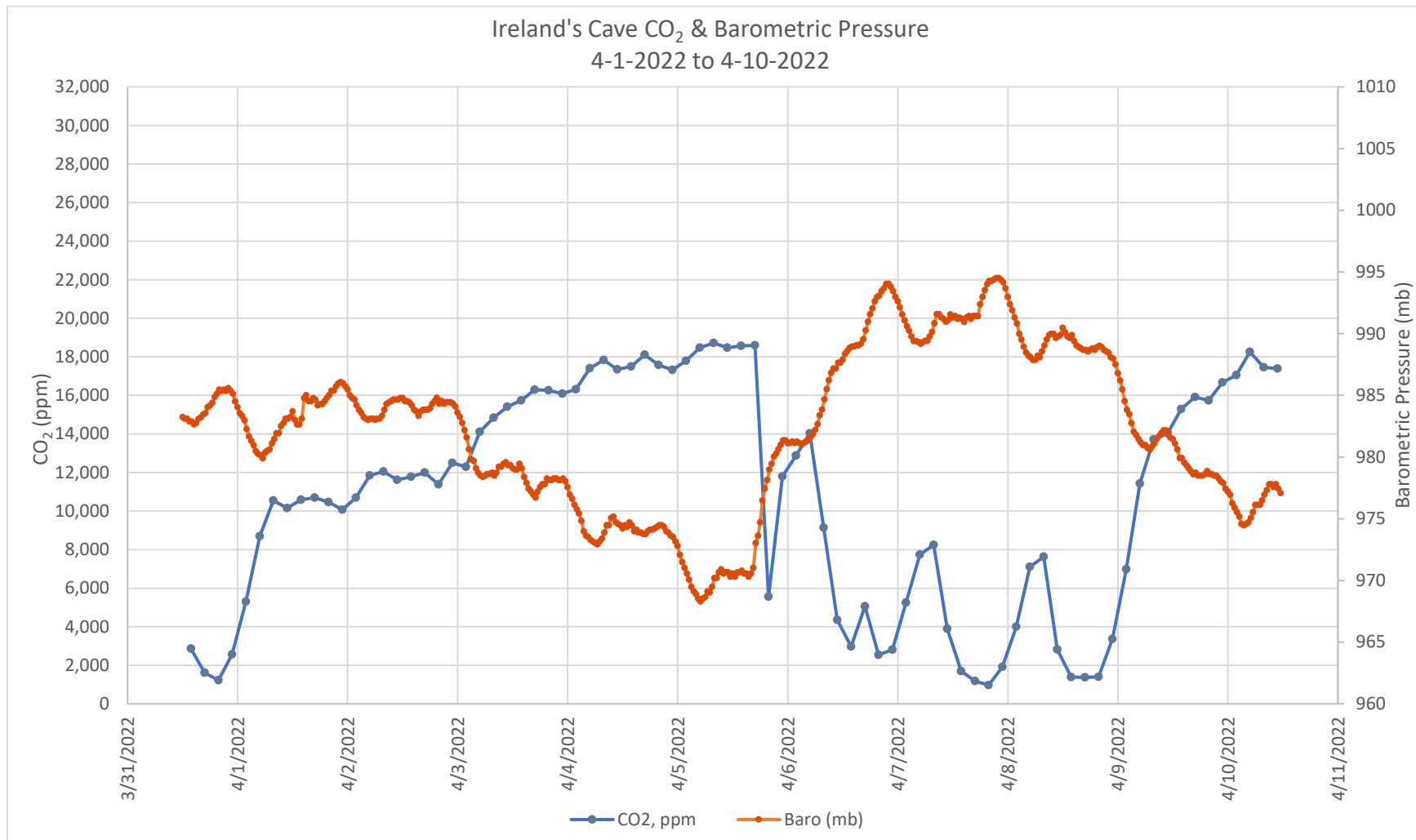


Figure 41. Ireland's Cave CO₂ & Barometric Pressure, 4-1-2022 to 4-10-2022

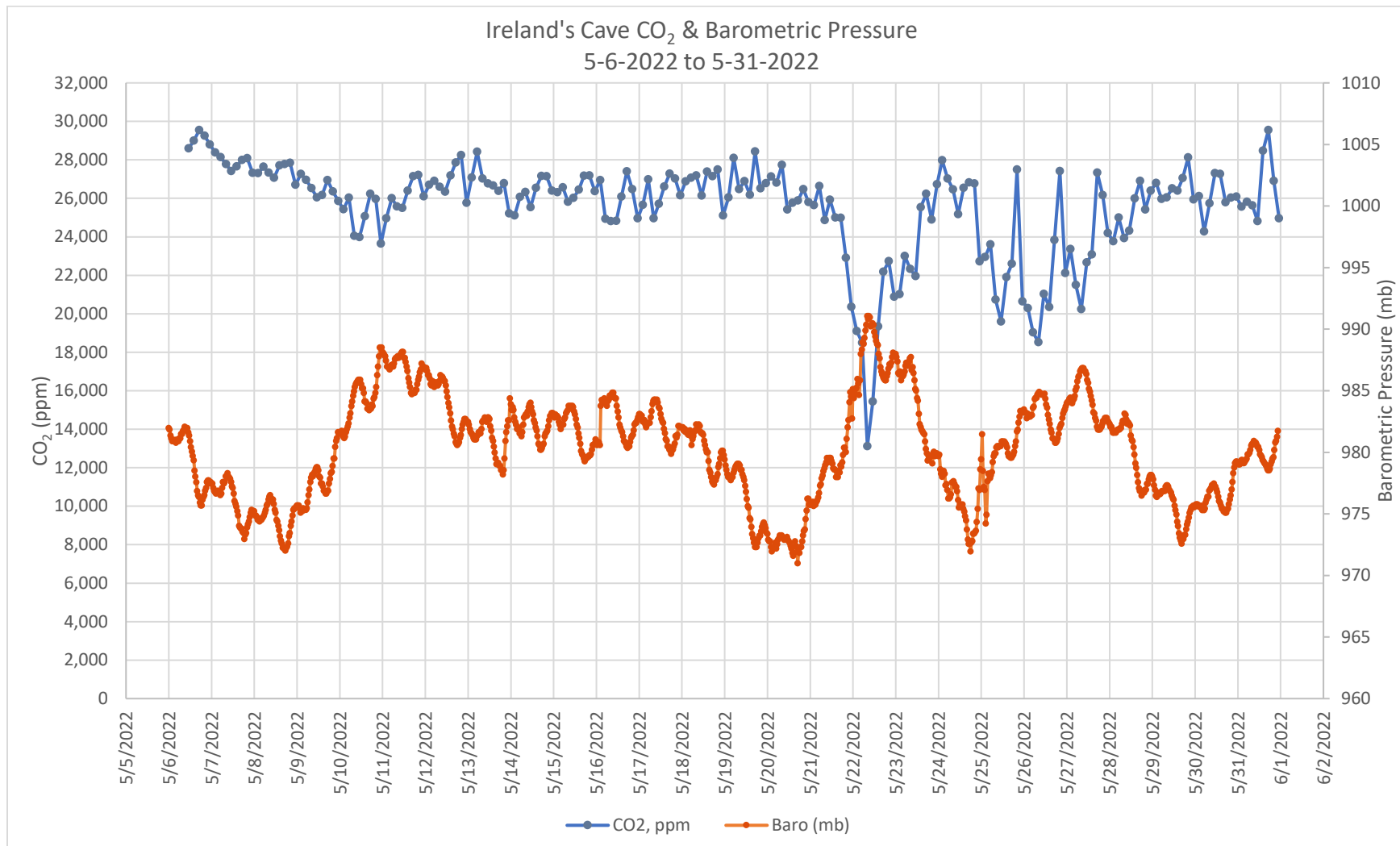


Figure 42. Ireland's Cave CO₂ & Barometric Pressure, 5-6-2022 to 5-31-2022

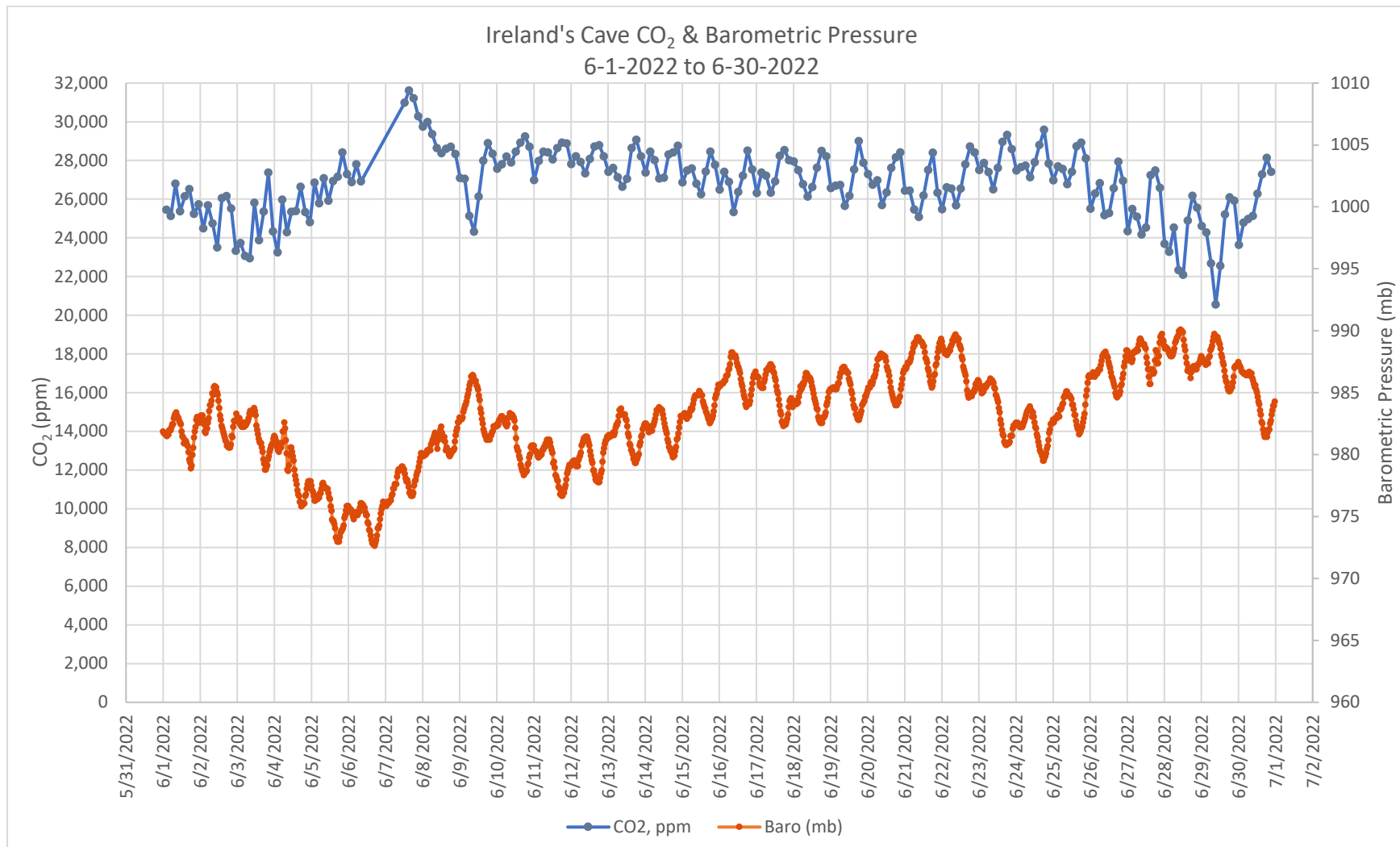


Figure 43. Ireland's Cave CO₂ & Barometric Pressure, 6-1-2022 to 6-30-2022

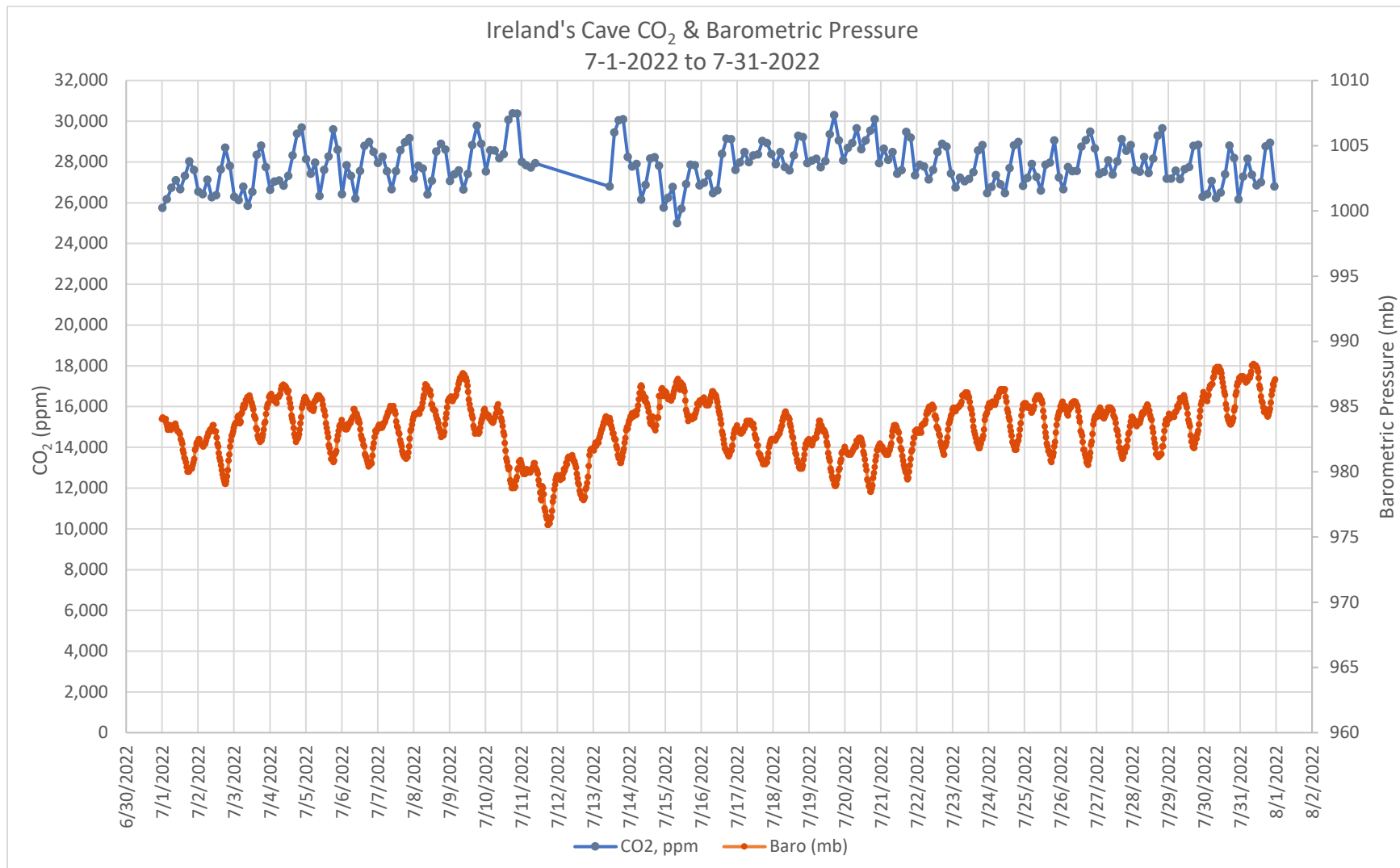


Figure 44. Ireland's Cave CO₂ & Barometric Pressure, 6-1-2022 to 6-30-2022

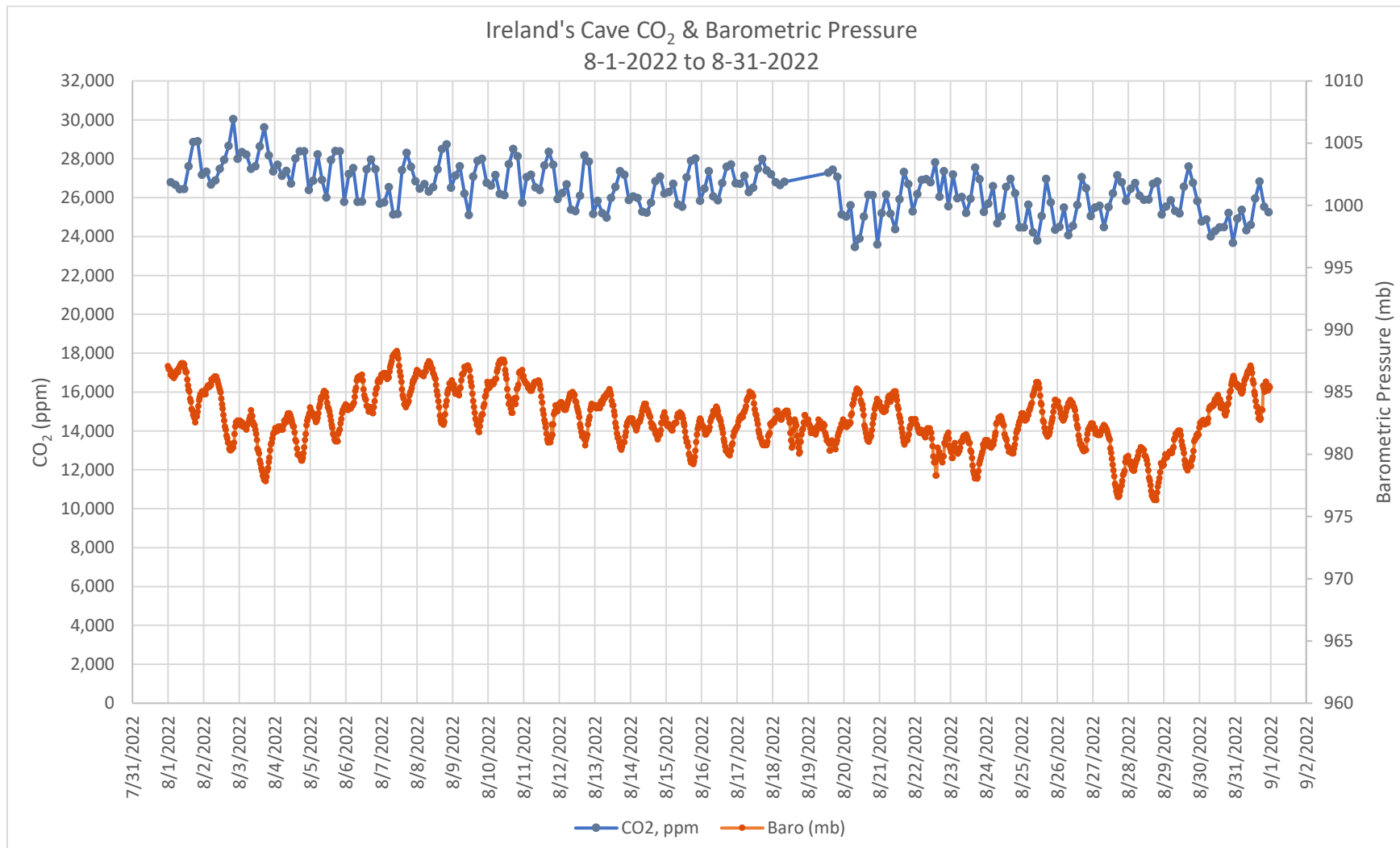


Figure 45. Ireland's Cave CO₂ & Barometric Pressure, 8-1-2022 to 8-31-2022

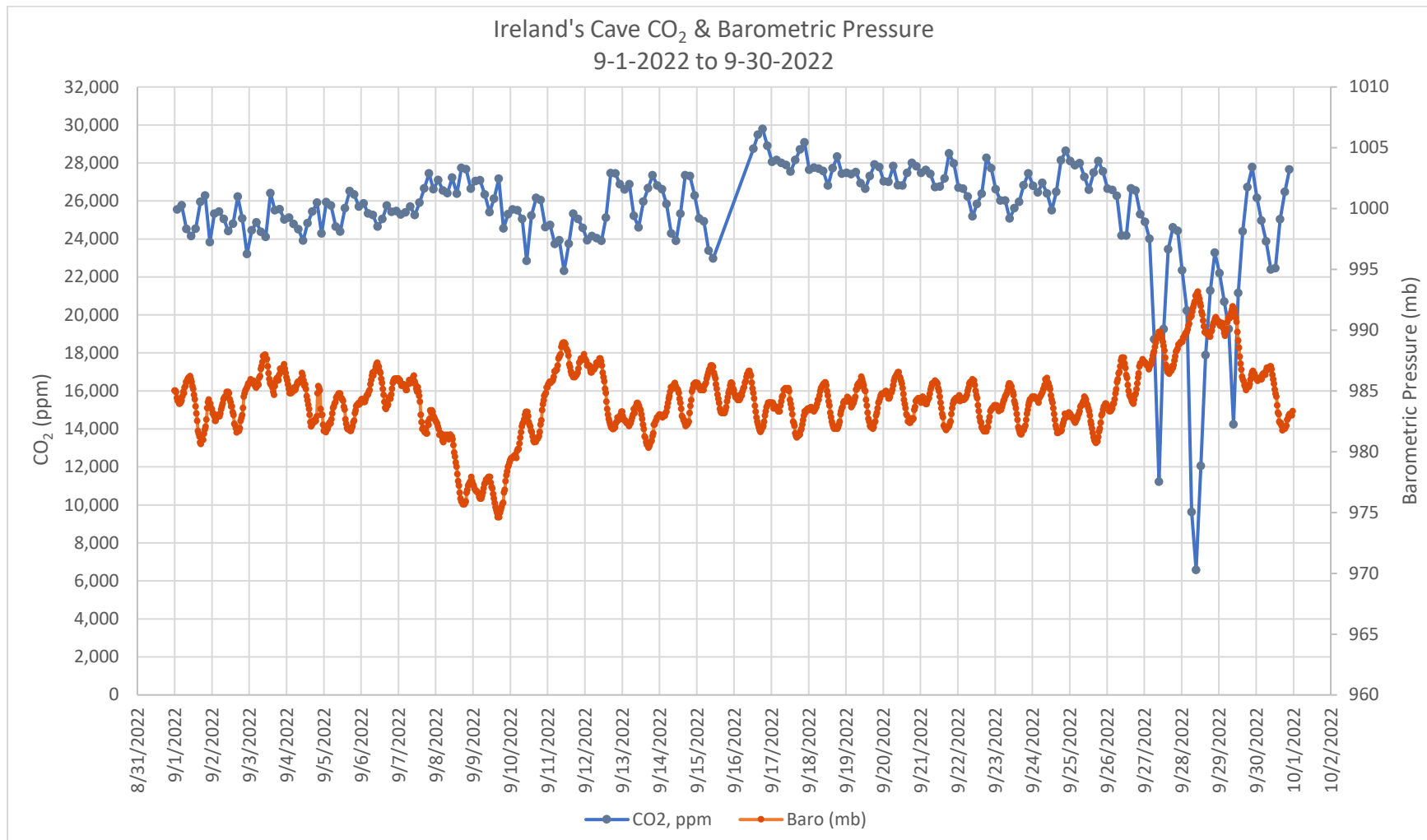


Figure 46. Ireland's Cave CO₂ & Barometric Pressure, 9-1-2022 to 9-30-2022

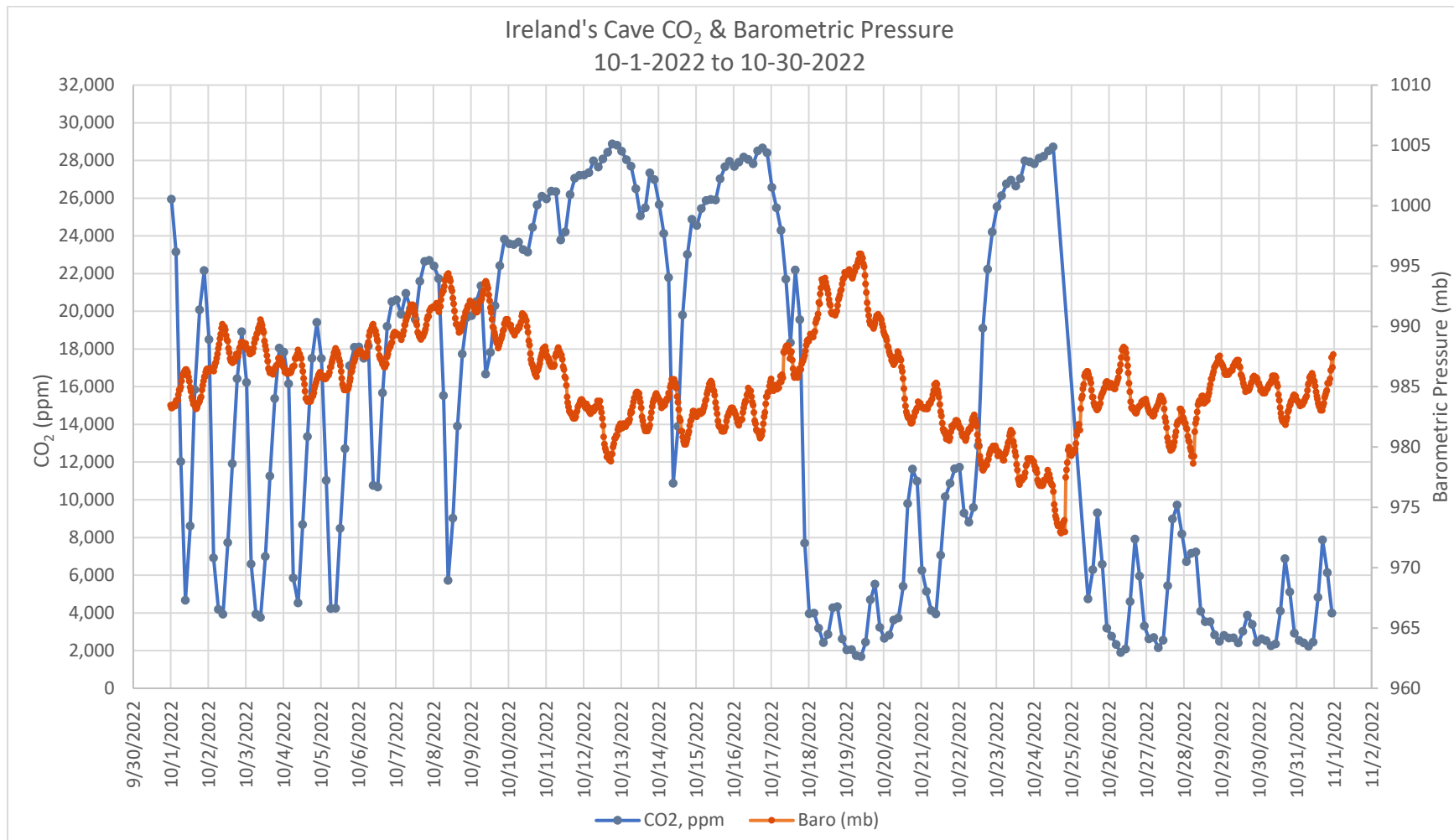


Figure 47. Ireland's Cave CO₂ & Barometric Pressure, 10-1-2022 to 10-30-2022

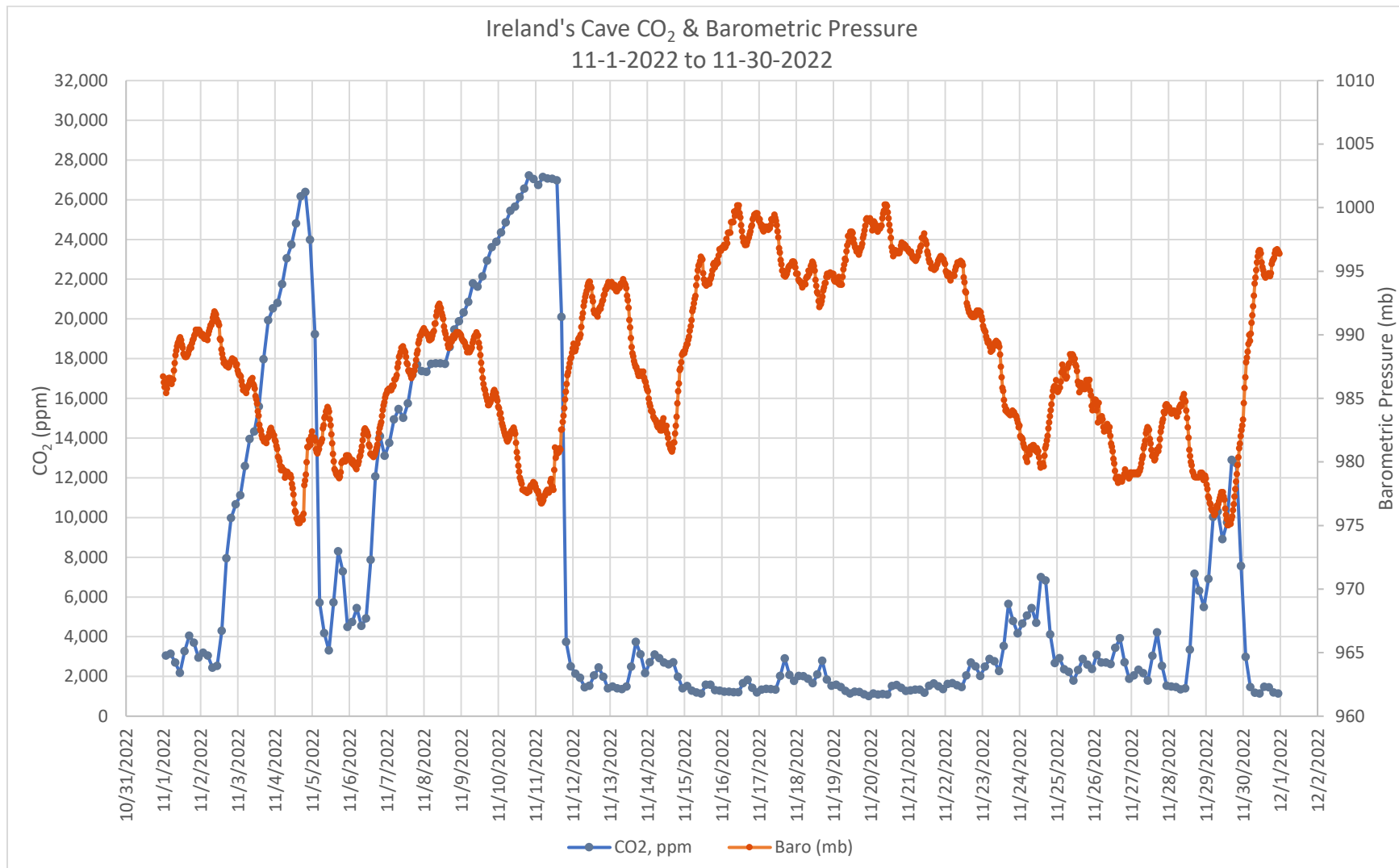


Figure 48. Ireland's Cave CO₂ & Barometric Pressure, 11-1-2022 to 11-30-2022

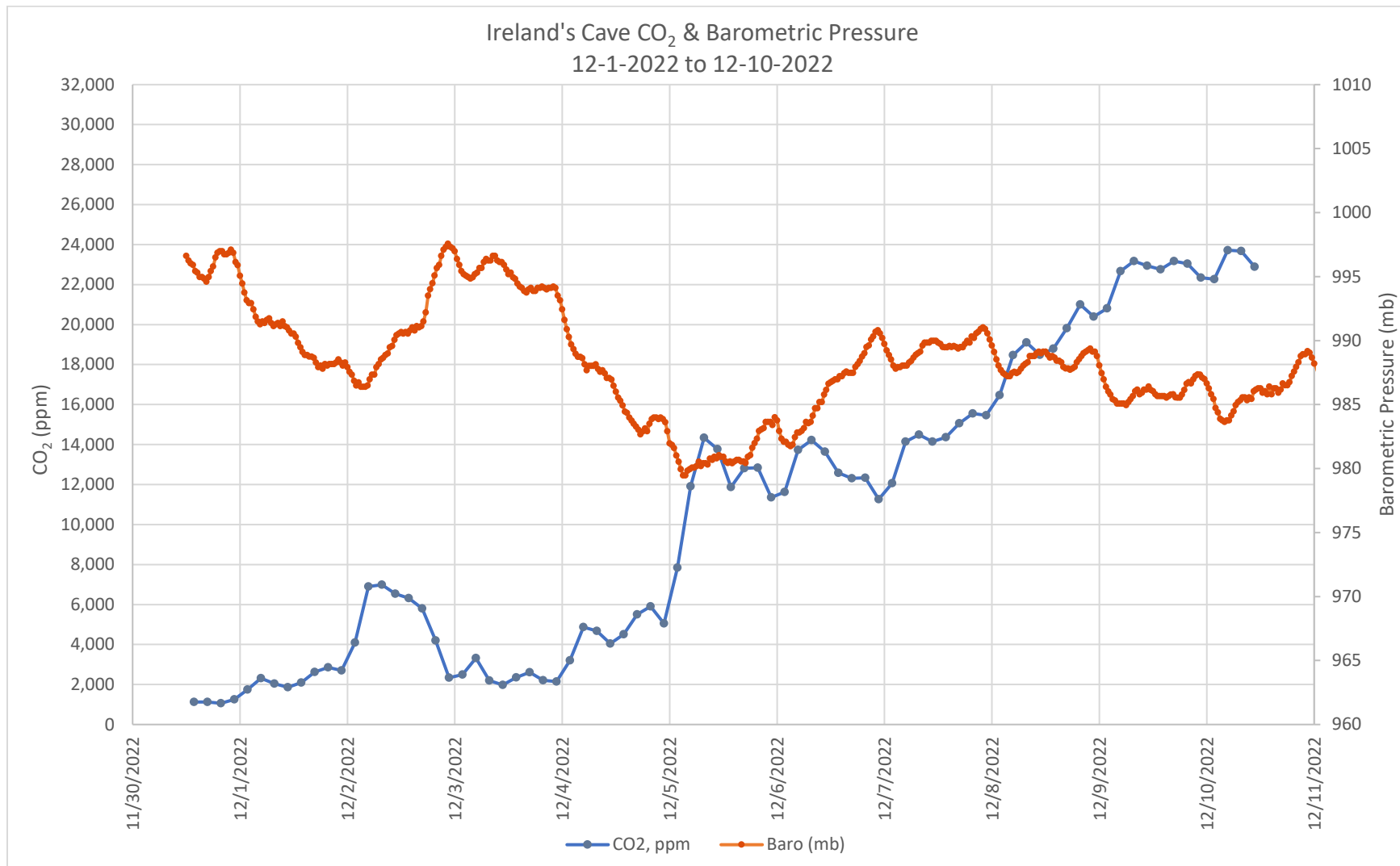


Figure 49. Ireland's Cave CO₂ & Barometric Pressure, 12-1-2022 to 12-10-2022

Figures 50 through 69 show CO₂ levels and barometric pressure in Whirlpool Cave over one-month periods. All graphs were adjusted so the CO₂ level and barometric pressure scales are the same on all the graphs for easier comparison. Some graphs only show partial months or have gaps in CO₂ data due to equipment failures. Starting in June there are one day gaps in the CO₂ data from when the meters were pulled to be charged.

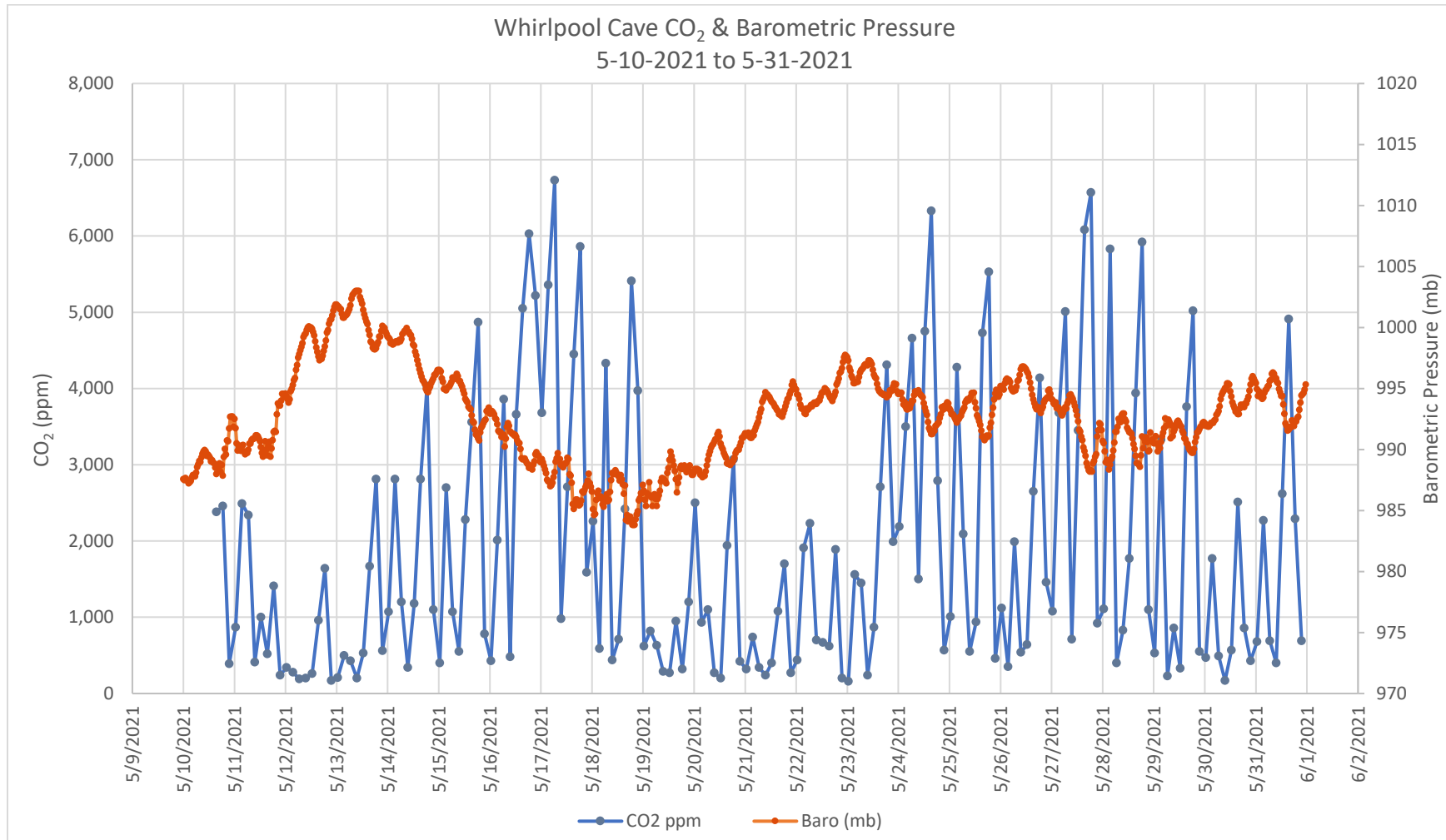


Figure 50. Whirlpool Cave CO₂ & Barometric Pressure, 5-10-2021 to 5-31-2021

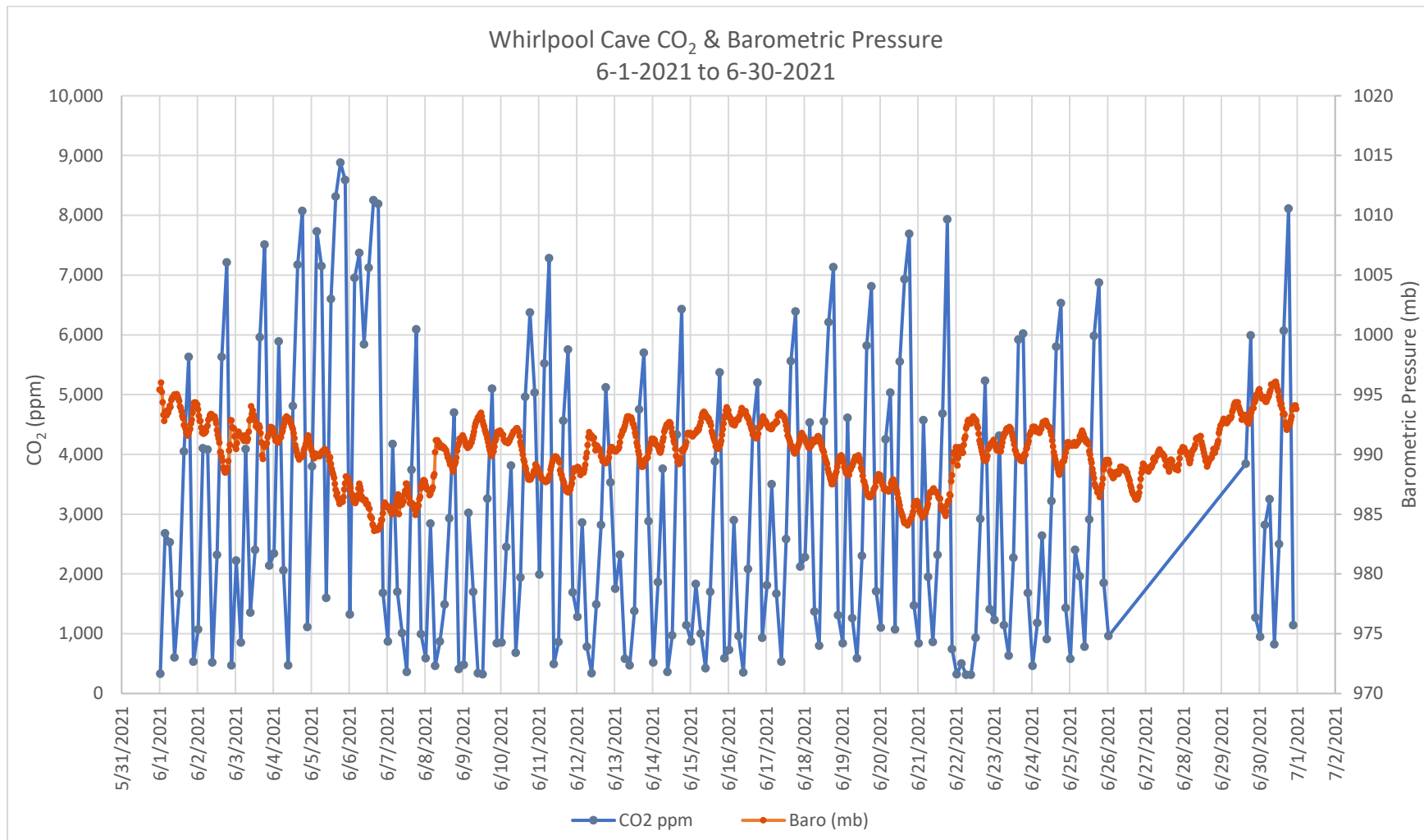


Figure 51. Whirlpool Cave CO₂ & Barometric Pressure, 6-1-2021 to 6-30-2021

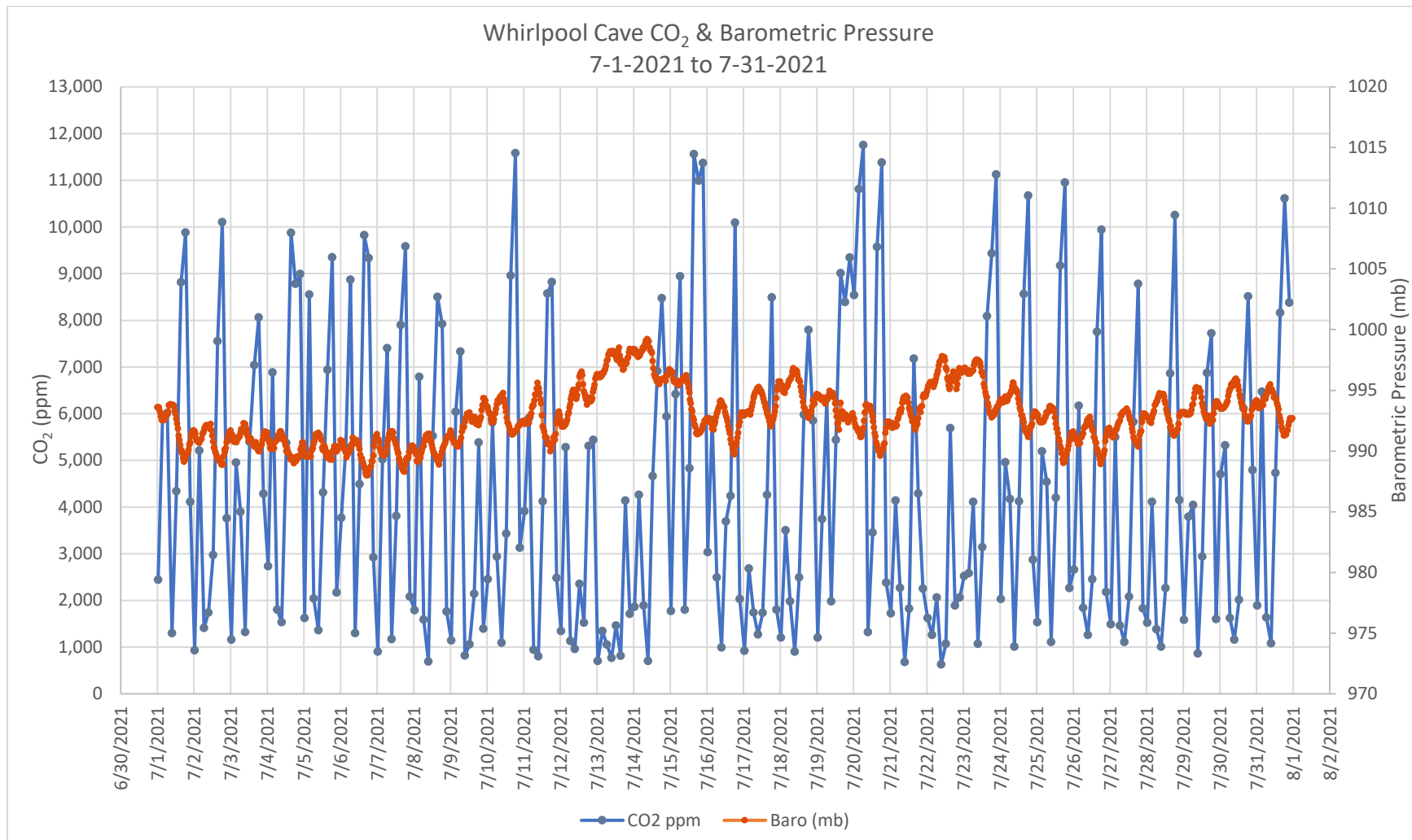


Figure 52. Whirlpool Cave CO₂ & Barometric Pressure, 7-1-2021 to 7-31-2021

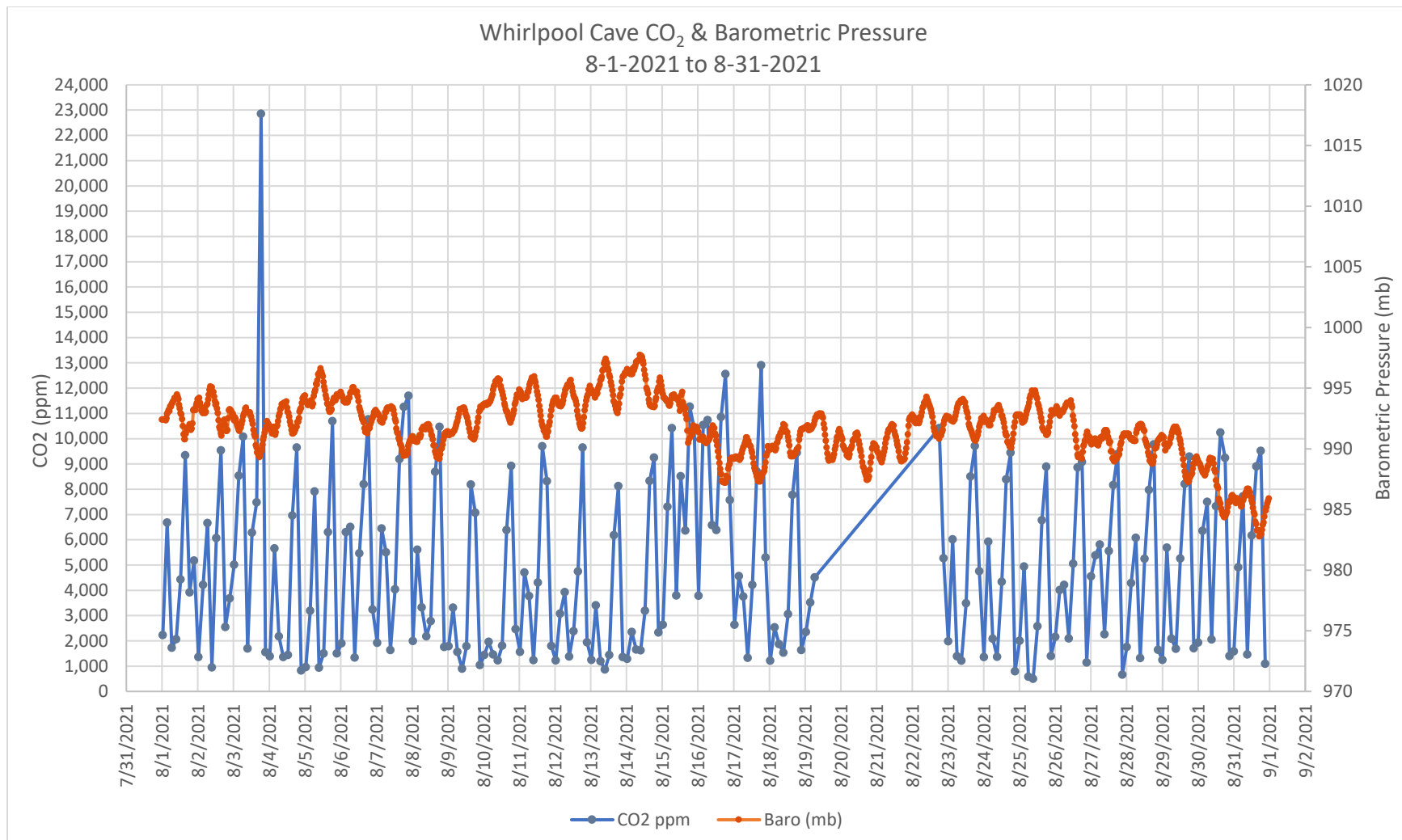


Figure 53. Whirlpool Cave CO₂ & Barometric Pressure, 8-1-2021 to 8-31-2021

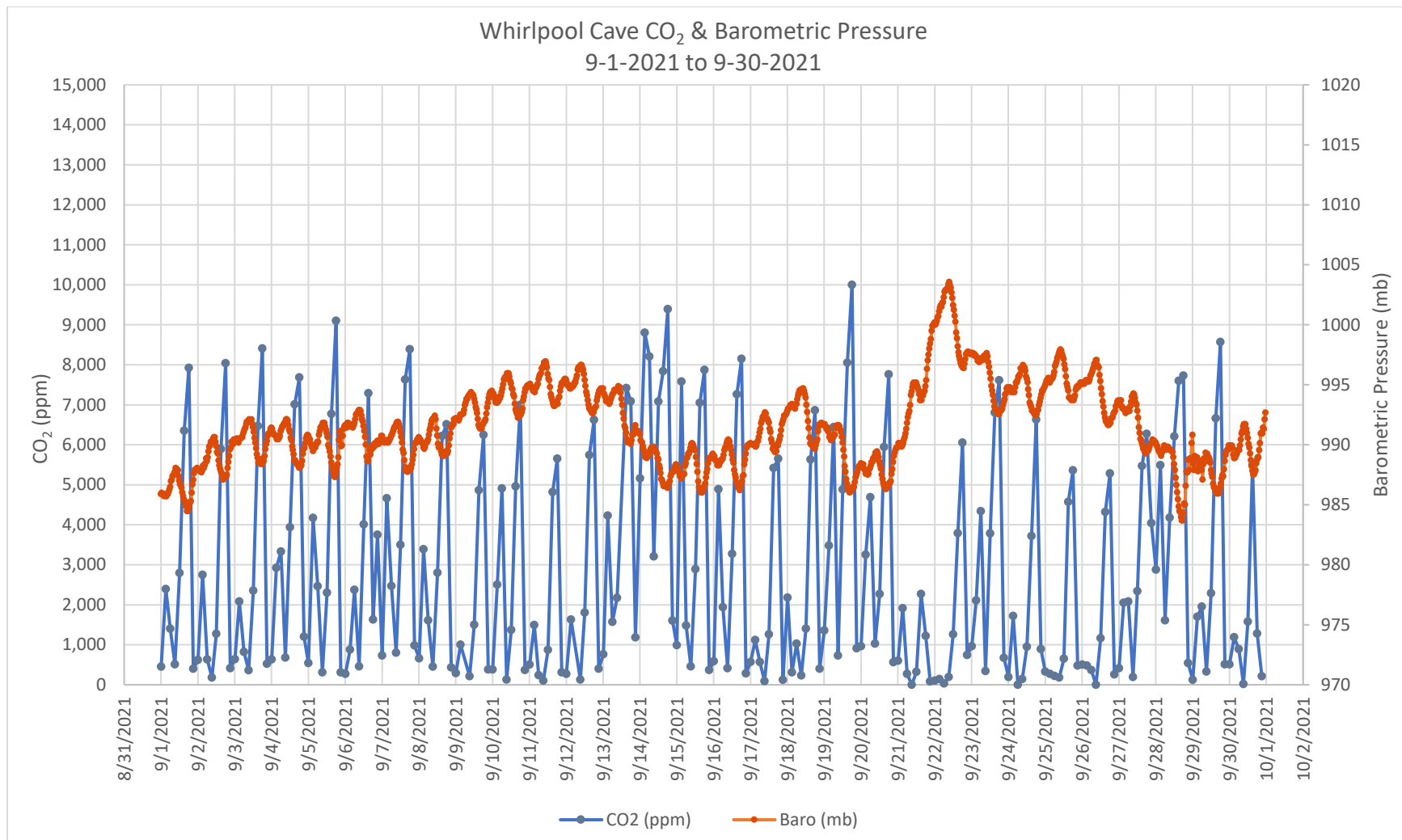


Figure 54. Whirlpool Cave CO₂ & Barometric Pressure, 9-1-2021 to 9-30-2021

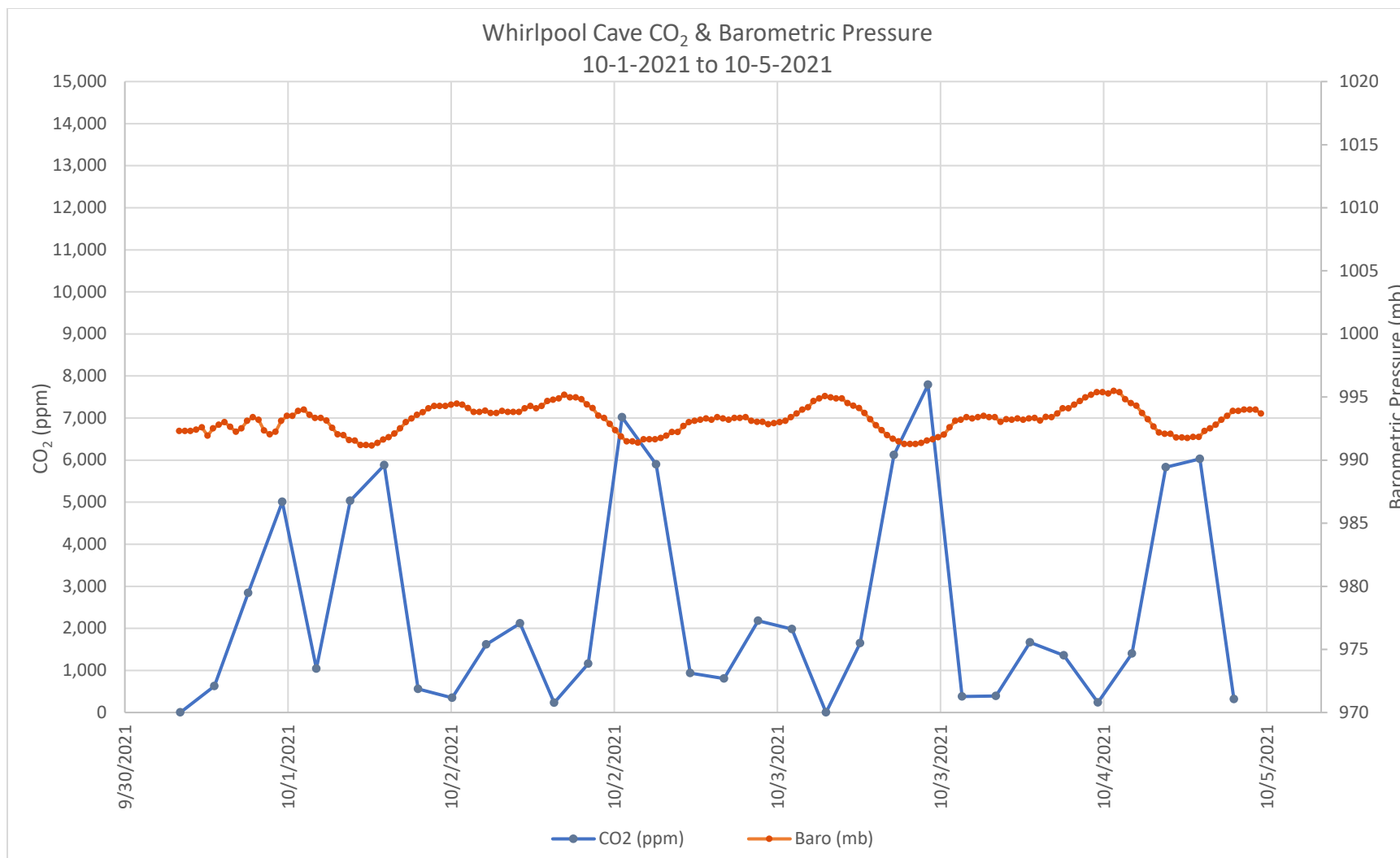


Figure 55. Whirlpool Cave CO₂ & Barometric Pressure, 10-1-2021 to 10-5-2021

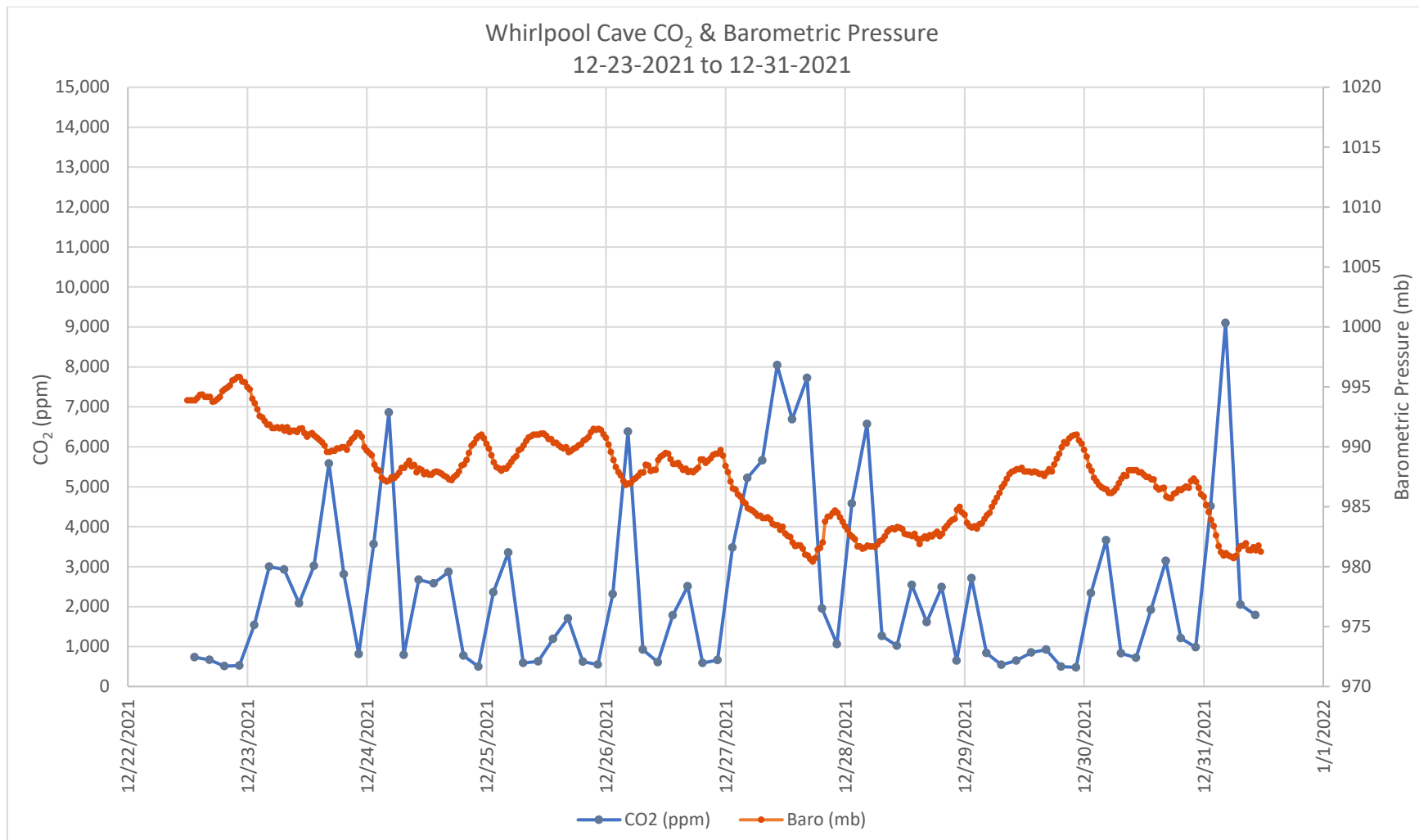


Figure 56. Whirlpool Cave CO₂ & Barometric Pressure, 12-23-2021 to 12-31-2021

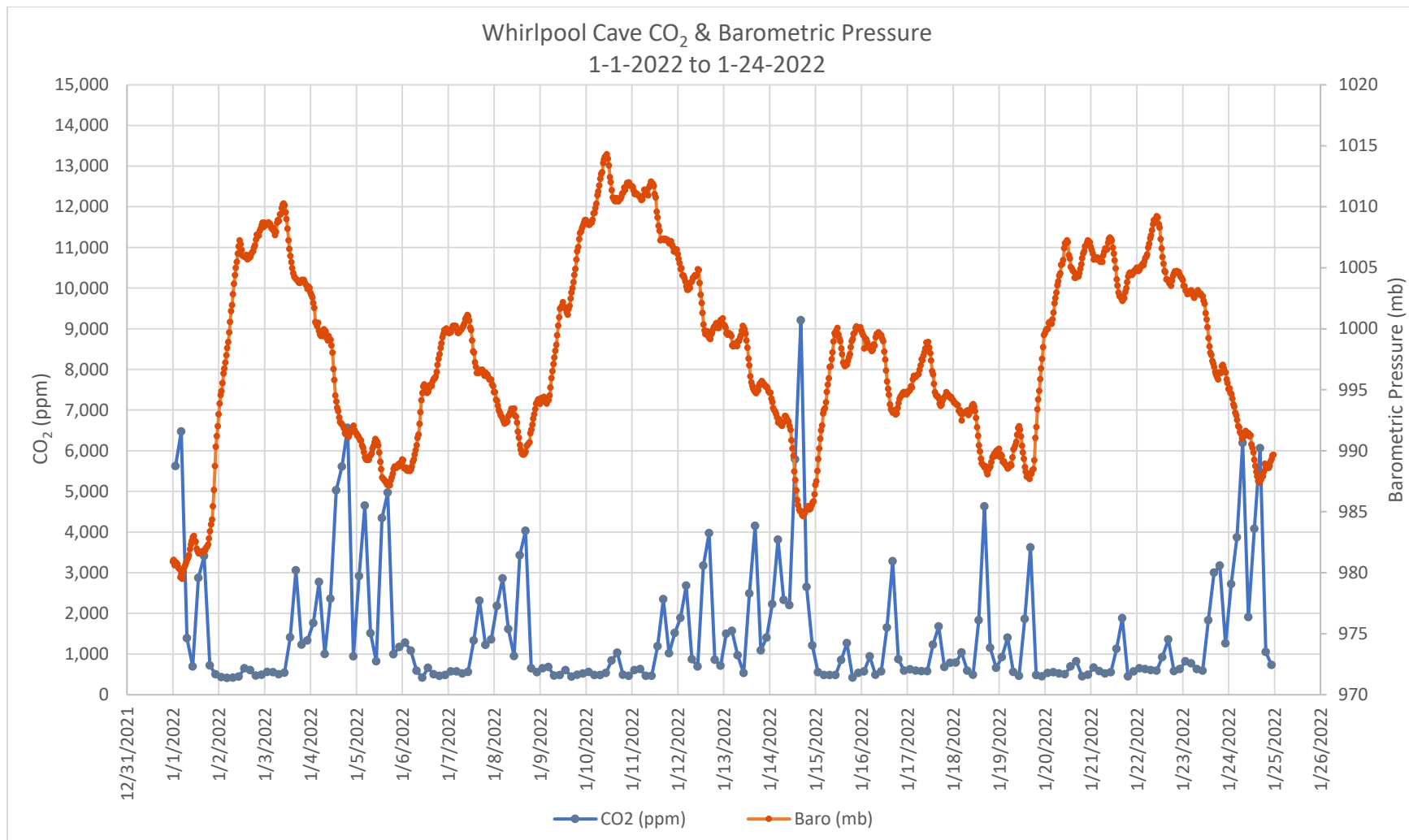


Figure 57. Whirlpool Cave CO₂ & Barometric Pressure, 1-1-2022 to 1-24-2022

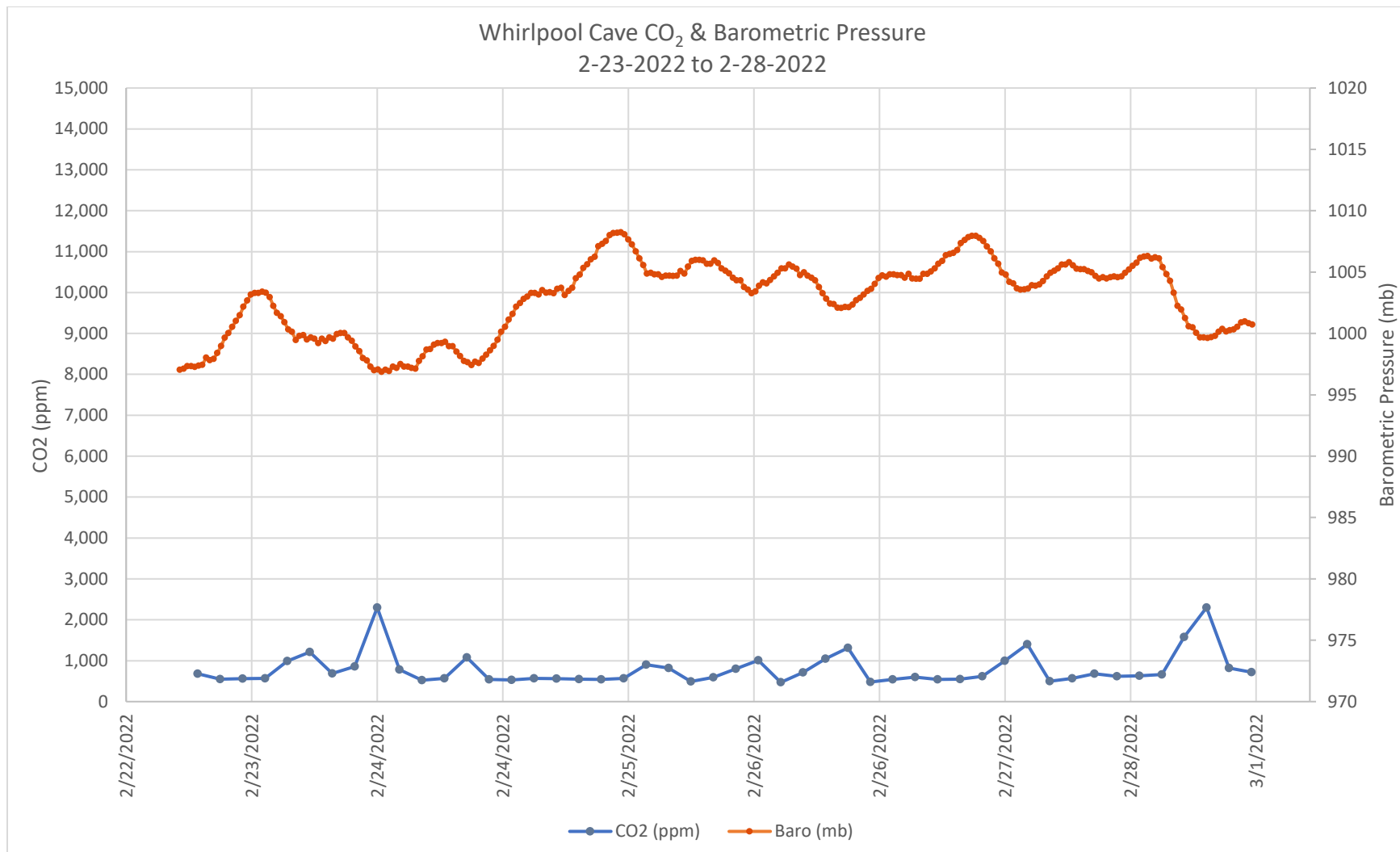


Figure 58. Whirlpool Cave CO₂ & Barometric Pressure, 2-23-2022 to 2-28-2022

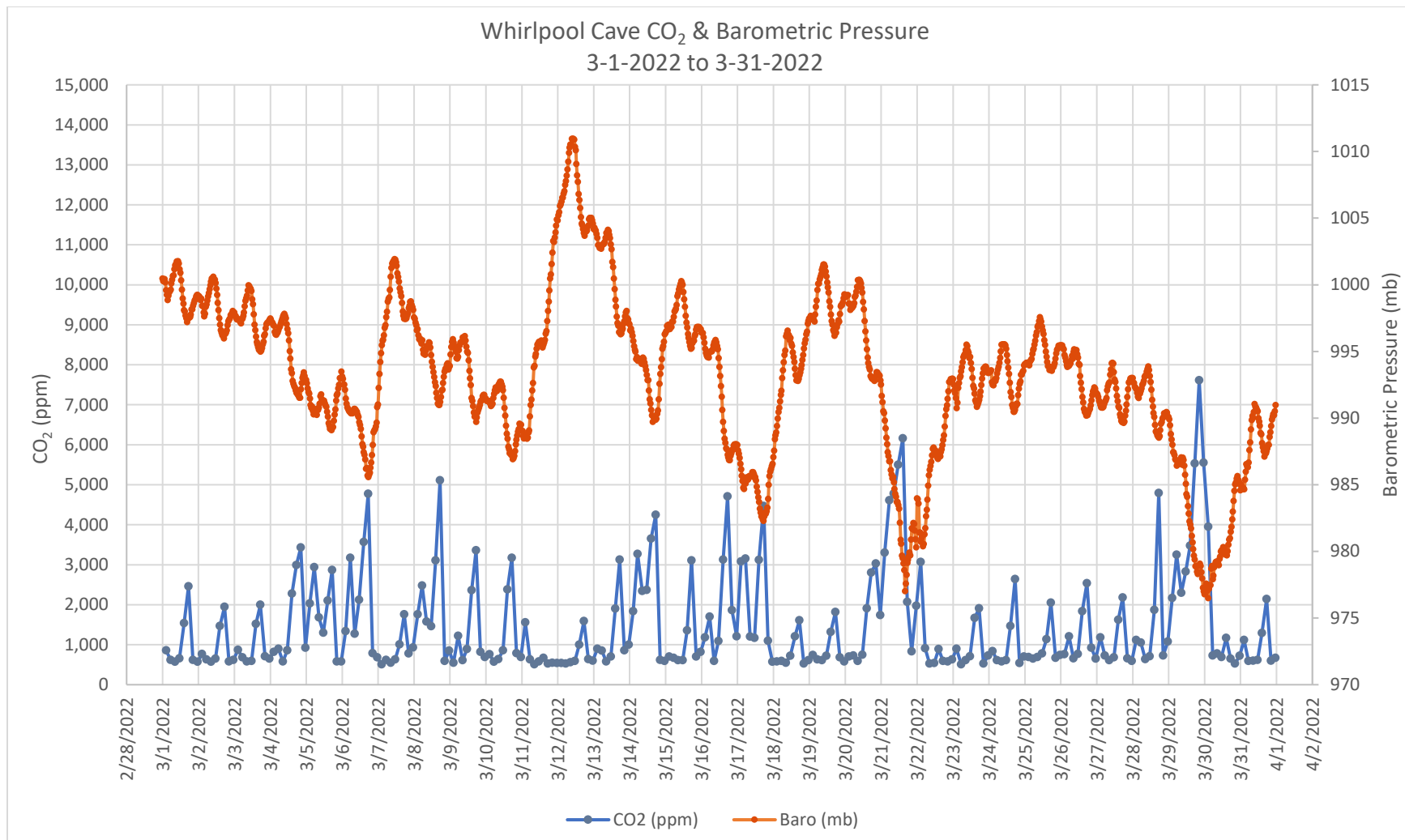


Figure 59. Whirlpool Cave CO₂ & Barometric Pressure, 3-1-2022 to 3-31-2022

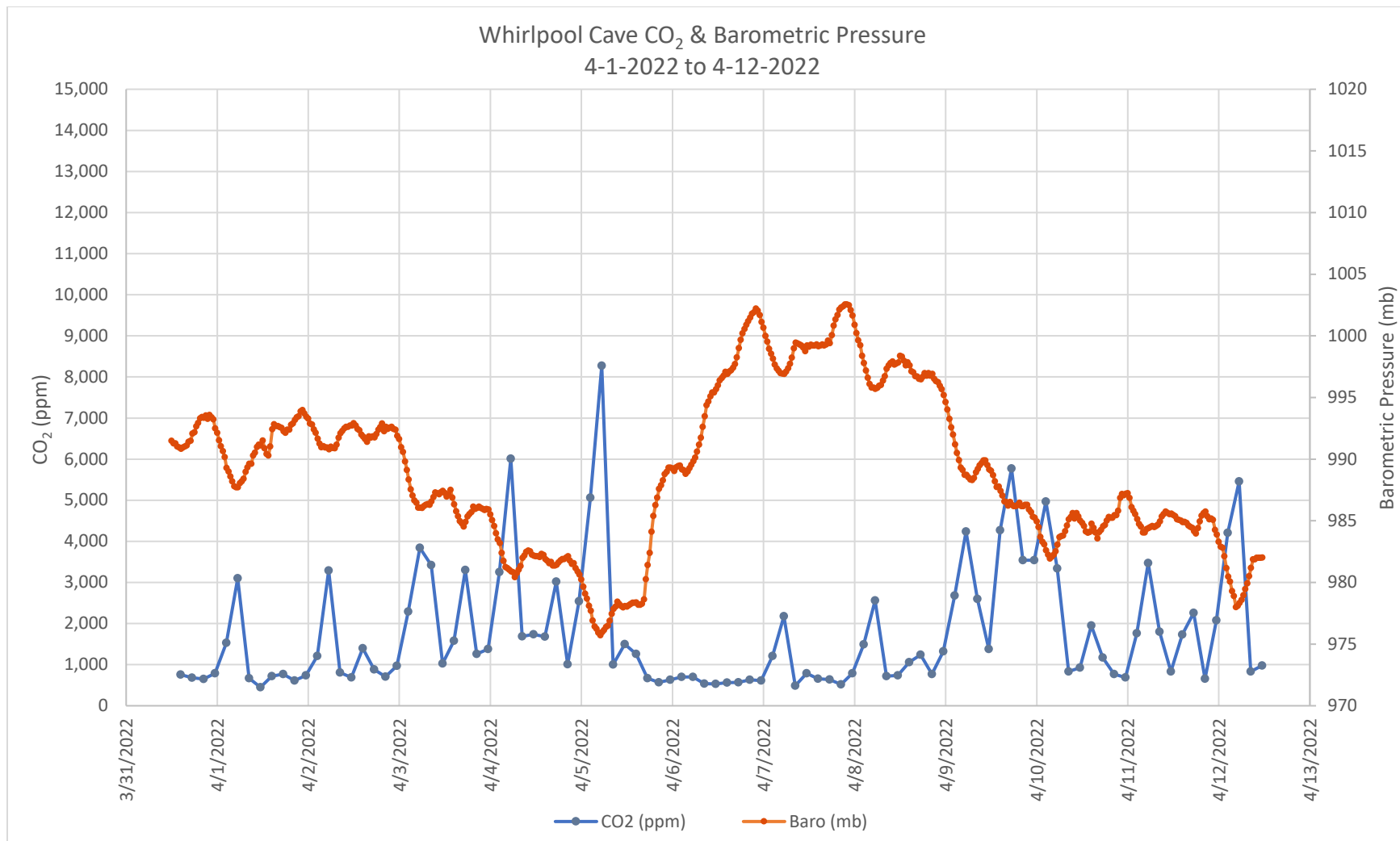


Figure 60. Whirlpool Cave CO₂ & Barometric Pressure, 4-1-2022 to 4-12-2022

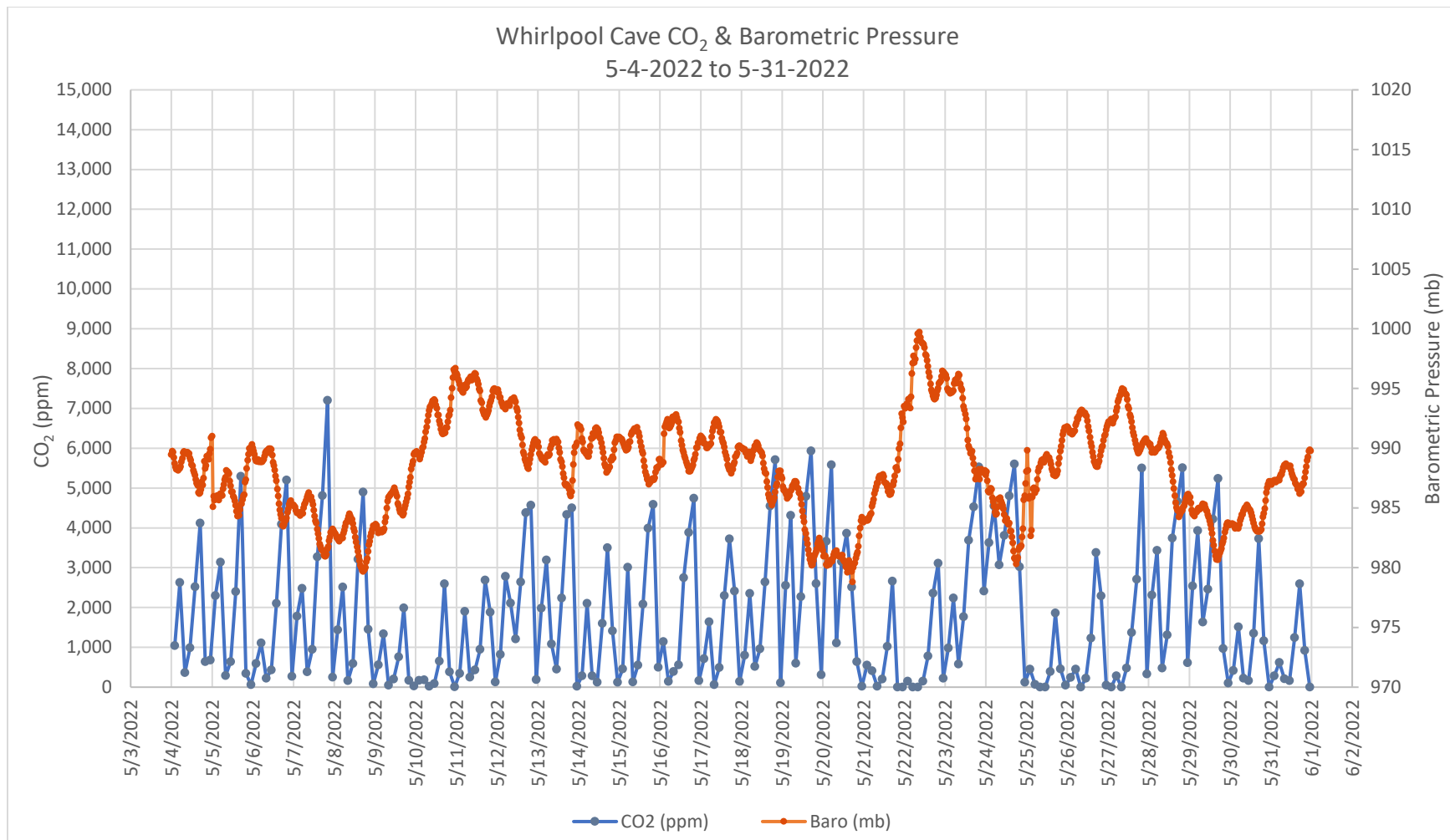


Figure 61. Whirlpool Cave CO₂ & Barometric Pressure, 5-4-2022 to 5-31-2022

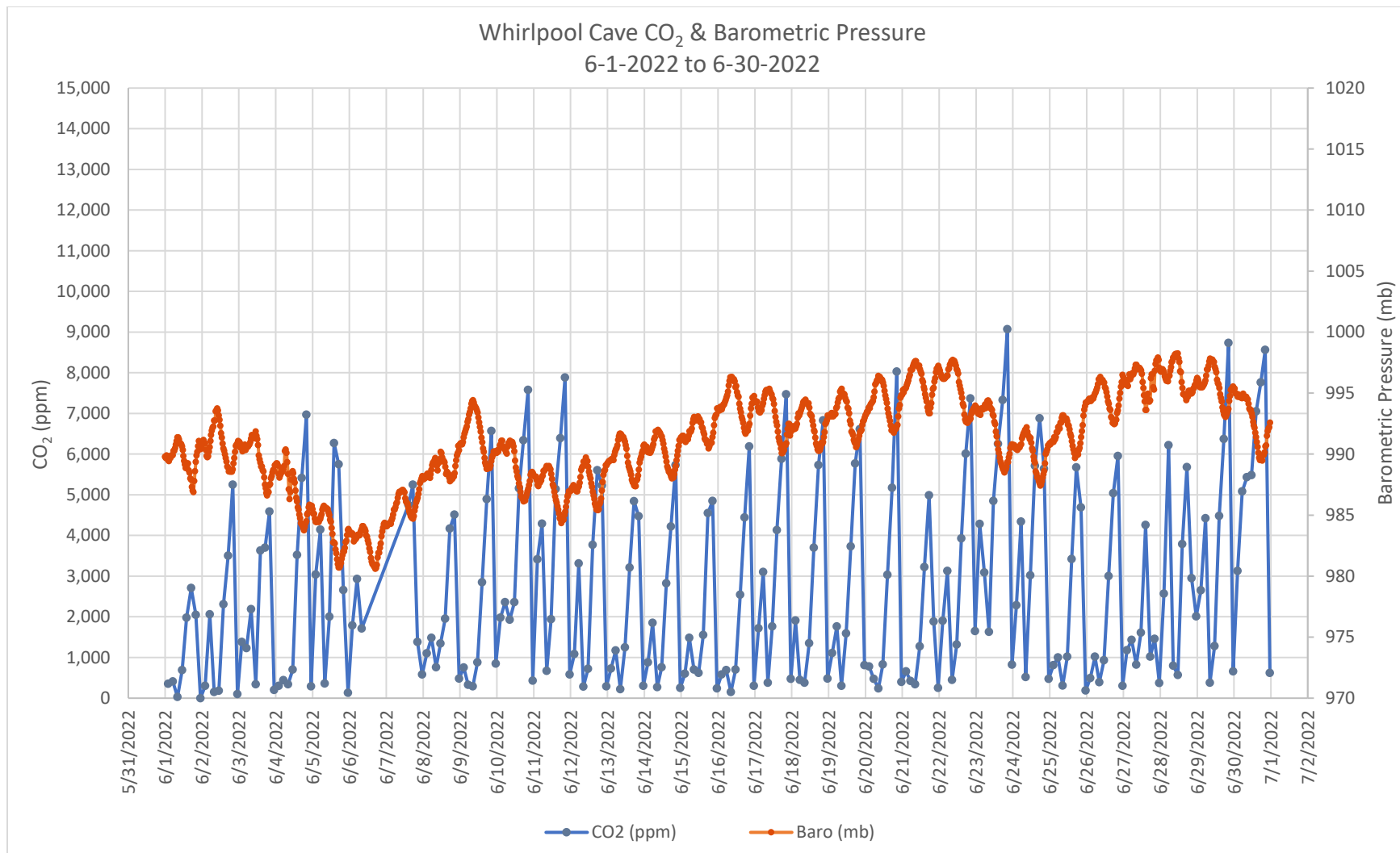


Figure 62. Whirlpool Cave CO₂ & Barometric Pressure, 5-4-2022 to 5-31-2022

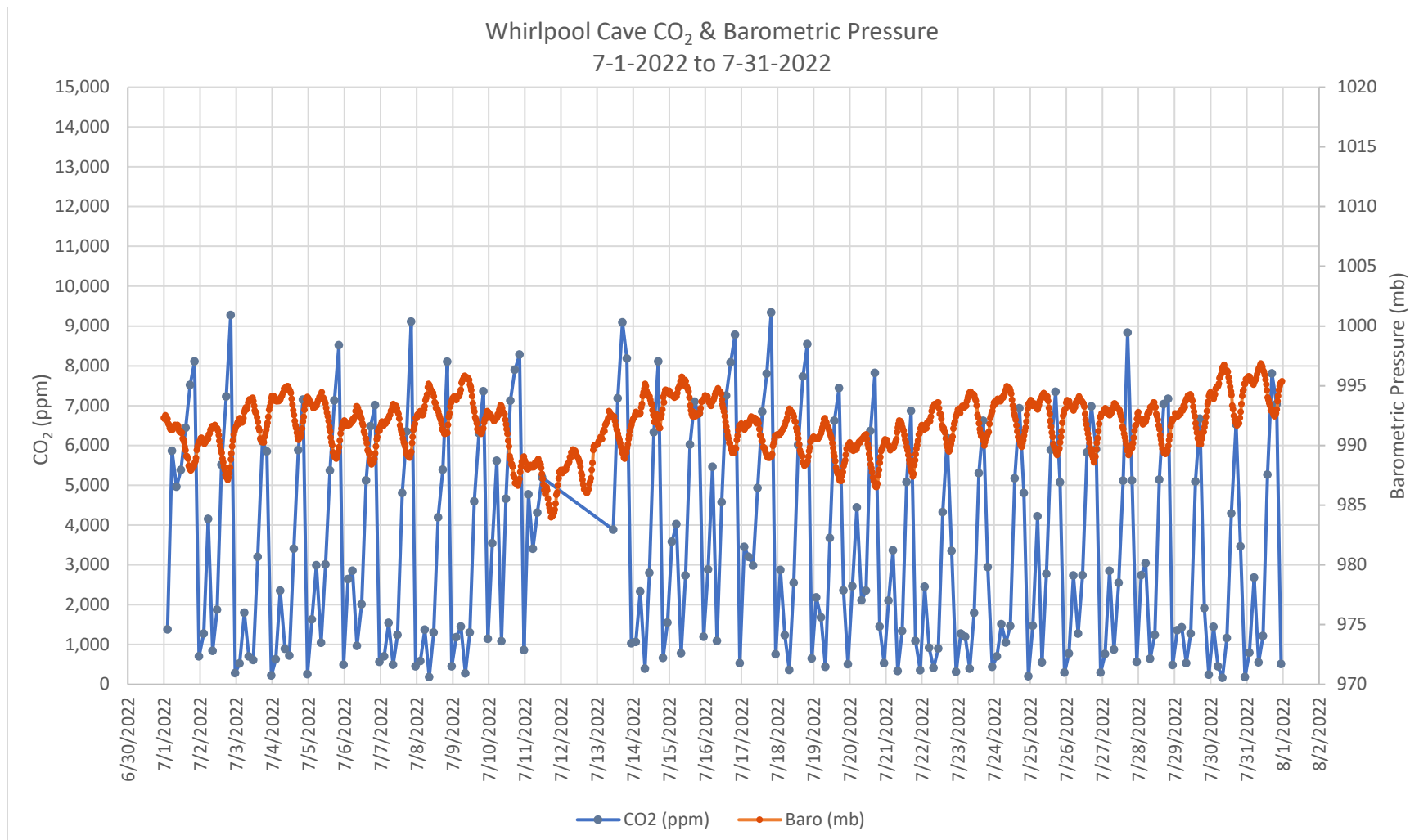


Figure 63. Whirlpool Cave CO₂ & Barometric Pressure, 7-1-2022 to 7-31-2022

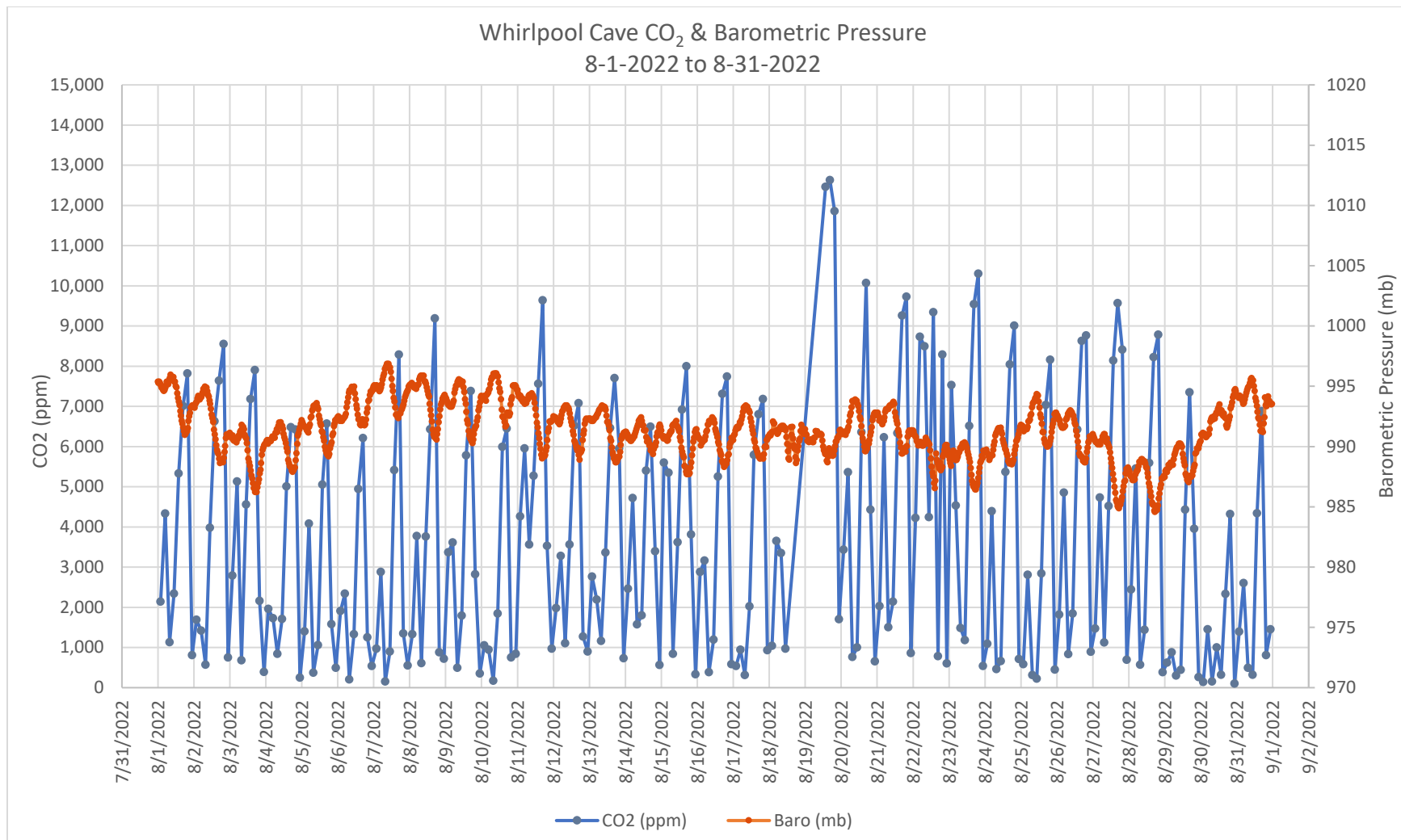


Figure 64. Whirlpool Cave CO₂ & Barometric Pressure, 8-1-2022 to 8-31-2022

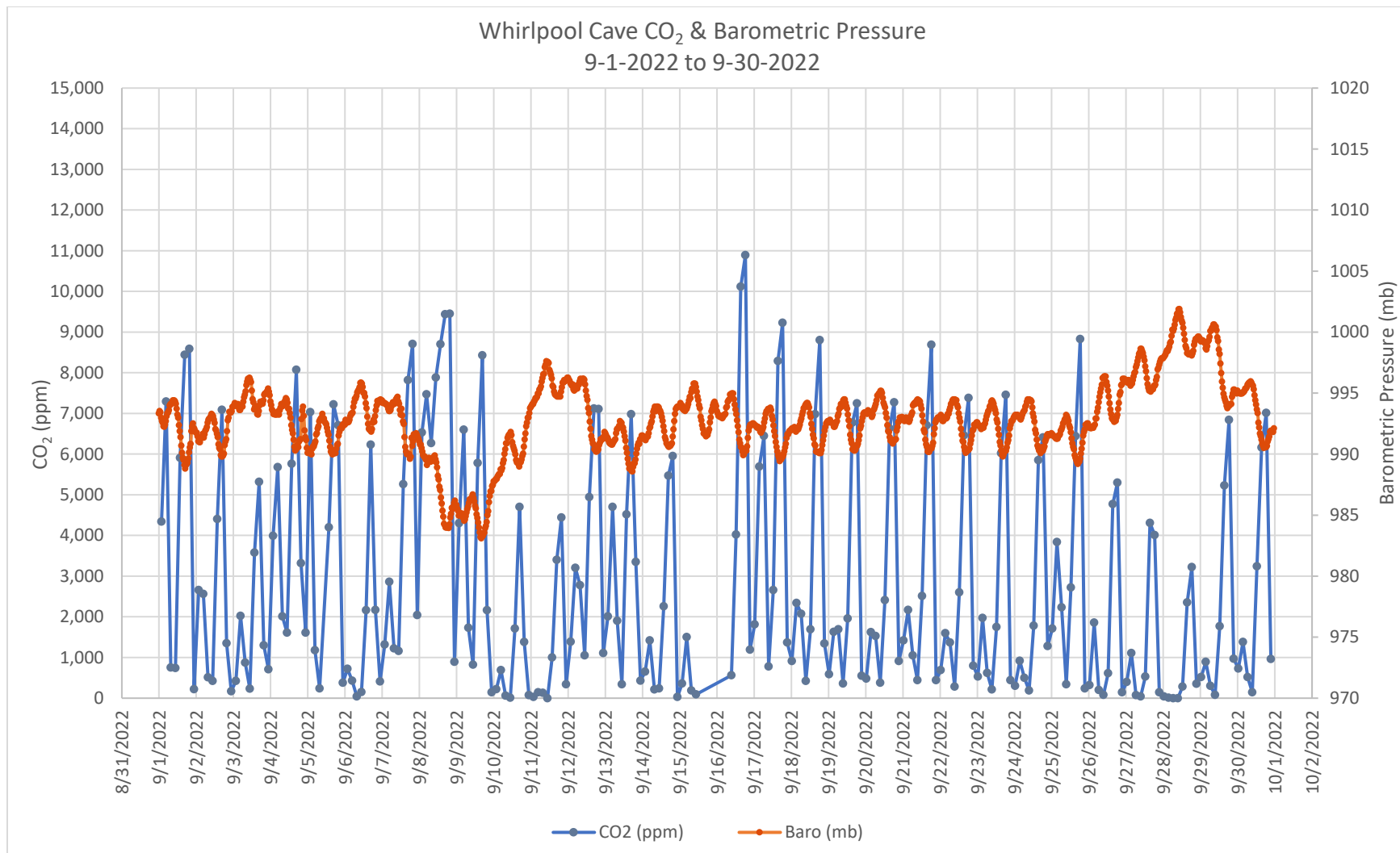


Figure 65. Whirlpool Cave CO₂ & Barometric Pressure, 9-1-2022 to 9-30-2022

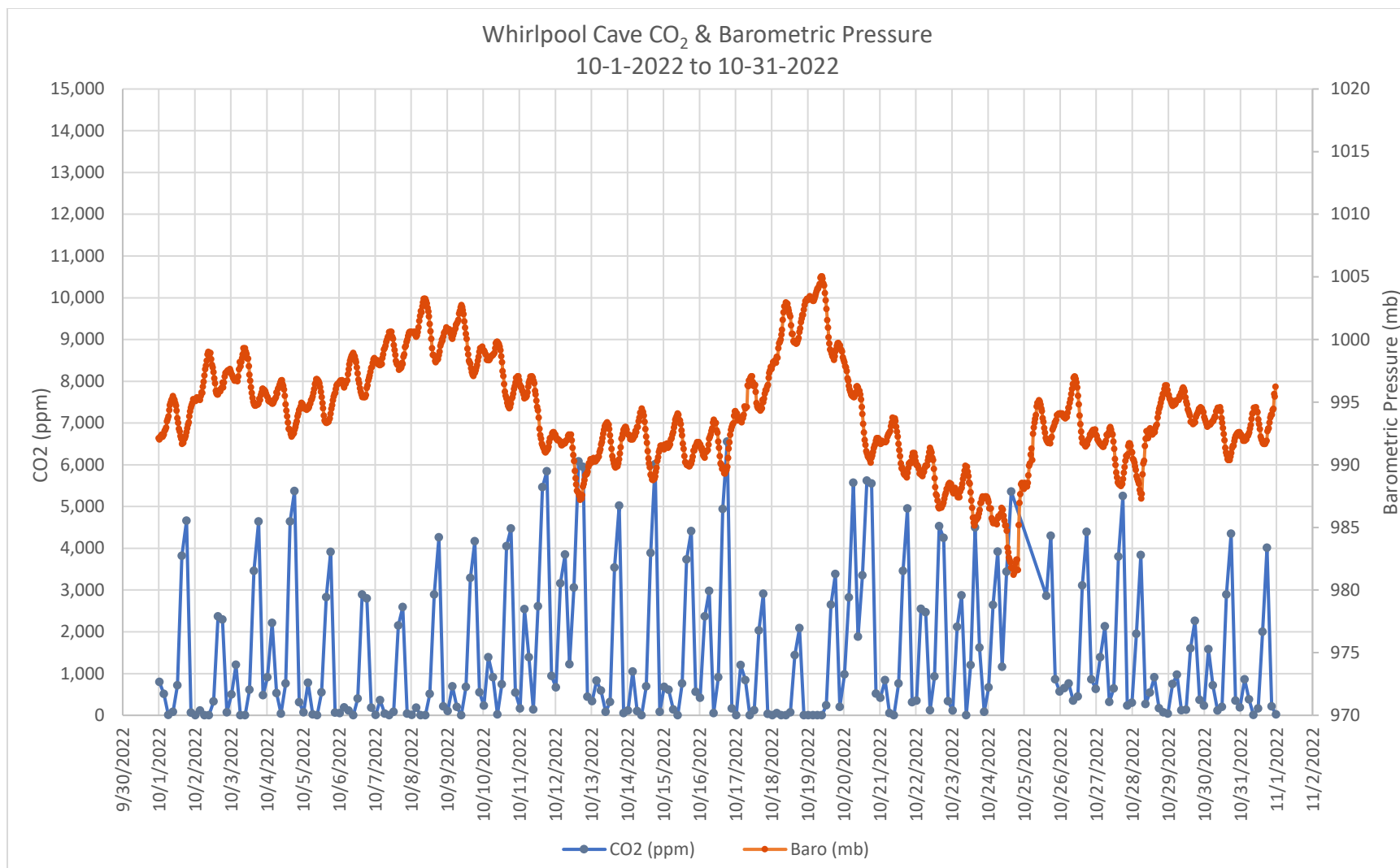


Figure 66. Whirlpool Cave CO₂ & Barometric Pressure, 10-1-2022 to 10-31-2022

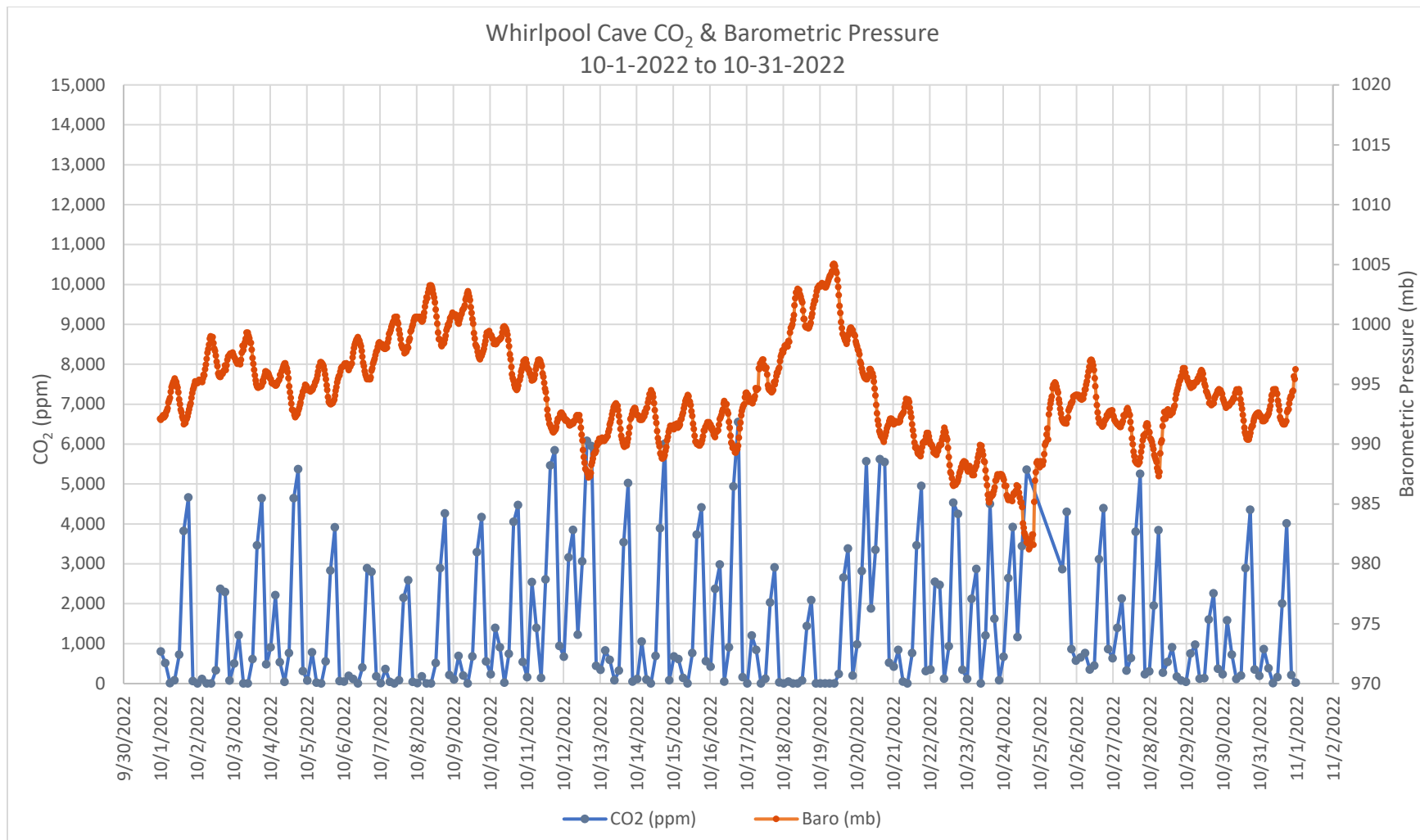


Figure 67. Whirlpool Cave CO₂ & Barometric Pressure, 10-1-2022 to 10-31-2022

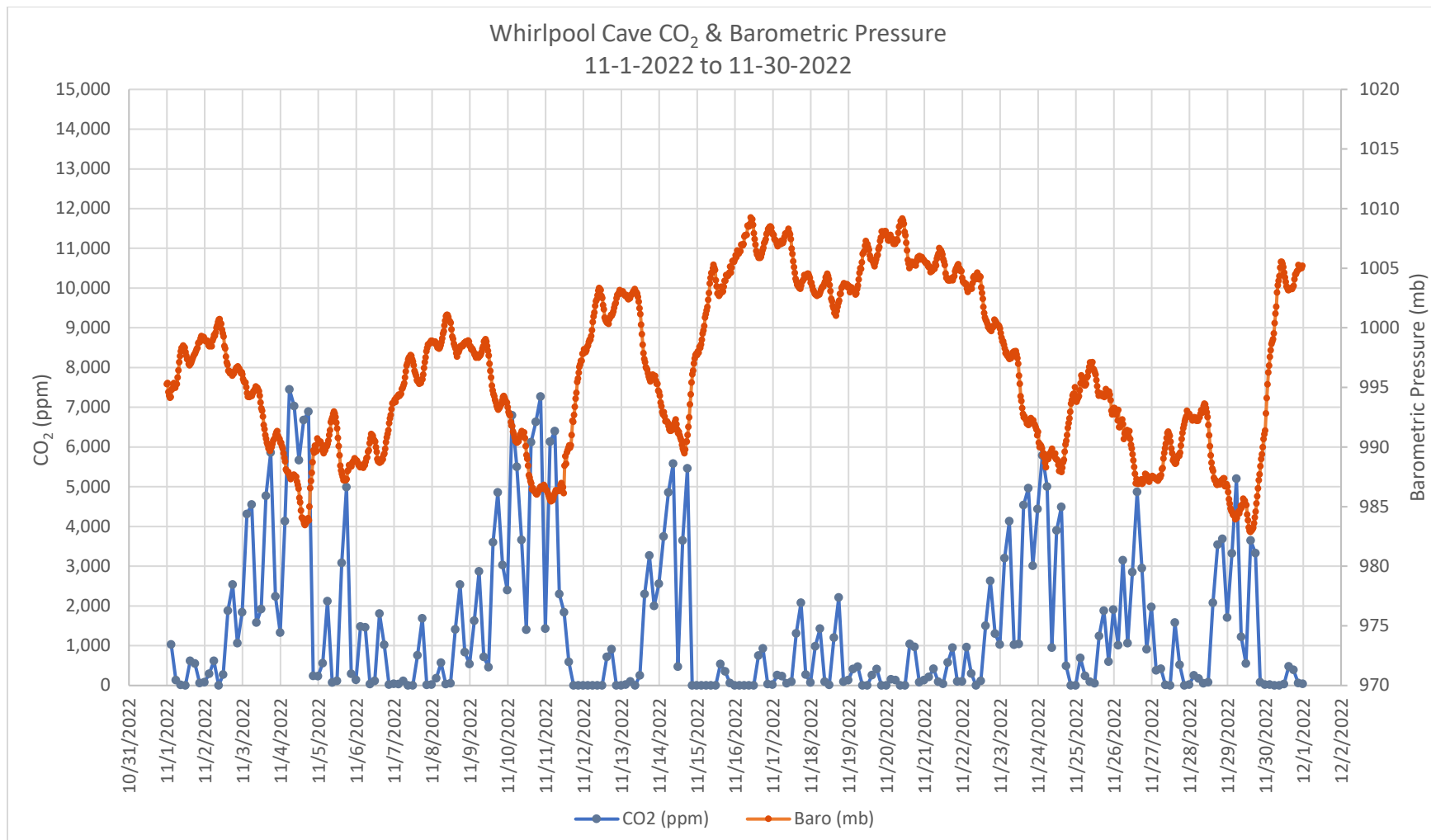


Figure 68. Whirlpool Cave CO₂ & Barometric Pressure, 11-1-2022 to 11-30-2022

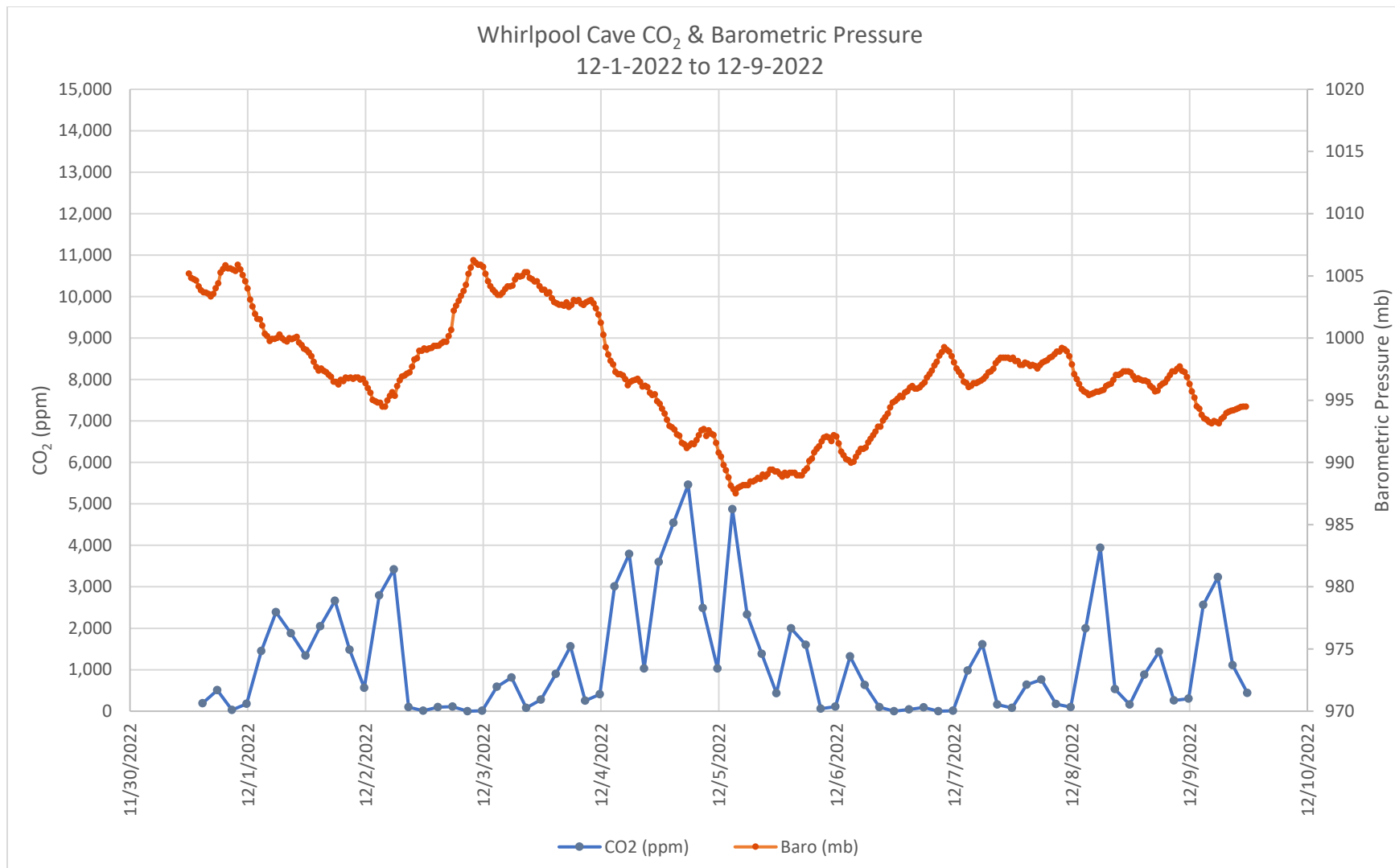


Figure 69. Whirlpool Cave CO₂ & Barometric Pressure, 12-1-2022 to 12-9-2022

Discussion

Figures 12 through 15 show that CO₂ levels are negatively correlated with barometric pressure and positively correlated with temperature. With the slope for barometric pressure being much steeper than that of temperature. But as can be seen in the month graphs above and figures 70 and 71 below, it is not so much the exact level of barometric pressure but rather if the pressure is rising or falling. I have not yet found a way to correlate a moving relationship like that, but it seems the relationship would have been much stronger if you could compare rising or falling barometric pressures to rising or falling CO₂ levels rather than just the pairs of readings individually. Another interesting thing is that when temperatures are dropping it reduces the relationship between CO₂ level and barometric pressure. This can be seen in Ireland's Cave in figures 72 and 73, as well as in figures 74 and 75. As the temperature is dropping, the CO₂ response to falling barometric pressure is reduced with CO₂ levels remaining low, but when the temperature stops dropping, the old relationship returns, which is shown at the end of graphs 72 and 73. Unfortunately an equipment failure left a gap in the data from 2/9/2022 to 2/23/2022, but figures 76 and 77 show the reduced pattern was still in place until the temperature rose on 3/1/2022 and the normal relationship between CO₂ level and barometric pressure resumed. It would help to visualize this data if three data sets could be graphed at once, but this is beyond the abilities of Excel.

Whirlpool and Grassy Cove are both utilized for large numbers of education trips. Figure 9 shows that the CO₂ levels in Whirlpool never get high enough to worry about, so the cave can be utilized year-round. Even in the warmer months it rarely exceeds 12,000 ppm (1.2% CO₂). There was one reading on 8/3/2021 of 22,850 ppm (2.29% CO₂) but that is a rare occurrence and still not at dangerous levels. Figure 7 shows that Grassy Cove can have high CO₂ levels all months of the year with the best months to visit being November through May. The CO₂ sensor in Grassy Cove is beyond an air restriction that causes CO₂ levels to be generally higher than those in the normal tour section of the cave. Figure 78 below shows that levels are still low in the hotter months in the morning from around 6:00 a.m. to noon, but not always. If the Barometric pressure is falling the CO₂ level will remain high. Weather Underground has a 10-day forecast that includes barometric pressure. If you are needing to enter a cave with high CO₂ such as Grassy Cove or Ireland's, you can plan your visit to fall in a multi-day period of rising barometric pressure and the CO₂ levels in the cave should be reduced [Austin, TX 10-Day Weather Forecast | Weather Underground \(wunderground.com\)](#).

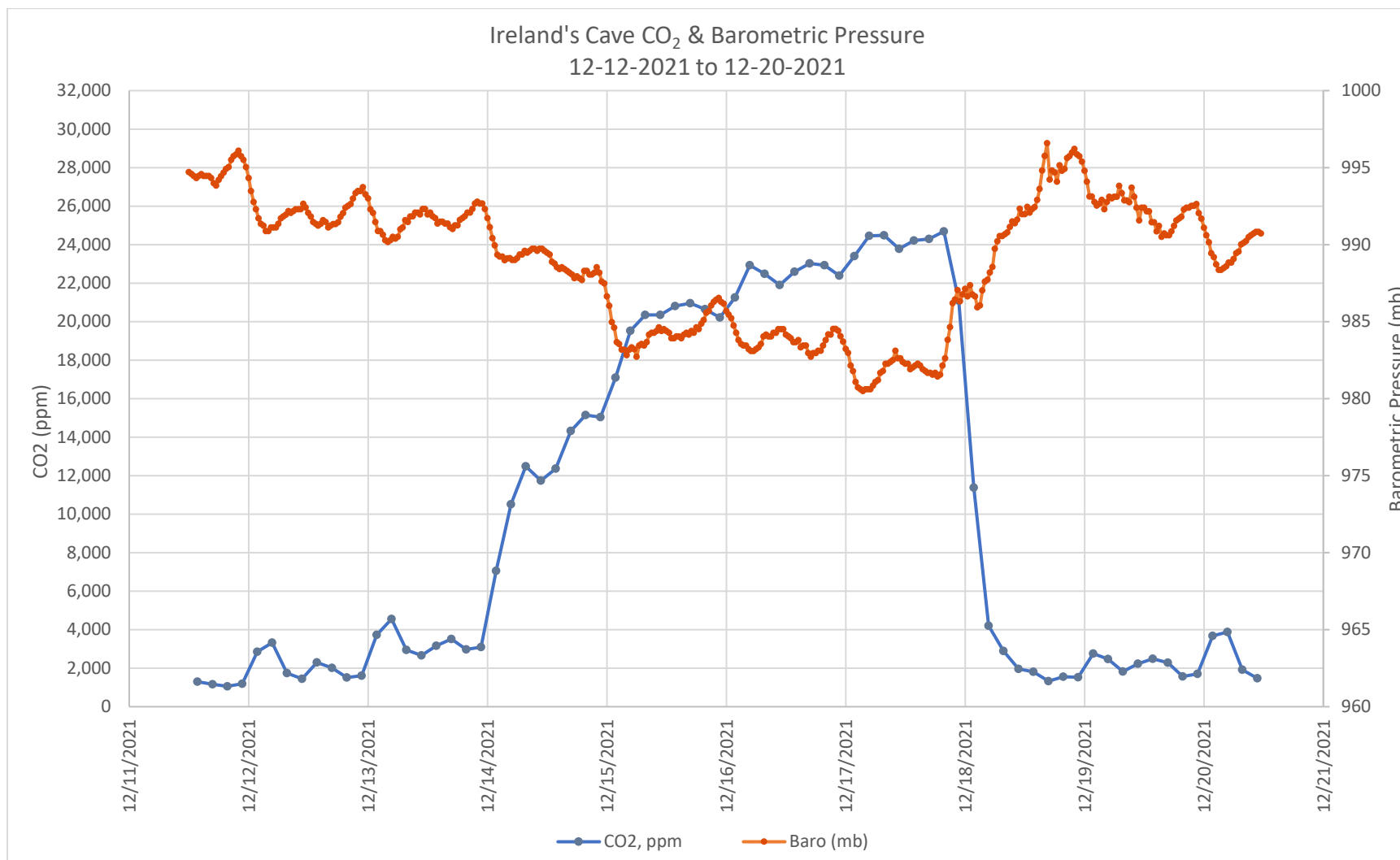


Figure 70. Ireland's Cave CO₂ & Barometric Pressure, 12-12-2021 to 12-20-2021

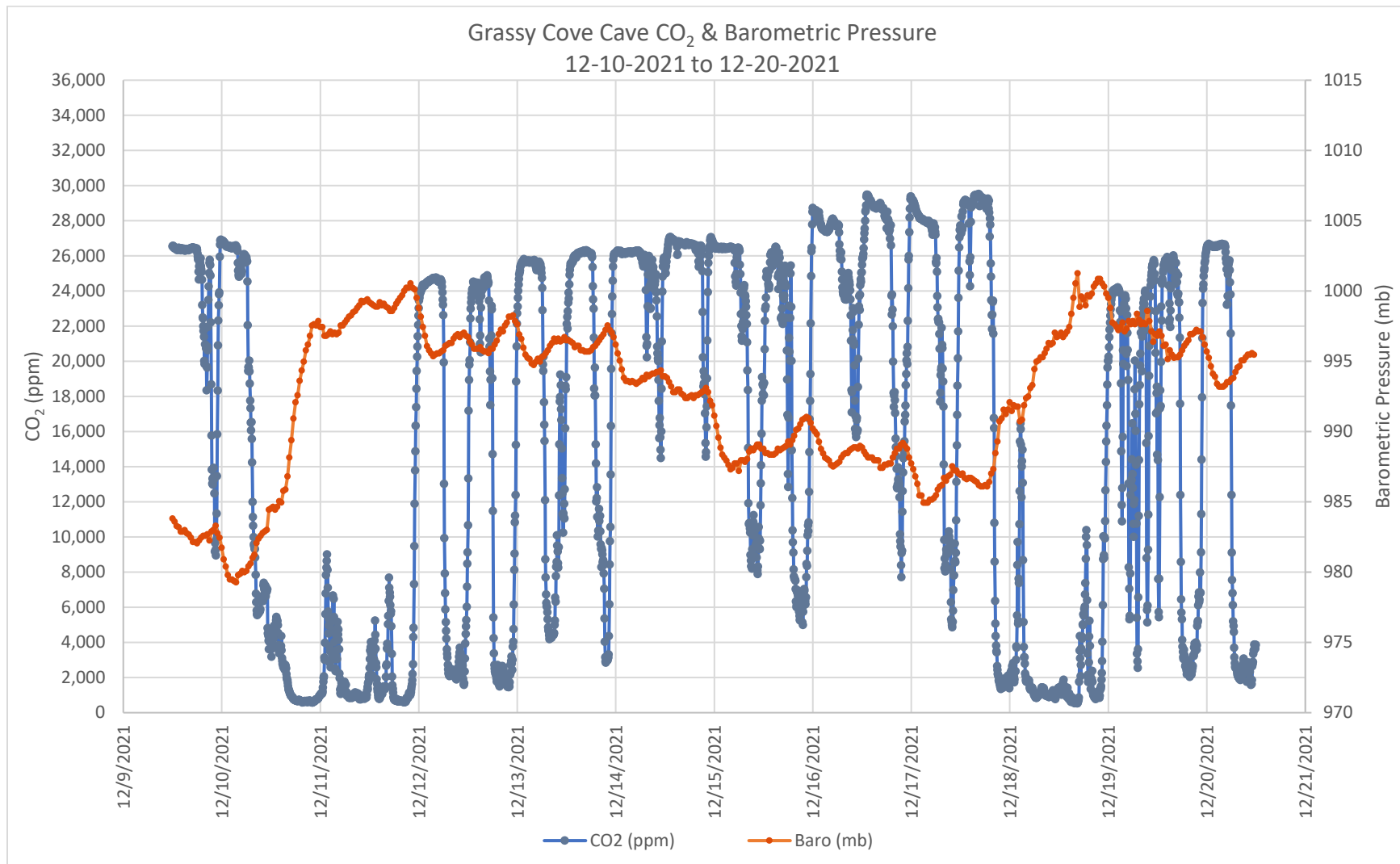


Figure 71. Grassy Cove Cave CO₂ & Barometric Pressure, 12-10-2021 to 12-20-2021

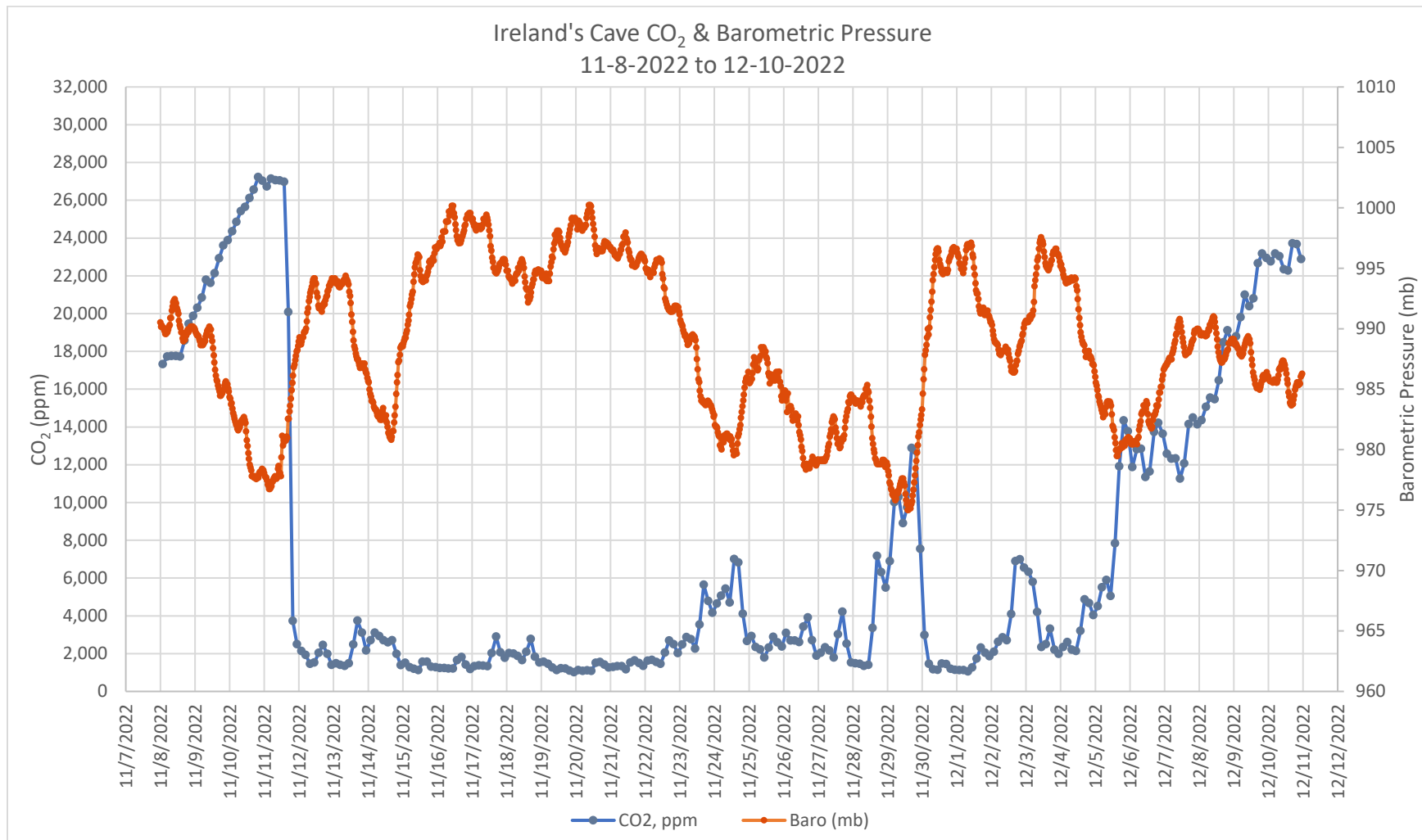


Figure 72. Ireland's Cave CO₂ & Barometric Pressure, 11-8-2022 to 12-10-2022

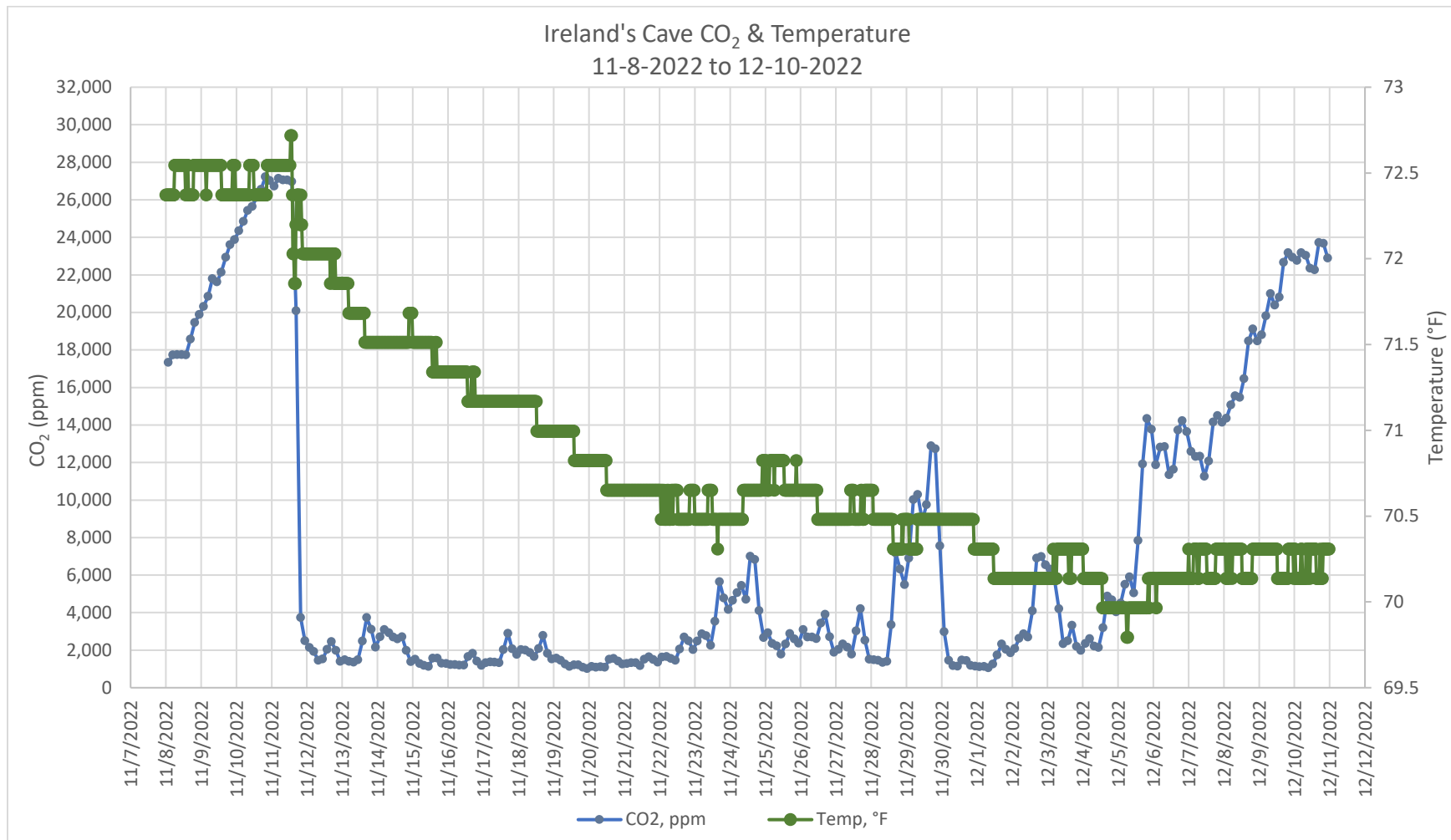


Figure 73. Ireland's Cave CO₂ & Temperature, 11-8-2022 to 12-10-2022

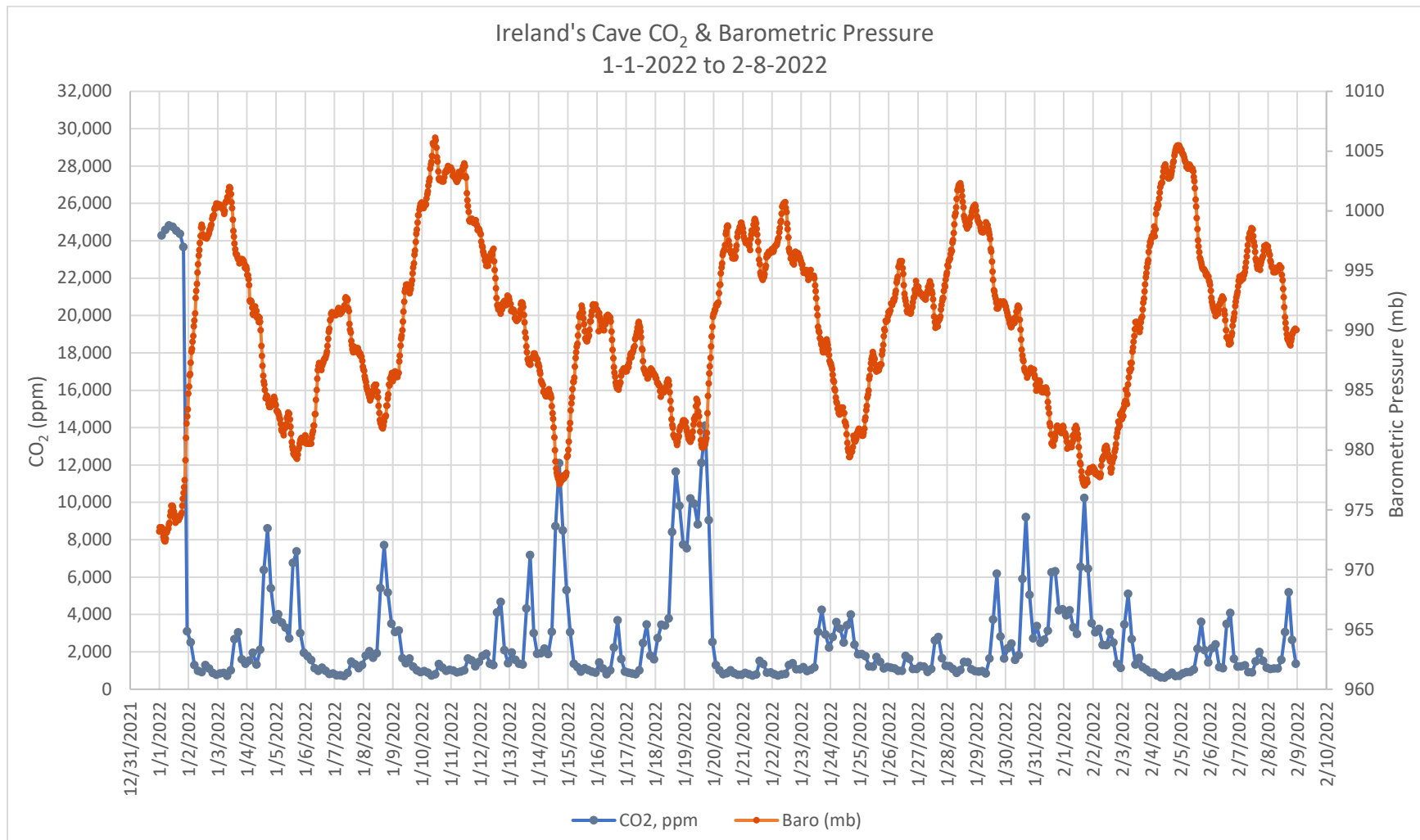


Figure 74. Ireland's Cave CO₂ & Barometric Pressure, 1-1-2022 to 2-8-2022

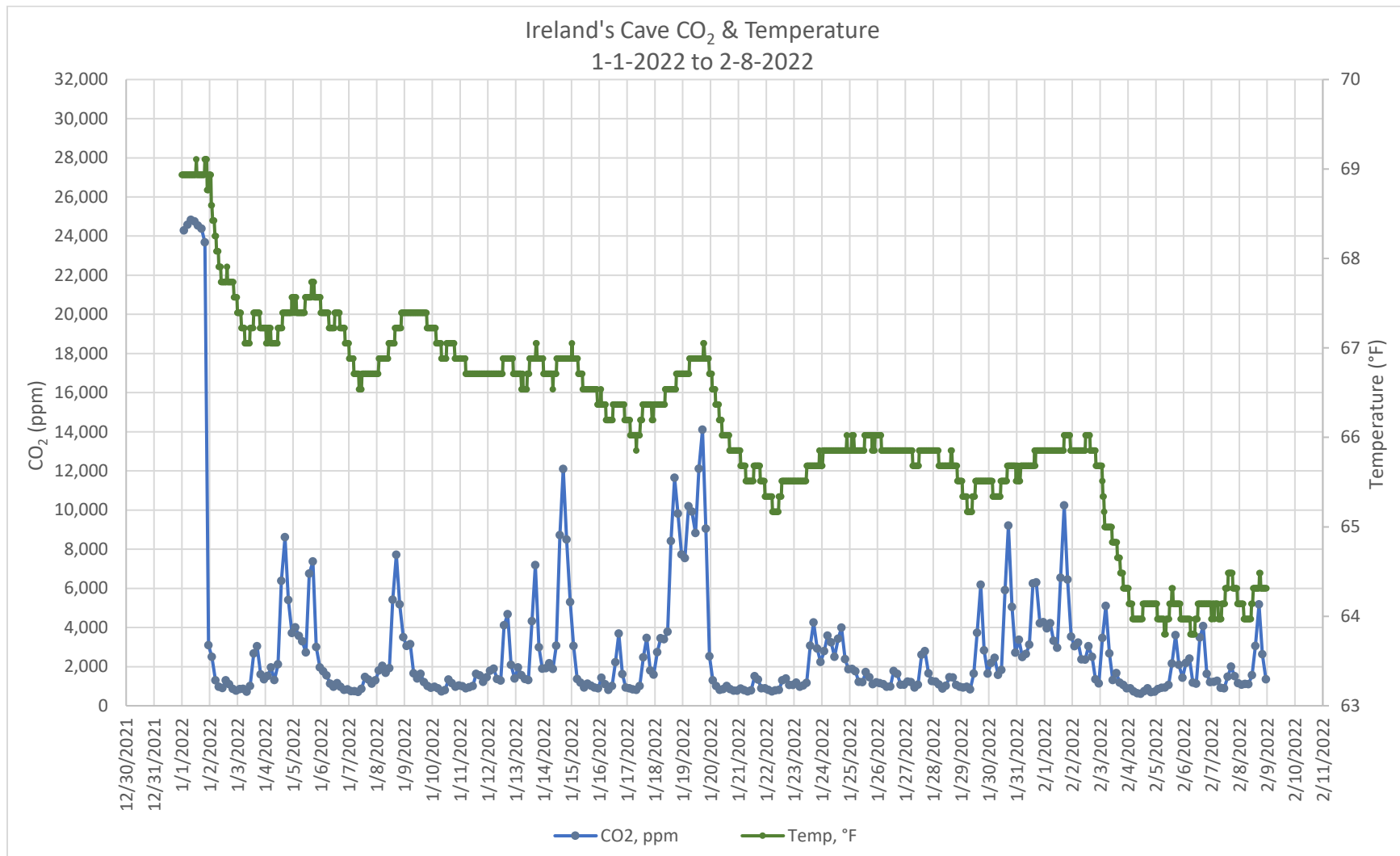


Figure 75. Ireland's Cave CO₂ & Temperature, 1-1-2022 to 2-8-2022

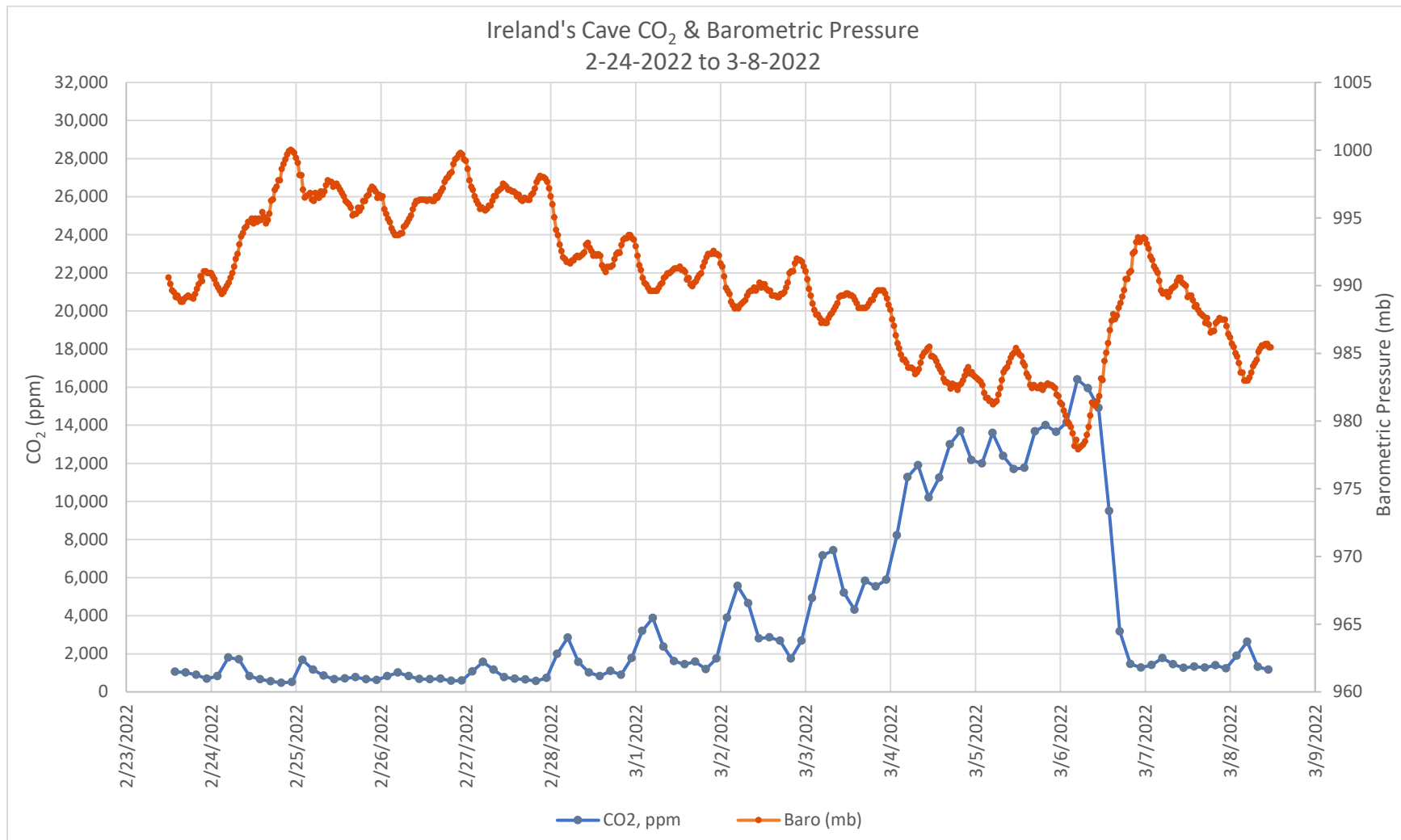


Figure 76. Ireland's Cave CO₂ & Barometric Pressure, 2-24-2022 to 3-8-2022

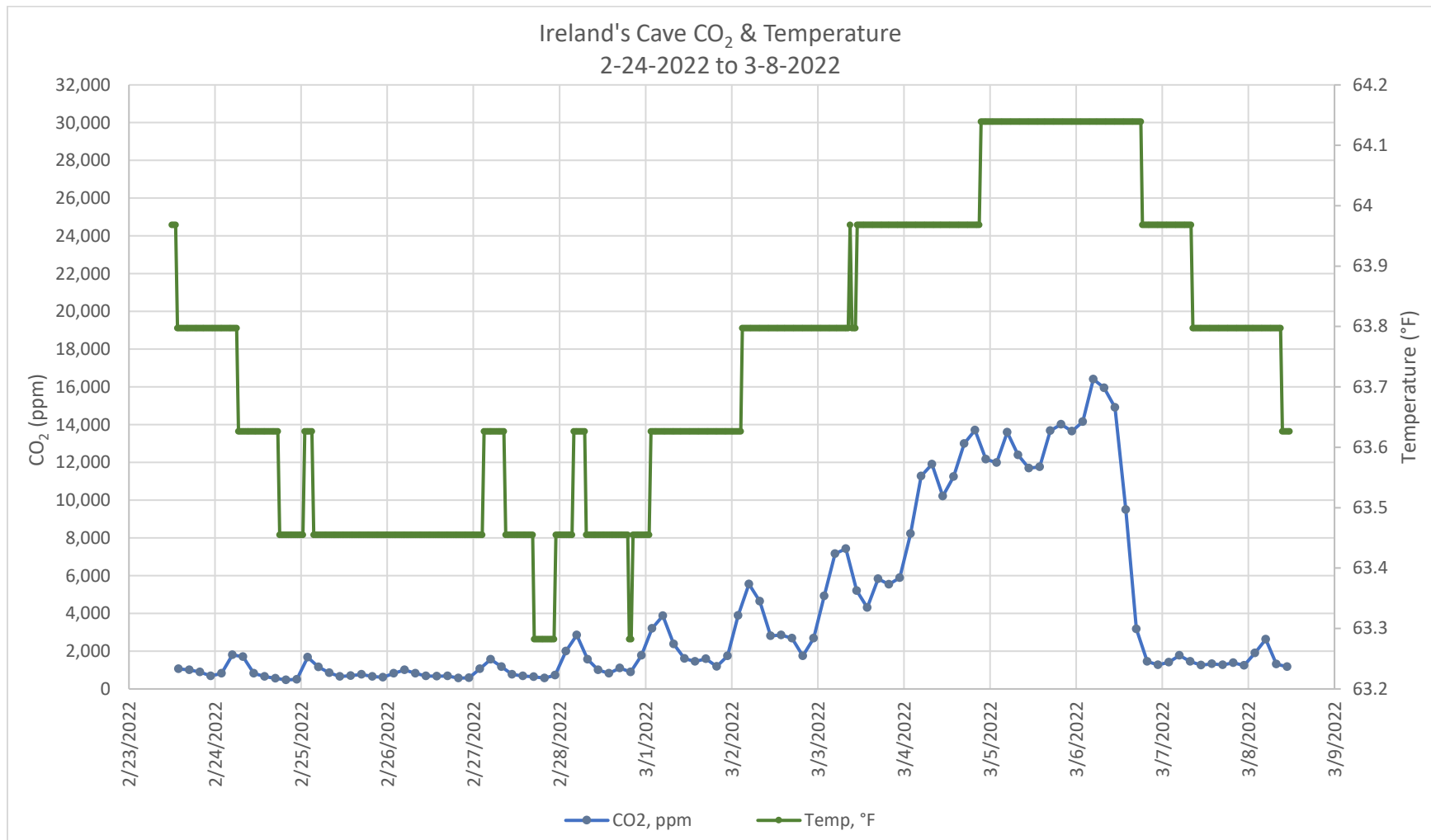


Figure 77. Ireland's Cave CO₂ & Temperature, 2-24-2022 to 3-8-2022

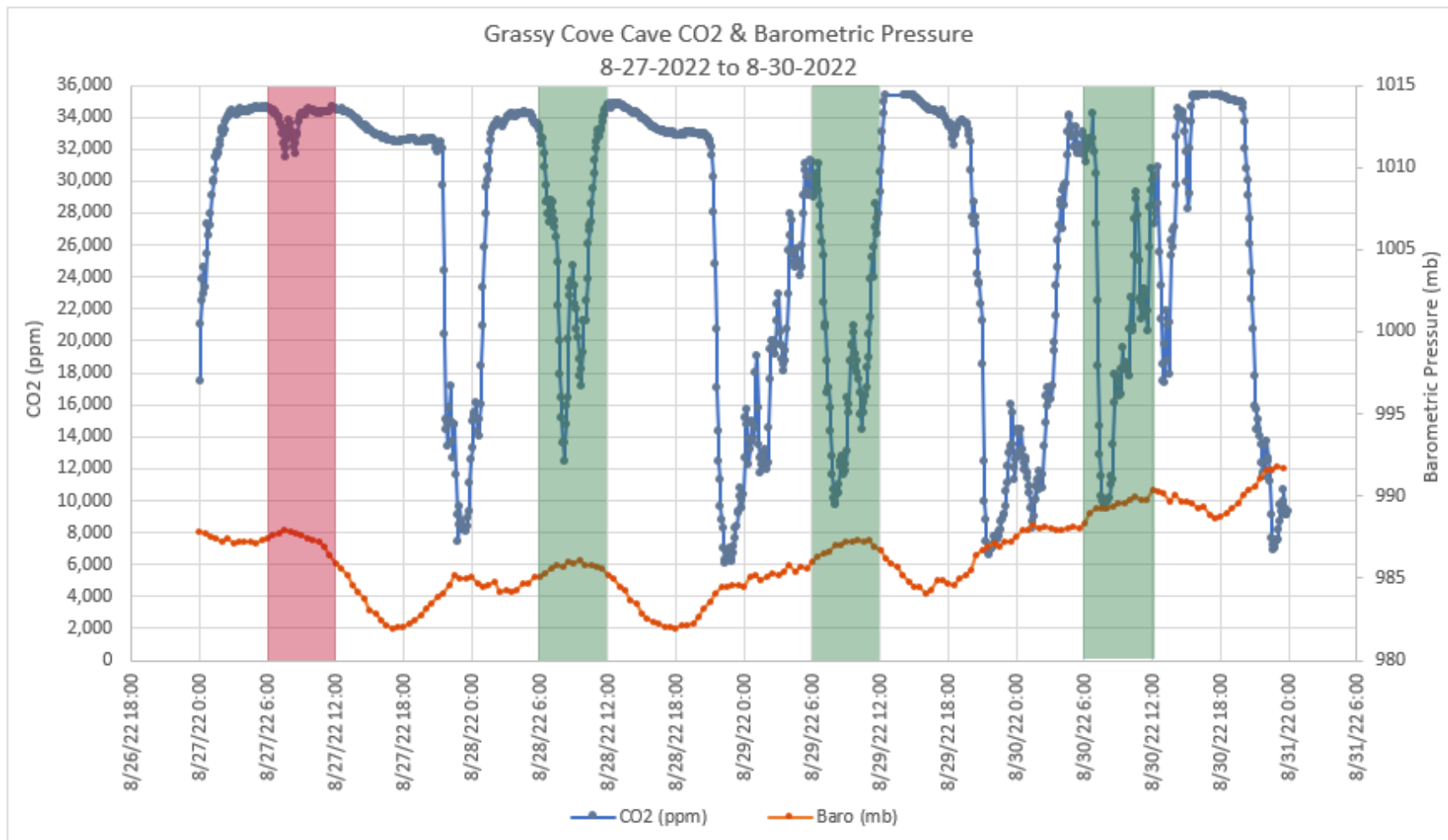


Figure 78. Grassy Cove Cave CO₂ & Barometric Pressure, 8-27-2022 to 8-30-2022, green bars showing periods from 6:00 a.m. to noon where CO₂ fell to low levels, while the red bar shows a 6:00 a.m. to noon period where level remained high.

Appendix

Table 1. Grassy Cove Cave CO₂ Summary Data

Year	Month	CO ₂ Average (ppm)	CO ₂ Median (ppm)	CO ₂ Max (ppm)
2021	April	16407	20808	25586
2021	May	17242	20974	24843
2021	June	20557	22140	30980
2021	July	24345	27956	32658
2021	August	27270	29980	35335
2021	September	22992	25055	35348
2021	October	19906	25765	35348
2021	November	14035	14838	28840
2021	December	17392	22960	29519
2022	January	12024	8381	28584
2022	February	9716	6049	25227
2022	March	11753	12416	23498
2022	April	16584	20974	25676
2022	May	21048	24625	28597
2022	June	25990	27931	31992
2022	July	28534	31556	35335
2022	August	25001	27469	35348
2022	September	25148	30769	35335
2022	October	21401	27303	35335

Table 2. Ireland's Cave CO₂ Summary Data

Year	Month	CO ₂ Average (ppm)	CO ₂ Median (ppm)	CO ₂ Max (ppm)
2021	December	12225	12210	24690
2022	January	3115	1555	24820
2022	March	6530	4310	20220
2022	May	25574	26180	29540
2022	June	26858	27070	31610
2022	July	27847	27810	30380
2022	August	26442	26520	30030
2022	September	25497	25955	29780
2022	October	14677	15440	28870
2022	November	7209	2825	27220

Table 3. Whirlpool Cave CO₂ Summary Data

Year	Month	CO ₂ Average (ppm)	CO ₂ Median (ppm)	CO ₂ Max (ppm)
2021	June	3047	2290	8880
2021	July	4400	3780	11750
2021	August	4809	4040	22850
2021	September	2779	1600	10000
2022	January	1477	820	9210
2022	March	1446	845	7610
2022	May	1727	1095	7200
2022	June	2639	1880	9070
2022	July	3399	2740	9340
2022	August	3609	2775	12630
2022	September	2808	1625	10890
2022	October	1458	660	6550
2022	November	1443	550	7450

Table 4. Regression Output - CO₂ & Barometric Pressure in Ireland's Cave 12/1/2021 to 12/11/2022

<i>Regression Statistics</i>	
Multiple R	0.590976
R Square	0.349252
Adjusted R Square	0.349007
Standard Error	4.618359
Observations	2651

<i>ANOVA</i>					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	30323.83	30323.83	1421.702	1.9E-249
Residual	2649	56501.15	21.32924		
Total	2650	86824.98			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	990.2591	0.160082	6185.958	0	989.9452	990.573	989.9452	990.573
X Variable 1	-0.00031	8.17E-06	-37.7055	1.9E-249	-0.00032	-0.00029	-0.00032	-0.00029

Table 5. Regression Output - CO₂ & Temperature in Ireland's Cave 12/1/2021 to 12/11/2022

<i>Regression Statistics</i>	
Multiple R	0.324446
R Square	0.105265
Adjusted R Square	0.104928
Standard Error	2.909989
Observations	2651

<i>ANOVA</i>					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	2639.097	2639.097	311.654	4.98E-66
Residual	2649	22431.82	8.468034		
Total	2650	25070.92			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	67.17857	0.100866	666.0169	0	66.98079	67.37635	66.98079	67.37635
X Variable 1	9.09E-05	5.15E-06	17.65373	4.98E-66	8.08E-05	0.000101	8.08E-05	0.000101

Table 6. Regression Output - CO₂ & Barometric Pressure in Whirlpool Cave 8/23/2021 to 12/10/2022

<i>Regression Statistics</i>	
Multiple R	0.590976
R Square	0.349252
Adjusted R Square	0.349007
Standard Error	4.618359
Observations	2651

<i>ANOVA</i>					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	30323.83	30323.83	1421.702	1.9E-249
Residual	2649	56501.15	21.32924		
Total	2650	86824.98			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	990.2591	0.160082	6185.958	0	989.9452	990.573	989.9452	990.573
X Variable 1	-0.00031	8.17E-06	-37.7055	1.9E-249	-0.00032	-0.00029	-0.00032	-0.00029

Table 7. Regression Output CO₂ & Temperature in Whirlpool Cave 8/23/2021 to 12/10/2022

<i>Regression Statistics</i>	
Multiple R	0.423158
R Square	0.179063
Adjusted R Square	0.17876
Standard Error	0.370815
Observations	2708

<i>ANOVA</i>					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	81.15938	81.15938	590.233	4.2E-118
Residual	2706	372.0857	0.137504		
Total	2707	453.2451			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	67.7501	0.009884	6854.583	0	67.73072	67.76948	67.73072	67.76948
X Variable 1	7.39E-05	3.04E-06	24.29471	4.2E-118	6.79E-05	7.99E-05	6.79E-05	7.99E-05