This document contains item-by-item responses to the reviewer's comments. The reviewer's comments are in black, non-italicized, regular fonts. Author responses are in *blue, italicized* fonts. Changes to the manuscript will be provided during revised submission, per instructions of the Copernicus editorial team (i.e., revised manuscript and diff file). Nonetheless, examples of the corrections and a detailed view of each experiment are provided in the attached discussion supplement.

General comments:

We thank Reviewer #2 for his comments and suggestions. Following his (and reviewer's #1) suggestions, we repeated the Mesonet temperature and relative humidity experiments under more controlled conditions, added more test sensors, and adjusted the result presentation. Therefore, the final comment below is written in light of the following changes:

- The Li-820 sensor originally named CO_2 Independent Sensor Outside is renamed Reference Sensor Out (Ref_OUT).
- The Li-840A sensor originally named CO_2 Independent Sensor Inside is renamed Reference Sensor In (Ref_IN).
- The Senseair K30 sensors originally named CO_2 Test Sensors 1 and 2 are renamed K30_##, where the first digit refers to its attached system (i.e. logger, temperature, and relative humidity sensors) and the second digit is its identification. This way the first Senseair K30 sensor of test system 2 is named K30_21.
- The Mesonet temperature and relative humidity experiments now have a "run" identification (i.e., "Mesunet Run 1 - Temperature", "Mesunet Run 2 - Temperature", "Mesunet Run 1 - Relative humidity", etc), where Run 1 is the data originally presented in the manuscript and Runs 2 and 3 are the repetition runs.

A "Discussion Supplement" (appended to the end of this reply) shows a summary of experiments and sensors used following the model in Arzoumanian (2019; doi:10.5194/amt-12-2665-2019), supporting material to explain the low CO_2 values seen in the Mesonet Experiment (Run 1). The results of the correction application on the Mesonet T/RH Experiment (Run 1) dataset, followed by the results for the Mesonet T/RH Experiment (Run 2 and 3), and the adjusted Bench temperature and relative humidity Experiments. The document ends with the supporting plot for the Pressure time-response correction ("ideal signal") and a brief discussion about the reported temperature from the Li-820 reference sensor.

Please note that even though the results for the correction application on the Mesonet T/RH Experiment (Run 1) dataset are presented in the attached "Discussion Supplement", they serve only as a comparison of the correction method. Following the reviewer's suggestion, the Mesonet T/RH Experiment (Run 1) dataset will be discarded. Only Mesonet T/RH Experiment (Run 2 and 3) will be analyzed in the revised manuscript.

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Reply for Anonymous Referee #2

General comments:

The first major concern is the lack of a calibrated and reliable reference dataset for ambient air CO2 dry air mole fractions (or as referred to in manuscript: the CO2 concentration). The authors LiCOR LI-840 and LI-820 systems as a reference. However, it is obvious that neither of the two instruments was appropriately calibrated. An indoor air concentration of 200-300ppm CO2 as reported in Figure 3 is completely unrealistic.

Ambient clean air data from NOAA can be found here: Global Monitoring Laboratory - Carbon Cycle Greenhouse Gases (noaa.gov) demonstrating that 200-300 ppm is not possible unless in artificial gas mixtures or environments. Given that the LiCORs are not calibrated it is also unlikely that they were properly tested for cross-sensitivities, offsets or non-linearity.

We agree with the reviewer. The 200-300 ppm values shown are not realistic for indoor concentrations. However, it is not an artifact of unreliable reference sensors. This considerable reduction in CO_2 concentration is caused by the Thunder Scientific 2500 chamber. Figure 1 in the discussion supplement shows the raw ppm values for the Li-840A (Ref_IN), the Li-820 (Ref_OUT), and four K30 sensors, before, during, and after the second run of the mesonet temp/RH experiments. In this figure, the Ref_IN and all four K30 sensors drop their reported values from ~500 ppm to ~250 ppm after the start of the experiment and return to ~450 ppm after the experiment ends. For the same time periods, the outside reference (Ref_OUT) is not affected.

Looking at the documentation of the Thunder Scientific 2500 chamber, there is mention of the use of Nitrogen to control pressure, temperature, and humidity. However, the chamber at the Mesonet Calibration Laboratory does not use this feature. In their configuration, the chamber uses water, a series of compressors, and pre-chambers to generate standard test conditions. More information about the inner workings of this chamber can be found at https://www.thunderscientific.com/humidity_equipment/model_2500.html.

Searching for an explanation for this CO_2 reduction we also investigated the behavior of the other variables during the experiment. The data in figure 2 and table 1, in the discussion supplement, show that none of the pressure sensors varied greatly (all sensors show a standard deviation of approximately 106 Pa). The data also shows this effect happens before large temperature and humidity changes and is also seen on the Ref_IN control sensor (which is independent of temperature and humidity changes in the test ranges).

After our thorough review of the documentation, it was not clear the exact source of this effect. Nevertheless, it is apparent when analyzing the data that this effect has a near-constant behavior throughout the experiments. Therefore, an offset correction can be applied without loss of generality.

In the data presented in the manuscript, we opted to bring all data to the level of the Ref_IN sensor (Li-840A). This decision was based on the robustness of the Li-840A when compared to the Li-820 (Ref_OUT), and our wish to analyze the data at the relative reference point of the chamber's environment. In hindsight, we understand how the unrealistic data presented with a lack of an explanation would confuse readers. Figure 3 of the discussion supplement illustrates the impact of these two different correction strategies. In the left panel, the result of correcting the data to the Ref_IN sensor, and in the right panel the result of correcting the data to the Ref_OUT sensor.

In the revised manuscript we have used the Ref_OUT sensor to correct the data from the mesonet experiments. we used the 60 minutes prior to the experiment (e.g., from 02:00 to 03:00 in figures 1 and 2) where the conditions are stable, to find an average offset for each sensor to the Ref_OUT sensor. This offset was then applied to the entire time series. An explanation of this strategy was also added in the revised manuscript.

To support our claims about the quality of the measurements of the Li-840A (Ref_IN) and the Li-820 (Ref_OUT), we have added plots and tables in the discussion supplement showing intercomparisons between the reference and test sensors, before and after each mesonet experiment. These comparisons support our strategy to use the Ref_OUT sensor to correct the data from the mesonet experiments. In these plots, the CO_2 concentration measured by the Atmospheric Radiation Measurement - Southern Great Plains (ARM SGP) reference tower was added to show these are reasonable atmospheric values for Oklahoma. ***We understand the distance between Norman and the ARM-SGP tower does not allow for a direct comparison of the data.*** *Nevertheless, it is presented here to demonstrate to the reviewers that the two reference sensors were measuring values within reasonable expectations. A version of these additional plots and tables with basic statistical metrics (without the ARM-SGP data), was added to the revised manuscript supplement.*

We also add here that the Li-840A was sent back to LiCOR for calibration on Jun/06/2020. The report provided by the company indicates the sensor had an offset of 1.098 ppm to Zero ppm and offsets of 0.9809 and 0.0148 to the two Span references.

The LI-820 and LI-40 have known temperature dependent drifts. According to the LI-840 manual this the calibration drift is <0.4ppm per degree C 840A_Manual_10690.pdf | Powered by Box (boxenterprise.net)

How can the reader be sure that there isn't a residual drift in the reference data?

The Li-840A and Li-820 have internal heaters that elevate their sampling chambers to a temperature of ~51 °C (reported in the discussion supplement submitted with this response), which is above the temperatures tested in our experiments (max:~40 °C). This characteristic eliminates their dependence within the range tested. These assumptions are validated by the new plots and tables for experimental conditions (e.g., discussion supplement figure 14 and table 13) and the results from the mesonet runs 2 and 3 (e.g. discussion supplement tables 14 and 20, and figures 14, 15, 20, and 21). In addition, the discussion supplement tables 15 and 21 show the slope, y-intercept, R^2, and RMSE for the Li-840A against pressure, temperature, relative humidity, and Ref_OUT measurements *during mesonet temperature experiments 2 and 3. Comparing the R^2 estimates for temperature and Ref_OUT (a.k.a. the Li-820), we can conclude that temperature measurements are approximately equal or worse at predicting the behavior of the Li-840A.*

Besides our analysis, we also forwarded this question to Li-cor's technical support team. The answer received was the following:

"Thank you for your email. If the heater is turned on, you should not see any significant drift in the response over the entire specified range of the LI-840A."

2.) The range for the temperature calibration is too small and only a single test (at only one RH level) was conducted. Atmospheric temperatures outside the tropics frequently reach values below 10_oC, which seems to have been the lowest temperature setting tested in section 3. Also, the chamber experiment holds the temperature stable for multiple hours. Is this really a realistic temperature profile for a drone flight?

We agree with the reviewer, there are many teams that operate these sensors below 10 °C. However, the operational configuration of the Thunder Scientific 2500 chamber at the Mesonet Calibration Laboratory does not produce reliable test conditions below 10 °C. Therefore, this is a limitation of this study. Nevertheless, when compared with other studies in the literature, the presented manuscript does expand the results available. For example, the results from Martin et. al (2017) are limited to 16-24 °C and Arzoumanian et. al. (2019) are limited to 16-32 °C.

Regarding the time scales of the experiments, the goal of the long intervals was to study the general behavior of the sensors and create a comparable dataset to other results in the literature (with the expansion of the temperature and RH test ranges). This type of experiment is important because these sensors could have presented temperature time-response issues (i.e., lags) on the scales of tens of minutes. Therefore, the long dwell (Mesonet) and the short impulse (Bench) tests complement each other.

Regarding the number of tests, as mentioned above, two more runs of each test (temperature and relative humidity) were added to the study. One more bench test of each variable (T/RH) was also added (see experiment summary in the discussion supplement).

3.) It is unclear how/if the lab bench setup described in figure 4 was able to provide a homogeneously heated air-stream to all instruments. It would be necessary have many more temperature sensors placed around the 2xK30 and the Li-COR to be sure they measured the same (temperature) air. Furthermore, the lab bench tests measured a response to a short-term temperature change within a few minutes, while the chamber test duration was over 6 hours with 2 hours time for instruments to equilibrate. How can those to experiments be compared? The low correlation seen in Figure 6 could well be related to the change in time scale of the experiment.

We agree with the reviewer. Our ability to ensure temperature homogeneity during the experiment was not clear in the original manuscript. Besides the mixing fan depicted in figure 4 (original manuscript), the diaphragm pump intakes for the CO_2 sensors (one for the *reference sensor and one for the two K30 sensors) were placed immediately after three PT-100 bead thermistors (10 Hz sampling, 1 Hz time response, sold and calibrated by InterMet Systems), and three IST HYT-271 capacitive hygrometers (10 Hz sampling, 4-second RH time response, and 5-second Temperature time response). The temperature shown in the original manuscript is an average of the temperature of the 3 thermistors. The placement of the thermistors and hygrometers as well as the plumbing of the CO_2 sensors was added to the experiment schematics in the revised manuscript.*

Specific comments:

L1: Suggestion to mention that this study focusses on (lower-cost) NDIR sensors

We agree with the reviewer. A comment was added to the revised manuscript indicating this study is particularly interested in low-cost, weight, size, and power systems. We also provided a statement about our understanding of the term low-cost (under US$300 for the total sensor package).

L14: Please clarify: what does "mentioned measurement systems" refers to. Also please add a citation of studies that demonstrated the claim that no suitable measurement systems existed for local and regional scale work. Since the 2010s cavity ring down spectroscopy (CRDS) and integrated cavity output spectroscopy (ICOS) systems have been in regular use for atmospheric CO2 measurements and have allowed high-resolution and accurate measurements, even on mobile platforms (e.g. Chen at al. 2010, AMT - High- accuracy continuous airborne measurements of greenhouse gases (CO2 and CH4) using the cavity ring-down spectroscopy (CRDS) technique (copernicus.org)).

The statement "mentioned measurement systems" refers to the "instrumented towers, satellites, and manned aircraft", mentioned in L10.

The manuscript does not claim there are "no suitable measurement systems for local and regional scales". What the statement in L14/15 indicates is that instrumented towers, satellites, and manned aircraft "... do not always support fast and comprehensive data collection near regional and local phenomena." For example, the Atmospheric Radiation Measurement - Southern Great Plains (ARM SGP) reference tower in Billings (OK) may not capture the nuances of a 40-minute traffic jam in Norman (OK) before an OU football game. Therefore, low-cost sensors may be an initial solution for initial exploratory studies. Such studies are also important because they help justify funding requisitions for more rigorous studies. Furthermore, outside developed countries (such as the US) the coverage of instrumented towers and manned aircraft is lower, and access to research funding is also lower. Thus increasing the need for low-cost tools to investigate local phenomena. As stated in L15/16, UAS-based measurement is a "... complementary in-situ observation tool for local atmospheric CO_2 profiles (Villa et al., 2016)."

L85: You mention the need for instrument specific correction coefficients, but only decided to measure 2 instruments. How representative are two units? Martin et al. 2017 (AMT -

Evaluation and environmental correction of ambient CO2 measurements from a low-cost NDIR sensor (copernicus.org)) tested at least 6 units of the K30 series.

We agree with the reviewer, two units may not be representative. As mentioned above we repeated the experiments with more units. A summary of the experiments and units tested is provided in table 1 of the discussion supplement. This table was also added to the revised manuscript.

Figure 2. It is very difficult to distinguish the time series of the different instruments.

We agree with the reviewer, the plot colors were updated in the revised manuscript and discussion supplement using more contrasting color palettes (similar to Martin et al. 2017). The colors were tested using this tool: https://projects.susielu.com/viz-palette.

L144, Figure 8: A linear fit does not seem appropriate for the left panels. Did you consider a non-linear instrument response?

We had not considered a non-linear fit because we had not found literature to support non-linear behavior. In fact, there is very little literature on the impact of humidity on low-cost NDIR sensors. Most studies found report the use of desiccants to eliminate humidity from the atmospheric samples. However, using desiccants in small UAS is not always possible (either due to cost, weight, or even fuselage access limitations), as desiccants need to be replaced frequently. Therefore, we understood the poor fit as an indication of low impact from the variable.

The new dataset for the repeated Mesonet Experiments (run 2 and 3) did not show the same behavior for the test sensors against relative humidity. In fact, figures 19 and 25 of the discussion supplement show a more linear behavior. Nonetheless, your suggestion is very interesting because the ~2 °C variation during both relative humidity experiments appears to be non-linear. At the time this response is being written we are analyzing the possibility of adding a complementary joint variation (T/RH) case to the revised manuscript. In this case, additional nonlinear analyses may be beneficial.

L170: The temperature experiment, especially Figure4 clearly show that the concentration inside and outside the chamber can (and do) differ. Why do you consider the LI-840 on the outside as a reliable reference here, especially after the potential 'unknown external interference'?

It is not clear to us what the reviewer is referring to in this comment. L170 in the manuscript offers a description of the Mesonet Pressure Dependence Experiment and Figure 4 illustrates the arrangement of the Bench Temperature and Relative Humidity experiments. The "unknown external interferences" mentioned in the manuscript are associated with the Mesonet Temperature and Relative Humidity experiments. Therefore, we will attempt to respond to the best of our understanding ***assuming the question is about the experiment arrangement detailed in L170.***

The Mesonet Pressure Experiment uses a different chamber than the Temp/RH experiments (as stated in L162/163). The pressure chamber (Cincinnati Sub-Zero Z16 with the custom gasket-based vacuum and compression system) uses two Thompson pumps to move air in and out of the chamber to raise and lower pressure. The air moved in and out of the chamber comes from the laboratory. Therefore, we placed the intake plumbing for the diaphragm pump of the Li-840A within 1 cm of the chamber's pump intake and exhaust to monitor the CO_2 *of the air coming in and out of the chamber.*

- *Attempt to respond to the best of our understanding **assuming the question is about the experimental setup for the Mesonet Temperature and Relative Humidity experiments:***

As detailed in L95 of the original manuscript, the temperature and humidity chamber (Thunder Scientific 2500) is not sealed. Therefore, there is exchange with air in the laboratory. Therefore our experiment design is dependent on a low variation of CO_2 *in the laboratory to isolate the impact of T/RH on the K30. Under this assumption, if both reference sensors (IN and OUT) showed low variation and the test sensors showed high variation, we could use the dataset to study the impact of the test variable. These conditions were achieved when we repeated the experiments (see sections 4 and 5 of the attached discussion supplement).*

L214: This is a major concern: Can the results reported here be useful to other researchers, If the time delayed response to pressure changes is specific to the inlet and housing design?

*As stated by Gaynullin et. al. (2016), Martin et. al. (2017), and stated in the original manuscript, all the calibrations and coefficients shown are unit specific. Therefore, this study focused on demonstrating a low-cost repeatable method to determine these coefficients. Thus, **other researchers can use the methods shown in this study** to determine the time constants of each of their specific systems. Furthermore, as stated in L254 - L258 (original manuscript), the referred researchers will need to repeat the presented methods over time to recalibrate and re-evaluate their systems to "account for temporal drift and sensor decay".*

L240: The accuracy of the instruments has not been investigated at all. No gas standards from NOAA or NIST was used here, neither were calibrated reference instruments.

The authors did demonstrate that they can reproduce measurements within 2.5ppm for same air sampling of another optical instruments under certain conditions.

We agree with the reviewer. Even though the comments in this document and the additional plots and tables provided in the discussion supplement indicate the reliability of the reference sensors, no gas standards were used. Therefore, we have added to the revised manuscript an explicit indication that our results are relative to the reference sensors.

Discussion Supplement for “The Impact of Environmental Variables on UAS-based Atmospheric Carbon Dioxide Measurements”

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1 Summary

Following the reviewers’ suggestions, we repeated the Mesonet temperature and relative humidity experiments under more controlled conditions, added more test sensors, and adjusted the result presentation. Therefore, this document is written in light of the following changes:

- The Li-820 sensor originally named CO2 Independent Sensor Outside is renamed Reference Sensor Out (Ref_OUT).
- The Li-840A sensor originally named CO2 Independent Sensor Inside is renamed Reference Sensor In (Ref_IN).
- The Senseair K30 sensors originally named CO2 Test Sensors 1 and 2 are renamed K30_##, where the first digit refers to its attached test system and the second digit is its identification. This way the first Senseair K30 sensor of test system 2 is named K30_21.
  - Test systems (labeled T_#) has its own pressure (two MS5611), temperature (three PT-100 bead thermistors), relative humidity (three IST HYT-271 hygrometer), and Carbon Dioxide (two Senseair K30).
- Environmental conditions during the experiments are labeled by chamber, reference sensor, and the test system they are associated with.
- The Mesonet temperature and relative humidity experiments now have a "run" identification (i.e., "Mesonet Run 1 Temperature", "Mesonet Run 2 Temperature", "Mesonet Run 1 Relative humidity", etc), where Run 1 is the data originally presented in the manuscript and Runs 2 and 3 are the repetition runs.

The following sections provide supporting material to explain the low CO_2 values seen in the Mesonet Experiment (Run 1). The results of the correction application on the Mesonet T/RH Experiment (Run 1) dataset, followed by the results for the Mesonet T/RH Experiment (Run 2 and 3), and the adjusted Bench temperature and relative humidity Experiments. The document ends with the supporting plot for the Pressure time-response correction ("ideal signal").

Please note that even though the results for the correction application on the Mesonet T/RH Experiment (Run 1) dataset are presented in the attached "Discussion Supplement", they serve only as a comparison of the correction method. Following the reviewer's suggestion, the Mesonet T/RH Experiment (Run 1) dataset will be discarded. Only Mesonet T/RH Experiment (Run 2 and 3) will be analyzed in the revised manuscript.

1.1 Experiments summary

The following tables cross lists all the experiments performed and their sensors. The sensor intercomparison experiments are not listed on the table. They were preformed before the first run of the Mesonet experiments, before the second run of the Mesonet experiments, in between the second and third runs, and after the third run of the Mesonet experiments.

Location	Name	Reference Sensors	Test Sensor
Mesonet	Run 1 Pressure	Ref_IN	K30_11, K30_12
	Run 1 Temperature	Ref_IN, Ref_OUT	K30_11, K30_12
	Run 1 Relative Humidity	Ref_IN, Ref_OUT	K30_11, K30_12
	Run 2 Temperature	Ref_IN, Ref_OUT	K30_21, K30_22, K30_31, K30_32
	Run 2 Relative Humidity	Ref_IN, Ref_OUT	K30_21, K30_22, K30_31, K30_32
	Run 3 Temperature	Ref_IN, Ref_OUT	K30_21, K30_22, K30_31, K30_32, K30_13, K30_14
	Run 3 Relative Humidity	Ref_IN, Ref_OUT	K30_21, K30_22, K30_31, K30_32, K30_13, K30_14
Bench	Run 1 Pressure Correction	Ref_IN	K30_21, K30_22
	Run 2 Pressure Correction	Ref_IN	K30_21, K30_22
	Run 3 Pressure Correction	Ref_IN	K30_21, K30_22
	Run 4 Pressure Correction	Ref_IN	K30_21, K30_22
	Pressure Time-response Learn 1	Ref_IN	K30_21, K30_22, K30_31, K30_32
	Pressure Time-response Learn 2	Ref_IN	K30_21, K30_22, K30_31, K30_32
	Pressure Time-response Test 1	Ref_IN	K30_21, K30_22, K30_31, K30_32
	Pressure Time-response Test 2	Ref_IN	K30_21, K30_22, K30_31, K30_32
	Run 1 Temperature	Ref_IN	K30_21, K30_22
	Run 1 Relative Humidity	Ref_IN	K30_21, K30_22
	Run 2 Temperature	Ref_IN	K30_21, K30_22
	Run 2 Relative Humidity	Ref_IN	K30_21, K30_22
	Run 3 Relative Humidity	Ref_IN	K30_21, K30_22

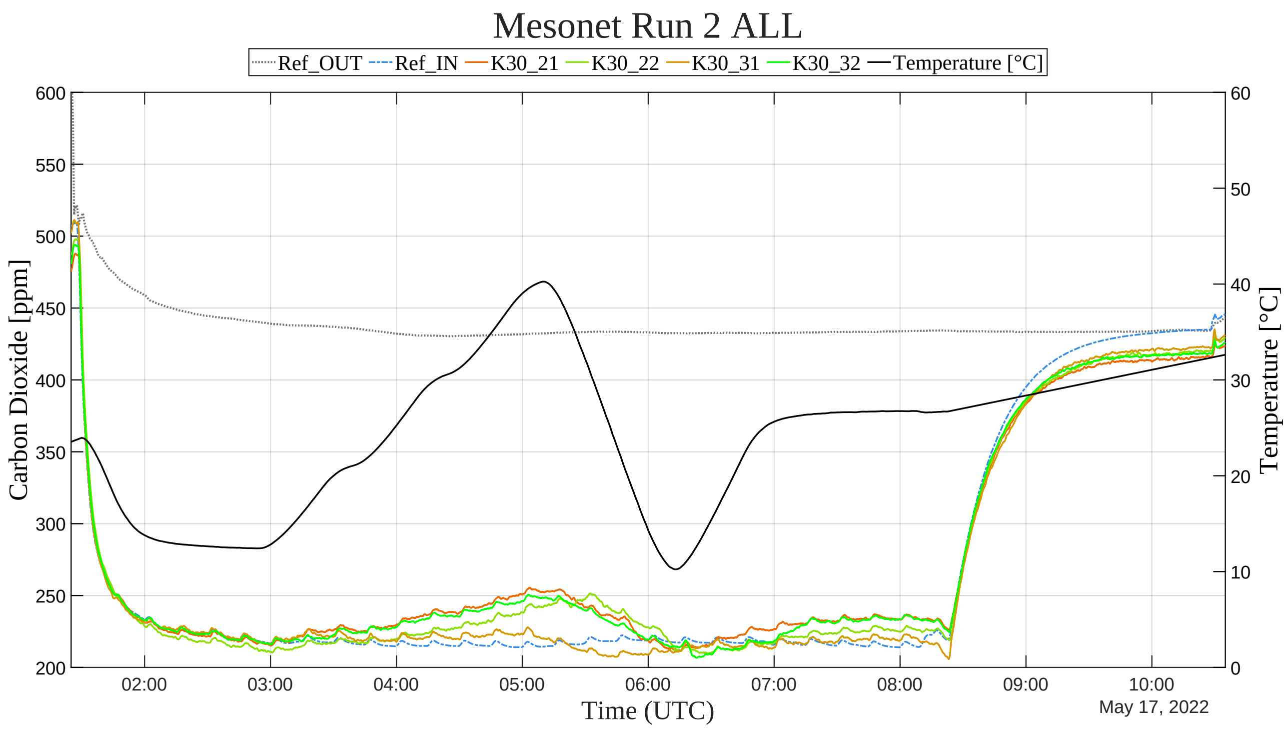

Figure 1. Data showing the impact of the Thunder Scientific 2500 chamber on the reported CO_2 values. The chamber was turned on at 01:29:37 and turned off at 08:24:43.

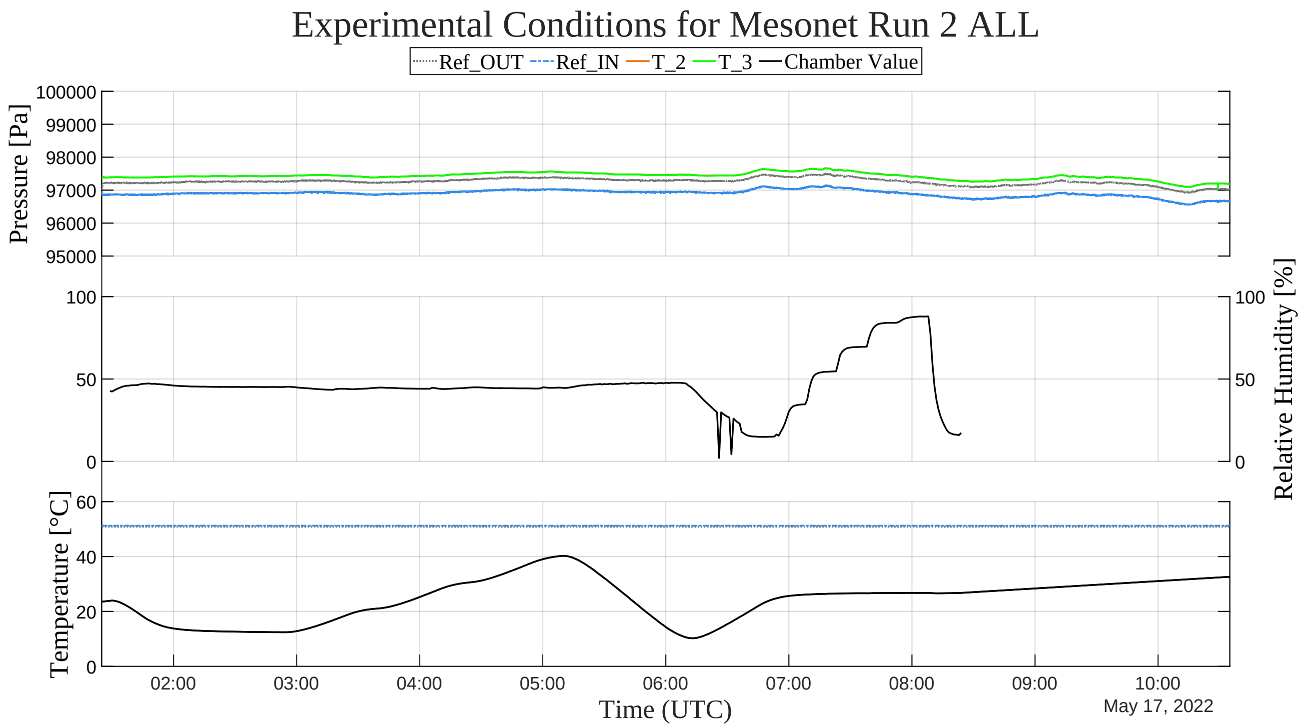

Figure 2. Environmental conditions during the second run of the Mesonet Temperature and Relative Humidity experiments. The chamber was turned on at 01:29:37 and turned off at 08:24:43. During this period the pressure (all sensors) and internal temperature (reference sensors) does not vary greatly.

Table 1. Metrics for the experimental conditions for the complete second run of the Mesonet Experiments.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
Pressure [Pa]	Ref_OUT	96910	97500	97262.68	105.94
	Ref_IN	96540	97160	96902.5	107.37
	T_2	97066.57	97669.28	97430.29	106.42
	T_3	97039.22	97665.22	97427.47	106.54
Temperature [°C]	Ref_OUT	50.91	50.91	50.91	**0***
	Ref_IN	51.17	51.28	51.23	0.01
	Chamber	10.23	40.26	-	-
Relative Humidity [%]	Chamber	2.06	88.03	-	-

***Please see section 10 of this document for explanation about this zero deviation.**

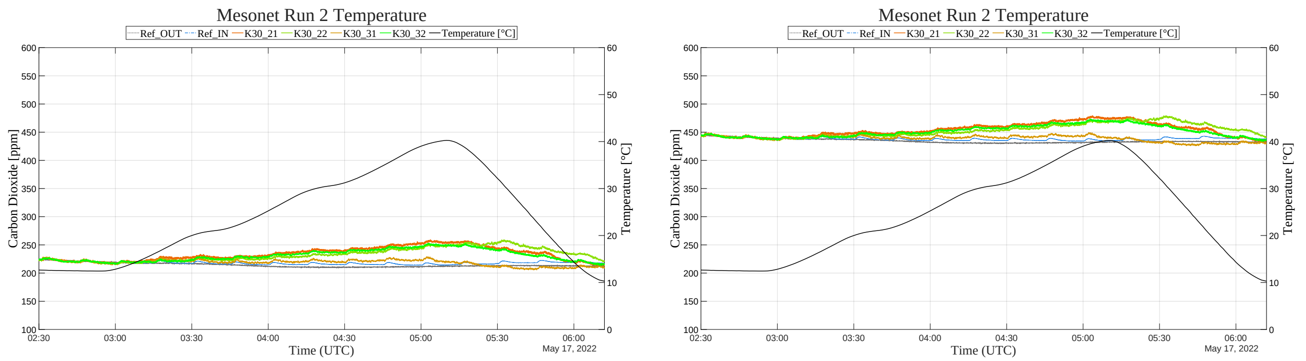

Figure 3. Comparison of the reference offset strategies. On the left the all sensors are brought to the level of the Ref_IN sensor, on the right, to the Ref_OUT sensor.

3 Mesonet Experiment 1

3.1 Reference Intercomparison

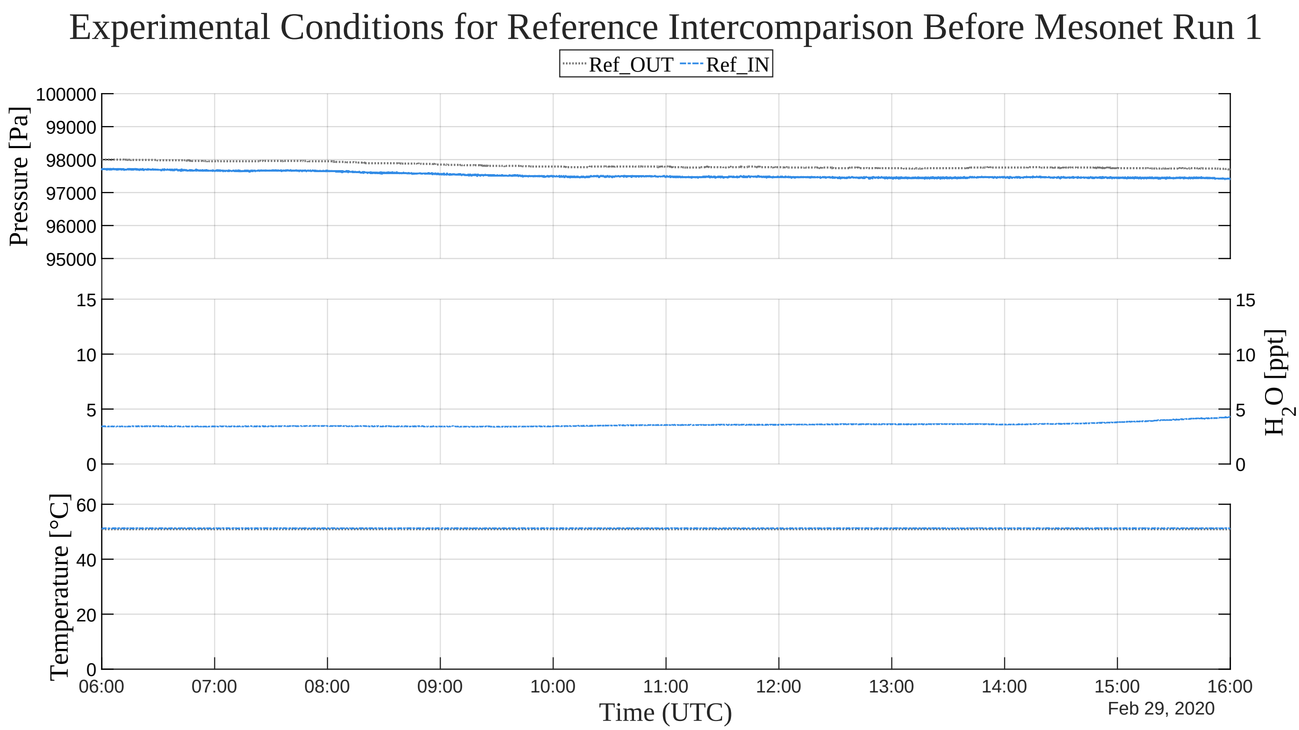

Figure 4. Environmental conditions during the intercomparison before the first Mesonet experiments.

Table 2. Metrics for the experimental conditions for the intercomparison before first Mesonet experiments.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
Pressure [Pa]	Ref_OUT	97700	98000	97819.24	87.62
	Ref_IN	97380	97740	97526.47	88.92
Temperature [°C]	Ref_OUT	50.91	50.91	50.91	**0***
	Ref_IN	51.17	51.25	51.22	0.02
H_2O [ppt]	Ref_IN	3.38	4.3	3.57	0.18

***Please see section 10 of this document for explanation about this zero deviation.**

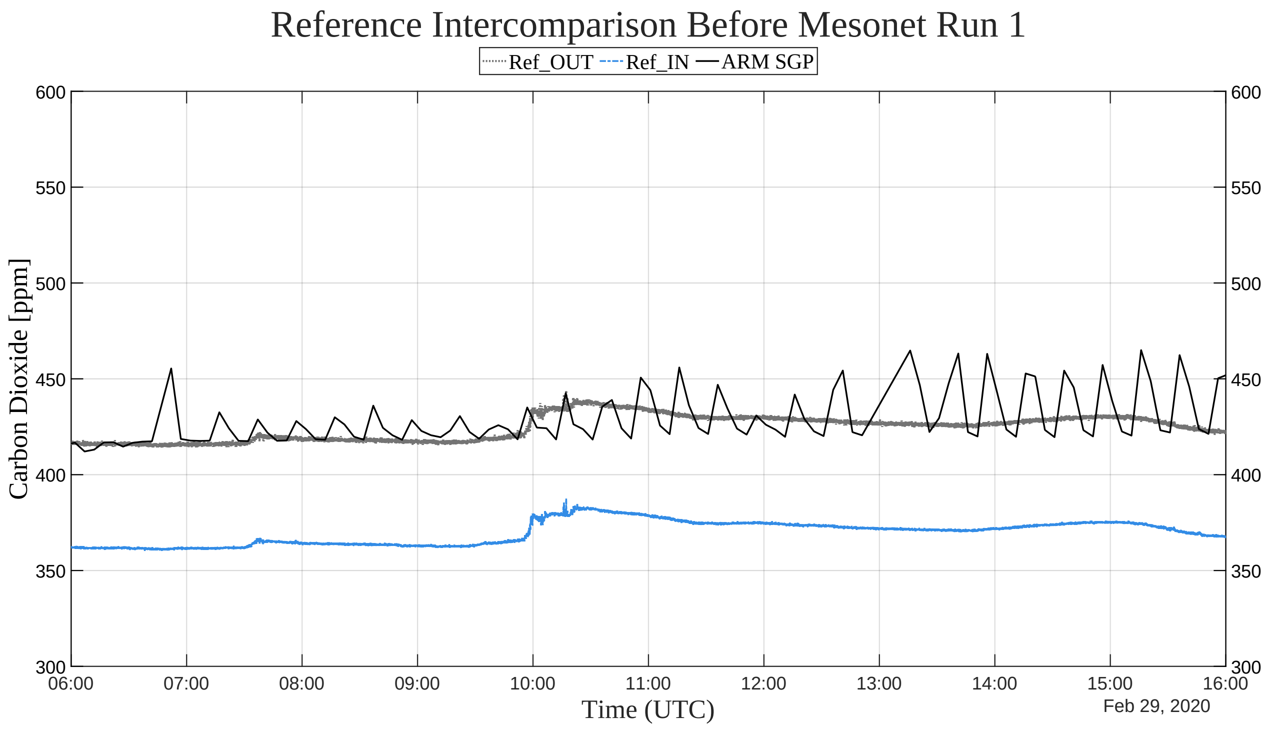

Figure 5. Results for the intercomparison before the first Mesonet experiment. At this date, the two reference presented a constant 54.75 ppm offset. After correcting this offset, the RMSE was $1.63 * 10^{-14}$ ppm.

Table 3. Metrics for the intercomparison before the first Mesonet experiments.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
CO_2 [ppm]	Ref_OUT	413.91	443.85	424.57	6.51
	Ref_IN	360.24	387.49	369.82	6.14
	ARM SGP	412.1	464.98	429.74	11.85

3.2 Temperature

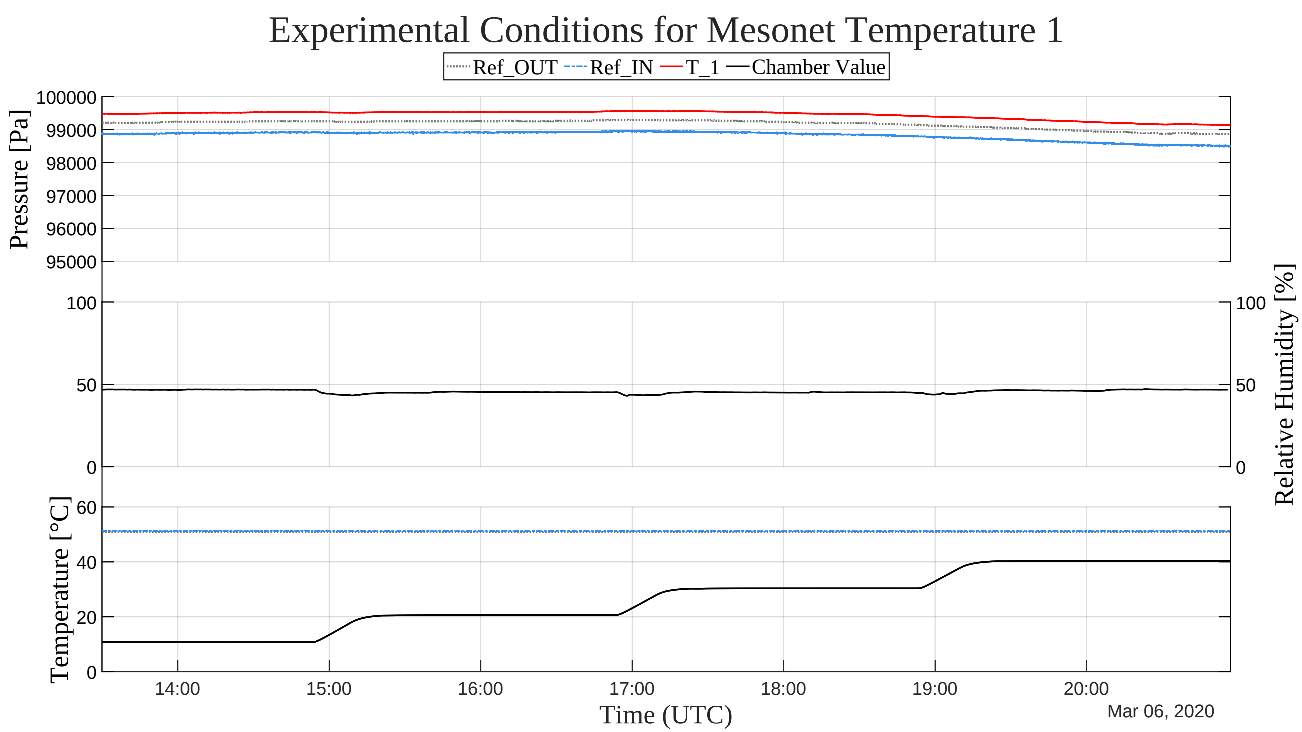

Figure 6. Experimental conditions during the first Mesonet Temperature run.

Table 4. Metrics for the experimental conditions during the first Mesonet Temperature run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
Pressure [Pa]	Ref_OUT	98860	99290	99170.04	128.85
	Ref_IN	98460	98970	98825.68	134.19
	T_1	99133.8	99565.99	99445.19	127.6
Temperature [°C]	Ref_OUT	50.91	50.91	50.91	**0***
	Ref_IN	51.17	51.28	51.23	0.01
	Chamber	10.74	40.32	-	-
Relative Humidity [%]	Chamber	43	47.09	45.64	0.98

***Please see section 10 of this document for explanation about this zero deviation.**

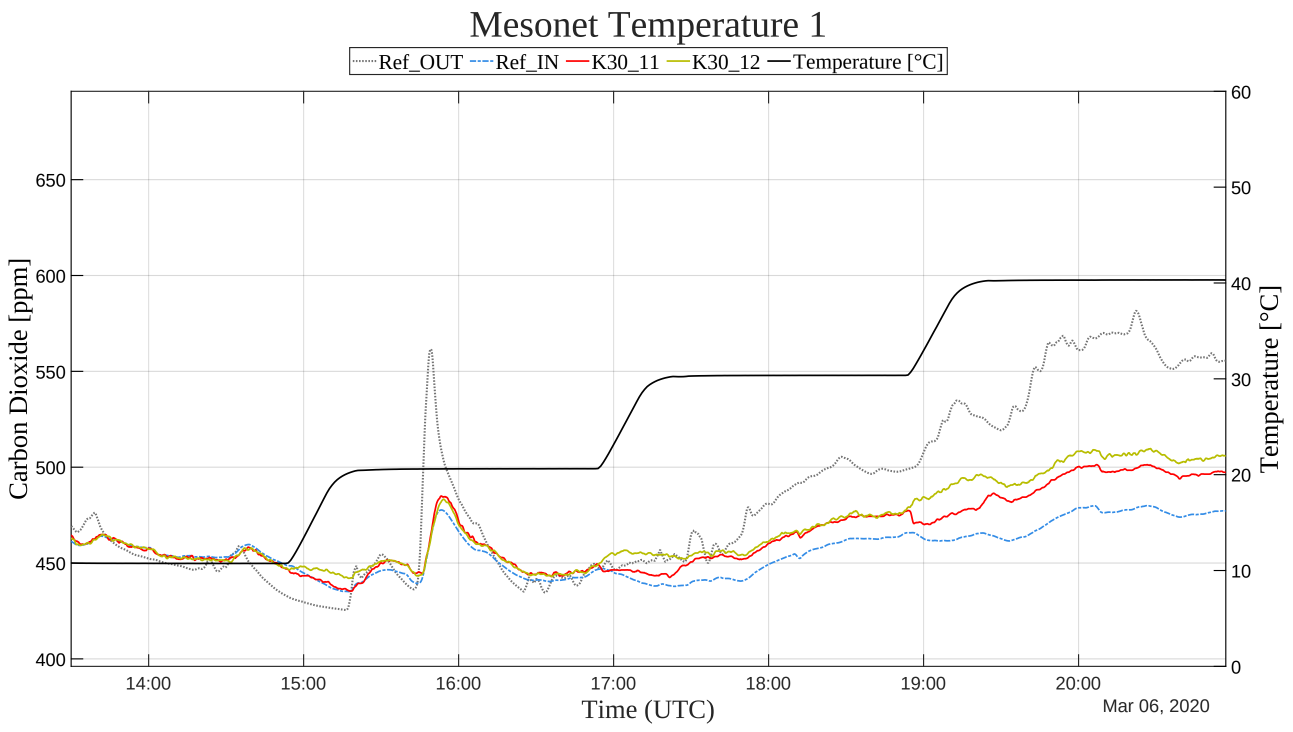

Figure 7. Results for the first Mesonet Temperature run.

Table 5. Carbon Dioxide metrics for the first Mesonet Temperature run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
CO_2 [ppm]	Ref_OUT	425.48	581.55	484.34	45.08
	Ref_IN	435.11	479.91	456.2	12.7
	K30_11	435.35	501.35	464.47	18.86
	K30_12	442.05	509.72	468.27	21.15

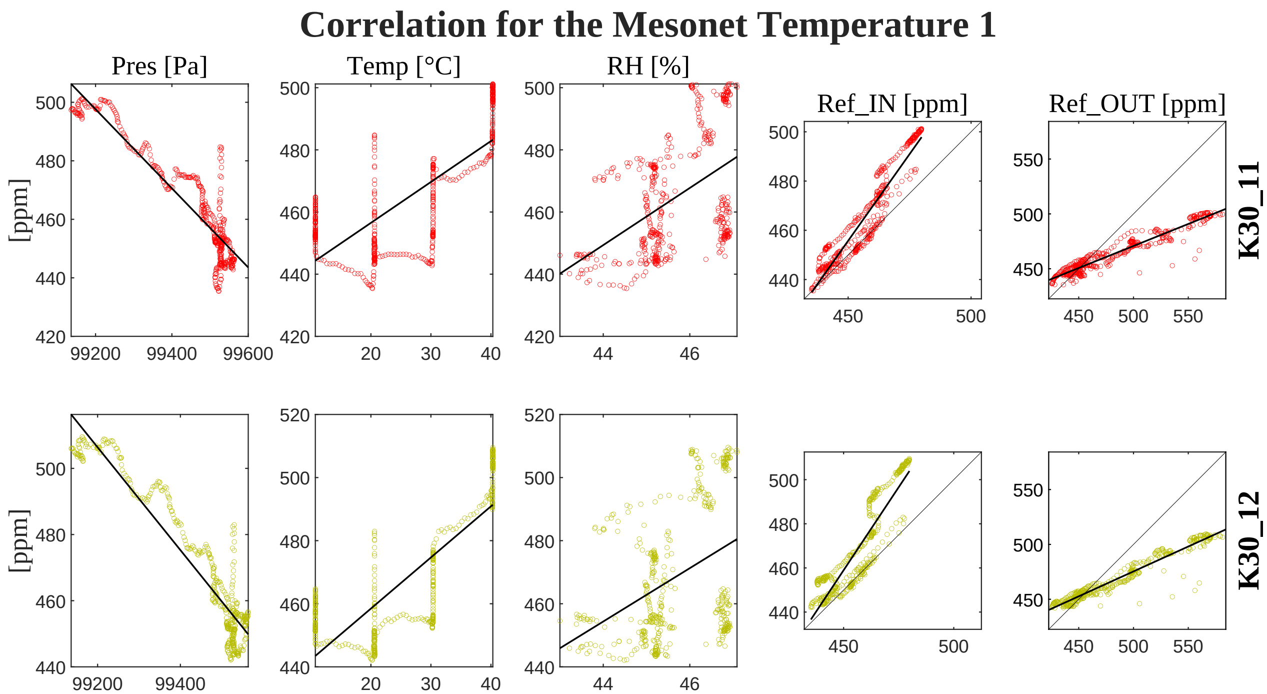

Figure 8. Scatter plots for the first Mesonet Temperature run.

Table 6. Linear fit metrics for the first Mesonet Temperature run.

Sensor	Predictor	Slope	Y-Intercept	R^2	RMSE
Ref_IN	Pressure	-0.08	8212.38	0.68	7.19
	Temperature	0.6	440.47	0.25	11
	Relative Humidity	7.42	117.68	0.33	10.43
	Ref_OUT	0.25	337.26	0.76	6.22
K30_11	Pressure	-0.14	13911.4	0.84	7.61
	Temperature	1.32	430.2	0.54	12.79
	Relative Humidity	9.19	44.89	0.23	16.57
	Ref_IN	1.41	-178.06	0.9	5.98
	Ref_OUT	0.4	270.02	0.92	5.31
K30_12	Pressure	-0.16	15918.25	0.88	7.38
	Temperature	1.62	426.07	0.65	12.5
	Relative Humidity	8.46	82.31	0.15	19.46
	Ref_IN	1.5	-218.19	0.82	9.08
	Ref_OUT	0.45	248.4	0.94	5.37

3.3 Relative Humidity

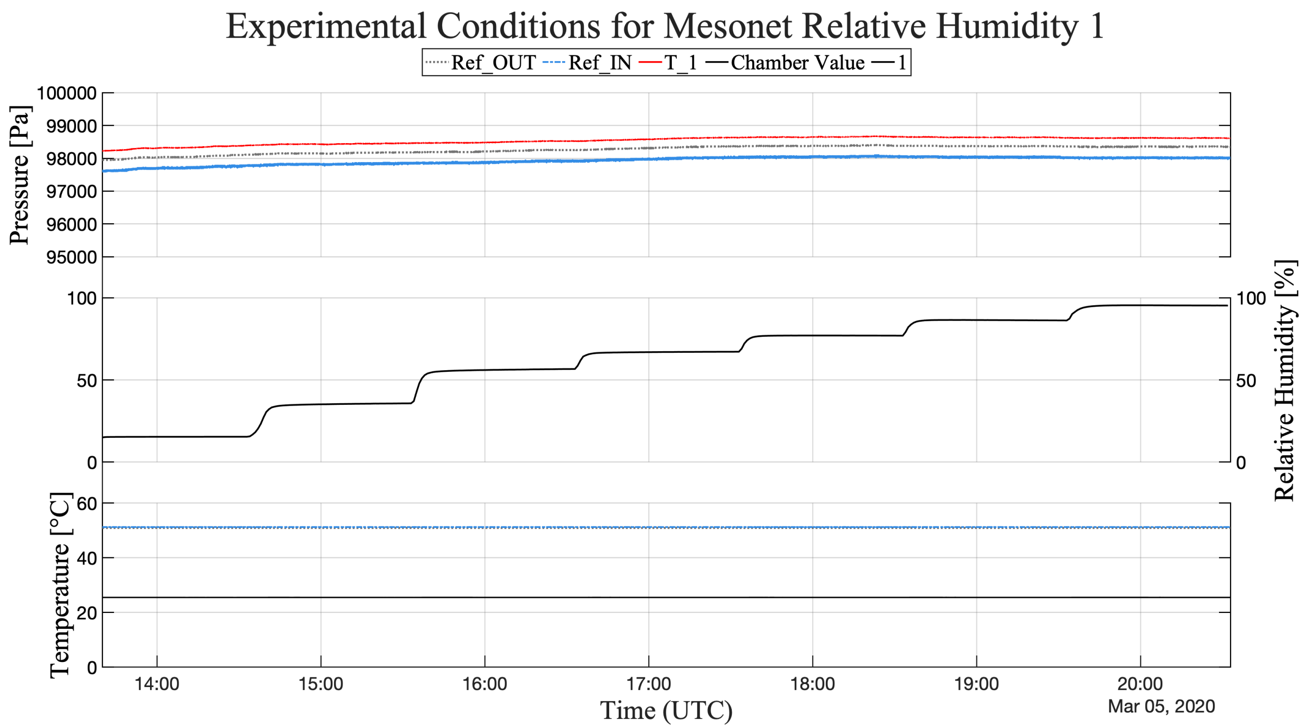

Figure 9. Experimental conditions during the first Mesonet Relative Humidity run.

Table 7. Metrics for the experimental conditions during the first Mesonet Relative Humidity run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
Pressure [Pa]	Ref_OUT	97950	98410	98264.73	121.25
	Ref_IN	97590	98100	97930.66	121.5
	T_1	98225.48	98674.64	98537.13	115.1
Temperature [°C]	Ref_OUT	50.91	50.91	50.91	0
	Ref_IN	51.17	51.28	51.23	0.01
	Chamber	25.47	25.5	25.48	0.01
Relative Humidity [%]	Chamber	14.97	95.48	-	-

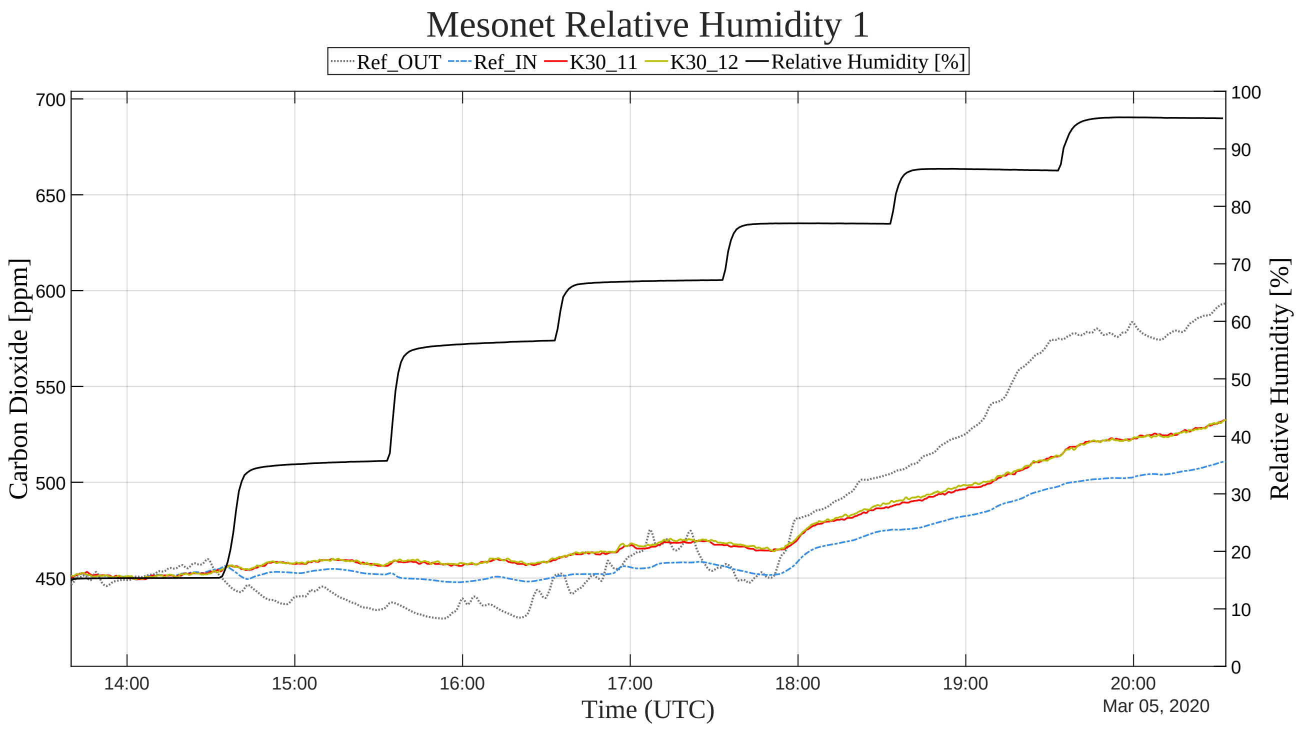

Figure 10. Results for the first Mesonet Relative Humidity run.

Table 8. Carbon Dioxide metrics for the first Mesonet Relative Humidity run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
CO_2 [ppm]	Ref_OUT	428.93	593.21	483	52.16
	Ref_IN	447.85	510.86	465.9	19.74
	K30_11	449.41	532.41	476.07	24.97
	K30_12	449.43	532.8	476.58	24.91

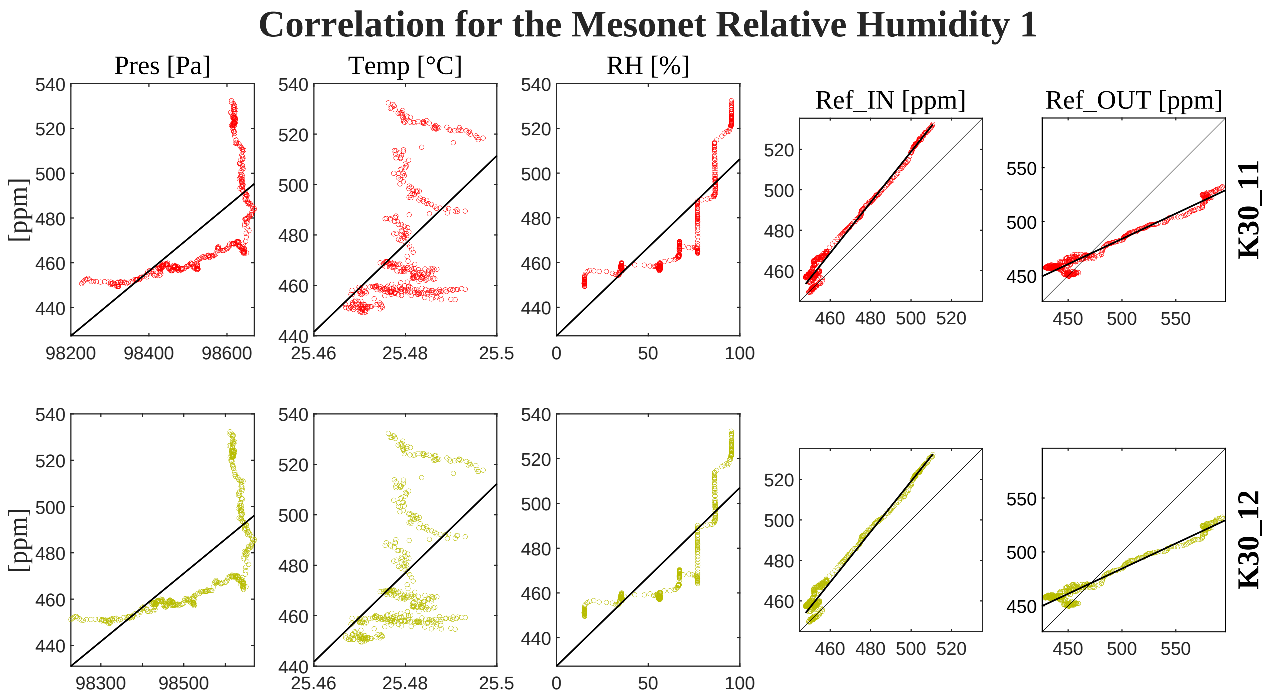

Figure 11. Scatter plots for the first Mesonet Relative Humidity run.

Table 9. Linear fit metrics for the first Mesonet Relative Humidity run.

Sensor	Predictor	Slope	Y-Intercept	R^2	RMSE
	Pressure	0.14	-13756.32	0.44	18.64
	Temperature	1747.35	-44046.02	0.19	22.52
K30_11	Relative Humidity	0.79	427.22	0.69	13.91
	Ref_IN	1.25	-107.72	0.98	3.48
	Ref_OUT	0.47	249.43	0.96	4.96
	Pressure	0.15	-14021.01	0.46	18.27
	Temperature	1765.67	-44512.15	0.19	22.4
K30_12	Relative Humidity	0.8	427.3	0.71	13.52
	Ref_IN	1.25	-104.56	0.98	3.81
	Ref_OUT	0.47	250.86	0.96	5.13

4 Mesonet Experiment 2

4.1 Reference Sensors

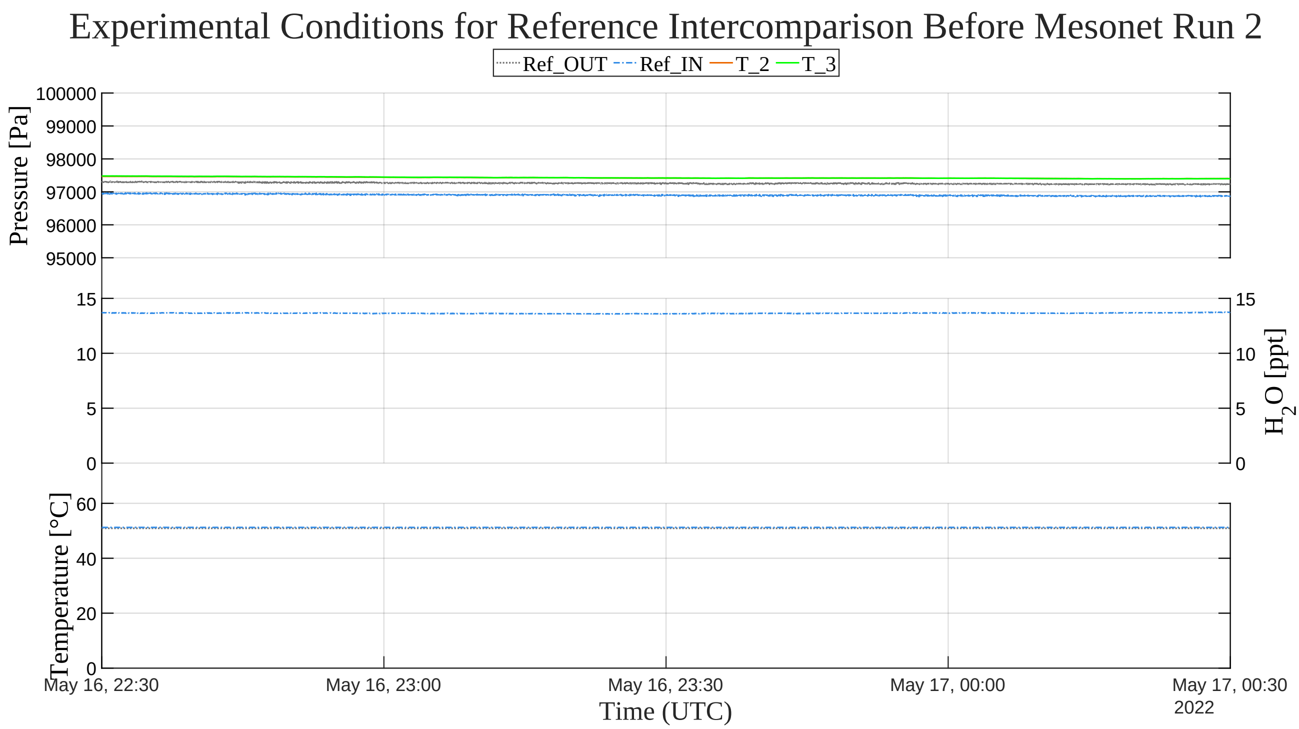

Figure 12. Experimental conditions for the intercomparison before second Mesonet experiments.

Table 10. Metrics for the experimental conditions for the intercomparison before second Mesonet experiments.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
Pressure [Pa]	Ref_OUT	97220	97320	97261.68	23.66
	Ref_IN	96830	96980	96904.07	26.97
	T_1	97395.68	97470.13	97427.53	20.73
	T_2	97393.41	97483.26	97430.47	25.02
Temperature [°C]	Ref_OUT	50.91	50.91	50.91	0
	Ref_IN	51.2	51.28	51.23	0.01
H_2O [ppt]	Ref_IN	13.57	13.75	13.65	0.03

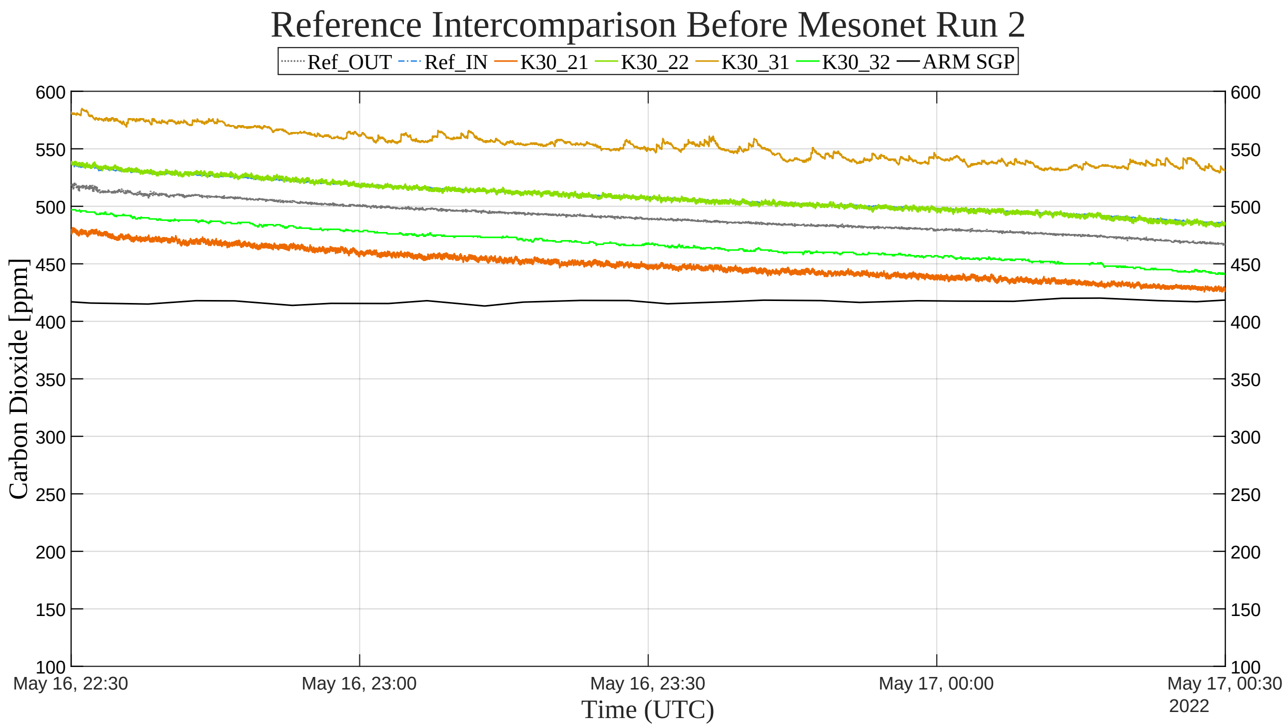

Figure 13. Results for the intercomparison before the second Mesonet experiment. At this date, the two reference presented a constant 18.23 ppm offset. After correcting this offset, the RMSE was $1.53 * 10^{-14}$ ppm.

Table 11. Metrics for the intercomparison before the second Mesonet experiments.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
	Ref_OUT	465.75	520.45	490.28	13.02
	Ref_IN	484.46	538.11	508.51	13.17
	ARM SGP	413.32	420.2	417.05	1.42
CO_2 [ppm]	K30_21	425.5	481.5	449.68	13.55
	K30_22	482	539	508.29	13.93
	K30_31	529	585	552.27	13.48
	K30_32	441	497	467.25	14.28

4.2 Temperature

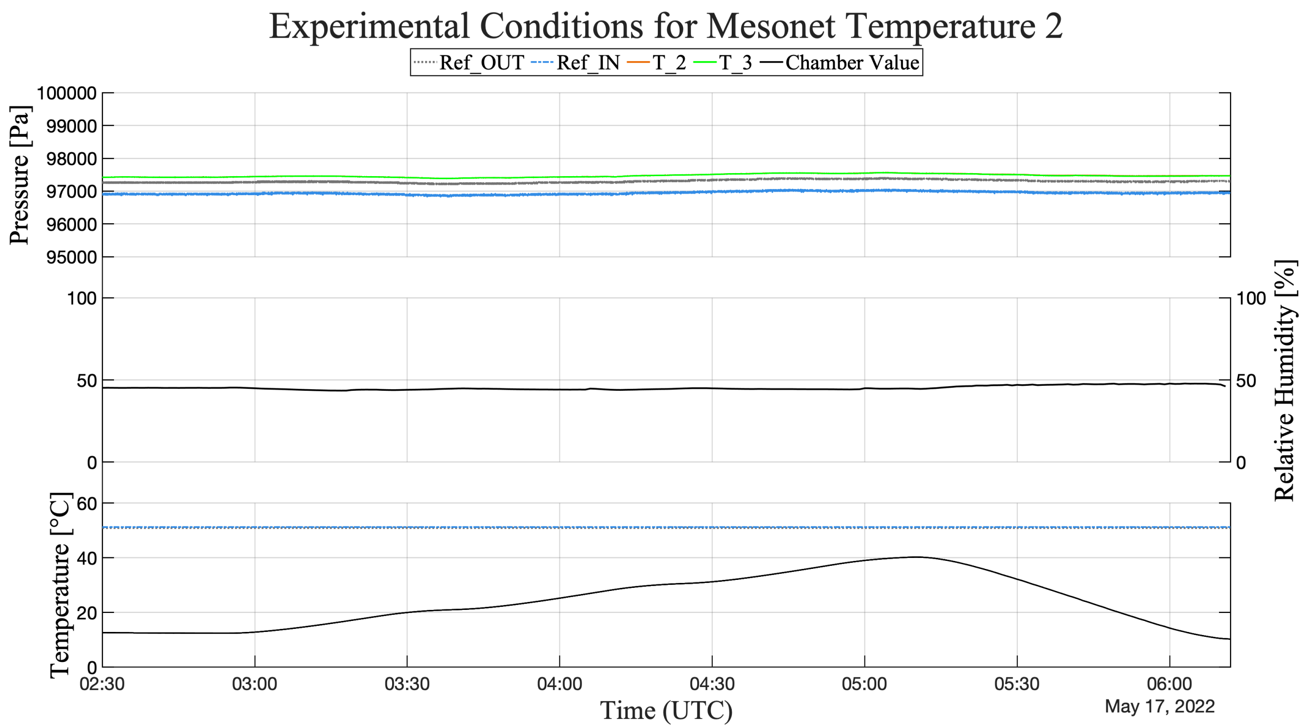

Figure 14. Experimental conditions during the second Mesonet Temperature run.

Table 12. Metrics for the experimental conditions during the second Mesonet Temperature run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
Pressure [Pa]	Ref_OUT	97210	97400	97304.12	47.69
	Ref_IN	96830	97050	96944.33	45.83
	T_2	97385.18	97565.27	97470.79	48.26
	T_3	97385.21	97563.27	97468.38	47.66
Temperature [°C]	Ref_OUT	50.91	50.91	50.91	0
	Ref_IN	51.17	51.28	51.23	0.01
	Chamber	10.28	40.26	-	-
Relative Humidity [%]	Chamber	43.48	47.81	45.17	1.23

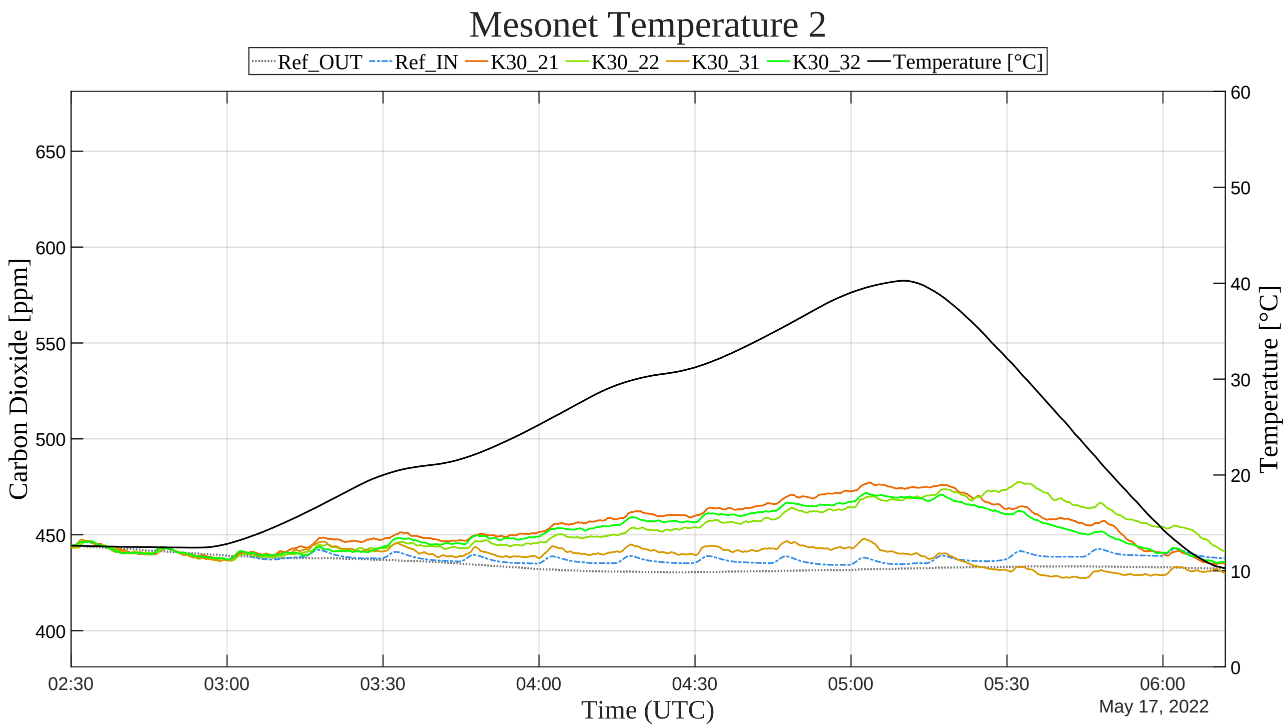

Figure 15. Results for the second Mesonet Temperature run.

Table 13. Carbon Dioxide metrics for the second Mesonet Temperature run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
CO_2 [ppm]	Ref_OUT	430.39	444.43	434.57	3.68
	Ref_IN	434.32	446.82	438.07	2.47
	K30_21	434.62	477.32	454.36	11.88
	K30_22	436.42	477.51	453.11	11.29
	K30_31	427.33	448.05	439.02	5.08
	K30_32	435.23	471.76	451.68	10.29

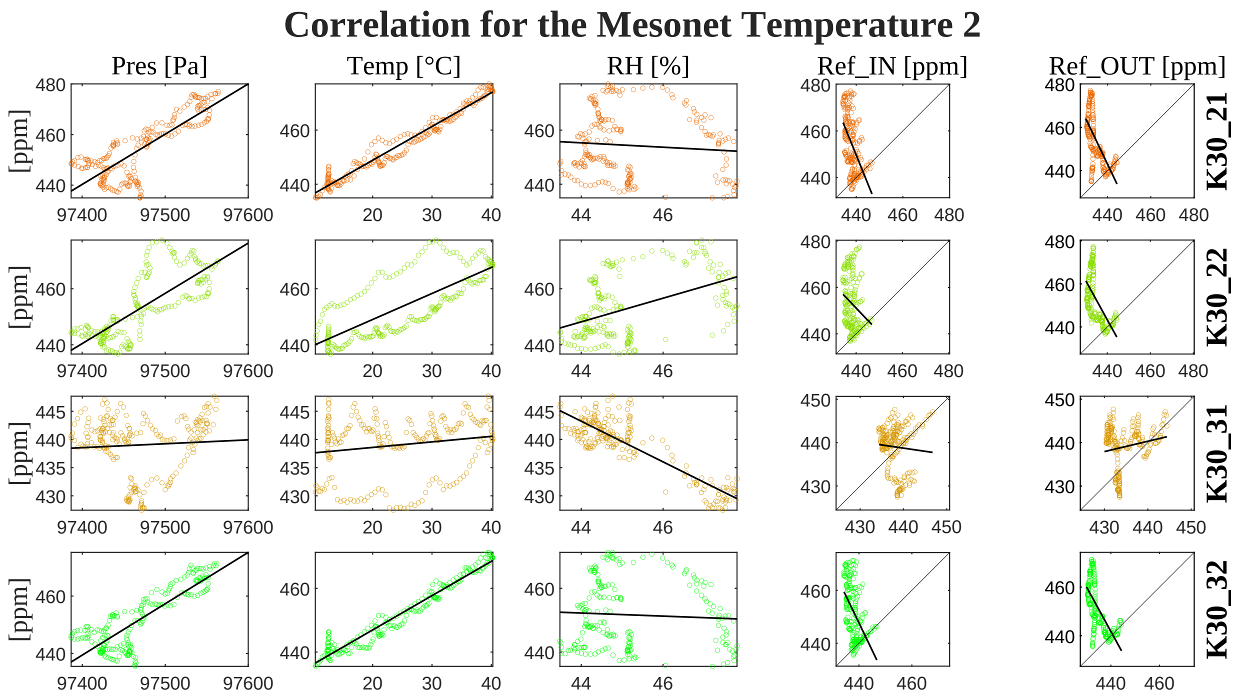

Figure 16. Scatter plots for the second Mesonet Temperature run.

Table 14. Linear fit metrics for the second Mesonet Temperature run.

Sensor	Predictor	Slope	Y-Intercept	R^2	RMSE
Ref_IN	Pressure	-0.02	2538.79	0.15	2.26
	Temperature	-0.17	442.25	0.42	1.87
	Relative Humidity	0.68	407.18	0.12	2.31
	Ref_OUT	0.44	245.07	0.44	1.83
K30_21	Pressure	0.2	-18931.25	0.65	6.99
	Temperature	1.25	423.91	0.96	2.35
	Relative Humidity	-0.81	490.97	0.01	11.83
	Ref_IN	-2.47	1536.34	0.26	10.21
	Ref_OUT	-2.09	1363.93	0.42	9.03
K30_22	Pressure	0.18	-17025.1	0.59	7.24
	Temperature	0.93	430.45	0.59	7.23
	Relative Humidity	4.22	262.52	0.21	10.03
	Ref_IN	-1.05	912.85	0.05	10.98
	Ref_OUT	-1.82	1242.14	0.35	9.08
K30_31	Pressure	0.01	-235.81	0	5.05
	Temperature	0.1	436.62	0.03	4.98
	Relative Humidity	-3.61	602.12	0.76	2.47
	Ref_IN	-0.15	503.29	0.01	5.05
	Ref_OUT	0.24	335.75	0.03	4.99
K30_32	Pressure	0.18	-16989.37	0.69	5.75
	Temperature	1.08	425.42	0.95	2.24
	Relative Humidity	-0.48	473.53	0	10.27
	Ref_IN	-2.08	1361.23	0.25	8.93
	Ref_OUT	-1.82	1243.47	0.43	7.79

4.3 Relative Humidity

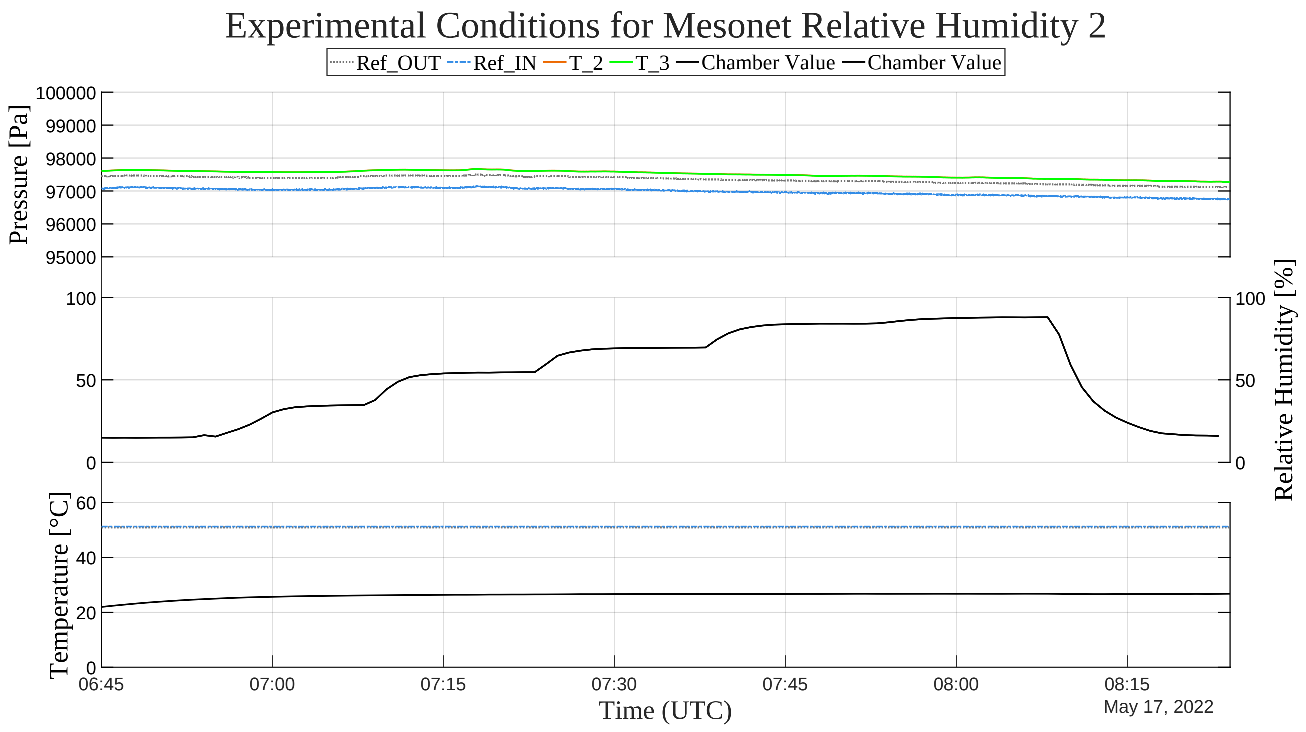

Figure 17. Experimental conditions during the second Mesonet Relative Humidity run.

Table 15. Metrics for the experimental conditions during the second Mesonet Relative Humidity run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
Pressure [Pa]	Ref_OUT	97100	97500	97342.03	111.34
	Ref_IN	96720	97160	96980.96	111
	T_2	97274.8	97669.28	97511.81	112.58
	T_3	97270.3	97665.22	97508.13	112.64
Temperature [°C]	Ref_OUT	50.91	50.91	50.91	0
	Ref_IN	51.2	51.28	51.23	0.01
	Chamber	21.95	26.76	26.2	0.95
Relative Humidity [%]	Chamber	14.87	88.03	-	-

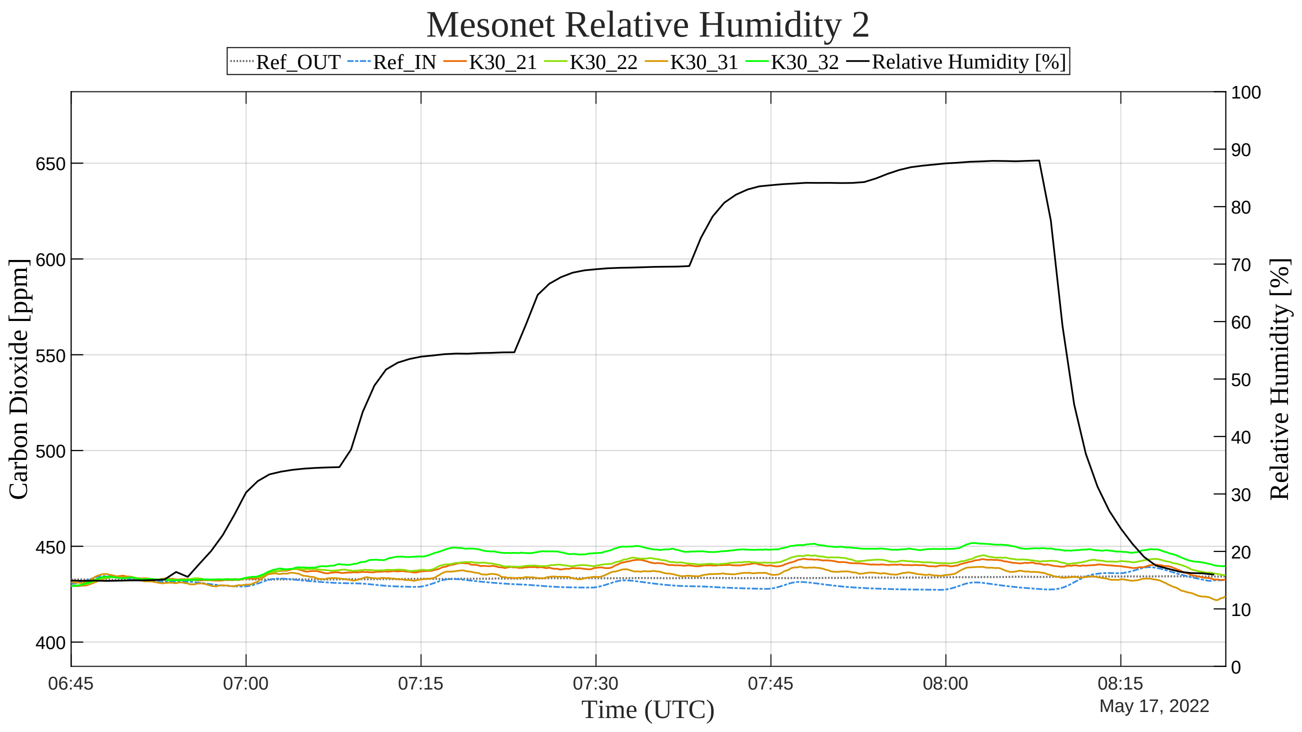

Figure 18. Results for the second Mesonet Relative Humidity run.

Table 16. Carbon Dioxide metrics for the second Mesonet Relative Humidity run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
CO_2 [ppm]	Ref_OUT	432.36	434.37	433.36	0.57
	Ref_IN	427.27	439.11	430.78	2.54
	K30_21	429.1	443.48	438.27	3.27
	K30_22	429.23	445.32	439.59	3.75
	K30_31	421.89	439.33	434.08	3.09
	K30_32	429.27	451.75	444.42	6.1

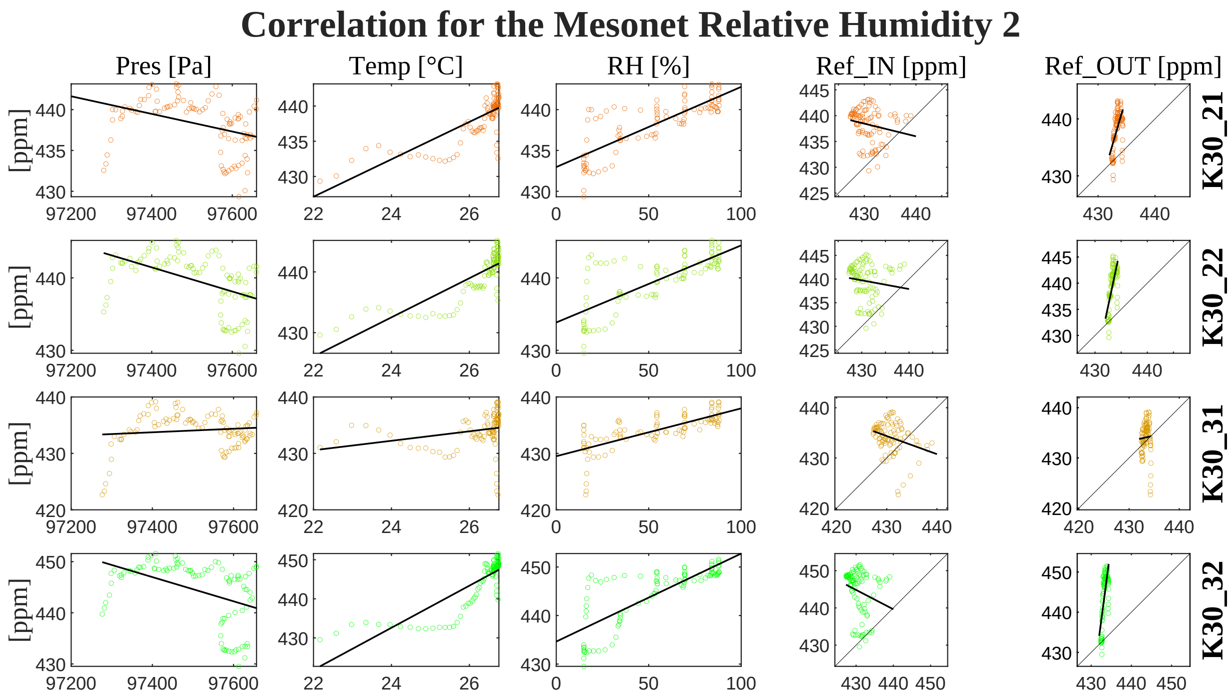

Figure 19. Scatter plots for the second Mesonet Relative Humidity run.

Table 17. Linear fit metrics for the second Mesonet Relative Humidity run.

Sensor	Predictor	Slope	Y-Intercept	R^2	RMSE
K30_21	Pressure	-0.01	1489.63	0.14	3.02
	Temperature	2.65	368.72	0.6	2.06
	Relative Humidity	0.1	432.97	0.65	1.92
	Ref_IN	-0.25	544.31	0.04	3.19
	Ref_OUT	3.42	-1043.98	0.35	2.62
K30_22	Pressure	-0.02	2062.65	0.25	3.24
	Temperature	3.22	355.25	0.67	2.16
	Relative Humidity	0.11	433.84	0.58	2.43
	Ref_IN	-0.18	519.04	0.02	3.71
	Ref_OUT	4.7	-1597.44	0.5	2.64
K30_31	Pressure	0	128.65	0.01	3.05
	Temperature	0.84	412.08	0.07	2.96
	Relative Humidity	0.08	429.5	0.55	2.07
	Ref_IN	-0.36	589.56	0.09	2.93
	Ref_OUT	0.23	335.68	0	3.07
K30_32	Pressure	-0.02	2753.61	0.19	5.48
	Temperature	5.39	303.33	0.7	3.32
	Relative Humidity	0.18	434.63	0.63	3.69
	Ref_IN	-0.52	668.32	0.05	5.95
	Ref_OUT	7.6	-2850.09	0.5	4.32

5 Mesonet Experiment 3

5.1 Temperature

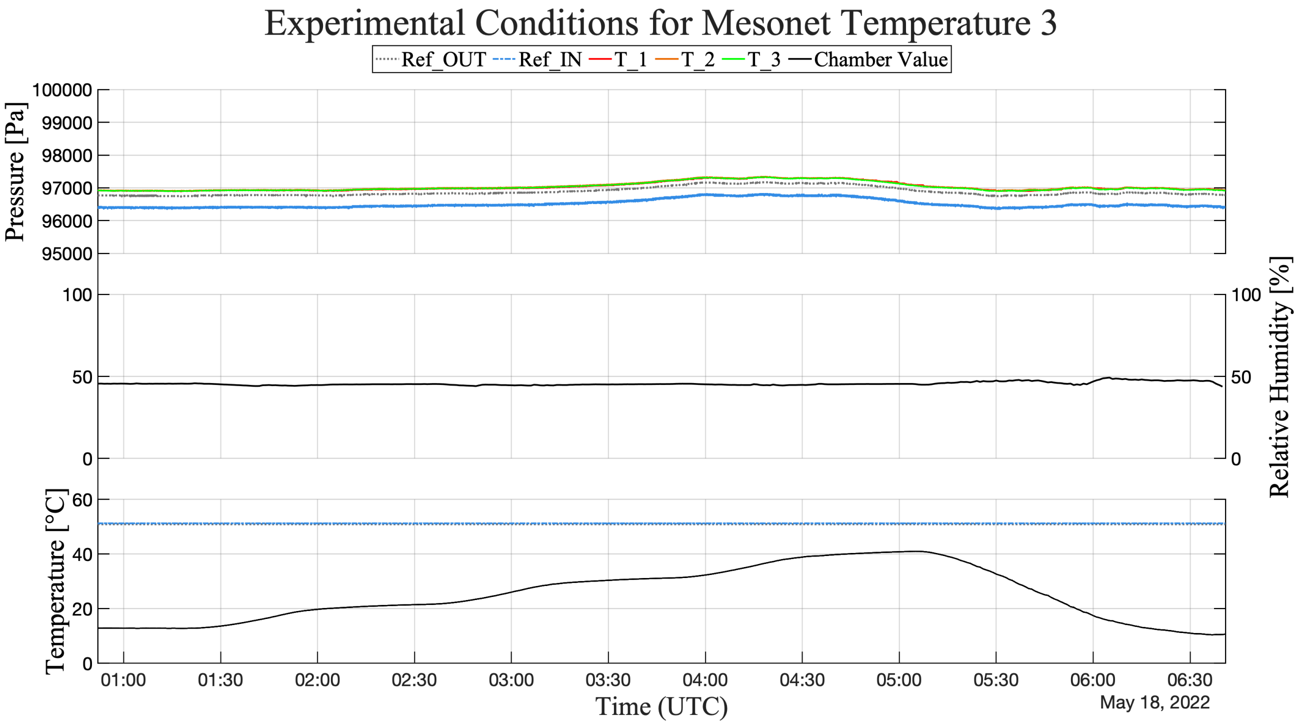

Figure 20. Experimental conditions during the third Mesonet Temperature run.

Table 18. Metrics for the experimental conditions during the third Mesonet Temperature run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
Pressure [Pa]	Ref_OUT	96730	97170	96886.92	133.07
	Ref_IN	96350	96820	96517.46	131.51
	T_1	96893.91	97325.16	97034.12	135.93
	T_2	96909.97	97343.58	97050.6	134.92
	T_3	96895.46	97326.49	97034.11	134.52
Temperature [°C]	Ref_OUT	50.91	50.91	50.91	0
	Ref_IN	51.17	51.28	51.23	0.01
	Chamber	10.44	40.98	-	-
Relative Humidity [%]	Chamber	43.78	49.27	45.56	1.05

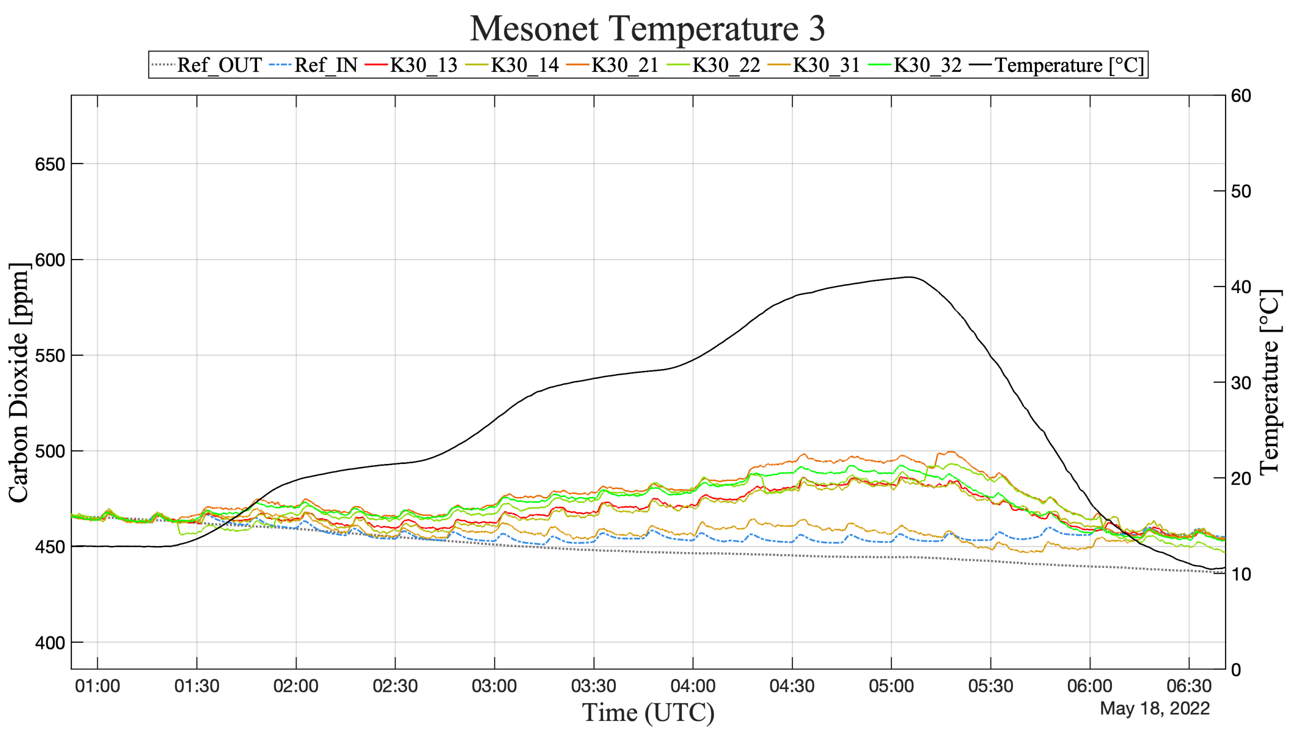

Figure 21. Results for the third Mesonet Temperature run.

Table 19. Carbon Dioxide metrics for the third Mesonet Temperature run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
CO_2 [ppm]	Ref_OUT	436.43	465.98	449.53	8.36
	Ref_IN	451.11	467.77	456.67	4.03
	K30_13	454.01	486.43	468.41	8.42
	K30_14	452.86	485.25	467.83	7.9
	K30_21	452.92	499.52	475.51	12.3
	K30_22	446.99	493.18	471.16	11.07
	K30_31	446.81	469.85	458.34	4.97
	K30_32	452.9	492.42	472.37	10.47

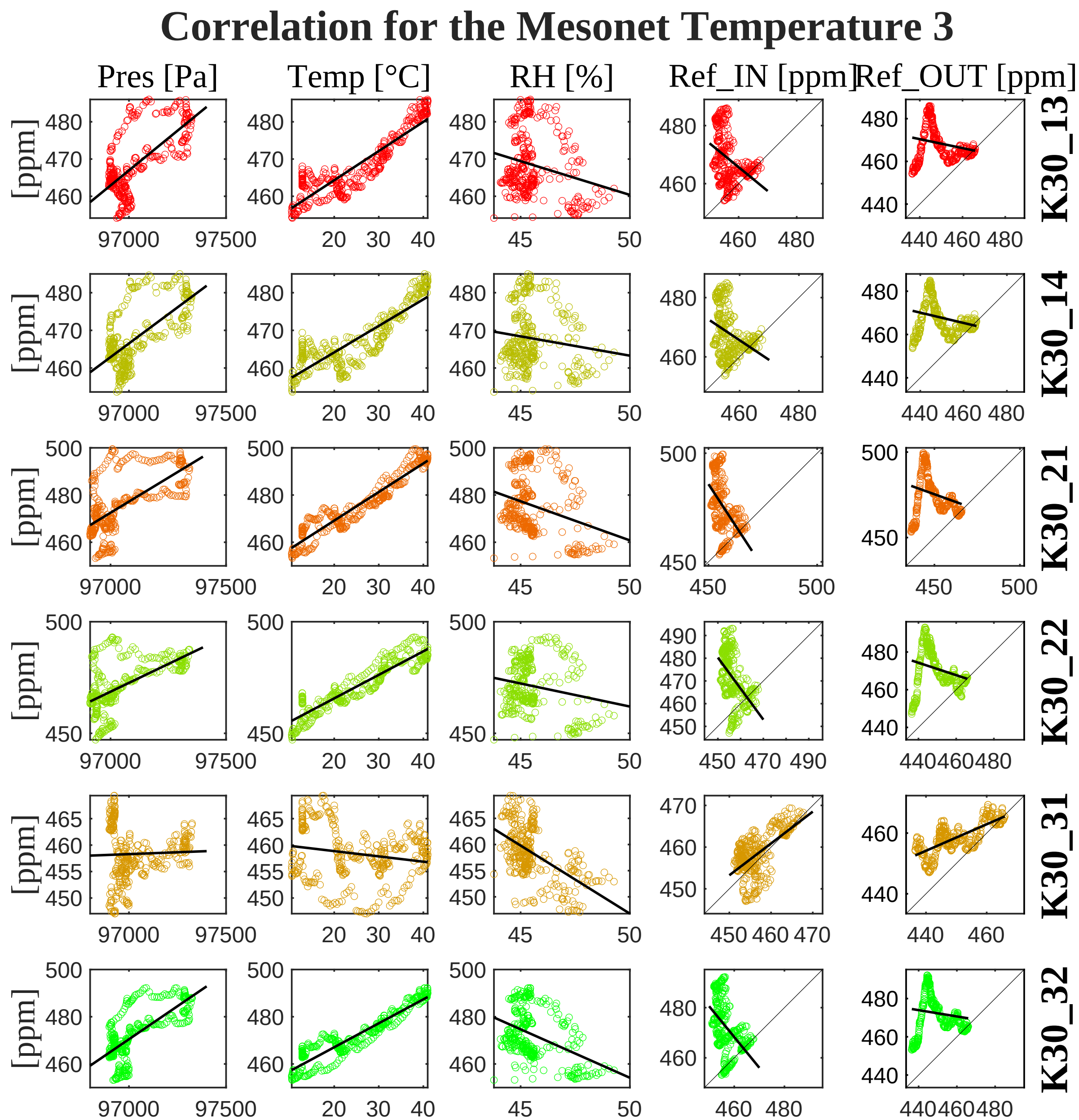

Figure 22. Scatter plots for the third Mesonet Temperature run.

Table 20. Linear fit metrics for the third Mesonet Temperature run.

Sensor	Predictor	Slope	Y-Intercept	R^2	RMSE
Ref_IN	Pressure	-0.02	2078.44	0.3	3.37
	Temperature	-0.3	464.16	0.51	2.81
	Relative Humidity	0.09	452.78	0	4.02
	Ref_OUT	0.32	313.36	0.44	3.01
K30_13	Pressure	0.04	-3669.06	0.47	6.1
	Temperature	0.78	448.64	0.81	3.64
	Relative Humidity	-1.81	550.89	0.05	8.2
	Ref_IN	-0.82	842.92	0.15	7.74
	Ref_OUT	-0.21	562.65	0.04	8.23
K30_14	Pressure	0.04	-3251.44	0.44	5.93
	Temperature	0.7	450.08	0.75	3.98
	Relative Humidity	-1.03	514.56	0.02	7.82
	Ref_IN	-0.67	772.65	0.12	7.42
	Ref_OUT	-0.24	574.91	0.06	7.64
K30_21	Pressure	0.06	-5286.77	0.42	9.33
	Temperature	1.21	444.97	0.91	3.71
	Relative Humidity	-3.32	626.54	0.08	11.8
	Ref_IN	-1.53	1175.94	0.25	10.64
	Ref_OUT	-0.36	637.62	0.06	11.92
K30_22	Pressure	0.05	-4347.35	0.37	8.81
	Temperature	1.05	444.56	0.85	4.25
	Relative Humidity	-2.07	565.27	0.04	10.85
	Ref_IN	-1.37	1094.61	0.25	9.6
	Ref_OUT	-0.33	619.19	0.06	10.72
K30_31	Pressure	0	321.94	0	4.96
	Temperature	-0.1	460.86	0.04	4.87
	Relative Humidity	-2.6	576.97	0.3	4.15
	Ref_IN	0.76	109.91	0.38	3.9
	Ref_OUT	0.44	262.08	0.54	3.36
K30_32	Pressure	0.06	-4964.63	0.52	7.27
	Temperature	1.01	446.77	0.88	3.59
	Relative Humidity	-4.11	659.47	0.17	9.55
	Ref_IN	-1.23	1032.26	0.22	9.24
	Ref_OUT	-0.16	546.35	0.02	10.38

5.2 Relative Humidity

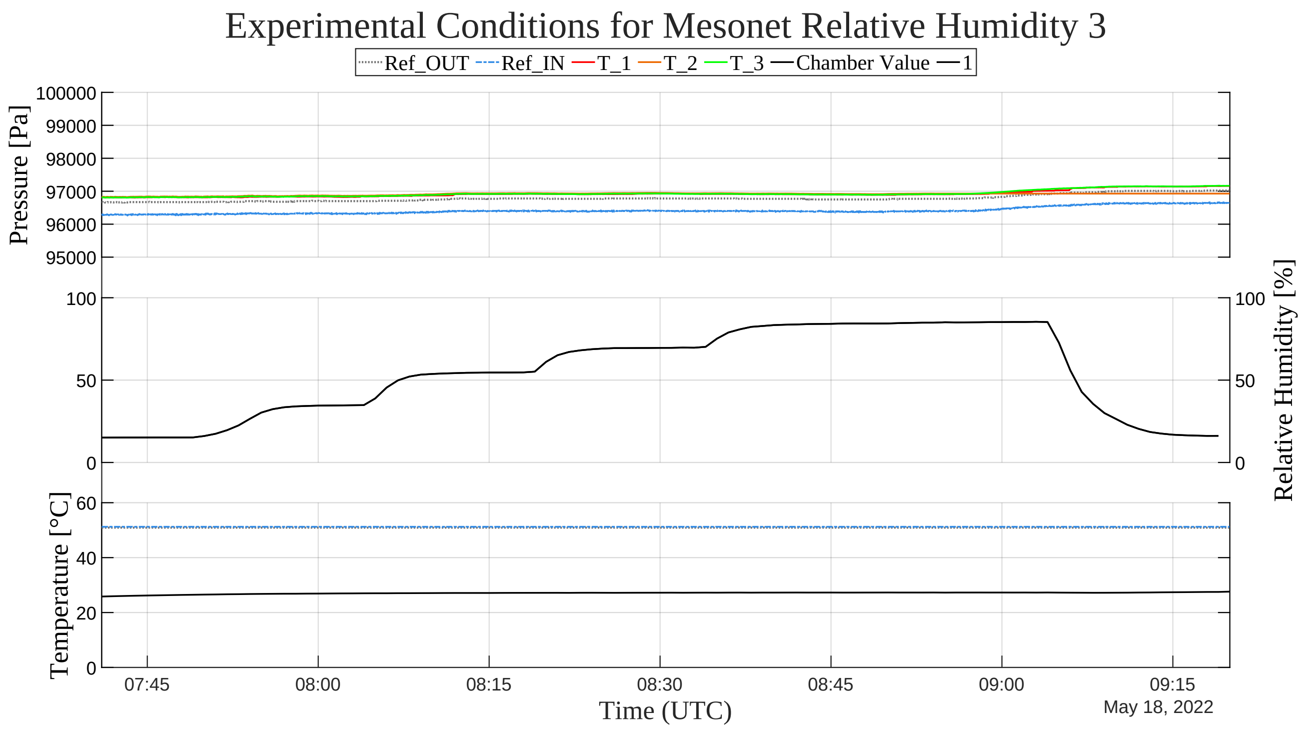

Figure 23. Experimental conditions during the third Mesonet Relative Humidity run.

Table 21. Metrics for the experimental conditions during the third Mesonet Relative Humidity run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
Pressure [Pa]	Ref_OUT	96660	97020	96787.52	101.93
	Ref_IN	96250	96680	96413.49	103.39
	T_1	96805.94	97161.59	96924.18	98.27
	T_2	96821.58	96951.79	96908.85	36.22
	T_3	96803.85	97169.14	96932.27	100.46
Temperature [°C]	Ref_OUT	50.91	50.91	50.91	0
	Ref_IN	51.17	51.28	51.23	0.01
	Chamber	25.83	27.61	27.08	0.33
Relative Humidity [%]	Chamber	15.1	85.4	-	-

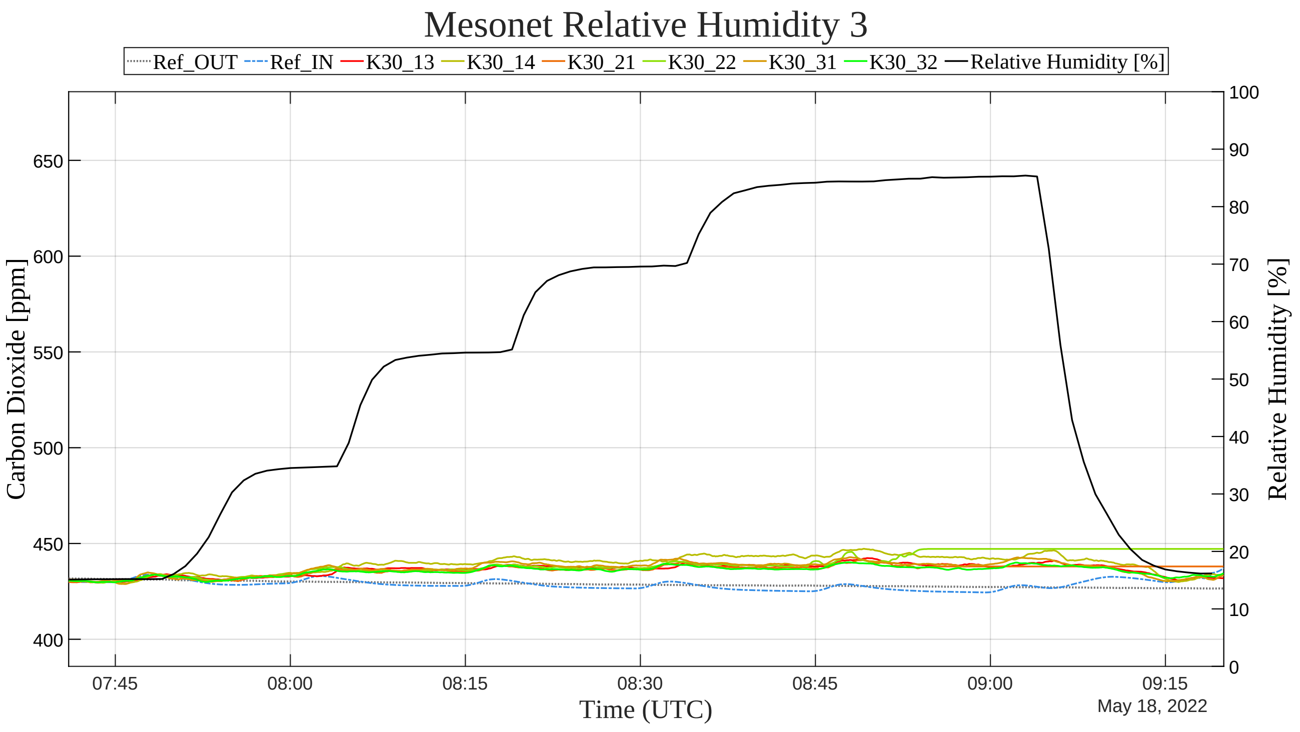

Figure 24. Results for the third Mesonet Relative Humidity run.

Table 22. Carbon Dioxide metrics for the third Mesonet Relative Humidity run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
CO_2 [ppm]	Ref_OUT	426.49	431.72	428.72	1.45
	Ref_IN	424.45	437.28	428.66	2.46
	K30_13	429.9	442.38	436.38	3.13
	K30_14	429.07	447.24	439.24	4.75
	K30_21	429.52	441.41	436.28	2.66
	K30_22	429.48	447.17	439.36	5.56
	K30_31	428.83	442.83	436.88	3.59
	K30_32	429.72	440.2	435.62	2.63

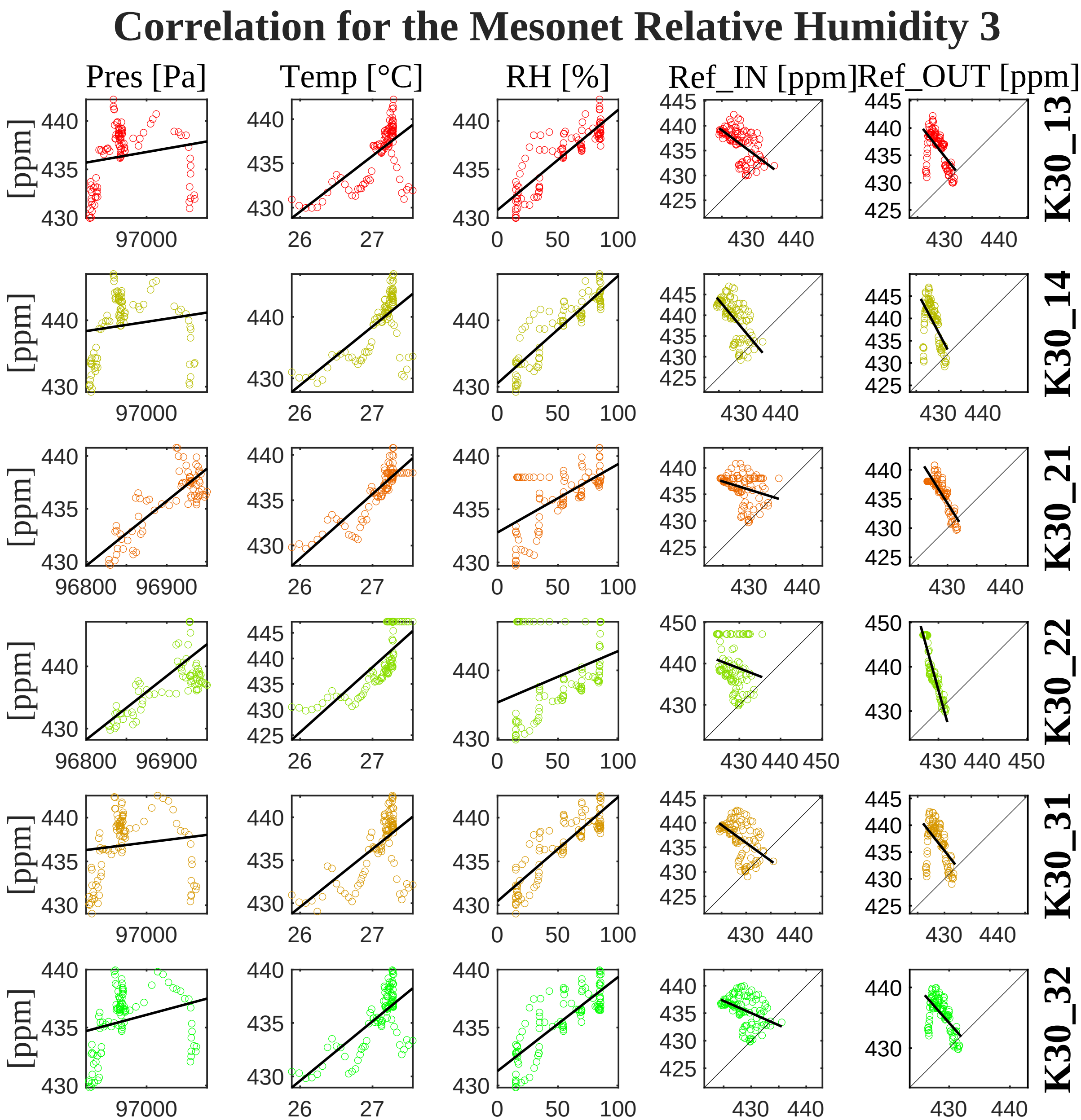

Figure 25. Scatter plots for the third Mesonet Relative Humidity run.

Table 23. Linear fit metrics for the third Mesonet Relative Humidity run.

Sensor	Predictor	Slope	Y-Intercept	R^2	RMSE
K30_13	Pressure	0.01	-92.64	0.03	3.08
	Temperature	6.31	265.53	0.45	2.33
	Relative Humidity	0.1	430.8	0.75	1.55
	Ref_IN	-0.75	756.54	0.34	2.53
	Ref_OUT	-1.27	981.63	0.35	2.52
K30_14	Pressure	0.01	-236.3	0.02	4.68
	Temperature	9.54	180.9	0.44	3.53
	Relative Humidity	0.16	430.51	0.8	2.1
	Ref_IN	-1.2	955.06	0.39	3.71
	Ref_OUT	-1.89	1249.99	0.33	3.86
K30_21	Pressure	0.06	-5512.96	0.7	1.45
	Temperature	7.11	243.81	0.79	1.23
	Relative Humidity	0.06	432.81	0.41	2.04
	Ref_IN	-0.31	569.21	0.08	2.54
	Ref_OUT	-1.59	1117.18	0.75	1.32
K30_22	Pressure	0.1	-9486.42	0.45	4.13
	Temperature	12.72	94.92	0.57	3.62
	Relative Humidity	0.08	435.27	0.13	5.18
	Ref_IN	-0.39	604.51	0.03	5.46
	Ref_OUT	-3.61	1988.63	0.89	1.84
K30_31	Pressure	0	18.48	0.01	3.55
	Temperature	6.75	254.08	0.39	2.8
	Relative Humidity	0.12	430.45	0.76	1.75
	Ref_IN	-0.73	748.53	0.25	3.11
	Ref_OUT	-1.28	983.93	0.27	3.06
K30_32	Pressure	0.01	-242.33	0.07	2.52
	Temperature	5.56	285.04	0.49	1.86
	Relative Humidity	0.08	431.25	0.66	1.52
	Ref_IN	-0.44	624.66	0.17	2.38
	Ref_OUT	-1.14	923.1	0.4	2.03

5.3 Reference Sensors

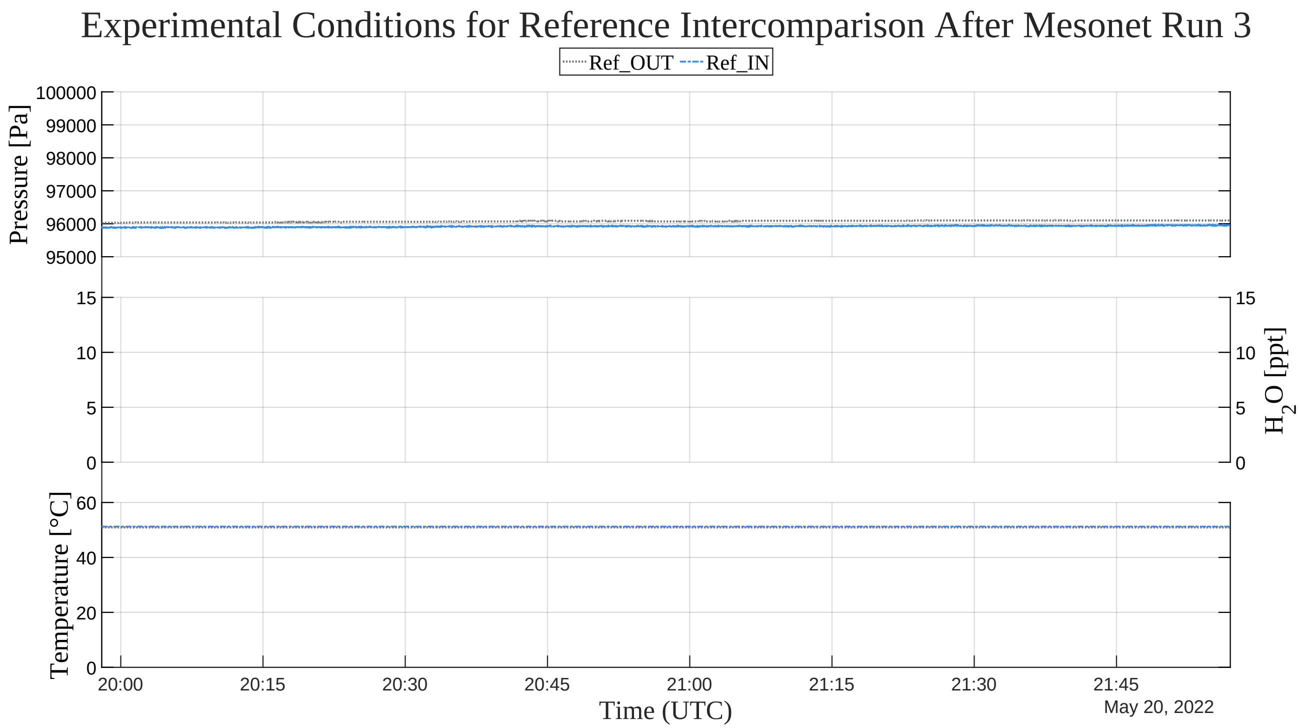

Figure 26. Experimental conditions for the intercomparison after third Mesonet experiments.

Table 24. Metrics for the experimental conditions for the intercomparison after third Mesonet experiments.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
Pressure [Pa]	Ref_OUT	96030	96120	96075.97	22.5
	Ref_IN	95850	95980	95921.67	24.51
Temperature [°C]	Ref_OUT	50.91	50.91	50.91	0
	Ref_IN	51.17	51.25	51.23	0.01
H_2O [ppt]	Ref_IN	18.03	20.88	18.87	0.61

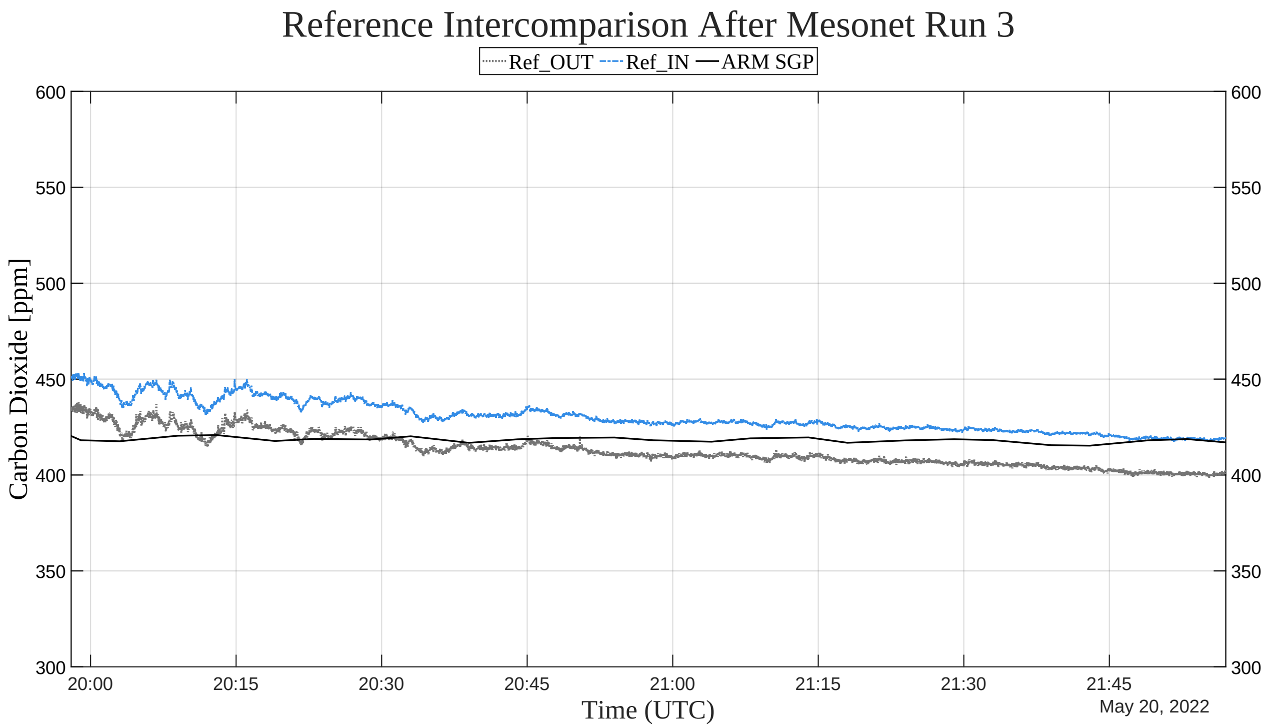

Figure 27. Results for the intercomparison after the third Mesonet experiment. At this date, the two reference presented a constant 17.24 ppm offset. After correcting this offset, the RMSE was $1.12 * 10^{-14}$ ppm.

Table 25. Metrics for the intercomparison after the third Mesonet experiments.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
	Ref_OUT	398.62	437.86	413.05	8.74
CO_2 [ppm]	Ref_IN	417.4	453.29	430.29	8.27
	ARM SGP	415.3	420.81	418.31	1.15

6 Benchtop Experiments 1

6.1 Temperature

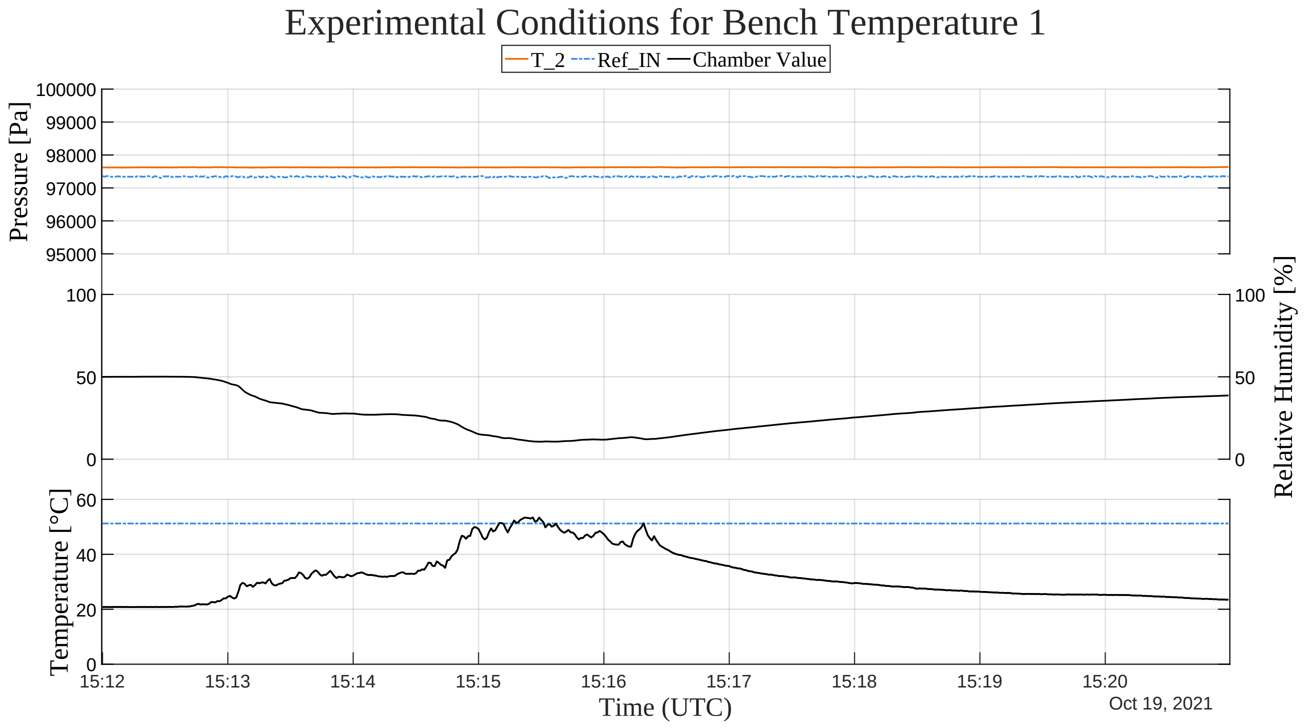

Figure 28. Experimental conditions during the first Bench Temperature run.

Table 26. Metrics for the experimental conditions during the first Bench Temperature run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
Pressure [Pa]	Ref_IN	97300	97370	97342.1	13.57
	T_2	97617.75	97634.8	97626.68	2.82
Temperature [°C]	Ref_IN	51.17	51.25	51.23	0.01
	T_2	20.75	53.41	-	-
Relative Humidity [%]	T_2	10.62	50.09	28.31	11.43

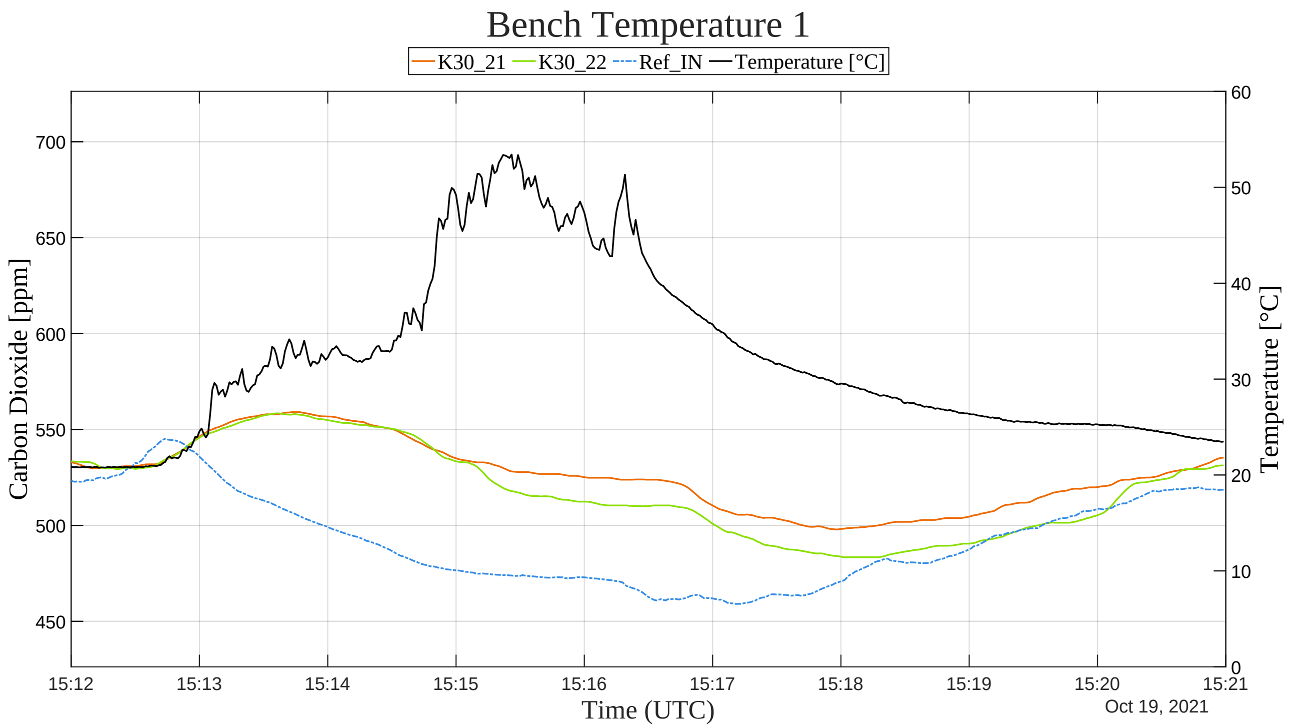

Figure 29. Results for the first Bench Temperature run.

Table 27. Carbon Dioxide metrics for the first Bench Temperature run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
	Ref_IN	459.04	545.15	492.49	23.76
CO_2 [ppm]	K30_21	497.84	559.03	525.9	17.94
	K30_22	483.39	558.39	518.05	23.47

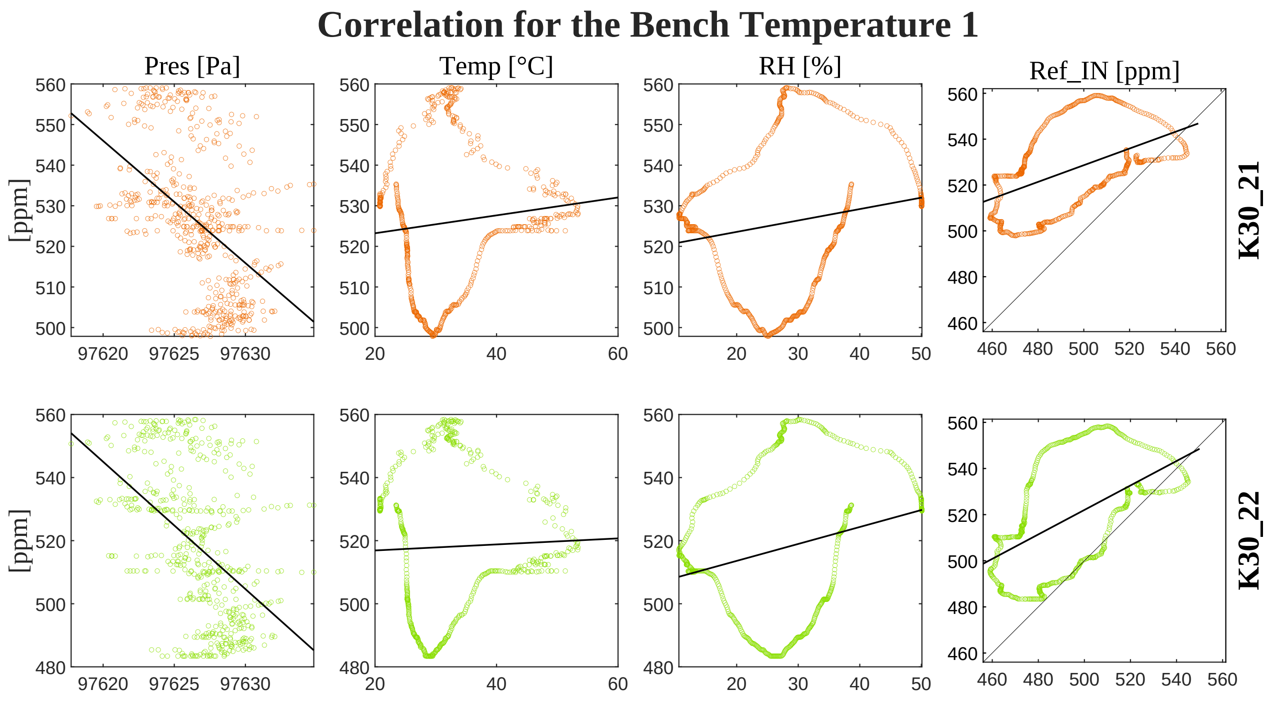

Figure 30. Scatter plots for the first Bench Temperature run.

Table 28. Linear fit metrics for the first Bench Temperature run.

Sensor	Predictor	Slope	Y-Intercept	R^2	RMSE
K30_21	Pressure	-3.01	294698.42	0.22	15.79
	Temperature	0.22	518.82	0.01	17.82
	Relative Humidity	0.28	517.94	0.03	17.63
	Ref_IN	0.36	346.62	0.23	15.7
K30_22	Pressure	-4.04	394541.7	0.23	20.51
	Temperature	0.1	514.98	0	23.43
	Relative Humidity	0.54	502.84	0.07	22.63
	Ref_IN	0.53	256.9	0.29	19.78

6.2 Relative Humidity

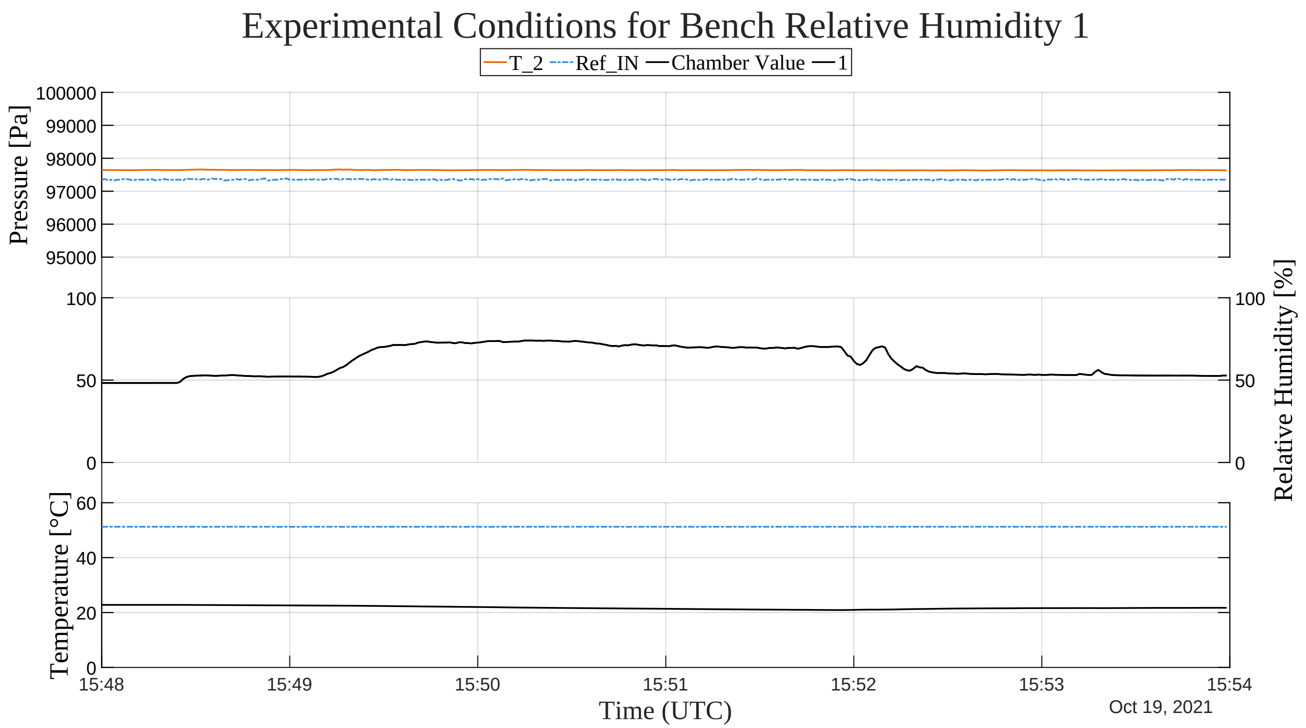

Figure 31. Experimental conditions during the first Bench Relative Humidity run.

Table 29. Metrics for the experimental conditions during the first Bench Relative Humidity run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
Pressure [Pa]	Ref_IN	97320	97390	97353	13.16
	T_2	97627.66	97659.9	97640.33	5.71
Temperature [°C]	Ref_IN	51.17	51.25	51.23	0.01
	T_2	20.9	22.79	21.81	0.58
Relative Humidity [%]	T_2	48.27	74.04	-	-

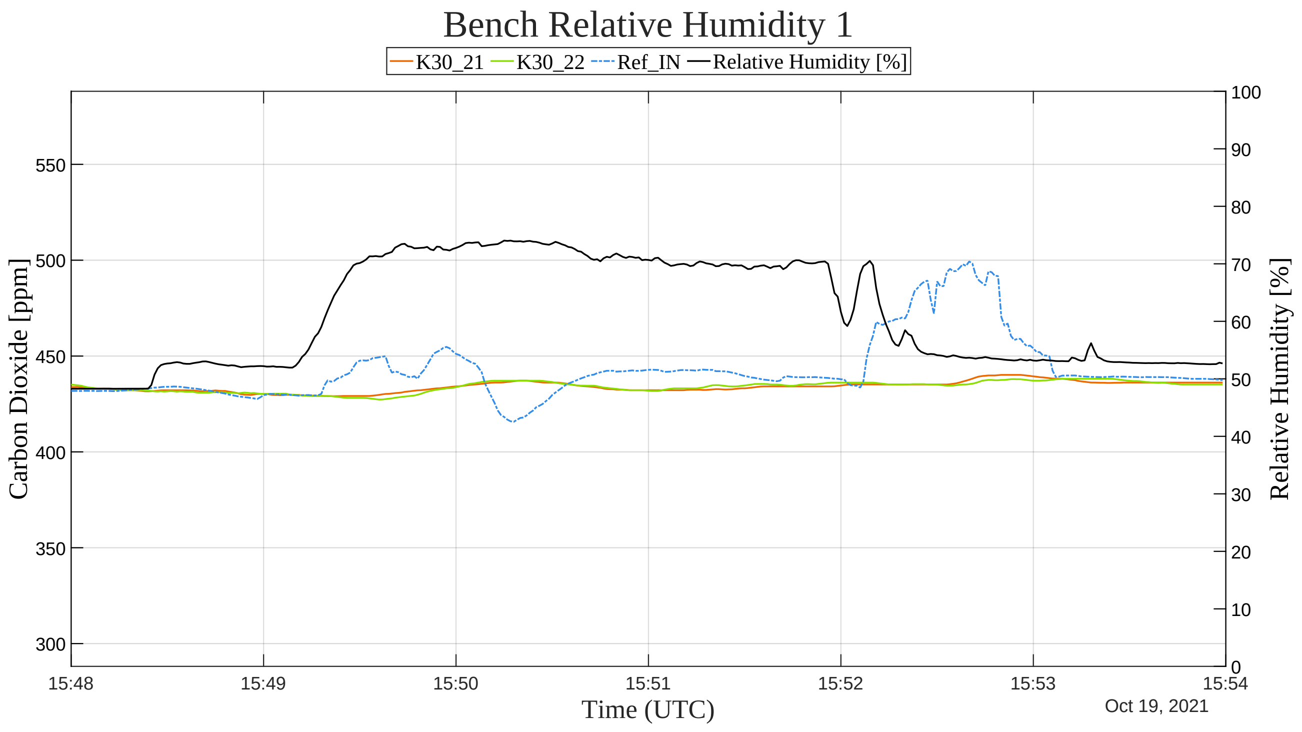

Figure 32. Results for the first Bench Relative Humidity run.

Table 30. Carbon Dioxide metrics for the first Bench Relative Humidity run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
	Ref_IN	415.71	499.36	443.18	16.68
CO_2 [ppm]	K30_21	429.07	440.17	434	2.74
	K30_22	427.3	438.15	433.97	2.85

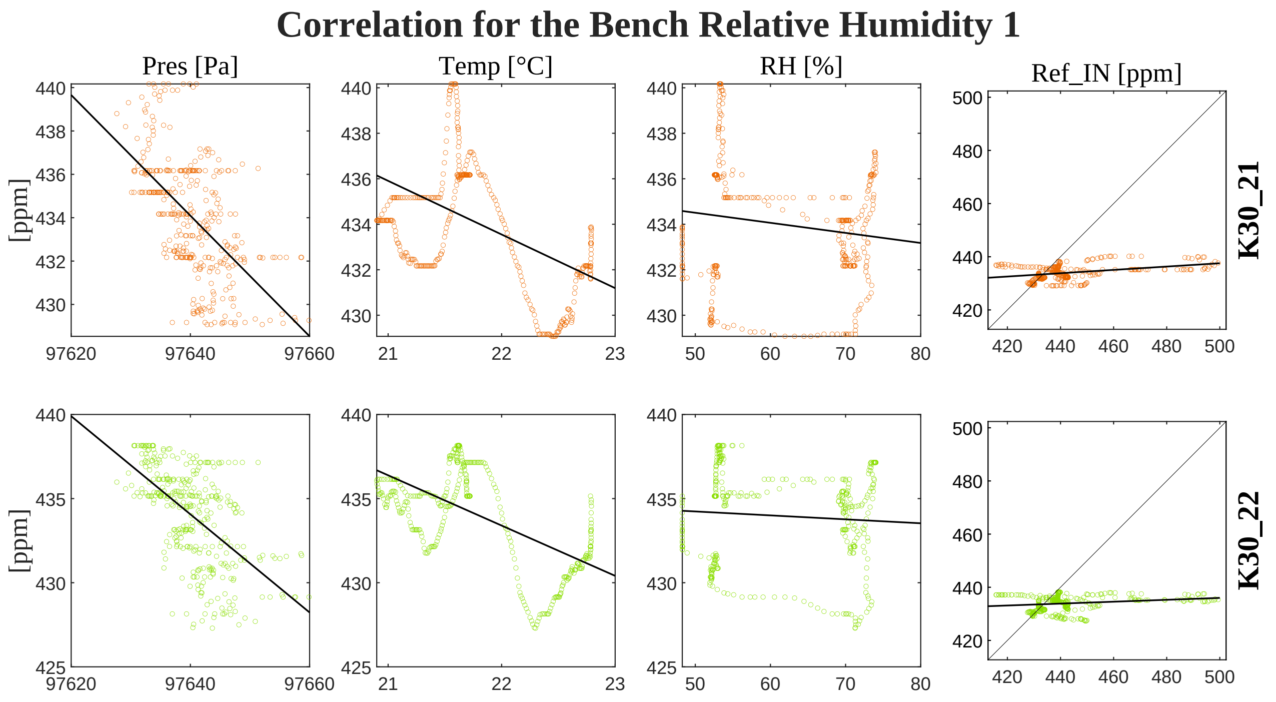

Figure 33. Scatter plots for the first Bench Relative Humidity run.

Table 31. Linear fit metrics for the first Bench Relative Humidity run.

Sensor	Predictor	Slope	Y-Intercept	R^2	RMSE
K30_21	Pressure	-0.28	27598.92	0.34	2.23
	Temperature	-2.36	485.44	0.25	2.37
	Relative Humidity	-0.04	436.72	0.02	2.71
	Ref_IN	0.06	406.28	0.14	2.54
K30_22	Pressure	-0.29	28917.54	0.34	2.31
	Temperature	-2.99	499.14	0.37	2.26
	Relative Humidity	-0.02	435.4	0.01	2.84
	Ref_IN	0.04	418.13	0.04	2.79

7 Benchtop Experiments 2

7.1 Temperature

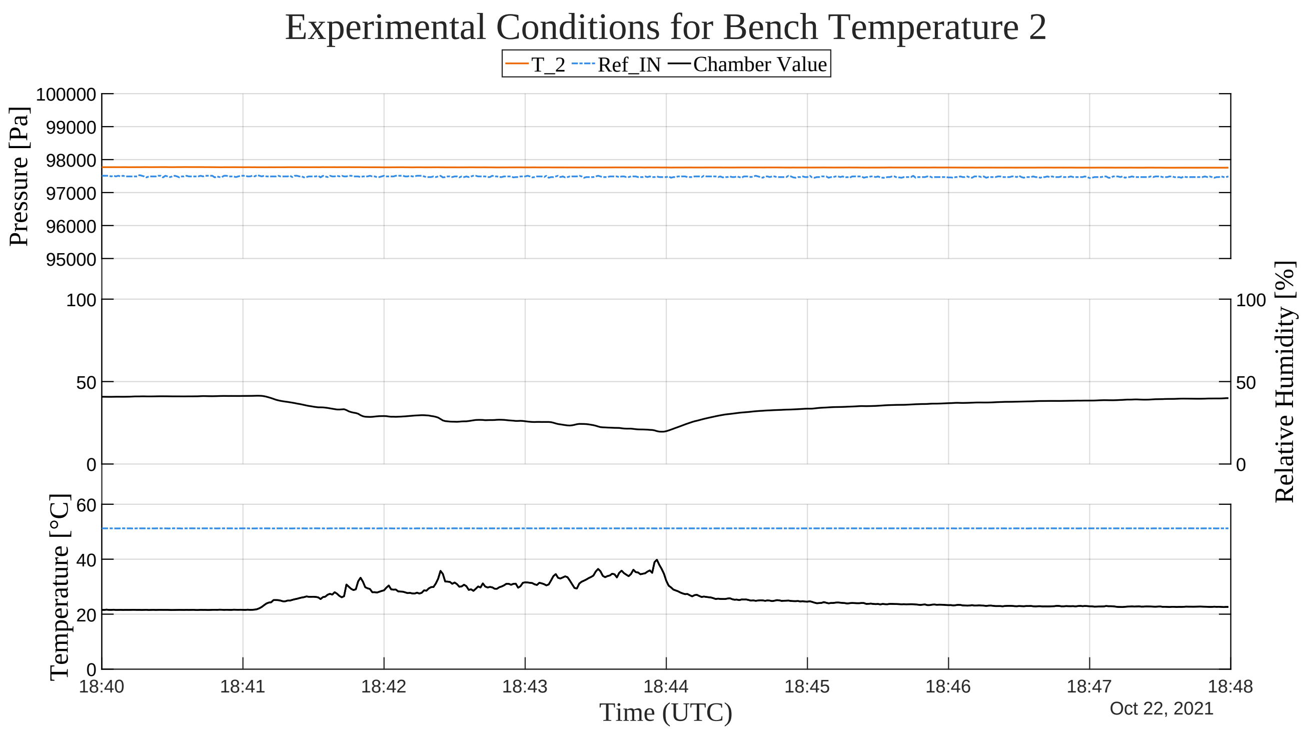

Figure 34. Experimental conditions during the second Bench Temperature run.

Table 32. Metrics for the experimental conditions during the second Bench Temperature run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
Pressure [Pa]	Ref_IN	97440	97530	97482.13	16.39
	T_2	97754.06	97773.67	97762.57	5.1
Temperature [°C]	Ref_IN	51.17	51.25	51.23	0.01
	T_2	21.51	39.81	-	-
Relative Humidity [%]	T_2	19.61	41.42	33.56	6.33

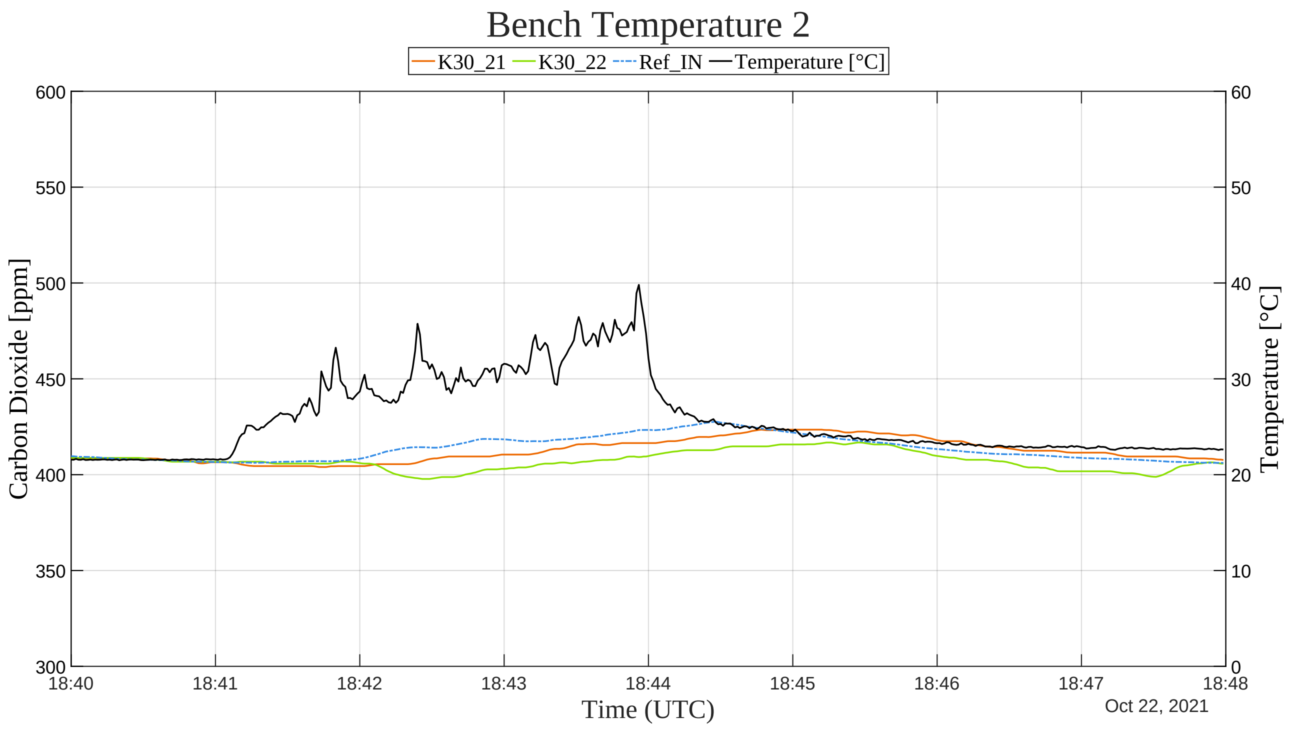

Figure 35. Results for the second Bench Temperature run.

Table 33. Carbon Dioxide metrics for the second Bench Temperature run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
	Ref_IN	406.13	427.64	413.68	6.41
CO_2 [ppm]	K30_21	403.99	423.49	412.55	6.05
	K30_22	397.77	416.77	407.28	4.96

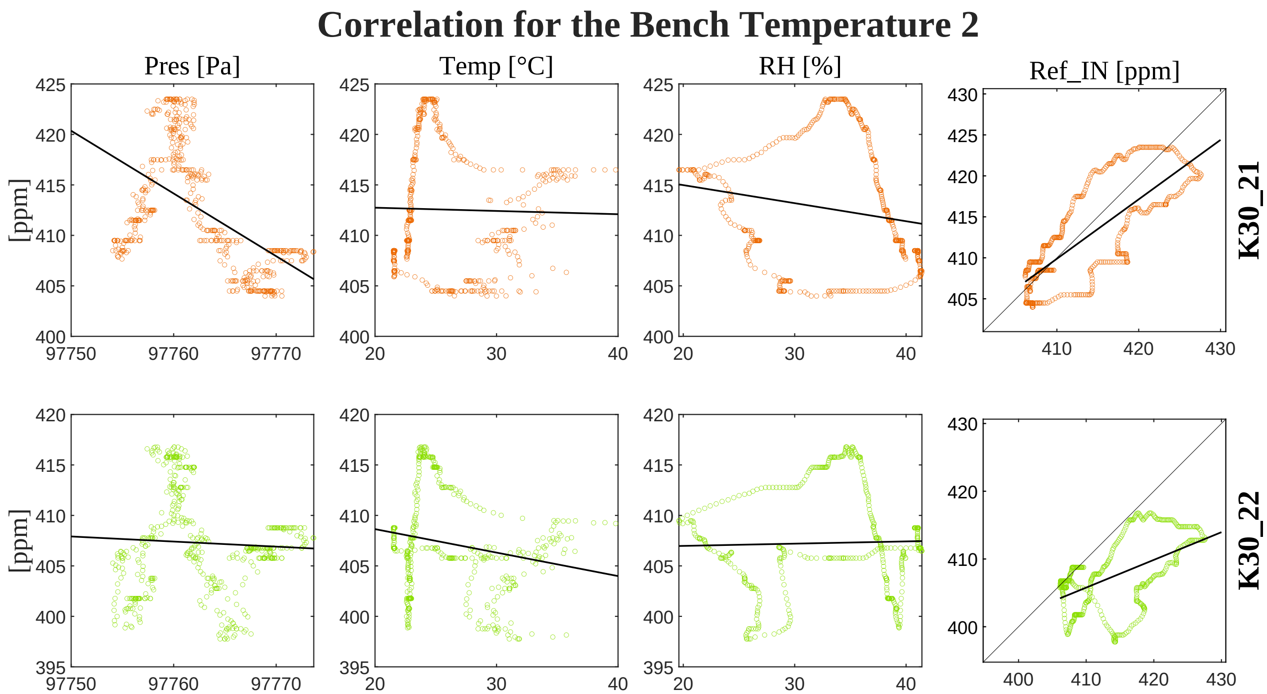

Figure 36. Scatter plots for the second Bench Temperature run.

Table 34. Linear fit metrics for the second Bench Temperature run.

Sensor	Predictor	Slope	Y-Intercept	R^2	RMSE
K30_21	Pressure	-0.62	61137.65	0.27	5.15
	Temperature	-0.03	413.39	0	6.04
	Relative Humidity	-0.18	418.56	0.04	5.94
	Ref_IN	0.73	112.51	0.59	3.87
K30_22	Pressure	-0.05	5327.96	0	4.95
	Temperature	-0.23	413.29	0.04	4.86
	Relative Humidity	0.02	406.54	0	4.96
	Ref_IN	0.41	238.09	0.28	4.21

7.2 Relative Humidity

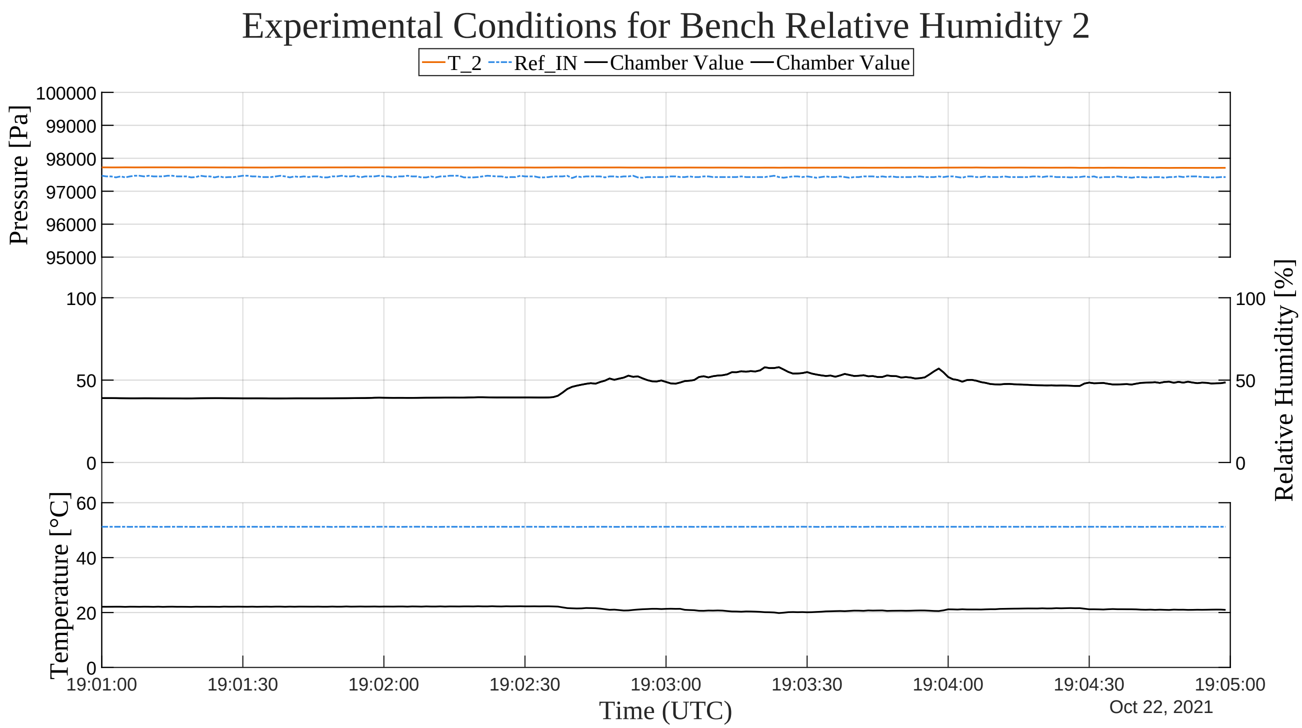

Figure 37. Experimental conditions during the second Bench Relative Humidity run.

Table 35. Metrics for the experimental conditions during the second Bench Relative Humidity run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
Pressure [Pa]	Ref_IN	97400	97470	97439.71	15.51
	T_2	97707.94	97724.89	97717.96	4.32
Temperature [°C]	Ref_IN	51.17	51.25	51.22	0.01
	T_2	19.8	22.3	21.44	0.69
Relative Humidity [%]	T_2	38.9	57.85	45.78	5.99

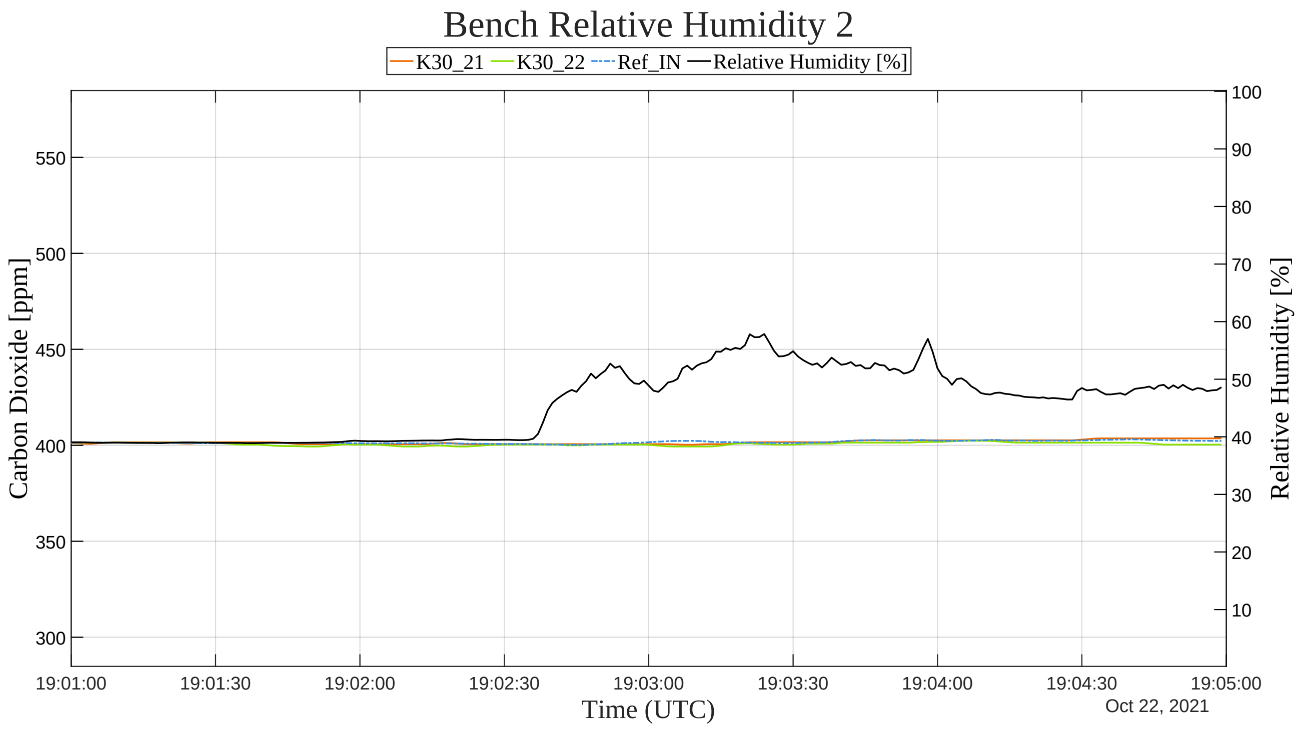

Figure 38. Results for the second Bench Relative Humidity run.

Table 36. Carbon Dioxide metrics for the second Bench Relative Humidity run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
	Ref_IN	400.31	403.6	401.63	1.04
CO_2 [ppm]	K30_21	399.36	402.36	400.68	0.79
	K30_22	400.24	403.09	401.65	0.75

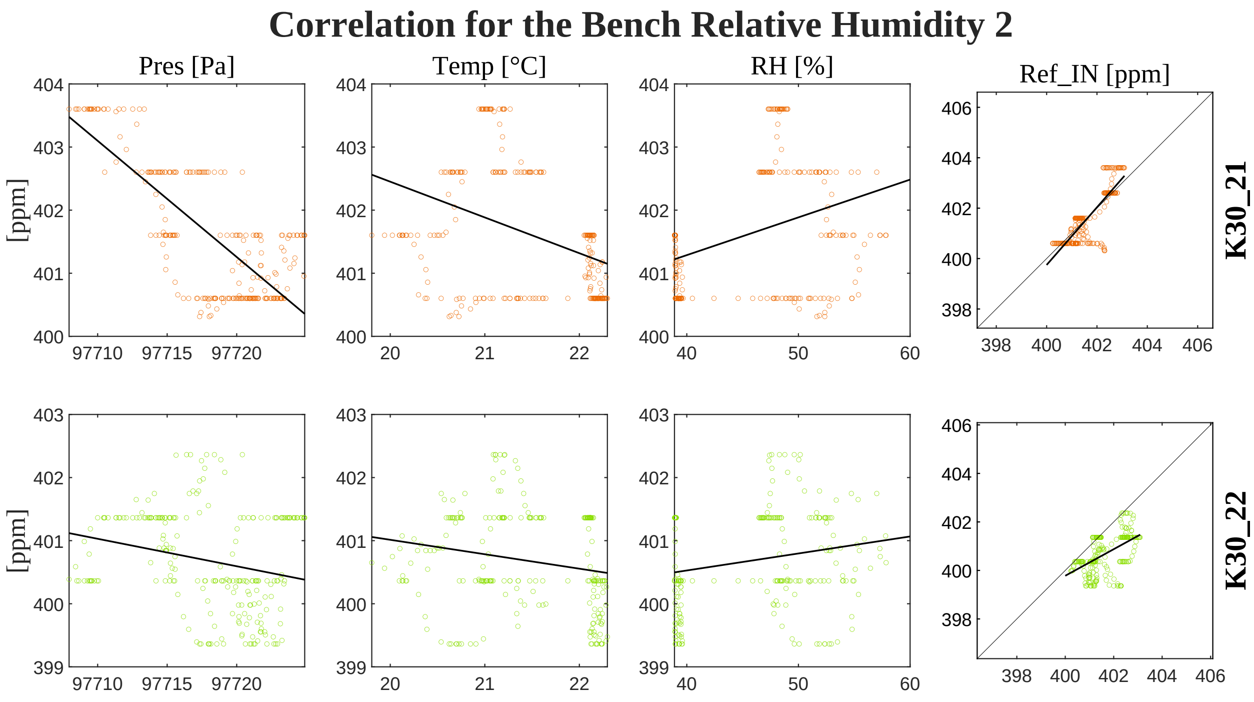

Figure 39. Scatter plots for the second Bench Relative Humidity run.

Table 37. Linear fit metrics for the second Bench Relative Humidity run.

Sensor	Predictor	Slope	Y-Intercept	R^2	RMSE
K30_21	Pressure	-0.18	18403.68	0.59	0.67
	Temperature	-0.57	413.78	0.14	0.96
	Relative Humidity	0.06	398.89	0.12	0.97
	Ref_IN	1.14	-57.65	0.68	0.59
K30_22	Pressure	-0.04	4655.61	0.06	0.76
	Temperature	-0.23	405.59	0.04	0.77
	Relative Humidity	0.03	399.45	0.04	0.77
	Ref_IN	0.55	180.63	0.27	0.67

8 Benchtop Experiments 3

8.1 Relative Humidity

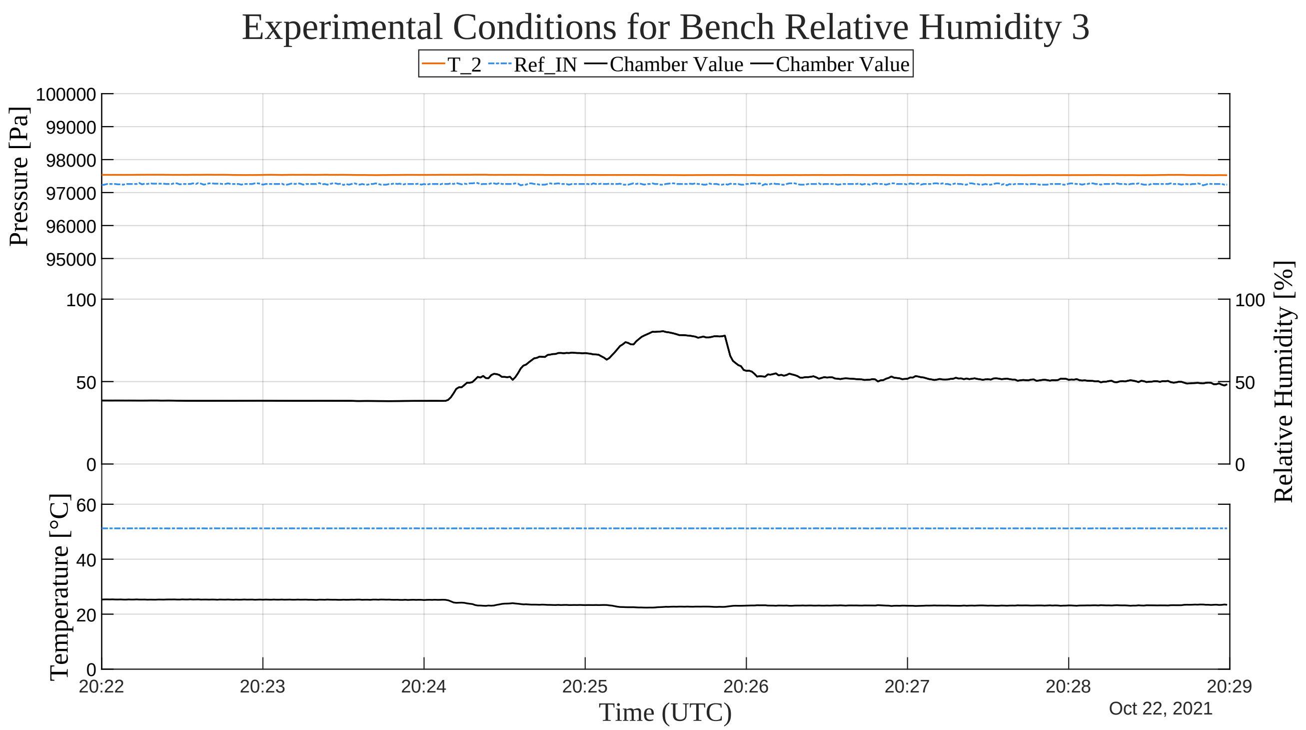

Figure 40. Experimental conditions during the third Bench Relative Humidity run.

Table 38. Metrics for the experimental conditions during the third Bench Relative Humidity run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
Pressure [Pa]	Ref_IN	97220	97290	97259.79	13.42
	T_2	97526.79	97542.3	97533.86	3.63
Temperature [°C]	Ref_IN	51.17	51.25	51.23	0.01
	T_2	22.38	25.39	23.82	1.02
Relative Humidity [%]	T_2	38.16	80.56	-	-

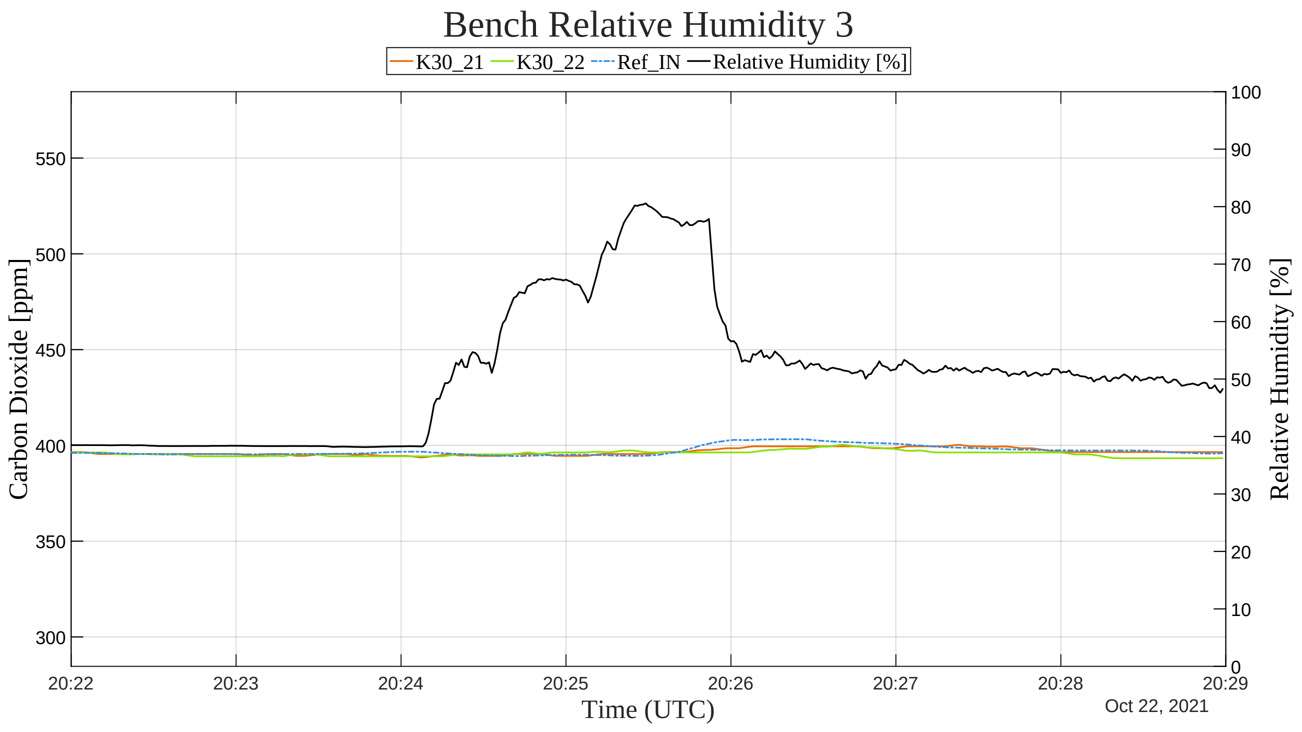

Figure 41. Results for the third Bench Relative Humidity run.

Table 39. Carbon Dioxide metrics for the third Bench Relative Humidity run.

Variable	Sensor	Minimum	Maximum	Average	Standard deviation
	Ref_IN	394.42	403.21	397.29	2.59
CO_2 [ppm]	K30_21	393.69	400.28	396.63	1.79
	K30_22	393.31	400.31	395.75	1.55

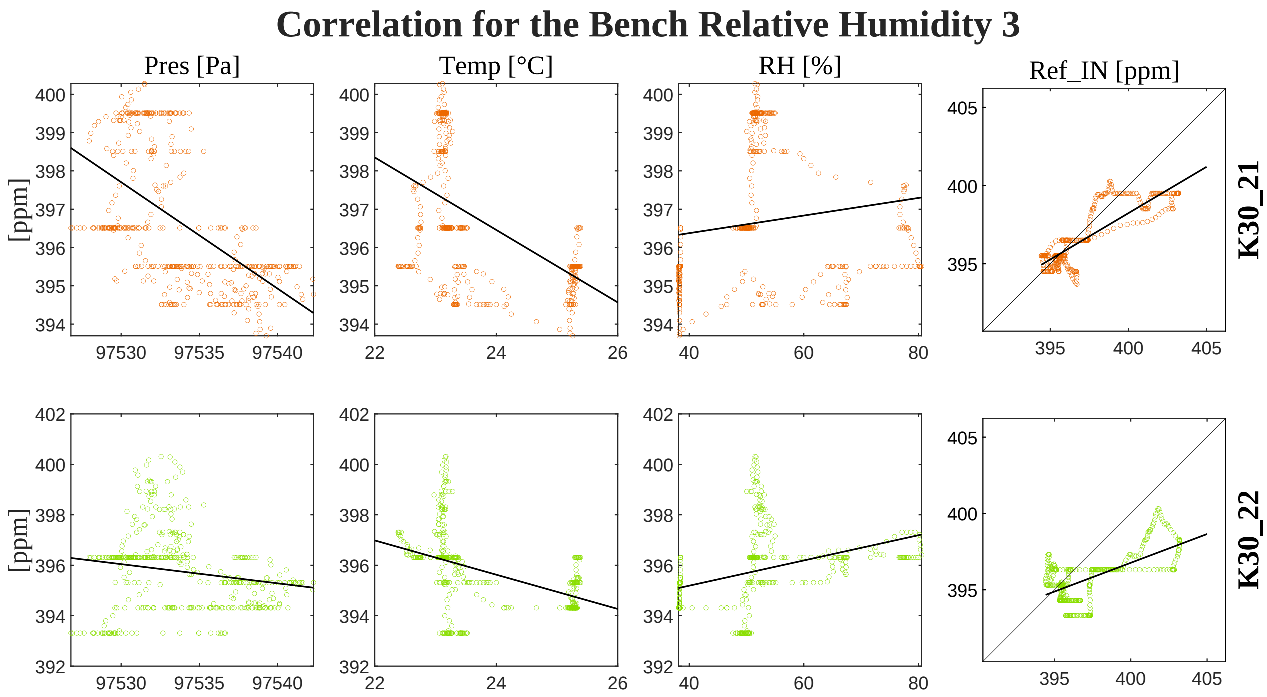

Figure 42. Scatter plots for the third Bench Relative Humidity run.

Table 40. Linear fit metrics for the third Bench Relative Humidity run.

Sensor	Predictor	Slope	Y-Intercept	R^2	RMSE
K30_21	Pressure	-0.28	27483.54	0.32	1.48
	Temperature	-0.95	419.17	0.29	1.51
	Relative Humidity	0.02	395.46	0.02	1.77
	Ref_IN	0.59	161.25	0.73	0.92
K30_22	Pressure	-0.08	7801.26	0.03	1.52
	Temperature	-0.68	411.93	0.2	1.39
	Relative Humidity	0.05	393.19	0.15	1.43
	Ref_IN	0.38	246.1	0.4	1.2

9 Ideal Pressure Time Response

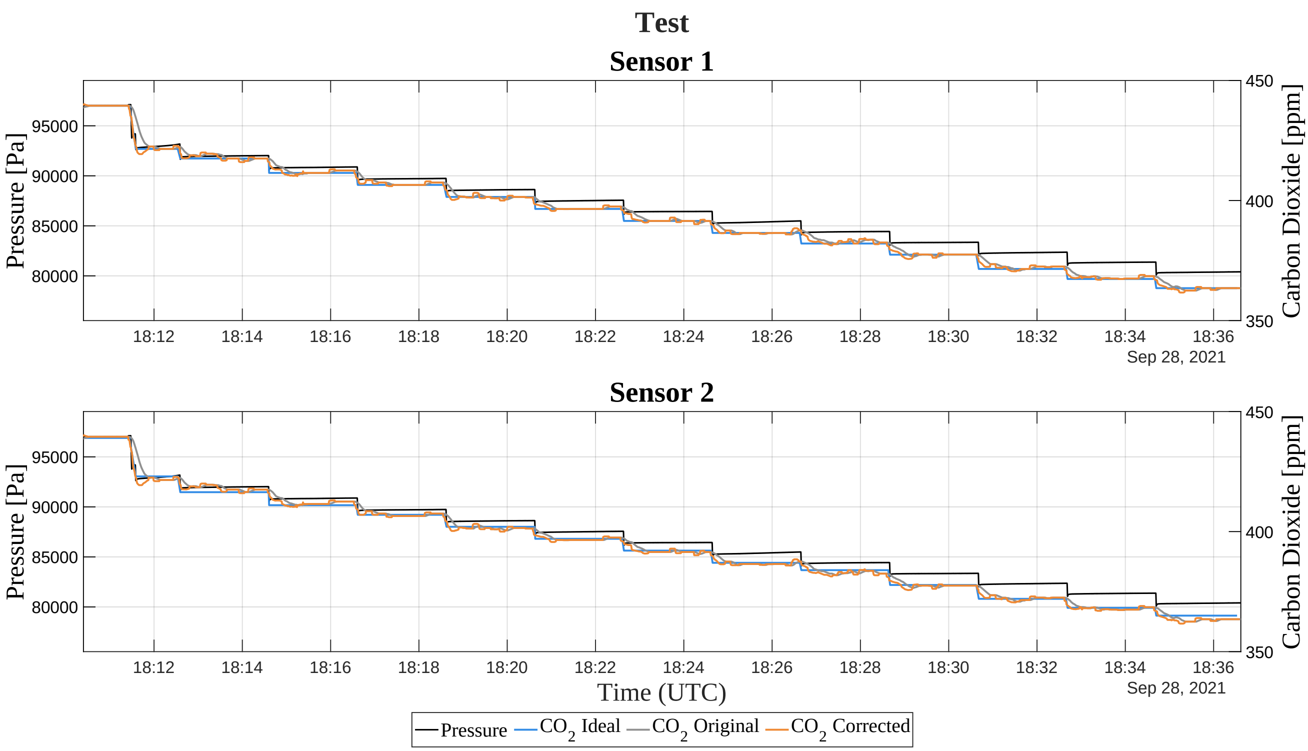

Figure 43. Example of idealized signal for pressure time-response correction. It is important to note that the referred idealized signal is an artificial signal with the pressure error but without the pressure time-response error. Therefore, ideal means the ideal impact of pressure (without pressure time-response error). It serves only as an evaluator of the pressure time-response algorithms. It should not be used for any pressure correction algorithms. The ideal signal was generated using the timestamps of the pressure step changes and the CO_2 values of the K30 after stabilization, after the step change.

10 Temperature Li-820 (Ref_OUT)

In all experimental condition tables in this document, the reported temperature for the optical chamber of the Li-820 (a.k.a. Ref_OUT) is 50.91 degrees Celsius with its standard deviation equal to zero. This may appear to be a manuscript preparation error (e.g., a copy and paste error), but it is not. To investigate the matter we first evaluated if our dataset ever showed any temperature different than 50.91 for this sensor. At beginning of all experiments our loggers recorded the warm-up ramp of this sensor with temperatures below 50.91 (as can be seen in figures 44 and 45). However, after this warm-up period the sensor does not report a value different than 50.91. Analyzing the temperatures reported by the Li-840A (a.k.a. Ref_IN), the largest deviation reported by this sensor for all experiments was 0.02 degrees Celsius. Therefore it is possible that the analog to digital converter (ADC) in the Li-820 is not capable of detecting these small fluctuations. Another contributing factor to the standard deviation equal to zero, is our data trimming strategy. We only calculates the deviation for the test periods. At the beginning of each test period, the Li-820's heater has had at least one hour to stabilize temperature of the sensor's optical chamber. At this point we do not have any reason to believe any malfunction on the sensor.

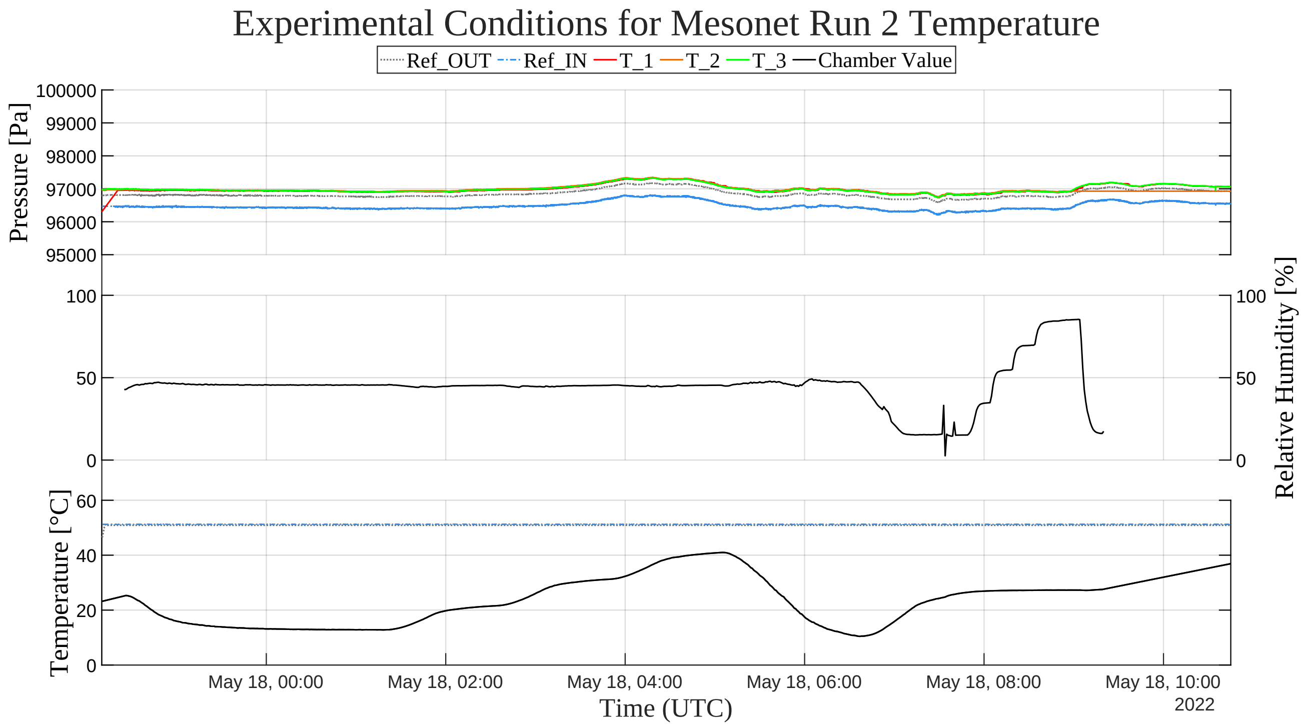

Figure 44. Complete data series for the experimental conditions of the second run of the Mesonet Temperature and Relative humidity experiments showing temperatures lower than 50.91 for a minutes.

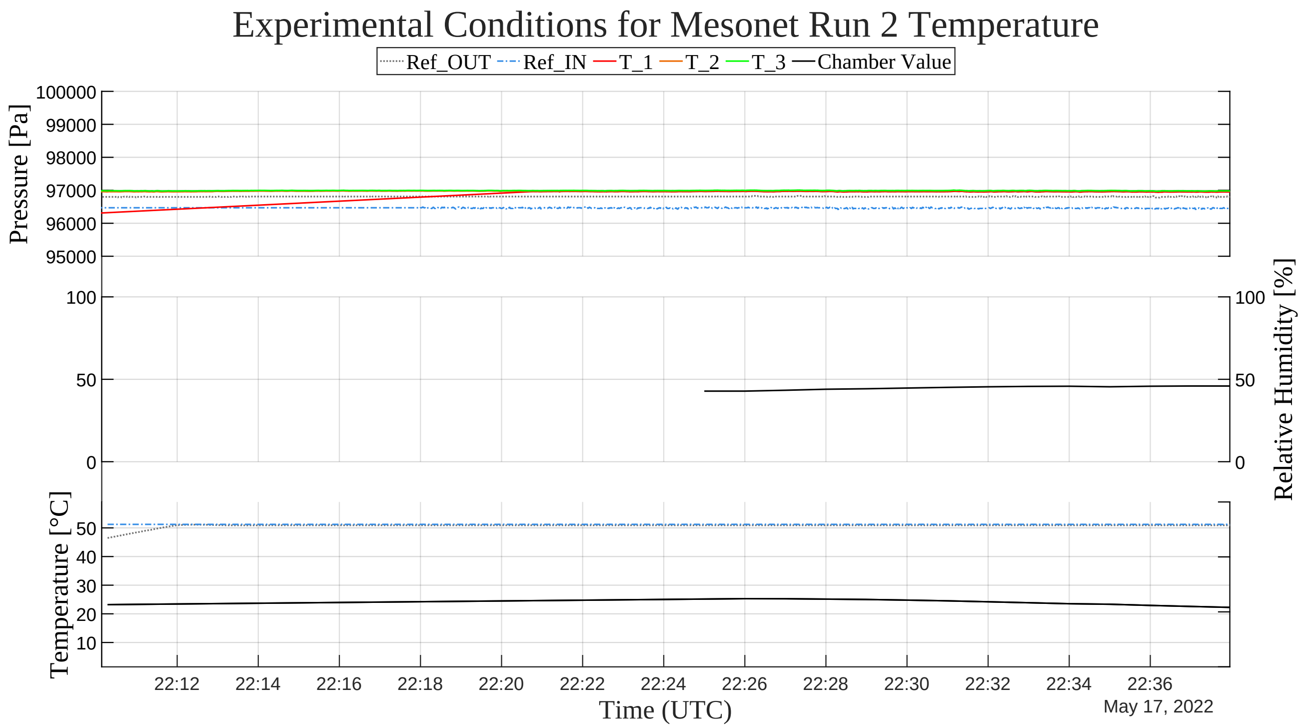

Figure 45. Zoomed view of figure 44 showing a temperature variation of the Li-820 (a.k.a. Ref_OUT) optical chamber.