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Weather Measurements During the CFS10 (10-Story Cold-Formed Steel Framed Building) Shake Table Test Program

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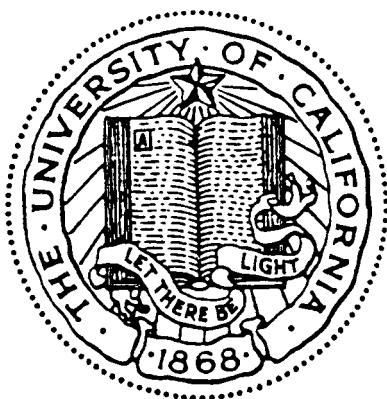
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**STRUCTURAL SYSTEMS
RESEARCH PROJECT**

Report No.
SSRP-2025/02
Final

**Weather Measurements During the CFS10
(10-Story Cold-Formed Steel Framed Building)
Shake Table Test Program**

By

D.A. Blair, T.Mueller, J.Zhang, D.Rivera and T.C. Hutchinson

Final Report.

December 12, 2025

Department of Structural Engineering
University of California San Diego
La Jolla, California 92093-0085

University of California San Diego
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DISCLAIMER

The opinions, recommendations, and conclusions contained within this report are solely those of the authors and do not necessarily reflect the views or policies of the project sponsors. This report does not constitute a standard, specification, or regulation.

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EXECUTIVE SUMMARY

A ten-story cold-formed steel (CFS) framed (CFS) building, herein referred to as CFS10, underwent seismic and post-seismic live fire testing at the 6-Degree-of-Freedom Large High-Performance Outdoor Shake Table (LHPOST6) facility at the University of California San Diego. Construction of the CFS10 specimen spanned from September 2024 to March 2025 and involved assembly using three different methods, namely: conventional stick-framing, two-dimensional (2D) prefabricated panels, and three-dimensional (3D) volumetric modular units. CFS10 was then outfitted with more than 1000 sensors (April - June 2025) and subjected to earthquake testing during a span of two weeks (June 2025), with motions reaching up to MCE_R -scaled events. Subsequently, the specimen was subjected to two post-earthquake live fire tests within distinct seismically damaged compartments (July 2025). This report summarizes the collection of three weather data streams (Elliott Station, Unit 1, Unit 2) located at or near the LHPOST6 facility, including one strategically positioned atop the 10-story building. Major events during the CFS10 program, notably construction, seismic and fire testing, are identified and correlated with the collected wind speed, wind direction, temperature, and relative humidity. Weather data is particularly valuable for correlation with ambient vibration measurements used to evaluate the structure's dynamic characteristics. The dataset also documents the direct influence of environmental conditions on construction and testing operations; for example, the Level 6 module lift was postponed when wind speeds reached 20 mph, demonstrating direct operational dependence on real time data. Strong agreement among the Elliott Station, Unit 1, and Unit 2 sensors, evidenced by average temperature differences of 2–4 °F and closely aligned wind direction trends, confirms the reliability of the data streams and supports their use in future system identification and structural performance studies of this landmark building test specimen. It is noted that digital CSV data files from each of the sensors, for all timelines available, are archived with the present report.

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1 Introduction

In this study, three sources of weather sensor data were used. The first source was Elliott Station, managed by the Dendra Science division of the UC Natural Reserve System [1]. The other two stations summarized in this report, referred to as Unit 1 and Unit 2, are maintained and located at the LHPOST6 facility. Unit 1 was located near the CFS10 specimen on the hydraulic power building, and Unit 2 was located on the roof of the test specimen during the seismic tests and the northwest corner of the LHPOST6 facility near ground level during live fire tests. Table 1 presents the locations of the weather stations and identifies their operational status during each landmark event. The exact locations and elevations of the three sensors are outlined in Table 2 and 3, with Figure 1 depicting the distance from LHPOST6 to Elliott Station and Figure 2 displaying the locations of Units 1 and 2 at LHPOST6. A comparison of weather data from multiple sources was essential to ensure the precision and reliability of environmental inputs throughout the CFS10 program. Since temperature, wind and humidity can influence sensor calibration, material behavior, and overall testing safety, cross-referencing multiple weather stations allowed the research team to identify potential data inconsistencies and better factor environmental conditions in data recordings.

Table 1: Landmark event schedule for CFS10 testing program.

Major Event	Date (YYYY–MM–DD)	Elliott Station	LHPOST6 Unit 1	LHPOST6 Unit 2
L2 Module Lift	2024-11-25	Active	Not Active	Active
L3 Module Lift	2024-12-06	Active	Not Active	Not Active
L4 Module Lift	2024-12-12	Active	Not Active	Not Active
L5 Module Lift	2025-01-02	Active	Not Active	Not Active
L6 Module Lift (Postponed)	2025-01-08	Active	Not Active	Not Active
L6 Module Lift (Successful)	2025-01-09	Active	Not Active	Not Active
L7 Module Lift	2025-01-14	Active	Not Active	Not Active
L8 Module Lift	2025-01-23	Active	Not Active	Not Active
L9 Module Lift	2025-01-29	Active	Active	Not Active
L10 Module Lift	2025-02-11	Active	Active	Not Active
Seismic Testing Day 1	2025-06-16	Active	Active	Active (Roof)
Seismic Testing Day 2	2025-06-17	Active	Active	Active (Roof)
Seismic Testing Day 3	2025-06-18	Active	Active	Active (Roof)
Seismic Testing Day 4	2025-06-20	Active	Active	Active (Roof)
Seismic Testing Day 5	2025-06-23	Active	Active	Active (Roof)
Seismic Testing Day 6	2025-06-25	Active	Active	Active (Roof)
Seismic Testing Day 7	2025-06-27	Active	Active	Active (Roof)
L9 Fire Test	2025-07-17	Active	Active	Active (Ground)
L6 Fire Test	2025-07-29	Active	Active	Active (Ground)
Deconstruction Period	2025-08-05 to 2025-08-15	Active	Active	Active (Ground)

Table 2: Collection dates and location of instruments.

Weather Station	Primary Location	Dates of Data Collection (YYYY–MM–DD)	Secondary Location	Secondary Location Dates (YYYY–MM–DD)
Elliott Station	Elliott Chaparral Reserve	2024-09-16 to 2025-08-15	N/A	N/A
LHPOST6 Unit 1	Hydraulic Building	2025-01-27 to 2025-08-15	N/A	N/A
LHPOST6 Unit 2	SW Corner of CFS10 Roof	2025-06-09 to 2025-07-01	NW Ground Position	2025-07-11 to 2025-08-15

Table 3: Coordinates and elevation of instruments. Note: The LHPOST6 facility elevation is approximately 525 ft above sea level.

Weather Station	Latitude (°)	Longitude (°)	Elevation (ft above sea level)
Elliott Station	32.89	-117.09	780.05
LHPOST6 Unit 1	32.89	-117.11	560.63
LHPOST6 Unit 2 (Seismic Testing)	32.89	-117.11	633.66
LHPOST6 Unit 2 (Live Fire Testing)	32.89	-117.11	527.66



Figure 1: Distance between weather stations.

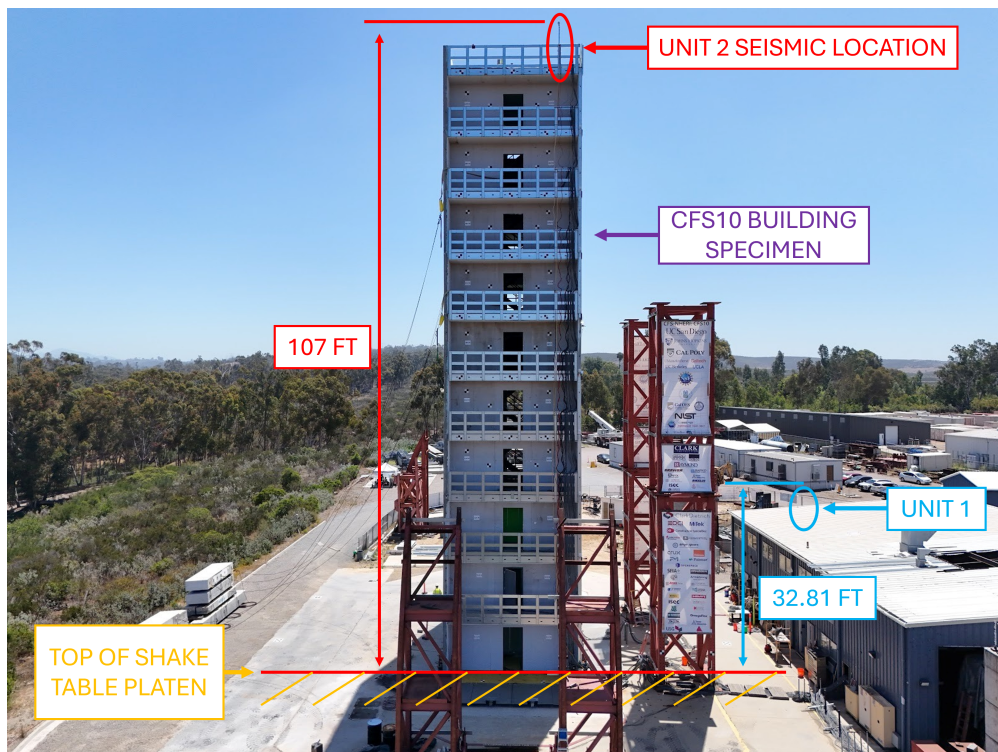


Figure 2: Unit 1 and Unit 2, in relation to CFS10 test specimen.

2 Instrument Specifications

2.1 Elliott Station

Located approximately a mile from LHPOST6, Elliott Station is a nearby weather station that sits on the western edge of the Elliott Chaparral Reserve, as shown in Figure 3. It is managed by the UC Natural Reserve System [1] and provides data to the Western Regional Climate Center (WRCC), a regional division of the National Oceanic and Atmospheric Administration (NOAA). NOAA generally provides data spanning only the previous 7 days; however, for this study, we accessed the Dendra archived database. This process enabled the retrieval of data for the entire project duration rather than on a weekly basis. It is also important to note that NOAA data is reported in local time adhering to time changes on Sunday, March 9, 2025 and Sunday, November 2, 2025. Meanwhile, the UC Reserve System operates year round on Public Standard Time (PST). For consistency across all weather sources, recorded timestamps from each station were converted and aligned to a unified Pacific Standard Time (PST) base prior to plotting and averaging for analysis.



Figure 3: Elliott station. (*Photo courtesy of UC Natural Reserve System*)

2.2 LHPOST6 Units

The onsite units located at the LHPOST6 facility were Vaisala WXT536 Weather Transmitters. Technical data specifications of the transmitters are provided in Appendix D. These units track pressure, temperature, humidity, precipitation, wind speed, and wind direction.

Wind measurements are obtained using three ultrasonic transducers on a horizontal plane. Wind speed and direction measurements are a result of the time it takes for the ultrasound to travel between transducers, along all 3 paths. The average values of wind speed and direction are calculated as a scalar average of all samples over a selected averaging time with a selectable updating interval. The sample count depends on the selected sampling rate. The minimum and maximum values of wind speed and direction represent the corresponding extremes during the selected averaging time. The Vaisala units were setup with a sampling frequency of 4 Hz, however, minimum, maximum, and average data values were recorded and written to the data files every 10 minutes.

The sampling was done via polling only, meaning that the unit transfers data only when the data acquisition requests it. Temperature measurements stem from a thin film sensor which tracks temperature by changing its electrical resistance. Finally, humidity was measured with a thin film polymer between two electrodes where the polymer absorbs or releases water vapor depending on the humidity, changing the sensor's capacitance which in turn, this change is converted into a humidity reading [2].

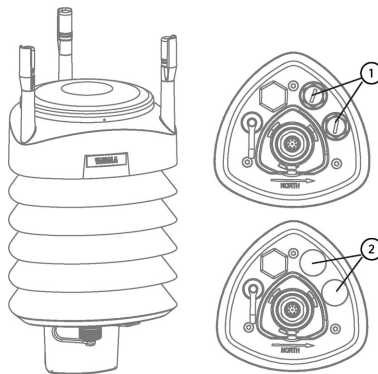


Figure 4: Schematic of WXT536.

Unit 1 is permanently mounted on the hydraulic power building, while Unit 2 was supported by AlertCalifornia and new to the facility. This second weather station is intended to be movable by researchers, and in the case of CFS10 was installed on the specimen roof during shake table testing and moved to the chaparral (northwest to the shake table plate) during the fire testing phase.

2.2.1 Unit 1

Located on the LHPOST6 (see Figure 5), Unit 1 was placed near the CFS10 test specimen on the hydraulic power system building approximately 32.81 ft or 10 m above adjacent ground level at the facility. This equated to the sensor being 560.50 ft or 170.83 m approximately above sea level. Data at this unit was recorded from 2025-01-27 to 2025-08-15. This unit captured data during major milestone events, beginning with the level 9 module lift (2025-01-29) until the level 6 fire test (2025-07-29).

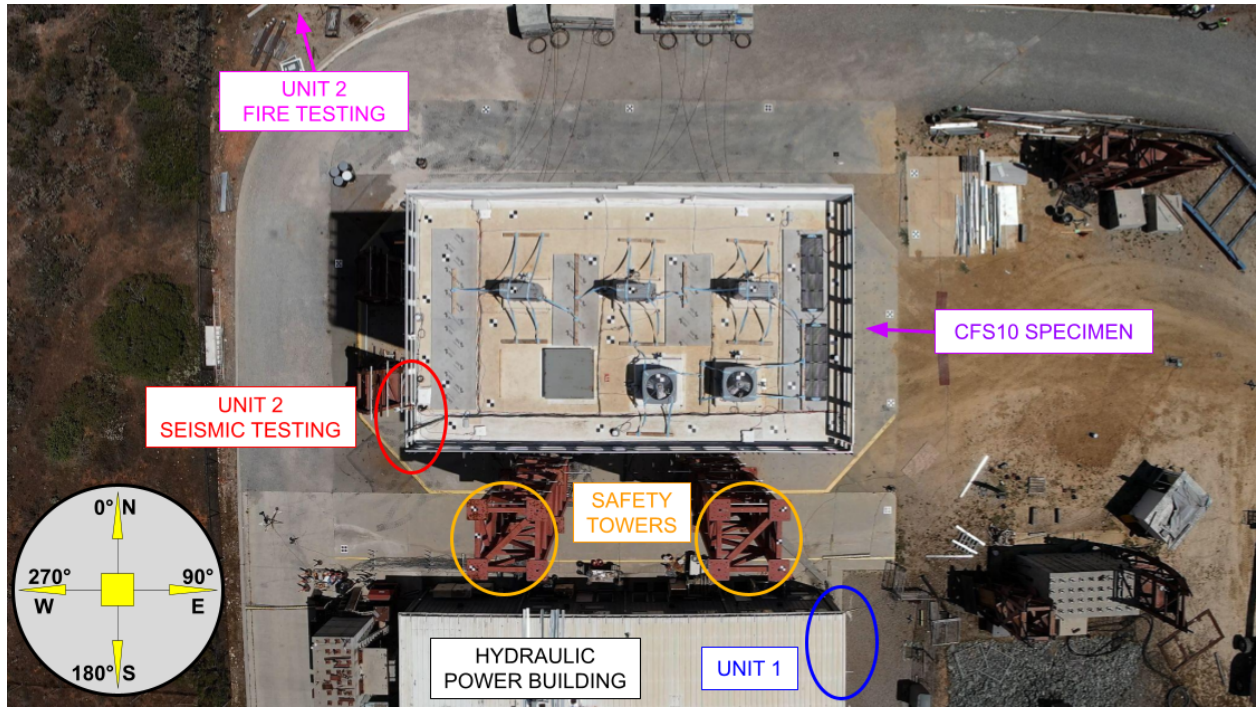


Figure 5: Plan view of LHPOST6 weather units.

2.2.2 Unit 2

Also located on the LHPOST6 facility, Unit 2 was placed on the roof of the CFS10 test specimen (106 ft or 32.31 m) from 2025-06-09 to 2025-07-01 (see Figure 6). This equated to the sensor being 633.66 ft or 193.14 m above sea level during the seismic test phase. This sensor was then relocated to minimize potential for damage during live fire test phase. From 2025-07-11, Unit 2 was placed northwest to the CFS10 specimen on the ground level in the nearby chaparral, bringing the elevation from sea level down to 527.66 ft or 160.83 m above sea level during the post-seismic live fire test phase. Unit 2 remained active during the deconstruction period, with the final data collection day on 2025-08-15.



Figure 6: Unit 2 installed above the roof level of the CFS10 specimen during seismic test.

3 Summary of Wind Data

3.1 Long term data analysis

Within this report, one of the primary objectives is to evaluate and compare the measurements across the three weather data sources. As shown in Figures 7 and 8, strong agreement is observed among the datasets across all measured parameters. For temperature, Elliott Station generally recorded values approximately 2–4 °F higher than Unit 1 and about 9 °F higher than Unit 2 on average. Relative humidity measurements demonstrated particularly strong agreement between Unit 1 and Unit 2, typically differing by only 1–2%. Larger discrepancies were observed when compared to Elliott Station, with differences of approximately 6–13% depending on the fire testing stage, likely attributable to variations in sensor elevation and surrounding terrain.

With respect to wind conditions, Unit 2 generally recorded slightly higher wind speeds than both Unit 1 and Elliott Station, while wind direction trends remained consistent across all three stations. These patterns were observed during both the seismic and live fire testing phases. However, data corroboration could not be performed for the construction phase, as Units 1 and 2 were not operational for a sufficiently long duration during that period (see Table 1). Overall, the strong correlation among the three measurement systems indicates that each data source reliably captured local weather trends despite their spatial separation.

It is also important to note that some data gaps are present, as shown in Figures 7 and 8. On June 16 and June 17, data from the Elliott Station are unavailable between 02:40 and 07:40. On July 21, Unit 2 weather data are unavailable between midnight and 08:20. Additionally, on July 26, data from both Unit 1 and Unit 2 are unavailable from 00:00 until 08:10. Finally, it is important to note, on July 31, Unit 2 began recording data at 10-second intervals rather than the previous 10-minute intervals between 14:10 and 15:20.

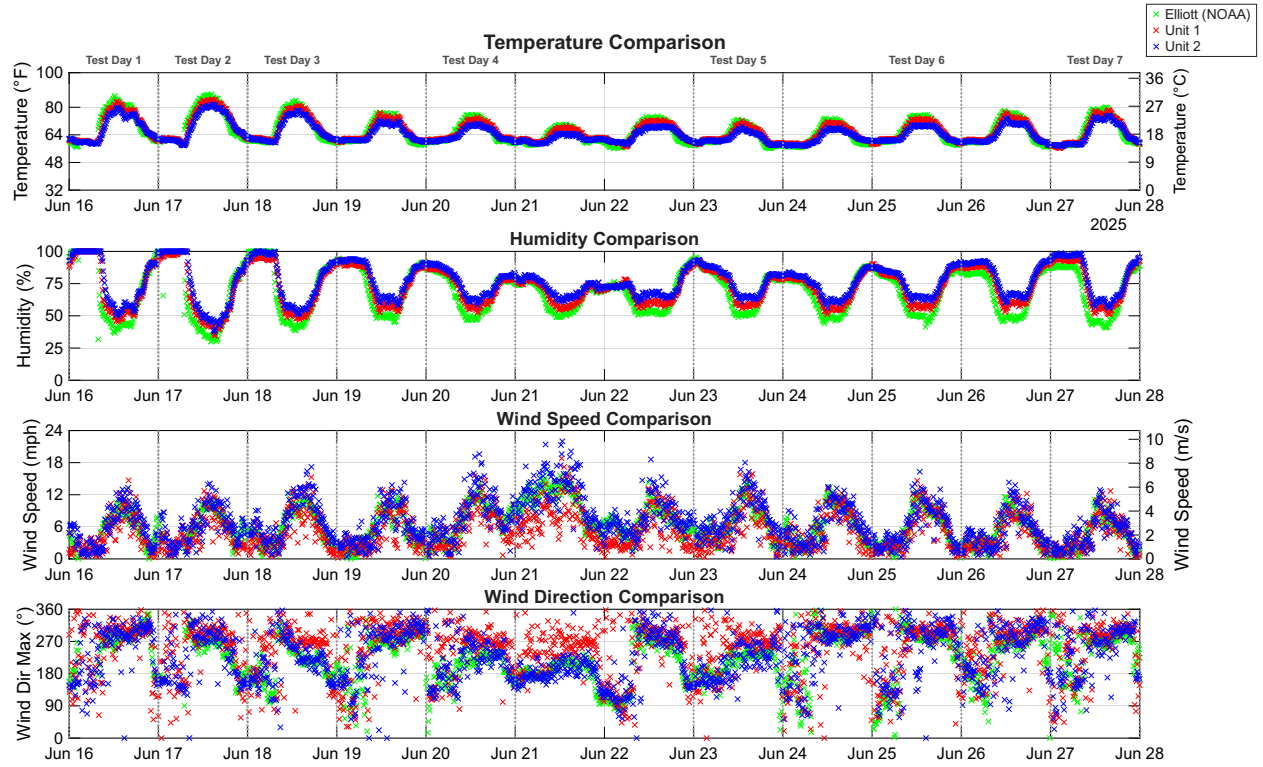


Figure 7: Weather station data during the seismic testing period. Note: Elliott Station data are unavailable on June 16–17 from 02:40–07:40. See Figure 5 for wind direction orientation relative to specimen.

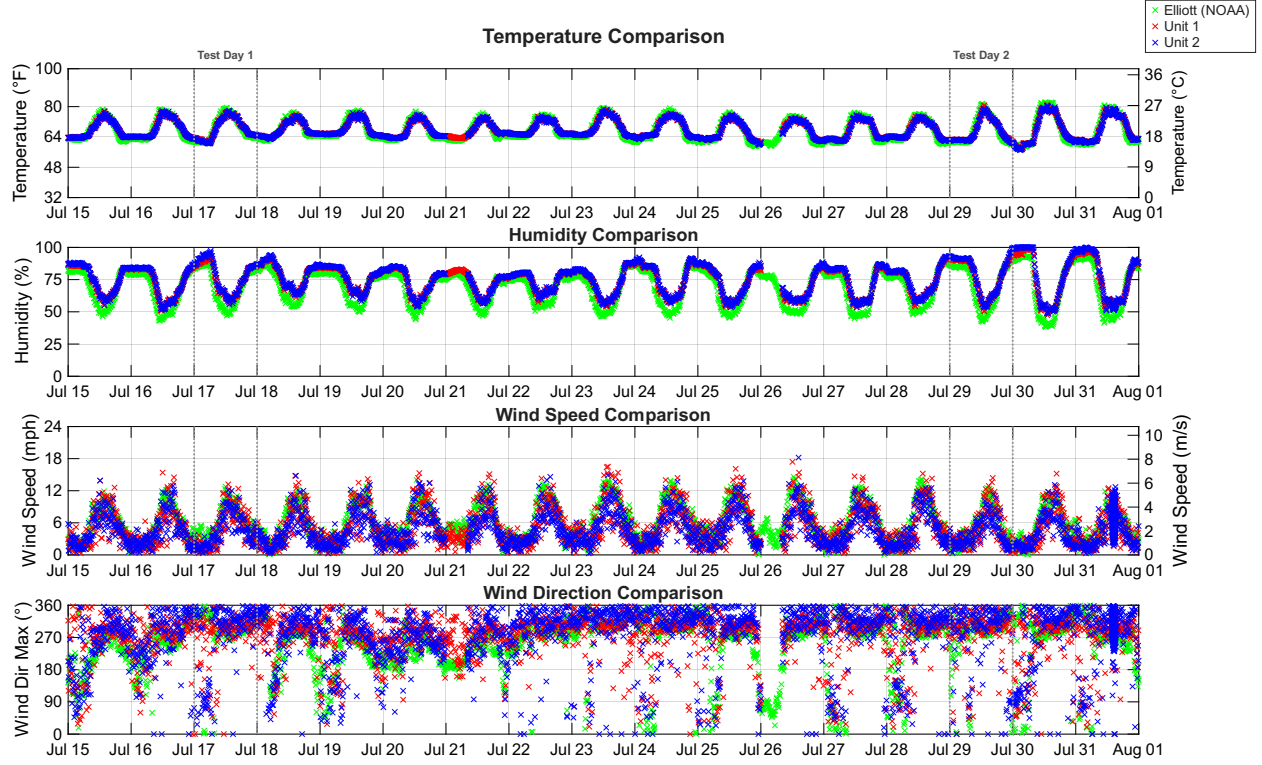


Figure 8: Weather station data during the live fire testing period. Note: Data gaps occur on July 21 (Unit 2, 00:00–08:20) and July 26 (Units 1–2, 00:00–08:10). On July 31, Unit 2 switched to 10-second sampling, rather than 10-minute sampling, from 14:10–15:20.

3.2 Module Lifts

Integrated into the design of the CFS10 test specimen, the east room, extending from the second story to the top of the building (i.e., Level 2 - Level 10), was constructed using three-dimensional (3D) volumetric modules assembled on-site. The first major milestone in the life cycle of the CFS10 test specimen was the lifting and placement of these 3D volumetric modules, as shown in Figure 9.



Figure 9: Level 10 module lift. (*Photo courtesy of David Baillot @ UC San Diego*)

Elliott station was the only weather station that remained online throughout the entire duration of the construction phase. Unit 1 commenced data collection on January 27, 2025 just before the lift of the level 9 module. For this reason, Table 4 and Figure 10, which track major lift events and characterize the weather data during those lifts, only utilize Elliott Station data.

Table 4: Module weight and wind speed during lifts per Elliott Station data.

Module	Date (YYYY-MM-DD) Time (Range)	Weight (kips)*	Avg Wind Speed (mph)	Avg Wind Dir (°)	Wind Origin	Avg Temp (°F)
L2	2024-11-25 12:45 - 13:15	17.29	6.71	313.42	NW	76.58
L3	2024-12-06 08:10 - 09:20	16.31	2.94	251.29	WSW	58.48
L4	2024-12-12 10:58 - 12:35	15.74	8.26	229.91	SW	63.49
L5	2025-01-02 08:55 - 09:35	14.94	1.66	279.06	W	68.32
L6	2025-01-09 07:10 - 07:47	14.87	5.18	78.49	ENE	53.38
L7	2025-01-14 08:16 - 08:47	11.70	3.97	168.18	SSE	58.94
L8	2025-01-23 09:49 - 11:07	12.68	13.59	83.73	E	76.40
L9	2025-01-29 08:15 - 09:15	12.20	7.80	117.17	ESE	53.70
L10	2025-02-11 08:10 - 09:15	13.20	7.90	184.64	S	49.99

*Weight includes the module but excludes the crane rigging and payload, measured at time of lift by crane operator. Data provided by Rivera [3].

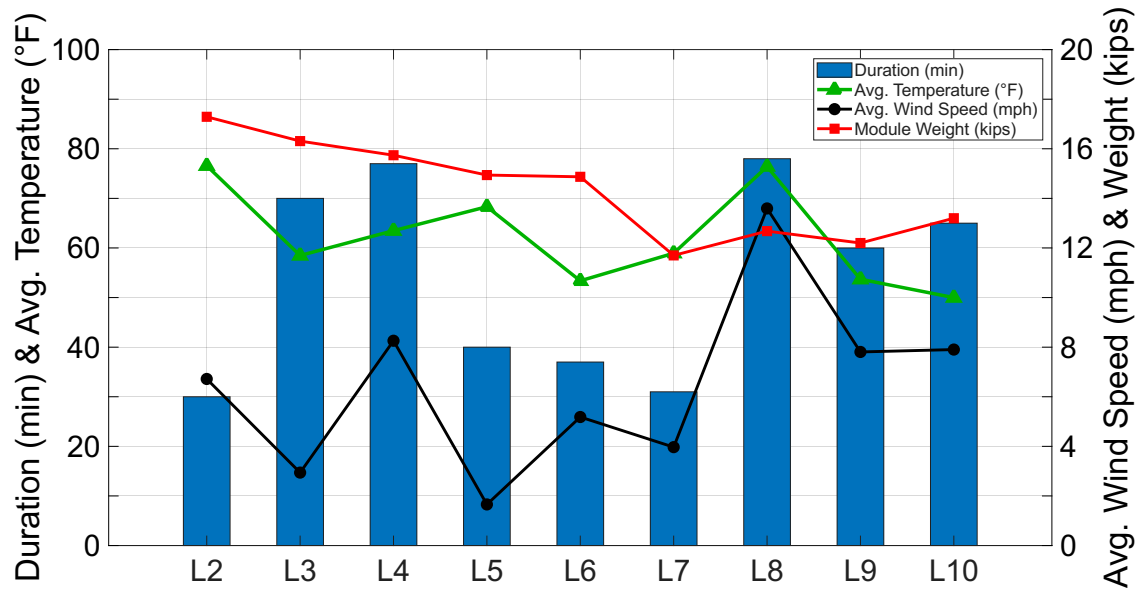
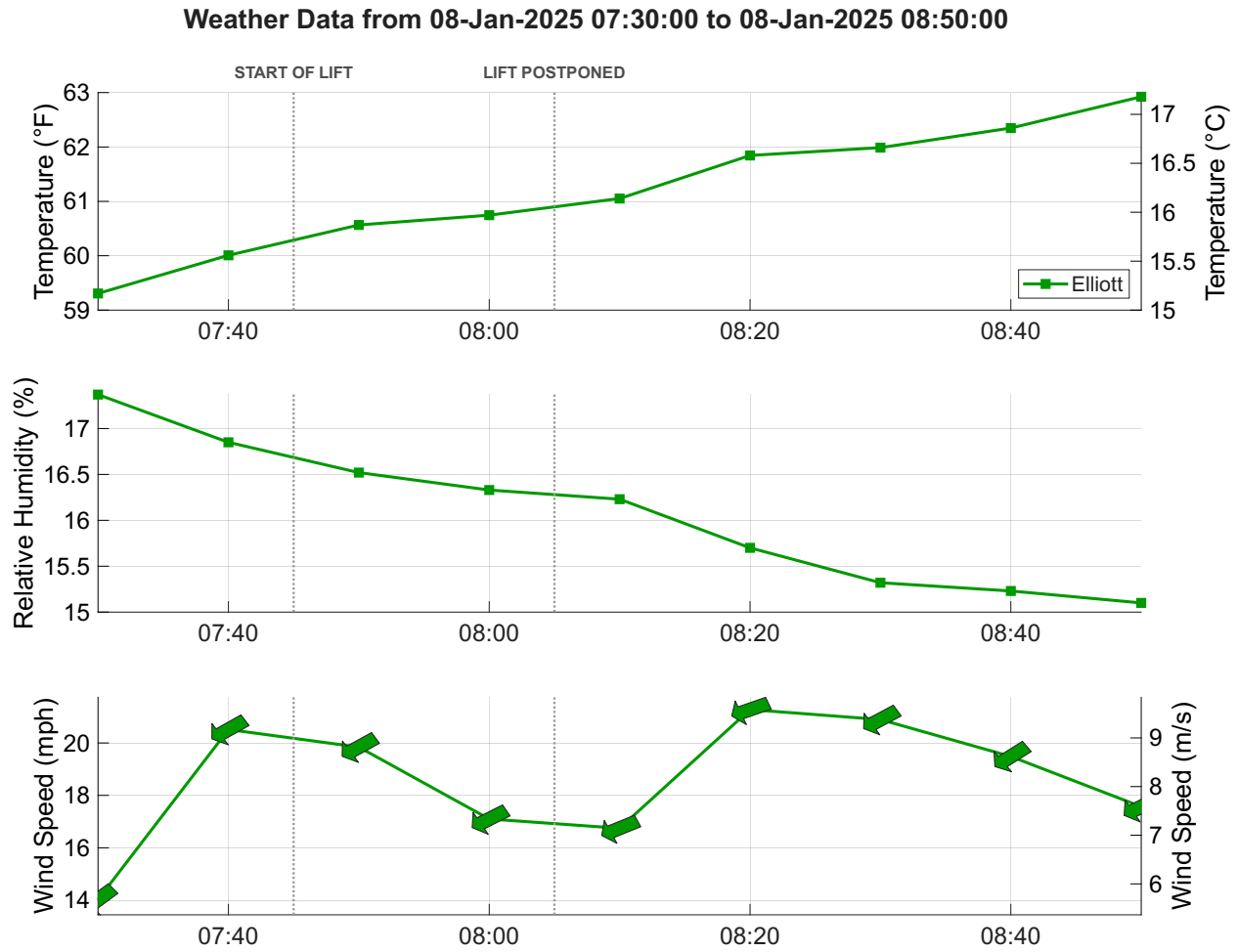
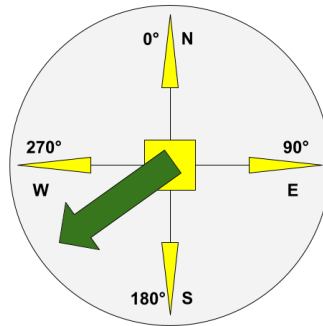


Figure 10: Duration & weight of lift compared with average measured temperature & wind speed, using Elliott Station data.

Throughout the construction process, wind data was used to inform the crane operator and construction team whether conditions were suitable to successfully lift a module. Only once throughout the construction process was a lift postponed due to heavy winds. Notably, this occurred when lifting the Level 6 module with an unsuccessful lift occurred on January 8, 2025 (2025-01-08) due to wind speed reaching 20 mph, as shown in Figure 11. These conditions were deemed unsafe by the construction team. Having to be postponed to the next day, Figure 12 shows the January 9, 2025 (2025-01-09) successful lift day.



(a) Temperature, relative humidity, wind speed and direction for L6 module lift.



(b) Wind direction for L6 module lift at 07:40. (Wind Direction: 56.75°, Wind Origin: Northwest)

Figure 11: Elliott Station weather data during postponed Level 6 module lift.

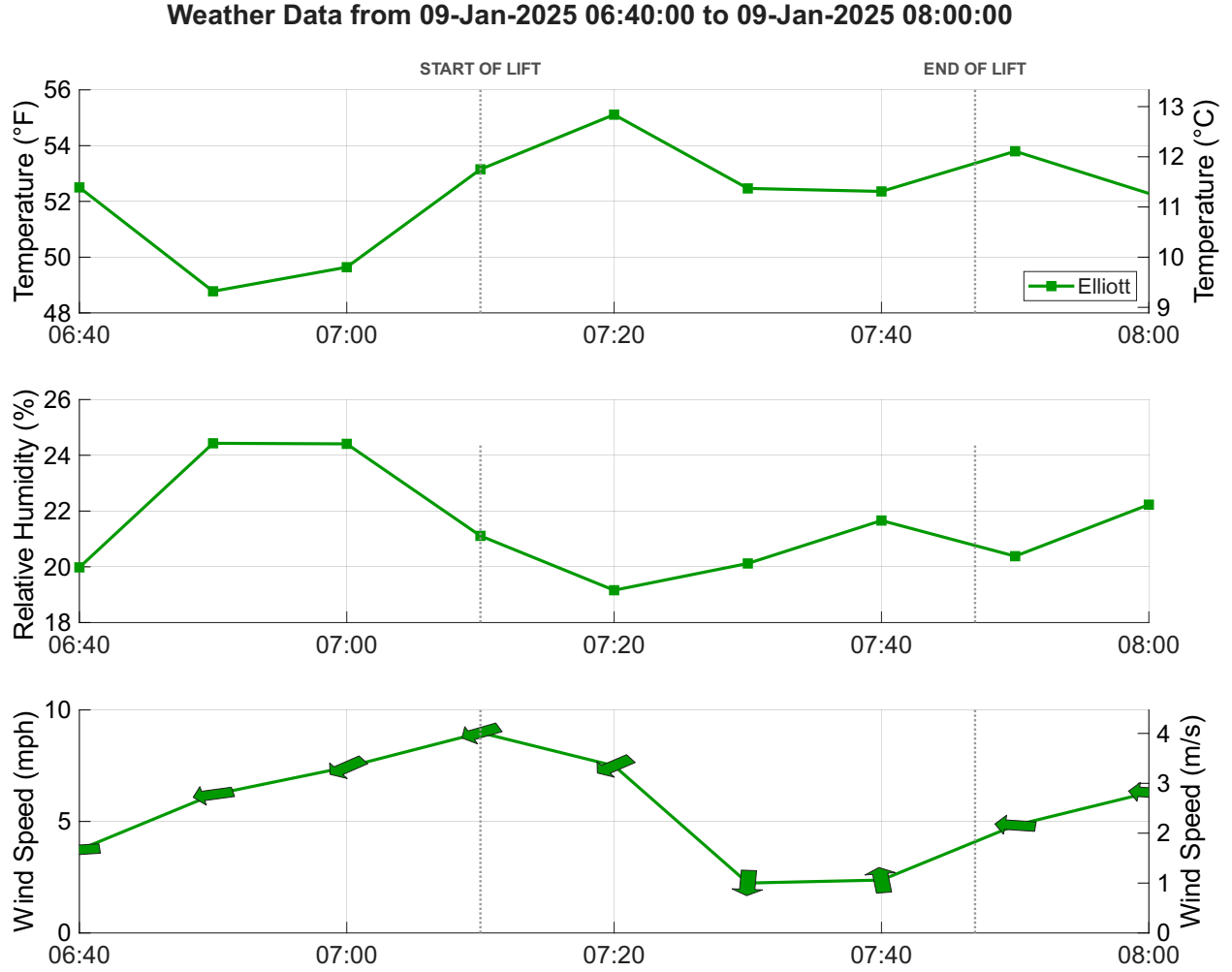


Figure 12: Elliott Station weather data during successful Level 6 module lift.

3.3 Seismic Testing

The seismic testing of the CFS10 specimen was conducted over a two-week period, comprising seven total days of testing. As shown in Figure 13, multiple seismic tests were performed each day to evaluate the structure's dynamic performance under increasing intensity earthquake motions. Throughout these tests, data from all three weather stations played an important role in contextualizing the seismic measurements. As shown in Figure 7, variations in wind speed, temperature, and relative humidity were monitored and offer complimentary data to the specimen's recorded seismic response. Periods of elevated wind speed were closely tracked due to their potential to introduce low-level structural oscillations, which could contribute noise to acceleration and displacement measurements. In addition, significant fluctuations in temperature and humidity may have induced minor changes in material stiffness and sensor calibration. The integration of weather data with the seismic response measurements are useful for distinguishing environmental effects from true structural responses.

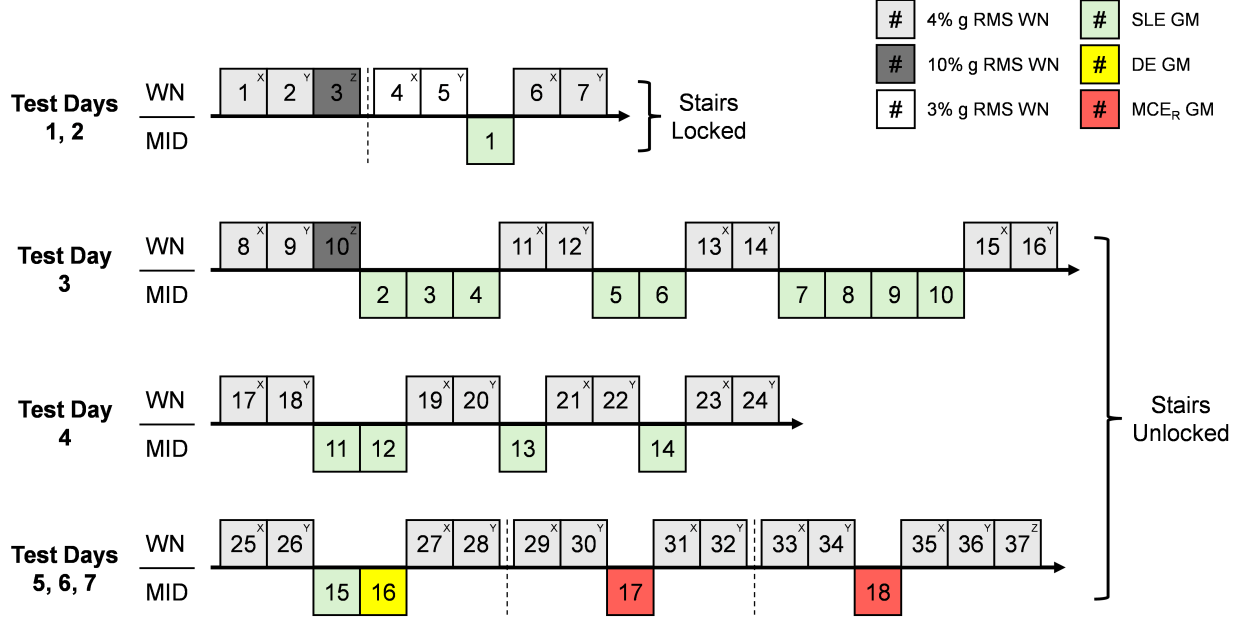


Figure 13: Sequence and nature of base input motions applied during the CFS10 testing [4]. Note: White noise amplitudes were the target values.

Figure 13 illustrates the full sequence of tests conducted during the CFS10 seismic test phase across the seven total testing days. Each numbered block represents an individual ground motion (GM) or white noise (WN) input, with color shading indicating the applied intensity level: white (3% g RMS white noise), gray (4% g RMS white noise), dark gray (10% g RMS white noise), light green (Service-Level Earthquake, SLE GM), yellow (Design Earthquake, DE GM), and red (Maximum Considered Earthquake, MCE_R GM). MID refers to motion identification number, a sequential number defined by the research team. The diagram also highlights the transition in test configuration when the internal stair system was locked and later unlocked. This figure defines the structured testing schedule executed throughout the seismic phase and provides critical context for interpreting the acceleration and response plots presented in Appendix B. As an example, on Seismic Testing Day 3 (Figure 14 and 15), wind speeds varied between 0–15 mph and relative humidity changed by roughly 10% throughout the day.

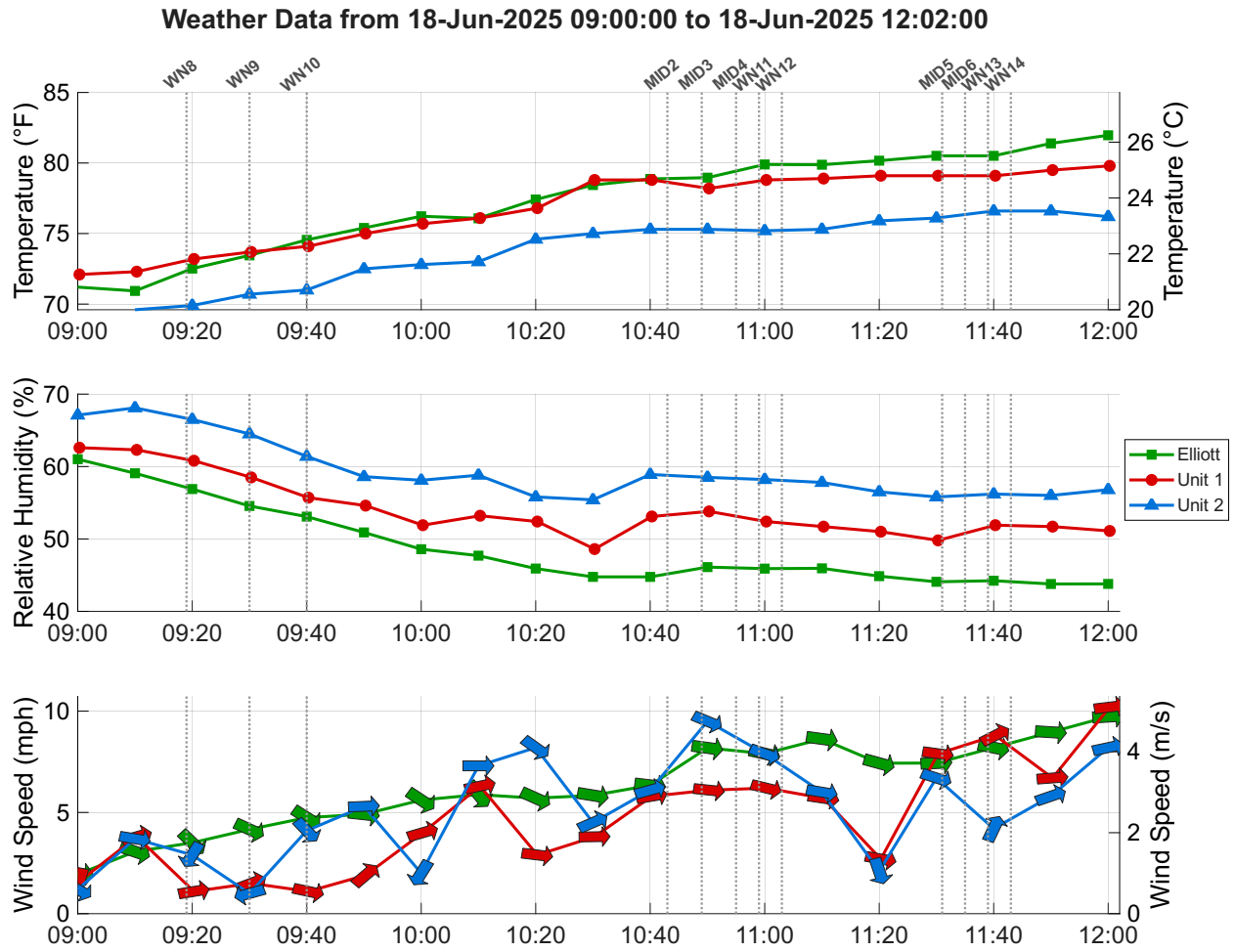


Figure 14: Weather station data during morning of seismic testing day 3.

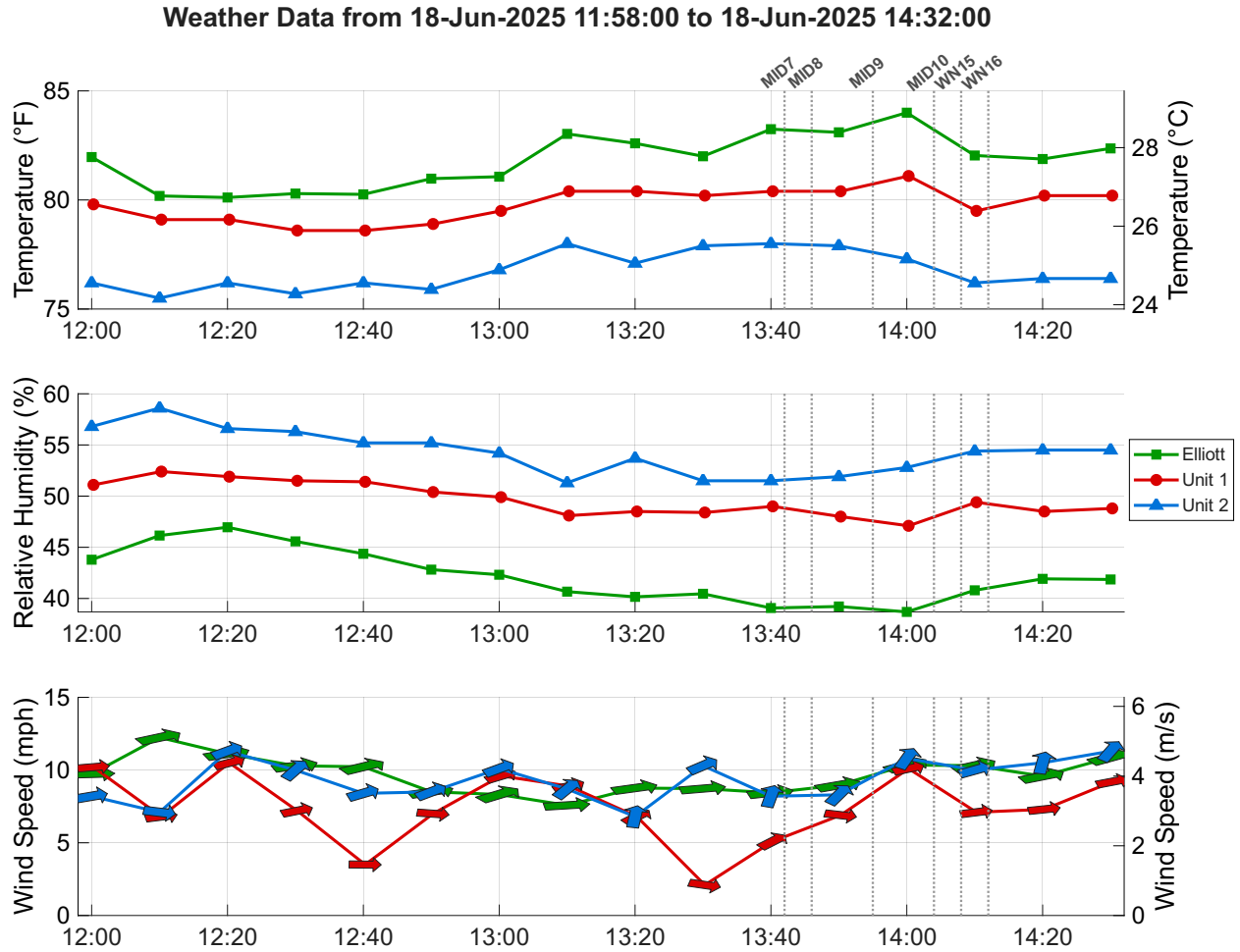


Figure 15: Weather station data during afternoon of seismic testing day 3.

Appendix E provides a detailed daily rendering of the environmental conditions during seismic testing. By isolating individual seismic test days, the appendix reveals consistent daily weather behavior, including gradual morning temperature increases, corresponding decreases in relative humidity, and elevated wind speeds later in the day. Seismic test days 1–3 begin with morning temperatures in the low 70 °F range and conclude in the high 70 °F range, while seismic test days 4–7 begin under cooler conditions in the mid-60 °F range before similarly warming into the high 70 °F range by the afternoon. Relative humidity exhibits an inverse trend across all days, decreasing from approximately 80 % in the morning to roughly 50 % by the end of the testing window. The repetition of these patterns across multiple testing days demonstrates that environmental conditions evolved in a predictable and stable manner, allowing normal variability to be distinguished from test-induced effects. This consistency strengthens confidence that observed structural responses are primarily attributable to seismic excitation rather than short-term environmental variability.

3.4 Post-Earthquake Live Fire Testing

After the conclusion of the seismic testing phase, post-earthquake live fire testing occurred at the Levels 6 and 9 east rooms on July 17 (2025-07-17) and July 29 (2025-07-29) respectively. The north window was the sole ventilation source for both tests, see Figure 16. With its proximity to the nearby chaparral as well as the California Interstate 15 and Pomerado Road, real time weather data was used to support the fire test and guide fire marshals in their decision making.



Figure 16: Level 9 fire testing.

Tables 5-10 compare the three different sources of weather data during the different stages of the Level 9 and Level 6 fire tests. The Elliott Station reports a single averaged wind speed value at each time point, which represents the average of its recorded maximum wind gusts. In contrast, both Unit 1 and Unit 2 sensors provide a fuller wind profile by reporting the

minimum, average, and maximum wind speeds for each recorded time stamp, allowing for a more detailed understanding of wind variability during each phase of the fire tests. It is important to note that the time intervals shown beneath each fire stage represent the official fire test timeline, while the “Weather Station Time Used” column reflects the actual timestamp range of sensor data that was available and used for averaging. Because each measurement source logs data at slightly different time intervals, the closest continuous set of recorded values within the requested fire-stage window was selected. For example, although the requested interval for the Growth Phase in Table 5 is 10:19–10:36, the weather stations only contained valid overlapping readings between 10:20–10:40, resulting in a slightly longer averaging window. As a result, the weather conditions reported in Tables 5-10 represent averages calculated from the true sensor-recorded intervals rather than the full nominal fire-stage durations, allowing for more accurate and consistent data comparison across the three measurement sources.

Table 5: Key event time and weather conditions from **Elliott Station** during **L9 fire test** (2025-07-17).

Stage of Fire*	Weather Station Time Used**	Avg Wind Speed (mph)	Avg Wind Dir (°)	Average Rel. Humidity (%)	Avg Temp (°F)*
Prior to Test <i>09:00–10:00</i>	<i>09:00–10:00</i>	5.93	288	57	74.02
Growth Phase <i>10:19–10:36</i>	<i>10:20–10:40</i>	7.80	305	56	75.61
Fully Developed Phase <i>10:36–10:55</i>	<i>10:40–10:50</i>	7.65	285	54	76.72
Decay Phase <i>10:55–11:50</i>	<i>11:00–11:50</i>	9.93	292	51	78.28
End of Test <i>11:50–12:50</i>	<i>11:50–12:50</i>	11.38	276	50	78.44

* Time stamps and average temperature courtesy of Professor Thomas Gernay [5].

** Weather stations record values in 10-minute averaged intervals; selected times correspond to the closest matching interval to the fire test times.

Table 6: Key event time and weather conditions from **Unit 1** during **L9 fire test** (2025-07-17).

Stage of Fire	Weather Station Time Used	Wind Min (mph)	Wind Avg (mph)	Wind Max (mph)	Avg Wind Dir (°)	Average Rel. Humidity (%)	Avg Temp (°F)
Prior to Test <i>09:00–10:00</i>	<i>09:00–10:00</i>	1.97	3.30	4.58	263	67	72.32
Growth Phase <i>10:19–10:36</i>	<i>10:20–10:40</i>	1.60	2.75	4.05	146	65	73.15
Fully Developed Phase <i>10:36–10:55</i>	<i>10:40–11:00</i>	5.30	6.75	8.50	275	66	73.55
Decay Phase <i>10:55–11:50</i>	<i>11:00–11:50</i>	3.44	5.86	8.14	202	64	74.74
End of Test <i>11:50–12:50</i>	<i>11:50–12:50</i>	3.63	5.58	7.92	272	61	76.65

Table 7: Key event time and weather conditions from **Unit 2** during **L9 fire test** (2025-07-17).

Stage of Fire	Weather Station Time Used	Wind Min (mph)	Wind Avg (mph)	Wind Max (mph)	Avg Wind Dir (°)	Average Rel. Humidity (%)	Avg Temp (°F)
Prior to Test <i>09:00–10:00</i>	<i>09:00–10:00</i>	2.55	3.53	4.47	291	69	71.40
Growth Phase <i>10:19–10:36</i>	<i>10:20–10:40</i>	2.55	3.10	3.75	322	66	72.85
Fully Developed Phase <i>10:36–10:55</i>	<i>10:40–10:50</i>	4.45	6.20	7.35	284	67	73.95
Decay Phase <i>10:55–11:50</i>	<i>11:00–11:50</i>	2.74	5.04	7.56	244	66	74.12
End of Test <i>11:50–12:50</i>	<i>11:50–12:50</i>	3.92	6.22	8.52	311	62	76.38

Table 8: Key event time and weather conditions from **Elliott Station** during **L6 fire test** (2025-07-29).

Stage of Fire	Weather Station Time Used	Avg Wind Speed (mph)	Avg Wind Dir (°)	Average Rel. Humidity (%)	Avg Temp (°F)
Prior to Test <i>09:00–10:00</i>	<i>09:00–10:00</i>	5.71	304	62	70.29
Growth Phase <i>10:06–10:18</i>	<i>10:10–10:20</i>	4.73	316	57	72.88
Fully Developed Phase <i>10:18–10:47</i>	<i>10:20–10:50</i>	5.69	298	56	73.83
Decay Phase <i>10:47–11:37</i>	<i>10:50–11:40</i>	5.65	300	49	77.48
End of Test <i>11:37–12:37</i>	<i>11:40–12:40</i>	7.54	307	44	80.85

Table 9: Key event time and weather conditions from **Unit 1** during **L6 fire test** (2025-07-29).

Stage of Fire	Weather Station Time Used	Wind Min (mph)	Wind Avg (mph)	Wind Max (mph)	Avg Wind Dir (°)	Average Rel. Humidity (%)	Avg Temp (°F)
Prior to Test <i>09:00–10:00</i>	<i>09:01–10:01</i>	1.07	2.50	4.07	293	79	65.72
Growth Phase <i>10:06–10:18</i>	<i>10:11–10:21</i>	0.50	3.30	6.20	288	72	68.90
Fully Developed Phase <i>10:18–10:47</i>	<i>10:21–10:51</i>	2.13	4.10	6.10	258	71	69.37
Decay Phase <i>10:47–11:37</i>	<i>10:51–11:41</i>	1.98	3.68	5.62	274	64	72.82
End of Test <i>11:37–12:37</i>	<i>11:41–12:41</i>	2.02	3.67	5.33	268	57	76.88

Table 10: Key event time and weather conditions from **Unit 2** during **L6 fire test** (2025-07-29).

Stage of Fire	Weather Station Time Used	Wind Min (mph)	Wind Avg (mph)	Wind Max (mph)	Avg Wind Dir (°)	Average Rel. Humidity (%)	Avg Temp (°F)
Prior to Test <i>09:00–10:00</i>	<i>09:01–10:01</i>	1.77	2.73	4.08	316	80	65.38
Growth Phase <i>10:06–10:18</i>	<i>10:11–10:21</i>	2.90	4.60	5.70	329	75	68.00
Fully Developed Phase <i>10:18–10:47</i>	<i>10:21–10:51</i>	2.07	3.53	5.17	247	71	69.50
Decay Phase <i>10:47–11:37</i>	<i>10:51–11:41</i>	2.22	3.46	4.58	312	65	72.44
End of Test <i>11:37–12:37</i>	<i>11:41–12:41</i>	2.15	3.88	5.62	300	59	75.83

Figures 17 and 18 supplement the tabulated fire-stage data by presenting expanded time-window plots that capture broader environmental conditions surrounding the Level 9 and Level 6 fire tests. These figures provide weather trends during the fire test periods and during the days immediately before and after each test, providing context for daytime wind, temperature, and humidity variability beyond the discrete fire test days.

Appendix F demonstrates strong agreement among the weather station data before, during, and after the fire tests, supporting the reliability of the fire test dataset. Throughout the fire testing period, temperature trends at the on-site units closely track those observed at Elliott Station, indicating that localized fire activity did not measurably influence ambient atmospheric readings. On both fire test days, morning temperatures began in the low 60 °F range and increased steadily to peak in the high 80 °F range by the afternoon. Relative humidity exhibited a consistent inverse pattern, starting in the mid-80 % range during the morning hours and decreasing to approximately 50 % by the end of the day. Wind speeds remained similarly stable across all stations, with daily maximum values consistently near 10 mph. Comparable daily trends are also observed on the day preceding each fire test and during the two days following, confirming that these conditions reflect normal environmental behavior rather than test-induced disturbances. The consistency of weather patterns across stations and across multiple days confirms that the recorded environmental data are representative of true ambient conditions, supporting the conclusion that the fire tests did not bias the instrumentation or weather measurements used in subsequent analyses.

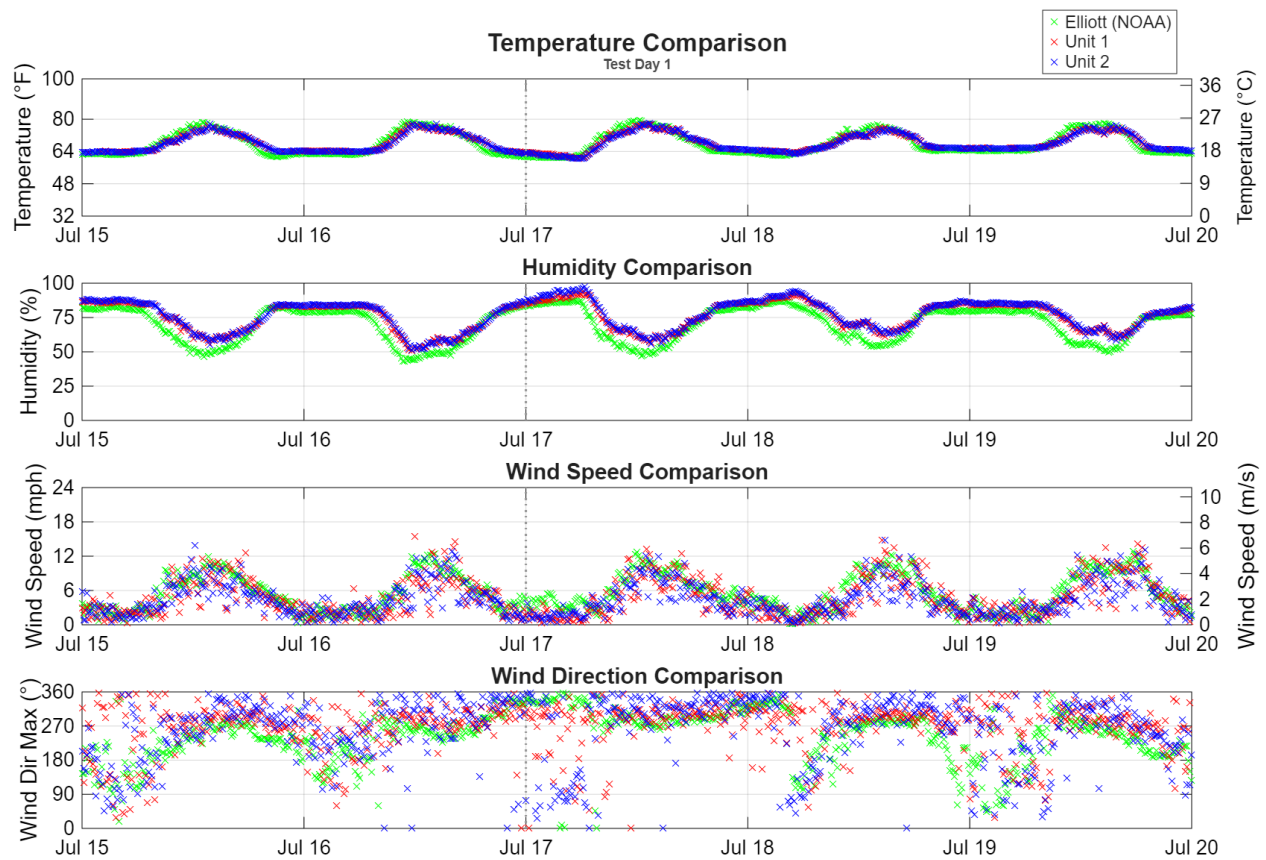


Figure 17: Weather station data during L9 live fire testing on July 17, 2025. (Test performed from approximately 09:00 –12:00).

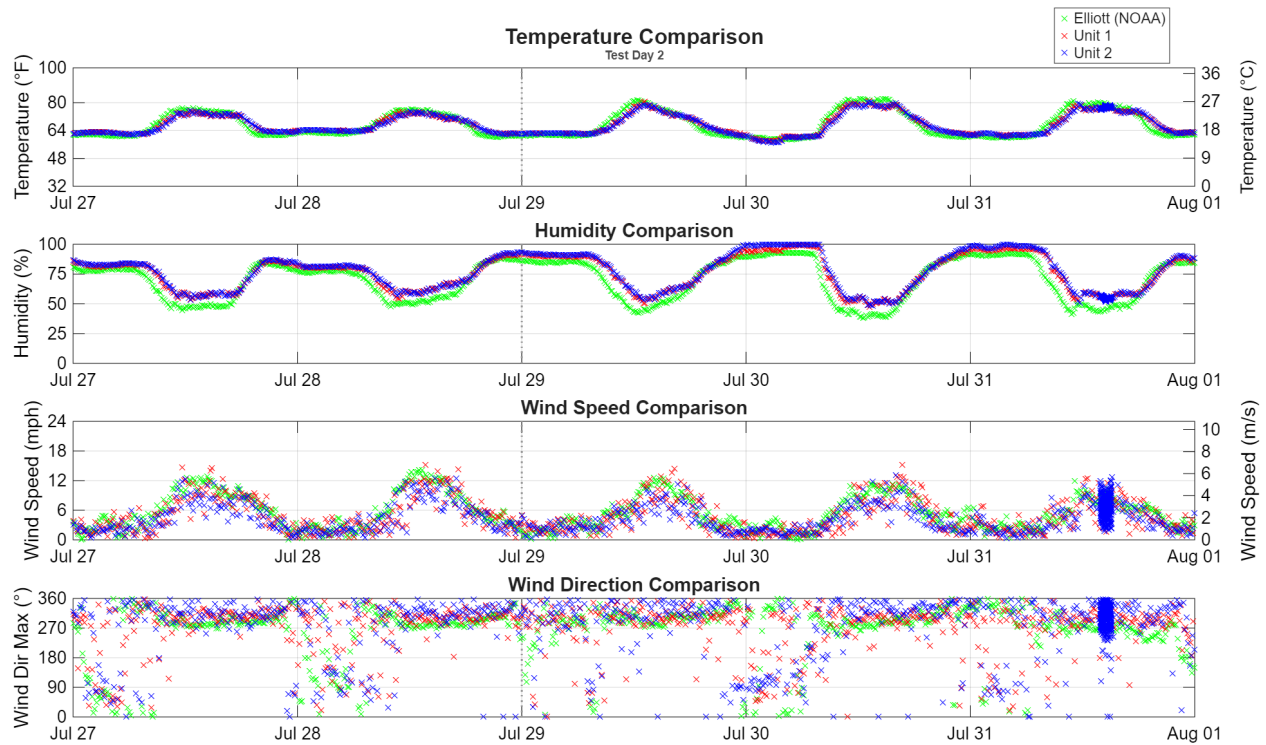


Figure 18: Weather station data during L6 live fire testing on July 29, 2025. (Test performed approximately from 09:00–12:00). Note: On July 31, Unit 2 switched to 10-second sampling from 14:10–15:20.

Overall, weather trends during the Level 6 and Level 9 fire tests showed similar weather conditions. The Level 9 test, conducted on July 17, experienced warmer and drier conditions with moderate wind speeds averaging around 8-10 mph, while the Level 6 test on July 29 occurred under slightly cooler and more humid conditions. Understanding these environmental distinctions is important for contextualizing thermal and structural data, ensuring that fire performance assessments accurately reflects real-world variability.

4 Concluding Remarks

This report compiles and cross-compares three weather measurement streams (Elliott Station, LHPOST6 Unit 1, and LHPOST6 Unit 2) to quantify wind speed, wind direction, temperature, and relative humidity during the construction-period, the seismic testing sequence, and post-earthquake live fire tests. Agreement was observed across all stations, with an average difference in temperature of 2-4°F and humidity levels within 1-2%, while wind direction patterns remained consistent across all three stations despite differences in elevation and sensor placement. Real time weather monitoring provided highly useful data during testing: directly supporting operational decision making regarding the postponement of the L6 module lift due to peak wind speeds. Moreover, early data collection of local weather conditions guided timing for the planned live fire testing - an essential safety support element. Collectively, these results confirm that the deployed weather stations reliably captured ambient atmospheric conditions during the CFS10 program and establish a defensible environmental baseline for interpreting vibration-based measurements, distinguishing environmental effects from true structural response, and supporting future system identification and structural health monitoring research using this landmark dataset. It is noted that digital CSV data files from each of the sensors for all timelines available are archived with the present report.

References

- [1] UC Natural Reserve System. Dendra Science. Retrieved Aug 25, 2025. <https://dendra.science/orgs/ucnrs/>.
- [2] Vaisala Oyj. Vaisala Weather Transmitter WXT530 Series User Guide. Retrieved Sep 2, 2025. <https://docs.vaisala.com/r/M211840EN-G/en-US>.
- [3] D. Rivera. Advancing Cold-Formed Steel Modular Construction for Tall Building Systems. Master's thesis, University of California San Diego, 2026.
- [4] J. Zhang, S. Sorosh, A. Singh, B. W. Schafer, and T. C. Hutchinson. Evolution of Modal Characteristics and Model Comparison for a 10-Story Cold-Formed Steel Framed Building under Seismic Excitation. In *Proceedings of the 44th International Modal Analysis Conference (IMAC-XLIV)*, Palm Springs, CA, 2026.
- [5] Y. Niu, R. Emberley, T. Hutchinson, B. Schafer, B. Meacham, and T. Gernay. Thermal modeling of post-earthquake fire tests on a 10-story cold-formed steel building. In *Proceedings of the 15th International Symposium on Fire Safety Science*, La Rochelle, France, 2026.

Appendix A: Module Lift Plots

Appendix A presents weather conditions at Elliott Station during the module lifts. The plots display temperature, relative humidity, and wind speed over time, with dashed vertical lines marking the start and end of lifting operations. To read these graphs, the top plot shows temperature, with Fahrenheit values referenced along the left y-axis and Celsius on the right y-axis, allowing interpretation in either unit. The middle plot shows relative humidity (%), which indicates the amount of moisture in the air at each timestamp. The bottom plot shows wind speed, with mph referenced along the left axis and m/s on the right, and directional arrows indicating the wind direction—arrows pointing upward represent north, downward south, right east, and left west. During Level 9 and Level 10 module lift, Unit 1 data, indicated in red, was added to graphs. These plots help evaluate whether changing weather conditions influenced lift safety and performance.

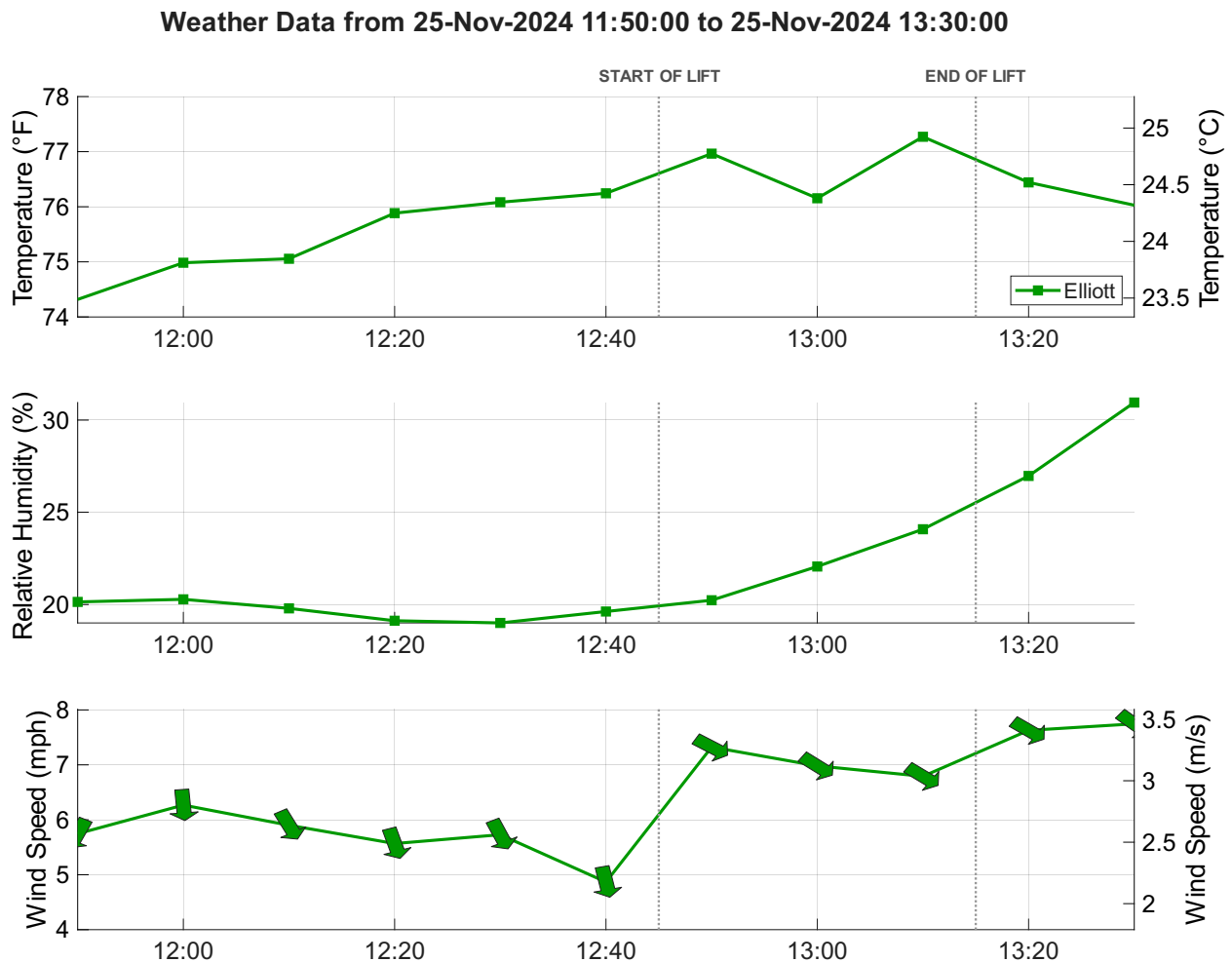


Figure 19: Weather station data during Level 2 module lift.

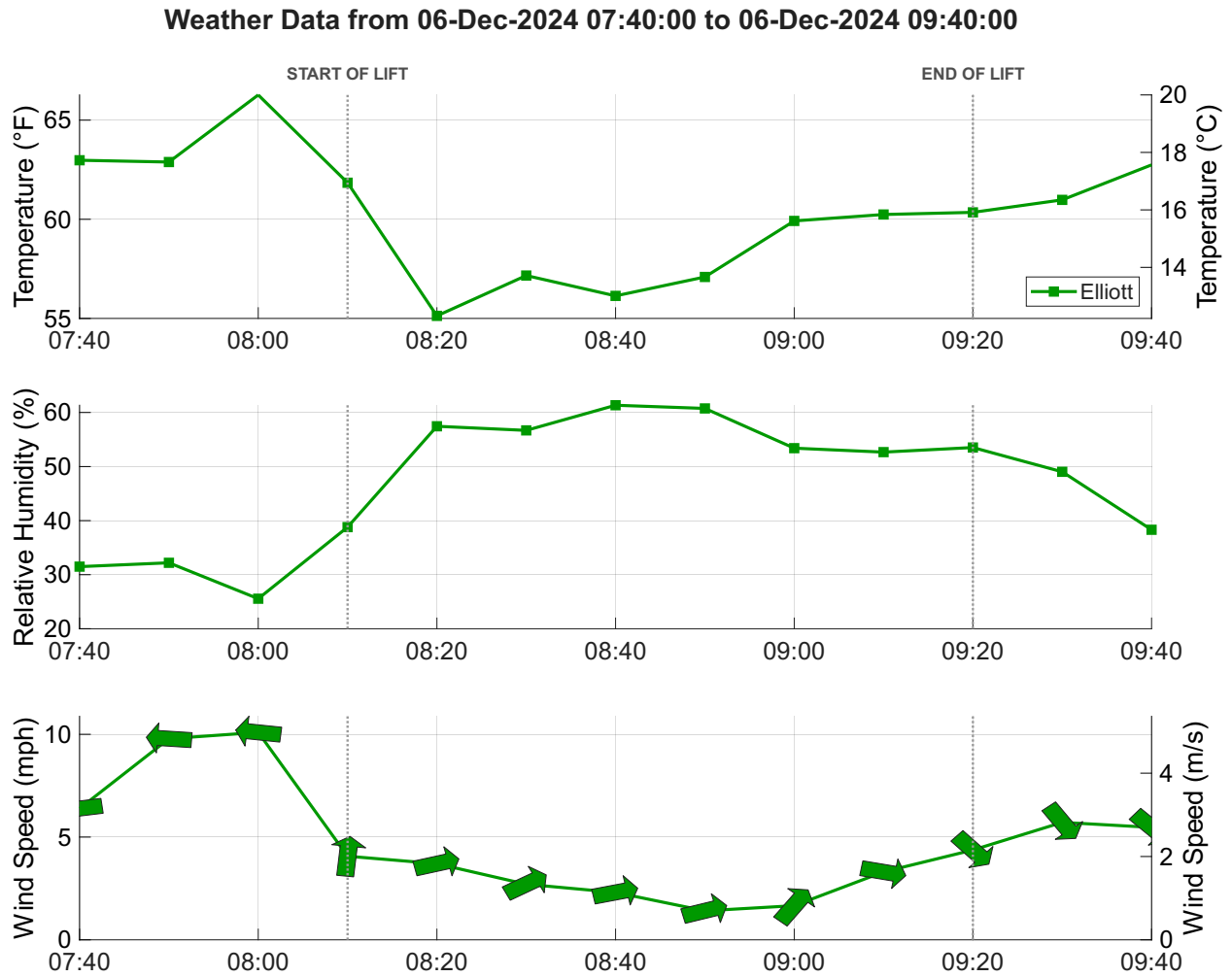


Figure 20: Weather station data during Level 3 module lift.

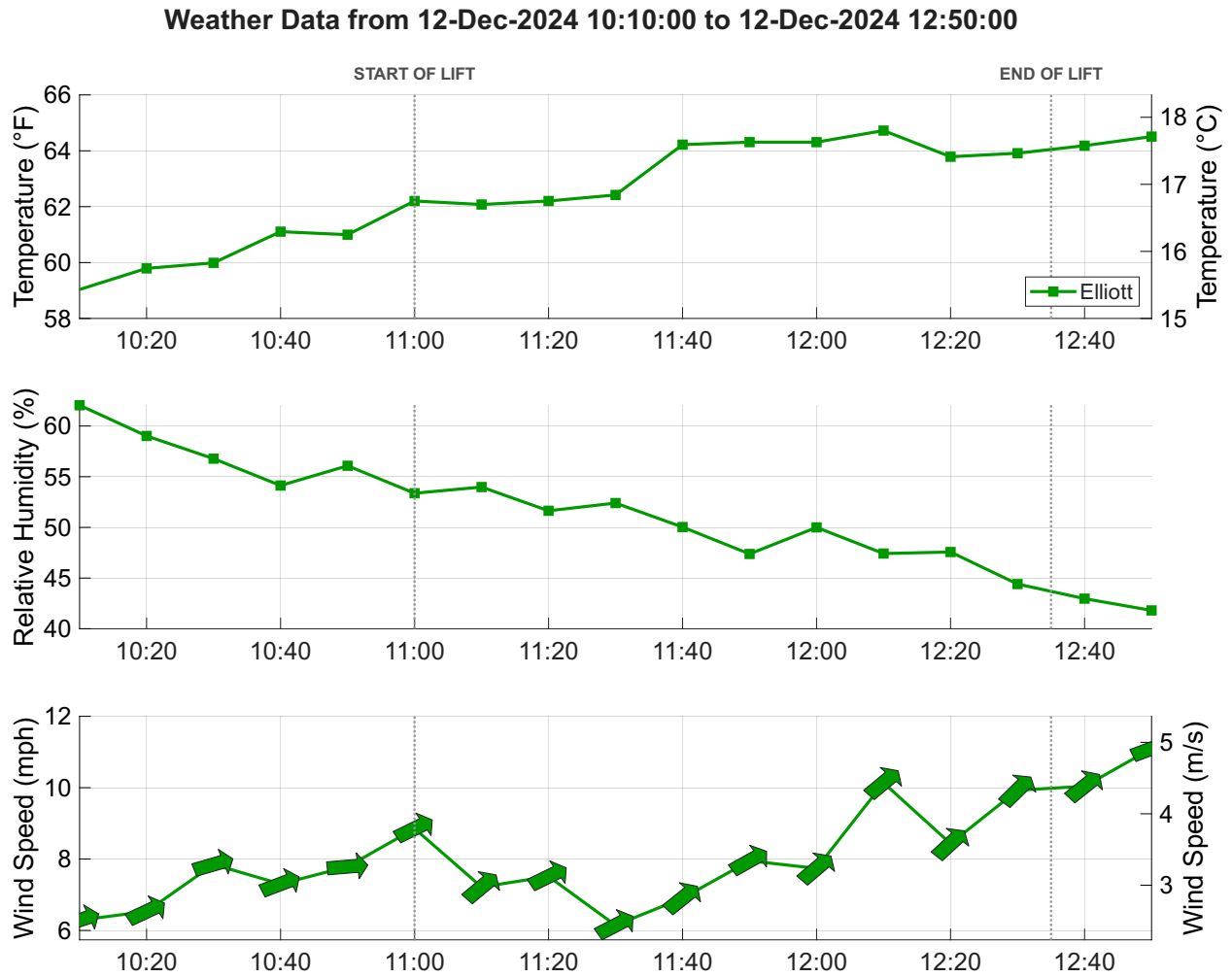


Figure 21: Weather station data during Level 4 module lift.

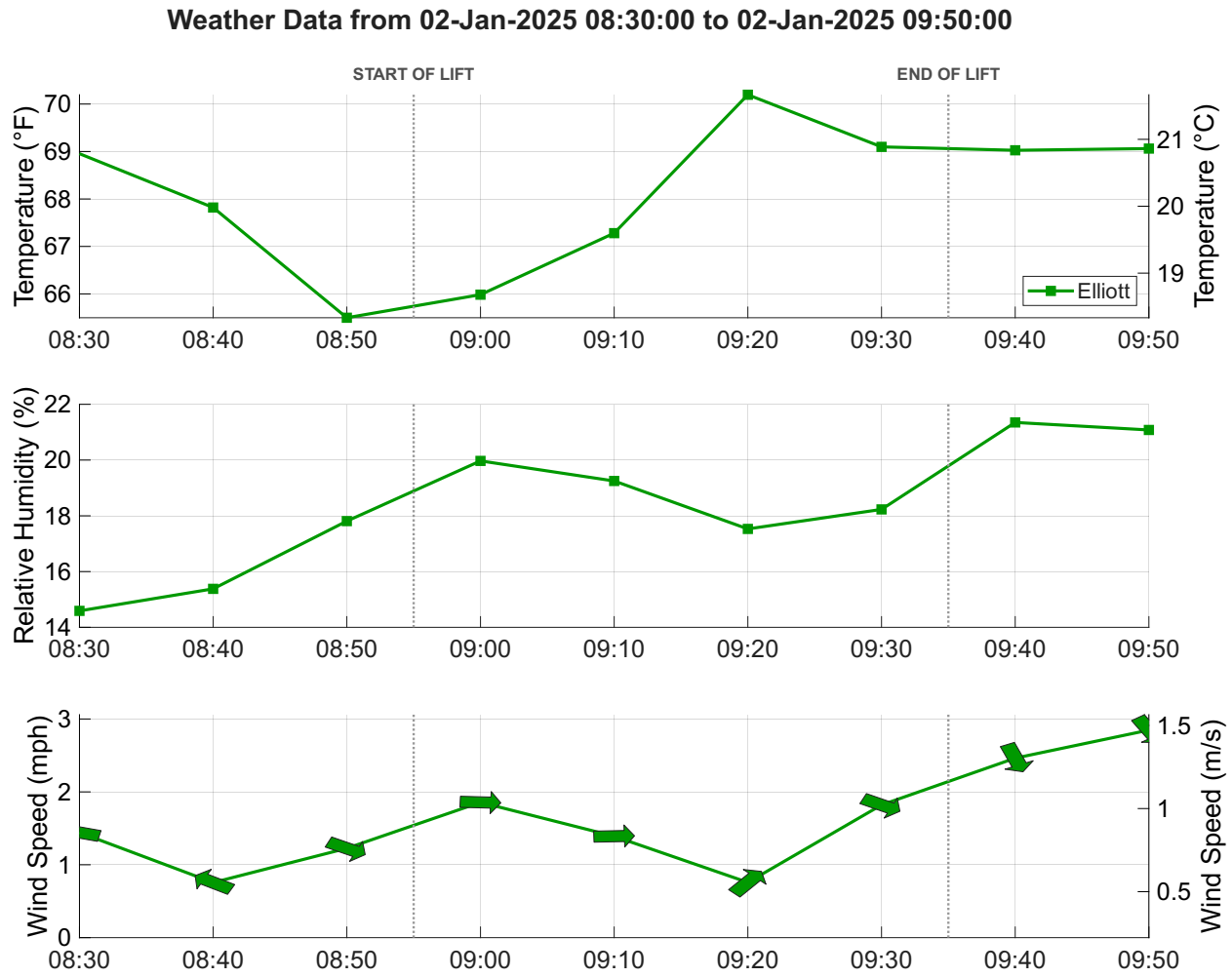


Figure 22: Weather station data during Level 5 module lift.

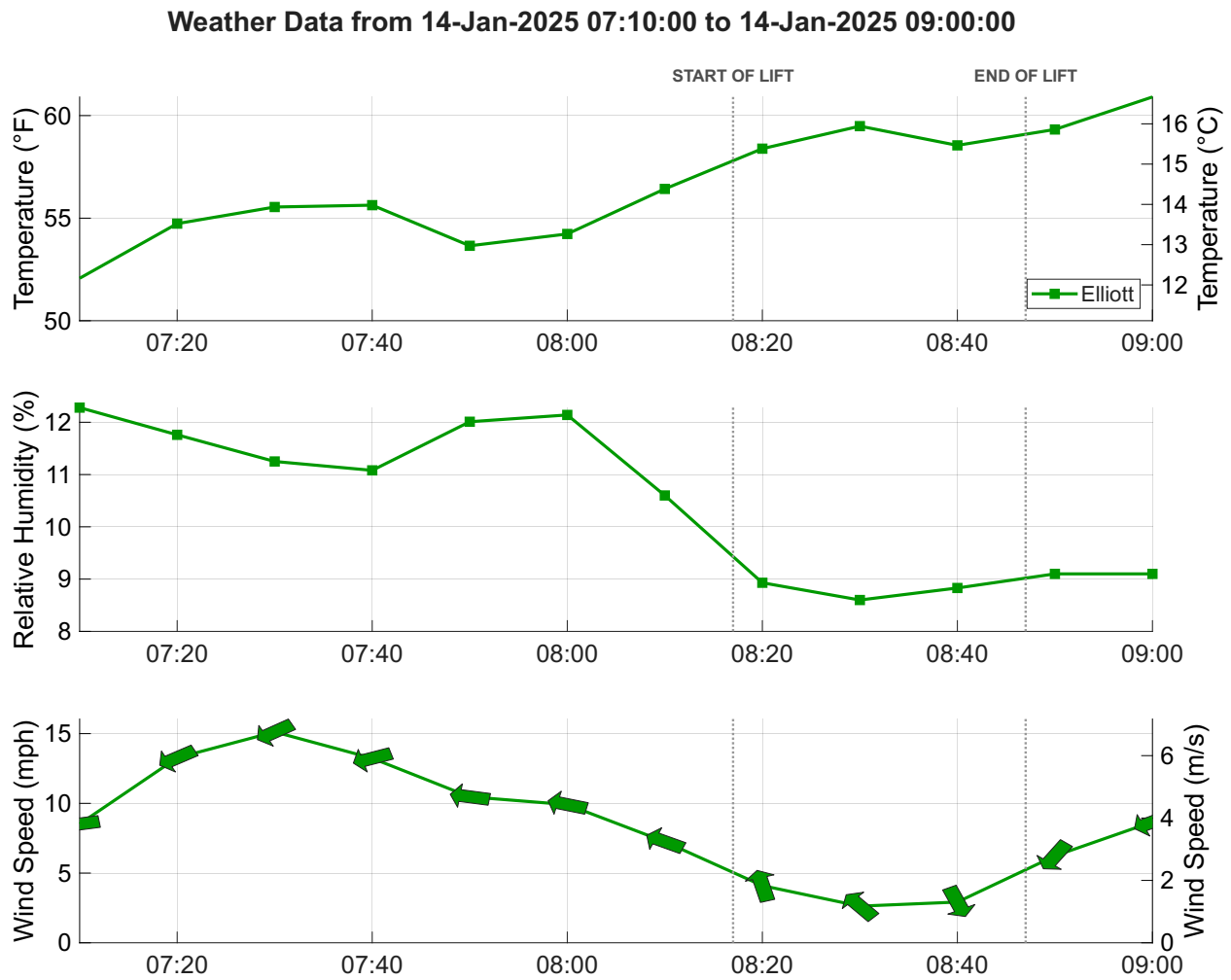


Figure 23: Weather station data during Level 7 module lift.

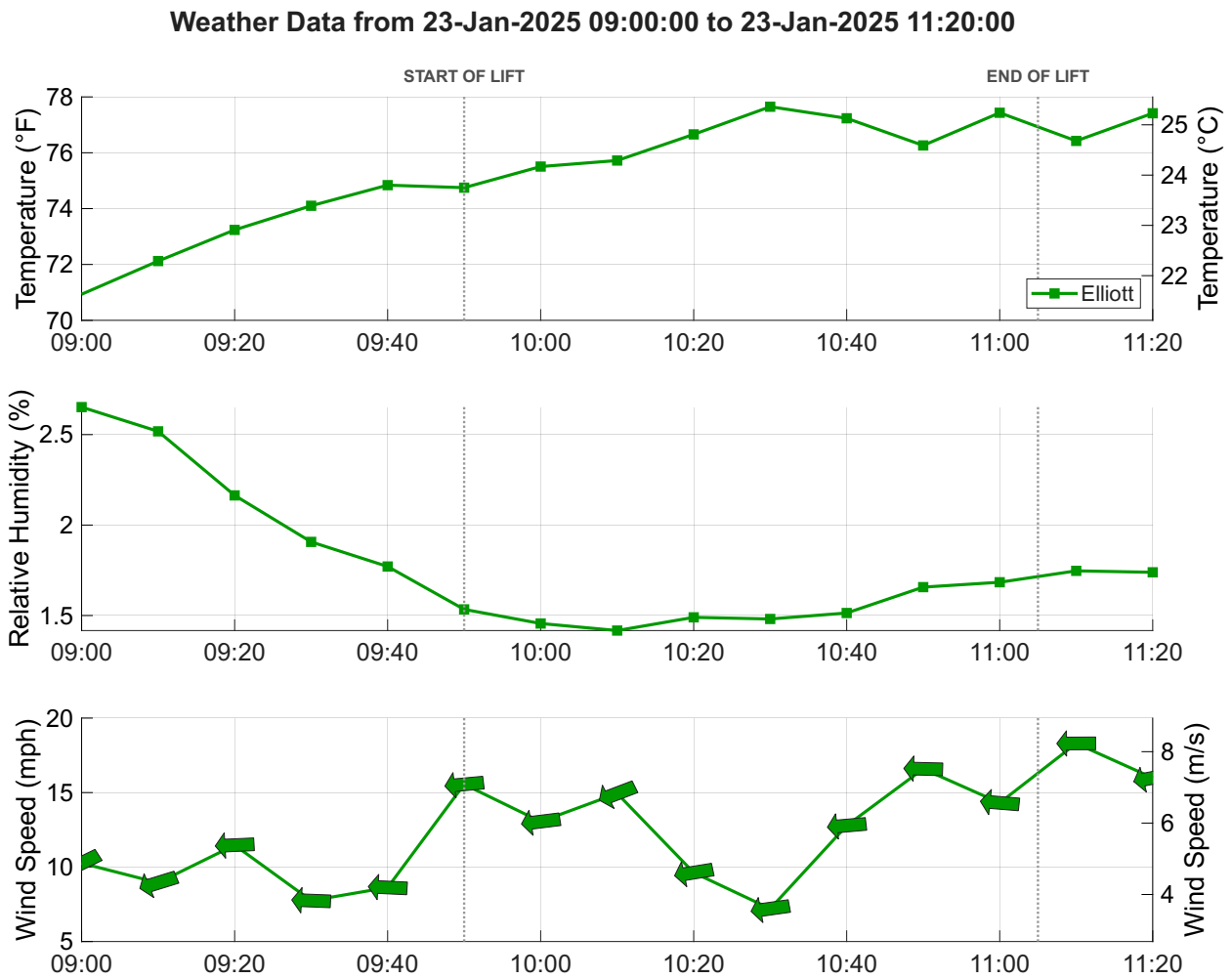


Figure 24: Weather station data during Level 8 module lift.

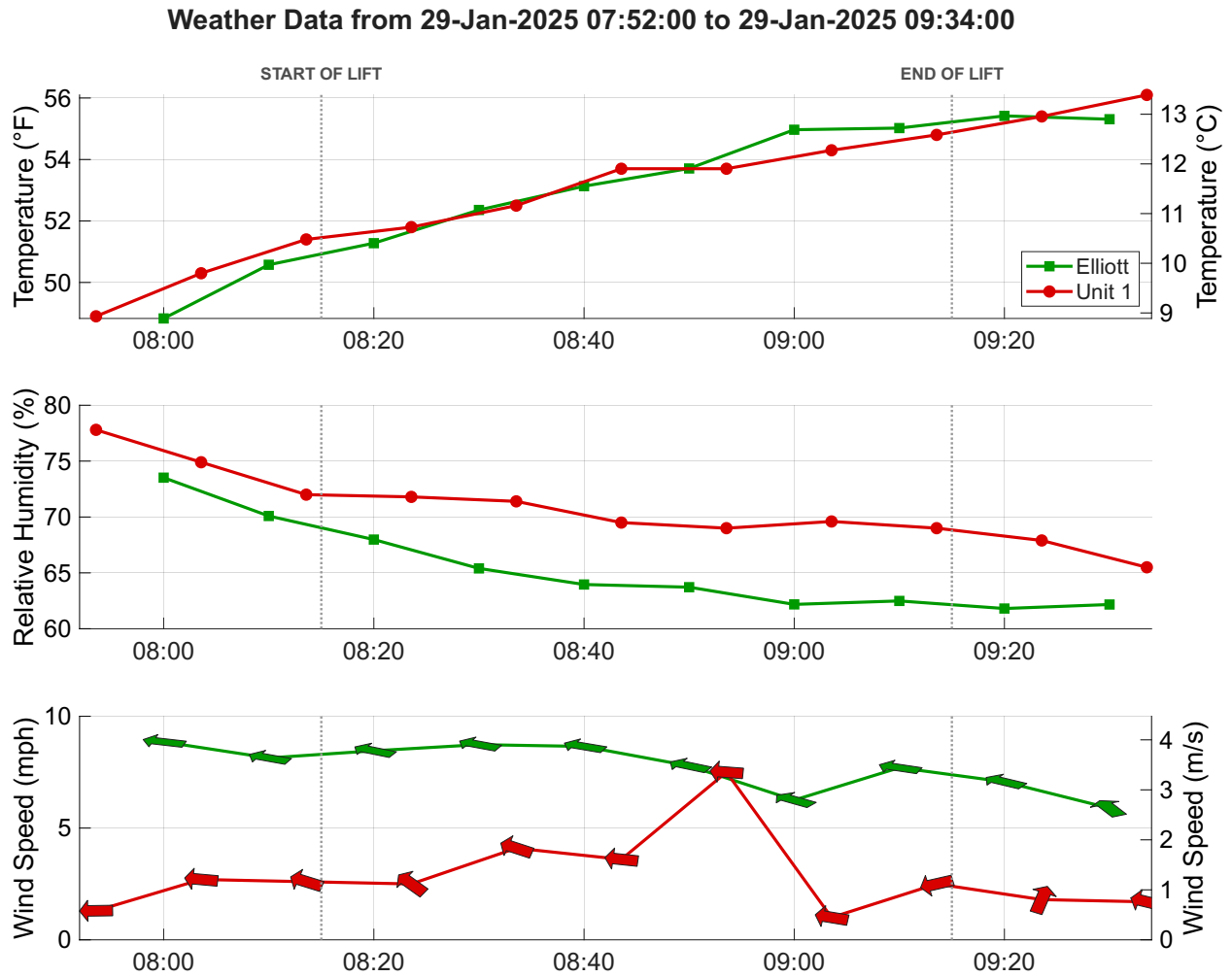


Figure 25: Weather station data during Level 9 module lift.

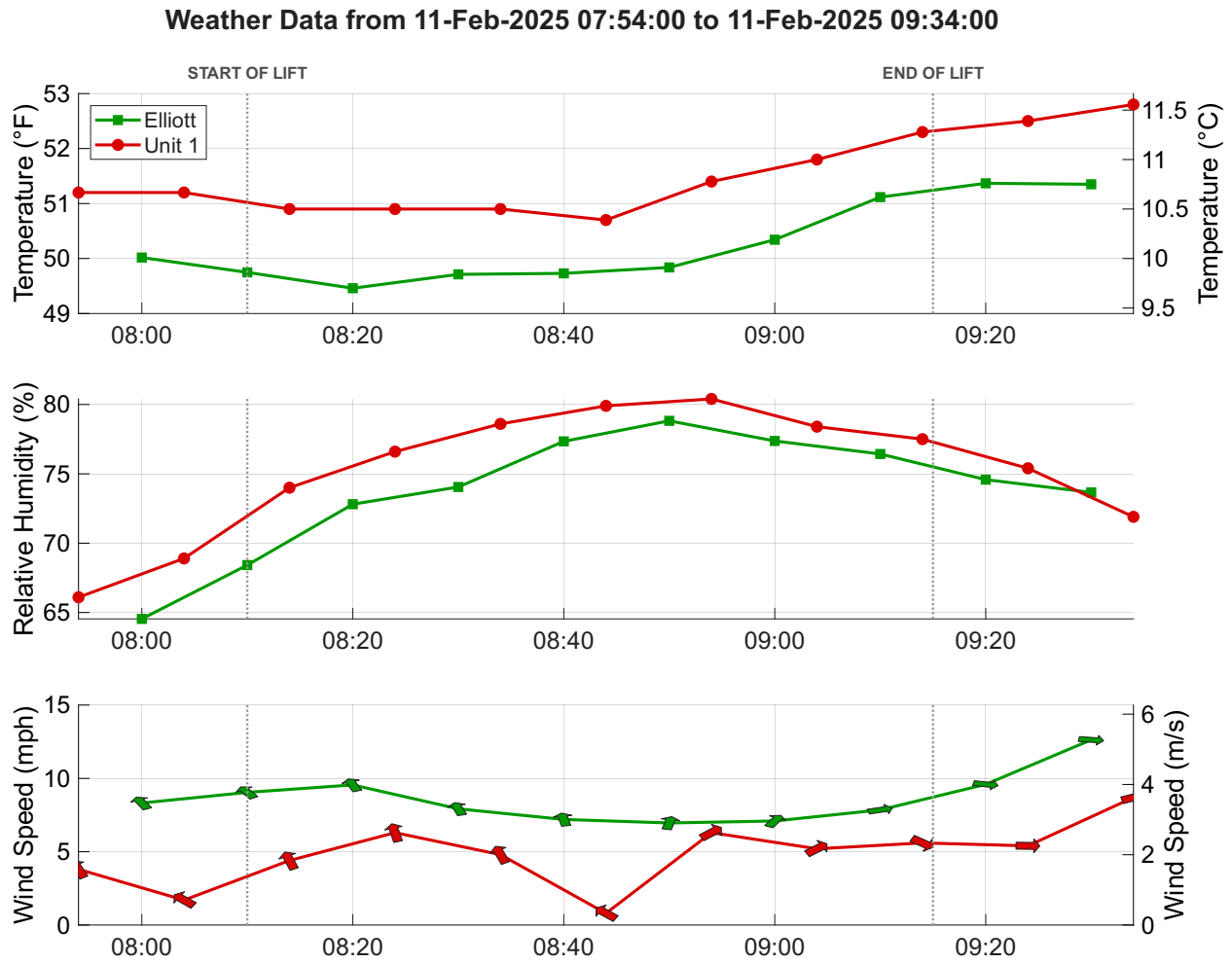


Figure 26: Weather station data during Level 10 module lift.

Appendix B: Seismic Testing Plots

Appendix B shows weather data collected simultaneously from Elliott Station (green), Unit 1 (red), and Unit 2 (blue) during seismic testing, with dashed markers identifying when and what seismic simulation occurred. In the top graph, temperature is plotted in Fahrenheit on the left axis and Celsius on the right, allowing direct comparison between monitoring sources. The second graph indicates relative humidity (%) over time, and the third shows wind speed with mph on the left axis and m/s on the right, with directional arrows illustrating the angle from which the wind was approaching—again interpreted using cardinal directions where upward represent north, downward south, pointing right east, and pointing left west. By comparing all three sensors in one plot, these figures highlight spatial variation in weather conditions across the testing area during active shaking events.

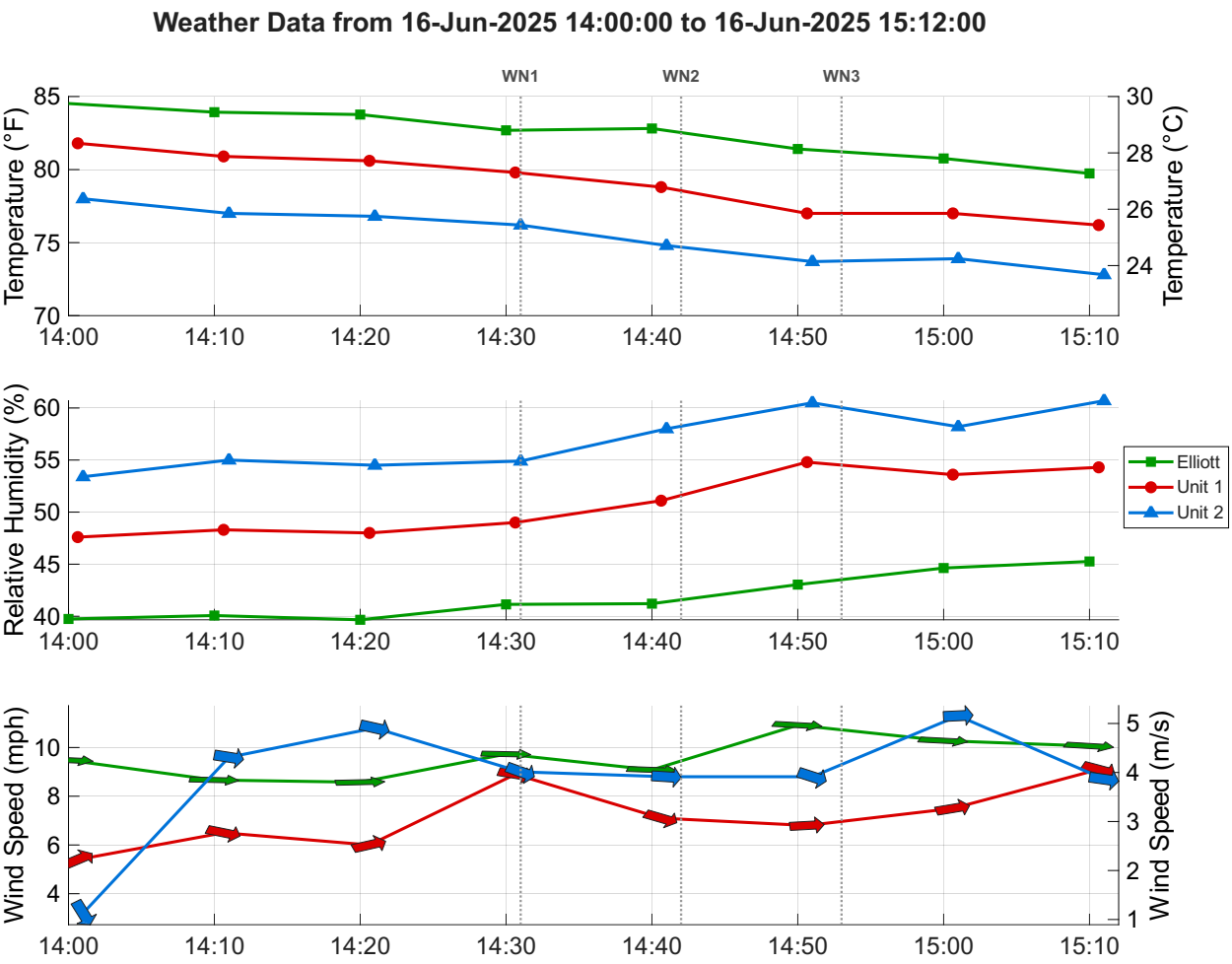


Figure 27: Weather station data for seismic testing day 1.

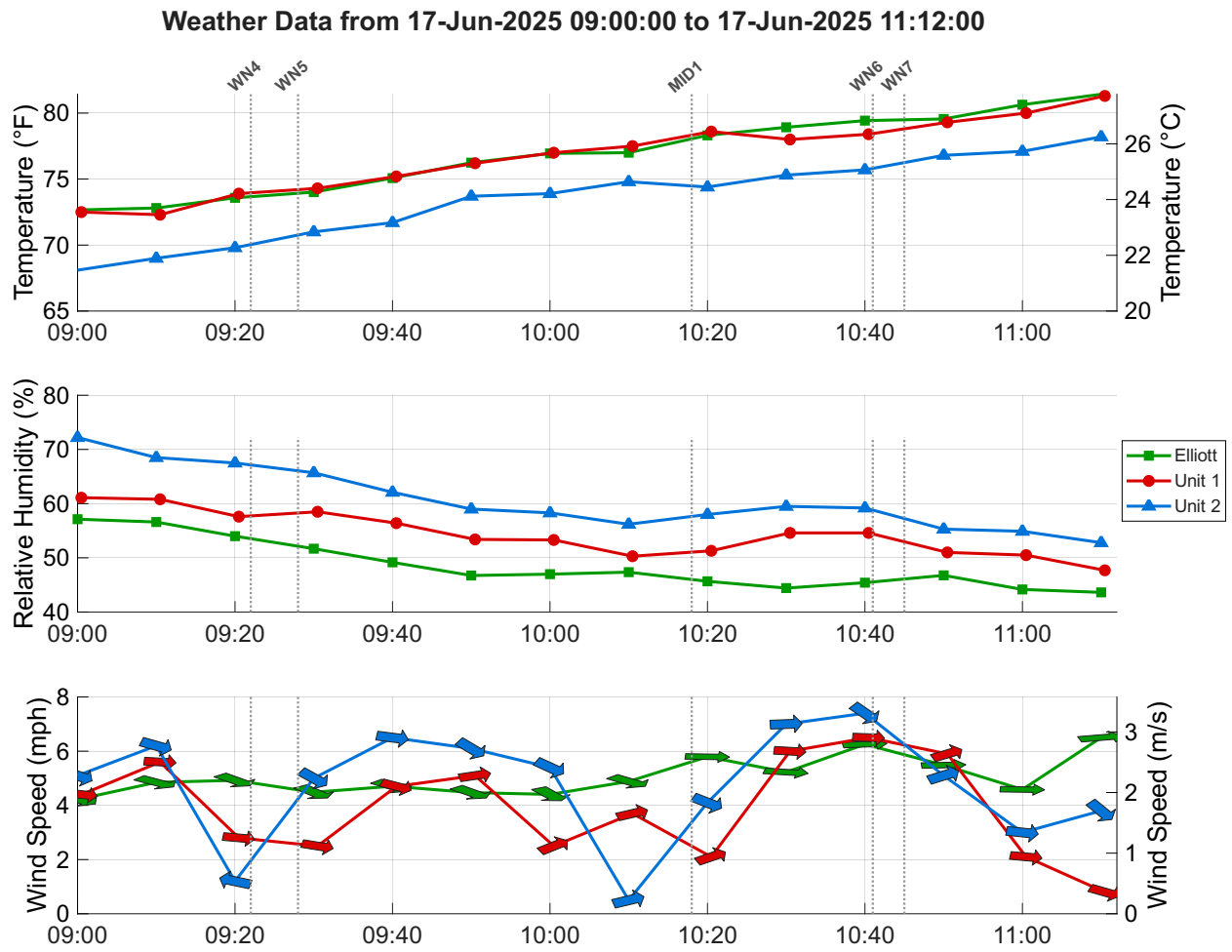


Figure 28: Weather station data for seismic testing day 2.

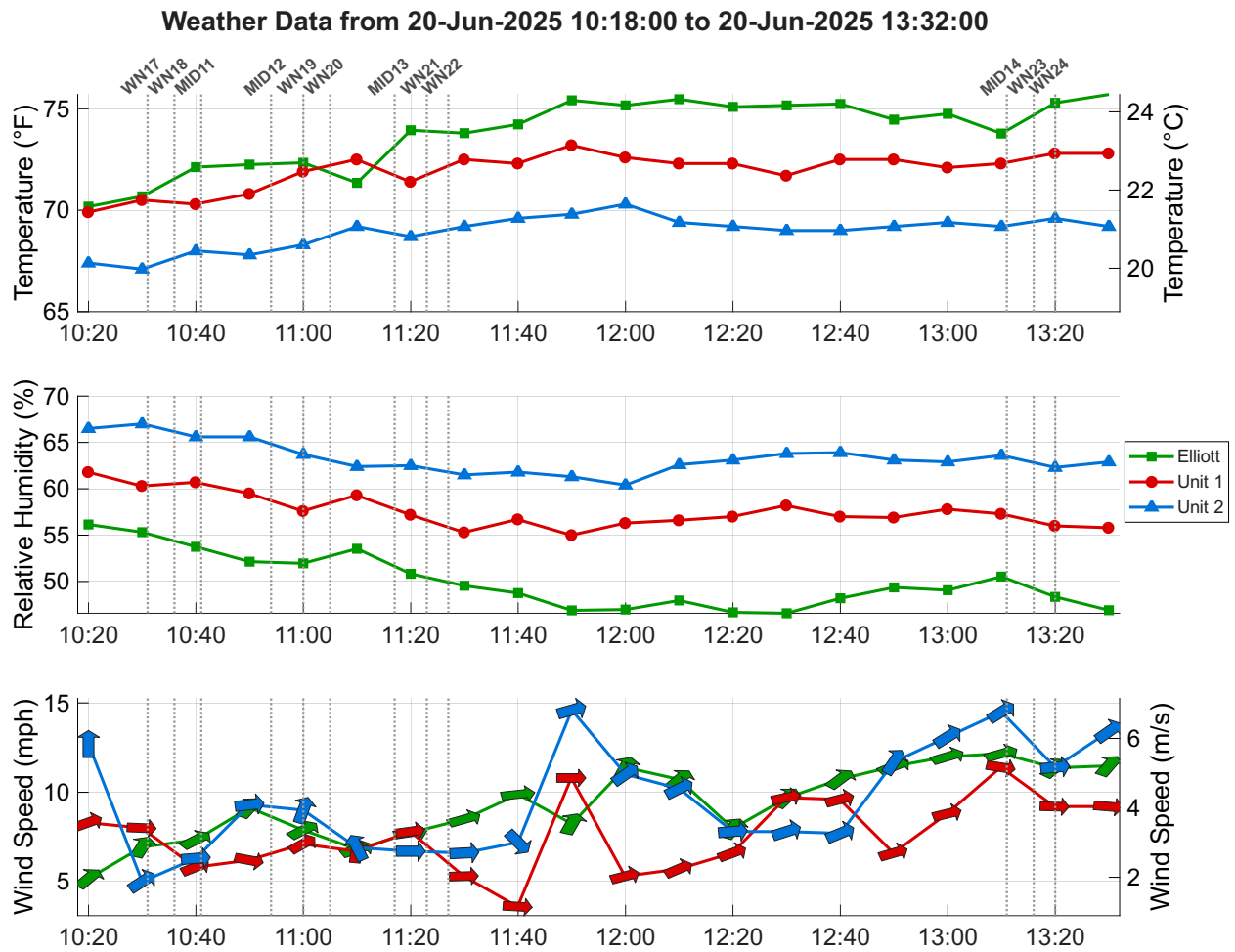


Figure 29: Weather station data for seismic testing day 4.

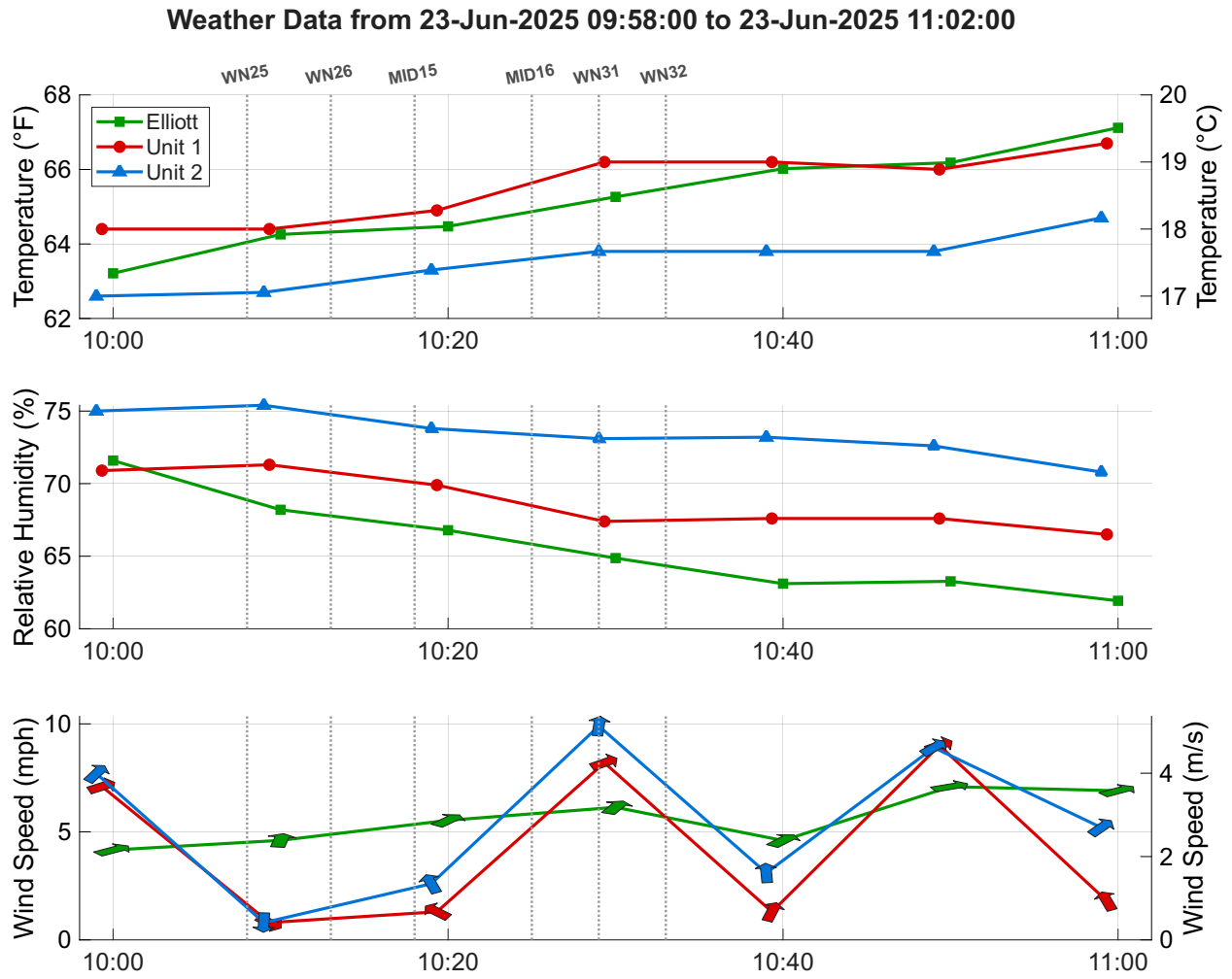


Figure 30: Weather station data for seismic testing day 5.

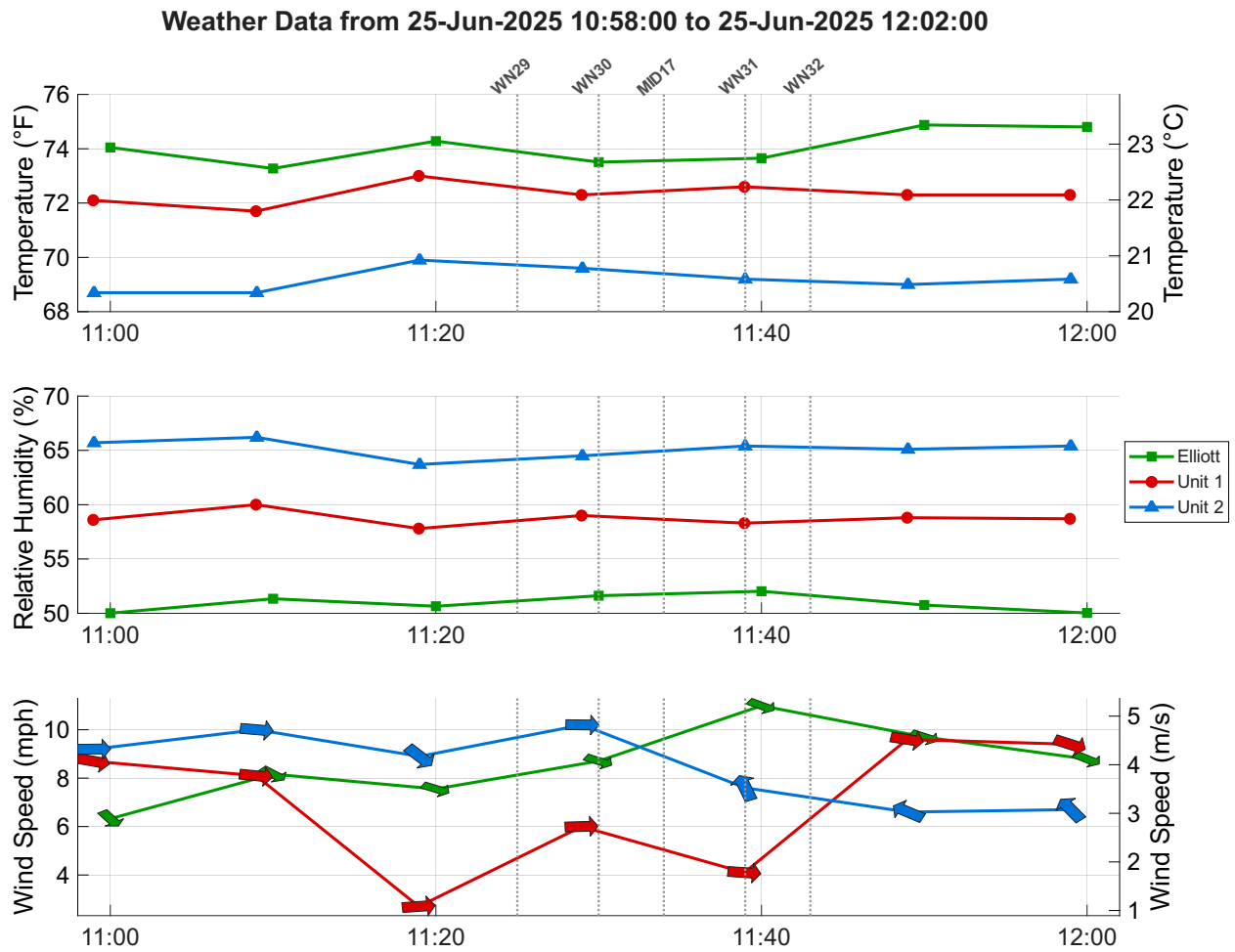


Figure 31: Weather station data for seismic testing day 6.

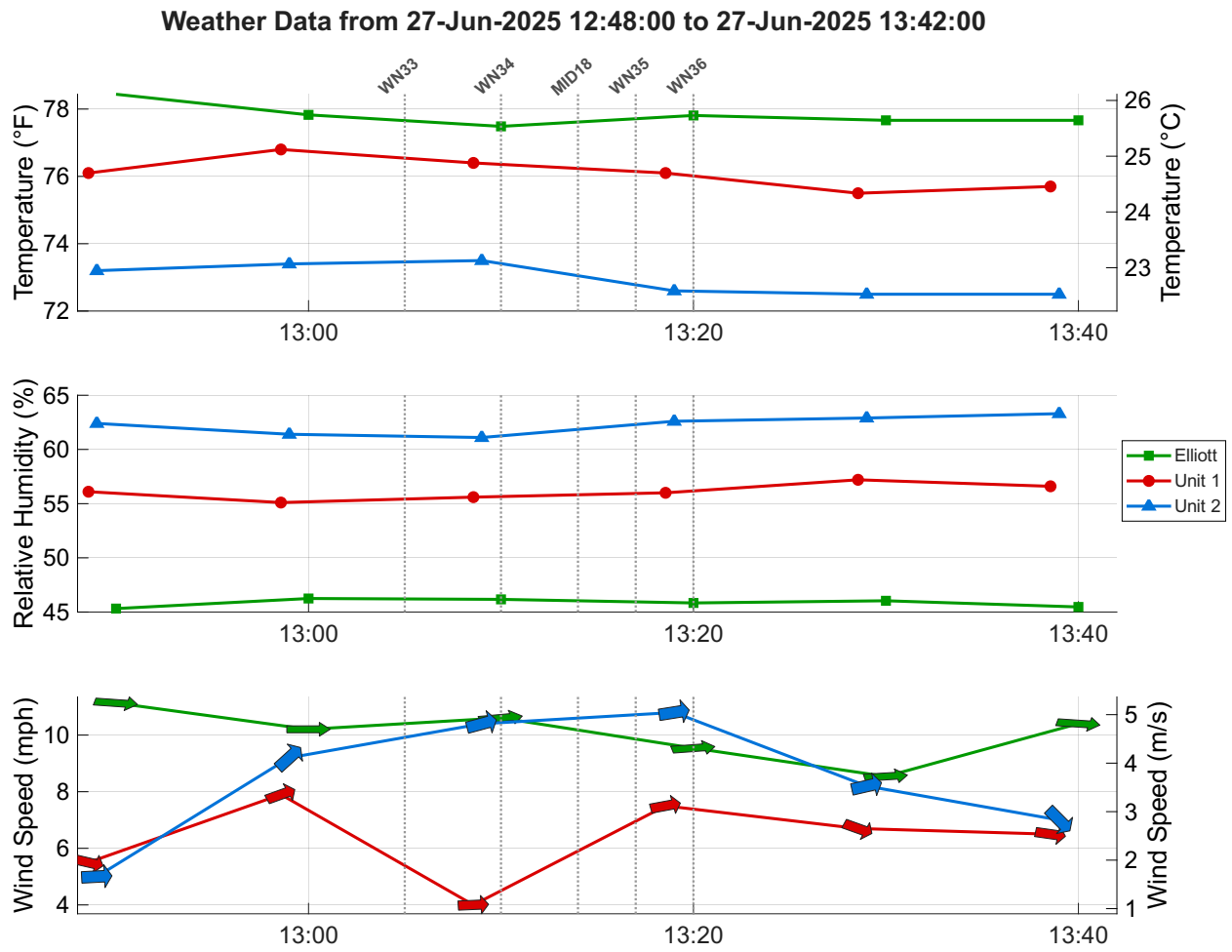


Figure 32: Weather station data for seismic testing day 7.

Appendix C: Post-Seismic Live Fire Testing Plots

Appendix C provides post-seismic live fire test weather trends, recorded across Elliott Station (green), Unit 1 (red), and Unit 2 (blue). Vertical reference lines mark Ignition, Flashover, End of Heating Phase, and End of Test, enabling correlation of environmental changes with fire progression. The top plot presents temperature in Fahrenheit (left axis) and Celsius (right axis), the middle plot shows relative humidity percentages, and the bottom plot displays wind speed with mph on the left axis and m/s on the right. Wind direction arrows indicate the orientation of the wind at each moment—arrows oriented upward represent north, downward south, pointing right east, and pointing left west, allowing interpretation of cross-winds and gust patterns that can affect fire behavior and sensor reliability. Together, these graphs provide critical insight into real time weather influences on fire dynamics and CFS10 system response.

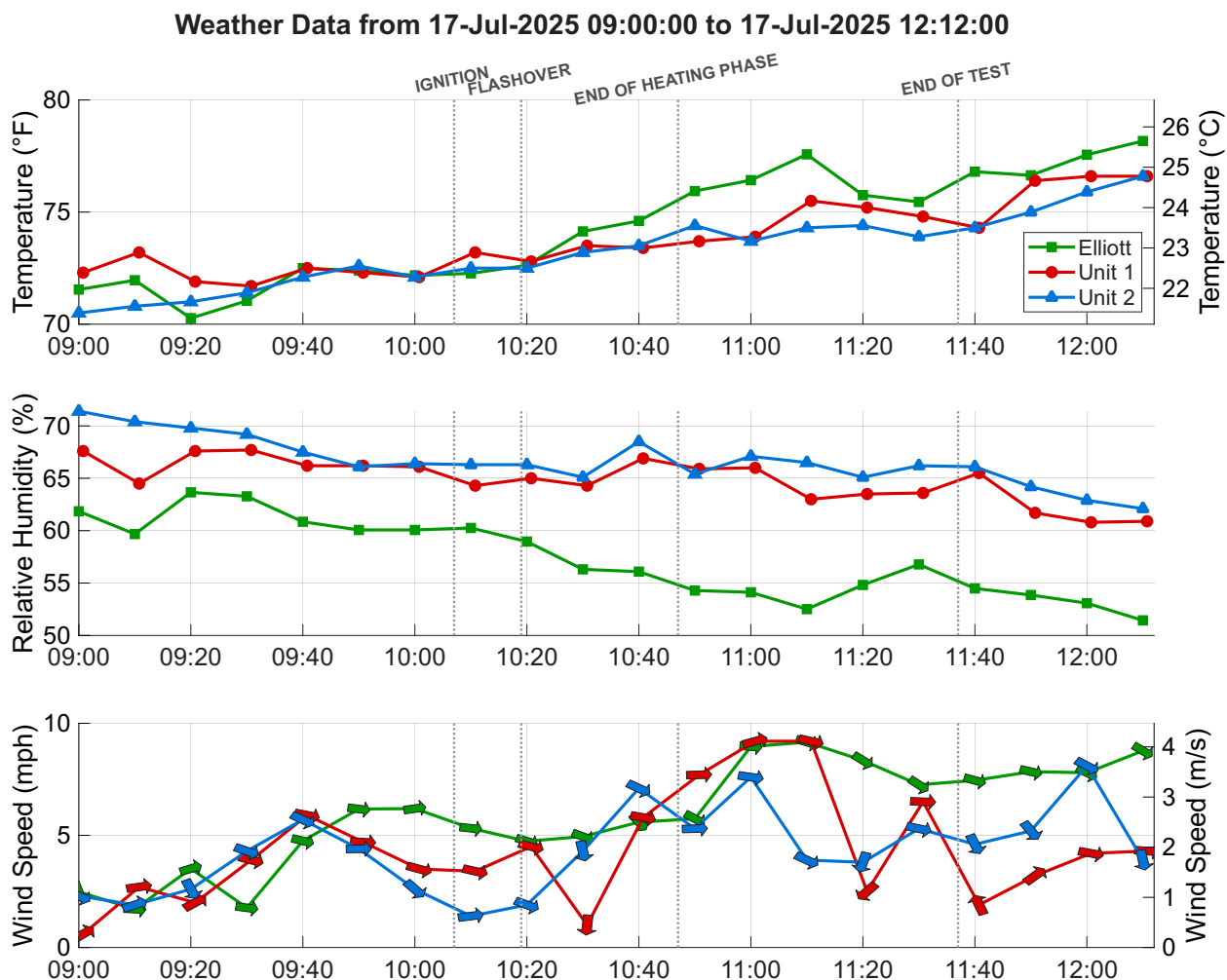


Figure 33: Temperature, humidity, wind speed, and wind direction level 9 fire.

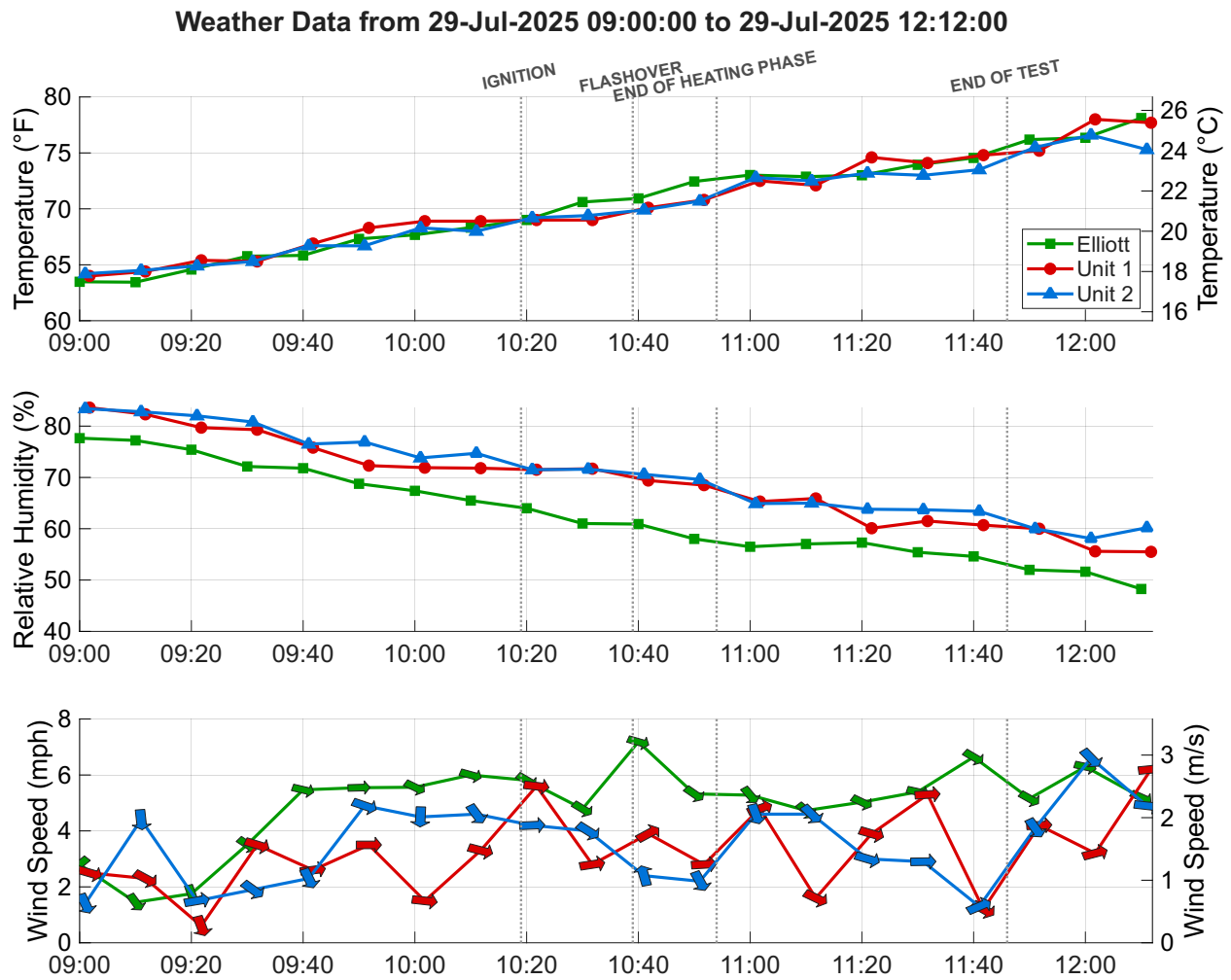


Figure 34: Temperature, humidity, wind speed, and wind direction level 6 fire.

Appendix D: Vaisala Weather Unit Data

Technical data

Barometric pressure measurement performance

Observation range	500 ... 1100 hPa
Accuracy (for sensor element) at 600 ... 1100 hPa	±0.5 hPa at 0 ... +30 °C (+32 ... +86 °F) ±1 hPa at -52 ... +60 °C (-60 ... +140 °F)
Output resolution	0.1 hPa / 10 Pa / 0.001 bar / 0.1 mmHg / 0.01 inHg

Air temperature measurement performance

Observation range	-52 ... +60 °C (-60 ... +140 °F)
Accuracy (for sensor element) at +20 °C (+68 °F)	±0.3 °C (±0.54 °F)
Output resolution	0.1 °C (0.1 °F)

Relative humidity measurement performance

Observation range	0 ... 100 %RH
Accuracy (for sensor element)	±3 %RH at 0 ... 90 %RH ±5 %RH at 90 ... 100 %RH
Output resolution	0.1 %RH

Wind measurement performance

Wind speed	
Observation range	0 ... 60 m/s (134 mph)
Reporting range	0 ... 75 m/s (168 mph)
Response time	0.25 s
Available variables	Average, maximum, and minimum
Accuracy	±3 % at 10 m/s (22 mph)
Output resolution	0.1 m/s (km/h, mph, knots)
Wind direction	
Azimuth	0 ... 360°
Response time	0.25 s
Available variables	Average, maximum, and minimum
Accuracy	±3.0° at 10 m/s (22 mph)
Output resolution	1°
Averaging time	1 ... 3600 s, sample rate 1, 2, or 4 Hz (configurable)

Mechanical specifications

Weight	
WXT534, WXT535, WXT536	0.7 kg (1.54 lb)
WXT531, WXT532, WXT533	0.5 kg (1.1 lb)

Operating environment

Operating environment	Outdoor use
Operating temperature	-52 ... +60 °C (-60 ... +140 °F)
Storage temperature	-60 ... +70 °C (-76 ... +158 °F)
Operating humidity	0 ... 100 %RH
Operating pressure	500 ... 1100 hPa
Wind ¹⁾	0 ... 60 m/s (0 ... 134 mph)
IP rating	Without mounting kit: IP65 With mounting kit: IP66

¹⁾ Due to the measurement frequency used in the sonic transducers, RF interference in the 200 ... 400 kHz range can disturb wind measurement.

Precipitation measurement performance

Collecting area	60 cm ² (9.3 in ²)
Rainfall ¹⁾	
Output resolution	0.01 mm (0.001 in)
Field accuracy for daily accumulation	Better than 5 %, weather-dependent
Duration	Counting each 10-second increment whenever droplet detected
Duration output resolution	10 s
Intensity	Running 1-minute average, 10 s steps
Intensity observation range	0 ... 200 mm/h (0 ... 7.87 in/h) (broader with reduced accuracy)
Intensity output resolution	0.1 mm/h (0.01 in/h)
Hail ²⁾	
Output resolution	0.1 hits/cm ² (1 hits/in ²), 1 hit
Intensity output resolution	0.1 hits/cm ² h (1 hits/in ² h), 1 hit/h

¹⁾ Cumulative accumulation after the latest automatic or manual reset.
²⁾ Cumulative number of hits against collecting surface.

Inputs and outputs

Operating voltage	6 ... 24 V DC (-10 ... +30 %)
Average power consumption	Minimum: 0.1 mA at 12 V DC (SDI-12 standby) Typical: 3.5 mA at 12 V DC (typical measuring intervals) Maximum: 15 mA at 6 V DC (constant measurement of all parameters)
Heating voltage	DC, AC, or full-wave rectified AC 12 ... 24 V DC (-10 ... +30 %) 12 ... 17 V AC _{rms} (-10 ... +30 %)
Typical heating current	12 V DC: 800 mA, 24 V DC: 400 mA
Digital outputs	SDI-12, RS-232, RS-485, RS-422
Communication protocols	SDI-12 v1.3, Modbus RTU, ASCII automatic and polled, NMEA 0183 v3.0 with query option

WXT536 analog input options

Solar radiation	0 ... 25 mV
Voltage input	0 ... 2.5 V, 0 ... 5 V, 0 ... 10 V
Tipping bucket rain gauge	0 ... 100 Hz
Temperature (Pt1000)	800 ... 1330 Ω

WXT532 analog mA output options

When the analog output option is applied, digital communication is not available.

Wind speed	0 ... 20 mA or 4 ... 20 mA
Wind direction	0 ... 20 mA or 4 ... 20 mA

Compliance

EU directives and regulations	EMC, RoHS
EMC compatibility	EN 61326-1, industrial environment CISPR 32 / EN 55032, Class B
Environmental	IEC 60068-2-1, 2, 6, 14, 30, 31, 78 IEC 60529, VDA 621-415
Maritime	IEC 60945 (Exposed) DNV GL Type Examination Certificate No. TAA00000VF
Compliance marks	CE, RCM, RoHS, China RoHS, UKCA

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Figure 35: Vaisala WXT530 data sheet.

Appendix E: Pre & Post Seismic Test Day Data

Appendix E presents weather data collected simultaneously from Elliott Station (green), Unit 1 (red), and Unit 2 (blue) during seismic testing and is formatted identically to the plots shown in Appendix B. The plots depict weather trends over the full duration of each testing day, restricted to the standardized testing window from 9:00 AM to 3:00 PM. Temperature is shown in Fahrenheit on the left axis and Celsius on the right, relative humidity (%) is shown in the second plot, and wind speed is displayed with mph on the left axis and m/s on the right, with directional arrows illustrating the direction from which the wind was approaching using cardinal orientation (up = north, right = east, down = south, left = west). Together, these figures illustrate weather variability across the testing area during active seismic operations.

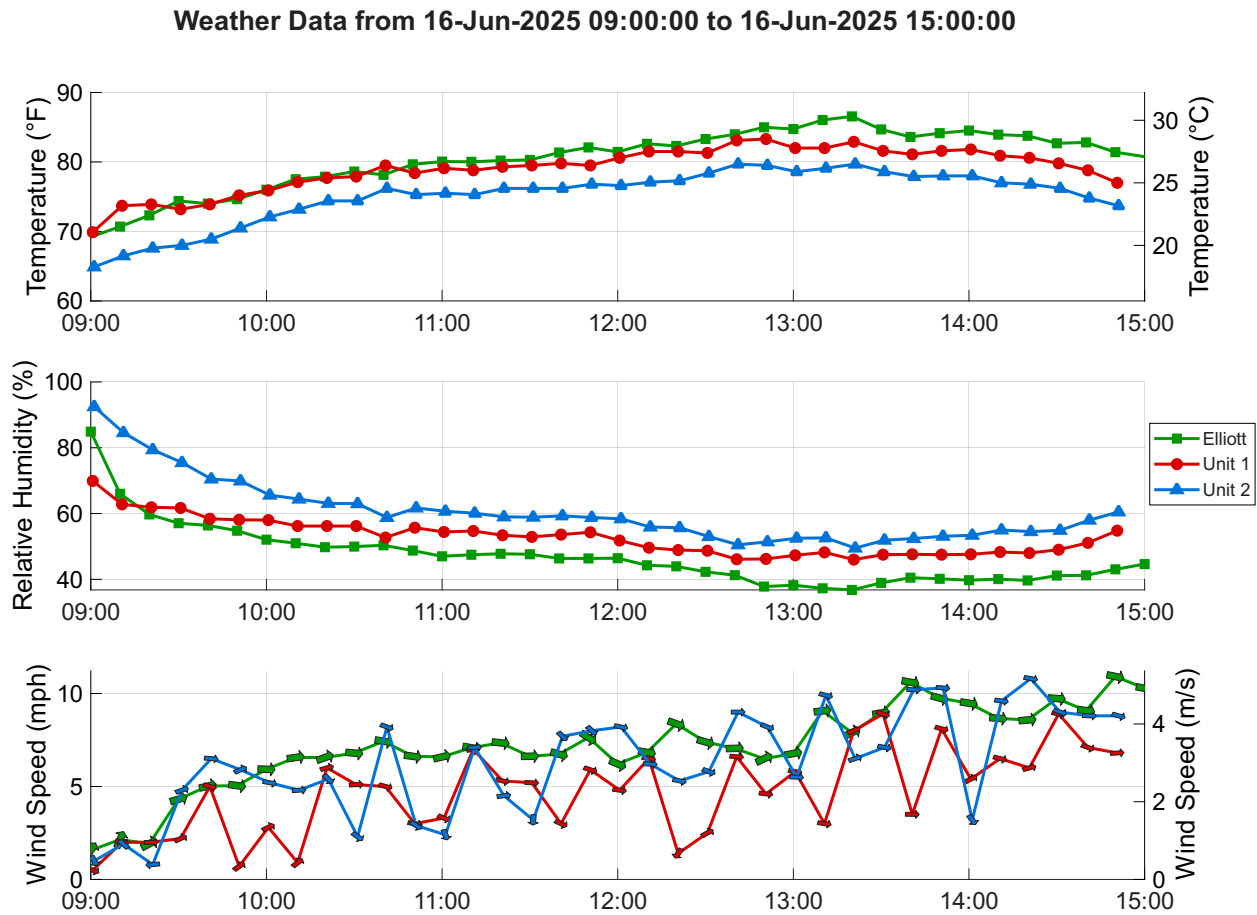


Figure 36: Seismic test day 1 data.

Weather Data from 17-Jun-2025 09:00:00 to 17-Jun-2025 15:00:00

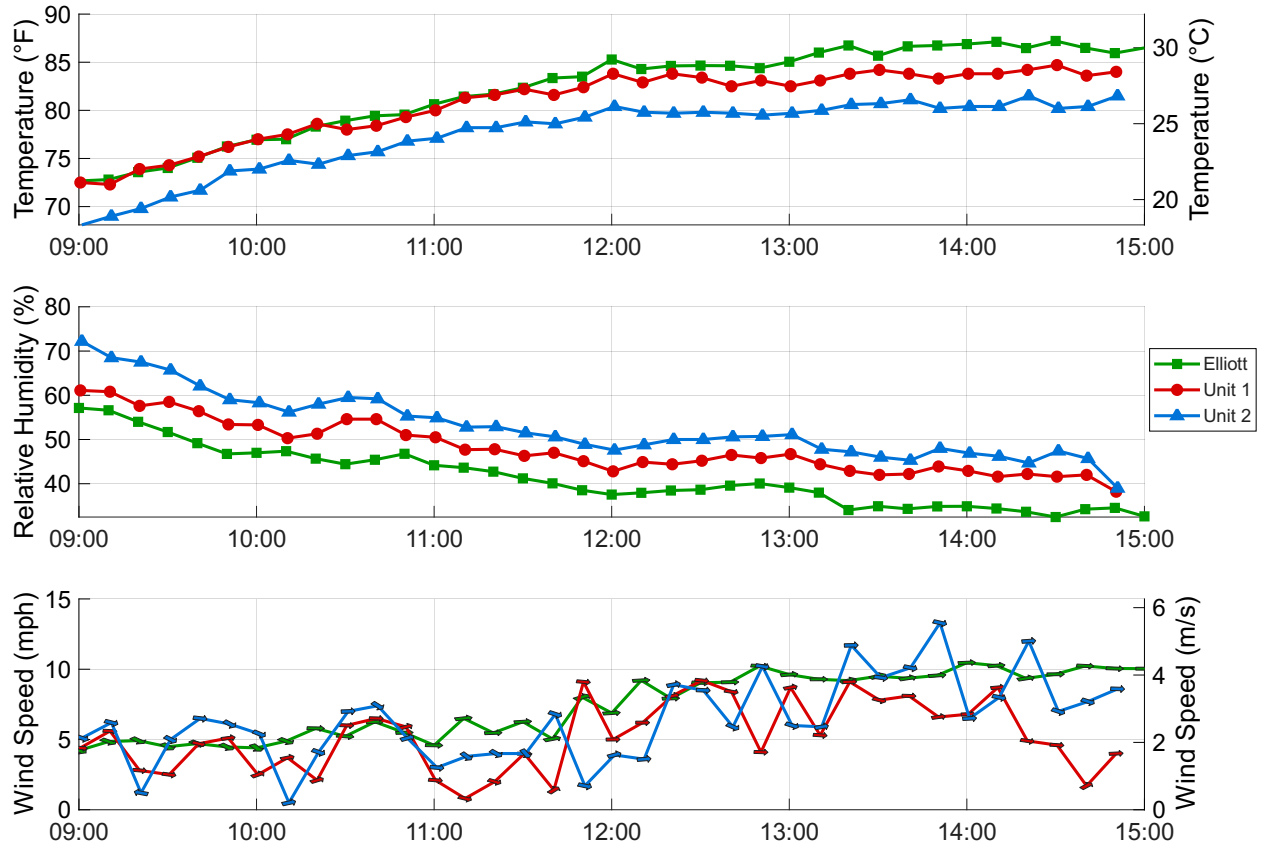


Figure 37: Seismic test day 2 data.

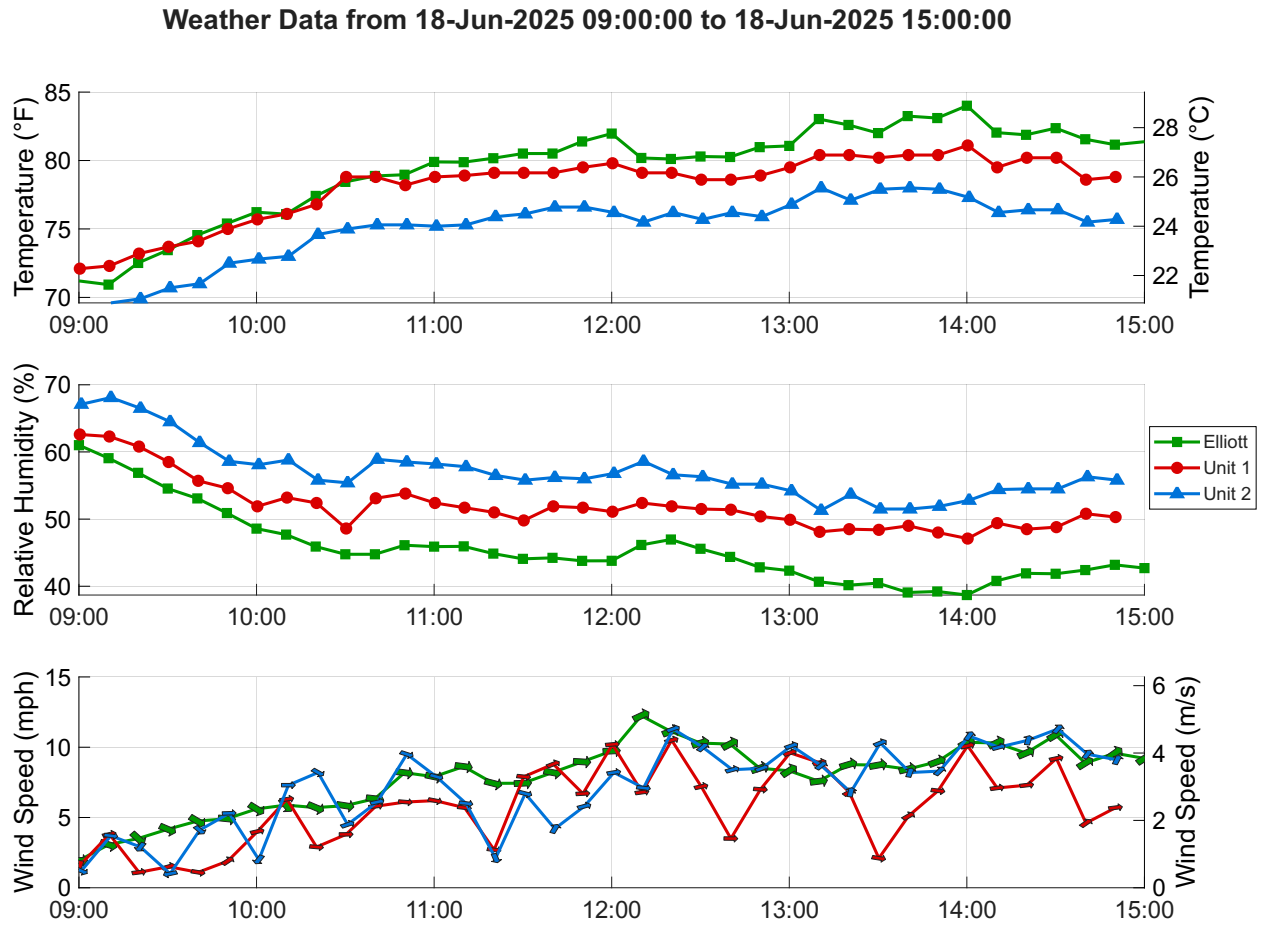


Figure 38: Seismic test day 3 data.

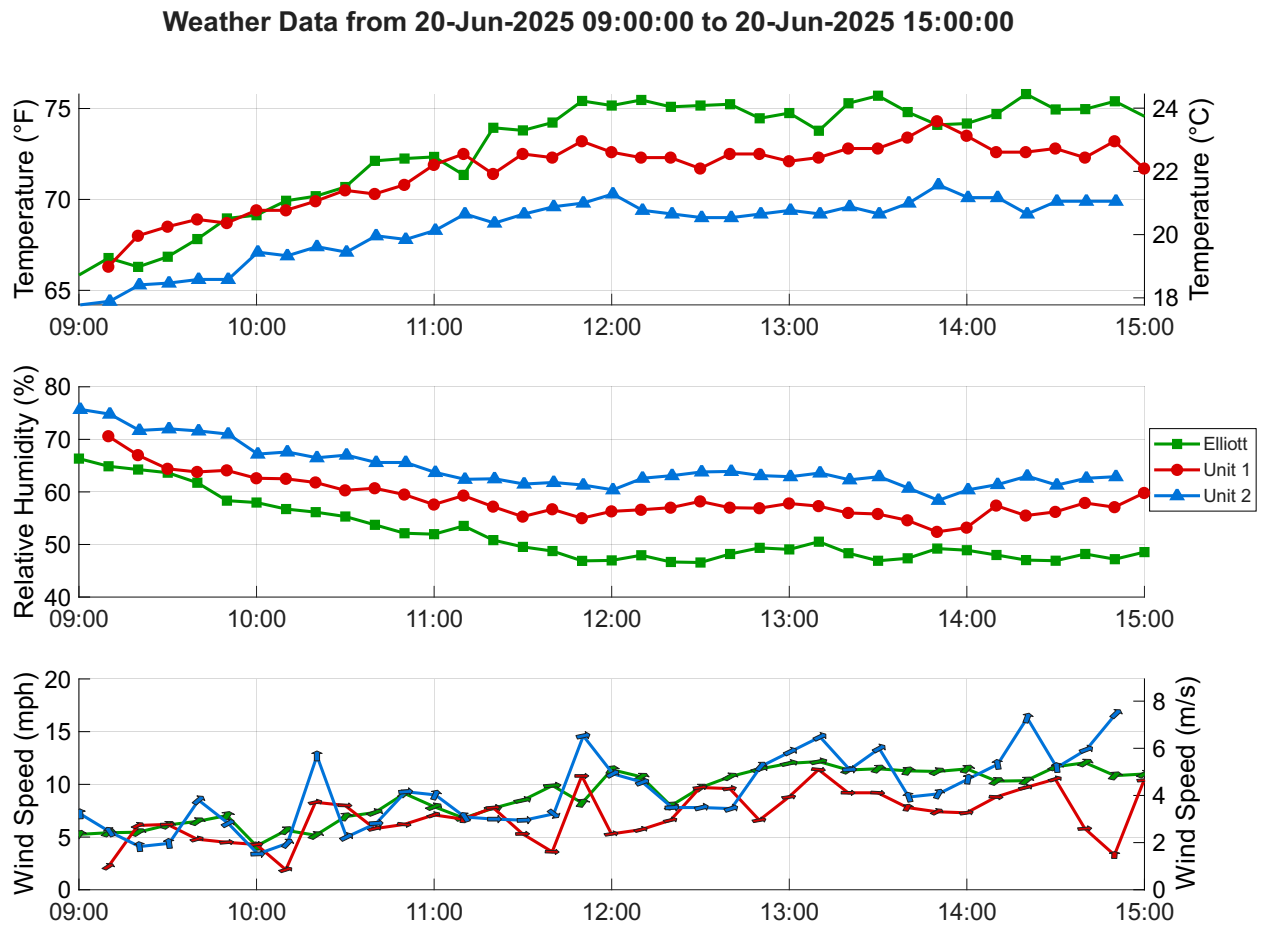


Figure 39: Seismic test day 4 data.

Weather Data from 23-Jun-2025 09:00:00 to 23-Jun-2025 15:00:00

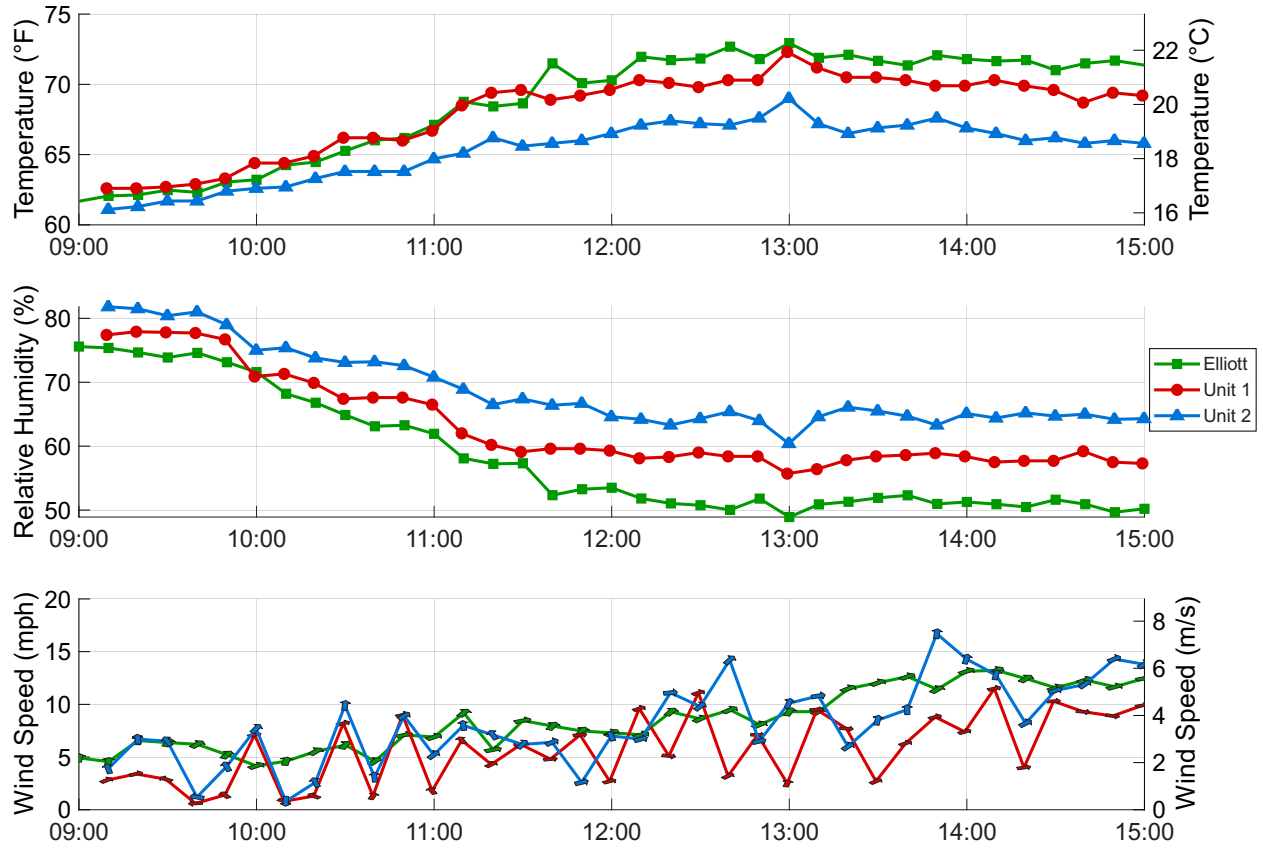


Figure 40: Seismic test day 5 data.

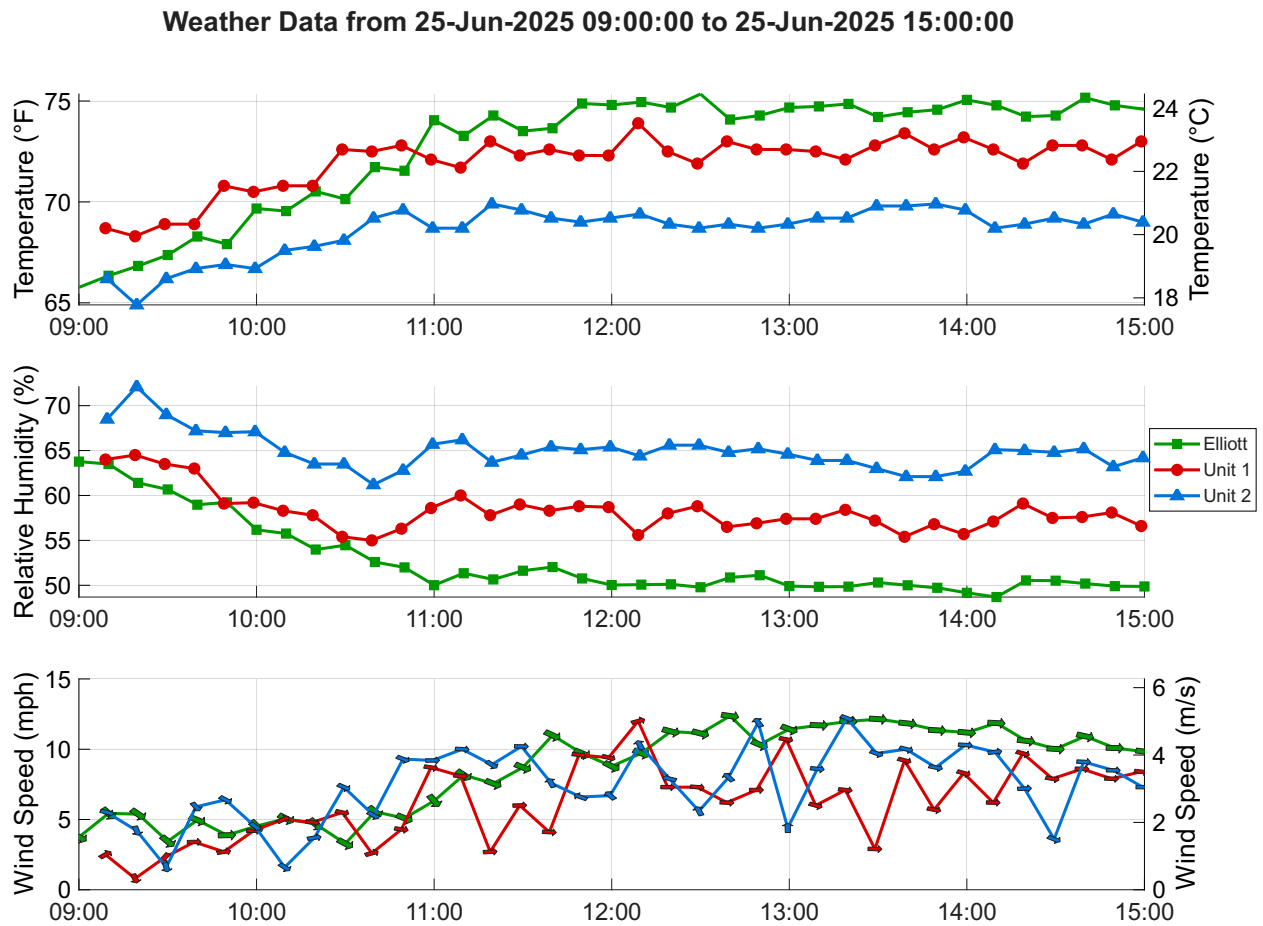


Figure 41: Seismic test day 6 data.

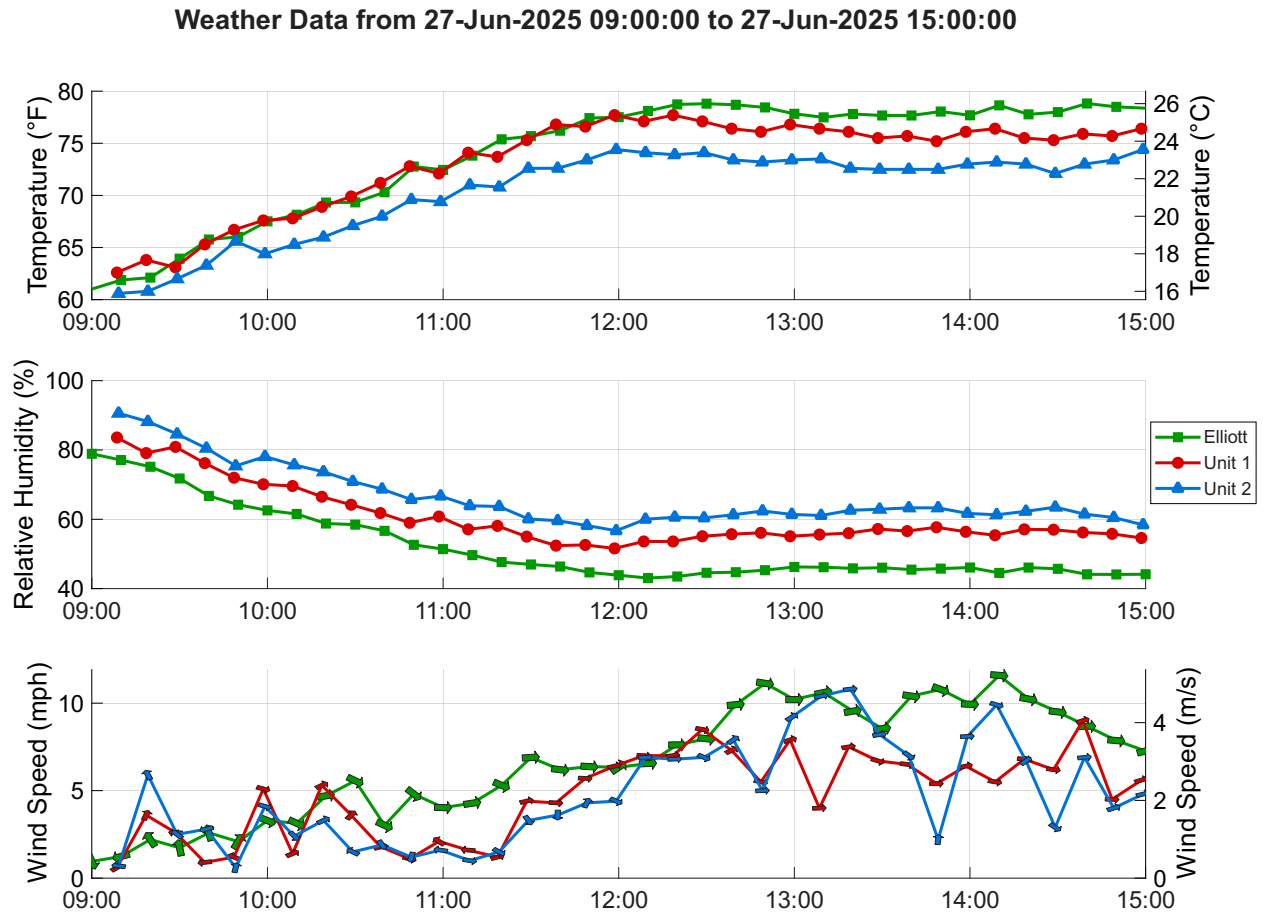


Figure 42: Seismic test day 7 data.

Appendix F: Pre & Post Fire Test Day Data

Appendix F presents weather data collected simultaneously from Elliott Station (green), Unit 1 (red), and Unit 2 (blue) during the live fire testing period and is formatted identically to the plots shown in Appendices B and E. These figures display weather conditions beginning at 12:00 AM and continuing through 3:00 PM on the day of fire testing. For context, additional data are shown for the standardized 9:00 AM to 3:00 PM testing window on the day prior to fire testing and for the two days following. Together, these plots illustrate short-term and multi-day weather variability surrounding the live fire testing event.

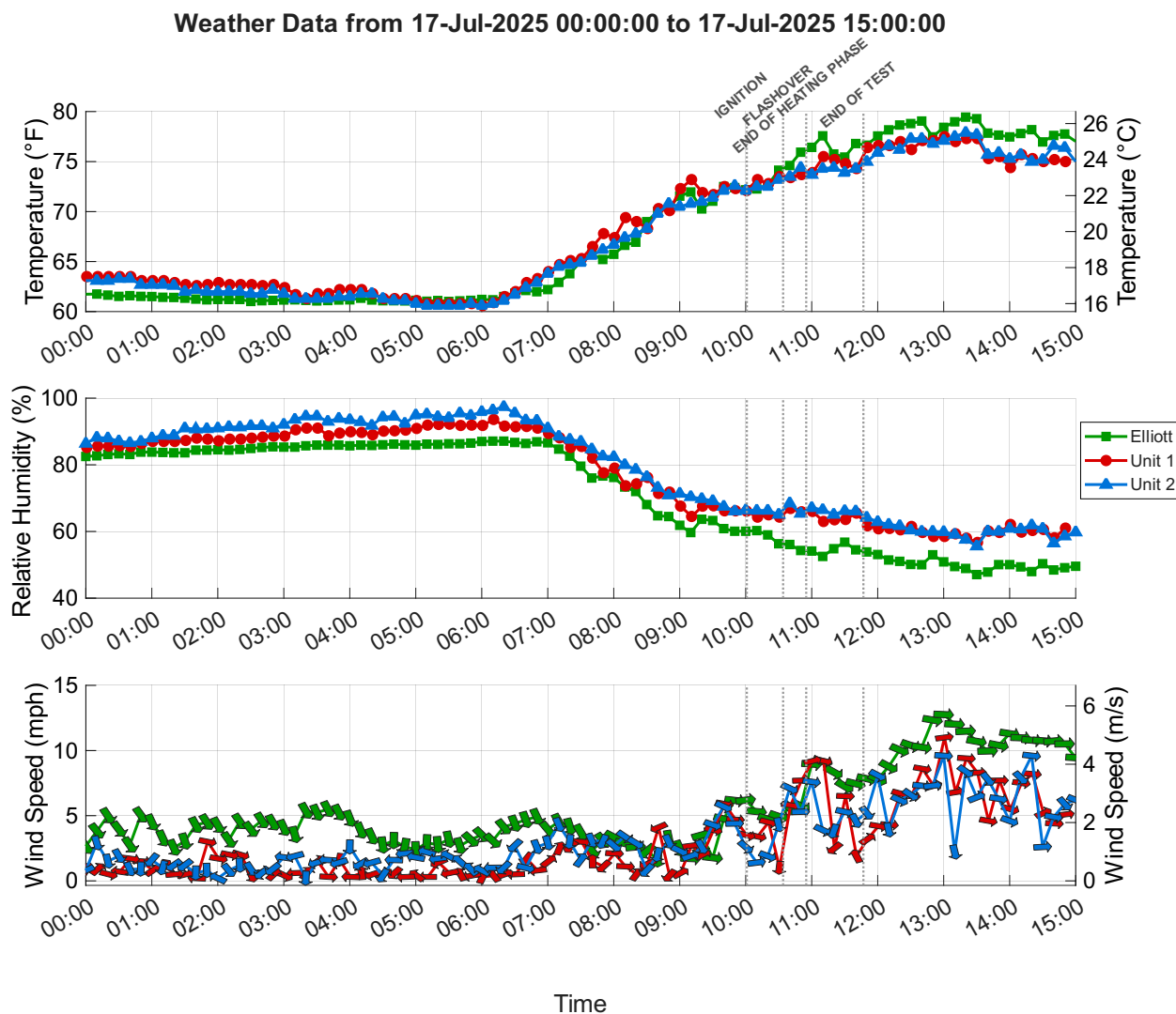


Figure 43: L9 fire test day data.

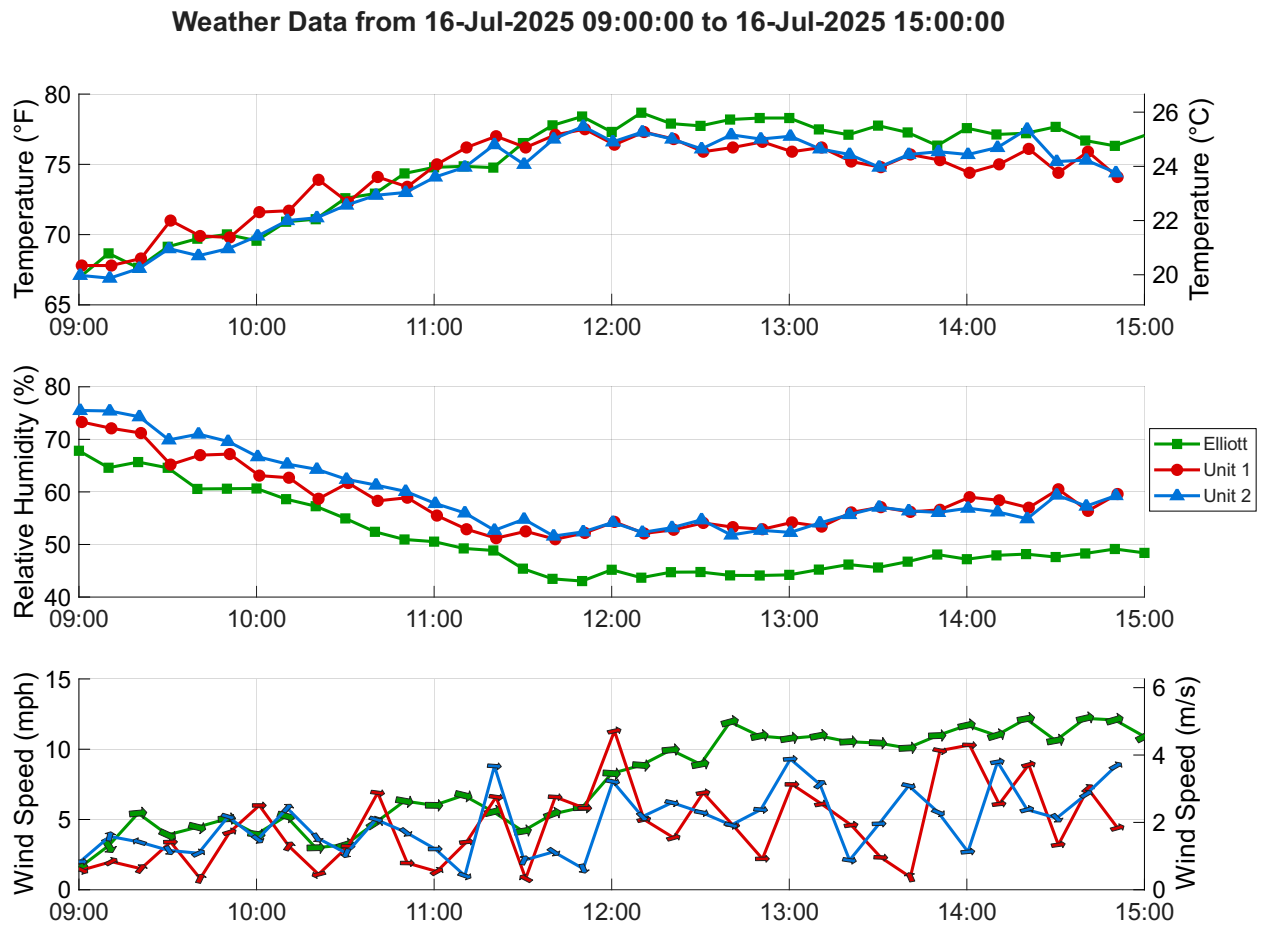


Figure 44: L9 fire test day before data.

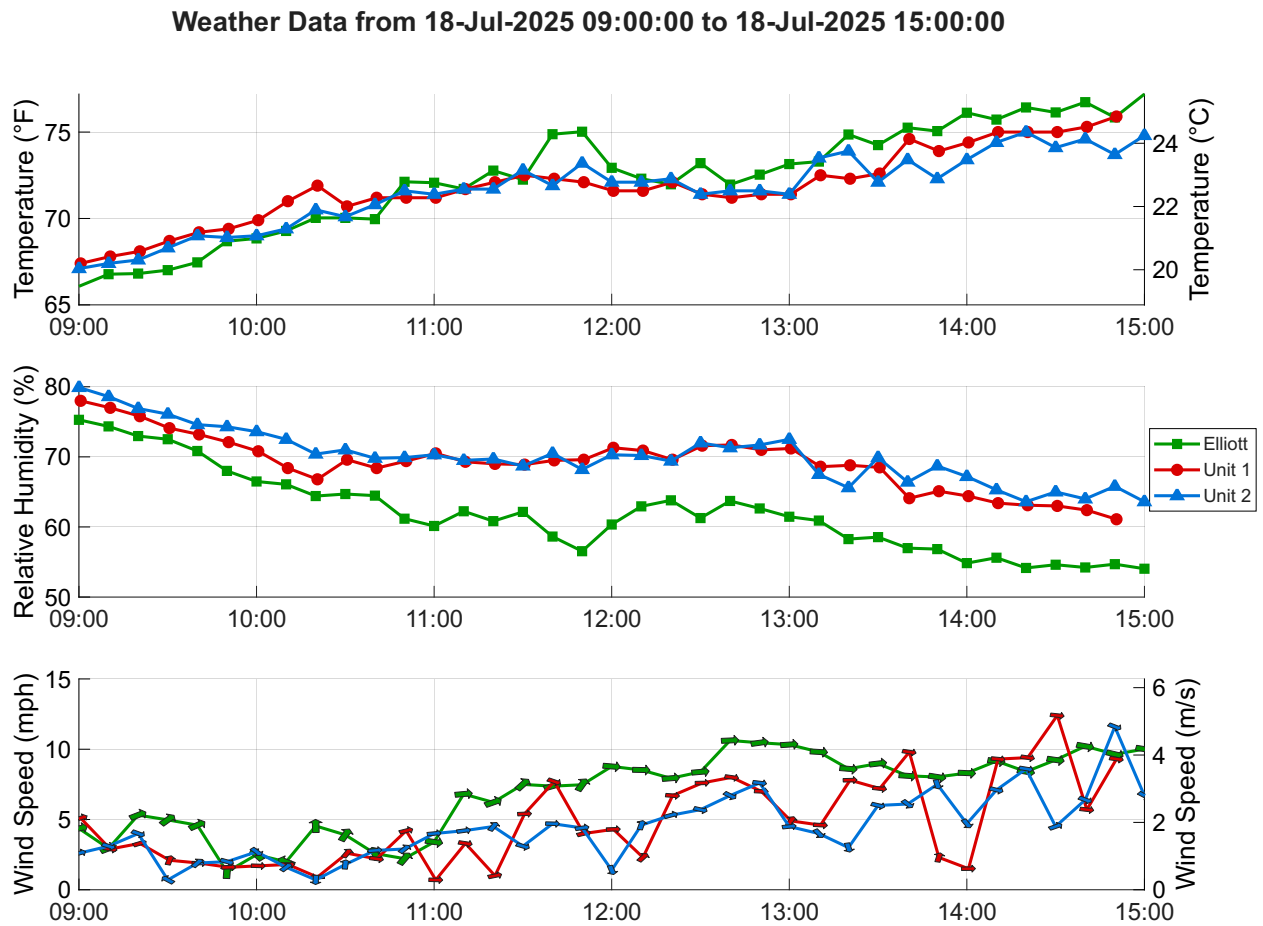


Figure 45: L9 fire test day after data.

Weather Data from 19-Jul-2025 09:00:00 to 19-Jul-2025 15:00:00

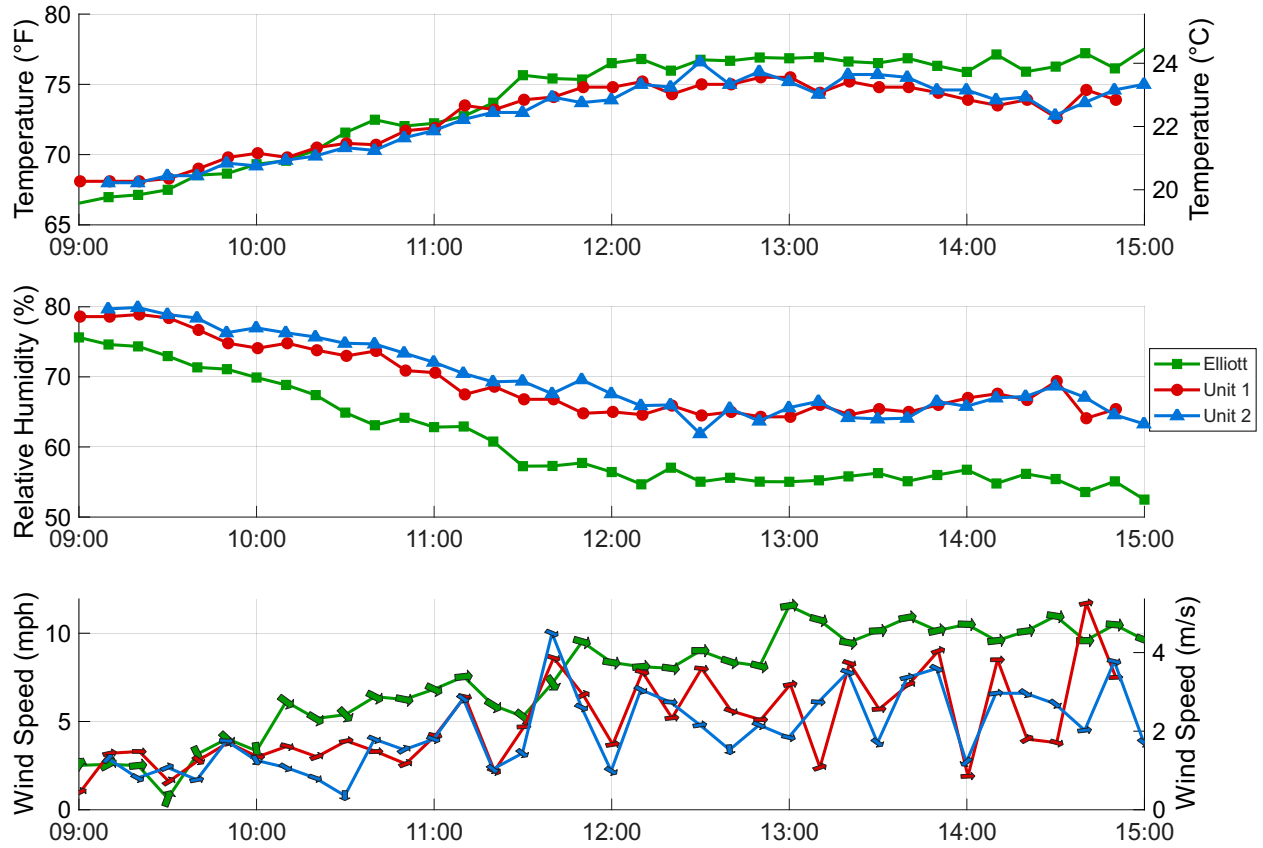


Figure 46: L9 fire test two days after data.

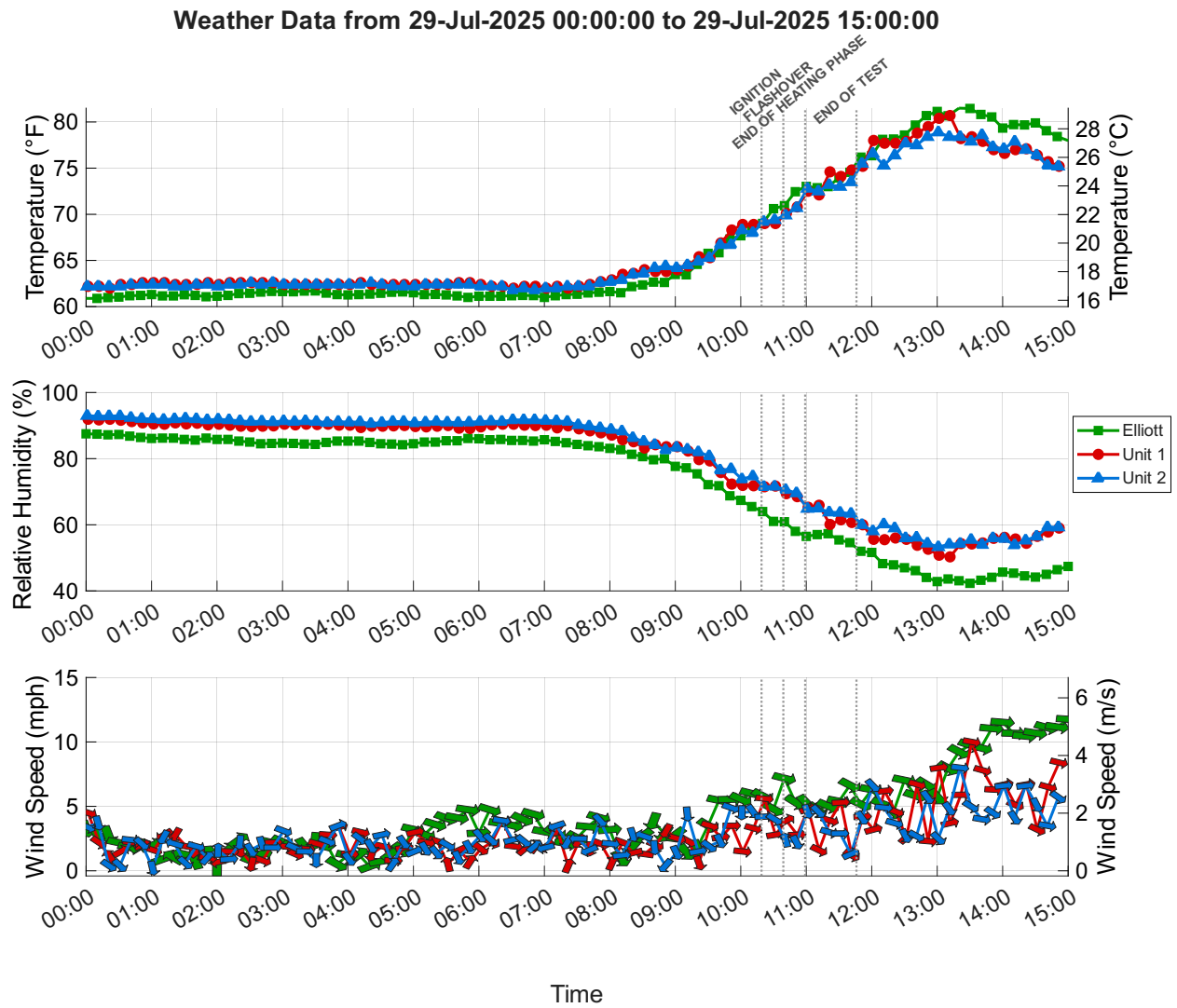


Figure 47: L6 fire test day data.

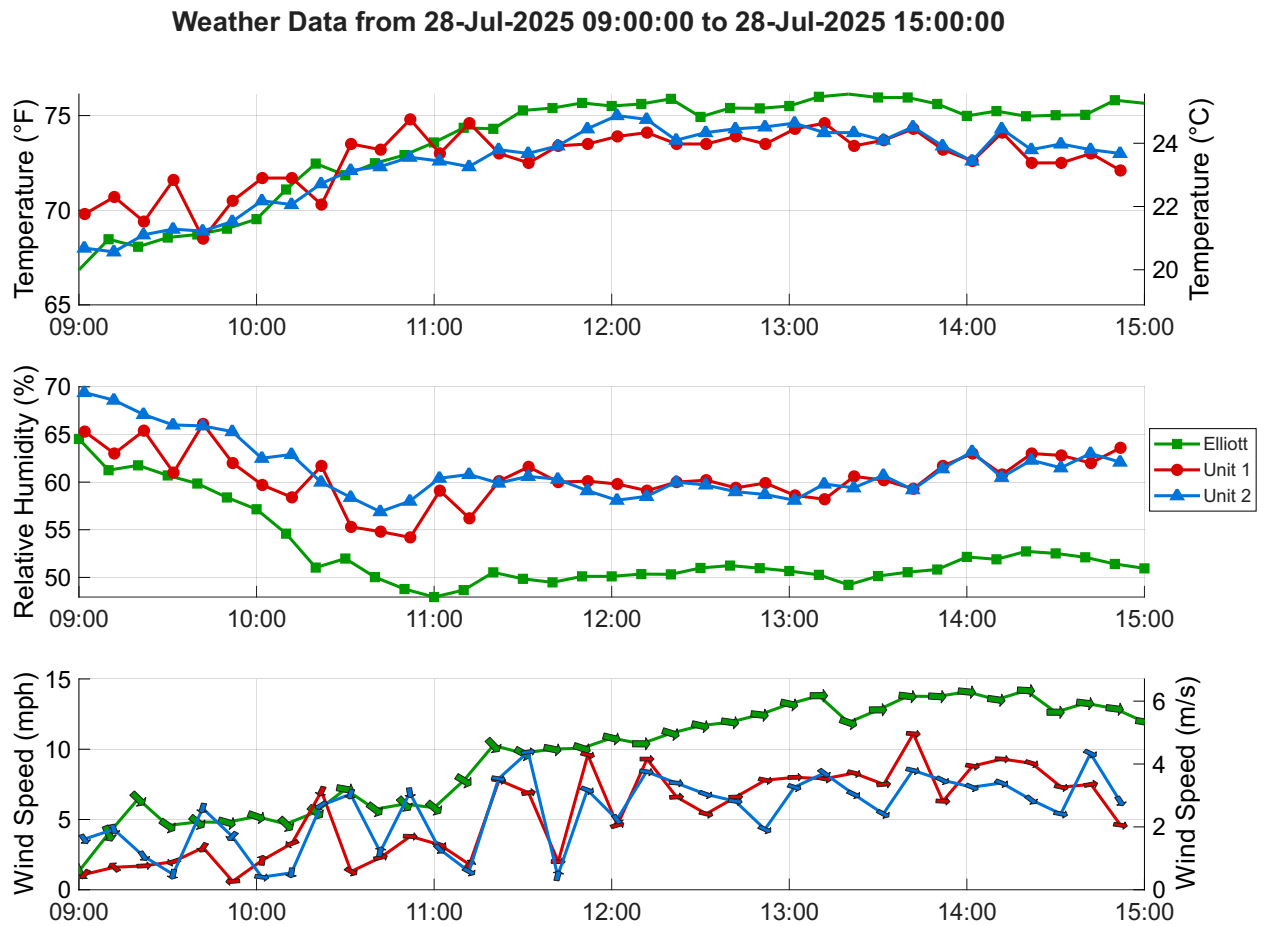


Figure 48: L6 fire test day before data.

Weather Data from 30-Jul-2025 09:00:00 to 30-Jul-2025 15:00:00

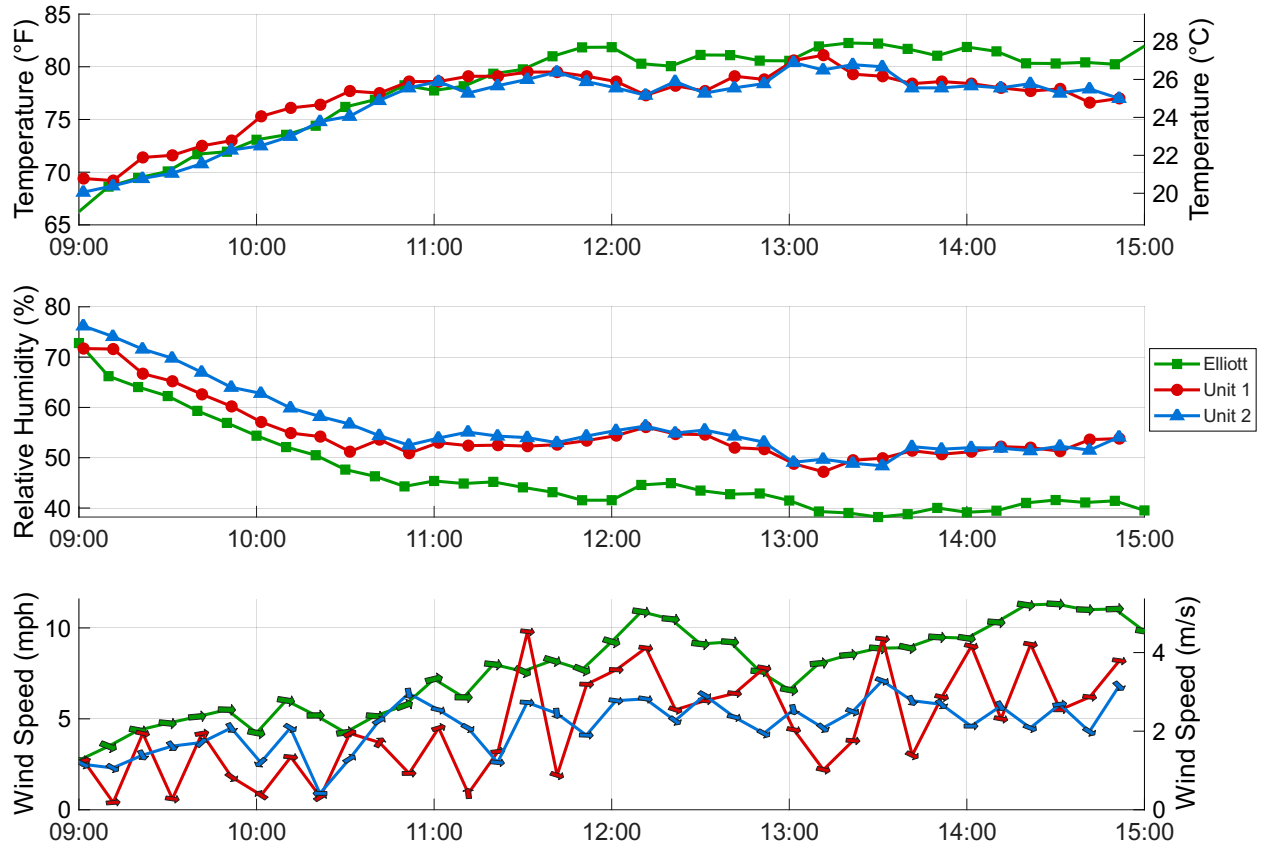


Figure 49: L6 fire test day after data.

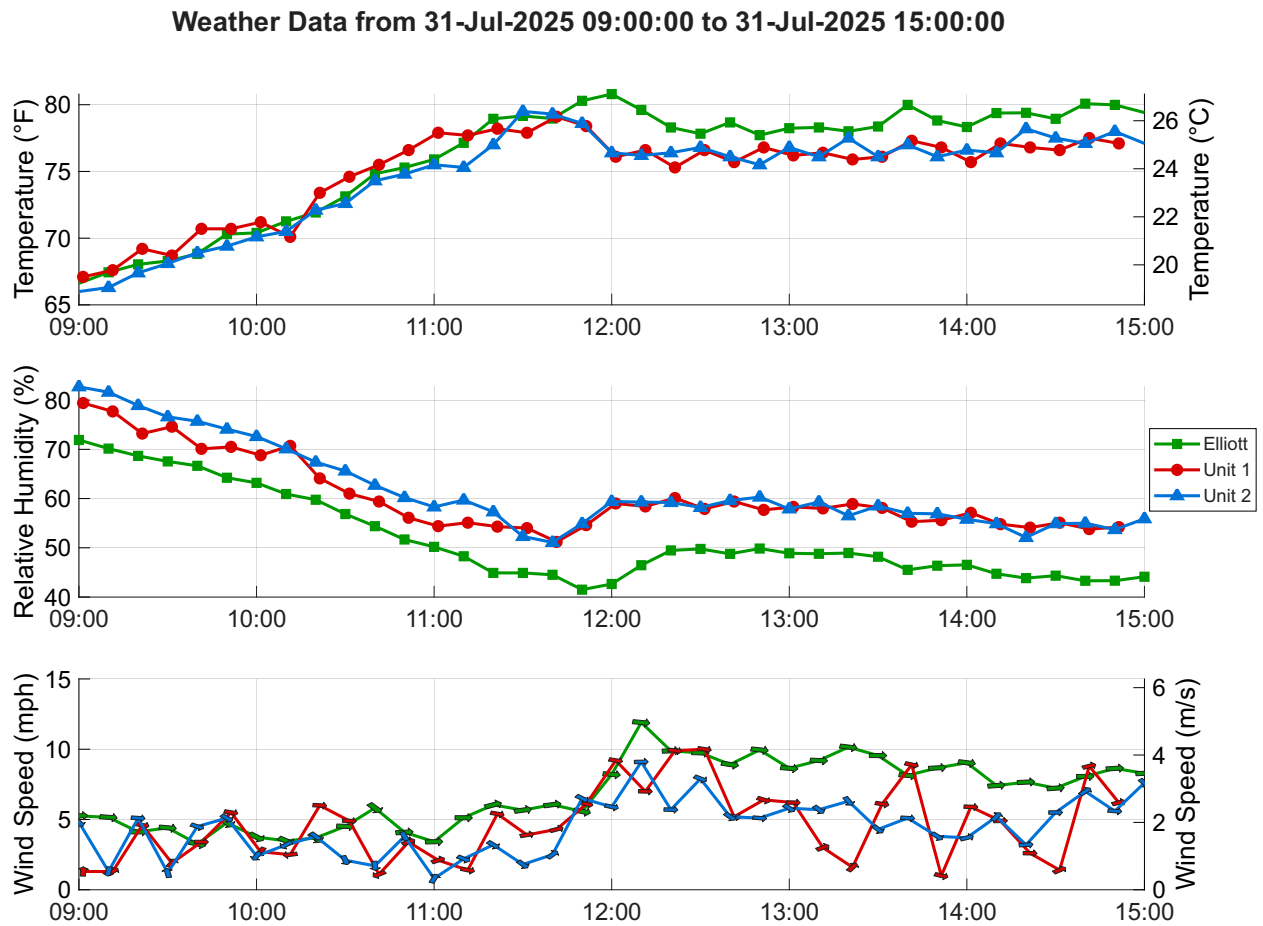


Figure 50: L6 fire test two days after data.