Real-World Temperature Field Test Comparison Report:

WS90 Featuring New Temperature Compensation Patent (US Patent No. 12,181,491B2) vs. Barani + WN31EP

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Key Findings and Application Value

The WS90 sensor demonstrates highly accurate and consistent temperature measurements in real-world conditions. It exhibits superior responsiveness to rapid temperature fluctuations, such as during sunrise or sudden rainfall, outperforming conventional radiation shield solutions like Barani + WN31EP. Due to its fast response and reliable accuracy, WS90 is well-suited for meteorological and environmental monitoring applications that demand precise temperature sensitivity.

Below is a detailed introduction of the test.

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Part 1｜Why is accurate temperature measurement so challenging?

For outdoor weather monitoring, direct sunlight, internal heat sources, and sudden wind changes can all cause temperature readings to drift. That's why many people believe that using a high-quality radiation shield is the best solution.

However, in truly outdoor weather and complex conditions, physical shielding alone is not enough. This is where temperature compensation algorithms make the difference.

This time, we put Ecowitt's WS90 — featuring our patented temperature compensation technology — to the test against the industry benchmark setup: a Barani radiation shield combined with the WN31EP sensor. The goal? To show that accurate temperature measurement relies not on a single method, but on the powerful combination of smart design and intelligent algorithms.

Part 2 | The Core Principle of Temperature Compensation | “Calculating the True Temperature”

Ecowitt's Temperature Compensation Patent **(US Patent No. 12,181,491B2)**
The core logic consists of 3 steps:

- **Dual-sensor design:**
  Each unit houses two temperature sensors — one positioned close to an internal heat source or large thermal mass (S1), and another located nearer to the external airflow (S2). This setup captures different temperature gradients within the device.

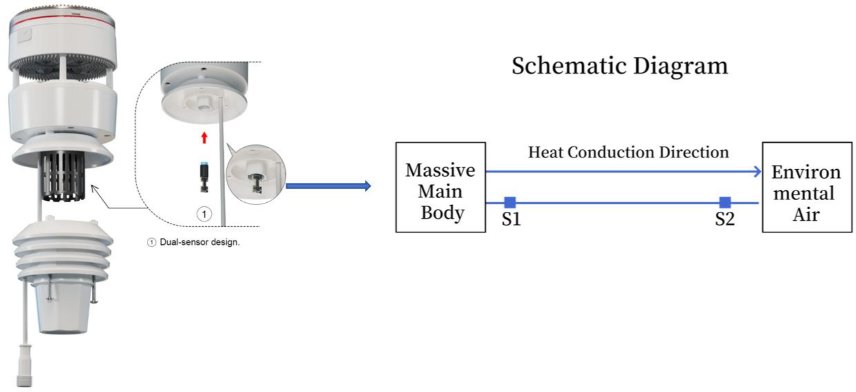


Figure 1

- **Wind Speed used for temperature data correction:**
  Taking into account the effects of wind speed and the time lag of temperature, wind speed data and a temperature lag term were incorporated into the modeling to develop a temperature compensation model.
- **Develop a model to obtain a temperature compensation algorithm:**
  Simply put, it makes the dual temperature sensors and environmental data work smarter through mathematics — so the measured temperature stays closer to the true ambient air temperature.

Part 3 | Why is Barani shield an Industry Benchmark?

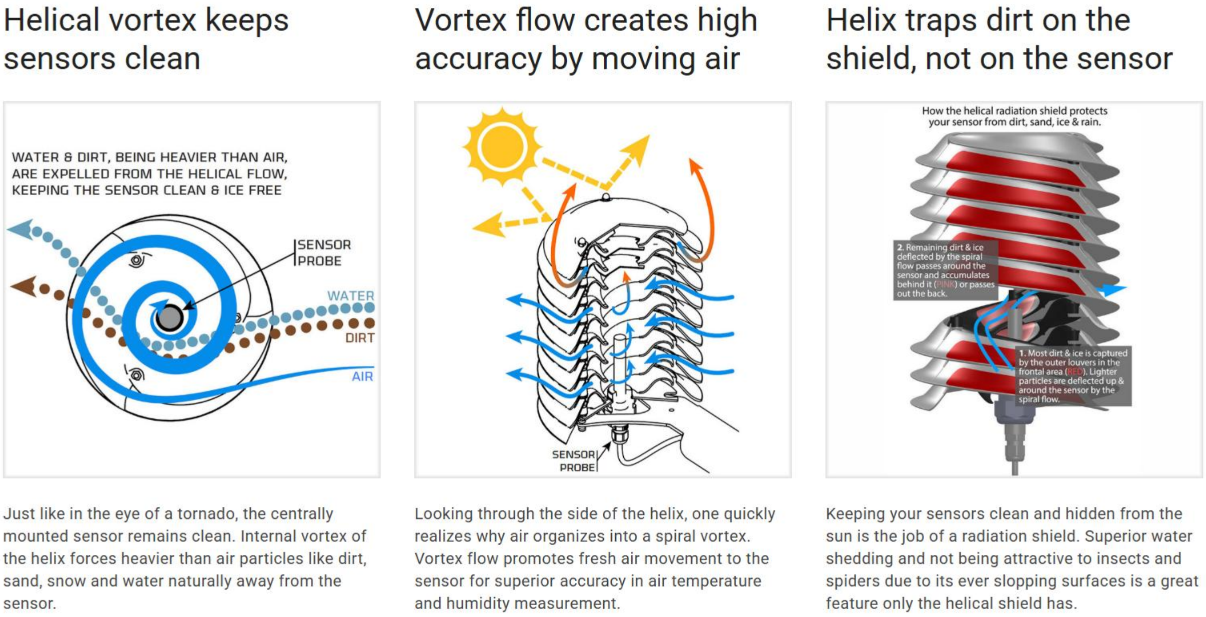
3.1 Barani's radiation shields features

Barani's radiation shields are recognized as one of the top products in the global weather monitoring field.

- They use a spiral airflow design that naturally draws in cool air, creates a vortex around the sensor probe to boost ventilation efficiency, and expels warm air through the top.
- Meanwhile, the white exterior reflects direct sunlight effectively (as shown in the

illustration).

This pure passive cooling and shading design is why Barani shields are widely used at research stations, agricultural weather sites, and professional monitoring networks.
It's also the reason we chose the Barani + WN31EP setup as our comparison baseline — because it represents a well-acknowledged gold standard in the industry.


Helical vortex keeps sensors clean

WATER & DIRT, BEING HEAVIER THAN AIR, ARE EXPELLED FROM THE HELICAL FLOW, KEEPING THE SENSOR CLEAN & ICE FREE

Just like in the eye of a tornado, the centrally mounted sensor remains clean. Internal vortex of the helix forces heavier than air particles like dirt, sand, snow and water naturally away from the sensor.

Vortex flow creates high accuracy by moving air

Looking through the side of the helix, one quickly realizes why air organizes into a spiral vortex. Vortex flow promotes fresh air movement to the sensor for superior accuracy in air temperature and humidity measurement.

Helix traps dirt on the shield, not on the sensor

How the helical radiation shield protects your sensor from dirt, sand, ice & rain.

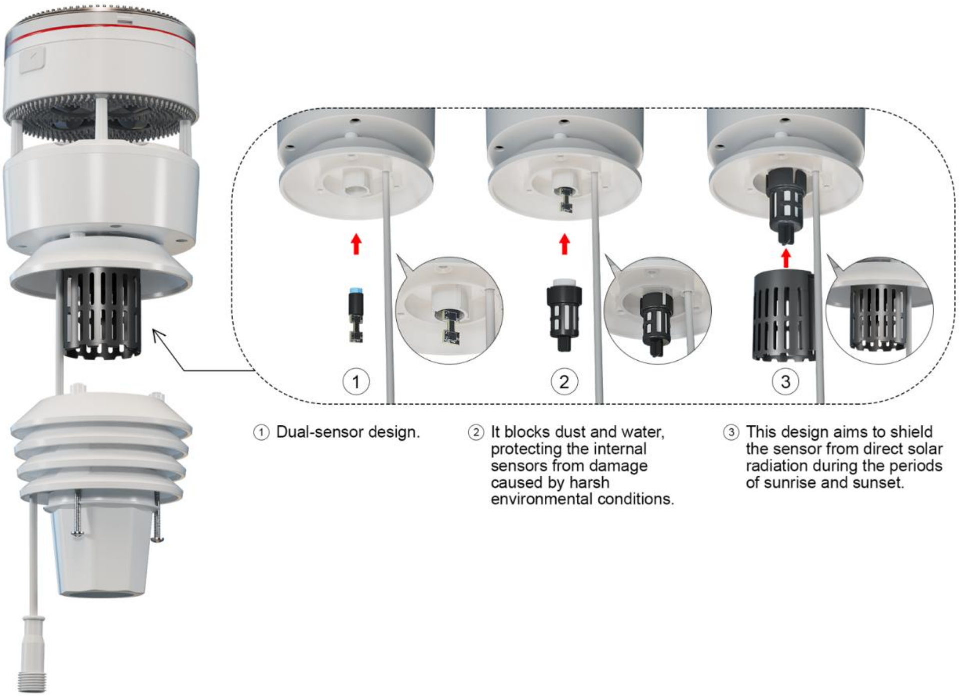
2. Remaining dirt & ice deflected by the spiral flow passes around the sensor and accumulates behind it (PINK) or passes out the back.

1. Most dirt & ice is captured by the outer louvers in the frontal area (RED). Lighter particles are deflected up & around the sensor by the spiral flow.

Keeping your sensors clean and hidden from the sun is the job of a radiation shield. Superior water shedding and not being attractive to insects and spiders due to its ever slopping surfaces is a great feature only the helical shield has.

Figure 2

3.2 Ecowitt WS90 Hardware Structure Design Highlights



① Dual-sensor design.

② It blocks dust and water, protecting the internal sensors from damage caused by harsh environmental conditions.

③ This design aims to shield the sensor from direct solar radiation during the periods of sunrise and sunset.

Figure 3

Part 4丨Real-World Test

WS90 vs. Barani+WN31EP: Which is More Accurate? Which Responds Faster?

4.1 Data Source Introduction

Comparison Object: Barani + WN31EP(Temperature and Humidity Sensor with SHT35 Probe)
Test Devices: Three WS90 units (models 510e, 610e, and 6102)

4.2 Testing environment

In this test, we placed the WS90 and the Barani radiation shield + WN31EP combination in the same testing environment —same time, same location. The installation height are 2 meters above ground level. For details, please refer to the images.

Figure 4

Exposed to the same direct sunlight and changing wind conditions, both setups recorded real-time temperature data.

4.3 Detailed Data Analysis

1. Good consistency and accuracy

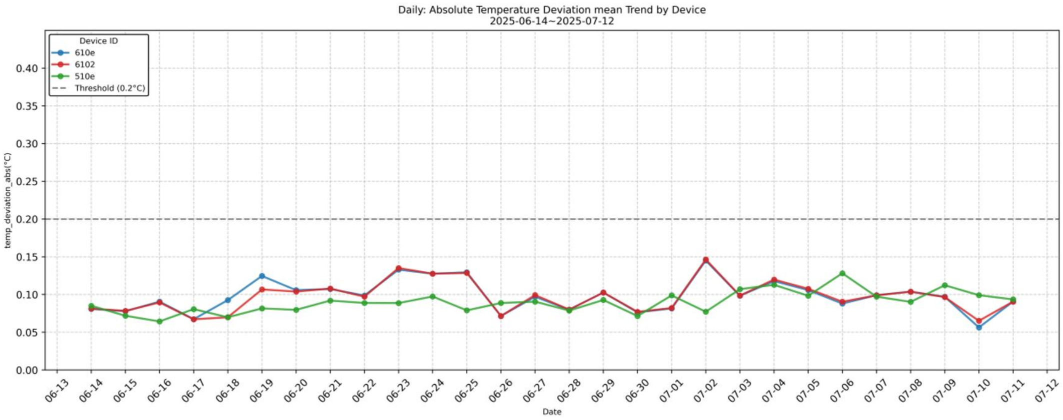


Figure 5 The overall absolute mean error of the three WS90 units is within 0.15˚C, demonstrating good consistency and accuracy.

2. The staged characteristics are clear — during the warming phase (6:00–11:00), high-temperature phase (11:00 – 16:00) and during the cooling phase (16:00 – 19:00)

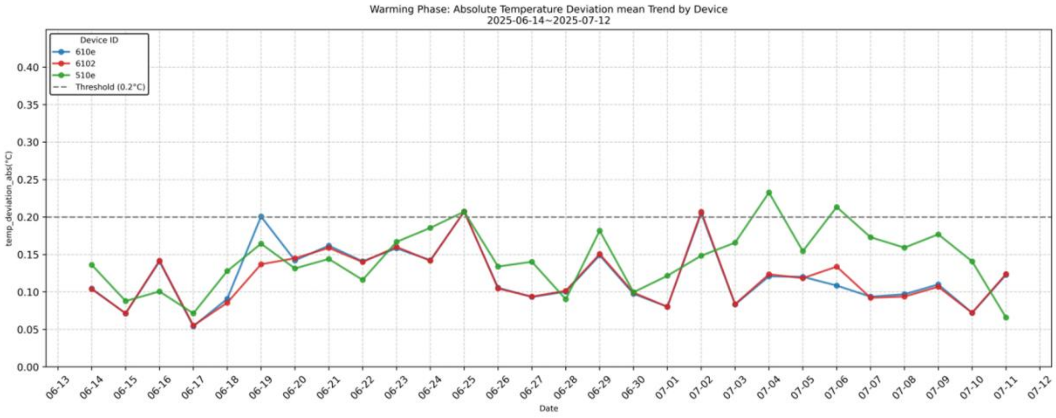


Figure 6 during the warming phase (6:00 – 11:00)

The devices responded sensitively to temperature changes. Compared with the Barani + WN31EP, the WS90 showed a faster initial response during the warming phase, with slope_diff mostly positive, indicating that the WS90 heats up first. The 610e and 6102 units had higher consistency, with the maximum average absolute error only 0.23˚C (the largest was for the 510e).

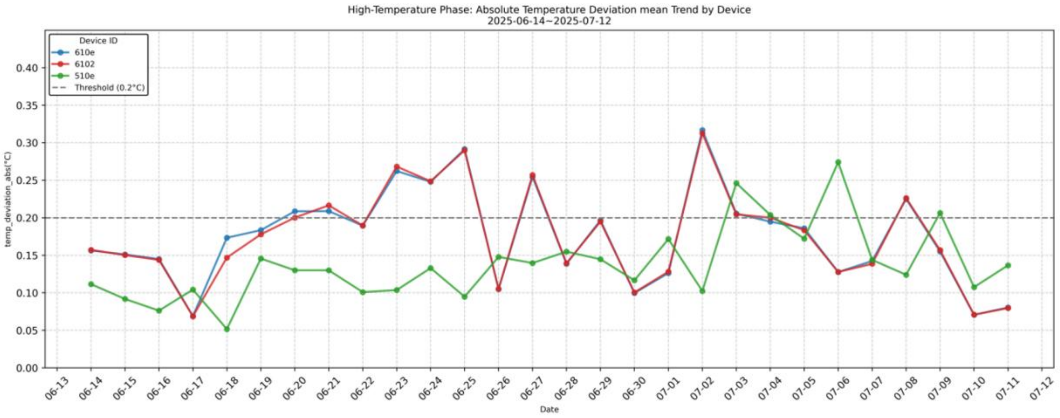


Figure 7 during the high-temperature phase (11:00–16:00)

The average absolute error slightly increased, reaching up to 0.32˚C (on July 2nd, for the 6102 and 610e), while the 510e performed more steadily with an error of only 0.1˚C. When encountering sudden local cooling or rainfall, the 510e showed a typical slope_diff pattern of shifting from positive to negative, indicating higher sensitivity to localized environmental disturbances.

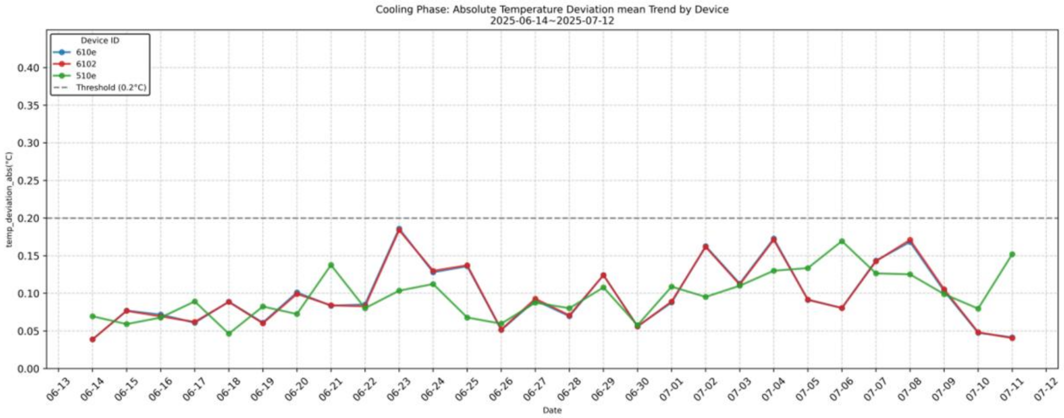


Figure 8——during the cooling phase (16:00－19:00)

The overall error further decreased, with all units remaining within 0.2˚C. The temperature curves were smooth and the performance was stable.

3.WS90 consistency and local variation characteristics

Minor environmental disturbances (such as local airflows or rainfall) may cause brief, localized fluctuations in individual units (such as the 510e). However, the maximum point-to-point error (e.g., a single-day peak of 1℃) is occasional, and the overall trend remains stable and reliable.

4. WS90’s Dynamic Response Speed Outperforms the Barani + WN31EP

— Characterized by a Typical “Positive-Then-Negative” Pattern in slope_diff

Multiple tests have demonstrated that the WS90 responds more rapidly to sudden temperature changes—such as sunrise warming or abrupt cooling during rainfall—than the Barani + WN31EP. This highlights the superior sensitivity and reliability of the WS90’s hardware and design under real-world conditions.

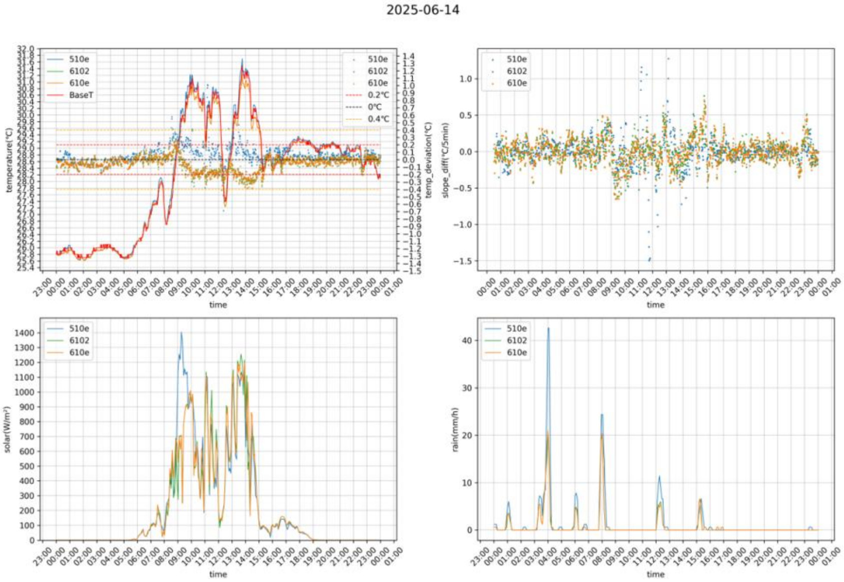


Figure 9 On the first day of testing (June 14th), during the warming phase, there was a period of error: the warming curves generally overlapped, but due to different rates of change, a larger deviation appeared. Around 8:10 AM, a rapid temperature rise began. In this period, the slope_diff metric shows that most data points between 8:00 and 9:00 AM were in the positive range, indicating that the WS90 warmed up faster than the WN31EP inside the Barani radiation shield.

Subsequently, between 9:00 and 10:00 AM, the data points shifted to negative values, showing that the WN31EP in the Barani shield then responded quickly, reflecting a delayed reaction in this rapid warming stage.

In the high-temperature period around 11:00 AM, there was a rapid cooling phase. From the trend of the curve, the overall error did not exceed 0.2 ℃, but point-to-point deviation reached the day's maximum of 1 ℃. The slope_diff of the 510e briefly showed **a typical “positive-then-negative” pattern**, while the other two units did not exhibit a strong corresponding change. This suggests that the factor causing this rapid temperature shift likely occurred first near the 510e (considering that the 510e was located closer to the WN31EP in Barani).

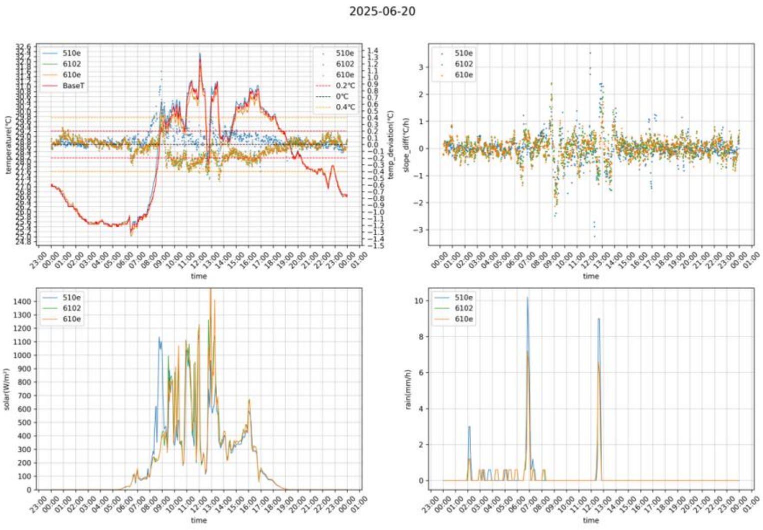


Figure 10 On June 20th, during the rapid warming phase, the slope_diff also showed a typical **“positive-then-negative” distribution pattern**, once again indicating that the WS90 responds faster to external changes.

At midday, a sudden rainfall caused a sharp temperature fluctuation, resulting in a brief slope_diff **“positive-then-negative” pattern** for the 510e.

During the high-temperature stage, when there were no rapid temperature changes, the temperature difference between the 510e and the reference unit was smaller, staying within -0.2 ℃ to 0.2 ℃, while the other two units were between -0.4 ℃ and 0 ℃.

In the cooling phase, the temperature dropped steadily and gradually, with the absolute temperature error remaining within 0.2 ℃.

Part 5丨Testing Ongoing — Stay Tuned

The testing is still in progress. We plan to provide third-party test results in the future to further validate the product’s performance. These tests are expected to take place during the summer season in Italy.

If you would like to learn more about the product or are interested in conducting comparison tests, please feel free to contact us. We are happy to offer support and explore collaboration opportunities.