DETAILS OF PARAMETERS DETECTED

Weather Flow Tempest system and smart weather stations

AIR (temperature, humidity, pressure and lightning)

For correct measurement of temperature, humidity, pressure and lightning, locate the AIR as follows:

- At least 3 feet off the ground
- In full shade or on a radiation shield If you don't have a fully shaded place all day, the small, wireless form factor makes it easy to move the AIR unit from season to season as the angle of exposure to the sun changes.
- Away from potential sources of heat and humidity (sprinklers, greenery, vents, bricks and other dark surfaces)
- Away from nearby sources of electromagnetic interference (antennas, electric fences, boilers, ovens, outdoor speakers, motion lights)

Orientation: AIR should be vertical for the most effective lightning detection. Proper moisture removal requires the AIR to remain upright unless the AIR is protected from water and condensation.

Relative Humidity Note: If the humidity reading appears to be high (or low), remember that AIR is reporting hyperlocal conditions. An accurate measurement can differ greatly from other sources you are used to. Remember, this is YOUR TIME, not airport time reported by your phone or TV news. Your yard has its own `` microclimate '' and will report the truth about the exact location your AIR is in - this means it will be wetter near things like trees, ground cover, wet decks, air vents 'dryer, etc. it will be closer to surfaces that receive direct sun.

Lightning ⚡ Detection Note: Although AIR should detect most lightning strikes, it may not log all lightning strikes. The lightning sensor is relatively sensitive to both position and direction. If the AIR detects regular "false positive" strikes, this could be due to another source of electromagnetic interference (motors, fluorescent lights, radios, computer electronics, etc.). Make sure you locate your AIR away from these sources. On the other hand, if you feel your AIR is detecting fewer real lightning strikes than you experience, try moving or rotating it slightly. Small changes in the positioning of AIR can make a difference.

AIR - Device observations

There is often an explanation for readings that seem just a little wrong. Observations from nearby weather stations and other data sources may not match exactly. Weather stations can be located differently and some areas are subject to microclimatic conditions. Instrumentation also varies between weather stations; different sensor manufacturers and instrument styles have different accuracy specifications and limitations.

Microclimates are localized atmospheric conditions that differ from those of the surrounding area. For example, most airport weather stations read higher temperatures and lower humidity as they are located on an asphalted surface where the ground material is best suited to radiate heat into the air above. These microclimates can be created by soil, soil vegetation and trees, streams, urban areas or soil influences, etc.

Location differences can also lead to different readings. Some personal home weather stations may be misplaced or simply experiencing the environment as it is around them. Moisture on wooden decks, dryer vents, lack of proper radiation shields, and direct sun exposure lead to distorted temperature readings.
If possible, try moving your AIR and analyzing the data - you may be surprised by the various microclimates around you and the careful location for accurate data.

Temperature

- **The temperature reading is high**: even in the case of direct sun exposure, the thermometer used in the Tempest device is shielded from direct solar radiation and the extra heat from the device is represented by the integrated software that corrects the radiation of the ambient temperature. For ease contact us if you have problems reading the temperature.
- **The temperature is low**: temperature discrepancies are often explained by differences in location and location. Other weather station equipment could be placed near heat sources or something that radiates heat such as a roof or the side of a house. Tempest software adjusts the raw temperature reading to an ambient temperature by simulating an ambient sucked by a fan. If other equipment (used for comparison) uses a thermometer drawn in by a fan, there may be cobwebs, leaves, or other debris that could restrict airflow. Some weather station equipment uses batteries that need to be replaced or fans with motors that need to be replaced. If other equipment is

not drawn in by the fan, this could explain why Tempest gives a cooler temperature reading.

Relative humidity

- **Relative humidity is high:** typically caused by nearby moisture sources. Check that the environment surrounding the AIR device does not have potential sources of moisture, soaking the wood, try moving AIR to a drier place if the humidity remains high for a long time. See https://help.weatherflow.com/hc/en-us/articles/115005229767-Proper-Siting-Installation#AIR.

Pressure

- **The pressure is not correct:** Check the AIR "ground clearance" setting in the app. This should be set as the height of the unit above the ground surface, not the elevation of your location above sea level. Open the app, go to Settings> Stations> choose your station> Manage devices> select an AIR> change ground clearance.

Lightning

- **False positives**: The lightning detector in AIR detects the small electromagnetic pulse produced by the lightning. While it will reject most triggers from non-lightning fast sources, it could signal false positives. Possible sources of EMI (electromagnetic interference): piezo lighters, electric drill, electric motors, ignition system (cars, boilers, ovens), appliances, fluorescent lights, televisions, light switches, high voltage cables, solenoids, motion detectors , speakers. Make sure you place the AIR away from such sources. Relocate your AIR if you receive false positives from electromagnetic interference. If you can't identify any obvious potential interference or are limited in placement options, subtle changes to AIR's placement can make all the difference. Try rotating the AIR so that the logo or the ventilation slots are facing another direction.
- If you can't find a location on your property that is free from electromagnetic disturbance, you can turn off lightning alerts in the app: settings> alerts> tap lightning alerts to disable them.

  You can also disable the lightning sensor altogether (make sure you have the latest app update installed): settings> stations> [select your station]> manage devices> [select your AIR device]> advanced> disable lightning . While disabling the lightning sensor isn't ideal, it's a good solution for those who simply can't avoid frequent false positives.

- **Does not detect lightning**: the lightning detector is designed to detect thunderstorm activity and approximate distance; it cannot detect every lightning bolt. Make sure your AIR is mounted vertically / upright and unshielded from a metal object from any direction. The lightning detection antenna inside the AIR is oriented in such a way as to optimize the uptake of lightning activity.
- If you are not receiving any lightning observations, check the app to make sure the lightning sensor is enabled: go to settings> stations> choose your station> manage devices> AIR> advanced> "Disable lightning" should be unchecked.

SKY (wind, rain and UV / solar)

Your SKY will report accurate data wherever it is installed. Your SKY doesn't need to be installed on a tall tree or roof - it's perfectly fine to install it on a fence post or shed, for example. For an ideal measurement of wind, rain and solar conditions, try positioning your SKY as follows:

- With full exposure to the sun and sky ... Shadows from trees and buildings can block light and rain sensors.
- With unobstructed wind exposure ... Obstacles upwind of your SKY will affect wind measurements. Try to install SKY over nearby obstacles in all directions permitted from your location. SKY also needs at least 15 cm (6 inches) of horizontal distance from any object for the wind sensor to function properly.

Mounting: make sure that the structure (pole, pole, tree roof, wall, railing, etc.) on which SKY is mounted does not move, does not move or otherwise transfer movement or vibrations to the SKY unit.

If you can easily trigger false rain readings by pushing the mount or mast, you might want to consider adjusting your setup. There are two standard ways to mount your SKY:

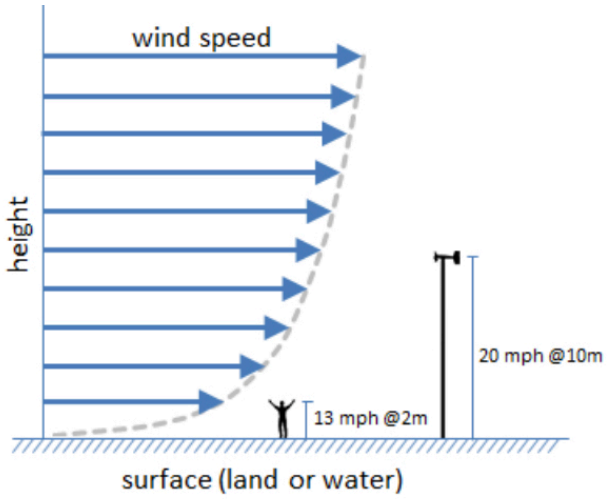
- The pole mount is designed to fit a standard "one inch" nominal pole (OD = 1.315 "or 33.4mm) as well as a 1.25" (32mm) OD pole and anything in the half. You can find a shaft length at your local hardware store or order one online.
- The flat base mount attaches to a horizontal surface via a 1/4 "-20 threaded insert (standard camera mount) or keyhole slot on a screw or nail.

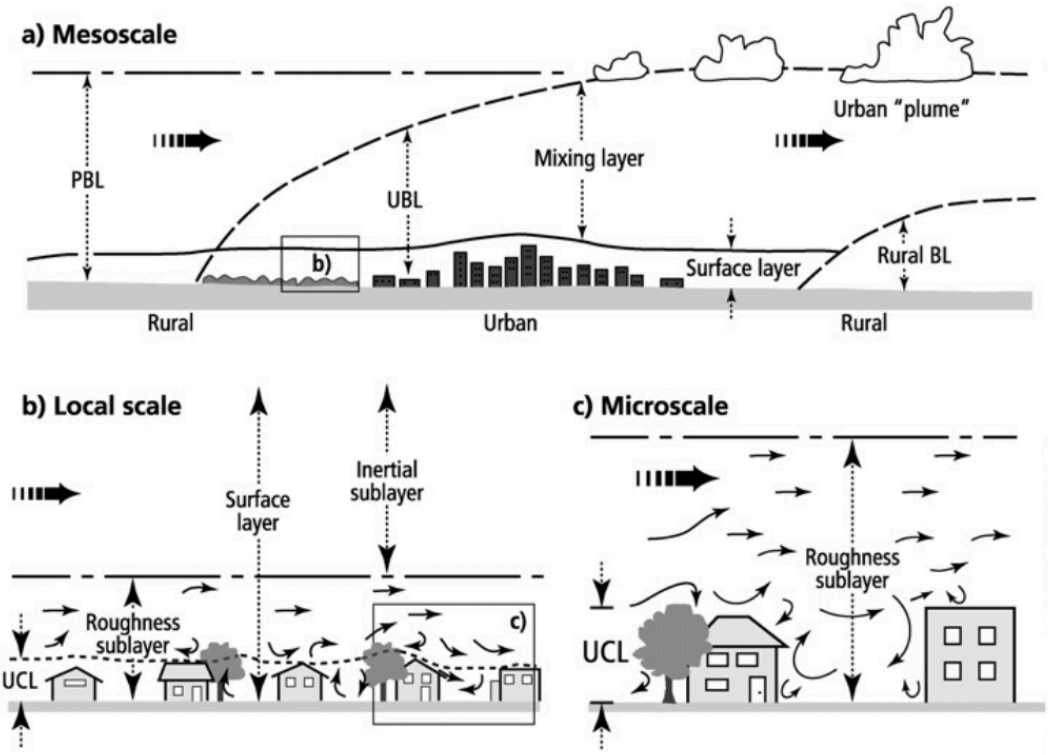
Rain Note: The SKY rain touch sensor detects rain by detecting the vibration caused by individual raindrops hitting the top surface. There are filters in place to identify and correct non-rainy sources of vibration (loose fitting, bird landing, etc.), but these filters err on the side of caution. This means that some sources

of vibration may appear to the sensor as real rain. If this "false rain" phenomenon occurs, the installation may need to be adjusted to avoid any movement or vibration that may cause it.

SKY sensor readings
Wind speed

- **The wind speed is incorrect** - make sure there is nothing between the transducers and the reflector plate, such as snow, leaves, bird droppings, or other debris.
- **The wind speed is too low**: observe the surrounding area, 360 ° around your Tempest device; take note of any obstacles that could affect wind flow. Winds are typically faster at higher altitudes due to surface turbulence. Notice how high your Tempest device is mounted. Tempest uses an ultrasonic anemometer to sample an instant wind speed, there is no inertia involved in the measurement. A rotating cup anemometer or any mechanical sensor relies on the momentum of the moving air to rotate the bearings. A method of measuring wind speed without inertia has inherent differences from a mechanical anemometer and the data provided will not be exactly the same. Tempest has a slower activation rate than most consumer anemometers; it is capable of measuring very light winds. Take note of any low calm readings that lower the average wind speed. Low pauses or speeds close to 0 are an indicator of turbulent flow around the device. Try to locate the Tempest device farther away from any obstacles that could create turbulent flow. You may find that the wind speed readings are more in line with expectations.
- **Unreal Wind Gust:** Incorrectly high gust readings are typically caused by water droplets or other debris on the lower reflector plate. In winter, ice buildup can also cause erroneous readings. Anything that obstructs the ultrasonic signals within the air gap can cause problems with the readings. Check if the super hydrophobic coating is still intact, look for signs of flaking that could allow water or debris to build up.





The direction of the wind

- **Wrong direction:** Make sure the "N" marked on the exterior of the SKY unit is pointed towards true North (not magnetic north). Also ensure the mast and SKY is level. See info on proper orientation for Tempest. If you notice anything off with any of the transducers, please contact us.
- **Direction is not displayed:** Sometimes direction cannot be determined during precipitation events. Check the SKY's sensor status in the Smart Weather app: go to settings > station > choose your station > tap Status > scroll down to SKY's Sensor Status. If you read a "Wind Failed" message, please contact us.

Rain

- **False rain readings:** Most false rain readings can result from strong winds on unstable mounts which cause the Tempest to sway or shake leading to vibrations detected by the haptic rain sensor. Check your mounting situation and see if you might be able to mitigate any unwanted vibrations. Sturdy masts and added cushioning on the mount can help improve structural stability and reduce wind driven vibrations.
  Birds can be another common cause of false rain. If birds become a problem, consider installing a higher perch for them to land on or use shiny, reflective stickers on the Tempest and/or the mast to deter avian visitors.
- **Over-reporting rain accumulation:** Excess rain accumulation is inevitable on wobbly, unstable mounts, especially in in strong winds. The haptic rain sensor in Tempest is a precision instrument that is very sensitive to vibrations. It is essential to install the Tempest unit on a sturdy mast with secure mount. Check your mounting situation and see if you might be able to mitigate any unwanted vibrations.
- **Under-reporting rain accumulation:** If your sensor is consistently under-reporting rain accumulation, please see the Rain Accumulation help page.
- **Inaccurate rain accumulation:** Please see the Rain Accumulation help page.
- **Not registering rain:** Tempest will pick up on light rain but trace amounts of precipitation are unlikely to be detected. If the rain was heavy enough to make an impact on the device, but no rain was reported, first **check the device's battery level** in the app. The haptic rain sensor will be disabled under 2.36v to conserve power.
  If the battery level is above 2.36v, check the Tempest's sensor status in the Tempest app to see if there has been a failure, go to settings > station > choose your station > tap Status > scroll down to Tempest's "sensor" status. Try power cycling the Tempest unit first, twist the device off its mounting attachment and flip the power switch off and back on. If you still see any failed sensor message, please contact us.
- **No accumulation after rain start:** If rain has started, but you are not seeing an accumulation value, simply wait for the accumulation to build. The rain is probably very light and if so, there will not be an accumulation above 0.01" immediately.

UV

- **Low UV readings:** check that nothing obstructs the UV sensor at the top of the SKY device; leaves, ice, debris, shadows, etc.
- **Inaccurate Calibration**: It can take many days of clear skies to properly calibrate the UV/solar radiation sensor as many cloudless days of measurement are needed to perform calibration routines. Be careful when comparing UV index readings from different equipment. If you find any abnormalities with the sensor readings or notice your UV readings do not improve after a month or so, please contact us.

Additional information on the operation of the lightning sensor

Tempest's lightning sensor has several features that highlight why the Tempest System is more than just hardware. The lightning sensor in your Tempest device can detect strikes up to 40 km away, and while it does a good job at detecting many strikes in this range, it is far from 100% efficient. The closer the strike, the more likely the sensor will detect it, but it can miss-report strikes at any distance. It can also be susceptible to nearby electromagnetic interference and sometimes it's difficult for the algorithms onboard to tell if a strike is real or a "false positive". Fortunately, the data reported by the individual sensor in your Tempest is supported by additional data and a sophisticated back-end process that significantly improves the reporting of lightning. This is accomplished by comparing data from your Tempest with other nearby Tempests along with several trusted, third-party lightning data sources. The result is the best lightning strike data available.

Features

- **Strike Confirmation:** Lightning strikes observed by a Tempest device are validated and processed normally.
- **False Strike Identification:** When a strike from a particular Tempest device cannot be validated, it is flagged as a false positive (useful for quality control & analysis), and not reported to the user.
- **Missed Strike Correction:** If the combined additional data sources confirm a lightning strike near a Tempest that was not detected by the device, the system will fill in the gap with the validated strike information.
- **Long-Term Improvement:** The Tempest lightning detection system is already the most accurate system available to consumers and, over time, you will see even better and faster results. The rapidly expanding Tempest network is

quickly making the system better and our Continuous Learning system will make adjustments to the lightning sensor configuration parameters in individual Tempest devices, when necessary.

This customized fine-tuning of the sensor will optimize its performance at its particular location. Also, quality control alerts will proactively notify users in case there is some action they can take (such as relocating the Tempest away from sources of EMF) to further improve performance.

Additional information of the tactile rain sensor and the Rain Check Software

Accuracy of the Haptic Rain Sensor

Rain Accumulation values are calculated over a 24 hour period from midnight to midnight using the station's local time. Be cautious when comparing rain accumulation readings to other sources, collection times may differ and rain does not fall evenly across regions, towns or even neighborhoods.

A default calibration is used for haptic rain sensors in the Tempest and SKY devices. The haptic rain sensor detects and quantifies rain through vibrations not directly by volume or weight and so, there are many factors that can influence the readings. Each and every haptic sensor in the field is subject to unique external factors that can contribute to accumulation discrepancies, for example, mount materials, mast height, environment, wind, and turbulence can all affect the rain accumulation readings.

When well sited and calibrated, the haptic sensor can measure rain accumulation very accurately (90-100% accuracy in Tempest and 80-100% accurate in SKY) compared to accumulation measured by a conventional rain gauge, which should also be well sited and co-located.

A conventional rain gauge can be highly precise but a haptic sensor is able to provide details on rain start time, event duration, relative intensity and rain rate at 1 minute resolution! Not to mention there is no need for the user to manually collect data after each rain event.

Calibration Adjustments

A calibration adjustment can help improve accuracy of the haptic sensor readings if accumulation measurements are way outside of accuracy specifications. Due to the factors that contribute to different vibration signatures, calibrations may need to be applied in the field, after final installation. You should first ensure that your mount is sturdy and there are no external vibration contributing to over-reporting accumulation. Calibration cannot fix the effects of an unstable mount or random vibrations caused by winds, birds, etc.

If you think your device needs a calibration adjustment, we'd be happy to help. Our meteorological data science team can apply a calibration update to your devices using comparison rain data.

- I have another rain gauge I can use for comparison data

Using rain accumulation data from another trusted gauge sited close by is by far the best method to re-calibrate with successful results. Please send us the comparison data, 24 hour rain accumulation (from midnight to midnight local time).

1. **Register your co-located gauge you are using for comparison data.**
2. Once registered, **report individual rain events**
   (ideally over a 24-hour period, from 12AM to 12AM local time)

   More data from a larger sample size of rain events is preferred. Submit comparison data from at least several precipitation events with varying intensity for the best results.
3. Follow up with us after you think you have submitted enough reports for a decent calibration adjustment.

- I do not have access to another gauge. Can I still get help with a calibration adjustment?

We can use data published online from nearby gauges and/or Rain Check values to help with calibration adjustments. If there is another trusted weather station close enough nearby that is reporting data online, we can review rain data to use as a reference for a calibration adjustment. Please contact us for assistance.

Rain Check

Rain Check is a free and an *optional* bonus tool in the app. Because rainfall can vary so greatly over small distances, the goal of Rain Check is to provide a

representation of daily rainfall at the "neighborhood" scale, rather than just the rain that landed exactly on your Tempest device.

The Rain Check accumulation value starts with and depends on raw data from the haptic sensor in your Tempest, but it also considers other measures of precipitation in your area (including other Tempest devices).

Rain Check data is provided in the app each and every day in the AM hours (exact times may vary depending on weather conditions), Rain Check compares the raw accumulation calculations from the haptic rain sensor against a reference data set described below to create an accurate representation of the average rainfall for your location.
It does not erase the saved raw data derived from the haptic rain sensor but it does replace the accumulation value shown in the app. You'll know if you're seeing Rain Check data if the logo appears next to the rain accumulation value in the app.

Availability

The Rain Check system currently only applies to stations located in the continental United States and some parts of Canada. WeatherFlow will continue efforts to make Rain Check or similar data available in other areas of the globe.

Troubleshooting

Rain Check accuracy has a lower confidence score in areas where brief showers/thunderstorms are frequent and large terrain influence is present.

Rain Check can be enabled or disabled in the app under the **advanced device settings:** go to settings > stations > choose your station > manage devices > choose your Tempest or SKY device > advanced > toggle Rain Check feature on/off.
A well-calibrated haptic sensor, in SKY or Tempest, installed on a stable mounting position, free of vibration, will produce rain accumulation values that are remarkably good. Rain Check will improve the accumulation values in cases where a particular device is not ideally mounted, which is difficult to do in most home locations (see these siting & installation tips for more details). If you believe your haptic sensor is experiencing significant accuracy issues over multiple rain events, please contact customer service.

Technical Details

Rain Check is a proprietary system that combines WeatherFlow device data with sophisticated 3rd party precipitation models that integrate up to seven (7) key precipitation data inputs to produce the most accurate rain accumulation estimate for a particular location. Precipitation inputs include: a reference network of over 25,000 quality-controlled precipitation gauges, climatological basemaps to account for complex terrain influences, a mosaic of state-of-the-science dual-pol estimated precipitation derived from NEXRAD radar sites, level-II radar reflectivity translated into a rainfall rate using standard Z-R algorithms, isopercental interpolation estimates in areas of complex terrain without adequate radar coverage, low altitude radar beam confidence rating to determine spatial suitability, and satellite rainfall estimates from NOAA's Center for Satellite Applications and Research (STAR) known as "Hydro-Estimator".

Solar Power & Rechargeable Battery

Solar Power Module & Internal Rechargeable Battery

The Tempest device uses an integrated solar power charge module with four south-facing (north-facing in the southern hemisphere), vertically-oriented solar panels. This geometry provides optimal solar charging even in low sun angles at high latitude locations.

The internal rechargeable battery in Tempest is an LTO (Lithium-titanate) type, 1300mAh battery. This is ideal for use outdoors and in extreme temperatures. LTO batteries are safe on the environment and have a very long lifetime of almost 50,000 cycles - which is decades of recharging.

Operation

Your Tempest is shipped with a full battery and should give you about 2 weeks of operation without any additional power input, but you should put it in the sun as soon as possible. Note, it must be powered on in order for battery charging to occur.

From an empty state, it takes about 4 hours of adequate sunlight (350 W/m2 or so) on one or more of the four solar panels to reach a full charge. This is a rule-of-thumb and your mileage may vary. It will charge faster in direct sun but can still charge slowly with indirect sunlight. As long as your Tempest gets the equivalent of at least 4 hours of adequate sunlight every two weeks, it will continue happily running along. In the event of extended periods of low light conditions, power management code in the firmware will help your Tempest operate for as long as possible.

The LTO battery will continue normal charging up to about 113°F (45°C) and down to about -40°F (-40°C). And the battery will continue providing power well outside this temperature range for as long as it has a charge - usually long enough to return to a range where the battery can resume charging again.

Battery Level Indicator

You can check the battery level for your device by viewing the status page for your station: In the app, go to Settings > Stations > (choose a station) > Status

Battery Card Display

You can display a device's battery voltage in the app. To enable a battery card indicator on the data display, go to Settings > Stations > (choose a station) > Advanced > toggle Enable Battery Card

If you're watching the voltage level (because you are a true weather geek!), it may appear the Tempest is not charging even when the sun is out. That's because there is a "start-charge" threshold that must be reached before charging begins. This prevents the battery from going through a multiple charge cycle "yo-yo" during the day. Don't worry, that's normal. Every battery is a little different, but once it starts charging it will continue until the sun is no longer shining or it gets to a maximum of around 2.7 or 2.8 volts. From there, with no further input, it will decrease relatively quickly (over a couple hours) to around 2.6v, and then very slowly from there until the cycle starts again when the sun comes back out. This is perfectly normal too!

Power Save Modes

Mode 0: Voltage ≥ 2.455

- All sensors enabled and operating at full performance

Mode 1: Voltage ≤ 2.415 from Mode 0 or ≥ 2.41 from Mode 2

- Wind sampling interval set to 6 seconds

Mode 2: Voltage ≤ 2.39 from Mode 1 or ≥ 2.375 from Mode 3

- Wind sampling interval set to one minute

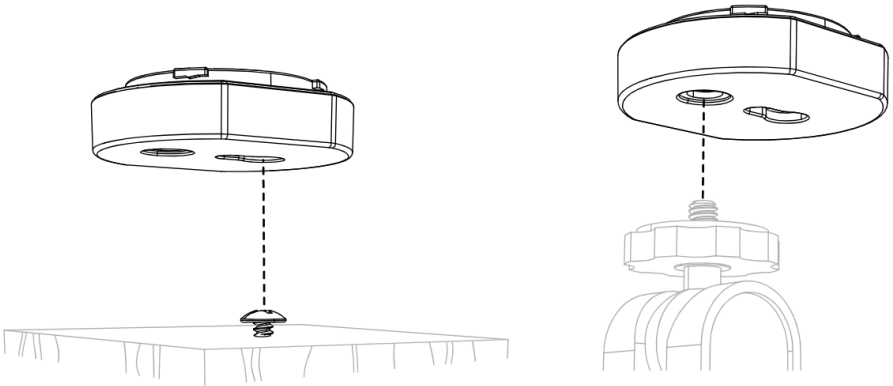
Mode 3: Voltage ≤ 2.355

- Wind sampling set to 5 minutes
- All other sensors' sampling interval set to 5 minutes
- Lightning sensor disabled
- Haptic Rain sensor disabled

Need some simple installation ideas? Check out some simple installation example esempi di installazione !

More information about the installations and height from the recommended land ...

- About 4 feet above the surface are sufficient for good reading and humidity reading.
- If you measure the speed and direction of the wind is important for you, we recommend that you get a cleaner wind. At about 6-10 feet from the ground is better if the surrounding area is free and open. Mounting above any nearby obstacles is better for ideal winds, but do so if the installation is feasible and easily accessible. Do not worry about mounting a roof line or a line of trees if it is too tiring. Professional anemometers are positioned at a standard height of 10 m (~ 33 feet from the ground) and have a clean wind detection (no obstacle to that height) for 10 times the distance of height, eg. It is almost impossible for the owner of a home meteorological station to meet these professional installation standards.
- For more ideal rain readings, it is recommended to place any all-in-one weather station at soil level in a waterproof area, away from trees, etc. For a higher precision, mounting on a robust structure, lowering the ground is particularly important for the Tactile Rain Temperature, which detects and quantifies the rain from vibrations.



Flat base, wood screw & keyhole slot mount option	Flat base & ¼-20 camera mount option

Additional Resources

Here is a link to the CWOP guide which outlines the general advice for the location of the personal meteorological stations: https://www.weather.gov/media/epz/mesonet/cwop-siting.pdf.
The CWOP location guide is a great reference, but for the vast majority of the user-friendly users simply you can not satisfy every guide line (especially being 100 feet from any concrete and no closer to 4 times the height of trees or buildings). It's okay! Your Tempest system is not a reference location for climate research. We invite you to consider your unbealing challenges / opportunities and observation needs when you decide where to fit your Tempest. Do not discuss you if your options are not ideal for each parameter. A common question among the observer meteorologists is that "you know a observation, is more useful", so we encourage all users to maintain their accurate and up-to-date metadata. This will improve your capacity of the Tempest system to provide you with the best weather data for your location.

18. TECHNICAL DATA

MEASUREMENTS	RANGE	ACURACY	INTERVAL
Air Temperature	-35°F - 140°F -37°C - 60°C	±0,7°F o ±0,7°C	1 minute
Relative humidity	0 - 100%	±2%	1 minute
Atmospheric pressure	Up to 1100mb	±1mb; station and sea level	1 minute
Lighting activity	0 to 40km (25 miglia)	Varies by distance	Instantly
Wireless	300 m (1000 ft++)	Sub-gHz telemetry	
Wind speed	0 to 100 mph 0 to 160km/h	±0,5 mph or ±0,5km/h	Continuous sampling
Wind direction	0 - 359°	±5°	Continuous sampling
Ambient light	1 to 128 kLUX	±100 mLUX	1 minute
UV index	0 to 11 +index		1 minute
Solar irradiance	0 to 1900 w/m2	±5%	1 minute
Rain onset		First rain drops	Instantly
Rain intensity	Light to torrential	±0,2mm / hr	Instantly
Rain duration	Daily total	1 minute	1 minute
Rain accumulation	Daily total	±10%	1 minute
Mount	Adjustable pole mount		
Power	Solar powered		

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